RICH Status

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SBS Weekly Meeting

Oct. 26, 2020

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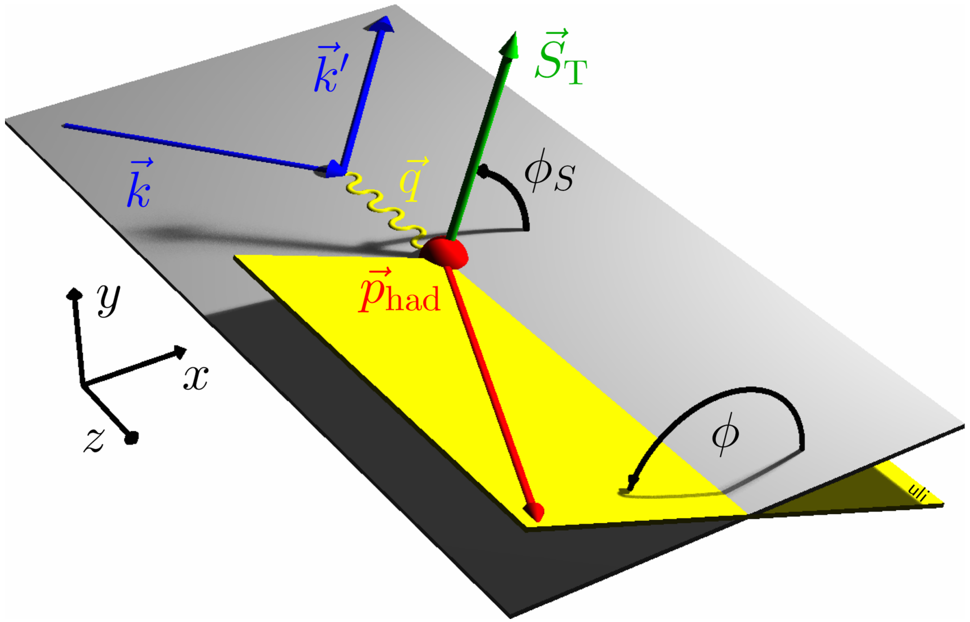
SIDIS overview



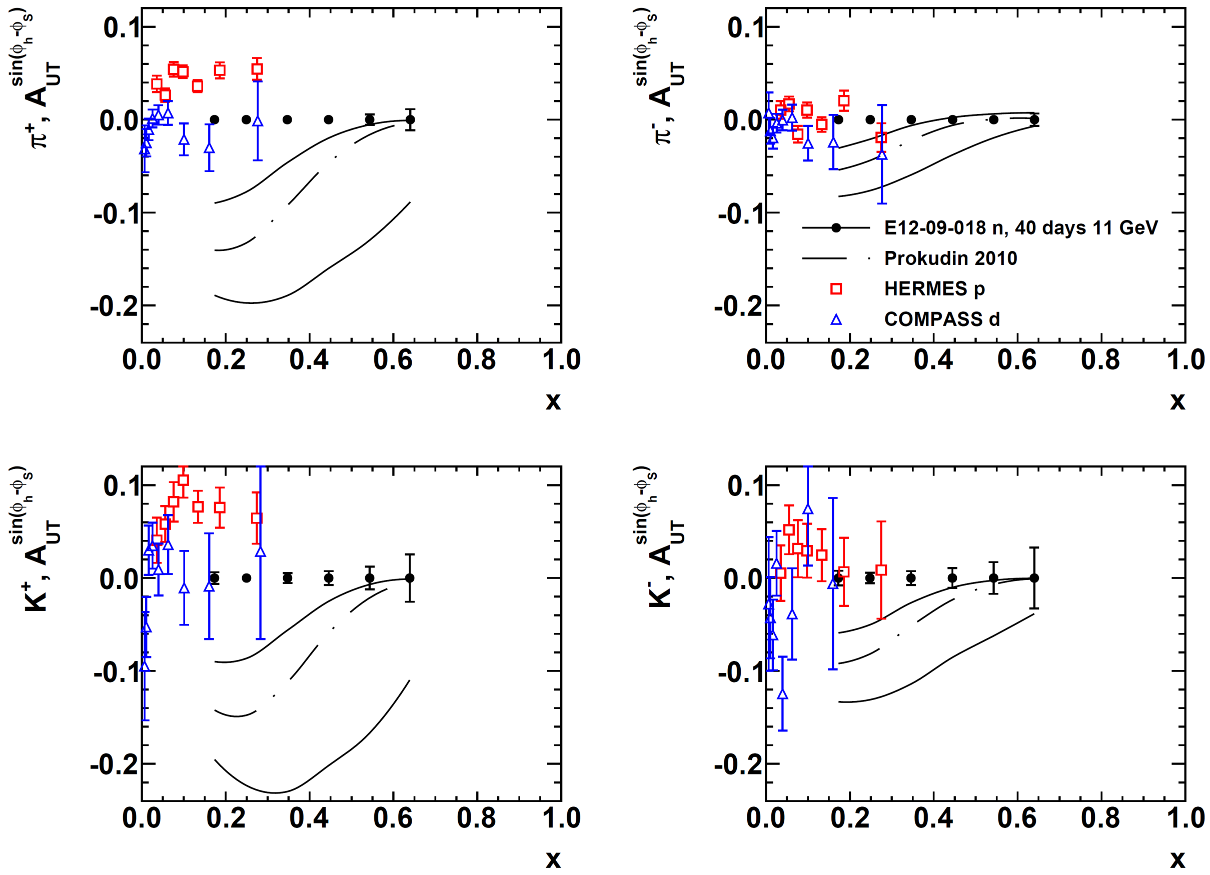
Goal: Measure single-spin asymmetries in Semi-Inclusive DIS on a transversely polarized Helium-3 target

