Design of a Fast Photon Beam Position Monitor for the KLF beamline

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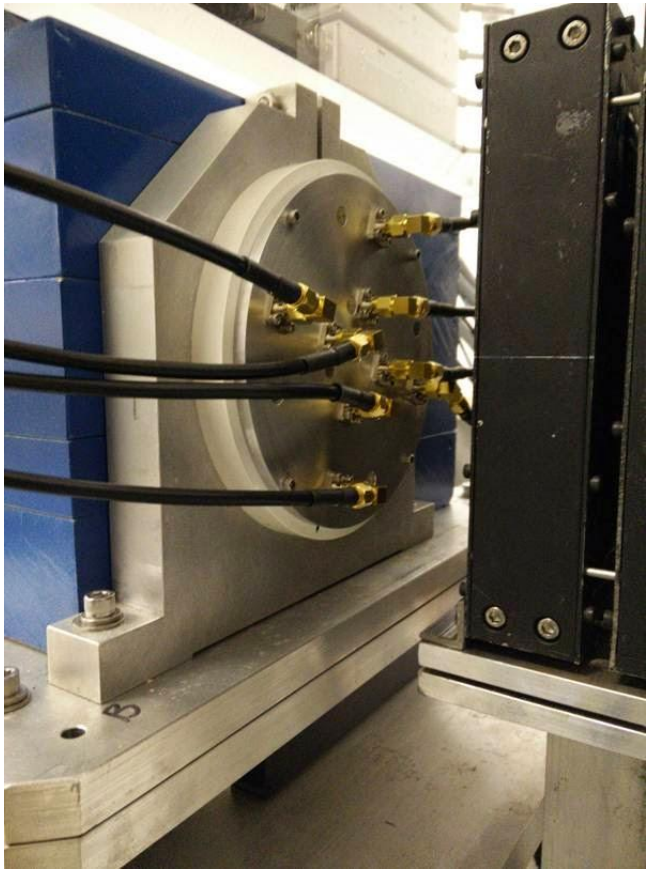
for the GlueX collaboration

Klong Facility collaboration meeting
September 19, 2023, Newport News

Design overview

- Tungsten pin-cushion detector
  - original design developed at SLAC in 1970's, **Miller and Walz, NIM 117 (1974) 33-37.**
  - adapted by GlueX for use as Hall D polarized photon beam "active collimator".
  - current device not suitable for KLF beamline, ***but***
  - **a new device** based on the same operating principles and similar geometry would serve the needs of KLF.



Design requirements

- Be target radius

  $r_{clearance} \geqq$ 30 mm

- Be target photon beam intensity

  $I_{KLF} \leqq 10^4 \times I_{GluexII}$

based on early CPS model design, Nuclear Inst. and Methods in Physics Research, A 957 (2020) 163429

