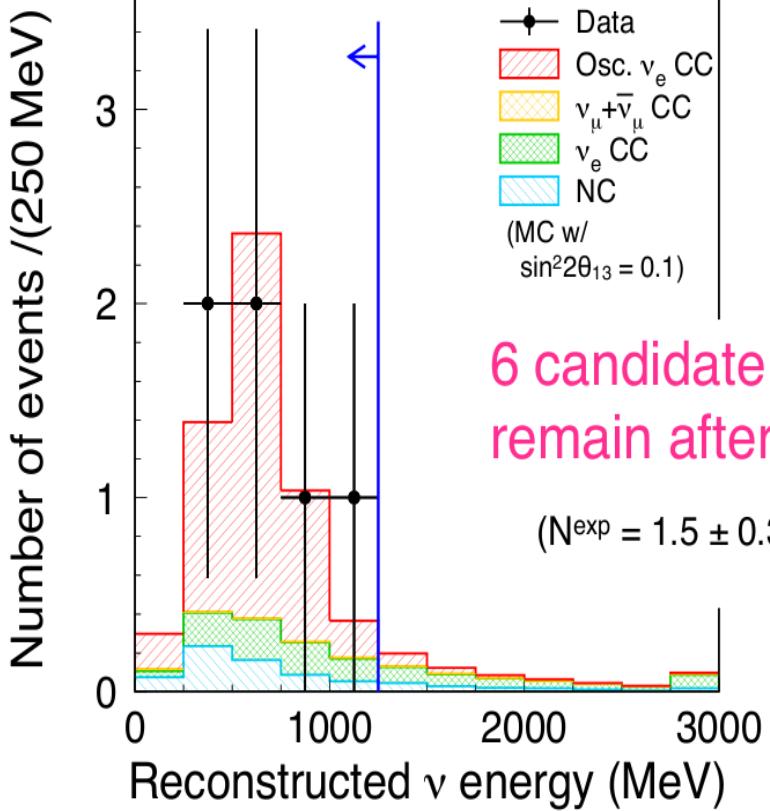


Group II activities at LNF

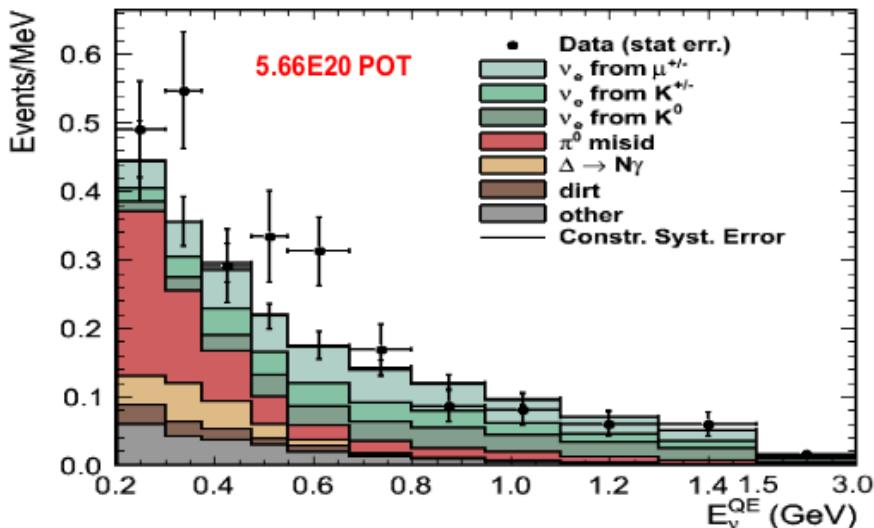
A. Paoloni

Consiglio di Laboratorio
6-7 luglio 2011

News from the world...



T2K hint for $\theta_B \neq 0$
(2.5σ statistical significance)



MiniBoone nu e anti-nu data, new reactor fluxes, BBN, CMB:
Sterile neutrinos ?



Group II activities @ LNF for 2012

Neutrino physics (mainly at LNGS)					
BENE-DTZ	BOREXINO	ICARUS	MARE-RD	OPERA	T2K
Search for rare processes (mainly at LNGS)					
CTF-RD	CUORE	DAMA	GERDA	LUCIFER-RD	LVD
WARP	XENON-RD				
Study of the cosmic rays by ground based and underwater experiments					
ANTARES	ARGO-YBJ	AUGER	MAGIC	NEMO	
Study of the cosmic rays by experiments in the space					
AGILE	AMS2	FERMI	JEM EUSO	WIZARD	
Search for gravitational waves					
AURIGA	LISA-PATHFINDER	RARENOISE-DTZ	ROG	VIRGO	
General physics					
GGG	MAGIA	MICRA	MIR	PVLAS	



0-2 FTE (ric. + tecnologi)



>2 FTE (ric. + tecnologi)



LNF nel 2011

Nessie (Neutrino Experiments with SpectrometerS In Europe), Design Study for a magnetic spectrometer based experiment on possible neutrino beam @ CERN PS to study sterile neutrinos: 0.2 FTE (2 persons)

OPERA

Anagrafica 2012

Ricercatori: 4.5 FTE (6 persone)

Tecnologi: -

Tecnici: 3.5 FTE (5 persone)

F. Terranova sta per prendere servizio come professore associato presso l'universita' di Milano Bicocca.

Andrea Longhin, neo-assunto, ha preso servizio all'inizio dell'anno.

Nicoletta Mauri, assegnista di ricerca, ha sostituito Mercedes Paniccia.

Richieste 2012

MI:	192 kE	(data taking, maintenance magnete, impiantistica, RPC, BH, coord.)
ME:	25.3	(meeting, coordinamento)
CO:	118	(spese di run, microscopi etc.)
CA:	5.5	(brick marking, etc.)

LNF group contribution

LNF group is heavily involved in data-taking with coordination duties in the OPERA management:

- Technical coordinator (M. spinetti)
- Electronics Detectors coordinator (A. Paoloni)

M. Ventura is the magnets project leader and A. Mengucci is on charge for the operation of the RPC gas system.

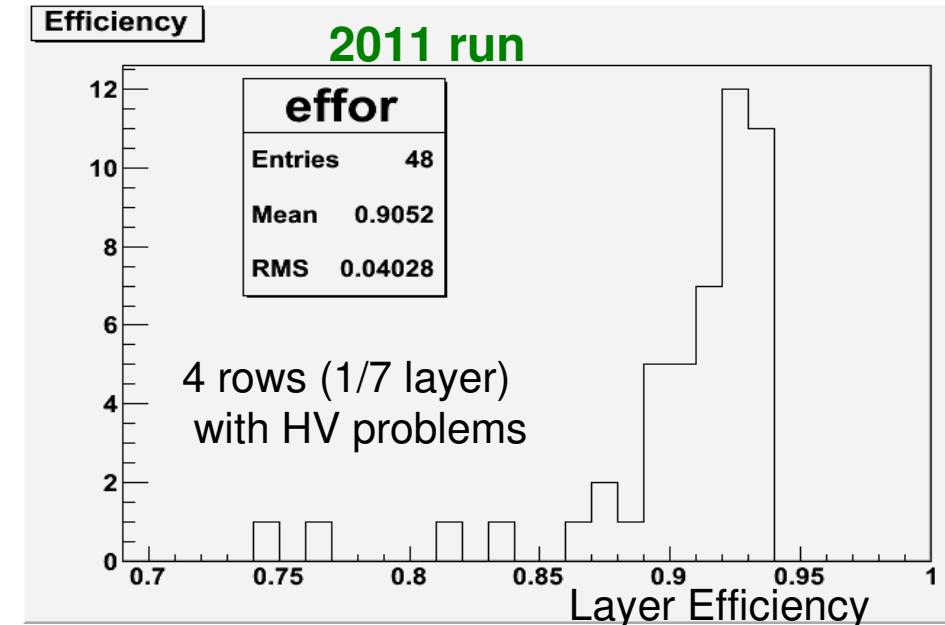
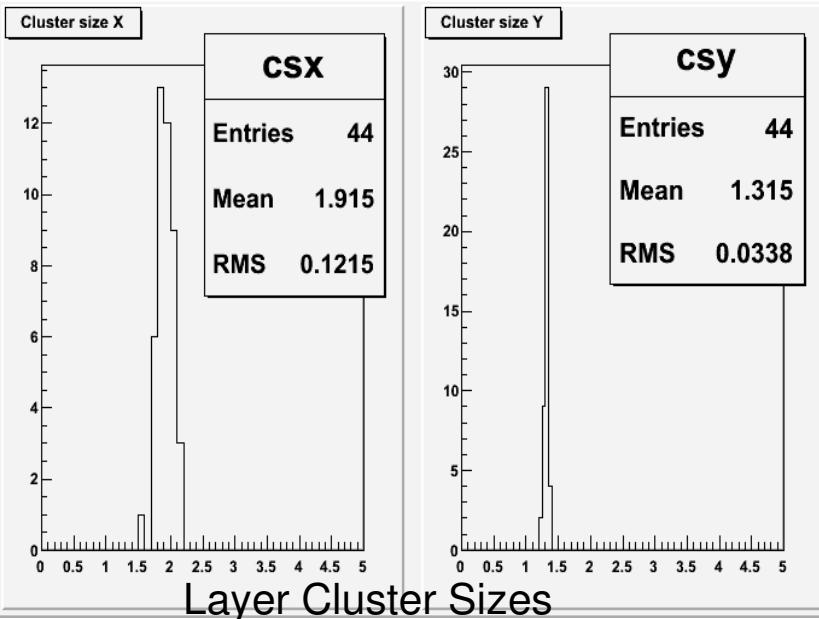
A. Cecchetti (SSE): maintenance of mechanical infrastructures.

