

Relative Simple Tutorial about Vertex Reconstruction

Ziyuan LI

SUN-YAT-SEN UNIVERSITY
zli@cern.ch

JUNO Software Workshop @ WHU

May 13, 2018

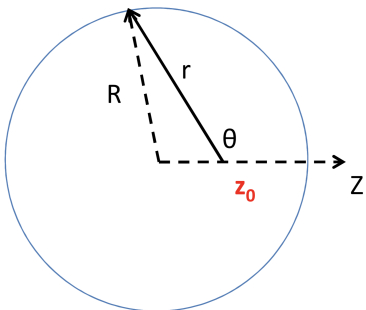
- 1 Introduction
- 2 Reconstruction Method
 - Charge Center Method
 - Time Likelihood Method
- 3 Command Line Practice
 - Practice in Virtual Machine
 - Practice in IHEP Server

Vertex reconstruction is essential for

- ▶ Non-uniformity correction in energy reconstruction.
- ▶ Fiducial volume determination.
- ▶ Event reconstruction quality evaluation.
- ▶ Background rejection.

Main reconstruction methods

- ▶ Charge Center Method.
- ▶ Time Likelihood Method.



- ▶ Light source deployed at Z_0 .
- ▶ Gamma evenly emitted in 4π solid angle of Z_0 .
- ▶ Charge center method reconstructs vertex at $2/3 Z_0$.

$$\begin{aligned} \bar{z} &= \frac{1}{4\pi} \int z d\Omega = \frac{1}{4\pi} \int_0^{2\pi} d\phi \int_0^\pi (z_0 + r \cdot \cos \theta) \sin \theta d\theta \\ &= \frac{1}{2} \int_0^\pi (z_0 + (\sqrt{R^2 - z_0^2 \sin^2 \theta} - z_0 \cos \theta) \cdot \cos \theta) \sin \theta d\theta \\ &= \frac{2}{3} z_0 \end{aligned}$$

When particles like e^+ , e^- or γ , deposit energy in liquid scintillator and light, define residual time for i th PMT:

$$t_{i,res} = t_i - tof - t_0$$

where:

- ▶ t_i : first hit time of i th PMT.
- ▶ tof : time of flight for scintillation photon.
- ▶ t_0 : real time of an event.

For point-like events, the residual time distribution obey the formula:

$$f(t) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(t-t_0)^2}{2\sigma^2}\right) * \left[\frac{\omega}{\tau_1} e^{-\frac{t}{\tau_1}} + \frac{\omega}{\tau_2} e^{-\frac{t}{\tau_2}}\right]$$

- ▶ σ : systematic uncertainty of first hit time.
- ▶ τ_1/τ_2 : time constant of fast/slow component of LS.

The Gaussian term represents PMT TTS effect and exponential term is responsible for LS luminescence.

Time Likelihood Method

Define Time Likelihood Function.

$$\Lambda(t) = -\sum_i \log(f(t))$$

Calculate the Likelihood Goodness.

- ▶ Use Charge Center Method to get initial value.
- ▶ Calculate $t_{i,res}$ for i th PMT.
- ▶ Calculate Likelihood value.

Iteration with Grid Point.

- ▶ Find the minimum Likelihood value point with grid cube, achieve 100 iterations before final result.

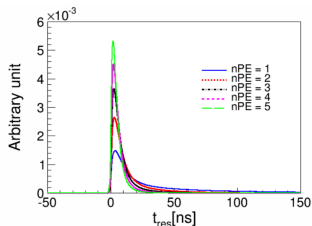
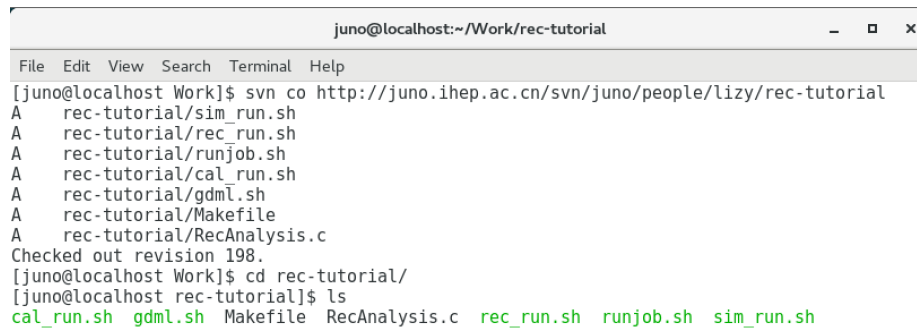


Fig. 7. PDF for different number of photons. The more PE, the sharper the PDF is. When number of PE is more than 5, the PDF are similar and obey gaussian distribution.

Practice in Virtual Machine

Open Virtual Machine

```
$ source $HOME/juno-dev/setup.sh
$ cd YOUR-WORK-DIR
$ svn co http://juno.ihep.ac.cn/svn/juno/people/lizy/rec-tutorial/
$ cd rec-tutorial
```



```
juno@localhost:~/Work/rec-tutorial
```

File Edit View Search Terminal Help

```
[juno@localhost Work]$ svn co http://juno.ihep.ac.cn/svn/juno/people/lizy/rec-tutorial
A   rec-tutorial/sim_run.sh
A   rec-tutorial/rec_run.sh
A   rec-tutorial/runjob.sh
A   rec-tutorial/cal_run.sh
A   rec-tutorial/gdml.sh
A   rec-tutorial/Makefile
A   rec-tutorial/RecAnalysis.c
Checked out revision 198.
[juno@localhost Work]$ cd rec-tutorial/
[juno@localhost rec-tutorial]$ ls
cal_run.sh  gdml.sh  Makefile  RecAnalysis.c  rec_run.sh  runjob.sh  sim_run.sh
```

Practice in Virtual Machine

gdml.sh : Generate gdml file

```
$ ./gdml.sh
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
#!/bin/sh

function jobtopdir() {
    echo ${TOPDIR:-$PWD}
}

function particletype() {
    echo ${PARTICLE:-e+}
}

function particleenergy() {
    echo ${ENERGY:-0}
}

function tag() {
    echo ${TAG:-test}
}

function runscript() {
    echo ${SCRIPTDIR:-$TUTORIALROOT/share}
}

function genname() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift
    echo ${prefix}-${seed}.${suffix}
}

31,0-1 Top
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help

seed=${1:-0};
evtmax=1
P=${2:-0}
ENERGY= echo ${P%.*}'
ENERGY=$((ENERGY+1))

jobdir=$(jobtopdir)/$(particletype)_$(particleenergy)MeV
echo $jobdir
[ -d "$jobdir" ] || mkdir -p $jobdir
output=$(genname sim $seed $evtmax root)
user_output=$(genname user-sim $seed $evtmax root)
log=$(genname simlog $seed $evtmax txt)

cd $jobdir
(time python $(runscript)/tut_detsim.py --evtmax $evtmax \
    --seed $seed \
    --output sample detsim.root \
    --user_output detsim_user.root \
    --pmtsd-v2 \
    --ce-mode 20inchfunc \
    --no-pmt3inch \
    --gdml \
    gun --particles e+ \
    --momentums $P \
    --positions 0 0 0) >& gdml.log

30,1 Bot
```


Practice in Virtual Machine

gdml.sh : Generate gdml file

```
$ ./gdml.sh
```

```
juno@localhost:~/Work/rec-tutorial/e+_1MeV
File Edit View Search Terminal Help
[juno@localhost rec-tutorial]$ ./gdml.sh
/home/juno/Work/rec-tutorial/e+_1MeV
[juno@localhost rec-tutorial]$ ls
cal_run.sh  e+_1MeV  gdml.sh  Makefile  RecAnalysis.c  rec_run.sh  runjob.sh  sim_run.sh
[juno@localhost rec-tutorial]$ cd e+_1MeV/
[juno@localhost e+_1MeV]$ ls
detsim user.root  gdml.log  geometry_acrylic.gdml  sample_detsim.root
[juno@localhost e+_1MeV]$
```

