Bernard Sadoulet
Dept. of Physics /LBNL UC Berkeley
UC Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC)

Experimental Systems for Neutrino Physics and Astrophysics

High Energy Astrophysics

- Cosmic rays from space: AMS, Aiglon, NEUCAL, n detector
- Auger (LIDAR), ANTARES,KM3NET
- Radio detection of UHE cosmic rays (LOFAR,LOPES)

Dark Matter Axions (CAST)

Neutrino Mass MARE

Gravitational Waves Accelerometer

I will complement as needed to give you a broader view

AMS-02

3 posters

- The Alpha Magnetic Spectrometer AMS-02 :soon in Space (V. Bindi)
- Performance of the AMS-02 Silicon Tracker (W. Burger)
- The Construction and Space Qualification of the Control Electronics for the Tracker Detector Cooling System of the AMS-02 Experiment (M. Menichelli)

Goals

Primordial anti-matter

Indirect search for Dark Matter signal

High statistics measurement of cosmic rays in GeV-TeV energy range till Z=26

Gamma ray astrophysics till 300 GeV energies

Schedule

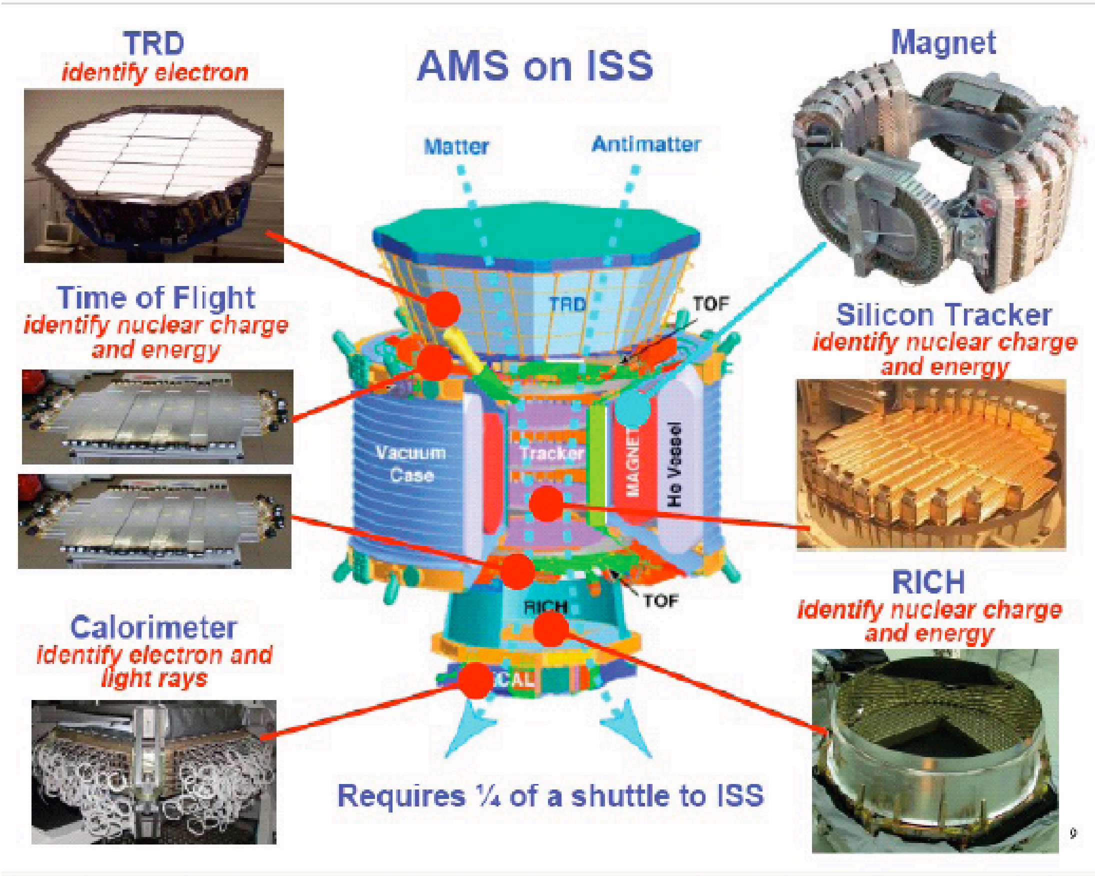
05/2009 magnetic field mapping @CERN
06/2009 flight integration @CERN
10/2009 test beam @CERN
11/2009 thermal vacuum and electromagnetic interference test @ESA
04/2010 preparation for the space shuttle lunch @NASA KSC

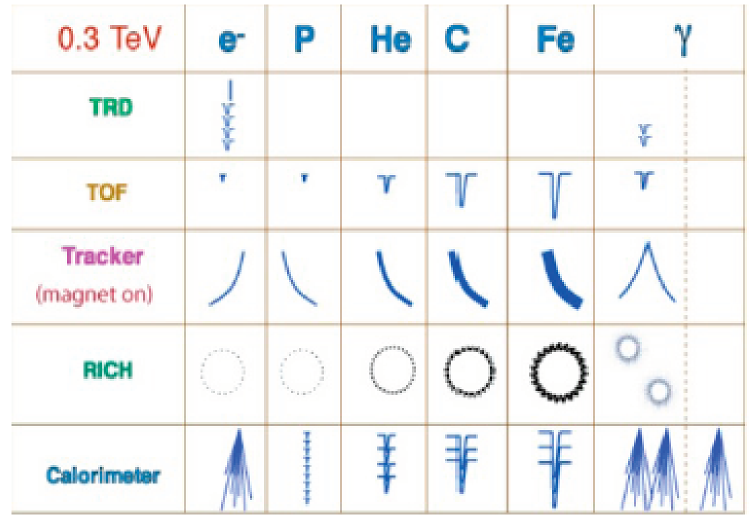
09/2010 AMS flight to ISS @NASA KSC (last Shuttle flight)

First 3 months: AMS remote control from NASA Center

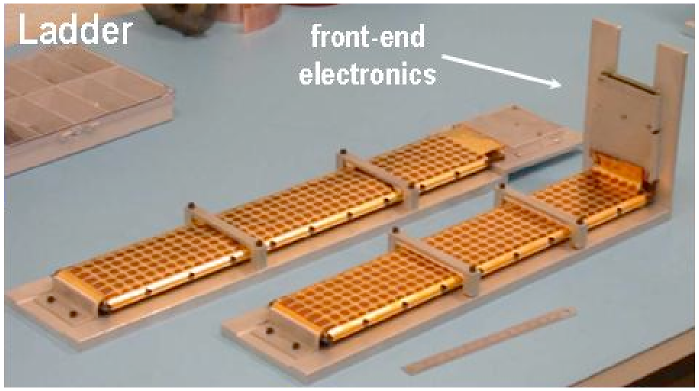
3 years: AMS remote control and data acquisition from CERN

AMS-02

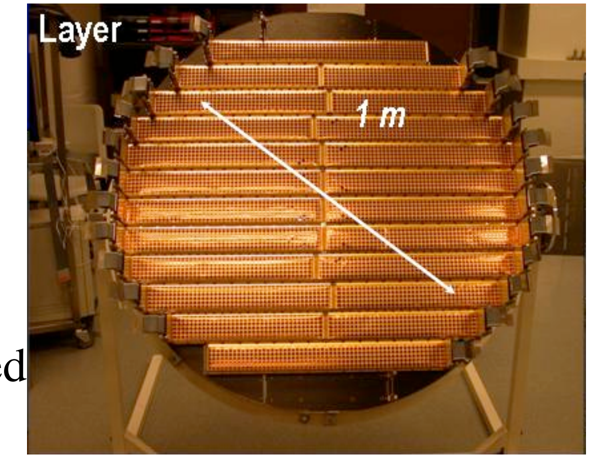

TRD
identify electron
AMS on ISS
Magnet
Matter
Antimatter
Time of Flight
identify nuclear charge
and energy
TRD
TOF
Silicon Tracker
identify nuclear charge
and energy
Vacuum
Case
Tracker
MAGNET
He Vessel
RICH
TOF
RICH
identify nuclear charge
and energy
Calorimeter
identify electron and
light rays
CAL
Requires ¼ of a shuttle to ISS


