pLAPPD ToF

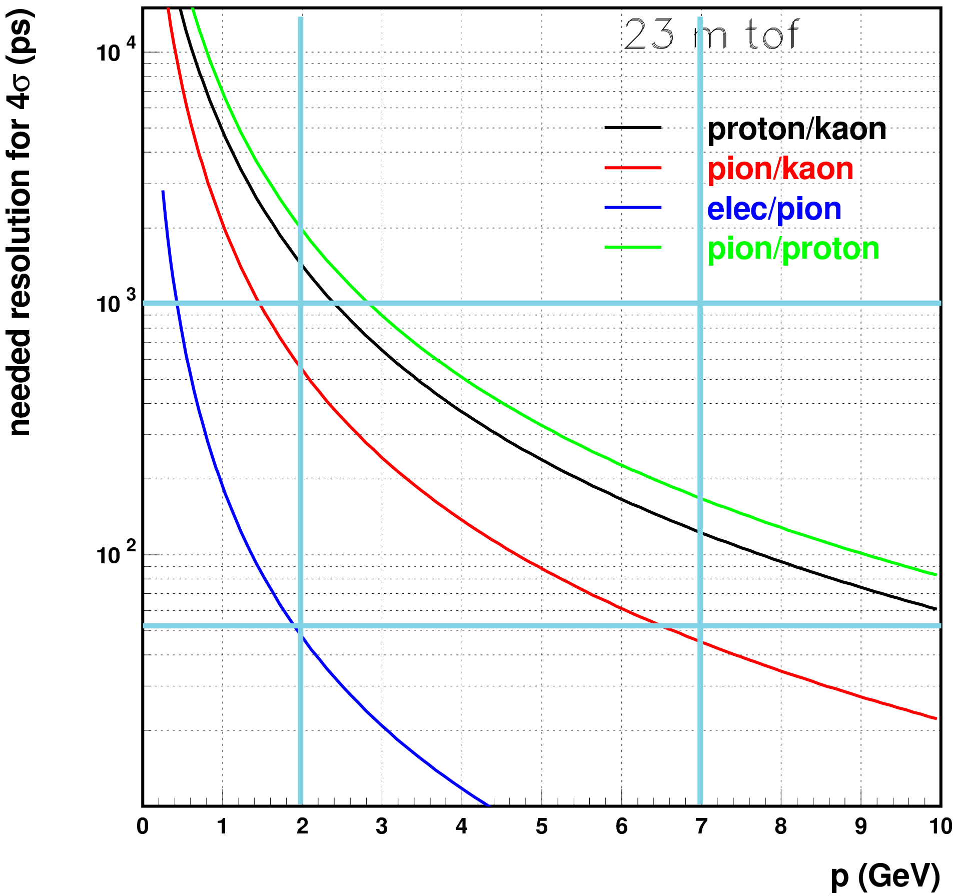
Jonathan Paley

ProtoDUNE SP Beamline Review

April 27, 2017

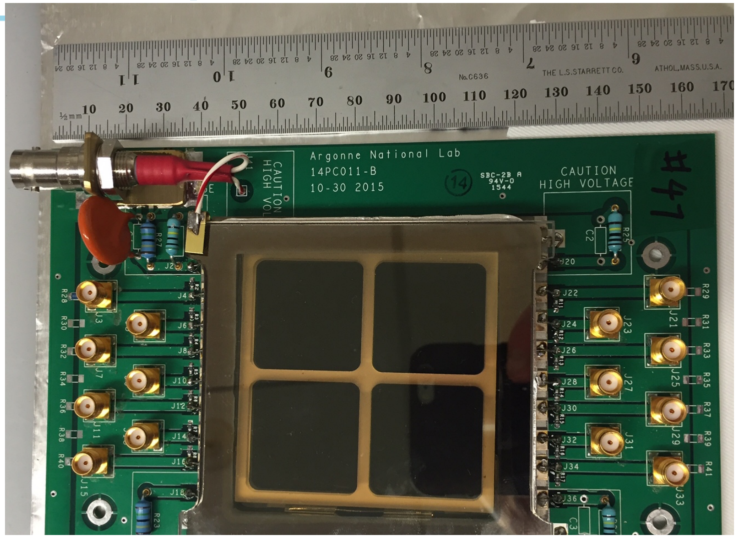
ToF - Motivation

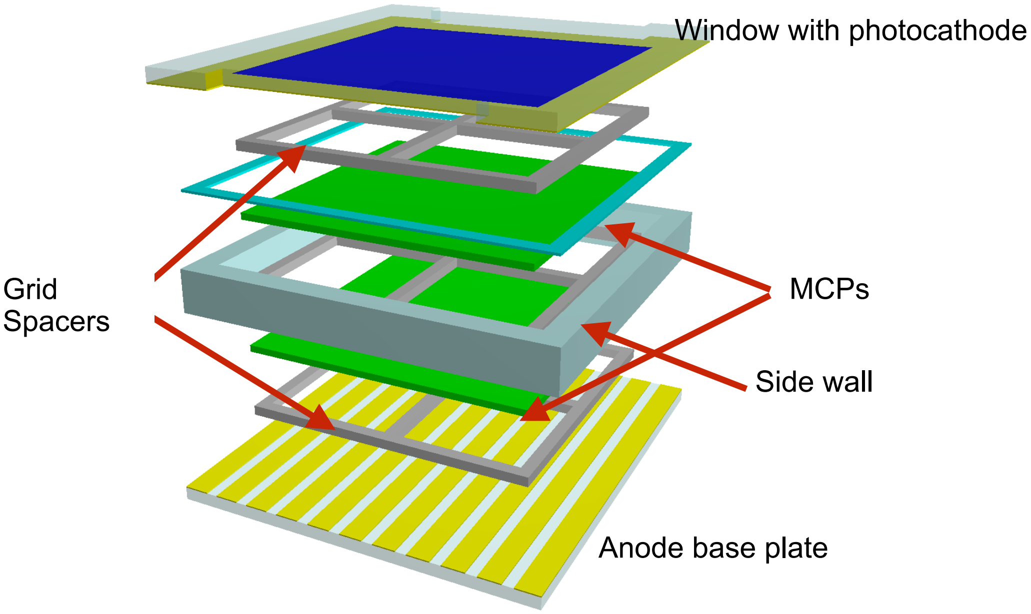
- Above ~2 GeV, we expect the XBPF ToF (~1 ns timing resolution) to have inadequate timing resolution to separate π/K/p.
- We have proposed using a ToF system that makes use of new photodetector technology that has < 50 ps timing resoution.
- With 50 ps timing resolution, pid separation at > 3 sigma is achieved for all planned beam momenta for protoDUNE-SP.
  - plot to left is for 4 sigma separation
  - assumes 23 m instead of 28 m



