The Square Kilometer Array Project (SKA)

Lourdes Verdes-Montenegro
(Instituto de Astrofísica de Andalucía-CSIC)

Fujitsu III HPC Users group, 24 Oct. 2014

OUTLINE

- General overview of SKA and scientific drivers

- International organization and schedule

- Spanish participation in SKA

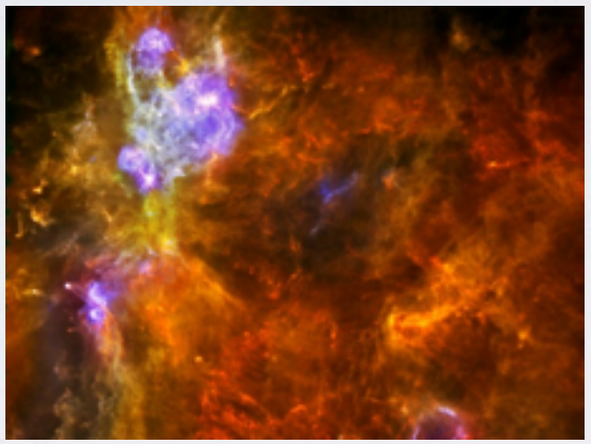
VIA-SKA

Why do I coordinate the technological participation of Spain in SKA?

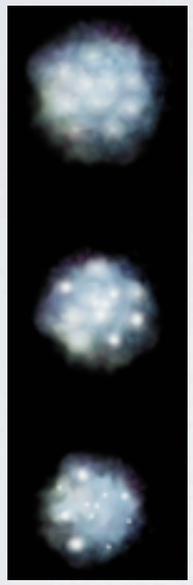
Why do I coordinate the technological participation of Spain in SKA?