Practice in Virtual Machine

sim_run.sh : Run Simulation

```
$ ./sim_run.sh
```

```
juno@localhost:~/Work/rec-tutorial  -  □  X
File Edit View Search Terminal Help
#!/bin/sh
}
function jobtopdir() {
    echo ${TOPDIR:-$PWD}
}
function particletype() {
    echo ${PARTICLE:-e+}
}
function particleenergy() {
    echo ${ENERGY:-0}
}
function tag() {
    echo ${TAG:-test}
}
function runscript() {
    echo ${SCRIPTDIR:-$TUTORIALROOT/share}
}
function genname() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift
    echo ${prefix}-${seed}.${suffix}
}
2.0-1 Top
```

```
juno@localhost:~/Work/rec-tutorial  -  □  X
File Edit View Search Terminal Help
seed=${1:-0}
P=${2:-0}
evtmax=${3:-10}
ENERGY=`echo ${P%.*}`
ENERGY=$((ENERGY+1))
jobdir=$(jobtopdir)/$(particletype)_$(particleenergy)MeV
echo $jobdir
[ -d "$jobdir" ] || mkdir -p $jobdir
output=$(genname sim $seed $evtmax root)
user_output=$(genname user-sim $seed $evtmax root)
log=$(genname simlog $seed $evtmax txt)
cd $jobdir
(time python $(runscript)/tut_detsim.py --evtmax $evtmax \
    --seed $seed \
    --output $output \
    --user-output $user_output \
    --pmtsd-v2 \
    --ce-mode 20inchf
unc \
    --no-pmt3inch \
    --no-gdml \
gun --particles e+ \
--momentums $P \
--material LS \
--volume pTarget) >& $log
58,17 Bot
```

Practice in Virtual Machine

sim_run.sh : Run Simulation

```
$ ./sim_run.sh
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
[juno@localhost rec-tutorial]$ ./sim_run.sh
/home/juno/Work/rec-tutorial/e+ 1MeV
[juno@localhost rec-tutorial]$ ls
cal_run.sh  e+ 1MeV  gdm1.sh  Makefile  RecAnalysis.c  rec_run.sh  runjob.sh  sim_run.sh
[juno@localhost rec-tutorial]$ ls e+ 1MeV/
detsim_user.root  geometry_acrylic.gdml  sim-0.root  user-sim-0.root
gdml.log          sample_detsim.root     simlog-0.txt
[juno@localhost rec-tutorial]$
```

Practice in Virtual Machine

cal_run.sh : Run Calibration

```
$ ./cal_run.sh
```

```
juno@localhost:~/Work/rec-tutorial - □ ×
File Edit View Search Terminal Help
#!/bin/sh

function jobtopdir() {
    echo ${TOPDIR:-$PWD}
}

function particletype() {
    echo ${PARTICLE:-e+}
}

function particleenergy() {
    echo ${ENERGY:-0}
}

function tag() {
    echo ${TAG:-test}
}

function runscrip() {
    echo ${SCRIPTDIR:-$TUTORIALROOT/share}
}

function genname() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift

    echo ${prefix}-${seed}.${suffix}
}

1,1 Top
```

```
juno@localhost:~/Work/rec-tutorial - □ ×
File Edit View Search Terminal Help
}

function genname() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift

    echo ${prefix}-${seed}.${suffix}
}

seed=${1:-0}
P=${2:-0}
evtmax=${3:-10}
ENERGY='echo ${P%.*}'
ENERGY=$((ENERGY+1))

jobdir=$(jobtopdir)/$(particletype)_$(particleenergy)MeV
echo $jobdir
[ -d "$jobdir" ] || mkdir -p $jobdir

input=$(genname sim $seed $evtmax root)
output=$(genname cal $seed $evtmax root)
log=$(genname callog $seed $evtmax txt)

cd $jobdir
(time python $(runscrip)/tut_det2calib.py --evtmax $evtmax \
    --input $input \
    --output $output \
    --detoption Acrylic) >& $log

_ _ _ 50,1-8 _ _ Bot ↵
```

Practice in Virtual Machine

cal_run.sh : Run Calibration

```
$ ./cal_run.sh
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
[juno@localhost rec-tutorial]$ ./cal_run.sh
/home/juno/Work/rec-tutorial/e+ 1MeV
[juno@localhost rec-tutorial]$ ls e+ 1MeV/
cal-0.root      detsim_user.root  geometry_acrylic.gdml  sim-0.root      user-sim-0.root
callog-0.txt   gdml.log          sample_detsim.root    simlog-0.txt
[juno@localhost rec-tutorial]$
```

Practice in Virtual Machine

rec_run.sh : Run Reconstruction

```
$ ./rec_run.sh
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
#!/bin/sh

function jobtopdir() {
    echo ${TOPDIR:-$PWD}
}

function particletype() {
    echo ${PARTICLE:-e+}
}

function particleenergy() {
    echo ${ENERGY:-0}
}

function tag() {
    echo ${TAG:-test}
}

function runscrip() {
    echo ${SCRIPTDIR:-$TUTORIALROOT/share}
}

function genname() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift

    echo ${prefix}-${seed}.${suffix}
}

1.1 Top
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help

function genname() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift

    echo ${prefix}-${seed}.${suffix}
}

seed=${1:-0}
P=${2:-0}
evtmax=${3:-10}
ENERGY=`echo ${P%.*}`
ENERGY=$((ENERGY+1))

jobdir=$(jobtopdir)/$(particletype)_$(particleenergy)MeV
echo $jobdir
[ -d "$jobdir" ] || mkdir -p $jobdir

input=$(genname cal $seed $evtmax root)
output=$(genname rec $seed $evtmax root)
log=$(genname reclog $seed $evtmax txt)

cd $jobdir
(time python $(runscrip)/tut_calib2rec.py --evtmax $evtmax \
    --gdm1 \
    --input $input \
    --output $output \
    --detoption Acrylic) >& $log

51,1-8 Bot
```

Practice in Virtual Machine

rec_run.sh : Run Reconstruction

```
$ ./rec_run.sh
```

juno@localhost:~/Work/rec-tutorial

File Edit View Search Terminal Help

```
[juno@localhost rec-tutorial]$ ./rec_run.sh
/home/juno/Work/rec-tutorial/e+_1MeV
[juno@localhost rec-tutorial]$ ls e+_1MeV/
cal-0.root          gdml.log           reclog-0.txt       simlog-0.txt
callog-0.txt        geometry_acrylic.gdml  sample_detsim.root  user-sim-0.root
detsim_user.root   rec-0.root         sim-0.root
```

Practice in Virtual Machine

Makefile : Generate executable file

```
$ make
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
@ll: RecAnalysis
MARCH:=`root-config --arch`
CXX:=`root-config --cxx`

SRC_U:=$(wildcard *.c)

OBS_U:=$(basename $(SRC_U) )

CPPFLAGS=-D_PGTRACK -isystem$(ROOTSYS)/include -isystem$(JUNOTOP)/offline/InstallArea/include
CXXFLAGS= -ggdb $(CPPFLAGS)

RecAnalysis:RecAnalysis.c
$(CXX) -o RecAnalysis $(CXXFLAGS) $@.c -L./ `root-config --cflags --libs` -L$(EVTNAVIGATORROOT)/$(CMTCONFIG) -lEvtNavigator -L$(GENEVENTV2ROOT)/$(CMTCONFIG) -lGenEventV2 -L$(SIMEVENTV2ROOT)/$(CMTCONFIG) -lSimEventV2 -L$(ELECEVENTROOT)/$(CMTCONFIG) -lElecEvent -L$(CALIBEVENTROOT)/$(CMTCONFIG) -lCalibEvent -L$(RECEVENTROOT)/$(CMTCONFIG) -lRecEvent -L$(EDMUTILROOT)/$(CMTCONFIG) -lEDMUtil -L$(BASEEVENTROOT)/$(CMTCONFIG) -lBaseEvent

clean:
@rm -fv $(OBS_U) 2>/dev/null
```


