Plan for measuring photon beam spot characteristics

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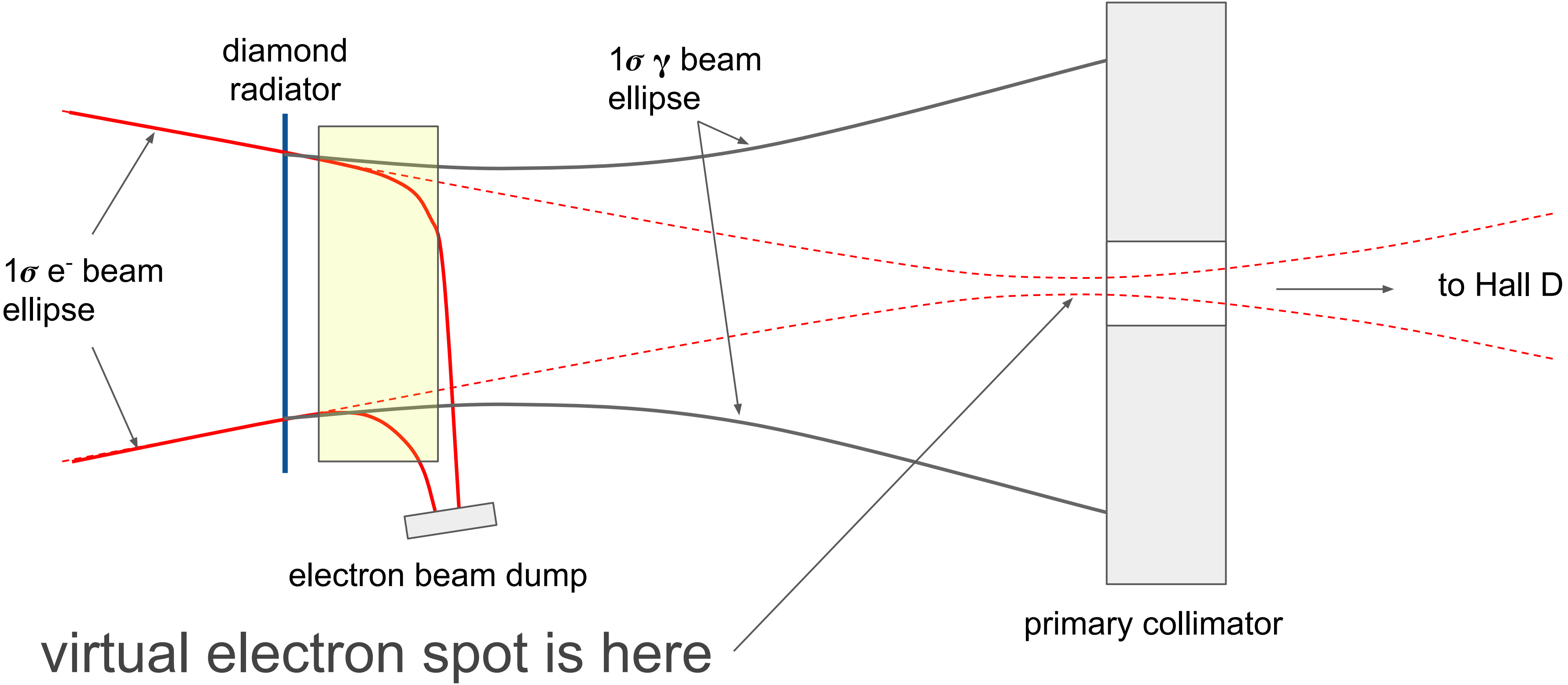
Original beamline spec. *(Hall D ICD, 2009)*

Electron beam emittance	**ε_x < 10 mm-μrad** **ε_y < 2.5 mm-μrad**	ok
Electron beam energy spread	**< 0.1%**	ok
Uncertainty in electron beam energy	**< 0.1 %**	✓
Spot size @ radiator	**800 μm < σ_x < 1600 μm** **300 μm < σ_y < 600 μm**	✓
Beam image size at 76m from radiator	**σ_x < 600 μm** **σ_y < 600 μm**	?
Beam halo*	**< 5×10^{-5}**	✓
Beam position stability at collimator	**Δx < 200 μm** **Δy < 200 μm**	✓
Electron beam current	**0.3 nA < I_e < 3 μA**	✗

