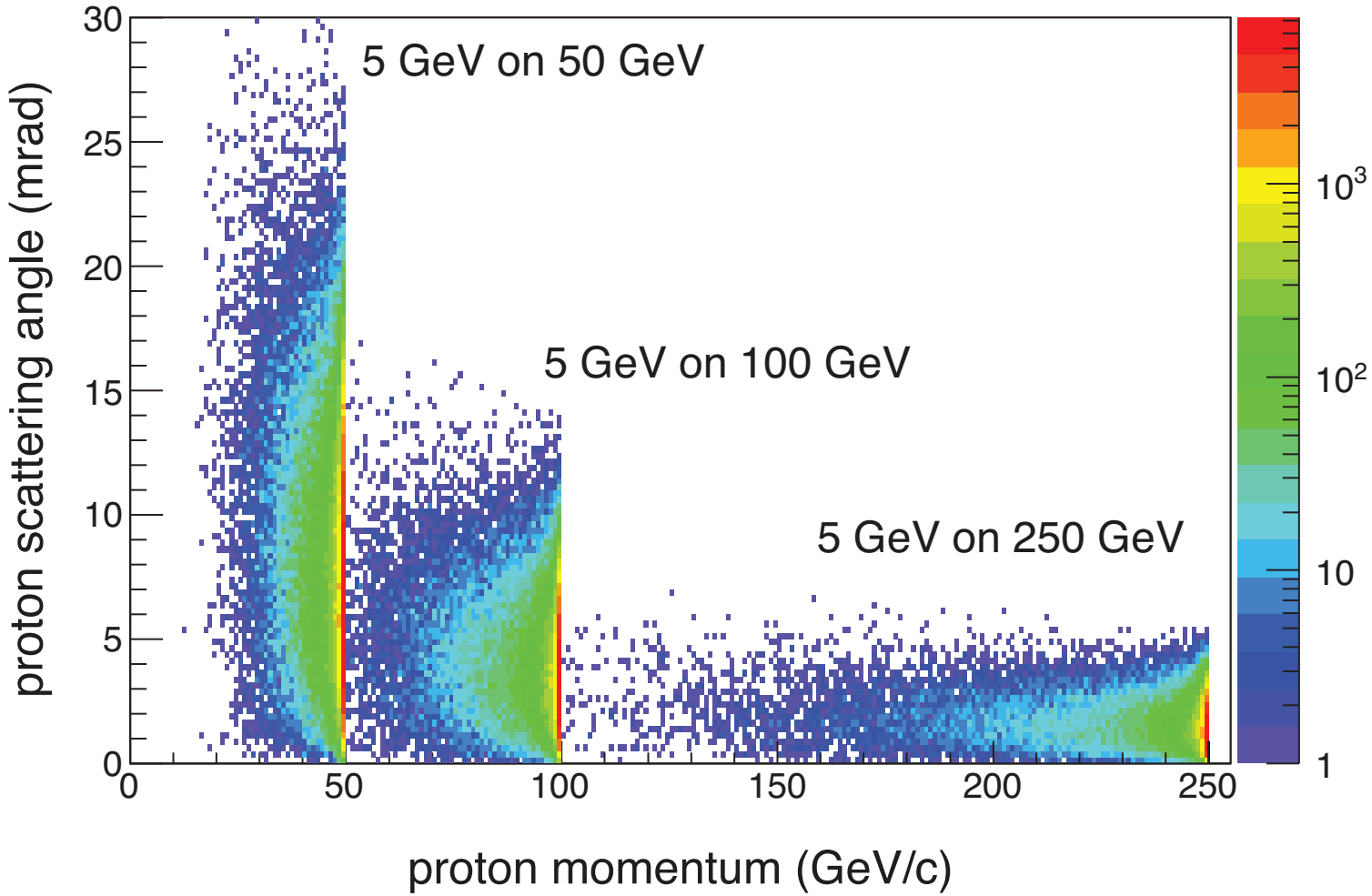
Precision Timing at the Electron Ion Collider

- The physics requirements of the EIC requires excellent forward and central coverage
- Particle Identification is also very important.
- Luminosity requirements implies compact experiments
- **Fast, inexpensive timing provides a way to get more information out of a given detector.**
- There is a significant effort at the LHC to develop 20ps timing or better for forward spectrometers.
- We seek to leverage these efforts to see if fast timing could help the EIC.

