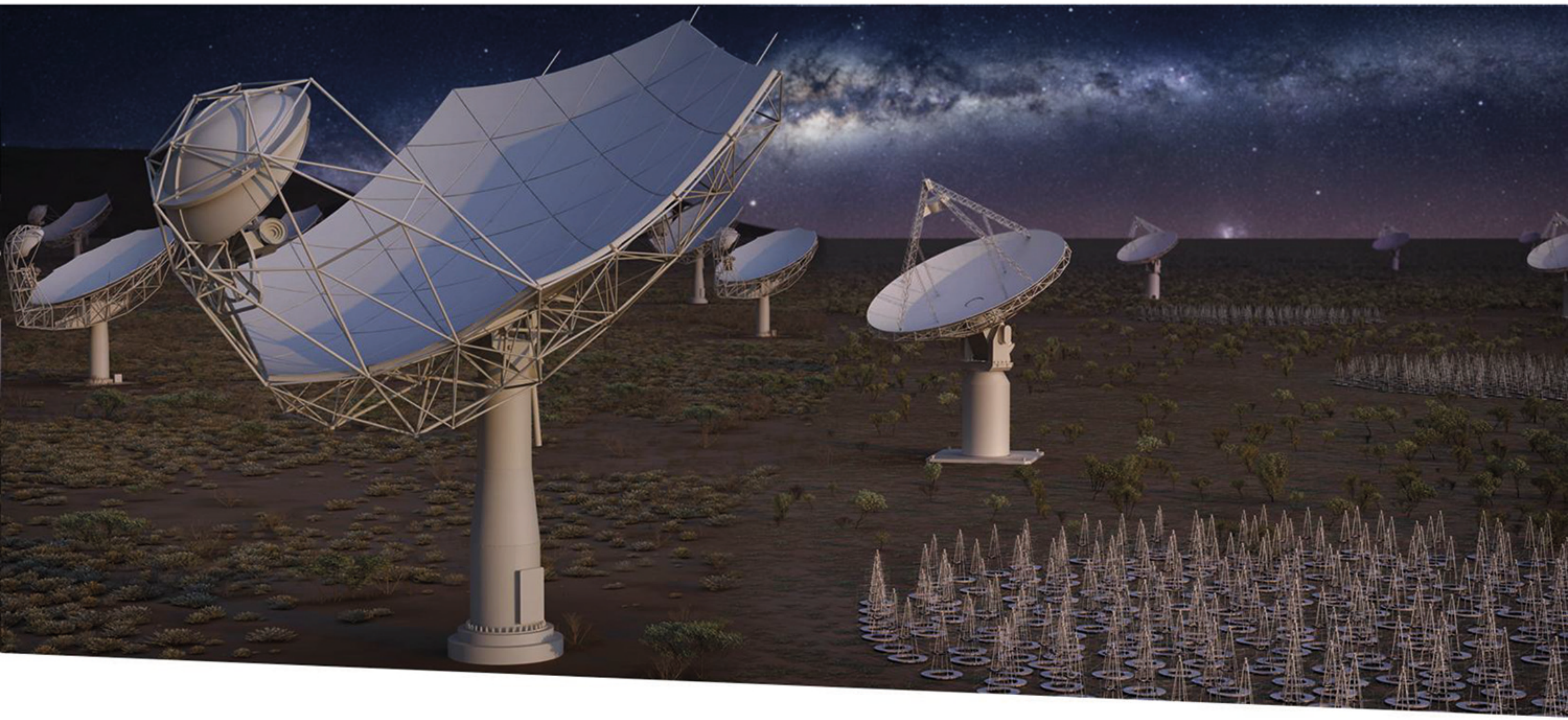
The SKA Project

Italian Involvement and Perspectives



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

I. Prandoni, M. Dolci, J. Monari,
A. Navarrini, A. Possenti

The SKA Project - Outline

This presentation:

1) General overview and institutional/scientific activities: Isabella Prandoni

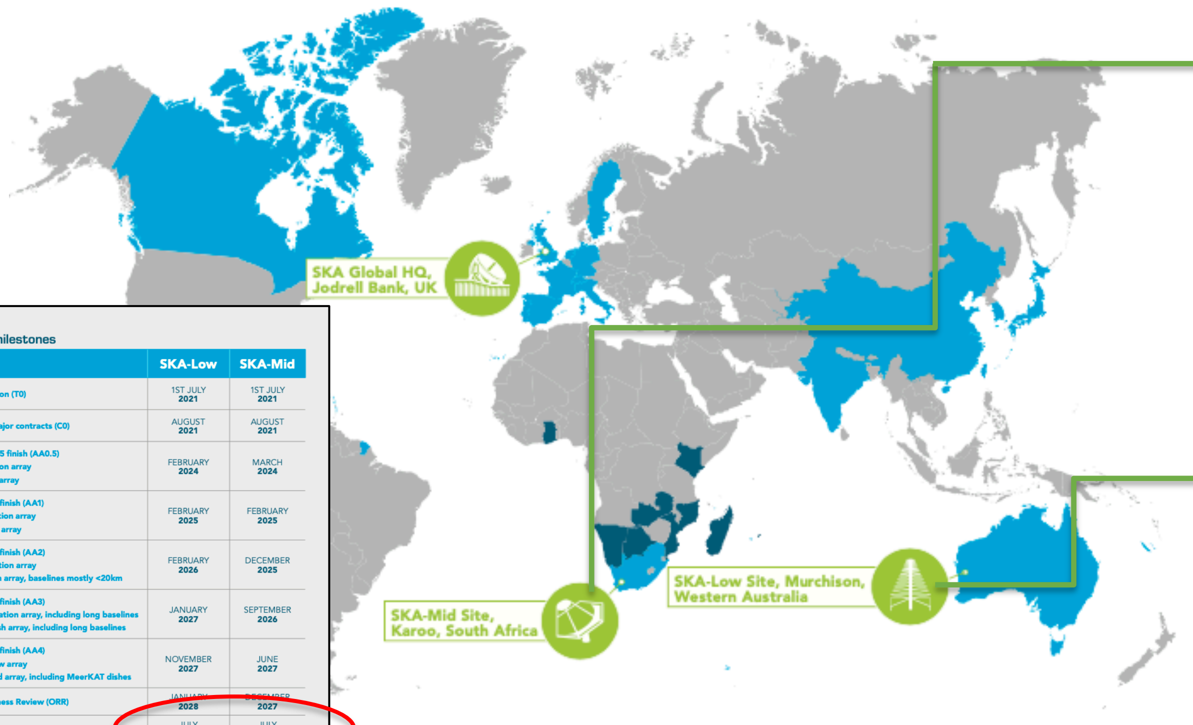
2) SRC (SKA Regional Centers): Andrea Possenti

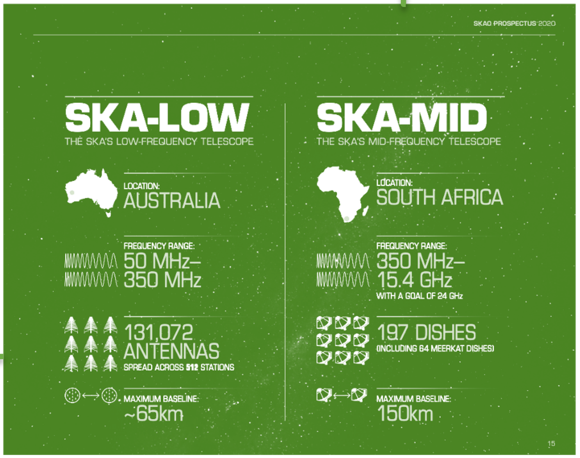
3) SKA-OMC : Mauro Dolci
   see also scheda MeerKAT+ for evolution of LMC-Dish: Corrado Trigilio

4) AIP-PAF: Alessandro Navarrini

5) SKA-LFAA: Jader Monari

The SKA Observatory in a nutshell





Key project milestones

	SKA-Low	SKA-Mid
Start of construction (T0)	1ST JULY 2021	1ST JULY 2021
Earliest start of major contracts (C0)	AUGUST 2021	AUGUST 2021
Array Assembly 0.5 finish (AA0.5) SKA-Low = 6-station array SKA-Mid = 4-dish array	FEBRUARY 2024	MARCH 2024
Array Assembly 1 finish (AA1) SKA-Low = 18-station array SKA-Mid = 8-dish array	FEBRUARY 2025	FEBRUARY 2025
Array Assembly 2 finish (AA2) SKA-Low = 64-station array SKA-Mid = 64-dish array, baselines mostly <20km	FEBRUARY 2026	DECEMBER 2025
Array Assembly 3 finish (AA3) SKA-Low = 256-station array, including long baselines SKA-Mid = 133-dish array, including long baselines	JANUARY 2027	SEPTEMBER 2026
Array Assembly 4 finish (AA4) SKA-Low = full Low array SKA-Mid = full Mid array, including MeerKAT dishes	NOVEMBER 2027	JUNE 2027
Operations Readiness Review (ORR)	JANUARY 2028	DECEMBER 2027
End of construction	JULY 2029	JULY 2029

SKA Partners– includes current Members of the SKA Organisation and current SKAO Member States* and Observers (as of February 2021)

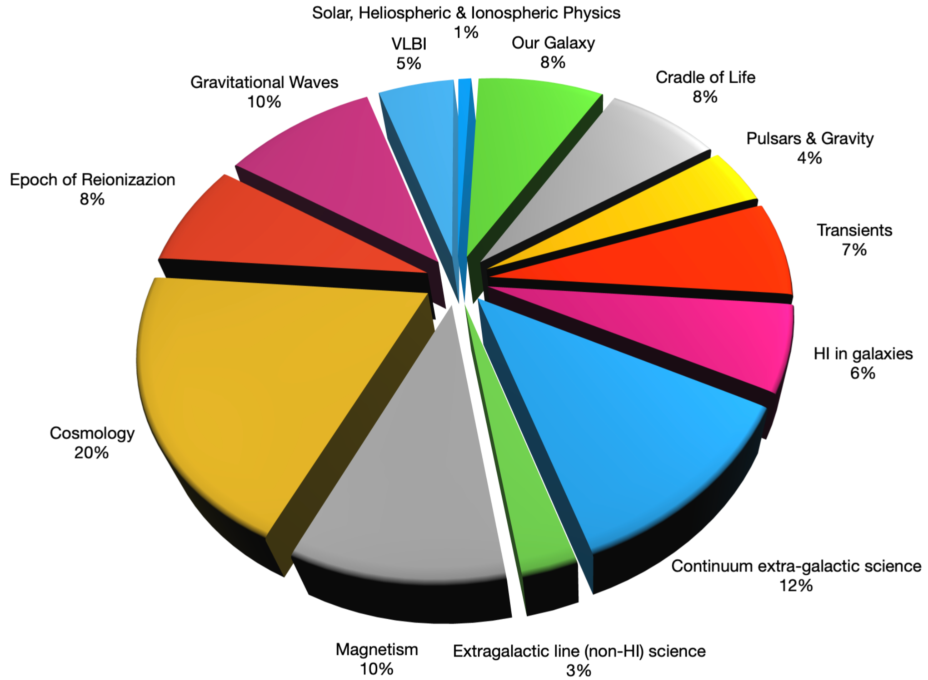
African Partner Countries

IGO current members: UK, RSA, Aus, ITA, NL, Portugal, China, France

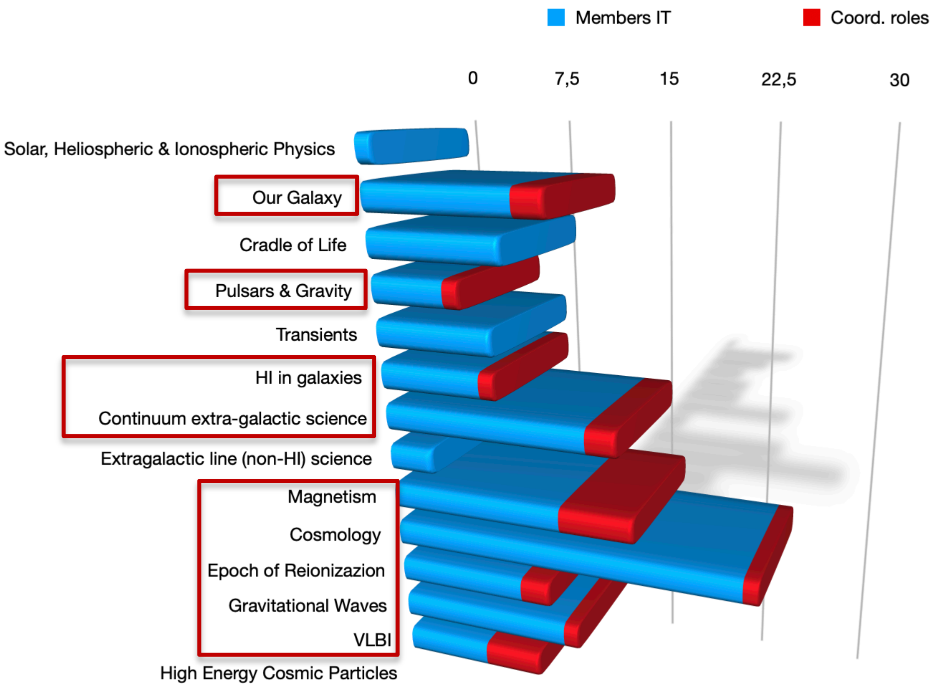
Italian Contribution: Science

Goal: maximal scientific return in the exploitation of SKA

- 14 SKA Science Working Groups: **93 IT Members** (9%) in 13 SWG - **6 Chairs - 19 IT with Coordination Roles in 9 SWG** – 15 INAF structures + 14 IT Universities (overall 7 FTE/yr 2021-2023)