The Lifecycle Of Gas In Galaxies

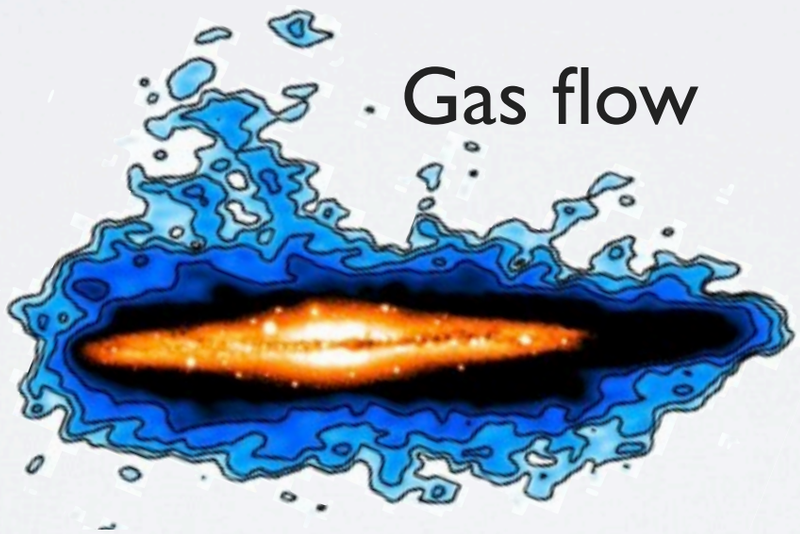
Gas and dust clouds



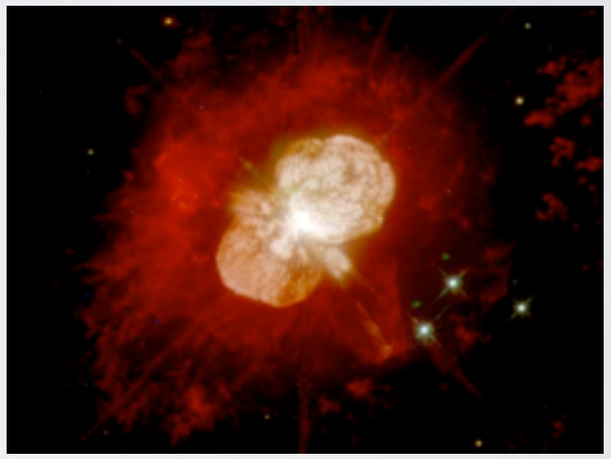
Gas collapse



Gas flow

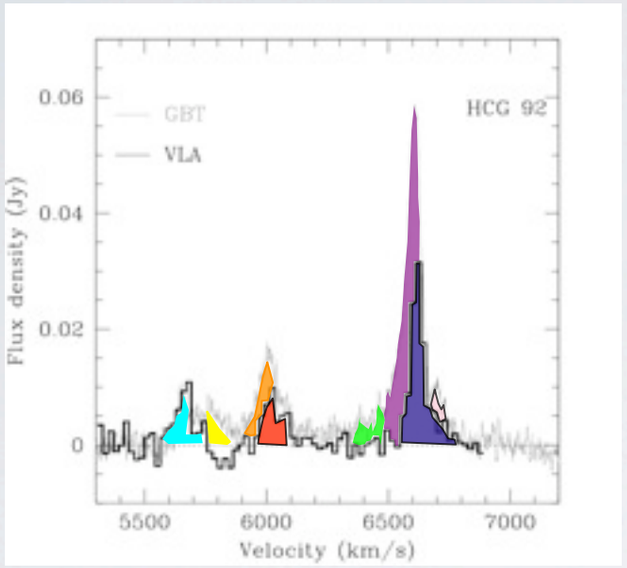


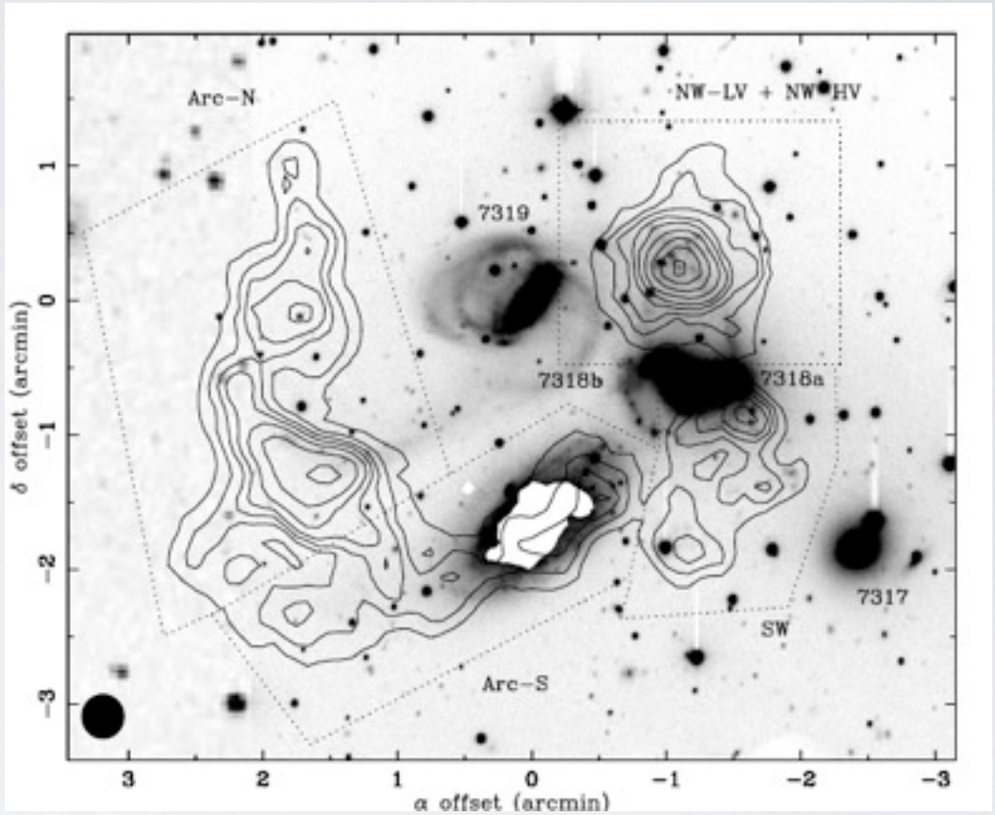
Feedback to the interstellar medium



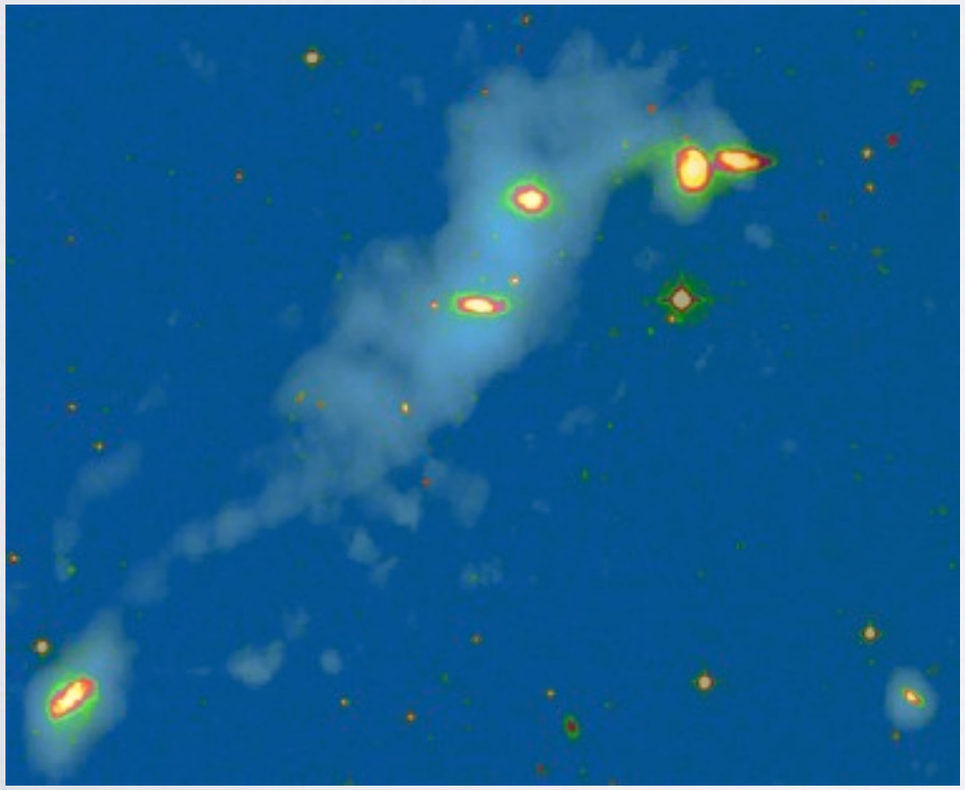
Star formation

Looking for the faintest gas





Verdes-Montenegro et al 2001, 2007



General overview of SKA and scientific drivers

WHAT WILL SKA BE?