Other duties:

X-ray marking machines maintenance.

Rows with blocked bricks recovery (A. Mengucci).

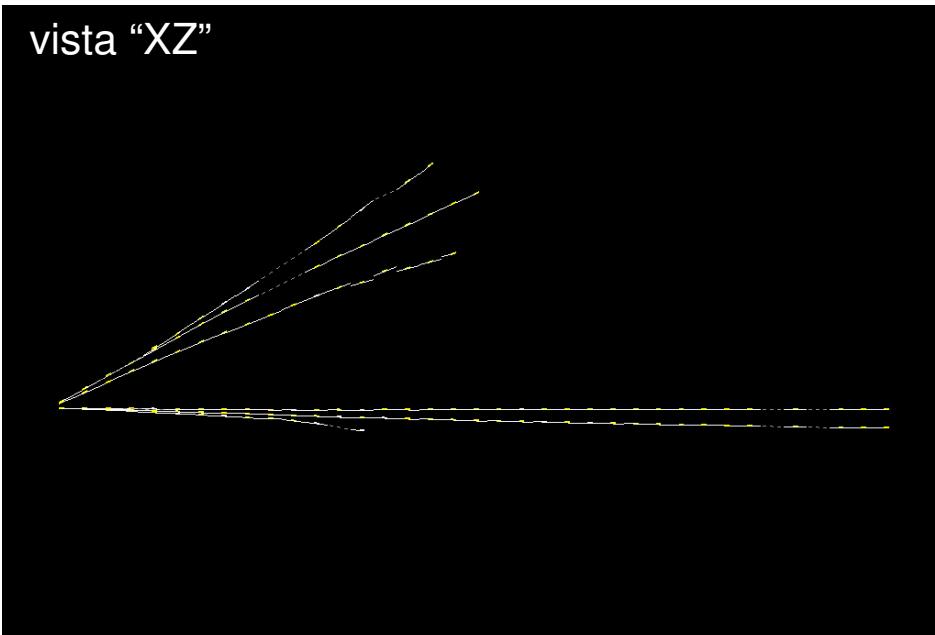
RPC performance monitoring and maintenance.



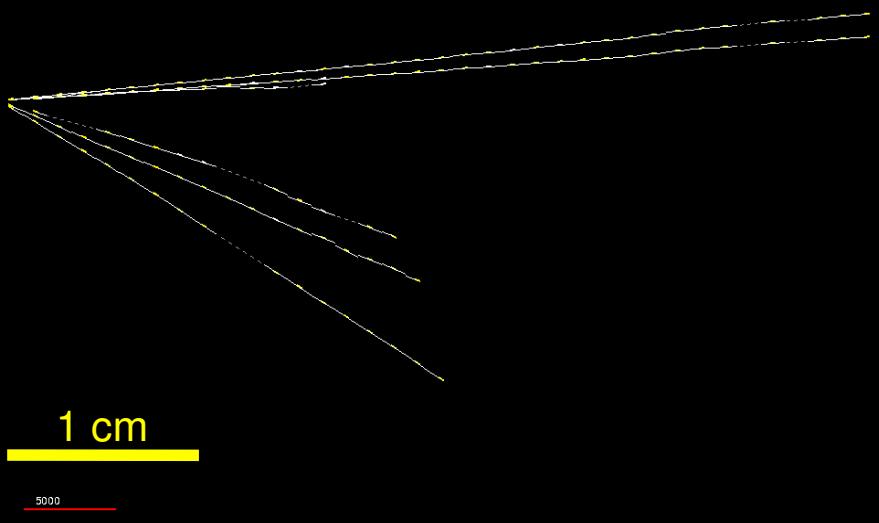
Laboratorio di scanning

(V. Chiarella, U. Denni, A. Longhin, N. Mauri)

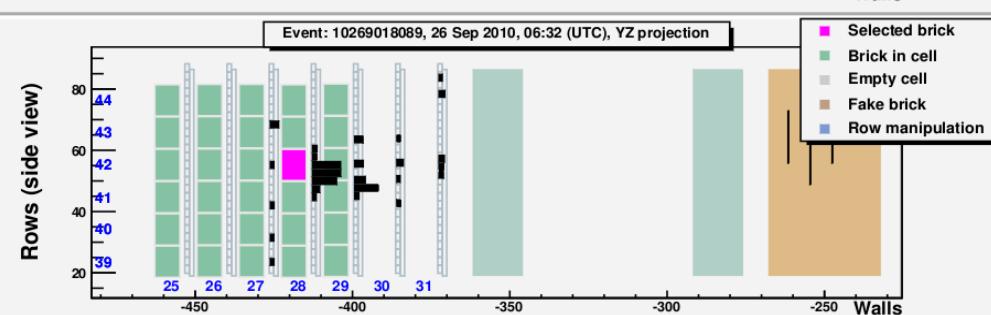
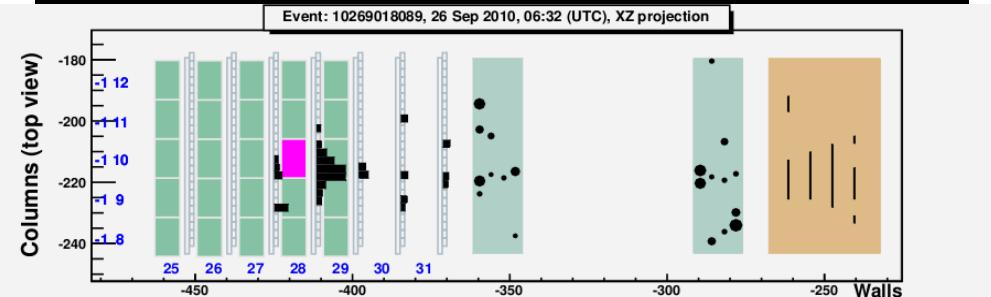
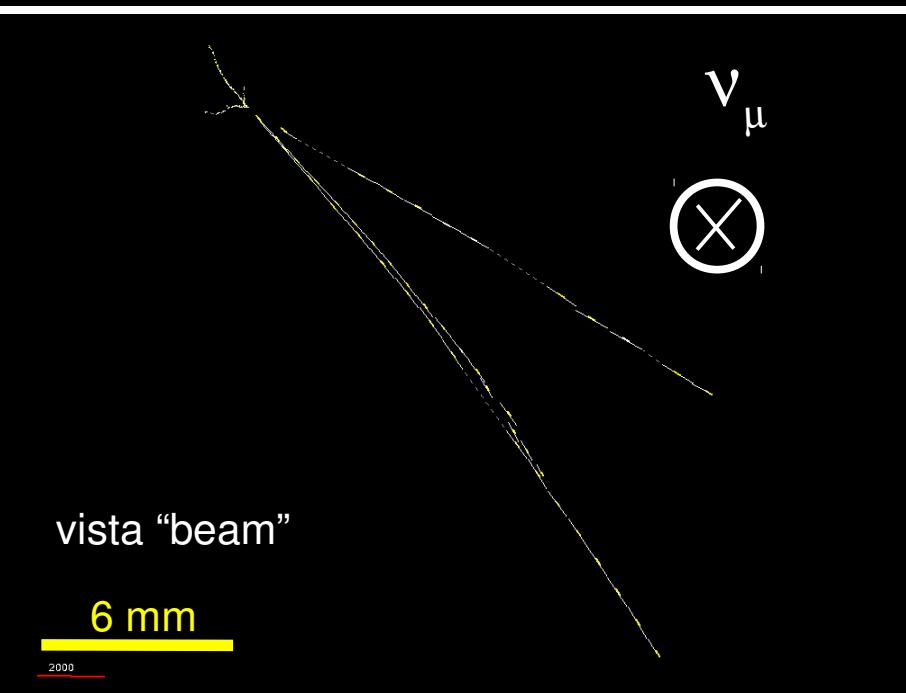
vista "XZ"



vista "YZ"



vista "beam"

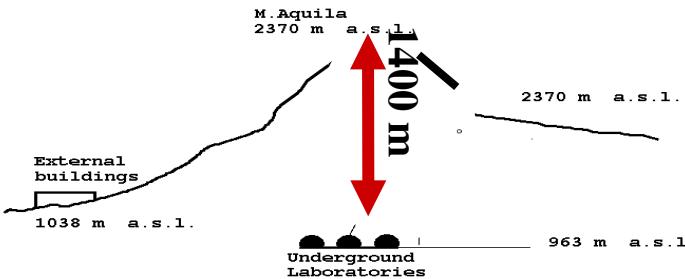


2008-2010 brick statistics

RUN 2008-2010	CC	NC	tot	%
delivered events	27	5	32	100
analysis not possible	0	0	0	0
scanning started	27	5	32	100
CS to brick OK	23	4	27	84
located v interaction	21	2	23	72
v interaction in dead material	2	0	2	6
passing through	0	0	0	0
new brick requested	0	0	0	0
CS reanalysis requested	1	0	1	3
Decay search	14	1	15	47
feedback in DB	13	1	14	44
brick in DB	9	1	10	31

In addition, scan-forth studies: tracks followed up to their stop or up to the end of the brick to study hadronic re-interactions from data.

