R&D effort for the LAPPD as part of the upcoming EIC

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Fermilab

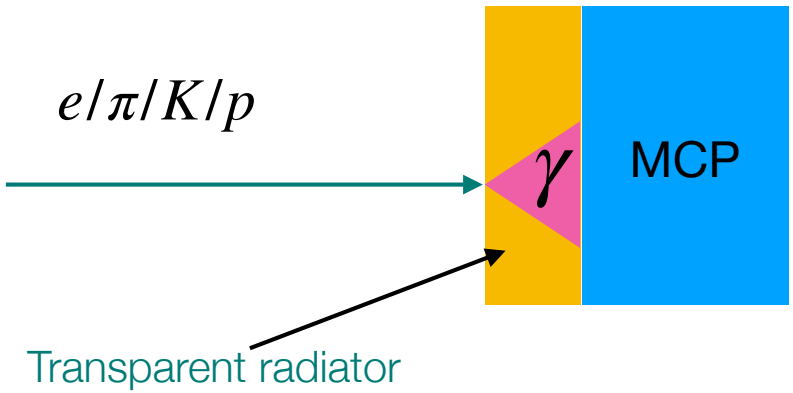
Motivation

$\sigma_t^{\text{det}} \sim$ ps → Reduce the physical dimension

$t_{\pm} = t_{\text{tran}}^{e,\gamma} \pm \delta t_{\text{tran}}^{e,\gamma}$ ← e, γ → Detector

Corresponds to t_{jitt}, $\delta t_{\text{tran}}^{e,\gamma} < \sigma_t^{\text{det}}$

Maximizing the numbers of measurable quantities ~ TeV scale detector



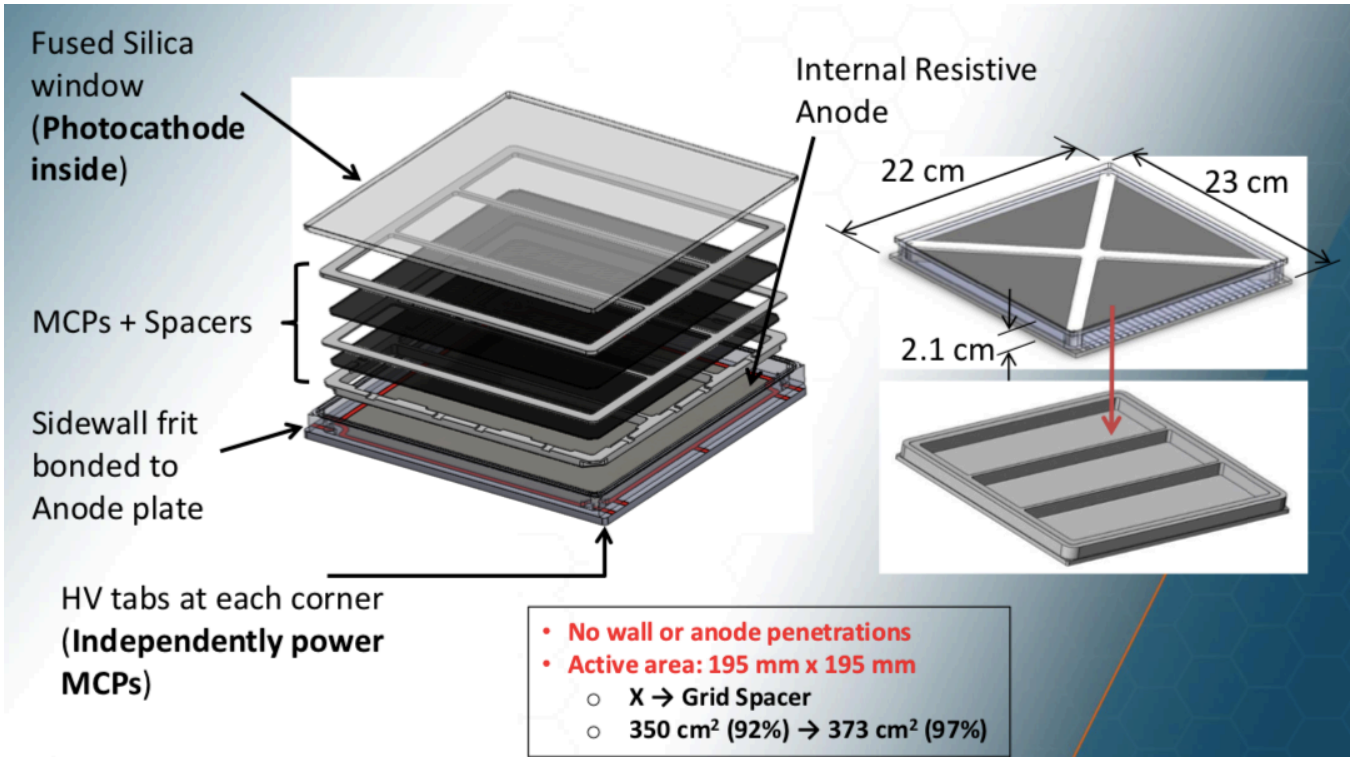
Idea cooked in the first decade of the current century (TEVATRON)
2004 : MCP's were passed the first test
H. Nicholson : replacing the PMTs with large area planar photodetector

