JUNO software -Atm neutrino

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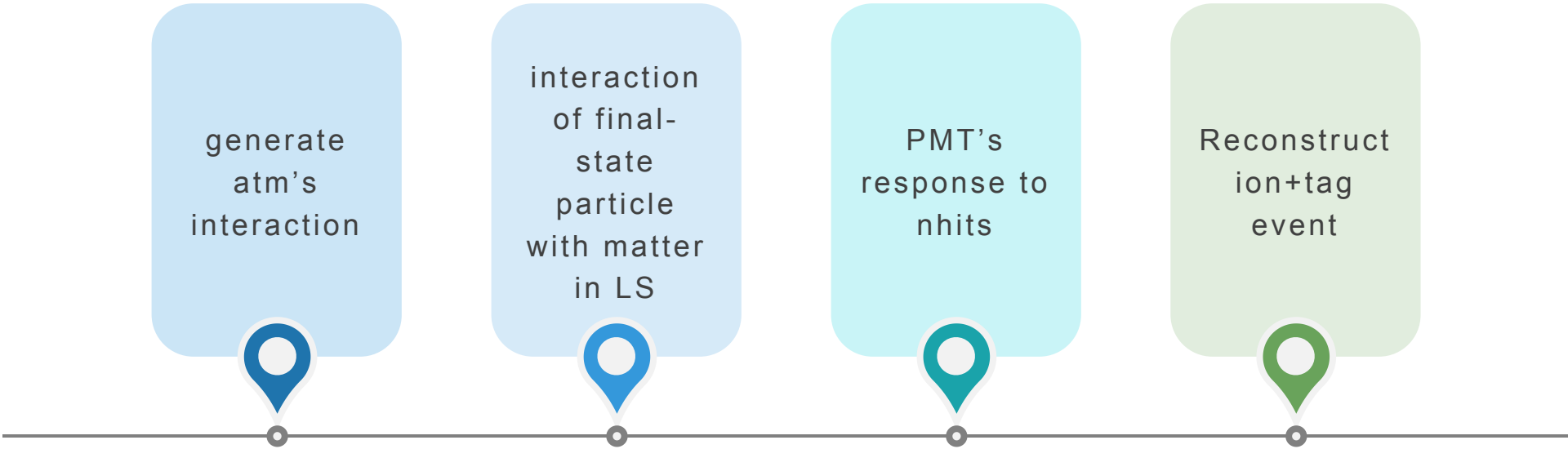
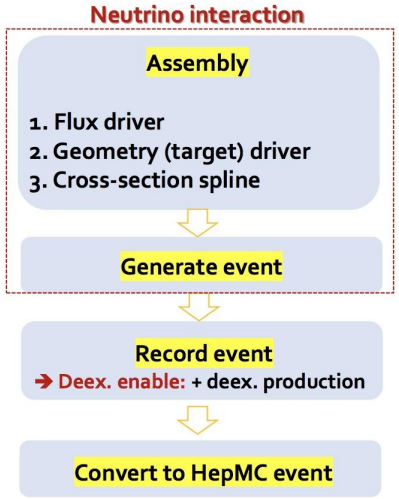
Weekly meeting

Precedure of atm data to OEC



neutrino generators in JUNO

- Neutrino interaction generators (GENIE, NuWro and GiBUU)
- Reference models for cross-section of different channel
- GANYMEDE group is study the Interaction Uncertainty
- GENIE is using for JUNO software.
- NuWro and GiBUU will be implemented to JUNO




```
source /cvmfs/juno.ihep.ac.cn/centos7_amd64_gcc1120/Pre-Release/J22.2.0-rc0/setup.sh

flux=HAKKM:/junofs/users/quzhenning/GENIECheck/flux/flux.dat[14],/junofs/users/quzhenning/GENIECheck/flux/flux.dat[-14]
tune=G18_10b_02_11b
gevgen_atmo -f ${flux} -n 100 -g 1000060120 -E 0.5,20 --tune ${tune} --cross-sections
/junofs/users/quzhenning/Spline/${tune}/${tune}.xml -r ${run} -o genie --seed ${randomseed}
gntpc -i genie.${run}.ghep.root -f gst
rm -rf genie.${run}.ghep.root
rm -rf genie-mcjob-${run}.status
```

