



LHAASO: Science goals and expected performances



Tiina Suomijärvi

Institut de Physique Nucléaire

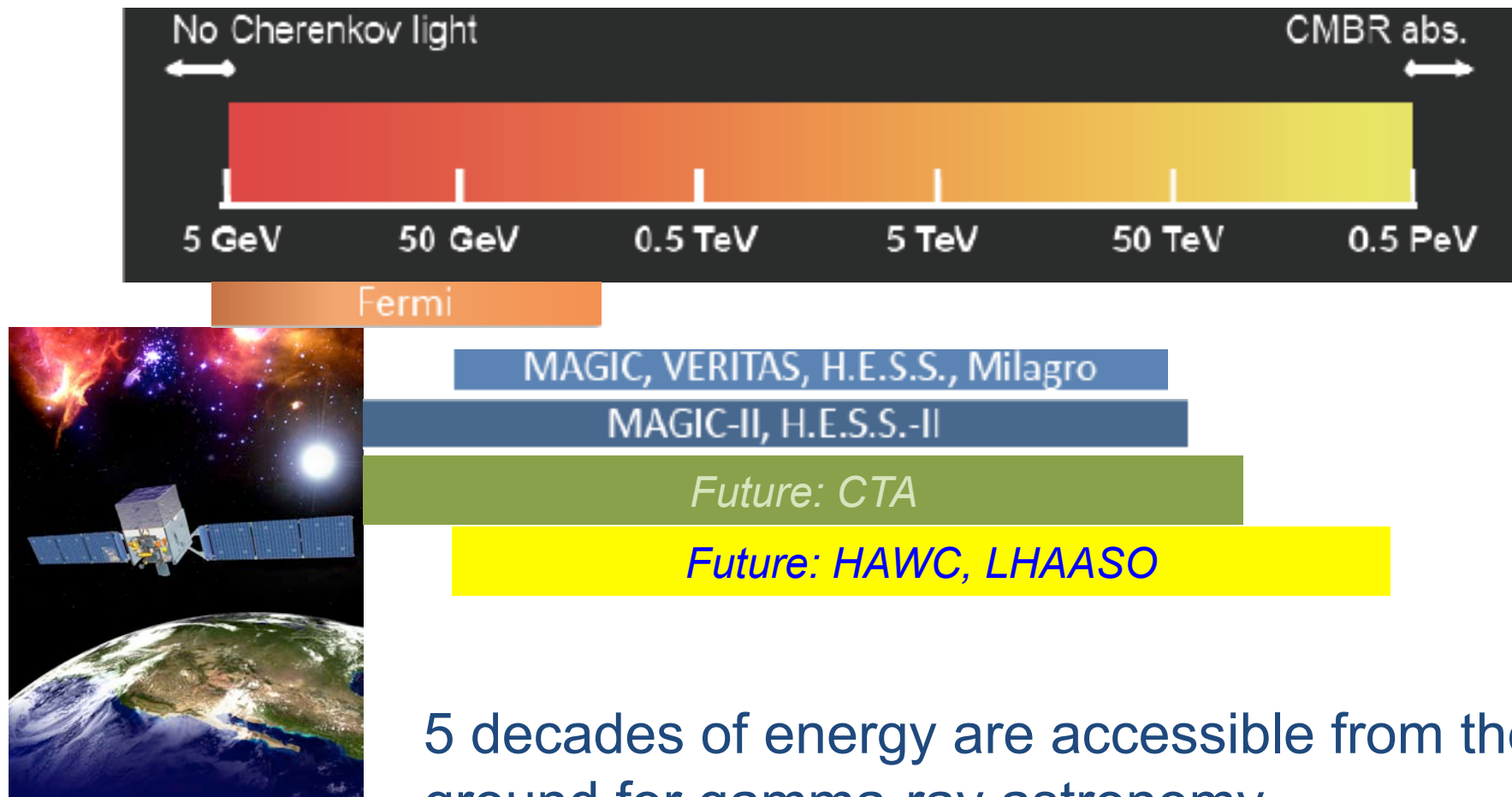
Université Paris Sud, Orsay, IN2P3/CNRS, France

FCCPL, 8-10 April 2014

Outline

- Gamma observations
- LHAASO science
- LHAASO observatory and site
- IPNO and OMEGA contributions
- Conclusions

Gamma observations



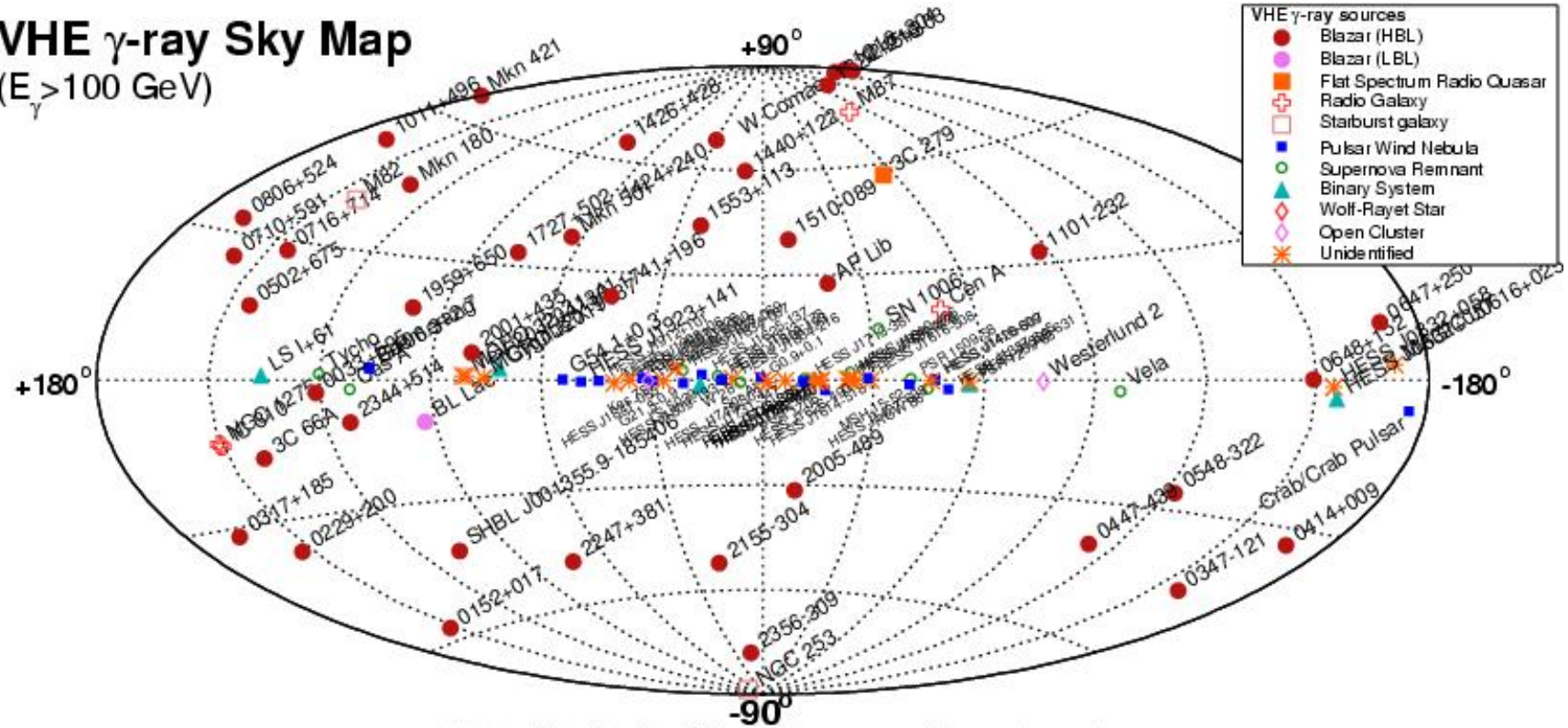
5 decades of energy are accessible from the ground for gamma-ray astronomy.

