TenTen: A new IACT Array for Multi-TeV Gamma-Ray Astronomy

Gavin Rowell ***,Victor Stamatescu, Roger Clay, Bruce Dawson, Ray Protheroe, Andrew Smith, Greg Thornton, Neville Wild***

(University of Adelaide, Australia)

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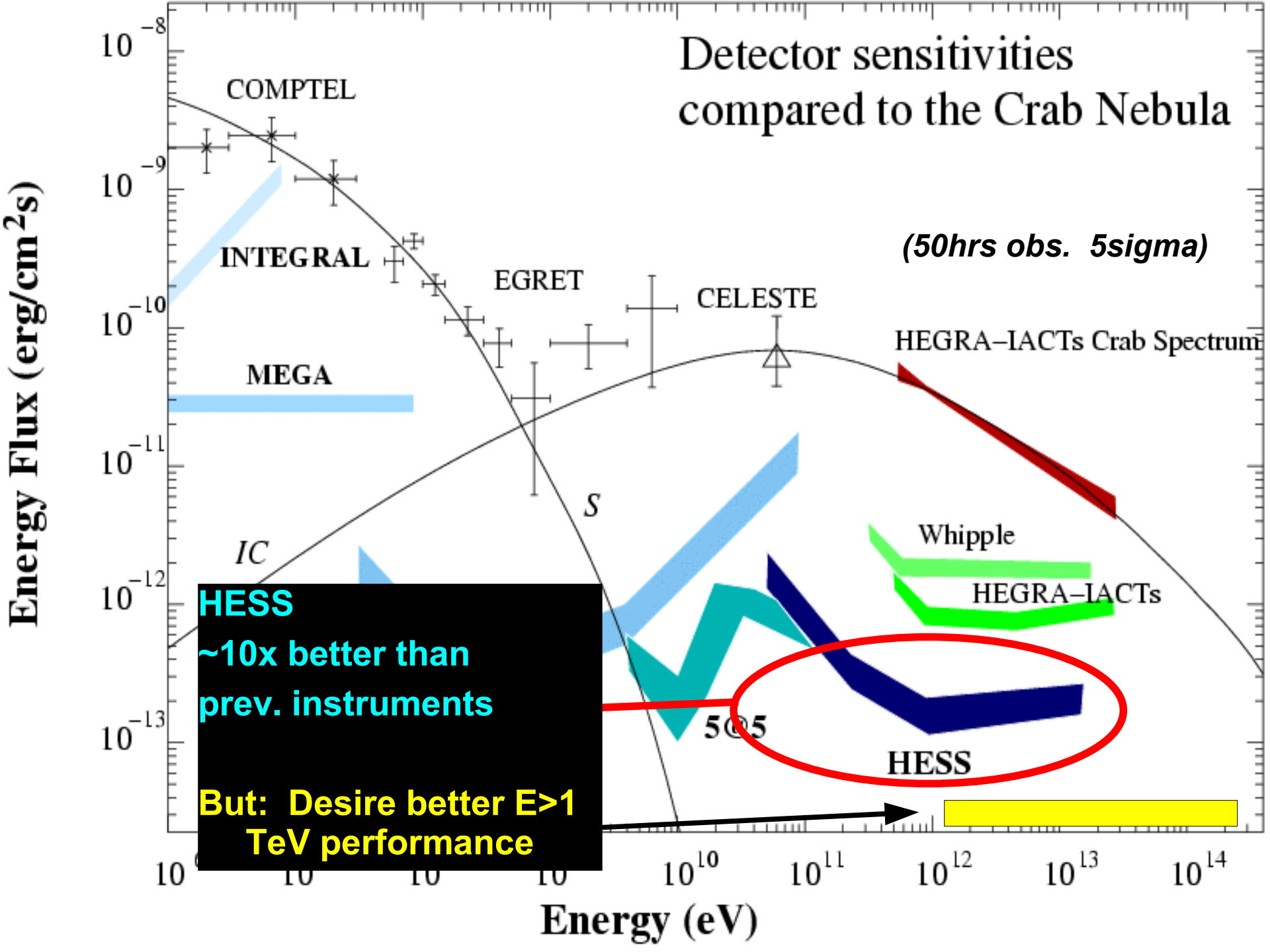
Why Consider multi-TeV energies?

- Growing number of Galactic TeV sources, most with
  hard spectra, some reaching >20 TeV --> there are definitely E>10 TeV sources
  Present instruments limited to few x 10 TeV
  E>0.1 TeV telescope programmes are packed

- Need to search for and understand Particle PeVatrons
  PeV Acceleration not well understood - Major mystery in astrophysics...
  E>10 TeV: Easier to separate hadronic & leptonic components
  (synchrotron 'cooling' of electrons & reduced IC cross-section)
  --> determine origin of parent particles in sources

.....

- E>10 TeV detection technically simple with small Cherenkov imaging telescopes & low evt rates per telescope
need >=10 km^2 collection area for sufficient statistics (few% Crab fluxes)
There is great potential for Gamma Ray telescopes dedicated to multi-TeV studies

