

# The Square Kilometre Array:

## Should we all wait until 2022?

Lourdes Verdes-Montenegro (IAA-CSIC)  
Juan de Dios Santander-Vela (ESO --> IAA)

V Simposio de Astrofísica  
XXXIII Reunión Bienal de Física de la RSEF

# QUICK OVERVIEW OF SKA

## COLLECTING AREA: **1 KM<sup>2</sup>**

- 1000 -1500 antennas x15m in 5km
- 1000 -1500 antennas x15m up to 3000 km

70 MHz -  $\geq 25$  GHz  
4-3m - 1.2 cm

200 - 1 SQ<sup>2</sup> FOV  
0.1'' - 0.001'' resolution

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## Key Science:

- History of HI: reionization - today
- Gravity test
- Origin & evolution of cosmic magnetism
- Proto-planetary disks

# QUICK OVERVIEW OF SKA

- **SKA1** = 10% collecting area, 70 Mhz - 3 GHz , 350 M€, 2016 -2019
- **SKA2** = 100% collecting area, 70 - 100 GHz, ~1100 M€, 2018 -2023
- **SKA3** High frequencies:  $\geq 25$  GHz. No defined dates
- Operational costs 100 M€/yr, European contribution ~40%

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## EVOLVING QUICKLY (19 countries involved): 2010-2012

- Organizational structure defined, SPO Jodrell Bank
- Pre-construction funding
- Site decision: Australia vs Southafrica

# ORGANIZATIONAL ISSUES

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- Detached in ESFRI and Astronet roadmaps
- High-priority in MICINN document  
“CONSTRUYENDO LA CIENCIA DEL SIGLO XXI”
- **MICINN requested Spain to be Observer Member in SKA Founding Board**

International Consortia and Industry clusters forming now  
Each WP in pre-construction Phase will go to a Consortium  
(2012)

# HISTORY OF H<sub>I</sub>: REIONIZATION

WMAP + High-z QSOs:

$z \sim 6$  End of Reionization

Rise in IGM neutral fraction at  $z \sim 6$

**SKA**

detailed pictures of structure formation  
and reionization

Redshifted H<sub>I</sub>: **typical galaxies at  $z=3$**

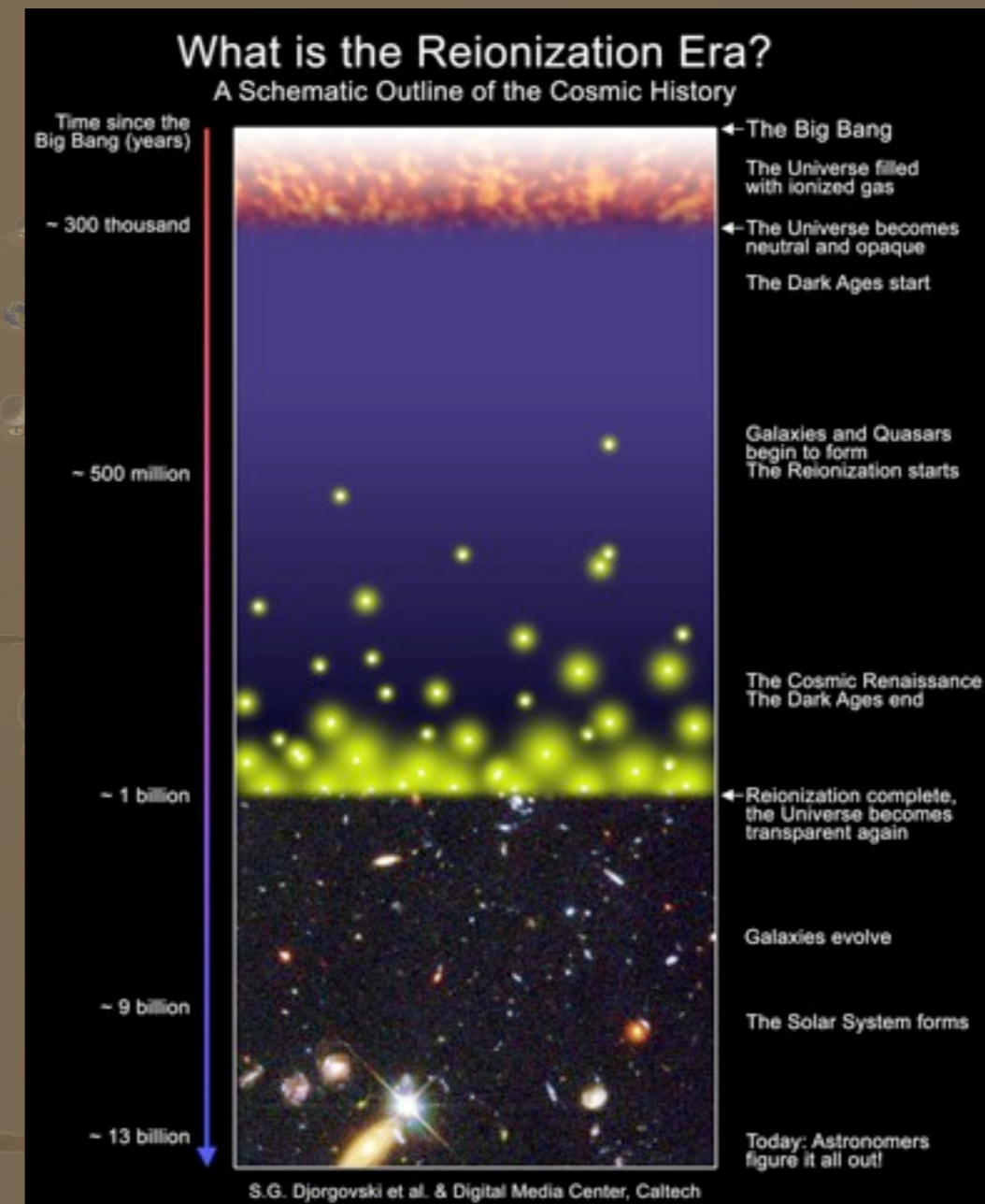
separating contributions from  $z$

reionization =  $f(t)$

Absorption spectra:

