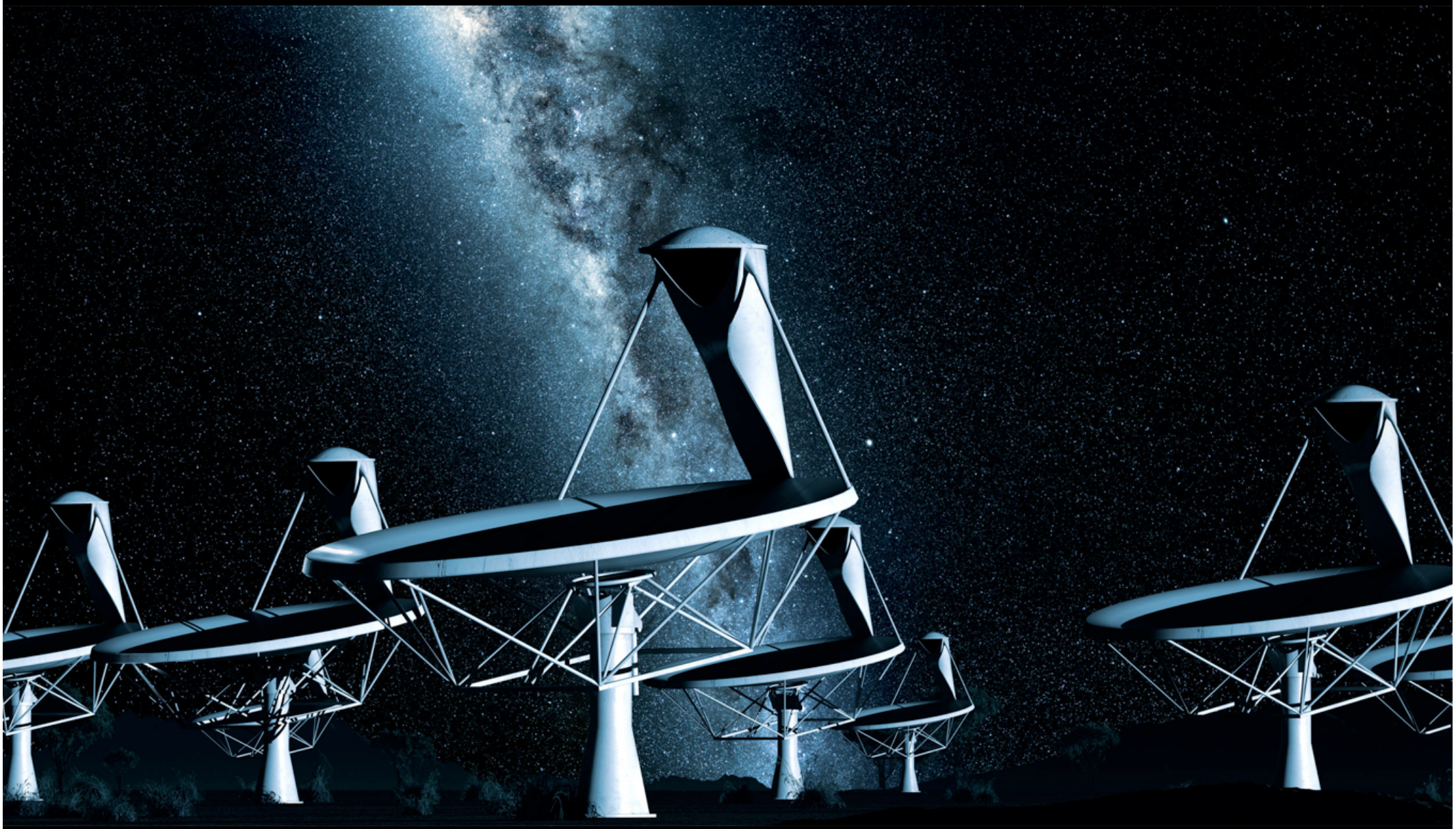

TRANSIENTS AND SYNERGIES WITH SKA AND PRECURSORS

S. CORBEL (UNIV. PARIS & CEA SACLAY/AIM & OBS. PARIS/USN)

OUTLINE

- Exciting science with radio transients ! Strong links with high energy emission
- SKA precursors: telescopes and capabilities of MeerKAT, ASKAP. NenuFAR at low frequencies. Warning : different calendars
- The Square Kilometre Array (SKA).
- Conclusions.

RADIO TRANSIENTS

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- Exploring the extreme events in the Universe: brightest, fastest, hottest, densest, most massive, most magnetized, …. + the Unknown !

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  - **Incoherent** synchrotron from explosive events ($T_b < 10^{12}$ K), images, **slow transients.**

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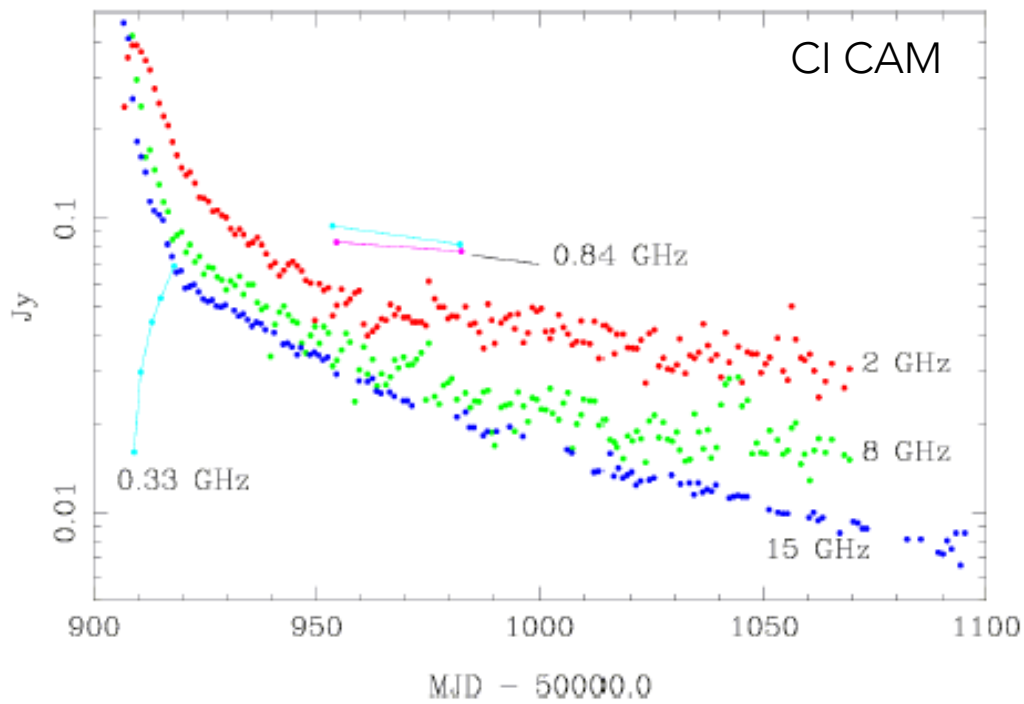