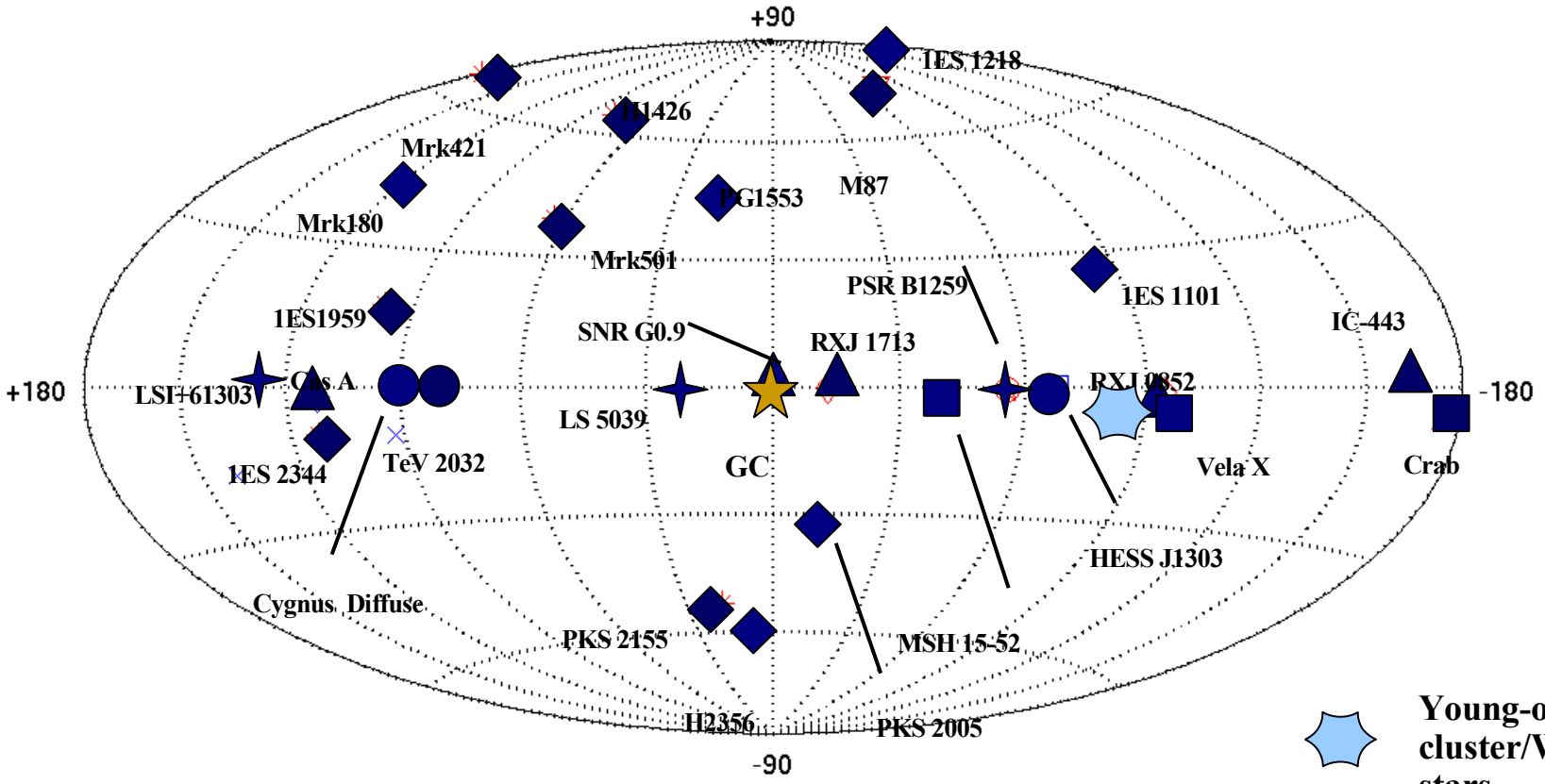

Detector sensitivities
compared to the Crab Nebula
(50hrs obs. 5sigma)
COMPTEL
INTEGRAL
EGRET
CELESTE
MEGA
HEGRA–IACTs Crab Spectrum
S
IC
Whipple
HEGRA–IACTs
5@5
HESS
HESS
~10x better than
prev. instruments
But: Desire better E>1
TeV performance
Energy Flux (erg/cm²s)
Energy (eV)