OPERA as a cosmic ray detector



OPERA vs previous and current underground experiments:
a deep underground detector with charge and momentum reconstruction and excellent timing capabilities (~ 10 ns).

Analyses under way:

- Atmospheric neutrino induced muons
- Coincidences among experiments (OPERA/LVD)
- **Atmospheric muon charge ratio**

The atmospheric muon charge ratio $R\mu \equiv N\mu^+/N\mu^-$ is being studied and measured since many decades

- Depends on the chemical composition and energy spectrum of the primary cosmic rays
- Depends on the hadronic interaction features
- At high energy, depends on the prompt component

It provides the possibility to check HE hadronic interaction models ($E > 1\text{TeV}$) in the fragmentation region, where no data exists

Atmospheric muon charge ratio in OPERA

N. Mauri

Data Analysis:

Data taken during the CNGS

Physics Runs

2008 (from Jun 18th until Nov 3rd)

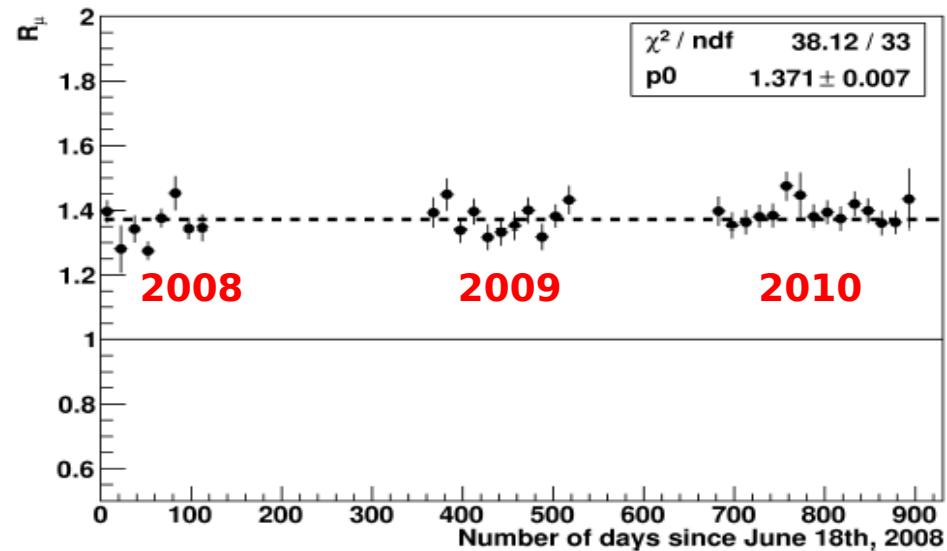
2009 (from Jun 1st until Nov 23rd)

2010 (from Apr 29th until Nov
22nd)

Selection of good quality running
periods:

Livetime: 407.1 days

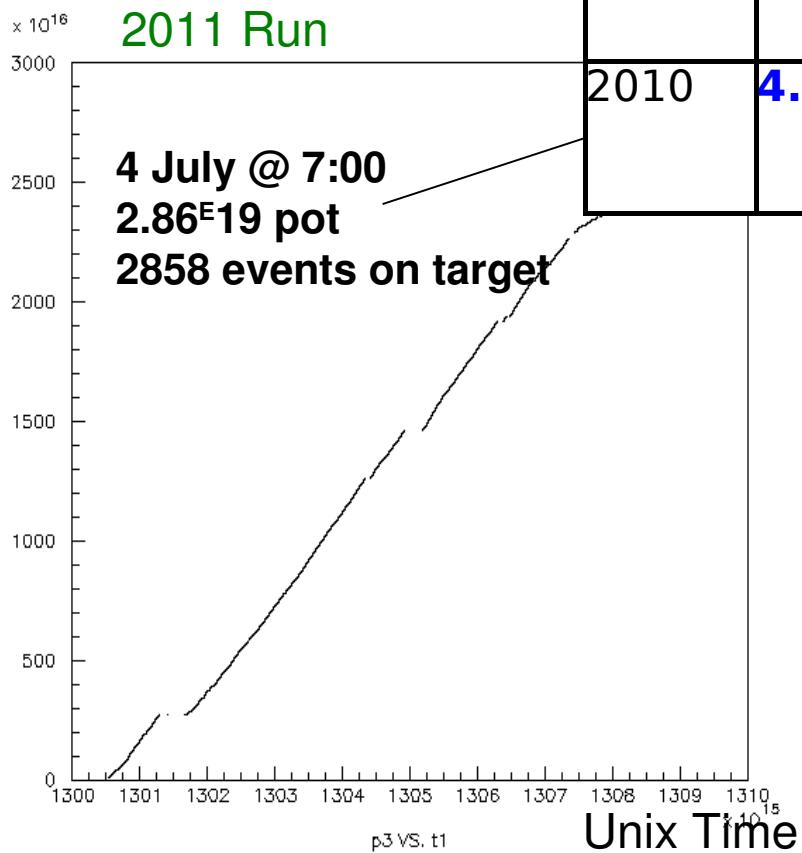
Total number of events: 1454057



Results for single and multiple muons separately:

N _μ	$\langle A \rangle$	$\langle E/A \rangle_{\text{primary}}$ [TeV]	H fraction	N _p /N _n	R _μ unf
= 1	3.35 ± 0.09	19.4 ± 0.1	0.667 ± 0.007	4.99 ± 0.05	1.403 ± 0.008
> 1	8.5 ± 0.3	77 ± 1	0.352 ± 0.012	2.09 ± 0.07	1.18 ± 0.03

CNGS and detectors performance



2006	0.076×10^{19} pot	no bricks	Commissioning
2007	0.082×10^{19} pot	38 ev.	Commissioning
2008	1.78×10^{19} pot	1698 ev.	Physics run
2009	3.52×10^{19} pot	3693 ev.	Physics run
2010	4.04×10^{19} pot	4248 ev.	Physics run

2011 run (18 March – November): $\sim 5 \times 10^{19}$ pot expected (4.5×10^{19} nominal value)

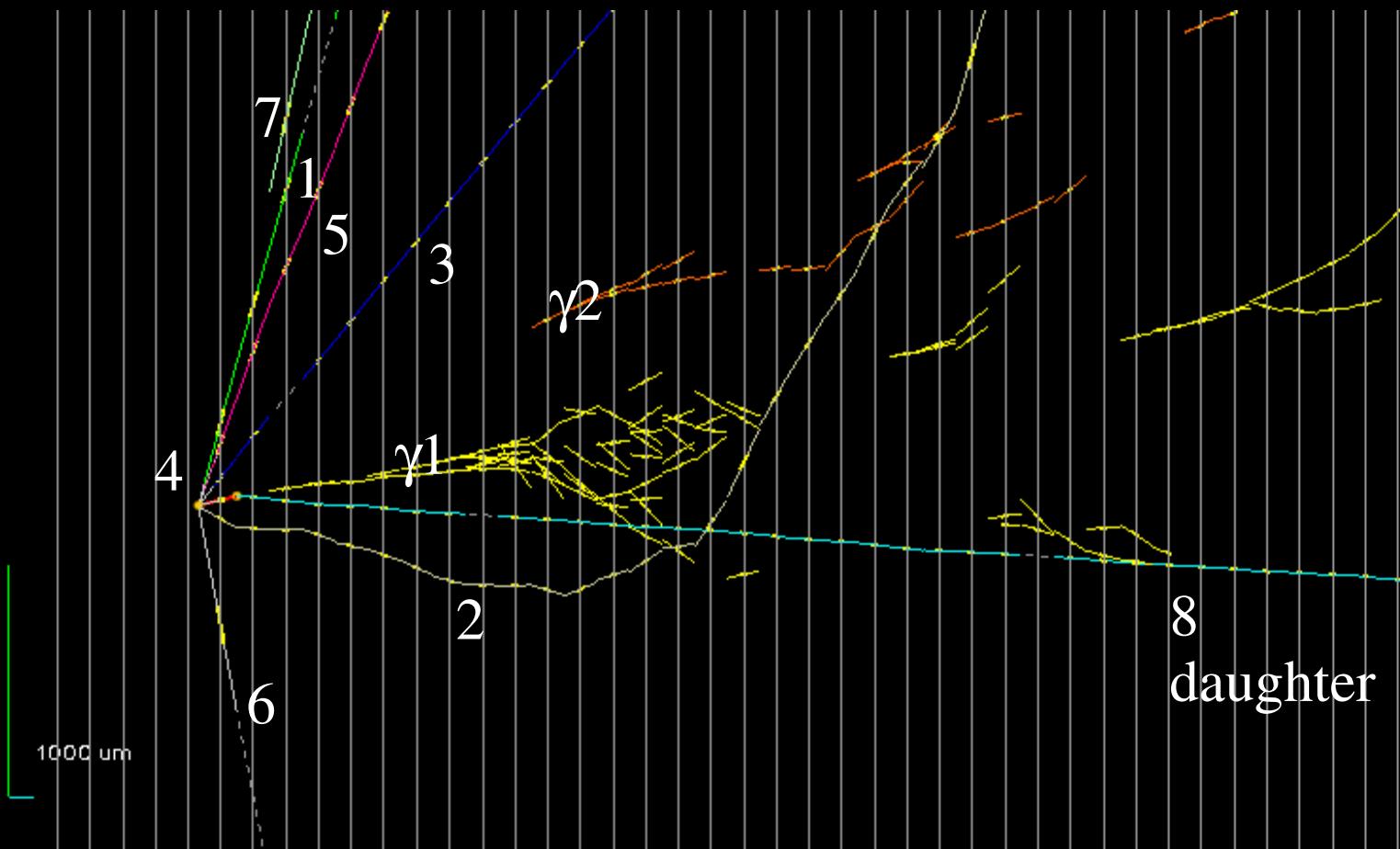
CNGS accelerator chain efficiency $\sim 80\%$

Proton intensity/extraction $\sim 2 \times 10^{13}$ pot

Electronics detectors & DAQ livetime $> 99\%$.