Italian SWG Membership



SKA-related science projects:
See schede with *SKA_Science* acronym in field 13

SKA-Italy: Organization

INAF
Scientific Director
F. Zerbi

Project Management
and System Engineering
[Ground-based]
D. Fierro

Radio Astronomy
Division
F.Govoni

Advisors

I.Prandoni

SKA

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

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

SKA Italy Board
Chair I. Prandoni
Deputy-Chair D. Fierro

+ 12 members:

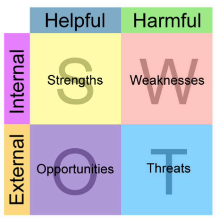
G. Bernardi	M. Dolci	R. Smareglia
G. Brunetti	J.Monari	C. Trigilio
R. Cassano	A. Navarrini	G. Umana
G. Comoretto	A. Possenti	T. Venturi

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

SKA-Italy: Roadmap

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

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



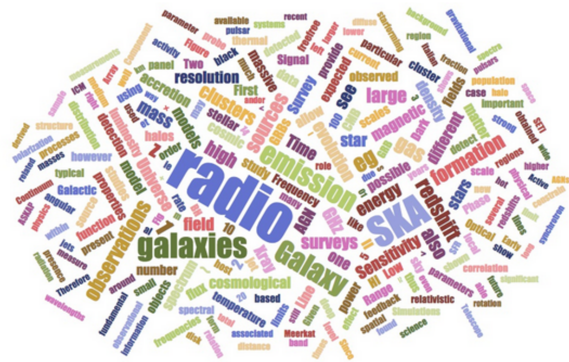
Recommend coordinated actions:

- ➢ **Get** prepared for SKA scientific **exploitation / maximise leading roles in future SKA KSPs**

<u>Actions based on Roadmap recommendations:</u>

- ➢ >2019 - Development of Italian SKA Regional Center (coord. by UTG-II HPC/Data Advisor)
  [opportunity: develop in house data handling/analysis expertise]
- ➢ >2020 - INAF involved in MeerKAT+ (coord. by UTG-II SKA-MID precursors Advisor)
  [weakness: facilitate access to SKA-MID precursors]
- ➢ >2021 - National Postdocs dedicated to SKA
  [build SKA generation]

An Italian Roadmap towards the SKA



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. Trigilio, G. Umana, T. Venturi

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

Release 1.0 - September 13th, 2019

SKA-Italy: budget & science support

- Funds (<2020): 22 Meu
  - SKA-MIUR / Astronomia Industriale SKA/CTA
  - IT share of SKA Org. + technology + PRIN SKA/CTA 2016
- Funds >2020:
  - IT share of IGO: 120 Meu
    - ➢ SKA construction & running costs
  - DM450 (SKA/CTA)
    - ➢ support SKA-related activities, <u>incl. Italian SRC and science</u>

<u>Work in progress:</u> Development of Scientific Roadmap

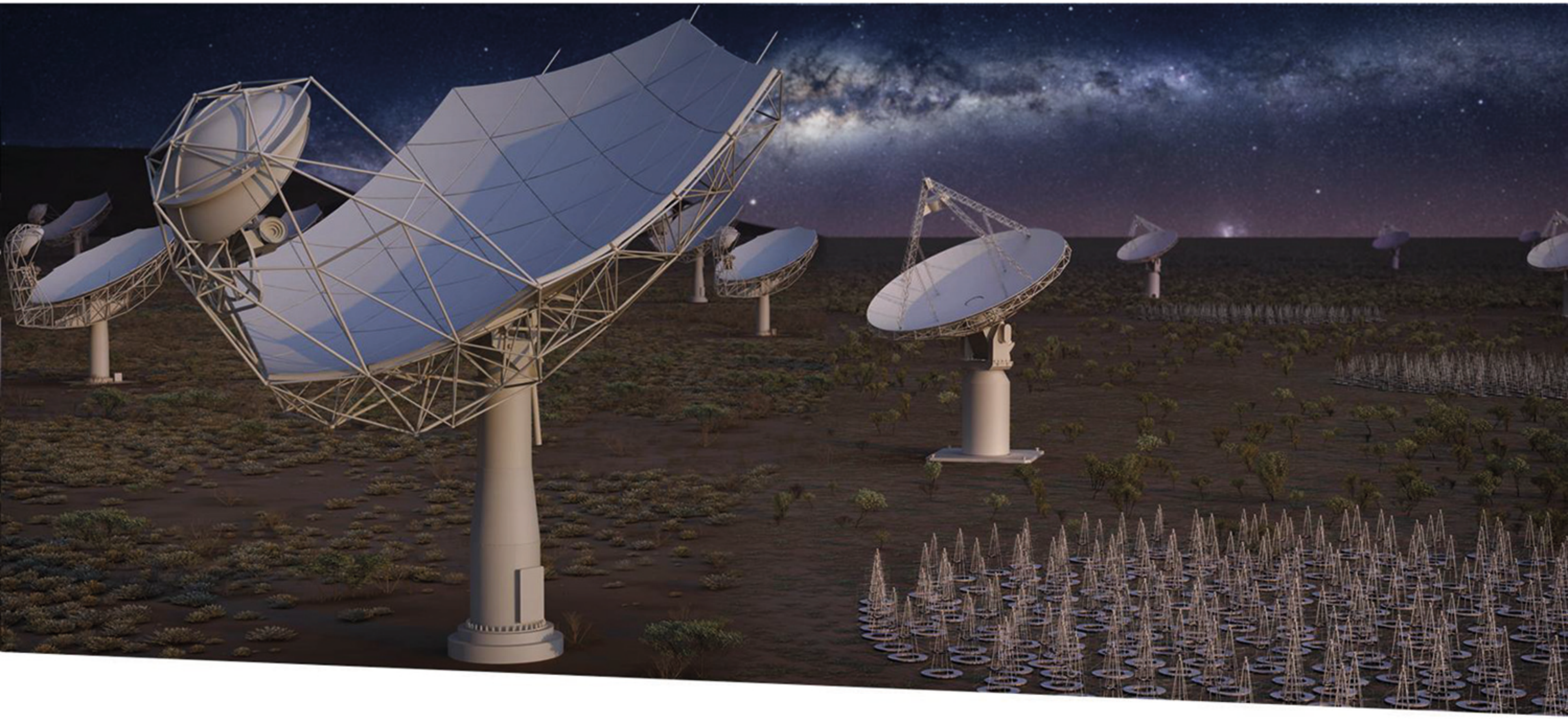
- ❖ regular funding over the next >10 years
- ❖ of the order of ≳10-15% of IGO IT share

SKA in numbers

€1.282 BILLION
CONSTRUCTION COST (2020 €)

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

SKA REGIONAL CENTER (SRC)



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Andrea Possenti

The scope of the SRC network

July 2016: the SKA Board deliberated:

"The SKA Observatory will coordinate a network of SKA Regional Centres that will provide the data access, data analysis, data archive and user support interfaces with the user community"

November 2018: the SKA Board deliberated:

"The mission of the SRC Steering Committee (SRC-SC) is to define and create a long-term operational partnership between the SKA Observatory and an ensemble of independently-resourced SKA Regional Centres.

The SRC-SC will be superseded in due course by the operational partnership that is formed as a result of its work"

The SRC working groups

	INAF member(s)
WG0: SRC Network Architecture	
WG1: Data Logistics Working Group	Matteo Stagni
WG2: Operations Working Group	Matteo Canzarii, Matteo Di Carlo, Isabella Prandoni, Riccardo Smareglia
WG3: SW Federated Computing and Data Software Services	Giuliano Taffoni, Alessandro Costa, Fabio Vitello, Eva Sciacca, Cristina Knapic
WG4: SW, Science Archive-VO-FAIR	Vincenzo Galluzzi, Alessandra Zanichelli, Cristina Knapic, Marco Molinaro, Franco Tinarelli
WG5: Compute Working Group	Ugo Becciani, Riccardo Smareglia
WG6: Science User Engagement — Co-chair: Andrea Possenti	Isabella Prandoni, Claudio Gheller, Carlo Baffa,Gianni Comoretto Claudio Codella, Marcella Massardi, Simone Riggi, Mauro Dolci, Paolo Serra

Instrument	Some key software activities developed within INAF
LOFAR	Data working group, Pipelines, Computing Code optimization & profiling, Porting on exascale machines
ASKAP	Caesar: source extraction & parametrization Algorithms to destripe single-dish images Source extraction from combined IR + Radio
MeerKAT	HI/continuum data analysis for inteferometric data Pulsar pipelines and schedule optimization
uGMRT	Optimization of existing pipelines
eMERLIN	Optimization of existing pipelines – combination with JVLA
JVLA	Optimization of existing pipelines
Other projects	VisiVo: big astronomical data 3D visualization Distributed data and computer center for SKA

INAF leadership

Involvement of INAF scientists

Fundamental role in order to develop requests and imagine solutions to the USE CASES for the SRCs

+

ANTICIPATE other foreign astro-scientists in ADAPTING to the new way for doing data reduction and computation in the SKA era

Total involvement:
2.6 FTE/yr for next 3 yrs

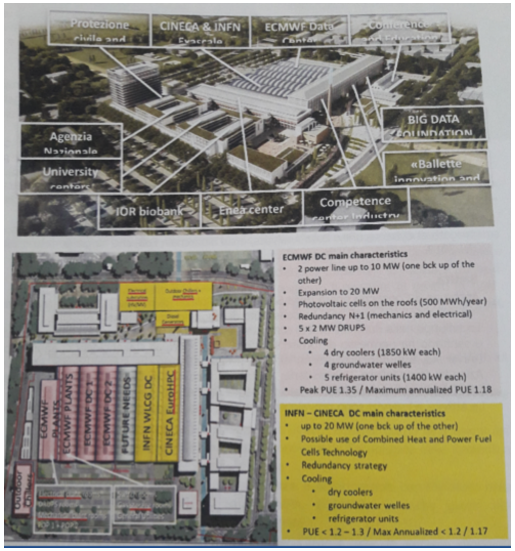
INAF expected outcomes

1. The identification of a kernel of "modi operandi" in the interactions among the various actors to secure an efficient and always developable science-needs driven system

2. The possibility for the regional communities to obtain access to the system (and keep a role of management/development of that) <u>at the minimum</u> in proportion to the local investments

3. The establishment of a SRC network with a significant pole located in Italy

Tecnopolo in Bologna will host:
- Leonardo 270 PFlops
- ECMWF
- INFN
- CINECA



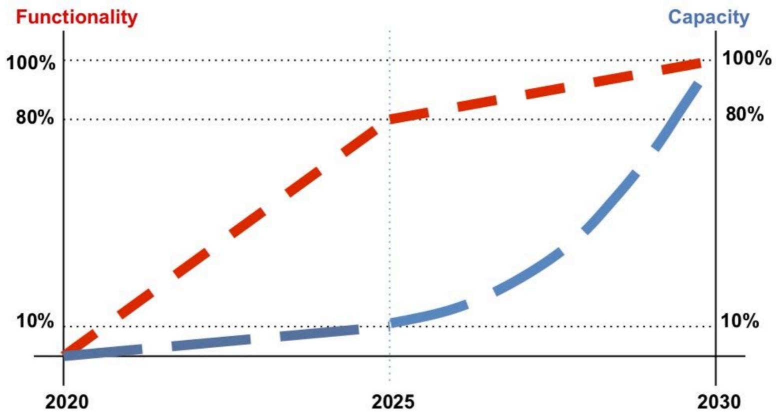
Needs for the whole network

At regime

Data Flow PB/yr	Processing PFlop/s	Network mean speed Gb/s
710	22	100

Data (M€/yr)	Processing (M€/yr)	Network (M€/yr)	Personnel (M€/yr)
18	2.4	5	10

Ramp up



Needs for the INAF pole

Keeping 6% level → 12 M€ over 2021/2030

Aimed 10% level → **20 M€ over 2021/2030**

Basically 0 € until 2020

for a linear growth → 0.43 M€ during 2021

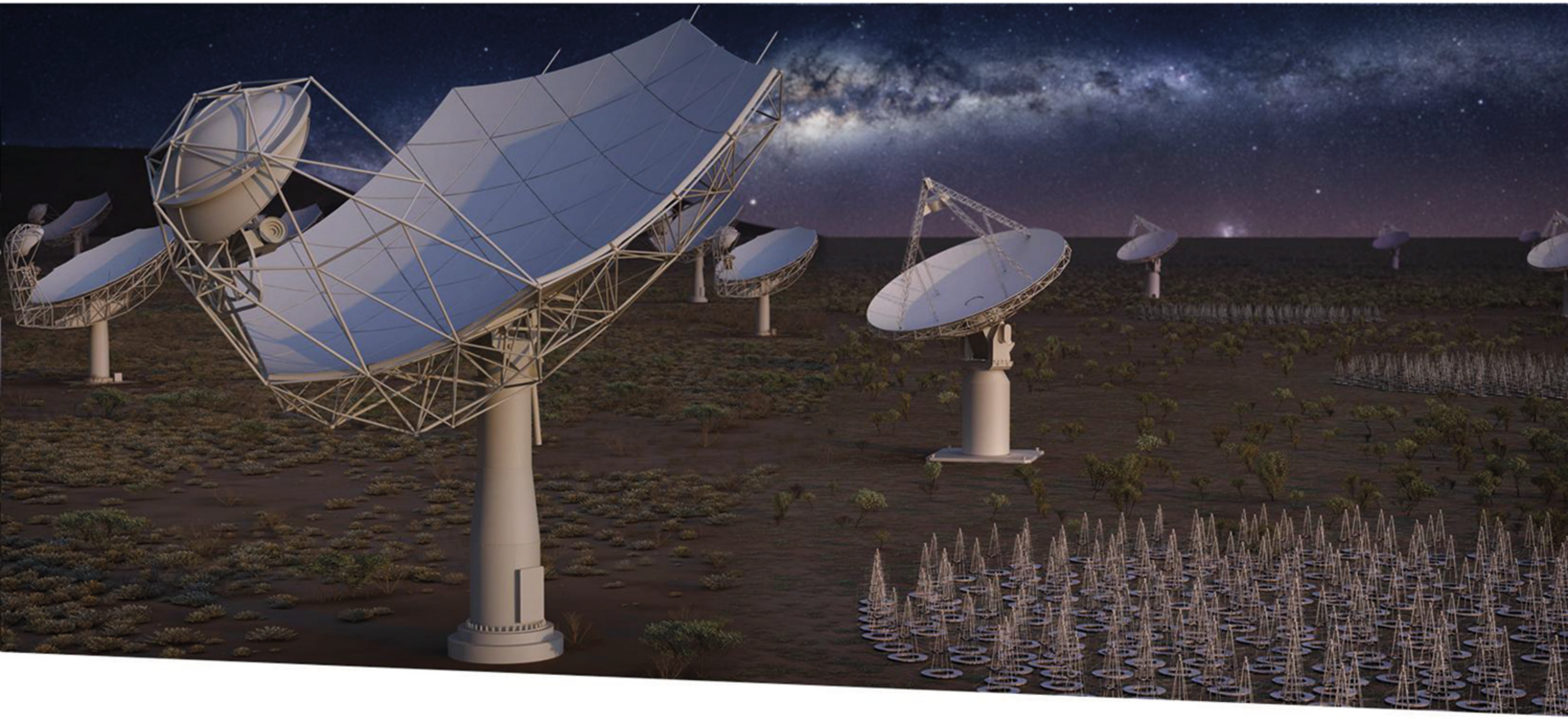
Personnel → **10-15 FTE/yr** to keep a leading role and support an INAF SRC pole

