"Measuring the Charged Pion Polarizability (CPP) in the $\gamma\gamma \rightarrow \pi^+\pi^-$ Reaction"

E12-13-008

Spokespersons: Ilya Larin, David Lawrence, Rory Miskimen, Elton Smith

"Measuring the Polarizability of the Neutral Pion with GlueX" (NPP)

E12-13-008A

Spokespersons: Mark Ito, Ilya Larin, Rory Miskimen, Elton Smith, Beni Zihlmann

Physics Division Liaison: Simon Taylor

Project implementation, resources and schedule
CPP-NPP Experimental Readiness Review
February 10, 2021

Running Conditions

$\varepsilon < 10 \times 10^{-9}$ rad*m

Configuration	Nominal GlueX I	Charged Pion Polarizability	Neutral Pion Polarizability
Electron Beam Energy	11.6 GeV	11.6 GeV	11.6 GeV
Coherent Peak Energy	8.4-9.0 GeV	5.5-6 GeV	5.5-6 GeV
Current	150 nA	27 nA	27 nA
Radiator thickness	50 μm diamond	50 μm diamond	50 μm diamond
Collimator aperture	5 mm	3.4 mm	3.4 mm
Peak polarization	35%	73%	73%
Tagging ratio	0.6	0.56	0.56
Flux 5.5-6.0 GeV	-	11 MHz	11 MHz
Flux 8.4-9.0 GeV	20 MHz	-	-
Flux 0.3-11.3 GeV	367 MHz	56 MHz	56 MHz
Target Position	65 cm	1 cm	1 cm
Target, length	LH2, 30 cm	^{208}Pb, 0.03 cm	^{208}Pb, 0.03 cm
Start Counter and DIRC	Nominal	Removed	Removed
Tagger microscope	Nominal for Peak at 9 GeV	Moved for Peak at 6 GeV	Moved for Peak at 6 GeV
Muon Detector	None	Installed behind FCAL	Not needed
Trigger	FCAL/BCAL (40 kHz)	TOF (30 kHz)	FCAL/BCAL (10 kHz)

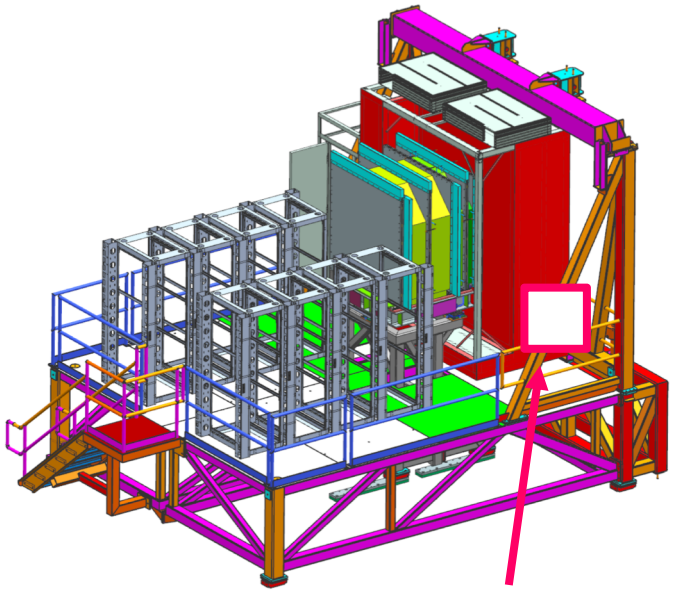
New equipment and installations

This Talk:
Concentrate on items in Blue

- Muon detector (UMass and Hall D Mechanical)
  - Modifications to forward platform
  - Modifications to FCAL dark room to allow installation
  - MWPC fabrication
  - Assembly of muon detector with MWPCs and iron shielding
  - Electronics and DAQ modifications for MWPCs
- Move tagger microscope to cover 6 GeV coherent peak
- Target and modifications to target area to use solid Pb target
- Development of TOF trigger
  - TOF design requirement document completed
  - Production trigger would include an 'OR' of the FCAL/BCAL trigger for NPP and the new TOF trigger for CPP + random, PS and LED calibration triggers
- Documentation

