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# The Application of SNiPER to the JUNO Simulation

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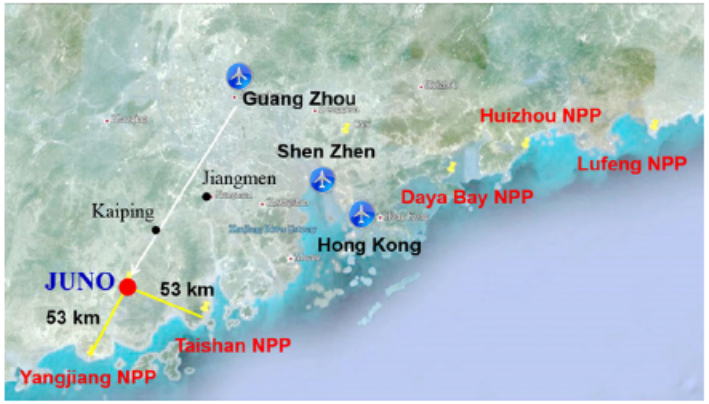
# Outline

- Introduction
  - JUNO experiment
  - JUNO offline software and SNiPER
- JUNO Detector Simulation Framework
- JUNO Electronics and Digitization Simulation
- Conclusion

# JUNO Experiment




- **Location**: Jiangmen, Guangdong, China
- **Status:** Under Construction

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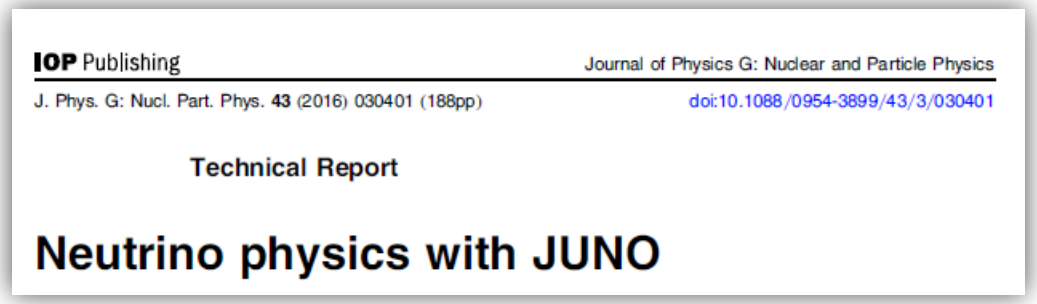
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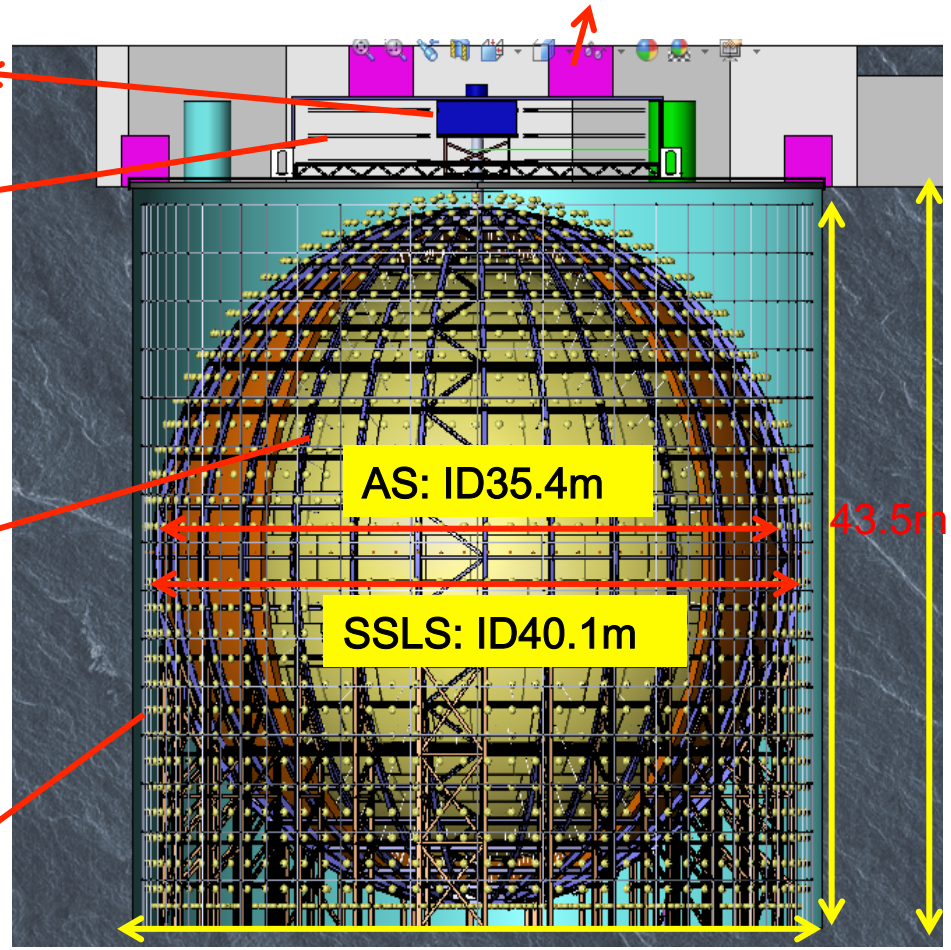
J. Phys. G: Nucl. Part. Phys. **43** (2016) 030401 (188pp) — doi:10.1088/0954-3899/43/3/030401