A revolutionary radio telescope made of **1000s of receivers**

Linked together across an area the **size of a continent**.

Total combined collecting area: **1 KM^2**

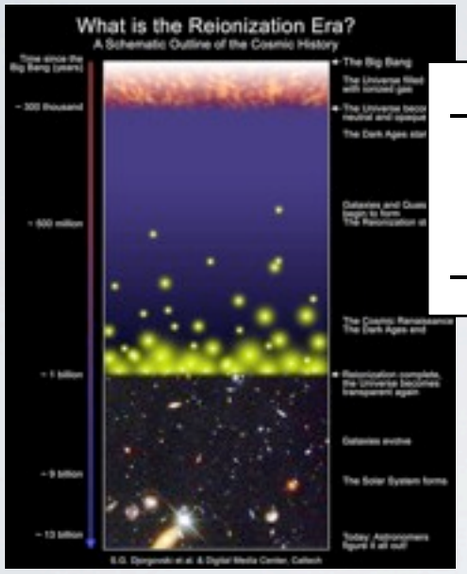
SKA, a Green ICT machine

- Its core: a city!
- Remote stations: spread villages
- The Universe camera, after an Exabyte and an Exaflop

cf. D. Barbosa

WHAT FOR? KEY SCIENCE

- HISTORY OF ATOMIC GAS (HI): REONIZATION - TODAY

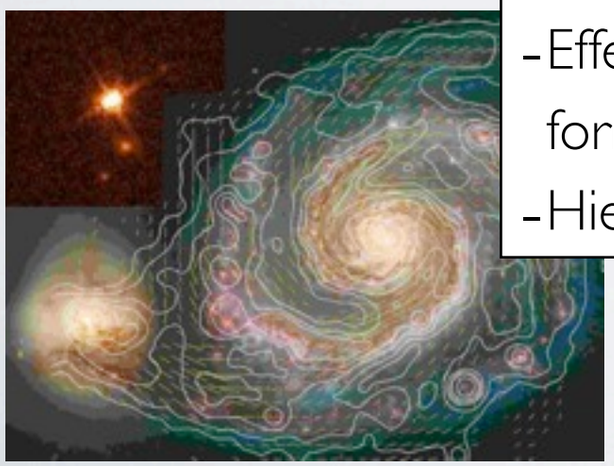


- Detailed picture of structure formation
- Most HI in galaxies: z=7

- GRAVITY TEST

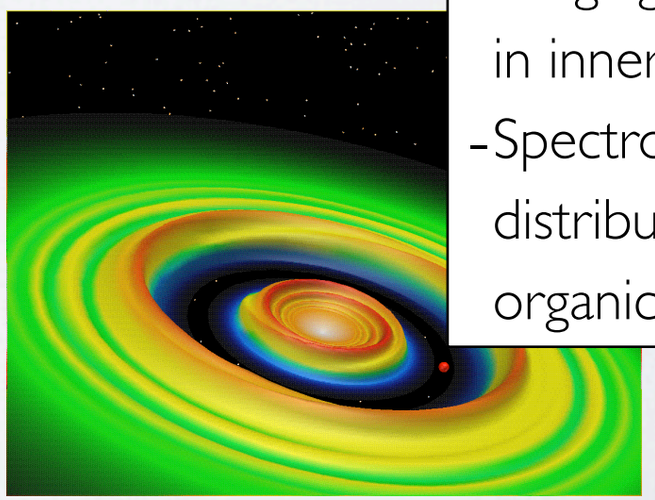
Discovery of
- 2000 (SKA1) pulsars
- 10.000 - 20.000 (SKA2) pulsars
- High precision timing
- Arms of gravitational wave detector

- ORIGIN & EVOLUTION OF COSMIC MAGNETISM



- Origin and evolution
- Effect on star and galaxy formation
- Hierarchical distribution

- PROTOPLANETARY DISKS



- Imaging of thermal emission in inner regions of disks
- Spectroscopy to map out the distribution of complex organic molecules

