

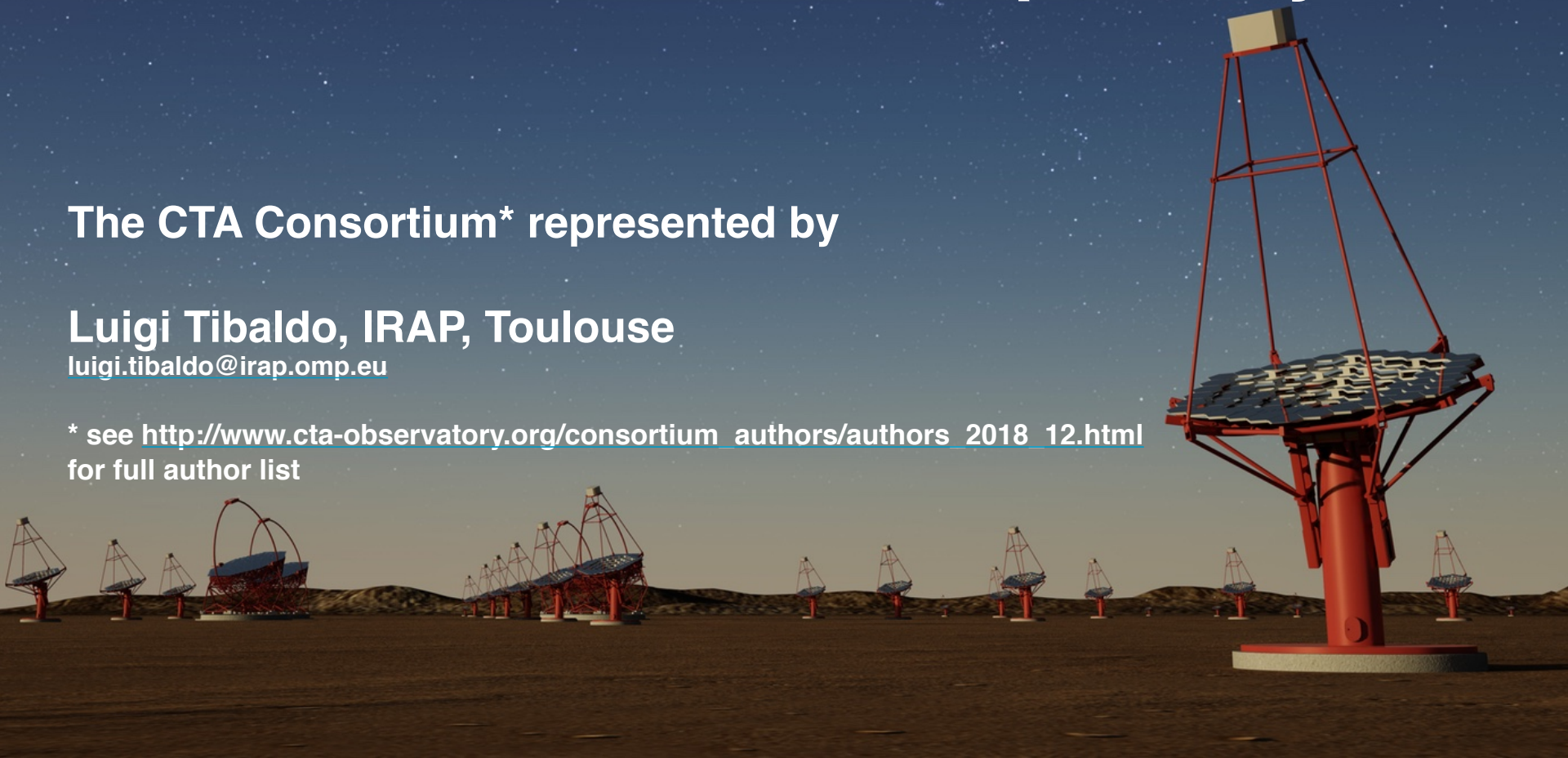
The Galactic Science Programme of the Cherenkov Telescope Array

The CTA Consortium* represented by

Luigi Tibaldo, IRAP, Toulouse

luigi.tibaldo@irap.omp.eu

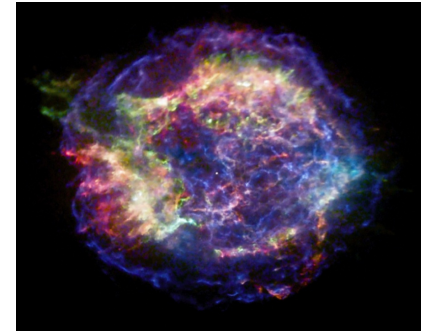
* see http://www.cta-observatory.org/consortium_authors/authors_2018_12.html
for full author list



The coming of age of VHE astronomy



- original motivation: find the sources of CRs, probably SNRs
- today astonishing variety of sources, of which many in the Milky Way: SNRs, SNR/molecular clouds, PWNe, pulsars, binary systems, massive-star forming regions, diffuse emission, Galactic centre

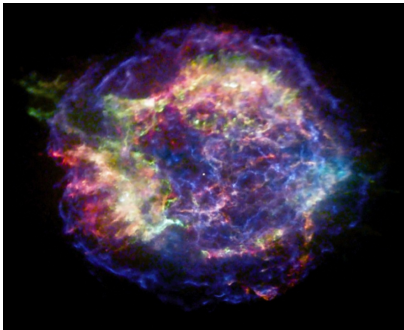


Galactic Science: questions



Origin and role of relativistic particles

Sites and mechanisms of CR acceleration

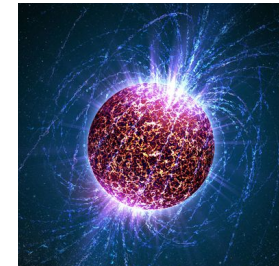


CR propagation and feedback on star-forming systems/Milky Way



Probing extreme environments

Physical processes close to neutron stars and black holes



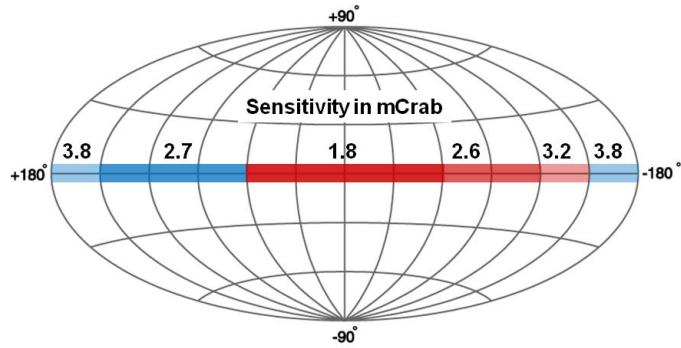
Relativistic jets, winds, and explosions



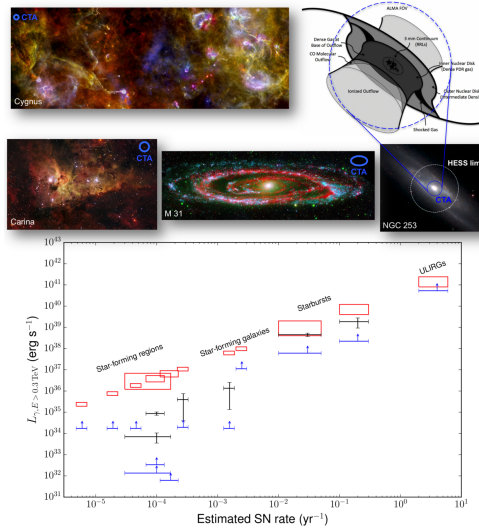
Galactic Key Science Projects

in press, World Scientific,
arXiv:1709.07997

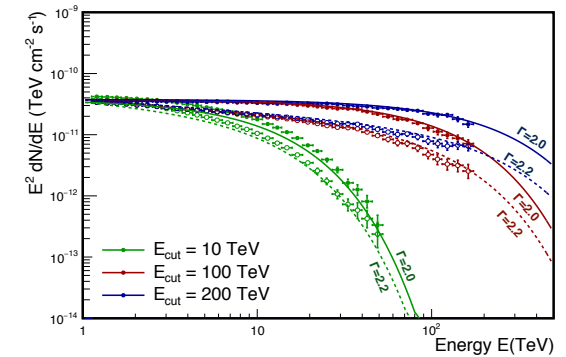
Galactic Plane Survey (GPS)



