Poster Overview for Photodetectors and Particle Identification Session (Experimental Applications)

Neville Harnew

University of Oxford

14th Pisa Meeting on Advanced Detectors

May 27 – June 2 , 2018

Frontier Detectors for Frontier Physics

UNIVERSITY OF OXFORD

Poster Overview (19)

ID	Title	Presenter
174	Upgrade of the Time-of-Flight system of the CMD-3 detector	AMIRKHANOV, Artem
302	Evaluation of a hybrid pixel detector prototype for time resolved experiments at the ODE beamline of the SOLEIL Synchrotron	BACHILLER-PEREA, Diana
70	The upgraded beam monitor system for the FAMU experiment at RIKEN-RAL	BONESINI, Maurizio
334	Proton flux monitor(s) for the UA9 Experiment	DUBOS, Sebastien
309	The Endcap Disc DIRC detector of PANDA	FÖHL, Klaus
271	Operational Evaluation of Silicon Photomultiplier Based Prototype Detector Modules Installed in the MAGIC Telescopes	HAHN, Alexander
431	PID techniques and performance at LHCb in Run 2	HUSHCHYN, Mikhail
390	MCP-PMT production for Belle II TOP detector and further R&D	INAMI, Kenji
283	Performance of X-rays crystal detectors with SiPM array readout exposed to the RIKEN RAL low energy muon beam	MENEGOLLI, Alessandro
196	First Experience with the Belle II Aerogel RICH Detector	MRVAR, Manca
145	Optimal Design of Plastic Scintillator Counter with Multiple SiPM Readouts for Best Time Resolution	ONDA, Rina
297	The Barrel DIRC detector of PANDA	SCHWARZ, Carsten
184	Linearity and Saturation Properties of Hamamatsu R5912-MOD Photomultiplier Tube for the ICARUS T600 light detection system	SPANU, Maura Ninuccia
229	A low energy x-ray Compton polarimeter prototype	SPILLMANN, Uwe
298	The PANDA barrel-TOF detector at FAIR	ZIMMERMANN, Sebastian
383	Fast Neutron detectors with silicon photomultiplier readouts	AKBAROV, Ramil
107	The TORCH PMT, a close packing, long life MCP-PMT for Cherenkov applications with a novel high granularity multi-anode	MILNES, James
407	Neutrino-Antineutrino identification in a liquid scintillator: towards a novel decay-at-rest based neutrino CPV framework	GRASSI, Marco
209	TORCH: a large area time-of-flight detector for particle identification	HARNEW, Neville

Poster themes

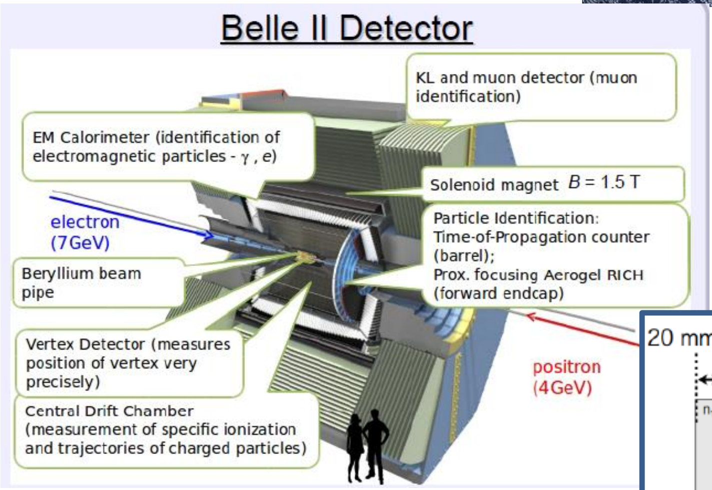
- Cherenkov detectors for running collider experiments and those in preparation
- Time-of-flight detectors
- Detectors for neutrino and astro-particle experiments
- Detectors for beam-line monitoring
- Atomic and nuclear physics detectors

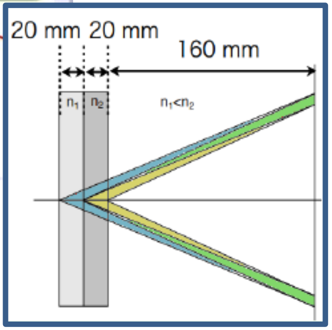
Cherenkov detectors for running collider experiments and those in preparation

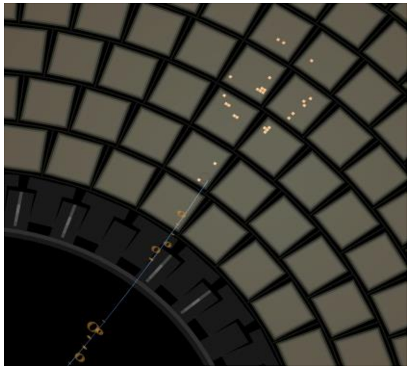
ID 196 : First Experience with the Belle II Aerogel RICH Detector

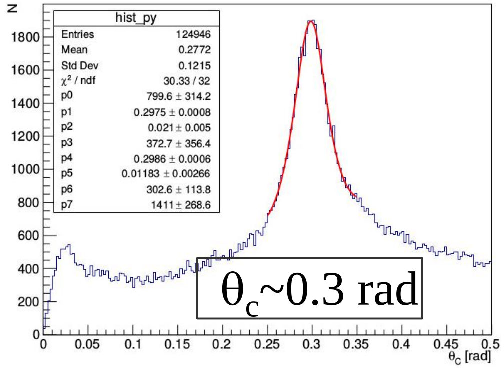
Manca Mrvar, Jožef Stefan Institute Ljubljana, Slovenia
(on behalf of Belle II ARICH group)

- Aerogel RICH detector was assembled in 2017 → into forward endcap of Belle II
- Separate charged kaons from pions for momenta between 0.5-4.0 GeV/c
- First global cosmic ray data were taken in February 2018 and first beam collision data in April
- Cherenkov rings, created by cosmic rays and by charged particles from beam collisions, have been observed
- A clear peak is seen in Cherenkov angle distribution
- Kaon identification efficiency was studied and will be calibrated with first collision data



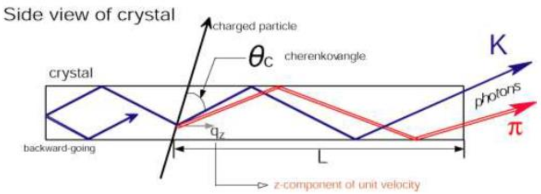




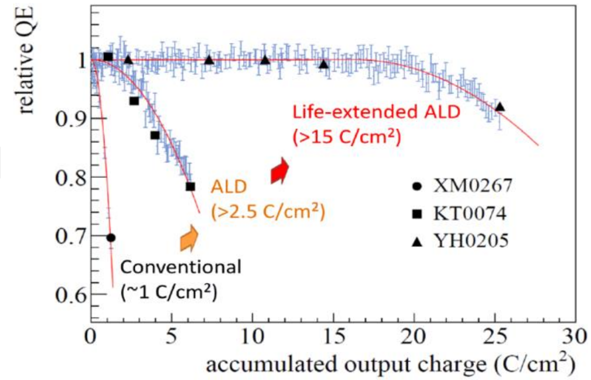


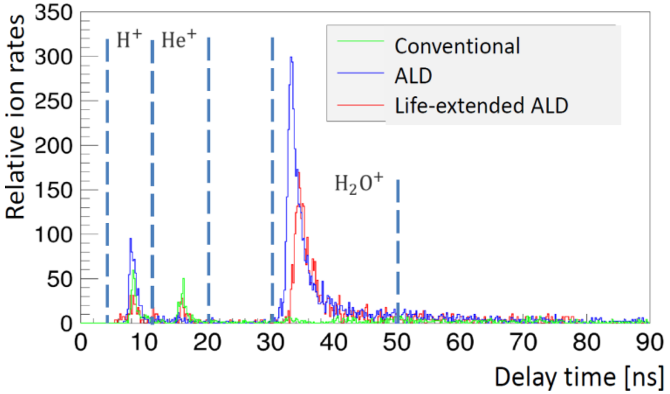
ID 390 : MCP-PMT production for the Belle II TOP detector and further R&D