Technical Report

**Neutrino physics with JUNO**

- Reactor Neutrinos (→ Mass hierarchy)
- Supernova Neutrinos
- Geo-neutrinos
- Solar Neutrinos
- ……



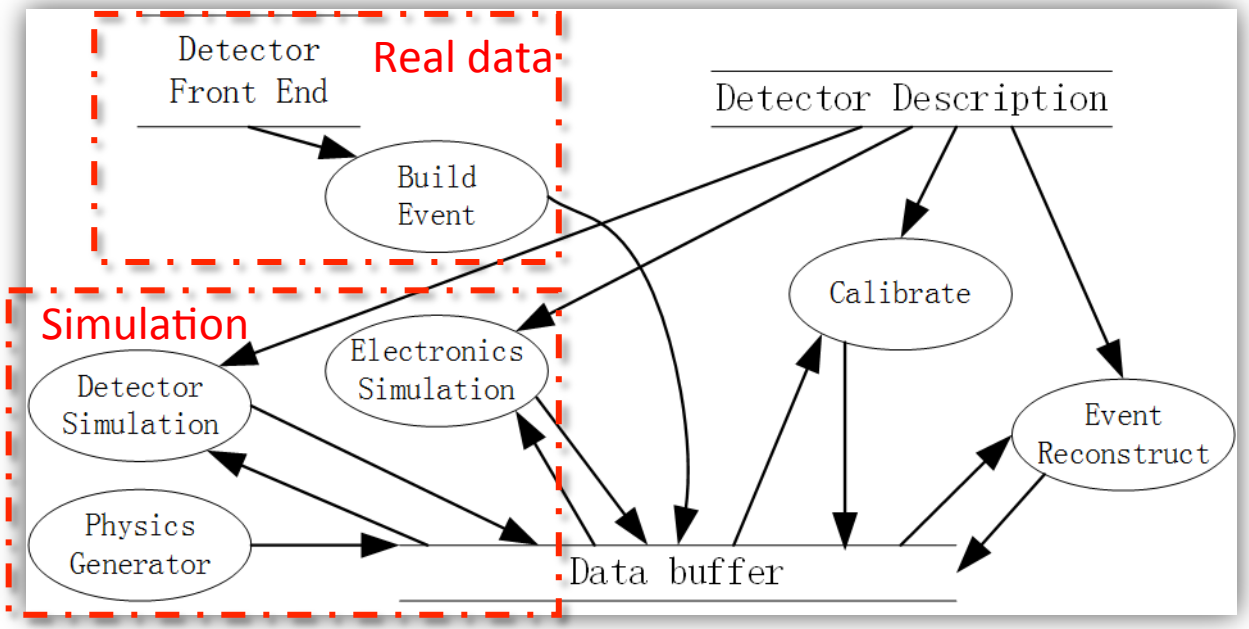

**Central detector**
Acrylic sphere+
20kt Liquid Scin.+
~17,000 20'' PMT+
~34,000 3'' PMT

**Water Cherenkov**
~2000 20'' PMT

AS: Acrylic sphere;
SSLS: stainless steel latticed shell

# JUNO Offline Software

- Mainly includes:
  - Framework, Simulation, Calibration, Reconstruction




- Software Development Environment
  - Language: C++ and Python 2
  - OS: Linux (Scientific Linux 6, gcc 4.4)
  - Framework:  SNiPER
  - Simulation: Geant4 9.4
  - Dependent: XercesC, CLHEP, HepMC
  - Software management: CMT & SVN
  - Installation Tool: junoenv (bash)