$$\vec{n}(e,e'h)X, h = \pi^+, \pi^-, \pi^0, K^+, K^-$$

$$A_{UT}^{(Sivers)} \propto \sin(\phi_h - \phi_S)$$

$$A_{UT}^{(Collins)} \propto \sin(\phi_h + \phi_S)$$

SBS as charged hadron spectrometer and PID detector requires GEMs and RICH in addition to HCAL



Projected neutron Sivers asymmetry precision from E12-09-018 (11 GeV data only) for π^+, π^-, K^+, K^-

- E12-09-018 approved 64 days by PAC38, A- rating
- 40 (20) days production at 11 (8.8) GeV

SIDIS Kinematic Configurations

As Proposed:

$E_e\ (GeV)$	$\theta_{BB}\ (deg)$	$d_{BB}(m)$	$\theta_{48D48}\ (deg)$	$d_{48D48}\ (m)$	$d_{HCAL}\ (m)$	Beam Line Configuration #
11.0	30.0	1.55	14.0	2.5	8.5	2
8.8	30.0	1.55	14.0	2.5	8.5	2

Using GEN beamline unmodified:

$E_e\ (GeV)$	$\theta_{BB}\ (deg)$	$d_{BB}(m)$	$\theta_{48D48}\ (deg)$	$d_{48D48}\ (m)$	$d_{HCAL}\ (m)$	Beam Line Configuration #
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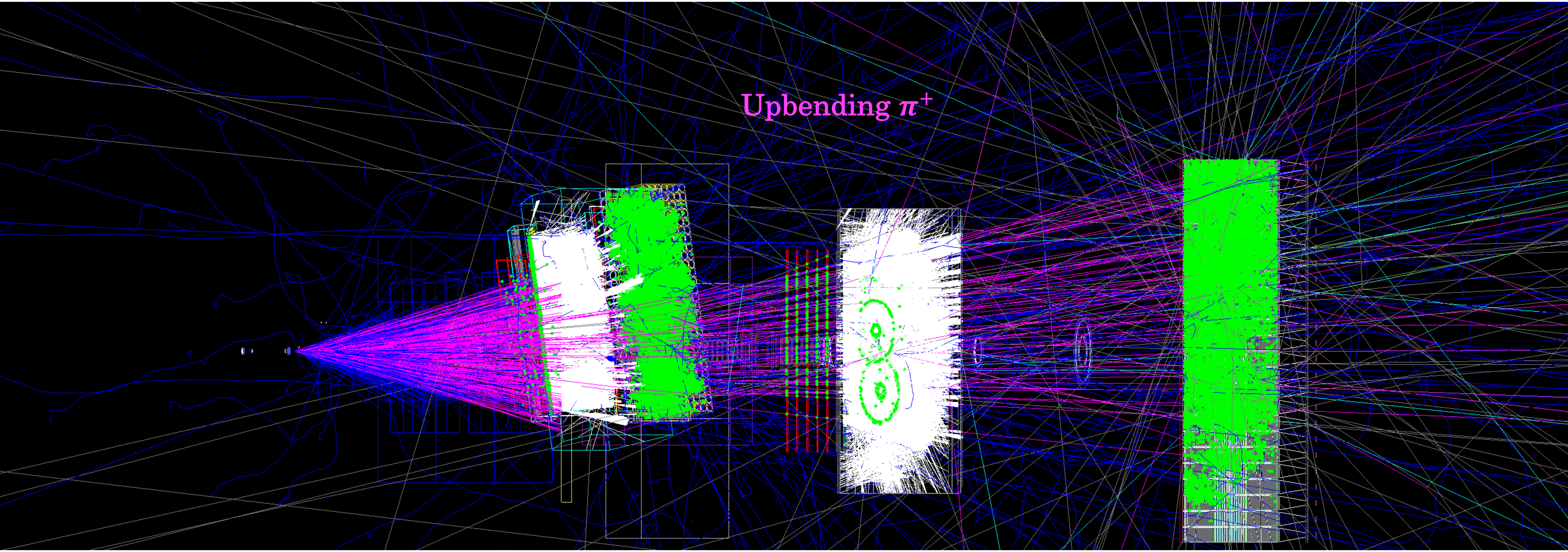
Slight compromise in hadron arm solid angle: $\frac{2.5^2}{2.8^2} = 0.8$

