E1039 Offline Software Status

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(For Software/Simulation WG)

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SpinQuest Collaboration Meeting
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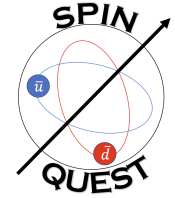


Outline

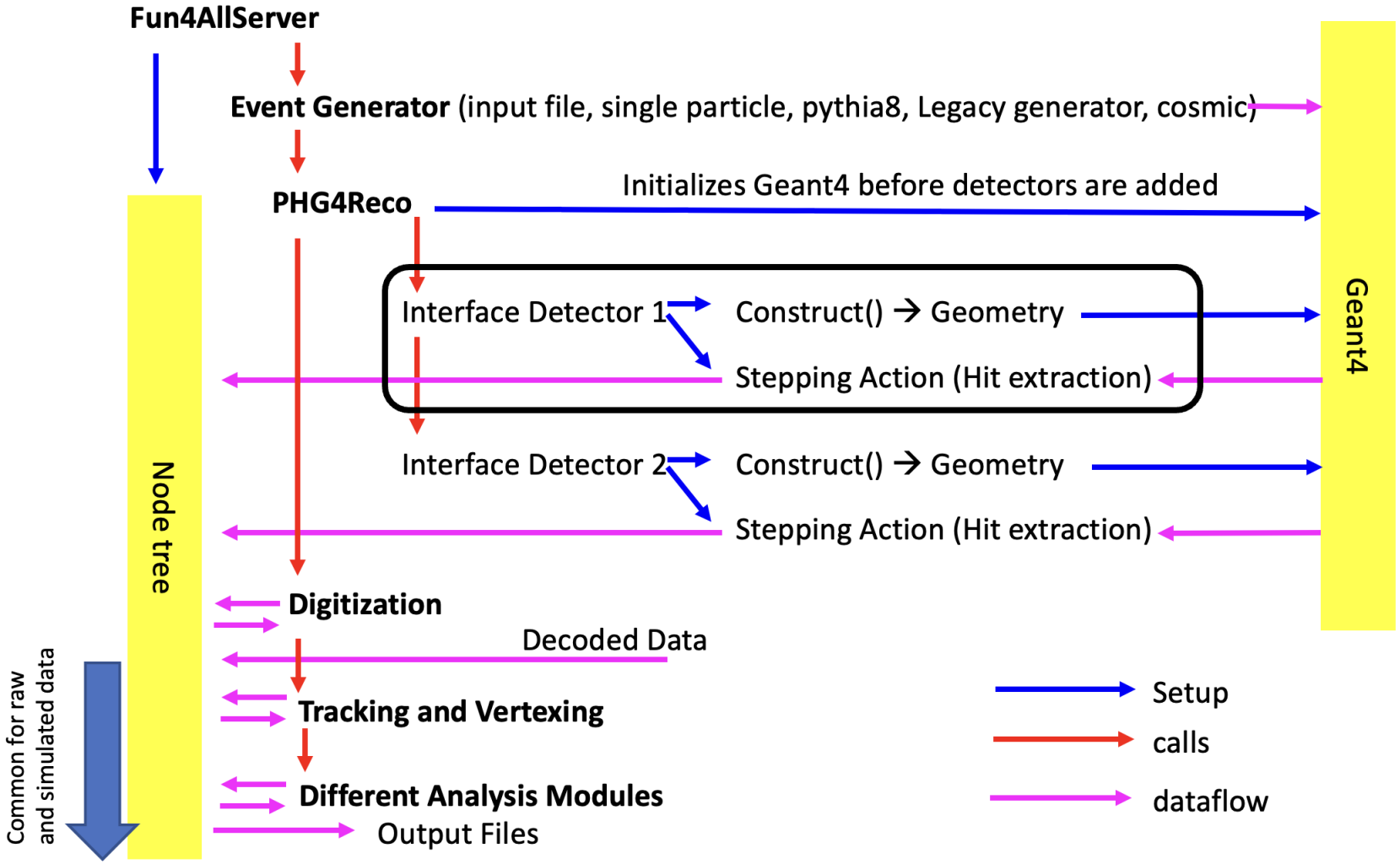
Outline

E1039-Offline Software: Status

- Fun4All software framework
  - Data analyzing framework developed by C. Pinkenburg for PHENIX experiment (2003)
  - Exported and implemented to SpinQuest experiment by Haiwang Yu
  - Tutorial: DocDB 7370
- Official GitHub Page: E1039-Collaboration
  - e1039-core: Repository containing core packages/framework of the E1039 software. (Developers/Contributors)
  - e1039-analysis: Repository containing analysis packages using framework from e1039-core area. (General Users)
  - wiki-page: Tutorials and How Tos..

