# LAPPD: Lab tests at Trieste and test beam

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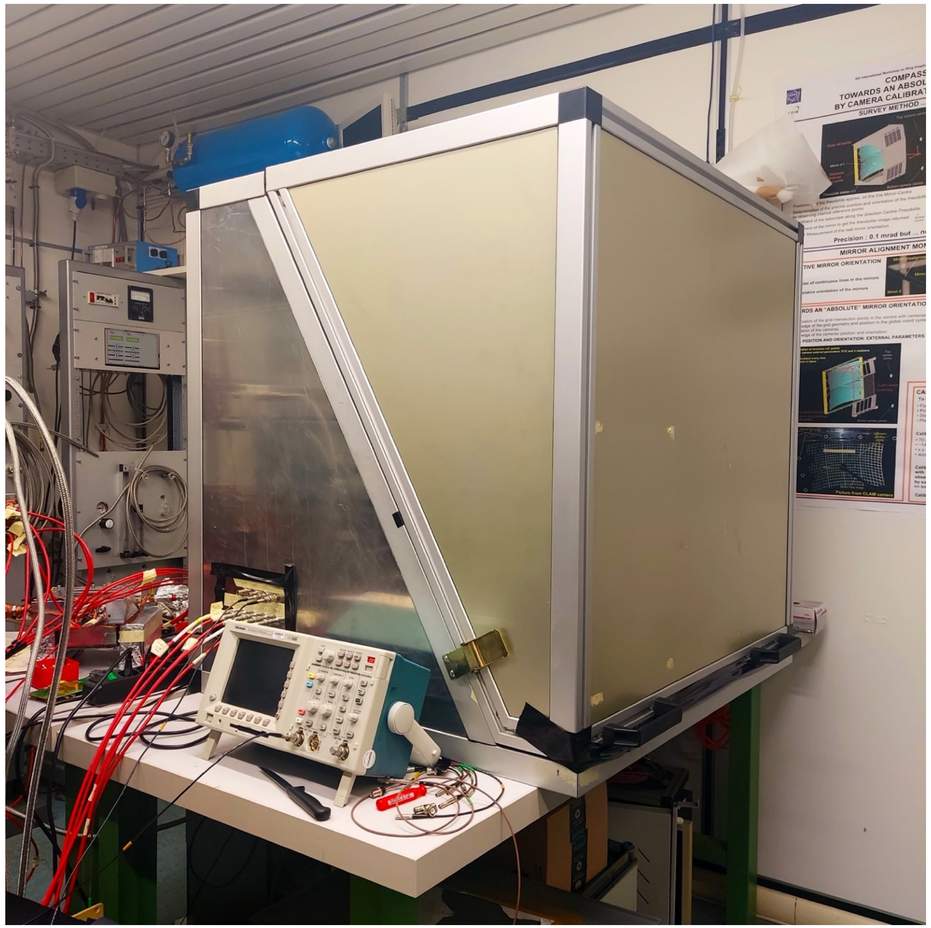
1 July 2022

# Outline:

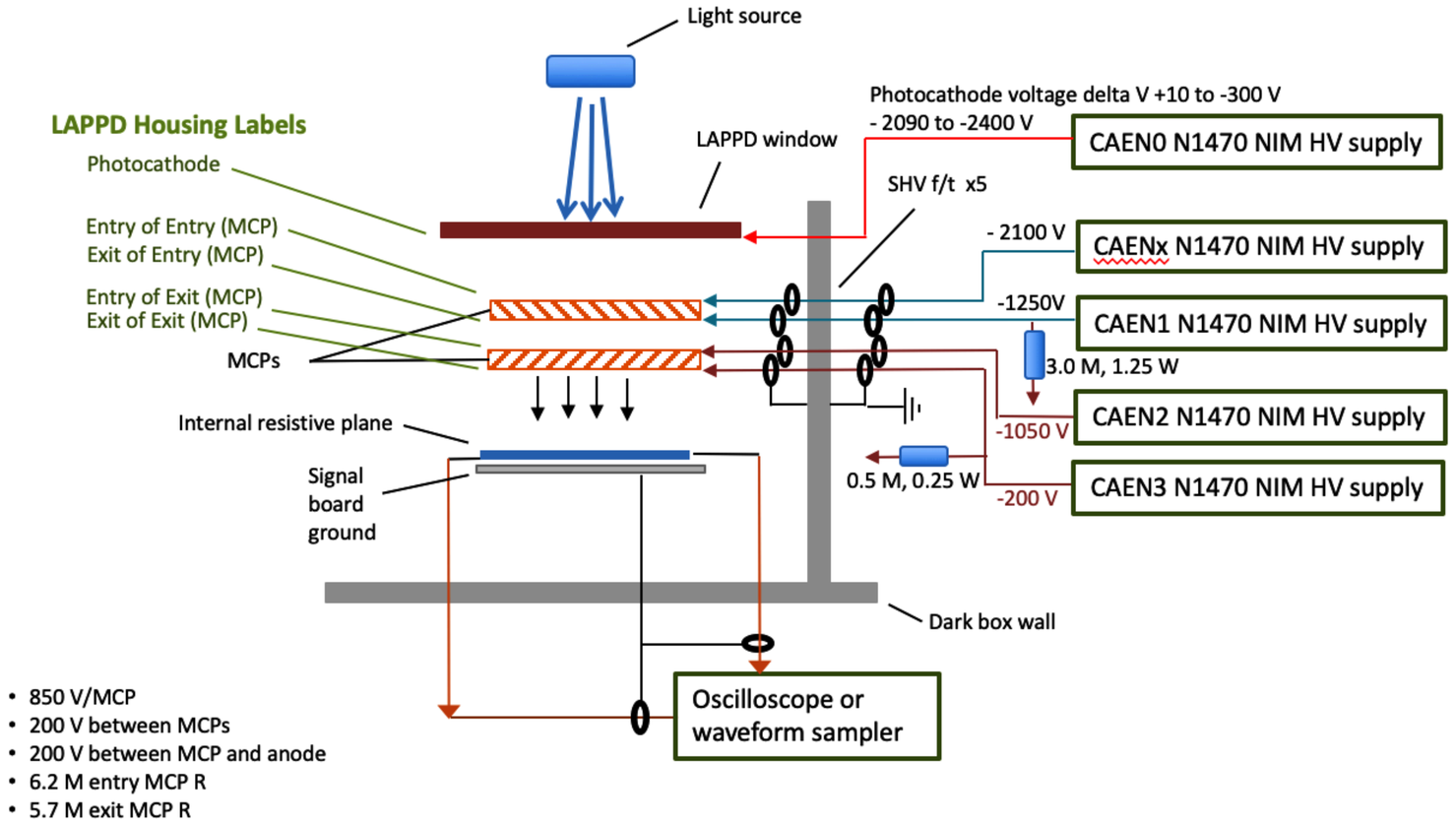
- R&D activity on the LAPPD at Trieste
- Programme to build synergies in LAPPD activities
- Recent news from the Fermilab Beam Test

