Summary of the Application session.

Ralf Hendrik Menk
Elettra Sincrotrone Trieste
INFN, Trieste

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INFN
Istituto Nazionale
di Fisica Nucleare

Inside Holmes experiment: 163Ho metallic target production for the micro-calorimeter absorber	Giulio Pizzigoni (GE)	yes	Calorimeters	
Development of a novel Micro Pattern Gaseous Detector for cosmic ray muon tomography	Fabrizio Petrucci (ROMA3)	yes	Cultural Heritage	Gaseous mircogap
Status of SLAC Testbeams	Dr. Carsten Hast (SLAC)	yes	facility	PMs
CERBEROS: a Tracking System for Secondary Pion Beams at the HADES Spectrometer	Joana Wirth (Physik Department E12, Technische Universität München, Graching, Germany)	yes	facility	SI STRIP & DIAMOND
UA9, a device for crystal assisted collimation in large hadron colliders	Dr. Walter Scandale (ROMA1)	yes	facility	PMs
Defocusing beam line design for an irradiation facility at the TAEA SANAEM Proton Accelerator Facility	Ms. Aysenur Gencer (METU)	yes	facility	
MC study of the measurement of Michel Parameters in the radiative leptonic decay of tau	Mr. Nobuhiro Shimizu (The University of Tokyo)	yes	MC in HEP	
TOFPETv2: a high-performance circuit for PET Time-of-Flight	Mr. Agostino Di Francesco (LIP Laboratorio de Instrumentacao e	yes	medical	SiPm
Performance of a 64-channel, 3.2x3.2cm2 SiPM tile for TOF-PET application	Mr. Alessandro Ferri (Fondazione Bruno Kessler)	yes	medical	SiPm
The Endo-Rectal probe prototype for the TOPEM project	Dr. Paolo Musico (I.N.F.N. Genova)	yes	medical	SiPm
Development Electron Tracking Compton Camera (ETCC) for multipurpose medical imaging	Prof. Toru Tanimori (Graduate School of Science Kyoto University)	yes	medical	TPC & μPIC
State of the art silicon photomultipliers with LSO: Ce codoped Ca scintillators achieve 84ps coincidence time resolution for PET	Mr. MYTHRA VARUN NEMALLAPUDI (CERN)	yes	medical	SiPm
Fast and Precise Large Area Topology Measurements Using Laser Distance Sensors	Mr. Ralph Müller (LMU)	yes	metrology	
Watt’s linkage based large band low frequency sensors for scientific	Prof. Fabrizio Barone (NA)	yes	metrology	
Fast Neutron and Gamma-ray Detection with Liquid-Xe Detector for Contraband Detection	Dr. David Vartsky (Weizmann Institute of Science)	yes	neutron Imaging	GEMs
Neutron Detection by Large NaI Crystal	Andrea Lavagno (TO)	yes	neutron Imaging	NaI
Properties of single crystal para-terphenyl as medium for high resolution	Matteo De Gerone (GE)	yes	particle physics	SiPm
Characterization of Pr:LuAG scintillating crystals for X-ray spectroscopy	Massimo Rossella (PV)	yes	scintillators TOF	SiPm
A compact muon tracking system for didactic and outreach activities.	Dr. ADRIANO DI GIOVANNI (NEW	yes	tracking	SiPm
Dosimetric approaches for laser-driven ion beams: an innovative Faraday Cup	Dr. Valentina Scuderi (Institute of Physics ASCR, v.v.i. (FZU), ELI-Beamlines Project, Na Slovance 2,	no		
Experimental Verification of Beam Position and Size Determination Using Scattered Charged Particles for Real Time Quality Assurance in Proton	Marco BATTAGLIA (UCSC and CERN)	no		
MONDO: a neutron tracker for particle therapy secondary emission fluxes measurements	Davide Pinci (ROMA1)	no		
Study of the performance of CdZnTe detectors	Mr. Xiangcui Lei (IHEP,CAS), Mr. Sen	no		
PRaVDA – Towards Clinical-Quality Proton CT	Dr. Tony Price (University of Birmingham)	no		

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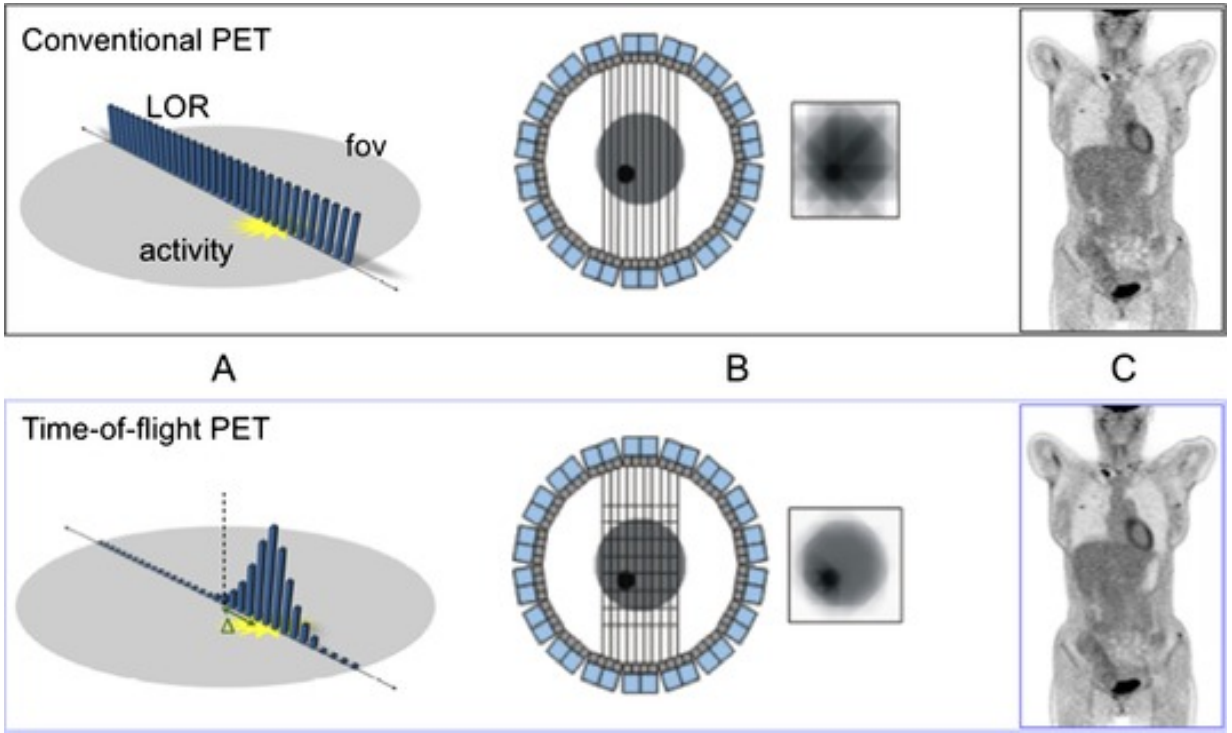
Medical Applications

- Medical applications
  - TOFPETv2: a high-performance circuit for PET Time-of-Flight Mr. Agostino Di Francesco (LIP Laboratorio de Instrumentacao e Fisica Experimental de Particulas)
  - Performance of a 64-channel, 3.2x3.2cm^2 SiPM tile for TOF-PET application Mr. Alessandro Ferri (Fondazione Bruno Kessler)
  - The Endo-Rectal probe prototype for the TOPEM project Dr. Paolo Musico (I.N.F.N. Genova)
  - Development Electron Tracking Compton Camera (ETCC) for multipurpose medical imaging Prof. Toru Tanimori (Graduate School of Science Kyoto University
  - State of the art silicon photomultipliers with LSO: Ce codoped Ca scintillators achieve 84ps coincidence time resolution for PET Mr. MYTHRA VARUN NEMALLAPUDI (CERN)

Medical Applications

State of the art silicon photomultipliers with LSO: Ce co-doped Ca scintillators achieve 84ps coincidence time resolution for PET

Mr. MYTHRA VARUN NEMALLAPUDI (CERN)



Requirements: fast scintillators & fast detectors & operation in high magnetic fields (MRI+PET)

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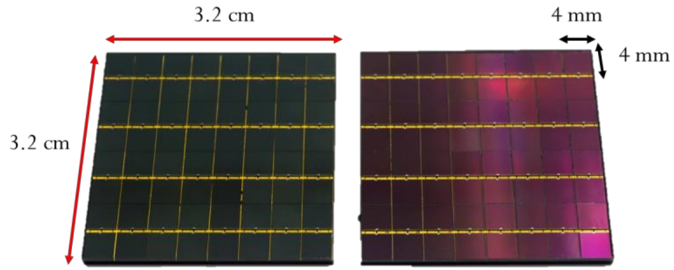
Medical Applications

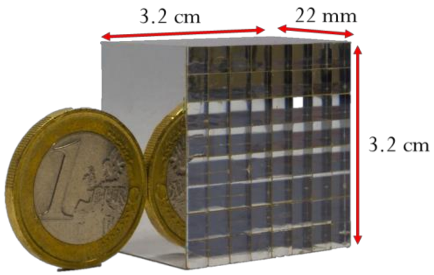
Performance of a 64-channel 3.2 x 3.2cm^2 SiPM tile for TOF-PET application

A.Ferri, FBK, Trento, Italy

- Development of 3.2x3.2 cm^2 tiles composed of 8x8 SiPM with 4x4mm^2 regular pitch. The tile fill factor is 85%.
- Manufactured with two SiPM technologies: RGB-HD and NUV.
- Estimation of energy and timing resolution of both versions using a segmented LYSO array with pixels of 4x4x22mm^3



Employed SiPM tiles:
RGB-HD (left) and NUV(right)



Employed LYSO array
Pixel size: 4x4x22 mm^3

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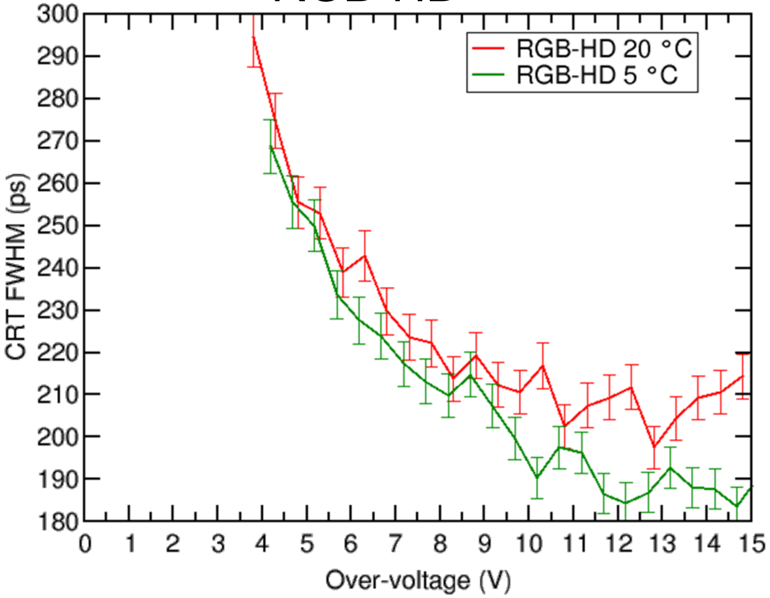
Medical Applications

Performance of a 64-channel 3.2 x 3.2cm^2 SiPM tile for TOF-PET application

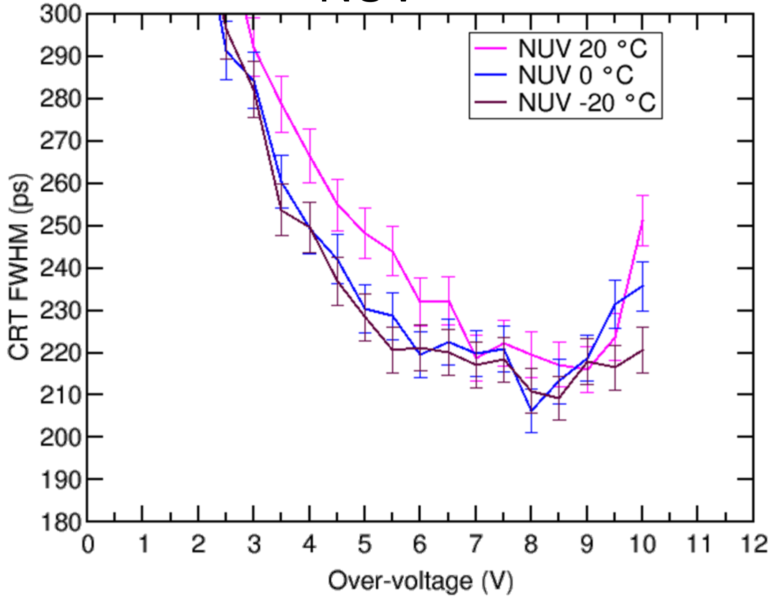
A.Ferri, FBK, Trento, Italy

- Similar resolution, close to 200 ps FWHM.
- NUV is less sensitive to different temperatures.

RGB-HD



NUV



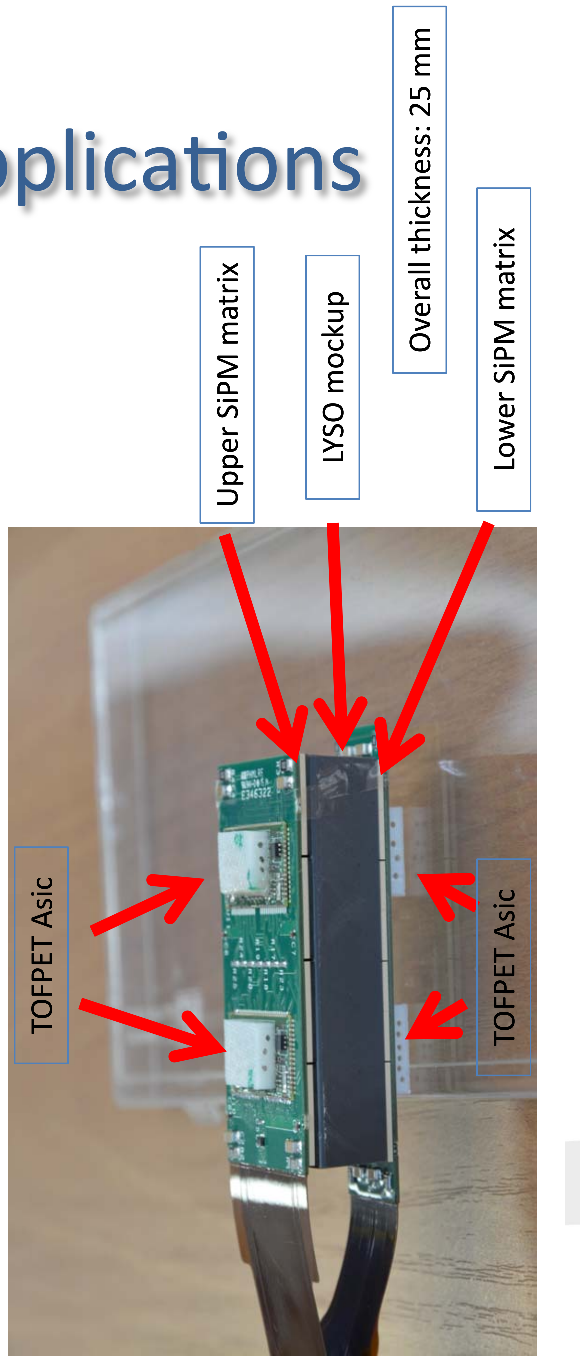
CRT coincidence resolving time

Medical Applications

The Endo-Rectal
probe prototype for the TOPEM project

Paolo Musico

- compatible with MRI for diagnosis and follow up of prostate cancer
- 128 SiPM matrix coupled to LYSO pixellated crystal
- Readout via TOFPET Asics



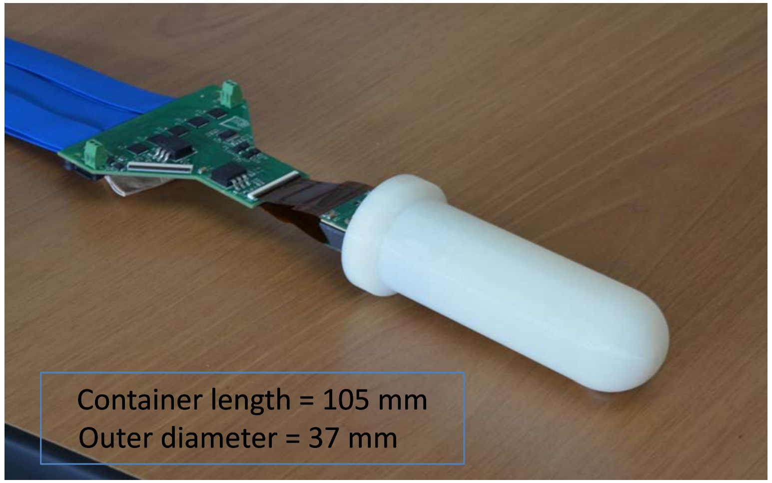
Medical Applications

The Endo-Rectal
probe prototype for the TOPEM project

Paolo Musico

- Applied 3-D printing technology. internal channels permit flowing of controlled temperature (≈ 35°C) water.
- Electronic components power is dissipated using an internal air flow kept at lower temperature (≈ 20°C).
- Probe is MR compatible: an antenna can be accommodated in the container permitting simultaneous imaging in MRI and PET systems.

