▶Exploring the non-thermal universe◀

the **C**herenkov **T**elescope **A**rray as a facility for gamma ray astronomy in the next decade

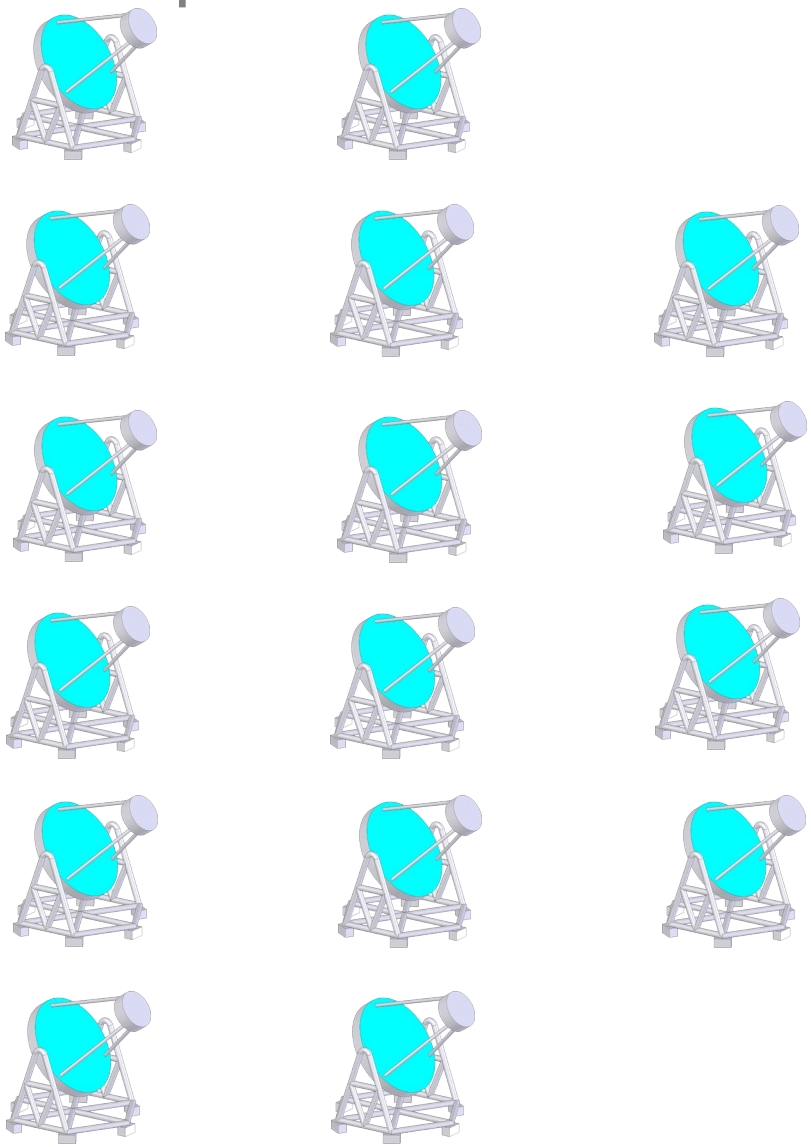
Outline

- Project goals
- Science case
- Strategic importance & impact
- Technology & maturity

The Cherenkov Telescope Array facility

CTA

An advanced facility for ground-based high-energy gamma ray astronomy



- aims to explore the sky in the 10 GeV to 100 TeV energy range
- builds on demonstrated technologies
- combines guaranteed science with significant discovery potential
- is a cornerstone towards a multi-messenger exploration of the nonthermal universe

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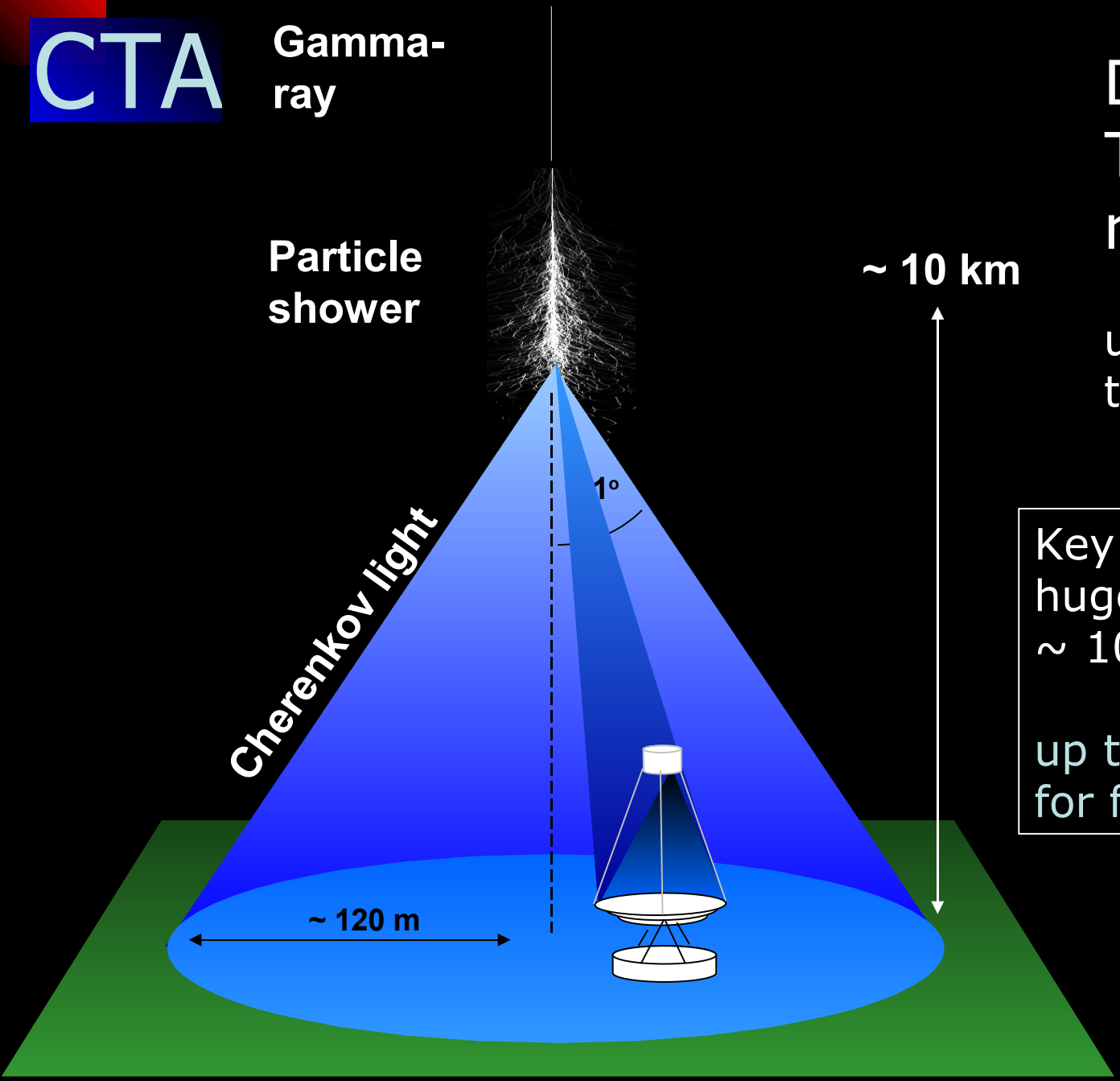

Detection of TeV gamma rays

using Cherenkov telescopes

Key issue:
huge detection area
~ 10^5 m^2

up to 10^6 m^2
for future array

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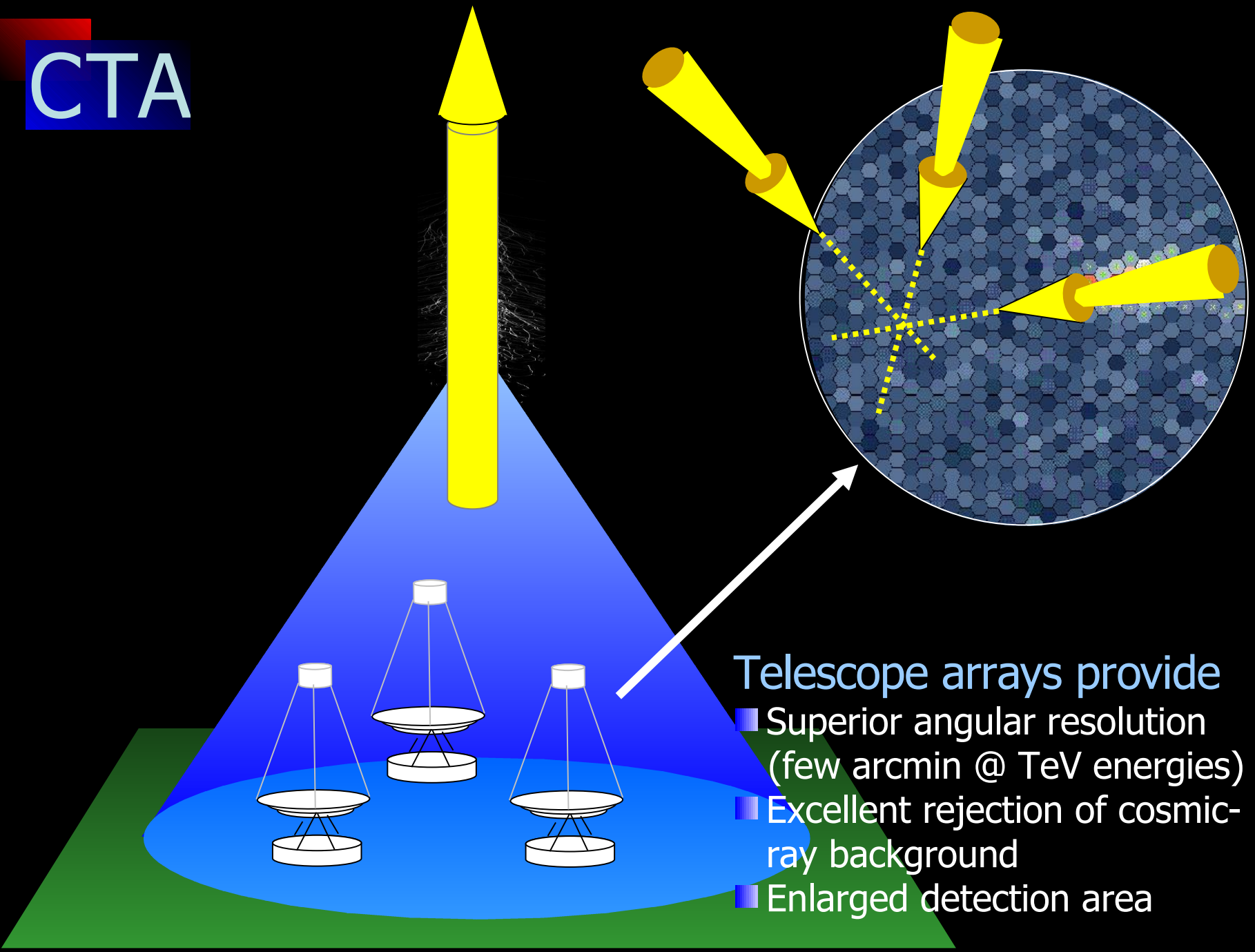

Telescope arrays provide

- Superior angular resolution (few arcmin @ TeV energies)
- Excellent rejection of cosmic-ray background
- Enlarged detection area

