Round table

- 1 slide per person / experiment / organisation
- 1 minute! (let’s at least try)

Christian Joram

- CERN, since 1994
- Detector physicist
  - DELPHI RICH
  - LHCb, RICH R&D
  - ATLAS ALFA, Scint. Fibre tracker
  - LHCb SciFi, Scint. Fibre tracker
  - AXIAL PET
- Photodetectors
  - HPD, MAPMT, SIPM, also digital
- Editor NIM A

A. Braem, P. Weilhammer, A. Braem, J. Séguinot, C. Joram

Why am I here?

- ECFA Roadmap, expert in TF4
- Peter and I were given the mandate to launch a Detector R&D (DRD) Collaboration on Photodetectors and Particle ID
- Helped to launch RD50 and RD51 collaborations
- Coordinator of EU MC network MC-PAD
- Coordinator of CERN Detector R&D Programme

Peter Križan

- University of Ljubljana and J. Stefan Institute
- Flavour physics and detectors
  - ARGUS @DESY
  - HERA-B @DESY: RICH with MaPMTs and C_4F_{10}
  - Belle @KEK: silicon strip vertex detector
  - Belle II: spoke, technical coordinator, Cherenkov detectors ARICH and TOP
  - Applications in medical imaging: Cherenkov based TOF-PET
- Photon detectors
  - MaPMTs, MCP-PMT, HAPD, SiPM
- Editor NIMA (2010-2022)

Why am I here?

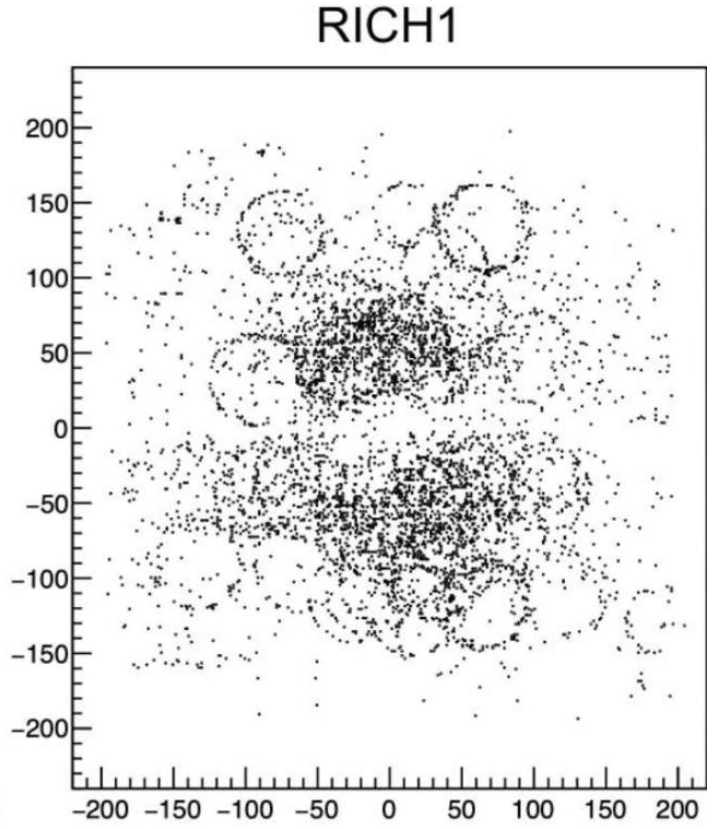
- ECFA Roadmap, co-convener of TF4 (together with Neville Harnew).
- With Christian given the mandate to launch a D(etector)RD Collaboration on Photodetector and PID
- Co-coordinator of the Photodector working group of the 2019 US DOE HEP-Instrumentation BRN effort
- Technical coordinator of Belle II (2015-2020)

Carmelo d'Ambrosio

Have been involved in the LHCb RICH System
(composed of two gaseous RICH detectors, PID from a few to ~100 Gev/c momenta)
from design to operation to R&D for Upgrades
(at present we are at its 2nd evolution, Run 3).

Started its 3rd (Run4) and 4th (Run 5) evolutions.

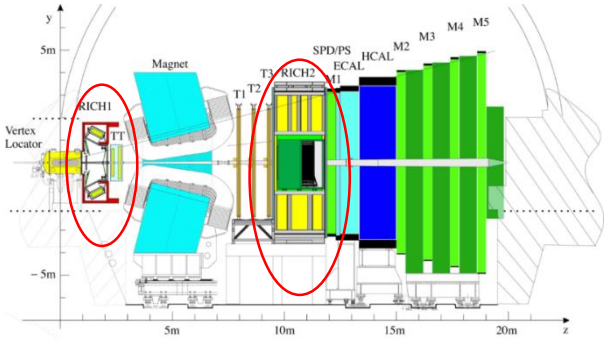
Main R&D lines (both inside the LHCb RICH Collaboration and the EP strategic R&D at CERN),
totally compliant with the latest ECFA Roadmap:
Time-resolved RICH detectors; Novel radiators studies;
Light-weight composite mirrors; Green-enhanced Photodetectors;
Green gases instead of fluorocarbon gases in RICH detectors;
Cryogenic cooling of SiPM arrays, Test beams for system testing.
(https://indico.cern.ch/event/999817/contributions/4253045/attachments/2239937/3797505/carmelo_2021_05_06.pdf)

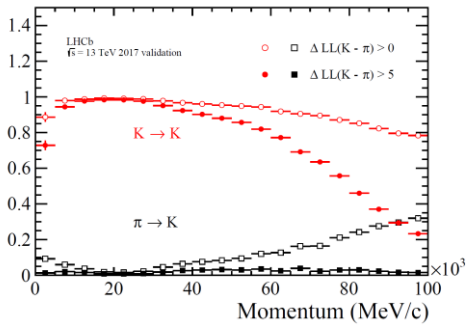


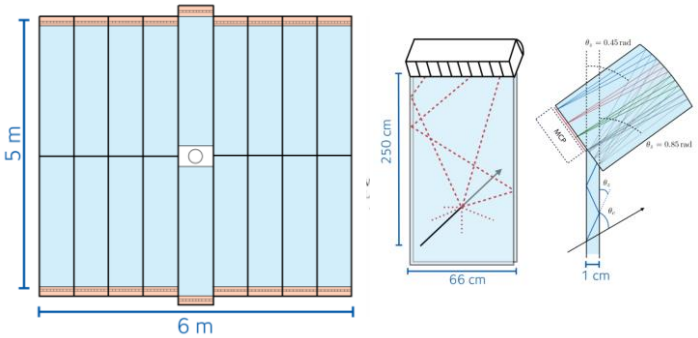
High multiplicity event in RICH 1 (Run 3) during commissioning.

Guy Wilkinson (University of Oxford)

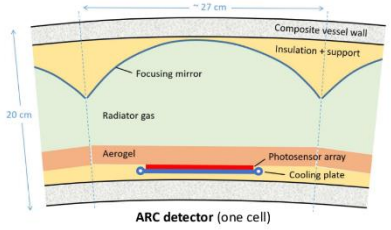
PID involvement through LHCb RICH system…. …more recently the TORCH….

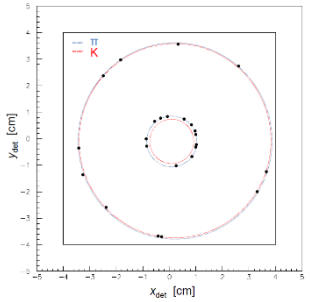


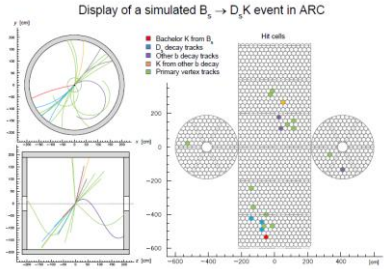




…and even more recently in PID through future e+e- colliders, recently joining forces with Roger Forty and a student to work on the ARC concept for FCC-ee.