0.3 TeV
e-
P
He
C
Fe
γ
TRD
TOF
Tracker
(magnet on)
RICH
Calorimeter

AMS-02 Tracker

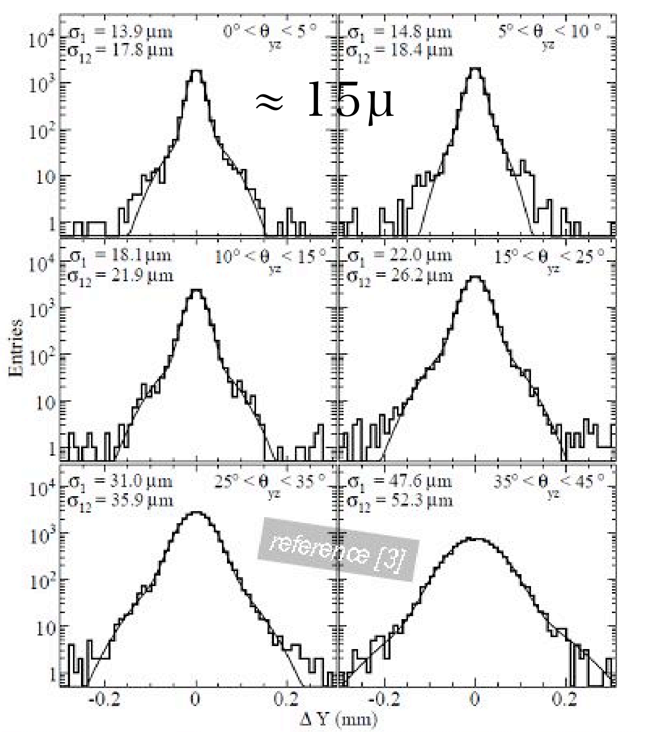


x 20
Double
Sided Si
wire bonded

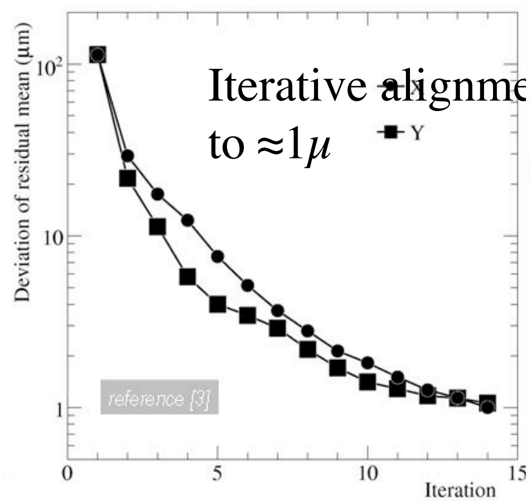


x 8

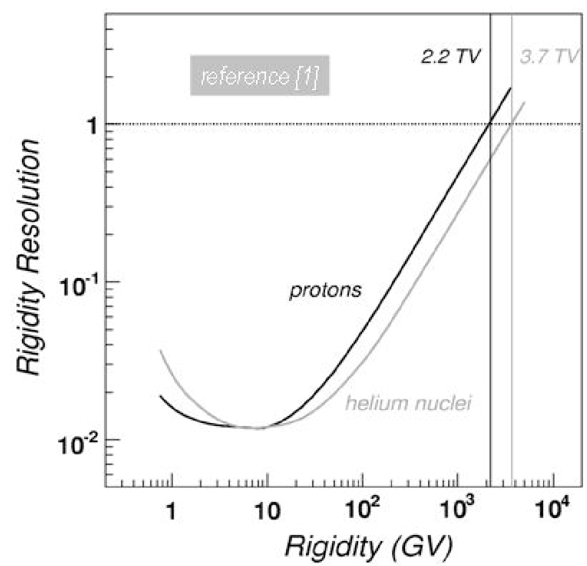
2 10^5
channels



$\approx$ 15µ



Iterative alignment
to $\approx 1\mu$



The AMS-02 Temperature Control

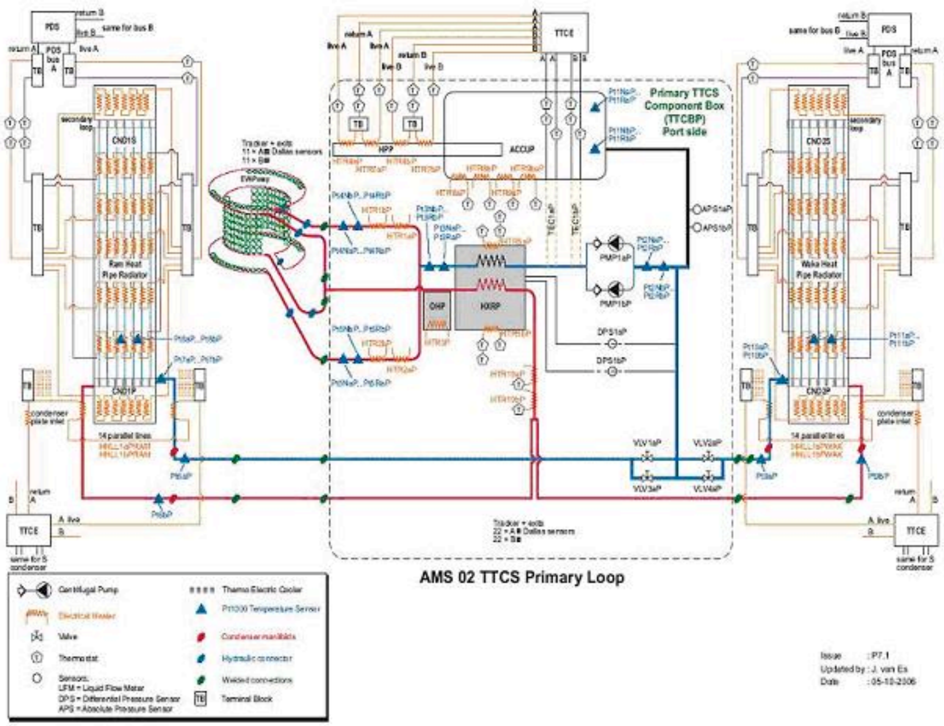
Temperature control system

The sensors include: Pt1000 thermistors, semiconductor thermal sensors, differential and absolute pressure sensors, and pump rotational speed sensors.

The actuators are: resistive heaters, peltier heat pumps, and liquid pumps

The AMS-02 Tracker Thermal Control System

A carbon dioxide two-phase cooling system . Its objective is to provide accurate temperature control of AMS Tracker front-end electronics.



Aiglon

Author: W. Burger

Goal: measurement of 10-100MeV electrons in space

Problem: Multiple Scattering

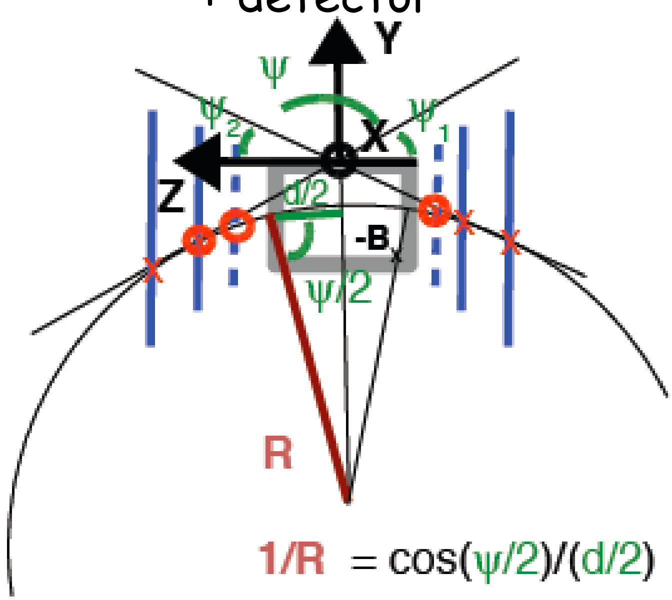
Solution: at least 1 slit => trade acceptance for resolution

Techniques => x10-100 area x solid angle

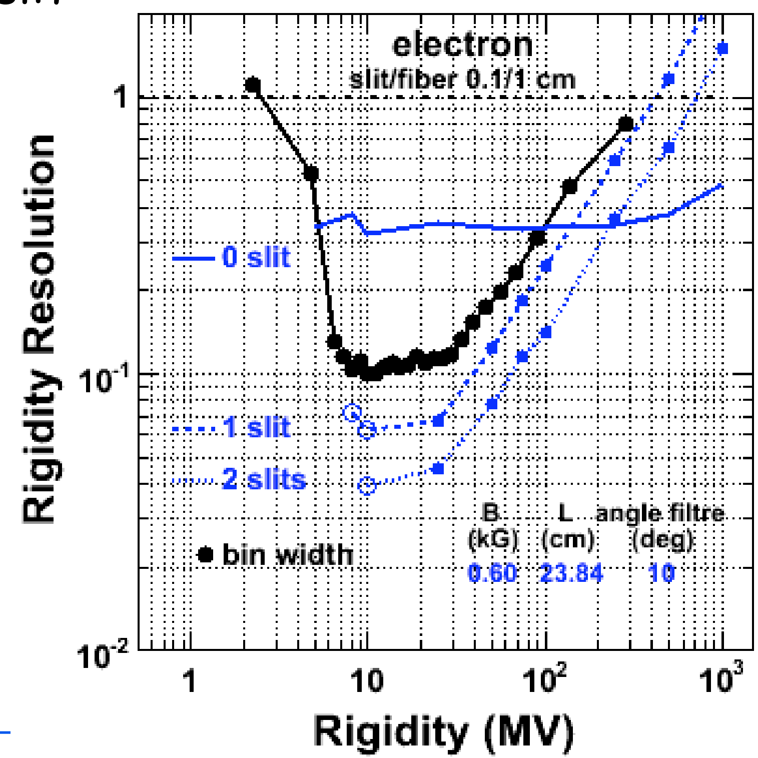
Permanent magnet

Scintillating fibers with Si PM

Patterned silicon planes as edgeless slit
+ detector



1 Slit Event – 3 point reconstruction



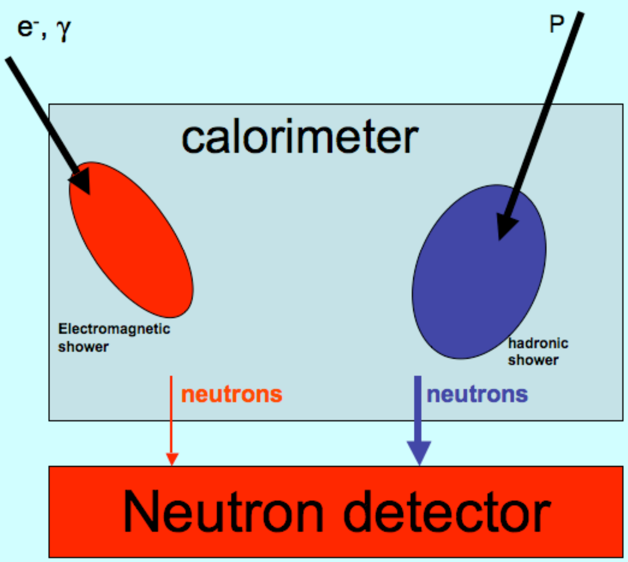
Compact Calorimetry in Space
NEUCAL

Authors: S. Bottai, O. Adriani, L. Bonechi, M. Bongi, G. Castellini, R. D'Alessandro, P. Papini, S. Ricciarini, G. Sguazzoni, G. Sorichetti, P. Sona, P. Spillantini, E. Vannuccini. *INFN (Florence) and University of Florence*

