WIEN-FILTER SPIN ROTATOR WITH INTEGRATED ION PUMP*

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ABSTRACT

Nuclear physics experiments performed at the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Laboratory (JLab) require highly polarized electron beams, produced from strained super-lattice GaAs/GaAsP photocathodes. To prolong the photocathode operational lifetime, the photogun and adjoining beamline should be maintained at the lowest possible pressure. This document describes a Wien-filter spin manipulator with Penning traps incorporated along the length of the high voltage electrodes. For some spin settings, the Wien filter acts as an ion pump. Although the Wien filters at CEBAF are relatively far from the photocathode, a Wien-filter spin manipulator with distributed pumping could serve to improve photocathode operating lifetime.

INTRODUCTION

- In 1898 Wilhelm Carl Werner Otto Fritz Franz ("Willy") Wien invented the device and measured cathode rays q/m ratio.
- Almost 80 years later C. K. Sinclair *et al* at SLAC designed and implemented a compact Wien filter to obtain transverse polarization from their polarized electron source.
- Great design replicated at the MIT-Bates, CEBAF, MAMI, and S-DALINAC for operation at 100 keV beam energy.
- More recently, the design robustness was further demonstrated by operating a modified version at Jefferson Lab with a 180 keV beam.
- The mutually orthogonal independent electric and magnetic fields configuration can be exploited to allow a Wien filter spin rotator to simultaneously act as an ion pump by adding Penning traps to the electrodes.

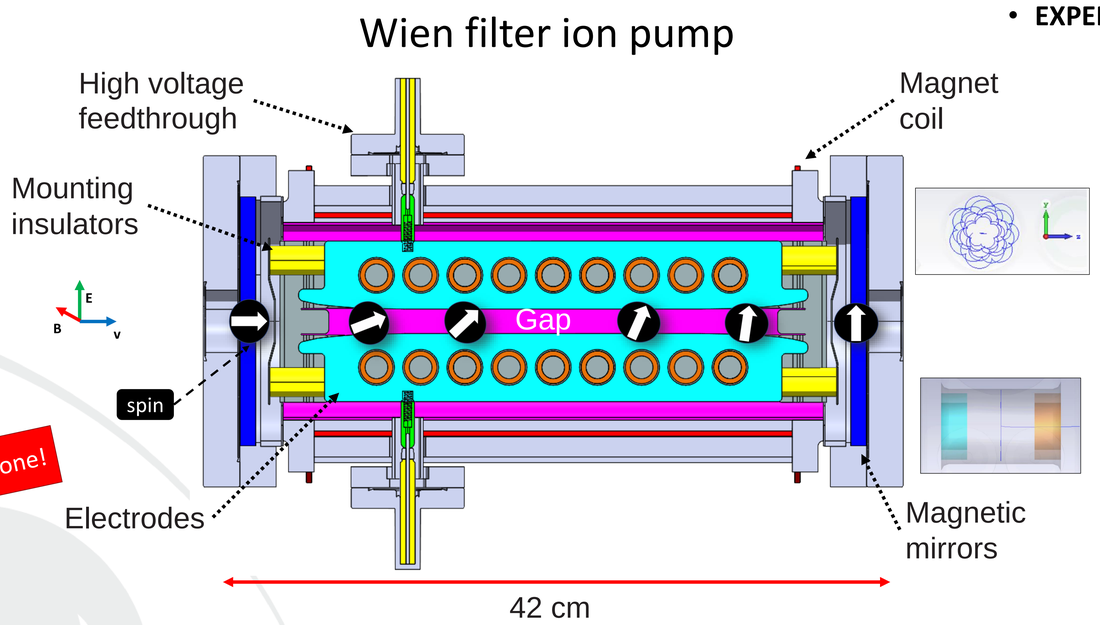
MOTIVATION:

- Lifetime of strained super-lattice GaAs/GaAsP photocathodes used for nuclear physics experiments at JLab benefits from ultra high vacuum conditions 10^{-12} Torr.
- Current and planned experiments require the use of Wien filter spin rotators, therefore a Wien filter with integrated ion pump would be beneficial.
- This could also benefit upcoming projects like EIC and ILC.

