

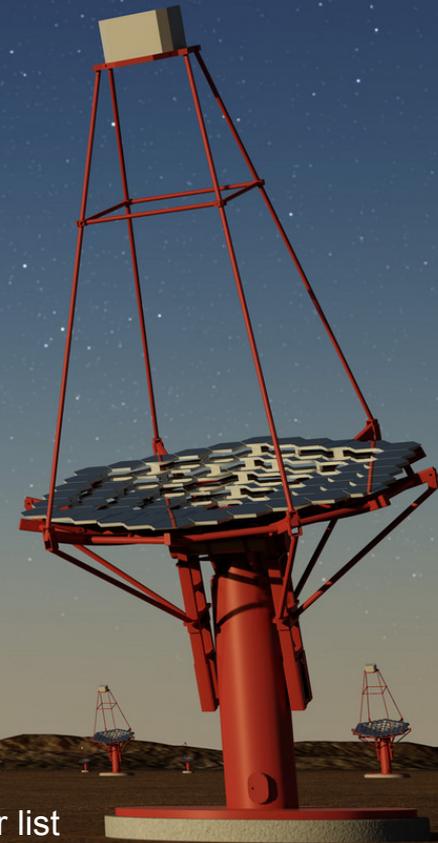


cherenkov
telescope
array

Exploring the Hot and Energetic Universe:
The second scientific conference dedicated to the
Athena X-ray observatory

CTA and Synergy with the X-ray Domain and Athena

The CTA Consortium¹ represented by Ivan Agudo²



¹ see http://www.cta-observatory.org/consortium_authors/authors_2018_09.html for full author list

² Instituto de Astrofísica de Andalucía-CSIC, Granada, Spain



Outline of the talk:

- CTA overview
- Astrophysical synergies between CTA and Athena
- Summary



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Overview



CTA: One observatory, two sites, and two office locations



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

- 31 countries, 204 institutes, >1400 members
- Construction planned for 2018-2022(2025)
- Chilean site under negotiations

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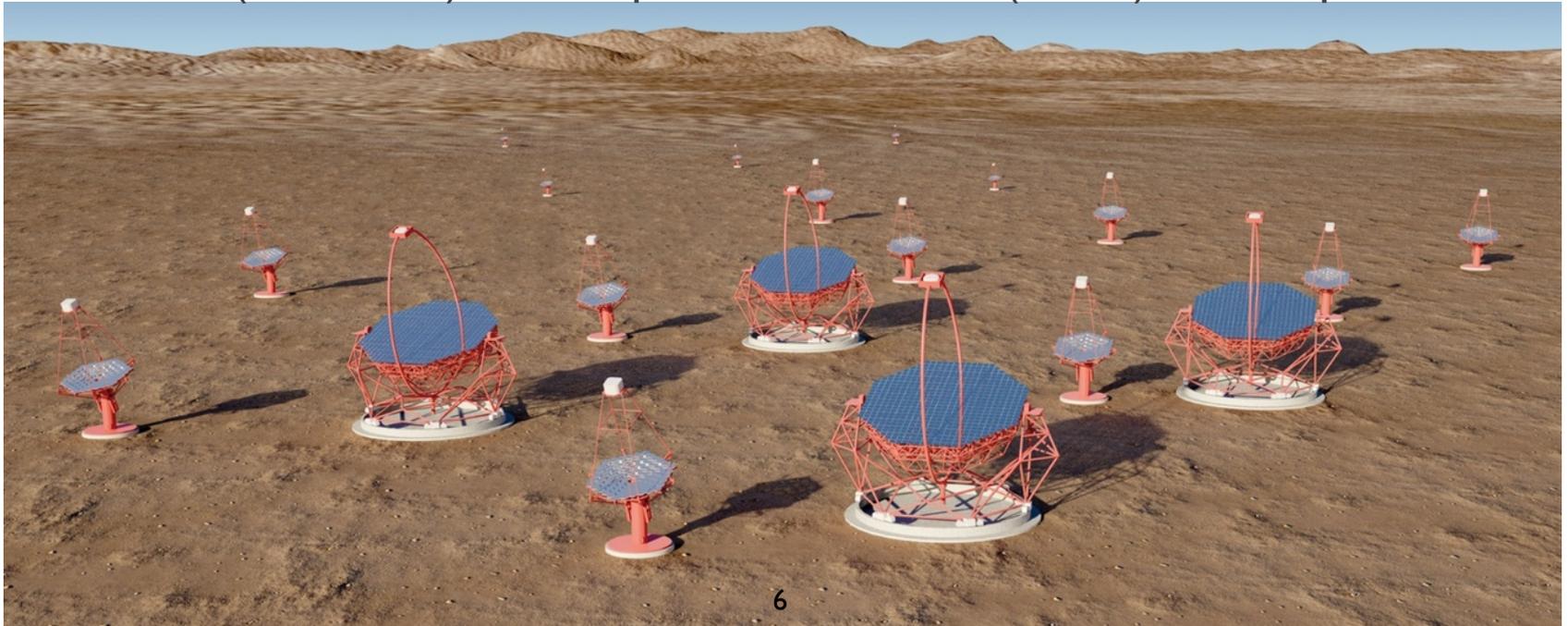
An open VHE observatory:

- First 10 years: ~40% time in Consortium Key Science Projects
- ~50% for Guest Observer programs from Announcements of Opportunity
- All data public after a proprietary period (probably one year)