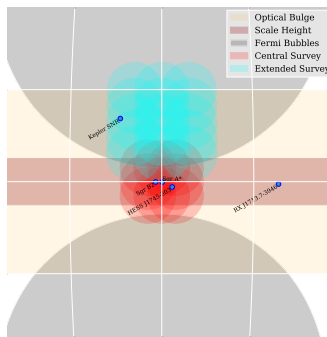
Star-Forming Systems



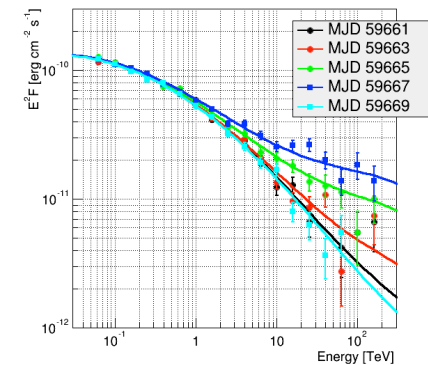
PeVatrons



Galactic centre survey



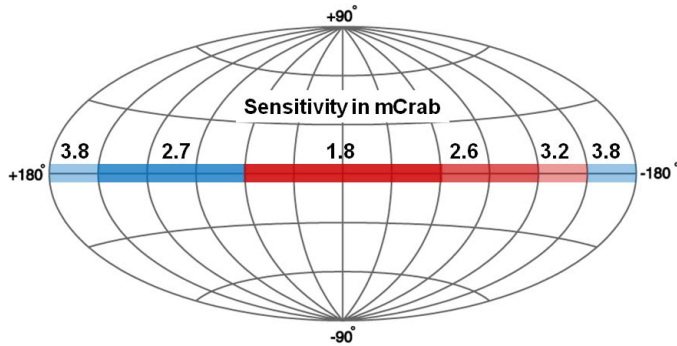
Transients



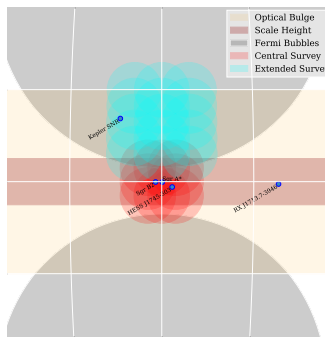
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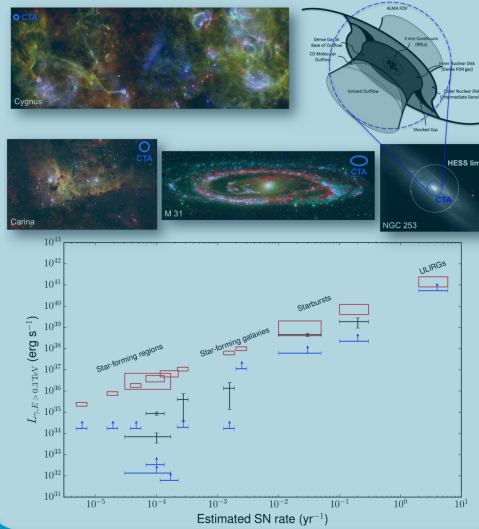
Galactic Plane Survey (GPS)



Galactic centre survey



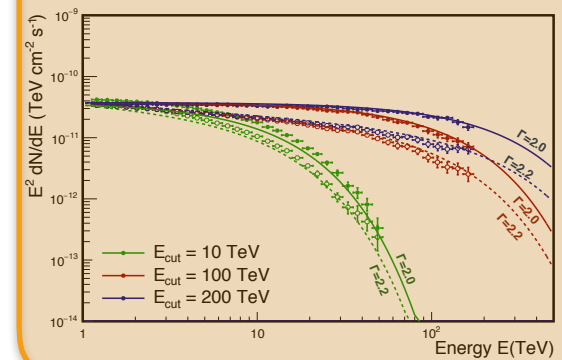
Star-Forming Systems



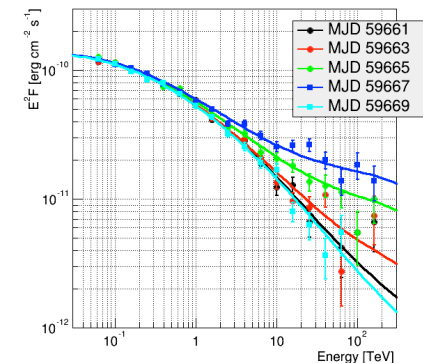
see talk by Rui Zhi

see talk by Sabrina

PeVatrons



Transients

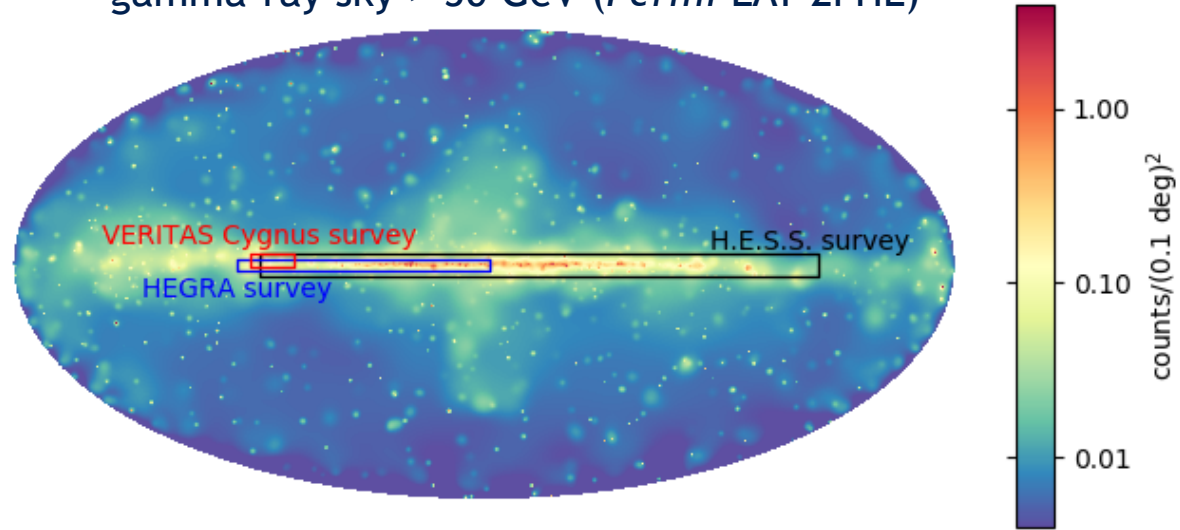


Existing IACT surveys of the Milky Way

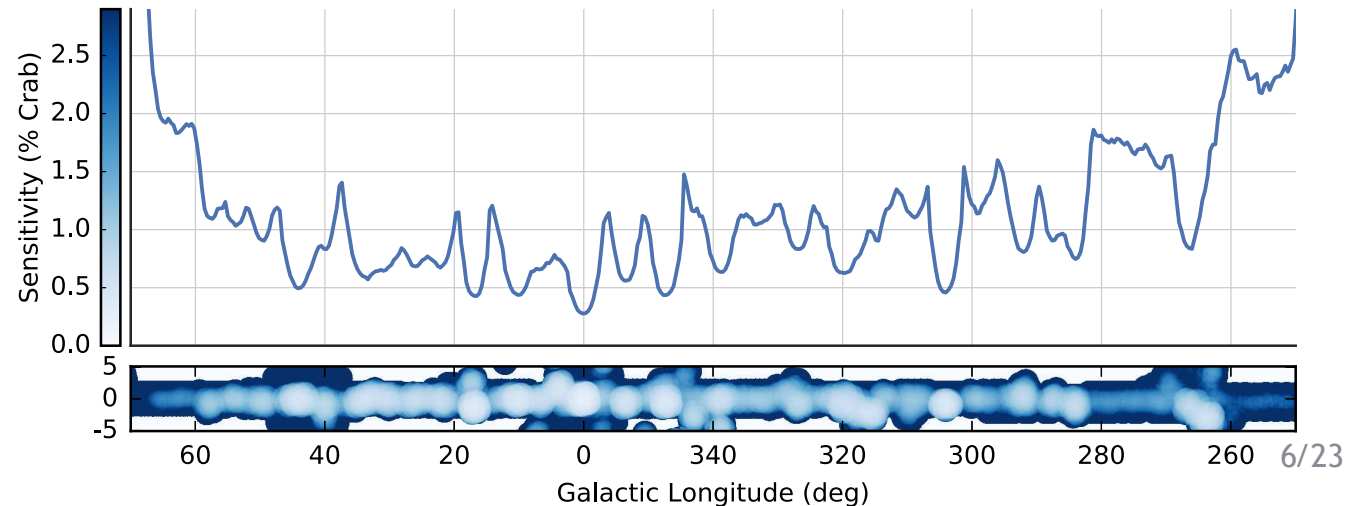


- limited coverage
- non-uniform exposure

gamma-ray sky > 50 GeV (*Fermi* LAT 2FHL)

