Astrofisica con Specchi a Tecnologia Replicante Italiana

cherenkov telescope array

Universidade de São Paulo
Instituto de Astronomia, Geofísica e Ciências Atmosféricas

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Credits:
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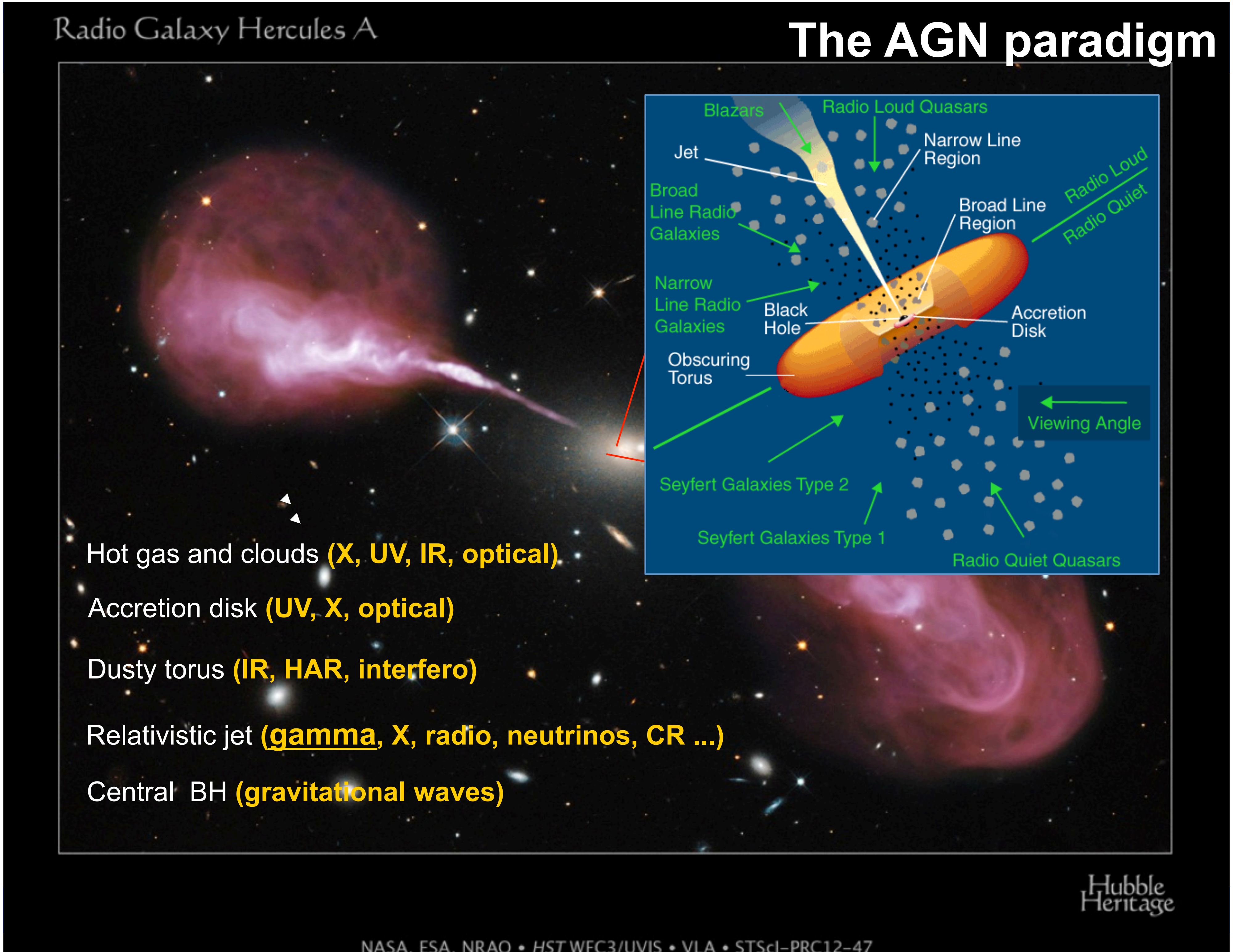
AGN prospects with CTA

Antonio Stamerra - INAF-Torino and SNS-Pisa

for the ASTRI Collaboration & the CTA Consortium

The AGN paradigm



Hot gas and clouds **(X, UV, IR, optical)**

Accretion disk **(UV, X, optical)**

Dusty torus **(IR, HAR, interfero)**

Relativistic jet **(gamma, X, radio, neutrinos, CR ...)**

Central BH **(gravitational waves)**

What are we looking for

The VHE view of AGNs

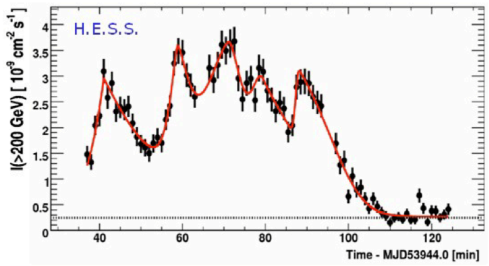
- Gamma-ray emission processes
- Jet physics (formation, magnetism, shocks,...)
- The environment: interaction between jet/disk/BLR/IR-torus
- LF of blazars; contribution to γ-ray diffuse emission
- Blazar sequence

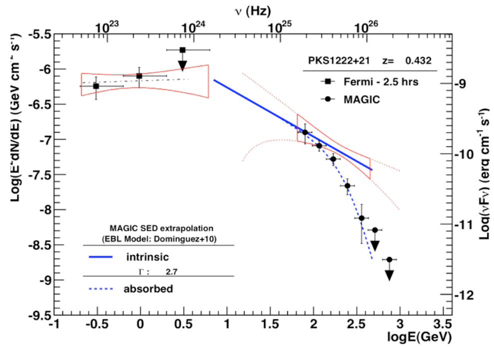
AGNs as cosmological probes

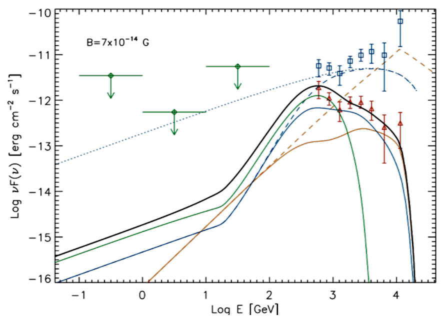
- EBL
- IGMF
- UHECR
- New Physics

Major discoveries from VHE observations

- ✦ Rapid variability ~min
  - shorter than BH dynamic scale
- ✦ GeV/TeV spectral breaks (or lack of...)
  - (no) BLR interaction
- ✦ Extreme blazars
  - weakly variable?
- ✦ Constraints on EBL
- ✦ EBL/IGMF relationship

