CALOROC Workfest

Maria Zurek
For BIC DSC

1. What is the capacitance of the detector per channel? (pF)

~500 pF (1 4x4 3mx3m array, Hamamatsu s14161-3050HS-04)

Detector Requirements for BIC

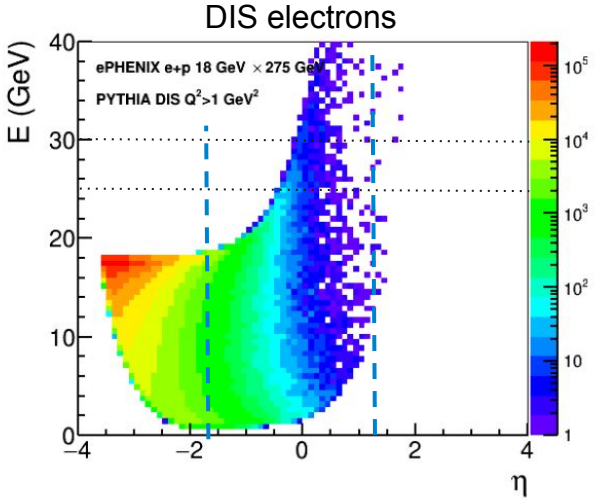
https://eic.jlab.org/Requirements/

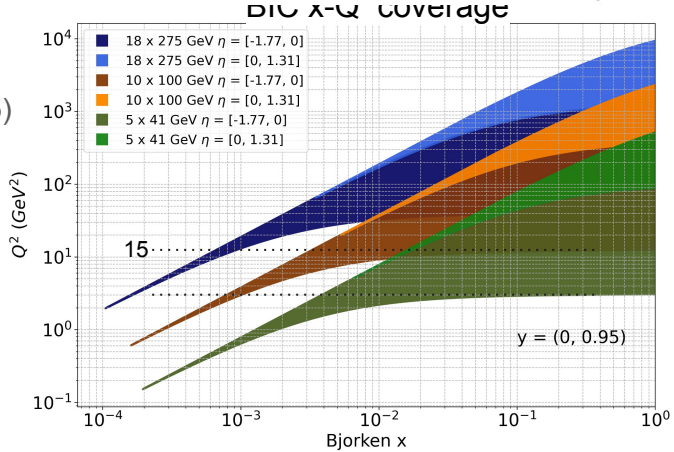
Identify scattered electrons and measure their energy, in high Q^2 events, also decay electrons, e.g. from vector or heavy flavor meson decays, and to measure DVCS photons and decay photons (G-DET-ECAL-BAR.16.10.05)

- **Electron ID up to 50 GeV** and down to 1 GeV and below (F-DET-ECAL-BAR.16.10.05)
  - Energy resolution < **10%/√(E) + (2-3)%** (P-DET-ECAL-BAR.16.10.05)
  - High power for **e/π separation down to 1 GeV/c** (P-DET-ECAL-BAR.26.10.05)
- **Photon measurements up to 10 GeV** (F-DET-ECAL-BAR.26.10.05)
- **γ/π^0 separation up to 10 GeV** (F-DET-ECAL-BAR.36.10.05)
  - Distinguishing two showers with opening angle down to 30 mrad (P-DET-ECAL-BAR.36.10.05)

Assist with muon identification (G-DET-ECAL-BAR.36.10.05)

Sufficient dynamic range to **detect MIP** signals in all layers (P-DET-ECAL-BAR.56.10.05)





Stimulations

Check max and mean energy deposit for the following cases:

- Extremes: 19 GeV electron at η = -1.7, 50 GeV electron at η = 1.4
- From the EIC detector requirements: 10 GeV photon in whole η range

Simulations translate energy loss to nphe using the measurements with GlueX BCAL SciFi/Pb matrix, known attenuation behavior, corrections for single-clad kuraray fiber, optical connection and light-guide efficiency