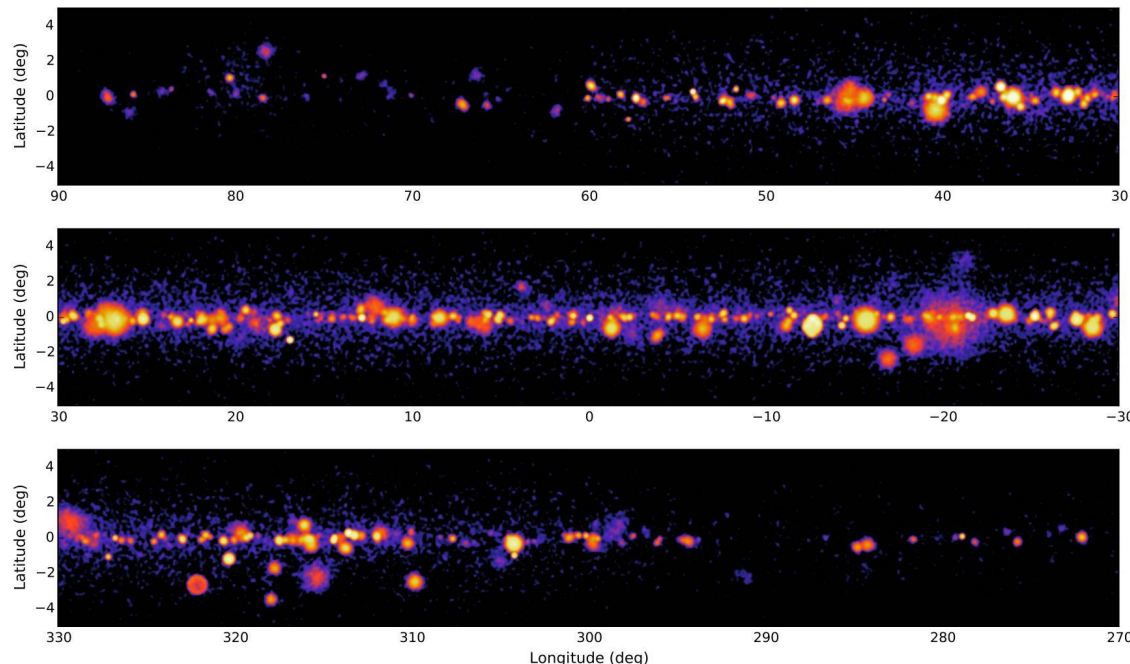


H.E.S.S. Galactic Plane Survey



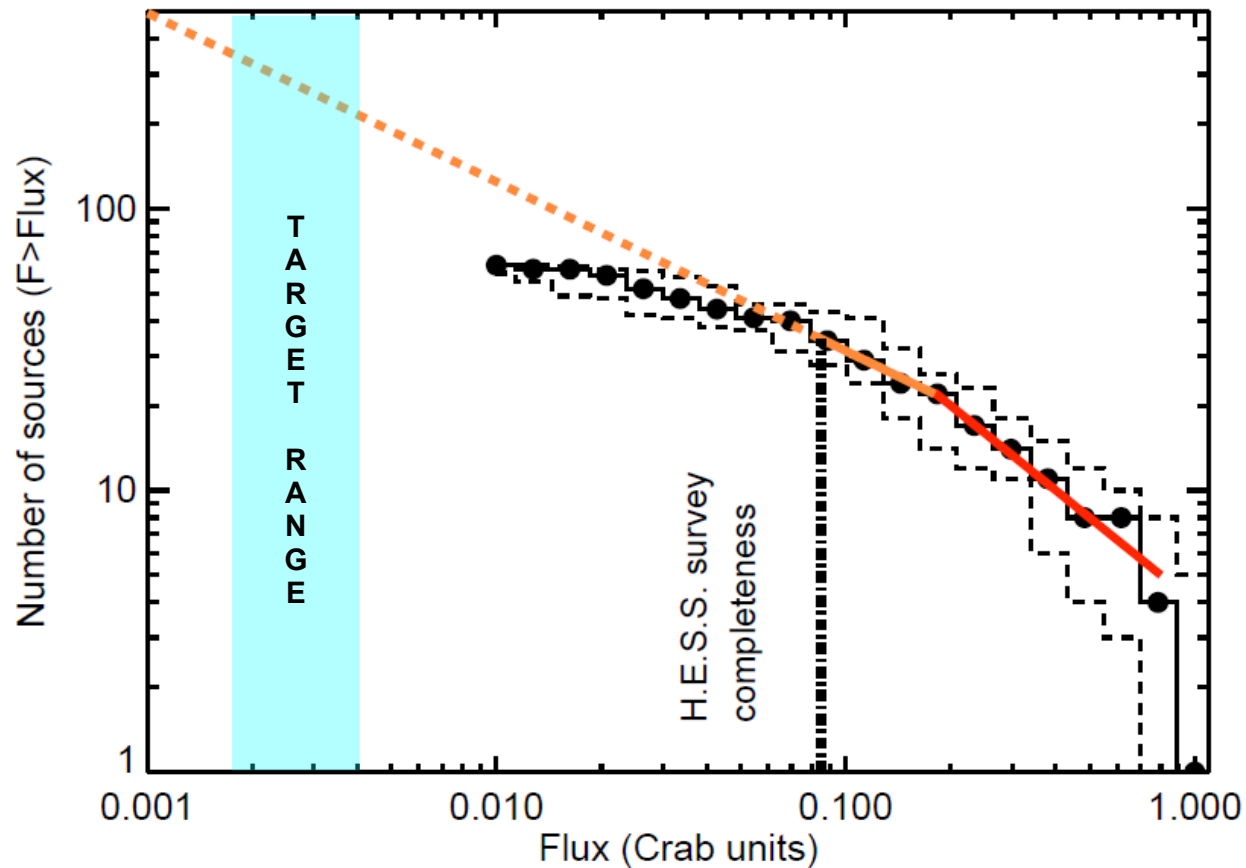
The CTA GPS: goals

1. census of Galactic VHE source populations
2. targets for follow up in other KSPs (e.g. PeVatrons) or by Guest Observers
3. diffuse emission
4. large and coherent legacy dataset for the community
5. discover new and unexpected phenomena



Cutout of simulated image of CTA GPS (from Science with CTA)