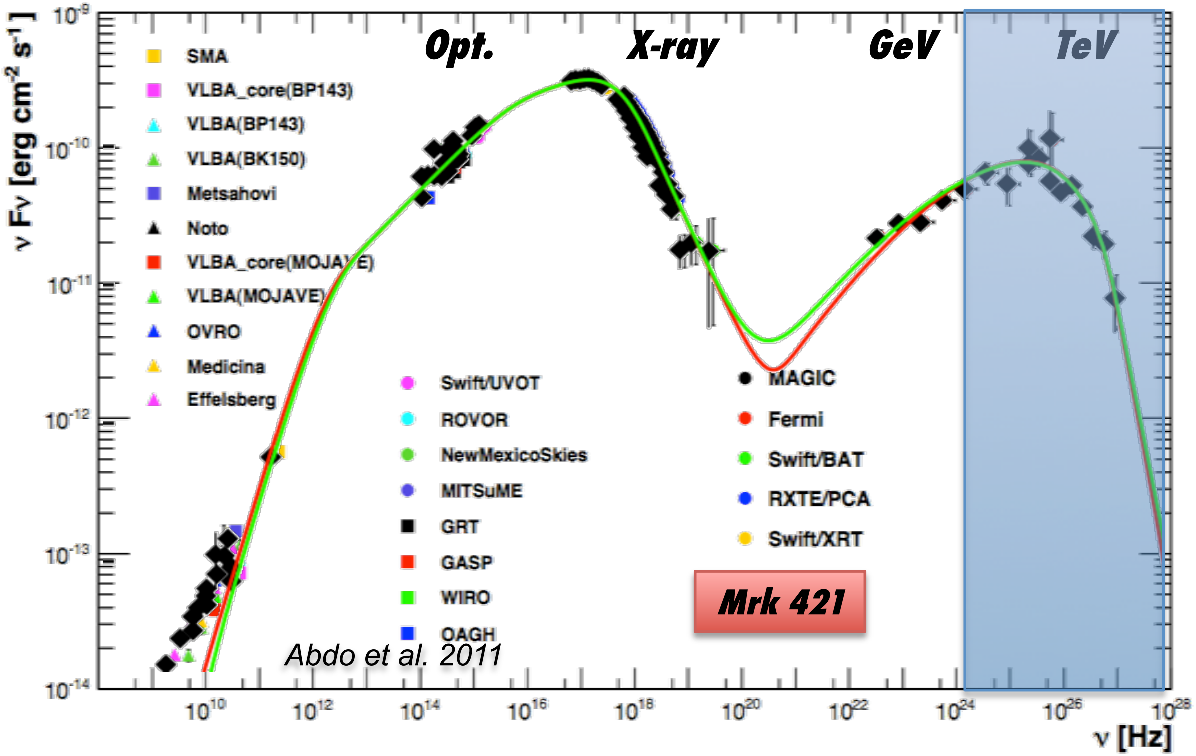






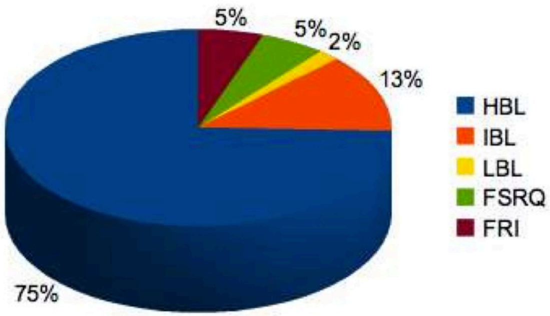
The tools

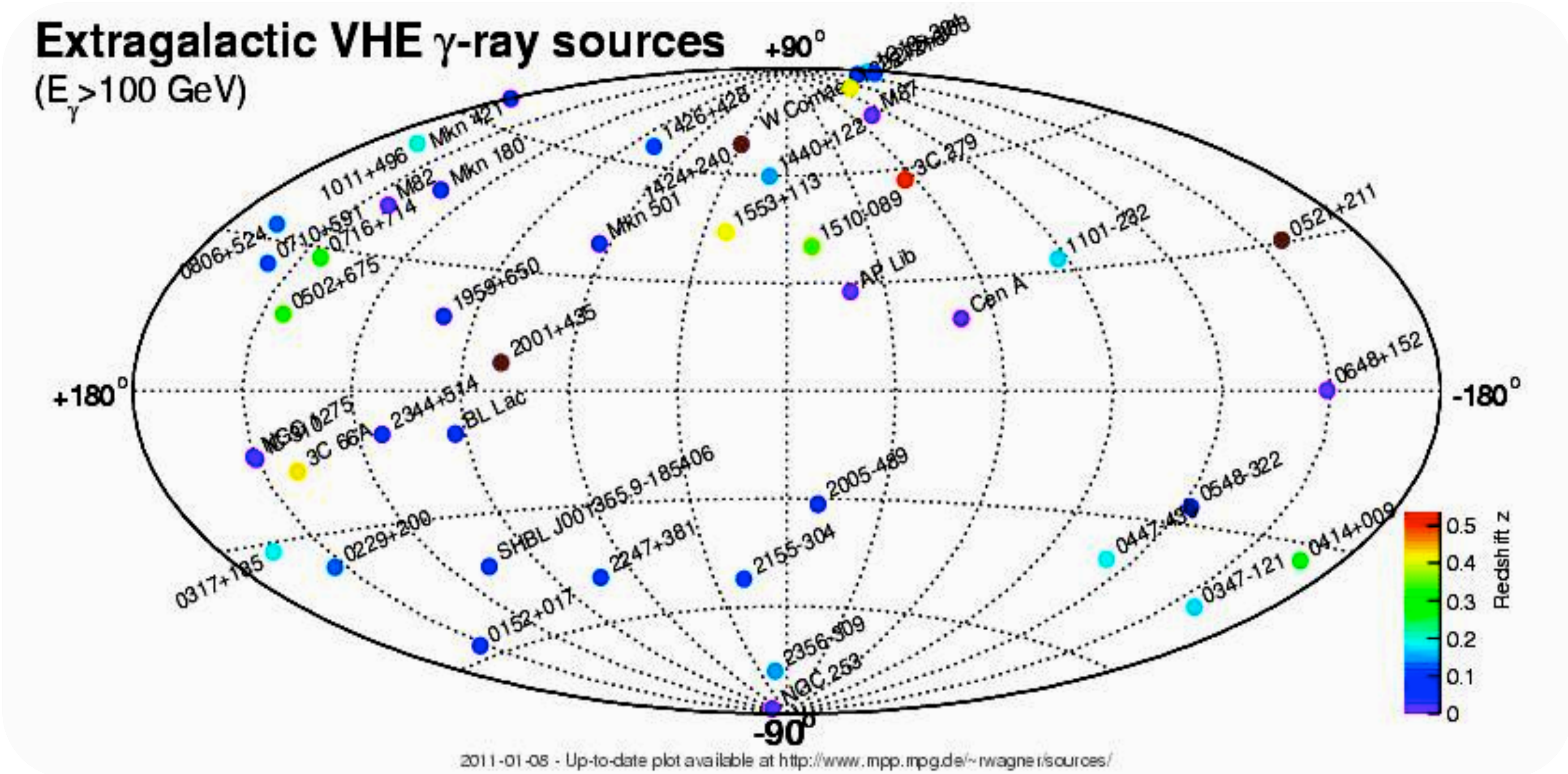
- ✦GeV/TeV spectra
- ✦Multi-wavelength SED
- ✦Multi-band correlations / lags
- ✦Variability



The VHE sky, today

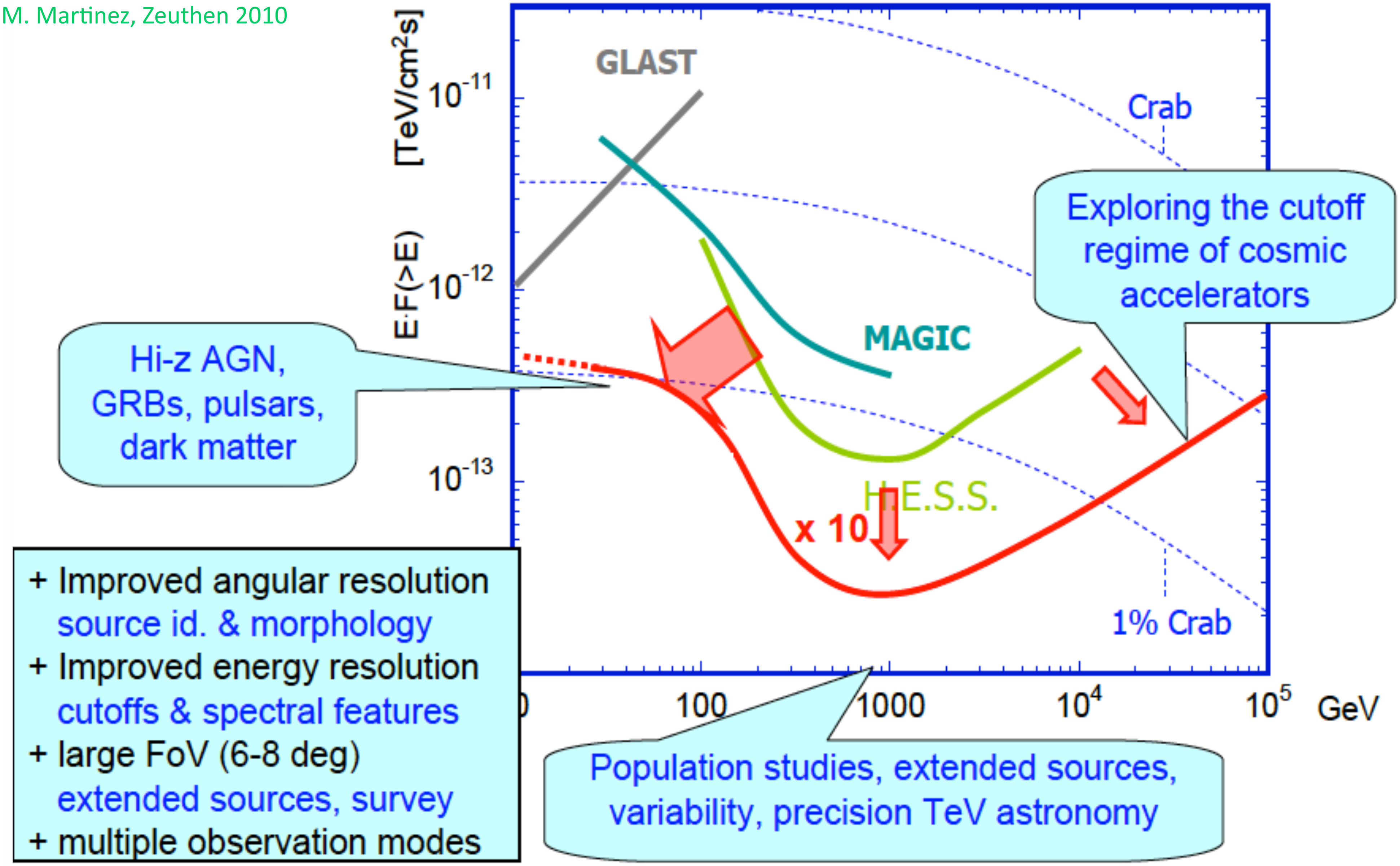
- ✦56 extragalactic sources
  - 41 HBL, 8 IBL/LBL, 4 FSRQ, 3 RG