# The detector



The dark-box: ad-hoc arrangement

**HV scheme as suggested by Incom. We are using 5 different HV channels.**

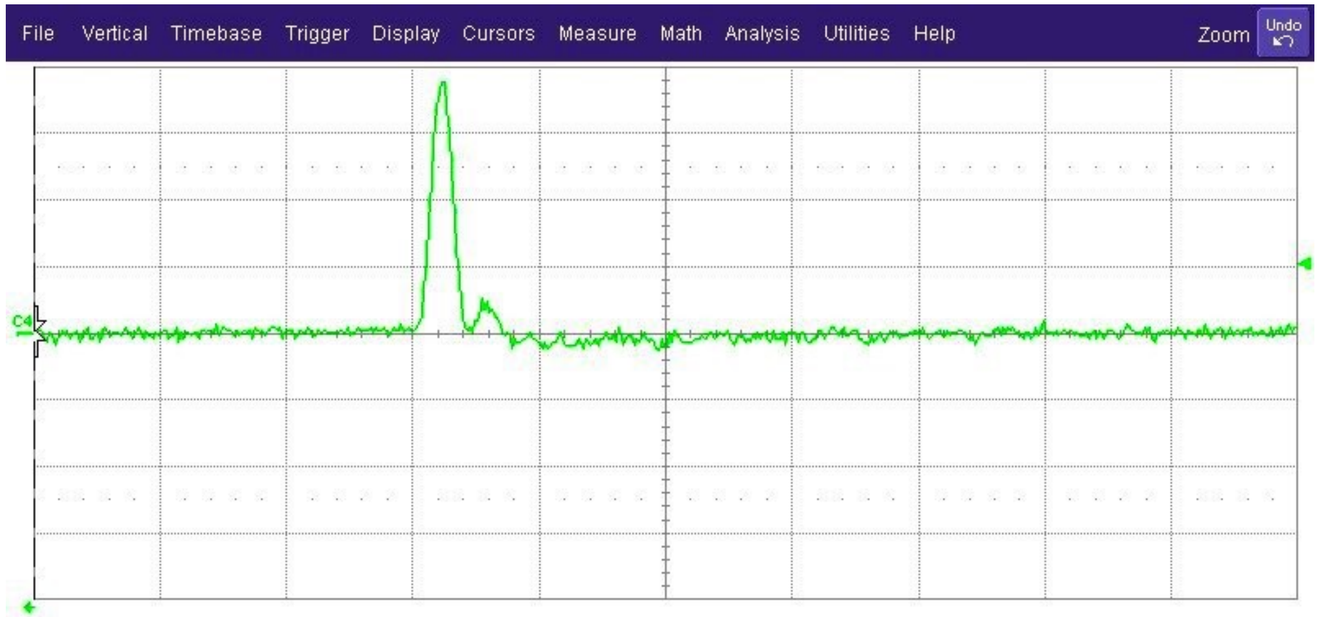



LAPPD 87

**The grounding scheme is modified:**

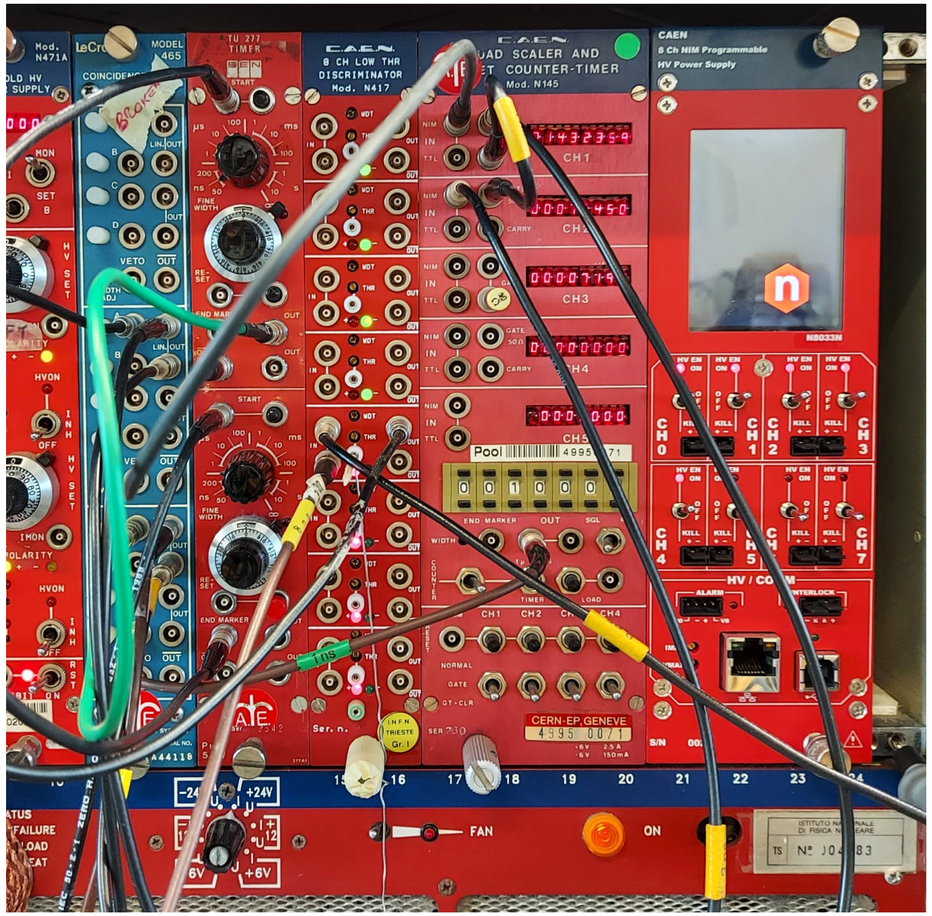
- **all the HV grounds are connected to the common detector ground**
- **more stability**
- **better safety**

# To study dark pulse rate:




**An example of a 'Dark Pulse' (due to thermal noise)**






**Classical setup for counting dark pulse**

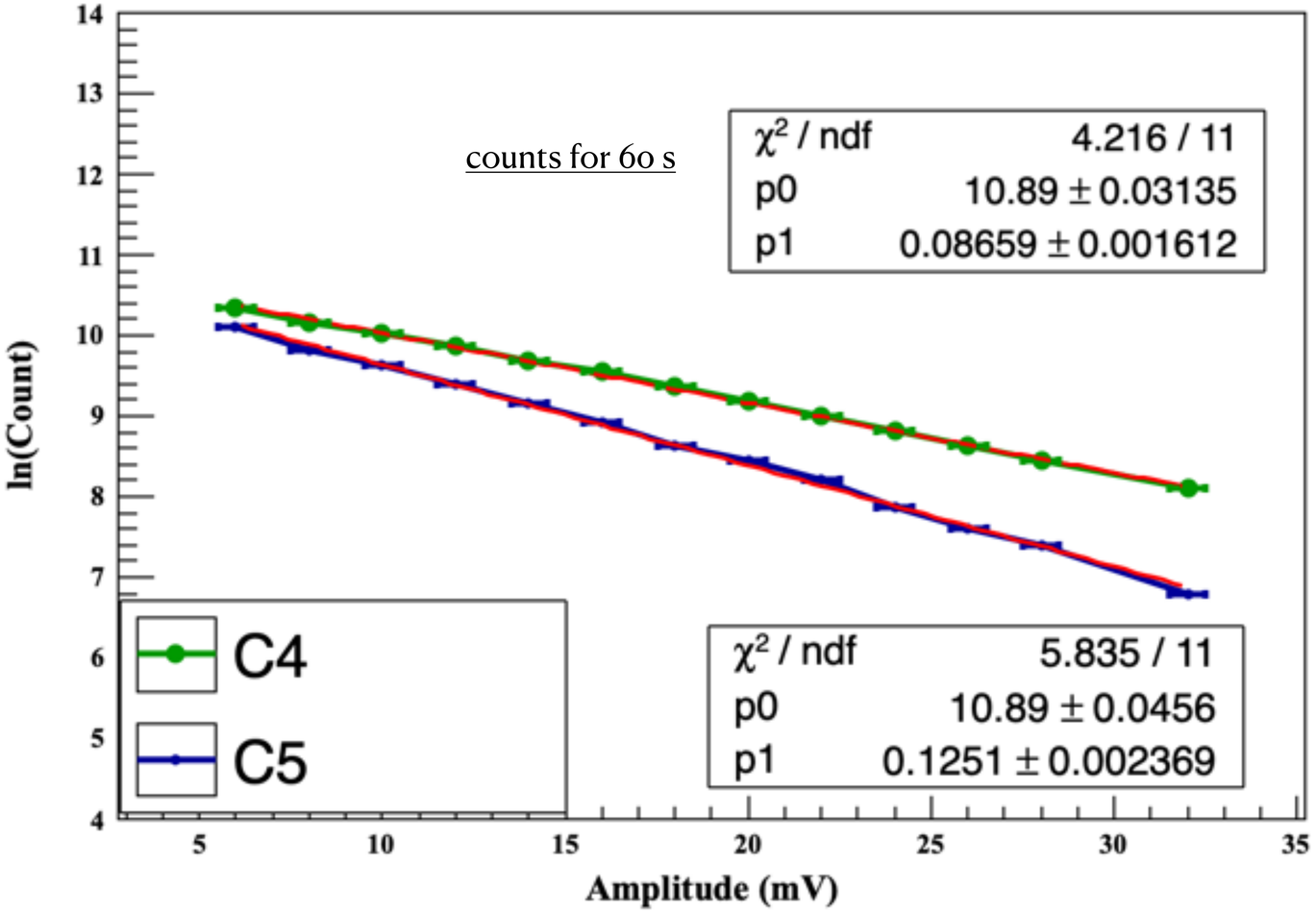
**The classical setup: Discriminator, Scalar Counter, Coincidence, Dual Timer**

