Athena

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IAPS/INAF

… . .

Athena and the Hot and Energetic Universe

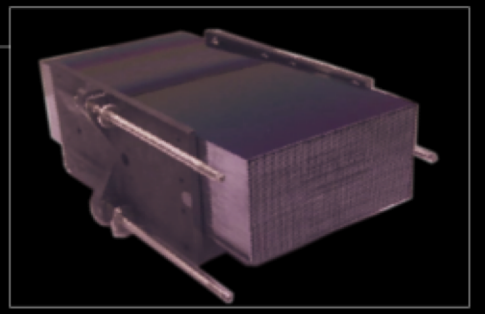
- ✓ ESA Large Mission (L2): Observatory class
- ✓ Hot & Energetic Universe Science theme:
  - ✓ Formation and Evolution of hot gas cosmological structures
  - ✓ Growth of black holes over cosmic time and their influence on galaxies
  - ✓ Transient phenomena, GRBs as probes of the early Universe and Multimessenger Astronomy
  - ✓ Observatory Science

ATHENA

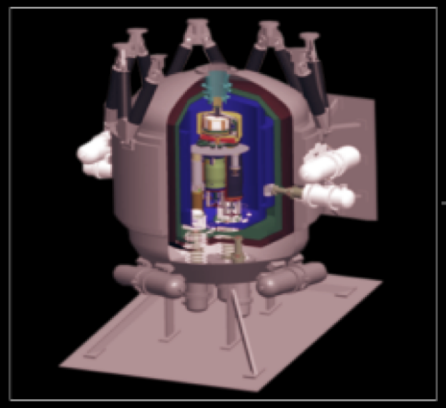
The Athena Observatory

Willingale et al, 2013
arXiv1308.6785

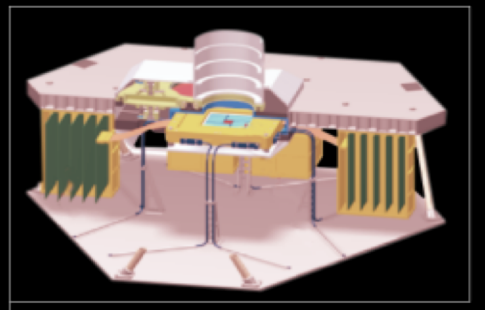
L1 orbit Ariane VI
TOO in 4 hrs
Mass 7 tons
Power 2500 W
4+6 year mission



Silicon Pore Optics:
1.4 m^2 at 1 keV
5 arcsec HEW
Focal length: 12 m
Sensitivity: 3 10^{-17} erg cm^{-2} s^{-1}



X-ray Integral Field Unit:
ΔE: 2.5 eV
Field of View: 5 arcmin
Operating temp: 50 mk



