Run plan, conditions, and configuration

(Charges 1,3 &5)

ERR

May 7, 2020

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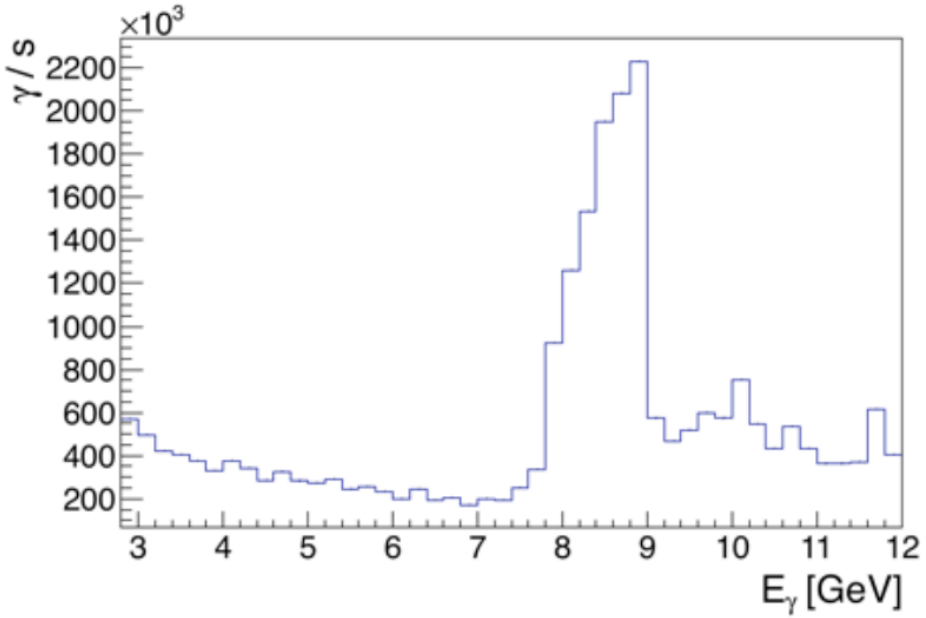
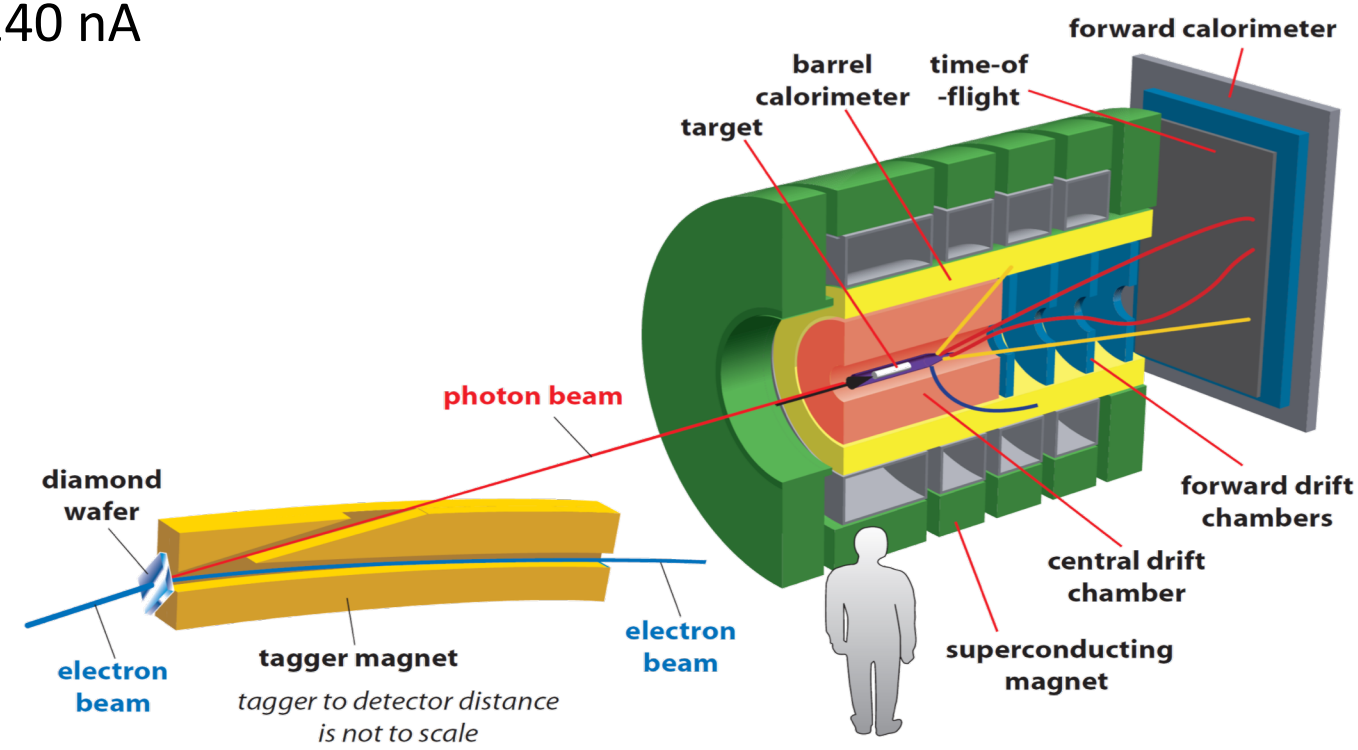