Electronics support for MWPCs

- Responsibility: Jlab Electronics (Fernando and Chris)
- Signal cables (new cables)
  - Six MWPCs, 144 wires/MWPC, 864 wires total
  - 6 cables/MWPC, 24 wires/cable, 36 cables total + spares
- Move crate from upstream platform to FCAL platform
  - Locate a half rack on the north side of the muon detecto
- 1 FADC signal crate (borrowed from CDC)
  - 864 FADC-125 channels
  - 12 FADC-125 modules, 72 channels/module
- CAEN HV crate (additional card in Ccal crate)
  - Need special transition connector (Chris)
  - 1 SHV cable/MWPC, 6 HV channels total



Location of new (half) rack

Electronics support for MWPCs (cont.)

- Low voltage to power MWPC electronics
  - Require two pairs +/-5 V inputs to each chamber (2x2x6 = 24 inputs)
  - MWPC chambers draw 1 A from each +5 and -5 V supply.
  - Need cable adaptor for connections to MWPC (Chris).
- Gas system (Hall D Mechanical)
  - Use the CDC gas supply to provide gas to the MWPCs
- Slow controls (Hovanes)
  - HV CAEN control
  - LV control of MPODs
  - Gas system
- DAQ modifications needed to read crate in new configuration (Serguei and Sasha)
  - Use name rocFMWPC1, used previously in beam test.
  - There are spare optical cables on the forward platform
  - All systems will be used except for DIRC, Ccal, Start, CDC

Geometry of Tagger

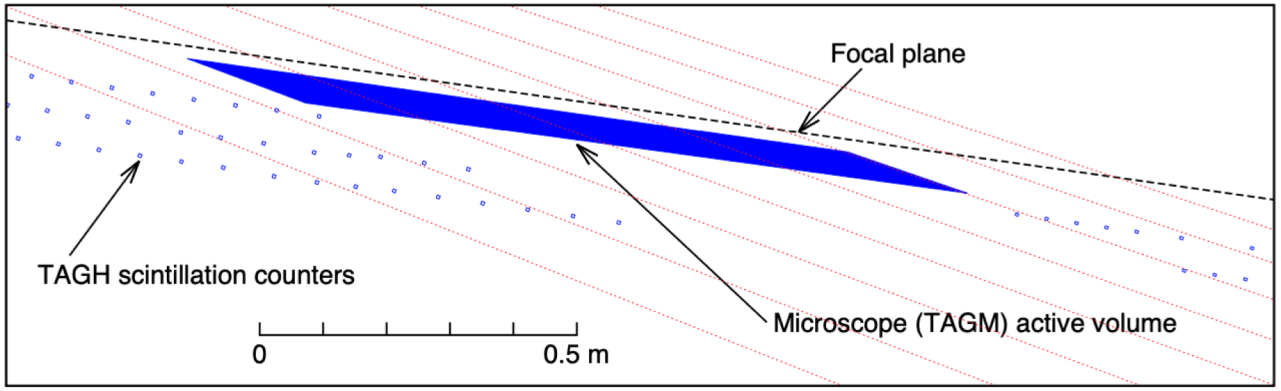
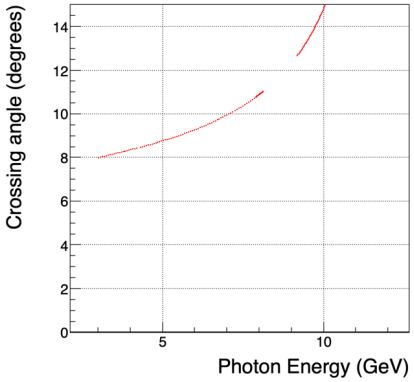
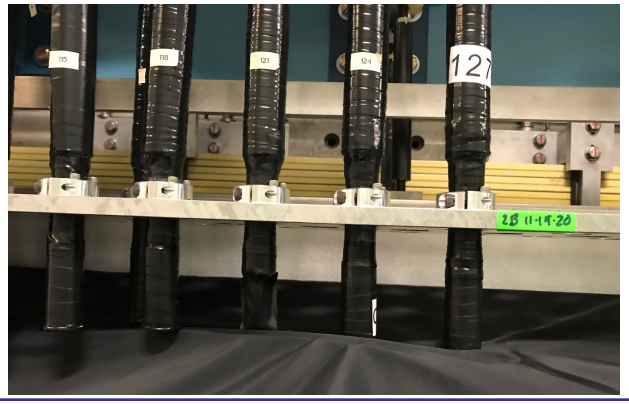


