

LAGO: Large Aperture for GRB Observatory in Latin America

Argentina, Bolivia, Brazil, Mexico, Venezuela, (Peru, Chile, Colombia)
Italia, Francia

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Detection of GRBs

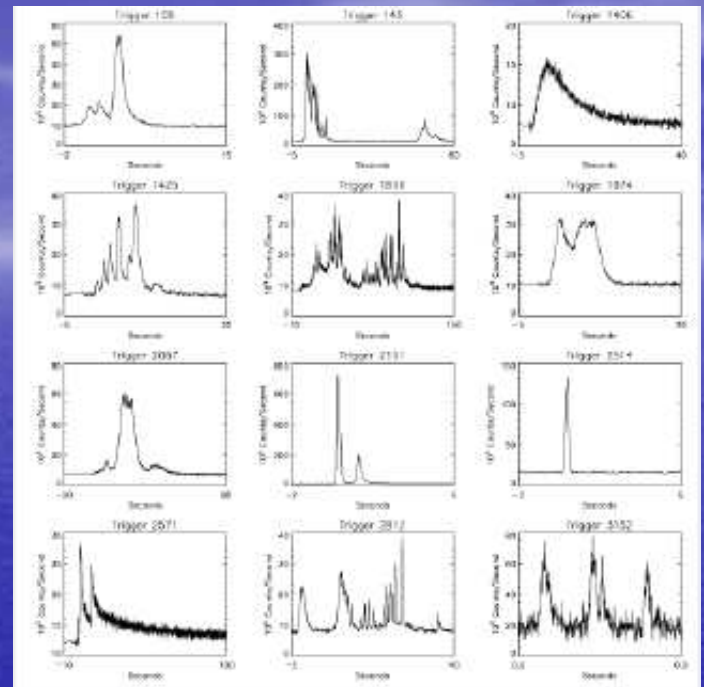
Vela 5

US military satellites Vela discovered GRBs accidentally in the 60's



BATSE: 1991-2000

On the Compton GRO
Full field of view (4π sr)
Bad angular resolution ($>4^\circ$)

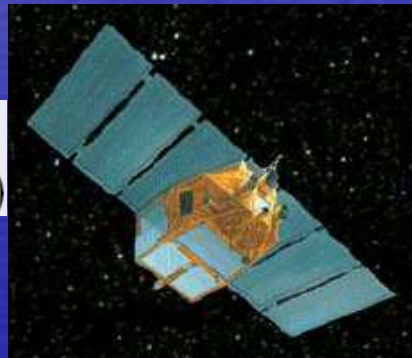


Beppo-SAX

GRB 970228

GRB monitor
X-rays detectors
75" AR

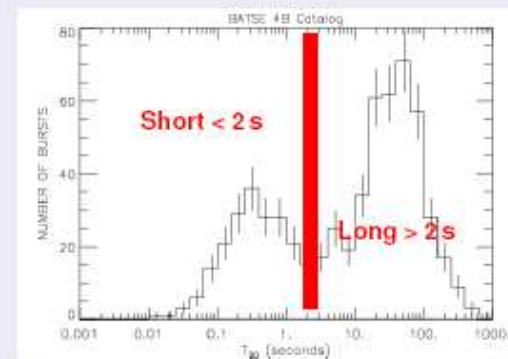
Observed in X
Afterglow (≈ 3 days)



SWIFT (2004-) allowed detection of short GRB afterglows, early flares, high redshifts GRBs...

GLAST (launched June 12 2008) to look at GeV range
(Fermi Gamma-Ray Space Telescope)

Duration



WHAT WE KNOW ABOUT GRBS??

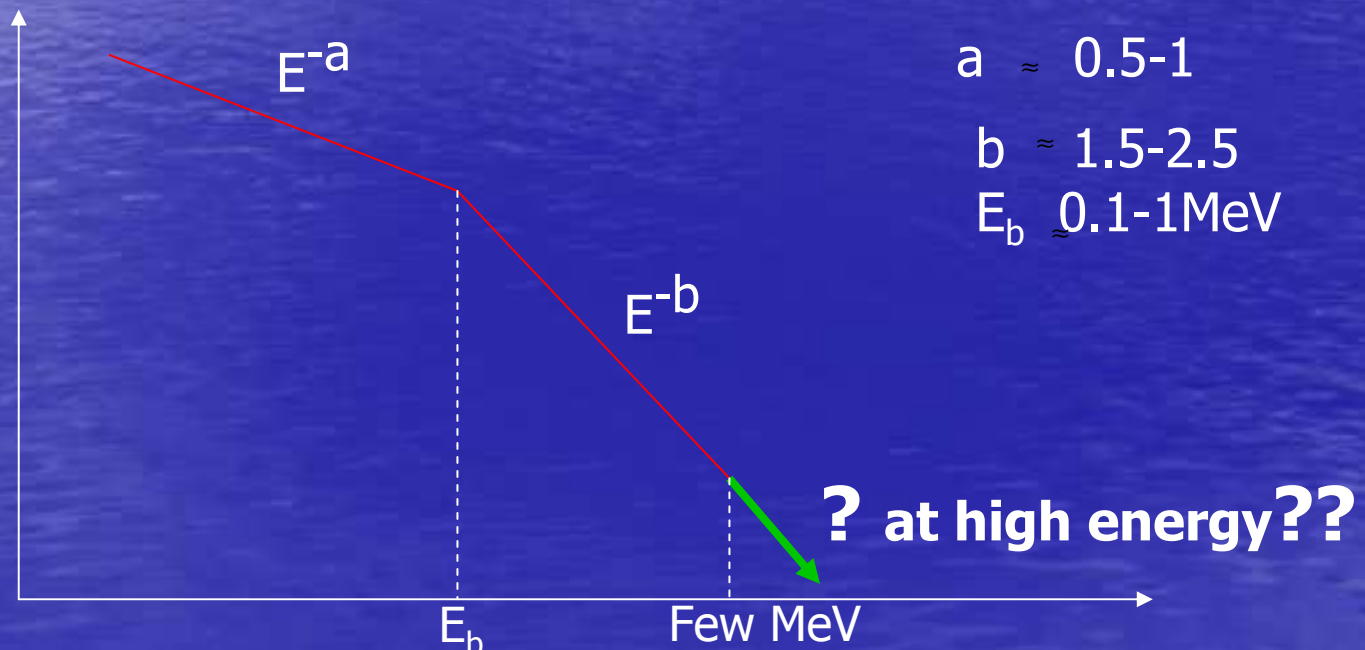
Most of GRBs have been observed in the KeV-MeV energy Region by satellite detectors

BATSE detected 2704 GRBs

Typical BATSE GRBs spectrum:

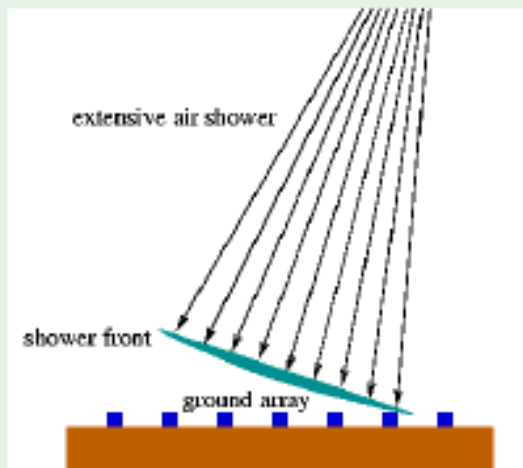
Power law with a break at energy $E = 0.1 - 1$ MeV

Maximum energy: few Mev

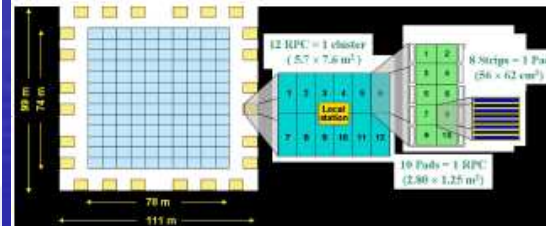


Ground based techniques

Extended Air Shower



Milagro: 5 000 m² @ 2600 m a.s.l. in New Mexico
Full sky survey



ARGO - YBJ
6 700 m² of RPCs in Tibet
@ 4300 m a.s.l.

