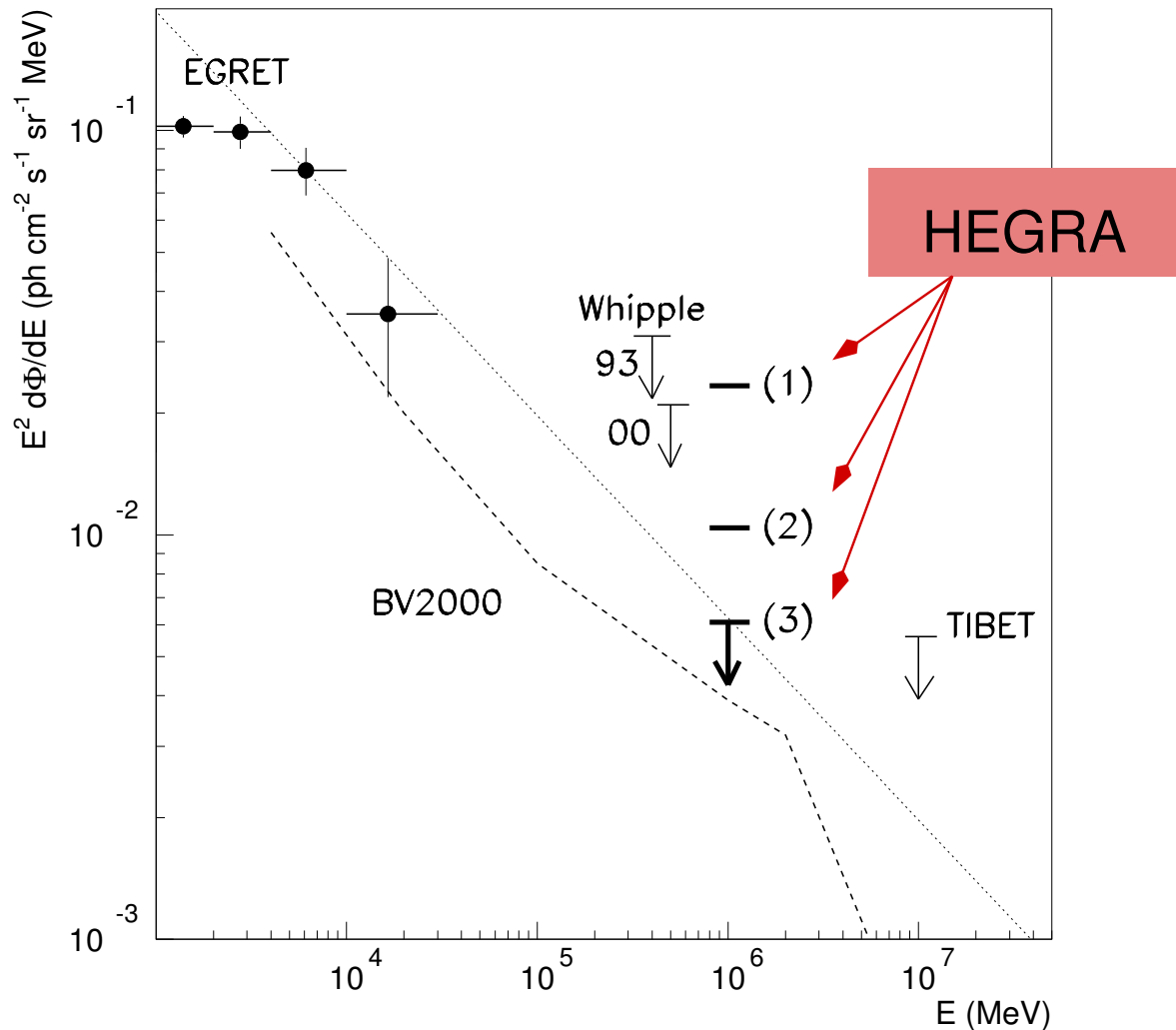


Diffuse emission at TeV energies – Observations with the HEGRA telescopes



HEGRA results:

Aharonian et al., A&A 375, 2001

Whipple (00) results:

LeBohec et al., ApJ 539, 2000

GCR & SCR modeling:

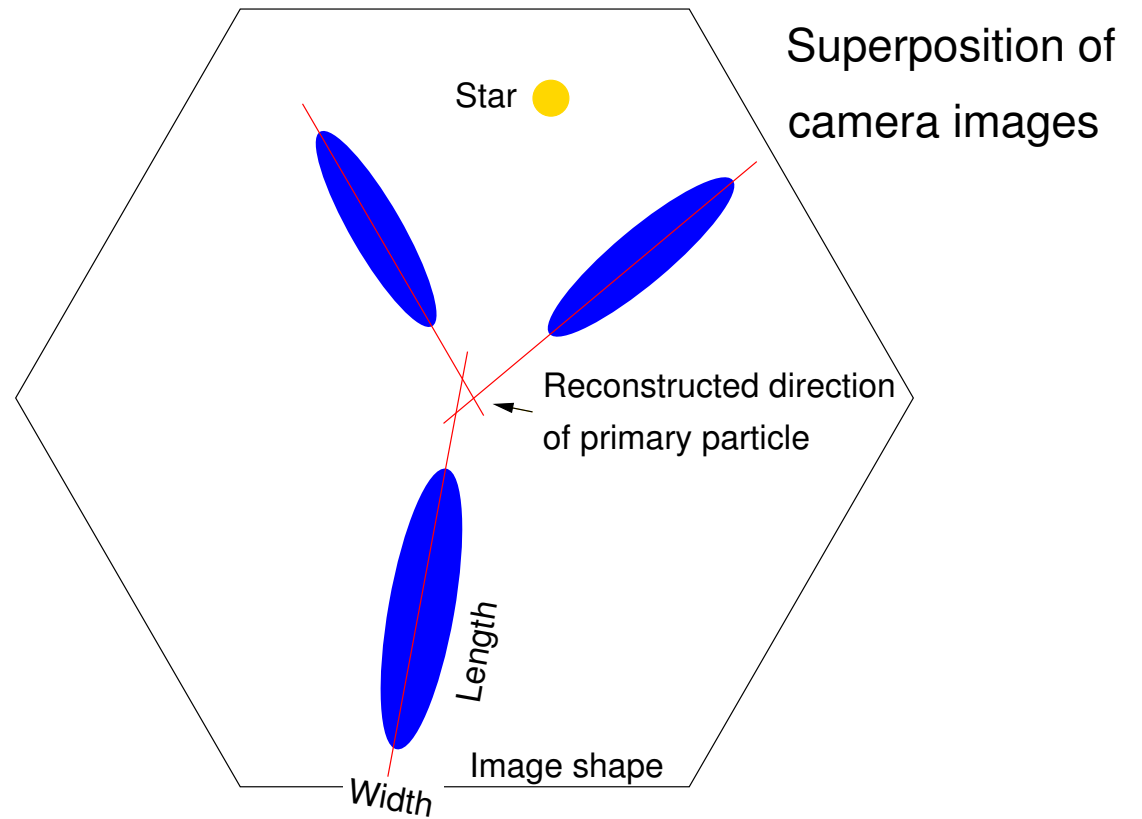
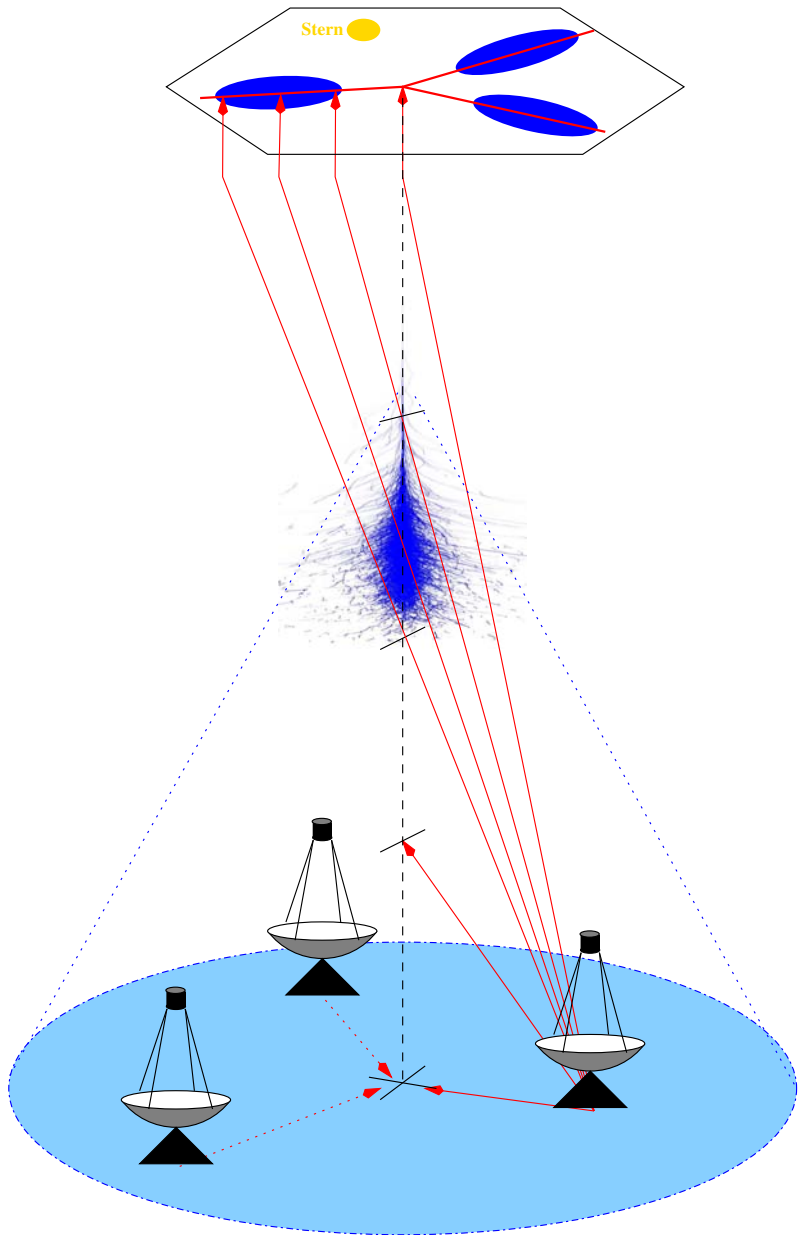
Berezhko & Völk, ApJ 540, 2000

