Developing Charged Particle Time-of-Flight at the Fermilab Test Beam Facility Using Commercially Produced LAPPD™ modules

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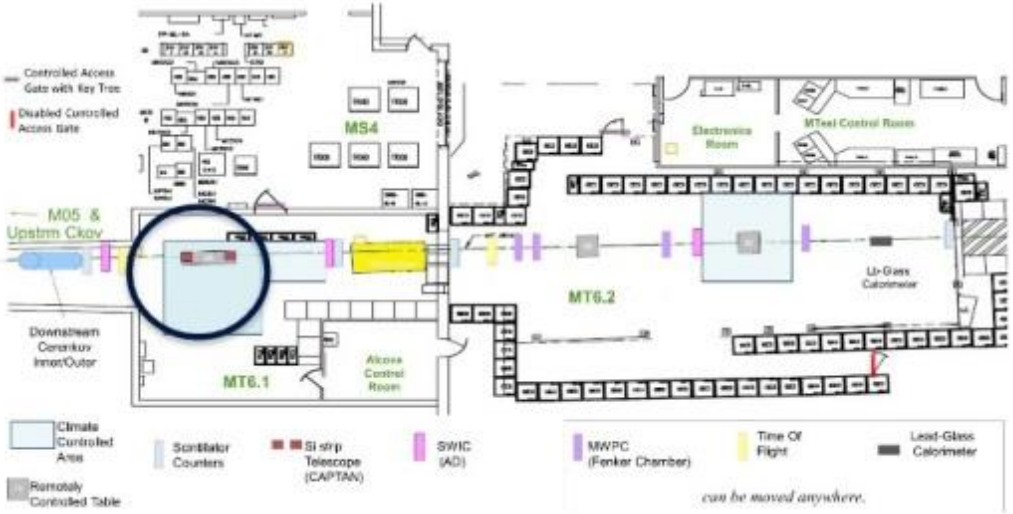
Beam Instrumentation Layout – MTest



Credit Mandy Rominsky
Hadron Production Wkshp, July 2017

Third time for psec timing in MTEST- a `loose collaboration' of Chicago, Fermilab, and Incom

Current draft

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Precision Time-of-Flight at the Fermilab Testbeam Facility

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Incom, Inc; Charlton, MA 01507
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Abstract

The first commercially-produced LAPPD^{TM} photodetectors are now available from Incom, Inc [1]. We propose to follow up the measurements with 2" Planacon MCP-PMTs in T979 [2, 3, 4] and T1075 [5] to optimize the timing resolution and to characterize the performance and life-time of two of the newly available 8" Incom modules at the Fermilab Testbeam Facility . The tests would use the 10 Gsample/sec PSEC4 waveform sampling electronics system developed by Eric Oberla et al. If successful we would then propose an upgrade of the Fermilab Testbeam Facility Time of Flight(TOF) system to up to 4 LAPPDs for particle ID. The goals thus are two-fold: 1) an installed long-term upgrade to the Fermilab Test Beam Facility; and 2) a validation of a new commercially-available technology for future detectors at the Energy and Luminosity Frontiers.

Motivation 1
Add routine precise particle ID to the test beam

- Many of the detector-development measurements made at the FTBF are sensitive to the particle type. For example, as calorimetry in collider detectors gets ever-more precise, particle-type-dependent calibration becomes essential. To precisely characterize the resolution for jets of higher-resolution calorimeter designs in simulations, one needs the capability to measure identified pions, kaons, and protons over the range characteristic of jet fragmentation in very high energy collisions(30-40 GeV at least). Particular effects that are usually integrated over in the simulation response functions, but which will contribute systematic errors to the tails of resolution functions, include:

- **Differences in π/K interaction lengths ;**
- **Differences in π/p/pbar interaction lengths;**
- **Differences in K^-/K^+ interaction lengths;**
- **Differences in $\pi^-/\pi^+$$ charge-exchange cross-sections;**
- **Electron fake rate from π- charge exchange**

These can be measured routinely (no change of settings, all particles) with a fast **large-area** TOF system.

