

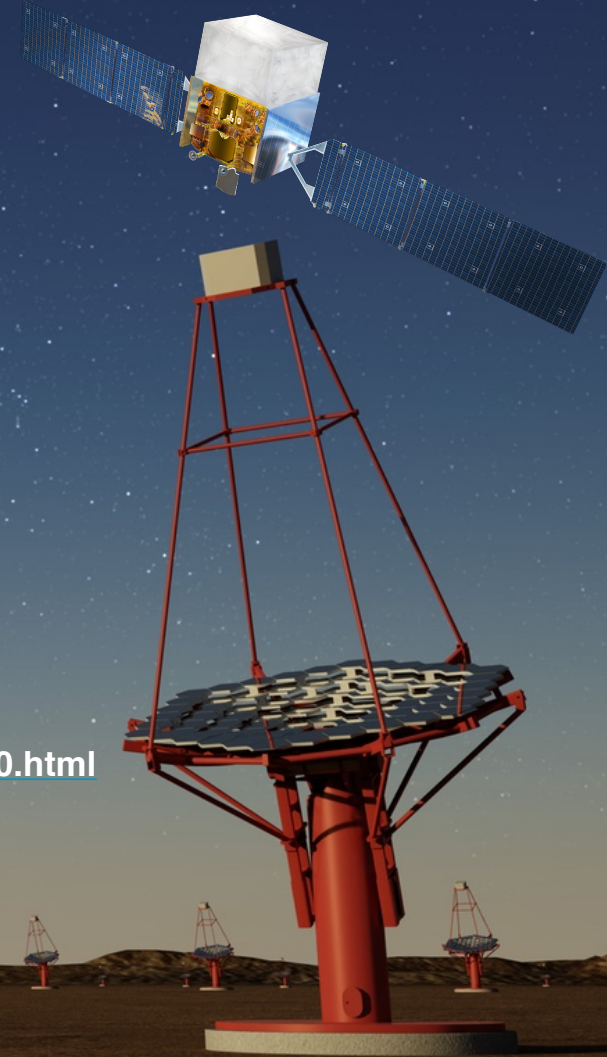
Synergies between *Fermi* and the Cherenkov Telescope Array

The CTA Consortium* represented by

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luigi.tibaldo@irap.omp.eu

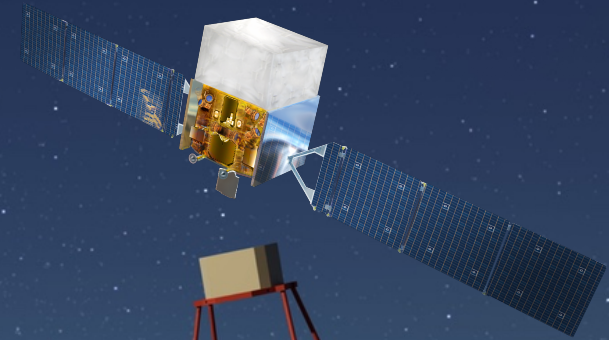
* see http://www.cta-observatory.org/consortium_authors/authors_2018_10.html
for full author list



1. Introduction to CTA

2. The impact of *Fermi* on the preparation of CTA

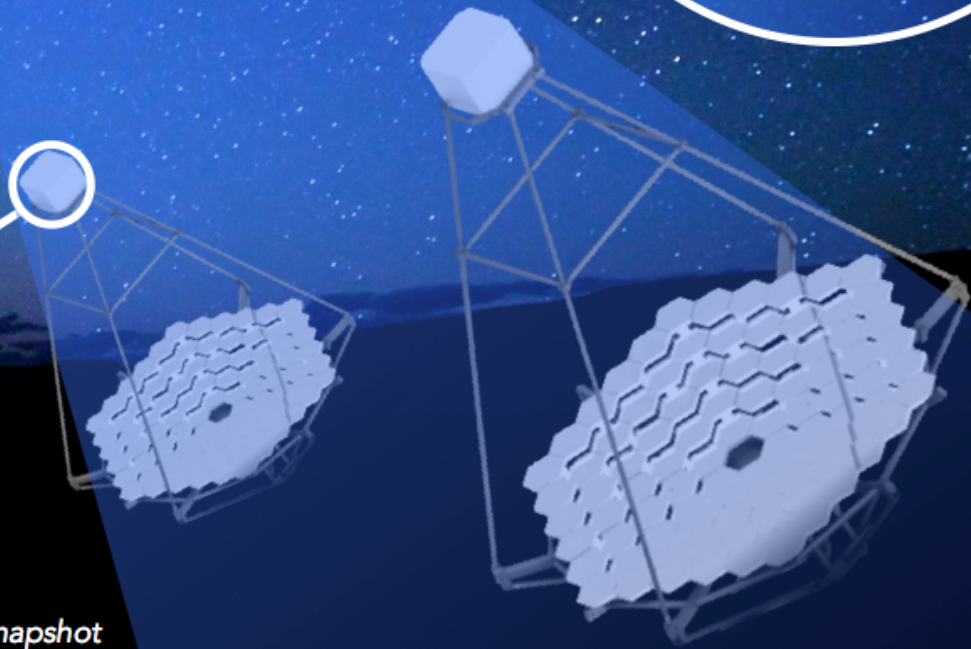
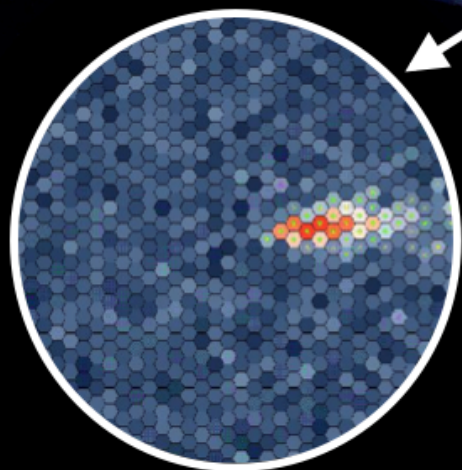
3. The future: *Fermi* meets CTA



γ -ray enters the atmosphere

Imaging Atmospheric Cherenkov Telescopes IACTs

Electromagnetic cascade

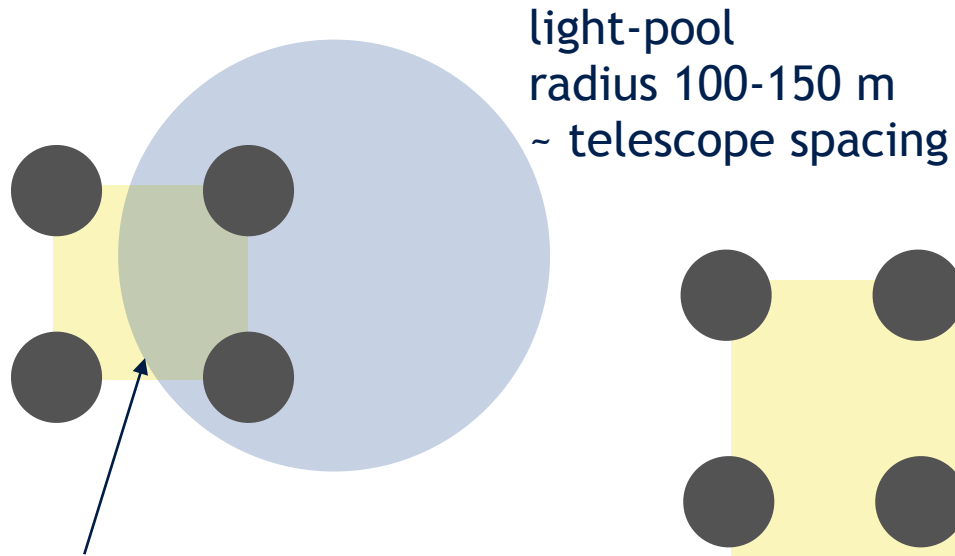


0.1 km² "light pool", a few photons per m².