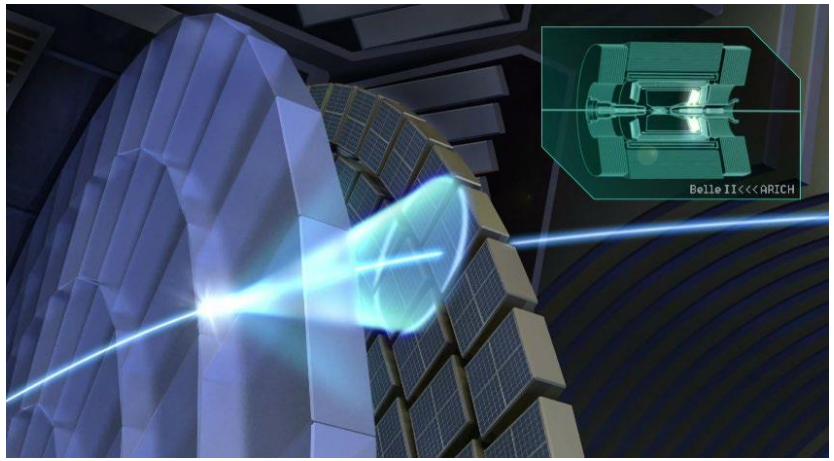




Interested in SiPM development, fast photodetectors, eco-friendly radiator gases…

DRD4 Belle II - ARICH

Samo Korpar, BELLE II



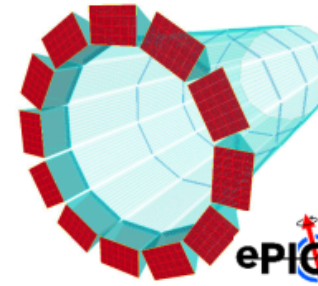
- ARICH - proximity focusing RICH with focusing aerogel radiator and HAPD photon sensor.
- R&D for future upgrades:
  - photon detector replacement for higher neutron fluences
    - SiPM - synergy with Belle II TOP, LHCb RICH …
    - MCP-PMT, LAPPD - synergy with TORCH, ePIC RICHes …
  - aerogel radiator optimisation with more transparent aerogels
  - front-end electronics upgrade - FastIC, FastRICH, PicoTDC …

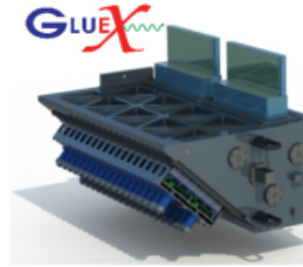
- Long-term experience with the development of RICH detectors at the JSI Photon detector lab
  - characterisation of photon detectors
  - radiation hardness studies of sensors and electronics
  - development of FE electronics and integration with sensors
  - involved in RICH detectors for HERA-B, Belle II, LHCb Upgrade 2

PANDA Detectors department at GSI:

Jochen Schwiening

- Instrumentation group, specialized in particle identification using DIRC technology
- Primary project: PANDA Barrel DIRC
- Participating in GlueX DIRC, ePIC hpDIRC, EIC Detector R&D (eRD4/eRD14/eRD103, EICGENRandD12)
- 10+ years of close cooperation on DIRC projects with groups and experts in Germany and the US
- Current R&D focus on PANDA Barrel DIRC and future DIRCs for ePIC and EIC Detector-2
  - mitigation of chromatic dispersion and multiple scattering, development of AI/ML PID methods
  - tests of fast, small-pixel photon sensors and readout electronics with DIRC prototype in beams or cosmics
- Future R&D interests in advancing DIRC counters, application of enabling technologies
  - new optical designs for DIRCs, material budget reduction, use of SiPM
  - DIRC-based time of flight
  - …





Christian Pauly <pauly@physik.uni-wuppertal.de>

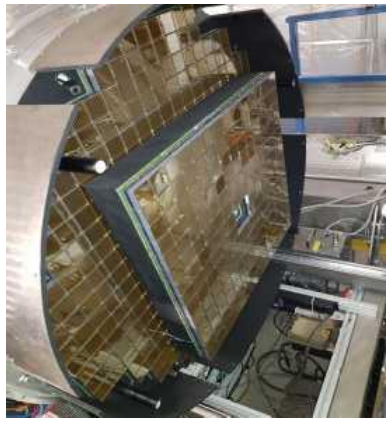
CBM- und HADES RICH working group

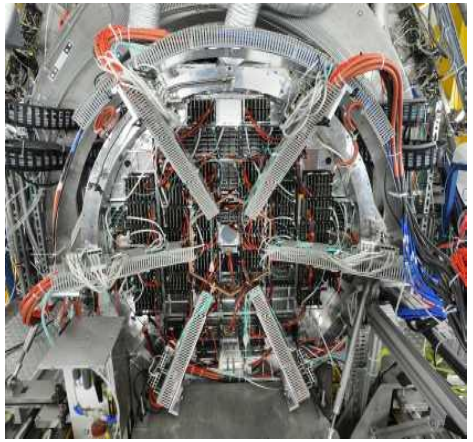
Justus-Liebig Universität Giessen (C. Höhne)
Bergische Universität Wuppertal (K.-H. Kampert)
GSI Darmstadt (M. Traxler)

Projects:

.HADES RICH photon detector upgrade

- → hadron-blind C_4H_{10} gaseous RICH, electron identification
- → in operation since 2019





HADES RICH photon detector upgrade 2019

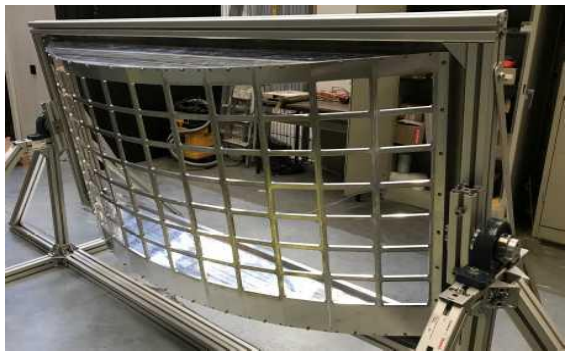
.mCBM mRICH Aerogel prototype

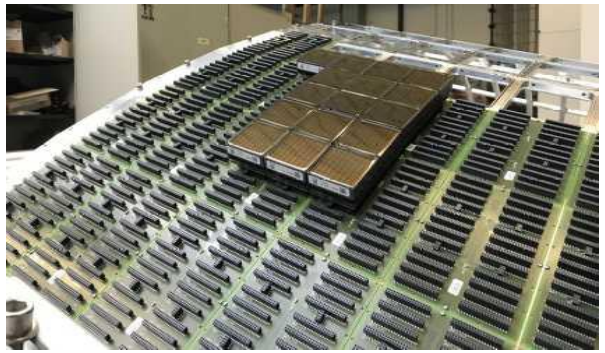
→ self-triggered, free-streaming readout concept
→ in operation since 2021

.CBM RICH Detector

→ CO_2 gaseous RICH detector for e / pi separation

- → self-triggered, free-streaming readout
- → high rate, high radiation





CBM RICH photon camera demonstrator 2022

R&D projects:

.Application of **MPPC-SiPM sensors for single-photon Cherenkov counting in combination with free-streaming, self-triggered readout**

→ need for local coincidence triggering in front-end electronics
→ as future alternative to MAPMTs

