Synergies of SPICA with radio, from cm to mm and submm




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Italian Workshop on SPICA, Monte Mario, 7-8/02/2013

OUTLINE

Main Scientific Topics

Big radio projects:

Sardinia Radio Telescope (cm/mm)
ALMA (mm/submm)
GMVA (mm- VLBI)
EHT (submm-VLBI)
LOFAR (cm)
SKA & precursors (cm)

Synergy between IR and radio on :

Star formation – galactic and extragalactic

radio cm emission from relativistic electrons accelerated by SN

mm free-free emission from excited HII regions

mm and submm thermal em from cold objects

Planetary disks

direct observations in mm/submm , high resolving power, ability to see fine details

cm emission from giant planets like Jupiter, characterized by strong magnetic fields

"water hole"

Synergy between IR and radio (cont.) :

Interstellar medium

radio: thermal emission of cold regions

many complex molecules

AGN

different components at different wavelenghts

radio: jets, regions close to the BH

Early Universe

early objects, EoR (redshifted HI)

Synergy between IR and radio (cont.) :

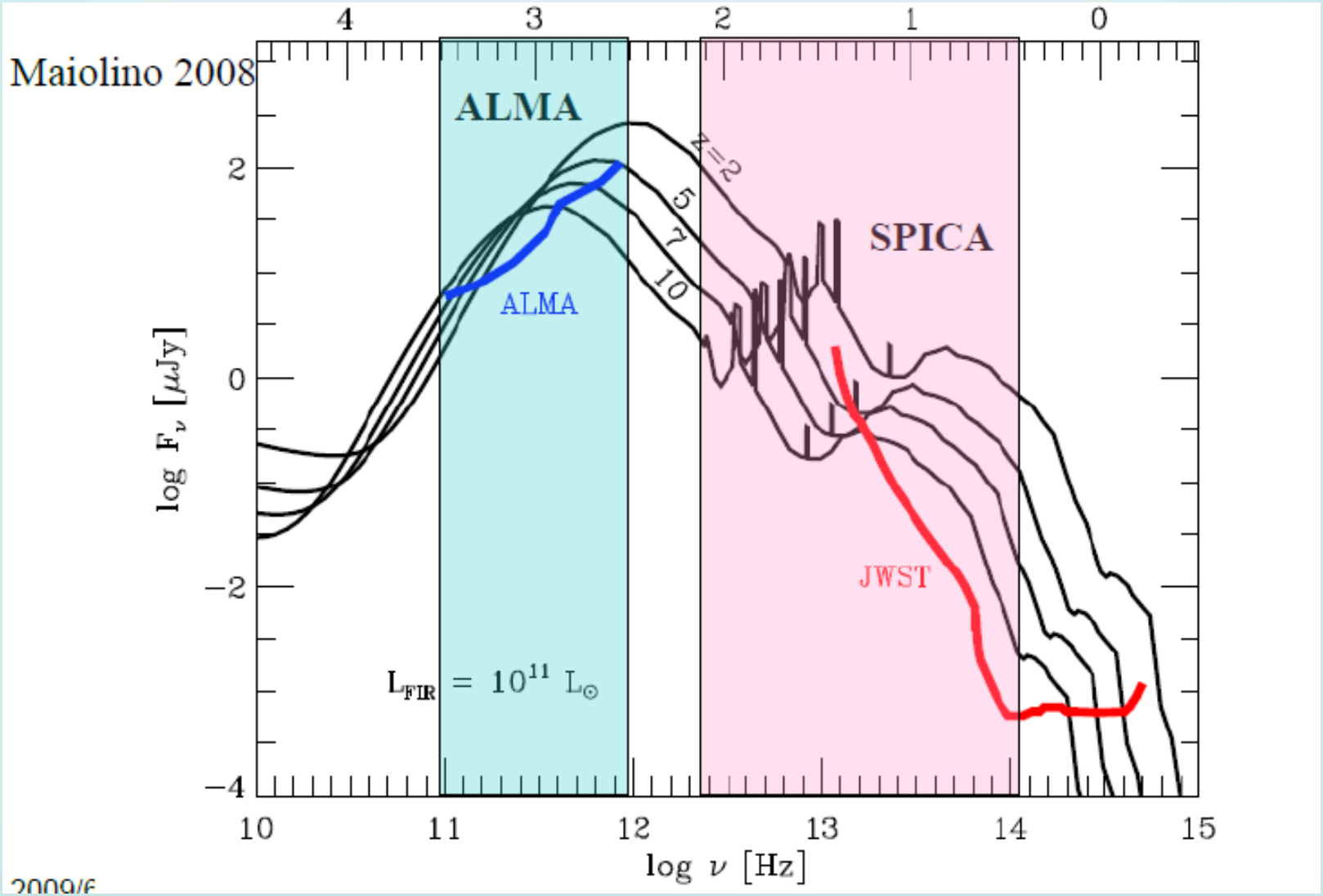
Surveys

the microJy and nanoJy radio sky

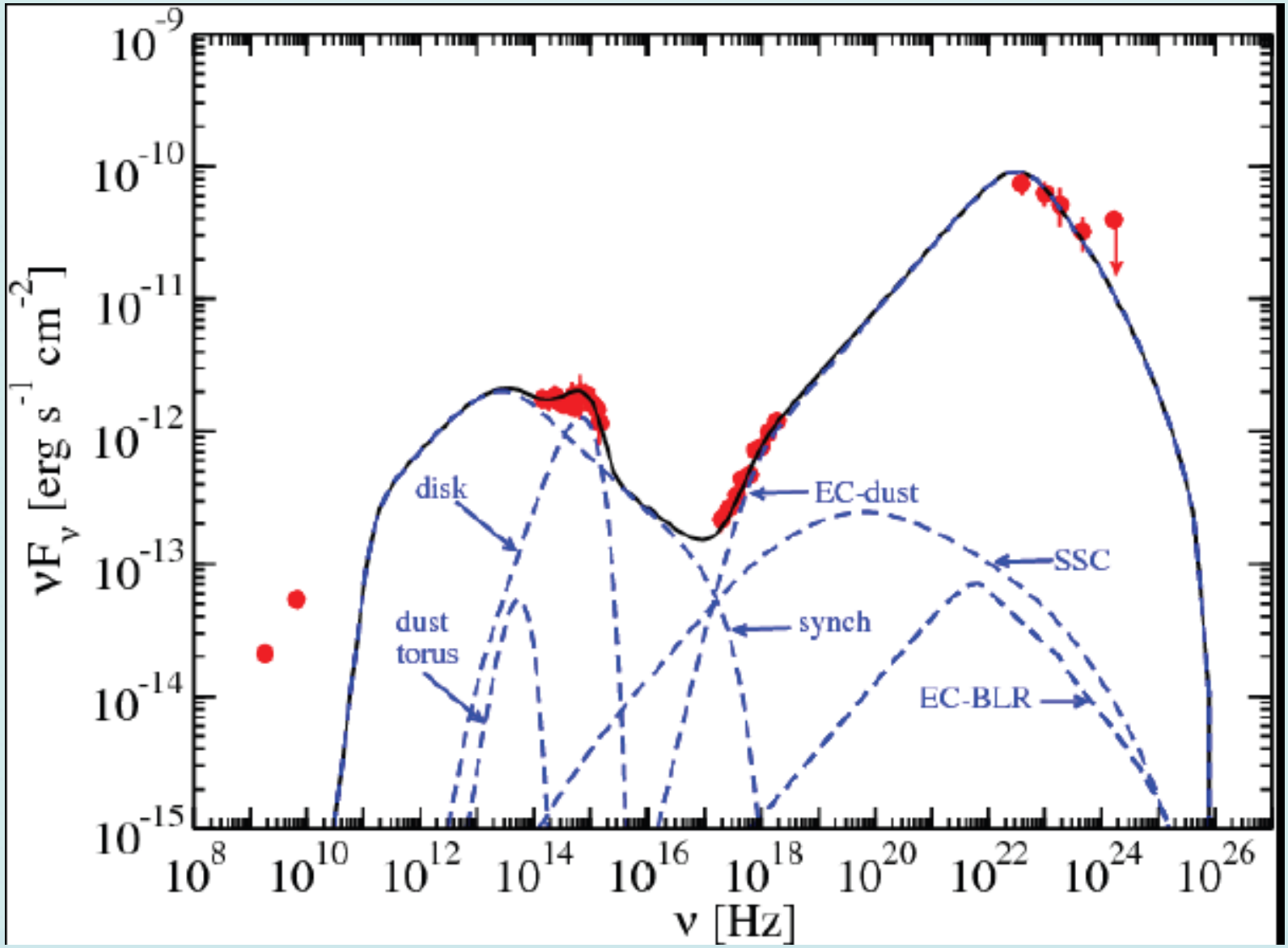
Radio - infrared surveys:

- separate AGN from SFG
- what is the role of AGN in galaxy formation and evolution
-co-existence and co-evolution of AGN and star formation in galaxy evolution (trigger of SF in galaxy collisions, quench of SF due to AGN feedback

SED of a Star Forming Galaxy
scaled from the SED of M82



PKS 2123-463 : a gamma ray blazar at z=1.67



D'Ammando et al. 2012

Radio Projects

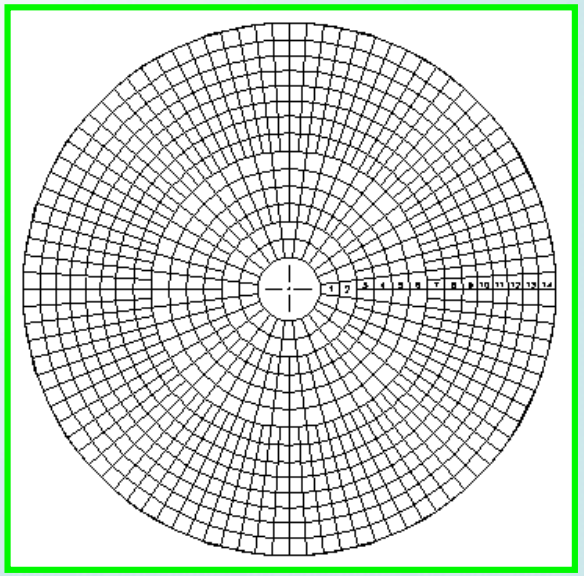
Sardinia Radio Telescope SRT

Fully steerable, 64m diameter, paraboloidal radio telescope.