From current IACTs to CTA

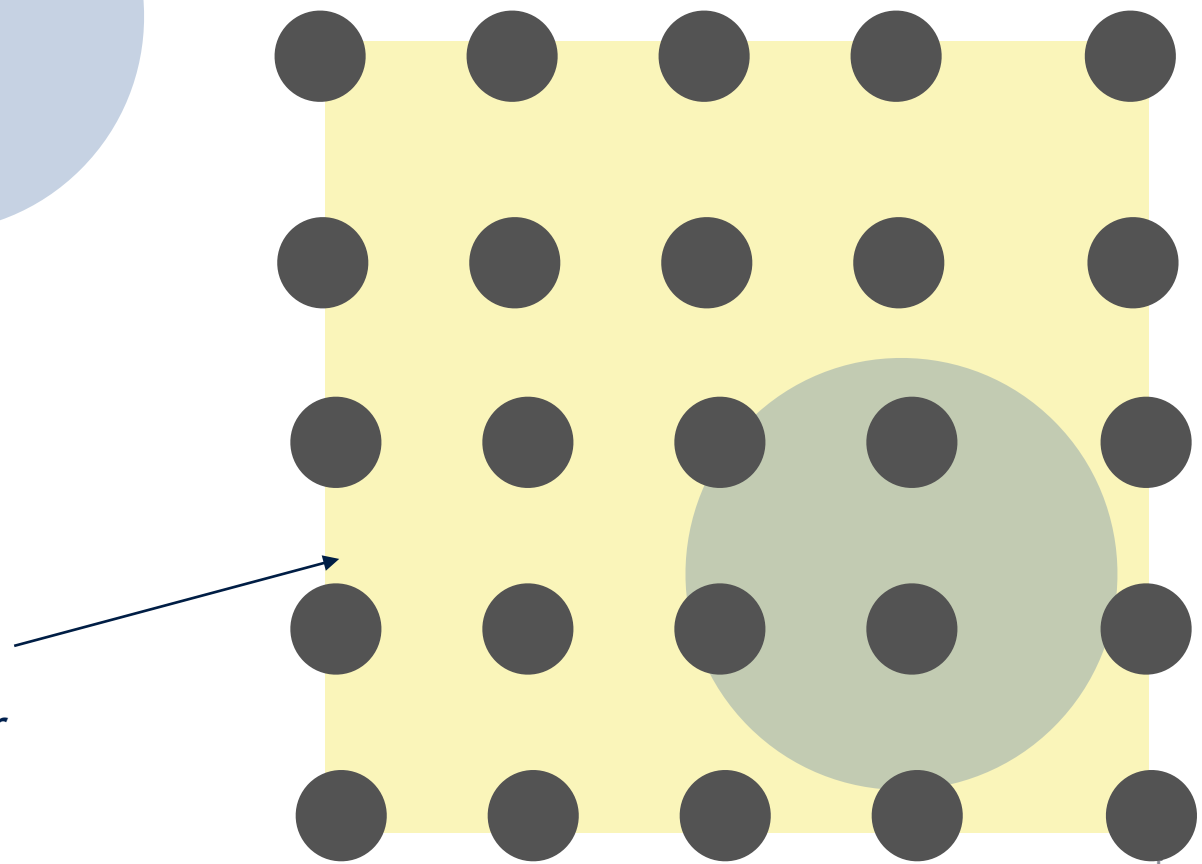


Credit: Werner Hofmann



sweet spot for trigger
and reconstruction:
most showers miss it

large detection area
more images per shower
lower trigger threshold

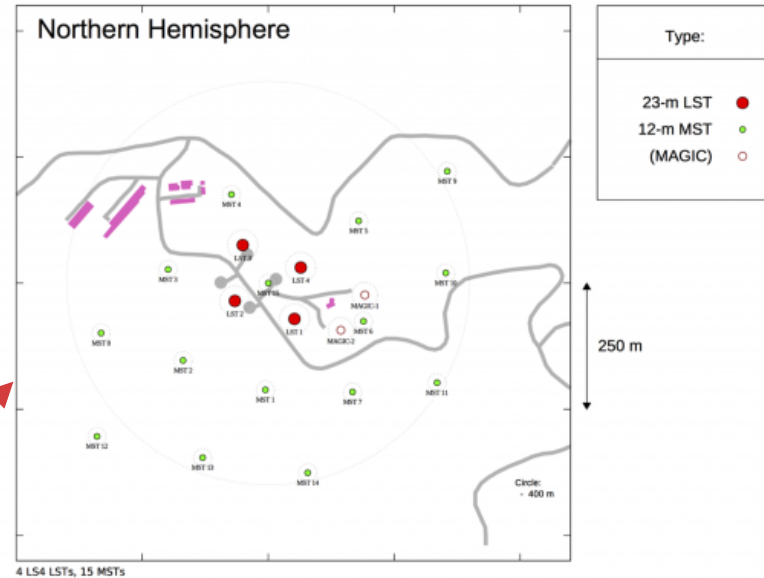


The Cherenkov Telescope Array

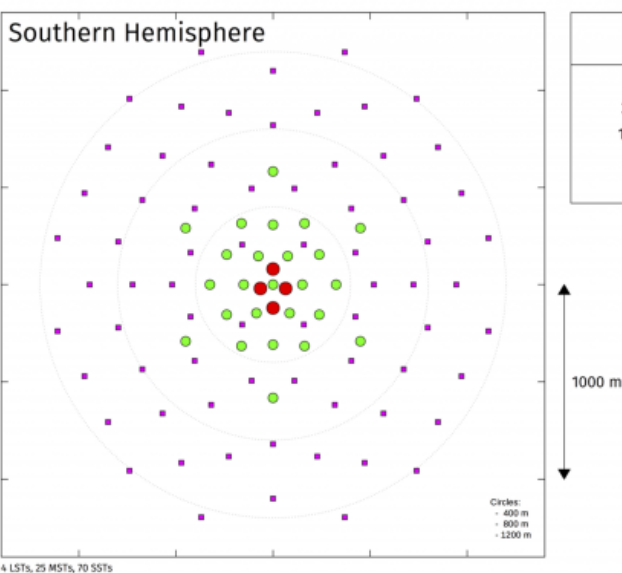


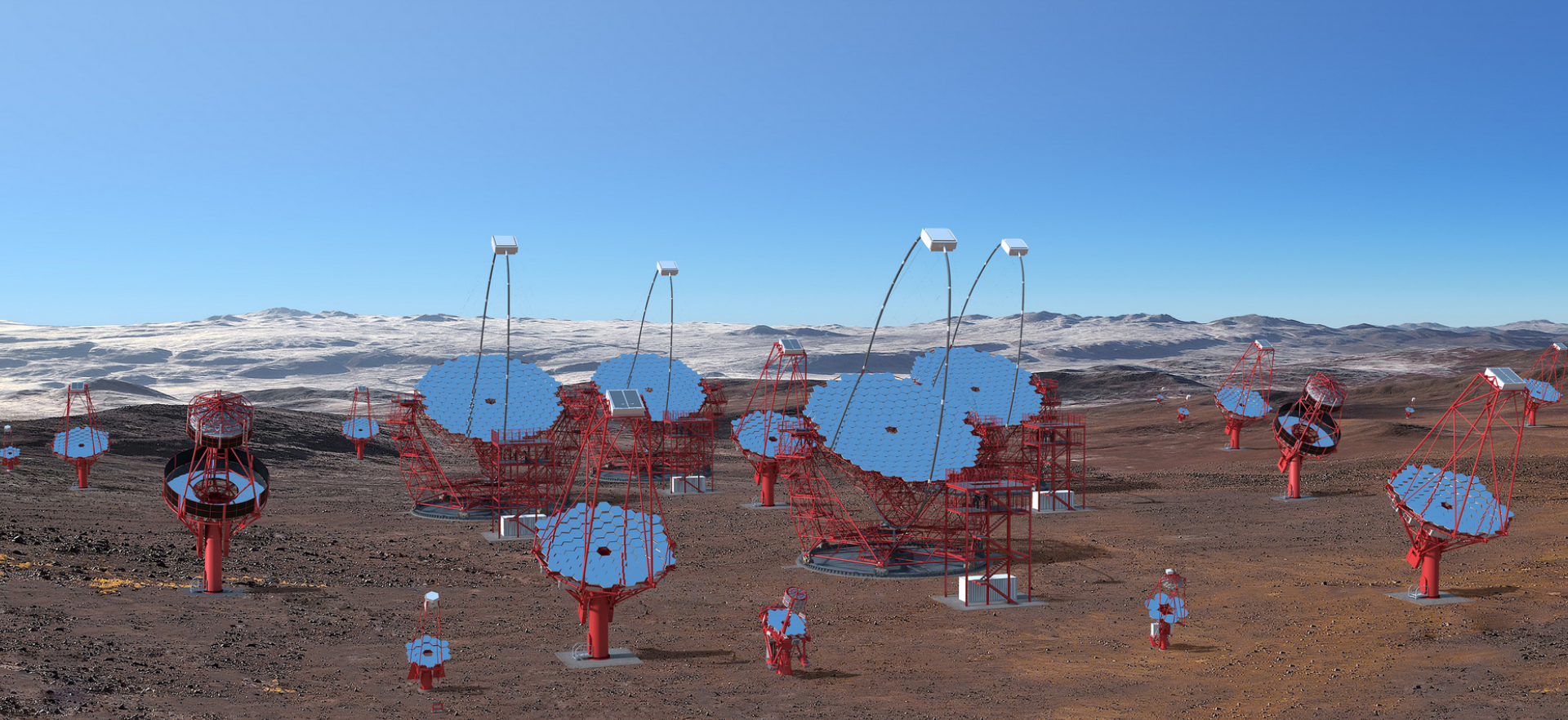
- two sites for full sky coverage
- > 100 telescopes of different sizes: optimal performance over wider energy range