# To study dark pulse rate

[ REMINDER ]

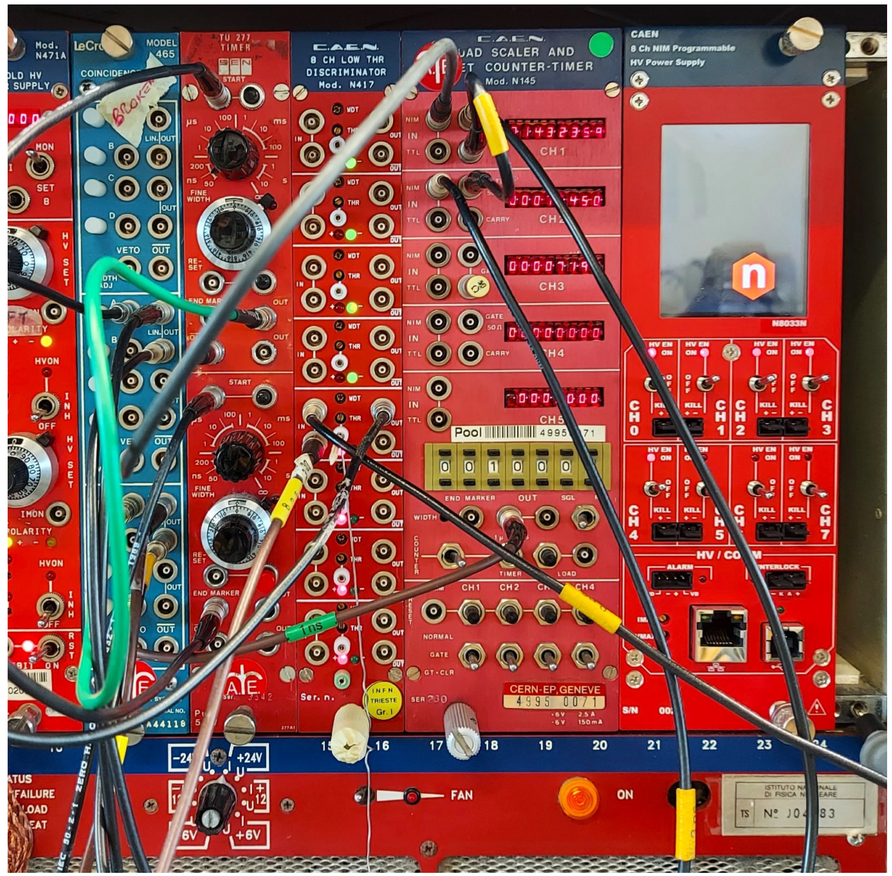
voltages: 2160 V, 2150 V, 1275 V, 1075 V, 200 V

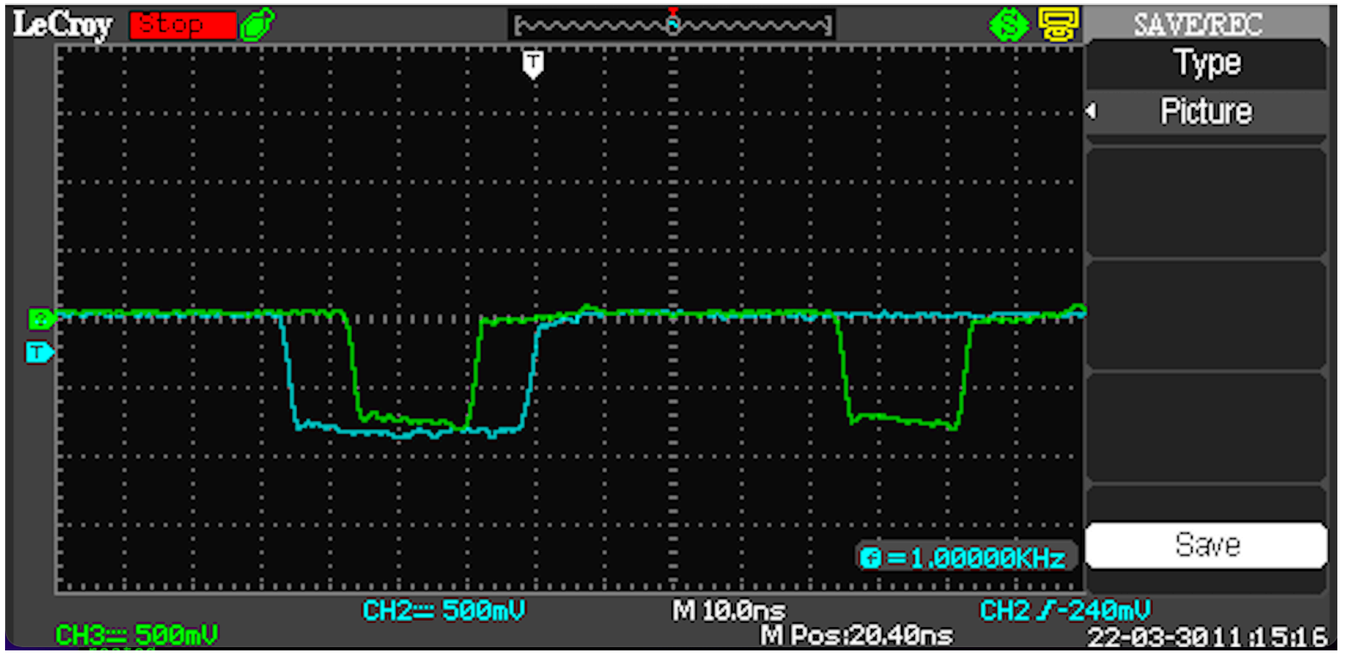
**PC = -10V, MCP = 875 V, Transfer gap = 200 V;**




- The ‘Count Vs Threshold’ is exponential in nature
- A linear fit in log scale gives intrinsic dark rate (independent of the threshold)
- Intrinsic dark rate = 900 Hz/Pixel = 140 Hz/cm^2 at room temperature.
- The rate is similar over a few pads
- Measured dark rate matches with Incom results for #87

