RIUNIONE EIC_NET- Referee 31/8/2022

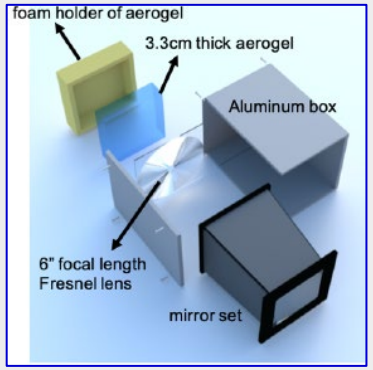
LAPPD

S. Dalla Torre
(per GE & TS)

Pro-memoria: motivazioni

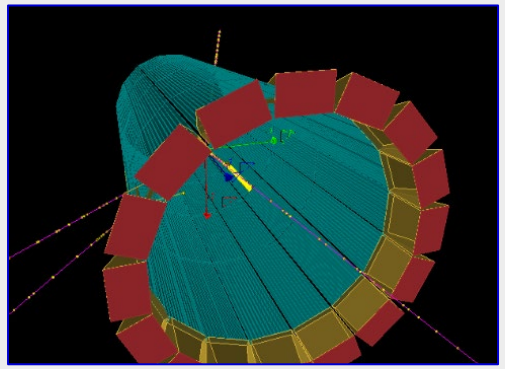
OVERWIEW dei sensori di singolo fotone per PID a EIC

Backward: mRICH
Proximity focusing aerogel RICH with Focalisation by Fresnel lenses



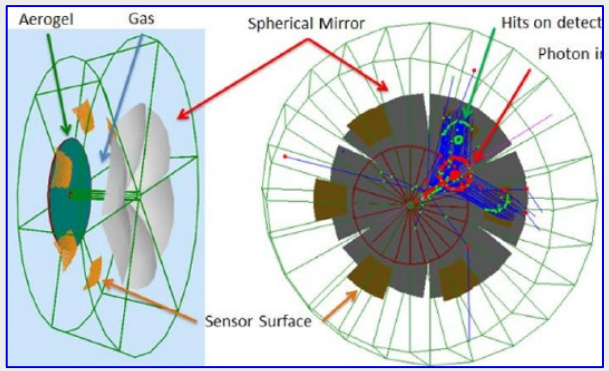
mRICH: fotosensori
- **SiPM** (validazione del principio, livello radiazione?, materiale per il cooling, hit rate in streaming read-out)
- **LAPPD** (campo B, intensita' e allineamento)
  - Offrirebbe in parallel misure di TOF

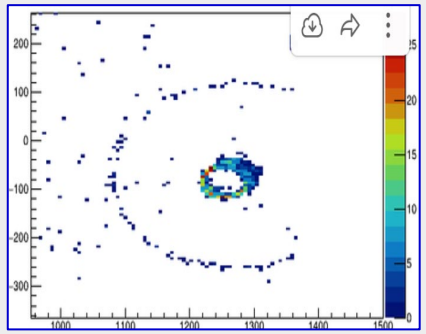
Barrel: high-performance DIRC
Focusing DIRC with lenses



hpDIRC: fotosensori
- **MCP-PMT, Photonis** (come in PANDA, allineamento campo B, costo!)
- **LAPPD**, se validati !

dRICH
2 radiators: Aerogel & gas

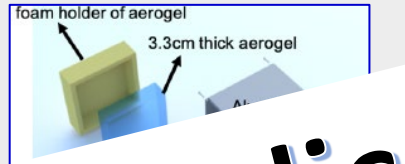




dRICH: fotosensori
- **SiPM** (validazione del principio, hit rate in streaming read-out)
- Backup: LAPPD, se validati !

OVERWIEW dei sensori di singolo fotone [illegible] a EIC

Backward: mRICH
Proximity focusing aerogel RICH with Focalisation by Fresnel len[illegible]



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g, hit

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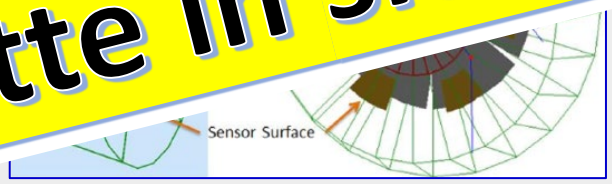
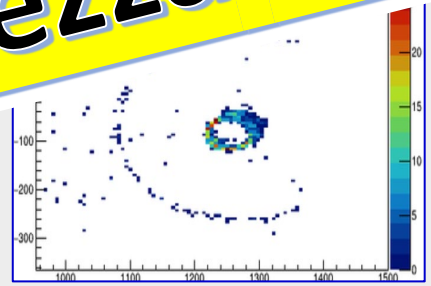




dRICH: fotosensori
- **SiPM** (validazione del principio, hit rate in streaming read-out)
- Backup: LAPPD, se validati !

