Analysis Software for Hypernuclear experiment

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Jefferson Lab

Experimental Readiness Review

June 4-5, 2026

Charges

- Charge 5:

  What is the simulation and data analysis software status for the experiment? Has readiness for expedient analysis of the data been demonstrated?

- Charge 4:

  Please provide a detailed and realistic evalution of the available FTE with names if possible.

Will be focusing on the data analysis software in this talk.
For the simulation, see Sho Nagao's simulation talk.

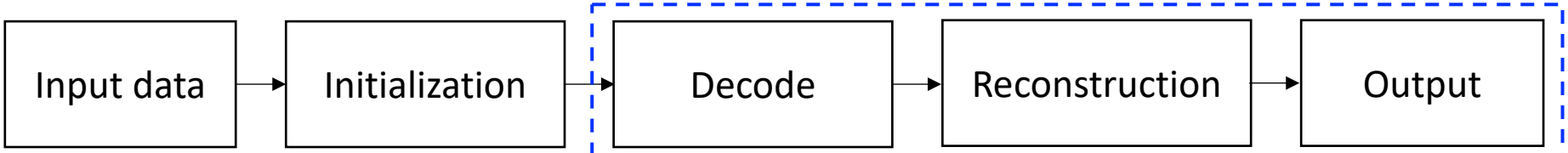
Software framework (Online/Offline Replay)

- Hall A analyzer(https://github.com/JeffersonLab/analyzer/):
  - ROOT/C++ based online and offline analysis package
- hcana (https://github.com/JeffersonLab/hcana):
  - Hall A analyzer (Podd) based software for standard HMS and SHMS spectrometers and detectors.
  - Many parts are written based on previous Hall C analyzer ENGINE (fortran).

- Analysis software for Hypernuclear experiment:
  - https://github.com/JeffersonLab/HYPAnalyzer
  - Taking advantages of existing hcana, Podd support
  - Decoders: FADC250, VETROC, VfTDC
  - Spectrometers (HKS, HES, ENGE)
  - Detector subsystems: Cherenkov, Drift Chamber, TOF, Sci-Fi

Workflow (Online/Offline Replay)

