Hall A Beam Line

Charge 7: Beam Line Commissioning and Machine Protection Systems

E12-09-16 Experimental Readiness Review

David Flay

Oct 22, 2020

Charge Being Addressed

Charge 7: Are the beam commissioning procedures and machine protection systems sufficiently defined at this stage?

Outline

Introduction

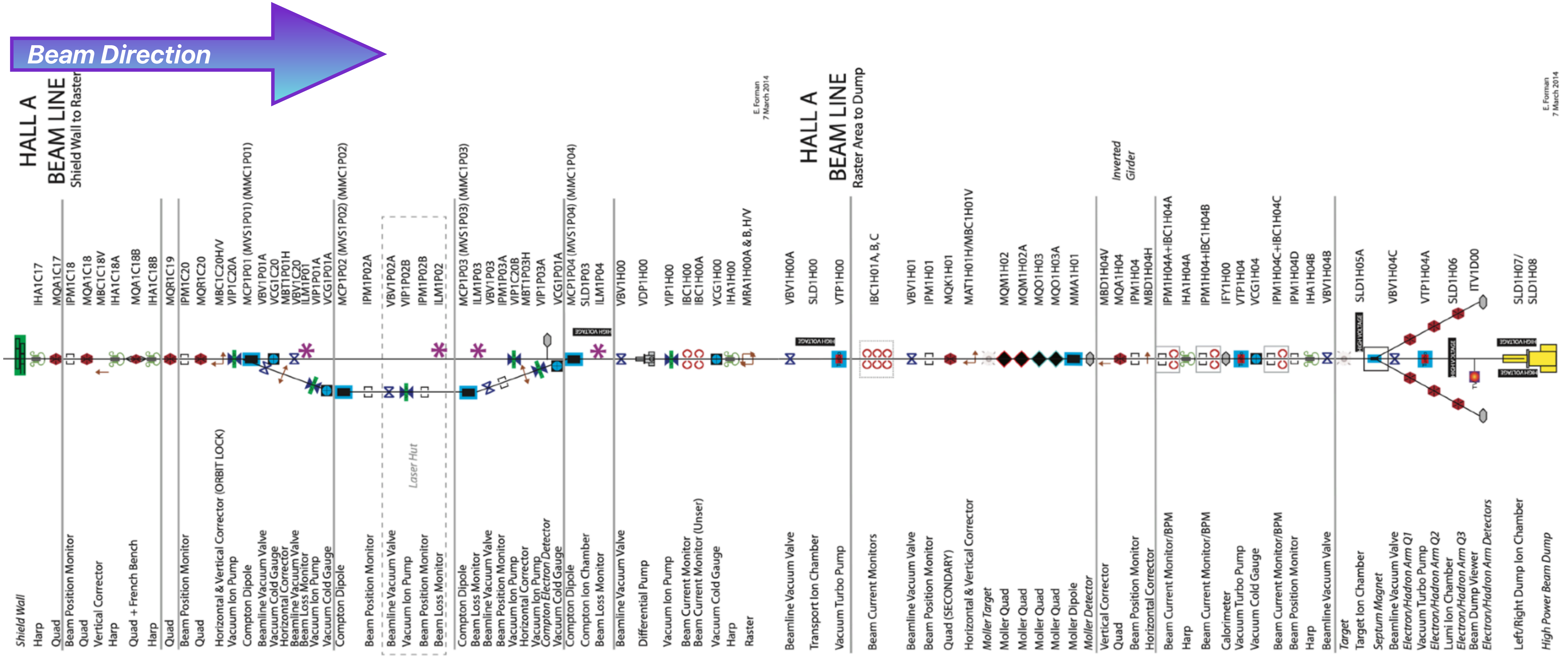
- Beam Line Components for GEn

Addressing Charge Questions

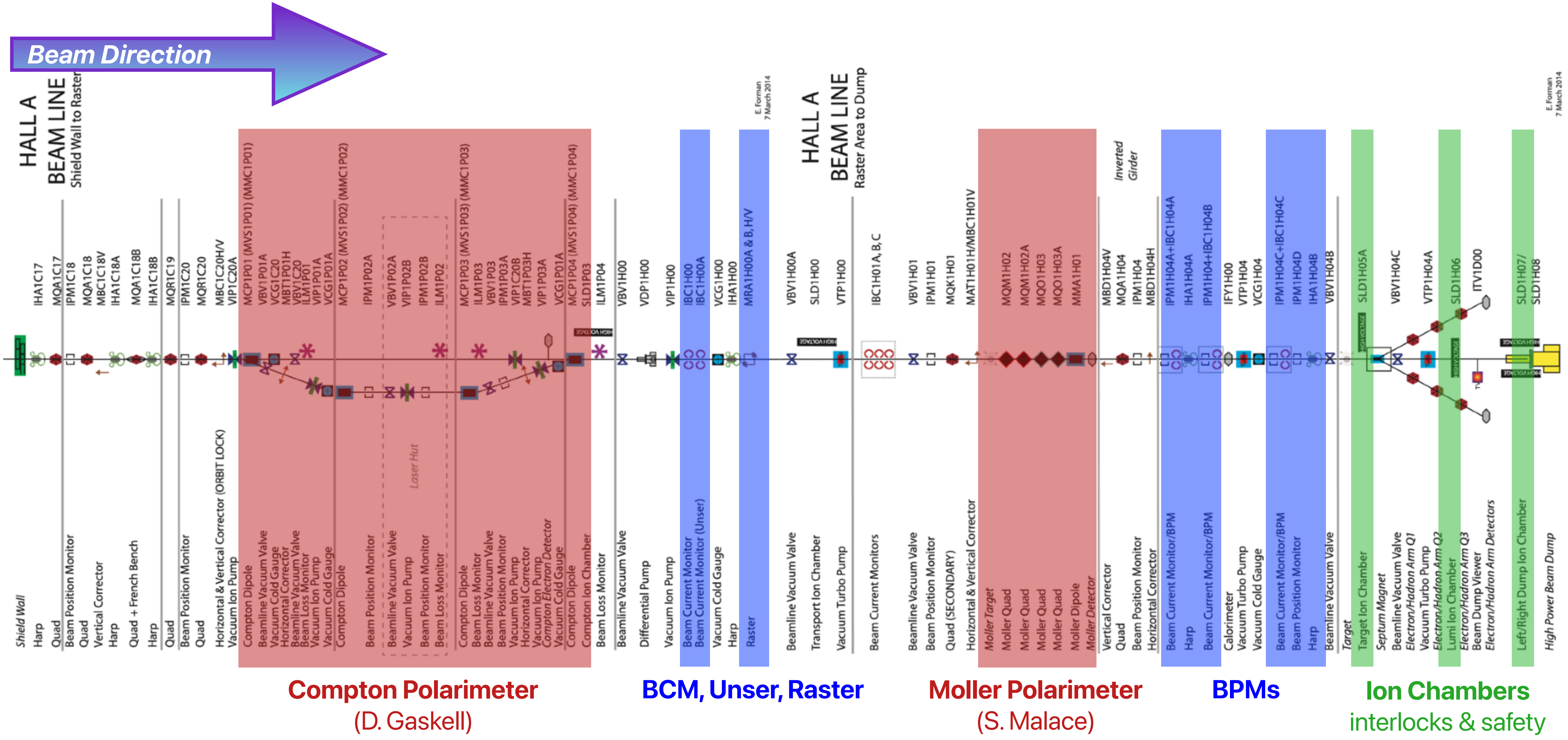
- Charge Part 1: Beam Commissioning Procedures
- Charge Part 2: Machine Protection Systems

