Hall A Beam Line Status & Plans

For the GMn, GEn-RP, nTPE, WAPP Run Group

David Flay

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Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

Outline

Introduction

- SBS Beam Parameter Overview
- The Hall A Beam Line

Subsystem Status & Tasks

- Upstream Components
- Downstream Components

Commissioning Plans

- Spectrometer B = 0
- Spectrometer B ≠ 0
- Online Monitoring
- Task List at a Glance

Summary

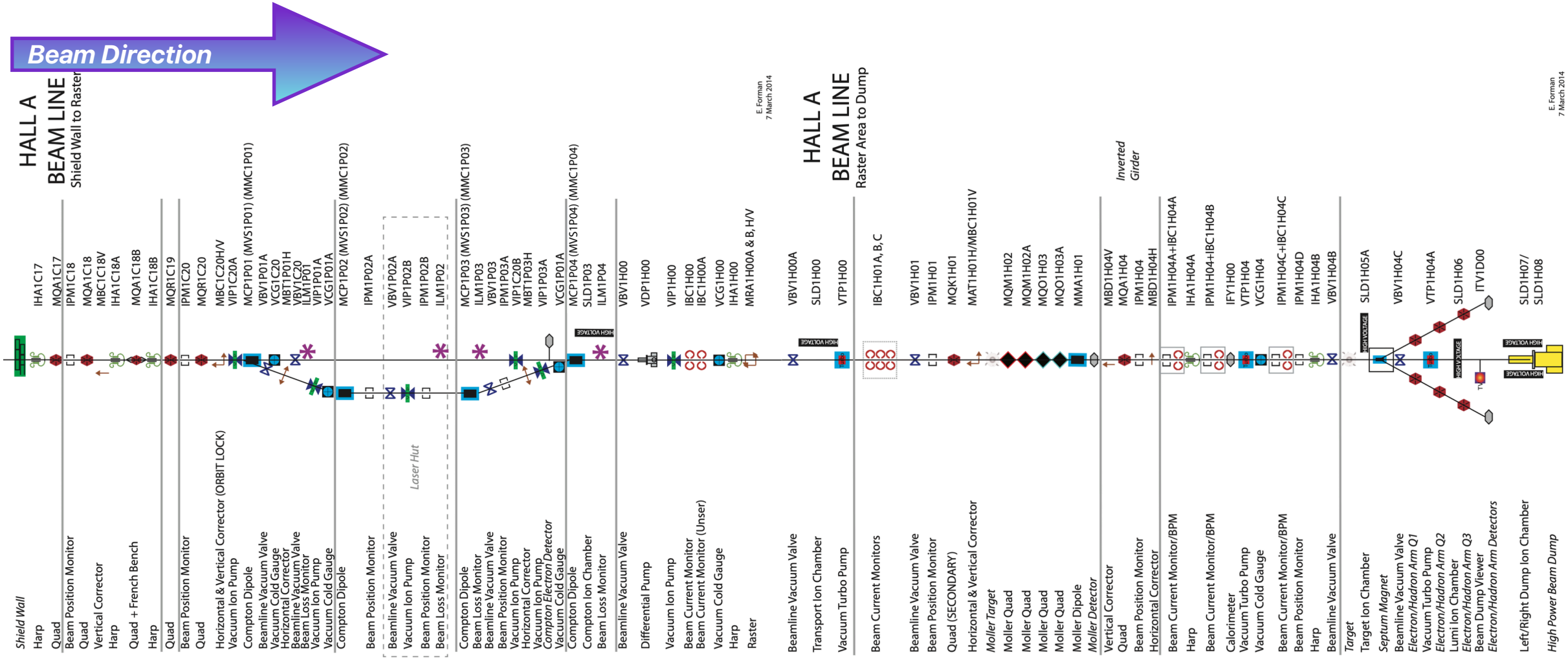
Program Overview — From a Beam Perspective

Experiment	Beam Energy (GeV)	Beam Current (μA)	Max Lumi ($cm^{-2}\,s^{-1}$)	P_{beam} (%)	Beam Diameter (mm)	Raster Size (mm x mm)	Target	Charge Norm. Uncertainty	Observable
GMn	3.74, 4.01, 5.99, 7.95, 9.91	30, 60	2.8×10^{38}	—	0.5	2 x 2 (sq.)	LD2 (15 cm)	—	σ_{unpol} ratios
nTPE	5.56	30	2.8×10^{38}	—	0.5	2 x 2 (sq.)	LD2 (15 cm)	—	$R_{n/p}$ ratio
GEn-RP	5.56	30	2.7×10^{38}	80 ± 1.6	0.5	2 x 2 (sq.)	LD2 (15 cm)	—	P_t, P_ℓ
WAPP	7.38	5	4.5×10^{37} (6×10^{37} w/Cu X_0)	85 ± 1.7	0.5	2 x 2 (sq.)	LD2 (15 cm)	—	K_{LL}, K_{LS}