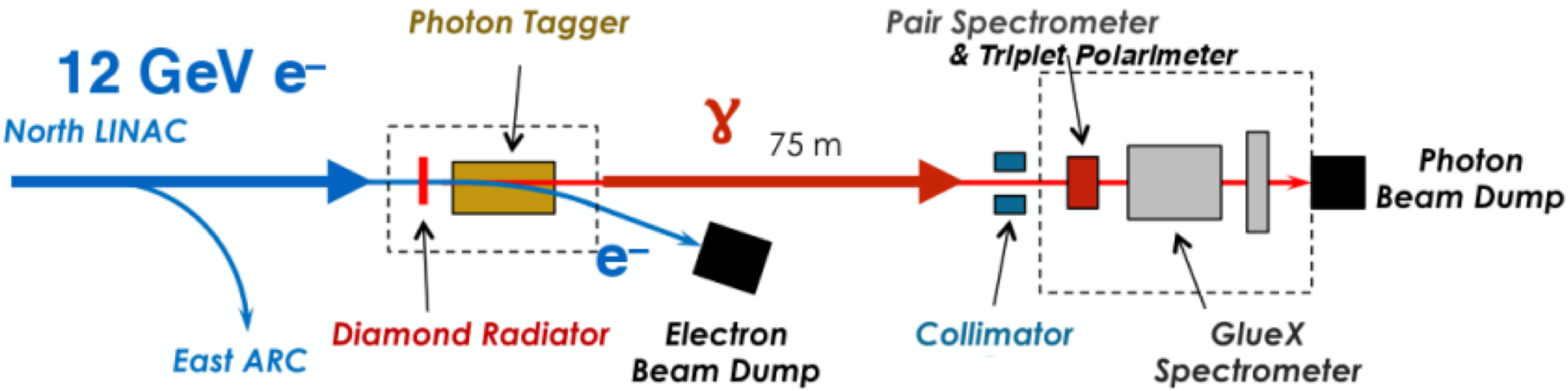
Charge 1: What are the running conditions for the experiment? Please state clearly the target and beamline configurations and operation.