Summary

Beam Line Components for GEn



Beam Line Components for GEn



Jefferson Lab

Beam Line Components for GEn

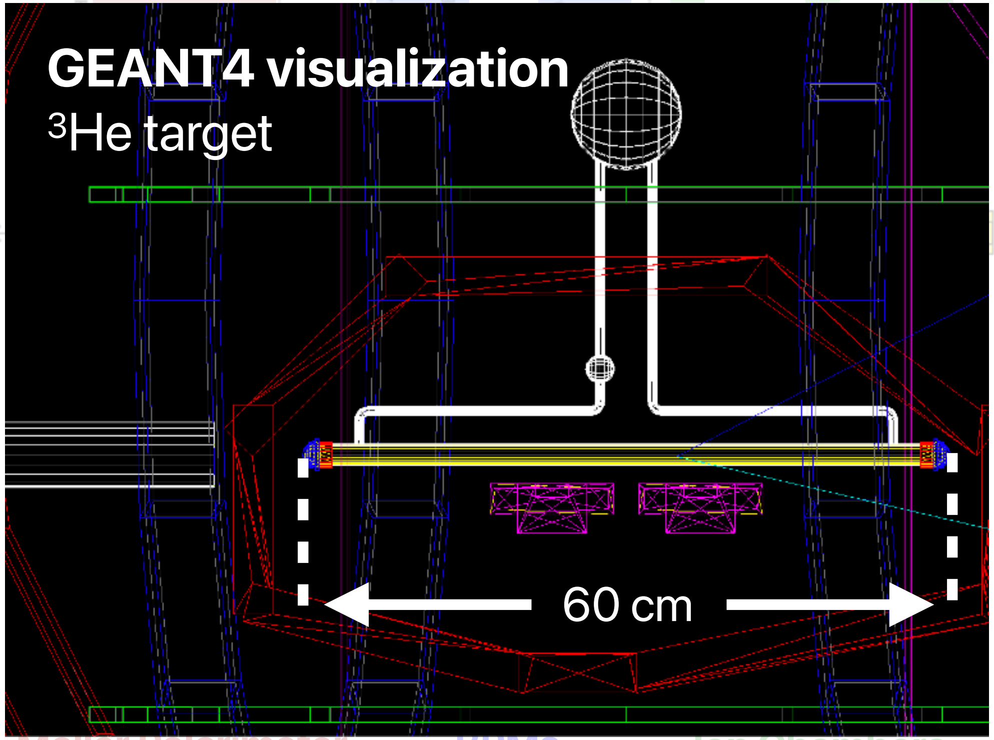
GEn will use standard beam line elements

Commissioning Needs

- Verification of systems (Polarimeters, BPMs, raster, corrector magnets)
- Calibration of BPMs, raster, ICs
- Center beam on target

Experiment Run Needs

- Protect the ^{3}He cell with strong beam controls



Beam Polarimetry

Compton Polarimeter

- Generally sensitive to beam-related backgrounds
- First time sending beam through Compton chicane, have accelerator expert work with Ops Team to get backgrounds to acceptable levels (~3 kHz for GEn). This is a well-known procedure
- Once beam backgrounds at good enough levels, can perform commissioning & checkout non-invasively