Kenji Inami (Nagoya University) for the Belle II TOP group



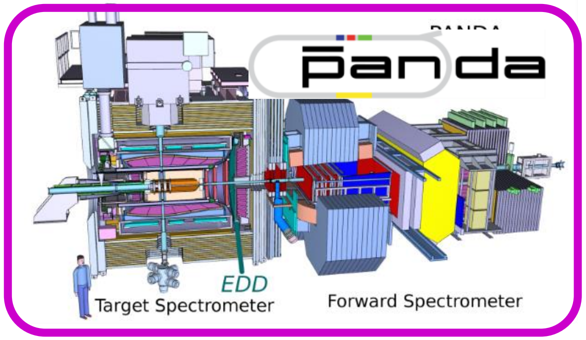
- The Belle-II TOP (Time of Propagation) barrel particle identification detector addressed in an oral presentation
- 1-inch square MCP-PMTs (Hamamatsu R10754-07-M16) have been developed which realize the precise timing measurement required σ<50ps for single photons
- Studies to improve the MCP-PMT photo-cathode lifetime: by applying ALD technique on MCP and further residual gas reduction process, the lifetime has improved significantly
- Produced >600 PMTs including spares, and installed 512 PMTs into Belle II TOP. Half of these are conventional MCPs which will be replaced in 2020
- To understand the mechanism of photo-cathode deterioration, ion feed-back signals have been studied it is not the fed-backed ions that primarily damage the photocathode condition, rather other contributions such as residual gas



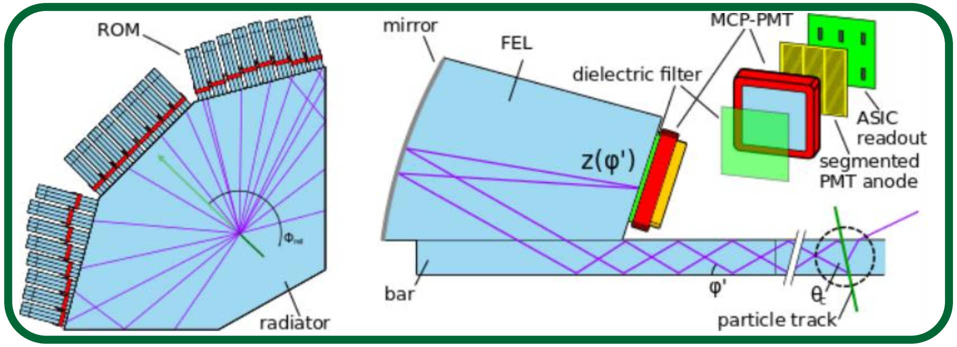


ID 309 : The Endcap Disc DIRC detector of PANDA

(DIRC: **D**etection of **I**nternally **R**eflected **C**herenkov light)

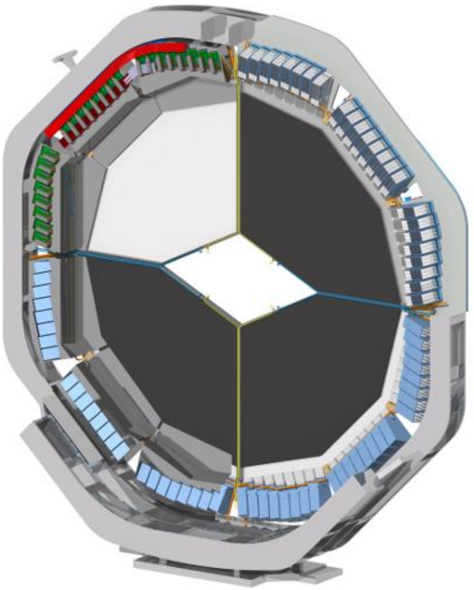


PID in PANDA at FAIR



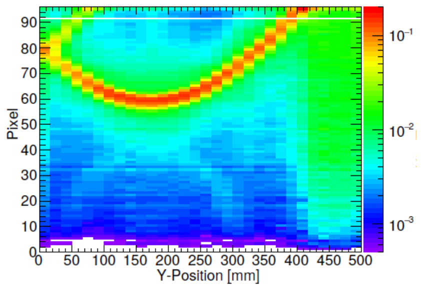
DIRC endcap disc using quartz radiator discs. MCP readout

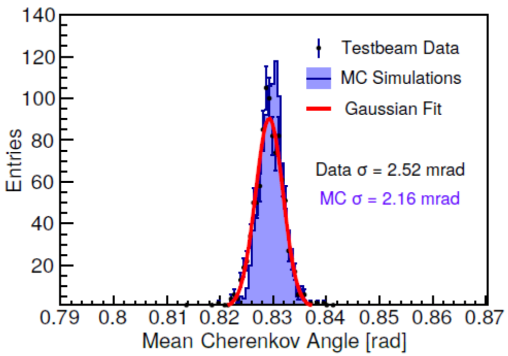
Klaus Föhl
on behalf of the
PANDA Cherenkov Group
II. Physikalisches Institut
Heinrich-Buff-Ring 16
D-35392 Gießen, Germany



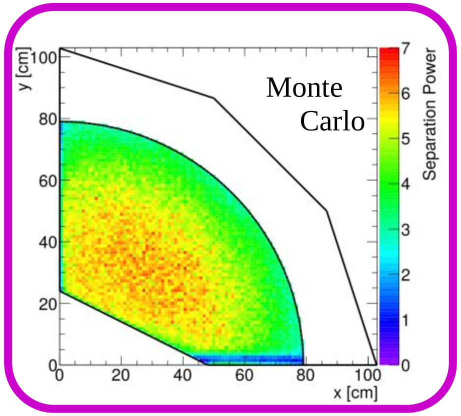
EDD cut-away view from downstream

Testbeam
3 GeV/c
electrons



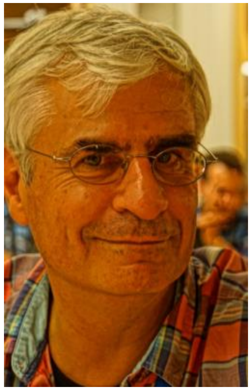


MC. kaon/pion 3 s.d. at 4 GeV/c

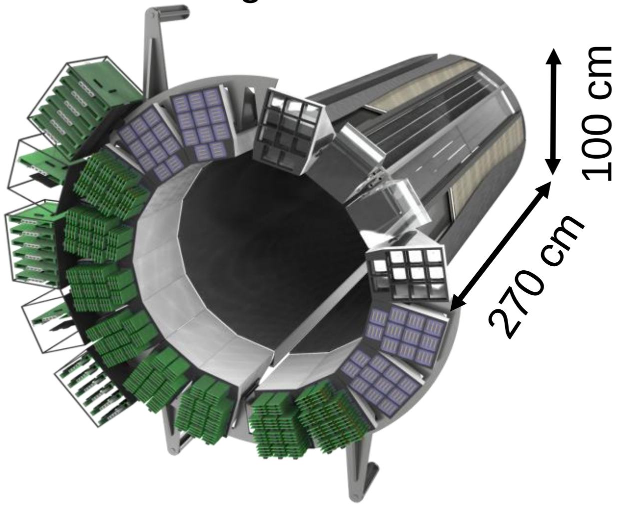


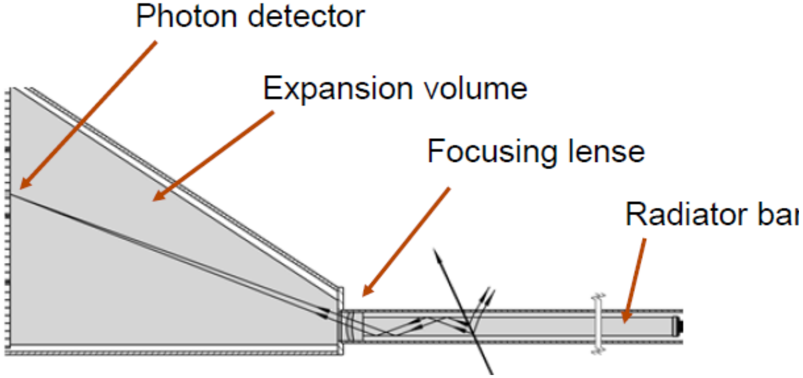
ID 297 : The Barrel DIRC detector of PANDA

Carsten Schwarz (C.Schwarz@gsi.de), GSI Darmstadt
(For the PANDA-Cherenkov group)

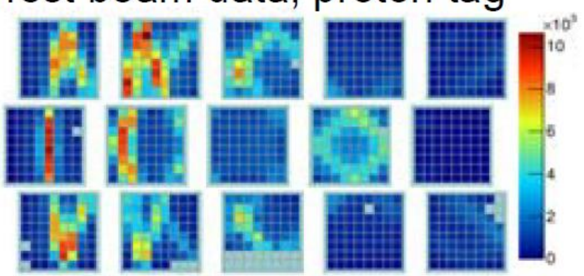


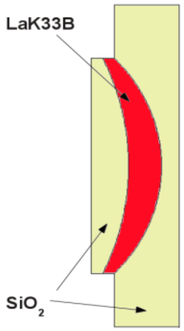
- The development of a DIRC counter aims for a compact Cherenkov counter with the photon detector outside of the active detector volume.
- Highly-polished artificial fused silica bars act as radiator and as light guide. MCP readout.
- Improvements over the successful BABAR-DIRC are smaller expansion volume, lens focusing and fast readout electronics.