2008+2009 analysis completed: 1 ν_τ observed

Side view



Muon-less event.

Track 8 + $\gamma_1 + \gamma_2$ invariant mass compatible with $\rho(770)$ mass.

B.R.($\tau^- \rightarrow \rho^- \nu_\tau$) = 25% .

Analysis Update

- Analysis of 2008+2009 data sample almost completed (92%).
- Re-evaluation of efficiency and backgrounds with a complete MC, simulating also brick finding, scanning procedures and decay search algorithms.
- Improved background rejection (muon identification by track follow-down, hadronic re-interactions rejection through black track search).

Decay channel	Number of signal events expected for		Detection efficiency
	22.5×10^{19} p.o.t.	Analysed sample	
$\tau \rightarrow \mu$	1.79	0.39	0.54
$\tau \rightarrow e$	2.89	0.63	0.59
$\tau \rightarrow h$	2.25	0.49	0.59
$\tau \rightarrow 3h$	0.71	0.15	0.64
Total	7.63	1.65	

Location efficiency:
 Internal events selection *
 Brick finding *
 Event location inside the brick

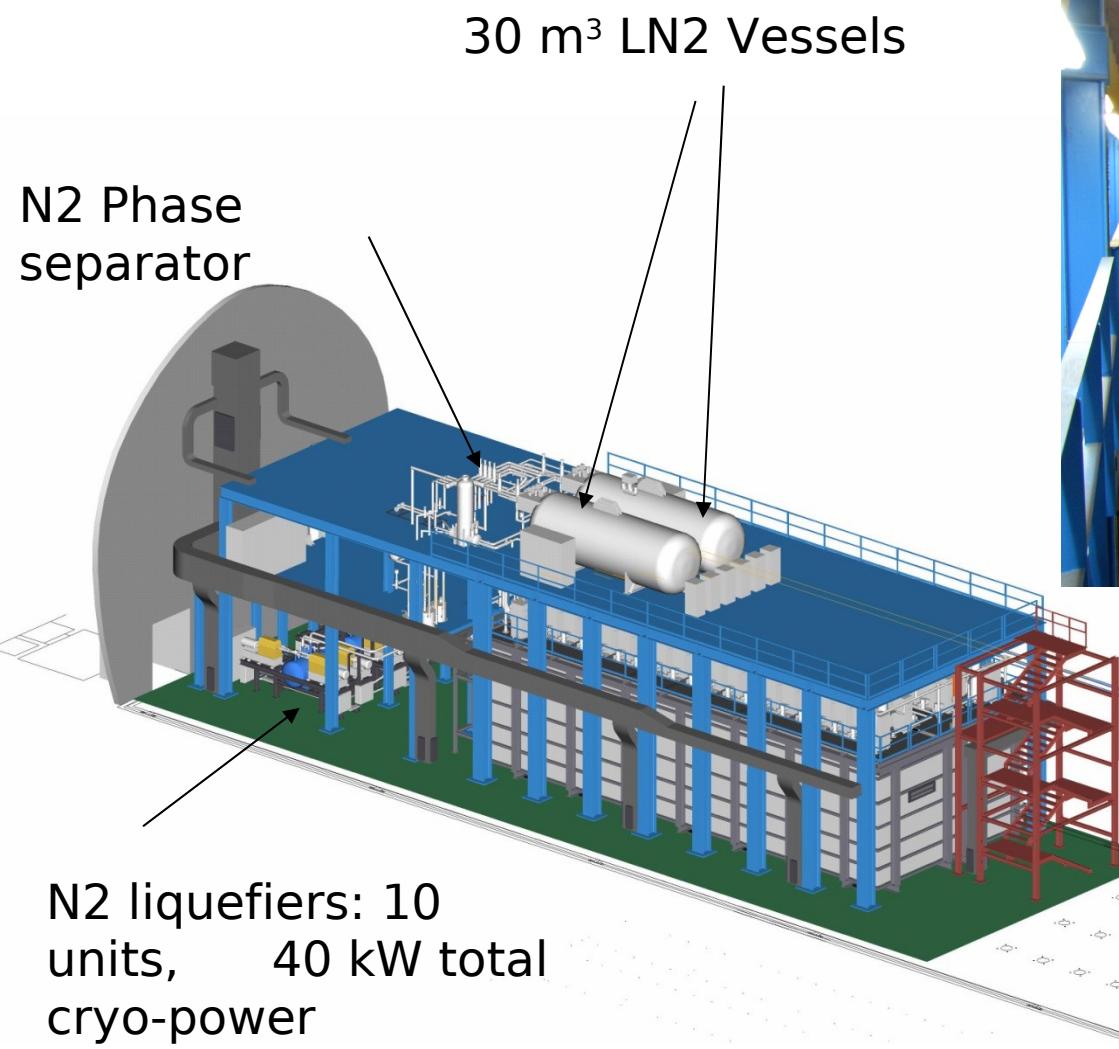


Assuming:
 $\Delta m^2_{\nu_3} = 2.5 \times 10^{-3} \text{ eV}^2$ and full mixing

Decay channel	Number of background events for:							
	22.5×10^{19} p.o.t.				Analysed sample			
	Charm	Hadron	Muon	Total	Charm	Hadron	Muon	Total
$\tau \rightarrow \mu$	0.025	0.00	0.07	0.09 ± 0.04	0.00	0.00	0.02	0.02 ± 0.01
$\tau \rightarrow e$	0.22	0	0	0.22 ± 0.05	0.05	0	0	0.05 ± 0.01
$\tau \rightarrow h$	0.14	0.11	0	0.24 ± 0.06	0.03	0.02	0	0.05 ± 0.01
$\tau \rightarrow 3h$	0.18	0	0	0.18 ± 0.04	0.04	0	0	0.04 ± 0.01
Total	0.55	0.11	0.07	0.73 ± 0.15	0.12	0.02	0.02	0.16 ± 0.03

- Expected number of τ decreased with respect to proposal (efficiency re-evaluation).
- Background almost unchanged (without track follow-down and black track search two times higher, according to new CHORUS results on charm production).
- Statistical significance for ν_τ appearance (2008+2009 data) = 95% for $\tau \rightarrow h$ (85% considering all the decay channels).

ICARUS T600 in LNGS Hall B



Preliminary results of first CNGS 2010 run

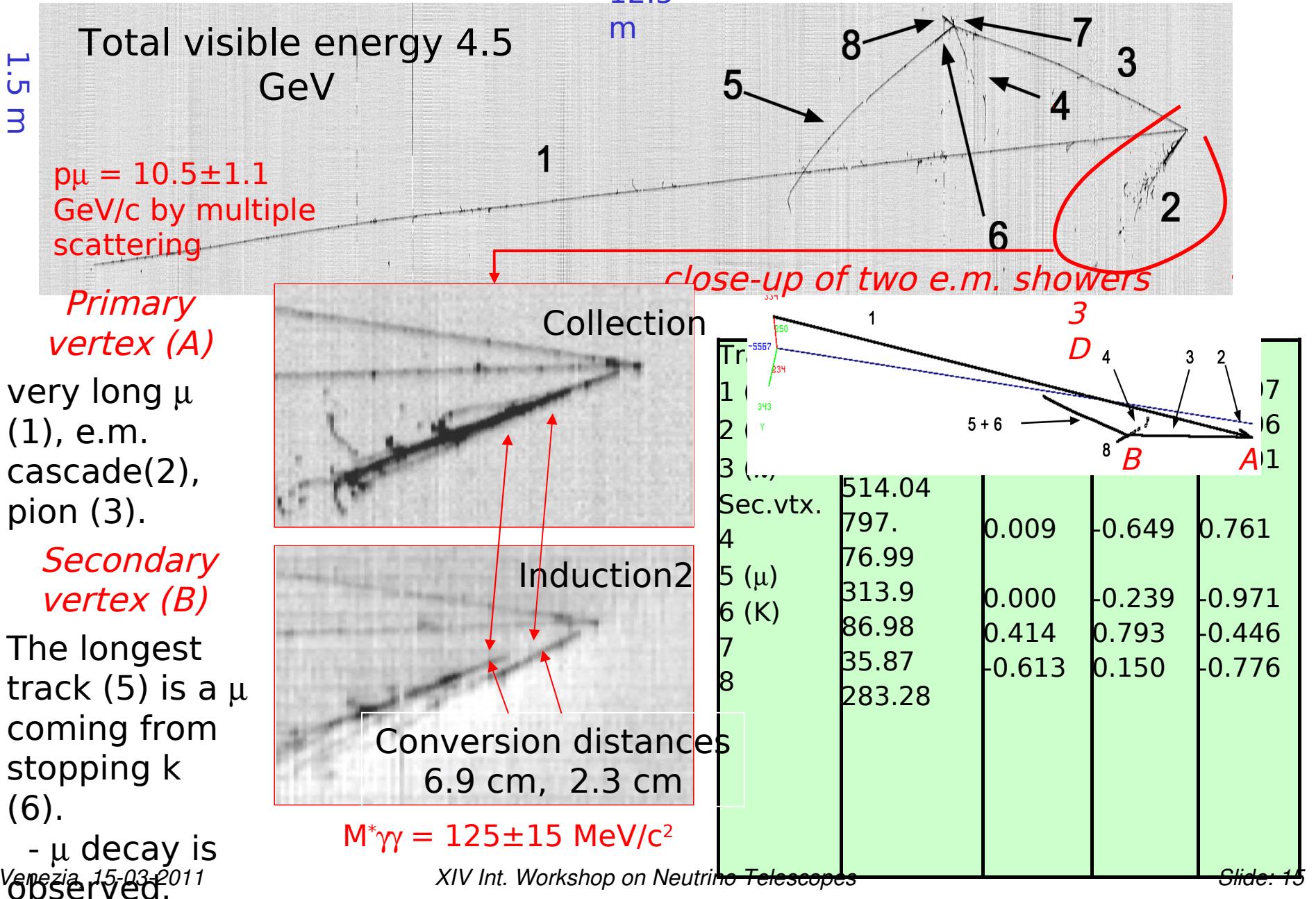
- Full sample analyzed, i.e. $5.8 \cdot 10^{18}$ pot. Classified by visual scanning into fiducial volume of 434 t.
- Number of collected interactions compared with number of interactions predicted ($(2.6 \nu \text{ CC} + 0.86 \nu \text{ NC}) 10^{-17} / \text{pot}$), in the whole energy range up to 100 GeV, corrected by fiducial volume and DAQ dead-time.