Note:

- *Luminosity calculated as (nucleons/cm^2) x (electrons/sec)*

Hall A Beam Line Components



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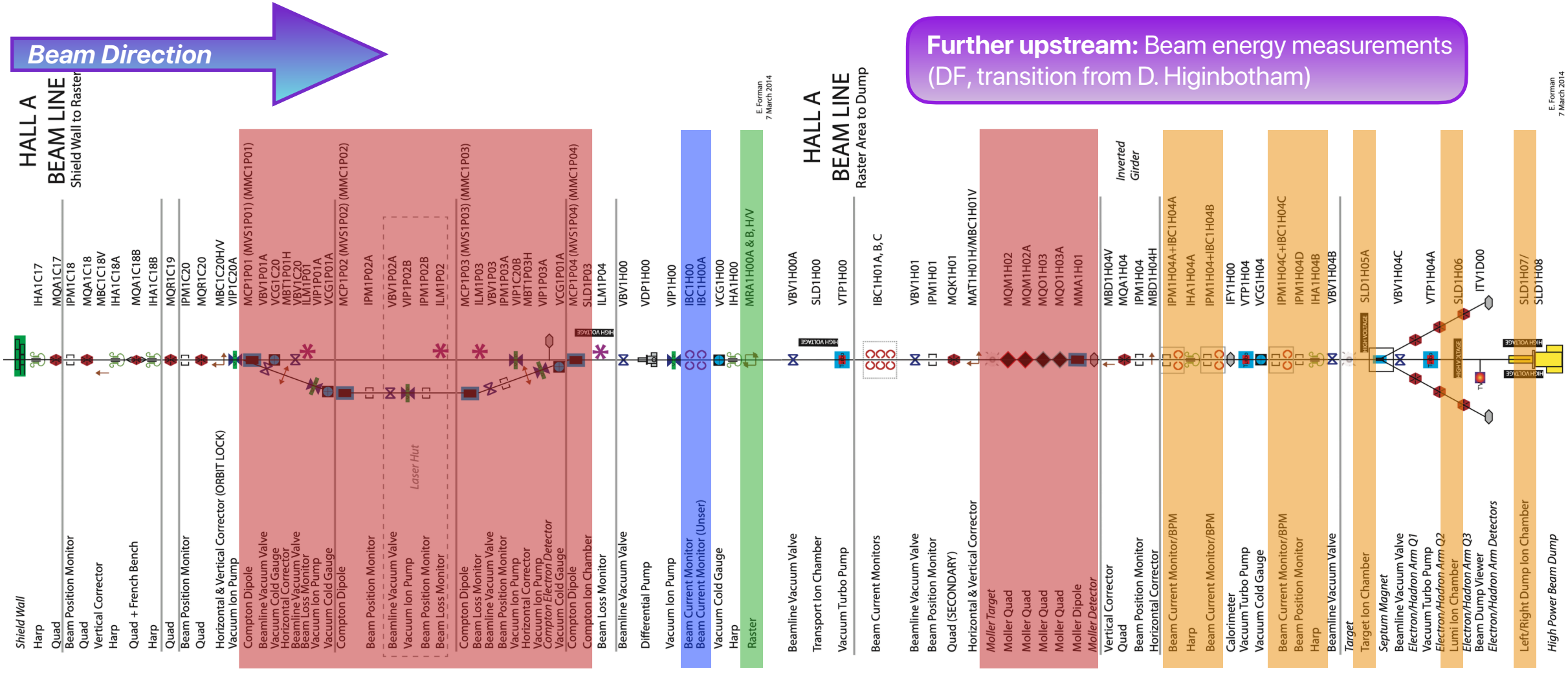
Hall A Beam Line Components



Further upstream: Beam energy measurements (DF, transition from D. Higinbotham)

Compton Polarimeter (D. Gaskell)

BCM, Unser (D. Mack)

Raster (B. Michaels)

Moller Polarimeter (S. Malace)

BPMs, Harps (Accelerator)

Ion Chambers (Accelerator)

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Beam Polarimetry (for GEn-RP, WAPP)

