Future and Status of CANGAROO(Japan-side)

CANGAROO III

- Status of CANGAROO-III
- Future of CANGAROO-Japan
- Future of Tibet

Toru Tanimori

Kyoto Univ.

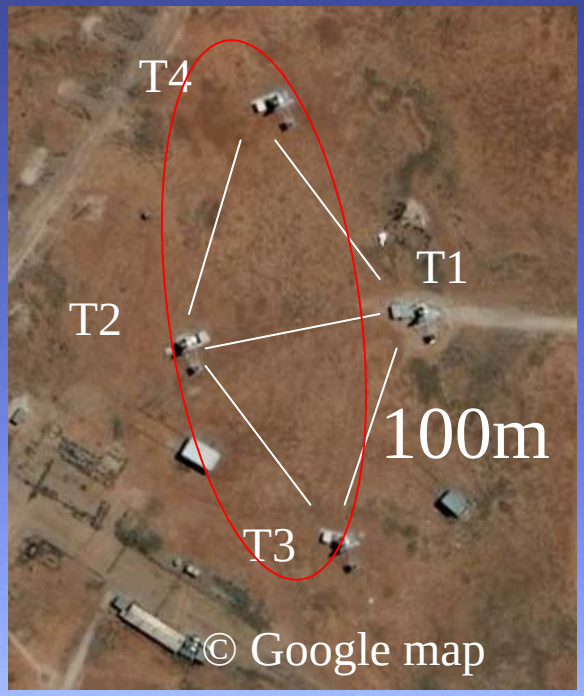
for the CANGAROO team

Towrds the future of TeV Gamma Ray Astronomy@SLAC

CANGAROO team

- University of Adelaide
- Australian National University
- Ibaraki University
- Ibaraki Prefectural University
- Konan University
- Kyoto University
- STE Lab, Nagoya University
- Kitasato University
- Australia Telescope National Facility
- Tokai University
- ICRR, University of Tokyo
- Yamagata University
- Yamanashi Gakuin University
- Hiroshima University
- National Astronomical Observatory of Japan

CANGAROO-III



location

136 47'E
31 06'S
160 m a.s.l.

T2-4, three Telescopes for Stereo Obs.