Wide Field Imager:
ΔE: 125 eV
Field of View: 40 arcmin
High countrate capability

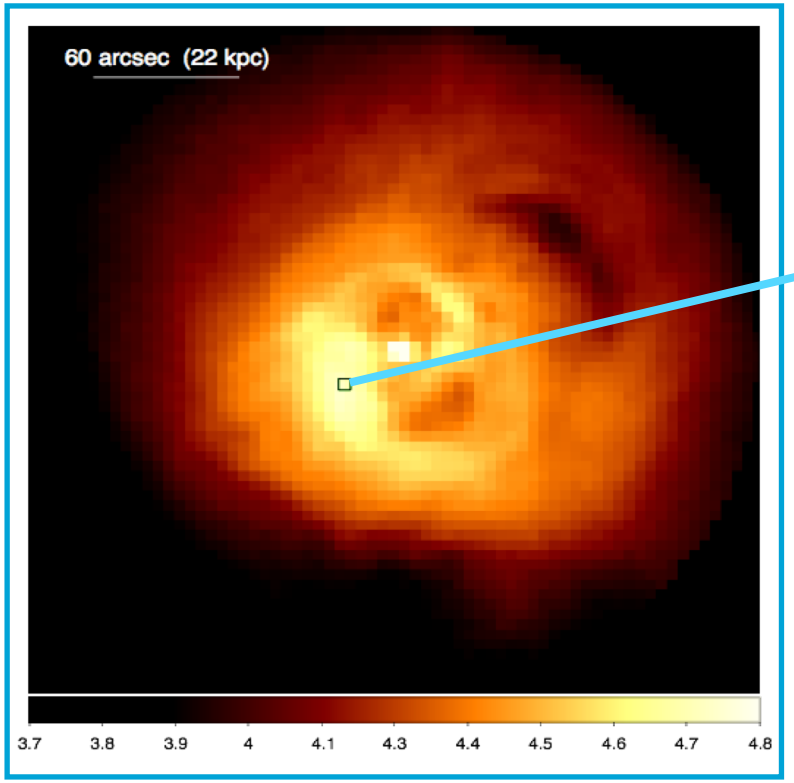
Barret et al., 2013 arXiv:1308.6784

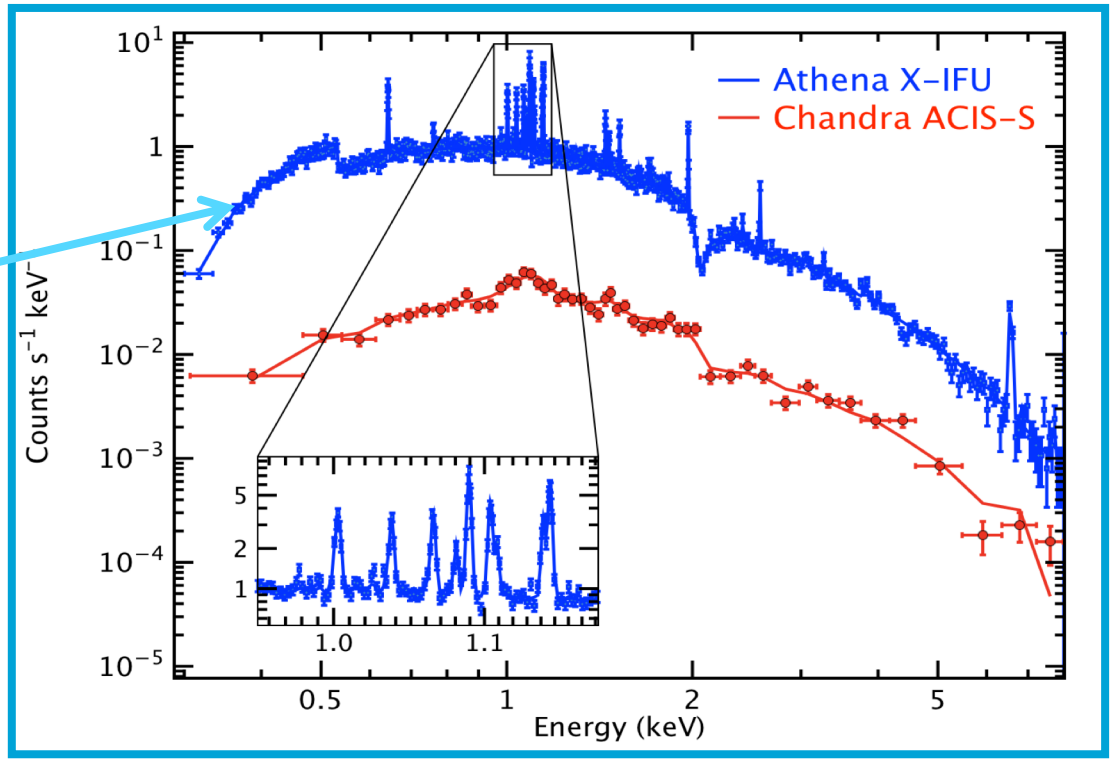
Rau et al. 2013 arXiv1307.1709

The first X-ray IFU

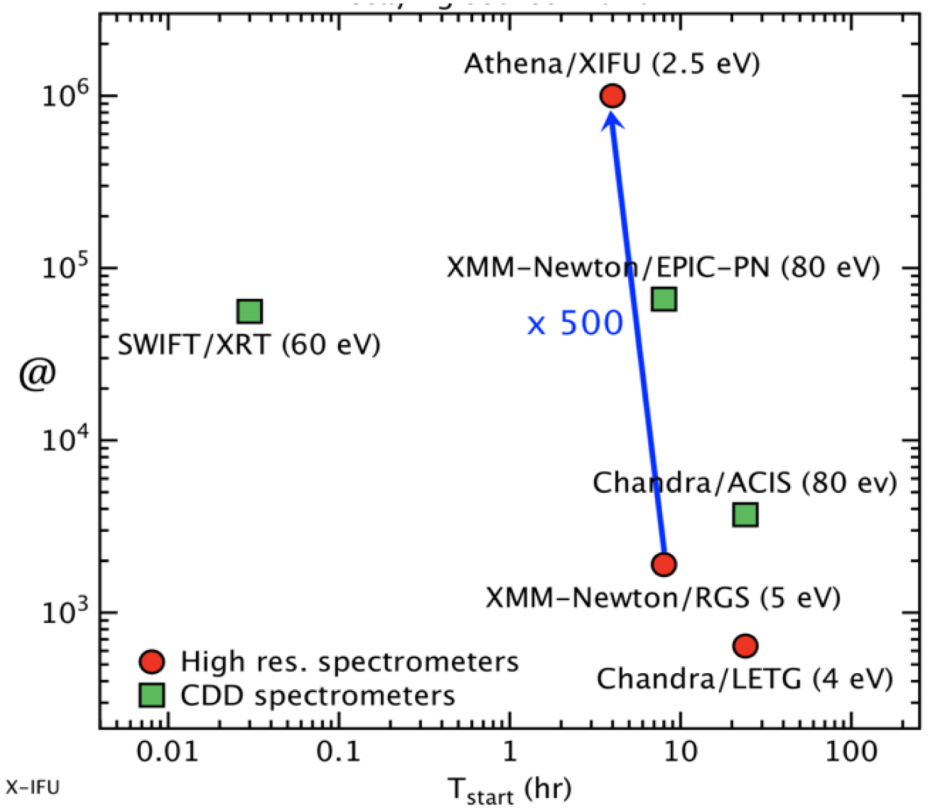
IFU

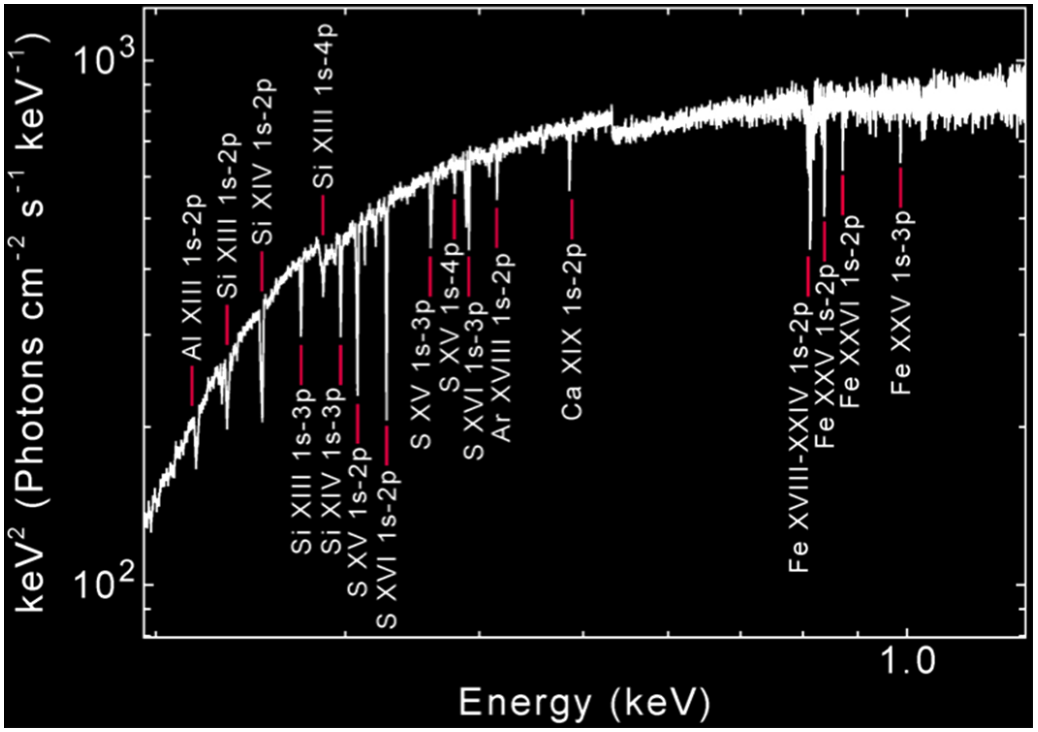
X-ray Integral Field Unit





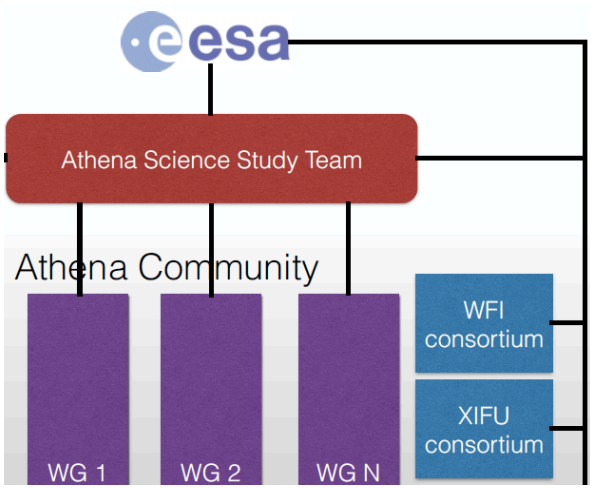
Transient Universe

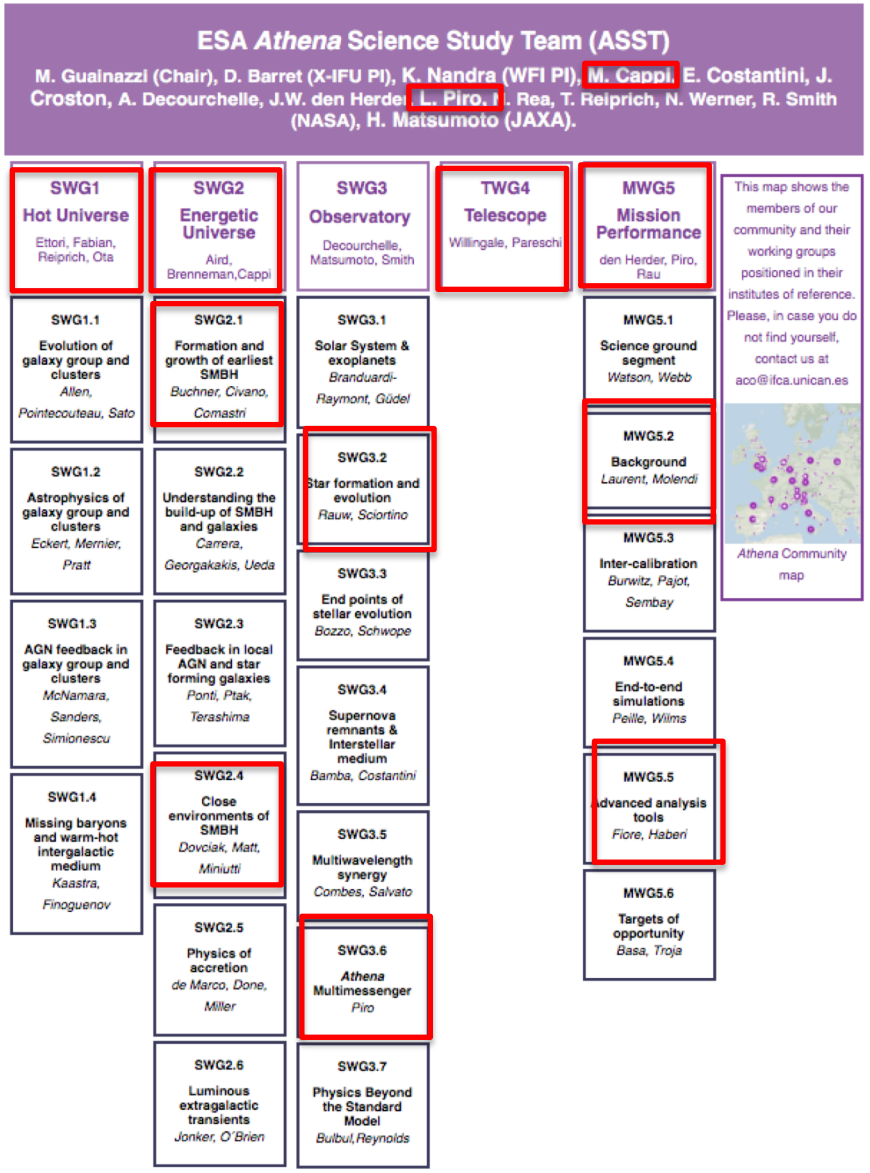




International Organization

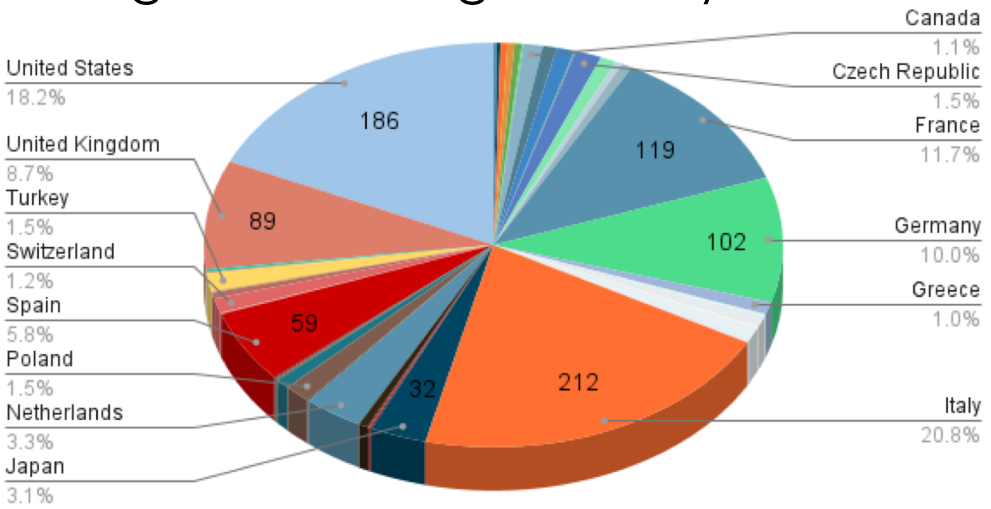
- ESA responsible at system level, spacecraft, launcher, mirror, operations and SOC
