The beam commissioning procedures and polarimetry

Charge Item 8: Are the beam commissioning procedures and machine protection systems sufficiently defined for this stage?

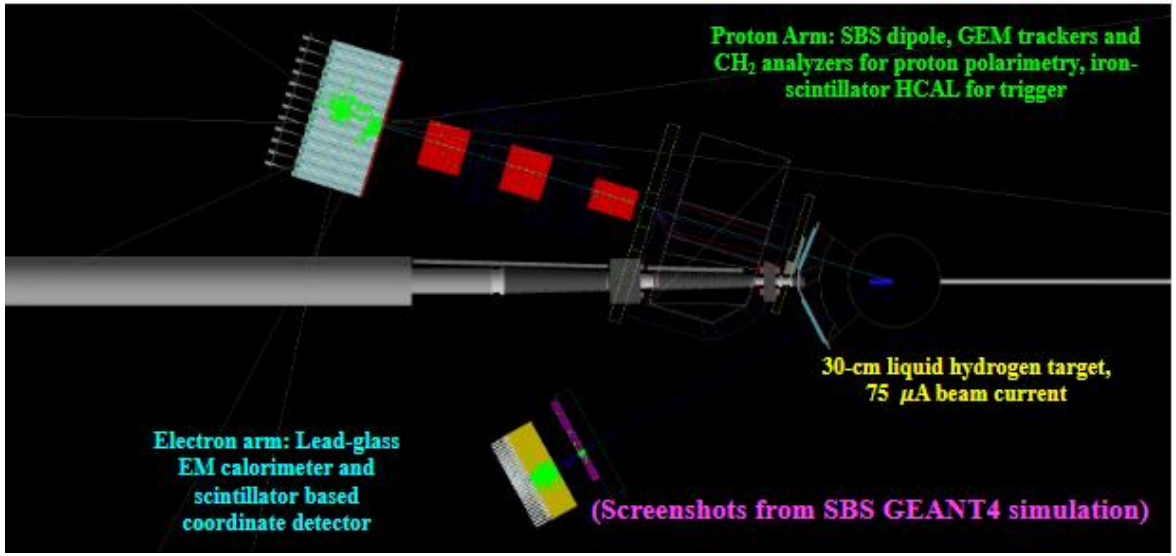
Bill Henry

Wednesday, April 12, 2023

Beamline: GEp requirements

- 30 cm long LH2 cryotarget
- Polarized Beam ~85%
- 75 uA beam
- SBS Magnet + correctors

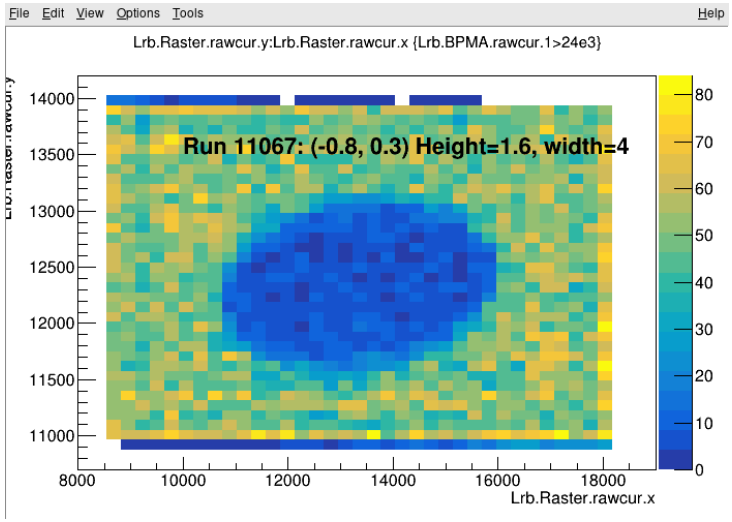
Passes	Energy(GeV)	# PAC Days
3-pass	6.4	2
4-pass	8.5	11
5-pass	10.6	32