Goal: reduce the size of calorimeters

for space instruments without giving up electromagnetic/hadronic discrimination

Basic idea

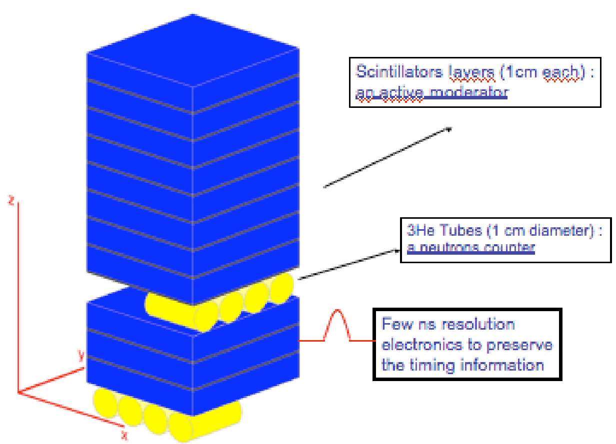


- Electromagnetic/hadronic showers identification is a common requirement in High Energy Physics and in particular for space detectors devoted to Astroparticle Physics.
- Space detectors make use of heavy and complex imaging calorimeters in order to achieve the necessary shower identification-rejection (*ATIC*,*PAMELA*,*CALET*….)
- Different neutron yields are also expected from hadronic and electromagnetic showers. The use of an appropriate neutron detector can be used to rescale the calorimeter without loosing in identification power.

NEUCAL

NEUCAL : detection principle

Neutron-proton elastic scattering in the plastic scintillators provide the active neutrons moderation. Scattered protons release their energy inside the scintillators and are detected.

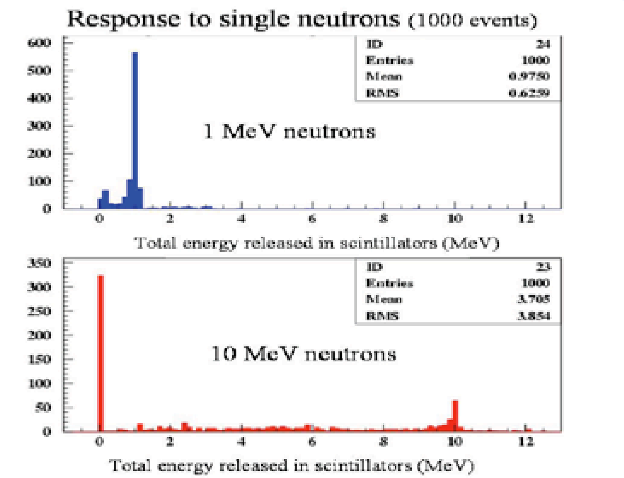


The energy released during the moderation process is detected by means of an active moderator composed of several plastic scintillator layers. Neutrons with energy in the KeV-MeV region are detected with high efficiency.

The moderated neutrons can be detected by means of nuclear capture followed by 0,765MeV proton emission in the 3He proportional counters.

Thin layers of lead could enhance signals for very high energy neutrons

NEUCAL : expected performance



Simulated response for a 12 scintillator layers detector. Neutrons with energy up to few MeV are fully moderated and detected with high efficiency. At 10 MeV 70% of neutrons gives detectable signals, while only 10% are fully moderated and detectable by the 3He Tubes

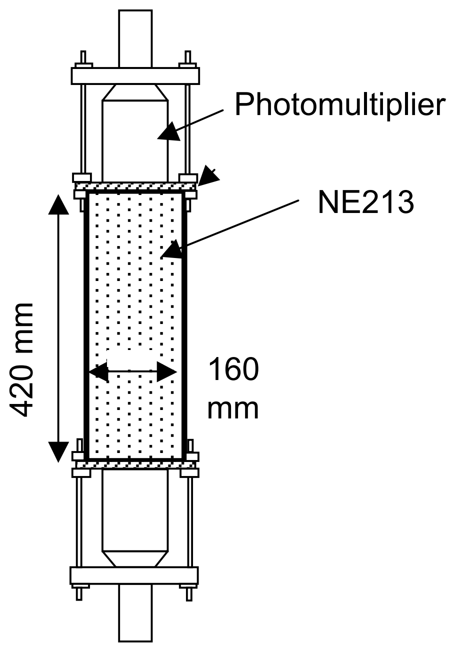
Comment:

Similar to Pamela
May be difficult to have a high rejection power
e.g. e^+ vs p (e.g. ATIC excess) cf talk on Fermi-GLAST

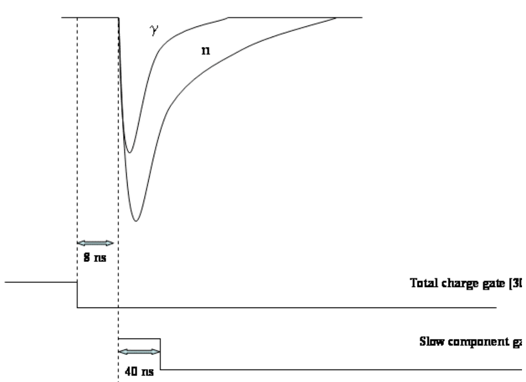
High Efficiency Large Volume Multiparametric Neutron Detector for Nuclear Physics and Nuclear Astrophysics Measurements

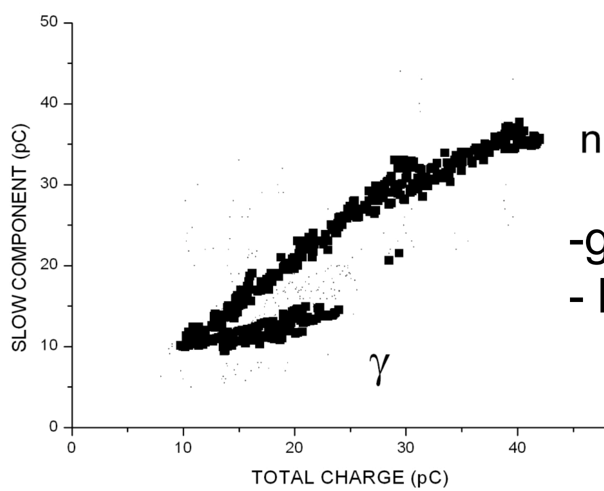
Lavagno[1], G. Gervino[2], C. Marino[2]
1.-Dipartimento di Fisica, Politecnico di Torino
2.-Dipartimento di Fisica Sperimentale, Università di Torino, via P. Giuria 1, I-10125 Torino (Italy)

Detector



- Tested with Am-Be source
- Efficiency around 55% for 10 MeV neutrons
- Efficiency around 50% for $E_{\gamma}=1275$ keV
- n-gamma discrimination done by two methods:
  - PSD canberra 2160 A (10% contamination above 500keV)
  - Charge Comparison Method





-gamma contamination down to 4%
- lower energy E = 100 keV

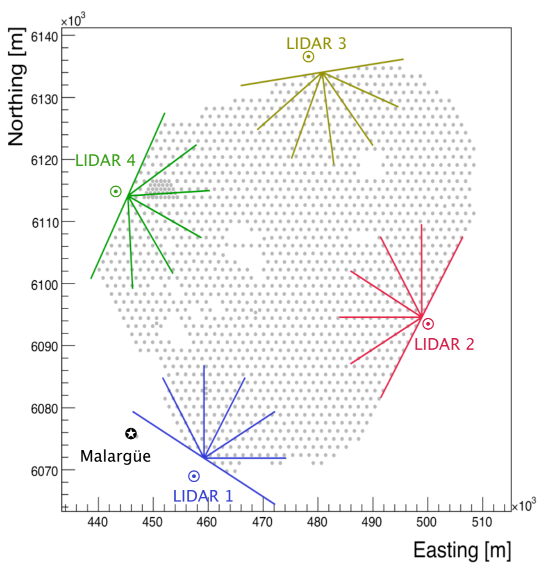
PIERRE
AUGER
OBSERVATORY

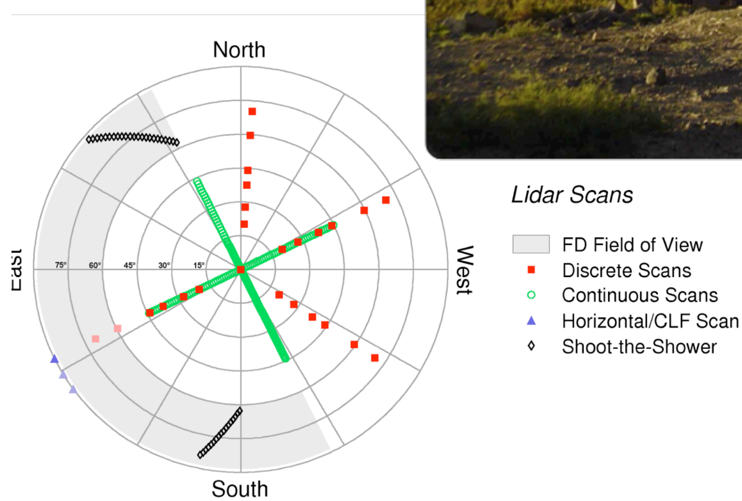
Atmospheric Monitoring with the LIDAR Network of the Pierre Auger Observatory

Aurelio Siro Tonachini for the Pierre Auger Collaboration
Università degli Studi di Torino

A system of **4 steerable LIDARs** that perform **periodic scans** following a hourly sequence formed by *horizontal shots*, *continuous sweeps*, and *scans at discrete angles*.