~ 1 decade of overlap possible with satellites.

TeV gamma sky

VHE γ -ray Sky Map

($E_\gamma > 100$ GeV)



2011-11-20 - Up-to-date plot available at <http://www.mpp.mpg.de/~rwagner/sources/>

- At TeV energies ~120 sources discovered
- Counterpart of accelerated electrons: inverse Compton scattering, Bremsstrahlung
- Is there a counterpart of accelerated hadrons?
- Crucial to get more sources (spectral index, cut-off above 100 TeV?...)
- Study of transient sources: full duty cycle and wide FOV measurements

Comparison

Imaging Atmospheric Cherenkov Telescopes (IACT)

- HESS, MAGIC, VERITAS
Future: CTA
 - Good hadron-gamma separation
 - Good spatial resolution (0.1°)
- BUT
- Low duty cycle
 - Limited field of view (4°)



H.E.S.S.

Ground detection of gamma-ray showers

- MILAGRO, ARGO, HAWC
Future: LHAASO
 - High duty cycle
 - Large field of view
- BUT
- Poorer hadron-gamma separation

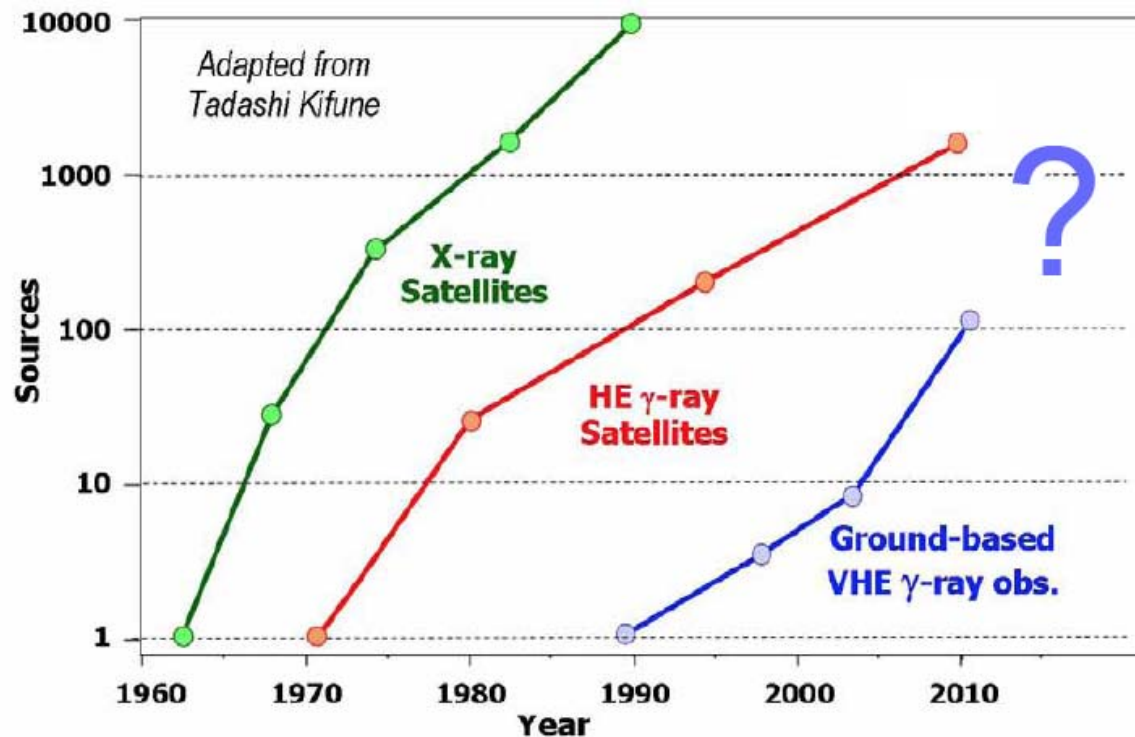


HAWC

LHAASO science: Gamma survey

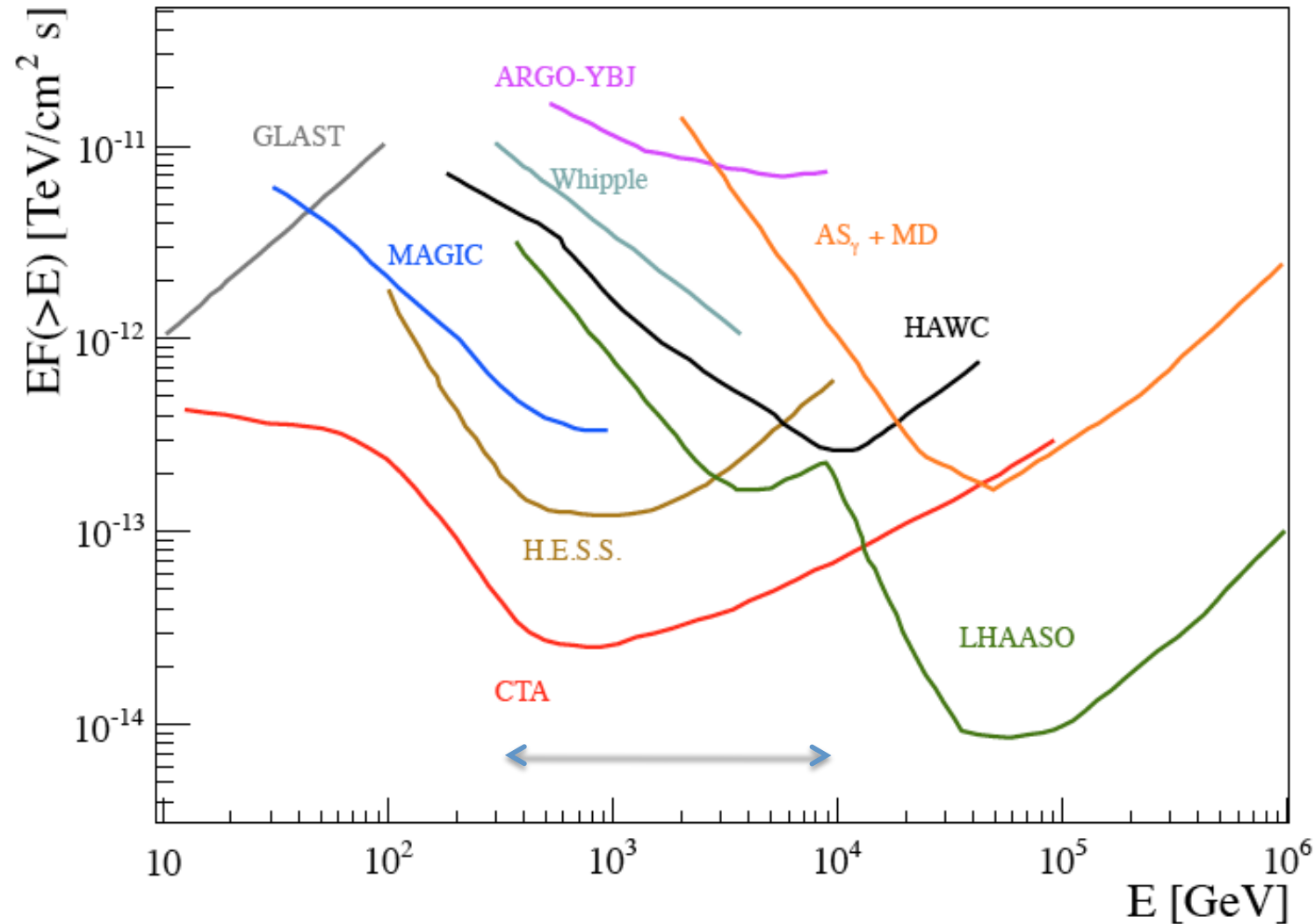
Survey of the gamma sky above 100 GeV

- Observation of transient sources
- Study cosmic accelerators and high-energy phenomena



Few hundred
new sources
are expected
for LHAASO.