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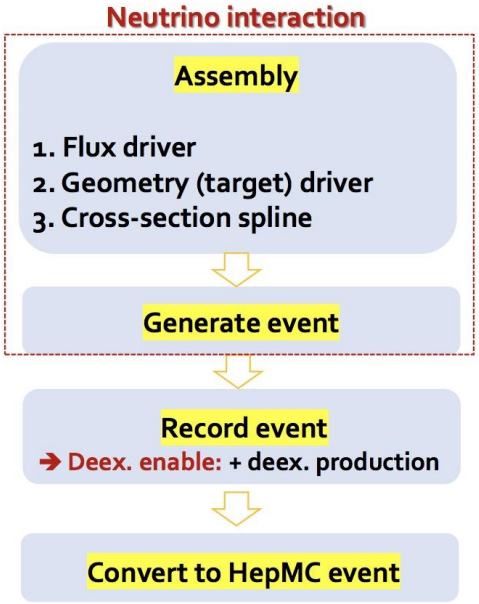
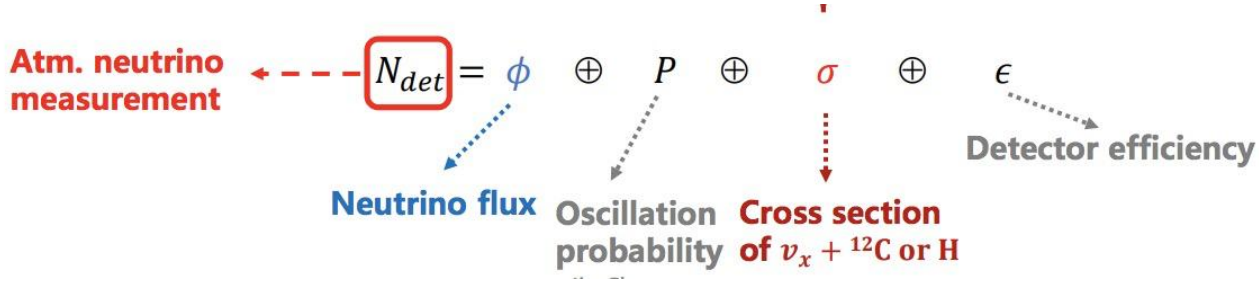
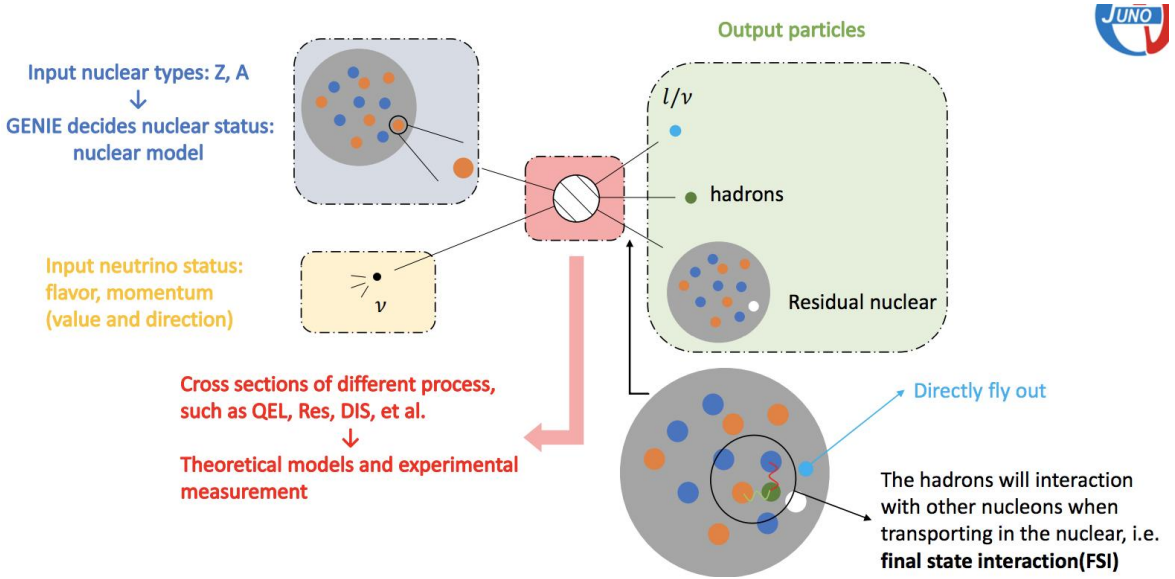
Generator Atm







JUNO-doc-9325-v1

flux: to earth, because L/E of atmo is small, not consider the oscillation

Detsim：interaction of final-state particle with matter in LS

command：

time python $JUNOTOP/offline/Examples/Tutorial/share/tut_detsim.py --no-gdml --evtmax ${NEV} --seed ${DETSEED} --output ${FDET} --user-output ${USRDET} --anamgr-normal-hit --pmtsd-merge-twindow 1 atmo --input ${GENFILE} --index 0 --volume pTarget >& logffile