Event type	Collected	Expected
$\nu\mu \text{ CC}$	115	129
$\nu \text{ NC}$	46	42
$\nu \text{ XC}$ *	7	-
Total	169	172

* Events at edges, with μ track too short to be visually recognized: further analysis needed.

Overall statistics **in agreement with expectations**.

LAr-TPC: powerful technique. Run 9927 Event 572



2011-2012 CNGS run: physics perspectives

- 2011-2012 run with dedicated SPS periods @ high intensity:
expected 10^{20} pot.
- For $1.1 \cdot 10^{20}$ pot: 3000 beam related $\nu\mu$ CC events expected in ICARUS-T600.

7 νe CC intrinsic beam associated events with visible energy < 20 GeV.

- At the effective neutrino energy of 20 GeV and $\Delta m^2 = 2.5 \cdot 10^{-3} \text{ eV}^2$, $P(\nu\mu \rightarrow \nu\tau) = 1.4\%$
- 17 raw CNGS beam-related $\nu\tau$ CC events expected
- $P(\tau \rightarrow e\nu\nu) = 18\% \Rightarrow 3$ electron deep inelastic events with visible energy < 20 GeV.

Background

Signal

- $\tau \rightarrow e\nu\nu$ events characterized by momentum unbalance (because of 2 ν emission) and relatively low electron momentum.
Selection criteria suggest a sufficiently clean separation with kinematic cuts and efficiency $\sim 50\%$, allowing to detect 1-2 $\nu\tau$ CNGS events expected in ICARUS T600 in next 2 years.

ICARUS - LNF

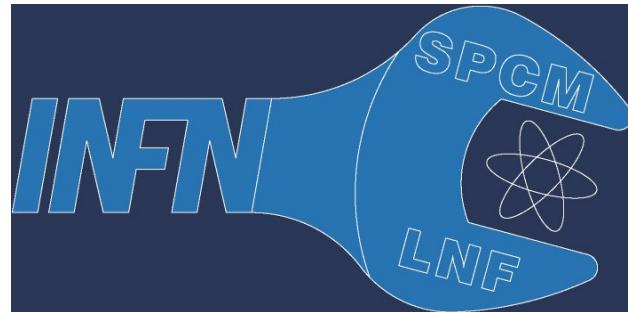
Composizione del gruppo:

G. Mannocchi, P. Picchi, L. Periale, G. Trinchero

1.5 FTE

CUORE_DTZ @LNF

Resp. A. Franceschi



Servizio Progettazione e Costruzioni Meccaniche
+
Divisione Acceleratori

Responsabilità:

Coordinamento Ingegneria

Integrazione Apparato Sperimentale

Impegno LNF 2012:

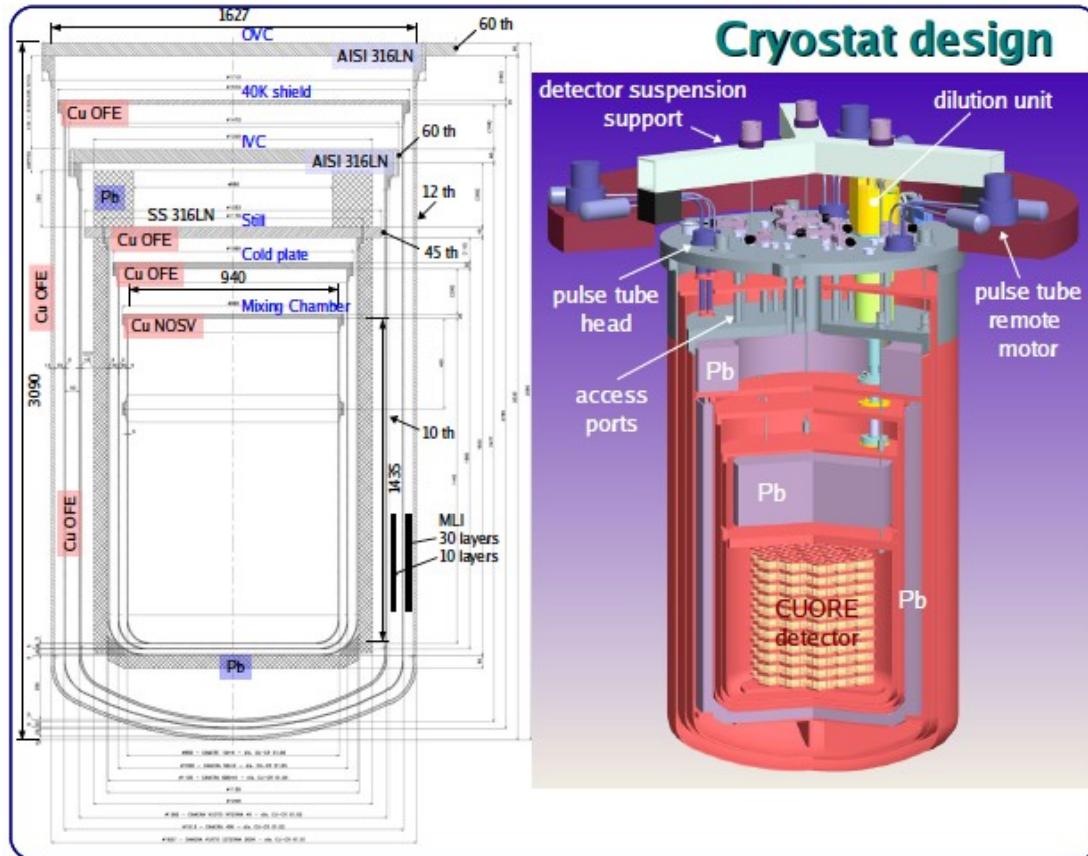
A. Franceschi 60%
C. Ligi* 40%
T. Napolitano 60%
A. Tiburzi 50%

* Div. Acceleratori

Ingegneria/Integrazione:

Torre Rivelatori
Pulizia Rame
Criostato/Criogenia
Schermature Piombo
Installazione Detector
Cablaggi Elettronica