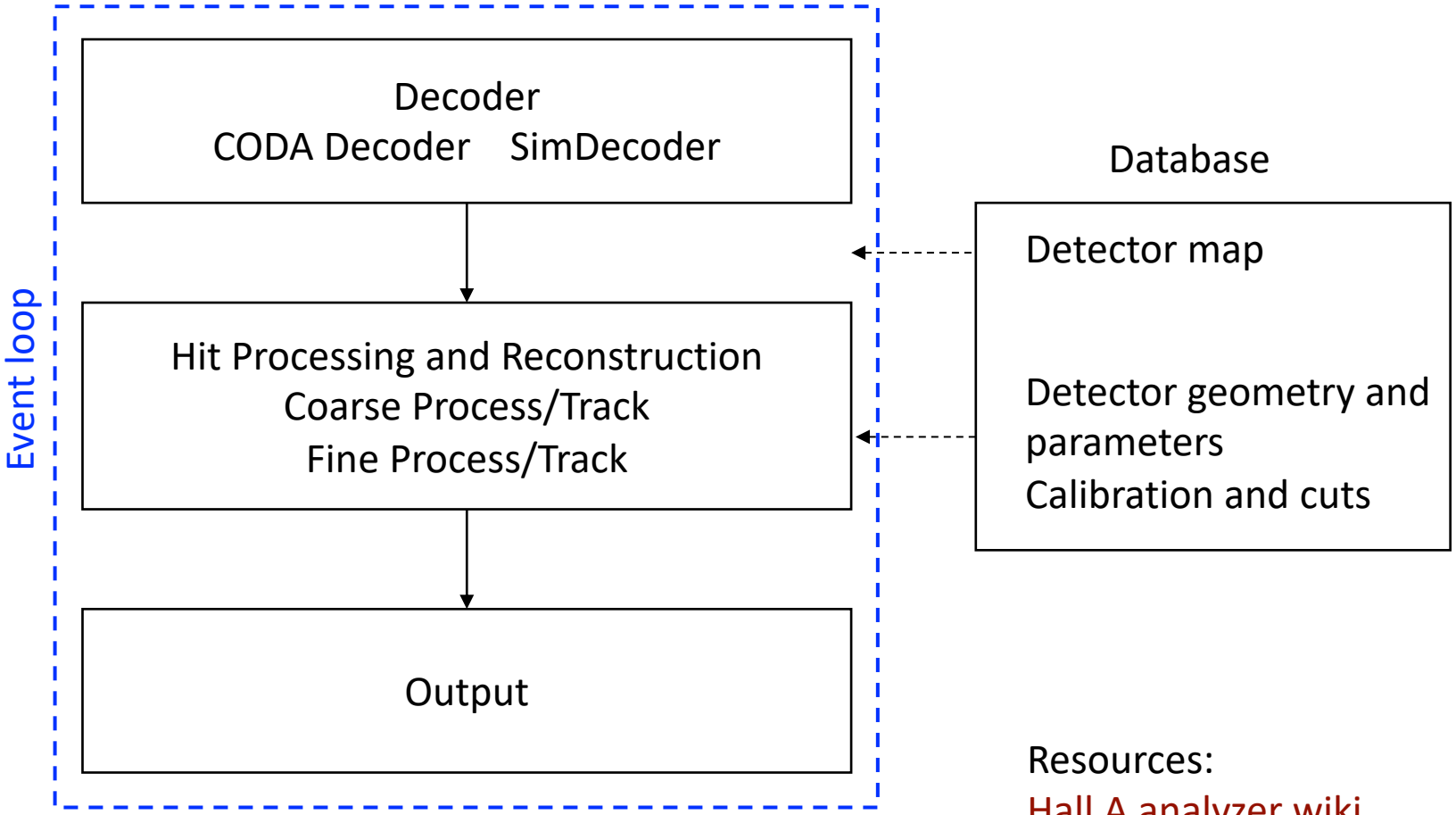
- General workflow of the analysis software



- EVIO file
- Initialize modules
- Set up detectors
- Load configuration and parameters
- Define output vars
- Decode raw signals, add to raw hit list
- Event loop
- CoarsePro cess/FineP rocess
- Tracking/P ID
- ROOT TTree, Histogra ms
- REPORT OUTPUT
- .def files to handle output variables

Worlflow (Online/Offline Replay)

- General workflow of the analyzer



Resources:
Hall A analyzer wiki
Analysis Workshop (2018, 2017)

Detectors and Readout

Spectrometer	Detector	FADC (ADC/TDC)	Low resolution TDC	High resolution TDC
HKS	KDC	-	640+640	
	TOF	88	-	88
	AC	42	-	-
	WC	48	-	-
HES	EDC	-	1120	-
	TOF	116	-	116
Number of total channels		294	2400	204