# Reaching ‘almost' single photon condition with an LED source and paper absorber



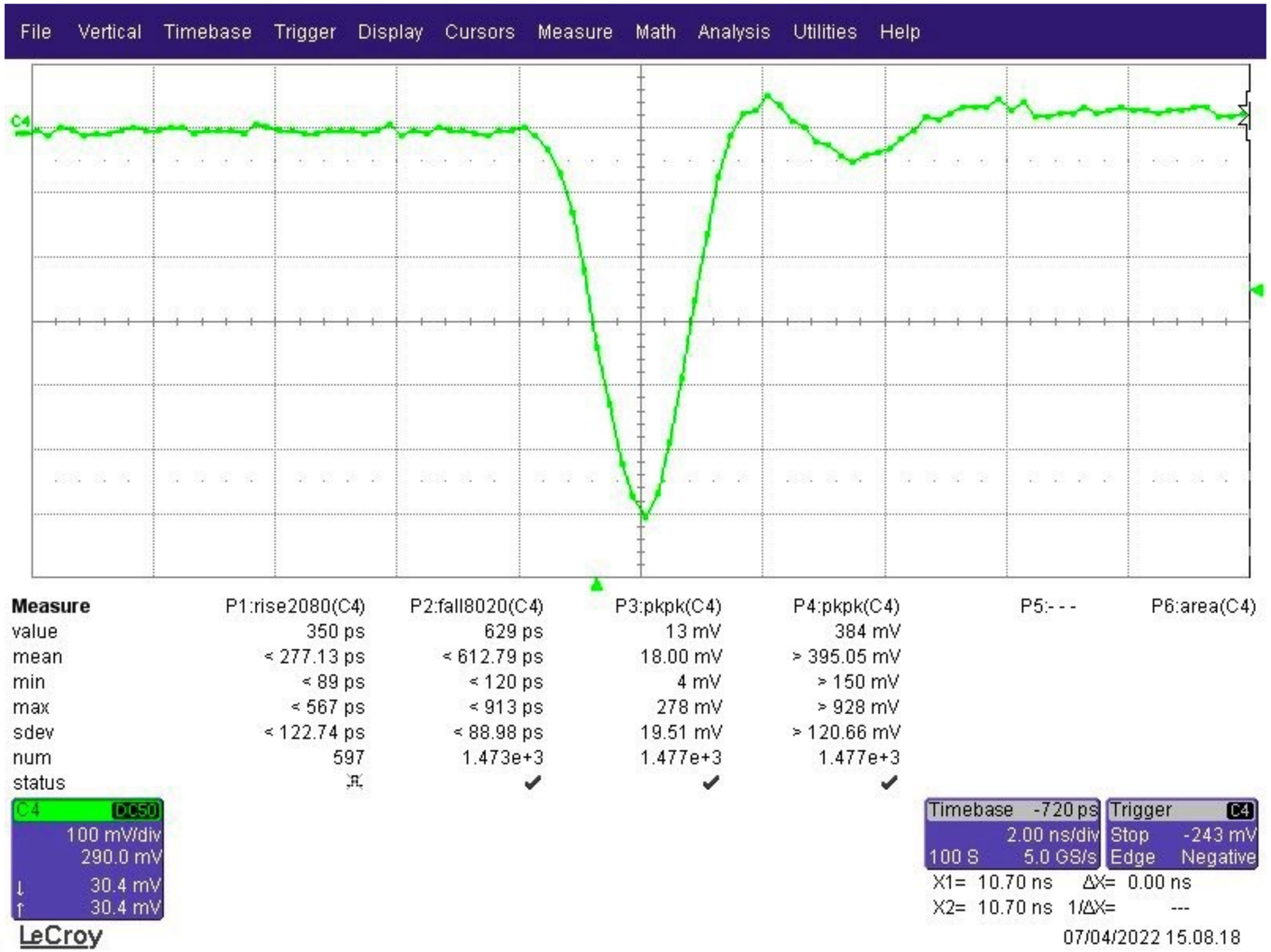

**Green => output of the discriminator (PE signal)**
**(note the ion feedback pulse, ~60 ns apart)**
**Blue => gate pulse for the Scalar-Counter**

**More than 95% of empty trigger pulses > Very close to Single Photon Condition**

# Quick Inspection with the Oscilloscope: LeCroy 6200A (2 GHz)

[ REMINDER ]

- A Pulser: Agilent 33220A
- A green LED (adhoc)




LED = 1V (Collimated)

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Each MCP = 900 V

two gaps = 200 V

PC at +10 V (magnitude).

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Signal => Inverting Amplifier (Genova) with gain ~10

====Assuming Triangular Shape=======

**Analysis on the Oscilloscope**

Rise time (20-80%) = 612.8 ps

Noise rms = 18 mV; (peak to peak = 9 mV)

Signal (peak to peak) = 395 mV

Signal to Noise Ratio = 395/9=43.89

*(S/N is better with this additional amplifier)*

Time Resolution = 612.8/43.89 = 13.96 = 14ps.

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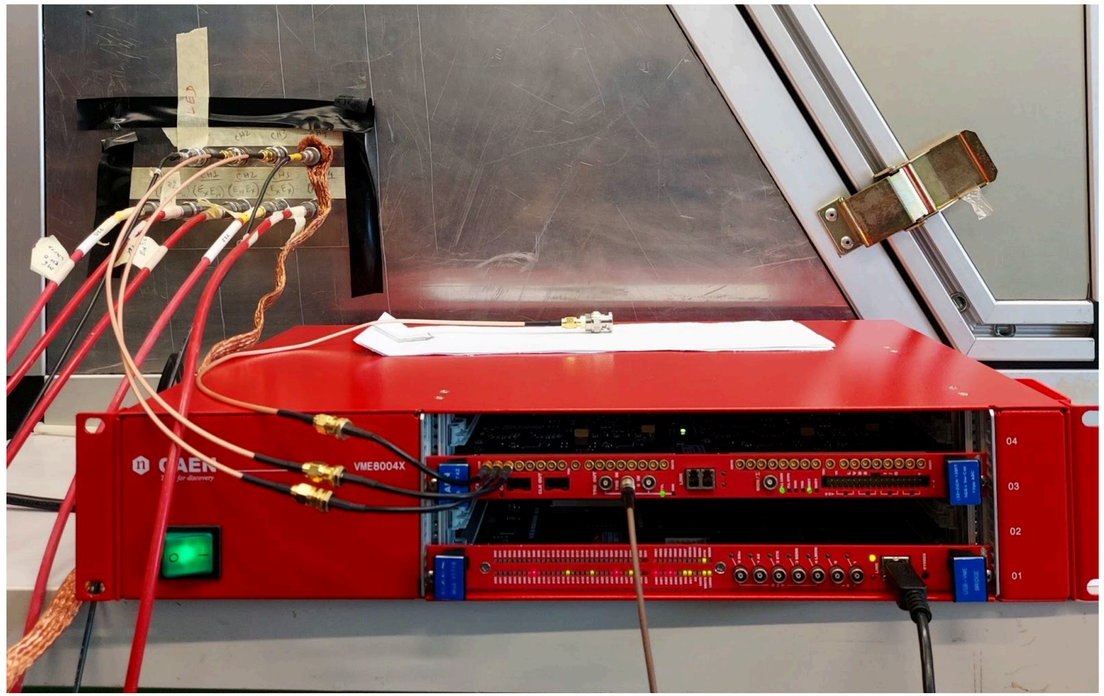
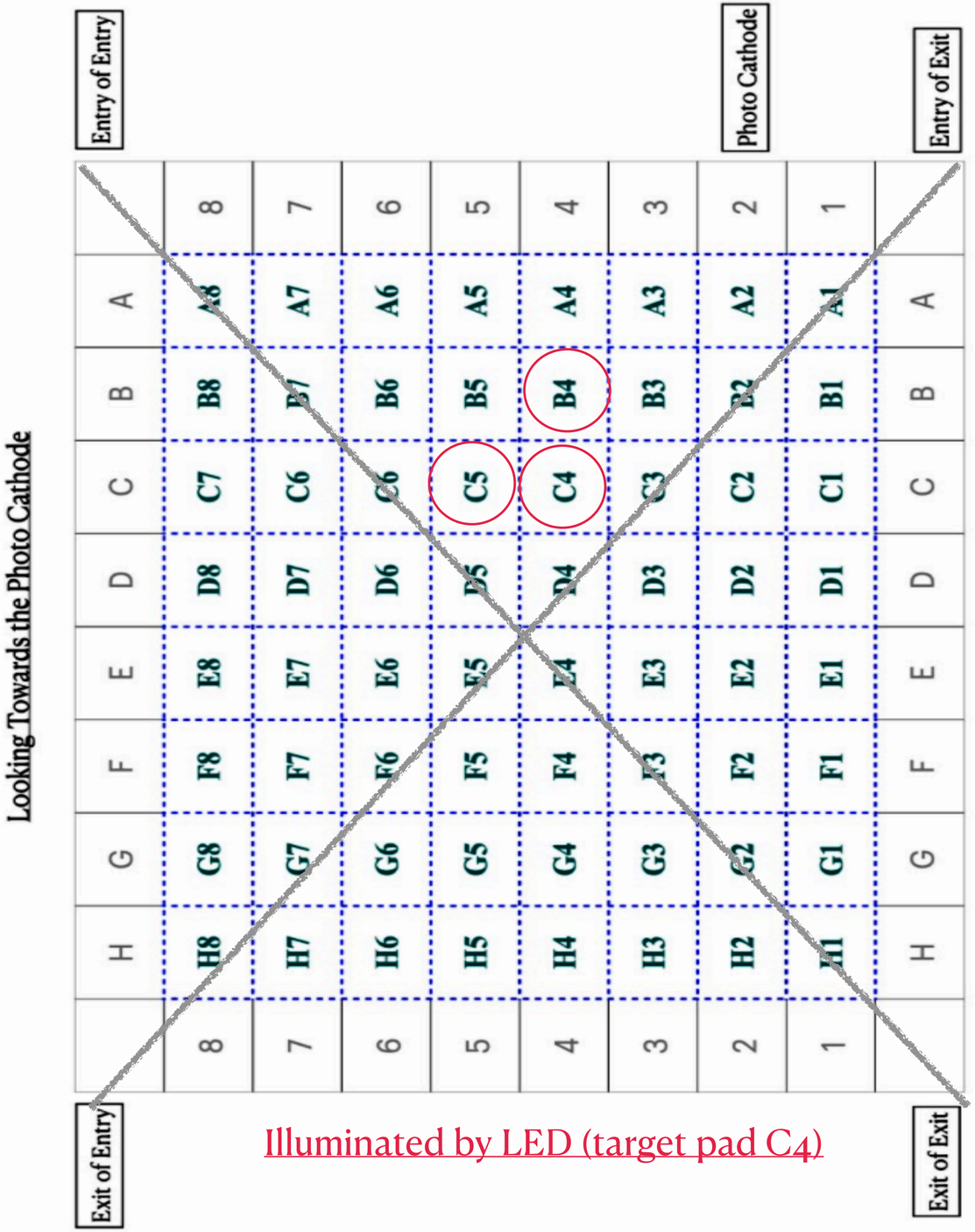
**Time Resolution (without amplifier) = ~35 ps**