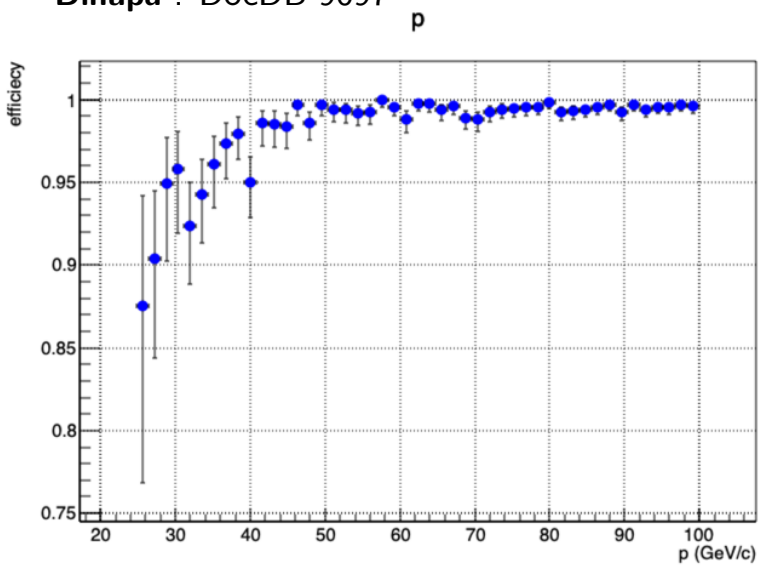
Simulation and Reconstruction Chain

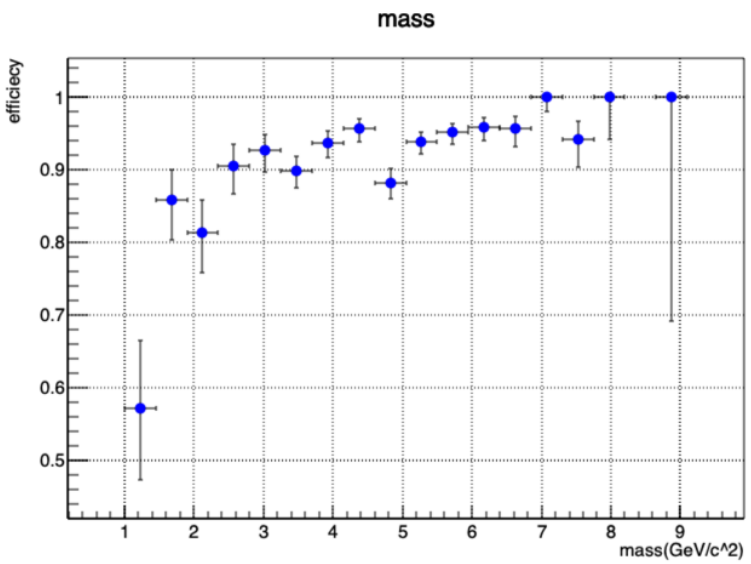
Chris P.'s talk: https://indico.bnl.gov/event/7254/



