Accordo n. 2016-24-H.0

per

"Attività di studio per la comunità scientifica di Cosmologia - COSMOS"

Codice Unico di Progetto (CUP) F82F16000450005

TRA

L'Agenzia Spaziale Italiana (d'ora innanzi denominata **ASI**), con sede in Viale del Politecnico snc ROMA - CAP 00133 - P. IVA C.F. 97061010589, rappresentata dal Direttore Generale dott.ssa Anna Sirica

e

il **Dipartimento di Fisica dell'Università di Roma "Tor Vergata"** (d'ora innanzi indicato come **TOR VERGATA**), Via della Ricerca Scientifica, 1 – 00133 Roma, codice fiscale n. 80213750583, partita IVA n. 02133971008, rappresentata dal suo Direttore di Dipartimento Prof.ssa Rossana Marra.

Il presente Accordo consta:

- di n. 15 articoli, per complessive n. 11 pagine
- di un Allegato Tecnico-Gestionale, per complessive n. 55 pagine
- di n. 1 allegato PSS, per complessive n. 6 pagine

SOMMARIO

PREMESSE

- L'ASI, ai sensi degli articoli 1 e 3 del proprio Statuto, emanato in attuazione del decreto legislativo 31 dicembre 2009 n. 213 e in coerenza con le disposizioni di cui al decreto legislativo 4 giugno 2003 n. 128, promuove, sviluppa e diffonde la ricerca scientifica e tecnologica applicata al campo spaziale e aerospaziale e lo sviluppo di sistemi innovativi;
- Lo studio della fisica dell'universo primordiale attraverso la rivelazione sempre più accurata della radiazione cosmica di fondo (CMB - Cosmic Microwave Backgroud) è uno degli obiettivi principali della Cosmologia e della Fisica fondamentale.
- I risultati della missione ESA Planck, se da una parte hanno permesso di raccogliere ormai pressoché tutta l'informazione contenuta nelle anisotropie di temperatura della CMB, dall'altra hanno indicato la prossima sfida della cosmologia osservativa: la rivelazione e lo studio dei modi di polarizzazione, in particolare dei "B-modes". La rivelazione dei B-modes necessita un grande sforzo in diversi settori quali la modellistica teorica, l'analisi dei dati già disponibili e l'ottimizzazione degli strumenti, supportato da adeguati strumenti di simulazione.
- La comunità scientifica italiana attiva nel settore della cosmologia ha grande esperienza in tutti questi settori, a seguito dell'esperienza acquisita in particolare con gli strumenti di Planck e, con il supporto di ASI, è già impegnata nei passi successivi sopra descritti. Al fine di mettere a frutto nel modo migliore le esperienze nazionali acquisite in tutti i settori di studi cosmologici, è necessario organizzare e supportare le attività della comunità in un modo integrato e sinergico, con lo scopo di definire una roadmap per i prossimi 5-15 anni e garantire un posizionamento di rilievo nelle prossime iniziative internazionali dedicate allo studio della CMB.

Viste pertanto le numerose attività di studio da portare avanti nei prossimi tre anni, l'ASI ha ritenuto necessario avere un coordinamento scientifico/programmatico da parte di uno degli istituti/enti partecipanti; si è valutato che il coordinamento possa essere svolto con efficacia dal Dipartimento di

AGENZIA SPAZIALE ITALIANA * ASI

Fisica dell'Università degli Studi di Roma "Tor Vergata", con il coinvolgimento di tutti gli enti che operano nel settore, e precisamente:

INAF/Osservatorio di Trieste

SISSA

Università di Milano/ Dipartimento di Fisica

Università di Milano Bicocca/Dipartimento di Fisica

Università di Padova/Dipartimento di Fisica

INAF/IASF Bologna

Università di Ferrara/Dipartimento di Fisica

Università di Genova/ Dipartimento di Fisica

INFN/Sezione di Pisa

Sapienza Università di Roma/Dipartimento di Fisica

Università degli Studi di Roma "Tor Vergata"/Dipartimento di Matematica

Le Parti, tutto ciò premesso, ai sensi dell'art. 15 della L. 241/1990, per la disciplina e tutela dei reciproci interessi convengono e stipulano quanto segue.

Le premesse costituiscono parte integrante e sostanziale del presente Accordo.

NORMATIVA APPLICABILE

L'attività di cui al presente Accordo è disciplinata, per quanto non previsto dalle clausole in esso riportate, nell'ordine:

a) dalle condizioni fissate nel presente Accordo e dalle disposizioni contenute nell'Allegato Tecnico Gestionale;

b) dai principi del Codice Civile in materia di obbligazioni e contratti in quanto compatibili, dalle leggi nazionali e comunitarie e dai regolamenti vigenti;

c) da tutti i documenti generati da ciascuna delle Parti ed approvati dall'altra al momento della stipula del singolo Accordo.

AGENZIA SPAZIALE ITALIANA * ASI *

ART. 1 Oggetto dell'Accordo

1. La realizzazione della "Attività di studio per la comunità scientifica di cosmologia - COSMOS", oggetto del presente Accordo, che TOR VERGATA si impegna a svolgere, è identificata nell'Allegato Tecnico Gestionale all'Accordo medesimo, del quale costituisce parte integrante e sostanziale.
2. TOR VERGATA si impegna a dichiarare all'ASI, al momento della sottoscrizione dell'Accordo, eventuali altri contributi di terzi per la medesima attività di ricerca oggetto del presente Accordo.

ART. 2 – Durata

1. L'Accordo entra in vigore con la sua sottoscrizione. Le attività avranno inizio con la riunione iniziale ed avranno termine entro 36 mesi.
2. La durata potrà essere prorogata, previo accordo tra le Parti, senza oneri ulteriori a carico ASI.

ART. 3 – Piano dei lavori

1. Nell'ambito del programma di ricerca di cui al seguente Accordo sono identificati i seguenti eventi chiave:
   a) Riunione Iniziale (Kick off), da tenersi entro 30 giorni dalla sottoscrizione;
   b) Riunione di Avanzamento n. 1 (RA1), da tenersi entro 6 mesi dal Kick-off;
   c) Prima Riunione Tecnica (RT1), da tenersi entro 12 mesi dal Kick-off;
   d) Riunione di Avanzamento n. 2 (RA2), da tenersi entro 18 mesi dal Kick-off;
   e) Seconda Riunione Tecnica (RT2), da tenersi entro 24 mesi dal Kick-off;
   f) Riunione di Avanzamento n. 3 (R31), da tenersi entro 30 mesi dal Kick-off;
   g) Riunione Finale (RF), da tenersi entro 36 mesi dal Kick-off.

AGENZIA SPAZIALE ITALIANA * ASI *

ART. 4 - Finanziamento e modalità di pagamento

1. Il programma di ricerca è partecipato. Quindi, a fronte del contributo dell'ASI, TOR VERGATA e gli altri Enti non erogano contributi, ma mettono a disposizione strutture e/o attrezzature e/o personale, per un importo pari ad € 3.239.871,00.
2. L'ASI per lo svolgimento delle attività di ricerca di cui al presente Accordo si impegna a corrispondere a TOR VERGATA l'importo di € 2.399.880,00 (escluso dal campo di applicazione dell'IVA). La somma messa a disposizione dall'ASI dovrà essere utilizzata per spese che si riferiscono al periodo di durata del presente Accordo e concernenti strettamente ed esclusivamente la realizzazione delle attività di ricerca oggetto dell'Accordo stesso.

   In occasione degli eventi di cui all'art. 3, punti b), d), f), g), TOR VERGATA invierà il rendiconto finanziario (impegni di spesa e spese effettuate) delle somme già erogate da ASI.

   La data ultima per l'ammissibilità delle spese coincide con la data di scadenza del presente Accordo o dell'eventuale proroga; le spese dovranno essere rendicontate entro il termine massimo di 3 mesi dalla data di scadenza e sono considerate ammissibili se sostenute comunque entro i limiti temporali dell'Accordo.
3. L'importo di cui al precedente comma 2, pari ad € 2.399.880,00 viene ripartito come segue:

Ente	**ASI Finanziamento (€)**	**Cofinanziamento (€)**
Dipartimento di Fisica - Università di Tor Vergata	249.434	341.371
Dipartimento di Matematica – Università di Tor Vergata	-------	55.952
Dipartimento di Fisica - Università di Milano	212.889	341.862
Dipartimento di Fisica – Sapienza Università di Roma	212.890	460.861
INAF-IASF Bologna	227.899	98.923
INAF-OATS	215.899	203.054
Dipartimento di Fisica - Università di Milano Bicocca	212.846	329.752
Dipartimento di Fisica - Università di Genova	211.922	300.451
INFN Sezione di Pisa	210.668	340.997

AGENZIA SPAZIALE ITALIANA * ASI *

WL

Dipartimento di Fisica - Università di Ferrara	211.433	241.740
Dipartimento di Fisica - Università di Padova	222.104	323.040
SISSA	211.896	201.868
TOTALE	**2.399.880**	**3.239.871**

4. IL Responsabile di Progetto ASI autorizzerà l'emissione della richiesta di pagamento relativa all'evento di cui all'art. 3.1, lettera a), per un importo pari a € 800.000,00 da corrispondersi entro 30 giorni dalla ricezione della stessa. Tutte le richieste di pagamento dovranno riportare il Codice Unico di Progetto (CUP).
5. I fondi residui, pari a € 1.599.880,00 concernenti gli altri costi saranno corrisposti, sempre previa autorizzazione da parte del Responsabile di Progetto ASI, secondo le modalità e gli importi di seguito indicati:
   a) € 800.000,00 entro 30 giorni dalla ricezione da parte di ASI della richiesta di pagamento a seguito dell'evento di cui all'art. 3.1, lettera b).
   b) € 700.000,00 entro 30 giorni dalla ricezione da parte di ASI della richiesta di pagamento a seguito dell'evento di cui all'art. 3.1, lettera d).
   c) € 19.076,00 entro 30 giorni dalla ricezione da parte di ASI della richiesta di pagamento a seguito dell'evento di cui all'art. 3.1, lettera f).
   d) € 80.804,00 entro 30 giorni dalla ricezione da parte di ASI della richiesta di pagamento a seguito dell'evento di cui all'art. 3.1, lettera g).

L'importo da corrispondere sarà determinato e autorizzato dal Responsabile di Progetto ASI entro 3 mesi dalla data della riunione finale, comunque dopo l'effettuazione dei necessari controlli amministrativi sui rendiconti presentati e fatta salva l'eventuale verifica sui giustificativi contabili a disposizione dell'ASI presso il Responsabile Scientifico e/o le strutture di TOR VERGATA di cui al successivo art. 8.

Le somme eventualmente corrisposte da ASI e non rendicontate entro i 3 mesi successivi alla

AGENZIA SPAZIALE ITALIANA * ASI *

scadenza dell'Accordo dovranno essere restituite all'ASI entro 60 giorni dalla comunicazione da parte del Responsabile di Progetto sull'esito delle verifiche contabili. La restituzione di detti importi costituisce condizione necessaria per la stipula di nuovi accordi.

ART. 5 - Norme di gestione

1. Nello svolgimento delle attività di ricerca e per l'effettuazione delle relative spese, TOR VERGATA opererà in piena autonomia e secondo le norme di legge ed i propri regolamenti, assumendo la completa responsabilità nella gestione dei fondi per l'esecuzione delle attività e nella rendicontazione delle relative spese, così come riportate nei rendiconti, di cui all'art. 4 comma 2.

ART. 6 - Oneri fiscali

1. Le attività oggetto del presente Accordo in quanto attività istituzionali di realizzazione di programmi scientifici, tecnologici ed applicativi, sono da considerarsi escluse dal campo di applicazione dell'IVA, secondo quanto disposto dall'art. 2 comma 3 lett. a) del D.P.R. 633/1972.
2. Il presente Accordo verrà registrato solo in caso d'uso.

ART. 7 - Personale

1. Lo svolgimento del programma sarà affidato al personale che verrà scelto ed impegnato ad esclusiva cura di TOR VERGATA, secondo le norme di legge, senza che per detto personale (ivi compresi eventuali collaboratori esterni) derivi alcun rapporto con l'ASI.
2. A tutti gli obblighi riferiti ai soggetti di cui sopra farà fronte TOR VERGATA senza possibilità di rivalsa, anche solo parziale, nei confronti dell'ASI stessa.
3. Il personale chiave potrà essere sostituito con personale di equivalente qualificazione, previo consenso scritto dell'ASI.
4. Non sono ammessi compensi al Responsabile Scientifico delle ricerche.

AGENZIA SPAZIALE ITALIANA * ASI *

5. TOR VERGATA esonera e tiene indenne l'ASI da qualsiasi impegno, onere e responsabilità ed a qualsiasi titolo che possa derivare nei confronti di terzi durante l'esecuzione delle attività concernenti l'oggetto dell'Accordo.

ART. 8 - Controlli

1. Il Responsabile di Progetto dell'ASI ha il compito di verificare la corrispondenza in qualità, quantità e tempi delle attività svolte a quanto stabilito nell'Allegato Tecnico e di Gestione.
2. Il Responsabile di Progetto dell'ASI, per tutta la durata dell'Accordo, esegue verifiche sullo stato delle ricerche, sull'impiego delle somme erogate, sull'utilizzazione delle apparecchiature e dei materiali acquistati e può convocare riunioni. A tal fine il Responsabile Scientifico e/o le strutture dedicate di TOR VERGATA si impegnano a prestare la dovuta collaborazione.

   I giustificativi contabili di cui all'art. 4, comma 2, restano a disposizione dell'ASI, per l'eventuale verifica, presso il Responsabile Scientifico e/o le strutture di TOR VERGATA.

   L'eventuale differenza tra le somme corrisposte e quelle rendicontate ad ogni evento di cui all'art. 3, sarà, previa esplicita e motivata richiesta di TOR VERGATA ed in seguito ad autorizzazione del Responsabile di Progetto ASI, resa spendibile e rendicontabile negli eventi successivi.

ART. 9 – Modifiche

1. Potranno essere introdotte, previo consenso scritto dell'ASI, le modifiche rese necessarie dall'evoluzione della ricerca oggetto del presente Accordo.
2. E' facoltà in ogni momento dell'ASI richiedere e di TOR VERGATA proporre modifiche tecniche, gestionali e di programmazione durante l'esecuzione dell'Accordo.

ART. 10 - Utilizzazione dei risultati

1. Poiché la ricerca è partecipata, tutti i risultati conseguiti sono di proprietà comune tra le Parti.

AGENZIA SPAZIALE ITALIANA * ASI *

2. Per quanto attiene alle cognizioni ed ai brevetti, si applica quanto previsto nel presente articolo, dall'art. 2588 del codice civile e dall'art. 65 del d. lgs. n. 30 del 2005.
3. Nelle pubblicazioni si dovrà esplicitamente dichiarare che il lavoro è stato eseguito nell'ambito del presente Accordo.
4. TOR VERGATA si impegna ad esplicitare formalmente nelle pubblicazioni ed in ogni altra forma di diffusione dei risultati, la partecipazione dell'ASI con la seguente indicazione: *La ricerca "Attività di studio per la comunità scientifica di cosmologia - COSMOS" è stata realizzata mediante il cofinanziamento/contributo dell'Agenzia Spaziale Italiana".*

   Copia di ogni pubblicazione dovrà essere consegnata in formato PDF al Responsabile di Progetto dell'ASI, che ne curerà la consegna alla Biblioteca ASI.