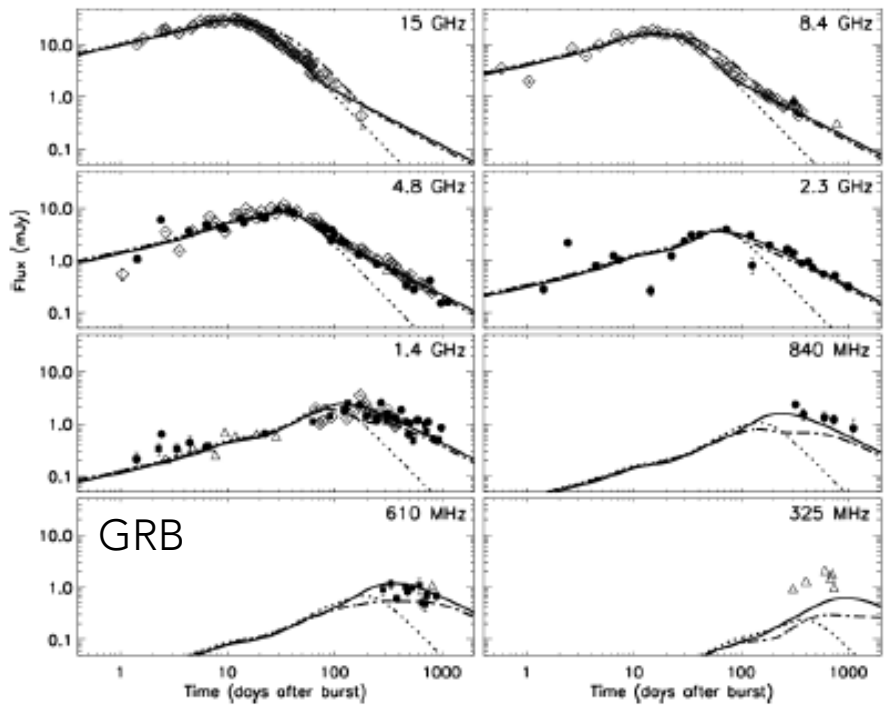

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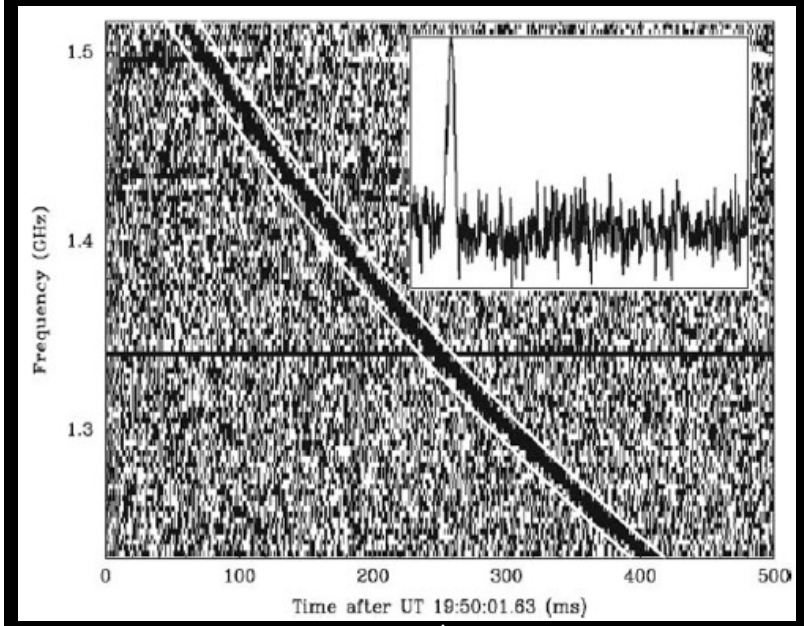
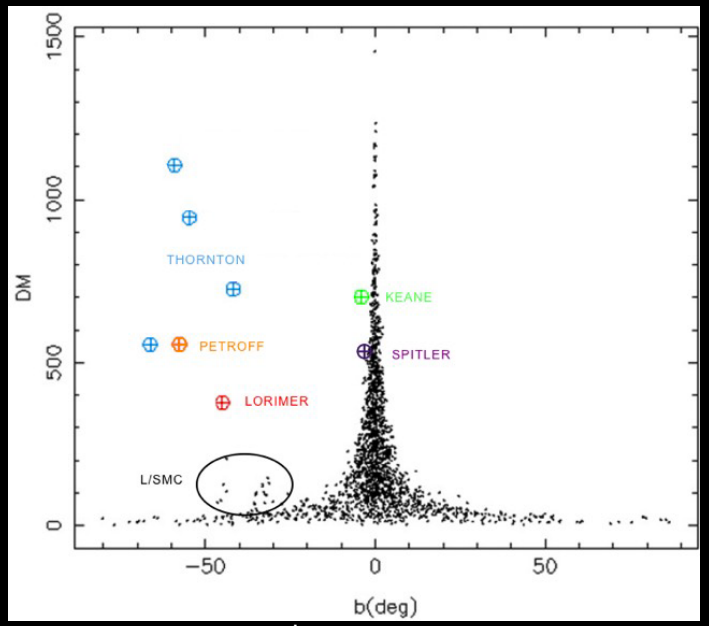
- « Slow » Transients: explosive injection of energy into an ambient medium —> shocks —> particles acceleration up to HE + synchrotron emission:

  - **XRBs** (BH, NS, WD), ULX, Isolated BH, magnetar, SNe, TDEs, AGNs, GRBs, Novae, ….

FAST TRANSIENTS: FRB



Lorimer et al. 2007



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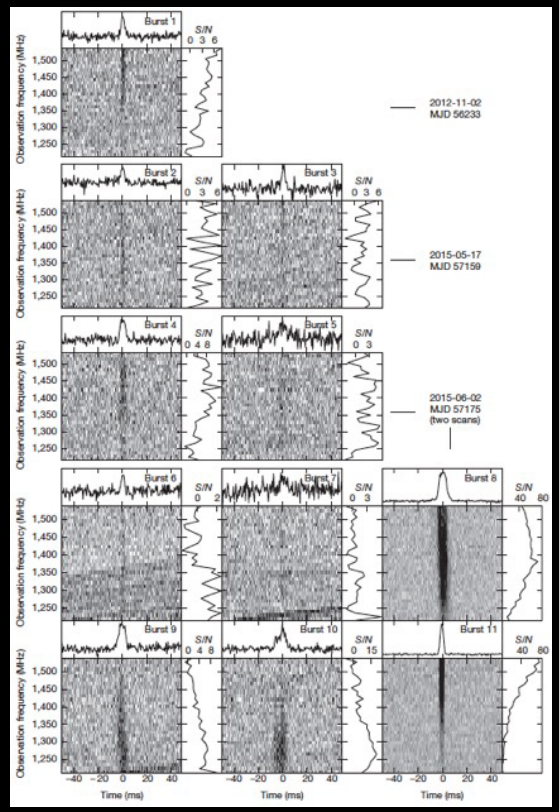

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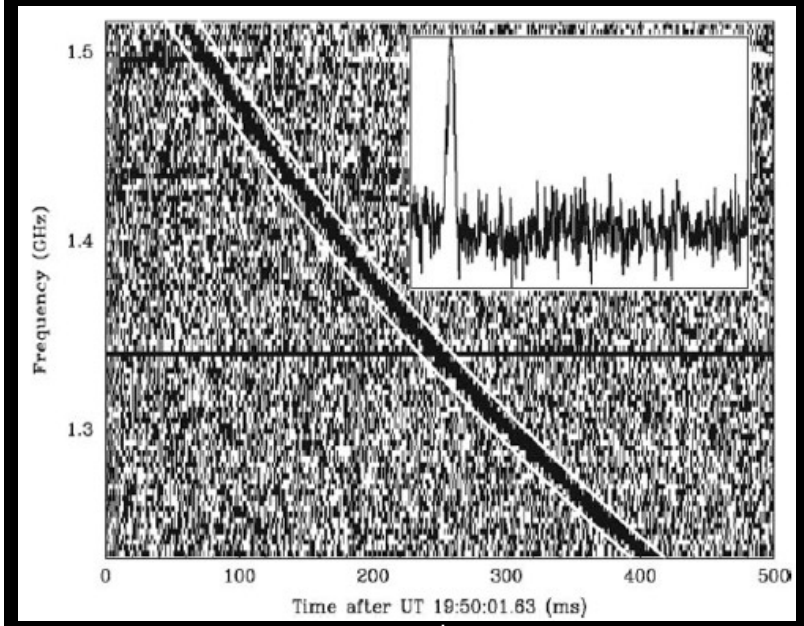

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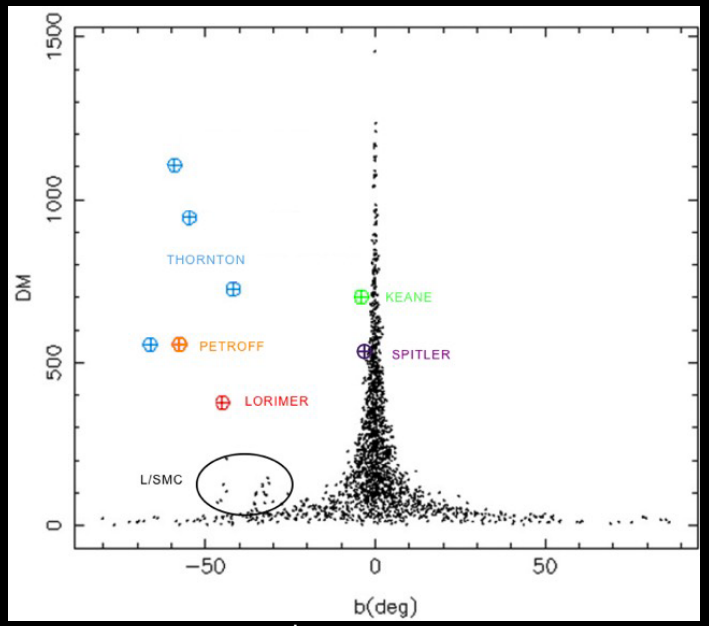

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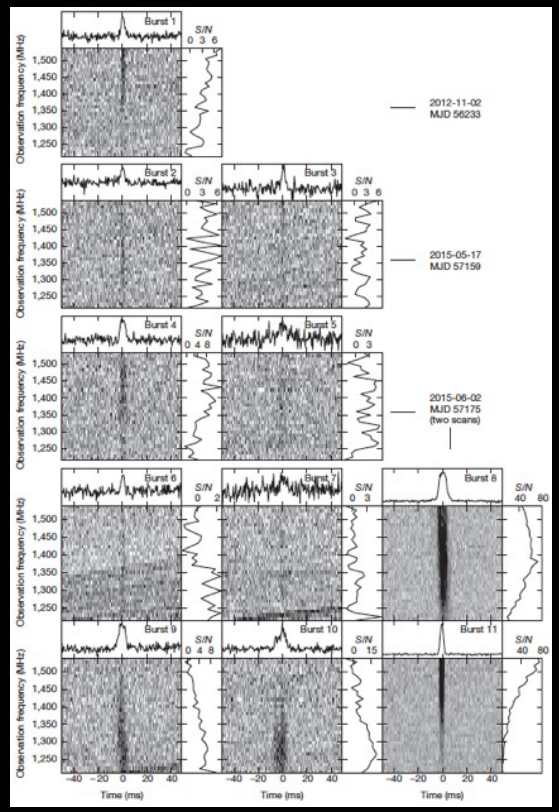