# To study the charge spectrum from PE

VME Crate: CAEN 8004X,  Digitizer: CAEN V1742




**Thanks to our colleagues from INFN Genova:**
**Mikhail Osipenko and Saverio Minutoli**

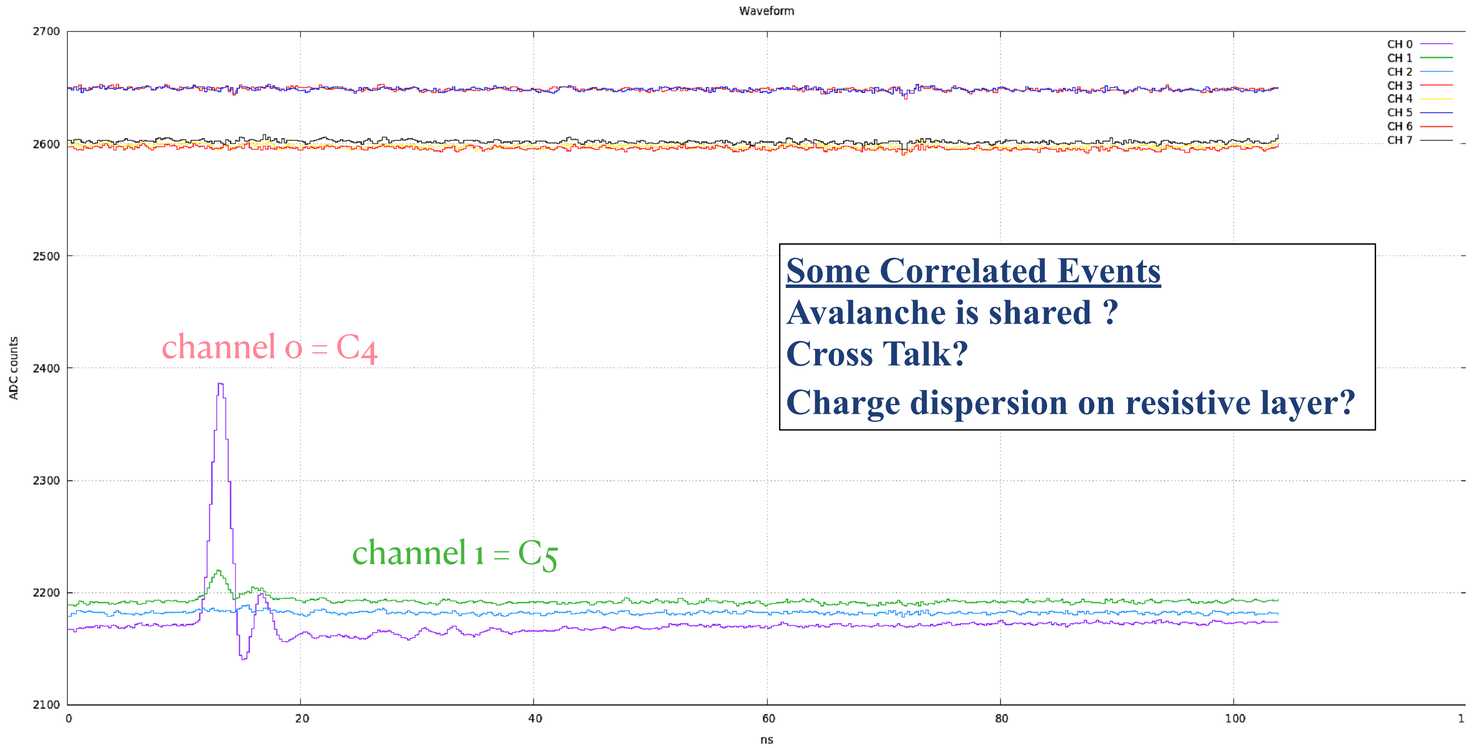



Illuminated by LED (target pad C4)