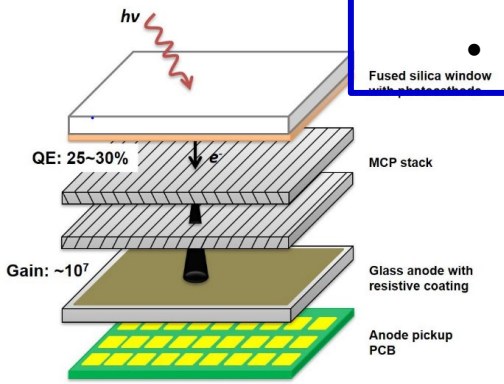
Validare per applicazioni Cerenkov a immagine
- **SiPM**
- **LAPPD**

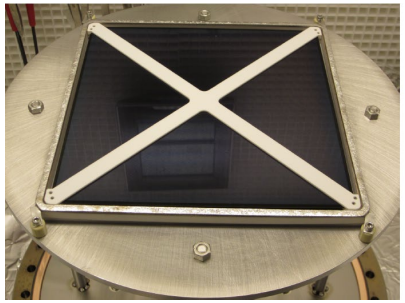
Mette in sicurezza l'intero PID a EIC

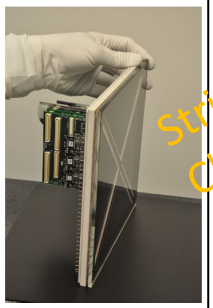
LAPPD – introduction

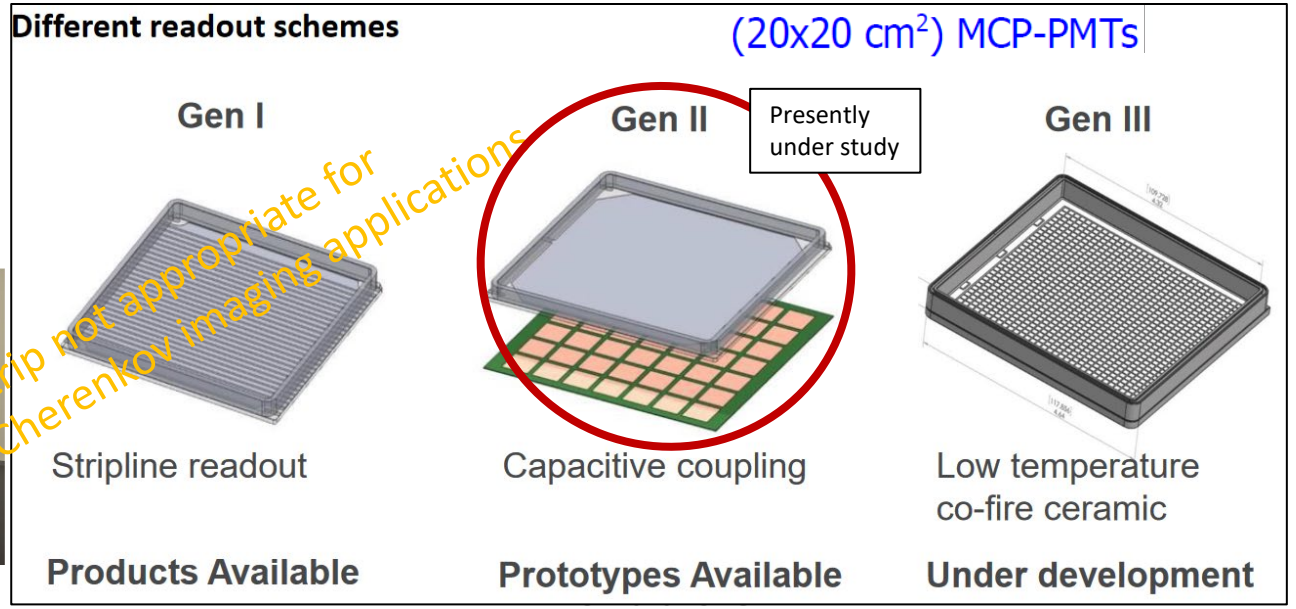
LAPPDs: large-size (200 x 200 mm^2) MCPs

- developed by Argone, University of Chicago and others
- industrial partner: INCOM
- main GOAL: large size at moderate cost per unit area (~1 $/$mm^2$, range similar to SiPMs)
- photon converter, presently: K_2NaSb (UV and visible)
- large gain: > 10^6
- low noise: ~ 2 k/cm^2
- this development has introduced: Atomic Layer Deposition (ALD)
  - orders of magnitude longer MCP life-time
  - quickly adopted by industrial producers of small-size MCPs









From M. Minot, INCOM.