   Il Responsabile di Progetto dell'ASI acquisirà, in occasione della Riunione Finale, l'elenco di tutte le pubblicazioni prodotte relative all'Accordo.

ART. 11 - Assicurazioni

1. Ciascuna parte provvederà alla copertura assicurativa di legge del proprio personale che, in virtù del presente Accordo, verrà chiamato a frequentare le sedi di esecuzione delle attività.

ART. 12 - Sicurezza

1. Il personale dell'ASI o di TOR VERGATA o altri da essi delegati, sarà tenuto a uniformarsi ai regolamenti disciplinari e di sicurezza in vigore nelle sedi di esecuzione delle attività attinenti al presente Accordo, secondo quanto prescritto dal d. lgs. n. 81 del 2008.

ART. 13 – Risoluzione dell'Accordo

1. L'Accordo sarà risolto sia nel caso in cui una delle parti si trovi nell'impossibilità, a qualsiasi causa dovuta, di attendere agli obblighi di cui al presente Accordo, sia nel caso in cui emergano gravi

AGENZIA SPAZIALE ITALIANA * ASI *

irregolarità nella gestione dell'Accordo stesso.

2. In caso di scioglimento anticipato del rapporto, TOR VERGATA restituirà le somme anticipate salvo il riconoscimento, previa rendicontazione, dell'importo delle spese sostenute e di quelle relative ad obbligazioni giuridiche assunte, in base all'Accordo, fino al momento dell'anticipato scioglimento.

ART. 14 – Controversie

1. Le eventuali controversie sorte dall'interpretazione e/o dall'applicazione del presente Accordo saranno devolute, ai sensi dell'art. 133, comma 1, lett. a) del d. lgs. n. 104/2010, alla giurisdizione esclusiva del giudice amministrativo.

ART. 15 - Trattamento dati personali

1. In conformità al disposto del d.lgs. n. 196 del 30/06/2003, e successive modifiche e integrazioni, le Parti dichiarano reciprocamente di essere informate e, per quanto di ragione, espressamente acconsentire, che i "dati personali" forniti, anche verbalmente per l'attività preparatoria del presente Accordo o comunque raccolti in conseguenza ed in corso dell'esecuzione dello stesso, vengano trattati esclusivamente per le finalità dell'Accordo e, inoltre, per fini statistici, con esclusivo trattamento dei dati in forma anonima, mediante comunicazione a soggetti pubblici, quando ne facciano richiesta per il perseguimento dei propri fini istituzionali, nonché a soggetti privati, quando lo scopo della richiesta sia compatibile con i fini istituzionali delle Parti.

Data, ……………………

Dipartimento di Fisica
dell'Università di Tor Vergata
Il Direttore
Prof.ssa Rossana Marra

Agenzia Spaziale Italiana
Il Direttore
Dott.ssa Anna Sirica

AGENZIA SPAZIALE ITALIANA * ASI *

ACCORDO N. 2016-24-H.0

"Attività di studio per la comunità scientifica di cosmologia - COSMOS"

ALLEGATO TECNICO GESTIONALE

INDICE

AGENZIA SPAZIALE ITALIANA * ASI *

AGENZIA SPAZIALE ITALIANA * ASI *

1.0 SCOPO

Questo documento costituisce l'allegato tecnico gestionale all'Accordo relativo al progetto "Attività di studio per la comunità scientifica di cosmologia - COSMOS". L'accordo è stipulato tra l'Agenzia Spaziale Italiana (ASI) e Dipartimento di Fisica dell'Università di Tor Vergata (UNITOR).

Nel presente documento sono descritte le attività da svolgere e le modalità per la gestione dell'Accordo da parte di ASI e UNITOR

1.1 OGGETTO DELL'ACCORDO

L'oggetto dell'accordo è uno studio integrato della comunità cosmologica italiana finalizzato alla definizione di una roadmap che renda tale comunità sempre più competitiva a livello internazionale, alla preparazione dell'analisi dati dell'esperimento LSPE e di future campagne osservative e alla formazione di una nuova generazione di cosmologi

2.0 DEFINIZIONI ED ACRONIMI

Le definizioni contenute nello standard ECSS-P-001 sono applicabili.

2.1 DEFINIZIONI

NA

2.2 ACRONIMI

ASDC	ASI Science Data Center
ASI	Agenzia Spaziale Italiana
ATG	Allegato Tecnico Gestionale
CMB	Cosmic Microwave Background
COrE+	Cosmic Origins Exolorer +
DA	Documento applicabile
DEL	(documento da consegnare)
DR	Documento di riferimento
EOS	Unità Esplorazione Osservazione Universo
ESA	European Space Agency
HW	Hardware
INAF	Istituto Nazionale di AstroFisica
INFN	Istituto Nazionale Fisica Nucleare
KO	Kick-off
LSPE	Large Scale Polarization Explorer
NA	Non Applicabile

AGENZIA SPAZIALE ITALIANA ASI

PTA	Piano Triennale d'Attività
RA1	Prima Riunione d'Avanzamento
RA2	Seconda Riunione d'Avanzamento
RA3	Terza Riunione d'Avanzamento
RF	Riunione finale
RT	Riunione tecnica
SW	Software
WPD	Work Package Description
WBS	Work Breakdown Structure

3.0 DOCUMENTAZIONE APPLICABILE E DI RIFERIMENTO

I seguenti documenti costituiscono parte integrante dell'accordo secondo la priorità definita nel paragrafo § 3.3 "Ordine di Precedenza".

3.1 DOCUMENTAZIONE APPLICABILE

Nessuno

3.2 DOCUMENTAZIONE DI RIFERIMENTO

I documenti di riferimento di seguito elencati forniscono informazioni relative al contesto nel quale si colloca l'iniziativa oggetto dell'Accordo, linee guida, dati di confronto, informazioni suppletive per la migliore descrizione degli obiettivi del progetto.

[DR 1] Piano Triennale di Attività ASI 2016-2018

[DR 2] "ECSS Glossary" – Doc. ECSS-P-001 Rev. B

3.3 ORDINE DI PRECEDENZA

L'ordine di precedenza tra i documenti applicabili al programma sarà il seguente:

- il presente Allegato Tecnico Gestionale (ATG)
- i Documenti Applicabili (DA) identificati nella sezione 3.1
- tutti i documenti generati dall'ASI ed accettati dall'Ente partecipante.

In caso di conflitto tra i requisiti ha prevalenza il più stringente.

L'Ente partecipante evidenzierà ogni eventuale conflitto tra requisiti e lo sottoporrà ad ASI per risoluzione.

AGENZIA SPAZIALE ITALIANA ASI

4.0 OBIETTIVI ED ATTIVITA'

4.1 CONTESTO DI RIFERIMENTO

Lo studio dell'universo primordiale attraverso misure sempre più accurate della radiazione cosmica di fondo (CMB - Cosmic Microwave Background) è uno degli obiettivi principali della cosmologia e della fisica fondamentale. Infatti, la CMB permette di porre dei limiti sui modelli della fisica delle particelle a energie che non potranno mai essere raggiunte in laboratorio, mettendo alla prova nuovi scenari che vanno oltre i modelli standard della cosmologia e delle particelle elementari.

La missione ESA Planck ha da una lato permesso di rivelare pressoché tutta l'informazione contenuta nelle anisotropie di temperatura della CMB, mentre ha dall'altro aperto la strada alla prossima sfida della cosmologia osservativa: la misura accurata della polarizzazione del fondo e cosmico, condizione essenziale per rivelare, tra le altre cose, i suoi modi B, che rappresentano l'impronta lasciata dalle onde gravitazionali primordiali e sono dunque intimamente legate alla fisica del paradigma inflazionario. L'ampiezza dei modi B conduce immediatamente alla conoscenza della scala di energia a cui l'inflazione si è accesa, un parametro fondamentale che non è pensabile vincolare altrimenti. Tuttavia, come mostrato dalle recenti osservazioni dell'esperimento BICEP2, condizione necessaria per poter "mappare" in maniera accurata la componente polarizzata del CMB è quella di poter caratterizzare in estremo dettaglio, e quindi rimuovere, i contributi spuri dovuti ai "foregrounds", cioè a tutto ciò che trovandosi tra noi e la superficie di ultimo scattering maschera e confonde il segnale primordiale. Tra questi foregrounds, particolarmente rilevanti sono l'emissione galattica diffusa, gli effetti del lensing gravitazionale, l'emissione delle altre galassie e il segnale Sunyaev-Zeldovich proveniente dagli ammassi. Allo stesso tempo, occorre tenere in debito conto tutti gli effetti strumentali, da caratterizzare con precisione tanto maggiore quanto più debole è il segnale delle onde gravitazionali primordiali nella polarizzazione della CMB.

La rivelazione e caratterizzazione dei B-modes necessitano quindi un grande sforzo corale, che va dalla modellistica teorica, all'analisi dei dati di CMB già disponibili, e all'ottimizzazione degli esperimenti – sia quelli in corso di realizzazione sia quelli ancora da progettare – con adeguati strumenti di simulazione. La comunità scientifica italiana attiva nel settore della cosmologia vanta una lunga tradizione e una profonda esperienza in tutti questi settori. Questo grazie alle attività connesse con la progettazione, la realizzazione e lo sfruttamento scientifico dei dati di esperimenti da terra, da pallone e dallo spazio. In particolare, il satellite Planck ha costituito un'insostituibile occasione di crescita della comunità, che è già unita nello sviluppo del dopo Planck. Sono infatti in corso di realizzazione gli esperimenti su pallone Olimpo e LSPE, dedicati rispettivamente a misure dell'effetto Sunyaev-Zeldovich e a misure di polarizzazione della CMB a grandi scale angolari, e stanno per prendere il via le attività di sviluppo tecnologico in vista di future missioni spaziali, in particolare CORE+, proposta ad ESA come M5 del programma "Cosmic Vision 2015-2025".

4.2 RISULTATI DEL PROGETTO

I risultati del progetto saranno:

- la definizione di una roadmap per la realizzazione di esperimenti da terra, da pallone e dallo spazio che rendano la comunità cosmologica italiana sempre più competitiva e ben inserita a livello europeo e mondiale;
- la preparazione dell'analisi dati dell'esperimento LSPE, già finanziato dall'ASI, e delle future campagne osservative in cui la comunità italiana è già coinvolta;
- la formazione, integrata a livello nazionale, di una nuova generazione di cosmologi in grado di inserirsi nella ricerca di frontiera nel campo teorico, sperimentale e dell'analisi dati, anche in vista di una nuova missione spaziale, operativa a cavallo tra la fine degli anni 2020 e l'inizio del decennio successivo.

4.3 DESCRIZIONE DELLE ATTIVITA'

Per raggiungere questi obiettivi, e per mettere a frutto nel modo migliore l'esperienza acquisita, la comunità cosmologica italiana metterà in campo azioni integrate e sinergiche tra Università, INFN e INAF, ed in ogni caso complementari a quelle già in corso grazie al supporto dell'ASI. Il presente accordo mira a finanziare e coinvolgere con attività specifiche tutti i gruppi attivi nel campo della cosmologia teorica e sperimentale, con la consapevolezza, supportata dall'esperienza di Planck, che solo attraverso uno sforzo sinergico si possono raggiungere massa critica e, quindi, competitività. In quest'ottica, verrà anche coinvolto il personale operante presso l'ASI Science Data Center sia per la legacy di Planck sia per lo sviluppo di nuove missioni CMB. Le attività che verranno realizzate nell'ambito di questo accordo possono essere così sintetizzate:

- Studi di fattibilità per future missioni per l'osservazione della CMB da terra, da pallone e dallo spazio:
    - verrà valutato il potenziale e la fattibilità tecnica di un programma di medio periodo per la misura della polarizzazione della CMB da terra, con particolare attenzione alle basse frequenze (<100 GHz), ma non trascurando la possibilità di estendere le osservazioni anche a frequenze superiori. Questo richiede una accurata definizione delle sensibilità strumentale, frequenze di osservazione e risoluzione angolare necessarie per raggiungere una detezione significativa del segnale di polarizzazione. Richiede inoltre di valutare la capacità di rimuovere contributi spuri dovuti all'emissione atmosferica e galattica. Tutto questo verrà studiato anche alla luce delle attività internazionali, quale per esempio il programma S4 americano finanziato da DOE e NSF;
    - si affronterà uno studio quantitativo della migliore strategia osservativa da pallone, definendo, anche in questo caso, frequenze di osservazione (>100 GHz), risoluzione angolare, copertura di cielo e tempo di osservazione, sensibilità strumentale e, soprattutto, la capacità di sottrarre con estrema precisione l'emissione polarizzata da polvere nella nostra galassia;
    - in attesa dei risultati del processo di selezione dell'ESA relativi alla call per una missione M5 dedicata allo studio della polarizzazione del fondo cosmico, ci si preparerà a contribuire allo sviluppo delle attività del satellite CORE qualora dovesse passare in fase A, senza trascurare tuttavia scenari alternativi

che ovviamente si intersecano in maniera molto stretta con le osservazioni da terra e da pallone.

Per ciascuno dei punti precedenti, si provvederà a definire lo stato dell'arte e gli sviluppi aspettati nel breve e medio periodo per quanto riguarda i rivelatori, con particolare attenzione alle tecnologie realizzative, al fine di definire una strategia realistica per rendere competitiva la comunità italiana rispetto a quella di altri paesi.

- Preparazione all'analisi dei dati dell'esperimento LSPE e delle successive missioni di cosmologia osservativa, mediante lo sviluppo di strumenti di simulazione e di pianificazione della missione atti a ottimizzare la strategia osservativa, le tecniche di calibrazione, gli effetti di un beam non necessariamente simmetrico e circolare, la cross-correlazione fra il rumore di differenti ricevitori. La messa a punto di una pipeline di alto livello avrà l'obiettivo di massimizzare il ritorno scientifico di questi esperimenti, sviluppando tecniche avanzate per la rimozione dei foregrounds galattici, delle sorgenti puntiformi extragalattiche, del contributo degli ammassi di galassie e del lensing gravitazionale. Questa è una premessa irrinunciabile per avere una detezione robusta degli spettri angolari dei modi B della polarizzazione del fondo cosmico e una stima la più precisa possibile dei principali parametri cosmologici.
- Gli aspetti più squisitamente tecnologici/sperimentali e di analisi dati saranno esaminati alla luce di una profonda conoscenza teorica della fisica dell'inflazione - con particolare riguardo al fondo stocastico di onde gravitazionali e alla statistica non gaussiana delle fluttuazioni primordiali - e della fisica fondamentale, con particolare riguardo alla fisica del neutrino e degli altri campi primordiali, alla violazione di simmetrie fondamentali e ai legami degli osservabili del CMB con teorie di gravità quantistica, quali i modelli di stringa.