CTA sensitivity

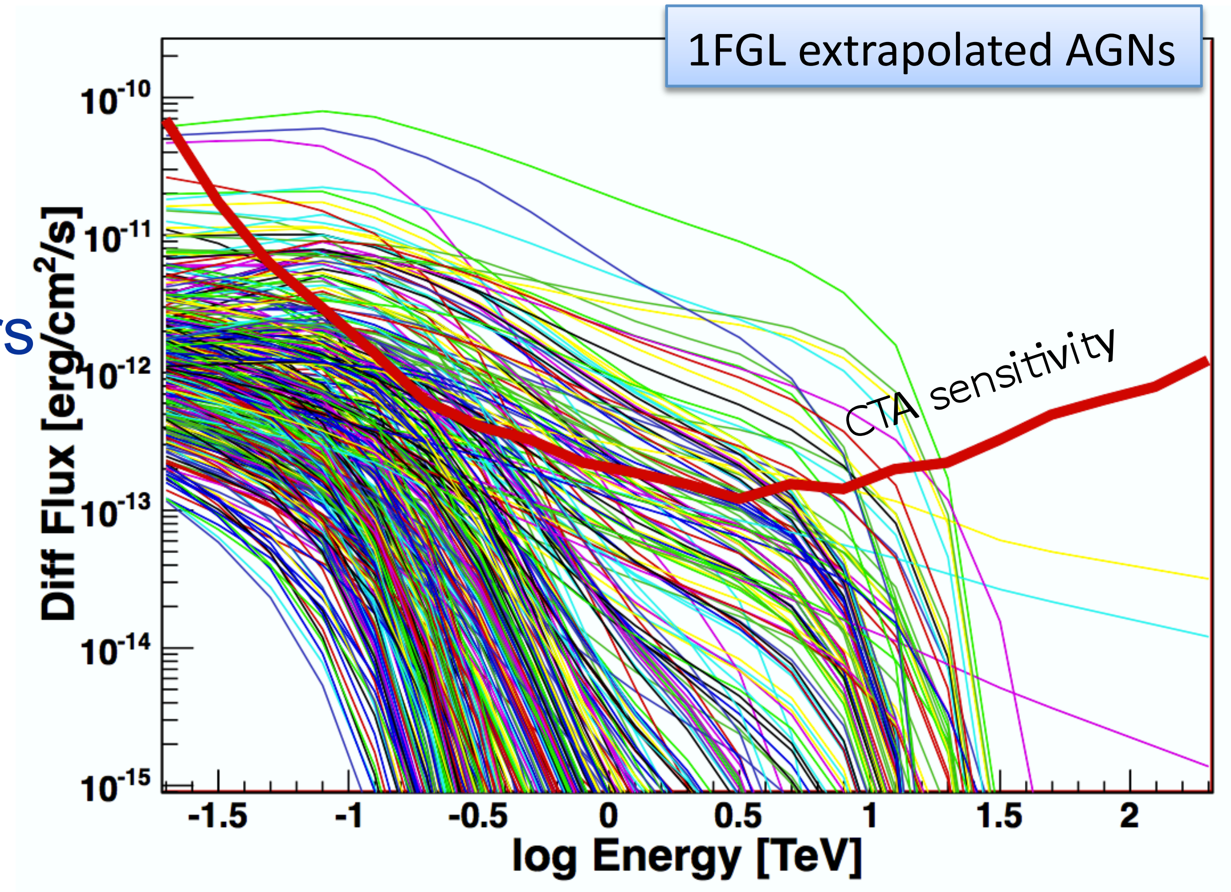
M. Martinez, Zeuthen 2010



New VHE AGNs

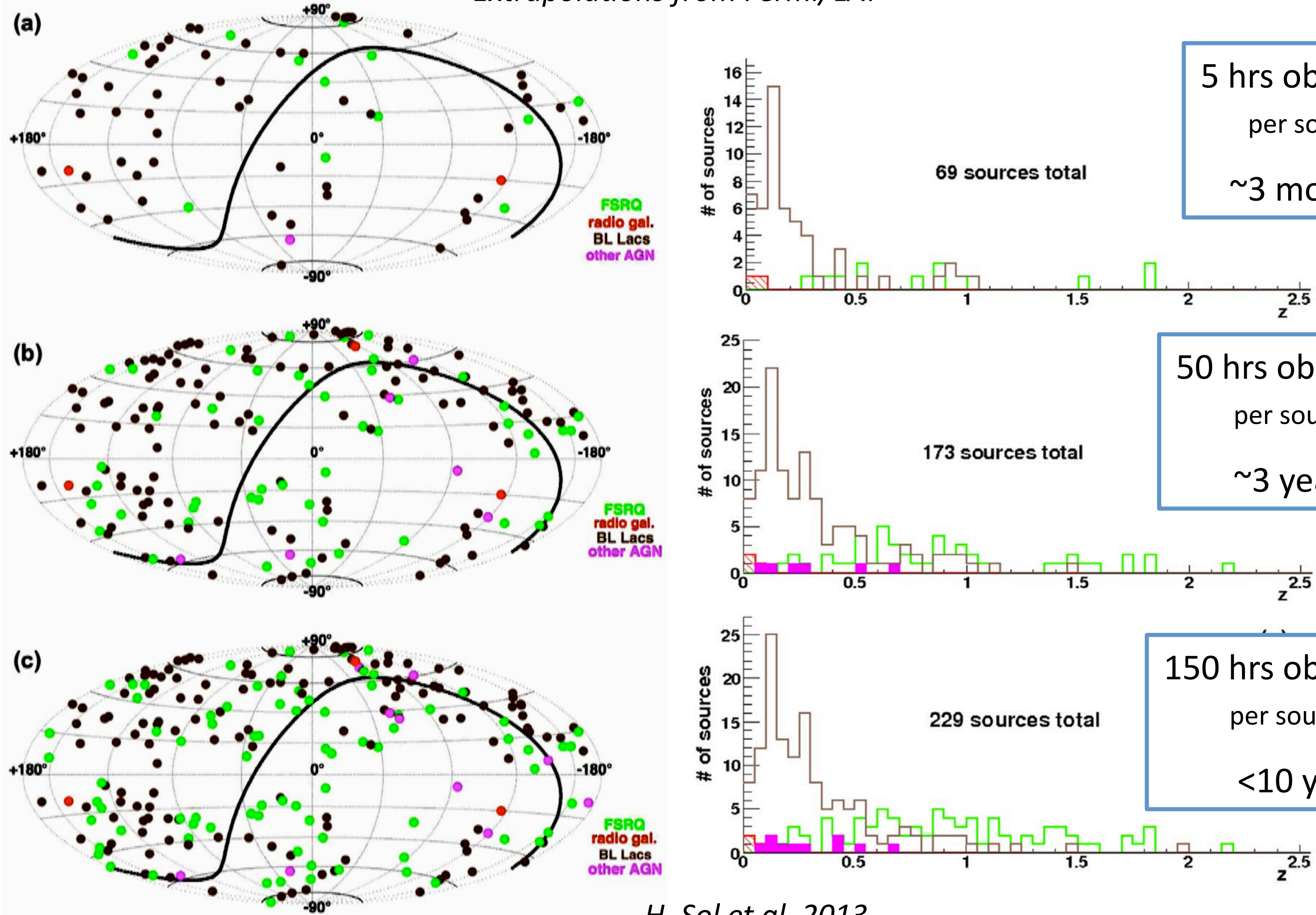
- Simple extrapolation from 1FGL/2FGL with EBL
- 120/400 AGN detectable in 50 hrs
- z_{max}~1.8

see also ***Sol et al. 2013***



New VHE AGNs

Extrapolations from Fermi/LAT



5 hrs obs. time per source ~3 months

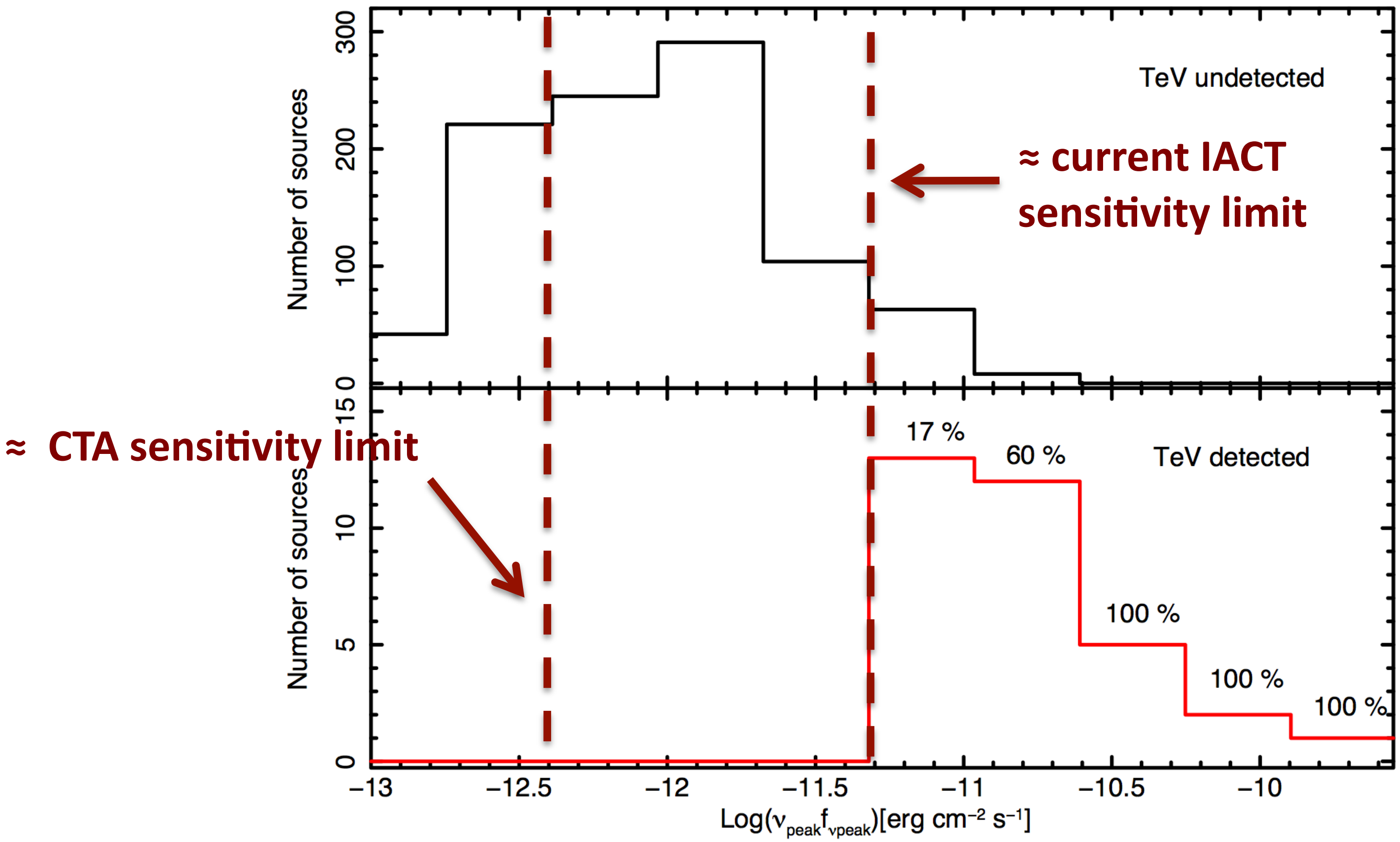
50 hrs obs. time per source ~3 years

150 hrs obs. time per source <10 yrs

H. Sol et al. 2013

New VHE AGNs

- WISE IR and X-ray data
  - FoM for TeV sources from synchrotron peak flux

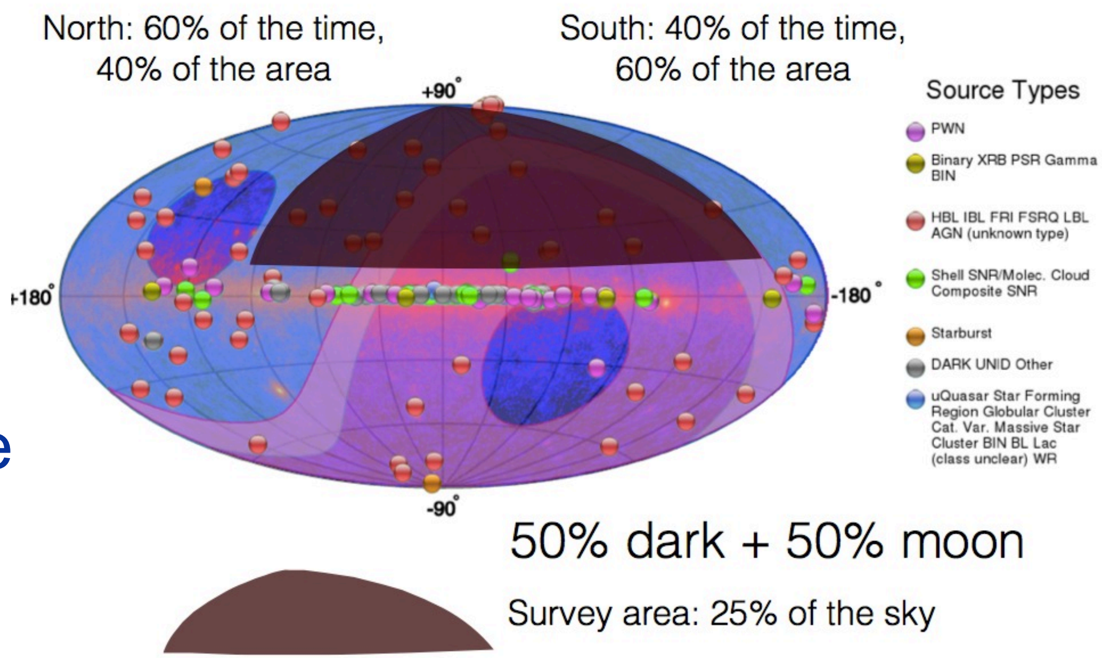


Arsioli, Fraga, Glommi et al. 2014

Extragalactic Survey

- Large FoV; ~2-3 hrs each obs. -> 6 mCrab; >100 GeV
- Possibility of a shallow survey on ¼ of the sky

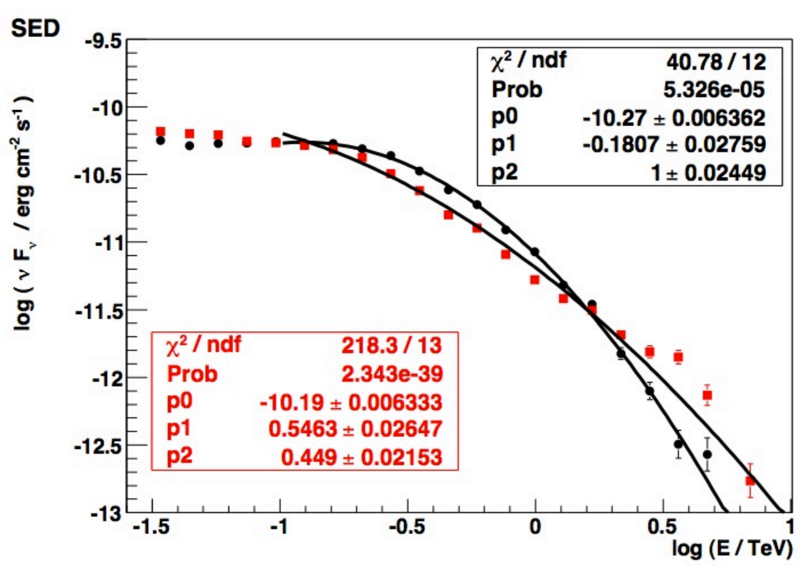
- CTA key-project
- Blazar LF
- Population studies
- Test of blazar sequence
- Dark accelerators

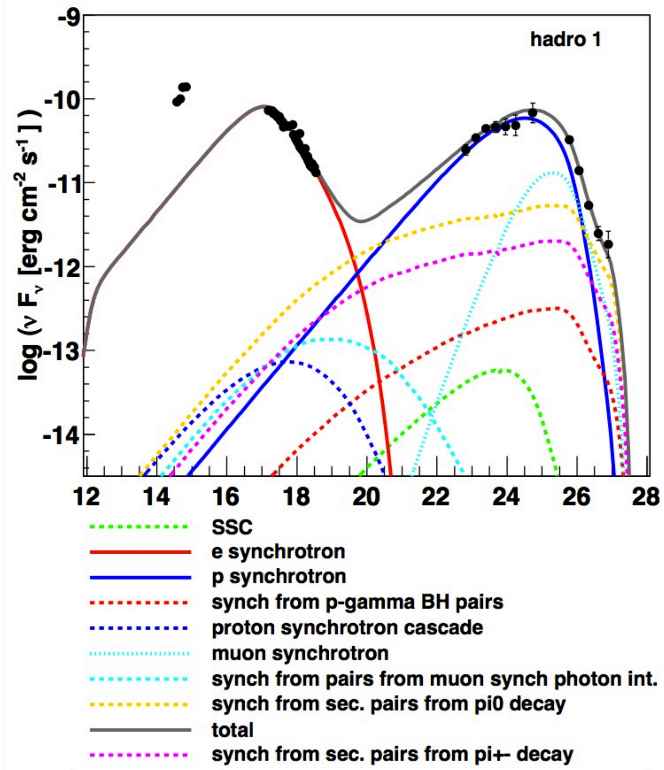


- Estimation from extrapolated LF and WISE/X-ray studies: ~70-150 sources.

