Pierre Auger Observatory

studying the universe's highest energy particles

Status dell'esperimento Auger

G. Cataldi, G. Cocciolo , M.R. Coluccia, A. Corvaglia, P. Creti, S. D'Amico, I. De Mitri, U. Giaccari, G. Marsella, D.Martello, L.Perrone, C. Pinto, M. Settimo

Dipartimento di Fisica

INFN Istituto Nazionale di Fisica Nucleare Sezione di Lecce

Il progetto Pierre Auger: range di operatività

Studio della radiazione cosmica di altissima energia

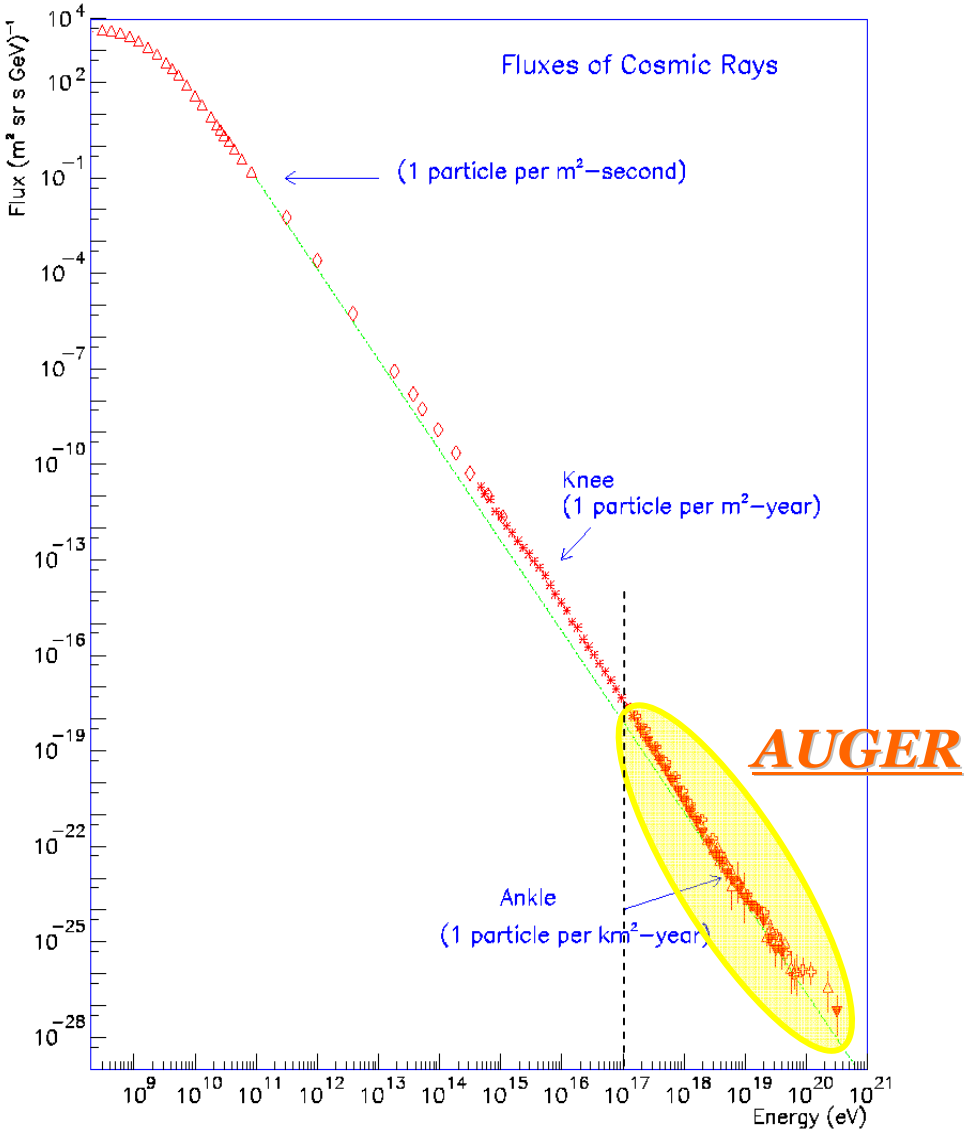
$(10^{17}$-$10^{21})$ eV

Flusso ad $E>10^{19.5}$ eV molto basso

1 particella/(km^2 sr secolo)

Apparato di grandi dimensioni: 3000 km^2 (Auger)

30 eventi/anno

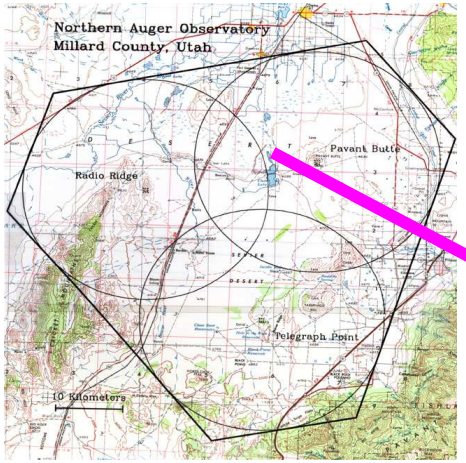


La collaborazione Pierre Auger

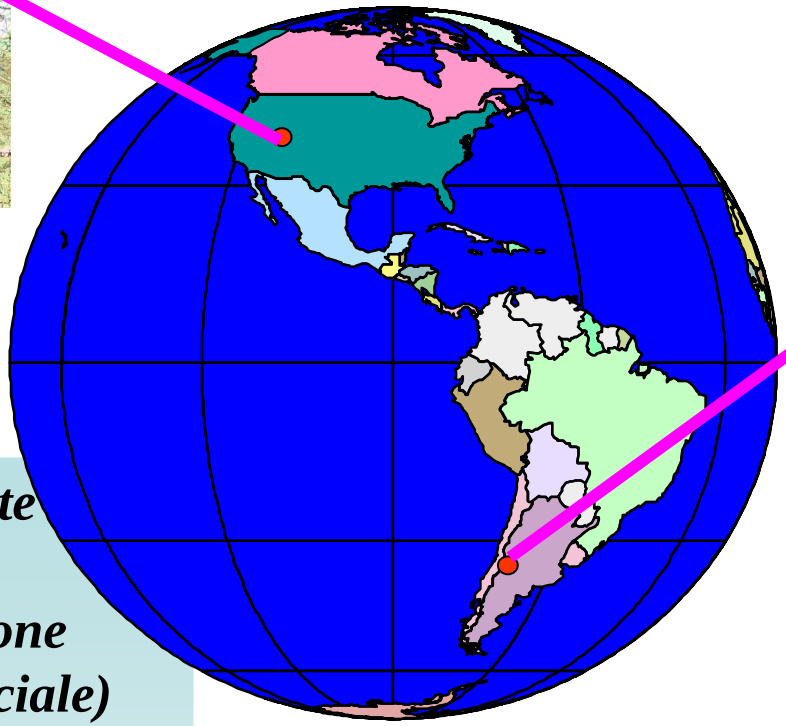
Argentina
Australia
Bolivia
Brazil
Czech Rep.
France
Germany
Italy
Mexico
Netherlands
Poland
Portugal
Slovenia
Spain
UK
USA
Vietnam

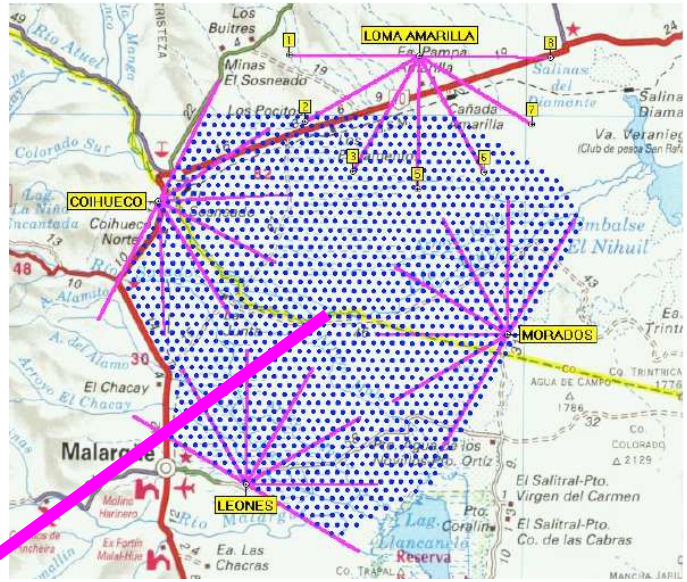
17 Countries
63 Institutions
~ 350 members

L'Osservatorio Pierre Auger



Northern hemisphere
Colorado, USA





- *Vasta regione pianeggiante*
- *Bassa densità di popolazione (scarsa illuminazione artificiale)*
- *Condizioni atmosferiche favorevoli (copertura nuvolosa, trasparenza, pioggie, temperatura…)*

Southern hemisphere
Malargüe (Mendoza)
Argentina

35°S latitude,
69°W longitude
Altitude ≈ 1.4 km

Osservatorio Pierre Auger: un rivelatore ibrido

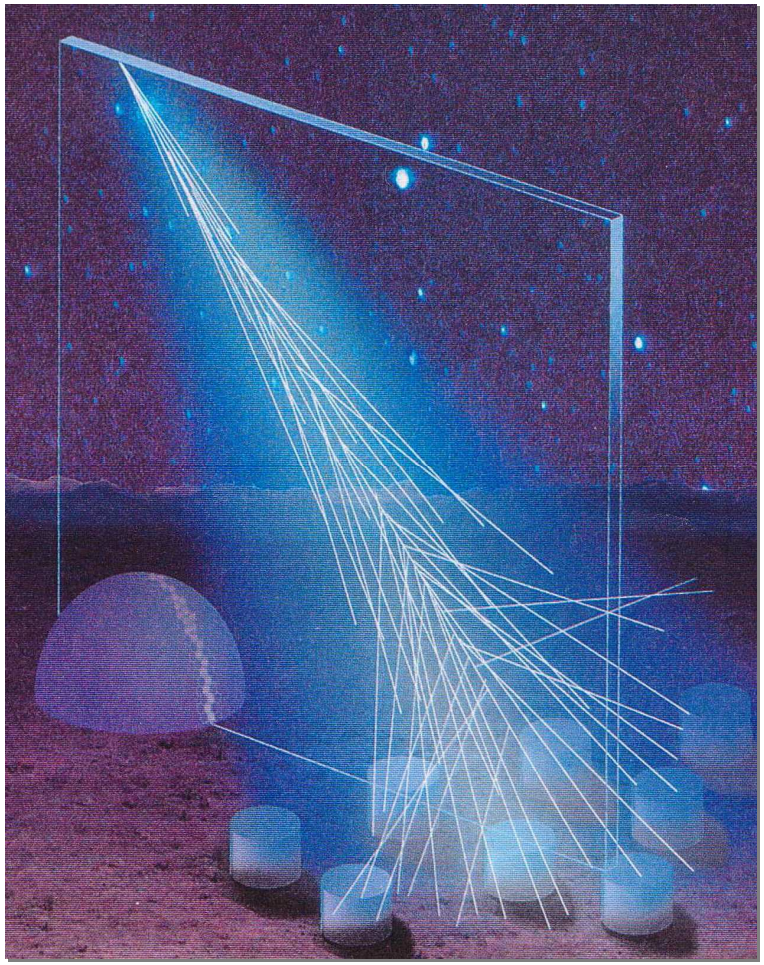
Lo stesso sciame è misurato simultaneamente con due tecniche indipendenti:

- **un apparato di superficie** per l'osservazione delle particelle dello sciame a terra

- **un rivelatore di luce di fluorescenza** che osserva lo sviluppo longitudinale dello sciame misurando la radiazione UV prodotta in aria al passaggio delle particelle cariche dello sciame

- **Determinazione accurata della direzione di arrivo degli eventi in un ampio range di energia**

- **Misura dell'energia del primario senza dipendenza dai modelli di interazione adronica**



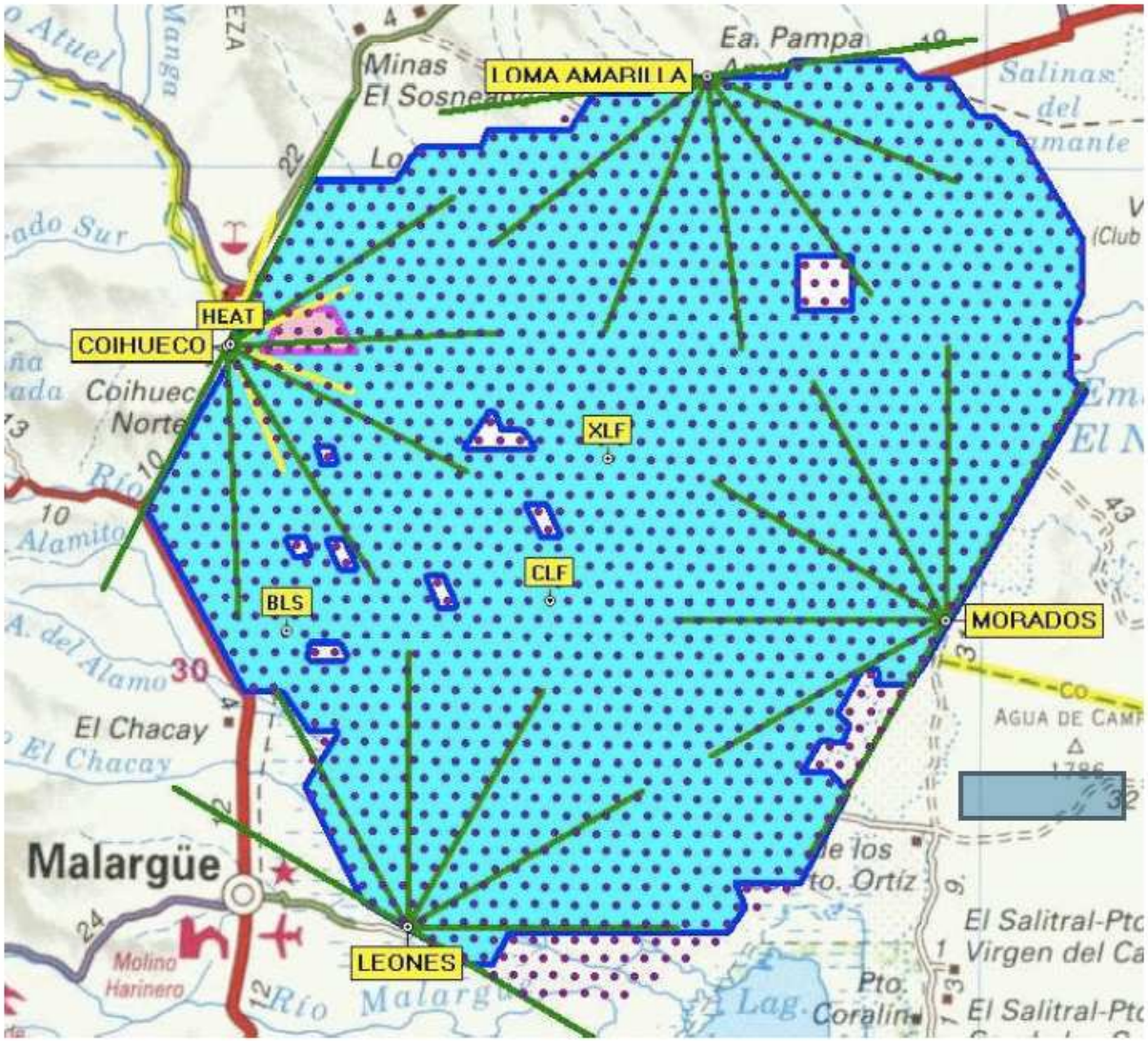
Tecnica di rivelazione ibrida

Il rivelatore ibrido: layout e status

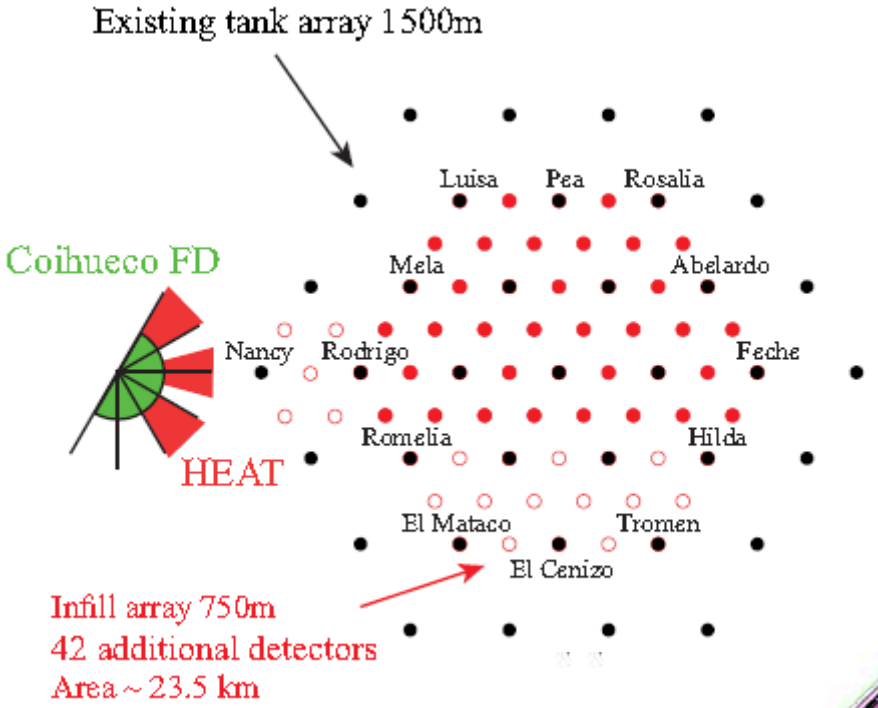
- ***Rivelatore di superficie*:**
  1600 stazioni Cherenkov
  a distanza di 1.5 km

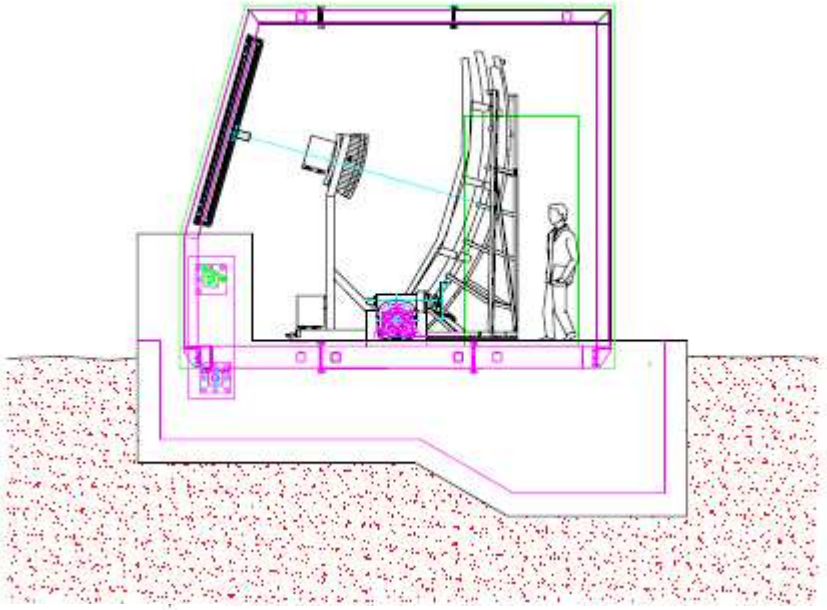
- ***Rivelatore di fluorescenza:***
  4 edifici periferici
  (ciascuno con 6 telescopi)

