JUNO Workloads

Xiaofei Yan, Tao Lin

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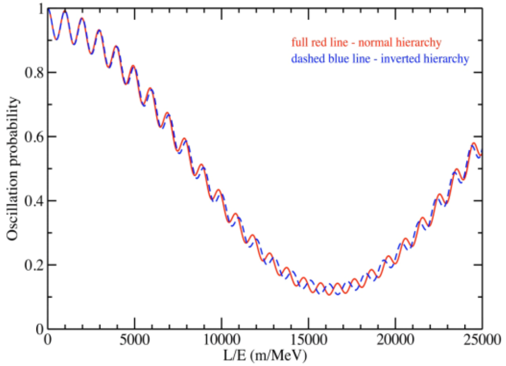
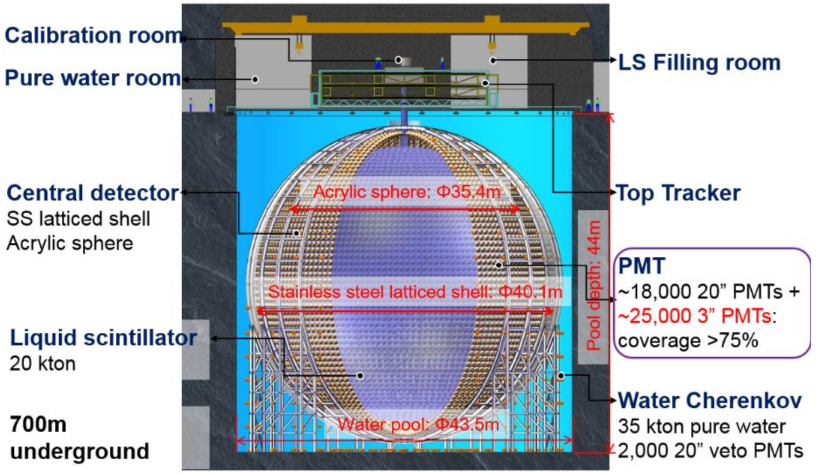
Outline

- Over view of JUNO Experiment
- Data Processing Workflow
- Workloads at JUNO
- Event mixing (or Pileup) in MC Production
- Answer questions

The JUNO Experiment

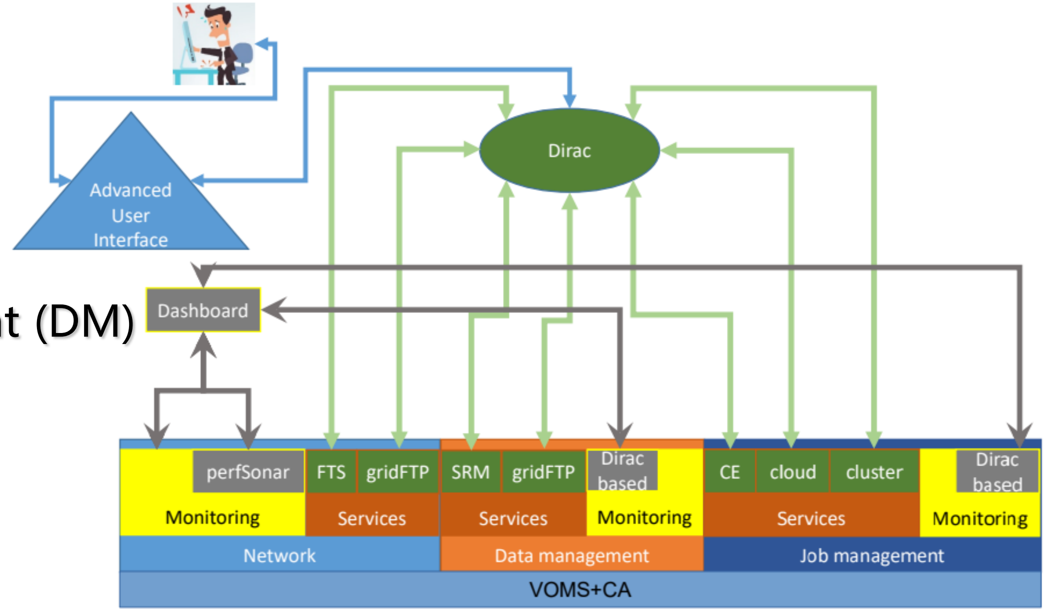
- The Jiangmen Underground Neutrino Observatory (JUNO):
  - Neutrino detected by Inverse Beta Decay (IBD);
  - Baseline: ~53 km from 2 nuclear power plants sites (26 GWth in 2020);
  - 20 kilotons high light yield and high transparency liquid scintillator;
  - >75% PMT photocathode coverage;
- Goals of JUNO:
  - Main: to determine the neutrino mass hierarchy at 3-4 σ sensitivity within 6 years by <3% energy resolution @ 1 MeV;
  - Other: solar oscillation parameters, supernova neutrino, geo-neutrino, etc.