- ~ 10 official versions have been released, the latest one is J16v2r1-Pre3

# SNiPER [CHEP2015, ICHEP2016]

*Software for Non-collider Physics Experiments*

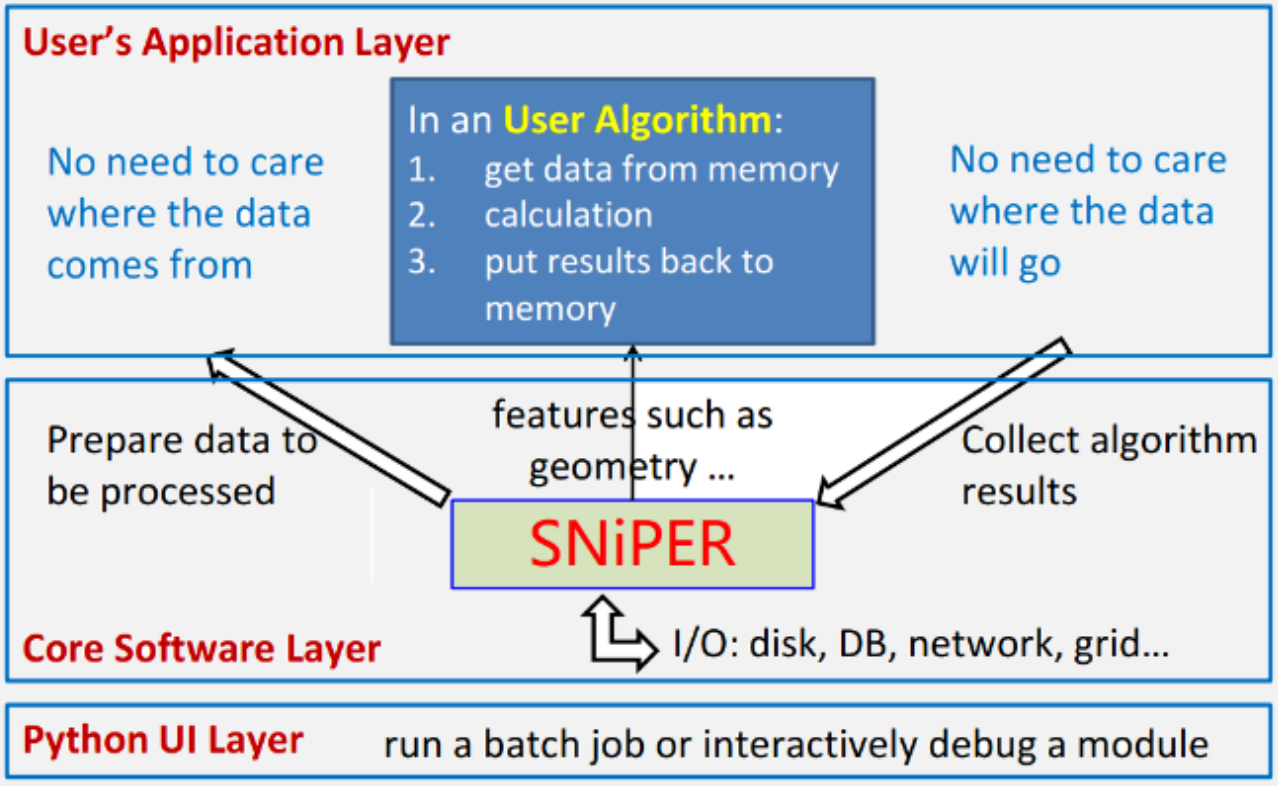



**Figure 1:** An overview of SNiPER

- Task, a lightweight application manager, controls Event Loop.
- Other tasks could be executed by Incident mechanism.