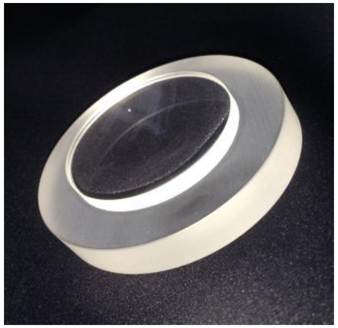


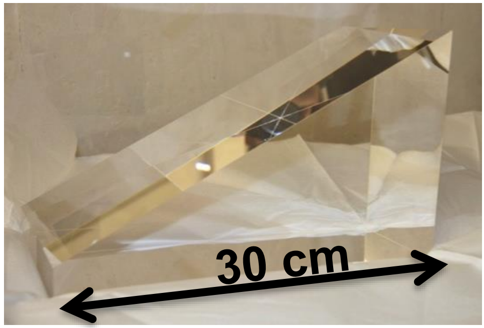


Test beam data, proton tag





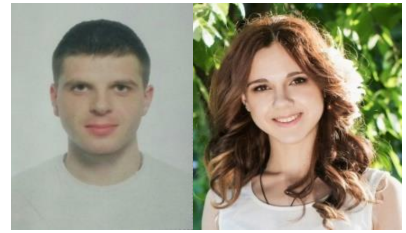




ID 431 : PID Techniques and Performance at LHCb in Run 2

Mikhail Hushchyn and Victoria Chekalina
on behalf of the LHCb collaboration

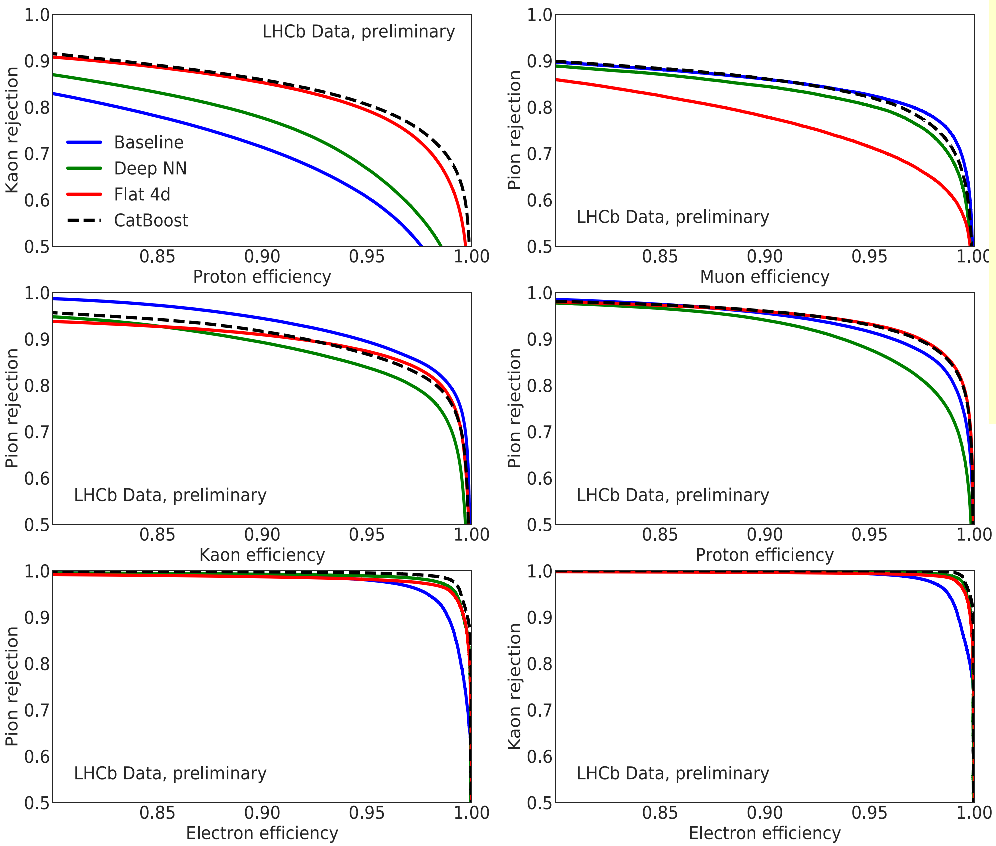
National Research University Higher School of Economics and Yandex School of Data Analysis



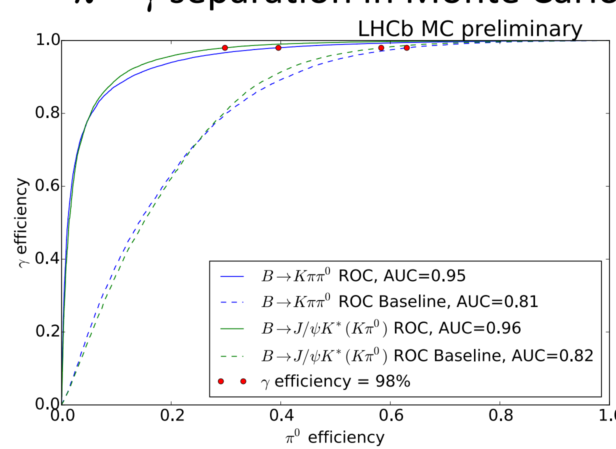
SCHOOL OF DATA ANALYSIS

- Charged particle PID is essential for all LHCb physics analyses
- Use advanced machine learning (multivariate) techniques to combine information from two RICH detectors, calorimeters & muon systems
- PID performance can also be improved for charged ID and neutral particle (π^0 γ) separation

Comparison of PID performance with Run 2 data



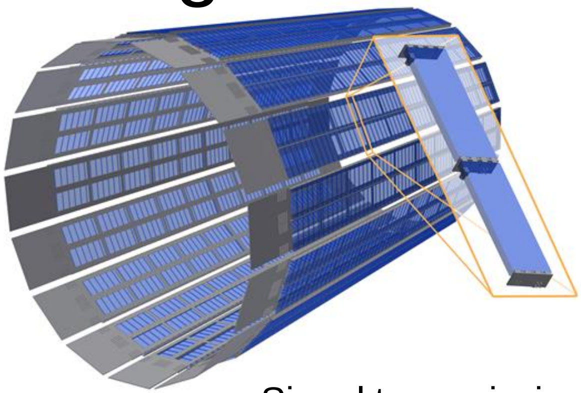
π^0 - γ separation in Monte Carlo



Time-of-flight detectors

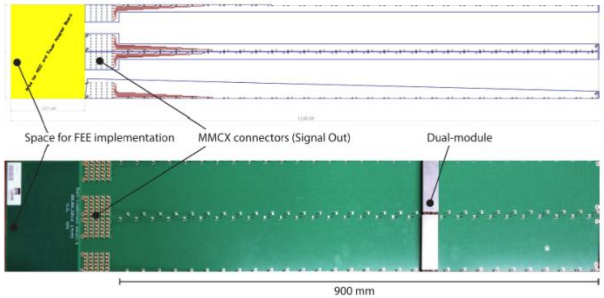
ID 298: The PANDA Barrel Time-of-Flight Detector

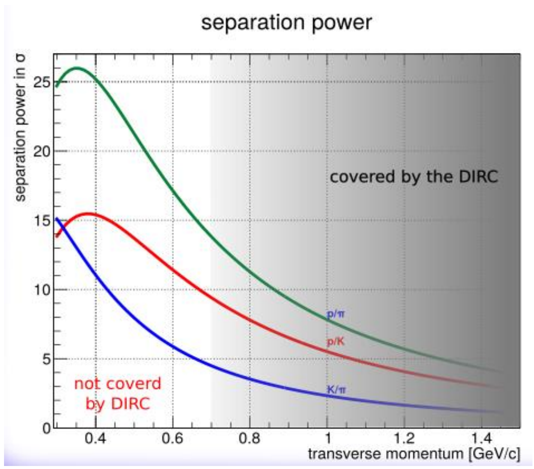
Authors: Sebastian Zimmermann, Stefan Meyer Institute Vienna, JLU Gießen
K. Suzuki, D. Steinschaden, N. Kratochwil, W. Nalti,
H. Orth, C. Schwarz, A. Lehmann, M. Böhm, K.-Th. Brinkmann