# To study the charge spectrum from PE

PC = -10V, MCP = 900 V, Transfer gaps = 200 V

## Example Photon-Event from Digitizer

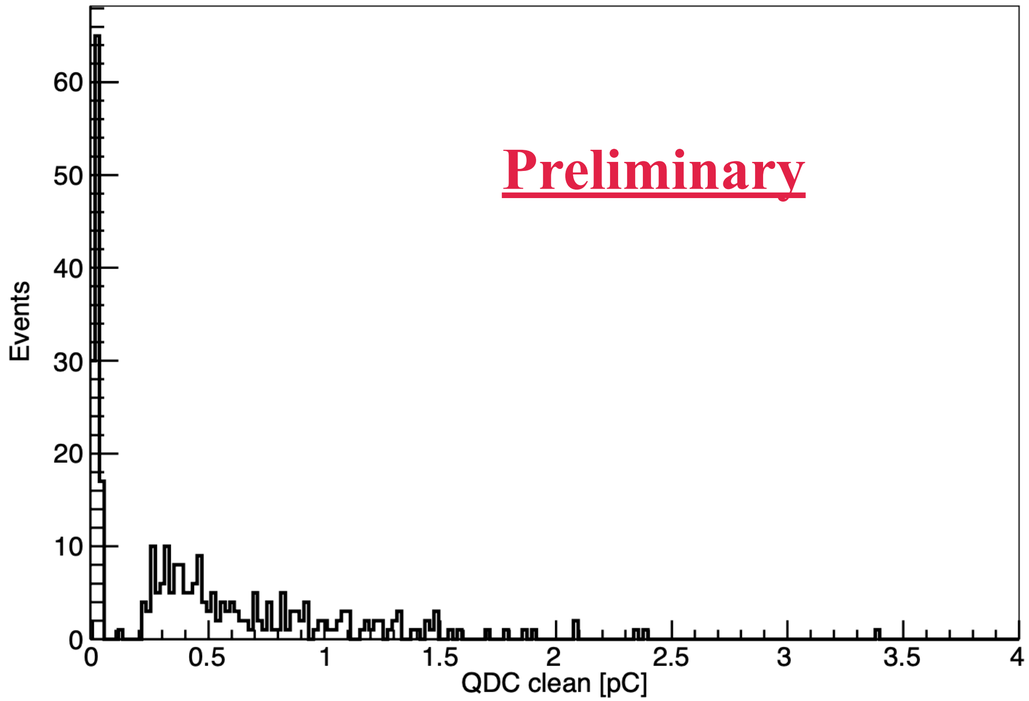



**Some Correlated Events**
**Avalanche is shared ?**
**Cross Talk?**
**Charge dispersion on resistive layer?**

1 time_bin = 0.2 ns.

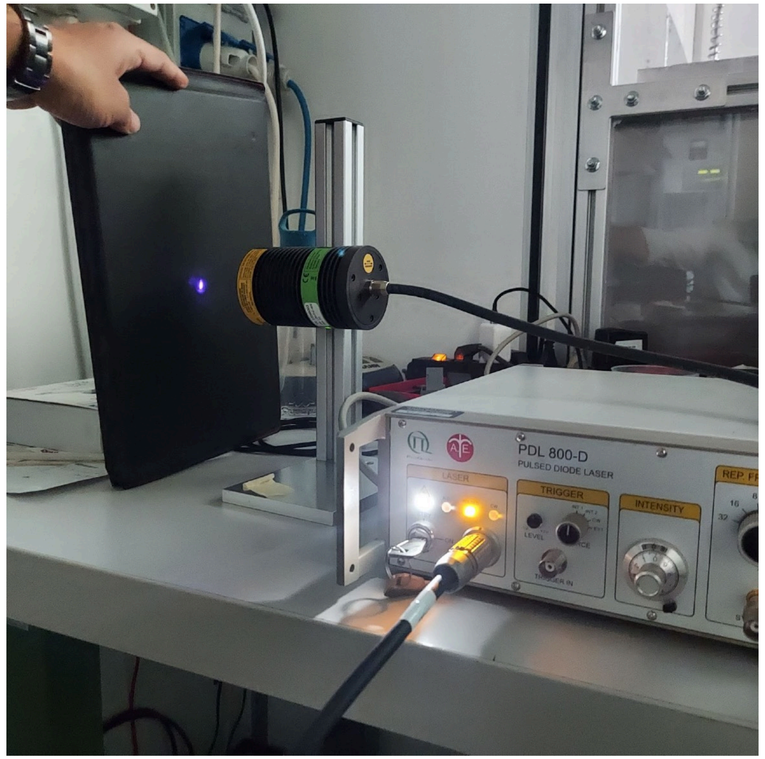
## Photo Electron Charge Distribution

For single PE, the distribution provides gain of the LAPPD

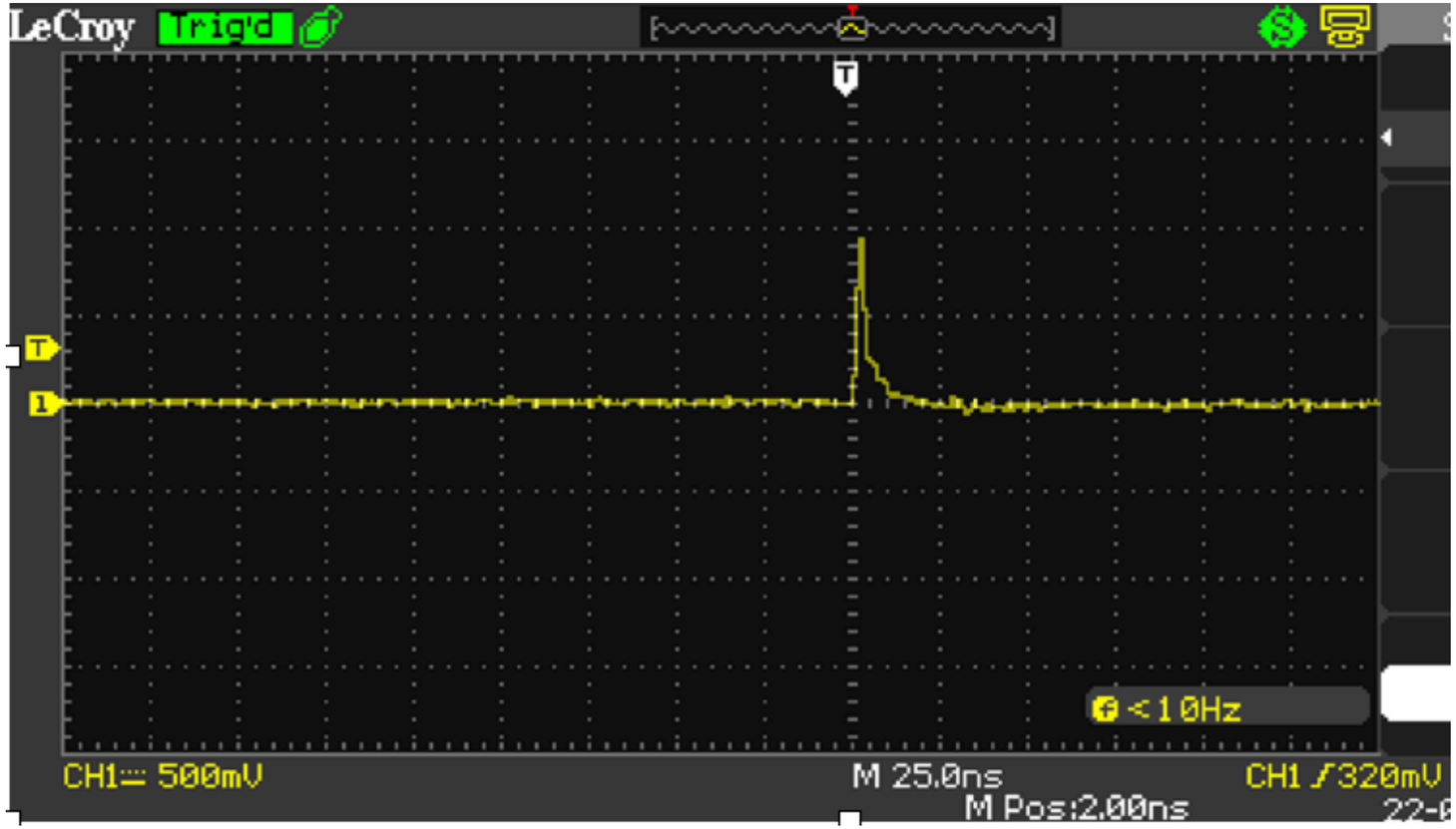



- **Charge calculated from all the pulses collected from Ch_0.**
- **LED can illuminated more than one pad.**
- **Correlated signals are observed.**
- **Fully uncorrelated signals on a single pad has to be better understood.**

# We have the LASER working




The LASER as we received is working fine




A pulse from the LAPPD with the LASER incident on it

- **Synergies in LAPPD activities**

## We have started to organize informal LAPPD Workshops (twice a year)

**The first workshop was organized on 21 March 2022 by:**

*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**
- **We expect to have the next workshop in the coming months**

**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.)

2022-03-21_BNL_w...