Motivation 2
Push TOF detector timing resolution down to limiting factors

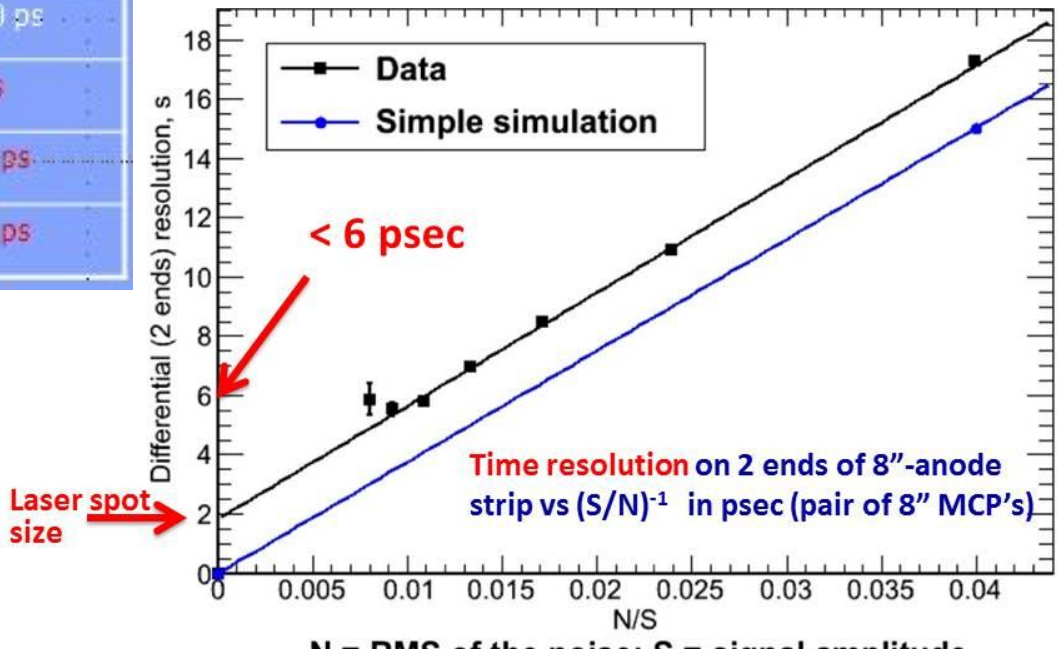
$$\Delta t = \frac{\Delta u}{U} \cdot \frac{1}{\sqrt{3 f_s \cdot f_{3dB}}}$$

•Assumes zer
aperture jitte

U	Δu	f_s	f_{3db}	Δt
100 mV	1 mV	2 GSPS	300 MHz	~10 ps
1 V	1 mV	2 GSPS	300 MHz	1 ps
100 mV	1 mV	20 GSPS	3 GHz	0.7 ps
1V	1 mV	10 GSPS	3 GHz	0.1 ps

100 fsec (!?) extrapolated if we can up bandwidth from 1.6 to 3 GHz; all other parameters are exceeded

