SBS Software Status

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SBS weekly meeting
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Outline

- Status of Monte Carlo
- Status of Digitization
- Status of Reconstruction:
  - Standalone GEM reconstruction software
  - SBS-offline: Podd-based reconstruction software for SBS program
- Recent Highlights
- Current status/challenges

G4sbs—Monte Carlo Simulation

- Documentation: https://hallaweb.jlab.org/wiki/index.php/Documentation_of_g4sbs
- Github repository: https://github.com/JeffersonLab/g4sbs
- Status: mature GEANT4 simulation infrastructure; used successfully for new proposal development/approval, clearing ERR for GMN/GEN-RP, design and planning of experiment
- Recent highlights:
  - optics planning/sieve slit design
  - GEN target geometry
  - Exit beamline geometry for GEN/SIDIS
  - Common downstream beamline geometry

"libsbsdig"—Simulation digitization

- On github: https://github.com/JeffersonLab/libsbsdig
- Purpose: simulation-reconstruction interface: develop, test, and benchmark performance of reconstruction algorithms
- Takes Monte-Carlo "hits" in sensitive volumes (position, time, energy deposition, etc) and produces realistic digital "pseudo-data" (crate, slot, channel, ADC, TDC): in a "pre-decoded" format (plane, module, strip, PMT #, etc.)
- Status:
  - **Initial version was "working" (doing more or less what we wanted it to do), but intolerably slow/not usable, due to speed bottlenecks unrelated to the actual digitization**
  - Initial version was nevertheless successfully used for many important studies for GEP tracking
  - Despite having been useful for simulated tracking studies, aforementioned speed/usability issues became a bottleneck for reconstruction development progress; a decision was taken after the most recent collaboration meeting to extract the useful parts of the code, and rewrite libsbsdig from scratch, in order to simplify the code and remove artificial speed bottlenecks caused by bad/inefficient code design.
- New digitization: "sbsdig_lw" branch: currently ~90% complete for GMN–initial results ~= 100X speed improvement
  - Design changes: the simulation digitization will no longer "encode" the simulated data in the "raw" EVIO CODA format only to "re-decode" the data, as this is a waste of CPU cycles—instead, the digitization will populate the equivalent of the "decoded" data structures, in which the unique channel index in the simulation is already associated with its physical location—for simulated data, the reconstruction will bypass the decoding step and proceed directly to reconstruction