Rationale for Running SIDIS After GEN

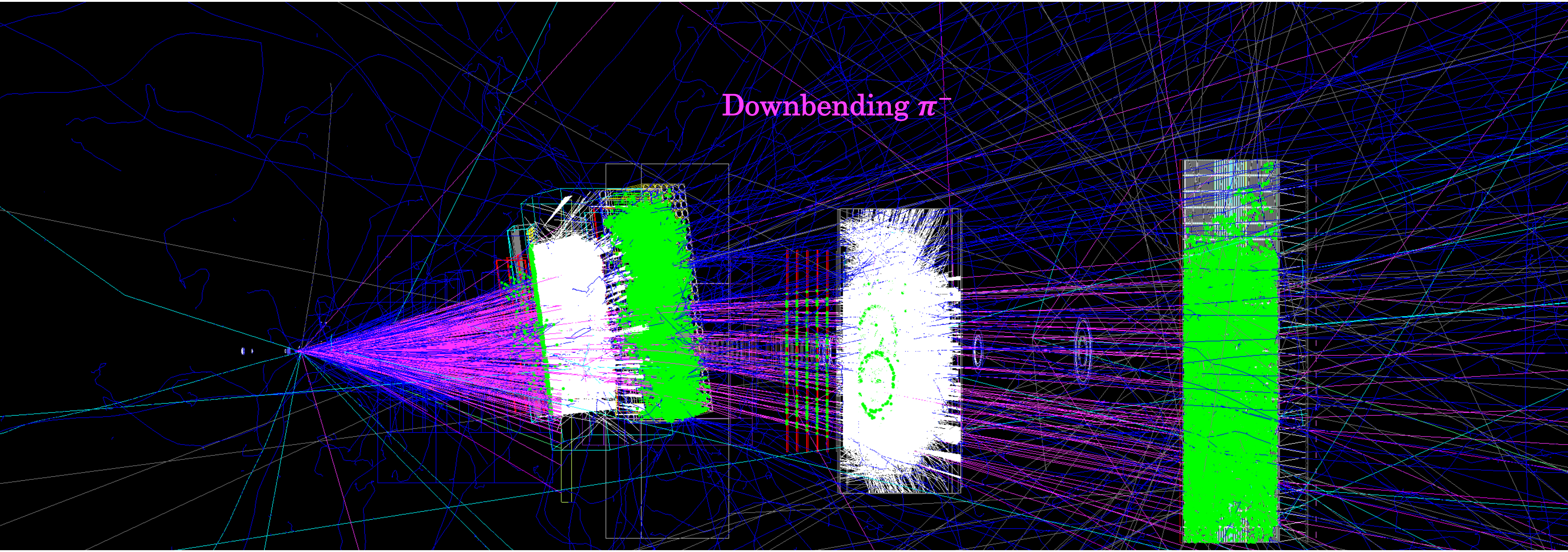
- SIDIS electron arm configuration is identical* to GEN:
  - BigBite spectrometer—only significant difference is desire to include GRINCH in BigBite trigger for SIDIS because the reaction is inclusive DIS and threshold is low (1 GeV). More gain from GRINCH in trigger for SIDIS than for GEN/GMN
- SIDIS can use identical beamline configuration as GEN (I'm reasonably confident)
- Hadron arm uses SBS magnet and HCAL.
- Main detector addition is charged particle tracking and PID on hadron side:
  - GEMs (UVA style) and RICH
- Target is also polarized ^{3}He, albeit with highly non-trivial differences compared to GEN
- COMPASS will be taking more deuteron SIDIS data with transverse polarization in 2021.
  - **While COMPASS precision won't be competitive with SBS+BB even with more data, this increases the urgency for JLab to weigh in on this physics!**
  - **On the other hand, GEP has no competition, and moreover 30-cm LH_2 cryotarget with 75 μA *may* require ESR-II upgrade (not sure).**
- E06-010, a similar experiment with 1,000 times lower figure-of-merit, produced eight physics publications so far, and the main result already has over 200 citations in INSPIRE
- These measurements are (arguably) interesting to and anticipated by a significantly larger cross section of the hadronic physics community compared to the elastic FFs, and represent an (arguably) greater advance in knowledge compared to existing.