Water channels`



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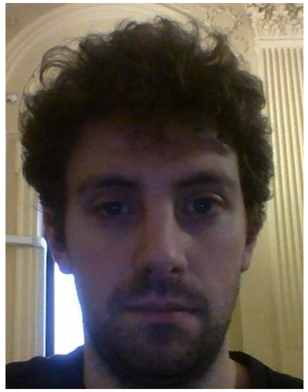
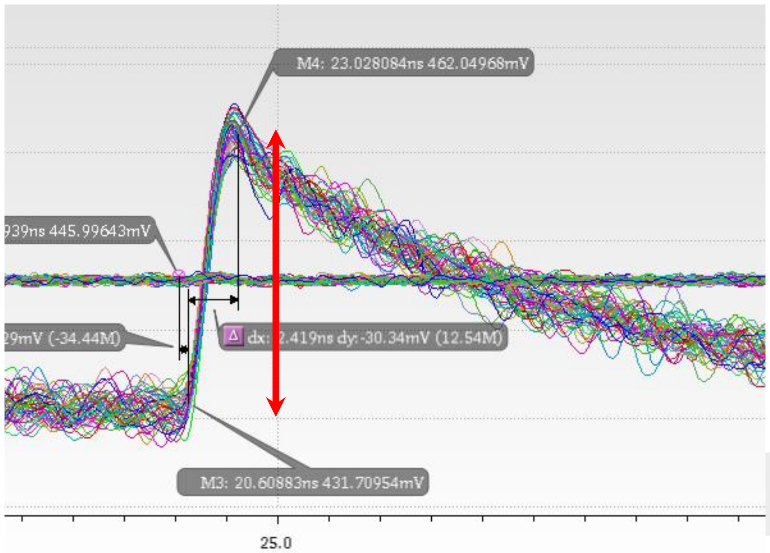
Medical Applications

TOFPET 2: a high-performance circuit for PET Time-of-Flight (under development – tape out June 2015)



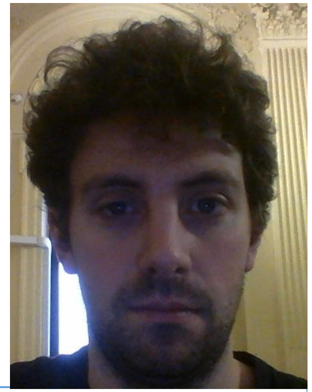
Agostino Di Francesco LIP, Portugal

- TOFPET 2 is a 64 channels readout and digitization chip for TOF-PET scanners and other applications utilizing SiPM.
- Front end based on a low input impedance current-to-voltage amplifier optimized for timing performances;
- Integration branch for linear charge measurement;
- Low power TDC/ADC for digitization of time and charge measurements;
- Back-end with 3.2 Gbit/s output data rate.

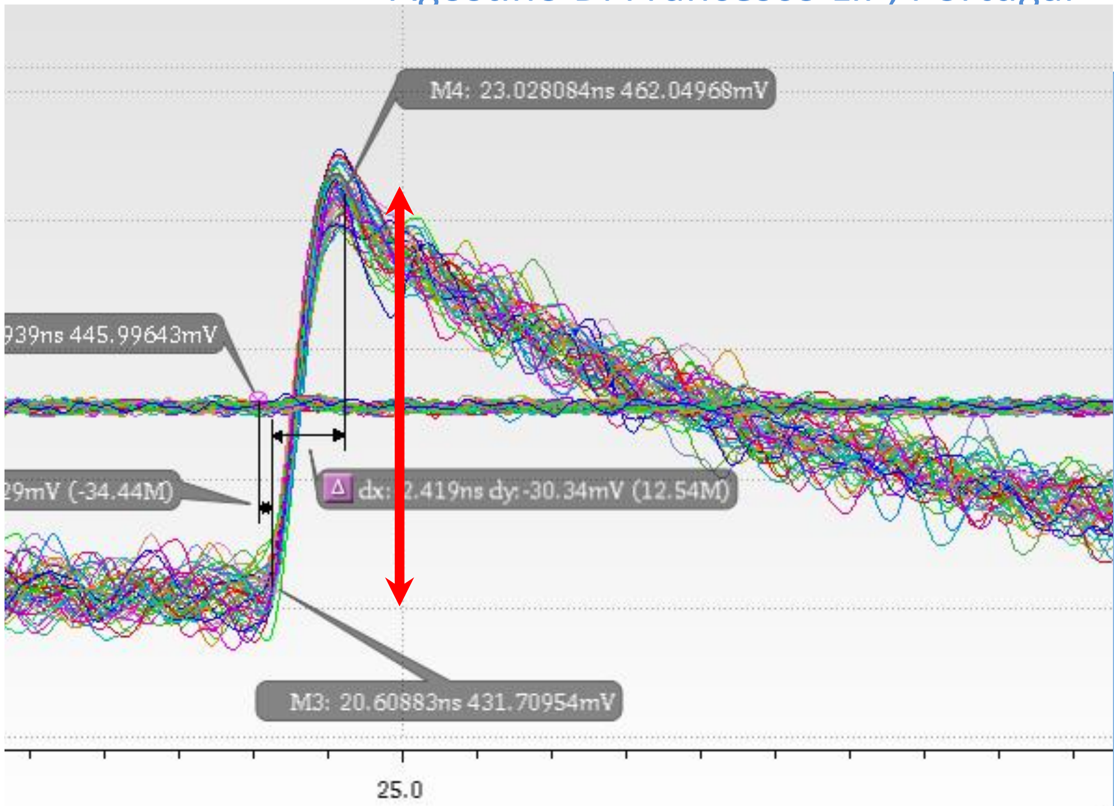


Medical Applications

TOFPET 2: a high-performance circuit for PET Time-of-Flight (under development – tape out June 2015)



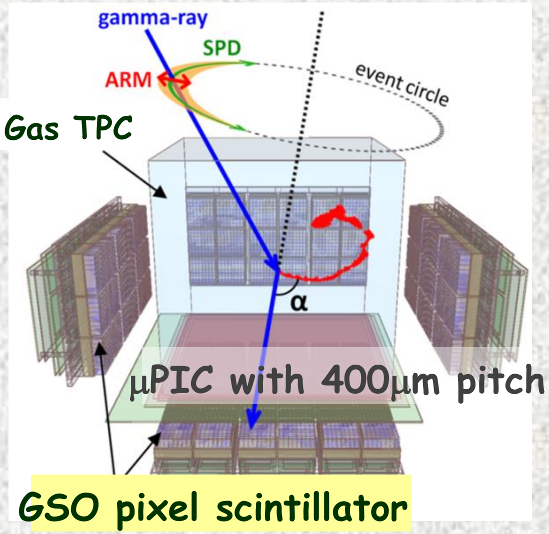
Agostino Di Francesco LIP, Portugal

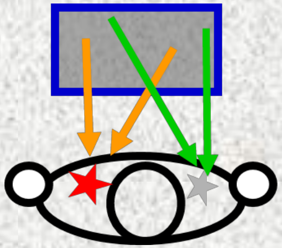


- For a 1 p.e. signal from a SiPM (gain 1.25 10^6) the front end can detect a signal with 74 ps jitter (r.m.s) and SNR of 24 dB.

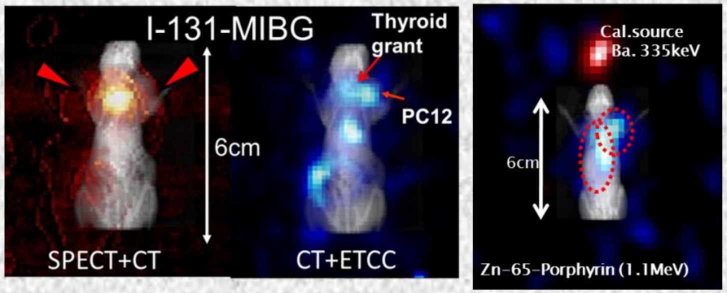
Development Electron Tracking Compton Camera (ETCC) for multipurpose medical imaging (T.Tanimori et al. Kyoto Univ. Japan)

- direction of photon by photon with SPD useful for Noise cut. & Clear Imaging
- Noise Reduction by dE/dx
- Large FoV >3str(good for monitoring)





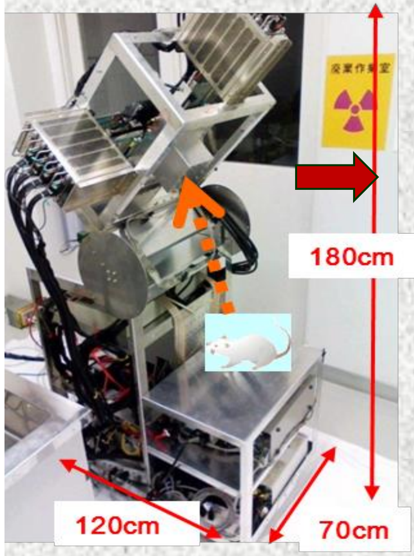
Clear images for >300keV γ in mice (08-12)



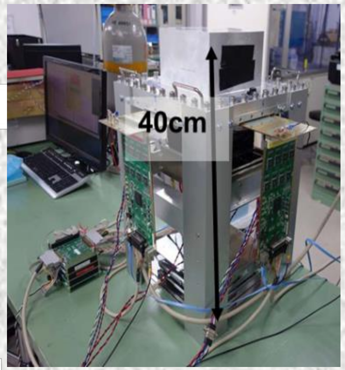
1st Medical 10cm-cube ETCC(06~12)

- Tacking efficiency 10% -> 100%
- Fast DAQ 30Hz -> ~1KHz
- Good Angular resolution 10° ->5°

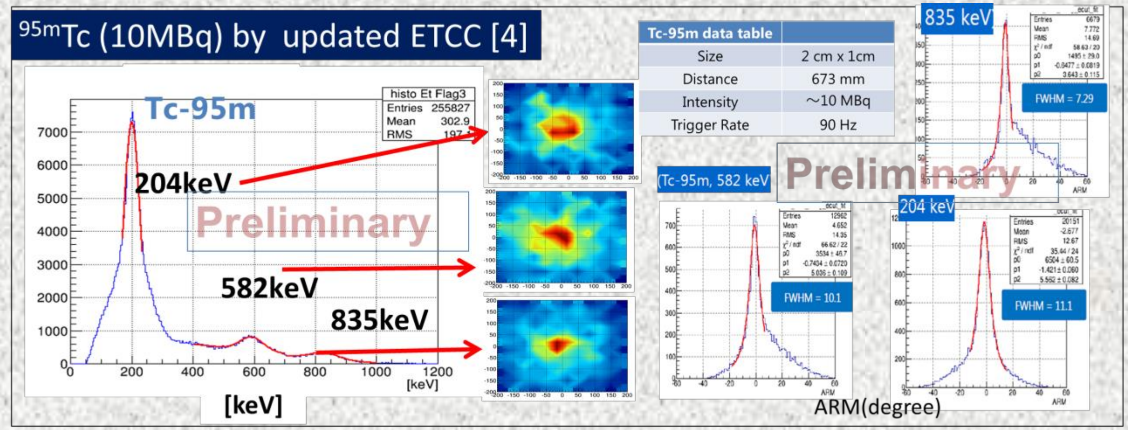
I-131:364keV)



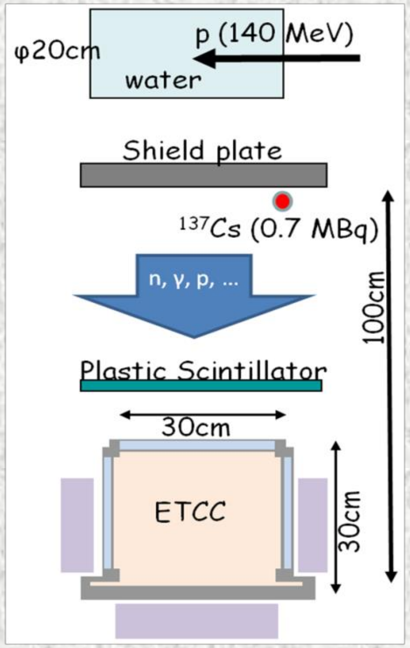
Updated Med. 10cmETCC (2014)

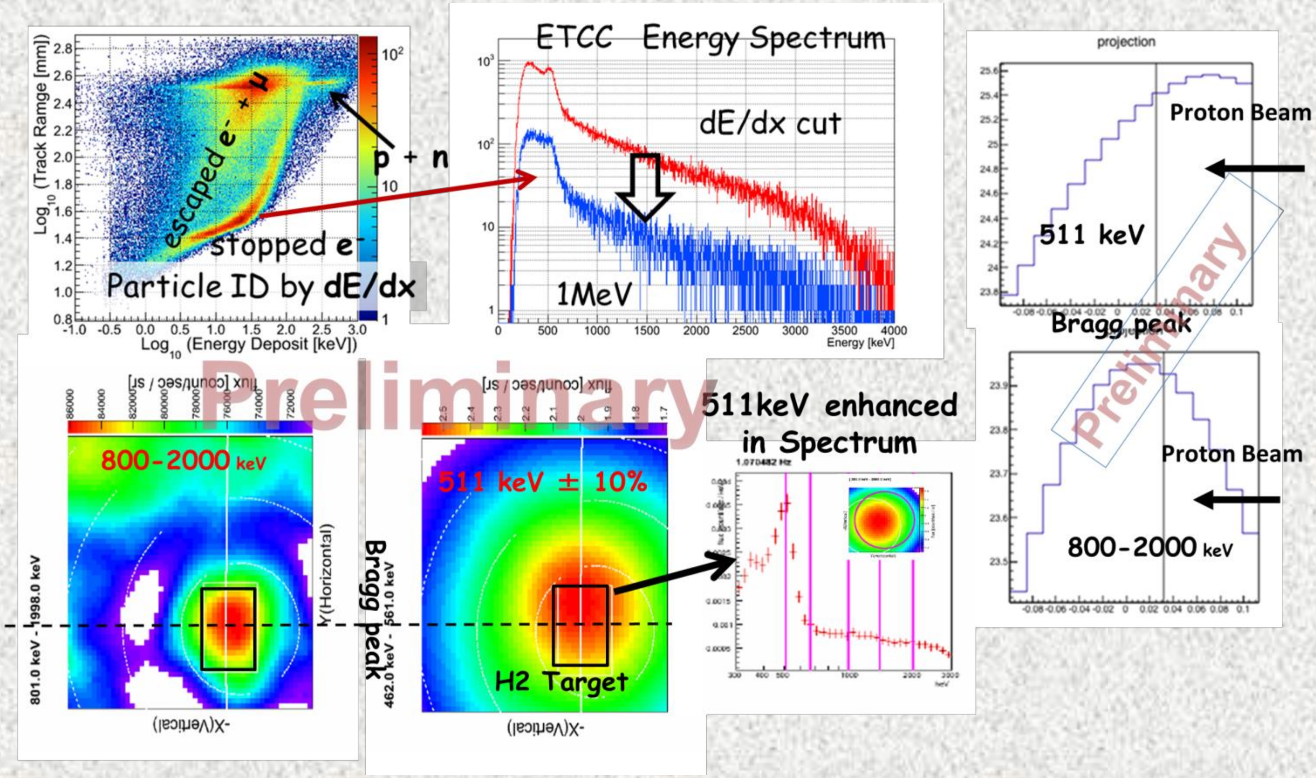


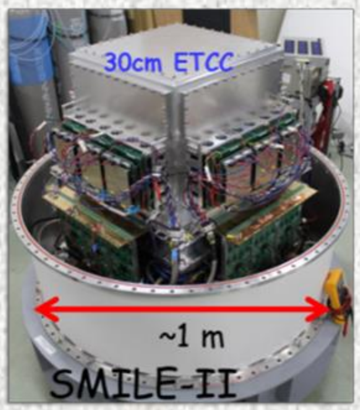
Multicolor image (3 energy γ emission)



Proton Therapy Beam-on Imaging with advanced ETCC for Astrophysics







Proton beam intensity	Several sub-nA (~1/3-5 of proton therapy
Measurement time	～ 30 minutes with 50% dead time-> Live time 14min.
# of obtained gamma rays	～ 2×10^4 for all gamma, 8 gammas /s >1MeV

Result: Peak position of the higher energy gamma ray image clearly shifts upper position of the beam line. → It is consistent to the simulation result.