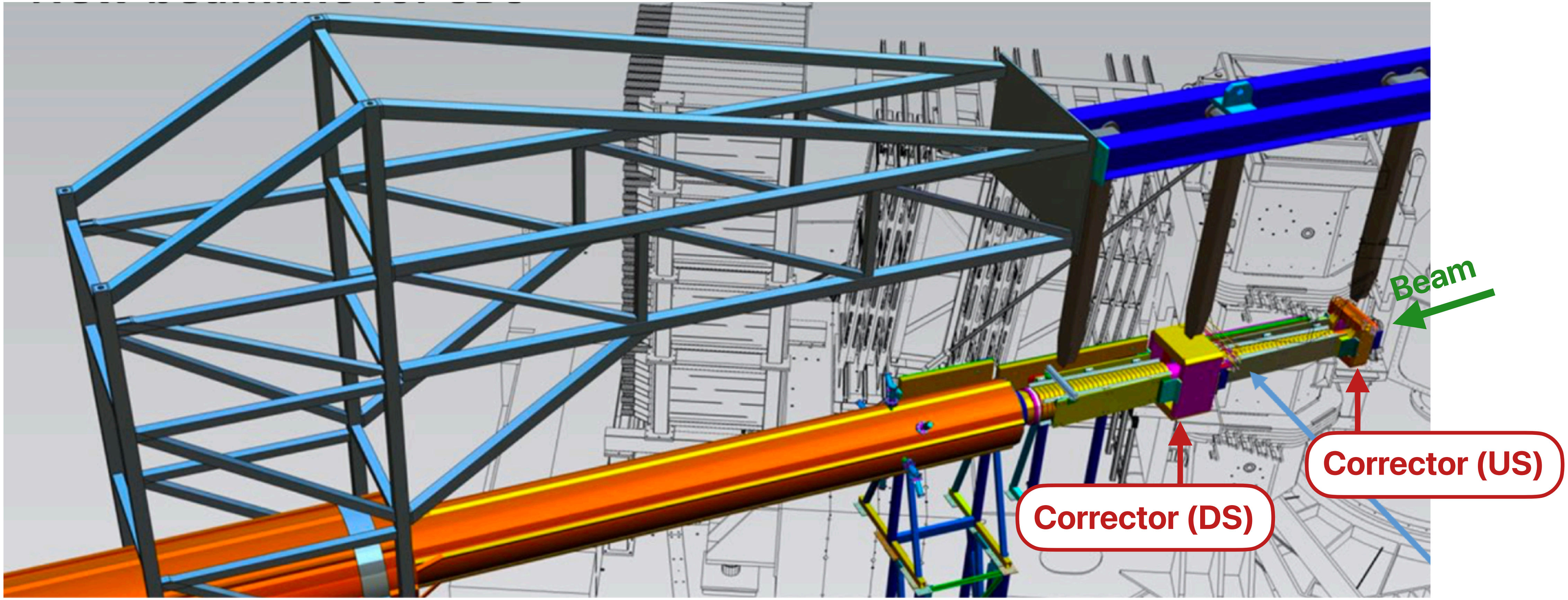
Moller Polarimeter

- We have documented procedures for performing the measurements
- If the beam line configuration does not change, the same beam setup procedure for PREX/CREX will be used. Otherwise, additional commissioning time will be needed for each beam energy
- 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

Raster

- Will use Hall C circular raster setup
  - Hall C EPICS software was updated for the circular raster; need to update Hall A's software
  - Can use Hall C equipment (function generators, amplifiers) in Hall A
- Need to install hardware and software, verify proper operation
- Operational Considerations— utilize experience from recent Hall C running
  - Hall C ran with 30 μA beam, 4 mm diameter raster
  - GEn will use 60 μA, 6 mm diameter => raster needs to be ~2.2x larger area; smaller beam energy of 8.8 GeV partially compensates for this
  - Main issue: raster upstream of quads coupled with long target length of 60 cm
    - Aside/consequence: Difference in raster sizes for MCC vs Hall "units"

Exit Beam Line Correctors



- Existing and functional equipment
  - Will have been commissioned and operational for GMn (summer 2021)
- Perform general checkout task: ramping both magnets to their nominal current values (38 kA*turn)

Ion Chamber Calibrations

- We will follow the Hall C procedure used during the recent d_2^n run
  - Updated procedures relevant for our target

1. The Hall C Ion Chamber Functional Test Procedure must be performed first, before this calibration procedure, if any of the following are true:
    - Since the last functional test, the H
      or ion chamber hardware has been
    - Since the last functional test, there
      hardware changes in the hall that r
    - Since the last functional test, the H
      graded in the System Readiness T
      "Ready" now).

   NOTE: SHMS and HMS changes DO
   test.