QUICK OVERVIEW OF SKA

- 1000 -1500 antennas x15m in ~100 km
- 1000 -1500 antennas x15m up to 3000 km

70 MHz - ≥ 25 GHz
4-3m - 1.2 cm

200 - 1 SQ^2 FOV
0.1" - 0.001" resolution

interferometer: escalable

SKA1 = 10% collecting area, 70 Mhz - 3 GHz

SKA2 = 100% collecting area, 70MHz-10 GHz, 2018 -2024

SKA3 = High frequencies: ≥ 25 GHz. No defined dates

ANTENNAS

- Frequency range > two decades:
- Combination of different types of antennas

Can observe towards several directions simultaneously

Aperture Array
70 - 450 MHz
Baselines 100 km

2018 -2020

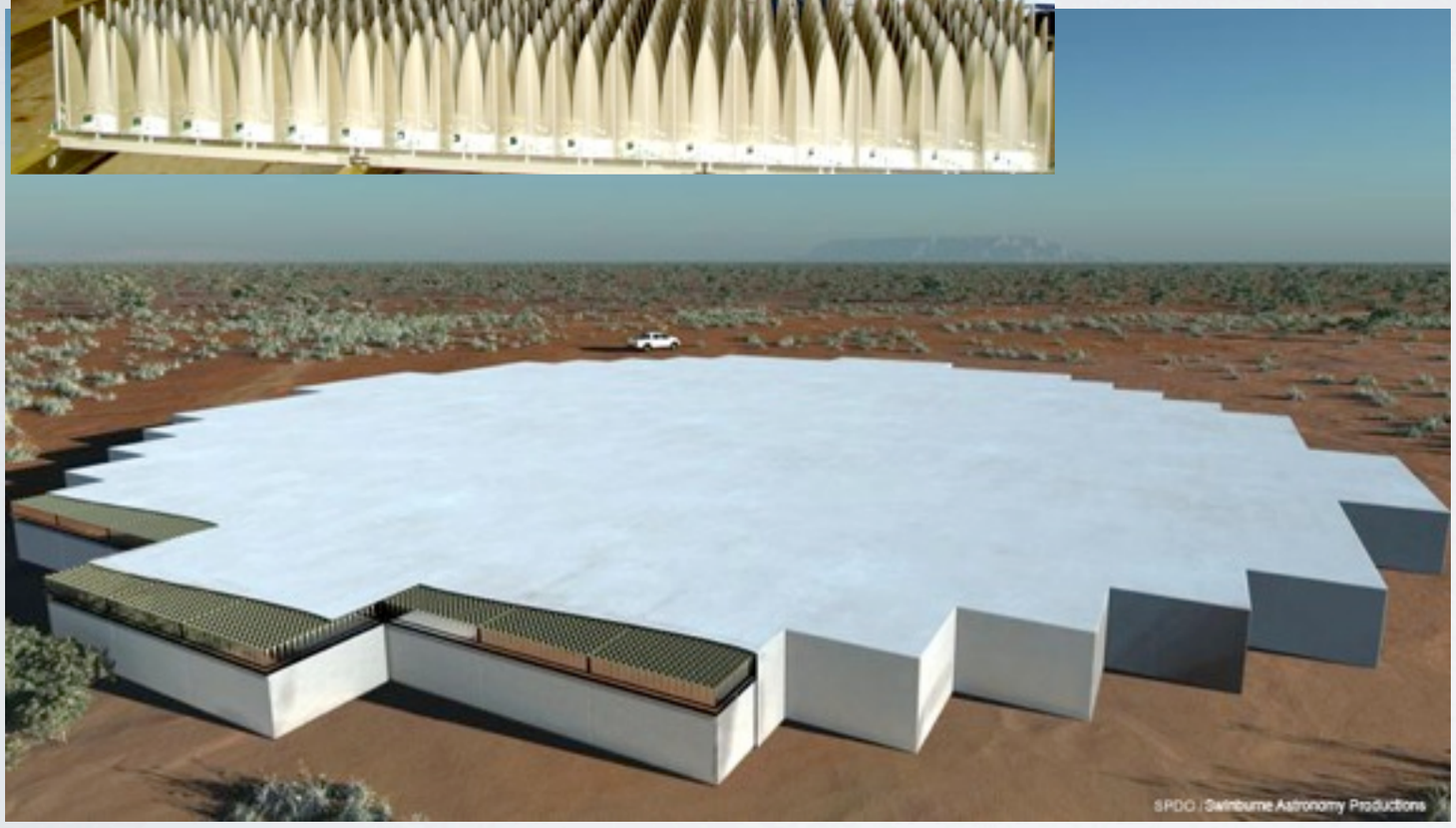
SKA1

single pixel feed
450 MHz - 3GHz
baselines 100 km

Advanced Instrumentation Program

ANTENNAS

Enhancing FOV



+ focal plane array

dense aperture array

200 - 500 MHz
200 deg2

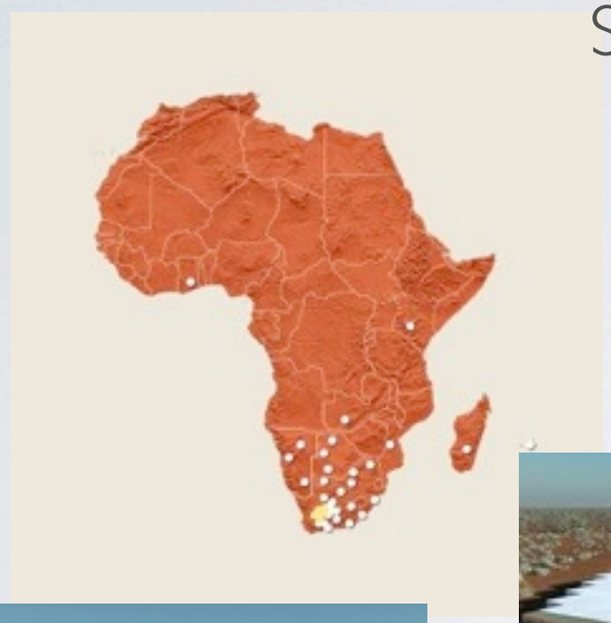
SKA2

2018 - 2024

Dual Site