CTA: North and South



Baseline: 99 (4+15+70) telescopes in South, 19 (4+15) telescopes in North



CTA: Prototypes

GCT
Meudon - France



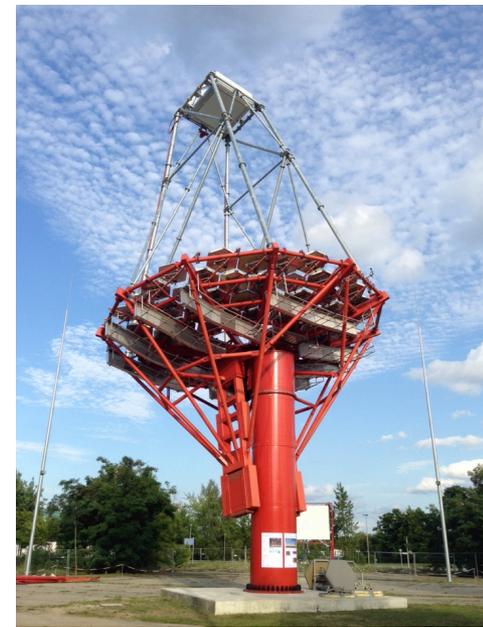
ASTRI
Serra La Nave - Italy



SST-1M
Krakow - Poland



4m-SSTs



12m-MST, Berlin-Adlershof, Germany



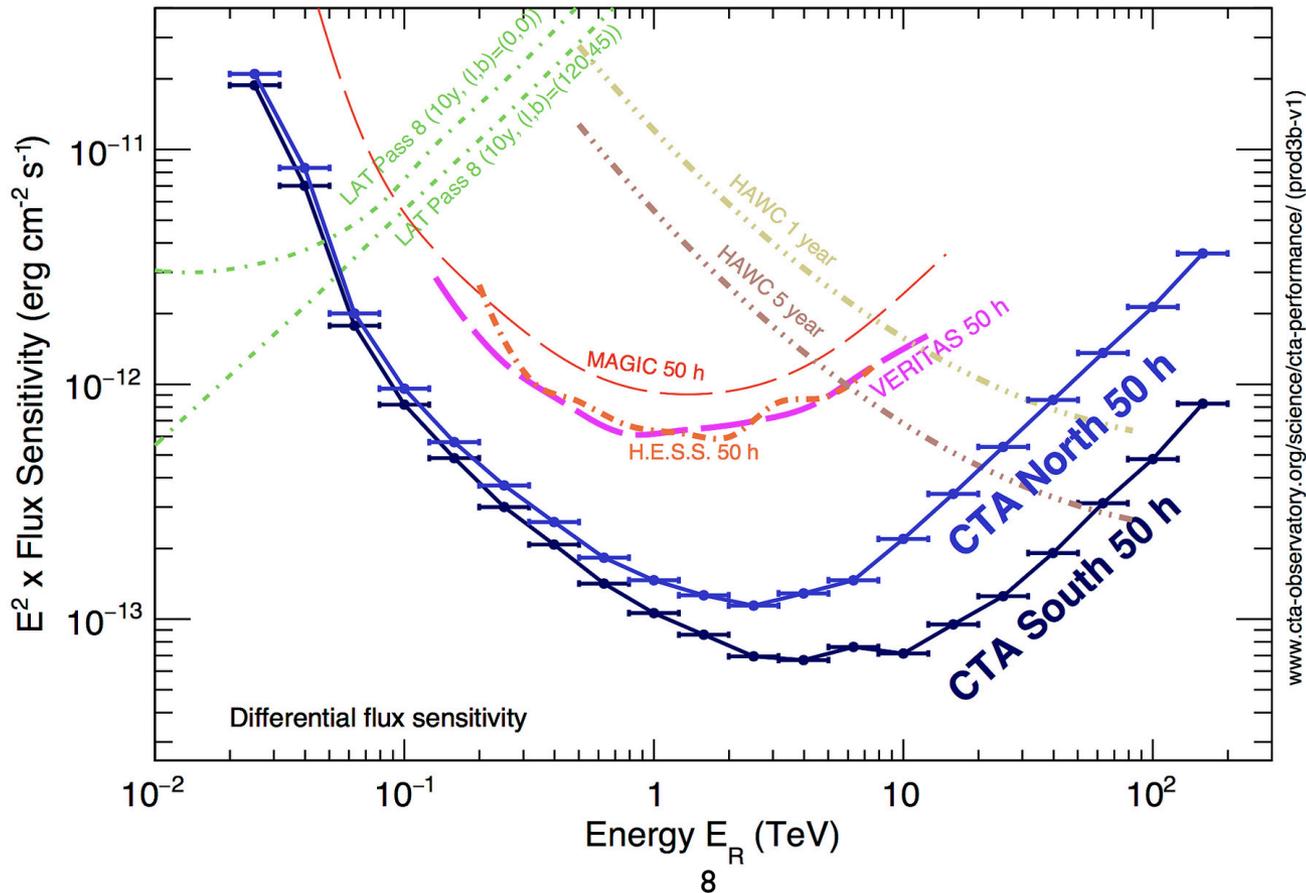
Construction of the 23m-LST1 essentially finished in La Palma!