The CTA GPS: sensitivity goal

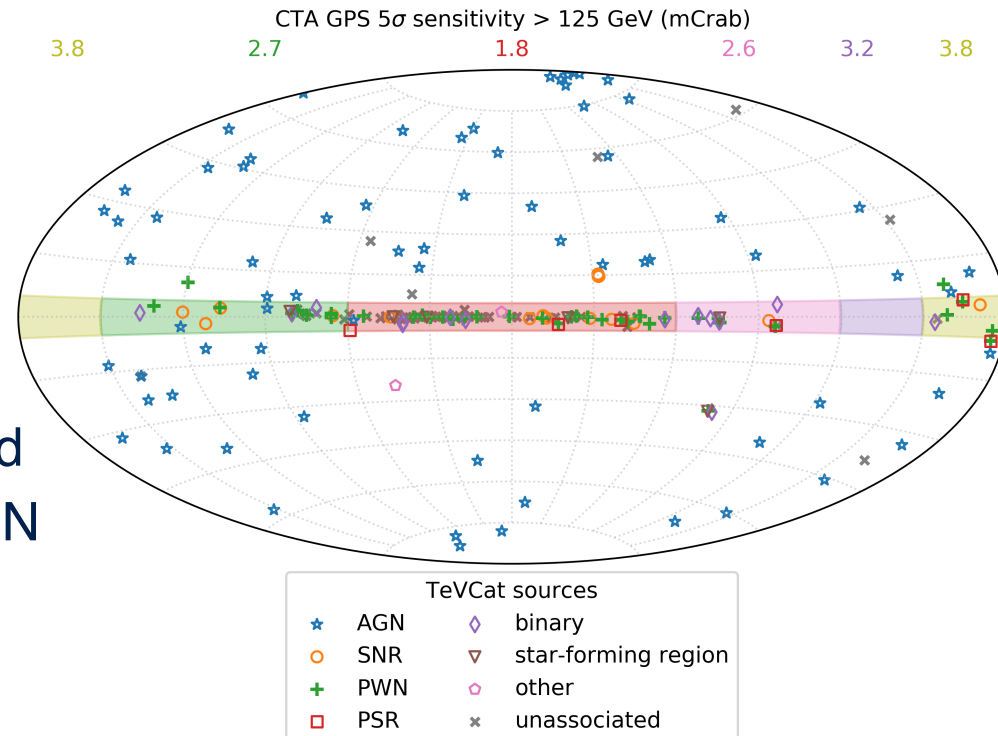


From Science with CTA,
adapted from Renaud 2009 44th Rencontres de Moriond

The CTA GPS: implementation

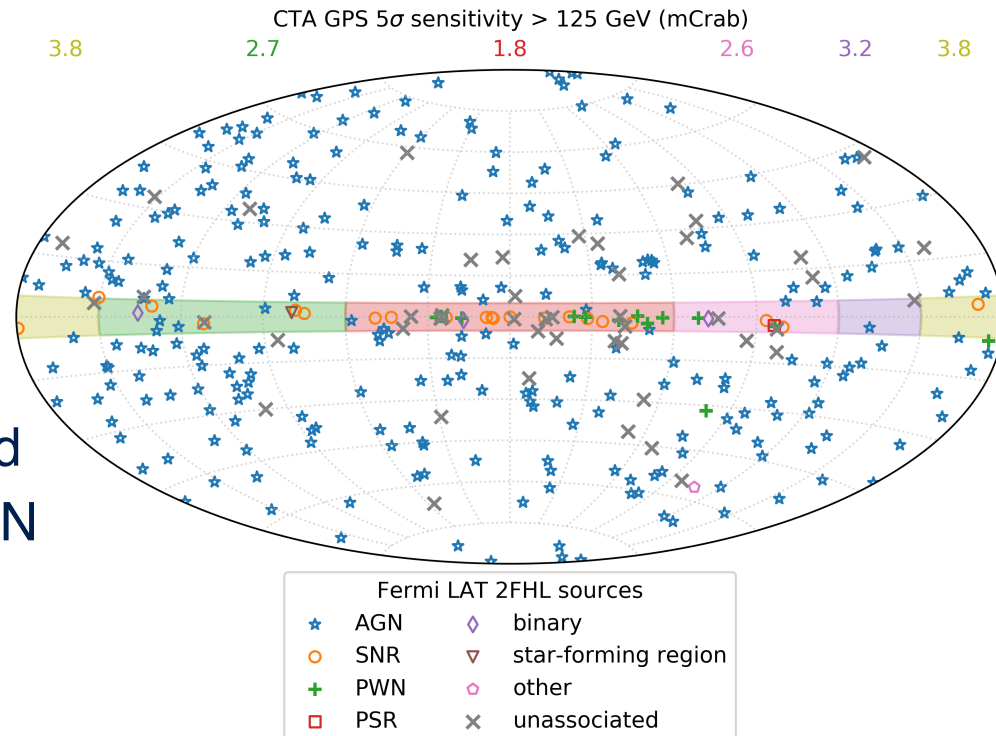


- cover whole Galactic plane (new discoveries, completeness)
- sensitivity better than 4 mCrab
- deeper observations of regions where more sources are expected
- observing time: 1020 h S + 600 h N
 - rapid start over first 2 years
 - final sensitivity after 10 years
 - periodic assessments of the program and data releases

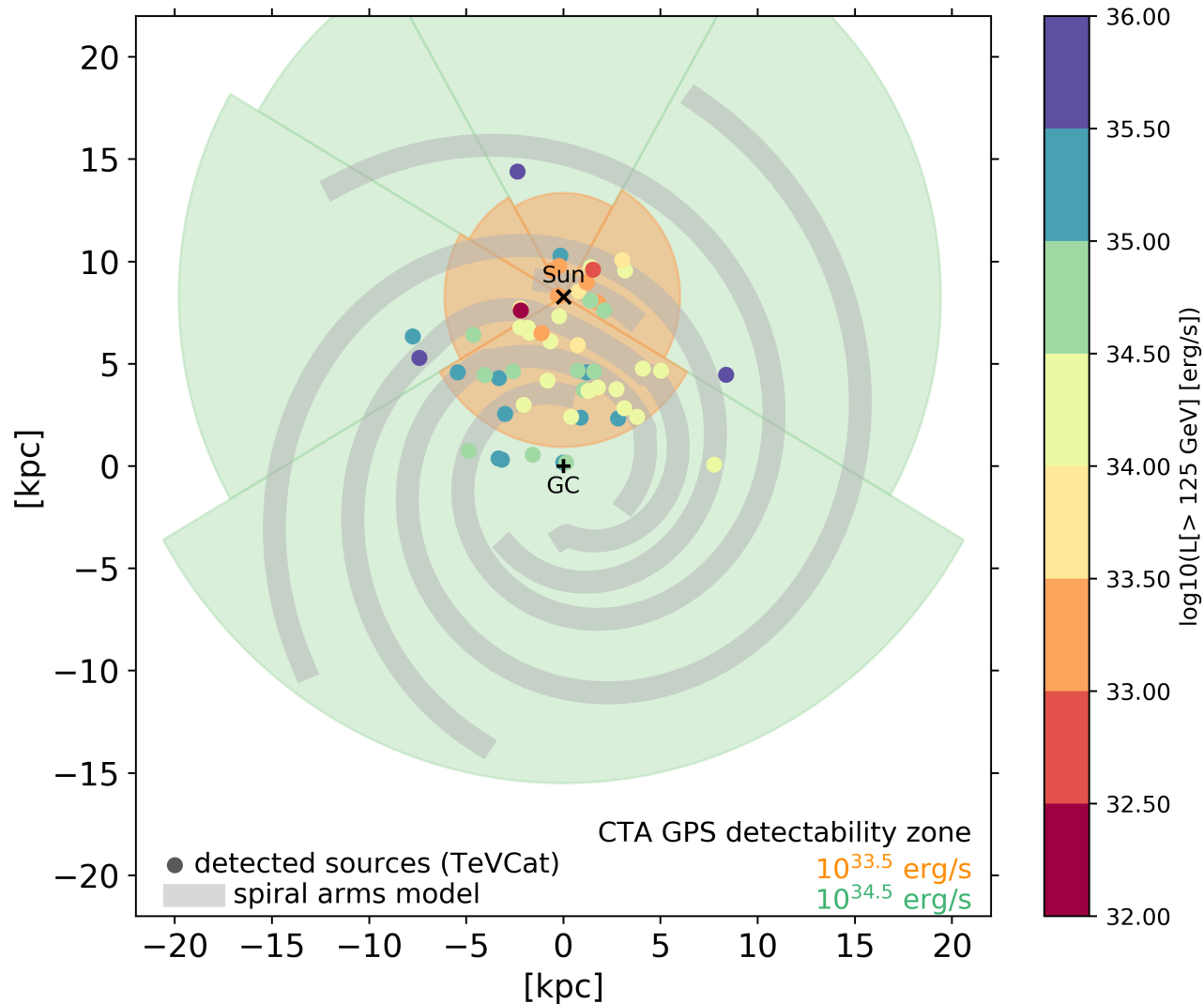


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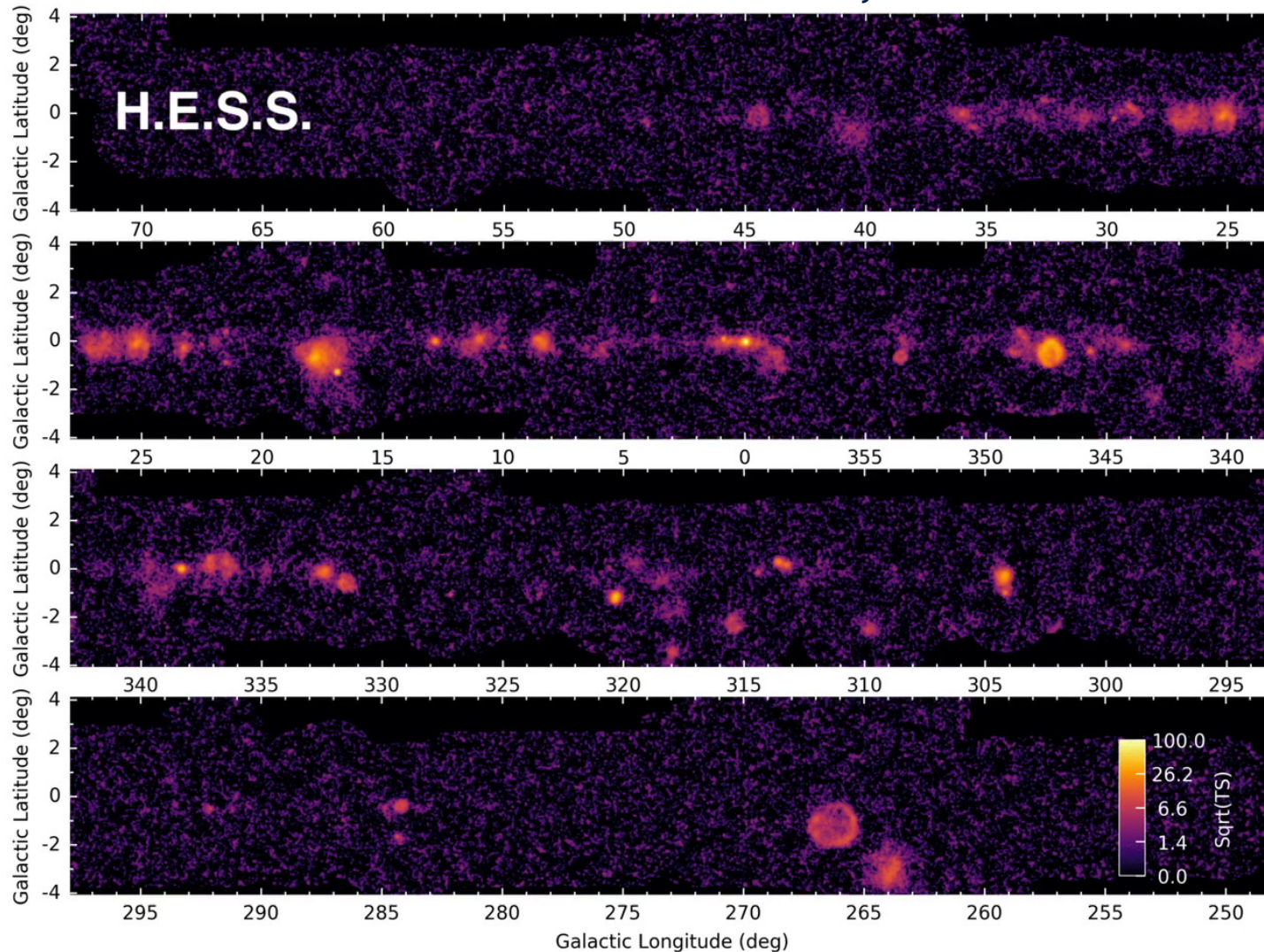
Galactic discovery reach



Comparison CTA - H.E.S.S.



