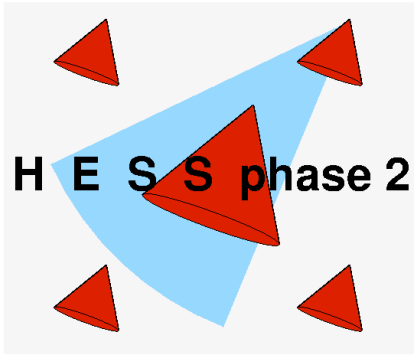


HESS-II and CTA performances for observation of molecular clouds

Serguei Vorobiov

LPTA, CNRS & UM2, Montpellier

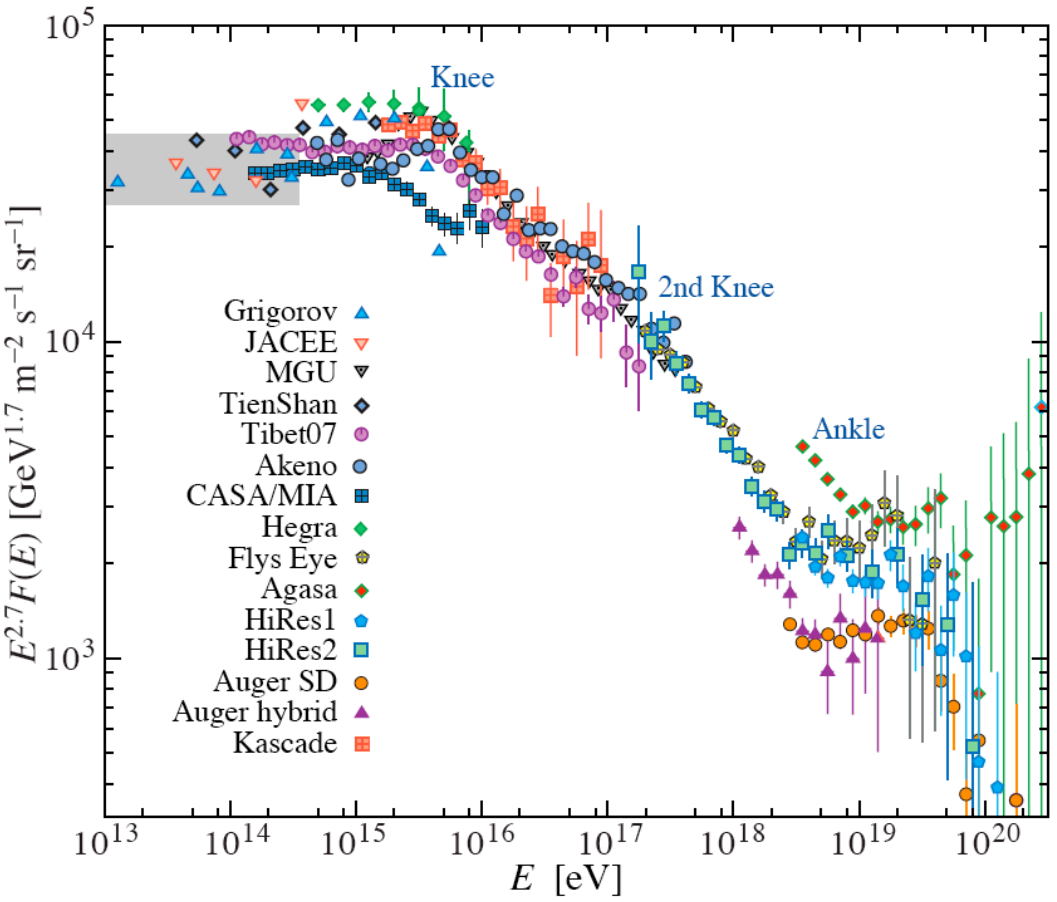
«MC as probes of CR acceleration in SNR» Palavas-les-Flots, 07-09 September 2009

Origin of Galactic CR, SNR & MC study : scientific goals

• to prove (or disprove)
the SNR hypothesis
for the galactic CR origin

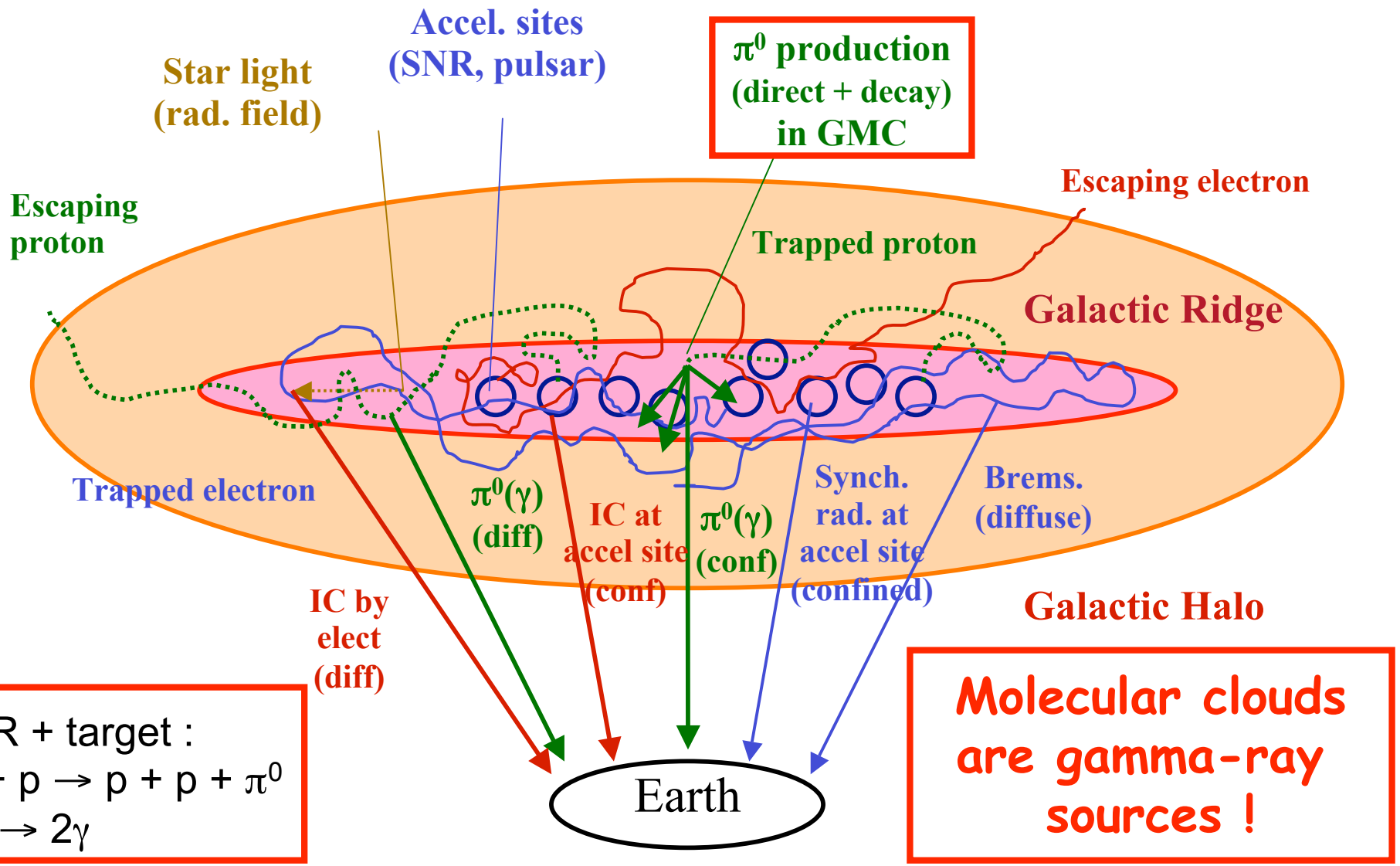
• diffusive shock acceleration:
magnetic field amplified
at shocks ?
=> Are SNR CR PeVatrons ?

• to probe the spatial and spectral
CR distribution in the Galaxy
=> diffusion of relativistic particles
in turbulent magnetic fields.



