The Fermilab Test Beam Facility Time of Flight Upgrade

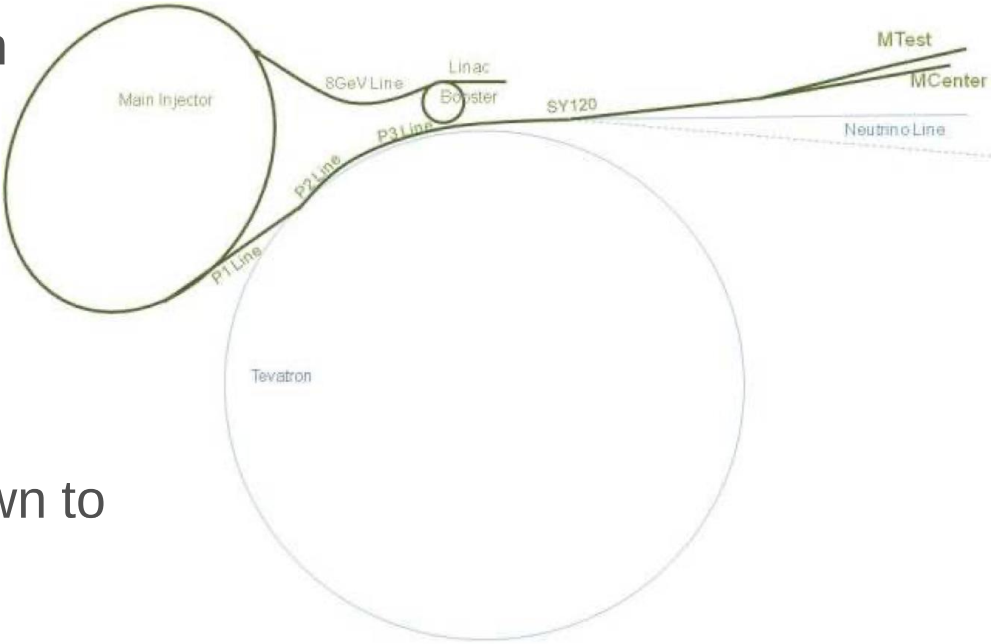
N. J. Pastika, P. M. Rubinov, H. J. Frisch, M. Heintz,
J. Park, B. W. Adams, E. Angelico

Introduction

- Fermilab Test Beam Facility (FTBF) – Supports a wide program of research and detector R&D
  - 2 Beamlines (MTest and MCenter) – can provide particles from 120 GeV protons to secondaries of ~200 MeV to 60 GeV
- Beam is available ~9 months a year (roughly October through June)

