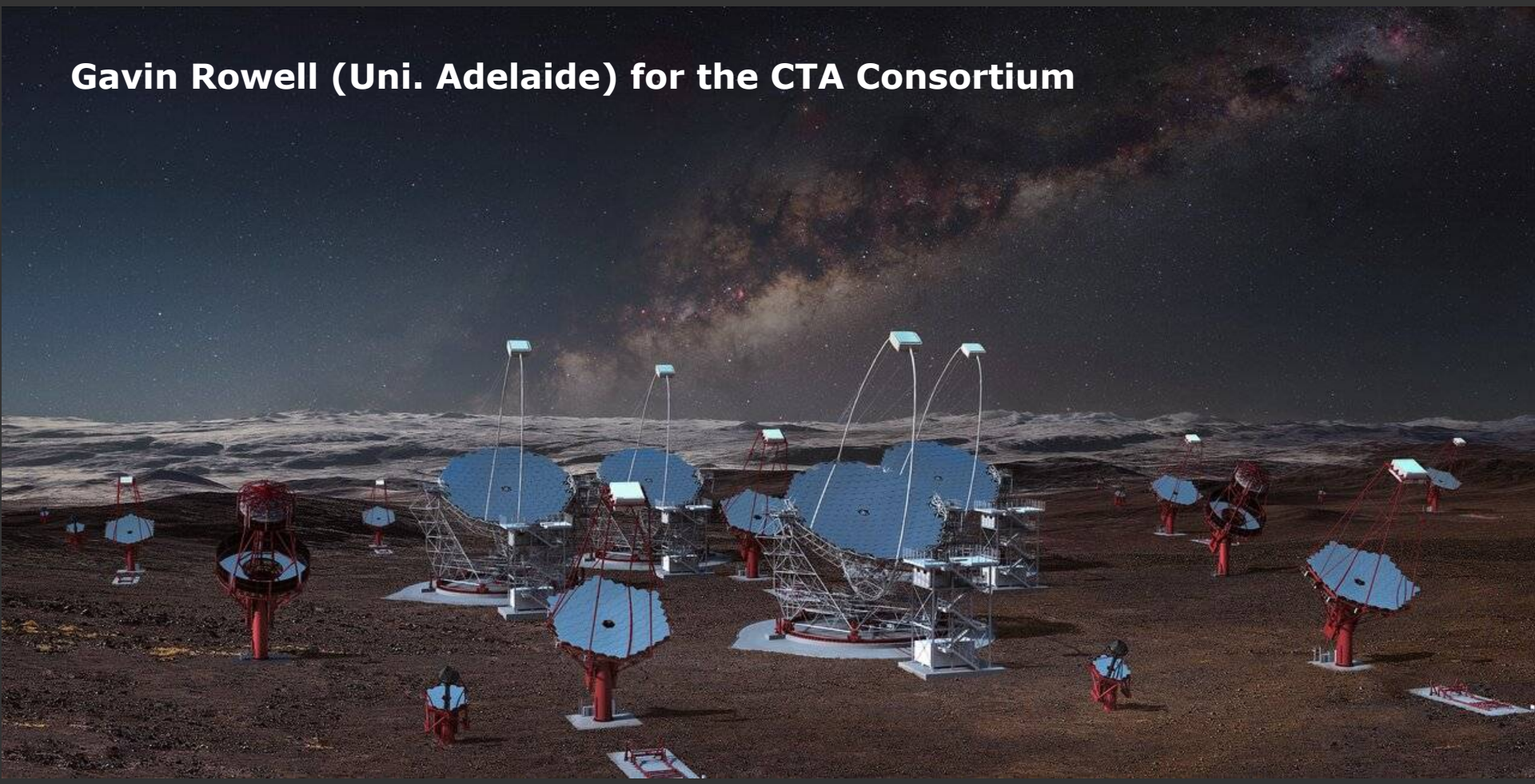
Cherenkov Telescope Array and ATNF Linkages

Gavin Rowell (Uni. Adelaide) for the CTA Consortium



ATUC Science Day 8 Nov 2022

CTA- The next step in TeV gamma-ray astronomy

- Building on HESS, MAGIC, VERITAS...

~ 0.03 to 100 TeV

~ 330 MEuro for construction (cash+in-kind) funds available

CTA Arrays "alpha" Configuration

– Northern Array: 4 LSTs + 9 MSTs (La Palma, Spain)
1st telescope in operation!