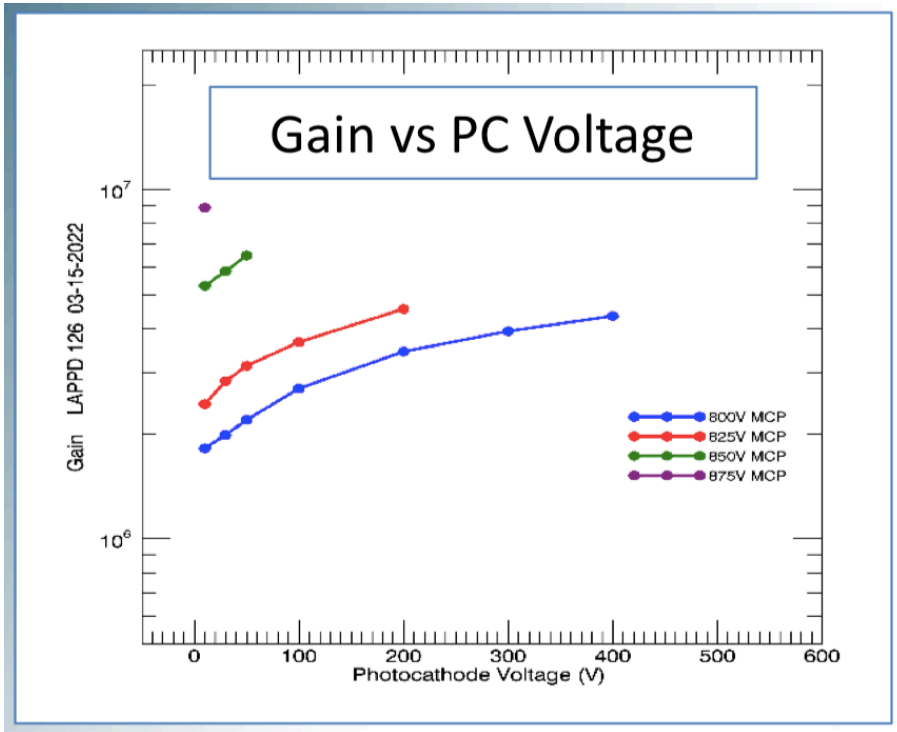
time jitter : the width of the statistical distribution in the arrival times of voltage transients with respect to the corresponding photon absorption times

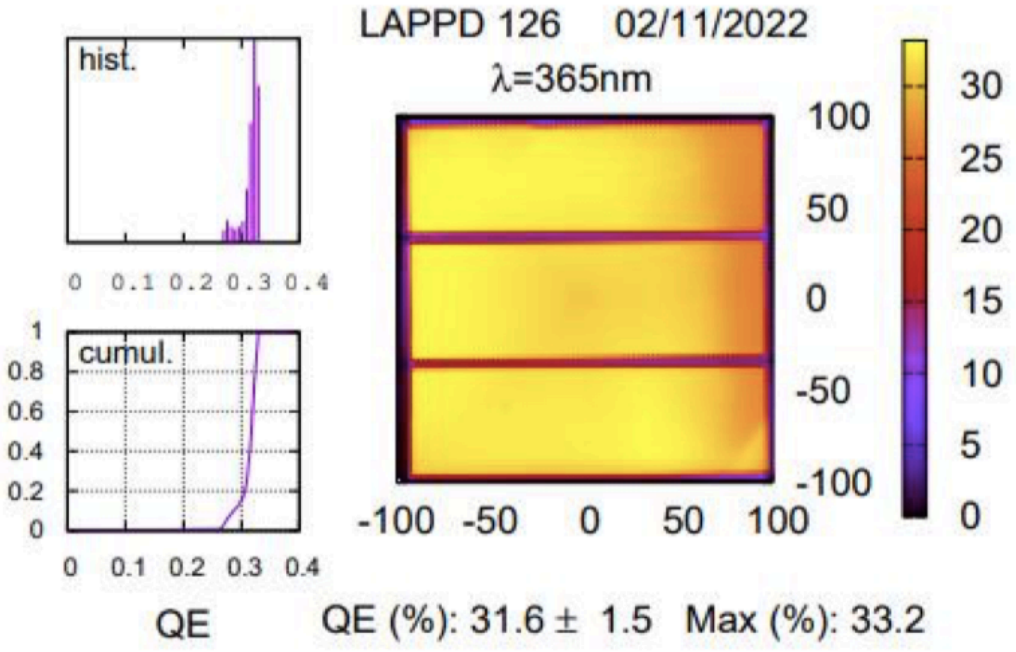
LAPPD

LAPPD :
Large area picosecond photo detector
planar geometry photodetector

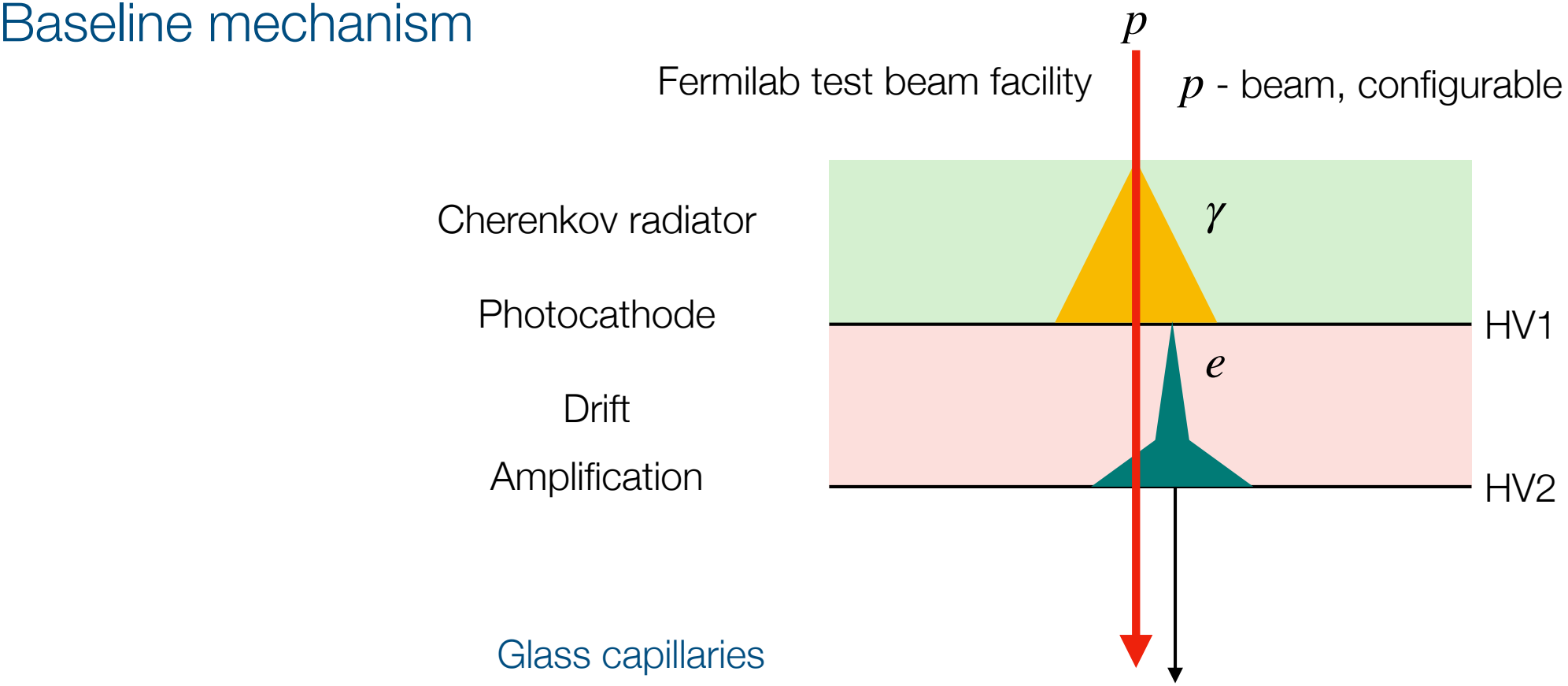
1. single photon sensitivity
2. high gain $\sim 10^7$
3. photocathode QE $\sim 25\,\%$
4. low noise
$100\,\mathrm{Hz/cm^2}(@\mathrm{gain} \sim 10^6)$
5. $\sigma_{xy} \sim$ mm, $\sigma_t \sim 50$ ps