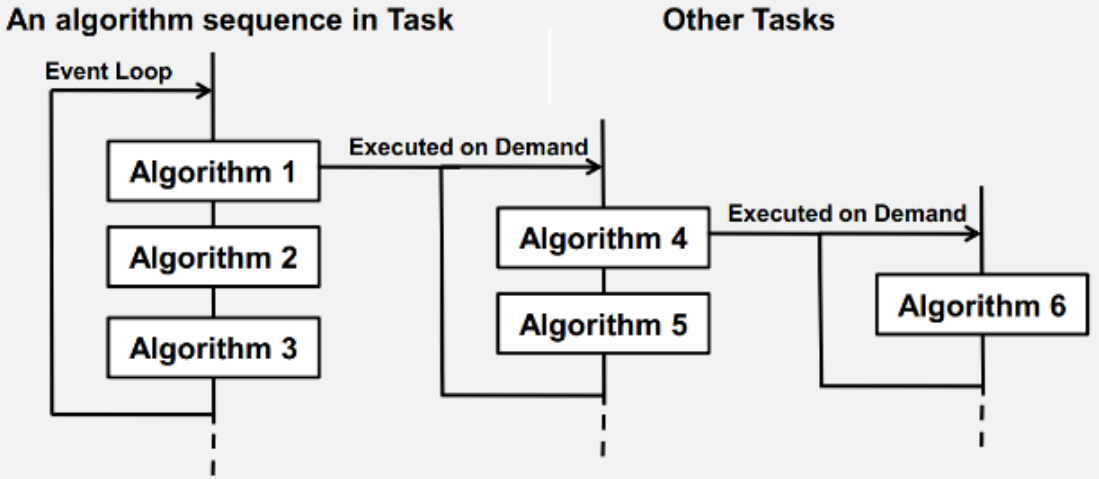
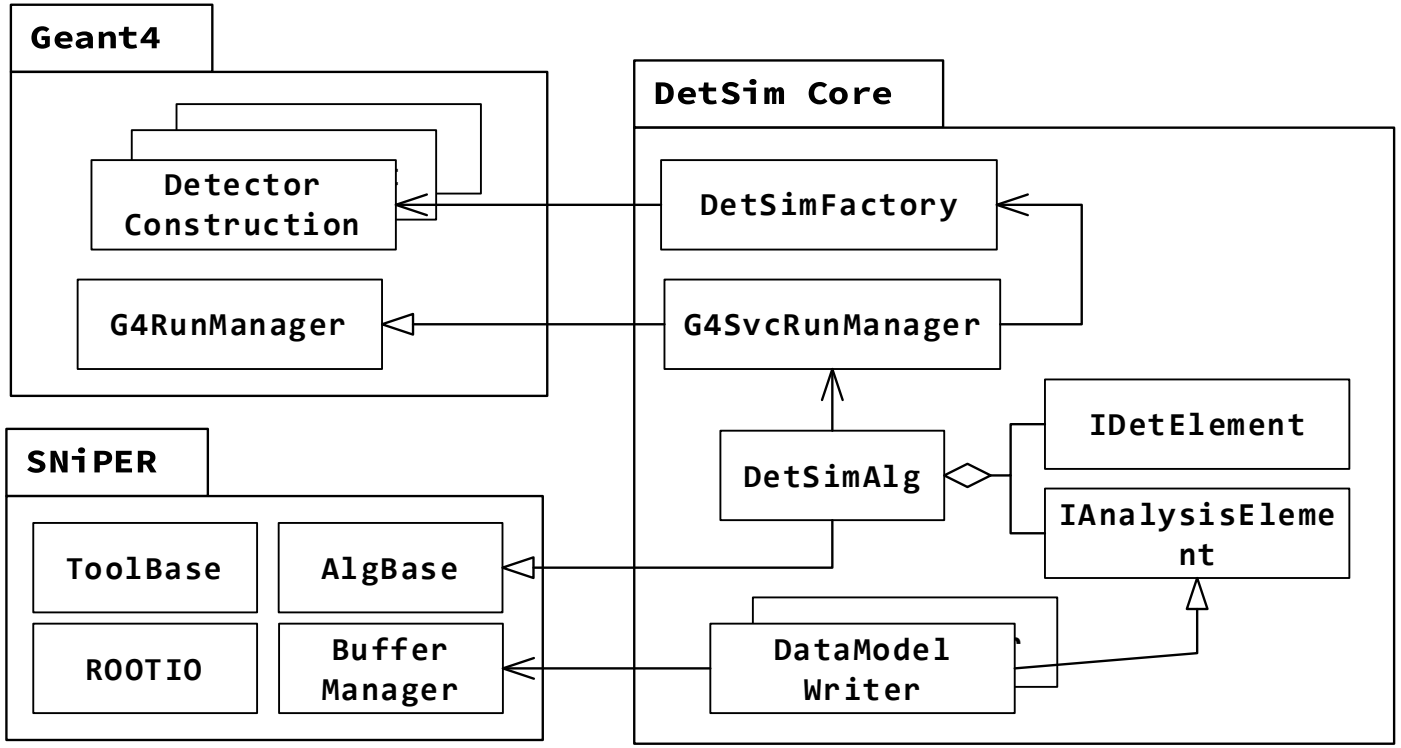