- Position resolution

  $\Delta x = \Delta y \leqq 1$ mm

- Dynamic range

  $I_{min} \leqq 10^{-4} I_{max}$

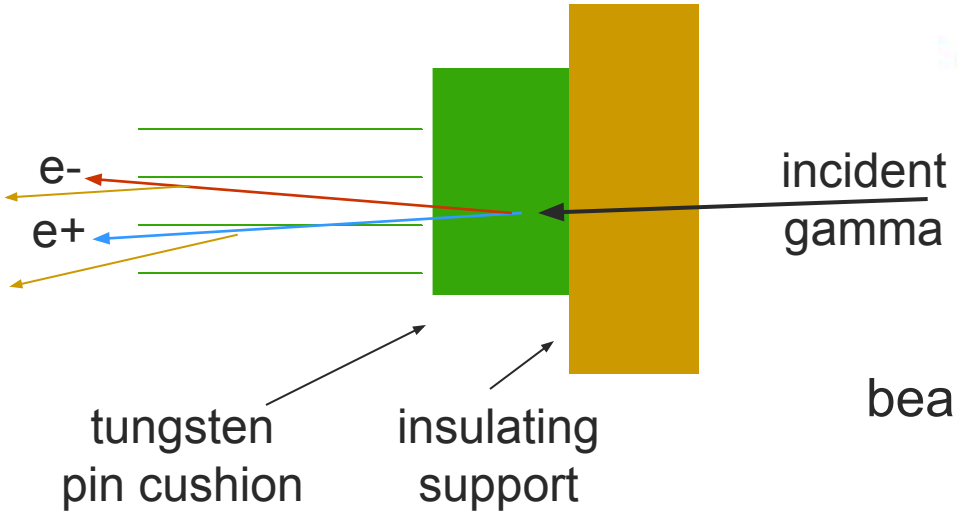
- Response time

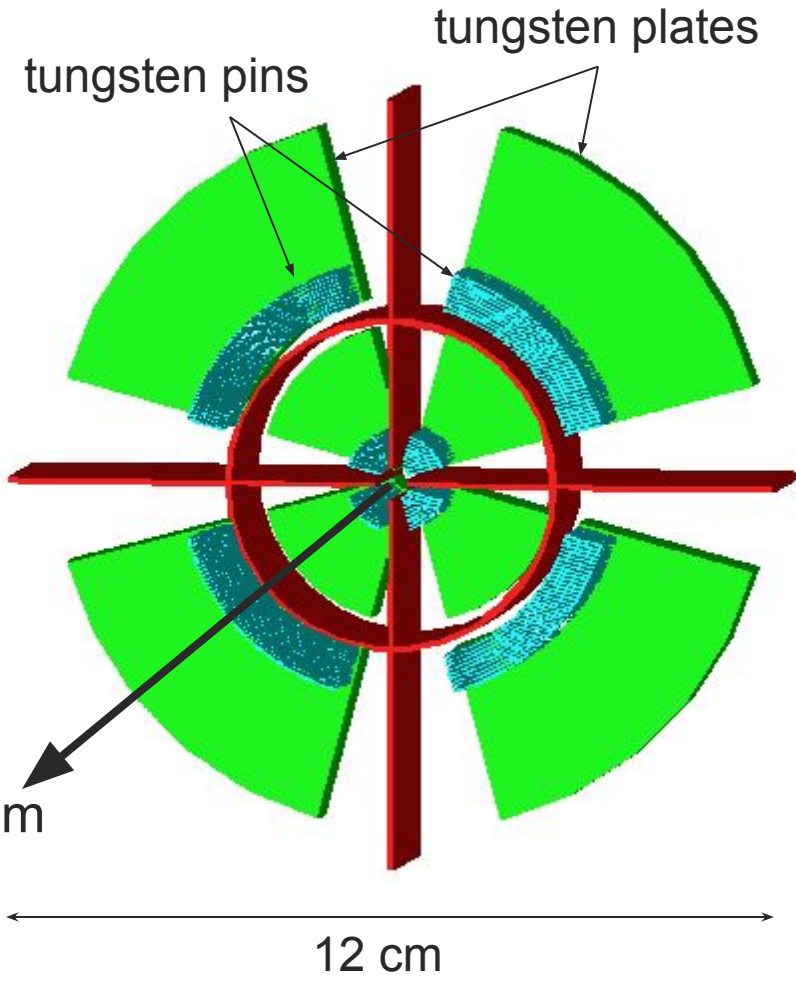
  $\tau \leqq$ 1 ms

projections based on known performance of the GlueX active collimator

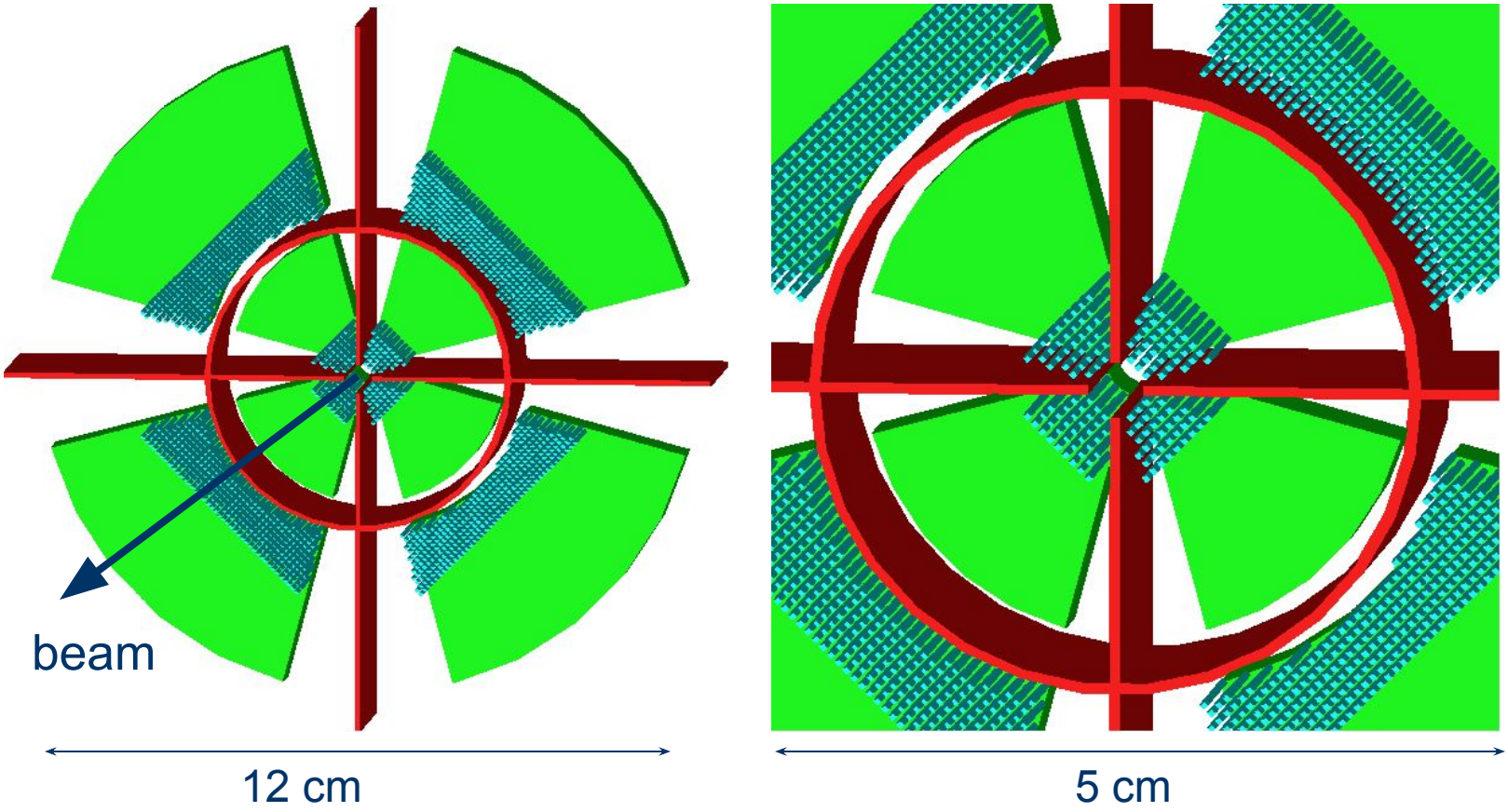
GlueX active collimator design

- measures current due to knock-ons in EM showers

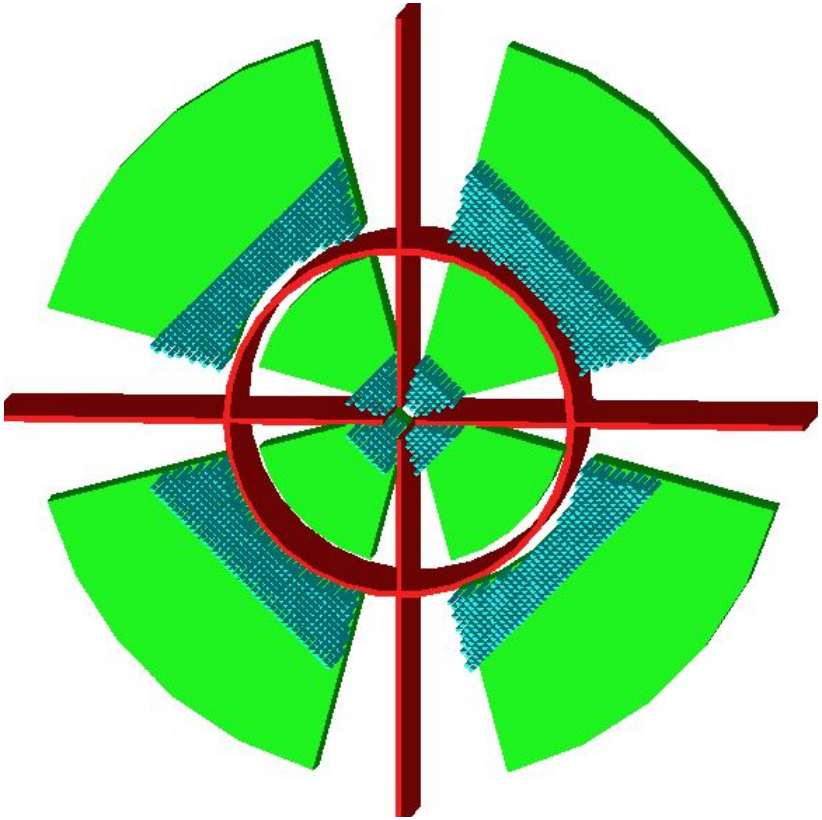




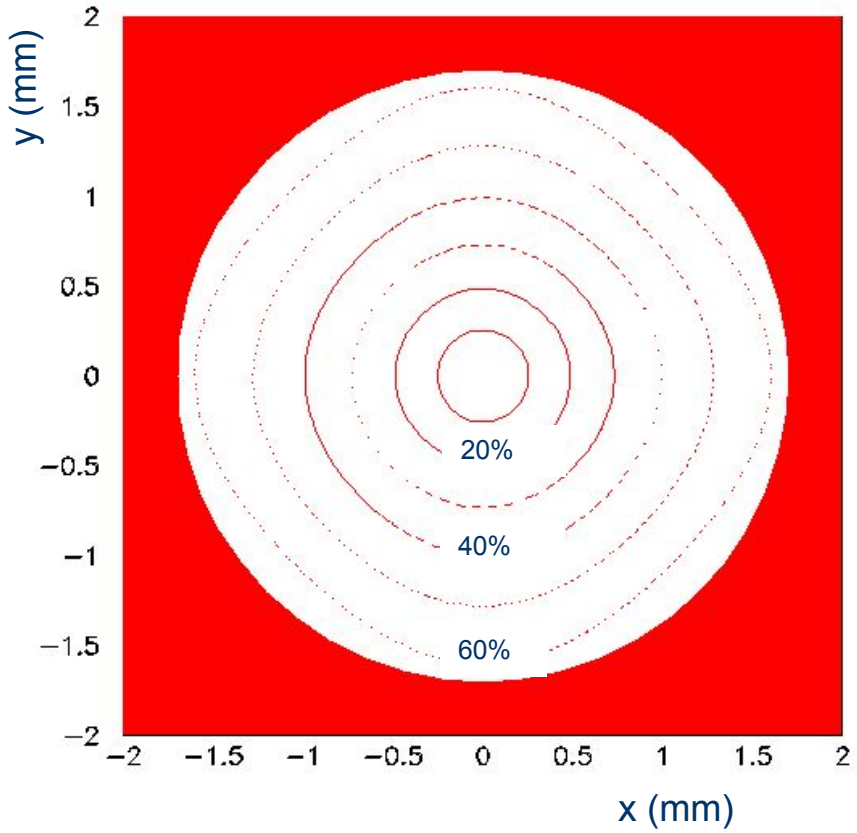
GlueX active collimator design