They measure the amount of backscattered light as a function of distance from 100 m to 25-30 km.



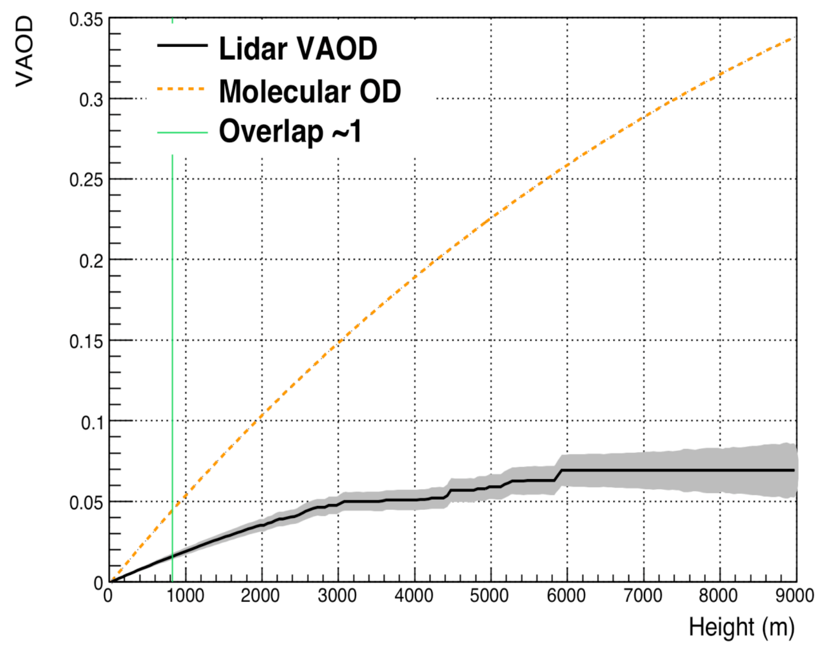


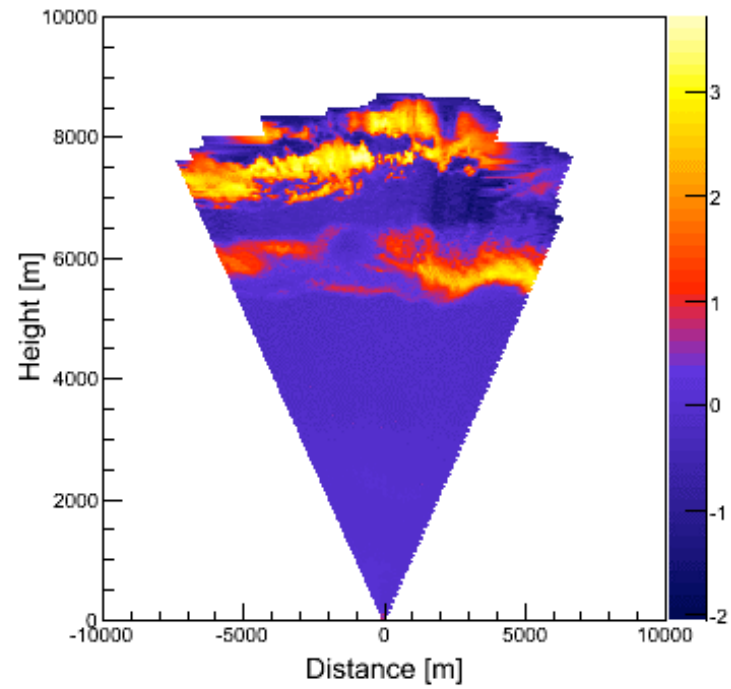
B.Sadoulet

Atmospheric Monitoring with the LIDAR Network of the Pierre Auger Observatory

Aurelio Siro Tonachini for the Pierre Auger Collaboration
Università degli Studi di Torino

- 3 long range + 1 short range mirrors
- Wide range soundings
- Measurements of **atmospheric opacity** at ground and versus height
- **Cloud detection**





SHOOT THE SHOWER:

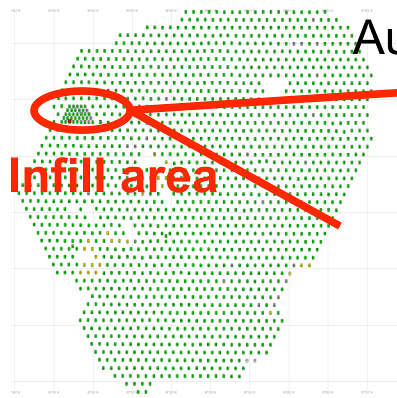
Atmosphere is promptly sampled simultaneously by all 4 LIDARs for the most energetic cosmic rays

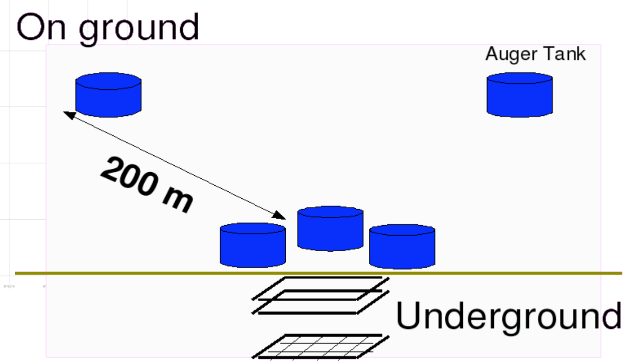
BATATA: a buried plastic scintillator muon telescope (I)

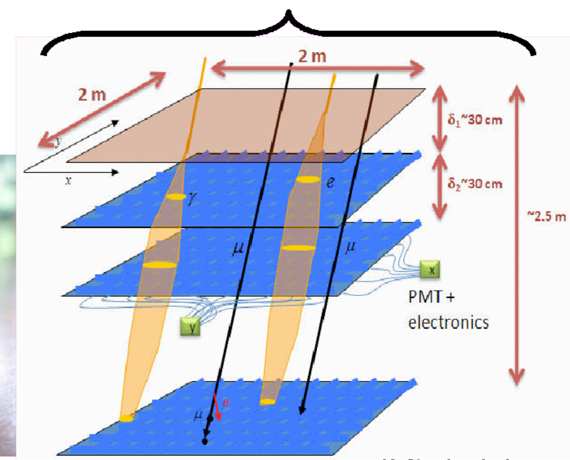
R. Alfaro Molina[1] , J.C. D'Olivo[2], A. Guzman[2], G.A. Medina-Tanco[2], E. Moreno Barroso[3], G. Paic[2], M. E. Patino Salazar[2], H. Salaz
F. Sanchez[2], A.D. Supanitsky[2], J.F. Valdes Galicia[4], M. A. Diozcora Vargas Trevino[5], S. Vergara Limon[5], L. M.Villasenor[6]
for the Pierre Auger Collaboration

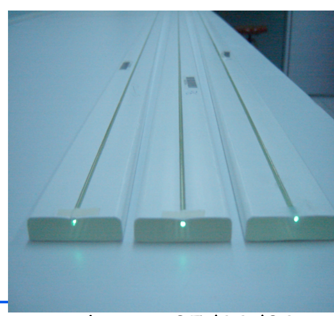
The telescope has three horizontal dual-layer scintillator planes buried at different depths. Each telescope layer consist of 49 scintillator strips 2 m long, 4 cm wide and 1 cm thick. Each scintillator is a MINOS-type with an embedded 1,5mm diameter Bicron BC-92 wavelength shifting fiber. Light is collected by Hamamatsu H7564B PMT of 64 pixels.

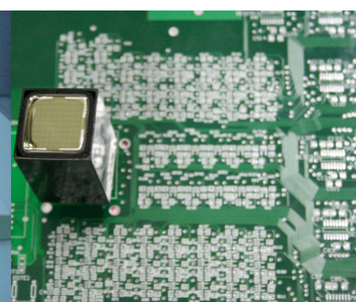
BATATA is combined with a small triangular array of Auger water Cherenkov detectors at a separation of 200 m. This surface component of the detector produce a GPS tagged threefold coincidence signal for cosmic ray showers of energy above 10 PeV.