Practice in Virtual Machine

Makefile : Generate executable file

```
$ make
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
[juno@localhost rec-tutorial]$ make
`root-config --cxx` -o RecAnalysis -ggdb -D PGTRACK -isystem/home/juno/juno-dev/ExternalLibs/ROOT/5
.34.11/include -isystem/home/juno/juno-dev/offline/InstallArea/include RecAnalysis.c -L./ `root-confi
g --cflags --libs` -L/home/juno/juno-dev/offline/DataModel/EvtNavigator/Linux-x86_64 -lEvtNavigator -L
/home/juno/juno-dev/offline/DataModel/GenEventV2/Linux-x86_64 -lGenEventV2 -L/home/juno/juno-dev/offli
ne/DataModel/SimEventV2/Linux-x86_64 -lSimEventV2 -L/home/juno/juno-dev/offline/DataModel/ElecEvent/Li
nux-x86_64 -lElecEvent -L/home/juno/juno-dev/offline/DataModel/CalibEvent/Linux-x86_64 -lCalibEvent -L
/home/juno/juno-dev/offline/DataModel/RecEvent/Linux-x86_64 -lRecEvent -L/home/juno/juno-dev/offline/D
ataModel/EDMUtil/Linux-x86_64 -lEDMUtil -L/home/juno/juno-dev/offline/DataModel/BaseEvent/Linux-x86_64
-lBaseEvent
RecAnalysis.c: In function 'int main(int, char**)':
RecAnalysis.c:338:9: warning: pointer to a function used in arithmetic [-Wpointer-arith]
    exit -l;
        ^
[juno@localhost rec-tutorial]$
```

Practice in Virtual Machine

RecAnalysis.c : Script to Analysis data

```
void RecAnalysis(TString Inputrecpath="lists_rec.txt", TString inputsimpth="lists_detsim.txt",
TString outputpath="rec_ana/rec_ana.root"){
    gStyle->SetOptFit(1111);
    gSystem->Load("libRecEvent.so");
    TH1F* h X= new TH1F("h X", "X {rec}-X {edep}", TH_NUM, TH_MIN, TH_MAX);
    TH1F* h Y= new TH1F("h Y", "Y {rec}-Y {edep}", TH_NUM, TH_MIN, TH_MAX);
    TH1F* h Z= new TH1F("h Z", "Z {rec}-Z {edep}", TH_NUM, TH_MIN, TH_MAX);
    TH1F* h R= new TH1F("h R", "R {rec}-R {edep}", TH_NUM, TH_MIN, TH_MAX);
    TH1F* h E= new TH1F("h E", "E {rec}", EHI_NUM, 1.05*energyIndex-1.05*energyIndex+2);
    TH1F* h Pos Edep = new TH1F("h Pos Edep", "R {Edep}", 100, 0, 18000);
    TH1F* h Pos Rec = new TH1F("h Pos Rec", "R {Rec}", 100, 0, 18000);
    TH1F* h Pos Edep3 = new TH1F("h Pos Edep3", "R {Edep}^{3}", 100, 0, 6000);
    TH1F* h_Pos_Rec3 = new TH1F("h_Pos_Rec3", "R {Rec}^{3}", 100, 0, 6000);

    TH2D* RecV_EdepV = new TH2D("RecV_EdepV", "R {Rec} : R {Edep}", 100, 0, 18000, 100, 0,
18000);
    TH2D* RecV3_EdepV3 = new TH2D("RecV3_EdepV3", "R {Rec}^{3} : R {Edep}^{3}", 100, 0, 60
00, 100, 0, 6000);
    TH2D* th2_vertex= new TH2D("th2_vertex", "th2_vertex", 100, 0, 6000, 100, -3000, 3000);
    TH2D* th2_energy= new TH2D("th2_energy", "th2_energy", 100, 0, 6000, 6000, 1.05*energyIndex-
1.1.05*energyIndex+2);

    TProfile* pro_vertex=new TProfile("profile_vertex", "profile_vertex", 25, 0, 6000, 1.05*ene
rgyIndex-1.1.05*energyIndex+2);
    TProfile* pro_energy=new TProfile("profile_energy", "profile_energy", 25, 0, 6000, 1.05*ene
rgyIndex-1.1.05*energyIndex+2);

    float sim x;
    float sim y;
    float sim z;
    float sim E;
    float vsigma;
    float emean;
    float esigma;

    std::vector<TString> rec_files_list;
    std::vector<TString> sim_files_list;

    std::ifstream fp(Inputrecpath);
    if (!fp.is_open()) {
        std::cerr << "ERROR: input lists does not exists." << std::endl;
    }
    34.0-1    10%
```

```
if (!fp.is open()) {
    std::cerr << "ERROR: input lists does not exists." << std::endl;
    return;
}
std::string rec tmp_line;
while(fp.good()) {
    std::getline(fp, rec tmp_line);
    if (rec tmp_line.size() == 0) {
        continue;
    }
    rec_files_list.push_back(rec tmp_line);
}
TChain* rec_ch = new TChain("Event/Rec/CDRecEvent");
for (std::vector<TString>::iterator it = rec_files_list.begin();
    it != rec_files_list.end(); ++it) {
    std::cout << "add rec file: " << *it << std::endl;
    rec_ch->Add(*it);
}

std::ifstream sfp(inputsimpth);
if (!sfp.is open()) {
    std::cerr << "ERROR: input lists does not exists." << std::endl;
    return;
}
std::string sim tmp_line;
while(sfp.good()) {
    std::getline(sfp, sim tmp_line);
    if (sim tmp_line.size() == 0) {
        continue;
    }
    sim_files_list.push_back(sim tmp_line);
}
TChain* sim_ch = new TChain("evt");
for (std::vector<TString>::iterator it = sim_files_list.begin();
    it != sim_files_list.end(); ++it) {
    std::cout << "add sim file: " << *it << std::endl;
    sim_ch->Add(*it);
}

TTree* rec = (TTree*)rec_ch;
JM:CDRecEvent* rh = new JM:CDRecEvent();
rec->SetBranchAddresses("CDRecEvent",&rh);
109.2-9    22%
```

Practice in Virtual Machine

RecAnalysis.c : Script to Analysis data

```
juno@localhost:~/Work/rec-tutorial - □ x
File Edit View Search Terminal Help
JM::CDRecEvent* rh = new JM::CDRecEvent();
rec->SetBranchAddresses("CDRecEvent",&rh);

TTree* sim = (TTree*)sim.ch;
sim -> SetBranchAddresses("edepX",&sim_x);
sim -> SetBranchAddresses("edepY",&sim_y);
sim -> SetBranchAddresses("edepZ",&sim_z);
sim -> SetBranchAddresses("edep",&sim_E);

int nentries = rec->GetEntries();
for(int i=0;i<nentries;i++){
    sim->GetEntry(i);
    rec->GetEntry(i);
    Float_t rec_x = rh->x();
    Float_t rec_y = rh->y();
    Float_t rec_z = rh->z();
    Float_t rec_E = rh->eprec();
    Float_t rec_nfit = rh->energy();
    Float_t rec_r = sqrt(rec_x*rec_x + rec_y*rec_y + rec_z*rec_z);
    Float_t diff_x = rec_x - sim_x;
    Float_t diff_y = rec_y - sim_y;
    Float_t diff_z = rec_z - sim_z;
    Float_t diff_E = rec_E / sim_E;
    Float_t edep_r = sqrt(sim_x*sim_x + sim_y*sim_y + sim_z*sim_z);
    Float_t delta_r = sqrt(diff_x*diff_x + diff_y*diff_y + diff_z*diff_z);
    h E -> Fill(rec_E);
    h X -> Fill(diff_x,1);
    h Y -> Fill(diff_y,1);
    h Z -> Fill(diff_z,1);
    h Pos Edep -> Fill(edep_r,1);
    h Pos Rec -> Fill(rec_r,1);
    h Pos Edep3 -> Fill(pow(edep_r/1000.,3));
    h Pos Rec3 -> Fill(pow(rec_r/1000.,3));
    RecV EdepV -> Fill(edep_r, rec_r,1);
    RecV3 EdepV3 -> Fill(pow(edep_r/1000.,3), pow(rec_r/1000.,3));
    th2 vertex->Fill(pow(edep_r/1000.,3),rec_r-edep_r,1);
    th2_energy->Fill(pow(edep_r/1000.,3),rec_E,1);
    pro_vertex->Fill(pow(edep_r/1000.,3),rec_r-edep_r,1);
    pro_energy->Fill(pow(edep_r/1000.,3),rec_E,1);
}
//output file
149,2-9 35%
```