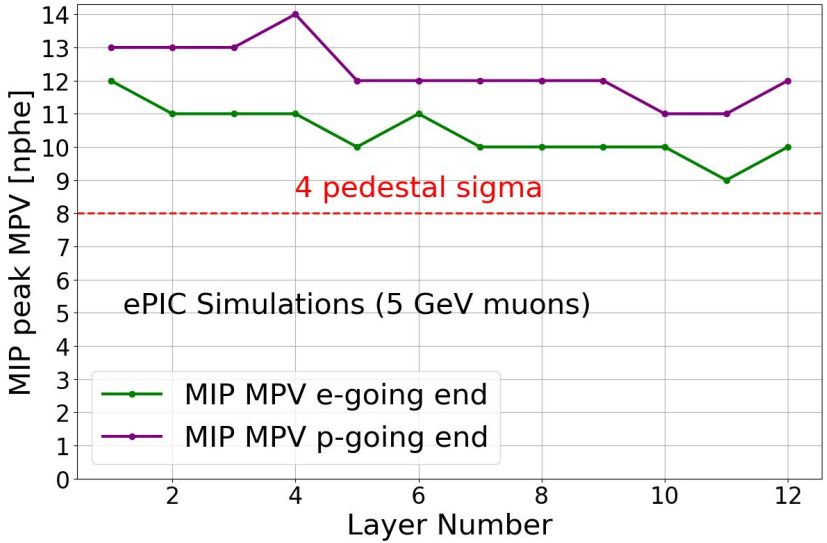
Charge is simply calculated using the expected gain at nominal operational voltage (2.7V for the S14 SiPM Matrix): $Q = G \cdot N_{pe} \cdot e$ (G - gain = 2.5 * 10^6)

What is the lowest signal measurement required? (fC)

10-11 phe

MIP peak MPVs vs SciFi/Pb layer
for **η = 0 (worst case scenario)**

0.004 - 0.0044 nC



What is the highest signal measurement required? (fC)

See Maria's presentation from June 24, 2025: https://indico.bnl.gov/event/27551/

10 GeV γ 45-135 deg: mean < 0.07 nC, max < 1.1 nC

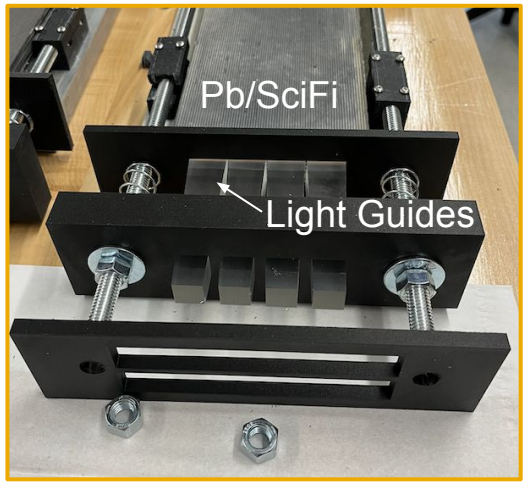
10 GeV γ < 45 deg: mean < 0.14 nC, max < 2.4 nC

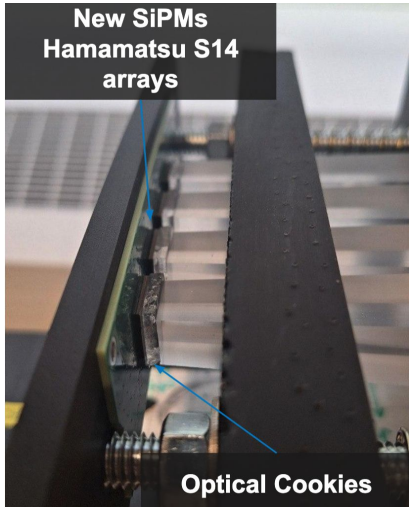
10 GeV γ > 135 deg: mean < 0.14 nC, max < 2.4 nC

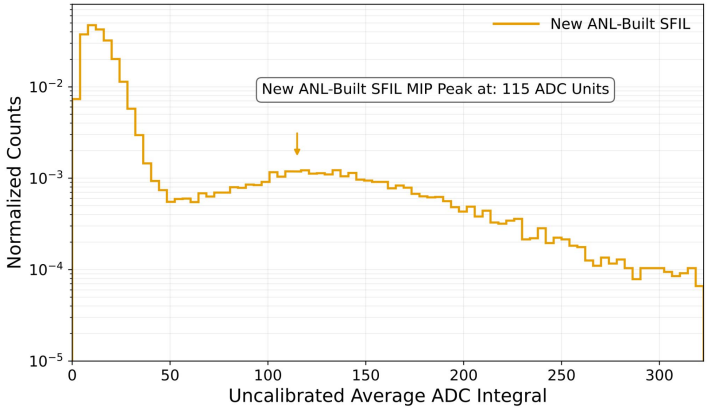
19 GeV electron at η = -1.7: mean < 0.30 nC, max < 4 nC
50 GeV electron at η = 1.4: mean < 0.60 nC, max < 8 nC

Do you have a measurement with certain settings of MIP peak, other fixed signal?