- → as possible upgrade for CBM RICH
- → radiation hardness…

.part of **NRW-FAIR project,** WP6: „Application of Si-based photon detectors [...]“

mCBM RICH - Aerogel

Photodetectors and Particle ID Detectors for the EIC

- About us:
  - Thomas Ullrich (absent): Coordinator of generic detector R&D program (2011-2021) and EIC project R&D (2022-present)
  - Alexander Kiselev: PI of eRD110 on photosensors/LAPPDs & coordinator of pfRICH for ePIC
- Ongoing R&D for EIC
  - EIC Project R&D (2022-2025(6)), only for ePIC baseline subdetector systems
  - Generic Program (target: 2nd EIC detector and ePIC upgrades), 2022++, funded by DOE (NP), open to international groups

EIC Project	Topic
eRD101	modular RICH / proximity focusing RICH with HRPPD readout
eRD102	dual RICH
eRD103	high performance DIRC
eRD110	Photosensors: LAPPD/HRPPD, SiPM radiation damage mitigation strategies
eRD112	ToF with AC-LGAD

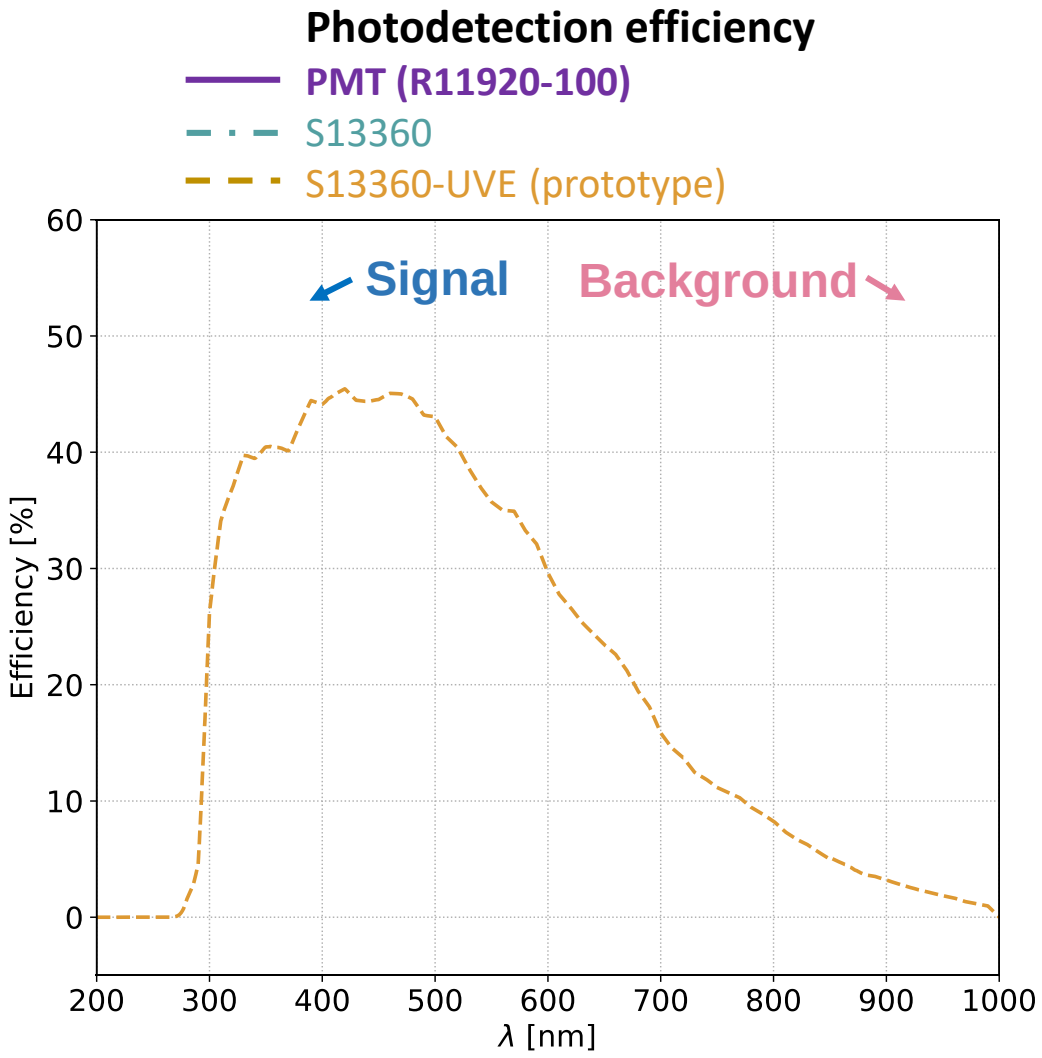
EIC Generic
MPGD-based transition radiation detector/tracker
Continued Development and Evaluation of a Low-Power High-Density High Timing Precision Readout ASIC for AC-LGADs (HPSoC)
Development of a Novel Readout Concept for an EIC DIRC
Tracking and PID with a GridPIX Detector
Particle identification and tracking in real time using Machine Learning on FPGA
Superconducting Nanowire Detectors for the EIC

Photosensors for Imaging Atmospheric Cherenkov Telescopes

- *Matthieu Heller (Unige-DPNC):* coordinator of the development of the future cameras for the Large-Sized Telescopes of CTA

- State of the Art in the field are the telescopes proposed for the *Cherenkov Telescope Array*:
  - For the Large and Medium-Sized telescopes, PMTs (R11920-100 from HPK) remain the baseline
  - For Small-Sized telescopes and camera upgrades, SiPMs are preferred:
    - S13360 (LCT5) and S14160 (LVR3) from HPK
    - NUV-HD from FBK

- The main R&D projects in the field aim at developing sensors with:
  - The highest sensitivity in the Cherenkov signal
  - The lowest sensitivity to the night sky background
  - The **shortest time response** (FWHM ~ 3 ns) to prevent pile-up of background photons
  - Lowest



Fulvio Tessarotto

Senior Physicist at INFN Trieste, expert in hadron physics, gaseous detectors, PID

PID experience:

CERN summer student in Tom Ypsilantis and Jacques Seguinot laboratory
RD26 – small prototypes and large MWPCs with CsI
COMPASS-RICH-1 design, construction, operation, upgrades, PID performance.
Serial production of CsI photocathodes
MAPMTs with lens telescopes
Development, construction, operation of THGEM-based photon detectors

Present Responsibilities:
Coordinator of the Photon Detectors laboratory at INFN-Trieste
P.I. of STRONG-2020 WP32 (gaseous detectors R&D)
Coordinator of the Italian Institutes participating in RD51
Coordinator of the INFN project IDEA on innovative photoconverters R&D
Co-spokesperson of the COMPASS Experiment at CERN

Present PID R&D activities:
Prototyping for and design of EIC ePIC dRICH
Study of Hydrogenated diamond nanograins for photocathodes in gaseous PDs
Implementation of new electronics for RICH streaming readout
Gaseous photon detectors with ~1mm space resolution