Reconstruction Efficiency

Dinupa : DocDB 9097



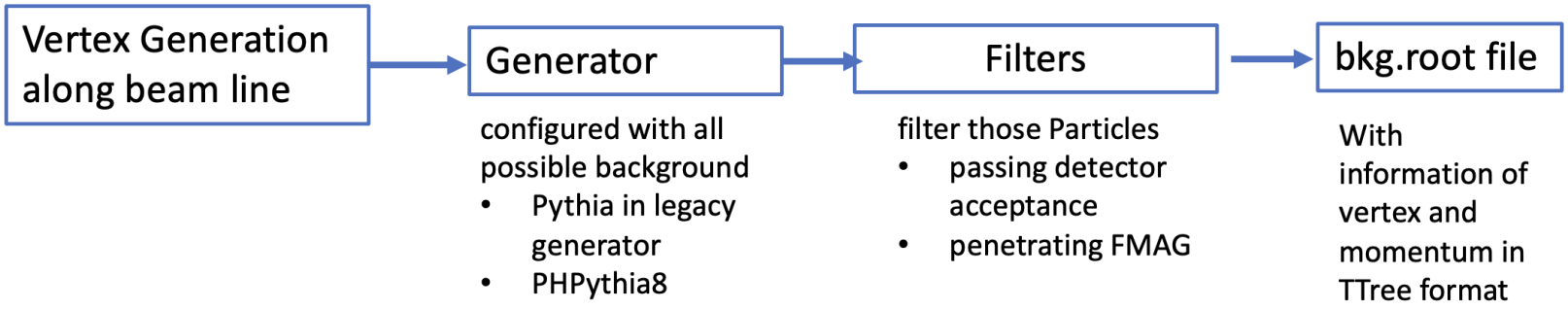


- Efficiency = Reconstructed / Detector-Accepted
- Single Track Reconstruction Efficiency $\sim$ 97 %
- Dimuon Reconstruction Efficiency $\sim$ 85 %
- To Do: Incorporate effort from DarkQuest group for back-partial track building: DocDB 9658

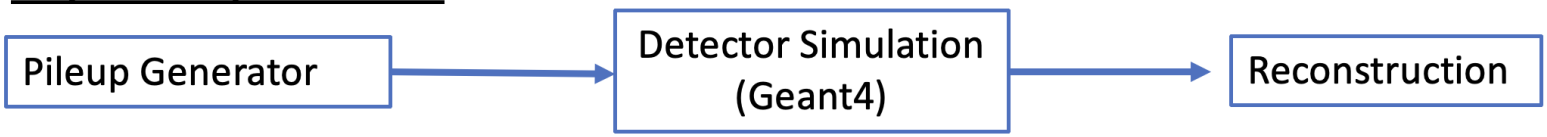
Full (Inclusive) Background Simulation: Fast GMC

Originally proposed by **David Kleinjain** and **Kun** (DocDB-1668)

Step 1: Generation of possible background candidates



Step 2: Pileup Generator



- Vertex generation and Filters mimics the Geant4 response to save the simulation time
- Technical Note: DocDB 9652,
- Detailed Summary Presentation: DocDB 9665

Full (Inclusive) Background Simulation: Fast GMC

- Fast MC method is faster (∼1e10) than Brut force method to generate background candidates
- Raw hit distributions in hodoscopes from Fast GMC follows the similar shape but differ in magnitude with those from E906 data.
- **Background Candidates**:
  - Location of sample files: */pnfs/e1039/persistent/users/apun/bkg_study/fullbg_candidates*
  - 1773 root files, each with 100M interaction: ∼ 3.5 % of typical one spill data (5e12 protons)
- **e1039-analysis/PileupDev**: Fun4All module for the piling up background events

J/ψ Trigger Road Set Generation

e1039-analysis/GenRoadSet: Analysis module by **Kenichi** (DocDBs; 8861, 9052, 9215)