- GRB photon shower reconstructed
- Excess in source direction
- Can have large surface
- High energy threshold

Huge background
Can get large collection surface
Atmosphere effect:

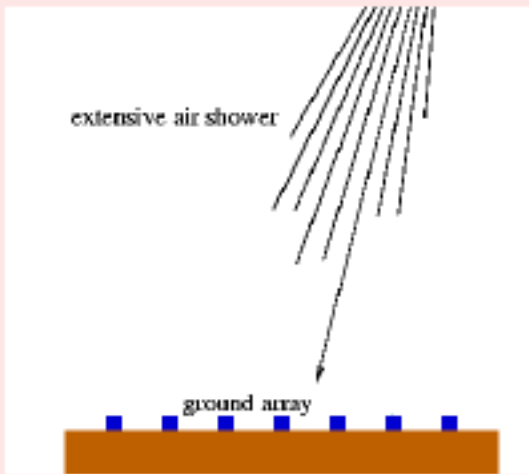
- ▶ absorbs low energy
- ▶ multiplies high energy

INCA detectors

Chacaltaya 5230

48 m²

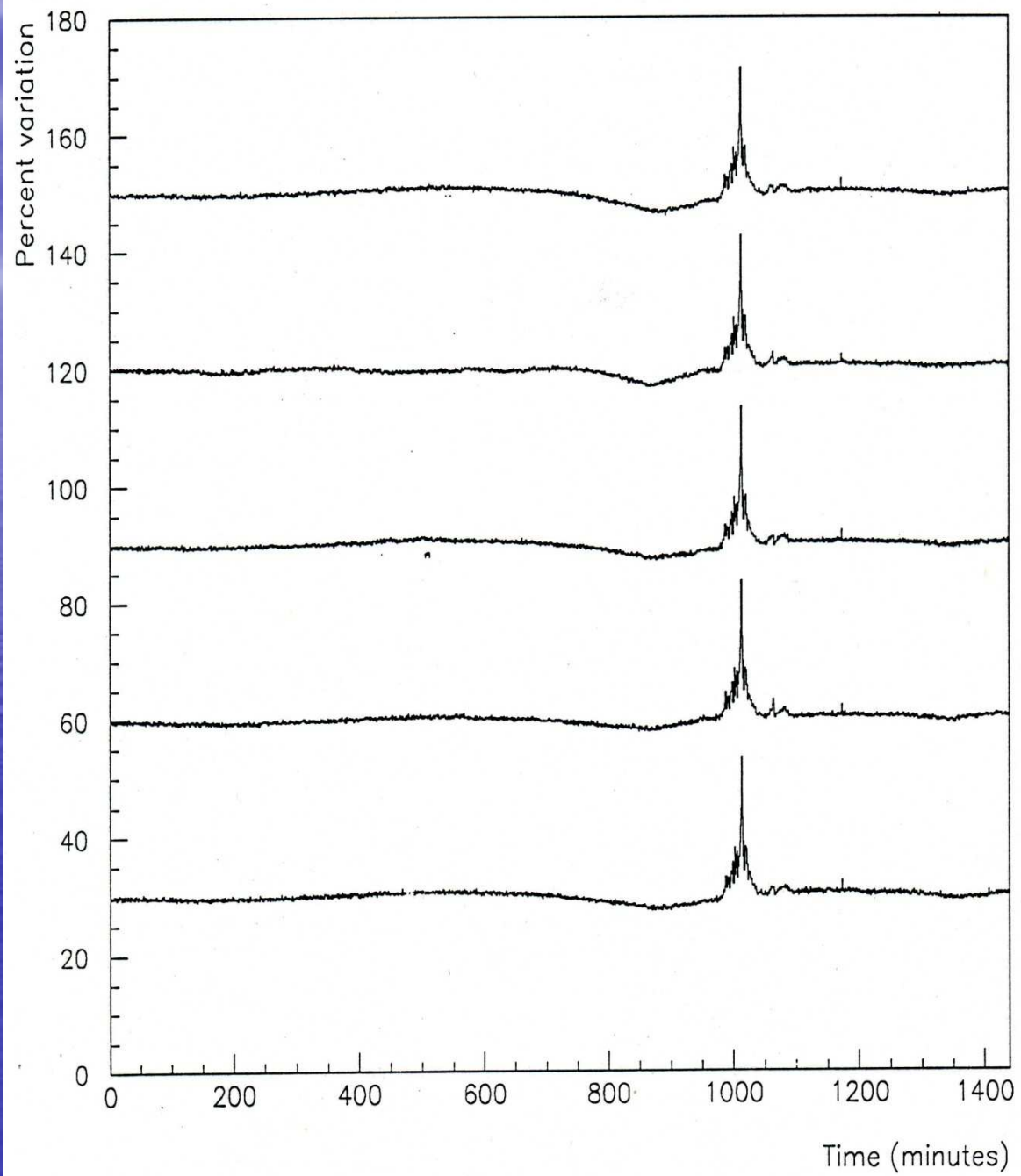
Single Particle



- no direction and/or energy reconstruction
- GRBs seen as an excess of counts over background
- Low energy threshold



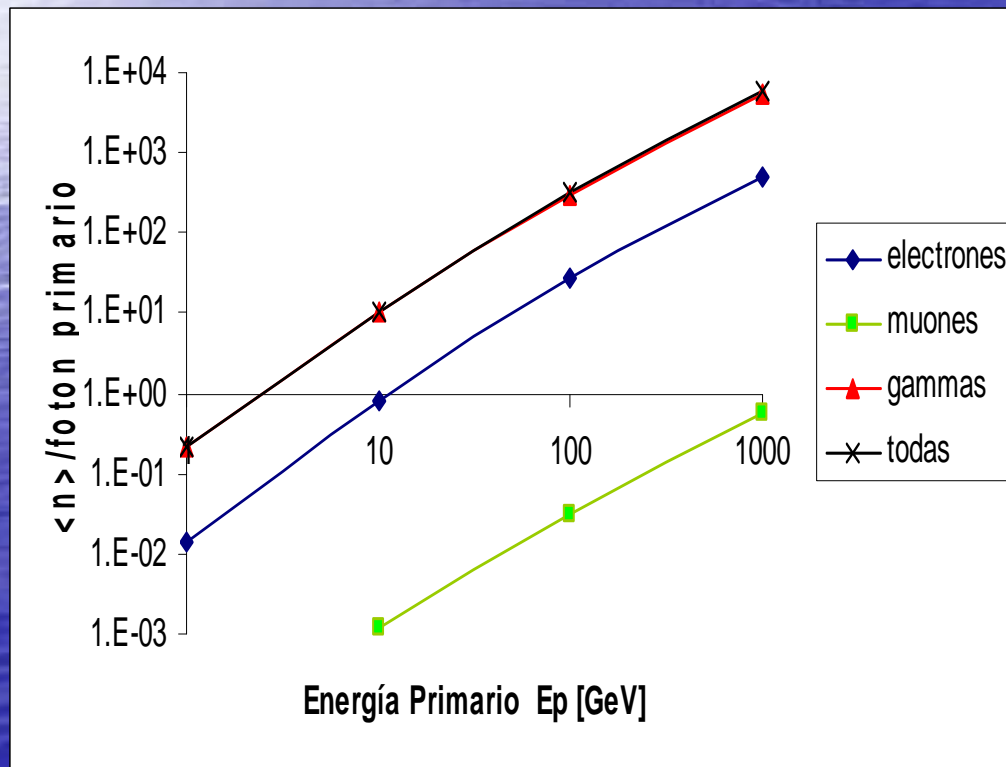
Run 35 Day 6



un evento falso

Número medio de partículas secundarias por fotón primario en función de la energía del γ primario.

