Fermilab June 2022 LAPPD beam test kick-off meeting

Alexander Kiselev (BNL)

eRD110 meeting
May 4, 2022

Dates, participants, contacts

- Dates: June 13-26, 2022; day shift, main users
- Installation starts on Monday June 13th
  - Martin: June 11 (Sa) – 16 (Th)
  - Bob: coming on June 13th
  - AK: June 11 – 28 (Tu)

→ ALL: arrange your travel NOW

- Points of contact: Mandy (rominsky@fnal.gov) and Evan (edniner@fnal.gov)

→ Will forward Mandy's feedback right after this meeting

- Other confirmed participants: Craig (2-d week), Junqi, Sanghwa (+ a postdoc), Deb …
- … and then hopefully Abhay and Tom provide 1-2 SBU postdocs like last time

→ Other (qualified) participants are more than welcome!

Objectives for eRD110

Goal: Reduce current risk associated with lack of reliable highly pixilated photodetectors working at 1.5-3 T.

- On the market (or in development by manufacturer)
  - SiPMs - radiation hardness
  - LAPPD/HRPPD - pixelation
  - MCP PMT – magnetic tolerance

- At the moment no funding available for the characterization of MCP-PMTs

Milestones and Timeline for CY22

LAPPD:

- Full evaluation of up to four different LAPPD and HRPPD tiles in the lab and under beam conditions. Evaluation includes determination of quantum efficiency, gain uniformity, operation under high rate, timing and position resolution measurements in a finely pixelated configuration.
  - Magnetic field test facility at Argonne ready for 20 cm tiles – **7/2022**
  - Various Gen II readout boards designed and delivered to BNL – **9/2022**
  - Fermilab beam test with the capacitively coupled LAPPDs / HRPPD – **10/2022**
  - Single photon position resolution report (bench tests with pixelated boards) by BNL – **12/2022**
  - Magnetic field tolerance report by Argonne – **2/2022**
  - Beam test data analysis and report - by **3/2022**
  - Preliminary assessment of the LAPPD / HRPPD feasibility for the EIC detector - by **3/2022**

→ As shown by Thomas / Patrizia last Friday

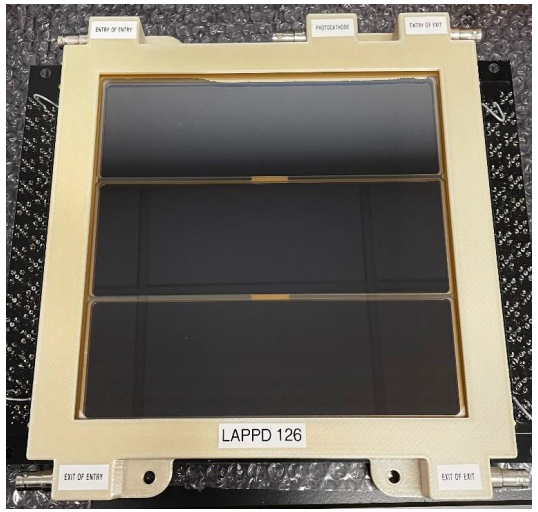
Main objectives for the coming beam test

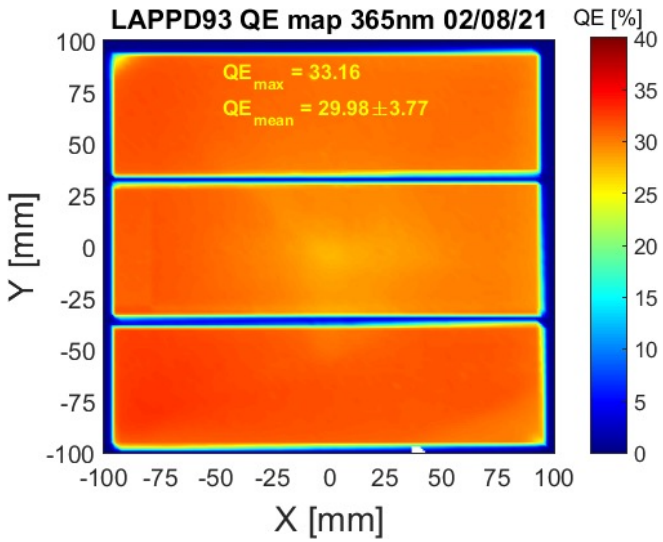
- Verify spatial extent of the induced signal and spatial resolution (for ring imaging purposes?)
- Verify single photon and “TOF blob” timing resolution

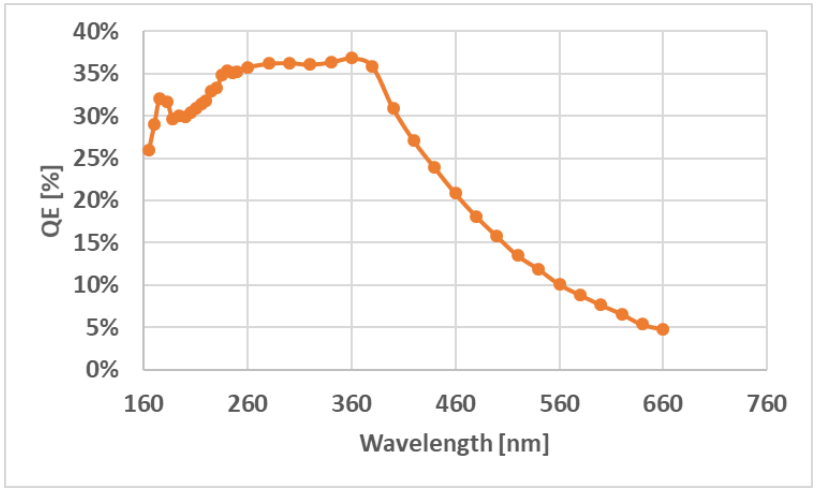
- Eventually provide a direct π/K separation measurement (need aerogel with n ~ 1.02 .. 1.03)
  - Most likely: in a simple proximity focusing configuration with a 20cm LAPPD tile
  - Potentially: with a mRICH mockup (using either HRPPD or individually pixelated LAPPD quadrants)

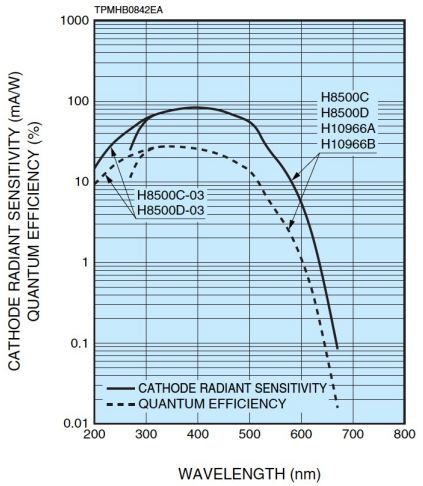
→ Open for a discussion

LAPPD (and HRPPD?)