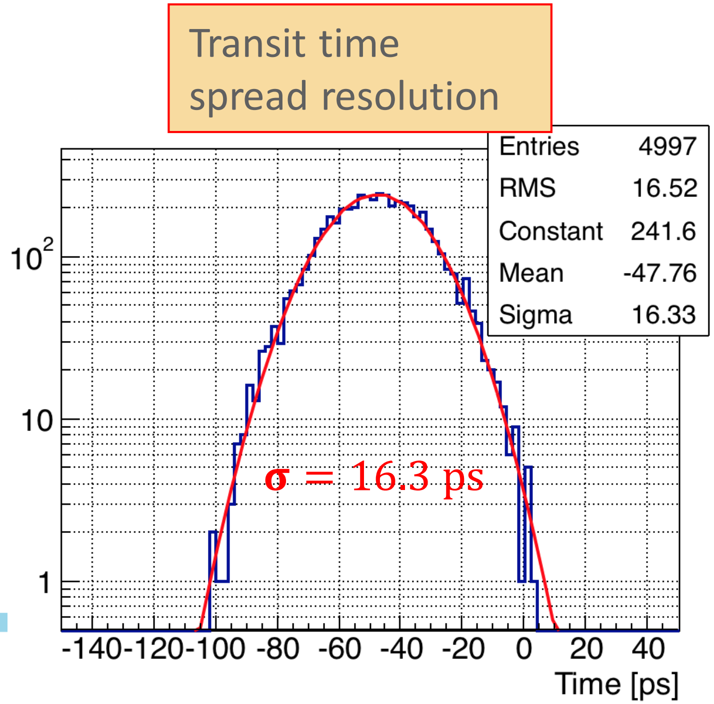
Introduction - Prototype Large-Area Picosecond Photodetectors (pLAPPDs)

- MCP-based photodetector, *capable* of 20 ps timing resolution.
- Pioneered by Argonne and U. Chicago, represents significant investment by DOE for detector R&D.
- Typical gain is ~1e6 at -2500V, ~10% QE, 50 ps absolute timing resolution. <10 ps relative resolution, allows for ~mm spatial resolution.
- No deadtime for rates below ~30 MHz/cm^2



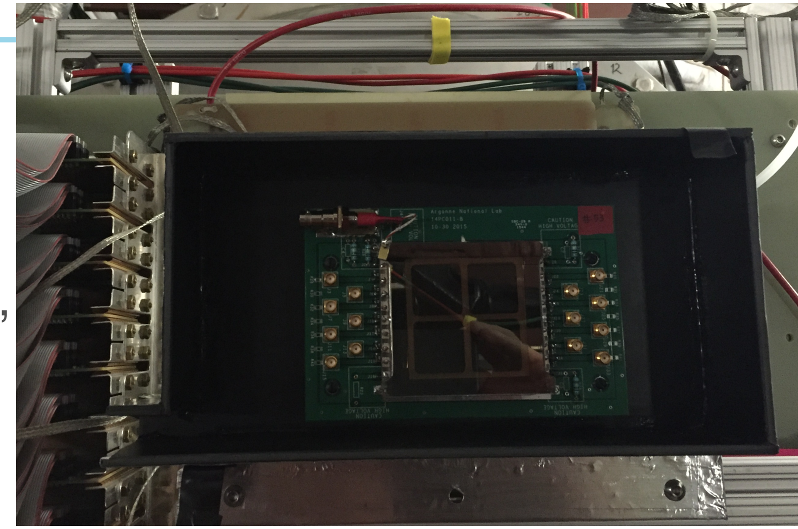


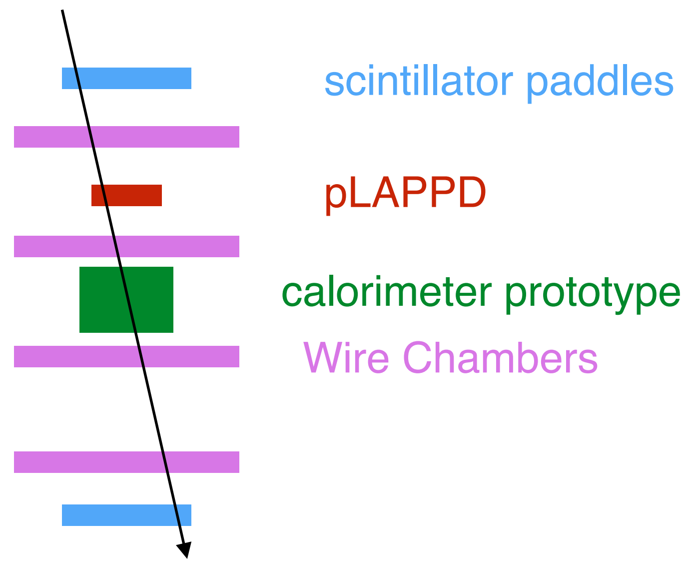
6x6 cm^2 ‘small tile’ blowout



Status

- Testing one pLAPPD (~5.e5 gain, ~10% QE) from Argonne to get operational experience, develop DAQ, etc.
- The tube was placed in a cosmic ray test stand, and operated at -2.5 kV (gain ~5e5) under 3 conditions: bare (no radiator), 2 mm thick scintillator in front, 1 cm thick fused quartz in front.
- Using the ***artdaq-based*** (similar to protoDUNE-SP!) LArIAT DAQ to record data from a CAEN V1751 (optical readout).
- Trigger formed by coincident between scintillator paddles and wire chambers. Rate is a few per minute.