Gal. Diffuse Emission, Accel. Sites, and CR Propagation

- Interplay of CR, ISM and B-field -



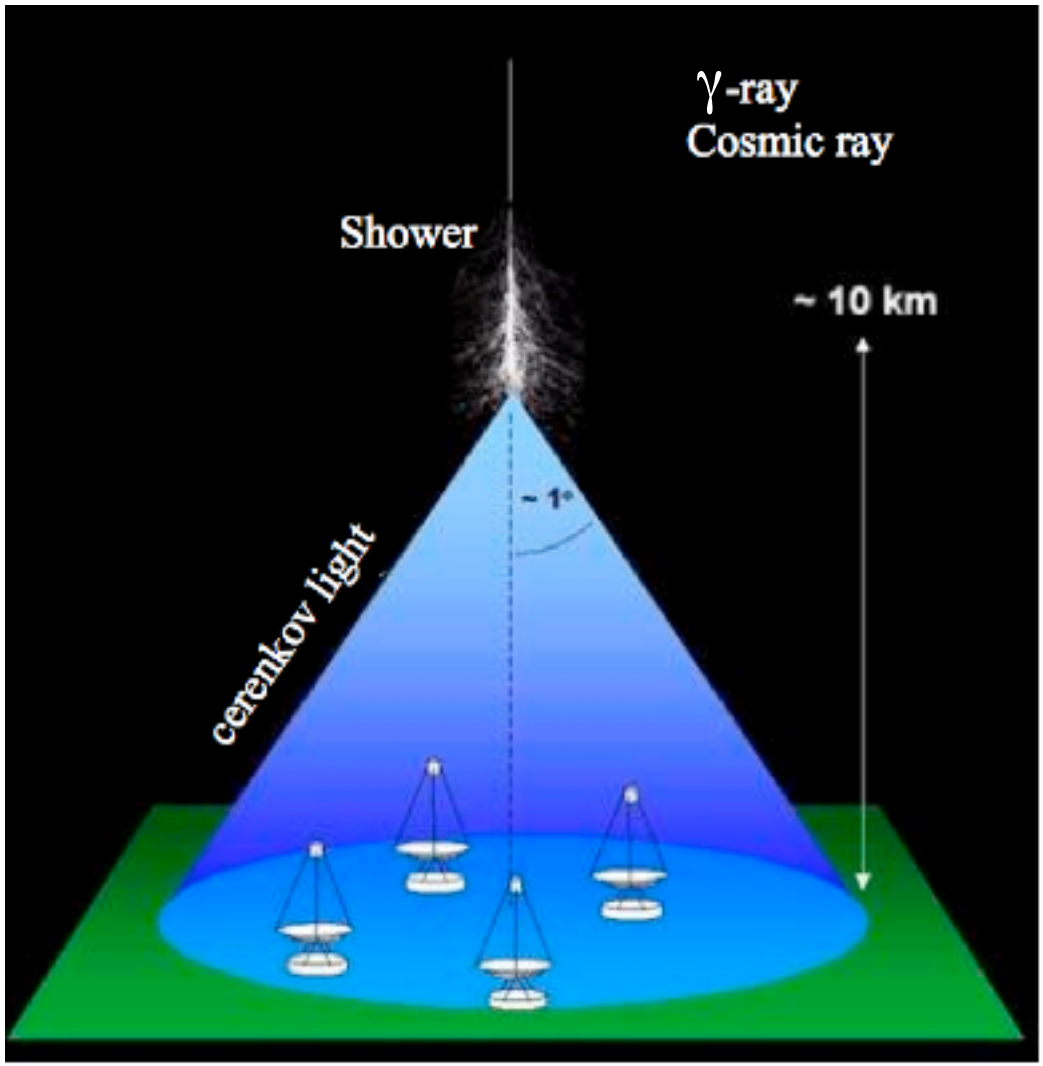
CR + target :

$p + p \rightarrow p + p + \pi^0$

$\pi^0 \rightarrow 2\gamma$

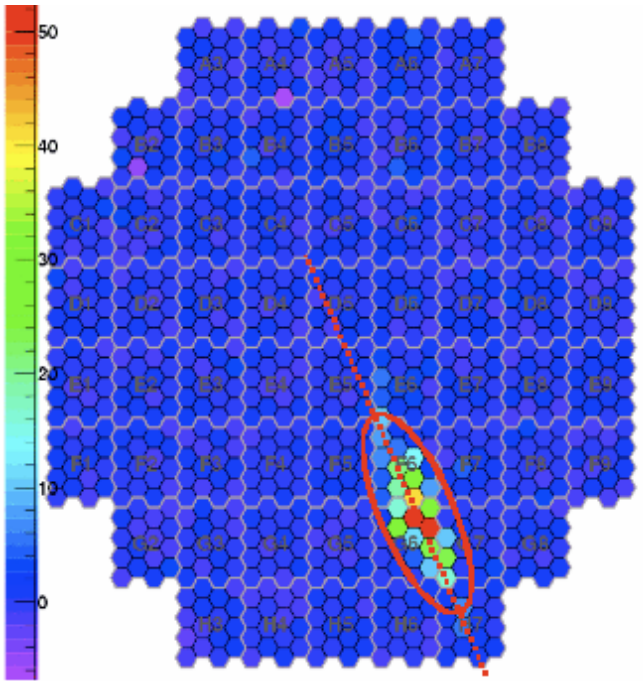
Molecular clouds are gamma-ray sources !

Imaging Atmospheric Cherenkov Telescopes (IACTs) : ideal instruments for studying molecular clouds

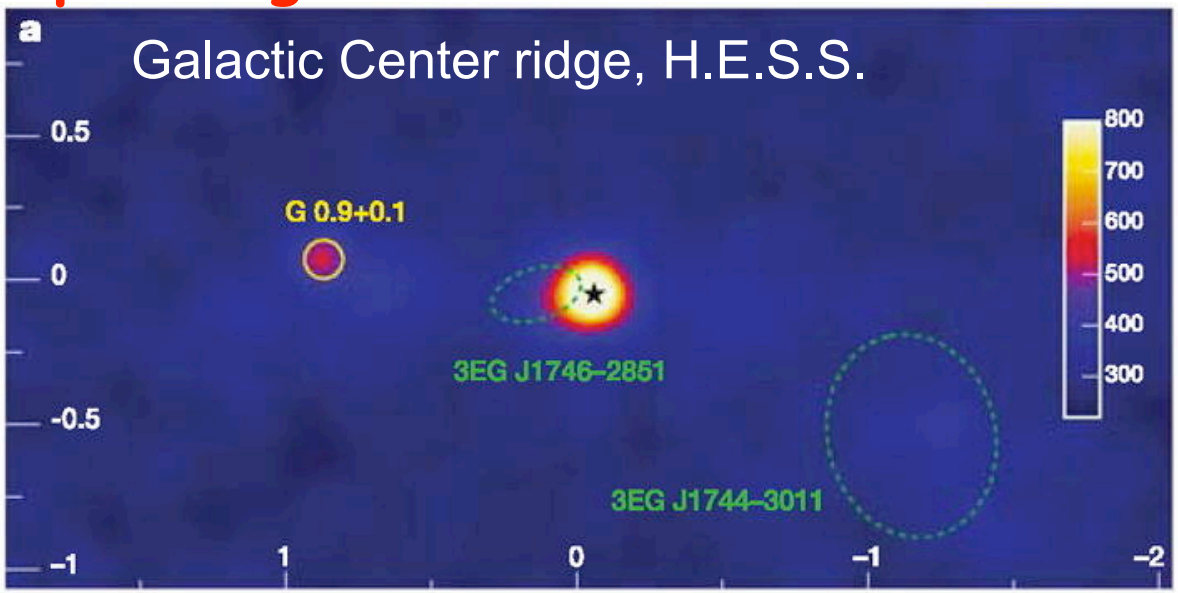


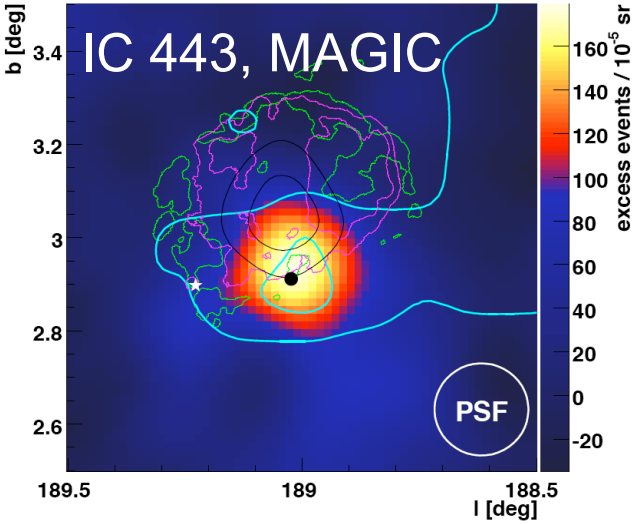
- Large (~ 5º) field of view
MC are extended objects