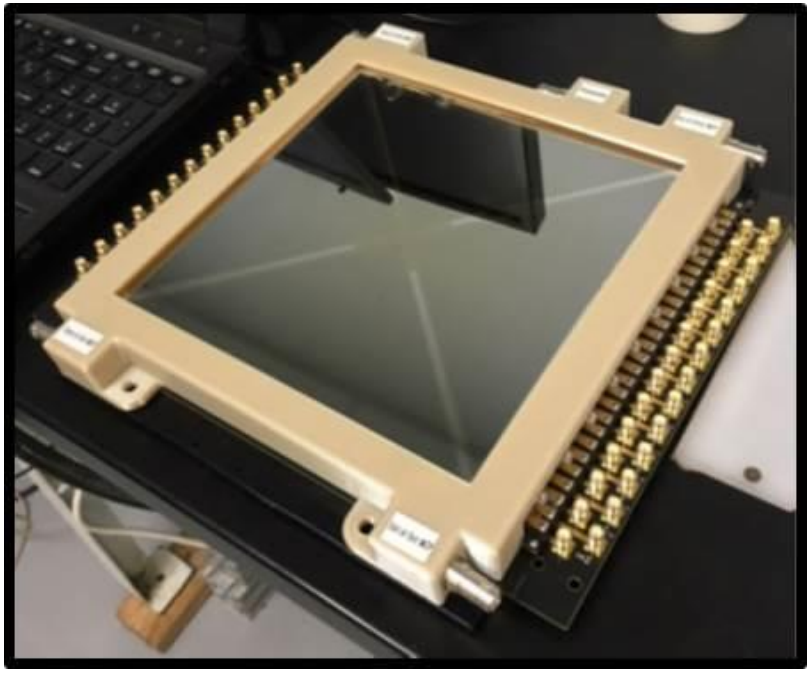
Differential resolution tho



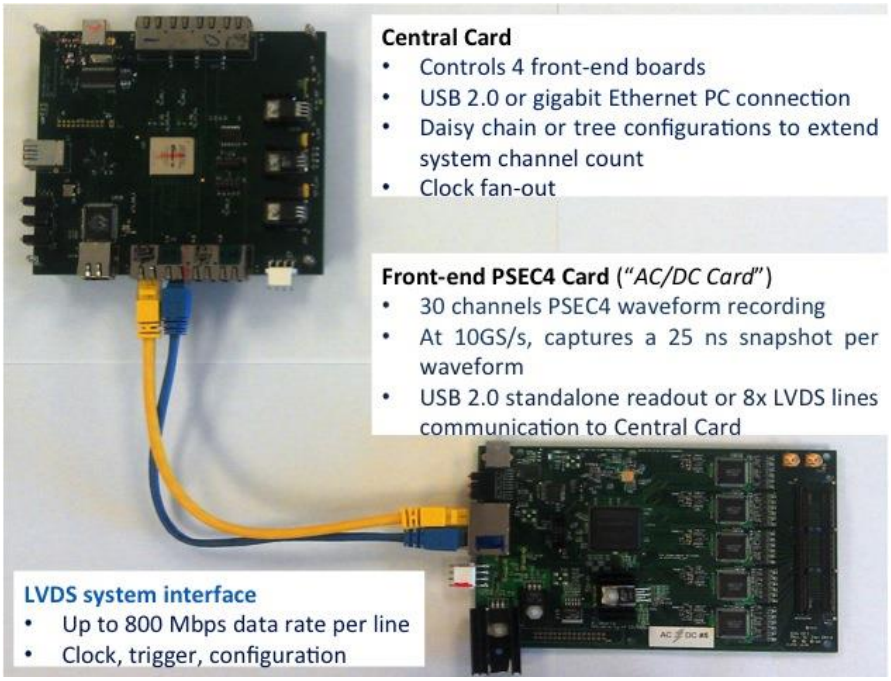
- Existing measurements go down to 5psec (Ohshima, Ronzhin et al, …);
- The 2-parameter Ritt extrapolation holds so far;
- We do not know the limiting factors yet;

Motivation 3
Characterize, establish, and improve current TOF detector technologies

- Provide a precision TOF facility for TOF detector development
- Establish experience in the US and international communities with psec TOF operation and performance
- Characterize first pre-production LAPPD modules with charged particles and Cherenkov light
- Further electronics systems/ASIC development for psec TOF

