

27 November 2023

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# The SKA Observatory

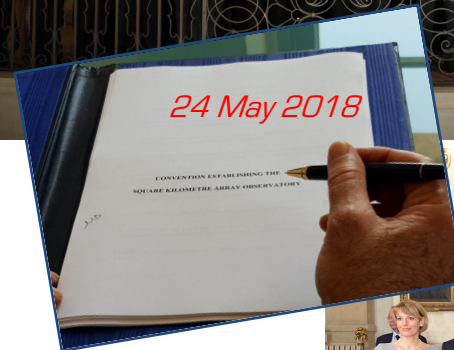
[from an Italian perspective]

Isabella Prandoni



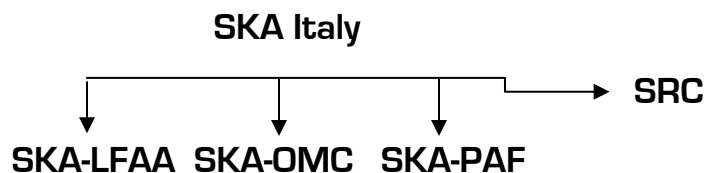
# SKAO - Milestones

- **December 2011:** Establishment of SKA Organization (Italy founding member)
- **October 2015:** Negotiations start for establishment of an IGO (under Italy coordination)
- **24 May 2018:** Italy first country initialling the IGO convention
- **12 March 2019:** IGO signing ceremony - Rome
- **2019 - MAECI funds the SKA**
- **5 February 2020:** Italy second country ratifying the IGO convention
- **15 January 2021:** SKA Observatory enters into force (Italy among 6 founding members)
- **01 July 2021:** SKAO Construction begins (Italy gets first contracts)



# SKA-Italy Structure

## Project structure:



### 9. Short Abstract (in English)

The SKA will be the most powerful radio-interferometer ever built, and will operate through two large antenna networks in Australia and Africa. Italy, through INAF, has been involved in the project since the establishment of the SKA Organization (2012) and is one of the six that founded the SKA Observatory in 2021. Italy has leading roles in several of the ongoing scientific and technological activities. This form a general overview of the Italian involvement in the SKA project and is integrated by four sub-forms, which describe in detail two technical macro-activities (SKA-LFAA, SKA-OMC, SKA-PAF), and the development activities for a dedicated data analysis centre (SRC). Some SKA-OMC-related activities are described in the Meerkat Plus form.

SKA in numbers

**€1.282 BILLION**  
CONSTRUCTION COST (2020 €)

**€0.704 BILLION**  
FIRST 10 YEARS OF OPERATIONS COST (2020 €)

2021

**WG F06-02**  
All Chairs & ex-Chairs  
SKA Science WGs  
+ selected core members

- S. Camera
- M. Giroletti
- A. Ingallinera
- B. Mesinger
- A. Raccanelli
- P. Serra
- V. Vacca

## Advisory Structure

**SKA Italy Board**  
*Chair I. Prandoni*

+ 12 members:

- |              |           |             |
|--------------|-----------|-------------|
| G. Bernardi  | M. Dolci  | A. Possenti |
| G. Brunetti  | D. Fierro | C. Trigilio |
| R. Cassano   | J. Monari | G. Umana    |
| G. Comoretto | T. Pisanu | T. Venturi  |

**Total FTE: 72**

Incl. SKA SWGs (based on Schede 2023)

2018

- (ex-)Chairs Science SKA WGs
- Coordinators SKA Design Consortia
- Coordinators of Bridging Teams
- SKA-related Advisors
- Head of ICT Office

# Italian Roadmap

[Sept. 2019 - Available at INAF UTG-II web page]

- SWOT analysis → identify opportunities/critical areas/ strengths/threads

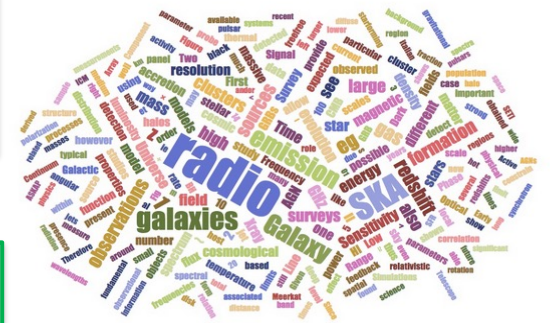


	Helpful	Harmful
Internal	S Strengths	W Weaknesses
External	O Opportunities	T Threats

## Recommend coordinated actions:

- > establish an Italian view to be played in the International SKA context
- > propose coordinated actions to maximize return of Italy investment in **technology, science, industry**