Required skills: in-depth understanding of the data acquisition systems at the 2 SKAO sites, management and development of the complex systems that will oversee the analysis of SKAO data and their archiving, the development of software for the various scientific cases, as well as interaction with national users in the preparation and management of SKA observation programs.

Not easy to find and enrol this kind of personnel

SKA_OMC

The INAF contribution to the SKA1 Observation Management and Control software development

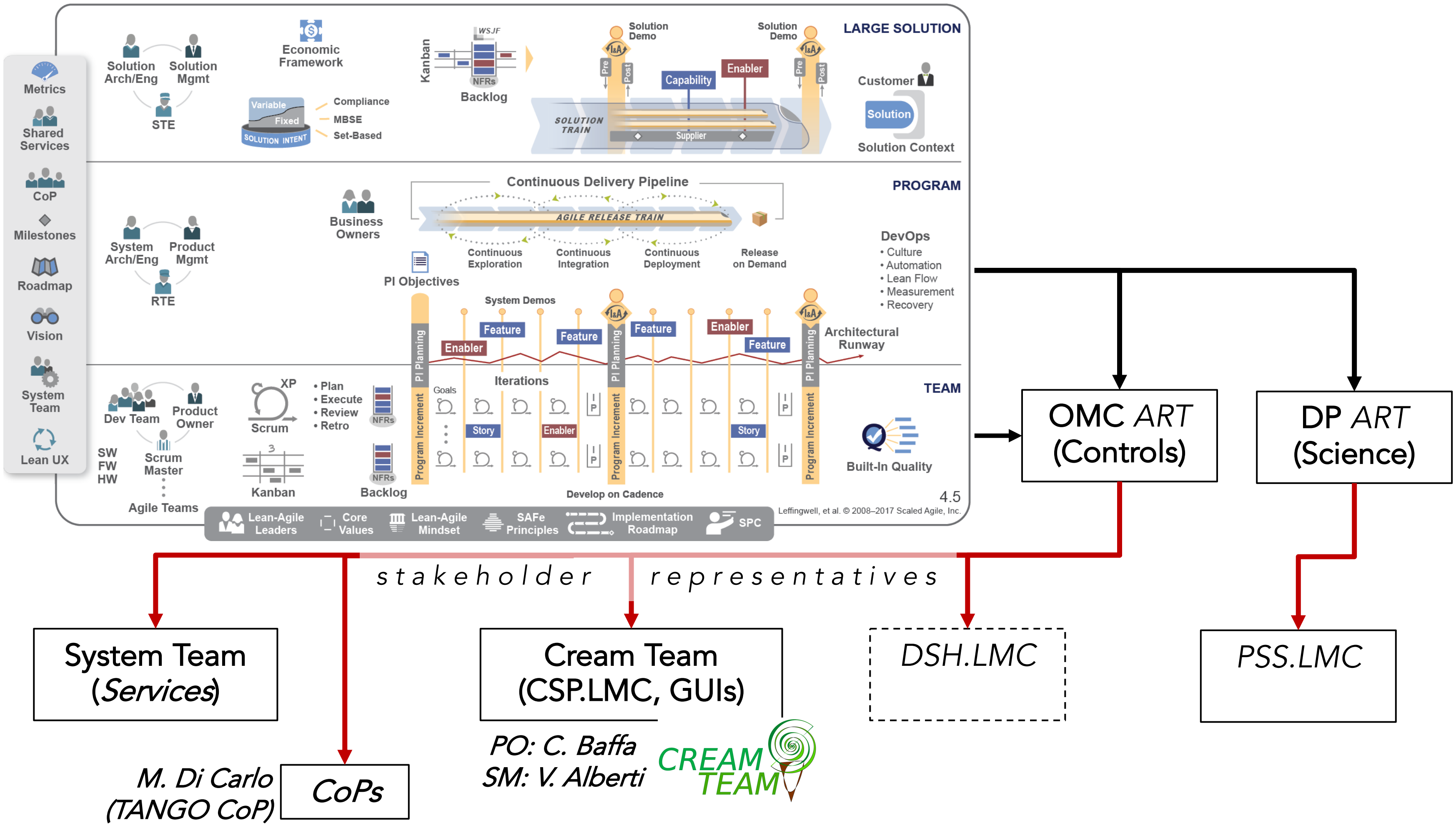


SQUARE KILOMETRE ARRAY

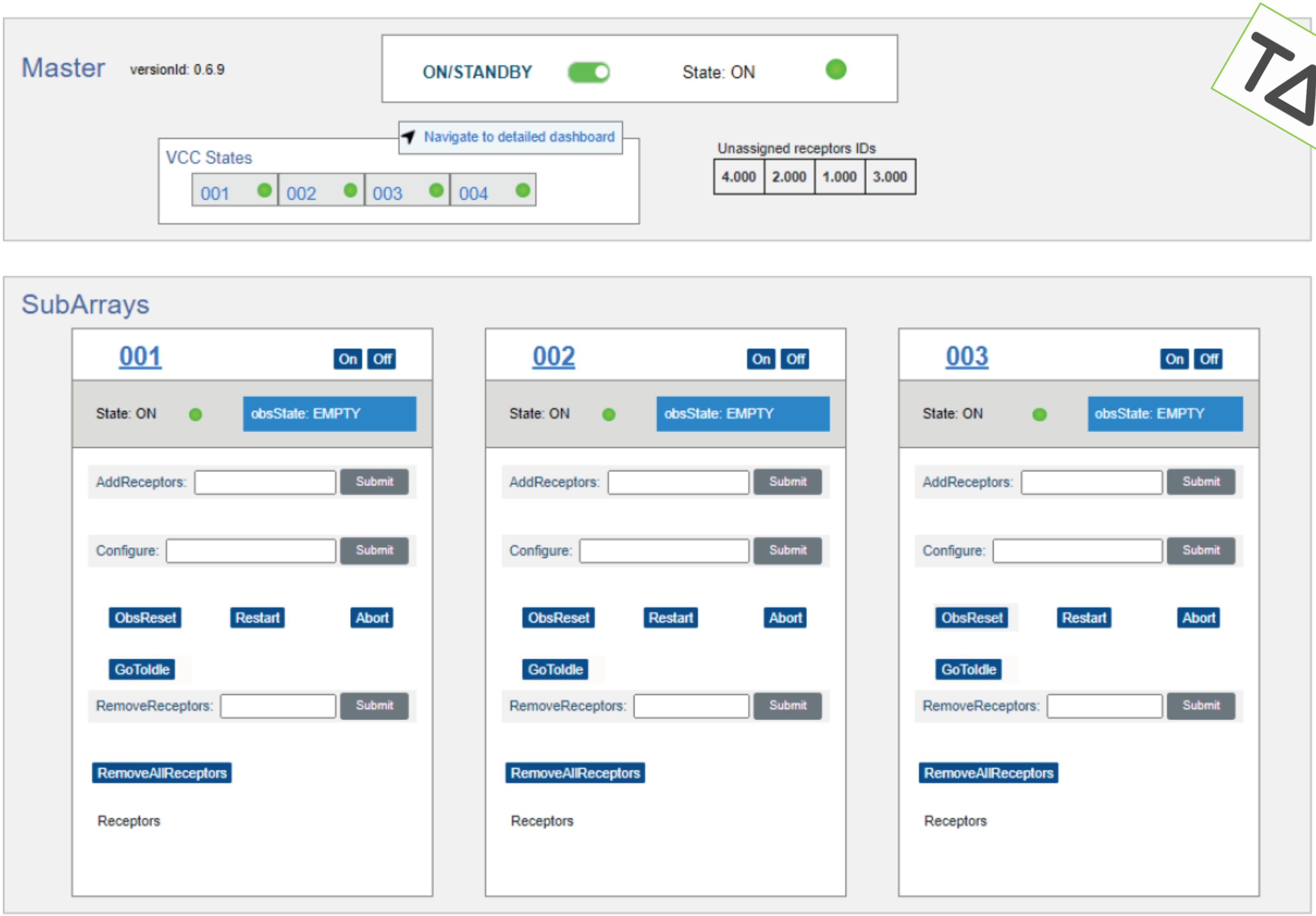
Exploring the Universe with the world's largest radio telescope

M. Dolci on behalf of the OMC team

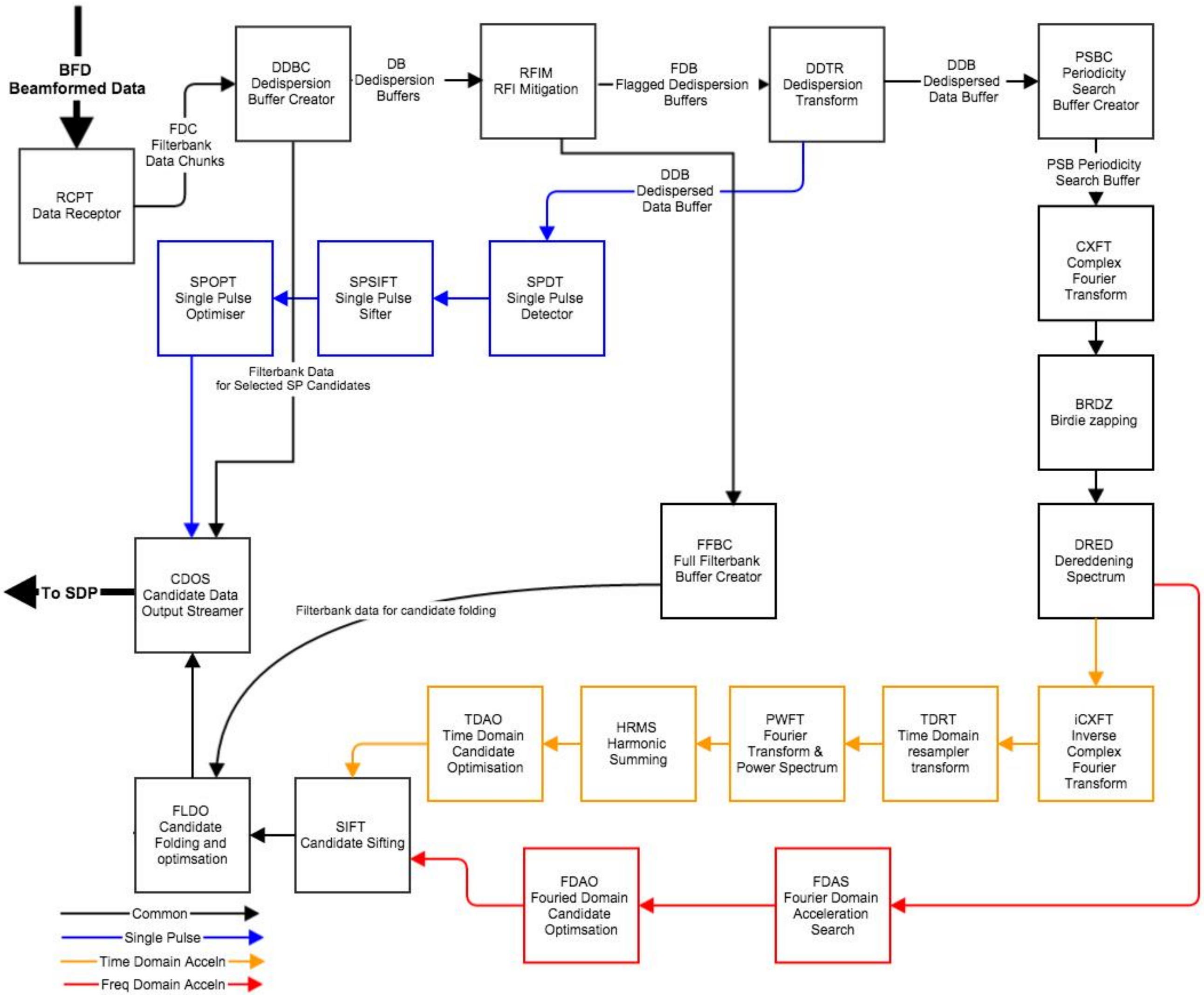
Work Organization – SAFe



UI dashboard example: *Subarrays Config*



SKA1 PSS pipeline



Products – A selection

CI/CD practices with the TANGO-controls framework in the context of the Square Kilometre Array (SKA) telescope project