Moller Polarimeter (Simona Malace)

- We have documented procedures for setting up the measurements
- Beam line will stay the same for this run group => the same beam setup procedure for PREX/CREX will be used
- Each beam energy needs a different Moller optics solution (to be determined via simulation). For each beam energy, must allocate 2 shifts: commissioning optics solution + time for one measurement

Compton Polarimeter (Dave Gaskell)

- Not needed or planned to be used for GEn-RP, WAPP

Beam Energy, Charge Monitors, Unser, Raster

Beam Energy (DF, transition from Doug)

- Last bend angle survey was 2018; scheduling a new one w/ Survey & Alignment (3-day effort)
- Each beam energy measurement takes 1 hr

BCMs, Unser (Dave Mack)

- Need to recover systems from parity experiments PREX/CREX
- Set up for beam currents relevant to GMn/GEn-RP/nTPE/WAPP (1—100 μA)
- Work estimate: 2 weeks @ half time

Raster (Bob Michaels)

- PREX/CREX ran with 1 XY pair; need to set up for XY XY configuration
- Estimate 2 weeks for installation and testing (Bill Gunning)

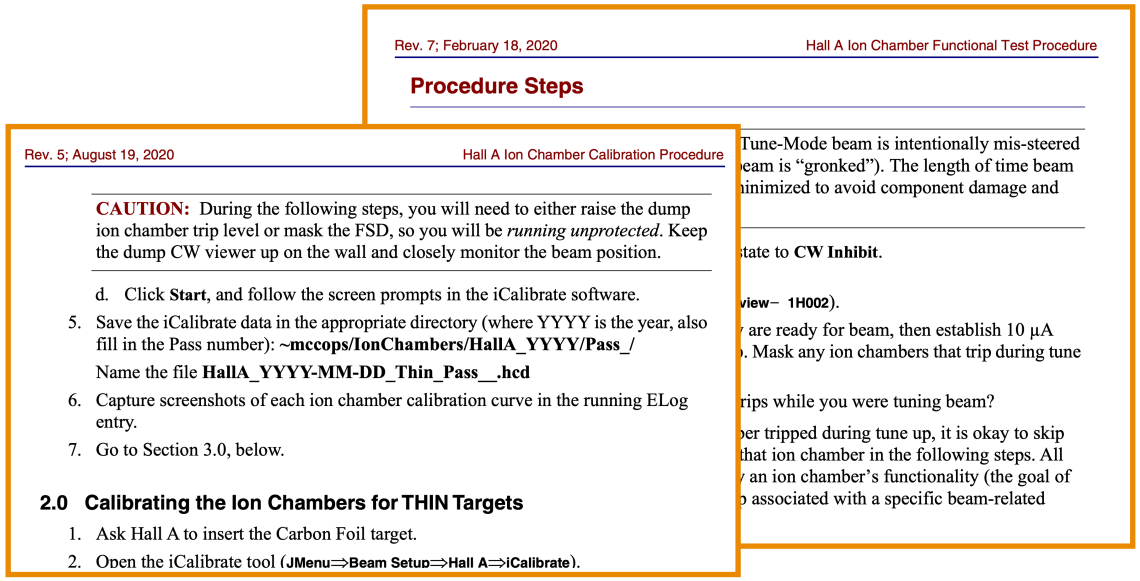
Beam Position Monitors, Harps, Ion Chambers

Beam Position Monitors, Harps

- Standard equipment maintained by Accelerator
- Checkout steps are included in standardized procedures
  - For Harps: Inject signal & check electronics, carriage motion; scan harps and identify wires that are faulty/need fixing
  - BPMs follow similar steps

Ion Chambers

- We will follow recently updated (2020) procedures
  - Calibration
  - Functional Tests



Rev. 7; February 18, 2020 — Hall A Ion Chamber Functional Test Procedure

Procedure Steps

Tune-Mode beam is intentionally mis-steered
eam is "gronked"). The length of time beam
inimized to avoid component damage and

state to **CW Inhibit**.

view– **1H002**).
are ready for beam, then establish 10 μA
. Mask any ion chambers that trip during tune

rips while you were tuning beam?

er tripped during tune up, it is okay to skip
that ion chamber in the following steps. All
an ion chamber's functionality (the goal of
associated with a specific beam-related

Rev. 5; August 19, 2020 — Hall A Ion Chamber Calibration Procedure

CAUTION: During the following steps, you will need to either raise the dump ion chamber trip level or mask the FSD, so you will be *running unprotected*. Keep the dump CW viewer up on the wall and closely monitor the beam position.

d. Click **Start**, and follow the screen prompts in the iCalibrate software.