- Instruments and Science Ground Segment by Instrument Consortia:
  - XIFU PI/CoPI: France, Holland, Italy (INAF/IAPS)
  - WFI PI: Germany
- NASA & JAXA contributions
- ESA Athena Science Study Team
  - Science &Mission WG





INAF leadership in ATHENA

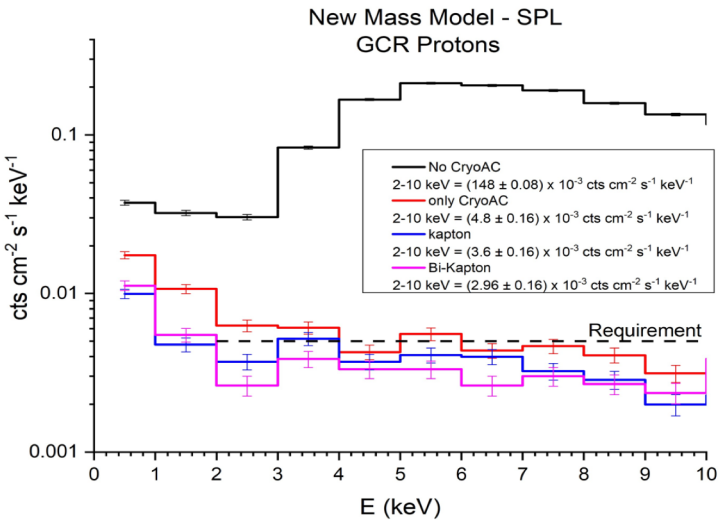
- XIFU CoPI-ship (INAF/IAPS) + synergical participation to WFI
- Italian responsibilities on XIFU: enabling science, high visibility:
  - cryoAC TES microcalorimeter
  - background
  - Filters
  - ICU
  - XSAT chairship
- System/satellite
  - Particle environment and orbit
  - Mirror calibration and module integration