Berezhko & Völk, ICRC 2003, p. 2433

Overview

- Imaging atmospheric Cherenkov technique
- The HEGRA IACT system
- Results from TeV measurements at Galactic longitude $l=40^\circ$
 - the HEGRA Galactic latitude scan
 - analysis techniques
- The impact of TeV measurements

The imaging atmospheric Cherenkov technique



primary direction

$\sim 0.1^\circ$

shower core

~ 10 m

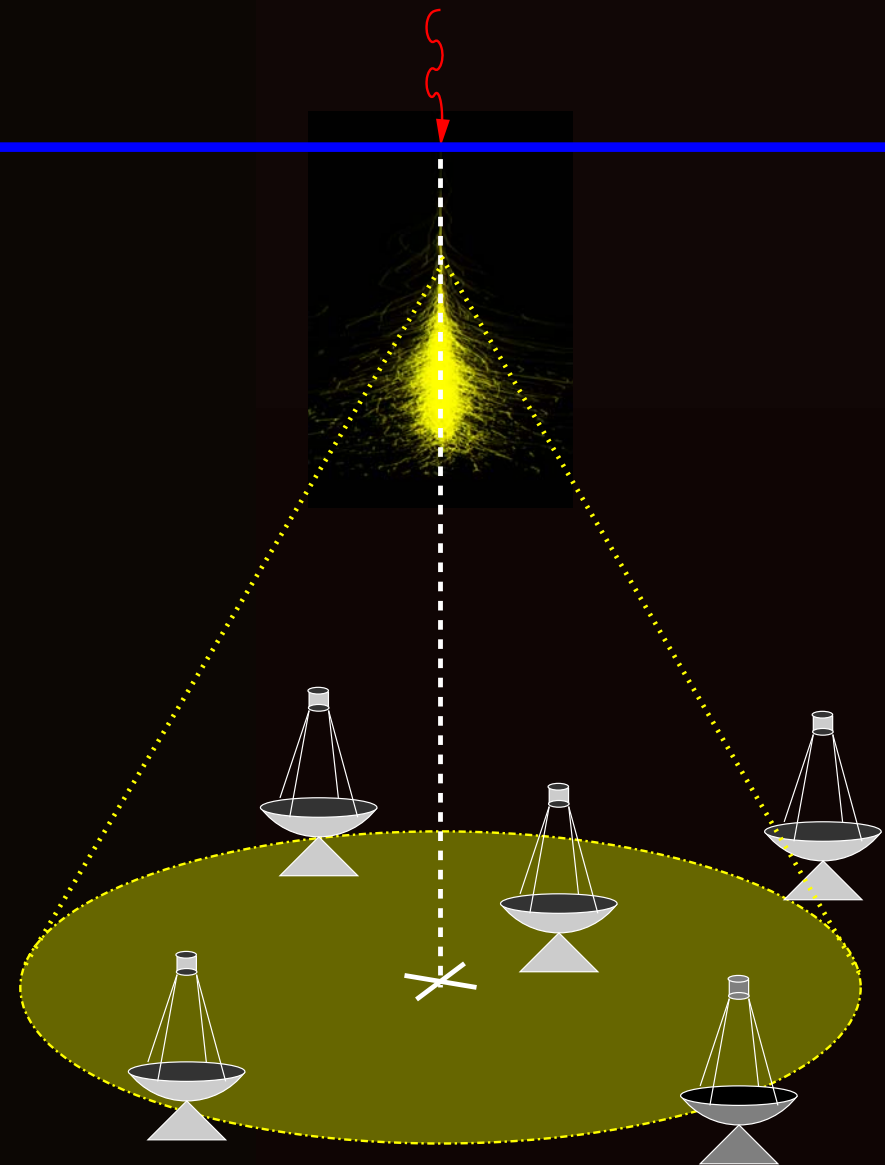
energy

10% – 20%

The HEGRA IACT system



system of 4 (later 5) 8.5 m² dishes
located on the Canary island La Palma
operational between 1997 and fall 2002



angular resolution: 0.1°
energy resolution: 10..20%
energy threshold: 500 GeV (zenith)

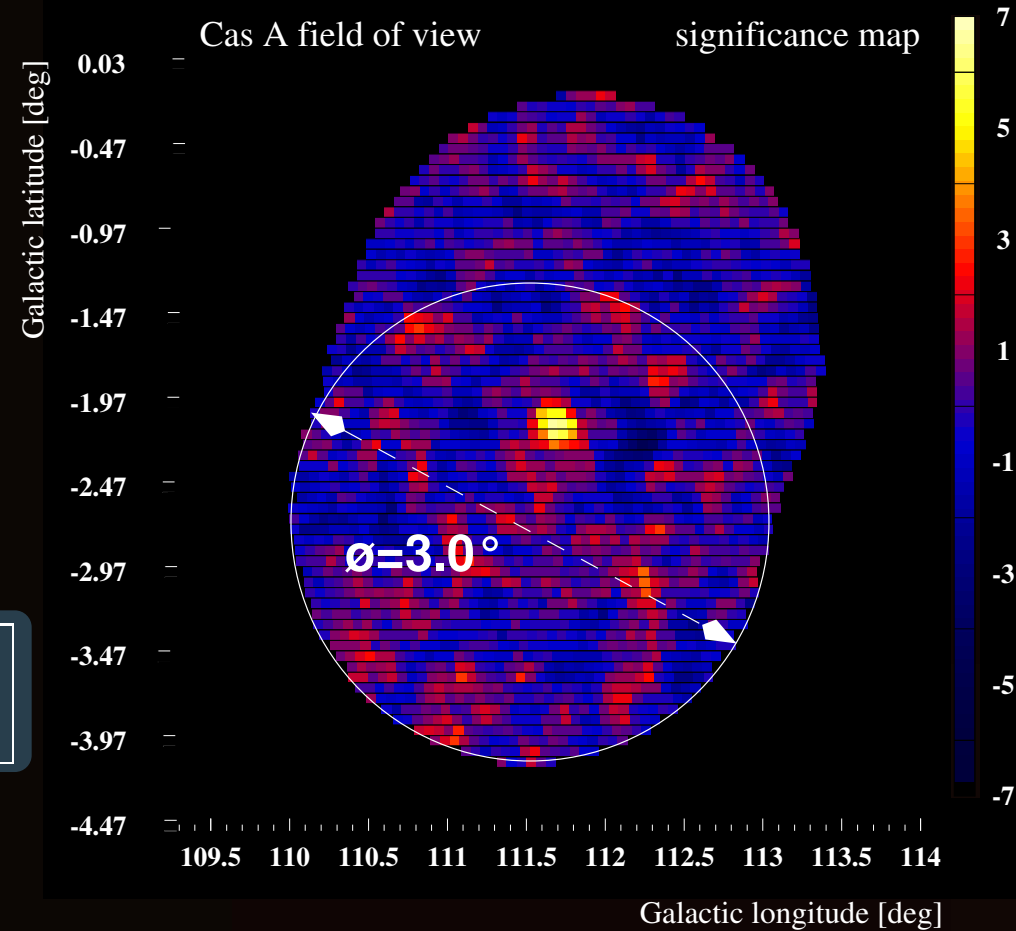
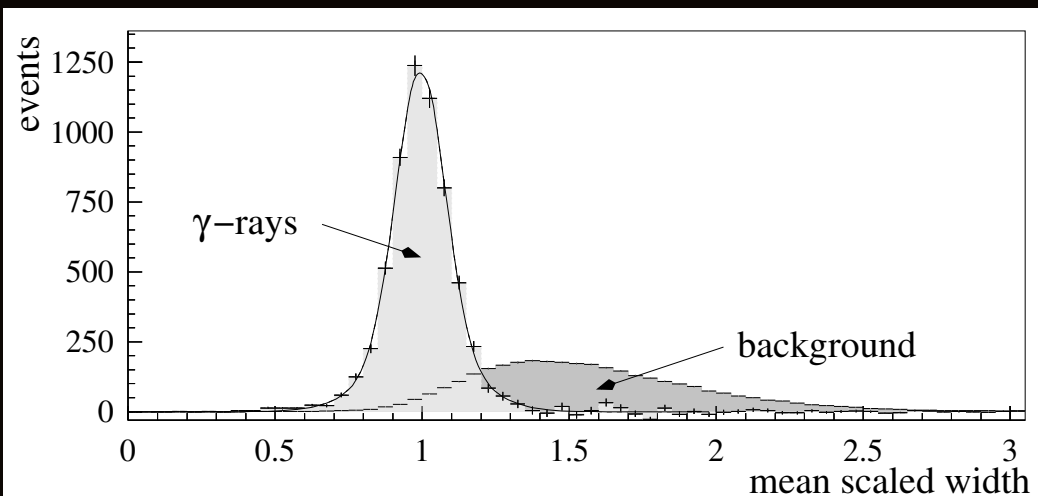
Properties of the HEGRA IACT system