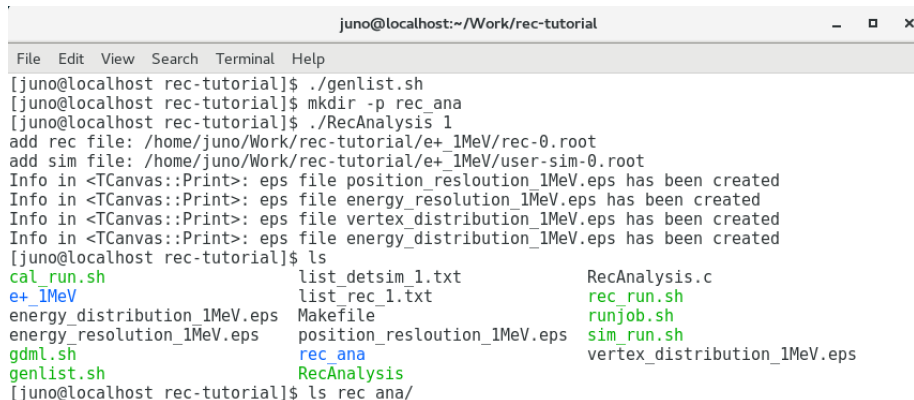
```
juno@localhost:~/Work/rec-tutorial - □ x
File Edit View Search Terminal Help
delete h E;
delete h Pos Edep;
delete h Pos Rec;
delete h Pos Edep3;
delete h Pos Rec3;
delete RecV EdepV;
delete RecV3 EdepV3;
delete th2 vertex;
delete th2_energy;
delete pro_vertex;
delete pro_energy;
delete fitGausConstant;
delete myc;
delete myc1;
delete myc_vertex;
delete myc_energy;
}

int main(int argc, char *argv[]){
    TString inputrecpath = "lists_rec.txt";
    TString inputsimpath = "lists_detsim.txt";
    TString outputpath = "rec_ana/rec_ana.root";
    if (argc == 1){
    }
    else if (argc == 2){
        inputrecpath=Form("list_rec_%.d.txt", atoi(argv[1]));
        inputsimpath=Form("list_detsim_%.d.txt", atoi(argv[1]));
        outputpath=Form("rec_ana/rec_ana_%.d.root", atoi(argv[1]));
        energyIndex=atoi(argv[1]);
    }
    else if (argc == 4){
        inputrecpath = argv[1];
        inputsimpath = argv[2];
        outputpath = argv[3];
    }
    else {
        cout << "ERROR :: Usage : RecAnalysis inputrec inputsim outputpath" << endl;
        exit -1;
    }
    RecAnalysis(inputrecpath, inputsimpath, outputpath);
    return 0;
}
342.1 Bot
```

Practice in Virtual Machine

RecAnalysis.c : Script to Analysis data

```
$ ./genlist.sh
$ mkdir -p rec_ana
$ ./RecAnalysis 1
```



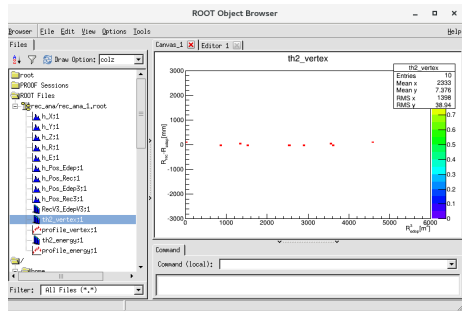
```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
[juno@localhost rec-tutorial]$ ./genlist.sh
[juno@localhost rec-tutorial]$ mkdir -p rec_ana
[juno@localhost rec-tutorial]$ ./RecAnalysis 1
add rec file: /home/juno/Work/rec-tutorial/e+_1MeV/rec-0.root
add sim file: /home/juno/Work/rec-tutorial/e+_1MeV/user-sim-0.root
Info in <TCanvas::Print>: eps file position_resloution_1MeV.eps has been created
Info in <TCanvas::Print>: eps file energy_resolution_1MeV.eps has been created
Info in <TCanvas::Print>: eps file vertex_distribution_1MeV.eps has been created
Info in <TCanvas::Print>: eps file energy_distribution_1MeV.eps has been created
[juno@localhost rec-tutorial]$ ls
cal_run.sh                list_detsim_1.txt        RecAnalysis.c
e+_1MeV                   list_rec_1.txt          rec_run.sh
energy_distribution_1MeV.eps Makefile                 runjob.sh
energy_resolution_1MeV.eps position_resloution_1MeV.eps sim_run.sh
gdm1.sh                   rec_ana                 vertex_distribution_1MeV.eps
genlist.sh                RecAnalysis
[juno@localhost rec-tutorial]$ ls rec_ana/
```

Practice in Virtual Machine

rec_ana/rec_ana_1.root : root file to store histogram

\$ root -l rec_ana/rec_ana_1.root

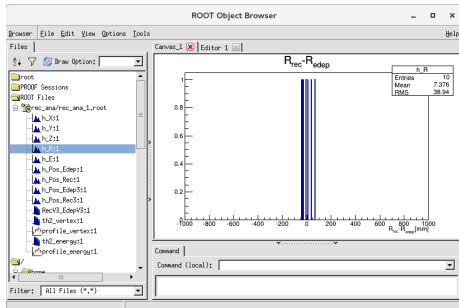
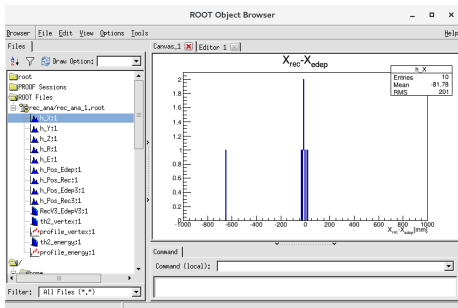
```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
[juno@localhost rec-tutorial]$ root -l rec_ana/rec_ana_1.root
root [0]
Attaching file rec_ana/rec_ana_1.root as _file0...
root [1] .ls
TFile**          rec_ana/rec_ana_1.root
TFile*           rec_ana/rec_ana_1.root
KEY: TH1F        h_X;1 X{rec}-X_{edep}
KEY: TH1F        h_Y;1 Y{rec}-Y_{edep}
KEY: TH1F        h_Z;1 Z{rec}-Z_{edep}
KEY: TH1F        h_R;1 R{rec}-R_{edep}
KEY: TH1F        h_E;1 E{rec}
KEY: TH1F        h_Pos_Edep;1 R_{Edep}
KEY: TH1F        h_Pos_Rec;1 R_{Rec}
KEY: TH1F        h_Pos_Edep3;1 R_{Edep}^{3}
KEY: TH1F        h_Pos_Rec3;1 R_{Rec}^{3}
KEY: TH2D        RecV3_EdepV3;1 R_{Rec}^{3} : R_{Edep}^{3}
KEY: TH2D        th2_vertex;1 th2_vertex
KEY: TProfile    profile_vertex;1 profile_vertex
KEY: TH2D        th2_energy;1 th2_energy
KEY: TProfile    profile_energy;1 profile_energy
root [2] TBrowser a
```



Practice in Virtual Machine

rec_ana/rec_ana_1.root : root file to store histogram

```
$ root -l rec_ana/rec_ana_1.root
```