Alt- Azimuth mounting

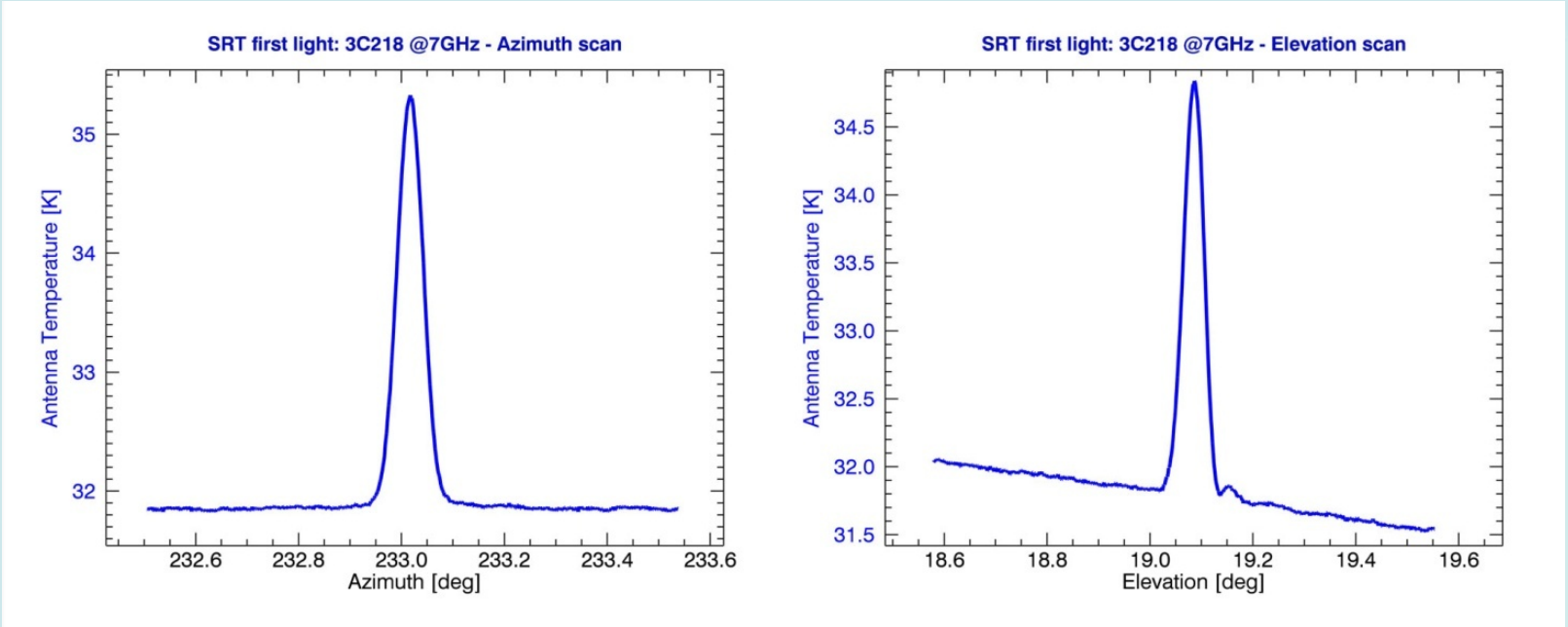
Fiber optic connection

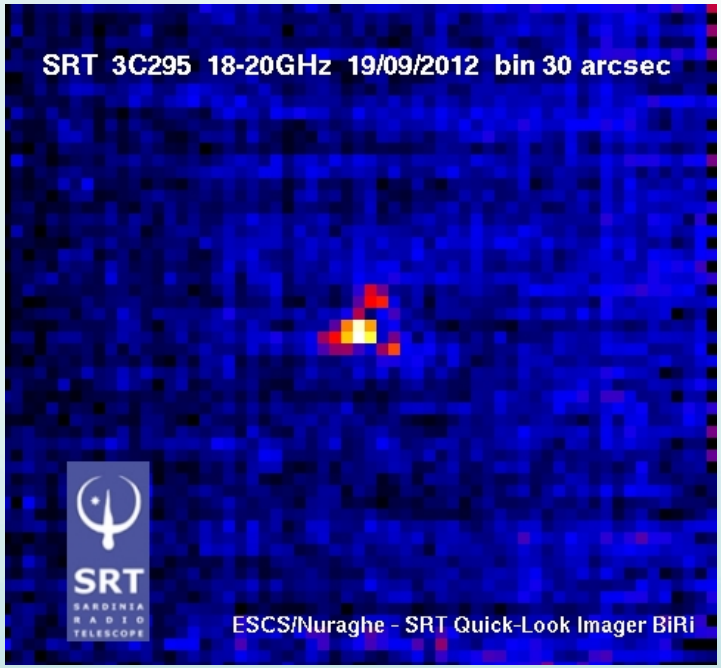
Transmitting capabilities



Main reflector active surface:

1008 panel + 1116 mechanical actuators

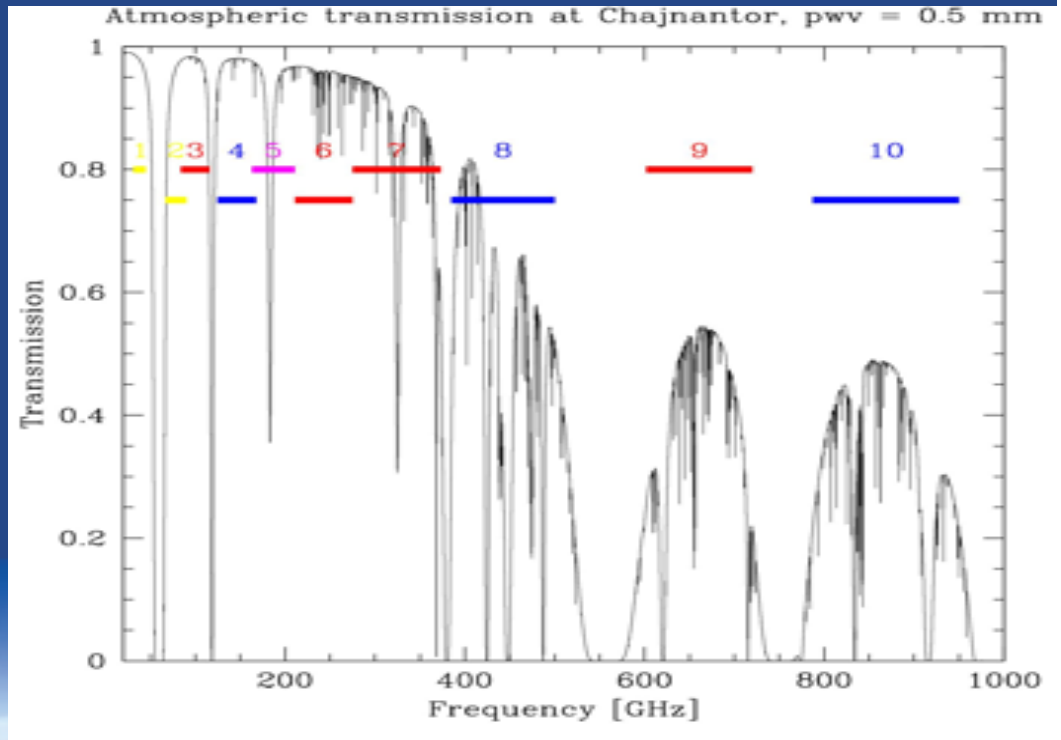


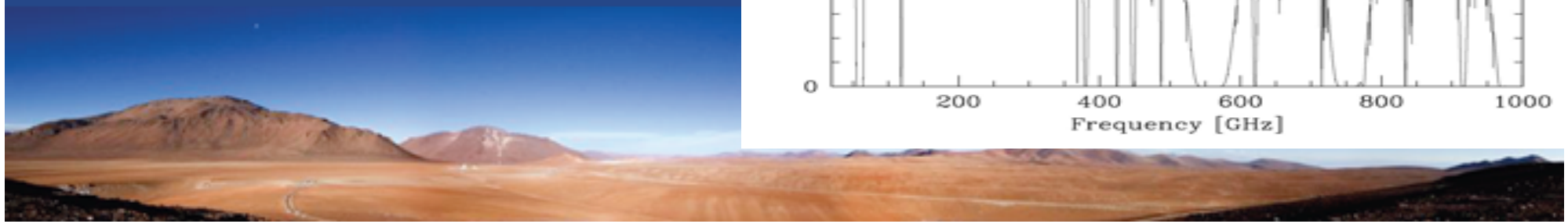


First light
First image

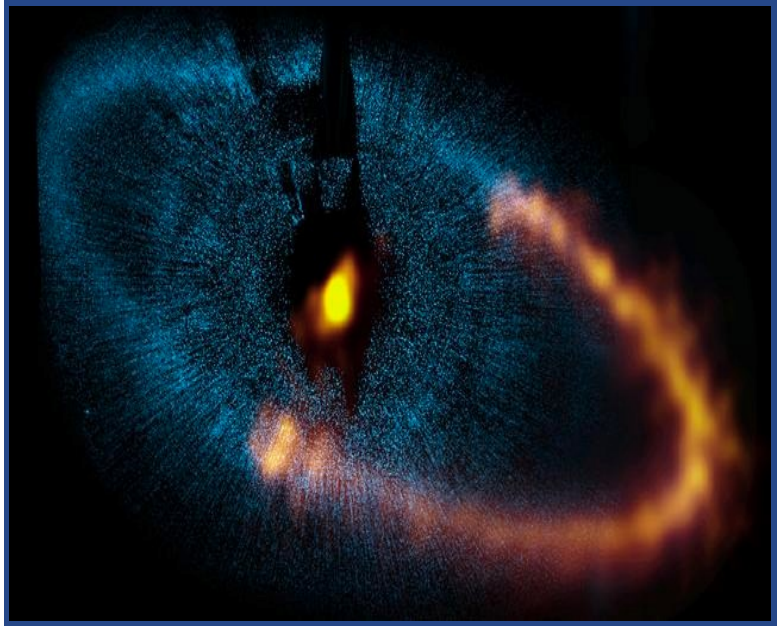
ALMA numbers

- The Atacama Large Millimeter Array is a **mm-submm reconfigurable interferometer**
- Under construction on the Chajinantor plain (**5000m**, Chile)
- Frequency range: **10 bands between 30-900 GHz** (0.3-10 mm)
- Antennas: **50x12m** main array + (**12x7m + 4x12m**) ACA
- Baselines length: **15m ->150m-16km** + **9m->50m**
- Resolution: **0.2" x (300/freq_GHz)x(1km/max_baseline)**
- FOV 12m array: **20.3"/(300/freq_GHz)**
- Bandwidth: **2 GHz x 4basebands for each of 2 polarisations**
- **World wide collaboration:**
- Europe: ESO (14 countries),
- North America: NRAO (USA, Canada),
- East Asia: NAOJ (Japan, Taiwan),
- Chile
- Contributors share the observing time





A taste of what was already done: Cycle 0



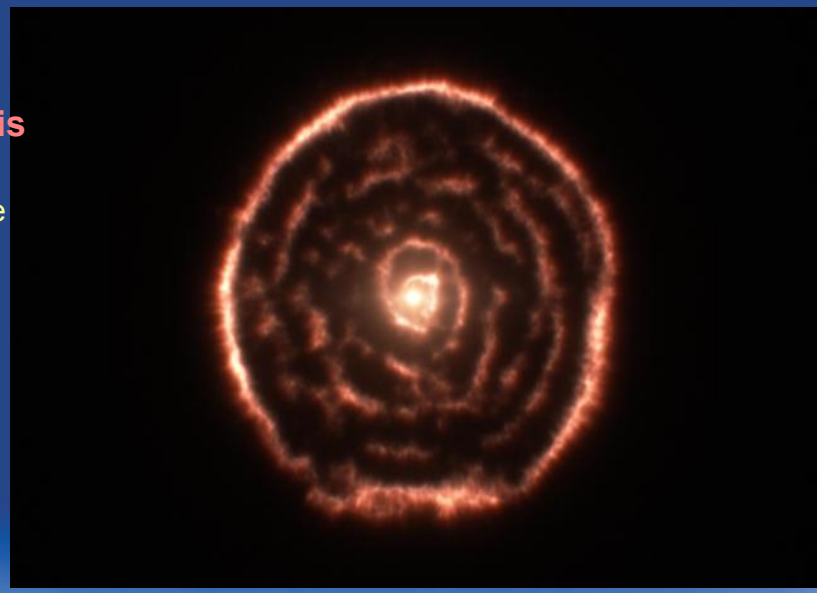
ALMA Reveals Workings of Nearby Planetary System observing a ring around the bright star Fomalhaut

This view shows a new picture of the dust ring around the bright star Fomalhaut from the Atacama Large Millimeter/submillimeter Array (ALMA). The underlying blue picture shows an earlier picture obtained by the NASA/ESA Hubble Space Telescope. The new ALMA image has given astronomers a major breakthrough in understanding a nearby planetary system and provided valuable clues about how such systems form and evolve. Note that ALMA has so far only observed a part of the ring.