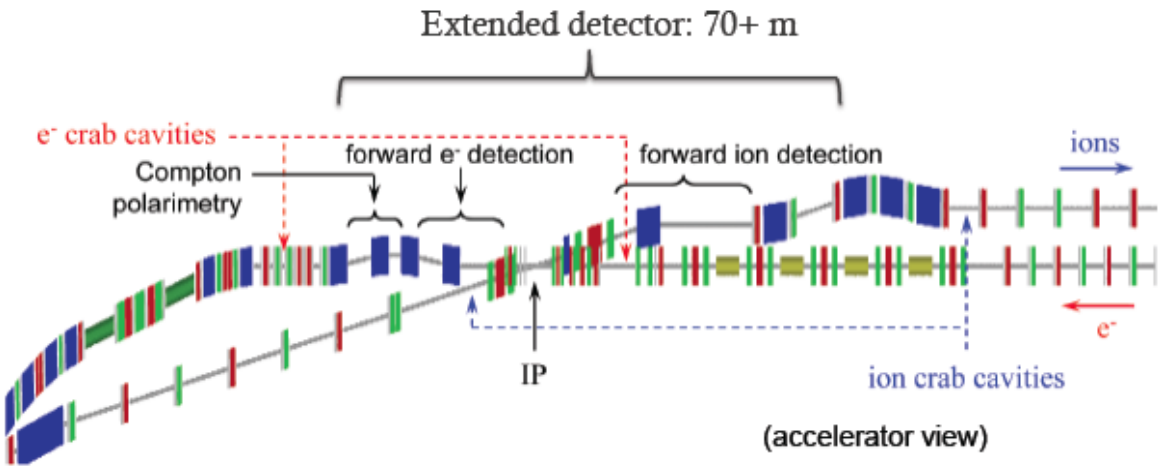
Christophe Royon, Michael Murray University of Kansas

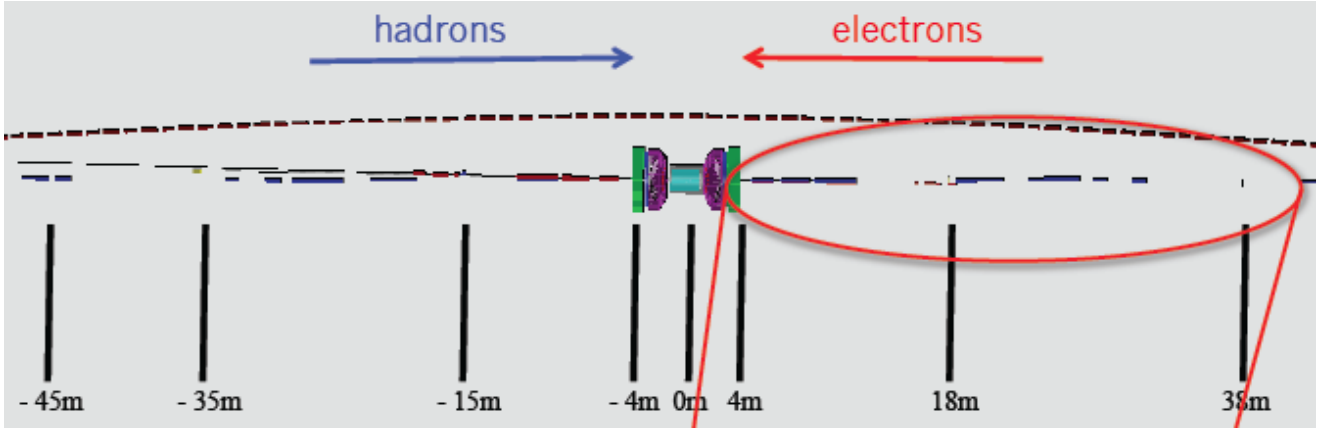
Forward Protons from DVCS



Need to measure high moment protons very close to the beam pipe and distinguish from background. We have the same issue at LHC.