high-z radio sources

growth of ionized regions around proto-galaxies



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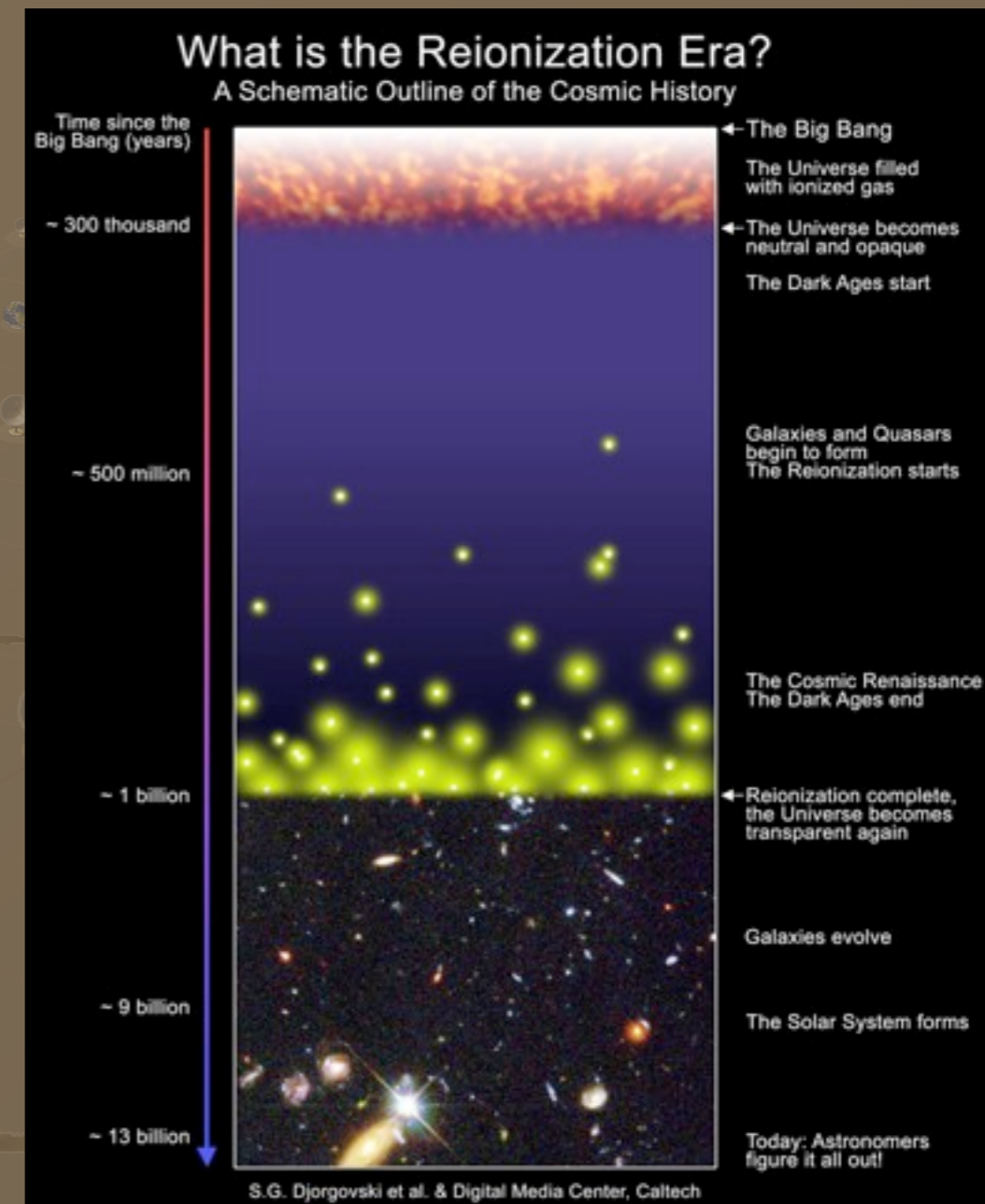
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**SKA can survey the entire visible sky in a year of operation**

**$10^9$  HI emission galaxies to redshift  $z=1.5$**





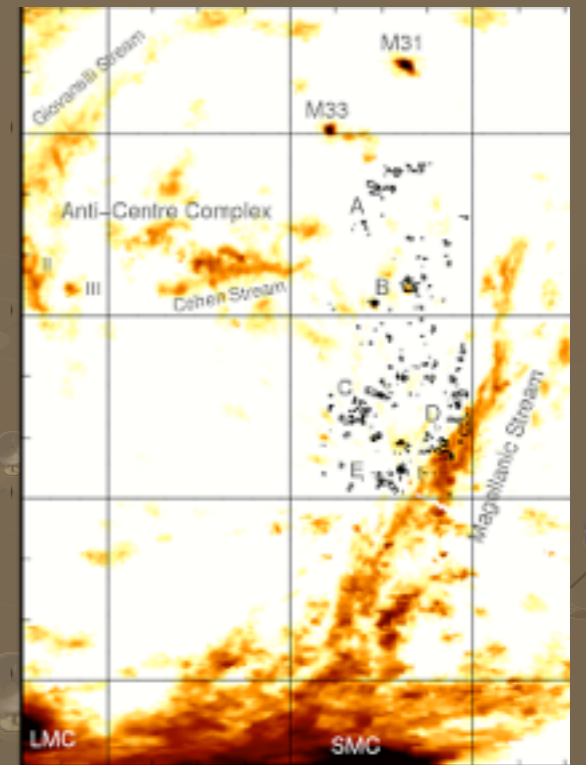
# HISTORY OF HI: LOCAL UNIVERSE

Faint/extended HI required to tell the full story

How do galaxies get their gas:

- cold clouds formation 1st step towards galaxy formation, only accessible in few nearby galaxies

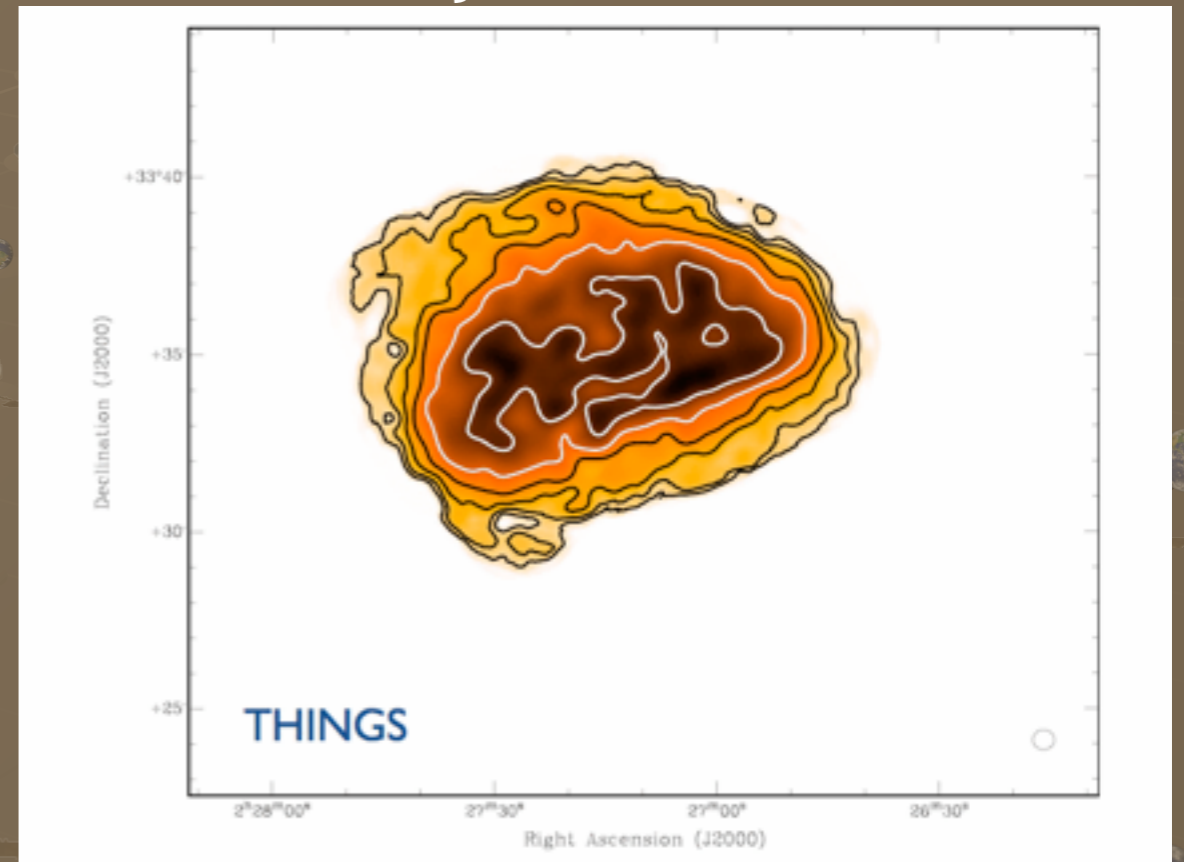
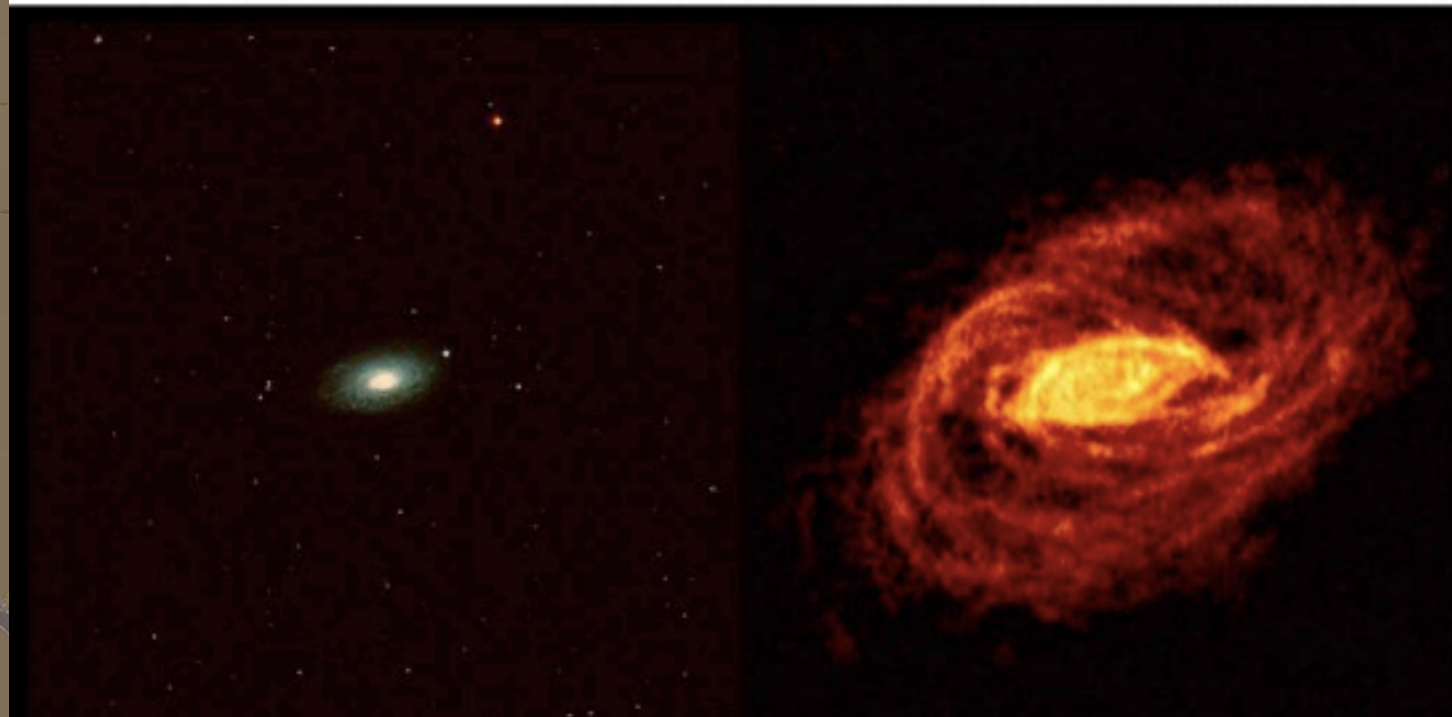
Magellanic Stream feasible in distant galaxies