angular resolution	per event:	median = $0^{\circ}09$
field of view	homogeneous γ -acceptance:	$\odot = 2^{\circ}$
	> 50% of peak γ -acceptance:	$\odot \simeq 4^{\circ}$

point sources are well contained in FoV

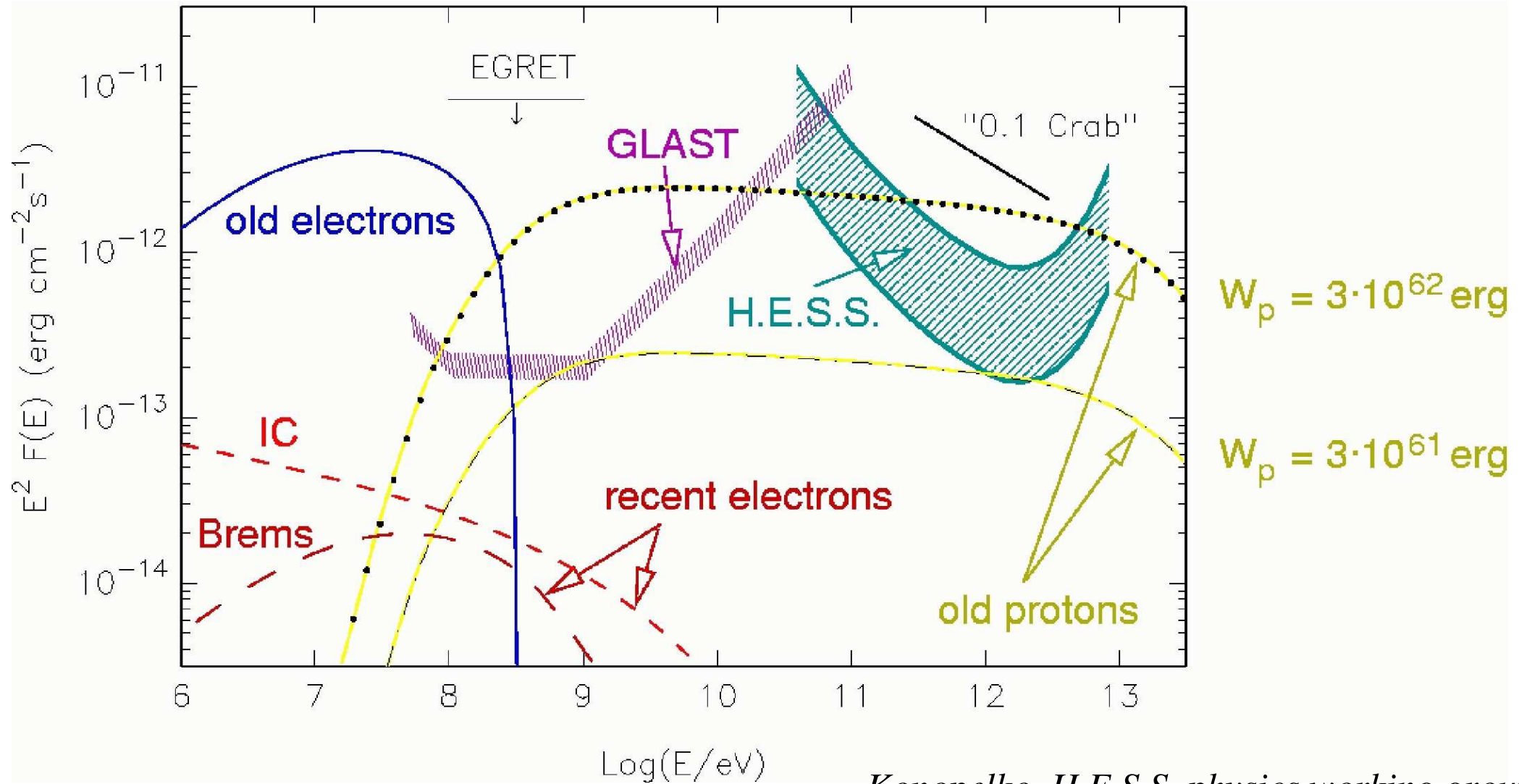
other parts of FoV can be used for background determination

flux sensitivity	quasi background-free, $t < 1$ h:	$0.3 \text{ Crab} \times (t/1 \text{ h})^{-1}$
	background dominated, $t > 1$ h:	$0.03 \text{ Crab} \times (t/100 \text{ h})^{-1/2}$