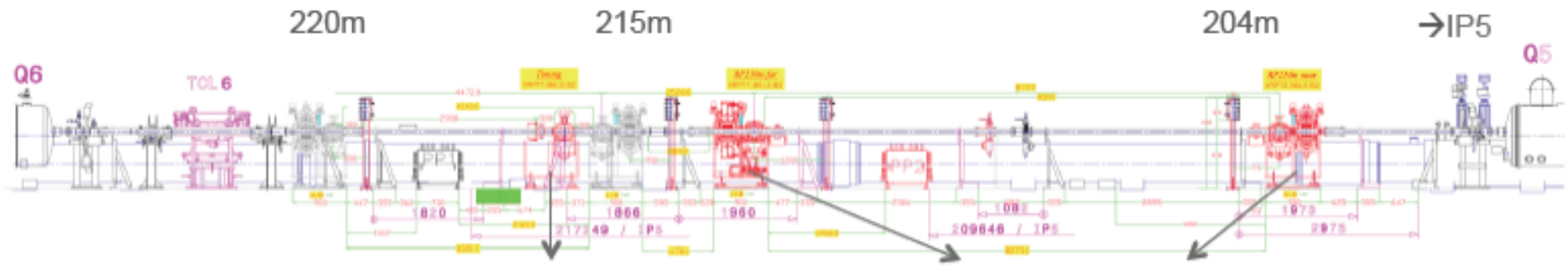
Forward spectrometers at EIC

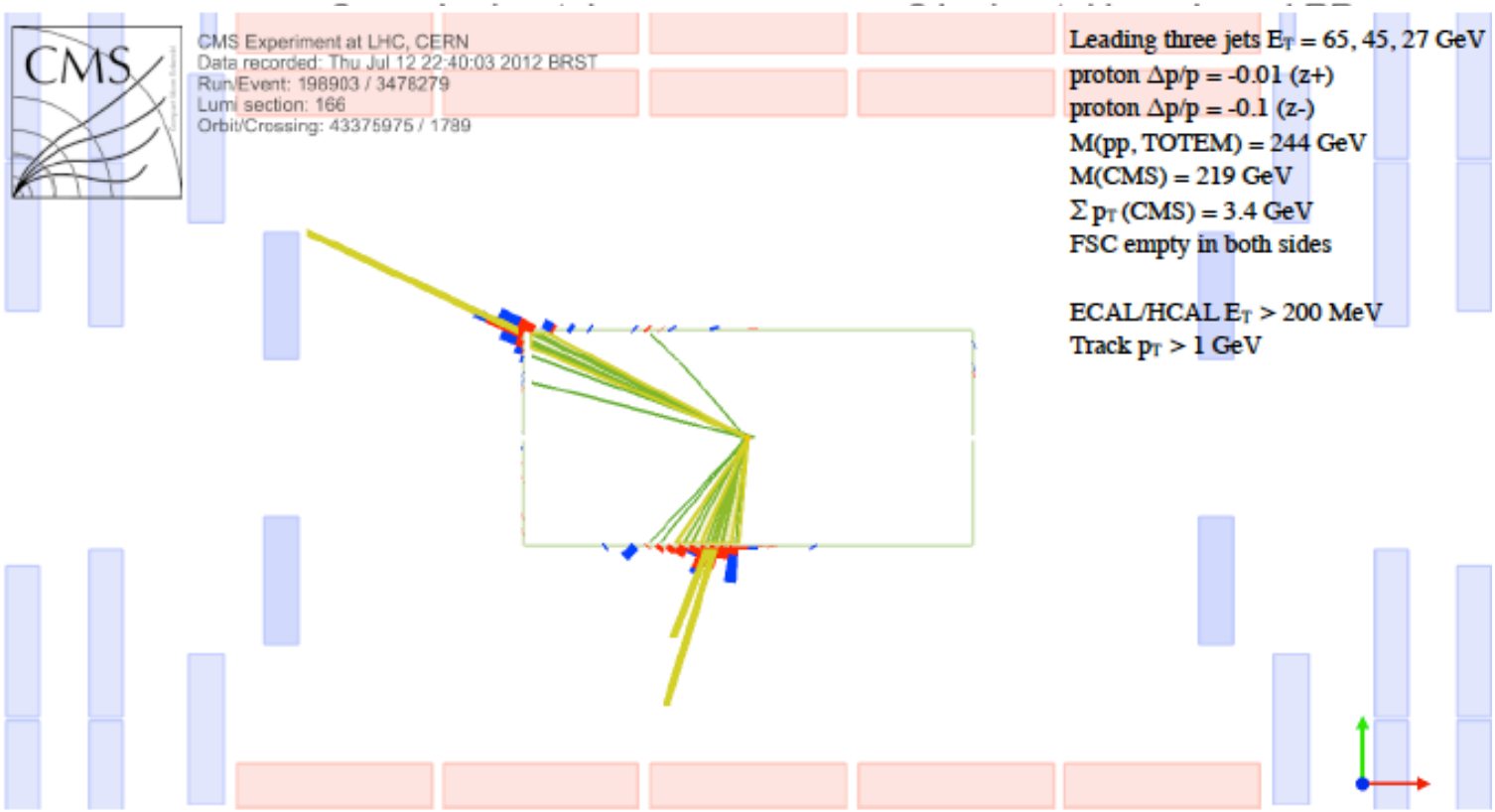




Both eRHIC and envision Forward Spectrometers with tracking detectors in Roman Pots.