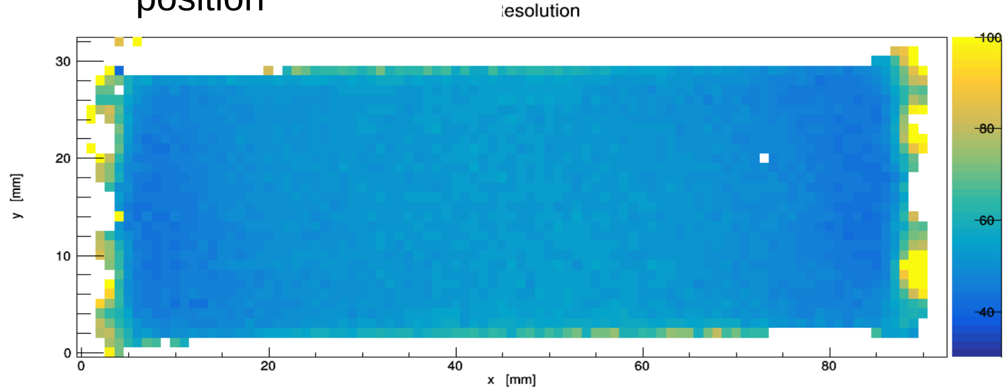
- PANDA ToF detector: radius 0.5 m, length 2 m.
- 1920 scintillator tiles, each 87x29x5 mm^3, read out by 15260 SIPMs.
- Large PCB (2m long) also acts as mechanical support.
- An average time resolution of ~51 ps for a scintillator has been achieved across the tile.
- Separation power below the Cherenkov threshold of the DIRC detectors is above 5 sigma.

Signal transmission





Time resolution (ps) as a function of position

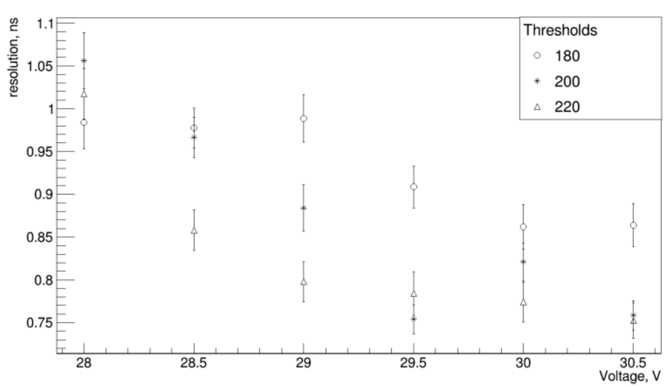


ID 174 : Upgrade of the Time of Flight system of the CMD-3 detector

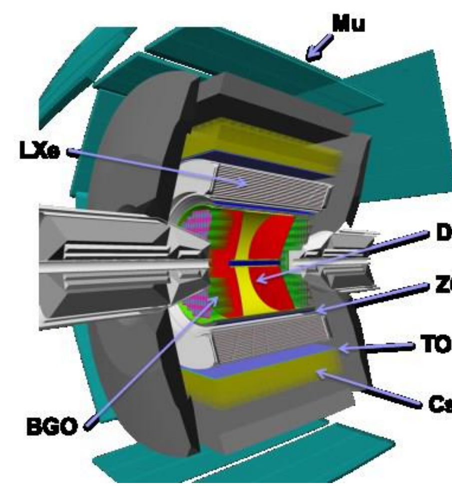
Artem Amirkhanov, on behalf of the CMD-3 collaboration

Budker Institute of Nuclear Physics, Novosibirsk, Russia

- The time-of-flight (TOF) system is installed at the CMD-3 detector at the VEPP-2000 e^+e^- collider at the Budker Institute of Nuclear Physics.
- The TOF is located inside the narrow gap (<6 cm) between two layers of the cylindrical calorimeter
- It is made from thin plates (thickness 5-7 mm) of plastic scintillator with wavelength shifting fibers read out at each end with silicon photomultipliers (SiPMs).
- High granularity of the system - 175 plates in total
- Special digitizing electronics have been produced



Time resolution vs SiPM bias voltage for different thresholds → resolution better than 1 ns.



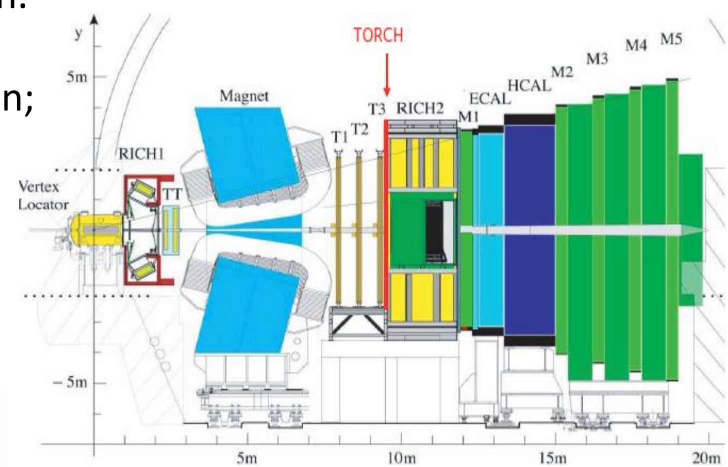
ID 209 **THE TORCH DETECTOR**

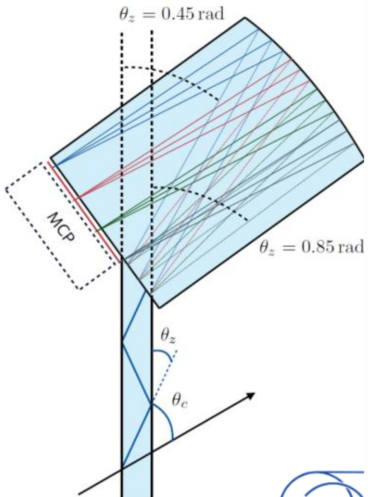
Time of Internally Reflected Cherenkov Light

S. Bhasin, T. Blake, N. Brook, T. Conneely, D. Cussans, M. van Dijk, R. Forty, C. Frei, E. P. M. Gabriel, R. Gao, T. Gershon, T. Gys, T. Hadavizadeh, T. H. Hancock, N. Harnew, M. Kreps, J. Milnes, D. Piedigrossi, J. Rademacker.

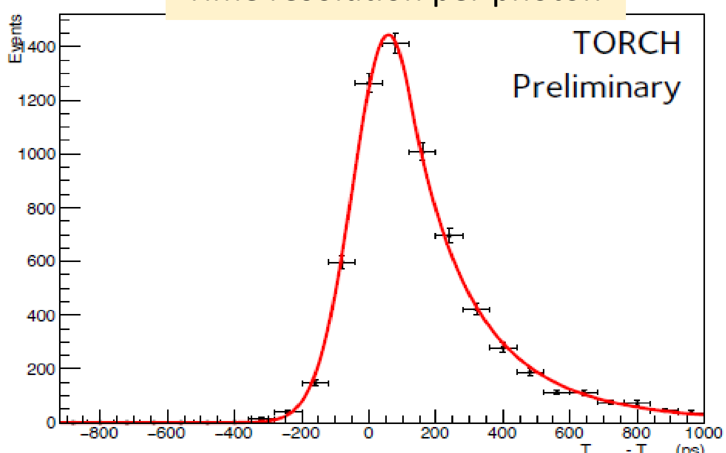
N. Harnew for the TORCH collaboration

- TORCH is a time of flight detector which gives positive PID for low momentum particles between 2-10 GeV/c over a 10m flight path.
- It is proposed for the LHCb Phase 2 Upgrade.
- Aim is to measure individual photons with ~70 ps time resolution; given 30 detected photons, this gives 15 ps per track.
- MCP-PMTs, developed in collaboration with Photek (see next slide), detect Cherenkov photons.
- Each MCP detector needs 128x8 effective granularity over 53x53mm^2 active area





Time resolution per photon



- A small-scale TORCH prototype tested in CERN PS 5 GeV/c pion-proton beam with a single MCP-PMT.
- Resolution of ~100 ps per single photon achieved.

