High luminosity, high rate and high radiation hardness workshop

Many measurements focus on exclusive and semi-exclusive processes. The need to detect several particles leads to low cross-sections requiring high luminosity to achieve a reasonable rate. Many large acceptance detectors data taking rates are limited by the detector rate capabilities instead of the beam current, so any improvement in rate capability will lead directly to gain the same statistics in the same given time. Bulk of experiments consists in finding several particles in the final state of a rare event in the middle of a large physics and accidental background. In order to select the event of interests one can take advantage of the detectors resolution:

- since the final state, a better timing resolution the better the signal to noise for a coincidence real event
- good energy and position resolutions allow us to determine the four-vectors of detected particles for the reconstruction of the missing particle with great accuracy

Another issue is a given a sees all a lot of particles for few particles of interest especially when the luminosity is increased, improved radiation hardness is a must to be able to have the detector last for the whole experiment duration without major impact on its performances.

Many detector technologies mostly driven by CERN LHC which requires higher rate, better timing resolution and higher radiation hardness. Though a compromise has to be found for smaller scale experiments which are common in nuclear physics. We would like to hold a workshop inviting experts of the different technologies available to determine what the current ultimate performances possible are and the limits of those technologies in terms of costs and radiation hardness. The goal of the workshop being to combine and optimize them to have the best cost vs performance for experiment at laboratories such as Jefferson Laboratory for 12 GeV and EIC forward detection among others high rate experiments.

For particle tracking, an improvement in timing and reduction of the material in trackers, can improve rate capability. There is R&D on GEM at CERN and Micromegas at CEA Saclay improving the timing response and opening the possibility to do time of flight measurement in addition to tracking in parallel to reduce the amount of material. Time projection chamber are also being developed for high rate environment. For solid state detectors a trend toward improvement in timing with the use of diamond detector or monolithic active silicon detectors for the CERN TOTEM or ALICE. Radiation hardness and timing are also improved using new techniques 3D solid state detectors.

Resistive Plate Chambers have been used at RHIC and LHC. Several internationation institutions participated in the development. R&D is ongoing at Tsinghua University and BNL for improved timing resolution using thin gap RPC. Those detector are able to cover large area of time of flight for a reasonable cost.

In the same way faster photo sensors, with shorter pulses and high timing resolution will allow high rate and better background rejection with tighter timing cuts. New processes in Microchannel plates show promising results for large and lower cost MCP PMT by Argonne, University of Chicago and the INCOM

Company. New development in solid state PMTs have been done by Hamamatsu for example to make them faster and more radiation hard. Superconducting detectors with their high quantum efficiency (up to 93% in IR), high radiation hardness and high timing resolution are also attractive especially where cryogenics temperatures are needed. Such technology still need to be developed.

Crystal scintillators technology is mostly driven by medical imaging with typical manufacturers Saint Gobain. New water based scintillator developed by BNL can be a cheap alternative to more costly scintillators oils.

Cerenkov detectors are straightforward using a Cerenkov medium where fast particle will radiates either a gas, liquid or a solid like quartz. It relies on standard photosensors so performances of the different Cerenkov techniques (Threshold, proximity focusing RICH, mirror focused RICH, DIRC, Hadron Blind Detector) will directly benefit from the photosensors R&D. Improved timing resolution has the potential to bring new analysis technique and to use of those as time of flight detectors. Quartz detector are known for their speed and radiation hardness but typically at the cost of light yield which would also greatly benefit of an increase of quantum efficiency.

Calorimetry is typically the main detector for trigger to looking for a high energy particle. They typically rely on Cerenkov or Scintillator crystals, two main manufacturers are Krytur and SICCAS for single crystals. Sampling calorimeters use a mix of absorber and scintillator, IHEP is a major provider of Shashlyk detector. Several technologies are being developed in the EIC R&D calorimeter consortium such as tungsten powder calorimeter. Finally particle flow calorimetry is being developed for ILC and is becoming easier to implement with the new trackers technologies.

Electronics plays a major part in handling high rates, faster detectors require more performant electronics and the easiest way to deal with combinatorial background is to increase the granularity. The new trend is pipelined electronics using Flash ADCs or sampling. Howewer the cost per channel, power requirements and the option to process large amount of channels close to the detector are the limiting factors. Several groups such as BNL, University of Hawai, CEA Saclay, Omega/IN2P3, University of Chicago are developing ASICs toward resolving this issue. For detectors located close froma cryogenics target superconducting electronics could also be considered for its high speed and radiation hardness.

Finally detectors technology can reach the picosecond level, in case of single arm time of flight the timing resolution from the beam structure could become the dominant uncertainty on timing, accelerator experts will be invited to understand what current limitations from accelerators in term of timing are and what performance could be expected in single arm. Accelerator people will also benefit from the new detector and electronics technologies that could allow higher sensitivity and faster response.

The workshop will invite existing people with experience on high rate experiments, and device manufacturers to share their experience with the different detector technologies and present the current ongoing R&D. Candidates are CERN, RHIC experiment, JLab parity experiment and detector manufacturer. This workshop will span over a few days with dedicated session for discussion and leaving time for people to discuss among each other. The main goal of the workshop being to see what reasonable cost and what improvement in performance would be expected for a detector using the latest technologies for an environment such as Jefferson Laboratory.

Proposal evaluation

Success of the workshop can be measured by the number of speakers and attendees and the different new collaboration that will be started. We also expect to have a proceed summarizing the workshop which can be used as reference for the different detector technologies.