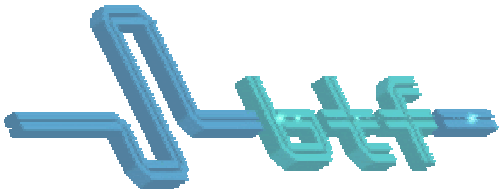
RAP: Thermoacoustic Detection at the DAΦNE Beam Test Facility

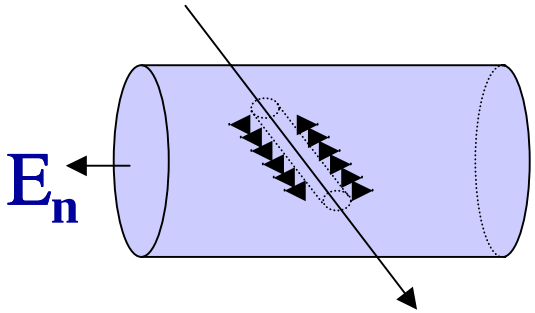


RAP Collaboration: S. Bertolucci, E. Coccia, S. D'Antonio, A. Fauth, A. de Waard, G. Delle Monache, D. Di Gioacchino, V. Fafone, G. Frossati, C. Ligi, A. Marini, G. Mazzitelli, G. Modestino, G. Pizzella, L. Quintieri, G. Raffone, F. Ronga, P. Tripodi, P. Valente

5th Amaldi Conference Tirrenia (Pisa), Italy 6-11 July 2003

LIGO-G030480-00-Z

Physical Motivation



The energy deposited by a particle is converted in a local increase of temperature

$\delta T = \delta E/(\rho C V)$; $\delta p = \gamma \cdot \delta E/V$;

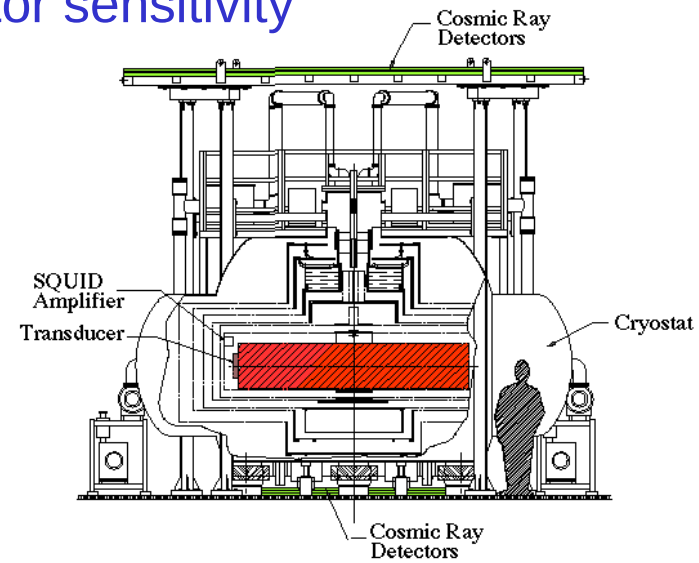
$\gamma = \alpha Y/(\rho C)$ γ = Grüneisen constant

$$E_n \propto \gamma^2 \cdot (dE/dx)^2 \cdot F^2_n$$

The Thermo Acoustic Model predicts very small signal for present resonant gravitational wave detector sensitivity