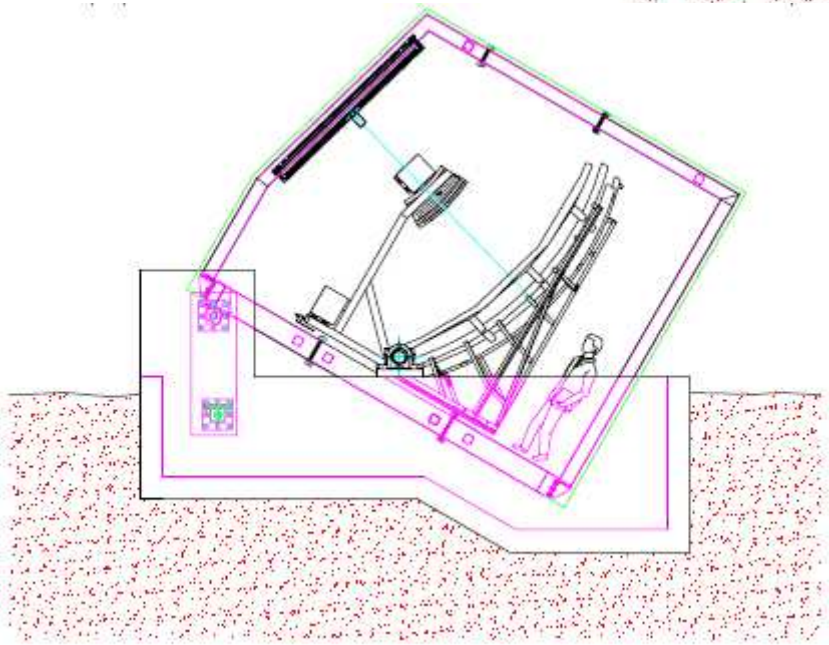
Configurazione di base completata nel giugno 2008



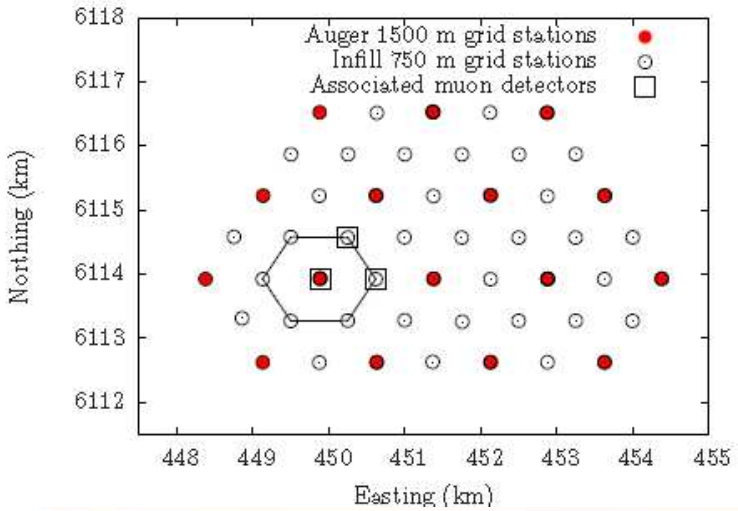
Upgrade e R&D

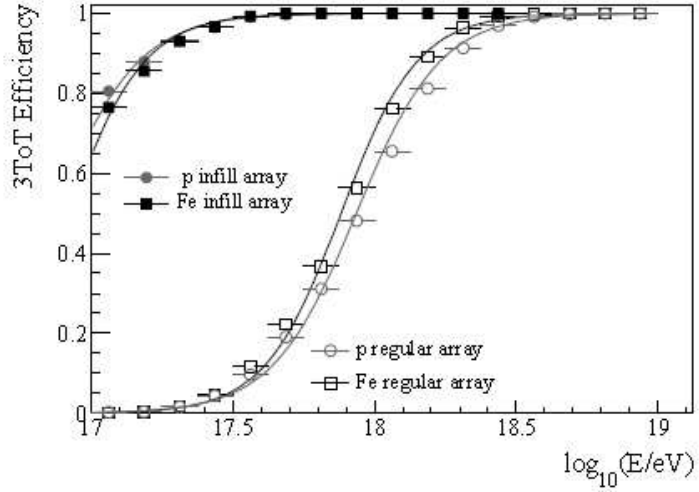

Existing tank array 1500m
Luisa
Pea
Rosalia
Coihueco FD
Mela
Abelardo
Nancy
Rodrigo
Feche
Romelia
Hilda
HEAT
El Mataco
Tromen
El Cenizo
Infill array 750m
42 additional detectors
Area ~ 23.5 km

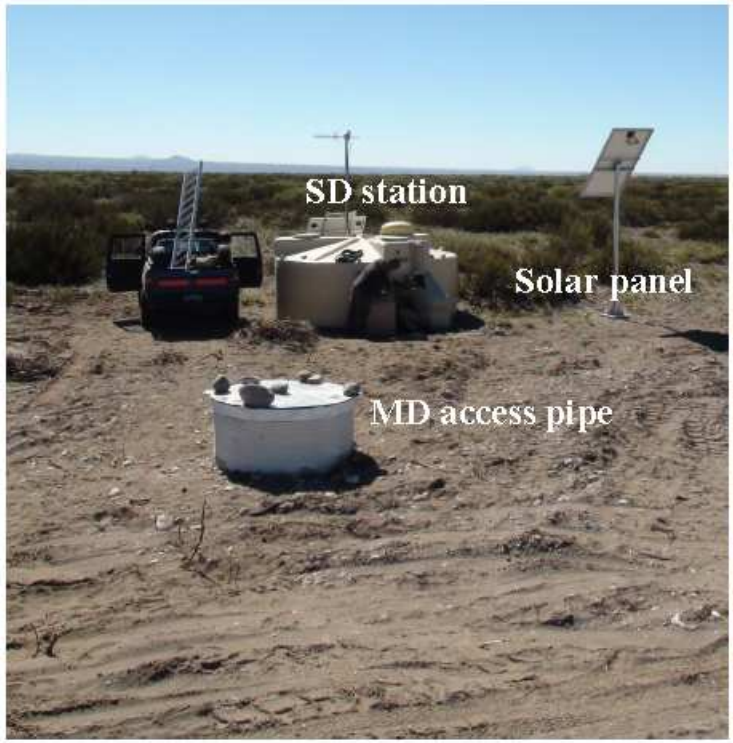


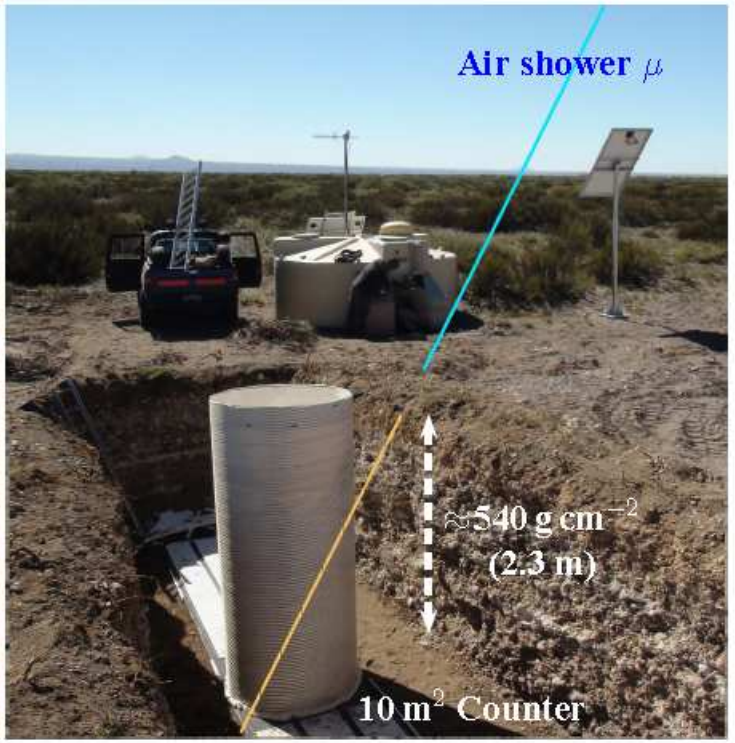


Upgrade e R&D


Auger 1500 m grid stations
Infill 750 m grid stations
Associated muon detectors
Northing (km)
Easting (km)
6118
6117
6116
6115
6114
6113
6112
448
449
450
451
452
453
454
455

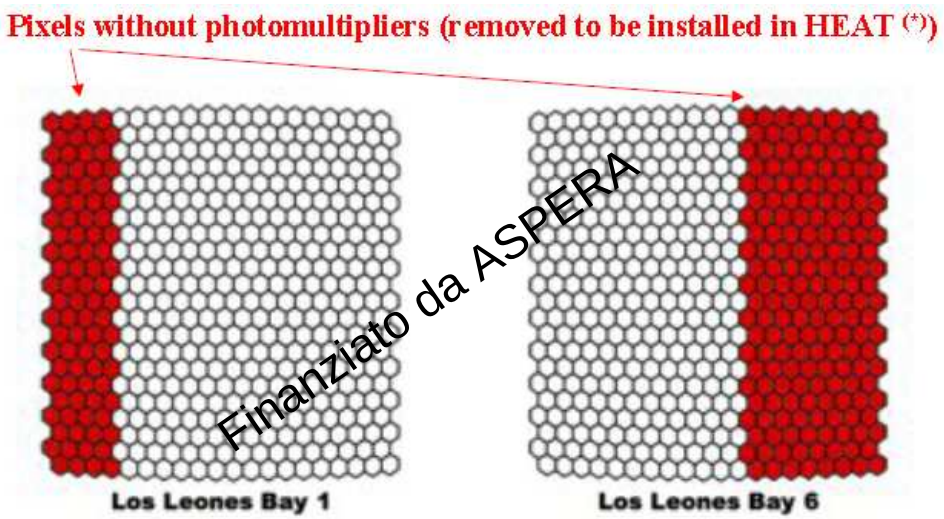

3ToT Efficiency
p infill array
Fe infill array
p regular array
Fe regular array
log10(E/eV)
1
0.8
0.6
0.4
0.2
0
17
17.5
18
18.5
19


SD station
Solar panel
MD access pipe


Air shower μ
≈540 g cm−2
(2.3 m)
10 m2 Counter

Upgrade e R&D

FDWAVE



Finanziato da ASPERA

EASIER

AUGER Nord

PASAG Report

Scenario C. Doubling of funding over a ten year period starting in FY 2009 (*i.e.*, funding in FY 2010 at the level provided by the FY 2009 President's Request, inflated by 6.5%, and continuing at this rate in the out-years).

Establishing the high-energy cutoff in the cosmic ray spectrum was a great achievement of the past decade. This also fundamentally **changed the intellectual landscape for the study of the highest energy cosmic rays, removing the need to explain them with new physics such as exotic, massive particles or topological defects at the GUT scale**. Now, the scientific focus is on finishing the quest to determine the astrophysical origin of the highest energy cosmic rays. Auger North is "shovel-ready", and the world is looking to the U.S. for leadership.

Auger North can only be substantially supported by HEP in the best funding scenarios

AUGER Nord

CB Santiago

The Pierre Auger Collaboration has reacted to this outcome and started reshaping its plans for realizing a large-scale cosmic ray observatory as a worldwide effort

…the Collaboration Board understood that the plans for constructing a much larger Observatory on a reasonable time scale can only be accomplished in a worldwide effort with strong and new strategic partners. Obviously, in order to become attractive for strong partners, an entirely new international collaboration may emerge from these activities.

A first open discussion for elaborating the science case of trans-GZK cosmic rays and for sketching plans on how to possibly detect them on a scale of 30 000 km2 or more could take place **in a specific workshop which is open to all interested parties**. **Such a workshop needs be arranged within the next year, even before the end of 2011 if possible. An attractive location for such a workshop could be CERN**.

The goal is to formulate a full proposal and to find possible sites and host countries within the next three years, i.e. **before 2014**

Principali Cambiamenti nella struttura della Collaborazione

Spokesperson

Karl-Heinz Kampert

CB chairman

Sergio Petrera

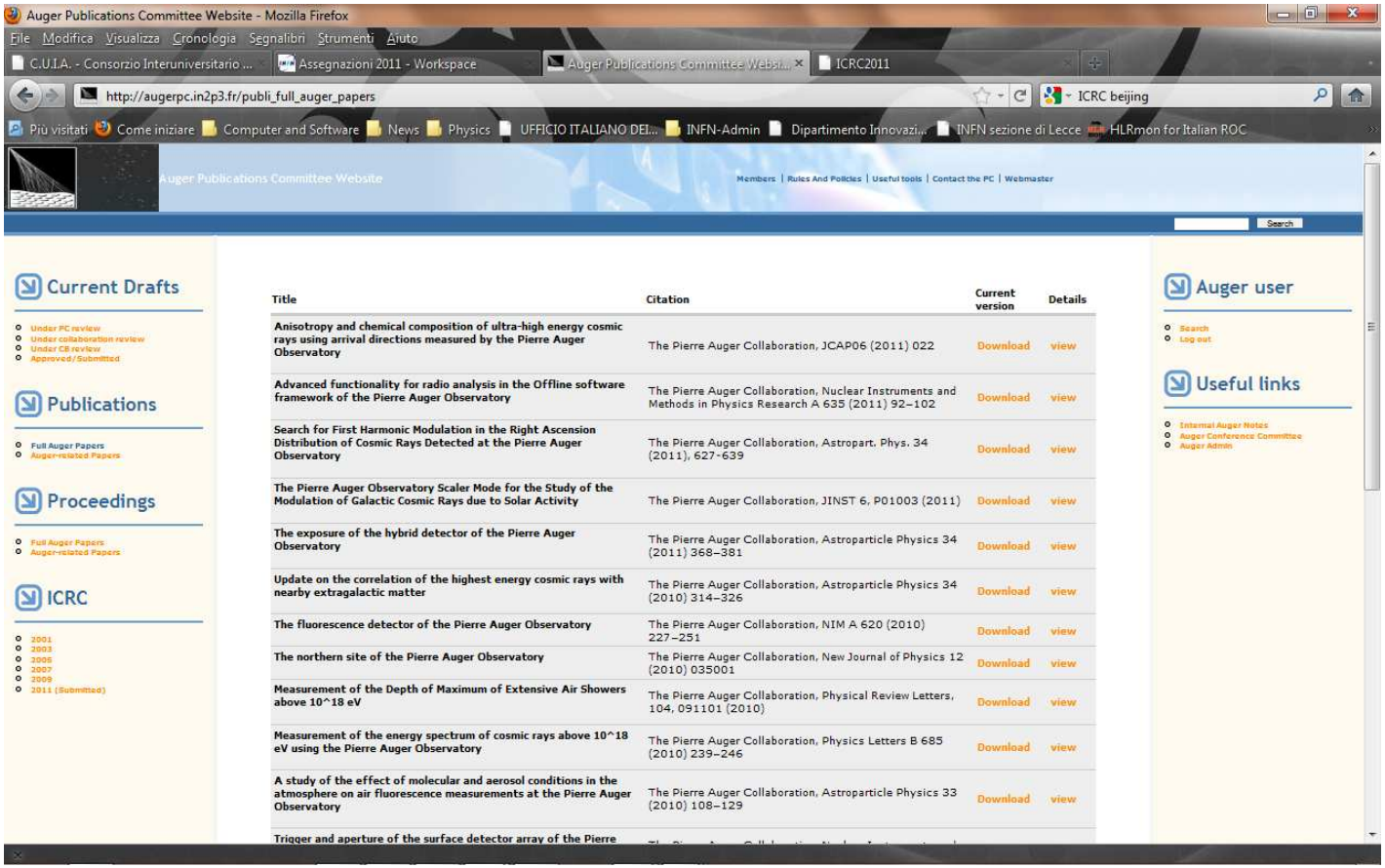
Detector Performance Tasks

Coordinators:Tiina Suomijärvi and Lorrenzo Perrone

1. SD PMTs: Carlo Morello, Dy-Holm Koang, and Marco Aglietta
2. SD saturation: Simone Maldera and Ivan De Mitri
3. FD calibration: Jeff Brack, Rossella Caruso
4. FD Auger Monitoring: Julian Rautenberg
5. Atmospheric monitoring: Lawrence Wiencke and Bianca Keilhauer
6. SD long term performance: Hernan Wahlberg and Angeles Lopez Aguera
7. SD event selection / aperture and trigger: Carla Bonifazi and Isabelle Lhenry-Yvon
8. Hybrid aperture and event selection: Lorenzo Perrone and Ralf Ulrich

updated 26-May-2011

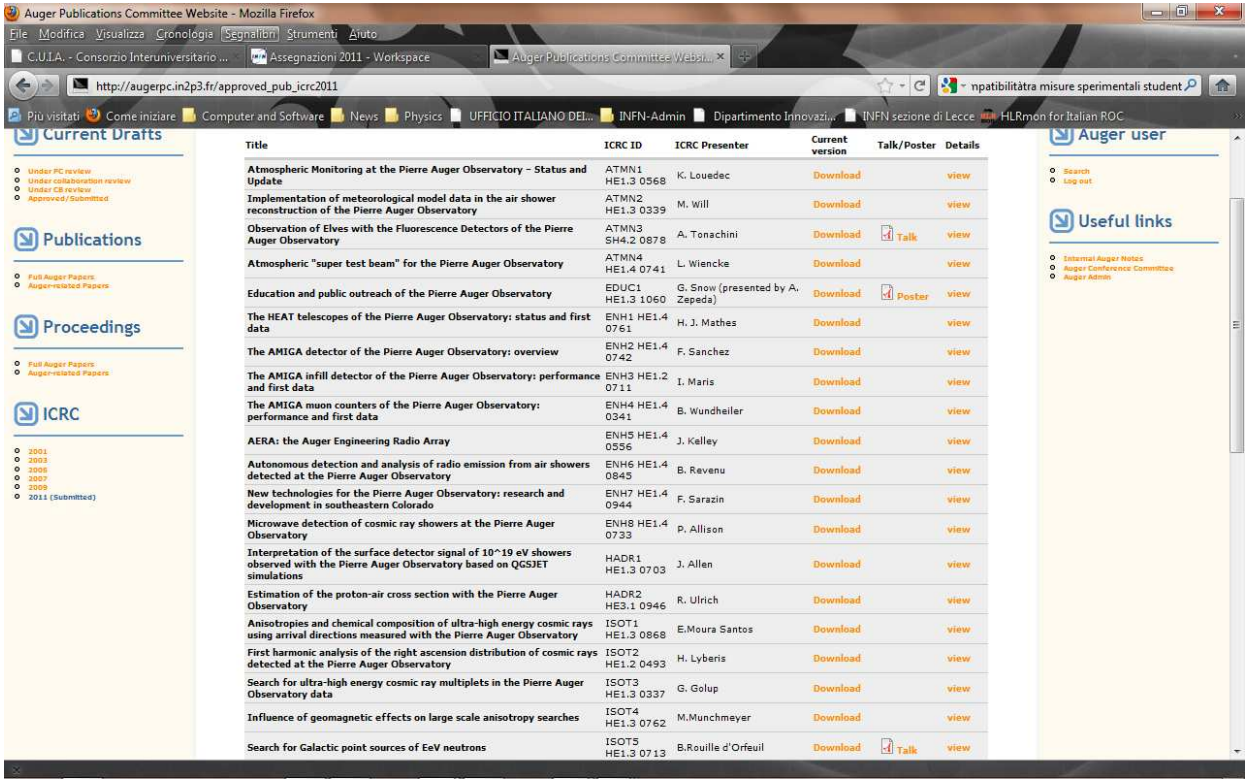
Attività Scientifica



10 nuove pubblicazioni su rivista
1 pubblicazione sottomessa (L. Perrone)
7 in fase di review interna
Svariate presentazioni a conferenze

ICRC

Wikipedia: "The **International Cosmic Ray Conference**, or ICRC, is a physics conference organized biennially by the International Union of Pure and Applied Physics (IUPAP) since 1947, where physicists from the whole world present the results of the experiences about cosmic rays they are working on."