pLAPPD Testing at Fermilab

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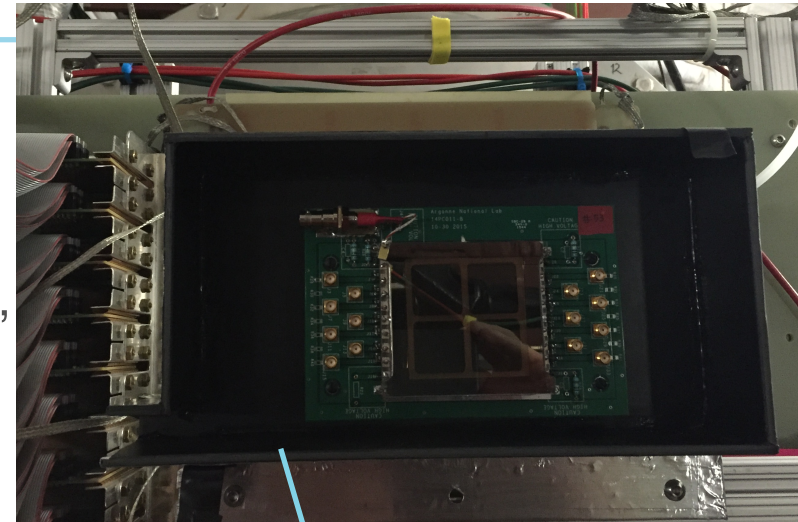
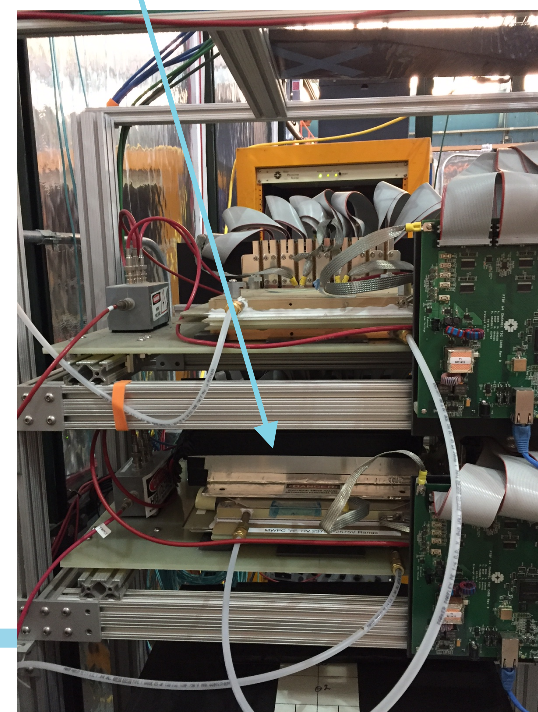
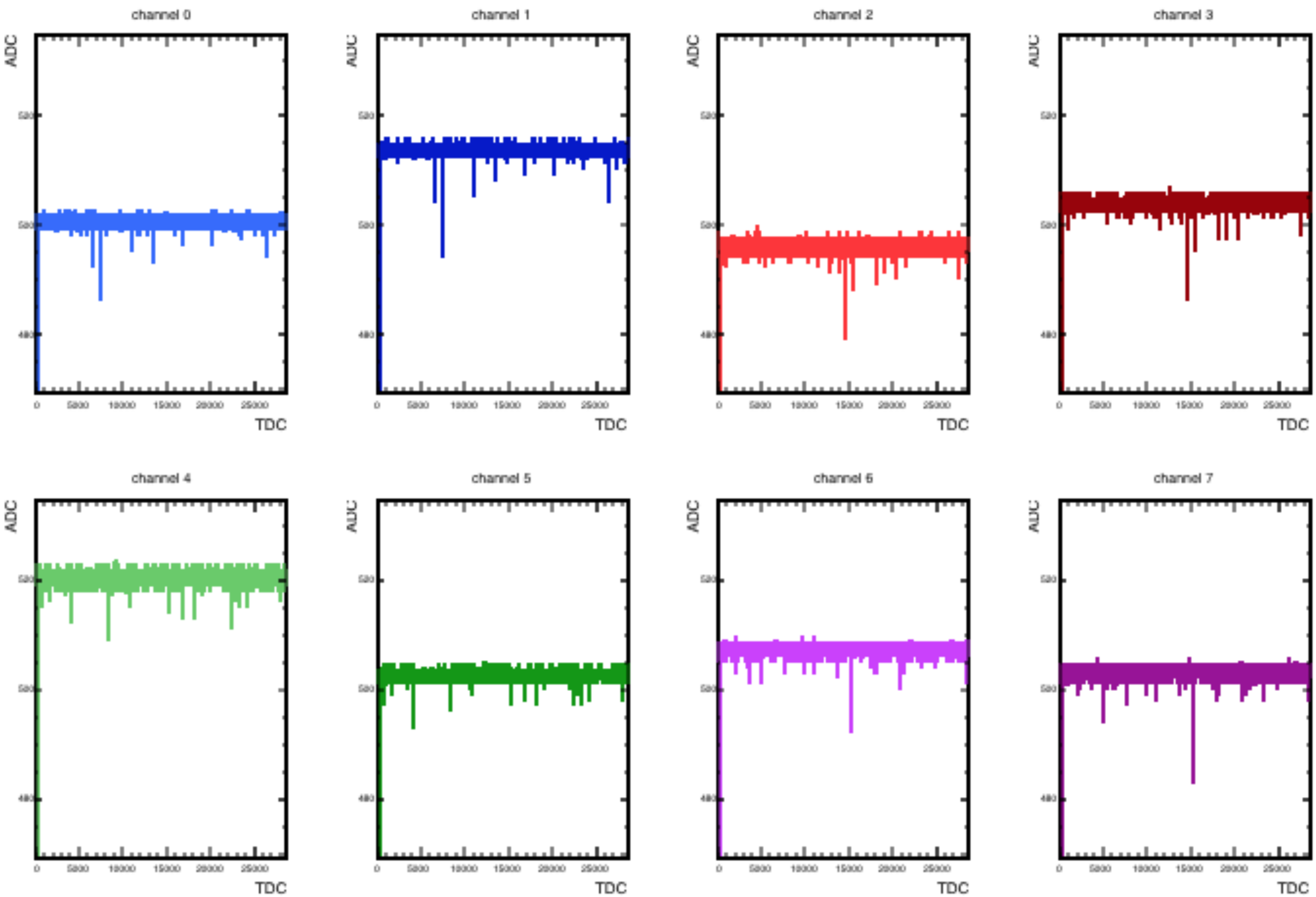