Rough Outline

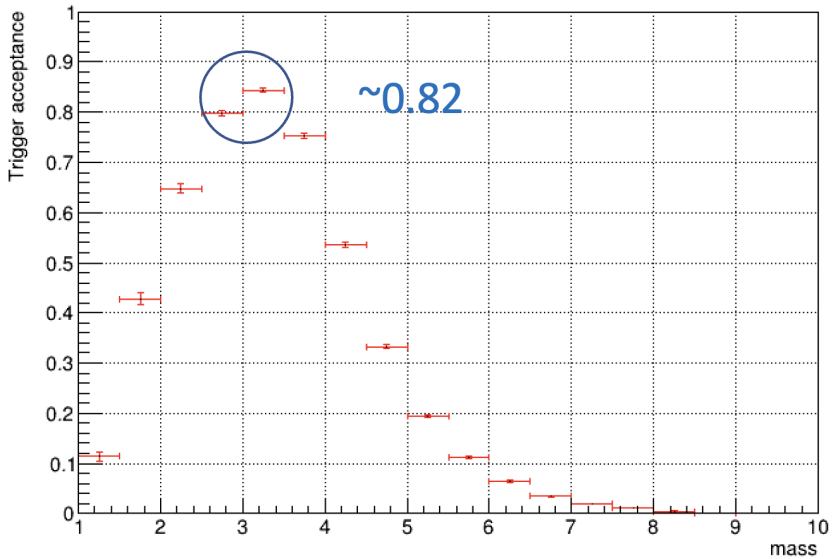
- Collect roads (combination of hodoscope element ID) with
  - Signals: DY dimuons, [0.5 - 9.0] GeV from simulation
  - Background hits (e906 NIM3 data or FullBG)
- Require FPGA1 (T+B or B+T) condition
- Tuning factors: Signal mass range, FoM ($S/\sqrt{BG}$) and QIE intensity cut
- Generate dedicated sets of roads and evaluate the
  - BG rate
  - Signal acceptance rate

J/ψ Trigger Road Set with FullBG hit

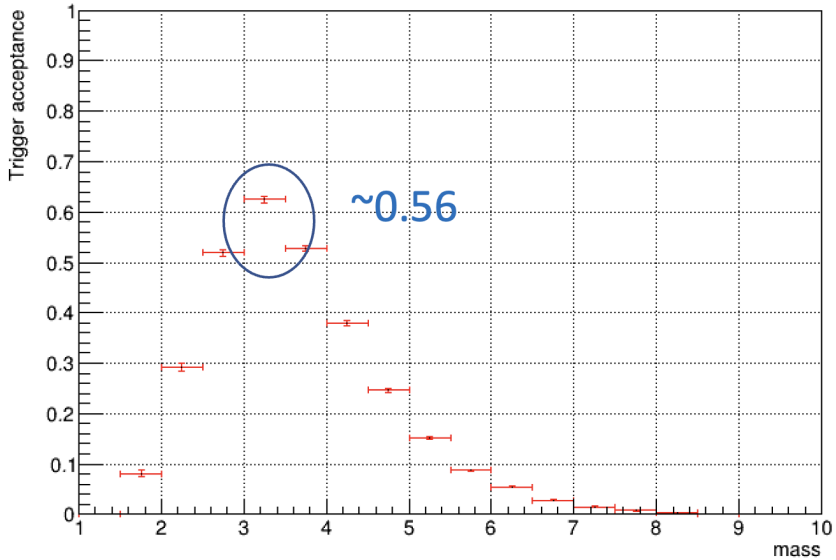
DocDBs; 9832, 9902, 9959

$$\text{Signal Acceptance} = \frac{[\textit{Triggered}]}{[\text{All T+B or B+T}]}$$

RS with Normal KMAG Polarity, Intensity Cut: 0, FoM: 0.04, mass = [2.5 - 3.5] GeV



RS with Reverse KMAG Polarity Intensity Cut: 43k, FoM: 0.0925, mass = [2.5 - 3.5] GeV



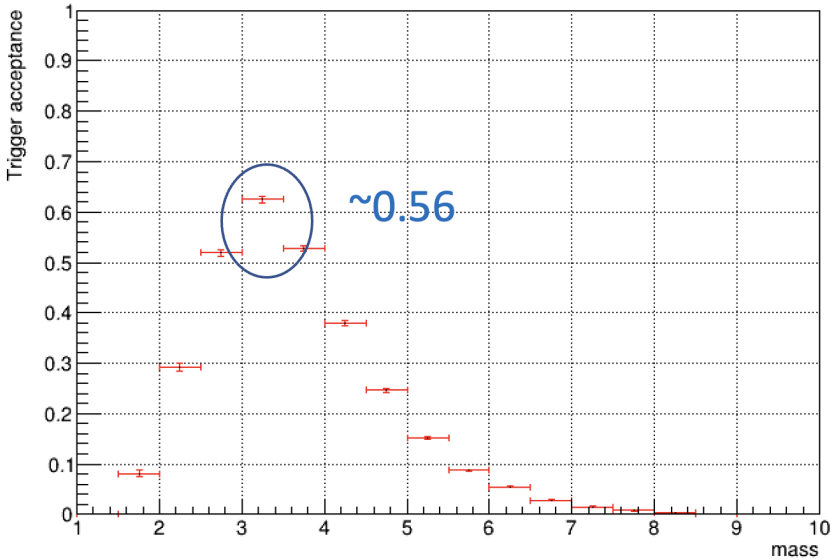
- Both cases tuned to get similar background trigger rate
- Reverse KMAG Polarity (FMAG-, KMAG+) increases the J/Psi signal yield by **5-6 fold** (**Forhad**: Doc-DB 9519)
- (Signal Rate $\times$ Acceptance)$_{reverse}$/(Signal Rate $\times$ Acceptance)$_{normal}$ $\approx$ 5.5 $\times$ 0.56/0.83 $\approx$ **3.6**