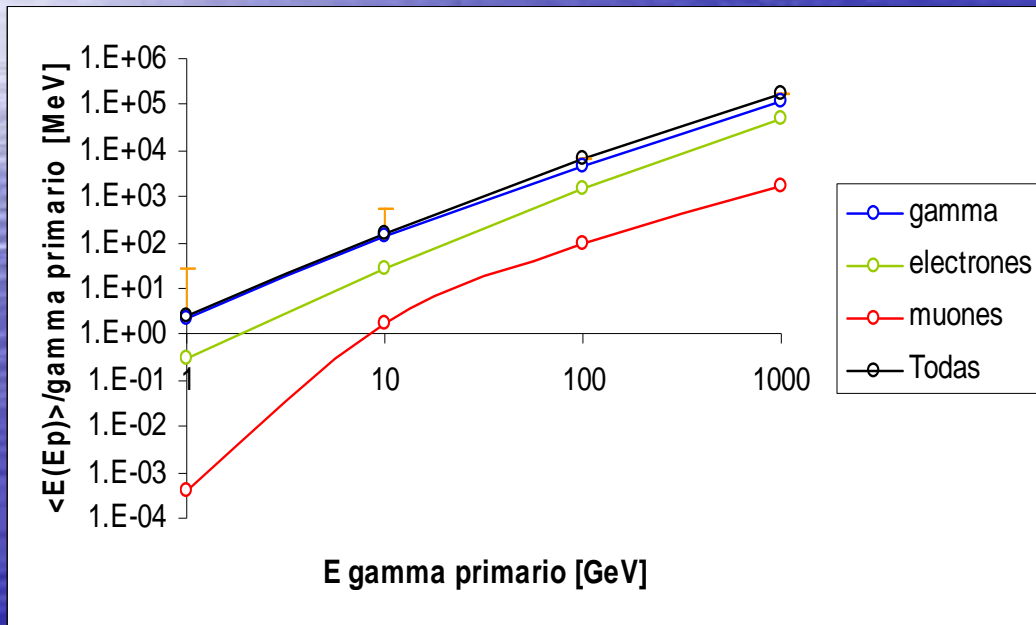
- Simulación AIREs
- Alexandra de Castro (LAGO Venezuela), Javier Quispe (LAGO Bolivia)



E [GeV]	e	μ	γ	Total
1	0.014	0	0.21	0.224
10	0.774	0.0012	9.98	10.76
100	26.22	0.032	291.2	317.5
1000	522	0.56	5513	6080

Energía media vs. Energía γ primario

- Simulación con AIRES.
- Alexandra de Castro (LAGO Venezuela), Javier Quispe (LAGO Bolivia)



γ primario	μ_{\pm}	e_{\pm}	γ	Todas
E_p [GeV]	$\langle E \rangle$ [MeV]			
1	0.0004	0.32	2.19	2.52
10	1.72	28.4	130.1	160.5
100	99	1538	4860	6500
1000	1700	50500	122100	174000

INCA and EAS-TOP results

Aglietta et al.
Astron. and Astrophys. 138, 595 (1999)

A.Castellina et al.
Astron. and Astrophys. 138, 599 (1999)

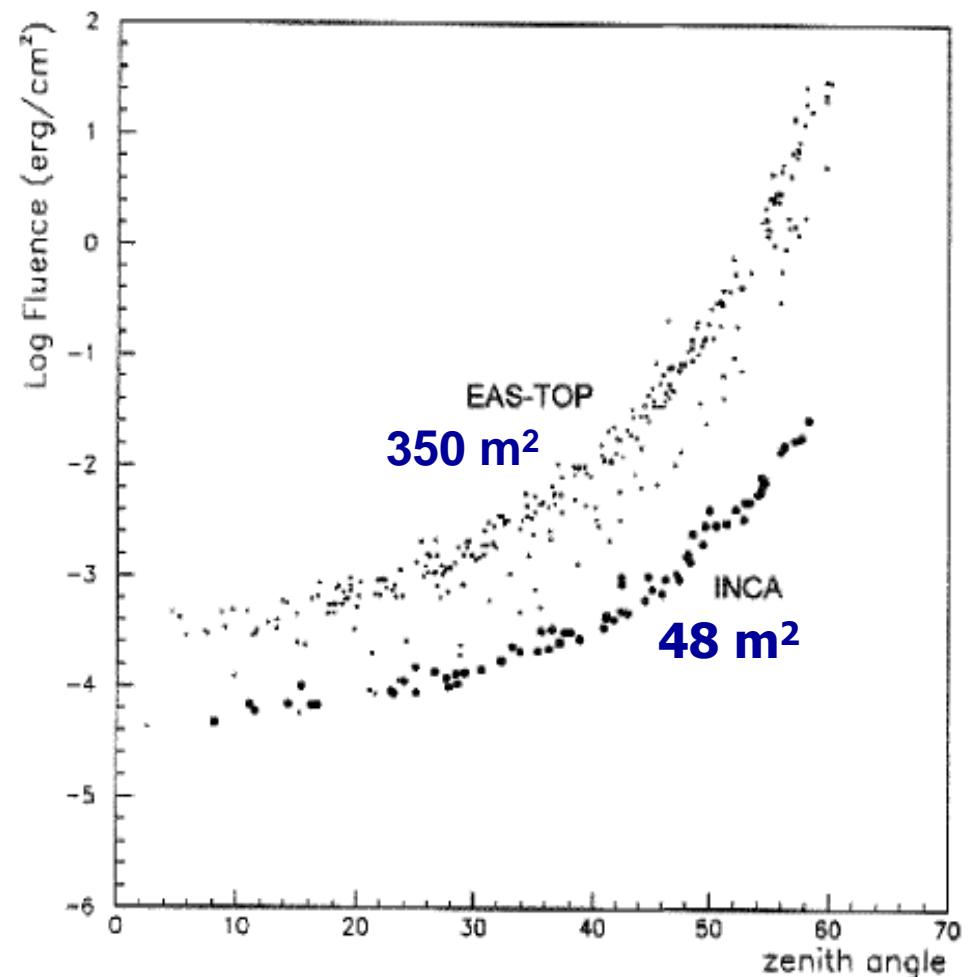


FIGURE 2. Upper limits on the energy fluence vs zenith angle in the energy range $1\text{GeV} - 1\text{TeV}$ for 70 GRBs events in the field of view of INCA for a time window of 10 s starting from BATSE trigger time. The same for the EAS-TOP experiment but in the energy range $10\text{GeV} - 1\text{TeV}$ obtained for 292 BATSE events in the field of view of EAS-TOP. The detector area of EAS-TOP is 350 m^2 while INCA's is only 48 m^2 .

AIP 566,11 (2001)

Cosmic Ray Observations at Chacaltaya and Cerro la Negra Combined with the Pierre Auger and Milagro Observatories: GRBs and Search for Cosmic Ray Correlations

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Abstract. We consider the possibility to search for cosmic ray phenomena time correlated among distant experiments that are currently running in the world. In particular we consider the correlations of events detected by four experiments: between Milagro, operating in USA, and Cerro La Negra Cosmic Ray Laboratory, under construction in Mexico, and between Chacaltaya, in Bolivia, and Auger Observatory, under construction in Argentina. Almost complete sky coverage with fairly uniform celestial exposure of the northern and the southern hemispheres by the above four experiments at the same time could provide important information on astrophysical phenomena. Search for Gamma Ray Bursts and search for non random coincidence between these experiments seem to be feasible under an international extensive air shower joint experiment with the main goal to watch GRBs and other astrophysical phenomena.

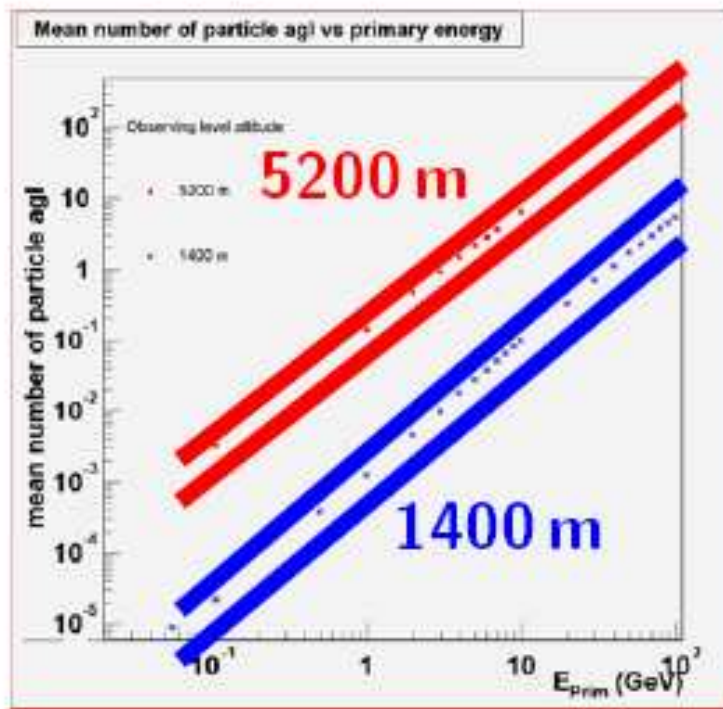
The Cherenkov Detector

La Paz prototype



Particles at ground level

At 5200 m



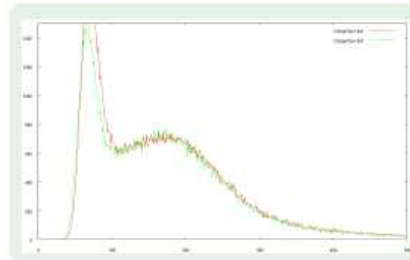
- ▶ 100 × more signal
- ▶ 8 × more background
- ▶ $S/\sqrt{B} \approx 35 \approx \sqrt{1600}$