γ-ray emission processes

- Discriminate between leptonic and hadronic emission processes
  - spectral features (bumps and flattening) are expected in hadronic processes

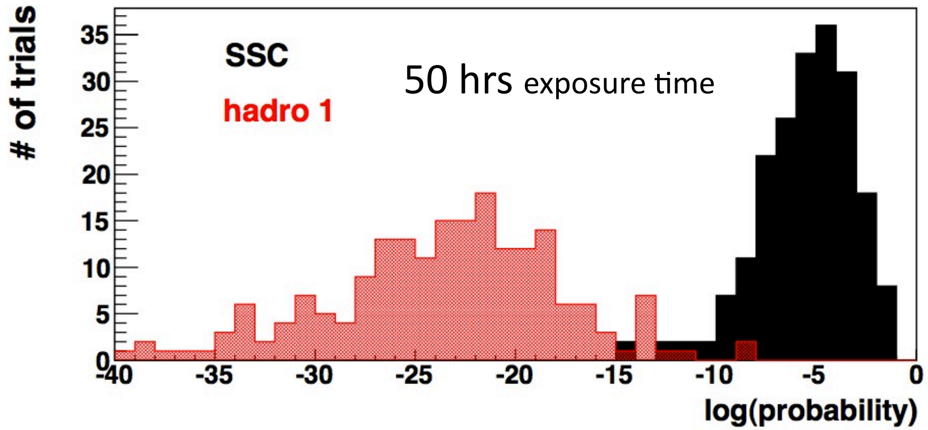


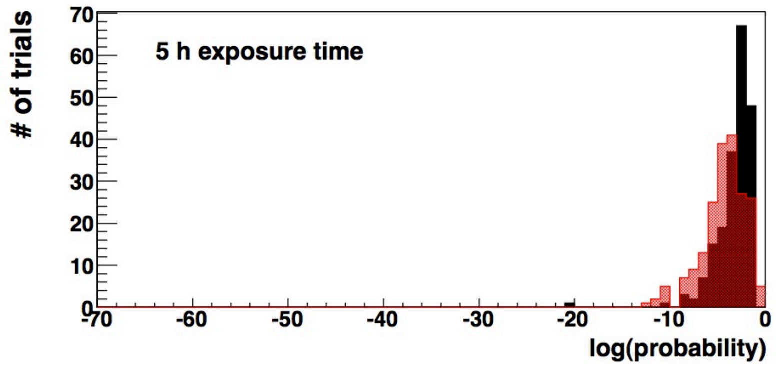


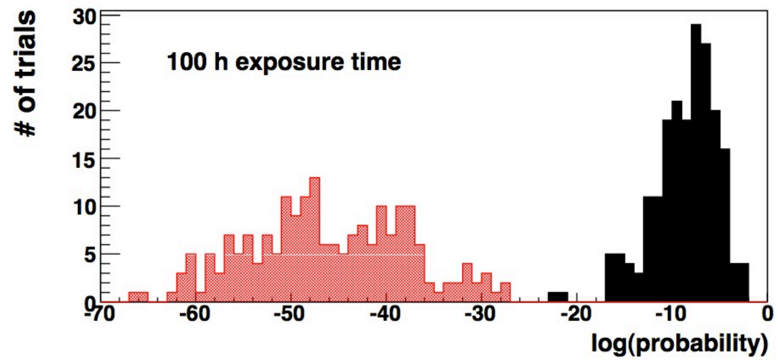
Zech & Cerruti 2013

γ-ray emission processes

- Discriminate between leptonic and hadronic emission processes
  - hadronic emission differs statistically from leptonic emission with a simple fit function, e.g. log-parabola
  - depends on the precision (uncertainty) on the spectrum, hence on the observation time





