Super Bigbite Software and Computing

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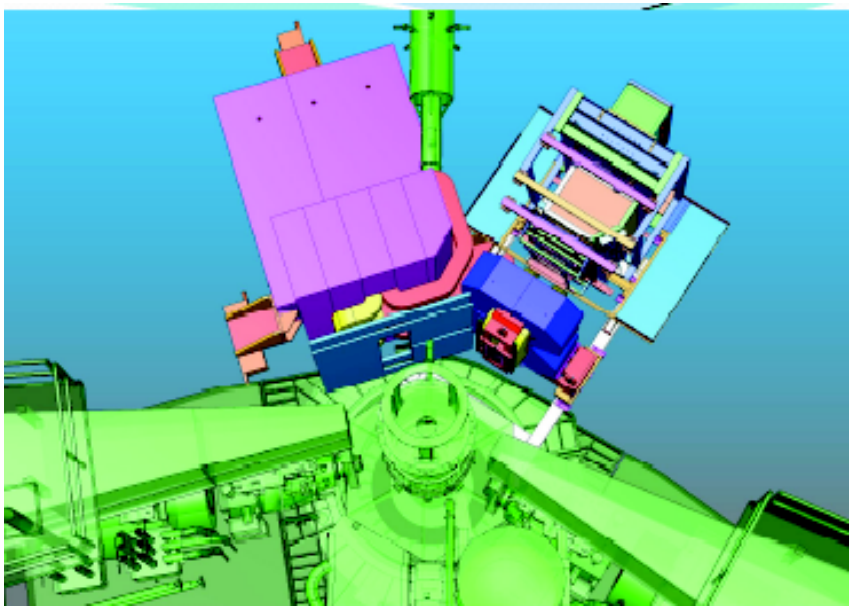
Overview

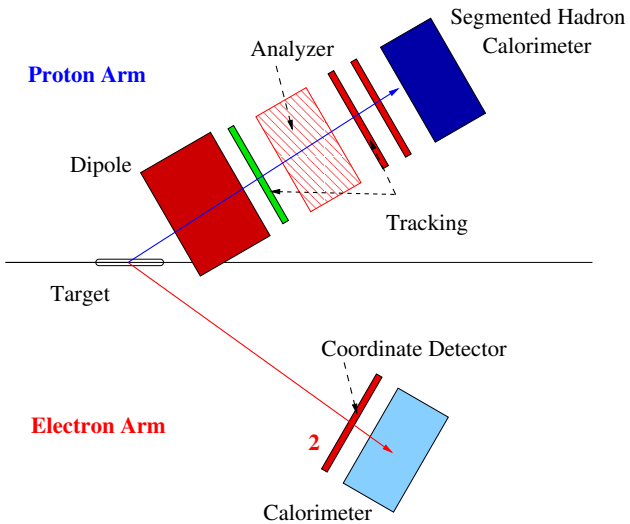
- Project Overview and Scope
- Task Responsibilities
- Status and Timeline