J/ψ Trigger Road Set with FullBG hits: Reverse KMAG

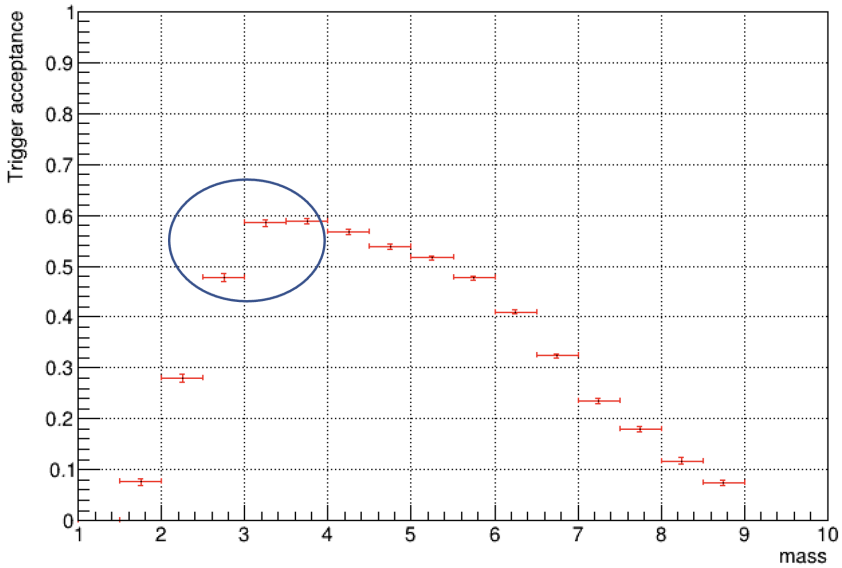
DocDBs; 9832, 9902, 9959

$$\text{Signal Acceptance} = \frac{[\textit{Triggered}]}{[\text{All T+B or B+T}]}$$

RS with Reverse KMAG Polarity, Intensity Cut: 43 k,
FoM: 0.0925, mass = [2.5 - 3.5] GeV



RS with Reverse KMAG Polarity Intensity Cut: 42k,
FoM: 0.12, mass = [2.0 - 9.0] GeV



- Both cases tuned to get similar background trigger rate
- Tuning the specific mass range might result into the complicated background shape.
- Both trigger roadsets shows similar signal acceptance near the J/ψ region

Work in Progress

- Testing and importing DarkQuest Group's work of back-partial track building
- Energy Loss in FMAG
- Multiple Scattering Correction in FMAG
- Target Geometry Setup
- General output format for analysis
- Alignment
- To Do lists for software: wiki-page (by Kenichi)

Outline

Semi-Online Reconstruction

- Automatic submission of grid jobs once the run is complete.
- Automatic re-submission of failed jobs (maximum 4).
- Default geometry and configuration is used for reconstruction.
- Status of the reconstruction (run level) is live on the data-summary page (**Kenichi**).
- The output can serve as the first look to the data quality and can also be used for detector performance study.
- Scripts available in SpinQuest GitHub repository.