SIDIS detector layout—baseline assumptions



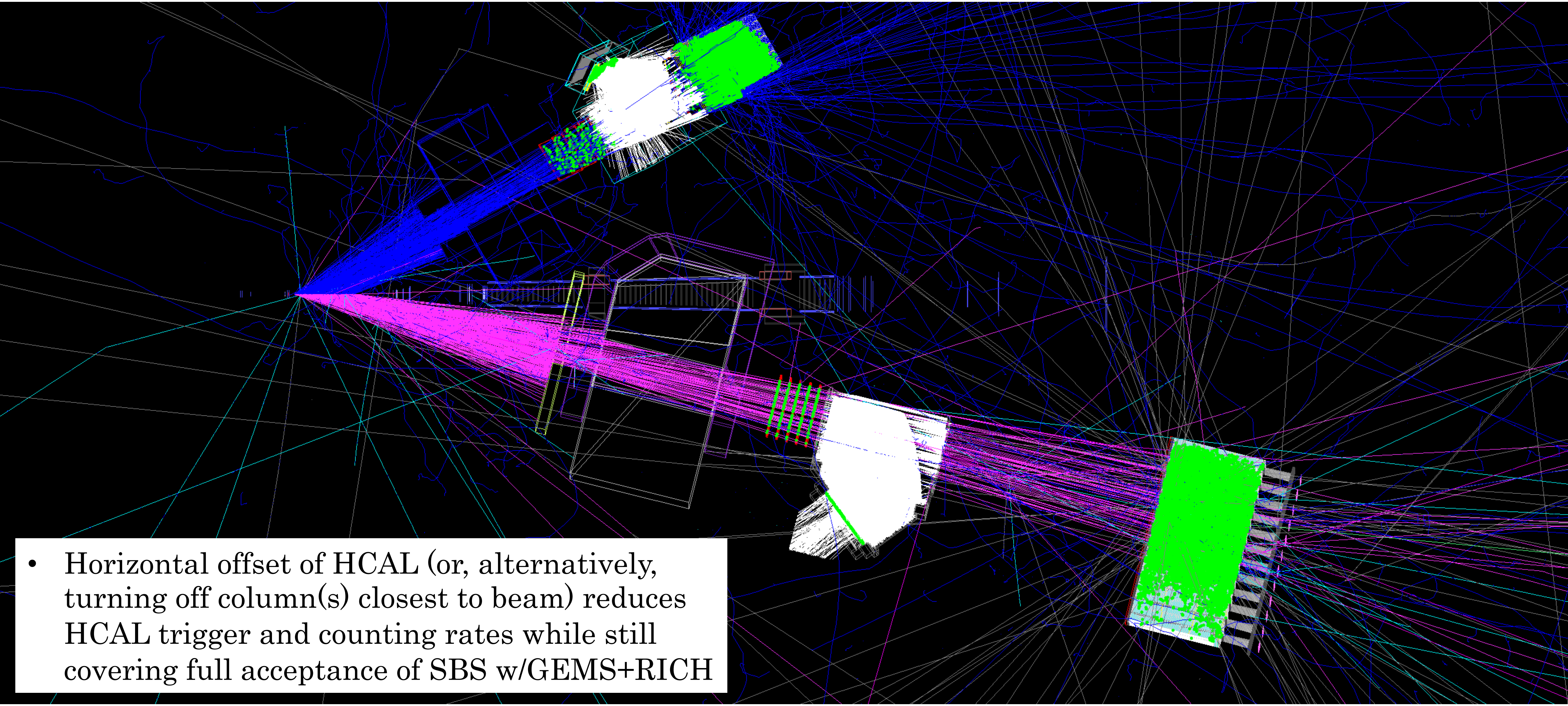
- SBS magnet distance: 2.8 m (match GEN so beamline can be reused unmodified)
- GEMs and RICH: distance as large as possible consistent with coverage matching or exceeding SBS magnet aperture
- HCAL: distance as large as possible while simultaneously covering charged hadron acceptance (upbending and downbending) for $P_h \geq 2\,\frac{GeV}{c}$
- SIDIS only requires ONE layout of BB+SBS for entire experiment. *You're welcome!*

SIDIS detector layout—baseline assumptions



- SBS field integral assumed to be 1.7 T*m
- Vertically symmetric SBS detector orientation assumed—same acceptance for positive and negative hadrons w/regular SBS polarity changes
- We assume 5-layer GEM-based tracker in front of RICH, based on UVA GEM modules (~60x200 cm^2 active area at each layer)