The Science Case

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Science topics

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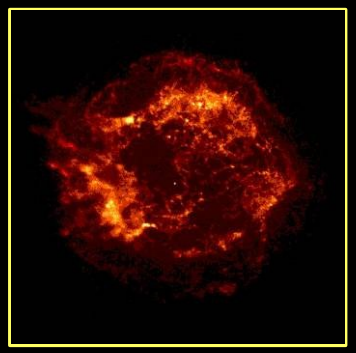
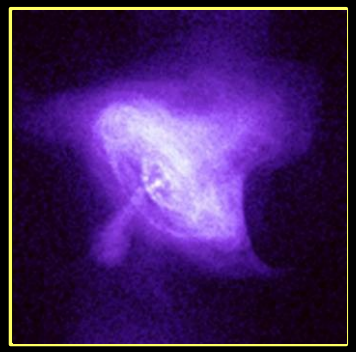
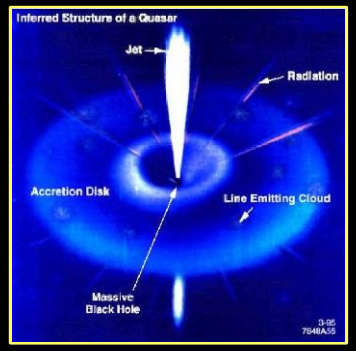
Origin of cosmic rays



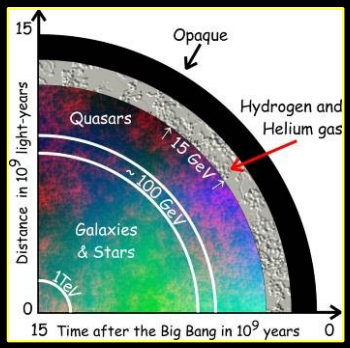
SNRs



Pulsars and PWN

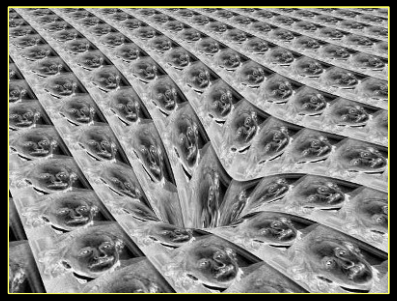


AGNs

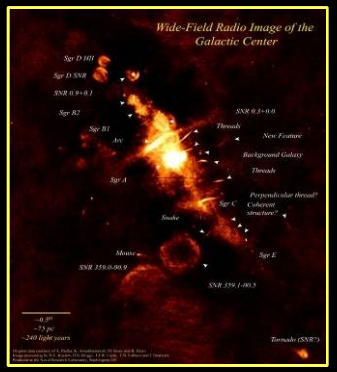


Cosmology

Space-time & relativity



Dark matter



GRBs

The Milky Way at very high energies

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Supernovae & pulsars: Vela region

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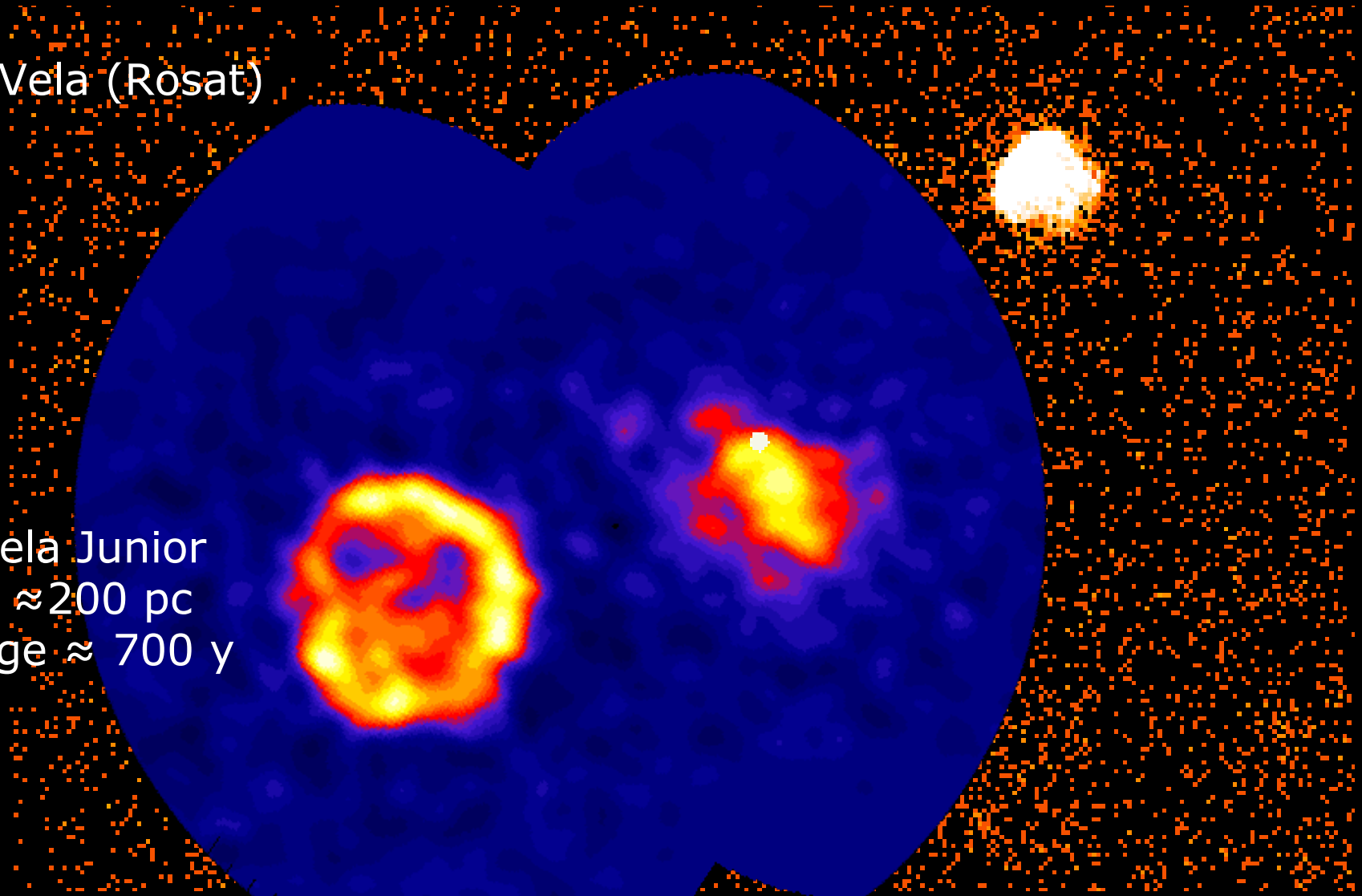

Mysterious "dark accelerators"

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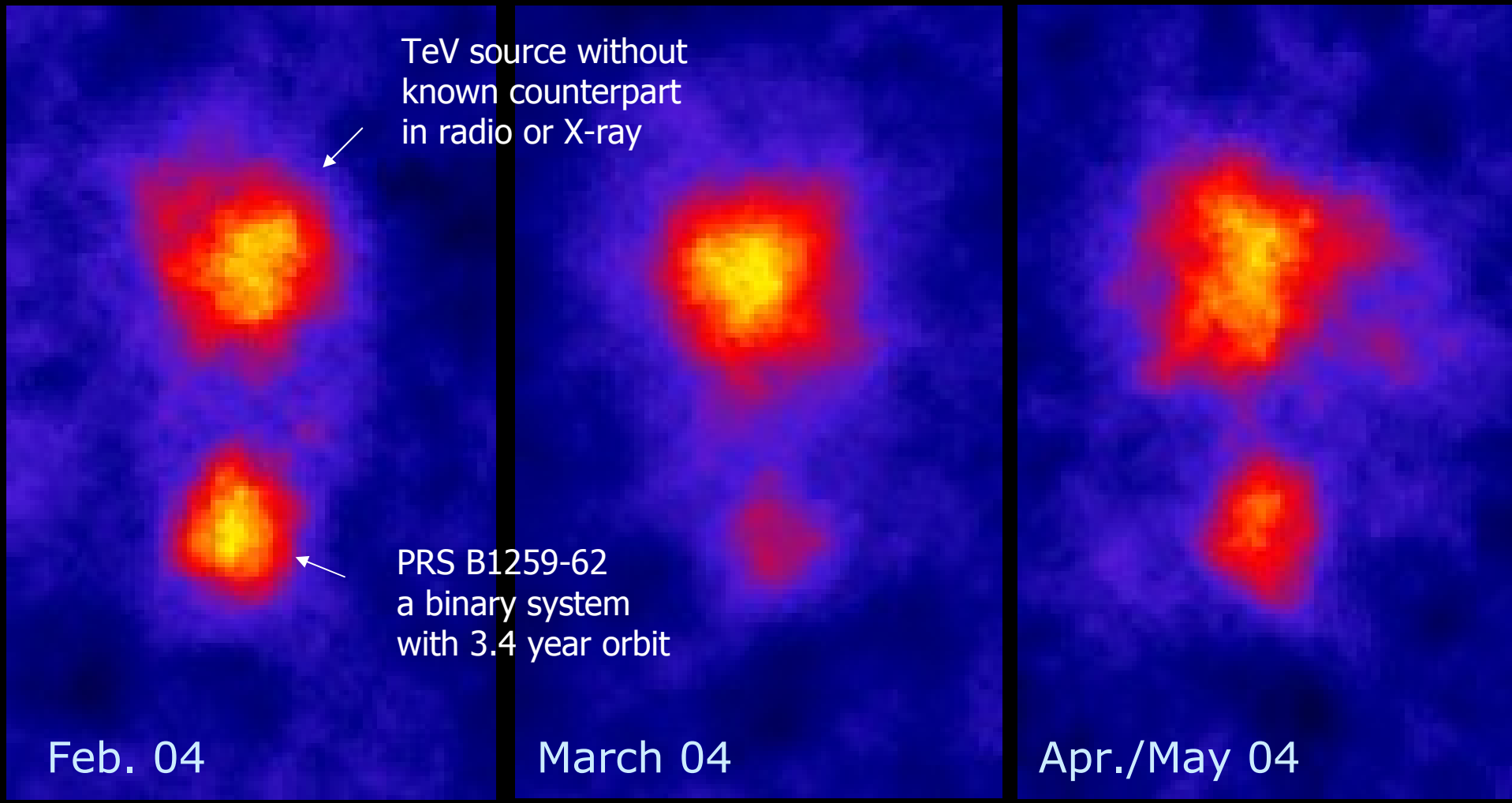

Tracing cosmic ray propagation

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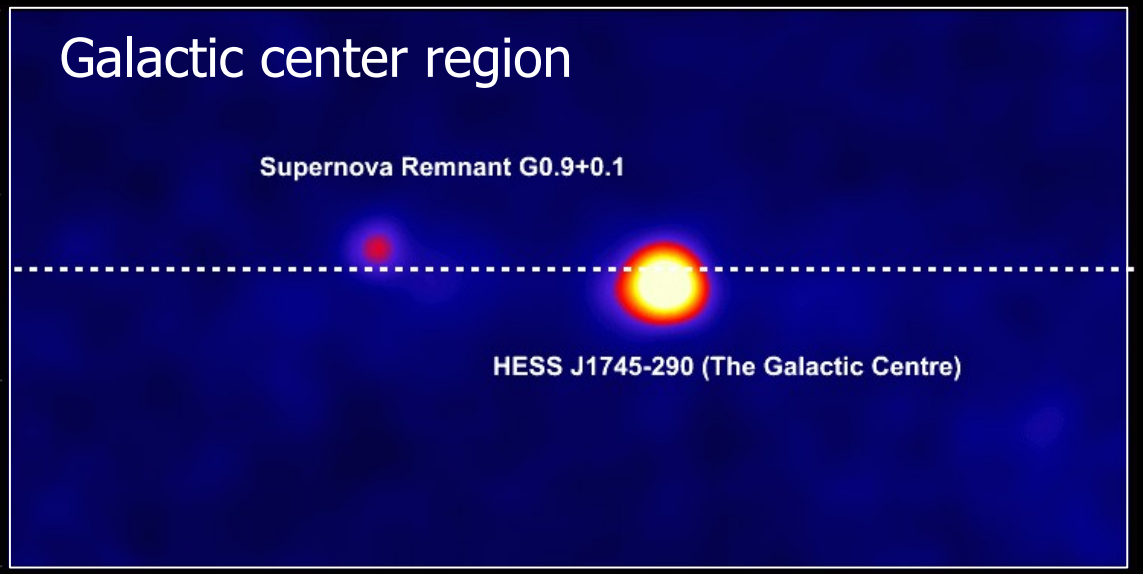