5. Save the iCalibrate data in the appropriate directory (where YYYY is the year, also fill in the Pass number): **~mccops/IonChambers/HallA_YYYY/Pass_/**

   Name the file **HallA_YYYY-MM-DD_Thin_Pass__.hcd**

6. Capture screenshots of each ion chamber calibration curve in the running ELog entry.
7. Go to Section 3.0, below.

2.0 Calibrating the Ion Chambers for THIN Targets

1. Ask Hall A to insert the Carbon Foil target.
2. Open the iCalibrate tool (**JMenu⇒Beam Setup⇒Hall A⇒iCalibrate**).

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Exit Beam Line Correctors

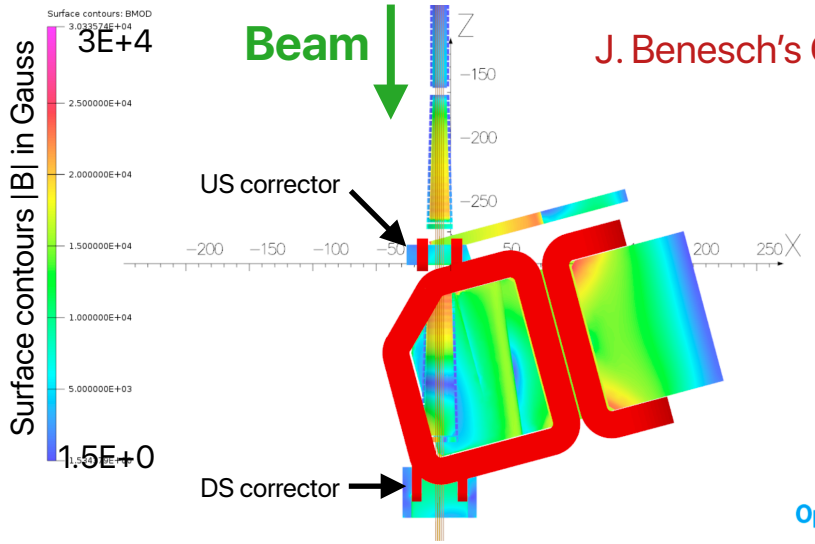
Why Corrector Magnets?

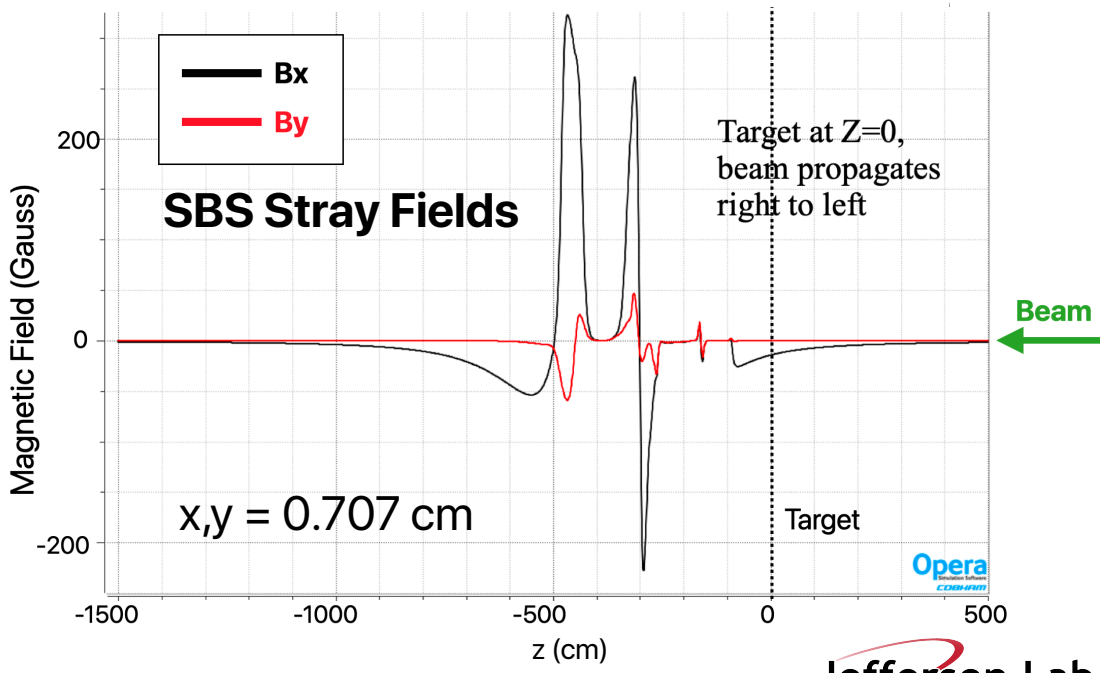
- SBS field (1.56 T-m) will have significant fringe field gradients
- Need to cancel gradients, optimize beam transport to dump
- Independent power for (beam) left and right coils => magnitude + gradient
  - Jay's calculations show powering DS corrector to 90% capacity in a 6/7 L/R ratio to simplify beam steering
  - Have full capacity of US corrector available