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optical **NGC 5055** neutral hydrogen WSRT

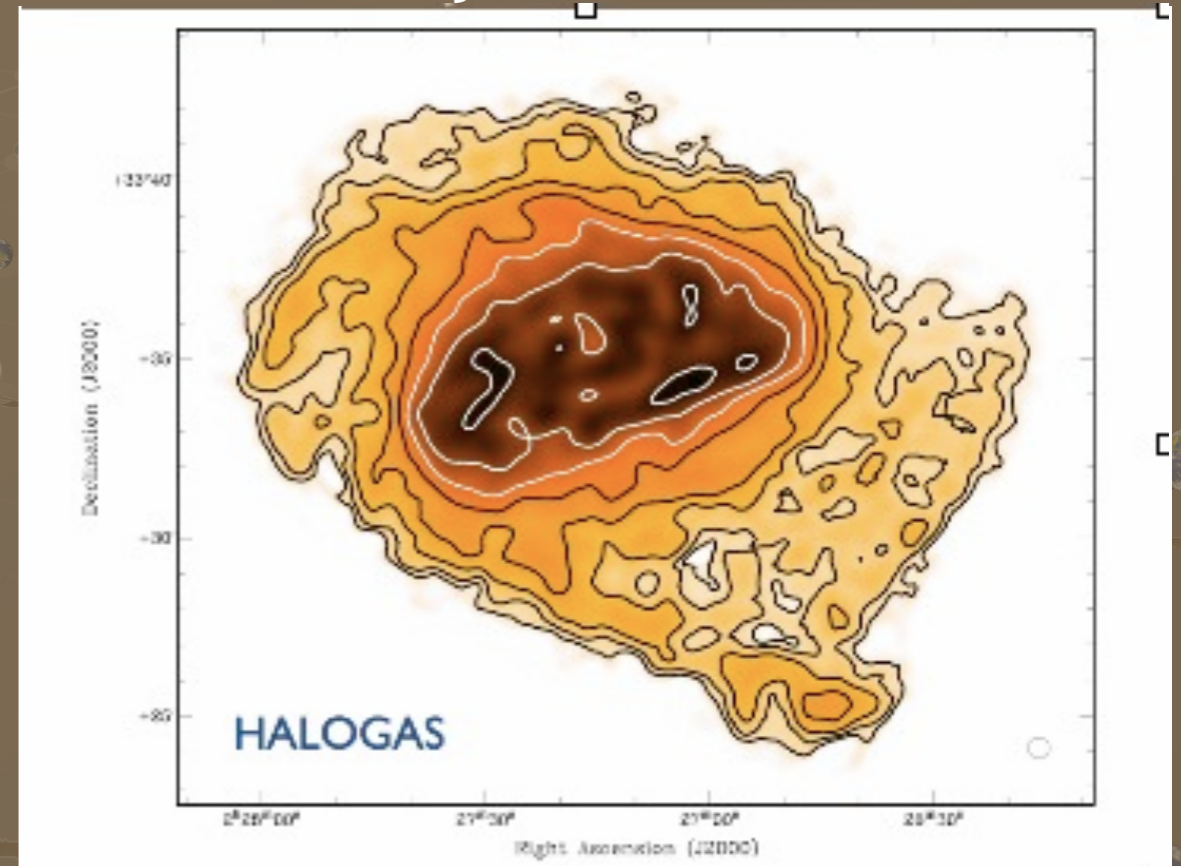
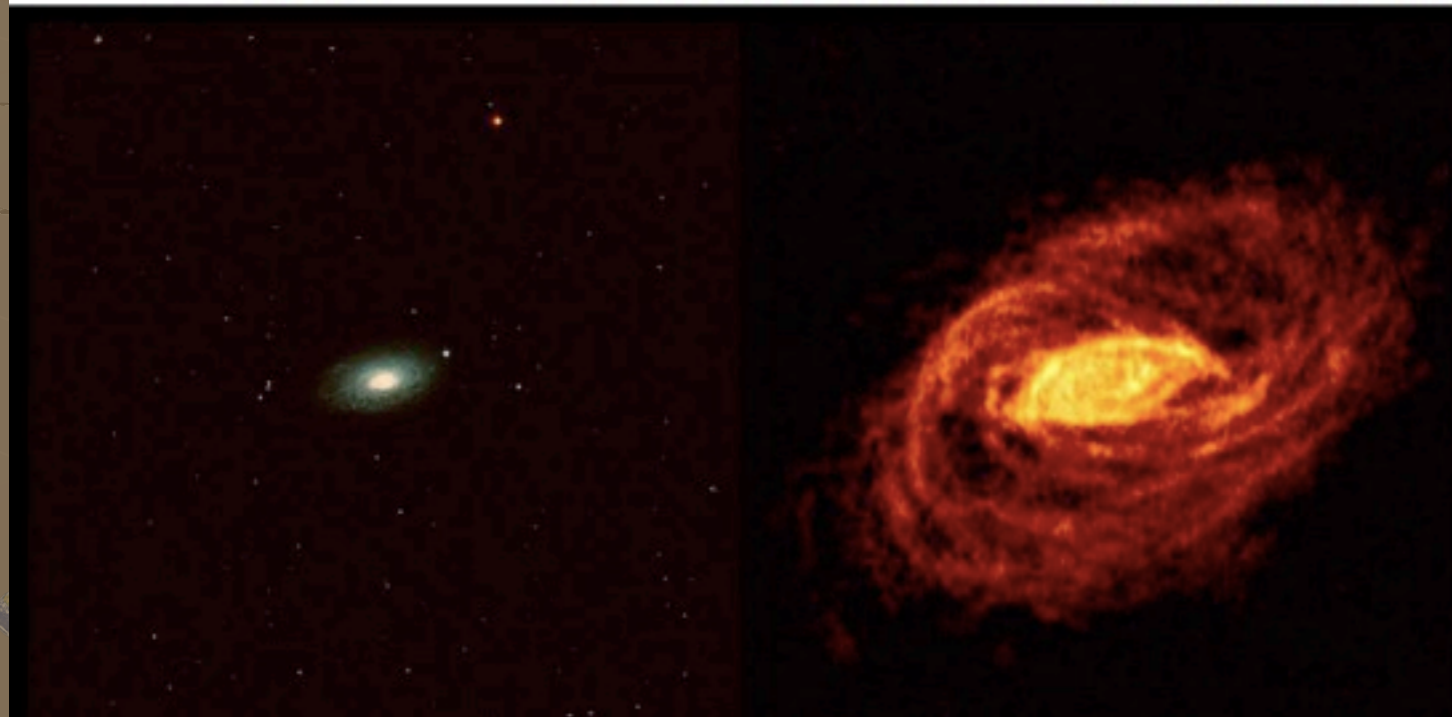