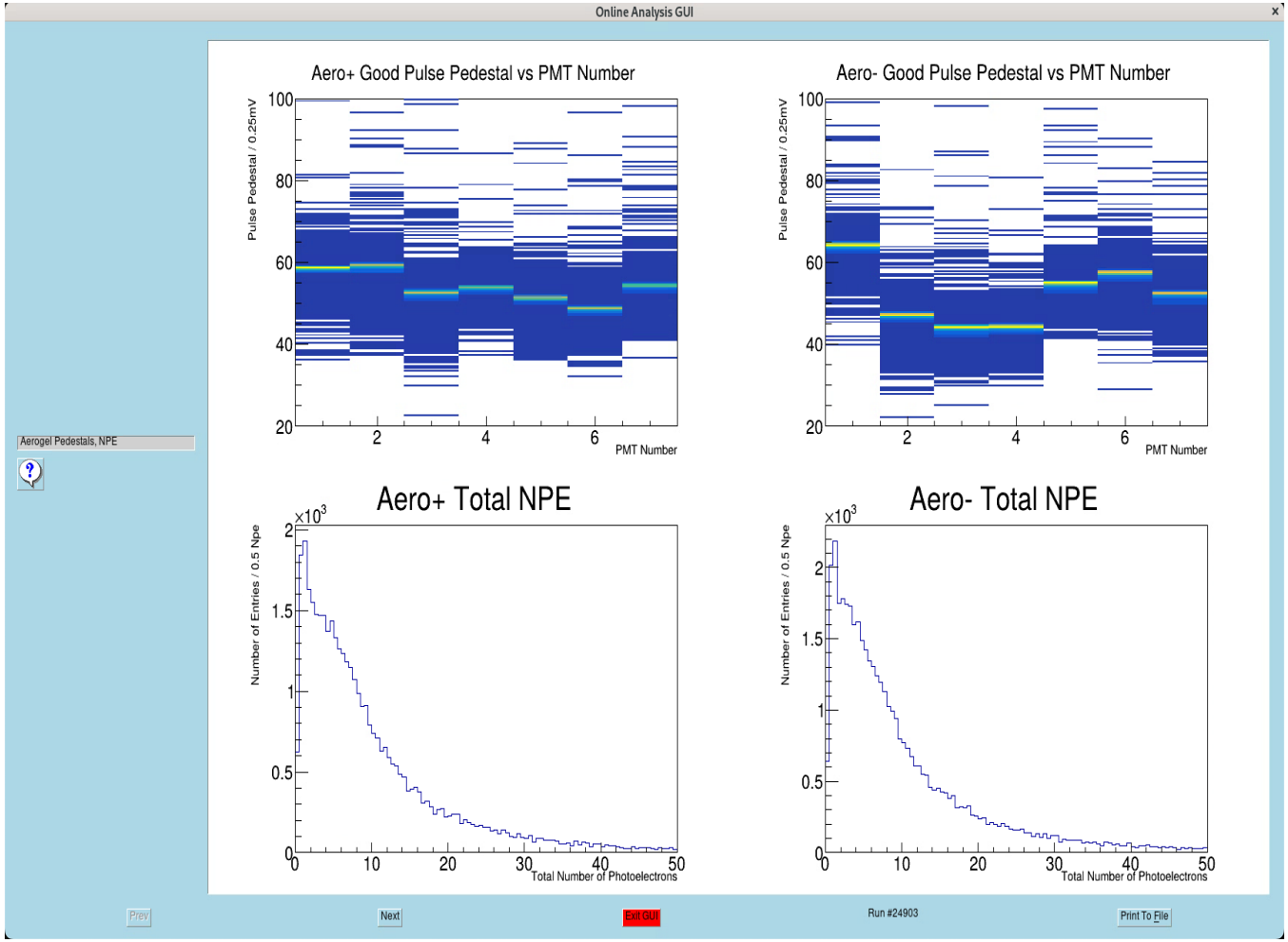
Spectrometer	Detector	ADC	TDC
ENGE	Fiber tracker	-	832
	Drift chamber	-	360
	Timing counter	-	96
Number of total channels		0	1416

- ADC/TDC: FADC250
- TDC: CAEN1190, VETROC, VfTDC
- Readout electronics used for previous Hall A/C experiments

- All decoders are implemented and tested

Replay software test with Hall C Data

- Cherenkov detector software tested using SHMS Aerogel data
- Demonstrated FADC250 decoding, writing pulse data and calculated number of photoelectrons into output files
- Replay → panguin (online monitoring) workflow also tested