CMS-Totem Precision Proton Spectrometer





How does timing help

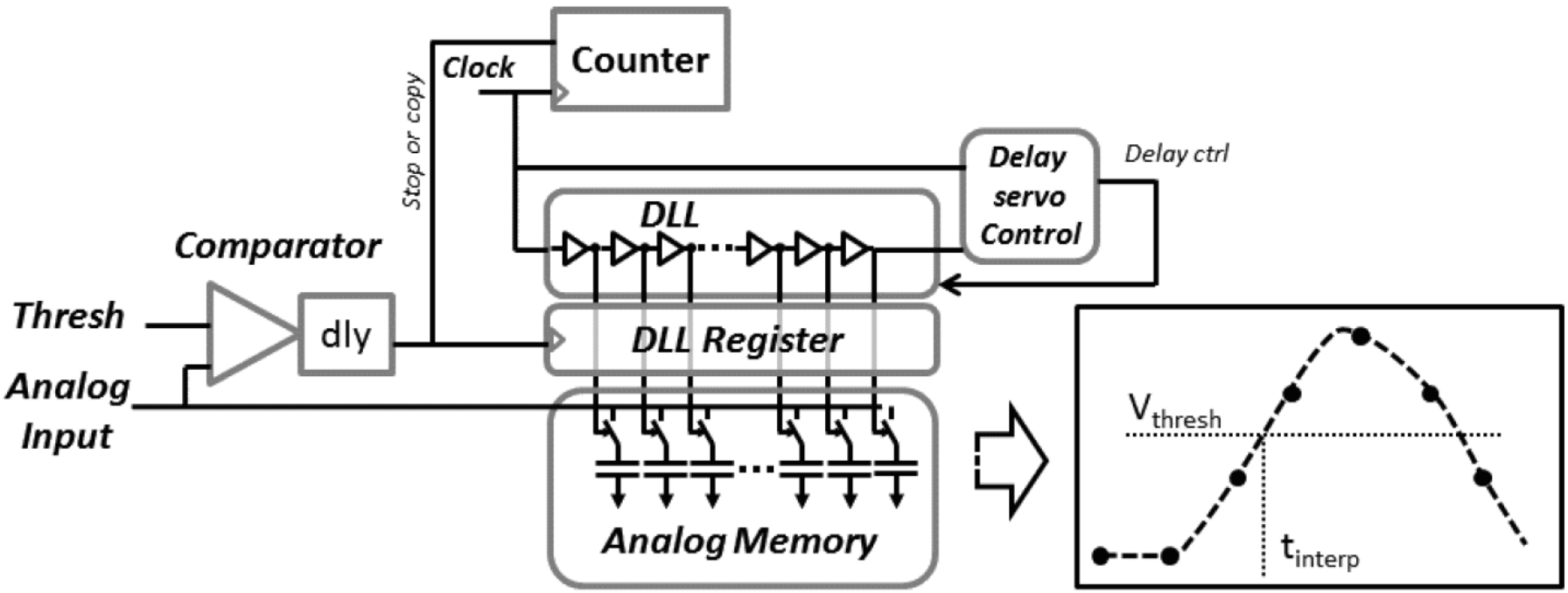
For a particle of mass m, momentum p measured over a flight path of length L the rate of change of time with mass is given by

$$\frac{dT}{dm} = \frac{L}{c} \cdot \frac{m\beta}{p^2}$$

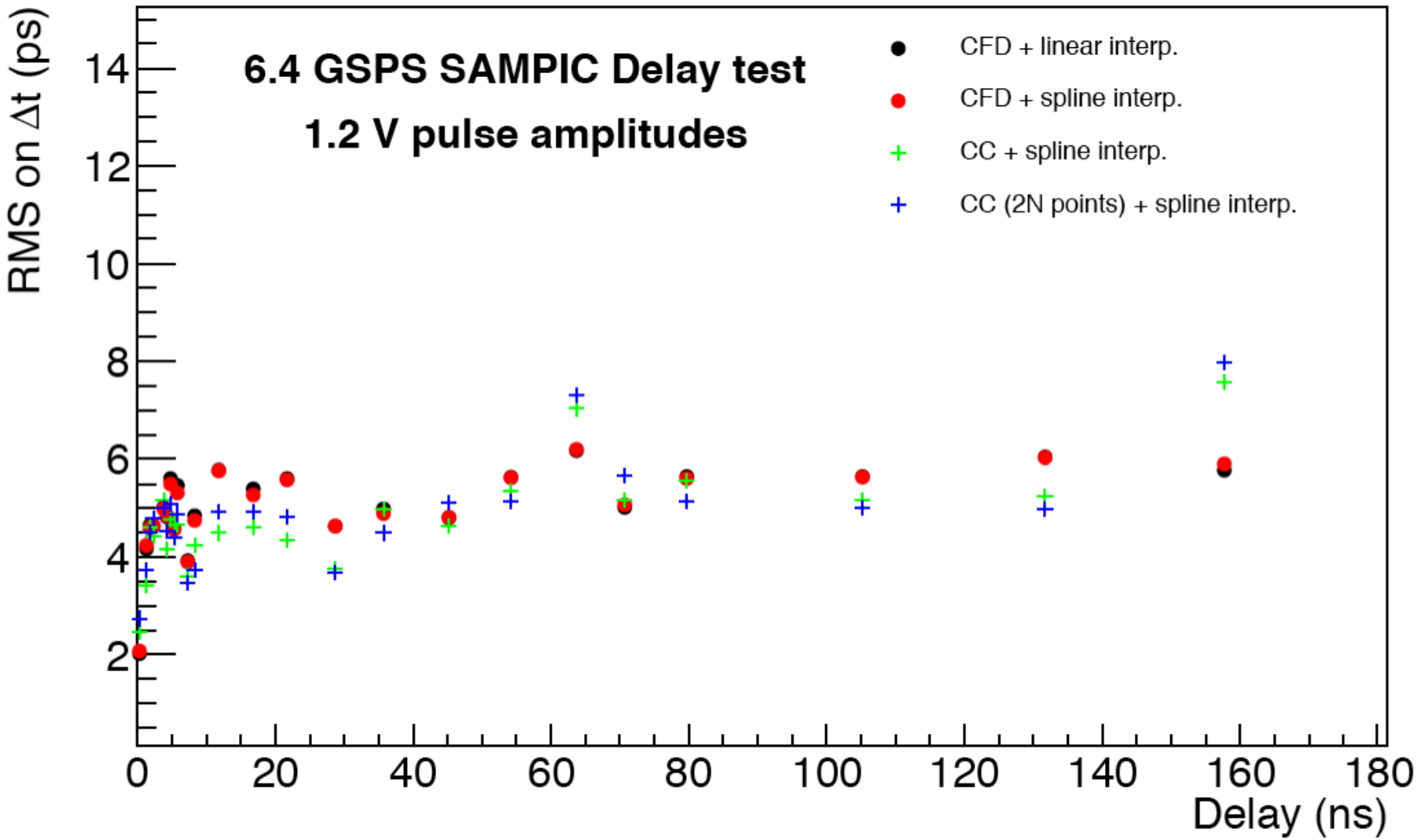
For a flight path of 40m and a momentum of 50 GeV dT/dm for a proton is ~ 50ps/GeV. Thus a timing resolution of 20ps give gives a significant new constraint for tracking and momentum.