Figure 10: Schematic of electron trajectories in the region of the microscope. Shown are the three layers of hodoscope counters on either side of the microscope and the region covered by the microscope.

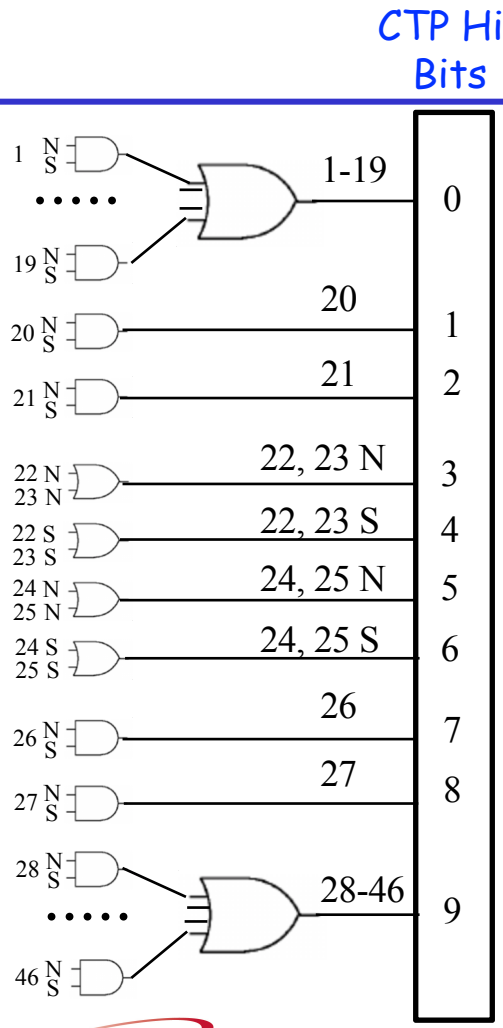




Move tagger microscope to cover 6 GeV coherent peak

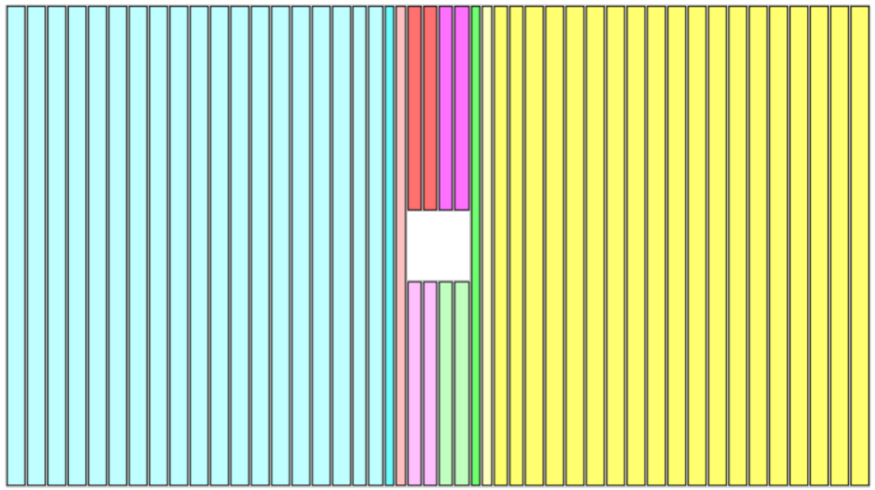
- Responsibility: UConn (Richard Jones)
- Alignment tools and hardware
  - Three pieces are needed: a). Triangular piece to set the beta angle of the first counter, b) Two pieces to set the location of the rails at 6 GeV.
  - Engineering drawings are being updated by James McIntyre (UConn) and parts will be ordered directly from their 3D model.
- Procedure for moving microscope
  - Detailed description will be documented by James McIntyre and implemented by Richard with JLab assistance
- Schedule for moving (~ 1-2 weeks)
- Hodoscope coverage
  - No change from current configuration
  - Note: coverage between 8.1-9.1 GeV will be missing.
- Alignment of diamond to 6 GeV during commissioning will use the hodoscope.