SIDIS detector layout—baseline assumptions

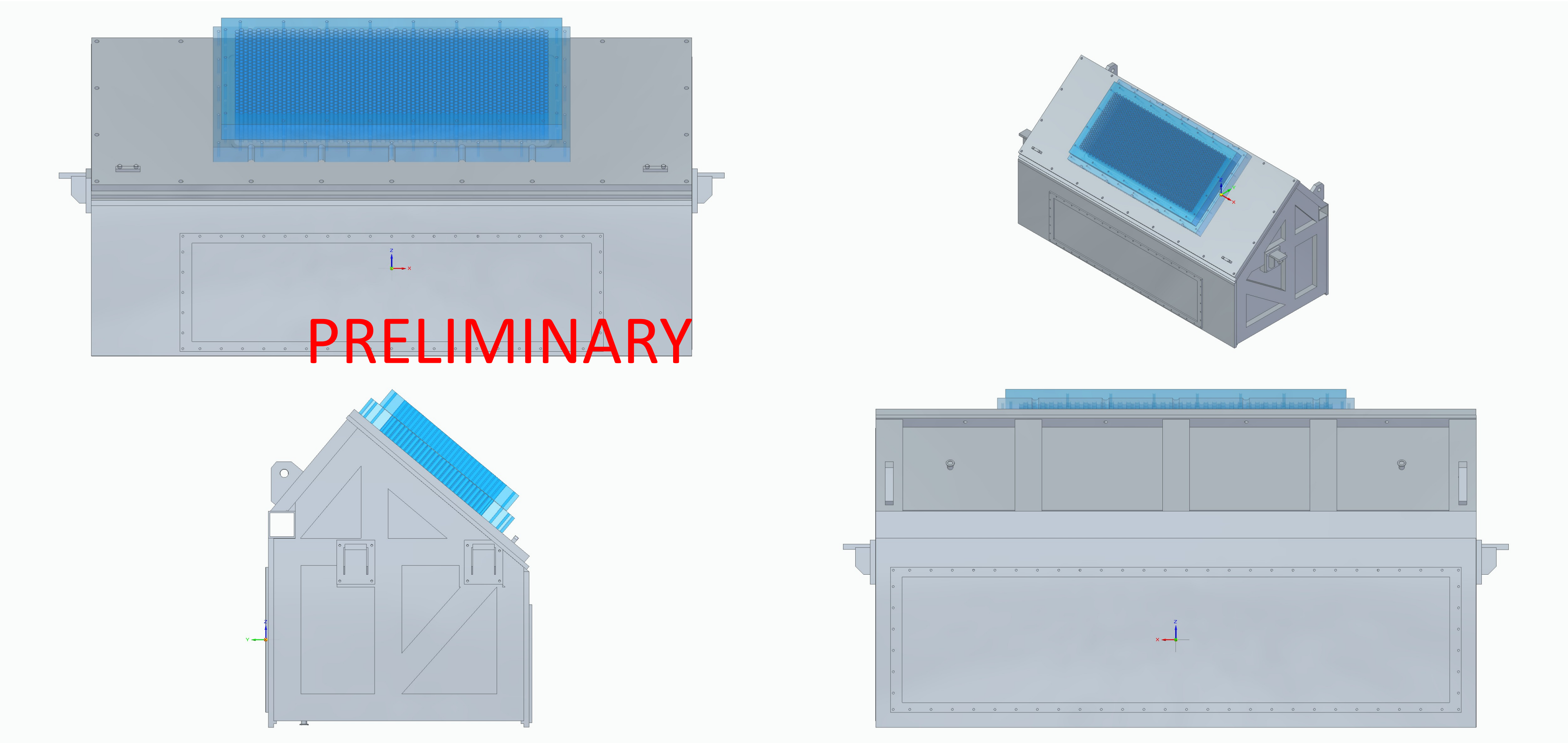


- Horizontal offset of HCAL (or, alternatively, turning off column(s) closest to beam) reduces HCAL trigger and counting rates while still covering full acceptance of SBS w/GEMS+RICH

RICH 3D Model

- Created from existing 2D .dwg drawings using SIEMENS SolidEdge, *by UConn undergraduate physics and mechanical engineering major Eva Gurra*
- According to Robin, SolidEdge is compatible with JLab's CAD system, so I hope this isn't useless as a starting point for support frame and other design…

- **2D drawings and 3D parts assembly given to Robin to start support frame design**
- This model is missing some additional details of the RICH hardware surrounding the PMT matrix, such as the cable routing harness, front-end electronics, HV distribution boards, and copper enclosure—needs to be considered in support frame design, but space not expected to be an issue