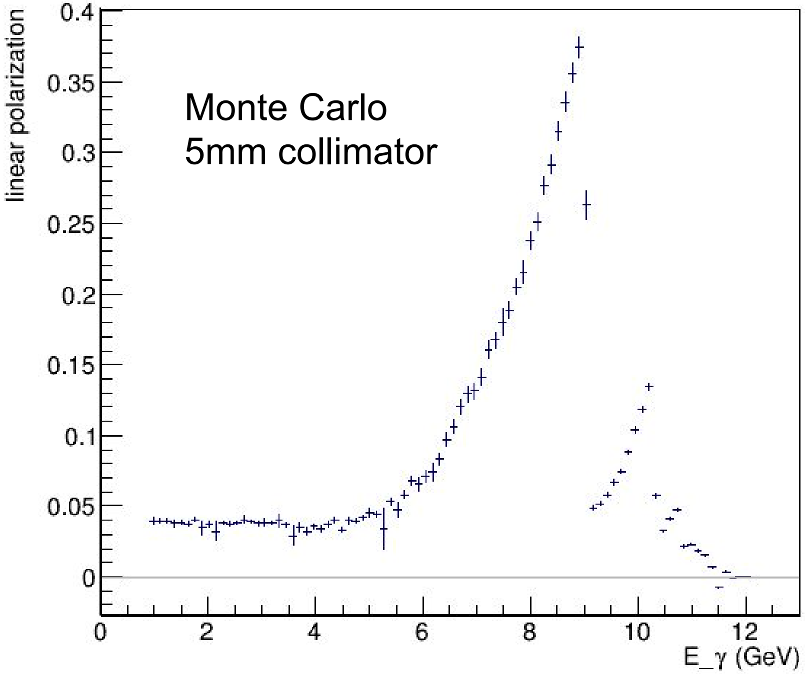
*** Fraction of electron beam outside a radius of 5 mm at goniometer**

Reminder: the beam optics

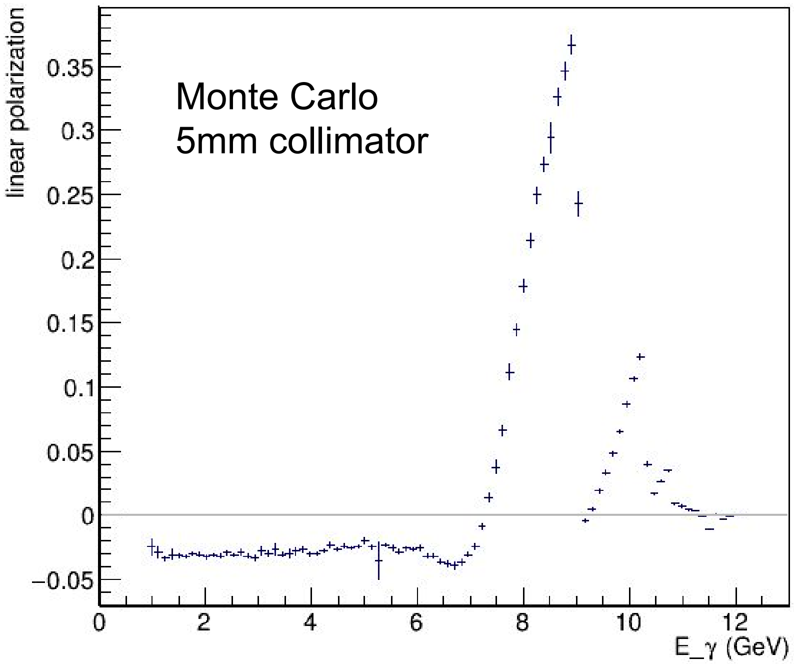


Reminder: why this matters

virtual spot 2.0 x 0.5 mm^2



virtual spot 0.5 x 2.0 mm^2



What was the original plan to measure this spec?

No means to check it was built in, because

1. the 12 GeV lattice had been modelled in detail;
2. sufficient diagnostics were built into the electron beamline to ensure the actual beam optics agrees with the model;
3. we don't actually care about this directly, only the effect it has on the polarization;
4. so if we monitor the polarization well and it agrees with the model, as a by-product we verify that this spec is met!

What do we do when anomalies are seen?