Reconstruction status

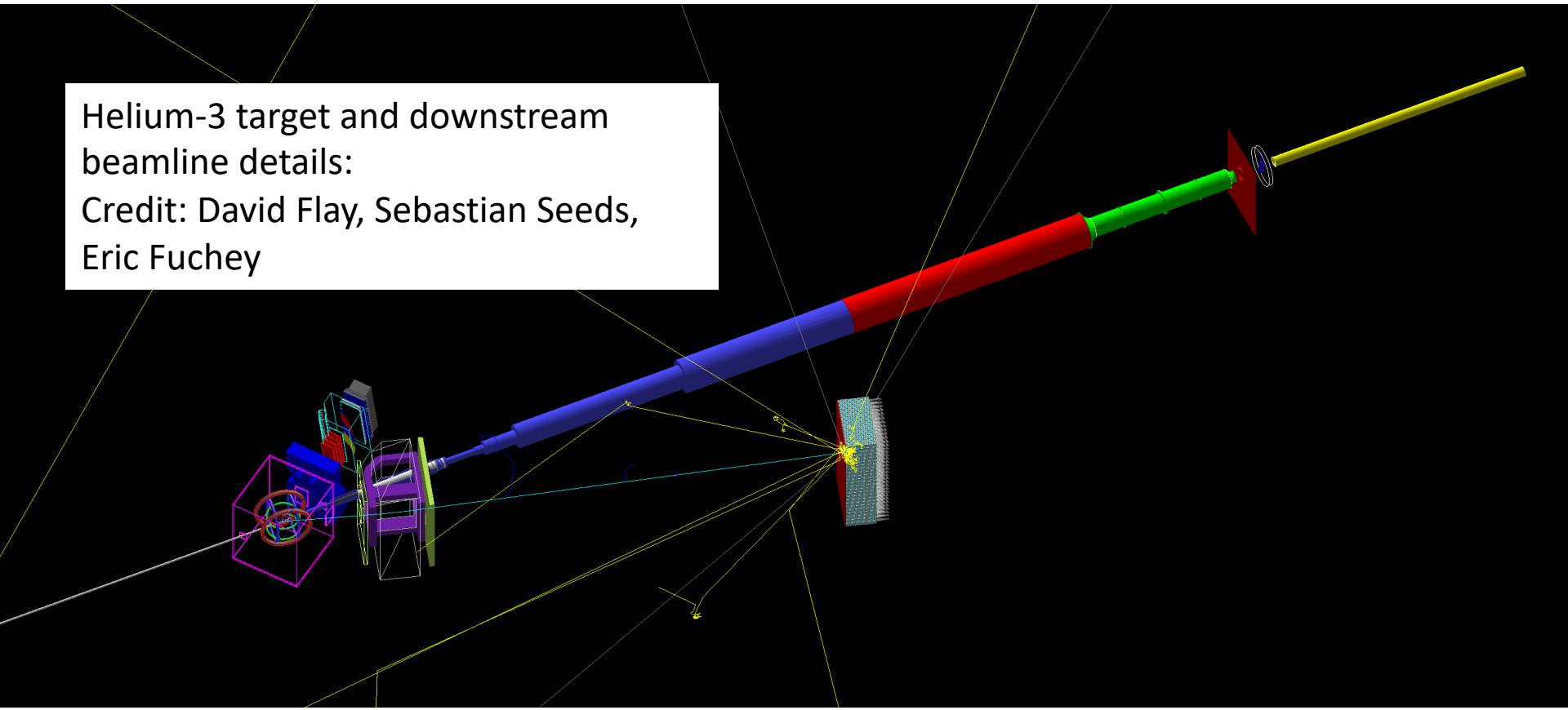
- SBS-offline on github: https://github.com/JeffersonLab/SBS-offline
- Cmake-based build system
- Built against analyzer/Podd version 1.7 (latest)
- Already in use for HCAL analysis
- Development for BigBite and other detectors delayed, at least in part due to lack of useable simulation digitization library, but also lack of useable test data for (some) detectors.
- Still need subsystem "white papers" requested over 1 year ago from most subsystems (see August, 2019 collaboration meeting talk, slide 12): https://hallaweb.jlab.org/12GeV/SuperBigBite/meetings/col_2019aug5/talks/Puckett_SBS_software_status.pdf
- Significant progress on GEP tracking since March