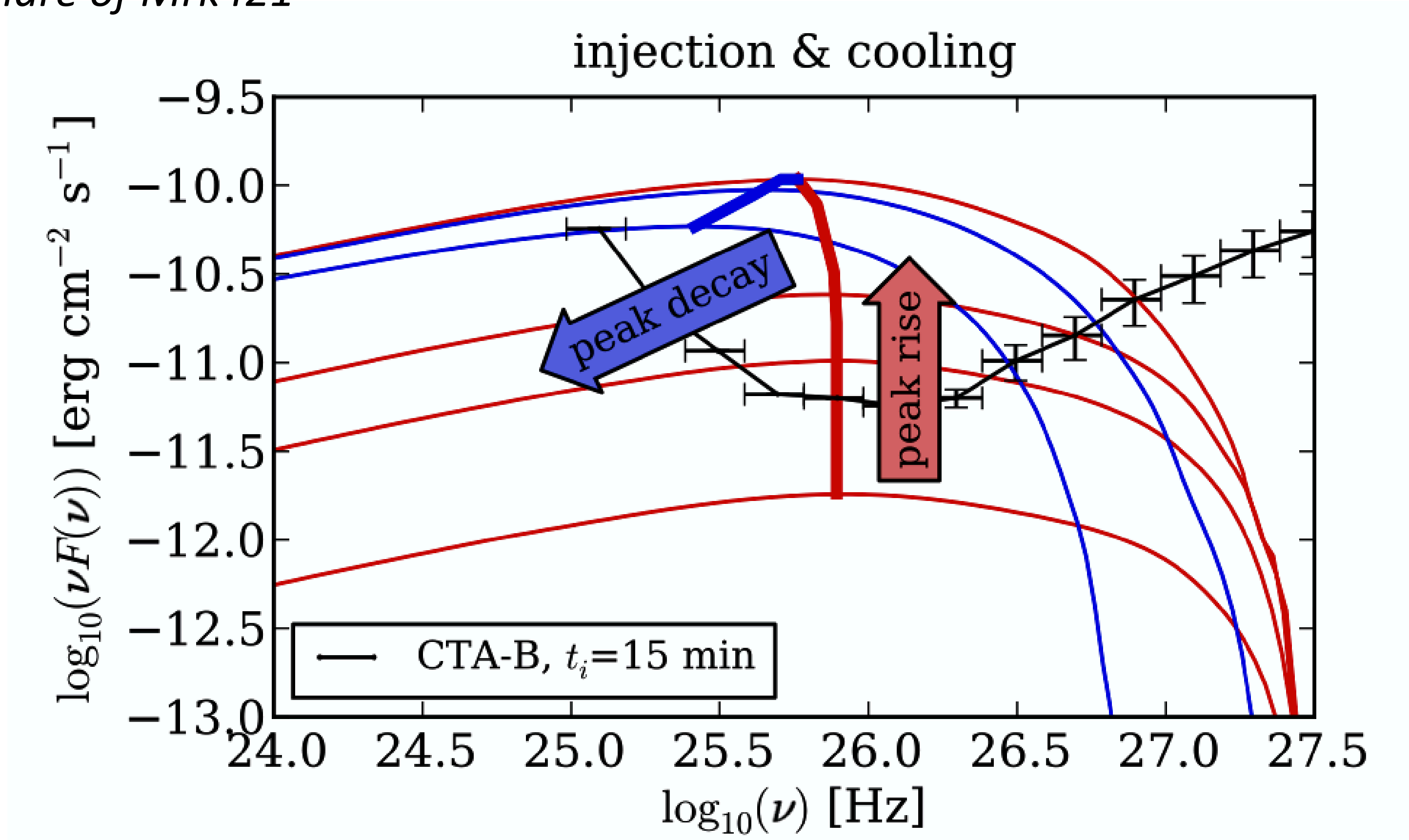


Zech & Cerruti 2013

Leptonic emission

- Identify the underlying process

highest flare of Mrk421



Leptonic emission

- Identify the underlying process

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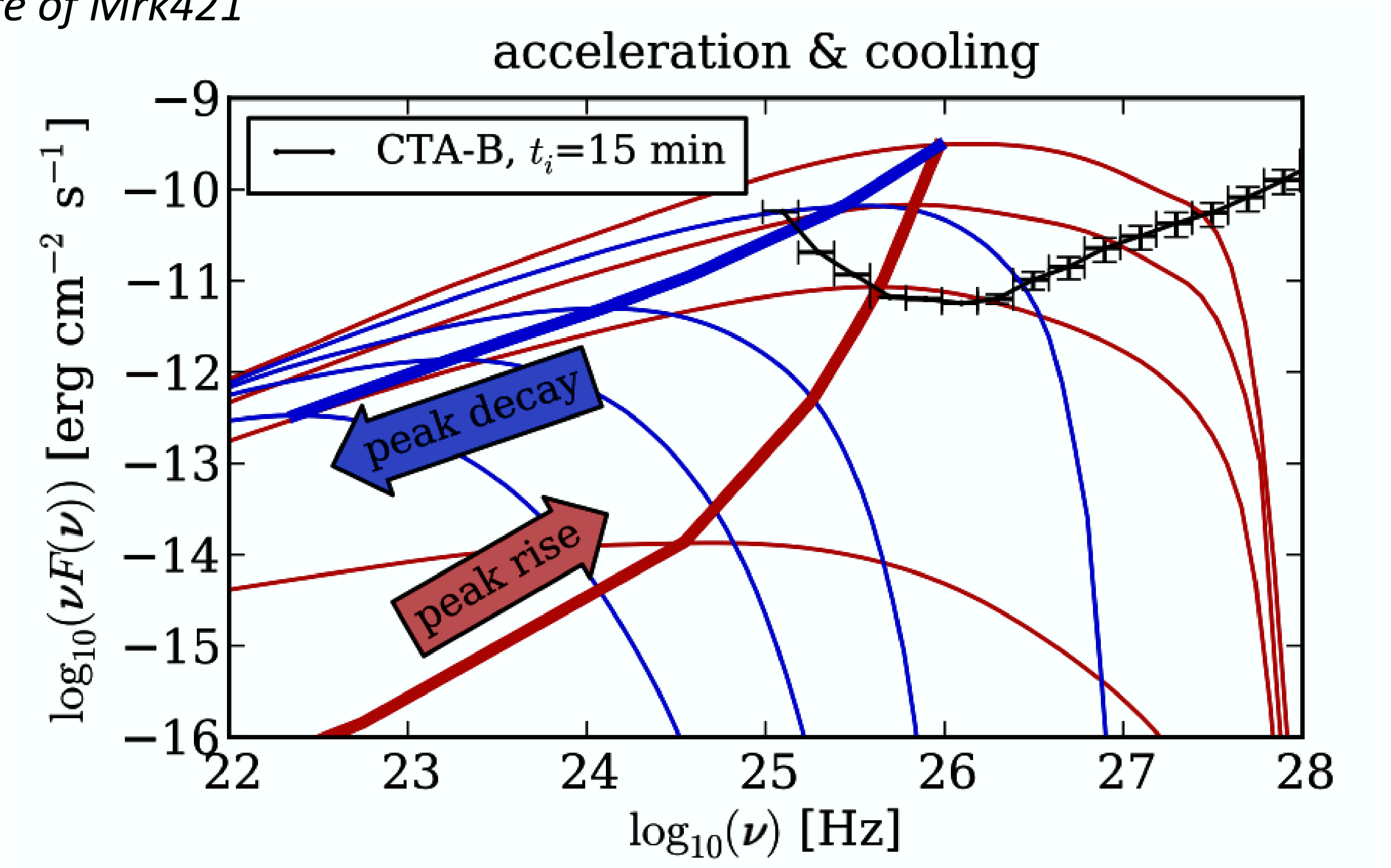
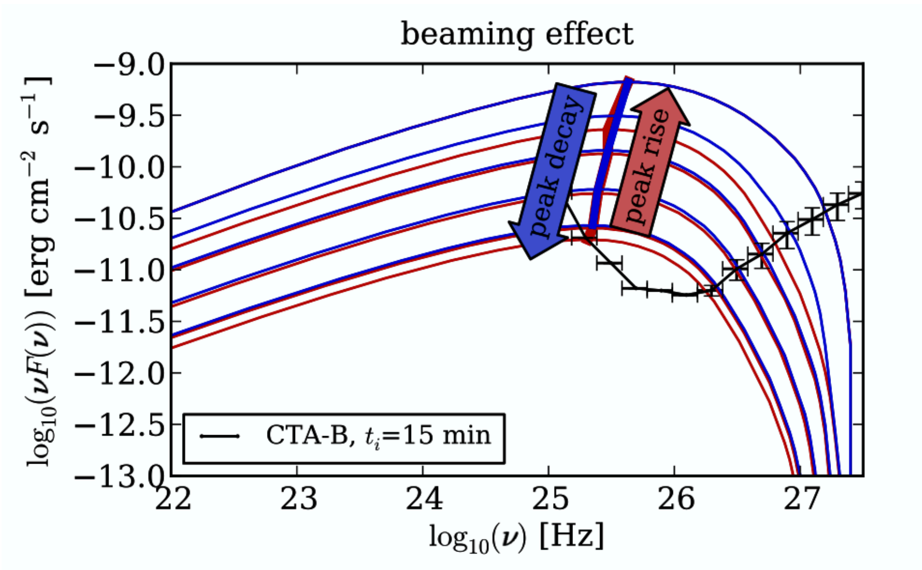


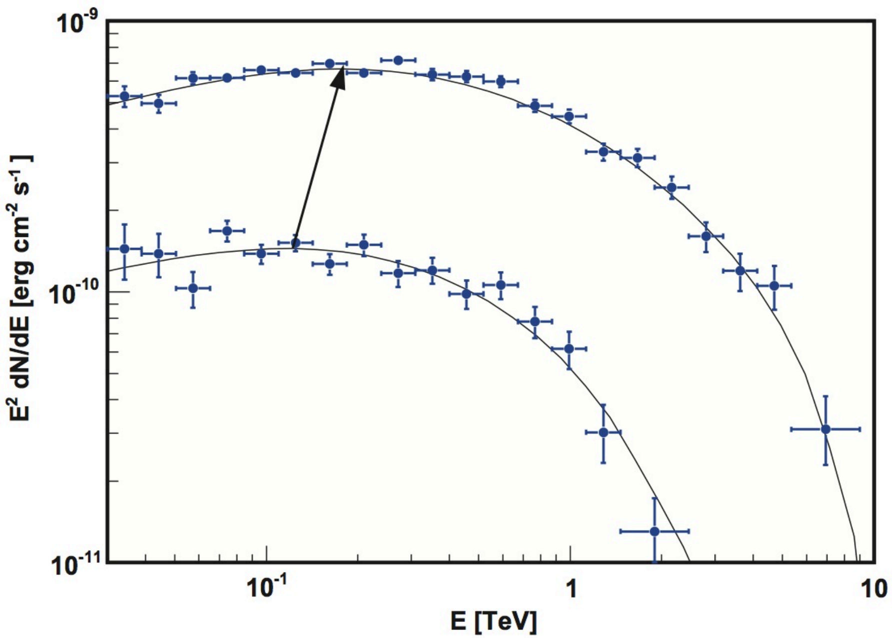
Flares - variability

Leptonic emission

- Identify the underlying process

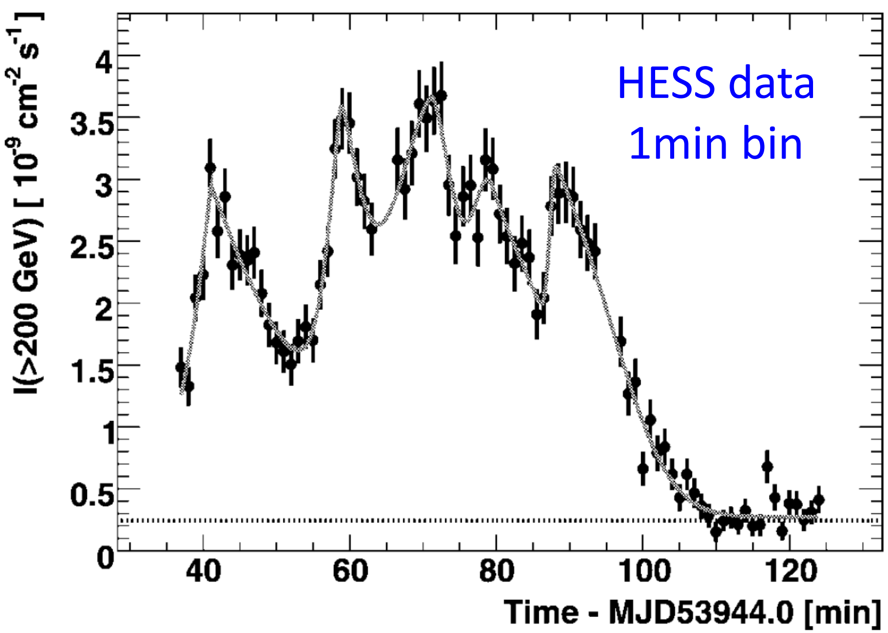
CTA simulation
highest flare of Mrk421
15 min. observation

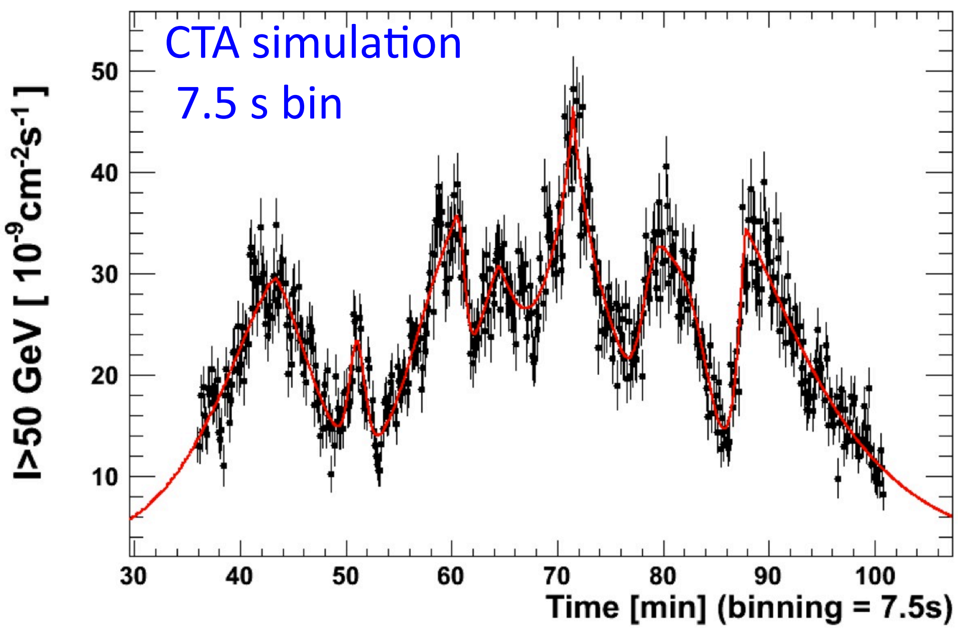




Test case: giant flare from PKS 2155-304

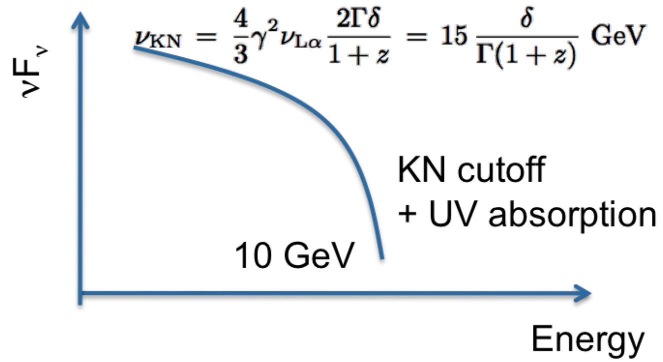
- CTA: ~10x time resolution
- Limits on the size of emission zone and processes
- Correlations with other bands, e.g. X-ray
- Studies of energy dependent lags