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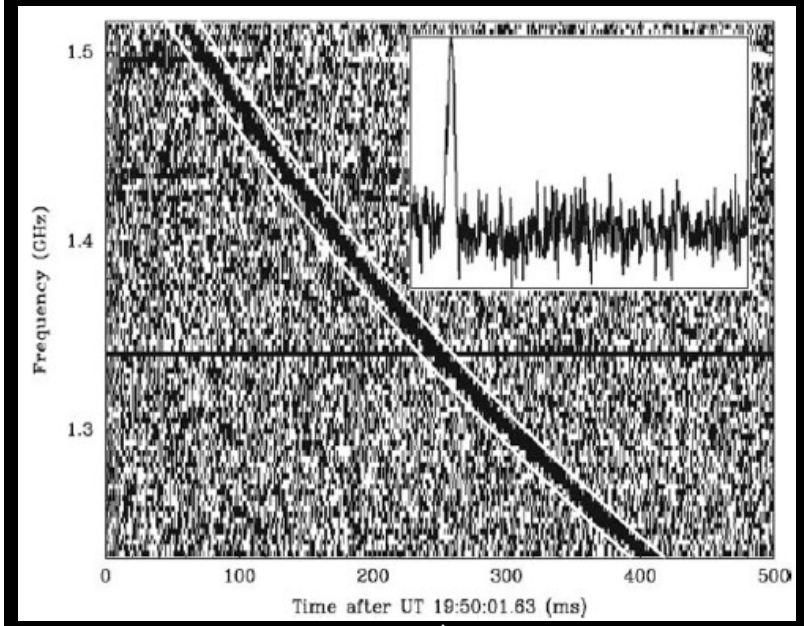

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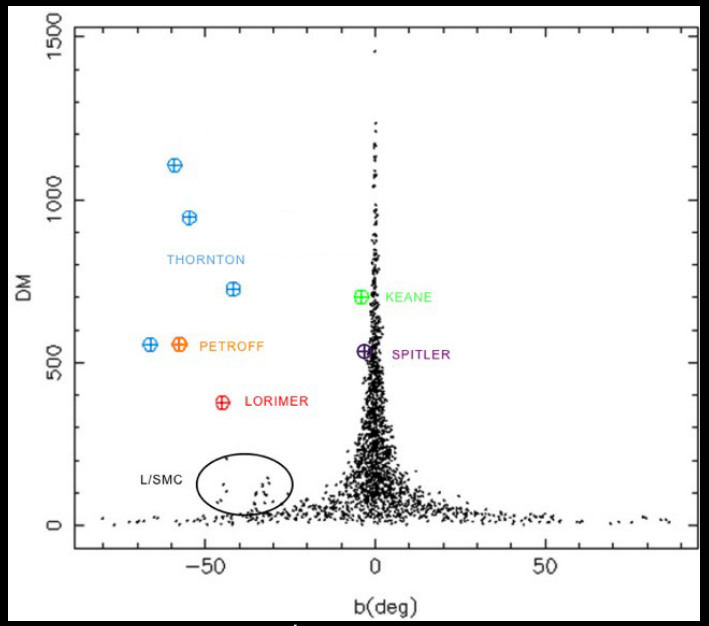

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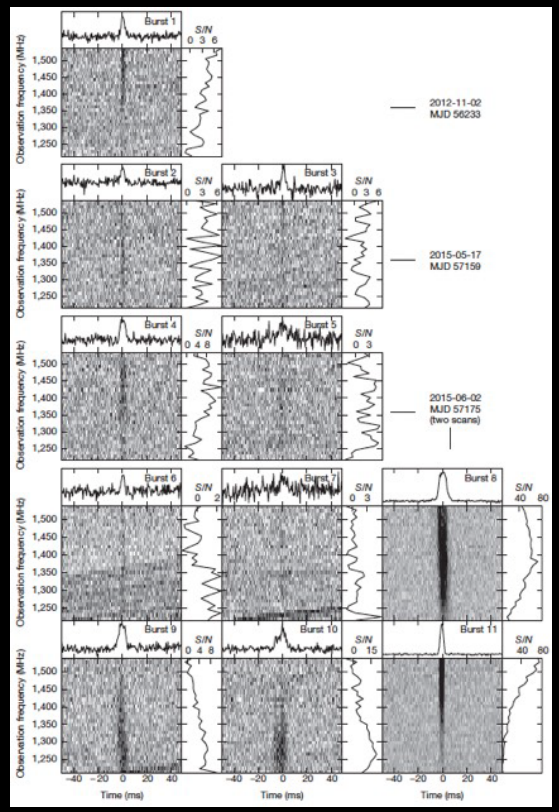

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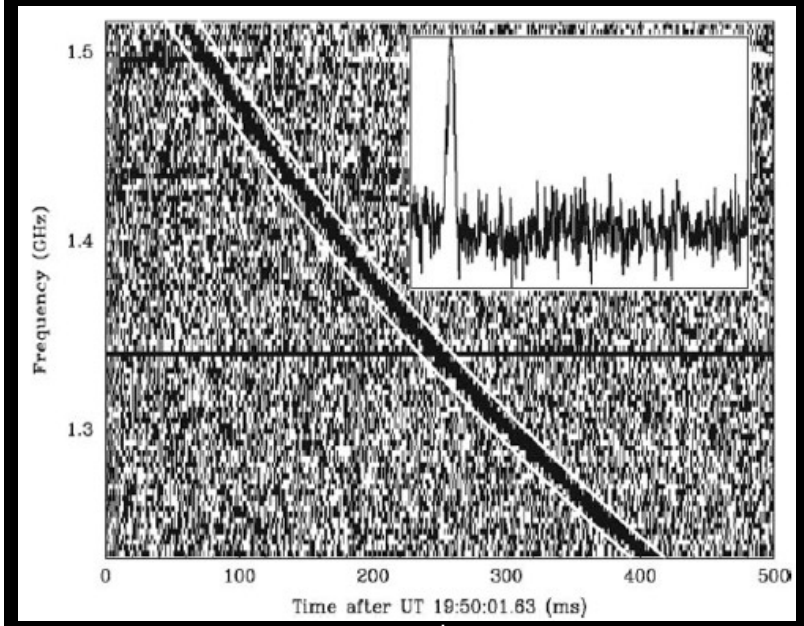

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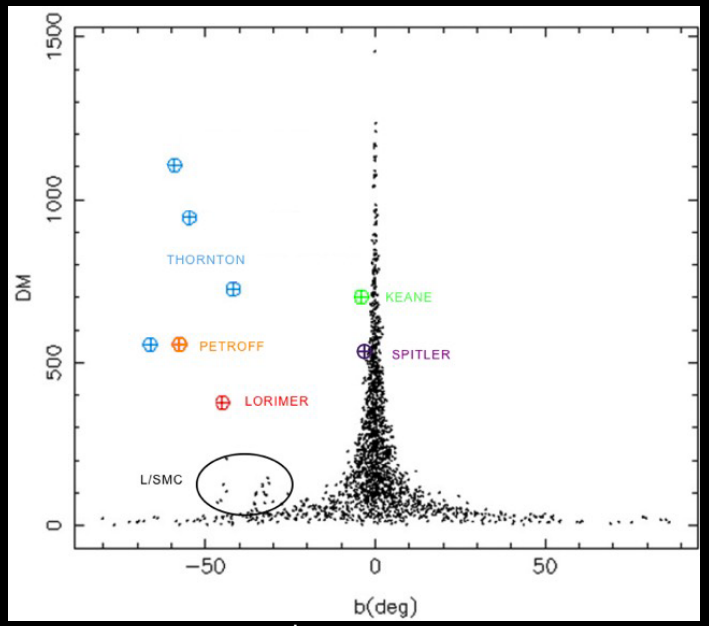

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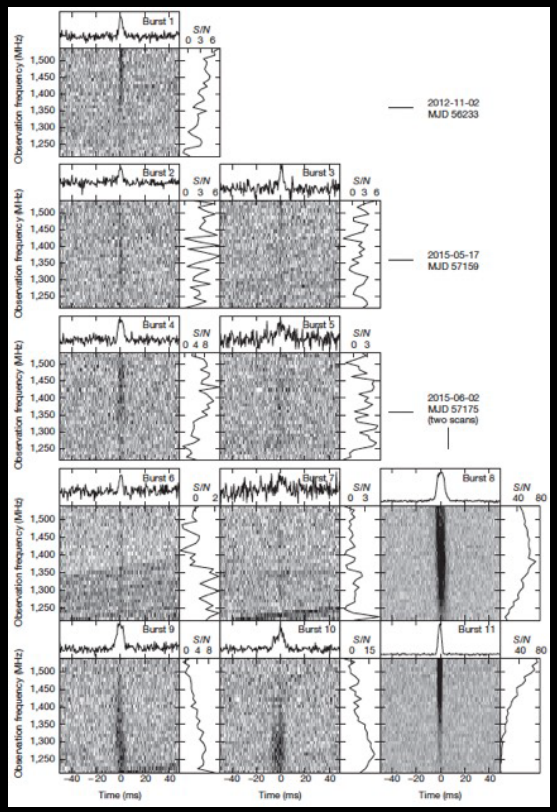

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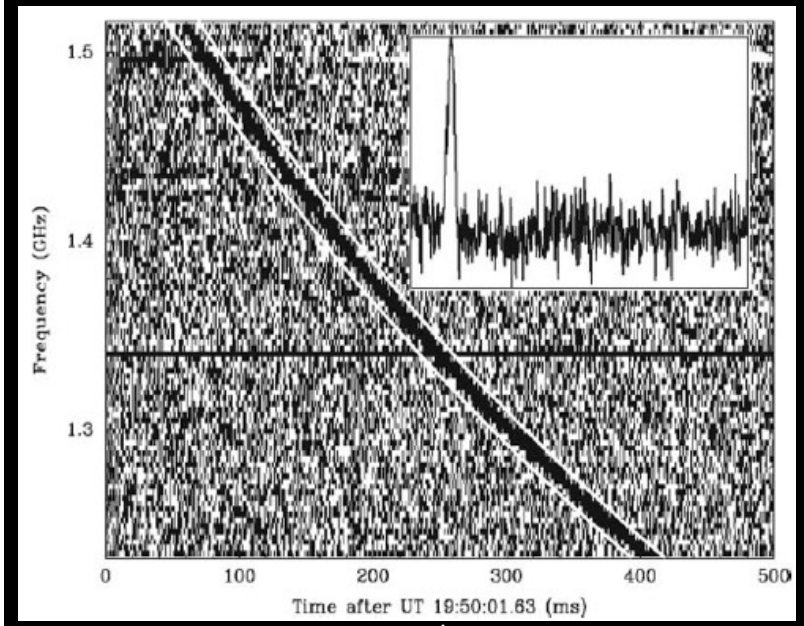