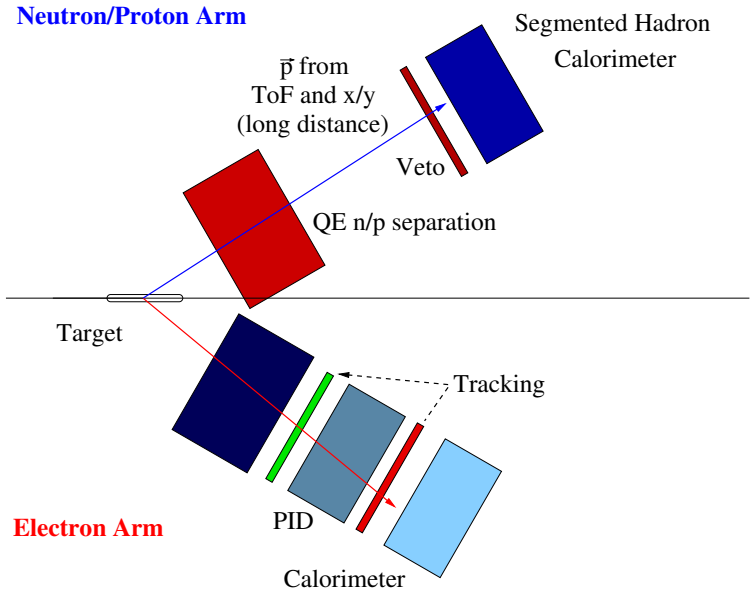
SBS Experimental Program

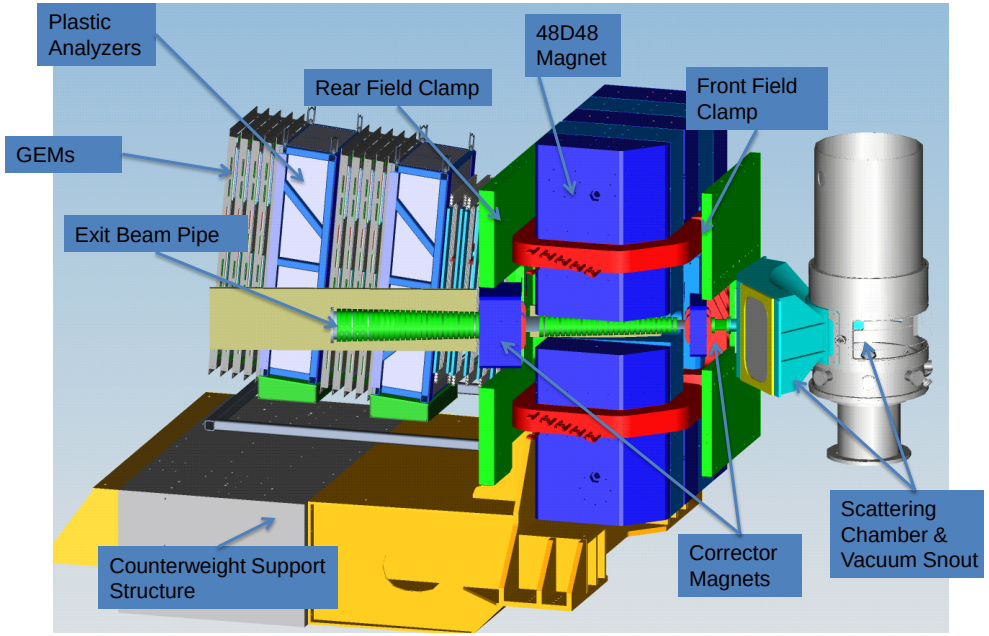
Overview

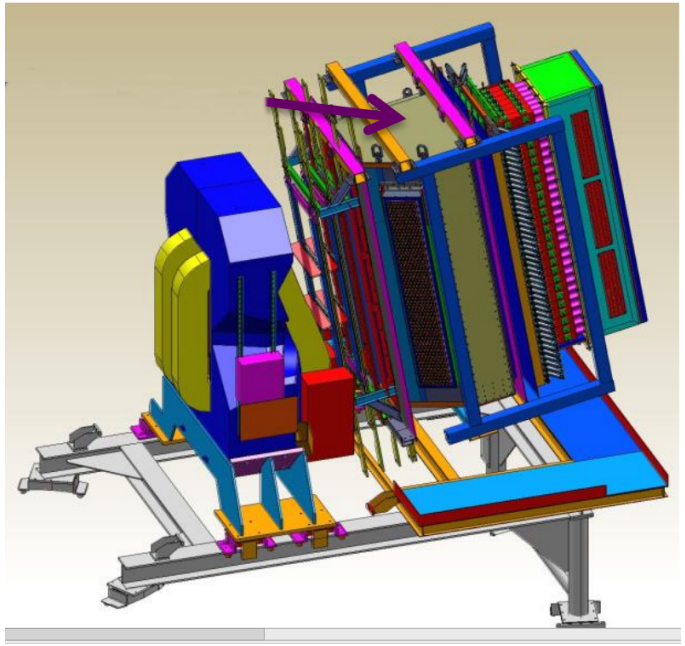
- Super Bigbite program measures three nucleon elastic form factors to high Q^2, SIDIS on $^3\overrightarrow{\mathrm{He}}$, (Cond. Appv. TDIS)
- Form factors $\rightarrow$ \$5M DOE Project
- Total 184 days of running approved (+ 27 cond.)