La Palma, Canary Islands, Spain

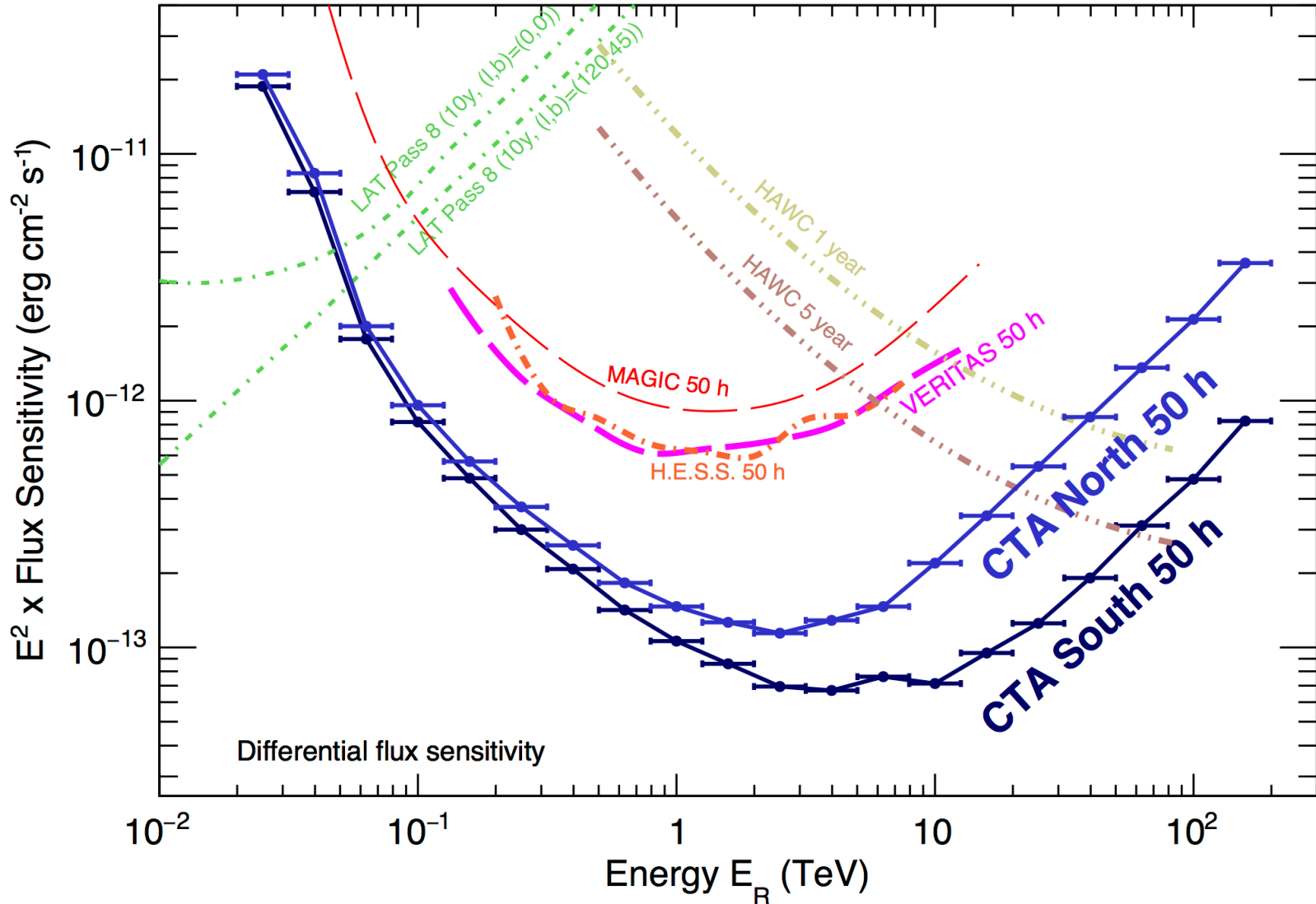


Paranal, Chile



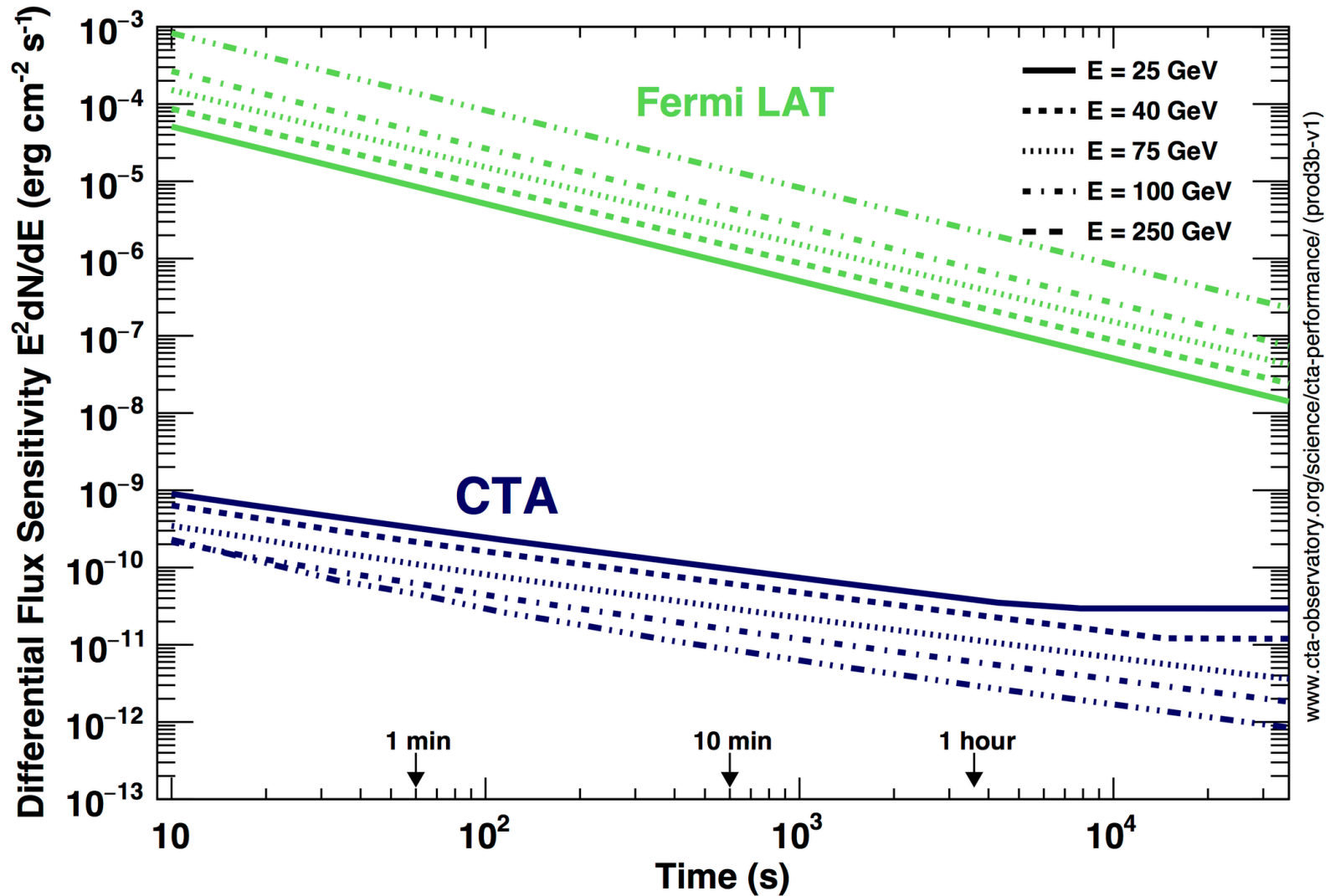


Sensitivity



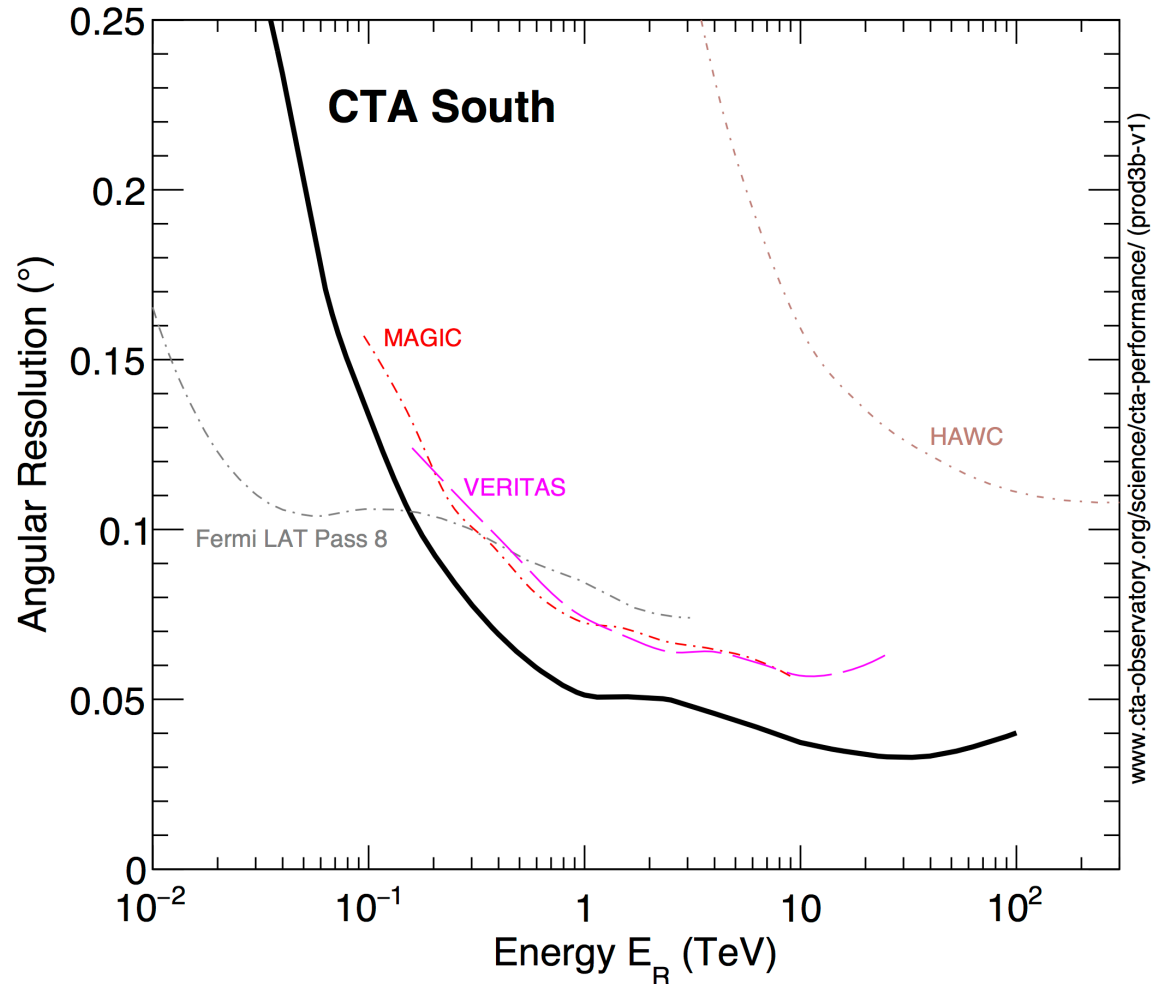
www.cta-observatory.org/science/cta-performance/ (prod3b-v1)

Sensitivity vs observation time



www.cta-observatory.org/science/cta-performance/ (prod3b-v1)

Angular resolution



event analysis optimized for best sensitivity,
angular resolution can be improved

First CTA telescope in La Palma



Status



Project Phases



Current Phase



First Pre-Production Telescopes on Site