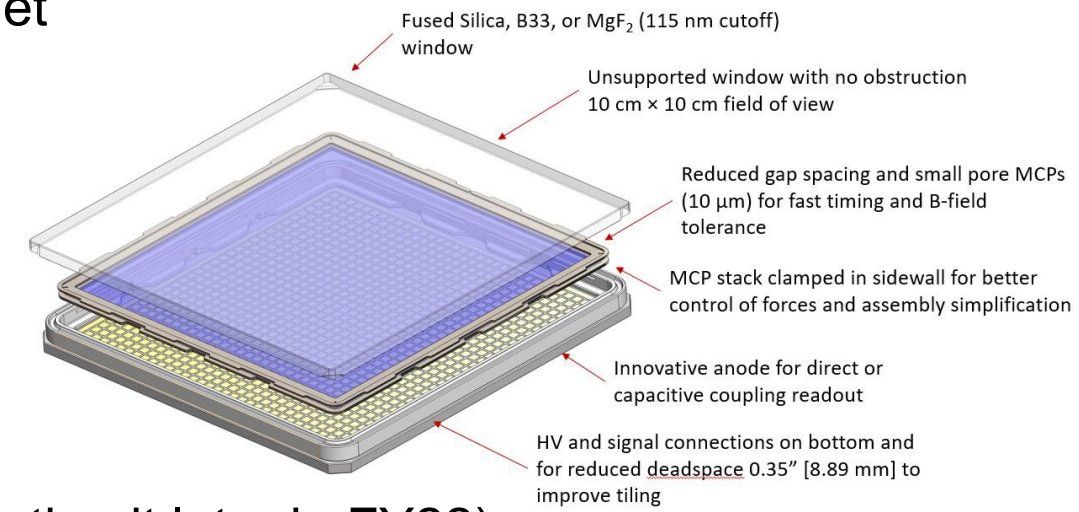






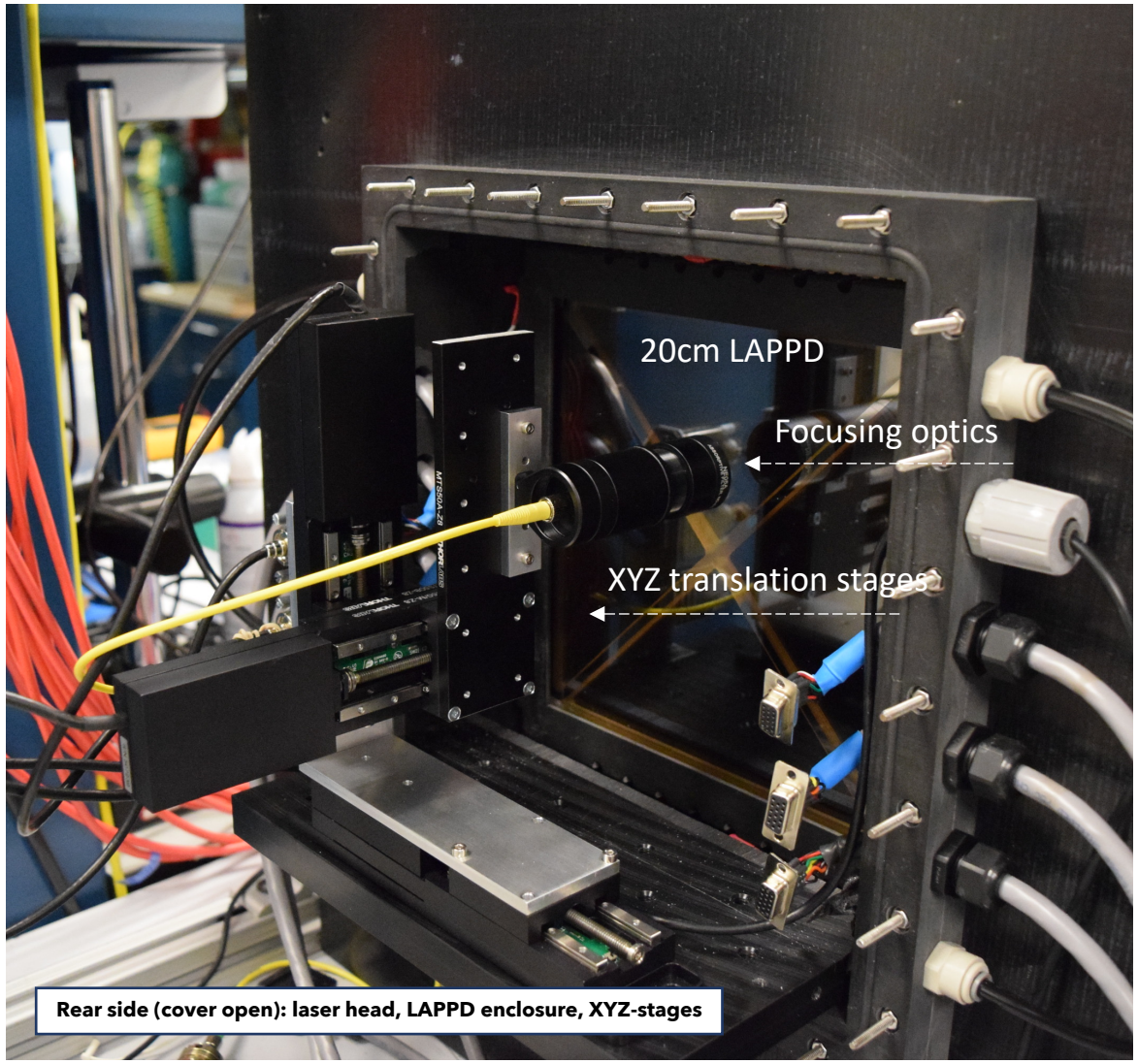
Compare to Hamamatsu H8500C

- LAPPD will be rented for May-August on eRD110 budget
  - New spacer configuration ☹
  - 10 μm pore MCPs
  - Hopefully: 2 mm thin ceramic base plate and short ceramic walls
  - Na_2KSb photocathode
  - Window material?