**08:40** → 08:55 **HRPPD Development** — 15m

**Speaker**: Michael Foley (Incom Inc.)

2022-03-21 Foley H...

**INCOM**

**Geometry, Photocathode**

**08:55** → 09:15 **LAPPD R&D effort at INFN Bologna** — 20m

**Speaker**: Vincenzo Vagnoni (INFN Bologna)

LAPPD Workshop 2...

**INFN Bologna**

**Time resolution, LHCb/ECal.**

**09:15** → 09:30 **Brookhaven Lab R&D on capacitively coupled LAPPDs with 2D pixelated readout planes for Ring Imaging Cherenkov detectors** — 15m

**Speaker**: Alexander Kiselev (BNL)

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**BNL**

**R&D on EIC**

**09:30** → 09:50 **LAPPD R&D effort at IJS Ljubljana** — 20m

**Speaker**: Rok Pestotnik (IJS )

2022-03-21-LAPPD-...

**IJS, Slovenia**

**RICH: LHCb, BELLE-II**

**10:00** → 10:20 **LAPPD R&D effort at Argonne** — 20m

**Speaker**: Junqi Xie (ANL)

LAPPD workshop-A...

**ANL**

**R&D on EIC**

**10:20** → 10:35 **Cherenkov and scintillation separation in water-based liquid scintillator using LAPPDs** — 15m

**Speaker**: Ed Callaghan (UC Berkeley)

**UC Berkeley**

**10:35** → 10:50 **LAPPDs in ANNIE: from test bench to a full experiment** — 15m

**Speakers**: Amanda Weinstein (Iowa State University) , Matthew Wetstein (Iowa State University)

wetstein.pdf

**ANNIE col.**

**Neutron Detection ANNIE**

**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)

2022- March - Nalu- ...

**NALU**

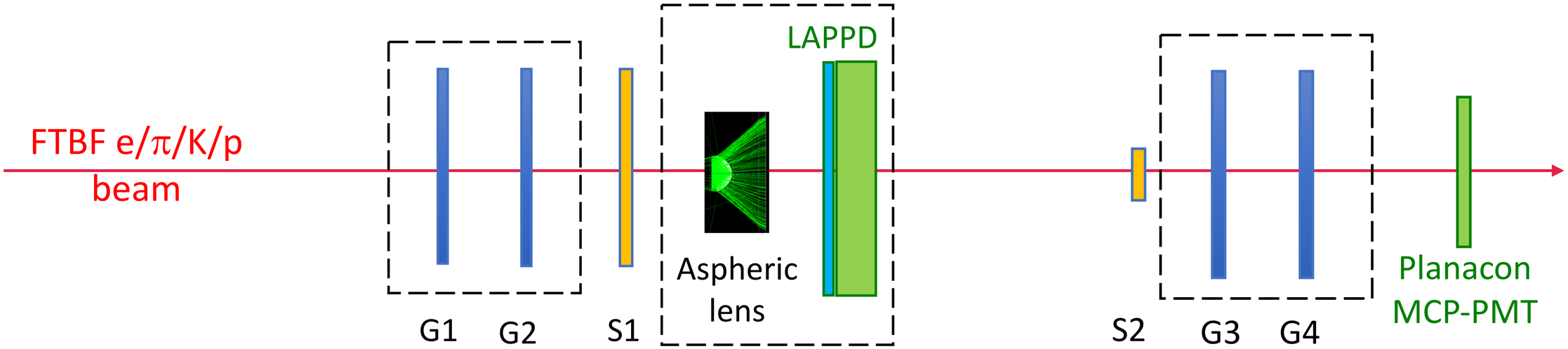
**Signal Induction Analysis New Readout/Electronics**

# Recent news from Fermilab Test Beam

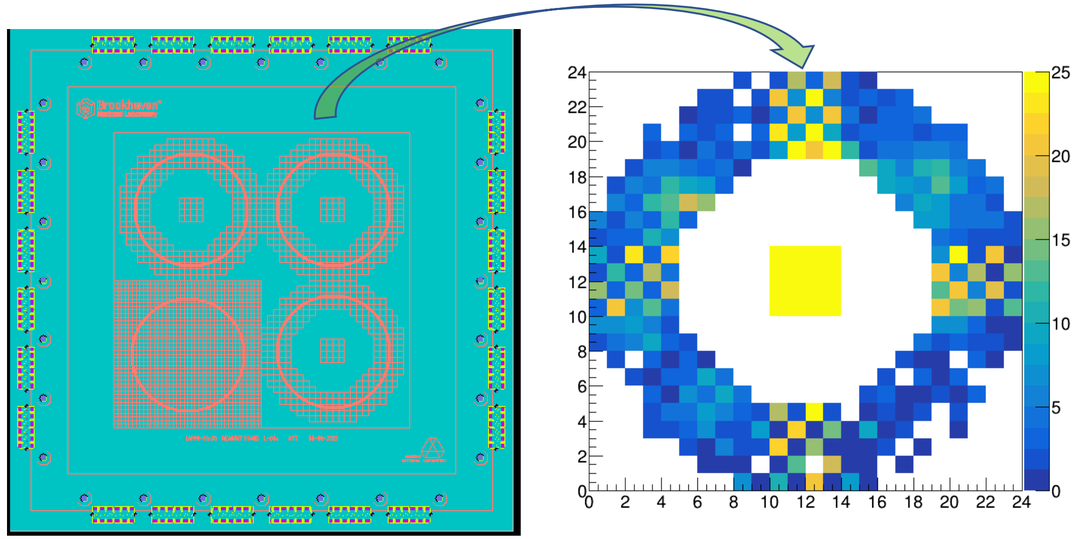
- There has been a beam test at the Fermilab Test Beam Facility 13-26 June 2022

- The key motivations:
  - Cherenkov ring radius resolution measurement (different pad sizes)
  - Timing resolution in multi photon mode (time of flight application)
  - Timing resolution in single photon mode
  - Nominal pi/K separation evaluation
  - Establish aerogel Cherenkov photon yield
  - Achieve mRICH/pfRICH configurations

# Recent news from Fermilab Test Beam




- Strong Signal produced by the particles passing through the LAPPD window.
- Cross talk is observed in the L03c board
- Grounding the central 4x4 pixels helps to overcome it