4.4 REQUISITI

NA

5.0 ORGANIZZAZIONE E INTERFACCE

Viste le numerose attività di studio da portare avanti nei tre anni, ASI ha ritenuto necessario avere un coordinamento scientifico/programmatico da parte di uno degli istituti/enti partecipanti. In occasione dell'evento "CMB Day" tenuto in ASI il 30 marzo 2016 alla presenza del Presidente dell'ASI, si è convenuto che il coordinamento possa essere svolto con efficacia dal Dipartimento di Fisica dell'Università degli Studi di Roma "Tor Vergata", con il coinvolgimento di tutti gli enti che operano nel settore, in dettaglio:

- Dipartimento di Fisica / Università di Milano
- Dipartimento di Fisica / Università La Sapienza
- INAF-IASF / Bologna
- INAF-OATS / Trieste
- Dipartimento di Fisica / Università di Milano Bicocca
- Dipartimento di Fisica / Università di Genova

AGENZIA SPAZIALE ITALIANA * ASI *

- INFN Sezione di Pisa
- Dipartimento di Fisica / Università di Ferrara
- Dipartimento di Fisica e Astronomia / Università di Padova
- SISSA
- Dipartimento di Fisica / Università Tor Vergata
- Dipartimento di Matematica / Università Tor Vergata

5.1 ORGANIZZAZIONE DELL'ASI

L'ASI, per la direzione ed il controllo delle attività, si avvarrà di un Responsabile di Programma che sarà nominato dall'ASI dopo la sottoscrizione dell'Accordo e il cui nominativo sarà comunicato all'Ente Partecipante entro 15 giorni dalla sottoscrizione dell'Accordo di collaborazione stesso.
Il Responsabile di Programma, nell'espletamento dei propri compiti di seguito riportati, farà capo alla struttura organizzativa dell'ASI e sarà supportato dalla struttura dell'ASI per il controllo delle attività.

Responsabile di Programma
Il Responsabile di Programma assumerà, per conto dell'ASI, la supervisione dell'attività al fine di assicurare il raggiungimento degli obiettivi previsti in accordo. Pertanto, il Responsabile di Programma:
- sarà il responsabile ed il rappresentante ufficiale dell'ASI nei confronti dell'Ente Partecipante,
- verificherà che le attività svolte siano corrispondenti a quanto stabilito dall'Accordo di collaborazione medesimo e dall'allegato tecnico,
- autorizzerà il pagamento delle rate di pagamento, evidenziando l'eventuale ritardo nelle consegne,
- approverà la documentazione di programma quando previsto,
- fornirà un parere sulla richiesta di proroga dell'accordo.

5.2 ORGANIZZAZIONE DELL'ENTE

Per lo svolgimento delle attività del presente accordo, l'Ente partecipante si avvarrà di un Responsabile scientifico dell'accordo, interfaccia formale con ASI, e di un Responsabile amministrativo il cui nominativo sarà comunicato alla riunione iniziale.

Responsabile Scientifico
Il Responsabile Scientifico assicurerà il coordinamento tecnico-programmatico delle attività previste nell'Accordo; egli è responsabile, nei confronti dell'ASI, della validità e completezza dei risultati scientifici e tecnici conseguiti. In particolare assicura:
- l'interfaccia dei rapporti con l'ASI,
- la direzione scientifica e tecnica ed il coordinamento delle attività interne,
- il coordinamento tra i gruppi di lavoro e con eventuali enti esterni,
- la soluzione dei conflitti fra aree di responsabilità e il controllo della programmazione temporale, degli stati di avanzamento e dell'esecuzione delle azioni,
- la supervisione ed approvazione della documentazione tecnico-contrattuale prodotta nel corso delle attività.

Responsabile amministrativo

Il Responsabile amministrativo dell'Ente gestisce, in accordo con il Responsabile Scientifico, gli aspetti legali, amministrativi e finanziari dell'Accordo, ivi compresi i riflessi derivanti dal rapporto con i gruppi di ricerca afferenti

6.0 RESPONSABILITA'

6.1 RESPONSABILITÀ DELL'ASI

NA

6.2 RESPONSABILITÀ DELL'ENTE

L'Ente Partecipante garantirà a tutti i componenti del gruppo di gestione del progetto ASI il pieno accesso ad informazioni, siti ed attività secondo le prescrizioni dell'accordo.

L'Ente Partecipante sarà responsabile delle verifiche e dell'accettazione delle forniture da terzi.

7.0 PIANIFICAZIONE DELLE ATTIVITA', FASI ED EVENTI CHIAVE

La durata delle attività è di 36 mesi a decorrere dalla riunione iniziale.

Sono previste le riunioni di programma indicate nella tabella qui di seguito.

Riunione	Pianificazione	Località
Kick-off (KO)	T0	Roma
Prima Riunione di Avanzamento (RA1)	T0+6	Roma
Prima Riunione Tecnica (RT1)	T0+12	Roma
Seconda Riunione di Avanzamento (RA2)	T0+18	Roma
Seconda Riunione Tecnica (RT2)	T0+24	Roma
Terza Riunione di Avanzamento (RA3)	T0+30	Roma
Riunione Finale (RF)	T0+36	Roma

8.0 FORNITURE DI RESPONSABILITA' DELL'ASI

NA

9.0 FORNITURE DI RESPONSABILITA' DELL'ENTE PARTECIPANTE

La fornitura consiste nella documentazione elencata nel par.11.1.

10.0 ORGANIZZAZIONE DELLE ATTIVITA'

10.1 WORK BREAKDOWN STRUCTURE

Le attività sono state organizzate come indicato nella WBS qui di seguito:

WP	Titolo	Istituto	WP Manager
1-1°	Project Management	Dip. Fisica / Università Tor Vergata	Nicola Vittorio
1-6X1	SZ signal extraction from future CMB data	Dip. Fisica / Università Tor Vergata	Pasquale Mazzotta
1-6X2	New point sources detection methods	Dip. Matematica / Università Tor Vergata	Domenico Marinucci
2-6X1	Future ground-based CMB experiments	Dip. Fisica / Università di Milano	Marco Bersanelli
2-6X2	Support to data analysis for LSPE/STRIP	Dip. Fisica / Università di Milano	Davide Maino
3-6X1	Future balloon borne CMB experiments	Dip. Fisica / Università La Sapienza	Paolo de Bernardis
3-6X2	Support to data analysis for LSPE/SWPE	Dip. Fisica / Università La Sapienza	Francesco Piacentini
4-6X1	Next Generation of CMB Space Missions	INAF-IASF / Bologna	Giuseppe Malaguti
4-6X2	HW/SW infrastructure for future CMB experiments	INAF-OATS / Trieste	Andrea Zacchei
5-6X1	RF Testing for future CMB experiments	Dip. Fisica / Università di Milano Bicocca	Mario Zannoni
5-6X2	CMB calibration and SRT	Dip. Fisica / Università di Milano Bicocca	Massimo Gervasi
6-6X1	Strategic solutions for new CMB detectors	Dip. Fisica / Università di Genova	Flavio Gatti
6-6X2	Readout electronics for future CMB missions	INFN Sezione di Pisa	Giovanni Signorelli
7-6X1	Astroparticle and Fundamental Physics	Dip. Fisica / Università di Ferrara	Paolo Natoli
8-6X1	Inflationary gravitational waves	Dip. Fisica e Astronomia / Università di Padova	Nicola Bartolo
8-6X2	Non Gaussianity from Inflation	Dip. Fisica e Astronomia / Università di Padova	Michele Liguori
9-6X1	Foreground modeling and removal	SISSA	Francesca Perrotta
9-6X2	CMB weak lensing reconstruction	SISSA	Carlo Baccigalupi

AGENZIA SPAZIALE ITALIANA * ASI *

I responsabili dei WP potranno essere variati, in caso di necessità, con il consenso di ASI.

10.2 DESCRIZIONE DEI PACCHI DI LAVORO (WPD)

I pacchi di lavoro sono di seguito descritti.

10.2.1 WP 1-1A: Management

PROJECT: **Studi di Cosmologia**		**WP REF.**: **1-1A**
WP TITLE: **Management** **CONTRACTOR**: **Dipartimento di Fisica, Università Tor Vergata** **START EVENT**: KO **END EVENT**: RF **WP MANAGER**: **Nicola Vittorio**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**: 01/09/2016

INPUTS

- Applicable documents

TASKS

- to manage relations with ASI
- to manage funding and corrective actions, when applicable
- to coordinate WPs activities
- to monitor technical and scientific activities and manage corrective actions, when applicable
- to plan and prepare progress meetings with ASI
- to coordinate and approve progress reports and funding resources reports to ASI
- to organize technical meeting

OUTPUTS

- Schedules
- Progress reports
- Funding resources reports

10.2.2 WP 1-6X1: SZ signal extraction from future CMB data

PROJECT: **Studi di Cosmologia**		**WP REF.**: **1-6X1**
WP TITLE: **SZ signal extraction from future CMB data** **CONTRACTOR**: **Dipartimento di Fisica, Università Tor Vergata** **START EVENT**: KO **END EVENT**: RF **WP MANAGER**: **Pasquale Mazzotta**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**:01/09/2016

INPUTS

- Hydro N-body simulations
- Planck Frequency Maps
- Instrumental responses of the relevant instruments
- Specification of noise level for the relevant instruments

TASKS

Main collaborations: Astronomical Observatory of Trieste

Through this project, a new imaging algorithm aiming at restoring the SZ signal to the highest resolution allowed by the local signal-to-noise ratio will be developed and tested. This goal will be achieved following a multiscale approach combining datasets at different frequencies, each of them being characterized by its own spatial resolution. Beyond the data analysis of space observatories (e.g. Planck or Core+), this approach will be relevant for combining the observations of space observatories with balloon-born and ground instruments working in several bands with different angular resolutions, such as ACT, SPT and the future CCAT. Moreover, the restoration of the bi-dimensional distribution of a local parameter estimated via spectroscopy is a general problem with applications at other wavelenghts: among them are the restoration of temperature maps in X-ray astronomy or spectral index maps in radio-astronomy. Inspired from recent development in radar imaging, this problem can be solved from a coupling between bayesian inference and multi-scale analyses. Multi-scale algorithms being routinely used for many applications in image denoising and compression, this approach might also apply outside astronomy.

This project will make use of advanced cosmological hydrodynamical simulations of galaxy clusters, which will include astrophysical processes, such as radiative cooling, star formation and the effect of feedback from supernovae and AGN. These simulations, which will reproduce basic X-ray observational properties of the intra-cluster medium (ICM), represents the starting point to produce detailed maps of pressure and of the Compton-y parameter, by including both the thermal and the kinematic components. These maps will be "observed" in realistic conditions, by producing SZ mock observations at different frequencies, beam smearing, realistic level of signal-to-noise, contaminating backgrounds and point sources. Producing the same maps in the X-ray band will further allow exploring the synergies between the next generation of mm and X-ray telescopes in tuning galaxy clusters as precision tools for cosmology.

OUTPUTS

Contribution to deliverable documents regarding:

- Pressure and Compton-y maps of simulated clusters at different redshifts
- Mock SZ observations

- definition of fully parametric component separation algorithm and results of the software package
- results of SZ map reconstruction software package that includes, curvelet analysis, denoising and Image deconvolution

SCHEDULE

First Year, 1st Semester:

- Hydrodynamical simulations
- Development of the fully parametric component separation algorithm,

First Year 2nd Semester:

- Development and implementation of instrument-optimized denoising algorithm,
- Implementation of curvlet analysis on sky patches.

Second year, 1st Semester:

- Production of idealized maps
- Test and optimization of the Algorithms on Planck data,
- Implementation of Image deconvolution,

Second year, 2st Semester:

- Production of mock SZ observations
- Development of new techniques to identify and reconstruct anisotropic features in atmosphere of clusters of galaxies.

Third year 1st Semester:

- Implementation of the multi-instrument (Space, Ballon-Borne and Ground) SZ signal extraction,
- Extension of the algorithm on the celestial sphere

Third year 2st Semester:

- Extension of the algorithm for the component separation of polarization maps.

AGENZIA SPAZIALE ITALIANA * ASI *

10.2.3 WP 1-6X2: New point source detection methods

PROJECT: Studi di Cosmologia		WP REF.: 1-6X2
WP TITLE: New point source detection methods CONTRACTOR: Dipartimento di Matematica, Università Tor Vergata START EVENT: KO END EVENT: RF WP MANAGER: Domenico Marinucci		Sheet: 1 of 1 Issue Ref: 1 Issue Date:01/09/2016

INPUTS

- *Data* This item can developed primarily out of Planck data; applications to future ground-based or satellite experiments can also be envisaged.
- *Technical Tools* As detailed below, this part of the project is going to build upon some very recent developments in the mathematical statistics literature, concerning multiple testing on spherical data.
- *Software* Our routines require specific packages for data analysis in the needlet domain. These packages are now well-developed within the *HealPix* paradigm.

TASKS

The main goal for this task is to develop and adjust for the requirements of CMB data analysis the state-of-the-art techniques in a statistical framework for the principled implementation of multiple testing algorithms. As well known, indeed, point-source detection in either the temperature or the polarization domains can be viewed as a typical multiple testing issue, where the possible presence of several thousands sources at different (unknown) locations is simultaneously investigated. There is currently a vast statistical literature on error control and power maximization in these circumstances; this literature, however, has typically been developed for the case where a fixed (albeit huge) number of tests is implemented, for instance for genome-wide arrays. On the other hand, in the CMB community multiple testing has often been implemented by simply considering the threshold significance of possible point sources on one-by-one basis, thus neglecting statistical issues on global error control. Indeed, a number of algorithms have been proposed for these tasks; these solutions have all been shown to perform well in practice, and indeed they have been widely applied to the analysis of Planck data: however, they have all avoided to face the specific challenges of multiple testing, and in particular none of them has been shown to control in any proper statistical way any aggregate statistics such as the classical Family-Wise Error Rate (FWER), False Discovery Proportion (FDP) or False Discovery Rate (FDR).

More specifically, the aim is to implement new techniques to control the False Discovery Rate (FDR) when detecting multiple point sources. FDR is defined as the proportion of selected peaks which are not point sources; for massive CMB data sets, it seems very reasonable to search procedures aimed at controlling the proportion of pixels wrongly identified as sources, rather than naively pretending that no such misclassification error can occur. The idea that is going to be pursueb is to exploit recent developments on the probabilistic properties of multi-scale data analysis techniques. In particular, the goal is to develop CMB maps into needlet components; the distribution of peaks for at high frequencies for these components can be derived analytically, and the control of FDR can then be achieved by a statistical procedure called STEM (smoothing and testing of local maxima). Some properties of these procedures for the analysis of spherical data have been investigated very recently in the mathematical statistics literature, but their calibration and implementation on CMB data is still an open issue for research; the approach is also suitable for application on spherical data outside the CMB framework.

One important extra-advantage of the procedure that is going to be developed is that it is not simply going to provide a list of candidate point sources (to be cross-cheched with existing catalogues); indeed, for each of them it will also provide an evaluation of the *p*-value or significance as a point source. This means, for instance, that when planning follow-up observational strategy astrophysicists will be able to decide on their own the level of significance for the sources to be included in their own catalogue. This result can be obtained by implementing on *Planck* CMB data some recent theoretical advances on the distribution of critical points and maxima for filtered spherical Gaussian maps.