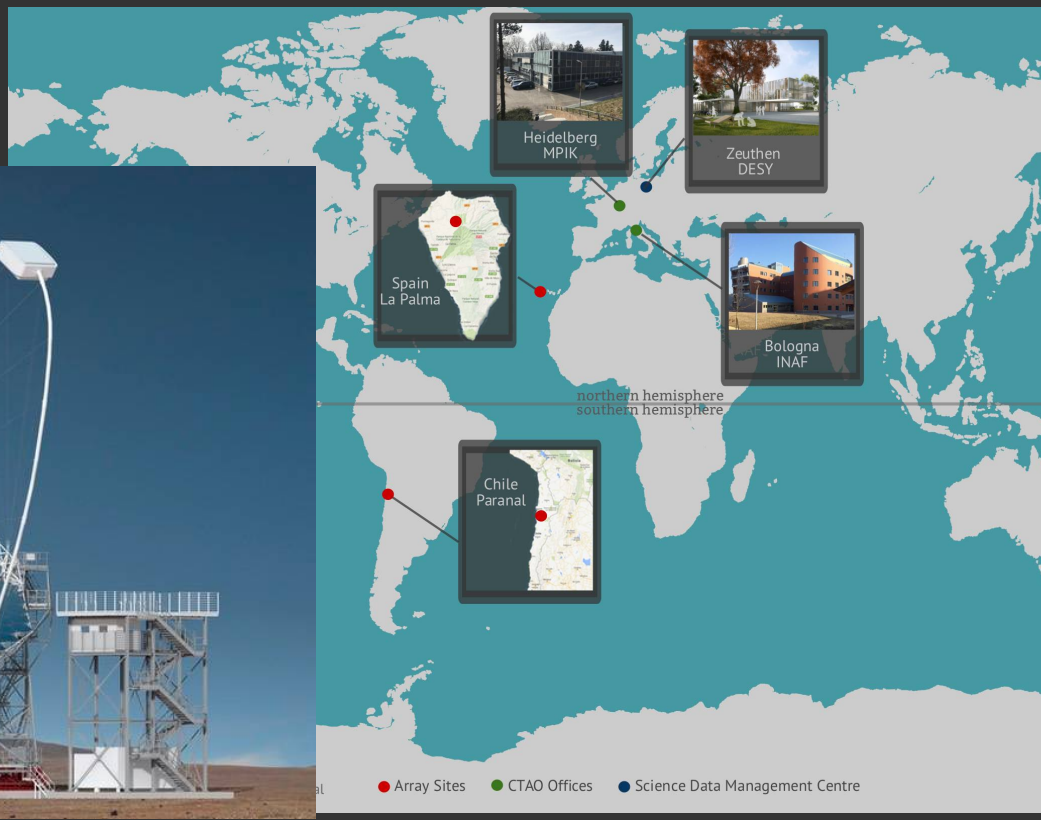
– Southern Array: 14 MSTs + 37 SSTs (Paranal, Chile)
site prep. work underway

- CTA HQ, Bologna

- CTA Data Centre, Berlin

https://www.cta-observatory.org/

SST – small sized telescopes
MST – mid-sized
LST – large sized



CTA Consortium (CTAC)

- 25 Countries collaborating to design, fund and construct telescopes

CTA Observatory (CTAO)

- Legal entity owning and operating CTA telescopes

CTA-Australia (U.Adelaide, WSU, ANU, UNSW, Monash, U. Syd., Curtin)

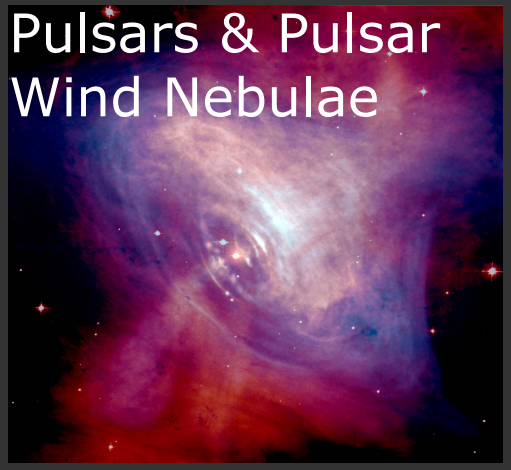
- >25 scientists, >10 students
- 2 MEuro from ARC-LIEF + NCRIS (via AAL) so far
- CTAO & CTAC member

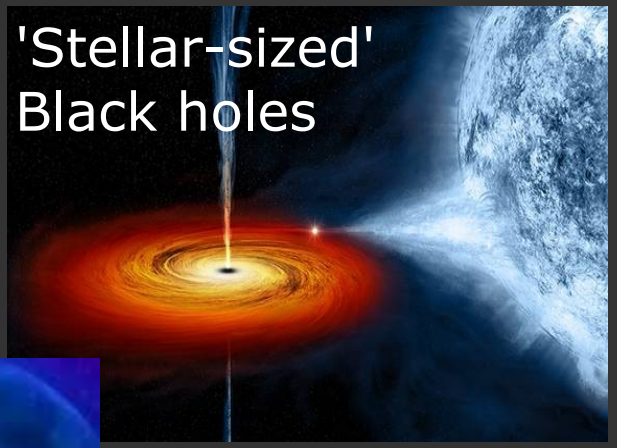
First open observatory in TeV gamma-ray astronomy

Key Science Projects ~ 40% time (led by CTAC)
Remaining time for guest observers, host countries, DDTs, ESO (majority for CTAO members)

https://www.worldscientific.com/worldscibooks/10.1142/10986

Some Cosmic-Ray and Electron Accelerators

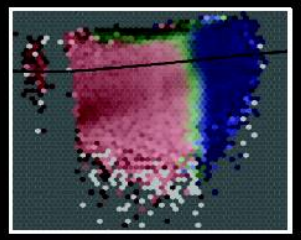




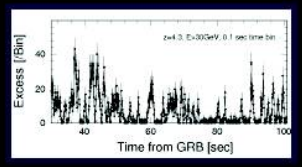
CTAC Key Science Projects (KSPs)
Major legacy science