Goal in a few years, Use of 2atm CF_4 with 3r.l. PSAs will increase to ~10^2 gamma >1MeV, which provides 1mm resolution of Bragg peak every second.

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facilities

- facilities
  - Status of SLAC Testbeams Dr. Carsten Hast (SLAC)
  - CERBEROS: a Tracking System for Secondary Pion Beams at the HADES Spectrometer Joana Wirth (Physik Department E12, Technische Universität München, Graching, Germany)
  - UA9, a device for crystal assisted collimation in large hadron colliders Dr. Walter Scandale (ROMA1)
  - Defocusing beam line design for an irradiation facility at the TAEA SANAEM Proton Accelerator Facility Ms. Aysenur Gencer (METU) (medical)

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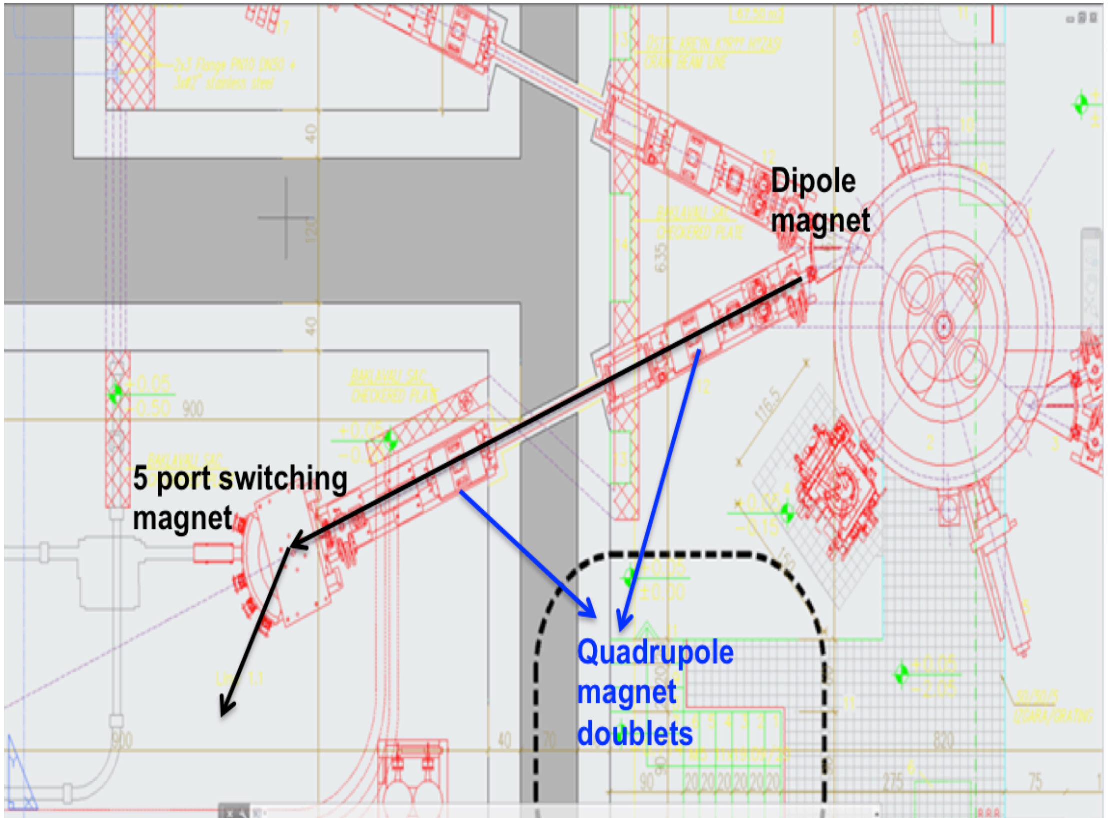
Facilities

Defocusing beam line design for an irradiation facility at the TAEA SANAEM Proton Accelerator Facility

Ms. Aysenur Gencer (METU), Turkey



- To perform irradiation tests using 30MeV proton beam @ Ankara, Turkey
- To satisfy space radiation requirements ESA ESCC-25100 standard:
  - Beam size must be enlarged (15.40cm x 21.55cm)
  - Beam flux must be reduced
  - (10^5 p/cm^2/s to at least 10^8p/cm^2/s)

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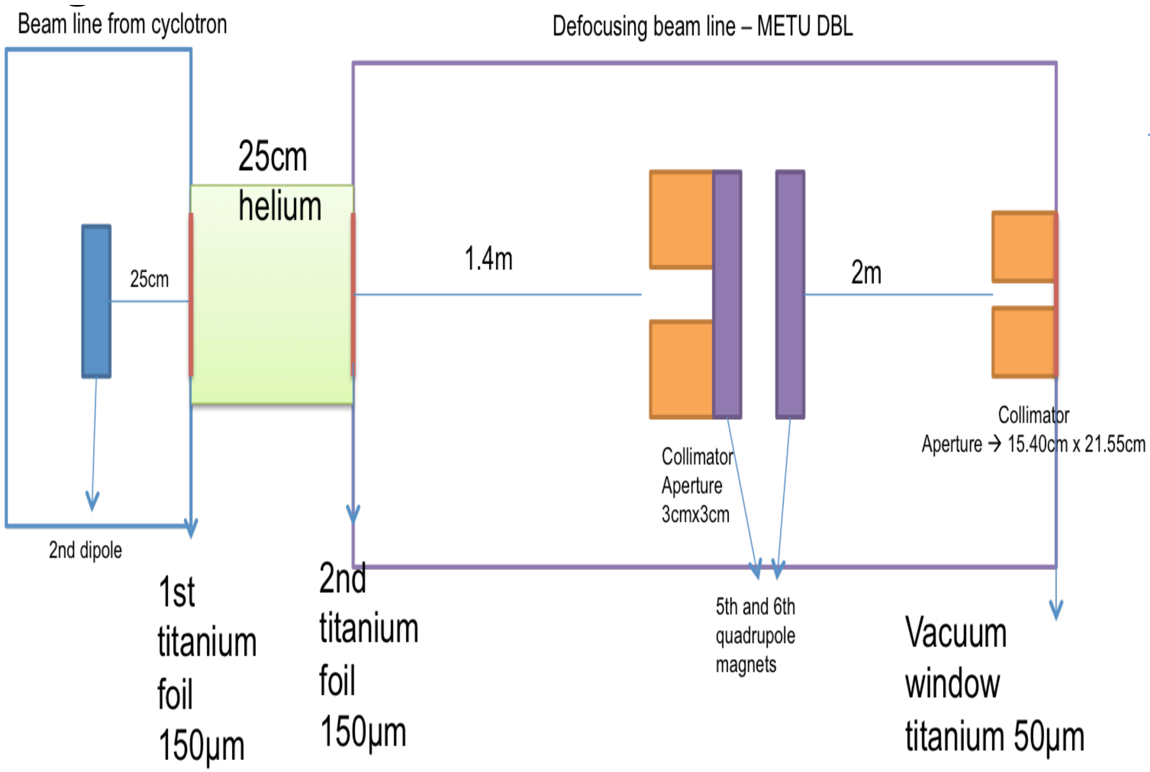
Facilities

Defocusing beam line design for an irradiation facility at the TAEA SANAEM Proton Accelerator Facility

Ms. Aysenur Gencer (METU), Turkey



- Quadrupole magnets -> enlarge the beam size
- Scattering foils -> reduce the flux
- Conceptual design is now finalized.
- Technical design report is being prepared.

The irradiation tests can be performed between
3.1×10^7 p/cm²/s to 1.9×10^9 p/cm²/s for an area of 15.40 cm x 21.55 cm

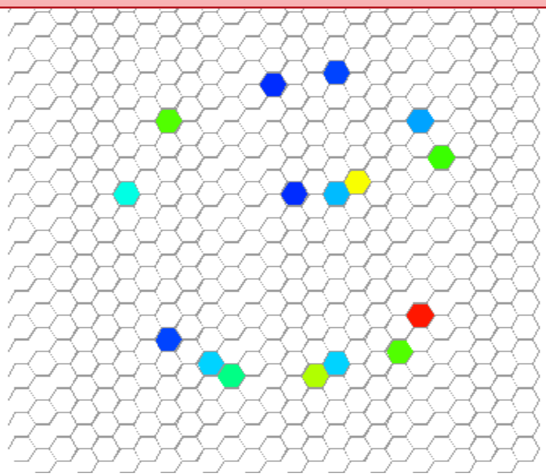
SLAC Beam Test Facilities Overview (emphasis ESTB)
Carsten Hast, SLAC

Facility	Purpose	Parameters
FACET	Accelerator R&D, Material Science, THz	Very focused and short bunches at 20GeV e+/-
ESTB	Detector R&D, LC MDI, Radiation Tests	2-15GeV primary LCLS beam or single e-
NLCTA	Accelerator R&D, Medical, Radiation Tests	60 to 160 MeV, small emittance, very versatile infrastructure
ASTA	Gun and RF Testing, RF processing, new Ultrafast Electron Diffraction Beam Line	<50MeV, X- and S-Band RF power

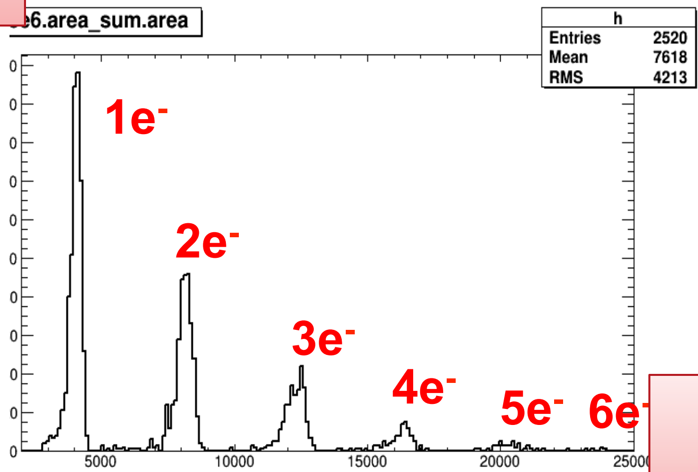
- All supported by SLAC's Test Facilities Department
- http://facet.slac.stanford.edu and http://estb.slac.stanford.edu
- e-mail: hast@slac.stanford.edu
- Google: SLAC FACET or SLAC ESTB

ESTB: Different Configurations for 1 to 100 Electrons for Detector R&D or Primary Beams up to 15GeV

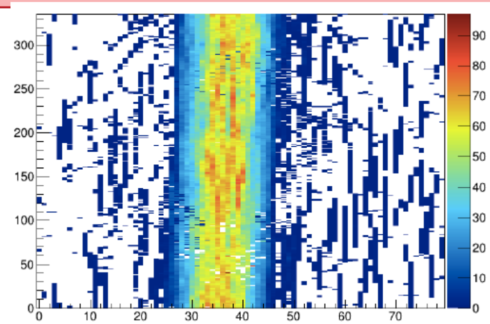
Single electron per event for Cherenkov or Calorimeters



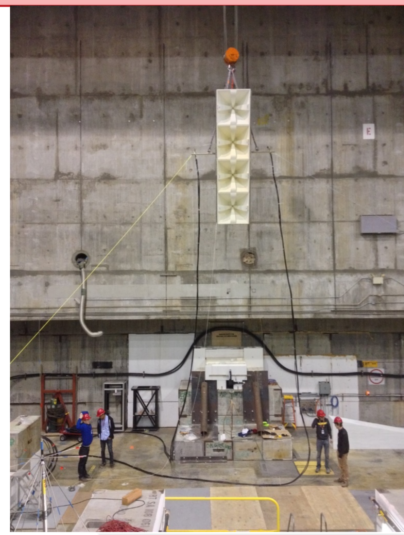
Multiple, well separated electrons per event



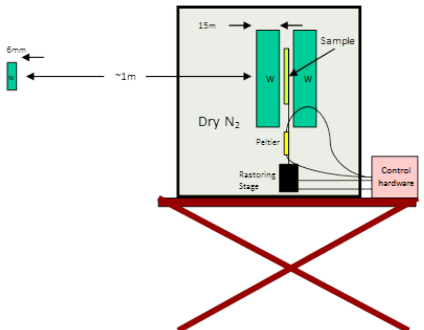
10 to hundreds of electrons per event for Silicon trackers



Primary Beam for Cosmic Air Shower Simulation

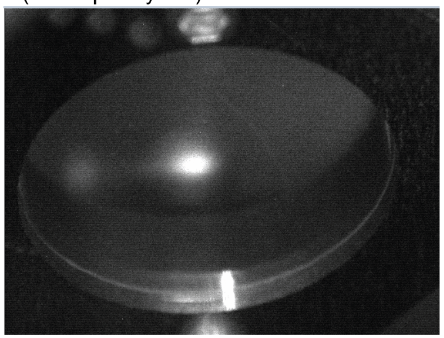


Primary Beam for Radiation 100MRad/day



Primary Beam for Beam Physics (eg: channeling)

❖≈ 450 μrad (in a 60μm crystal!)