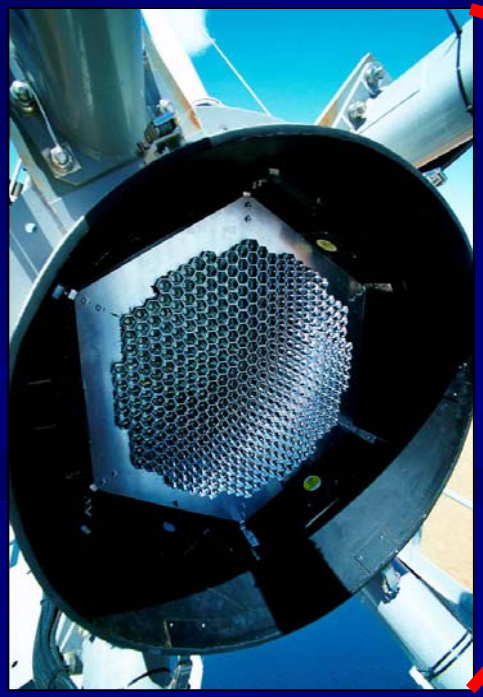
Basic specifications

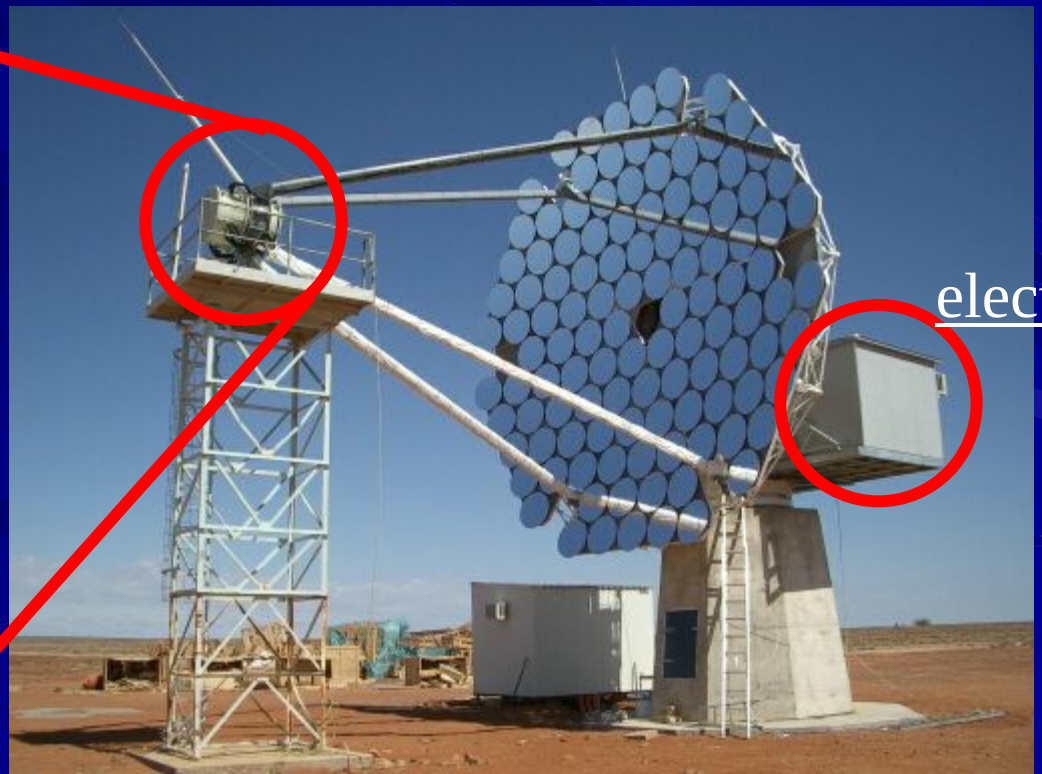
telescope

- 114 80cmϕ FRP mirrors
- 8m focal length (F=0.8)
- Alt-azimuth mount

camera

- 427 ch PMTs
- 4degree FOV



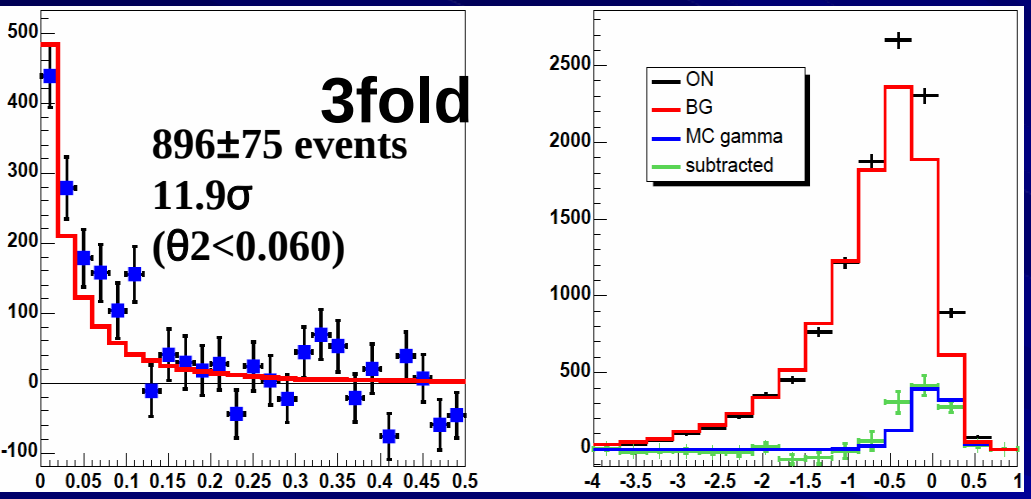


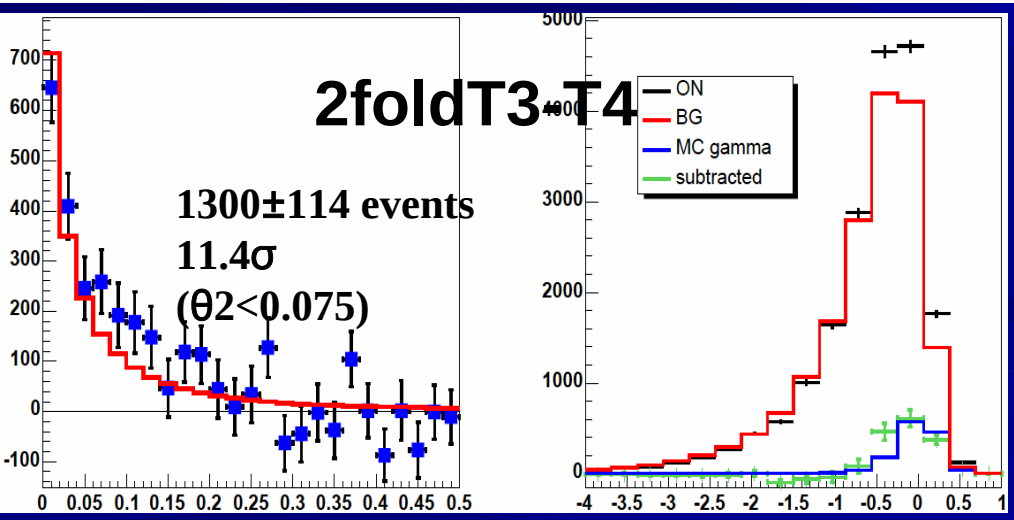
electronics

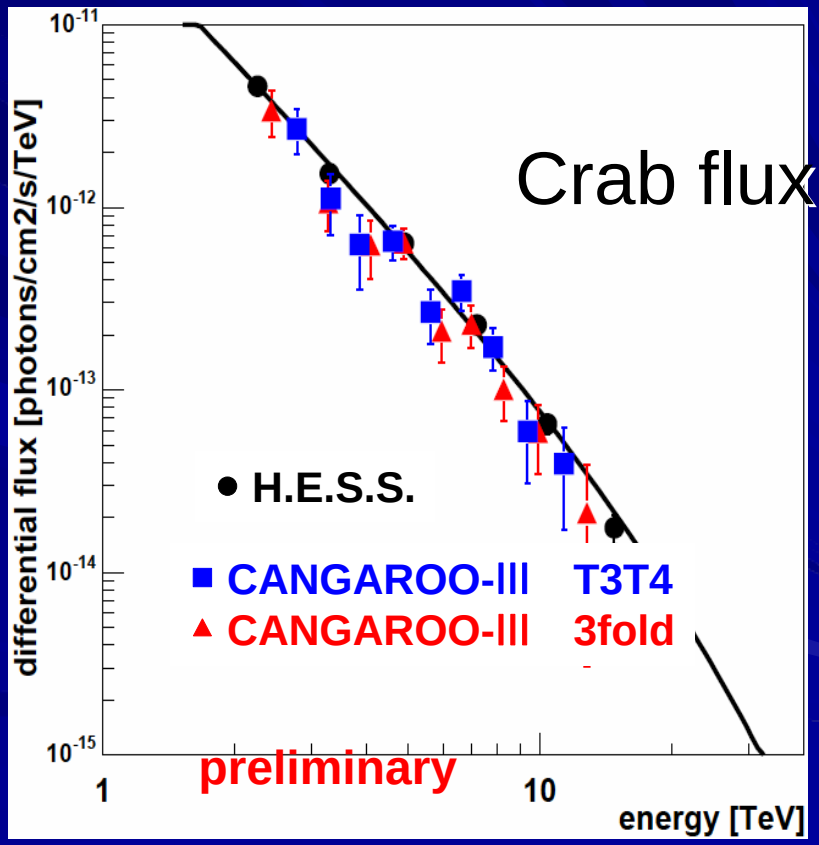
Charge ADC
multi-hit TDC

Crab 2005

- 2005 Nov, Dec,
- Large zenith, > 55degree
- ~40hours wobble





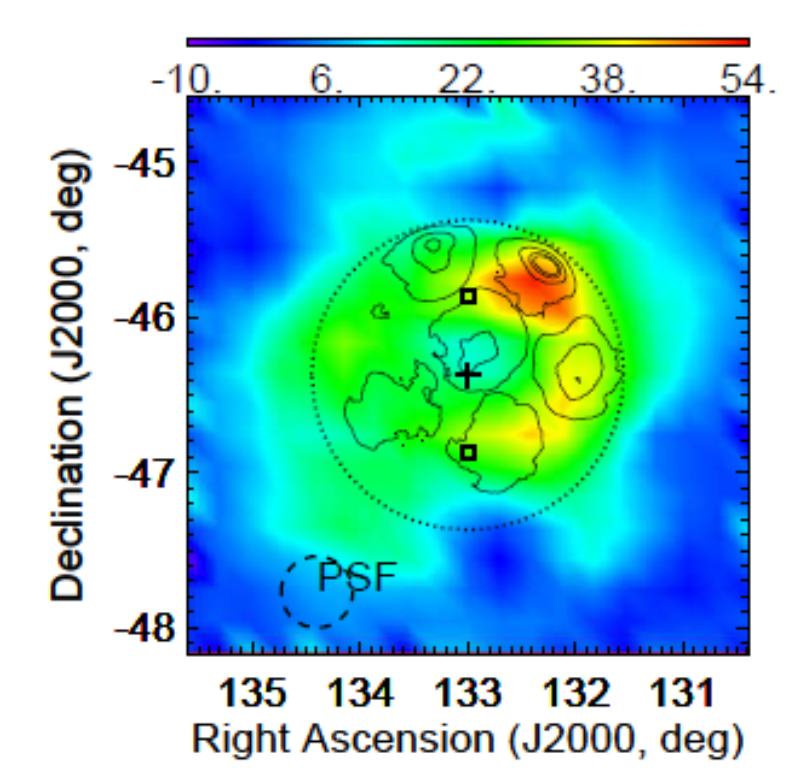


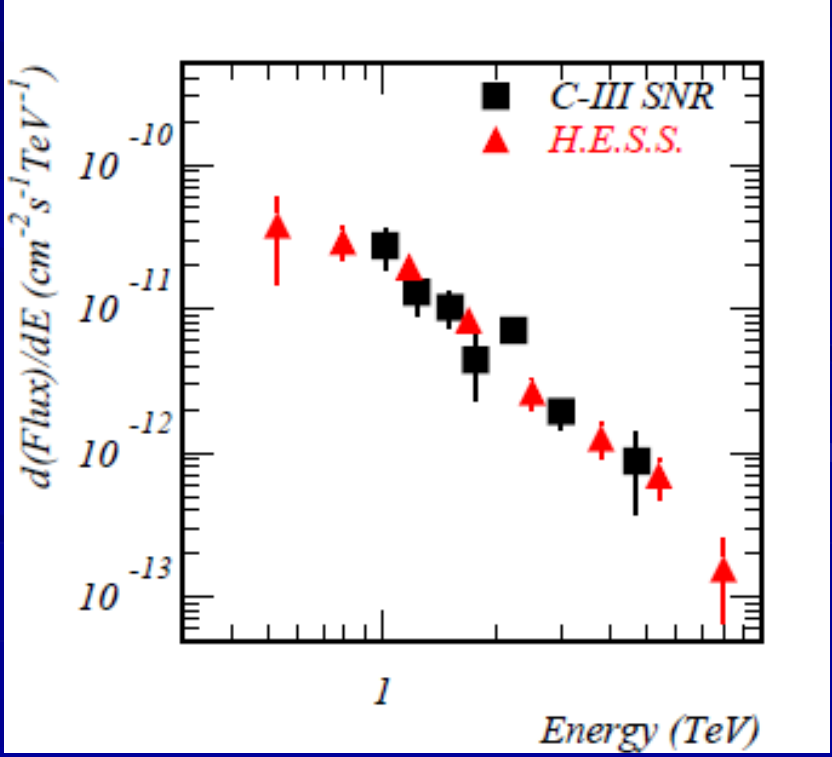
SNR : RX J0852.0-4622

Enomoto et al., ApJ ,2006

- D ~ 1kpc (Moriguchi et al. 2005)
- ~ 1 degree radius shell

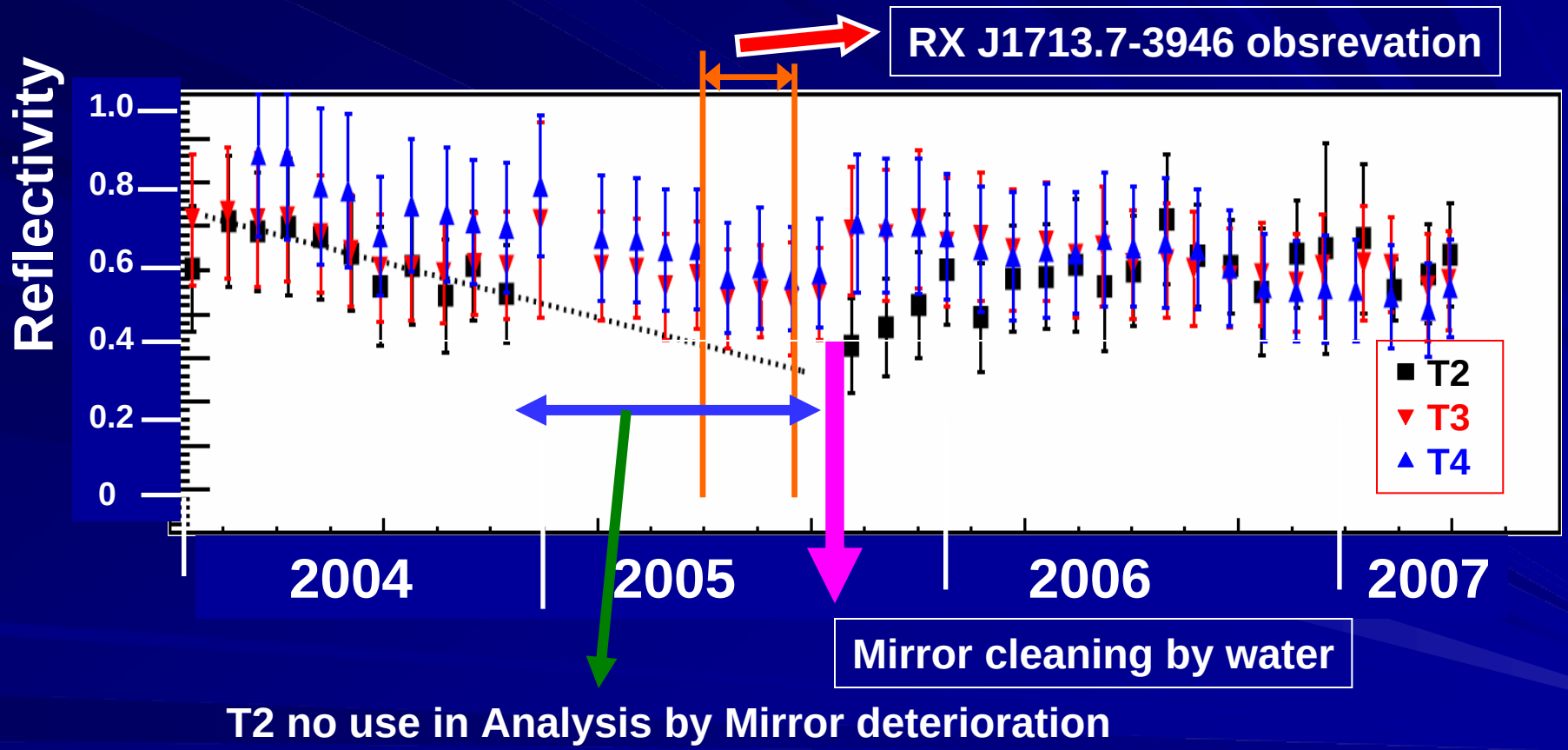
- 2004 Jan-Feb
- ON 18.8 hours / OFF 18.0 hours





Telescopes Condition

- reflectivity measure by cosmic muon



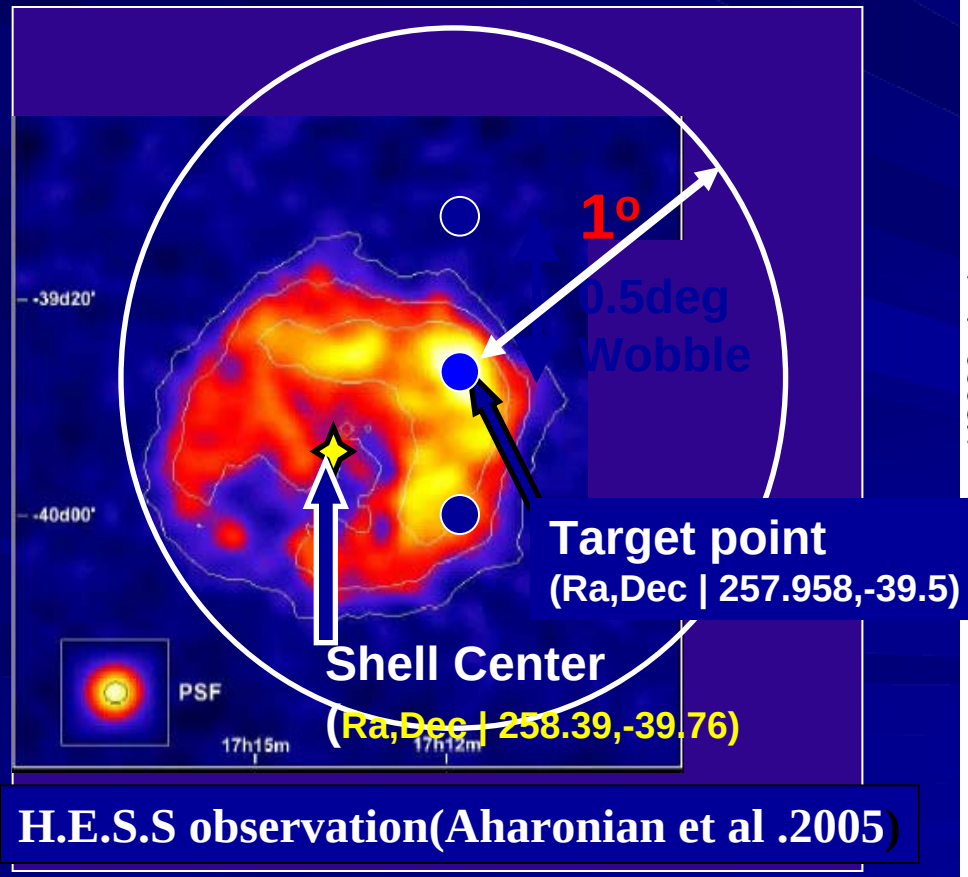
RXJ1713.7-3946, PKS2155-304(quiet season), Galactic Center, H2356-304 under Analysis Using T3-T4 folding data