1. PARA / PERP differences in collimated intensity

   fix the goniometer mount so the radiator stays in the beam

2. significantly degraded peak polarization after the collimator

   get an accelerator expert to retune the electron beam ⇐ !!

3. large PARA / PERP differences in the peak polarization

   explore the systematics of the polarization measurement

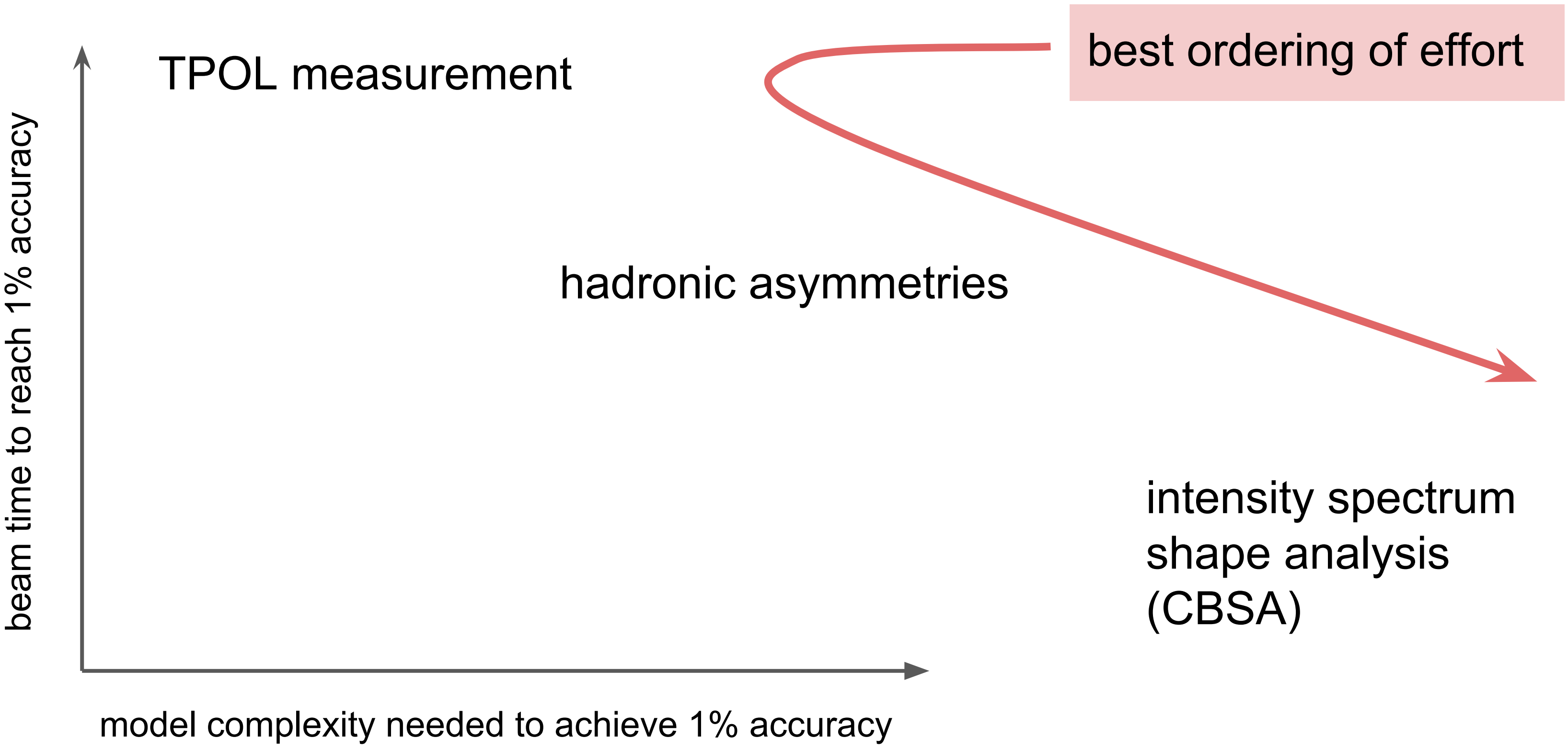
4. large polarization with an amorphous radiator, large φ offsets

   ditto

5. persistence of significant polarization below the peak

   check for reflections from high-order planes in the crystal

Polarization anomalies: where we stand now



Polarization anomalies: where we stand now

Spring 2017 data have greatly improved our understanding:

1. 4 orientations instead of 2
2. TPOL statistical errors smaller by factor 2 (for each setting)

Spring 2016 TPOL polarization, 8.4 - 9.0 GeV

Beam orientation	Polarization
0 degrees	0.402 +/- 0.018
90 degrees	0.388 +/- 0.017

Chi2 / Ndf = 1.7 / 3

Spring 2017 TPOL polarization, 8.2 - 8.8 GeV

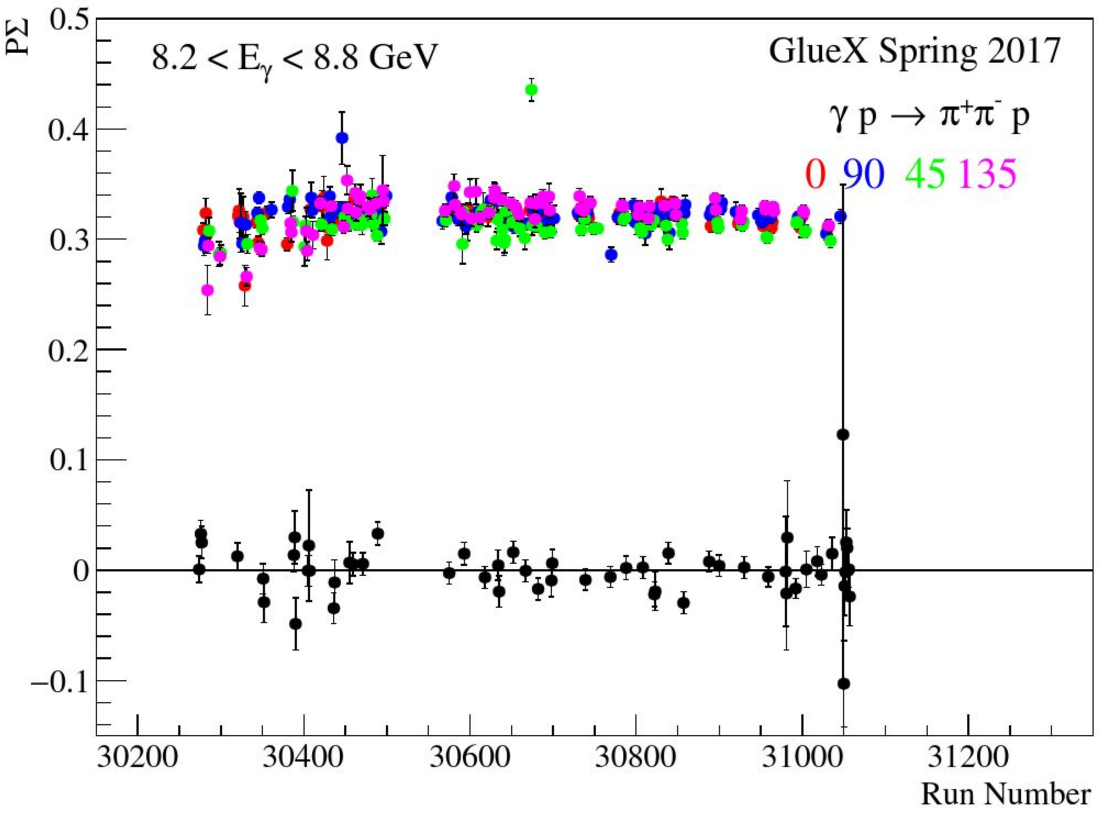
Beam orientation	Polarization
0 degrees	0.3743 +/- 0.0086
45 degrees	0.3774 +/- 0.0087
90 degrees	0.3626 +/- 0.0084
135 degrees	0.3727 +/- 0.0087

Polarization anomalies: where we stand now

Spring 2017 data have greatly improved our understanding.

ρ^0 asymmetry * P

Fluctuations, spread in P both improve over the course of the run period.