CTA Offices Open in Bologna

Infrastructure Design & Procurement



ERIC Established

Q1 2017

Q3 2017

Q1 2018

Q3 2018

Q1 2019

Q3 2019

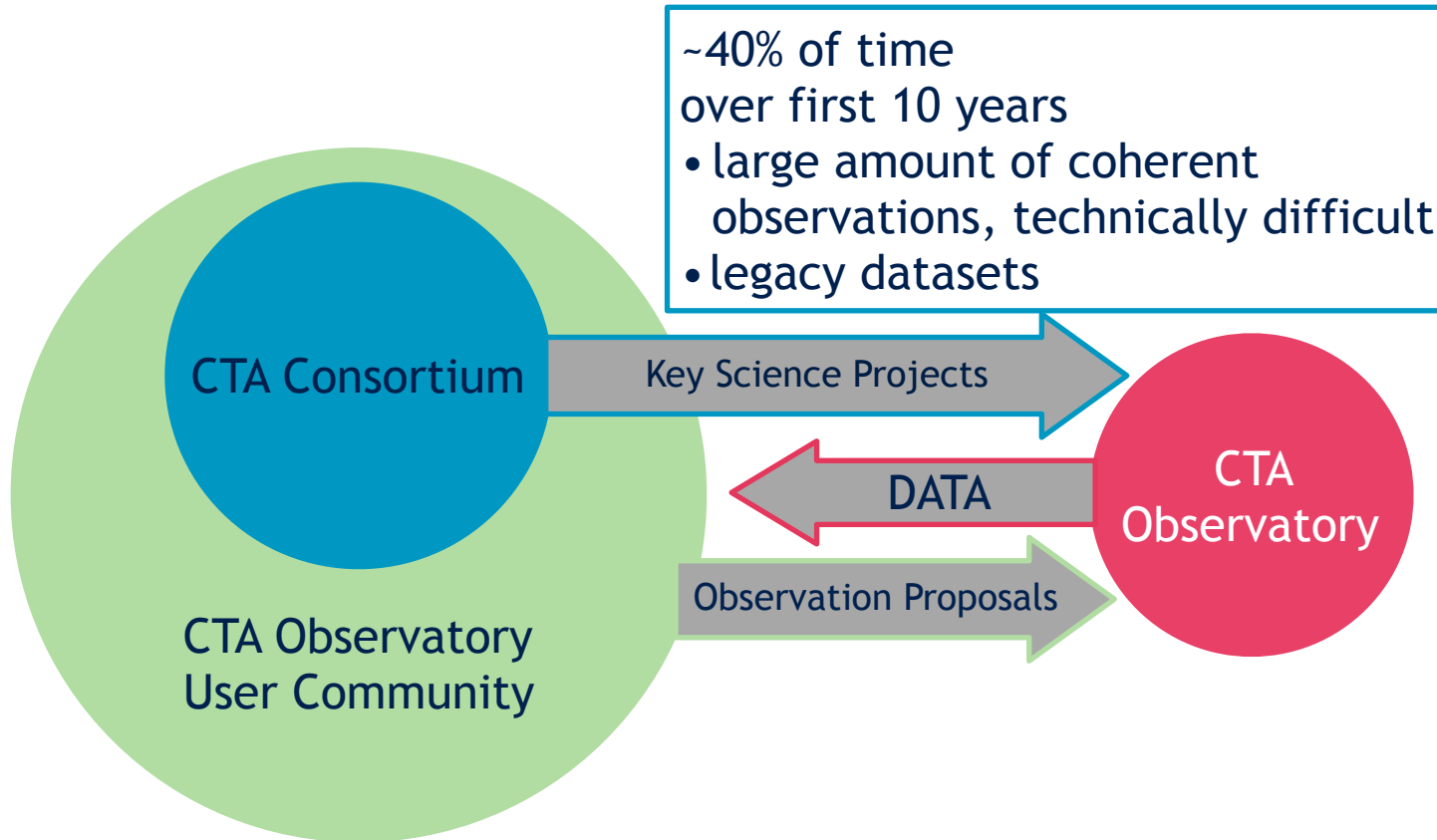
Q1 2020

LST 1 Prototype Completed on North Site



Financial Threshold Reached

Novel: Open Observatory



Science Book



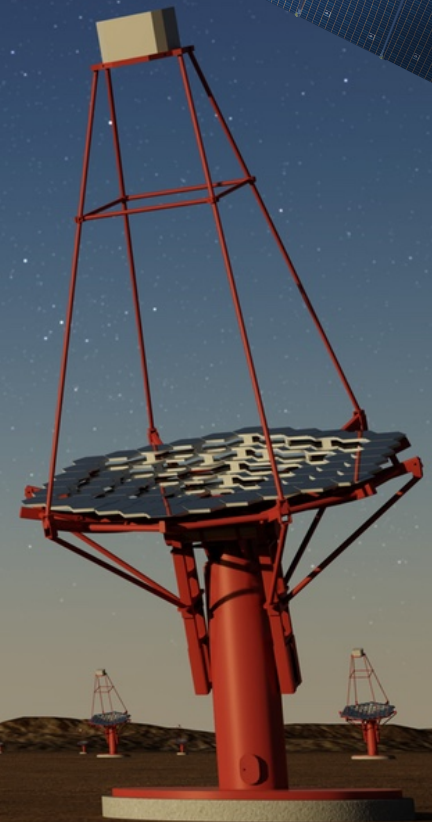
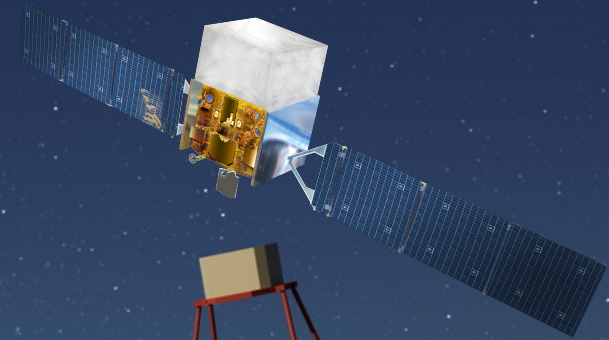
Science with the Cherenkov Telescope Array

- Science capabilities
- Dark matter program (see talk by G. Zaharijas)
- Key Science Projects
- Science beyond gamma rays
- Synergies