RX J1713.7-3946

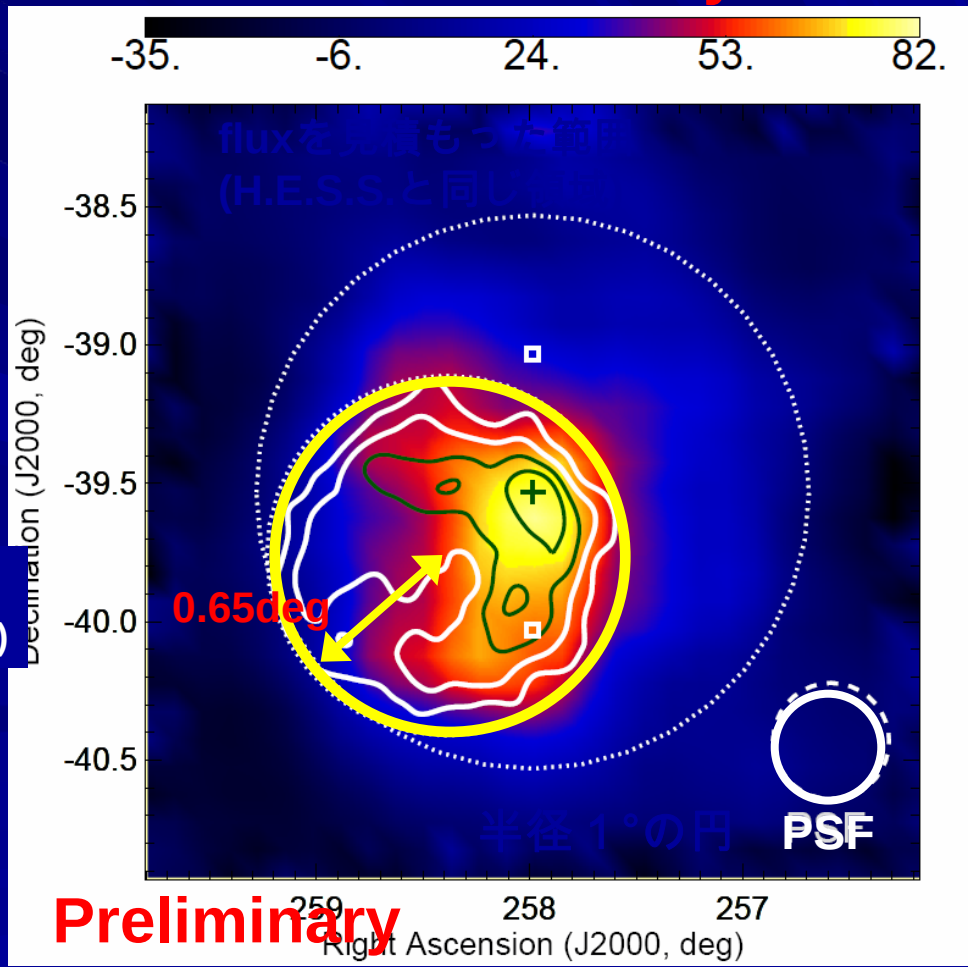
2005, May, July 39hours

Wobble from NE rim

T3-T4 2-fold Analysis



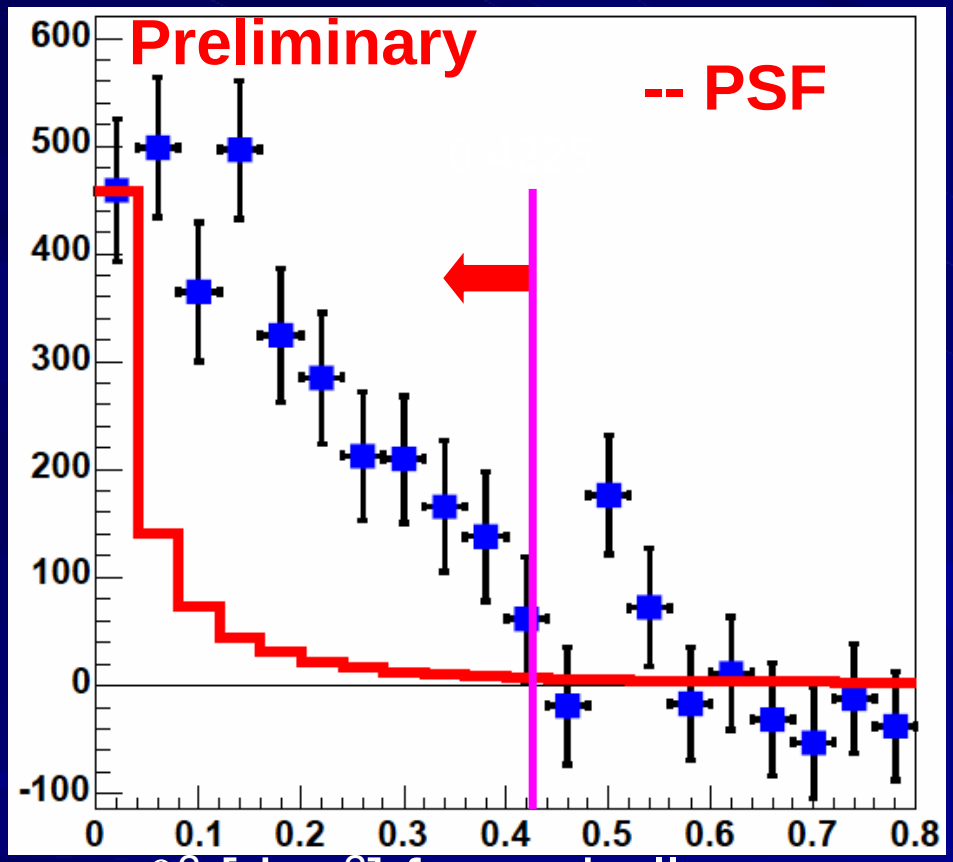
H.E.S.S observation(Aharonian et al .2005)

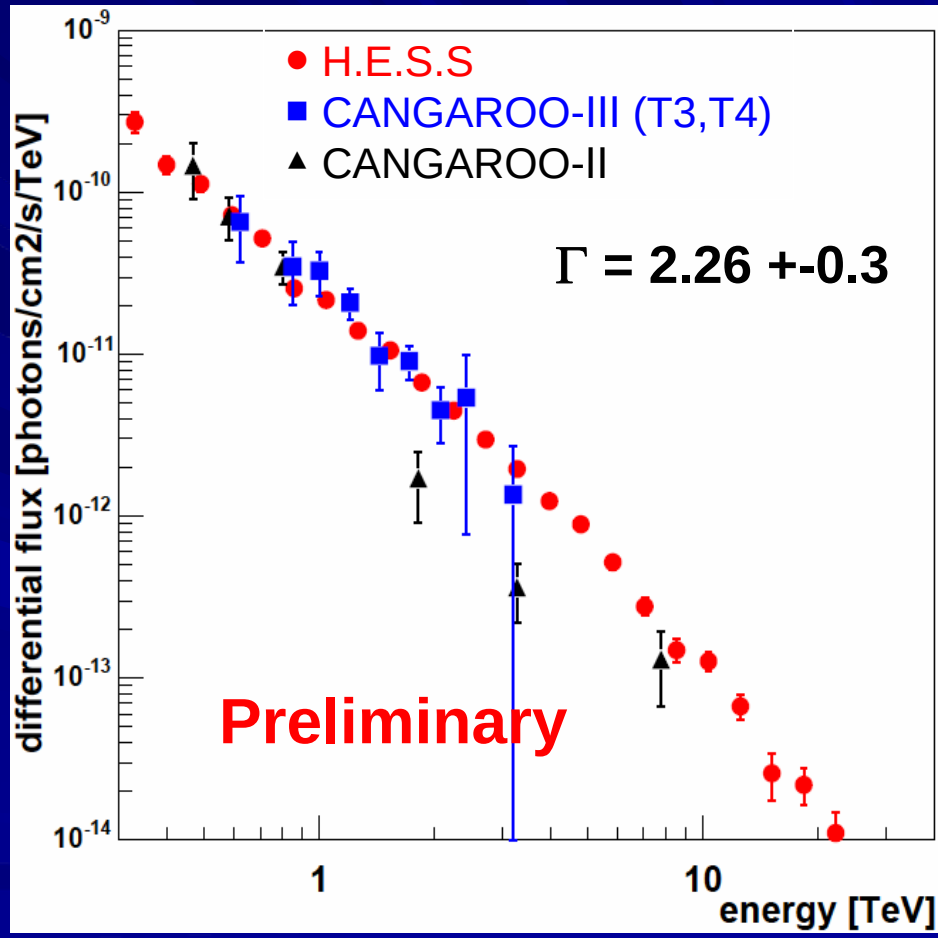


Preliminary

RXJ1713.7-3940

RX J1713





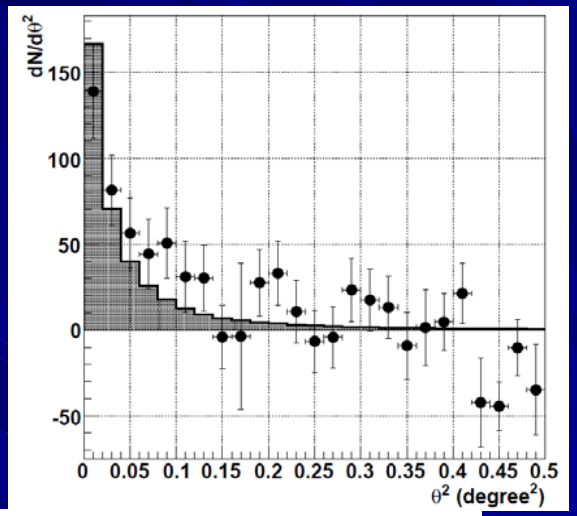
3154 ± 194 events

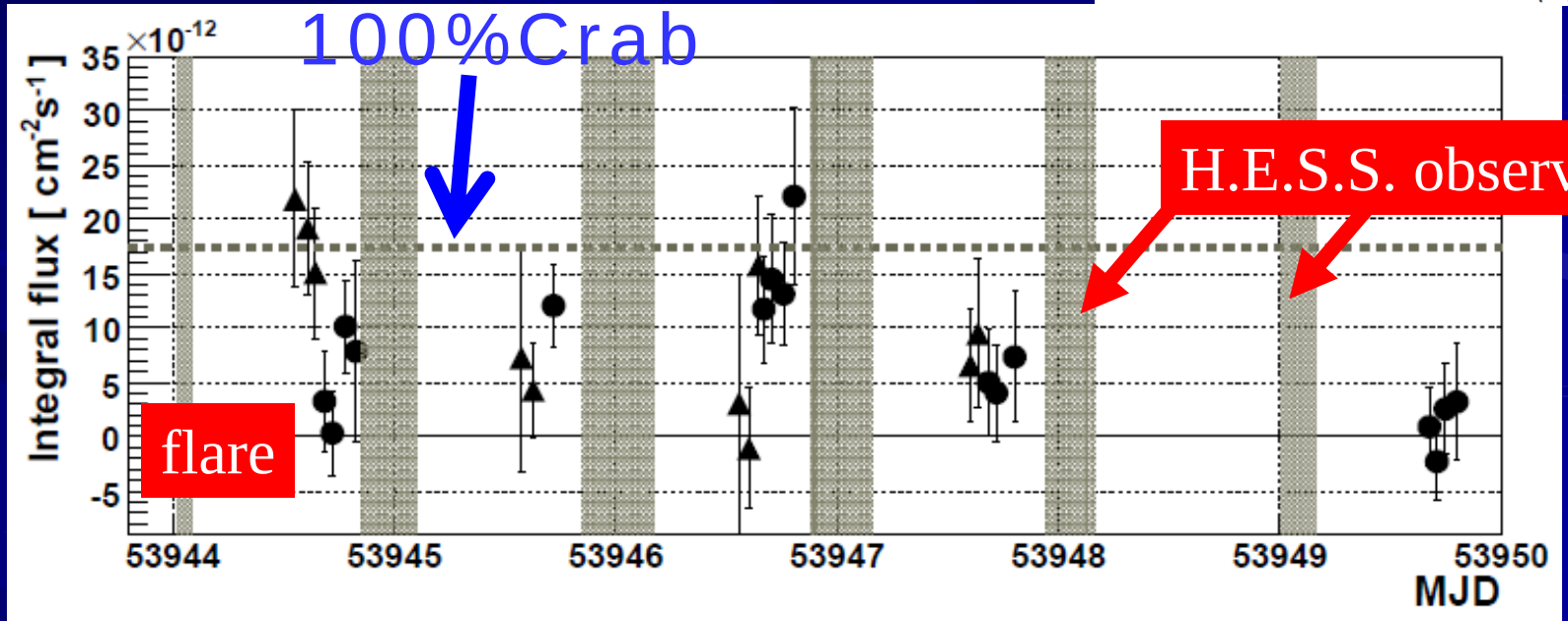
16.1σ(excess region θ<0.65)

Blazar : PKS2155-304

Sakamoto et al., ICRC2007

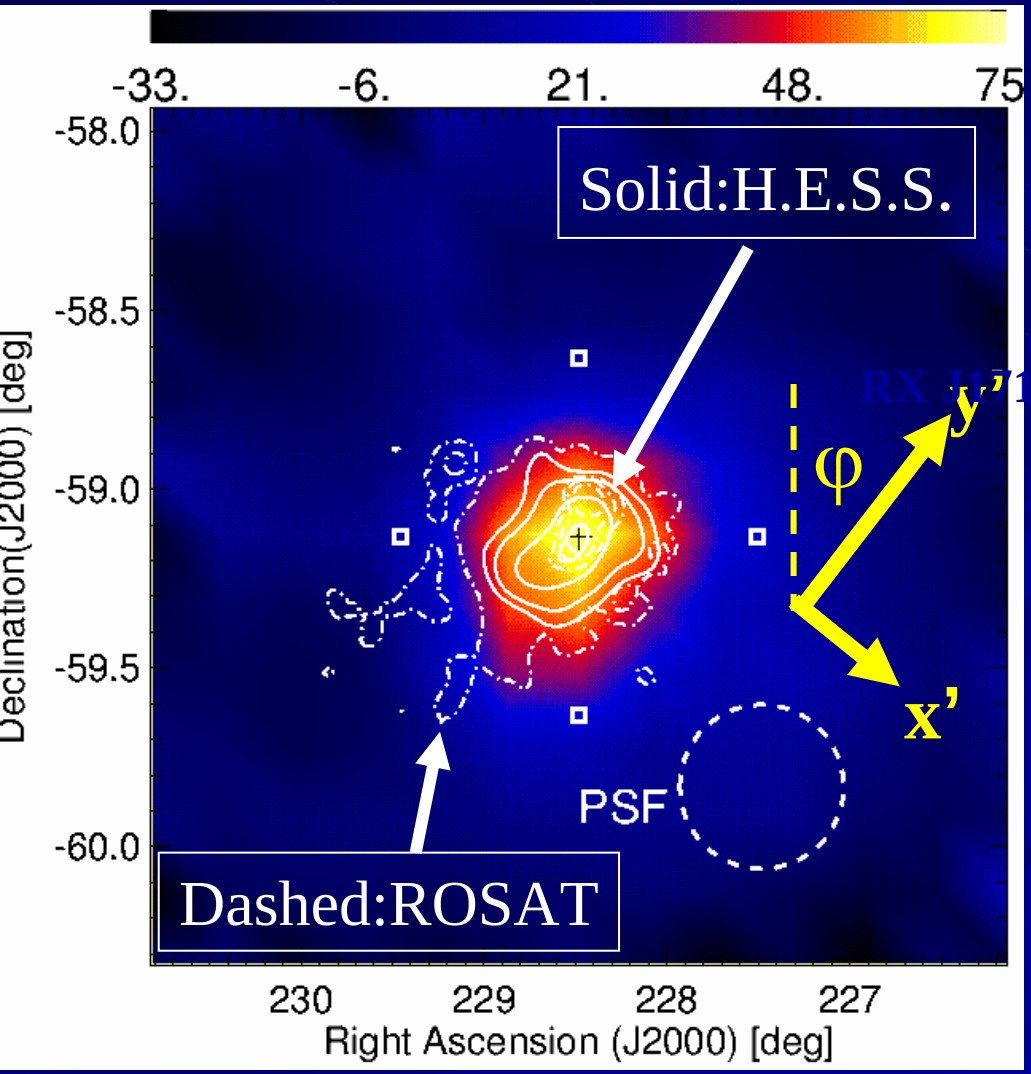
- HBL (z=0.116)
- Alert by H.E.S.S. (av.~7Crab)
- CANGAROO ToO observation
- 2006 Jul 28 – Aug 2
- 10.5 hours for 5 nights