Title	ICRC ID	ICRC Presenter	Current version	Talk/Poster	Details
Atmospheric Monitoring at the Pierre Auger Observatory – Status and Update	ATMN1 HE1.3 0568	K. Louedec	Download		view
Implementation of meteorological model data in the air shower reconstruction of the Pierre Auger Observatory	ATMN2 HE1.3 0339	M. Will	Download		view
Observation of Elves with the Fluorescence Detectors of the Pierre Auger Observatory	ATMN3 SH4.2 0878	A. Tonachini	Download	Talk	view
Atmospheric "super test beam" for the Pierre Auger Observatory	ATMN4 HE1.4 0741	L. Wiencke	Download		view
Education and public outreach of the Pierre Auger Observatory	EDUC1 HE1.3 1060	G. Snow (presented by A. Zepeda)	Download	Poster	view
The HEAT telescopes of the Pierre Auger Observatory: status and first data	ENH1 HE1.4 0761	H. J. Mathes	Download		view
The AMIGA detector of the Pierre Auger Observatory: overview	ENH2 HE1.4 0742	F. Sanchez	Download		view
The AMIGA infill detector of the Pierre Auger Observatory: performance and first data	ENH3 HE1.2 0711	I. Maris	Download		view
The AMIGA muon counters of the Pierre Auger Observatory: performance and first data	ENH4 HE1.4 0341	B. Wundheiler	Download		view
AERA: the Auger Engineering Radio Array	ENH5 HE1.4 0556	J. Kelley	Download		view
Autonomous detection and analysis of radio emission from air showers detected at the Pierre Auger Observatory	ENH6 HE1.4 0845	B. Revenu	Download		view
New technologies for the Pierre Auger Observatory: research and development in southeastern Colorado	ENH7 HE1.4 0944	F. Sarazin	Download		view
Microwave detection of cosmic ray showers at the Pierre Auger Observatory	ENH8 HE1.4 0733	P. Allison	Download		view
Interpretation of the surface detector signal of 10^19 eV showers observed with the Pierre Auger Observatory based on QGSJET simulations	HADR1 HE1.3 0703	J. Allen	Download		view
Estimation of the proton-air cross section with the Pierre Auger Observatory	HADR2 HE3.1 0946	R. Ulrich	Download		view
Anisotropies and chemical composition of ultra-high energy cosmic rays using arrival directions measured with the Pierre Auger Observatory	ISOT1 HE1.3 0868	E.Moura Santos	Download		view
First harmonic analysis of the right ascension distribution of cosmic rays detected at the Pierre Auger Observatory	ISOT2 HE1.2 0493	H. Lyberis	Download		view
Search for ultra-high energy cosmic ray multiplets in the Pierre Auger Observatory data	ISOT3 HE1.3 0337	G. Golup	Download		view
Influence of geomagnetic effects on large scale anisotropy searches	ISOT4 HE1.3 0762	M.Munchmeyer	Download		view
Search for Galactic point sources of EeV neutrons	ISOT5 HE1.3 0713	B.Rouille d'Orfeuil	Download	Talk	view

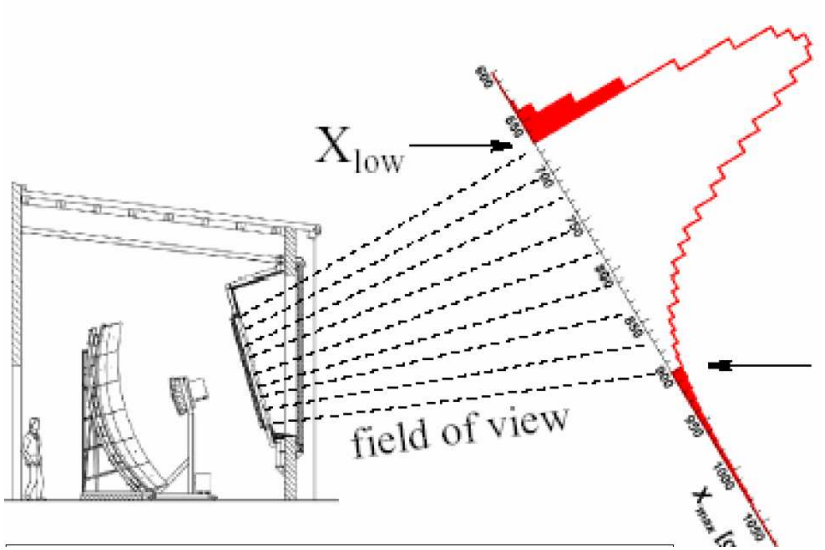
38 Contributi presentati dalla collaborazione

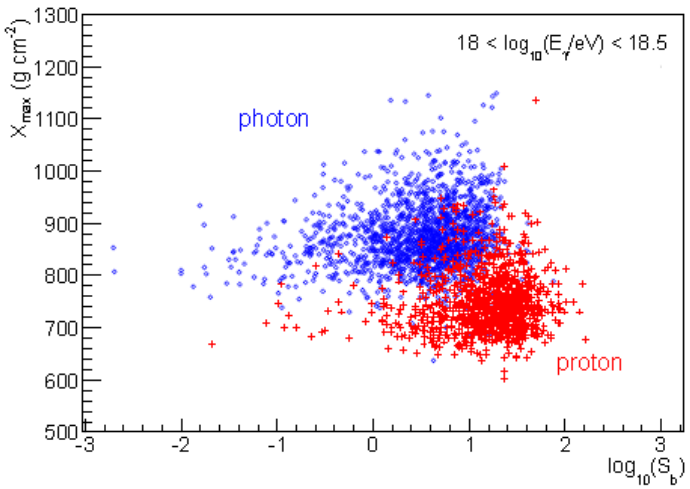
6 Contributi assegnati ad Italiani

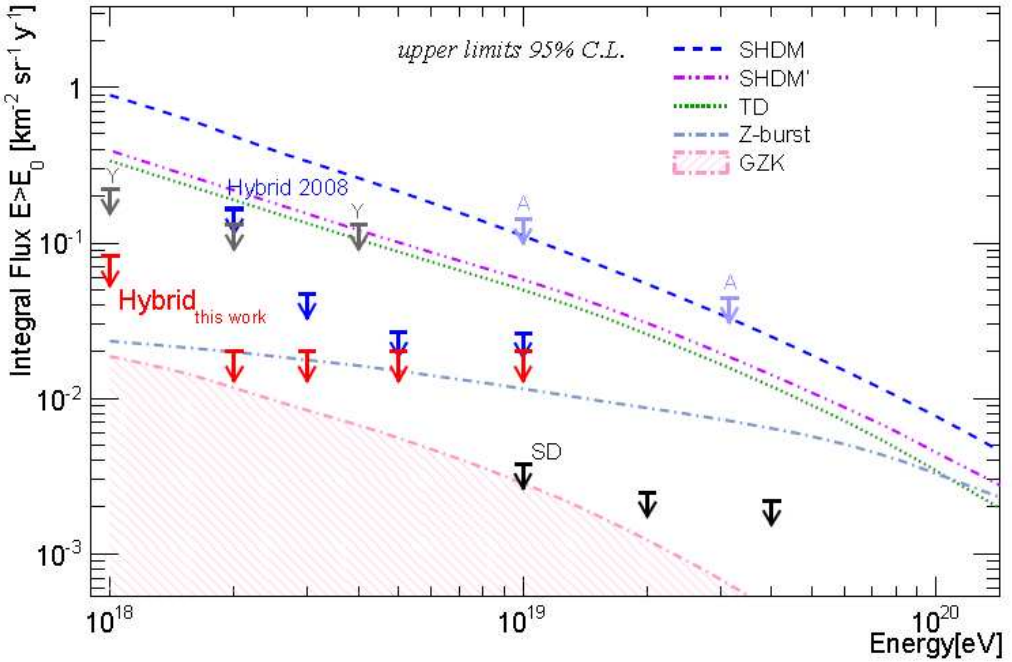
2 Contributi assegnati a (ex) giovani formati a Lecce

Search for ultra-high energy photons using the Pierre Auger Observatory

Discriminazione di sciami iniziati da fotoni da sciami prodotti da adroni

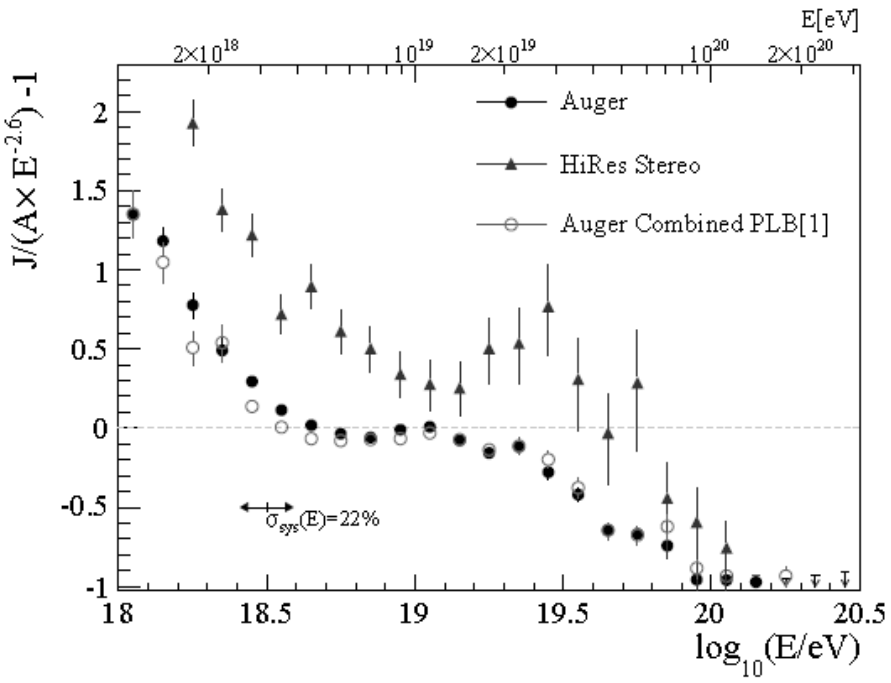


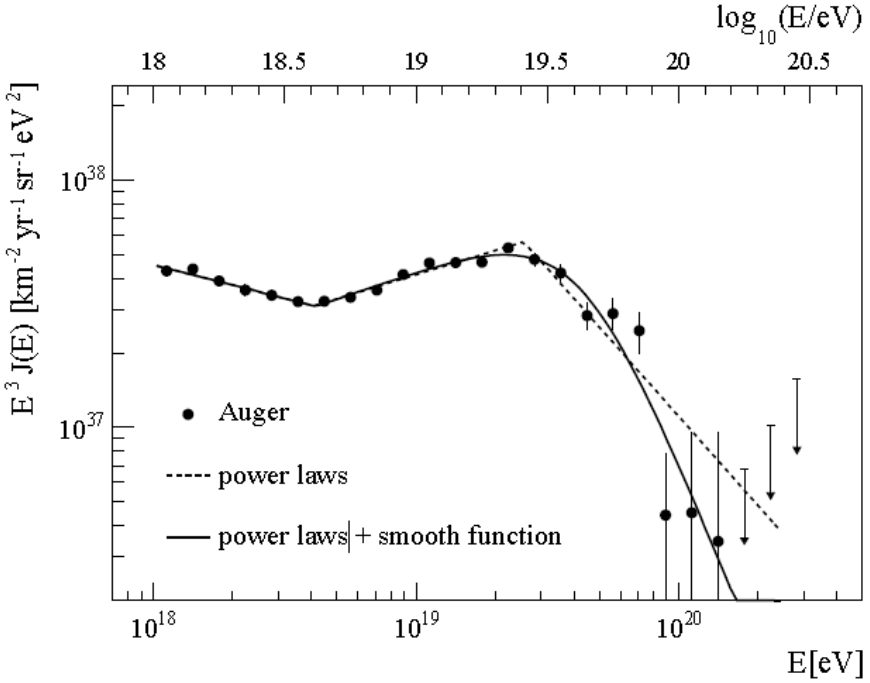




$$S_b = \sum_i S_i \left(\frac{R_i}{R_{\rm ref}} \right)^b$$

Update on the measurement of the CR energy spectrum above 1018 eV made using the Pierre Auger Observatory





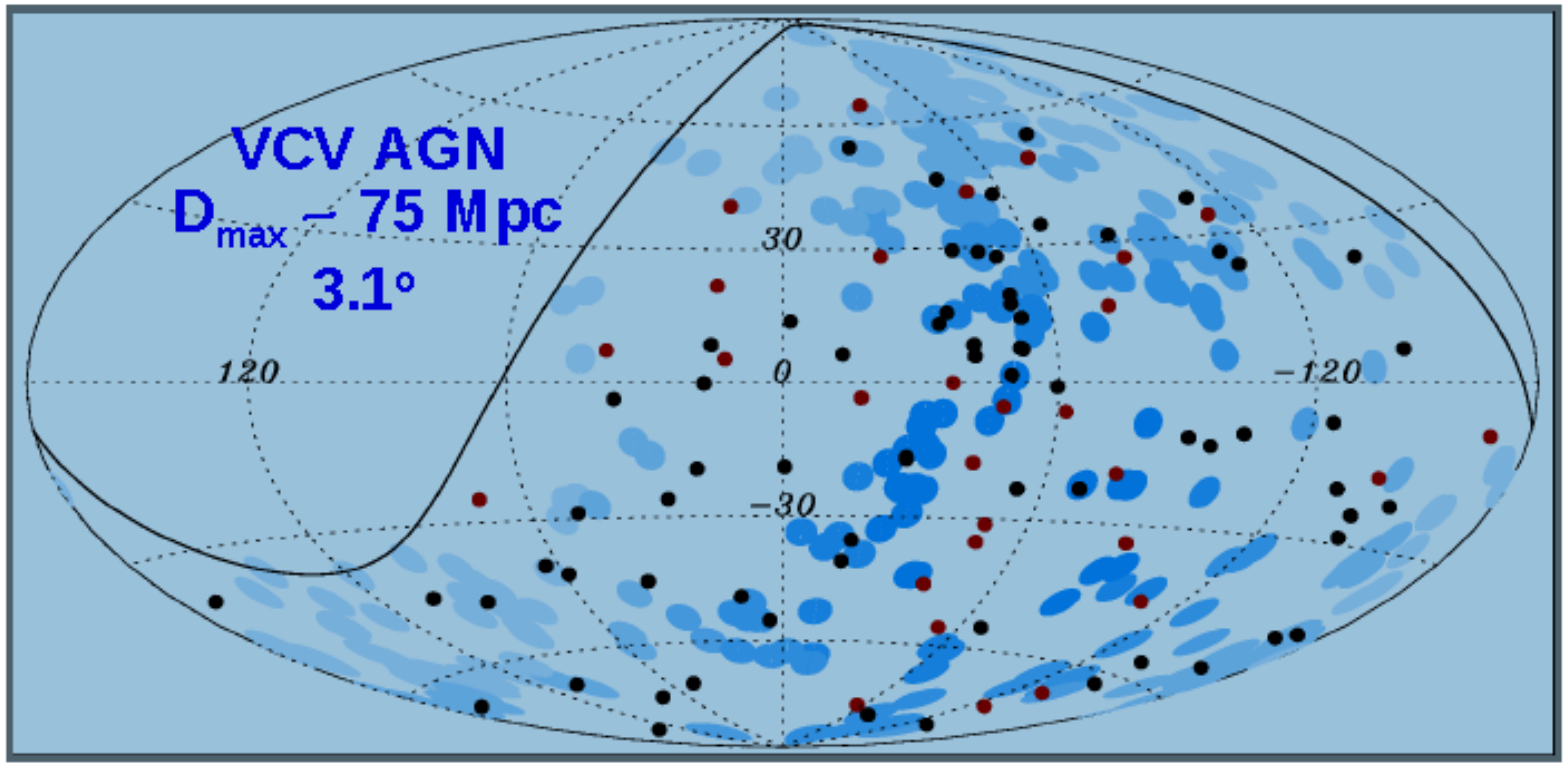
A combined spectrum has been derived with high statistics covering the energy range from 10^{18} eV to above 10^{20} eV.

The combination of spectra enables the precise measurement of both the ankle and the flux suppression at highest energies.