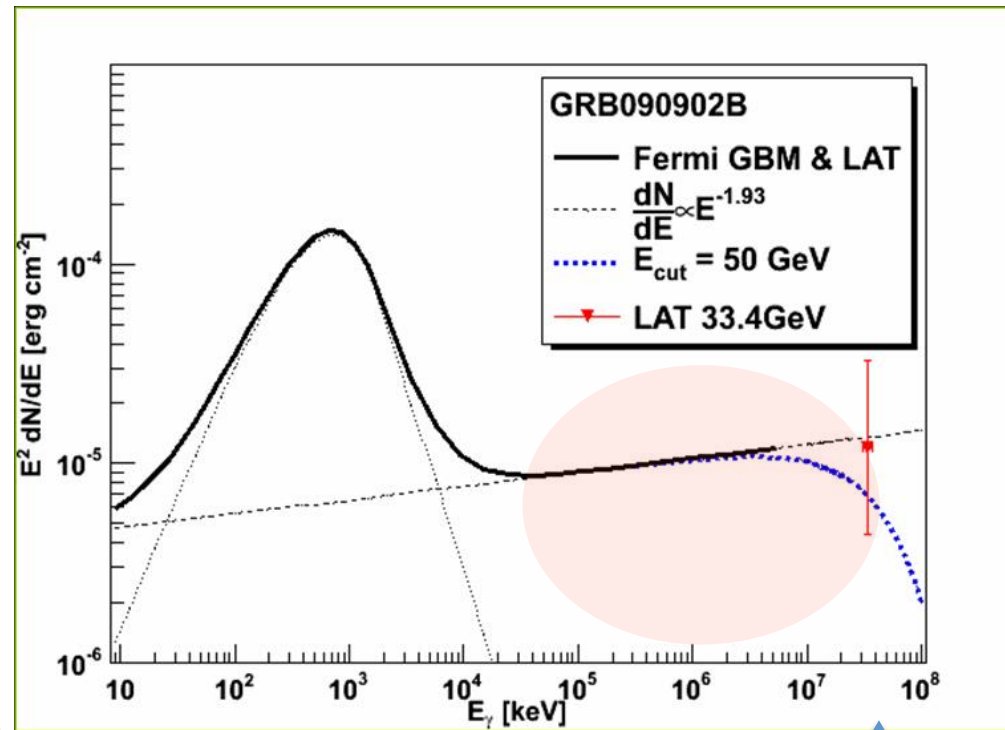
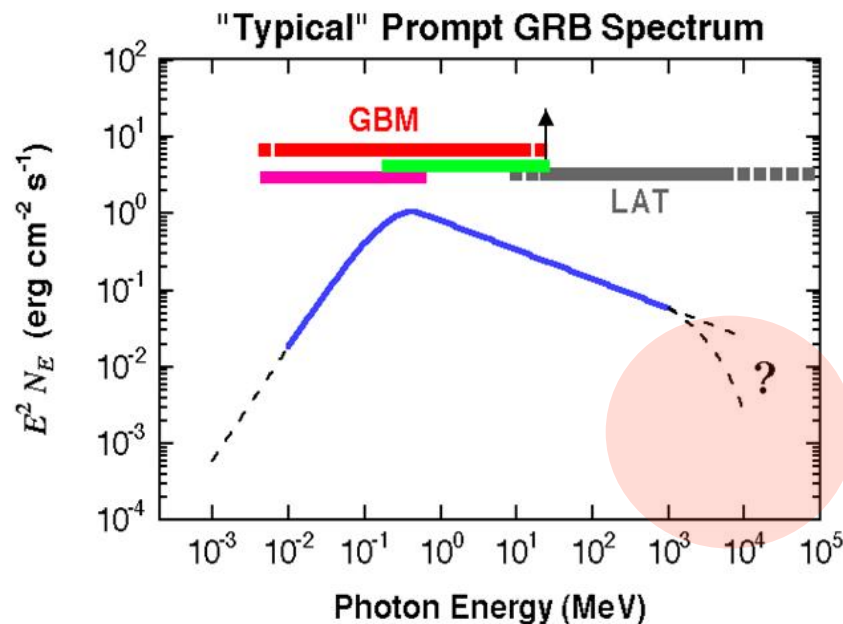
LHAASO sensitivity for gamma survey



Calculation is based on a one-year observation of the Crab for detection at 5σ level.

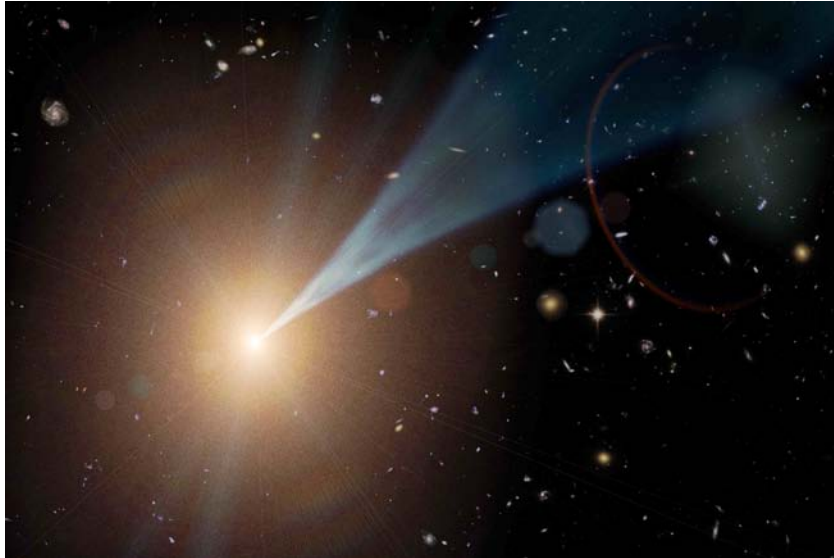
Survey of GRBs

Measurement of the highest energy gamma rays is necessary to understand GRB acceleration processes and energy budget.