PWN MSH15-52

Nakamori et al., ICRC2007



- MSH15-52/RCW89
- PSR B1509-58
- dE_rot/dt ~ 2E+37 erg/s

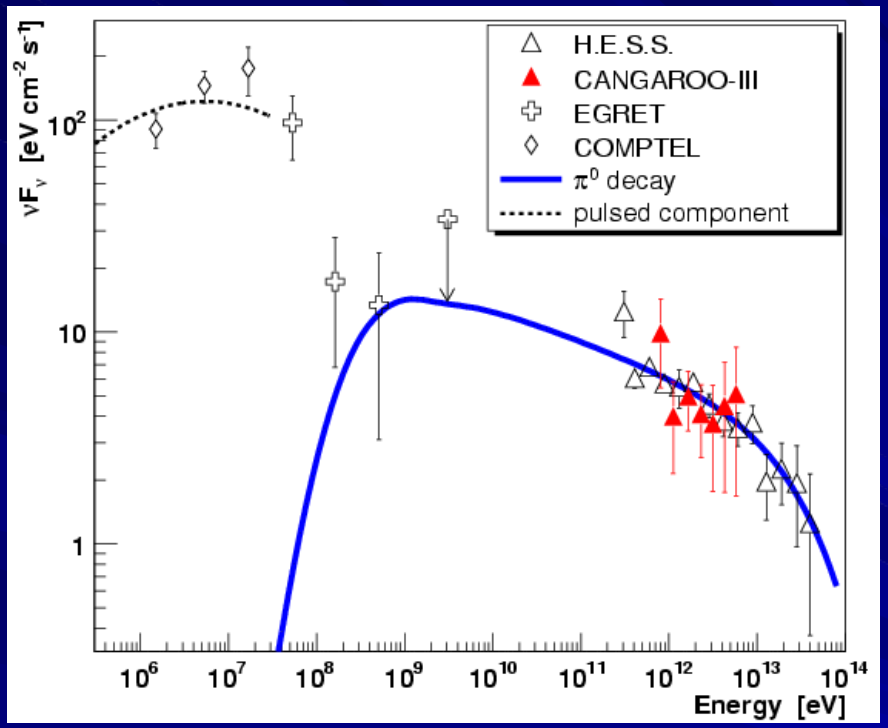
- 2006Apr-Jun
- 48.6 hours
- Extended emission
- 582 events, 7.6σ

φ ~ 30 deg

σx' = 0.07 ± 0.07 deg
σy' = 0.21 ± 0.08 deg

(in submitted)

MSH 15-52 radiation model



index = 2.16 ± 0.05

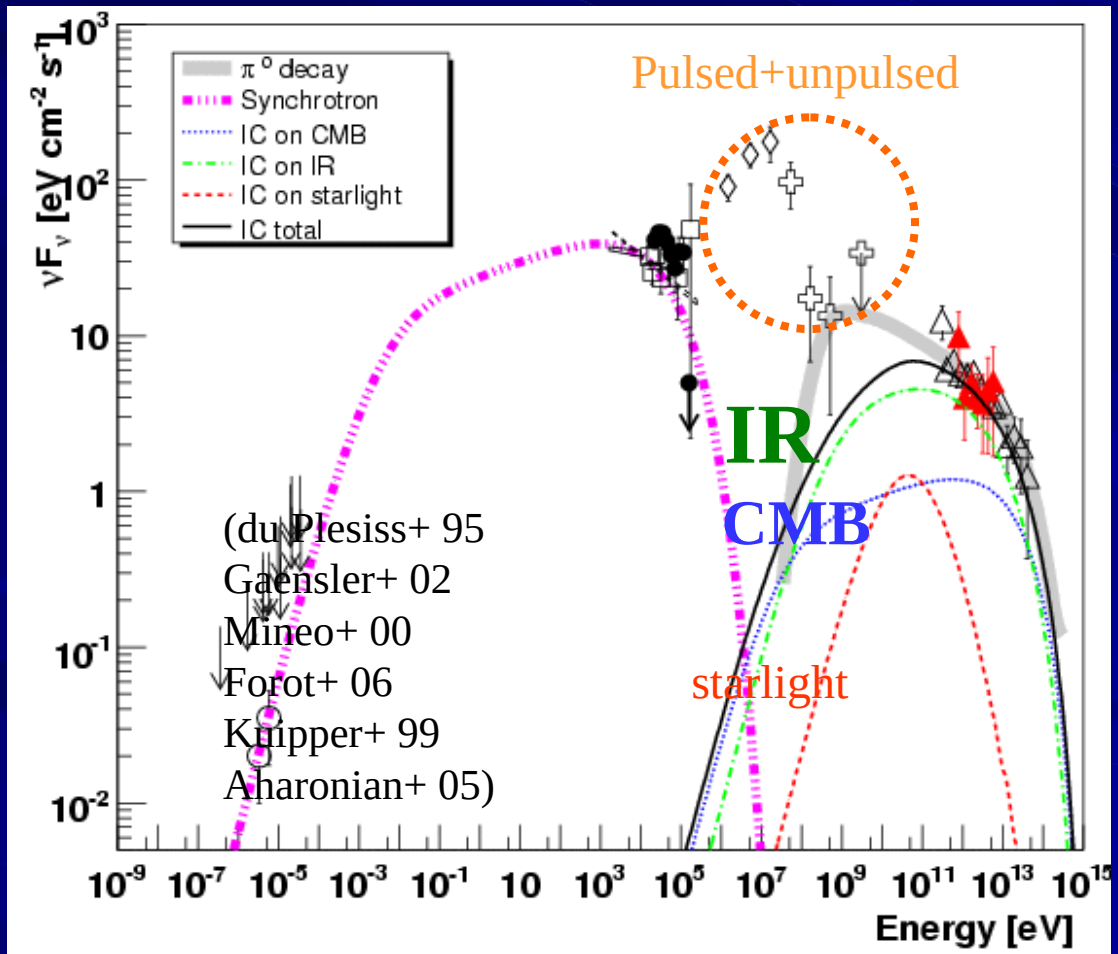
cutoff = 530 ± 399 TeV

total E_{hadron} = 3.2e51 ergs

$$\int_0^{\tau} E_{rot} dt \sim 10^{48} erg$$

MSH 15-52 radiation model(lepton)

- BeppoSAX/MECS for soft X-ray (Mineo et al., 2000)
- including the pulsar

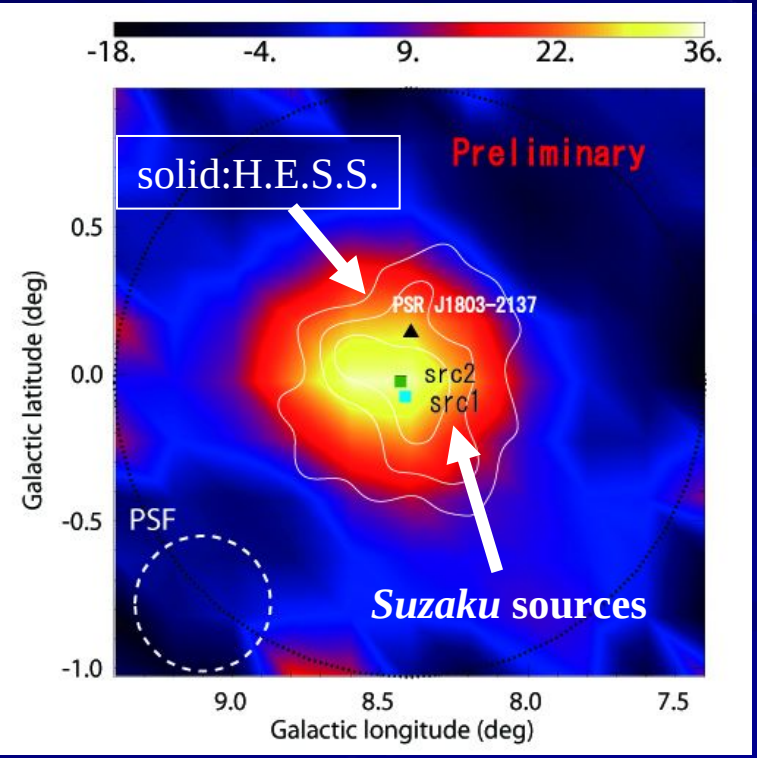


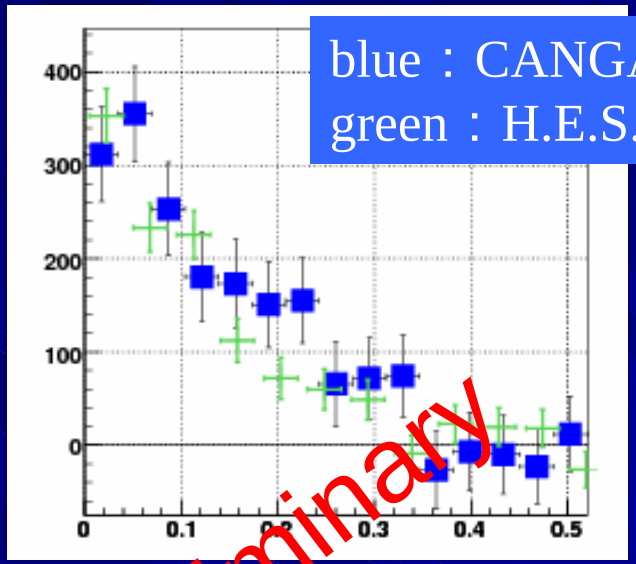
- B = 17 μG
- Starlight 1.4 eV cm-3
- IR necessary (1.4 eV/cc)
- $E_{electron}$ = 5E48 ergs

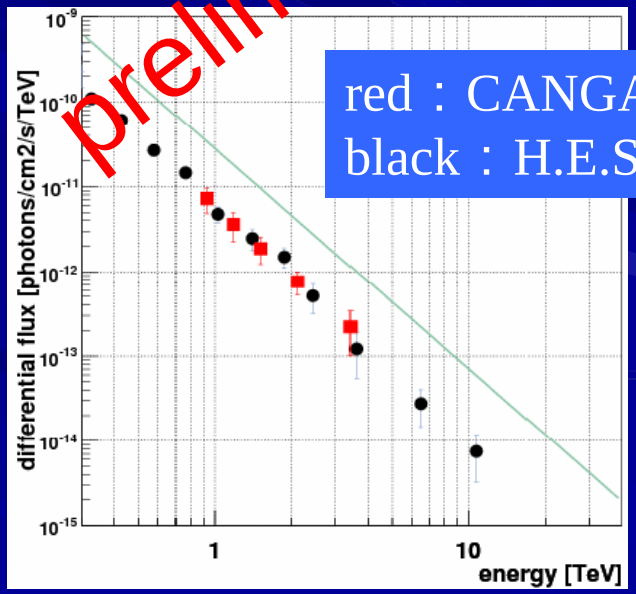
Nakamori et al., in submitted.

unID : HESS J1804-216

- Discovered by H.E.S.S. survey
- 2006 Jun-Aug
- 62.5 hours
- 920events 10.5σ (θ^2<0.1)

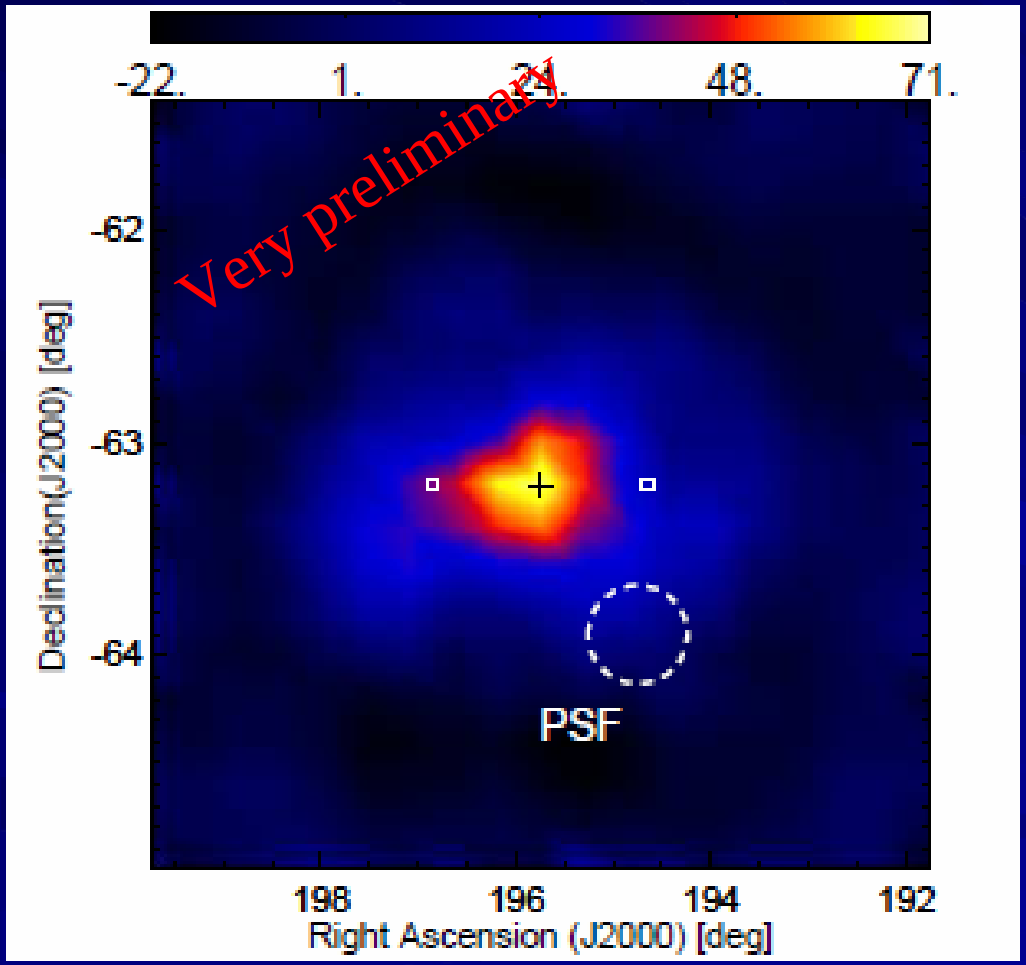






Higashi et al, ICRC2007

unID : HESS J1303-631



Discovery by H.E.S.S.