cherenkov telescope array

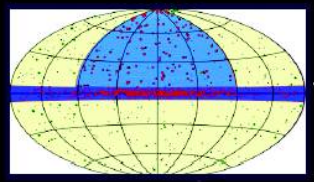
KEY SCIENCE PROJECTS



Dark Matter Programme

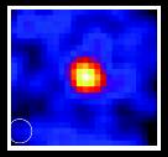


Transients



ExGal Survey

Galaxy Clusters

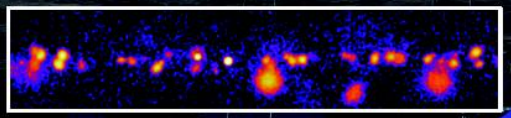


Extragalactic

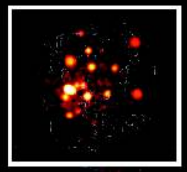
Star Forming Systems

AGN

Galactic

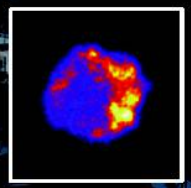


LMC Survey

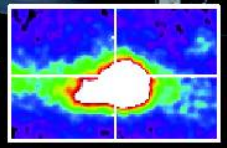


Galactic Plane Survey

PeVatrons



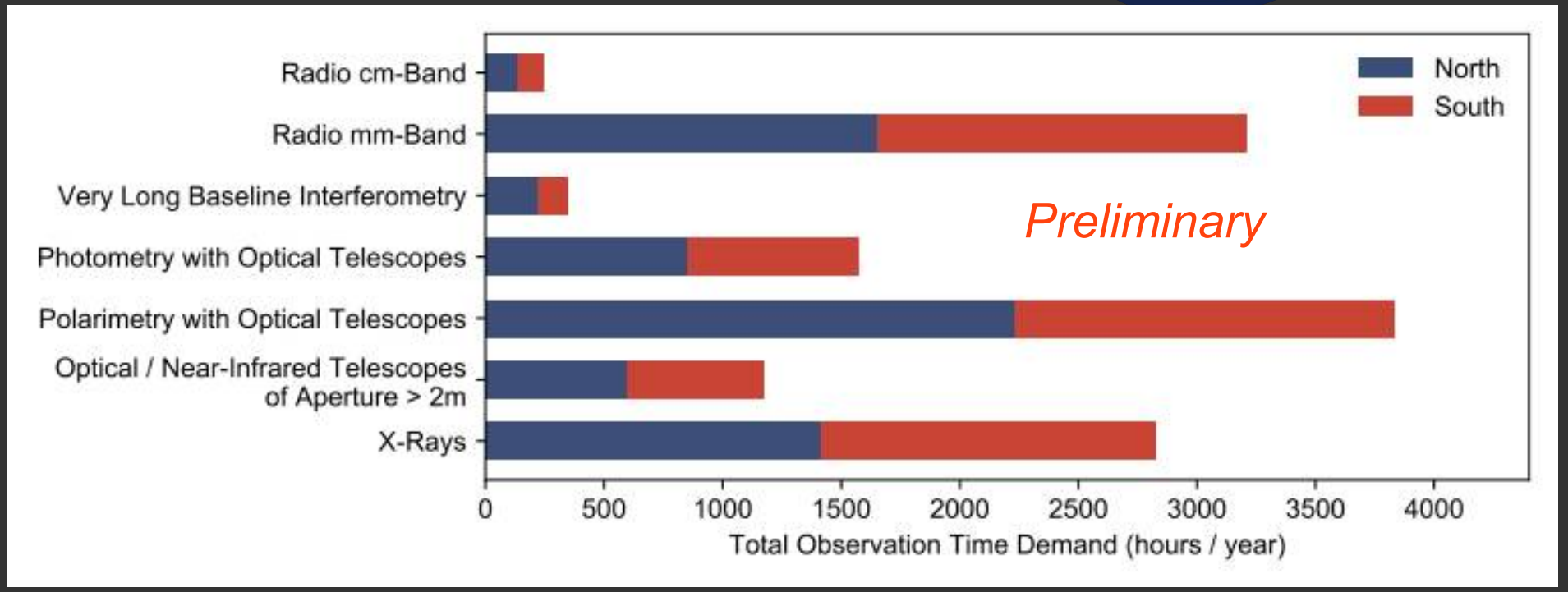
Galactic Centre



MWL Needs for Key Science Projects (Transients, Variable)

Up ~1000 hr/yr for most radio to-optical coverage **(huge potential for Australia)**

+ much more MWL needed for non-KSP time!



MWL Needs for Key Science Projects++ (Survey Data)