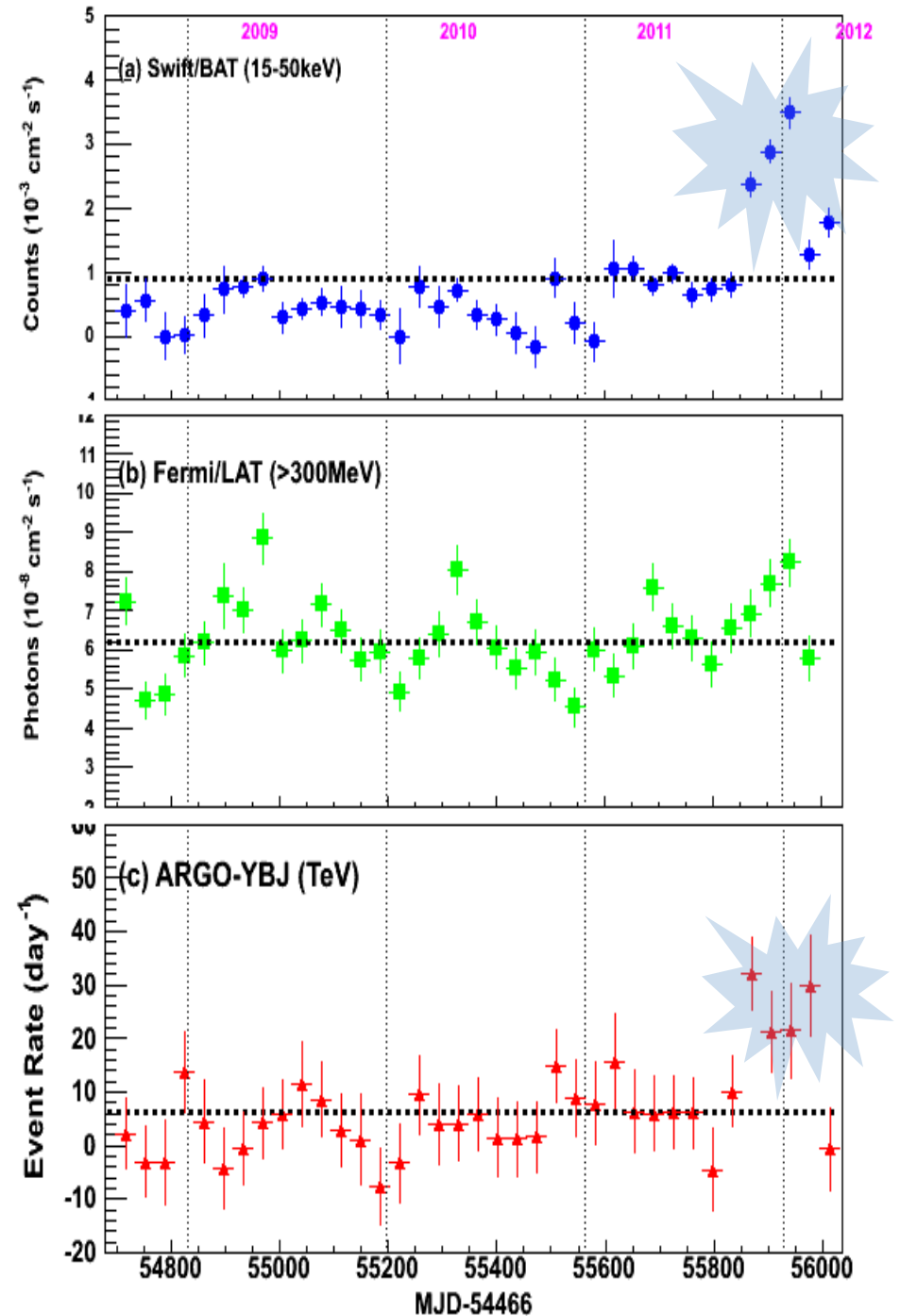
33.4 GeV

Survey of transient AGNs



Transient AGNs : Mrk421

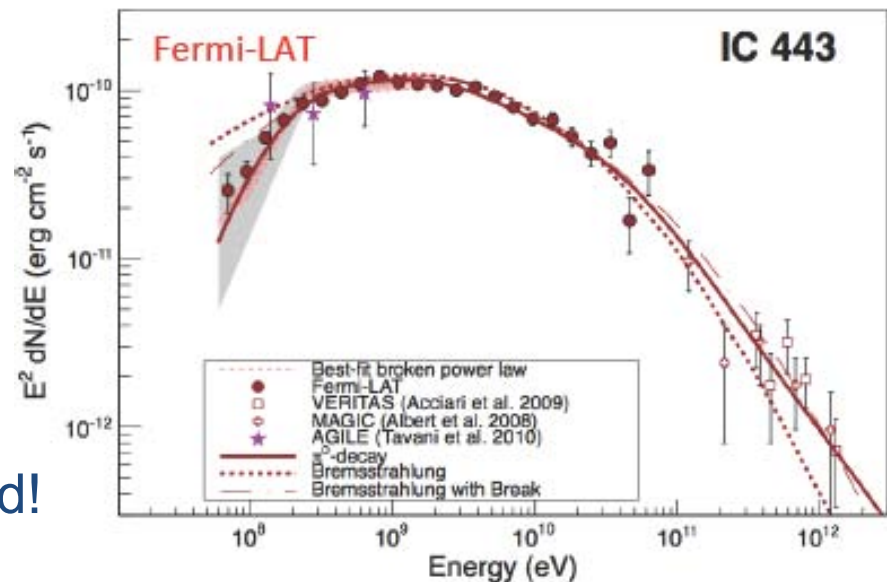
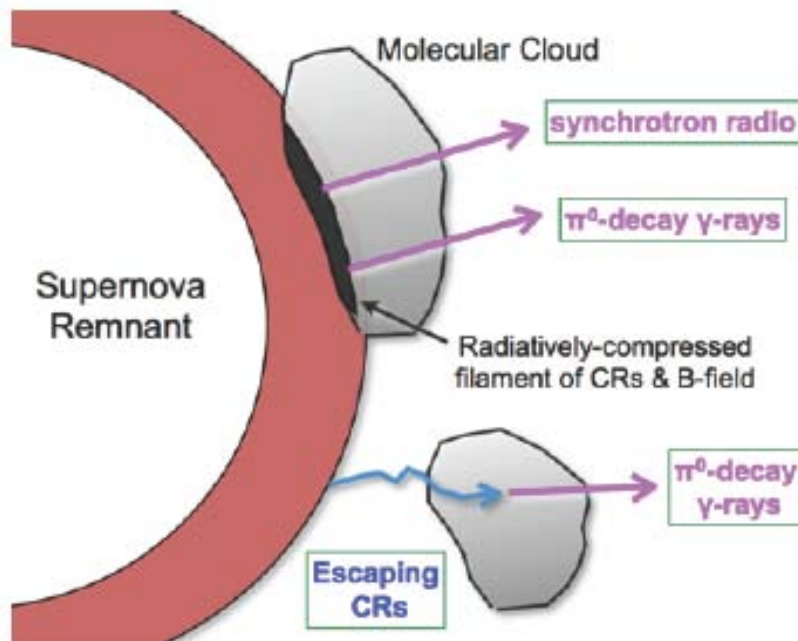
Markarian 421 is a blazar located in the constellation Ursa Major.