Extended
Non-time variable (for 4 months)
spectral index = 2.44
17 % crab (>380GeV)
unID

CANGAROO-III observation

2006Mar-May
35 hours
Under analysis

Kushida et al., ICRC2007

Status Summary

- Analysis of stereo observations are now established, and application to other sources are underway.
- Sensitivity < 10%Crab (50h, small zenith, >600GeV)
- We reanalyze 1706 & 1006 C-III data in 2004 using present analysis method, and in 2008 final results about the inconsistency of those objects with HESS will be presented (with C-I checking).
- Recent results:
  - Recent Detections
    - PKS2155-304(Flare), MSH15-52, HESS J1804-216, HESS J1303-631, RXJ1713.4-3940, Vela PWN
  - Upper limits
    - Cen A, ω Cen, SN1987A, Abel 3667, Abel 4038

Report of 2006 ICRR external review committee

- … The committee supports and encourages attempts to seek funding for the upgrade of CANGAROO. In the medium to long-term future participation in the developing multinational efforts towards development of a next-generation instrument is recommended, as compared to smaller-scale national activities.

Committee members: B. Barish, J. Cronin, W. Hofmann, K. Kodaira, K. Nakai, H. Sugawara (chairman), A. Suzuki, Y. Tanaka

Future Plan(Only Japan Cangaroo)

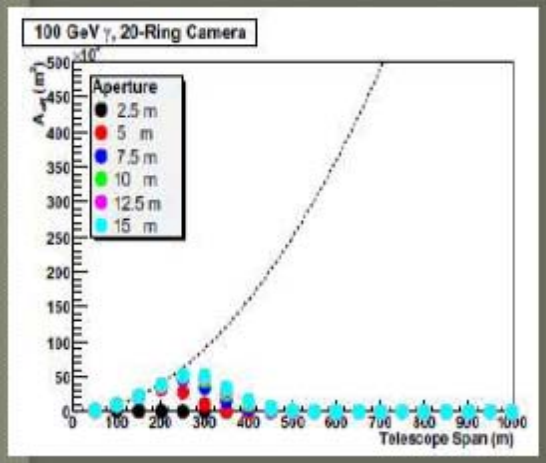
- Contribution to International Collaboration program to cover full range of 10GeV-100TeV
- Middle Energy Range 0.5TeV-100TeV with a few mCrab sensitivity.
- Telescope Array with a 10mϕ class Mirror and a wide FoV Camera(~6$^{o}\phi$)
- Array size a few km^{2} with a Telescope interval of ~500m

Distance of Telescopes

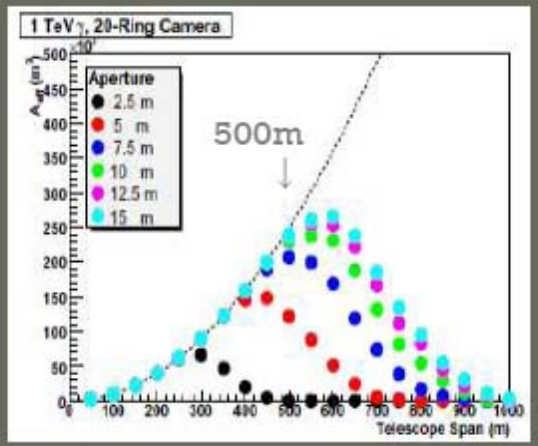
T.Yoshikoshi, "Towards a Network of Atmospheric Cherenkov Detectors VII" (2006)

Model array simulation

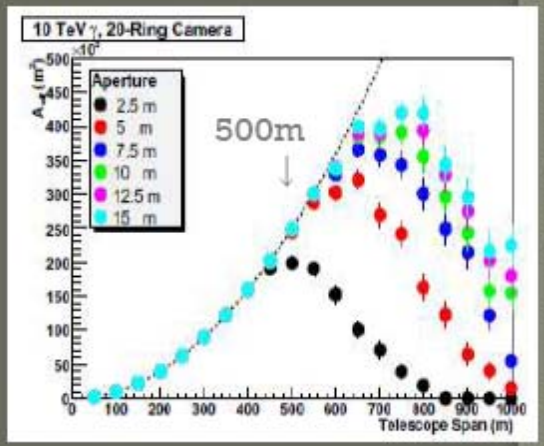
100 GeV γ



1 TeV γ

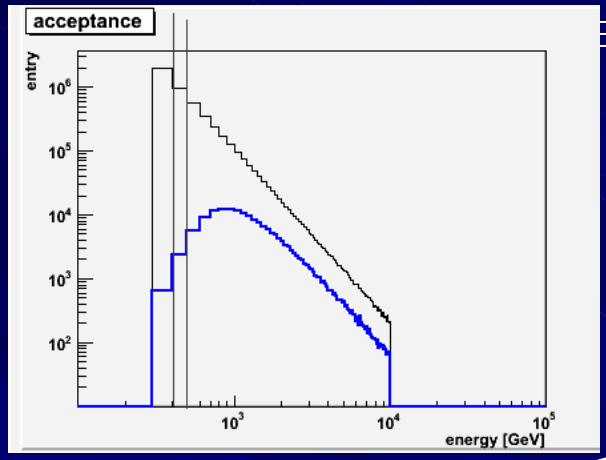


10 TeV γ



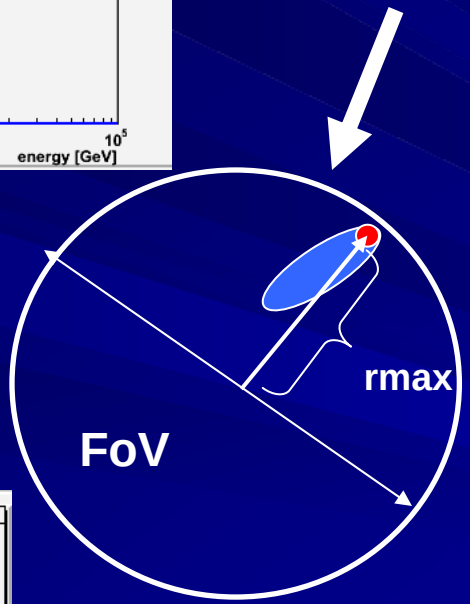
- 10m 4telescopes with large FoV Camera (6º Diameter)

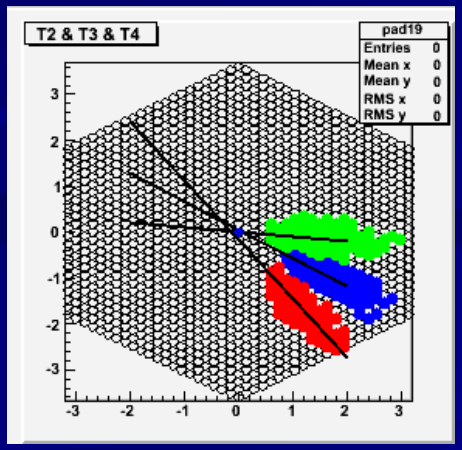
FoV simulation using C-III 3Telescopes)

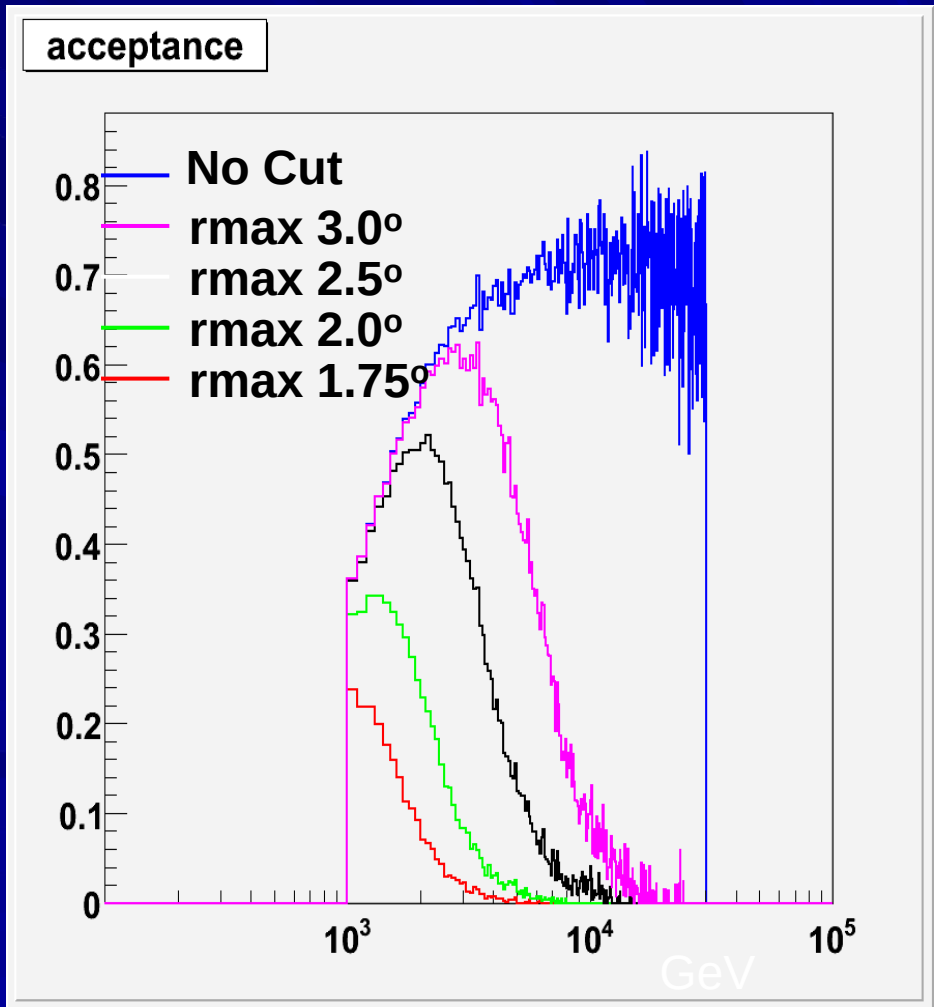


Acceptance =survive event/ generate event

Three showers are perfectly inside FOV.







R & D items

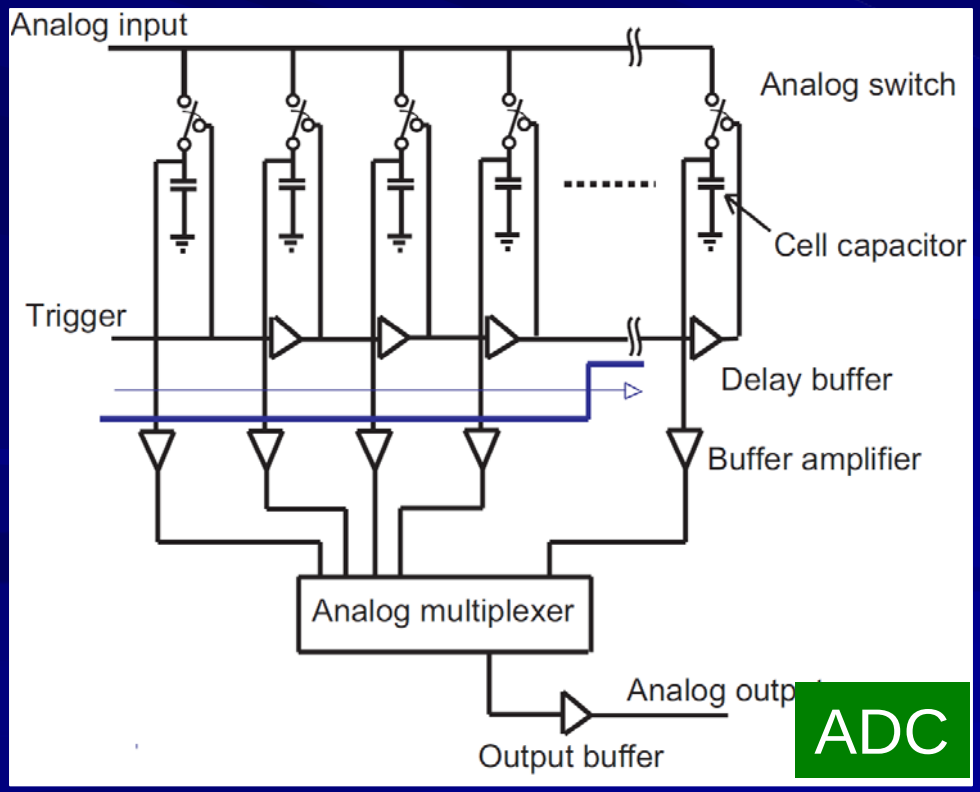
- Large FoV Camera (>6$^{o}\phi$;)

  ~800 photo-pixels with high Q.E.