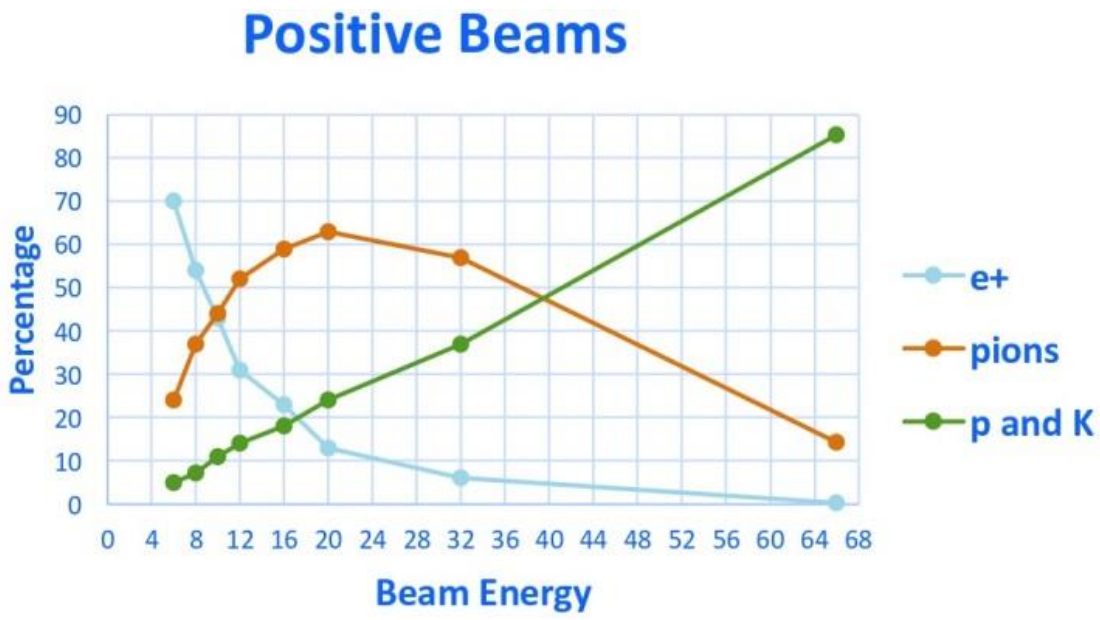


Incom Tile 31

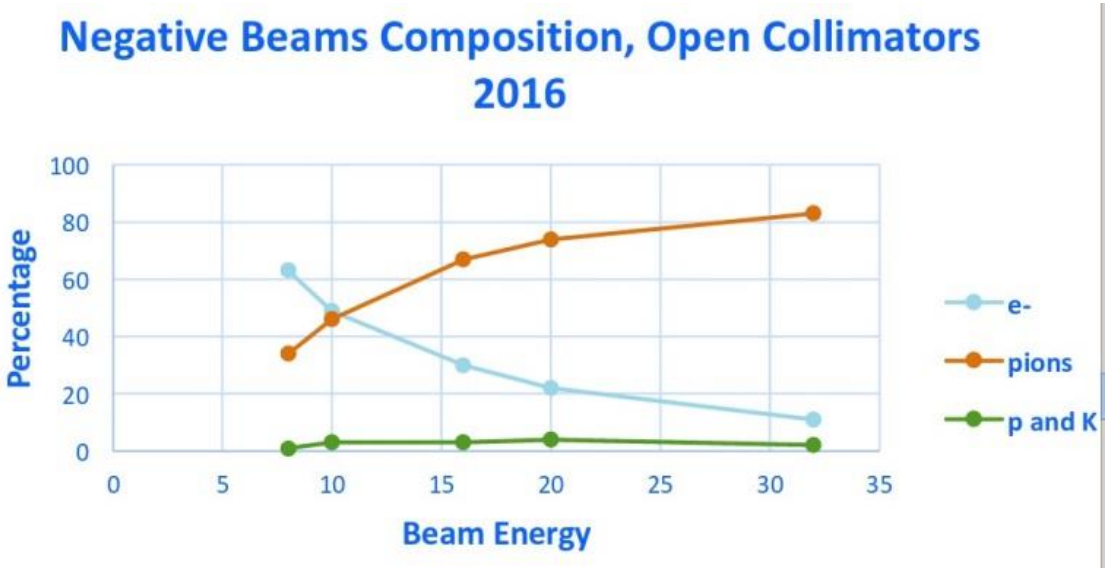


Oberla, Bogdan,…

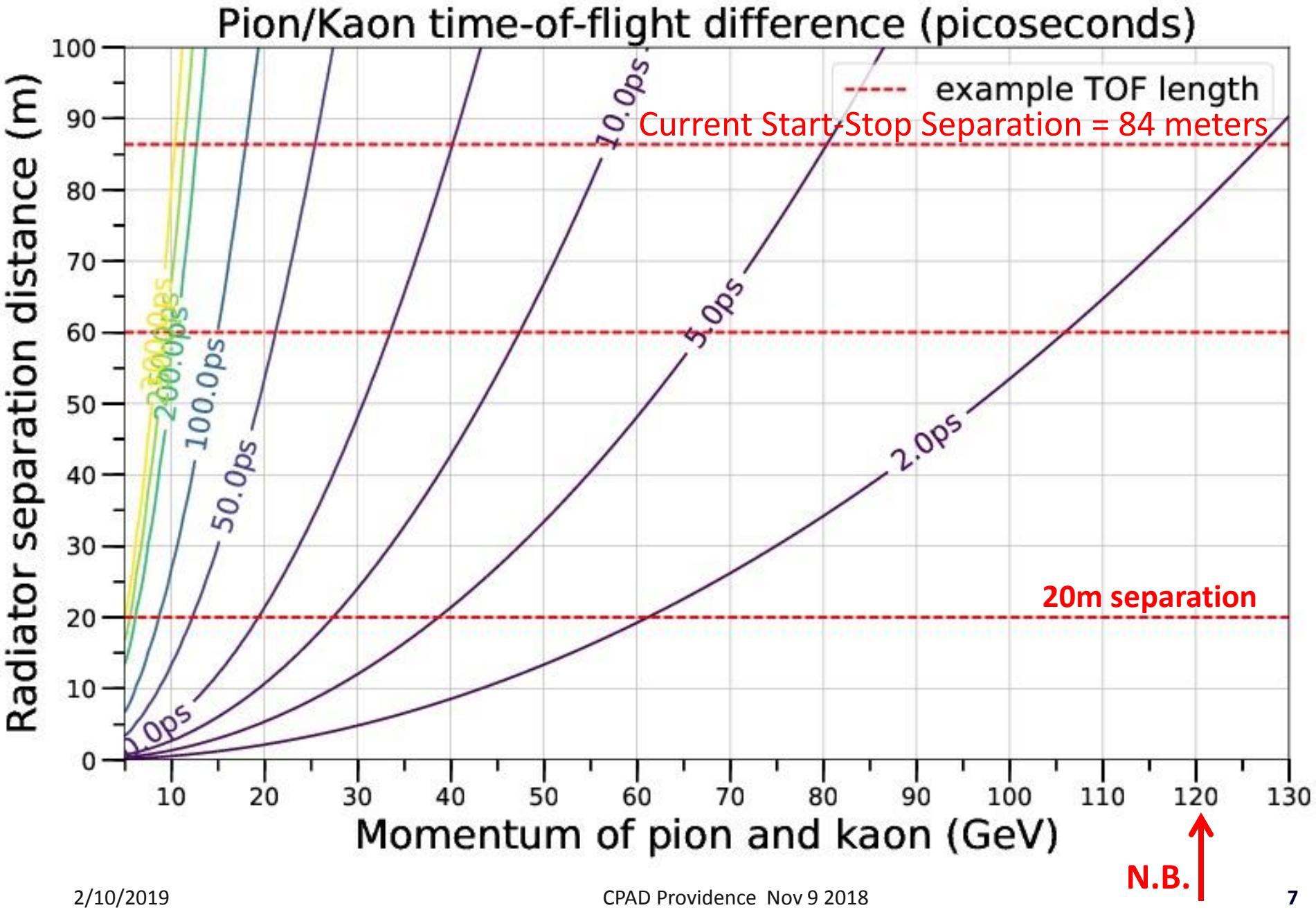