An Italian Roadmap towards the SKA



## INAF actions based on Roadmap recommendations:

- > >2020 - **INAF involved in MeerKAT+** (coord. by UTG-II SKA-MID precursors Advisor)  
International LOFAR Telescope joined in 2018  
[weakness: no access to SKA-MID precursors]
- > >2021 - **Italy joins SRC Network** (coord. by UTG-II HPC/Data Advisor)  
[opportunity: develop in house data handling/analysis expertise]
- > >2023 - **National Postdocs dedicated to SKA** (6 positions)  
[opportunity: build SKA generation and future leaderships]

See talks by  
G. Brunetti  
G. Umama  
A. Possenti

by  
the Italian SKA Board  
I. Prandoni, D. Fierro, G. Bernardi, G. Brunetti,  
R. Cassano, G. Comoretto, M. Dolci, J. Monari,  
A. Navarrini, A. Possenti, R. Smareglia,  
C. Trigglio, G. Umama, T. Venturi

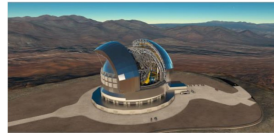
and  
of the INAF-UTG-II Radioastronomy  
F. Govoni

September 10 - September 13th, 2019

[ Sept. 2019 ]



# Strengthening The Italian Leadership in ELT & SKA



## STILES

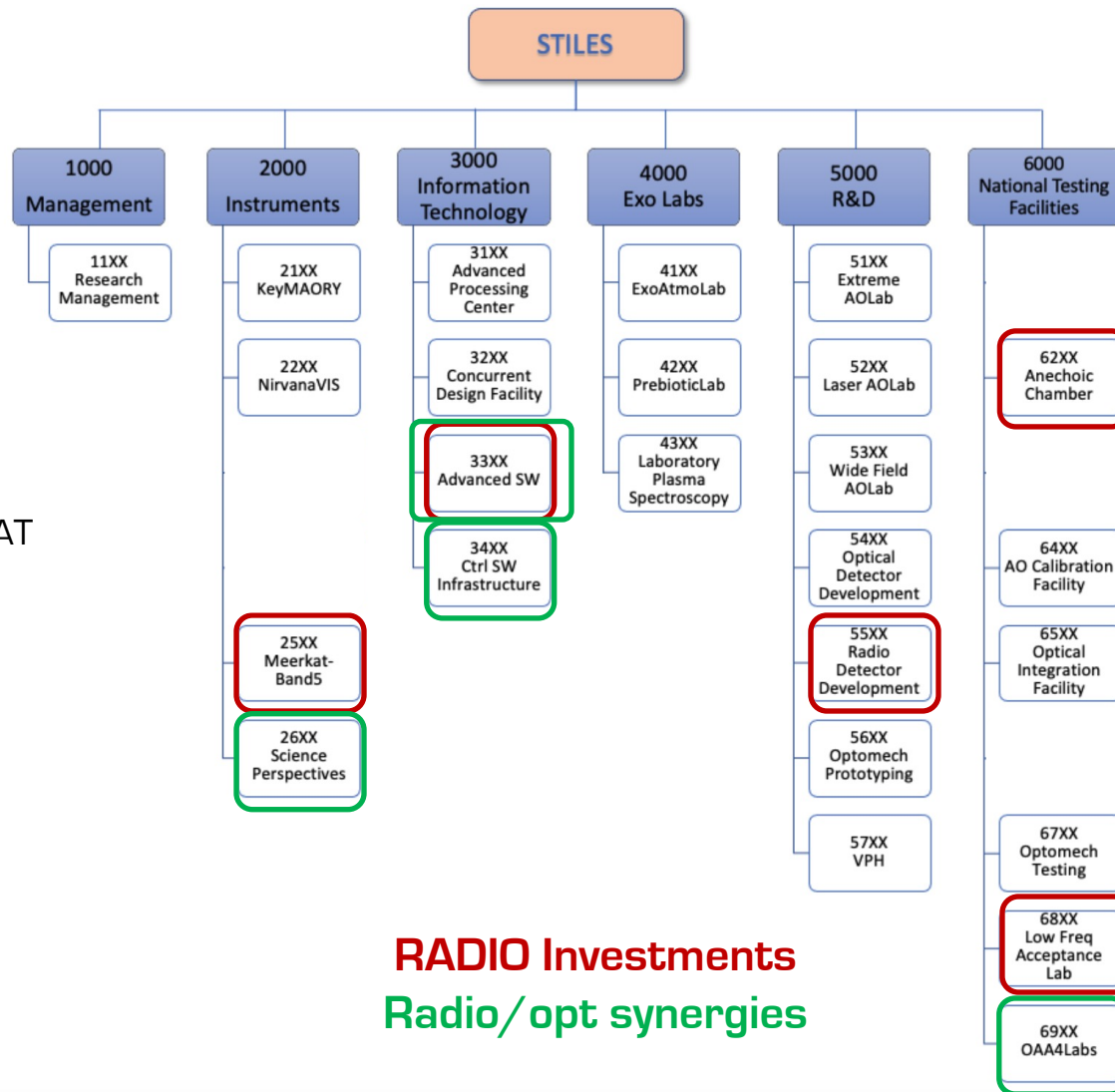


Coordinated programme to foster Italian leadership towards ELT & SKAO

Upgrades and strengthening of Italian radio and optical infrastructures/laboratories  
Investments in next generation instrumentation for ELT and SKAO

WP1000 Mgmt	WP2000 Instruments	WP3000 IT	WP4000 ExoLabs	WP5000 R&D	WP6000 Nat. Testing Facilities	TOTAL:
1 Activity 1 SdR	5 Activity 4 SdR	23 Activity 12 SdR 3 Università	4 Activity 2 SdR (*) 1 Università	15 Activity 9 SdR 1 Università	14 Activity 7 SdR 2 Università	70 MEu incl. overhead