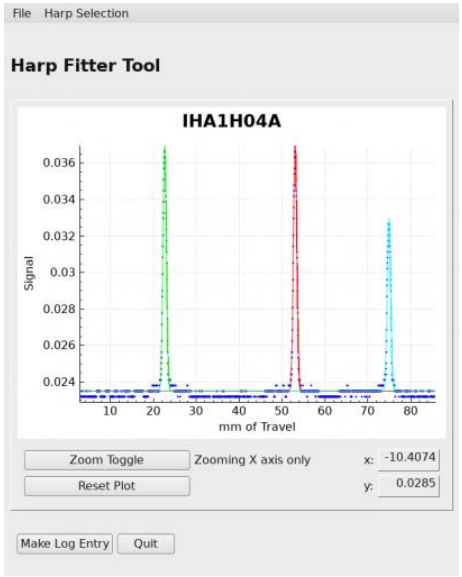


Beamline: Commissioning Procedures

The beam commissioning procedures from GMn will be used for GEp

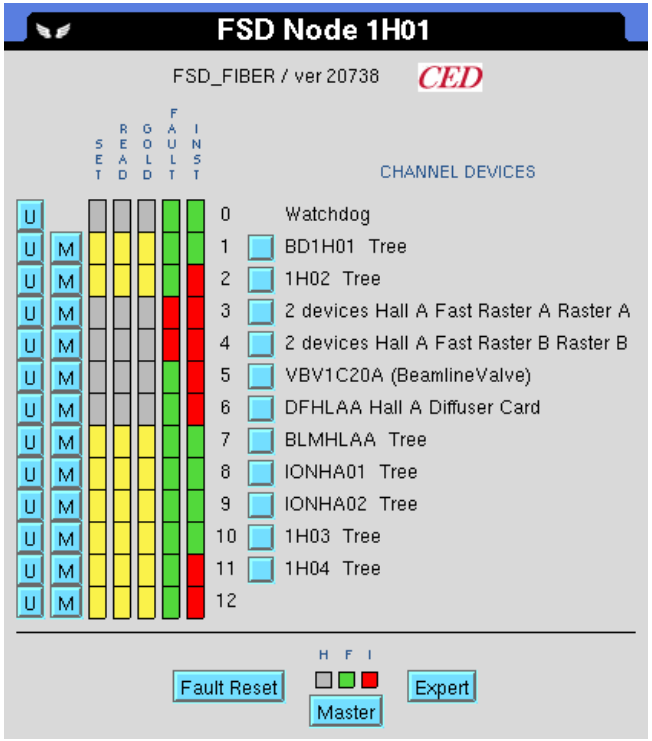
- Beam Delivery to Dump (2021)
- Carbon Hole for beam centering
- Raster Checkout (2014)
- Harp scan for beam profile
- Ion Chamber Calibration (2020)
- Fast Shut Down nodes halog
- BCM Calibrations Linearity Tests (2014) and Unser calibration (2014)
- SBS Dipole Setup Procedure (2021)