- Extended disks with spiral structure
- Asymmetries, lopsideness
- Clouds, tails, filaments around galaxies
- Reservoirs of extraplanar gas

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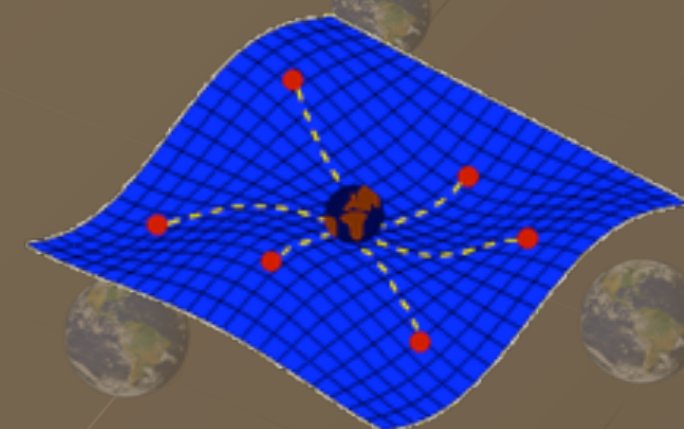
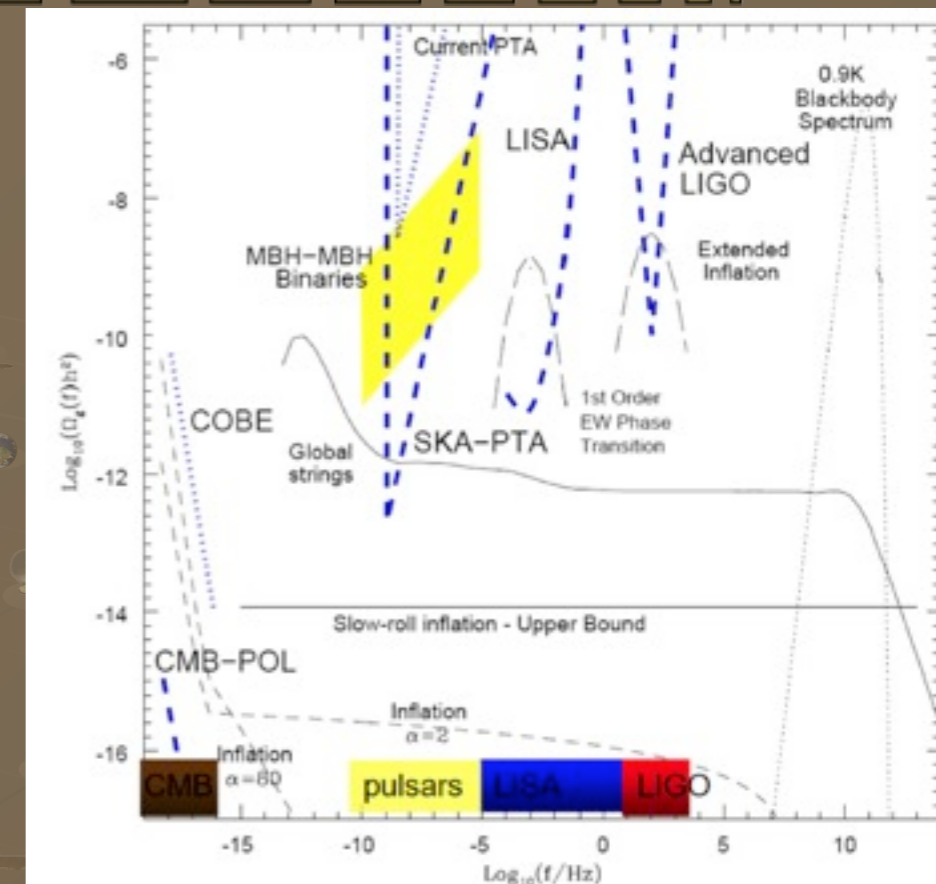
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# GRAVITY TEST

