Synergies between *Fermi* and the Cherenkov Telescope Array

The CTA Consortium* represented by

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1. Introduction to CTA

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

3. The future: *Fermi* meets CTA
Imaging Atmospheric Cherenkov Telescopes (IACTs)

$\gamma$-ray enters the atmosphere

Electromagnetic cascade

10 nanosecond snapshot

0.1 km$^2$ "light pool", a few photons per m$^2$. 
From current IACTs to CTA

light-pool radius 100-150 m
~ telescope spacing

sweet spot for trigger and reconstruction:
most showers miss it

large detection area
more images per shower
lower trigger threshold

Credit: Werner Hofmann
The Cherenkov Telescope Array

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

\[ E^2 \times \text{Flux Sensitivity (erg cm}^{-2} \text{s}^{-1}) \]

\[ 10^{-13} \rightarrow 10^{-12} \rightarrow 10^{-11} \]

\[ \text{Differential flux sensitivity} \]

\[ \text{Energy } E_R \text{ (TeV)} \]

\[ 10^{-2} \rightarrow 10^{-1} \rightarrow 1 \rightarrow 10 \rightarrow 10^2 \]
Sensitivity vs observation time

- **Fermi LAT**
  - Various energy levels (E = 25 GeV, 40 GeV, 75 GeV, 100 GeV, 250 GeV)

- **CTA**
  - Continuous lines represent different energy levels

Differential Flux Sensitivity $E^2 dN/dE$ (erg cm$^{-2}$ s$^{-1}$)

- Time axis (s): 10s, 100s, 1000s, 10000s
Angular resolution is optimized for best sensitivity, angular resolution can be improved.
First CTA telescope in La Palma
Novel: Open Observatory

~40% of time over first 10 years
• large amount of coherent observations, technically difficult
• legacy datasets

CTA Consortium

Key Science Projects

DATA

Observation Proposals

CTA Observatory

CTA Observatory User Community
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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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

Fermi sources > 50 GeV (2FHL)
New sources

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

![Image](image_url)

1FHL Catalog
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

- 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

- **Fermi**: large field of view, low background
- **CTA**: high angular resolution, high statistics
PKS 2155-304
AGN KSP

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

GW170817

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