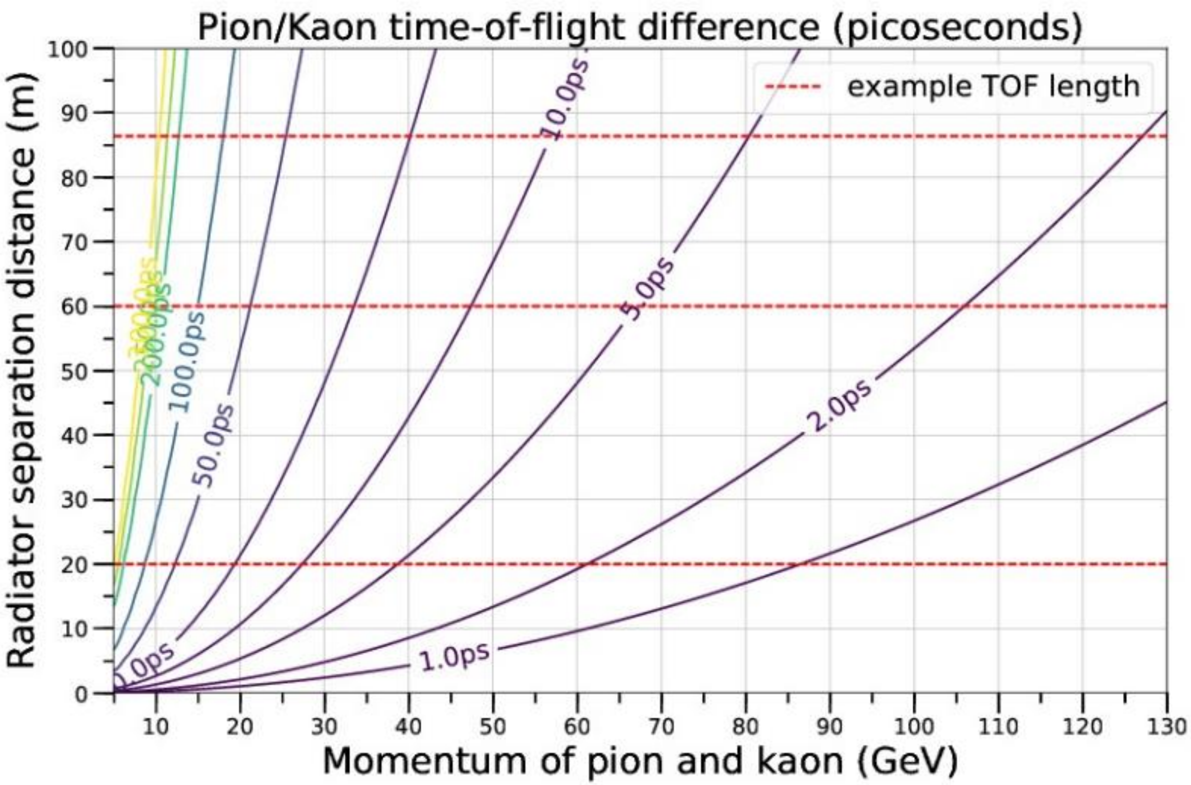
FTBF Beamline Details

- 4 second beam spill every 60 seconds, available 24/7
- ~1000 to 900,000 particles per spill
- MTest
  - 120 GeV primary protons
  - 1-66 GeV secondary beam
  - ~2cm spot size
  - 1-4 week runs
- MCenter
  - Secondary beam
  - Two tertiary beamlines down to 200 MeV
  - longer term experiments