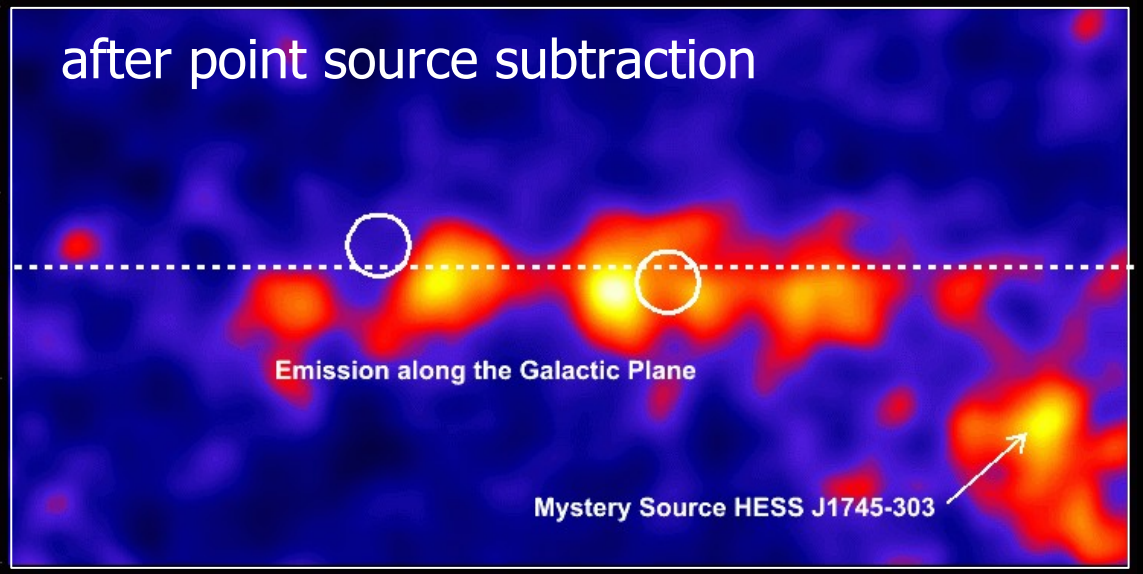

Extending the energy coverage

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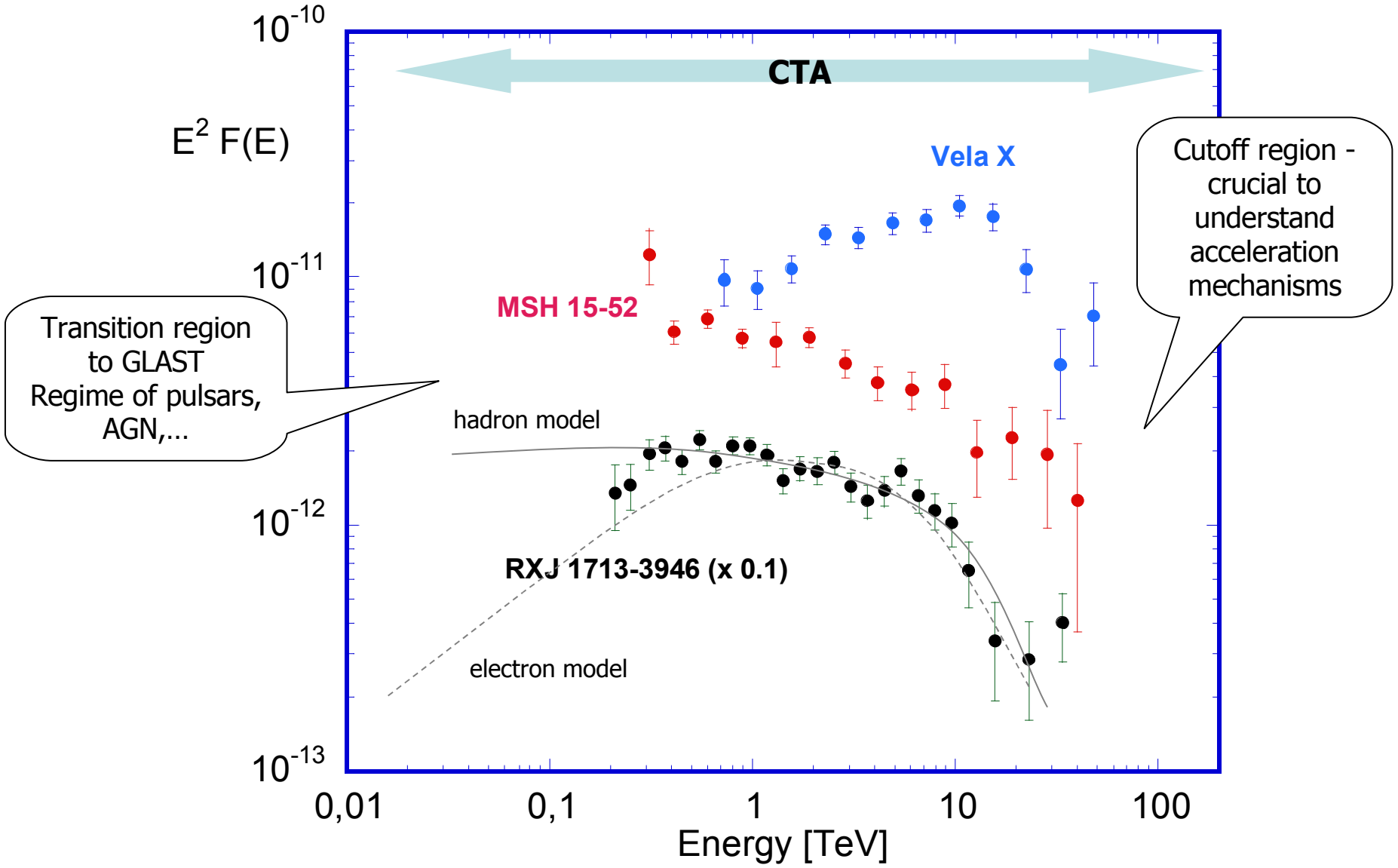
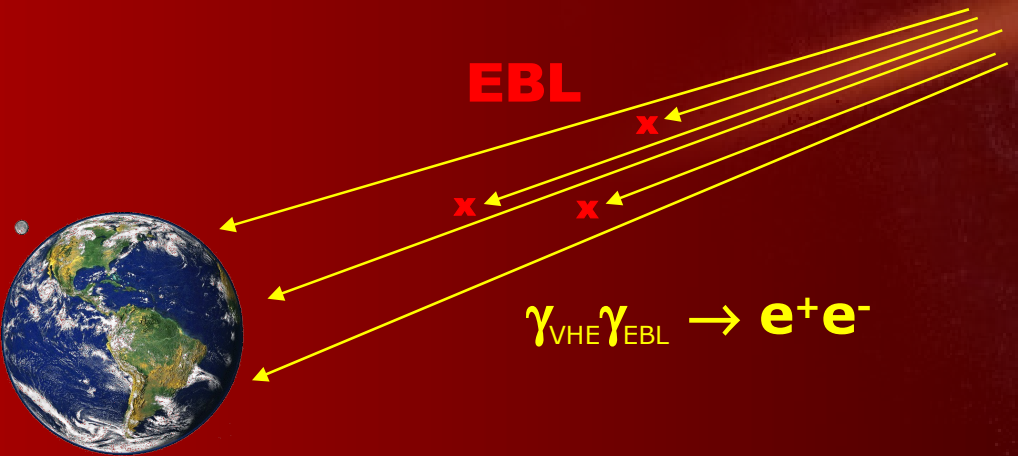


Extragalactic TeV astronomy

- Physics of AGN jets
- Density of cosmological extragalactic background light (EBL)



Variability probes AGN jets

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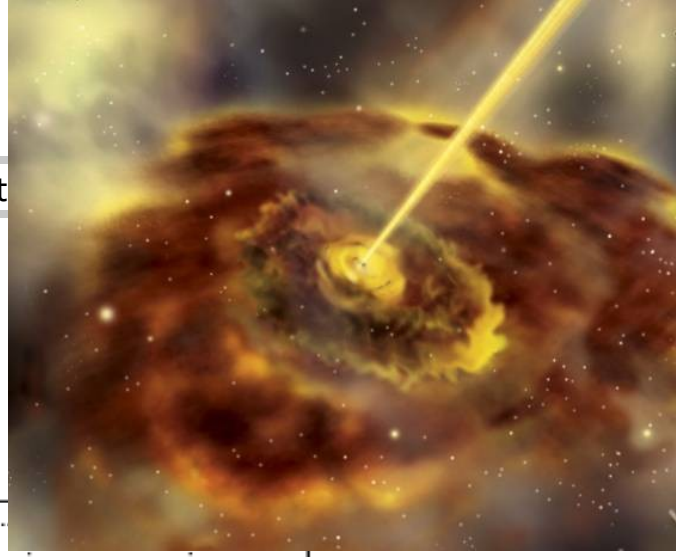