JUNO Computing

- JUNO Distributed Computing system was built on DIRAC
  - Handles heterogeneous and distributed resources
  - Provides workload management (WM) and data management (DM)



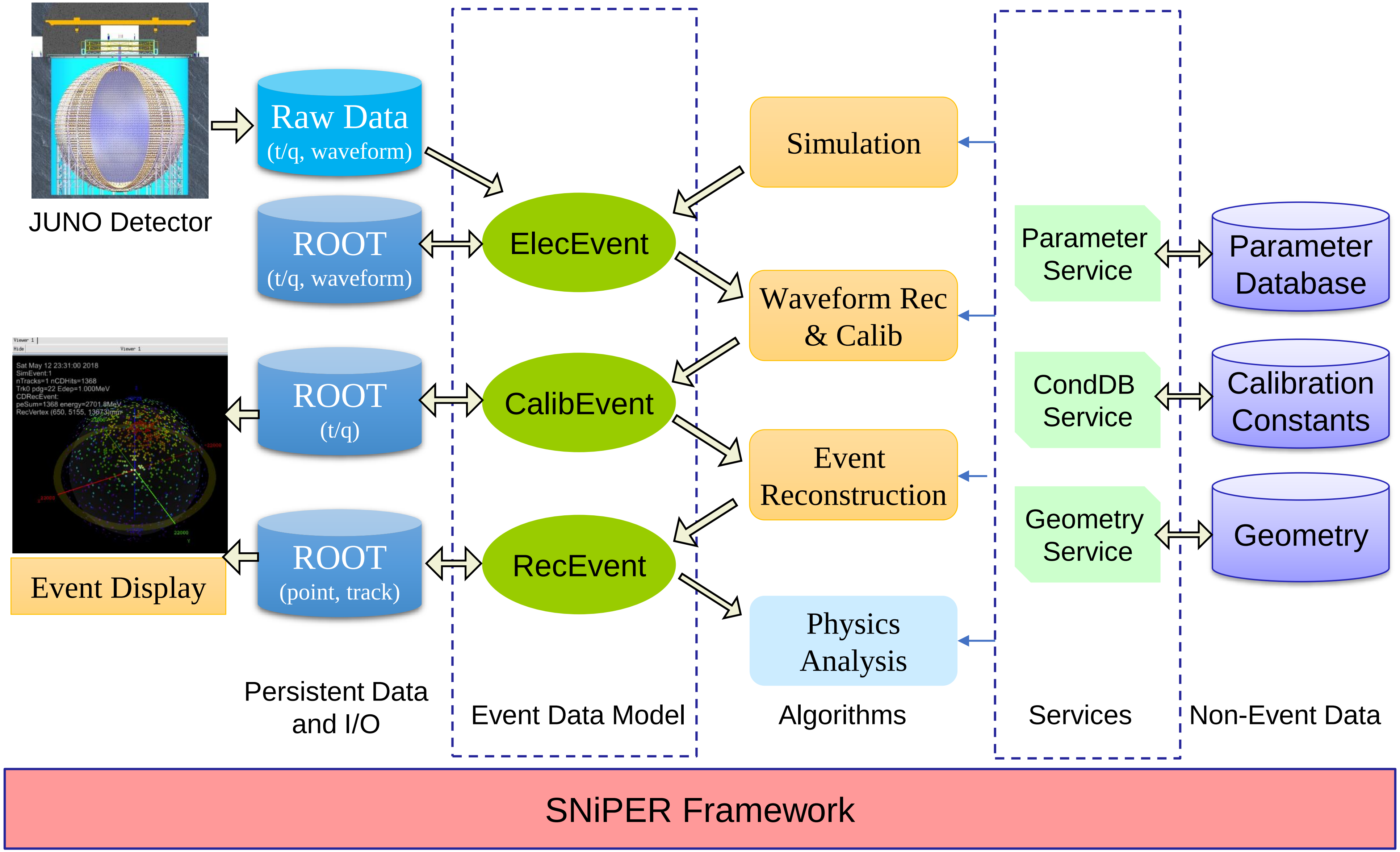
JUNO Data centers roles

IHEP	CCIN2P3	INFN CNAF	MSU	JINR DUBNA
Main storage		Secondary storage		Secondary storage
Data quality				
First reconstruction		Secondary reconstruction		Secondary reconstruction
Analysis	Analysis	Analysis	Analysis	Analysis
Simulation	Simulation	Simulation	Simulation	Simulation

Country	Institute	Country	Institute	Country	Institute
Armenia	Yerevan Physics Institute	China	IMP-CAS	Germany	U. Mainz
Belgium	Universite libre de Bruxelles	China	SYSU	Germany	U. Tuebingen
Brazil	PUC	China	Tsinghua U.	Italy	INFN Catania
Brazil	UEL	China	UCAS	Italy	INFN di Frascati
Chile	PCUC	China	USTC	Italy	INFN-Ferrara
Chile	UTFSM	China	U. of South China	Italy	INFN-Milano
China	BISEE	China	Wu Yi U.	Italy	INFN-Milano Bicocca
China	Beijing Normal U.	China	Wuhan U.	Italy	INFN-Padova