Time of Flight System Specifications

New permanent facility infrastructure available to all Users



W. Badgett et al., Precision Time-of-Flight at the Fermilab Testbeam Facility (2018)

- Distance: ~80m
- Timing resolution: ~5ps

Apparatus: LAPPD

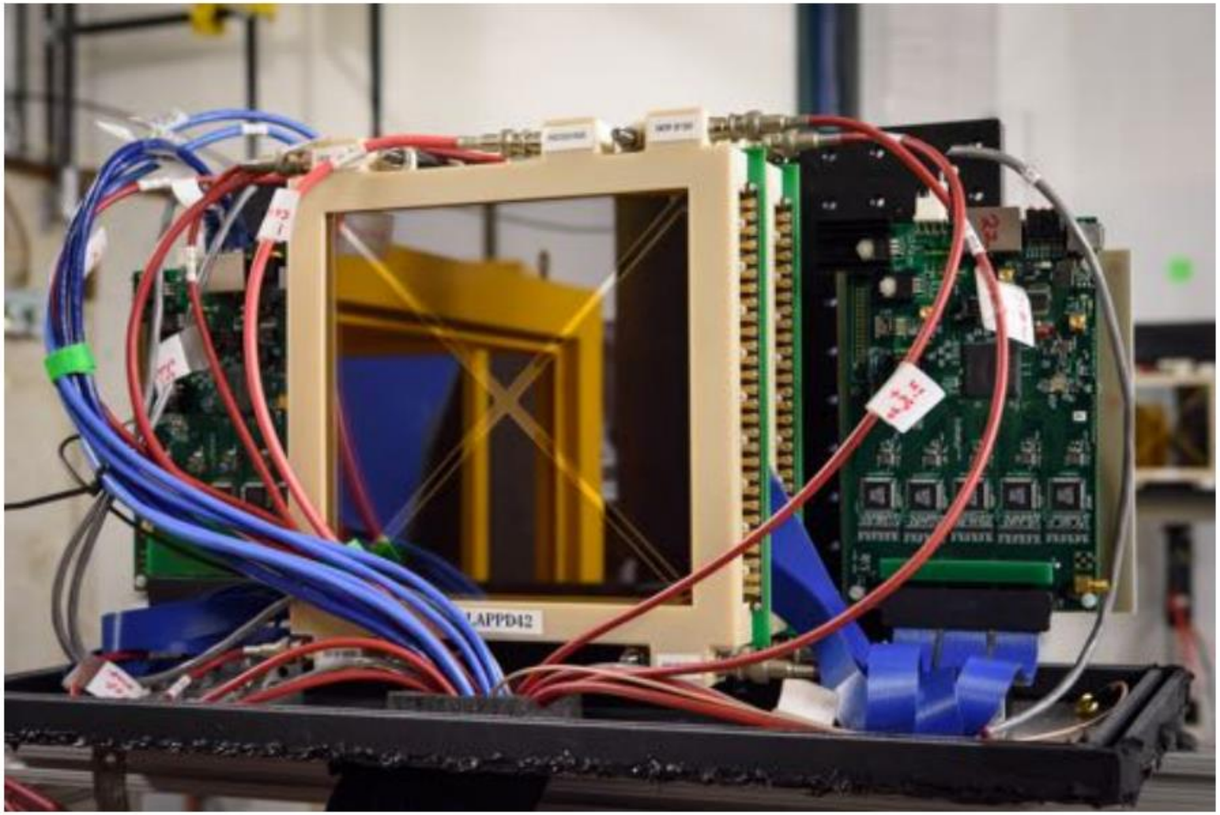


Figure 4.1: The front face of Incom LAPPD 42 instrumented with high voltage inputs, digitizing electronics, and mechanical fixturing for use in the FTBF LAPPD TOF system. A dark-box comes down from above and mates with the black cardboard rim seen at the bottom of the photograph. In this particular photo, two LAPPDs are stacked one after the other for a close-proximity particle-coincidence measurement. Photograph credit: Giulio Stancari.

Adopted from Evan Angelico (2020)

Apparatus: LAPPD

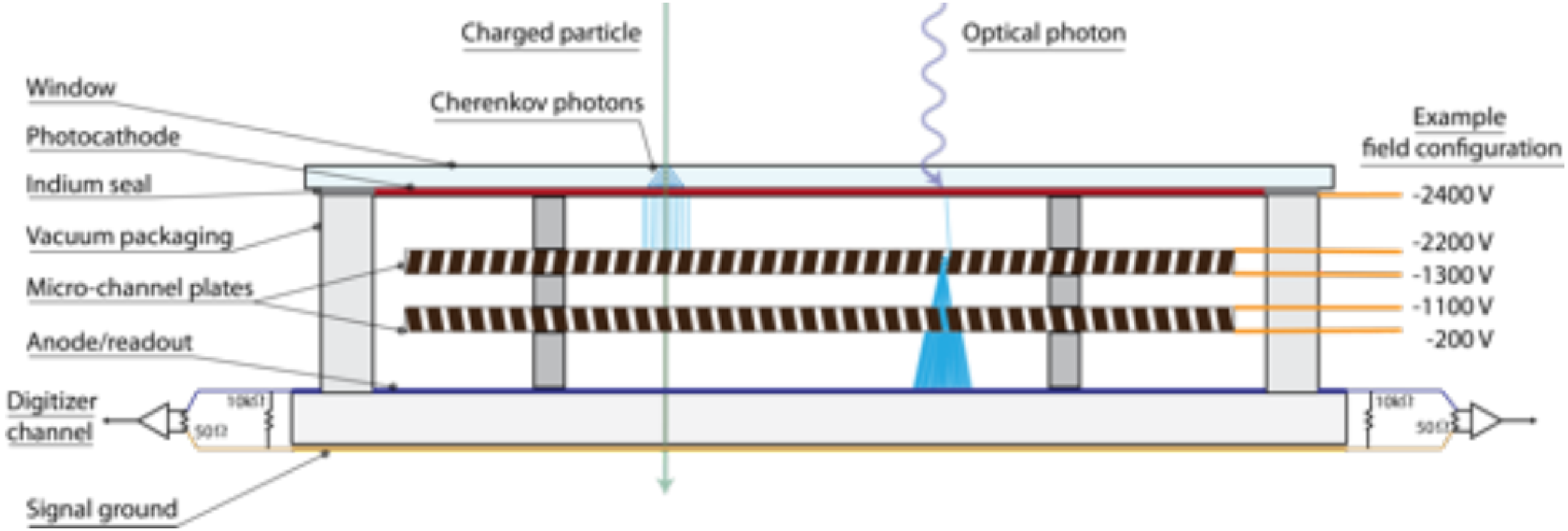


Figure 1.1: Photo-detection starts with a photon impinging on the glass window. The photon is converted by the photocathode into a photoelectron with probability equal to the quantum efficiency. Accelerating high voltage is applied to the internal components to accelerate the photoelectron into an MCP pore. The MCPs are coated with a secondary-emitting layer. Electrons strike the pore walls ~10 times, forming an electron avalanche or cloud. The electron cloud, typically comprised of 10^7 electrons, produces a negative polar pulse with 10% to 90% rise-time on the order of 250-1000 ps depending on the geometry of the internal components, and 10 - 40 mV amplitude on 50 Ω impedance transmission lines.