LHAASO science: Cosmic-ray origin

Search for cosmic-ray origin among galactic gamma-ray sources

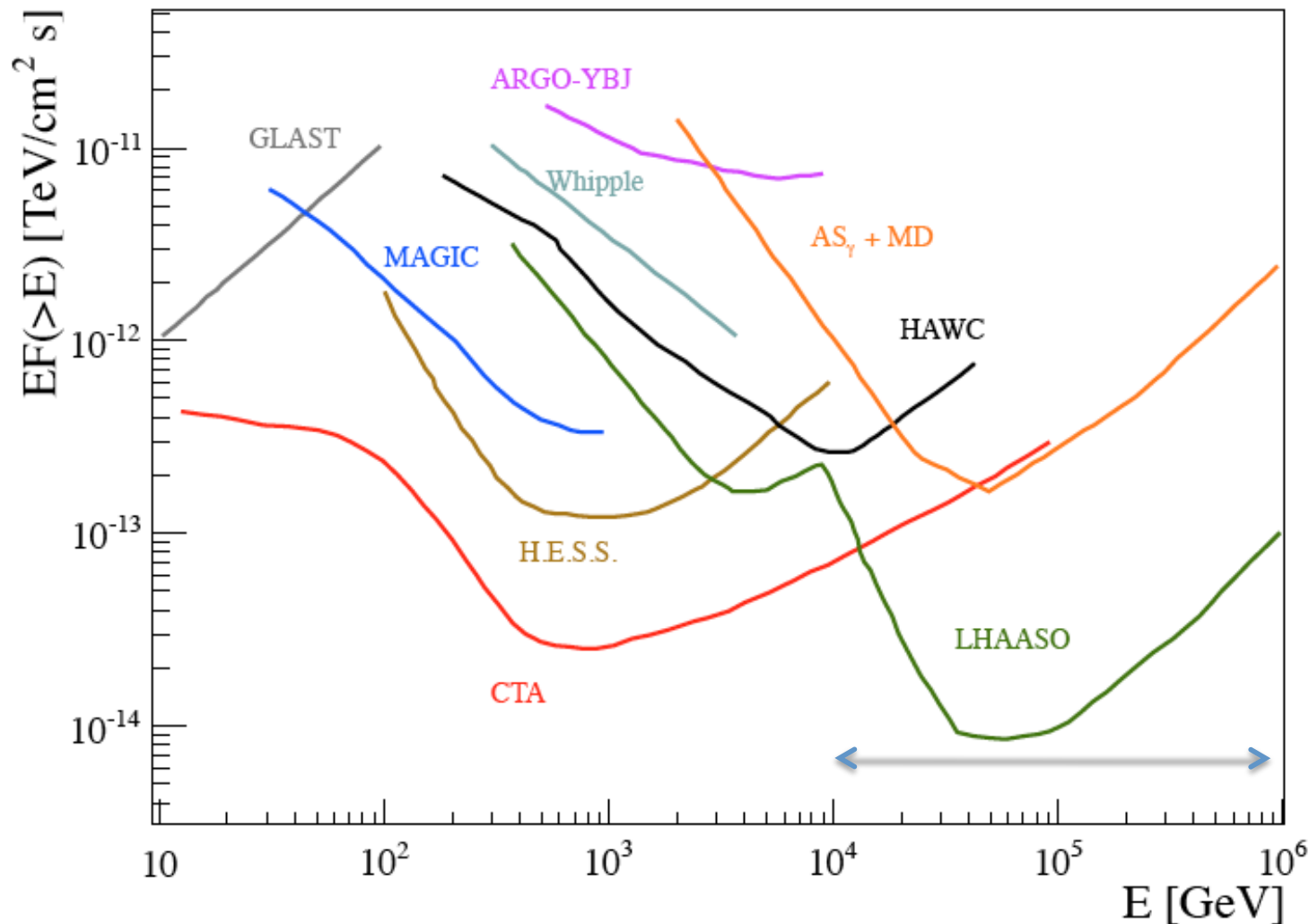
Possible scenario: Interaction of accelerated protons (or other hadrons) with target (molecular cloud).



Ackermann et al., 2013

Very high energy gamma rays are emitted!

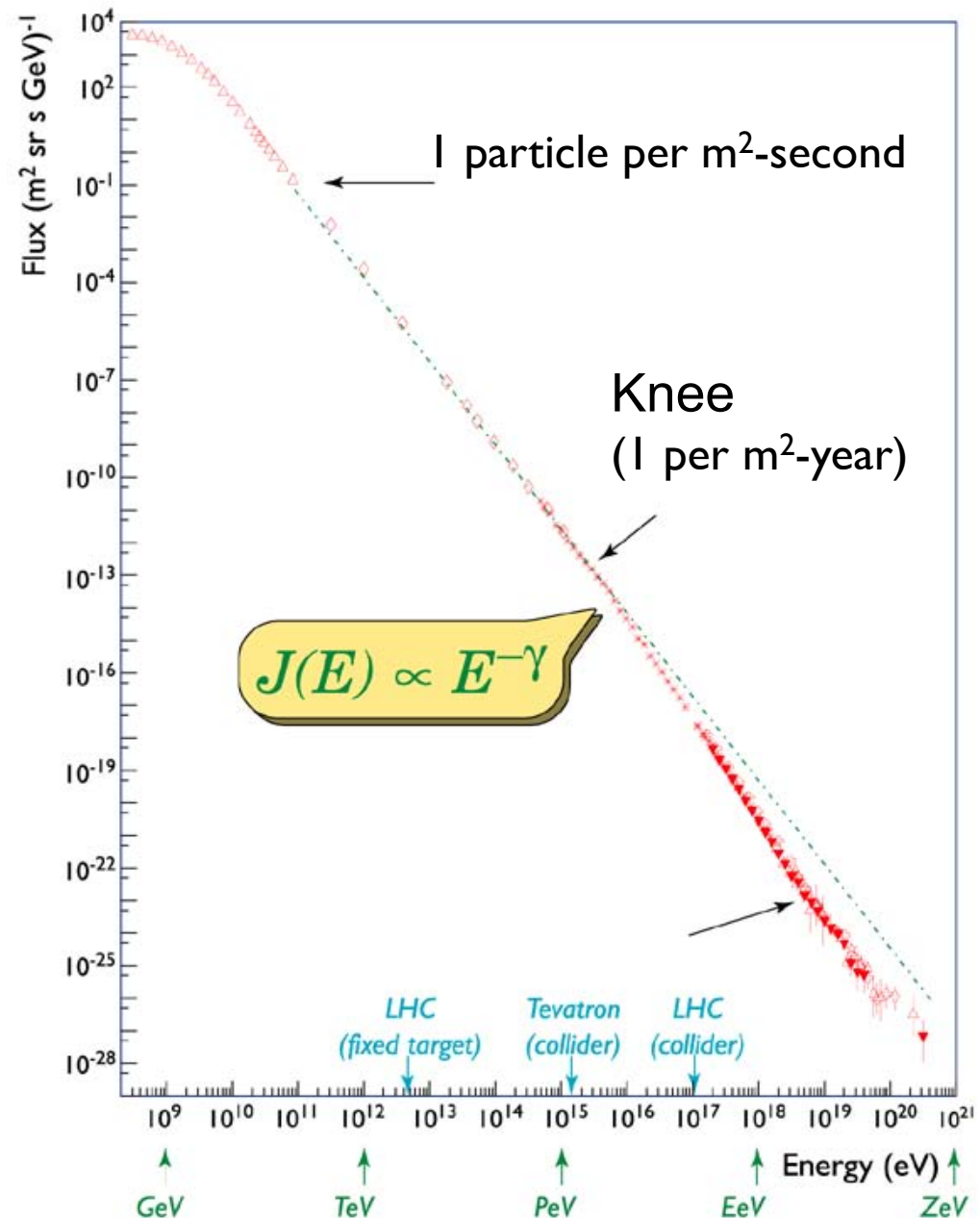
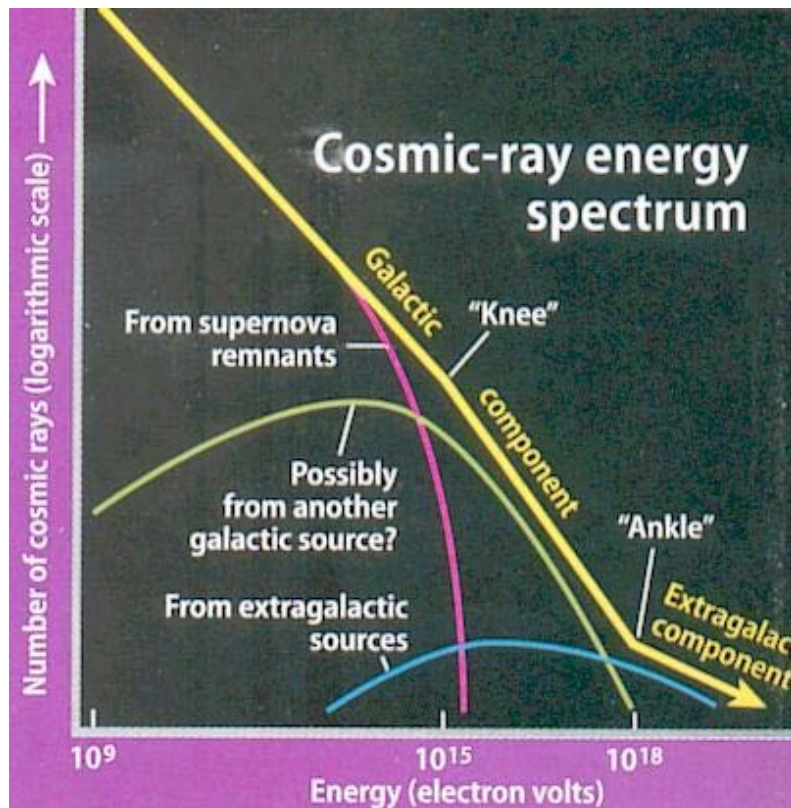
LHAASO sensitivity at the highest energies