Mtest Beam Composition



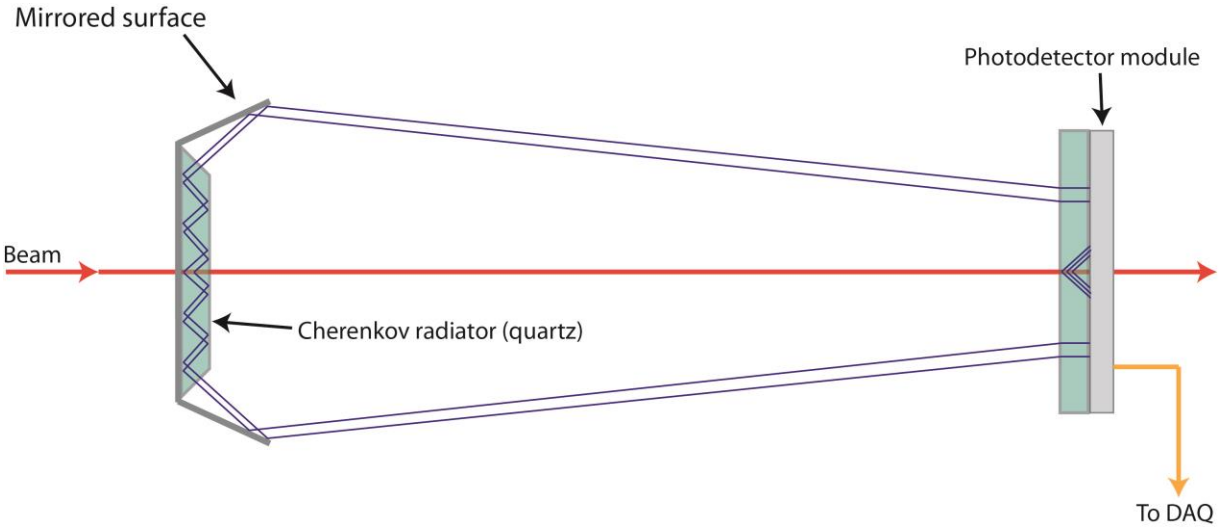
E. Skup and D. Jensen (from M. Rominsky, Hadron Production Workshop July 2017)