A Quick Look at the Raw Data



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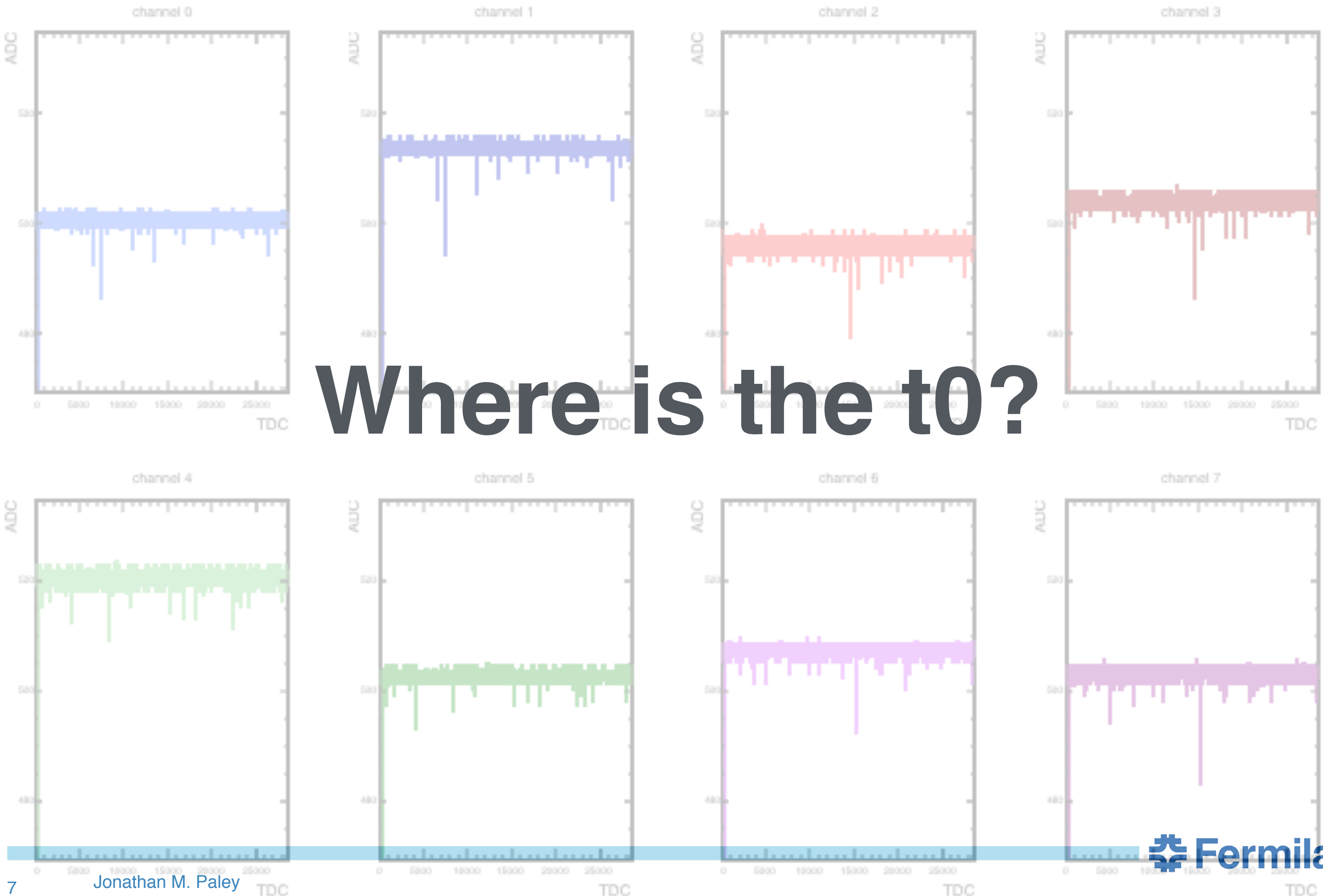
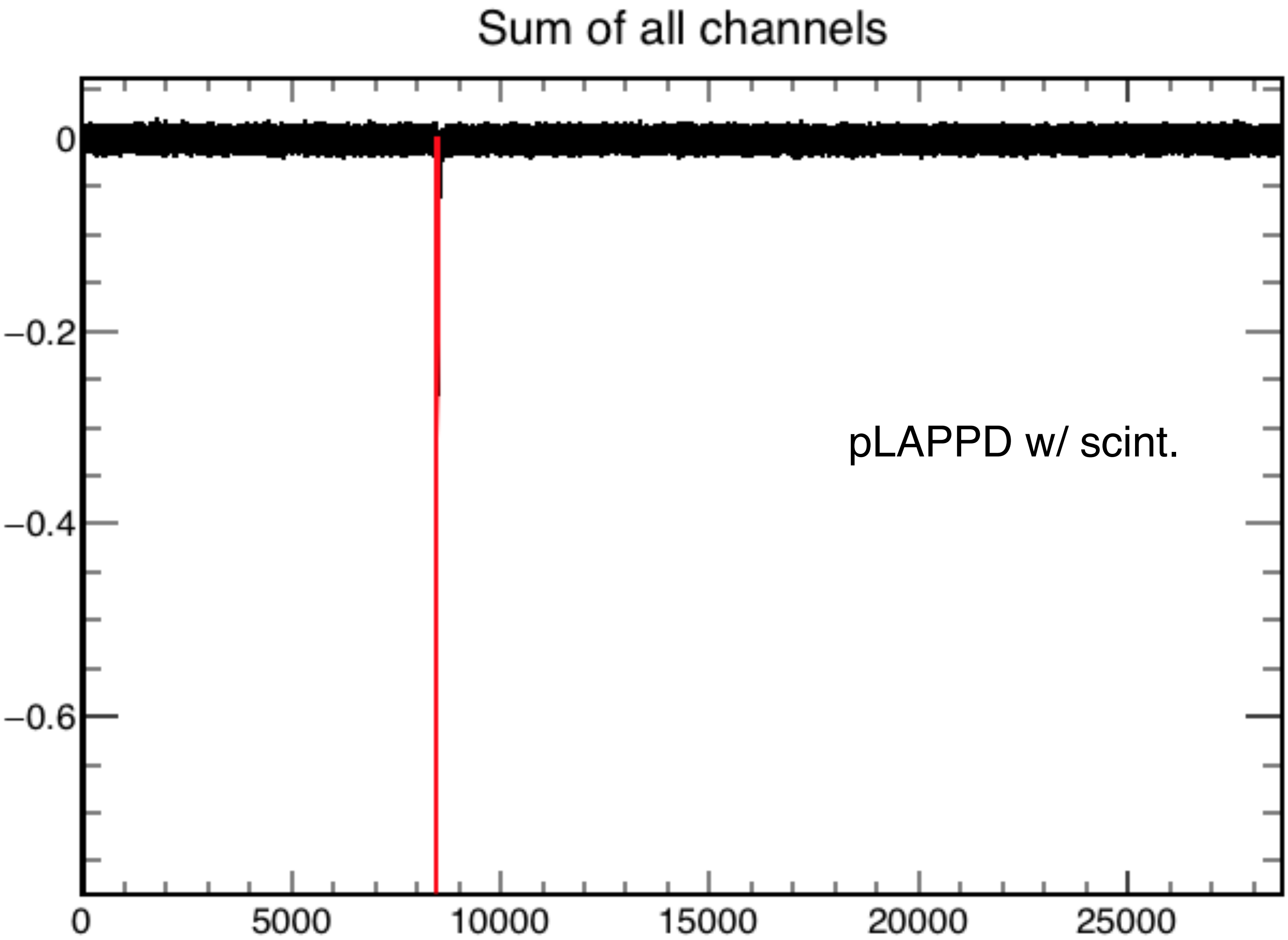


Where is the t0?