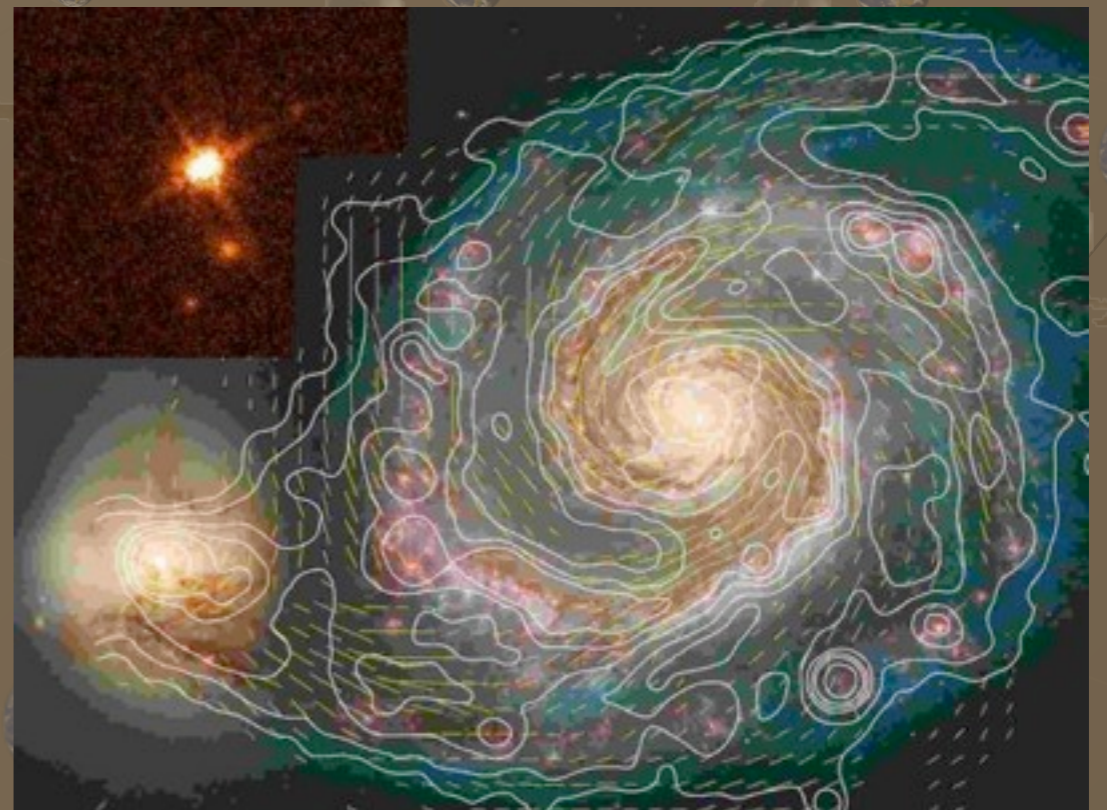
- Strong-field tests:
  - pulsars period in BH gravitational field
  - BHs themselves
- Discovery of 10.000 - 20.000 pulsars
- High precision timing
- Pulsars around MW SMBH
  - spin, mass, quadrupole moment of BH
- Dense array of millisec pulsars
  - precision of  $< 100$  ns: arms of gravitational wave detector
  - LISA : free-falling masses in spacecraft
  - LIGO: suspended mirrors
  - SKA: free falling millisec pulsars



# COSMIC MAGNETISM

- Where does magnetism come from ?
- How does it maintain its strength over billions of years ?
- How magnetism affects the creation of stars and galaxies ?
- How is it distributed in galaxies and clusters of galaxies ?
- How does it evolve with time from the early Universe ?

Magnetism probed by radio waves now:  
only for nearby galaxies



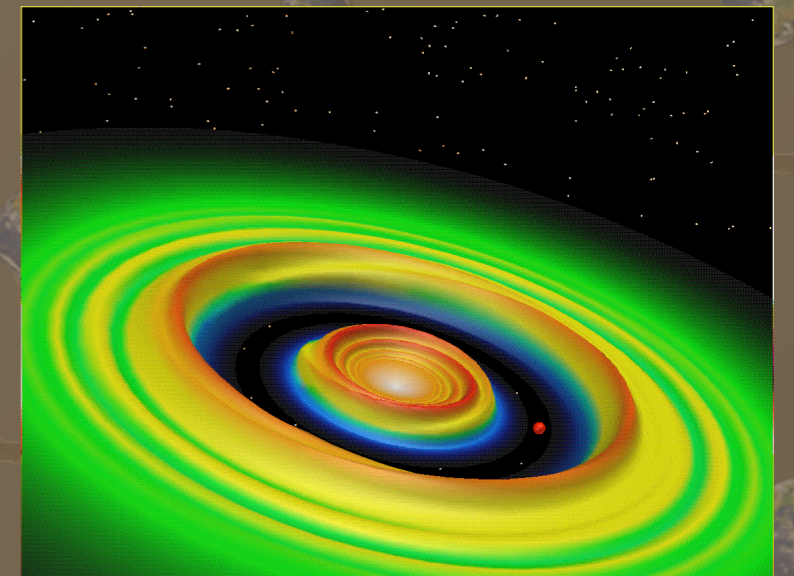
# PROTOPLANETARY DISKS

Imaging, with the required angular resolution, the thermal emission from dust in the inner regions of disks where Earth-like planets are likely to be located

Our solar system @ 500 light-year = 1 arcs

milliarcseconds resolution to map planetary gaps following evolution over orbital timescales

**Requires highest frequencies**



## A **GLOBAL** challenge:

- Antennas
  - Power supply: towards a *GREEN SKA*
  - Massive data transport, storage and processing
  - Science extraction
  - Outreach
- 

Frequency range > two decades:

Combination of different types of antennas



Can observe towards **several directions simultaneously**

Aperture Array

70 - 450 MHz

Baselines 100 km

**SKA1**

single pixel feed

450 MHz - 3GHz

baselines 100 km





## Enhancing FOV



+ focal plane array

dense aperture array

200 - 500 MHz  
200 deg<sup>2</sup>

SKA2

# POWER CONSUMPTION

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Major issue:

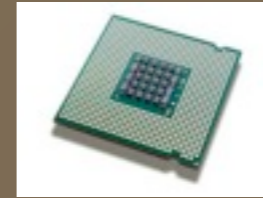
SKA performance maybe power limited

- cooling in the desert
  - concentrated loads
  - distributed loads
- 
- 100 MW for 1 exaflop/s
  - to remote stations (thousands of kms)

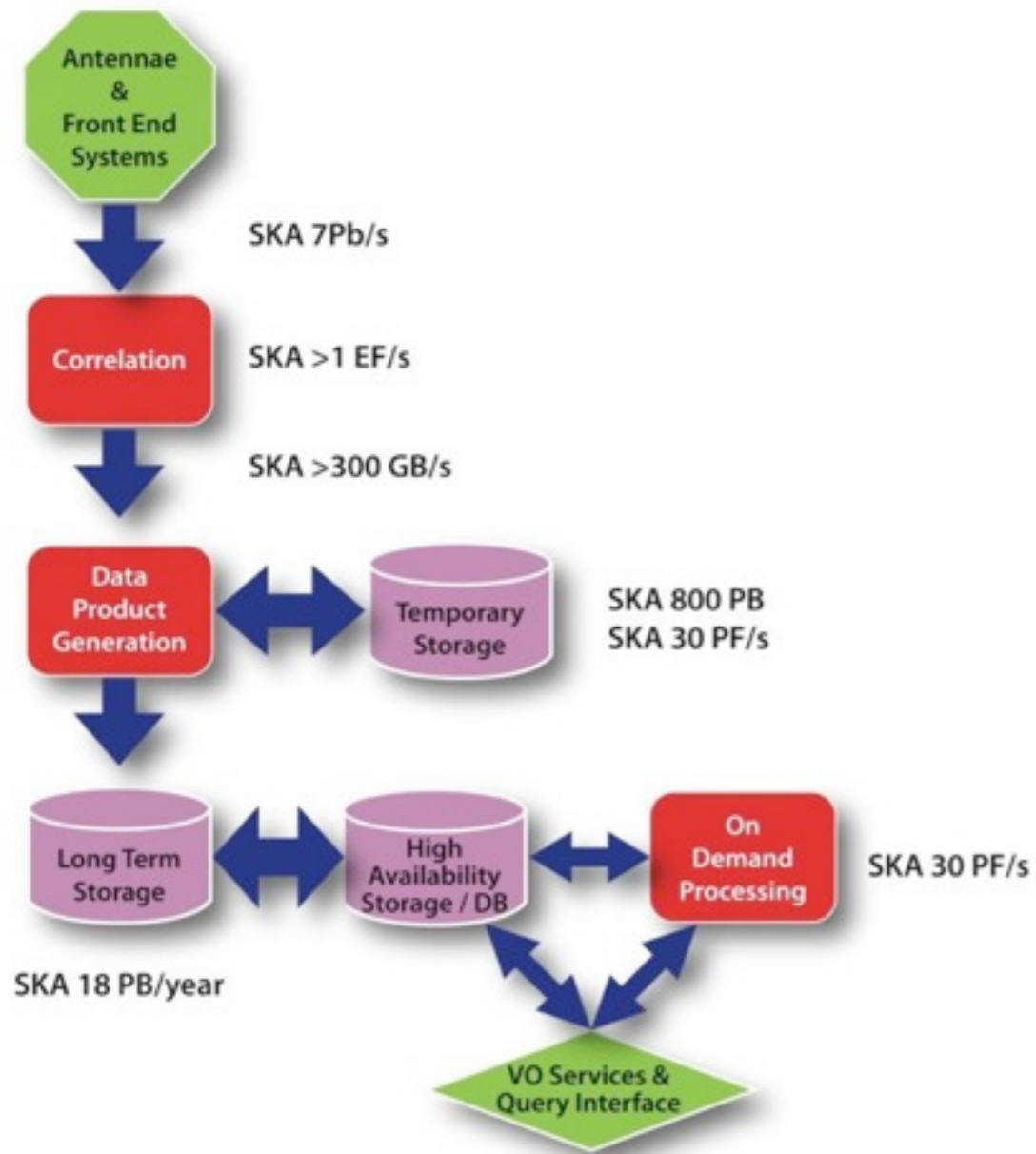
Sustainable energies developments are key for SKA