Performance Goals

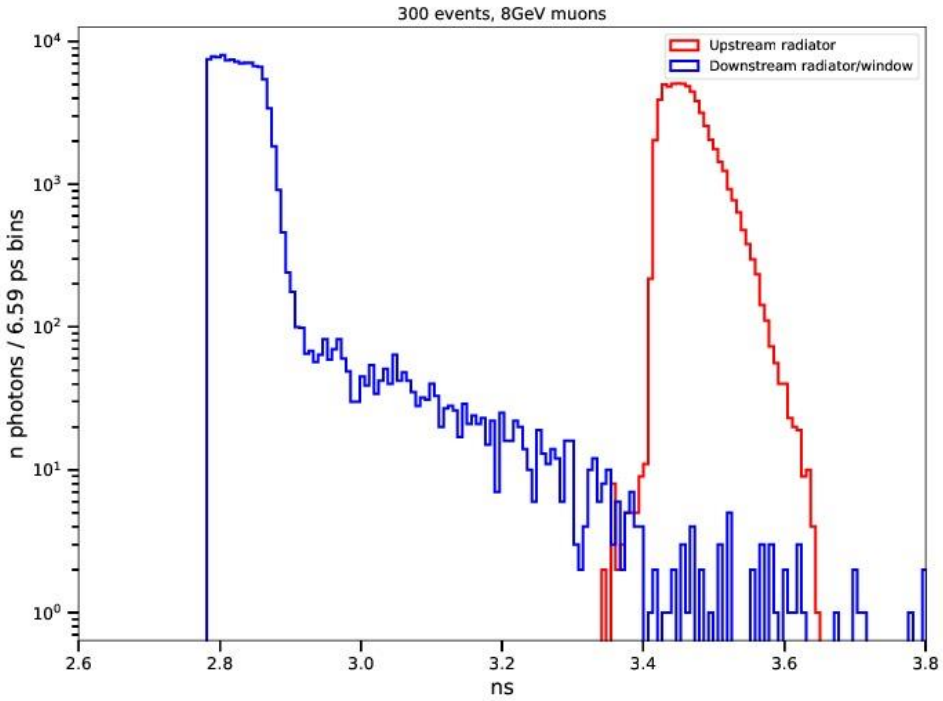


Phase I (Evan Angelico Ph.D)