Apparatus: LAPPD

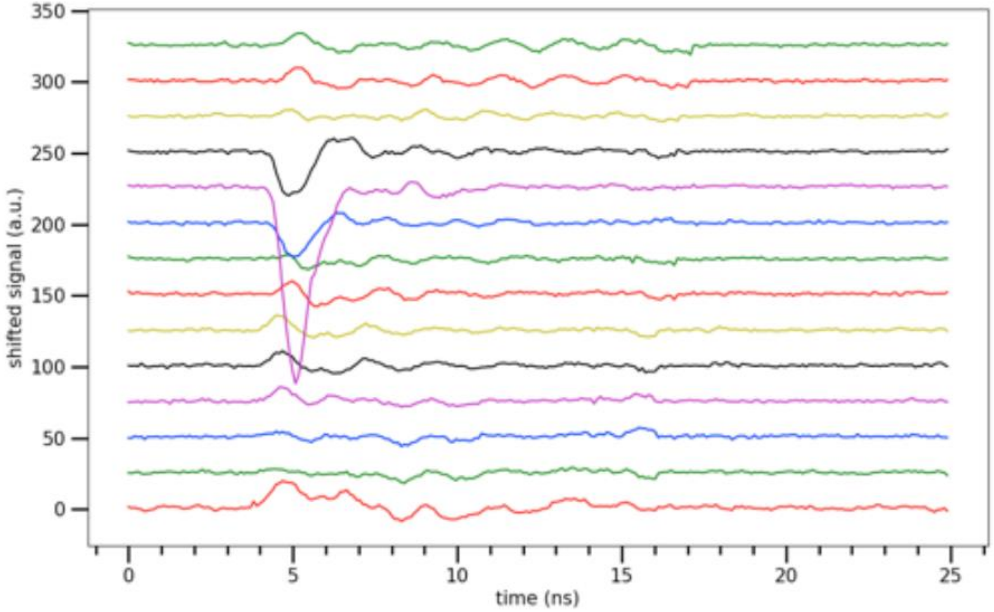
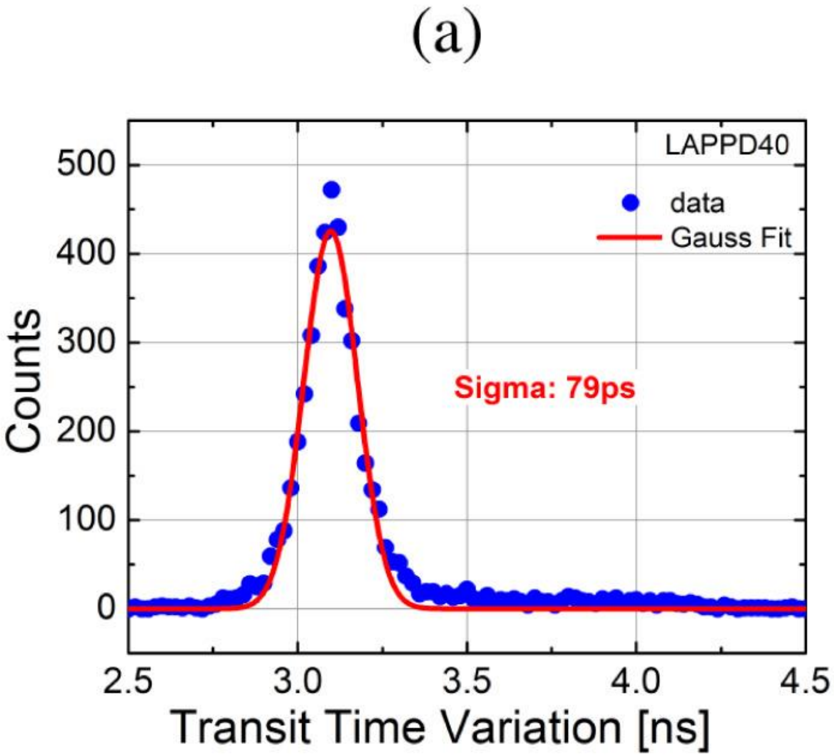