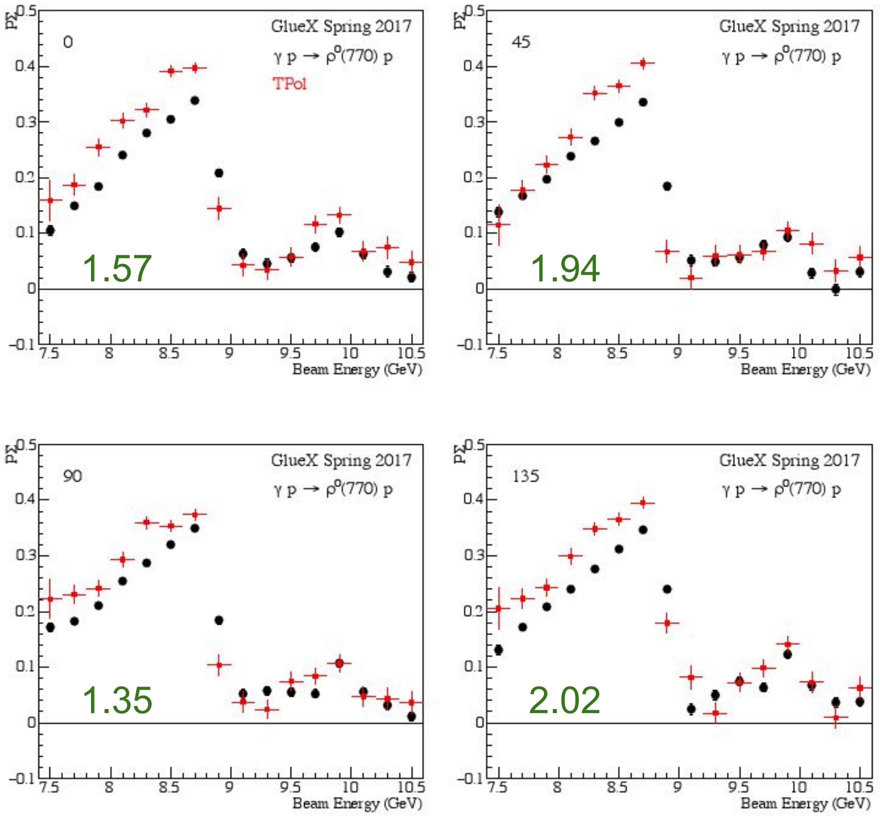
Are TPOL and hadronic PΣ consistent?

Alex Austregesilo

Spring 2017 data have greatly improved our understanding.

ρ^0 asymmetry * P

Can a single constant factor Σ bring these two spectra into agreement?



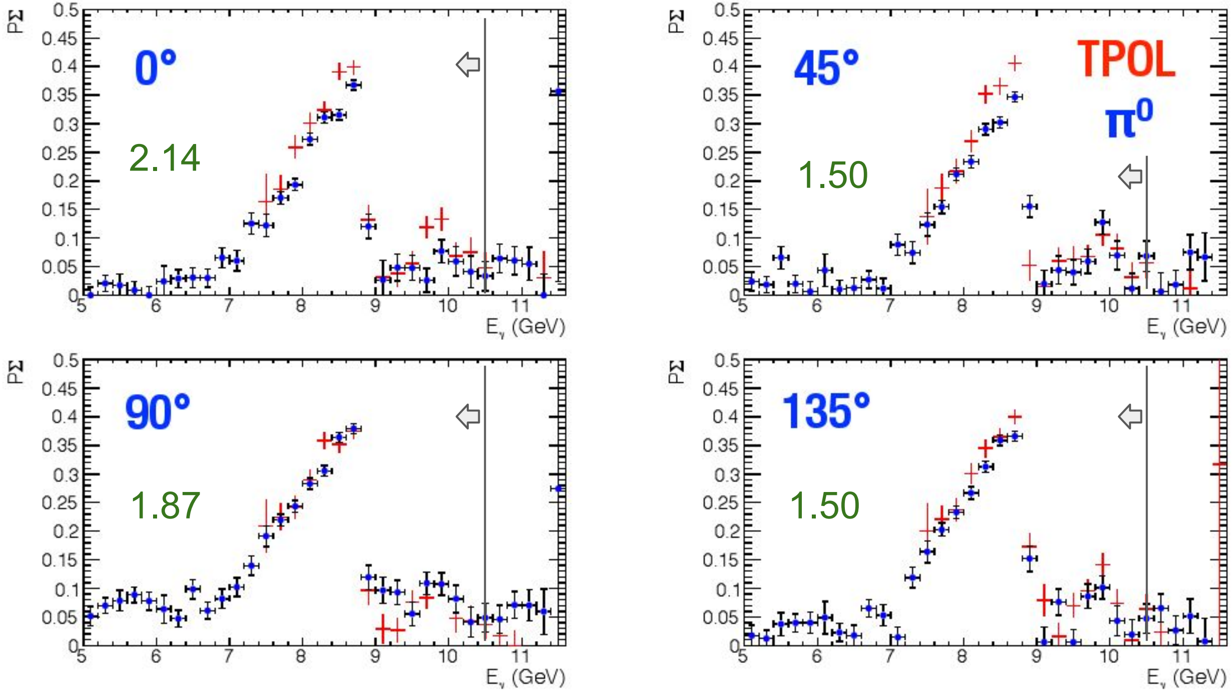
Are TPOL and hadronic PΣ consistent?