Standalone GEM tracking code

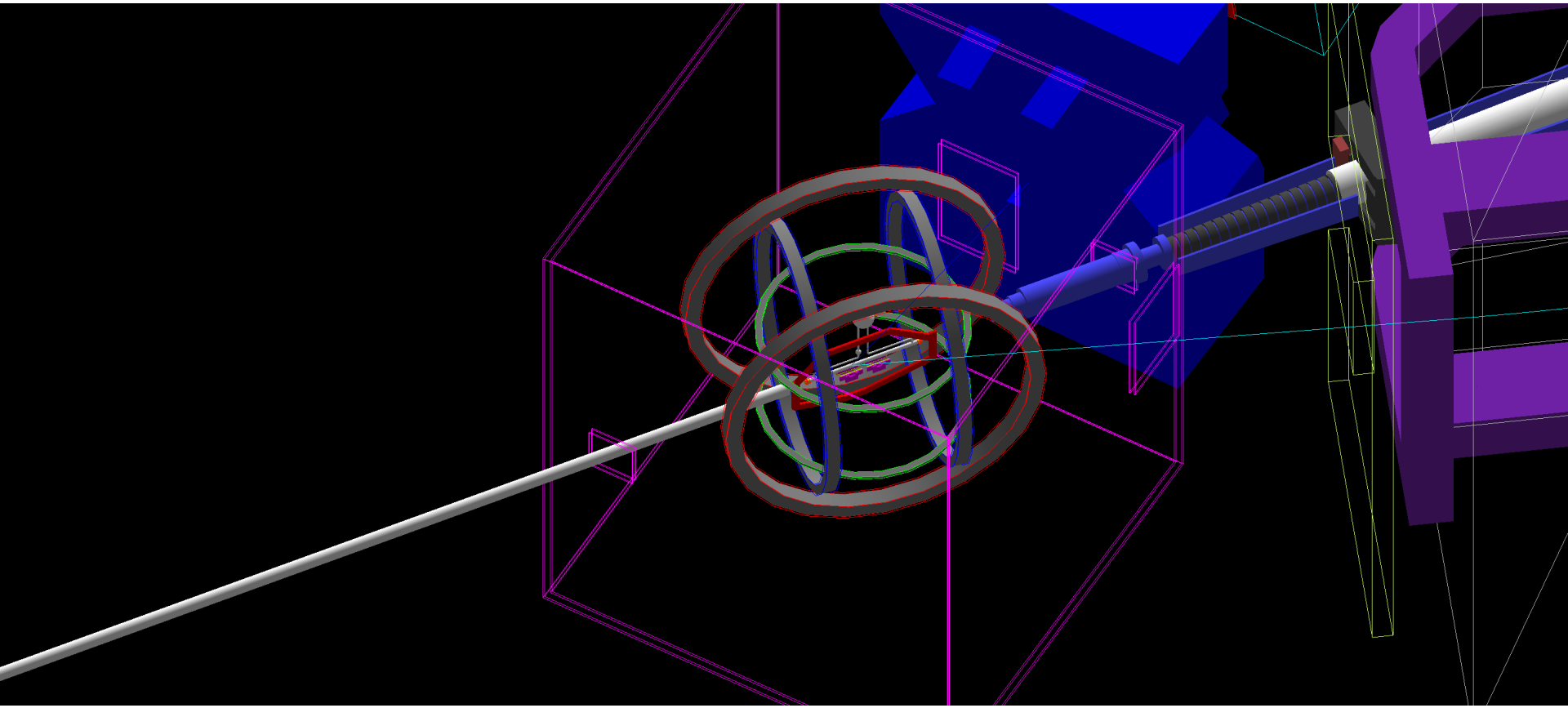
- Github repository: https://github.com/ajpuckett/SBSGEM_standalone/
- Clustering, tracking, and alignment code
- Used successfully for analysis of cosmic data from INFN GEMs, UVA GEMs
- Also used for analysis of PREX GEM data, Hall A beam test data from 2016
- Ongoing usage for UVA GEM commissioning, resumed since ~late August
- For more details, see July, 2020 Collaboration Meeting talk: https://www.jlab.org/indico/event/389/contribution/29/material/slides/0.pdf

Recent highlights--simulation geometry

Helium-3 target and downstream beamline details:
Credit: David Flay, Sebastian Seeds, Eric Fuchey