10m-SCT, FLWO, USA

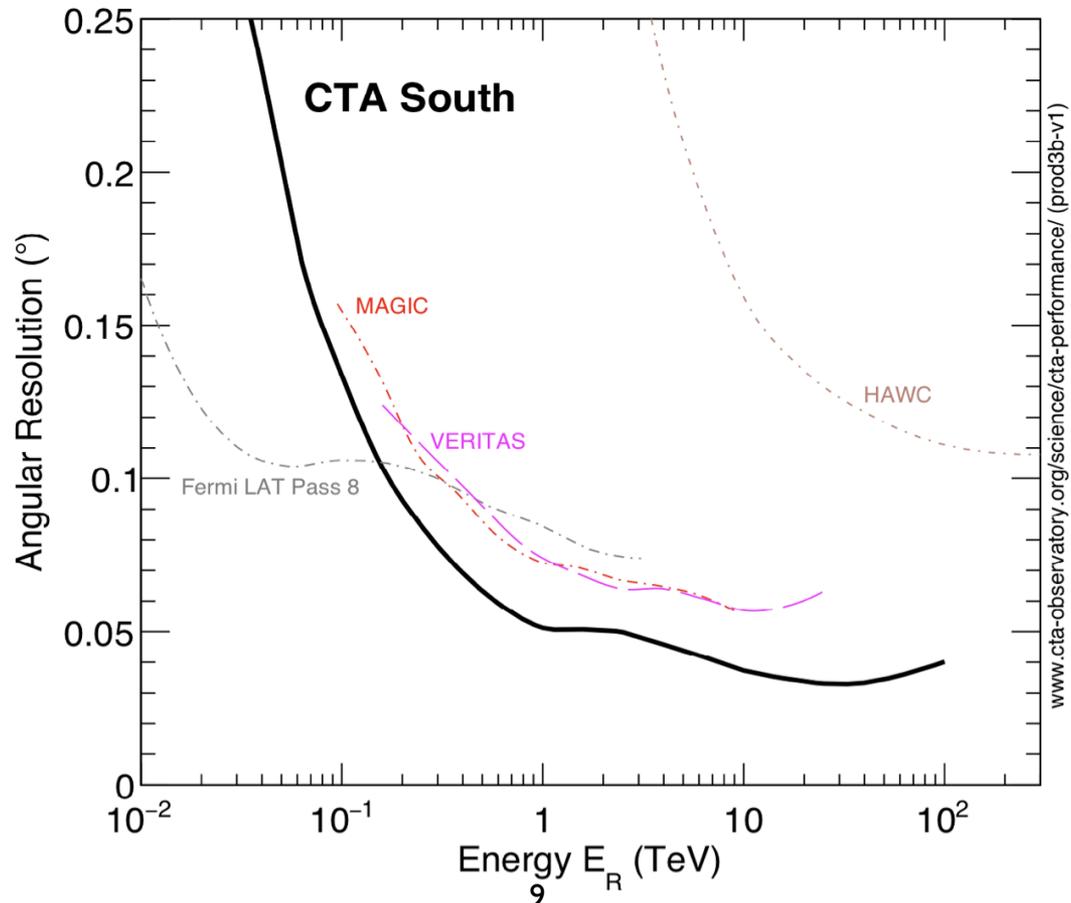
CTA: Profile

- Energy range ~ 20 GeV to >300 TeV (10x better E coverage than before)
- An order of magnitude better sensitivity at TeV energies
- Larger field of view (4.5 to 9 deg., depending on energy)
- Improved angular resolution (~ 2 arcminute scale at >0.1 TeV)
- Full sky coverage (combining North+South sites)



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CTA: Science

Theme 1: Understanding the Origin and Role of Relativistic Cosmic Particles

- What are the sites of high-energy particle acceleration in the universe?
- What are the mechanisms for cosmic particle acceleration?
- What role do accelerated particles play in feedback on star formation and galaxy evolution?



CTA: Science

Theme 2: Probing Extreme Environments

- What physical processes are at work close to neutron stars and black holes?
- What are the characteristics of relativistic jets, winds and explosions?
- How intense are radiation fields and magnetic fields in cosmic voids, and how do these evolve over cosmic time?



CTA: Science

Theme 3: Exploring Frontiers in Physics

- What is the nature of dark matter? How is it distributed?
- Are there quantum gravitational effects on photon propagation?
- Do axion-like particles exist?

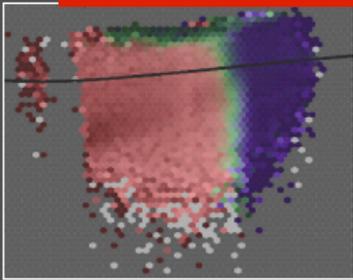
All this science will be developed by a number of CTA Key Science Projects

The CTA Consortium, 2018, World Scientific, ISBN: 978-981-3270-08-4

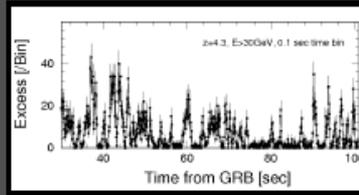
<http://arxiv.org/abs/1709.07997>



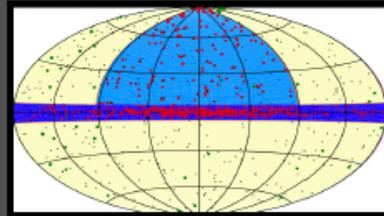
CTA: Science



Dark Matter Programme

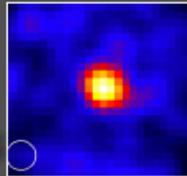


Transients



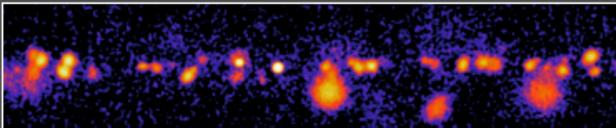
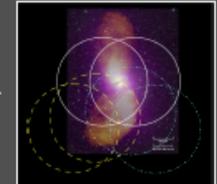
ExGal Survey