Practice in Virtual Machine

runjob.sh : Script to run more events for different momentum

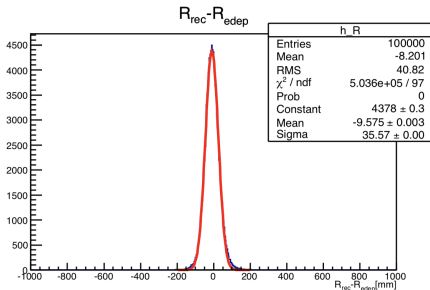
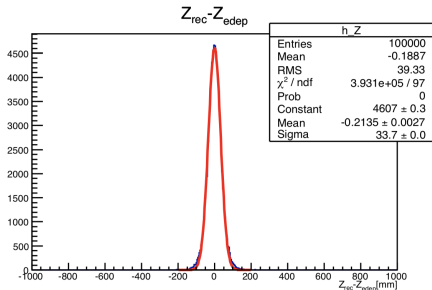
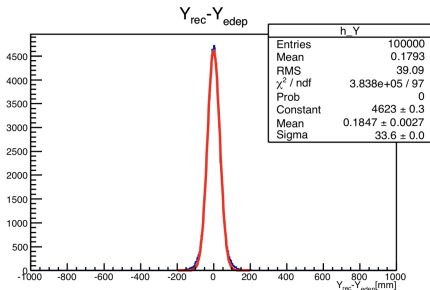
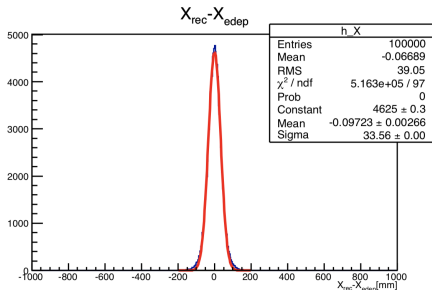
```
$ ./runjob.sh
```

```
juno@localhost:~/Work/rec-tutorial
File Edit View Search Terminal Help
#!/bin/bash

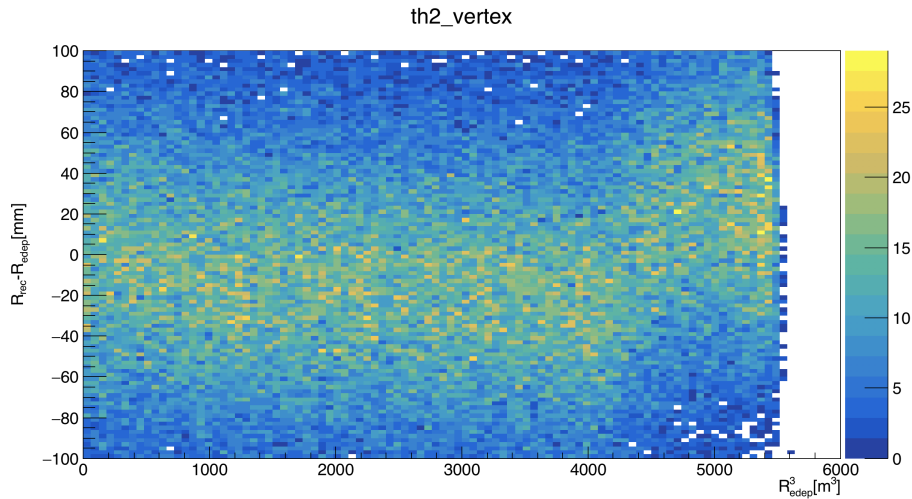
N=5
PARALLEL=3
EVEMAX=10

#declare -a arr=("0" "1.398" "2.436" "3.451" "4.460" "5.465" "6.469")
declare -a arr=("0")
echo "start gdm1"
for p in "${arr[@]"; do echo $p; done | xargs -i -n1 -P${PARALLEL} ./gdm1.sh 0 {}
mkdir -p rec_ana
for p in "${arr[@]"; do
    echo "start Momentum ${p}MeV"
    echo "start sim run"
    for i in $(seq 0 $N); do echo $i; done | xargs -i -n1 -P${PARALLEL} ./sim_run.sh {} $p $EVEMAX
    echo "start cal run"
    for i in $(seq 0 $N); do echo $i; done | xargs -i -n1 -P${PARALLEL} ./cal_run.sh {} $p $EVEMAX
    echo "start rec run"
    for i in $(seq 0 $N); do echo $i; done | xargs -i -n1 -P${PARALLEL} ./rec_run.sh {} $p $EVEMAX
    ENERGY=`echo ${p%.*}`
    ENERGY=$((ENERGY+1))
    echo "start generate file list"
    ls $PWD/e+_${ENERGY}MeV/user-sim-* > list_detsim_${ENERGY}.txt
    ls $PWD/e+_${ENERGY}MeV/rec-* > list_rec_${ENERGY}.txt
done
```

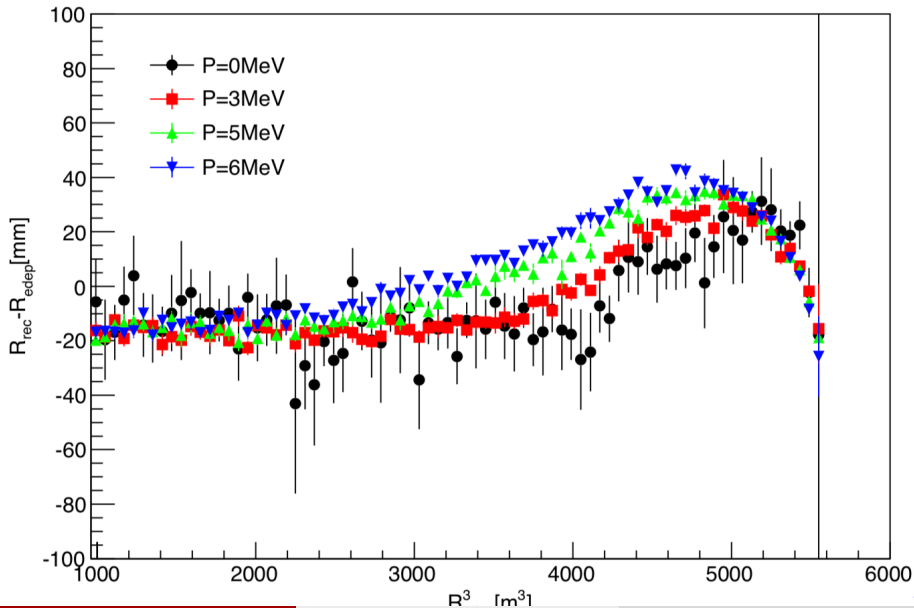
Practice in Virtual Machine



Practice in Virtual Machine



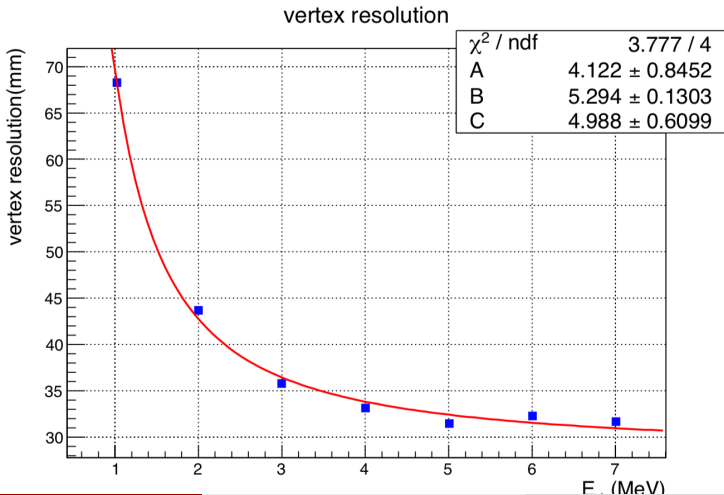
Practice in Virtual Machine



Practice in Virtual Machine

resolution.c : Script to draw resolution plot

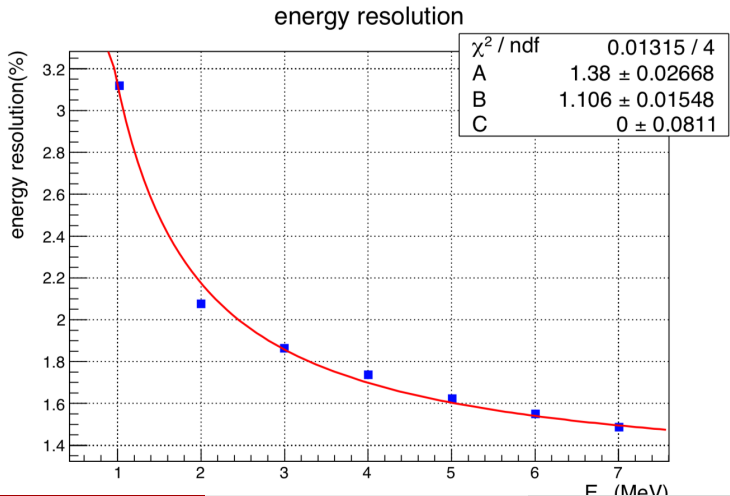
```
$ root -l resolution.c
```



Practice in Virtual Machine

resolution.c : Script to draw resolution plot

```
$ root -l resolution.c
```



Practice in IHEP Server

ssh to IHEP server : `ssh -XY lizy@lxslc6.ihep.ac.cn`

Copy Script to your own directory

```
$ mkdir -p /junofs/users/$USER/juno/tutorial/whu
$ cp -r /junofs/users/lizy/juno/tutorial/whu/vertex
  /junofs/users/$USER/juno/tutorial/whu
$ cd /junofs/users/$USER/juno/tutorial/whu/vertex
$ ls
```