These tasks have a number of connections and interactions with other topics of the project, in particular *Foreground Cleaning* and *Delensing*, both located at Sissa Trieste. The importance of point source detection for foreground cleaning need not be explained; for delensing, the exploitation of cross-correlation techniques for the reconstruction of the lensing potential will be further enhanced, an issue on which the collaboration with SISSA has been going on quite rapidly in the last few years.

OUTPUTS

Contribution to deliverable documents regarding:

- Results of the software to implement the Multiple Testing Algorithm for full-sky temperature and polarization data
- Results of the software to implement the algorithm on small patches of the sky observed at very high resolution.

SCHEDULE

- First Year, first semester: The Multiple Testing Algorithm is implemented on Planck temperature data
- First year, second semester: The Multiple Testing Algorithm is optimized for Planck temperature data
- Second year, first semester: The Multiple Testing Algorithm is implemented on Planck temperature data
- Second year, second semester: The Multiple Testing Algorithm is optimized for Planck Polarization data
- Third Year, first semester: The algorithm is implemented on small sky patches, observed at very high resolution
- Third year, second semester: The algorithm is optimized for small sky patches, observed at very high resolution

10.2.4 WP 2-6X1: Future ground-based CMB experiments

PROJECT: Studi di Cosmologia		WP REF.: 2-6X1
WP TITLE: Future ground-based CMB experiments SUB-CONTRACTOR: Dip. Fisica / Università di Milano START EVENT: KO END EVENT: RF WP MANAGER: Marco Bersanelli		Sheet: 1 of 1 Issue Ref: 1 Issue Date:01/09/2016

OBJECTIVES

- Design a "medium-term ground-based" (MTGB) experiment to measure the polarization of the CMB and foreground components in the low frequency range (<100GHz), to contribute, in the next 5 years or so, to the on-going CMB international efforts (European coordination, S4).
- Study the feasibility of a "long-term ground-based" (LTGB) experiment, as an ambitious programme to measure CMB B-modes at low frequencies from the ground, to be considered a long-term contribution to CMB European coordination & S4.

INPUTS

- Contract and Technical Annex
- Work plan & Schedule
- Planck (and other CMB experiments) data

TASKS

Main collaborations: all nodes

- Survey the state-of-the-art technology for polarized detectors at low frequencies (10-100GHz), and extrapolate into the next 10 years. Analyse the current status in Italy (capabilities, institutions, industry, possible new partners) and the potential for future technology progress (detectors, antennas/OMTs, telescopes, cryogenics, electronics, mechanics). Identify international collaboration opportunities (e.g. US for next generation of HEMT LNAs). In particular, carry out a feasibility study of extension of Italian bolometer technology to low frequency (e.g. Ka and Q band) for ground operation (in close collaboration with INFN/Genova).
- Develop an atmospheric model to estimate atmospheric noise into polarization measurements. Comparative analysis of observing sites (Tenerife, White Mountain, Atacama, South Pole, Argentina, etc.).
- Develop an instrument configuration for a medium-term (~5 years) ground-based, low-frequency experiment (MTGB) aimed at precision measurements of CMB polarization and synchrotron, as a successor of LSPE/STRIP. This is conceived as a first contribution to the ongoing collaborative effort in Europe (in particular at the Tenerife site) and in the US (S4). This requires careful design, confirmed by numerical simulations, of the optical/detection/cryo systems, including laboratory tests of selected key subsystems: telescope (in particular cross polarization and sidelobes), high performance feed horn arrays, polarizers and OMTs arrays (to achieve high polarization purity), electronics, cryogenics, mechanics.

- Develop an instrument configuration for a long-term ground-based (LTGB) experiment, as an ambitious programme to measure primordial B-modes at low-frequencies (5-100GHz) from the ground. This is conceived as a long-term (~10-15 years) contribution to the ongoing collaborative effort in Europe and in the US (S4). The study will consider simultaneously foregrounds limitations (in close collaboration with SISSA, Trieste) and technological opportunities/approaches. Identify and study main trade-offs. Identify optimal modular strategy for large arrays deployment. This requires careful design, confirmed by numerical simulations, of the optical/detection/cryo systems, including laboratory tests of selected key subsystems: telescope, optical coupling, polarization selection (OMTs). Identify feasible solutions for electronics, cryogenics, mechanics, and required test facilities. Identify institutional partnership in Italy (ASI, INFN, INAF) and International Collaborations to implement such long term ground based program.

The feasibility studies described in the last two items will directly involve all the other nodes of this project: La Sapienza and Bologna for coordination with our parallel studies on balloon and space; Milano-Bicocca, Genova, Pisa for hardware design, testing and calibration strategies; SISSA for foreground analysis; OAT/INAF for data analysis support; Roma2, Ferrara and Padua for detailed definition of science goals).

OUTPUTS

Contribution to deliverable documents regarding:

- Feasibility study of a medium-term ground-based experiment to measure to high precision the polarized sky (CMB and synchrotron emission) at low frequencies for implementation in a ~5yr time scale, with maximum science return for the Italian community.
- Feasibility study of a long-term ground-based programme to measure to measure CMB B-modes at low frequencies for implementation in a ~10-15yr time scale, with maximum science return for the Italian community.
- Development of an atmospheric model capable of evaluating the impact of atmosphere on low frequency measurements (including polarization) from different observing sites.
- Survey of current and future capabilities in the field, identifying strategic opportunities in Italy and through international collaboration.

SCHEDULE

First Year, t0+6 months

- Review of state-of-the-art in Italy on low frequency critical technologies
- Review of synchrotron and CMB polarization models and data
- Preliminary simulations of atmospheric effects and new atmospheric model.
- Preliminary design options for the MTGB

First Year, t0+12 months

- Complete review of state-of-the-art in Italy and worldwide on low frequency critical technologies
- Complete review of synchrotron and CMB polarization models and data
- Preliminary feasibility of extension to Ka and Q band of Italian bolometer technology
- Complete atmospheric model.

AGENZIA SPAZIALE ITALIANA ASI

- Design options and trade-offs for the MTGB experiment: choice of observing site, frequencies, technology, optical system, preliminary scanning strategy.

Second year, t0+18 months

- Complete preliminary design of MTGB experiment
- Design and construction of prototypes of selected key units for the MTGB experiment polarization measurement
- Complete scientific assessment of foregrounds and CMB for the LTGB experiment (in collaboration with...)

Second year, t0+24 months:

- Complete design of MTGB experiment
- Design and construction of prototypes of selected key subsystems for the MTGB experiment polarization measurement
- Design options and trade-offs for the LTGB experiment: choice of observing site, frequencies, technology, optical system, preliminary scanning strategy.

Third year, t0+30months:

- Performance test of key units and subsystems for the MTGB experiment
- Performance test of key subsystems for the spectral measurement
- Preliminary design of the LTGB experiment.
- Preparation of data analysis for MTGB (in collaboration with...)

Third year, t0+36months:

- Final design of LTGB
- Complete scientific assessment of LTGB

AGENZIA SPAZIALE ITALIANA * ASI *

10.2.5 WP 2-6X2: Support to data analysis for LSPE/STRIP

PROJECT: Studi di Cosmologia		WP REF.: 2-6X2
WP TITLE: Support to data analysis for LSPE/STRIP SUB-CONTRACTOR: Dip. Fisica / Università di Milano START EVENT: KO END EVENT: RF WP MANAGER: Davide Maino		Sheet: 1 of 1 Issue Ref: 1 Issue Date:01/09/2016

OBJECTIVES

- Prepare quantitative simulations of STRIP datasets including optimized scan strategy and known systematic effects
- Coordinate and contribute to the development of the analysis pipeline
- Test the performance of the pipeline by means of simulated datasets and devise strategies to mitigate systematics.
- Perform the data analysis

INPUTS

- Contract and Technical Annex
- Work plan & Schedule
- LSPE/STRIP documentation

TASKS

Main collaborations: all nodes included in the LSPE collaboration

- Develop a detailed instrument model and simulator
- Campaign Planning
- Simulate and optimize pointing
- Simulate and optimize instrument calibration
    - Beams
    - Noise spectrum (white and 1/f)
    - Polarization leakages
    - Polarization angles
    - Linearity
- Analyze instrument calibration data
- Map-making algorithms
- Noise estimation algorithms
- Monte-Carlo techniques for error assessment
- Component separation codes
- Study ancillary datasets to be used for component separation

- Angular power spectra estimators
- Likelihood estimators
- Define and develop null-tests for STRIP-only data
- Define and develop null-tests for STRIP-vs-SWIPE data
- Define and develop null-tests for STRIP-vs-SWIPE data
- Cosmological parameters estimates
- Astrophysics science outputs

OUTPUTS

Contribution to deliverable documents regarding:

- Simulation pipeline
- Simulations database
- Calibration database
- Analysis pipeline
- Analysis results

SCHEDULE

First Year, t0+6 months

- Instrument model developmnent
- Simulations development

First Year, t0+12 months

- Definition of calibration procedures

Second year, t0+18 months

- Analysis of calibration data
- Simulations database
- Pipeline implementation

Second year, t0+24 months:

- Analysis of simulated dataset and optimization of analysis pipeline

Third year, t0+30months:

- Preliminary data analysis

Third year, t0+36months:

- Data analysis

10.2.6 WP 3-6X1: Future balloon borne CMB experiments

PROJECT: Studi di Cosmologia		**WP REF.: 3-6X1**
WP TITLE: Future balloon borne CMB experiments **SUB-CONTRACTOR: Dip. Fisica / Università La Sapienza** **START EVENT:** KO **END EVENT:** RF **WP MANAGER: Paolo De Bernardis**		**Sheet:** 1 **of** 1 **Issue Ref:** 1 **Issue Date:**01/09/2016

OBJECTIVES

- Design a high-frequency experiment for CMB B-modes search and foregrounds cleaning, to complement, in the medium term, the ground-based efforts (S4), and to prepare the technology/methodology for the next-generation CMB satellite.
- Study the feasibility of a balloon-borne measurement of the spectral distortions of the CMB (both absolute and anisotropic).

INPUTS

- Contract and Technical Annex
- Work plan & Schedule
- Planck (and other CMB experiments) data

TASKS

Main collaborations: all nodes

- Review of Interstellar Dust Polarization using current data at mm/submm wavelengths
- Quantitative study of the best detection method, polarimetry method, observation wavelengths, angular resolution, sky coverage for a CMB survey
- Optimization of instrument configuration and balloon-borne platform for a multiband survey of mm and submm polarization at high Galactic latitudes, aimed at sensitive measurements of CMB B-modes and precise cleaning from the polarized interstellar dust foreground. This requires careful design, confirmed by numerical simulations, of the optical/detection/cryo systems, including laboratory tests of selected key subsystems: telescope (in particular emissivity), baffling (to avoid straylight), polarization modulator (to achieve high modulation efficiency at high frequency), spectral filtering (to avoid leakage), detection pixels (to maximize sensitivity), etc.
- Review of spectral-spatial anisotropies and spectral distortion of the CMB
- Review of spectral features in the residual atmosphere at balloon altitude in the mm/submm range
- Quantitative study of the best spectral measurement method, observation wavelengths, angular resolution, sky coverage for a spectral-spatial anisotropy survey and/or absolute spectrum survey.
- Optimization of instrument configuration and balloon-borne platform for a spectral survey of the mm and submm sky at high Galactic latitudes, aimed at sensitive measurements of spectral features in the CMB (both absolute, if feasible at the required precision, and anisotropic). This requires careful design, confirmed by numerical simulations, of the optical/detection/cryo systems, including laboratory tests of selected key subsystems:

telescope (temperature and emissivity), window, spectral modulation (over a wide spectral coverage including selected optimal wavelengths), differencing method (reference in the sky or internal).

OUTPUTS

Contribution to deliverable documents regarding:

- Optimized payload configuration (telescope, polarimeter, detectors, scanning) for CMB polarization surveys at high frequency
- Optimized observations plan and performance estimate
- Flight requirements
- Optimized payload configuration (telescope, spectrometer, detectors, reference, scanning) for spectral-spatial anisotropy or absolute spectrum measurements
- Optimized observations plan and performance estimate
- Flight requirements

SCHEDULE

First Year, t0+6 months

- Review of ISD polarization models and data
- Review of CMB polarization models and data
- Review of spectral distortions of the CMB
- Simulation of atmospheric effects in polarization and spectral emission/anisotropy

First Year, t0+12 months

- Review of the spectrum of the residual stratospheric atmosphere
- Review of state-of-the-art detection technology
- Review of available polarimetric techniques
- Review of available spectral measurements techniques
- Review of available stratospheric-flight opportunities and capabilities

Second year, t0+18 months

- Preliminary design of a payload for an S4-level high-frequency polarization survey on a stratospheric balloon
- Preliminary performance/cost optmization
- Assessment of the feasibility of absolute spectral measurements
- Assessment of the feasibility of differential spectral measurements

Second year, t0+24 months:

- Design and construction of prototypes of selected key subsystems for the polarization measurement

- Design and construction of prototypes of selected key subsystems for the spectral measurement
- Preliminary design of a payload for a spectral distortion survey on a stratospheric balloon

10.2.7 **WP 3-6X2: Support to data analysis for LSPE/SWIPE**

PROJECT: **Studi di Cosmologia**		**WP REF.: 3-6X2**
WP TITLE: **Support to data analysis for LSPE/SWIPE** **SUB-CONTRACTOR**: **Dip. Fisica / Università La Sapienza** **START EVENT**: KO **END EVENT**: RF **WP MANAGER**: **Francesco Piacentini**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**:01/09/2016

OBJECTIVES

- Prepare quantitative simulations of SWIPE datasets including optimized scan strategy and known systematic effects
- Coordinate and contribute to the development of the analysis pipeline
- Test the performance of the pipeline by means of simulated datasets and devise strategies to mitigate systematics.
- Perform the data analysis

INPUTS

- Contract and Technical Annex
- Work plan & Schedule
- LSPE/SWIPE documentation

TASKS

Main collaborations: all nodes included in the LSPE collaboration

- Develop a detailed instrument model and simulator
- Mission Planning
- Simulate and optimize attitude and pointing
- Simulate and optimize instrument calibrations
    - o Beam
    - o Responsivity
    - o polarimetric efficiency
    - o cross-polarization
    - o time response
    - o noise
- Analyze instrument calibration data
- Customize efficient data cleaning algorithms
- Customize efficient noise estimation algorithms
- Customize efficient monte-carlo techniques for error assessment
- Customize component separation codes

- Study ancillary datasets to be used for component separation
- Customize Angular power spectra estimators
- Customize likelihood estimators
- Define and develop null-tests for LSPE data
- Customize cosmological parameters estimates
- Optimize secondary science outputs

OUTPUTS

Contribution to deliverable documents regarding:

- Simulation pipeline
- Simulations database
- Calibration database
- Analysis pipeline
- Analysis results

SCHEDULE

First Year, t0+6 months

- Instrument model developmnent
- Simulations development

First Year, t0+12 months

- Definition of calibration procedures

Second year, t0+18 months

- Analysis of calibration data
- Simulations database
- Pipeline implementation

Second year, t0+24 months:

- Analysis of simulated dataset and optimization of analysis pipeline

Third year, t0+30months:

- Preliminary data analysis

Third year, t0+36months:

- Data analysis

AGENZIA SPAZIALE ITALIANA * ASI *

10.2.8 WP 4-6X1: Next generation of CMB space missions

PROJECT: **Studi di Cosmologia**		**WP REF.: 4-6X1**
WP TITLE: **Next generation of CMB space missions** **SUB-CONTRACTOR**: **INAF-IASF / Bologna** **START EVENT**: KO **END EVENT**: RF **WP MANAGER**: **Giuseppe Malaguti**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**:01/09/2016

OBJECTIVES

The current inflationary models and the state-of-the-art of CMB polarization observations (mainly based on Planck and BICEP/Keck results) point towards the need of a complementary approach of space projects, focussed on CMB analysis, and of sub-orbital observations for precise, multifrequency (including low frequencies) foreground treatment and very high resolution mapping in order to be able to detect and characterise primordial B-mode polarization from a stochastic background of gravitational waves with a primordial perturbation tensor-to-scalar ratio r=T/S around 10-3. The main object of this WP is aimed at:

- Definition and design implementation of a next CMB space mission.
- Definition and read-map implementation of sub-orbital (ground and balloon) experiments/projects/facilities to complement space mission.