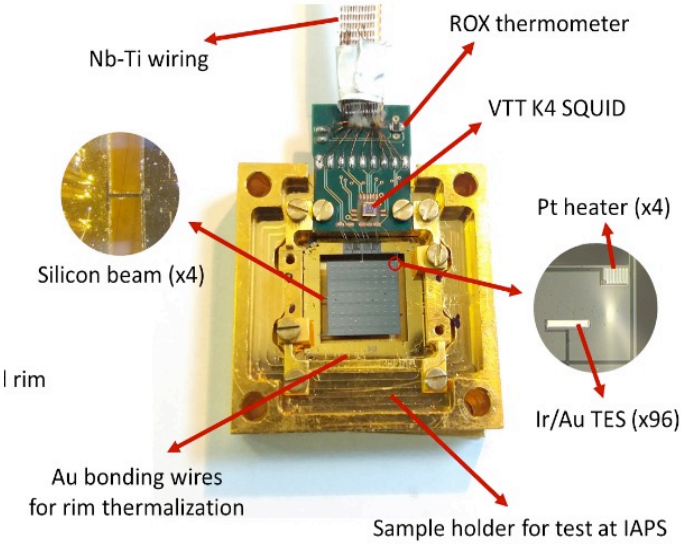


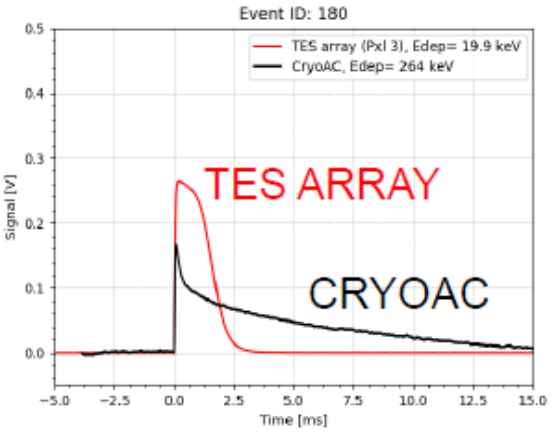
- Italian representatives in ASST &WGs: 2 ESA Study Team, 9 co-chairs of Mission & Science WGs, 212 members (largest contribution vs total 1020)
  - INAF: IAPS(lead of the Athena Italian Consortium), IASF-MI, IASF-Bo, IASF-Pa, OAB, OABo, OATo, OAPa, OATs, OAR, plus all other INAF obs for participation to wgs
  - Univ. &INFN Genova, Univ Rm1,Rm2,Rm3, Univ. Bo, Univ. Pa, Uni.Mi
  - CNR, IFN-RM

Bkg and TES CryoAnticoincidence

- Enables XIFU science for faint &diffuse sources (INAF/IAPS, UNI&INFN/Ge, INAF/IASF-Mi, CNR/IFN-RM
- The first large area (1 cm2) TES array: longstanding development by INAF&INFN/UniGe
- The only European TES onboard

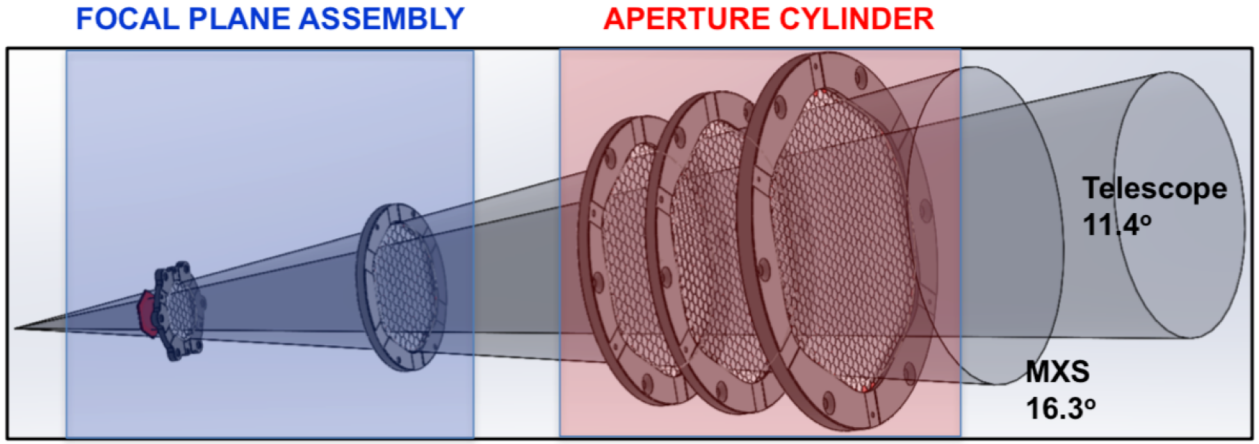




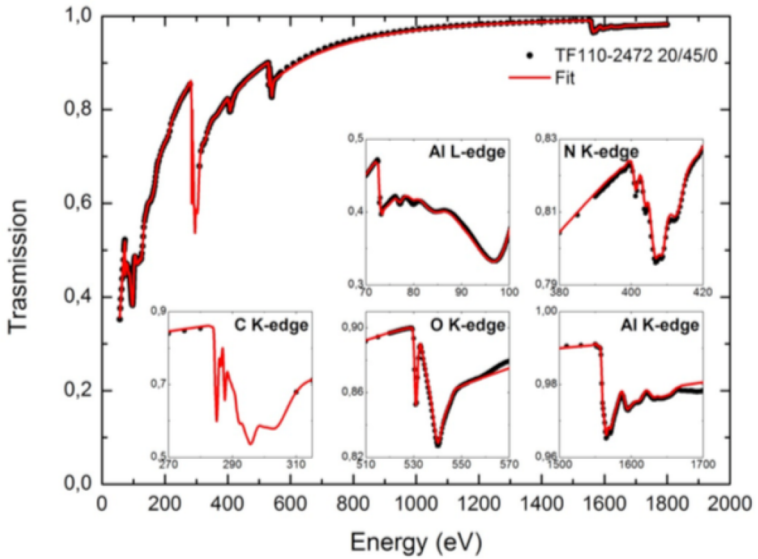


- Particle bkg & Environment(INAF: IAPS, IASF-Mi, IASF-Pa, OAS)