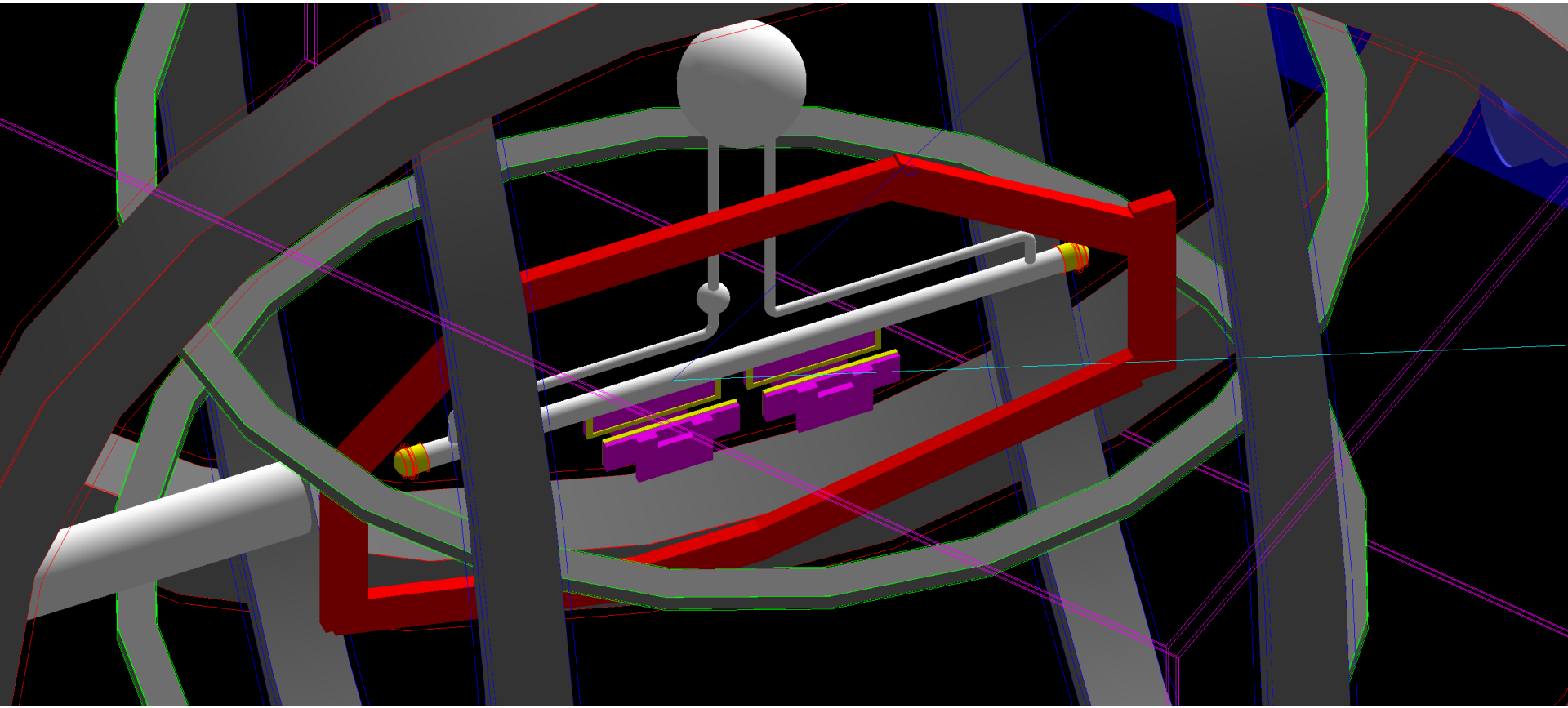


Helium-3 Target details: Credit D. Flay

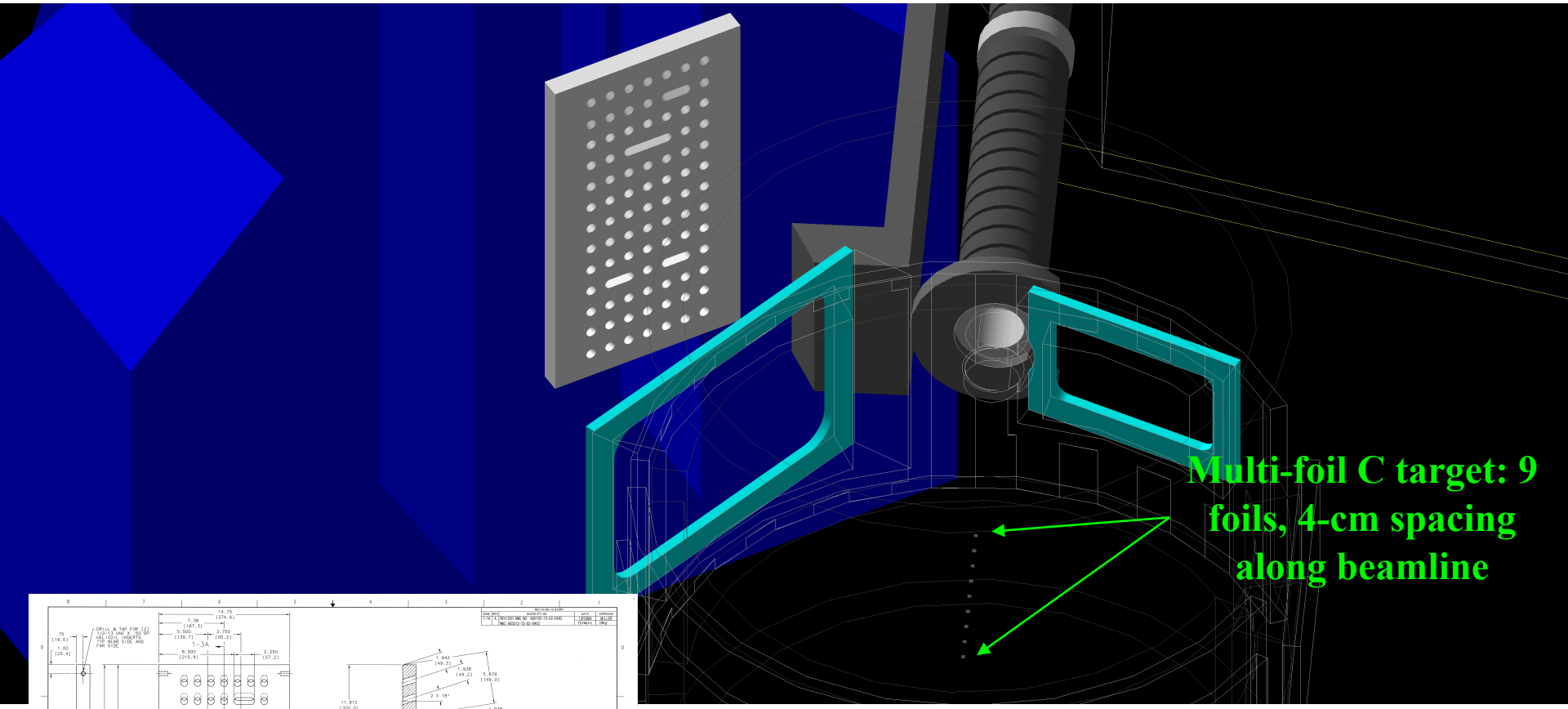


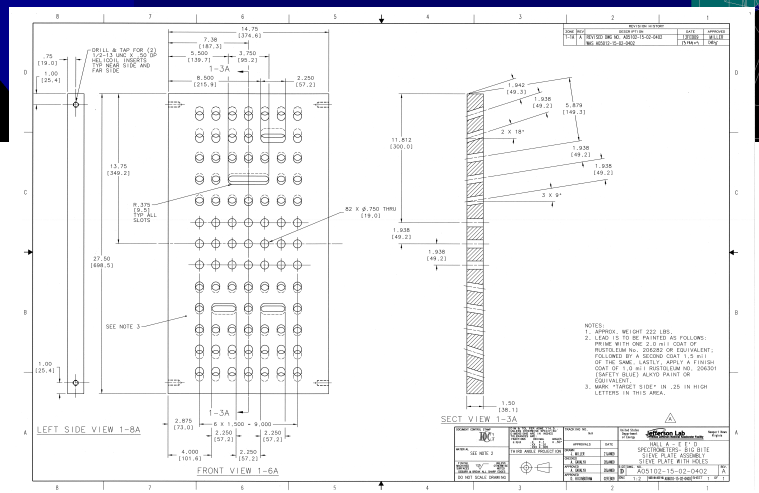
- All essential details of helium-3 target geometry (for simulation purposes) now included: target cell, metal endcaps, transfer tubes, pumping cell, target ladder, pickup coils, Helmholtz coils, iron shield box with apertures