- Several major new systems -
  Experiments have different combinations

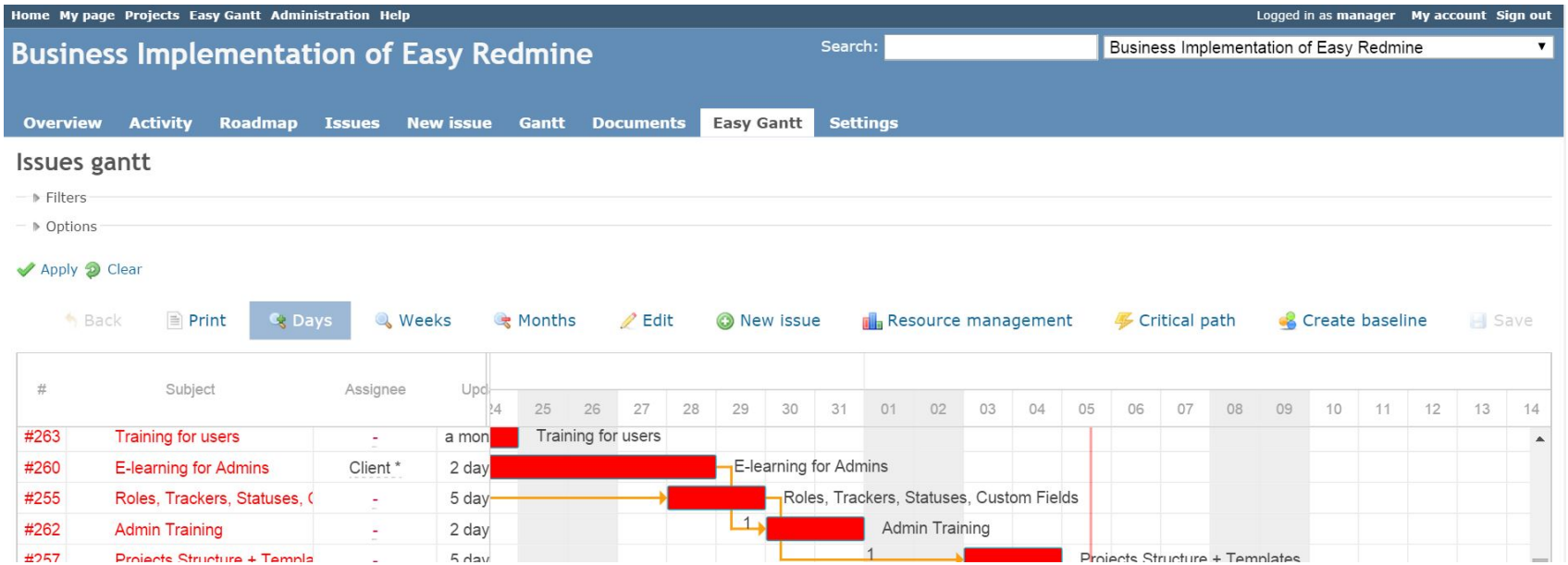
Several sets of GEM trackers	∼100k strips
Hadronic Calorimeter	288 FADC ch
Electromagnetic Calorimeter	1700 ADC ch
Scint. Coord. Det	2k TDC ch
Gas Cherenkov	550 TDC ch
Scintillator Timing Plane	360 TDC/ADC ch

- Resuse of existing Bigbite EM calorimetery (∼200 PMTs), HERMES RICH (∼2k PMTs)

Software Goals

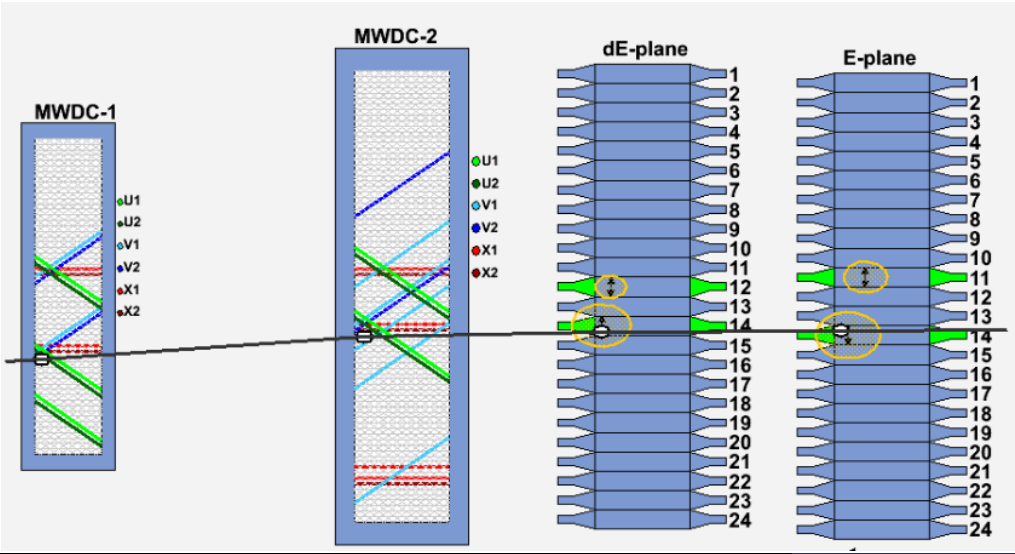
Need full software chain before start of running