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

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

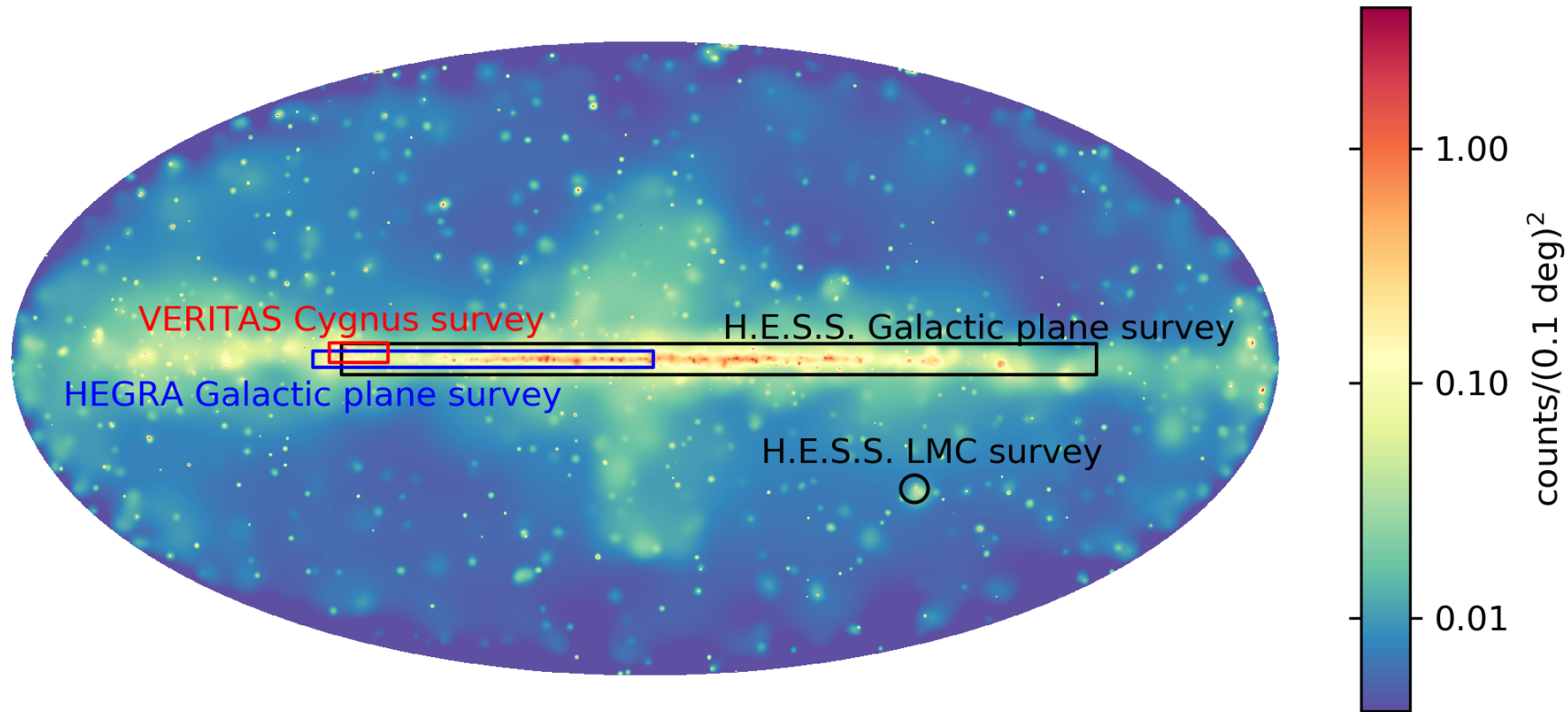
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2. The impact of *Fermi* on the preparation of CTA
3. The future: *Fermi* meets CTA



Fermi and the CTA core program



- CTA Science book mentions *Fermi* 108 times
- unique: *Fermi* surveys the whole sky and overlaps in energy with CTA

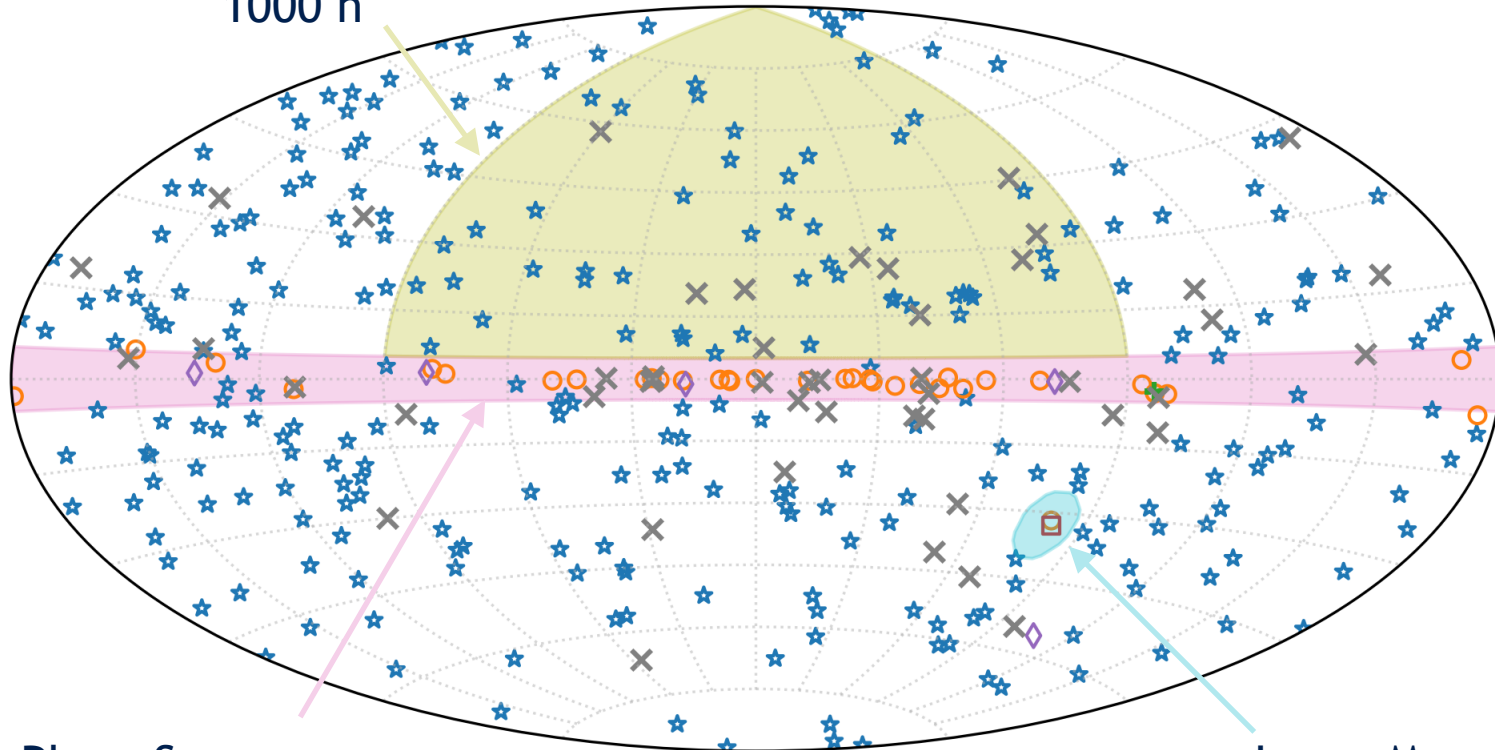


Fermi skymap > 50 GeV (2FHL)