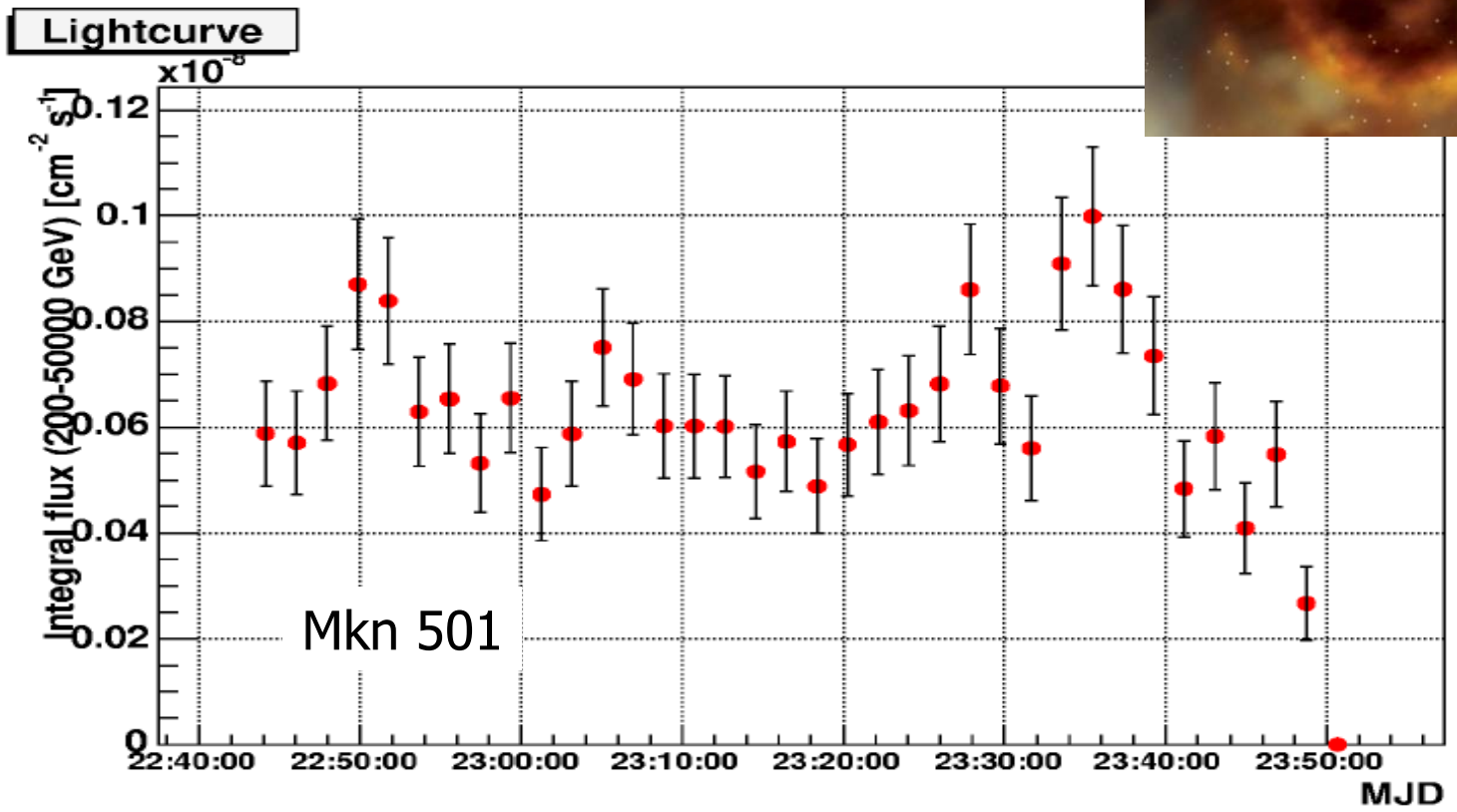

Gamma ray horizon and early stars

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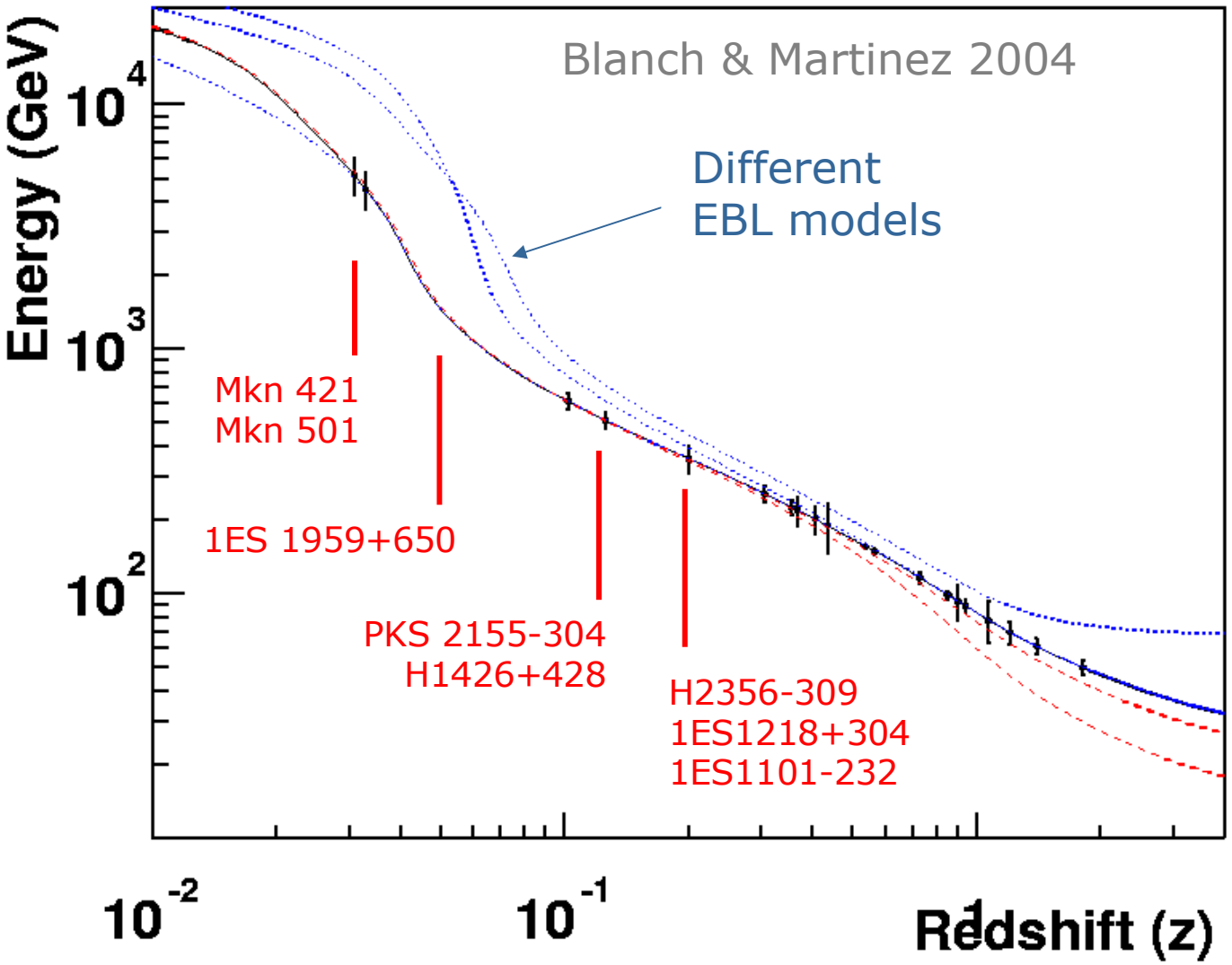

Science potential

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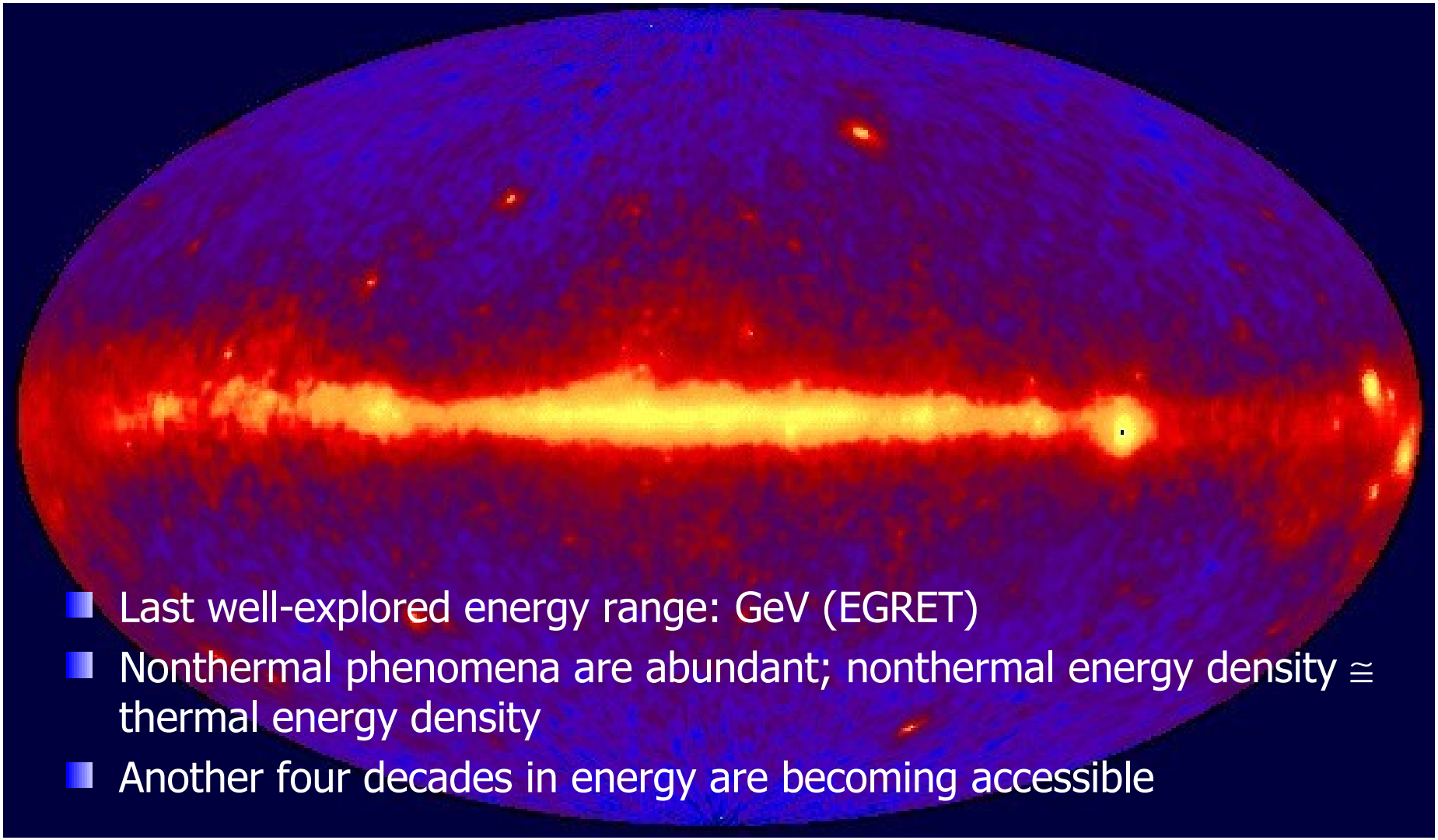

- Last well-explored energy range: GeV (EGRET)
- Nonthermal phenomena are abundant; nonthermal energy density ≅ thermal energy density
- Another four decades in energy are becoming accessible

Science potential

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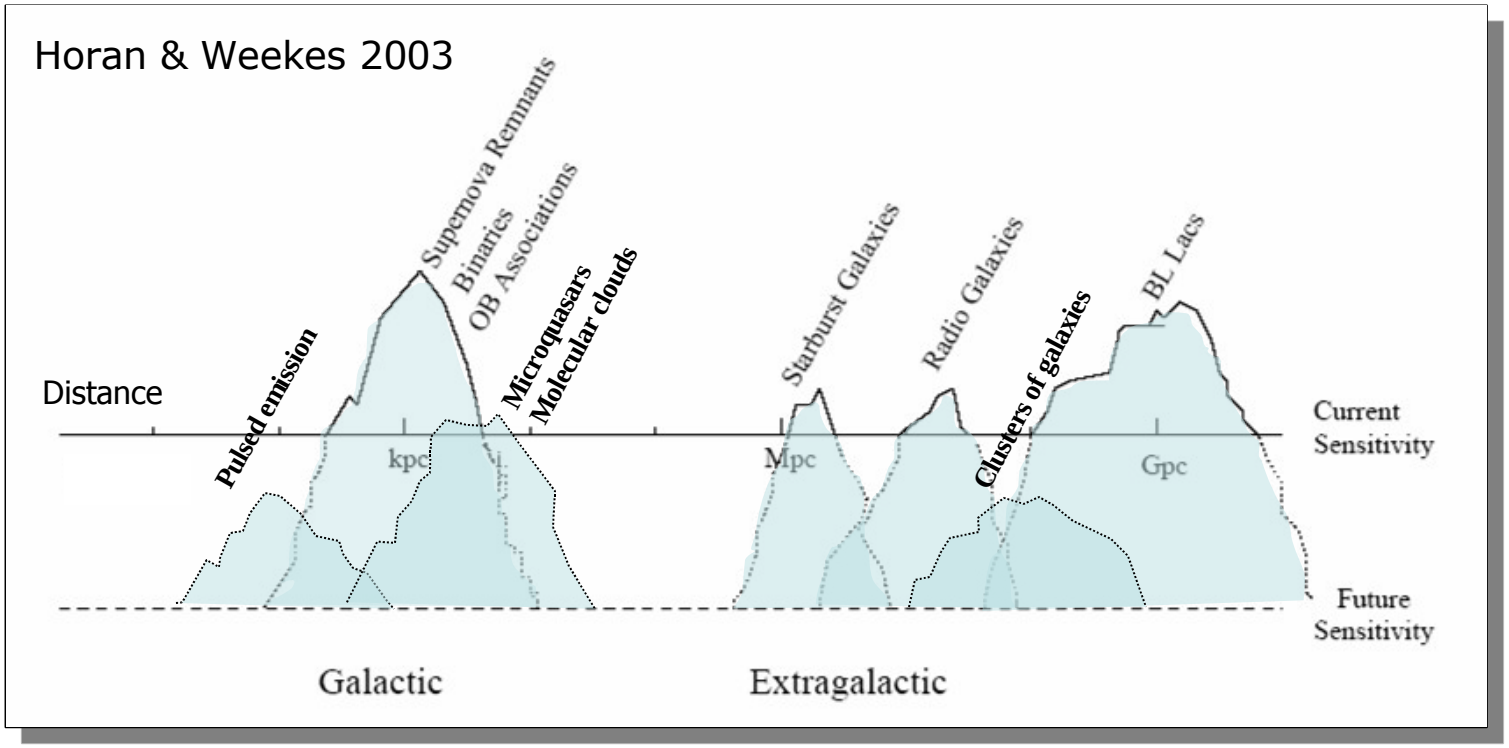