INPUTS

- Contract and Technical Annex.
- Work plan & Schedule.
- Planck Data; data from other CMB projects and from radio-far-IR projects.
- Planck Software pipeline, simulations, component separation methods/Software.
- Input from other WPs :
  - Project Management
  - SZ signal extraction from future CMB data
  - New point sources detection methods
  - Future ground-based CMB experiments
  - Support to data analysis for LSPE/STRIP
  - Future balloon borne CMB experiments
  - Support to data analysis for LSPE/SWPE
  - HW/SW infrastructure for future CMB experiments
  - RF Testing for future CMB experiments
  - CMB calibration and SRT
  - Strategic solutions for new CMB detectors
  - Readout electronics for future CMB missions
  - Astroparticle and Fundamental Physics
  - Inflationary gravitational waves

- Non Gaussianity from Inflation
- Foreground modeling and removal
- CMB weak lensing reconstruction.

TASKS

- Analysis of theoretical cosmological models and of their observational feasibility.
- Analysis of foreground and foreground residual limitation and of observational needs.
- Analysis of systematic effects of their potential residual; design of minimization/trade-off approaches in space mission and sub-orbital projects.
- Definition and design of optimal space mission in terms of frequency coverage, sensitivity, resolution, observational strategy, cryogenic solutions.
- Definition of optimal set of ancillary observations in terms of frequency coverage, sensitivity, resolution to complement space observations.
- Definition of optimal prototypal chain of pipeline for space mission data analysis and science extraction.

OUTPUTS

Contribution to deliverable documents regarding:

- Definition of optimal CMB space mission (orbital and sub-orbital) focussed to polarization, compatible with allocated resources.
- Definition of feasible approaches to other CMB scientific targets (spectral distortions, cross-correlation of anisotropies and distortions) and of a road-map towards their observational study.
- Assembling of ground based information for foreground control.
- Identification of state-of-the-art technology for mission implementation.

SCHEDULE

First Year, T0+6 months

- Ingesting of available tools and data sets.
- Design and simulation planning.
- Otuline of future CMB space missions in the orbital&sub-orbital frameworks

First Year, T0+12 months

- Definition and implementation of interfaces with other WPs.
- Ingestion and preliminary analysis of input from other WPs.

Second year, T0+18 months

- Optimization activity.
- Ancillary observations planning.
- Preliminary road-map definition.

AGENZIA SPAZIALE ITALIANA * ASI *

Second year, T0+24 months:

- Advanced road-map definition.
- Definition of feasible scientific targets.
- Preliminary definition of prototypal chain of pipeline

Third year, T0+30months:

- Preliminary design and implementation definition.

Third year, T0+36months:

- Optimal design and implementation definition in the Orbital/sub-orbital framework
- Road map for the future.

10.2.9 WP 4-6X2: HW/SW infrastructure for future CMB experiments

PROJECT: **Studi di Cosmologia**		**WP REF.: 4-6X2**
WP TITLE: HW/SW infrastructure for future CMB experiments **CONTRACTOR: INAF-OATS / Trieste** **START EVENT**: KO **END EVENT**: RF **WP MANAGER: Andrea Zacchei**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**:01/09/2016

OBJECTIVE

- Provide to the whole Italian CMB community a software infrastructures
- Assure the availability of the software infrastructure
- Allow to the whole Italian CMB community the access to the Planck data to be used as cross check
- Provide support to the LSPE data analysis

INPUTS

- Planck Data
- Planck Software
- Simulation SRD and URD
- Simulations request

TASKS

The target of this WP is to provide to the whole Italian CMB community a software infrastructure where deploy and develop algorithms needed to simulation or data analysis. Based on the experience acquired during the Planck project, where the centralization of the code development, execution and products was crucial, this WP was included, it can be intended as transversal vs all the more scientific aimed WPs. Two software environment will be made available, one dedicated to the development and run of simulations that are critical in any CMB observation from ground, balloon and Space; and the other for optimization, development and running of algorithms necessary to exploit existing data and prepare study for future mission. The first step will be to support the LSPE data analysis that will heavily rely on the use of synthetic data, produced by an instrument simulator, taking into account a sky model as well as instrument characteristics, performance, calibration, uncertainties and systematic effects. This tool requires significant computational resources to run, roughly estimated at 10^{20} Flop. Maps will need to be created out of time-ordered flight information for both real and simulated data. To this purpose, highly efficient algorithms must be used, capable of optimally minimizing the impact of instrumental noise in the final maps. The computational cost of the data reduction is dominated by the processing of simulations, and its impact is comparable to the cost required to generate synthetic data.

To create a software infrastructure able to satisfy those requirements INAF-OATs will make available a cluster (HotCat) with 400 Cores HP DL560 G9), Infiniband 40 Gbps, RAM 16 GB/core as main computation queue and a small queue for test and developping composed by 240 cores (Xeon SixCore E5645 2,40Ghz), Infiniband 40 Gbps, RAM 6 GB/core. Together with the HPC an estimated storage of about 200 TB will be made available with all the necessary facilities to allow share code development and information flow (SVN, GitHub and Wiki page). Through the HotCat system will be possible to access all the Planck data release (principally all the maps and auxiliary products with raw and calibrated timelines offline) allowing quick cross check and validation of the new algorithms.

OUTPUTS

Contribution to deliverable documents regarding:

- LSPE SRD and SDD
- Simulated fields with different valid instrumental effects
- Simulation code and related documentation

SCHEDULE

- Requirement definition (verify what is required by different WPs): T0+6months
- Environment set-up: T0+8 months
- Dedicated storage acquisition: T0+4 months
- Code development / integration / run: T0+6 months (start of the activity)
- Code development / integration / run: T0+36 months (end of the activity)
- Simulation runs respect the requirements: T0+12 months (first Run), then one run every 6 months (linked to code development)

10.2.10 WP 5-6X1: RF testing for future CMB experiments

PROJECT: Studi di Cosmologia		WP REF.: 5-6X1
WP TITLE: RF testing for future CMB experiments SUB-CONTRACTOR: Dip. Fisica / Università di Milano Bicocca START EVENT: KO END EVENT: RF WP MANAGER: Mario Zannoni		Sheet: 1 of 1 Issue Ref: 1 Issue Date:01/09/2016

OBJECTIVES

- A detailed survey of testing capabilities (cryogenics and RF) within the Italian CMB in the light of the requirements of the current and future CMB experiments, and eventual recommendations for possible upgrades to cope with the high level of accuracy requested.
- A parametric study of the key components of the optical chain of a typical CMB mission (Telescope, HWP, Filters, Detectors, Feed-Horns, OMT, LNAs) aimed at translating scientific requirements on astrophysical/cosmological quantities into technological/instrumental specifications.

INPUTS

- Contract and Technical Annex
- Work plan & Schedule
- Instrumental responses of the relevant instruments
- Specification of noise level for the relevant instruments

TASKS

Main collaborations: all nodes

- Identification of procedures and instrumentations (test facilities within the Italian community) to perform system and sub-system level tests and characterizations at room and cryogenic temperature
- Study of the instrumental systematic effects of current and future architectures of CMB polarization experiments
- Translation of scientists' specifications for future experiments/missions into technologists' specifications
- Support to LSPE/STRIP data analysis (systematics analysis)

OUTPUTS

Contribution to deliverable documents regarding:

- A detailed map of the Italian facilities fit for a deep characterization of RF components with the attainable accuracy
- A parametric study of the systematic effects induced by the components of a typical optical chain for CMB polarization expressed in technologist units.

SCHEDULE

First Year, t0+6months

- Identification of the facilities within the Italian Community

First Year t0+12months

- Final Map of the existing test facilities for what, where, when to do and with what accuracy.

Second year, t0+18months

- A draft of the parametric study

Second year, t0+24months:

- A preliminary version of the parametric study

Third year, t0+30months:

- A revision of the Map of the existing test facilities

Third year 2st Semester:

- Final version of the parametric study

AGENZIA SPAZIALE ITALIANA * ASI *

10.2.11 WP 5-6X2: CMB calibration and SRT

PROJECT: Studi di Cosmologia		WP REF.: 5-6X2
WP TITLE: CMB calibration and SRT SUB-CONTRACTOR: Dip. Fisica / Università di Milano Bicocca START EVENT: KO END EVENT: RF WP MANAGER: Massimo Gervasi		Sheet: 1 of 1 Issue Ref: 1 Issue Date:01/09/2016

OBJECTIVES

- A detailed survey of sky calibration sources for CMB polarization experiments, procedures and strategy of observation with CMB experiments and with SRT.
- A study of the accuracy achievable in the calibration of CMB polarization signals using sky sources, through the observation of few representative sky sources with SRT.

INPUTS

- Contract and Technical Annex
- Work plan & Schedule
- Instrumental responses and specification data sheets of SRT
- Public documentation of relevant sky calibration sources

TASKS

Main collaborations: all nodes

- Identification of procedures and strategies to observe and characterize sky calibration sources with SRT
- Identification of sky sources to be observed as calibration signal for CMB polarization experiments
- Observation and study of few representative sky sources at SRT in intensity and polarization, in the available frequency bands, using the available receivers
- Support to LSPE/STRIP data analysis, providing supplementary information on sky calibration sources

OUTPUTS

Contribution to deliverable documents regarding:

- recommendation of the procedures and strategies to observe sky calibration sources by CMB polarization experiments and by SRT for supporting them
- list of the most representative sky sources to be used as calibration signal in CMB experiments and their most relevant features
- estimation of the accuracy achievable in the calibration of the CMB signal using sky sources.

SCHEDULE

First Year, t0+6months

- Preliminary procedures and strategies to observe and characterize sky calibration sources

First Year t0+12months

- Preliminary list of the most representative sky polarized sources to be used for CMB calibration.

Second year, t0+18months

- Observation and study of the first representative sky source at SRT in intensity and polarization.

Second year, t0+24months:

- Updated observation procedures and strategies and updated list of sources

Third year, t0+30months:

- Observation and study of the most representative sky sources at SRT in intensity and polarization.

Third year 2st Semester:

- Final recommendations for procedures and strategies to observe and characterize sky calibration sources, final list of the most representative sky polarized sources.

10.2.12 WP 6-6X1: Strategic solutions for new CMB detectors

PROJECT: Studi di Cosmologia		WP REF.: 6-6X1
WP TITLE: Strategic solutions for new CMB detectors SUB-CONTRACTOR: Dip. Fisica / Università di Genova START EVENT: KO END EVENT: RF WP MANAGER: Flavio Gatti		Sheet: 1 of 1 Issue Ref: 1 Issue Date:01/09/2016

OBJECTIVES

In the last decade a rapid development of detectors for the GHz and THz of the electromagnetic spectrum has been observed, motivated by the needs of higher performing instrument for investigating the CMB features at the finest level. IR and Radio astronomy as well high resolving power molecular spectroscopy have multiplied the efforts of the instrument scientists in improving the already established detectors as well as introducing new detection concepts.

Presently a large number of new and interesting detection concepts are envisaged and tested at some level, while well established ones are exploited in many configurations for large area focal plane instruments.

Over a long timescale this give a quite puzzling scenario in which high TRL devices which requires complex associated technologies, e.g. cryogenics and electronics, have to be compared with low TRL but promising devices in terms of performance and simpler operating techniques.

This WP would like to make an up to date assessment of the status, the short and long term expectations coming from the study of the different approaches to the detection issue, their technologies, the impact on the instrument performance, design and operation. This study will try give the most updated strategic plan in different timescale for detector development projects aiming to nulling the technology gap with other countries.

INPUTS

- Detector design and performance of present and past CMB experiments
- Design Study Reports of detector for CMB and Astrophysics
- Specification from WP Future Groud-Based CMB experiments
- Specifications from WP Future balloon borne CMB experiments
- Specifications from WP Next Generation CMB space missions
- Specifications from WP Readout electronics for future CMB missions

TASKS

Main collaborations: INFN–Pisa, Uni Roma1, Uni Milano

Detectors for GHz and THz with demonstrated or projected NEP or NET in the interesting range for CMB investigations ranges from TES, KID, HEB, SIS, SIN which are under different good level of investigations, the Paramagnetic and Magnetic Penetration Depth Bolometer, that are tested at prototype level and new concept with nanostructured hetero-structure, e.g. quantum point and quantum point contact.

The tasks are:

- Survey of the present detector concept technologies

- Evaluation of superconducting devices based on transport properties: present and future projection.
- Evaluation of devices based on magnetic properties: present and future projection.
- Evaluation of nanostructured devices: present and future projection.
- Trade off study among detector parameters and ground, balloon, space based CMB experiment requirements.
- Trade off study of the detectors and readout electronics

OUTPUTS

Contribution to deliverable documents regarding:

- Survey of the present detector technology for application to CMB studies
- Present and Future projection of the CMB detector technologies
- Present and Future of the detector for CMB: a strategic study for the next experiments.

SCHEDULE

First Year, t0+6 months

- Survey of the present detector technology.

First Year t0+18 months

- Study of superconducting devices based on transport properties
- Study of devices based on magnetic properties.
- Study of devices based on nanostructured.

Second year, t0+24 months

- Study of the impact on the readout electronics

Second year, t0+30 months

- Trade off study among detector parameters and CMB experiment requirements
- Study of others possible detector concepts and detection methodologies

Second year, t0+36 months:

- Critical study for a strategic plan for mid and long term for detector development for future CMB experiments

10.2.13 WP 6-6X2: Readout electronics for Future CMB missions

PROJECT: **Studi di Cosmologia**		**WP REF.: 6-6X2**
WP TITLE: **Readout electronics for Future CMB missions** **CONTRACTOR**: **Istituto Nazionale di Fisica Nucleare/Pisa** **START EVENT**: KO **END EVENT**: RF **WP MANAGER**: **Giovanni Signorelli**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**:01/09/2016

OBJECTIVES

Read-out electronics provides the interface between the radiation detector and the acquisition computer, between analogue and digital signals, between sub-millikelvin temperatures and "room" temperature. It receives the analogue signals from the detectors and translates them to digital form by means of dedicated and specially designed hardware.