1 detector at 5200 m \approx 1600 Auger detectors at 1400 m

Bariloche



Pico espejo, Venezuela



LAGO a Torino

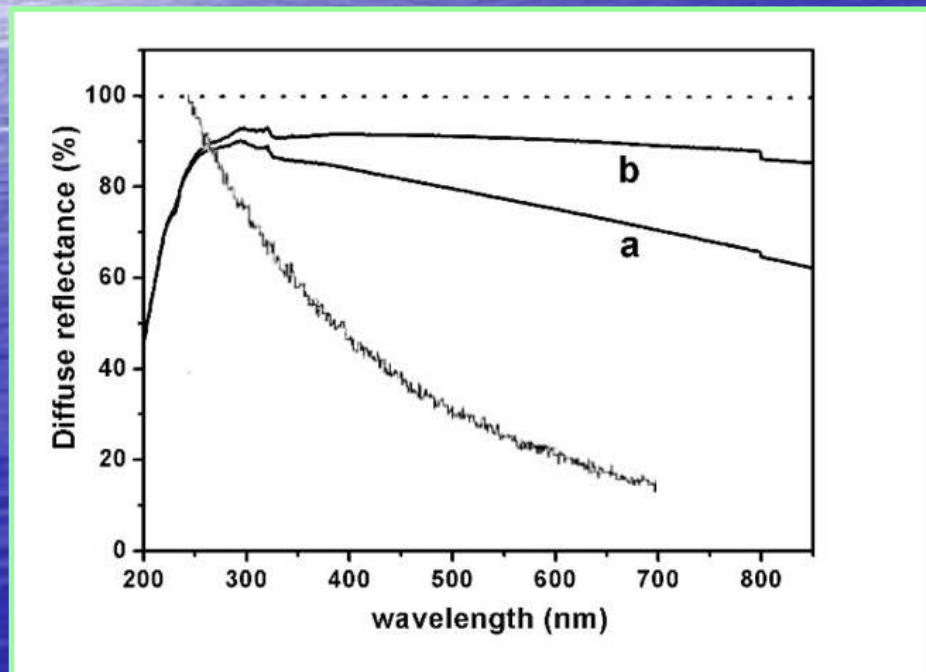
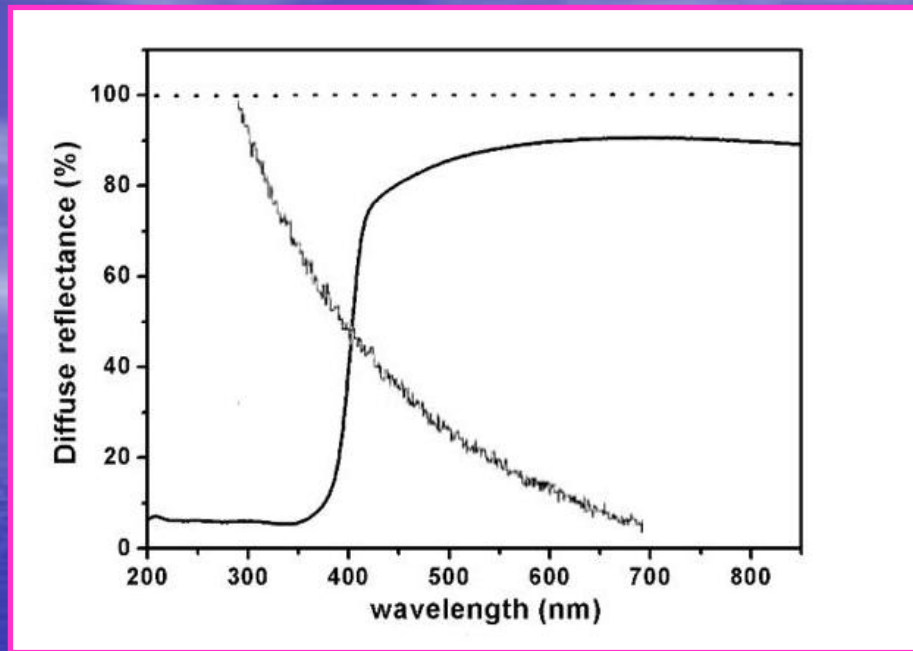
Aglietta, Bolognino, Saavedra



PHOTONIS: modello XP1805D1
Fotocatodo con superficie estesa
($d = 230 \text{ mm}$ (9"))
8 dinodi
Efficienza quantica $\lambda = 420 \text{ nm}$: 23%
Alta tensione direttamente sulla base
partitore
Amplificatore del dinodo x32

Plastic scintillator

VERNICE A BASE DI BIOSSIDO DI TITANIO



TEFLON

MISURA DEL GUADAGNO: tecnica del singolo fotoelettrone

$$P(n) = \frac{e^{-\mu} \mu^n}{n!}$$

$$n = 0 \rightarrow P(0) = e^{-\mu} = 0.90$$

$$n = 1 \rightarrow P(1) = \mu e^{-\mu} = 0.095$$

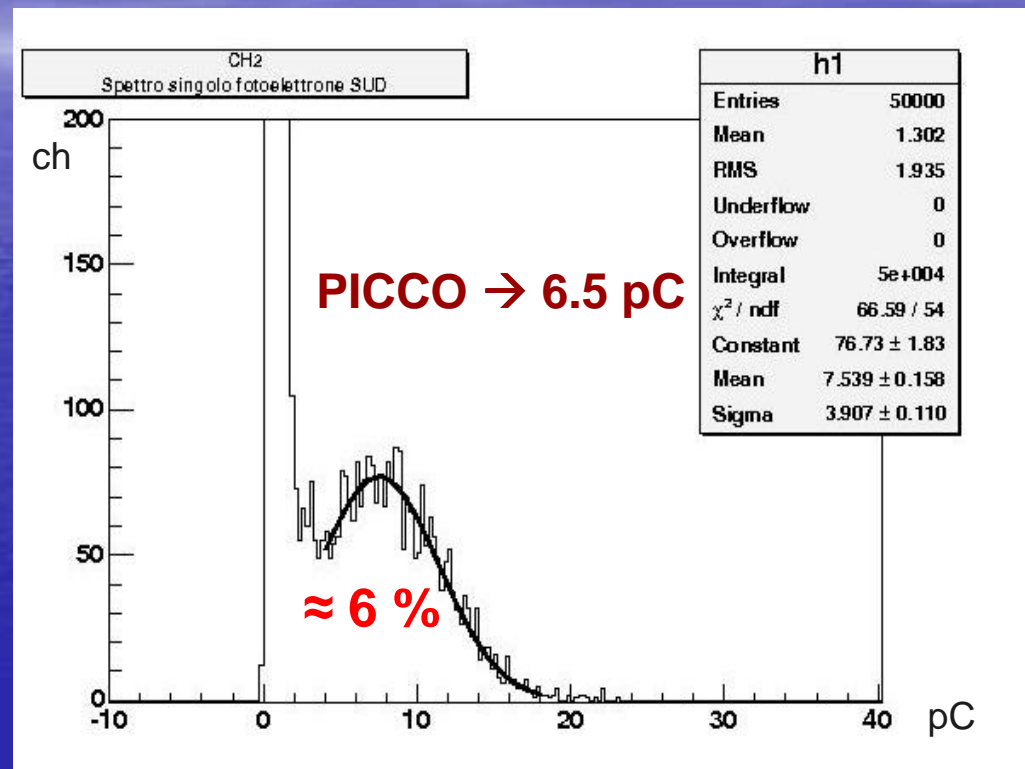
$$n > 1 \rightarrow P(n > 1) = 1 - 0.9 - 0.095 = 0.005$$