As of 2022-08-17 15:53:40

Run	*N* of DST Files	Status	
4352	0	0	Skipped
4351	1	0	Skipped
4350	1	0	Skipped
4349	1	0	Skipped
4348	1	0	Skipped
4347	2	2	Completed
4346	7	2	Completed
4345	7	2	Completed
4344	7	2	Completed
4343	7	2	Completed
4342	7	2	Completed
4341	7	2	Completed
4340	7	2	Completed
4339	7	2	Completed
4338	7	2	Completed
4337	7	2	Completed
4336	7	2	Completed
4335	1	0	Skipped
4334	1	0	Skipped
4333	1	0	Skipped
4332	1	0	Skipped

- Status
  - 0 = Skipped
  - 1 = Being Processed
  - 2 = Completed

Outline

Summary

- Offline software framework is ready and stable for data analysis.
  - Some optimization needed in energy loss and multiple scattering correction due to FMAG.
  - Possible improvements as listed in wiki-page: contributions are welcome.
- J/ψ trigger road-set with FullBG Hits
  - With similar background trigger rate, Road-set tuned with reverse KMag polarity and [2.5-3.5] GeV mass produces ~ 3.6 factor more signal yield than that from normal polarity case.
  - Road-set with reverse KMag polarity: [2.0-9.0] vs [2.5-3.5] GeV mass range tuning
    - Both Road-sets produces similar yield around the J/ψ region.
  - Proposal: Test both road-sets in the beginning of run.
  - Possibility of running same road-set for J/ψ and DY (?)
- Semi-online reconstruction is running on cosmic muon data.