- GlueX in standard configuration
- diamond radiator (standard 2×10^{-4} X_0)
- coherent peak at approximately 9 GeV (energy range 8.4 - 9.1 GeV)
- 2×10^7 photons/s flux, beam current 140 nA

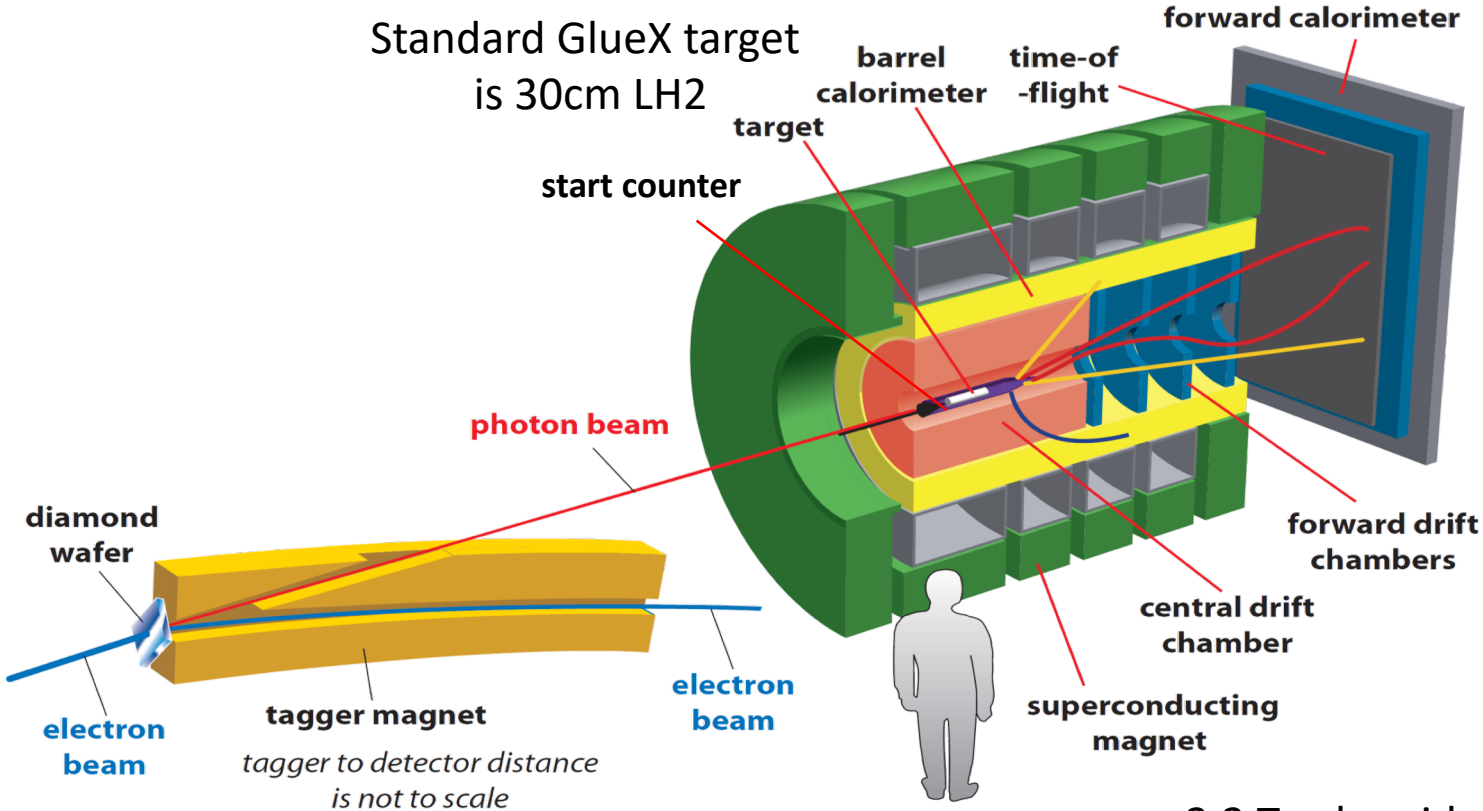




Standard Hall D photon beam line:



Coherent Bremsstrahlung on standard diamond crystal wafer
Collimation -> coherent peak at 8.4-9 GeV



Hadrons: $\sigma_p/p \sim 1\text{-}3\%$
γ: $\sigma_E/E \sim 6\%/\sqrt{E} \oplus 2\%$
Acceptance 1°-20°

2.2 T solenoid provides field for tracking

Run Plan Summary:

13 beam days data-taking
+ 9.5 shifts overhead

Targets: 12C foil, D, and 4He

Target	Thickness [cm] / % X_0	Atoms	Run Time (days)
LH	30 / 3.4	$1.28 \cdot 10^{24}$	GlueX
D	30 / 4.1	$1.51 \cdot 10^{24}$	4.5
^{4}He	30 / 4.0	$5.68 \cdot 10^{23}$	1
^{12}C	1.9 / 7	$1.45 \cdot 10^{23}$	7

Run Plan:

Condition	Scheduled Work (Activities)	Total Time	Beam Conditions
Pre-experiment	Install C target	3 shifts	no beam
	Disassemble beam pipe. Retract target. Remove Start Counter (ST). Remove vacuum snout. Remove GlueX cell. Mount carbon foils (survey). Attach vacuum snout. Attach ST. Target in place. Assemble beam pipe. Pump vacuum.* Ramp magnet*	1 shift assembly 1 shift for survey & align 1 shift for pumping vacuum*	
Detector checkout		2.5 shifts	140 nA
	Establish typical tagged photon beam, check/calibrate sub-detectors, Trigger, and DAQ (some tests can be done during pumping vacuum)		
Run with C target		7 days	140 nA

*Hall in Beam Permit

Run Plan (cont.):

Condition	Scheduled Work (Activities)	Total Time	Beam Conditions
Target change	Install liquid D target	5 shifts	no beam
	Ramp magnet down	1 shift	
	Disassemble beam pipe. Retract target. Remove ST. Remove vacuum snout. Remove carbon foils. Mount GlueX cell. Survey. Mount heat shield (needed for helium). Attach vacuum snout. Attach ST. Target in place. Assemble beam pipe.	1 shift assembly 1 shift for survey & alignment	
	Ramp magnet.* Pump vacuum.*	1.5 shifts	
Run with empty target		0.5 days	140 nA
Target preparation	Cool target*.	1 shift	

*Hall in Beam Permit

Run Plan (cont.):

Condition	Scheduled Work (Activities)	Total Time	Beam Conditions
Run with D target		4.5 days	140 nA
Target change	Switch to liquid He target	1.5 shifts	
	Boil LD_2*. Pump D_2 from tanks. Replace with helium. Cool target*.		
Run with He target		1 day	140 nA

*Hall in Beam Permit

13 beam days data-taking

+ 9.5 shifts overhead

Charge 3: Has the spectrometer, detector configuration been defined, including ownership, maintenance and control during beam operations?

- GlueX in standard configuration
- Detector support will come from Hall D staff members and have confirmed:

FDC	L. Pentchev (Jlab)
CDC	B. Zihlmann (Jlab)
BCAL/FCAL	M. Dalton (Jlab) / Z. Papandreou (Regina)
ST	M. Itoh (Jlab)
TOF	B. Zihlman (Jlab) / P. Eugenio (FSU)
Beamline	A. Deur/A. Somov (Jlab)
Slow Control	H. Eigian (Jlab)
DAQ	S. Furletov (Jlab)
Trigger	A. Somov (Jlab)
Tracking	S. Taylor (Jlab)
Detector Calibration	S. Dobbs (FSU)
Data processing	A. Austregesilo (Jlab/CMU)
Target	Target Group (Jlab)