Galaxy Clusters



Star Forming Systems

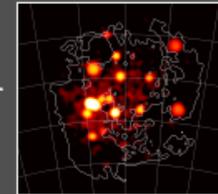
AGN



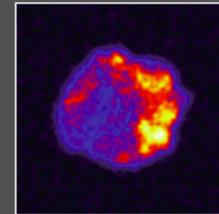
Galactic Plane Survey

Galactic

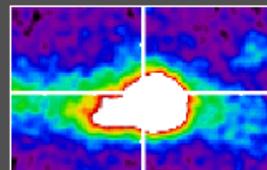
LMC Survey



PeVatrons



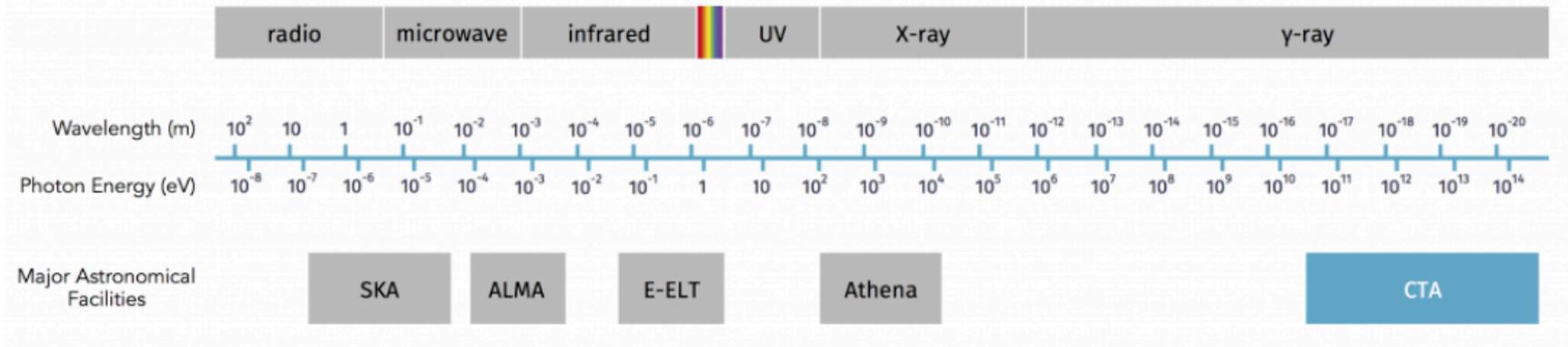
Galactic Centre Survey



Synergies between CTA and Athena

Exploring Synergies between CTA and Athena

Athena: 0.2-10 keV. CTA: 20 GeV-300 TeV. ~6-12 orders of mag. difference.



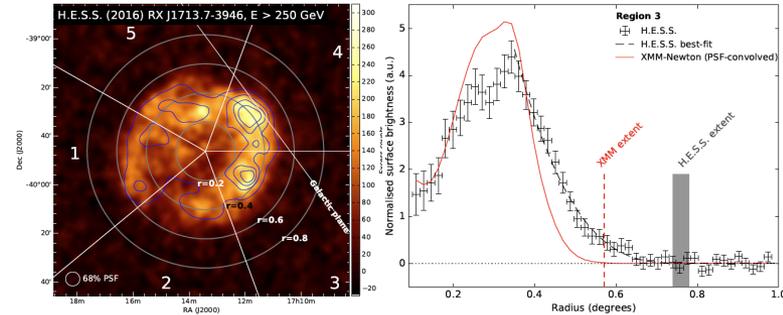
Thermal X-ray emission often associated with shock waves, accretion or high velocity outflows, particle acceleration and gamma-ray emission. Provides valuable information about plasma properties (e.g. temperatures, densities) and energetics (e.g. outflow/shock velocities).

Non-thermal synchrotron X-ray emitting electrons ($E \sim 100$ TeV) can easily produce gamma rays through inverse Compton process. Provides a natural tracer of locations of extreme particle acceleration. Constrains B strengths, the particle E distribution and the e^- to p ratio.

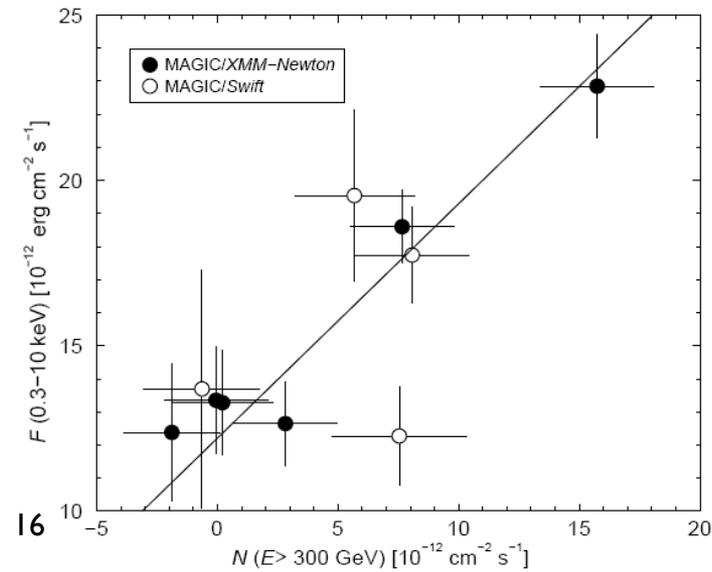
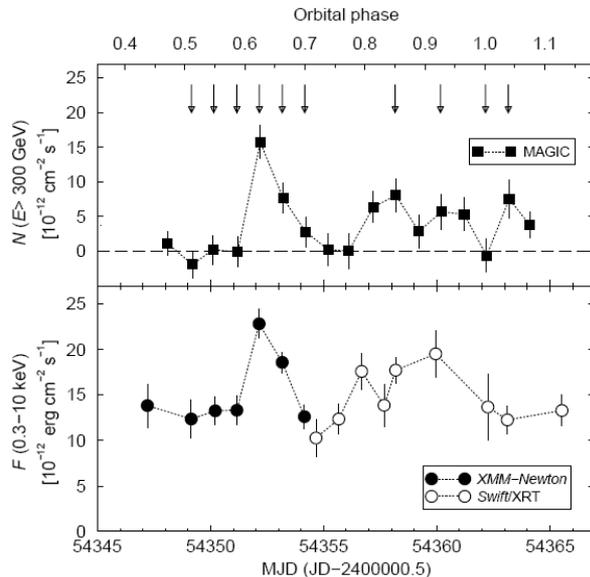
Exploring Synergies between CTA and Athena