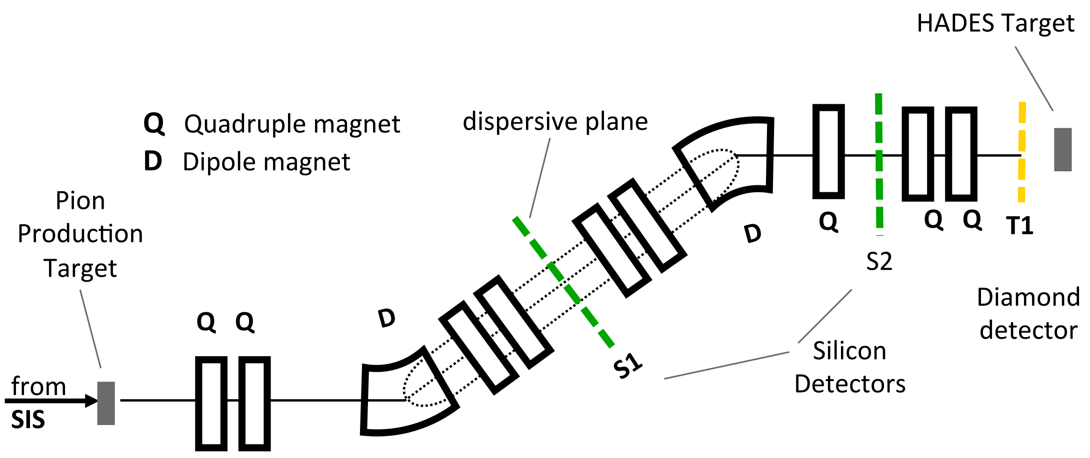


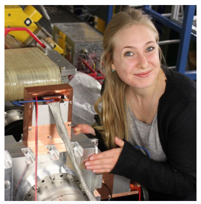
CERBEROS: a Tracking System for Secondary Pion Beams at the HADES Spectrometer

Secondary pion beam production: N beam (10^{11} particles/s) on a Be target

- **Wide momentum spread ($\Delta p/p$ = 8%) and spatial spread of the pion beam**
- **Requirement for exclusive analysis: momentum resolution < 0.5 %**

→ CERBEROS: momentum measurement & online beam monitoring





Requirements:

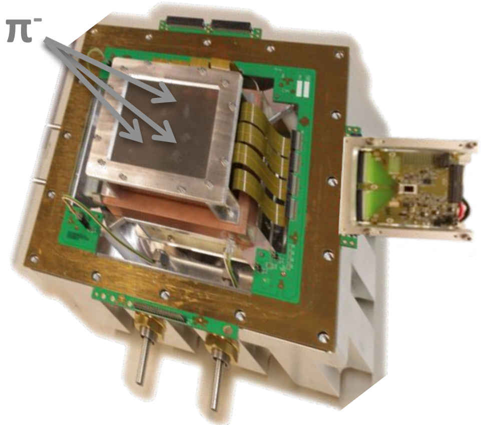
- Cope with high beam rates (up to 10^7 particles/s)
- In-vacuum operation (10^{-7} mbar)
- Minimal multiple scattering
- Position sensitive:
  - Provides four spatial coordinates to evaluate the beam momentum on the basis of the beam optics transport code

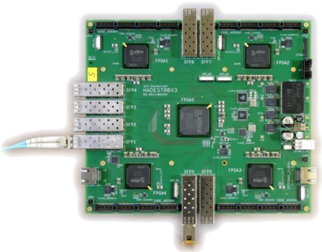
CERBEROS: a Tracking System for Secondary Pion Beams at the HADES Spectrometer

CONFIGURATION OF THE 1st STATION

Double-sided silicon sensor:

- 10 x 10 cm^2
- 300 µm thick
- 2 x 128 strips
- p-type bulk





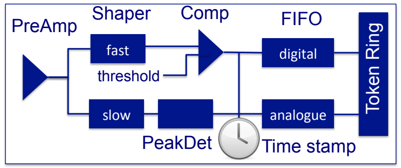
TRB3 aquistion system:

- Highly customizable FPGA read-out board
- GbE connectivity

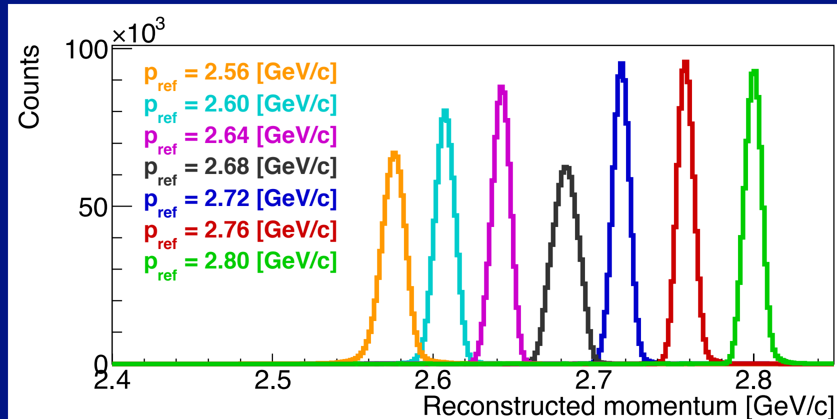
→ **time window selection and event building**

n-XYTER front-end read-out:

- **Self-triggered** architecture
- Internal **time stamp generator**
- 32 MHz read-out, on average 160 kHz



Momentum Calibration with a proton beam



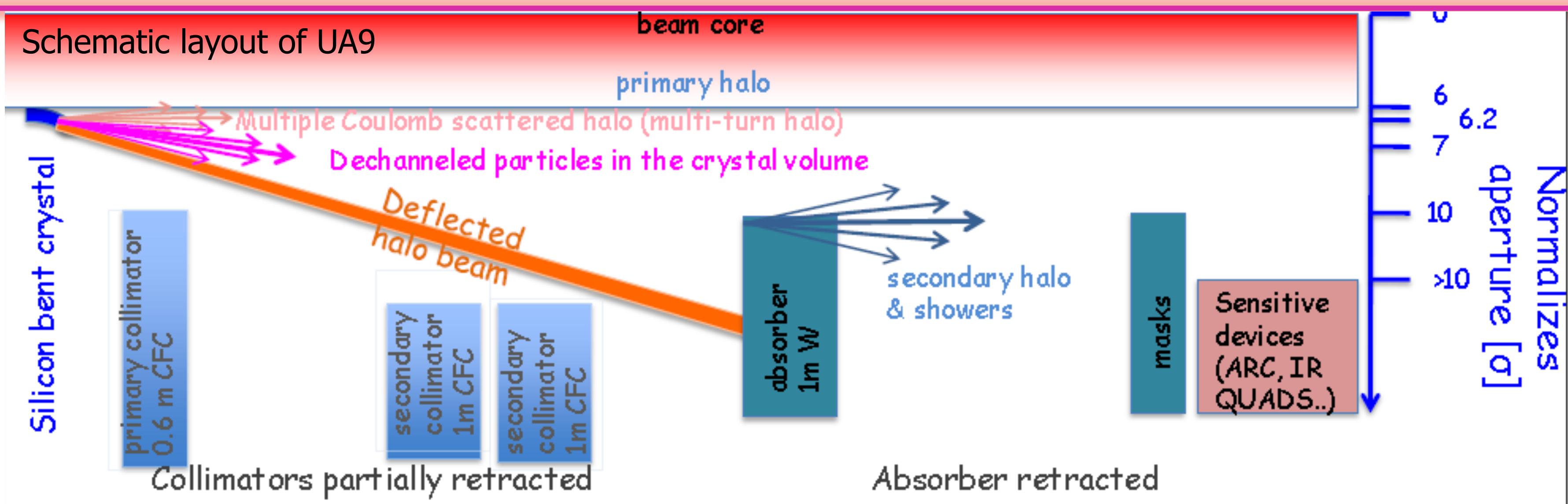
→ Resolution: 0.18 % ≤ σ ≤ 0.29 %, better than the requirement (0.5 %)

Frontier Detectors for Frontier Physics, Elba, Italy, May 2015 13th Pisa Meeting on Advanced Detectors

UA9 a device for crystal assisted collimation in large hadron colliders

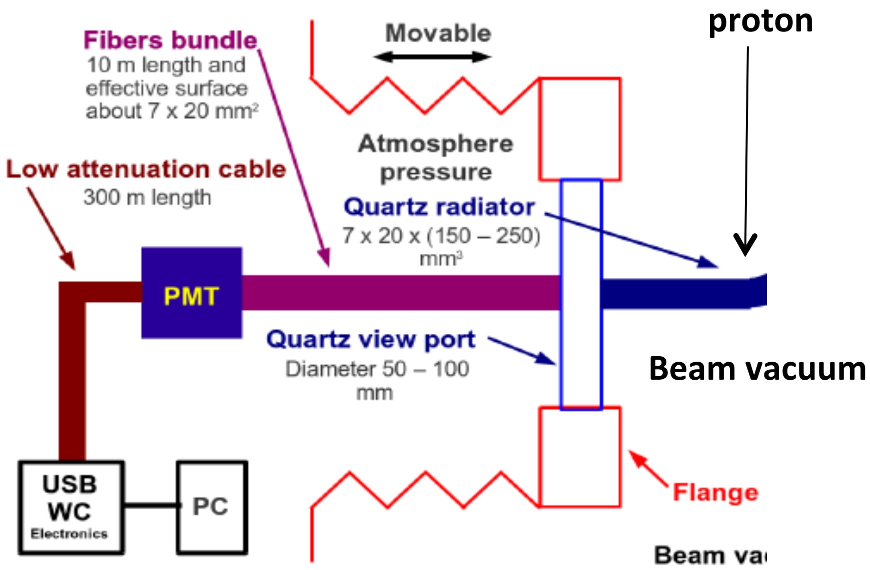
W. Scandale[3], D. Breton[1], L. Burmistrov[1], F. Campos[1], G. Cavoto[2], S. Conforti[1], V. Chaumat[1], M. Garattini[3], Y. Gavrykov[4], F. Iacoangeli[2], J. Jeglot[1], J. Maalmi[1], S. Montesano[3], V. Puill[1], R. Rossi[2], A. Stocchi[1], J.F Vagnucci[1]

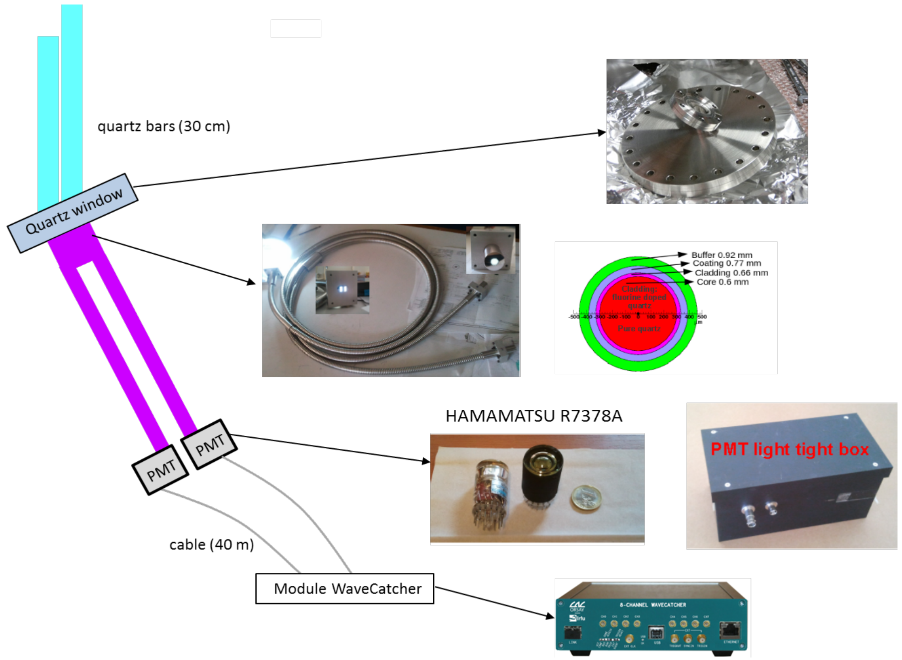
[1] LAL, Univ Paris-Sud, CNRS/IN2P3, Orsay, France
[2] INFN Roma, Piazzale A.Moro, 2 00185 Roma Italy
[3] CERN - European Organization for Nuclear Research, CH-1211 Geneva 23, Switzerland
[4] Petersburg Nuclear Physics Institute,188300 Gatchina,Leningrad Region,Russia

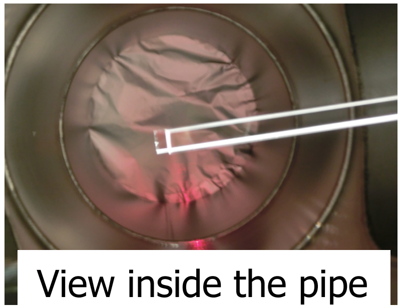


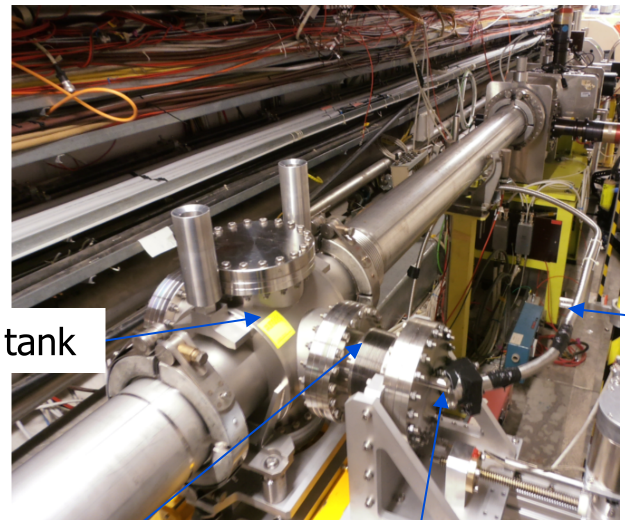
- Charged particles interacting with a bent crystal can be trapped in channeling states and deflected.
- The UA9 experiments investigate **collimation assisted by bent crystals at the CERN-SPS and in LHC**.
- The CpFM (**Cherenkov detector for proton Flux Measurement**), resolving the single particle, located inside the vacuum pipe itself, will be used to evaluate the **channeling efficiency**.
- The CpFM is made by a fused silica radiator, a long quartz fibers bundle and a photomultiplier readout by the WaveCatcher electronics. All the components except for the electronics have to withstand very high rate of radiation.