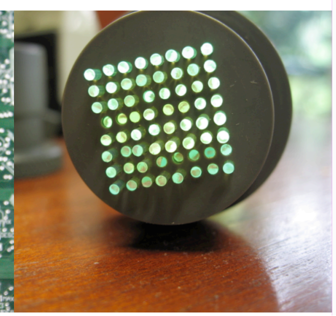












The ANTARES neutrino telescope: Performance one year after its completion

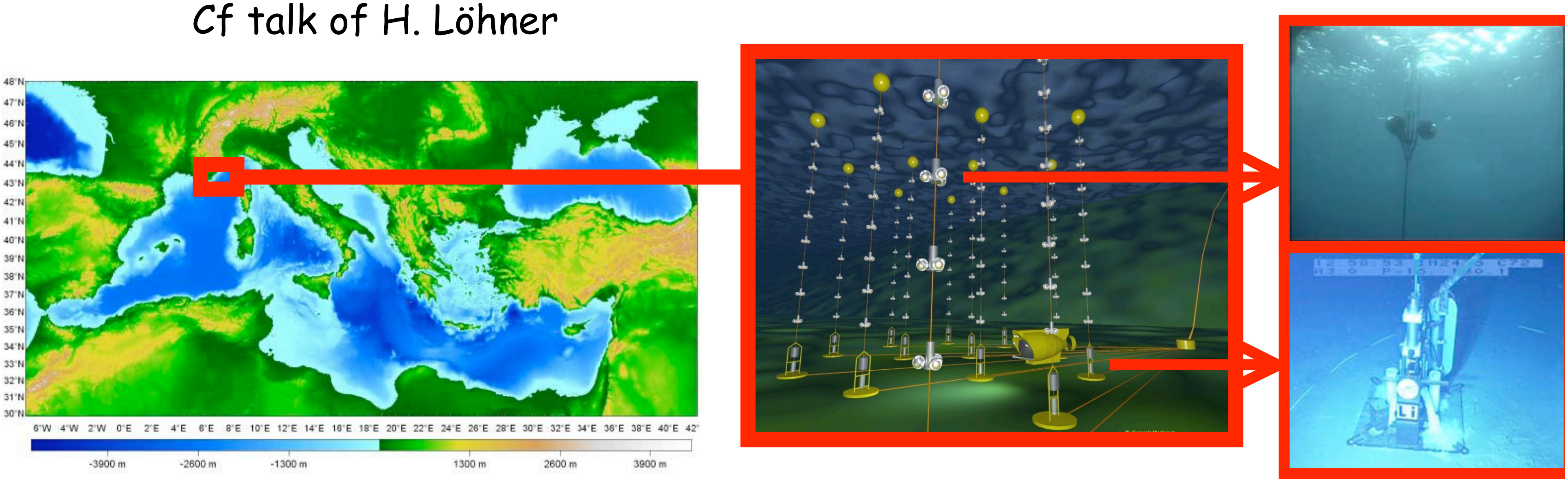
M.Bou-Cabo, J.A. Martínez.-Mora on behalf of the ANTARES Collaboration
Institut d'Investigació per a la Gestió Integrada de Zones Costaneres. Universitat Politècnica de València

Goal: ANTARES (Astronomy with a Neutrino Telescope and Abyss environmental Research) is a high energy neutrino undersea telescope, with an effective area of 0.1 km^2. Detection by Cerenkov light.

Challenges:

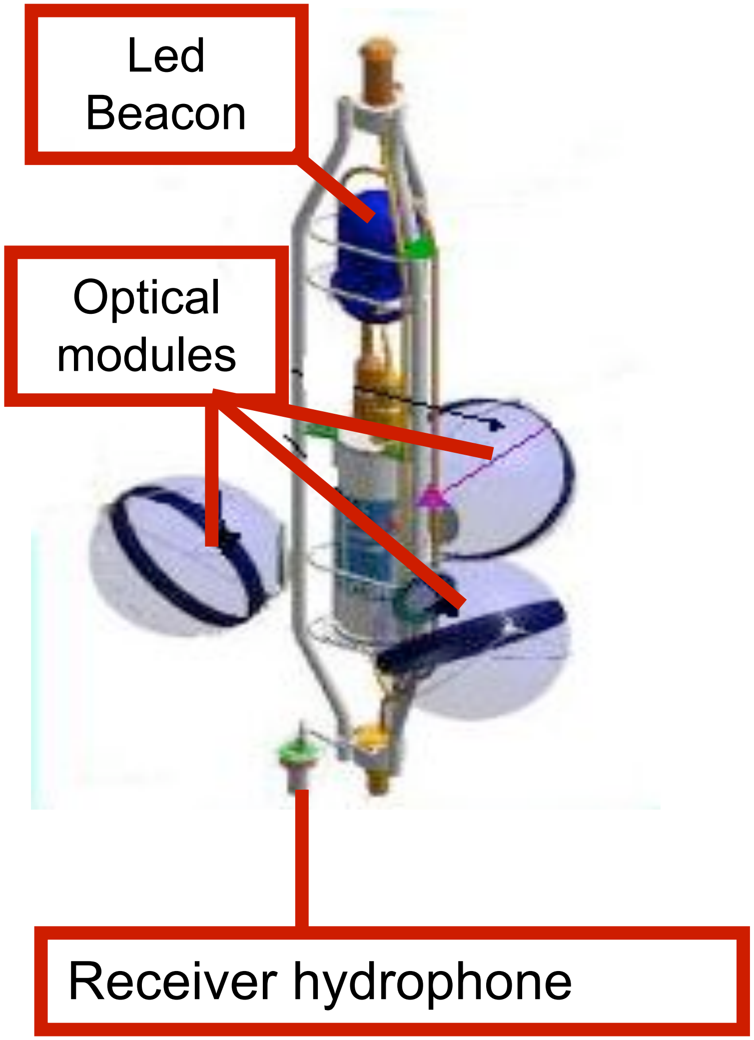
3-D array sea at a depth of 2400m (12 strings 25 storeys with 3 PMs)
42 km electro-optical cable to shore
Connection by remote vehicle
Water proof connections
Bioluminescence

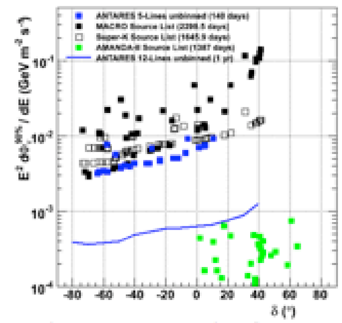
Cf talk of H. Löhner



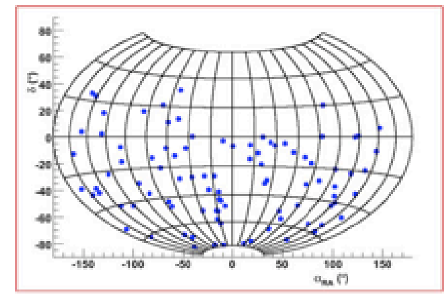
ANTARES

First results

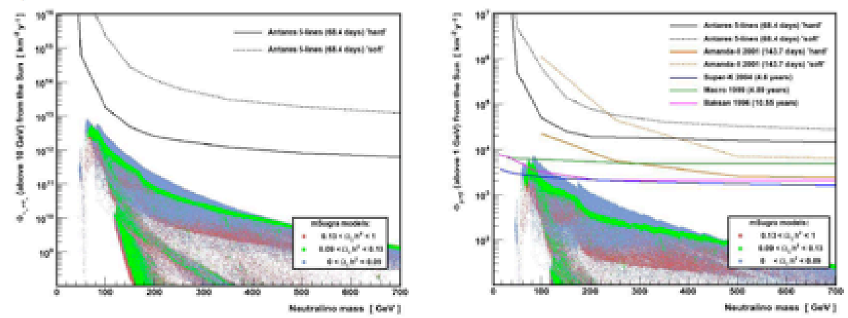




Flux (upper limits) of ANTARES for some candidate sources, compared with other experiments.



Skymap plot witht he 94 events founds in the analysis



Limit on neutrino flux (E > 10 GeV) (left) and neutrino induced muon flux (E > 1 GeV) (right) coming from the Sun obtained by ANTARES with the data of the 5-Line period in comparison to the expected flux from neutralino annihilations in mSugra models.

3 D positioning

Goals

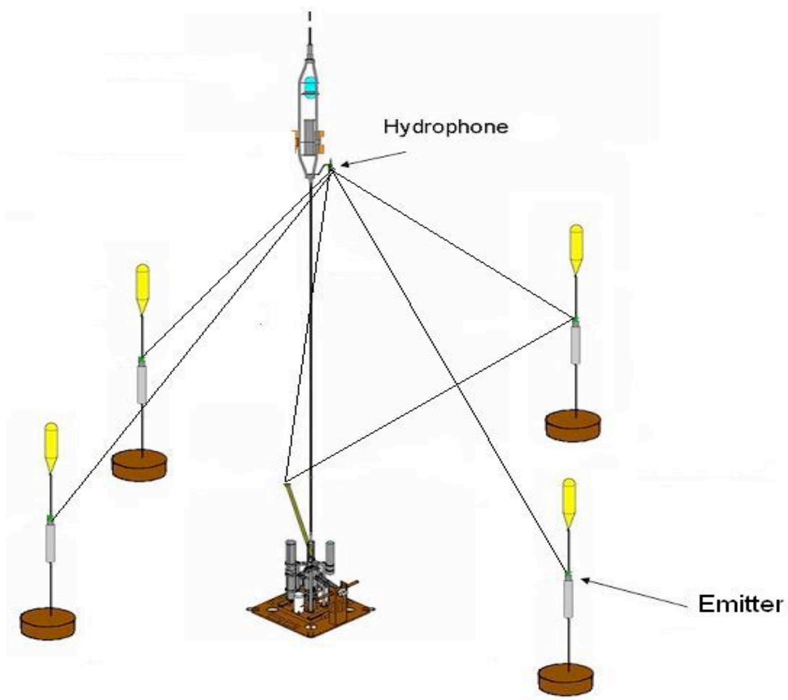
An acoustic triangulation system is needed to determine their positions, so as to provide the tracking precision and angular resolution required for astronomical neutrino source searches.