Rough Timeline & Tasks

- Estimate to install in April/May
- 12 days for:
  - Installation, survey, alignment
  - Connection of power, temperature sensors, LCW
- Must allocate time to power on the coils and test:
  - Power magnets
  - Measure field magnitude and direction
- CASA working on commissioning and operation plan w/beam

Personnel
J. Butler & team
J. Segal & team
Accelerator
DF





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SBS Beam Line Commissioning (Spect. B = 0)

Step	Description	Beam Type	Raster	Target at Pivot	Duration Estimate (hrs)
Beam Centering	Directions on Wiki: Scan beam position in both x and y directions, and observe rates on rate monitor. Center beam on carbon hole according to rate monitor data	Tune	OFF	Carbon Hole	3–4
BPM Calibration	BPM checkout: record BPM data and perform HARP scans.	Tune	OFF	None (Dump diffuser)	2
Beam Delivery to Dump	Follow Ops procedures to send pulsed beam to beam dump.	Tune	OFF	None (Dump diffuser)	4
IC Calibrations and CW Test	Perform Ion Chamber calibrations; then send CW beam into the hall	Tune/CW	OFF	Target under IC calib None (CW)	1
Raster Checkout	Enable beam rastering and take data. Step up from minimal to full production size. Coordination between MCC and Hall A	CW	ON	None (Dump diffuser)	0.5
BCM Calibrations	Linearity tests and Unser calibration	CW	OFF	None (Dump diffuser)	1.5
Moller Polarimeter Checkout	Perform first measurements according to standard procedures	Tune/CW	OFF	None (Dump diffuser)	16

Green = Updated 2020

SBS Beam Line Commissioning (Spect. B ≠ 0)

Step	Description	Beam Type	BB/SBS Magnet Currents (A)	Raster	Target at Pivot	Duration Estimate (hrs)
Impact of BB, SBS Magnets + Corrector Magnets	Ramp BB and SBS magnets to nominal values for each kinematic point; observe how beam position changes at the dump. Accelerator drafting ops procedure.	Tune/CW	710/2000	ON	None (Dump diffuser)	TBD
Beam Alignment	Directions on Wiki: Scan beam position in both x and y directions, and observe rates on rate monitor. Center beam on carbon hole according to rate monitor data	Tune	710/2000	ON	Carbon Hole	3–4

Online Monitoring & DAQ Details

Monitoring Categories

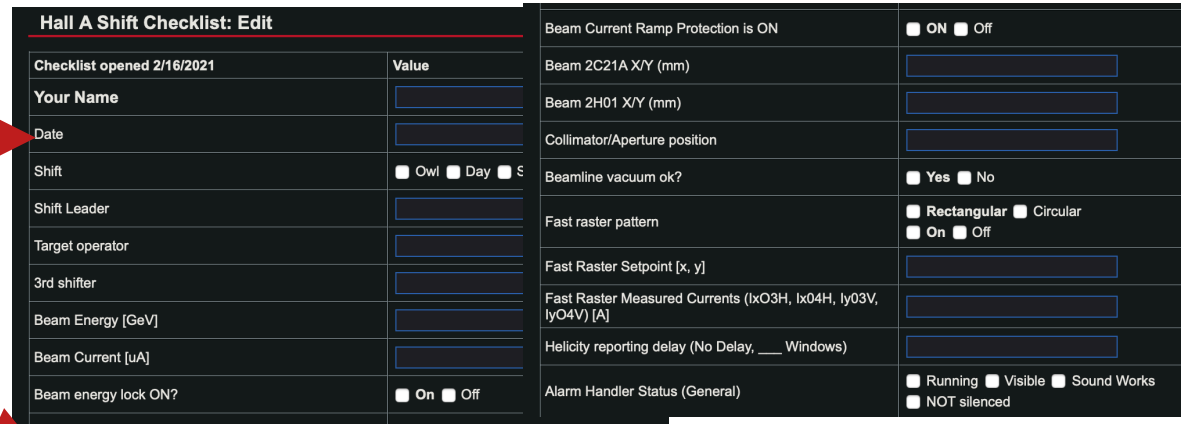
- **Shift checklist:** Top-level (once per shift) check of nominal items
  - Beam energy, current
- **EPICS variables:** Items to monitor on the ~hr time scale
  - BPM, beam energy & dp/p, ion chambers
- **Alarms:** Items that need immediate attention as needed
  - Key BPMs, ICs
  - Three handlers: 1) for target; 2) for spectrometers/vacuum systems; 3) an improved version of the parity alarm handler for general use (Cameron Clarke, SBU)
  - Need to determine optimum setup/combination of these options