The CpFC conceptual design







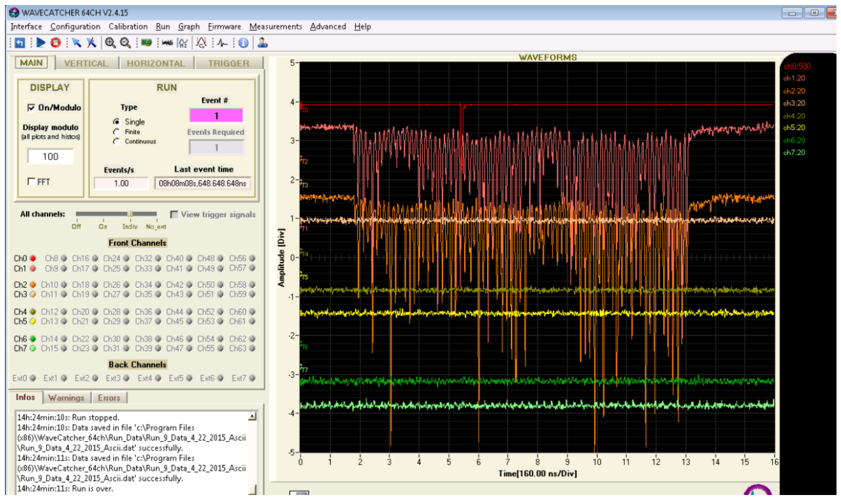


tank

Quartz fiber bundle

bellow to put the CpFM in garage position when not in operation

Quartz viewport



Background induced by a set of 25 ns spaced bunches circulating in the SPS

Scintillators

- Scintillators
  - Properties of single crystal para-terphenyl as medium for high resolution TOF detector Matteo De Gerone (GE)
  - Characterization of Pr:LuAG scintillating crystals for X-ray spectroscopy Massimo Rossella (PV)

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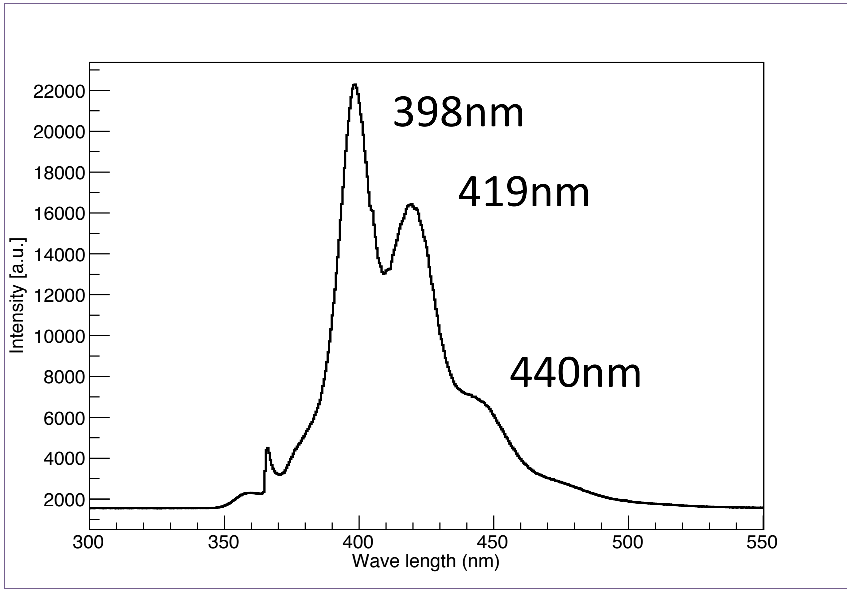
Trieste

Particle physics

Properties of Single Crystal Para-Terphenyl as medium for High Resolution TOF Detector

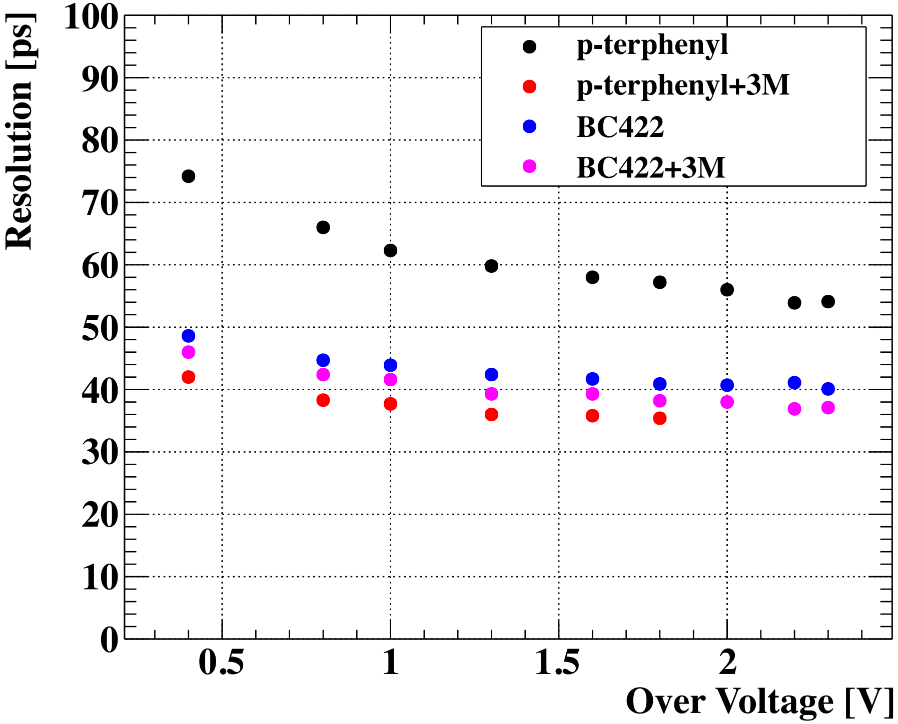
Matteo De Gerone (GE)

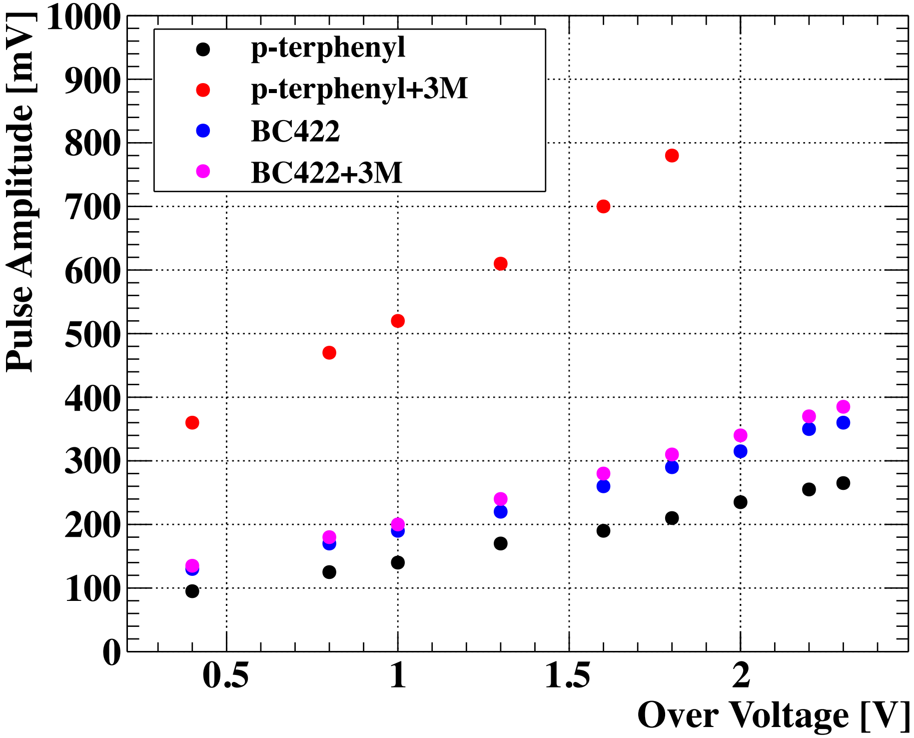
- organic compound, para-terphenyl ($C_{18}H_{14}$) mono crystalline
- Coupled to Hamamatsu S10931-050P SiPMs- 20x30x3 mm^3 TOF detector with dual-side read-out
- irradiated with ^{90}Sr source (β), time resolution of ~35ps



Particle physics

Properties of Single Crystal Para-Terphenyl as medium for High Resolution TOF Detector



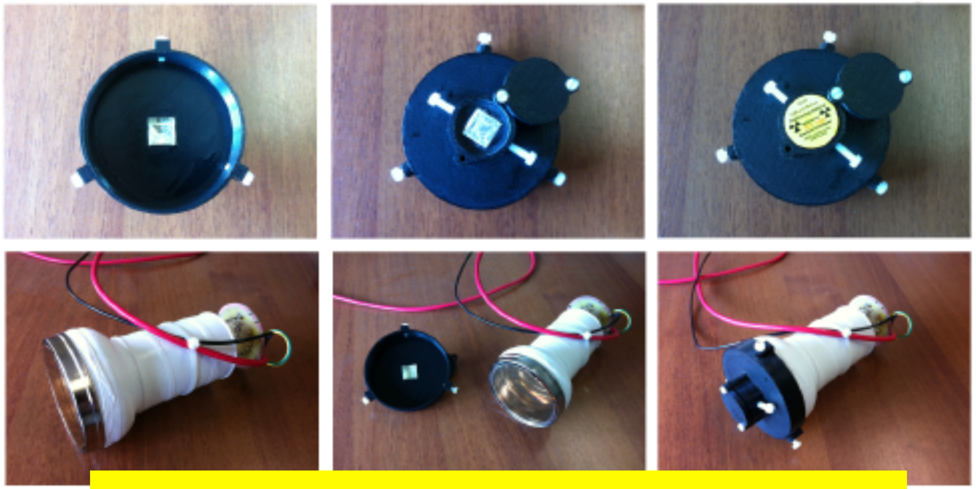


Characterization of Pr:LuAG scintillating crystals for X-ray spectroscopy

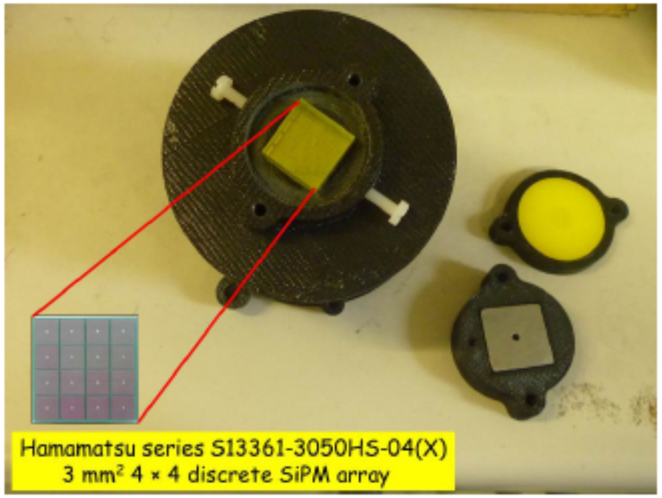
R. Bertoni[1], M. Bonesini[1], M. Clemenza[1], A. De Bari[2,3], A. Falcone[2,3], R. Mazza[1], A. Menegolli[2,3], M. Nastasi[1], M. Rossella[3]

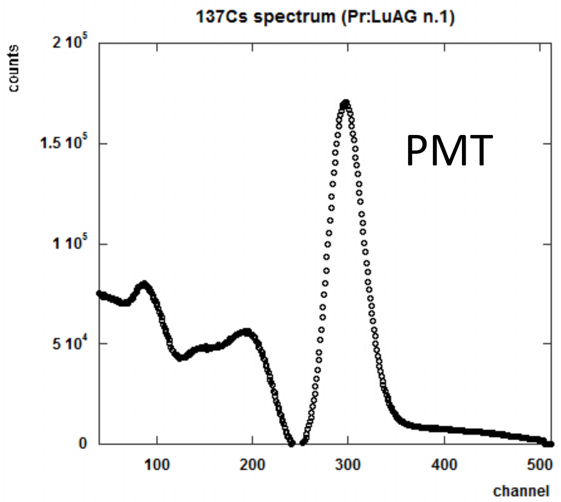
[1]INFN, Sezione di Milano Bicocca
[2]Università degli Studi di Pavia
[3]INFN, Sezione di Pavia

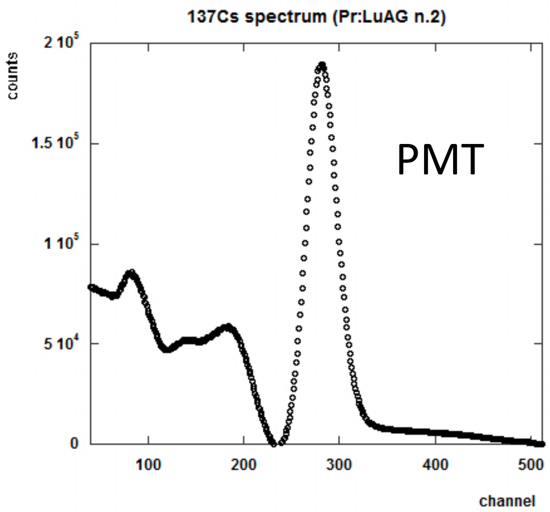
- Rare earth activated wide band gap oxide crystals can be very useful as detectors of ionizing radiation in a number of applications.
- $Lu_3Al_5O_{12}$:Pr (Pr:LuAG) is preliminary characterized for its application on FAMU experiment, whose goal is the measurement of the muon hydrogen proton radius, to solve the so called *proton radius puzzle*.
- Two experimental setups have been realized, either with a high QE Hamamatsu PMT (R11065) or with Hamamatsu SiPM arrays.

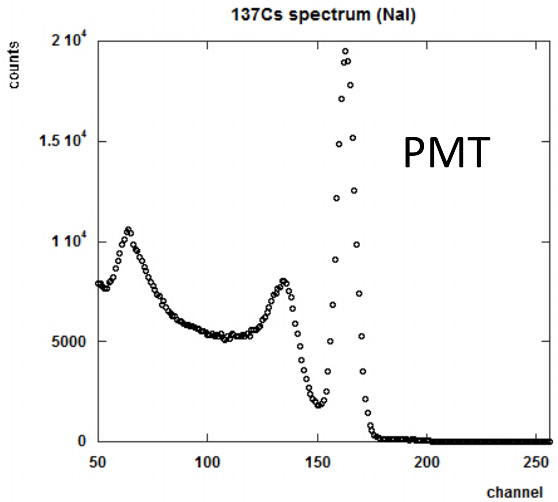


Pr:LuAG crystal faced to PMT window, inside a custom housing and ^{137}Cs source

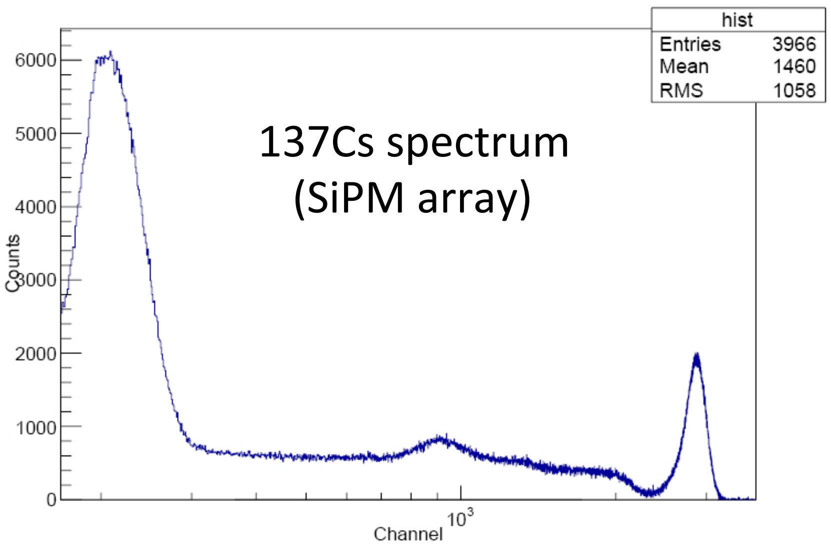








^{137}Cs 662 keV gamma peak is always well resolved. Energy resolution with PrLuAG ~ 13% (PMT setup) and ~ 10% (SiPM setup). NaI ~ 6% for comparison.



Effects, limiting the light collection from Pr:LuAG emission are under investigation:

- the Pr:LuAG light auto-absorption;
- the non-optimization of the reflector material (a deposition of $BaSO_4$ should improve the reflectivity).