Clear **synergies** to **constrain physical parameters** in many scientific cases:

Morphological studies of PWNe and SNRs.
Nature leptonic/hadronic emission.
 B strength and photon field density.
(e.g., RX J1713.7–3946 XMM/HESS).



X-ray/TeV correlations of variable sources: e.g. gamma-ray binaries, AGN.
Constrain leptonic/hadronic emission (e.g. LSI+61303 XMM/MAGIC).



Exploring Synergies between CTA and Athena

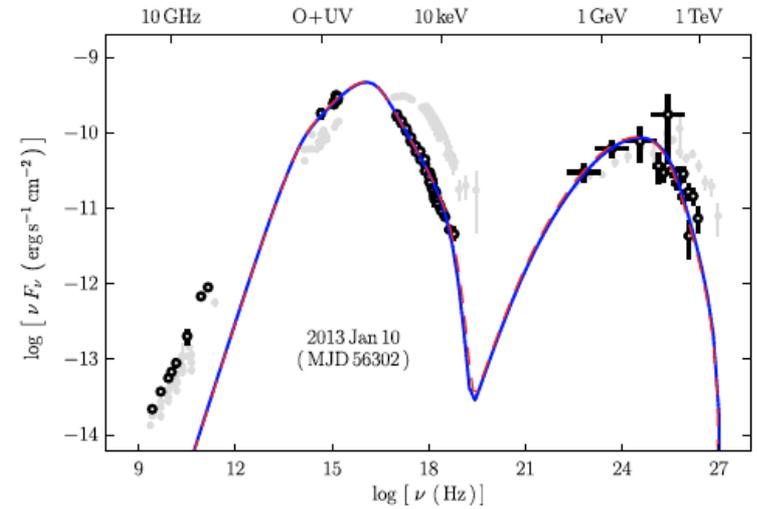
Most **general** case:

SED model fitting over the whole EM spectrum in many types of sources (e.g., Mrk 421 by NuSTAR/MAGIC)

Transient sources:

X-ray obs. provide crucial information (e.g. QPO) to trigger CTA in **microquasars** constrain E_{max} of accelerated particles by stellar-mass BHs.

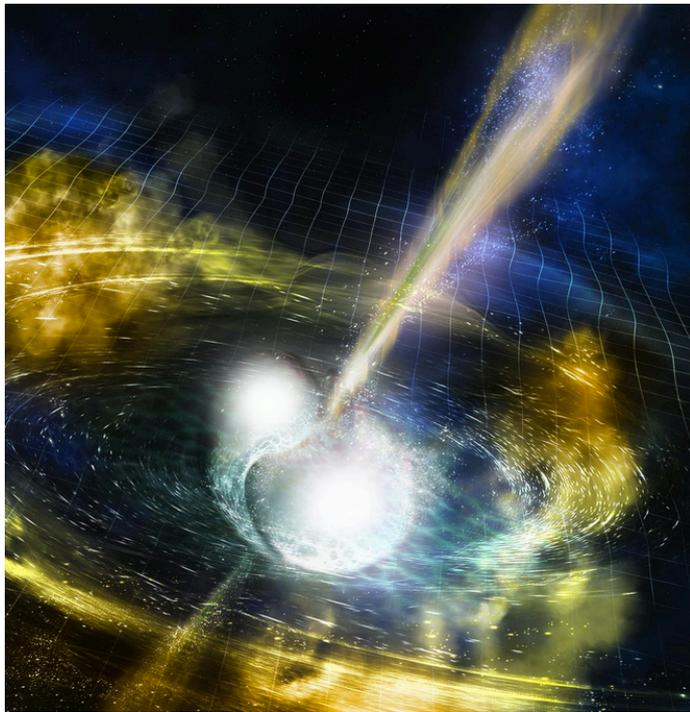
Long GRBs. MW information needed to model light curves from keV to multi-GeV: understand GRB prompt and/or early afterglow emission, probe hadronic emission processes, distinguish nature of cutoffs