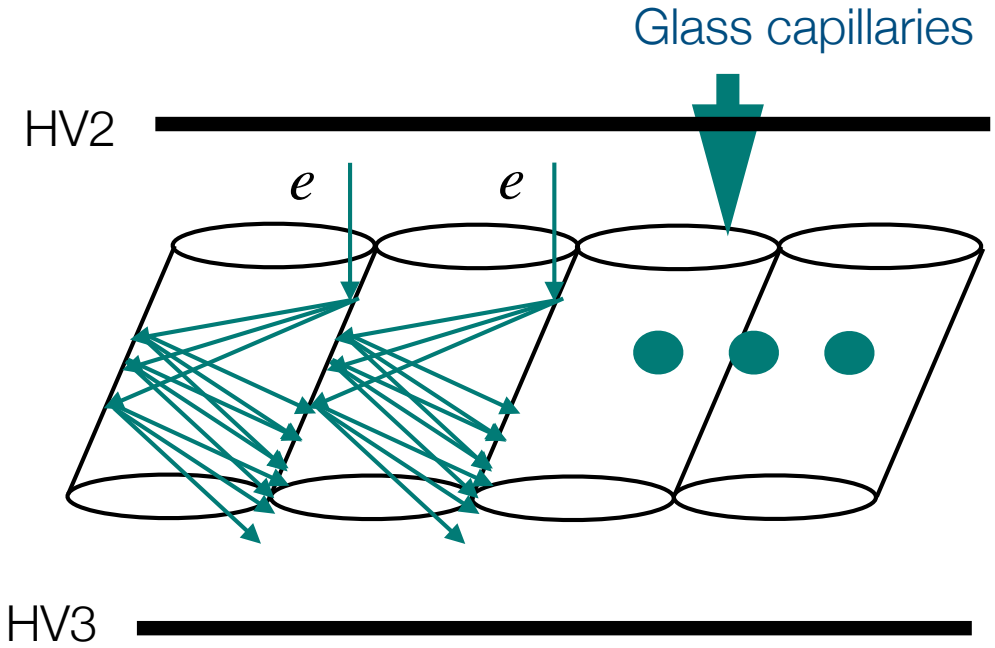






Baseline mechanism

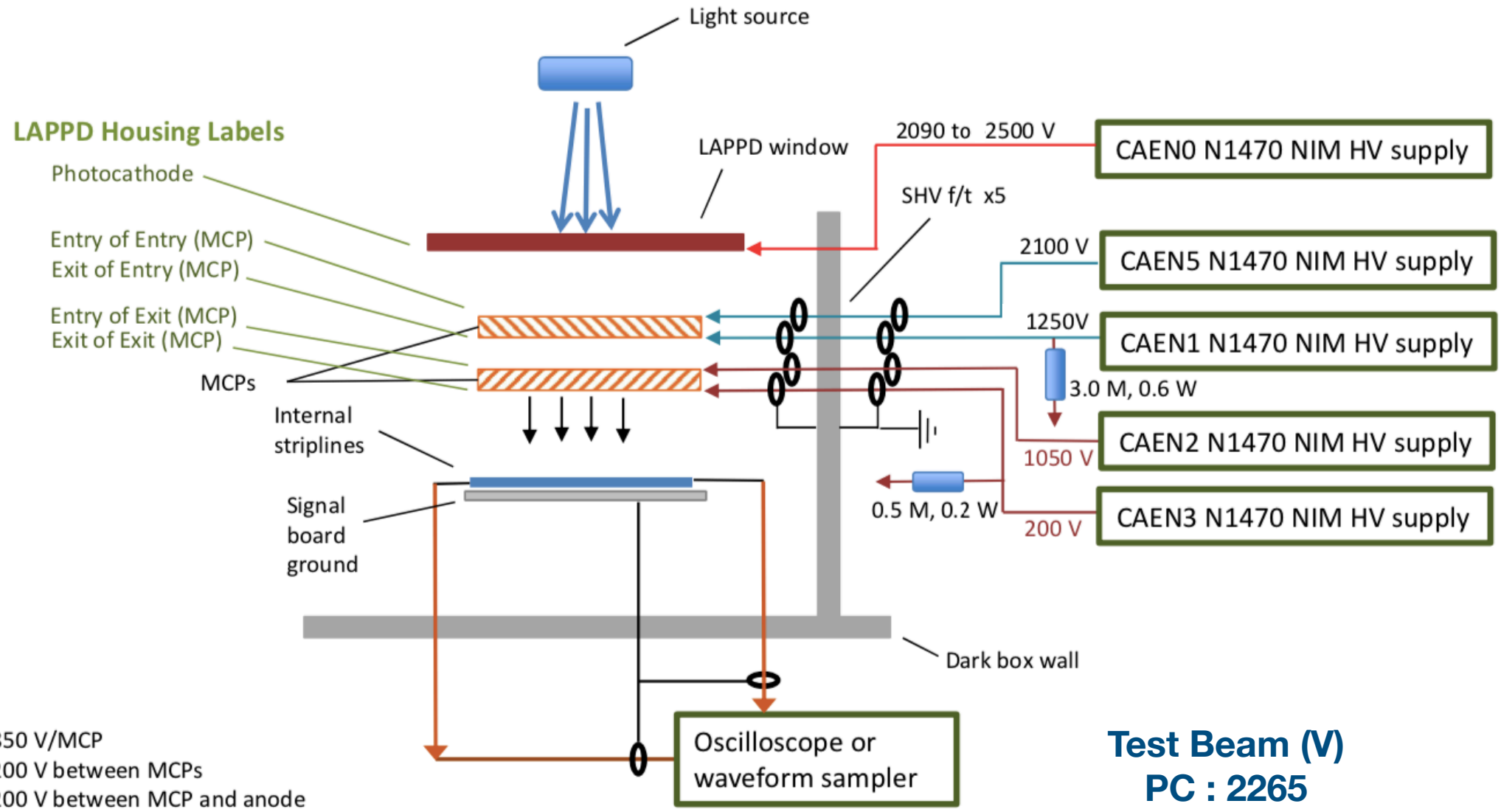




MCP : resistive and emissive atomic layer deposition (ALD) coatings to glass capillary array (GCA)