A Distributed Sensor Network at the Scale of Two Continents

South-Africa & Australia/ New Zealand Joint Site



SKA1		SKA2	
SKA1_LOW		SKA2_LOW	
SKA1_MID		SKA2_MID	
SKA1_SURVEY		SKA2_AA	

International organization and schedule

2008-2013 Preparatory Phase: system design and costing

- SKA1 Definition, and Project Execution Plan (PEP)
- New legal entity: **the SKA Organisation**
  - Non-for-profit limited liability company, incorporated in the UK
- Work Breakdown Structure & Statements of Work Jan 2012
- Call for Expressions of Interest May 2012
- Request for Proposals & Evaluation March 2013 - 10th Jun

2013-16 Detailed design & pre-construction phase

2017-20 SKA 1 construction

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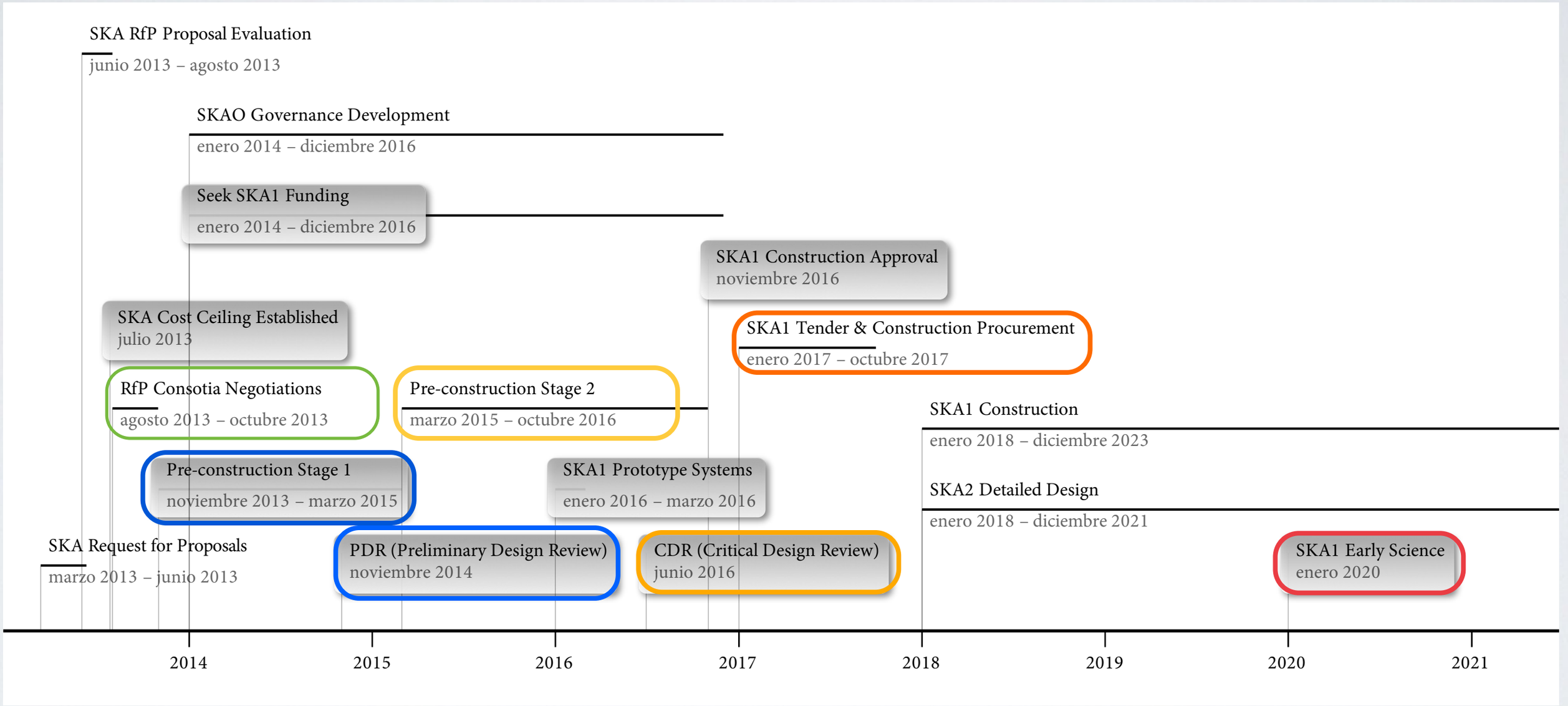
11 Members:
Australia, Canada, China, Germany, Italy, New Zealand, SouthAfrica, Netherlands, UK, Sweden, India