China	CAGS	China	Xi'an JT U.	Italy	INFN-Perugia
China	ChongQing University	China	Xiamen University	Italy	INFN-Roma 3
China	CIAE	China	Zhengzhou U.	Latvia	IECS
China	DGUT	China	NUDT	Pakistan	PINSTECH (PAEC)
China	ECUST	China	CUG-Beijing	Russia	INR Moscow
China	Guangxi U.	China	ECUT-Nanchang City	Russia	JINR
China	Harbin Institute of Technology	Czech R.	Charles University	Russia	MSU
China	IHEP	Finland	University of Jyvaskyla	Slovakia	FMPICU
China	Jilin U.	France	LAL Orsay	Taiwan-China	National Chiao-Tung U.
China	Jinan U.	France	CENBG Bordeaux	Taiwan-China	National Taiwan U.
China	Nanjing U.	France	CPPM Marseille	Taiwan-China	National United U.
China	Nankai U.	France	IPHC Strasbourg	Thailand	NARIT
China	NCEPU	France	Subatech Nantes	Thailand	PPRLCU
China	Pekin U.	Germany	FZJ-ZEA	Thailand	SUT
China	Shandong U.	Germany	RWTH Aachen U.	USA	UMD1
China	Shanghai JT U.	Germany	TUM	USA	UMD2
China	IGG-Beijing	Germany	U. Hamburg	USA	UC Irvine
China	IGG-Wuhan	Germany	FZJ-IKP		

77 members

Overview of Data Processing Workflow (1)