Census of gamma-ray sources



Extragalactic survey KSP
1000 h



Galactic Plane Survey
(GPS) KSP
1600 h

Large Magellanic
Cloud (LMC) KSP
340+150 h

★	AGN	□	galaxy
○	SNR/PWN	◇	other
+	PSR	×	unassociated

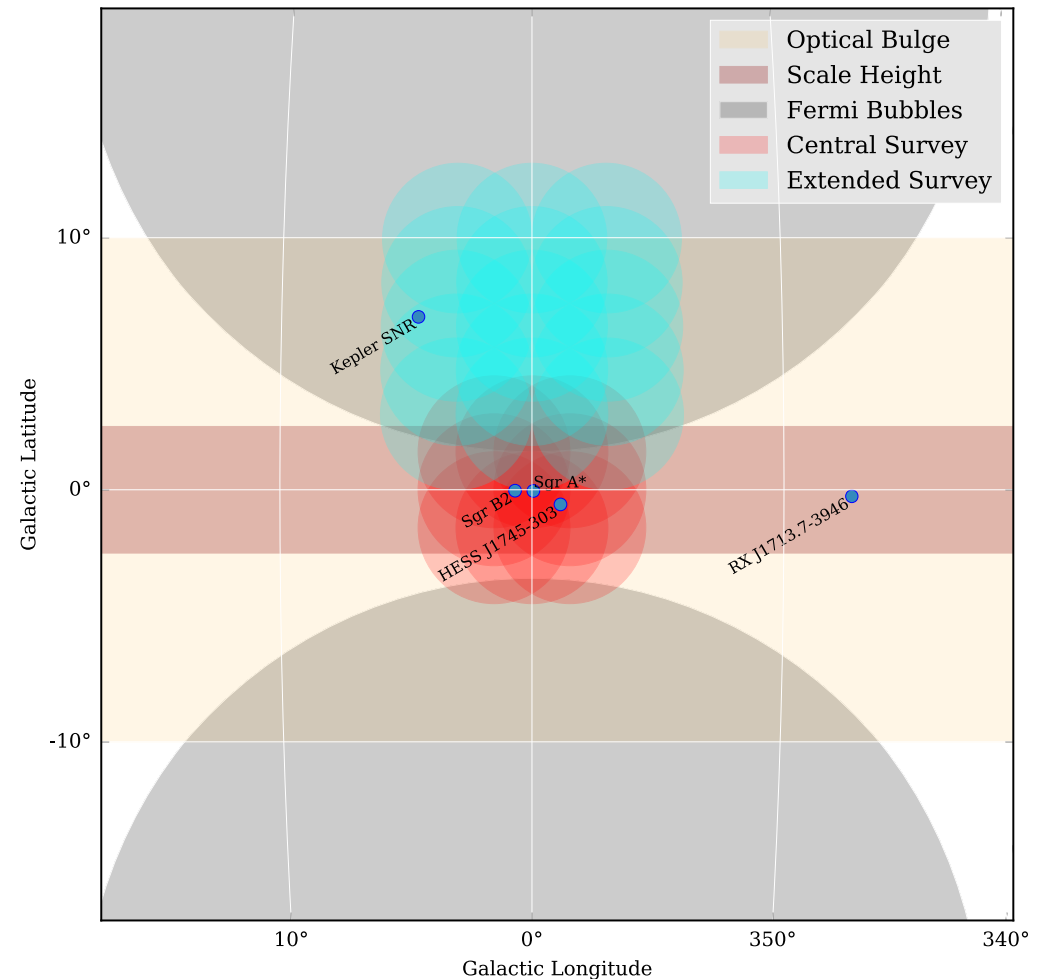
Fermi sources > 50 GeV (2FHL)

New sources



- *Fermi* bubbles, Cygnus cocoon, ...
- observing strategy to sample sources comparable or larger than field of view

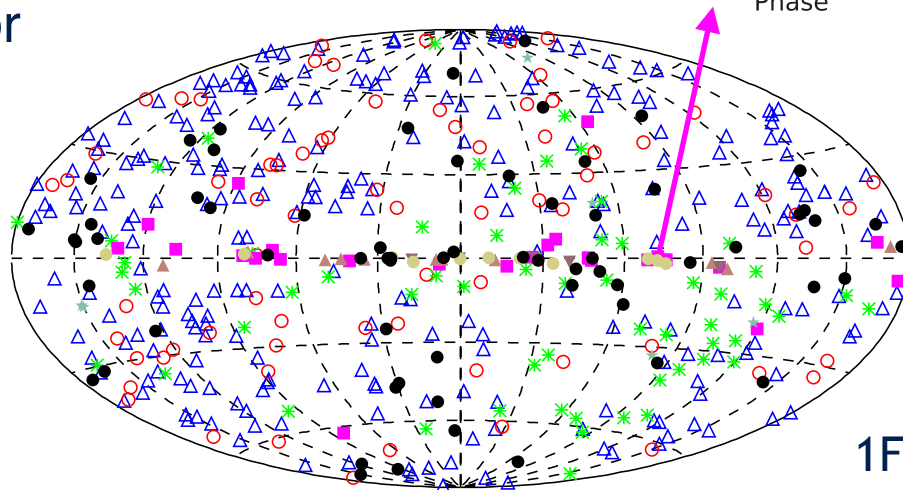
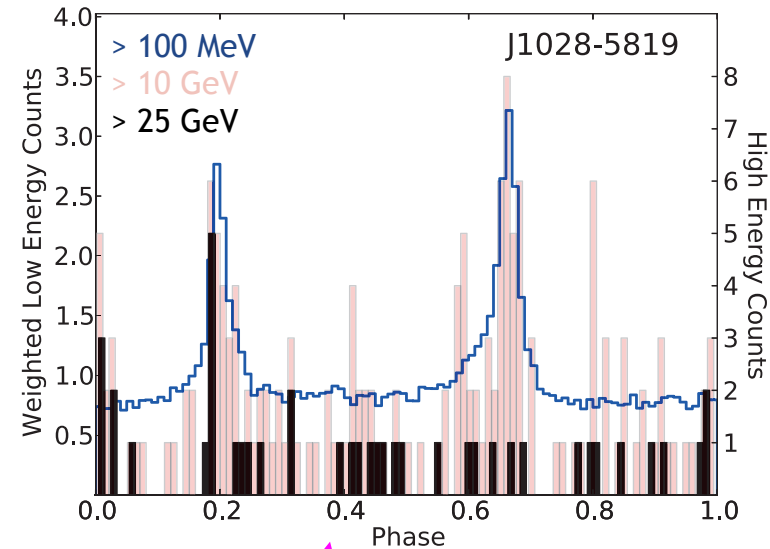
Galactic center survey KSP 800 h



Old sources, new very-high-energy emitters



- source classes newly observed to reach the CTA domain: pulsars, GRBs, ...
- e.g., pulsars
 - three detected by current IACTs
 - *Fermi* found a dozen interesting as targets for CTA

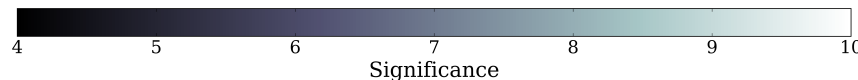
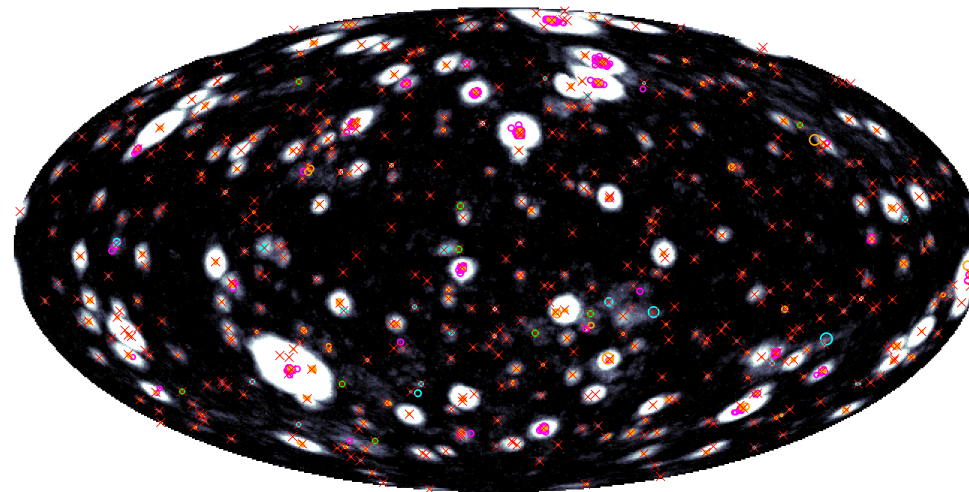


1FHL Catalog

△	BL Lac	○	FSRQ	*	AGN of unknown type
■	PSR	▲	SNR	▼	PWN
●	Other Galactic object	★	Other (non-beamed) Extragalactic object	●	No association

The flaring gamma-ray sky

- widespread rapid gamma-ray variability
 - GRBs, AGNs, gamma-ray binaries
 - new classes: novae, PWNe (Crab)
- Transients KSP includes follow-up of *Fermi* flares and investigation of new transient classes discovered by *Fermi*



2FAV catalog of
flaring gamma-ray sources

Open Observatory legacy



NASA National Aeronautics and Space Administration Goddard Space Flight Center Fermi • FSSC • HEASARC Sciences and Exploration

Celebrating 10 Years of Fermi
June 11, 2018

Home Support Center Observations **Data** Proposals Library HEASARC Help

Data

- ▶ Data Policy
- ▶ Data Access
- ▶ Data Analysis
- ▶ Caveats
- ▶ Newsletters
- ▶ FAQ