**Figure 3:** Conditional execution of algorithm subsets

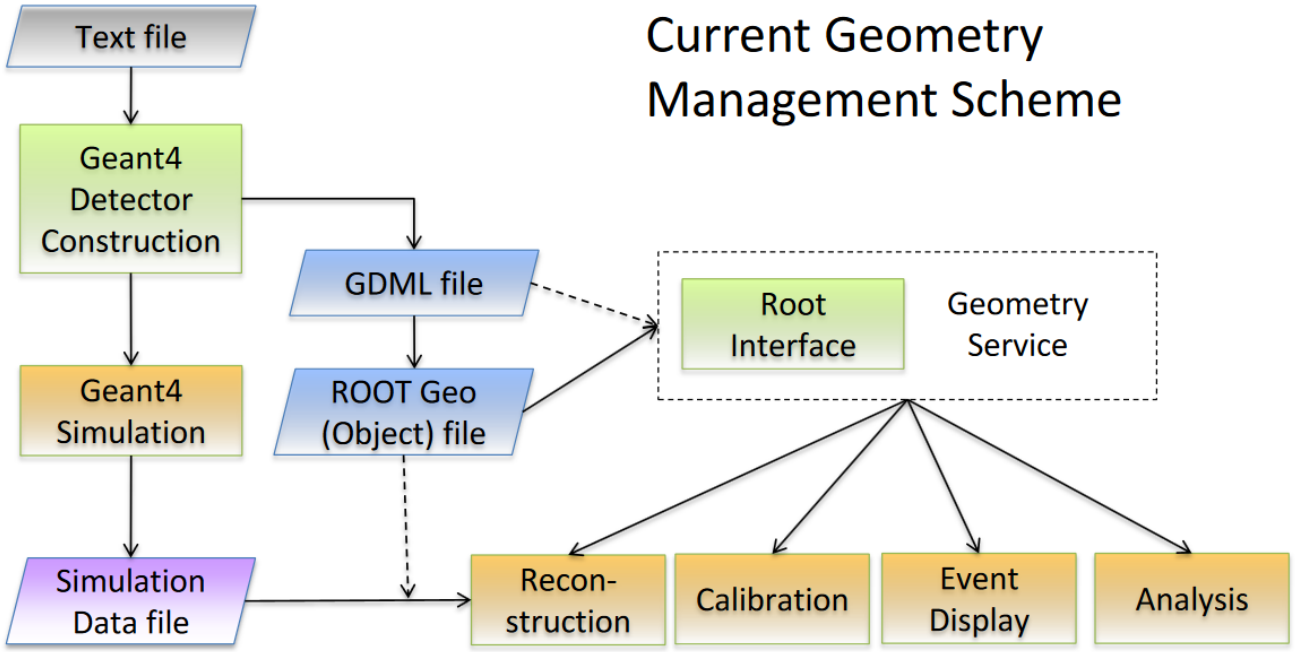
# Detector Simulation Framework

- Integrate SNiPER & Geant4 (9.x).

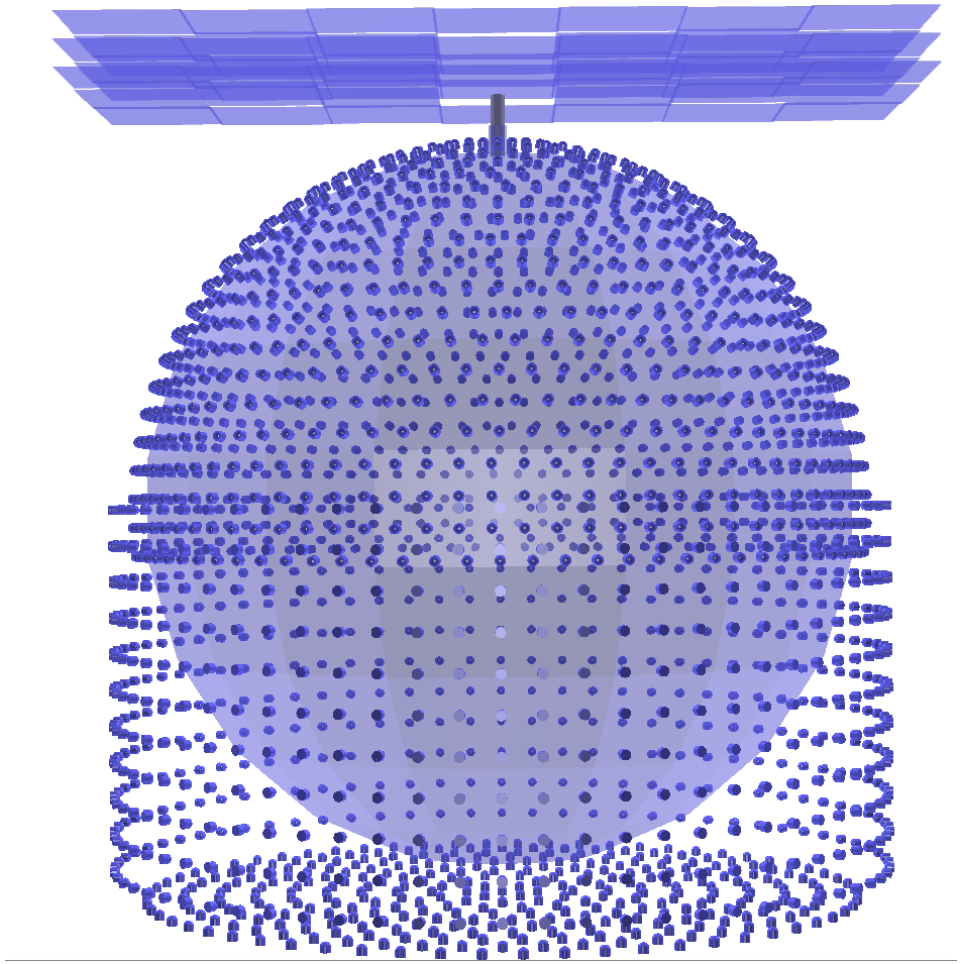



- Features:
  - Lightweight simulation framework.
  - Easy to migrate from standalone application.
  - Support both batch and interactive modes.
  - Support Geant4's macro files/commands in Python.
- Plan:
  - Supporting multi-threading Geant4 (10.x).