  Embedded electronics system
- Accurate, light & Cheap facets production
- Cheap Telescope design
- Detailed Simulation Work

Analog Memory Cell (AMC)

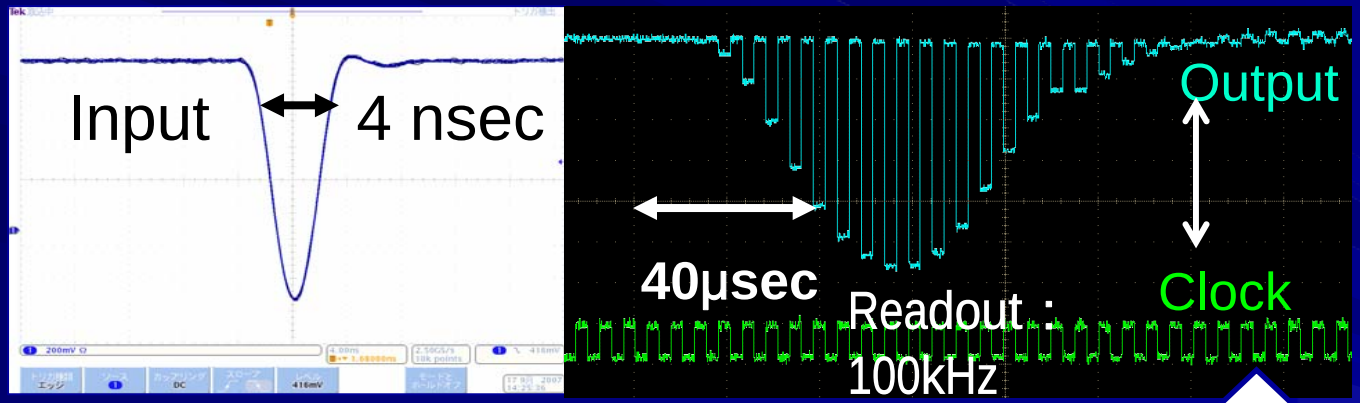
- Development by KEK, Tokyo, Kyoto, & Hamamatsu Photo
- 1GHz Sampling
- 64 Capacitor Array (at Present)
- In near future, ADC will be embedded.

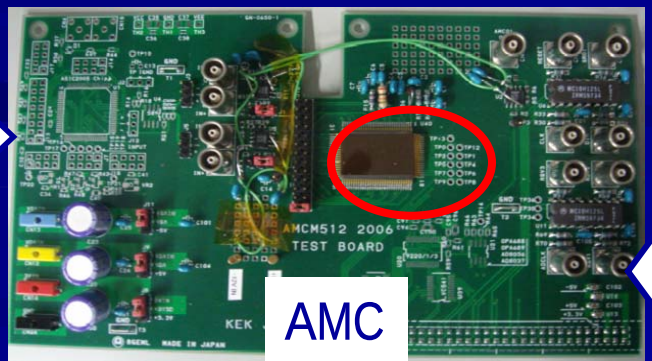


- Low Power (~70 mW/channel)
- Compact (4mm*4mm / channel)

AMC-TEST

	AMC (+10MHz FADC)	FADC
speed	1~2 GHz	0.5~1 GHz
power/channel	$\lesssim$0.5W	1~2W
cost/channel	$\sim 10^4$yen	$5 \times 10^4 \sim 10^5$yen
depth(# of stages)	512~1024	$\gtrsim 10^4$
linearity	$\gtrsim$ 10 bit	$\sim$ 8 bit



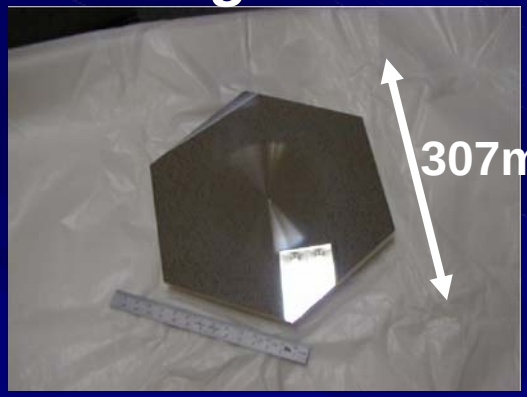


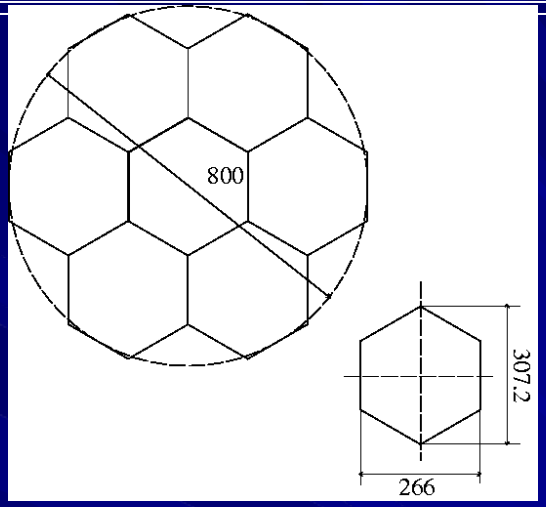
Trigger

Readout clock

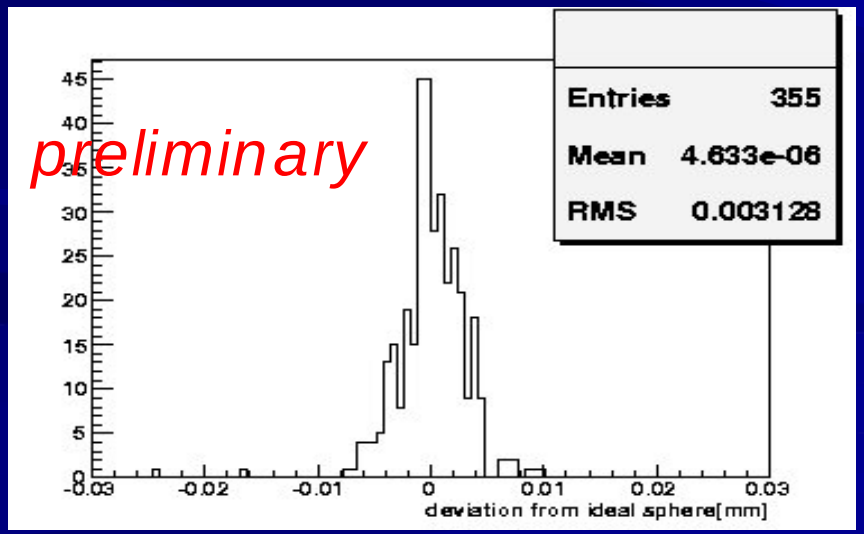
Mirror Development (1)

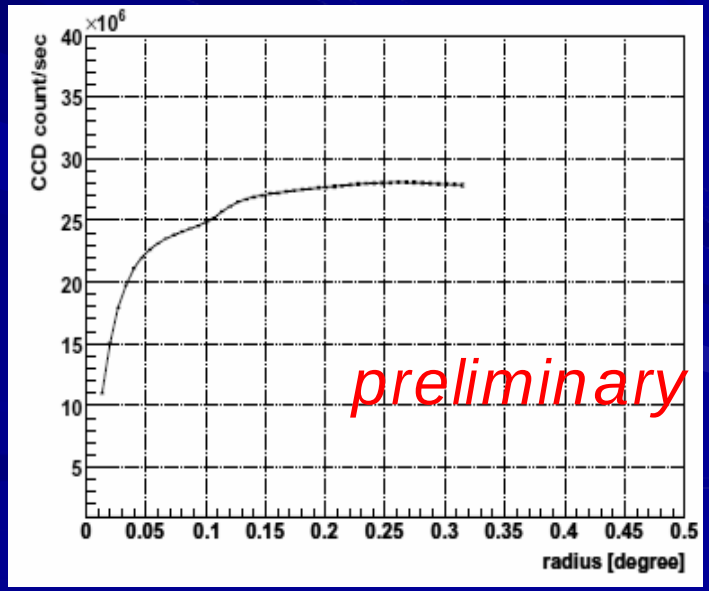
Metal Cutting





Surface Deviation =2μm



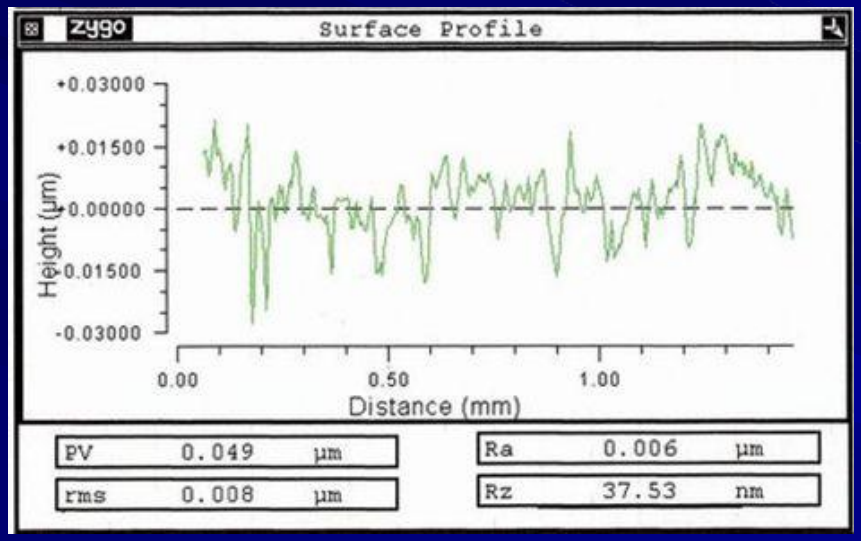


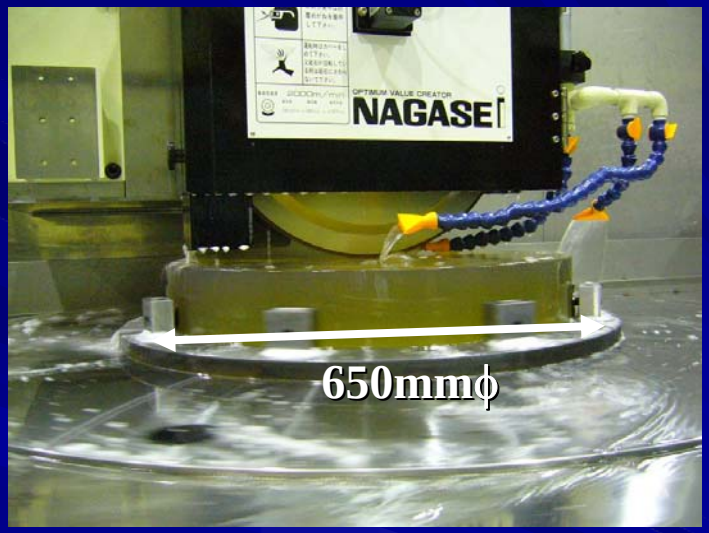
90% concentration @0.1degree

Mirror Development (2)

- Glass Cutting is being developed by Dept. of Astronomy, Kyoto Univ. for Optical multi mirror telescope Max 1300mmϕ.
- In 2008, we will try this method by reducing cutting time.