ALMA resolution is comparable to HST

Curious spiral spotted by ALMA around red giant star R Sculptoris

Observations using the Atacama Large Millimeter/submillimeter Array (ALMA) have revealed an unexpected spiral structure in the material around the old star R Sculptoris. This feature has never been seen before and is probably caused by a hidden companion star orbiting the star. This slice through the new ALMA data reveals the shell around the star, which shows up as the outer circular ring, as well as a very clear spiral structure in the inner material.



A taste of what was already done: Cycle 0

Side-by-side comparison of ALMA observations and artist's impression of the disc and gas streams around HD 142527

Left: observations made with the Atacama Large Millimeter/ submillimeter Array (ALMA) telescope of the disc of gas and cosmic dust around the young star HD 142527, showing vast streams of gas flowing across the gap in the disc. These are the first direct observations of these streams, which are expected to be created by giant planets guzzling gas as they grow, and which are a key stage in the birth of giant planets.

The dust in the outer disc is shown in red. Dense gas in the streams flowing across the gap, as well as in the outer disc, is shown in green. Diffuse gas in the central gap is shown in blue. The gas filaments can be seen at the three o'clock and ten o'clock positions, flowing from the outer disc towards the centre. The dense gas observed is HCO+, and the diffuse gas is CO. The outer disk is roughly two light-days across. If this were our own Solar System, the Voyager 1 probe — the most distant manmade object from Earth — would be at approximately the inner edge of the outer disk.

Right: artist's impression of the disc and gas streams, for illustration.

Contact details

Follow the ALMA news on http://www.alma.info/en/home

Enter the ALMA world through the Science Portal www.almascience.org

Send your request to the Italian ARC www.alma.inaf.it help-desk@ira.inaf.it

The Global Millimeter VLBI Array (GMVA)

Imaging with ~40 μas resolution at 86 GHz

Baseline Sensitivity

in Europe:

30 – 300 mJy

in US:

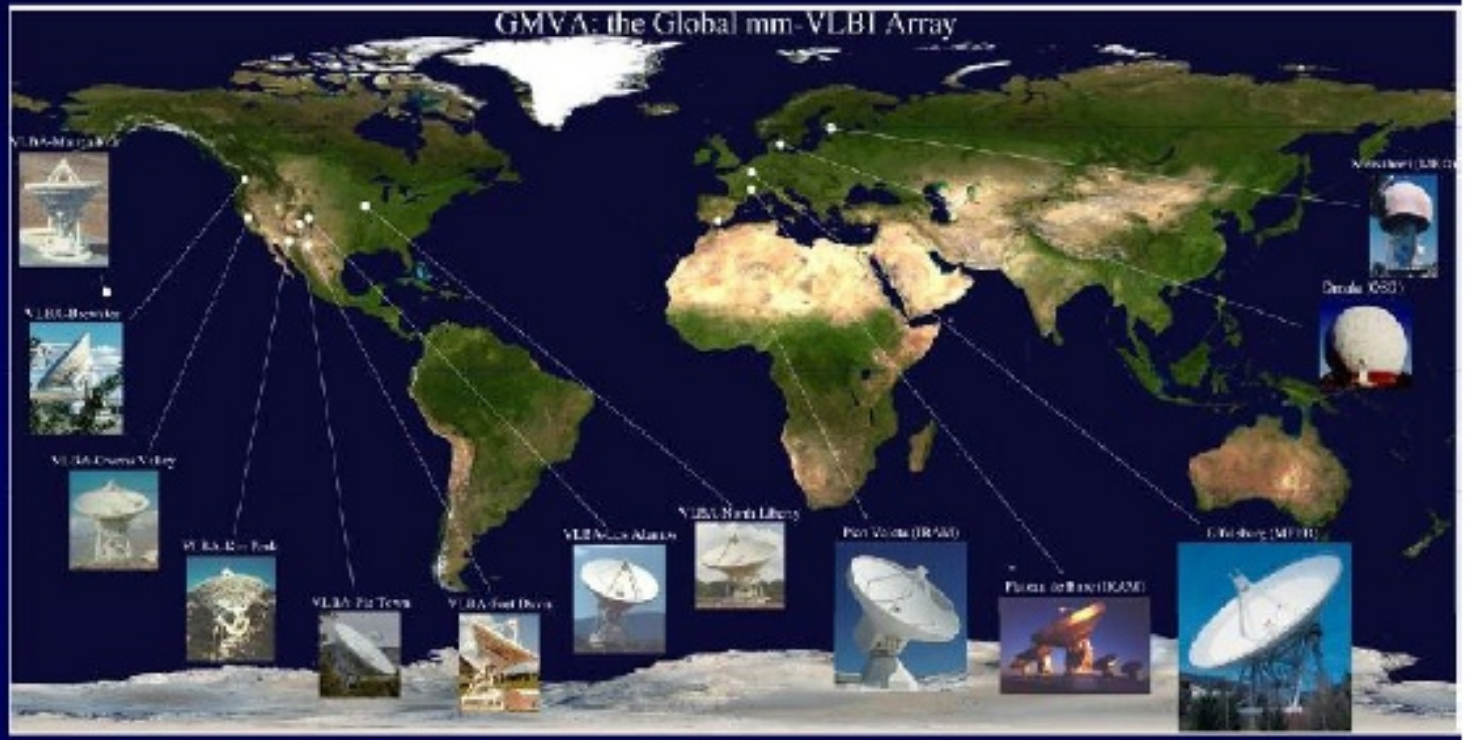
100 – 300 mJy

transatlantic:

50 – 300 mJy

Array:

1 – 3 mJy / hr



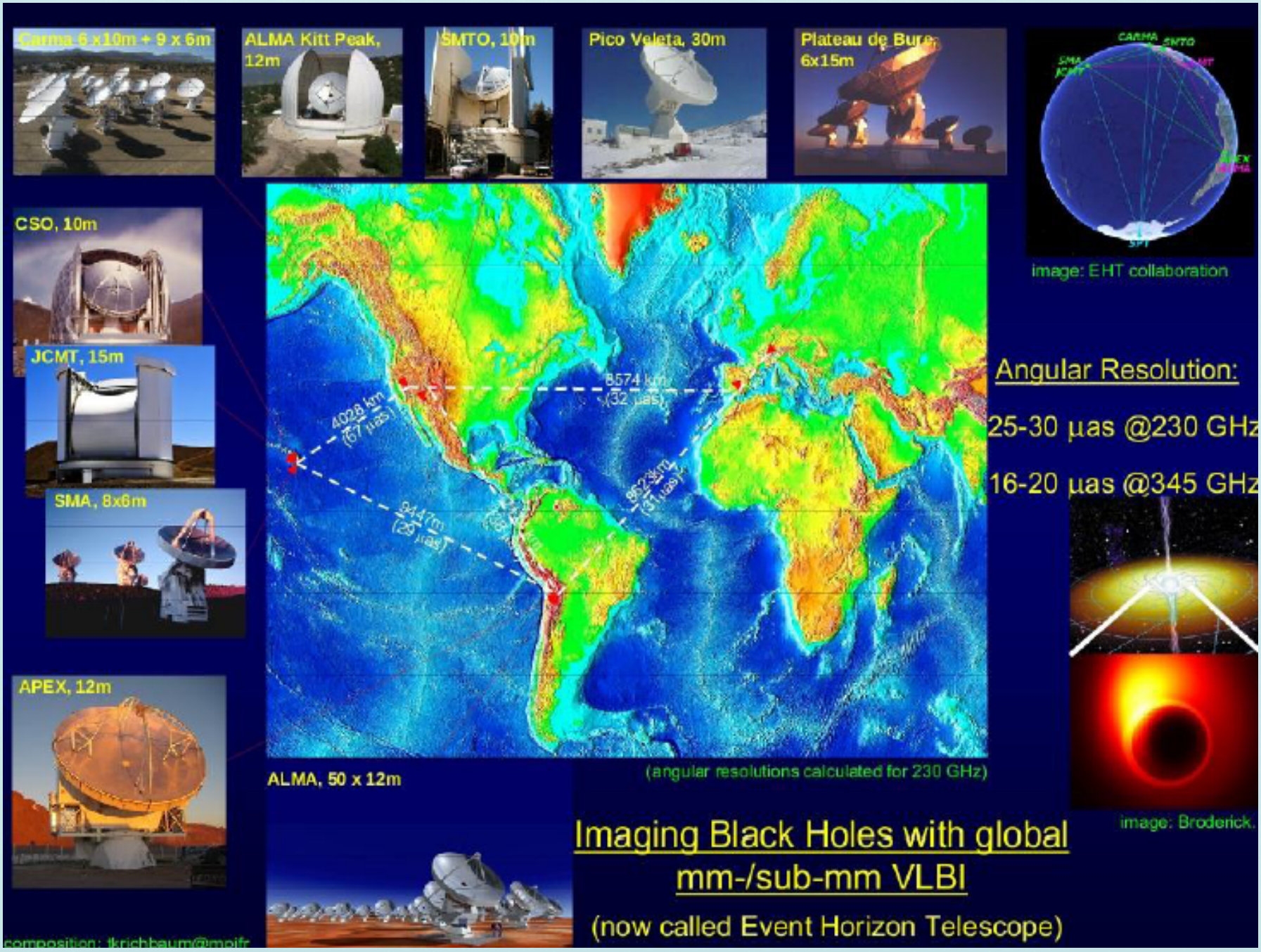
(assume 7σ, 100sec, 512 Mbps)

http://www.mpifr-bonn.mpg.de/div/vlbi/globalmm

- Europe: Effelsberg (100m), Pico Veleta (30m), Plateau de Bure (35m), Onsala (20m), Metsähovi (14m), Yebes (40m), planned: GBT (100m), KVN, SRT, ALMA, ...
- USA: 8 x VLBA (25m)