1.0 Determining if a Calibration is Required

1. Are either of the following statements true?
    - The beam energy delivered to Hall C has changed (i.e., a Hall C pass change or CEBAF energy change).
    - The SHMS configuration has changed (including magnet currents, magnet polarities, and spectrometer angle) and beam is no longer visible on the CW dump viewer, ITV3H10A.

      NOTE: The SHMS configuration is controlled
      Operations, so the configuration could change
      being informed. It is, therefore, critical for Oper
      dump viewer, ITV3H10A, to maintain positive
      beam is making it to the dump.

      NOTE: HMS configuration changes do not re
      recalibration.

   NO YES → **A.** A new ion chamber calibration must be perforn
   tion data is already available for the same runni
   Section 2.0, page 4.

2. Select the intended target configuration, below.

   Required Calibrations for Fall 2019/Spring 2020

1. Open an FSD Overview Screen (**JMenu⇒Operations⇒FSD⇒FSD Overview**) and verify the following:
    - On FSD node **3H02**, the **HVIONHC01 VME-CAEN-ION** bit is unmasked and clear
    - From FSD nodes **IONHC01** and **IONHC02**, open the expert screens and verify the following.
        - All six ion chambers are unmasked.
        - All **Threshold** values have been set to their maximum value, 65535.
        - All **Max** values have been set to ~20K.
        - All **Bias** values have been set to their maximum value, 65535.
2. Perform an Allsave and include the comment *"Before Hall C Ion Chamber Calibration"*.
3. Start a running ELog entry with the title *"Hall C Ion Chamber Calibration for Target xx, at pass/energy xx"*.

Part 1: Commissioning Procedures (Spect. B = 0)

Step	Description	Beam Type	BB/SBS Magnet Currents (A)	Raster	Target at Pivot
Beam Centering	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	0/0	OFF	Carbon Hole
BPM Calibration	BPM checkout: record BPM data and perform HARP scans.	Tune	0/0	OFF	None (Dump diffuser)
IC Calibrations and CW Test	Perform Ion Chamber calibrations up to 60 µA; Then send CW beam into the hall	Tune/CW	0/0	OFF	Target under IC calib None (CW)
Beam Delivery to Dump	Follow Ops procedures to send pulsed beam to beam dump.	Tune	0/0	OFF	None (Dump diffuser)
Raster Checkout	Enable beam rastering and take data. Step up from minimal to full production size. Coordination between MCC and Hall A	CW	0/0	ON (D = 6 mm)	None (Dump diffuser)
BCM Calibrations	Linearity tests and Unser calibration	CW	0/0	OFF	None (Dump diffuser)
Compton Polarimeter Checkout	CASA & Ops reduce beam backgrounds during first delivery through chicane; continue with non-invasive tasks. *Then check low current CW*	Tune/CW	0/0	OFF	None (Dump diffuser)
Moller Polarimeter Checkout	Perform first measurements according to standard procedures	Tune/CW	0/0	OFF	None (Dump diffuser)

Updated 2020

Part 1: Commissioning Procedures (Spect. $B \neq 0$)

Step	Description	Beam Type	BB/SBS Magnet Currents (A)	Raster	Target at Pivot
Impact of BB, SBS Magnets	Ramp BB and SBS magnets to nominal values; observe how beam position changes at the dump. Will follow procedure used for SHMS.	CW	710/2000	ON (D = 6 mm)	None (Dump diffuser)
Corrector Magnet Checkout	Ramp correctors to nominal values; verify beam spot on dump	CW	710/2000	ON (D = 6 mm)	None (Dump diffuser)
Target Scraping Check	Check alignment to center of target; move beam in x and y to find target edges. Low beam current. Step raster up from small values to full production size. *Use reference cell for safety.*	CW	710/2000	ON (small and increase to D = 6 mm)	Reference Cell (N2)
Beam Energy Measurements	For a given beam energy, perform measurement according to the written procedure	CW	710/2000	OFF	None (Dump diffuser)