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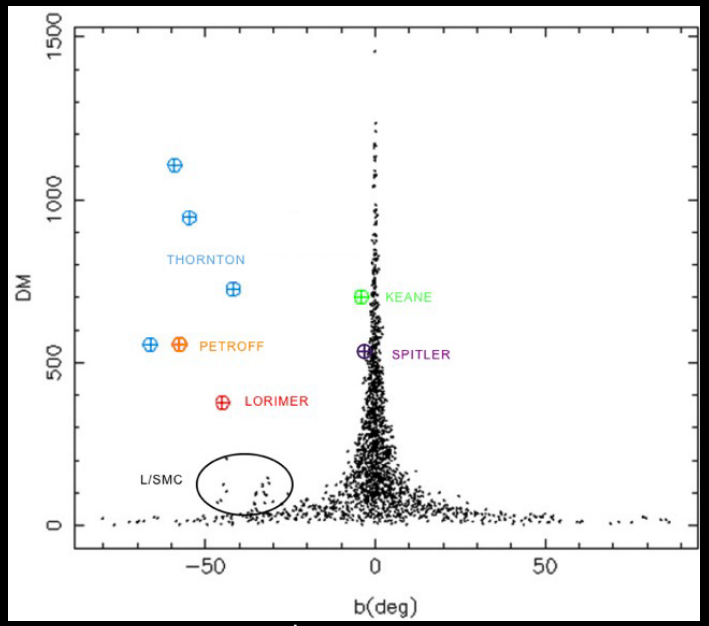

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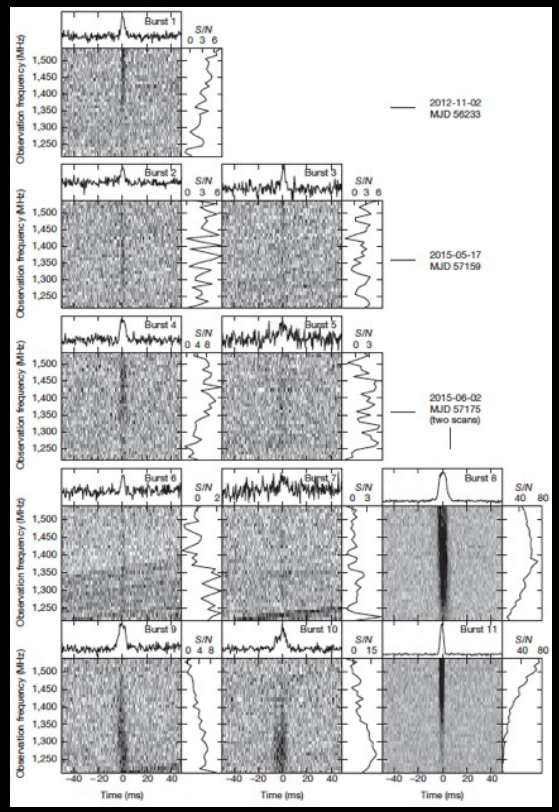

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- Cosmological probes: measuring baryon content (from DM contributions)

MOTIVATIONS FOR SLOW TRANSIENTS

- Accretion: the most powerful source of energy in the Universe !
- Whenever you have accretion, you always see ejection !! Nature of the existing fundamental coupling ? Is it universal along the mass scale ?
- Synchrotron flares from stellar mass compact objects : a unique laboratory with associated variabilities accessible with our lifetime.
- Astrophysics in extreme environments : density, temperature, gravity, velocity, ... !
- Jets: Composition? Formation ? Energetics ? Kinetic feedback on their environment ?
- Existence of intermediate mass black holes ? Seeds of supermassive BHs ? EOR ?

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STRONGLY CONNECTED TO SCIENTIFIC OUTCOME OF THESEUS

TRANSIENTS & RADIO OBSERVATIONS

- A new generations of radio observatories to probe the variable radio Universe: LOFAR and NenuFAR, MeerKAT, ASKAP, … towards the SKA !
- Advantages of radio observations :
  - Probing the non thermal electrons (similarly to HE telescopes).
  - Large FOV, daily/night; huge sensitivity, precise localis., poss. high resolution imaging, fast reaction time (< 1 min) with response to external triggers.
  - Sometimes coupled with simultaneous multi wavelength observations.
  - Towards the Radio All Sky Monitor and automatic generation of alert by VO events.
  - Transient buffer board (low frequency telescope) —> transient precursors ?