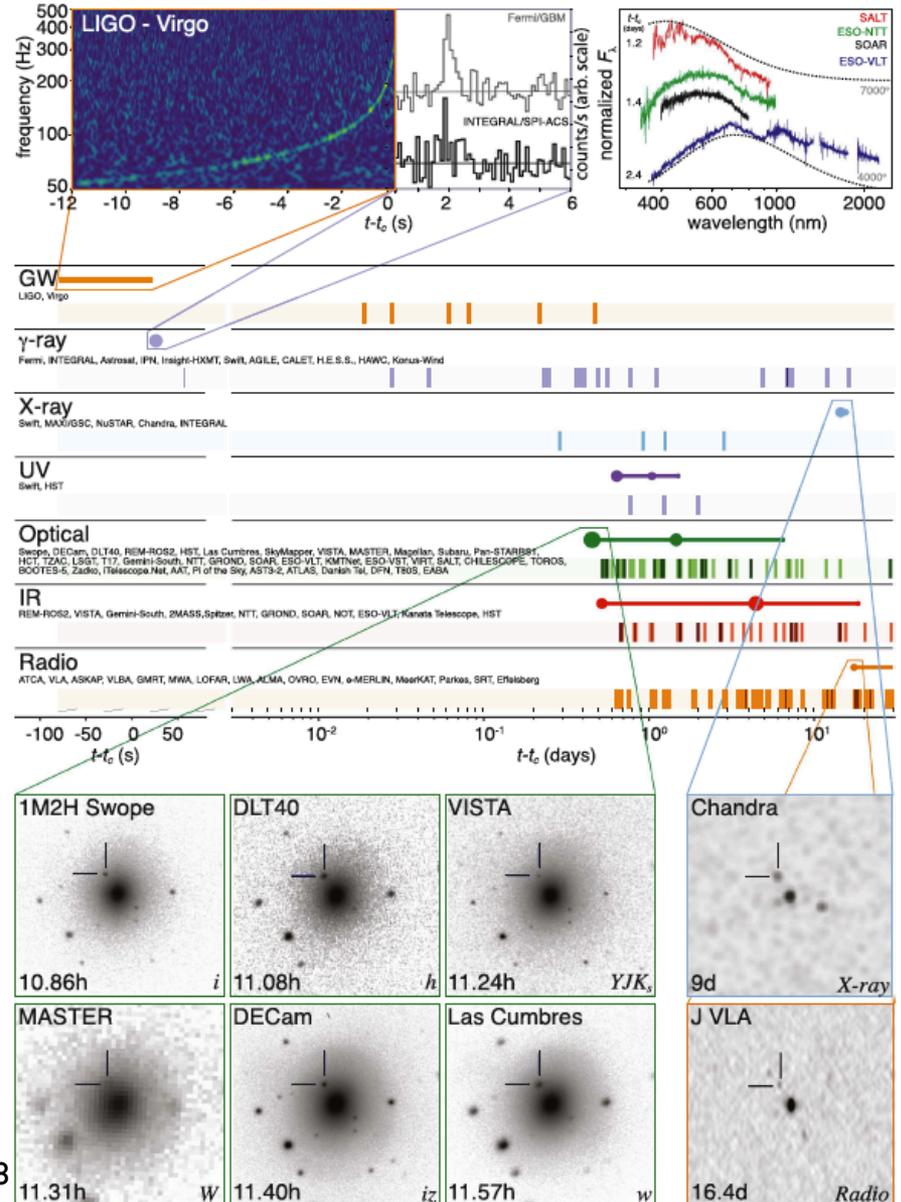
Exploring Synergies between CTA and Athena

Short GRBs and GWs. Fast response and large FoV of Athena will help identification of X-ray counterparts.

Detection by CTA more difficult than with Fermi due to limited FoV. Joint operation would be desirable.



GW170817



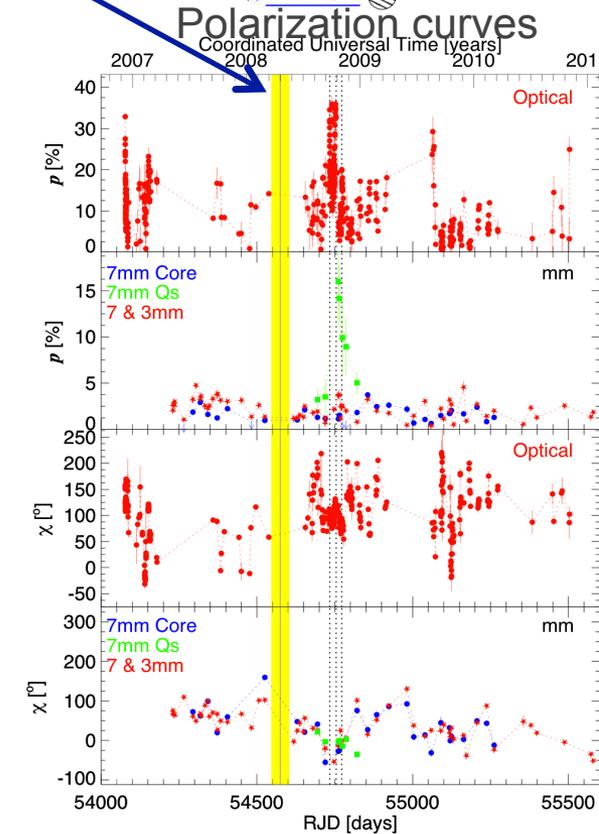
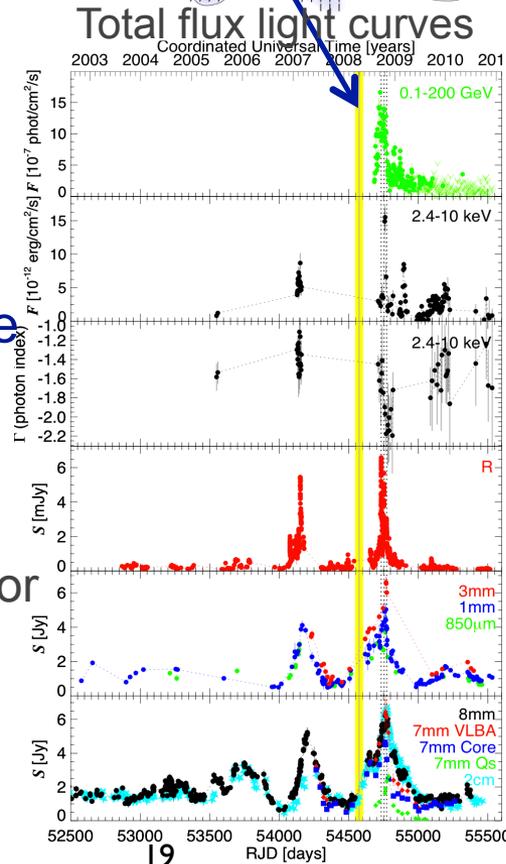
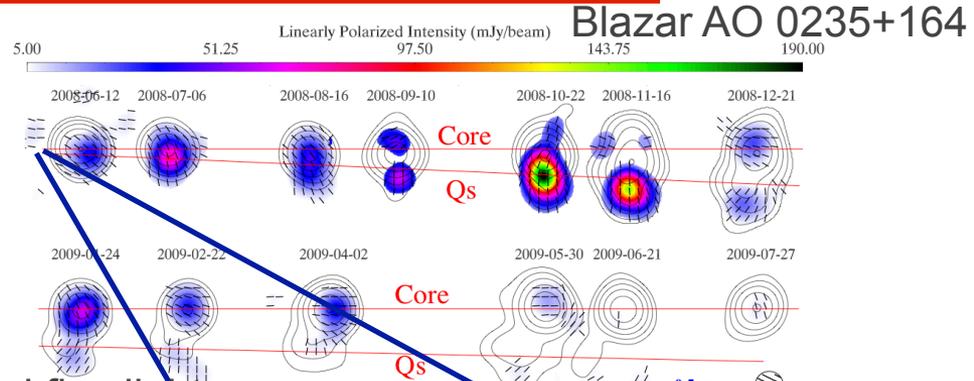
Exploring Synergies between CTA and Athena