<b>S</b> 22 K€ <b>P</b> 369 K€ <b>O</b> 0 K€ <b>T</b> 0 K€	<b>S</b> 23.900 K€ <b>P</b> 795 K€ <b>O</b> 0 K€ <b>T</b> 388 K€	<b>S</b> 7.723K€ <b>P</b> 1.185 K€ <b>O</b> 907 K€ <b>T</b> 335 K€	<b>S</b> 3.366 K€ <b>P</b> 384 K€ <b>O</b> 0 K€ <b>T</b> 0 K€	<b>S</b> 14.267 K€ <b>P</b> 529 K€ <b>O</b> 0 K€ <b>T</b> 0 K€	<b>S</b> 6.305 K€ <b>P</b> 866 K€ <b>O</b> 3.804 K€ <b>T</b> 155 K€	<b>S</b> 55.583 K€ <b>P</b> 4.127 K€ <b>O</b> 4.711 K€ <b>T</b> 878 K€

- S** Strumentazione
- P** Personale TD
- O** Infrastrutture Civili
- T** Training/ PhD



See talks by  
G. Umata  
F. Schilliro'

**Highlight:**

Band 5 Receivers for MeerKAT  
64 antennas  
(13 Meu)

**Not only technology ..**

National Training and Fixed  
Term Research Positions  
[7 PhD + 5 TD]  
(1 Meu)

**RADIO Investments**  
**Radio/opt synergies**

# Italian Involvement: Technology

## Goal: Maximal return in terms of technology know-how and industrial contracts

- SKA Design Consortia (2013-2018) - Bridging phase (2019-2020) – Construction (2021-2029) + SKA AIP



## Italian Leaderships & Construction Contracts:

- **LFAA:** antenna & receiver chain design
  - ➔ **Tier 1 Contracts:** SIRIO (antennas) and ELEMMASTER (Signal Processing System) + INAF (consulting and support) [Ref. J. Monari]
- **OMC:** GUIs, TANGO framework services & LMC systems, SKA Pulsar Search Engine & CSP pulsar processing prototypes
  - ➔ **Tier 2 Contracts:** INAF [Ref. M. Dolci] + IDS - Interactive Design Solutions
- **AIP:** PAF technology (integrated receivers and digital beam forming) [Ref. T. Pisanu]

### SKA design consortia

#### COMPONENTS

- ➔ Assembly, Integration and Verification
- ➔ Central Signal Processor
- ➔ Dish
- ➔ Infrastructure South Africa