$$G = \frac{p}{A \cdot e}$$



A=32

$$G = 1.3 \cdot 10^6 \quad (\sigma = 10\%)$$



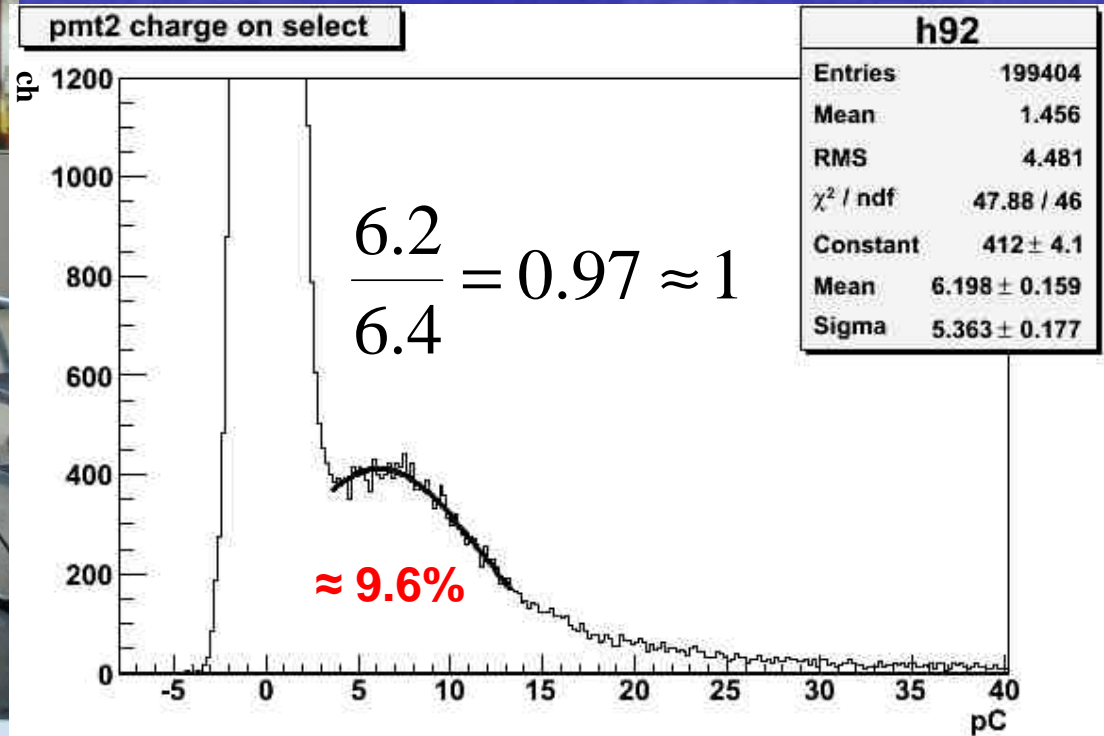
EFFETTO CHERENKOV IN ARIA



Scintillatori plastici 36x36 cm²

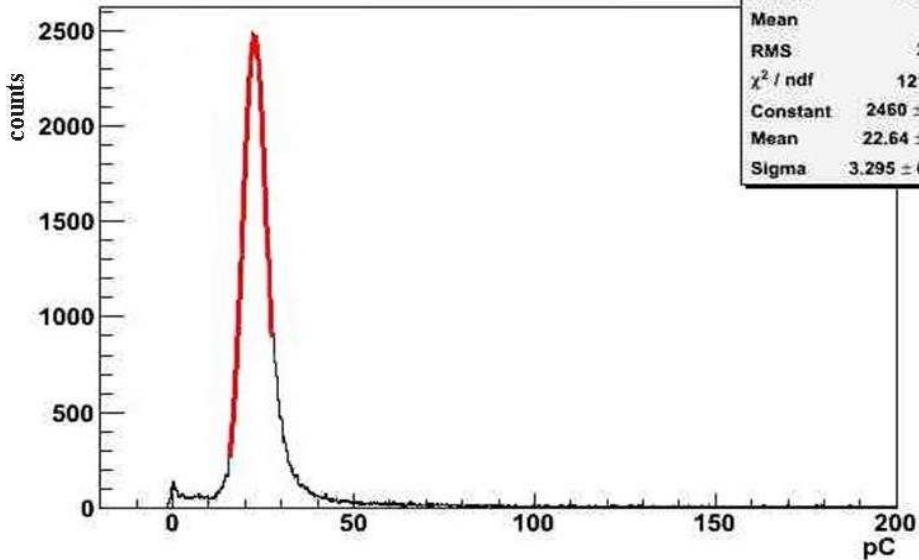
190 cm

Coincidenza $\approx 1 \mu/s$



pmt1 charge on select

ANODO



h91	
Entries	130000
Mean	28.4
RMS	23.78
χ^2 / ndf	121 / 56
Constant	2460 \pm 10.7
Mean	22.64 \pm 0.01
Sigma	3.295 \pm 0.014