H.E.S.S. Galactic Plane Survey

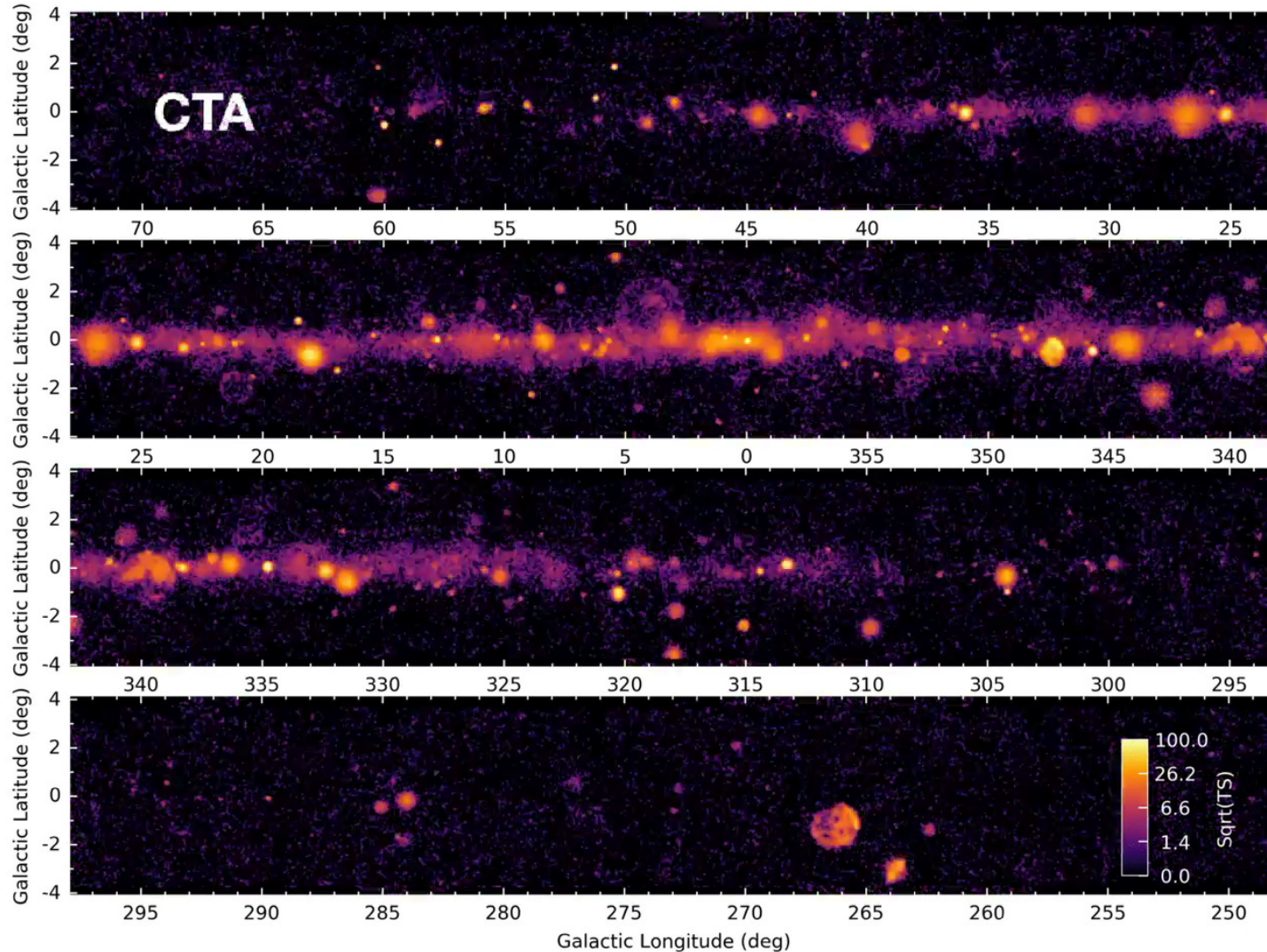


Plot credits: Christoph Deil, Roberta Zanin

Comparison CTA - H.E.S.S.



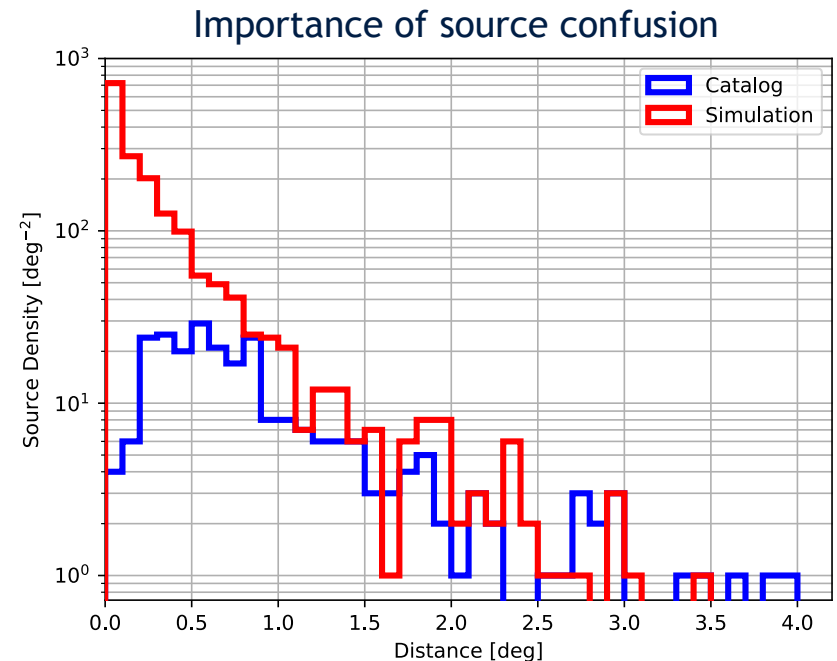
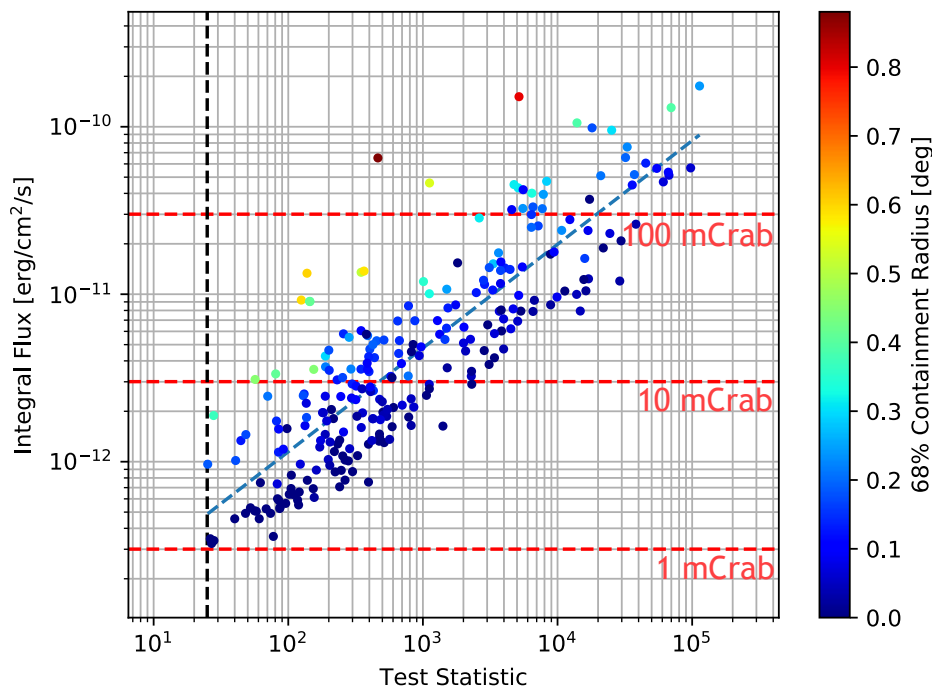
Cutout of CTA GPS from first Data Challenge