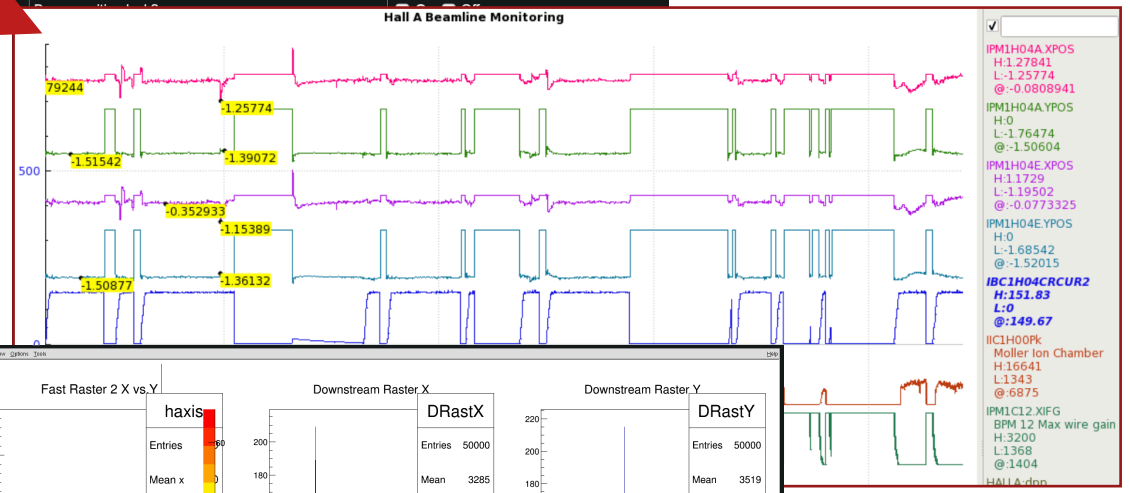
Raster Notes

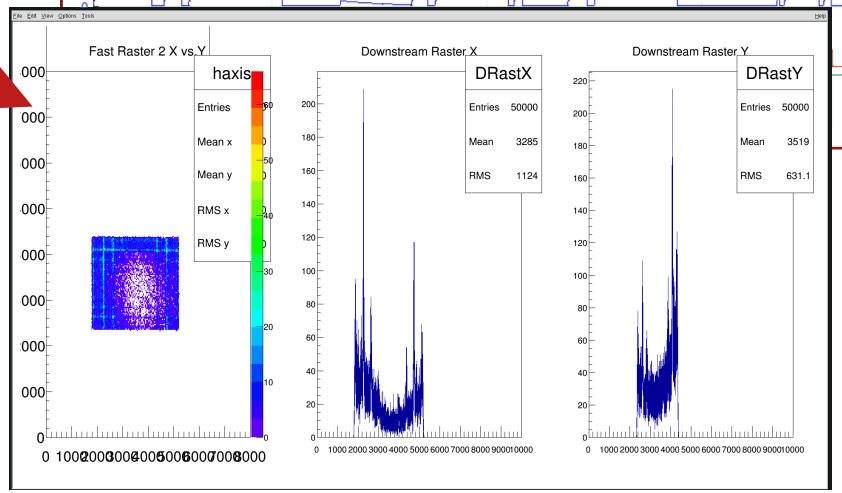
- Raster spot++ usage will be similar to what it was for LHRS/RHRS (though no RHRS version now)

DAQ Readout

- Bob M: Considering reviving the LHRS readout of beam quantities
  - Signals are already in the LHRS for BPM, BCM, helicity, raster currents
  - If these data are redundant in the main SBS DAQ, instructions may be different (TBD)