**Will hear more later and tomorrow..**

### SKA-LOW Prototype station

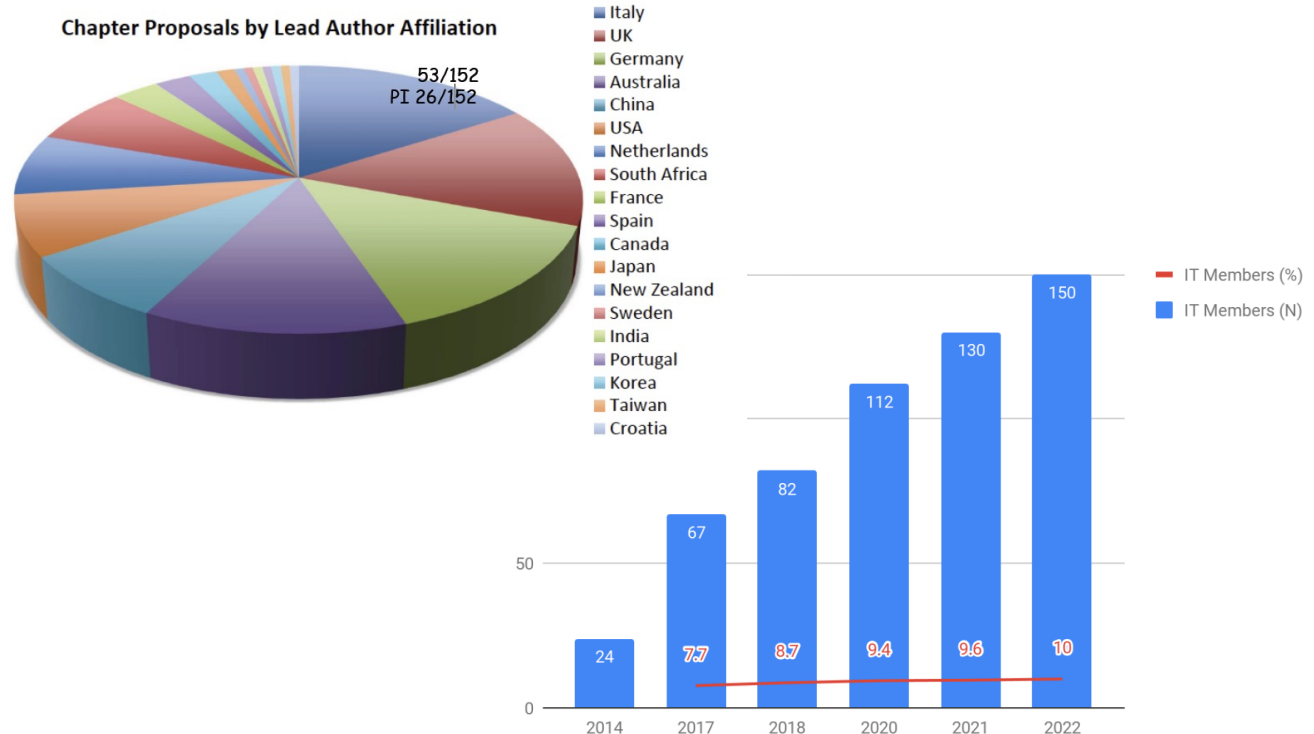
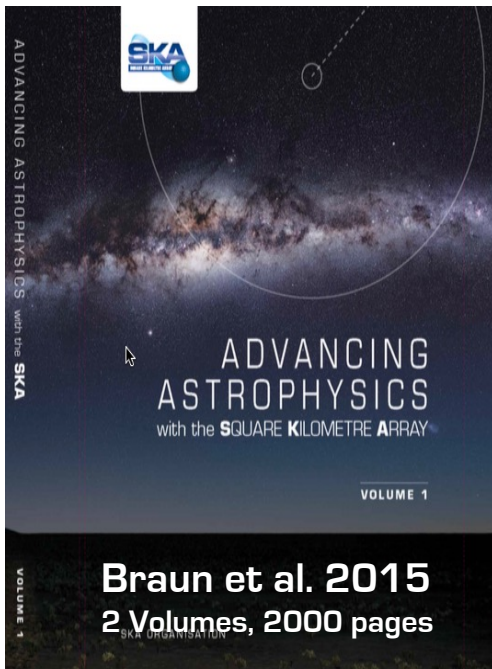
Antenna design SKALA 4.1AL



# Italian Involvement: Science

## Goal: maximal scientific return in the exploitation of SKA

- Italian SKA White Book (2014): >80 IT co-authors
- SKA Science Book 2015 - 135 chapters: **56 with IT co-authors** (41%) - **20 with IT first authors** (15%)