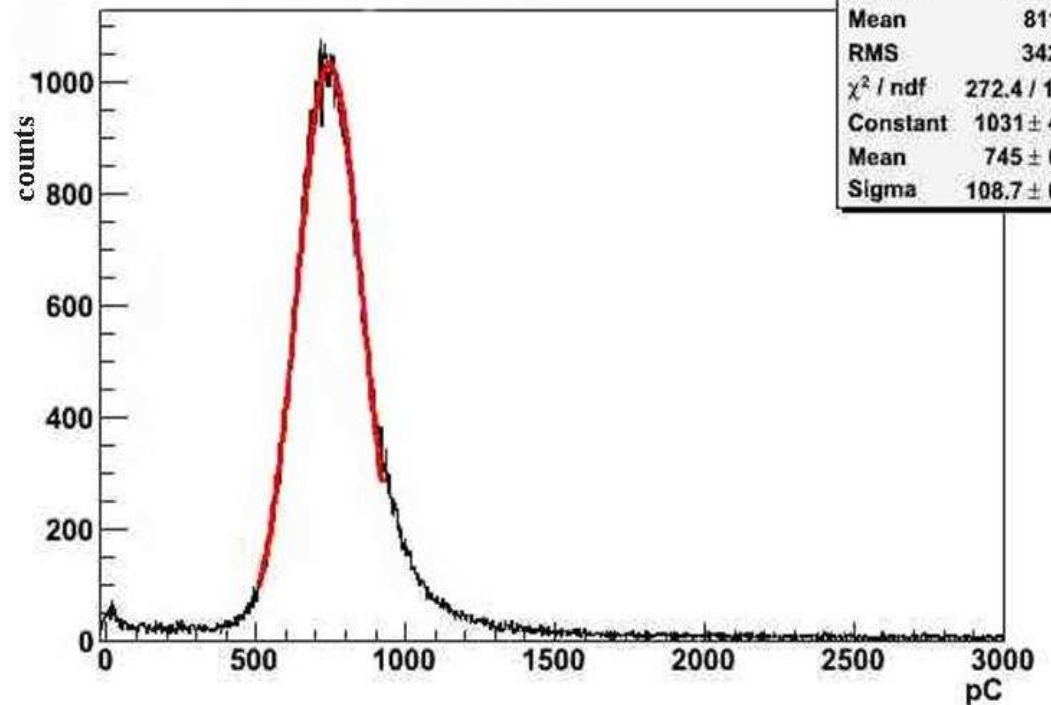
MUONI VERTICALI IN ACQUA PURA

$$n_{fe}^{\circ} = \frac{745 \text{ pC}}{6.36 \text{ pC}} = 117$$

1 fotoelettrone per cm
di percorso

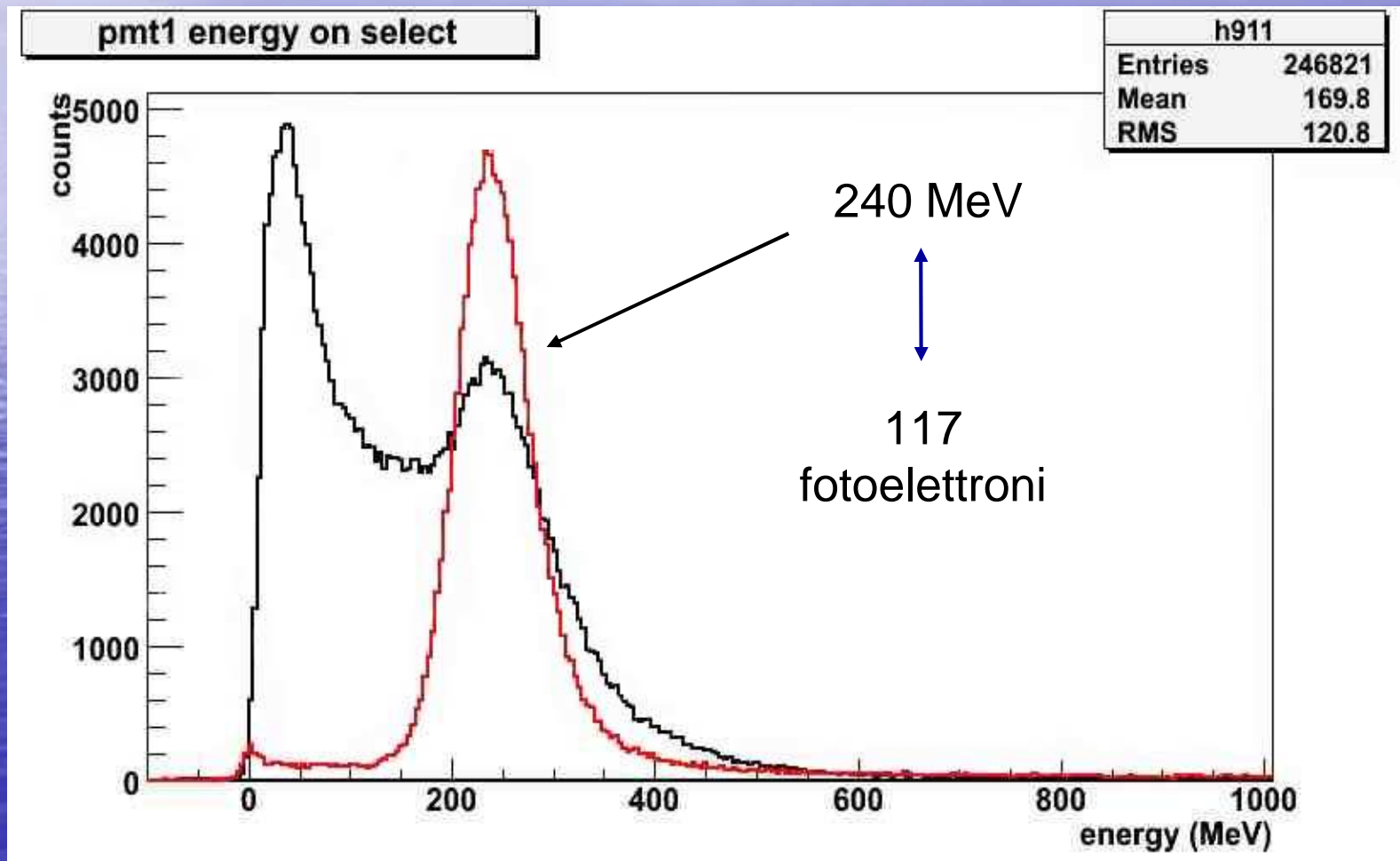
pmt2 charge on select

DINODO



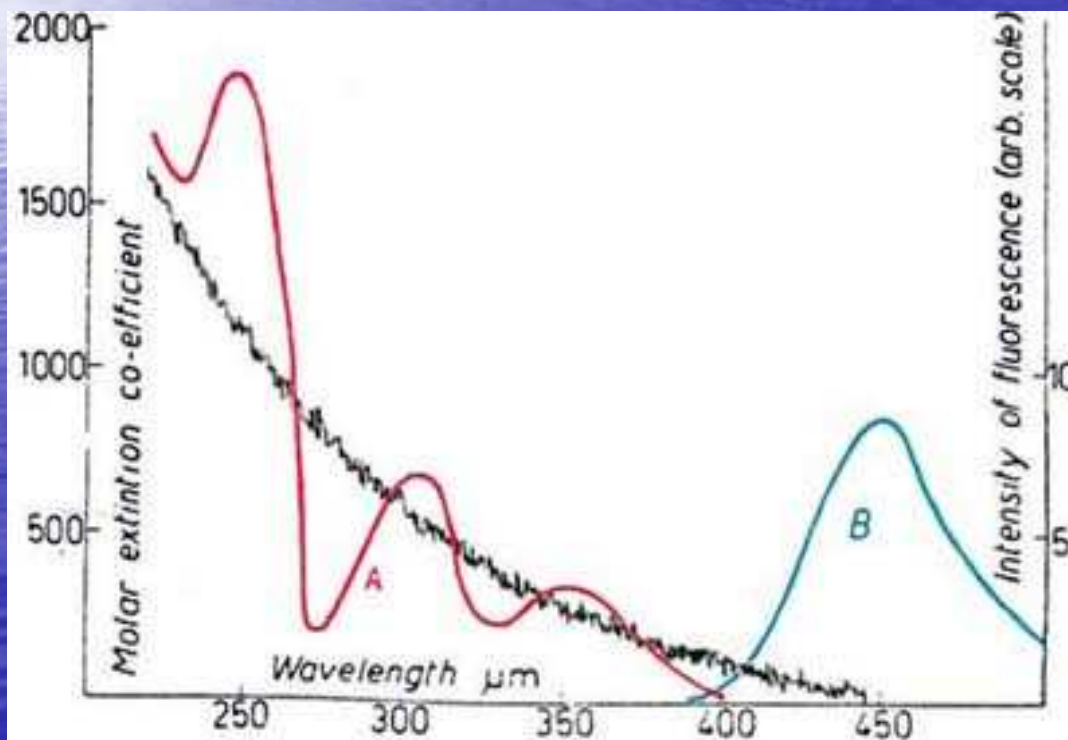
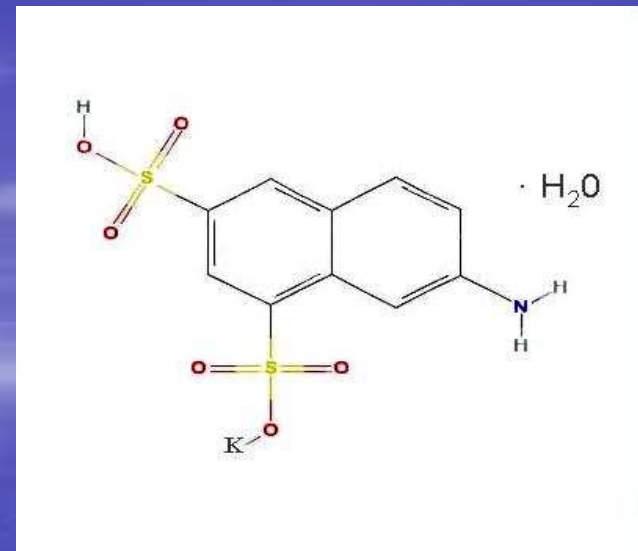
h92	
Entries	130000
Mean	811.8
RMS	342.3
χ^2 / ndf	272.4 / 148
Constant	1031 \pm 4.4
Mean	745 \pm 0.4
Sigma	108.7 \pm 0.4

MUONI OMNIDIREZIONALI IN ACQUA PURA



AMINO-G

Monopotassium 7-Amino-1, 3-naphthalenedisulfonate Hydrate,
 $C_{10}H_8KNO_6S_2 \cdot H_2O$