Di Carlo M.[a], Yilmaz U.[b], Harding P.[b], Bartolini M.[b], Le Roux G.[c], and Dolci M.[a]

[a]INAF Osservatorio Astronomico d'Abruzzo, Teramo, Italy
[b]SKA Organisation, Macclesfield, UK
[c]SKA South Africa, SA

ABSTRACT

The Square Kilometre Array (SKA) project is an international effort to build two rad
Africa and Australia to form one Observatory monitored and controlled from the

SKA Pulsar Search: Technological Challenges and Best Algorithms Development

C. Baffa[b] on behalf of the SKA-TDT-Group[a]

[a]SKA Time Domain Team, SKAO, Jodrell Bank Observatory, Manchester, UK [b]INAF Osservatorio di Arcetri, Largo E.Fermi 5, Firenze, Italy;

ABSTRACT

A radio telescope is a large survey for pulsars both in isolated and
r search engine is expected to reach 0.6TeraSamples/sec. For the
hese streams, we need a complex search strategy which allows us

Satisfying wishes for SKA engineers: how Taranta Suite meets users' needs

Matteo Canzari[a], Valentina Alberti[b], Hélder Ribeiro[c], Ajaykumar Dubey[d], and Vincent Hardion[e]

[a]INAF, Osservatorio Astronomico d'Abruzzo, Teramo, Italy
[b]INAF - OATs, Trieste, Italy
[c]FCUP - Centro de Investigação em Ciências Geo-Espaciais (CICGE), Portugal
[d]Persistem System, Pune, India
[e]MaxIV Institute, Lund, Sweden

ABSTRACT

SKA Construction phase we are now in a transition phase that hopefully will prepare us for the next challenge: start building the SKA. One of the targets of this period is to evaluate the suitability of the Taranta (proper Webjive) Suite for creating engineering User Interfaces (UIs). The Taranta suite is a framework that allows the

OMC – Budget and Critical Issues

Effort from INAF:

- Planned 2021-2028 = 35 fte
- Consolidated 2021-2023 = 12.5 fte

Construction budget allocated to INAF (2021-2028): 3.9 M€

Criticalities:

- Some competencies still needed:

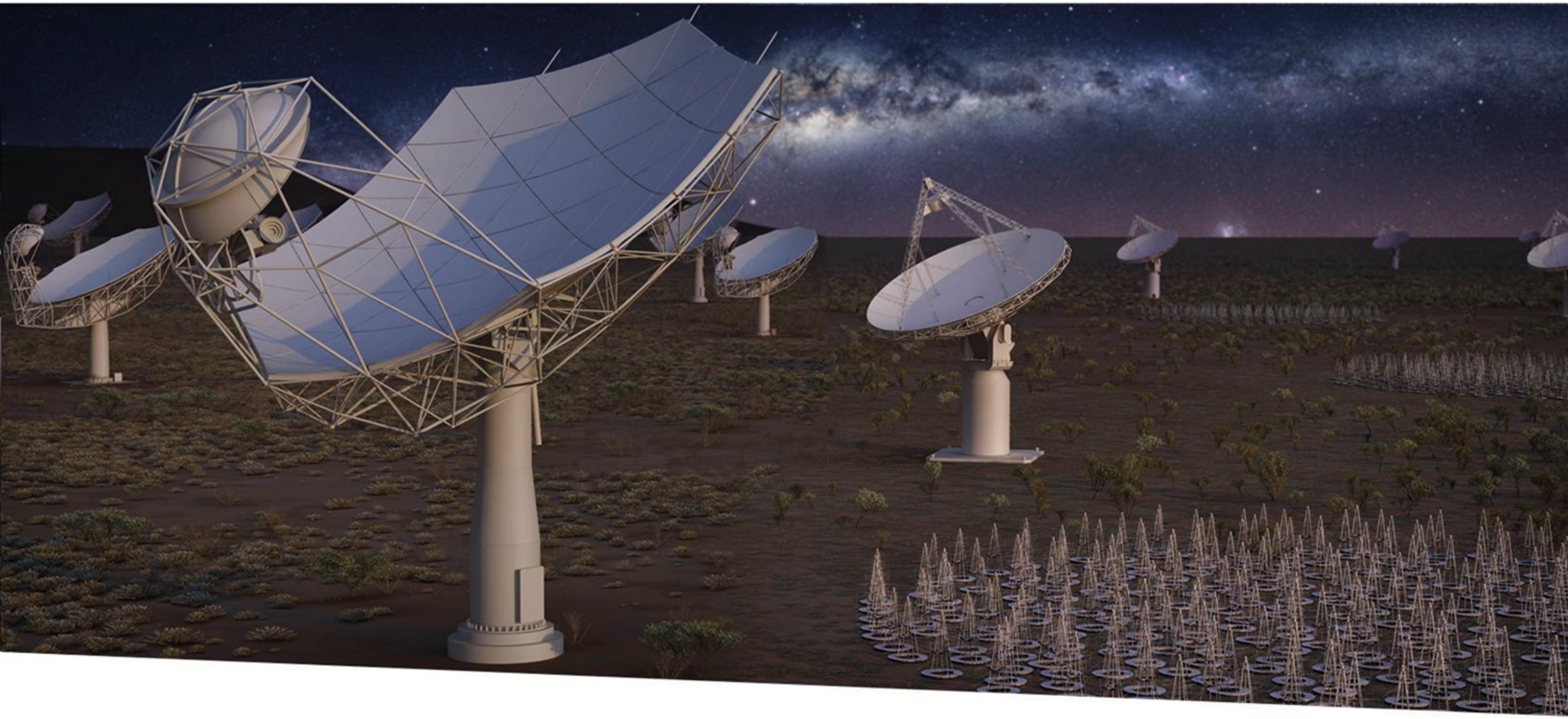
a) a deeper knowledge of virtualization tools (e.g. Docker, Kubernetes)
b) some aspects of advanced software architectural concepts and tools
c) advanced large projects management skills.

- Manpower:

a) team currently at its minimum size
b) strong need of clever young people to support the overall development
c) need to have a stable recruitment path for the people structural to this development.

SKA_PAF

The INAF contribution to the SKA Advanced Instrumentation Programme on Phased Array Feeds (PAF)



SQUARE KILOMETRE ARRAY

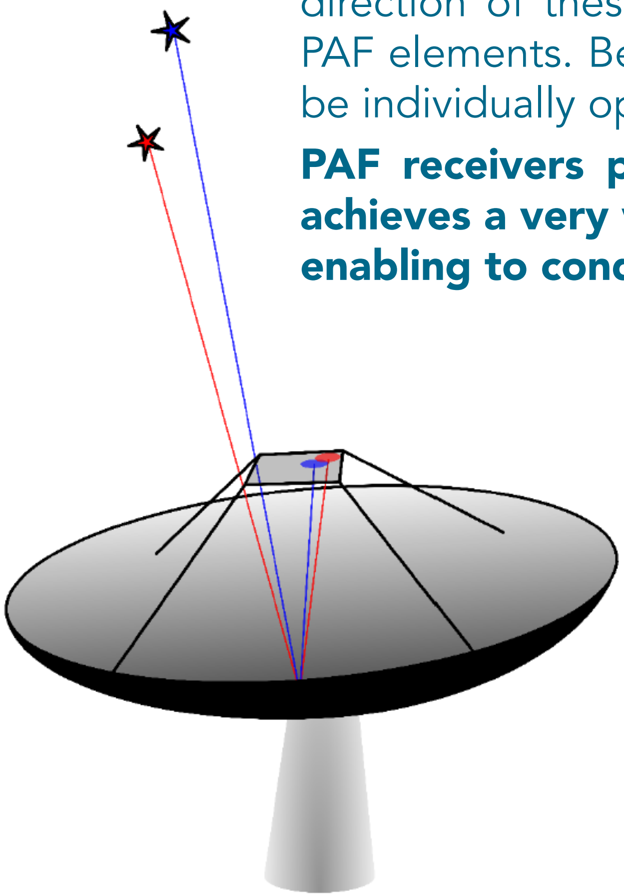
Exploring the Universe with the world's largest radio telescope

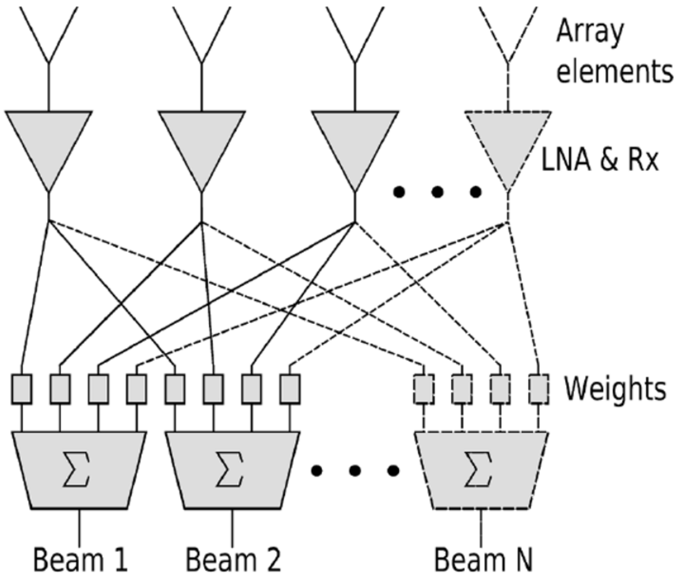
A. Navarrini on behalf of the INAF PAF team

Phased Array Feed

A PAF receiver is a dense array of antenna elements placed at the focus of a reflector telescope. Each element samples the energy on the focal plane. The output of these elements are combined to form multiple beams on the sky. The direction of these beams is controlled by varying the "weights" of individual PAF elements. Beamshapes and directions are electronically controlled and can be individually optimized over a large frequency band.

PAF receivers provide a wideband multi-pixel "camera" on the sky that achieves a very wide Field-of-View (FoV) with high mapping efficiency, thus enabling to conduct high-sensitivity large-scale radio surveys.

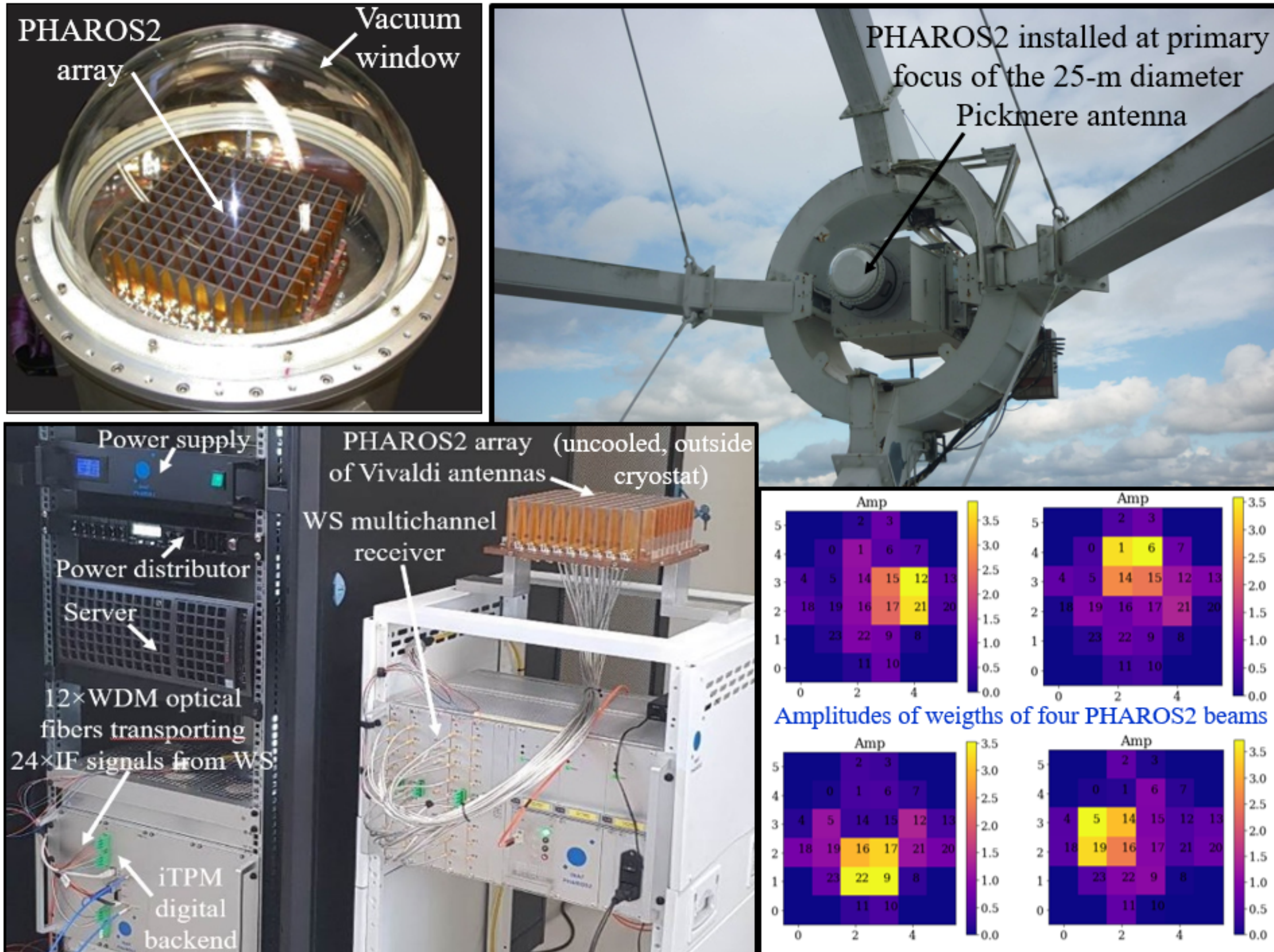




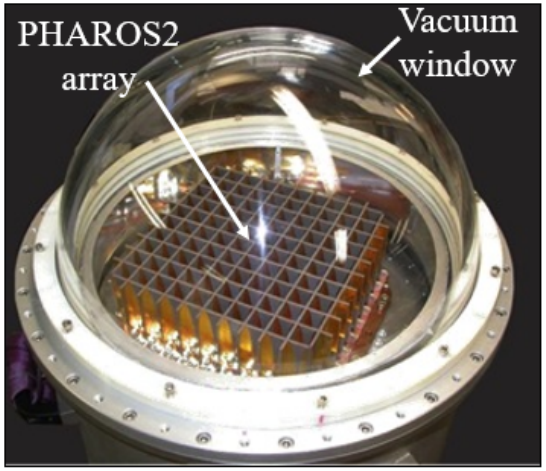
PAF Advanced Instrumentation Programme (AIP)