Finding the t0



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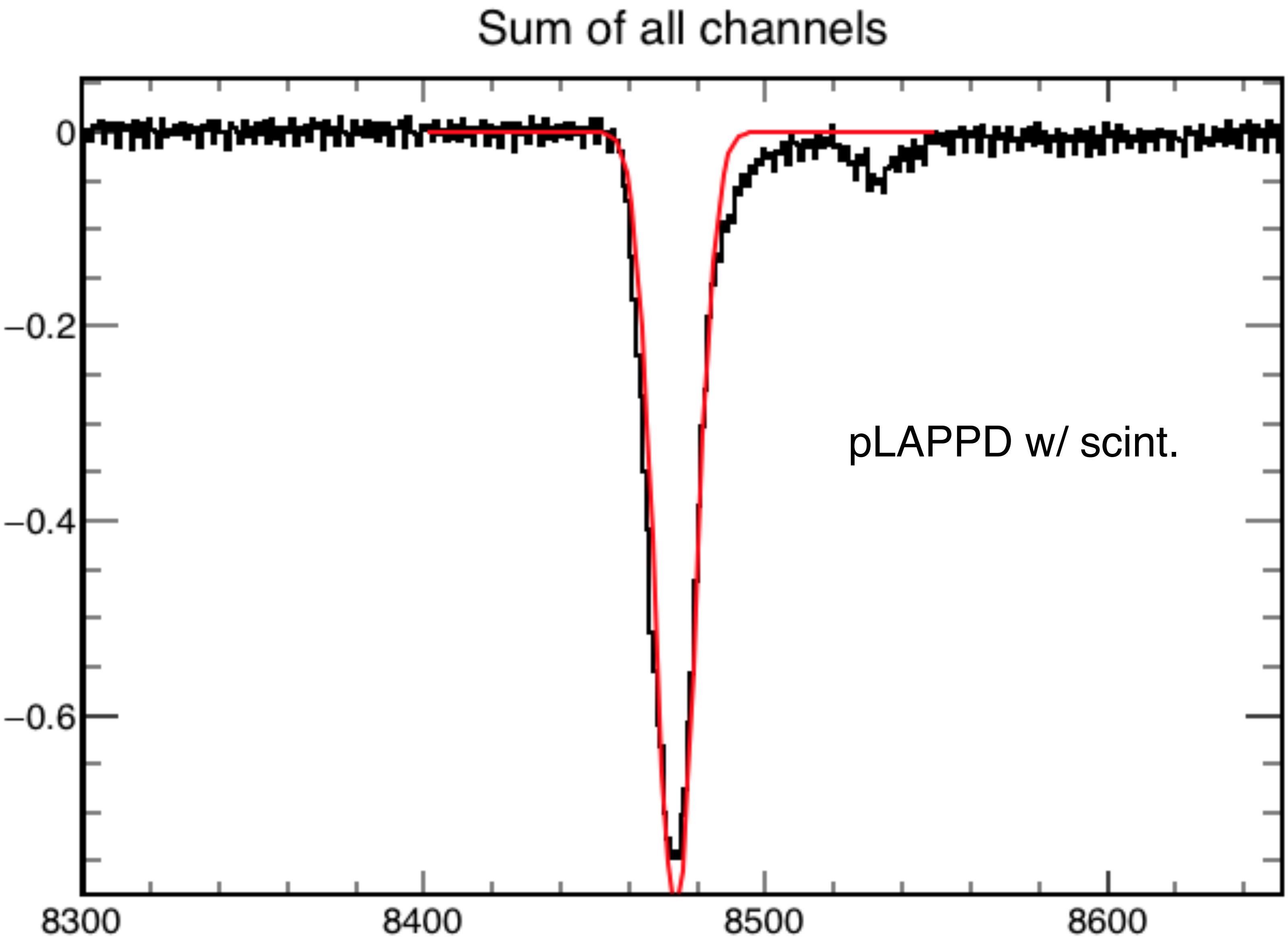