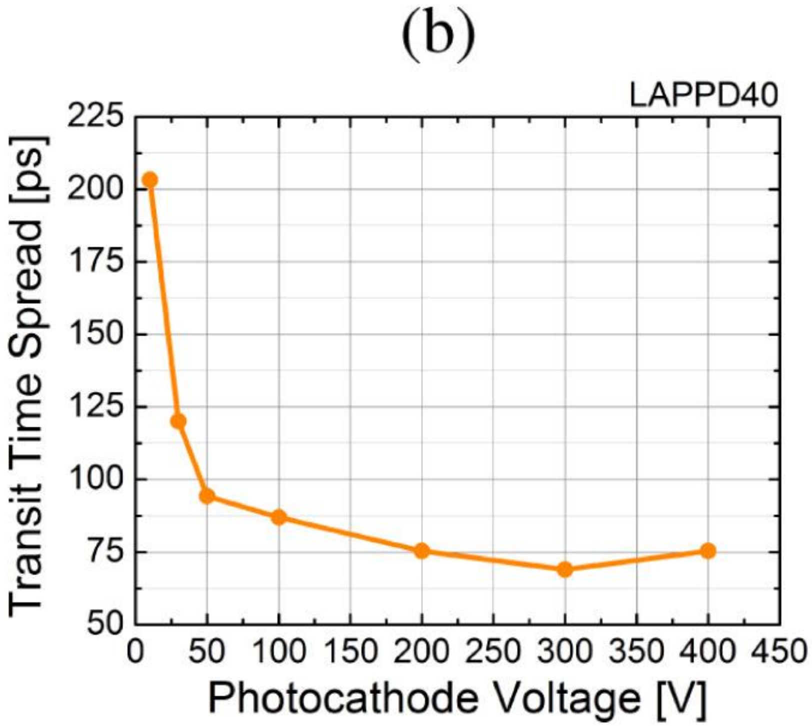
Figure 3.2: The digitized signals of 14 adjacent strip-lines of LAPPD 43 induced by a charged particle. The signal from each strip-line is offset by 25 mV on the y-axis for clarity. The amplitudes as a function of strip number can be used to constrain the position of the electron cloud in the dimension transverse to the strip-lines to around 700-1000 μm [8, 5].

Adopted from Evan Angelico (2020)