Plot credits: Christoph Deil, Roberta Zanin

Towards a GPS source catalog

- systematic search and characterisation of sources in the first Data Challenge (DC-1) GPS data
- preparation for multiwavelength support

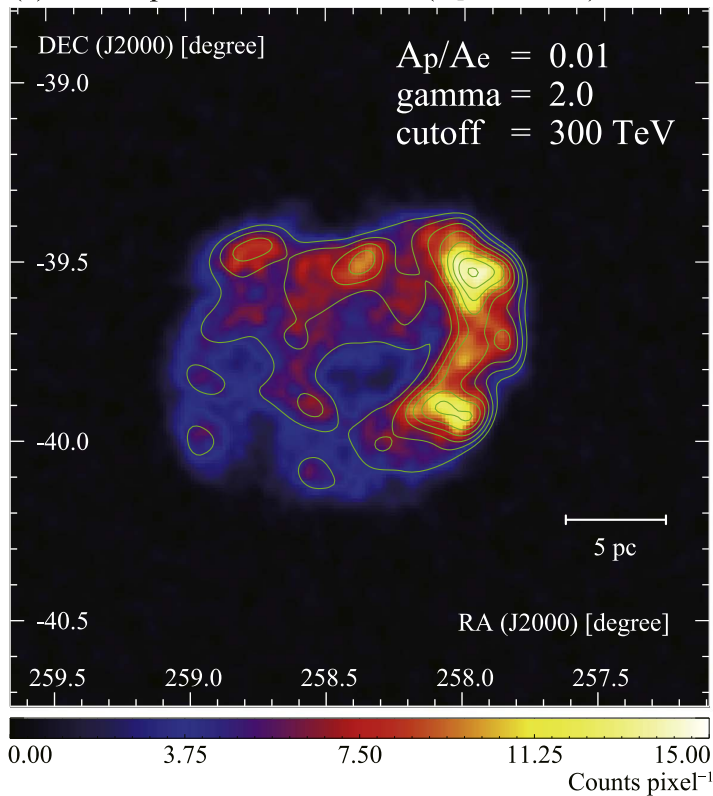


Source list from DC-1 GPS simulations. Plot credits: Josh Cardenzana

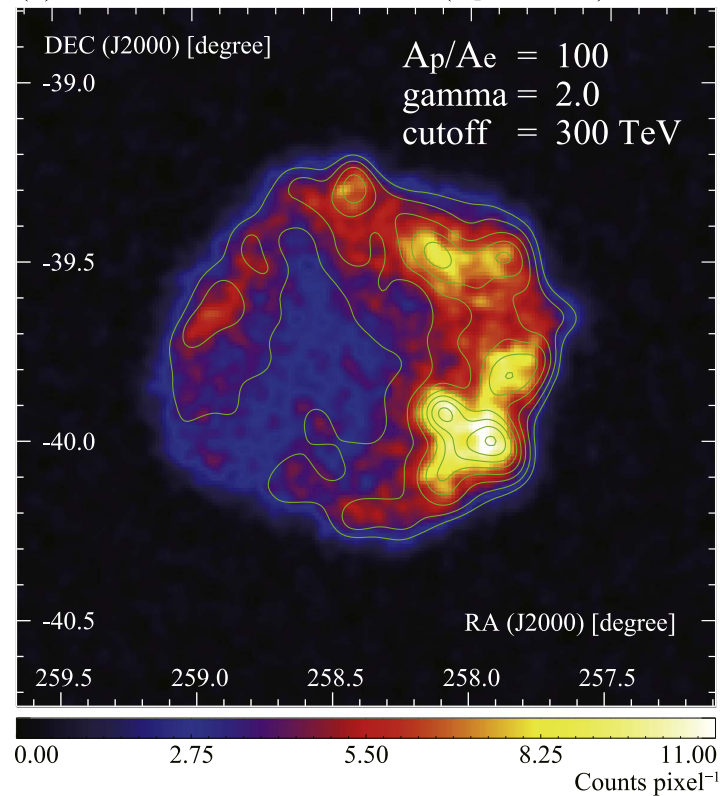
Resolving extended sources

Simulated images of RX J1713 (50 h) for different physical models

(a) CTA lepton-dominated case ($A_p/A_e=0.01$)



(b) CTA hadron-dominated case ($A_p/A_e=100$)

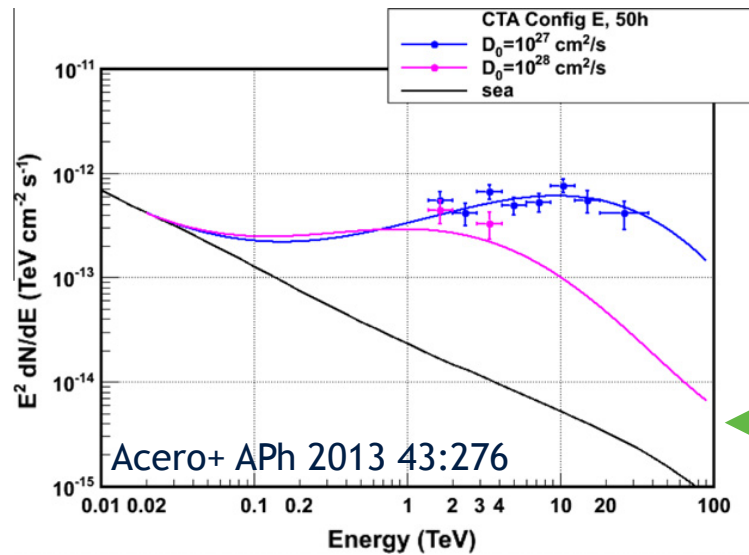


Diffuse emission

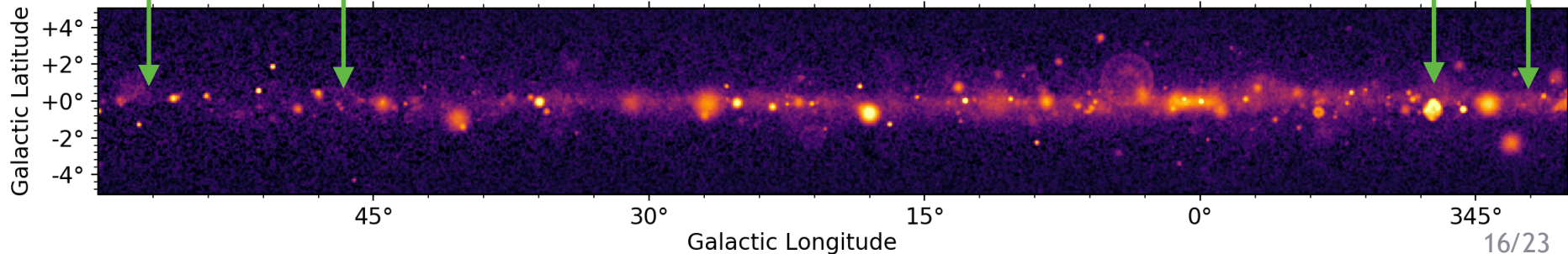


measure large-scale trends

CR interactions or unresolved sources?



CRs escaping from source?