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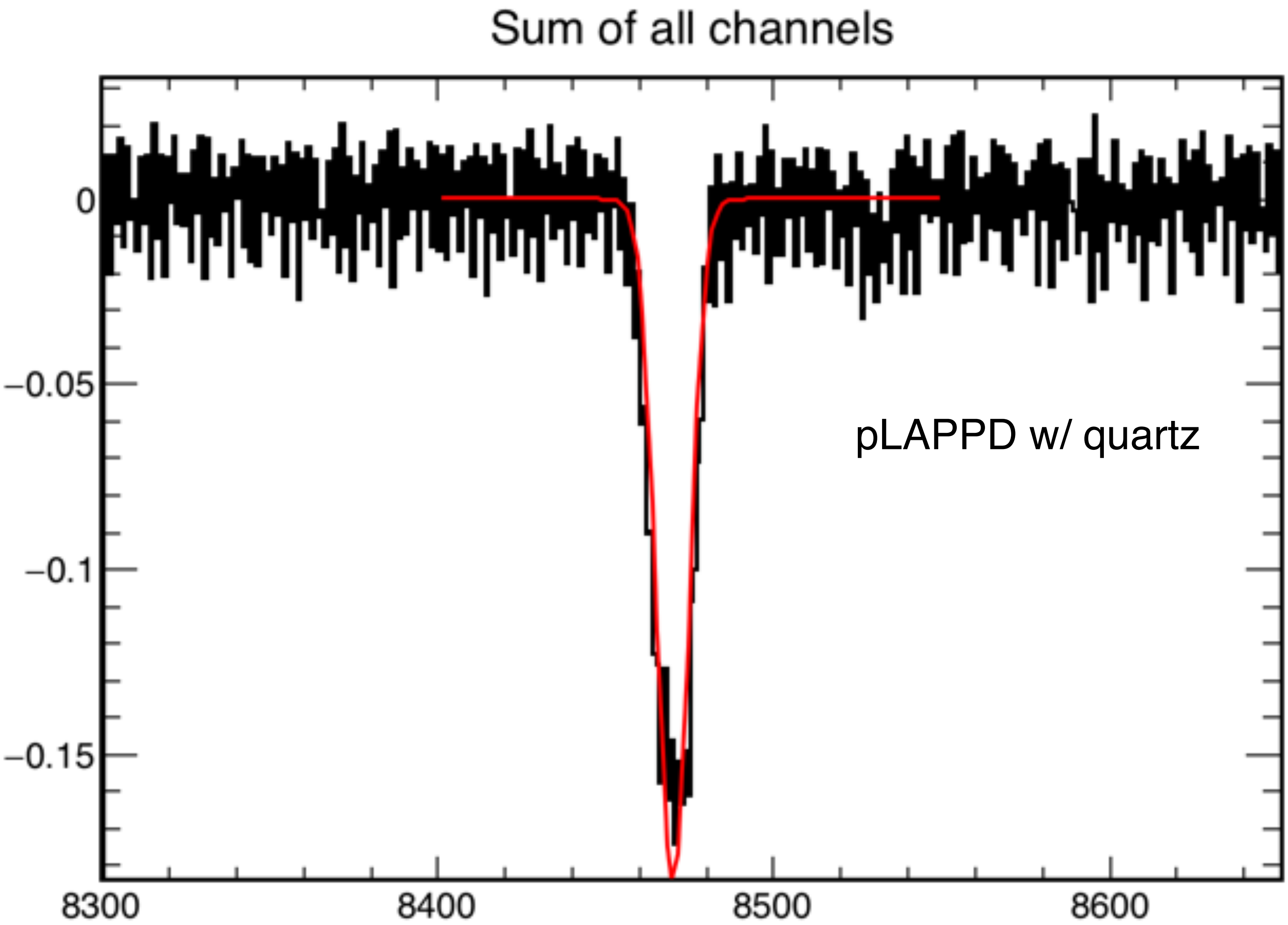

Measurements of Hit Efficiency

- Determined t0 for each strip (4/7).
- Define a signal hit as any ADC above threshold (= 4 x pedestal width) from +/- 3σ of the t0, recorded on both ends of a strip, for any number of strips.
- Define a noise hit in a similar fashion, but outside this time window.

Radiator	Efficiency for strips 3-6	Mean and RMS of Signal Amplitude	Noise Rate	HV Setting
None	18.5 ± 0.4%	Mean: 20.9 RMS: 18.5	36 kHz	-2.5 ± 0.1 kV
Scintillator	20.7 ± 0.6%	Mean: 32.5 RMS: 25.9	36 kHz	-2.5 ± 0.1 kV
Fused Quartz	24.1 ± 0.5%	Mean: 20.2 RMS: 17.4	36 kHz	-2.5 ± 0.1 kV

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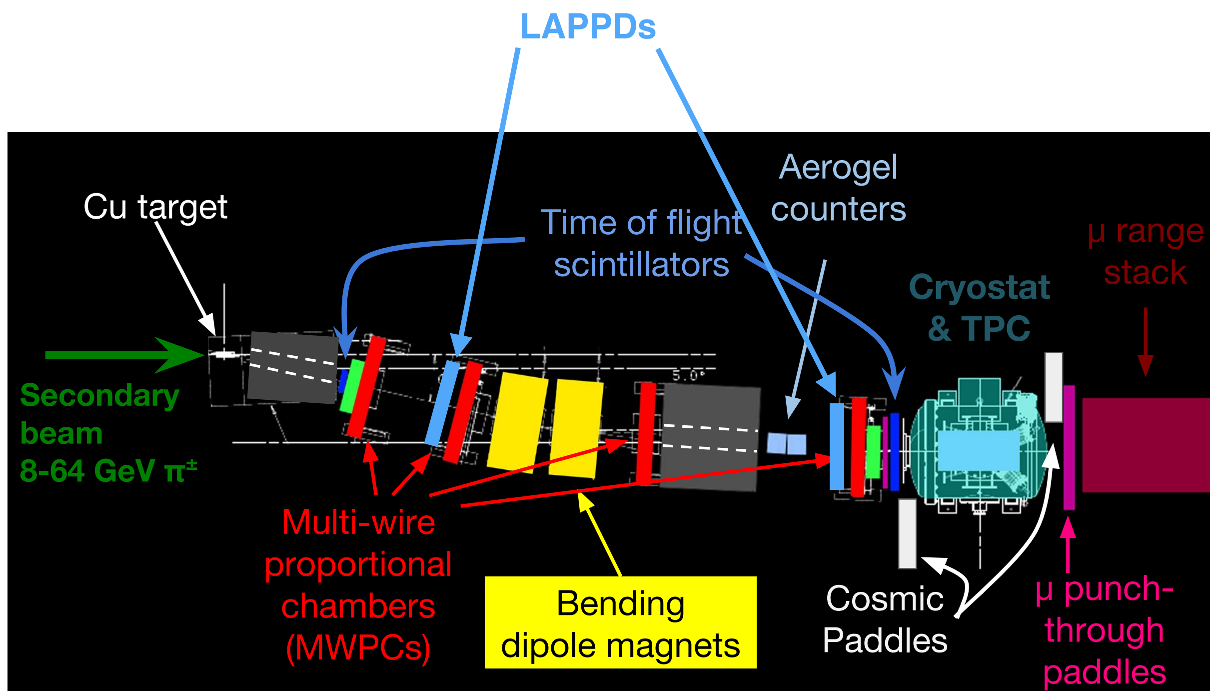