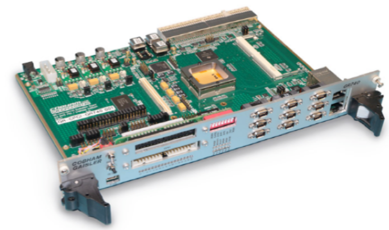
Thermal Filters



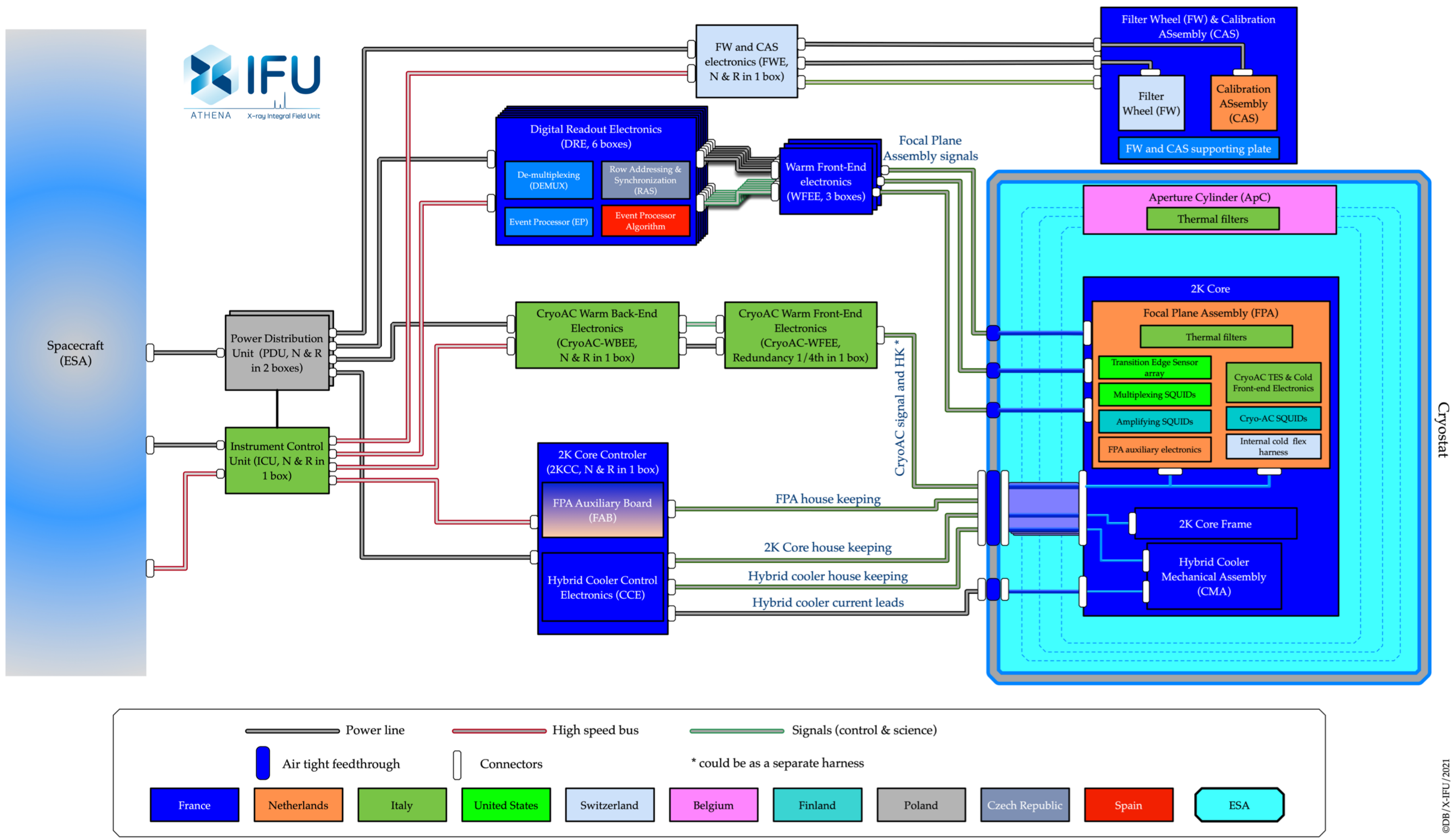
- Block thermal inputs and EMI onto the TES vs soft X-ray transmission
- 5 filters from 300K to 50 mK, 4 x larger than XRISM.
- OaPA & UniPa



XIFU ICU

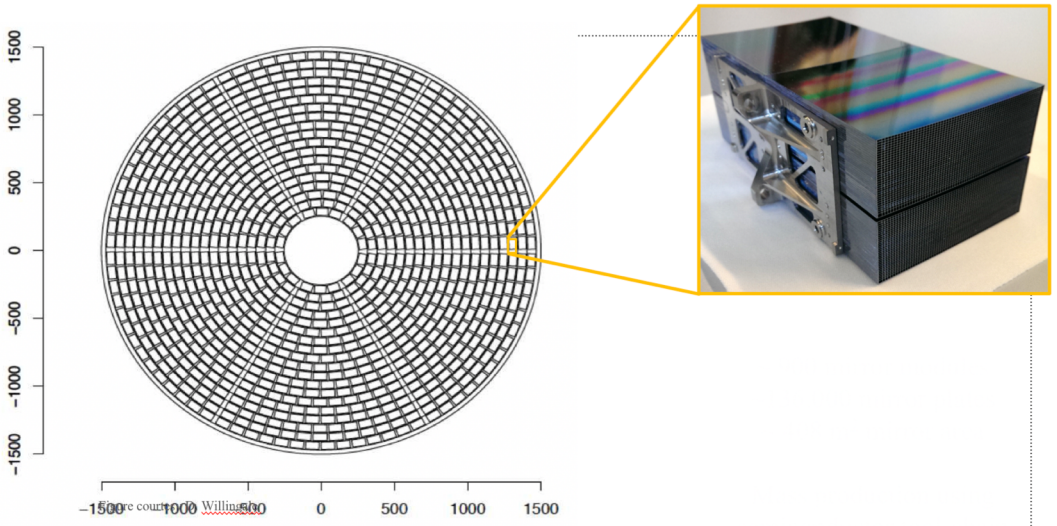


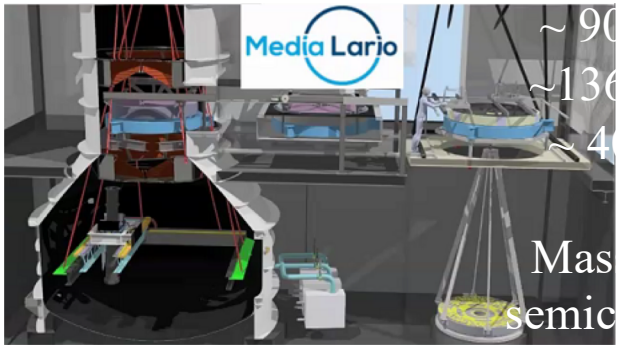
- Commanding all XIFU subsystems
- Euclid heritage
- OAS &OaTO