The TeV Gamma Ray Sky – today

Galactic, Extragalactic, GC, plus several unidentified

- many new source discoveries in the last 3 years

- now at least 7 source types! *Many are pulsar wind nebula (accel electrons)*



Better multi-TeV sensitivity & Large(r) FoV needed

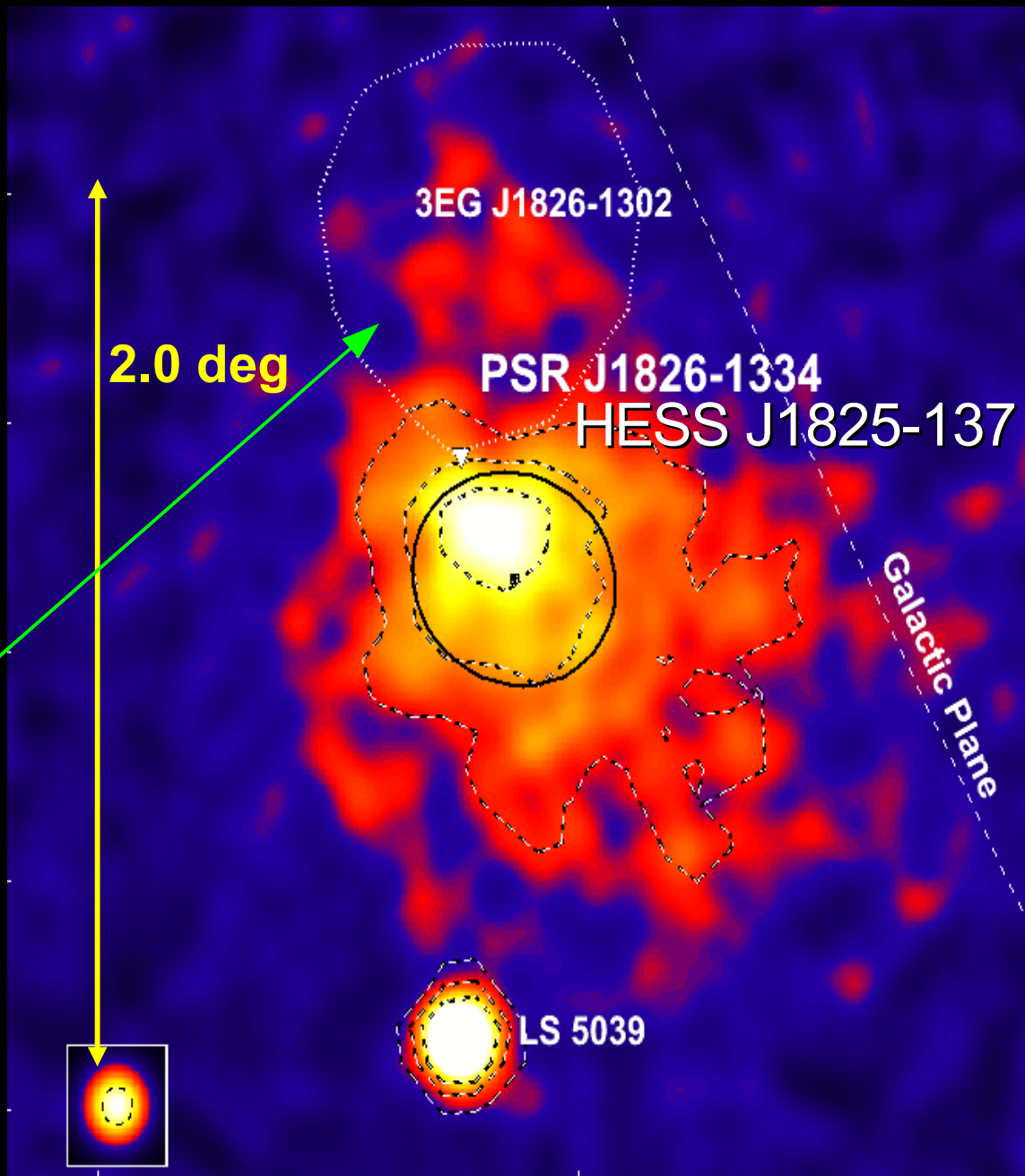
Complex source structures & strengths

- extended & pointlike
- strong & weak

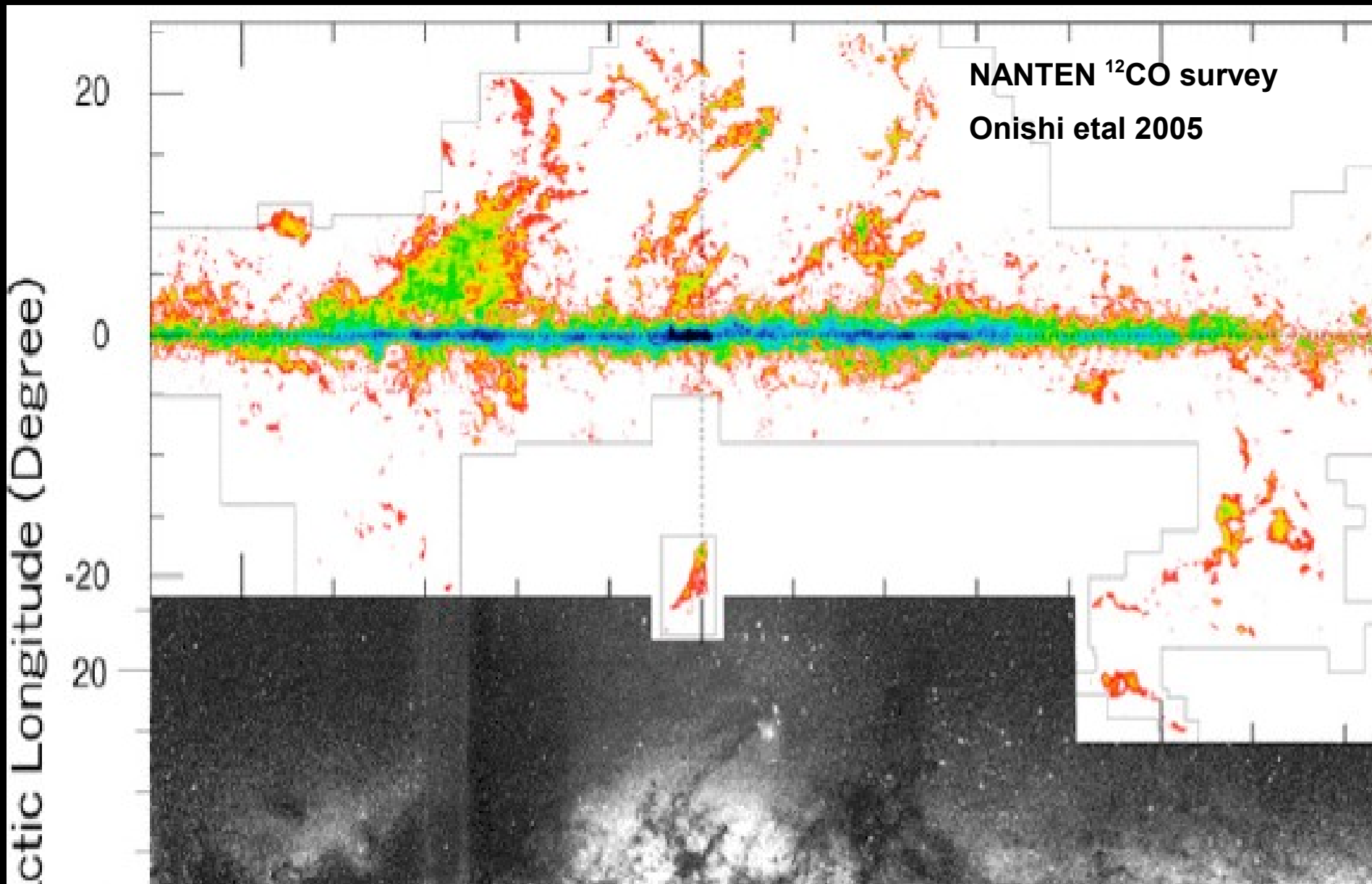
HESS J1825-137 Field after ~60 hrs observation

New, weak source appears

HESS cannot study this source any further



As we probe deeper --> can expect TeV gamma-ray sources to mimic galactic gas structures (scale ~few deg)