This must be taylored depending on the specificity of the detector (TES, KIDs, CEBs...). The activity of this working package will start from a review of the status-of-the-art of both detectors (in close collaboration with WP5) and electronics readout chain, trying to undestand how to cover the technological gap between present activities in Italy and abroad.

The comparison of different architectures and readout techniques (frequency, time domain or time-coded multiplexing just to name a few) is of utmost importance, together with the investigation of possible departures from the present implementations by means of Field-Programmable Gate Arrays (FPGAs) by using dedicated ASICs or Graphic Process Units (GPUs) with special emphasis on power consumption and noise level with future balloon and space experiments in mind, not neglecting an evaluation of the costs of all implementations.

The study of the necessary steps towards spatialization are as well part of this WP (survey, study and selection of rad-hard components, development of watch-dog algorithms, study of the performance in space environment).

A survey of the technologies and expertise present in industries in Italy is also mandatory in order to assess the possible commitment of italian community in future experiments.

Here is a breakout of the foreseen activities:

- Survey of the present technologies for readout in the various frequency bands (40 GHz – 600 GHz);
- Evaluation of the needs for a future experiment in term of multiplexing multiplicity, electronics noise, power needs ;
- Detailed evaluation (also supported by simulation) of the readout chain as a function of the detector technology in all the frequency bands;
- Survey of present or future implementation technologies for the warm readout (FPGAs, ASICs, GPUs);
- Survey, implementation and tests of software and firmware algorithms to accomplish the desired readout;
- Survey of expertise and technologies present in italian industries to estabilish possible partnerships in view of the deployment of the technology studied;
- Techniques for noise and glitches (e.g. cosmic rays) reduction in the data stream;

At the end of the study the relation between electronics performance and sensitivity to physics results will be clear enough to speed up the real implementation of a readout chain for future experiments.

All the activity will be carried on in close connection with WP6-6X1 (new detector technologies) and WP5-6X1 (test facilities). For the survey to be effective collaborations with WP3-6X1 and WP4-6X1 (future balloon-borne and space experiments) are vital. A collaboration in data analysis is essential in designing the path from the physics signal to the physics result.

INPUTS

- Contract and Technical Annex
- Work plan & Schedule

TASKS

- Survey of present worldwide technology for detectors and related readout electronics in all the frequency range. Comparative table of the readout techniques being devised with particular emphasis on noise and sensitivity performance – 6 m;
- Analysis of possible implementation platforms to be used in a future experiment compatible with the expected multiplexing, multiplicity, noise – 6m;
- Design and simulation of alternative detector-readout schemes compatible with the physics requirements and the technological limitations (e.g. simulation of cross talk between adjacent signals, behavior of transmission lines, definition of optimal parameters such as ADC/DAC resolution) – 12 m;
- Study of possible implementations of readout chains from a realization viewpoint (cost, power consumption, ADC/DAC model availability, transmission line details) – 12 m
- Design of the software and firmware algorithms for the control and readout of detector chains – 18 m;
- Survey of possible industrial partnerships in Italy to be able to deploy a complete detector-electronics chain – 6 m;
- Develop a complete design concept for next generation balloon and/or space experiments with detailed evaluation of noise and sensitivity level, costs, power needs – 12 m.
- Study of the impact of cosmic rays in the signal of various detectors and development of dedicated algorithms for raw data cleaning – 12 m;
- Application of such techniques to perform LSPE SWIPE experiment data reduction – 12 m;

OUTPUTS

Contribution to deliverable documents regarding:

- Comparison of detectors and readout technologies
- Assessments on sensitivity/objectives to perform physics searches;
- Comparison of current and possible implementation platforms
- Algorithms and software for CR removal in SWIPE/LSPE data

- Complete design of a realistic implementation of a readout chain for future ground, balloon and space experiments with clear plans from the technological choices to the details of the implementation including firmware/software, costs, power needs, calibrations.

SCHEDULE

SEMESTER 1

- (to other WPs) Comparative table of readout technologies being developed in the various frequency ranges;
- (from WP6-6X1) Comparative table of detector technologies being developed with respective readiness level and technical characteristics;
- (from WP3-6X1 e WP4-6X1) Preliminary table containing assessments on sensitivity/objectives to perform physics searches;

SEMESTER 2

- (to other WPs) Comparative table of current and possible implementation platforms;
- (to other WPs) Comparative table of alternative detector-readout schemes compatible with the physics requirements and the technological limitations;
- (to other WPs) Preliminary algorithms for CR removal in SWIPE/LSPE data;
- (from WP3-6X1 e WP4-6X1) Table containing assessments on sensitivity/objectives to perform physics searches;

SEMESTER 3

- (to other WPs) Table of noise/power performance based on detailed simulation/implementation of some possible detection chains;
- (to other WPs) Assessment of CR immunity of various detector schemes;
- (to other WPs) Preliminary scheme of firmware and software needs for the control/readout of the detector chain;
- (from data analysis WPs) Software architecture for the implementation of raw signal cleaning algorithms for the LSPE/SWIPE data;
- (from WP3-6X1 e WP4-6X1) Possible calibration schemes for detector/readout chains

SEMESTER 4

- (to other WPs) Table of of possible implementations of readout chains from a realization viewpoint (cost, power consumption, ADC/DAC model availability, transmission line details);
- (to other WPs) Detailed performance study of raw signal cleaning and CR/glitch removal for the SWIPE/LSPE data;

SEMESTER 5

- (to other WPs) Complete scheme of firmware and software needs for the control/readout of the detector chain;
- (to other WPs) Table of industrial and technological partnerships and interlinks that could give a major contribution to the construction of a detector/readout scheme;

SEMESTER 6

- (to other WPs) Final report containing a complete design of a realistic implementation of a readout chain for future ground, balloon and space experiments with clear plans from the technological choices to the details of the implementation including firmware/software, costs, power needs, calibrations;
- (to other WPs) Clean TOD for SWIPE/LSPE data flagged for glitch/CR.

10.2.14 WP 7-6X1: Astroparticle and fundamental physics

PROJECT: **Studi di Cosmologia**		**WP REF.: 7-6X1**
WP TITLE: **Astroparticle and fundamental physics** **SUB-CONTRACTOR: Dip. Fisica / Università di Ferrara** **START EVENT**: KO **END EVENT**: RF **WP MANAGER**: **Paolo Natoli**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**:01/09/2016

OBJECTIVES

- Forecasts and constraints for neutrino parameters (mass, hierarchy, effective number) in standard and non standard scenarios
- Forecast and constraints for primordial nucleosynthesis in standard and non-standard scenarios.
- Tests of fundamental symmetries, cosmological constraints on non standard electrodynamics, constraints on polarization rotation (cosmological birefringence)
- Provide numerical codes to constrain the model parameters: CMB likelihood and other approaches.
- Study the implications for the physics of the early universe of primordial features in the CMB and their connection to so-called anomalies.

INPUTS

- Theoretical modeling and predictions on CMB anisotropy
- Data from CMB experiments, including Planck's legacy
- Simulated data for experimental setups

TASKS

Main collaborations: Padova, SISSA, RM2, Bologna

High quality constraints on astroparticle and fundamental physics are a major expected return from next generation CMB surveys, with the potential to uncover new physics. The main purpose of this WP is to study how to maximize the return of present and future CMB experiment to these objective. The WP is organized around four main tasks:

- theoretical predictions will be reviewed, selecting relevant models and identifying their significant parameters. It will then make sure that numerical CMB anisotropy predictions can be derived from parameters, and in case modify the publicly available Boltzmann codes.
- it will be checked that the simulation tools for the CMB signal involved are adequate and, where needed, develop appropriate tools to simulate the effect; these simulations will then be incorporated into realistic pipelines for current and forecasted experiments, conjunction with other relevant units (e.g. Bologna for satellite missions)
- appropriate tools to constrain the effects under study will be developed; this may range from state-of-the-art CMB likelihood machinery, to be incorporated in standard Monte Carlo Markov Chain sampling, to specific estimators when the former path is not feasible or

convenient. The expertise from other units (in particular SISSA and Padova) on component separation is key to properly fold in the component separation layer

- tools and simulations will be applied to allow for improved reanalysis of existing data, in particular relying on the Planck legacy dataset, focusing on models untested in the mainstream analysis; realistic forecasts for future experiment will be also computed, aiming in particular to assessing the feasibility and convenience of planned instrumental efforts, as well as optimizing their configuration towards science return gravitational waves).

OUTPUTS

Contribution to deliverable documents regarding:

- Inference on relevant model parameters, based on existing data.
- Forecasts for future experiments
- Numerical codes to provide constraints and accompanying realistic simulations
- Contributions to feasibility studies, final reports for the project, white papers and scientific publications.

SCHEDULE

First Year, t0+6months

- Review of theoretical model, assess parameters, planning of activities.

First Year, t0+12months

- Set up simulation pipeline for theoretical signal and realistic sky model.
- Set up data analyses on Planck legacy, validation checks
- Set up of relevant tools for likelihood modeling and other forms of parameter constraints

Second year, t0+18months

- Set up of analysis pipeline in view of a selection of experiments present and planned
- Begin of folding of component separation activities,

Second year, t0+24months:

- Continue with component separation, integration into parameter estimation pipelines

Third year, t0+30months:

- Production of constraints on legacy data.
- Production of forecasts, especially in view of feasibility studies for future ground based, balloon borne or satellite missions, as part of this project
- Start writing up results and contribution to reports

Third year, t0+36months:

- Finish with production of constraints
- Finalize write up of papers and reports, including feasibility studies for future missions
- Write documentation for software to be distributed

10.2.15 WP 8-6X1: Inflationary gravitational waves

PROJECT: Studi di Cosmologia		WP REF.: 8-6X1
WP TITLE: Inflationary gravitational waves SUB-CONTRACTOR: Dip. Fisica e Astronomia / Università di Padova START EVENT: KO END EVENT: RF WP MANAGER: Nicola Bartolo		Sheet: 1 of 1 Issue Ref: 1 Issue Date:01/09/2016

OBJECTIVES

- Inflationary parameter forecasts for future B-mode surveys
- Joint analyses: CMB and interferometers
- Component separation methods for B-mode maps
- Study of theoretical implications for Inflation

INPUTS

- Grid of target inflationary models for gravitational waves and their predictions for the expected signal
- Planck (and other CMB experiments) data
- Synthetic mock data

TASKS

Main collaborations: Ferrara, RM2, SISSA

The exploitation of CMB B-mode data has the primary goal to probe the existence of primordial gravitational waves which are a smoking gun of inflation.
One of the aims of this WP is to understand how to optimally exploit future (and present) CMB data to constrain the parameter space of inflationary models.
The WP will be characterized by three main levels. An investigation of theoretical predictions, accompanied by forecasts for future space, ground an balloon-born CMB experiments, with particular focus, as far as the forecasts are concerned, on specific instrumental characteristics of a given CMB experiment, systematics and component separation methods. The forecasts activity will include an analysis of the complementarity between CMB and other possible future measurements of the inflationary stochastic background of gravitational waves (e.g., direct detection experiments like LISA). The second main task of this WP will be to develop an analysis pipelines for B-mode data in forthcoming CMB experiments, to constrain the parameter space of inflationary models. Use of mock datasets accounting for realistic conditions will be used. A major part of the WP will be also devoted to the development of new component separation methods, in strict connection to the WP on primordial non-Gaussianity. Here the issue is to separate the primordial B-mode signal from the foregrounds, especially galactic dust. Since the foreground component is highly non-Gaussian (and anisotropic), it is planned to build algorithms of foreground cleaning based on non-Gaussianity estimators with directional dependence, originally developed for measurements of primordial non-Gaussianity (such as estimators of needlet bispectrum and trispectrum).

The goals of the second task will allow us to perform an analysis on present CMB data to calibrate and test the tools developed, in such a way to prepare for future data analyses.
According to the results that will be found, a study of implications for models of inflation will be drawn. Finally a study of inflationary models beyond the standard power spectrum analyses to test non-Gaussian signatures in the gravitational wave signal (in connection with the non-Gaussianity WP) and to test features beyond the standard scenarios (like e.g., parity breaking features and deviations from the standard consistency relations for the amplitude of the inflationary gravitational waves) will be performed.

OUTPUTS

Contribution to deliverable documents regarding:

- Combined inference of Early Universe parameters (amplitude of primordial gravitational waves, amplitude and spectral index of primordial curvature perturbations, from available datasets (also in combination with the primordial non-Gaussianity WP results) from available datasets
- Forecasted constraints on the inflationary parameter space according to the characteristics of a given (future) CMB experiment
- Algorithms for B-mode component separation methods
- Forecasts about complementarity between CMB and other possible future observables (e.g., direct detection experiments like LISA).

SCHEDULE

First Year, t0+6months

- Theoretical predictions, forecasts and study of theoretical implications for inflation

First Year, t0+12months

- Theoretical predictions, forecasts and study of theoretical implications for inflation
- Preparation of analysis pipelines for B-mode data in forthcoming CMB experiments, to constrain the parameter space of inflationary models
- Data analyses on available datasets, to be used also as a cross-check

Second year, t0+18months

- Preparation of analysis pipelines for B-mode data in forthcoming CMB experiments, to constrain the parameter space of inflationary models
- Development of component separation techniques for polarized foregrounds (especially B-mode), based on estimators targeted to measurements of directional primordial non-Gaussianity (in strong connection with the non-Gaussianity WP)

Second year, t0+24months:

- Development of component separation techniques for polarized foregrounds (especially B-mode), based on estimators targeted to measurements of directional primordial non-Gaussianity (in strong connection with the non-Gaussianity WP).

AGENZIA SPAZIALE ITALIANA ASI

Third year, t0+30months:

- Development of component separation techniques for polarized foregrounds (especially B-mode), based on estimators targeted to measurements of directional primordial non-Gaussianity (in strong connection with the non-Gaussianity WP).
- Forecasts about complementarity between CMB and other possible future observables (e.g., direct detection experiments like LISA); forecasts on constraints on the inflationary parameter space w.r.t. to specific instrumental characteristics of a given CMB experiment, systematics and component separation methods.

Third year, t0+36months:

- Analyses of inflationary models beyond the standard power spectrum analyses to test non-gaussian signatures in the gravitational wave signal (in connection with the non-Gaussianity WP) and to test features beyond the standard scenarios (like e.g., parity breaking features and deviations from the standard consistency relations for the amplitude of the tensor modes)

AGENZIA SPAZIALE ITALIANA * ASI *

10.2.16 WP 8-6X1: Non-Gaussianity from Inflation

PROJECT: Studi di Cosmologia		**WP REF.: 8-6X2**
WP TITLE: Non-Gaussianity from Inflation **SUB-CONTRACTOR: Dip. Fisica e Astronomia / Università di Padova** **START EVENT**: KO **END EVENT**: RF **WP MANAGER: Michele Liguori**		**Sheet: 1 of 1** **Issue Ref**: 1 **Issue Date**:01/09/2016

OBJECTIVES

- Primordial non-Gaussianity (PNG) parameter forecasts, using temperature and polarization bispectrum and trispectrum in future CMB surveys
- PNG parameter forecasts using CIB
- PNG parameter forecasts, using correlations between CMB spectral distortions and temperature/polarization anisotropies
- Development of NG estimators for future datasets.