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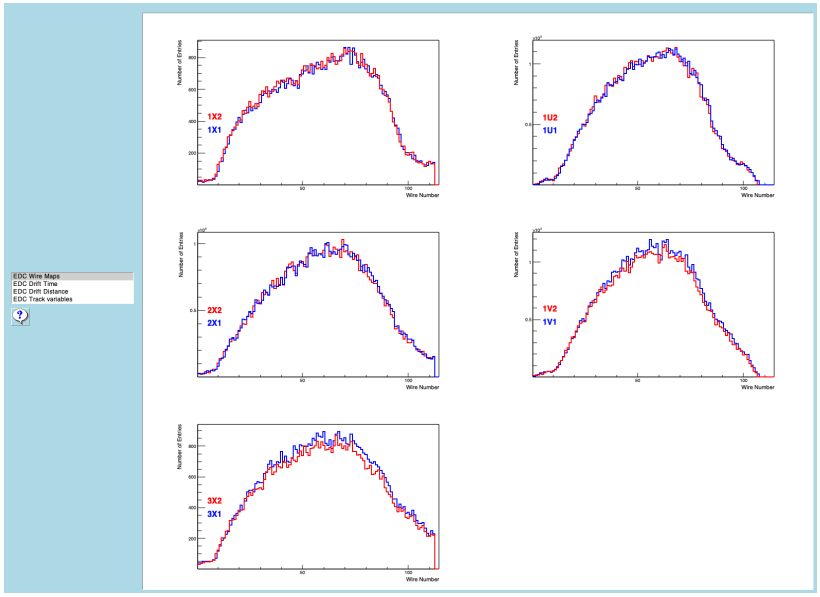
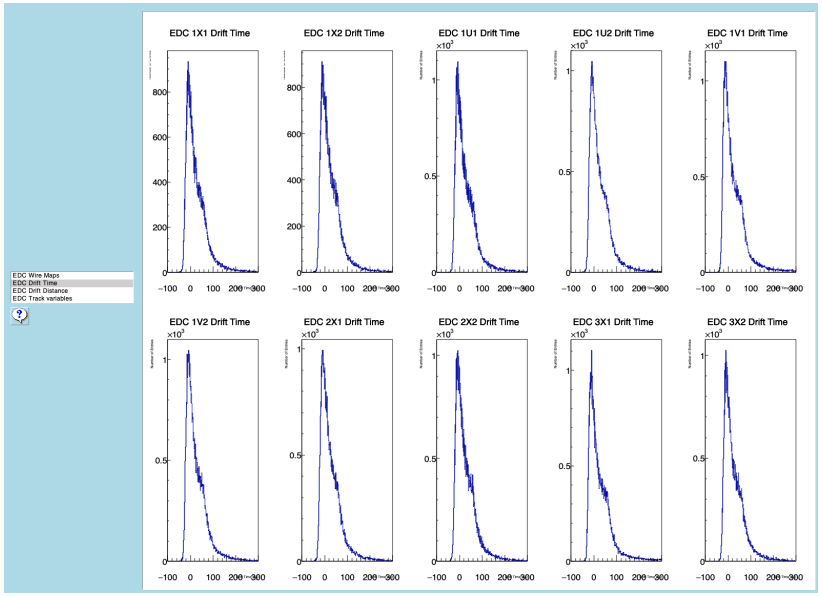
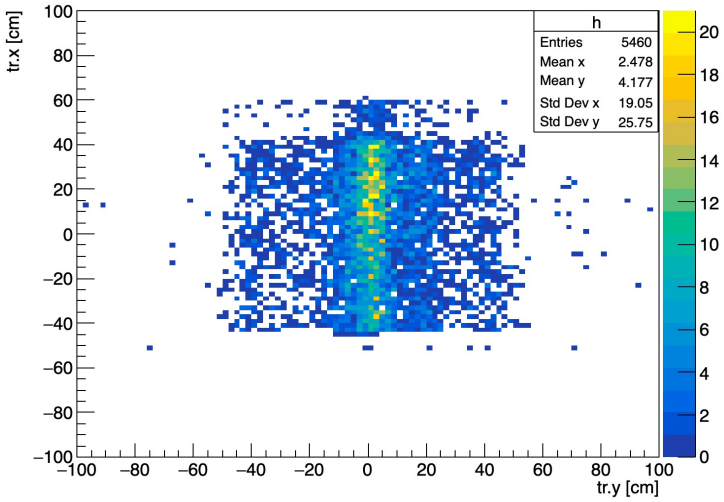
Replay software test with ESB cosmic data