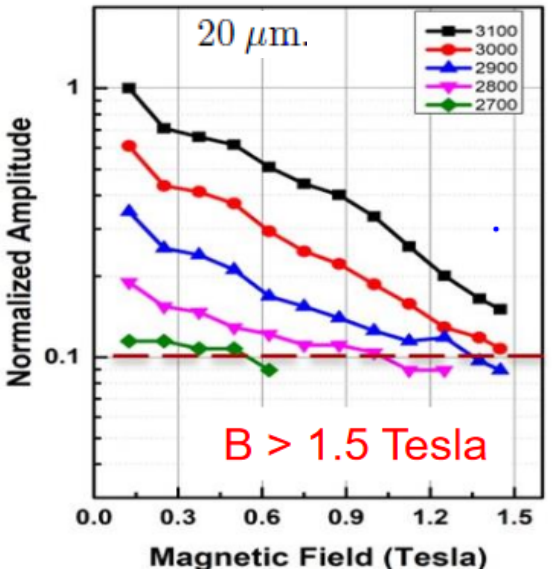
Table 1 - LAPPD Pricing Schedule (05-18

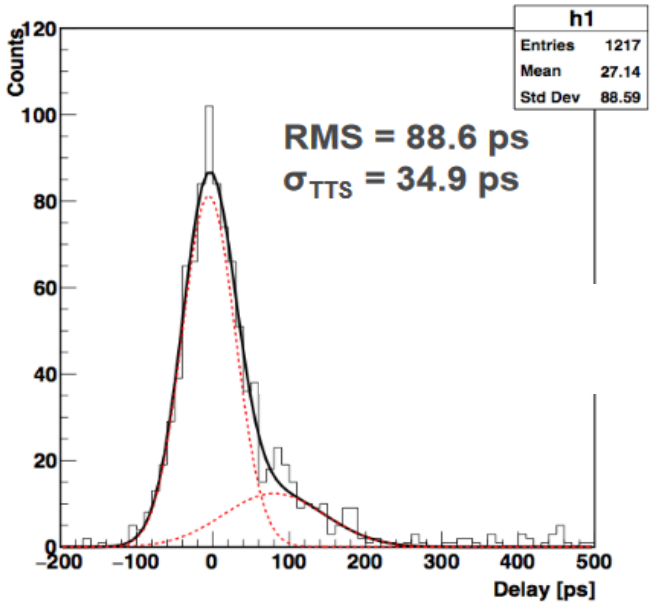
# Sold	Unit Price	Sales
1	$ 50,000	$ 50,000
2	$ 47,044	$ 94,088
3	$ 43,440	$ 130,319
4	$ 41,461	$ 165,842
5	$ 40,111	$ 200,557
6	$ 39,095	$ 234,571
7	$ 38,284	$ 267,988
8	$ 37,611	$ 300,890
9	$ 37,038	$ 333,343
10	$ 36,540	$ 365,398
20	$ 36,100	$ 721,995
50	$ 33,334	$ 1,666,694
75	$ 30,000	$ 2,250,007
100	$ 28,633	$ 2,863,335
300	$ 27,702	$ 8,310,468
500	$ 24,414	$ 12,206,898
750	$ 23,021	$ 17,265,691
1000	$ 21,972	$ 21,972,132

LAPPD – introduction

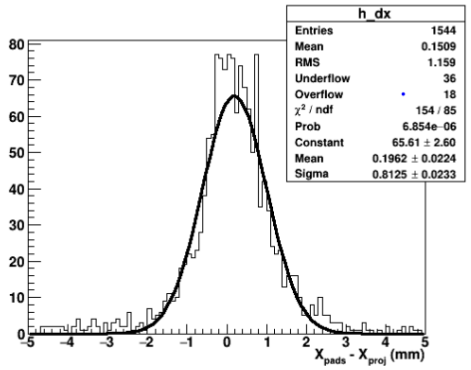
recently measured performance

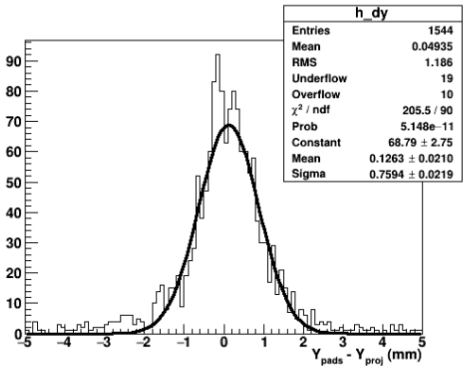
JUNQI XIE
1st EIC YR workshop, March 2020,
J. Xie et al.,NIMA A955 (2020) 163234