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At a Glance: Tasks & Time Estimates

Task	Personnel	Time Estimate
BEAM OFF		
BCM, Unser Prep	D. Mack	2 weeks (at half time)
BPM, Harp Checkout	Accelerator	(part of ops procedures)
Corrector Installation, Checkout	J. Butler & team, J. Segal & team, Accelerator, DF	2 weeks+
Raster Preparations	B. Gunning, B. Michaels	2 weeks
ARC Bend Angle Survey	Survey & Alignment	3 days
BEAM ON		
BB, SBS B = 0 Commissioning	Accelerator	13 hrs
BB, SBS B ≠ 0 Commissioning	Accelerator	TBD
Moller Setup and Measurement★	S. Malace, Accelerator	16 hrs
Beam Energy Measurement	DF, transition from D. Higinbotham	1 hr

- Beam-off tasks being scheduled with Jessie

★ Note polarimetry tasks are only valid for GEn-RP and WAPP. Tasks are required for each beam energy

Summary

- We have our task list & personnel identified for beam off and beam on items
- Scheduling beam-off items with Jessie
  - Major item: Corrector installation & setup plan; working with AD to get procedures in place
- Have a beam line commissioning procedure with and without BB, SBS powered
- FSD list being updated to include BB, SBS magnets, correctors

Backup

Machine Protection Systems

- **Fast Shutdown Lock** list refined and checked this past run
  - Outcome of Beam Line Controls task force

FSD Card Name	CED Card Type	Interlocked Device Name	Device Description
FSD_1H01	FSD_FIBER		
		FSD_BD1H01	FSD Card
		FSD_BD1H02	FSD Card
		Hall A Fast Raster A	raster A power
		Hall A Fast Raster B	raster B power
		VBV1C20A	beamline vacuum valve
		DFHLAA Hall A Diffuser Card	dump diffuser plate motion controls
		FSD_BLMHLAA	FSD Card
		FSD_IONHA01	FSD Card
		FSD_IONHA02	FSD Card
		FSD_1H03	FSD Card
FSD_1H02	FSD_ELEC		
		PREX Target Motion	PREX target ladder motion
		9 Vacuum Devices:	monitors beamline valves and thermocouple gauges VBV1C20, VBV1H00, VBV1H00A, VBV1H00B, VBV1H04B, VBV1H04C, VBV1H04X, VTC1H04X, and VTC1H04D
		4 Vacuum Devices:	monitors beamline valves VBV1P01, VBV1P02, VBV1P03, and VBV1P04
		Septum Magnet	septum magnet power
		Hall A Aperture Waterflow	aperture water flow
		Hall A Diffuser Blower Status	dump diffuser blower fan
		Hall A Electron Detector	monitors compton electron detector position
		Hall A Moeller Target	monitors Moeller target motion
		PREX Target Water Flow	PREX target cooling water flow
		PREX Inlet Temperature	PREX target cooling water inlet temperature
FSD_1H03	FSD_ELEC		
		HVIONHA01 (HVCard6CH)	High voltage power supply for Hall A ion chambers
FSD_BLMHLAA	FSD_BLM		
		ILM1P01	beam loss monitor
		ILM1P02	beam loss monitor
		ILM1P03	beam loss monitor
		ILM1P04	beam loss monitor
FSD_IONHA01	FSD_ION		
		Moeller Target Ion Chamber	ion chamber
		Target Upstream Ion Chamber	ion chamber
		Target A Ion Chamber	ion chamber
		Dump Left Ion Chamber	ion chamber
		Dump Right Ion Chamber	ion chamber
FSD_IONHA02	FSD_ION		
		Compton Ion Chamber	ion chamber
		Target B Ion Chamber	ion chamber
FSD_BD1H01	FSD_FIBER		
		FSD_BD1H02	FSD Card
		FSD_BD1H03	FSD Card
FSD_BD1H02	FSD_ELEC		
		IBD1H05 Hall A H2 Alarm	Beam dump hydrogen sensor
FSD_BD1H03	FSD_ADC		
		IBD1H05 Hall A Water Flow	beam dump lcw flow
		IBD1H05 Hall A Differential Pressure	beam dump lcw differential pressure
		IBD1H05 Hall A Supply Pressure	beam dump lcw supply presure
		IBD1H05 Hall A Supply Temperature	beam dump lcw supply temperature