- Current instruments have passed the critical sensitivity threshold and reveal a rich panorama, but this is clearly only the tip of the iceberg
- Broad and diverse program ahead, combining guaranteed astrophysics with significant discovery potential

Sensitivity

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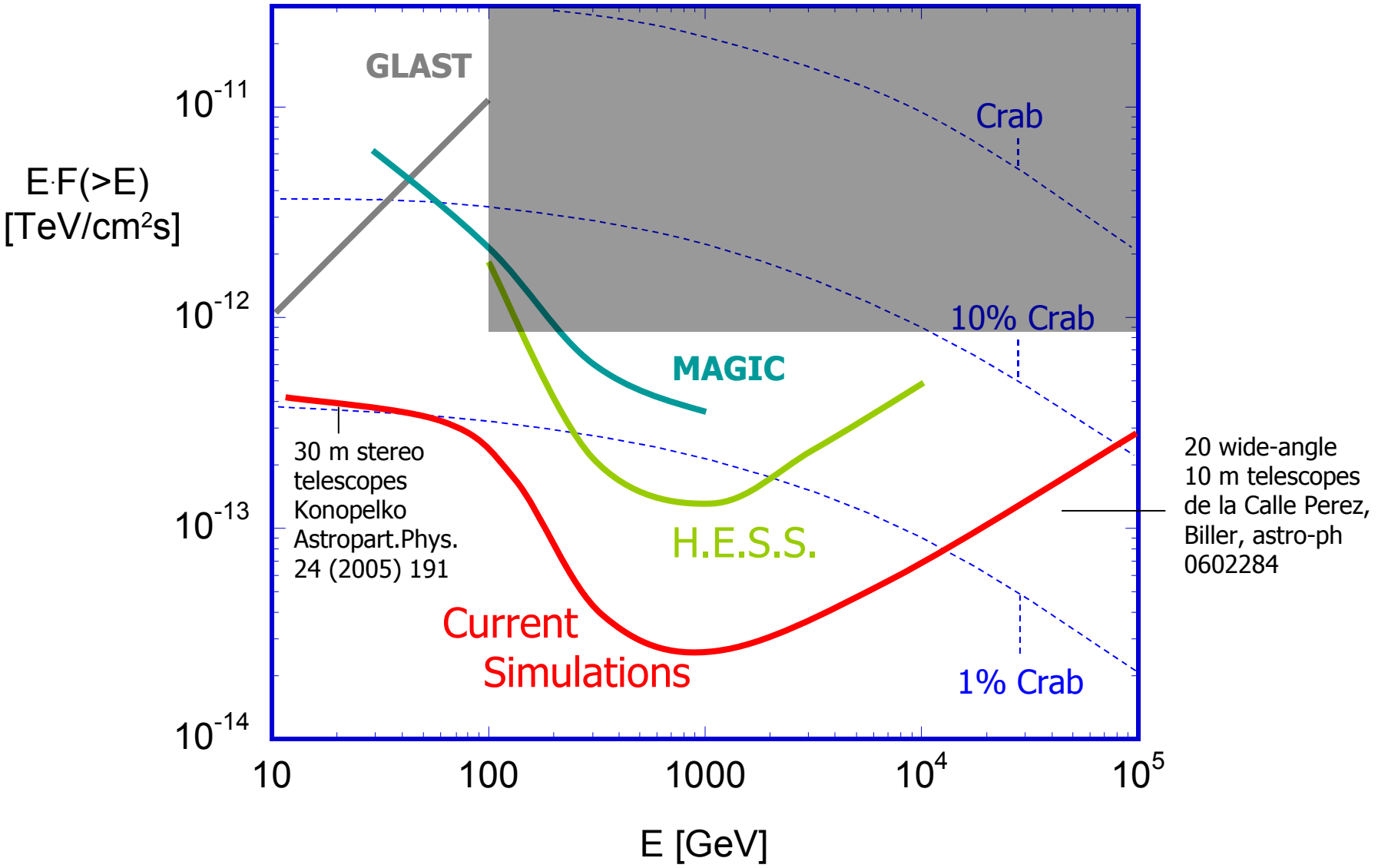

CTA and GLAST

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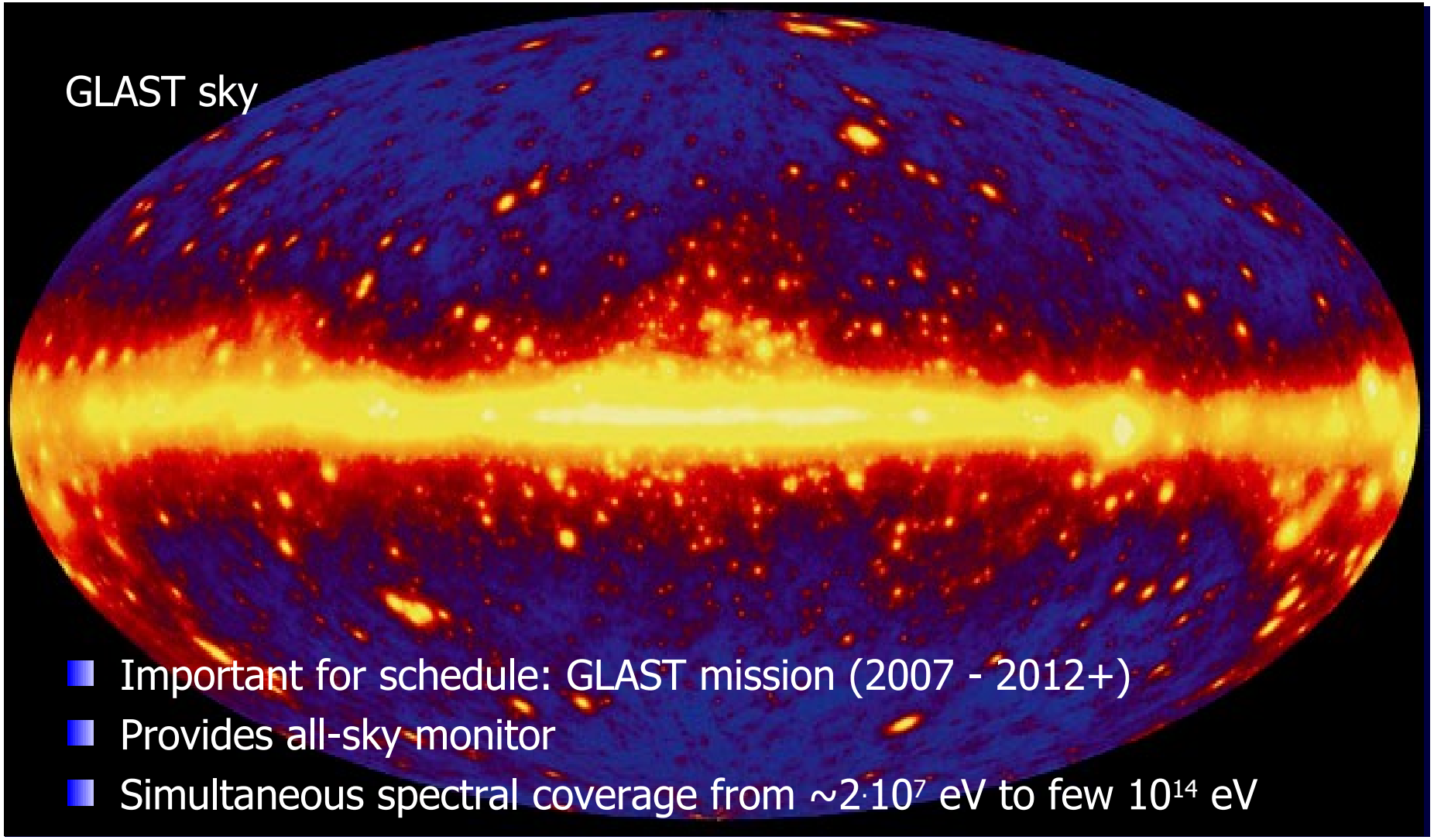

- Important for schedule: GLAST mission (2007 - 2012+)
- Provides all-sky monitor
- Simultaneous spectral coverage from ~$2 \cdot 10^7$ eV to few 10^{14} eV

CTA and GLAST

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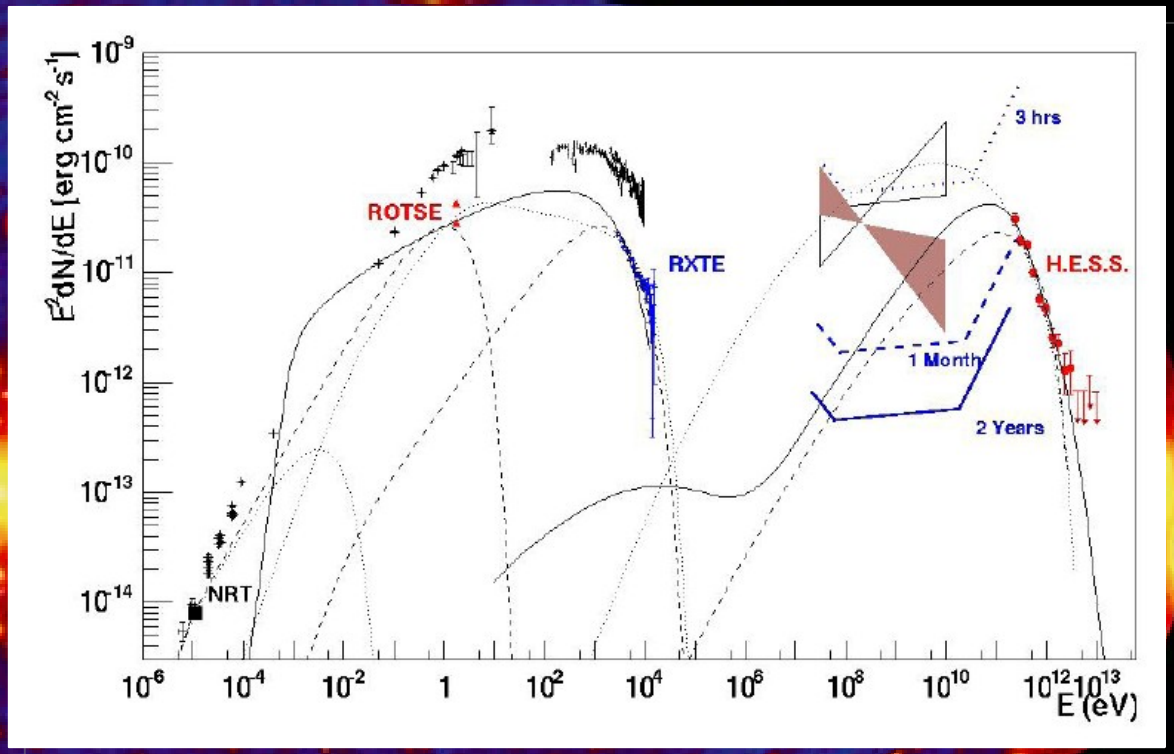
GLAST sky



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Strategic Importance and Impact

