TRIUMF Discovery, accelerated

PIONEER

THE UNIVERSITY OF BRITISH COLUMBIA

Characterization and Simulation of a Purity Monitor Assembly for LXe Applications

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Overview

A *purity monitor assembly* (PUMA) [Fig. 1] is needed for precision experiments like PIONEER and nEXO to measure impurities affecting effective light yield in LXe. PUMA must be calibrated by determining the transparency of the grids mounted inside of it.

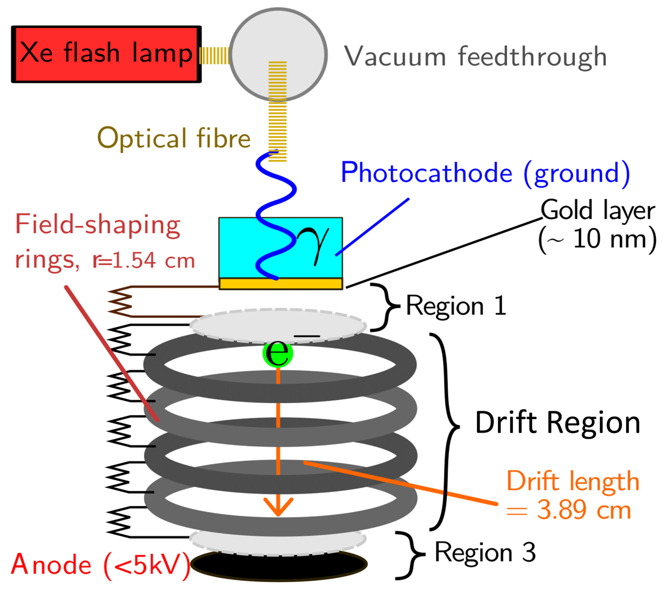

Figure 1: PUMA Drift Chamber

Grid transparency 'k' (medium-dependent) is defined in vacuum as:

$$k = \frac{\text{anode charge } [Q_a]}{\text{cathode charge } [Q_c]}$$

Goal: develop and test a calibration device ("little PUMA") [Fig 3] that measures grid transparency and simulate particle drift in PUMA.

PUMA & Little PUMA

The two assemblies are used in tandem; PUMA [Fig. 2] *monitors impurities* while little PUMA [Fig. 3] *determines the grid transparency* of PUMA. PUMA is being tested in LolX cryostat at McGill; little PUMA is being tested at TRIUMF.

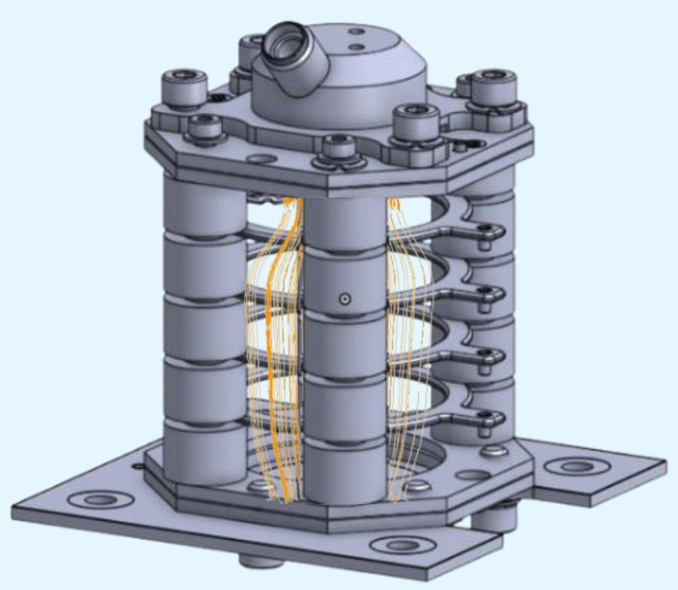

Figure 2: PUMA Model with e^- drift lines

PUMA [Fig. 2]: Light produced by a xenon flash lamp emits e^- from the gold cathode, which drift through ringed region. e^- attach to impurities: comparing signals at anode and cathode determines impurity level.