Proposal deadlines: February 1st, August 1st

Event Horizon Telescope



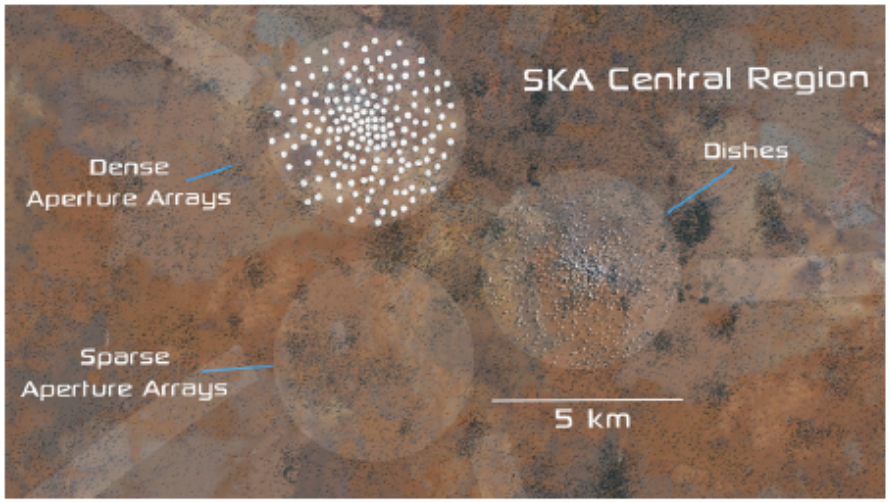
LOFAR: Low Frequency Array

10-240 MHz

120-240 MHz 30-80 MHz

SKA

SQUARE KILOMETRE ARRAY



SKA Specifications

Frequency : 70 MHz ÷ 25 GHz
Bandwidth : ± 50% of frequency
Spectral channels: 16384 per band per baseline

Rms Sensitivity : 400 μJy in 1 min at 70-300 MHz
200 μJy in 1 min at 0.3-10 GHz

Field of view: 200 deg^2 at 70 MHz
200-1 deg^2 at 0.07-1 GHz
1 deg^2 at 1-10 GHz

At least 4 simultaneous FoV

Maximum baseline : > 3000 km

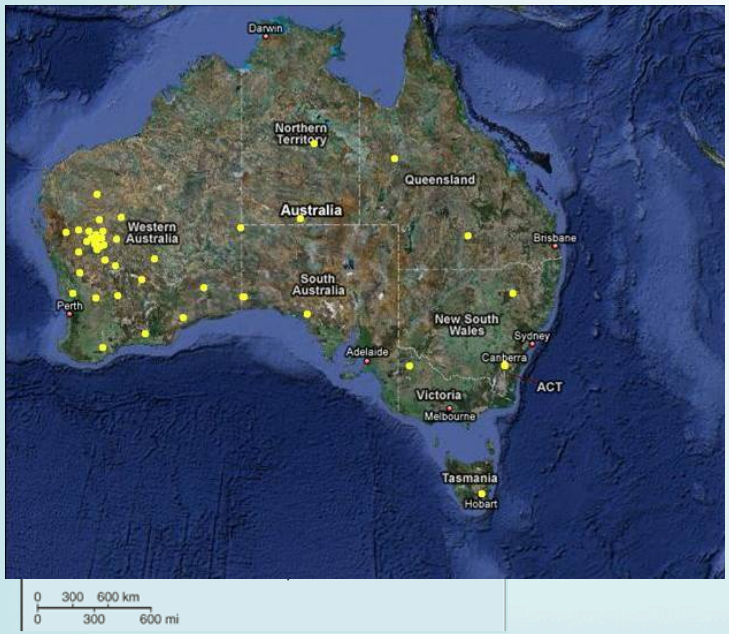
Angular resolution : < 0.1"

Calibrated polarization purity: 10000:1

Image dynamic range : > 1.000.000

SKA Site

Extremely radio quiet environment
At least 3000 km in extent
Low ionospheric turbulence
Low tropospheric turbulence



Australia
ASKAP

South Africa + 8 countries
MeerKAT

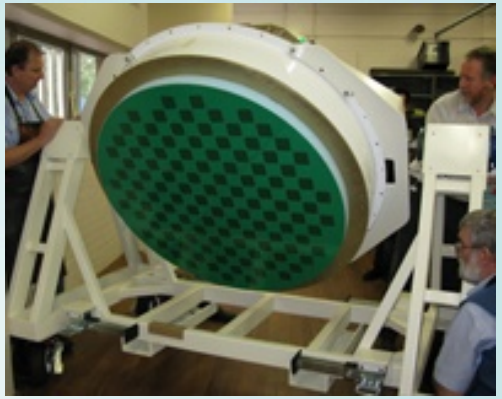
ASKAP (Australia SKA Precuror)

36 dishes, each 12m diam, equipped with PAF

30^{o2} field of view FoV
simultaneous beams

0.7-1.8 GHz, bandw 0.3 GHz, 16000 channels
➔ 20" res at 1.4 GHz,

max baseline ~ 6 km



Phased Array Feed (PAF) : 30 separate /simultaneous beams of 1 sq deg to give a FoV of 30 square degrees at 1.8 GHz

Meer KAT (South Africa SKA Precuror)

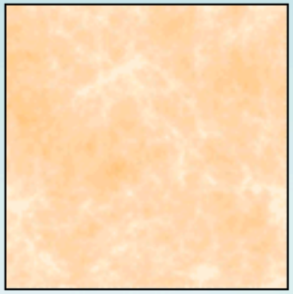
64 dishes

13.5 m diam

0.5 – 14.5 GHz
Centrally condensed,
maximum baseline ~ 20 km

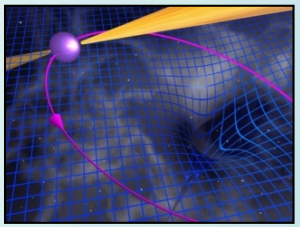
KAT 7 : 7 dishes
made of fibre glass
freq 1.2 – 1.95 GHz
max baseline 185 m

SKA Key Science Projects



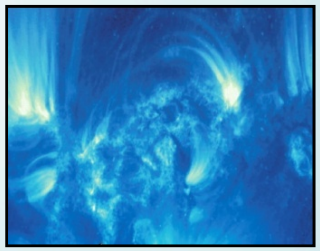
Origin of the Universe :

1. Formation of first objects/EoR
2. Evolution of galaxies/ Cosmology/ DE



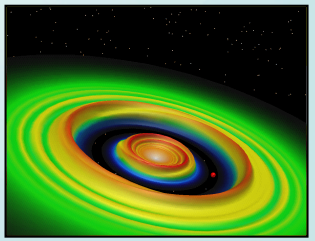
Fundamental Physics :

3. Pulsars/ General Relativity/ Gravitational Waves
4. Cosmic Magnetism



Origin of life :

5. Cradle of life and intelligent life



Total intensity survey : down to sub-μJy flux level

The MicroJy and NanoJy Radio Sky: Source Population and Multi-wavelength Properties

2011

Paolo Padovani*
European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching bei München, Germany

All objects that will be detected from currently planned all-sky surveys in X-rays, optical, infrared, will have **a radio counterpart** with SKA.