X res (mm)	Y res (mm)
0.81	0.76





ANL version 4
IBD design 10 μm MCP
reduced spacing

Further improvement if needed:
Smaller pore size: 6 μm, version 4 -> 5 (future)

Pro-memoria: stato settembre 2021

OVERWIEW degli studi di fotosensori in EIC_NET

USA:
Argonne, U. of Chicago,
BNL, Jlab (?)

Estratto dalle slide mostrate 2/9/2021

Attivita' gia' in Corso in USA
nuova per noi
Strategica per PID e alter applicazioni

- **LAPPD (GE, TS)**
  - **Attivita' preparatoria nel 2021, operative nel 2022**
  - **<u>Caratterizzazione dei sensori</u> quali rivelatori di singolo fotone per applicazioni Cherenkov a imagine**

Attivita’ 2022 & 2023

LAPPD – 2022 activity

2022

- collaboration within the EIC NET between TS and GE groups to perform this R&D in collaboration is operative:
  - Task distribution organized;
  - Periodic meetings in zoom;
  - 2 periods of common lab activity (second one on next week)

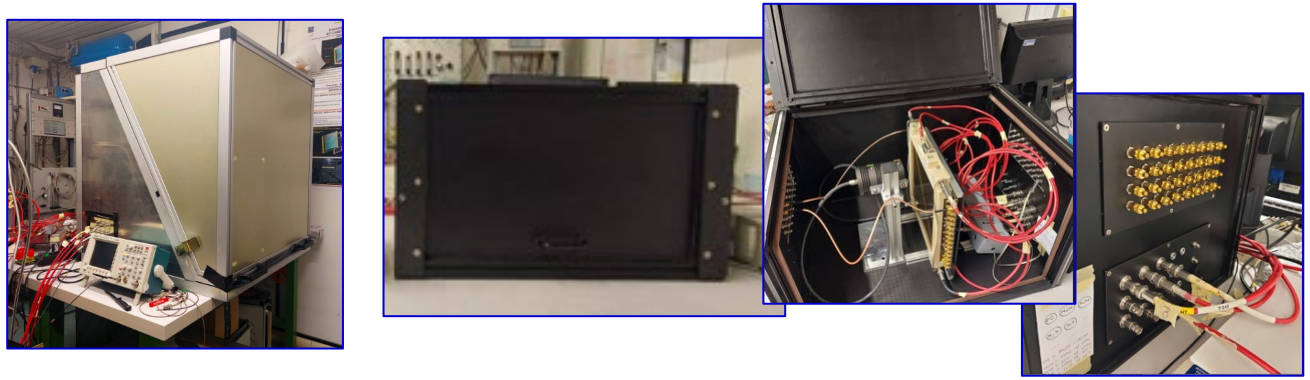
- Equipment:
  - **dark box equipped according to needs** (initially an existing one, non optimized; then a dedicated one adequate also for test beam and future studies in mag. Field);
  - **digital scope** (initially: LeCroy6200A, 2 GHz; when delivered: LeCroy OSCILLOSCOPE WAVERUNNER 9254, 2.5 GHz)
  - **PICOQUANT** pulsed laser source; device existing, equipped with a **new head providing visible light** (405 nm)
  - **Pulser**: AGILENT: 33220A

- Equipment, cont.:
  - Operation of the **read-out chain** consisting in the **32-channel V1742** by CAEN based on the front-end ASIC DRS4; basic **acquisition/reconstruction software** developed
  - *Amplifier (single channel) developed and test → 8-ch boards being produced for the October test beam*