1992 NAUTILUS was equipped with a cosmic ray veto system

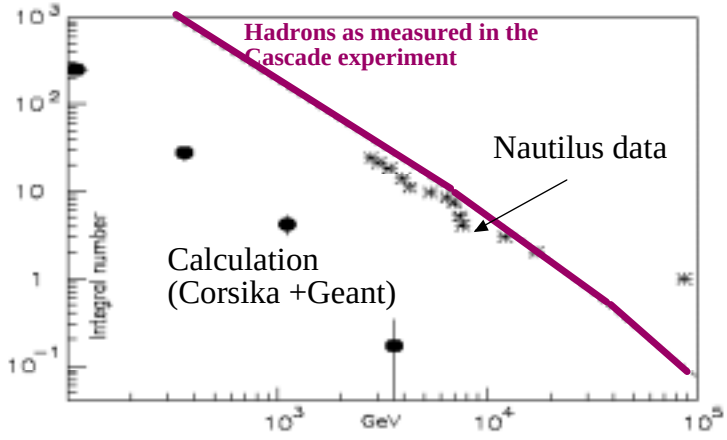
Nucl.Instrum.Meth.A355:624-631,1995



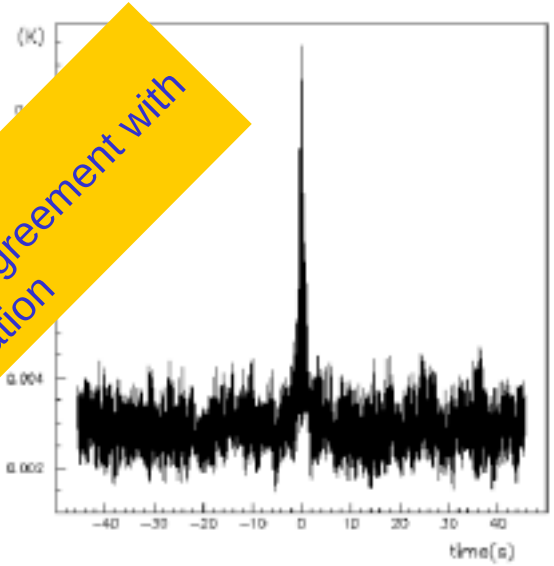
Physical Motivation (con't)

1999 first measurement of cosmic rays signature in the NAUTILUS antenna, Phys. Rev. Lett. **84** (2000) 14.

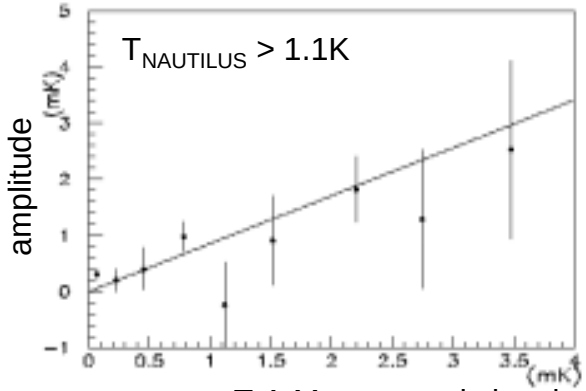
2000 anomalous signal detected,
Phys. Lett. **B499** (2001) 16.



20 σ signal
Fully in agreement with calculation



2001 dependence from NAUTLUS thermodynamic temperature,
Phys. Lett. **B540** (2002) 179.



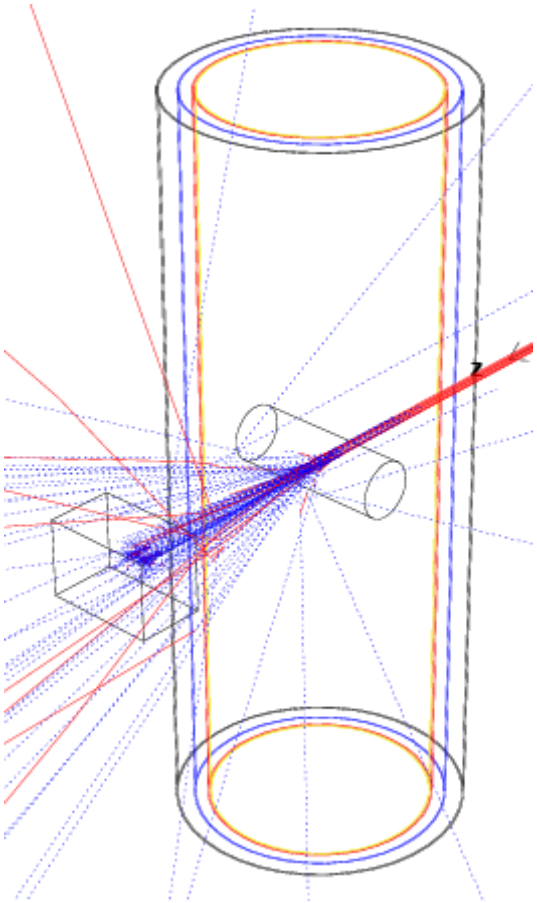
T.A.M. expected signal
Induced by measured shower

End of 2001 RAP Proposal,
LNF-01-027(IR)

The RAP Experiment

thermal and mechanical energy lose Geometric factor

$$E_n \propto \gamma^2 \cdot (dE/dx)^2 \cdot F^2_n$$



GEANT simulation

In order to understand:

γ enhancement of Grüneisen factor in super-conducting state

(dE/dx) enhancement of energy conversion in super-conducting state

(dE/dx) exotic component of cosmic rays (nuclearites, monopoles)

The thermo-acoustic model has been proven effective at room temperature by previous experiments