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn...
[[lizy@lxslc601 vertex]$ ls
caljob          env.sh          gdm1.sh        Makefile        recjob          runRec.sh
cal_run.sh      env.txt         genlist.sh     modifyUser.sh   rec_run.sh      simjob
cleandir.sh     gdm1job        job            RecAnalysis.c   resolution.c     sim_run.sh
[lizy@lxslc601 vertex]$
```

Practice in IHEP Server

env.txt/env.sh : Environment Setting

```
$ ./env.sh
```

```
$ source $HOME/.bashrc
```

```
zli — env.sh (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.c...  
cp ~/.bashrc ~/.bashrc_whu_bkg  
cat env.txt >> ~/.bashrc
```

```
zli — env.txt (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.c...  
alias junoenv="source /afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/setup.sh"  
alias cq="condor_q -name job@schedd01.ihep.ac.cn"  
alias cs="condor_submit -name job@schedd01.ihep.ac.cn"  
alias cm="condor_rm -name job@schedd01.ihep.ac.cn"  
alias cmtconfig="cmt br cmt config"  
alias cmtmake="cmt br cmt make"  
export VTXUT=/junofs/users/$USER/juno/tutorial/whu/vertex
```

Practice in IHEP Server

Modify to your own user name

```
$ ./modifyUser.sh
```

gdmljob/gdml.sh : Submit job to IHEP server to generate gdml

```
$ cs gdmljob
```

```
$ cq $USER
```

```
zli — modifyUser.sh (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.i...  
grep -r1 lizy | xargs sed -i "s/lizy/$USER/g"
```

```
zli — lizy@lxslc601:~/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn...  
[[lizy@lxslc601 vertex]$ cs gdmljob  
Submitting job(s).....  
7 job(s) submitted to cluster 63356265.  
[[lizy@lxslc601 vertex]$ cq $USER
```

```
-- Schedd: job@schedd01.ihep.ac.cn : <192.168.51.33:47525?...
```

ID	OWNER	SUBMITTED	RUN_TIME	ST	PRI	SIZE	CMD
63356265.0	lizy	5/13 12:24	0+00:00:00	I	0	0.0	gdml.sh 0 1
63356265.1	lizy	5/13 12:24	0+00:00:00	I	0	0.0	gdml.sh 1 1

Practice in IHEP Server

Modify to your own user name

```
$ ./modifyUser.sh
```

gdmljob/gdml.sh : Submit job to IHEP server to generate gdml

```
$ cs gdmljob
```

```
$ cq $USER
```

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn...
```

```
[[lizy@lxslc601 vertex]$ ls  
caljob          e+_2.0MeV    e+_6.0MeV    gdmljob       Makefile      rec_run.sh    sim_run.sh  
cal_run.sh     e+_3.0MeV    e+_7.0MeV    gdml.sh       modifyUser.sh resolution.c  
cleandir.sh    e+_4.0MeV    env.sh        genlist.sh    RecAnalysis.c runRec.sh  
e+_1.0MeV     e+_5.0MeV    env.txt      job           recjob        simjob  
[[lizy@lxslc601 vertex]$
```

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex/e+_1.0MeV — ssh -l lizy lxslc601.i...
```

```
[[lizy@lxslc601 e+_1.0MeV]$ ls  
detsim_user.root  gdml.log  geometry_acrylic.gdml  sample_detsim.root  
[[lizy@lxslc601 e+_1.0MeV]$
```


Practice in IHEP Server

simjob/sim_run.sh : Submit Simulation job to IHEP server

```
$ cs simjob
```

```
$ cq $USER
```

```
zli ~ — simjob (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.c...
Universe = vanilla
Executable = sim_run.sh

Requirements = Target.OpSysAndVer =?= "SL6"
Accounting_Group = juno
#log = test.log
#output = output.log

TOPDIR = /junofs/users/lizy/juno/tutorial/whu/vertex
SETUPSCRIPT = /afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/setup.sh
SCRIPTDIR = /afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/Examples/Tutorials/share/

SEED = 1000
EVTMAX = 10
N = 10

P=0
environment = "SEED=$(SEED) PARTICLE=e+ ENERGY=1.0MeV P=$(P) TOPDIR=$(TOPDIR) SETUPSCRIPT=$(SETUPSCRIPT) SCRIPTDIR=$(SCRIPTDIR)"
Arguments = $(Process) $(EVTMAX)
Queue $(N)

P=1.398
environment = "SEED=$(SEED) PARTICLE=e+ ENERGY=2.0MeV P=$(P) TOPDIR=$(TOPDIR) SETUPSCRIPT=$(SETUPSCRIPT) SCRIPTDIR=$(SCRIPTDIR)"
Arguments = $(Process) $(EVTMAX)
Queue $(N)

P=2.436
@
26,0-1 Top
```

```
zli ~ — sim_run.sh (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.c...
}

jobdir=$(job-top-dir)/$(particle-type)_$(particle-energy)
echo $jobdir
[ -d "$jobdir" ] || mkdir -p $jobdir

seed=$((1-10)); shift
evtmax=$((1-10)); shift

echo \SEED: $SEED
seedstart=$((SEED:-200000))
seed=$((Seed+$seedstart))

output=$(gen-name sim $seed $evtmax root)
user_output=$(gen-name user-sim $seed $evtmax root)
log=$(gen-name simlog $seed $evtmax txt)

cd $jobdir
source $(setup-script)/tut_detsim.py --evtmax $evtmax \
--seed $seed \
--output $output \
--user-output $user_output \
--pntsd-v2 \
--ce-mode 20inchfunc \
--no-pmt3inch \
--no-gdml \
gun --particles e+ \
--momentums $P \
--material LS \
--volume pTarget) >& $!

"sim_run.sh" 64L, 1619C 64,45 Bot
```

Practice in IHEP Server

simjob/sim_run.sh : Submit Simulation job to IHEP server

```
$ cs simjob
```

```
$ cq $USER
```

```
[[lizy@lxslc601 vertex]$ cs simjob
Submitting job(s).....
70 job(s) submitted to cluster 63367492.
```

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn — 111x32
[[lizy@lxslc601 vertex]$ ls e+_1.0MeV/
detsim_user.root      sim-1002.root  sim-1008.root  simlog-1004.txt  user-sim-1000.root  user-sim-1006.root
gdml.log              sim-1003.root  sim-1009.root  simlog-1005.txt  user-sim-1001.root  user-sim-1007.root
geometry_acrylic.gdml sim-1004.root  simlog-1000.txt simlog-1006.txt  user-sim-1002.root  user-sim-1008.root
sample_detsim.root   sim-1005.root  simlog-1001.txt simlog-1007.txt  user-sim-1003.root  user-sim-1009.root
sim-1000.root         sim-1006.root  simlog-1002.txt simlog-1008.txt  user-sim-1004.root
sim-1001.root         sim-1007.root  simlog-1003.txt simlog-1009.txt  user-sim-1005.root
[[lizy@lxslc601 vertex]$
```

Practice in IHEP Server

caljob/cal_run.sh : Submit Calibration job to IHEP server

```
$ cs caljob
$ cq $USER
```

```
zli — caljob (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.c...
Universe = vanilla
Executable = cal_run.sh

Requirements = Target.OpSysAndVer =?= "SL6"
Accounting_Group = juno
#log = test.log
#output = output.log

TOPDIR = /junofs/users/lizy/juno/tutorial/whu/vertex
SETUPSCRIPT = /afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/setup.sh
SCRIPTDIR = /afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/Examples/Tutoria
l/share/

SEED = 1000
EVTMAX = 10
N = 10

P=0
environment = "SEED=$(SEED) PARTICLE=e+ ENERGY=1.0MeV P=$(P) TOPDIR=$(TOPDIR) SETUPSCRIPT=$(
SETUPSCRIPT) SCRIPTDIR=$(SCRIPTDIR)"
Arguments = $(Process) $(EVTMAX)
Queue $(N)

P=1.398
environment = "SEED=$(SEED) PARTICLE=e+ ENERGY=2.0MeV P=$(P) TOPDIR=$(TOPDIR) SETUPSCRIPT=$(
SETUPSCRIPT) SCRIPTDIR=$(SCRIPTDIR)"
Arguments = $(Process) $(EVTMAX)
Queue $(N)

P=2.436
@
*caljob* 61L, 1686C 26,0-1 Top
```

```
zli — cal_run.sh (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac...

function gen-name() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift

    echo ${prefix}-${seed}.${suffix}
}

jobdir=$(job-top-dir)/$(particle-type)_$(particle-energy)
echo $jobdir
[ -d "$jobdir" ] || mkdir -p $jobdir

seed=${1:-0}; shift
evtmax=${1:-10}; shift

echo \SSEED: $SEED
seedstart=$(SEED:-200000)
seed=$((Seed+Seedstart))

input=$(gen-name sim $seed $evtmax root)
output=$(gen-name cal $seed $evtmax root)
log=$(gen-name callog $seed $evtmax txt)

cd $jobdir
source $(setup-script)
(tine python $(run-script)/tut_det2calib.py --evtmax $evtmax \
--input $input \
--output $output \
--detoption Acrylic) >& $!

56,55 Bot
```