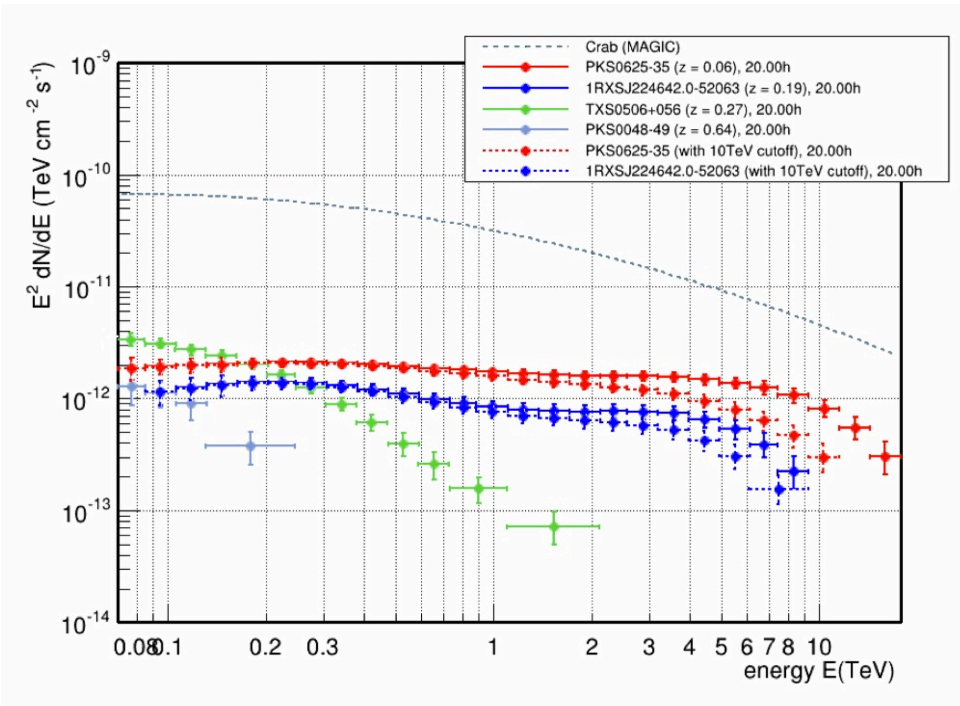


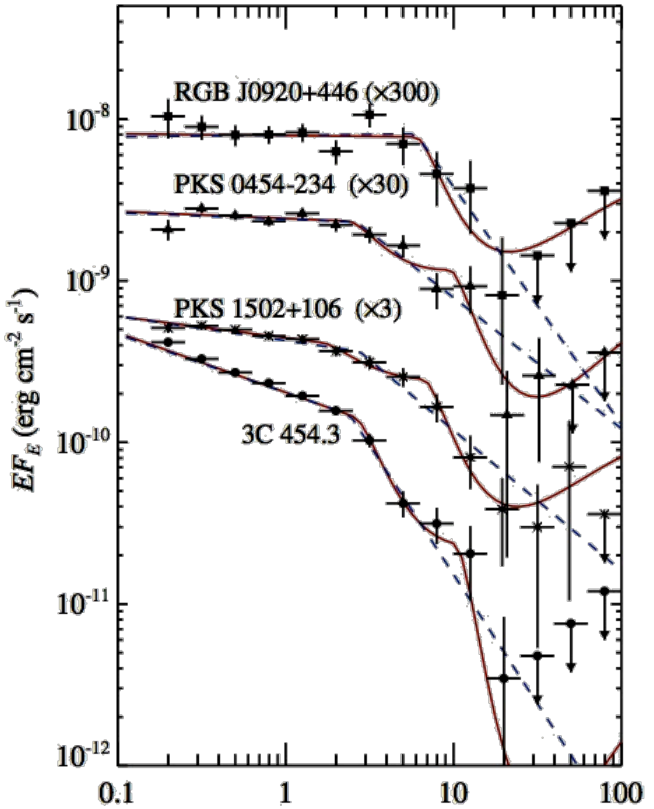


The jet/BLR interaction

- ✦ Interaction of γ of the jet with external radiation field
- ✦ BLR opaque to VHE γ
  - features due to absorption



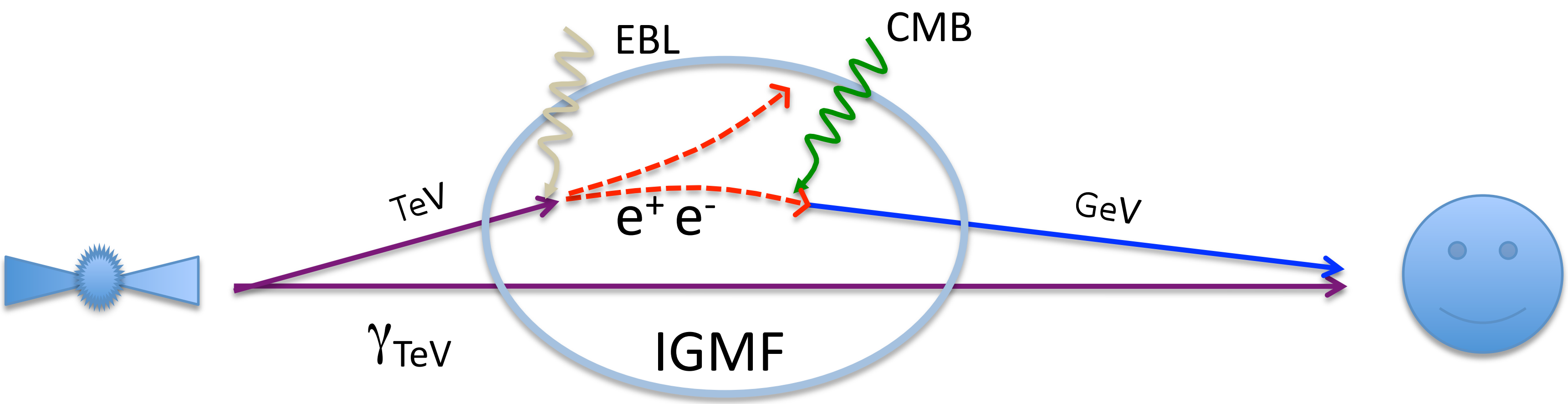




Limits on IGMF

Reprocess of TeV photons in the GeV band

- ✦spectral features
- ✦Extended emission

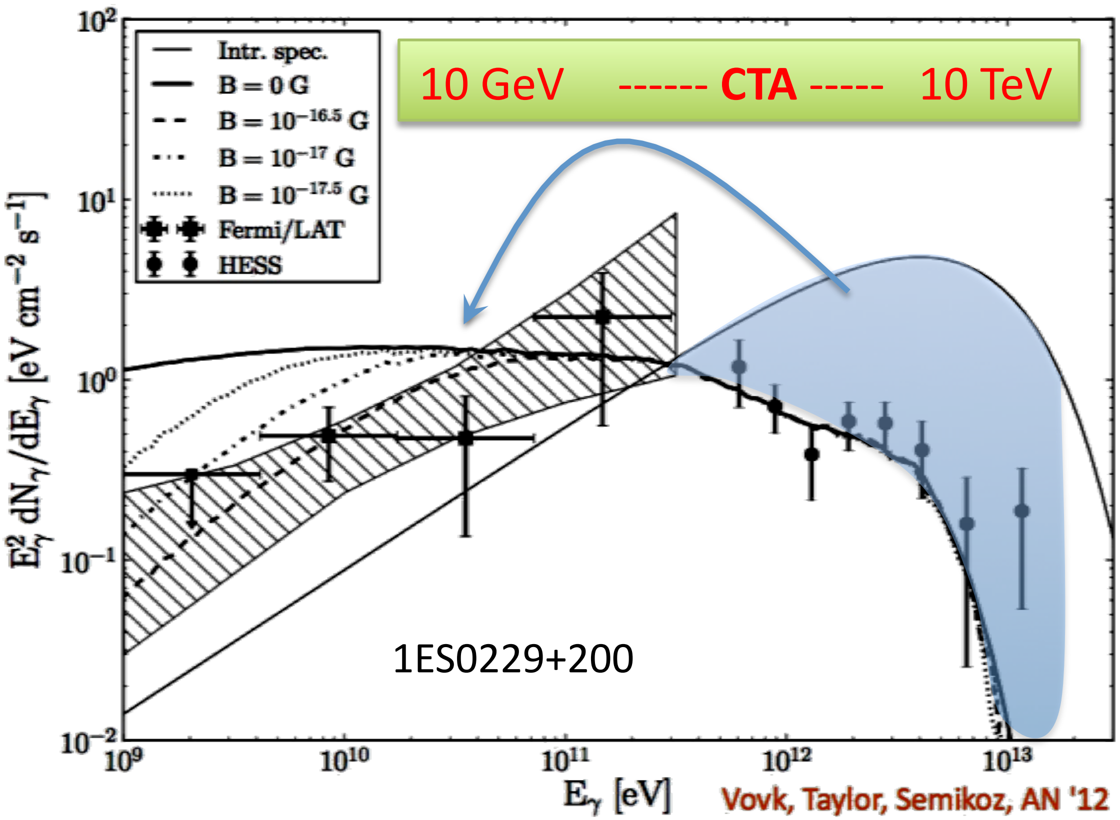


Limits on IGMF

- Reprocessing of TeV photons in the GeV range:

$$E_\gamma \approx 0.32 \left[\frac{E_{\gamma_{source}}}{20TeV}\right]^2 TeV$$

see also Tavecchio et al. 2010, Neronov&Semikoz 2009

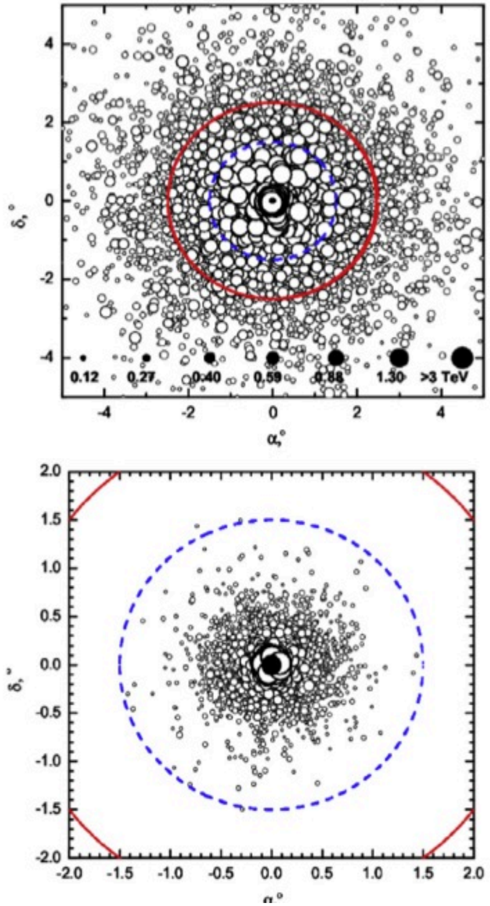


Vovk, Taylor, Semikoz, AN '12

Limits on IGMF

- ✦ IGMF deflects pairs → **extended emission** around the point source.
- ✦ ***PSF and FoV critical...***

$$\Theta_{ext} \approx \frac{0.5^\circ}{(1+z)^2}\left(\frac{\tau}{10}\right)^{-1}\left(\frac{E_\gamma}{0.1TeV}\right)^{-1}\left(\frac{B_0}{10^{-14}G}\right)$$