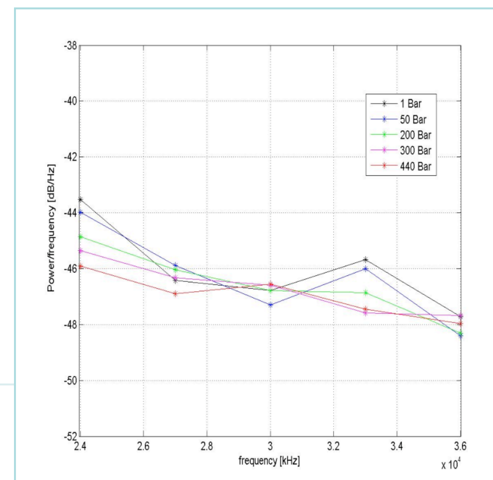
Prototype for Km3NeT (European km^3 neutrino detector)

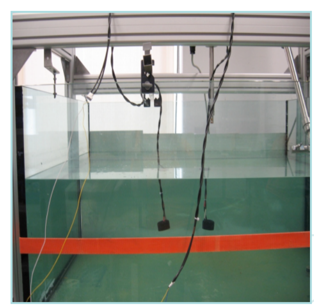
cf. Herbert Löhner's talk

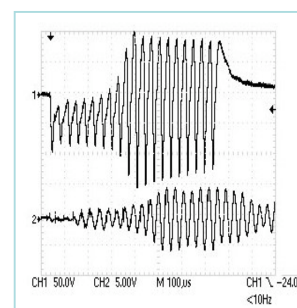
Challenges: Pressure and reliability

"Free Flooded Ring"

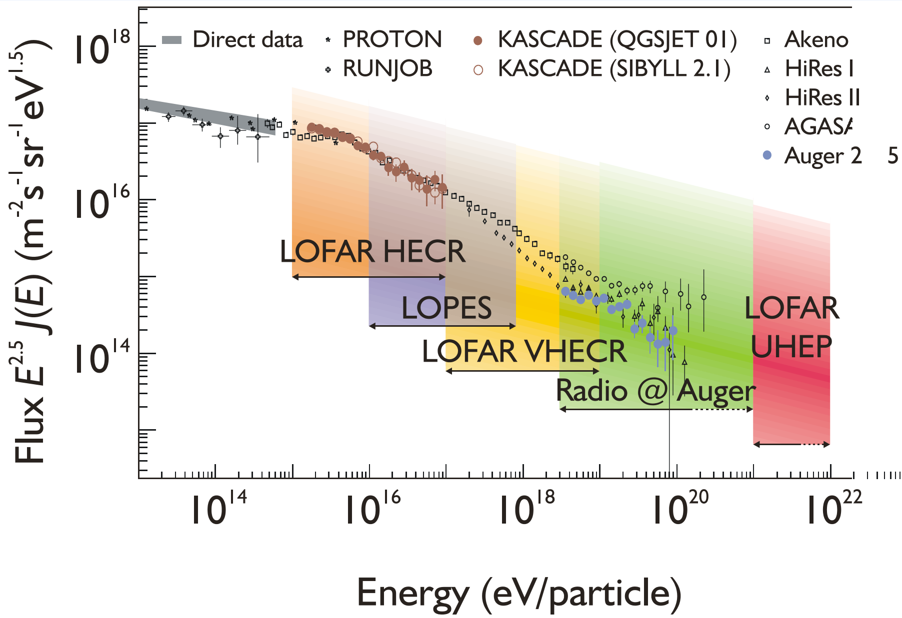








VHE Cosmic Rays and Neutrinos



Radio detection of showers Cf Huege's talk

Synchrotron in B field from e's inside a shower in the atmosphere

Coherent < 100MHz

Provide both direction and energy

Large interest in the community

In addition to Auger, 2 posters here

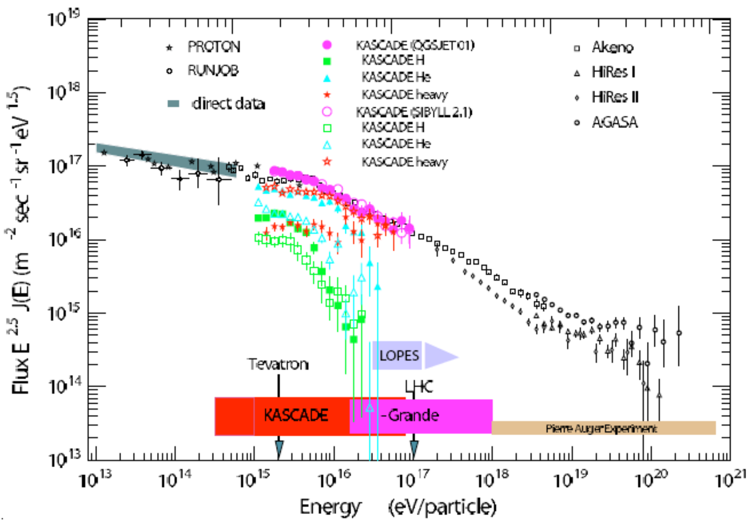
Cosmic ray Measurement with Lofar A. Horneffer

Measuring the Radio Emission of Cosmic Ray Showers with LOPES F. Schroeder

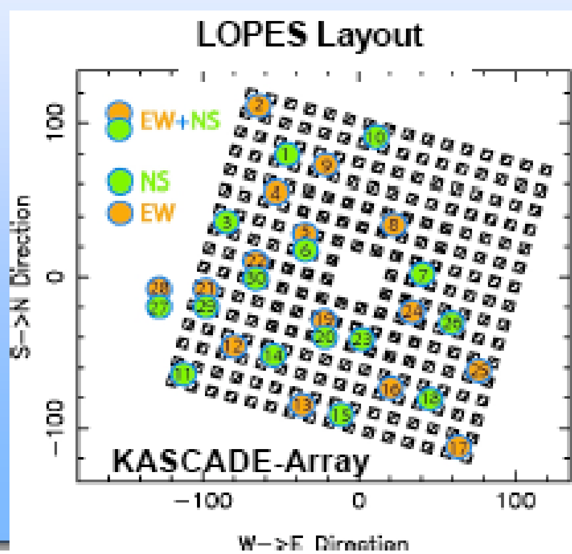
Also notable

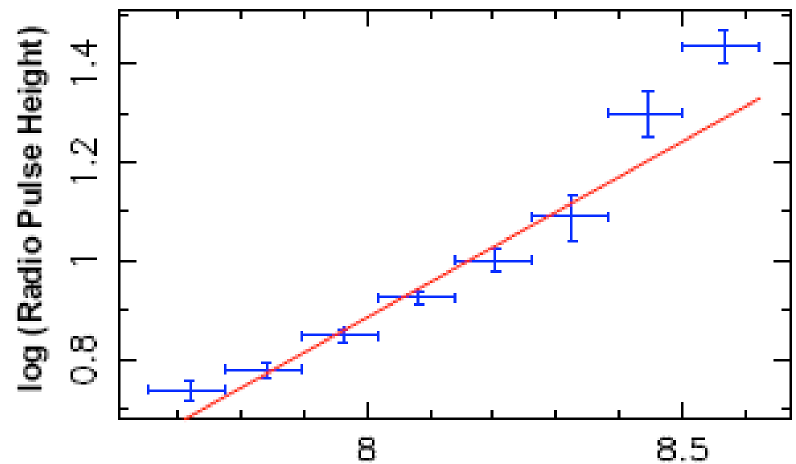
Arianna: 100km^3 ice (Ross Ice Shelf) for neutrinos

LOPES



- LOPES: triggered by and located at KASCADE (Karlsruhe)





A. Horneffer

Frank Schröder, PISA Conference, May 2009

poster presented by Tim Huege

Cosmic Ray Measurements with LOFAR

Presented by Andreas Horneffer for the
LOFAR CR-Team

New digital radio telescope in the Netherlands and Europe

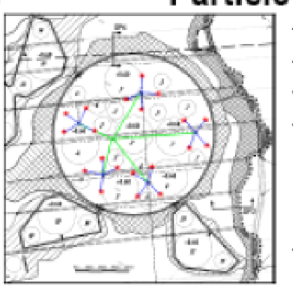
Will have higher sensitivity and resolution at 10-240 MHz than all other telescopes

Can measure cosmic rays by detecting:

air showers ($E_{CR} < 10^{19}$ eV)

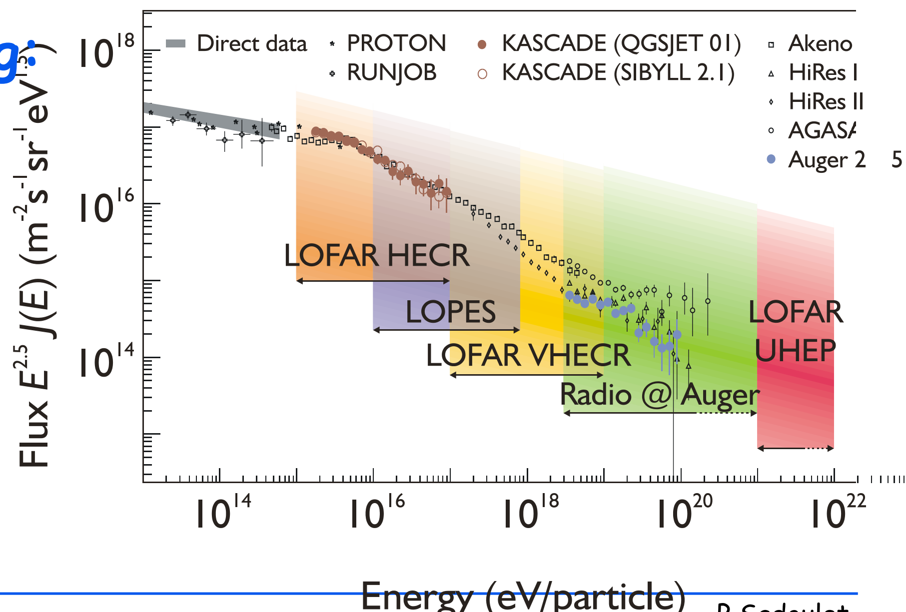
radio pulses from the Moon ($E_{CR} > 10^{21}$ eV)

Particle Detector Array



- + Small particle detector array
- + Inside the central super-station
- + 5 station with 4 detectors each
- + Help for the development of the radio-only trigger and additional data for hybrid measurement
- + Main Goal: Proof the we indeed detect air showers.