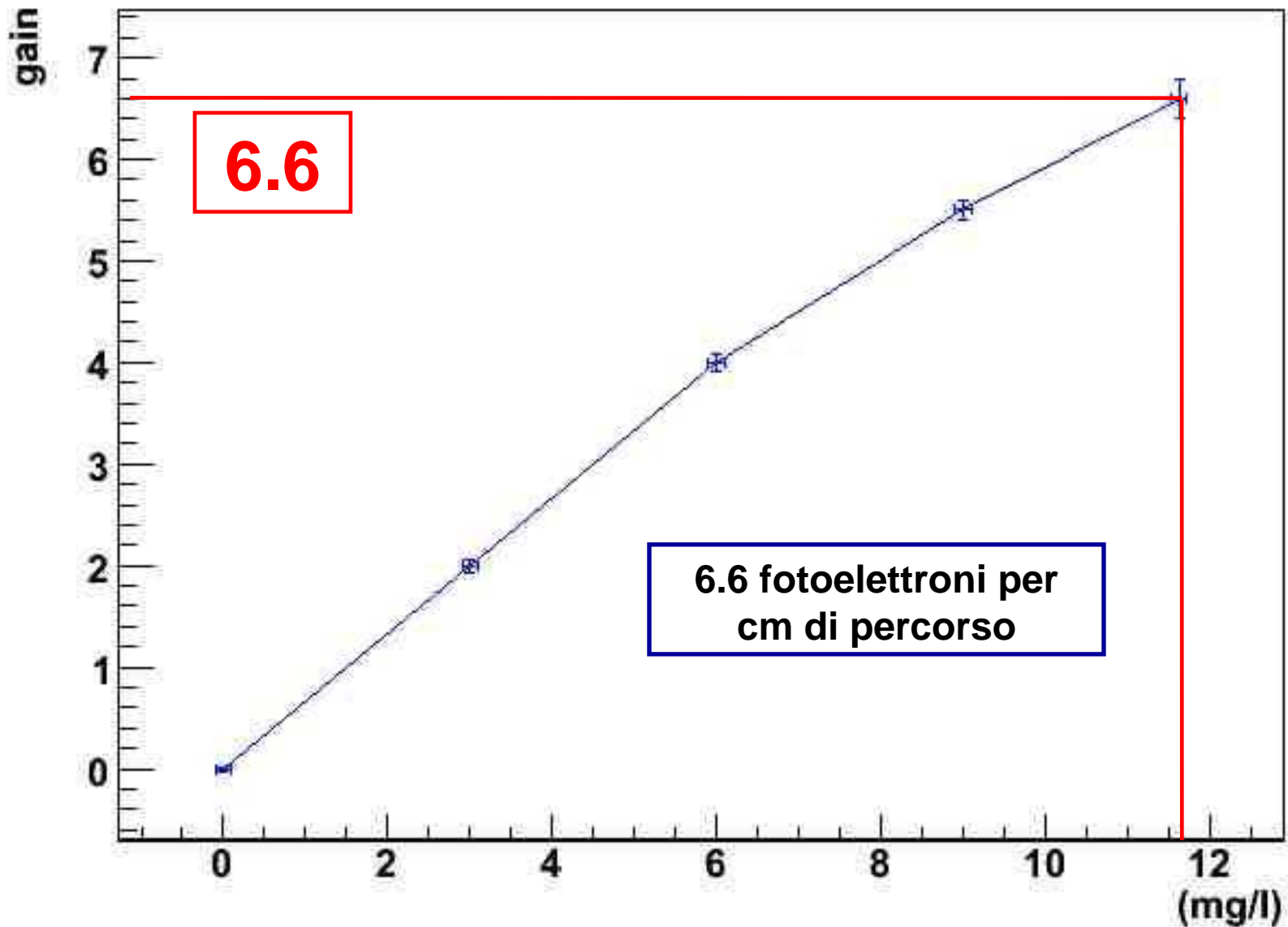


■ Spostatore di lunghezza d'onda: shift dei fotoni Cherenkov a $\lambda \approx 400$ nm

➔ massima efficienza quantica

■ Procedimento: concentrazioni via via crescenti

Gain obtained adding amino-G salt



Putre, Chile 3600 m s.l.m.





Observatory



Geographic Coordinates



Geomagnetic Coordinates [2005]



Magnetic dip equator[2005]

LARGE APERTURE GRB OBSERVATORY



Colombia

Sierra Negra
4550 m a.s.l.

Guatemala

Merida,
Venezuela
4765 m a.s.l.

Huancayo, Peru
3313 m a.s.l.

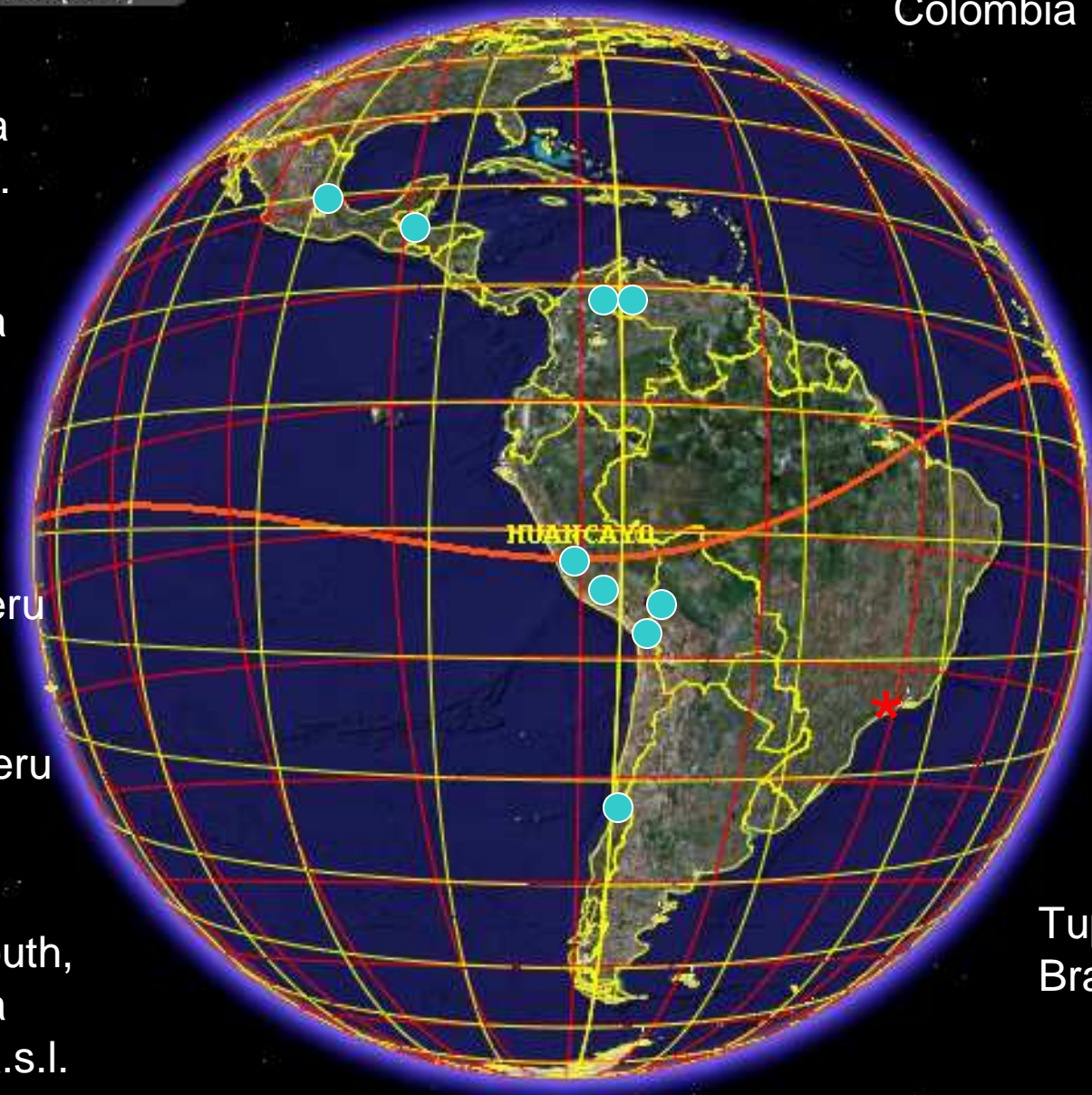
Arequipa, Peru

Chacaltaya,
Bolivia
5230 m a.s.l.

Auger South,
Argentina
1400 m a.s.l.

Putre, Chile
3600 m a.s.l.