Active collimator simulation



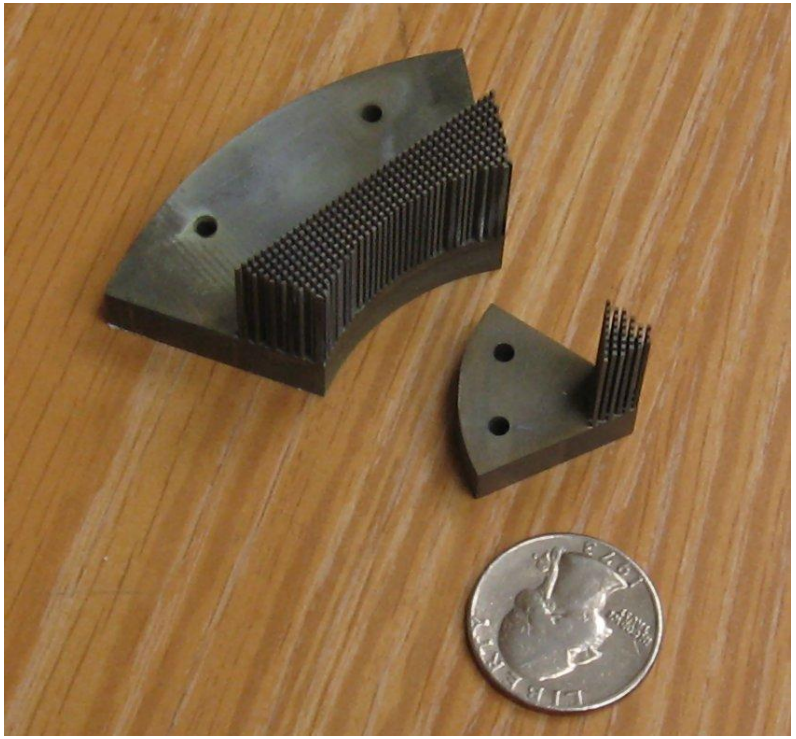
inner asymmetry vs. beam offset



Tungsten pin construction

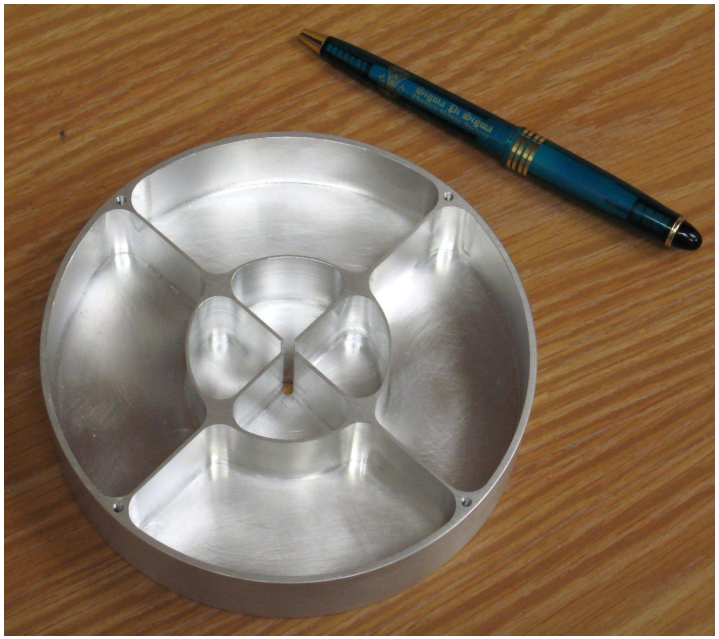
Pin cushions fabricated using electrical discharge machining (EDM)

- pure tungsten too brittle, pins snap off during fab.
- machinable tungsten OK
- finding the right material is crucial



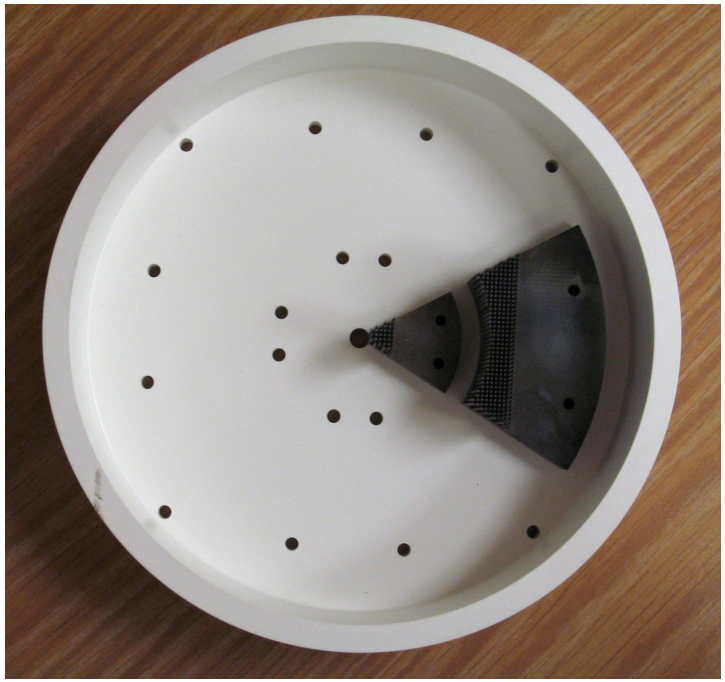
GlueX active collimator housing

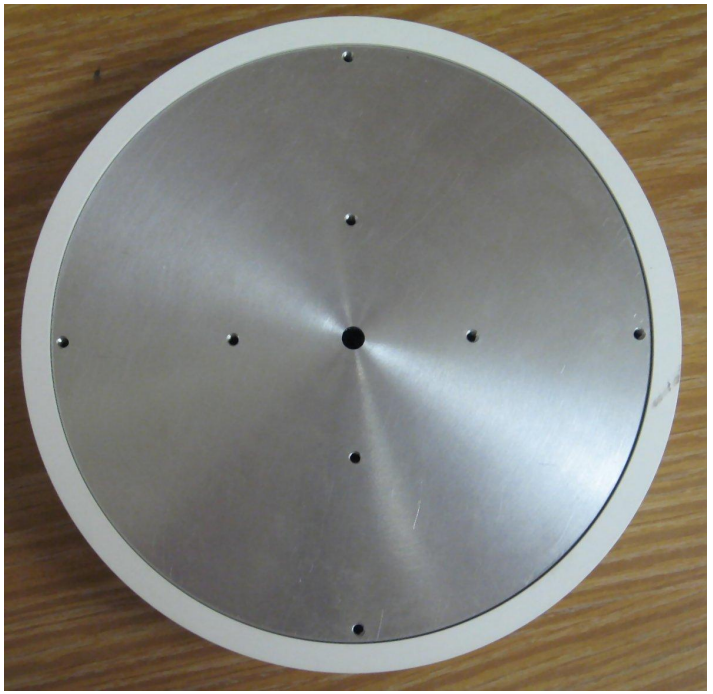
partitioned anode (Al)



insulating cathode holder (BN)