100 participating organisations across about 20 countries:
All member countries + Brazil, France, Japan, Malta, South Korea, Poland, Portugal, Russia, Spain, the USA

Official Timeline



SKA DESIGN IS BROKEN DOWN IN ELEMENTS

Each Working Package is managed by **an International Consortium**

Spanish participation in SKA

2011: MINECO funds Scientific Network

UV, IAA, CAB, OAN, UB, IEEC, UGR, UJ, IAC, IFCA, UPTC

November 2011: MINECO funds VIA-SKA

"Feasibility study of the Spanish technological participation in SKA" (Lead by IAA-CSIC; 75.000€)

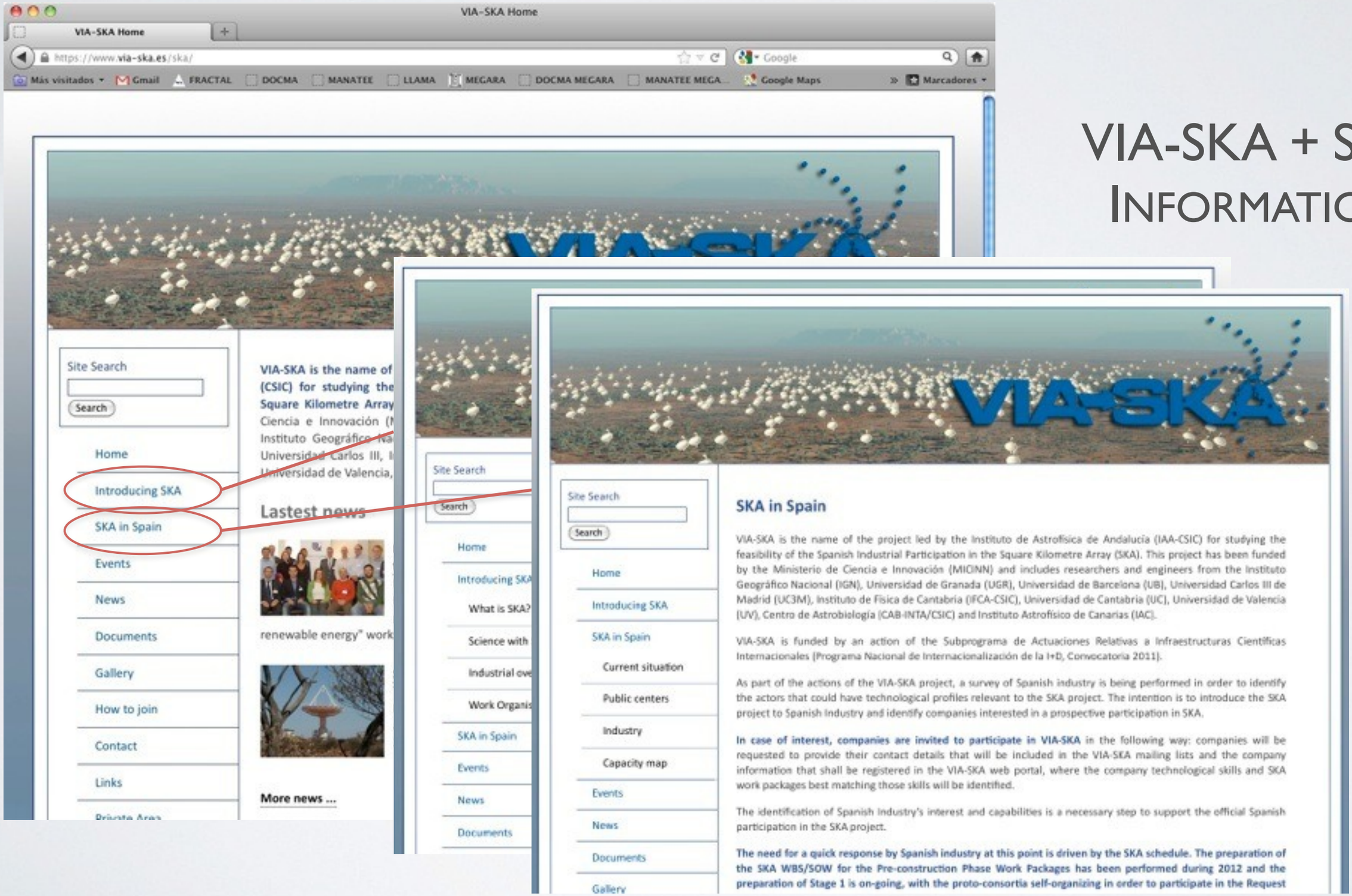
Subprograma Infraestructuras Científicas Internacionales

Participants: 7 research institutions (4 from CSIC) + 8 Universities

- CSIC: **IAA**, CAB, ICE, IFCA
- IGN - OAN
- Instituto de Astrofísica de Canarias
- Universities of Granada, Barcelona, Cantabria, Valencia, Jaén, Carlos III, and Politécnica de Cartagena
- National Institute for Aerospace Technology (INTA)

ACTIVITIES

VIA-SKA + SKA INFORMATION



Form allowing an easy search of public and/or private organizations registered in VIA-SKA filtering by Working Package or Expertise domains