CTA **AGN flare program**. MWL coverage is crucial, at least for the most prominent flares, for variability studies and dynamical spectral modeling.

Emission processes at high energies and particle acceleration mechanisms

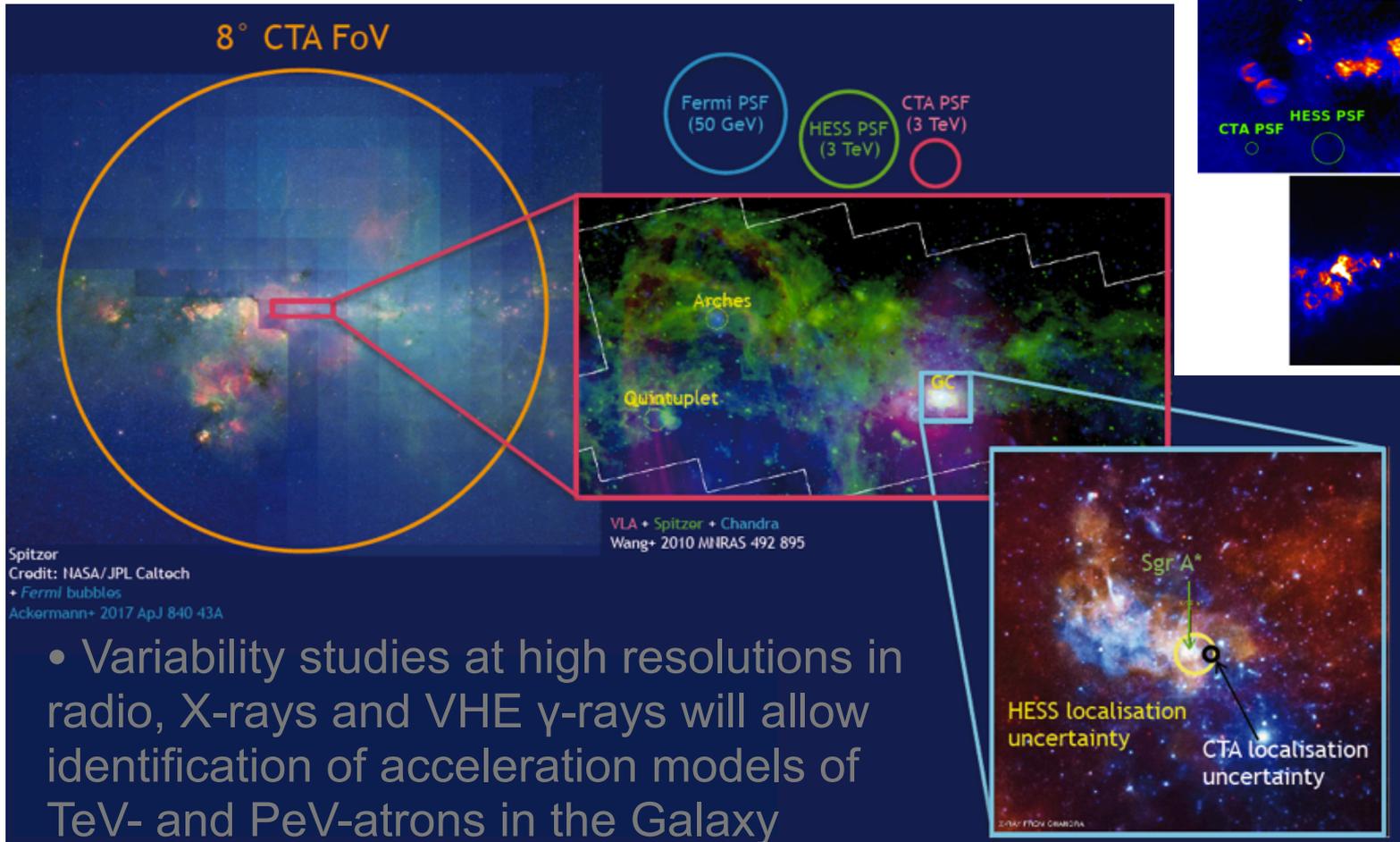
VLBI crucial to have an absolute localization of the relevant emission regions

- However, this is done so far only for a handful of sources only and the actual emission and acceleration mechanisms are still not well constrained.