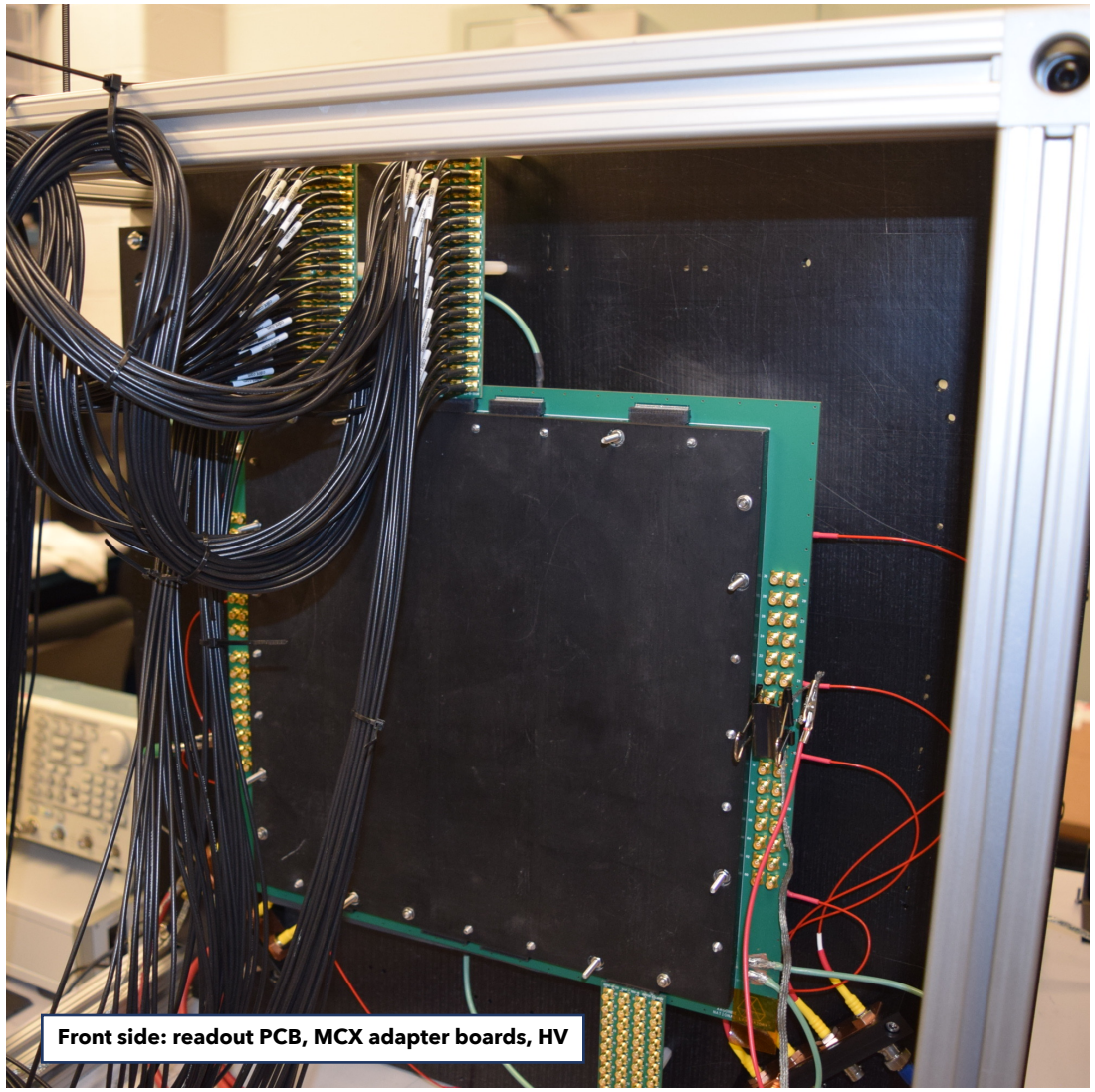


- HRPPD may or may not happen in June (but we are renting it later in FY22)