# Geometry Management (1)



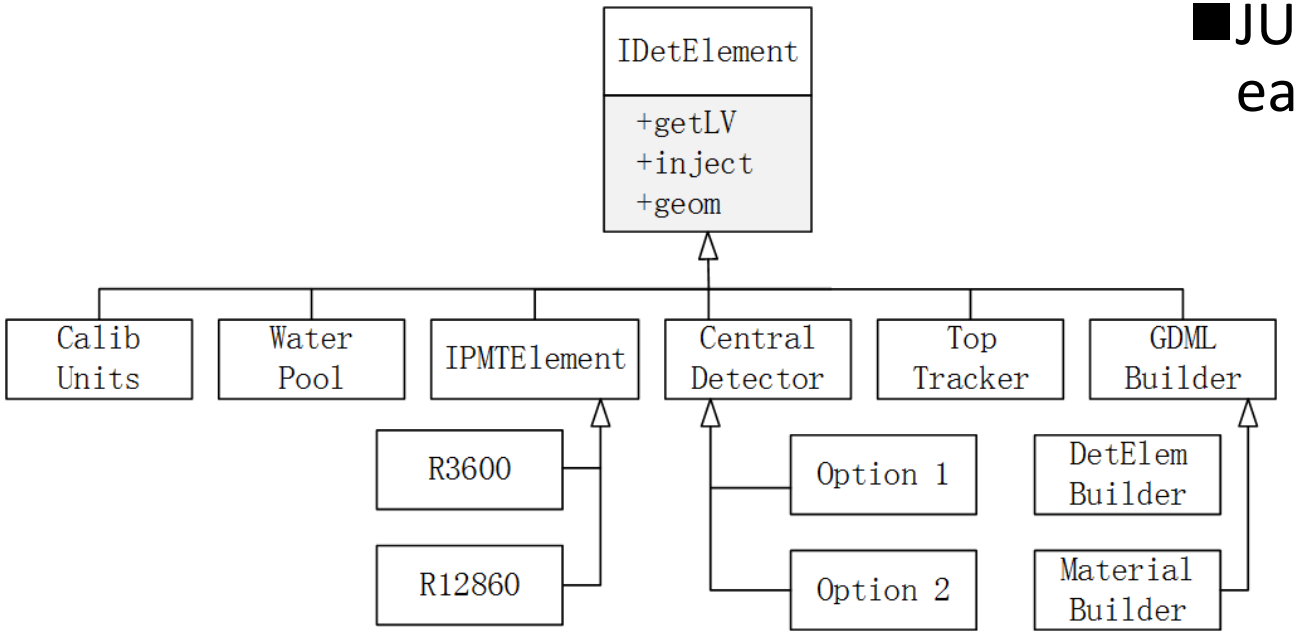

- GDML description including 3” PMTs, node size
  ~54k PMTs, ~330k nodes
- Geant4 generation and ROOT conversion time
  ~30 sec
- File size: GDML file 22 MB, ROOT file 3 MB



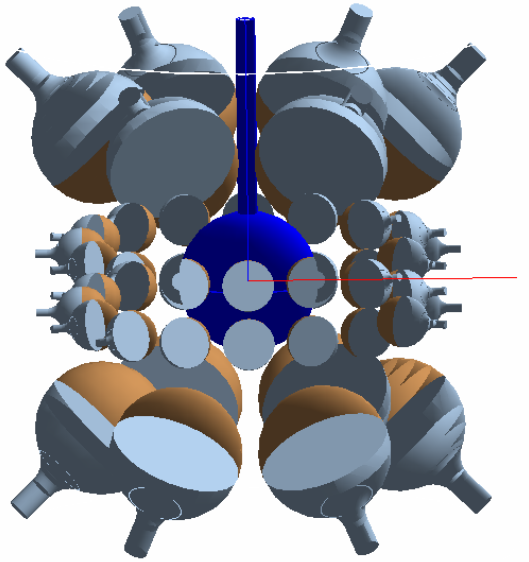
JUNO Veto PMTs, rendered using ROOT

# Geometry Management (2)

- Most of detector elements is constructed from code.
  - Each part could be configured and constructed at runtime.
  - Useful for detector design and calibration units.

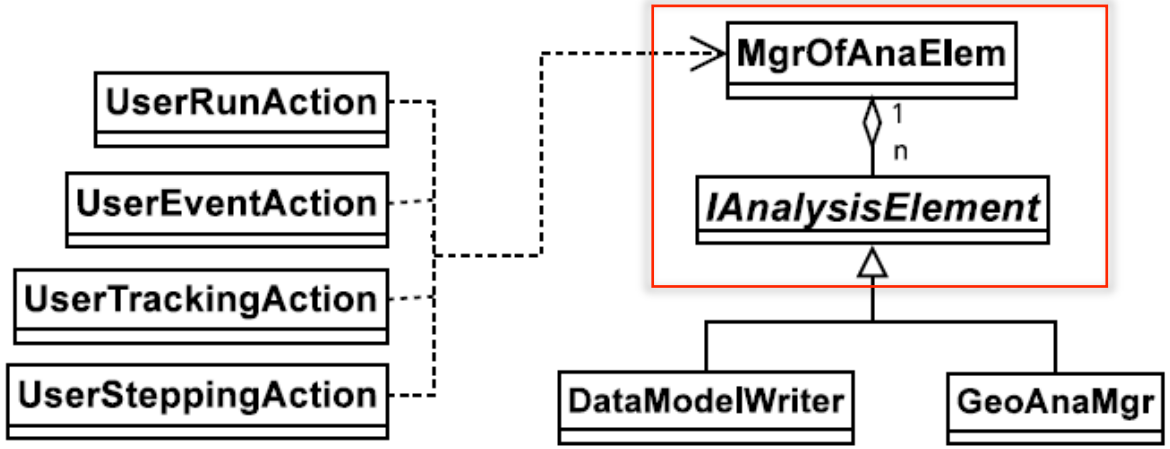



- JUNO prototype detector could be setup easily using the same simulation software.