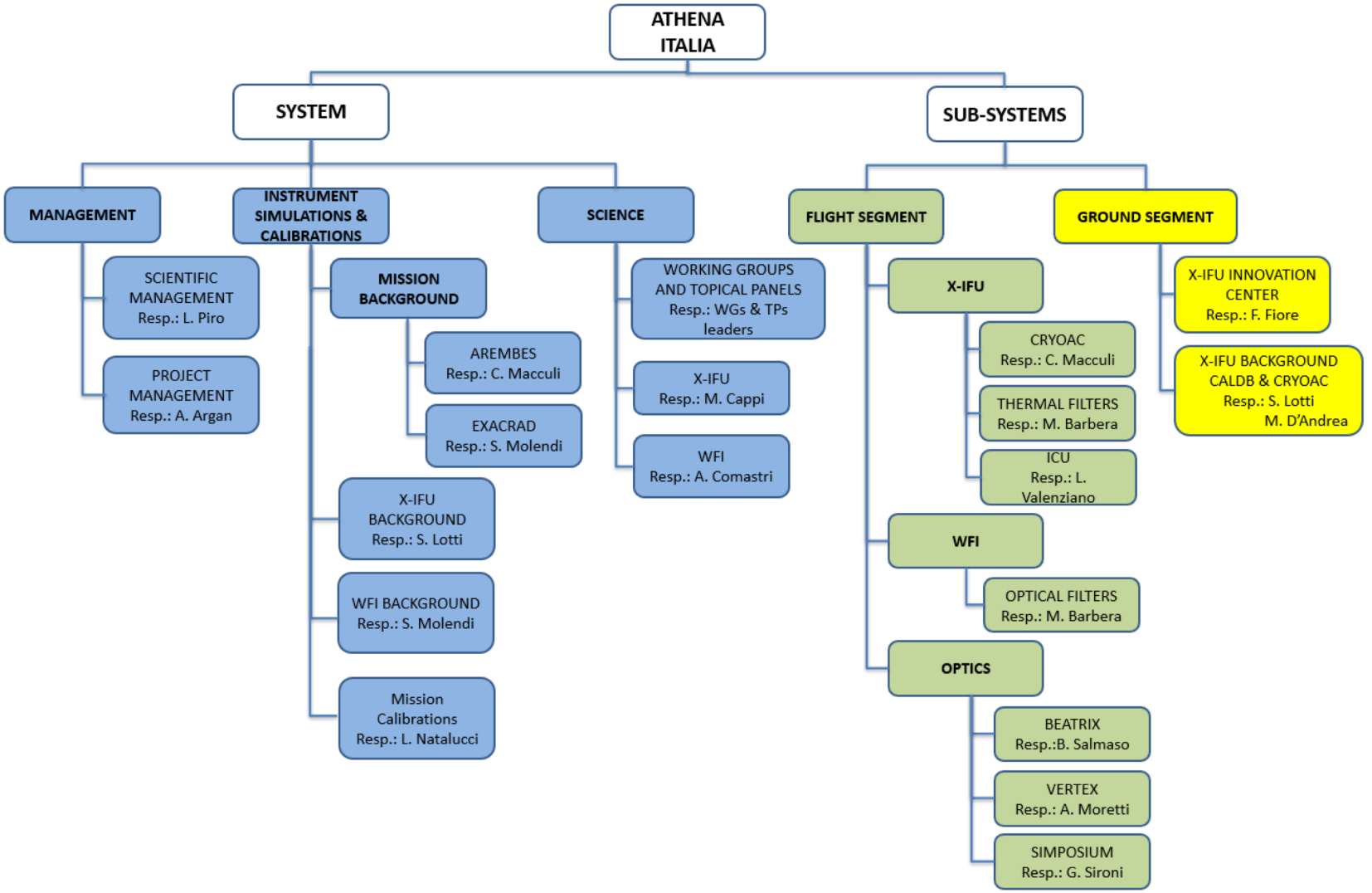
Mirror Integration & Calibration

- Facilities @ INAF (OAB) for proper Mirror Modules assembly (600 MM) and calibration: Beatrix & VERTEX