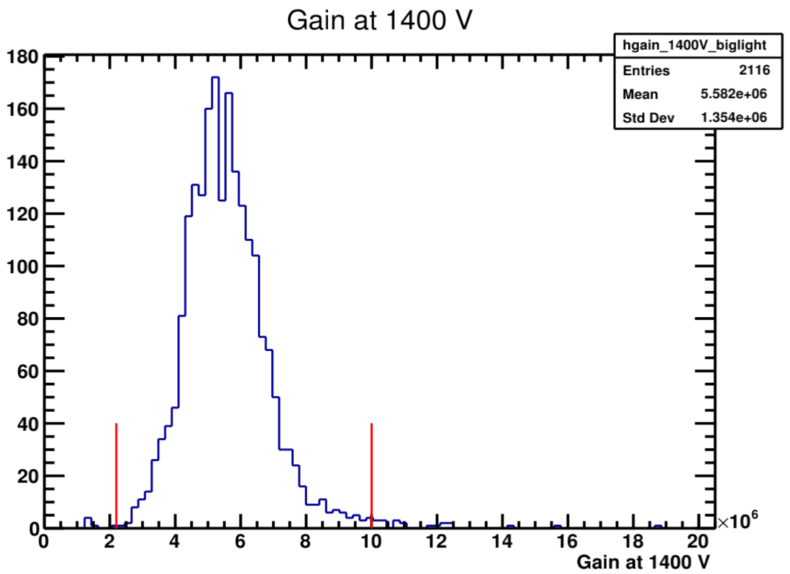
RICH Integration in SBS

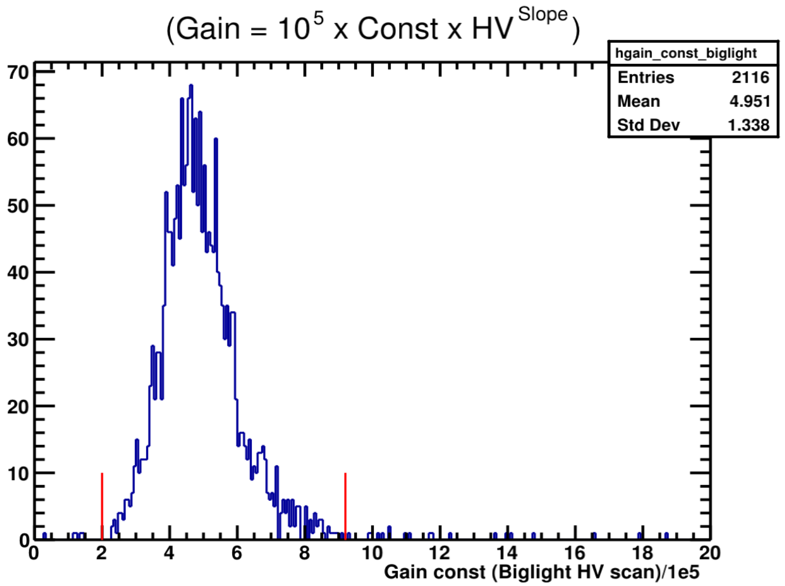
- The basic requirement for SIDIS is to have a 5-layer GEM tracker assembled from UVA-style XY modules in front of the RICH
  - There is space for more detectors (GEMs?) between RICH and HCAL, but unclear how useful this would be
- All detectors in a vertically symmetric, and vertically centered orientation/perpendicular to SBS center line
- SBS is at 14 degrees at a distance of 2.8 m
- BigBite is at 30 degrees, at a distance of 1.55 m
- Simulation is being used to optimize RICH positioning to maximize acceptance/minimize background production
- RICH will "share" the front-end and readout electronics with CDET—NINO cards + VETROC FPGA TDC--"digital" readout only. Required timing resolution ~1 ns or better
- Some simple, compact, passive patch panel (IDC header → twisted-pair ribbon cable) will likely be needed to interface RICH PMT signals to NINO cards
- HV distribution can be reused from HERMES RICH; need ~64 channels of +HV power supplies, connect to distribution boards via standard SHV connectors/cables.