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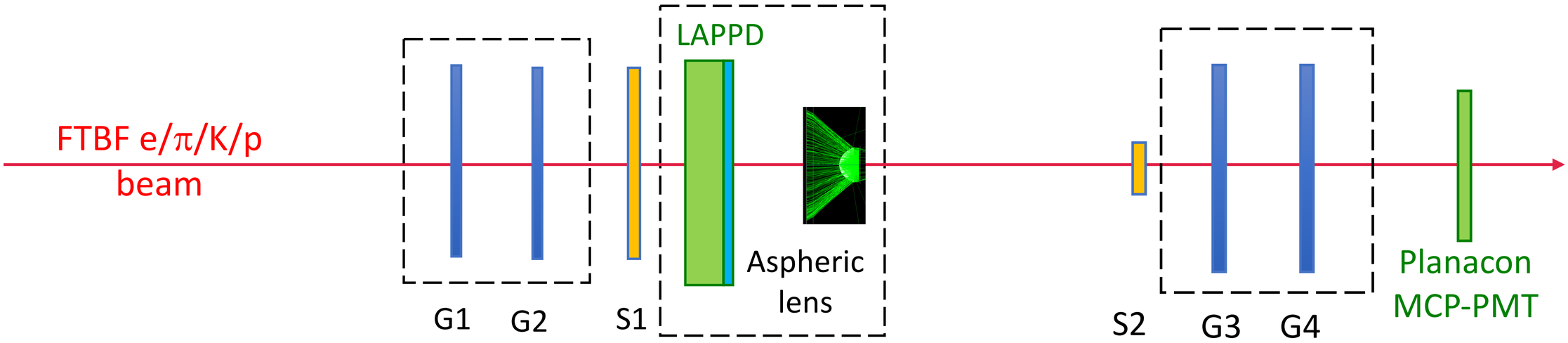
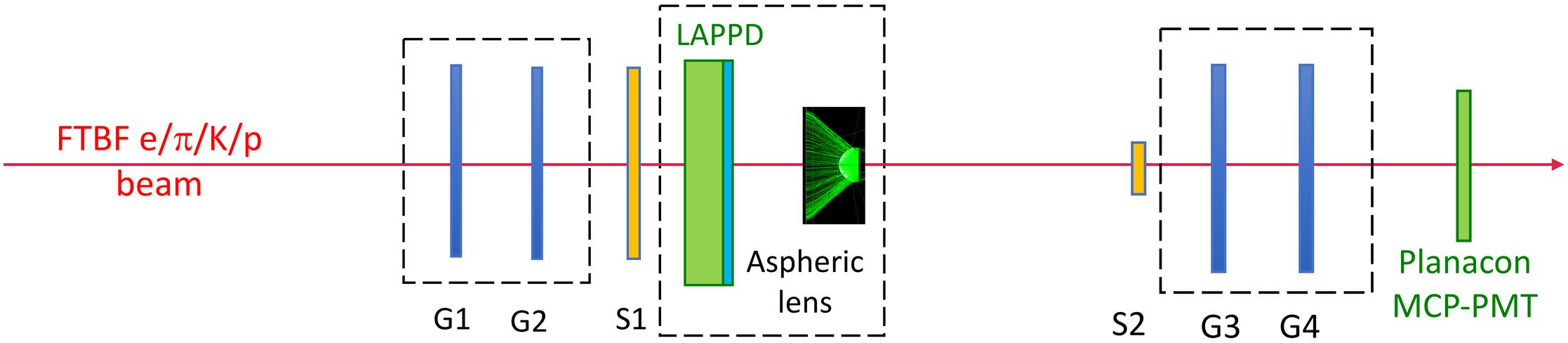


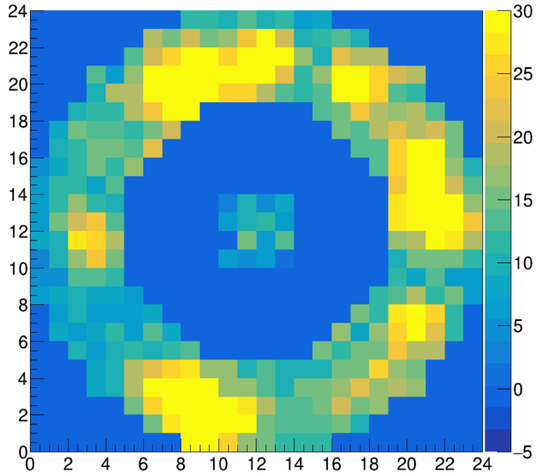

- **Imaging part of the program:**

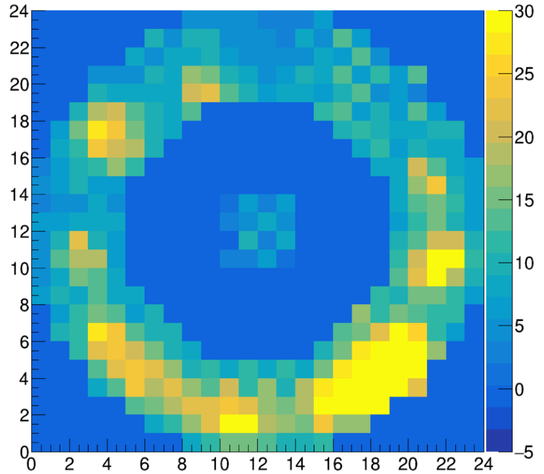
  Observed blurred, asymmetric, but well-populated rings produced by the aspheric lens
  Installed the acrylic filter, at an expected cost of ~80% p.e. yield loss
  Since then, cannot see a convincing ring picture any longer

# Recent news from Fermilab Test Beam



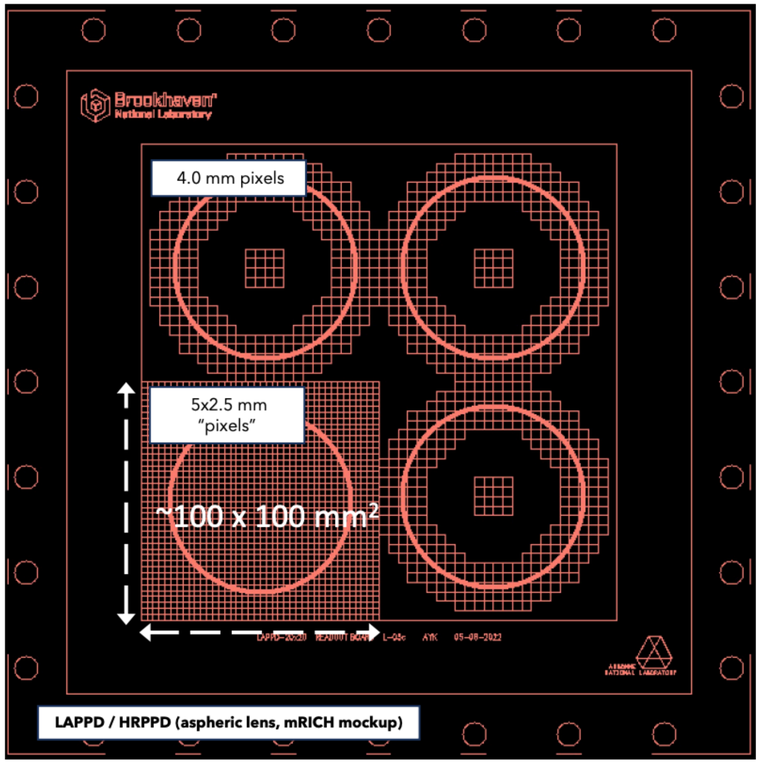

- all these photons are UV
- rms width of the ring ~2.5 mm (still within required limit)
- intrinsic resolution is better than a mm.
- the same data can be used for single photon timing
- TOF data have been collected will be processed





# Recent news from Fermilab Test Beam

- Alexander Kiselev (BNL) will send us a new board which we can test at Trieste with our LAPPD
- The geometry is tuned to a aspheric lens



- **To Conclude:**

  - At Trieste we are building a setup to fully characterize LAPPDs and run R&D.
  - DAQ and Analysis framework is being developed.
  - The collaboration between INFN-Trieste and INFN-Genova is very effective.
  - With LAPPD#87, we have understood dark/thermal count rate and got an idea on the time resolution. We are now ready to start with a LASER source.

- On a larger scale, we are creating synergies in all type of LAPPD activities.

  - A beam test at Fermilab is just done. Some more interesting results would come.

**Thank you!**

- **Acknowledgement:**

**Mikhail Osipenko and Saverio Minutoli (INFN - Genova)**
**Alexander Kiselev (BNL)**
**Sanghwa Park (Mississippi State University)**
**And many other colleagues**