weak sources can only be detected after strong background suppression

Sensitivity to point sources and extended sources

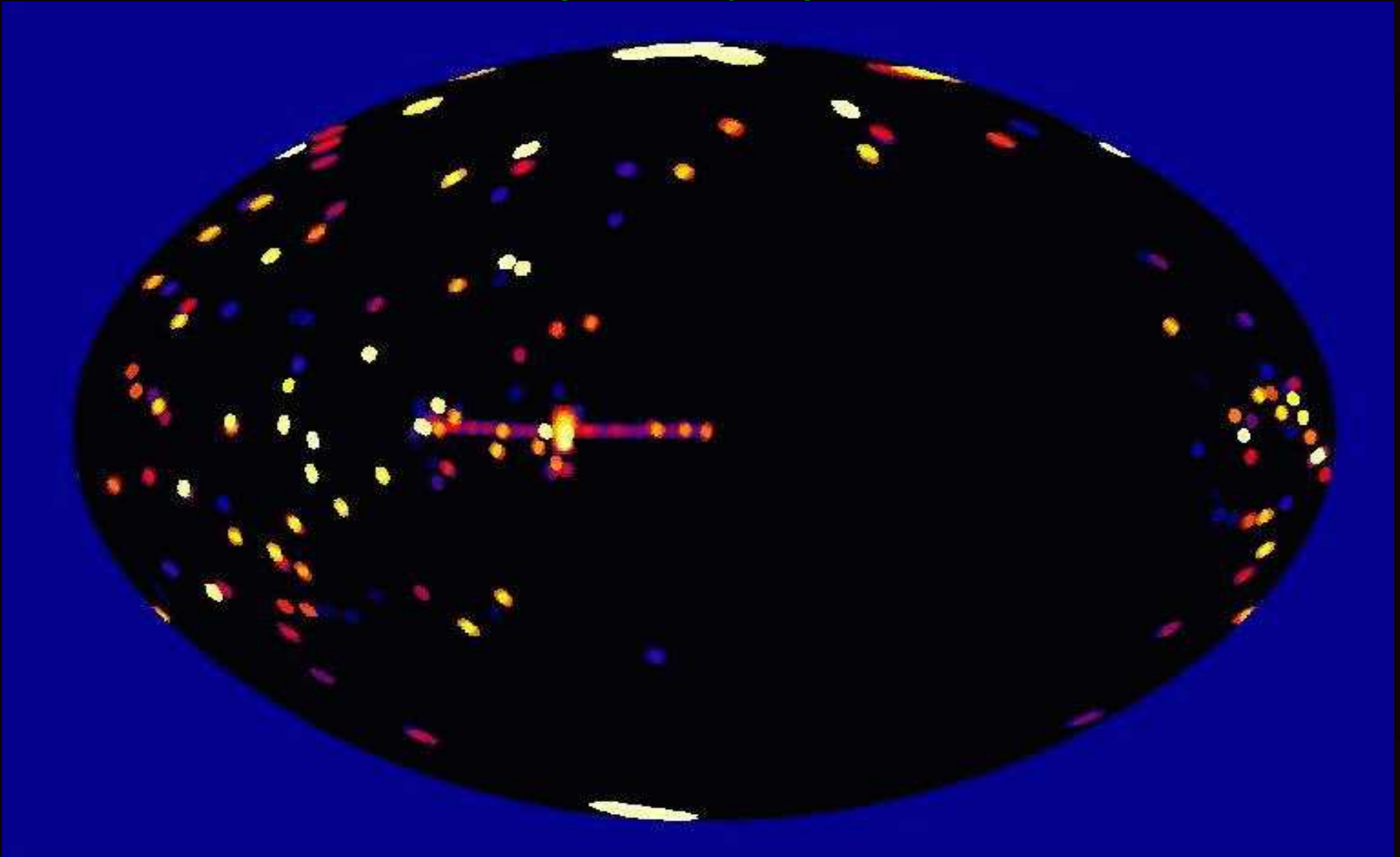


Konopelko, H.E.S.S. physics working groups

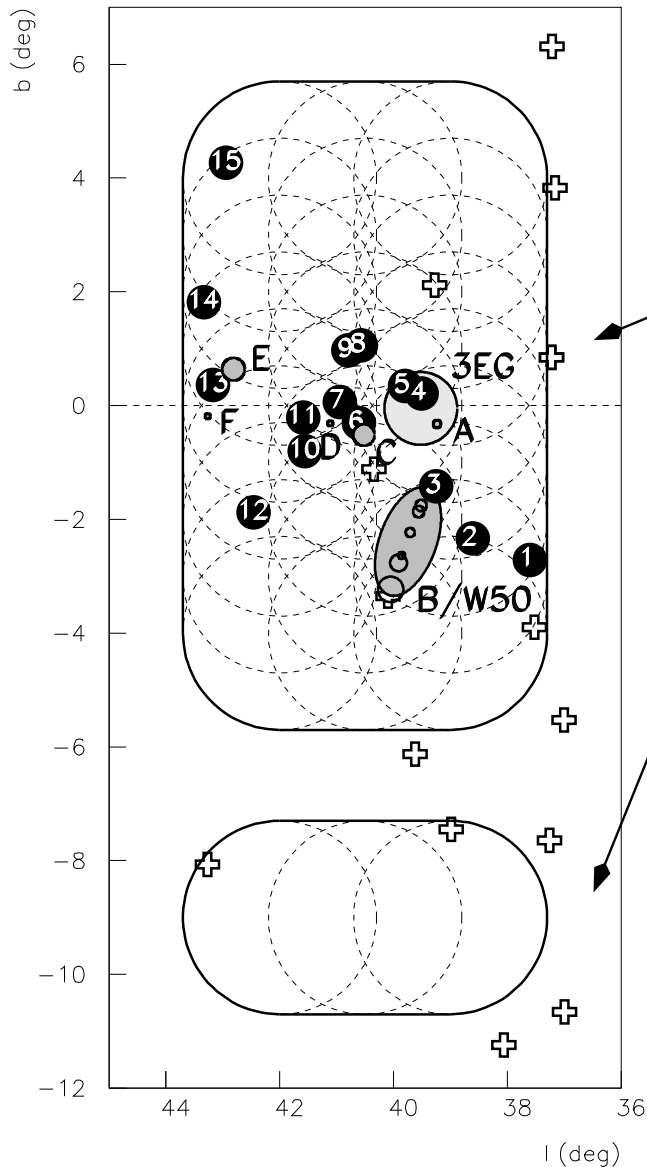
for TeV Cherenkov detectors: $\sim R_{\text{source}}$

The TeV gamma ray sky: HEGRA exposure time

HEGRA IACT Exposure Sky Map Above 500 GeV



The HEGRA Galactic latitude scan



HEGRA system:

41.7 hrs scan, zenith angle $\sim 30^\circ \rightarrow E_{\text{thr}} \sim 900$ GeV

4.1 hrs @ control region

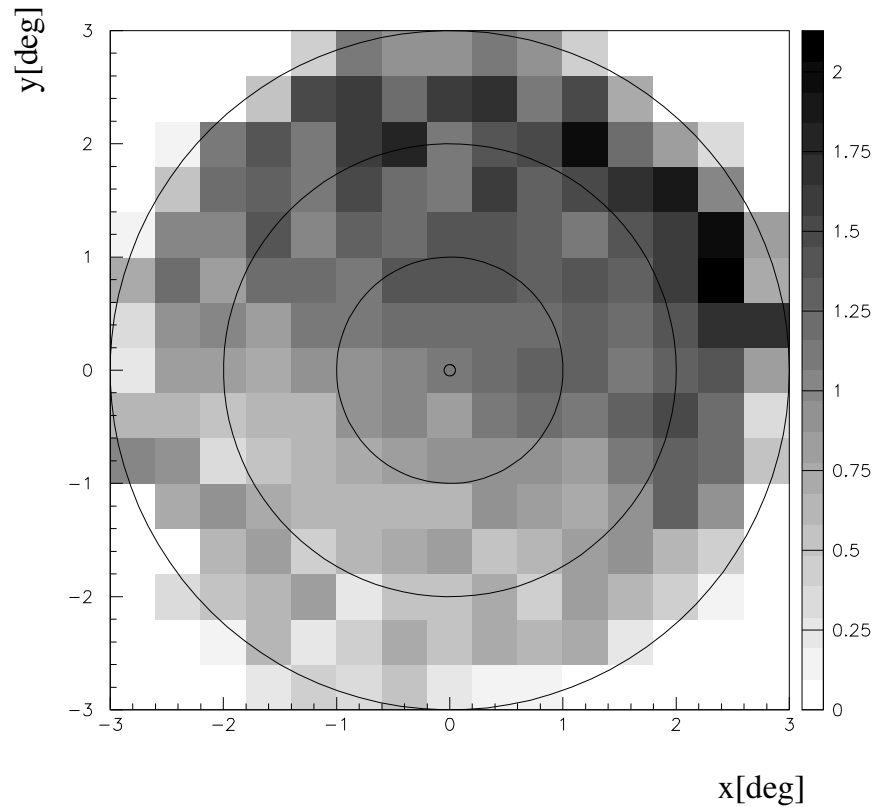
Whipple (00):

7.9 hrs on $b=0^\circ$, 7.9 hrs off data

(4.7/4.7 hrs @ 500 GeV, 3.3/3.3 hrs @ 700 GeV)