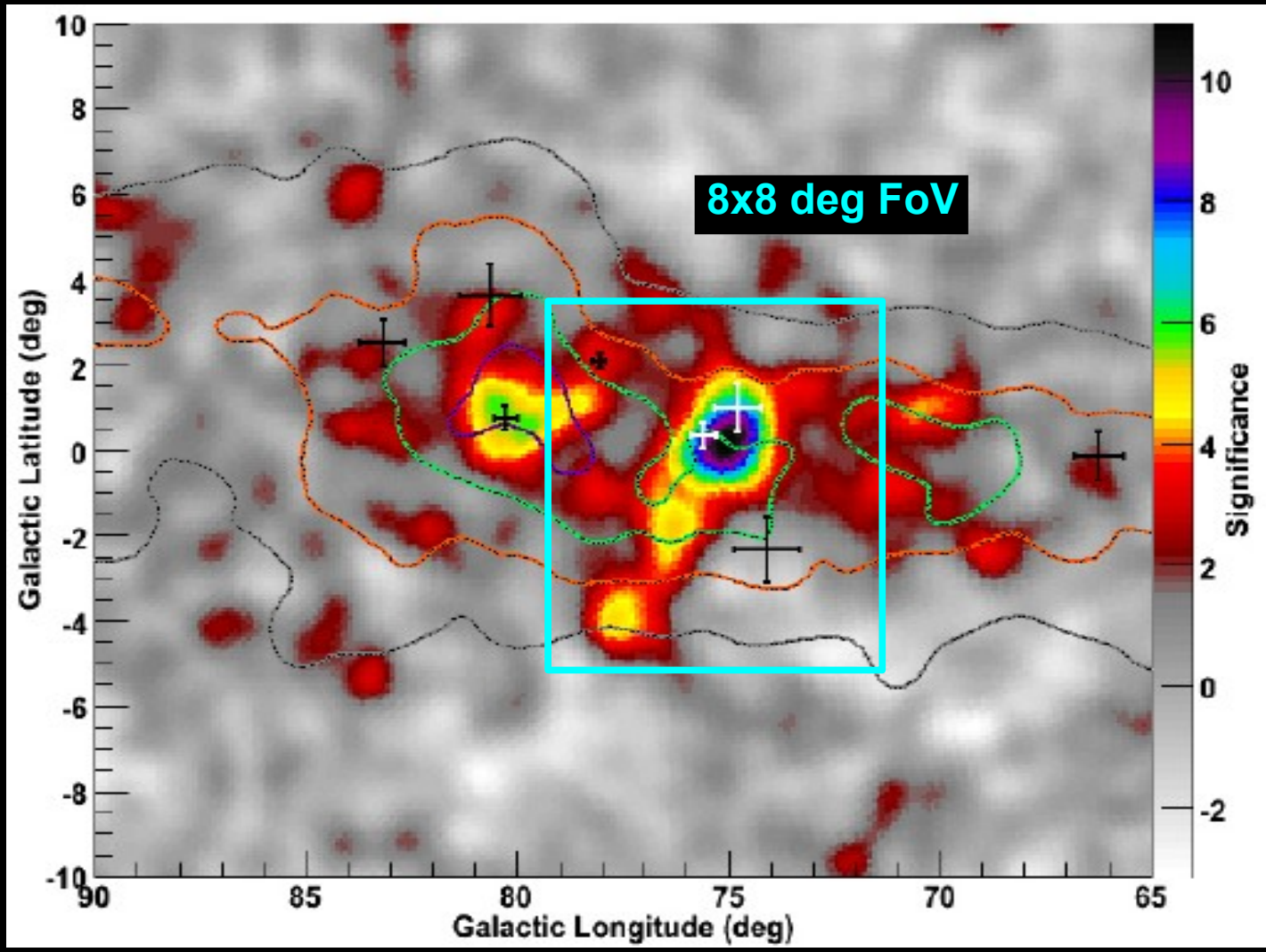
MILAGRO: Diffuse TeV from the Cygnus Region

Abdo etal 2006

E_{median} ~12 TeV

contours matter density

HI (Kalberla etal 2005)
CO (Dame etal 2001)

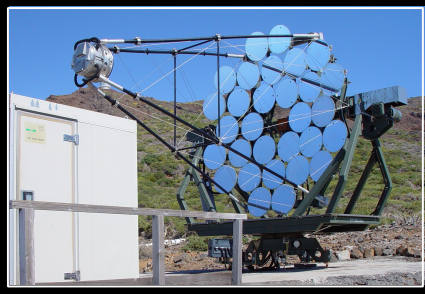


> 8x8 deg FoV of TenTen is fine for detailed studies of large-scale sources

TenTen concept

based on Plyasheshnikov et al. (2000)

Key Aim: Photon Statistics from huge collection area



eg. HEGRA IACT System Telescope

Requirements 4 or 5 telescope 'Cell'

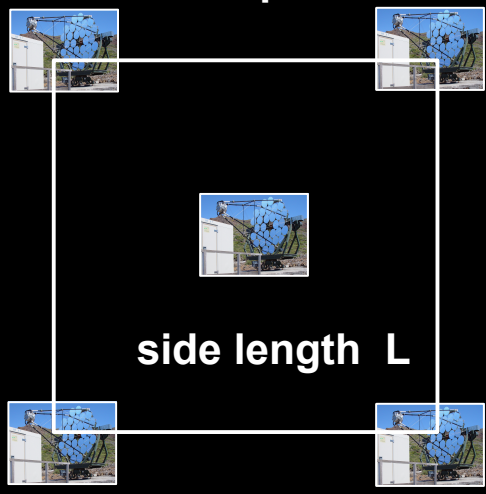
- Smaller mirror area/size (~10-30 m^2) HESS ~100 m^2
- Larger camera field of view (8°-10°) HESS ~5°

(image impact parameters > 250m)

- Larger telescope spacing (L >200 m) HESS 120 m

(see also de la Calle Perez 2006, LeBohec etal 2006, Yoshikoshi 2005)

Telescope Cell



Extend to ~10 x Cells

10 km^2 at E >10 TeV ---> *'TenTen'*

and >1km^2 at ~1 TeV

x 5-10 better flux sensitivitiy than H.E.S.S.

Sites: Sea-level altitude obs. is fine for E>10 TeV

--> *Australian sites*

Simulation Study

`corsika v6.204 & sibyll` EAS simulations
30deg zenith angle gammas, protons 1-10, 10-100 TeV

`sim_telarray` tel & electronics simulation K. Bernloehr

Initial study (comparator, 20ns (F)ADC gate width....1-2ns rise/fall, ray-tracing)

results see Adelaide Workshop webpage

http://www.physics.adelaide.edu.au/astrophysics/pev_workshop/index.html

6 metre diam mirror f/1.5 23.8 m^2 200 m a.s.l.