TOF trigger



Existing TOF trigger has same structure but different mapping

Graphic Representation for one plane. Repeat for second plane



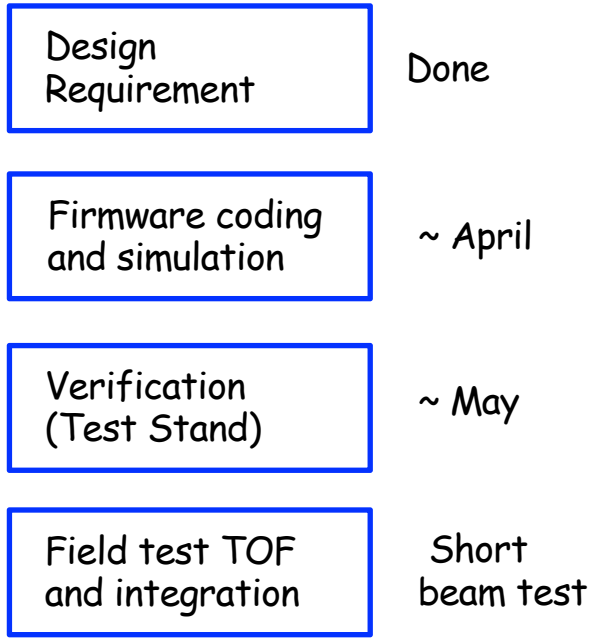
≥ 2 CTP Hit Bits vertical

≥ 2 CTP Hit Bits horizontal

TOF Trigger

Combined FCAL/BCAL and TOF triggers

- Responsibility: Fast Electronics (Chris/Hai) and Sasha Somov
- TOF trigger (CPP)
  - Ilya has developed a proposal for various TOF configurations that would provide an efficient trigger for CPP
  - The fast electronics group (Hai, Chris) has updated the former firmware requirement documentation to reflect the new TOF geometry and the new TOF trigger bit structure.
  - The trigger firmware upstream is agnostic to this new TOF-CTP firmware.
- FCAL/BCAL trigger (NPP)
  - The neutral trigger is the same as the usual GlueX trigger with optimized thresholds.
- The full experiment trigger would include the TOF and FCAL/BCAL triggers plus random, PS, and LED triggers.