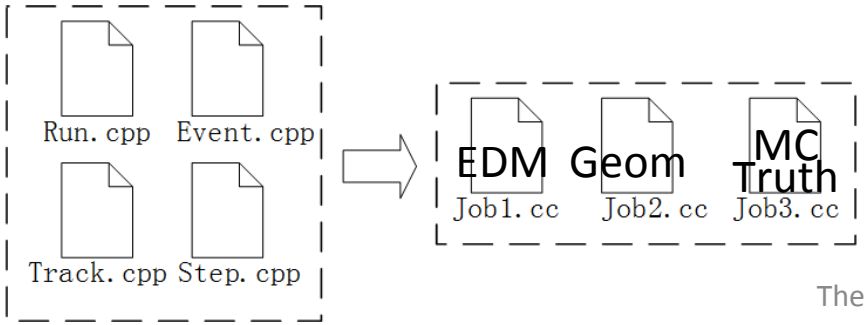


# MC Truth and User Action

## ■Modular design of User Action.




- Design, Pluggable and configurable.




## ■ Event Data Model (ROOTIO)

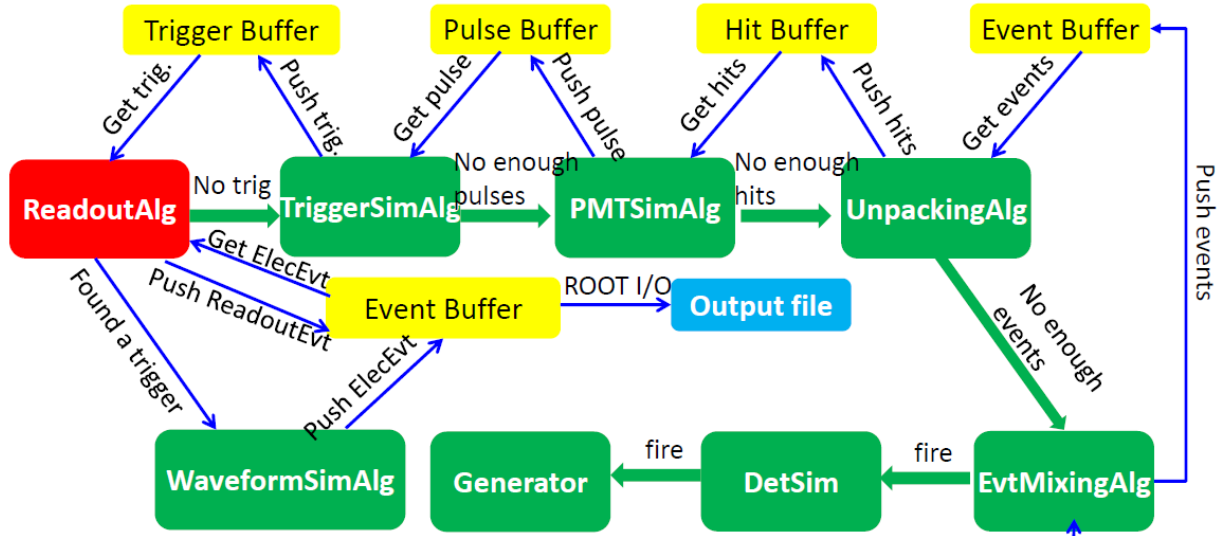
- Separation of Header and Event, for lazy loading.

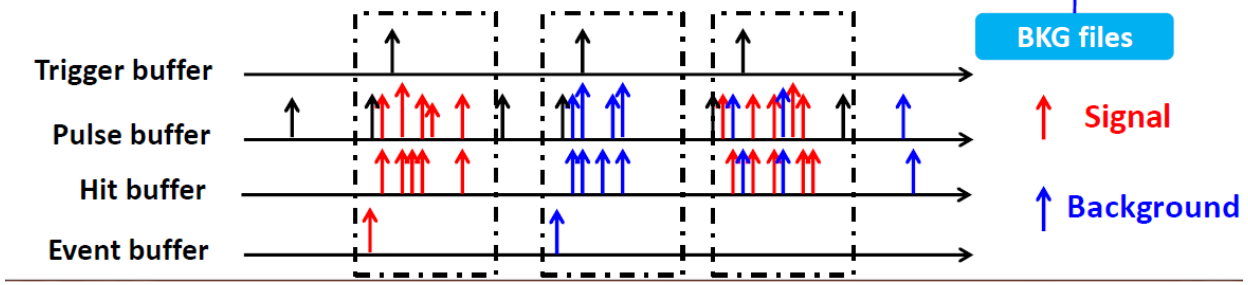
| | | |
|---|---|---|
| Physics Generator | HepMC | |
| Detector Simulation | SimHeader | |
| | SimEvent | |
| | | SimTrack |
| | | SimPMTHit |
| | | SimTTHit |