INPUTS

- Non-Gaussian CMB simulated maps
- *Planck* (and other CMB experiments) data
- Modeling of CIB
- Specification of noise levels for relevant experiments and characterization of component separation methods

TASKS

Main collaborations: Ferrara, ROMA2, SISSA

A crucial observable to probe the physical mechanism behind inflation is *primordial non-Gaussianity* (PNG), in that it allows to test the interactions among quantum fields during inflation. Therefore, along with primordial gravitational waves, PNG can allow to probe fundamental aspects of inflation and to distinguish among very different inflation models.
The main target of this WP is to prepare for the analysis of future CMB datasets to constrain PNG by exploiting different observables that can be extracted from CMB measurements through a variety of methods. The WP contains three main levels of tasks. Firstly, a pipeline to measure CMB 3- and 4-point correlation functions among CMB temperature and polarization anisotropies will be developed and calibrated. This will be done in different domains, like, e.g., harmonic, needlet and real space. A second task is devoted to fully characterize the exploitation of the CIB power spectrum (that can be extracted from the high frequency channels of *Planck* or future CMB surveys) in relation to non-Gaussian signatures that can be left imprinted on it (via, e.g, the so called ``scale-dependent'' halo bias on the largest scales). To fulfill this task a study of the CIB power spectrum modeling is required and a characterization of the dust contributions will be carried on as well. The study of the CIB power spectrum offers also the opportunity to investigate cosmological signatures other than PNG, such, e.g. general relativistic effects on very large scales.
A third task will be devoted to the analysis of how to exploit the spectral content of the CMB spectrum in the frequency domain. In particular the correlations (2- and 3-point) between CMB anisotropies (in temperature and polarization) and CMB spectral distortions will be investigated as a

powerful potential tool to greatly improve current constraints on PNG. For that respect predictions and forecasts for specific models of inflation producing an enhanced signal that can be already constrained with present or forthcoming data will be first provided, and then realistic conditions for the exploitation of these observables from future experiments, dealing with foreground subtraction and systematics, will be characterized.
Finally, as part of the activities of this WP, some of the techniques developed for measurements of primordial NG in other related issues will be exploited: on one side component separation techniques for polarized foregrounds (especially B-mode), based on estimators targeted to measurements of directional PNG (in strict connection with the WP on Inflationary Gravitational waves) will be developed; on the other hand PNG-based statistical estimators will be applied to investigate secondary anisotropies at low redshift, such as CMB lensing and SZ effects, with the goal of measuring Modified Gravity parameters and neutrino masses.

OUTPUTS

Contribution to deliverable documents regarding:

- Simulations of CMB datasets
- Results CMB data analysis software
- Results of data analysis pipelines for CMB 3 and 4-point functions
- Estimators of cross-correlation between CMB anisotropies and spectral distortions
- Estimators to exploit CIB data

SCHEDULE

First Year, t0+12months

- Calibration of different pipelines (in different domains, e.g. harmonic, needlet and real space) to measure CMB 3- and 4-point correlation functions (focus on CMB polarization data)
- Study of the CIB power spectrum in relation to non-Gaussian signatures that can be left imprinted on it

Second year, t0+18months

- Modeling of CIB power spectrum. Characterization and analysis of the dust contributions and of general relativistic effects present on the largest cosmological scales
- Development of component separation techniques for polarized foregrounds (especially B-mode), based on estimators targeted to measurements of directional PNG

Second year, t0+24months:

- Study of correlations (2 and 3-point functions) among spectral distortions (e.g. μ e y) and CMB anisotropies in temperature and polarization. Predictions and forecasts for specific models of inflation producing an enhanced signal that can be already constrained with present or forthcoming data.

Third year, t0+30months:

- Study of correlations (2 and 3-point functions) among spectral distortions (e.g. μ e y) and CMB anisotropies in temperature and polarization. Predictions and forecasts for specific models of inflation producing an enhanced signal that can be already constrained with present or forthcoming data.

- Forecasts for PNG measurements for future missions exploiting a joint analysis of different datasets, and all techniques studied earlier (CMB, CIB, 2- and 3-point correlation functions of CMB temperature and polarization

Third year, t0+36months:

- Study of non-Gaussian signatures from secondary anisotropies at low redshifts: CMB lensing, Sunyaev-Zeld'ovich effect. Estimators for bispectrum and trispectrum of SZ y-Compton parameter and related forecasts/measurements, in relation to neutrino mass and Modified Gravity constraints.

AGENZIA SPAZIALE ITALIANA * ASI *

10.2.17 WP 9-6X1: Foreground modeling and removal

PROJECT: Studi di Cosmologia		**WP REF.: 9-6X1**
WP TITLE: Foreground modeling and removal **SUB-CONTRACTOR: SISSA** **START EVENT:** KO **END EVENT:** RF **WP MANAGER: Francesca Perrotta**		**Sheet:** 1 **of** 1 **Issue Ref:** 1 **Issue Date:**01/09/2016

OBJECTIVES

The Foreground Modeling and Removal Work Package (FMR) has the following main objectives: modelization of the diffuse Galactic foregrounds, in particular for polarization, the separation of Cosmic Microwave Background (CMB) polarization anisotropies from polarized diffuse foregrounds in the Galaxy. The main links with other WPs are: CMB@LF (MI), CMB@HF (RMI), CMB from Space (BO), Inflationary GWs and Non-Gaussianity (PD), Point Source extraction (RMII), Astroparticle and Fundamendal Physics, Support to LSPE and Simulations (INAF-OATs).

INPUTS

Observed or Simulated multi-frequency CMB maps. Characterization of noise statistics, angular resolution. Characterization of non-diffuse astrophysical signals.

TASKS

- Task 1 - Experimental design: support for forecasting foreground cleaning for feasibility study
- Task 2 - Polarized Foreground modeling: 3D Modeling of Galactic diffuse polarized emission, comparison with existing data and model updating
- Task 3 - Foreground cleaning: production and testing of foreground cleaning data analysis software finalized to polarization and B-modes
- Task 4 - Data analysis: application of algorithms to data

OUTPUTS

Contribution to deliverable documents regarding:

- Results of the software for forecasting of foreground cleaning capabilities (Task 1)
- Optimal configurations in terms of number of bands and sensitivity for feasibility studies (Task 1)
- Unified Galactic magnetic field model for Dust and Synchrotron (Task 2)
- Inclusion of data from Quijote, optimization of synchrotron emission (Task 2)
- Production of sky model for exploitation in data analysis (Task 2)
- CMB and diffuse foreground separation from data (Task 2)
- Results of prototype software for parametric foreground fitting (Task 3)
- Results of prototype software for internal linear combination (Task 3)

- CMB and diffuse foreground separation from data (Task 4)

SCHEDULE

- Task 1, T+0 - T+6M
- Task 2, T+0 – T+36M
- Task 3, T+0 - T+36M
- Task 4, T+24M – T+36M

10.2.18 WP 9-6X2: CMB weak lensing reconstruction

PROJECT: Studi di Cosmologia		**WP REF.: 9-6X2**
WP TITLE: CMB weak lensing reconstruction **SUB-CONTRACTOR: SISSA** **START EVENT:** KO **END EVENT:** RF **WP MANAGER: Carlo Baccigalupi**		**Sheet:** 1 of 1 **Issue Ref:** 1 **Issue Date:**01/09/2016

OBJECTIVES

The CMB Weak Lensing Characterization Work Package (CMBWLC) has the following main objectives: the reconstruction of the CMB distortion caused by lensing due to matter distribution traced by Galaxies along the line of sight, its subtraction from the B-mode CMB polarization anisotropies. The main links with other WPs are: CMB@LF (MI), CMB@HF (RMI), CMB from Space (BO), Inflationary GWs and Non-Gaussianity (PD), Point Source extraction (RMII), Astroparticle and Fundamendal Physics, Support to LSPE and Simulations (INAF-OATs).

INPUTS

CMB anisotropy maps in polarization and total intensity. Characterization of noise statistics, angular resolution, foreground residuals resulting from FRM.

TASKS

- Task 1 - Experimental design: support for forecasting foreground cleaning for de-lensing
- Task 2 - De-lensing: characterization of LSS Tracers through Populations of Galaxies
- Task 3- De-lensing: production and testing of de-lensing algorithms
- Task 4 - Data analysis: application of algorithms to data

OUTPUTS

Contribution to deliverable documents regarding

- Results of the software for forecasting of foreground de-lensing capabilities (Task 1)
- Optimal configurations in terms of number of bands and sensitivity for feasibility studies (Task 1)
- Characterization of Galactic populations (Task 2)
- Simulation of CMB GLs through Galaxy Catalogues (Task 2)
- LSS tracer algorithms in generalized domains (Task 2)
- Source Characterization and LSS algorithms from data (Task 3)
- Results of prototype software from internal de-lensing (Task 3)
- Results of prototype software from cross-correlation, interfaced with Galaxy catalogues (Task 3)
- Validation on simulated and available data (Task 3)
- Separation of CMB B-modes from cosmological GWs and from GL from data (Task 4)

SCHEDULE

- Task 1, T+0 - T+6M
- Task 2, T+0M - T+24M
- Task 3, T+12M - T+24M
- Task 4, T+30M – T+36M

10.3 PIANO DEI LAVORI

Il piano dei lavori e delle verifiche di avanzamento e di rendicontazione dei costi coincide con la pianificazione delle milestone riportata al par.7

10.4 CONTROLLO E CONSUNTIVAZIONE PERIODICA DELLE ATTIVITÀ

Il controllo dei lavori sarà svolto attraverso la verifica dello stato delle attività alle riunioni d'avanzamento.

Per ciascuna riunione verrà prodotto un rapporto d'avanzamento delle attività svolte. Il rapporto di avanzamento tratterà dei seguenti argomenti:

- Stato di avanzamento di ogni pacco di lavoro;
- Descrizione delle attività svolte per ogni pacco di lavoro;
- Descrizione delle attività previste per il periodo successivo.

A valle di ciascuna riunione tra l'ASI e l'Ente partecipante, verrà redatta una Minuta di riunione che sarà firmata da entrambi le parti.

L'Ente partecipante presenterà all'ASI il rendiconto periodico delle spese vive sostenute, come prescritto nel testo dell'Accordo.

10.5 ANALISI DEI RISCHI

NA

11.0 GESTIONE DELLA DOCUMENTAZIONE E DEI DATI

11.1 PRESENTAZIONE DELLA DOCUMENTAZIONE

L'Ente partecipante metterà a disposizione la documentazione riportata nella tabella seguente. L'ASI si riserva di richiedere, durante tutta la durata dell'accordo, ulteriore documentazione inerente le attività in corso. L'Ente partecipante dovrà inoltre inviare all'ASI, anche dopo la scadenza dell'accordo, copia di tutte le pubblicazioni scientifiche realizzate.

CODICE	TITOLO	ASI RESP	EVENTO DI CONSEGNA
DEL 001	Rapporti d'avanzamento	R/A	RA1, RA2, RA3
DEL 002	Rapporto finale	R/A	RF
DEL 003	Pubblicazioni	R	RA1, RA2, RA3, RF

11.2 LINGUA

La documentazione potrà essere in lingua inglese.

Roma,

Università di Tor Vergata
Dipartimento di Fisica
Il Direttore
Rossana Marra

L'Agenzia Spaziale Italiana

Il Direttore Generale
Anna Sirica

5.2.0004

Subject:	**COSMO**	Economic Conditions:	**JAN 2017**
Conversion Rate:	**1 EUR = 1.000000 EUR**	Contractual Phase:	**ALL**
WBS Branch:	**COSMO**		

Node:

1	UniRoma2
2	UniMilano
3	UniRoma1
4	INAF
5	Milano Bicocca
6	New detectors and readout elec
7	UniFerrara
8	UniPadova
9	SISSA

Labour		Avg.Sld.Hrs.	Hours	FTE	Rate	EUR	EUR
1	PO UniFerrara	( )	1,125		80.7486	90,842	90,842
10	Tecnologo INAF	( )	2,284		34.6556	79,153	79,153
11	RIc INAF 3-3	( )	1,523		37.0985	56,501	56,501
12	PO INAF	( )	914		56.3389	51,494	51,494
13	PO UniPadova	( )	2,125		80.7500	171,594	171,594
14	PA UniPadova	( )	1,750		46.4500	81,288	81,288
15	Ric. UniPadova	( )	2,200		31.8900	70,158	70,158
16	TD UniPadova	( )	4,500		34.5196	155,338	155,338
17	PO UniMilano	( )	1,350		69.2023	93,423	93,423
18	PA UniMilano	( )	1,580		49.3980	78,049	78,049
19	PA UniMilano	( )	1,580		46.4784	73,436	73,436
2	PA UniFerrara	( )	2,000		46.4784	92,957	92,957
20	Tecnico UniMilano	( )	360		32.4700	11,689	11,689
21	Tecnico UniMilano	( )	360		20.1800	7,265	7,265
22	TD UniMilano	( )	4,500		32.5692	146,561	146,561
23	PO SISSA	( )	2,250		66.2378	149,035	149,035
24	PA SISSA	( )	450		46.4784	20,915	20,915
25	Ric. SISSA	( )	900		35.4646	31,918	31,918
26	TD SISSA	( )	5,160		28.2200	145,615	145,615
27	PO UniRoma1	( )	1,140		81.0300	92,374	92,374
28	PA UniRoma1	( )	810		59.9000	48,519	48,519
29	PA UniRoma1	( )	1,050		47.4200	49,791	49,791
3	PA UniFerrara	( )	1,125		51.5036	57,942	57,942
30	Ric. UniRoma1	( )	900		48.3600	43,524	43,524
31	RTB UniRoma1	( )	1,470		38.5400	56,654	56,654
32	AdR UniRoma1	( )	1,800		16.6666	30,000	30,000
33	TD UniRoma1	( )	4,500		32.5691	146,561	146,561
34	Ric. MilanoBicocca	( )	1,800		35.4646	63,836	63,836
35	PA MilanoBicocca	( )	1,650		51.5040	84,982	84,982
36	PO MilanoBicocca	( )	900		66.2380	59,614	59,614
37	Tecnico MilanoBicocca	( )	1,200		24.7300	29,676	29,676
38	Tecnico MilanoBicocca	( )	1,200		20.3700	24,444	24,444
39	TD MilanoBicocca	( )	4,500		32.5600	146,520	146,520
4	TD UniFerrara	( )	4,500		32.2608	145,174	145,174
40	PO UniRoma2	( )	2,080		107.6000	223,808	223,808
41	PA UniRoma2	( )	1,170		55.1400	64,514	64,514
42	PO UniRoma2	( )	910		80.8100	73,537	73,537
43	RIC. UniRoma2	( )	1,040		34.1000	35,464	35,464
44	TD UniRoma2	( )	4,680		31.0205	145,176	145,176
45	Ric INFN	( )	3,000		34.3975	103,193	103,193
46	Ric. INFN	( )	1,200		30.0500	36,060	36,060
47	Tecnologo INFN	( )	1,200		36.8181	44,182	44,182
48	Dirigente Ric. INFN	( )	900		78.1518	70,337	70,337
49	Dirigente Ric. INFN	( )	800		71.5325	57,226	57,226
5	Primo Ric. v classe INAF	( )	609		57.0597	34,749	34,749
50	PA UniGE	( )	3,206		47.4500	152,125	152,125
51	PA UniGe	( )	1,973		54.0900	106,720	106,720
52	Tecnologo UniGE	( )	1,720		24.1900	41,607	41,607
53	TD UniGE	( )	5,160		28.2248	145,640	145,640
54	TD INFN PI	( )	4,800		30.0928	144,445	144,445