Practice in IHEP Server

caljob/cal_run.sh : Submit Calibration job to IHEP server

```
$ cs caljob  
$ cq $USER
```

```
[[lizy@lxslc601 vertex]$ cs caljob  
Submitting job(s).....  
70 job(s) submitted to cluster 63369208.  
[[lizy@lxslc601 vertex]$ cq $USER
```

```
-- Schedd: job@schedd01.ihep.ac.cn : <192.168.51.33:47525?..  
ID OWNER SUBMITTED RUN_TIME ST PRI SIZE CMD
```

```
0 jobs; 0 completed, 0 removed, 0 idle, 0 running, 0 held, 0 suspended
```

```
[[lizy@lxslc601 vertex]$ ls e+_1.0MeV/  
cal-1000.root cal-1009.root callog-1008.txt sim-1003.root simlog-1002.txt user-sim-1001.root  
cal-1001.root callog-1000.txt callog-1009.txt sim-1004.root simlog-1003.txt user-sim-1002.root  
cal-1002.root callog-1001.txt detsim_user.root sim-1005.root simlog-1004.txt user-sim-1003.root  
cal-1003.root callog-1002.txt gdml.log sim-1006.root simlog-1005.txt user-sim-1004.root  
cal-1004.root callog-1003.txt geometry_acrylic.gdml sim-1007.root simlog-1006.txt user-sim-1005.root  
cal-1005.root callog-1004.txt sample_detsim.root sim-1008.root simlog-1007.txt user-sim-1006.root  
cal-1006.root callog-1005.txt sim-1000.root sim-1009.root simlog-1008.txt user-sim-1007.root  
cal-1007.root callog-1006.txt sim-1001.root simlog-1000.txt simlog-1009.txt user-sim-1008.root  
cal-1008.root callog-1007.txt sim-1002.root simlog-1001.txt user-sim-1000.root user-sim-1009.root  
[[lizy@lxslc601 vertex]$ █
```

Practice in IHEP Server

recjob/rec_run.sh : Submit Reconstruction job to IHEP server

```
$ cs recjob
```

```
$ cq $USER
```

```
zli — recjob (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.c...
Universe = vanilla
Executable = rec_run.sh

Requirements = Target.OpSysAndVer =?="SL6"
Accounting_Group = juno
#log = test.log
#output = output.log

TOPDIR = /junofs/users/lizy/juno/tutorial/whu/vertex
SETUPSCRIPT = /afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/setup.sh
SCRIPTDIR = /afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/Examples/Tutoria
1/share/

SEED = 1000
EVTMAX = 10
N = 10

P=0
environment = "SEED=$(SEED) PARTICLE=e+ ENERGY=1.0MeV P=$(P) TOPDIR=$(TOPDIR) SETUPSCRIPT=$(
SETUPSCRIPT) SCRIPTDIR=$(SCRIPTDIR)"
Arguments = $(Process) $(EVTMAX)
Queue $(N)

P=1.398
environment = "SEED=$(SEED) PARTICLE=e+ ENERGY=2.0MeV P=$(P) TOPDIR=$(TOPDIR) SETUPSCRIPT=$(
SETUPSCRIPT) SCRIPTDIR=$(SCRIPTDIR)"
Arguments = $(Process) $(EVTMAX)
Queue $(N)

P=2.436
Q
*recjob* 61L, 1686C 26,0-1 Top
```

```
zli — rec_run.sh (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac...
function gen-name() {
    local prefix=$1; shift
    local seed=$1; shift
    local evtmax=$1; shift
    local suffix=$1; shift

    echo ${prefix}-${seed}.${suffix}
}

jobdir=${job-top-dir}/${particle-type}_${particle-energy}
echo $jobdir
[ -d "$jobdir" ] || mkdir -p $jobdir

seed=${1:-0}; shift
evtmax=${1:-10}; shift

echo \${SEED: $SEED}
seedstart=${(SEED:-200000)}
seed=$((seed+seedstart))

input=${gen-name cal $seed $evtmax root}
output=${gen-name rec $seed $evtmax root}
log=${gen-name reclog $seed $evtmax txt}

cd $jobdir
source $(setup-script)
(time python $(run-script)/tut_calib2rec.py --evtmax $evtmax \
--gdl \
--input $input \
--output $output \
--detoption Acrylic) >& $!&

57,55 Bot
```

Practice in IHEP Server

recjob/rec_run.sh : Submit Reconstruction job to IHEP server

```
$ cs recjob
```

```
$ cq $USER
```

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn — 111x32
```

```
[[lizy@lxslc601 vertex]$ cs recjob
```

```
Submitting job(s).....
```

```
70 job(s) submitted to cluster 63369637.
```

```
[[lizy@lxslc601 vertex]$ cq $USER
```

```
-- Schedd: job@schedd01.ihep.ac.cn : <192.168.51.33:47525?...
```

```
  ID      OWNER      SUBMITTED      RUN_TIME ST PRI SIZE CMD
```

```
0 jobs; 0 completed, 0 removed, 0 idle, 0 running, 0 held, 0 suspended
```

```
[[lizy@lxslc601 vertex]$ ls e+_1.0MeV/
```

cal-1000.root	callog-1005.txt	rec-1007.root	sim-1001.root	simlog-1006.txt
cal-1001.root	callog-1006.txt	rec-1008.root	sim-1002.root	simlog-1007.txt
cal-1002.root	callog-1007.txt	rec-1009.root	sim-1003.root	simlog-1008.txt
cal-1003.root	callog-1008.txt	reclog-1000.txt	sim-1004.root	simlog-1009.txt
cal-1004.root	callog-1009.txt	reclog-1001.txt	sim-1005.root	user-sim-1000.root
cal-1005.root	detsim_user.root	reclog-1002.txt	sim-1006.root	user-sim-1001.root
cal-1006.root	gdm1.log	reclog-1003.txt	sim-1007.root	user-sim-1002.root
cal-1007.root	geometry_acrylic.gdml	reclog-1004.txt	sim-1008.root	user-sim-1003.root
cal-1008.root	rec-1000.root	reclog-1005.txt	sim-1009.root	user-sim-1004.root
cal-1009.root	rec-1001.root	reclog-1006.txt	simlog-1000.txt	user-sim-1005.root
callog-1000.txt	rec-1002.root	reclog-1007.txt	simlog-1001.txt	user-sim-1006.root
callog-1001.txt	rec-1003.root	reclog-1008.txt	simlog-1002.txt	user-sim-1007.root
callog-1002.txt	rec-1004.root	reclog-1009.txt	simlog-1003.txt	user-sim-1008.root
callog-1003.txt	rec-1005.root	sample_detsim.root	simlog-1004.txt	user-sim-1009.root
callog-1004.txt	rec-1006.root	sim-1000.root	simlog-1005.txt	

Practice in IHEP Server

recjob/rec_run.sh : Submit Reconstruction job to IHEP server