--anamgr-normal-hit To reduce the data volume of detsim user data, now all the hit/photon level truth are disabled. Please use option "–anamgr-normal-hit" to enable them.

https://juno.ihep.ac.cn/~offline/Doc/user-guide/detsim/structures.html

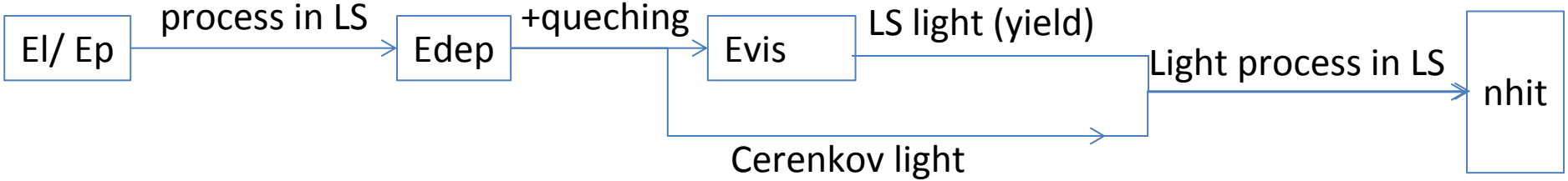
Detsim function-result

input：final states particle type

pass through the LS in the detector (detector construction)

particle process [different kinds of particle interaction with LS]

light process in LS(LS's optical parameters)



queching

quenching refers to the phenomenon in which the measured signal or response of a detector is lower than expected based on the amount of energy deposited.

$$\frac{dN_{\text{Scint}}}{dx} = \text{LY} \cdot \frac{\frac{dE}{dx}}{1 + kB(\frac{dE}{dx}) + kC(\frac{dE}{dx})^2}$$

Birks' lawer : the relationship between the true energy and the quenched energy of the charged particle in a scintillator material.

- LY is the absolute scintillation light yield, dE/dx is the stopping power of the particle in the medium.
- kB is the well-known Birks constant, and kC is the coefficient of the secondary term.
- The Birks constant could be different for heavy charged particles (proton, alpha) and e+/e-/gamma.

Edep Evis/QEdep nphoto nhits nPE

Edep: deposited energy==energy loss in detector

Evis: visible energy==queched Edep in detsim

nphoto : scintillator photos + Cerenkov photos

nhits: nphoto process(absorb/reemission/scatter) in LS to PMT(with a coverage rate)

nPE(elesim): nhits * DE

$$\frac{dN_{\text{Scint}}}{dx} = \text{LY} \cdot \frac{\frac{dE}{dx}}{1 + kB(\frac{dE}{dx}) + kC(\frac{dE}{dx})^2}$$

Birks' law

$$\frac{d^2N_{\text{Ceren}}}{dxd\lambda} = \frac{2\pi\alpha z^2}{\lambda^2}\left(1 - \frac{1}{\beta^2 n^2(\lambda)}\right)$$

Frank-Tamm formula

Edep Evis/QEdep nphoto nhits nPE - ture situation

energy scale in JUNO, which is defined as the average PE number per MeV calibrated by events of neutron capture on hydrogen at the CD center:

$$S = N_{\mathrm{PE}}^{\mathrm{nH}} / E_{\mathrm{true}}^{\mathrm{nH}}$$

where the Evis is defined as the ratio of detected PE number to the energy scale

$$E_{\mathrm{vis}}(E_{\mathrm{true}}) = \frac{N_{\mathrm{PE}}(E_{\mathrm{true}})}{S}$$

Elesim： PMT’s response and readout

command：

python $JUNOTOP/offline/Examples/Tutorial/share/tut_det2elec.py --input ${FDET} --output ${FELEC} --user-output ${USRELEC} --evtmax -1 --Trigger_FiredPmtNum 300 --Trigger_window 300 --enableWP --enableWPDarkPulse --rate 0.001 --seed ${ELECSEED} >& ${FlogEle}

https://juno.ihep.ac.cn/~offline/Doc/user-guide/elecsim/elecsim_script_options.html?highlight=rate

Elesim

- Hit-level event mixing
- to model the PMT response to hits:PE
- to model the readout electronics of CD, WP and TT
- global trigger simulation