- Current situation
- Public centers
- Industry
- Capacity map
- Events
- News
- Documents
- Gallery
- How to join
- Contact

Capacity map form

Name

Institution type

SKA Work Package of interest

Expertise domains

- Analog ASIC design
- Analog beamforming hardware
- Analog beamforming software
- Analog filterbank design
- Analog sensors
- Analog signal processing
- Antenna system beam profile measurement
- Antenna system sensitivity measurement
- Cabling
- Civil engineering
- Control system design
- Cooling: Cryogenics
- Cooling: Heat recovery
- Cooling: Thermal insulation
- Cost modelling
- Cryogenic LNAs (450MHz-2GHz)
- Digital ASIC design
- Digital beamforming
- Digital Fieldbuses
- Digital filterbank design
- Digital sensors
- Digital signal processing
- Digital signal transport networks
- Dipole antenna array construction
- Dipole antenna array design
- Dish antenna construction
- Dish antenna design
- Electro-magnetic compatibility design
- FFT digital signal processing
- FPGA computing
- ✓ FPGA design
- High Performance Computing: event-based computing
- High Performance Computing: GPU computing
- High Performance Computing: grid computing
- High-accuracty timing systems
- High-voltage electrical engineering
- Logistics engineering
- Low-RFI Power conversion
- Mecatronics
- Mechanical engineering
- Mechanical tooling
- Monitoring software and systems
- Non-cryogenic LNAs (70MHz-450MHz)
- Photovoltaic solar thermal energy
- Power engineering
- Power engineering: budgeting

CAPACITY MAP

ÁREAS TECNOLÓGICAS / EMPRESAS	ACTURRI	AIDO	ALTRAN INNOVACIÓN	ARIEMA	ASTURFEITO	CRISA	CRYOVAC	DEIMOS	EMPRESARIOS AGRUPADOS	FRACTAL	GMV	GTD	HTS	IDOM	IK4-TEKNIKER	INSA	INTEGRASYS	ISOFOTON	IXION Industry & Aerospace	JEMA	LIDAX	PROCOM SYSTEMS	SCHWARTZ-HAUTMONT	SENER	SEVEN SOLUTIONS	TAPCO METAWIRELESS	TECNOBIT	TELSTAR Vacuum Solutions	THARSIS TECHNOLOGY	TTI	VINCI ENERGIA	VLC Photonics
Analog ASIC design						x																					x					
Analog beamforming hardware																													x			x
Analog beamforming SW																x													x			
Analog filterbank design																x											x					
Analog sensors		x													x	x									x				x			
Analog signal processing						x									x	x	x							x	x		x		x			
Antenna system beam profile measurement	x																x															
Antenna system sensitivity measurement	x																x															
Cabling						x			x																				x			
Civil engineering									x					x										x								
Control system design	x					x				x		x		x	x		x					x		x			x		x	x		
Cooling: Cryogenics						x	x						x	x	x					x								x		x		
Cooling: Heat recovery									x				x	x	x					x								x		x		
Cooling: Thermal insulation							x						x	x						x								x				
Cost modelling															x	x	x															
Cryogenic LNAs (450MHz-3GHz)													x			x				x										x		
Digital ASIC design						x																					x		x			
Digital beamforming						x										x														x		
Digital Fieldbuses						x																	x									
Digital filterbank design																x											x					
Digital sensors		x				x									x	x									x		x					
Digital signal processing		x				x					x				x	x	x								x					x		
Digital signal transport networks						x					x				x												x					
Dipole antenna array construction	x				x				x				x	x																x		
Dipole antenna array design	x								x				x	x																x		
Dish antenna construction	x	x			x				x					x									x							x		
Dish antenna design	x								x				x	x																x		
Electro-magnetic compatibility design						x			x						x												x					
FFT digital signal processing						x					x				x	x									x		x			x		
FPGA computing						x					x				x	x						x			x	x	x			x		
FPGA design						x					x				x	x						x			x	x	x			x		
High Performance Computing: event-based computing								x				x	x													x	x					
High Performance Computing: GPU computing								x			x	x					x									x	x					
High Performance Computing: grid computing								x			x	x				x																
High-accuracy timing systems						x		x			x	x				x	x									x				x		
High-voltage electrical engineering						x															x					x				x		
Logistics engineering														x												x						
Low-RFI Power conversion																															x	
Mecatronics		x	x								x	x	x	x											x					x	x		
Mechanical engineering	x	x	x						x				x	x											x					x	x		
Mechanical tooling	x	x	x										x	x											x					x			
Monitoring SW and systems	x	x				x		x	x	x				x																			
Non-cryogenic LNAs (706MHz-850MHz)																	x														x	
Photovoltaic solar thermal energy	x	x												x				x		x												
Power engineering				x		x			x			x		x											x					x		x	
Power engineering: budgeting				x		x		x	x				x												x								
Power management		x		x		x		x		x	x	x	x	x											x					x			
RF engineering 0,03-0,15 m (2-10GHz)													x			x	x													x			
RF engineering 0,12-0,30 m (10-25GHz)																x	x													x			
RF engineering 0,15-0,7 m (450MHz-2GHz)																x	x													x			
RF engineering 0,7-4 m (70-450MHz)																x	x										x			x			
RF engineering: risk assessment																x														x			
RF Interference measurement																	x													x			
RF Interference sensitivity																	x													x			
RF optical design		x														x																	x
RF optical simulation		x														x											x						x
RF system simulation																x														x			
RFI shielding					x											x														x			
Risk assessment					x		x				x		x	x	x																		
Sensor networks											x			x		x									x		x		x	x			
SW engineering		x				x		x	x	x	x				x		x			x					x	x	x	x		x			
SW engineering: behavioural modelling						x		x		x	x					x														x			
SW engineering: data modelling						x		x		x	x					x														x			
SW engineering: high-performance computing algorithms						x		x		x	x					x									x	x				x			
SW engineering: human-computer interaction		x				x		x		x	x					x									x					x			
SW engineering: quality assurance						x		x		x	x					x										x				x			
SW engineering: requirements analysis						x		x		x	x					x									x	x				x			
SW engineering: risk assessment						x		x		x	x					x										x				x			
SW engineering: structural modelling		x				x		x		x	x					x		x												x			
SW engineering: system simulation		x				x		x		x	x					x		x												x			
Synchronization and timing equipment						x									x				x														
System engineering		x	x			x		x		x	x			x	x	x	x					x			x	x				x			
Thermal-electric compatibility						x																x								x			
Wavelet digital signal processing																														x			
Wideband receiver design																x														x			