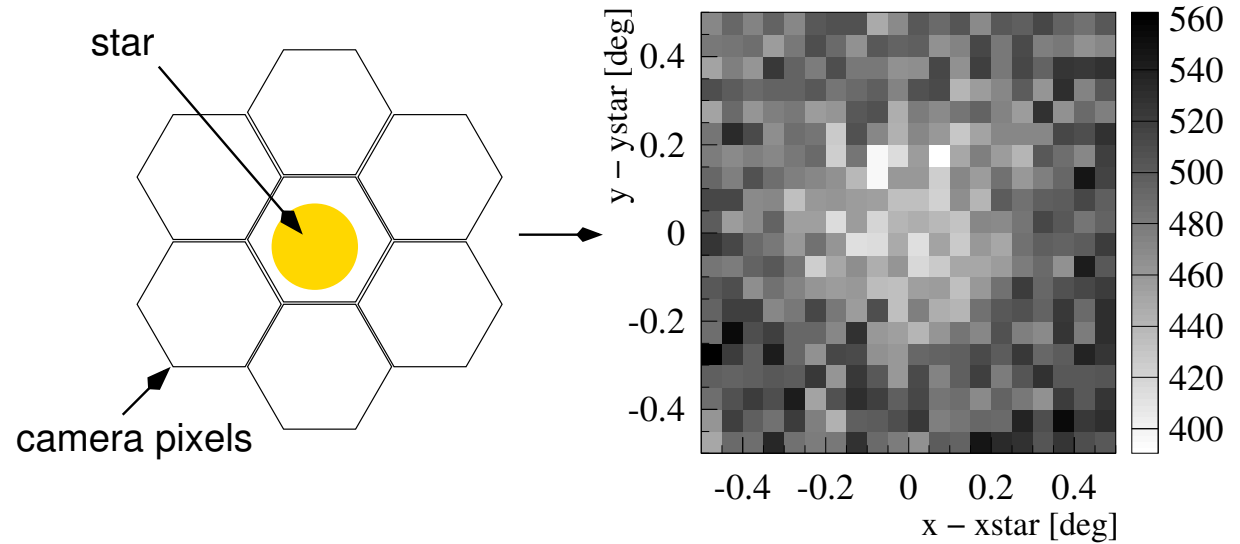
Acceptance calibration across the FoV with BG events

Whipple



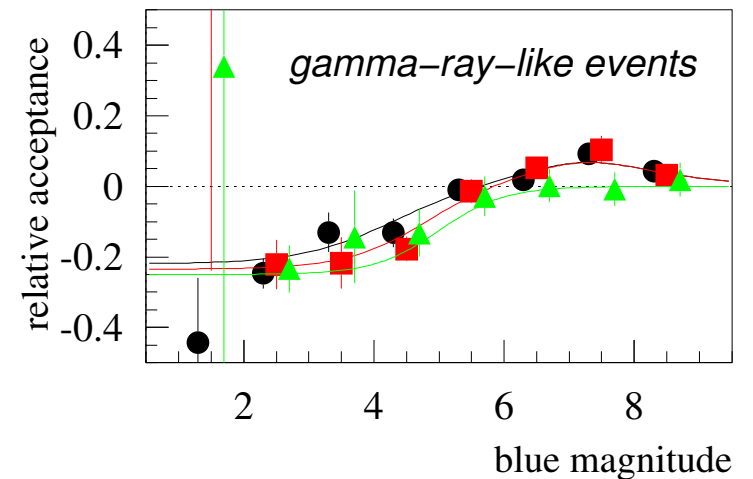
LeBohec et al., ApJ 539, 2000

HEGRA



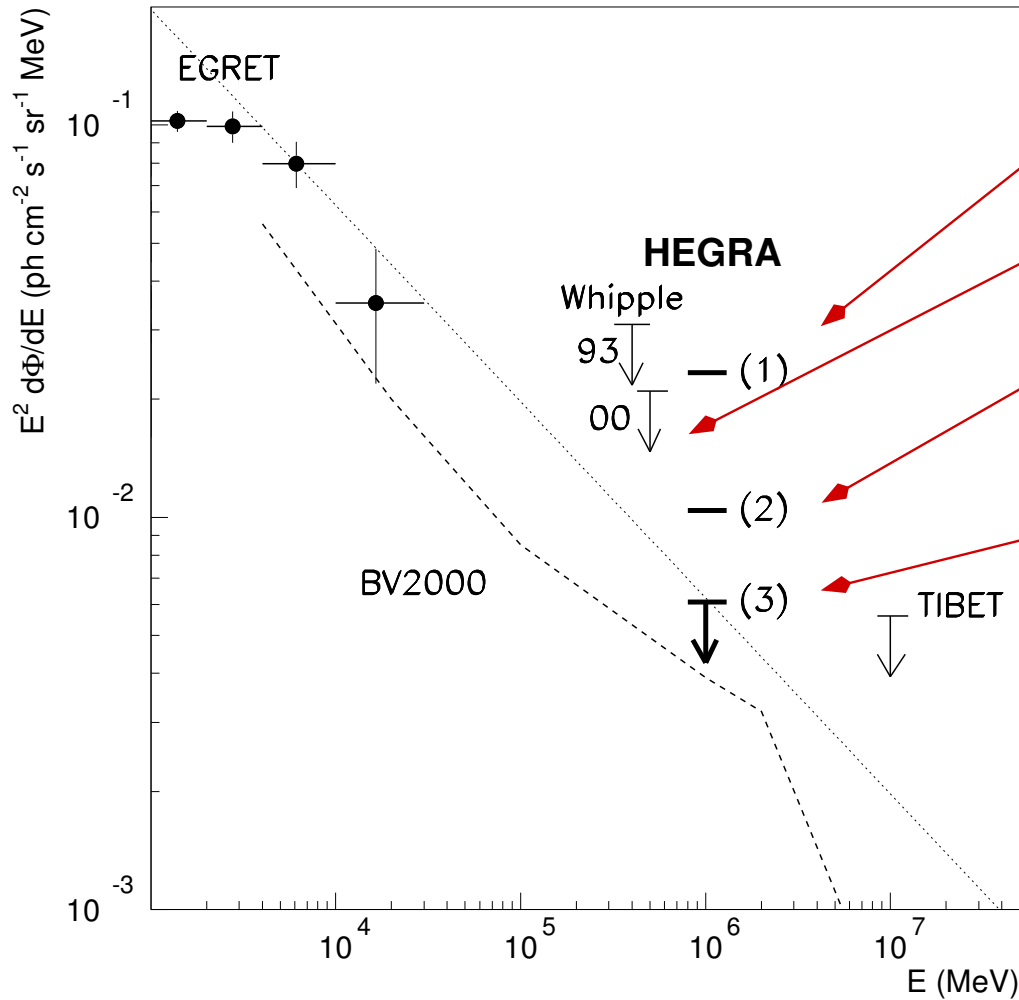
pixels with $DC > 3\mu A$
are set to 0

→
lack of events
from star position



Pühlhofer, ICRC 2003

TeV upper limits on the diffuse emission of the Galactic plane



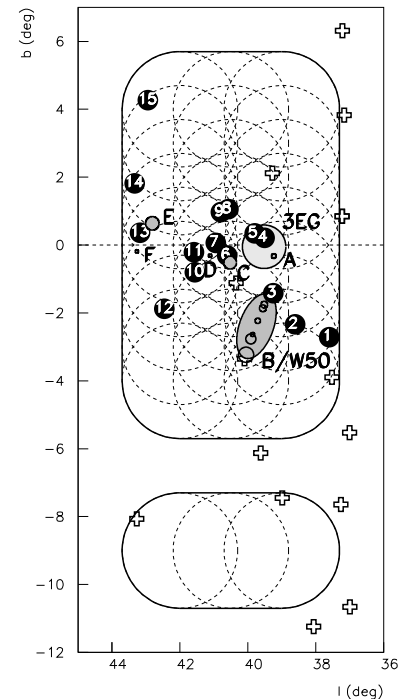
different procedures:

"background-free": very strong cuts

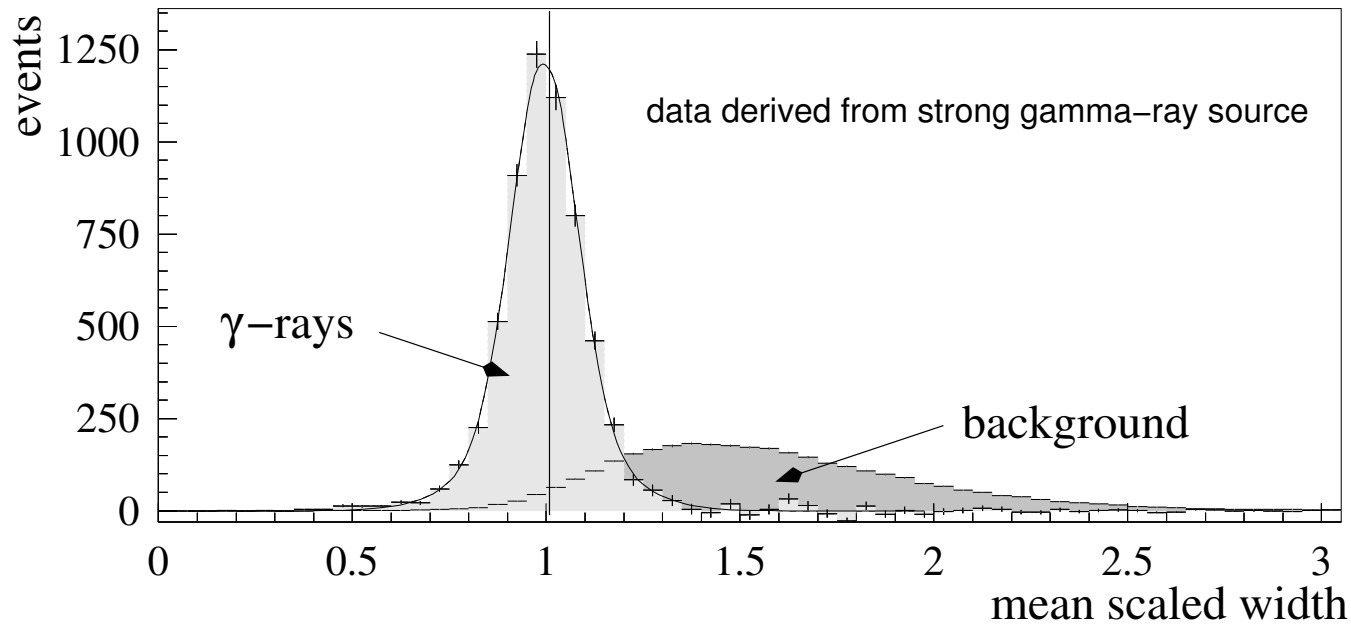
on – off, FoV acceptance x GeV profile

on – off (small off sample)

assume GeV profile,
compare $|b| < 2^\circ$
with $|b| > 2^\circ$



HEGRA: Quasi-"background-free"



optimize signal/background: mean scaled width < 1.0

count all events after cuts in $|b| < 5^\circ$ as gamma-ray candidates

$$\frac{d\Phi}{dE}(E = 1 \text{ TeV}) < 23.4 \times 10^{-15} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \text{ MeV}^{-1}$$

limit on:

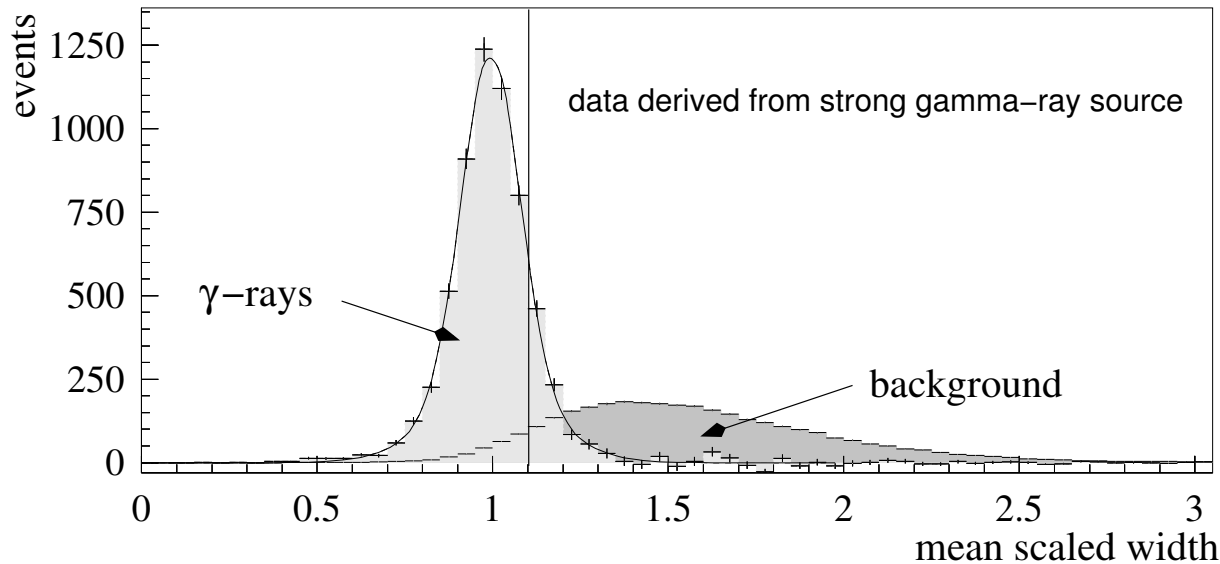
diffuse gamma-ray flux

diffuse electron flux

robust but least sensitive limit

contains tail of the distribution of cosmic-ray nuclear showers

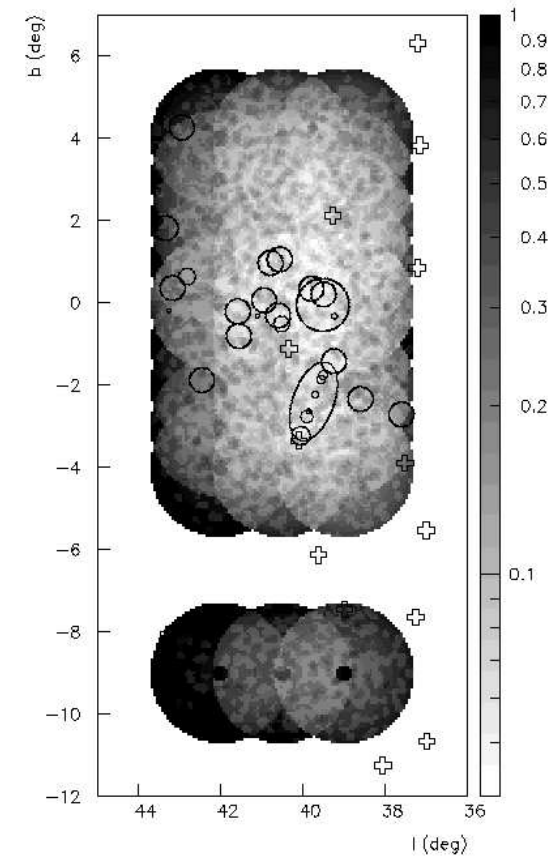
HEGRA: Background-subtracted: off counts from latitude $\leq -6^\circ$



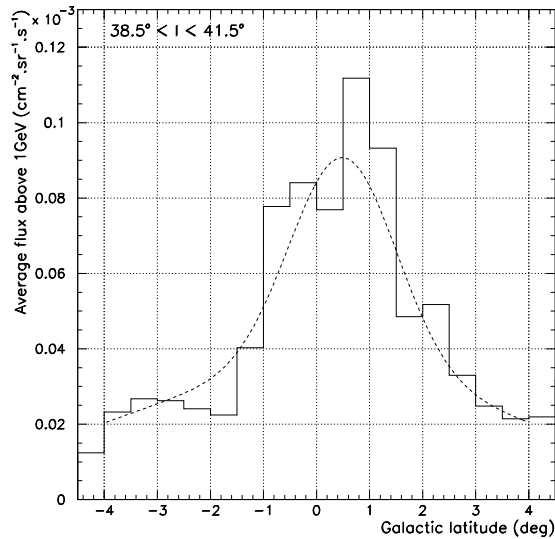
optimize signal/ $\sqrt{\text{background}}$: mean scaled width < 1.1
count events after cuts and background subtraction
in $|b| < 5^\circ$ as gamma-ray candidates

$$\frac{d\Phi}{dE}(E = 1 \text{ TeV}) < 10.4 \times 10^{-15} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \text{ MeV}^{-1}$$

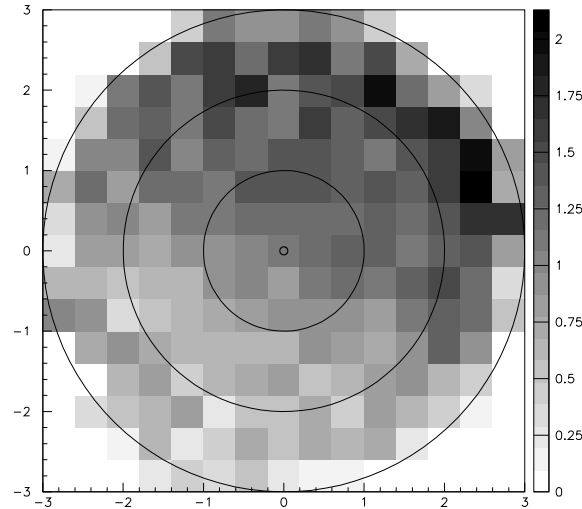
problem in HEGRA data sample: small off-exposure (4.1h)