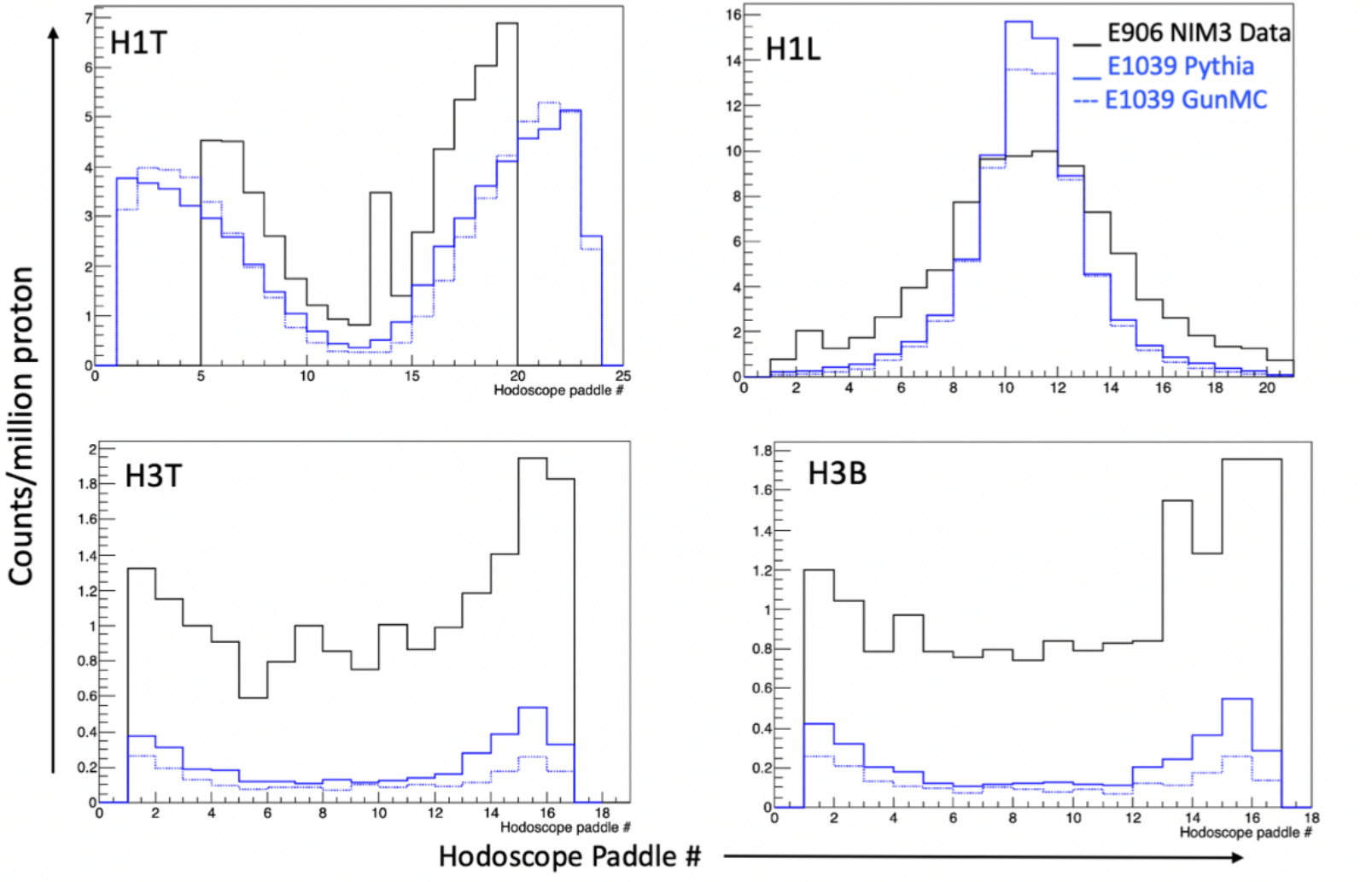
Fun4All: Node Tree

- Storage for Data Objects. The center of the Fun4All software universe (but it's more or less invisible to users). It's the way our data is organized and make them accessible to modules.
- NOT a Root TTree
- 3 different Types of Nodes:
  - PHCompositeNode: contains other Nodes
  - PHDataNode: contains any object
  - PHIODataNode: contains objects which can be written out to DST
- PHCompositeNodes and PHIODataNodes can be saved to a DST and can be read back
- This DST contains root TTrees, the node structure is saved in the branch names.
- Input Managers put objects as PHIODataNodes on the node tree, output managers save selected PHIODataNodes to a file.

Fun4All: PHG4Reco

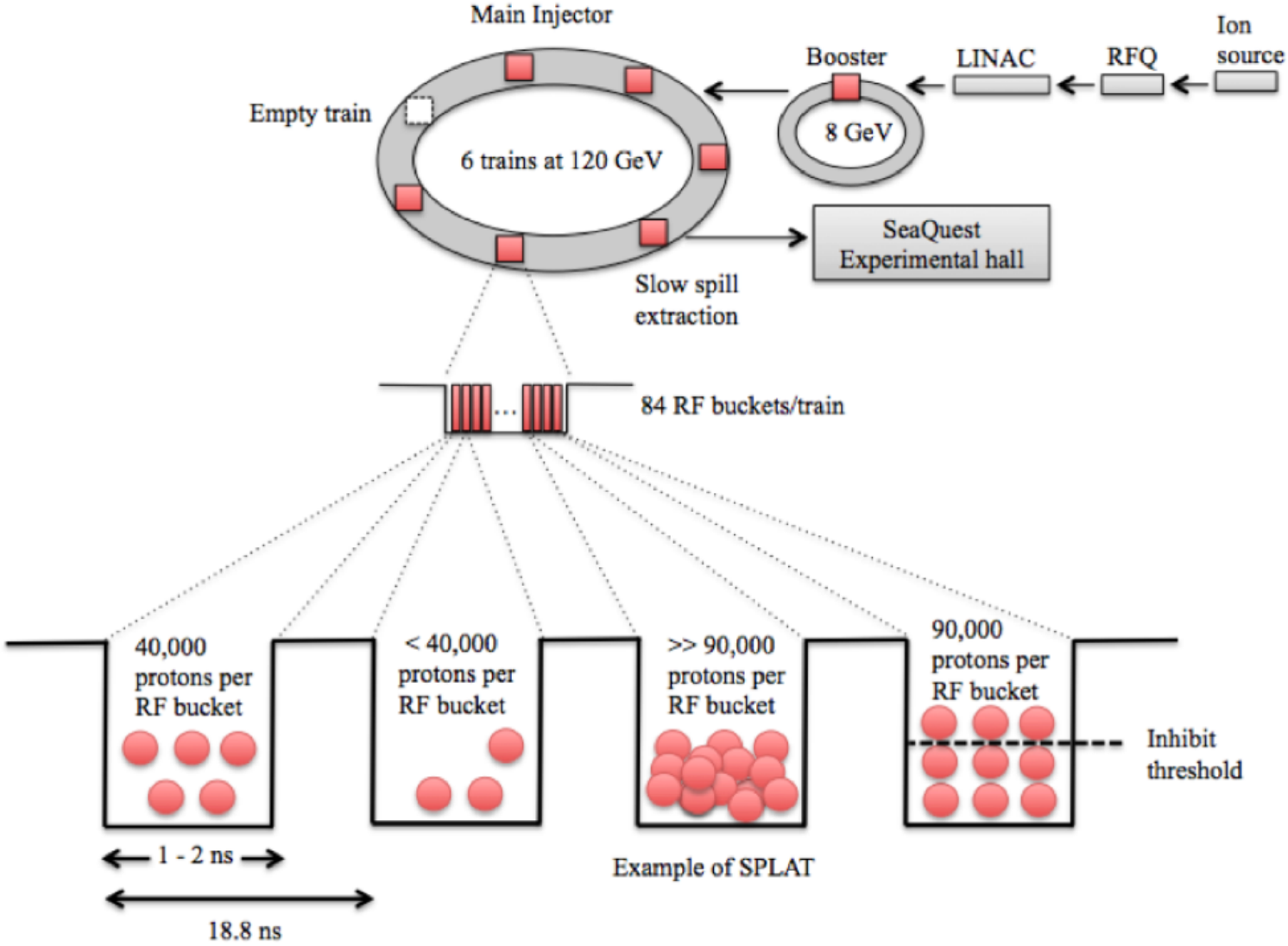
- Fun4All Interface to GEANT4 (is itself a Subsys Reco module)
- Sets features of the world (size, shape, material, magnetic field, physics list)
- Provides interface to GEANT command line (especially useful for event display)
- Manages our detectors
- Totally configurable on macro level