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Neutrons

- neutrons
  - Fast Neutron and Gamma-ray Detection with Liquid-Xe Detector for Contraband Detection Dr. David Vartsky (Weizmann Institute of Science)
  - Neutron Detection by Large NaI Crystal Andrea Lavagno (TO)

^{3}He crisis

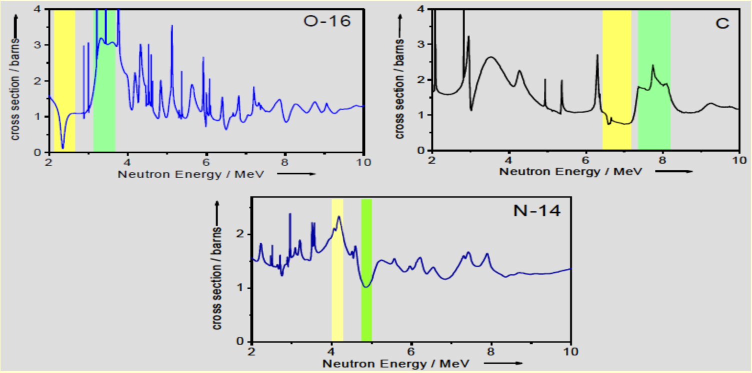
LIQUID Xe DETECTOR FOR CONTRABAND DETECTION

D. Vartsky[a], I. Israelashvili[a,c], M. Cortesi[b], L. Arazi[a], A.E Coimbra[a], E. Erdal[a], D. Bar[a], M. Rappaport[a], E. N. Caspi[c] & A. Breskin[a]

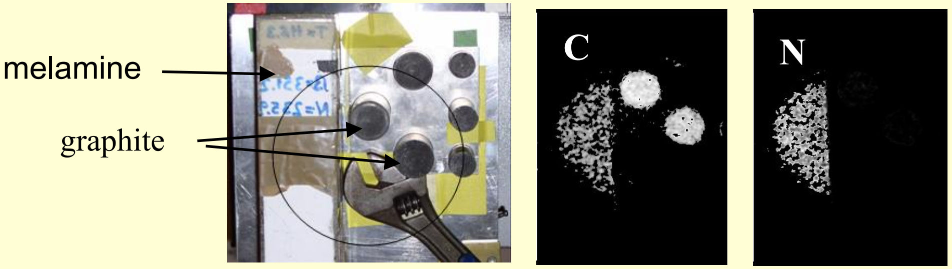
[a] Weizmann Institute of Science (WIS), Rehovot 76100, Israel
[b] National Superconducting Cyclotron Laboratory, East Lansing 48823 (MI), USA
[c] Nuclear Research Center of Negev (NRCN), Beer-Sheva 9001, Israel

Goal: Detection of hidden explosives & fissile materials in cargo and containers using Fast Neutron Resonant transmission Radiography **(FNRR)** and Dual Discrete Gamma-ray Radiography **(DDGR).**

- **FNRR** - 2-D, element-specific fast neutron imaging uses resonance features in X-sections of low-Z elements such as C, O, N and H which are the main constituents of explosives. A broad 1-10 MeV ns pulsed incident neutron spectrum is used for transmission radiography.



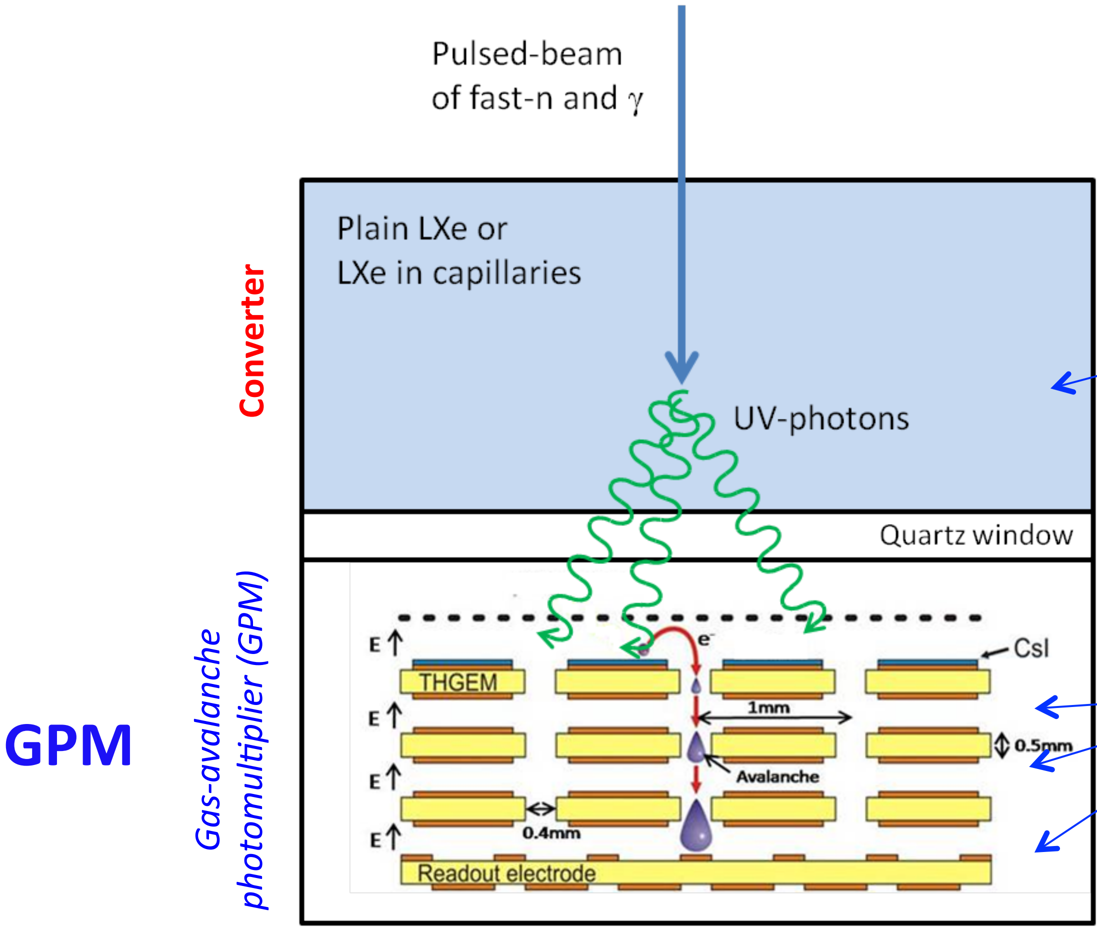
O, C, and N neutron cross-sections showing resonant features

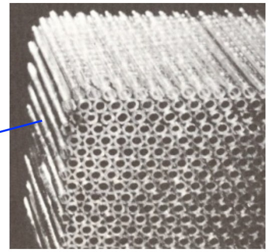


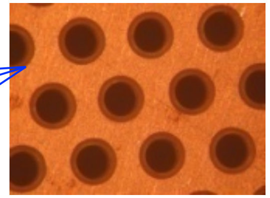
- In **DDGR** two discrete gamma-rays at 4.43 MeV and 15.1 MeV are applied for separating high-Z elements such as U and Pu from other objects.
- Both types of radiations are produced adequately in $^{11}B(d,n;\gamma)^{12}C$ reaction .

LXe 2D Imaging Detector for Fast-Neutrons & Gammas

***Fast-neutron /Gamma imaging detector.** Neutrons/gamma interact with **liquid-xenon**; the resulting scintillation (UV) photons are detected with a double-THGEM, CsI-coated gaseous photomultiplier.*







- **Large-area, efficient, economic**
- **Neutrons and gamma-rays detected by same detection medium (LXe)**
- **<u>LXe technologies:</u> mastered, rather simple**

Neutron Detection by Large NaI Crystal

A. Lavagno[1] and G. Gervino[2]

1. Department of Applied Science and Technology, Politecnico di Torino and INFN Torino, Italy
2. Department of Physics, Università di Torino and INFN Torino, Italy

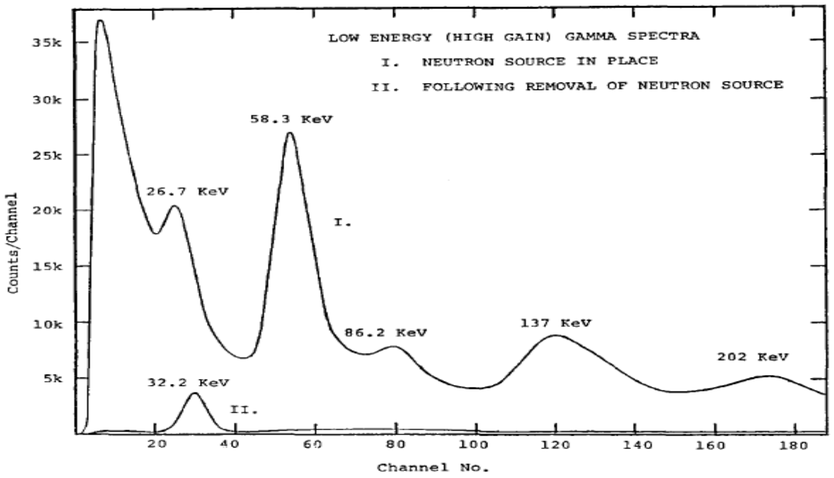
In present days new neutron detection methods are under development due to the global shortage of ^{3}He and the toxicity of BF_3. The performance of a cylindrical NaI crystal, 4" diameter and 8" length as indirect neutron detector have been investigated. Measurements were performed with bare and shielded NaI detector. The indirect detection of neutrons by photons has several advantages:
a) this method can in principle be suited by any gamma spectrometer with only slight modications that do not compromise its gamma spectrometry measurements;
b) fission neutron sources and neutron generators can be discriminated thanks to their different gamma energy spectra, a discrimination easily done by NaI spectrometer.

$$ {}^{127}\mathrm{I} + n \longrightarrow \overset{T_{1/2}=25\ \mathrm{min}}{{}^{128}\mathrm{I} + \gamma} \xrightarrow{\beta^-} {}^{128}\mathrm{Xe}(93.1\%) $$

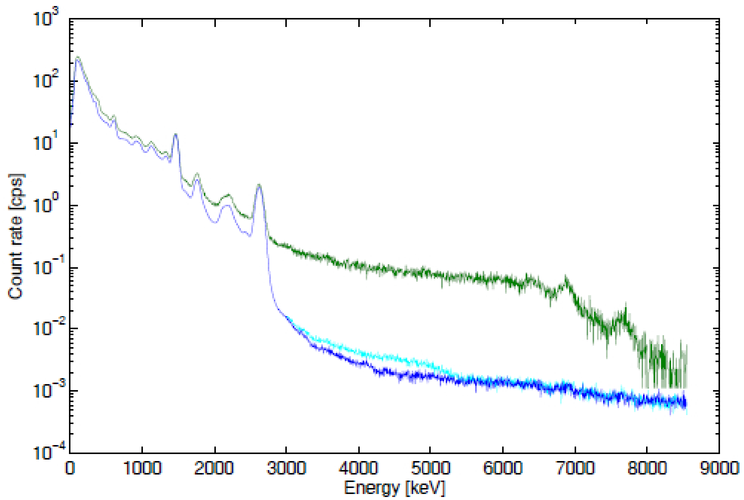
$$ {}^{128}\mathrm{I} \xrightarrow{EC+\beta^+} {}^{128}\mathrm{Te}(6.9\%) $$

$$ {}^{23}\mathrm{Na} + n \longrightarrow \overset{T_{1/2}=15\ \mathrm{h}}{{}^{24}\mathrm{Na} + \gamma} \xrightarrow{\beta^-} {}^{24}\mathrm{Mg} $$

Main neutron reactions inside NaI crystal



Typical gamma spectra obtained with NaI. Spectrum I, was collected when ^{256}Cf neutron source was in place, Spectrum II, was obtained after the removal of the neutron source.



Gamma detection taken with a NaI cylinder. The green line shows the ^{256}Cf spectra, the dark blue line shows the background, the light blue line shows the same background measurement taken after the neutron source measurement: the increasing counting rate from around 2.0 up to 5 MeV in the background indicates that the NaI crystal was slightly activated by the neutron flux.

The preliminary results demonstrate that a neutron detection ability can be added to a NaI spectrometer with only slight modifications. One of the future goals will be to find a proper neutron moderator specifically studied for home security applications. A 10 cm thick poliethylene shield could be a reasonable solution, a good compromise between size, weight, neutron thermalization performance and increasing of neutron detection efficiency.

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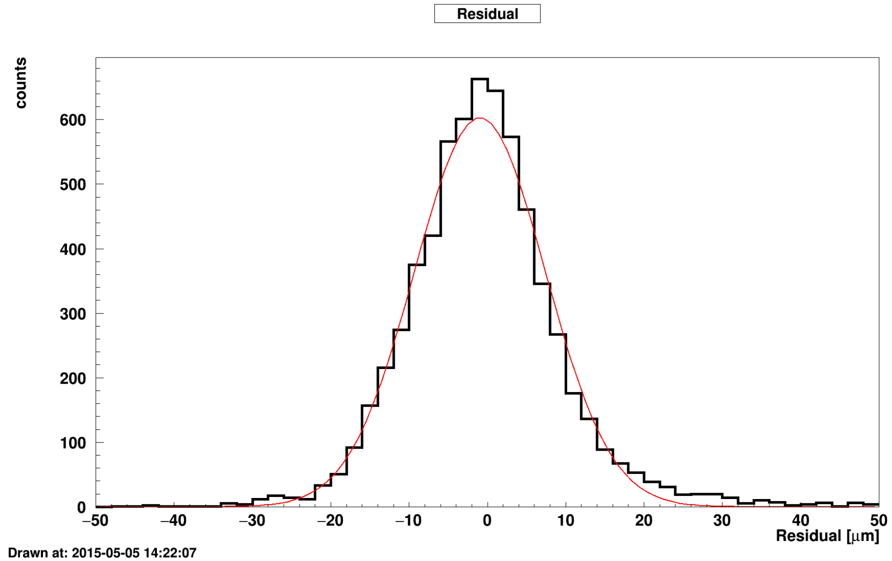
metrology

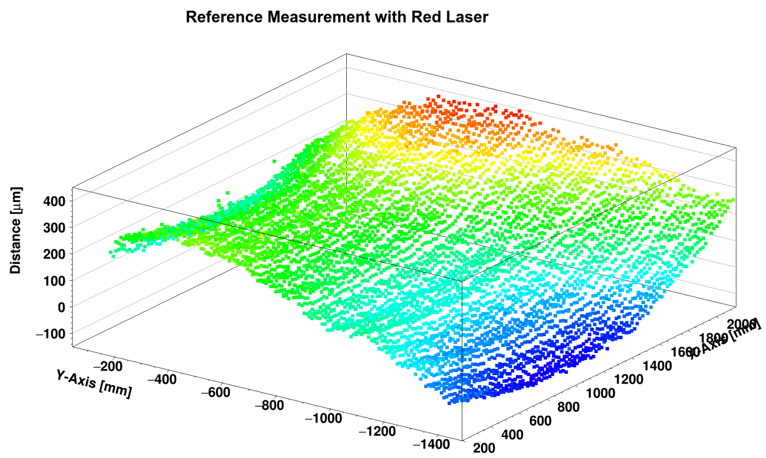
- metrology
  - Fast and Precise Large Area Topology Measurements Using Laser Distance Sensors Mr. Ralph Müller (LMU)
  - Watt's linkage based large band low frequency sensors for scientific applications Prof. Fabrizio Barone (NA)

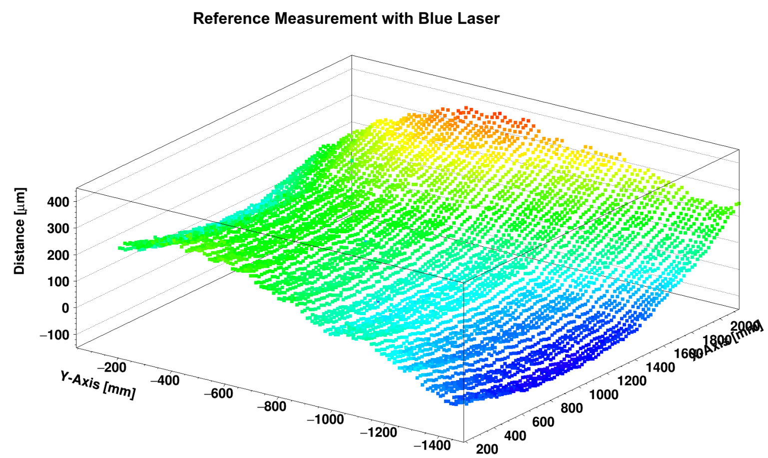
Granitetable as Reference Surface

- Planarity of granite table: $\sigma_{ref} < 6\ \mu m$
- Use of granite table as reference surface to eliminate miss measurement caused by bending of CMM
- Bending of CMM in order of 0.5 mm
- Two sensors available
  red laser $\lambda_{red} = 670\ nm$
  blue laser $\lambda_{blue} = 405\ nm$
- Less penetration of surface with shorter wavelength
  $\Rightarrow$ smoother reference surface with blue laser