Timing Resolution of LAPPD

- Single photoelectron timing resolution: ~50ps



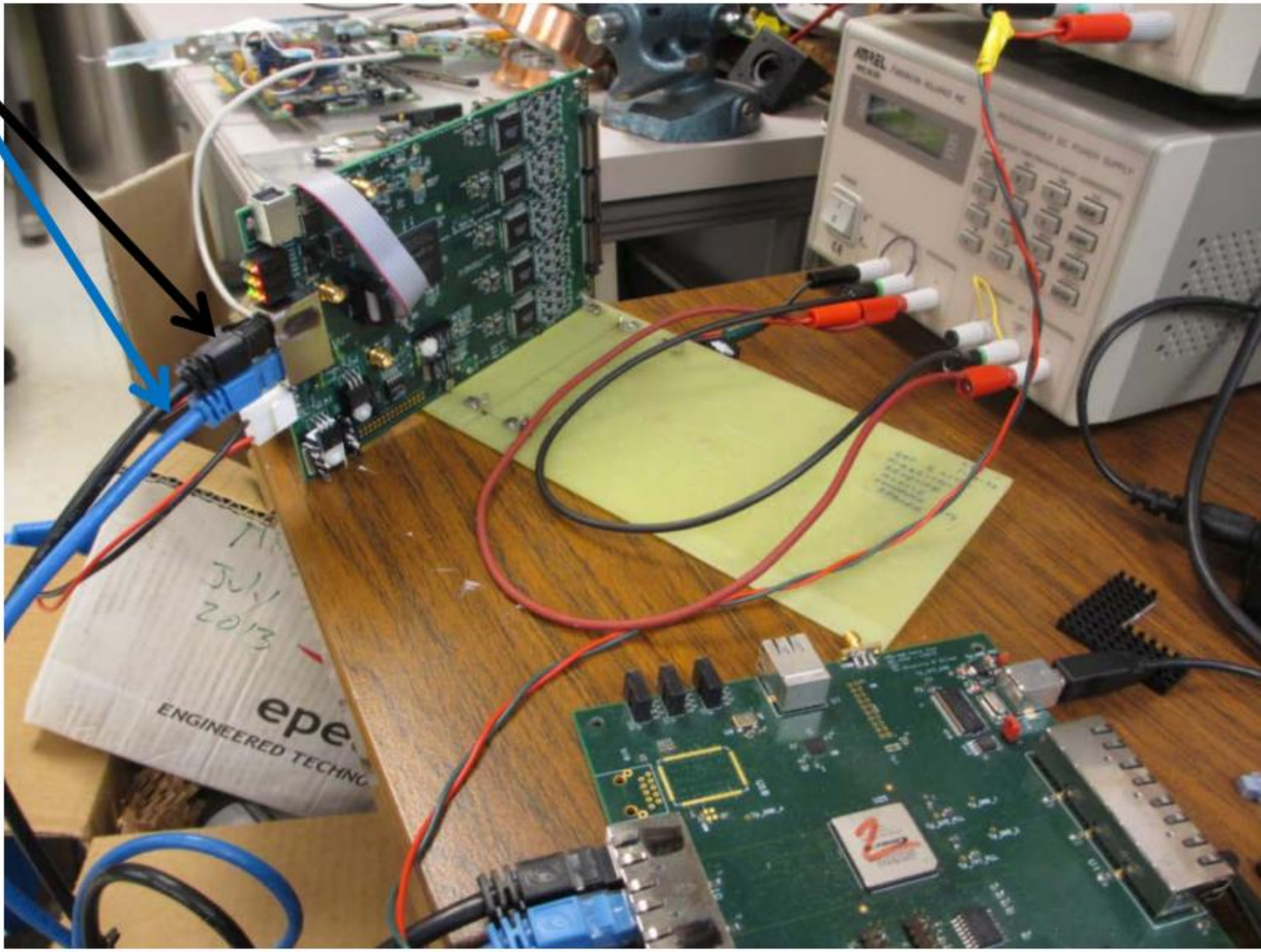


- Particle timing resolution: ~5ps ($\frac{\sigma}{\sqrt{N}}$)