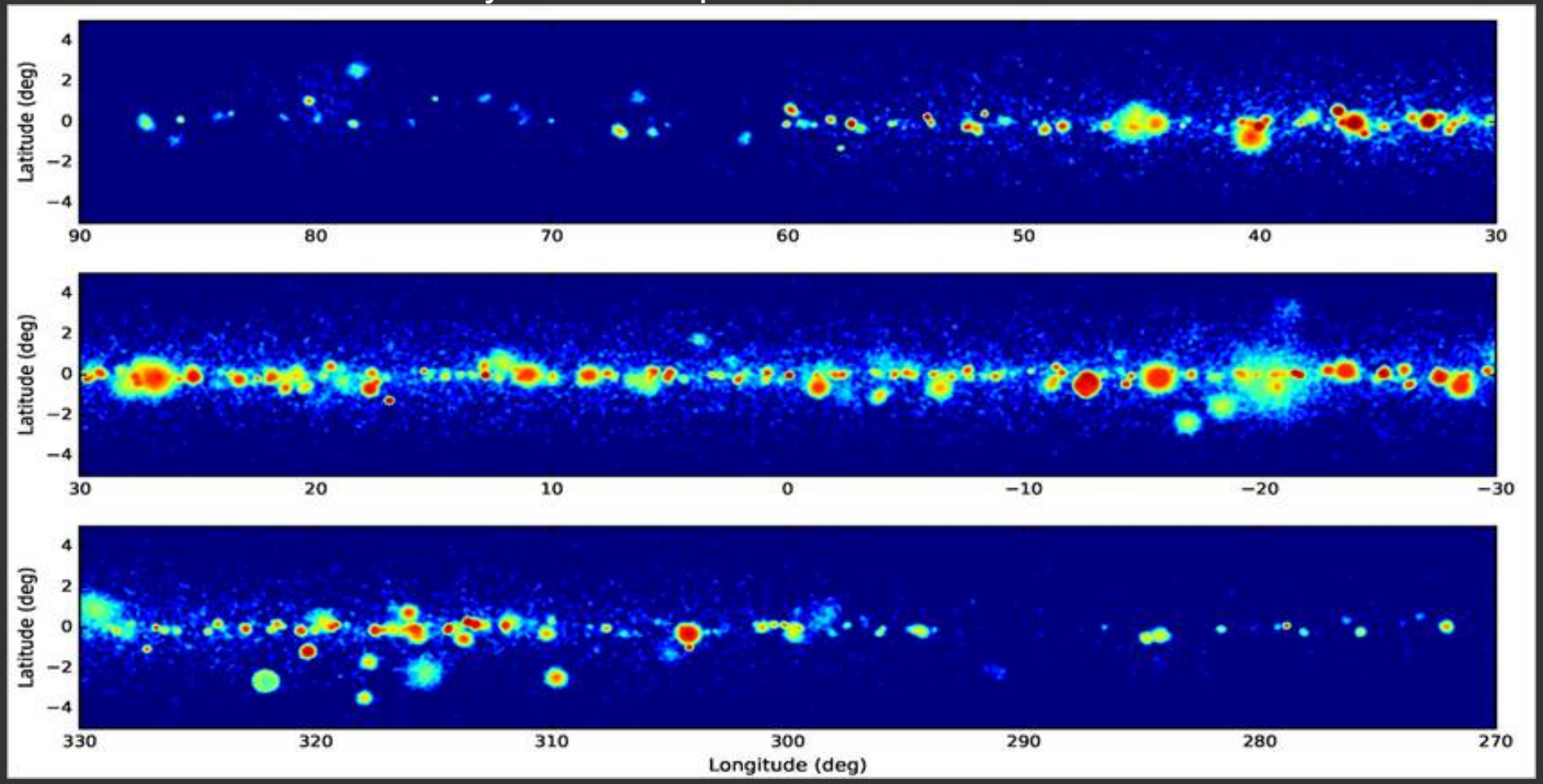
- ISM surveys — arc-min or better resolution

- Radio/X-ray continuum — measure synchrotron component

Linkages underpinned by fundamental physics of non-thermal emission

Galactic Plane: A major astrophysical challenge for CTA

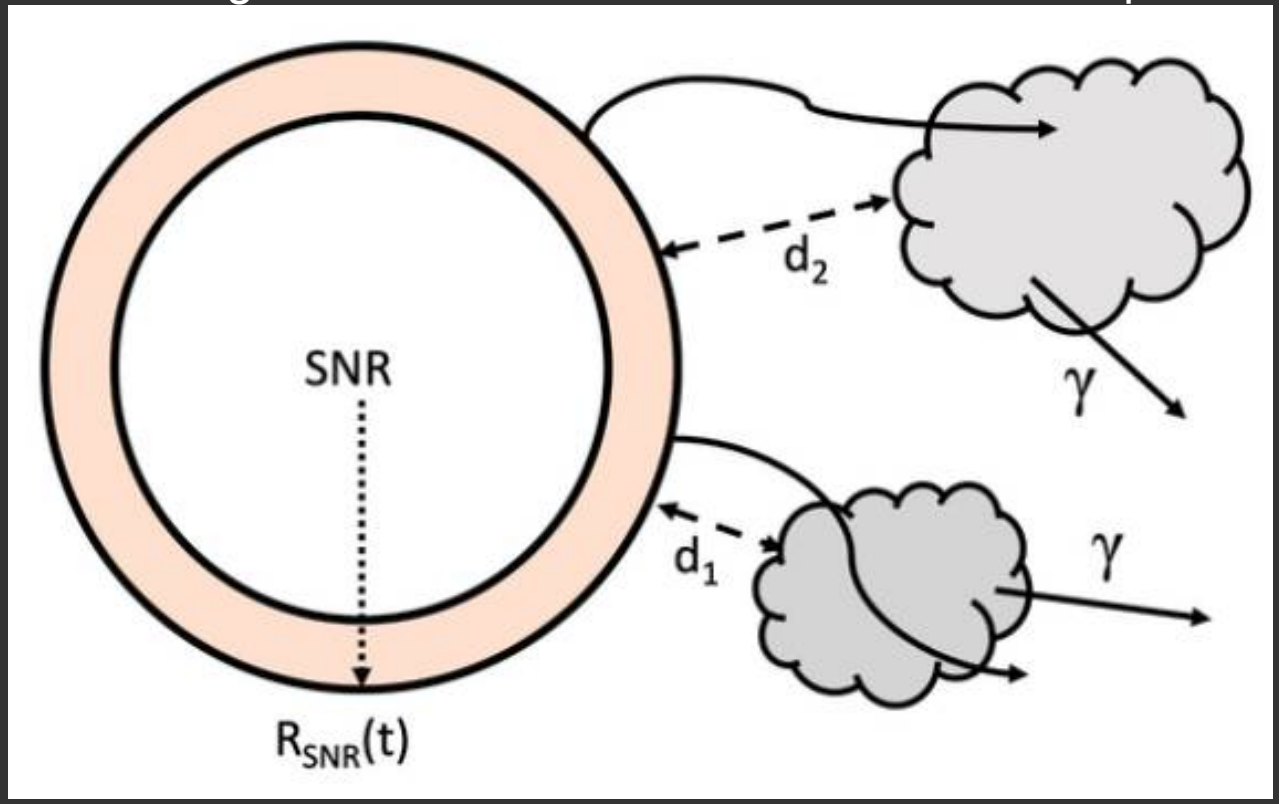
CTA will see a confusing mix of local and diffuse emission resolved to arc-min scales. How do we identify these components?