- PAF technology is not part of SKA1. The SKA Observatory includes a SKA Observatory Development Programme (SODP) of telescope development towards SKA2 for enhancements/extensions of SKA1;
- SKA1-Mid antennas have been designed to incorporate PAF receivers in the future. PAF technology might find application in SKA-Mid;
- The SKA AIP on PAF was established in 2016. Nine international institutions are part of the PAF Consortium, including INAF;
- The SKA AIP on PAF is currently funded by in-kind contributions of the member institutes that are focussed on their own PAF R&D programs – with no real focus on SKA PAFs yet;
- PHAROS2 is a PAF developed by the collaboration of five Institutions as part of the SKA AIP on PAFs:

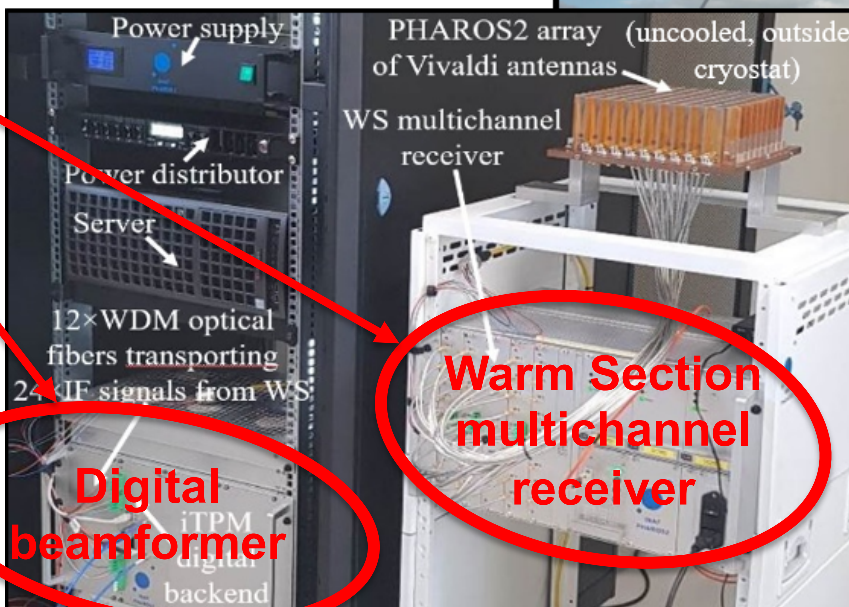
PHAROS2: cryogenic 4-8 GHz PAF with digital beamformer was developed and tested on telescope

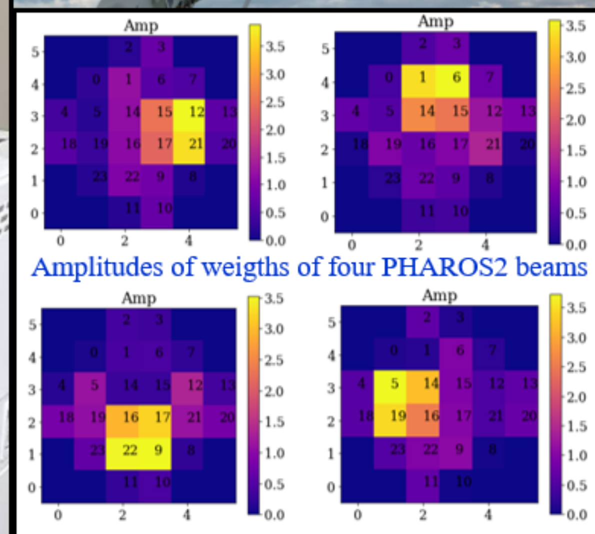


PHAROS2: cryogenic 4-8 GHz PAF with digital beamformer was developed and tested on telescope



INAF leadership





Amplitudes of weigths of four PHAROS2 beams

INAF PAF technical team

Current and future, period 2021-2023: 11 people from 2 observatories, 4.05 FTEs (average 1.35 FTE/year for the next three years):

Person	INAF Observ.	Role in the project
A. Navarrini	OA Cagliari	Coordinator of PAF activities and system design
P. Ortu	OA Cagliari	Monitor and control and bias electronics
P. Marongiu	OA Cagliari	Mechanical system and cryostat
T. Pisanu	OA Cagliari	Electromagnetic simulations and beam-pattern tests
A. Ladu	OA Cagliari	Design and characterization of RF module
A. Melis	OA Cagliari	Development of digital beamformer
R. Concu	OA Cagliari	Development of digital beamformer
L. Schirru	OA Cagliari	Electromagnetic simulations, beam-pattern tests
R. Nesti	OA Arcetri	Electromagnetic design and antenna coupling
G. Comoretto	OA Arcetri	Development of digital beamformer
Digital engineer (AdR being hired)	OA Arcetri	Development of digital beamformer/RFSoC

In the period 2017-2019, the INAF PAF team included personnel from IRA and OA Catania

Total envelope of INAF PAF personnel from 2017 to 2023: 27 people, 13.90 FTEs

INAF PAF funds

From "Astronomia industriale 2017 (SKA e CTA)" and "Fondo Pluriennale SKA-CTA 2019" :

Year	Beneficiary	Funds [k€]
2017	INAF-OA Cagliari	75
2018	INAF-OA Cagliari	75
2019	INAF-OA Cagliari	75
2020-2021	INAF-OA Cagliari	95
	INAF-OA Arcetri	45
Total		**365**

Needed funds for the period 2021-2023:

Estimated 2021	Estimated 2022	Estimated 2023
0 €	**120 k€**	**120 k€**

INAF PAF goals for the period 2021-2023 and beyond

- Develop a demonstrator of a cryogenic PAF with antennas and LNAs integrated in a compact module for extended C-band (3.0-7.7 GHz) based on RFSoC (Radio Frequency System-on-Chip) technology. The instrument will be entirely developed by INAF using state-of-the-art breakthrough technologies.
- Test the demonstrator on a radio astronomy antenna.
- Verify INAF PAF technologies with reduced hardware (a few beams & reduced BW);
- Develop the key technologies, capability and design knowledge for PAF systems enabling to commence a specific SKA PAF design in 2024.

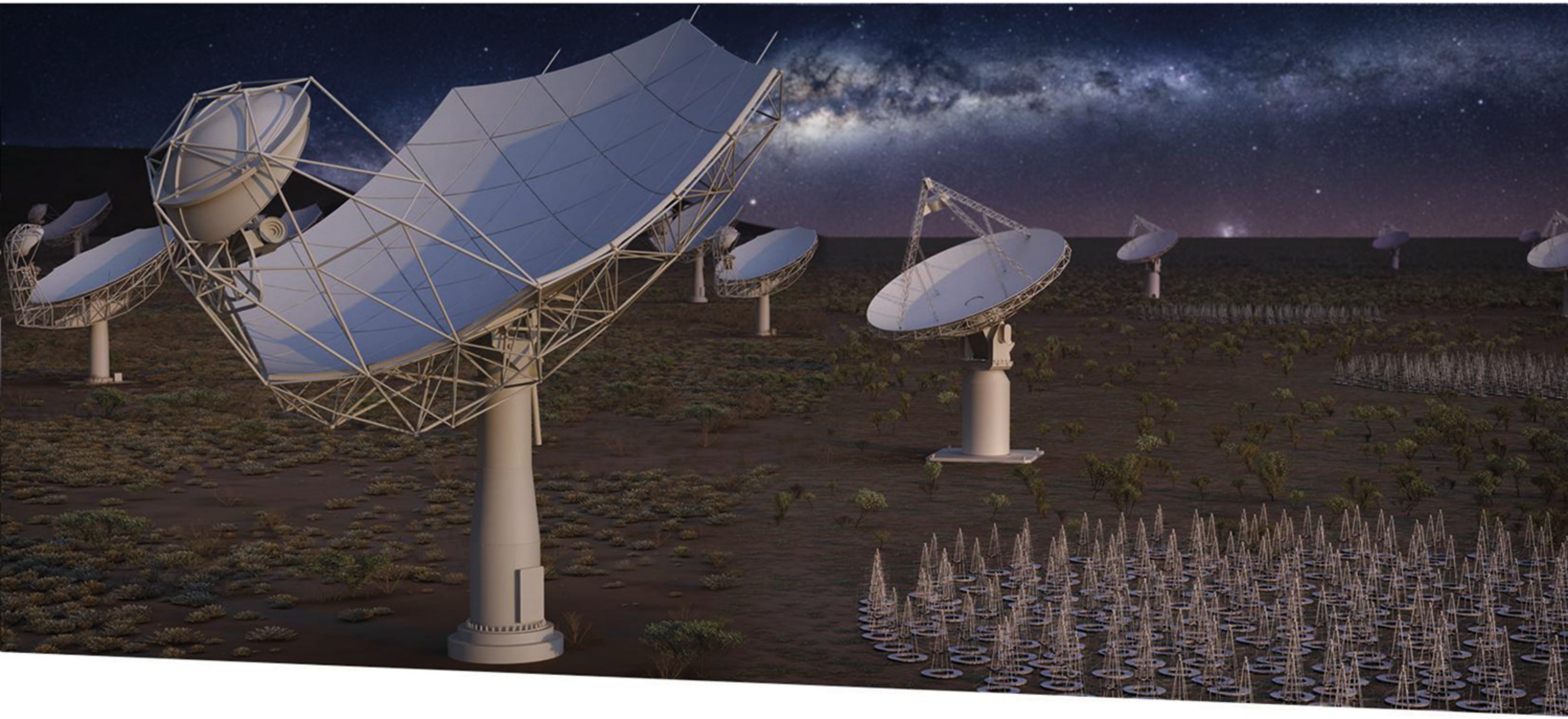
Criticalities

- Need to gain experience on RFSoC technology for future integration with analogue array (commercial RFSoC boards under evaluation not suitable for integration):
  funds for one digital engineer and for hardware to be confirmed for next two years;