Tupi, Rio
Brazil



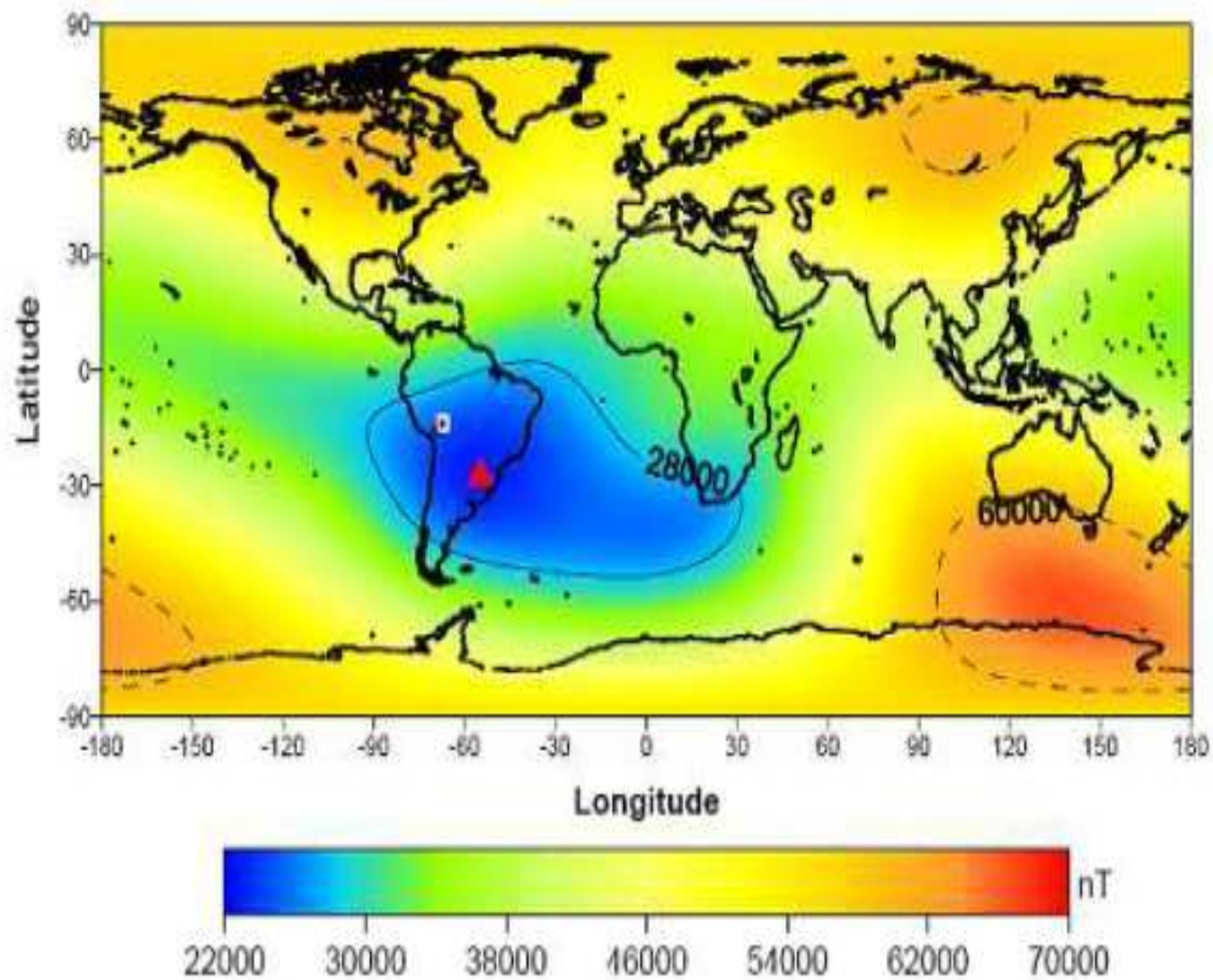


FIG. 1: Geographic distribution of geomagnetic field intensity. The SAA boundary is around $B = 28000 \text{ nT}$. The triangle and the square indicate the localizations of the Tupi facility and the LAGO-Bolivia station respectively.

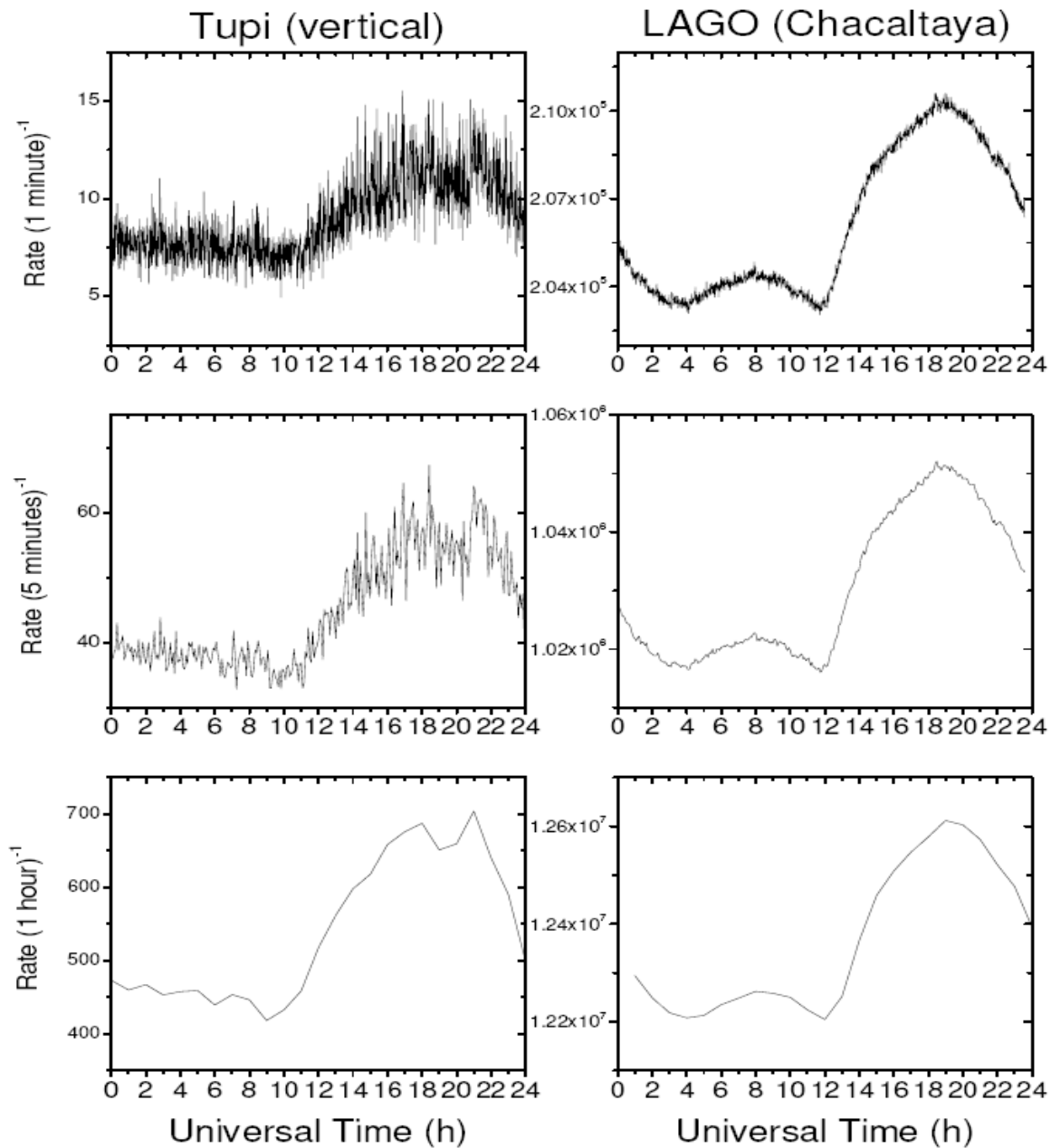


FIG. 7: Hourly variation of the counting rate over one month (September, 2008), obtained in the vertical Tupi telescope (left column frames) and LAGO Chacaltaya water Cherenkov detector (right column frames). Both columns are for one minute binning (upper), five minutes binning (central), and one hour binning (lower).

CONCLUSIONS

A large Latin America network of WCD is under construction for detection of GRB

WCD are very efficient to detect GRB and transient solar phenomena from ground

Astroparticle, Solar and Atmospheric physics are underway