- Using the ESB cosmic data for testing DC and TOF software







- EDC/KDC cosmic data taken at ESB with vfTDC module
- Replay software can successfully decode the data and process TDC hits
- Same tracking algorithm used in the previous HKS experiment implemented
- Replay → panguin (online monitoring) workflow also tested

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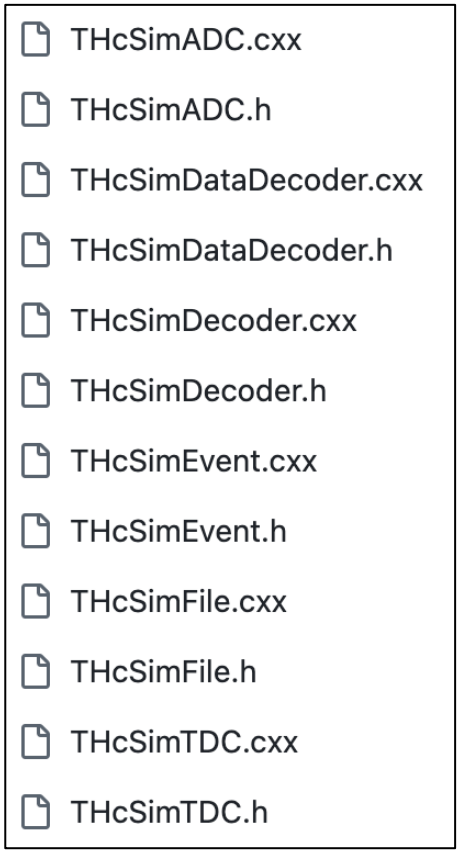
Simulation interface

- Implement the simulation interface used for SBS experiment
  - Allows to use simulation data as an input in the analysis chain
  - THcSimFile: THaRunBase. Use simulation output ROOT file to fill the event object (THcSimEvent) instead of CODA data
  - THcSimDataDecoder: Provide sim adc/tdc data structure, Encoder/Decoder
  - THcSimDecoder: Unpack the event object into slot data
  - THcSimADC, THcSimTDC: Simulated ADC and TDC modules
- Need to redefine simulation input data structure



Software tasks

- **DC:**
  - Add vfTDC decoder
  - Subdetector classes, hit/cluster objects based on hcana
  - Clustering, track fitting
  - Analyze ESB test data
  - Review/Update DB parameters (geometry, cuts)
- **Cherenkov:**
  - Add base class to handle decoding and basic hit processing
  - Reconstruction
  - Review/Update DB parameters (geometry, cuts)
- **TOF:**
  - Implement FADC250 and vfTDC decoding
  - Reconstruction: Hit processing and track matching
  - Review/Update DB parameters (geometry, cuts)
- **Sci-Fi:**
  - Add detector class, reconstruction
  - Review/Update DB parameters

Done
In progress
Not started yet

Software tasks

- **Spectrometer:**
  - Add new spectrometer class for hypernuclear
  - Add/verify target quantity calculations
- **Beamline:**
  - Raster analysis module (already exist in hcana)
  - Implement BPM module to process with FADC signal (new module added to hcana)
  - Test with the data
- **Using simulation data in replay (feature)**
  - Implement support framework
  - Define simulation input data structure
  - Test with simulation files
- **Documentation**
  - Provide documentation of the analysis software, reconstruction methods, instructions
- **Detector calibrations:**
  - Standalone calibration analyses with ESB cosmic data
  - Update the macros/scripts for replay output