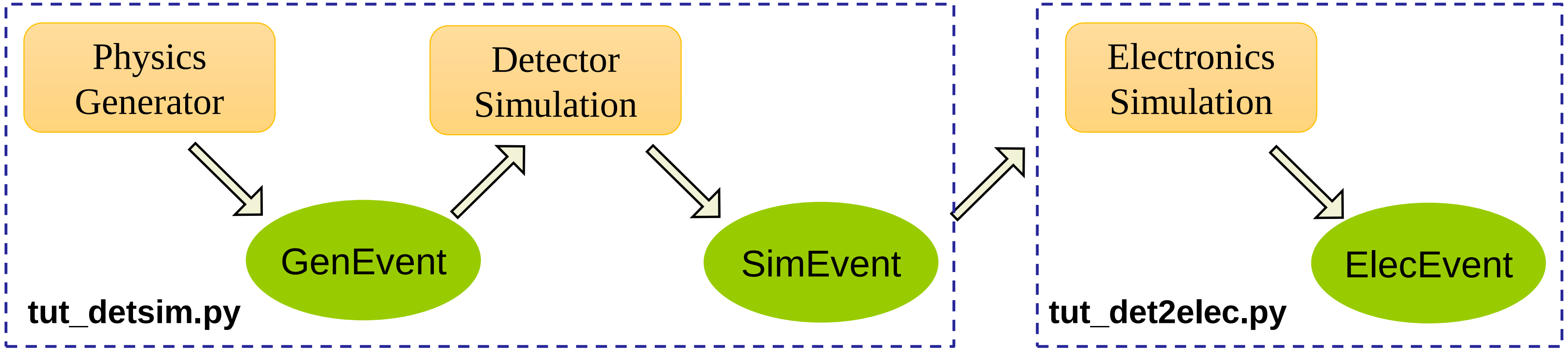


Overview of Data Processing Workflow (2)

- There are three steps in JUNO simulation
  - Physics Generator
  - Detector Simulation
  - Electronics simulation (Event mixing) + OEC (optional)
- The first two steps are running together
- The third step could run w/o or w/ reconstruction algorithms
  - w/o reconstruction: waveforms stored.
  - w/ reconstruction: no waveforms stored, saving disk usage.

JUNO-Workload

tut_detsim.py	GEN-SIM
tut_det2elec.py	Elect-SIM
tut_elec2calib.py	Calib REC
tut_calib2rec.py	Event REC