Rev.Sci.Instrum.71:1345-1354, 2000 and pervious papers

Grüneisen "constant"

$$\gamma = \alpha Y/(\rho C)$$

Mechanical and thermal proprieties of the detector are contained in the Grüneisen parameter, assumed almost constant with the temperature.
The extrapolated value at zero Kelvin from measurements done at 4 K, give: $\gamma = 1.6$

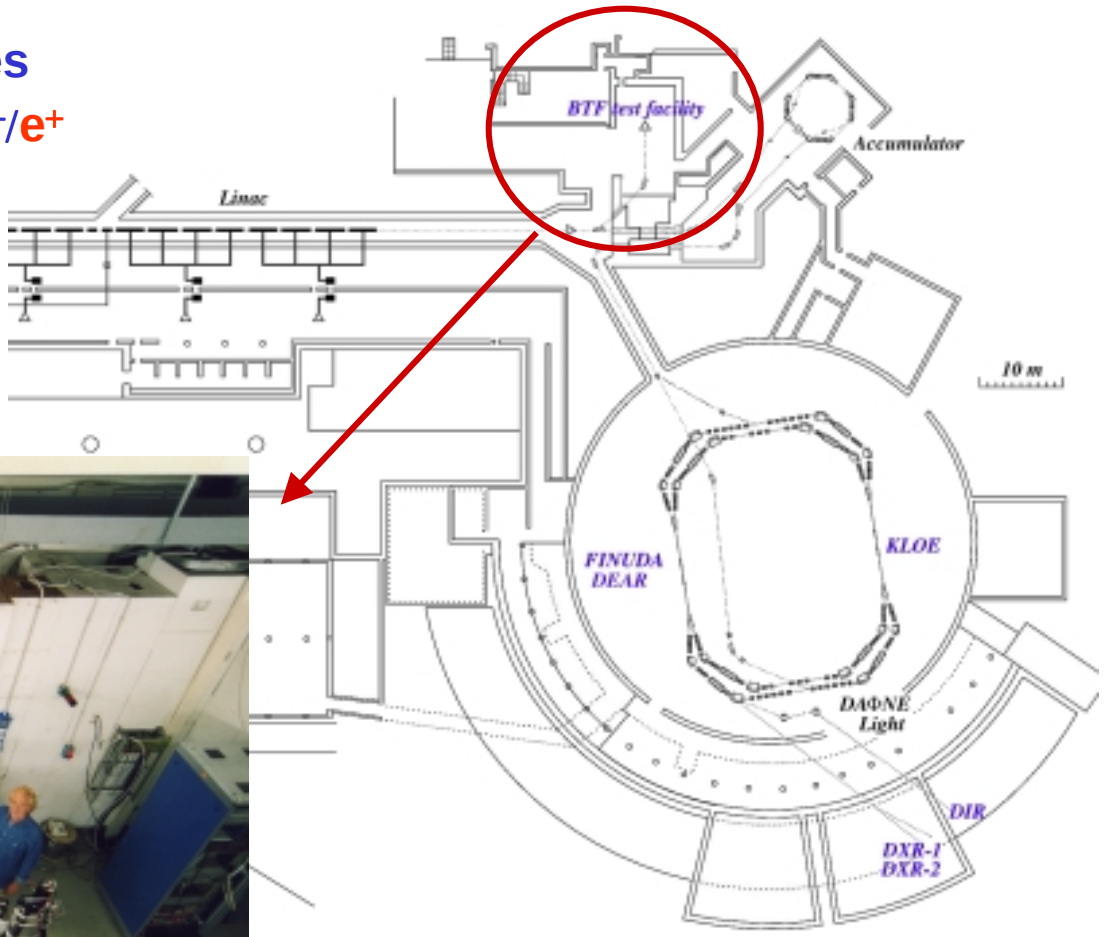
γ (actually α) can not be directly measured at temperatures below Tc. Recent evaluation based on critical magnetic field $H_c(P,T)$ measurements and specific heat give a different value of the Grüneisen parameter in the super-conducting state. In particular at T=Tc:

$$\gamma_s = -10.7 \pm 0.8$$

A. Marini, under publication

DAΦNE Beam Test Facility

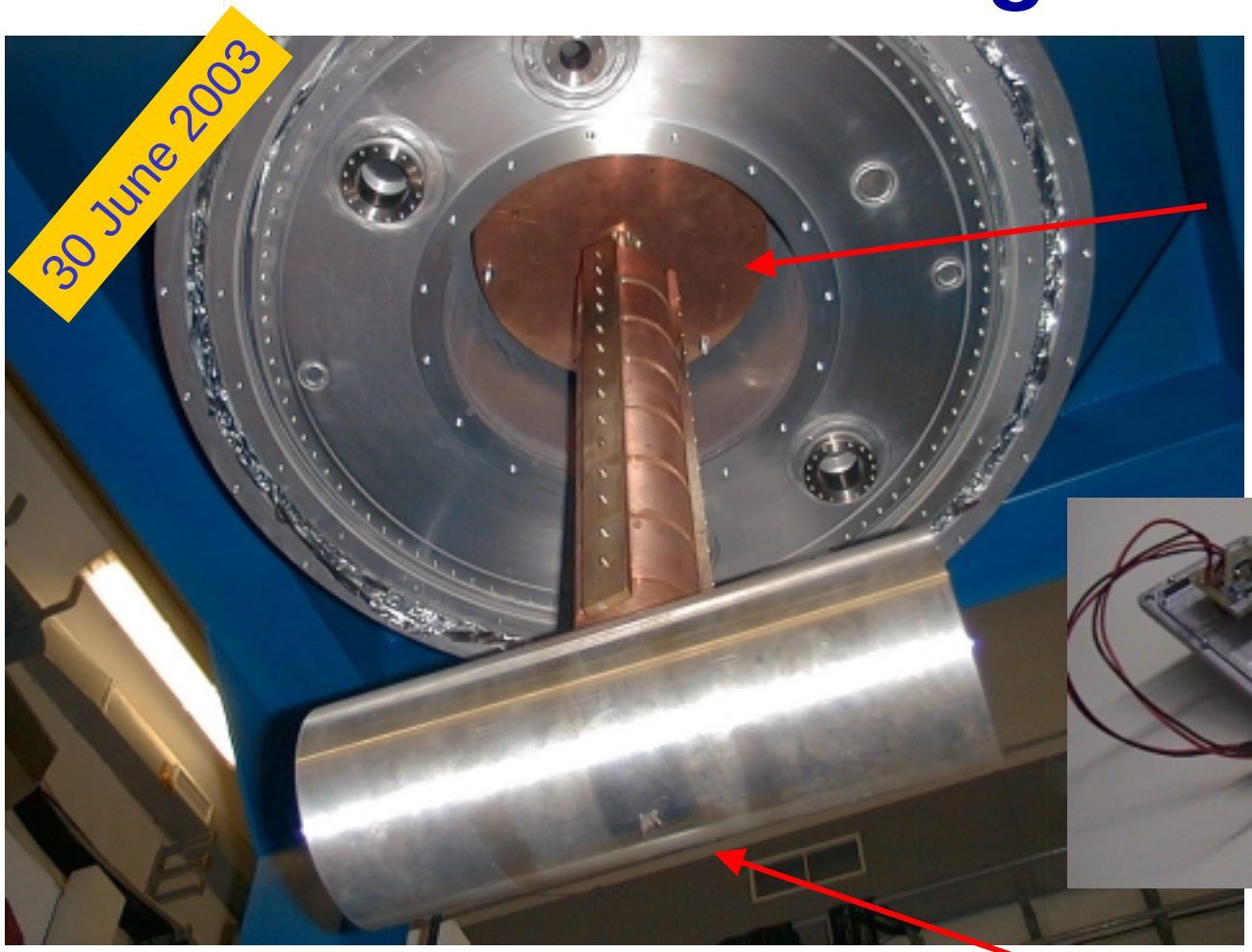
e^- / e^+ $n_{average}$ = 1 - 10^{10} particles
Energy: 20–800 MeV e^-/e^+
Repetition rate: 50 Hz
Pulse Duration: 1–10 ns
1% energy selection
100 m^2 Experimental Hall



