

PROJECT X PHYSICS STUDY WORKSHOP (PXPS 2012)

Working Group on Time of Flight

Conveners: Mike Albrow (FNAL) & Bob Wagner (ANL)

New directions in fast timing:

What are the needs of precision timing in Project X experiments?

Have the proponents considered how better timing (how much better) can help?

How might more ambitious goals (if useful) be achieved?

Can we identify an R&D project (or projects) on the scale of say 0.2 – 2.0 M\$ for a targeted or generic project for DOE/OHEP funding?

(With a team that wants to do it!)

In this group, let us not be 100% focused on PX.

Detector developments will have wider application (e.g. LHC, Cosmic rays, p-decay, etc)

Developments driven by LHC or other needs may find application in PX projects.

Wide-ranging, lateral thinking, ideas welcome, discussion!

Planned sessions (so far):

Today (Sat): 11:00 – 12:30, go to Large Area Det gp, 2NE
16:00 – 17:30 2NW

16:00 - 17:30

Room: *WH2NW Black Hole*
Location: *Fermi National Accelerator Lab*
Conveners: *Bob Wagner, Michael Albrow*

Contributions

16:00 Introduction
16:15 Timing needs mu-egamma, mu-eee
16:35 Timing detectors ATLAS forward protons
16:55 QUARTIC for CMS protons

[View contribution list](#)

Contributions

09:00 MCP with ALD timing properties
09:20 Fermilab test beam and timing detector development
09:40 Ultrafast lasers

[View contribution list](#)

Monday 9:00 – 10:30 2NW

Contributions

14:00 k0pi0 timing
14:20 timing in n-nbar

[View contribution list](#)

Monday 14:00 – 15:30 2NW

Room for more contributions!

Uses for timing, classes, mostly not PX, not all needing super-precision):

Together with p or E : identification of particle type (PID)

in beam (small area $\sim \text{cm}^2$)

OR in large area ($\sim 10 \text{ m}^2$) e.g. CDF/D0 size

OR very large area ($\sim 100\text{s m}^2$) e.g. Large water Cherenkov

Together with another time (or reference time): Position of origin in space (spacetime)

Again: cm^2 areas (e.g. forward protons at LHC, $p + X + p$, Brandt, Albrow)

$\sim \text{m}^2$ (PET)

to 100's m^2 areas (e.g. photons in $K^0 \rightarrow \pi^0 \nu \nu$, Littenberg)

Actual time an event occurred

Examples:

Time of a neutrino interaction (wrt production) for speed (mass?!) measurement

Supernova neutrinos

Background reduction (referred to a pulsed beam/ source, e.g.)

Within a $< 1\text{ns}$ bunch crossing at LHC

Directionality

Example: timing shower front in AUGER for cosmic ray direction, source search.

Others?

Detector Techniques:

Cherenkov light (solids, liquids, gases) :

prompt, directional, speed-dependent (both mount and direction)

Very large masses (ICECUBE, HYPER-K) possible with solid & liquid radiators.

Gases for low-mass, e.g. timing intense beam, few mm low pressure gas (rad hard)

Detecting the Cherenkov light:

Classic PMTs, MCP-PMTs (faster) – Large area development, SiPMs good for small areas.

Scintillation light (solids, liquids, gases) :

Classic, not as fast (but maybe fine),

Wavelength shifting collection also “slow”, inefficient ($< 1/6$), but area reduction can be crucial.

Ionization (gases) :

E.g. Drift chamber (to wires) main purpose tracking, but multiple time measurements for free.

or TPC, timing \rightarrow track position reconstruction from time of drift.

Parameters of importance (sometimes)

Time resolution: ps, 10ps, 100ps, ns, ..?

Size of unit area: cm²? m²?

channels and Cost per unit area or per channel

Electronics (speed, cost, location) to read out to DAQ

Thinness, physical and probably in radiation lengths X_0

Radiation hardness?

Rates ... from $10^{10}/s$ to $10^{-8}/s$!

Electronics issues

Crucial issue ... speed, #channels, integration

Time information required (or useful) in 1st level triggers?

Into fast trigger processors perhaps.

Does it need to be rad hard? compact?

Reference time signals, <ps clock and transmission (PLL?)

Time stretcher electronics x10, x50 ...

R&D DIRECTIONS ???

Large area fast photodetectors, e.g. Photocathodes and MCPs (Elagin's talk)

Material budget minimization (inside tracking?)

Cherenkov radiator materials

Solid state photodetectors e.g. SiPM and others

Geometries (experiment specific)

Very fast electronics (e.g. CERN HPTDC 25ps → 10 ps)

New ideas: streak camera detector? jet timing ring? X? Y ?

Not to forget (keep in mind):

Non-HEP applications, e.g.

PET (of course)

Other medical?

Industrial (source location "bomb in truck")

You name it.