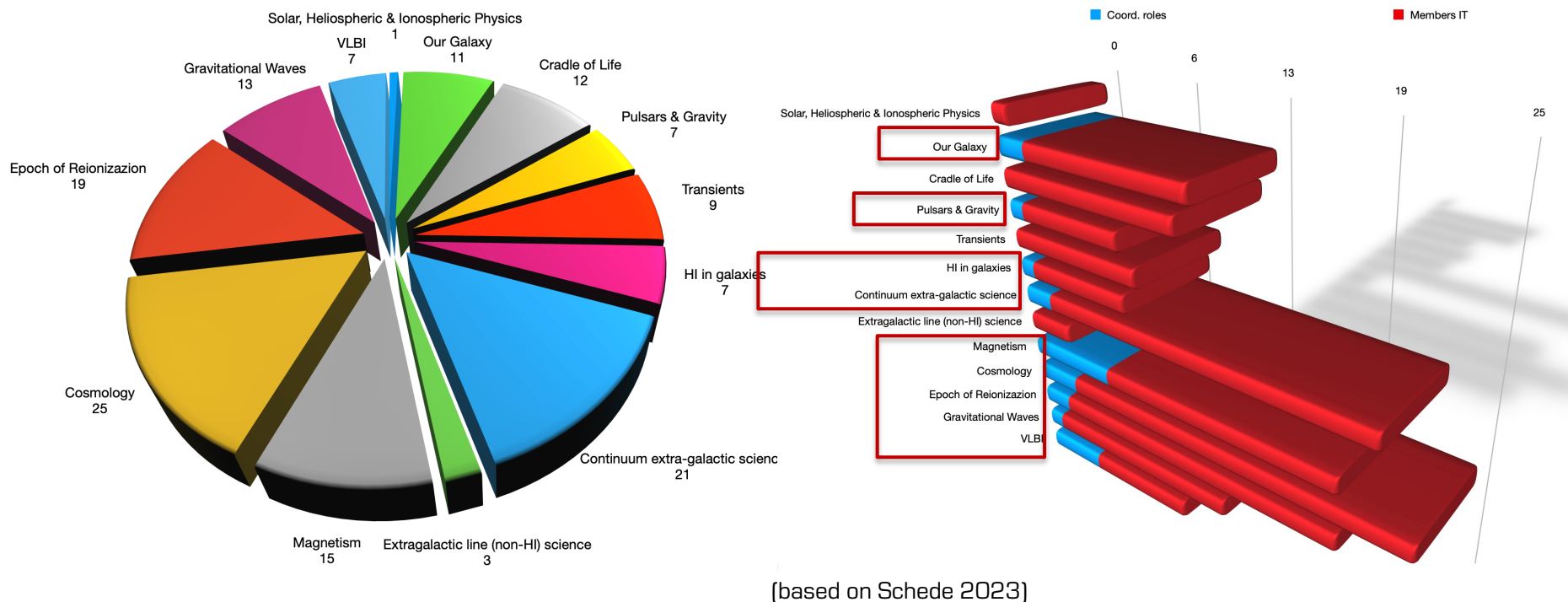




# Italian Involvement: Science

## Goal: maximal scientific return in the exploitation of SKA

- 14 SKA Science Working Groups: **122 IT Members** (10.2%) in 13 SWG - **5 Chairs** - **22 IT with Coordination Roles** in **9 SWG** – 14 INAF structures + 15 IT Universities (overall 5 FTE/yr 2023-2025)



**Rich and diverse ongoing scientific activities**

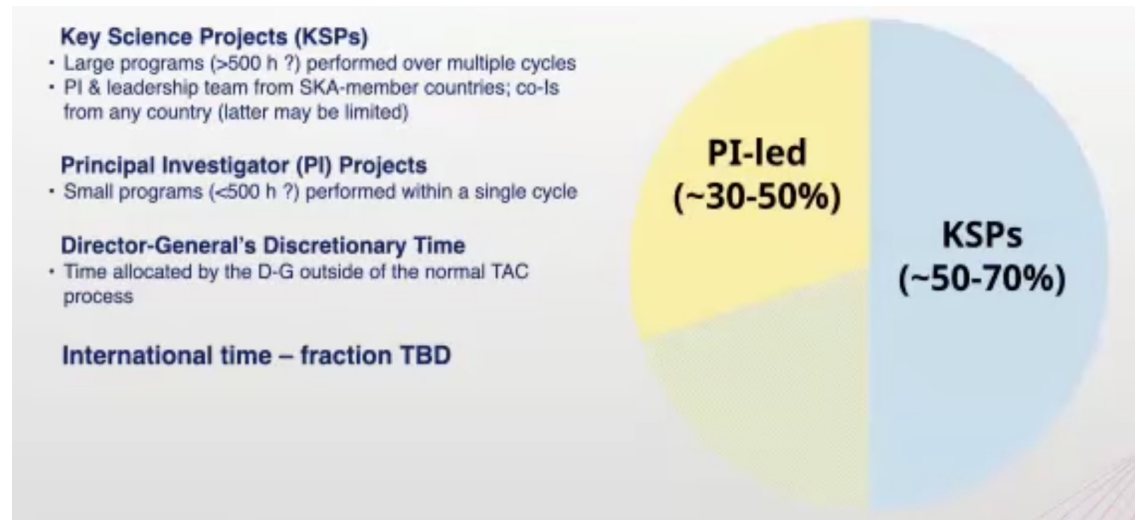
# Next SKAO Milestones

## SKAO: Scientific Timeline

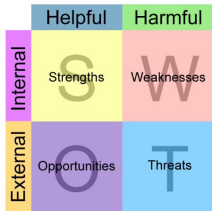
Credit: SKAO

### Telescope Access:

Science driven,  
based on  
contribution level



# SKA-Italy: Scientific Roadmap



Recommend coordinated actions:

- Support SKA science teams
- maximise leading roles in future SKA KSPs

## The Scientific Pathway to the SKA: Italian Prospects

by  
the Italian SKA Board & the Italian SKA Science Working Group

(Version 1)

[ Near to completion ]  
Expands original Roadmap

### Outline

Preamble

Executive summary

1. International Scientific Framework
  - 1.1. SKAO Science drivers and high priority objectives
  - 1.2. New SKA Scientific Themes
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Appendix A

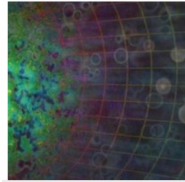
Appendix B

Appendix C

Appendix D

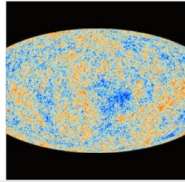
# SKA-Italy: Scientific Roadmap

## Science Drivers



**Cosmic Dawn and the epoch of reionisation**

WHERE DID IT ALL BEGIN?  
HOW AND WHEN DID THE FIRST STARS, GALAXIES AND BLACK HOLES FORM?  
The SKA will uniquely enable the measurement of a complete time sequence



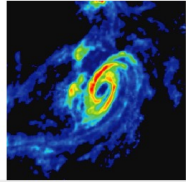
**Cosmology and dark energy**

CAN WE UNCOVER THE MYSTERIOUS NATURE OF DARK ENERGY?  
HOW AND WHY HAS IT BECOME THE MAJOR PLAYER IN OUR UNIVERSE?  
The SKA will fundamentally advance our understanding of the mysterious dark



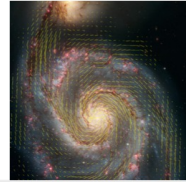
**Forming stars through cosmic time**

HOW AND WHEN WERE THE FIRST STARS BORN?  
HOW HAS THE RATE OF STAR FORMATION CHANGED OVER TIME, AND WHY?  
There is evidence that star formation



**Galaxy evolution**

WHAT IS THE LIFE-CYCLE OF A GALAXY?  
WHERE DO THEY COME FROM, WHERE DO THEY GO?  
WHAT ARE THE PROPERTIES OF THE MYSTERIOUS DARK ENERGY?



**Cosmic magnetism**

HOW DID THE UNIVERSE BECOME MAGNETIC?  
WHERE AND WHEN DID MAGNETISM ORIGINATE?  
HOW HAS IT EVOLVED?



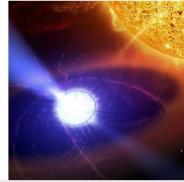
**The bursting sky**

WHAT ARE THE COUNTERPARTS OF THE FAST AND FURIOUS BURSTS OF RADIO WAVES?  
WHAT CAN THEY TELL US ABOUT THE CONSTITUENTS OF THE UNIVERSE?  
SKA will enable us to



**The cradle of life**

HOW DO YOU MAKE A PLANET FROM SPACE PEBBLES?  
ARE WE ALONE IN THE UNIVERSE?  
The SKA will have sufficient resolution to watch the assembly of planets in Earth-like orbits about their parent stars.



**Challenging Einstein: gravitational waves**

WAS EINSTEIN RIGHT ABOUT GRAVITY?  
CAN WE FIND AND UNDERSTAND WHERE GRAVITATIONAL WAVES COME FROM?  
The SKA will use our entire galaxy to

Credit: SKAO

New	Scientific	Themes
Multi-messenger	Fast Radio Bursts	SNRs & Cosmic Rays
AGN feedback at all scales	RQ QSO and obscured AGN populations	Cosmic Web
Exo-planet Magneto-sphere	Matter life cycle	