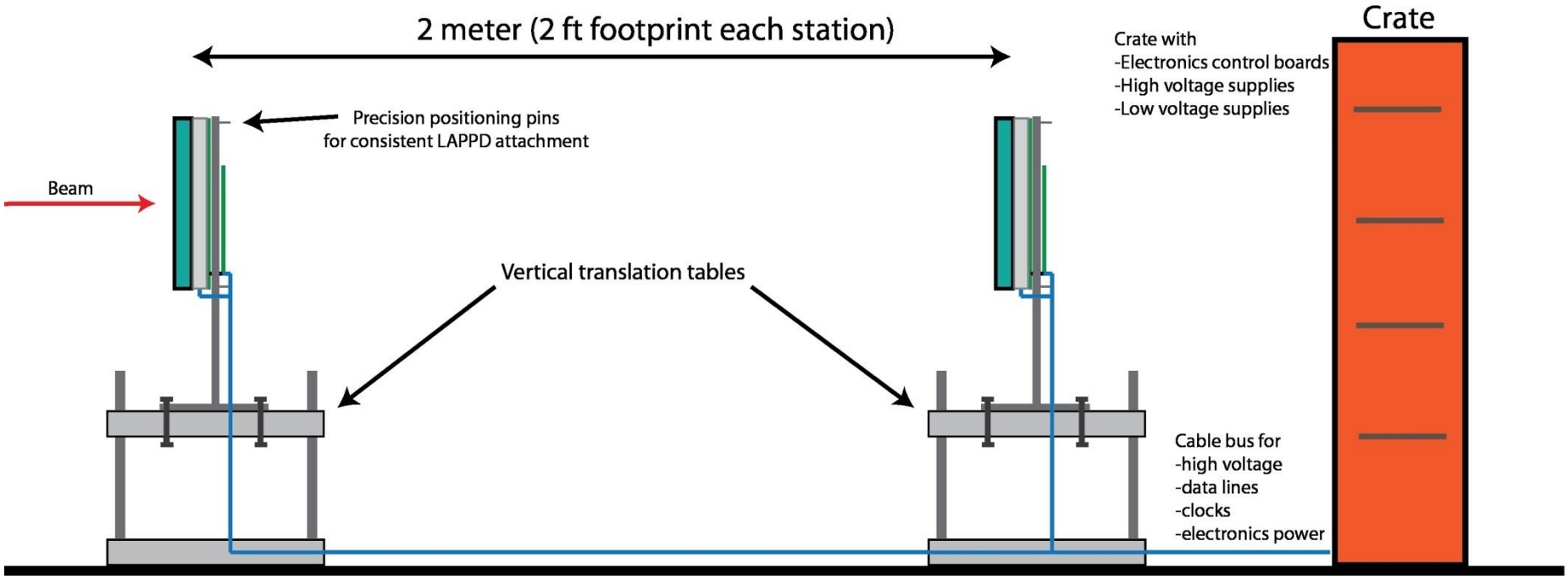
(Jury-rigged) answer to: How do you do TOF with only one LAPPD?

“MIRCAT”