(Cheap, light and accurate surface)





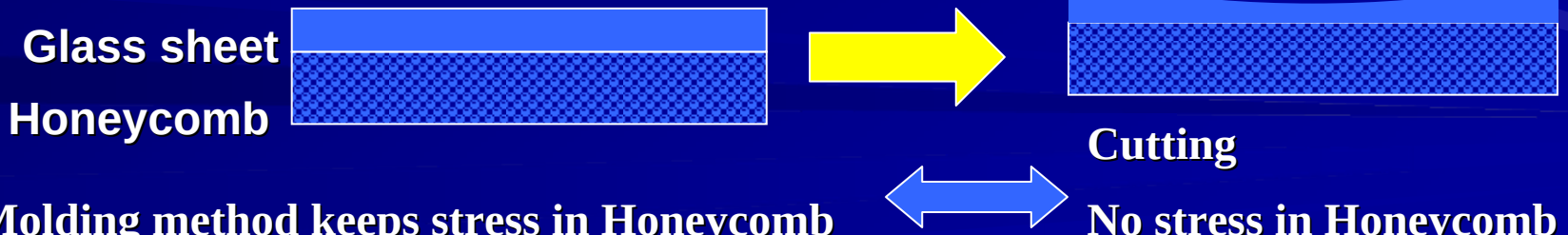
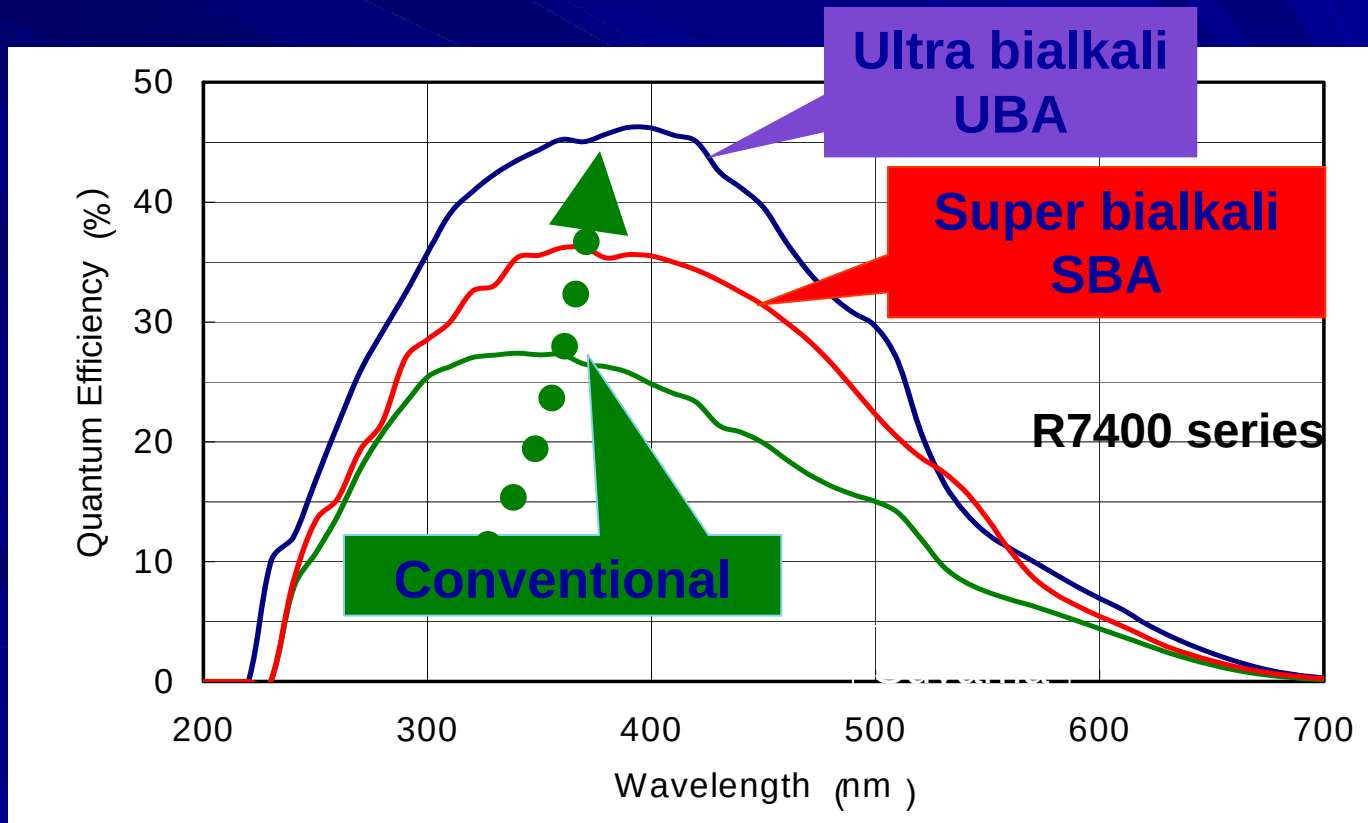


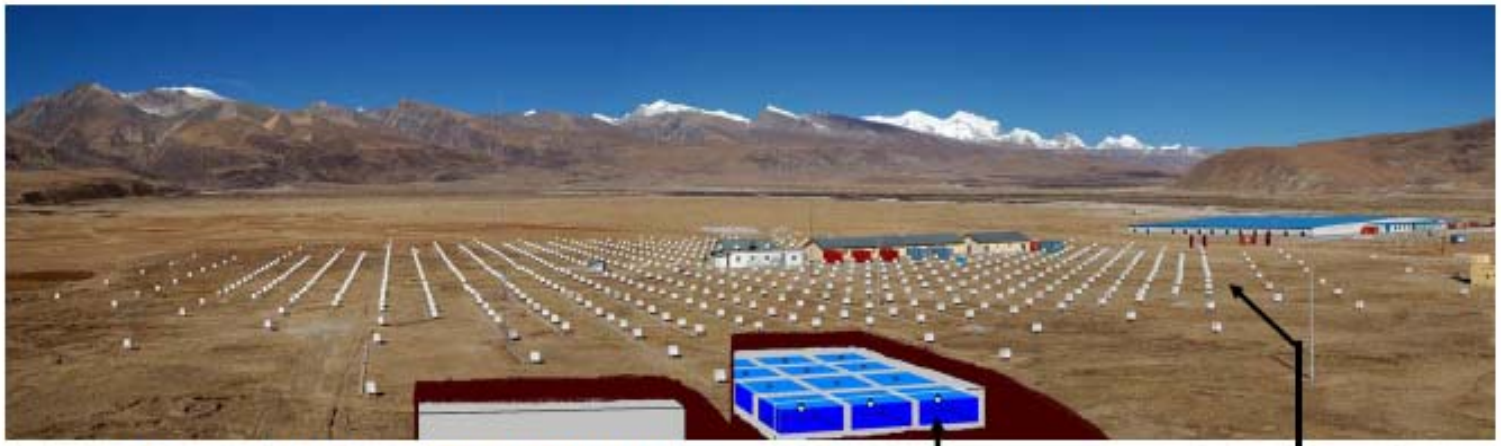
Photo Sensor

Photo Sensor Candidates

1. **SiPMT but (dark count, effciency (~30%), after pulse, temperature dependence,,,, too early**
2. **Improved PMT-> looks better at present.**
   For example, Flat Panel PMT with Ultra bialkakli



Future Plan : Tibet AS + MD

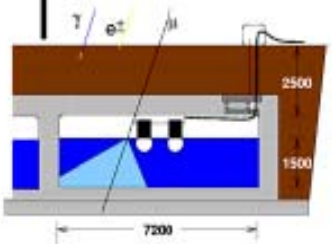


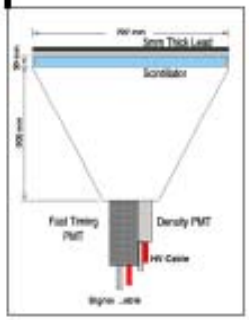
Schematic View of Tibet AS + MD

Site: Tibet :(90.522°E, 30.102°N) , 4300 m asl

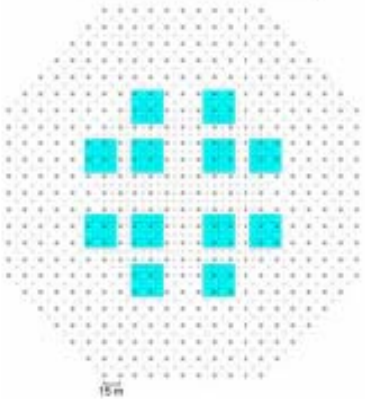
AS: 37,000 m^2 → ~83,000 m^2
Modal Energy : ~3 TeV
Angular Res: ~0.2 deg@100 TeV
Energy Res: ~40% @100TeV
Field of View: ~2 sr

MD: ~10000m^2 in area, 2.5 m underground,
Water Cherenkov type, 20'' ϕ PMT x 384

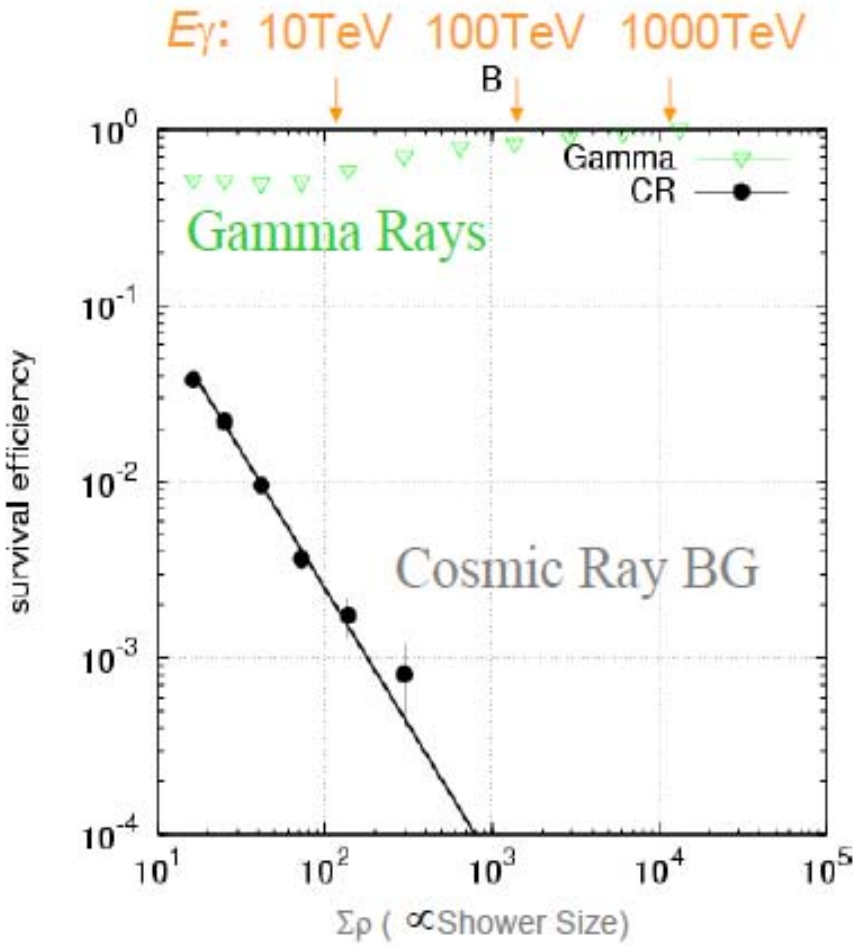


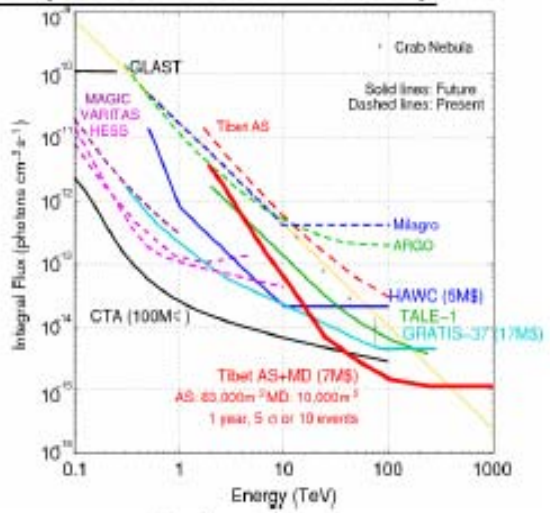


20''ϕPMT

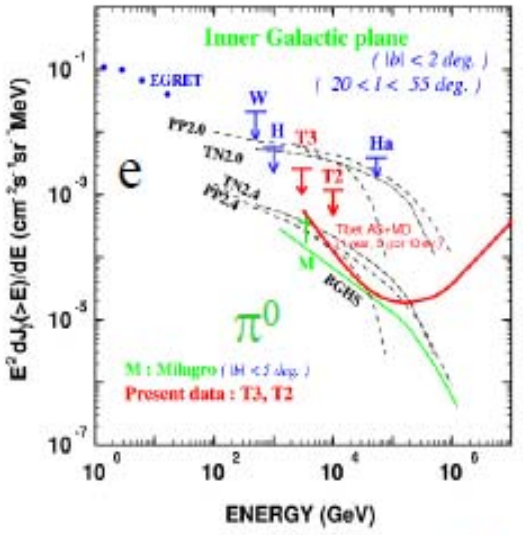


Hadron rejection and Sensitivities (Tibet AS+MD)





Point Source



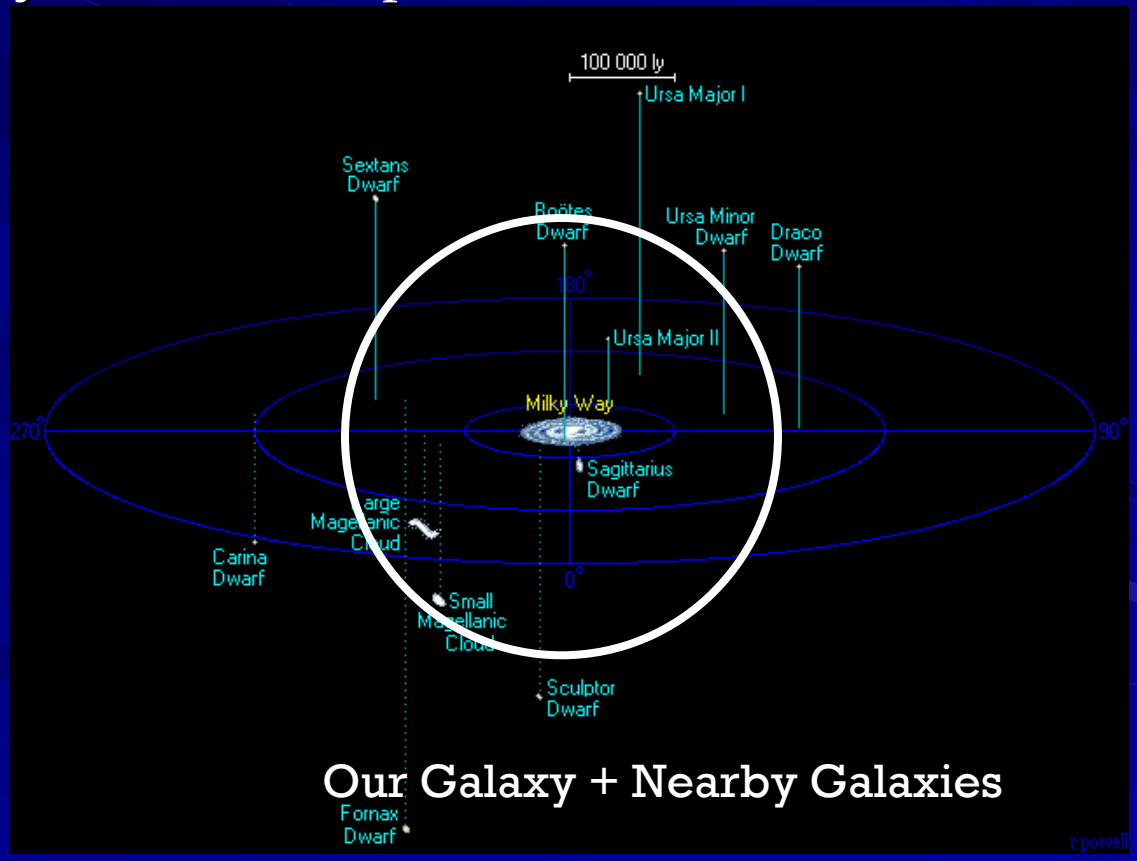
Diffuse source

R & D Summary

- Large FoV Camera (>6$^{o}\phi$; ~800 photo-pixels & embedded electronics system)
- Accurate, light & Cheap mirror production
- Cheap Telescope design
- Group construction (Now only discussion in Japanese Cangaroo institutes, but we need more large group for funding).