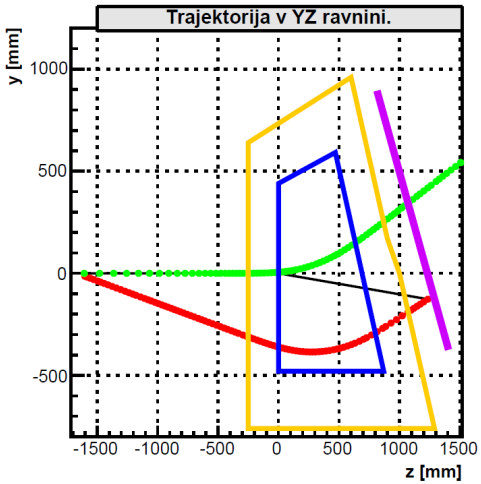
- Need for all stages: development, commissioning, and running
- Event reconstruction and inter-detector correlations will be critical to ensure experimental operation
- High event rates will make experimental analysis difficult
- Require significant coordination between subgroups to be successful
- Software project management for organization



Detector Subsystem Software

- Add to analyzer framework GEMs, CDet, GRINCH, ECal, RICH, Bigbite
- Have GEM classes from previous experiments integrated with TreeSearch tracking - test of clustering algorithms
  - Probably single most difficult task
- New decoders that need to be written
  - MPD written and available in repository
  - Need analysis class for HCal FADCs
- Expect much will be done during construction and early commissioning
- Event displays required
- Individual hardware development groups have taken on responsibility





Subsystem Responsibilities

General Purpose Software	
analyzer Development	Hansen
Front End Decoders	Camsonne
Event Reassembly	JLab DAQ Group

SBS Specific	
Repository Maintenance	Riordan
MPD Decoding	SBU, JLab, UVA, INFN
GEM Tracking	INFN, JLab
HCal Analysis	Franklin
ECal Analysis	Puckett
Coord. Det	CNU (Monaghan, Brash)
GRINCH	Averett
BigBite Legacy	Riordan

Experiment Analysis Specific		
GMn	Quinn	Bigbite, HCal
GEn	Riordan	Bigbite, HCal, ^{3}He target
GEp	Cisbani	ECal, Coord. det, SBS w/ trackers
SIDIS	Puckett	Bigbite, SBS w/ trackers and RICH
TDIS	Dutta	SBS e^- w/ trackers and RICH, LAC, RTPC

GEM Tracking Requirements

Common: straight tracks (field-free region)

- **BigBite:** GEMs, assisted by ECAL; low rate; BigBite optics
- **SIDIS H-arm:** GEMs, assisted by HCAL; low rate; 48D48 optics
- **GEp(5) front:** GEMs, restricted to narrow search region; very high rate; requires iterative kinematic correlation analysis; 48D48 optics
- **GEp(5) back:** GEMs, similar search region; high rate; requires bridging between tracker regions

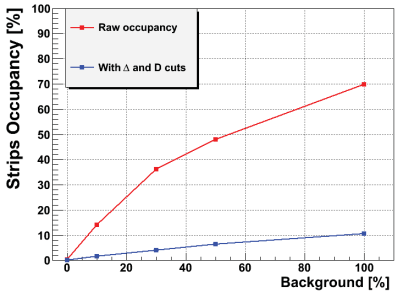
Each item involves (somewhat) different reconstruction algorithm.
Significant code sharing possible, if well planned