GlueX active collimator assembly

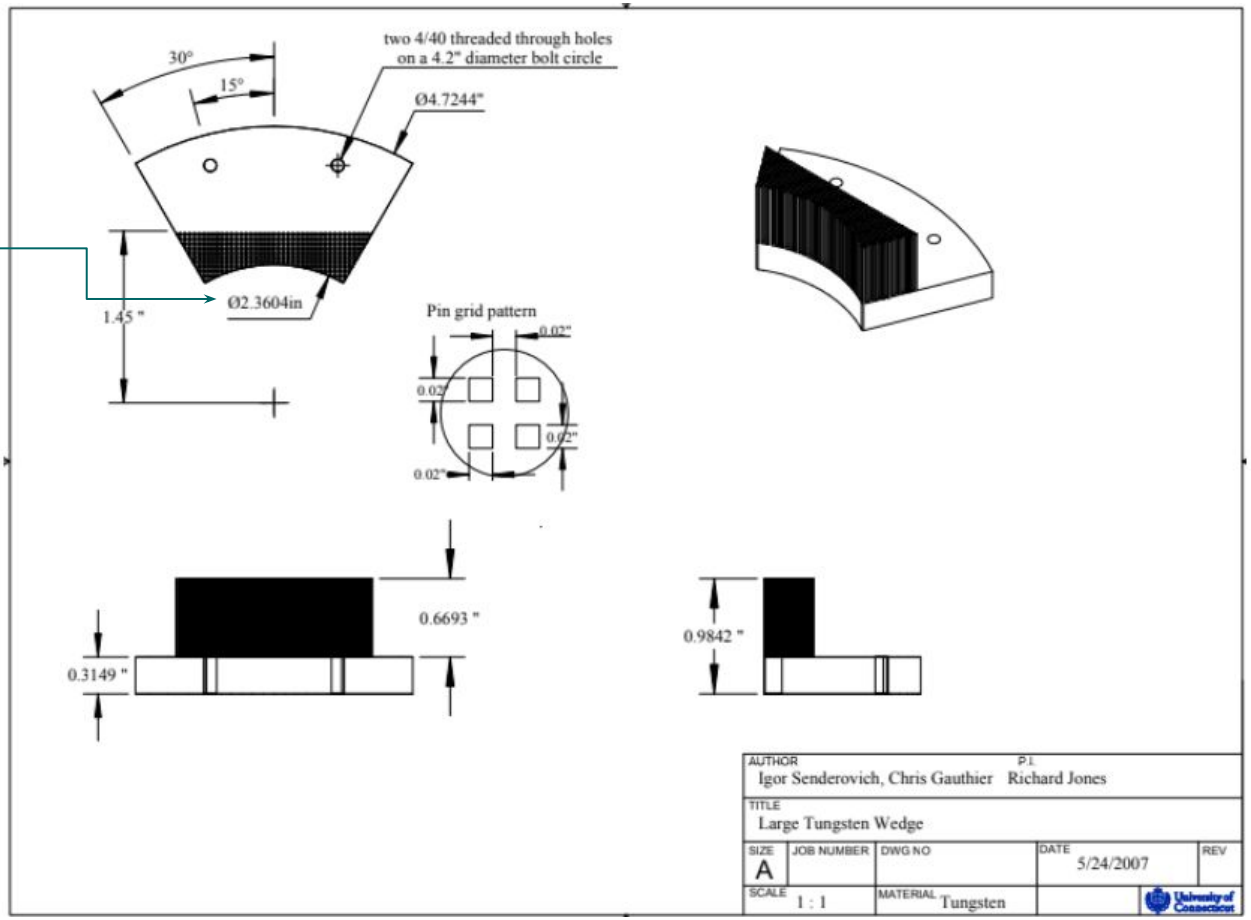




Design changes for KLF

New housing with 3cm radius inner clearance circle

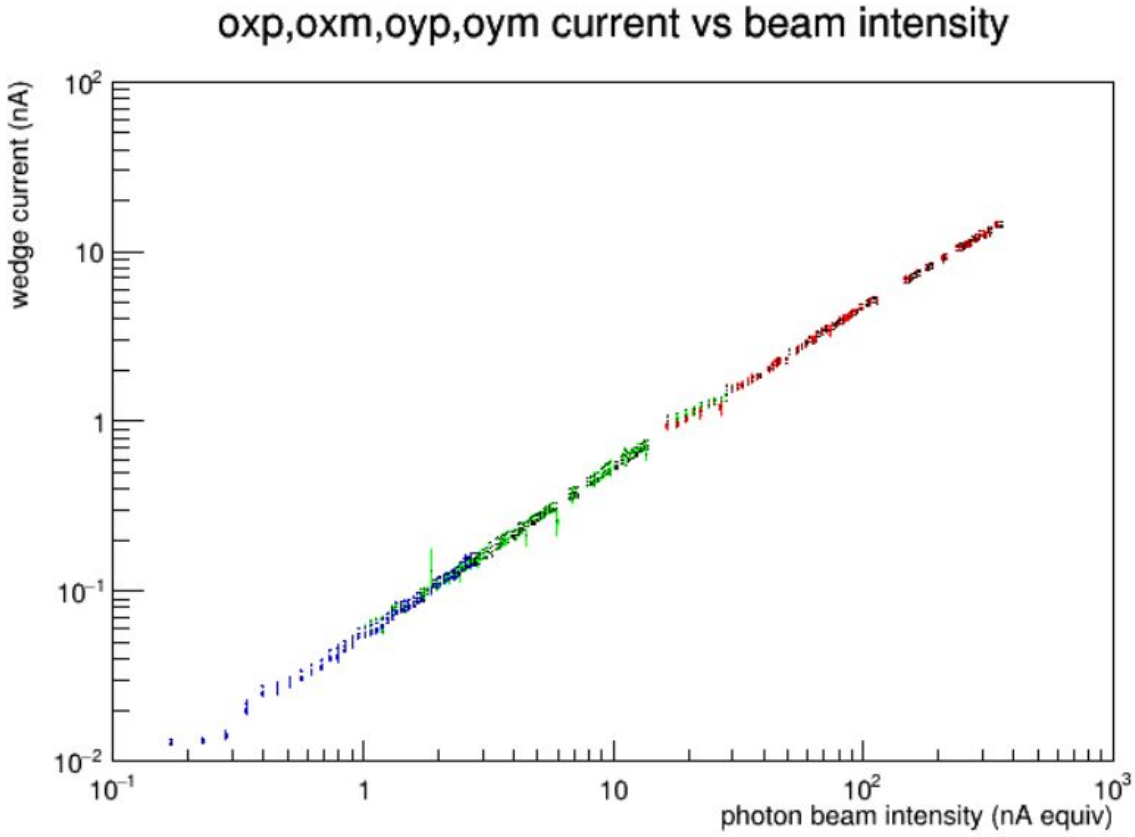
- just one ring, four quadrant wedges
- can reuse existing tungsten wedges
- small adjustments can accommodate extra clearance



Can it scale by 10^4 intensity?