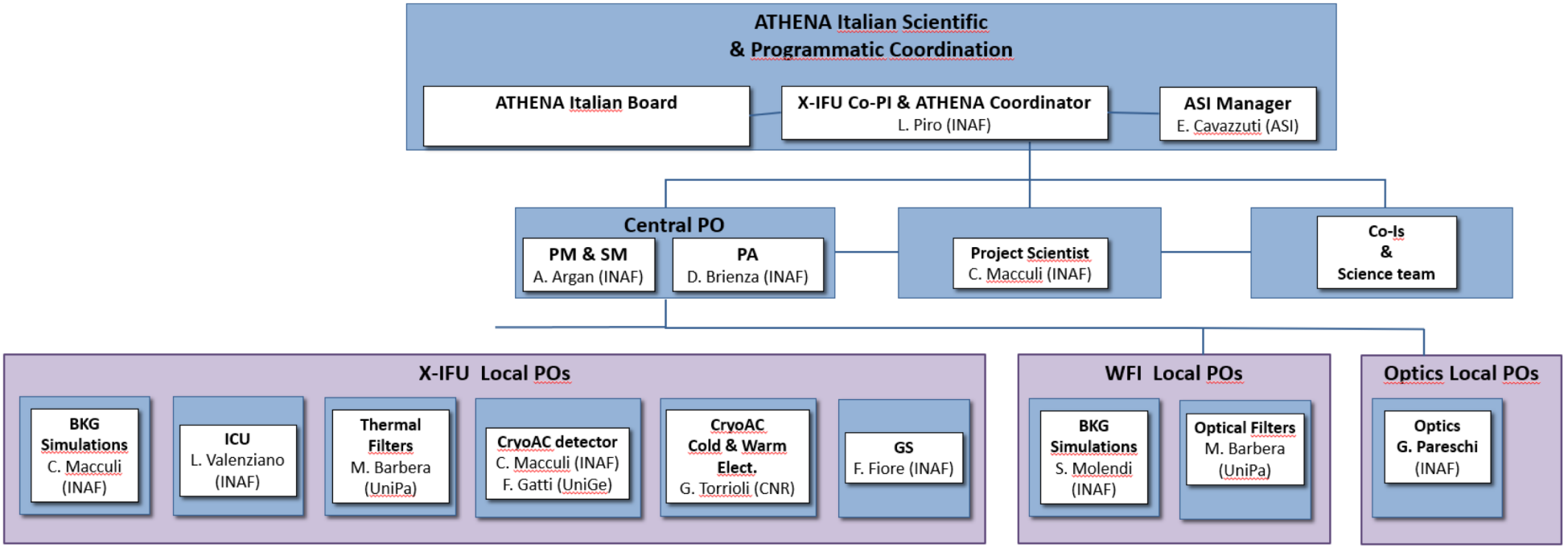




WBS Italy

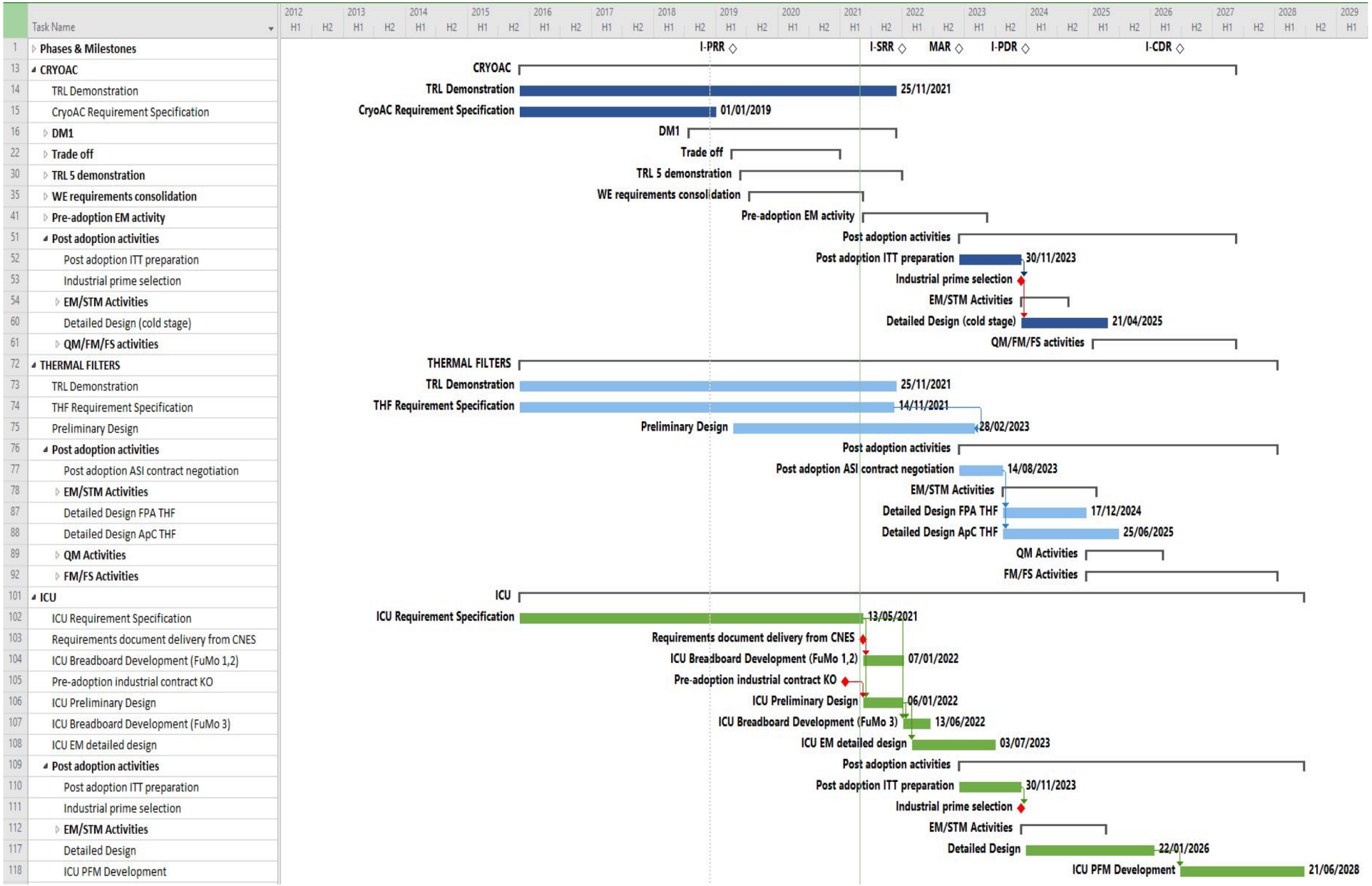

ATHENA ITALIA
SYSTEM
SUB-SYSTEMS
MANAGEMENT
INSTRUMENT SIMULATIONS & CALIBRATIONS
SCIENCE
FLIGHT SEGMENT
GROUND SEGMENT
SCIENTIFIC MANAGEMENT Resp.: L. Piro
PROJECT MANAGEMENT Resp.: A. Argan
MISSION BACKGROUND
AREMBES Resp.: C. Macculi
EXACRAD Resp.: S. Molendi
X-IFU BACKGROUND Resp.: S. Lotti
WFI BACKGROUND Resp.: S. Molendi
Mission Calibrations Resp.: L. Natalucci
WORKING GROUPS AND TOPICAL PANELS Resp.: WGs & TPs leaders
X-IFU Resp.: M. Cappi
WFI Resp.: A. Comastri
X-IFU
CRYOAC Resp.: C. Macculi
THERMAL FILTERS Resp.: M. Barbera
ICU Resp.: L. Valenziano
WFI
OPTICAL FILTERS Resp.: M. Barbera
OPTICS
BEATRIX Resp.:B. Salmaso
VERTEX Resp.: A. Moretti
SIMPOSIUM Resp.: G. Sironi
X-IFU INNOVATION CENTER Resp.: F. Fiore
X-IFU BACKGROUND CALDB & CRYOAC Resp.: S. Lotti M. D'Andrea

OBS Italy


ATHENA Italian Scientific
& Programmatic Coordination
ATHENA Italian Board
X-IFU Co-PI & ATHENA Coordinator
L. Piro (INAF)
ASI Manager
E. Cavazzuti (ASI)
Central PO
PM & SM
A. Argan (INAF)
PA
D. Brienza (INAF)
Project Scientist
C. Macculi (INAF)
Co-Is
&
Science team
X-IFU Local POs
BKG Simulations
C. Macculi (INAF)
ICU
L. Valenziano (INAF)
Thermal Filters
M. Barbera (UniPa)
CryoAC detector
C. Macculi (INAF)
F. Gatti (UniGe)
CryoAC Cold & Warm Elect.
G. Torrioli (CNR)
GS
F. Fiore (INAF)
WFI Local POs
BKG Simulations
S. Molendi (INAF)
Optical Filters
M. Barbera (UniPa)
Optics Local POs
Optics
G. Pareschi (INAF)