SAMPIC for fast & cheap timing

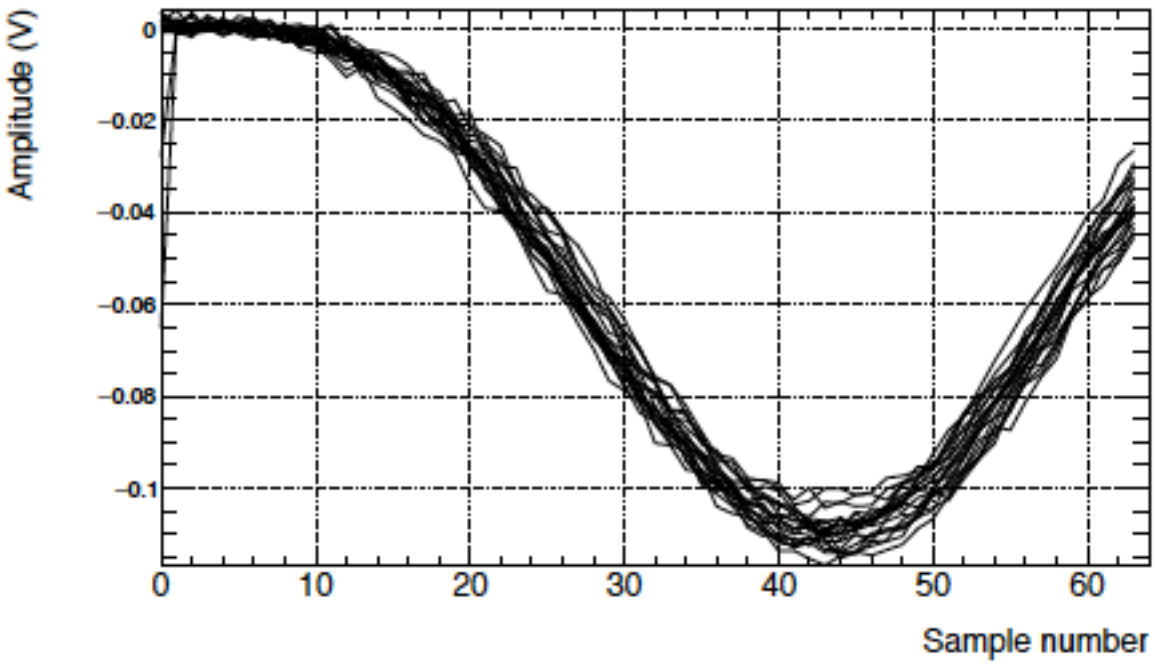
Taking many samples gives much more information to estimate timing. Resolution of chip is ~ 5ps.