## ■Other MC Truth are saved in plain TTrees using RootWriter.

# Electronics and Digitization Simulation

- "PULL" workflow (data-driven)
  - Starts from ReadoutAlg.
  - Using SNiPER's Task+Incident to call TriggerSimAlg when buffer is empty.
- Handle event mixing and event splitting gracefully.
  - Such as IBD events (prompt and delay signals)
- Each part is designed and implemented as a module.



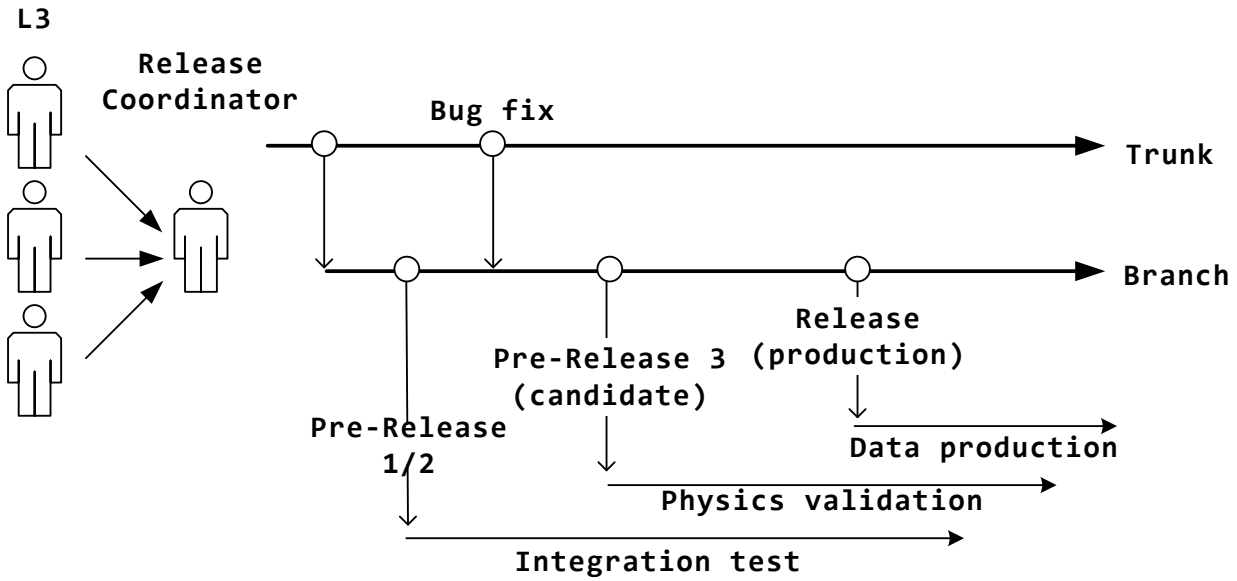




```
python tut_det2elec.py \
        --input IBD:ibd1.root \
        --input U:u.root \
        --rate IBD:1.0 \
        --rate U:3.0
```

IBD

U

# Data validation and production




**UPDATED** Proposal: chains to test

- 3 chains to compare the outputs of:
- (1) DetSim → "Calib" converter → Vtx+Ene rec (the 'old' way)
- (2) DetSim → ElecSim in deterministic mode (no evt mixing) → Waveform rec → Vtx+Ene rec (the 'new' way)
  - *no evt mixing, so that each simulated event is digitized 1-to-1 and can be inspected before and after ElecSim*
- (3) DetSim → ElecSim with evt mixing → Waveform rec → Vtx +Ene rec (the 'new' way)
  - *with evt mixing, so that each simulated event is overlapped with bkgs as it happens in real life.*
  - *Bkgs = simulate natural $^{238}U$ + overlap Dark Noise at 50 KHz?*

- "JunoTest Production" supports both validation and production.
- ".ini file" is used for configuration.

Validation.ini

```
[Chain]
seed = 42
evtmax = 500
njobs = 1
tags = e+_0.0MeV e+_1.398MeV
```

Production.ini

```
[Chain]
seed = 42
evtmax = 1000
njobs = 100
tags = e+_0.0MeV e+_1.398MeV
```

- Full chains of simulation and reconstruction are ready.
- First round validation is on going.
- Data Production will start soon.

# Conclusions

- JUNO uses SNiPER as underlying framework.
- Based on SNiPER, simulation software was developed.
  - Detector simulation framework integrates SNiPER and Geant4.
  - Electronics simulation supports “PULL” workflow, allows hit level mixing.
- The full data processing chain is completed.
- MC Data challenge is preparing, will start soon.