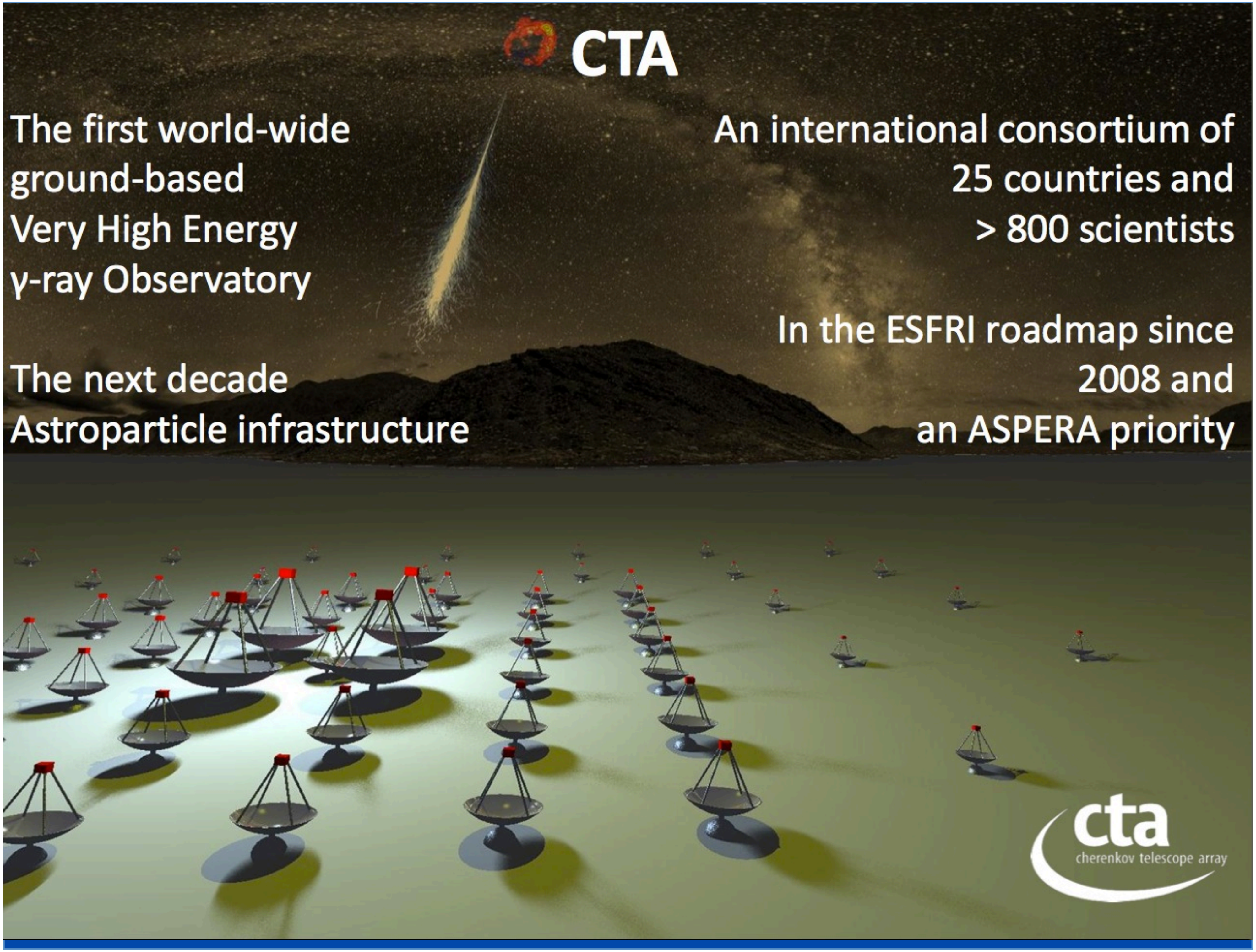


Formation of pair halo:

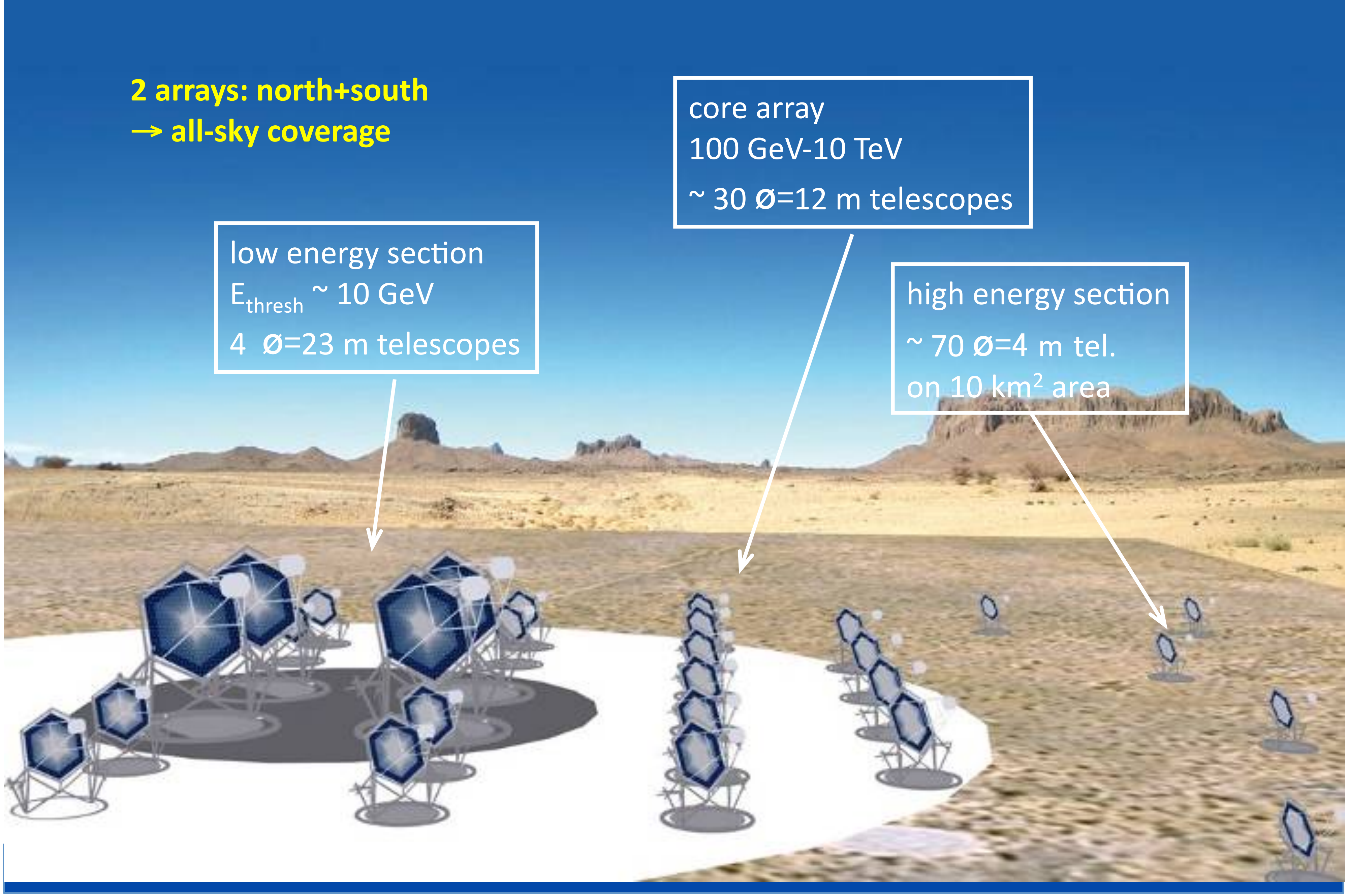
Arrival direction of primary and secondary gamma-rays from a source at 120 Mpc.
IGMF = 10^{-14} G (upper panel)
IGMF = 10^{-15} G (lower panel)

Red circle: field of 2.5°
Blue circle: field of 1.5°
→ well fit into the CTA FoV

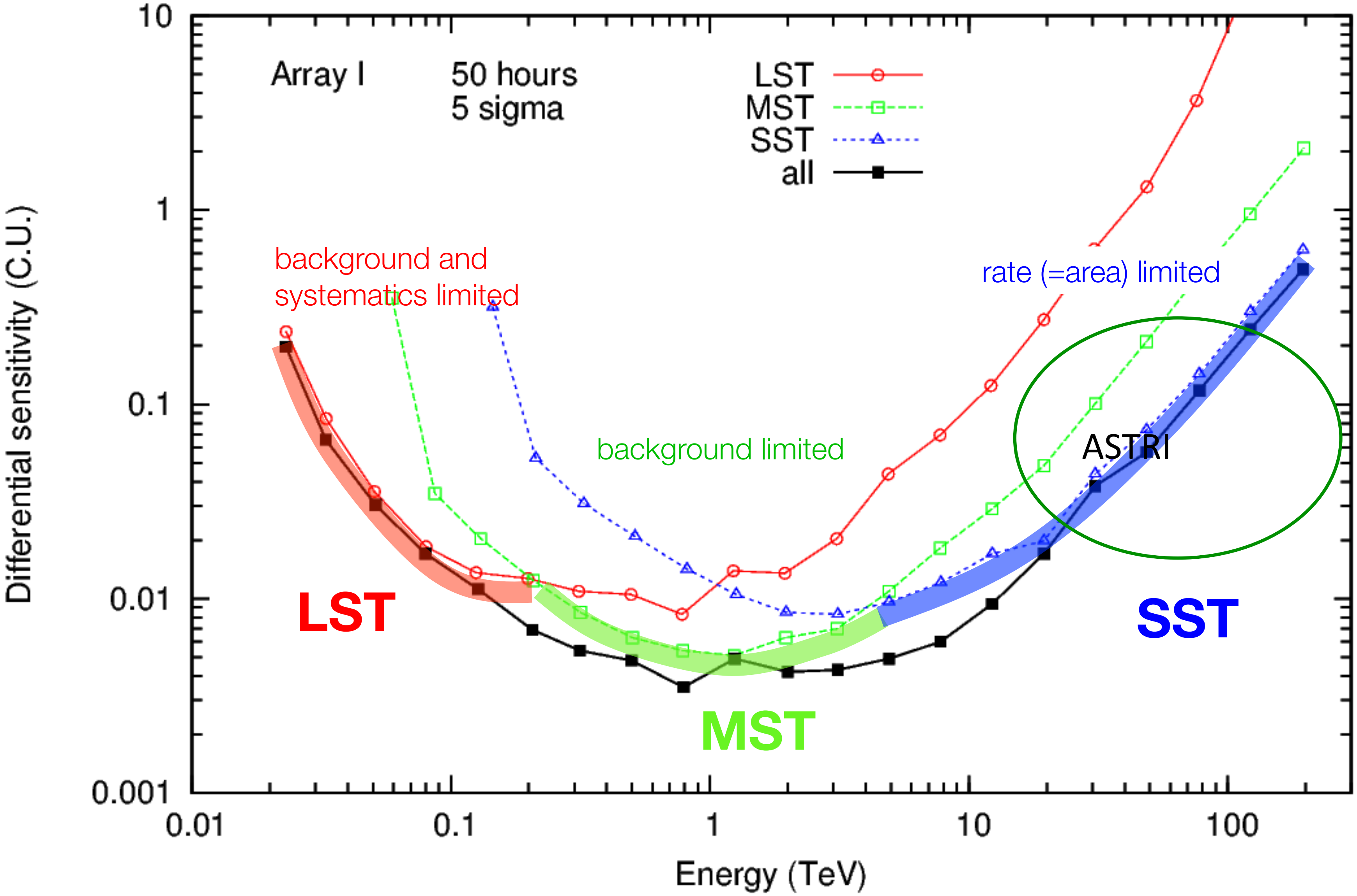
(Elyiv et al, 2009)


CTA
The first world-wide ground-based Very High Energy γ-ray Observatory
The next decade Astroparticle infrastructure
An international consortium of 25 countries and > 800 scientists
In the ESFRI roadmap since 2008 and an ASPERA priority
cta
cherenkov telescope array

The CTA concept



Sensitivity (in units of Crab flux)



The highest energies

✦E>10 TeV

Information about:

✦Acceleration process (maximum energy)

- cut-off in spectrum; X-ray correlation

✦Emission models: Klein-Nishina effect, secondary SSC, hadronic components

✦EBL at long wavelengths

☹ γ-ray horizon limited due to EBL

- Nearby sources z<~0.05; flares

The ASTRI Collaboration …

Principal Investigator: G. Pareschi

Co-PI (Instrument): O. Catalano
Co-PI (Science): S. Vercellone
Program Manager: M. Fiorini
System Engineer: L. Stringhetti
INAF/CTA Responsible: P. Caraveo

INAF Institutions

- IASF Milano
- IASF Bologna
- IASF Palermo
- OA Brera
- OA Bologna
- OA Capodimonte
- OA Catania
- OA Roma
- OA Padova
- OA Torino
- OA Arcetri
- *and* INAF HQ Roma