F. Salamida

UPDATE ON THE CORRELATION WITH NEARBY EXTRAGALACTIC MATTER

Same analyses as in Astroparticle Physics 34 (2010) 314–326 with data until 15 June 2011: 98 events with E > 55 EeV



- 69 events until December 2009
- 29 events January 2010 – June 2011

LECCE Activity

Analisi, Detector Performance e attività di supporto

- **Studio dell'efficienza di trigger di Infill (LTP e full simulation)**
- **Ricerca di sorgenti (E > 1 EeV, E> 5 EeV)**
- **Esposizone ibrida (spettro standard)**
- **Esposizione ibrida per i fotoni (Corsika full simulation)**
- **Primi approcci di studio di long term performance per FD**
- **Saturazioni**
- **Worker Node on Demand**

Maintenance & R&D correlati

- **Status SDECO**
- **Maintenance PMT sul Campo**
- **Test PMT**
- **AMY**
- **Sviluppo ADC**

Analysis Meeting 2010 a Lecce

Infill Trigger Efficiency

Lateral Trigger Probability functions for an individual SD station used to calculate the trigger efficiency of the infill array

Parametrizations based on full Corsika+Offline simulations provide a robust and simple method to estimate the energy or zenith angle dependence of SD acceptance for any configuration (including the infill array)

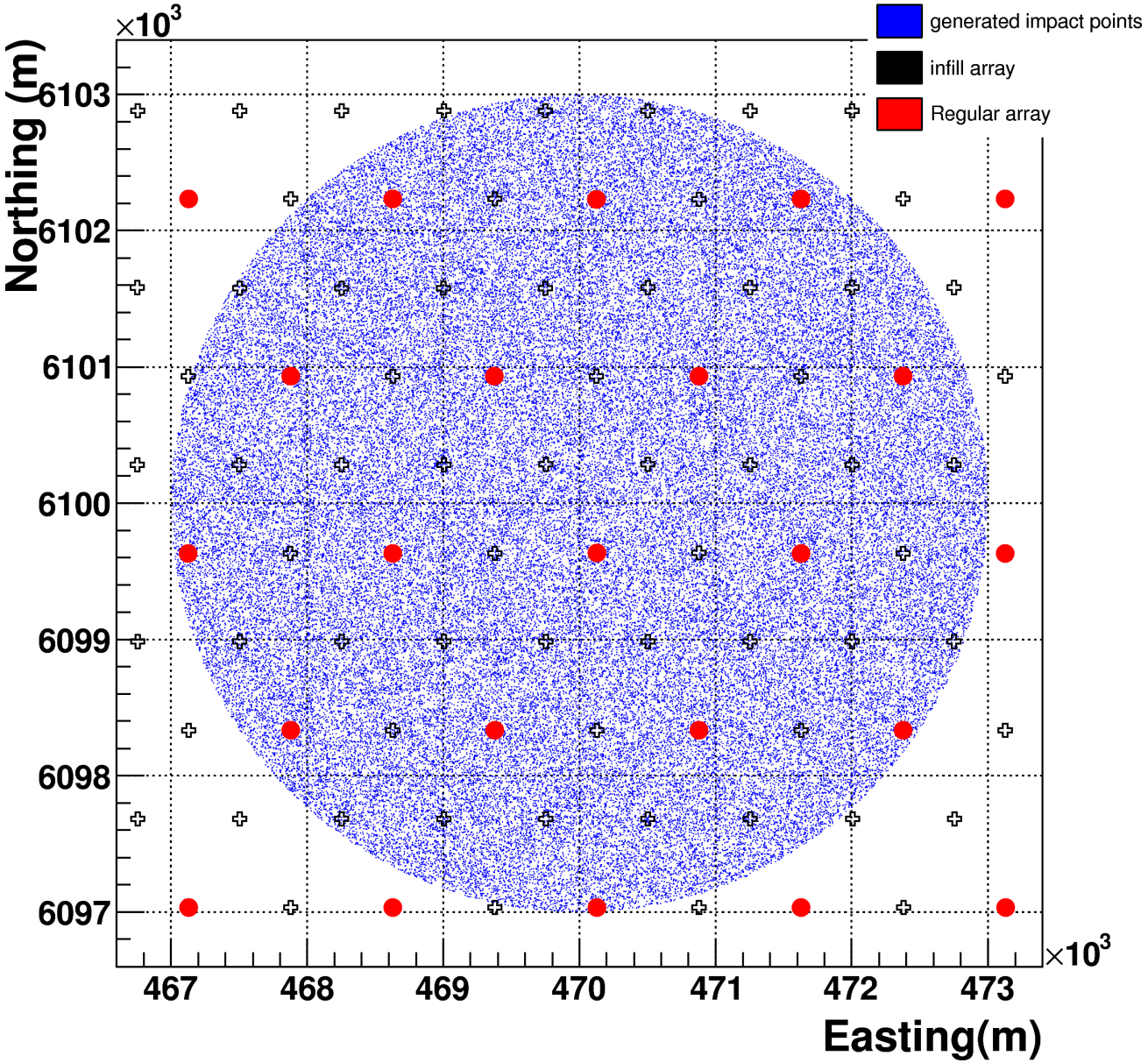
Largely based on the work developed for the regular array

Physics case

Calculate the energy threshold for full efficiency of the infill array as a preliminary requirement for deriving the energy spectrum at low energies

Method (step 2): generate the events

Impact point at the ground are generated uniformly in a circle of 3 km radius, placed in the middle of the array



<u>Generated event</u>

- primary type

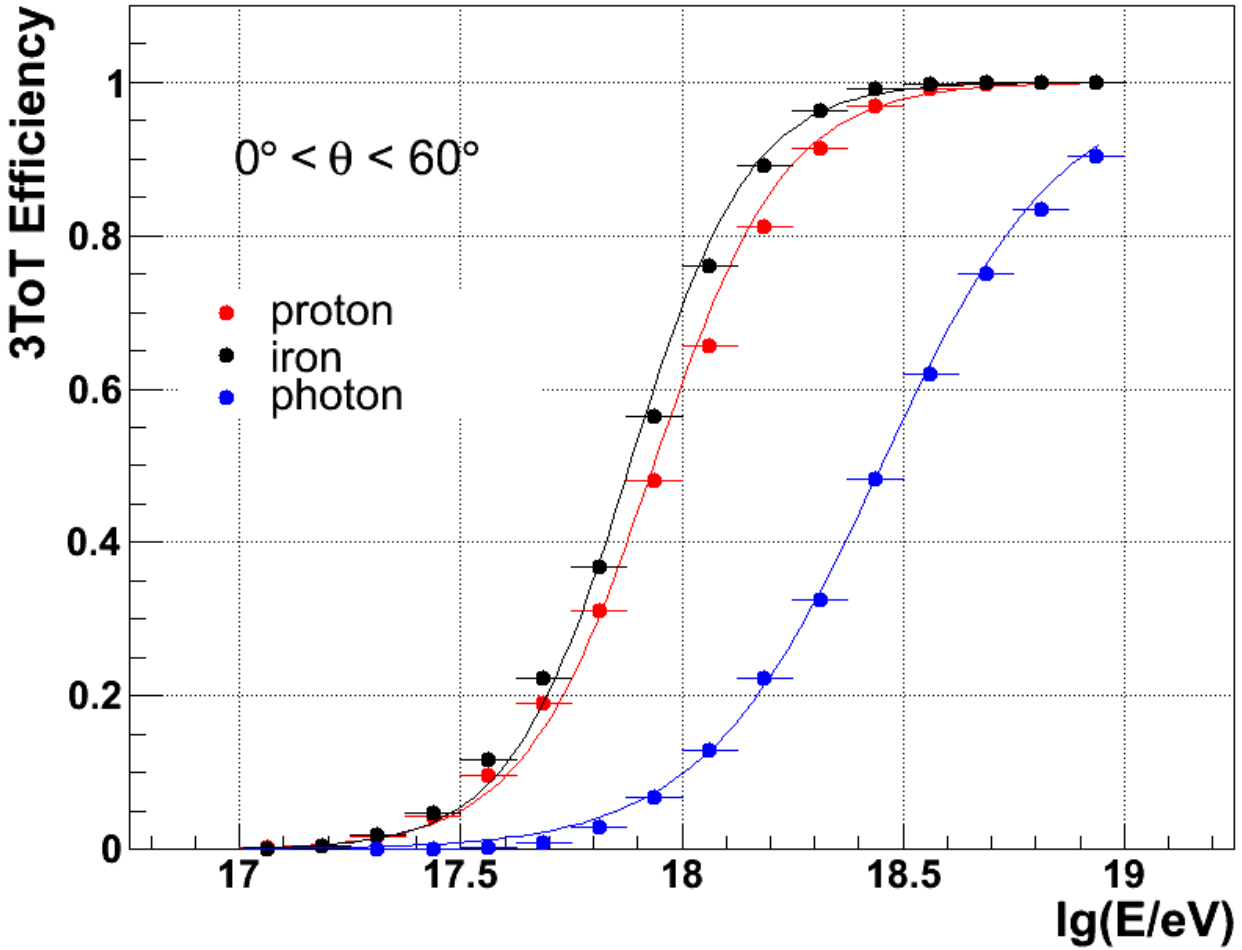
- impact point at the ground

- energy flat distributed on lg (E/eV) between 0.1 and 10 EeV

- zenith angle distributed according to $\sin\theta\cos\theta$

Overall sample: 10^5 proton, 10^5 iron, 10^5 photon

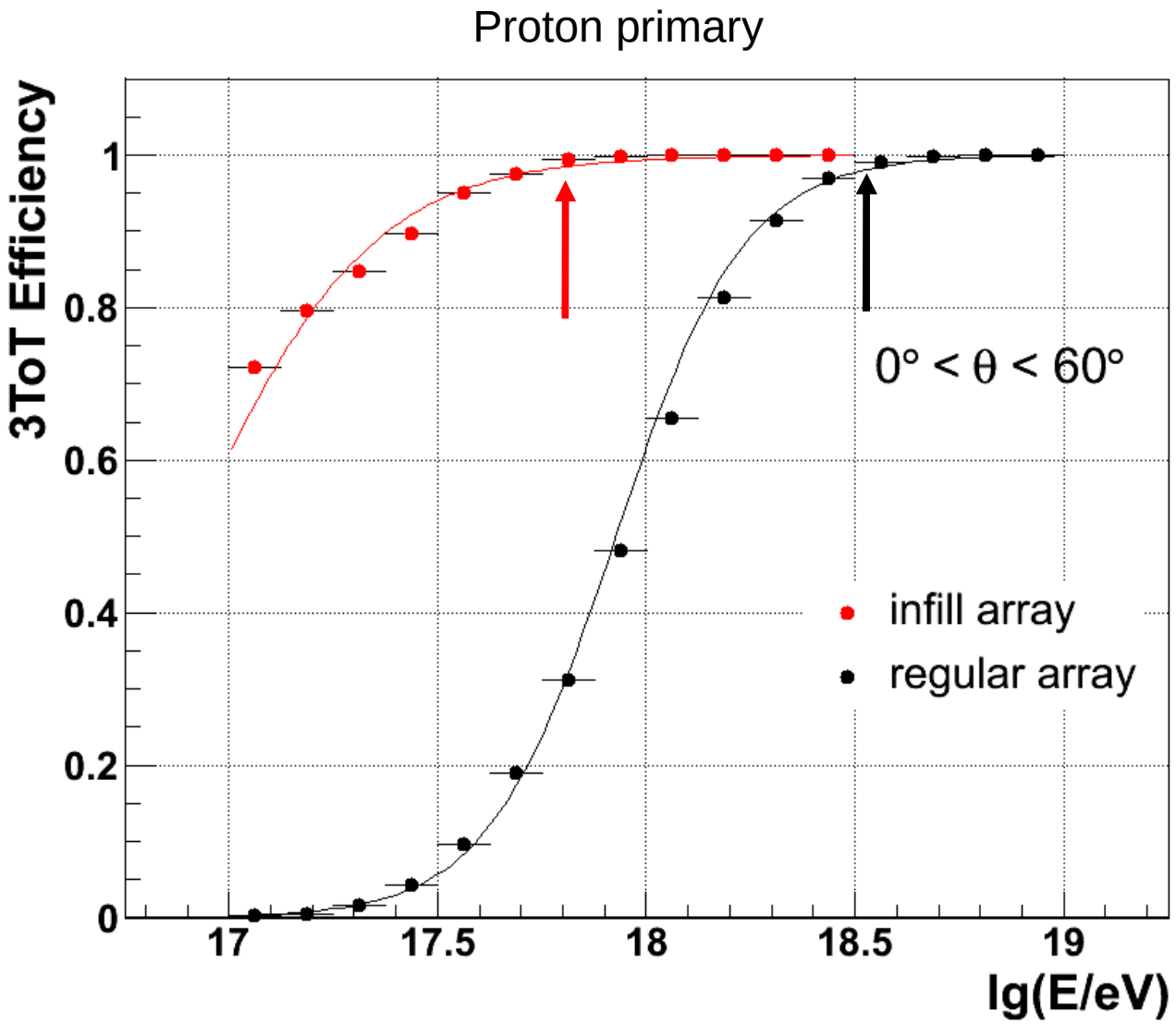
Check on the standard SD array



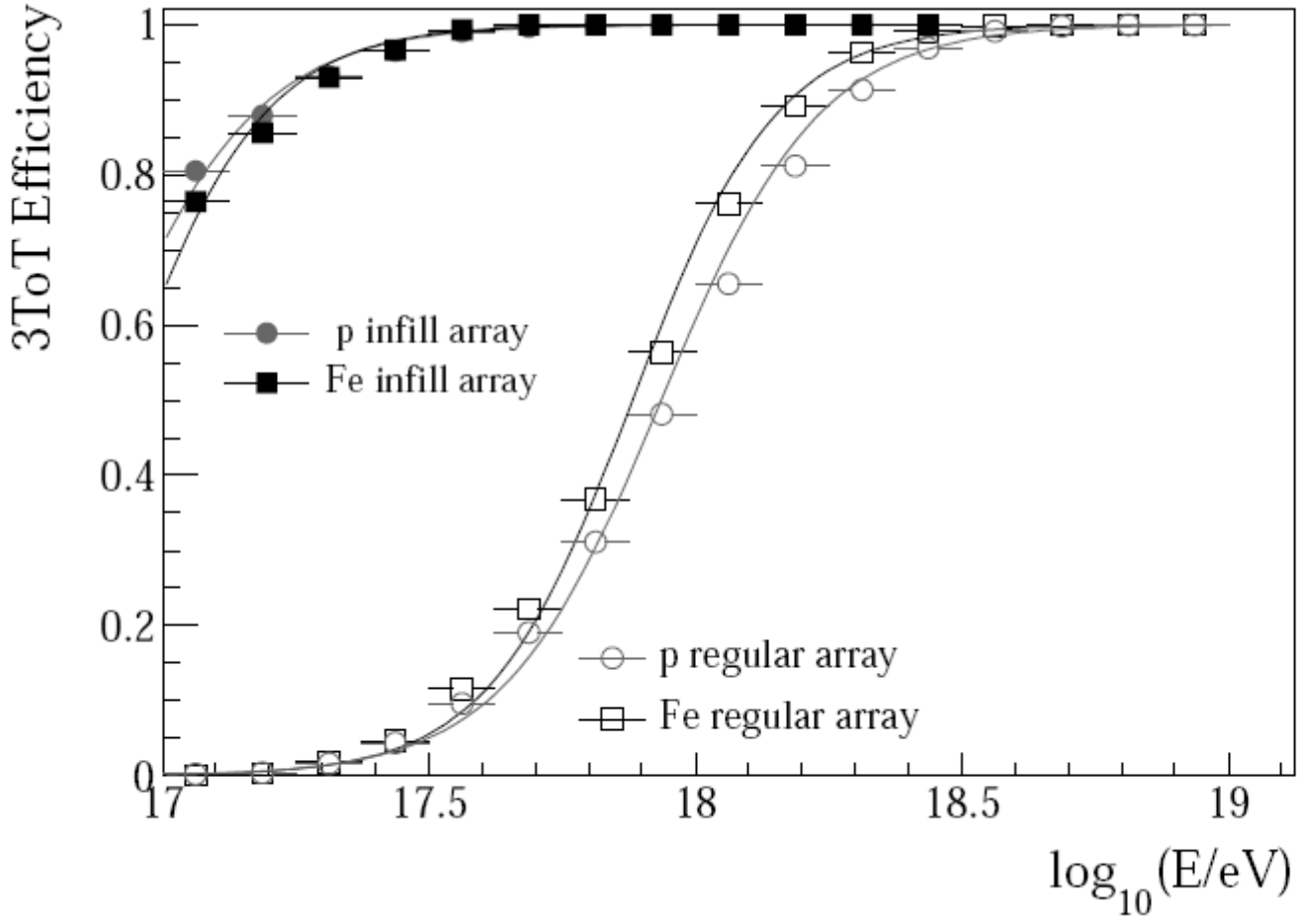
Trigger efficiency of the regular array for different primaries

Full agreement with the study with Corsika-Geant4 simulation published in NIM A613 (2010), 29-39.

Infill vs Regular array



Infill array: Zenith <60°, full efficiency for $\log_{10}(E/eV) > 17.8$



F. Sanchez @ ICRC 2011

I. Maris @ ICRC 2011

Ricerca di sorgenti puntiformi

Lavoro di Ugo Giaccari per la sua tesi di dottorato

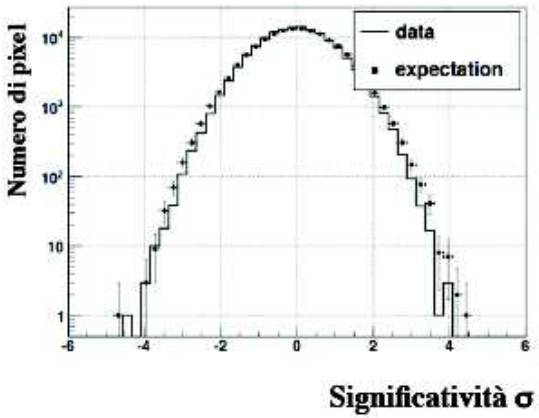
- Ricerca di eventuali indicatori di composizione per gli eventi utilizzati nell'analisi delle correlazioni S3, Delta1000 (S1000), Curvatura

- Ricerca di sorgenti e mappa dei limiti sui flussi attesi

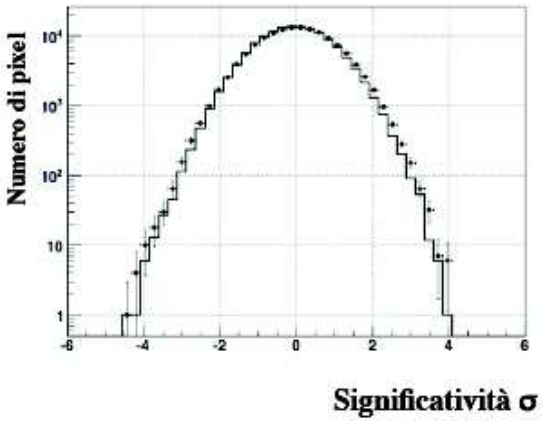
Energia > 1 EeV
Energia > 5 EeV

Significativita di LiMa in funzione della soglia energetica

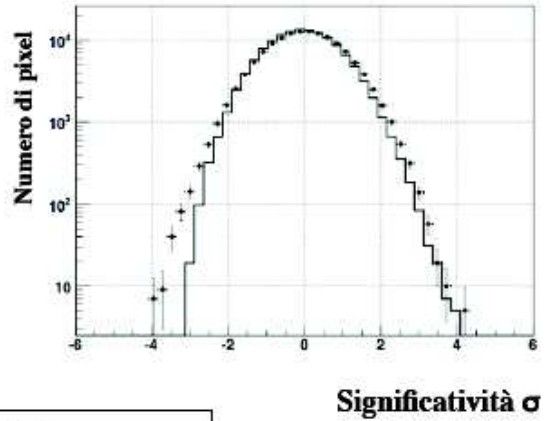
E > 1 EeV



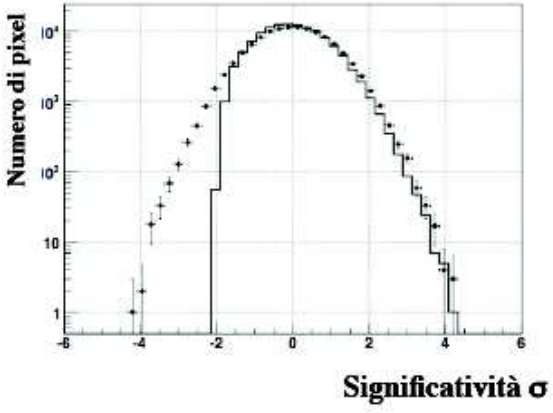
E > 2 EeV



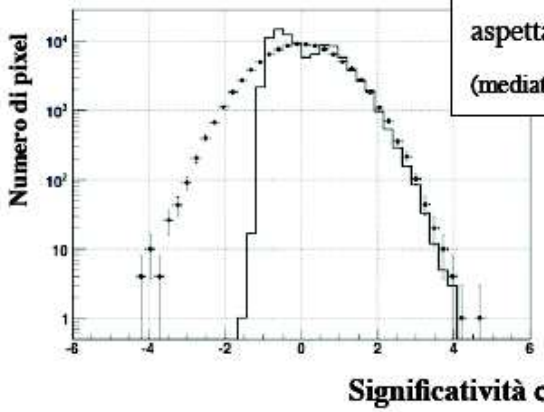
E > 3 EeV



E > 5 EeV



E > 10 EeV



significatività

aspettazione isotropa

(mediata su 2σ)