- Expect rates up to $\sim 500\ \mathrm{kHz/cm^2}$ for most challenging kinematics

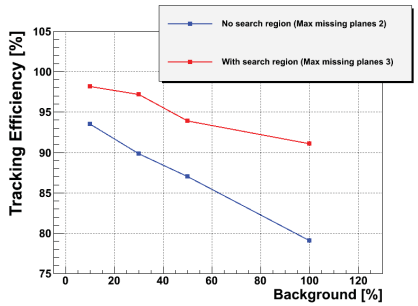
GEM Tracking

2011 GEp(5) Tracking Study: Results (with Vahe Mamyan, CMU)

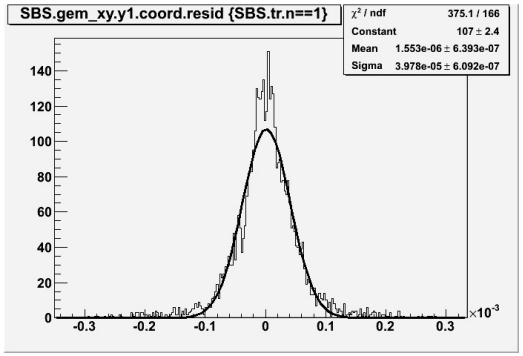
Front tracker GEM strip occupancy



Tracking Efficiency



Track reconstruction accuracy

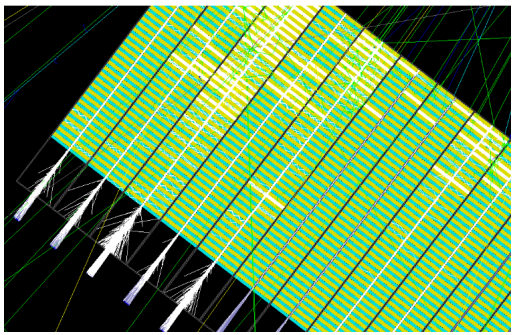


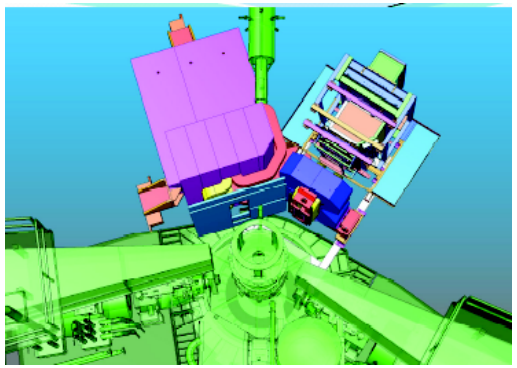
- Realistic digitization of GEM & electronics response
- Simplifying assumptions made (see next)
- $>$ 90% tracking efficiency
- 5% ghost track probability
- $\approx$ 40 μm track position resolution

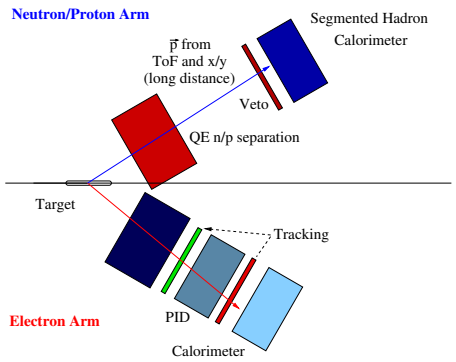
- Significant work already done in tracking under realistic requirements with Hall A TreeSearch algorithm
- Have only done realistic tracking for Front (most difficult) tracker to prove feasilibity
- Have Postdoc Eric Fuchey (UConn) who is presently engaged with using latest simulation and integrating into SBS package

Experiment Analysis Software

- Need development for analysis of each specific experiment
- Algorithms for PID and associating between detectors/arms needs to be in place
- Optics, spin transport, target specific analysis very important
- Databasing long time-scale variables not in EPICS (e.g. target polarization)
- Scripts for commissioning and calibration