12 p.e. @ 2 pix next-neighbour 0.25deg pix x 1024 8.2 deg FOV

60 p.e. image SIZE

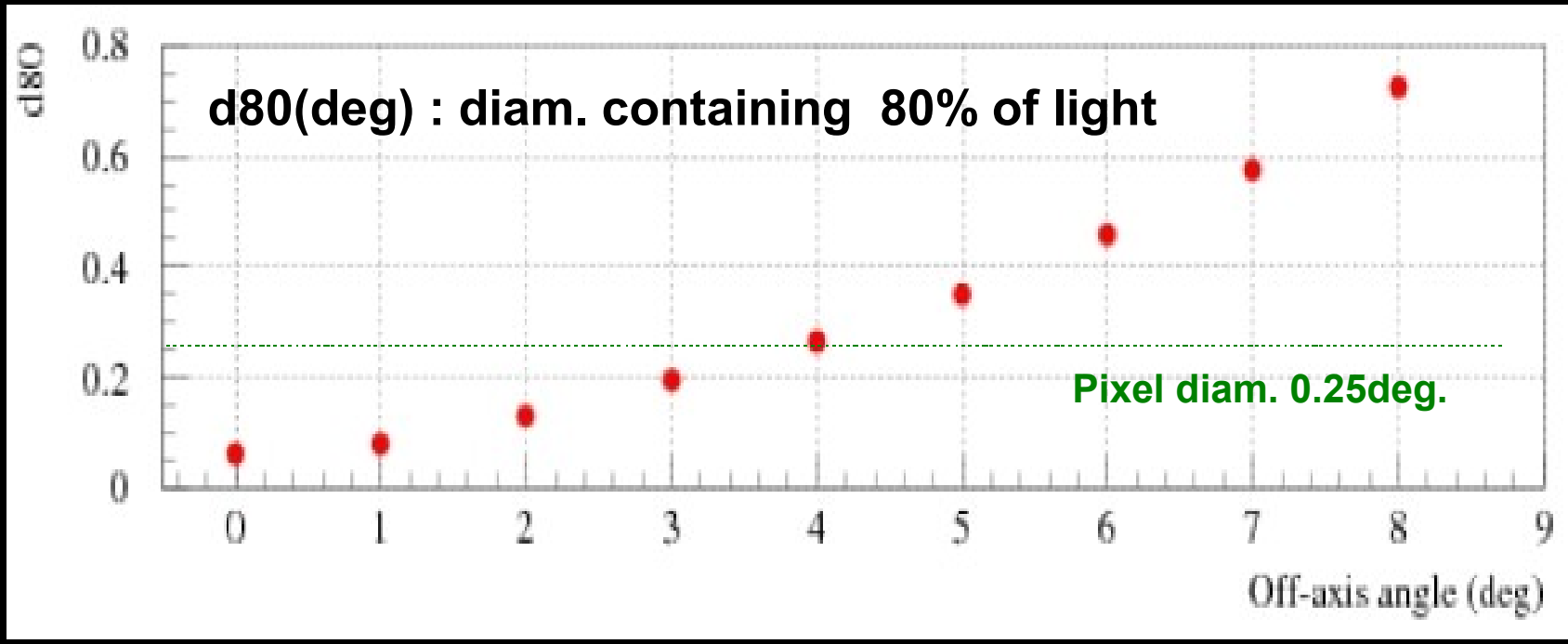
dis < 3.5 deg

ntels >= 2 (stereo analysis)

Telescope Optics – 84 x 60cm diam mirror facets

D = 6m, f/1.5 Elliptic dish shape $\delta = 5.0$, r = 0.85f

(see eg. Schliesser et al 2005 Astro.Part Phys. 24, 382)



with mirror canting (on-axis rays at focus)

tessellation ratio 0.1 = mirror / dish

d80 : diameter containing 80% of light

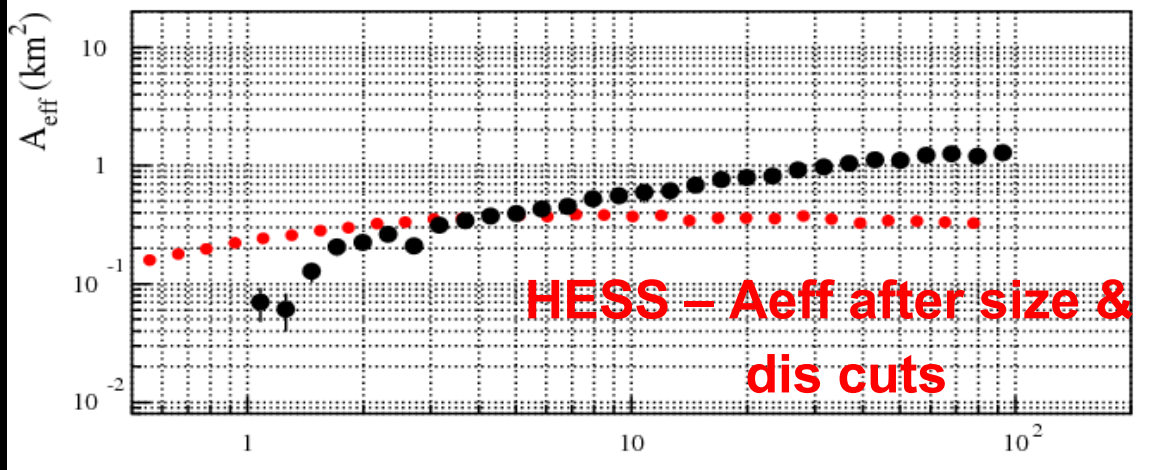
8 deg FoV possible

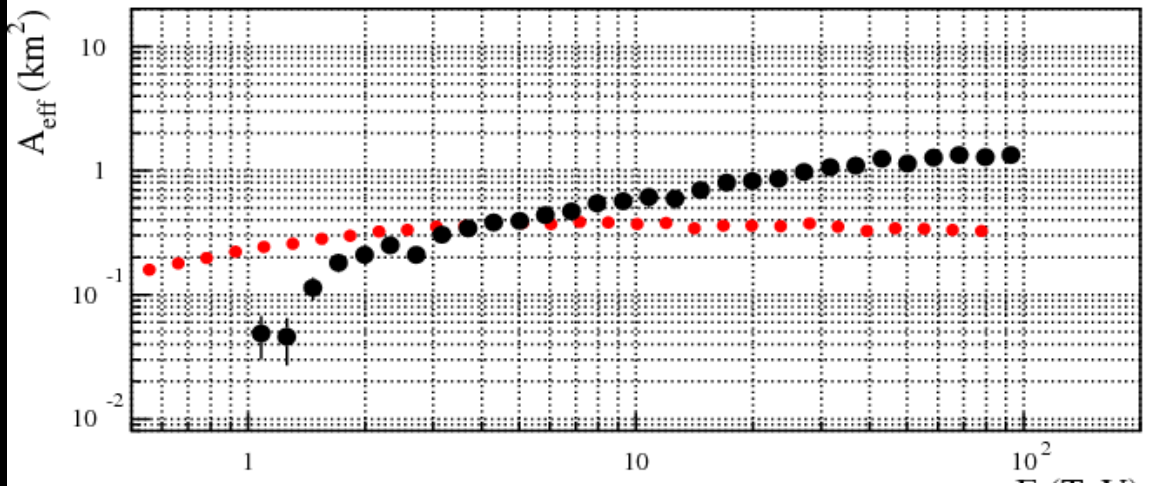
Effective Areas (Aeff)
6 metre dish 200m a.s.l