Documentation (drafts available)

- Conduct of Operations (COO)
  - Minor changes required
- Experimental Safety Assessment Document (ESAD)
  - Minor changes required
- Radiation Safety Assessment Document (RSAD)
  - Experiment runs at 27 nA on a 5% lead target compared to 150 nA on a 3.4% hydrogen target for GlueX I.
  - Pavel Degtiarenko from RadCon has provided a preliminary RSAD.
- Emergency Response Guidelines (ERG)
  - No changes needed

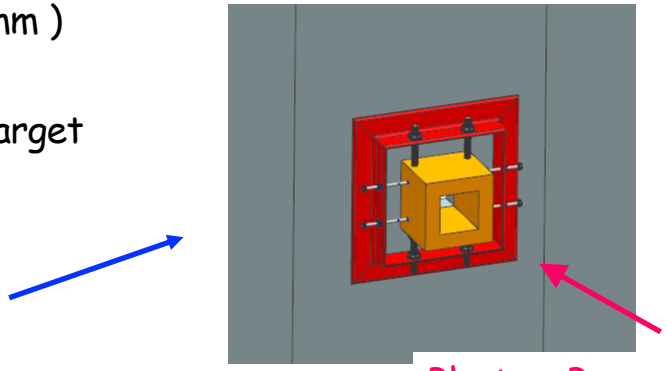
Documentation (cont.)

- OSP for MWPCs
  - Draft completed, feedback from Bert and Ed
- HDList for Assembly of Muon Detector
- Procedure for FCAL Maintenance
  - Draft in progress, some questions but few modifications from existing procedure. Questions: a) Fire safety, b) "Knock-out panels" in new configuration, c) ladder and space considerations