- Good (few arc min.) angular resolution => morphology studies

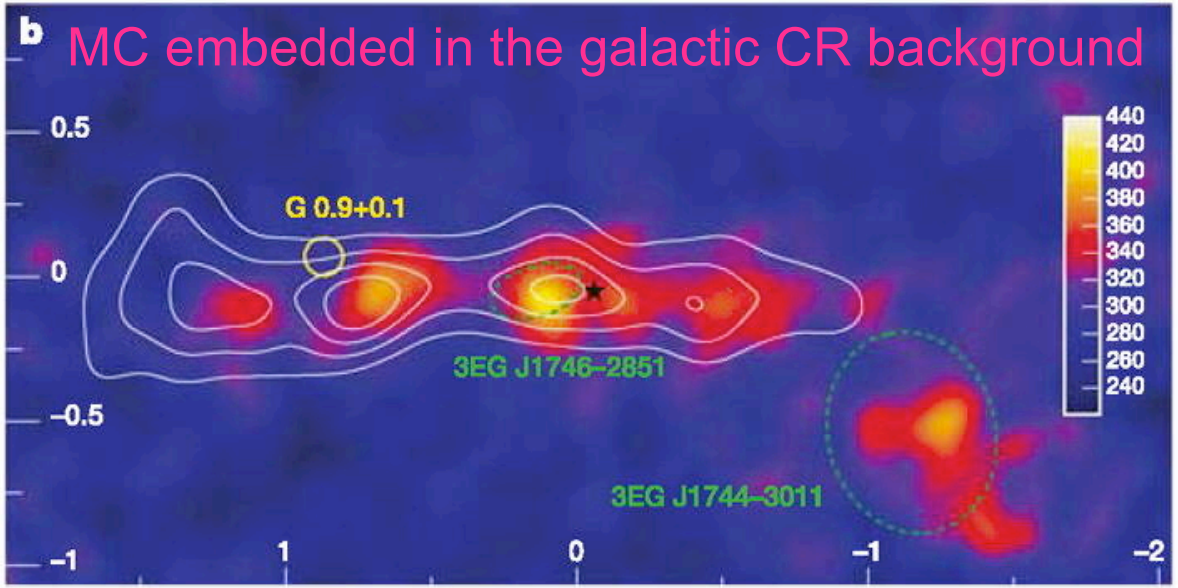


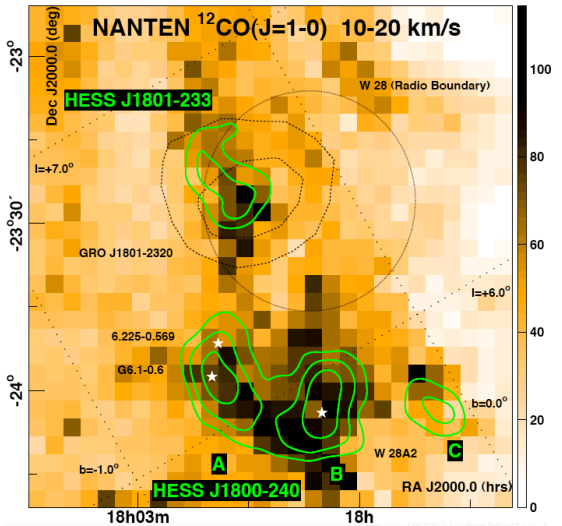
(Some of the) VHE γ - MC associations revealed by the operating IACTs