Our test stand equipment

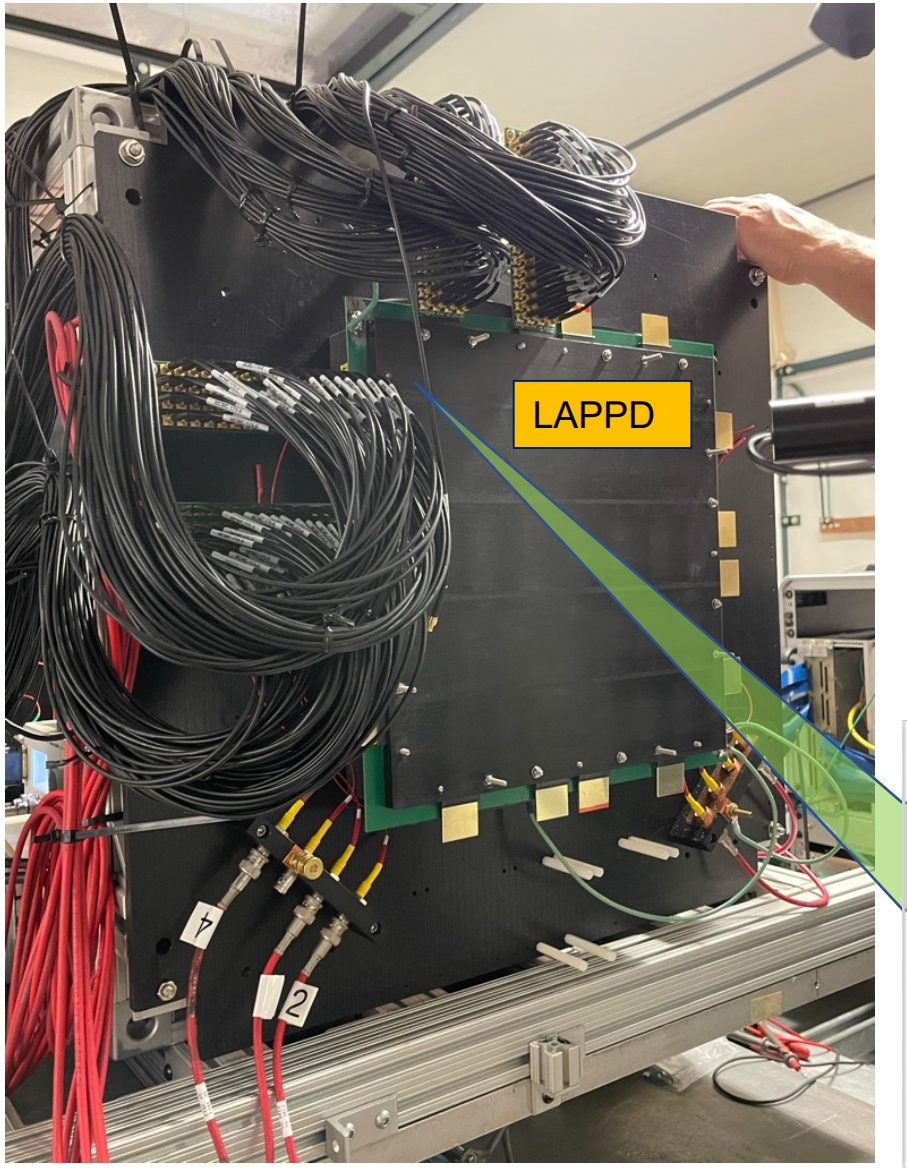


Rear side (cover open): laser head, LAPPD enclosure, XYZ-stages

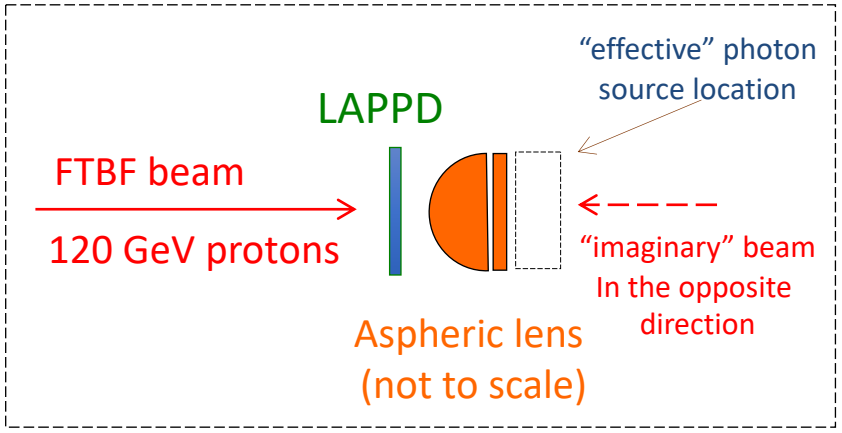


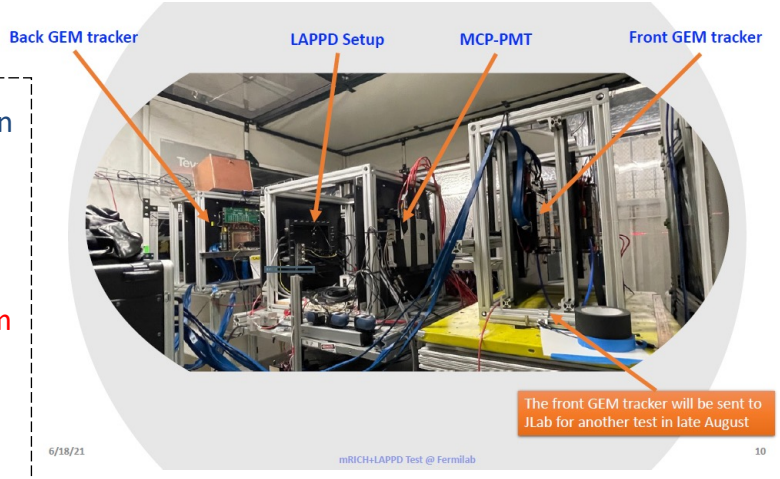
Front side: readout PCB, MCX adapter boards, HV

Experimental setup in MT6.2C (2021)

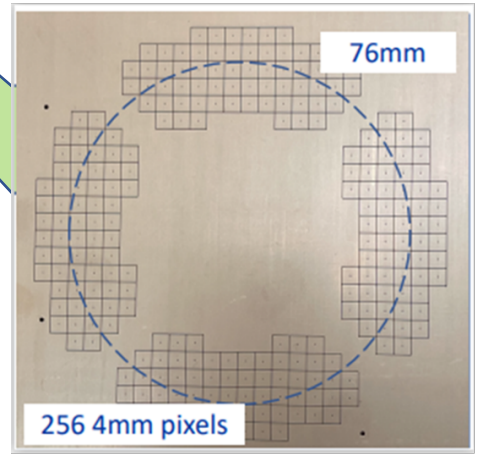


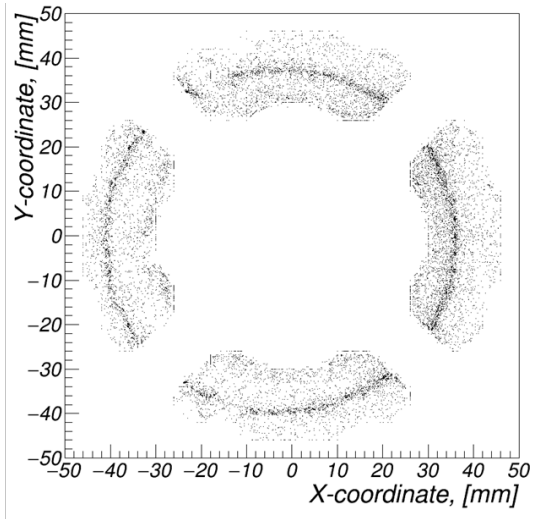
Beam test schematic view

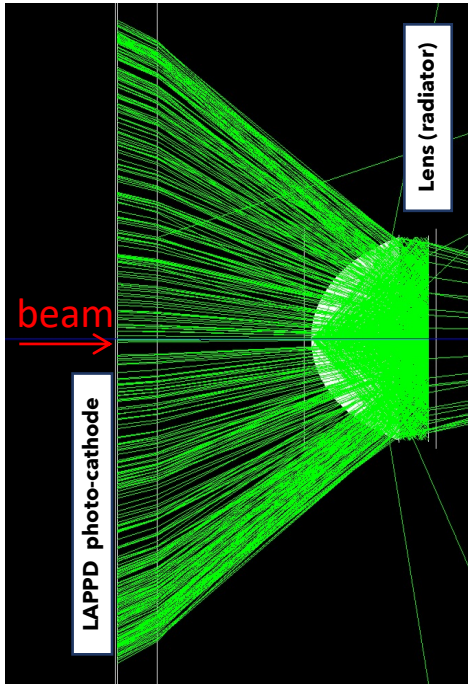




Pixel pattern & accumulated single photon XY-coordinates



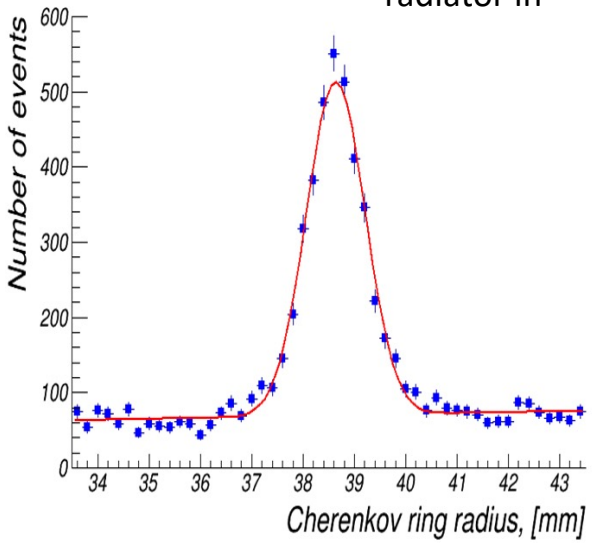




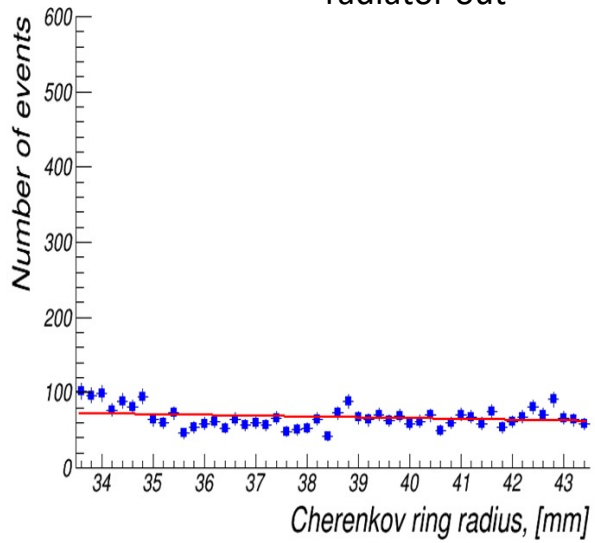
The main (so far) result from 2021 beam test campaign