Proposed HV benchmark

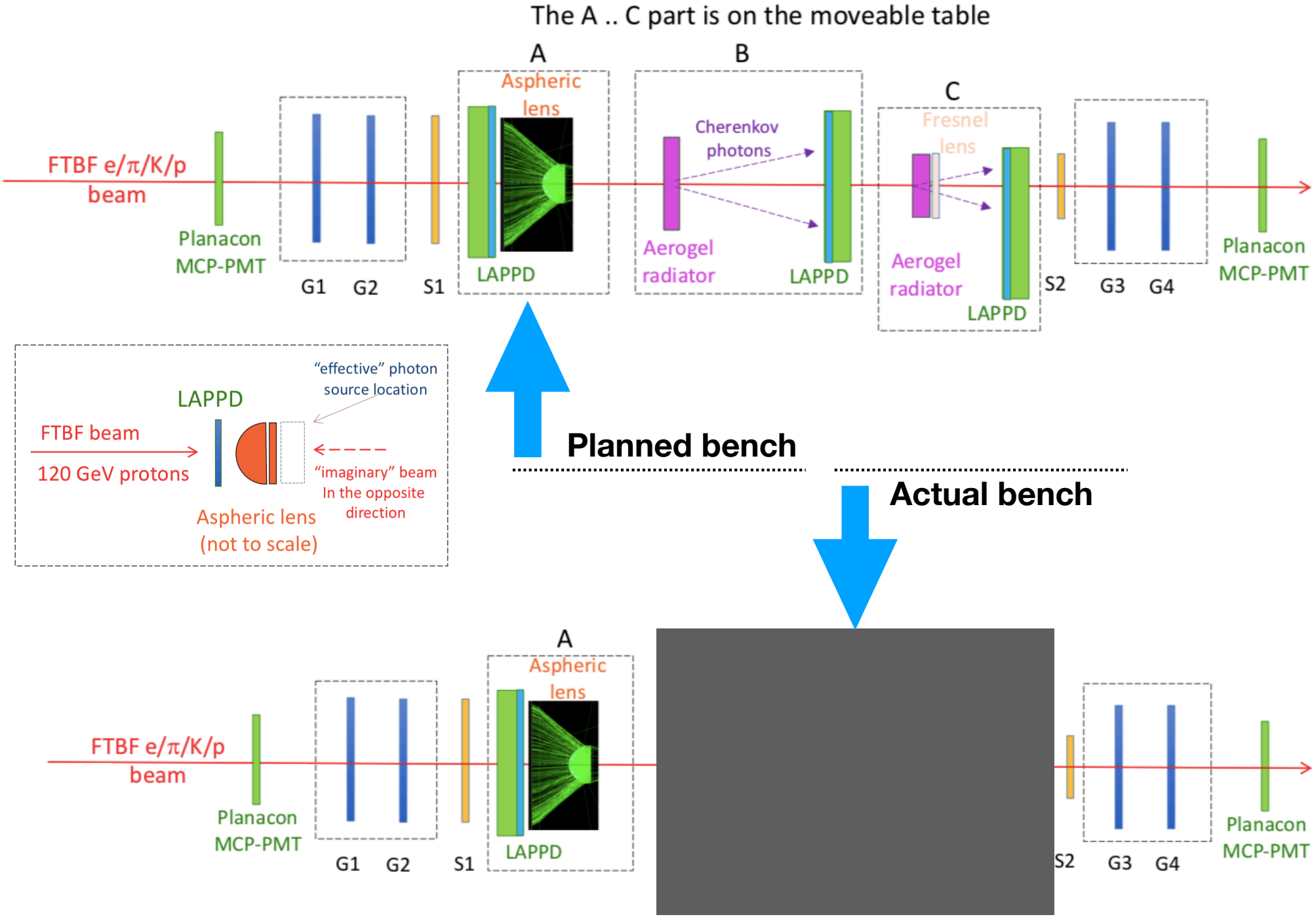
INCOM set up



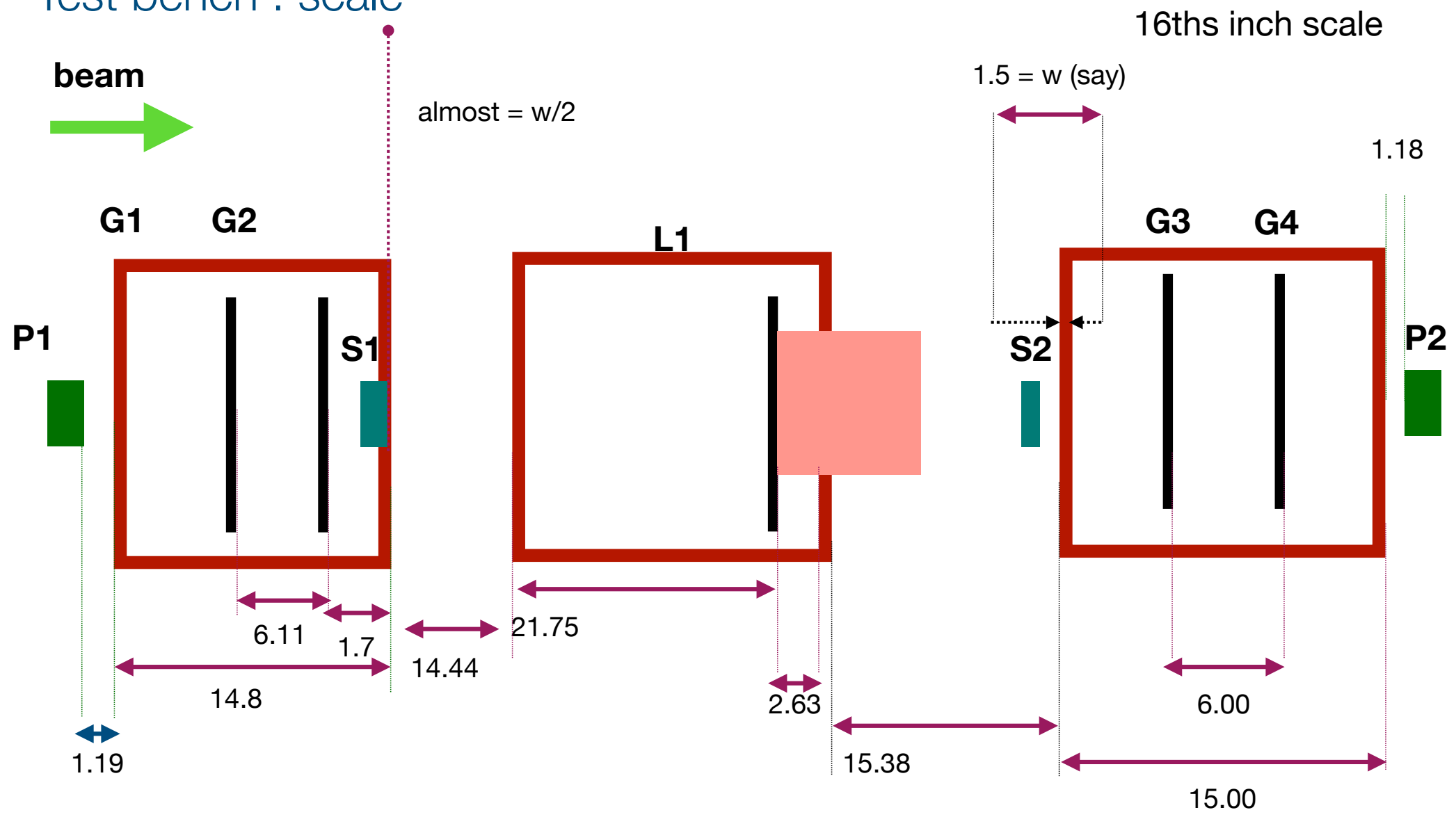
- 850 V/MCP
- 200 V between MCPs
- 200 V between MCP and anode
- 5.25 Mohms entry MCP
- 5.16 Mohms exit MCP

Test Beam (V)
PC : 2265
MCP : 2190, 1320, 1120, 250

Test bench


The A .. C part is on the moveable table
A
B
C
Aspheric lens
Cherenkov photons
Fresnel lens
FTBF e/π/K/p beam
Planacon MCP-PMT
G1
G2
S1
LAPPD
Aerogel radiator
LAPPD
Aerogel radiator
LAPPD
S2
G3
G4
Planacon MCP-PMT
"effective" photon source location
LAPPD
FTBF beam
120 GeV protons
"imaginary" beam In the opposite direction
Aspheric lens (not to scale)
Planned bench
Actual bench
A
Aspheric lens
FTBF e/π/K/p beam
Planacon MCP-PMT
G1
G2
S1
LAPPD
S2
G3
G4
Planacon MCP-PMT