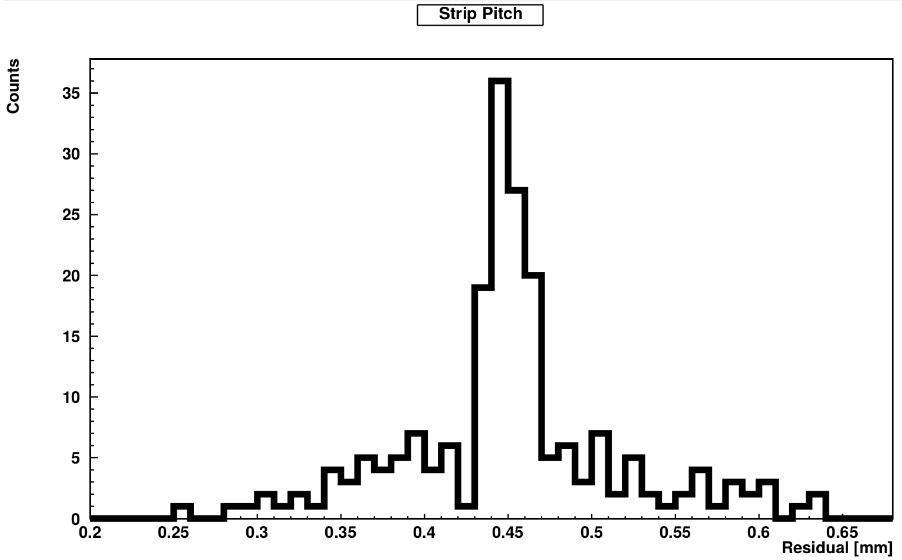
- Difference between reference measurements: $\sigma_{red-blue} = 9\ \mu m$

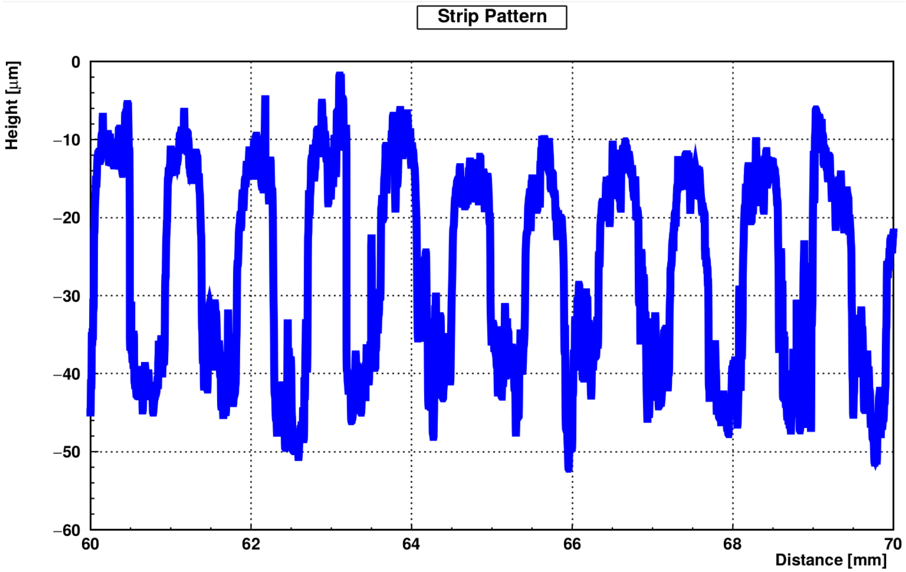


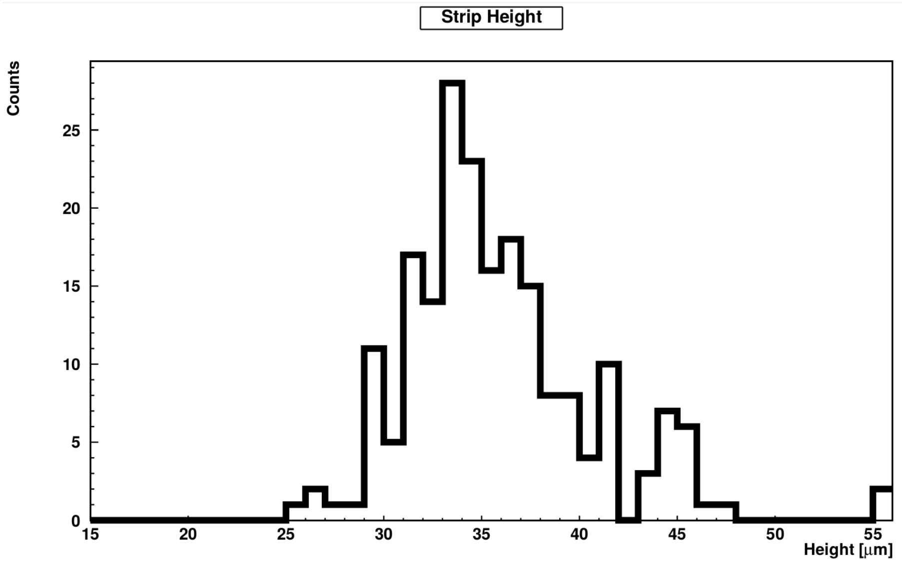


Copper Strips on FR4 PCB Material

- Scan of FR4 with 35 μm thick Cu-strips with a pitch of 450 μm
- Constant movement across surface
  Continuous readout
  $\Rightarrow$ 1 measurement point / μm
- Gaussian fit to strip pitch:
  $\mu_{pitch} = 451\ \mu m; \quad \sigma_{pitch} = 11\ \mu m$
- Gaussian fit to strip height:
  $\mu_{height} = 35\ \mu m; \quad \sigma_{height} = 3\ \mu m$





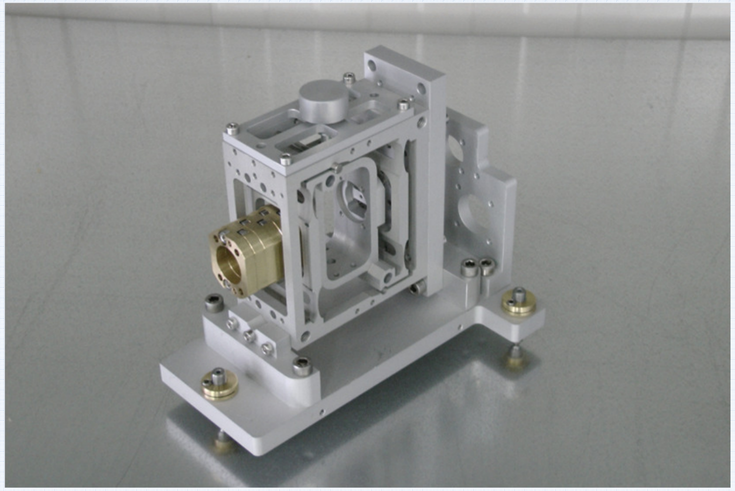


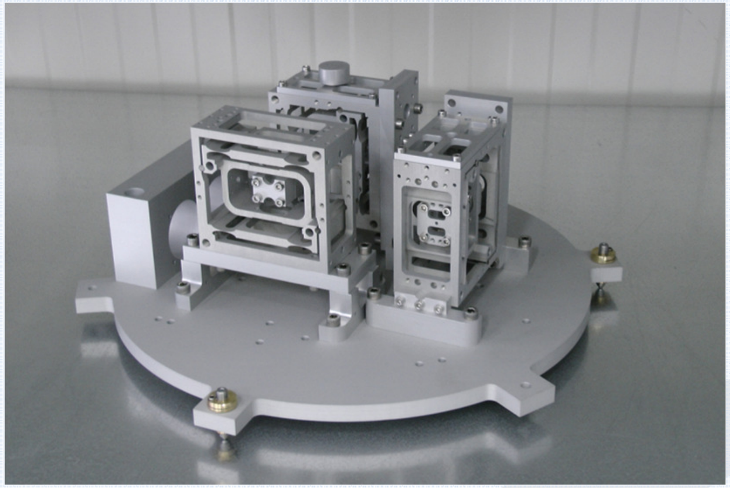
Watt's linkage based large-band low-frequency sensors for scientific applications

F. Barone, G. Giordano, F. Acernese, R. Romano
Università di Salerno and INFN, Sezione di Napoli, Italia

Goal: **implementation of triaxial seismometers and accelerometers for ground, space, and underwater applications, including ultra-high vacuum and cryogenics.**

Solution: **UNISA Folded Pendulum (Watt's linkage architecture).**





Horizonthal Monolithic Uniaxial and triaxial Seismometer/Accelerometer (2015)

UNISA Folded Pendulums Performances Ranges:

Band: $0{,}0001\ \mathrm{mHz} < B < 1\ \mathrm{kHz}$

Sensitivity: $10^{-15}\ \mathrm{m/Hz^{1/2}} < S < 10^{-6}\ \mathrm{m/Hz^{1/2}}$

Directivity: $> 10^4$

Quality Factor: Q > 16000 (UHV) - Q > 2000 (air)

Res. Freq. $50\ \mathrm{mHz} < f_0 < 1\ \mathrm{kHz}$

Scalability and Tunability

Modular Readouts: shadow meter, optical lever (PSD, quadrant photodiode), laser interferometer, optical fibre bundle, LVDT, capacitive sensor, etc.

Active Applications and Collaborations

Geophysics: Low –frequency seismic noise monitoring for characterization in the frequency band (10^{-8} – 10^{2}) of the Sos Enattos Mine (Lula) in Sardinia.

Historical Heritage: real-time low frequency monitoring of relevant italian monuments for structural characterization and conservation.

Bridges Safety: real-time low frequency monitoring of bridges for structural analysis and safety.

In Progress:

Very low Frequency seismometer: 20 mHz UNISA Folded Pendulum for geophysics.

Underwater low frequency microphone: Deep underwater (4 km) microphone .

Newtonian noise measurement: specialised version of theUNISA folded pendulum.

Control Accelerometer: open loop accelerometer for multi-stage suspensions .

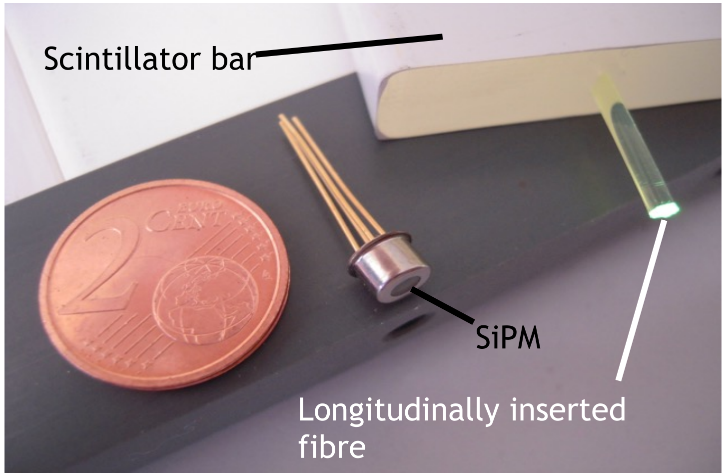
tracking

- tracking
  - A compact muon tracking system for didactic and outreach activities. Dr. ADRIANO DI GIOVANNI (NEW YORK UNIVERSITY ABU DHABI)

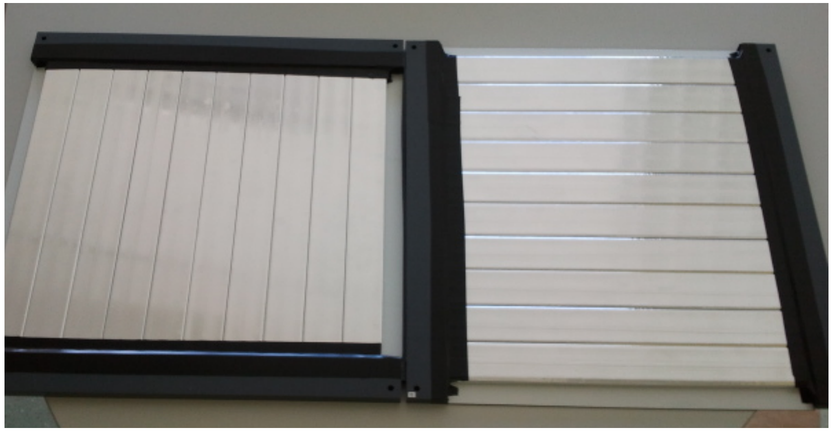
A Compact Muon Tracking System
for didactic and outreach activities

R. Antolini, Candela, A. Candela, V. Conicella, M. De Deo, M. D' Incecco, D. Sablone
Gran Sasso National Laboratory - Assergi (AQ), Italy
F. Arneodo, M. L. Benabderrahmane, A. Di Giovanni, L. Pazos Clemens[*]
New York University - Abu Dhabi, UAE
G. Franchi, M. d'Inzeo
Age Scientific srl - Capezzano Pianore (LU), Italy

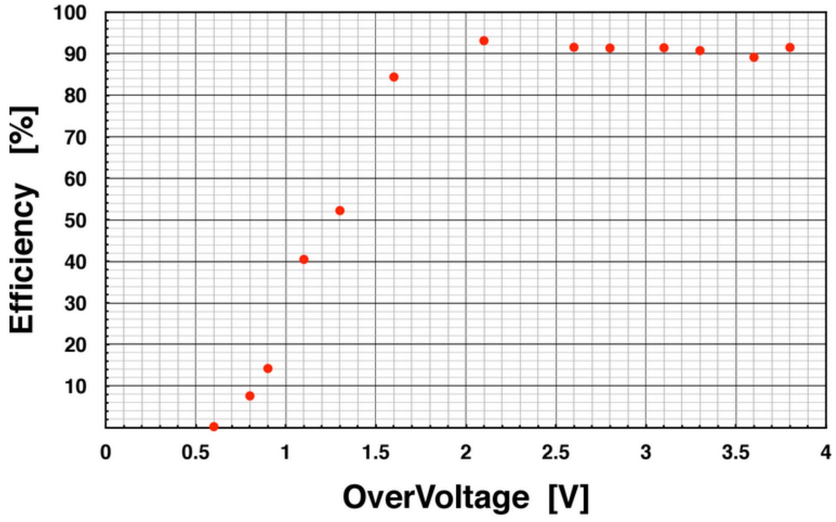
- Based on scintillator bars coupled to SiPMs.
- 10 scintillating levels, each one composed of 2 orthogonal planes of scintillator bars.
- 2 PCB controller boards.
- One viewing panel with LEDs per controller board.



Two monolithic boards serve as readout, trigger logic and to monitor the working parameters



A wavelength shifting fibre is inserted into each scintillator bar to shift the wavelength and propagate the light towards SiPMs.



The efficiency of a SiPM reaches 90% when an overvoltage of ≥2V is applied.

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Muon tomo

- Muon tomo
  - Development of a novel Micro Pattern Gaseous Detector for cosmic ray muon tomography
    Fabrizio Petrucci (ROMA3)

Development of a novel Micro Pattern Gaseous Detector for cosmic ray muon tomography

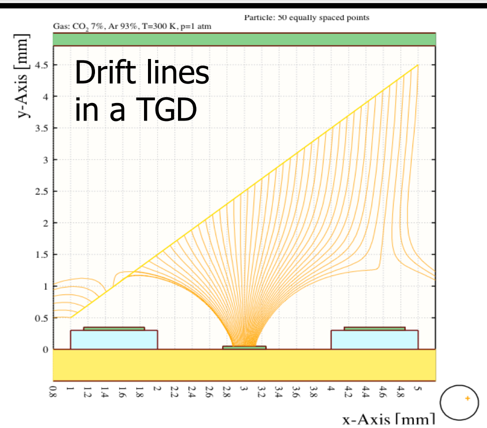
The use of cosmic ray tomography on a large scale is still disfavored because of the high cost and complexity of the detectors.