σ_R ~ 600 μm

radiator in

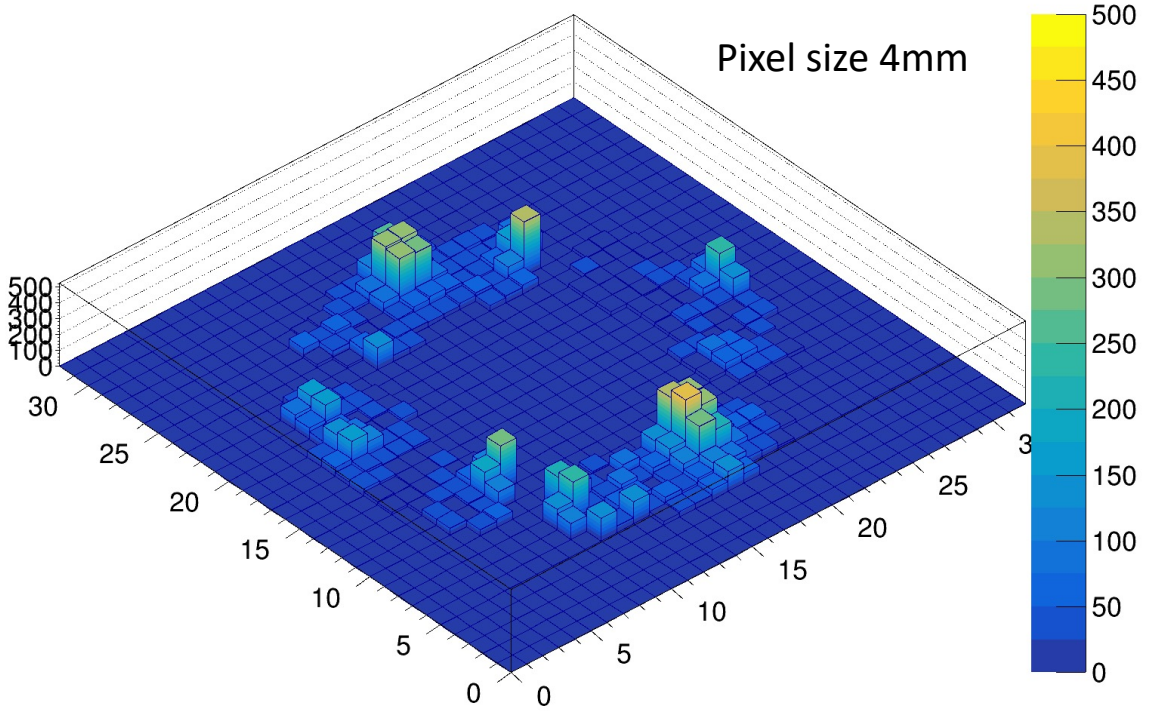


radiator out



Single photon ring radius resolution

Pixel size 4mm

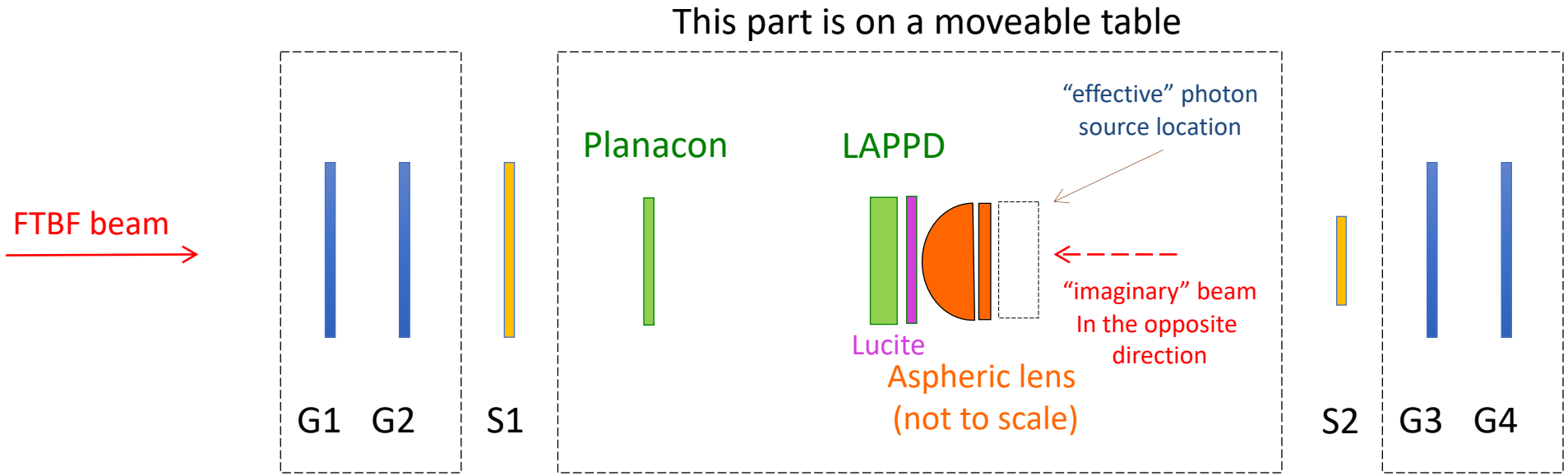


Single event with multiple photon clusters

- Yes, one can measure single Cherenkov photons with sub-mm spatial resolution using pixelated Gen II LAPPDs!

Paradigm change in the Cherenkov ring imaging data analysis: overlapping clusters rather than single pixel hits