- distribuzione consistente con isotropia
- E > 3 EeV distribuzioni S_{LiMa} non gaussiane

Gennaio 2004 - Ottobre 2010

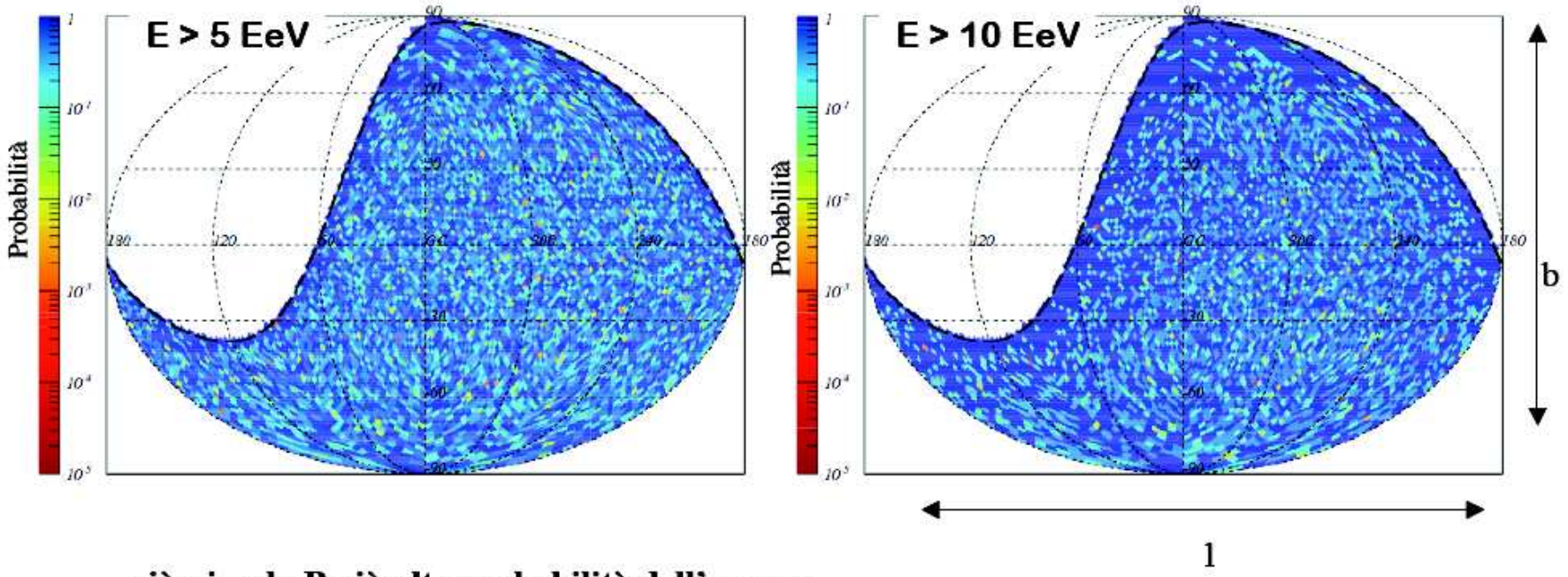
Alta energia (→bassa statistica) fluttuazioni non sono simmetriche

ricerca di eccessi $E > 5 \times 10^{18}$ eV

$E > 5 \times 10^{18}$ eV la formula di LiMa non può essere usata per stimare la significatività degli eccessi (bassa statistica)

PRIMO METODO: in ogni direzione del cielo N_{ON} e N_{OFF} seguono una distribuzione poissoniana probabilità (P) che N_{ON} o più eventi siano dovuti ad una fluttuazione del fondo N_{OFF}

MAPPE DI POISSON



più piccola P più alta probabilità dell'eccesso

ricerca di eccessi $E > 5 \times 10^{18}$ eV

SECONDO METODO

approccio alla Feldmann e Cousin:

direzione del cielo

N_{OFF} eventi attesi (fondo isotropo)

N_{ON} eventi osservati

UPPER LIMIT (UL)

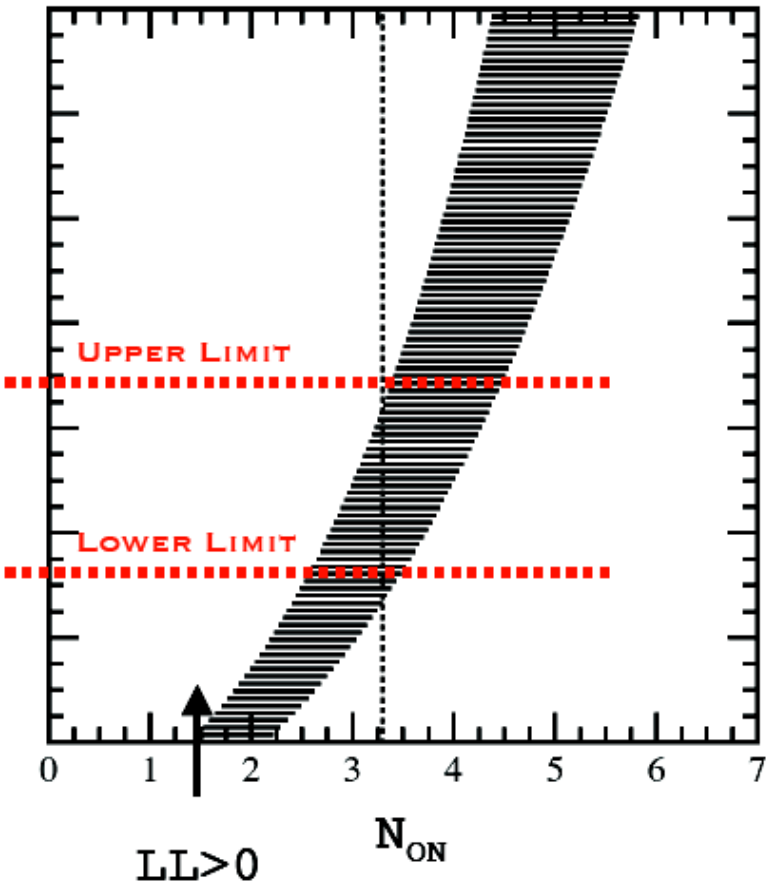
Estremo superiore dell'intervallo di confidenza

LOWER LIMIT (LL)

Estremo inferiore dell'intervallo di confidenza

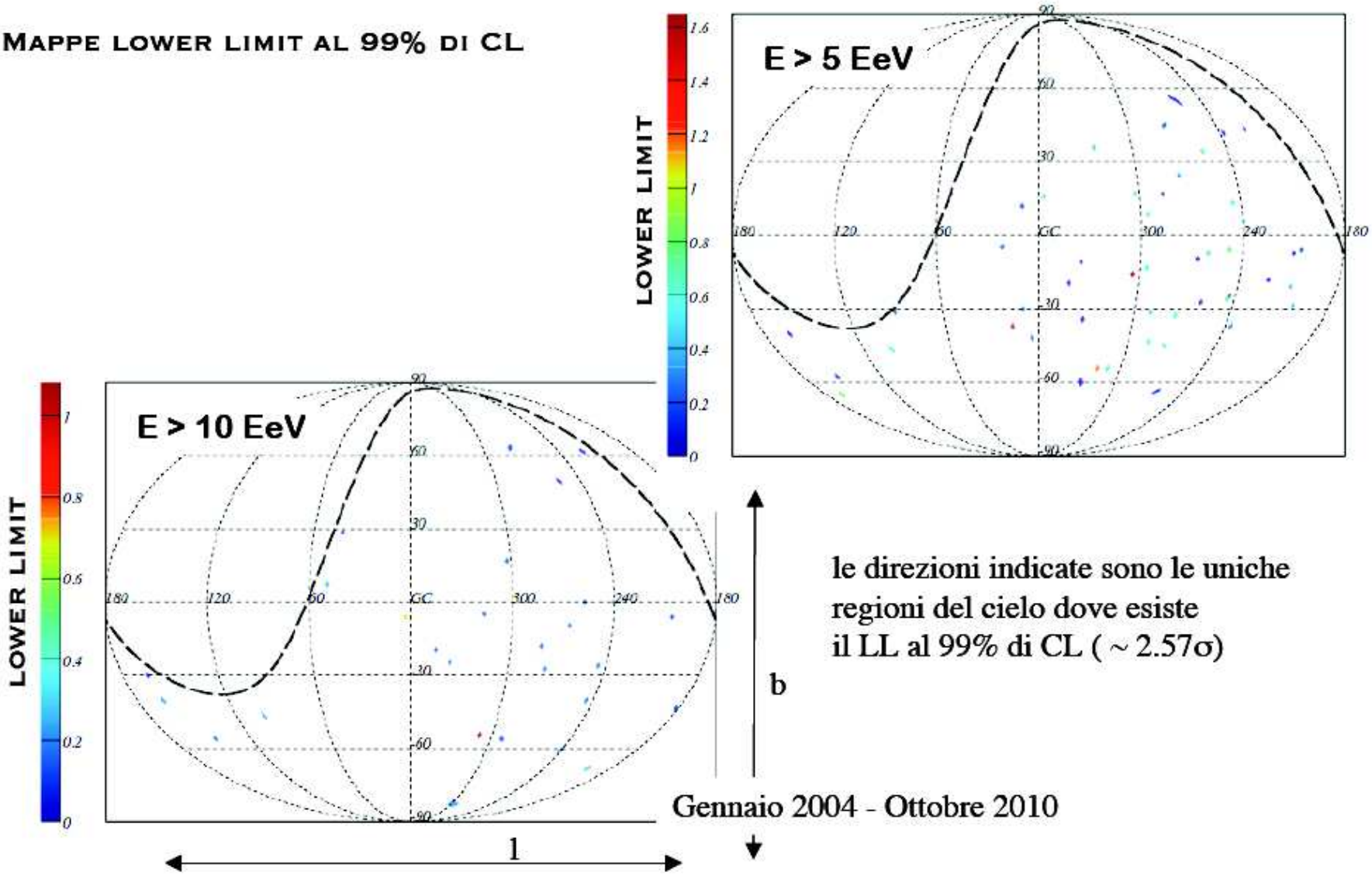
LOWER LIMIT > 0 COME INDICATORE DELLA PRESENZA DI UN POTENZIALE ECCESSO

determinazione intervallo di confidenza (α) del segnale



Mappe dei Lower Limit

MAPPE LOWER LIMIT AL 99% DI CL



le direzioni indicate sono le uniche regioni del cielo dove esiste il LL al 99% di CL (~ 2.57σ)

Gennaio 2004 - Ottobre 2010

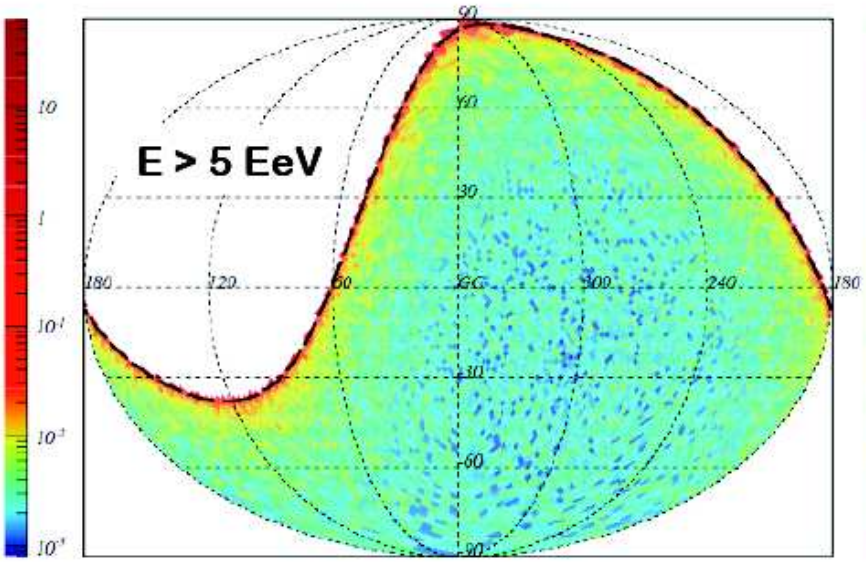
Mappe di Upper Limit sul Flusso

$$\Psi(99\ \mathrm{CL}\ \%) = \frac{UL(99\ \mathrm{CL}\ \%)}{\mathrm{AT}}$$

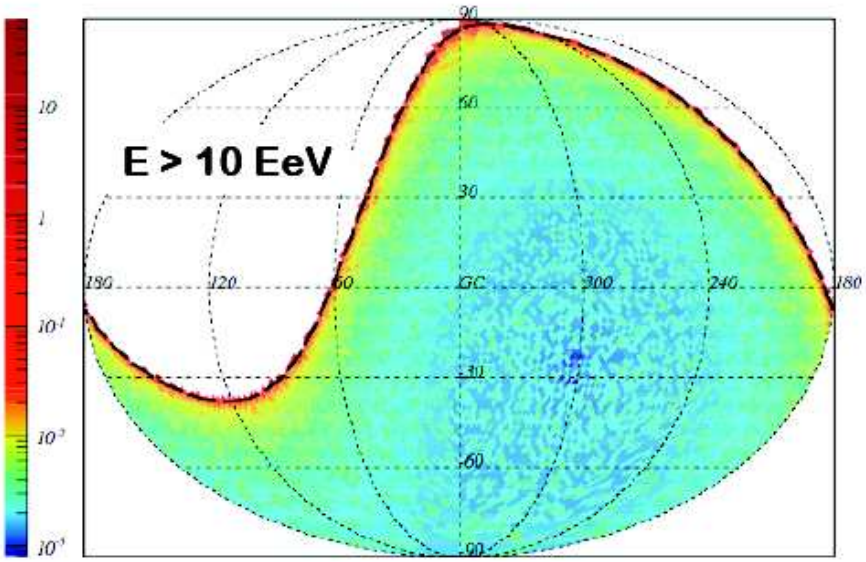
$UL(99\ \mathrm{CL}\ \%)$ upper limit sugli eventi (Feldman Cousin)

AT mappa dell'esposizione

particelle / km^2 anni

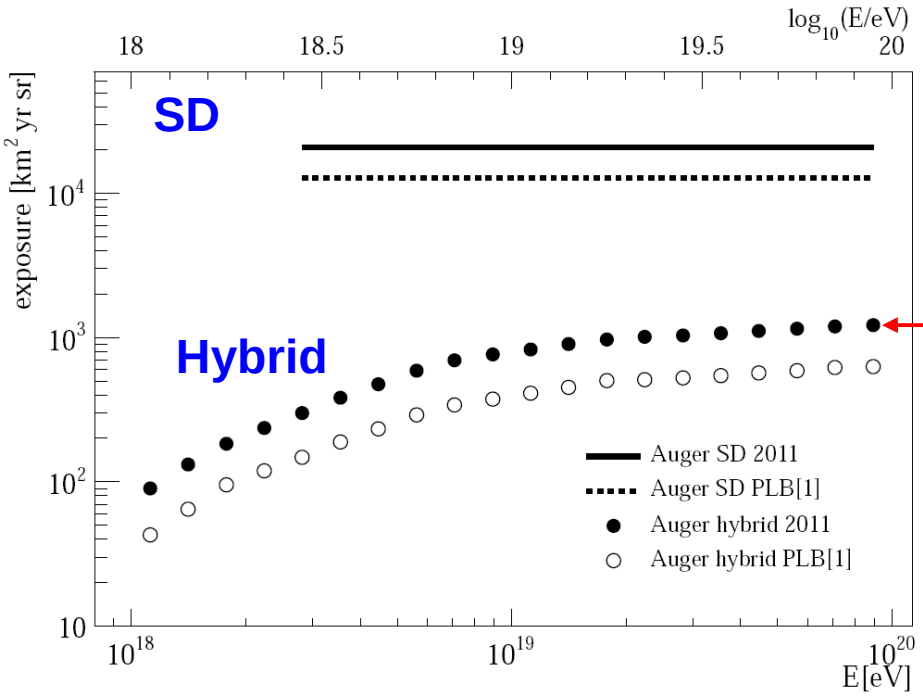


particelle / km^2 anni



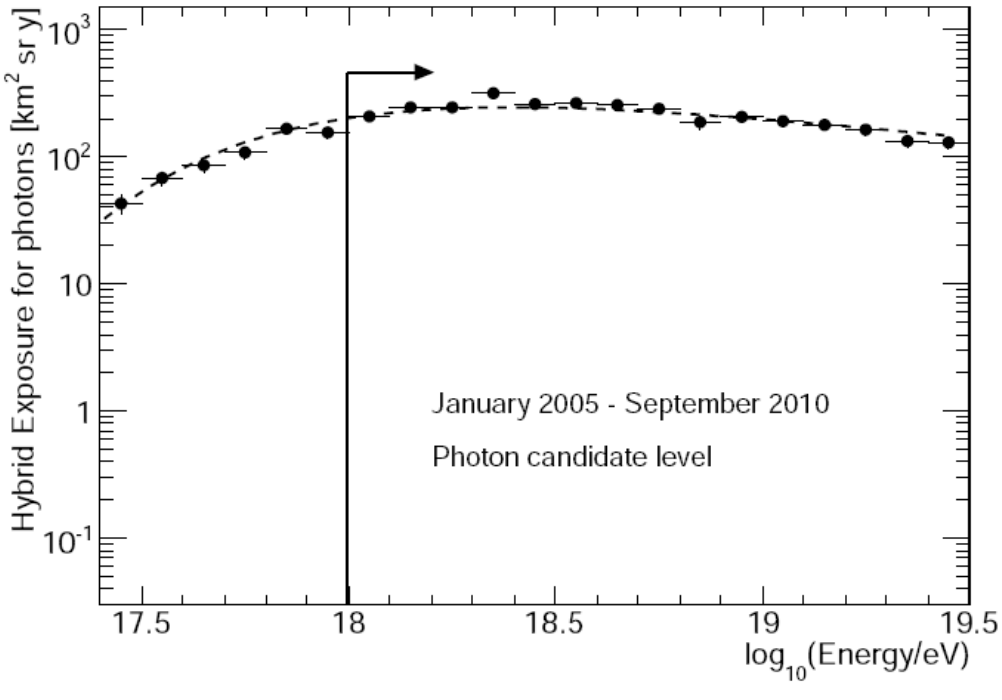
Hybrid Exposure

First Method : Conex+LTP (large statistics, no signal in the stations)
Second Method : Corsika+Geant4 (less statistics, signal in the stations)