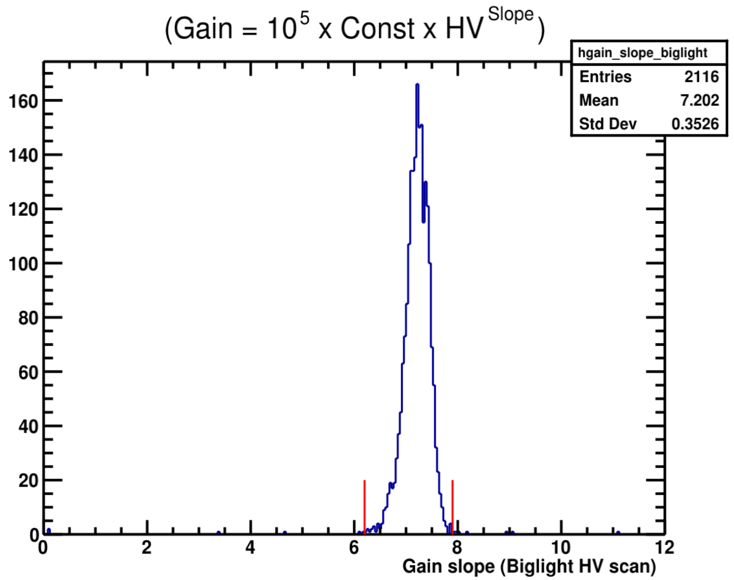
RICH remaining tasks

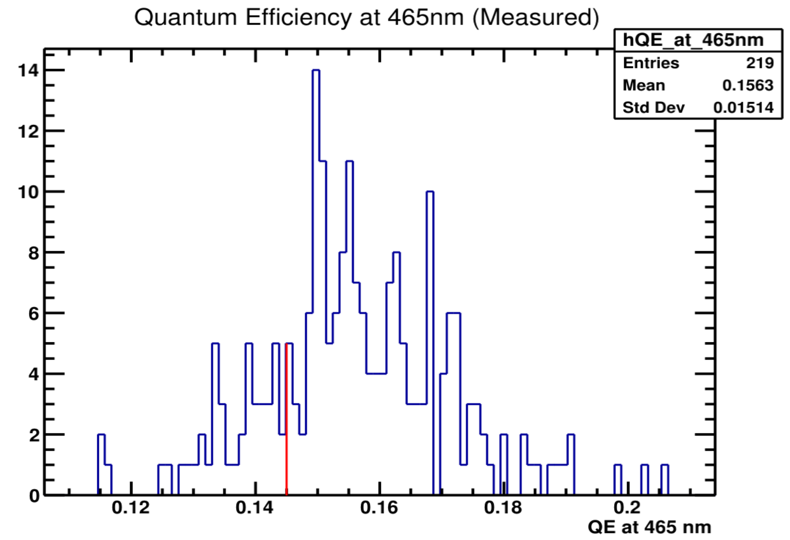
- Move RICH out of storage into testlab for commissioning
  - Tentative plan is to occupy some of the space vacated by HCAL after HCAL moves to Hall A. We want to be near CDET test stand to share some electronics: can use either existing Fastbus or new VETROC setup for testing;
  - Full DAQ system could be checked out w/cosmics, but aerogel condition and mirror performance would be difficult to test with cosmics unless we could orient the detector with the entry window facing the sky (making it more difficult to work with).
  - Cosmic ray checkout would benefit from having a GEM-based tracker in front and/or trigger scintillators above and below
- Support frame design/fabrication/procurement: **need help from Hall A engineering/design staff**
- Gas handling system design/fabrication/procurement—basically copy GRINCH design, make any necessary modifications for larger RICH volume: **need help from detector support group/Hall A tech. staff**
- Design simple, passive patch panels to connect PMT signal cables to NINO front end cards; figure out how/where to mount NINO cards near RICH: **need help from JLab electronics group**
- Plan detailed signal, HV, and LV power supply and cable requirements: length, routing, connectors, repeaters, etc.
- We will need to open the RICH main box, check mirror condition/alignment, and check aerogel condition
- We will probably want to blow air through the PMT enclosure when in Hall A, both for cooling of the PMT matrix and to prevent helium intrusion.
- **Goal is to be ready for possible SIDIS run after GEN in ~late 2022-early 2023; start of actual detector work as well as design/procurement items during my upcoming sabbatical in 2021 is critical, despite the current focus on GMN/GEN-RP/GEN-II.**