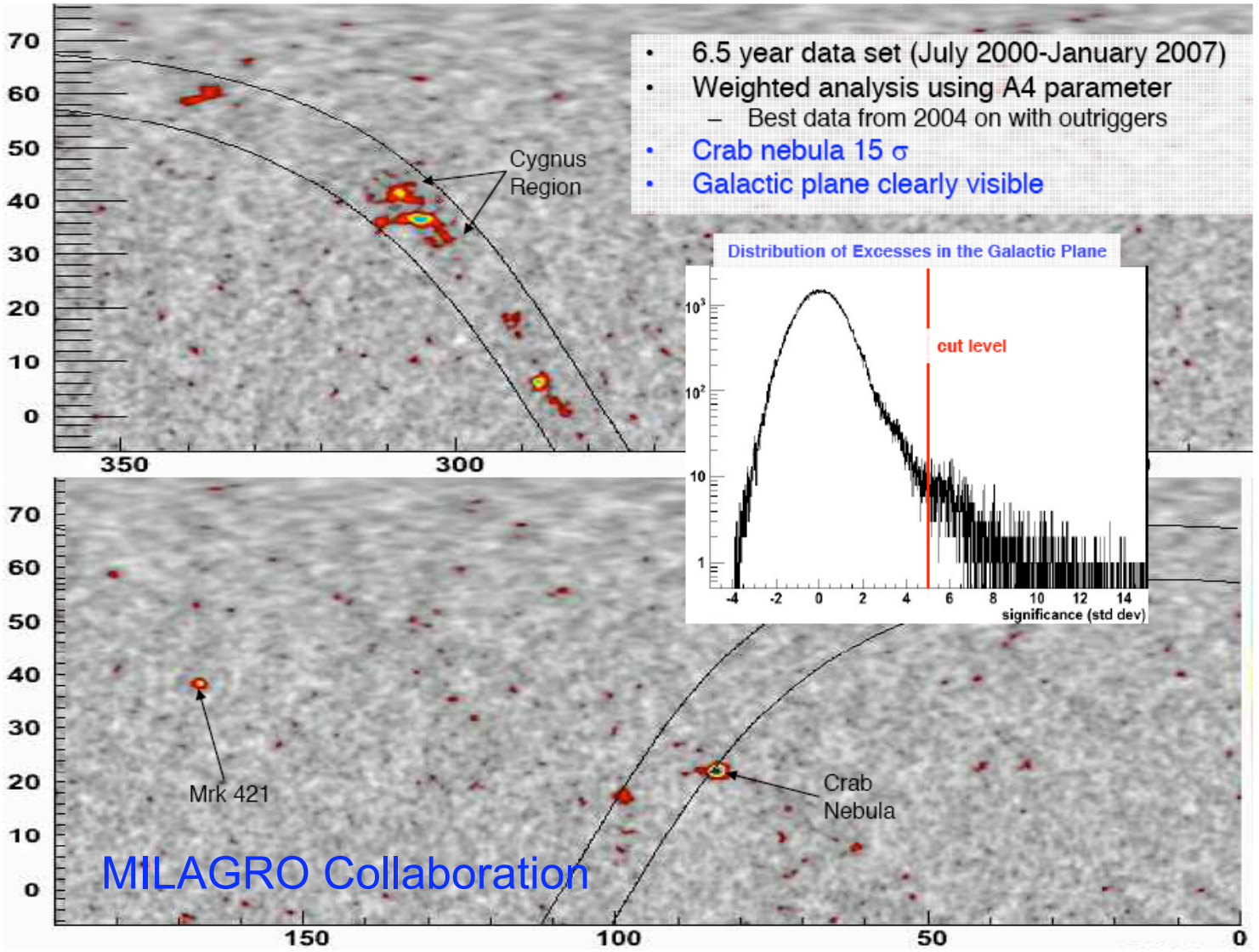


MC - SNR association



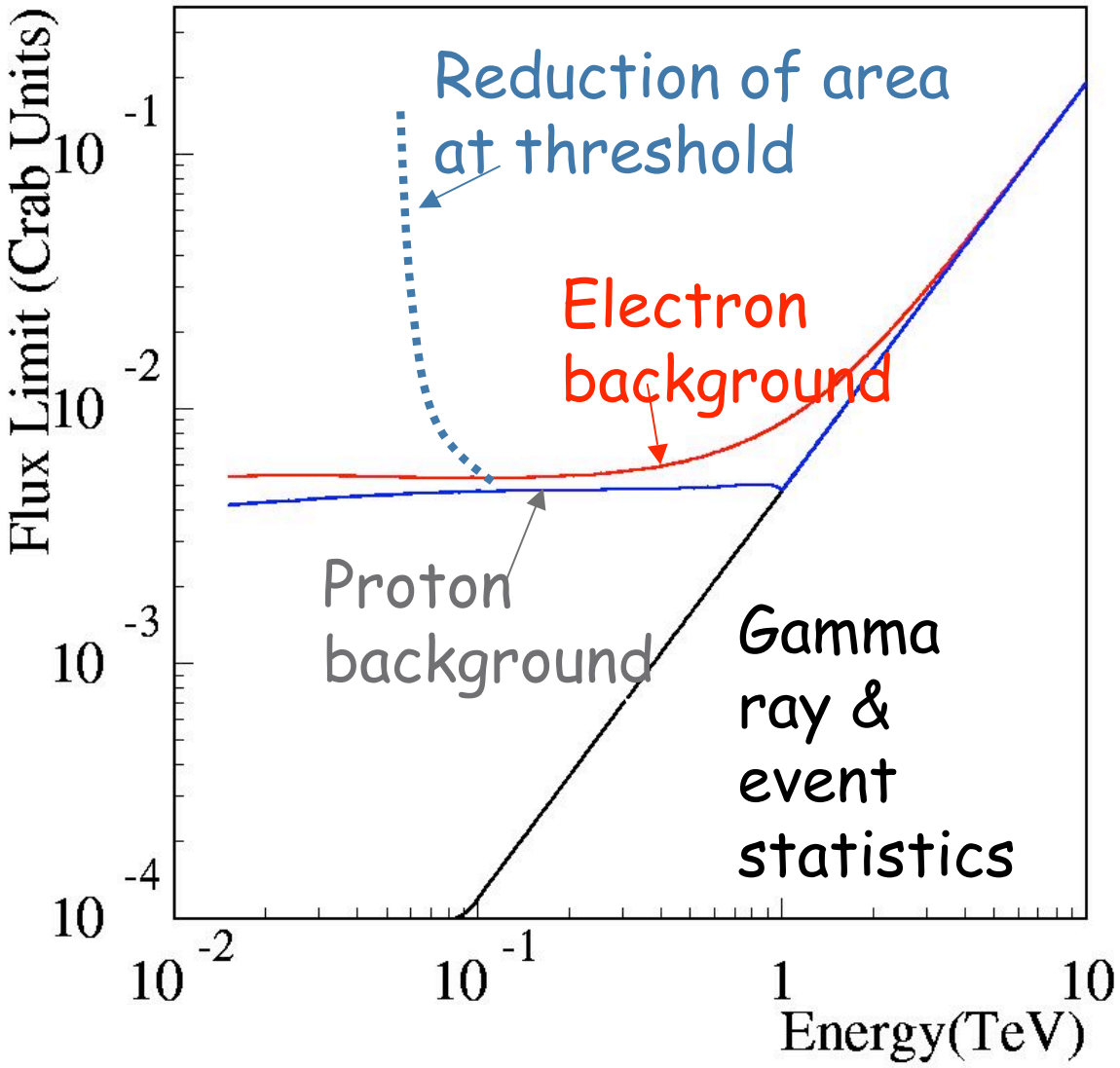


W 28 region, H.E.S.S.

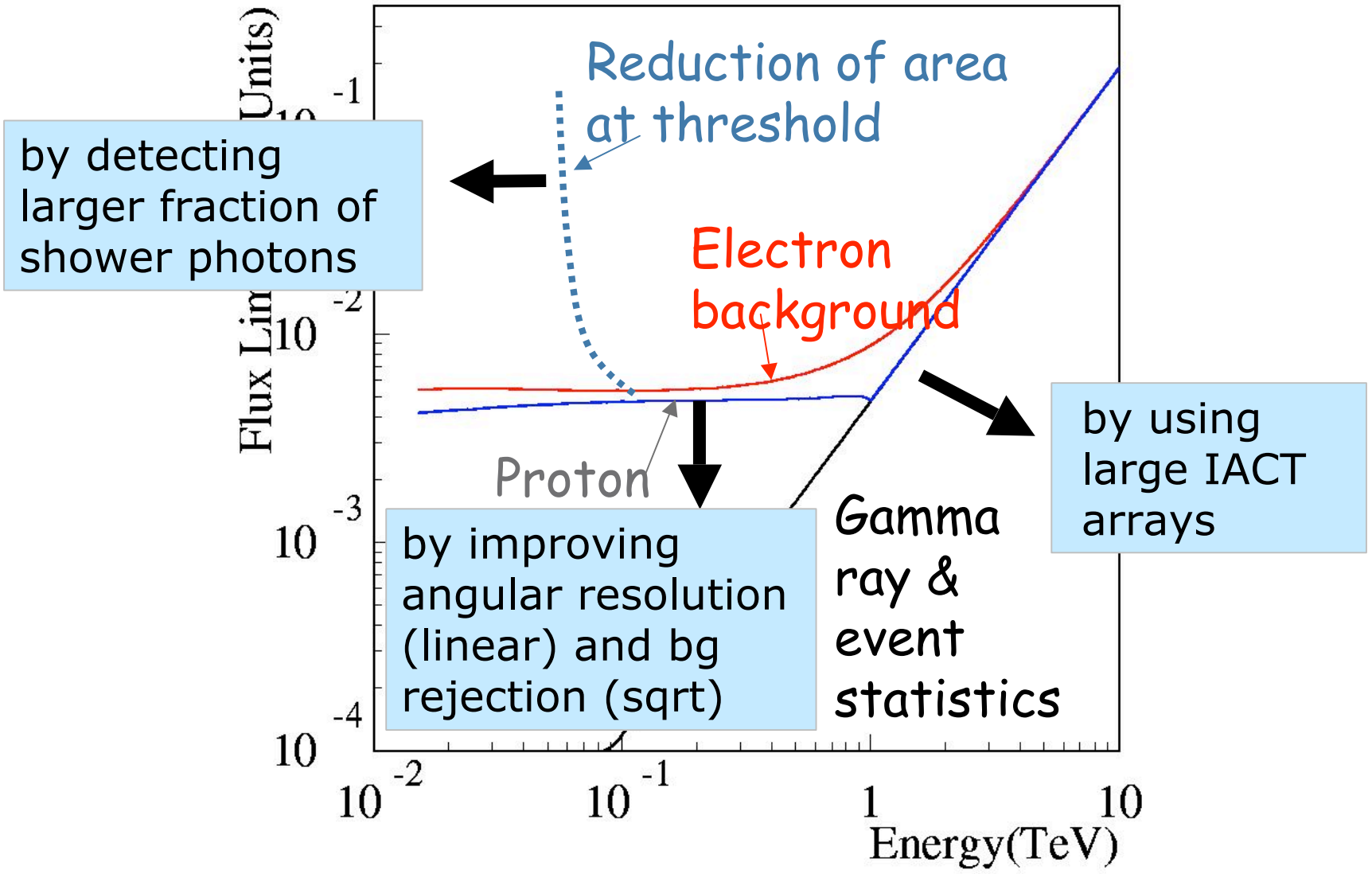


Are (some of the) non-identified TeV sources «active» MC?