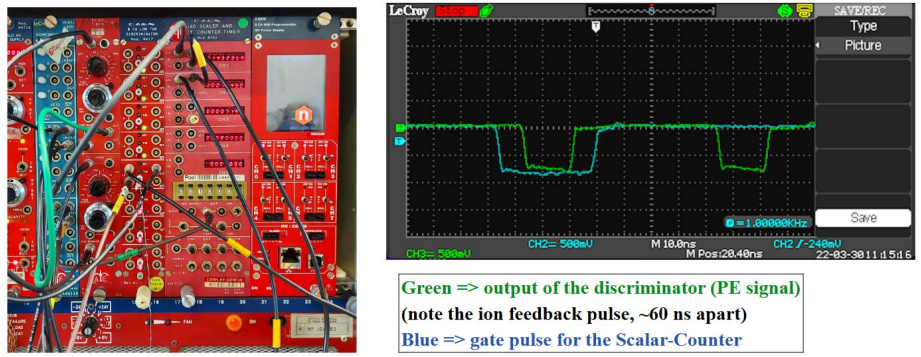
- LAPPD characterization
  - Study of the dark count rate at different voltage/gain
  - Study of the charge spectrum
  - Contributing to the analysis of an LAPPD-dedicated test beam by US colleagues at Fermilab
  - Time resolution [presently w/o including the transit time spread] estimated
  - *Time resolution including transit time: test beam to study timing properties (parasitic dRICH/SiPM test beam) in Oct. 2022*

- Building-up world-wide synergies:
  - First LAPPD workshop on 21 March 2022, organized by INFN TS, BNL and ANL (https://indico.bnl.gov/event/15059/)
  - A following-up workshop at the end of October

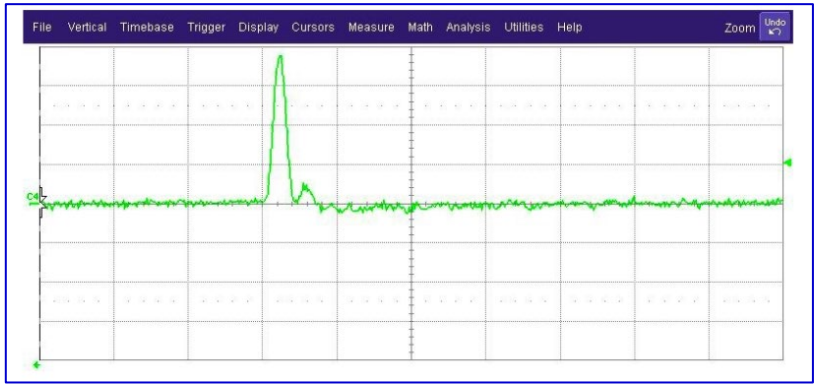
LAPPD – 2022 activity, highlights in gallery format



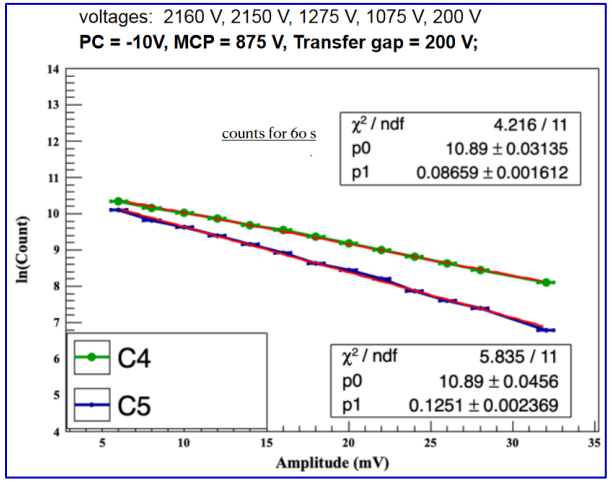
Initial dark-box; then, optimized dark-box modified to improve light-tightness and operative needs