LHAASO will be the most sensitive detector for 10 TeV gamma sky!

LHAASO science: Cosmic rays

Measurement of
cosmic rays above
30 TeV (see talk of
Zhen Cao)



Experimental strategy

- Gamma-ray source survey: Water Cherenkov Detector Array (WCDA) with a total active area of $90\,000\text{m}^2$
- High-energy end of the gamma spectra: Particle detector array with an effective area of 1km^2 (KM2A) including an array of 1200 muon detectors (MD) with $940\,000\text{m}^2$ active area and an array of 6000 scintillators (ED).
- Cosmic-ray spectra and composition: 24 wide FOV Cherenkov telescope array (WFCTA) and high threshold core detector array (SCDA) with an effective area of 5000m^2
Accurate measurement of composition by combining information from KM2A.

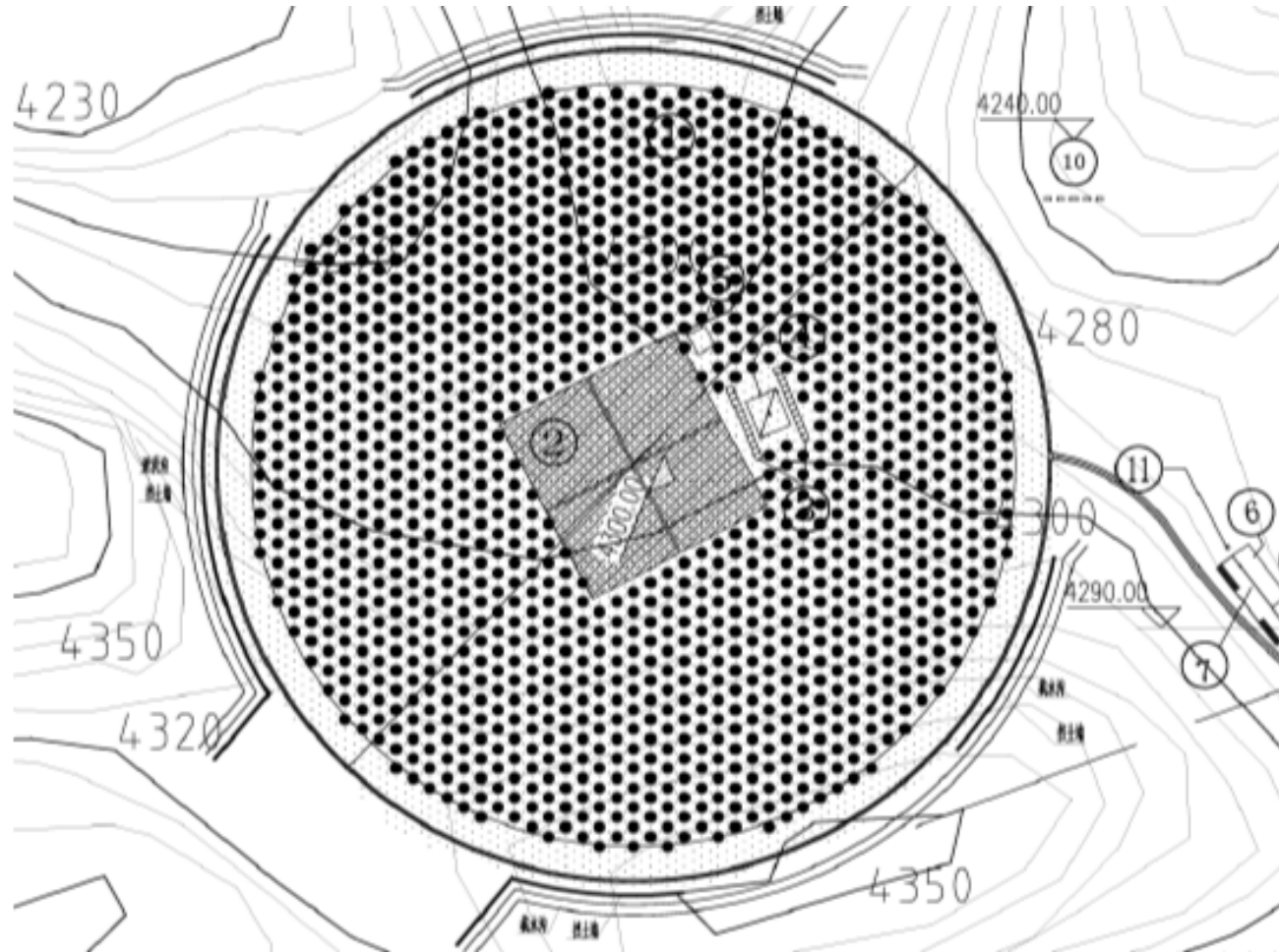
The LHAASO observatory

90k square meter
Water Cherenkov
Detector array (WCDA).