- Cosmic test bench set up at ANL for testing of various design components
  - I.e. HGCROC fiber type, light guide, optical cookie
- Various Pb/SciFi Interlayers (**SFILs**) available
  - Two from GlueX pre-production, one newly built at ANL







16 SiPMs in each array read separately and summed in analysis

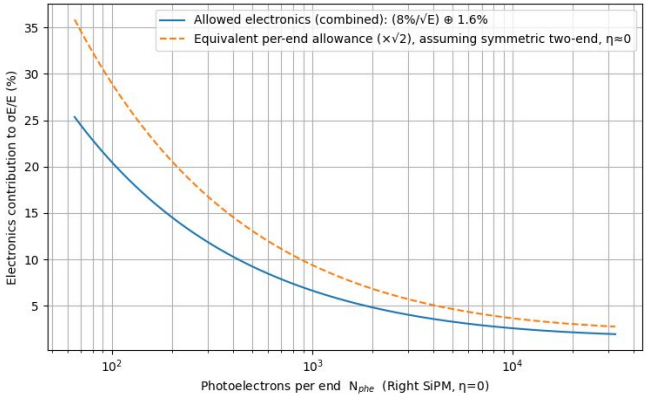
What is the charge resolution requirements? (Percentage as a function of charge, not in bits)

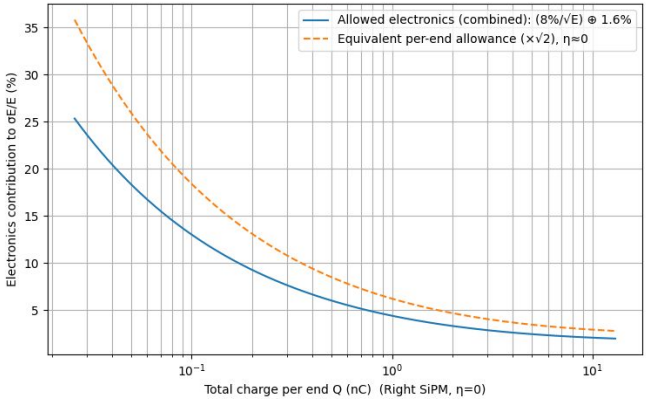
Crude estimation, require still some thinking

The upper limit taken from the energy resolution requirement < 10%/√(E) + 2% and compared to the resolution straight from the simulation (no electronics impact) at η = 0

Example for η = 0 (we should also check two extreme ends)

This estimate is for the ***total reconstructed shower charge*** (sum over layers). Translating it into *per-layer* requirements depends on shower sharing across the 12 longitudinal layers and will be refined using layer-by-layer signal distributions and assumed electronics-noise.



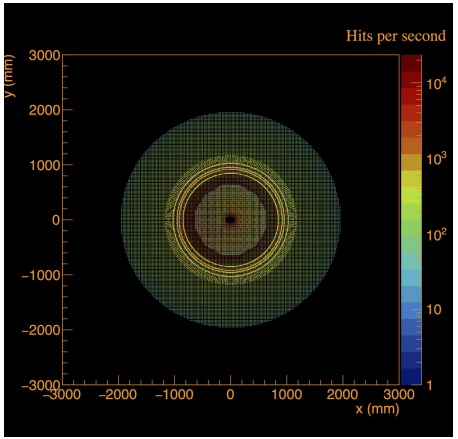


What is your timing requirements/measurements?

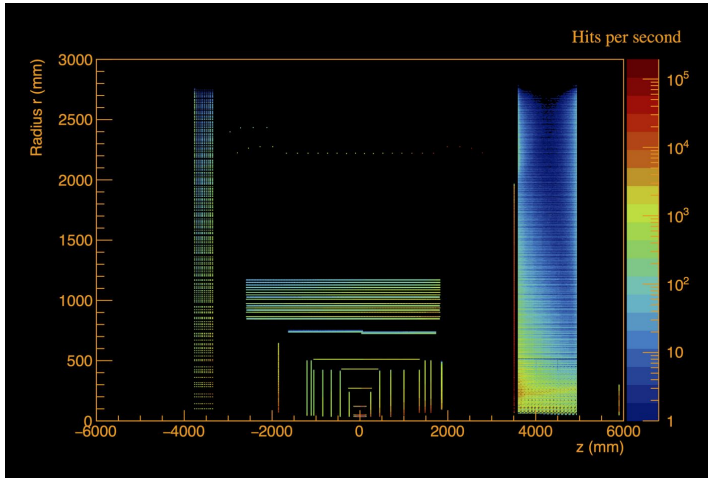
~100 ps to get ~1 cm and 1 GeV position resolution form combining both ends signal.