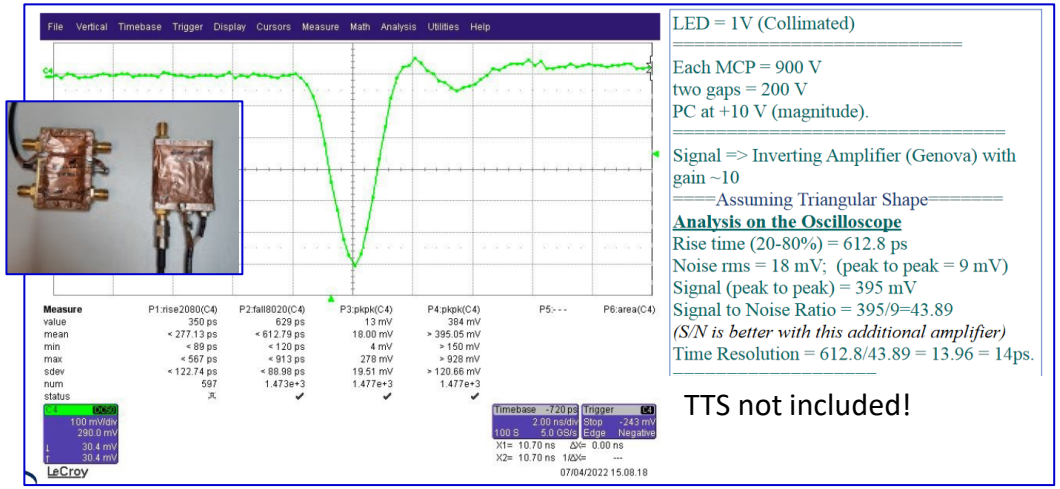


Single photoelectron condition using a pulse LED



Example of dark-pulse signal and studies of the dark-pulse rate

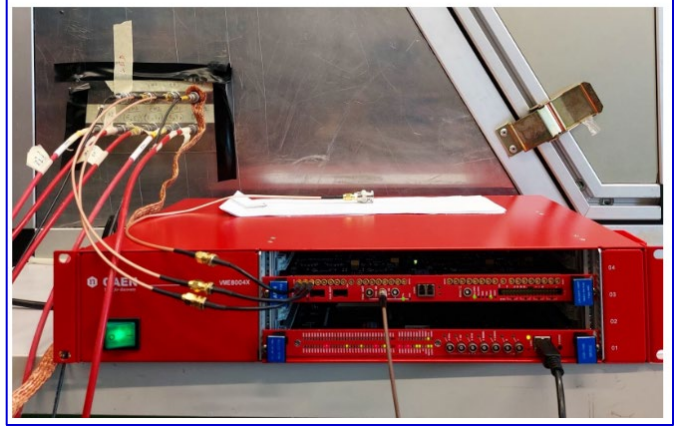




Using the pre-amplificator: signal analysis at the scope

LAPPD – 2022 activity, highlights in gallery format

VME Crate: CAEN 8004X, Digitizer: CAEN V1742



First exercises with the digitizer

Example Photon-Event from Digitizer

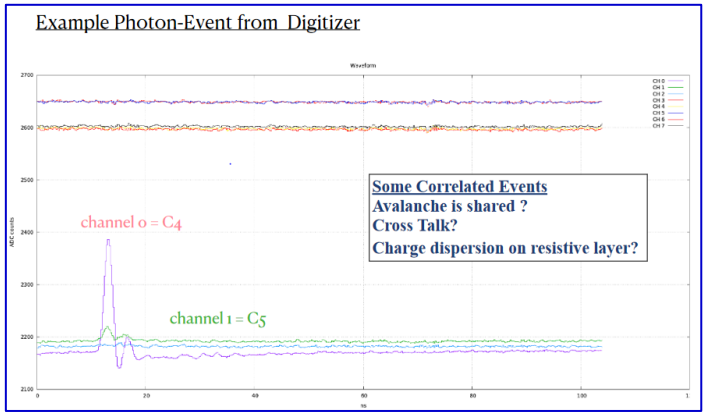
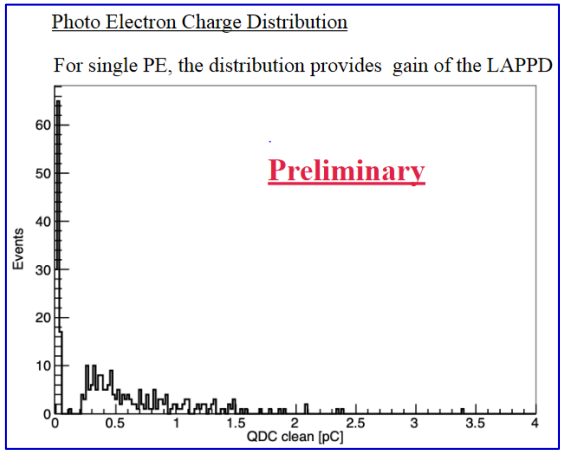
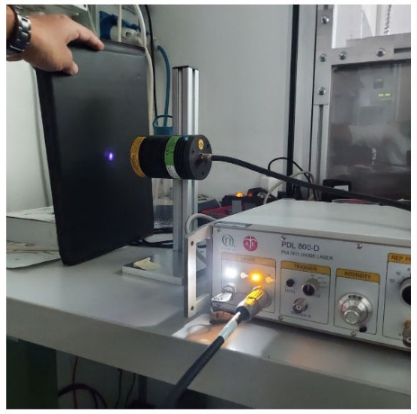