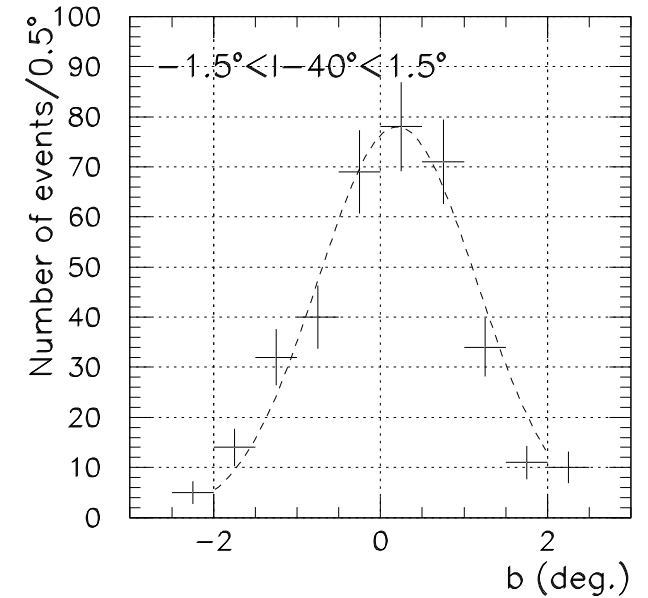
Whipple: On-Off, instrument acceptance x GeV profile



GeV latitude profile



x gamma acceptance (projected) →

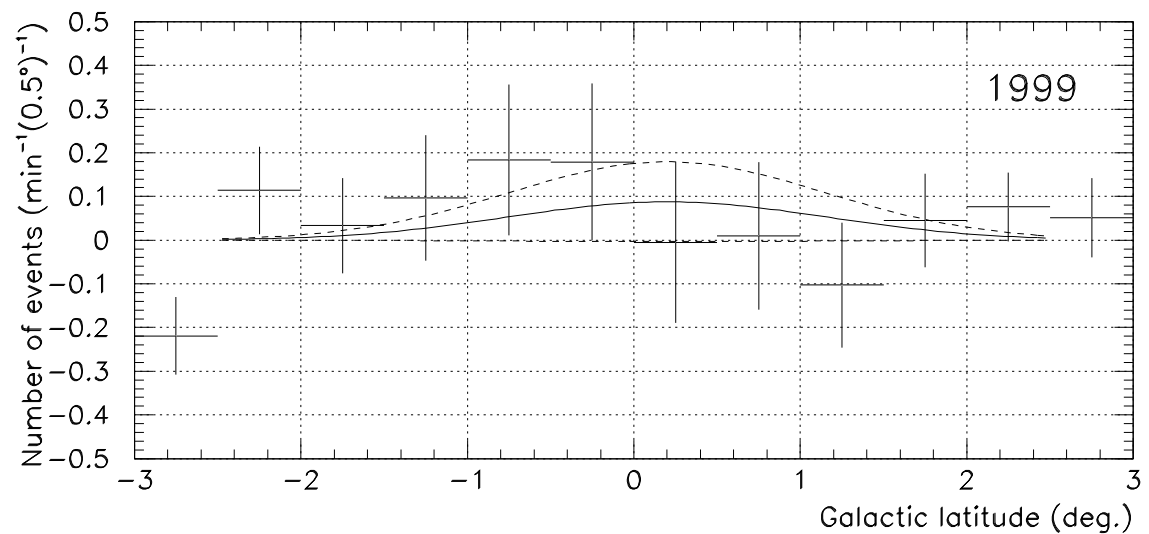


expected TeV profile

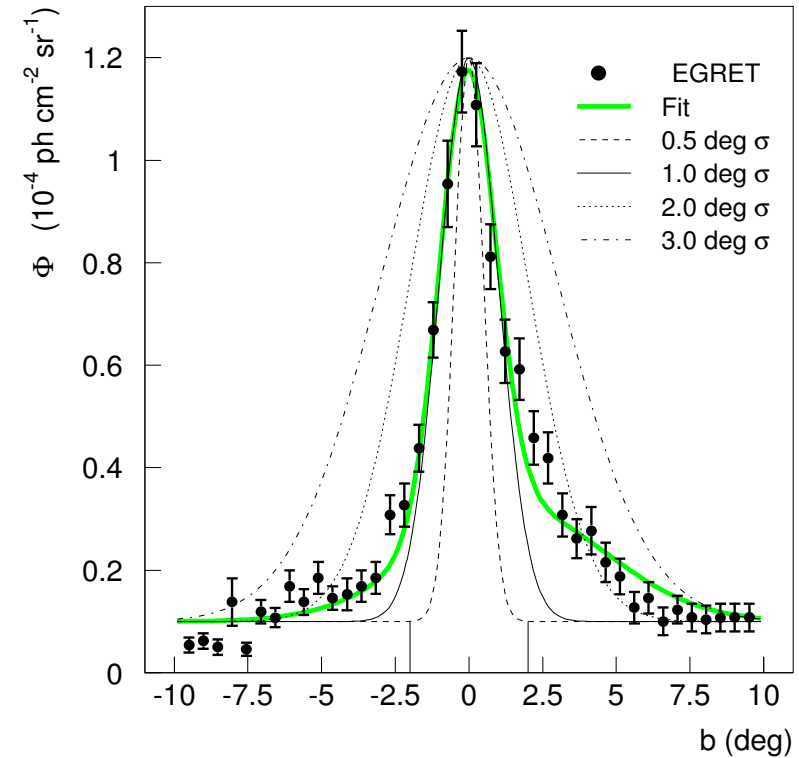
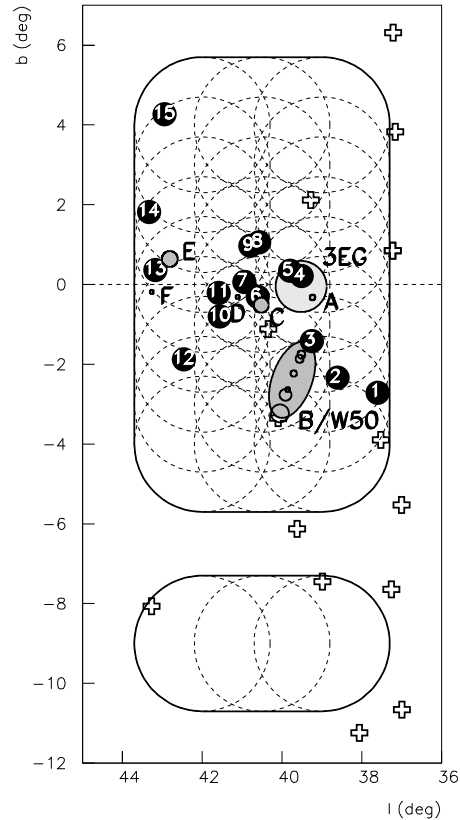
TeV data:

$$\Phi(E > 500 \text{ GeV}) < 3.0 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