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Fermilab

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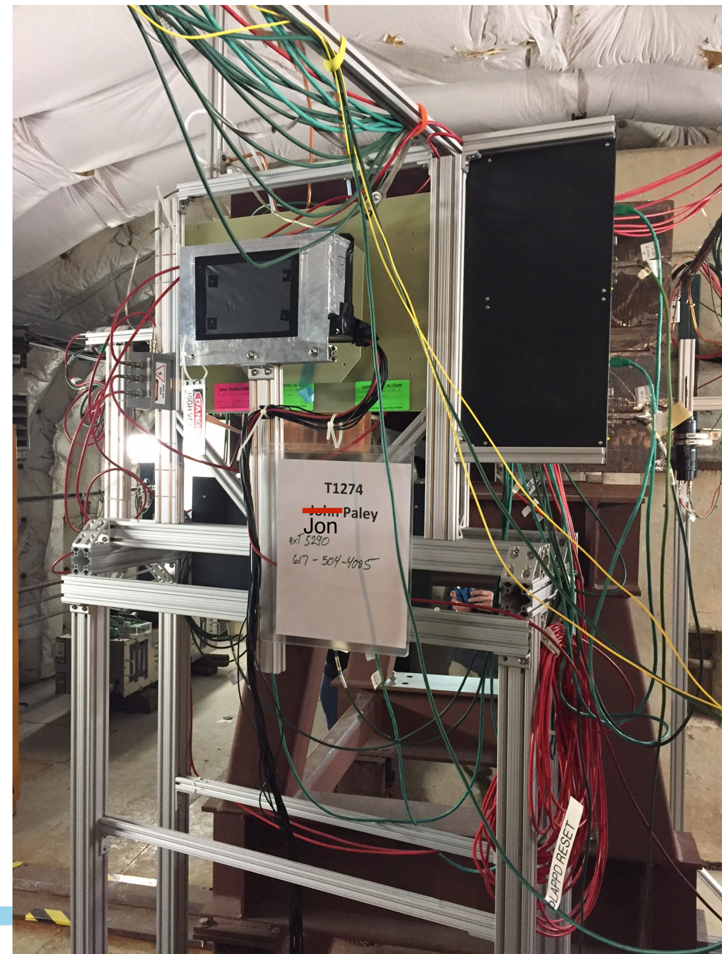

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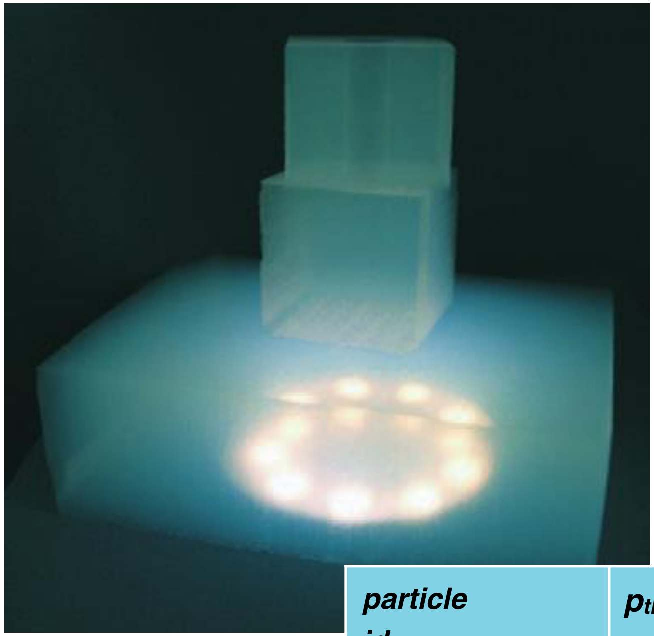
- Also hoping to investigate aerogels as possible radiator. Japanese friends have offered samples for testing.



particle id	p_{thresh} (GeV/c) n=1.05	p_{thresh} (GeV/c) n=1.02
π	0.4	0.7
K	1.5	2.5
p	2.9	4.7