Machine Protection Systems

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Raster

- Fast raster power supplies

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		FSD_BD1H02	FSD Card
		Hall A Fast Raster A	raster A power
		Hall A Fast Raster B	raster B power
		VBV1C20A	beamline vacuum valve
		DFHLAA Hall A Diffuser Card	dump diffuser plate motion controls
		FSD_BLMHLAA	FSD Card
		FSD_IONHA01	FSD Card
		FSD_IONHA02	FSD Card
		FSD_1H03	FSD Card
FSD_1H02	FSD_ELEC		
		PREX Target Motion	PREX target ladder motion
		9 Vacuum Devices:	monitors beamline valves and thermocouple gauges VBV1C20, VBV1H00, VBV1H00A, VBV1H00B, VBV1H04B, VBV1H04C, VBV1H04X, VTC1H04X, and VTC1H04D
		4 Vacuum Devices:	monitors beamline valves VBV1P01, VBV1P02, VBV1P03, and VBV1P04
		Septum Magnet	septum magnet power
		Hall A Aperture Waterflow	aperture water flow
		Hall A Diffuser Blower Status	dump diffuser blower fan
		Hall A Electron Detector	monitors compton electron detector position
		Hall A Moeller Target	monitors Moeller target motion
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FSD_1H03	FSD_ELEC		
		HVIONHA01 (HVCard6CH)	High voltage power supply for Hall A ion chambers
FSD_BLMHLAA	FSD_BLM		
		ILM1P01	beam loss monitor
		ILM1P02	beam loss monitor
		ILM1P03	beam loss monitor
		ILM1P04	beam loss monitor
FSD_IONHA01	FSD_ION		
		Moeller Target Ion Chamber	ion chamber
		Target Upstream Ion Chamber	ion chamber
		Target A Ion Chamber	ion chamber
		Dump Left Ion Chamber	ion chamber
		Dump Right Ion Chamber	ion chamber
FSD_IONHA02	FSD_ION		
		Compton Ion Chamber	ion chamber
		Target B Ion Chamber	ion chamber
FSD_BD1H01	FSD_FIBER		
		FSD_BD1H02	FSD Card
		FSD_BD1H03	FSD Card
FSD_BD1H02	FSD_ELEC		
		IBD1H05 Hall A H2 Alarm	Beam dump hydrogen sensor
FSD_BD1H03	FSD_ADC		
		IBD1H05 Hall A Water Flow	beam dump lcw flow
		IBD1H05 Hall A Differential Pressure	beam dump lcw differential pressure
		IBD1H05 Hall A Supply Pressure	beam dump lcw supply presure
		IBD1H05 Hall A Supply Temperature	beam dump lcw supply temperature

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Raster
- Fast raster power supplies

Beam polarimetry
- Moller & Compton ion chambers
- Moller target motion

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		VBV1C20A	beamline vacuum valve
		DFHLAA Hall A Diffuser Card	dump diffuser plate motion controls
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		FSD_IONHA01	FSD Card
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Target — to be adapted to SBS, under preparation
- Ladder motion
- Auxiliary systems

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Target — to be adapted to SBS, under preparation
- Ladder motion
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Beam Exit — to be adapted to SBS, under preparation
- Diffuser monitors, BLMs, LCW monitors
- Need to add SBS magnet, correctors

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		HVIONHA01 (HVCard6CH)	High voltage power supply for Hall A ion chambers
FSD_BLMH[illegible]AA	FSD_BLM		
		ILM1P01	beam loss monitor
		ILM1P02	beam loss monitor
		ILM1P03	beam loss monitor
		ILM1P04	beam loss monitor
FSD_IONHA01	FSD_ION		
		Moeller Target Ion Chamber	ion chamber
		Target Upstream Ion Chamber	ion chamber
		Target A Ion Chamber	ion chamber
		Dump Left Ion Chamber	ion chamber
		Dump Right Ion Chamber	ion chamber
FSD_IONHA02	FSD_IO		
		Compton Ion Chamber	ion chamber
		Target B Ion Chamber	ion chamber
FSD_BD1H01	FSD_FIBER		
		FSD_BD1H02	FSD Card
		FSD_BD1H03	FSD Card
FSD_BD1H02	FSD_ELEC		
		IBD1H05 Hall A H2 Alarm	Beam dump hydrogen sensor
FSD_BD1H03	FSD_ADC		
		IBD1H05 Hall A Water Flow	beam dump lcw flow
		IBD1H05 Hall A Differential Pressure	beam dump lcw differential pressure
		IBD1H05 Hall A Supply Pressure	beam dump lcw supply presure
		IBD1H05 Hall A Supply Temperature	beam dump lcw supply temperature