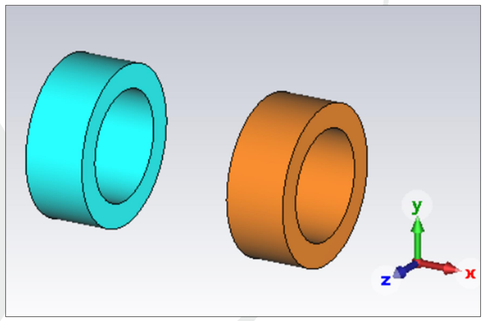
$$\theta = \frac{eL}{m_0 c \beta \gamma^2}\left[\frac{E_y}{v_z}\right]$$

Spin rotation from Thomas- BMT equation

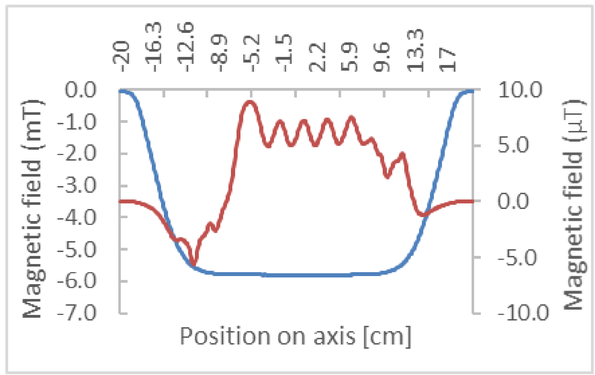
Milestone!



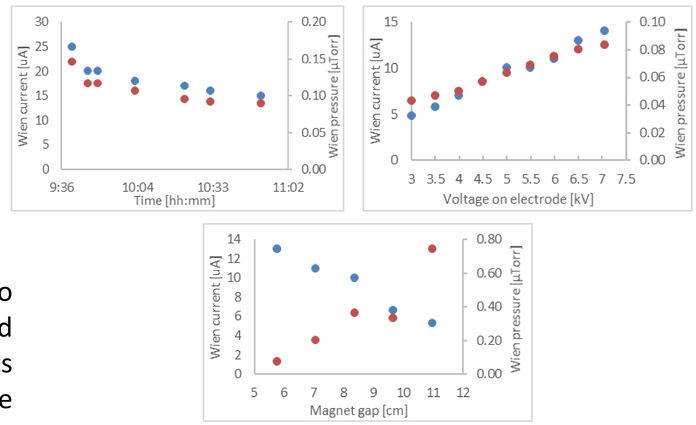
- **MODIFICATIONS:**
- Each electrode (in turquoise) thickness was increased to 3.5 cm, and nine 1 cm radius equidistant Penning traps were machined in the electrode body.
- Permanent ring-magnet pairs with 180 mT magnetic field at their surface were simulated.



- **SIMULATIONS:** It is preponderant to minimize the impact of the magnetic field induced by the permanent ring-magnets added in the modifications, to the one produced by the coils at the beam path



- **EXPERIMENT:**
- Two 316/316L highly polished stainless steel electrodes including the penning traps were used.
- Four (two for each side) 28.7×3.6×0.3 cm getter titanium and tantalum plates were attached to the vacuum chamber lateral walls.
- Without window frame coils a pair of 7.5×20×5.5 cm 180 mT permanent magnets, were placed on top of the positively biased electrode, outside of the vacuum chamber.



- **CONCLUSIONS:**

A Wien filter spin rotator with integrated ion pump was modeled, simulated, and tested, showing that it is capable of performing as an ion pump maintaining a 0.1×10^{-6} Torr vacuum level while acting as a Wien filter simultaneously, capable of rotating the spin angle of a 100keV electron beam by $\pm\pi/2$ rad. More sophisticated beam dynamics simulations will be further investigated

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