M.A. Franceschi



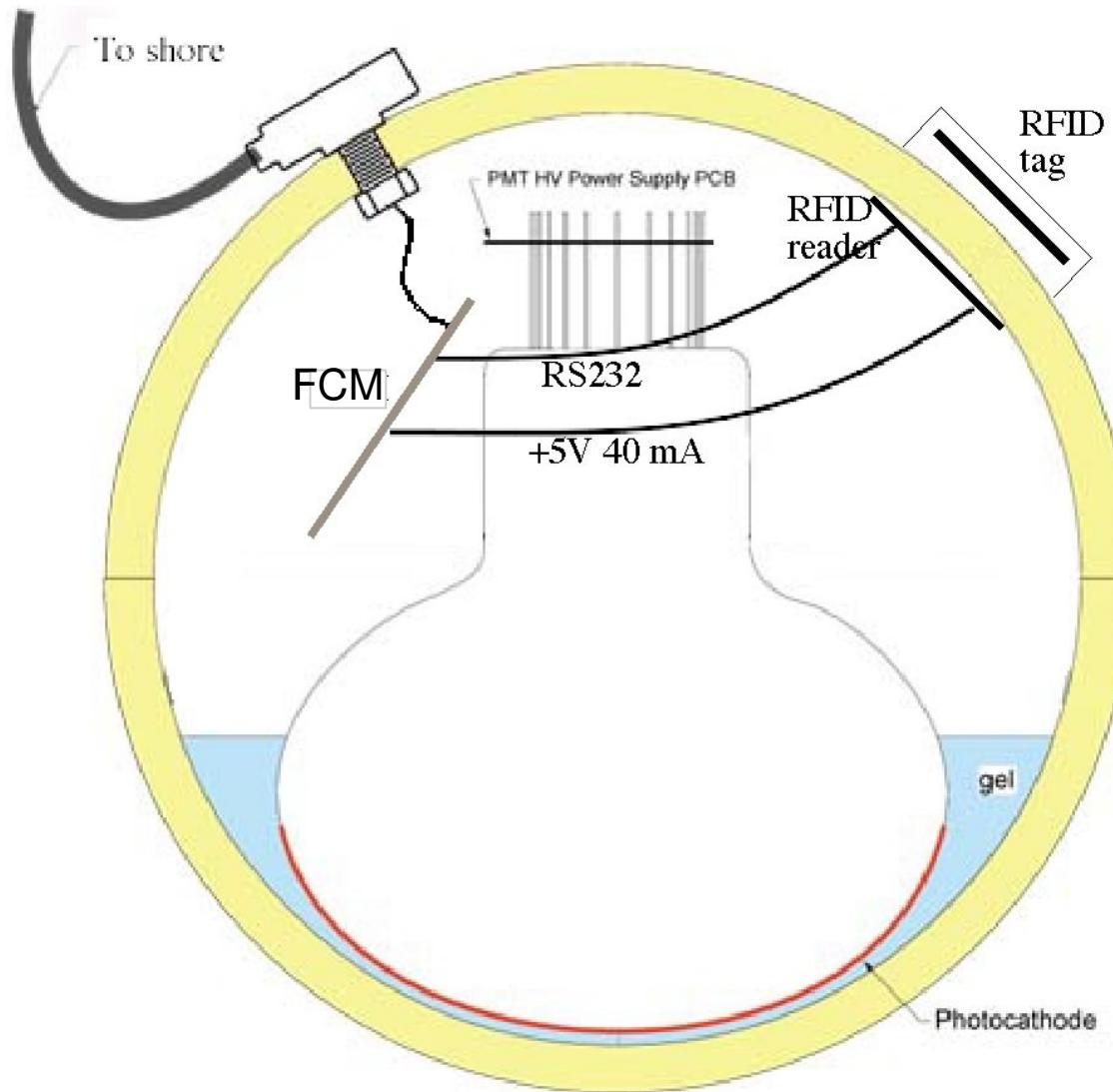
PORFIDO

Physical Oceanography by
RFID
Outreach

Oceanography Data

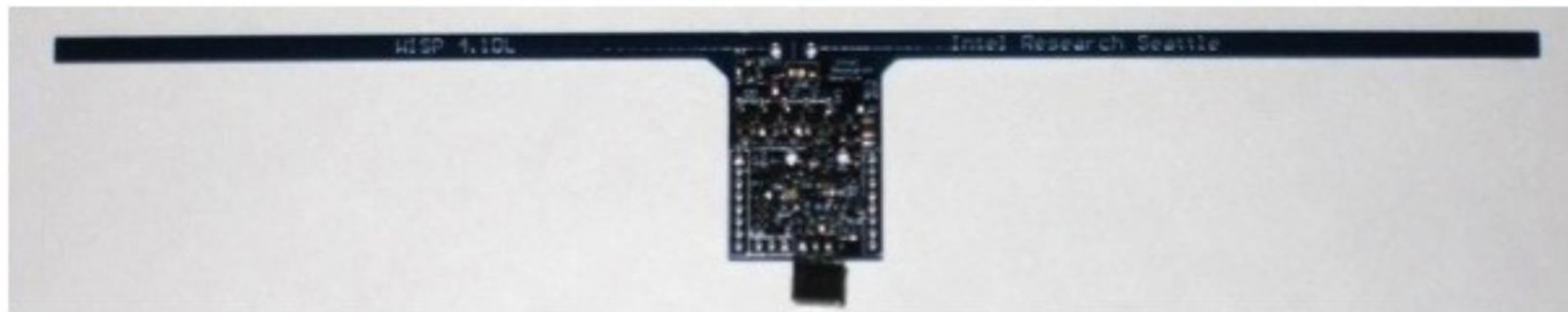
- Continuous data
- Non intrusive (reliability)
- No battery
- No connectors
- RFID

Connections

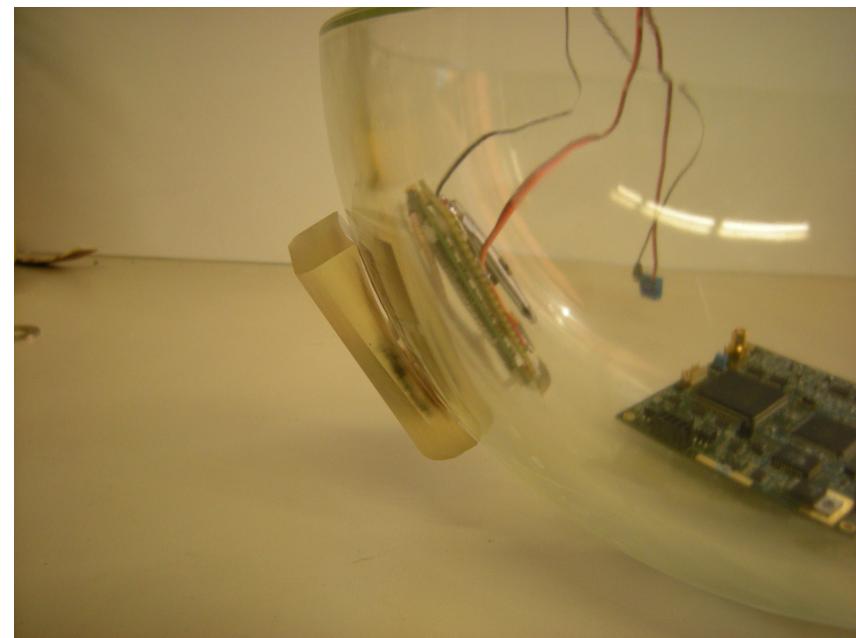
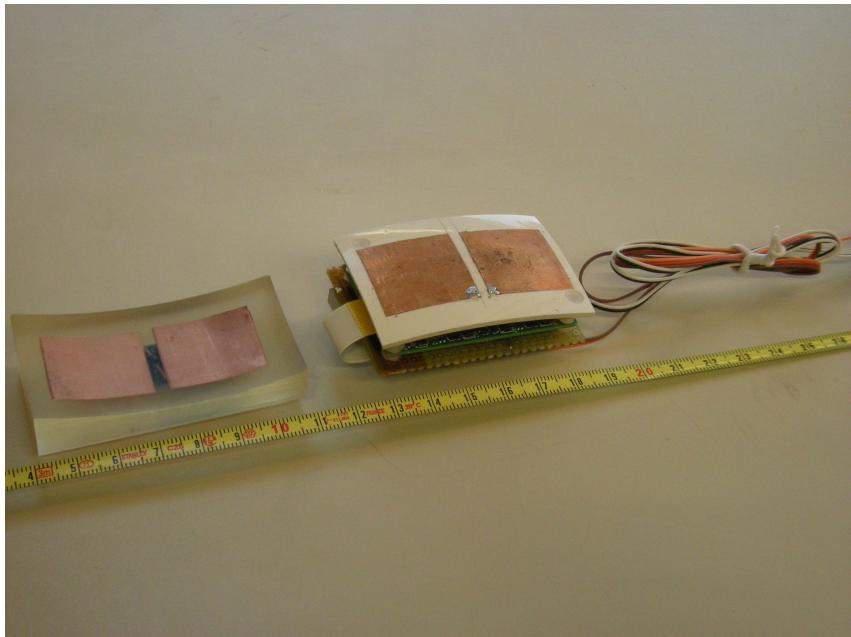


Tag - WISP

- Passive (no batteries) – Power from RF
- Includes temperature and inclinometer
- can add new sensors



Optical Module



NEMO Phase 2

- 4 PORFIDOs
- 3 reading temp
- 1 reading inclinometer

NEMO

Ricercatori						
	Nome	Età	Contratto	Qualifica	Aff.	%
1	Cordelli Marco		Dipendente	Primo Ricercatore	CSN I	30
2	Habel Roberto		Associato	Pensionato	CSN II	0
3	Trasatti Luciano		Dipendente	Primo Ricercatore	CSN II	100
Numero Totale Ricercatori						3 FTE: 1.3
Tecnologi						
	Nome	Età	Contratto	Qualifica	Aff.	%
1	Martini Agnese		Dipendente	Tecnologo	CSN I	40
Numero Totale Tecnologi						1 FTE: 0.4
Tecnici						
	Nome	Età	Contratto	Qualifica	Aff.	%
1	Ciaffoni Orlando		Dipendente	Collaboratore Tecnico E.R.	M.A.C.	50
Numero Totale Tecnici						1 FTE: 0.5

WIZARD/PAMELA

**Ricerca di antimateria e materia oscura
nella radiazione cosmica**

(CSNII-Linea 4 - Studio della radiazione cosmica nello spazio)



Collaborazione:

Italia: INFN Bari, Firenze, LNF, Napoli, Roma 2-Tor Vergata, Trieste
IFAC-CNR (FI), ASI, Univ.Tor Vergata (Dip.Ing.El.)