Hybrid Spectrum
(F. Salamida @ICRC 2011) Conex+LTP

~ factor 2 higher than for the PLB hybrid spectrum



Used for deriving the upper limits to photon fluxes
(M. Settimo @ICRC2011) - Corsika+G4

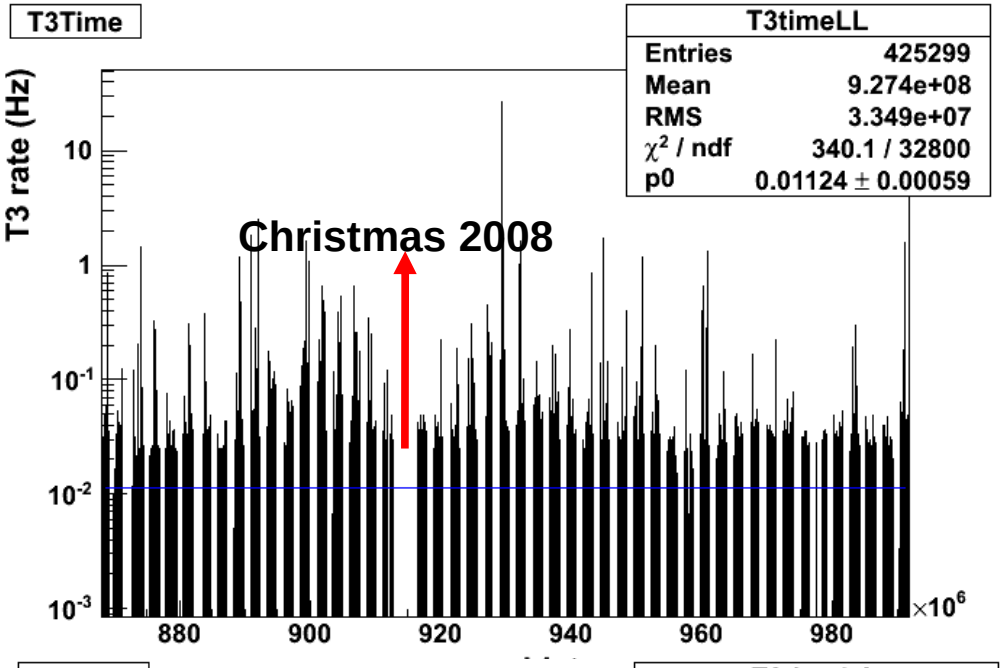
Combined Xmax and Sd variables analysis
(simulation of of the signal in the station required)

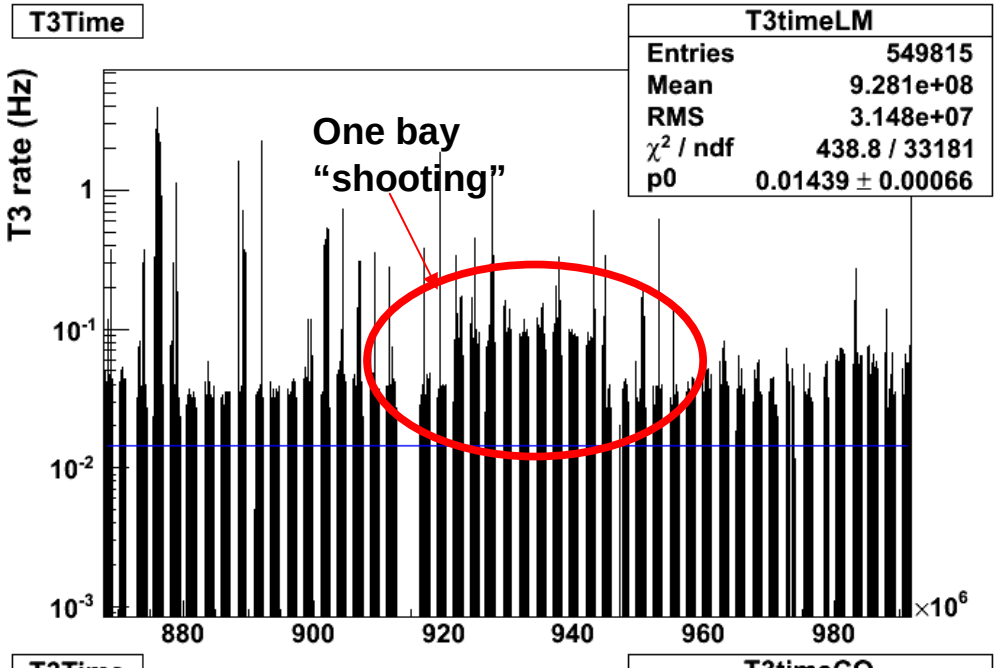
L. Perrone

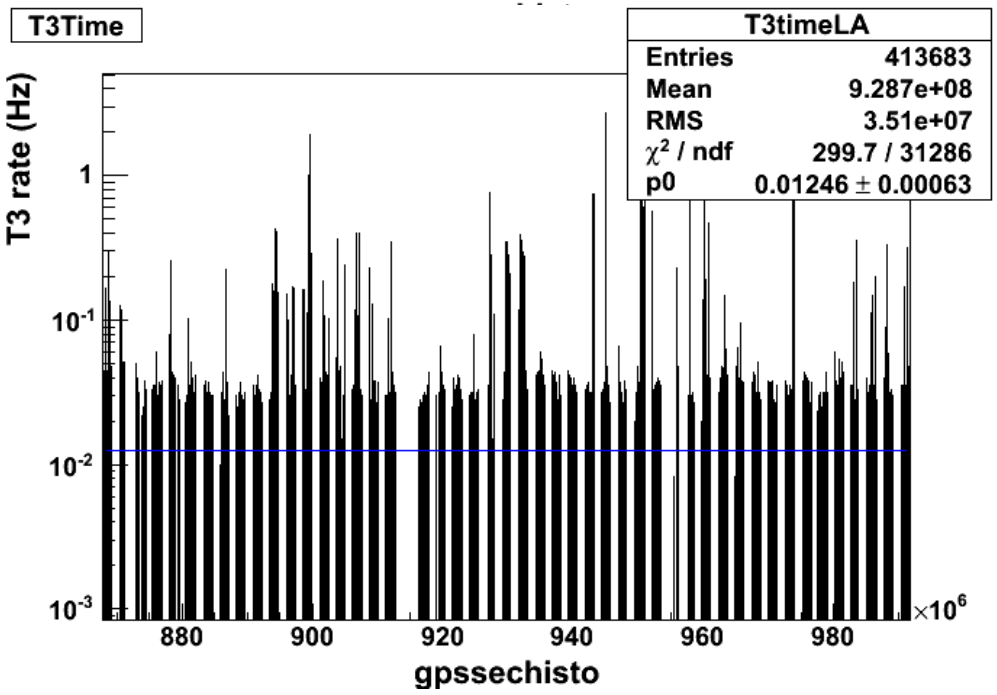
From the Monitoring Database

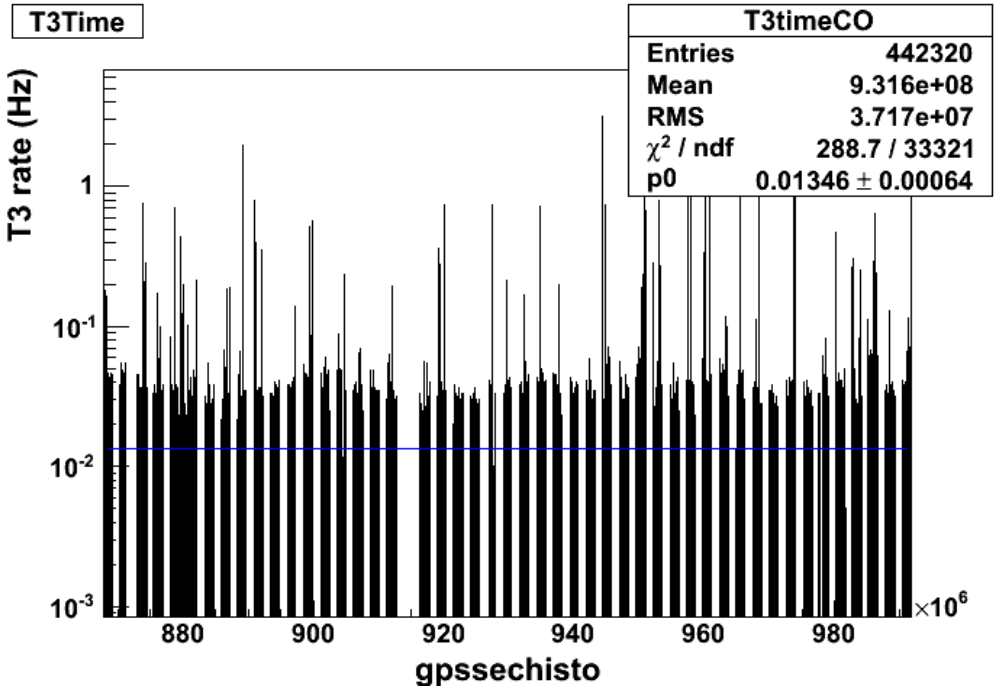
FD T3 rate – all sites

Jul/1/2007 - June/20/2011







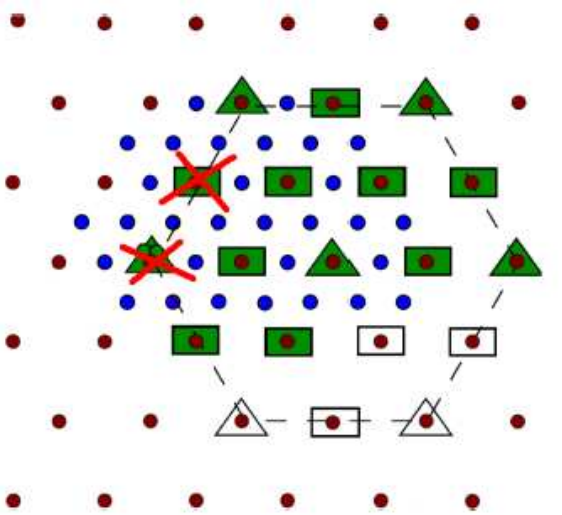


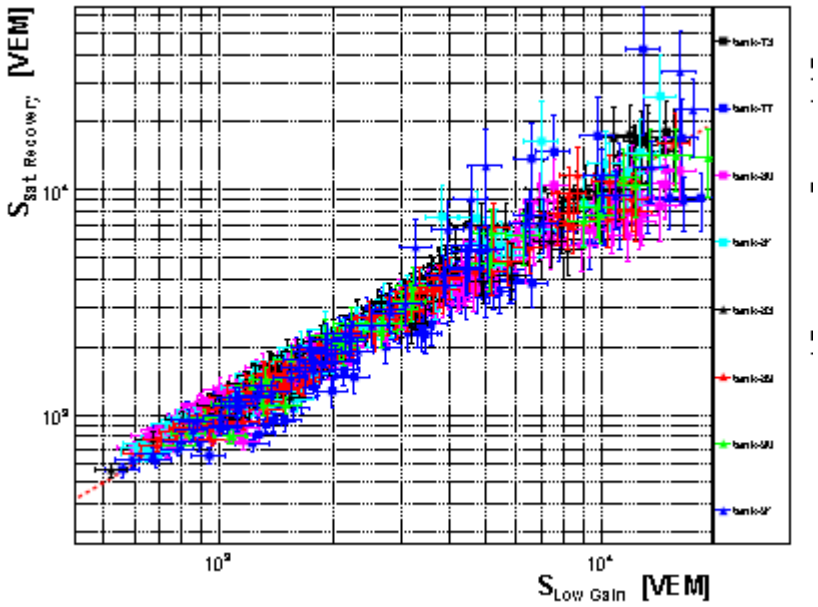
SD signal saturation: Tests with low gain PMTs

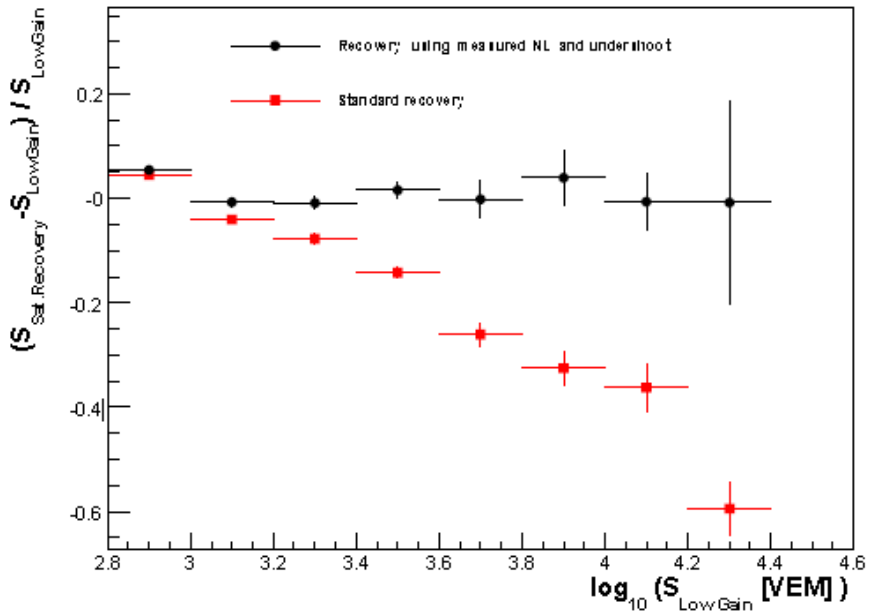
M.Aglietta[a], A.Castellina[a], I.De Mitri[b], S.Maldera[a], R.Sato[c]

[a] IFSI-INAF, Università di Torino and INFN-Torino, Italy
[b] Università del Salento and INFN-Lecce, Italy
[c] Pierre Auger Observatory, Malargüe, Argentina

Si e' abbassato il guadagno di uno dei tre PMT in alcune tank e si e' confrontato il segnale proveniente dal PMT a basso guadagno con il risultato della procedura di recovery su gli altri 2 PMT saturati







Aspetti critici

Grid in Auger finora è stata usata solo per simulazione/ricostruzione di "Rivelatore Ideale" e produzione di sciami in aria. "Rivelatore reale" (access DB) non è disponibile. I gruppi italiani e internazionali all'interno di Auger producevano Rivelatore Reale su farm locali: e.g. Lecce, Napoli, Karlsruhe.
Processamento Dati e produzione ADST viene fatta anch'essa su farm locali.

Problema di accesso al DB :

1. Modifica del codice per definire un accesso DBserverless.
2. Lasciare il codice come è ed inserire un (MySql) DB server every few (<10) nodi.

Critico in termini di manpower

Impossibile su nodi "standard" ma …

Configurazione ad hoc per WNoDes

- Un MySql server sul nodo virtuale permette di avere il DB server localmente.
  - Abbiamo il DB fisicamente su un disco residente quindi "update" indipendente dall'immagine virtuale, mentre l'immagine virtuale vede le tabelle come un link esterno. (soluzione in fase di test)

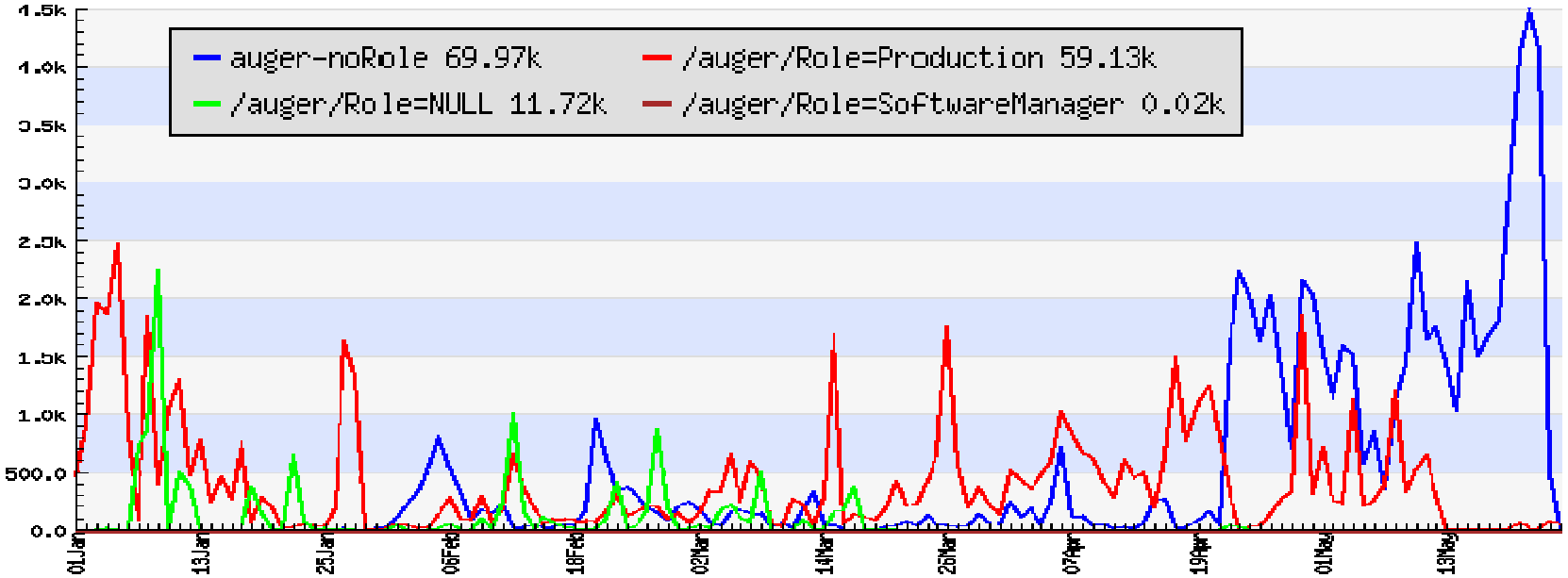
- Da FARE: Image selection per run con DB dipendente o indipendente.
- Possibile configurazione macchina ad hoc per installazione/build?