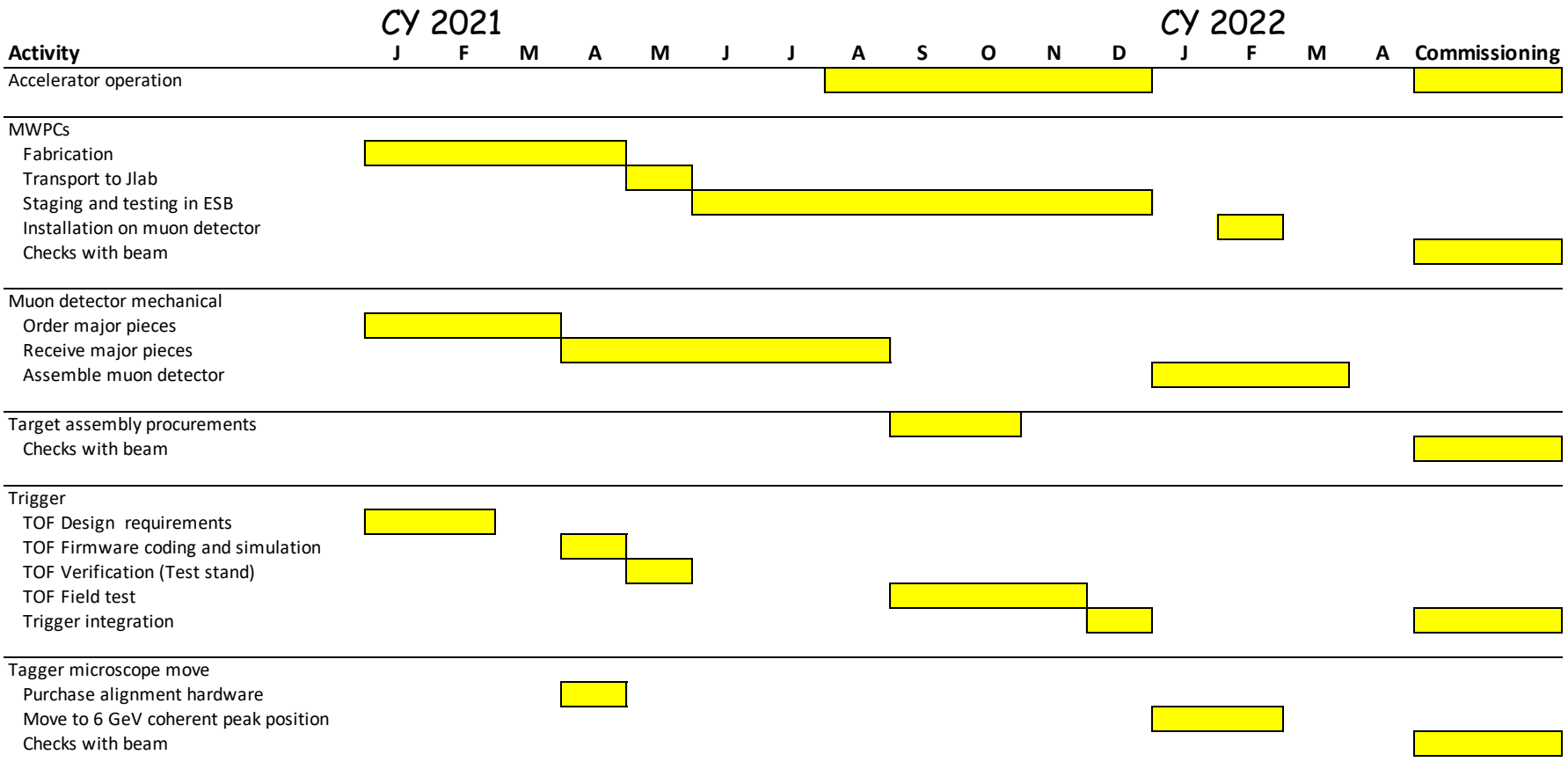
Mockup in Fcal Dark Room

Preliminary run plan

- Calibrations (5 PAC days / 10 calendar days)
  - Microscope is a new position
    - Align diamond to 6 GeV coherent edge
    - Check rates in microscope in new position
  - Check rates for two collimator configurations (5 and 3.4 mm)
    - Use profiler to stabilize the beam during test
  - Check radiation and backgrounds rates in Hall D with Pb target
  - Check currents and hit distributions in the MWPCs
  - Compare empty vs full target rates
  - Adjustable Pb absorber (upstream of muon detector)
  - Commission trigger
- Production (20 PAC days / 40 calendar days)
  - Need to schedule 2 TAC runs
  - Take production data alternating the 0°/90° diamond configurations



Coarse schedule



Summary

- All tasks have been outlined
  - Responsible parties have been identified
  - Estimates for completing the jobs with the available resources, including person-power and equipment, fit within the planned timeframe