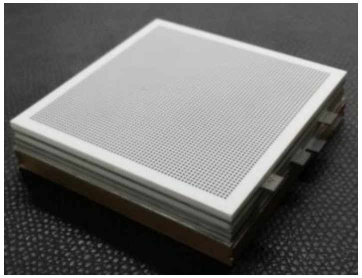
University of BRISTOL · CERN · The University of Edinburgh · erc European Research Council · University of Oxford · PHOTEK Envisage the future · WARWICK The University of Warwick · LHCb

ID 431: The TORCH PMT, a close packing, long life MCP-PMT for Cherenkov applications with a novel high granularity multi-anode

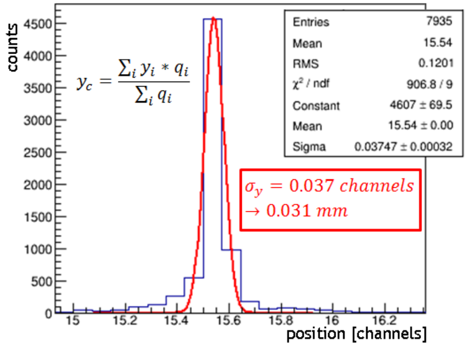
J S Milnes[(a)], T M Conneely[(a)] & J Lapington[(b)]*

TORCH is an R&D project to upgrade LHCb Particle ID capabilities in the 2-10 GeV/c momentum region and has received ERC grant funding. Photek's role was to develop a novel square MCP detector with < 50 ps photon timing accuracy and the following technical aims:

- A lifetime of 5 C/cm^2 of accumulated anode charge or better
- A multi-anode readout equivalent to 8x128 pixels over 53 mm^2, fine pitch resolution target σ = 0.12 mm
- Close packing on two opposing sides with a fill factor of 88% or better (within a 60 mm envelope)



Position resolution: with single position of focussed laser spot on detector, and using charge division between pixels: σ = 0.031 mm



L. Castillo García et al JINST 11 C05022 (2016)

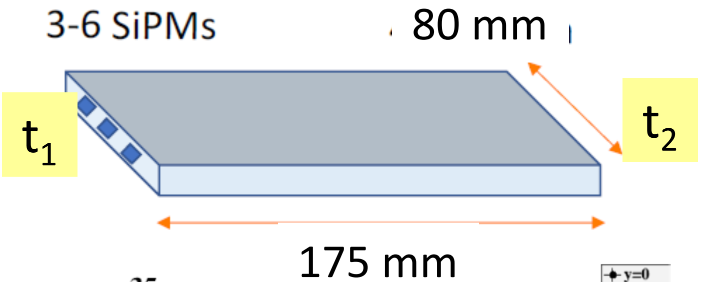
(a) Photek Ltd, St Leonards on Sea, East Sussex, UK.
(b) University of Leicester, Leicester, UK
**Presenting Author*

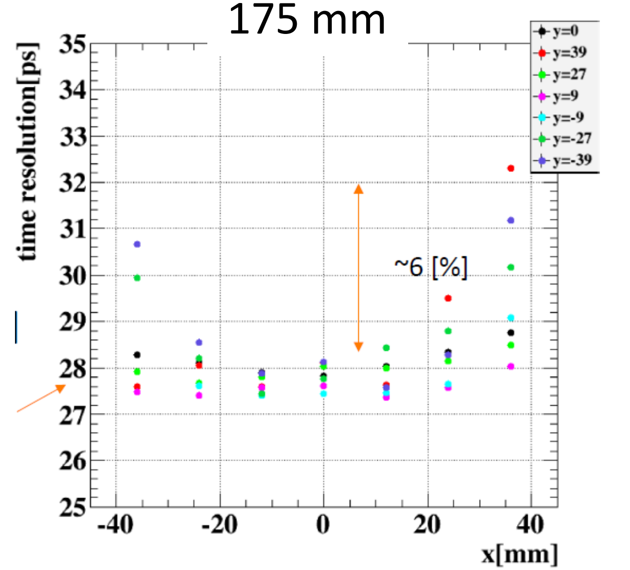
ID 145 : Optimal Design of Plastic Scintillator Counter with Multiple SiPM Readouts for Best Time Resolution

Rina Onda, K. Ieki, T. Iwamoto, S. Kobayashi, N. Matsuzawa, T. Mori, M. Nakao, M. Nishimura, S. Ogawa, W. Ootani, Y. Uchiyama

The University of Tokyo

- The study aims to make a timing counter with best possible time resolution using a ~10 cm square plastic scintillator read out by multiple SiPMs. To achieve this, the following features were investigated:
  - Optimal connection scheme of SiPMs
  - Optimal scintillator and geometry
- 28 ps time resolution has been achieved with a counter read out by 4 SiPMs on each side and EJ230 scintillator, size of $80 \times 175 \times 5$ mm^3





Detectors for Neutrino and Astro-Particle Experiments

Neutrino-Antineutrino Identification in a Liquid Scintillator Detector

ID407 Towards a novel decay-at-rest-based neutrino CPV framework

M. Grassi *[APC/CNRS (Paris FR)], F. Pessina, A. Cabrera, S. Dusini, H. Nunokawa, F. Suekane*

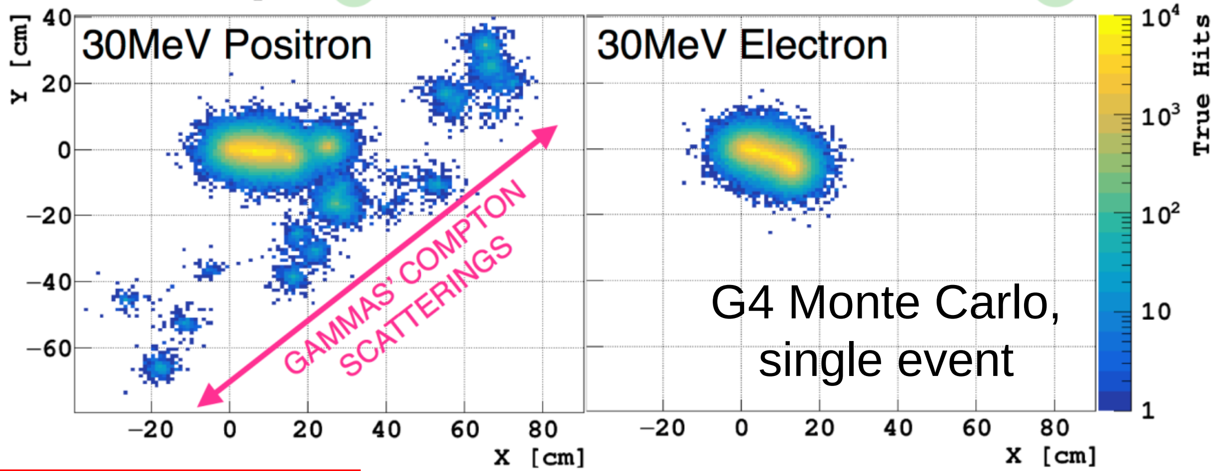
Purpose: to perform a low-systematics neutrino CP violation experiment by measuring oscillation probabilities of (anti)neutrinos emitted by pion and muon decay at rest

Inverse beta decay

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

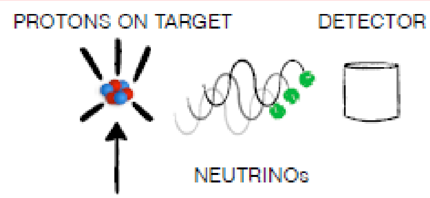
Pb-loaded inverse beta decay

$$\nu_e + {}^{208}\mathrm{Pb} \rightarrow {}^{208}\mathrm{Bi}^* + e^-$$

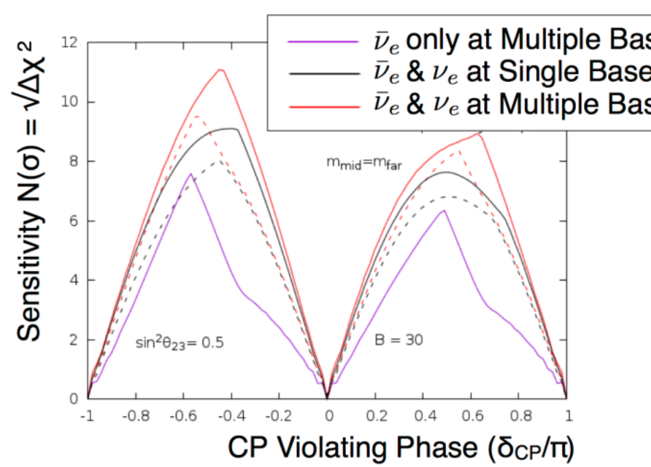


$$\pi^+ \rightarrow \mu^+ + \nu_\mu^{(\pi)}$$

$$\mu^+ \rightarrow e^+ + \nu_e^{(\mu)} + \bar{\nu}_\mu^{(\mu)}$$



How: visualize (anti)neutrino interactions taking place in a liquid scintillator loaded with a heavy element (eg. Pb), which provides e+ and e- discrimination