Part 2: 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

Part 2: Machine Protection Systems

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Raster

- Fast raster power supplies

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		FSD_BD1H02	FSD Card
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		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
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		Hall A Aperture Waterflow	aperture water flow
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		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

Part 2: Machine Protection Systems

- **Fast Shutdown Lock** list refined and checked this past run
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Raster

- Fast raster power supplies

Beam polarimetry

- Moller & Compton ion chambers
- Moller target motion

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		ILM1P03	beam loss monitor
		ILM1P04	beam loss monitor
FSD_IONHA0[illegible]	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

Part 2: Machine Protection Systems

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  - Outcome of Beam Line Controls task force

Raster

- Fast raster power supplies

Beam polarimetry

- Moller & Compton ion chambers
- Moller target motion

Target — to be adapted to SBS, under preparation

- Ladder motion
- Auxiliary systems

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Part 2: Machine Protection Systems

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

Raster
- Fast raster power supplies

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

Target — to be adapted to SBS, under preparation
- Ladder motion
- Auxiliary systems

Beam Exit: Diffuser monitors, BLMs, LCW monitors

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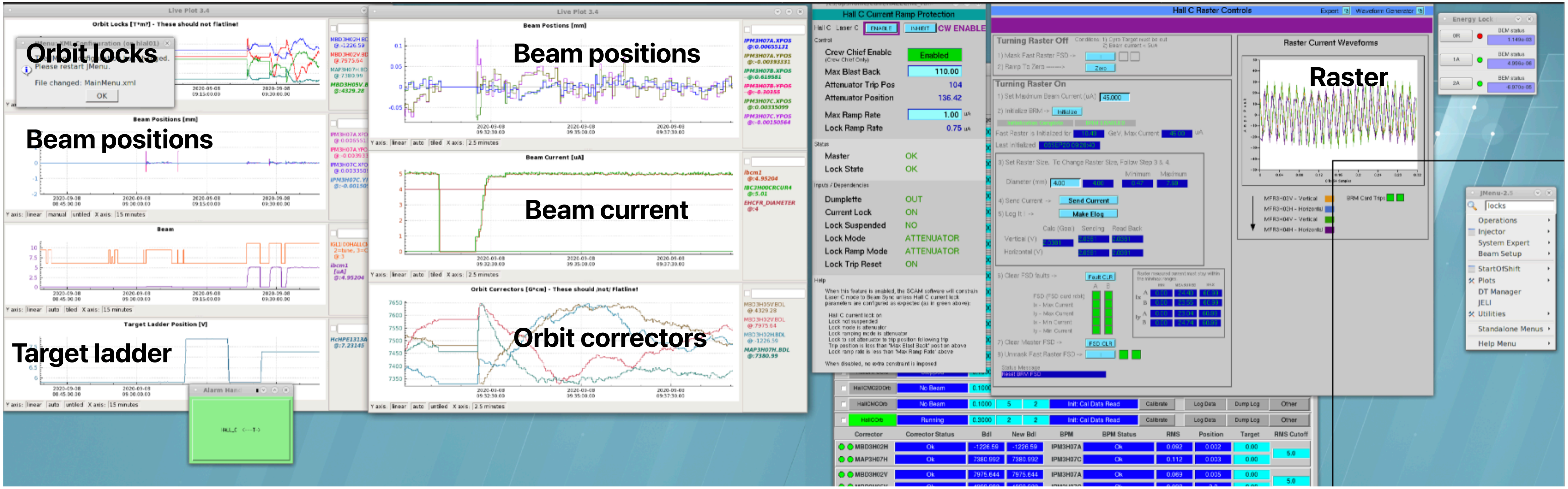
		IBD1H05 Hall A Differential Pressure	beam dump lcw differential pressure
		IBD1H05 Hall A Supply Pressure	beam dump lcw supply presure
		IBD1H05 Hall A Supply Temperature	beam dump lcw supply temperature

Part 2: Machine Protection Systems

- **Monitoring on shift:** Follow Hall C approach with dedicated screens for monitoring crucial beam line metrics
  - Orbit locks, beam positions, beam current, raster
  - With upgraded Hall A counting house (Ole's design), take advantage of improved display setup to mark off dedicated area for beam monitoring
- Incorporate operational lessons learned from recent Hall C run



Snapshot of Hall C beam monitoring setup

Summary

Are the beam commissioning procedures and machine protection systems sufficiently defined at this stage?