# MASSIVE DATA TRANSPORT, STORAGE & PROCESSING

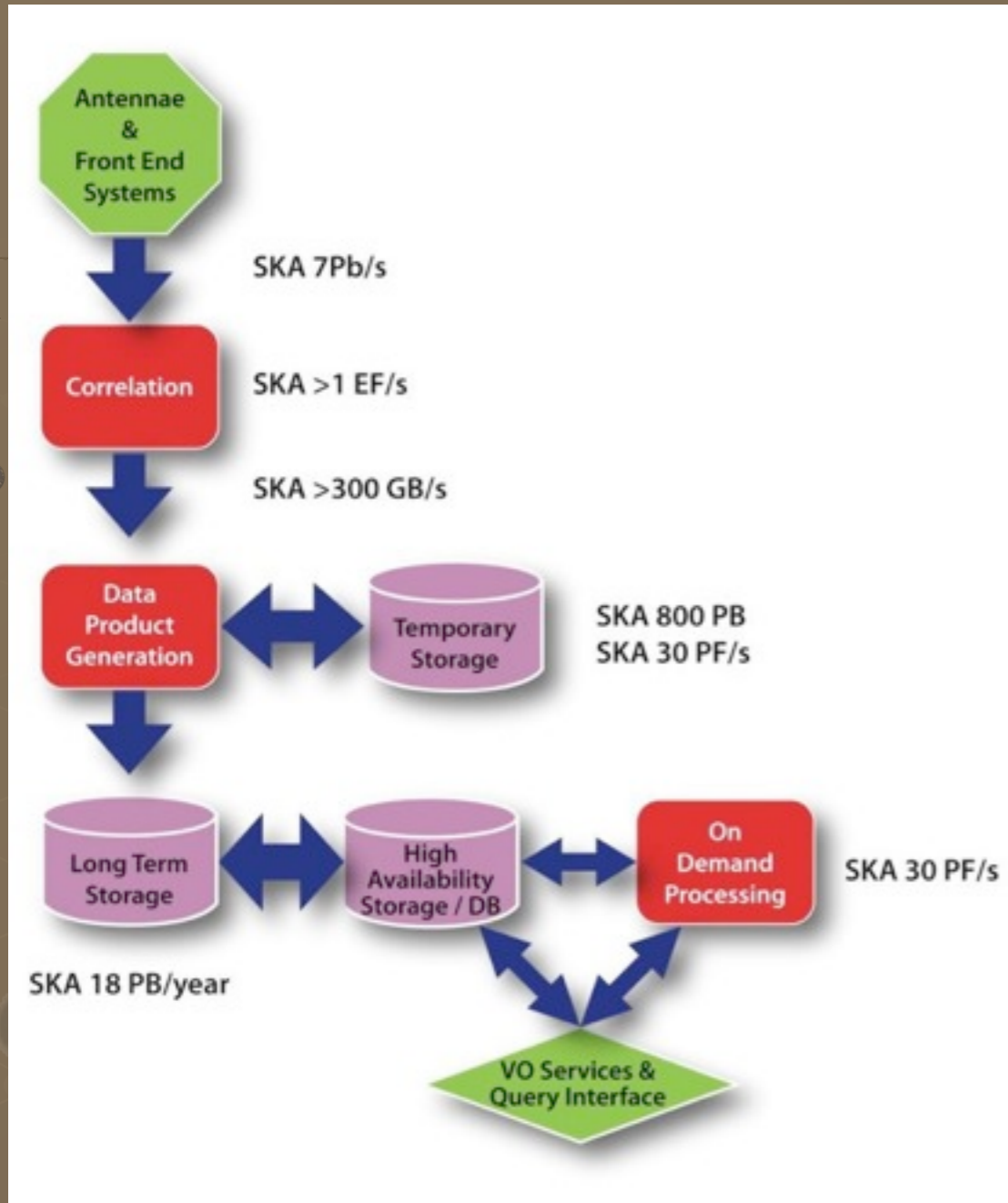
## Processing



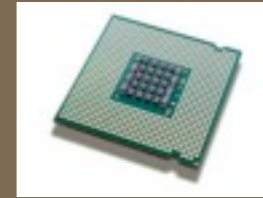
- Processing needs:  
10\*9 top range PCs



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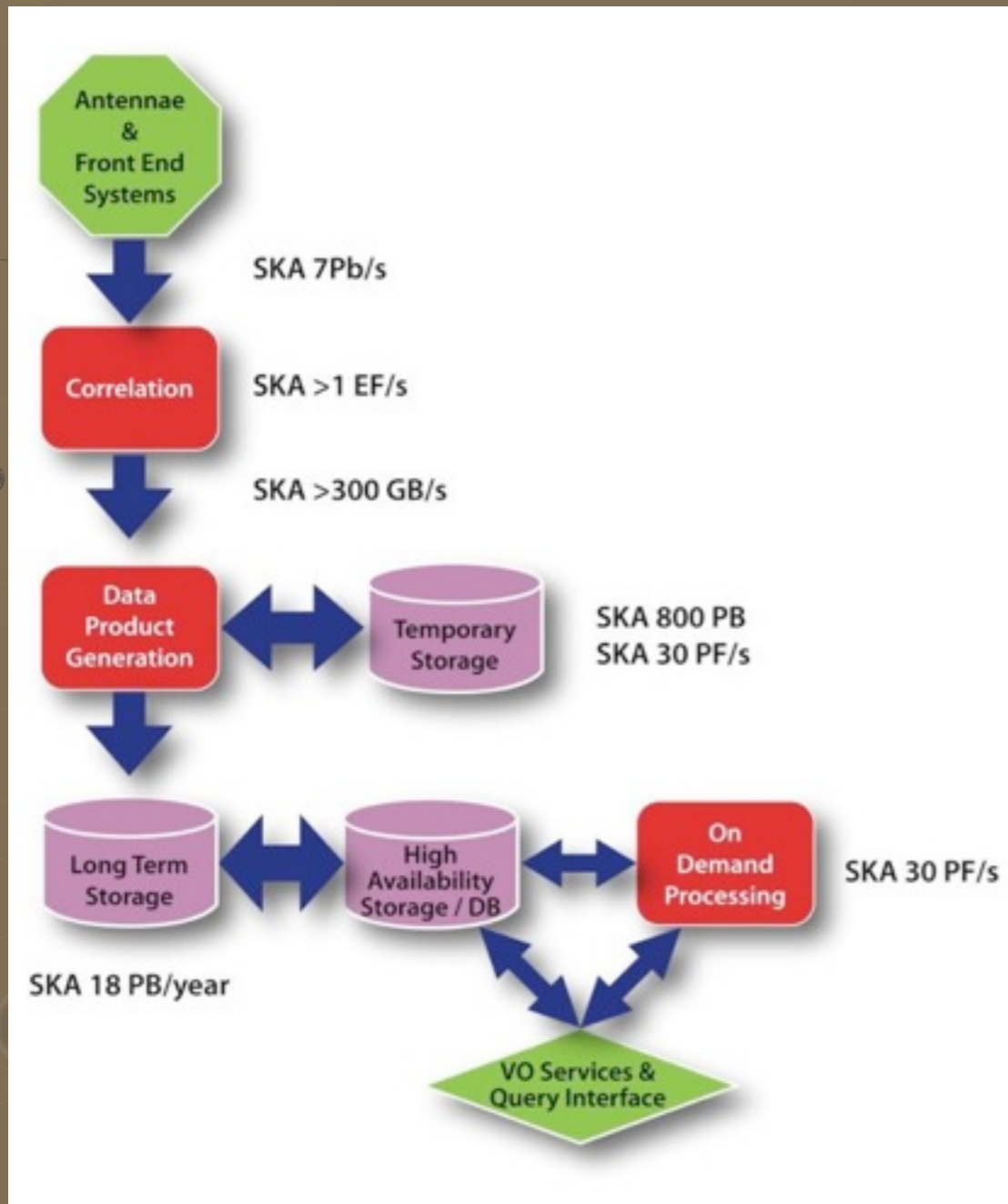
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## Storage