FullBG: Raw Hits in Hodoscopes



RF Buckets

1 spill $\sim$ 230 M bunches $\sim$ 5 x 10^{12} protons



RS: NIM3 E906 Hits vs FullBG Hits

BKG Hits Evaluation	Evaluation Intensity Cut	BG events/spill: K RS-NIM3	BG events/spill: K RS-FullBG
Full BG Hits	No cut	(44.95 ± 1.43)	(12.30 ± 0.75)
NIM3 Hits	No cut	(37.54 ± 1.17)	(21.58 ± 0.89)

- **BG Rates without cut**
  - Same RS – Different Hits
    - RS-NIM3 (Full BG Hits)>RS-NIM3(NIM3 Hits)
    - RS-FullBG (Full BG Hits) <RS-FullBG (NIM3 Hits)
  - Different RS- Same Hits
    - RS-NIM3(Full BG Hits)>RS-FullBG(Full BG Hits)
    - RS-NIM3(NIM3 Hits)>RS-FullBG(NIM3 Hits)
- Biased towards the way it is generated
- BG rate is underestimated by RS-FullBG (factor of ~ 1/2 for NIM3 hits and ~ ¼ for Full BG Hits)

Reverse KMAG RS with FullBG: [2.5 - 3.5] vs [2.0-9.0] GeV

	Intensity Cut	FoM	N of enabled Roads μ^+T	μ^+B	μ^-T	μ^-B	BG events/spill: K	
FMAG - KMAG + Optimized: [2.5-3.5] GeV	PoT: 43000	0.0925	56	58	67	65	wo cut	(12.88 ± 0.76)
							45 k	(1.63 ± 0.27)
							63 k	(3.16 ± 0.38)
							80.5 k	(4.65 ± 0.46)
FMAG – KMAG + Optimized: [2.0-9.0] GeV	PoT: 42000	0.12	94 (52)*	94 (52)*	91 (61)*	87 (60)*	wo cut	(13.33 ± 0.78)
							45 k	(1.22 ± 0.23)
							63k	(2.94 ± 0.36)
							80.5 k	(4.34 ± 0.44)

- Both roadsets are generated with reverse KMAG polarity
- Intensity Cut and FoM are tuned s.t. both roadsets have similar BG trigger rate
- *: common roads between two road sets