Time resolution versus delay



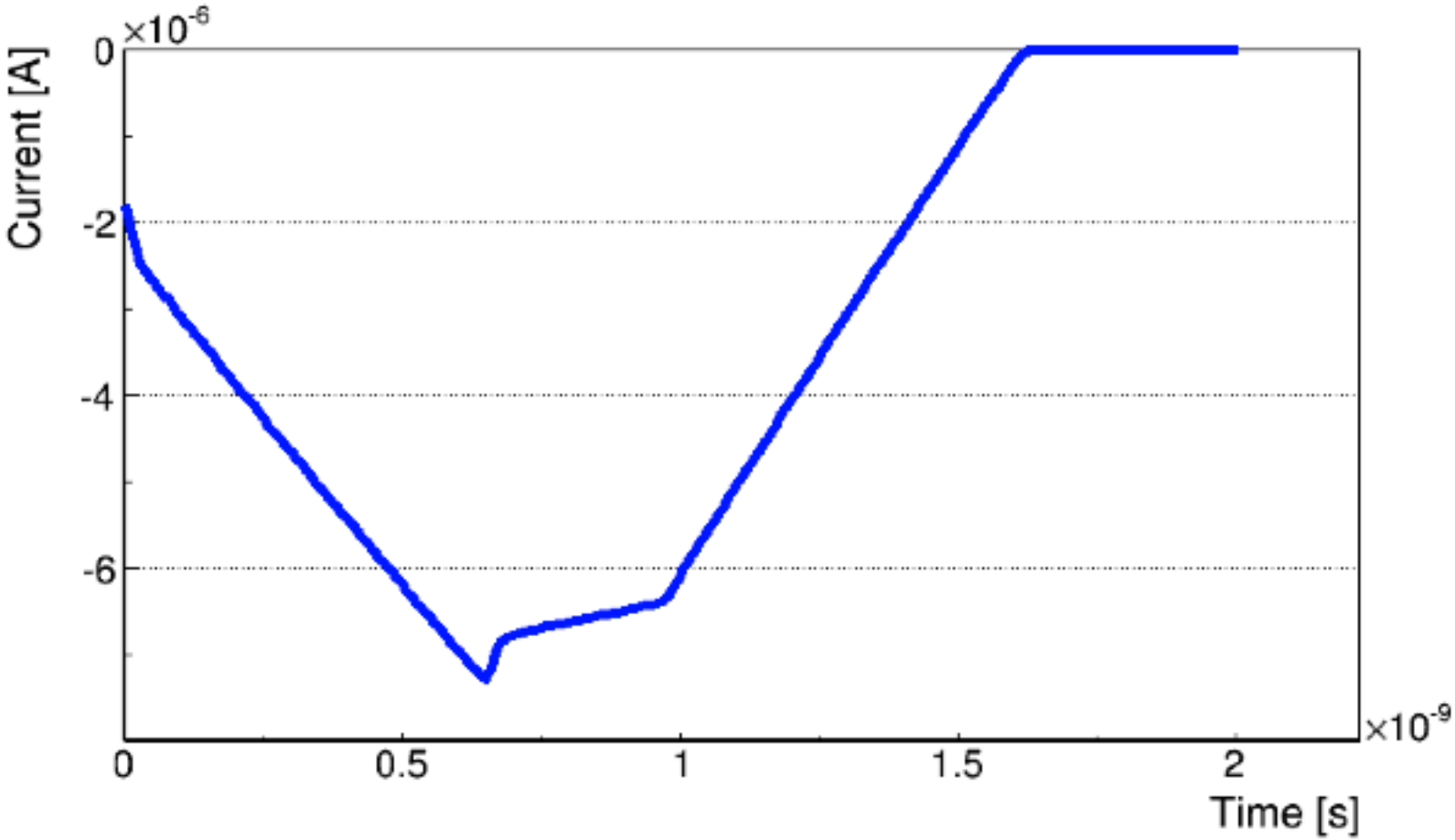
Ultra-fast silicon detectors



Ultra fast silicon signal amplified with a CIVIDEC C2-BDA amplifier readout by SAMPIC chip at 6.4 GHz.

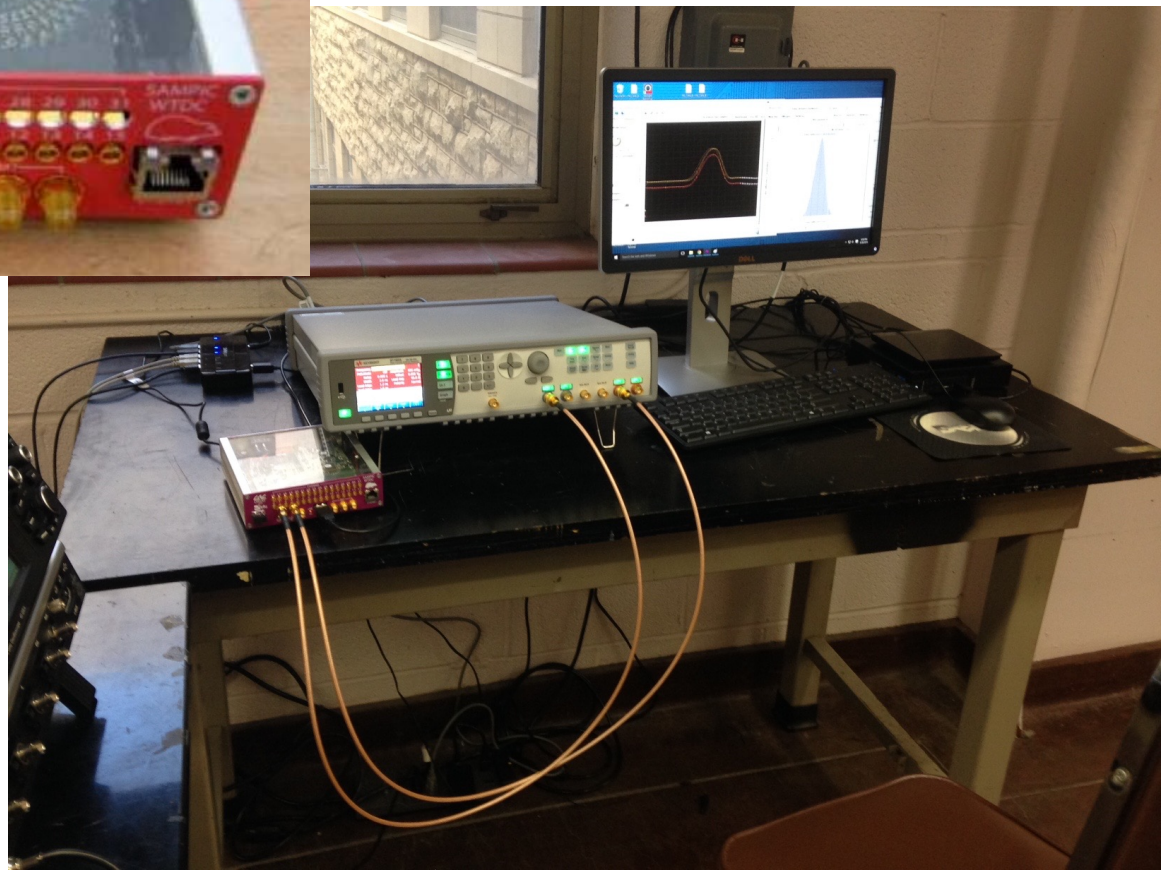
KU group is testing such detectors in Kansas before starting a series of radiation tests. We are also working with Torino on preamps for such detectors.