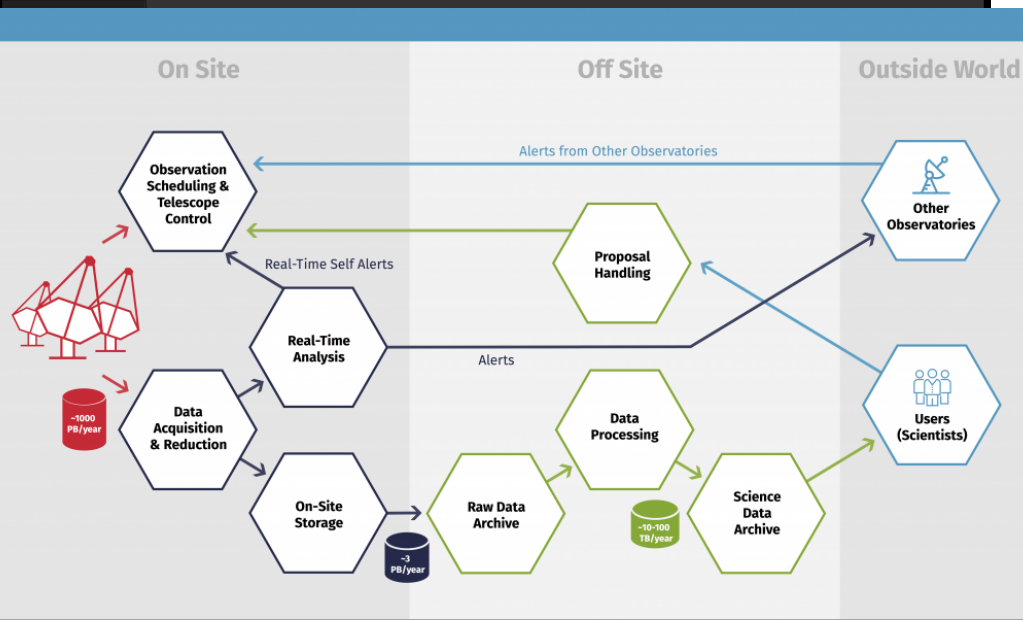
Fermi Data

This is the portal to the Fermi data and the software to analyze them. Before the data or software are released, they are described here.

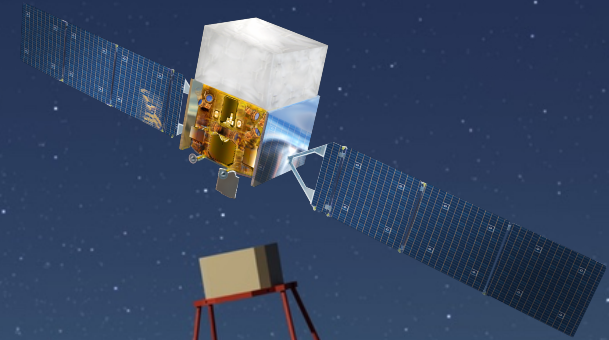
- Data Access - the Fermi science data
- Data Analysis - the software to analyze Fermi data
- Data Policy - a summary of the policies governing the release of Fermi science data

As a resource for proposers the Fermi LAT consortium, through an agreement with NASA, has provided a [source catalog](#) based on data from the first year of the mission.

- CTA is the first ever ground-based gamma-ray open observatory
- *Fermi* has been inspiring
 - data format and analysis tools
 - data access
 - interactions with other observatories
 - preparation of the team Science program



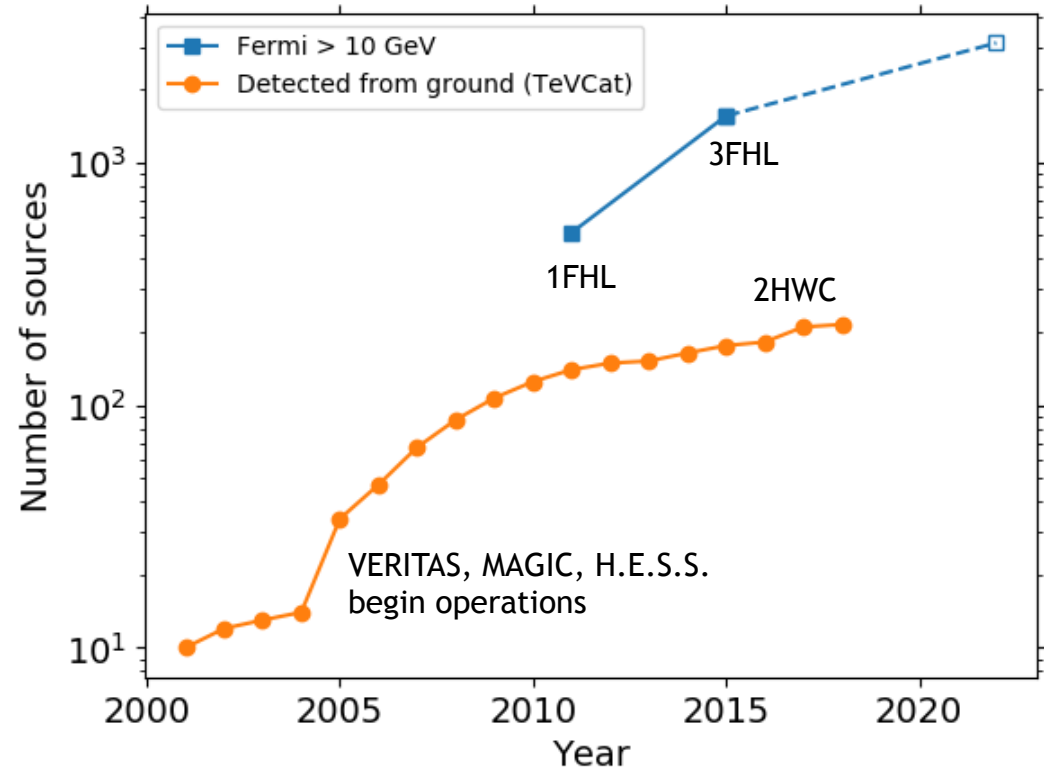
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Targets for CTA



- 1556 sources in 3FHL
- count limited, number of sources increases linearly with time
- > 3000 sources at the beginning of CTA scientific operations