Simulation of the Gal. Plane with CTA (Ong et al 2019)

Galactic Plane: A major astrophysical challenge for CTA

A closer look at the 'local' component: Cosmic rays escaping an accelerator (e.g. SNR) and interacting with ISM clouds at different distances to produce gamma rays



Mitchell et al 2021

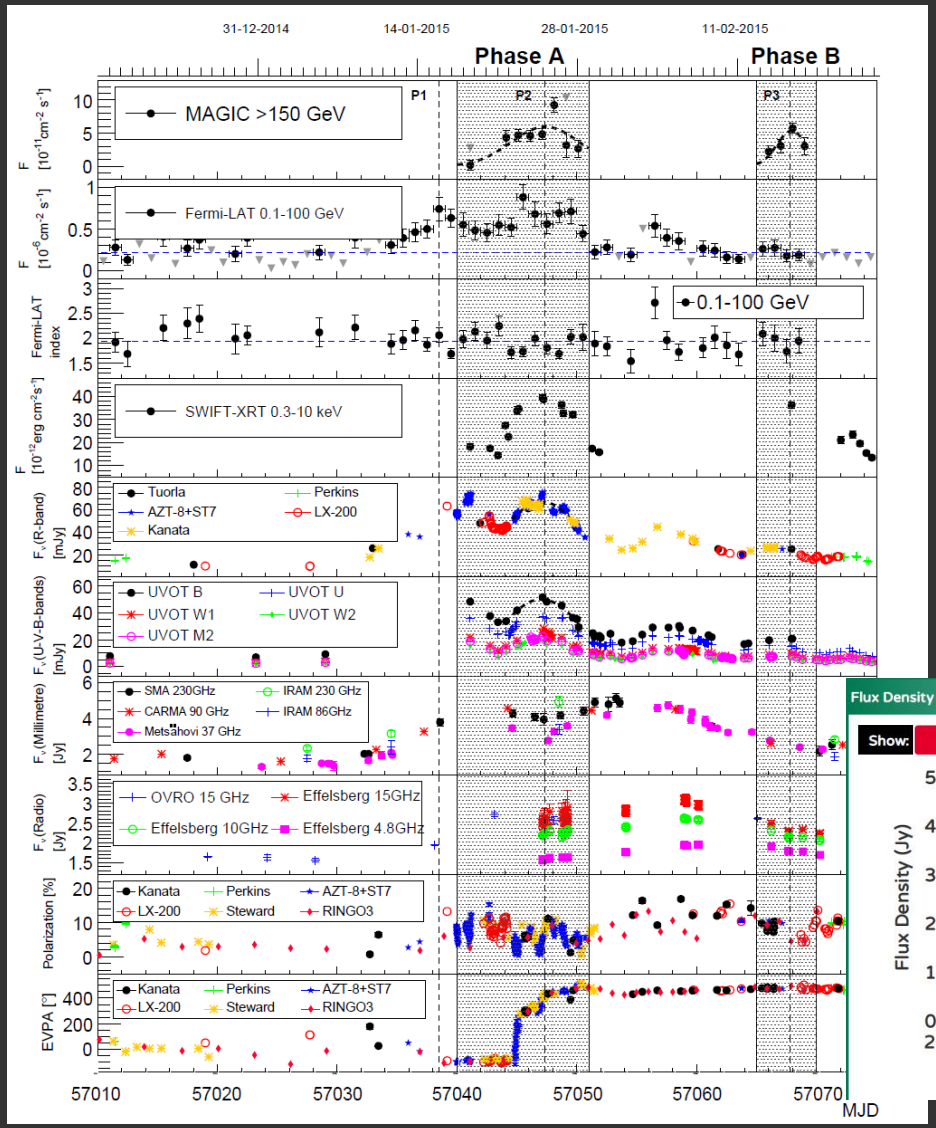
Physics we need to know:

- Time-history of particle acceleration and 'escape' into the ISM
- 3D ISM down to arc-min or better scales
- Particle diffusion, advection, and radiative loss properties
- B field magnitude and direction down to arc-min scales

AGN Blazar Flares: MWL Synergies

MWL light-curve (MAGIC 2018)

BL-Lac S5 0716+714



Enhanced HE and VHE gamma-ray activity from the FSRQ PKS 0346-27

ATel #15020; *S. Wagner (U. Heidelberg, Germany), for the H. E.S. S. collaboration an*
B. Rani (KASI, S. Korea), on behalf of the Fermi Large Area Telescope Collaboratio
*on **6 Nov 2021; 18:38 UT***
Credential Certification: Stefan J. Wagner (swagner@lsw.uni-heidelberg.de)