Simulated signal from fast silicon



Simulated signal produced by a MIP passing through a 50 µm ultra-fast produced using the Weightfield2 package

Sampic chip at test stand at Kansas



How does timing help DVCS

$$ep \rightarrow e'p'\gamma$$

- Typically electron is very well measured with TOF, Cerenkov, (tens of picosecond resolution) and tracking (path length correction)

- Photon measured by ECal (few percent energy resolution, nanosecond level resolution timing resolution, millimeter position resolution)

- Proton detected in Roman Pots (tens of picosecond timing resolution, micrometer position resolution, percent momentum resolution with TOF)

- Good timing could improve :
  - Timing resolution in e' γ coincidence to improve signal to background
  - Resolution on γ in e'p coincidence to improve energy resolution on γ where photon calorimetry is poor or non existent

Questions for Simulation

- How good does RP timing have to be?
- How much does timing help in extracting the physics ?
- How does RP acceptance improve overall detector acceptance?

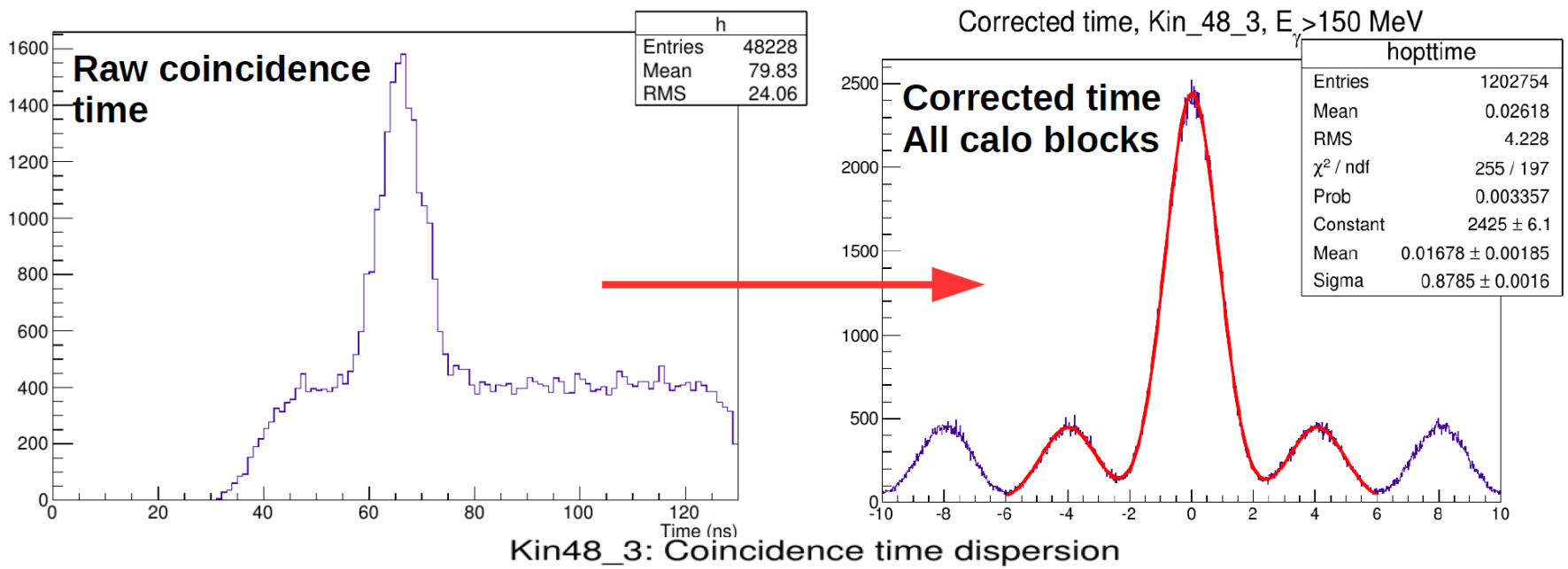
These questions need simulation

- Use existing framework for JLEIC and eRHIC
- Add detector layout and timing resolution
- Use realistic event generators for physics processes
- (MILOU for DVCS, SIDIS) and background (PYTHIA)