Helium-3 target in g4sbs (closeup)



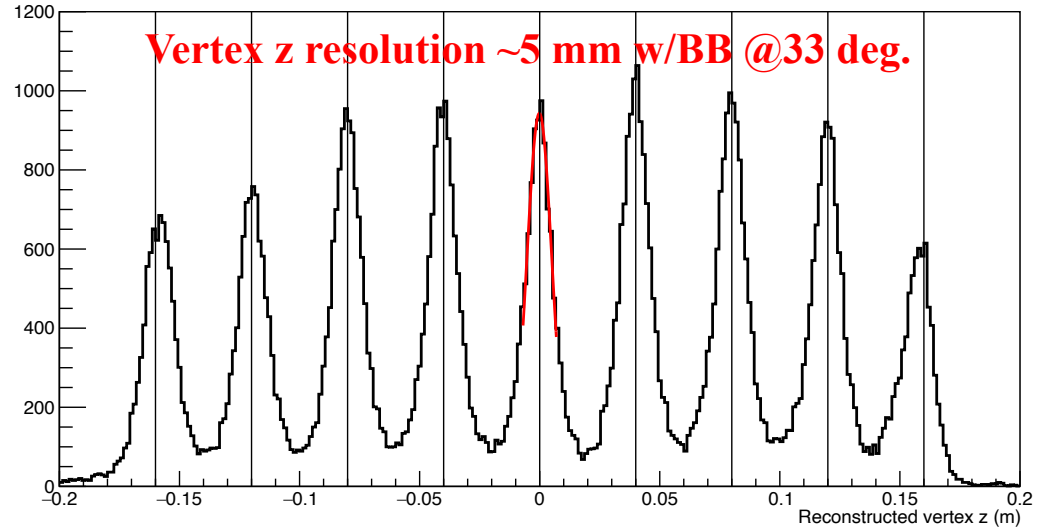
Review: Sieve Slit/multi-foil simulation