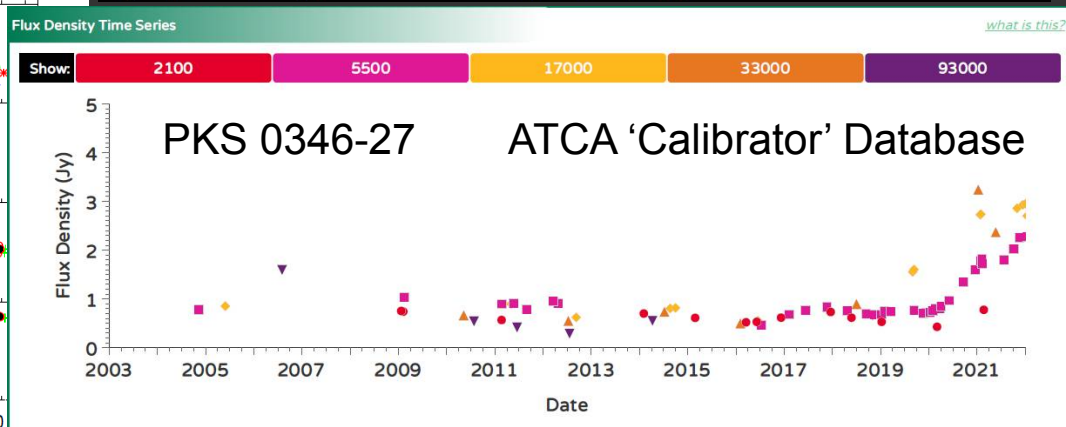
Subjects: Gamma Ray, >GeV, VHE, AGN, Blazar, Quasar

Referred to by ATel #: 15092

Tweet

The Large Area Telescope (LAT), one of the two instruments on the Fermi Gamma-ray Space Telescope, has observed enhanced gamma-ray activity from a source positionally consistent with the flat-spectrum radio quasar PKS 0346-27, also known as 4FGL J0348.5-2749 (The Fermi-LAT collaboration 2020, ApJS, 247, 33), with coordinates RA=03h 48m 38s, Dec=-27d 49' 14" (J2000; Beasley et al. 2002 ApJS, 141, 13), and a reported redshift of z=0.991 (White et al. 1988 ApJ, 327, 561).

The H.E.S.S. array of imaging atmospheric Cherenkov telescopes was used to carry out observations of PKS 0346-27. On November 03 (MJD 59521.9), a two hour observation shows a >5 sigma excess in the very-high-energy gamma-ray band compatible with the direction of PKS 0346-27. Preliminary analysis shows a very soft power law (photon spectral index > 4). H.E.S.S. observations are ongoing.



ATNF Facilities: Current (with HESS) & Future (with CTA)

ATCA

- AGN monitoriing 'calibrator' C1730 (P. Edwards) — HESS AGN included
- TANAMI (P. Edwards) — increased TeV focus
- Auto-follow-up of TeV GRBs C3374 (G. Anderson) — HESS trigger
- StarFISH C3145 (S. Breen) — dense ISM
- C3348 (N. Tothill) — ionised ISM

Parkes

- SPLASH OH (J. Dawson) — first comparison to HESS
- SUPERB FRB (Petroff etal.) — HESS follow-up

Mopra

- CO Survey (Burton etal.) — Data release 4 almost ready!
- *Many projects* on dense ISM — see http://www.physics.adelaide.edu.au/astrophysics/MopraGam/

VLBI

- cm & mm — esp. mm for rapid timescales

ASKAP (R. Norris, M. Filipovic,J. Dawson, K. Jameson, N. Pingel..)

- GASKAP HI + OH — pilot region includes HESS source
- RACS & EMU — synchrotron
- POSSUM — B-fields
- HESS + ASKAP 'shadowing' obs. — discussions commenced

[+ MWA (synchrotron) and UTMOST (FRBs) linkages to HESS in place]

CTAO-SKAO MoU (29 January 2020)

https://www.cta-observatory.org/ctao-signs-cooperation-agreement-with-the-skao/

The CTAO Signs Cooperation Agreement with the Square Kilometre Array Organisation - Cherenkov Telescope Array

29 January 2020 – The Cherenkov Telescope Array Observatory (CTAO) and the Square Kilometre Array Organisation (SKAO) will engage in closer collaboration under a new agreement signed by the two research infrastructures. The Memorandum of Understanding (MOU) will facilitate greater sharing of knowledge and expertise in areas including engineering, science, technology and administration.

The CTAO and SKAO are both large international collaborations and have several member countries in common, including many European countries but also astronomy organisations in Australia and South Africa. Like CTA, which will have two arrays of telescopes on different continents observing gamma rays, one in Chile and one on La Palma in the Canary Islands (Spain), the SKA will also have radio telescopes in Australia and South Africa. The two observatories are due to begin delivering science within just a few years of each other.

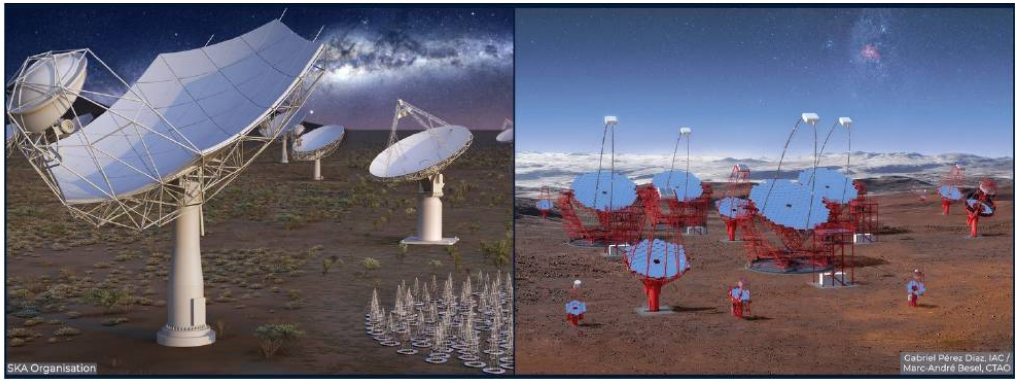
Both have also begun transitions on the governance front; the CTAO is becoming a European Research Infrastructure Consortium (ERIC), while the SKA is becoming an intergovernmental organisation or IGO.