A. V. Lyashenko et al., Performance of Large Area Picosecond Photo-Detectors (LAPPD™)(2020)

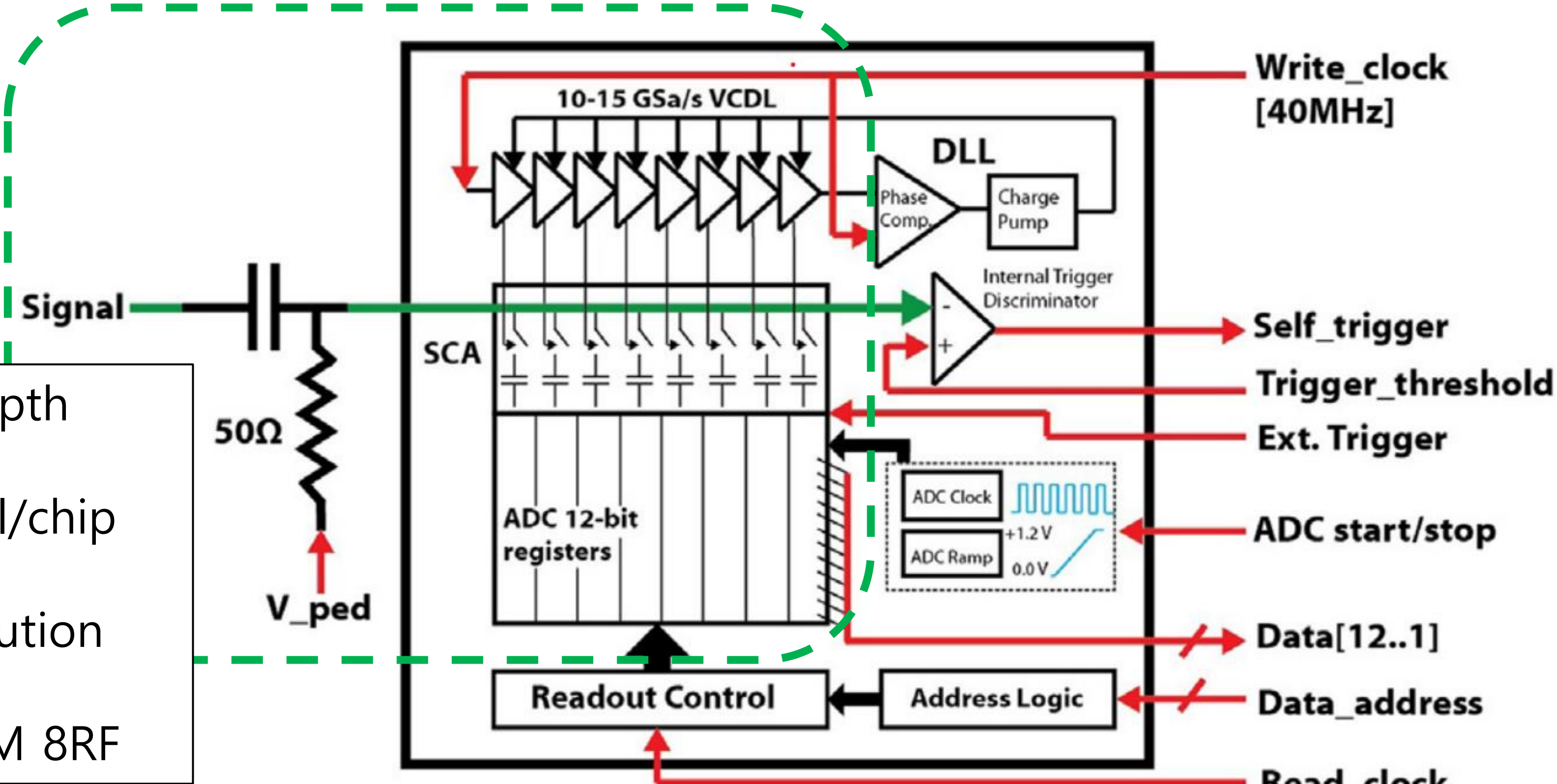
Apparatus: ACC/ACDC System

- Eight 800 Mbps LVDS pairs
- Data, clock , trigger, configuration
- Front-end card houses 5 PSEC4 chips (30 channels)
- Each front-end card houses jitter cleaner that cleans system clock and distributes to PSEC4s
- Newest board revision has optional mezzanine plug-in for adding a gain stage



