Snowmass 2021 Expression of Interest: MPGD-based Transition Radiation Detector

B. Azmoun[4], F. Barbosa[1], C. Dickover[1], S. Furletov[1], Y. Furletova*[1], K. Gnanvo[2], M. Hohlmann[5], A. Kiselev[4], N. Liyanage[2], L. Pentchev[1], M. Posik[3], M.L. Purschke[4], B. Surrow[3], C. Woody[4], and B. Zihlmann[1]

[1] *Jefferson Lab, Newport News, VA*
[2] *University of Virginia, Charlottesville, VA*
[3] *Temple University, Philadelphia, PA*
[4] *Brookhaven National Lab, Upton, NY*
[5] *Florida Institute of Technology, Melbourne, FL*

Identification of secondary electrons is one of the critical issues for physics at the Electron-Ion Collider(EIC). It tights together with an efficiency for indentifications of such processes as J/ψ production (branching ratio to e^+e^- pair is the order of 6%), D-mesons production (with its Br($D^+ \to e + X$) $\sim$ 16%), as well as B-mesons production (lepton Br($B^\pm \to e + \nu + X_c$) $\sim$ 10%) [1]. Electron identification plays an important role for many other physics topics, such as spectroscopy, beyond the standard model physics, etc.

The next generation of high intensity accelerator and high demand on precision measurements from the physics have to result on the development of high granuarity detectors. A high granularity tracker combined with a transition radiation option for particle identification could provide additional information necessary for electron identification or hadron suppression.

The initial concept and first design of GEM-based Transition Radiation detector was proposed for the EIC detector R&D program [2]. This program is supported by the DOE Office of Nuclear Physics.

The basic concept of GEM-based TRD is shown on the Fig. 1. A standard GEM tracker [3] with high granularity (400 μm strip pitch) capable of providing high resolution tracking was converted into a transition radiation detector and tracker (GEM-TRD/T). This was achieved by making several modifications to the standard GEM tracker. First, since heavy gases are required for efficient absorption of X-rays, the operational gas mixture has been changed from an Argon based mixture to a Xenon based mixture. Secondly, the drift region also needed to be increased from $\sim$3 mm to 20-30 mm in order to detect more energetic TR photons. Then to produce the TR photons, a TR radiator was installed in front of the GEM entrance window. Finally, the standard GEM readout (originally based on the APV25) was replaced with one based on the relatively faster, JLAB developed, flash ADC (FADC) [4]. During this work a small 10 $\times$ 10cm prototype, as shown in the Fig 1 has been build and tested [5].

To determine the electron identification efficiency and pion rejection power we tested several methods: total energy deposition, cluster counting, and a comparison of the ionization distribution along a path using maximum likelihood and neural network (NN) algorithms. The maximum likelihood and NN algorithms demonstrated similar performances. However, the NN algorithm has an advantage in practical application as it allows for the optimization of various test parameters and was used as the main analysis method. The ionization along the track was used as input to a neural network program (JETNET [6], ROOT-based TMVA [7]).

Further developmnt of Machine Learning algorithms for e/π separation is ongoing. The plan is to develop and build a functional demonstrator for FPGA Machine Learning application. A FPGA-based Neural Network application would offer real-time, low latency (1-4 μs), particle identification. It would also allow for data reduction based on physical quantities during the early stages of data processing. This will allow us to control data traffic and offers the possibility of

*Contact:(yulia@jlab.org)

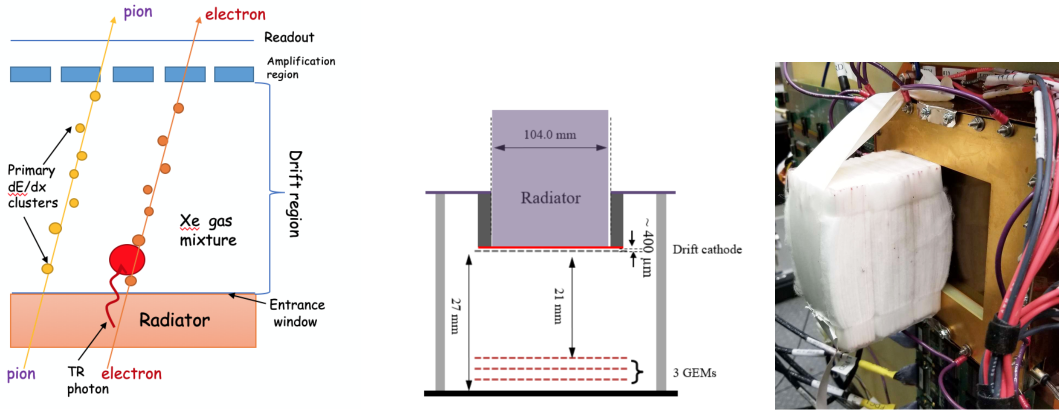

Figure 1: The basic concept of GEM-based TRD (left), the prototype scheme (middle), and prototype at the testbeam setup (right)

including detectors with PID information for online high-level trigger decisions, or online physics event reconstruction.

We would like to continue this effort and are happy to invite experimantalist to develop MPGD-types of TRDs for the future experiments as EIC and beyond.

References

[1] M. Tanabashi et al. Particle data group. *Phys. Rev.*, D 98:030001, 2018.

[2] EIC Detector R&D programm. https://wiki.bnl.gov/conferences/index.php/eic_r&d.

[3] F. Sauli. The gas electron multiplier (gem): Operating principles and applications. *NIMA*, 805:2–24, 2016.

[4] Gerard Visser, D Abbot, F.J. Barbosa, Chris Cuevas, H Dong, E Jastrzembski, B Moffit, and B Raydo. A 72 channel 125 msps analog-to-digital converter module for drift chamber readout for the gluex detector. pages 777 – 781, 12 2010.

[5] S. Furletov and et al. A new transition radiation detector based on gem technology. *Nuclear Instruments and Methods in Physics Research*, 942:162356, 2019.

[6] L. Lönnblad C. Peterson, T. Rognvaldsson. Jetnet 3.0-a versatile artificial neural network package. *Computer Physics Communications*, 81:185–220, 1994.

[7] A. Hoecker at al. Tmva: Toolkit for multivariate data analysis. *PoS ACAT*, page 40, 2007.