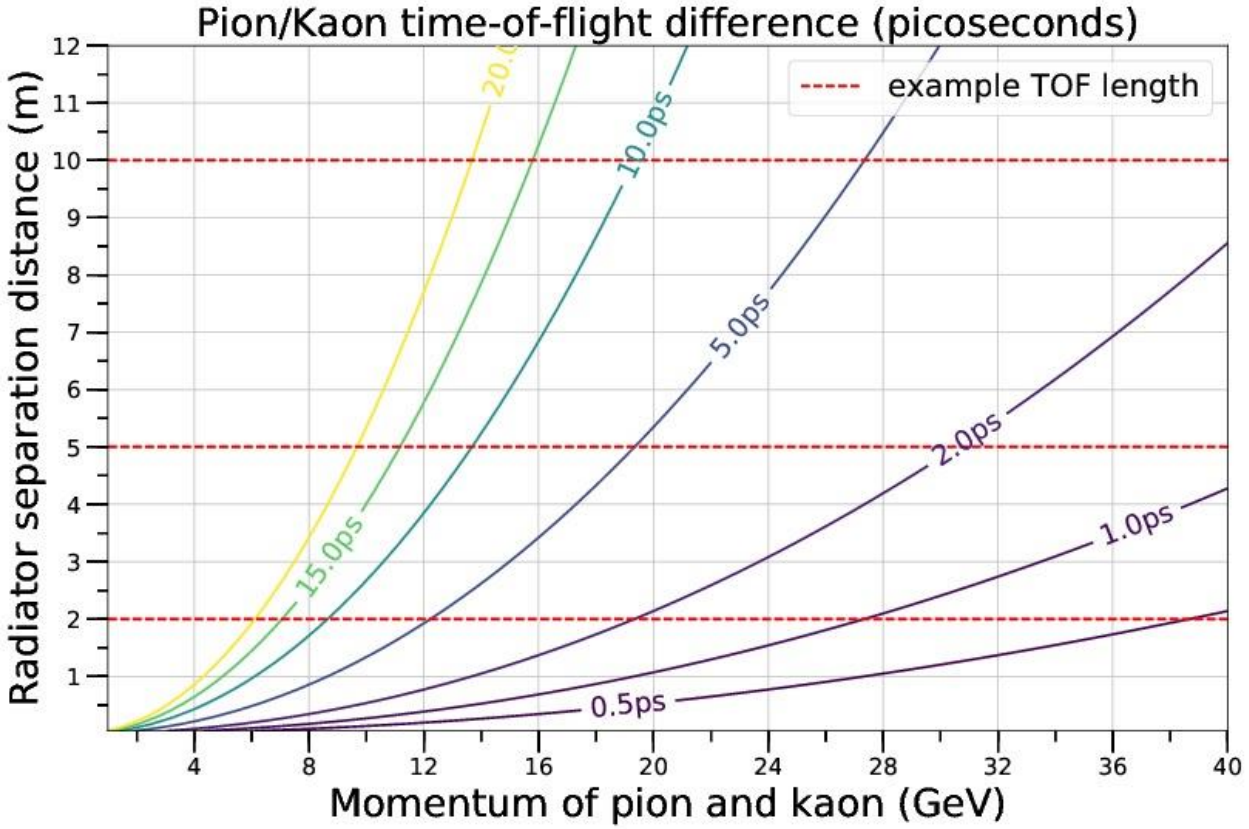
Evan’s simulation of LAPPD response

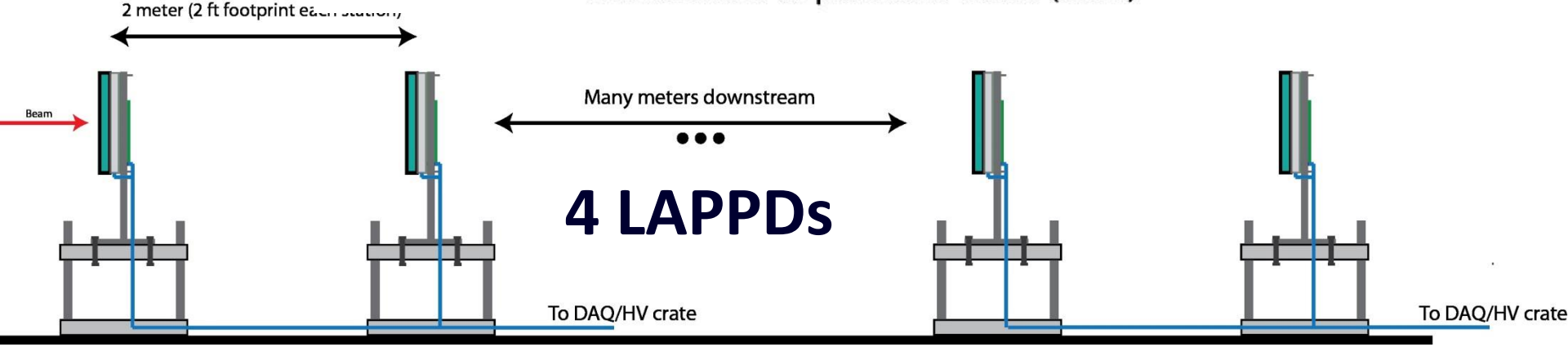
Design for FTFB Phase II (2LAPPD)



FTBF TOF with 2 LAPPDs: Hopefully 1 of them Gen II?

FTFB Phase III- Facility Upgrade





4 LAPPDs

Current Status

- Fermilab has purchased an LAPPD™ from Incom- being prepared for delivery by end of year.
- Precision mounting, electronics/cable interface being designed and built at UC (students)
- PSEC4 electronics ACDC and ACC cards being prepared
- Phase I Mircat design in progress.
- Approaching other constituencies (e.g. EIC, UC, Natl Labs, CERN expts,…) who may be interested and able to buy one or more LAPPDs.
- Getting ready to have the necessary formal discussions with Fermilab FTFB management

Acknowledgements

- H. Marsiske, M. Shinn, and the US DOE Office of Science
- Technical and Support Staff at Chicago, Fermilab, and Incom
- Special thanks to Leo Bellantoni, John Kyle, and JJ Schmidt for help with the Fermilab MTEST details.
- Fermilab management for purchasing our first (tho after ANNIE and others) LAPPD™