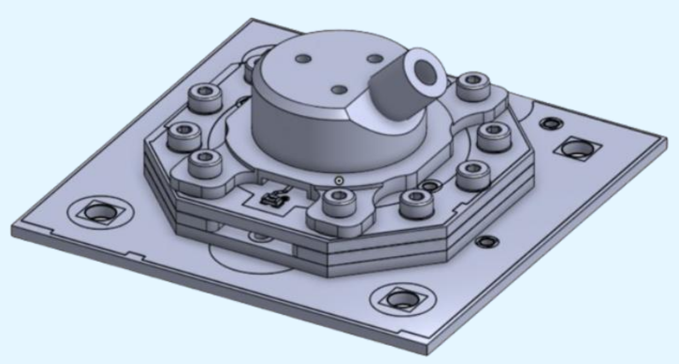

Figure 3: Little PUMA Model

Little PUMA [Fig. 3]: Similar design as PUMA, but with small drift region and no rings (only grid). Comparison of signals at anode and cathode determines grid transparency.

PUMA Simulations

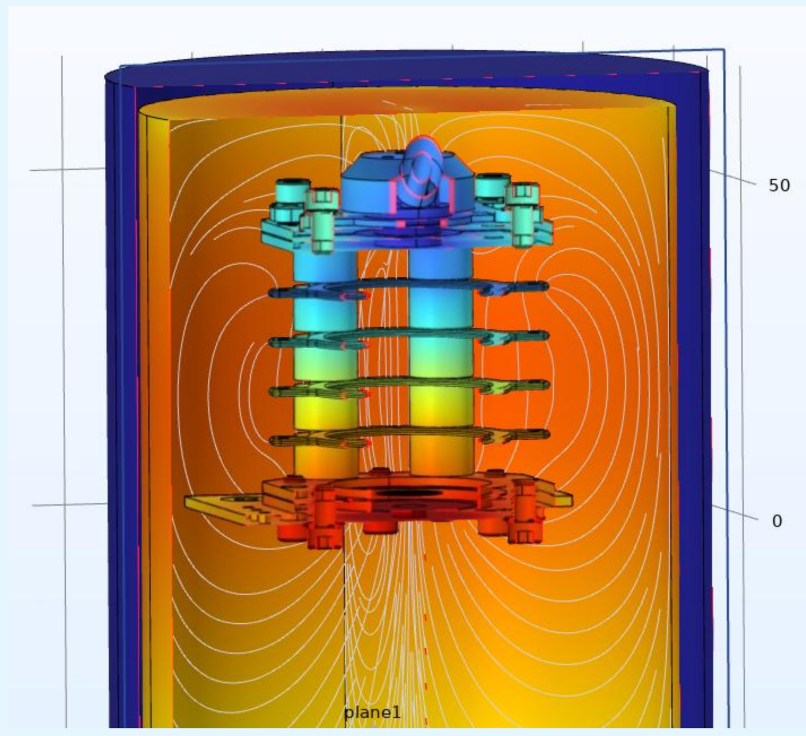

Figure 4: PUMA Electric Field and Potential

Simulations of PUMA were conducted with COMSOL Multiphysics (for generation of field maps) and with Garfield++ (a C++ library for simulation of particle drift in gaseous media).

Guiding questions for simulations:

- What is the drift velocity and trajectory of e^- in drift region?
- Can E-Field be approximated as uniform in drift region?
- Do e^- reach a constant saturation velocity in between grids?

Vacuum System

A vacuum system was designed and built for testing of little PUMA.