Photo Electron Charge Distribution

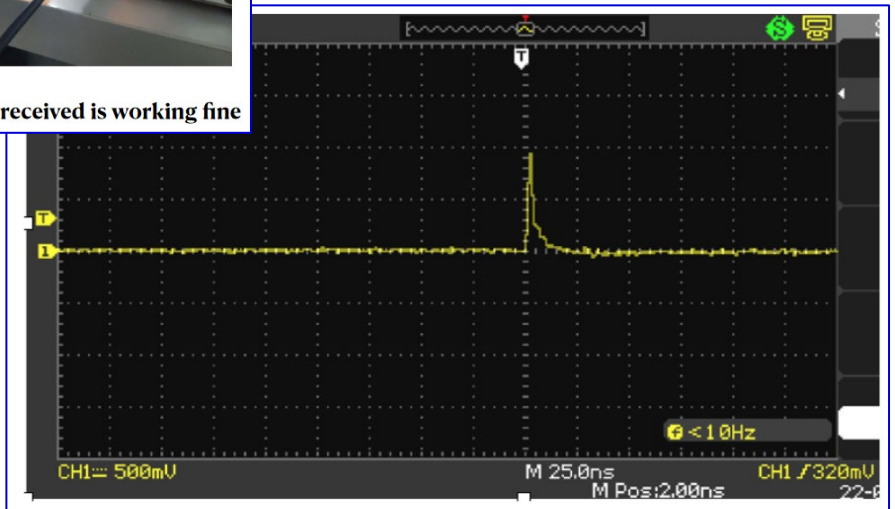
For single PE, the distribution provides gain of the LAPPD





The LASER as we received is working fine

Getting familiar with the new head (405 nm) of the PICOQUANT pulsed laser source



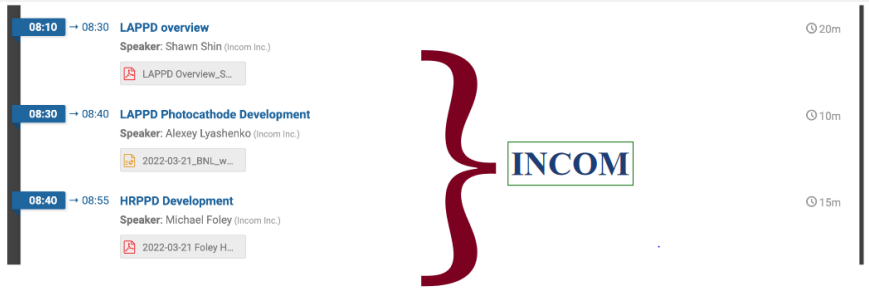
A pulse from the LAPPD with the LASER incident on it

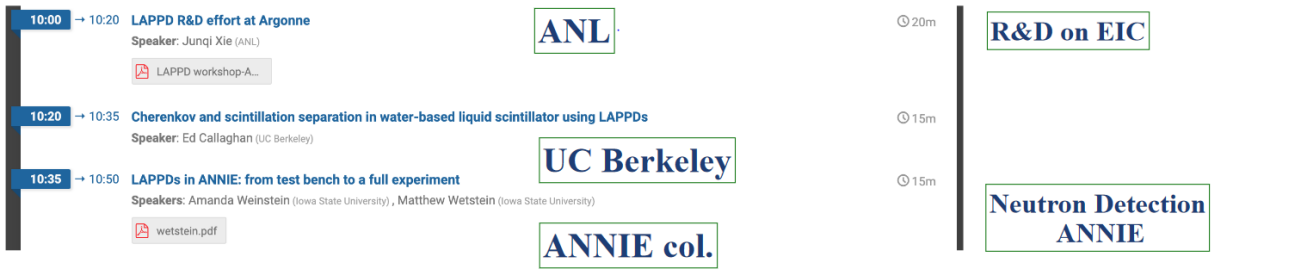
LAPPD – 2022 activity, highlights in gallery format

Building-up world-wide synergies:

- First LAPPD workshop on 21 March 2022 by INFN TS, BNL and ANL (https://indico.bnl.gov/event/15059/)
- A following-up workshop at the end of October

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





- **Participation has been overwhelming: peaked at 80**
- **Number of contributions is larger than expected**
- **A clear indication to create more synergies**

LAPPD –2023 activity

2023

- **measuring the variation in gain and efficiency of LAPPD in intense (up to 1-1.5 T) magnetic field** with different field orientation
  - A magnet with adequate magnetic field and large bore has to be identified; two options, one at CERN and a second one at DESY (logistic aspects and availability) → **traveling resources requested (s.j.)**
  - preparatory exercise: modify those setup elements that are not compatible with operation in intense magnetic field → **costs included in the request of consumable for the laboratory**

- **Space resolution studies**
  - It can be performed using the pulsed diode laser source properly collimated by scanning with small step size (50-100 mm) the LAPPD surface
  - **3-axis translation system need** (the third axis has a shorter range and is used to focus the light onto the detector entrance window) → **resources requested**
  - Need to read-out a larger portion of the surface: a second V1742 unit needed → **resources requested**

2023, cont.