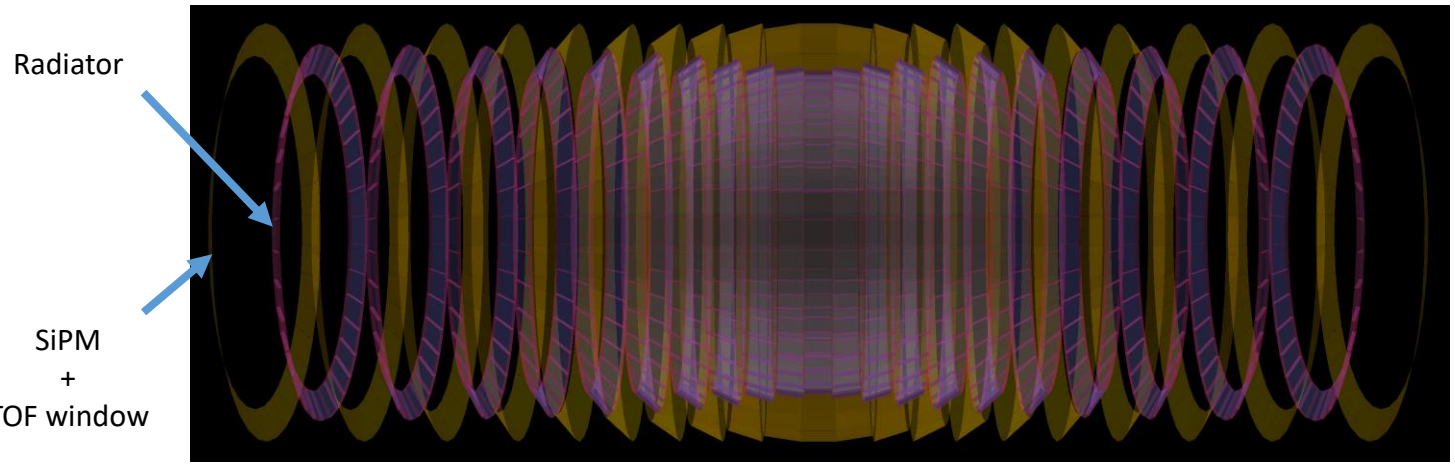
Antonello Di Mauro, CERN

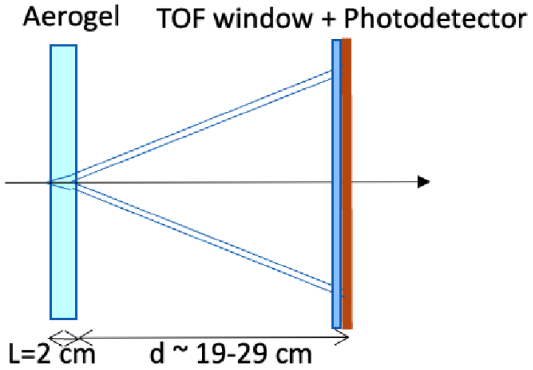
- Member of CERN RD26 (CsI PC development, 1995-97), ALICE HMPID RICH Tech. Coord. (2000-2013), RICH ISAC (2006-)
- Presently head of ALICE EP-AID group (Detectors and Systems) and ALICE Upgrade coordinator (ALICE3 in LHC RUN5 and 6)
- Member of ALICE3 RICH Work Package (external institutes: INFN Bari, UNAM Mexico, Tokyo University)

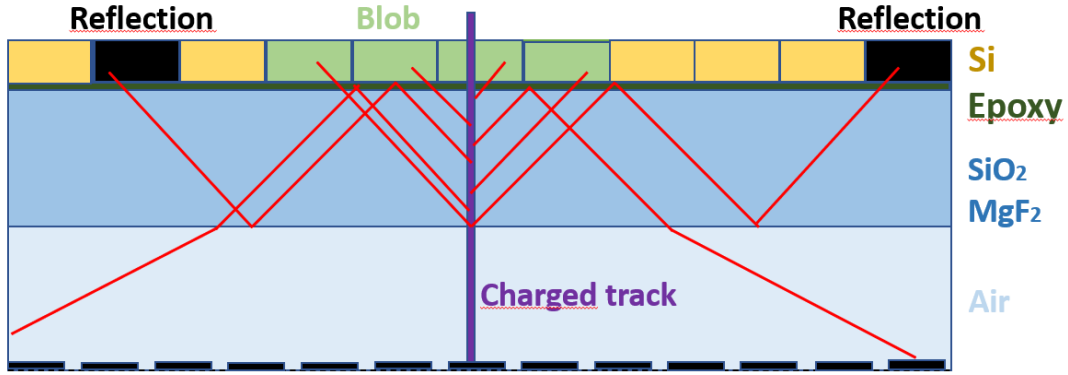
⇒ Main detector parameters:

- Cherenkov radiator: aerogel n~ 1.03 (~ 30-40 m^2), possibility of dual radiator layout with gas mixture (CO2+C5F10O) n~ 1.0006
- Photon detector: SiPM , 1x1 mm pixel, ~ 30-40 m^2 active area
- Additional option: high n glass thin window coupled to SiPM for TOF measurement based on Cherenkov radiation

- Requirements and R&D selected topics:
  - Digital SiPM (2.5 D or 3D): DCR (+cooling), rad. hardness (+annealing)
  - Time resolution < 50 ps
  - PDE > 40-50% in visible range (+ textured AR coating)
  - Module concept, large area (integration up to 20x20 cm2), silicon photonics

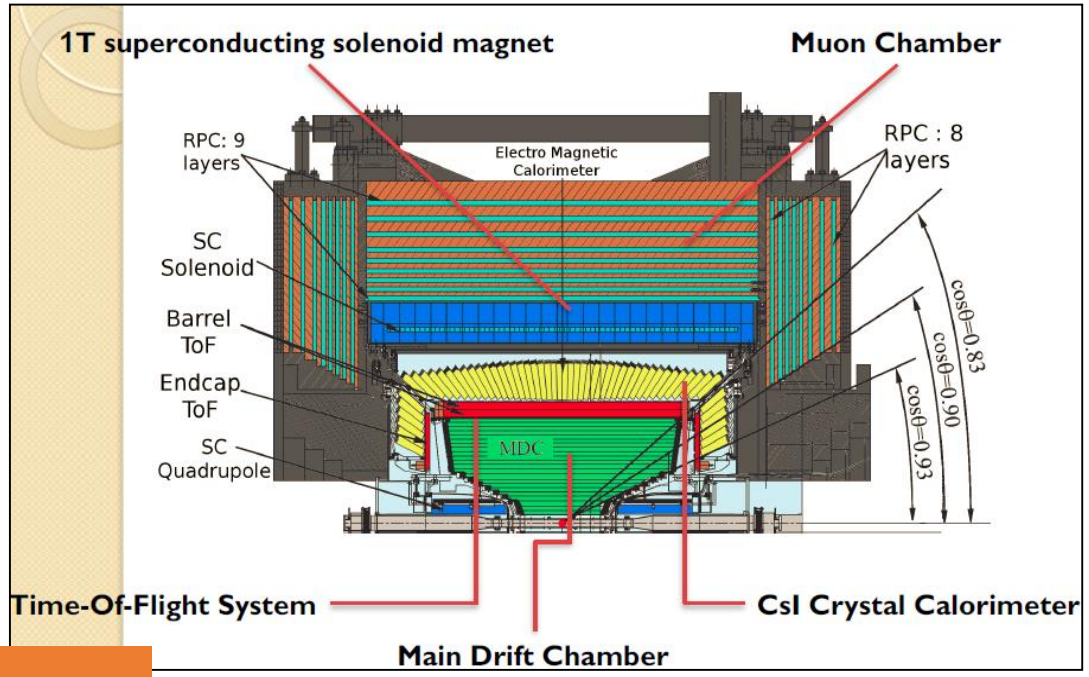






- Zhi Wu, Institute of High Energy Physics, Chinese Academy of Science, wuz@ihep.ac.cn
- In charge of BESIII TOF operation since 2012
- BESIII TOF: plastic scintillator + PMT mode; replace with MRPC for Endcap in 2016
- My interests for (future) R&D
  - (MCP-)PMT related detectors
  - SiPM based TOF
  - New T0 detector
- Now I also work on JUNO experiment

Beijing Electron-Positron Collider II (BEPCII)
τ-charm factory



Barrel TOF: 70 ps
Endcap TOF: 65ps(new) 110(old)