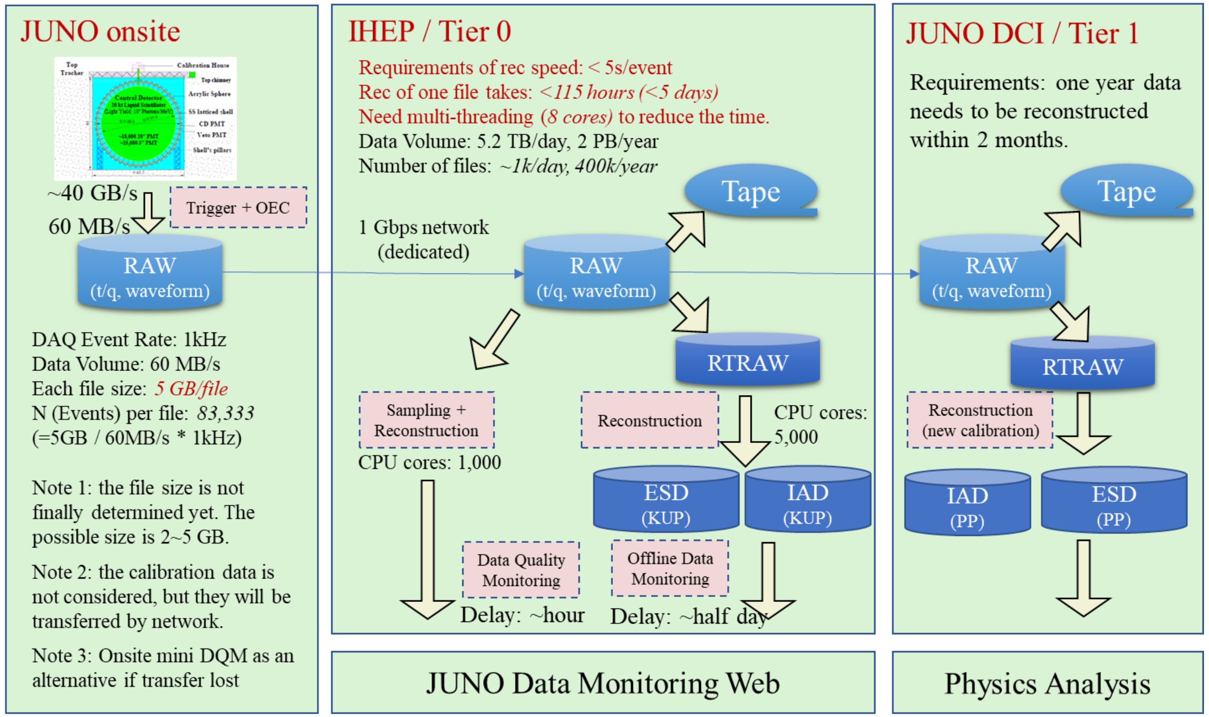


Workloads at JUNO

- Keep Up Production (KUP) at Tier 0
- Data Quality Monitoring (DQM)
- Physics Production (PP) at DCI
- MC Production at DCI

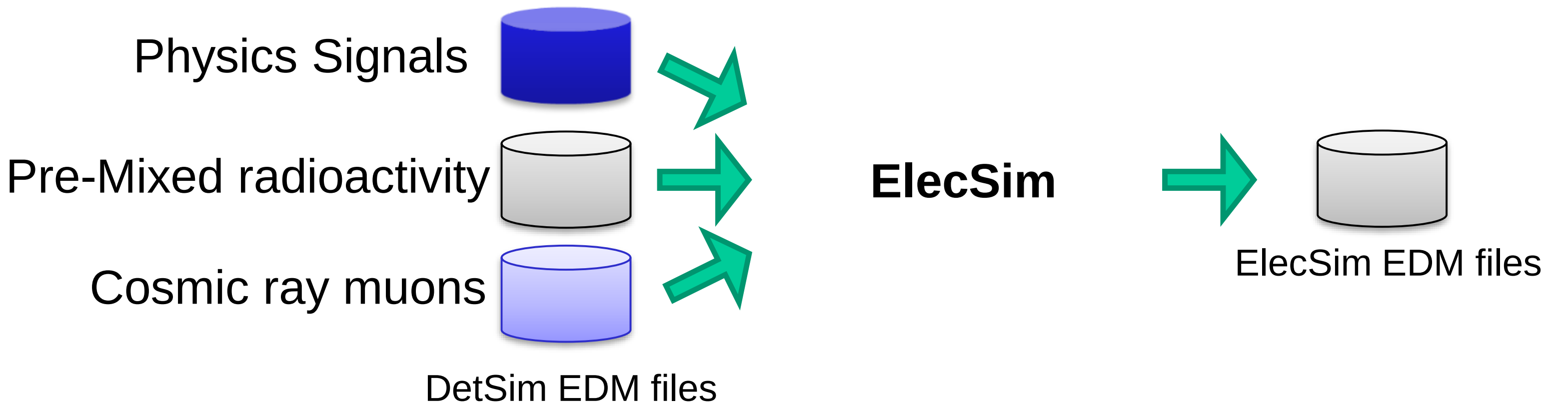
Real Data (KUP, DQM, PP)

MC Data (MC Production)



MC Production (1)

- Due to all the physics signals and backgrounds need to be produced before event mixing, the MC production include two major steps
  - Production of different samples at detector simulation level
  - Event mixing, electronics simulation and reconstruction
- The radioactivity backgrounds are pre-mixed to reduce the number of input files.



MC Production (2)