"In this age of multi-messenger astronomy, building alliances with observatories across the spectrum is critical to achieving our common missions to expand our view and understanding of the Universe," says Federico Ferrini, CTAO Managing Director. "The CTAO-SKAO partnership was an obvious fit due to our vast similarities, and we are looking forward to the collaboration."

"Both the SKA and CTA are pushing the boundaries of what's possible technically, scientifically and logistically, and some of the challenges that brings are common to both projects," says Simon Berry, Director of Strategy for the SKA. "This MOU formalises our relationship, so we can keep learning from each other's experiences and share expertise for the benefit of both observatories."

While the respective telescopes will observe opposite ends of the electromagnetic spectrum, there are exciting areas of scientific synergy between them. Both radio and gamma rays are a probe of the violent and variable Universe, including the study of active galactic nuclei, transient events such as gamma-ray bursts and fast radio bursts, accretion into compact objects and gravitational wave counterparts.

As the world's largest radio telescope, SKA is one of several next-generation facilities targeting cosmic sources by detecting other wavelengths or messengers (such as neutrinos or gravitational waves) that will be complementary to CTA. Coordinated observations between such facilities can give a more complete picture of astronomical sources and phenomena, resulting in greatly enhanced scientific discoveries.



SKAO+CTAO synergies White Paper under discussion.

Seconded positions with CTAO
(FTE credit to CTAO operations costs)

Opportunity for Australia to lead!
(coordination, chapter leads..)

Discussions with CTAO Project Scientist (R. Zanin) ongoing.

CTAO+ESO White Paper also under discussion.

Summary

CTA is progressing well & funded for construction ‘alpha’ array

CTA-North - signals already seen from 1st telescope
CTA-South - site prep work underway

MWL radio linkages underpinned by fundamental physics.

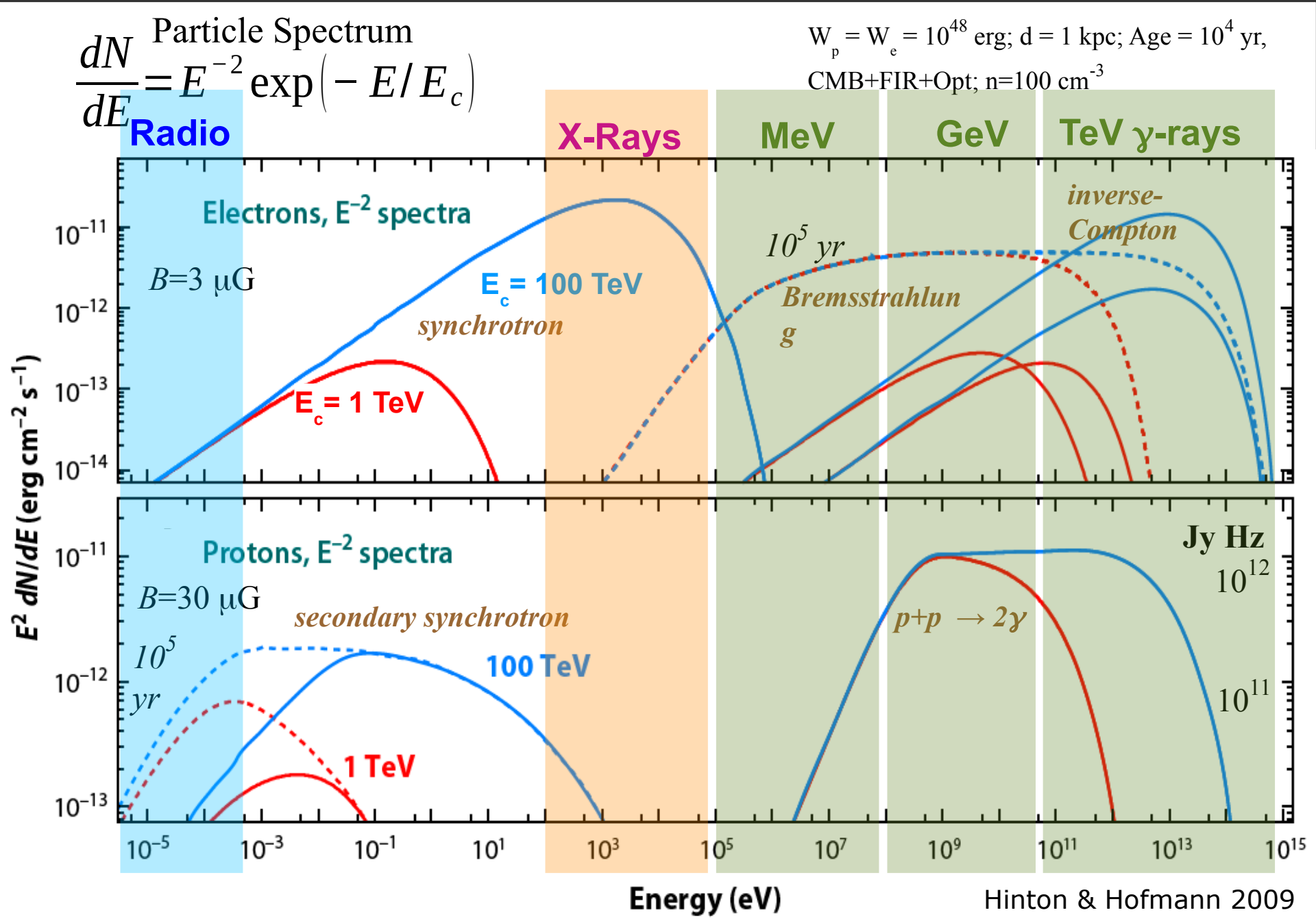
ATNF facilities important or essential to ensure CTA science
→ New opportunties for Australian radio astronomy.