- **Lab characterization of a more advanced prototype**
  - the 20 x 20 cm^2 prototype used so far has 20 μm pore diameter and "thick" exit window (quartz);
  - Aiming at testing a **more advanced prototype** with 10 μm pore diameter and thin ceramic exit window (larger signals!) → **resources for rental requested** (part within EIC_NEt., part within AMBER)
  - Improving the lab setup with **a remotely controlled HV unit** to monitor V/I in parallel with data taking → **resources requested**

- **Pico TDC application for LAPPD**
  - V1742 with DRS4 is not an adequate approach for large-scale systems and high event rate
  - The superior timing resolution featured by LAPPDs must be exploit by adequate electronics (photon emission point, ToF information as by product)
  - picoTDC chip: 64 ch.s, 3 ps bins
  - a frontend stage needed (NINO or FastIC)
  - Development of **a custom board for Pico TDC and FE ASIC** (potential synergies with LACb) → **resources requested**

We also require traveling resources to continue the successful GE-TS collaboration

RICHIESTE 2023

LAPPD – richieste 2023

sede	capitolo	rich. (keuro)	rich. s.j.(keuro)	descrizione	note
TS	consumo	7		2 mesi noleggio LAPPD	in sinergia con richiesta complementare AMBER (CSN1), **OFFERTA ALLEGATA**
		3		metabolismo laboratorio per studi LAPPD	allestimento compatibile con operazione in campo magnetico, inclusi elementi ottici per trasporto in fibra ottica
	inventario	17		Sistema di movimentazione a 3 assi	studio della risoluzione spaziale dei sensori LAPPD, **OFFERTA ALLEGATA**
	missioni	3		attivita' di collaborazione TS-GE sul LAPPD	(2 +1) settimane uomo a GE
			3	misura della risposta degli LAPPD in forte campo magnetico	2*10gg a CERN o Desy
GE	consumi	10		Sviluppo scheda custom per PicoTDC + NINO o FastIC	primi esemplari PicoTDC (sviluppo CERN) disponibili entro 2022, costi prevalenti; disegno board e componentistiuca, ipotesi di sinergie con LHCb
		2		cavettereia, connettori ed altra componentistica	
	inventario	9.5		digitizer CAEN V1742 32 ch	lettura di 64 canali (attualmente solo 32), **OFFERTA ALLEGATA**
		1.5		A4818 - USB 3.0 to CONET Adapter	per collegamento fibra ottica digitizer-PC, **OFFERTA ALLEGATA** (attualmente, link USB VME-PC)
		3		6533N - 6 Channel VME Programmable HV	per alimentazione del LAPPD controllata da remoto, **OFFERTA ALLEGATA** (per monitoraggio V/I acquisibile in real time)
	missioni	2.5		attivita' di collaborazione TS-GE sul LAPPD	2 * 1 settimana uomo a TS
			2.5	misura della risposta degli LAPPD in forte campo magnetico	2 settimane uomo a CERN o Desy

INFORMAZIONI COMPLEMENTARI

Contesto R&D LAPPD per applicazioni CERENKOV

Sinergie di vari progetti e gruppi

- EIC
  - Rivelatore per il PID (aerogel, hpDIRC, dRICH)
  - Gruppi USA (Argonne, U. of Chicago, BNL, Jlab?)
  - Gruppi INFN (TS, GE)
- AMBER
  - Necessita' RICH 0 per il programma di fisica di AMBER
- AIDAinnova
  - Concetto dei RICH compatti per collider (EIC, circular e+e-)
  - Il supporto e' usato per manpower

eRD110 – EIC photon detectors

- Also **LAPPD** studies included
- 2022: 20 k$ assigned for INFN activity in this sector (mainly resources for personnel)

Una possibilita', attualmente in fase embrionale → LAPPD Workshops!

- Un CONSORZIO LAPPD per coordinamento fra tutti gli studi LAPPD, anche al dila' del Cerenkov