Germania: Siegen Univ.

Svezia: Stockholm KTH Univ.

Russia: Moscow(MEPhi, FIAN), IOFFE St. Petersburg, TsSKB-Progress Samara

Linea di Ricerca

- Studio di spettri, flussi e meccanismi di produzione di particelle e antiparticelle (e^- , e^+ , p , \bar{p}) nei Raggi Cosmici**
- Ricerca di possibili indicazioni indirette di Dark Matter**
- Ricerca di antimateria cosmica (antielio)**
- Studio composizione nucleare e isotopica raggi cosmici**
- Fisica solare**

PAMELA è in orbita e funziona regolarmente da 5 anni:

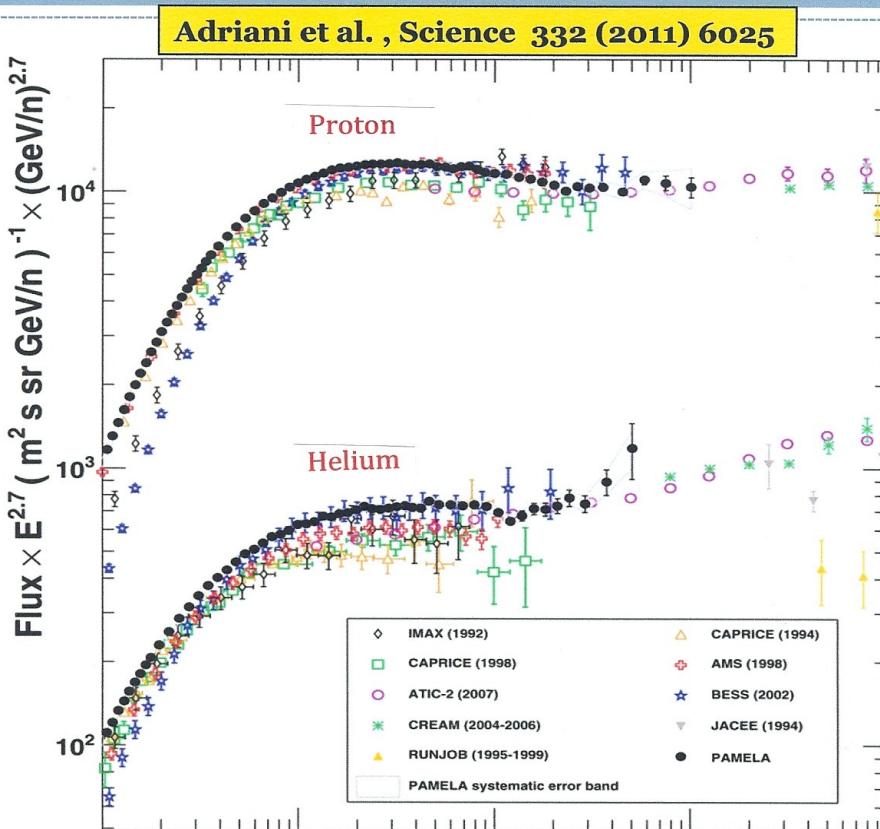
> 10^9 triggers registrati e > 20 TB di dati finora trasmessi a terra.

La missione è prevista terminare a fine 2011, salvo ulteriori accordi con Agenzia Spaziale Russa.

**IL RISULTATO PIU'
RILEVANTE DEL 2011**



GLI SPETTRI DI PROTONI ED ELIO DIFFERISCONO AD ALTE ENERGIE!



Adriani et al. , Science 332 (2011) 6025
PAMELA
Measurements of Cosmic-Ray Proton and Helium spectra

L'indice spettrale delle due specie cambia significativamente intorno ai 235 GV

Non è possibile descrivere gli spettri con una singola legge di potenza

Lo scenario della produzione e accelerazione dei RC nelle SNR seguite dalla propagazione diffusiva nella Galassia sembra non poter più sussistere:
Altri meccanismi?

p & He absolute fluxes @ high energy

Deviations from single power law (SPL):

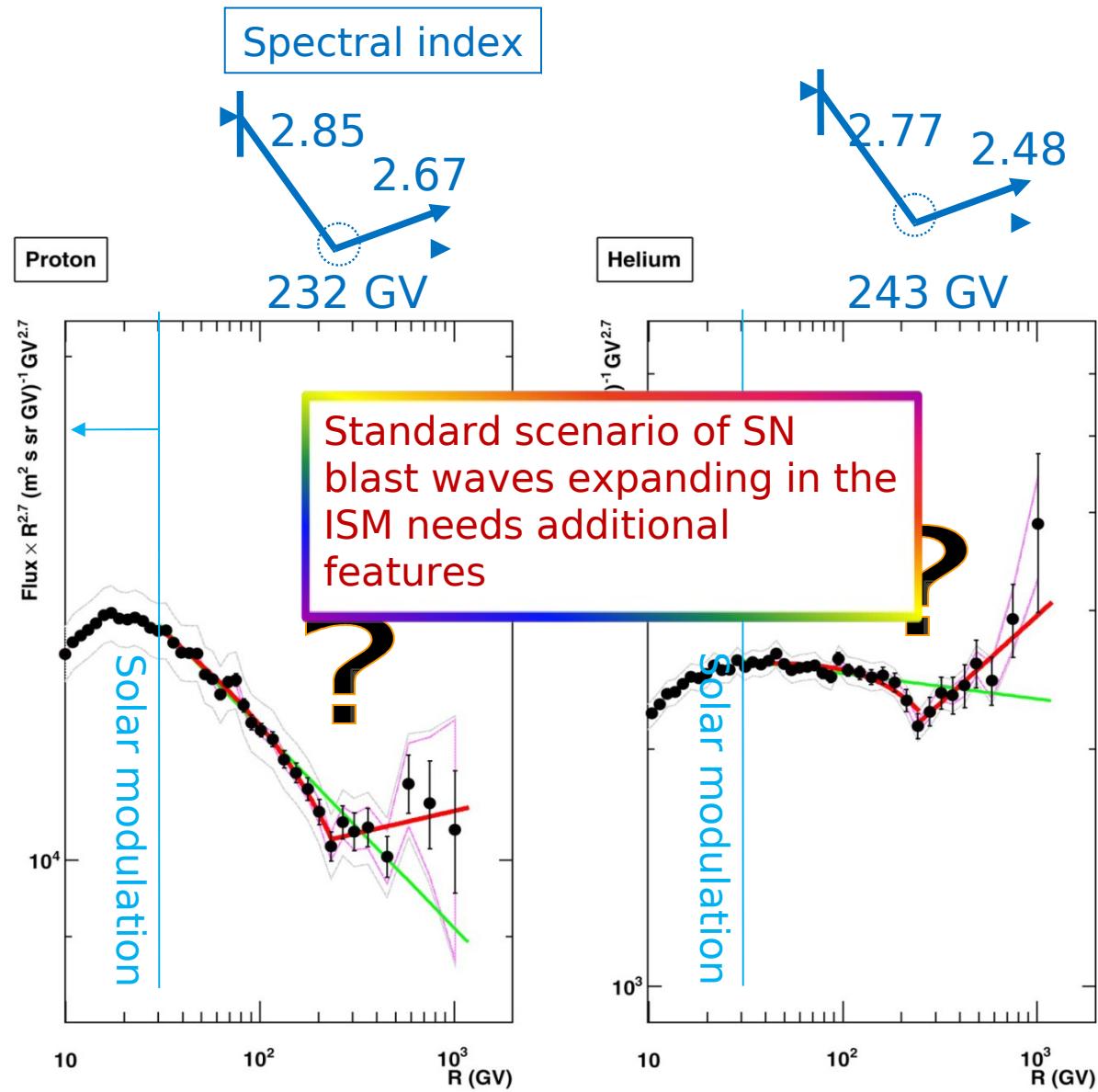
- Spectra gradually soften in the range 30÷230GV

- Abrupt spectral hardening @ ~235GV**

Eg: statistical analysis for protons

- SPL hp in the range 30÷230 GV rejected @ >95% CL

ZOOM AD ALTE ENERGIE INTORNO A 235 GV



Altri risultati rilevanti

- **Electron absolute flux** → Measured up to ~600GeV.
No evident deviations from standard scenario, but not inconsistent with an additional electron component.
- **High energy positron fraction**
- (**>10 GeV**) → Increases significantly (and unexpectedly!) with energy.
→ Primary source? Dark Matter?
- **Antiproton energy spectrum** → Measured up to ~200 GeV:
No significant deviations from secondary production expectations.
- **Solar physics**: measurement of modulated fluxes and solar-flare particle spectra
- **Physics of the magnetosphere**: first measurement of trapped antiproton flux

Studi e analisi in corso di prossima pubblicazione:

- Upgrade of positron analysis (increased statistics, higher energy)
- Primary and secondary-nuclei abundance (up to Oxygen)
- Jupiter CR proton and electron signatures
- Solar modulation (long-term flux variation and charge-dependent effects)
- Upper limit to anti-He abundance

La Collaborazione PAMELA, nella
persona del suo Spokesman
Piergiorgio Picozza, ha ricevuto l' invito
a pubblicare su “Physics Reports” la
rassegna dei risultati ottenuti in questi
5 anni di missione in orbita.