Test bench : scale

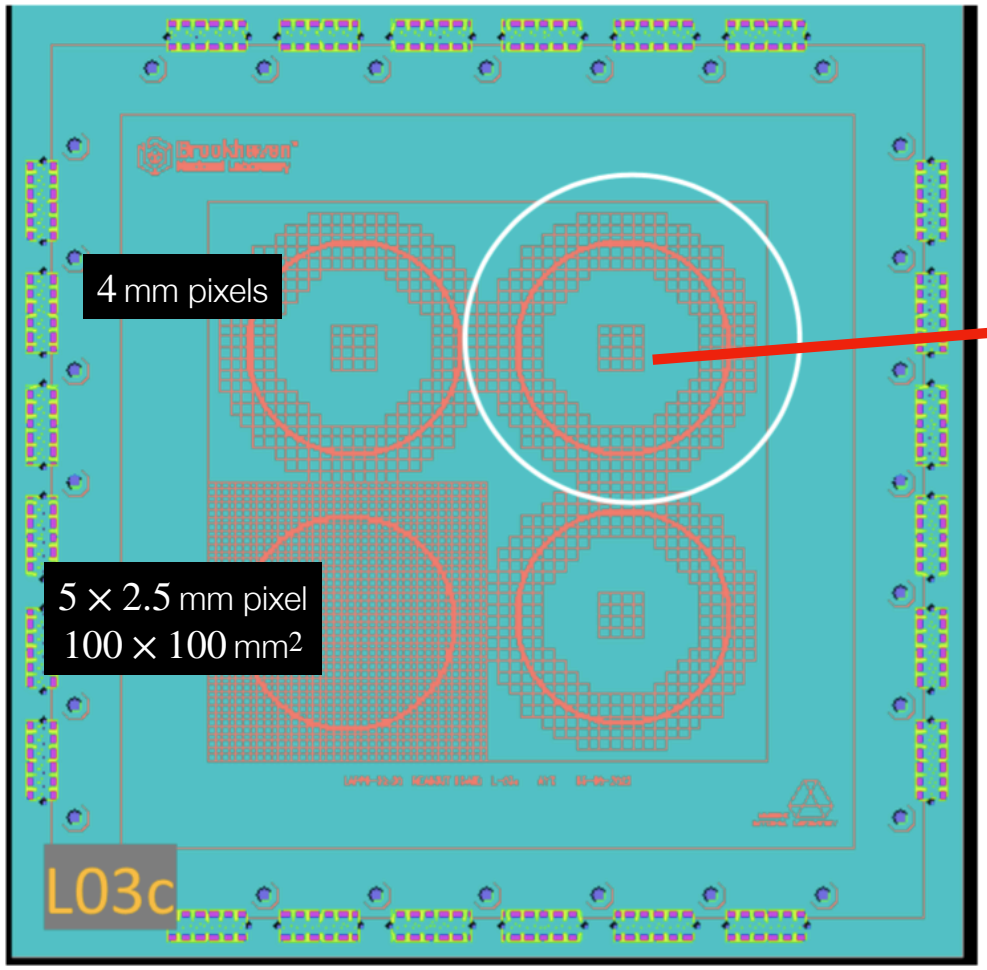


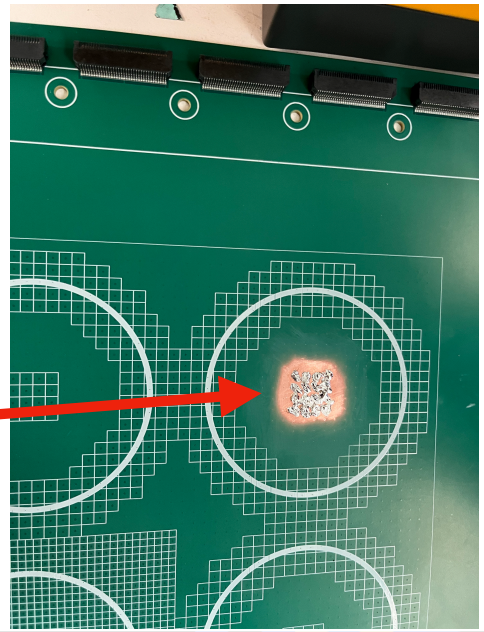
Here 6.11 means 6.11 inch

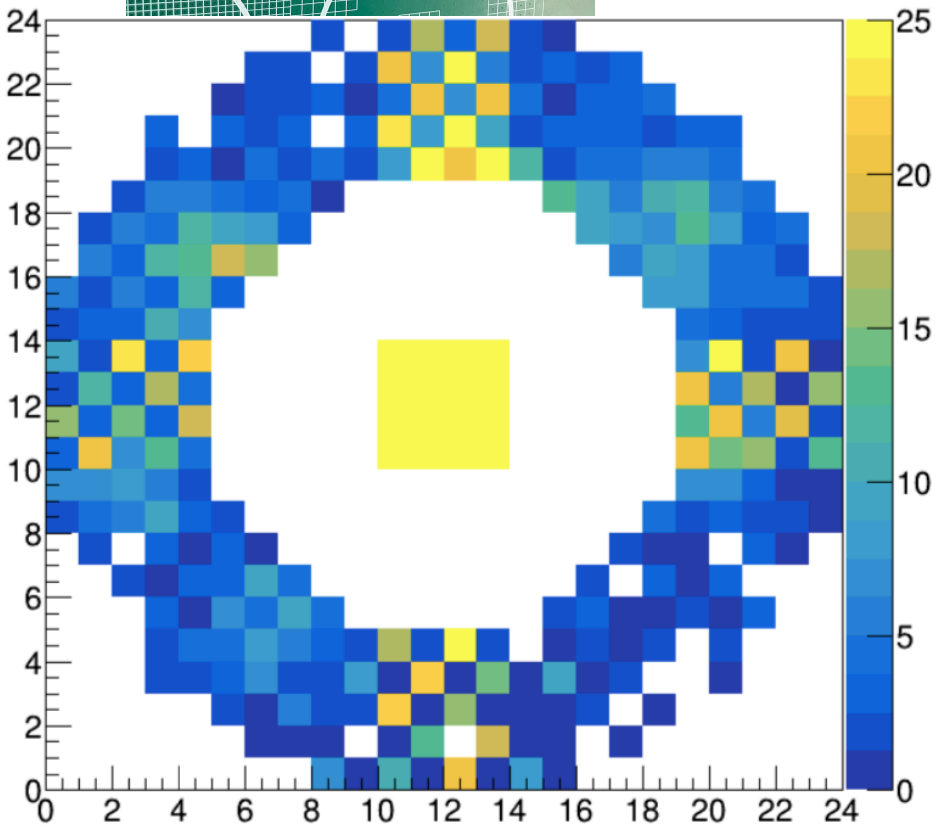
For instance $d^{BF}_{(G1,G2)} = 6.11\,\text{inch} \sim 155.2\,\text{mm}$