Adopted from Eric Oberla's talk at ps workshop 2014

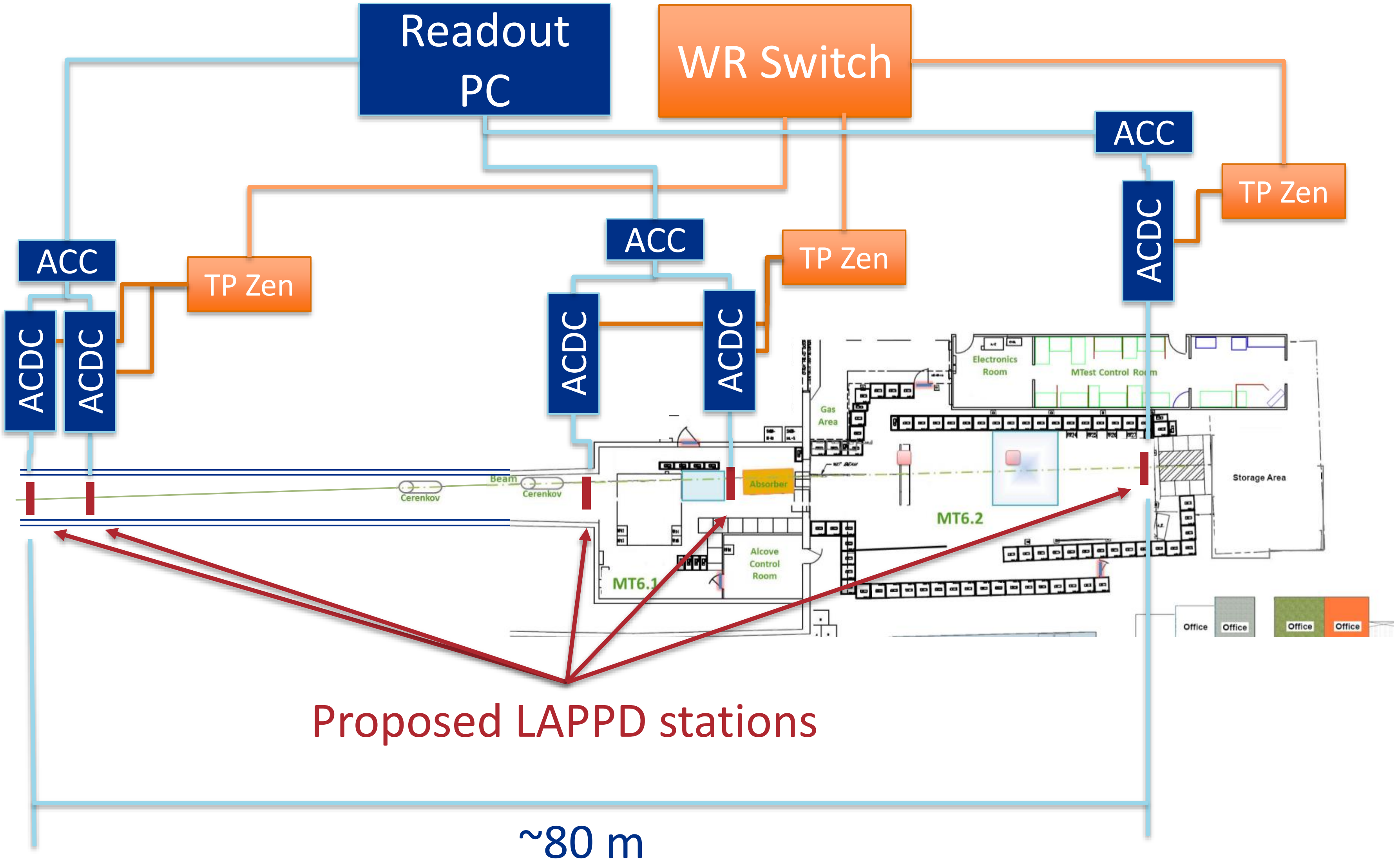
Apparatus:PSEC4



- 12-bit depth
- 6 channel/chip
- 5ps resolution
- 130ns IBM 8RF

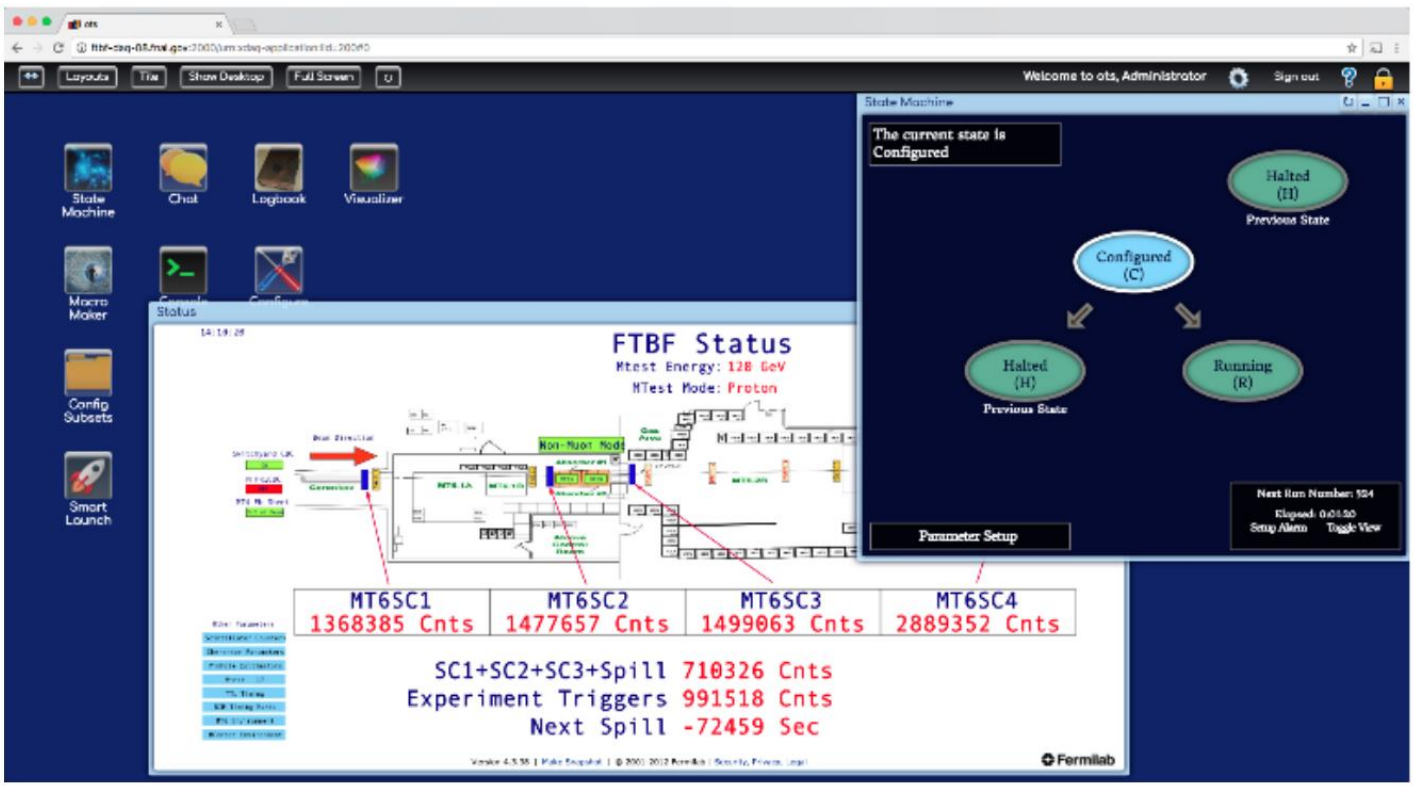
E. Oberla , J.-F. Genata, H. Grabasa, H. Frisch, K. Nishimura, G. Varner, arxiv.org/abs/1309.4397

Instrumentation Layout - MTest



otsdaq Integration

otsdaq is a "ready-to-use" Data Acquisition (DAQ) system that is also capable of configuring and controlling individual experiments through a GUI.



K.Biery et. al, The Fermilab Test Beam Facility Data Acquisition System Based on otsdaq