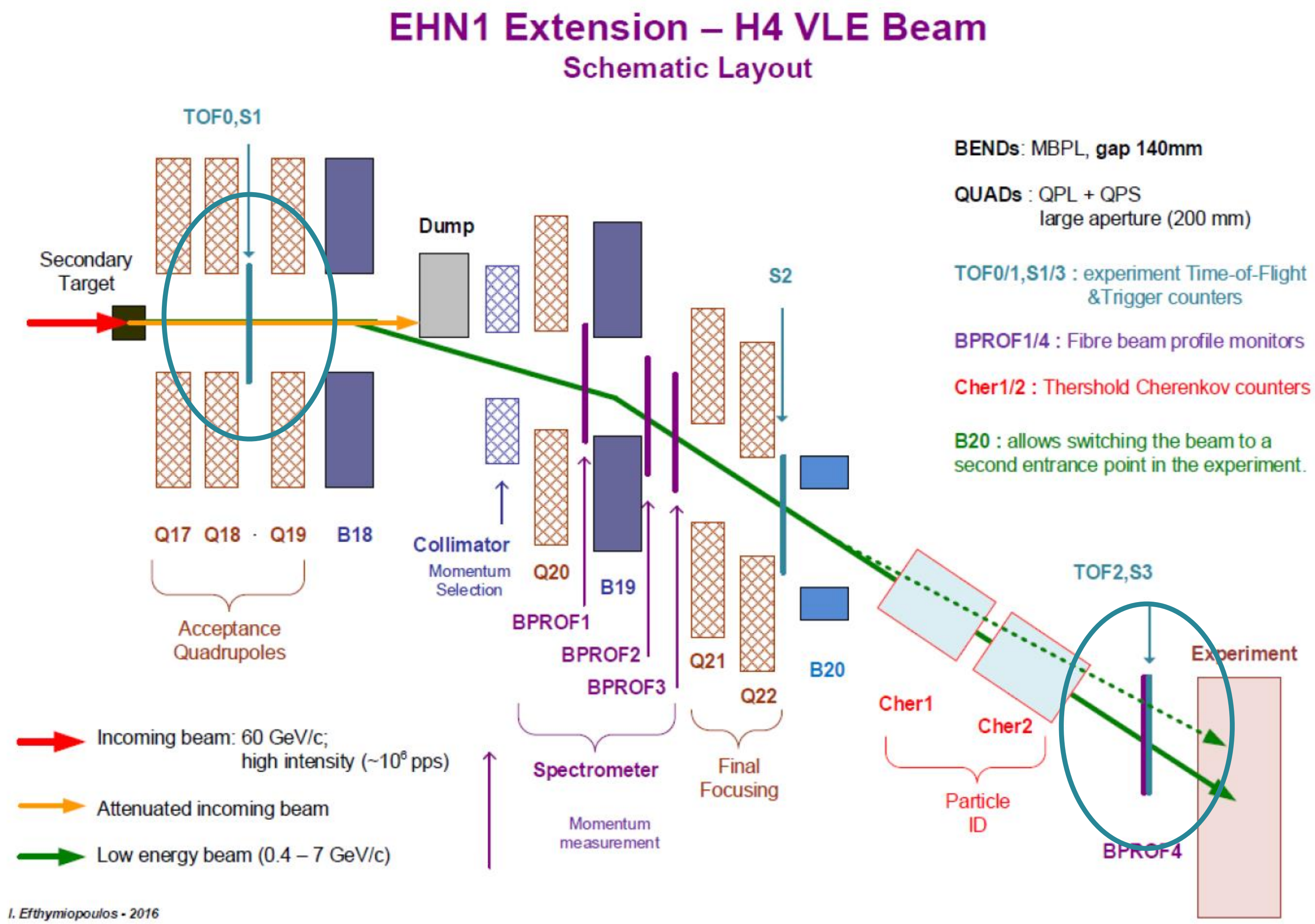
ProtoDUNE-SP Integration

- Electronics and DAQ:
  - Use a CAEN V1742 module (32-channel, 12 bit @ 5 GS/s)
    - Optical readout via A3818C PCIe card (purchased for protoDUNE-SP)
    - Being tested now in LArIAT
    - Note: considering using unused channels for other beamline detectors (low-momentum ToF & Ckovs)
  - Discussions are on-going regarding using ToF for triggering
- Each ToF station will cover ~60 cm^2 of the beam profile.
- We will investigate the possibility of using the same mounting box as for the XBPFs. If that does not work out, we will consult with CERN engineers and technicians to design, and FNAL will construct, new light-tight mounting fixtures.
- Each pLAPPD requires approx. -2500V, will need to remotely control and monitor power.
- Digitized signals will be read out via the TPC DAQ. TPC DQM will also monitor the V1742 data.

Argonne Production Schedule

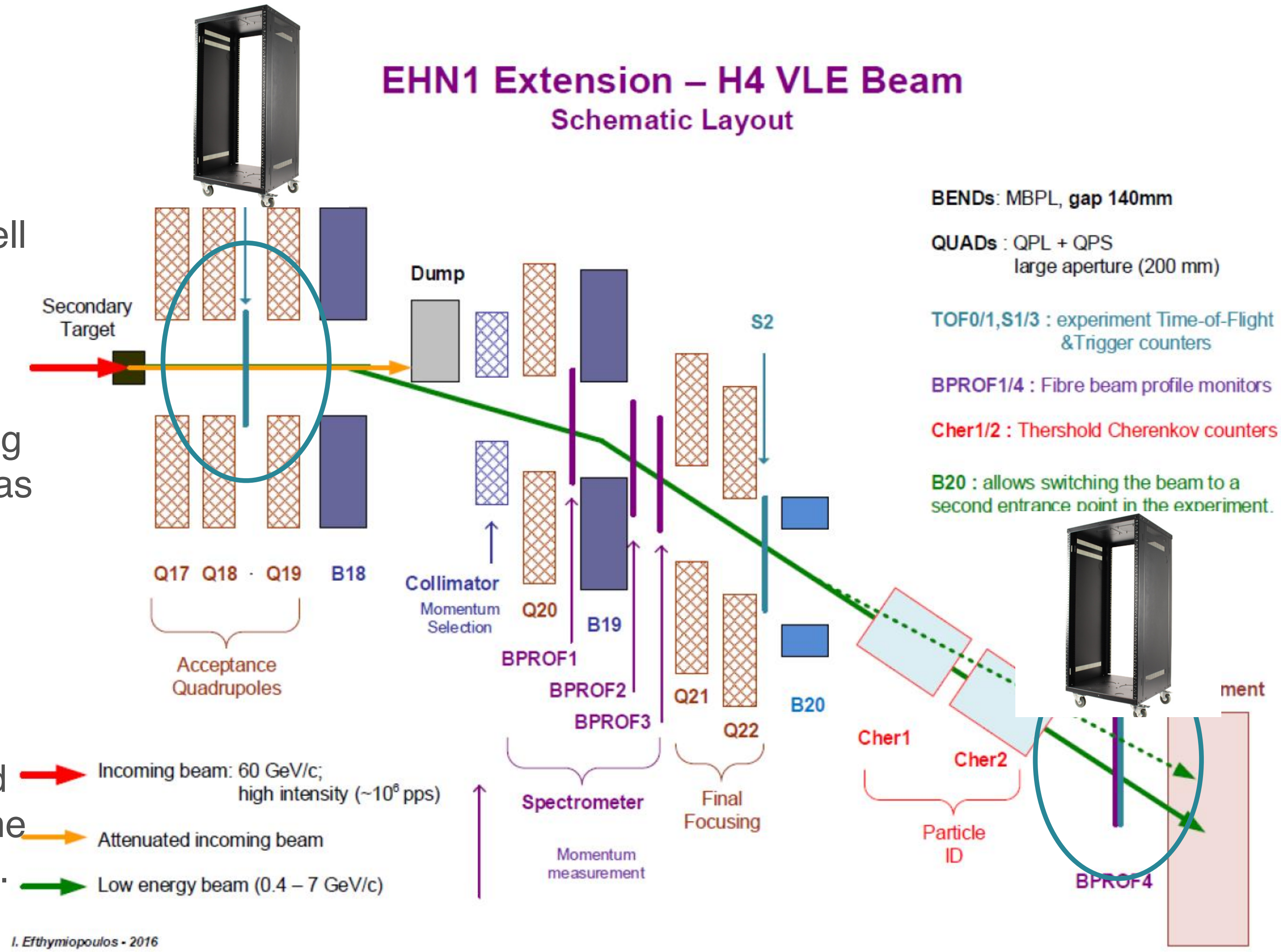
- Argonne claims they can produce 4 for protoDUNE-SP, however we have no formal agreement.
  - The LAPPD Project has no more funding from DOE for R&D.
  - There is some very limited funding to produce tubes for protoDUNE-SP as well as some other customers.
- The current rate for production of a pLAPPD at Argonne is about 3 weeks.
- They recently produced 2 tubes, one of which has a failed vacuum seal. Still waiting to hear about the other. A third tube was in the final stages of production approximately a week ago.
  - The limited history of the lifetime of these devices indicates tubes that survive the first couple of weeks have continued to operate with the same performance parameters.
- Assuming 100% contingency for production schedule, we should have all 4 devices by the end of October 2017.
  - We should have 1-2 new devices in hand by this summer.
- ***Reminder: Argonne is not charging us for these devices.***

Installation Details and Commissioning Schedule



Installation Details and Commissioning Schedule

- Readout electronics must be close to the pLAPPDs.
- Racks and VME crates needed, as well HV and networking cables, and optical fiber.
- Discussions regarding these needs as well as installation schedule are on-going w/ CERN-based personnel.
- Commissioning of detectors is expected to happen at the same time as the beamline.



Questions?