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Unifying European efforts

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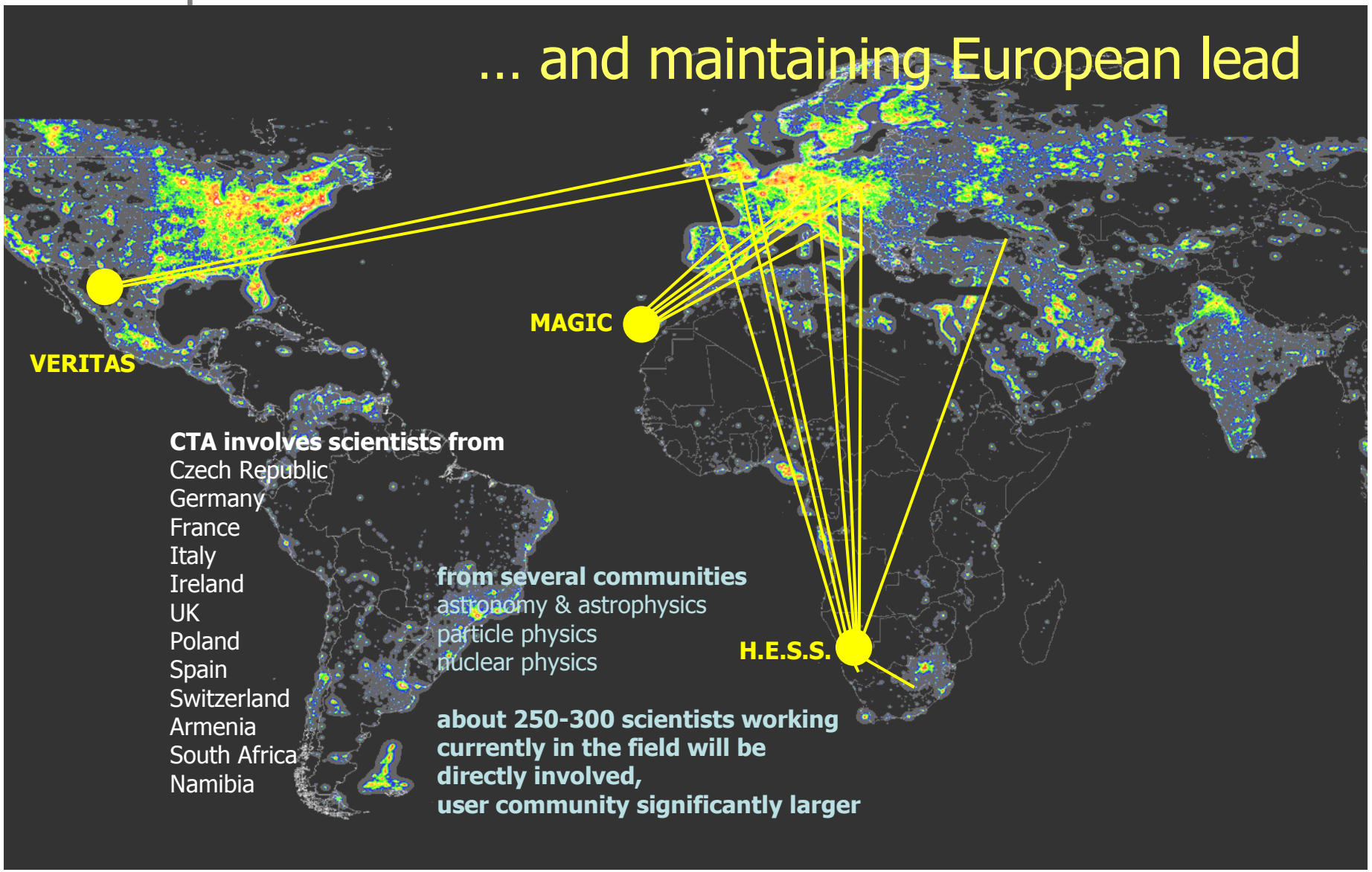

Multiwavelength / multimessenger astronomy

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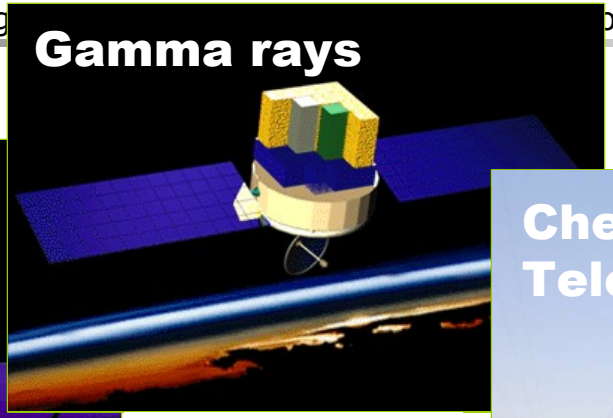
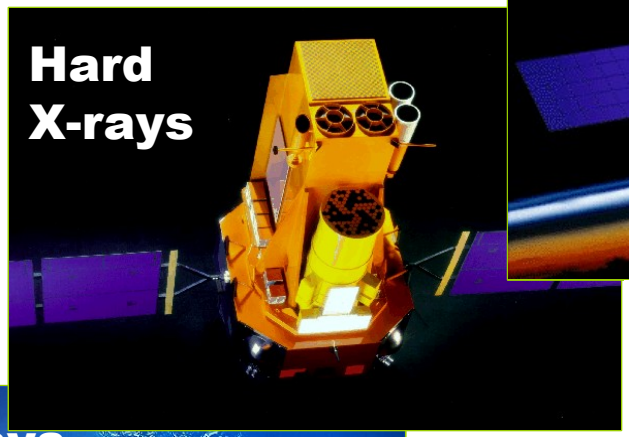
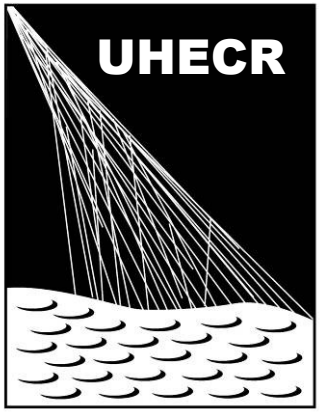
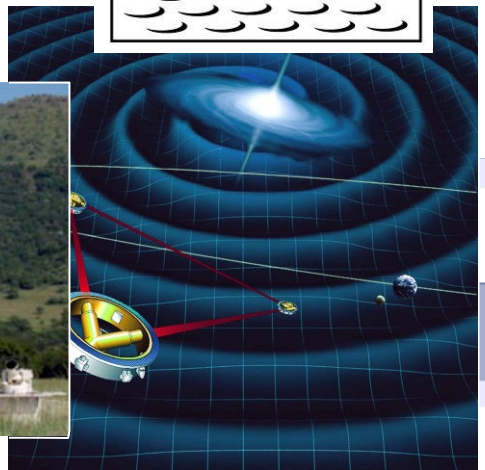
An advanced facility for g onomy









M3NeT

KM3NeT

Transfer, education and outreach

- Interdisciplinary cooperation and training across communities & frontiers
  - Astrophysics & cosmology
  - Particle physics
  - Information & data mining
  - Environmental science
- Technology development & technology transfer to industry
  - Photon detectors
  - Signal processing hardware and software
  - Optical elements (low-cost mirrors, Fresnel lenses,…)
  - Grid tools
- Outreach
  - A new window onto the high-energy universe
  - Virtual observatory

Technology and Maturity

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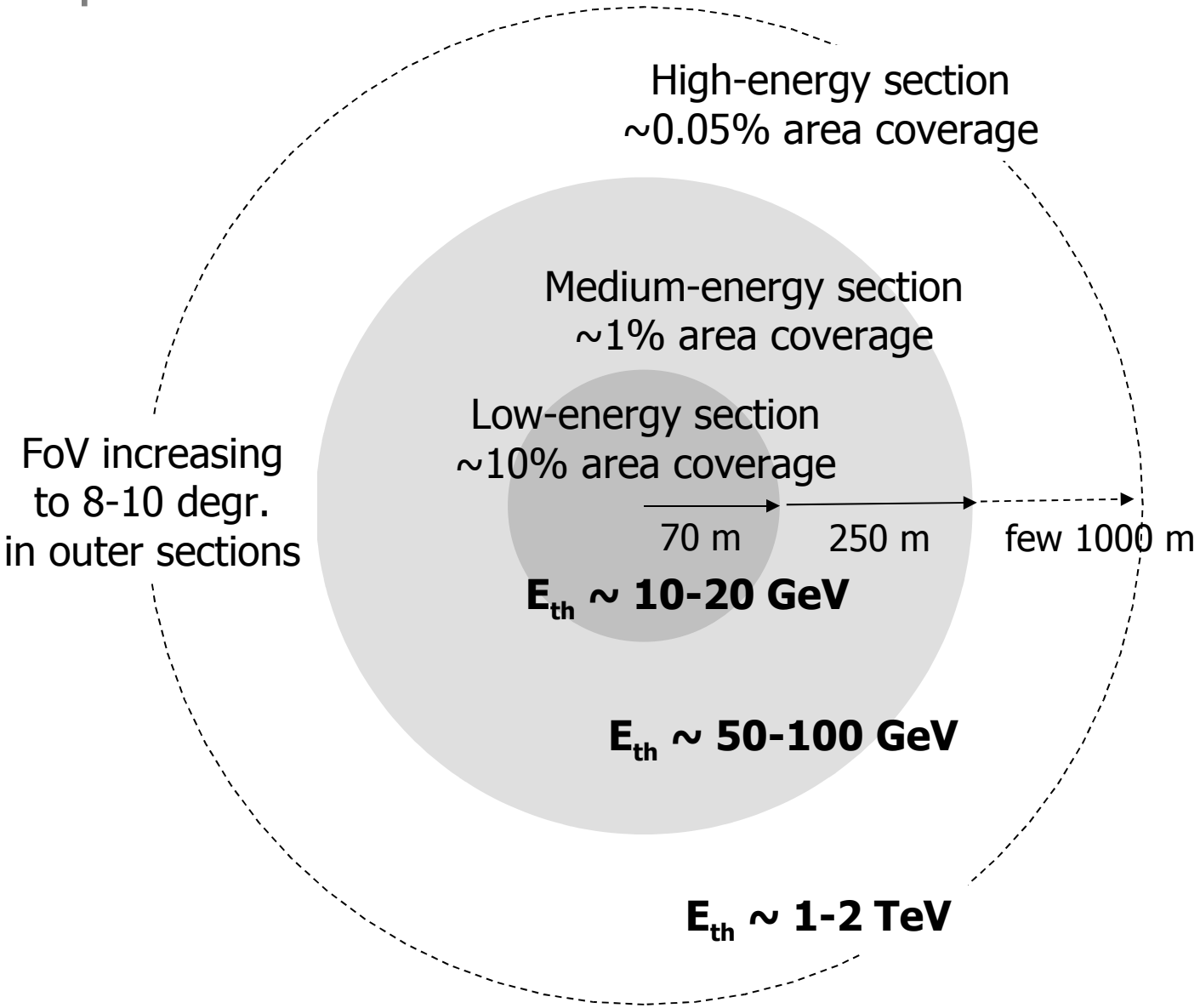
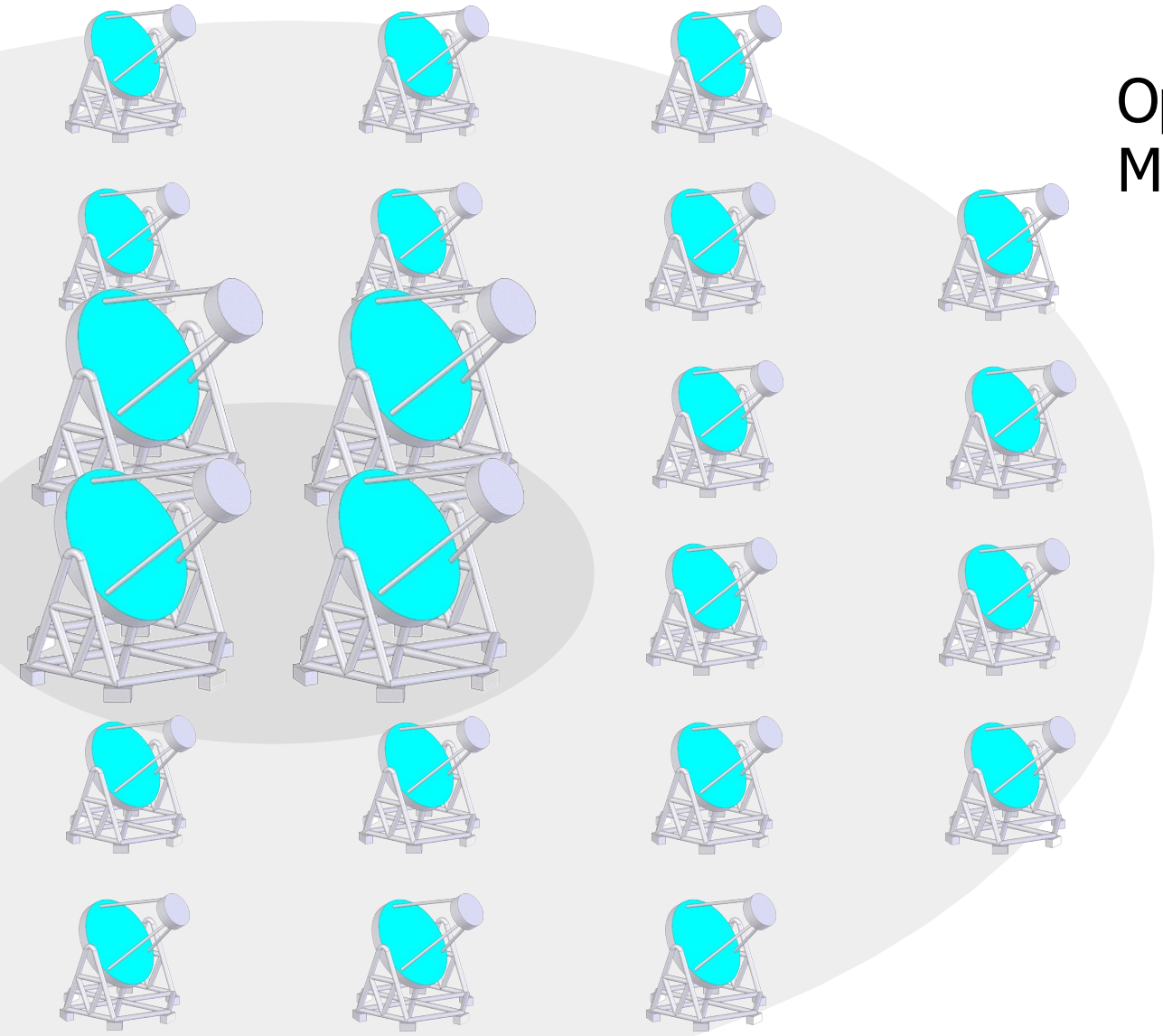
Array layout: 2-3 Zones





