LAPPD Workshop

Monday 21 Mar 2022, 08:00 → 12:00 America/New_York

Description Organizers: Silvia Dalla Torre (INFN), Alexander Kiselev (BNL), Deb Sankar Bhattacharya (INFN), Junqi Xie (ANL)

Hosted by CFNS: https://stonybrook.zoom.us/j/98025752609?pwd=WTlicTlwTmxkNE9wODlOZEx2NU1sUT09

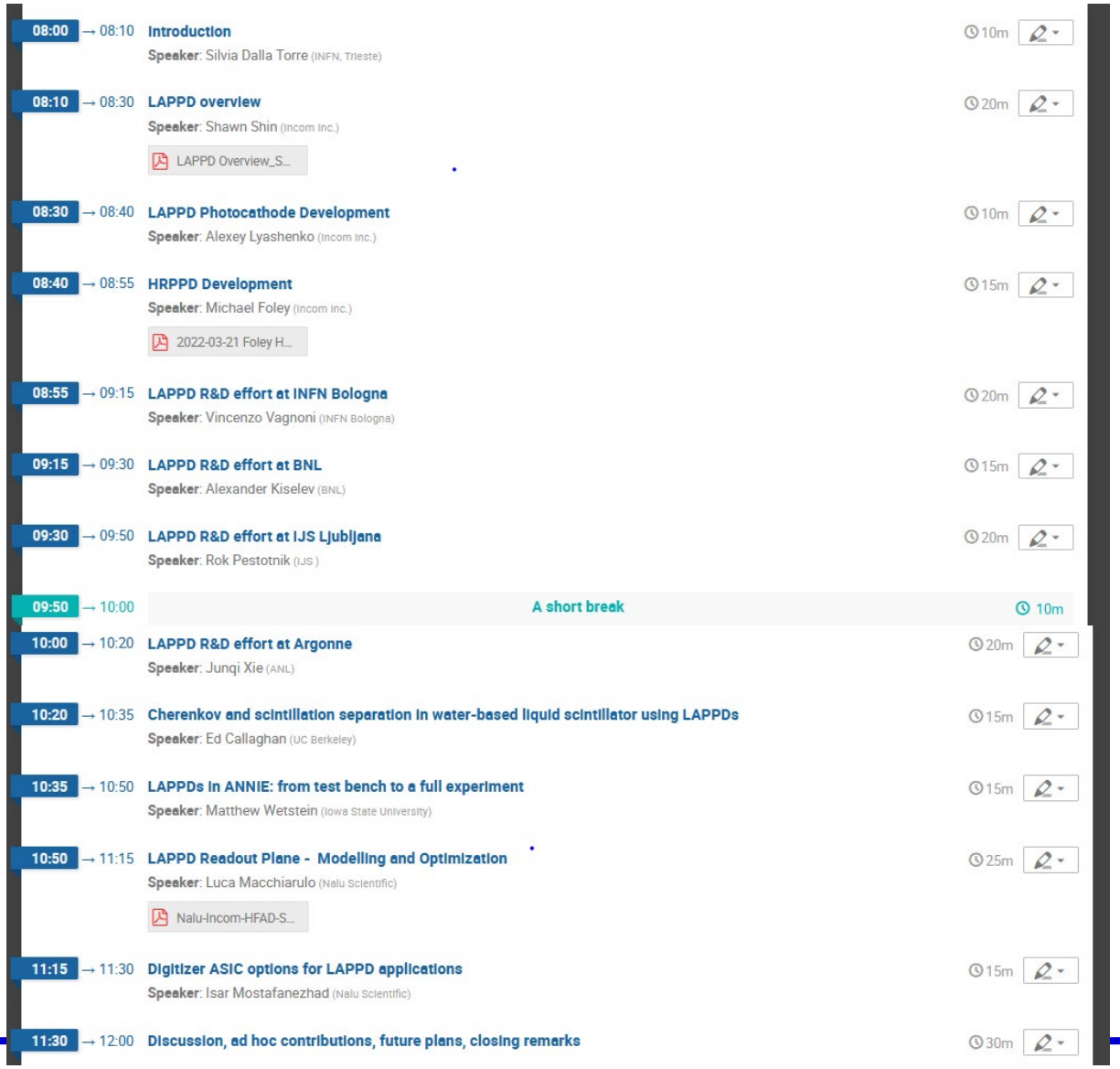
Argonne NATIONAL LABORATORY

Brookhaven National Laboratory

INFN

Center for Frontiers in Nuclear Science

AGENDA



08:00 → 08:10 **Introduction** 10m
Speaker: Silvia Dalla Torre (INFN, Trieste)

08:10 → 08:30 **LAPPD overview** 20m
Speaker: Shawn Shin (Incom Inc.)
LAPPD Overview_S...