Sorting Best PMTs for SBS-RICH



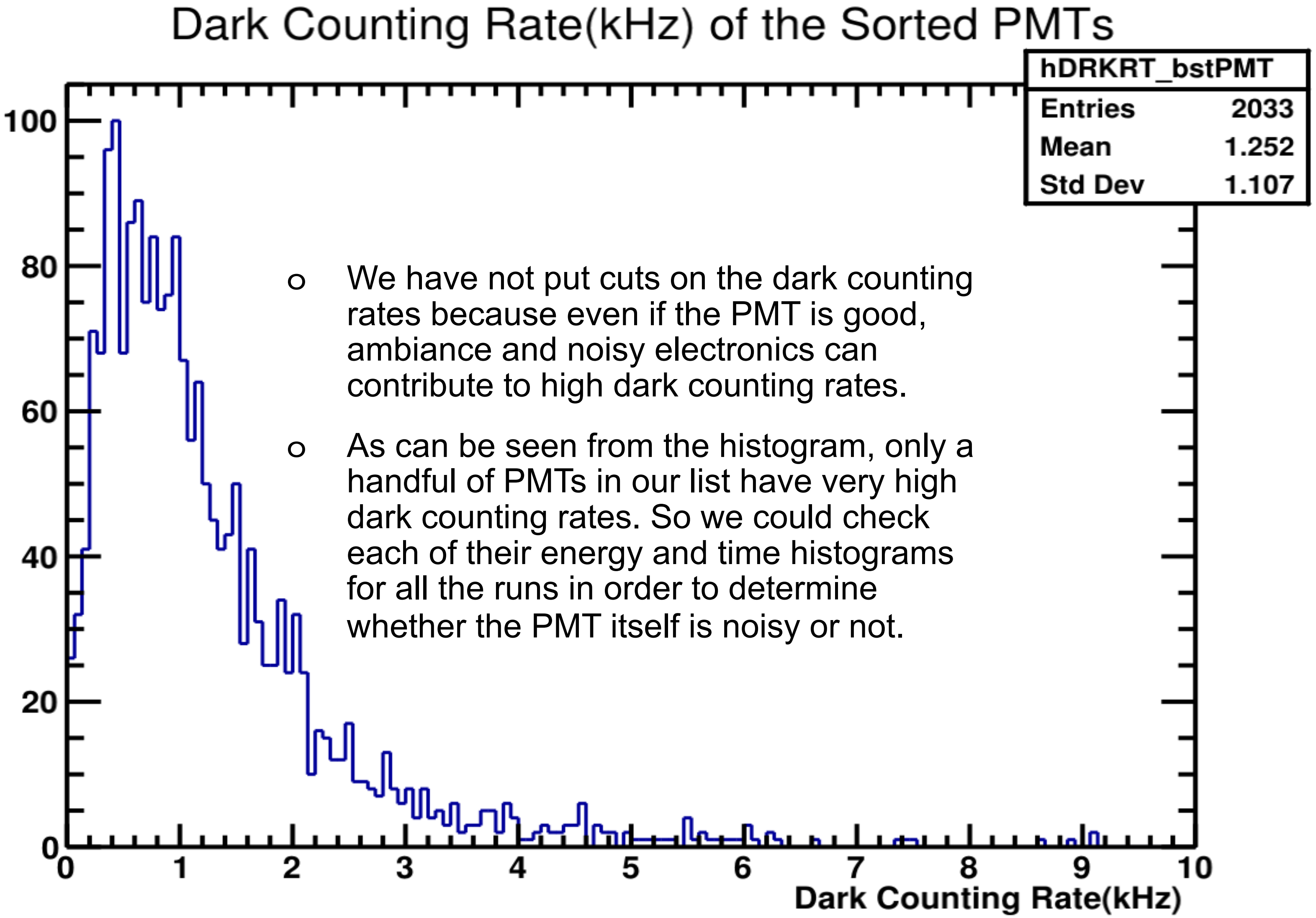






- **We have tested 2151 PMTs among which only 1934 are needed for the SBS-RICH.**
- **In order to choose only the best ones we have used the following few cuts (indicated by red verticle lines in the plots):**
  - **Gain at 1400 V should be between 2.2M and 10M.**
  - **Gain constant should be between 0.2M and 0.92M.**
  - **Gain slope should be between 6.2 and 7.9.**
  - **Quantum Efficiency (measured) at 465nm should be above 0.145.**

Sorting Best PMTs for SBS-RICH cont.



- We have not put cuts on the dark counting rates because even if the PMT is good, ambiance and noisy electronics can contribute to high dark counting rates.
- As can be seen from the histogram, only a handful of PMTs in our list have very high dark counting rates. So we could check each of their energy and time histograms for all the runs in order to determine whether the PMT itself is noisy or not.

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Sorting Best PMTs for SBS-RICH cont.

Table 1: List of all sorted PMTs with serial number (PMT SN) and all the other relevent parameters.

SN	PMT SN	NPEREFLED	Gain at 1400V	Gain constant	Gain slope	Dark Rate (Hz)	QE at 465 nm	QE M/E	RICH row	RICH column
1	4148	578.963	5.61e+06	486335	7.26778	944.192	0.150882	M	16	58
2	8669	485.901	4.24e+06	372787	7.22994	824.558	0.200116	E	22	56
3	8663	381.197	5.19e+06	410148	7.54697	8603.54	0.156381	E	21	56
4	8709	402.537	4.88e+06	405199	7.39804	356.367	0.149365	M	25	56
5	8593	662.280	5.32e+06	419759	7.54842	687.717	0.154324	M	21	57
...	...	...	...	...	...	...	...	...	...	...
2032	4545	392.349	5.00e+06	380263	7.66214	596.608	0.160468	M	18	57

- **Using the method described in the previous two slides we have been able to sort 2032 PMTs with reasonably good specifications. Since we just need 1934 PMTs for the SBS-RICH, this leaves us with 98 spares.**
- **We have prepared a spreadsheet which contain all the relevant parameters of these 2032 PMTs as shown in the above table (Table 1). This spreadsheet will come very handy when we start installing PMTs in SBS-RICH early next year.**

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