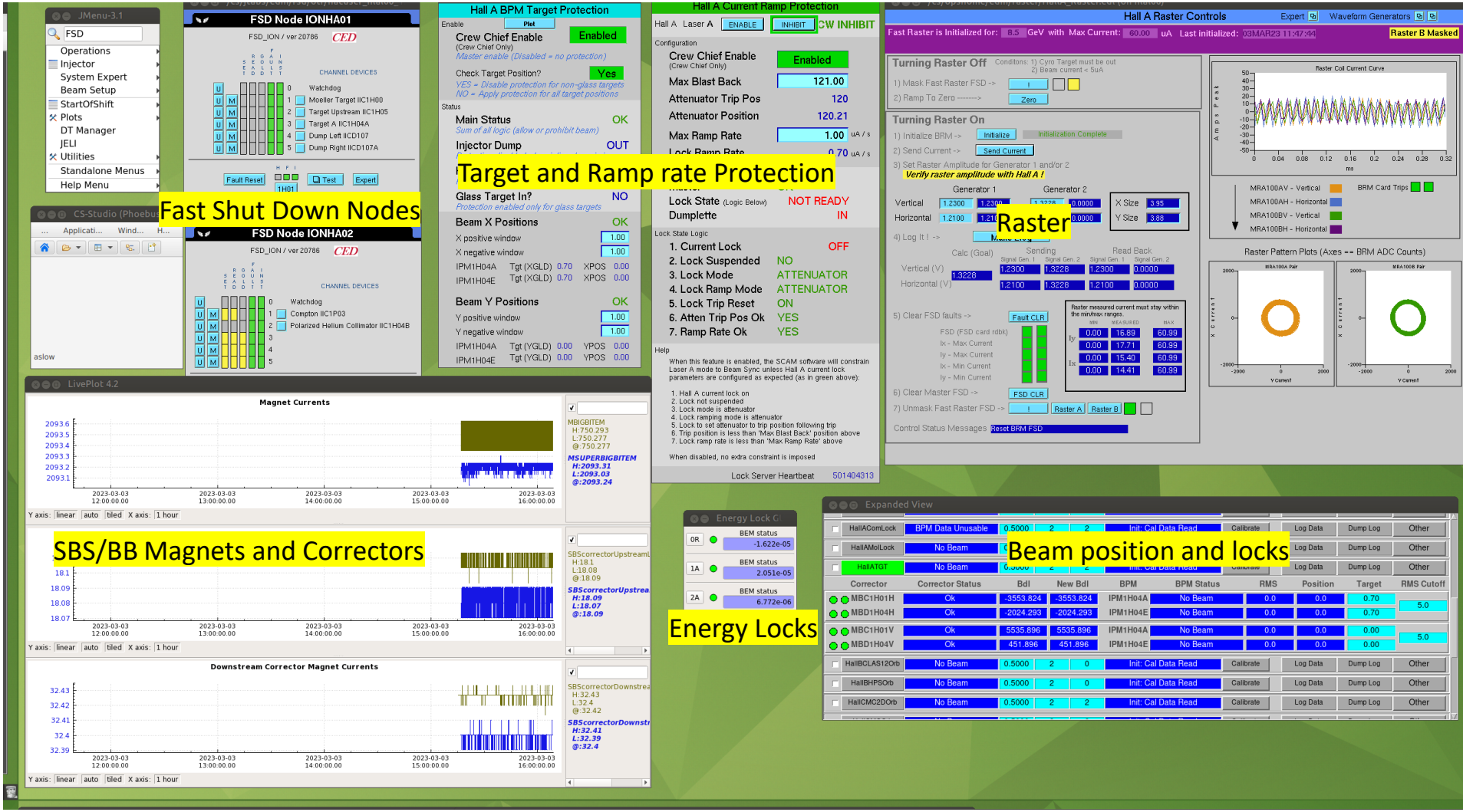


Beamline: Machine Protection Systems (MPS)

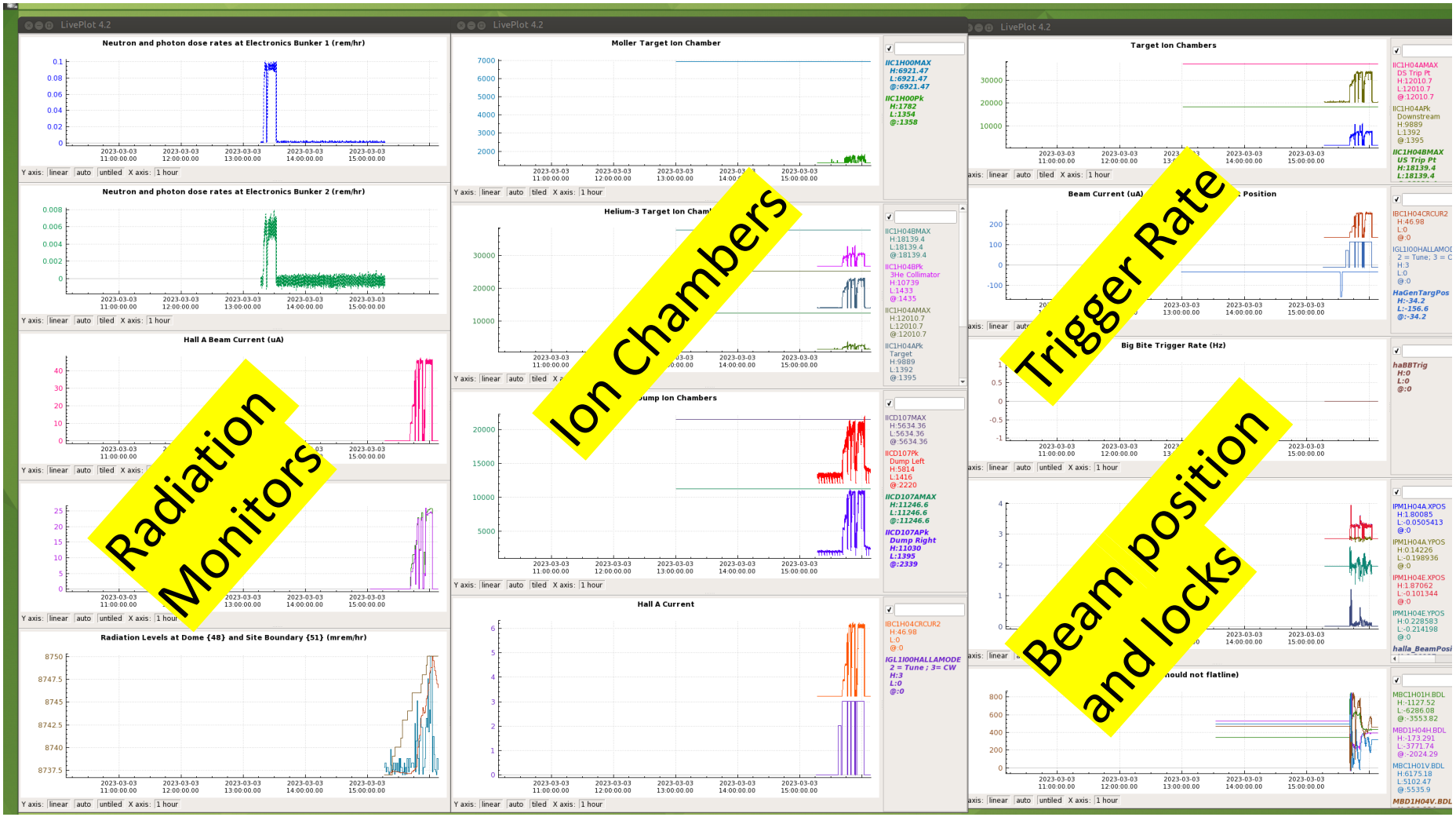
- Fast Shutdown system was refined and checked for GMn by D. Flay See GEn ERR
- FSD nodes include
  - Raster power
  - Beam Loss Monitors
  - Ion Chamber
  - Target Position
  - Beam Dump (H2 Sensor, LCW, diffuser)
  - Beamline vacuum
- GEp will use the same MPS as Gen-RP