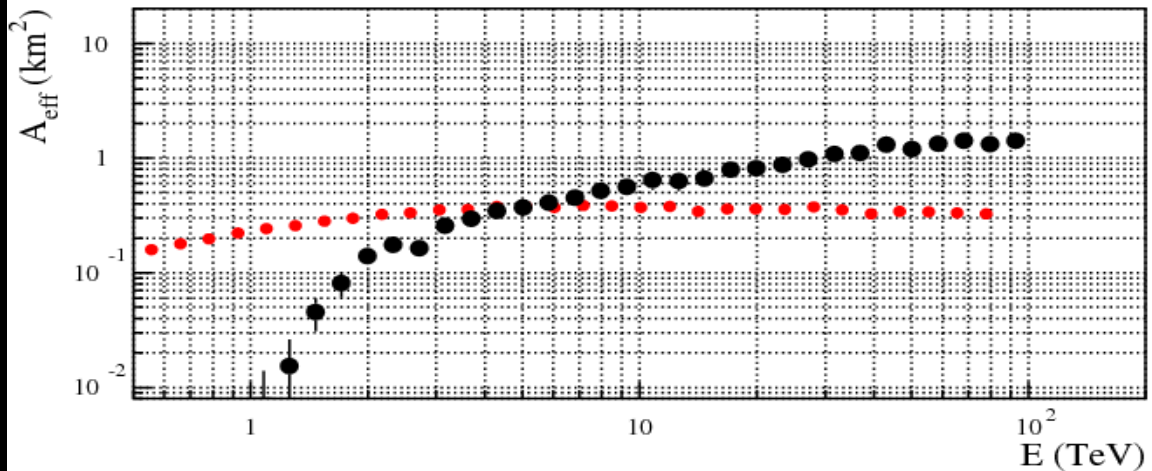
L=200m

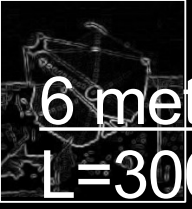
L=300m

L=500m





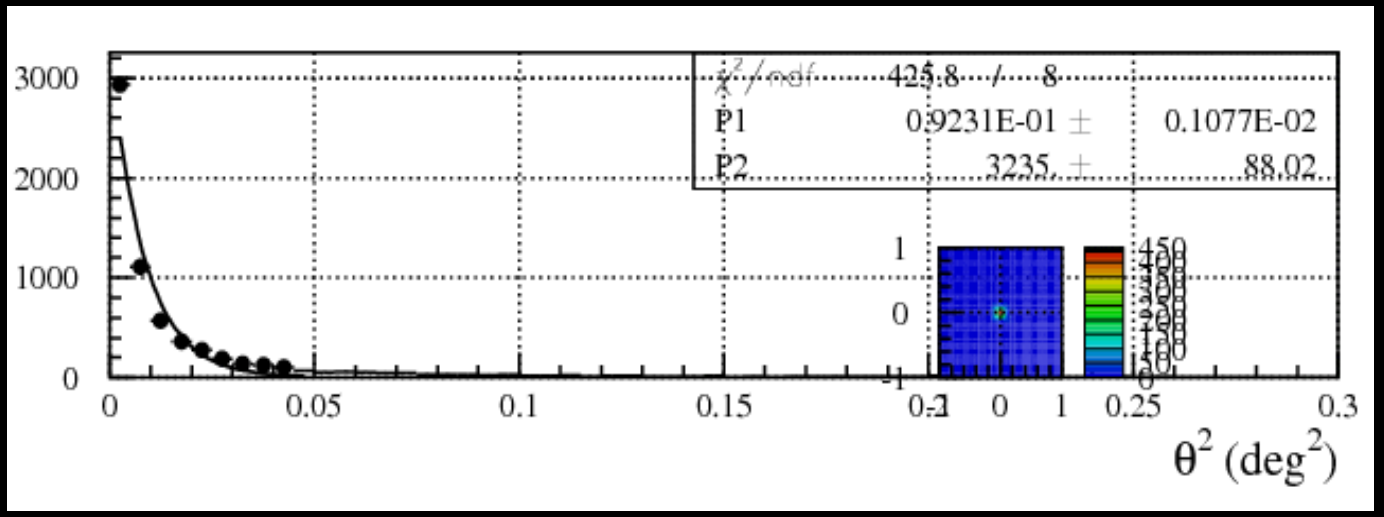


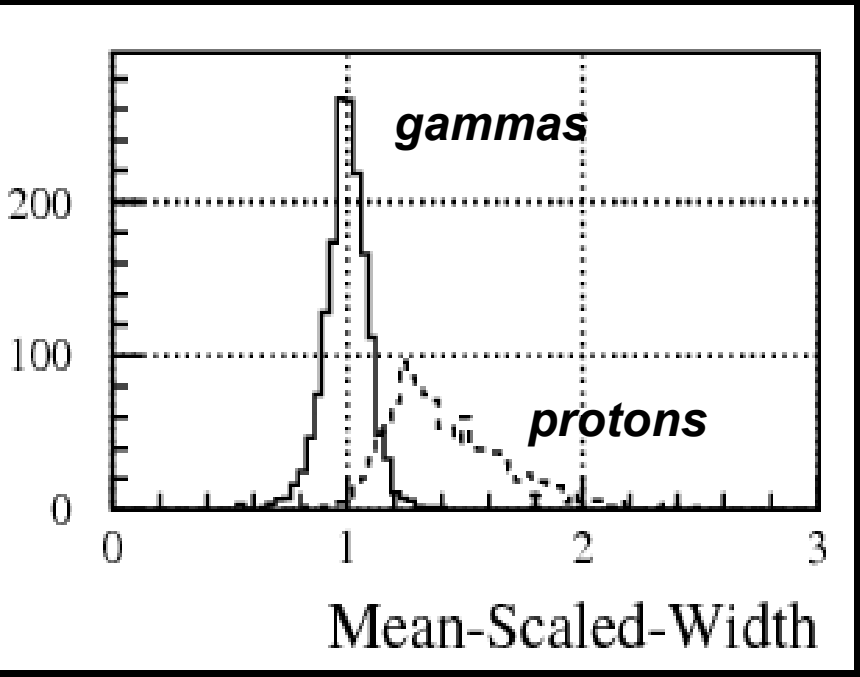


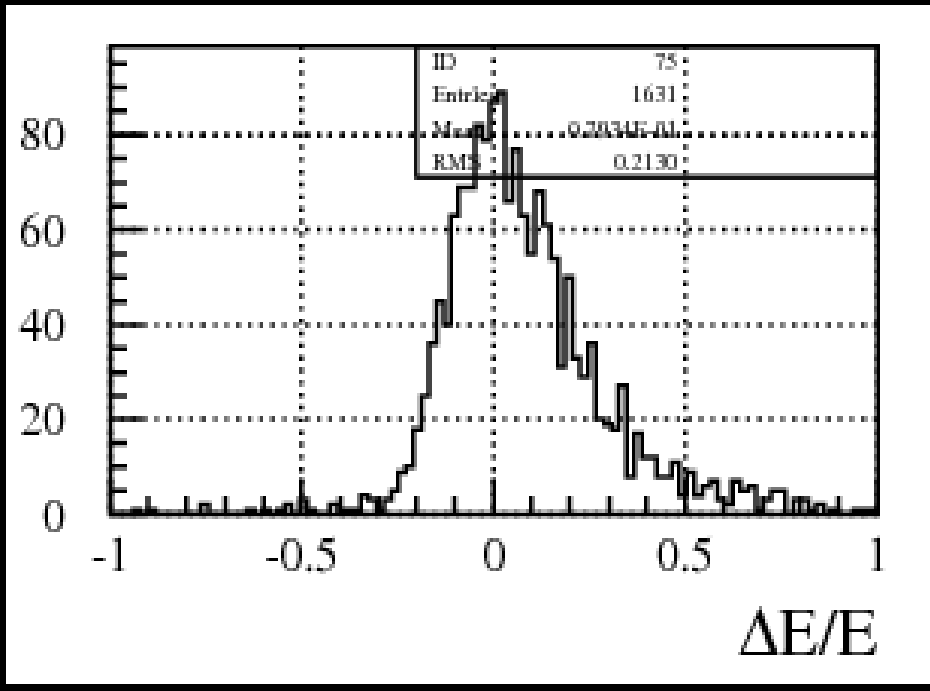
6 metre dish
L=300m

similar to H.E.S.S & HEGRA

Ang. resolution







True Shower 'Core'