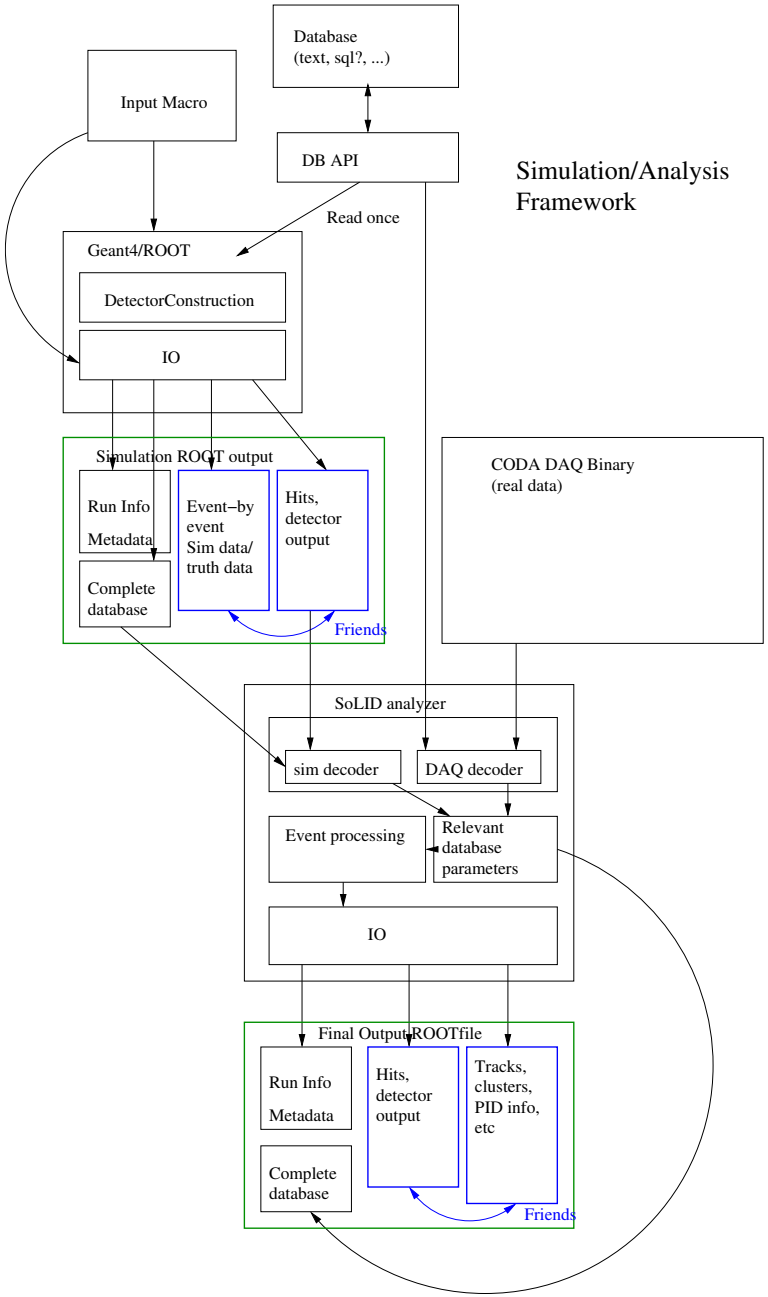






Further Experiment Analysis Software

- Major goal of "end to end" simluation with production of pseudodata - simulation of data sizes
- Requires realistic digitization of new subsystems from Geant4 responses
- Ultimate demonstration of event-by-event analysis for full experiment
- Non-trivial and requires well defined standards/interfaces for flexible design



Data Storage and Computing Requirements

		Days	Data rate MB/s	Seconds	Total data TB
E12-12-09-019	GMN	25	1000	2160000	2160
E12-09-016	GEN	50	1000	4320000	4320
E12-07-109	GEP/GMP	45	1000	3888000	3888
E12-09-018	SIDIS	64	1000	5529600	5529.6
	Total	184		15897600	15897.6
Actual days	Actual years		Time in s		
368	1.01	184	15897600		

- Estimates for data sizes calculated - expect 300-400 MB/s 1GB/s assumed upper bound $\rightarrow$ 16 TB total to tape
- kHz analysis rate $\rightarrow$ 40k CPU hours over $\sim$ 5 years
- Data rates primarily driven by GEM channels ($\sim$100k)