Option:
Mix of telescope types

Not to scale !

Modes of operation

- Deep wide-band mode: all telescopes track the same source
- Survey mode: staggered fields of view survey sky
- Search & monitoring mode: subclusters track different sources
- Narrow-band mode: halo telescopes accumulate high-energy data, core telescopes hunt pulsars
- …

Not to scale !

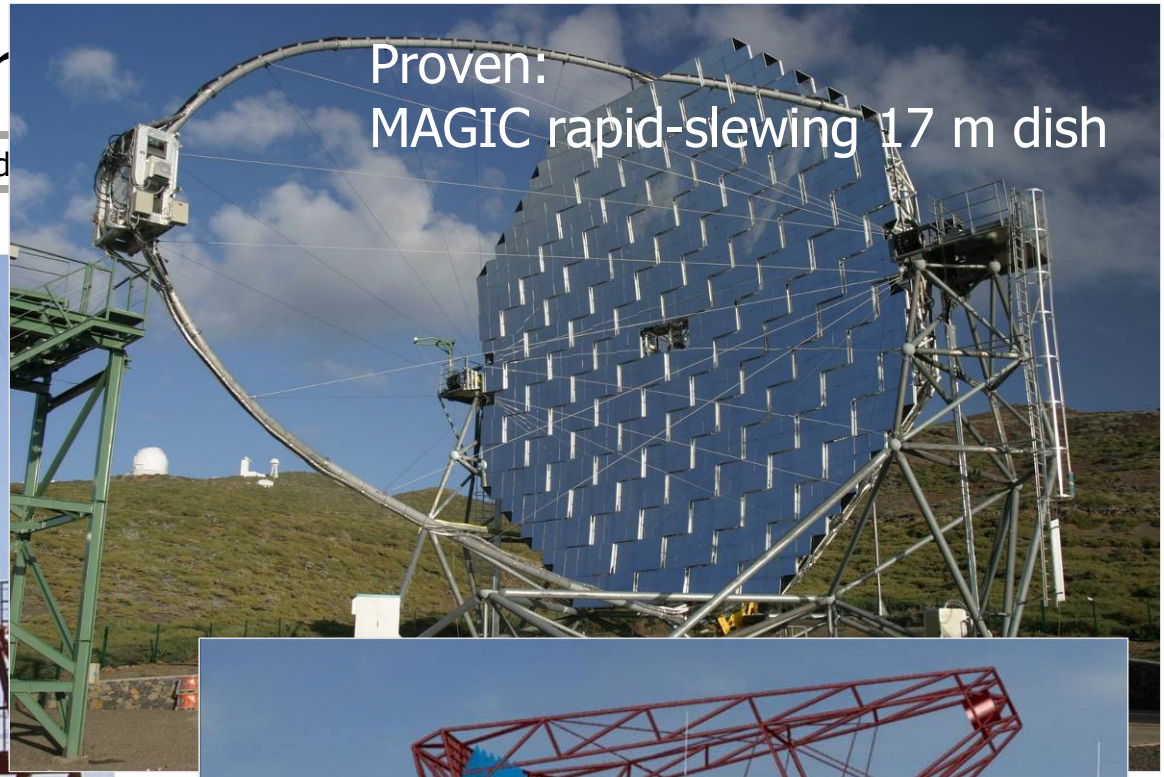
Option: Single dish type

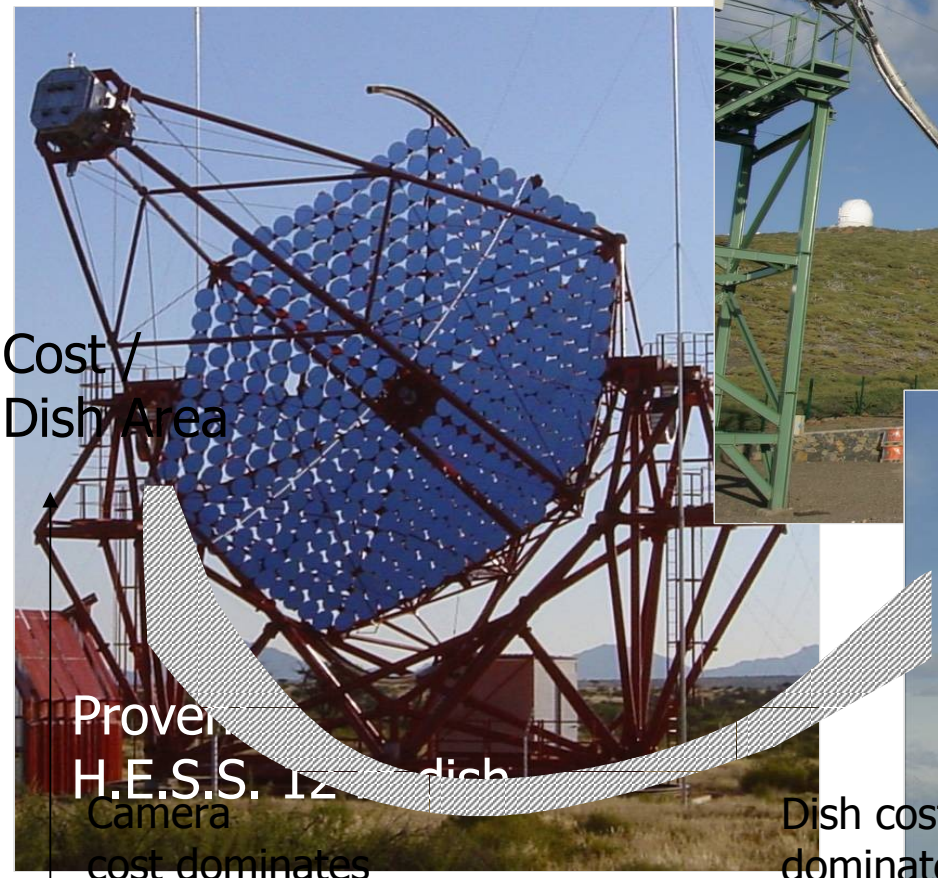
Requires further development of trigger system for central cluster, allowing to combine pixel signals from multiple telescopes