- Part 1: Beam Commissioning Procedures
  - Yes, we have developed a comprehensive plan to ensure our systems are working, calibrated, and ready to deliver beam to the target
- Part 2: Machine Protection Systems
  - Yes, we have a vetted list of FSD locks in place to protect beam line elements and the target
  - In discussions to update FSD list for ^{3}He target system, and corrector magnets

Backup

Beam Controls Working Group

- Working group: Yves Roblin, Jay Benesch, Brian Freeman, Brad Sawatzky, DF
- Focus: Improvement of communication between Ops & Physics; improve controls to ensure safe beam steering on target

July Milestones

- Ops: Consolidated ion chamber calibration procedures, with specific details for different targets
- Yves: Reviewed Fast Shutdown lock configurations, verified for safe operation in recent run (and minimal risk)
- Starting to think about protective collimator(s) upstream of target

Oct—Nov Tasks

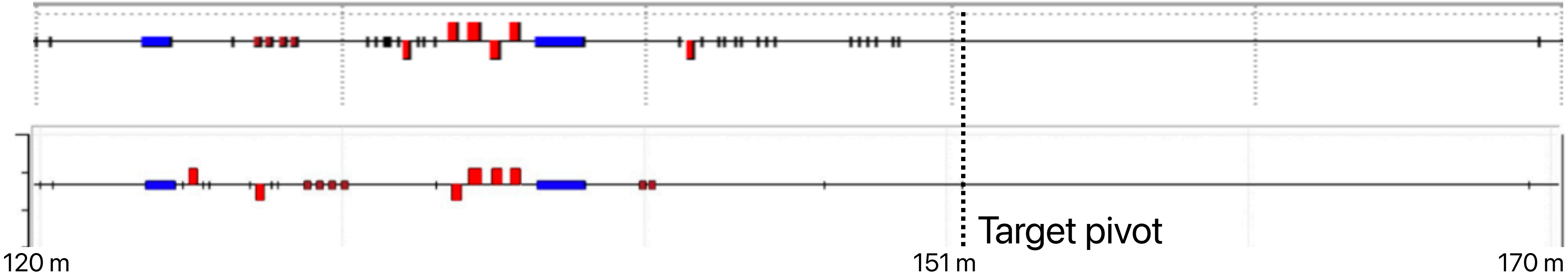
- Investigate protective collimators for SBS targets [DF]
- Work with Instrumentation & Controls regarding frequent BLM trips due to non-RF FSDs [DF]
- Determine location of ion chamber inside target B shield [DF]
- Determine range of operational parameters (particularly for long targets) [YR]

Proposed Hall A Beam Line Optics Updates

- Jay Benesch proposed a reconfiguration of the Hall A beam line that could make the raster response more regular + smaller spot size at the target pivot (JLAB-TN-20-036)
  - New components: two BPMs, one 20 A power supply, two corrector magnets

Beam line elements: Quadrupoles, Dipoles, Correctors

- Current setup
- Proposed setup



Advantages

- Greatly simplify beam steering and repeatability for SBS/GEn — more important for longer cells (60 cm vs 40 cm in Hall C)
- Helps decouple x & y beam translation (frequently needed in Hall C's ^{3}He run) vs beam focusing effects at the target
- Reduce dependence of raster size and shape on beam position and quad steering (MCC vs Hall "units")
- Uniformity and shape of raster is very important with long cells
- Required for MOLLER anyway — early installation streamlines the process and benefits the immediate programs ahead