BF = Face opposite to the beam direction

Cross talk reduction





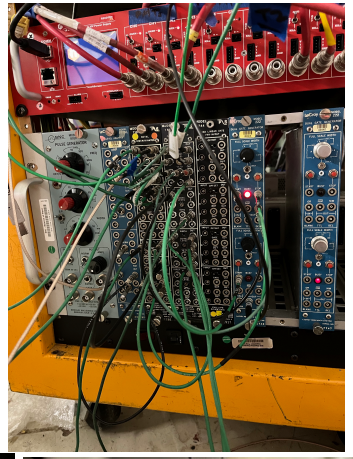
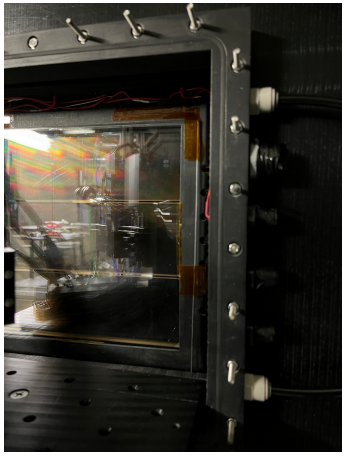
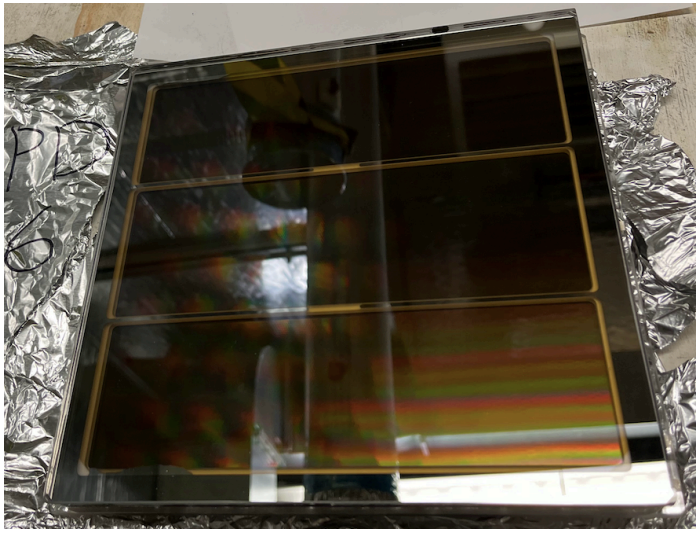
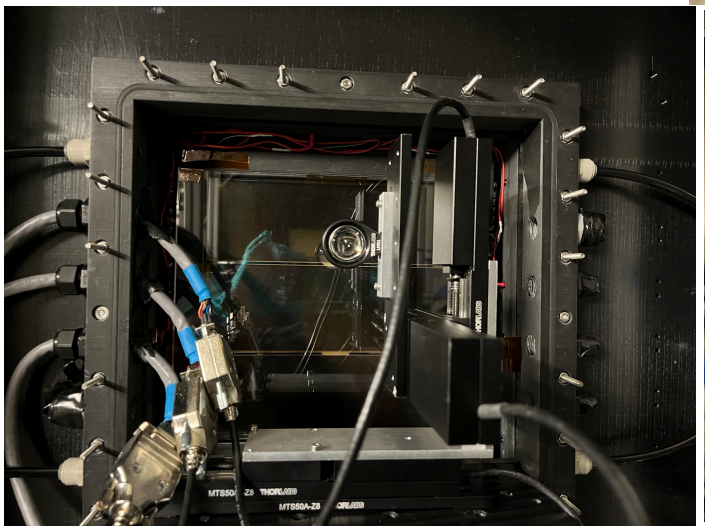
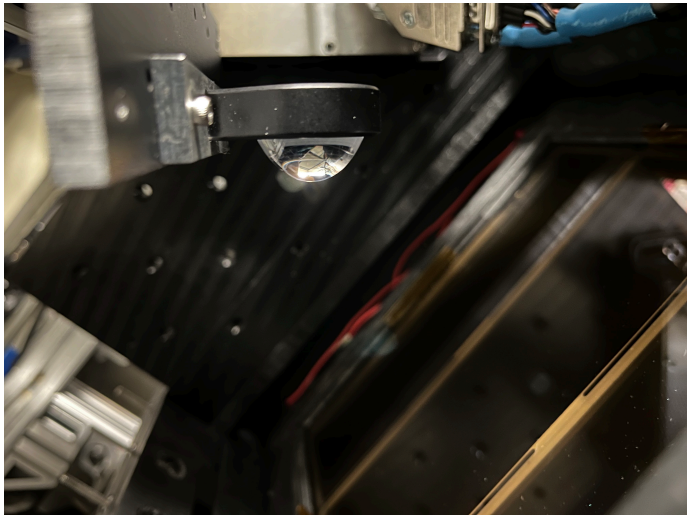
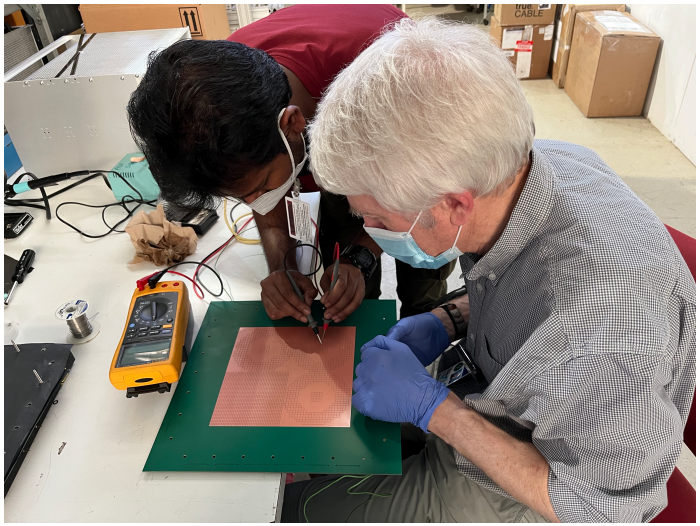
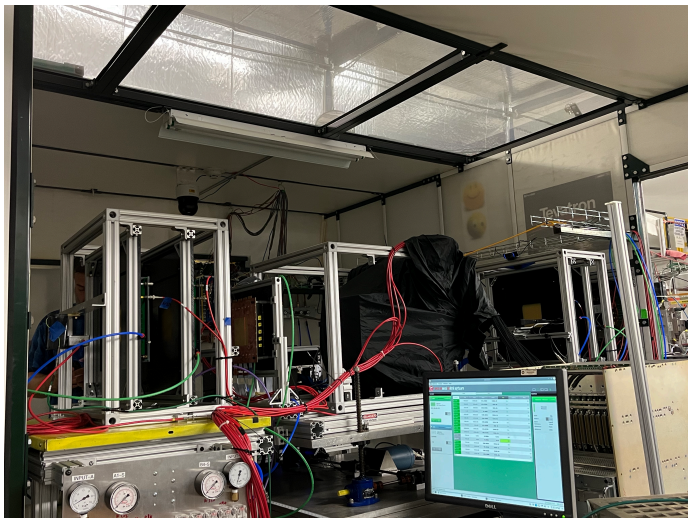
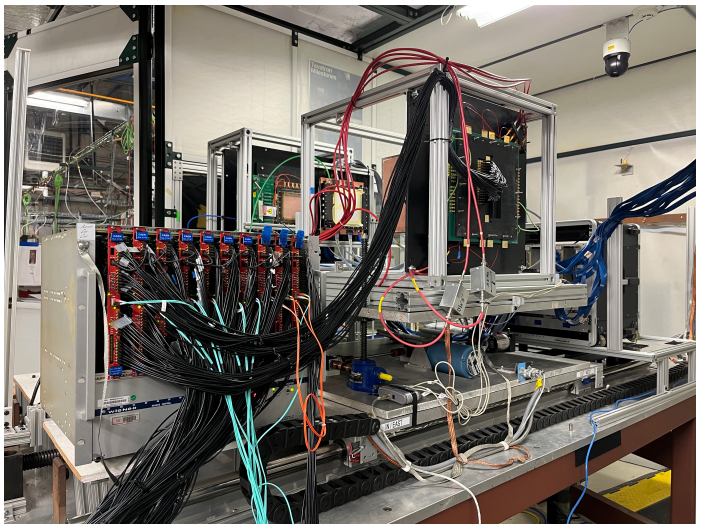