08:30 → 08:40 **LAPPD Photocathode Development** 10m
Speaker: Alexey Lyashenko (Incom Inc.)

08:40 → 08:55 **HRPPD Development** 15m
Speaker: Michael Foley (Incom Inc.)
2022-03-21 Foley H...

08:55 → 09:15 **LAPPD R&D effort at INFN Bologna** 20m
Speaker: Vincenzo Vagnoni (INFN Bologna)

09:15 → 09:30 **LAPPD R&D effort at BNL** 15m
Speaker: Alexander Kiselev (BNL)

09:30 → 09:50 **LAPPD R&D effort at IJS Ljubljana** 20m
Speaker: Rok Pestotnik (IJS)

09:50 → 10:00 **A short break** 10m

10:00 → 10:20 **LAPPD R&D effort at Argonne** 20m
Speaker: Junqi Xie (ANL)

10:20 → 10:35 **Cherenkov and scintillation separation in water-based liquid scintillator using LAPPDs** 15m
Speaker: Ed Callaghan (UC Berkeley)

10:35 → 10:50 **LAPPDs in ANNIE: from test bench to a full experiment** 15m
Speaker: Matthew Wetstein (Iowa State University)

10:50 → 11:15 **LAPPD Readout Plane - Modelling and Optimization** 25m
Speaker: Luca Macchiarulo (Nalu Scientific)
Nalu-Incom-HFAD-S...

11:15 → 11:30 **Digitizer ASIC options for LAPPD applications** 15m
Speaker: Isar Mostafanezhad (Nalu Scientific)

11:30 → 12:00 **Discussion, ad hoc contributions, future plans, closing remarks** 30m

- **the LAPPD question is pending since too long**
- **sharing knowledge, analyze together within a community as wide as possible as a way to overcome the pending question**

→ **Understand if LAPPDs are adequate, reliable, mature for use in particle/nuclear experiment**
  → **Time properties in detail?**
  → **Adequate for single photon detection ?**

The organizers from EIC community, fully open to a larger Community in view of common interests

ABOUT SINGLE PHOTON DETECTORS

3 families (grouping by technologies)

Vacuum based PDs

- **PMTS** (SELEX, Hermes, BaBar DIRC, NA62)
- **MAPMTs** (HeraB, COMPASS RICH-1 forward region, LHCb upgrade, GlueX, CLASS12, Panda forward-RICH)
- **Hybride PMTs** (LHCb)
- **HAPD** (BELLE II aerogel-RICH)
- **MCP-PMT** (BELLE II barrel: TOP detector)
- **LAPPDs – large size MCP-PMTs, development ongoing**

Gaseous PDs

- **Organic vapours - in practice only TMAE and TEA** (Delphi, OMEGA, SLD CRID, CLEO III, …)
- **CsI and open geometry** (HADES, COMPASS, ALICE, STAR, JLAB-HALL A)
- **CsI and MPGDs** (PHENIX HBD, no imaging, NEW: COMPASS RICH-1 2016-17 upgrade)

SiPMs

- **Silicon PMs** (not used so far in any experiment)
  - radiation hardness , intrinsic noise
  - cooling to moderate them → more material, complexity

A FEW WORDS ABOUT SINGLE PHOTON DETECTORS
cont.