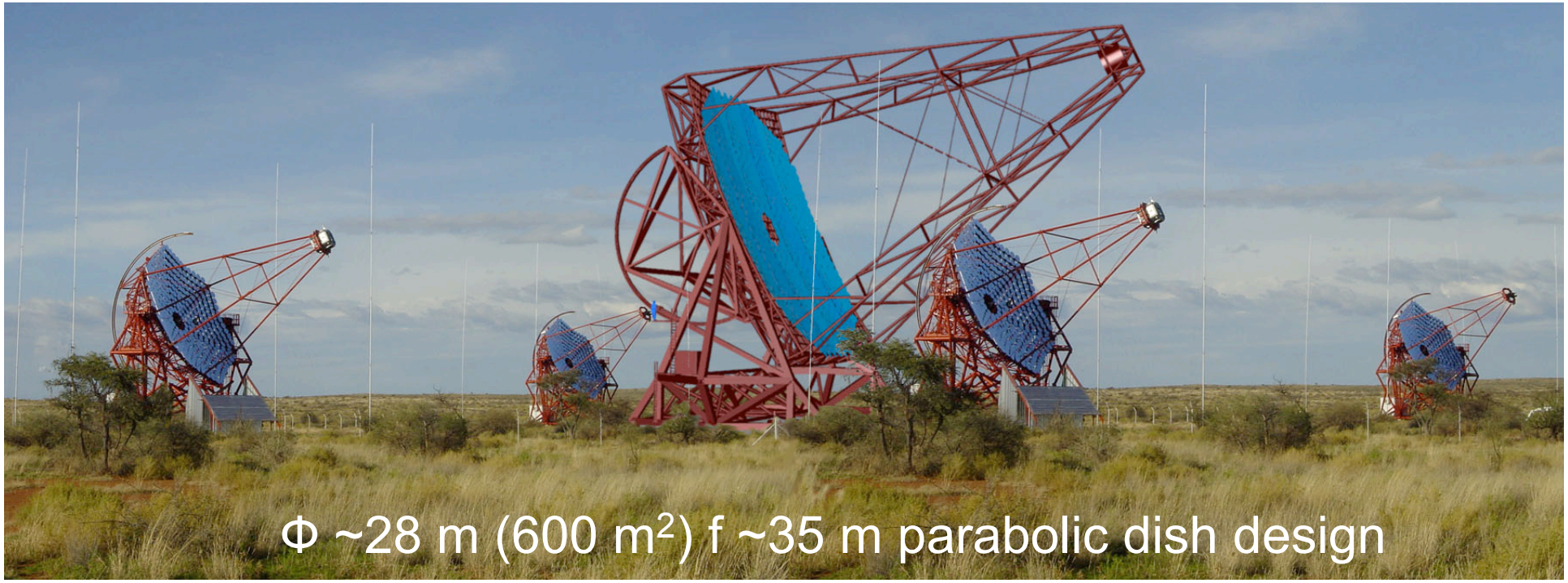
Sensitivity of IACTs : limitations …



…and the ways to improve it



The next step : HESS-II - Very Large Central IACT

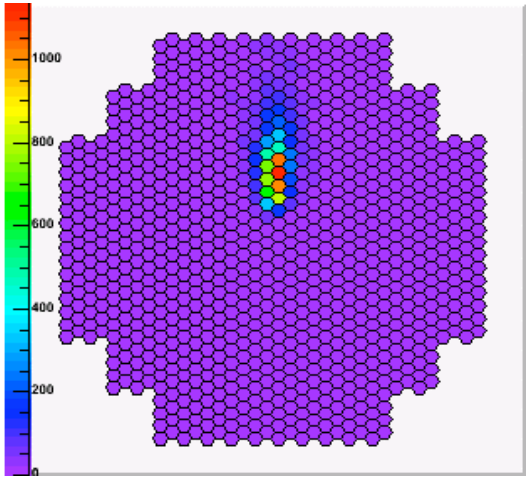


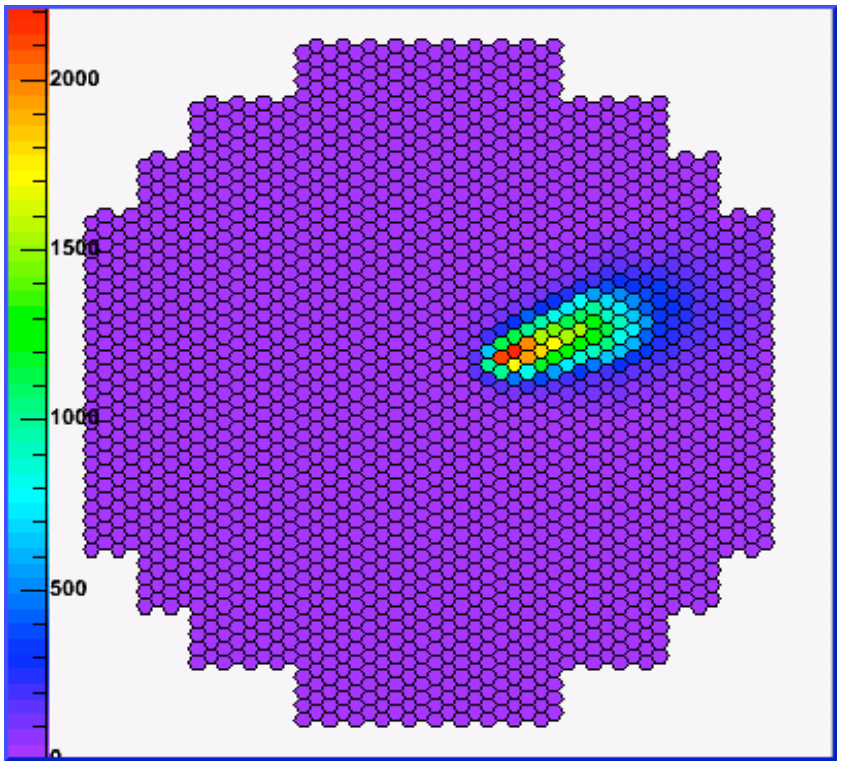
- Lower threshold and increased energy range in standalone mode

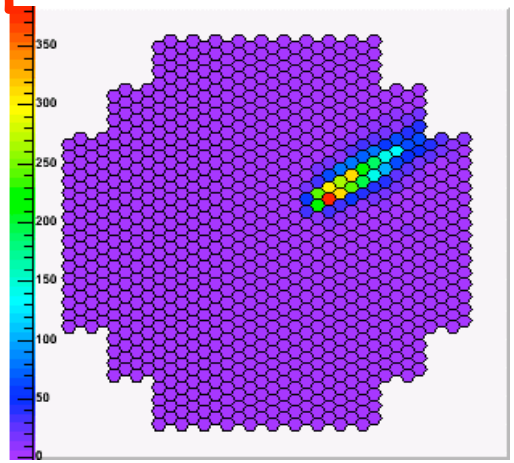
- Improved sensitivity and angular resolution (~2) at higher energy in coincidence mode

- Extending spectra for VHE sources; complementarity with Fermi GST
- Pulsars, Microquasars, ...
- Unidentified sources
- AGNs and cosmology; redshift coverage
- GRBs
- Dark matter

A 2 TeV hybrid γ-ray event

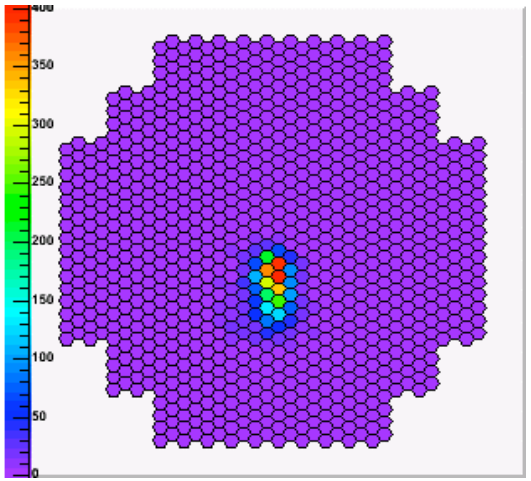




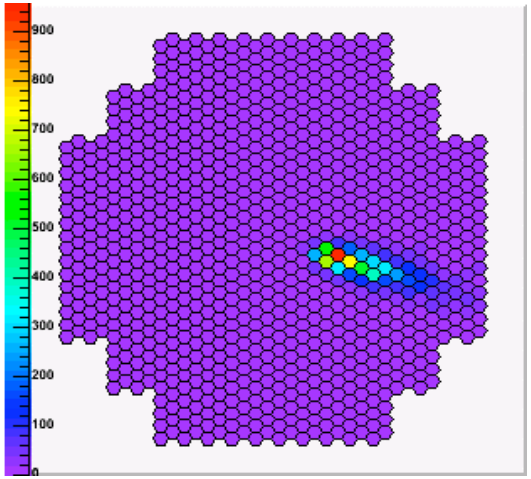


2048 pixels
~ 3.5° field

pixel size ~0.07°
(better image
sampling)