SKA-LFAA

INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

SKA
SQUARE KILOMETRE ARRAY
Italy



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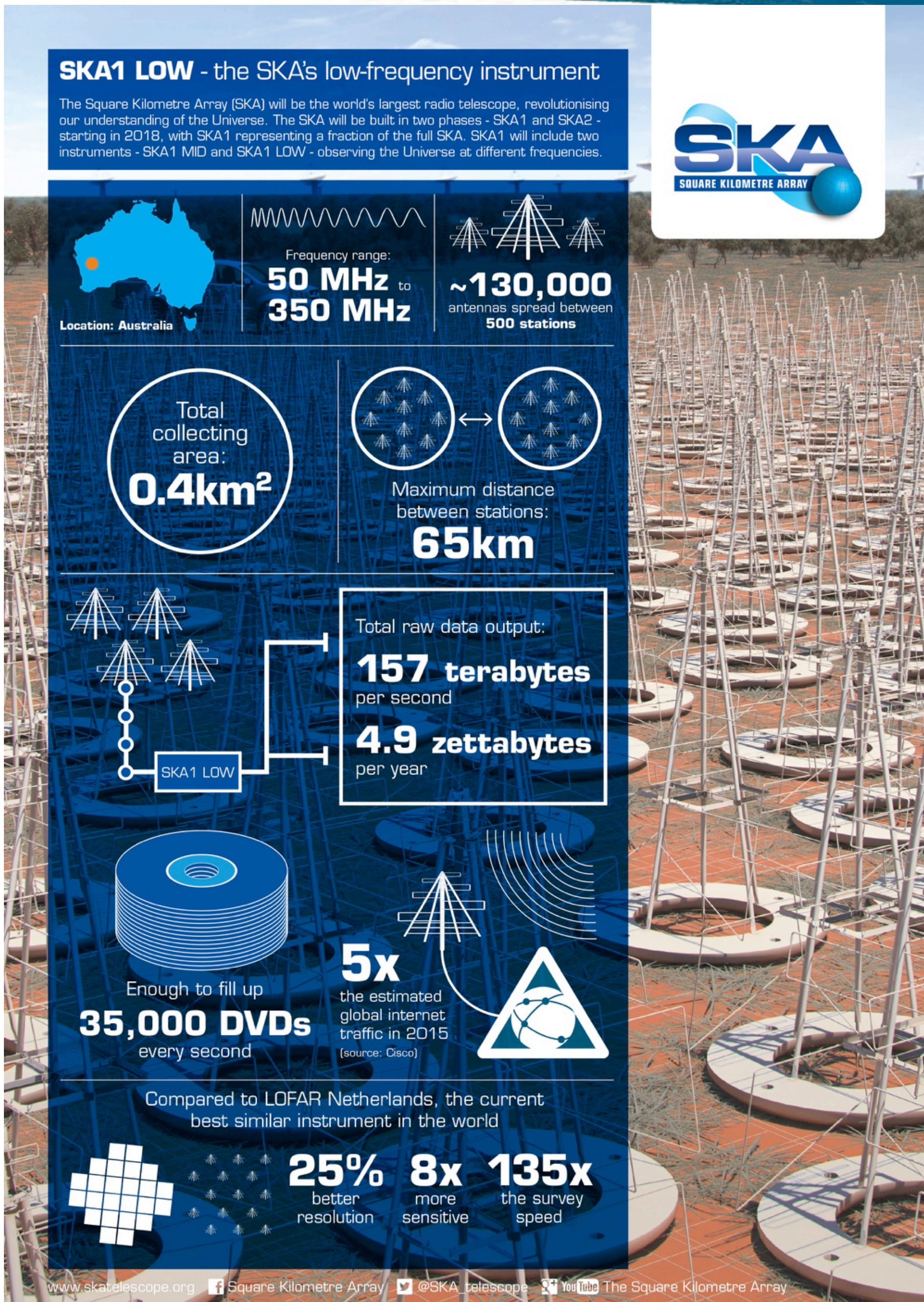
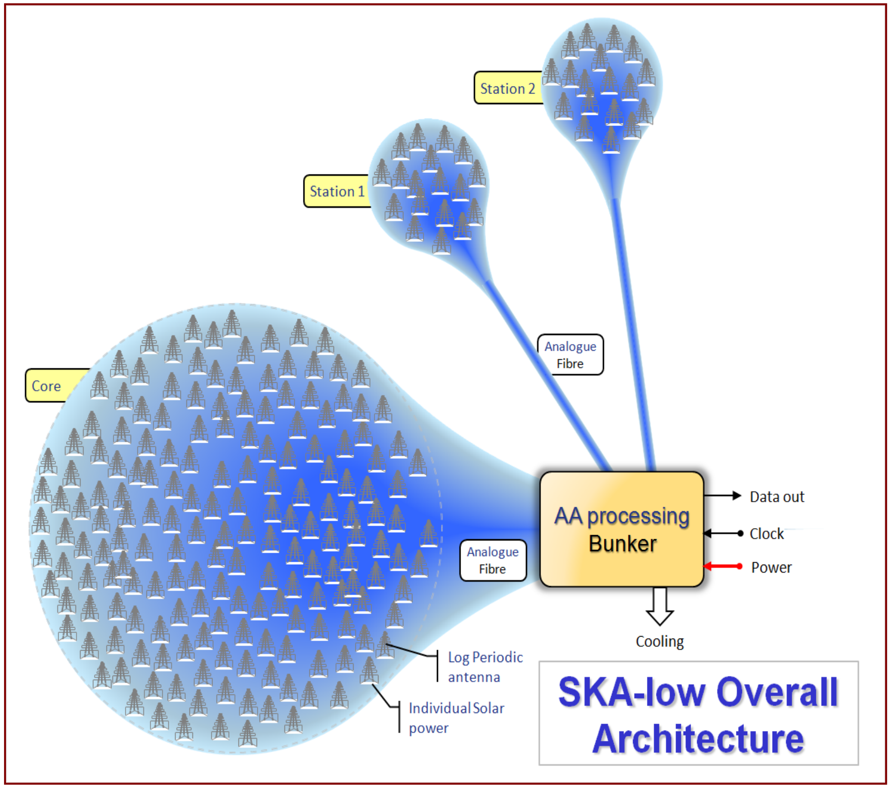
Exploring the Universe with the world's largest radio telescope

Jader Monari

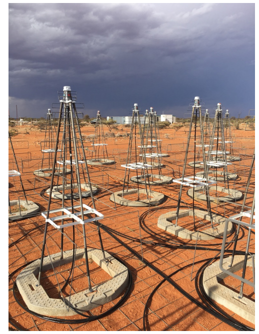
Italian LFAA Program Manager

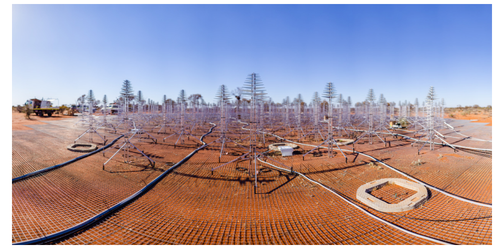




~500 station 30m (256 antennas). Aperture Array Stations 50-350MHz

History of the INAF participation SKA





LFAA CDR

SCDR

PRR

Dawn project	BEST era	Middle age	Renaissance

2002
First SKA meeting

2004
Preparation requests UE – FP6-SKADS

2005–2009
SKADS

2010–2015
AAVP

2015-2018
AADC-RT

2018-2022
Bridging phases
Pre-procurement

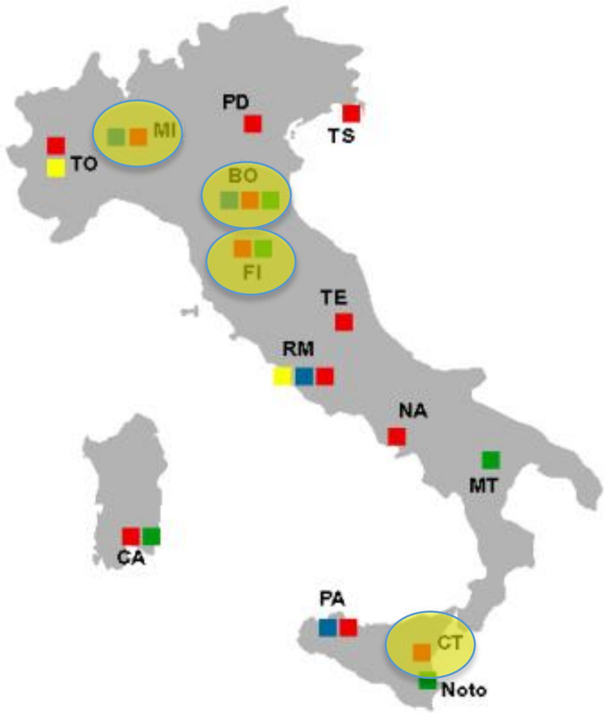
2018-2022
Bridging phases 1-2-3
Pre-procurement

2023-2028
AA0.5-AA3*

INAF - LFAA technical group (internal organigram)

IRA **Jader Monari** PM

- **Pietro Bolli** — Antenna & LNA — OAA
- **Federico Perini** — Receiver — IRA
- **Francesco Schillirò**, **Monica Alderighi** — Acquisition System — OACT, IASF-Mi
- **Gianni Comoretto** — FW beamforming — OAA
- **Marco Schiaffino** — Mechanics — IRA
- **Gianni Bernardi** — Observation — IRA



Research Contracts (2012-2020)

- CNR-IEIIT & POLITO (WP-AL)
- UNIBO (WP-RX)
- UNIFI (WP-AL/RX/SP)

UniBO — Analogue Optical fibre

CNR-IEIIT — Antenna & Calibration

POLITO — Flying measure facility

UniFi — Reliability

Industrial Contracts (2017-2020)

OPTEL OPTOELETTRONICA TELECOMUNICAZIONI

MFC

PROTECH ENGINEERING

FINMECCANICA

DIAMOND the fiber meeting

Sanitas EG DIGITAL SYSTEMS, RESEARCH AND INNOVATION

SIRIO antenne

AAVID THERMAL DIVISION OF BOYD CORPORATION

CAMPERA electronic systems

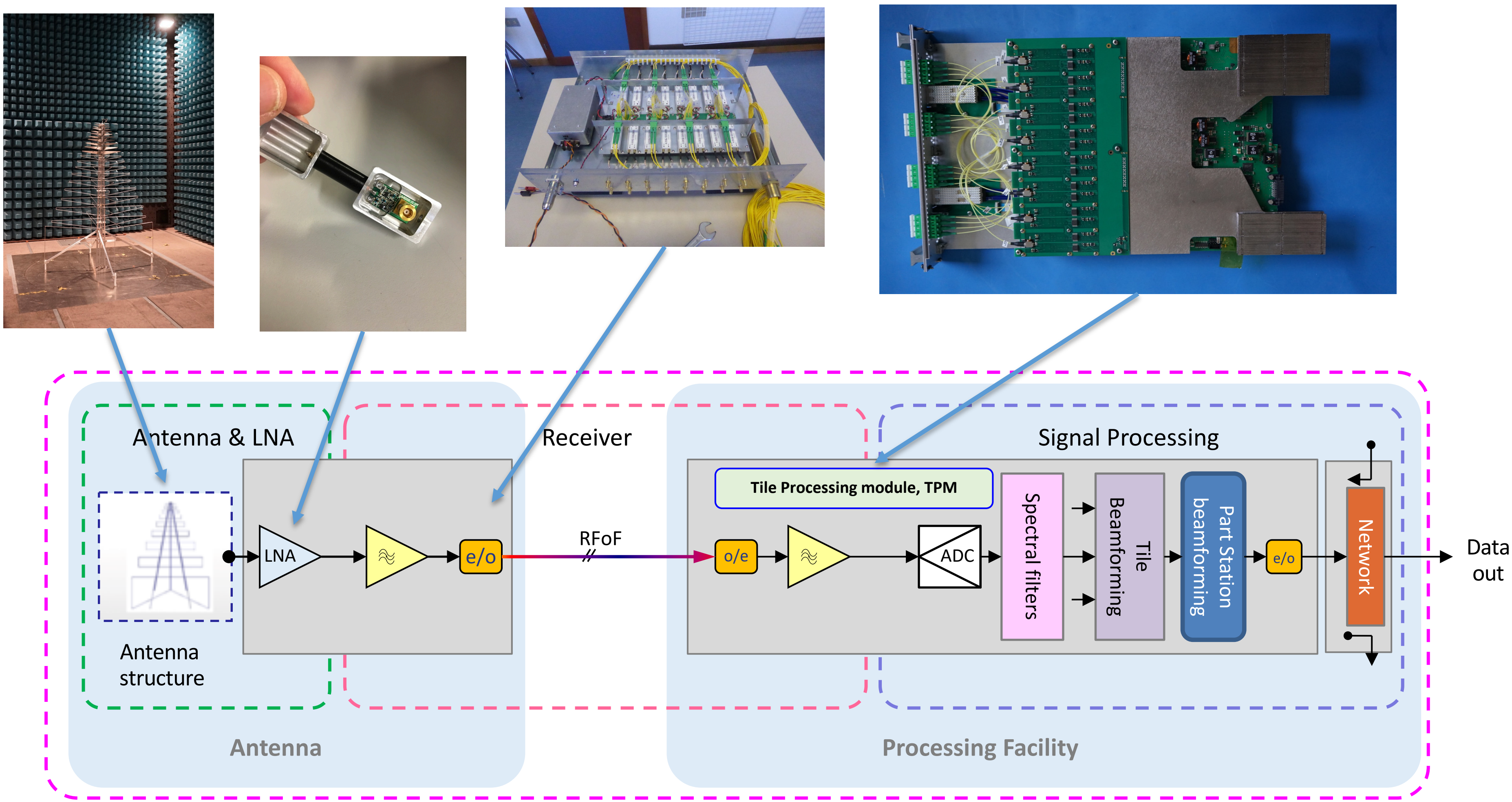
RGM PARTNER OF LEADERS

IDS INGEGNERIA DEI SISTEMI

Italdron

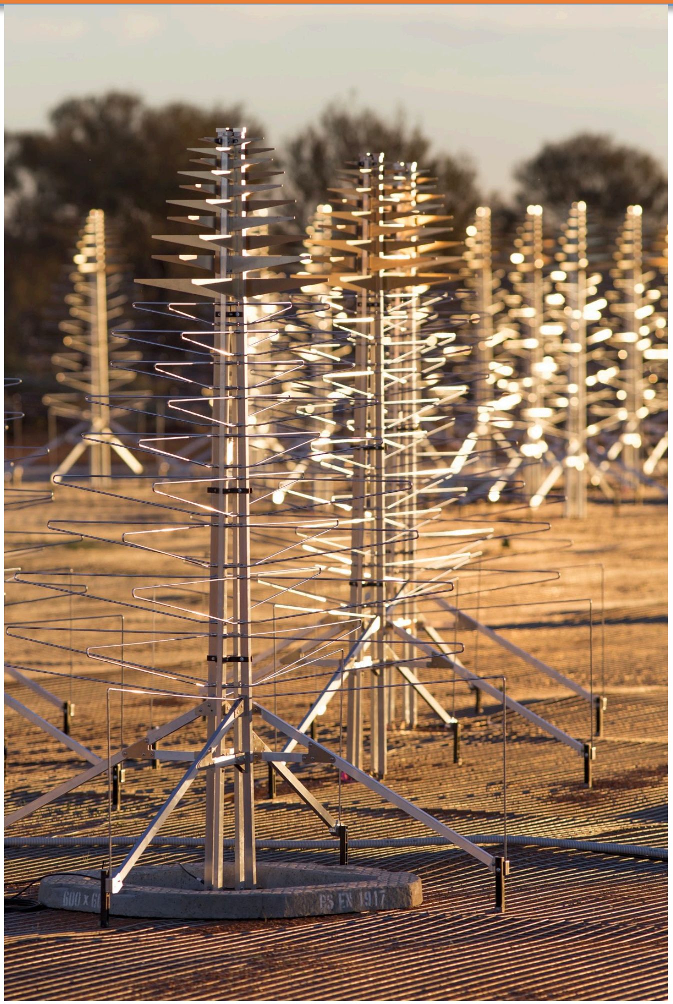
LighTech Fiber Optics Components and Accessories