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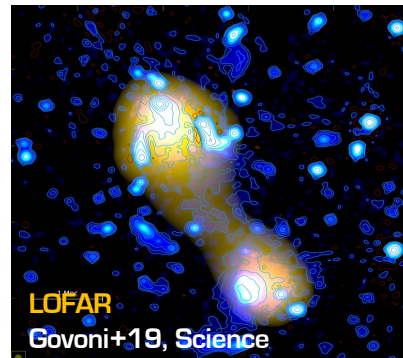
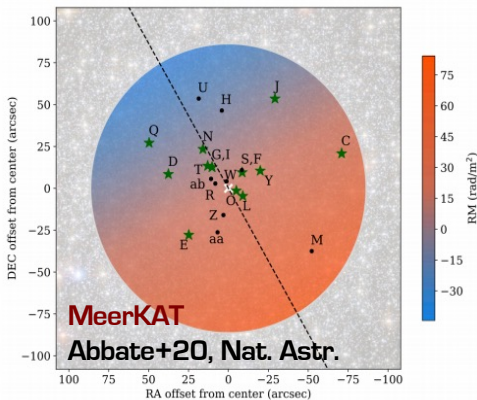
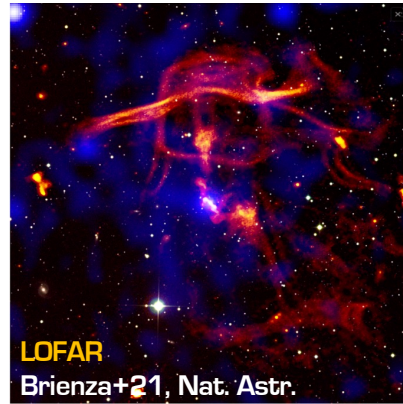
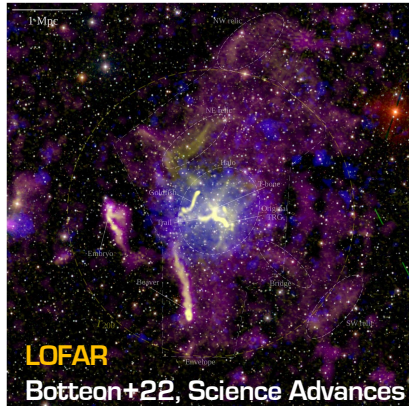
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Appendix A  
Appendix B  
Appendix C  
Appendix D

# SKA-Italy: Scientific Roadmap

Recommend coordinated actions:

- Support SKA science teams
- maximise leading roles in future SKA KSPs



## Outline

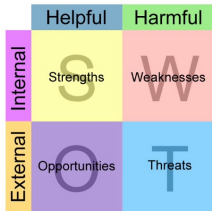
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# SKA-Italy: Scientific Roadmap



Recommend coordinated actions:

- Support SKA science teams
- maximise leading roles in future SKA KSPs

## The MeerKAT Fornax Survey - I. Survey description and first evidence of ram pressure in the Fornax galaxy cluster

P. Serra<sup>1,\*</sup>, F. M. Maccagni<sup>2,1</sup>, D. Kleiner<sup>2,1</sup>, D. Molnár<sup>1</sup>, M. Ramatsoku<sup>3,1</sup>, A. Loni<sup>4,1</sup>, F. Loi<sup>1</sup>, W. J. G. de Blok<sup>2,5,6</sup>, G. L. Bryan<sup>7</sup>, R. J. Dettmar<sup>8</sup>, B. S. Frank<sup>9,10,6</sup>, J. H. van Gorkom<sup>7</sup>, F. Govoni<sup>1</sup>, E. Iodice<sup>11</sup>, G. I. G. Józsa<sup>12</sup>, P. Kamphuis<sup>8</sup>, R. Kraan-Korteweg<sup>6</sup>, S. I. Loubser<sup>13</sup>, M. Murgia<sup>1</sup>, T. A. Oosterloo<sup>2,5</sup>, R. Peletier<sup>5</sup>, D. J. Pisano<sup>6</sup>, M. W. L. Smith<sup>14</sup>, S. C. Trager<sup>5</sup>, and M. A. W. Verheijen<sup>2</sup>