Dataset Name	Generators to be used	Number of Events	Rates (used in elecsim)	Shift persons	Status
Muon	Muon.exe	1,000,000 events (x10)	28.2 Hz	Jilei Xu	1,000,000 (x10)
U238@LS	GRDM	1,000,000 events (x13)	3.234 Hz	Cailian Jiang	1,000,000 events (x13)
Th232@LS	GRDM	1,000,000 events (x10)	0.733 Hz	shift	1,000,000 events (x10)
K40@LS	GRDM	1,000,000 events	0.53 Hz	shift	1,000,000 events
Pb210@LS	GRDM	1,000,000 events (x3)	17.04 Hz	shift	1,000,000 events (x3)
C14@LS	GRDM	1,000,000,000 events	3.3e4 Hz	shift	1,000,000,000 events
Kr85@LS	GRDM	1,000,000 events	1.163 Hz	shift	1,000,000 events
U238@Acrylic	GRDM	10,000,000 events (x13)	98.41 Hz	shift	10,000,000 events (x13)
Th232@Acrylic	GRDM	10,000,000 events (x10)	22.29 Hz	shift	10,000,000 events (x10)
K40@Acrylic	GRDM	10,000,000 events	161.25 Hz	shift	10,000,000 events
U238@node/bar	GRDM	100,000,000 events (x13)	2102.36 Hz	shift	100,000,000 events (x13)
Th232@node/bar	GRDM	100,000,000 events (x10)	1428.57 Hz	shift	100,000,000 events (x10)
K40@node/bar	GRDM	100,000,000 events	344.5 Hz	shift	100,000,000 events
Co60@node/bar	GRDM	100,000,000 events	97.5 Hz	shift	100,000,000 events
U238@PMTGlass	GRDM	1,000,000,000 events (x13)	4.90e6 Hz	shift	1,000,000,000 events (x13)
Th232@PMTGlass	GRDM	1,000,000,000 events (x10)	8.64e5 Hz	shift	1,000,000,000 events (x10)
K40@PMTGlass	GRDM	1,000,000,000 events	4.44e5 Hz	shift	1,000,000,000 events
Tl208@PMTGlass	GRDM	1,000,000,000 events	1.39e5 Hz	shift	Not start
Co60@Truss	GRDM	N events	? Hz	shift	Not start
Tl208@Truss	GRDM	N events	? Hz	shift	Not start
Rn222@WaterRadon	GRDM	100,000,000 events (x7)	90 Hz	shift	100,000,000 events (x7)

About 20 radioactivity backgrounds need to be produced in MC production

Questions(1)

1. Please details the workloads provided to the Task force
    1. Does your experiment process the whole chain (gen-sim-reco) event by event, or is each step (gen, sim, reco) processing a whole set of events before moving to the next step?
        1. Two types:
            1. Mock Data: inclusive Need to separate
            2. Physics events, such as IBD without event mixing, Could be done both.
        2. Do things both ways, but processing step by step is better/more convenient
    2. In the case of the generation (simulation) which physics process (pileup configuration) is used?
        1. Each radioactivity particle present in the medium/detector is simulated independently then merged at the electronics simulation step. At this step we can have more than 20 different sets of input files, each with their own different rate. [TODO: put correct number for sets of input files]
        2. Random trigger is in digi-level, pre-mixing is in hit level . random trigger could be used for MC tuning.
    3. Do these workloads represent the processing chain submitted on the grid?
       Do they include some extra-step not used in production? Eg debug modules
        1. Most workloads are submitted to grid, however for now merging of files is being done locally due to the very specific requirements needed for that task.
           Extra step is pre-mixing.

Questions(2)

2. Software stack
    1. Are the software features currently in the container still the most recent ones?
        1. Upgrade two version
    2. Could you summarise the plans about future, known, major upgrades of the software foreseen in your Experiment?
        1. Software evolutions should be mostly following LHC standards. We need however to include some GPU acceleration (particularly for simulating photon propagation).
        2. a standalone example is now working with Opticks.
        3. Wenjie had developed a GPU based rec. SYCL based (in future)
    3. Do you plan / have done to migrate your offline code to non-x86 CPUs (ARM/Power) or to adopt accelerators (GPUs)
        1. need to use GPUs for photon propagation (currently in preparation based on Opticks – https://simoncblyth.bitbucket.io/opticks/). Some discussion about an ARM port is also being discussed to use some opportunistic resources available.

3. Experience in integrating the Experiment's workloads in the HEP standalone containers
    1. What is your overall experience in using the build procedure designed by the HEPiX Benchmarking WG to create standalone containers?
        1. Use other experiment's workloads such as LHCb, to create juno workload project.
    1. Do you have comments about the resolution measured by the working group in the repeated executions of your workloads during the validation procedure?
        1. Current JUNO workload software， initialization and finalization phases included in the reported time.
    2. Do you have suggestions? What would you improve?
        1. Current JUNO software version, output only event running time.
4. In the scenario that an HEPscore22 benchmark will be defined from a combination of the current HEP-workloads (Run3, year 2021/22), what would be the position of your Experiment about these statements:

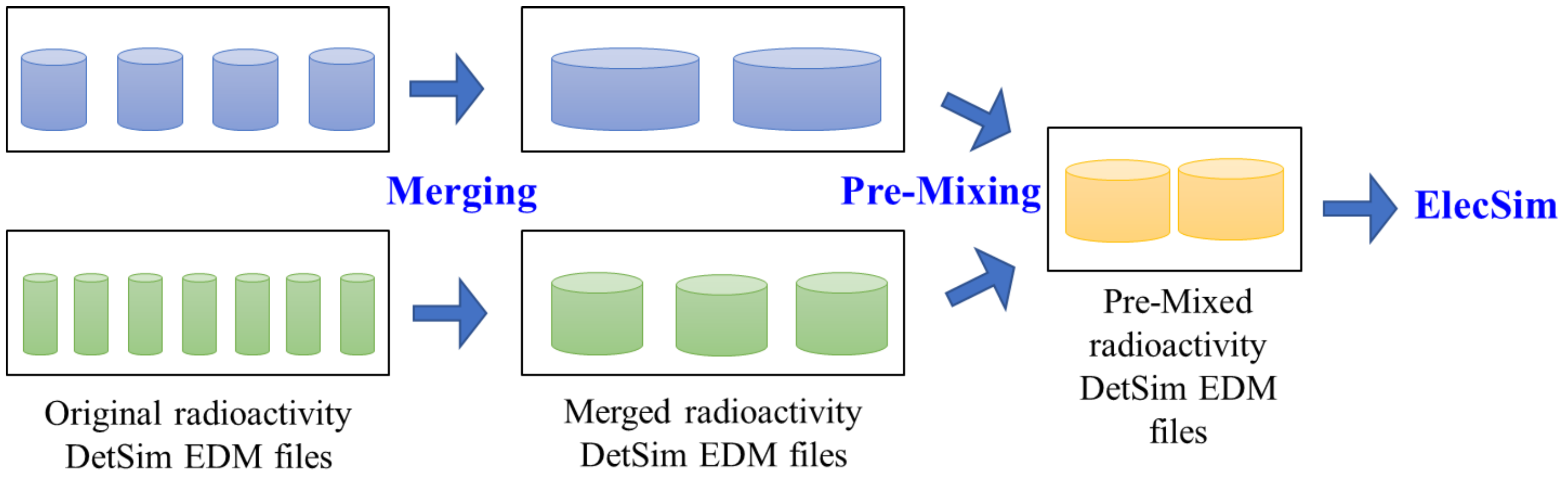
- If we know the percentage of total CPU time spent on different workloads such as simulation, reconstruction etc., we can obtain the weighted average of benchmarking results by using the percentage as a weight. The weighted average might be better than an average benchmarking result for a specific HEP experiment.

- Thanks and questioans!

Backup Slides

MC Production (3)

- The radioactivity backgrounds data are merged and pre-mixed.




```
- label: Pb210-LS
  rate:  17.04
  input: /junofs/grid/user/r/rli/merge_test/Pb210-LS.root
- label: C14-LS
  rate:  3.3e4
  input: /junofs/grid/user/r/rli/merge_test/C14-LS-1.root
- label: Kr85-LS
  rate:  1.163
  input: /junofs/grid/user/r/rli/merge_test/Kr85-LS.root
- label: U238-Acrylic
  rate:  98.41
  input: /junofs/grid/user/c/cjiang/test/centos7_amd64_gcc830/Pre-Release/J22.1.0-rc0/merged/U238-Acrylic.root
- label: Th232-Acrylic
  rate:  22.29
  input: /junofs/grid/user/c/cjiang/test/centos7_amd64_gcc830/Pre-Release/J22.1.0-rc0/merged/Th232-Acrylic.root
- label: K40-Acrylic
  rate:  161.25
  input: /junofs/grid/user/c/cjiang/test/centos7_amd64_gcc830/Pre-Release/J22.1.0-rc0/merged/K40-Acrylic.root
- label: U238-node-bar
```

Note: This extra step is currently processed at local computing node.
Using a YAML file to specify all the inputs and rates.