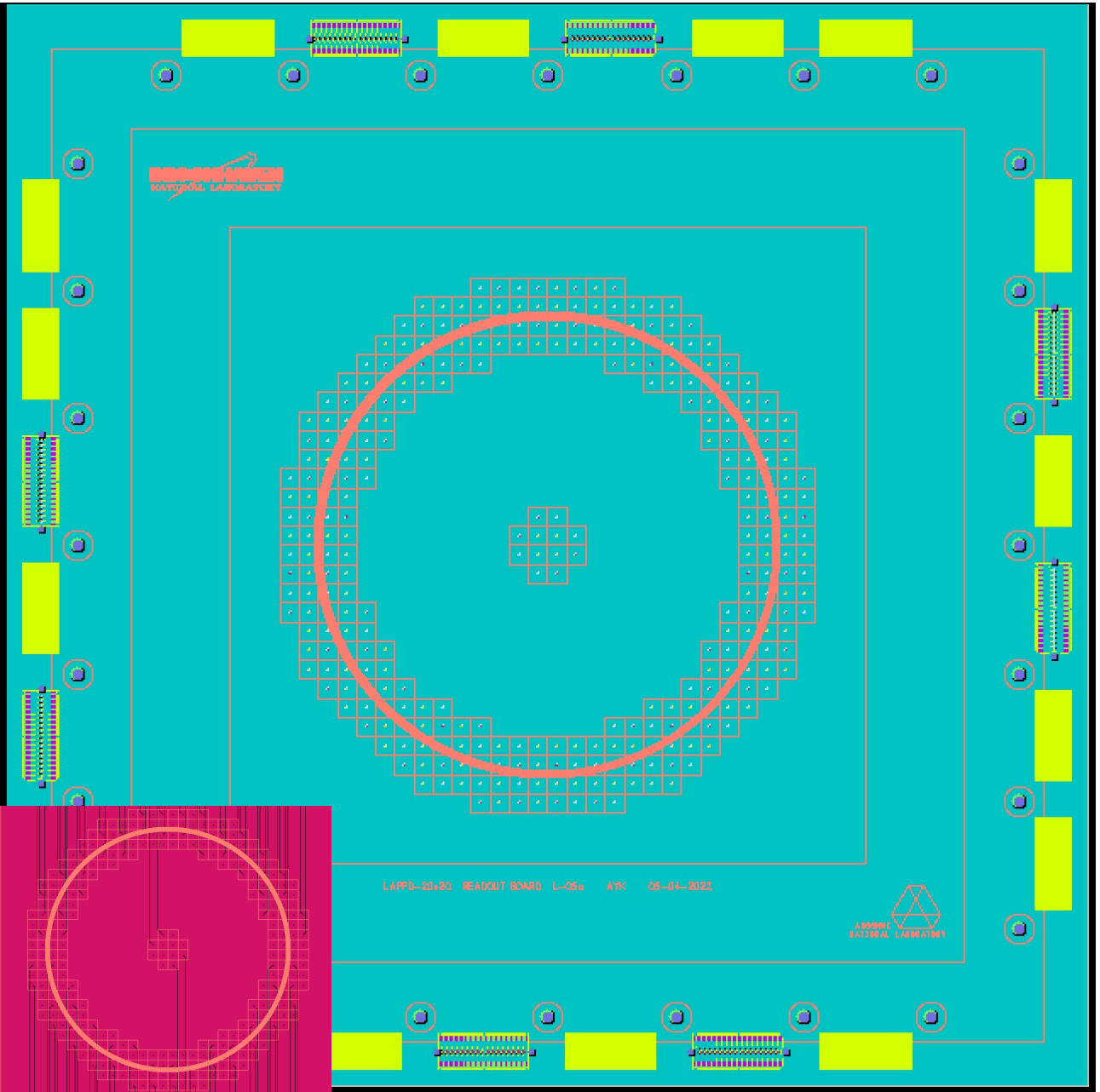
Proposed experimental setup in MT6.2C (2022)

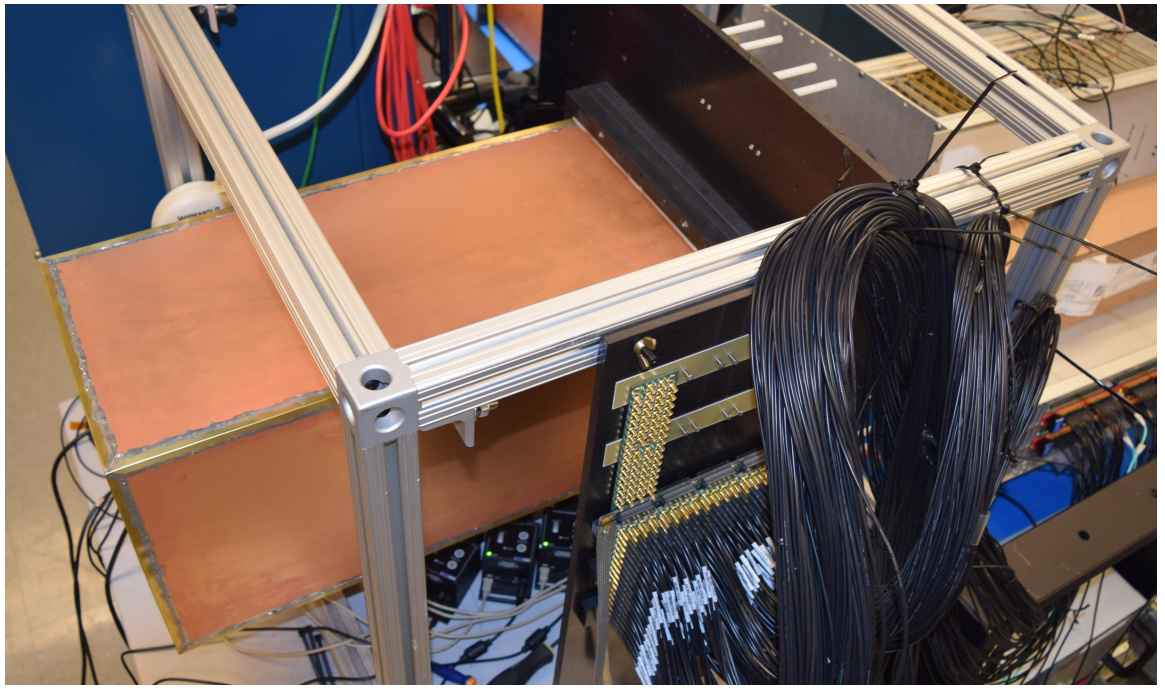


- G1 .. G4 – COMPASS GEM reference tracker (~20-30 μm XY-resolution @ LAPPD)
- S1 .. S2 – trigger scintillator counters

- Either mRICH or pfRICH configurations require
  - Replacing aspheric lens by aerogel container (and a Fresnel lens in case of mRICH)
  - a 180-degree rotation of the LAPPD assembly

New readout board #1: pfRICH mockup





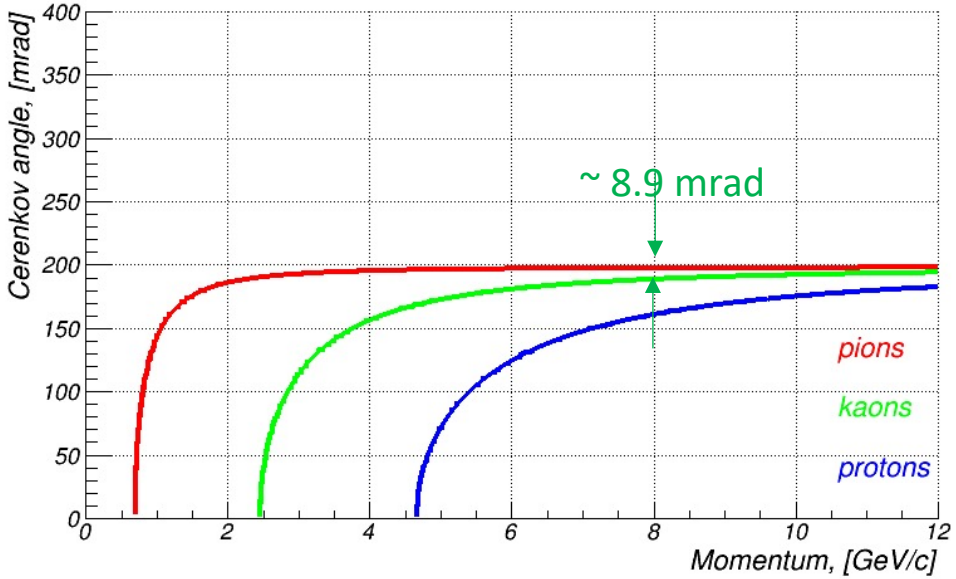
Up to ~50 cm expansion volume

- 320 DRS4 channels overall
- 6mm square pixels
- Tuned for ~150 mm diameter ring
- Aerogel with n ~ 1.020 would be ideal (~200 mrad Cherenkov saturation angle)