RAP Installation @ BTF

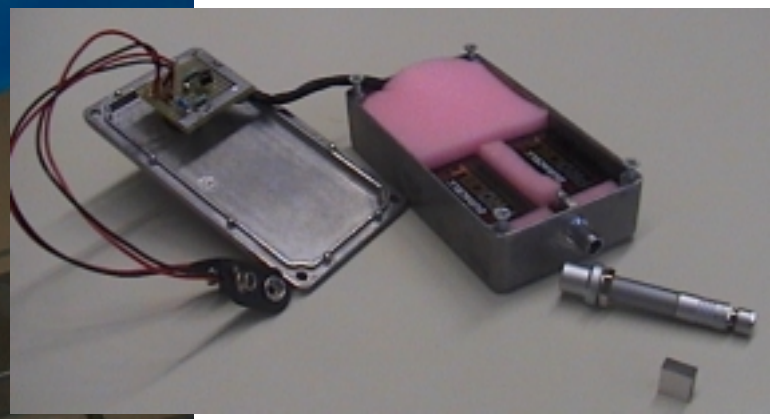
18 June 2003

RAP Signal Read Out



7 OFCH copper masses
1 OFCH copper tube
Attenuation: –200db@5KHz

Al 5056 bar, 50x18 cm



Read-out:
piezo-electric ceramic
JFET amplifier
1nVHz$^{-1/2}$@ 5KHz
bandwidth 25KHz

operating temperature 100 mK

RAP Data Acquisition

amplifier
STANFORD
SR560 4nV*Hz$^{-1/2}$

ADC
INCAA 5758

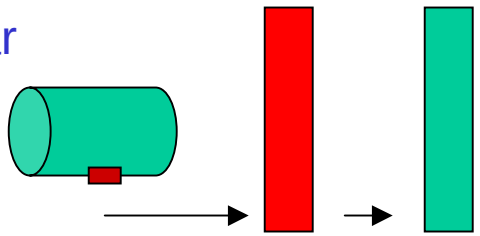
SCALER

LINUX VME
controller

LN-JFET-AMP

ADC
VMIC 3123

bar



100 KHz

1nVHz$^{-1/2}$@ 5KHz
bandwidth 25KHz

1 Hz

synthesizer

0.3 Mb/s

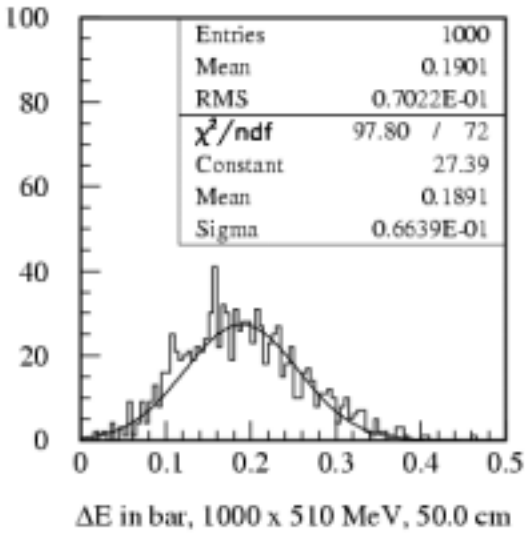
auxiliary channels

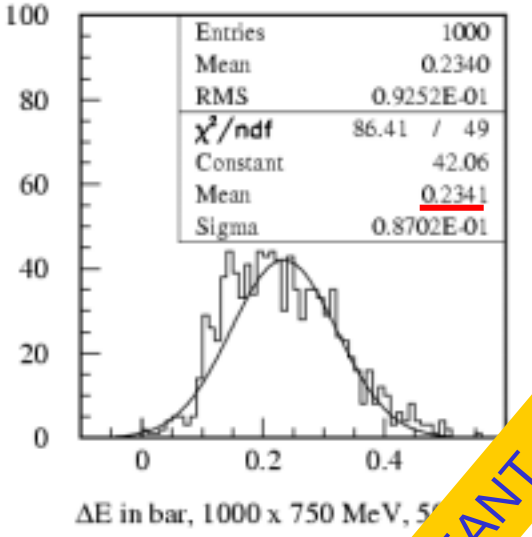
LabView™run
controller & monitor

beam trigger

LIGO-G030480-00-Z

Expected signal @ BTF





GEANT simulation

$\gamma = 1.6$

$E_1(K) = 4 \cdot 10^{-13} \cdot N_e^2 \cdot (dE/MeV)^2$

noise temperature = 0.5 K

SNR (energy) = 100 →
$N_e = 4 \cdot 10^4$ electrons@750MeV

SNR (energy) = 100 →
$N_e = 10^6$ electrons@750MeV
at room temperature

From 300 K to 100 mK

- ***Phase 1***: installation and test of full apparata at room temperature, suspension, electronics, DAQ, mechanical structure ready (done)
  first measurement at room temperature
  (coming soon…)
- ***Phase 2***: cryogenic test, and low temperature measurement in non super-conducting state (September 2003)
- ***Phase 3***: dilution refrigerator installation measurement in super-conducting state (2004)

The 6th Amaldi Conference will end the history

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RAP on The WEB

http://www.lnf.infn.it/esperimenti/rap/