- We have a preliminary beam commissioning plan to prepare for production
- Drafts of the required documentation are available
- We are excited to be able to include the CPP and NPP experiments on the Experimental Schedule

Running Conditions

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Current	150 nA	20 nA	20 nA
Radiator thickness	50 μm diamond	50 μm diamond	50 μm diamond
Collimator aperture	5 mm	5 mm	5 mm
Peak polarization	35%	72%	72%
Tagging ratio	0.6	0.72	0.72
Flux 5.5-6.0 GeV	-	11 MHz	11 MHz
Flux 8.4-9.0 GeV	20 MHz	-	-
Flux 0.3-11.3 GeV	367 MHz	74 MHz	74 MHz
Target Position	65 cm	1 cm	1 cm
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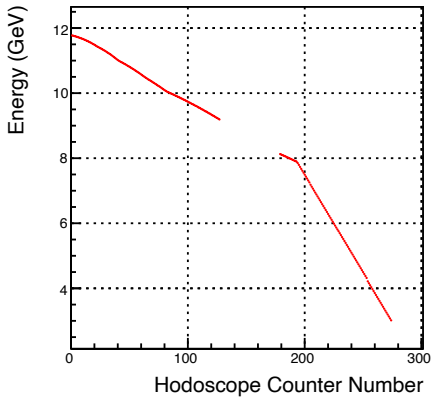
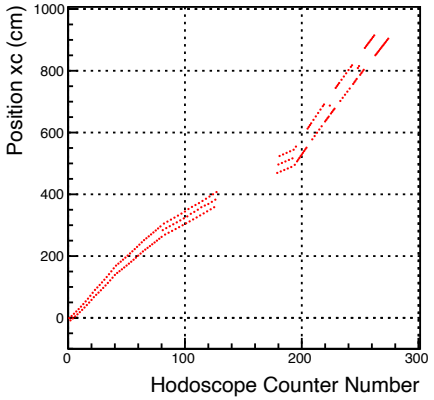
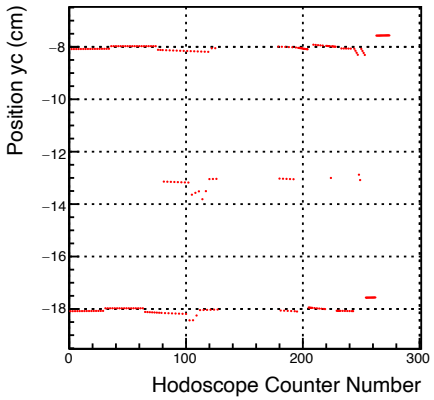
Start Counter	Nominal	Removed	Removed
Tagger microscope	Nominal for Peak at 9 GeV	Moved for Peak at 6 GeV	Moved for Peak at 6 GeV
Muon Detector	None	Installed behind FCAL	Not needed
Trigger	FCAL/BCAL (40 kHz)	TOF (30 kHz)	FCAL/BCAL (10 kHz)

