ATNF and CTAO

Radio to gamma-ray connections

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for CTA-Oz

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About this talk

1. Multiwavelength / multimessenger perspective rather than purely radioastronomy
2. In Hobbs Space: Happy Friendly Dragons

Summary for the impatient

1. There is a significant requirement and opportunity to carry out mm-wave science in collaboration with CTA
2. These opportunities can be found across the ATNF portfolio, and can be built into future programmes

What is CTA?

The next-generation imaging atmospheric Cherenkov telescope (IACT):

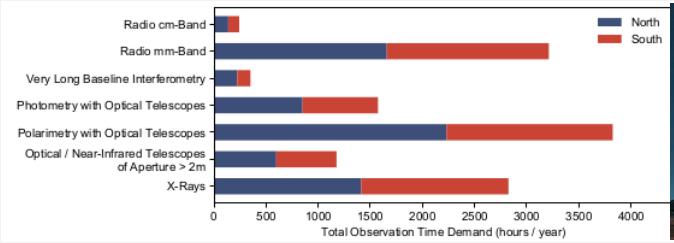
- all-sky coverage
- VHE gamma-rays
- Multinational project; mainly European
- construction budget: Eur344M $\approx$ 260 mSKA
- 23 m LST-1 is the first telescope of the N Array

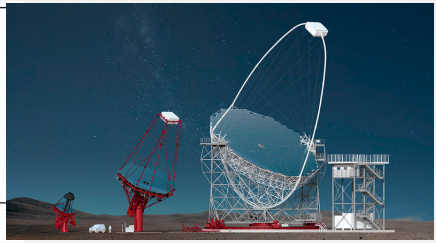
KSPs

- Dark Matter
- Galactic Centre, Plane
- LMC
- extragalactic
- transients
- pevatrons
- SFsystems
- AGN
- clusters

The CTA Science Programme

- CTA will be a northern (La Palma) and a southern (Paranal) array, seeing the whole sky.
- Northern array will specialise more in extragalactic lower-energy γ
- Southern array: Galactic Plane, higher-energy γ, up to PeV





1600h/year = 130 12h shifts; 100h/year = 8 12h shifts

Cosmic rays in the ISM

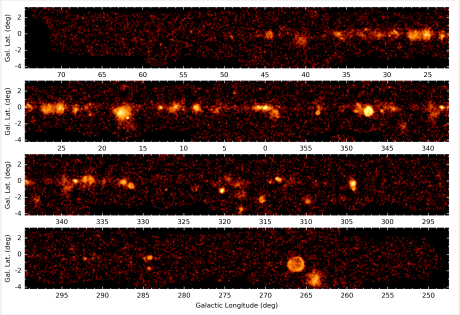
Understanding cosmic rays in the universe is a major driver for CTA
Cosmic rays are a significant constituent of the baryonic universe.
Energy density $\sim$ magnetic fields, starlight, gas KE
VHE Gamma rays are produced by cosmic rays hitting interstellar gas.
(Mainly pion production and decay to VHE γ)
Skewed to higher energies
gamma rays probe:

- the ISM as a target for cosmic rays
- the effect of cosmic rays on the ISM
- cosmic ray physics

but you need to know your target…which requires mm-wave observations

What are we looking for?

We're looking for cosmic-ray targets, i.e. lots of nucleons; or lots of electrons.
We're looking for the effects of cosmic rays, i.e. ionisation leading to magnetic effects
CTA's angular resolution (around 10TeV) is $\sim 2'$ (observing time dependent), and could go down to $\sim 0.5'$
So we're looking for resolutions of 0.5–1 arcminute
Mainly spectral-line observations of dense gas tracers



Single-dish mm-wave to date

Mopra	MopraGAM	7 mm	$\sim 1'$	CS 1–0, SiO 1–0	dense gas
	HOPS	12 mm	$\sim 2'$	NH_3, H_2O	dense gas, temperature, masers
	MopraGPS	3 mm	$\sim 0.5'$	CO 1–0	molecular clouds, isotopologues
ATCA	StarFISH	7 mm	$\sim 1'$	CS 1–0	dense gas
	N/A	3 mm	$\sim 0.5'$	HCO^+	molecular gas ionisation

Single-dish mm-wave options

ATCA	7 mm	$\sim 1'$	CS 1–0	dense gas
	3 mm	$\sim 0.5'$	HCO^+	molecular gas ionisation
Murriyang-Parkes	12 mm	$\sim 0.6'$	NH_3++	dense gas, temperature, masers
Mopra	7 mm	$\sim 1'$	CS 1–0, SiO 1–0	dense gas
	12 mm	$\sim 2'$	NH_3, H_2O	dense gas, temperature, masers
	3 mm	$\sim 0.5'$	CO 1–0	molecular clouds, isotopologues

Aperture synthesis with ATCA

smallest antenna separation: 30m
largest antenna separation: $\sim$ 1000m

λ	ν/GHz	spatial sensitivity/arcmin	uses
12 mm	22	1.8	NH_3
7mm low	35	1.2	e.g. DC_3N, CCS
7mm high	45	0.9	CS 1–0, SiO 1–0
3mm low	90	0.5	HCO^+ 1–0
3mm high	110	0.4	CO 1–0

What could we do with high-frequency ASKAP?

smallest antenna separation: 20m
largest antenna separation: 100m ?
pwv statistics unknown

λ	ν/GHz	resolution/arcmin	spatial sensitivity/arcmin	uses
12 mm	22	0.5	3	NH_3
7mm low	35	0.4	1.8	e.g. DC_3N, CCS
7mm high	45	0.3	1.4	CS 1–0
3mm low	90	0.1	0.7	HCO^+ 1–0
3mm high	115	0.1	0.5	CO 1–0

smallish n, small d, compact array
Magellanic Clouds could use longer baselines

Summary

1. There is a significant requirement and opportunity to carry out mm-wave science in collaboration with CTA
2. These opportunities can be found across the ATNF portfolio, and can be built into future programmes
3. as tradeoffs are considered, mm-wave capabilities can be enhanced/maintained
   - 3.1 high-frequency ASKAP
   - 3.2 ATCA mm-wave with BIGCAT
   - 3.3 Murriyang-Parkes
   - 3.4 Mopra reboot

We advocate:
that ATNF development pathways should include mm-wave options for multiwavelength/multimessenger science

We're from CTA-Oz, and we're here to help...

Gavin Rowell (Adelaide)
Sabrina Einecke (Adelaide)
Miroslav Filipovic (WSU)
Roland Crocker (ANU)
Csaba Balasz (Monash)
et al

CSIRO is a partner organisation.
Australian participation in CTA is funded via LIEF grants and NCRIS through AAL.
We are represented on the board and committees by AAL and our members.
We have regular meetings (about twice a year)

CTA-Oz Consortium

Adelaide

ANU

Curtin

Monash

UNSW

Sydney

Western Sydney

One more thing…

What about the cm-wave data?
High-energy electrons launch VHE γ-rays via inverse Compton scattering
VHE γ coupled to synchrotron radiation
CTAO and SKAO have an MoU
CTA-SKA synergy chapter to appear in next SKA science book

Also: transients…