Gruppo WIZARD/PAMELA-LNF

Composizione 2012
G. Basini, G. Pizzella, M. Ricci
TOT 0.9 FTE

Attività svolta 2010 (II sem.) - 2011

- Controlli/gestione missione e Data taking
- Analisi dati - Conferenze – Pubblicazioni
- Contributo originale LNF: studio e analisi possibili correlazioni nei RC con particelle da Giove (protoni ed elettroni) → talk a ICRC 2011

Attività prevista II sem. 2011 – 2012

- Controllo missione fino alla conclusione
- Analisi dati – Pubblicazioni - Conferenze

Rich. finanz. 2011
minimali per
Missioni e Consumo
(Calcolo/Storage dati)

~ 30 K€

ATTIVITA' DEL GRUPPO ROG 2010

LNF : Giordano, Marini, Pizzella, Ronga (2.1 FTE)

Tecnici: Iannarelli, Lenci, Turri (1.3 FTE)

- Le due antenne EXPLORER e NAUTILUS del gruppo ROG hanno raccolto dati in modo continuativo rispettivamente da 6 e 7 anni (inizio operazioni 20 e 15 anni fa rispettivamente)
- Explorer è stato spento a Giugno 2010
- Il duty cycle è limitato essenzialmente dalle operazioni di manutenzione criogenica e supera il 90%.
- I dati hanno qualità costante e non sono molto influenzati dalle normali attività umane nel laboratorio...ma non vero se si trivella e scava..



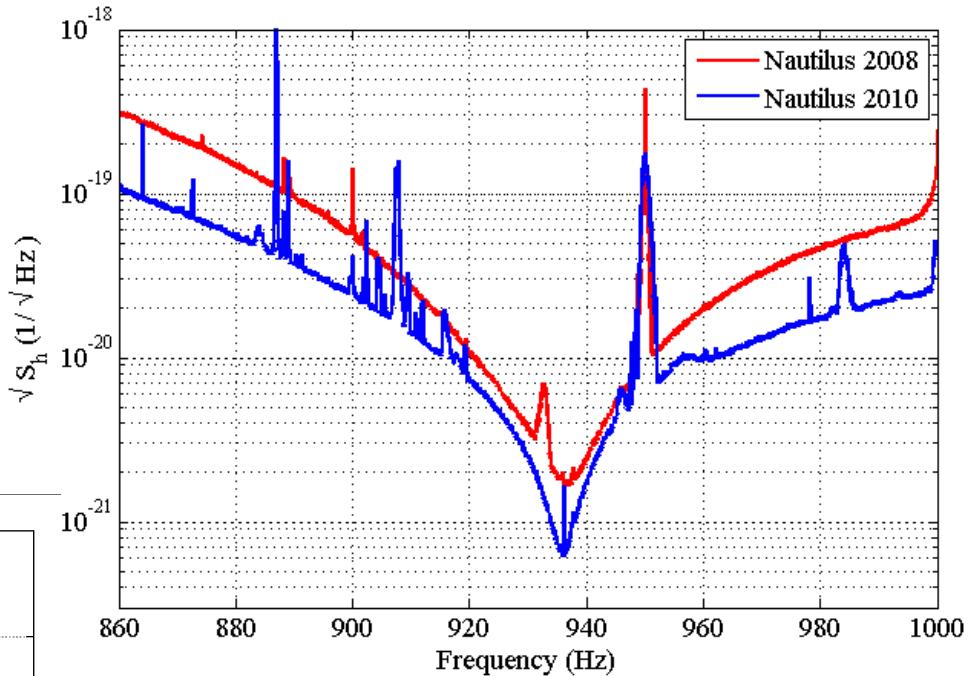
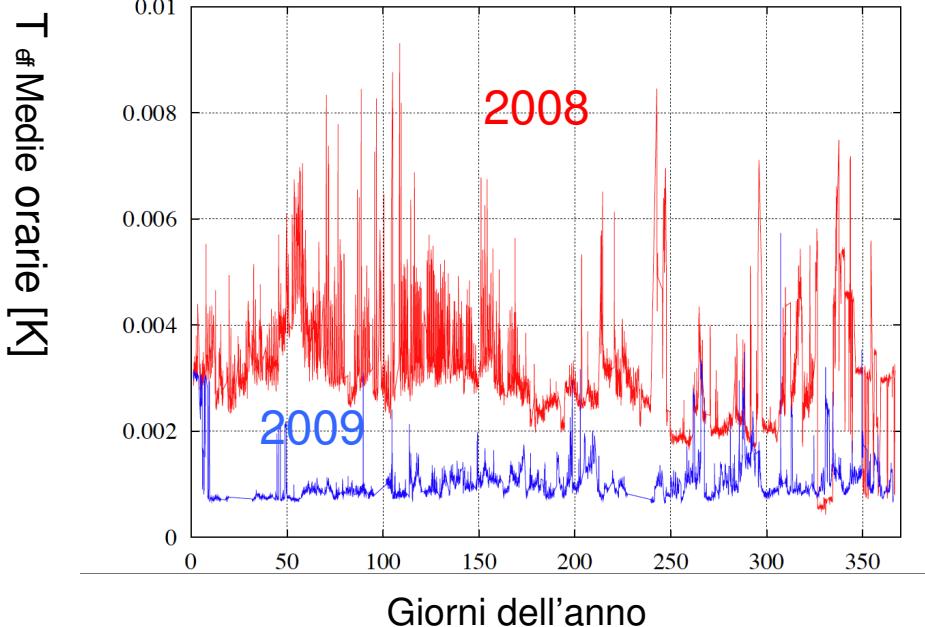
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EXPLORER (CERN)

NAUTILUS - INFN Frascati

Nel 2009 miglioramento della sensibilità di NAUTILUS di un fattore 3 : riduzione rumore elettronica (era circa 2.5 mKelvin ora è circa 0.7 mKelvin)



Detectable: Galactic burst with $10^{-6} M_{\text{sun}} c^2$
converted in GWs

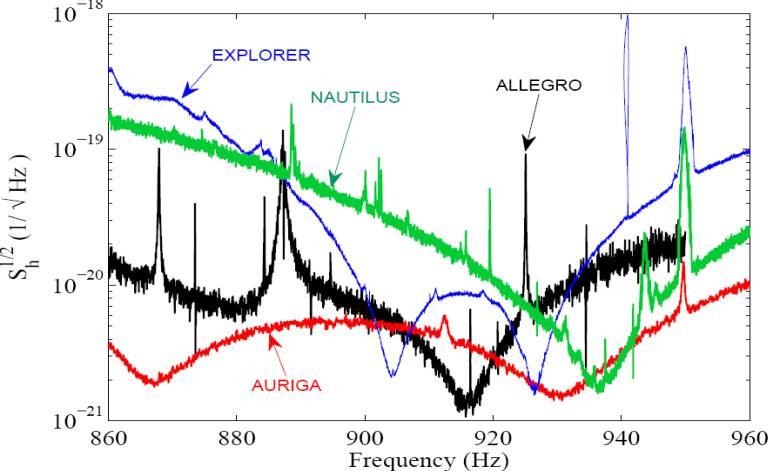
Peak strain sensitivity $6 \times 10^{-22} 1/\sqrt{\text{Hz}}$

Displacement sensitivity
 $7.2 \times 10^{-22} \text{ m}/\sqrt{\text{Hz}}$

Unprecedented: World Record

ANALISI DATI

Collaborazione IGEC 2 :
ALLEGRO (USA LSU) - AURIGA (LNL) -
- EXPLORER (CERN) - NAUTILUS (LNF)



- Pubblicazione su Phys. Rev. D82,022003 (2010)
- analisi essenzialmente del gruppo ROG (Giordano, Visco). Ultimo lavoro con 4 antenne.
- **515 giorni di osservazione dal 16 Novembre 2005 al 14 Aprile 2007.** Ricerca di coincidenze triple e quadruple. **Nessuna coincidenza trovata su un fondo di 1 evento / secolo**

Analisi in coincidenza EXPLORER - NAUTILUS

- Analisi di circa 3 anni di dati Explorer-Nautilus (dopo IGEC 2) da aprile 2007 a giugno 2010.
In corso....

Collaborazione Auriga-ROG :
AURIGA (LNL) - NAUTILUS (LNF)

- Funzionamento in modalita' **astrowatch** : analisi in caso di trigger astrofisici interessanti. Scambio dati e analisi da parte dei due gruppi di entrambi i detectors con metodologie differenti.

ATTIVITA' DEL GRUPPO ROG 2012

- Virgo/Ligo pausa per costruzione rivelatori Advanced da 2011 a ≥ 2015
- Decisione CSN2: si continua con NAUTILUS ed AURIGA fino alla messa in funzione degli Advanced in attesa Supernova galattica (rate~3/100 anni) (probabilità piccola ma non 0!!; in 5 anni: $P \sim 1/6$) ...e possibili sorprese (Gamma Ray Burst vicino..)
- runs di Nautilus e impianti criogenici connessi
- acquisizione ed analisi dati

Richiesta ROG LNF

- ~ 120 K€ principalmente per Elio ed Azoto per Nautilus, manutenzioni e riparazioni (vecchi liquefattore e impianto di recupero gas)
- potenziamento attuale supporto tecnico