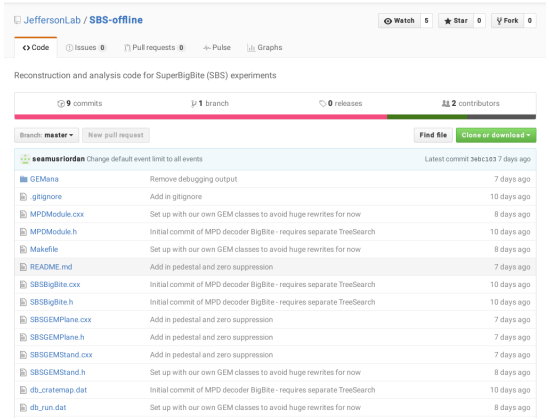
Current Status

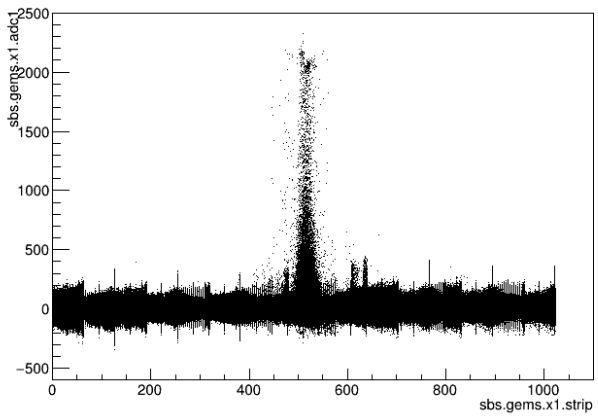
Have working whitepaper and repository

`http://cinder.physics.sunysb.edu/~seamus/sbs/sim_whitepaper.pdf`

`http://github.com/JeffersonLab/SBS-offline`

- Now transitioning from hardware development to analysis
- Responsibilities within subgroups defined
- Raw data analysis chain partially defined
  - Resuing existing framework from legacy detectors
  - GEM MPD decoding with examples
  - OLYMPUS collaborators with operational GEM experience
  - Remaining systems need skeletal definition for subgroups to fill in
- Postdoc Eric Fuchey (UConn) actively working on next iteration of tracking





Future SBS Software Milestones

- Nov 2016 - Software Review
- Jan 2017 - Start Digitized Simulation Output
- Apr 2017 - Decoders for all DAQ modules written
- Jul 2017 - Each detector system in analyzer, experiment configurations, basic reconstruction algorithms
  - Can fully analyze raw data at this point
- Dec 2017 - Simulation Interfaced to analysis, Have detector event displays, calibration scripts
- Jan 2018 - Start simulated analysis for detector reconstruction
- Jun 2018 - Begin simulated experimental analysis for core form factor experiments
- Jan 2019 - Ready for beam for form factor, start simulated experimental analysis for SIDIS and TDIS

- Spring 2019 likely earliest start of neutron experiments
- Spring 2020 likely earliest start for GEp

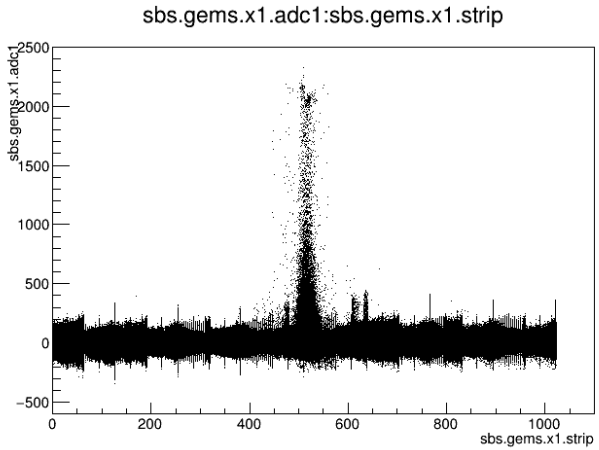
Summary

- Software efforts by collaboration have been significantly ramping up over last year
- Now focusing on work for raw data analysis and tracking and then transition to full event reconstruction
- Tasks and milestones are defined for period up to running

BACKUP

GEM-Specific Work

- GEM test stand used with CODA readout
- Decoding done with stand-alone reading directly EVIO
- Have done integration with modular decoder (analyzer 1.6) based on Danning and Evaristo's work
- Must get TreeSearch algorithm and existing (modified) GEM classes to work with this decoder
- Improved GEM digitization using UVA commissioning data
  - Underway by UVA



- SBS-offline repository
- `http://github.com/JeffersonLab/SBS-offline`
- Has example code and databases to replay