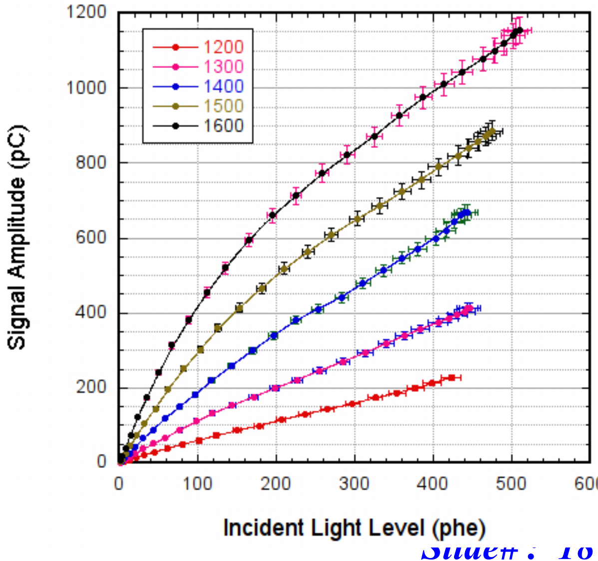
ID 184 : Linearity and Saturation Properties of Hamamatsu R5912-MOD Photomultiplier Tube for the ICARUS T600 light detection system

*M. Babicz[1,2], V. Bellini[3], M. Bonesini[4], T. Cervi[5], A. Falcone[6], A. Menegolli[5], C. Montanari[5], F. Pietropaolo[2], G.L. Raselli[5], M. Rossella[5], **M. Spanu[7]**, M. Torti[4], F. Tortorici[3], A. Zani[2]*

maura.spanu@cern.ch

[1]Institute of Nuclear Physics PAN, Crakow, Poland; [2]CERN, Geneva, Switzerland; [3]Università di Catania e INFN, Catania, Italy; [4]INFN Sezione di Milano Bicocca, Milano, Italy; [5]Università di Pavia e INFN, Pavia, Italy; [6]University of Texas at Arlington, Arlington, USA; [7]Brookhaven National Laboratory, Brookhaven, USA

- The ICARUS T600 liquid argon time projection chamber (LAr-TPC) will be used as the far detector of the Short Baseline Neutrino (SBN) program at FNAL.
- A new scintillation light detection system is required to distinguish the actual beam related events from the huge cosmic background.
- The response of the 8” Hamamatsu R5912-MOD PMT model as a function of the incident light intensity has been evaluated in terms of linearity and saturation.
- Good linearity observed, operating voltage dependent
- The behavior at cryogenic temperature (87 K) has also been tested.
- Results confirm the suitability of this PMT model to the use in liquid-argon time-projection-chambers



ID 271 : Operational Evaluation of Silicon Photomultiplier Based Prototype Detector Modules Installed in the MAGIC Telescopes

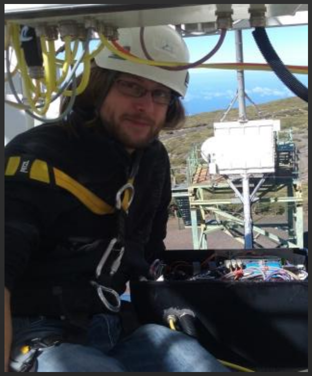
MAX-PLANCK-GESELLSCHAFT

Max-Planck-Institut für Physik (Werner-Heisenberg-Institut)

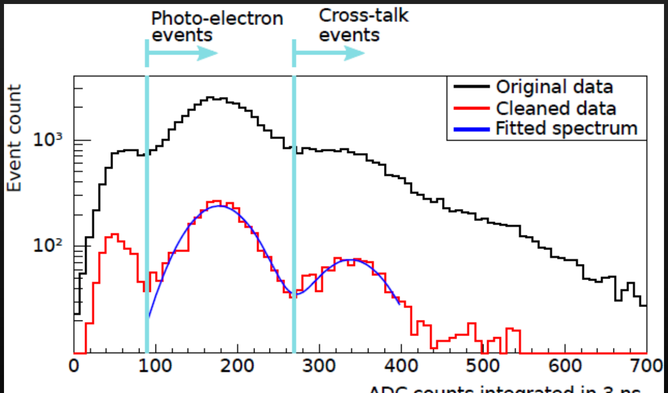
A. Hahn[1]*, D. J. Fink[1], D. Mazin[1,2], R. Mirzoyan[1], M. Teshima[1,2], A. Dettlaff[1]

[1] Max-Planck-Institute for Physics, Munich, Germany

[2] Institute for Cosmic Ray Research, Tokyo, Japan



- MAGIC is a stereoscopic system of two imaging atmospheric Cherenkov telescopes located at the Canary Islands.
- Each imaging camera consists of 1039 1-inch diameter Hamamatsu photomultiplier tubes.
- The aim is to replace seven PMTs with seven 3x3 SiPM matrices
- Developed three different prototype SiPM based detector modules installed in MAGIC-1 camera alongside PMTs
- The detection efficiency of monochromatic light pulses is in the expected range
- Detection efficiency study using Cherenkov light from air showers is ongoing



Unfiltered and filtered charge spectrum of a Gen. 1 pixel

Detectors for beam-line monitoring

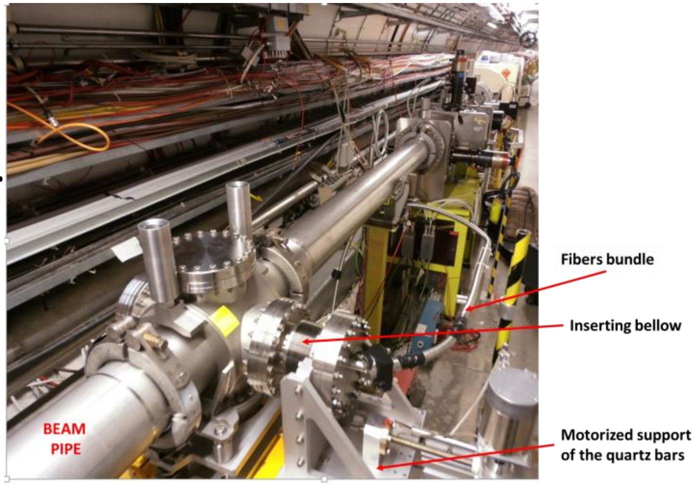
ID 334 : Proton flux monitor(s) for the UA9 Experiment

S. Dubos[1,*], F. Addesa[2], D. Breton[1], L. Burmistrov[1], V. Chaumat[1], M. Garattini[3], J. Maalmi Di Bello[1], S. Montesano[3], A. Natochii[1,4], V. Puill[1], W. Scandale[3], A. Stocchi[1]

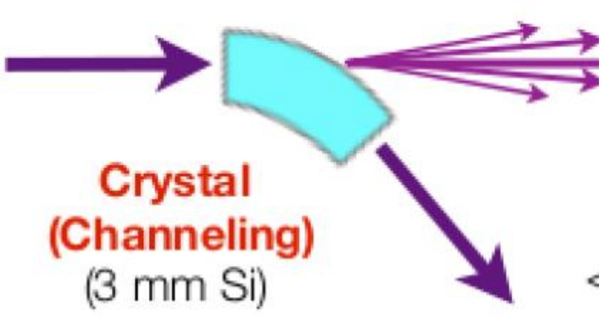
[1]*Laboratoire de l'Accélérateur Linéaire (LAL), Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France*
[2]*Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Roma I, Rome, Italy*
[3]*European Organization for Nuclear Research (CERN), Geneva, Switzerland*
[4]*Taras Shevchenko National University of Kyiv (TSNUK), Nuclear Physics Department, Kiev, Ukraine*

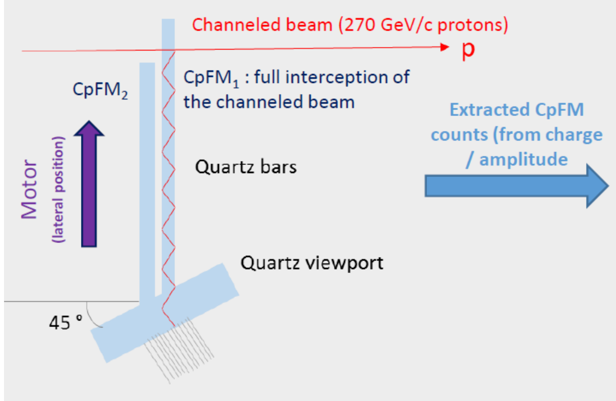
[*]Sébastien Dubos, research engineer, Detector group, LAL, Orsay, France
Email: dubos@lal.in2p3.fr

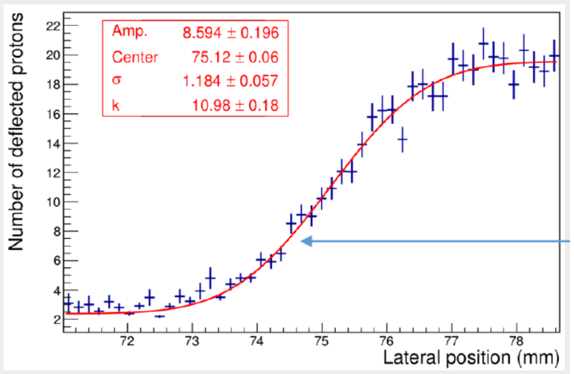
- Bent crystals can be used as small deflectors for positive charged particles. The UA9 Experiment at CERN investigates how they can be used to steer particle beams.
- The Cherenkov detector for proton Flux Measurement (CpFM) is being developed. Quartz radiator is read out by Hamamatsu R7378 PMT.
- The in-vacuum, radiation-hard detector counts the number of deflected protons by the UA9 bent crystals.
- Now calibrated & installed in the SPS at CERN.