On large areas of the sky, and at lowest flux levels (< 0.1 μJy), radio sources detected with SKA will have no counterparts: rely only on radio information for size, morphology redshift, etc.

Optical/IR match : on small areas

Padovani 2011

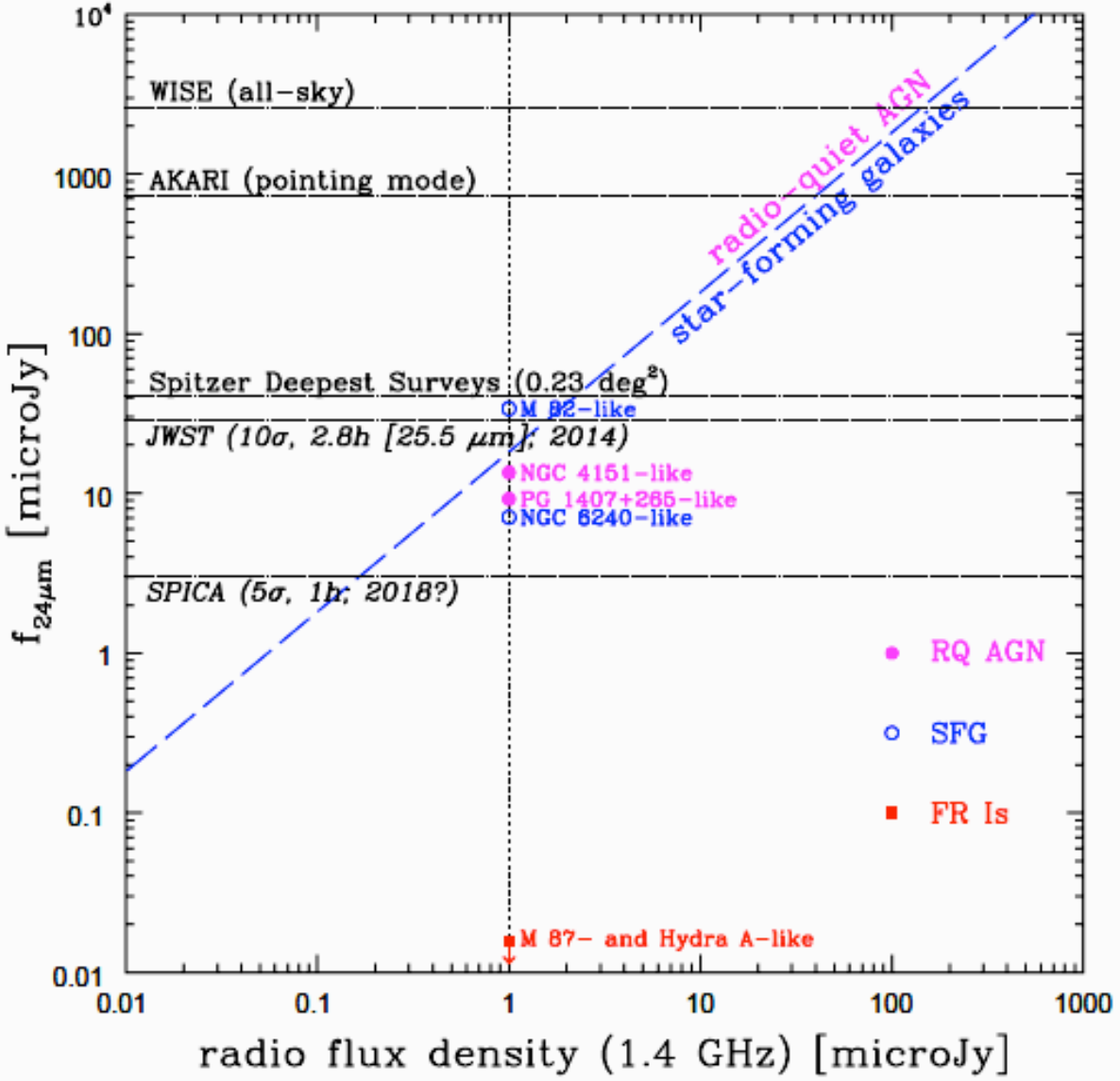


Figure 4. 24μm flux density vs. the 1.4 GHz radio flux density for faint radio sources. The diagonal dashed line represents the locus of SFG and radio-quiet AGN based on the "IR-radio relation". The scaled IR flux densities of prototypical representatives of the three classes at $S_{1.4\rm GHz} = 1$ μJy are also shown, with FR Is being so faint as to be actually off the plot at $f_{24\mu m} \sim 0.2-0.8$ nanoJy. The horizontal dot-dashed lines indicate the approximate point-source limits of (from top to bottom): WISE, AKARI (pointing mode), the deepest Spitzer surveys, JWST, and SPICA. Launch dates for future missions, or best guesses at the time of writing, are also shown. See text for more details.

Conclusions

Big projects will give big answers to questions of modern astrophysics but coordinated studies will be crucial to reach a comprehensive view

Thank you