Gluex BCAL: ~0.089 ns/$\sqrt{E} \oplus$ 0.058ns

What is the expected occupancy per channel from simulation?
What is the maximum hit rate per channels needed if all channels are activated at the same time?



	DIS	Electron Beam Background	Proton Beam Background	All Sources
ScFi/Pb Layers				
Channel Max	7.4 kHz	8.8 kHz	430.0 Hz	15.2 kHz
Channel Avg	2.8 kHz	875.1 Hz	132.5 Hz	3.8 kHz
Total	16.1 MHz	5.0 MHz	763.4 kHz	21.9 MHz



Signal ~symmetric in η, module attenuation

The answer to the max hit rate with full activation:
Need to understand a bit better

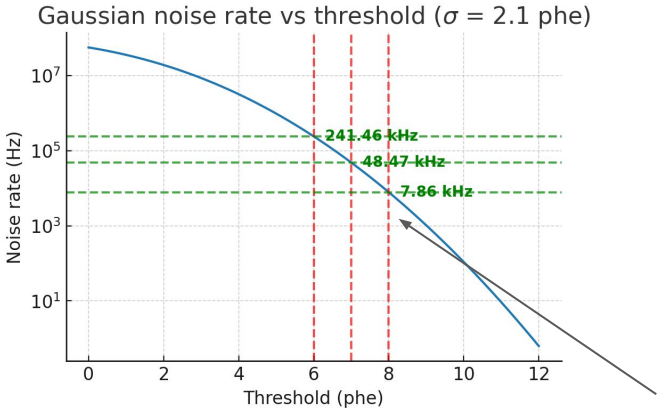
Example for DIS

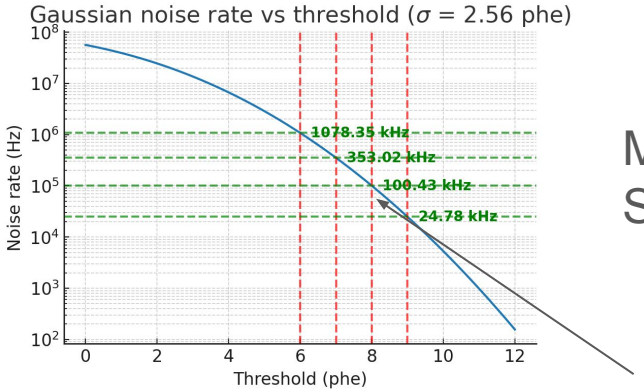
What is the expected dark noise rate?
What is the maximum hit rate required for a single channel?

See the detailed discussion here:
https://docs.google.com/presentation/d/1vD-_sGhnS_WSCz4QA6T9oSc3x-XOBeTmyzwEaGtoPEA/edit?usp=sharing

At **112.97 MHz** of DCR (7 deg SiPMs after 140 fb-1 running - numbers from the Project).

Rate dependent on pulse template shape: **GlueX-like shape left, "1x1" template right**





MIP is 10-11 nphe
So 8 phe threshold

What is the double pulse separation needed? Overlap signals from two independent bunch crossings?

- For BIC our signals will overlap if two showers enter the same Δφ of our readout
- With the 25 ns sample, we cannot separate templates
- 435 cm/15 cm/ns = ~29 ns to travel through **full calorimeter**
- **It's important for us to reconstruct the energy of the sum of the signals properly** and we will need to reply on **AstroPix layers** to separate the energy for those cases
- With realistic Minho's simulations we study the exact separation capabilities

How many number of samples you require as minimum (max is 7 now in CALOROC)?

Depending on shaping, current (GlueX-like) shaping gives us ~100 ns length with ~50 ns tail (see the Dark Noise presentation). We studies with 7 sample template looked ok.

1A or 1B?

1B