Time resolution (σ)

- PMTs, MAPMTs >/~ 0.3 ns
- MCP-PMT <100 ps
- SiPM <100 ps
- MWPCs >/~ 20 - 400 ns
  - FE dependent, ballistic deficit implications (*)
- MPGDs ~ 7-10 ns (INTRINSIC)

(*) COMPASS – Gassiplex 400 ns, ballistic def. 50%
APV25 20ns, ballistic def. 25%

Effective QE range

- Vacuum-based devices & SiPMs
  λ > 300, 250, 200 nm
- Gaseous devices (CsI):
  λ < 205 nm
- On-going studies with H-ND
  λ < 200 nm, still preliminary stage

Operation in magnetic field

- PMTs, MAPMTs, HPMTs NO
- MCP-PMT ~YES
- MWPCs, MPGDs YES
- SiPM YES

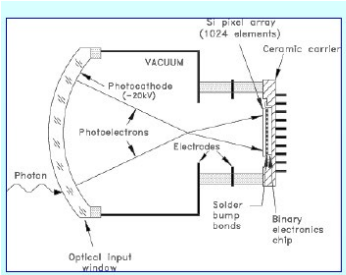
COSTS

- Gaseous (*) - $ (0.2-0.4 M / m^2)
- MAPMTs - $$ (0.5-1 M / m^2)
- SiPM - $$ (0.8-1 M / m^2)
- MCP-PMT - $$$ (???)
  - LAPPD - $$ (0.8-1 M / m^2)

(*) UV: gas system, mirrors more DEMANDING → expensive

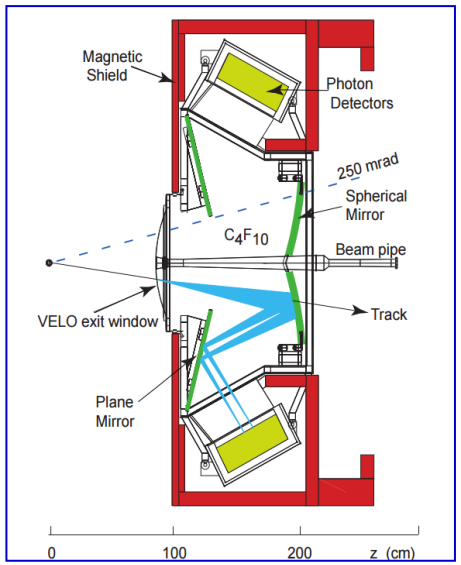
PMTs & MAGNETIC FIELD

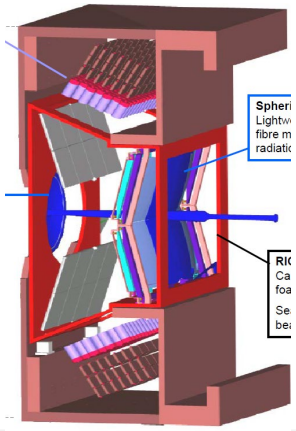
LHCb

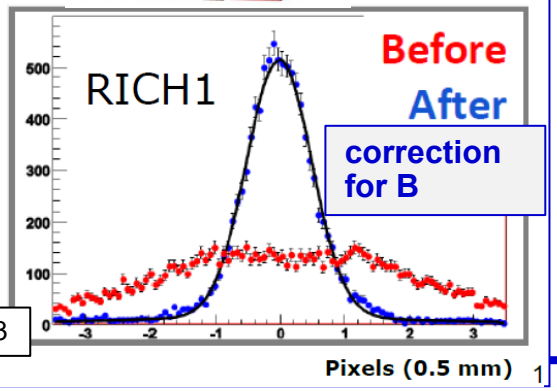


HPM, LHCb custom
1024 anods

Impressive mag. shielding







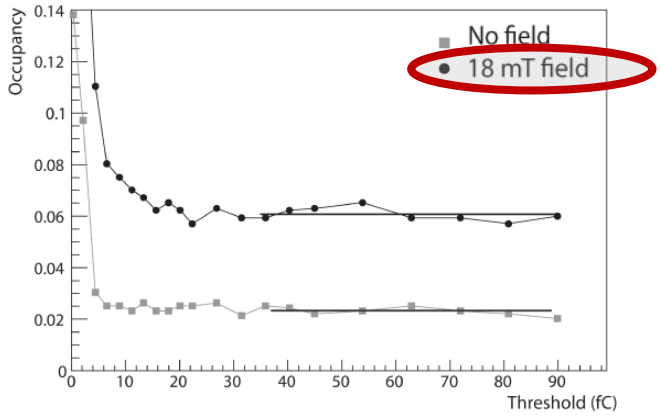
correction for B

Nevertheless:

A. Papanestic, RICH 2013

COMPASS

P. Abbon et al., NIMA 616 (2010) 21

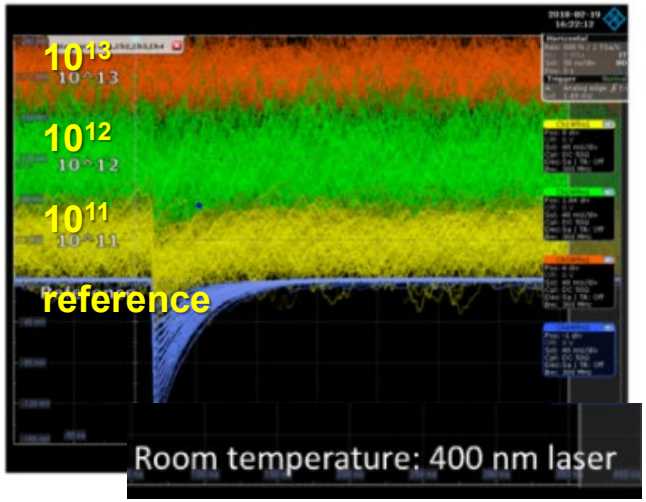


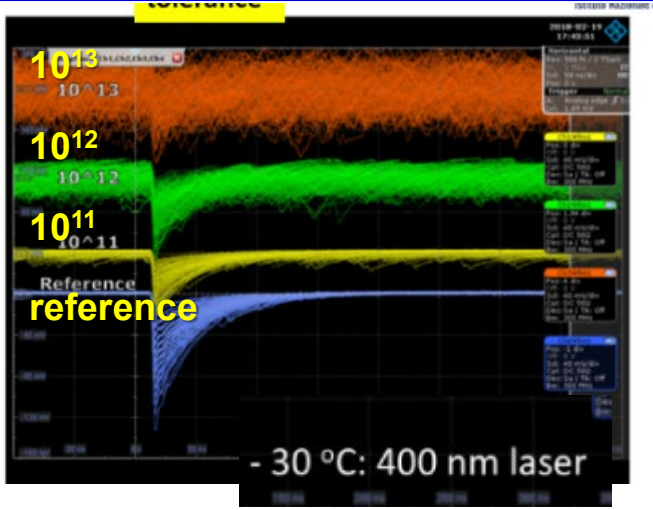
MAPMT type R7600-03-M16 by Hamamatsu

Individual soft iron shielding → B < 2 mT (external B ~ 20 mT)