```
$ cs recjob
```

```
$ cq $USER
```

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn — 111x32
```

```
[[lizy@lxslc601 vertex]$ cs recjob
```

```
Submitting job(s).....
```

```
70 job(s) submitted to cluster 63369637.
```

```
[[lizy@lxslc601 vertex]$ cq $USER
```

```
-- Schedd: job@schedd01.ihep.ac.cn : <192.168.51.33:47525?...
```

```
  ID      OWNER      SUBMITTED      RUN_TIME ST PRI SIZE CMD
```

```
0 jobs; 0 completed, 0 removed, 0 idle, 0 running, 0 held, 0 suspended
```

```
[[lizy@lxslc601 vertex]$ ls e+_1.0MeV/
```

cal-1000.root	callog-1005.txt	rec-1007.root	sim-1001.root	simlog-1006.txt
cal-1001.root	callog-1006.txt	rec-1008.root	sim-1002.root	simlog-1007.txt
cal-1002.root	callog-1007.txt	rec-1009.root	sim-1003.root	simlog-1008.txt
cal-1003.root	callog-1008.txt	reclog-1000.txt	sim-1004.root	simlog-1009.txt
cal-1004.root	callog-1009.txt	reclog-1001.txt	sim-1005.root	user-sim-1000.root
cal-1005.root	detsim_user.root	reclog-1002.txt	sim-1006.root	user-sim-1001.root
cal-1006.root	gdm1.log	reclog-1003.txt	sim-1007.root	user-sim-1002.root
cal-1007.root	geometry_acrylic.gdml	reclog-1004.txt	sim-1008.root	user-sim-1003.root
cal-1008.root	rec-1000.root	reclog-1005.txt	sim-1009.root	user-sim-1004.root
cal-1009.root	rec-1001.root	reclog-1006.txt	simlog-1000.txt	user-sim-1005.root
callog-1000.txt	rec-1002.root	reclog-1007.txt	simlog-1001.txt	user-sim-1006.root
callog-1001.txt	rec-1003.root	reclog-1008.txt	simlog-1002.txt	user-sim-1007.root
callog-1002.txt	rec-1004.root	reclog-1009.txt	simlog-1003.txt	user-sim-1008.root
callog-1003.txt	rec-1005.root	sample_detsim.root	simlog-1004.txt	user-sim-1009.root
callog-1004.txt	rec-1006.root	sim-1000.root	simlog-1005.txt	

Practice in IHEP Server

genlist.sh : Generate file list

```
$ ./genlist.sh
```

```
zli — genlist.sh (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.cn — 102...
#!/bin/bash -

for i in {1..7} ; do ls $PWD/e+_${i}MeV/user-sim-*.root > list_detsim_${i}.txt; done
for i in {1..7} ; do ls $PWD/e+_${i}MeV/rec-*.root > list_rec_${i}.txt; done

zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn — 102x28
[[lizy@lxslc601 vertex]$ ./genlist.sh
[[lizy@lxslc601 vertex]$ ls
caljob          e+_5.0MeV  genlist.sh      list_detsim_6.txt  list_rec_6.txt  resolution.c
cal_run.sh      e+_6.0MeV  job             list_detsim_7.txt  list_rec_7.txt  runRec.sh
cleandir.sh     e+_7.0MeV  list_detsim_1.txt  list_rec_1.txt     Makefile        simjob
e+_1.0MeV      env.sh     list_detsim_2.txt  list_rec_2.txt     modifyUser.sh   sim_run.sh
e+_2.0MeV      env.txt    list_detsim_3.txt  list_rec_3.txt     RecAnalysis.c
e+_3.0MeV      gdmljob    list_detsim_4.txt  list_rec_4.txt     recjob
e+_4.0MeV      gdml.sh    list_detsim_5.txt  list_rec_5.txt     rec_run.sh
[lizy@lxslc601 vertex]$
```


Practice in IHEP Server

Makefile : Generate executable file

\$ make

zli — Makefile (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.cn — 102x28

```
all: RecAnalysis
MARCH:='root-config --arch`
CXX:='root-config --cxx`

SRC_U:=$(wildcard *.c)

OBJS_U:=$(basename $(SRC_U) )

CPPFLAGS=-D_PGTRACK_ -isystem$(ROOTSYS)/include -isystem$(JUNOTOP)/offline/InstallArea/include
CXXFLAGS=-ggdb $(CPPFLAGS)

RecAnalysis:RecAnalysis.c
    $(CXX) -o RecAnalysis $(CXXFLAGS) $@.c -L./ `root-config --cflags --libs` -L$(EVTNAVIGATORROOT)/$(CMTCONFIG) -lEvtNavigator -L$(GENEVENTV2ROOT)/$(CMTCONFIG) -lGenEventV2 -L$(SIMEVENTV2ROOT)/$(CMTCONFIG) -lSimEventV2 -L$(ELECEVENTROOT)/$(CMTCONFIG) -lElecEvent -L$(CALIBEVENTROOT)/$(CMTCONFIG) -lCalibevent -L$(RECEVENTROOT)/$(CMTCONFIG) -lRecEvent -L$(EDMUTILROOT)/$(CMTCONFIG) -lEDMUtil -L$(BASEEVENTROOT)/$(CMTCONFIG) -lBaseEvent

clean:
    @rm -fv $(OBJS_U) 2>/dev/null
```

Practice in IHEP Server

Makefile : Generate executable file

\$ make

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn — 102x28  
[[lizy@lxslc601 vertex]$ make  
`root-config --cxx` -o RecAnalysis -ggdb -D_PGTRACK_ -isystem/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/Externallibs/ROOT/5.34.11/include -isystem/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/InstallArea/include RecAnalysis.c -L./ `root-config --cflags --libs` -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/EvtNavigator/amd64_linux26 -lEvtNavigator -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/GenEventV2/amd64_linux26 -lGenEventV2 -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/SimEventV2/amd64_linux26 -lSimEventV2 -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/ElecEvent/amd64_linux26 -lElecEvent -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/CalibEvent/amd64_linux26 -lCalibEvent -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/RecEvent/amd64_linux26 -lRecEvent -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/EDMUtil/amd64_linux26 -lEDMUtil -L/afs/ihep.ac.cn/soft/juno/JUNO-ALL-SLC6/Release/J17v1r1/offline/DataModel/BaseEvent/amd64_linux26 -lBaseEvent  
RecAnalysis.c: In function 'int main(int, char**)':  
RecAnalysis.c:326: warning: pointer to a function used in arithmetic  
[[lizy@lxslc601 vertex]$
```

Practice in IHEP Server

runRec.sh : Run RecAnalysis in a parallel way

```
$ ./runRec.sh
```

```
zli — runRec.sh (/junofs/users/lizy/juno/tutorial/whu/vertex) - VIM — ssh -l lizy lxslc601.ihep.ac.cn — 102...
```

```
#!/bin/bash -
```

```
mkdir -p rec_ana  
for i in {1..7}; do echo $i; done | xargs -i -n1 -P7 ./RecAnalysis
```

```
zli — lizy@lxslc601:/junofs/users/lizy/juno/tutorial/whu/vertex — ssh -l lizy lxslc601.ihep.ac.cn — 102x28
```

```
[lizy@lxslc601 vertex]$ ls  
caljob                                energy_resolution_7MeV.eps          position_resloution_1MeV.eps  
cal_run.sh                            env.txt                              position_resloution_2MeV.eps  
cleandir.sh                           gdm1job                             position_resloution_3MeV.eps  
e+_1.0MeV                             gdm1.sh                             position_resloution_4MeV.eps  
e+_2.0MeV                             genlist.sh                           position_resloution_5MeV.eps  
e+_3.0MeV                             job                                   position_resloution_6MeV.eps  
e+_4.0MeV                             list_detsim_1.txt                   position_resloution_7MeV.eps  
e+_5.0MeV                             list_detsim_2.txt                   rec_ana  
e+_6.0MeV                             list_detsim_3.txt                   RecAnalysis  
e+_7.0MeV                             list_detsim_4.txt                   RecAnalysis.c  
energy_distribution_1MeV.eps          list_detsim_5.txt                   recjob  
energy_distribution_2MeV.eps          list_detsim_6.txt                   rec_run.sh  
energy_distribution_3MeV.eps          list_detsim_7.txt                   resolution.c  
energy_distribution_4MeV.eps          list_rec_1.txt                       runRec.sh  
energy_distribution_5MeV.eps          list_rec_2.txt                       simjob  
energy_distribution_6MeV.eps          list_rec_3.txt                       sim_run.sh  
energy_distribution_7MeV.eps          vertex_distribution_1MeV.eps
```

ANY QUESTION?