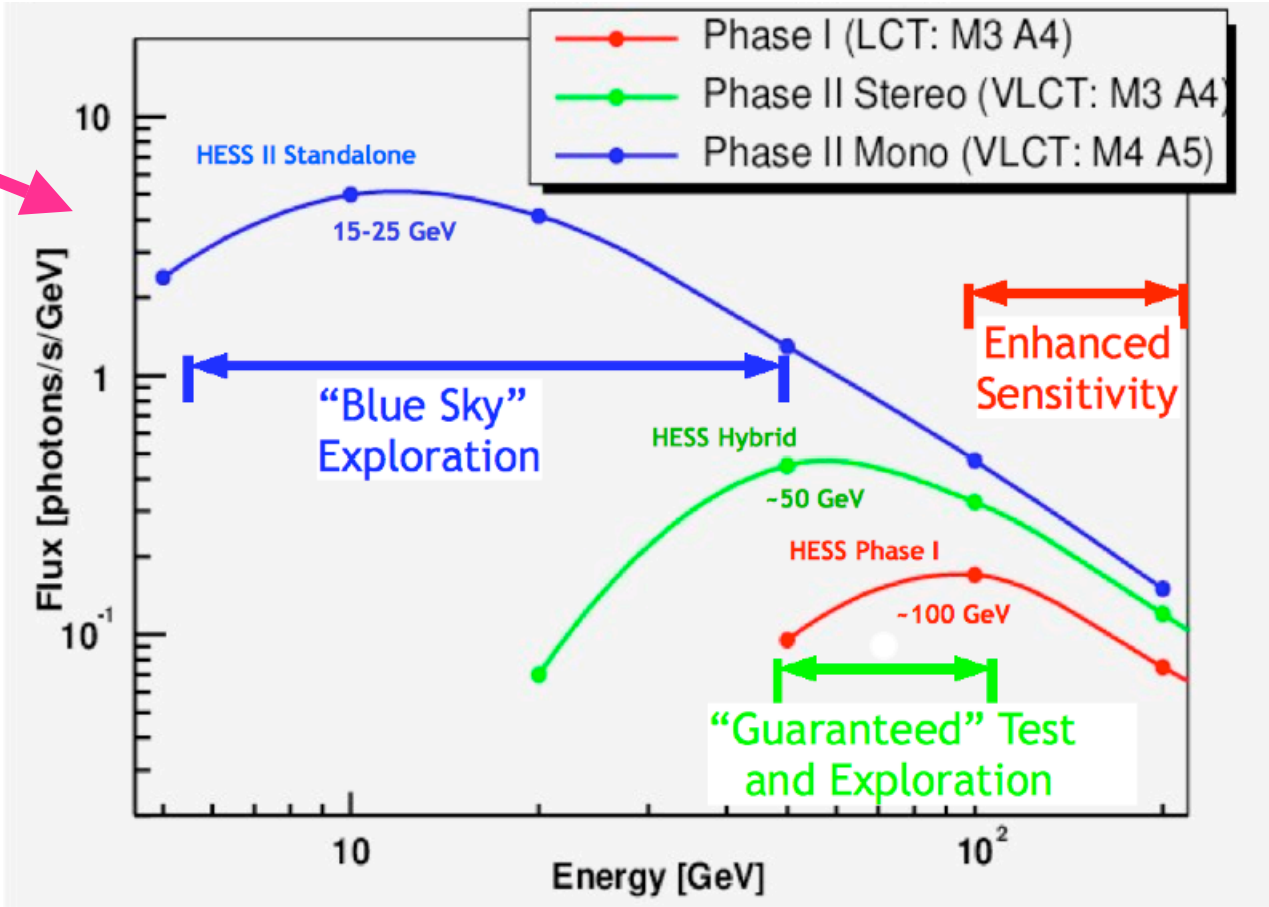


Cylindrical camera
2m x ø2.5m, 2500 kg



Estimated performances HESS II Mono & Hybrid

γ-ray response
(E^{-2} spectre)

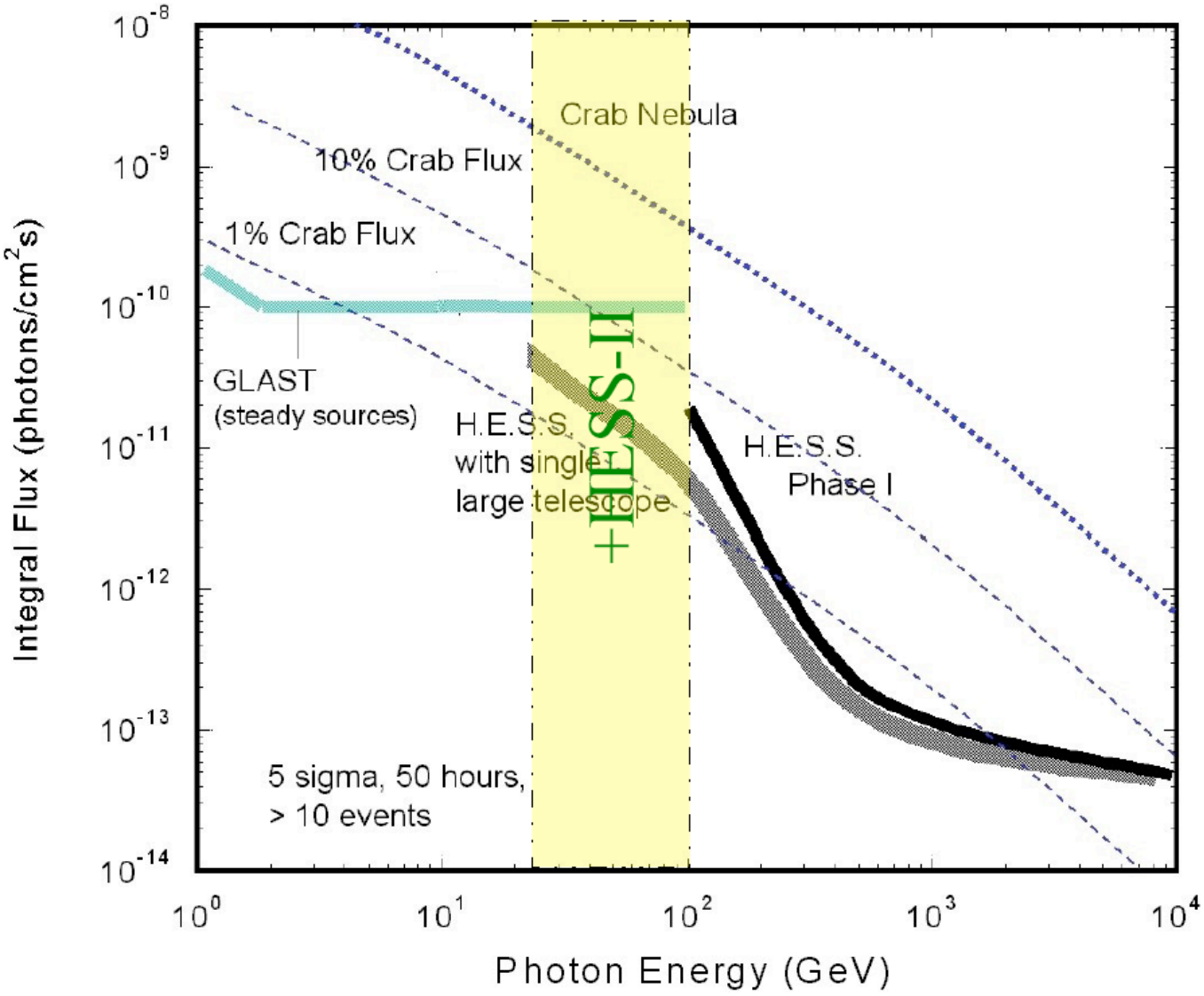


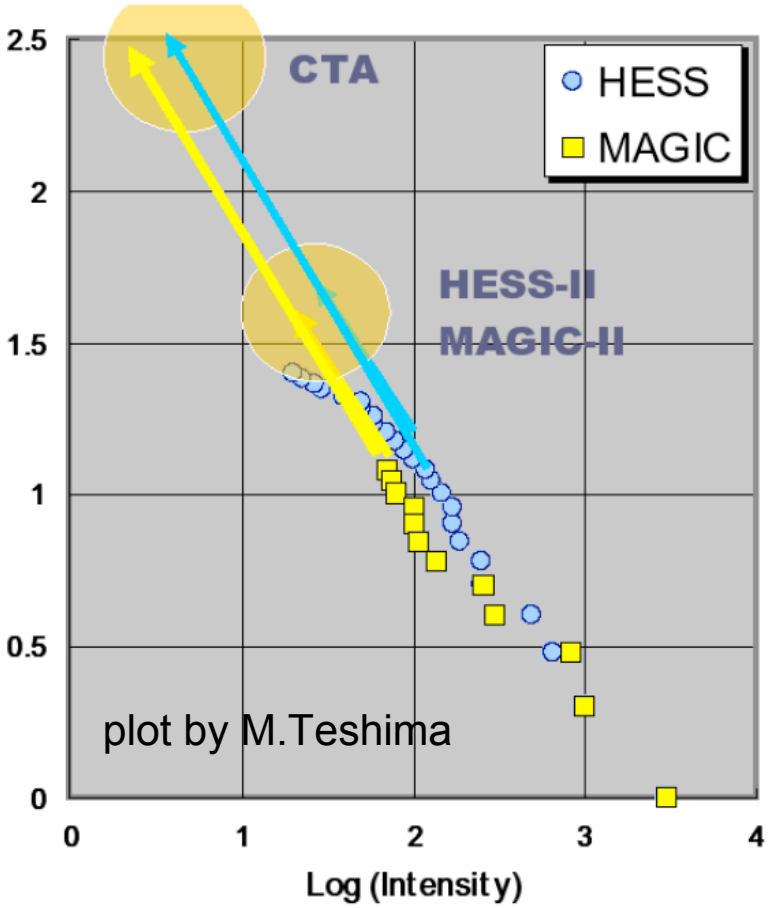
Background (p, He, μ)
trigger rate
full simulations
- in good agreement for HESS-I,
- reasonable values for HESS-II