Done
In progress
Not started yet

Software to-do list and FTE estimation

Item	Task	Status	FTE	Target date
Sci-Fi Detector	Add new detector class, test with cosmic/pseudo-data	Not implemented	0.5 FTE 2 months	End of 2026
PID/track matching	TOF hit and DC track matching	In progress	0.5 FTE 1 month	End of 2026
Spectrometer target variables	Add/Verify target quantity variables	In progress	0.5 FTE 1 month	End of 2026
Physics Modules	Add modules for Primary/Secondary kinematics	Not implemented	0.5 FTE 2 months	End of 2026
Documentation	Provide documentation of the analysis software and instructions	Not started yet	0.5 FTE 1 month	End of 2026
Replay DB, scripts	Update DB files, scripts for general uses	Initial set for cosmic data test prepared, Need update for commissioning data	1 FTE 1 month	Before commissioning data taking
Detector calibrations	Develop calibration macros	In progress	1 FTE for 12 months	Before commissioning data taking

Milestones, timeline, personnel

- Milestones:
  - **Replay software** **--- End of 2026**
  - **Documentation** **--- End of 2026**
  - **Fully Integrate simulation data in analysis chain*** **--- June 2027** *: Not required for Day 1
  - **Setting up analysis, computing environment at CH** **--- End of 2027**
    - List of plots and configuration files for monitoring
    - replay scripts for shift users, instruction

- Personnel:

Item	Coordinators	Senior personnel	Contributors
Replay software	S. Park (JLab)	S. Park (JLab) O. Hansen (JLab) M. Jones (JLab)	S. Park (JLab, 0.4 FTE) K. Nishida (U. Tokyo, 0.2 FTE)
HallC Computing	H. Liu (JLab)	N/A	N/A
Detector calibrations (Tracking)	B. D. Pandey (VMI)	B. D. Pandey (VMI) L. Tang (Hampton/JLab)	K. Nishida (U. Tokyo, 0.1 FTE), R. Kumaragamage (Hampton, 0.2 FTE)
Detector calibrations (Hodoscope/PID)	T. Gogami (Shiga U) R. Marinaro (CNU)	T. Gogami (Shiga U) R. Marinaro (CNU)	R. Marinaro (CNU, 0.1 FTE), K. Higashimoto (U. Tokyo, 0.2 FTE)
Detector calibrations (BPMs)	TBD		K. Nishi (U. Tokyo, 0.1 FTE)
Physics analysis	Refer to the list of PIs and Ph.D students from S. Nakamura		
Simulation	S. Nagao (U. Tokyo)	S. Nagao (U. Tokyo)	J. Takahashi (U. Tokyo), ..

Computing resources

- Expected data rate is ~50 MB/s. The total data volume on tape is estimated to be 0.6 PB (similar to other Hall C experiments) and is compatible with available resources.
  - The capacity of the current Hall C file server for raw data is around 30 TB with data transfer speed up to 40Gpbs.
- Counting house resource (online analysis)
  - The analysis output is expected to be similar to other Hall C experiments
  - cdaql1-3 are dedicated machines for online analysis, each with 20 cores, 64 GB memory and 20-30 TB disk space
- JLab SciComp (offline production, analysis)
  - Batch farm system for offline data analysis
    - Hall C 8% allocation
  - /work disk for HKS: 3 TB
  - /volatile for HKS: 4 TB

Summary

- Charge 5:
  What is the simulation and data analysis software status for the experiment? Has readiness for expedient analysis of the data been demonstrated?