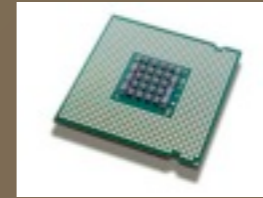


- 1 day = annual world data production

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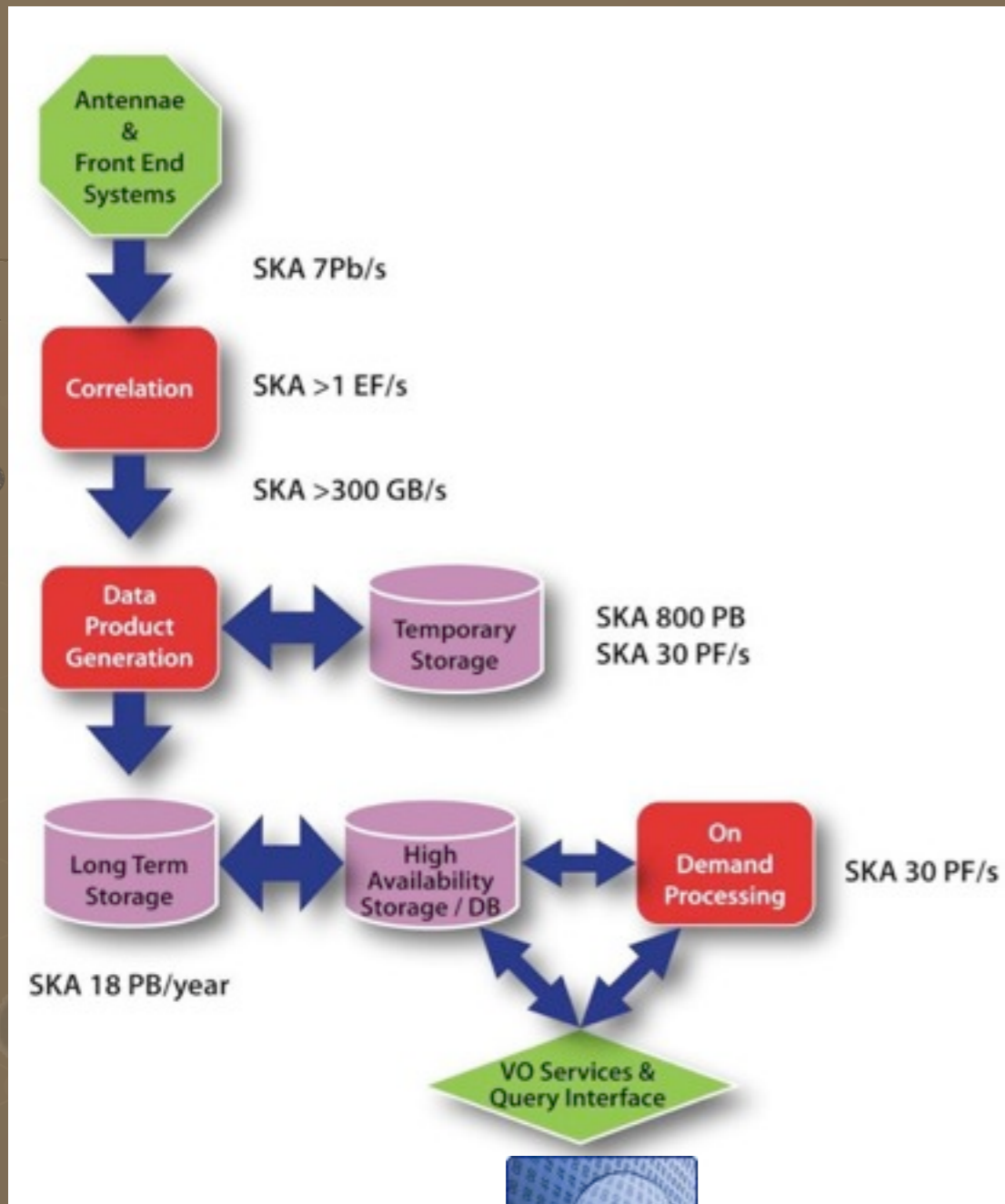
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## Bandwidth



- Typical survey  
1000 cubes = 5 days  
read time @ 10GB/sec
- Aperture arrays =  
250 times current  
**Global Internet**  
traffic