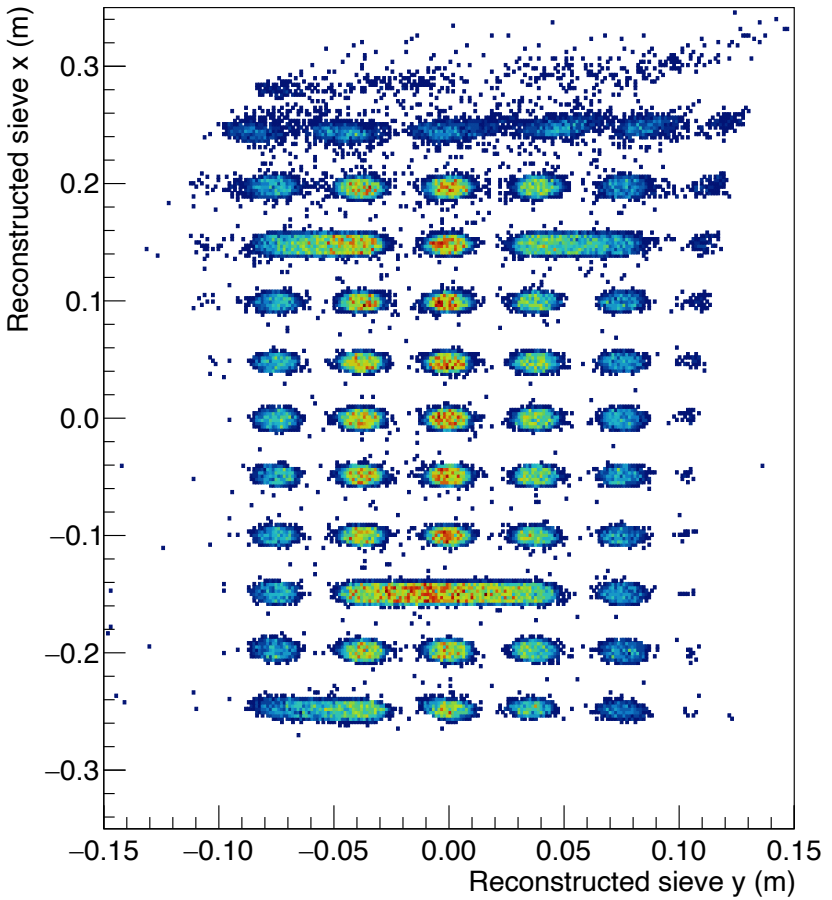


- BigBite Sieve plate design from C. Soova implemented in g4sbs.
- Multi-foil Carbon target for optics calibration added according to GMN run plan
- Test adequacy of sieve plate material, thickness, hole pattern/size/spacing/etc.

BigBite Optics Planning: Vertex and sieve pattern reconstruction



- Current GMN plan calls for optics target with 9 C foils, spaced at 4-cm intervals along z
- **With sieve plate at its nominal position, the two outermost columns and the top and bottom rows of holes seem to be mostly absent from the acceptance.**
- **The performance of the starting (4th-order) optics model is poor near the vertical extremes of the acceptance, particularly at large +X (the bottom)**
- **Basic cuts on track quality, and the preshower+shower E/p ratio after track momentum reconstruction are sufficient to suppress "punch-through" tracks; the reconstructed sieve hole pattern is relatively "clean"**
- ***Next step: implement and test realistic optics calibration, where MC truth info on vertex/track angles is replaced by rays computed from foil and sieve hole positions.***



- Note: both vertical and horizontal axes of TRANSPORT coordinate system are inverted relative to the image on previous slide: +X = vertically down, +Y = left (increasing scattering angle)

BigBite optics developments—latest

- Holly S.-Vance developed and tested realistic optimization program for angle and vertex reconstruction
- Converging on final sieve hole pattern for BigBite—check performance with the most relevant kinematic settings in GMN/GEN-RP/GEN
- SBS sieve design also being evaluated in g4sbs—planning of calibration slightly more complicated since it has to be done with protons instead of electrons—punch-through is an issue for calibration with protons
- Plan for SBS optics calibration will be somewhat different between GEN-RP/SIDIS/GEP

GEP tracking—latest developments (W. Xiong)

Performance and results

Single track efficiency [%]

	0% bg	10% bg	20% bg	50% bg
Old	97.2	93.4	89.6	75.3
new	97.0	92.3	88.5	73.4

Single track accuracy [%]

	0% bg	10% bg	20% bg	50% bg
Old	99.7	99.0	98.3	87.7
new	99.6	98.9	97.6	88.3

Time per event [ms]

	0% bg	10% bg	20% bg	50% bg
Old	0.05	2.6	73.6	40000 to 60000
new	0.06	0.1	0.2	0.6

New fast track-finding algorithm (“3D tree search”) by Weizhi Xiong produces 10^5 X (@50% of full GEP luminosity) speed improvement compared to “brute force” approach in current standalone code

Summary

- Strong core simulation and software working group
- Weekly meetings productive
- Simulation digitization almost back on track
- Need better organization and higher-level discussion on global reconstruction software design, need more input from subsystem contacts
- Full details of GEN geometry now in simulation—ready for ERR charge
- Weekly meetings Friday, 1 PM
- Mailing list: sbs_software@jlab.org
  https://mailman.jlab.org/mailman/listinfo/Sbs_software