$$|b| < 2^\circ$$



HEGRA: on-off (compare $|b| < 2^\circ$ with $|b| > 2^\circ$), GeV profile



optimize signal/sqrt(background): mean scaled width < 1.1

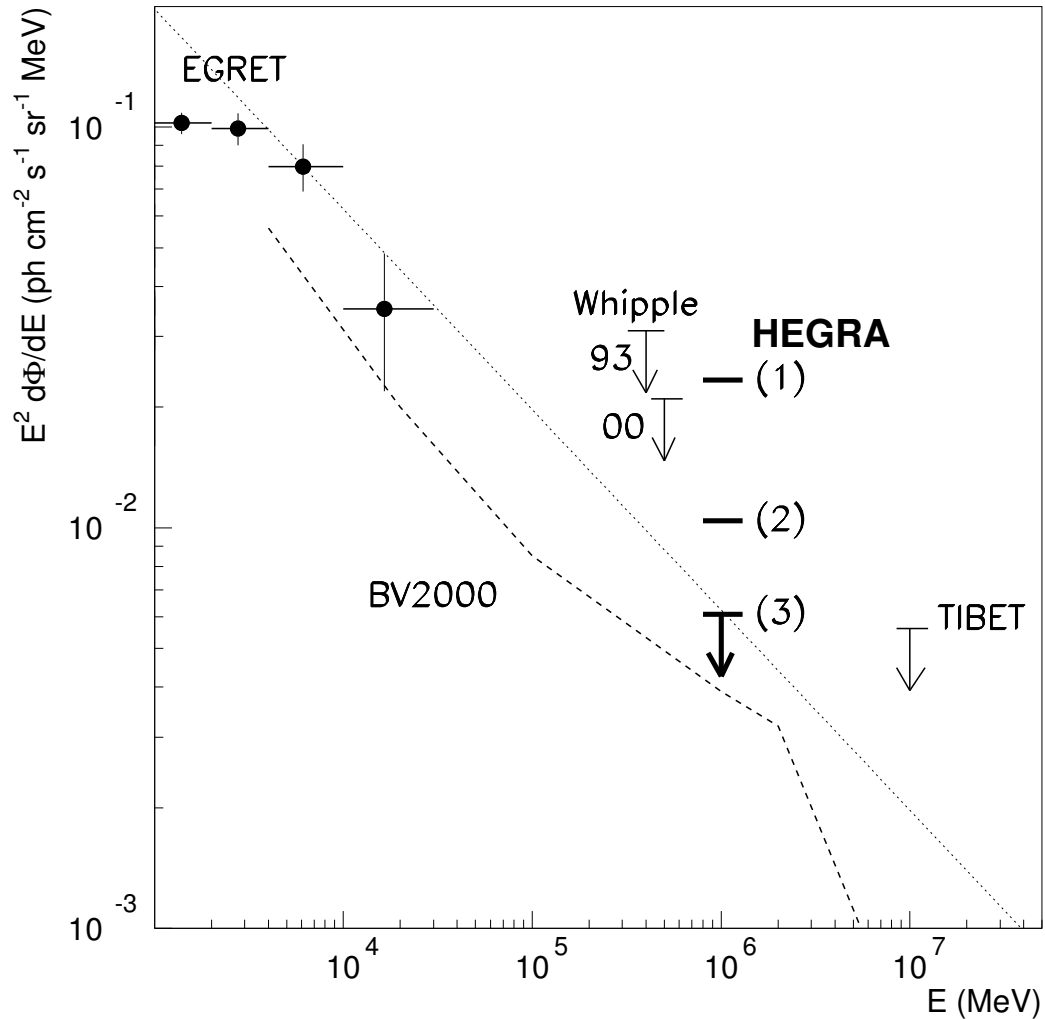
count events after cuts and background subtraction ($|b| > 2^\circ$)

in $|b| < 2^\circ$ as gamma-ray candidates

$$\frac{d\Phi}{dE}(E = 1 \text{ TeV}) < 6.1 \times 10^{-15} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \text{ MeV}^{-1}$$

best limit, but higher degree of assumptions

Impact of TeV results



EGRET extrapolation:

Whipple (00):

$$\alpha < -2.31$$

HEGRA:

$$\alpha < -2.5$$

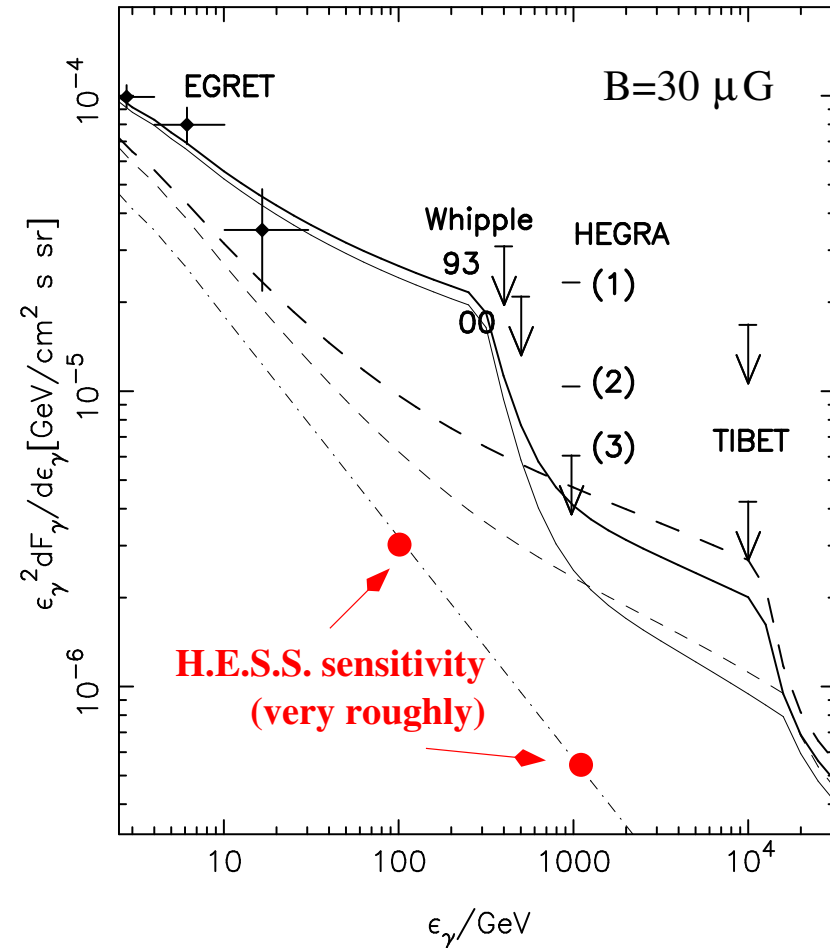
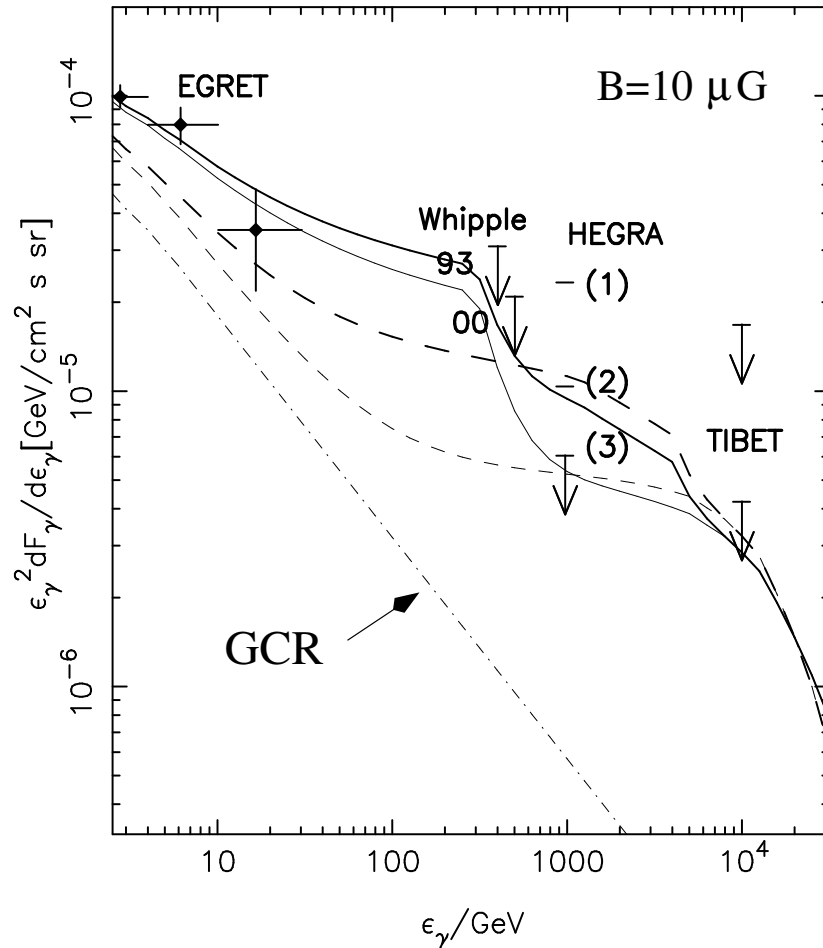
BV 2000:

contribution from source cosmic rays

The contribution from source cosmic rays (including IC)

solid lines: 32% of SN energy into wind bubbles

Berezhko & Völk, ICRC 2003



B in SNR: $B=10 \mu\text{G}$: IC-dominated

$B=30 \mu\text{G}$: π^0 -dominated

HEGRA limit: o.k. if $T_{\text{SN}} = 2 \times 10^4$ years

o.k.

The H.E.S.S. Cherenkov Telescope System in Namibia

System of 4 12m diameter air-Cherenkov telescopes

120 m array spacing

15 m focal length, 5° field of view

~ 100 GeV threshold, centi-Crab sensitivity

Status:

2 tels running in stereo mode

3rd camera installed now

full system early 2004