A FEW WORDS ABOUT SiPMs 1/2

From recent literature

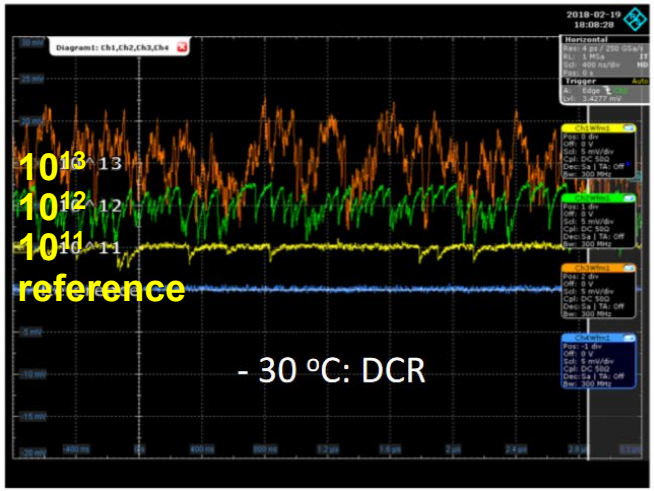


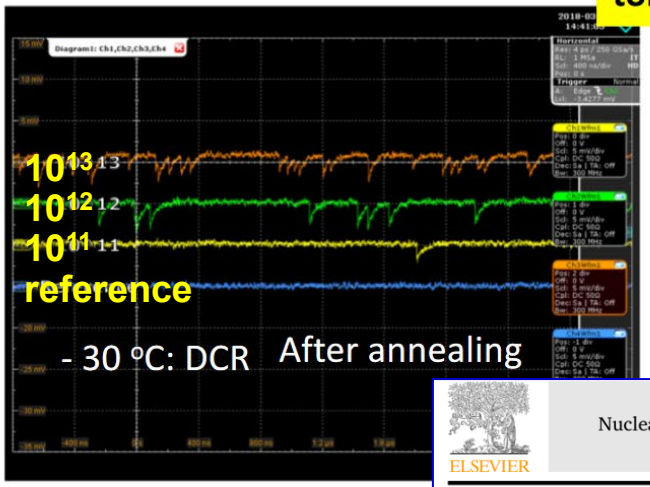


Room temperature NOT an option !

Radiation damages and recovering via annealing (@175 °C)

Radiation tolerance

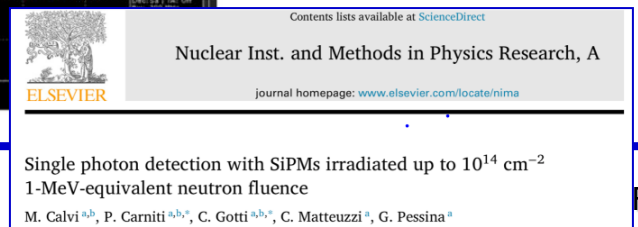




SiPMs

- **@ – 30 °C**
- **With annealing**

Compatible with integrated fluence ~ 10^{11}neq/cm^2 ?


Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

ELSEVIER

Single photon detection with SiPMs irradiated up to 10^{14} cm^{-2} 1-MeV-equivalent neutron fluence

M. Calvi [a,b], P. Carniti [a,b,*], C. Gotti [a,b,*], C. Matteuzzi [a], G. Pessina [a]

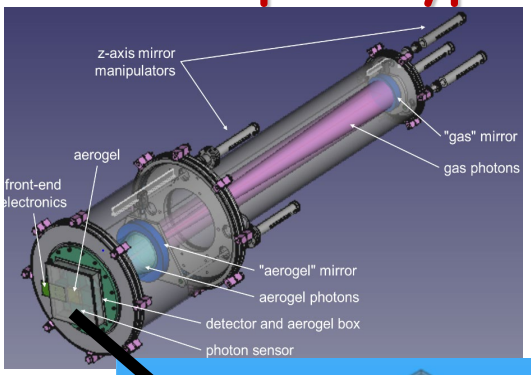
A FEW WORDS ABOUT SiPMs 2/2

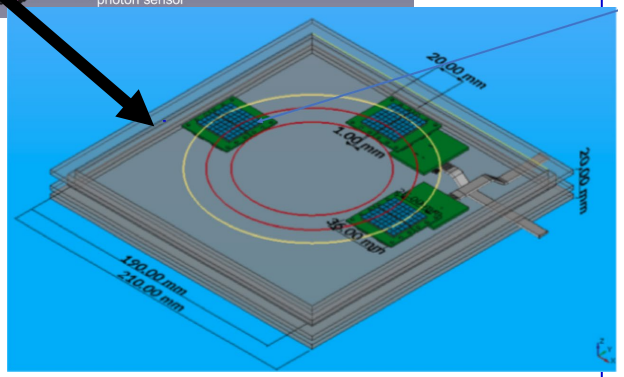
A dedicated effort for application at EIC by a cluster of INFN groups

- SiPMs from different producers mounted on a RICH prototype
  - Part as received
  - Part irradiated
  - Part irradiated and thermal annealing cycle

→ Performance in a test beam

- Coupled to specific FE r-o:
  - ALCOR, developed for DarkSide





MULTIUPLE MANIFACTURES	
SENSEL (OnSemiconductors)	microFJ-30020-TSV
	microFJ-30035-TSV
Broadcom	AFBR-SAN33C013
Hamamatsu Photonics	S13360-3050VS
	S13360-3025VS
	S14160-3015HS
	S14160-3050HS
FBK, Fondazione Bruno Kessler	custom SiPM

Hoping in a fruitful workshop,

Thank you for accepting our invitation