Reconciling Haiyan's rate estimate

$$N_{SRC} = N_{HallA} \frac{d\sigma_{SRC}}{d\sigma_{HallA}} \cdot \frac{\Omega_{SRC}}{\Omega_{HallA}} \cdot \frac{\mathcal{L}_{SRC}}{\mathcal{L}_{HallA}} \cdot \frac{t_{SRC}}{t_{HallA}}$$

$$N_{SRC} = 1900 \cdot (0.092) \cdot (200) \cdot (3.1 \cdot 10^{-4}) \cdot (4.3) = 47$$

My back-of-the-envelope estimate is:

$$N_{SRC} = \frac{d\sigma}{\mathrm{d}\Omega_{cm}} \times \Omega_{cm} \times \mathcal{L} \times t$$

$$N_{SRC} = \left(4.0 \cdot 10^{-35} \frac{cm^2}{sr}\right) \times (3.9\ sr) \times\ (3.0 \cdot 10^{31} cm^{-2} s^{-1}) \times (4.3 \cdot 10^5\ s) = 2000$$

Relative Cross Section

- Hall A's highest data point was at $s = 11.3 \text{ GeV}^2$.

- If we assume an 8 GeV beam on a stationary neutron, $s = 15.9 \text{ GeV}^2$.

- $(11.3/15.9)^7 = 0.09$

This is not controversial.

Relative Bin Size

- Assumed factor of 200x increase for GlueX
  - 6 msr for Hall a
  - 1.2 sr for GlueX

- How much is 1.2 sr?
  - $2\pi \cdot [\,95.5^{\circ} - \;84.5^{\circ}]$
  - $2\pi \cdot [\,20^{\circ} - \;41^{\circ}]$

GlueX will cover a much larger area. It’s not clear if this extra area will be less relevant for color transparency.

Relative Luminosity

- Hall A
  - 1.3 x 10^{11} photons/s
  - 15 cm liquid deuterium

- GlueX
  - 2 x 10^{7} photons/s
  - 30 cm liquid deuterium

Relative factor of 3.1e-4 is not controversial.

Relative run time

- Hall A's highest kinematics: 28 hours
- GlueX: 5 days = 120 hours

This mixes actual run time (including accelerator inefficiency) with number of scheduled PAC days.

GlueX wall clock time might be 2x larger.

Number of Hall A

- Highest Hall A data point had 2.3% statistical uncertainty:

$$N = \frac{1}{(0.023)^2} = 1900$$

(Ignores additional statistical uncertainty from background, etc.)

Conclusions

I think these rough estimates are reconciled by:

- Solid Angle Coverage
  - 200x -----> 4000x
- Run Duration
  - 4x -----> 8x

50 events * 20 *2 = 2000 events

Relevant numbers

Solid target	Rad. Length [cm]	Int. Length [cm]	e^- Density [cm^{-3}]	Density [g/cm^3]	Transparency	a2
Carbon	19.32	38.83	6.65 E23	2.21	0.44	4.5
Calcium	10.42	77.31	4.67 E23	1.55	0.29	4.7
Iron	1.76	16.77	2.20 E24	7.87	0.26	4.8
Lead	0.56	17.59	2.69 E24	11.35	0.17	4.8

Our originally proposed carbon target was:

- 1.9 cm thick
  - 0.07 radiation lengths
  - 1.45E23 C / cm^2
  - 1.26E24 e^- / cm^2
- Divided into 8 foils, each 2.4 mm thick

Expected $p\pi$- yield:

- 740 MF events/PAC day
- 230 SRC events/PAC day

Scenario 1: Replace 1/8th total e^- density with Fe

Iron Target Thickness:

$$\frac{1.26\ E24\ e^-/cm^2}{8} \cdot \frac{1}{2.20\ E24\ e^-/cm^3} = 716\ \mu m$$

$$716\ \mu m \cdot 7.87\,\frac{g}{cm^3} \cdot \frac{mole}{56\ g} \cdot \frac{6E23}{mole} = 6.0E21\ cm^{-2}$$

Our multi-foil would be:

- $6.0E21\ cm^{-2}$ Iron
- $1.3E23\ cm^{-2}$ Carbon 648 MF/day, 201 SRC/day

Scenario 1: Replace 1/8th total e^- density with Fe

What rates do we expect? Scale from Cabon:

$$R_{Fe} = R_C \cdot \frac{\rho_{Fe}}{\rho_C} \cdot \frac{N_{Fe}}{N_C} \cdot \frac{T_{Fe}}{T_C}$$

I'm ignoring a2 for the moment.

- $R_{Fe}^{MF} = \frac{740}{day} \cdot \frac{6.0E21}{1.45E23} \cdot \frac{30}{6} \cdot \frac{0.26}{0.44} = 90/day$
- $R_{Fe}^{SRC} = \frac{230}{day} \cdot \frac{6.0E21}{1.45E23} \cdot \frac{30}{6} \cdot \frac{0.26}{0.44} = 28/day$

Summary of Iron Scenarios

Events per day

Event Type	0/8th ρ_{e^-} Fe	1/8th ρ_{e^-} Fe	2/8th ρ_{e^-} Fe	3/8th ρ_{e^-} Fe
C MF	740	648	555	463
C SRC	230	201	173	144
Fe MF	0	90	180	270
Fe SRC	0	28	56	84

Scenario 2: Replace 1/8th total e⁻ density with Pb

Lead Target Thickness:

$$\frac{1.26\,E24\,e^{-}/cm^{2}}{8}\cdot\frac{1}{2.69\,E24\,e^{-}/cm^{3}} = 586\ \mu m$$

$$586\ \mu m\cdot 11.35\,\frac{g}{cm^{3}}\cdot\frac{mole}{208\,g}\cdot\frac{6E23}{mole} = 1.9E21\,cm^{-2}$$

- $R_{Pb}^{MF} = \frac{740}{day}\cdot\frac{1.9E21}{1.45E23}\cdot\frac{126}{6}\cdot\frac{0.17}{0.44} = 79/day$
- $R_{Pb}^{SRC} = \frac{230}{day}\cdot\frac{1.9E21}{1.45E23}\cdot\frac{126}{6}\cdot\frac{0.17}{0.44} = 24/day$

Summary of Lead Scenarios

Events per day

Event Type	0/8th ρ_{e^-} Pb	1/8th ρ_{e^-} Pb	2/8th ρ_{e^-} Pb	3/8th ρ_{e^-} Pb
C MF	740	648	555	463
C SRC	230	201	173	144
Pb MF	0	79	158	237
Pb SRC	0	24	48	72