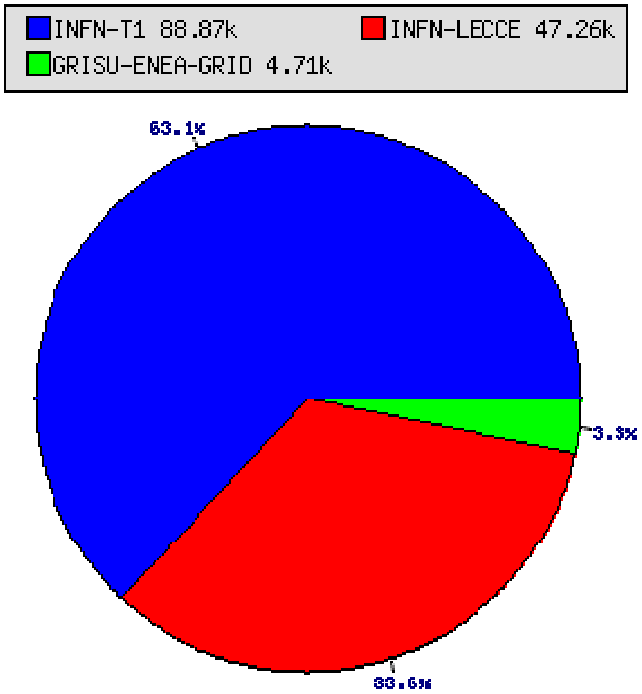
A WNoDeS Adoption Case: Auger

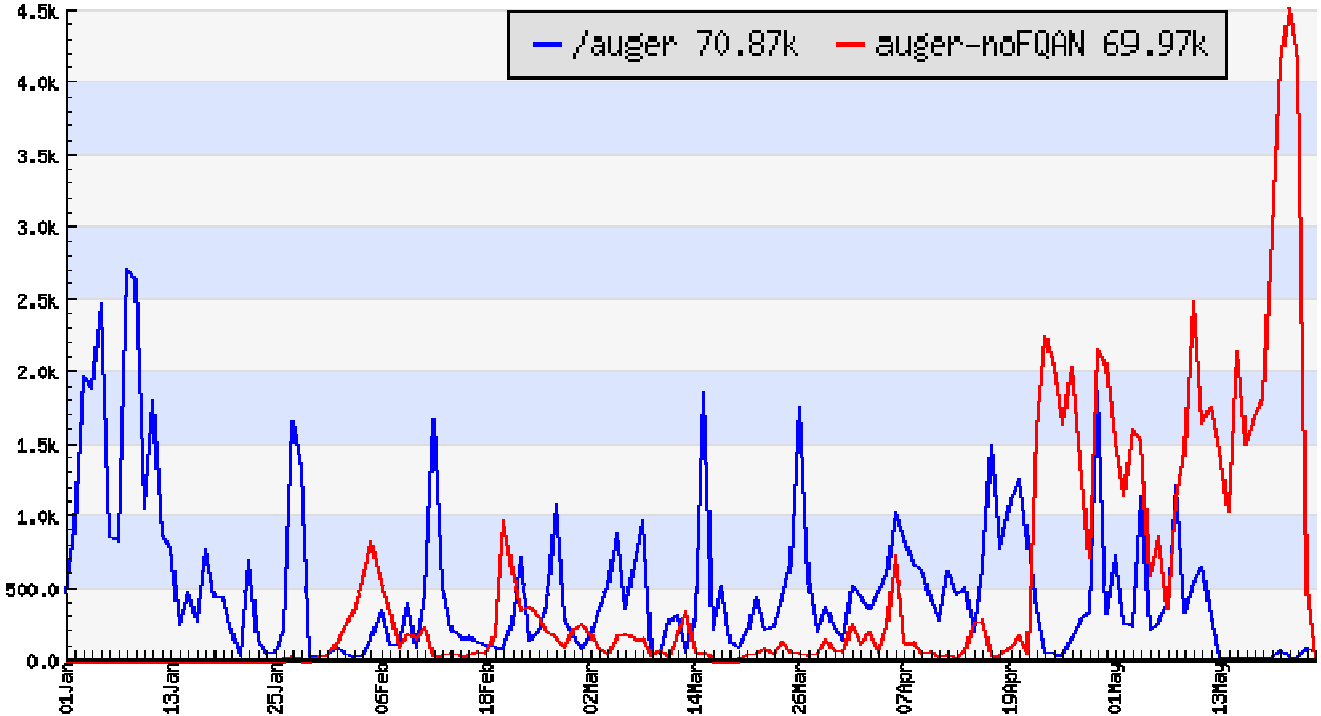
- **Auger**: a 3000 m^2 cosmic ray observatory located in Argentina, studying ultra-high energy cosmic rays.
- Need read-only access to a mysql-based condition database to perform detector simulation from hundreds of compute nodes concurrently. Two solutions using WNoDeS were tested for this:
  1. A VM, dedicated to Auger and including mysqld and the condition DB, was created. Each compute node (each VM) is completely independent. This works well, but requires rebuilding the VM image every time the condition DB changes.
  2. A VM, dedicated to Auger and including mysqld but accessing the condition DB over a networked file system (GPFS at CNAF), was created. All compute nodes see the same mysql tables. When the condition DB needs to be updated, the tables stored on GPFS are changed. This works well, but puts some strain on GPFS metadata; the storage subsystem then needs to be adequately architectured. This is our current solution.
- In both cases, WNoDeS provided a flexibility to Auger that would not have been possible with a classical set-up.

Tempo di CPU e totale di utilizzo di macchine dal 1-1-2011

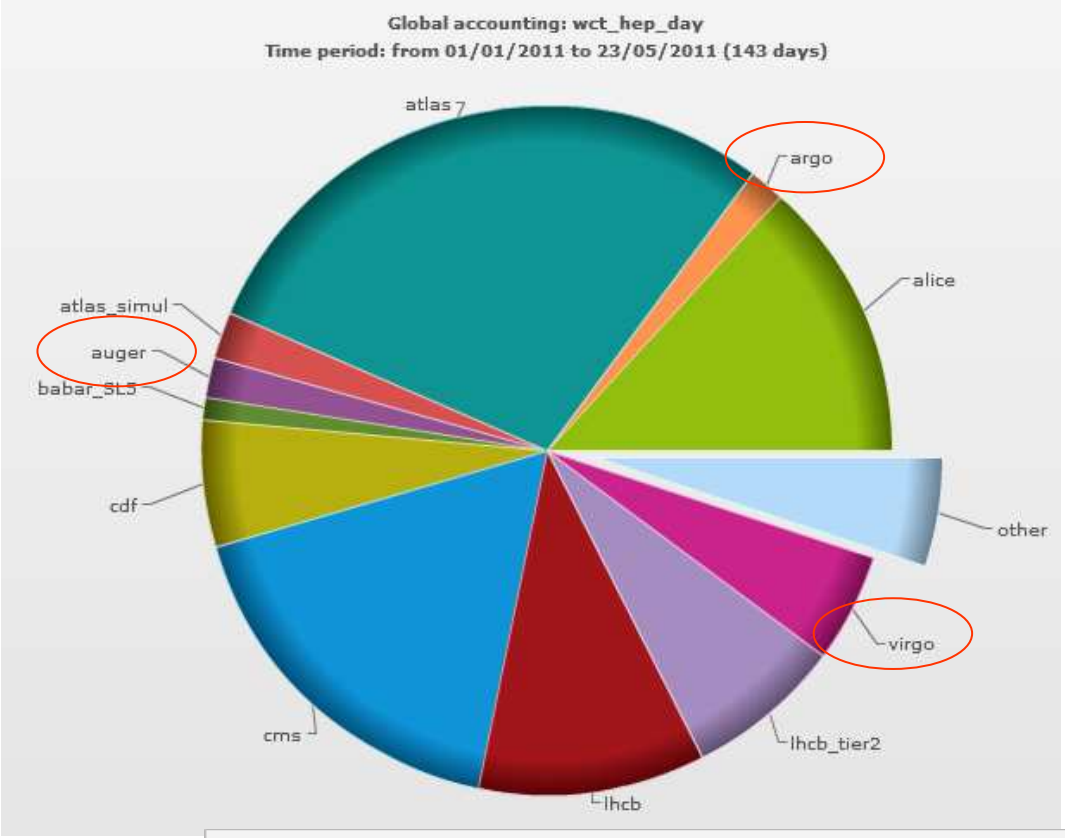
Dichiarate su GRID

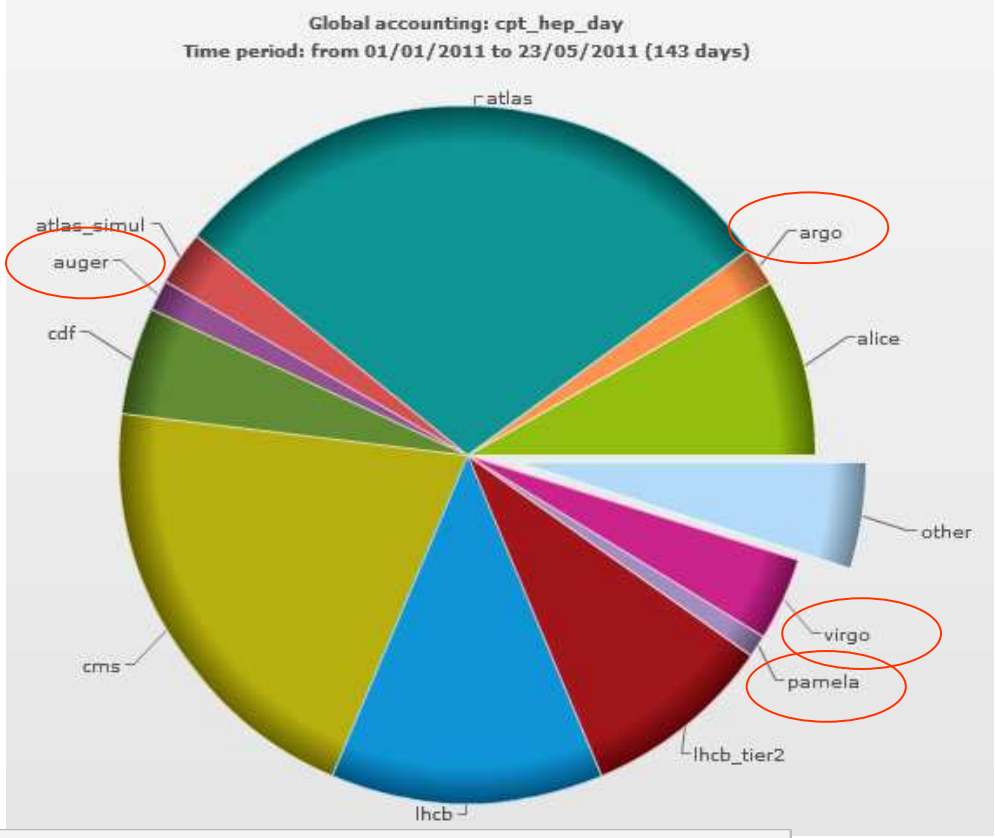


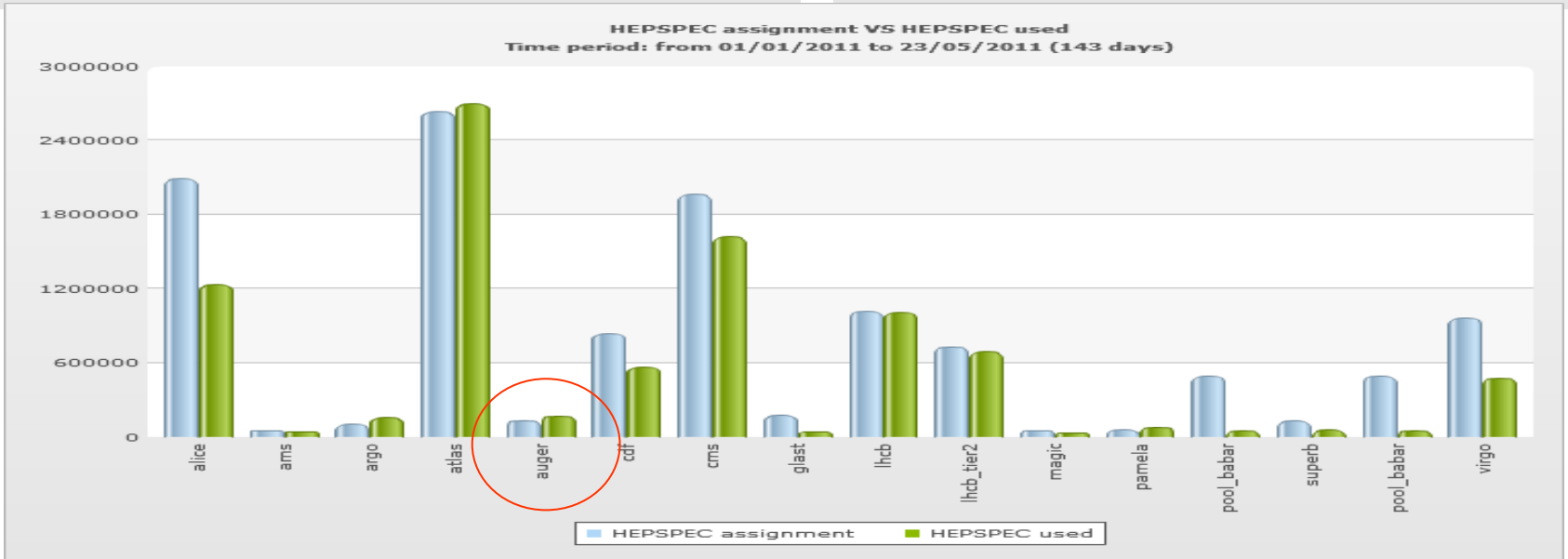




Utilizzo delle risorse al CNAF







LECCE Activity

Analisi, Detector Performance e attività di supporto

- **Studio dell'efficienza di trigger di Infill (LTP e full simulation)**
- **Ricerca di sorgenti (E > 1 EeV, E> 5 EeV)**
- **Esposizone ibrida (spettro standard)**
- **Esposizione ibrida per i fotoni (Corsika full simulation)**
- **Primi approcci di studio di long term performance per FD**
- **Saturazioni**
- **Worker Node on Demand**

Maintenance & R&D correlati

- **Status SDECO**
- **Maintenance PMT sul Campo**
- **Test PMT**
- **AMY**
- **Sviluppo ADC**

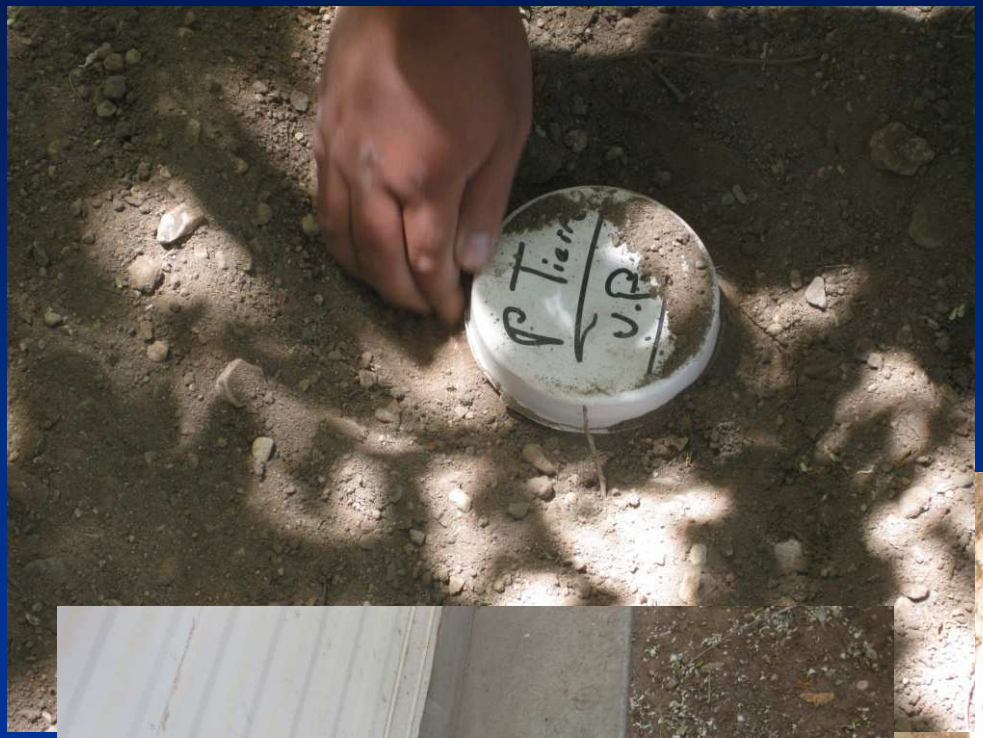
SDECO

- SDECO upgrates
- Installation and test of new splitter
- Led operation point
- New ACQ with VME

Recent upgrades

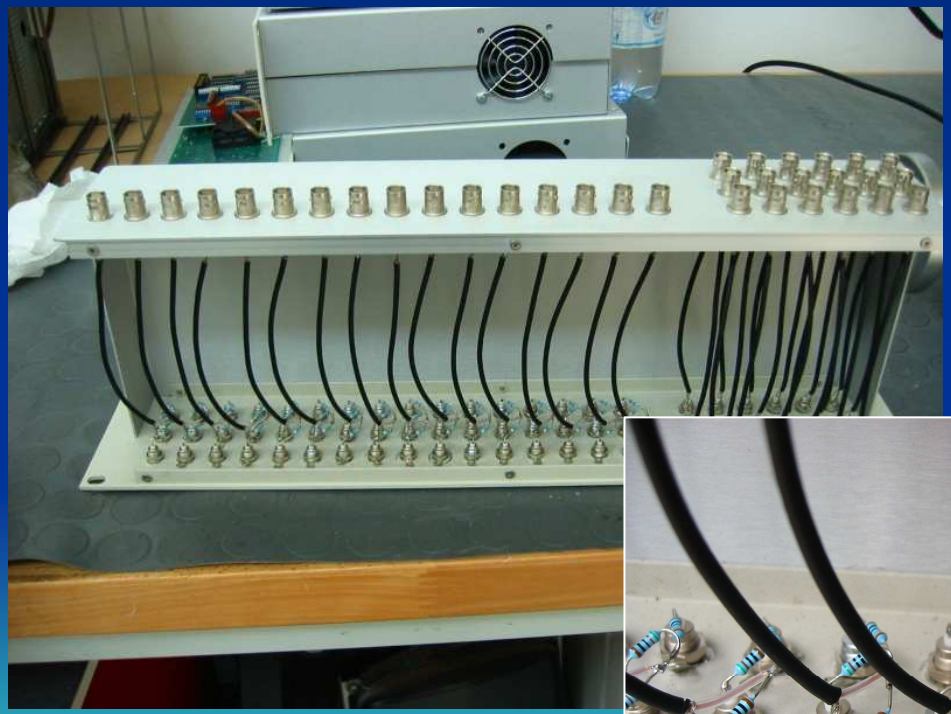
- **UPS**
  - A new UPS (filtering) of 3kW power and 0,5h autonomy has been installed.
- **Ground**
  - Digged a new hole for the ground and changed the relative cables.