Linear scan: full interception of channeled beam for counting



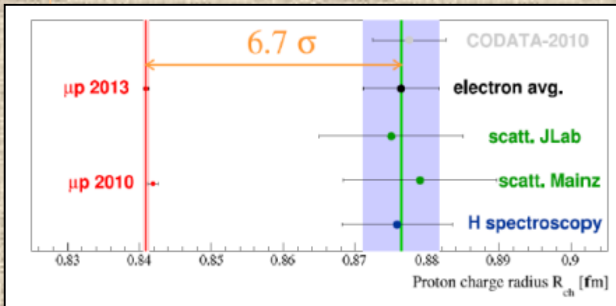




ID 70 : The upgraded beam monitor system of the FAMU experiment at RIKEN-RAL

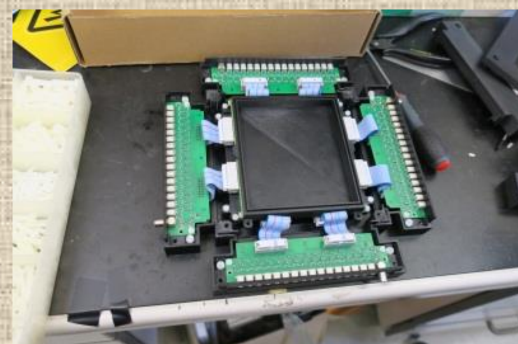
M. Bonesini[1], R. Benocci[1], R. Bertoni[1], R. Mazza[1], T. Cervi[1], A. deBari[2], A. Menegolli[2], M.C. Prata[2], M. Rossella[2], L. Tortora[3], E. Mocchiutti[4], A. Vacchi[4], E. Vallazza[4]

INFN Milano Bicocca, Dipartimento di Fisica G. Occhialini, Milano, Italy[1], INFN Pavia, Dipartimento di Fisica, Pavia, Italy [2], INFN Roma Tre, Roma, Italy [3], INFN Trieste, Trieste, Italy [4]

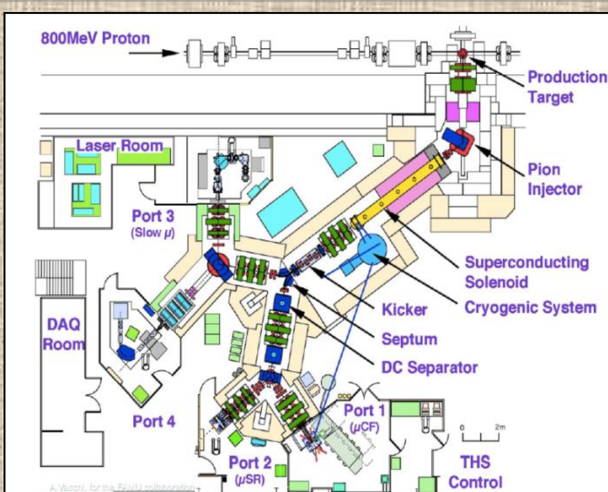


- 7σ discrepancy in the proton charge radius measurement from e and μ measurements
- The FAMU experiment will attempt to solve this puzzle

- μ^+ beam (20-120 MeV/c) stops in a hydrogen target and forms a muonic atom
- Essential to steer the beam into the target (need beam hodoscopes)

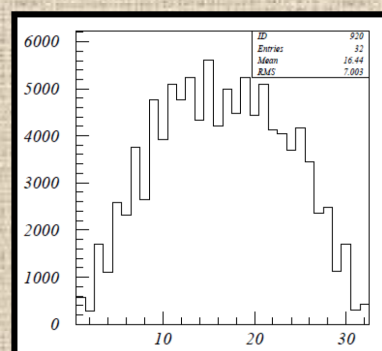


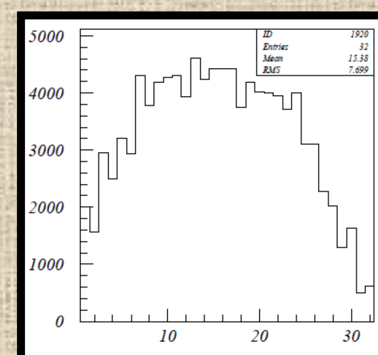
The RiKEN-RAL muon facility



The FAMU hodoscope system

- The system is based on 3 different hodoscopes (1 with 1 mm and 2 with 3 mm pitch), with similar design
- 2 X/Y Bicron BCF12 square single clad scintillating fiber planes read out by 3x3 mm^2 (or 1x1 mm^2) Hamamatsu (Advansid) SiPM
- EMA coating (Al film wrapping) for 1 mm (3 mm) fibers to avoid light cross-talk
- The 1 mm pitch hodo is installed (in front of the target) for beam monitoring. Additional ones used for beam characterization in special runs





X/Ybeam profile (in mm)

Atomic and nuclear physics detectors

Performance of X-rays crystal detectors with SiPM array readout exposed to the RIKEN RAL low energy muon beam

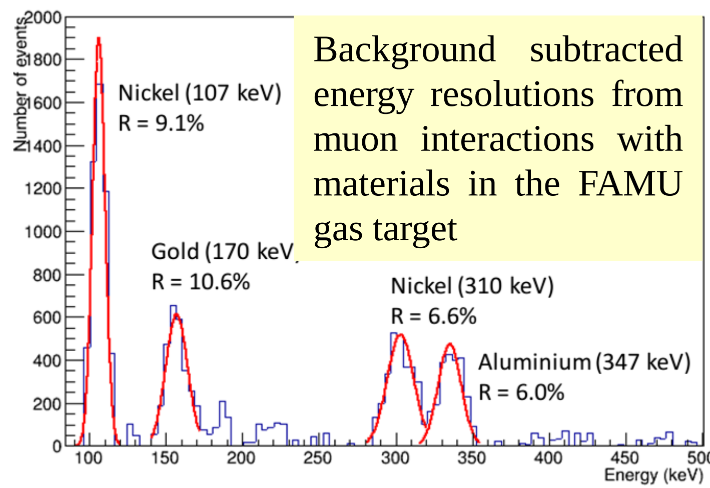
ID 283

R. Benocci[(1)], R. Bertoni[(1)], M. Bonesini[(1)], T. Cervi[(2,3)], M. Clemenza[(1)], A. De Bari[(2,3)], C. De Vecchi[(3)], A. Menegolli[(2,3)], E. Mocchiutti[(4)], M. Rossella[(3)]

[(1)]INFN, Sezione di Milano Bicocca
[(2)]Università degli Studi di Pavia
[(3)]INFN, Sezione di Pavia
[(4)]INFN, Sezione di Trieste

- The FAMU experiment goal is the detection of the characteristic X-rays emitted during the de-excitation of muonic hydrogen after the excitation of the hyperfine splitting resonance with an IR laser.
- Aim is to measure the proton radius in muonic atom with unprecedented precision.

- To equip regions of the FAMU detector otherwise difficult to instrument, it was chosen to use 1/2” scintillating crystals, rare-earth based (eg LaBr3:Ce), with a compact 4x4 SiPM array readout.



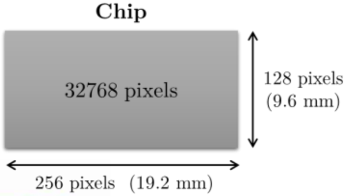
Background subtracted energy resolutions from muon interactions with materials in the FAMU gas target

- Once exposed to the intense low energy RIKEN RAL muon beam, these detectors show good performance in terms of resolution at the energies of few hundred keV.
- The performance is comparable with the FAMU baseline choice, which foresees LaBr3:Ce detectors with standard PMT read-out.