5.2.0004

Subject:	COSMO	Economic Conditions:	JAN 2017
Conversion Rate:	1 EUR = 1.000000 EUR	Contractual Phase:	ALL
WBS Branch:	COSMO		

6	Primo Ric IV classe INAF	( )	127	51.0630		6,485	6,485
7	CTER INAF	( )	456	29.0200		13,233	13,233
8	TD INAF	( )	9,138	32.2876		295,044	295,044
9	RIC INAF 3-4	( )	1,524	39.6077		60,362	60,362
1. Total Direct Labour Hours and Cost			111,149	40.8528	A	4,540,747	4,540,747

Internal Special Facilities			No of Units	EUR /Unit			
1	Use of mm-wave VNA	( )	240	100.0000		24,000	24,000
10	analysis runs on dedicated multicore ser	( )	3,000	5.0000		15,000	15,000
11	Simulation Tools COMSOL, ZEMAX, ADS	( )	1	10,000.0000		10,000	10,000
12	use of mm-wave VNA	( )	200	186.0000		37,200	37,200
13	use of cryogenic test falicities	( )	200	100.0000		20,000	20,000
14	Electronic laboratory	( )	1,500	10.0000		15,000	15,000
15	Cryogenic laboratory	( )	1,500	10.0000		15,000	15,000
2	Use of anechoic test facility	( )	240	100.0000		24,000	24,000
3	Clusters PC	( )	6,000	5.0000		30,000	30,000
4	structural simulation on dedicated multi	( )	2,000	5.0000		10,000	10,000
5	electromagnetic simulation on dedicated	( )	2,000	5.0000		10,000	10,000
6	use of mm-wave free-space test facility	( )	300	50.0000		15,000	15,000
7	use of sub-K cryogenic test facility	( )	100	200.0000		20,000	20,000
8	use of mm-wave VNA	( )	500	50.0000		25,000	25,000
9	simulation runs on dedicated multicore s	( )	9,000	5.0000		45,000	45,000
2. Total Internal Special Facilities Cost					B	315,200	315,200

Other cost elements			Base	% OH	Overhead			
3. 4	Electricl Parts	( )	7,000				7,000	7,000
3. 6	Ext.Maj.Product	( )	191,000				191,000	191,000
3. 7	Extern Services	( )	83,000				83,000	83,000
3. 9	Travl/Allowance	( )	422,000				422,000	422,000
3. Total Other Direct Costs						C	703,000	703,000

4. Sub Total Direct Cost	(A+B+C)	D	5,558,947	5,558,947

General Expenses		Base	% OH				
5. 1 General & Admin. Expenses	( )	1,616,075	5.00		E	80,804	80,804
Total General Expenses						80,804	80,804
8. Total Company Cost				(D+E+F+G)	H	5,639,751	5,639,751
12. Total Company Price				(H+I+J+K)	L	4,983,248	4,983,248
13. Total Sub-Contractor Price					M		
14. Reduction for Company Co-Funding					N	-3,239,871	-3,239,871
15. Total Price for ESA				(L+M-N)		2,399,880	2,399,880
Price Type: 1. Firm fixed price						2,399,880	2,399,880

5.2.0004

Project:	COSMO	Economic Conditions:	JAN 20	Contractual Phase:	"ALL"
WBS Branch::	COSMO	Conversion Rate:	1 EUR = 1.000000 EUR	Company:	

			TOR VERG	TOR VERG	TOR VERG	MILANO	MILANO	ROMA 1	ROMA 1	BOLOGNA	TRIESTE
Node:		Total	1-1A	1-6X1	1-6X2	2-6X1	2-6X2	3-6X1	3-6X2	4-6X1	4-6X2
WBS Title:		COSMO	Management	SZ signal extract ion from future C	New point source detection methods	Future ground-bas ed CMB experiment	Support to data a nalysis for LSPE/	Future balloon bo rne CMB experimen	Support to data a nalysis for LSPE/	Next Generation C MB space missions	HW/SW infrastruct .or future CMB ex
Company:		INFR	INFR	INFR	INFR	INFR	INFR	INFR	INFR	INFR	INFR
1	PO UniFerrara	1,125									
10	Tecnologo INAF	2,284								456	1,828
11	RIc INAF 3-3	1,523								609	914
12	PO INAF	914									914
13	PO UniPadova	2,125									
14	PA UniPadova	1,750									
15	Ric. UniPadova	2,200									
16	TD UniPadova	4,500									
17	PO UniMilano	1,350				900	450				
18	PA UniMilano	1,580				630	950				
19	PA UniMilano	1,580				630	950				
2	PA UniFerrara	2,000									
20	Tecnico UniMilano	360				360					
21	Tecnico UniMilano	360				360					
22	TD UniMilano	4,500				3,000	1,500				
23	PO SISSA	2,250									
24	PA SISSA	450									
25	Ric. SISSA	900									
26	TD SISSA	5,160									
27	PO UniRoma1	1,140						750	390		
28	PA UniRoma1	810						540	270		
29	PA UniRoma1	1,050						570	480		
3	PA UniFerrara	1,125									
30	Ric. UniRoma1	900						750	150		
31	RTB UniRoma1	1,470						990	480		
32	AdR UniRoma1	1,800						600	1,200		
33	TD UniRoma1	4,500						3,000	1,500		
34	Ric. MilanoBicocca	1,800									
35	PA MilanoBicocca	1,650									
36	PO MilanoBicocca	900									
37	Tecnico MilanoBicocca	1,200									
38	Tecnico MilanoBicocca	1,200									
39	TD MilanoBicocca	4,500									
4	TD UniFerrara	4,500									
40	PO UniRoma2	2,080	1,040	520	520						
41	PA UniRoma2	1,170		1,170							
42	PO UniRoma2	910			910						
43	RIC. UniRoma2	1,040		520	520						
44	TD UniRoma2	4,680	4,680								
45	Ric INFN	3,000									
46	Ric. INFN	1,200									

Project: COSMO	Economic Conditions: JAN 20	Contractual Phase: *ALL*
WBS Branch:: COSMO	Conversion Rate: 1 EUR = 1.000000 EUR	Company:

47	Tecnologo INFN	1,200									
48	Dirigente Ric. INFN	900									
49	Dirigente Ric. INFN	800									
5	Primo Ric. v classe INAF	609								609	
50	PA UniGE	3,206									
51	PA UniGe	1,973									
52	Tecnologo UniGE	1,720									
53	TD UniGE	5,160									
54	TD INFN PI	4,800									
6	Primo Ric IV classe INAF	127								127	
7	CTER INAF	456								456	
8	TD INAF	9,138								4,569	4,569
9	RIC INAF 3-4	1,524								153	1,371
	Total Direct Labour Hours	111,149	5,720	2,210	1,950	5,880	3,850	7,200	4,470	6,979	9,596
1.	Total Labour Cost	4,540,747	257,080	138,198	147,221	239,346	171,077	302,280	165,143	246,445	350,576
2.	Internal Special Facilities Cost	315,200				48,000	30,000	80,000	60,000		
3. 4	Electricl Parts	7,000									
3. 6	Ext.Maj.Product	191,000		9,000		30,000		10,000		30,000	
3. 7	Extern Services	83,000	23,000					18,000			18,000
3. 9	Travl/Allowance	422,000	15,000	21,500	28,500	15,500	13,500	12,500	18,500	43,000	43,000
3.	Total Other Costs	703,000	38,000	30,500	28,500	45,500	13,500	40,500	18,500	73,000	61,000
4.	Sub-Total Direct Cost	5,558,947	295,080	168,698	175,721	332,846	214,577	422,780	243,643	319,445	411,576
5-7.	General Expenses	80,804	7,259			4,885	2,443	4,885	2,443	7,376	7,376
8.	Sub-Total Company Cost	5,639,751	302,339	168,698	175,721	337,731	217,020	427,665	246,086	326,822	418,953
	Total Price EUR	5,639,751	302,339	168,698	175,721	337,731	217,020	427,665	246,086	326,822	418,953
	Converted to: EUR	5,639,751	302,339	168,698	175,721	337,731	217,020	427,665	246,086	326,822	418,953
12.	Total Company Price	4,983,248	190,435	168,698	175,721	337,731	217,020	427,665	246,086	326,822	418,953
	Converted to: EUR	4,983,248	190,435	168,698	175,721	337,731	217,020	427,665	246,086	326,822	418,953
14.	Reduction for Company Contribution	-3,239,871	-111,904	-138,198	-147,221	-189,638	-152,224	-284,572	-176,289	-98,923	-203,054
	Converted to: EUR	-3,239,871	-111,904	-138,198	-147,221	-189,638	-152,224	-284,572	-176,289	-98,923	-203,054
15.	Total Price for ESA	2,399,880	190,435	30,500	28,500	148,093	64,796	143,093	69,797	227,899	215,899
	Converted to: EUR	2,399,880	190,435	30,500	28,500	148,093	64,796	143,093	69,797	227,899	215,899

5.2.0004

Project: COSMO | Economic Conditions: JAN 20 | Contractual Phase: 'ALL'

WBS Branch:: COSMO | Conversion Rate: 1 EUR = 1.000000 EUR | Company:

		MI Bicocca	MI Bicocca	Genova	Pisa	Ferrara	Padova	Padova	SISSA	SISSA
Node:		5-6X1	5-6X2	6-6X1	6-6X2	7-6X1	8-6X1	8-6X2	9-6X1	9-6X2
WBS Title:		RF testing for fu ture CMB experime	CMB calibration a nd SRT	Strategic solutio ns for new CMB de	Readout electroni cs for future CMB	Astroparticle and Fundamental Phys	Inflationary grav itational waves	Non Gaussianity f rom Inflation	Foreground modeli ng and removal	CMB weak lensing reconstruction
Company:		INFR	INFR	INFR	INFR	INFR	INFR	INFR	INFR	INFR
1	PO UniFerrara					1,125				
10	Tecnologo INAF									
11	Ric INAF 3-3									
12	PO INAF									
13	PO UniPadova						1,000	1,125		
14	PA UniPadova						1,125	625		
15	Ric. UniPadova						750	1,450		
16	TD UniPadova						2,200	2,300		
17	PO UniMilano									
18	PA UniMilano									
19	PA UniMilano									
2	PA UniFerrara					2,000				
20	Tecnico UniMilano									
21	Tecnico UniMilano									
22	TD UniMilano									
23	PO SISSA								1,000	1,250
24	PA SISSA								100	350
25	Ric. SISSA								600	300
26	TD SISSA								2,580	2,580
27	PO UniRoma1									
28	PA UniRoma1									
29	PA UniRoma1									
3	PA UniFerrara					1,125				
30	Ric. UniRoma1									
31	RTB UniRoma1									
32	AdR UniRoma1									
33	TD UniRoma1									
34	Ric. MilanoBicocca	1,000	800							
35	PA MilanoBicocca	650	1,000							
36	PO MilanoBicocca	450	450							
37	Tecnico MilanoBicocca	600	600							
38	Tecnico MilanoBicocca	600	600							
39	TD MilanoBicocca	3,000	1,500							
4	TD UniFerrara					4,500				
40	PO UniRoma2									
41	PA UniRoma2									
42	PO UniRoma2									
43	RIC. UniRoma2									
44	TD UniRoma2									
45	Ric INFN				3,000					
46	Ric. INFN				1,200					

5.2.0004

Project:	COSMO
WBS Branch::	COSMO
Economic Conditions:	JAN 20
Conversion Rate:	1 EUR = 1.000000 EUR
Contractual Phase:	*ALL*
Company:	

47	Tecnologo INFN				1,200					
48	Dirigente Ric. INFN				900					
49	Dirigente Ric. INFN				800					
5	Primo Ric. v classe INAF									
50	PA UniGE			3,206						
51	PA UniGe			1,973						
52	Tecnologo UniGE			1,720						
53	TD UniGE			5,160						
54	TD INFN PI				4,800					
6	Primo Ric IV classe INAF									
7	CTER INAF									
8	TD INAF									
9	RIC INAF 3-4									
	Total Direct Labour Hours	6,300	4,950	12,059	11,900	8,750	5,075	5,500	4,280	4,480
1.	Total Labour Cost	223,489	185,583	446,091	455,442	386,914	232,867	245,511	164,972	182,512
2.	Internal Special Facilities Cost	67,200			30,000					
3. 4	Electricl Parts				7,000					
3. 6	Ext.Maj.Product	10,000	15,000	20,000	30,000	20,000		17,000		
3. 7	Extern Services	12,000		12,000						
3. 9	Travl/Allowance	8,500	13,500	27,000	22,000	39,000	18,500	23,500	28,500	30,500
3.	Total Other Costs	30,500	28,500	59,000	59,000	59,000	18,500	40,500	28,500	30,500
4.	Sub-Total Direct Cost	321,189	214,083	505,091	544,442	445,914	251,367	286,011	193,472	213,012
5-7.	General Expenses	4,884	2,442	7,282	7,222	7,259	3,797	3,970	3,640	3,640
8.	Sub-Total Company Cost	326,073	216,525	512,373	551,665	453,173	255,164	289,980	197,112	216,652
	Total Price EUR	326,073	216,525	512,373	551,665	453,173	255,164	289,980	197,112	216,652
	Converted to: EUR	326,073	216,525	512,373	551,665	453,173	255,164	289,980	197,112	216,652
12.	Total Company Price	326,073	79,782	512,373	551,665	211,433	255,164	123,864	197,112	216,652
	Converted to: EUR	326,073	79,782	512,373	551,665	211,433	255,164	123,864	197,112	216,652
14.	Reduction for Company Contribution	-193,009	-136,743	-300,451	-340,997	-241,740	-156,924	-166,116	-92,164	-109,704
	Converted to: EUR	-193,009	-136,743	-300,451	-340,997	-241,740	-156,924	-166,116	-92,164	-109,704
15.	Total Price for ESA	133,064	79,782	211,922	210,668	211,433	98,240	123,864	104,948	106,948
	Converted to: EUR	133,064	79,782	211,922	210,668	211,433	98,240	123,864	104,948	106,948