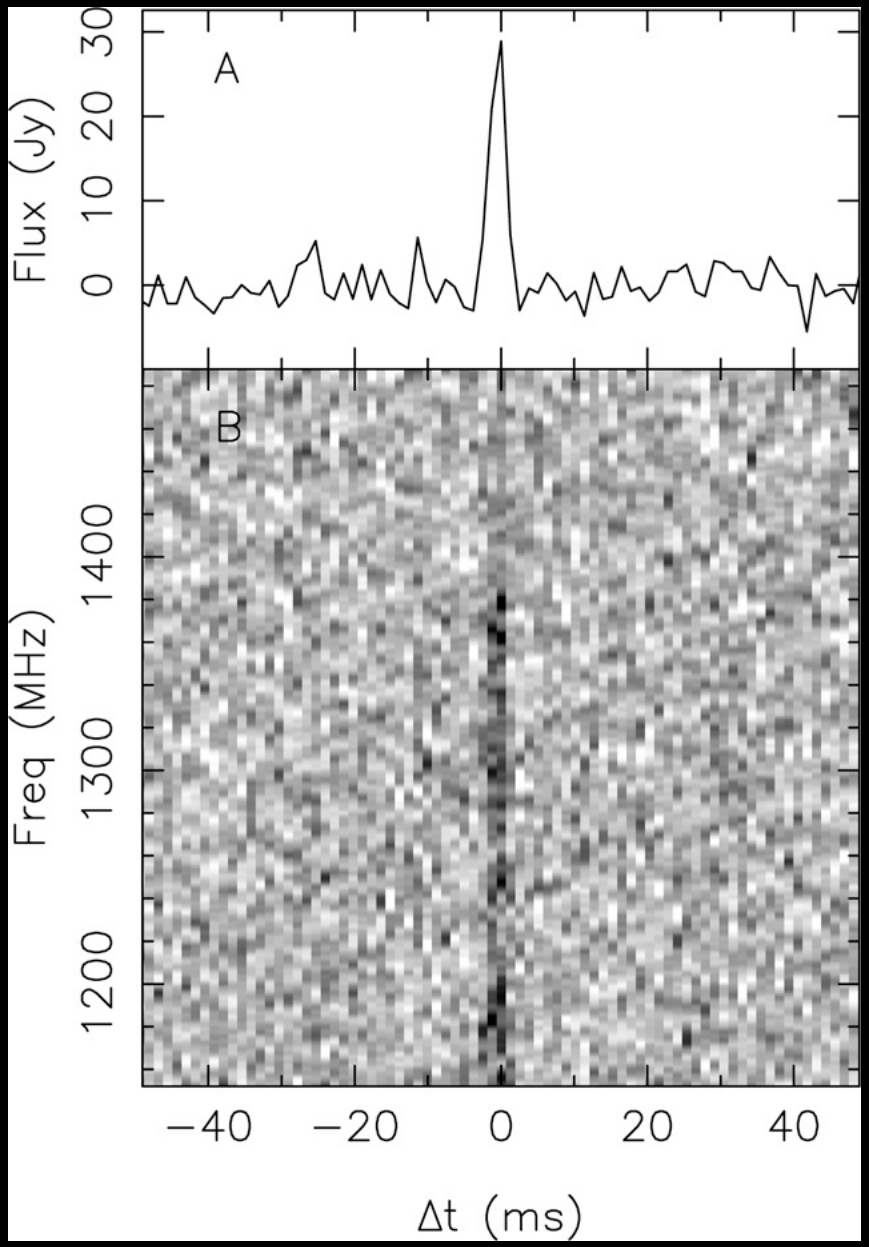
THE SKA PRECURSORS AND PATHFINDERS

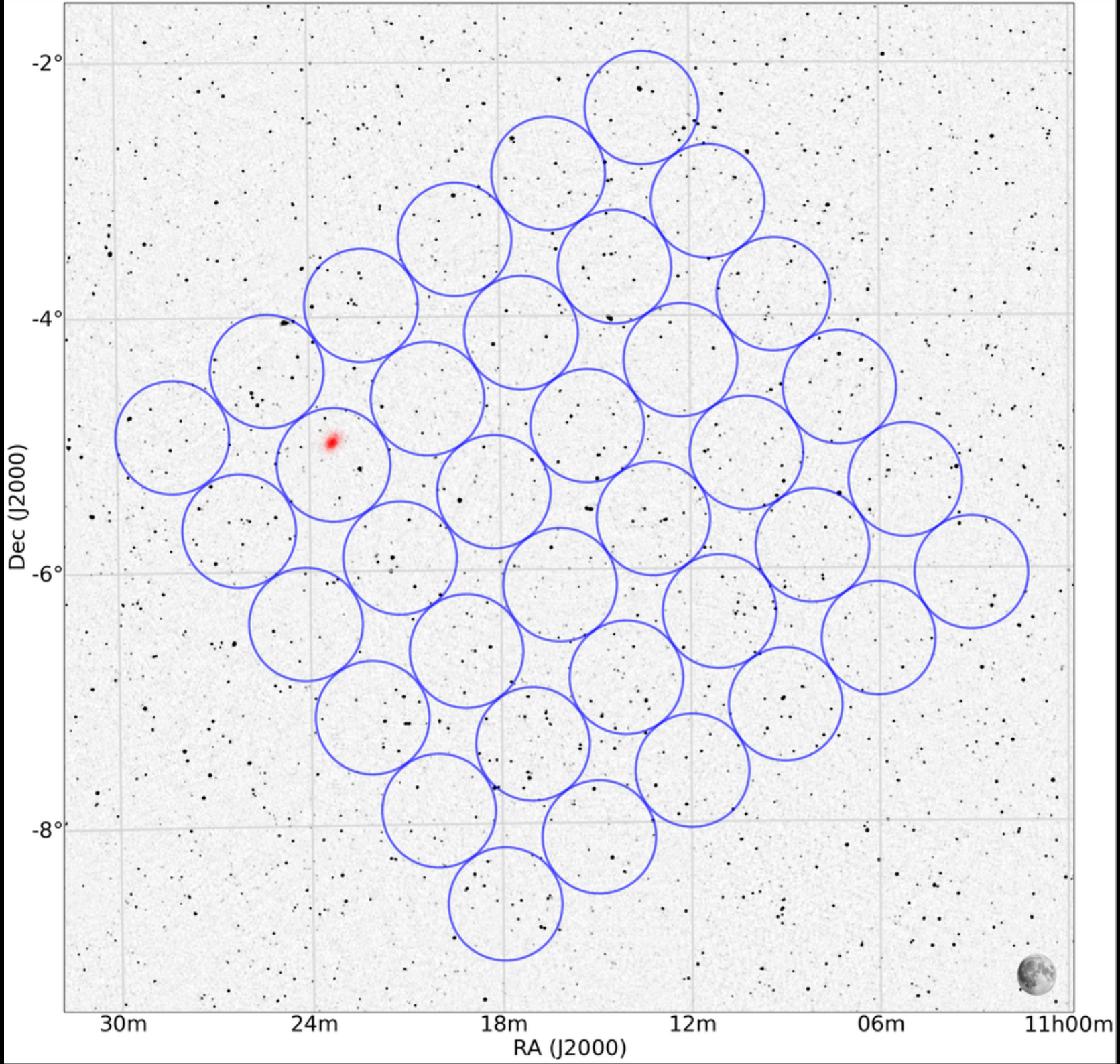
SKA PRECURSORS: ASKAP

- Location: Australia
- Max Baseline : 6 km
- Frequency coverage: 0.7-1.8 GHz
- 36 antennas (12 m) with PAF (30 deg^2 FOV)
- Fully operational, all antennas equipped with PAF

FIRST ASKAP FRB IN MAY 2017!

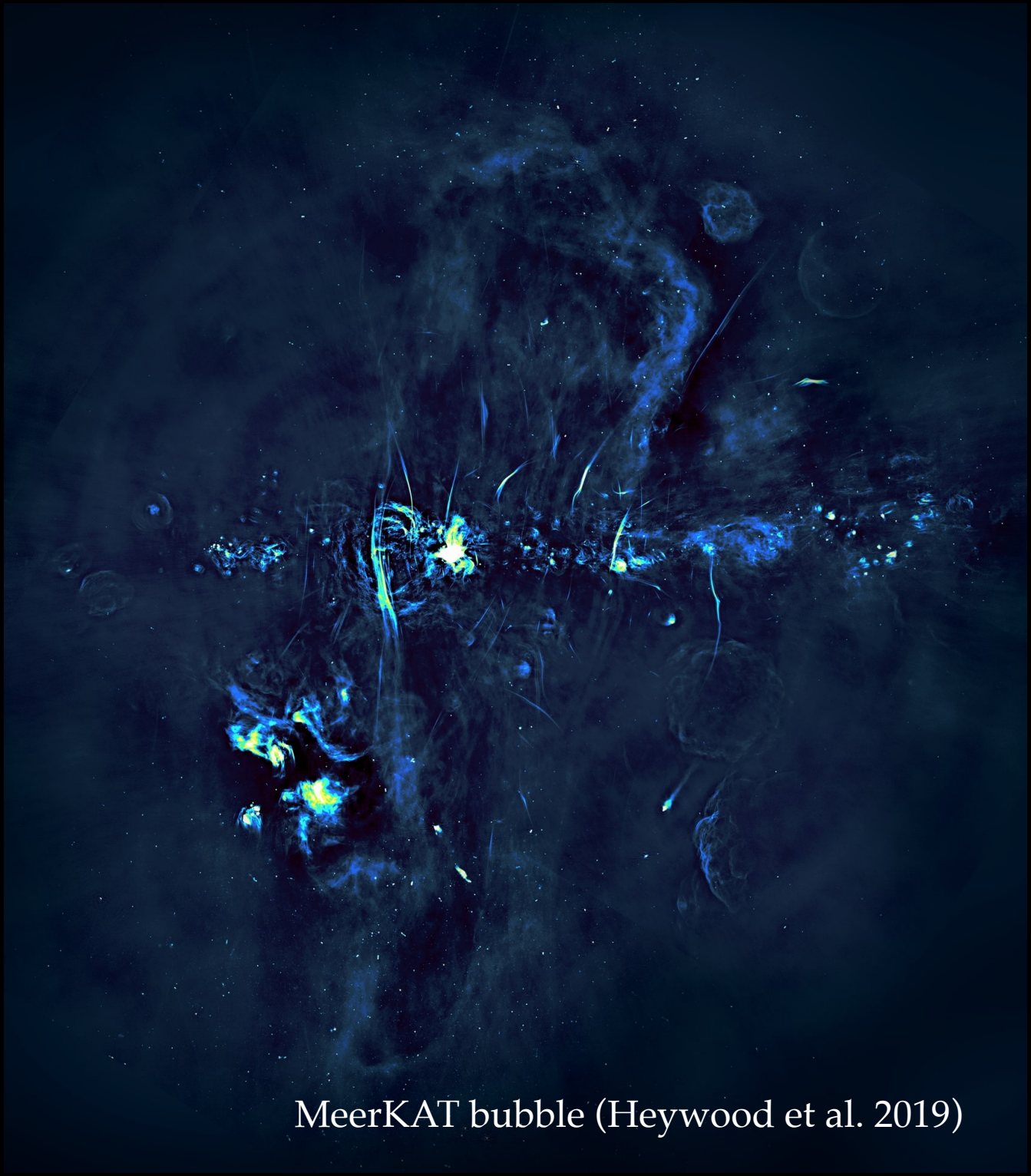
« ASKAP has found its first FRB after less than four days of searching (8 antennas). The discovery came so quickly that the telescope looks set to become a world champion in this fiercely competitive area of astronomy. » ASKAP press release. CRAFT




-2°
-4°
-6°
-8°
Dec (J2000)
30m
24m
18m
12m
06m
11h00m
RA (J2000)

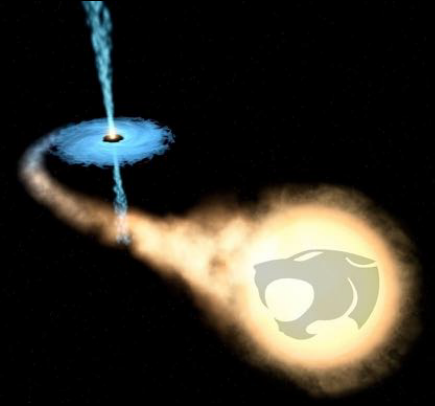
SKA PRECURSORS: MEERKAT

- Location: South Africa
- 64 antennas (13.5 m) over an 8-km baseline
- Frequency coverage: 0.5-10 GHz (now L-band (0.9–1.67 GHz), UHF (0.58–1.0 GHz) : 56 active antennas, S-band (1.75–3.5 GHz – by MPIfR) to come.
- Expanded MeerKAT+20 15-m dishes, baseline up to 18 km
- FOV: 1.69 deg^2 @ 1 GHz
- Inauguration in July 2018. Observations continue for MeerTime, ThunderKAT, MIGHTEE, and Open Time projects