Original design worked in SLAC (pulsed) e- beam!

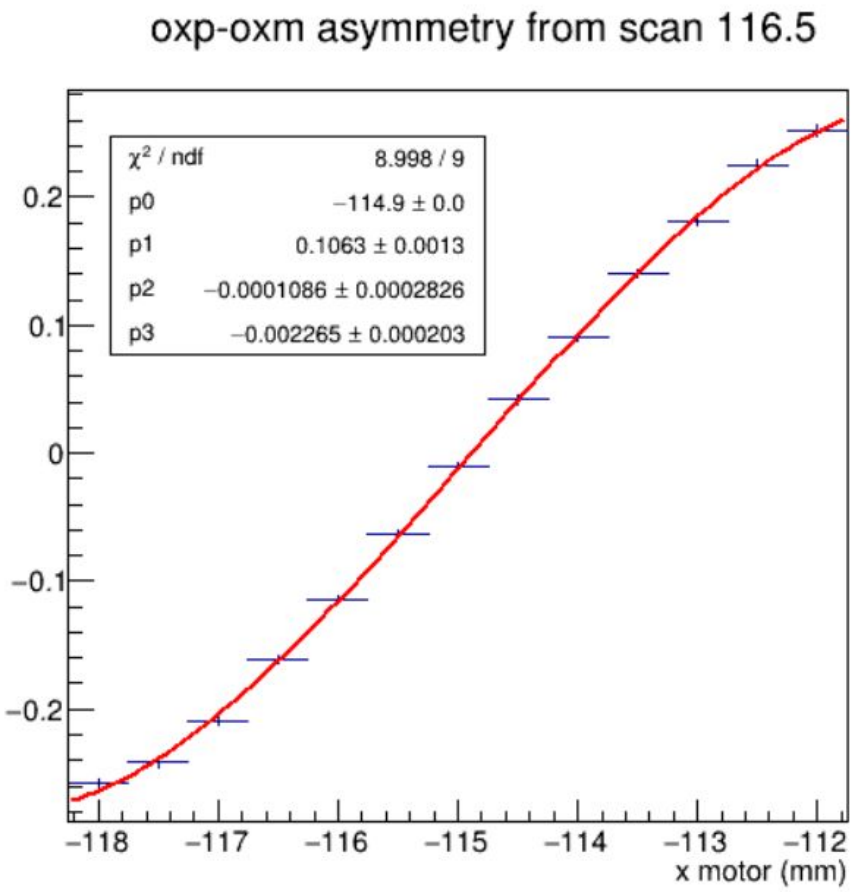
- unit gain, like an ion chamber
- charging effects mitigated using 50V bias on the electrodes
- large dynamic range used by GlueX



Position resolution

Electronic noise is negligible at GlueX Phase 2 intensity

- $\sigma_x = \sigma_y$ = 0.3 mm @ 60Hz
- spot size (mult. scatt. in CPS radiator) will smear this by some factor
- smearing also increases current on the wedges, reduces halo fraction