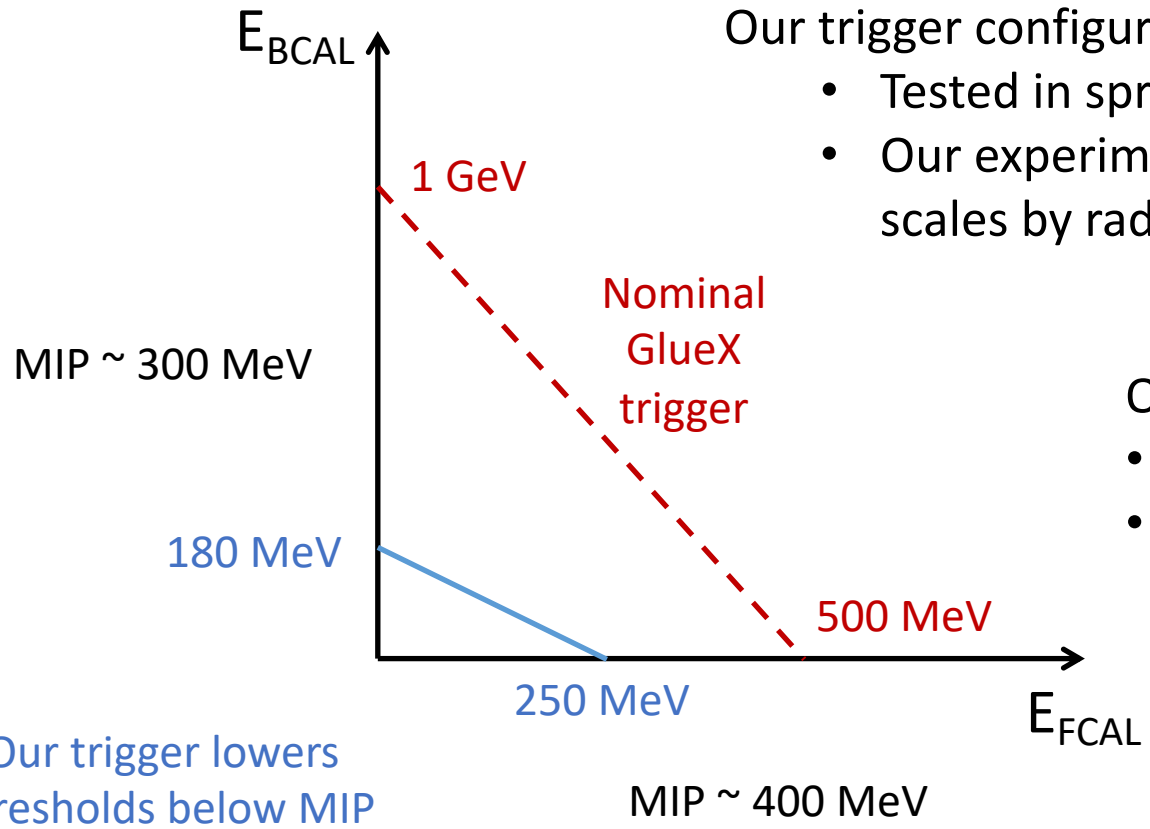
https://halldweb.jlab.org/level-1/manpower.pdf

Charge 5: What is the expected data rate for the experiments?

Nominal GlueX trigger: 80 kHz, 90% livetime, 1.1 Gb/s

Our trigger configuration: 78 kHz, 90% livetime, 1 Gb/s (5×10^7 γ/s)

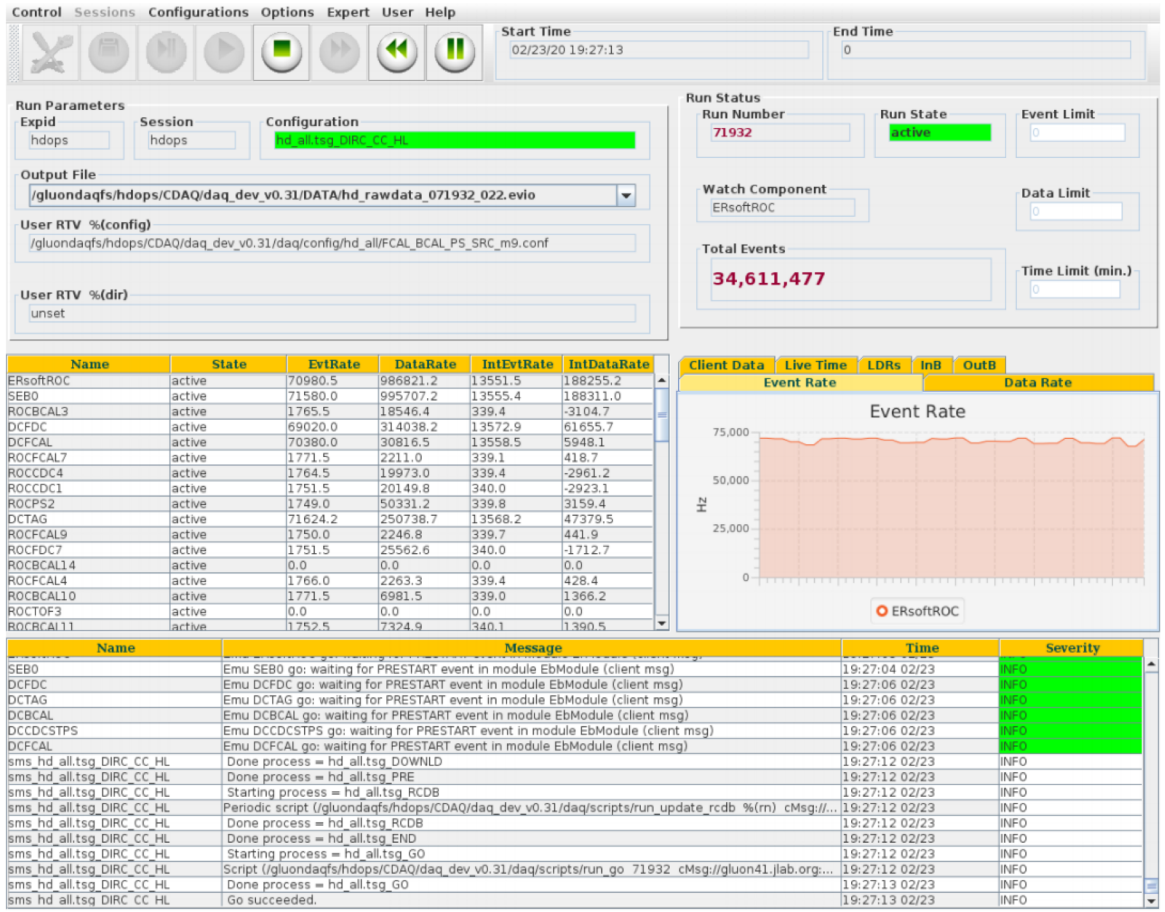
- Tested in spring 2020, see https://halldweb.jlab.org/level-1/src
- Our experiment ~x0.5 γ/s, but C target has x2 rad length (EM bg scales by rad length and hadronic bg scales by attenuation)