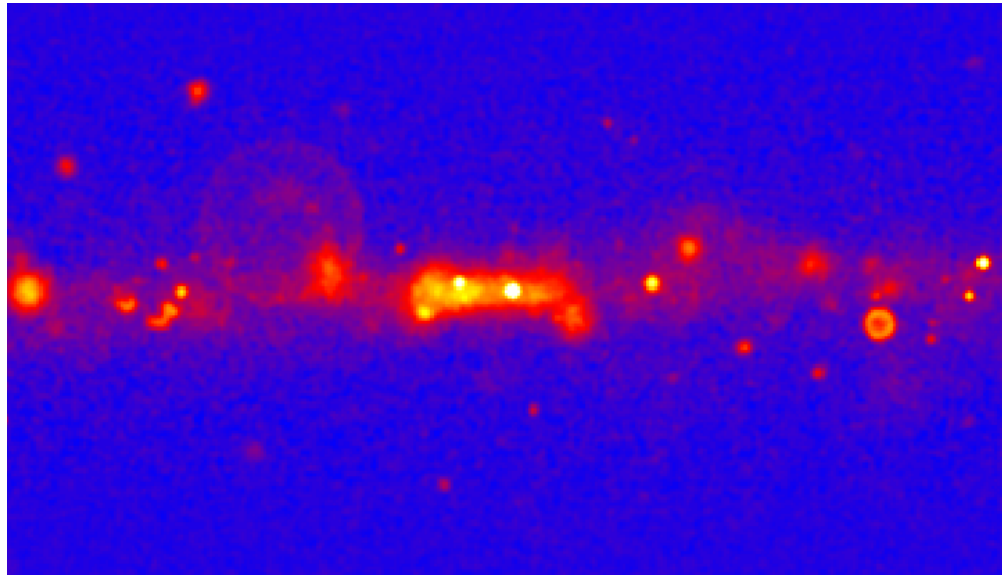


Cutout of CTA GPS from first Data Challenge

The Galactic centre survey: goals



1. nature of the central source: Sgr A*?
2. *Fermi* bubbles: large-scale outflow?
3. extra-deep census of VHE sources
4. diffuse emission from central molecular zone: particle acceleration and transport
5. dark-matter searches

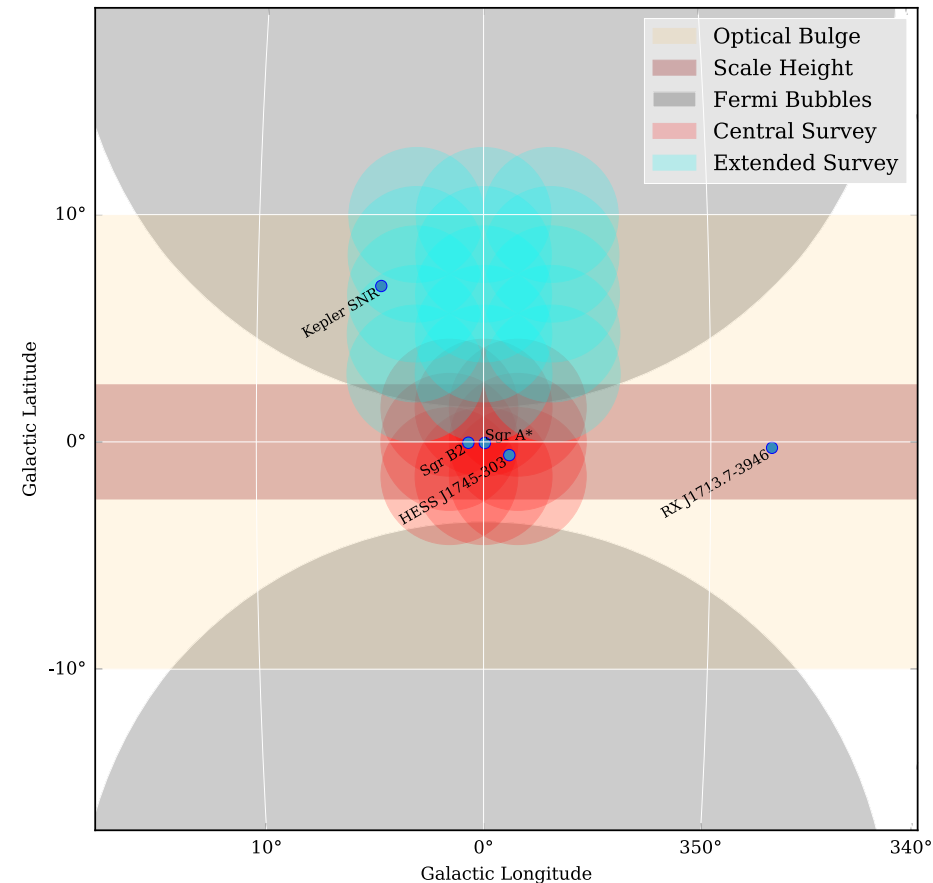


Simulated CTA image of the GC region

The GC survey: implementation



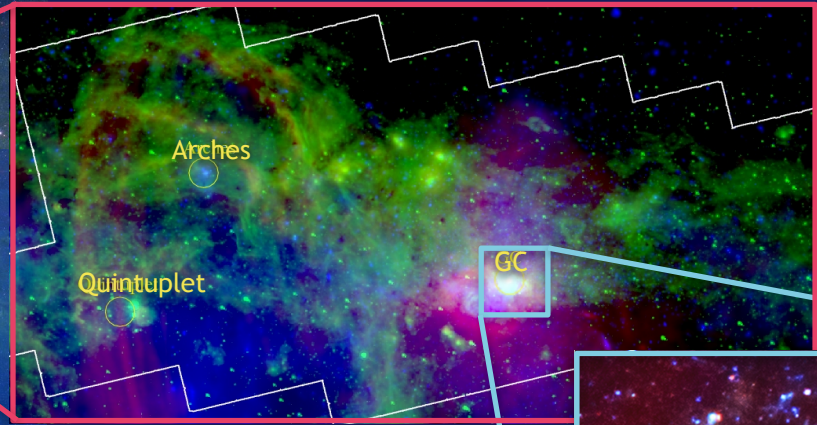
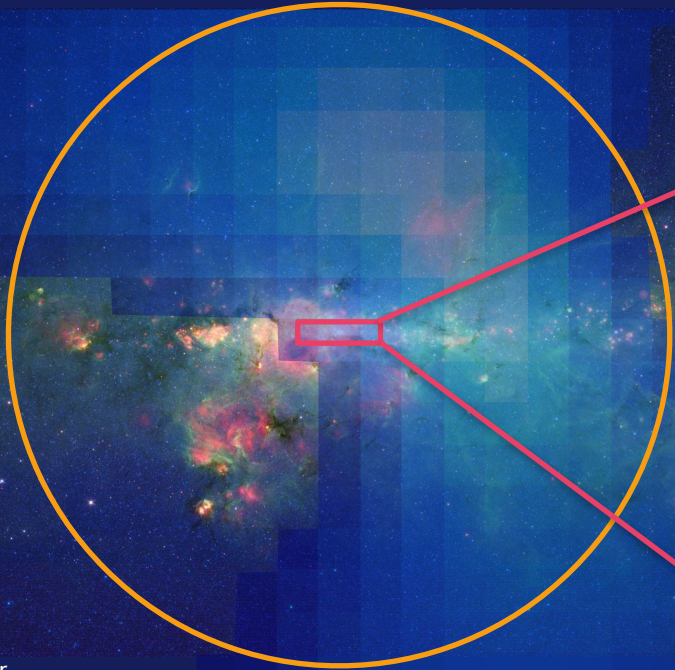
- first three years: deep survey of central region (525 h)
- later: extended survey up to 10° (300 h)
- to be optimised based on final CTA characteristics and new multiwavelength information



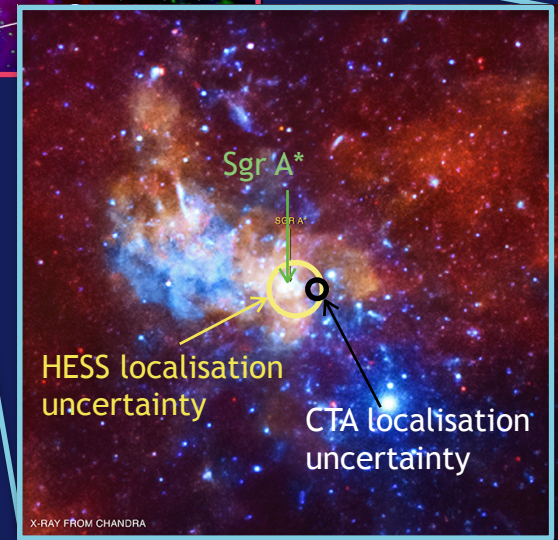
The GC on multiple scales with CTA



8° CTA FoV



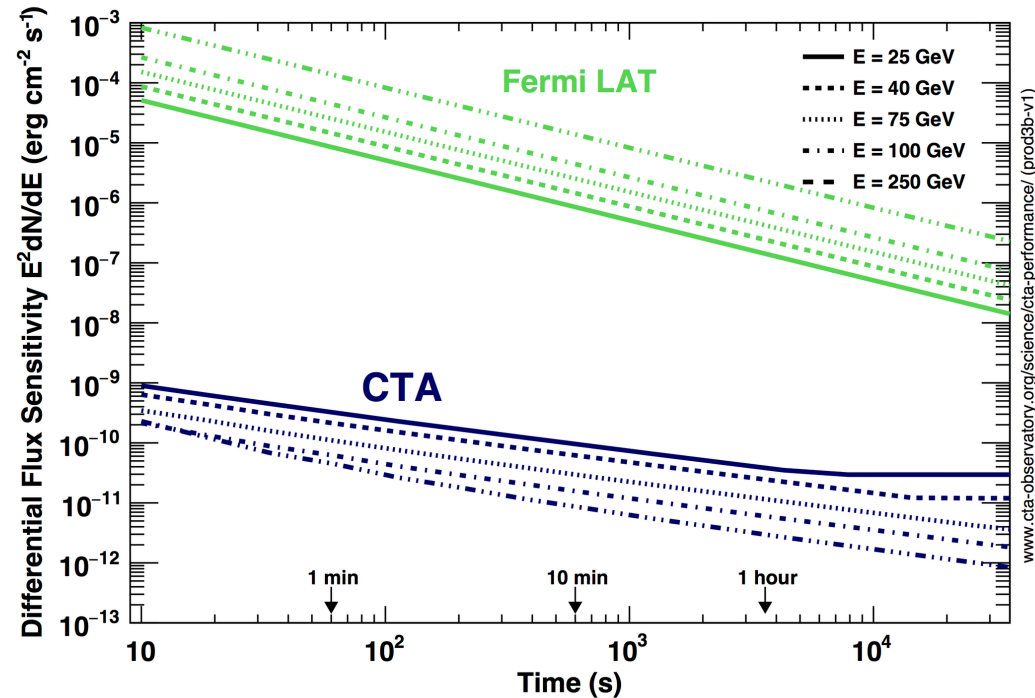
VLA + Spitzer + Chandra
Wang+ 2010 MNRAS 492 895