Exploring Synergies between CTA and Athena

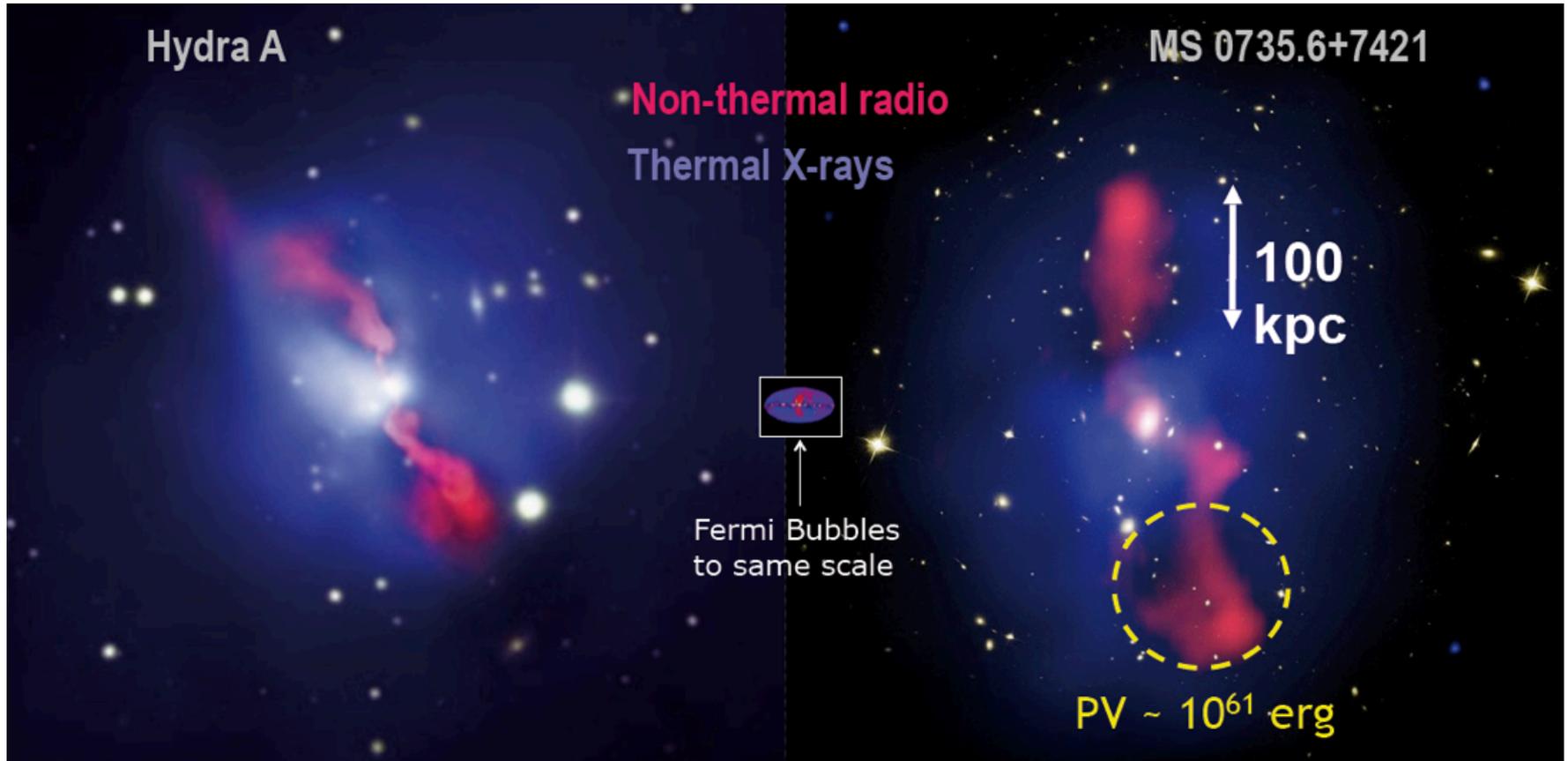
Sgr A* and the Galactic Plane:



- Variability studies at high resolutions in radio, X-rays and VHE γ -rays will allow identification of acceleration models of TeV- and PeV-atrons in the Galaxy

Exploring Synergies between CTA and Athena

Clusters of galaxies:



(slide from S. Markoff)

CTA will investigate VHE γ -ray emission associated to the non-thermal component in clusters, which will add complementary information to the comprehensive data sets expected from Athena and SKA. This will permit a better understanding of cluster energetics and AGN feedback

Summary

- CTA and Athena will observe together by the end of next decade
- Unprecedented sensitivity and FoV along the electromagnetic spectrum
- Variety of exciting science to be done together with CTA and Athena
 - Short GRBs, gravitational wave - electromagnetic event studies
 - Other transient and/or explosive phenomena (e.g. neutrino sources, TDEs, long GRBs)
 - AGN jet studies
 - Sgr A* and the Galactic Plane
 - Galaxy clusters
- CTA - Athena synergies and joint operation modes should be explored and developed by a joint WG

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Thanks a lot for your attention!