→ Need to order NOW

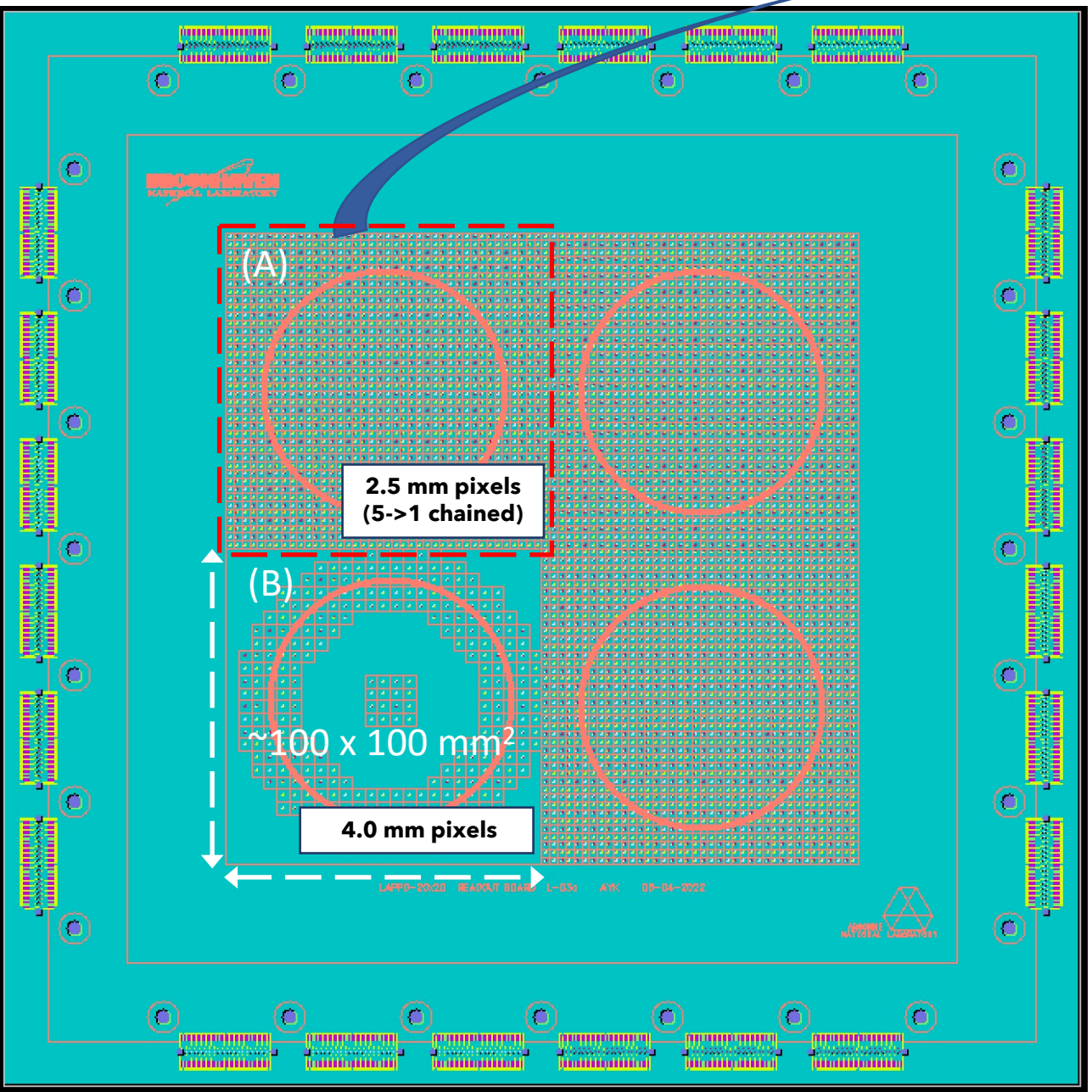
pfRICH mockup: back of the envelope estimates

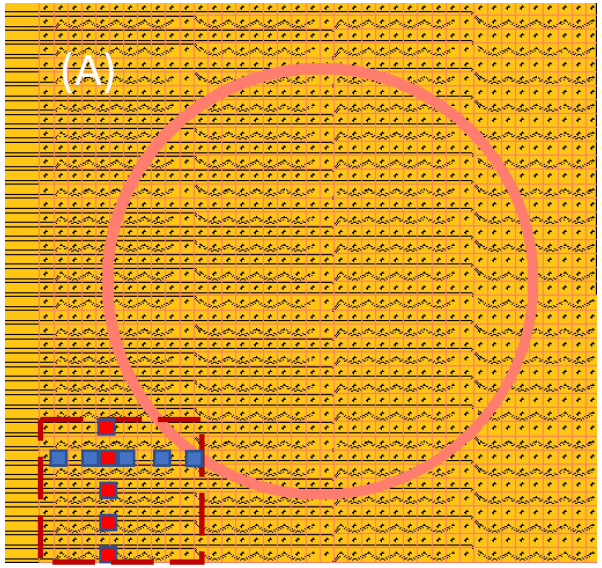
- Input numbers:
  - 3cm thick aerogel with <n> = 1.02; expansion volume ~400 mm; 6 mm LAPPD pixels
  - Saturated Cherenkov angle for this <n> is ~200 mrad
  - Expect $\langle n_\gamma \rangle$ ~ 5-7, but this needs to be verified
- Emission point contribution:
  - $\sigma_\theta \sim$ (30mm * 0.2 / $\sqrt{12}$) / 400 mm -> 4.3 mrad
- Pixel size contribution (worst case scenario):
  - $\sigma_\theta \sim$ (6.0mm / $\sqrt{12}$) / 400 mm -> 4.3 mrad
- Chromatic distortion:
  - Expect ~3.0 mrad, like H8500C Hamamatsu MaPMT

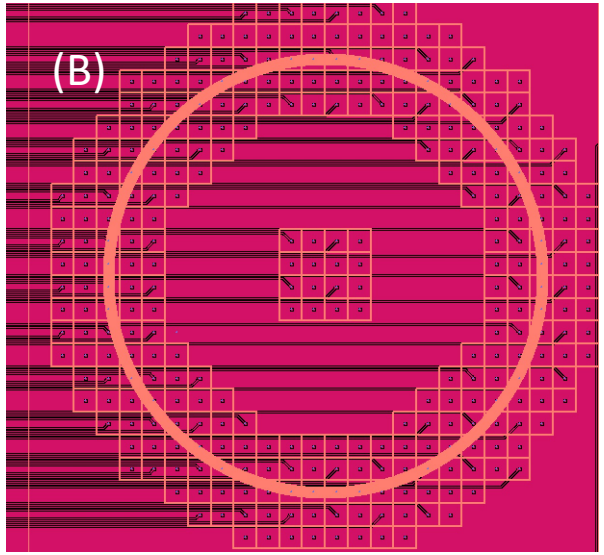


- All together in quadrature is ~6.8 mrad, and times $1/\sqrt{n_\gamma}$ ~2.8 mrad