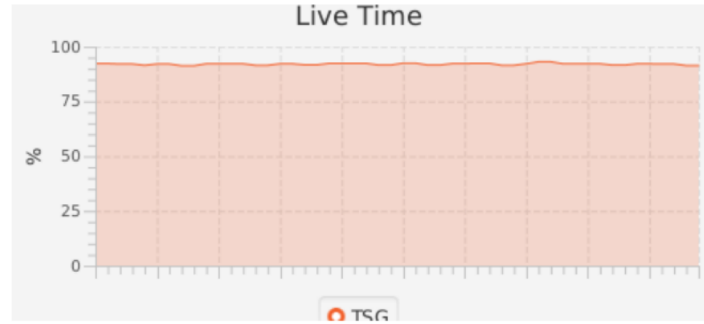


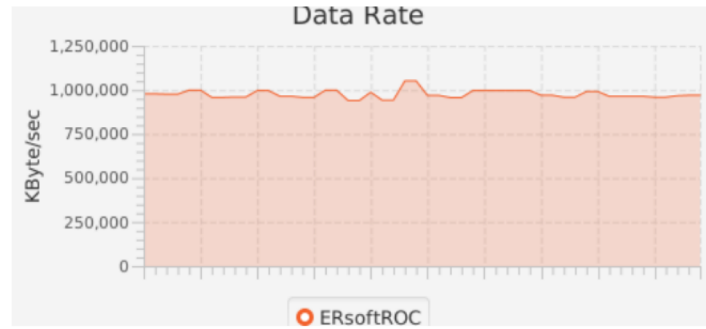
Our trigger lowers thresholds below MIP and requires one hit in start counter

Our trigger requirements:

- Proton, pion final state -> MIP
- Already accept multiparticle final states by default







Trigger rate: 78 kHz GlueX rate: 80 kHz

Summary

Charge 1: What are the running conditions for the experiment? Please state clearly the target and beamline configurations and operation.

- GlueX in standard configuration, standard diamond radiator
- coherent peak at 9 GeV (energy range 8.4 - 9.1 GeV)
- x2 lower flux than standard GlueX at $2x10^7$ photons/s flux (140 nA)
- Run plan for 15 days with 12C, D, 4He targets presented

Charge 3: Has the spectrometer, detector configuration been defined, including ownership, maintenance and control during beam operations?

- Spectrometer and detectors in standard GlueX configuration
- Detector and beamline support from Hall D staff
- Target support from JLab Target Group

Charge 5: What is the expected data rate for the experiments?