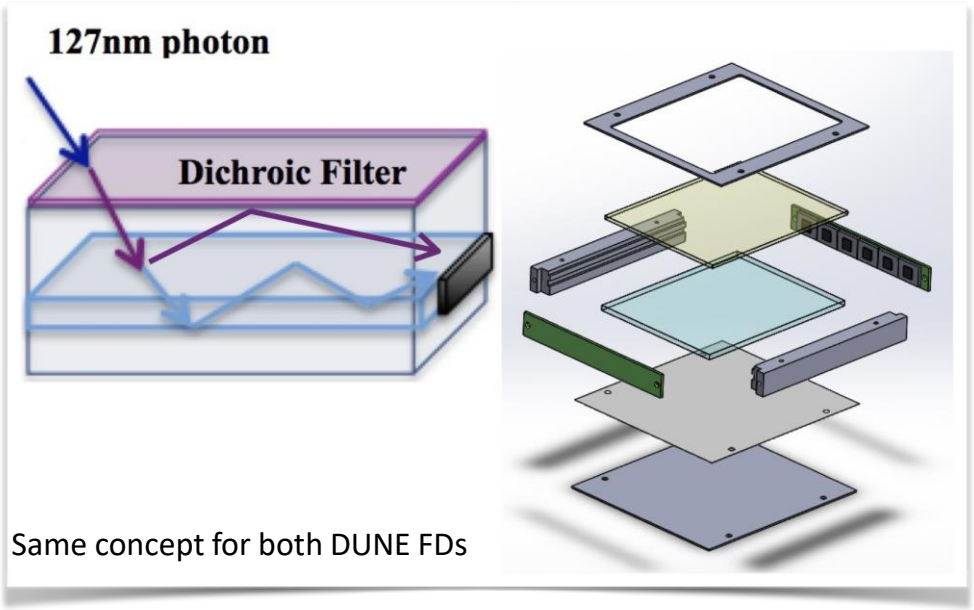
Beijing Spectrometer III (BESIII)

Photon Detector for DUNE

Filippo Resnatti
1/2

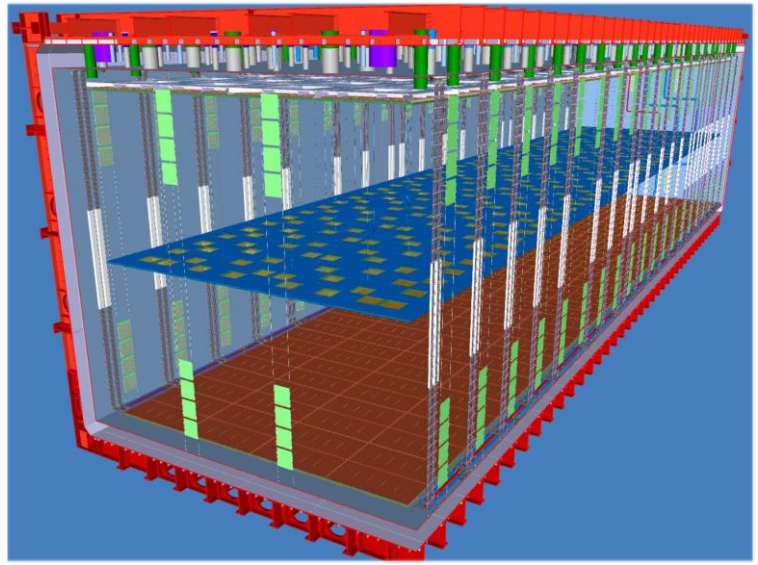
DUNE: long (~1300 km) baseline neutrino oscillation experiment in construction in the US.
Neutrino beam from Fermilab, far site (1.5 km underground) at SURF (South Dakota).
4 Far Detector Modules (2 baselined): Liquid argon Time Projection Chambers.

xArapuca concept



Same concept for both DUNE FDs

Deployment in Vertical Drift Module of DUNE



Cryostat wall (~320x) and cathode (~320x) instrumented to increase uniform coverage

Liquid argon scintillation:

- @ 128 nm $\tau_s \approx 6\text{ns}, \tau_t \approx 1.5\mu s$

Advantages:

- TPC timing, low energy event trigger

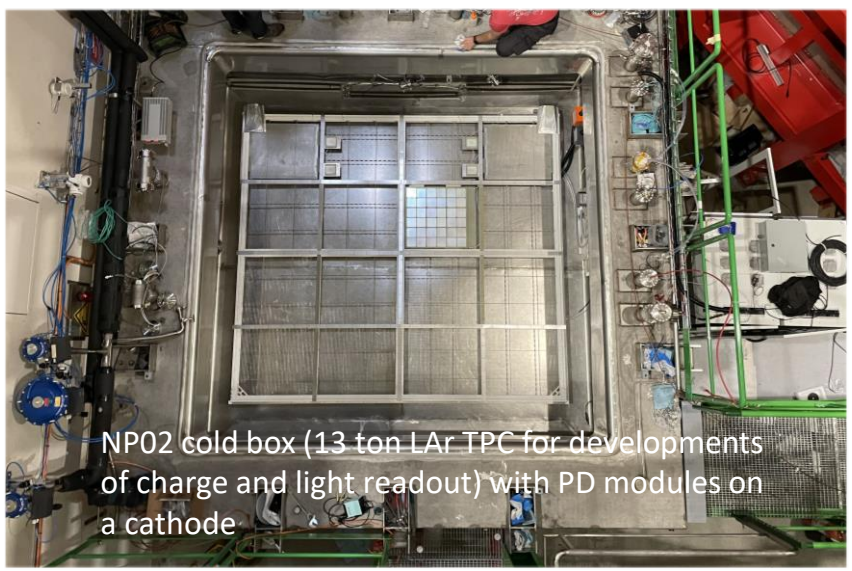
Challenges for Vertical Drift Module:

- Operation on at -300 kV (cathode) -> PoF & SoF
- Efficiency / coverage -> large module xArapucas
- Rayleigh scattering / light yield -> Xe doping