Electronic noise spectrum

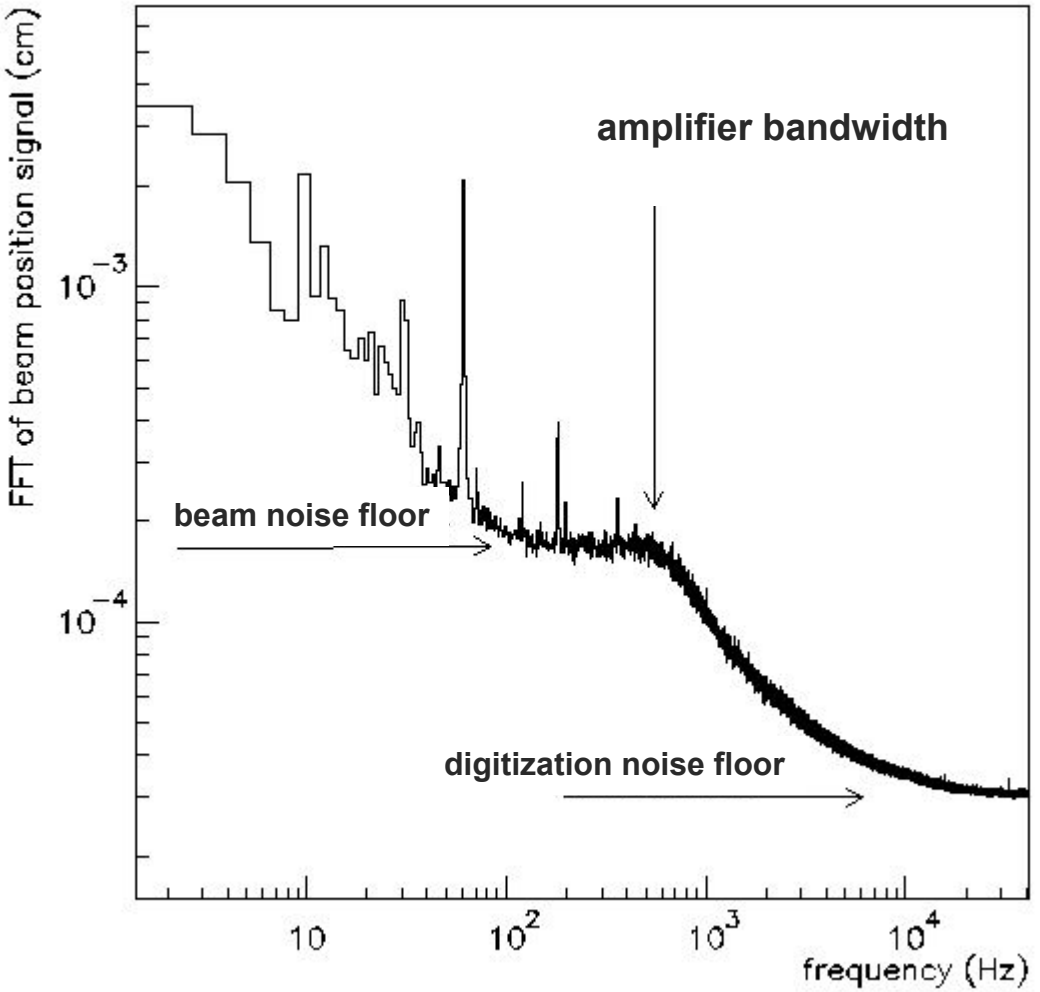
results @ 60nA

- beam noise floor:
  18 μm @ 600Hz
- readout noise floor
  3 μm @ 600Hz

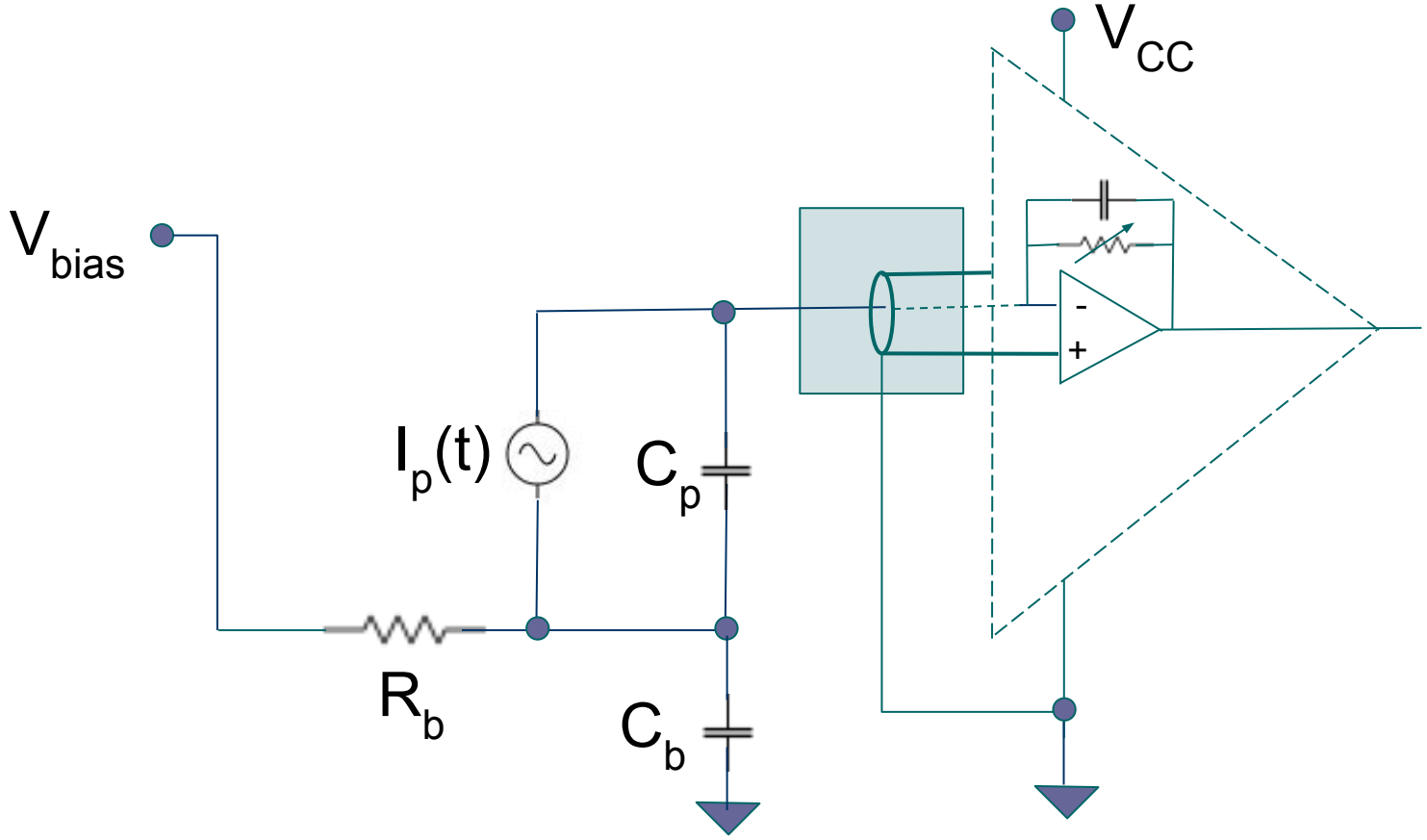
scaling to 0.6nA

- readout noise floor

  130 μm @ 120Hz



Necessary changes to the readout



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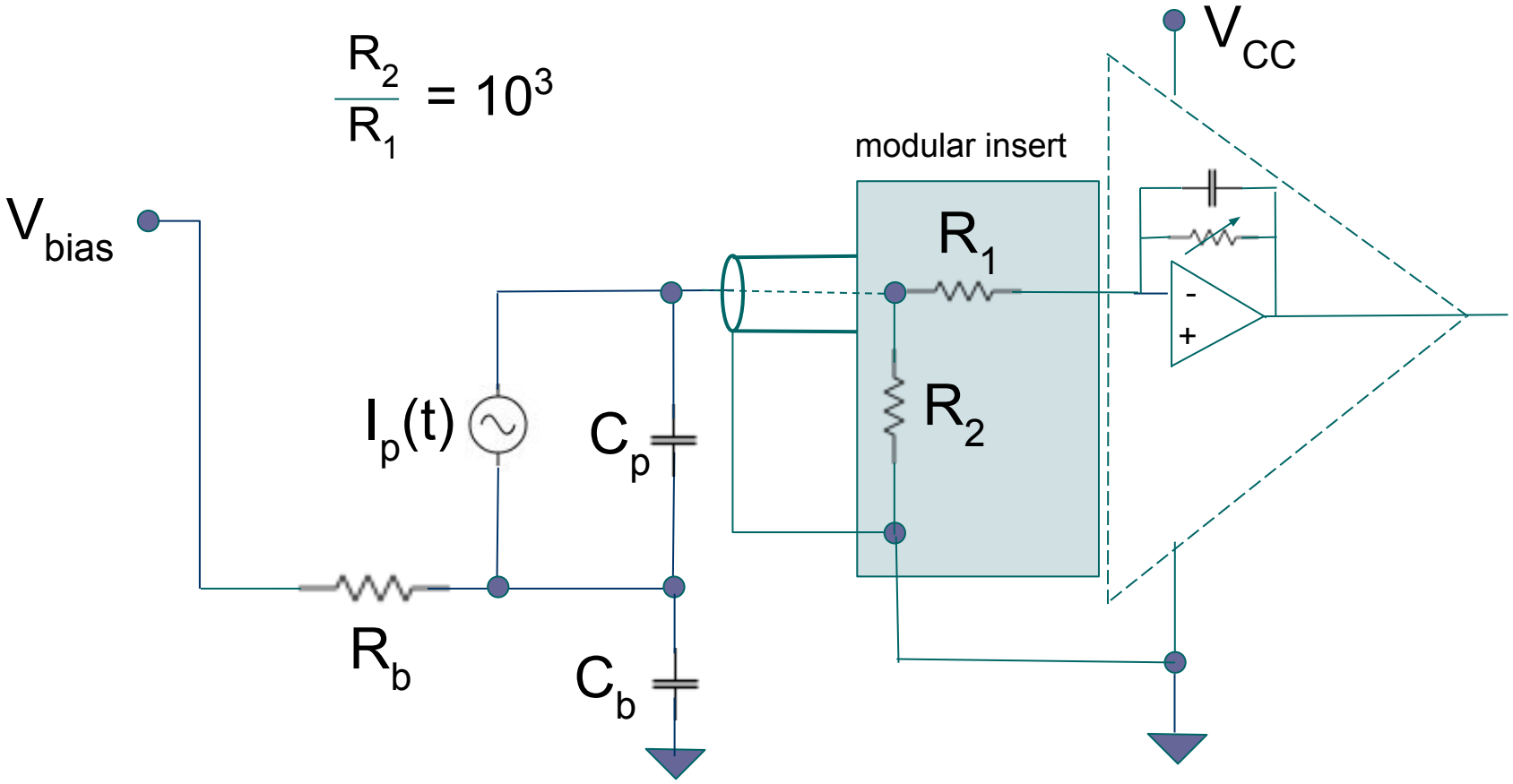


Summary

- A variant of the GlueX active collimator will provide a fast, reliable photon beam position monitor for KLF.
- Some bits (readout, outer wedges) can be borrowed from the existing setup.
- Cost of new bits (mainly housing) estimated at $10k.