Layout of the LOFAR air shower array: The small and big dashed circles show the LOFAR antenna fields, the red stars the particle detectors and the blue and green lines the connection inside and between stations.



Search for Solar ALPs in the Low Energy Range at CAST

Authors:

G. Cantatore, M. Karuza, V. Lozza, G. Raiteri(INFN Trieste and University of Trieste) CAST Collaboration

Goals:

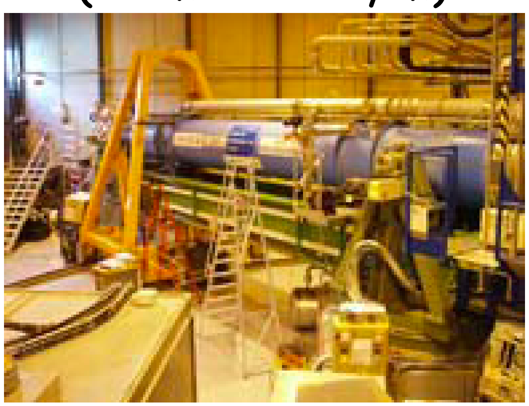
Search for axion-like particle emitted by the sun
use LHC magnet pointed at the sun a+γ(B)-> γ(X ray)

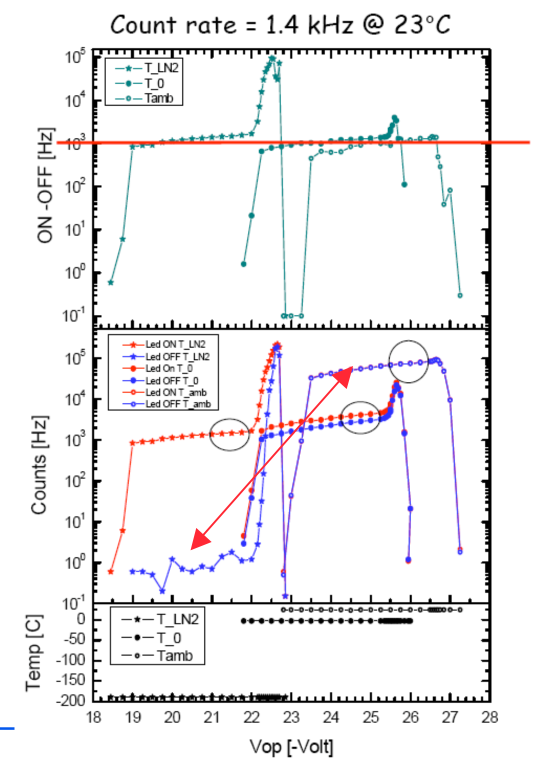
Method:

Second generation: Liquid N_2 cooled Geiger mode-APD instead of cooled PM

Main result:

At LN2 the Dark Count Rate is about 1 Hz
≈10^5 lower than at ambient temperature
(diameter 80μm)





MARE

A. Nucciotti for Milano, Goddard and Foundation Bruno Kessel (Trento)

"Microcalorimeter Arrays for a Rhenium Experiment

Goals:

direct and calorimetric measurement of the electron antineutrino mass with sub-electronvolt sensitivity in ^{187} Rhenium (Q=2.6keV)

Lower systematics due to poorly known branching ratio to final atomic states

Challenge:

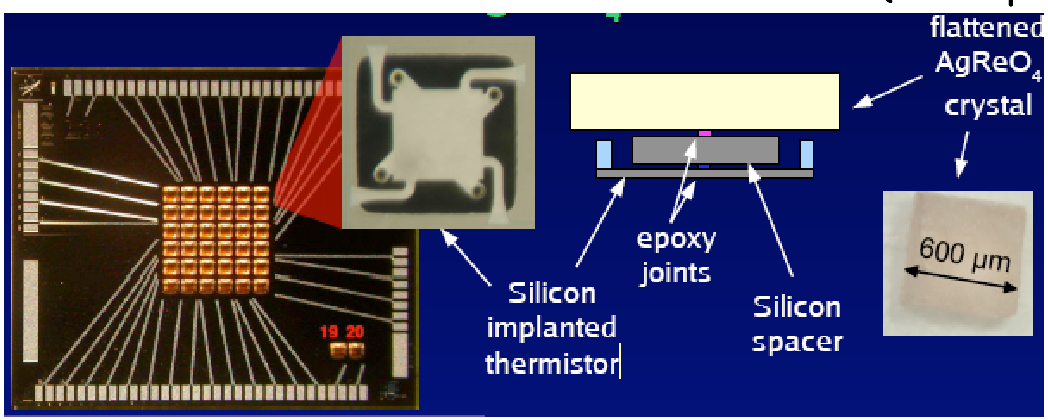
resolution

pile up => many small calorimeters

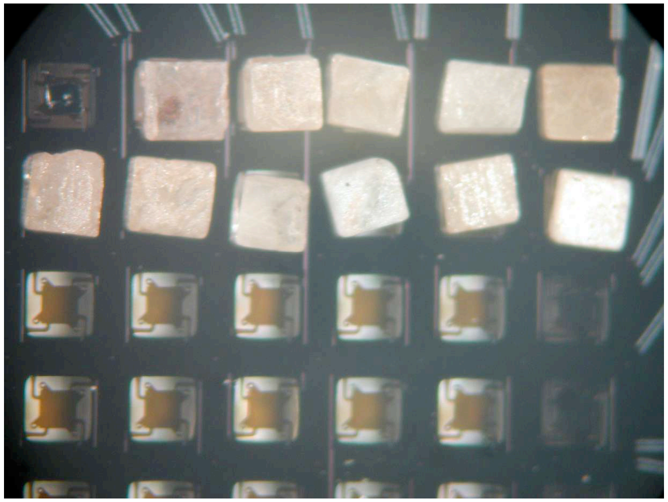
Method: low temperature calorimetry

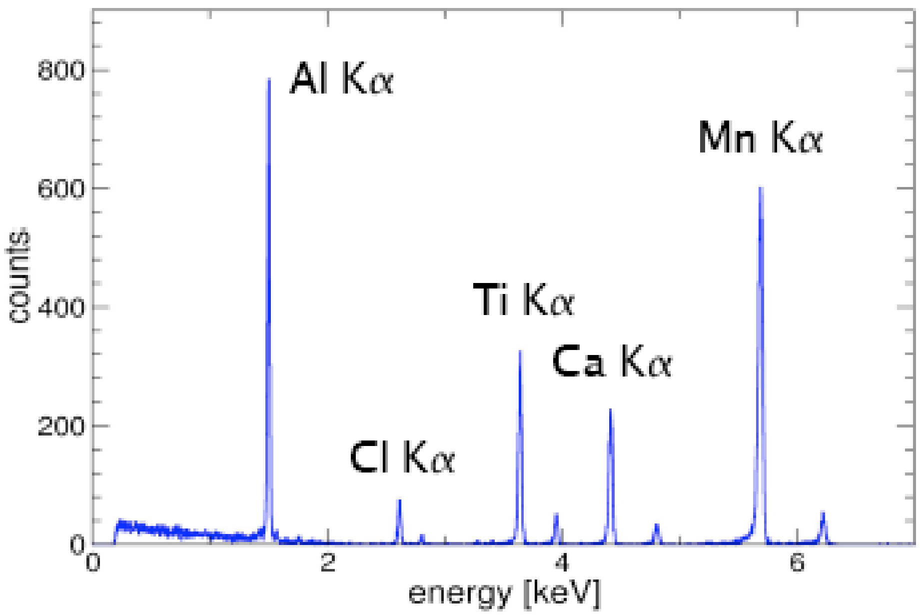
MARE1: Use Goddard XRS2 Si implanted thermistor array (36) + AgReO4
8xXRS2=288 detectors => 1eV