University Partners

- University of Padova
- University of Perugia

ASTRI inauguration

ASTRI SST-2M

- Energy threshold 1 TeV

Telescope properties

- Primary mirror = 4.3m
- Secondary mirror = 1.8m
- M1-M2 distance = 3m
- Effective area = $6.5 m^2$
- $F/D_1 = 0.5$, F = 2.15m

Camera properties

- Number of pixels = 1984
- Pixel size = 0.17°
- Field of View = 9.6°
- Sensors type = SiPMs

MEDIA INAF

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PRONTO IL PROTOTIPO DI UNO DEI TELESCOPI

Prove di CTA sull'Etna

Mercoledì 24 settembre presso la stazione osservativa di Serra la Nave dell'INAF-Osservatorio Astrofisico di Catania, inaugurazione di SST, il prototipo dei telescopi di piccola taglia che comporrà parte della estesa rete di rivelatori del Cherenkov Telescope Array (CTA). Giovanni Pareschi (INAF): «siamo il primo gruppo che farà un test con un telescopio prototipale completo che rispetta perfettamente i requisiti imposti dal programma CTA»

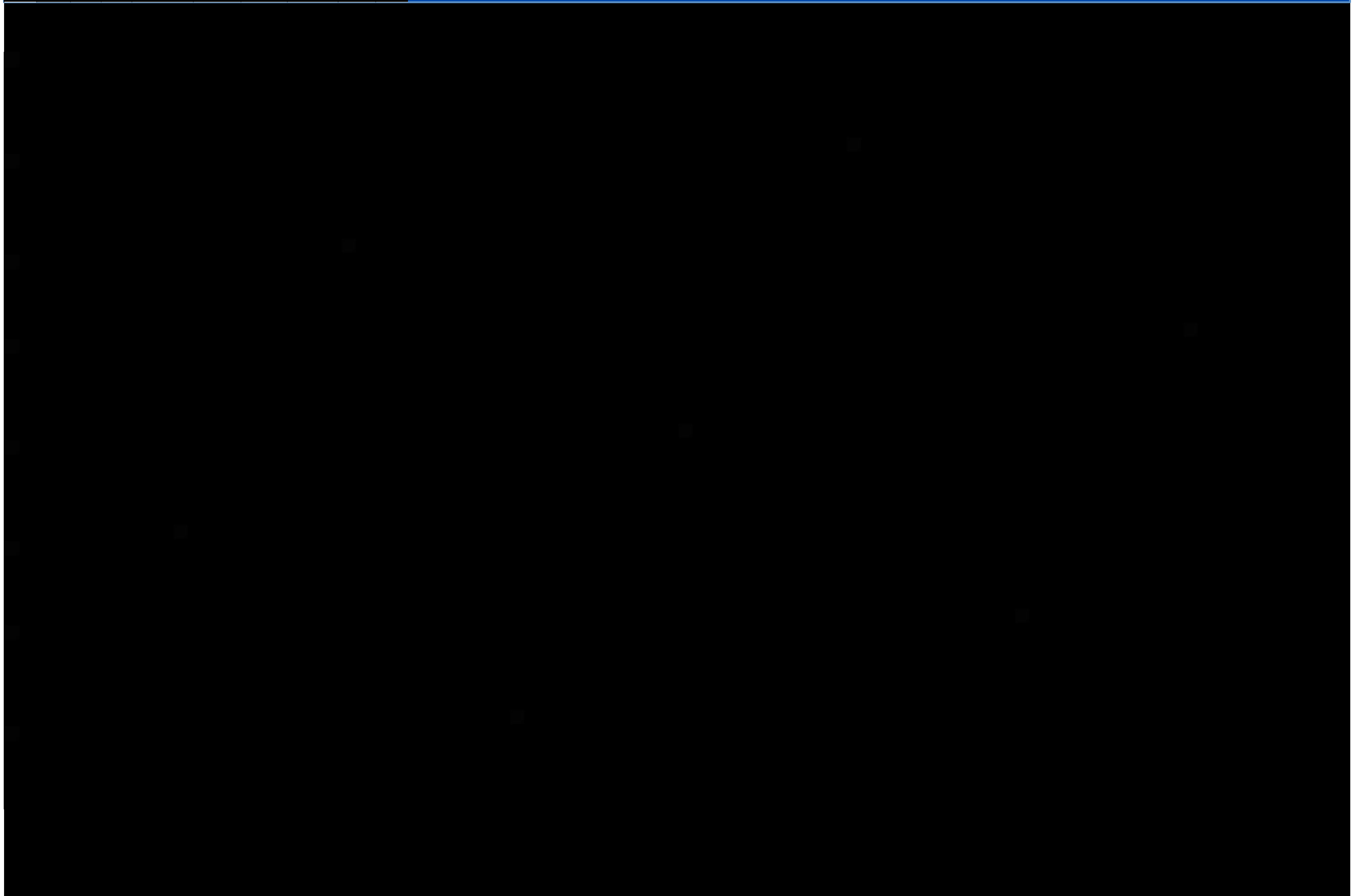
di Marco Galliani — venerdì 19 settembre 2014 @ 16:44

Il telescopio ASTRI a Serra La Nave sul Monte Etna, che sarà inaugurato ufficialmente il 24 settembre

Deserto della Namibia o altipiani delle Ande? Forse meglio il complesso dell'Osservatorio astronomico del Leoncito in Argentina? La scelta del sito che ospiterà la porzione a sud dell'equatore del Cherenkov Telescope Array (CTA), una batteria di telescopi destinati a studiare le sorgenti di radiazione gamma provenienti dall'universo che, una volta realizzato, sarà il più potente e sensibile osservatorio per i raggi gamma mai costruito, non è stata ancora presa.

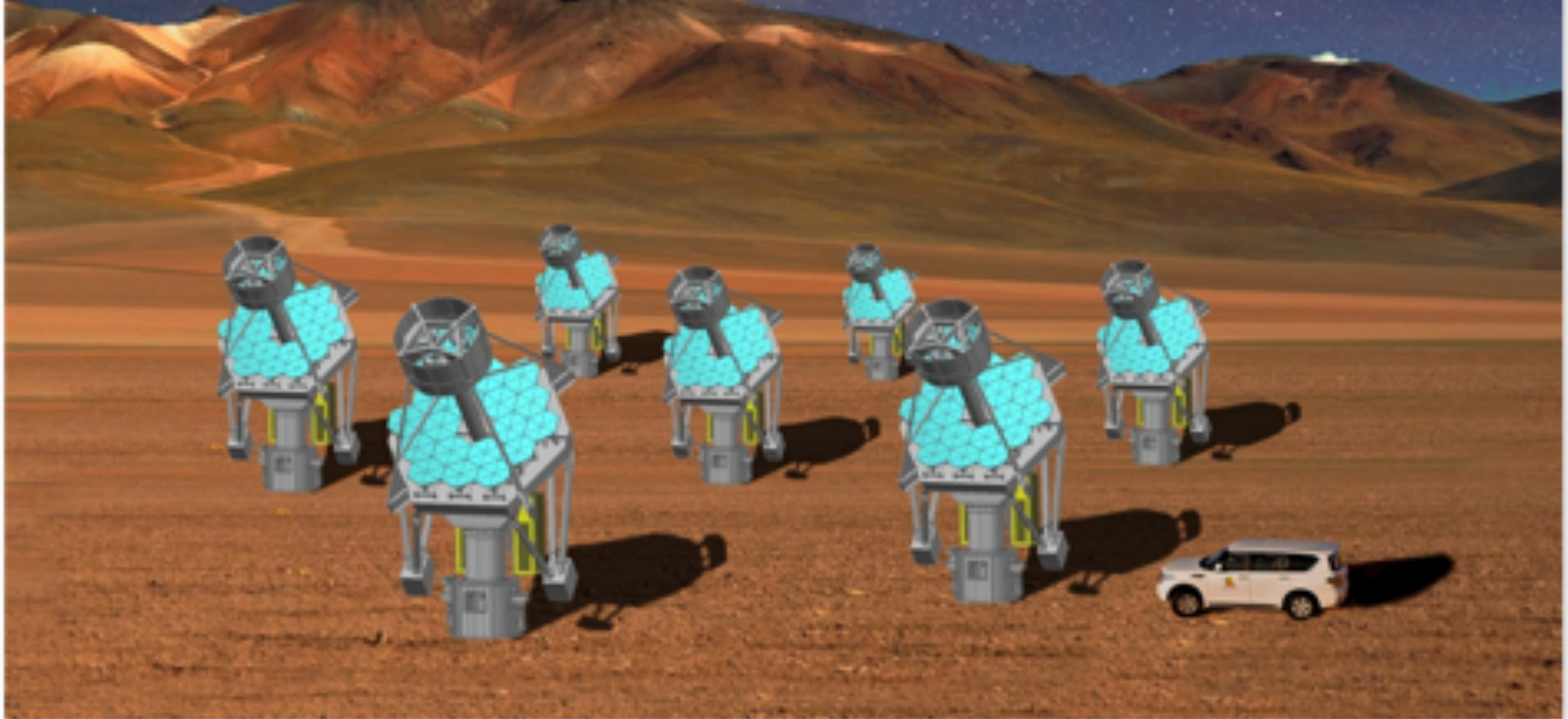
Di certo però ora c'è che il prototipo del gruppo di telescopi di piccola taglia che comporranno questa fantastica rete di strumenti per indagare i più violenti fenomeni che avvengono nello spazio è italiano e verrà inaugurato il 24 settembre prossimo sulla stazione osservativa di Serra La Nave sull'Etna, gestita dall'Osservatorio Astrofisico di Catania dell'INAF. Lo strumento si chiama SST ed è stato realizzato nell'ambito di ASTRI (Astrofisica con Specchi a Tecnologia Replicante Italiana), il "Progetto Bandiera" finanziato dal MIUR e condotto dall'INAF.

ASTRI inauguration



ASTRI mini-array

- Led by the Italian National Institute for Astrophysics (3 units) supported by the ASTRI and TeChe.it projects
- Additional contributions from
  - Universidade de São Paulo, Brazil (3 units)
  - North-West University, Potchefstroom, South Africa (1 unit)



Conclusions

How the VHE sky will improve with CTA

✦ Sensitivity x10

- higher dynamic range -> quiescent states
- higher statistics: lower uncertainties in SED
- fast variability

✦ Angular resolution x2-x5

- extended emission (e.g. lobes)
- counterpart identification
- study of IGMF (diffuse AGN emission)

✦ Wide F.o.V. (8-10 deg)

- Survey: 0.5 hr -> 10% Crab

✦ Energy resolution x3-x5

- spectral features
  - absorption, cut-off
  - EBL signatures
- Better EBL correction

CTA as an observatory gives you the opportunity to observe your source(s)!

✦ Wider energy range (20 GeV – 100 TeV)

Low energy:

- study cutoff in 10-100 GeV range
- cover gap with Fermi/LAT
- new populations (e.g. NLSy1)

High energy:

- EBL studies: cover near-IR/IR region (~50μm)
- New gamma-emitters (e.g. FR0)
- Hadronic emission (e.g. starburst)

✦ New topics on AGN studies

- microvariability (subminutes)
- new classes of sources
  - FR0 - >10-100 TeV
- identification of components (compact/ extended)? (10" resolution) – knots, lobes, IGMF diffuse emission
- increased VHE source statistics... (surveys, luminosity function of blazars)