J. Stevens

Spring 2017 data have greatly improved our understanding.

π^0 asymmetry * P

Can a single constant factor Σ bring these two spectra into agreement?



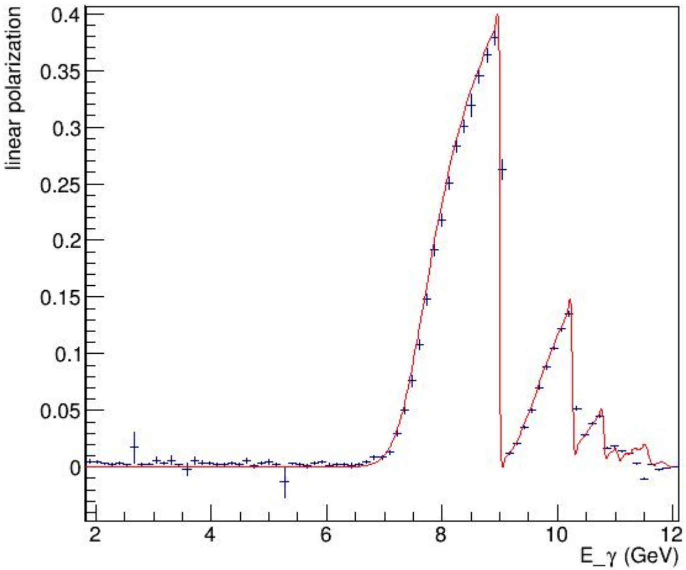
Summary of comparison

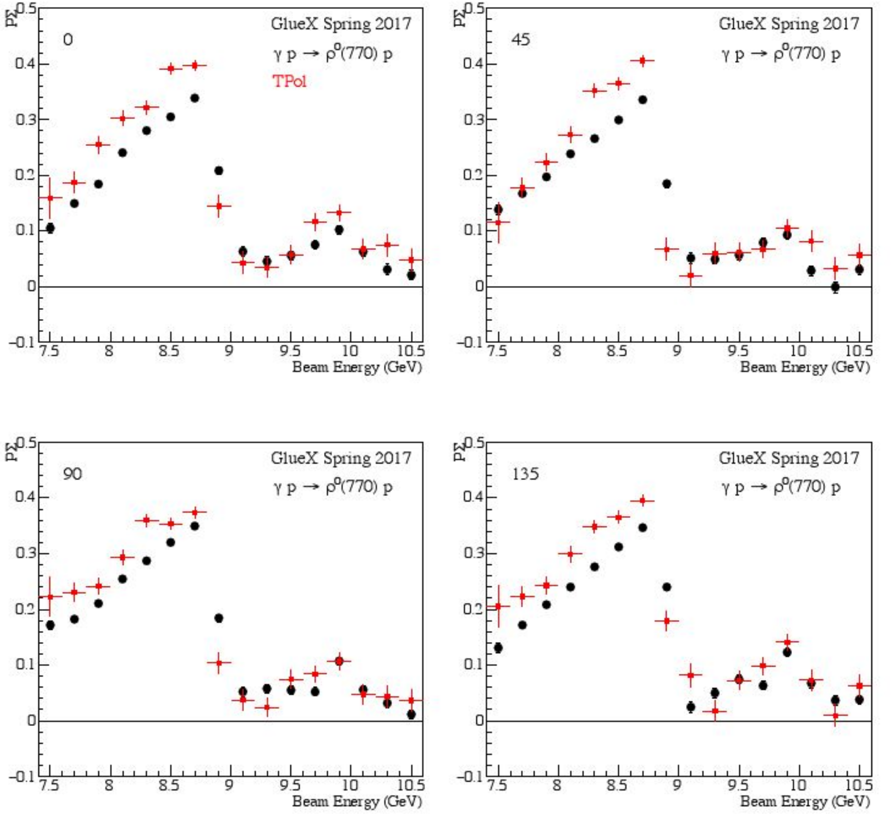
- There is fair agreement between the TPOL polarization spectra and the ρ^0 and π^0 rescaled by an arbitrary factor close to 1.
- Differences between 0° / 90° / 45° / 135° in the shape of the polarization peak persist at the level of 2% absolute.
- Below the primary peak, there is structure that appears to come from unwanted reflections -- *under study.*
- Remaining differences in the 0° / 90° / 45° / 135° suggest that if there is a virtual spot asymmetry, it is much smaller than 4:1.