backup slides

Simulated detector response

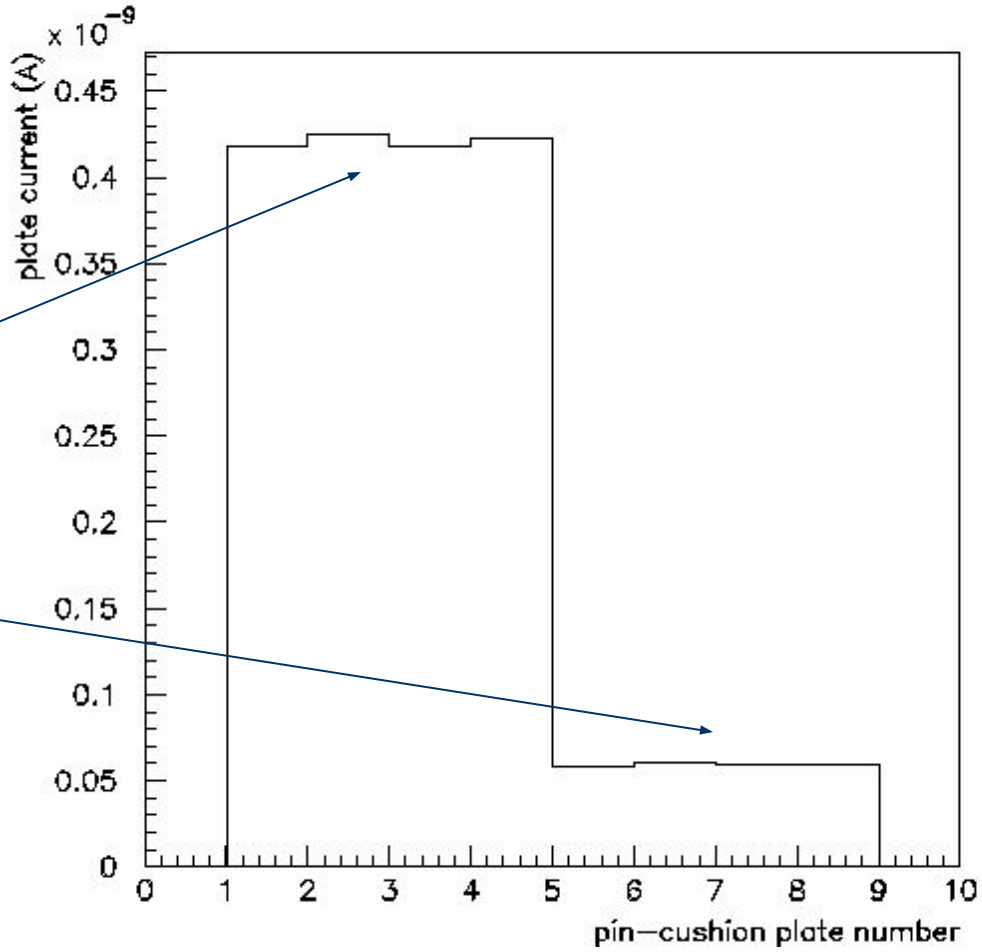
Monte Carlo

inner ring of
pin-cushion plates

outer ring of
pin-cushion plates

10^{-4} radiator

I_e = 1μA



Simulated position sensitivity

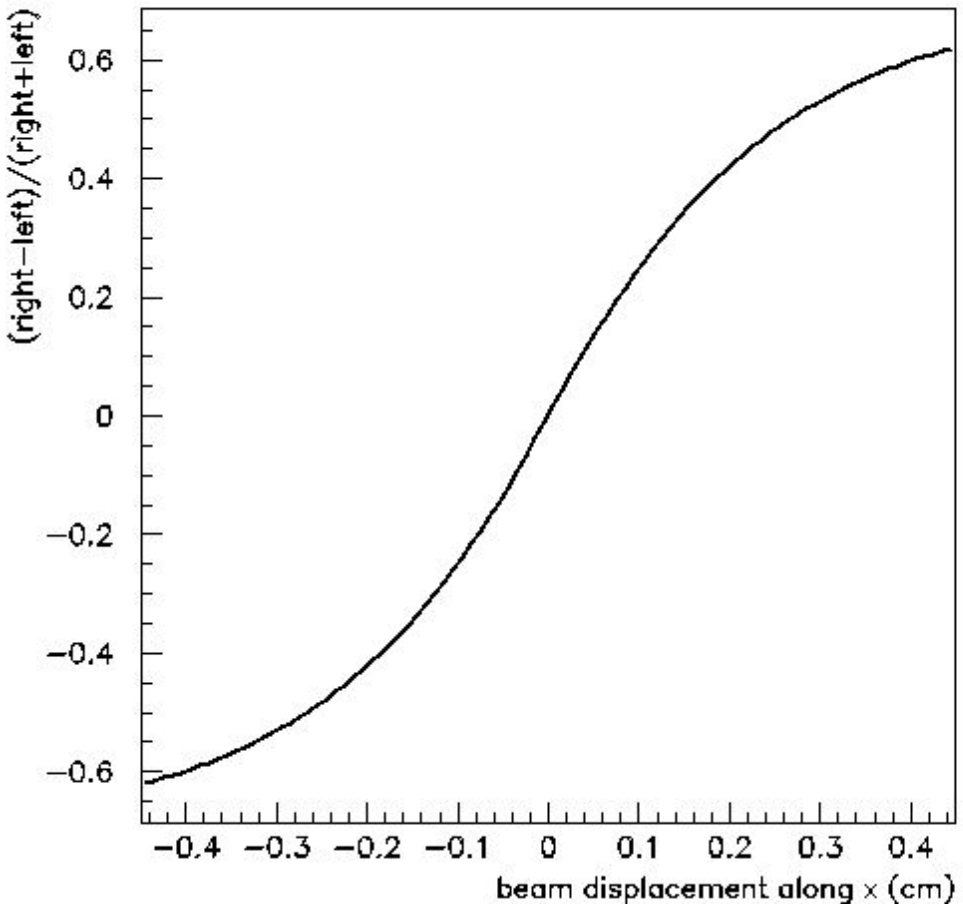
Monte Carlo

±200 μm of motion of beam centroid on photon detector

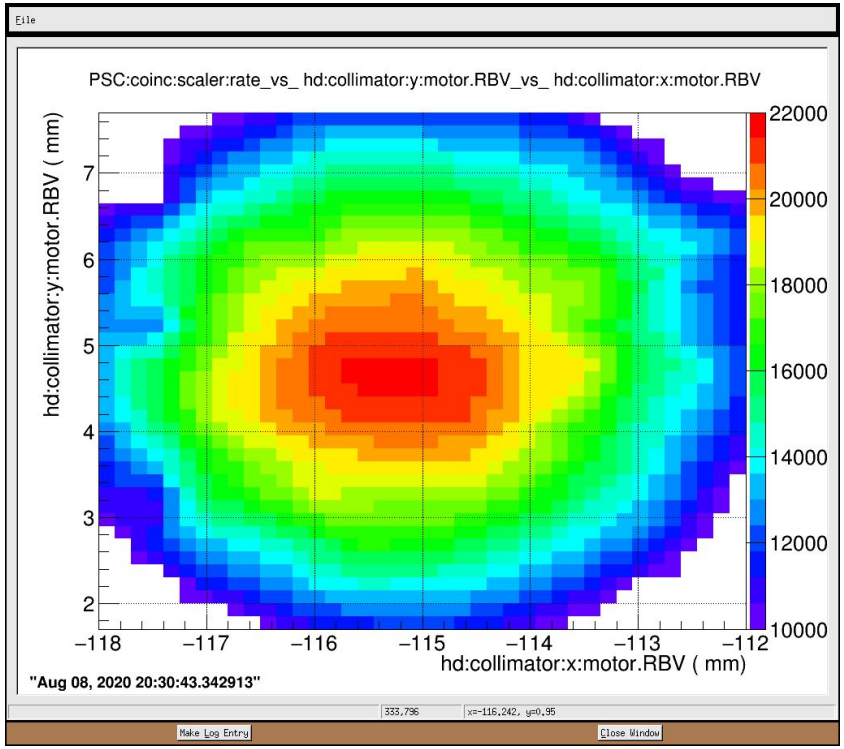