Energy, position and crossing angle of hodoscope counters

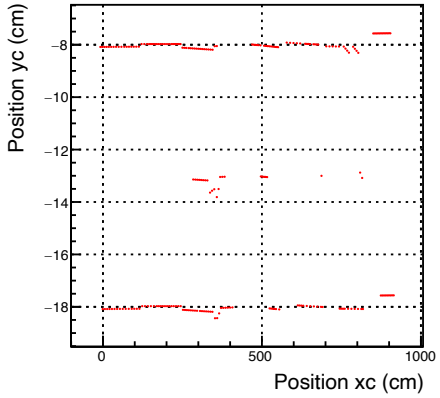


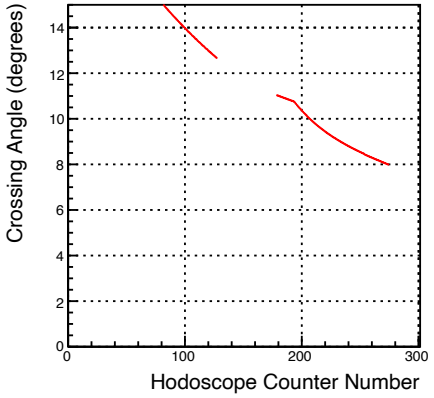


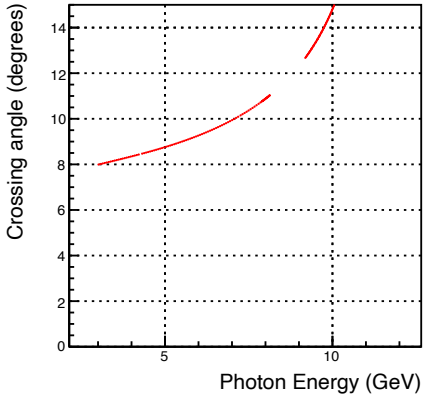


Microscope transverse size
= 17x6x0.2cm=20.4cm

Length at 8.8 GeV
= 20.4cm/sin(12°) = 98 cm
ΔE ~ 8.2 - 9.2 GeV







Length at 6 GeV
= 20.4cm/sin(9.2°) = 130 cm
ΔE ~ 4.8 – 6.3 GeV

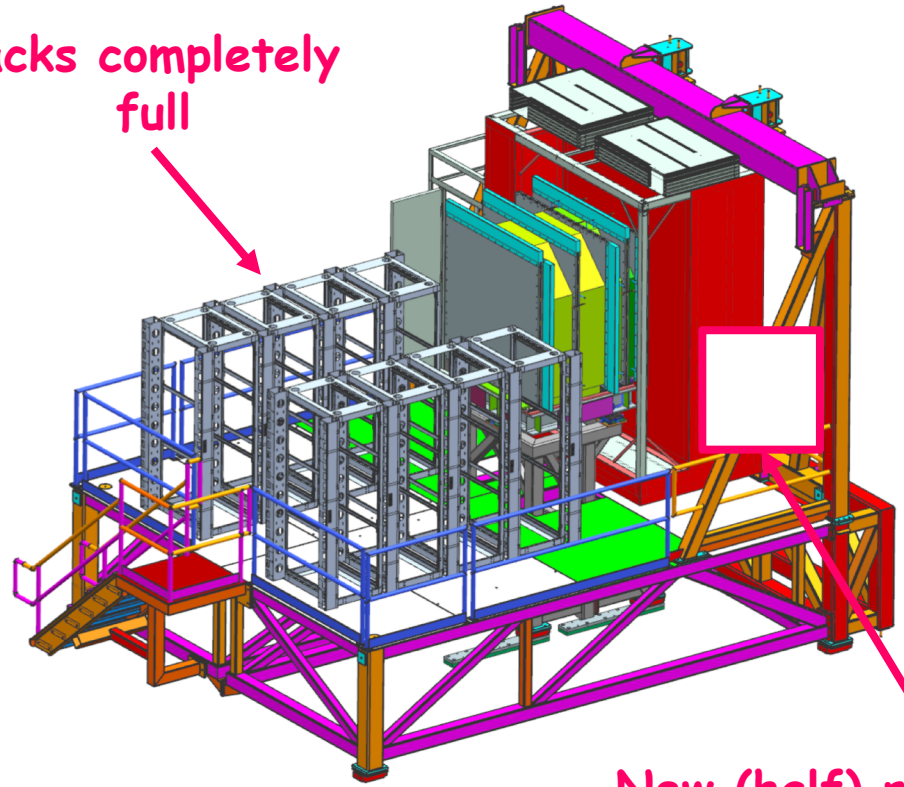
Solid lead target and support

- Responsibility: JLab/UMass
- PRIMEX ^{208}Pb target will be used
- Target frame (UMass)
  - Use existing PRIMEX frame for target itself
  - Need additional "empty" target frame
- Target cart/support (Jlab)
  - Location of target is z=1cm
  - Capability to remove target and insert "empty" frame
- Beamline to target
  - New section of vacuum pipe
- Beamline from target to FDCs
  - He bag

Simulation and Reconstruction

- Simulation
  - GEANT4 models of the MWPCs were developed for the proposal and need to be updated to the current design (David Lawrence)
  - Simulation of tagger consists of a lookup table, which needs to be modified to the new energy range
- Reconstruction (MWPCs)
  - Low-level objects based on the FMWPC1 readout controller was developed for the 2018 beam test. It needs to be updated to the final detector and fed into the online analysis for monitoring (David Lawrence).
  - Simple high-level objects will be instantiated to be used for muon-pion identification.
- Reconstruction (Tagger)
  - The tagger hodoscope is unchanged. No changes needed.
  - The low level reconstruction of the microscope does not change, but the mapping to energy must be modified.

Rack position on north of detector



Interferences?

New (half) rack location?

Movable cabinet

Preliminary run plan (cont.)

- Commission trigger
  - Desire to test TOF trigger during 2020 run to check firmware.
  - Establish FCAL/BCAL trigger, set thresholds.
  - Check rates for TOF trigger.
  - Setup FCAL/BCAL + TOF triggers for production
  - Add the random pulser, PS, and LED triggers
  - Set beam current based on trigger studies
    - Scale measured rates during test to CPP conditions:
      - Current = 20 nA (5 mm collimator)
      - Target = 5% Rad. Length
      - FCAL/BCAL Trigger rate < 10 kHz
      - TOF Trigger rate ~ 30 kHz
    - GlueX II runs at twice this rate

Estimated FCAL/BCAL trigger rate on LH_2 target using random trigger