- 78 kHz, 90% live time, data rate of approximately 1 GB/s (tested at $5x10^7$ photons/s)
- 4He and D comparable, 12C double radiation length (and attenuation effects)
- Trigger has lower ECAL and BCAL thresholds, hit in start counter

Back-up slides

Reminder: Physics observables

Exclusive Proton Reactions	Exclusive Neutron Reactions
$\gamma + p \rightarrow \pi^0 + p$	$\gamma + n \rightarrow \pi^- + p$
$\gamma + p \rightarrow \pi^- + \Delta^{++}$	$\gamma + n \rightarrow \pi^- + \Delta^+$
$\gamma + p \rightarrow \rho^0 + p$	$\gamma + n \rightarrow \rho^- + p$
$\gamma + p \rightarrow K^+ + \Lambda^0$	$\gamma + n \rightarrow K^0 + \Lambda^0$
$\gamma + p \rightarrow K^+ + \Sigma^0$	$\gamma + n \rightarrow K^0 + \Sigma^0$
$\gamma + p \rightarrow \omega + p$	x
$\gamma + p \rightarrow \phi + p$	x
…	…

	Low XS $\gamma + n \rightarrow \pi^- + p$		High XS $\gamma + n \rightarrow \rho^- + p$		
Target	**MF**	**SRC**	**MF**	**SRC**	**PAC days**
D	12240	675	51300	2700	4.5
4He	1600	84	6800	350	1
12C	5192	1633	21583	6417	7

MF = mean field
SRC = short-range pairs

Option B: Consideration if neutron rates are too high when running deuterium

1. Lower intensity

	Low XS $\gamma + n \rightarrow \pi^- + p$		High XS $\gamma + n \rightarrow \rho^- + p$	
photon flux	**MF**	**SRC**	**MF**	**SRC**
$2x10^7$	13600	750	57000	3000
$1x10^7$	6800	375	28500	1500

MF = mean field
SRC = short-range pairs

2. Change to 4He sooner than planned (all physics goals still attainable)

Consideration for 4He target density

- We anticipate that 4He target density is known to approximately 5% (or better), and this is acceptable.
- PrimEx will measure the absolute density prior to our experiment, and we expect this to be similar. Compare PrimEx densities between 2019 and 2021 to determine if Option B needed.

- Option B: Measuring the 4He absolute density (use remaining 2.5 shifts overhead)
  - At the start of our D2 target running, before ramping field, take 2h run (1/3 photon flux) with Compton calorimeter. Then, proceed to ramp magnet.
  - At the end of our 4He run, ramp magnet to 0, take 2h run with Compton calorimeter.

Energy loss in Carbon foil targets:

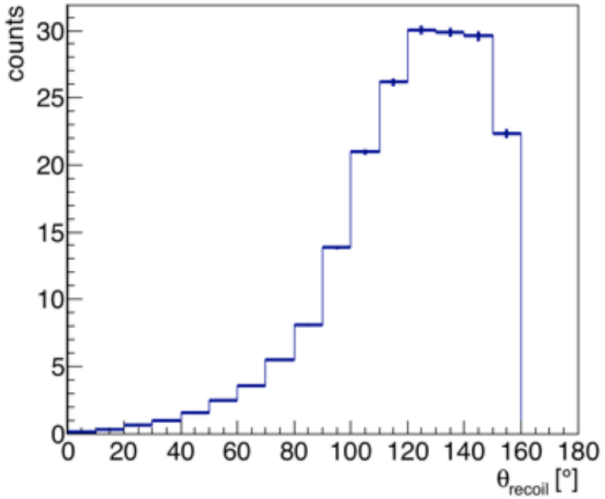
- 3 cm vertex resolution
- 8 foil targets (total is 7% rad length, 1.9 cm total), each is 0.24 cm thick
- 100MeV-> 6.488 MeV cm2/g, 2 g/cm3-> E loss of 13 MeV/cm
- For 100 MeV proton (p=430 MeV/c):
  - At thickness, 3 MeV loss per C foil
  - At 150 deg, 3.6 MeV loss per C foil

Effects of Al shielding around cryo target cell:

- Thickness is 0.5mm
- 100 MeV -> 5.678 MeV cm2/g , 2.71 g/cm3->E loss of 15.4 MeV/cm
- For 100 MeV proton (p=430 MeV/c):
  - At thickness, 0.77 MeV loss
  - At 150 deg, 0.89 MeV loss

Al shielding not a problem for recoiling proton!

Angular distribution of recoil nucleon



Acceptance and Efficiency for recoil protons in GlueX at different vertex locations