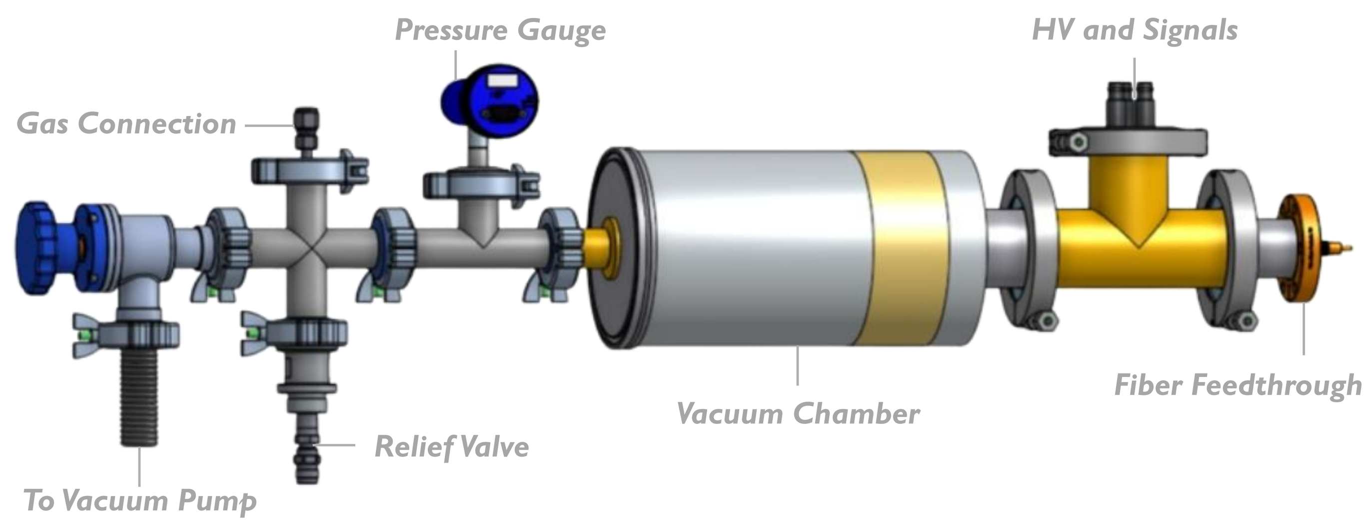

Figure 5: Preliminary vacuum system design in OnShape for little PUMA tests

The purpose of the system was to contain little PUMA, provide connections to Xenon lamp & power supplies, and display internal pressure. System allows for measurement in vacuum and gas (Argon used).

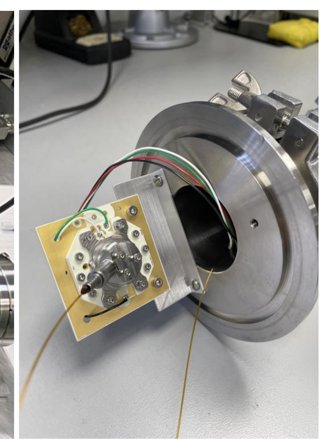

Figure 6 [left]: Vacuum System setup　　*Figure 7 [right]: Little PUMA integration*