Building towards SKA linkages
SKAO-CTAO synergies white paper
FTE ‘secondments’ to work on this task

This work was conducted in the context of the CTA Consortium. We gratefully acknowledge financial support from the agencies and organizations listed here https://www.cta-observatory.org/consortium_acknowledgments/

Backup...

Non-Thermal Photon Energy-fluxes (hypothetical particle accelerator)



Hinton & Hofmann 2009

Ojha etal 2010,
Mueller et al 2018

Studies of >100 AGN (southern)
+ some gamma-ray binaries

[northern - MOJAVE Lister etal 2018]

- Radio monitoring + VLBI >1 GHz
- X-ray to gamma-rays

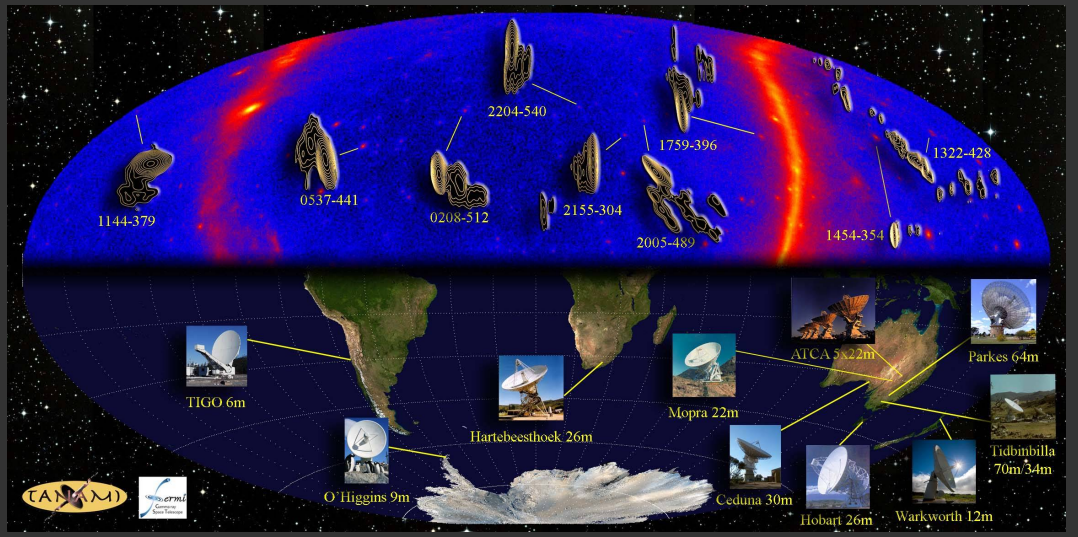
VLBI triggered by activity in
Radio, X-ray and gamma-rays

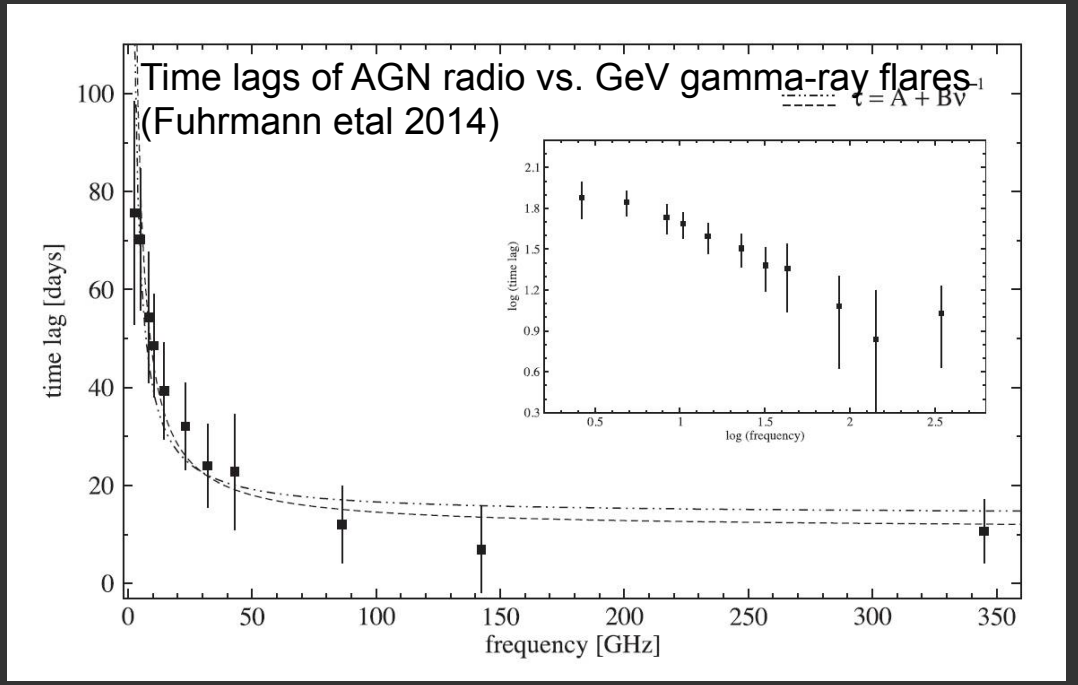
GeV gamma-rays with Fermi-LAT

More recently

→ AGN overlapping IceCube
neutrino events

→ TeV-active AGN with HESS,
and eventually, CTA.





High freq favoured for radio-gamma correlation
(although there are exceptions!)..