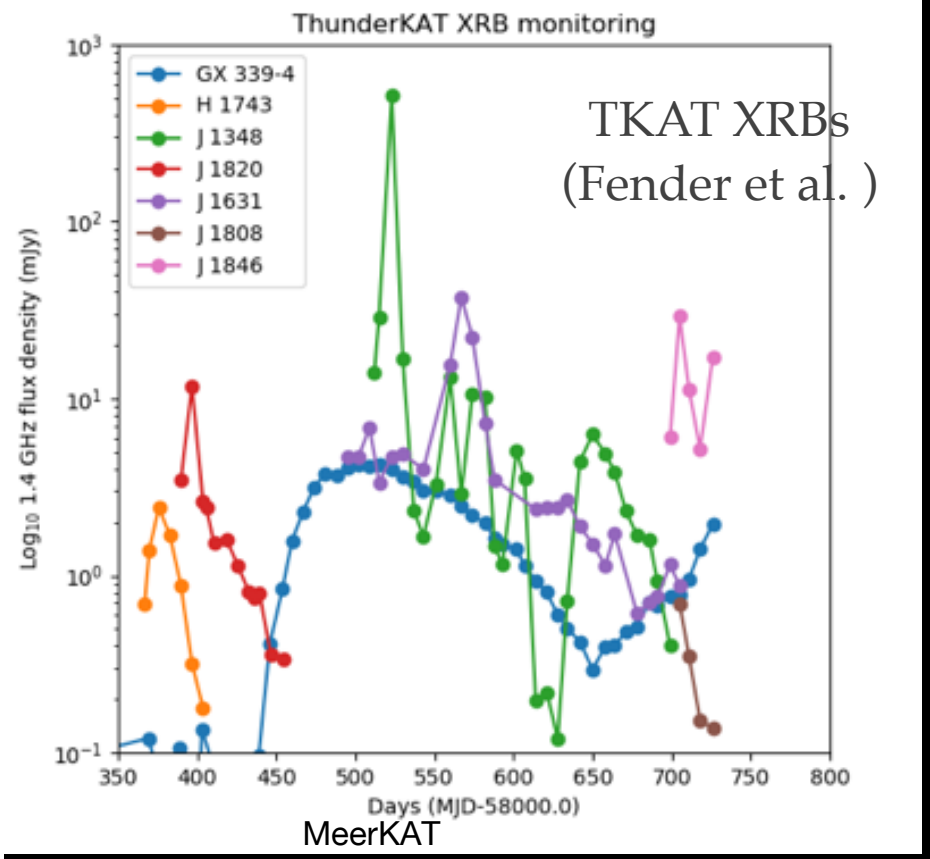
MeerKAT bubble (Heywood et al. 2019)

THUNDERKAT
(PI: FENDER/WOUDT)

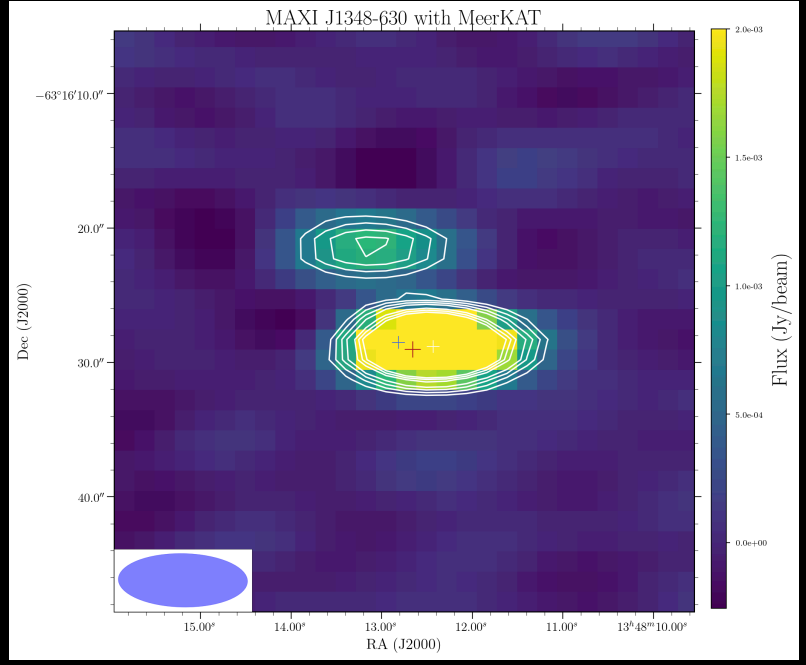


A MeerKAT Large Survey Project for synchrotron radio transients

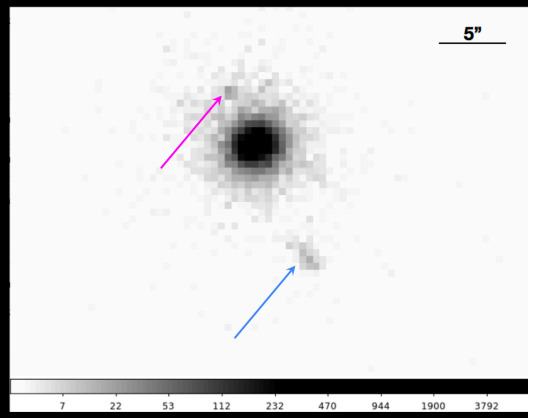
- **Survey** and **monitor** populations of Galactic and extragalactic **synchrotron radio transients**
- **Commensal** observations + **pointed** observations (3000 h = 100 min/day) typically for follow-up + simultaneous optical observations with **MeerLicht**.
- **Large international collaboration** (56 co-Is from 9 countries): AIM, IAP, IRAP, GEPI