Trigger (γe x PM)	HESS-I (Hz)	Real Rate (Hz)	HESS-II (Hz)
2.5 x 5	410 ± 20	492	3060 ± 40
3.5 x 5	240 ± 10	254	2250 ± 40

Energy threshold for γ's
~ 20 GeV in mono
~ 50 GeV in hybrid mode

Estimated HESS II Sensitivity





Cherenkov Telescope Array (CTA) !!!

Current IACT generation:

- 60 sources published,
- other detected

Log(N) ~ -1.0 Log(S) ??

What's next ??

Aimed CTA performances

- Gain of factor 10 in sensitivity, down to mCrab:

⇒deeper VHE vision, new source classes

- Very large spectral coverage (a few 10 GeV to above 100 TeV)

⇒new source classes, explore emission mechanisms

- Improved angular resolution down to arc-minute range

⇒high resolution mapping of extended sources

- Temporal resolution down to sub-minute time scale

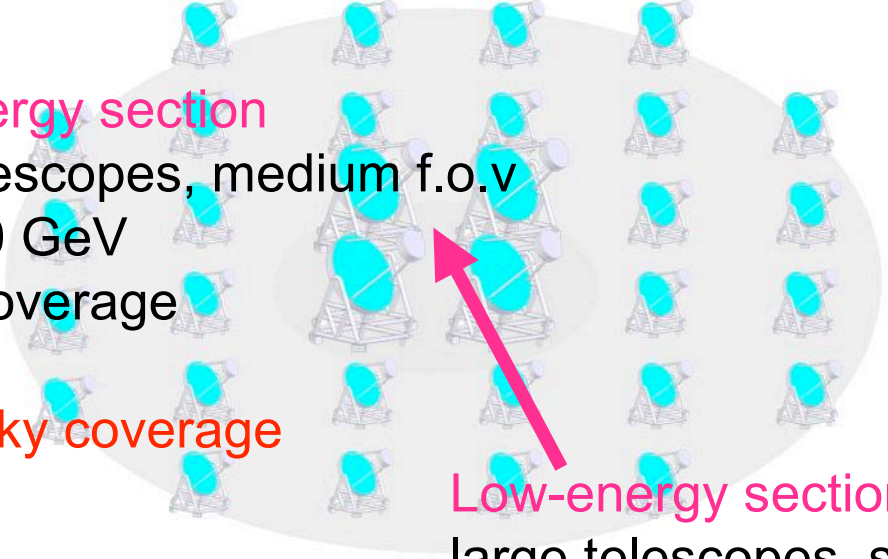
⇒variability studies of pulsars, binaries, blazars

- Flexibility of operations

⇒different operation modes: deep field, monitoring, survey, alerts

- Full sky coverage using North & South installations

Array layout scheme



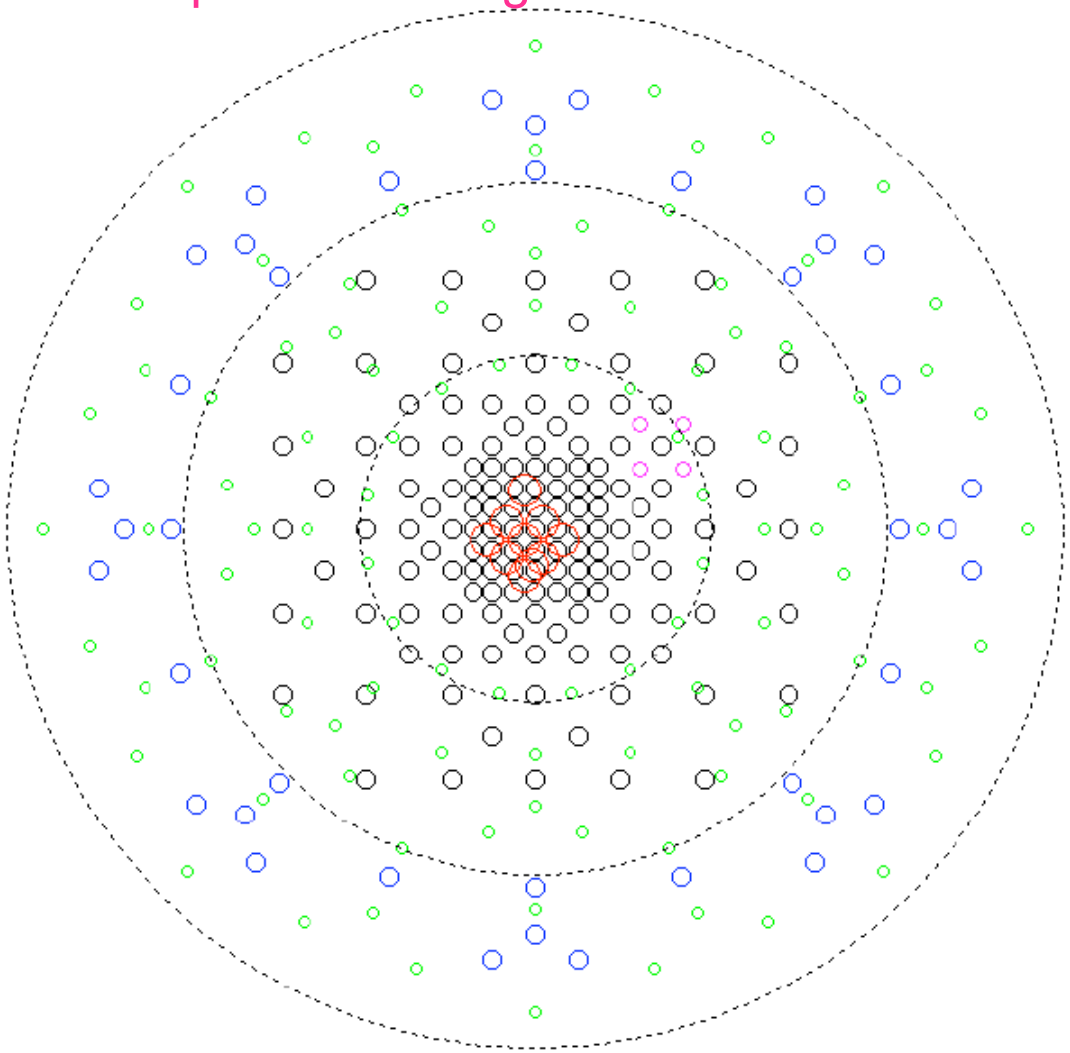
High-energy outer section
small telescopes, large f.o.v
E_{th} ~ 1-2 TeV
~0.05% area coverage
r ~ 1000 m
EHE regime of galactic sources

Medium-energy section
mid-size telescopes, medium f.o.v
E_{th} ~ 50-100 GeV
~1% area coverage
r ~ 250 m
Deep TeV sky coverage

Low-energy section
large telescopes, small f.o.v.
E_{th} ~ 10-20 GeV
~10% area coverage
r ~ 70 m
Extending spectra to low energy
AGN and pulsar physics

Optimizing detector performances : CTA MC (Monte-Carlo !) Work Package (WP)

=> objectives: simulation of air showers and detector response to find an optimized design