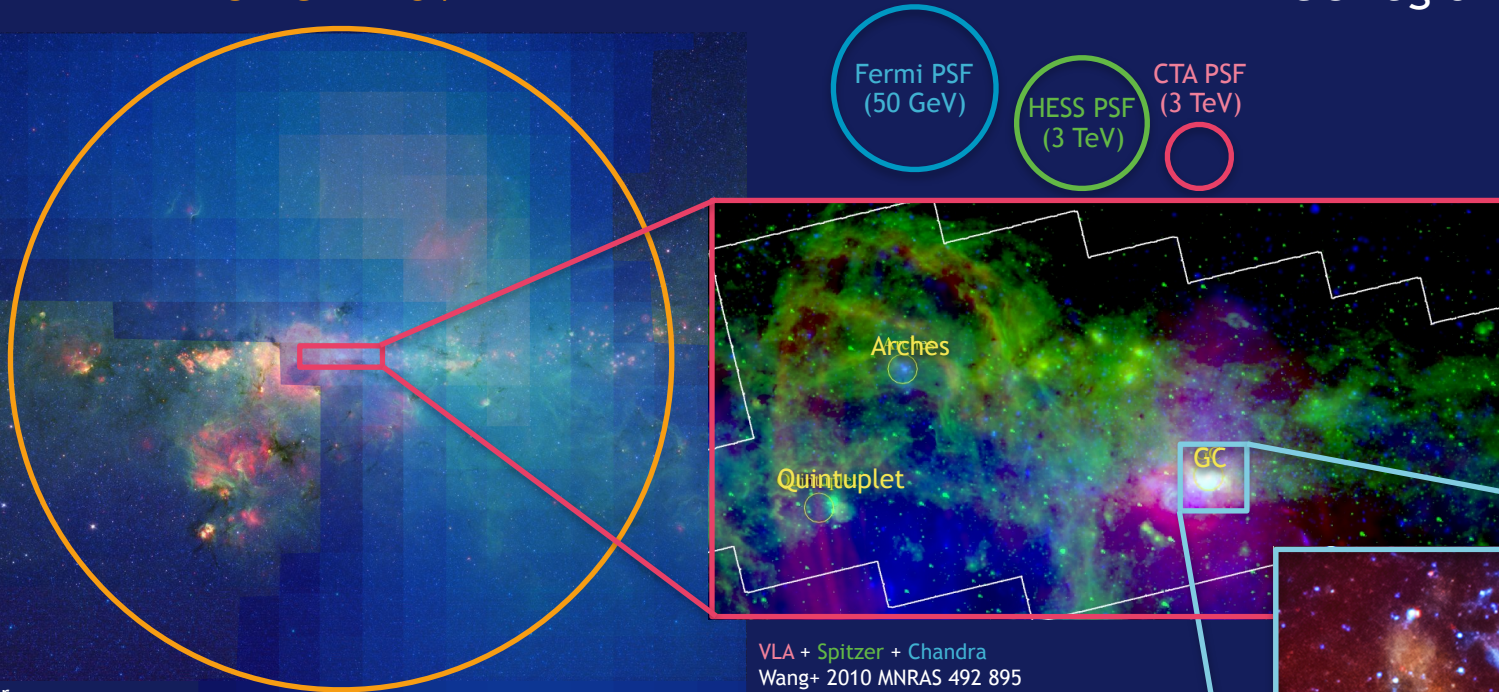


Complementary imaging capabilities

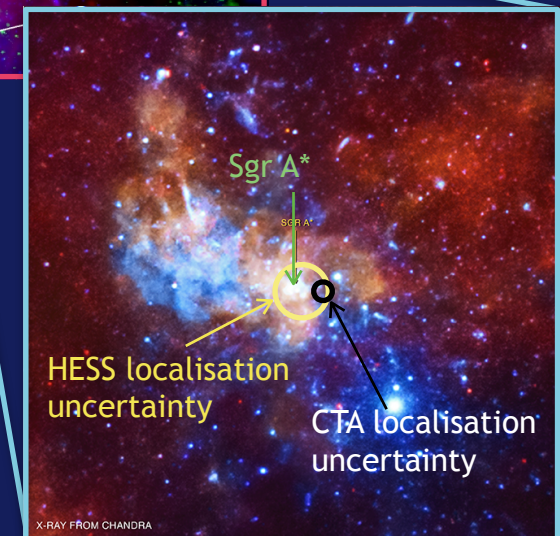


8° CTA FoV

GC region



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

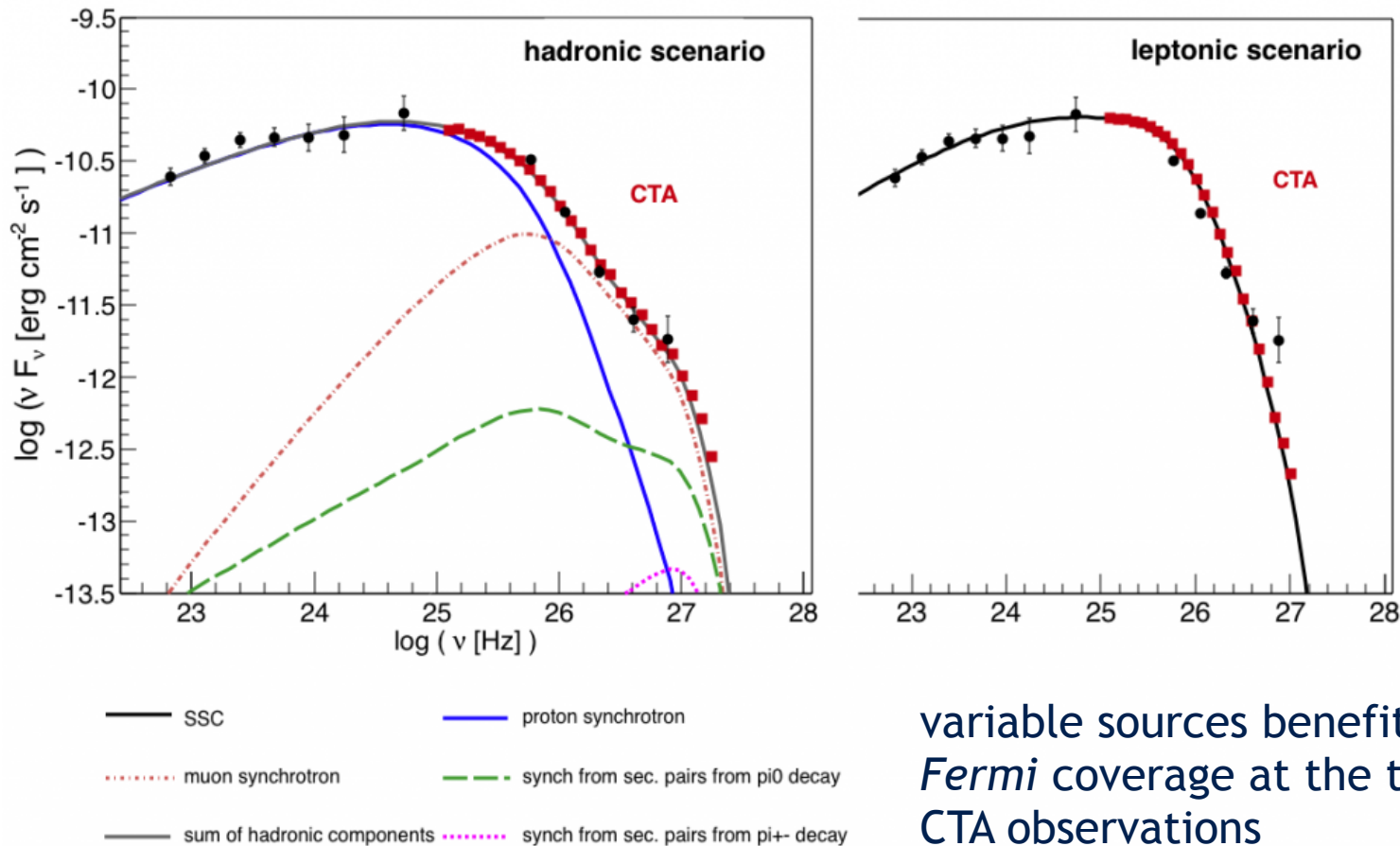


- *Fermi*: large field of view, low background
- CTA: high angular resolution, high statistics

Broadband spectral coverage



PKS 2155-304
AGN KSP

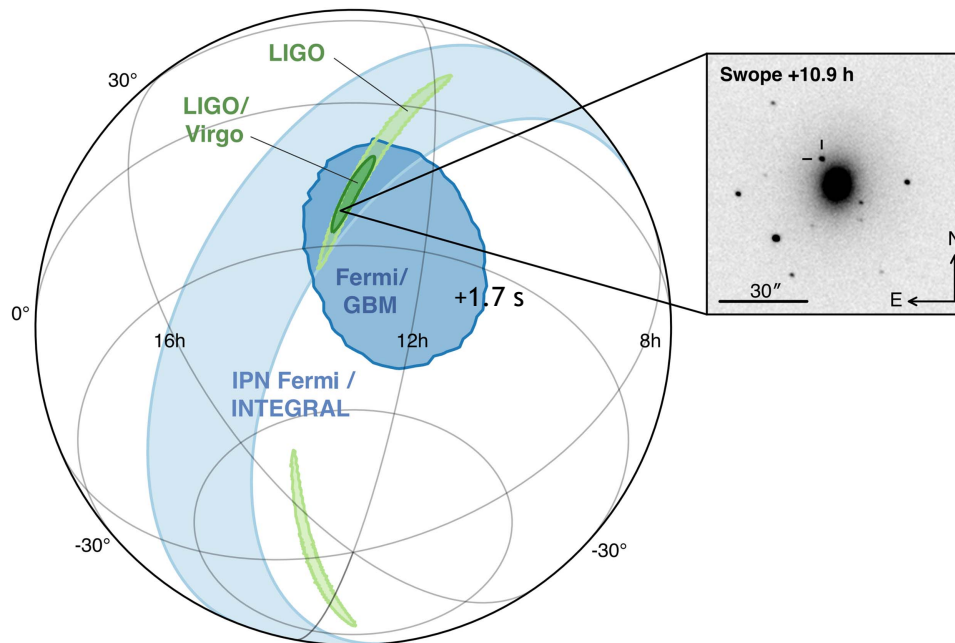


variable sources benefit from
Fermi coverage at the time of
CTA observations

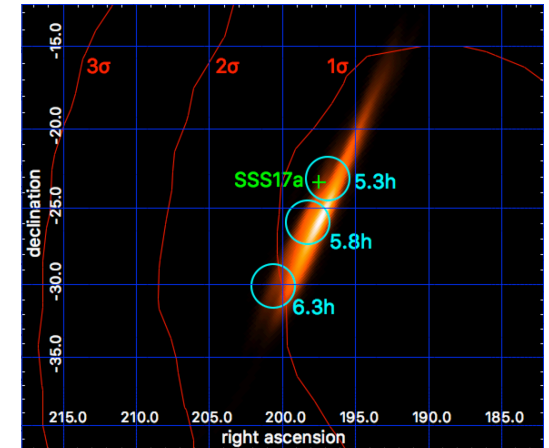
Transient triggers

GW170817

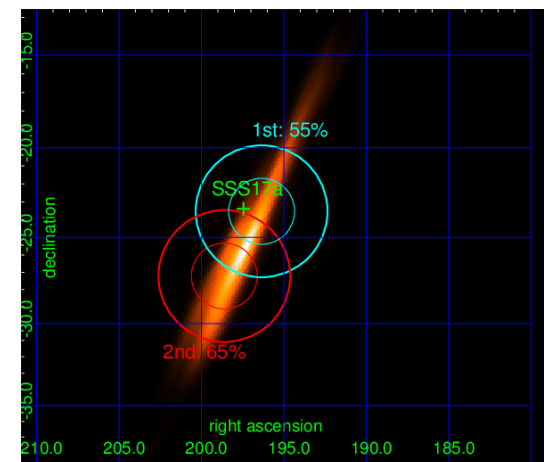
Abbot et al. (2017) ApJ 848L 12



H.E.S.S. follow up within 24 h
Abdalla et al. (2017) ApJ 850L 22A



simulated follow up with CTA
credit: Fabian Schüssler



CTA large telescopes will slew to any observable direction in < 50 s (goal 20 s)

Final remarks



- CTA making progress toward scientific operations
- *Fermi* helped defining and shaping CTA's Science program
- *Fermi* and CTA together: complementary imaging capabilities, broadband spectral coverage, time-domain astronomy