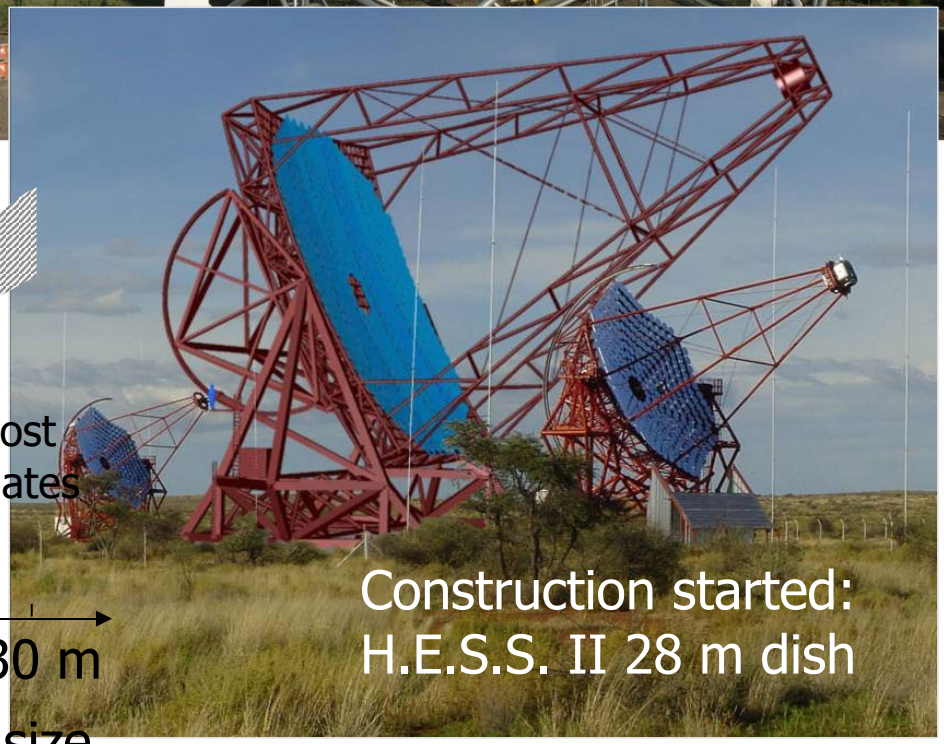
CTA

Telescope str

An advanced facility for ground







Cost / Dish Area

Camera cost dominates

Dish cost dominates

0

10 m

20 m

30 m

Dish size

Photon detector technology

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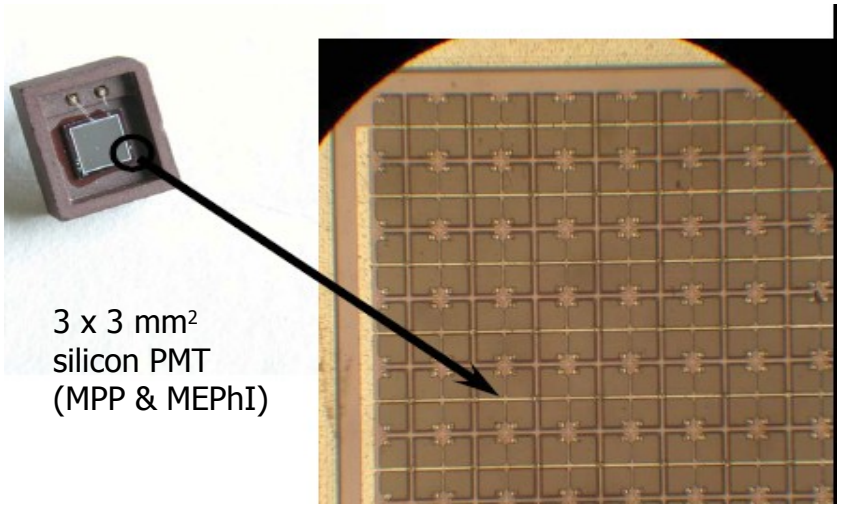
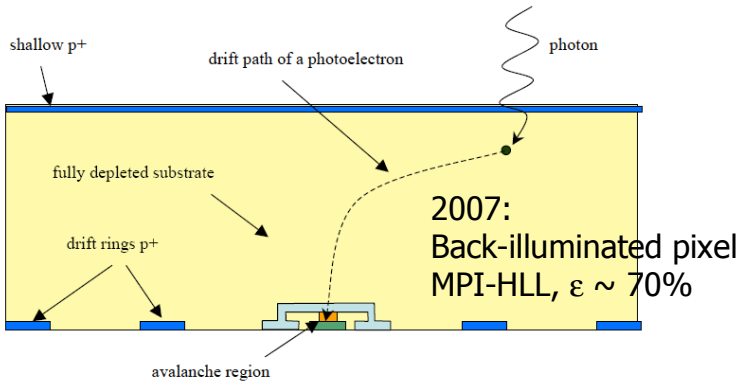
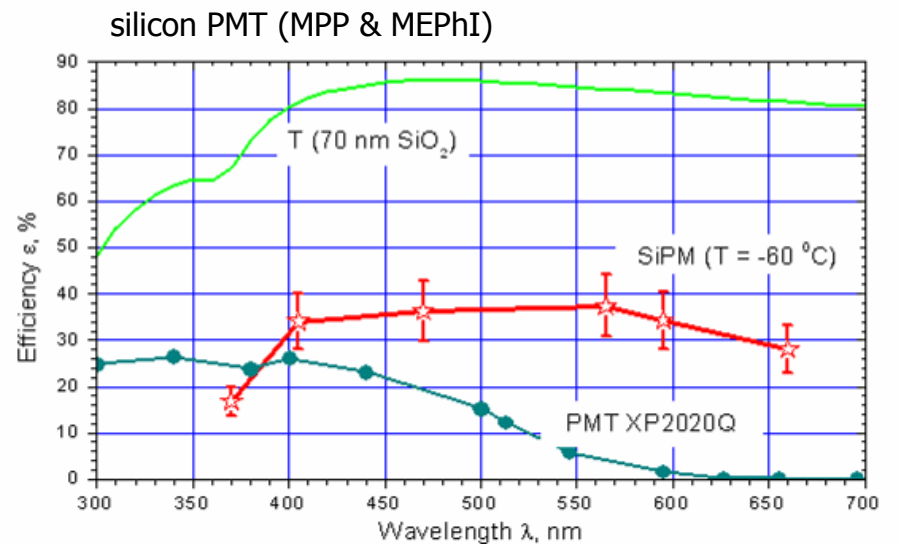
Improved photon detectors under development allow further improvements in sensitivity and threshold

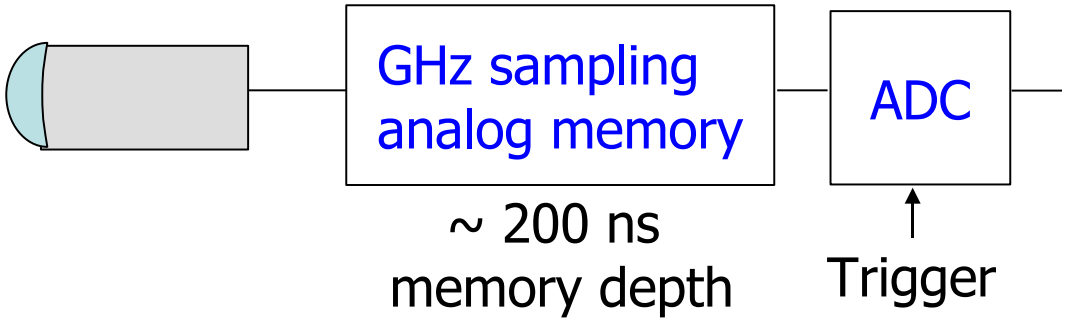
- Conventional PMTs with improved cathodes, coatings
- GaAs photo cathodes
- Semiconductor single-photon detectors: photon counting with small pixels

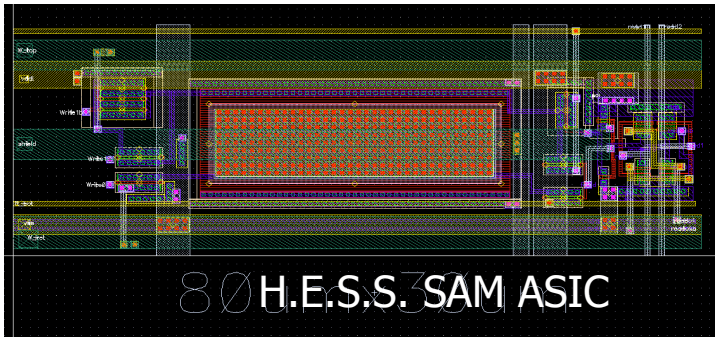


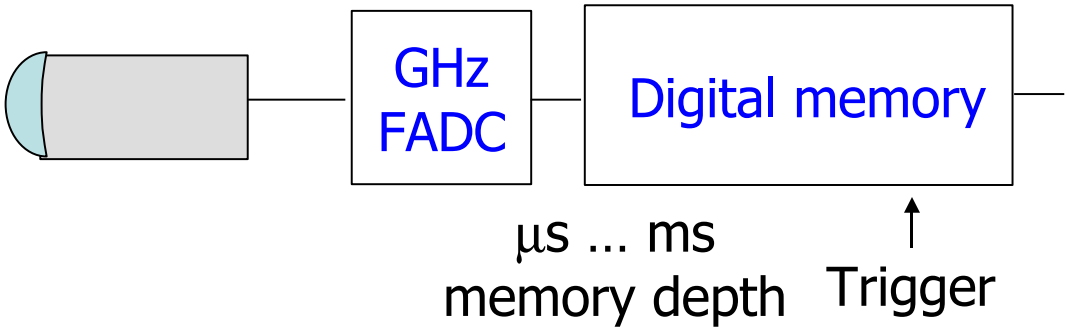




Readout technology







- Several proven solutions
- Optimise further, decide on basis of cost, power consumption, performance

Data processing

- Data volume: few % of LHC
- Smart front-end data reduction required
- Use GRID technology for analysis and simulations

Aim for two sites to cover the full sky

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South:
Khomas Highland,
Namibia, 23° S, 1800 m

North:
Canary Islands, IAC sites
28° N, 2000+ m

Option: South-American
High-altitude sites, 3500+ m

Multiple sites would be designed, constructed and operated by a single consortium

Tentative schedule

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	06	07	08	09	10	11	12	13
Site exploration								
Array design								
Component prototypes								
Telescope prototypes								
Array construction								
Partial operation								
Full operation								

GLAST

Cost

Telescope type	Cost/Unit	Units
Large (30 m class) telescope	10 – 15 M€	~ 3-4
Medium (15 m class) telescope	2.5 – 3.5 M€	~ 15-20
Small (<10 m class) telescope	0.5-1.0 M€	~ many

Rough guess; detailed cost, mix, number and layout of telescopes remains to be determined!

Total ~ 100 M€ for general-purpose southern site
~ 50 M€ for "extragalactic" northern site

Organisation

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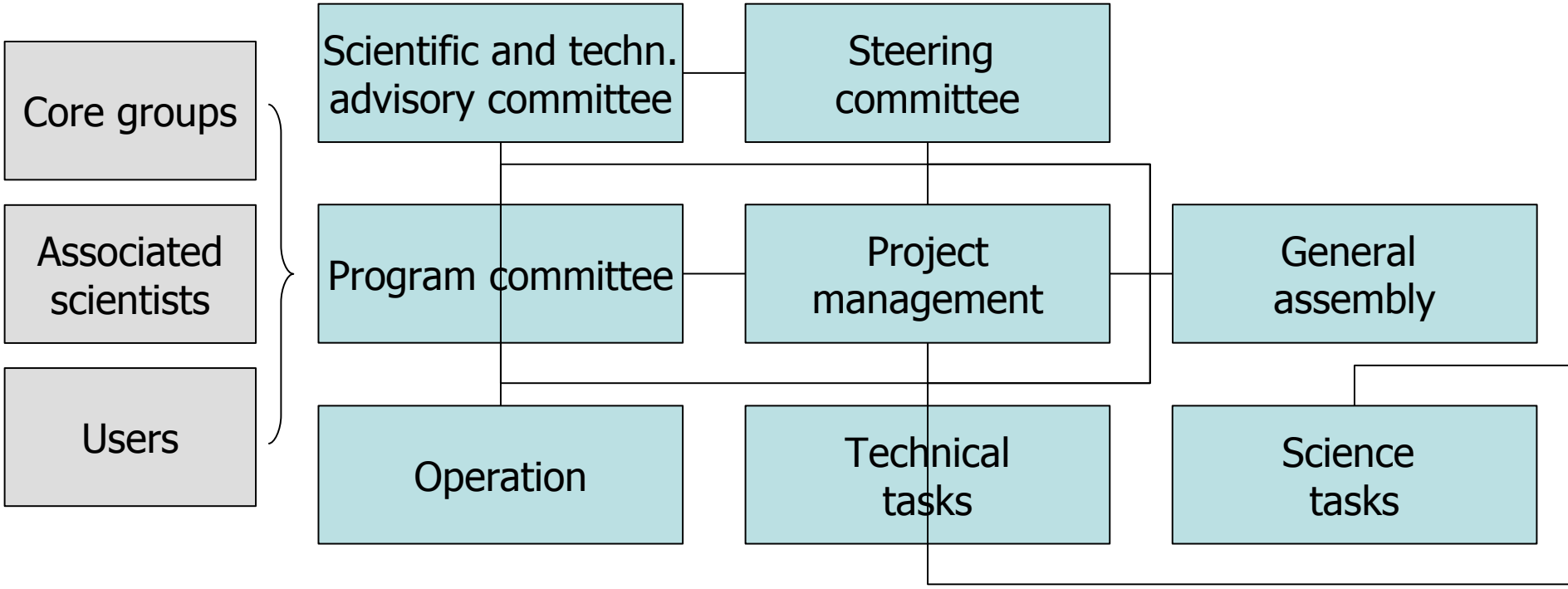
- Facility with mix of open and guaranteed time
- Public data (after grace period)



To be defined: organisational form / host organisation

Next steps

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- Project will receive high priority in upcoming APPEC roadmap
- Strong support by MPG, CNRS,…
- Plan to apply for FP7 design study
- In parallel, continue
  - site exploration
  - simulations & design optimization
  - technical developments
  - tests with existing instruments
  - funding discussion
- Next goals: conceptual & technical design