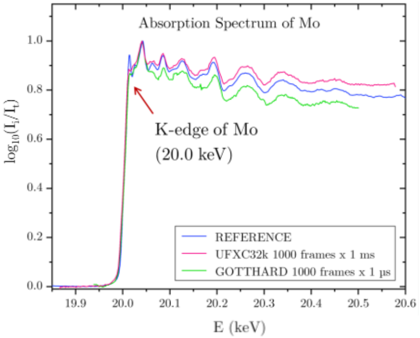
ID 302 : Evaluation of a Hybrid Pixel Detector Prototype for Time Resolved Experiments at the ODE Beamline of the SOLEIL Synchrotron

D. Bachiller-Perea, F. Baudelet, J. Coquet, Q. Kong, F. Orsini, and A. Dawiec

New ultrafast X-ray detector developed for time resolved experiments at the SOLEIL synchrotron

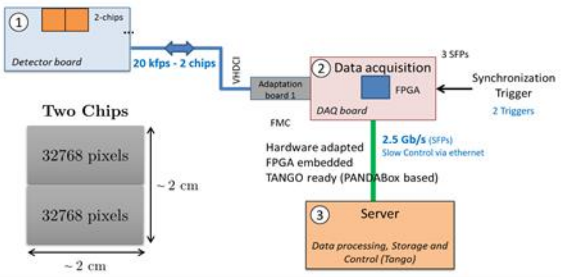


Single-chip prototype: characterization and first tests on a synchrotron beamline



X-Ray Absorption measurements

Development of a 2-chip camera



SOLEIL SYNCHROTRON

ID 229 : A low energy x-ray Compton polarimeter prototype

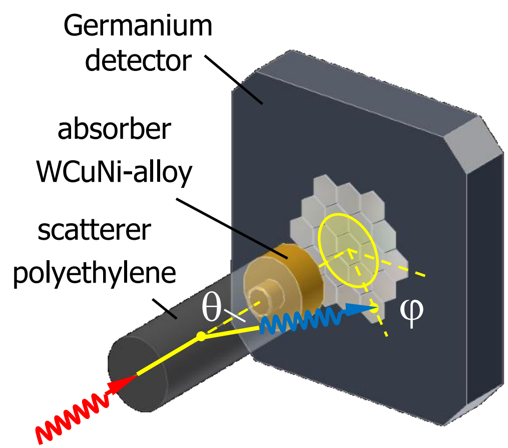
U. Spillmann[1], Th. Stöhlker[1,2,3], T. Krings[4]

[1] GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstr. 1, 64291 Darmstadt, Germany
[2] Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena, Germany
[3] Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena, 07743 Jena, Germany
[4] Forschungszentrum Jülich GmbH, Institut für Kernphysik, 52425 Jülich, Germany

Why do we need a polarimeter ?

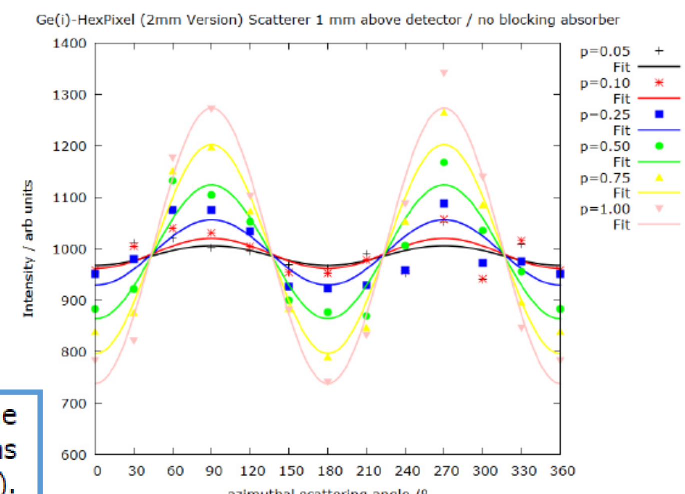
- To learn about the dynamics of atomic transitions in the mid- and high-Z regime, need to perform a measurement of the polarization of emitted x-rays from the reaction channel of interest.
- To cover an energy range from a few keV to ~30 keV a prototype Compton polarimeter has been developed to determine the degree of linear polarization of this radiation.

The concept of the polarimeter



Geometry of the Compton scattering process: Incident photon (red); scattered photon (blue)

- 20 mm² Ge-detector demonstrator tested with 19 hexagonal pixels, good energy resolution
- Optimization of the detector geometry (number of pixels, shape and size of pixels, …), preamplifiers with cooled first stage
- Measurement of the linear polarization



Azimuthal scattering distributions for a 5 mm thick polyethylene (PE) scatterer in 1 mm distance to the detector, displayed as function of the linear polarization of the incident photon (5–100 %).

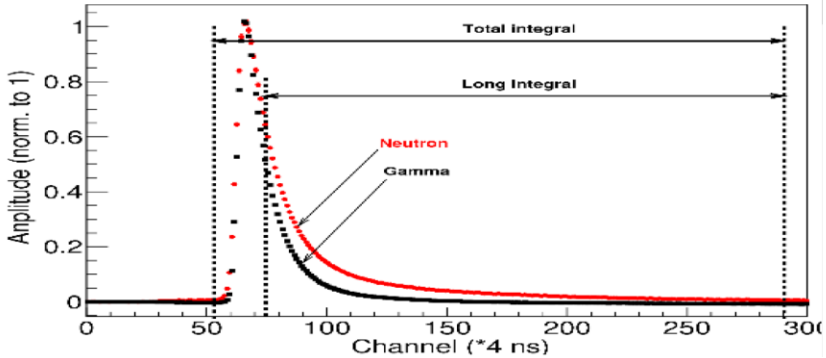
ID 383

FAST NEUTRON DETECTORS WITH SILICON PHOTOMULTIPLIER READOUTS

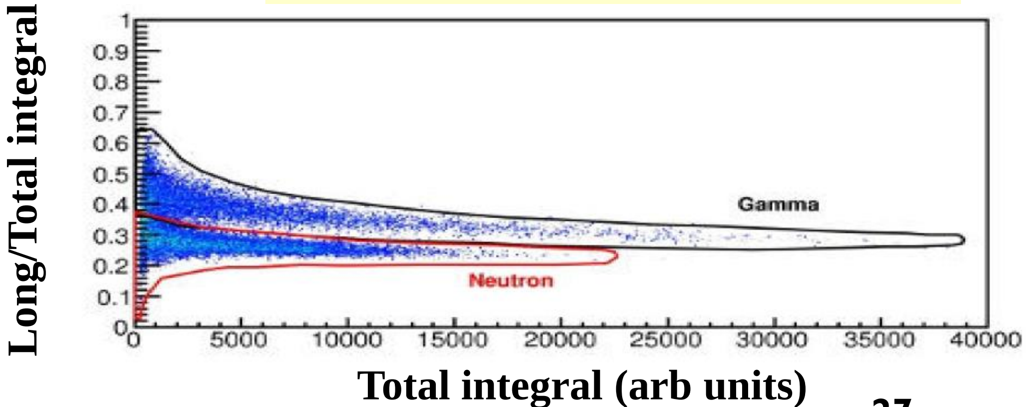
R. A. Akbarov[a,b,c], S. M. Nuruyev[a,b], G. S. Ahmadov[a,b,c], Z. Y. Sadiqov[a,c], F. Ahmadov[b,c], S. Tyutyunnikov[a], A. Sadigov[b,c], R.Mammadov[c], M. Holik[d], D. Berikov[a]

[a] Joint Institute for Nuclear Research (Russia, Dubna)
[b] Institute of Radiation Problems ANAS (Azerbaijan, Baku)
[c] National Nuclear Research Center (Azerbaijan, Baku)
[d] Institute of Experimental and Applied Physics, CTU, Czech Republic

- Comparison of fast neutron detection performance of 2 different silicon photomultipliers, MAPD-3NK and MCCP-S1272-01OP, and 2 different plastic scintillators → stilbene and p-terphenyl
- Performance tested using a PuBe neutron source. Comparison of pulse discrimination techniques of neutron and photon signals
- Encouraging results. Promising possibilities to use these types of detectors for fast neutron detection.



Plot of pulse shape discrimination (MAPD coupled to stilbene)



Concluding remarks

- The PID/experimentation posters are extremely interesting, addressing several cutting edge technologies
- Thanks to the authors for producing posters and slides in a timely manner
- My apologies for being unable to do all the contributions justice in the limited time available
- Please enjoy the poster sessions and discussions with the contributors