Software framework ~70% complete with remaining work identified and schedule for completion in place well before installation completion:

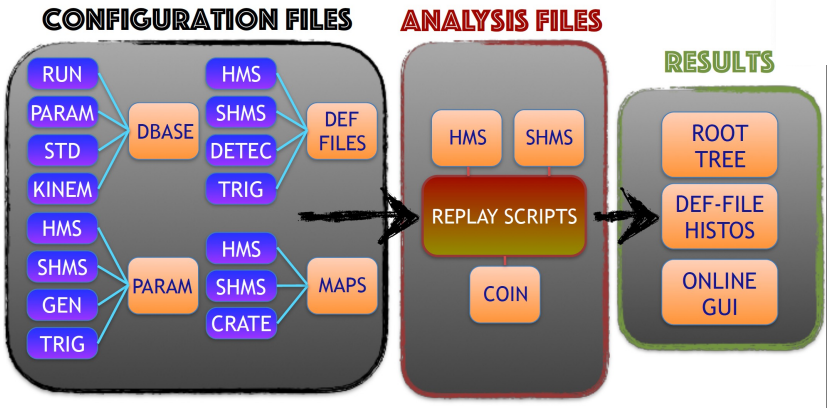
- Data analysis software has been developed based on hcana/Podd framework. Functioning decoding and reconstruction have been established and being tested with cosmic data. All detector subsystems except Sci-Fi have been implemented
- Simulation software based on Geant4 has been fully developed (S. Nagao's talk)
- The online monitoring tool, Panguin has been extensively tested, and no additional development work required

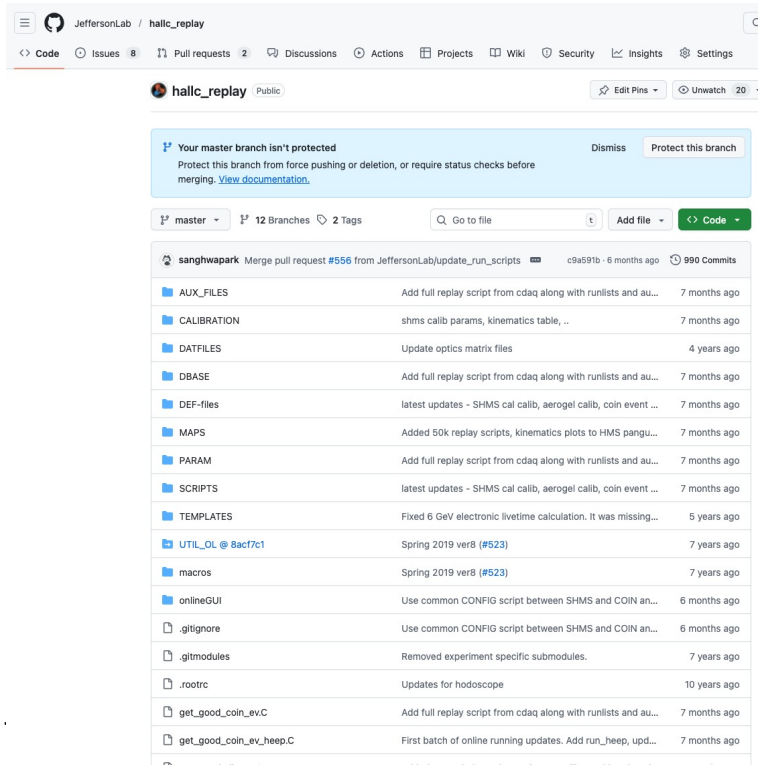
Summary

- Charge 4:
  Please provide a detailed and realistic evaluation of the available FTE with names if possible.
  - Milestones and available FTEs have been identified (slide 13)
  - S. Park will continue working on the software framework development as a main contributor (0.4 FTE), and the collaboration is providing graduate students (0.2 FTE). Since the major part of the development has been largely completed, the currently assumed person-power is sufficient to reach the milestone by the end of 2026
  - Detector calibrations will be carried out by a group of graduate students with support from senior personnel and JLab staff

Backup

Replay workflow (traditional Hall C format)





- Database files
  - DATFILES: spectrometer matrix elements
  - DBASE: standard kinematics, database file list to include
  - MAPS: Crate and detector maps
  - PARAM: parameter files for all detectors (geometry, cuts, calibration, reconstruction parameters)
  - DEF-files: output tree variables, histograms
  - TEMPLATES: template files for REPORT OUTPUT