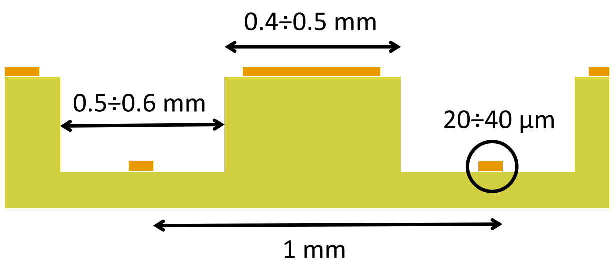
We propose a novel detector:
Thick Groove Detector (TGD)
with a single-layer spatial resolution of the order of 500 μm.

Main goals:

① Construction simplicity → limited costs;
② Potential for industrial mass production;

The TGD has a thin (<1 mm) amplification gap formed by alternate anode/cathode microstrips layers at different heights and a larger drift region. Its structure recalls the micro-groove detector [R. Bellazzini, et al., NIM A424 (1999) 444]



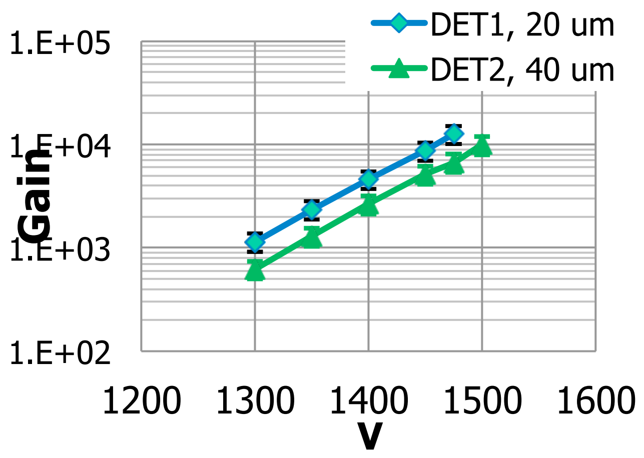


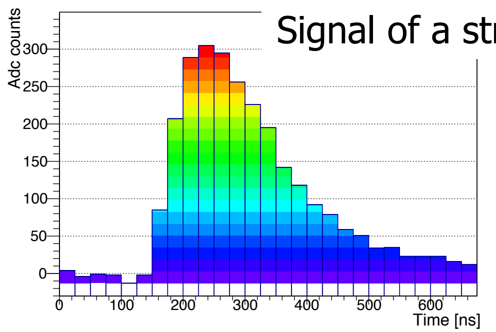
The first TGD prototype at CERN. It has a 10x10cm^2 active surface and it is divided in 4 different regions (25 strips each) with different test geometry.

M.Biglietti, V.Canale, S.Franchino, P.Iengo, M.Iodice, ***F.Petrucci***

Development of a novel Micro Pattern Gaseous Detector for cosmic ray muon tomography

The preliminary tests and the characterization of the detectors were performed using a Fe^{55} source. $Ar:CO_2$ 70:30 gas mixture was used. Anodic strips were connected to ground with a 100 kOhm resistor and the signal was sent to a preamplifier, a shaper and eventually to a multichannel analyzer. The currents were also measured to compute the gain.

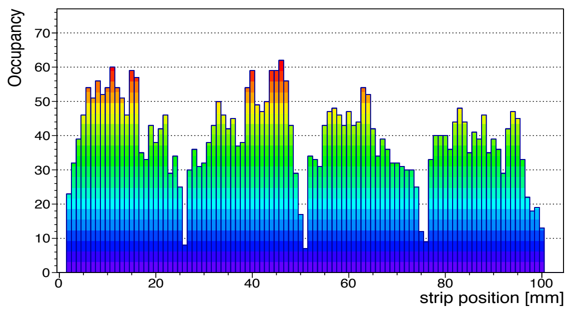




Signal of a strip.

The TGD prototype was exposed to cosmic rays. The detector was read-out with 2 APV-25 chips and operated with an $Ar:CO_2$ 93:7 gas mixture.

The occupancy of the 100 strips of the detector is fairly uniform, showing that all four regions are working. The drop of efficiency for the strips at the edges of each region is due to a distortion in the amplification field (edge effects).



For more details...have a look at the poster!

M.Biglietti, V.Canale, S.Franchino, P.Iengo, M.Iodice, ***F.Petrucci***

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calorimeters

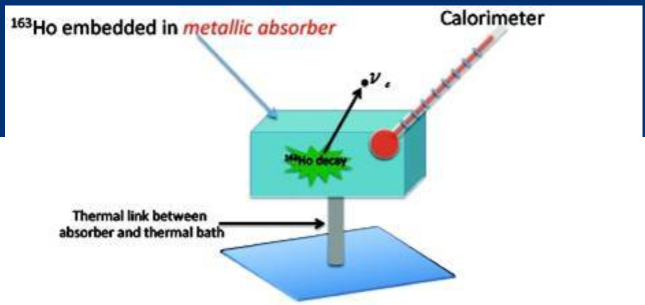
- Calorimeters
  - Inside Holmes experiment: 163Ho metallic target production for the micro-calorimeter absorber
    Giulio Pizzigoni (GE)

Inside HOLMES experiment: ^{163}Ho metallic target production for the micro-calorimeter absorber

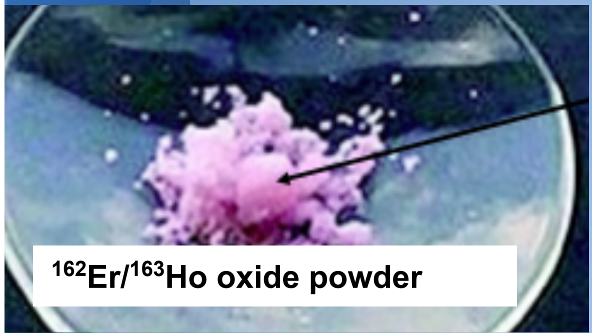
Giulio Pizzigoni - University and INFN of Genoa
Poster #306

European Research Council

The HOLMES experiment is aimed at directly measuring the electron neutrino mass using the electron capture (EC) decay of ^{163}Ho. HOLMES will deploy a large array of low temperature microcalorimeters with implanted ^{163}Ho nuclei. The resulting mass sensitivity will be as low as 0.4eV.



Holmium Reduction Distillation



^{162}Er/^{163}Ho oxide powder

^{163}Ho is not present in nature. One of the easier method for the ^{163}Ho production is neutron irradiation of enriched ^{162}Er samples, which is typically in oxide form therefore the final product is composed mainly by both Ho and Er oxides. Because the presence of oxide Ho would modify the shape of the calorimetric spectrum, it is necessary to purify the Ho sample by means of a reduction and distillation process.

In our laboratory we have proved how it is possible to obtain metal Ho starting from oxide Ho using the reduction distillation technique. Heating a mixture of metal Yttrium and oxide Holmium above the melting point, the oxygen is captured by Yttrium, leaving pure metallic Holmium which is free to evaporate from the mixture.

Metal Ho reduced and distilled from oxide Ho

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MC

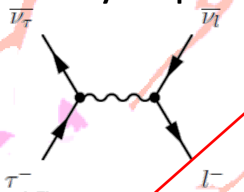
- MC
  - MC study of the measurement of Michel Parameters in the radioactive leptonic decay of tau Mr. Nobuhiro Shimizu (The University of Tokyo)
- ごめんなさい
- Gomen'nasai

MC study of the measurement of Michel parameters in the radiative leptonic decays of tau at Belle

The University of Tokyo Aihara/Yokoyama lab.
Nobuhiro Shimizu*, H.Aihara, Denis.E on behalf of Belle Collaboration

- Michel parameters (MP)
  - Assuming QFT and Lorenz invariance, amplitude of τ's leptonic decay are generally expressed as sum of S, V and T interactions with g_{ij}^{N} .

$\mathcal{M} =$



S : scalar
V : vector
T : tensor

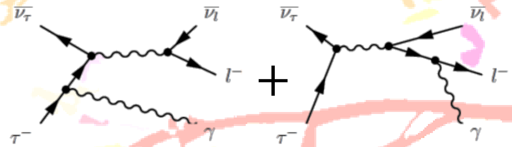
$$= \frac{4G_F}{\sqrt{2}} \sum_{\substack{N=S,V,T \\ i,j=L,R}} g_{ij}^{N} \left[\overline{u_i}(l^-)\Gamma^N v_n(\overline{\nu_l})\right] \left[\overline{u_m}(\nu_\tau)\Gamma_N u_j(\tau^-)\right]$$

good unbiased test of the SM, where only $g_{LL}^{V} = 1$ is nonzero

  - bilinear combinations of g_{ij}^{N} are experimentally observable →$\rho, \eta, \xi\delta, \xi, \bar{\eta}, \xi\kappa$
  - Measurement of $\rho, \eta, \xi\delta, \xi$ are already ongoing in ordinary leptonic decay $\tau \to l\bar{\nu}\nu$.
  - Of all MPs, $\bar{\eta}, \xi\kappa$ are measured only by radiative leptonic decay $\tau \to l\bar{\nu}\nu\gamma$
    - Small branching ratio : $\mathcal{B}_r(\tau \to e\bar{\nu}\nu\gamma) \sim 1.75\%$, $\mathcal{B}_r(\tau \to \mu\bar{\nu}\nu\gamma) \sim 0.36\%$, $E_\gamma > 10$ MeV (CLEO experiment)

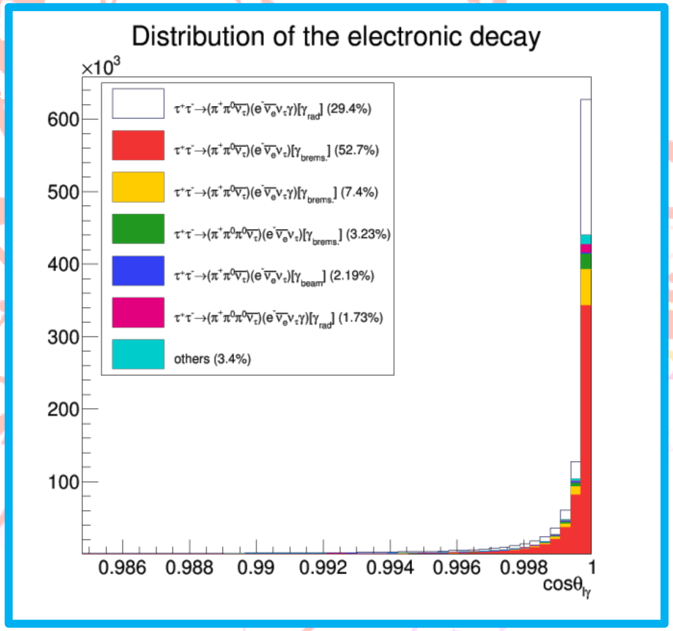
$$\bar{\eta} = \left|g_{RL}^{V}\right|^2 + \left|g_{LR}^{V}\right|^2 + \frac{1}{8}\left(\left|g_{RL}^{S} + 2g_{RL}^{T}\right|^2 + \left|g_{LR}^{S} + 2g_{LR}^{T}\right|^2\right) + 2\left(\left|g_{RL}^{T}\right|^2 + \left|g_{LR}^{T}\right|^2\right)$$

$$\xi\kappa = \left|g_{RL}^{V}\right|^2 - \left|g_{LR}^{V}\right|^2 + \frac{1}{8}\left(\left|g_{RL}^{S} + 2g_{RL}^{T}\right|^2 - \left|g_{LR}^{S} + 2g_{LR}^{T}\right|^2\right) + 2\left(\left|g_{RL}^{T}\right|^2 - \left|g_{LR}^{T}\right|^2\right)$$

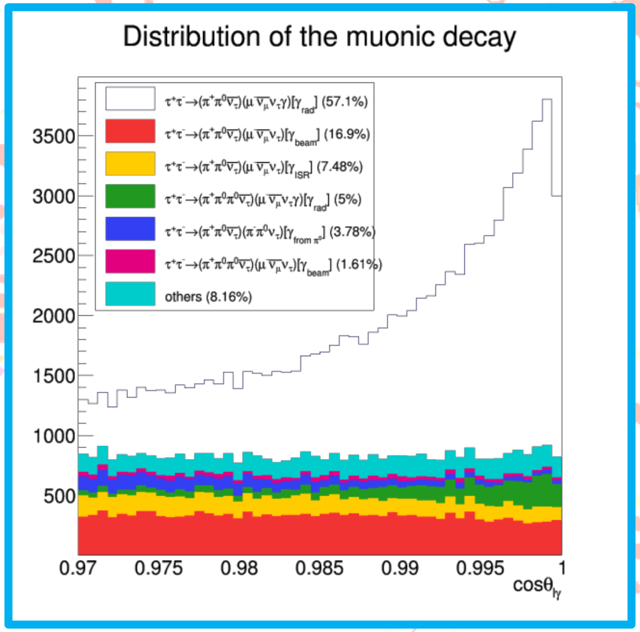


MP	ρ	η	$\xi\delta$	ξ	$\bar{\eta}$	$\xi\kappa$
SM	0.75	0	0.75	1	0	0
EX	$0.747 \pm 0.010 \pm 0.006$ 1.2%	$0.012 \pm 0.026 \pm 0.004$ 2.6%	$0.0745 \pm 0.026 \pm 0.009$ 2.8%	$1.007 \pm 0.040 \pm 0.015$ 4.3%	not measured yet	

In order to extract the Michel parameters $(\bar{\eta}, \xi\kappa)$, $(\tau, \tau) \rightarrow (\pi\pi^0, l\gamma)$ events are used.
Here $l = e, \mu$.
Background events for this mode was determined as follows:



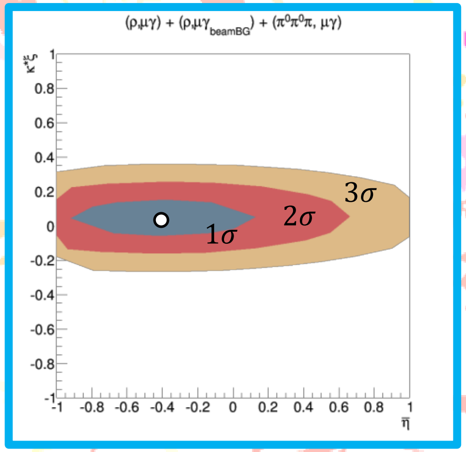
$(\tau, \tau) \rightarrow (\pi\pi^0, e\gamma)$



$(\tau, \tau) \rightarrow (\pi\pi^0, \mu\gamma)$

Electron mode:
major BG is "extra"-brems.

Muon mode:
1. beam BG
2. ISR γ + $(\pi\pi^0, l)$
3. $(\pi\pi^0\pi^0, l\gamma)$



Probability density function of events is calculated on the 12 dimension phase space and it is used to construct likelihood function.
Minimization of the likelihood function gives us the Michel parameters.

$$P(\vec{x}) = (1 - \sum_i \lambda_i) \cdot \frac{S(\vec{x})\varepsilon(\vec{x})}{\int d\vec{x} S(\vec{x})\varepsilon(\vec{x})} + \sum_i \lambda_i \frac{B_i(\vec{x})\varepsilon(\vec{x})}{\int d\vec{x} B_i(\vec{x})\varepsilon(\vec{x})} \Rightarrow \mathcal{L}(\bar{\eta}, \xi\kappa) = - \sum_{k=1}^{Nevents} \log P\left(\overrightarrow{x^{(k)}}\right)$$