L03c : passing particle in the lappd window : strong trace-to-trace cross talk is high

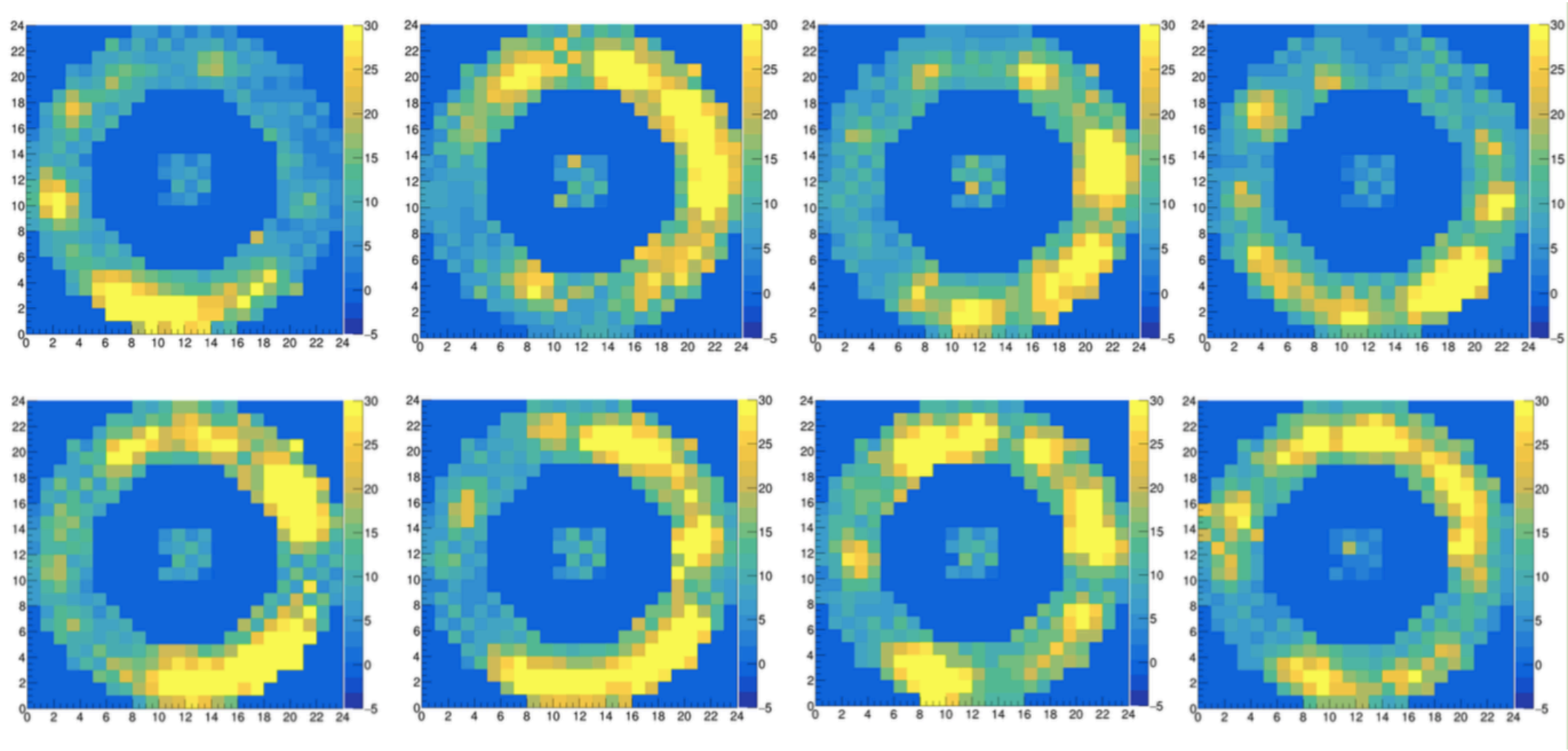
For tile #136 we : central area was grounded

2022 picture gallery

Test beam 120 Gev proton beam, 13-26 June 2022
First week : Commissioning :
Tracker, trigger , NIM logic, DAQ, computing, lappd #126 ($20\,\mu$m pores)
2nd week : #136 ($10\,\mu$m pores)

Some good events and to do list



1. It seems the we moderately managed to populate Cherenkov rings
2. The single photon clusters are visible in a few ~% of events $\mathcal{O}(10^3)$
3. Full data analysis is yet to be done
4. Slide credit : Mark Popecki , Shawn S. Shin (Incom), Alexander Kiselev(BNL)

Back -up

$$E^{\text{kin}} = (\gamma - 1)m_0c^2$$

$$\gamma \simeq \frac{E^{\text{kin}}}{m_i c^2} + 1$$

$$i \in \pi^{\pm}, K^{\pm}, \mu^{\pm}$$

$$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$

$$\beta = v_{\text{ph}}/c$$

$$\theta_{\text{ch}} = \cos^{-1}\left(\frac{1}{\beta n}\right)$$