**MeerKAT**

Serra+2019,2023 – ERC Starting 2015

## The LOFAR LBA Sky Survey

II. First data release\*

F. de Gasperin<sup>1,2</sup>, H. W. Edler<sup>2</sup>, W. L. Williams<sup>3</sup>, J. R. Callingham<sup>3,4</sup>, B. Asabere<sup>4</sup>, M. Brügger<sup>2</sup>, G. Brunetti<sup>1</sup>, T. J. Dijkema<sup>4</sup>, M. J. Hardcastle<sup>5</sup>, M. Iacobelli<sup>4</sup>, A. Offringa<sup>4</sup>, M. J. Norden<sup>4</sup>, H. J. A. Röttgering<sup>3</sup>, T. Shimwell<sup>3,4</sup>, R. J. van Weeren<sup>3</sup>, C. Tasse<sup>6</sup>, D. J. Bomans<sup>7</sup>, A. Bonafede<sup>8,1</sup>, A. Botteon<sup>8,1</sup>, R. Cassano<sup>1</sup>, K. T. Chyży<sup>9</sup>, V. Cuciti<sup>2,1</sup>, K. L. Emig<sup>10</sup>, M. Kadler<sup>11</sup>, G. Miley<sup>3</sup>, B. Mingo<sup>12</sup>, M. S. S. L. Oei<sup>3</sup>, I. Prandoni<sup>1</sup>, D. J. Schwarz<sup>13</sup>, and P. Zarka<sup>14,15</sup>

**LOFAR**

De Gasperin+2021,2023 – ERC Consolidator 2022

- + Several Scientific PI-ships and WP leaderships in large ongoing surveys
- + many Open Time Projects

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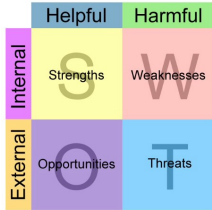
Appendix A

Appendix B

Appendix C

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# SKA-Italy: Scientific Roadmap



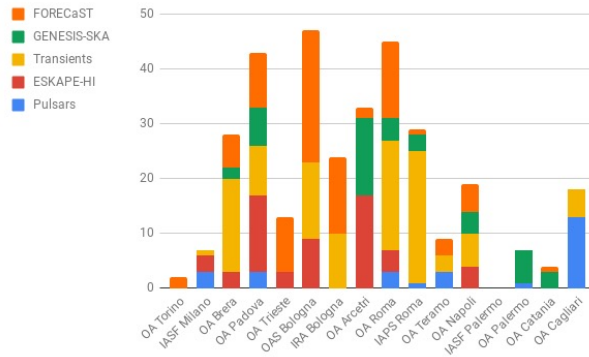
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- Support SKA science teams
- maximise leading roles in future SKA KSPs

## Other ERC:

ERC Starting: AIDA (2007) – Mesinger  
 MAGCOW (2017)– Vazza  
 DRANOEL (2017) – Bonafede

## INAF: SKA/CTA 2016



Large Grants  
 2022+2023:  
 10% SKA-related

GO/GTO  
 2022+2023:  
 12% SKA-related

Schede INAF 2023: 13% SKA-related

## Outline

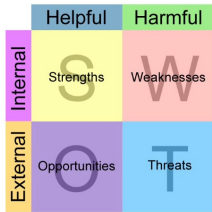
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# SKA-Italy: Scientific Roadmap



Recommend coordinated actions:

- Support SKA science teams
- maximise leading roles in future SKA KSPs

[ Work in progress / to be completed ]

Policy	Scientific Theme	Leadership
Single KSP	EoR Cosmology	Co-PI/WG Leader WG Leader
Multi-purpose survey	Pulsars & Gravity Multi-messenger Gal. Evolution HI Gal. Evolution RC Clusters & LSS Magnetism	KSP PI KSP PI KSP PI KSP PI / Tier PI KSP PI / Survey co-PI KSP PI
PI project	Clusters & LSS Magnetism Gal. Evolution HI Gal. Evolution RC	PI PI PI PI

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# Summary

## Strengths

- Recognized leaderships in SKA technology (SKA Tier 1 and Tier 2 contracts / MeerKAT+ / LOFAR 2.0) / PNRR
- Recognized leadership in SKA science (SWG chairs/coordination roles)
- PI-ships and leadership roles in both SKA MID and SKA LOW precursors

## Opportunities

- LOFAR 2.0 and MeerKAT+ key science programmes under definition
- Strong involvement in a number of other next-generation facilities (CTA/Euclid/Athena/LIGO/VIRGO, etc.)
- Strong expertise in data analysis/observations (radio interferometry) & computational research

## Weaknesses

- Need strategic plan to support future SKA science teams since the early stages of data delivery (>~2027)
- Need man power for national SRC

- Maintain and possibly increase scientific visibility of Italian community
- Support over the years national teams able to get leadership roles in SKA KSPs (scientific and data analysis expertise)

- Support LOFAR 2.0 /Mk+ leadership ambitions
- Exploit synergies to widen involvement & expertise
- Build on data/computational expertise to develop Italian SKA Data Center

- Foster formation of national KSP teams (both science and data analysis)
- Foster engagement in early SKA observations (commissioning, SV, ..)
- Foster international KSP leaderships

**Way forwards will be discussed as part of parallel sessions...**