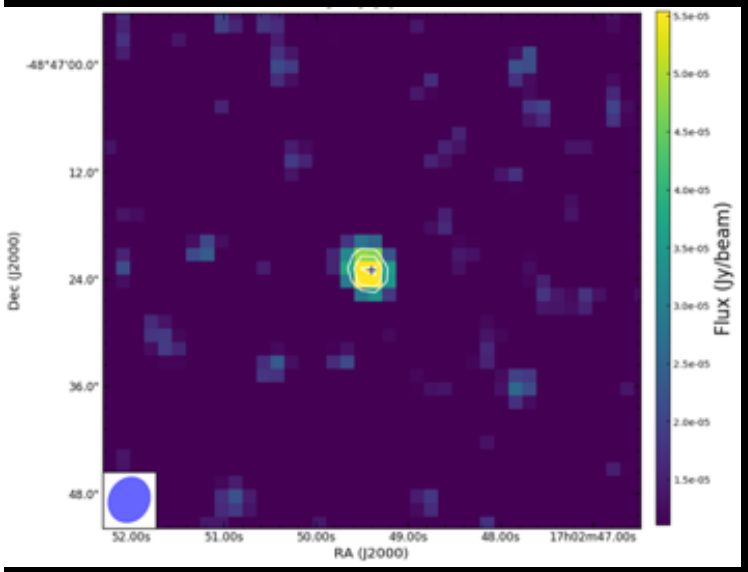
MeerKAT



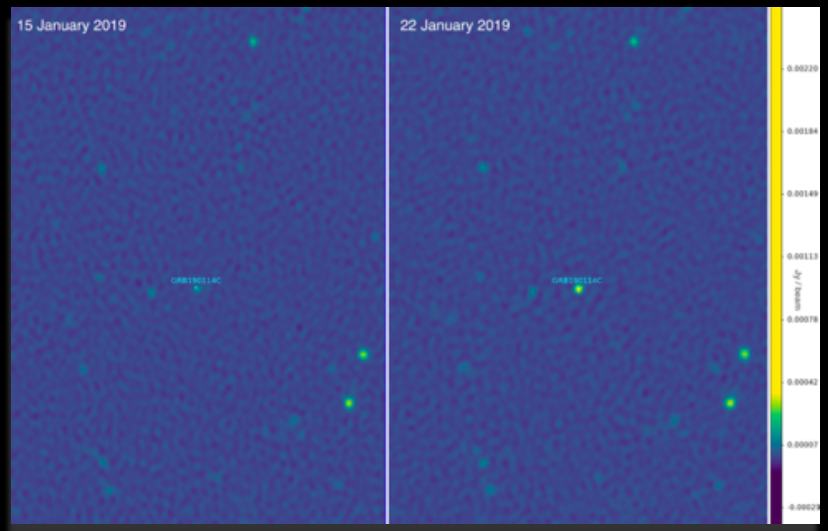
Carotenuto et al. 2019



Espinasse et al. 2019



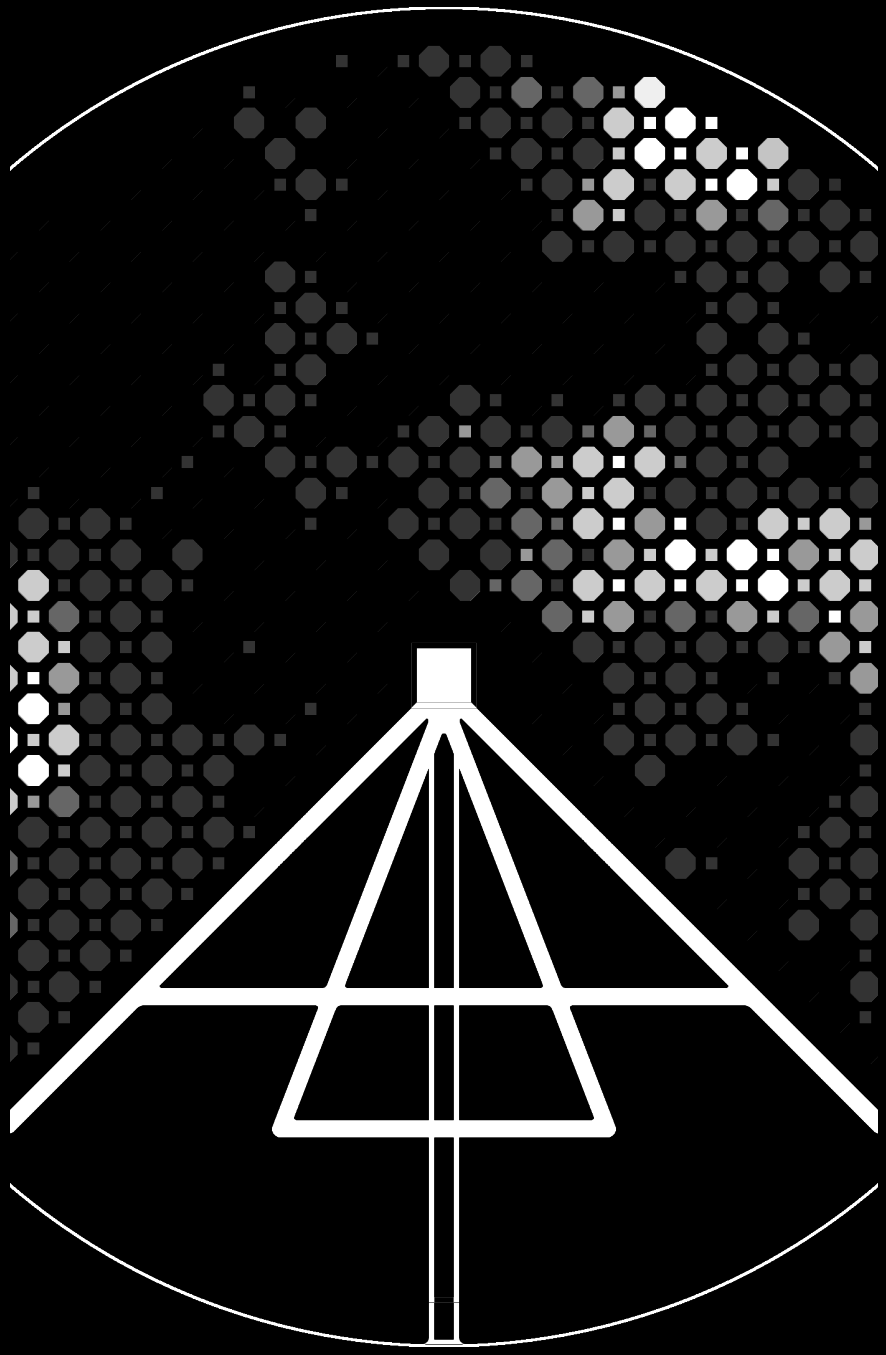
GX 339-4: Tremou et al. 2019



GRB 190114C: Tremou et al. 2019b

NenuFAR

A giant low-frequency radiotelescope in Nançay
and
a SKA pathfinder



NENUFAR ARRAY IN FRANCE

NENUFAR ARRAY IN FRANCE

SKA

SKA– KEY SCIENCE DRIVERS: THE HISTORY OF THE UNIVERSE

Testing General Relativity
(Strong Regime, Gravitational Waves)

Cosmic Dawn
(First Stars and Galaxies)

Galaxy Evolution
(Normal Galaxies z~2-3)

Cradle of Life
(Planets, Molecules, SETI)

Cosmology
(Dark Energy, Large Scale Structure)

Cosmic Magnetism
(Origin, Evolution)

Exploration of the Unknown

Extremely broad range of science!

SKA ORGANISATION & OBSERVATORY

Members of the SKA Organisation
Host Countries: Australia, South Africa, United Kingdom

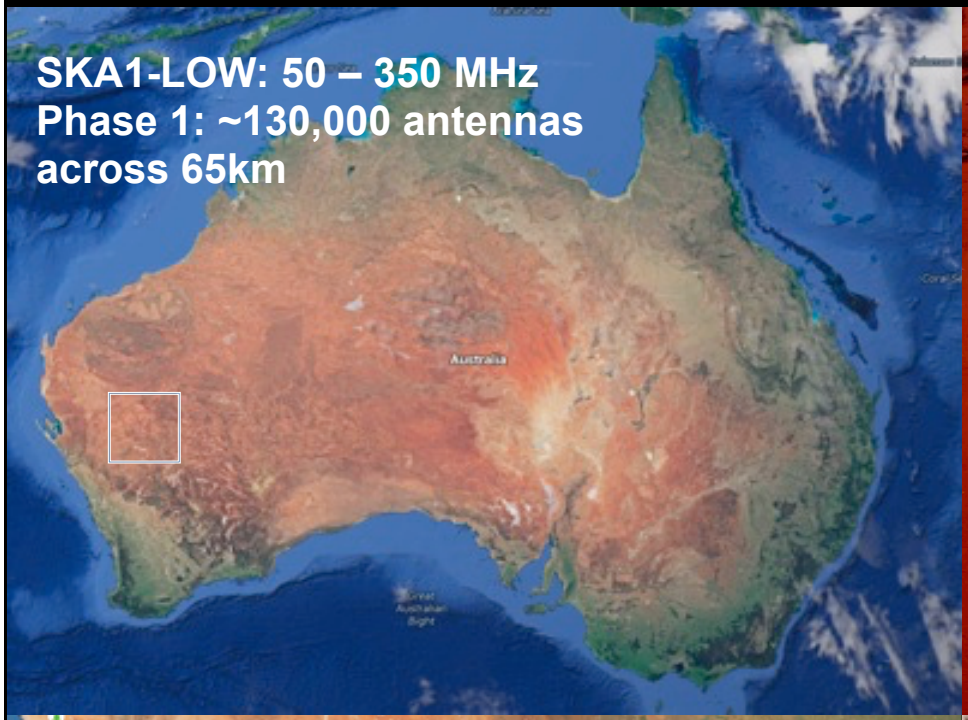
African Partner Countries

SKA Observatory will be established as an Intergovernmental Organisation in 2020, taking over from the SKA Organisation. It will undertake the construction and operation of the telescope.

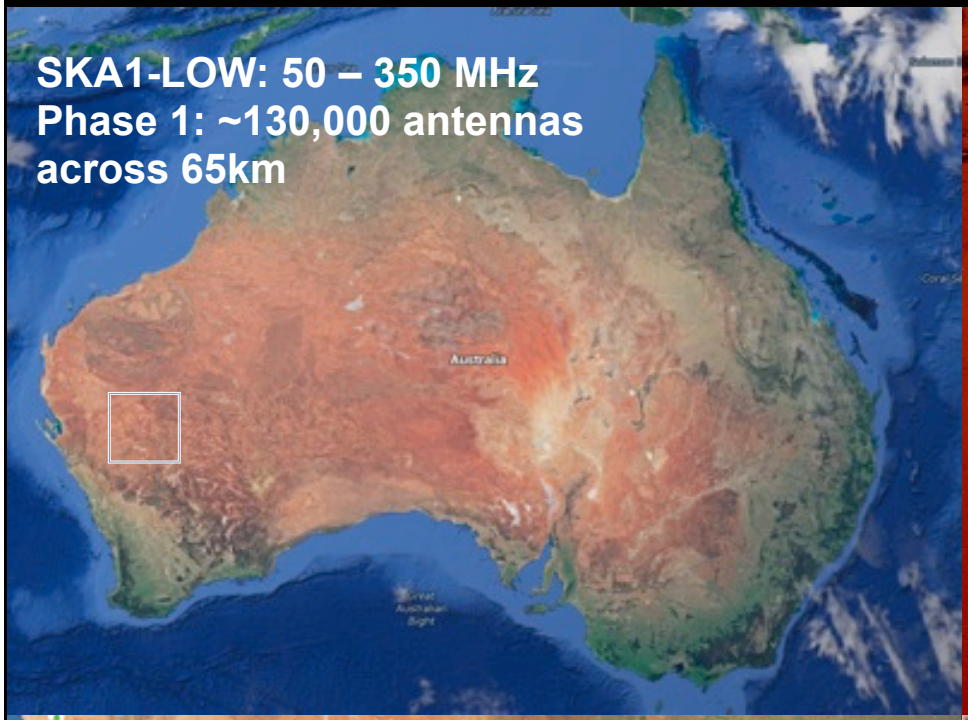
As of March 2019, confirmed SKA Observatory members are

THE SQUARE KILOMETER ARRAY (SKA)

- 3 sites; 2 telescopes + HQ —-> 1 Observatory
- Design Phase: > €170M; 600 scientists+engineers
- Phase 1:
  - Construction: 2021 – 2028
  - Construction cost cap: 674.1M€ (inflation-adjusted)
  - Operations cost: under development
- Phase 2: > 2030 ?
  - ~2000 dishes across 3500km of Southern Africa
  - Major expansion of SKA1-Low across Western Australia
- A telescope available for 50+ years !!!



Construction: 2021 – 2028; Cost cap: €675M



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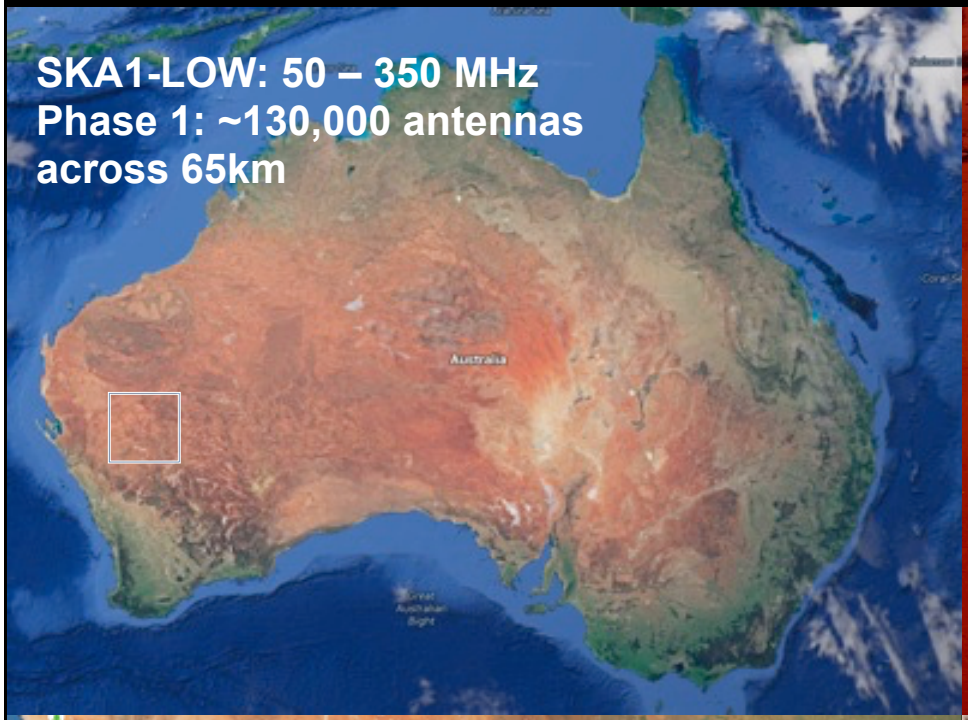