Areas of expertise and SKA WPs of the registered companies

SKA Work Packages / EMPRESAS	ACTURRI	AIDO	ALTRAN INNOVACIÓN	ARIEMA	ASTURFEITO	CRISA	CRYOVAC	DEIMOS	EMPRESARIOS AGRUPADOS	FRACTAL	GMV	GTD	HTS	IDOM	IK4-TEKNIKER	INSA	INTEGRASYS	ISOFOTON	IXION Industry & Aerospace	JEMA	LIDAX	PROCOM SYSTEMS	SCHWARTZ-HAUTMONT	SENER	SEVEN SOLUTIONS	TAPCO METAWIRELESS	TECNOBIT	TELSTAR Vacuum Solutions	THARSIS TECHNOLOGY	TTI	VINCI ENERGIA	VLC Photonics
Dish-array element		x	x		x		x		x				x	x	x						x			x					x		x	
Low Frequency Aperture Array			x		x		x		x				x	x	x	x					x								x			
Signal and Data Transport / Sync and Timing						x						x				x	x							x	x		x					x
Central Signal Processor		x				x		x			x	x					x	x						x	x		x		x			
Science Data Processor						x		x		x	x	x				x			x							x	x					
Telescope Manager	x							x		x	x	x			x	x			x													
Power		x		x	x	x						x		x				x		x								x		x		
Site and Infrastructure		x							x					x		x								x			x					
Science																																
Management and Engineering	x		x			x		x	x	x	x		x	x		x	x							x					x			

SPANISH PARTICIPATION IN SKA PRE-CONSTRUCTION

- 9 Spanish research centres and 11 companies participate in above SKA Pre-construction Consortia
- 2M€ of in-kind contributions officially acknowledged by SKA Board

- **2014:** Spain is regularly invited to Board meetings.

Jodrell Bank Observatory. March 2014

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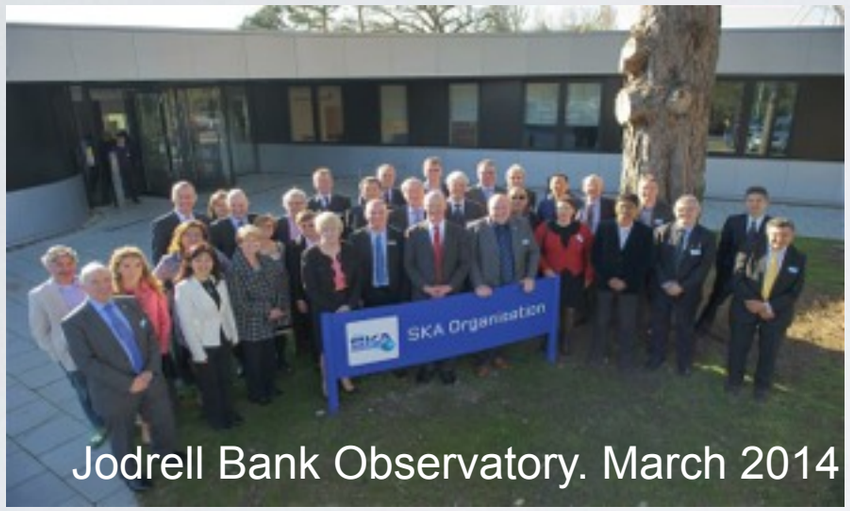

Jodrell Bank Observatory. March 2014

- **23rd October 2014 (Yesterday!)**

Registered participants from 18 academic institutions and 17 companies

IAA PARTICIPATION IN SKA PRE-CONSTRUCTION

- Participation in Science Data Processor: Susana Sánchez