Spitzer
Credit: NASA/JPL Caltech
+ Fermi bubbles
Ackermann+ 2017 ApJ 840 43A

X-RAY FROM CHANDRA

Galactic gamma-ray transients

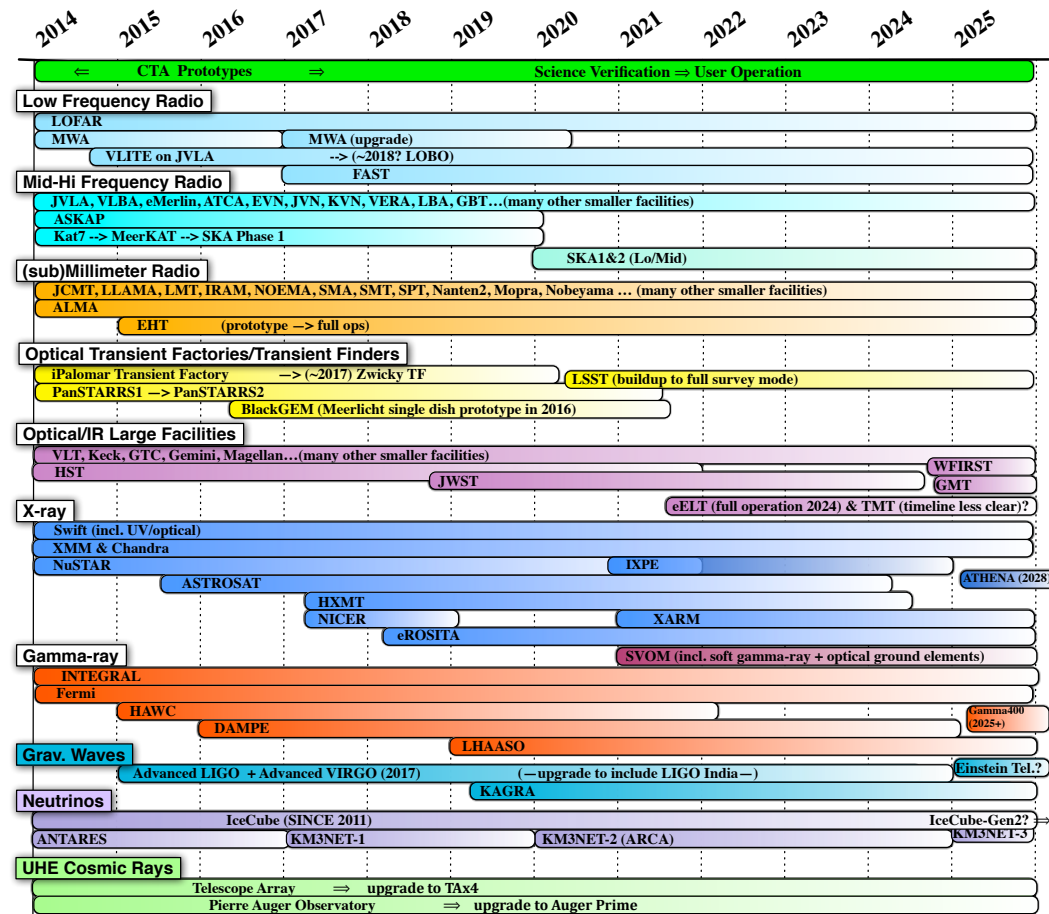


- not detected by ground-based instruments yet
- known classes (space telescopes): PWNe, magnetars, microquasars, transient binary pulsars, novae
- new discoveries?
 - multiwavelength/ multimessenger follow-ups
 - serendipitous CTA observations (real time analysis)

The transients KSP



- start before array completion
- 180 h dedicated to Galactic transients up to year 2 of Science operations
- continuation contingent to VHE discovery
- + 210 h follow-up of MWL/MM triggers and serendipitous discoveries
- **MWL/MM support essential**
 - expanding on work by current IACTs

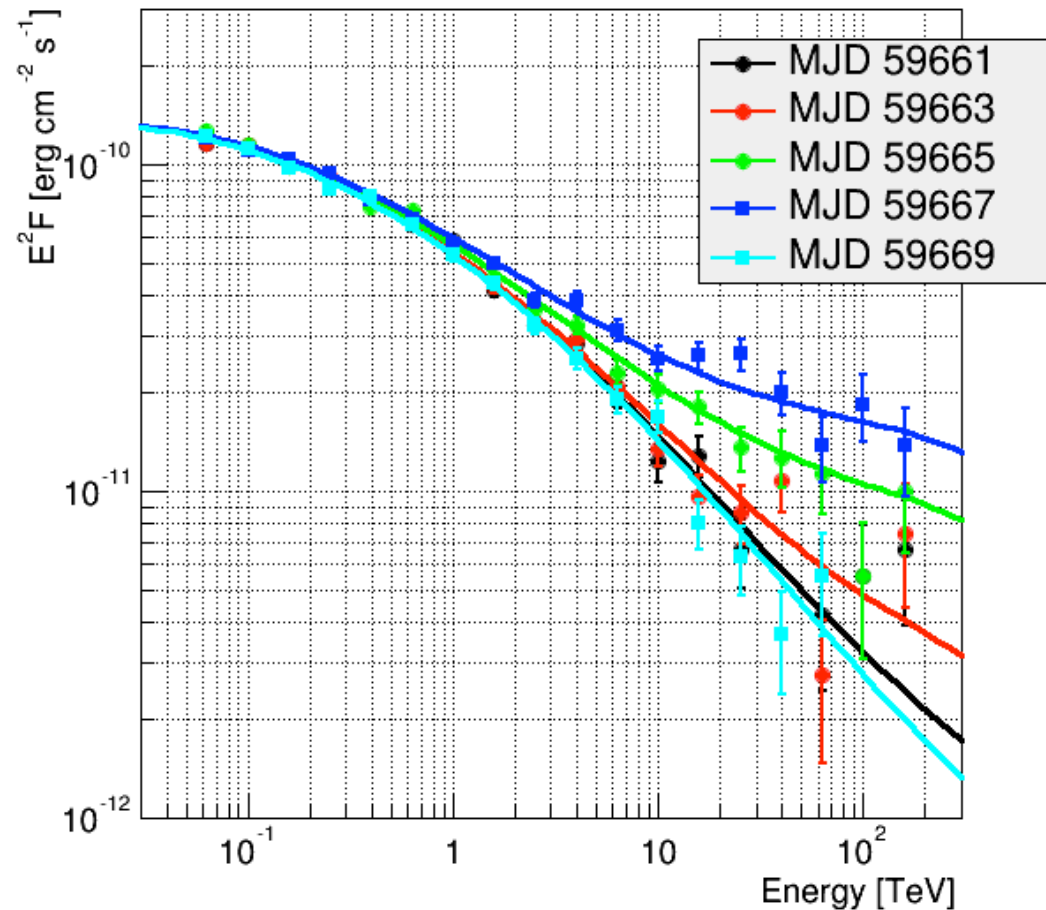


From Science with CTA

Galactic transients: forecast?

- exploring uncharted territory
- some models predict detectability of flares from a few sources: Crab nebula, Cygnus X-3

Simulated CTA spectra of Crab Nebula flare
4 h X 10 nights



From Science with CTA



Final remarks



- CTA Key Science Projects → tremendous push to our understanding of the Milky Way at VHE
 - first **complete VHE survey** with angular resolution of few arcmin, increase number of sources by an order of magnitude
 - deep survey of **Galactic centre** region, probing particle acceleration and transport on multiple spatial scales
 - search for **Galactic transients** in the multiwavelength/multimessenger context
- next talks: specific topics of particular relevance for CR origin/transport
 - massive-star clusters → Rui Zhi
 - PeVatrons → Sabrina
 - SNRs → Pierre