Summary of comparison

Alex Austregesilo

virtual spot 0.5 x 0.5 mm^2

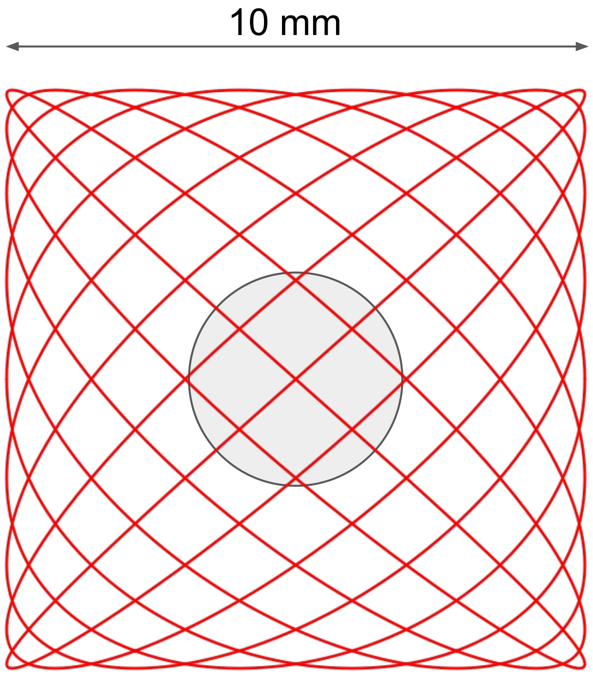




Proposal

“Fast” raster of the electron beam

- X/Y rectangular raster
- Lissajous figure sampling full rectangle
- two incommensurate frequencies 5-25 Hz
- several cycles within a 1.5s readout interval
- 10x10mm square on active collimator



Rough estimate for time for hires scan

$$(30 * 30) * 10 * 10^4 / 10^5 = 900 \text{ s}$$

xy binning

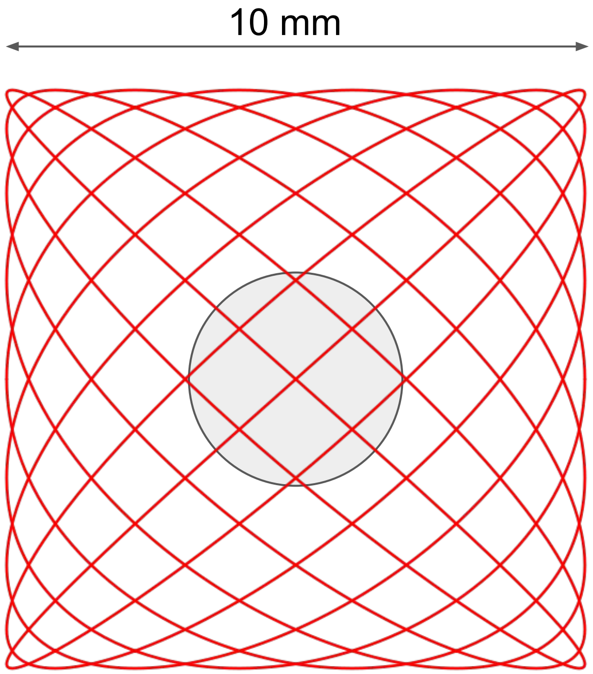
E slices

counts / bin / slice

PS trigger rate

Purpose

- Comparison of TPOL - hadronic PΣ suggests residual 2-3% systematic.
- Next step - fit the collimated spectrum (CBSA)
- Requires detailed electron beam model
- One critical unknown for this model that we need to measure: ***virtual spot profile***
- ***With CBSA working, we get polarization spectra in minutes!***



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