Receiver Chain - Technology made in Italy

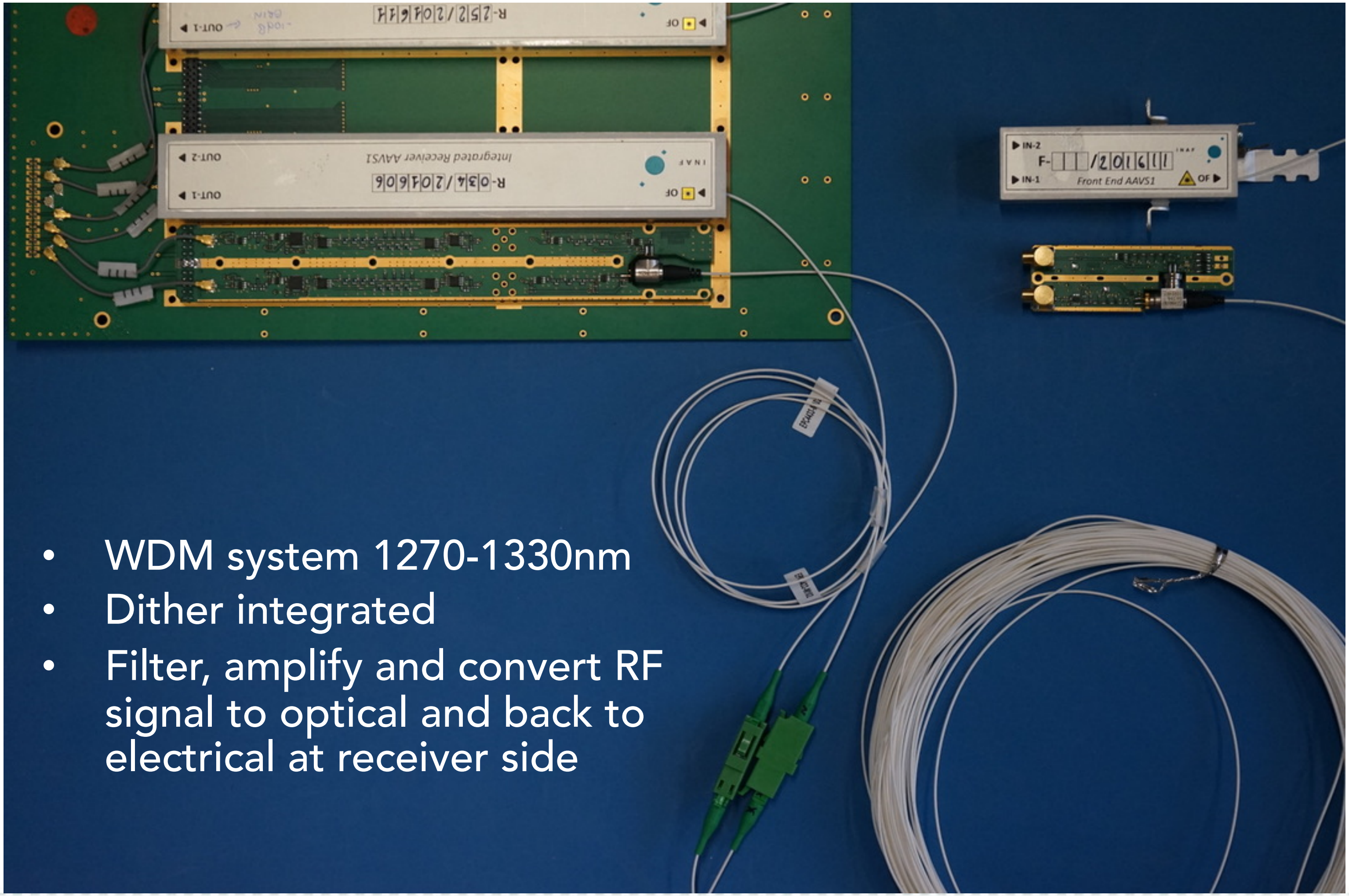


SKALA4.1AL Antenna

- Dual-polarized LPDA.
- 20 dipoles: 19 triangular-tooth plus 1 bow-tie at the bottom of the antenna.
- Solid dipoles on the high-frequency elements and wire dipoles on the low-frequency ones.
- 1-degree tilted boom.
- Aluminium-made.
- Electrical connection of the antenna to the ground plane.
- Antenna matched to a single-ended 50-ohm LNA.
- LNA encapsulated in the top-cap of the antenna and connected to a coaxial cable embedded in the antenna booms.

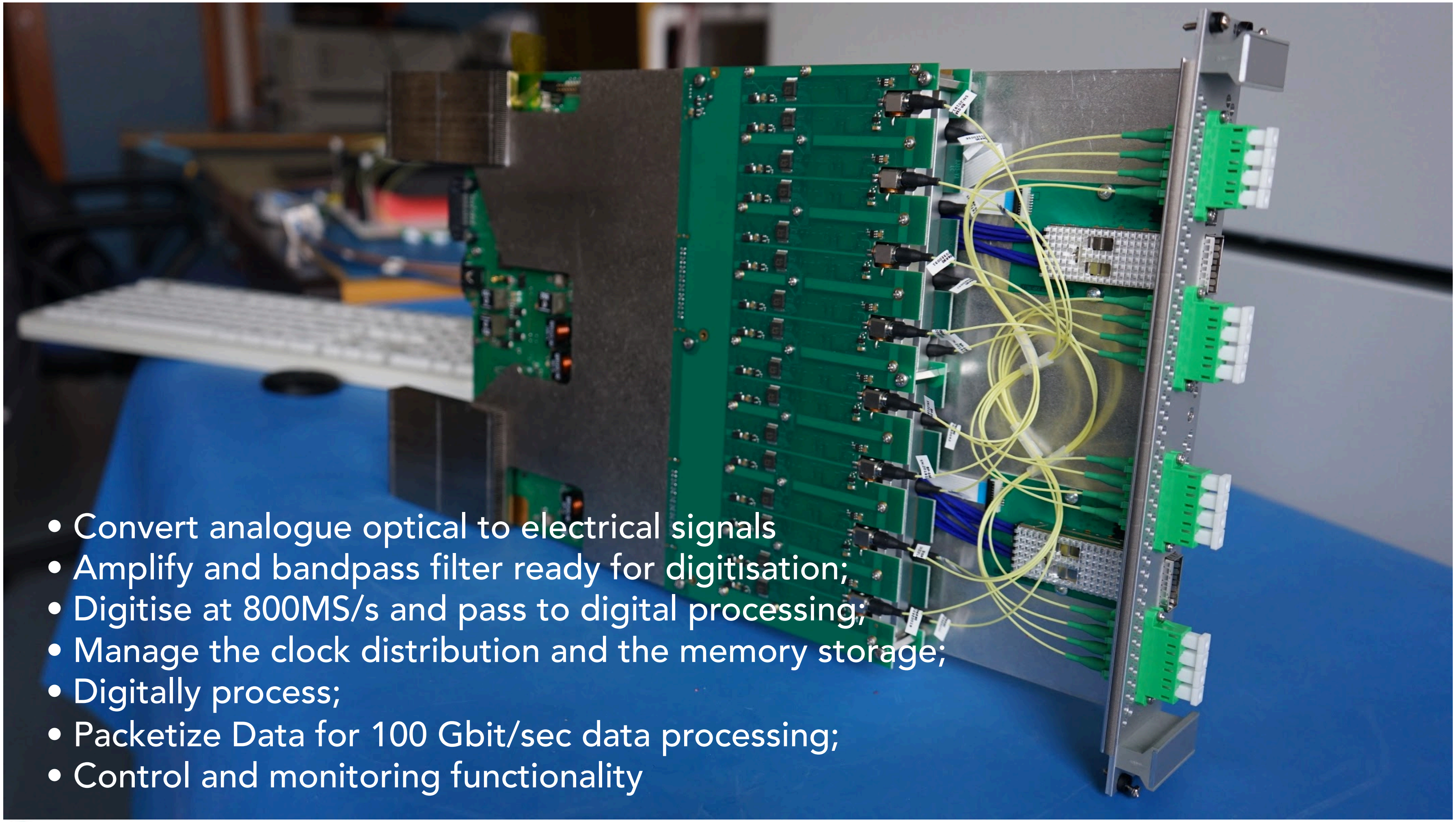


Analogue RFoF link



- WDM system 1270-1330nm
- Dither integrated
- Filter, amplify and convert RF signal to optical and back to electrical at receiver side

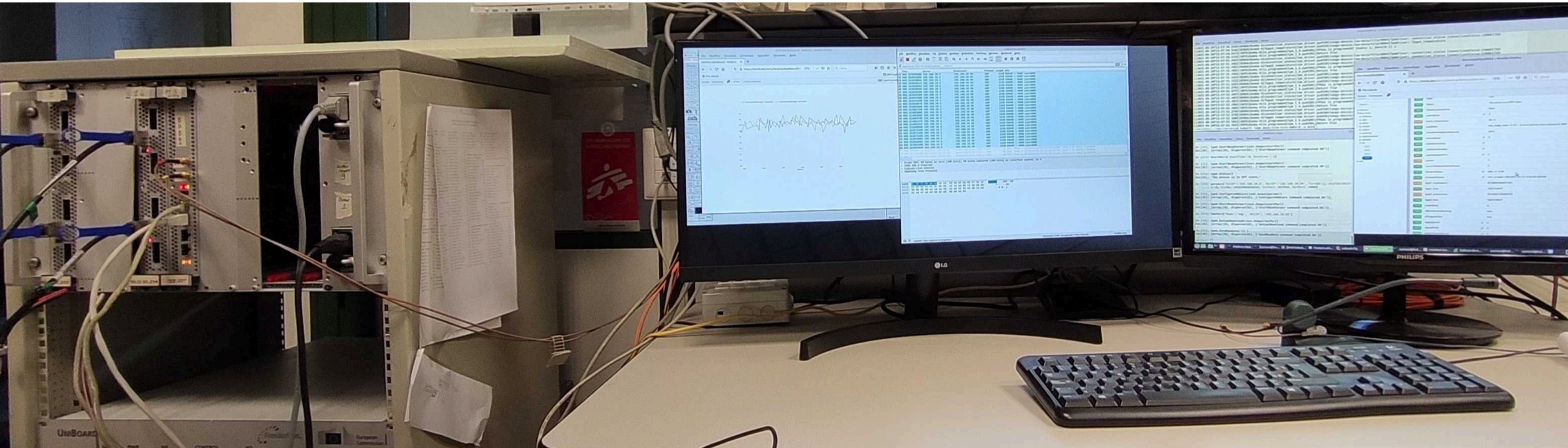
Tile Processing Module



- Convert analogue optical to electrical signals
- Amplify and bandpass filter ready for digitisation;
- Digitise at 800MS/s and pass to digital processing;
- Manage the clock distribution and the memory storage;
- Digitally process;
- Packetize Data for 100 Gbit/sec data processing;
- Control and monitoring functionality

Firmware

- LFAA firmware used in the iTPM board to
  - Channelize, calibrate and align antenna signals
  - Combine 256 antennas in up to 48 beams
  - Format and transmit beamformed signals to correlator
  - Format and transmit selected signals to calibration server
- Prototype firmware used in AAVS array
- Significant work required for industrial grade final system
- People: 3 persons (1 FTE) INAF, 4 persons (3 FTE) UK

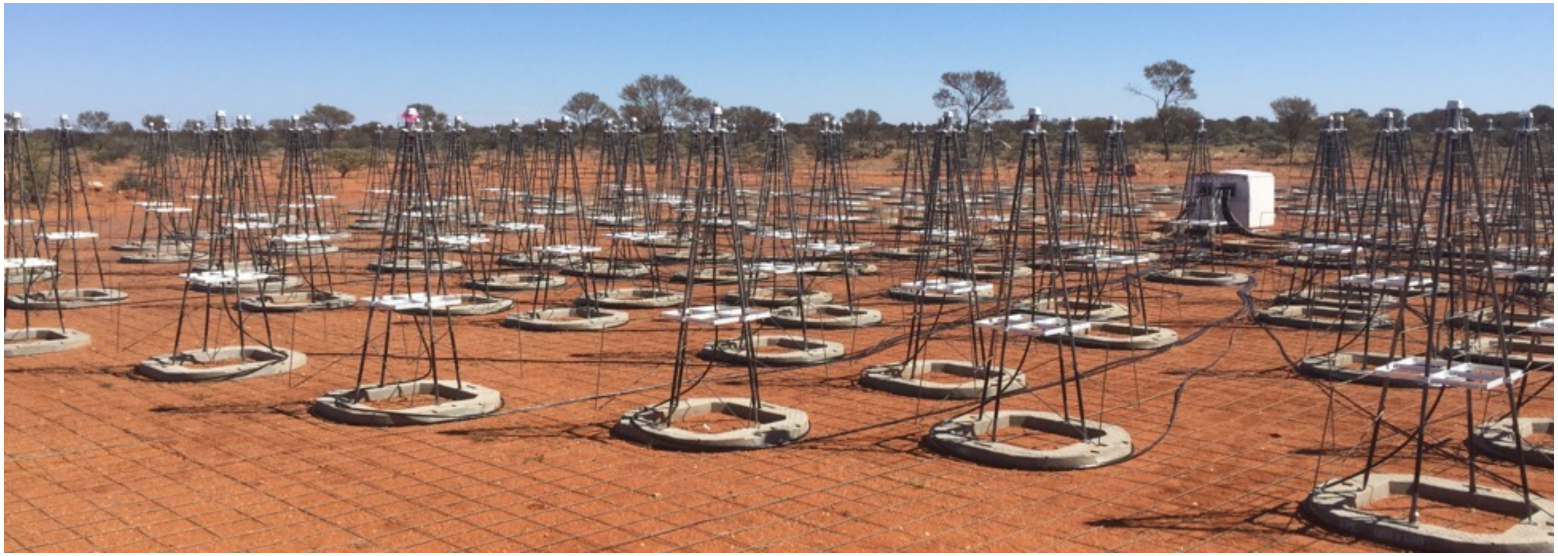


Software

- Low level control software
  - Hardware drivers: developed together with firmware blocks
  - General standalone software, used at AAVS array
  - Control of cabinet and subrack electronics (power management, temperature, cooling)
- Integration of hardware in SKA Low LMC
  - Device software in the Tango Control environment
  - Hardware related problems: antenna pointing, beam management, obsrvation management, calibration strategies
  - Interface with other systems (correlator, telescope manager)
  - Network design and management (SKA as a network defined instrument)