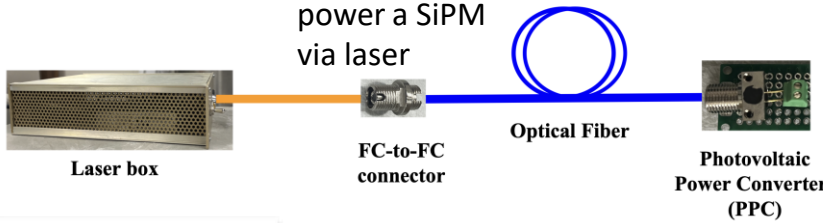
PD developments & CERN

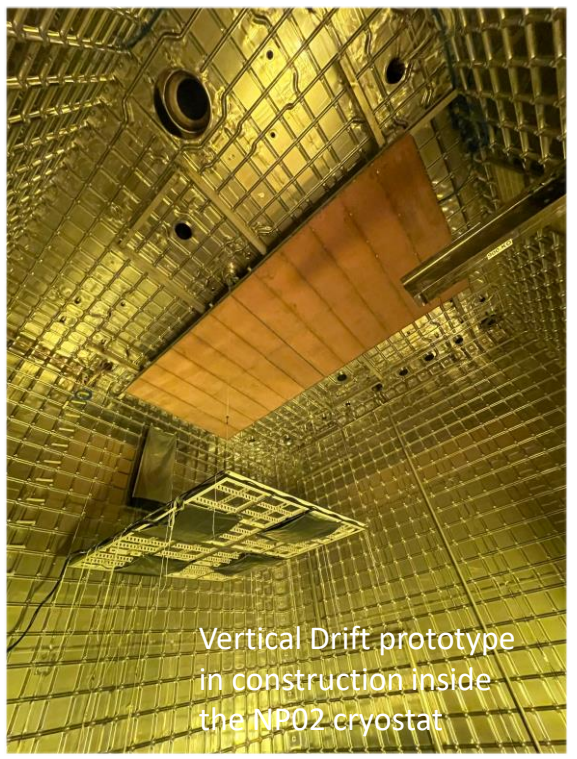
Filippo Resnatti
2/2

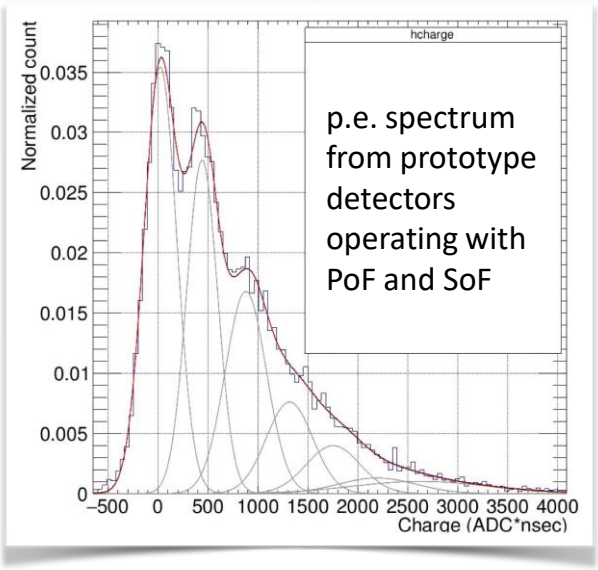
R&D within of the PD consortium of the DUNE experiment
Small, medium and large scale facilities available at Neutrino Platform at CERN
Some dedicated to the developments of PDs for LAr scintillation


NP02 cold box (13 ton LAr TPC for developments of charge and light readout) with PD modules on a cathode

PoF concept:
power a SiPM
via laser




Vertical Drift prototype in construction inside the NP02 cryostat



p.e. spectrum from prototype detectors operating with PoF and SoF

Antonis Papanestis – STFC RAL

- LHCb group leader @ RAL
- The LHCb group is a member of the RICH project since 2000 and recently a member of the Mighty Tracker
  - Close collaboration with RAL Technology Department
- Currently doing R&D on SiPMs (testing and evaluating performance, before/after irradiation)
  - Well equipped lab, could expand to other photon detectors. Potentially, expand as a facility for UK community.
- Have a proposal under PPRP review to develop cryogenic cooling for SiPMs for a RICH detector (1.5 FTE for TD)

Science and Technology Facilities Council

My Background

Highly granular calorimeters with SiPM since 2002

- CALICE Analogue HCAL, SiPM-on-Tile technology
- application of SiPMs at large scale
- co-convenor for scintillator section of CMS HGCAL upgrade

Organisation of international cooperation in detector R&D

- CALICE Spokes 2008-2012
- AIDA-2020 and AIDAinnova Scientific Coordinator
- Member of ECFA Detector Roadmap Coordination group

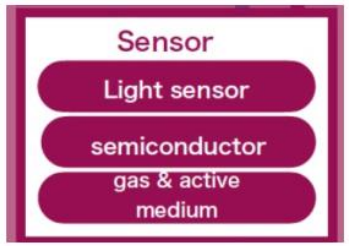
DRD4: Photodetectors & PID Inputs from KEK/JPN

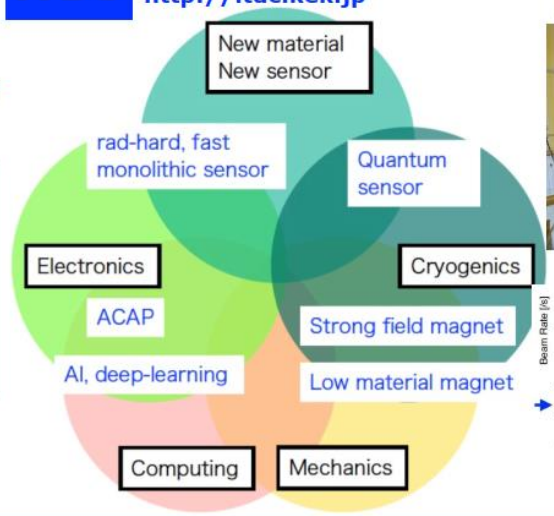
Kenji Inami (Nagoya/KEK), Kazu Hanagaki (KEK), Ichiro Adachi (KEK)

- PID activities in Japan
  - A lot of studies for major experiments like SK, T2K, Belle, Belle II and HK including fixed target experiments at J-PARC
  - Long and strong relations with HPK
    - Not only for vacuum detectors but also for solid state sensors
  - Silica aerogel production center at KEK/Chiba
- Instrumentation Technology Detector Center (ITDC)
  - Newly established in 2022
  - Effective detector R&D without borders in "next-generation" projects

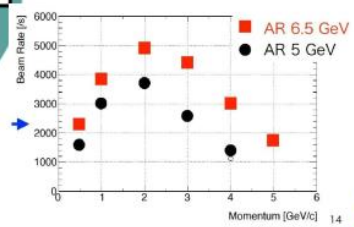
ITDC http://itdc.kek.jp

"Sensor" is the one of the exciting topics





e⁻ test beam line



KEK/IPNS projects

Workshop/Education

Industry

ECFA DRD4

Close and coherent collaborations

More ITDC members are expected to join the May community meeting.