New readout board #2: ~~aspheric lens~~ or mRICH mockup





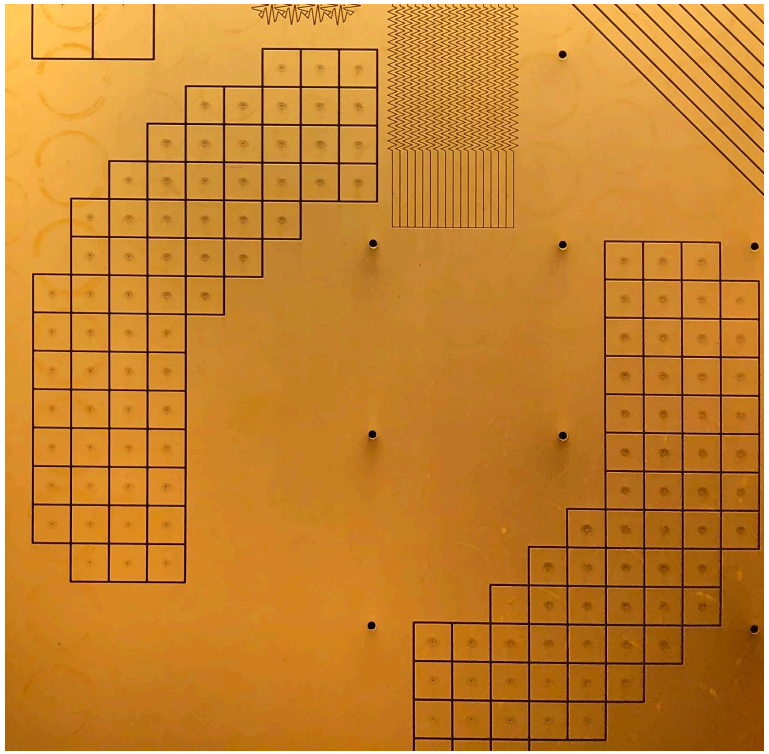


- 320 DRS4 channels per quadrant
  - (A) full 100x100 mm^2 coverage; 2.5mm square pixels, in chains of 5
  - (B) a ring of D ~ 76mm + a central spot; 4.0mm square pixels
- Mechanically compatible with HRPPD
- Pattern (A): three different pad-to-ground gaps
- Can be used for ring imaging and TOF at once
- Can be used with aspheric lens

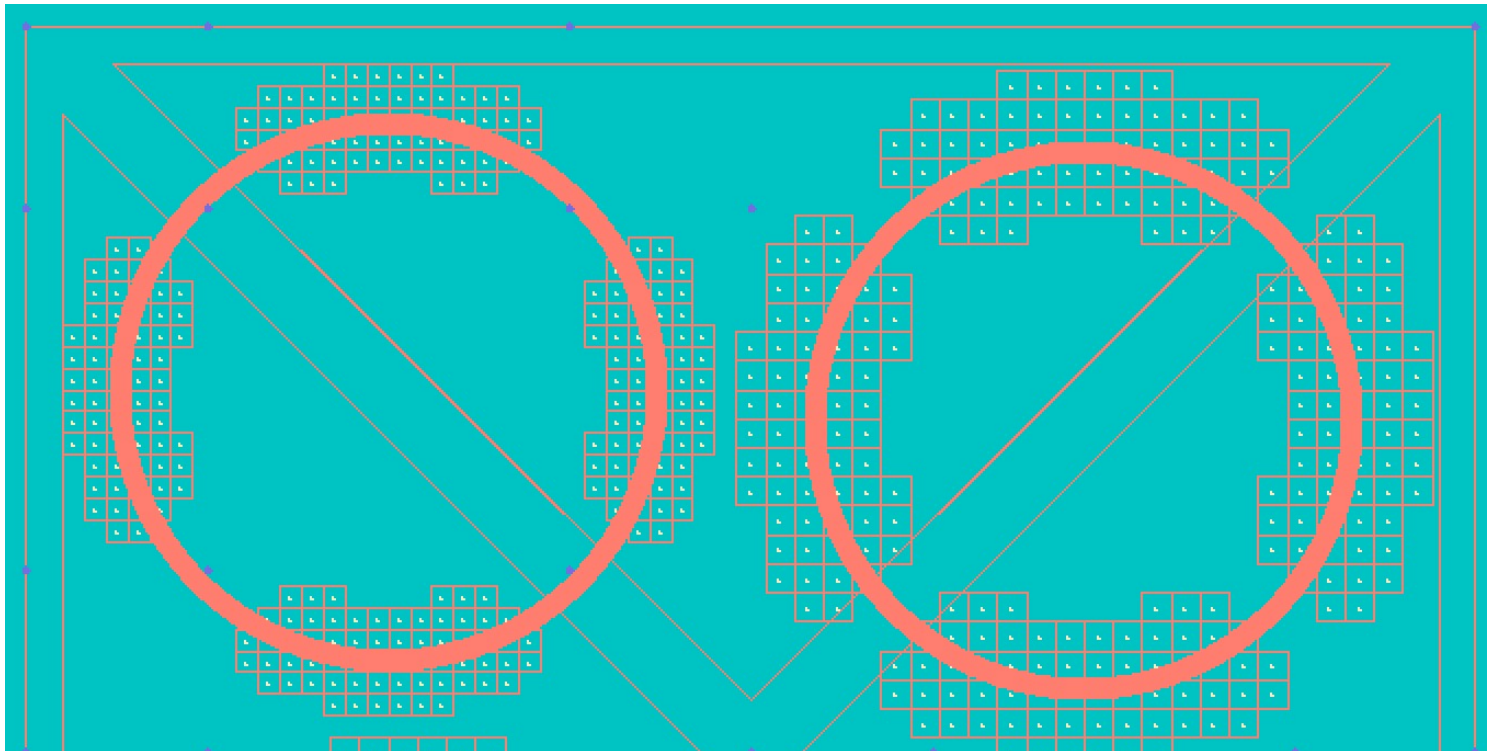
→ Need to order NOW

Fallback options

- Can use old readout boards tuned to detect D ~ 76mm rings (but no central area coverage):



L00e: 128x 5mm pixels



L02b: 256x 3mm or 4mm pixels

→ Both are not ideal for the new LAPPDs, but we know these boards work

Pending issues

- DREAM readout electronics driver bug fixes (AK)
- DAQ synchronization (Martin)
- Online monitoring (Sanghwa?)
- DRS4 calibration (AK)

- New readout boards
- LAPPD production delays

- Aerogel!
- …