Example of what we want to simulate

- Generate DVCS timing corrections

Coincidence time corrections:

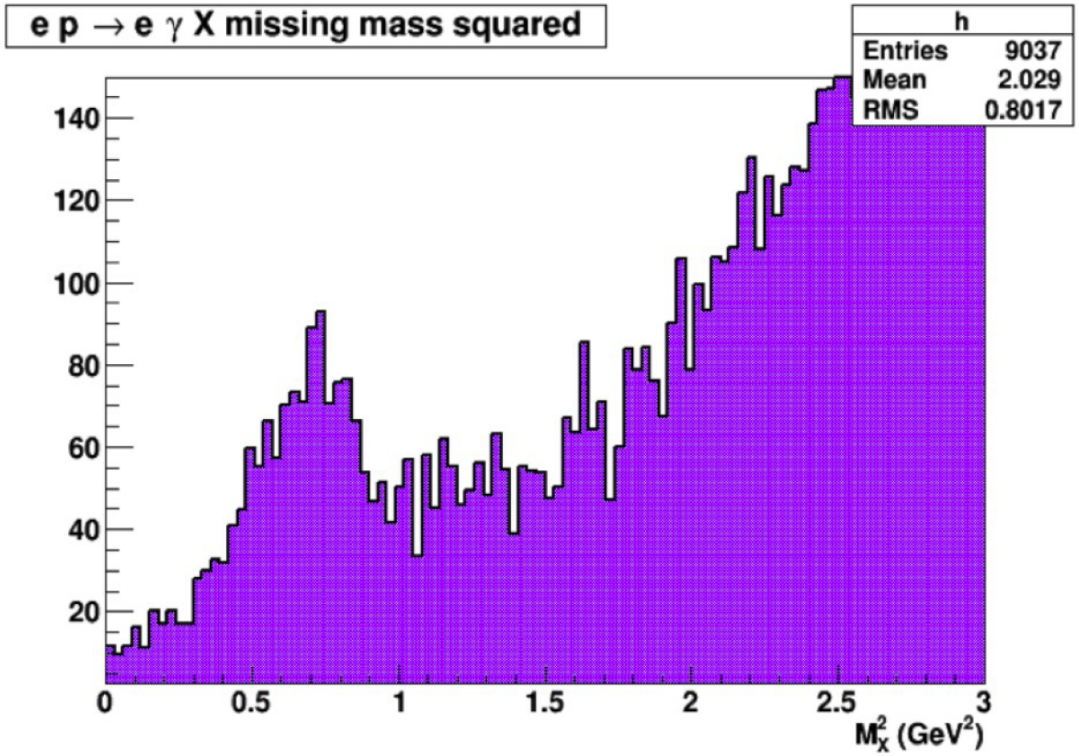


Example Hall A DVCS experiment eγ coincidence timing spectrum

Mongi Diamini, Ohio University Hall A collaboration meeting

Example of what we want to simulate

- **Generate DVCS plots : missing mass spectrum**



Example Hall A DVCS experiment eγ missing mass spectrum, can also look at ep e pX missing mass plot

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Mongi Diamini, Ohio University Hall A collaboration meeting

Workplan, deliverables & personnel

Period	Task
Oct - Nov	Setting GEMC on local machines
Nov - May	Study x,y and time distributions in Roman Pots
Oct - Jan	Radiation tests for ultra-fast silicon detectors
Jan - May	Test of new pre-amplifiers for ultra-fast silicon
May - Oct	Study of proton identification in Roman Pots
May - Oct	Timing tests on KU test stand

We currently have 3 postdocs and 4 graduate students working on fast timing detectors and their electronics. This work is done in very close collaboration with Jlab, Orsay, Saclay, Torino, Santa Cruz but these institutes are not requesting EIC funding.

Budget

50% FTE existing postdoc	$24,000
Other personnel	$800
Fringe	$8,600
Travel	$2,000
Indirect	$18,272
Total	$53,752

Summary

- High precision timing offers another dimension for tracking and identifying particles.
- There are natural connections between the forward programs of the LHC and EIC but timing may also be useful in the central detector as well.
- Kansas is heavily involved in fast timing for the LHC and has strong connections to European groups working on electronics and fast silicon detectors
- Support for ½ FTE would allow us to understand how fast timing could help the forward detectors at EIC.

Pico Second Timing Workshop

Kansas City, September 15-18 2016

http://www-d0.fnal.gov/~royon/timing_kansas/