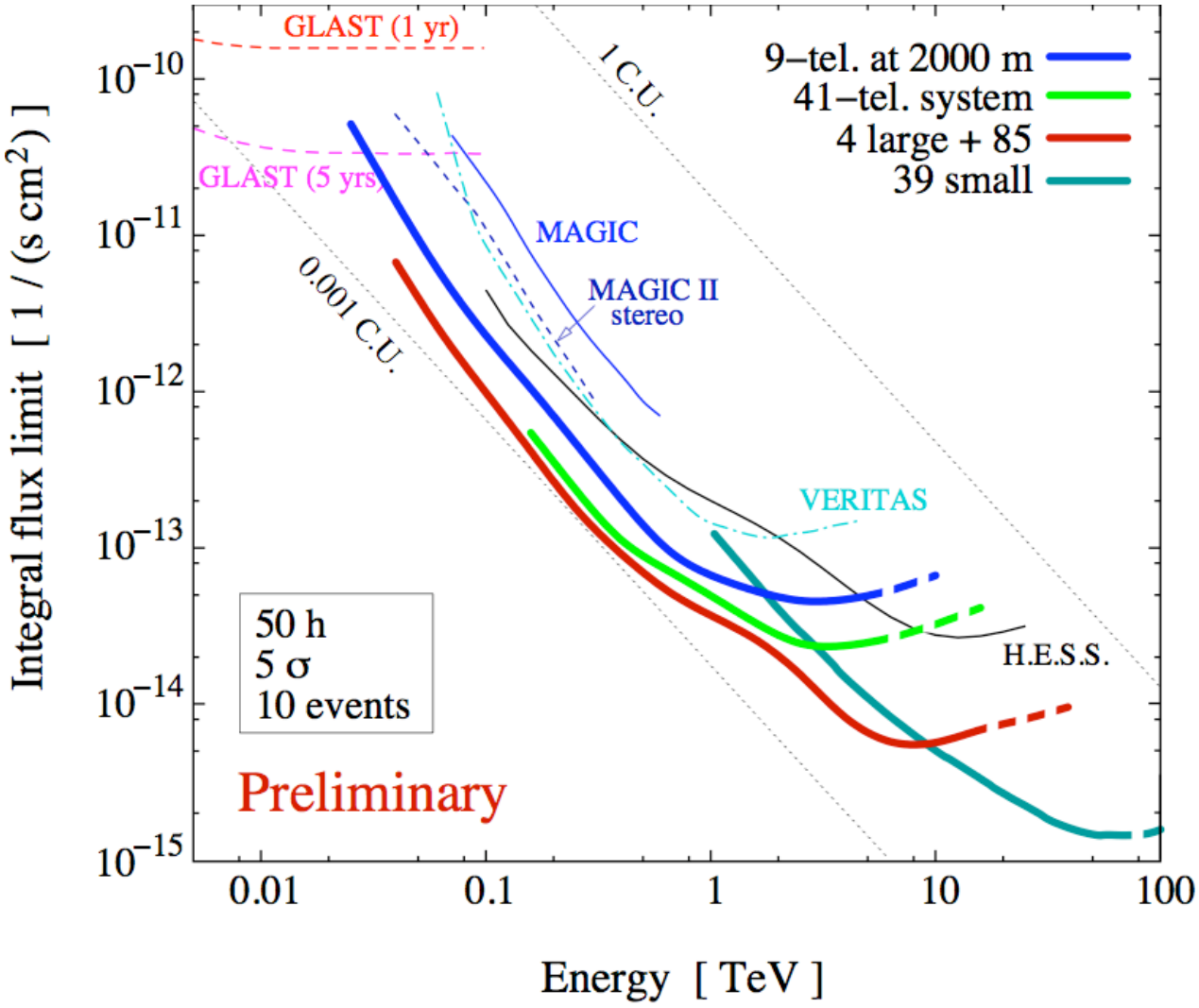


Large scale simulation of "Hyper-Array" with 275 telescopes of 5 different types, sizes, …

→ Selection of candidate sub-arrays under cost constraints
→ Study of performance
→ Assessment within the WP PHYSICS

~ 0.5 Billion events generated during last few months, using the Grid (Spain, France, Germany, Switzerland, …)
coordinated by LAPP

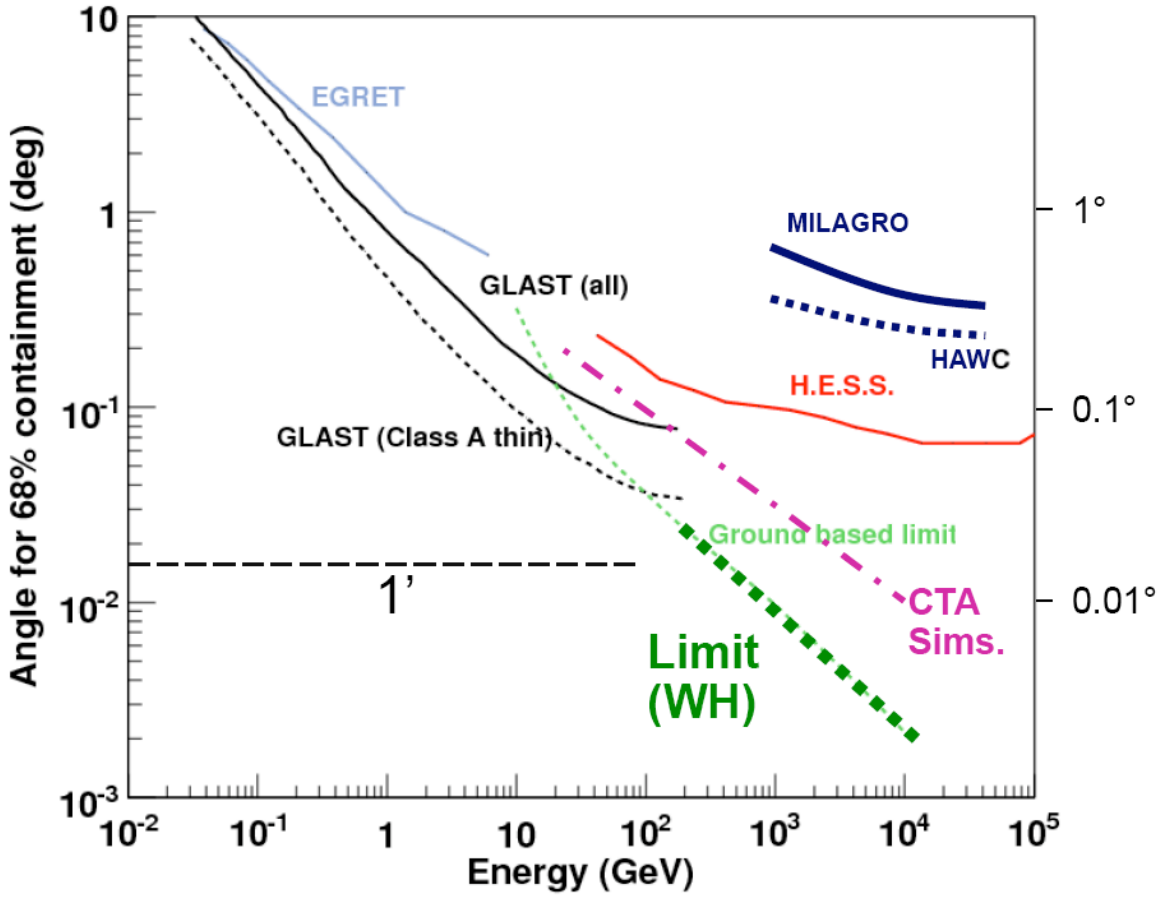
CTA WP MC: preliminary sensitivity curves



"small" = ∅14 m
"large" = ∅28 m

K. Bernlöhr, 2008, arXiv:0810.5722v1

Preliminary angular resolution predictions



Adapted from Funk et al. ApJ 679 (2008)1299

Ultimate limit from Hofmann (2006) astro-ph/0603076v2 (all Cherenkov photons detected)

Predictions on the MC detectability with CTA

(WP PHYS CR/SNR/MC group, task leader S.Gabici)

CTA will detect passive clouds if:

$$d_{kpc} < 2\,\delta\,M_5^{2/3}$$

non-universality of CR spectrum

if $\delta \gtrsim 4$ ➔ **CTA will detect active clouds EVERYWHERE in the Galaxy!!!**

Cosmic Ray Barometers!!!

CTA will probe the CR spectrum in different regions of the Galaxy ➔ **Diffusion coefficient!!!**