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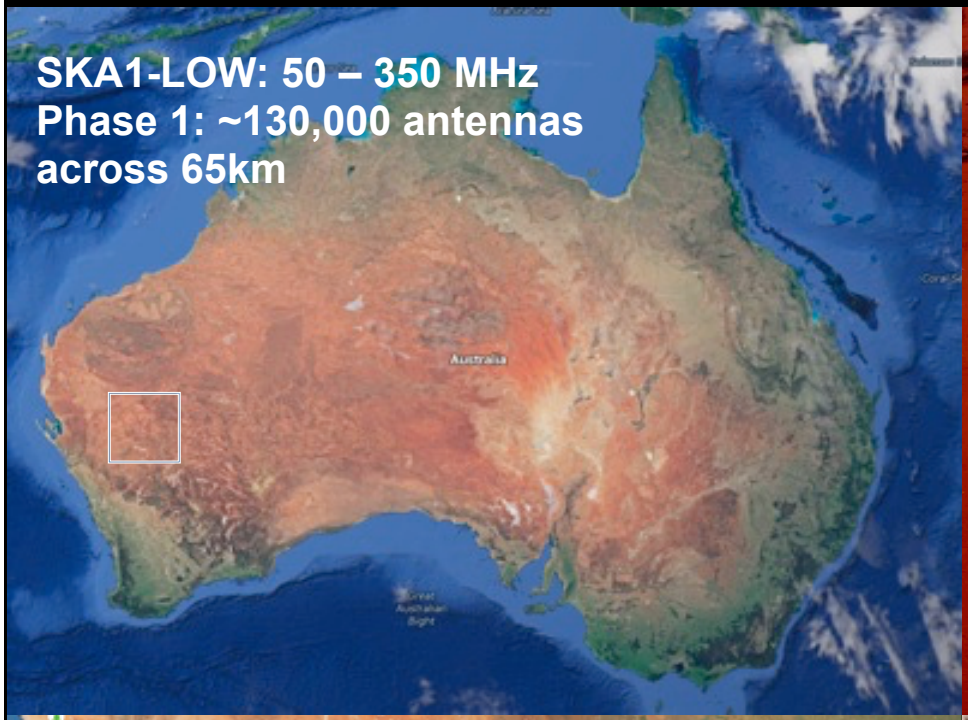

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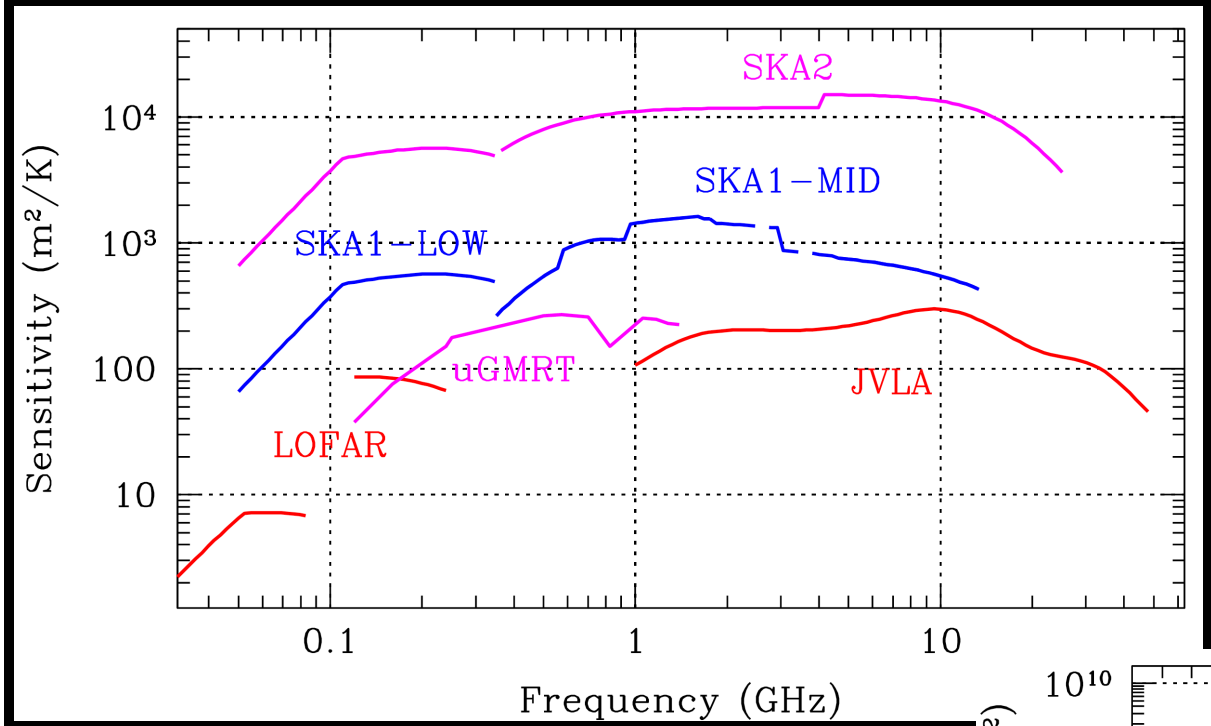
SKA1 CAPABILITY VS STATE-OF-THE-ART

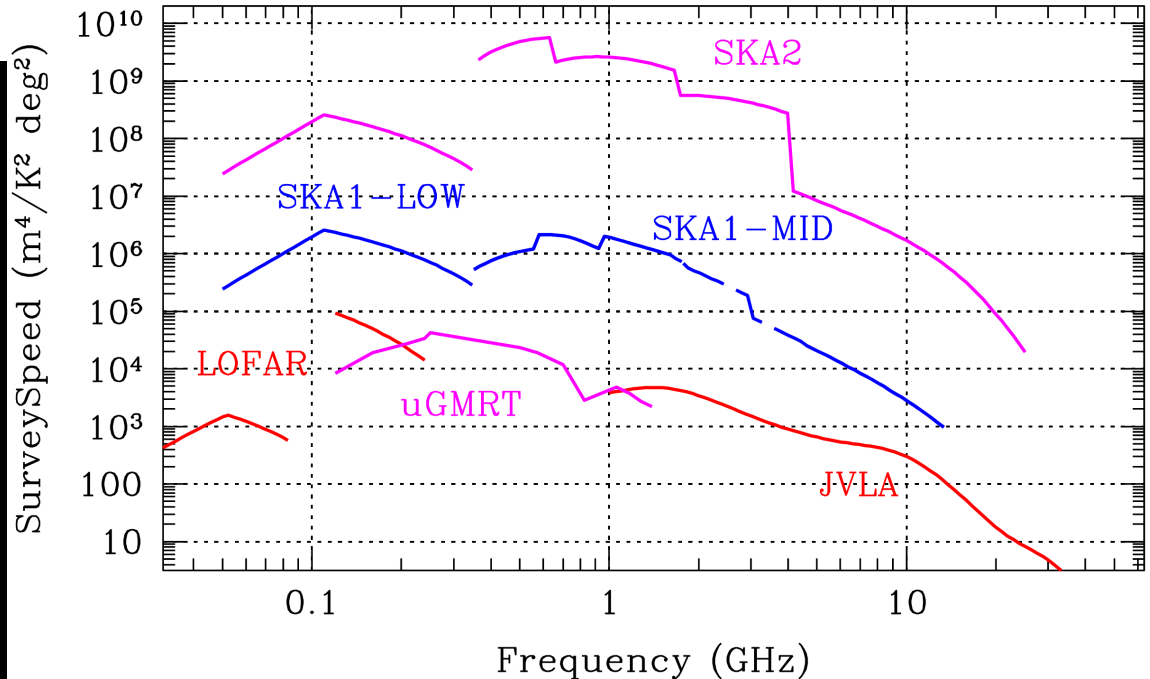


Point-source sensitivity:

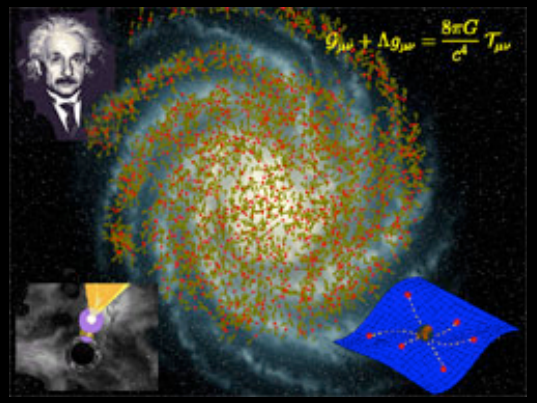
~ 4 – 20 times state-of-the-art

Survey speed:

~ 10 - 100 times state-of-the-art



CONCLUSIONS



- Strong synergies between radio observatories and Theseus regarding transients but not only (e.g. EoR).
- Deployment of ASKAP and MeerKAT is done. NenuFAR is still building up. Different calendars.
- First results from ASKAP and MeerKAT
- SKA is proceeding with construction foreseen in 2020+ and to be completed by 2032. Mostly survey…