Mode	Description	Default configuration	options
MC-truth based vertex fitting(default in elecsim)	Vertex info from MC truth	80ns window 300 nPMT threshold 16ns slip	--LpmtTrigger_alg MC-based
Grid based vertex fitting (VFL)	Divide CD into 179 sub volumes for tof calculation	48ns window 100 nPMT threshold 16ns slip	--LpmtTrigger_alg real-logic --Trigger_Mode onlyVFL
Standard majority trigger	Standard global trigger	300ns window 300 nPMT threshold 16ns slip	--LpmtTrigger_alg real-logic --Trigger_Mode onlyStd
OR-mode trigger	standard & grid based vertex fitting	Logic OR	--LpmtTrigger_alg real-logic --Trigger_Mode OR-ed

https://juno.ihep.ac.cn/~offline/Doc/user-guide/elecsim/elecsim_workflow.html

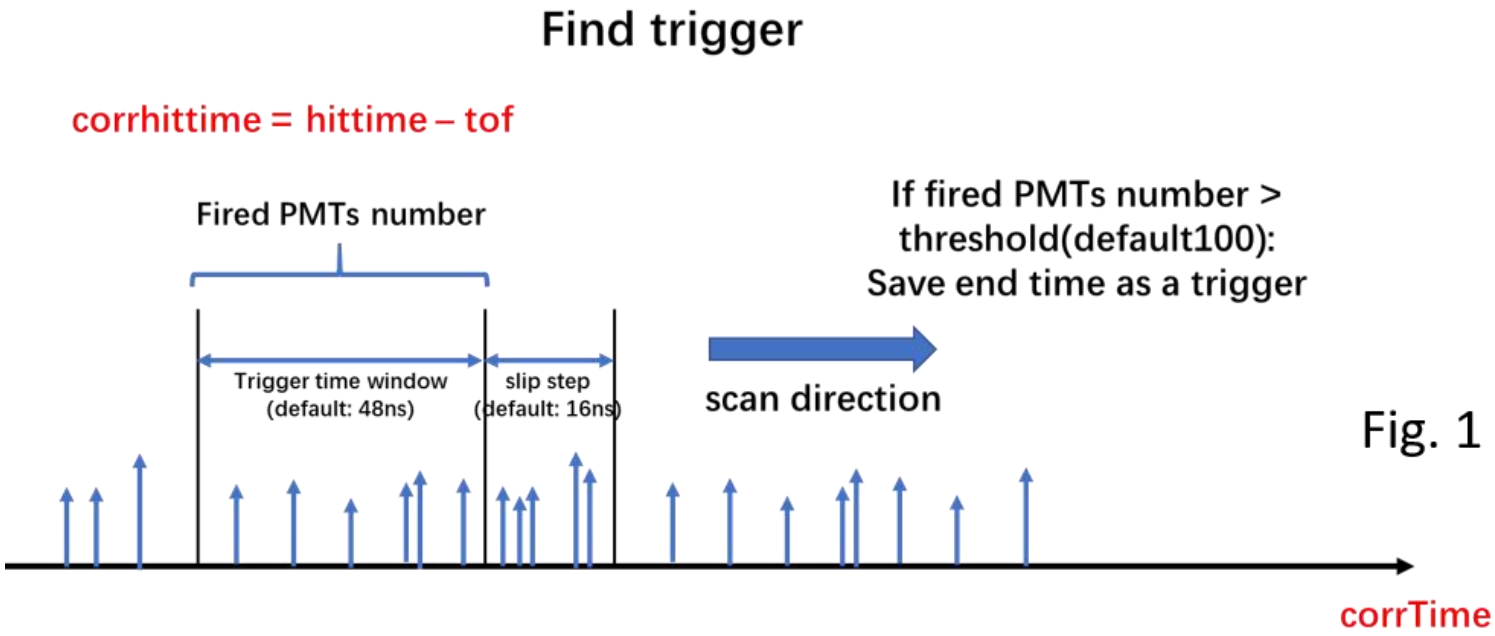

Find trigger
corrhittime = hittime – tof
Fired PMTs number
If fired PMTs number > threshold(default100): Save end time as a trigger
Trigger time window (default: 48ns)
slip step (default: 16ns)
scan direction
corrTime

Fig. 1

Other function of JUNO software and script

tut_detsim.py: generators and detector simulation

tut_det2elec.py: electronics simulation

tut_elec2calib.py: PMT waveform reconstruction

tut_det2calib.py: skip electronics simulation and waveform reconstruction, convert objects from SimEvent to CalibEvent.

tut_calib2rec.py: vertex/energy/track reconstruction.

tut_elec2rec.py: do a simulation chain electronics –> calibration –> reconstruction.