# SCIENCE EXTRACTION

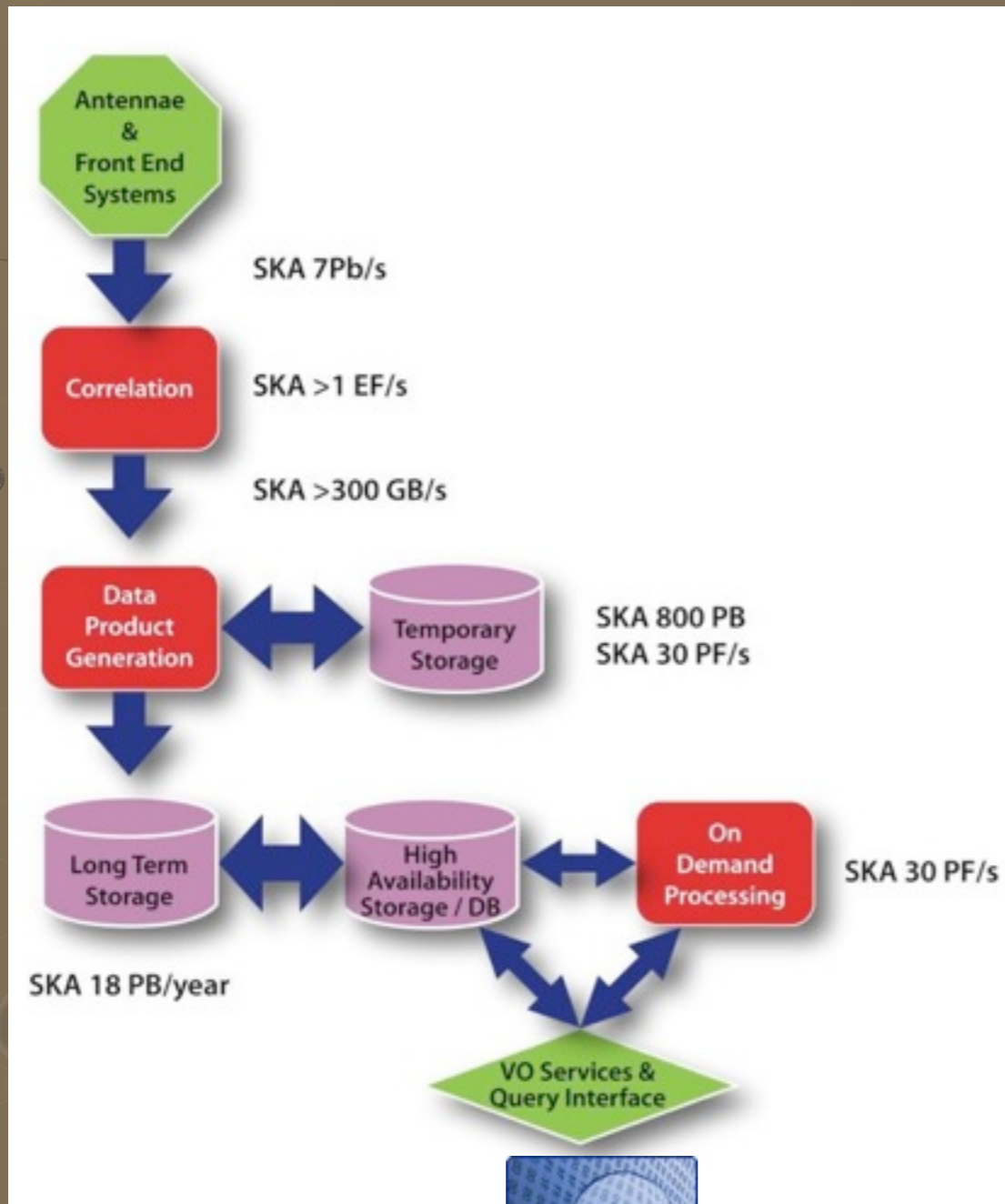


**BUT A NEW CHALLENGE  
STARTS HERE**

# SCIENCE EXTRACTION

Extraction of scientifically relevant information from huge data volumes

- Visualization of enormous catalogs into multiD parameter spaces
  - Efficient packaging of scientific methodology
  - Collaborative science
- Transfer of knowledge to society



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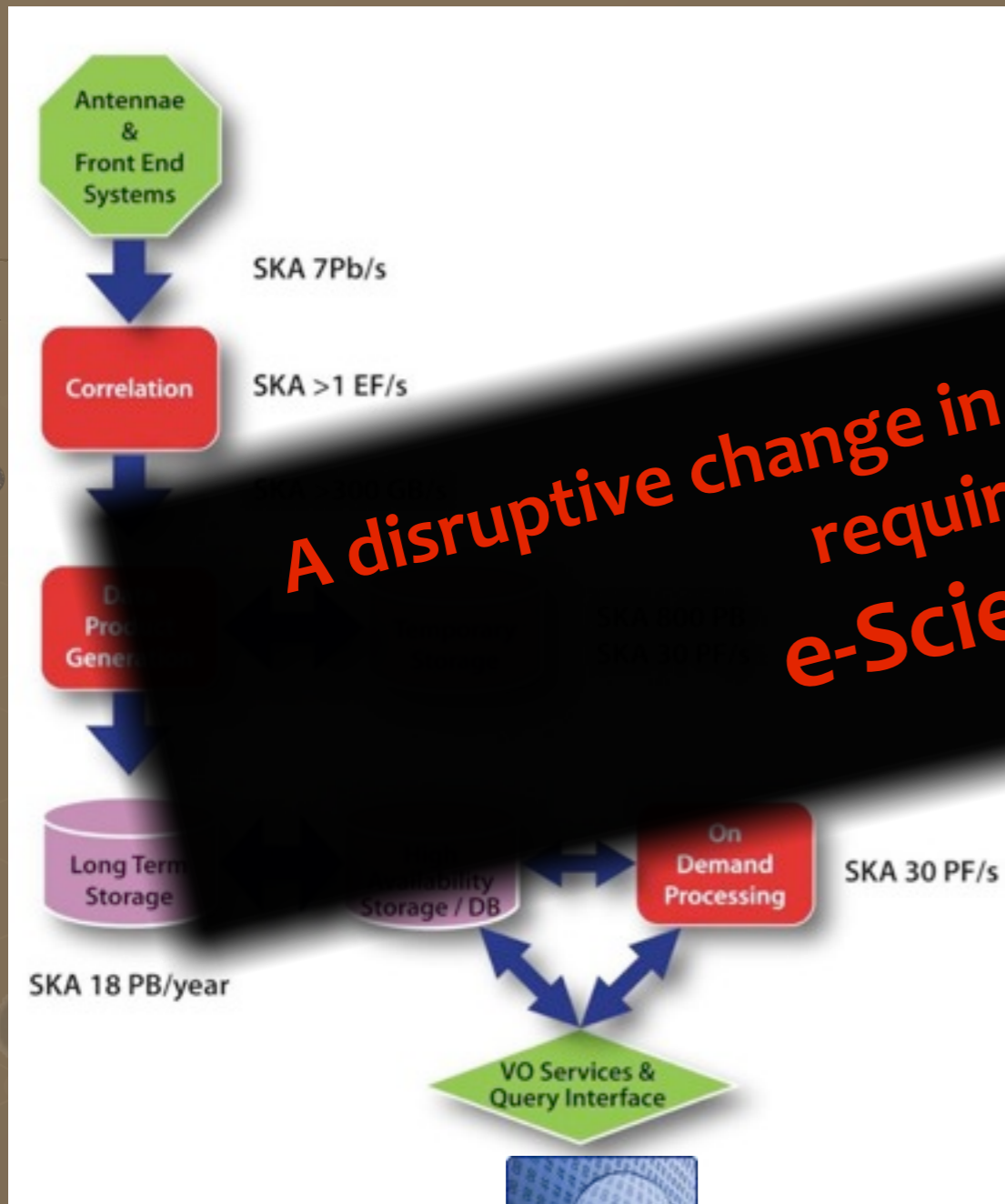
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**A disruptive change in the methodology required e-Science**

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- Efficient packaging of scientific methodology
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# POSSIBLE NICHEs FOR SPANISH PARTICIPATION

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- Outreach (WP1)
- Scientific definition (WP2)
- Antenna Design & Assembly (WP5)
- Receivers (WP5/6)
- LNAs (WP6)
- Design FPGAs/ASICs (WP6/8)
- Control Systems 8P99
- e-Science for petabyte scales (WP2/9)
- Renewable Energies (WP10)

**Spain world leader + Portugal, in position to be major players**

# ONGOING INITIATIVES YOU CAN JOIN

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## **Scientific Network (J. C. Guirado, Univ. Valencia)**

Acción Complementaria para Red Española SKA

Participants:

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

## **Industry Participation (L. Verdes-M., IAA-CSIC)**

Estudio de Viabilidad de Participación Industrial Española  
en SKA (VIA-SKA)

(Subprograma Actuaciones Infraestructuras Científicas Internacionales)

Participants:

IAA, IGN, UGR, UB, UV, CAB-CSIC, UC3M, IFCA-UNICAN,  
IAC