24 Wide FOV air
Cherenkov image
Telescopes (FWCTA).

6100 scintillator
Detectors and 1200
 μ -detectors form an
array covering 1 km²
(KM2)

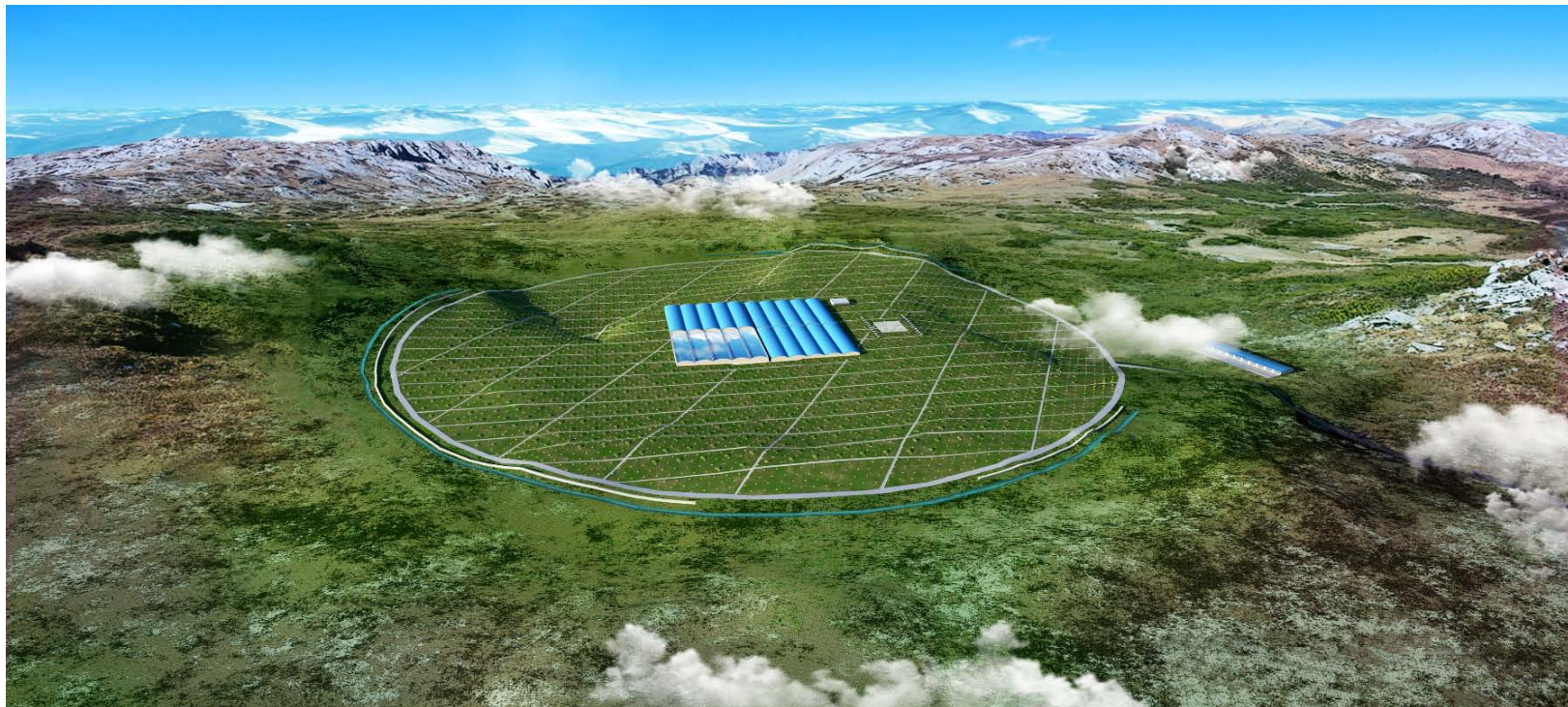
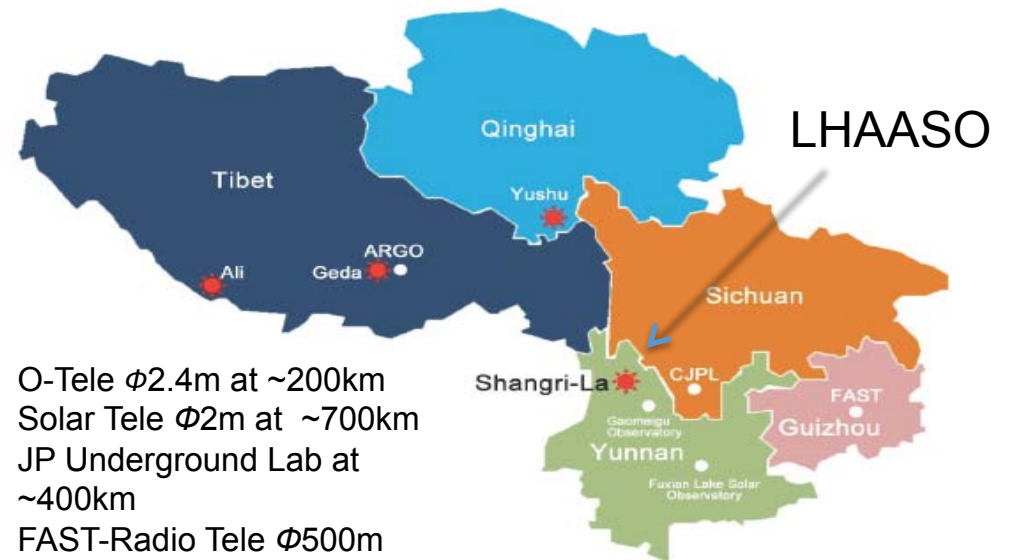
Core detector array
for high energy
secondary particles
near the core of air
showers (SCDA)



LHAASO Layout in 1 km² at 4400m a.s.l.

LHAASO site

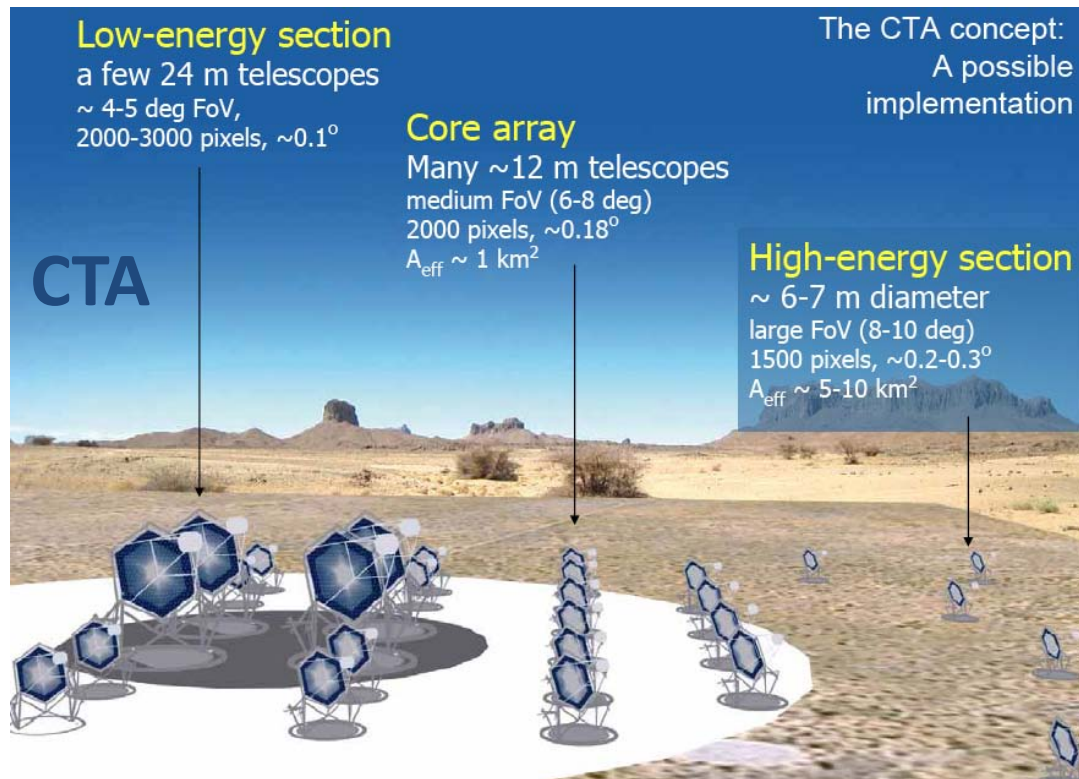
Sichuan province
4400 m a.s.l.