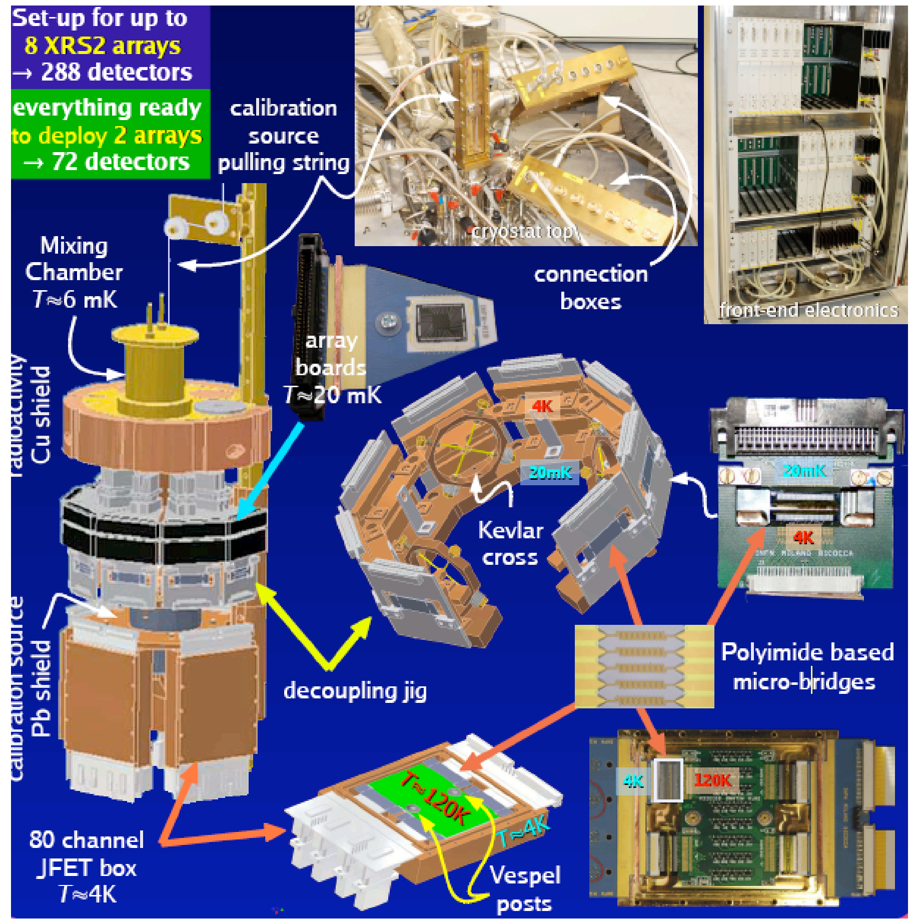
MARE2 10,000 detectors => 0.2 eV: Kinetic Inductance (multiplexed)



MARE





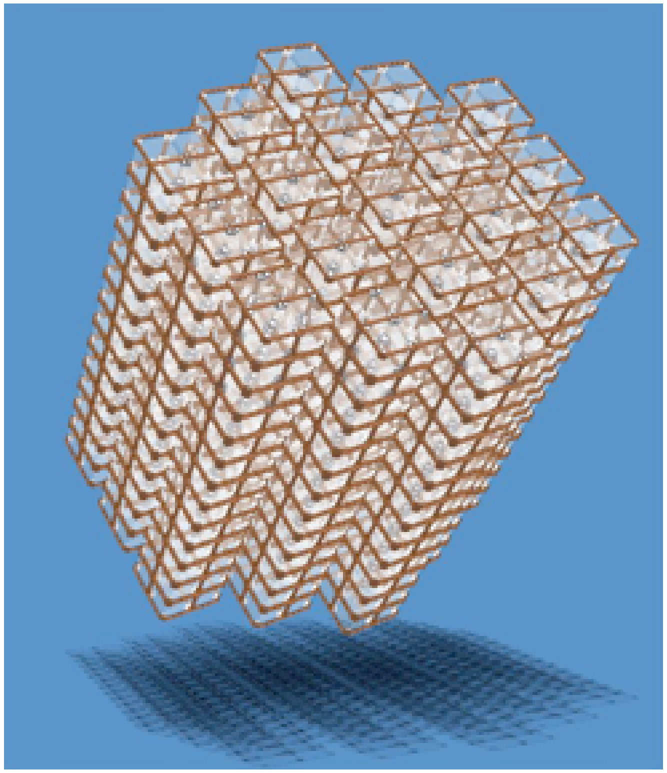


Everything ready for 72 detectors

Other Low Temperature Experiments

For completeness (no posters!)

Large size



CUORE 988 x750g TeO2
cf also Gironi's talk
Neutrinoless Double Beta

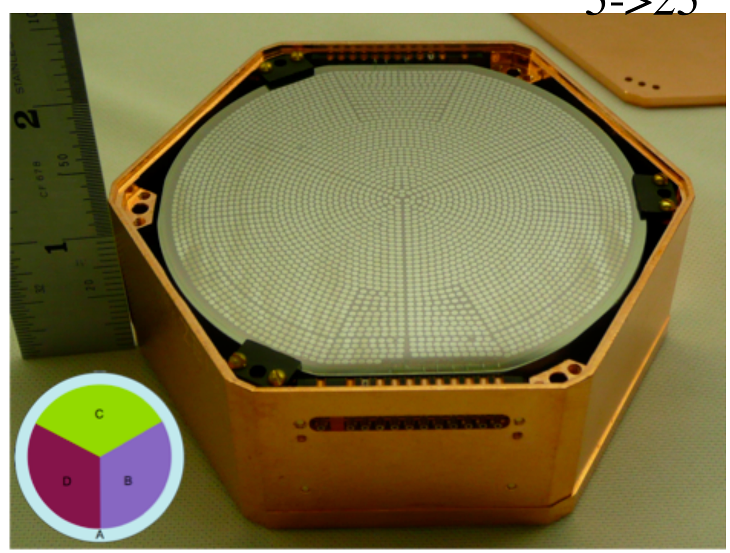
Dark Matter

CRESST

17x 300g $CdWO_4$

Also EDELWEISS

CDMS 600g Ge
5->25



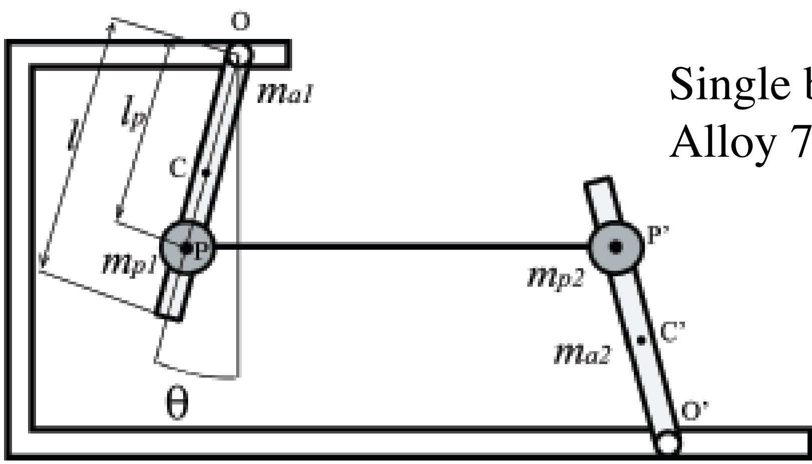
Gravitational Waves

TUNABLE MECHANICAL MONOLITHIC HORIZONTAL ACCELEROMETER FOR LOW FREQUENCY SEISMIC NOISE MEASUREMENT

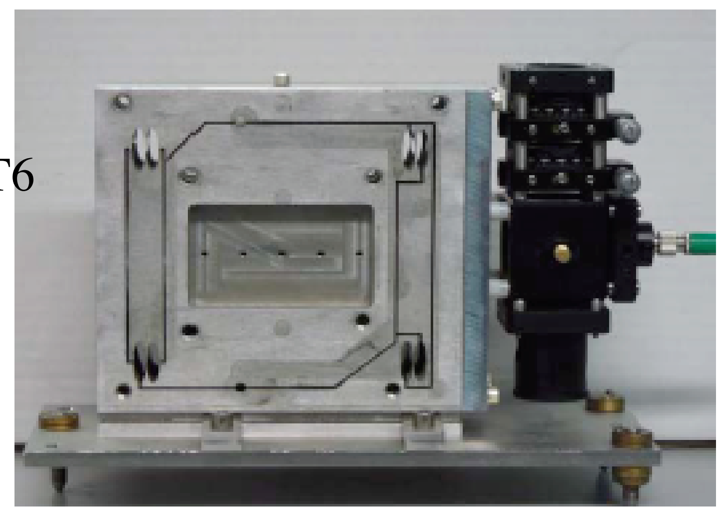
F.Acernese, R.De Rosab, G. Giordanob R. Romano F. Barone
Salerno, Napoli,INFN Napoli

Goals:

- Resonant frequency reduction → increase the resolution and the frequency band ≈70mHz-few Hertz + tunning through feedback
- Monolithic design implementation → high Q, low hysteresis and dissipation, low thermal noise, low coupling between different degrees of freedom.
- Optical readout system development → low noise, high resolution and low coupling with electromagnetic noise: promise to be thermally limited below 1Hz



Single block
Alloy 7075-T6



Conclusions

Very active field

Neutrino Physics

- Reactors
- Double beta decay
- Neutrino mass

High Energy Astrophysics

- Gammas
- Cosmic rays
- Neutrino

Dark Matter

- WIMPs, axions

Gravitational Waves

Lots of technological overlap

- Particle/nuclear physics -> astrophysics
- Astrophysics methods -> particle astrophysics (UHE radio, dark matter) => merging

Well worth to increase coverage of low temperature detectors in the Pisa Meeting

Thanks for the invitation from the organizing committee!