2010 November site visit



SDECO upgrades

- Splitter
  - The splitter has been replaced successfully. It has been redesigned and realized by C. Pinto in order to make it more precise, easy to use and stable. This is the new one



Short term upgrade

LED

- The LED system showed some minor problems. In particular the DAC values set to get single photoelectron varies often. We propose to monitor the source to check if aging problems are present and eventual other problems connected. I installed a new routine in order to get automatic calibration and monitoring of the working point fo the LED.

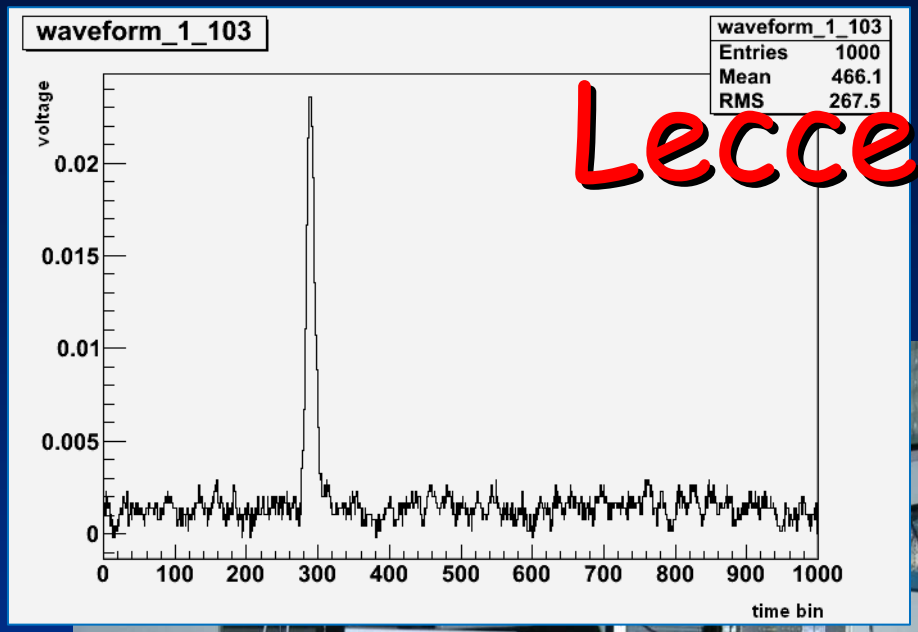
SDECO new ACQ

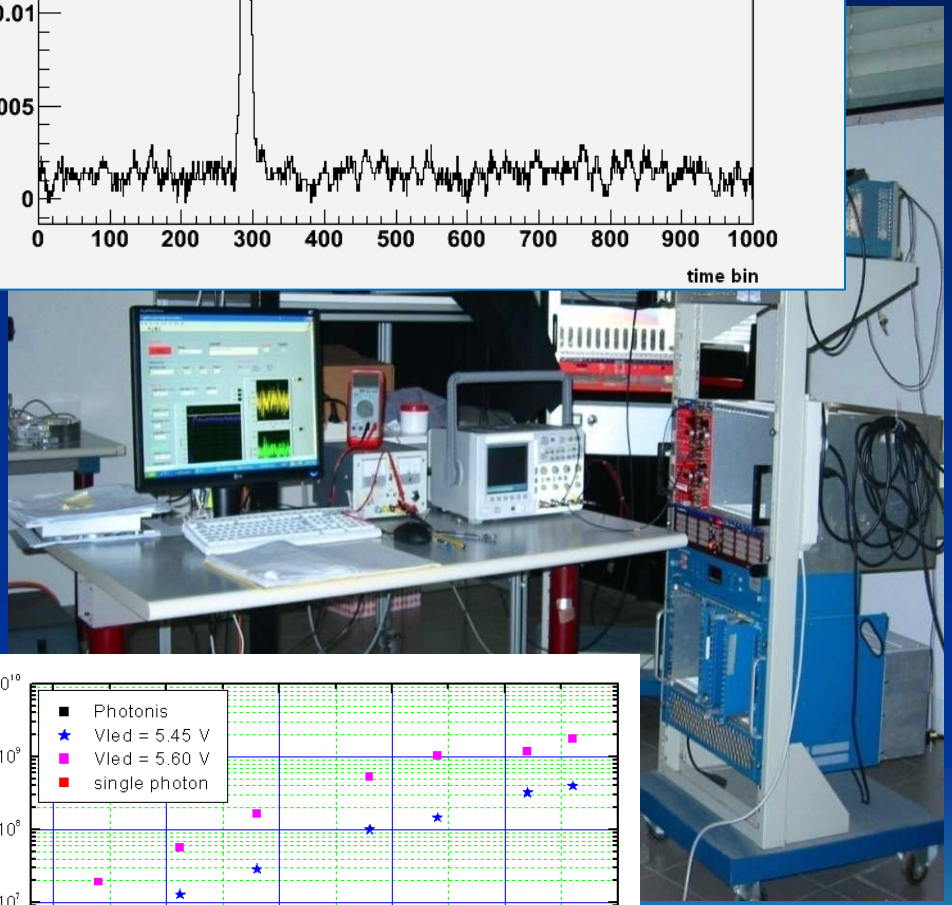
- N.1 WV1718XAAAAA V1718 - VME-USB 2.0 Bridge
- N.3 WV792XNCAAAA V792NC - 16 Channel Multievent Charge ADC
- N.1 WV1495XAAAAA V1495 - General Purpose VME Board
- N.1 WA395XDAAAAA A395D - 8 NIM/TTL input/output channels interface for V1495
- N.1 WA395XEAAAAA A395E - 8 channel 16Bit ±5V DAC for V1495
- **Tot Cost: 14,999,00 Euro**

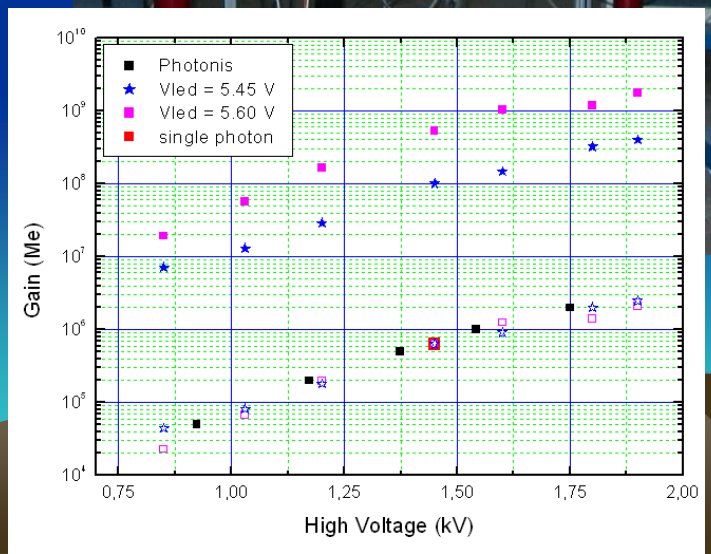
Shift

- Dedicated shift coordinated with Torino for extraordinary PMTs maintenance in the field. ~40 PMTs fixed in 2 weeks
- Described in detail the polishing procedure for PMTs

Lecce's facility







- Setup ready for new PMT characterization
- Software tools developed
- Test performed with PHOTONIS PMT
- Ready for linearity measurements with HAMATSU PMT (two methods)
- We already have all the tools in order to reproduce the SDECO acquisition system (computer, Vme crate, adc module,..)

AMY- Tests in Lecce AstroParticle Lab

Signal Generator
R&S SMB100A
9kHz to 3.2GHz

The Signal Generator is optioned with Pulse Modulator and Generator, that allows to pulse inside a gate signal (Δt_{min} = 10 ns)

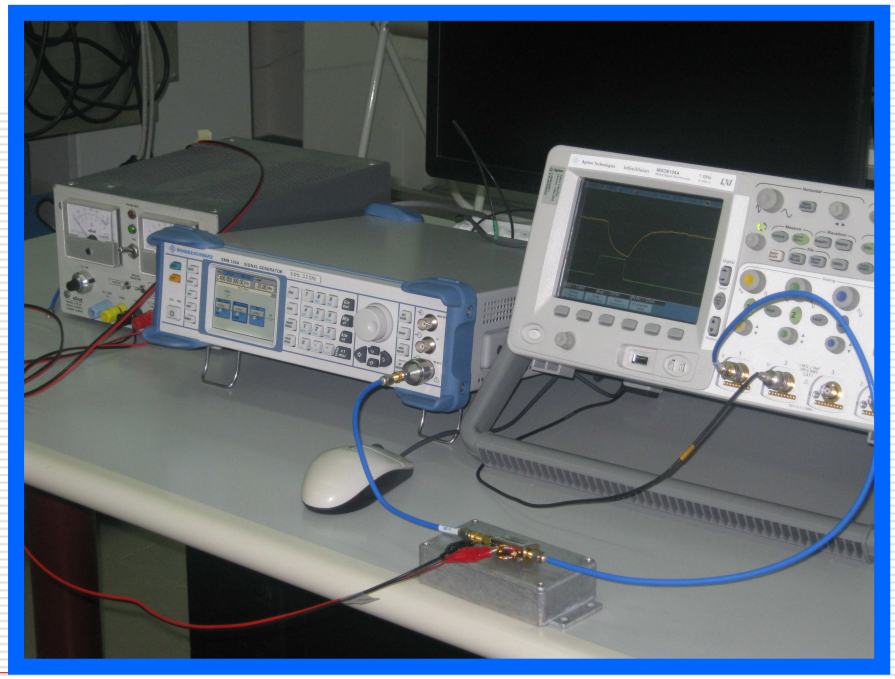
A simple setup just to start…

Power Detector *ZX47-60-S+ containing AD8318*

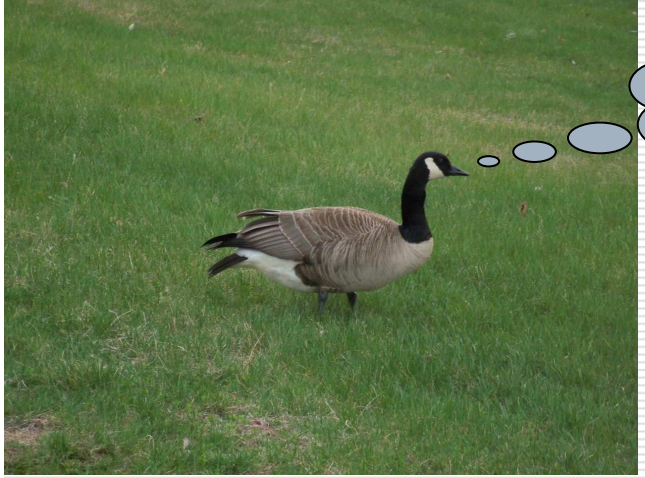
From Data Sheet

Rise Time 400nsec / Fall Time 10 nsec

(from -60 dBm to +5 dBm)



G.Cataldi, M.R. Coluccia, P.Creti



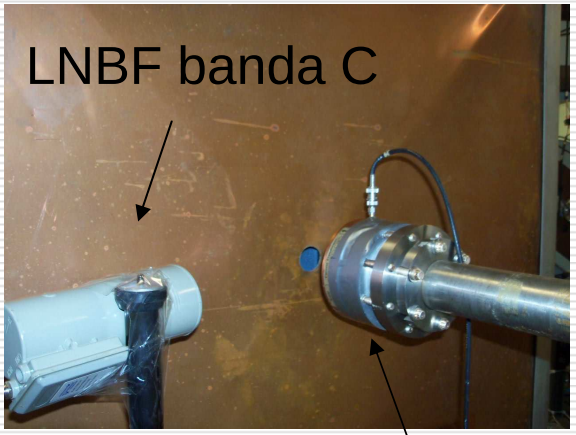
Argonne Test Beam Aprile 2011
G. Cataldi

Comincio con il descrivere il setup sperimentale:
Nella camera hanno:

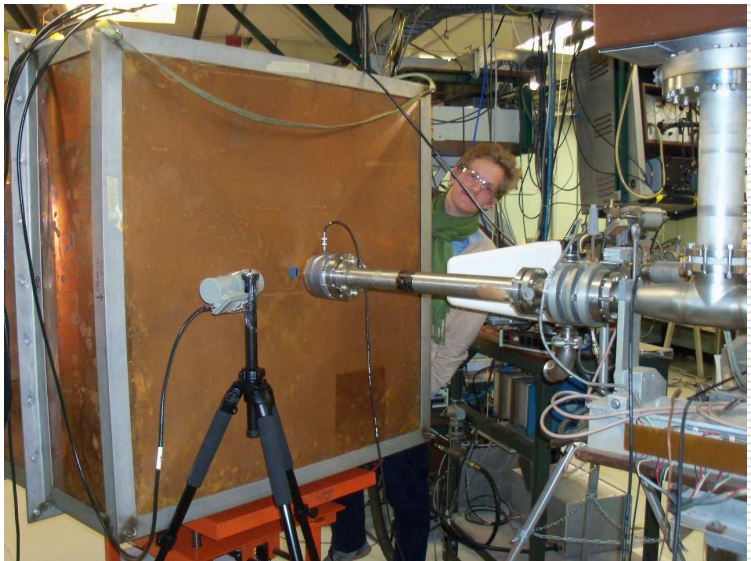
1) 1 log-periodica identica a quella prevista per AMY
2) 1 LNBF banda C (quelli di Midas)
3) 1 LNBF banda Ku WS International

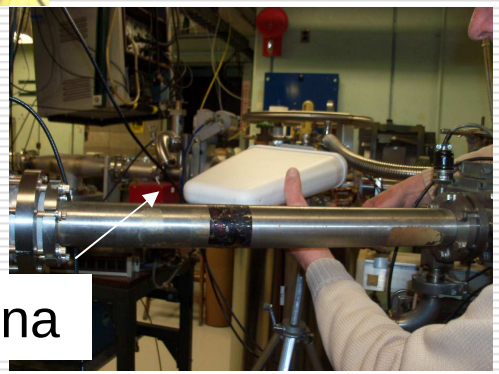
Fuori dalla camera hanno gli stessi LNBF e una antenna identica

Camera ground



Finestra uscita fascio





Log periodica esterna

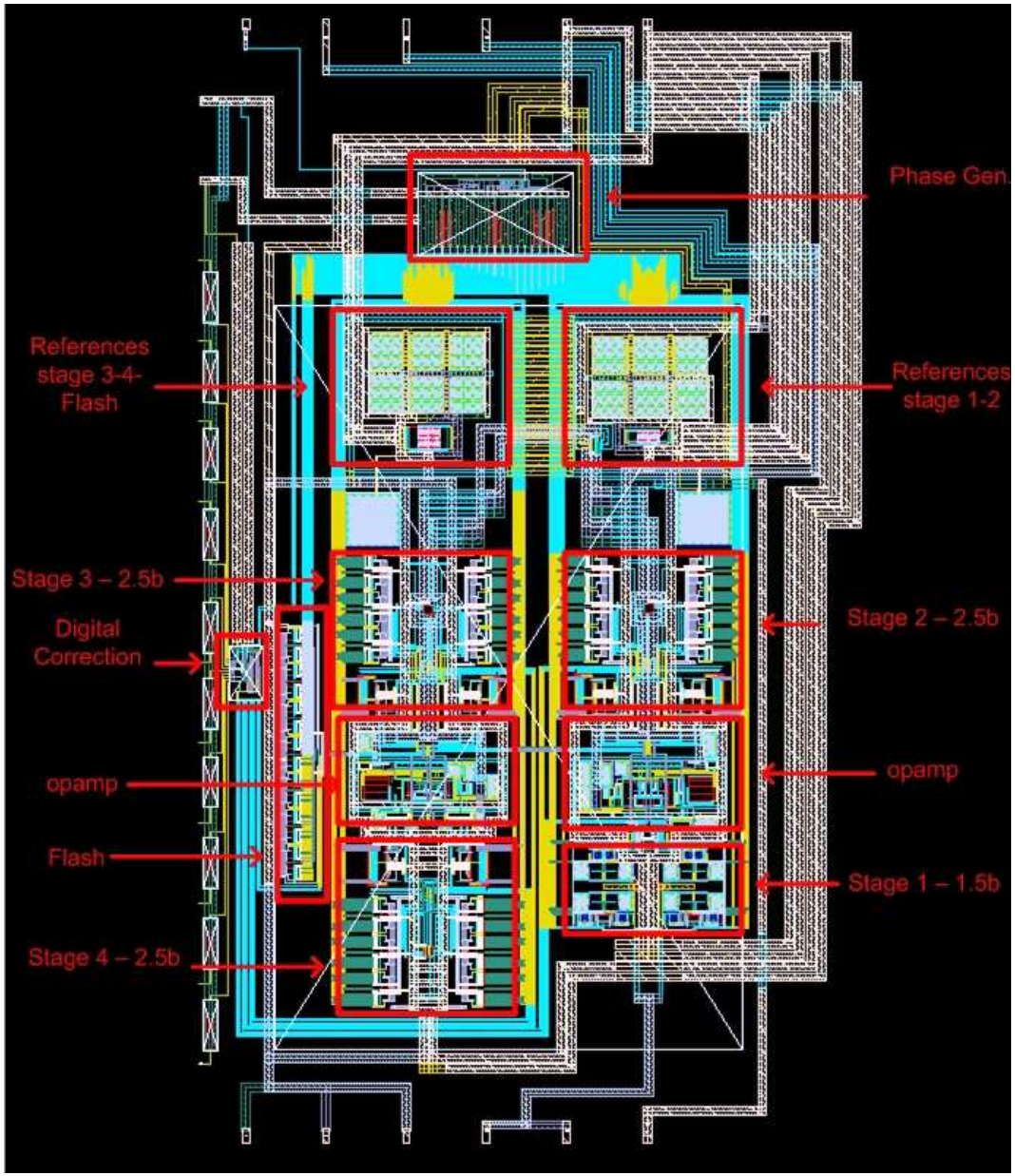
Argonne Test Beam Aprile 2011 G: Cataldi

Spectrum Analyzer in banda C:
La differenza tra quelle due curve
(circa 3 dBm) potrebbe essere il segnale.
Sembra essere indipendente dalla polarita'
E quindi non legato a transition radiation.
Inoltre non vedono differenza tra ingresso attraverso un foro e ingresso attraverso un foglio di alluminio,
Nei giorni scorsi hanno fatto misura di Power Vs Intensity del fascio e si direbbe "lineare" all'interno della camera

ADC Dev. Objectives

- Bonding inductance effect has to be investigated;
- Reference re-design;
  - More stable references;
  - Decoupling ;
- Stage re-design;
  - Opamp;
- Overall decoupling of analog supply and references voltages.
- Digital section re-design;
  - Phase generator improved;
- Layout improvement

NEXT IMPROVEMENTS - ADC Layout



Fonderia Sett.-Ott. 2011

S. D'Amico et al.