corresponds to

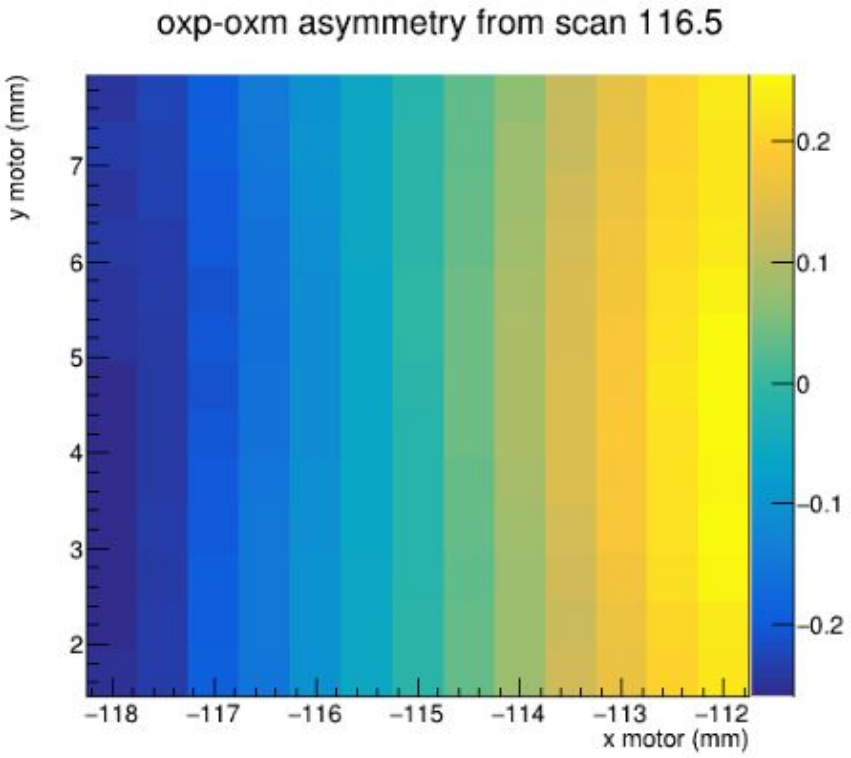
±5% change in the left/right current balance in the inner ring

using inner ring only for fine-centering



Measured position sensitivity





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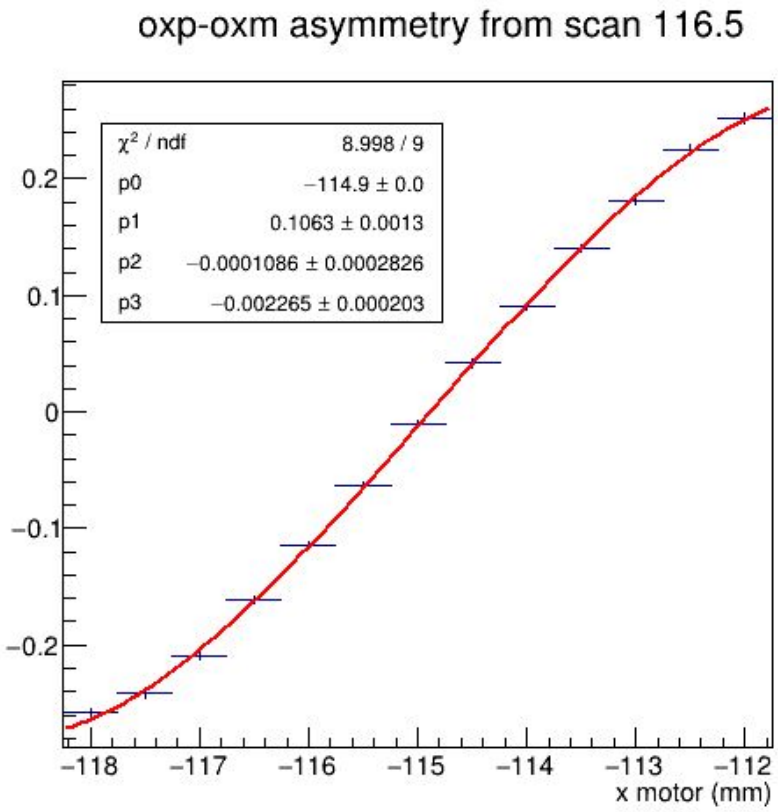

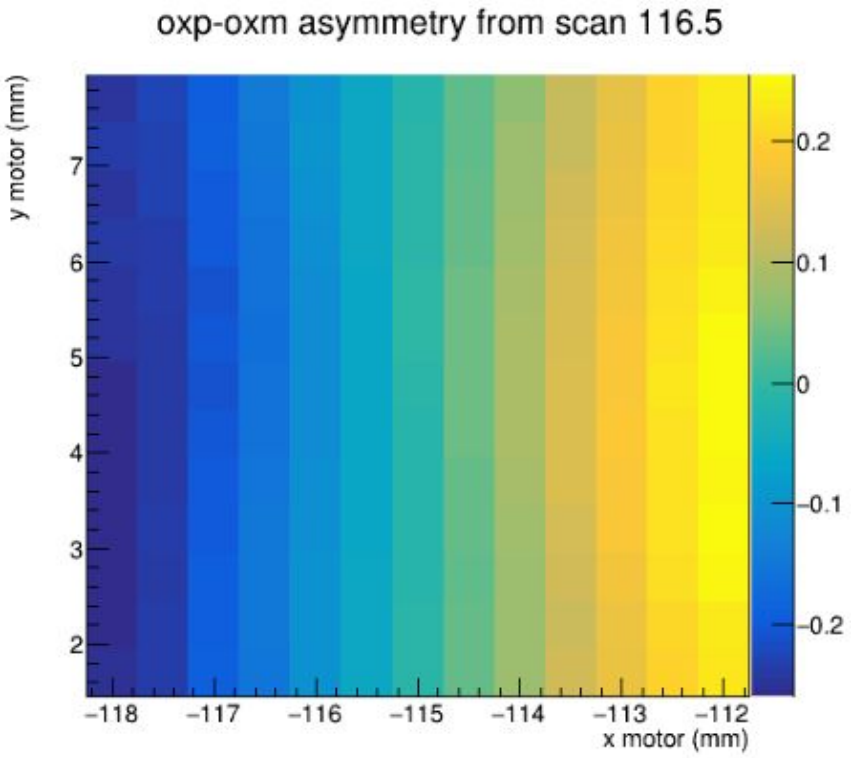

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