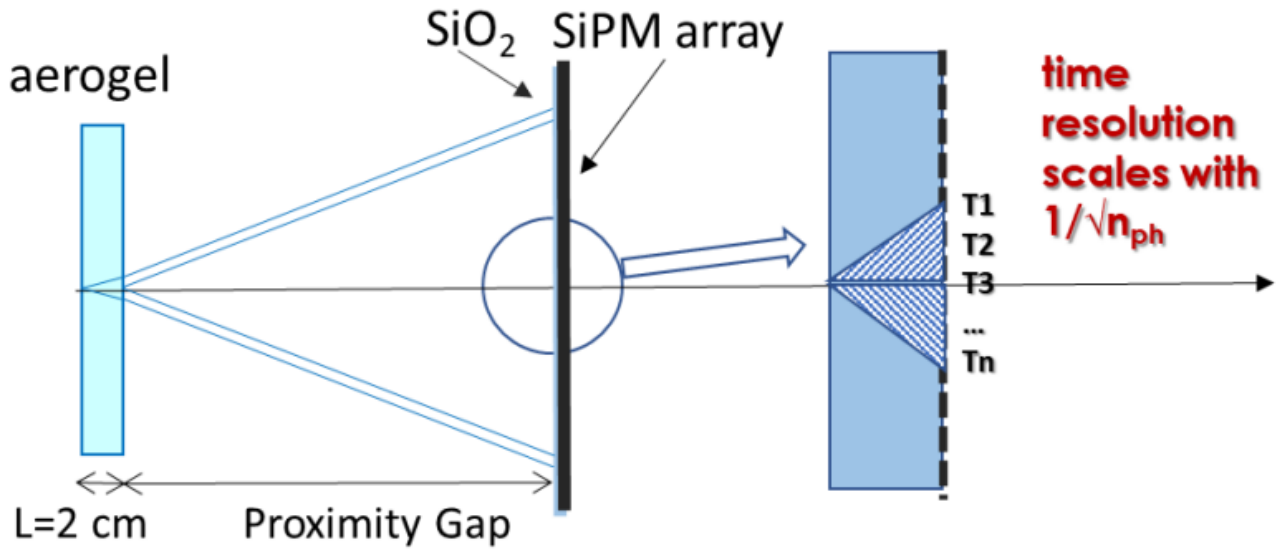
Eugenio Nappi

Staff at INFN

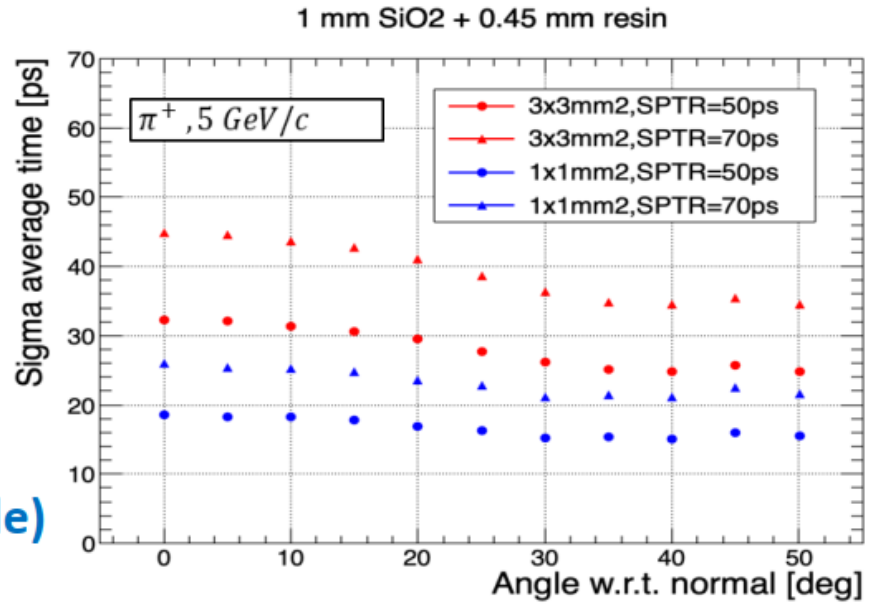
- Co-leader with F. Piuz of the RD26 project for the development of large area CsI photocathodes (From 2000 to 2006 Project Leader of the ALICE RICH detector – the largest CsI RICH detector ever built)
- Pioneered and designed the first RICH detector with an aerogel radiator for the HERMES experiment at DESY
- In 1993, he promoted with T. Ypsilantis the successful series of Workshops on Cherenkov Imaging Techniques, which has become an important venue for knowledge exchange for many researchers involved in this field
- Member of the ICFA panel for instrumentation since 2011, he contributed in 2022 to the definition of the ECFA Detector R&D roadmap as expert for the DRD4 panel on PID and Photon Sensors

ONGOING R&D:

MERGE TWO PID APPROACHES (TOF & RICH) INTO ONE DETECTOR



Property	SiO_2	MgF_2	Epoxy	High-n glass
Refractive index (400 nm)	1.47	1.40	1.55	1.84
Cherenkov angle (saturation)	47.1°	44.3°	49.8°	57.1°
Direct detected photons	16/mm	14/mm	17/mm	21/mm



APPLICATION: BARREL PID SYSTEM FOR ALICE 3 (see A. Di Mauro's slide)

Fondazione Bruno Kessler
Custom Silicon Photomultipliers

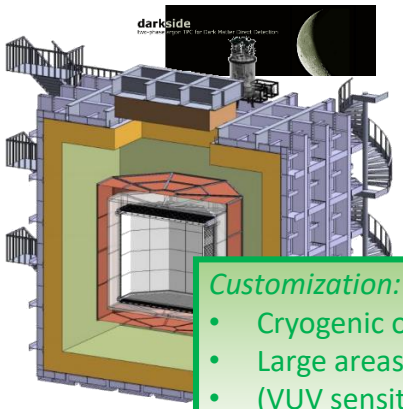
FBK is active in the field of *silicon radiation detectors since > 20 years* (e.g., production of strip and pixel detectors for ALICE, ongoing production of 3D and pixel detectors for ATLAS and member of RD50).

FBK develops *state-of-the-art SiPM technologies*, which are being employed or evaluated for the *future upgrades of several Big Physics Experiments*. Typically, such applications require a *deep customization of the SiPM technology*, not always possible in a commercial CMOS foundry.

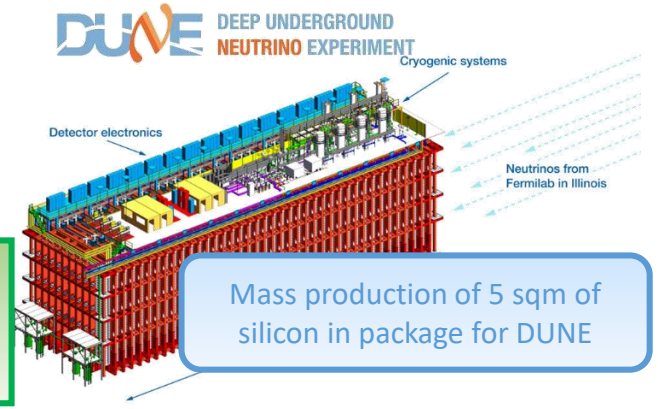
This perfectly fits FBK mission as *research center* and is *supported by a team of researchers*, who are experienced / motivated to work in the science field. FBK typical approach is *collaborating on these projects with other scientific partners* (e.g. INFN).

After R&D phase, FBK is *capable of supporting medium to large volume productions* → see DUNE mass production.

Cryogenic TPCs



Customization:
- Cryogenic operation
- Large areas
- (VUV sensitivity)



Mass production of 5 sqm of silicon in package for DUNE

Cryogenic SiPMs will be employed in experiments such as DarkSide-20k

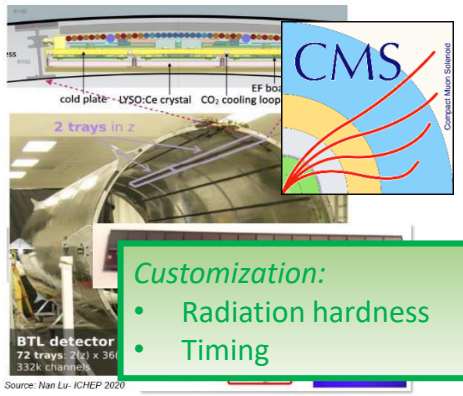
FBK will carry out the production of approx. 150k cryogenic SiPMs, in package, for the DUNE experiment.

CTA

Customization:
- Low CT
- Maximum PDE

Prototype pSCT installed in the VERITAS, equipped with FBK SiPMs.

HEP: CMS BTL



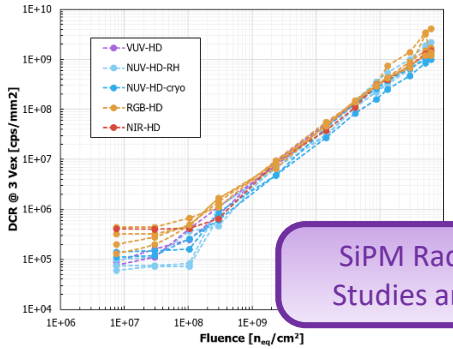
Customization:
- Radiation hardness
- Timing

NUV-HD SiPMs are being evaluated for the MIP timing detector of CMS (LYSO scintillator readout).

Fondazione Bruno Kessler
Roadmap and research interests

R&D topics of interest, currently being investigated by FBK in the field of SiPMs, include:

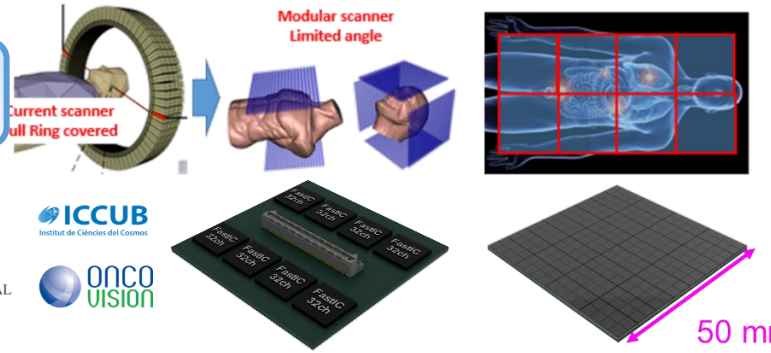
- Study / Optimization of SiPMs for radiation hardness
- 3D integration techniques to build TSVs for SIPMs and BSI SIPMs
- Deep segmentation for ultimate timing performance
- Hybrid, 3D integrated SiPMs: custom sensing layer coupled to advanced CMOS readout, for *optimal performance in both tiers* (single-cell access or mini-SiPM concept)



SiPM Radiation Hardness Studies and Enhancement

DCR vs fluence measured on several FBK SiPM technologies.