Schedule

✓ Hot&Energetic Univ. Theme selected for ESA L2	Nov. 2013
✓ Athena Mission selected	Jun. 2014
✓ Phase A and B1	on going
✓ Implementation Phase	2023
✓ Launch	2033/34
✓ Operations:	4 +6 years


Task Name
2012 H1 H2 2013 H1 H2 2014 H1 H2 2015 H1 H2 2016 H1 H2 2017 H1 H2 2018 H1 H2 2019 H1 H2 2020 H1 H2 2021 H1 H2 2022 H1 H2 2023 H1 H2 2024 H1 H2 2025 H1 H2 2026 H1 H2 2027 H1 H2 2028 H1 H2 2029 H1
1 Phases & Milestones
I-PRR ◇
I-SRR ◇
MAR ◇
I-PDR ◇
I-CDR ◇
13 CRYOAC
CRYOAC
14 TRL Demonstration
TRL Demonstration
25/11/2021
15 CryoAC Requirement Specification
CryoAC Requirement Specification
01/01/2019
16 DM1
DM1
22 Trade off
Trade off
30 TRL 5 demonstration
TRL 5 demonstration
35 WE requirements consolidation
WE requirements consolidation
41 Pre-adoption EM activity
Pre-adoption EM activity
51 Post adoption activities
Post adoption activities
52 Post adoption ITT preparation
Post adoption ITT preparation
30/11/2023
53 Industrial prime selection
Industrial prime selection
54 EM/STM Activities
EM/STM Activities
60 Detailed Design (cold stage)
Detailed Design (cold stage)
21/04/2025
61 QM/FM/FS activities
QM/FM/FS activities
72 THERMAL FILTERS
THERMAL FILTERS
73 TRL Demonstration
TRL Demonstration
25/11/2021
74 THF Requirement Specification
THF Requirement Specification
14/11/2021
75 Preliminary Design
Preliminary Design
28/02/2023
76 Post adoption activities
Post adoption activities
77 Post adoption ASI contract negotiation
Post adoption ASI contract negotiation
14/08/2023
78 EM/STM Activities
EM/STM Activities
87 Detailed Design FPA THF
Detailed Design FPA THF
17/12/2024
88 Detailed Design ApC THF
Detailed Design ApC THF
25/06/2025
89 QM Activities
QM Activities
92 FM/FS Activities
FM/FS Activities
101 ICU
ICU
102 ICU Requirement Specification
ICU Requirement Specification
13/05/2021
103 Requirements document delivery from CNES
Requirements document delivery from CNES
104 ICU Breadboard Development (FuMo 1,2)
ICU Breadboard Development (FuMo 1,2)
07/01/2022
105 Pre-adoption industrial contract KO
Pre-adoption industrial contract KO
106 ICU Preliminary Design
ICU Preliminary Design
06/01/2022
107 ICU Breadboard Development (FuMo 3)
ICU Breadboard Development (FuMo 3)
13/06/2022
108 ICU EM detailed design
ICU EM detailed design
03/07/2023
109 Post adoption activities
Post adoption activities
110 Post adoption ITT preparation
Post adoption ITT preparation
30/11/2023
111 Industrial prime selection
Industrial prime selection
112 EM/STM Activities
EM/STM Activities
117 Detailed Design
Detailed Design
22/01/2026
118 ICU PFM Development
ICU PFM Development
21/06/2028

Schedula

- EM
  - Cryoac cold stage: Q1 2023
  - Filtri : Q2 2023
  - Cryoac warm eletronics: Q3 2024
  - ICU: Q3 2024
- FM
  - Cryoac cold stage: Q4 2025
  - Cryoac warm elect: Q2 2027
  - Filtri: Q2 2026
  - ICU: Q4 2027

Fondi e risorse

- ASI: Athena phase A-B1 contract + addendum; fase di implementazione in discussione
- EU: AHEAD & AHEAD2020
- ESA tenders: Bkg simulations (PI: IAPS); bkg measurements (PI:IASF/MI), Mirror (PI: OAB);TES Technology (IAPS, participant), Filter(OaPA, participant)
- INAF fondi CaC (primariamente ASI): 15Me
- FTE INAF: 350 FTE

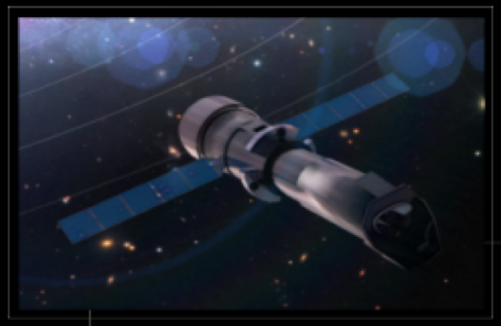
Criticitá

- A livello programmatico la complessitá della integrazione del sistema XIFU porta in avanti nel tempo il feedback dai test di sistema ai sottosistemi e rende particolarmente importante la realizzazione del modello EM.
  La schedula di integrazione richiede di anticipare in fase B una serie di attivitá relative all'EM di long lead items (tipiche quindi della fase C) come la CryoAC e i filtri. Alcune criticitá programmatiche e budgetarie connesse sono in via di risoluzione con ASI.
- Stabilitá dei finanziamenti ASI (sperabilmente superato)
- Pre-contratto industriale KO in anticipo rispetto congelamento I/F requirements e design
- La consegna del red book è stata spostata a Febbraio 2022 in modo da basarlo su performance scientifiche comprovate, come richiesto da ESA.
- Personale con bkg ingegneristico e project managing fondamentale per il progetto. Aspetto strategico per INAF

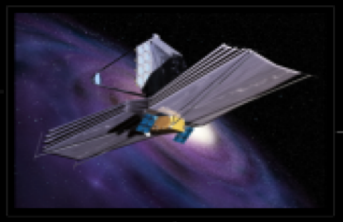
ATHENA

Athena in context of large facilties

ATHENA

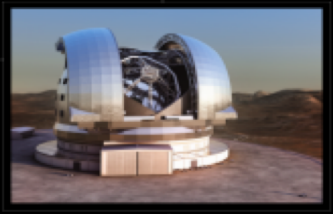


JWST

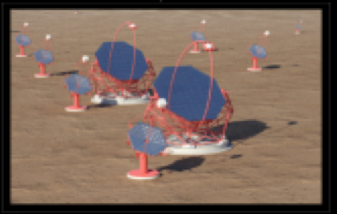


ALMA

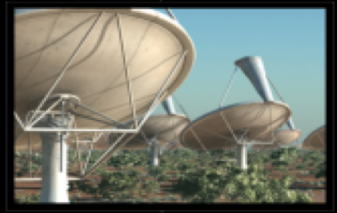
E-ELT



CTA



SKA



Multimessenger (ν's and GW): KM3NET, IceCube, ALIGO,AVIRGO, ET

Athena is a crucial part of the suite of large observatories needed to reach the science objectives of astronomy in the coming decades