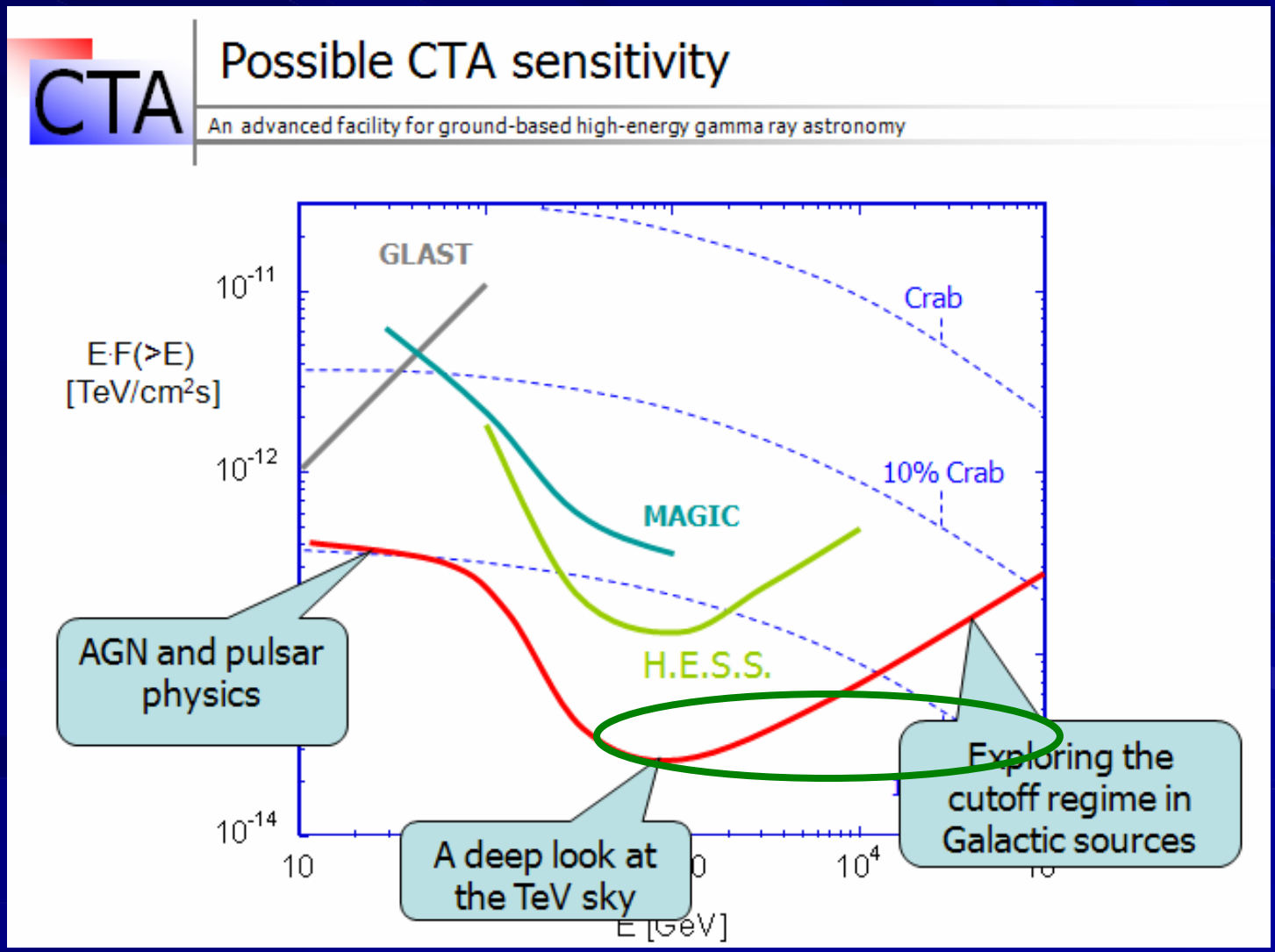
How far can we see?

- Crab (d=2 kpc)
- Present d=~10kpc→ ~5m Crab Sensitivity
- 1m Crab sensitivity -> d<~50kpc



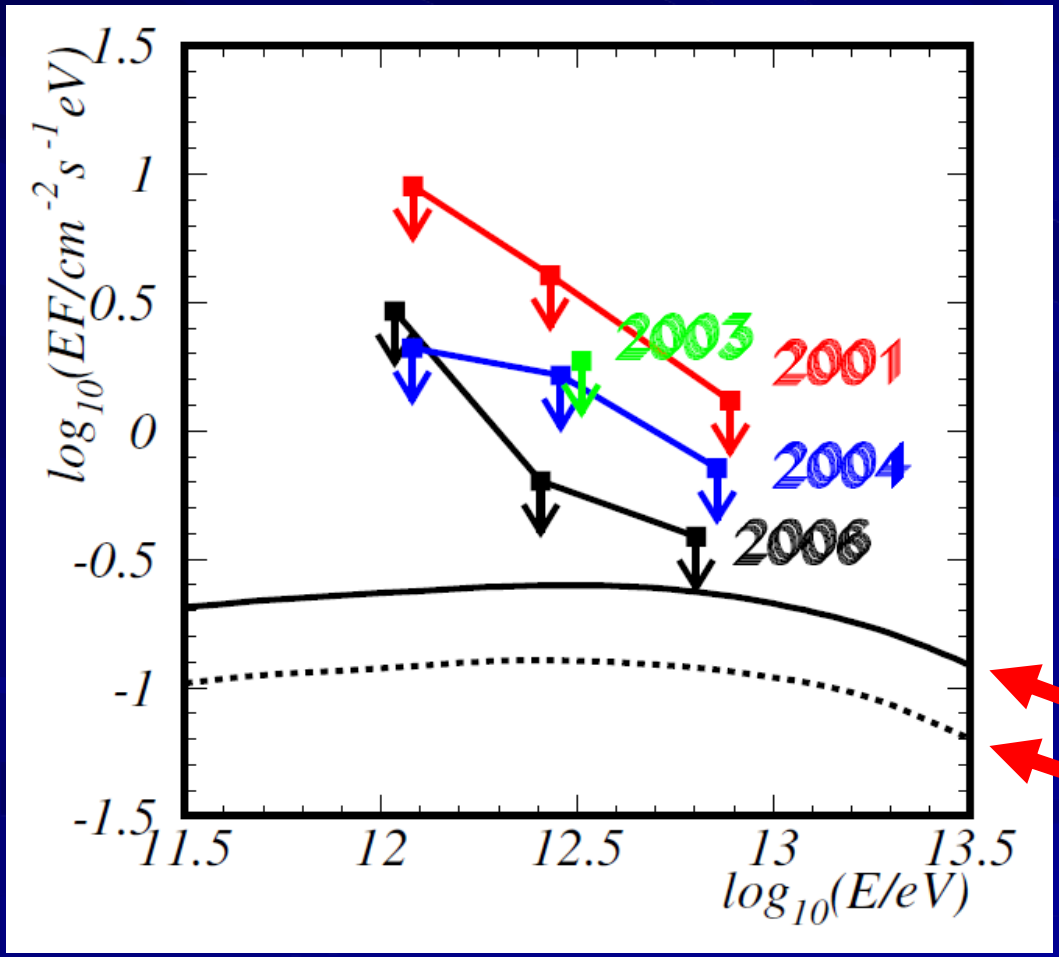
Ref: http://www.mpi-hd.mpg.de/hfm/CTA/paris_march07/

Expected sensitivity



SN1987A

Enomoto et al., submitted to ApJ



- 2001: CAN-II Enomoto et al. 2003
- 2003 :H.E.S.S. Rowell et al. 2005

- 2004: 10.5h Offline stereo
- 2006: 21.8h Online stereo

Berezhko & Ksenofontov (2006)

8249 days

7300 days

After the SN

c.f.
~ 6500 days@2004 obs.
~ 7200 days@2006 obs.

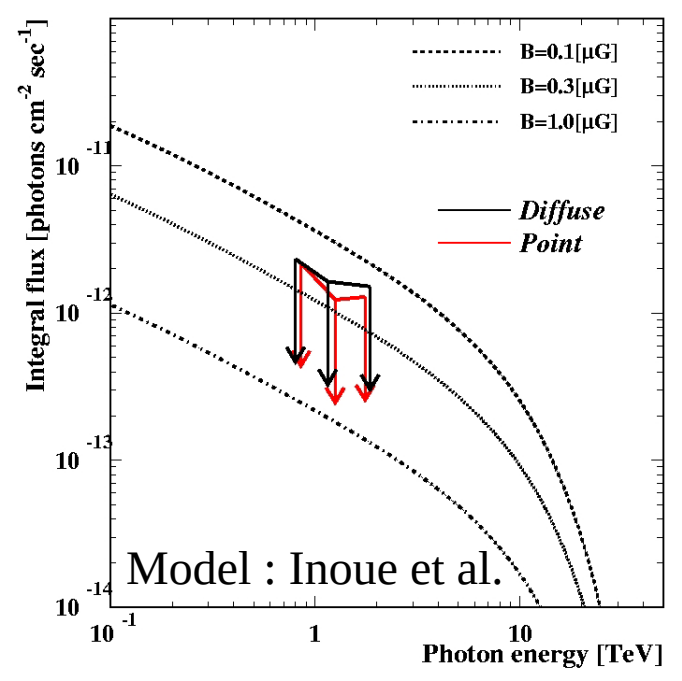
Cluster of galaxy : A3667/A4038

Kiuchi et al., ICRC2007

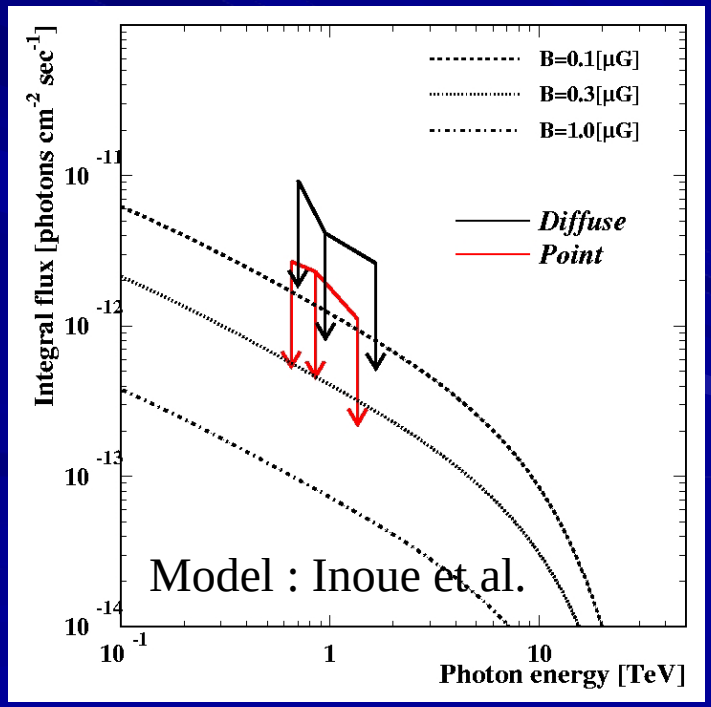
Abel 3667

- z = 0.55
- M ~ 2E15 $\mathbf{M_\odot}$
- **X-ray + radio structure**

- 2006 Jul-Aug
- ON 29.7 / OFF 23.7 hours



Abel 4038

- z = 0.029 **(as close as Coma cluster)**
- M ~ 5E14 $\mathbf{M_\odot}$

- 2006 Aug-Sep
- ON 23.8 / OFF 17.7 hours