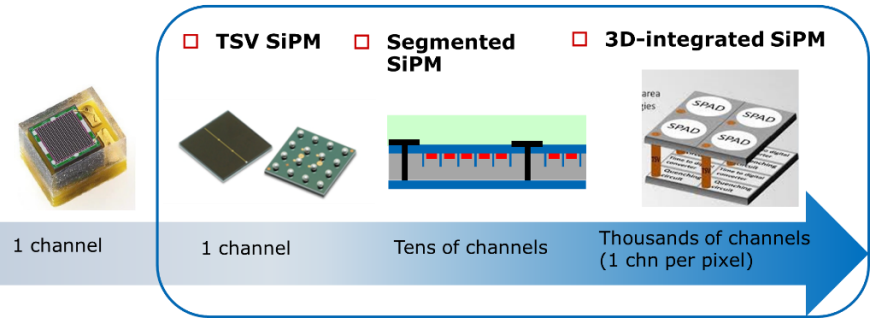
SiPM segmentation for ultimate timing



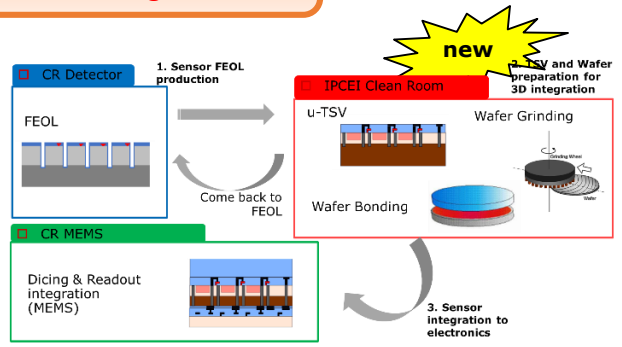
PET module with high segmentation based on FBK SiPMs with TSVs and ICCUB ASIC, under development for optimal timing performance (PetVision project).

IPCEI on Microelectronics

New clean-room under construction for 3D integration

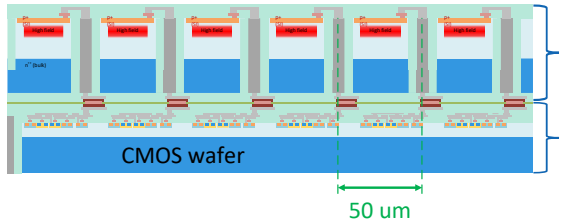


Range of technologies being developed within IPCEI for optical sensors



The future system composed of 3 research clean-rooms in FBK.

Hybrid SiPM concept

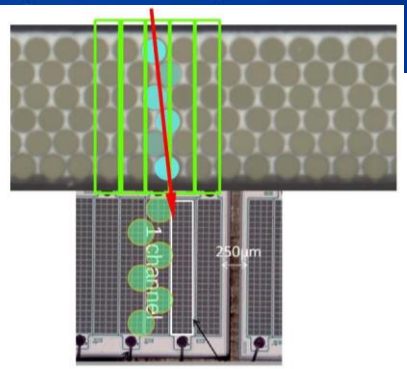


Hybrid SiPM concept: custom sensing layer with single-cell access is coupled to CMOS readout layer. Implementation with TSVs or BSI SiPMs.

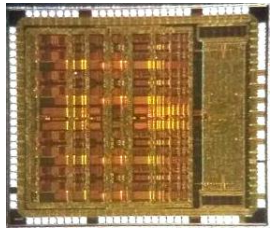
Expertise and main achievements

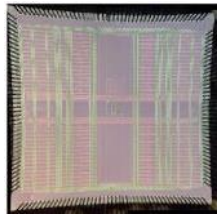
David Gascón
Institute of Cosmos Sciences
Universitat de Barcelona

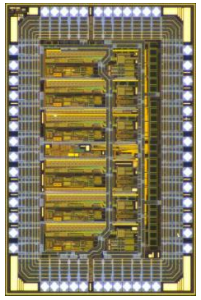
- Our main R&D activities are on:
  - Single Photon Sensors (LHCb, CTA, space…)
  - Integrated readout electronics (ASICs)
- Main achievements:
  - Readout of LHCb calorimeters and SciFi trackers
    - Photosensor selection and optimization with industry
    - ICECAL and PACIFIC ASICs
      - PACIFIC in collaboration with Univ. Heidelberg, IFIC and LPC
  - Cameras of LST and MST telescopes of CTA
    - Optimization of photosensor for single pe resolution at very low gain
    - Three different ASICs: PACTA, ACTA and L0 triggers
  - Scientific and industrial collaborations with industry
    - SiPM modules for ToF-PET
- More than 50,000 produced for LHCb and CTA
  - Quality control of mass production with a robotic system developed in-house
- Our main R&D activities are on:
  - Single Photon Sensors and integrated readout electronics (ASICs)
  - Hybrid solid state photo-detectors based on vertical integration
  - Picosecond detectors and electronics

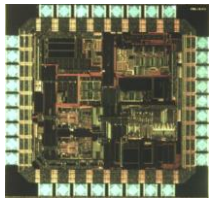


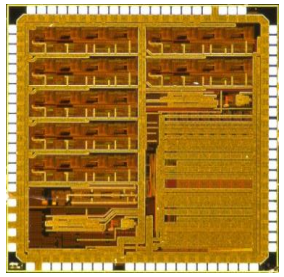
SciFi (LHCb)


ICECALv3 (LHCb)


PACIFIC (LHCb)


ACTA (CTA)

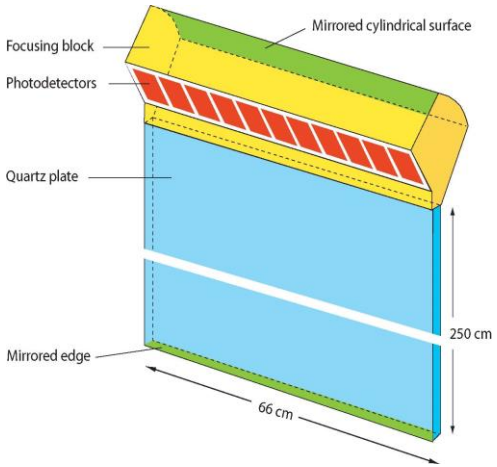

PACTA (CTA)


L0 Trigger (CTA)

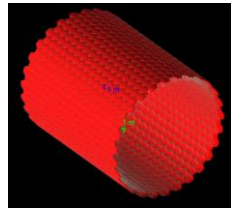
ICCUB Institute of Cosmos Sciences
EXCELENCIA MARÍA DE MAEZTU

Roger Forty

- CERN research staff member (EP department)
  Member of the ECFA detector panel with specific responsibility for PID and photon detectors, under discussion to join the DRDC
- Member of LHCb, previously participated in designing the original RICH system, member of advisory committee for the RICH conference series
  - Working on development of the **TORCH** detector for LHCb Upgrade 2 (installation in LS4)
  - Also developing a **compact RICH** for a future Higgs Factory experiment (such as at FCC-ee)
- R&D interests:
  - Polished **quartz** supply for TORCH-like detectors
  - Environmentally-friendly RICH **radiator gases** to replace fluorocarbons (and now also Novec fluids?)
  - **Fast photodetectors** for TORCH and RICH, single photon sensitivity with high QE and granularity: MCP-PMTs, SiPMs



TORCH module



ARC concept