Beam Line: Online Monitoring



Beam Line: Online Monitoring

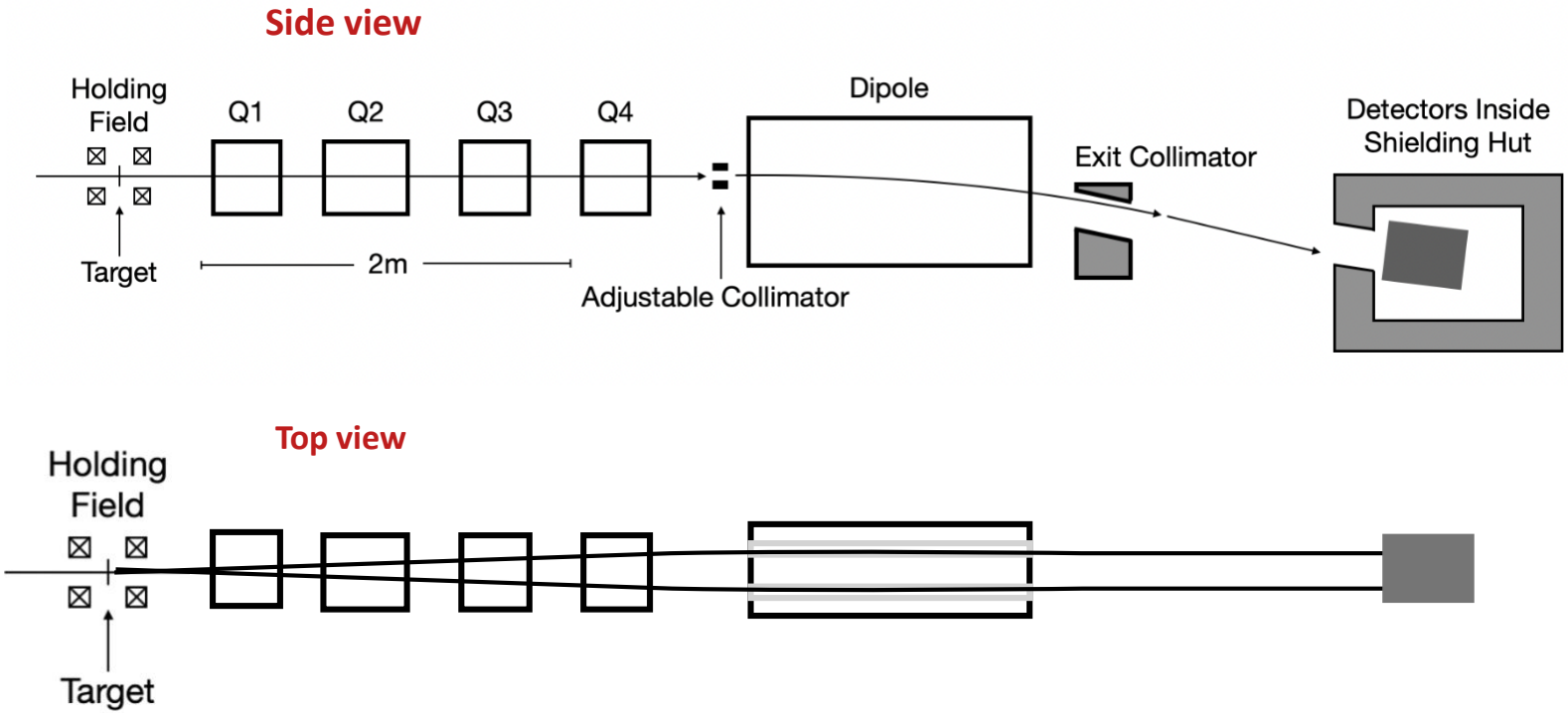


Moller Polarimetry

- Polarimetry cancels to first order in the ratio measurement for GEp
  - Some calculations are better with knowledge of polarization
  - Need to ensure polarization is high
- Polarization will not be optimal given that both A and B want polarized beam for the whole of this run period.
- Both halls will run 10-20 degrees off longitudinal making us more sensitive to small energy/precession changes.

Passes	Energy(GeV)	# PAC Days	Suggested Number of Moller Measurements
3-pass	6.4	2	1 Moller measurements
4-pass	8.5	11	1-2 Moller measurements
5-pass	10.6	32	2-3 Moller measurements

Moller Polarimetry: Optics Solutions



We have solutions for the quad and dipole currents so that the Moller electron pair both make it through the dipole “slots” over a wide energy range.

Demonstrated the ability to find new solutions on the fly with new tools developed.

Slide courtesy of Don Jones

Moller Polarimeter Update

- DAQ seems to be healthy with bugs worked out during GEp
  - Analyzer had several issues that were solved
  - Issues with BCM signals early on but we were able to solve them in real time and appear to have a stable setup now
  - Issue with clock input stability were figured out and we are now aware of what to look for and how to solve it
- Quadrupole and dipole power supplies have issues and there are ongoing discussions with DC power on how to solve these
  - Considering using the BigBite power supply for the dipole and purchasing new power supply for problematic quad 3 and perhaps one new backup before GEp
- Target magnet and motion controls worked well during GEp with single quench due to insufficient time training the magnet before ramping to high field (4T)

Slide courtesy of Don Jones

Discussion of Measurements and Error

- Might take 1 shift to commission
- If things go well expect 1 shift per measurement
  - MCC setup 2 hr
  - Magnet ramp 1 hr
  - Gain matching and calibration 2 hr
  - Measurements 2 hr
  - Ramp down and back out 1 hr
- Systematic error on measurement *per se* will be about 1-1.2%
- Systematic error on polarization for GEp will likely be larger
  - Most of the systematic error will come from extrapolation over time
  - Changes in photocathode (heat and reactivation, spot changes, QE depletion) can cause polarization changes
  - Drifts in energy lead to precession changes which can potentially give significant polarization shifts (not be fully longitudinal but sharing with Hall B)

Slide courtesy of Don Jones

Discussion of Measurements and Error

- Hall B wants polarized beam at 5-pass the whole run. Optimal Wien launch angle for B is -30.6 degrees.
- B and A will average the optimal angle to share polarization equally.
- The following table was constructed using 12 GeV Spin Doctor GUI
- Sensitivity is either 1. change in polarization angle per 0.01% change in momentum **or**
  2. % change longitudinal polarization per 0.01% change in momentum dp/p
- Typical drifts over a few days are are ~0.01%

Pass	Optimal Shared Wien Angle (deg)	Hall A degrees off longitudinal	Expected polarization (assumes 87%)	dP/P Sensitivity (deg/0.01%)	dP/P Sensitivity (%/0.01%)
3-pass	-14.3°	-15.7°	83.8%	0.7°	0.32
4-pass	-47.4°	17.3°	83.1%	1.26°	0.68
5-pass	-28.8°	-1.3°	87%	negligible	negligible

These are from spin calculator but without a spin dance we could be a couple of degrees off these estimates.

Slide courtesy of Don Jones

Beamline: Personal

- Hall A beamline
  - Jiwan P
  - Bill H.
  - Ciprian G.
- Hall A Moller
  - Don Jones (Lead)
  - Eric King
  - Faraz C.
  - Dave G.
  - Bill H.
- Hall A Raster
  - Bill Gunning
  - Bill Henry (needs training)