Preliminary Results

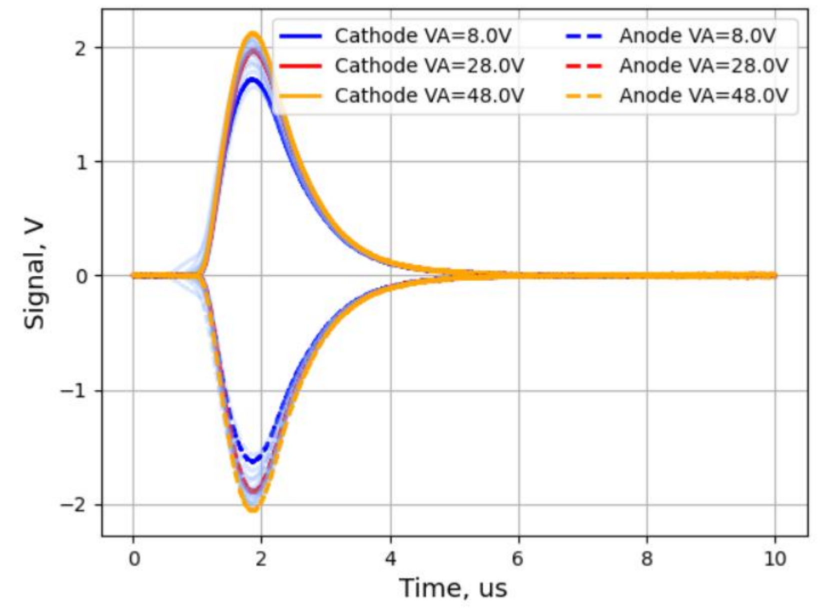

Figure 8: Cathode/Anode signals: varying E-Field ratio

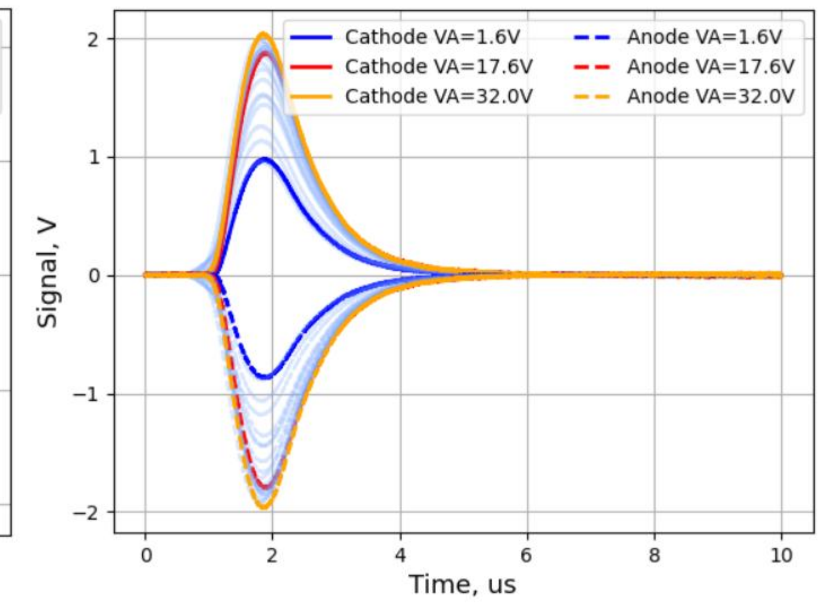

Figure 9: Cathode/Anode signals: constant E-Field ratio

Experimental Procedure

- Xenon flash lamp sends 10 flashes to photocathode which emits e^-
- e^- drift through grid from cathode to anode
- PCBs at cathode and anode capture signal produced by e^- [Figs. 8, 9]
- Charge is found by integrating signal and diving by amplifier impedance

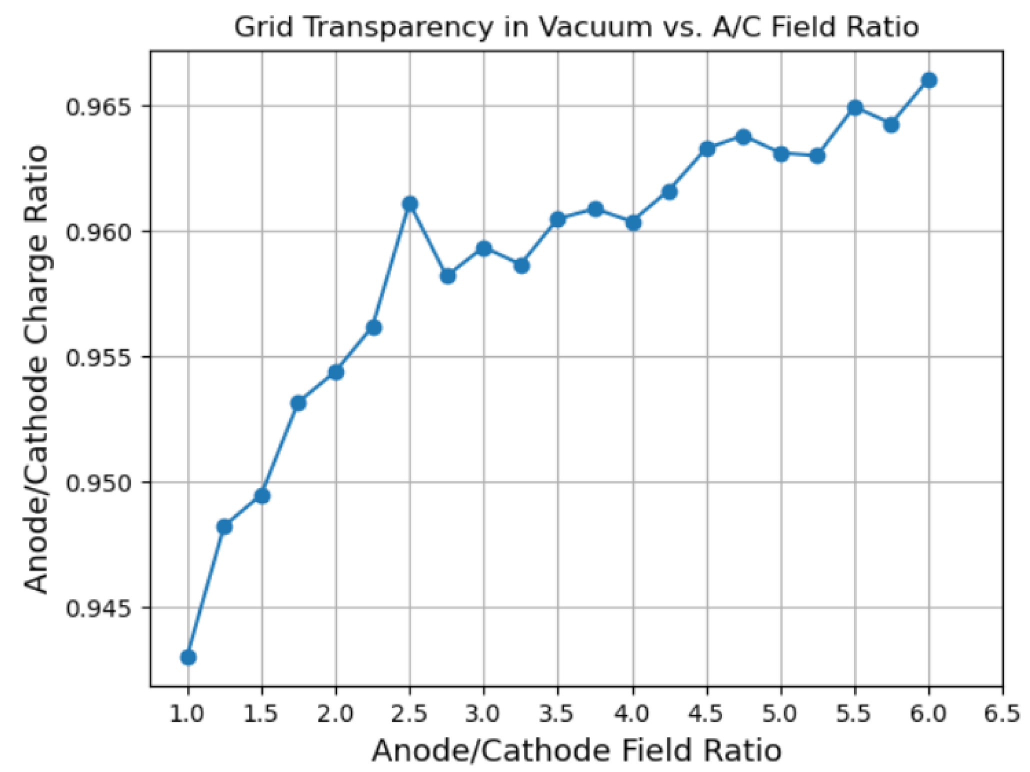

Figure 10: Grid transparency in vacuum

Results in vacuum:

Grid transparency, k, is close to unity (perfectly transparent).

Transparency k improves with increase in E-Field in grid-anode region [Fig. 10].

Next Steps

- Finish data collection and determine grid transparency in Argon gas
- Mount little PUMA in LolX with PUMA as calibration while data taking progresses
- Eventually, integrate PUMA & little PUMA into experiments such as PIONEER and nEXO to maximize performance of calorimeters

Link to GitHub repository:

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