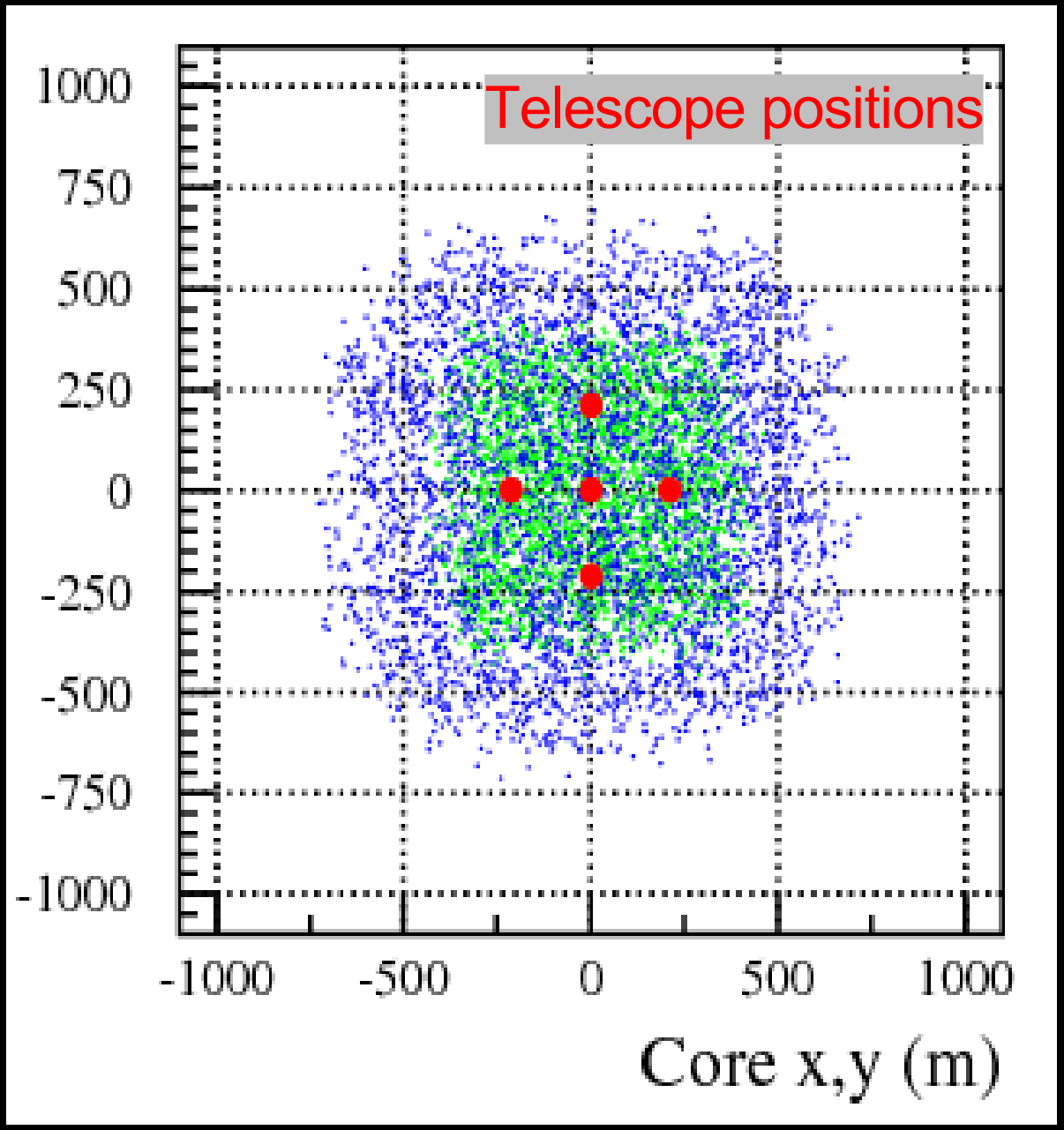
6 metre dish

L=300m

Energy 1-10 TeV

Energy 10-100 TeV

Core resolution
RMS <20 metres



Extend to Multiple Cells

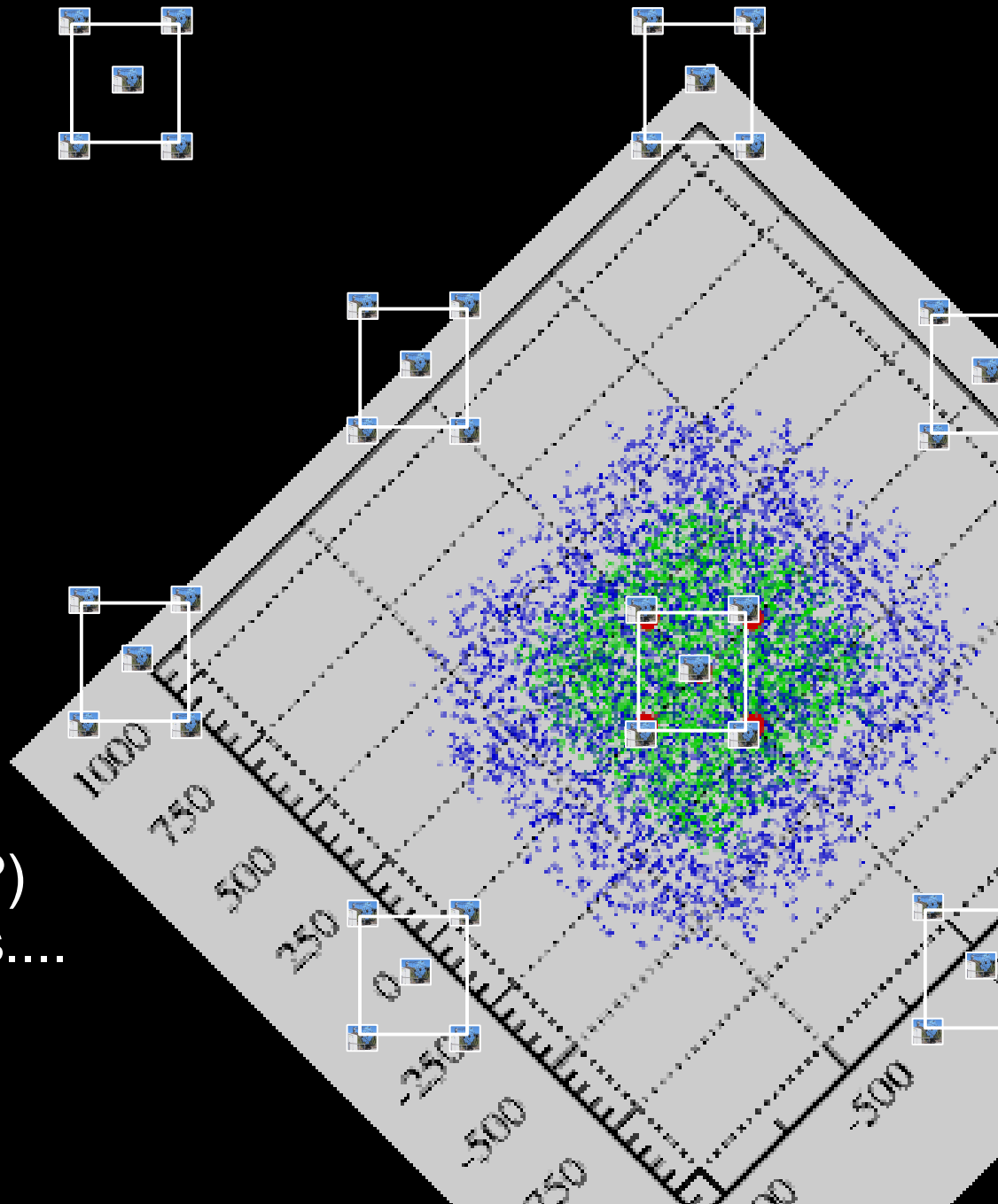
Maximal Effective Area

- 1-10 TeV
Lower energy events

- 10-100 TeV
Higher energy events

Aeff ~ N x Aeff $_{cell}$

Intercell spacing (~1 km?)
optimised via simulations....



Current Activities

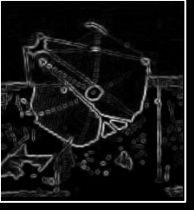
- Timing of large core distance images
  wide FoV = large core distances (<~ 400 metres)

  Electronics concepts, PMTs

- Telescope trigger & cell spacing L
  NSB simulation & accidentals

- Alternative optics eg. Vassiliev etal 2006
  Primary+secondary optic --> small focal plane scale
  --> small Multi Anode PMTs
  1000 pixels < 3kg (Hamamatsu H8500 8x8 @ 6mm pixels)

- Site surveys in Australia



The *TenTen* Concept: Summary

Initial Simulation Study

5-telescope Cell - 300 m spacing 6metre dishes 200m a.s.l.

Area ~ 2 TeV ~0.2 km^2

~ 10 TeV ~0.6 km^2

~100 TeV >1 km^2

Ang, Energy resolution similar to HEGRA, HESS: - confirms earlier studies Plyasheshnikov et al. (2000)

Extend this to 10 or more cells aiming for 10 km^2 above 10 TeV (for independent cells) --> TenTen array few TeV – few 100 TeV range

- Optimisation studies underway

- Observational & Astrophysical motivation is clear

- Can be done NOW! Using established ideas