Status of LHAASO

- LHAASO has been included in the roadmap of the infrastructure construction for basic science in a short term (5 years). Total 16 projects are included.
- The Sichuan province government has approved the LHAASO site.
- Technology that used in LHAASO are currently tested with engineering arrays at scales of 1%-10% of the full project.
- Steps ahead: environment impact evaluation, feasibility reviewing, TDR reviewing

LHAASO complementary to CTA and HAWC



HAWC

Mexico, 4200m a.s.l.



LHAASO:

- Continuous, wide field of view survey
- Study of extended sources
- Higher energies than CTA (CR origin)
- Source variability monitoring

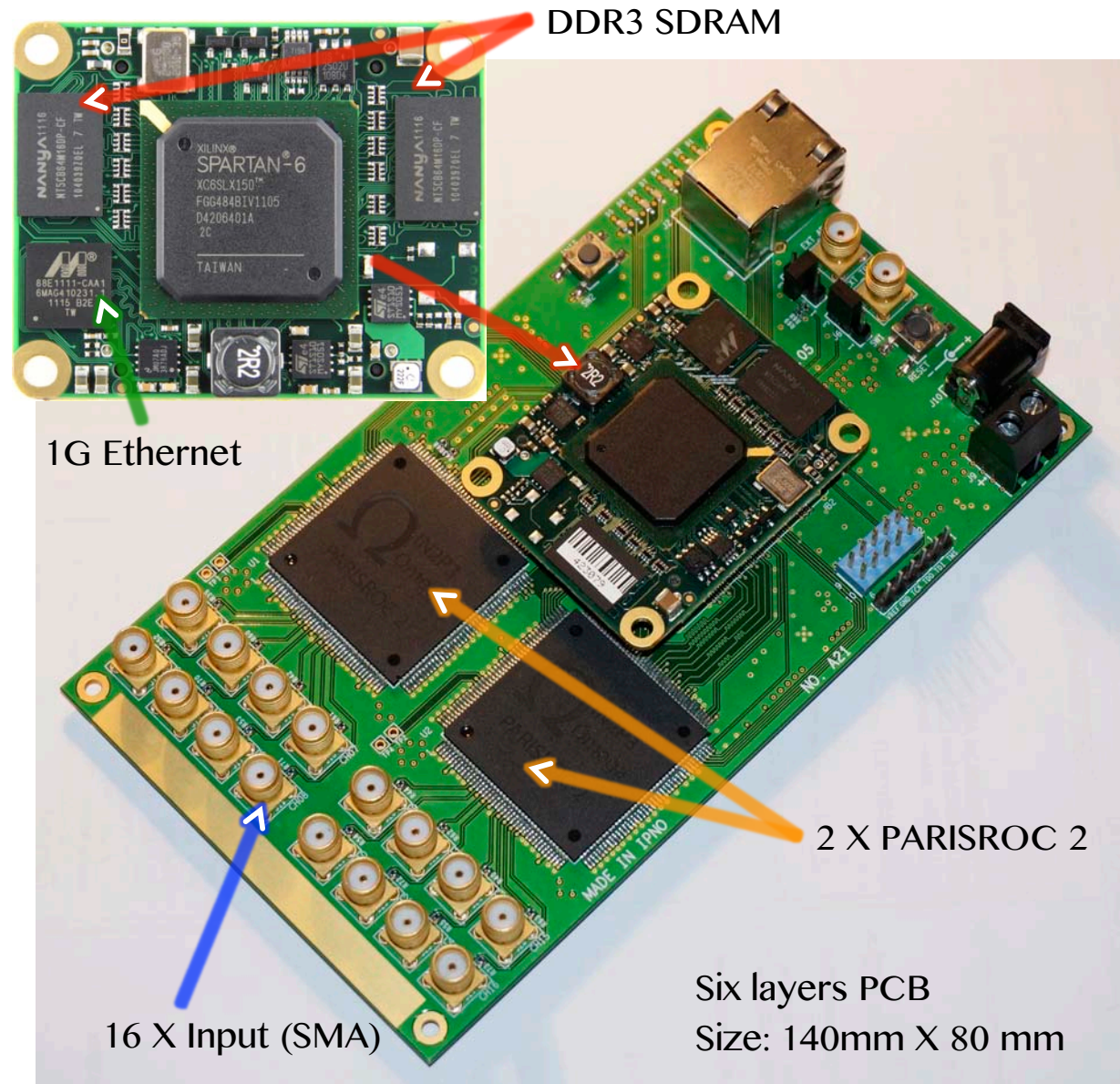
CTA:

- Detailed source morphology studies

HAWC and LHAASO are at about the same latitude (28°N) but opposite sides of the globe. Together they provide continuous survey of the Northern hemisphere !

IPNO and OMEGA contributions

- Development of FEE (see talk of Yingtao Chen)
- Collaboration: IPNO-OMEGA-IHEP
- Simulations



Collaboration

- **Physicists (IPN-Orsay)**

- **Yingtao Chen (PhD student funded by CSC)**, Olivier Deligny, Isabelle Lhenry-Yvon, Tiina Suomijärvi, Francesco Salamida (post-doc), Diane Martraire (PhD student)
- New PhD student, Zizhao Zong, currently applying funds from CSC

- **Technical group**

- Valérie Chambert, Bengyun Ky, Emmanuel Raully, Thi Nguyen Trung, Eric Wanlin (IPN-Orsay)
- Gisèle Martin-Chassard, Frederic Dulucq, Christophe de la Taille (OMEGA)
- Collaboration with the Chinese LHAASO groups, in particular with the group of Zhen Cao from IHEP.

Funding in 2014

- 1.1 M CNY obtained from CAS for the collaboration
- T. Suomijärvi invited by CAS as visiting professor for 2 months in IHEP

Request from FCCPL:

- For the French groups:
 - LHAASO collaboration meeting in China: $4 \times 1500\text{€} = 6000\text{€}$
 - Discussions on electronics in IHEP: $2 \times 1500\text{€} = 3000\text{€}$
- For the Chinese groups:
 - Discussion on electronics and simulations in Orsay: $2 \times 20000\text{ CNY} = 40000\text{ CNY}$
 - Discussion on relevant Physics topics in Orsay: $4 \times 20000\text{ CNY} = 80000\text{ CNY}$

Total = 120000 CNY

Conclusions

- New observatories coming on-line: CTA, HAWC and LHAASO
- LHAASO observatory
 - Unique at 10 TeV gamma monitoring
 - Window for evidence for hadronic origin of cosmic rays
 - Provides also crucial CR data around the knee region
- LHAASO has been selected for funding in China.
- R/D is in progress.
- Agreement with the Sichuan province for site has been obtained.
- IPNO and OMEGA:
 - R&D on ASIC electronics is well advanced.
 - Simulations are also in progress.