UAV

AAVS1



AAVS2 & EDA2

2 demonstrators built at MRO site to verify SKA1-low system before construction

EDA2 (2019)
256 **MWA dipoles**
LNA modified for
50-350 MHz
35 m diameter

AAVS2 (end of 2019)
256 **SKALA 4.1** log-periodic
LNA optimized for
full **50-350 MHz**
38 m diameter

Aerial view of EDA2 and AAVS2 - Credits: Icrar/Curtin

Efforts spent

	FTE	FTE partner	Total FTE	Industry	Development	Travel	Total per year
2012-2013	7,64	1,38	9,02	- €	185.000 €	20.000 €	205.000 €
2013-2014	7,91	1,42	9,33	100.000 €	256.000 €	20.000 €	376.000 €
2014-2015	8,00	1,48	9,48	- €	165.000 €	49.800 €	214.800 €
2015-2016	9,91	1,33	11,24	589.300 €	212.200 €	41.000 €	842.500 €
2016-2017	11,64	1,30	12,94	227.000 €	153.000 €	50.000 €	430.000 €
2017-2018	11,64	1,30	12,94	188.000 €	61.000 €	60.400 €	309.400 €
2018-2019 (P2 ext)	11,18	1,59	12,77	198.000 €	56.000 €	60.400 €	314.400 €
2019-2020 (low B)	11,27	1,52	12,79	937.000 €	95.200 €	100.000 €	1.132.200 €
2020-2021	10,39	0,91	11,30	687.000 €	96.300 €	- €	783.300 €
TOTAL	89,57	12,24	101,82	2.926.300 €	1.279.700 €	401.600 €	**4.607.600 €**

TI	46,85
TD	42,73
Totale INAF	89,57
Altri enti	12,24
Totale Italia	101,82

Activities foreseen

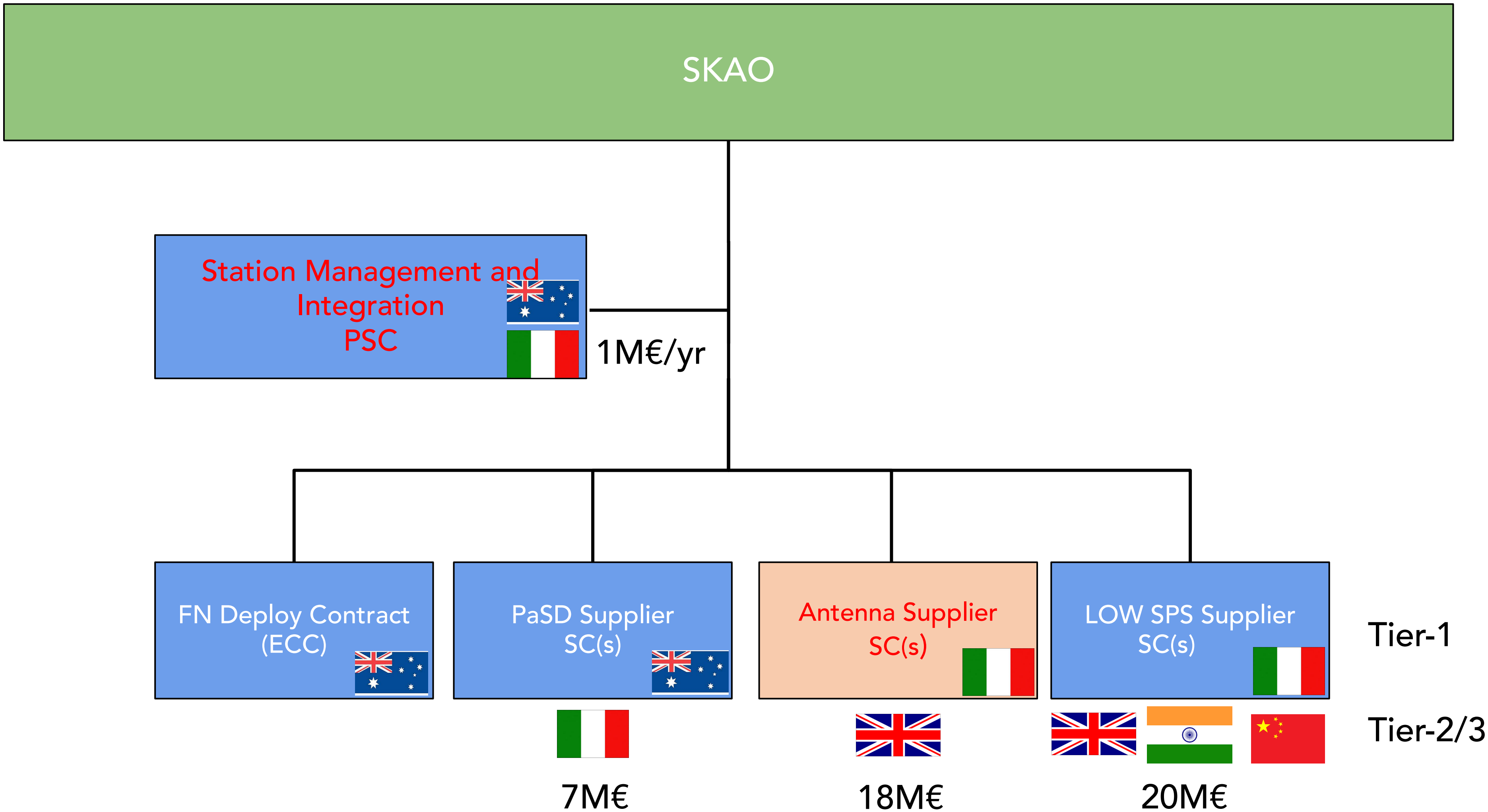
- **Antenna/LNA**
  Analysis of the LNAs failures in the field
  LNA MTBF reliability model
  Measurements of the LNA operative temperature at MRO
  Low Freq IP2/IP3 measurement @ MRO
  NF measurement vs Temperature
  Finalization and improvement of the LNA noise parameter measurements

- **RX**
  FEM reliability model / qualification of WDM optical source suppliers
  PreADU fine tuning of LP 350MHz filter
  Linear / non-linear RF modeling review of the entire receiving chain from LNA to ADC
  FEM DFM

- **SPS**
  Develop all FW/SW functionalities to control/monitor subrack subsystem
  Test plan for Subrack
  (Cabinet integration support/ New Clocks distribution Architecture)

- **OBS**
  Performing regression testing following any new installation or modification happening on site (highest priority)
  Support towards the objectives and priorities defined in the: SKA Station Calibration Task Phase 2/3 Program Objectives document.

Opportunity



ITF or CDF…

- l'INAF ha massima probabilità di avere attribuita dal Board di SKA la responsabilità dello SKA System Integration Centre (pagato da SKAO su territorio italiano). Citando le parole di Phil Diamond: "*SKA will require a SKA System Integration Centre (SSIC), similar to the Front-End Integration Centres for ALMA, which were located in Japan, USA and UK. Current planning calls for a single SSIC. Italy would be well-placed to provide such a facility, which would be funded by the SKAO. The SSIC would require access to laboratory space; cryogenic test facilities; RF, fibre and digital test equipment and the ability to run end to end tests of SKA elements to ensure they function correctly before shipping them to South Africa and/or Australia to be deployed. Italian industry has a strong record in system integration*"

Weakness

- Given the number of activities in which INAF is involved in SKA-LFAA and given the duration of the project, it is first of all necessary to plan actions for the **transfer of "generational" knowledge** and to carry out an effective turnover. Colleagues close to retirement need an overlapping of at least 1 year for the transfer of know-how and to allow the youngest to take over.

- A strong investment must also be made in the **observation / verification group** (the one that works closest to the instrument and on the raw data for the verification of the requirements). These personnel units, which are a technical / scientific hybridization, are very rare and sought after by the various communities and will be essential in the commissioning phase of SKA1 at all stages.

- Another highly sought after figure are **firmware / software programmers and RF designers** who are now fundamental fields for modern radio technologies. As soon as they graduate, they are absorbed by companies attracted to more attractive positions than those that INAF can offer to a new employee.

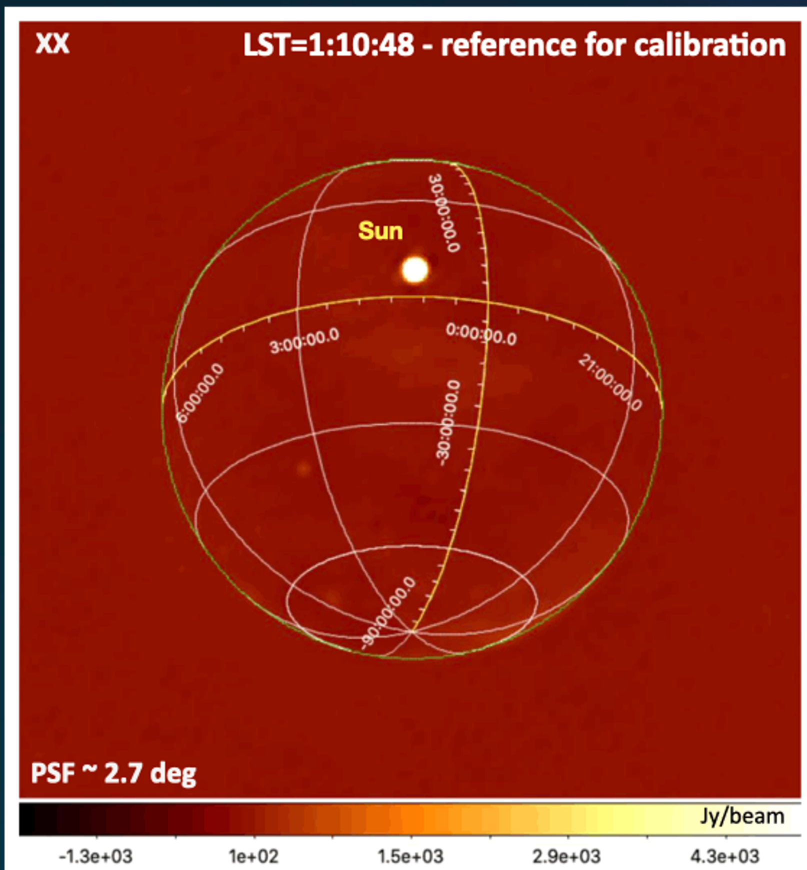
- Finally, the now usual criticality in our work and a big bottleneck for the development of very dynamic projects as is the demand of these times, is **the administration too slow** for the acquisitions and the issuing of calls for services due to the bureaucracy too complicated.

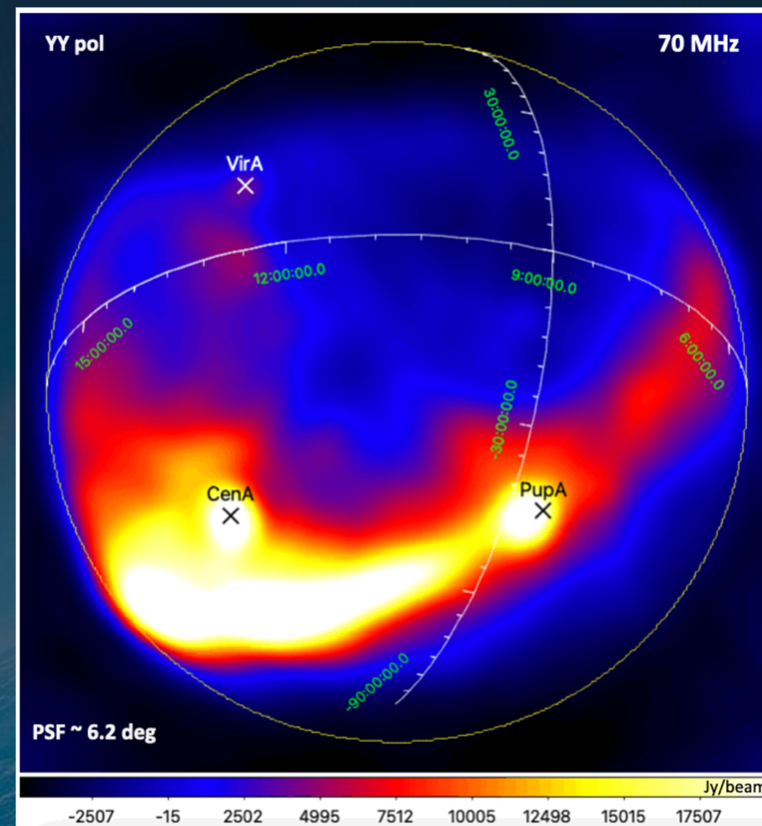
SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

SKA SQUARE KILOMETRE ARRAY Italy





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