Simulation Study

31 Jul. 2013

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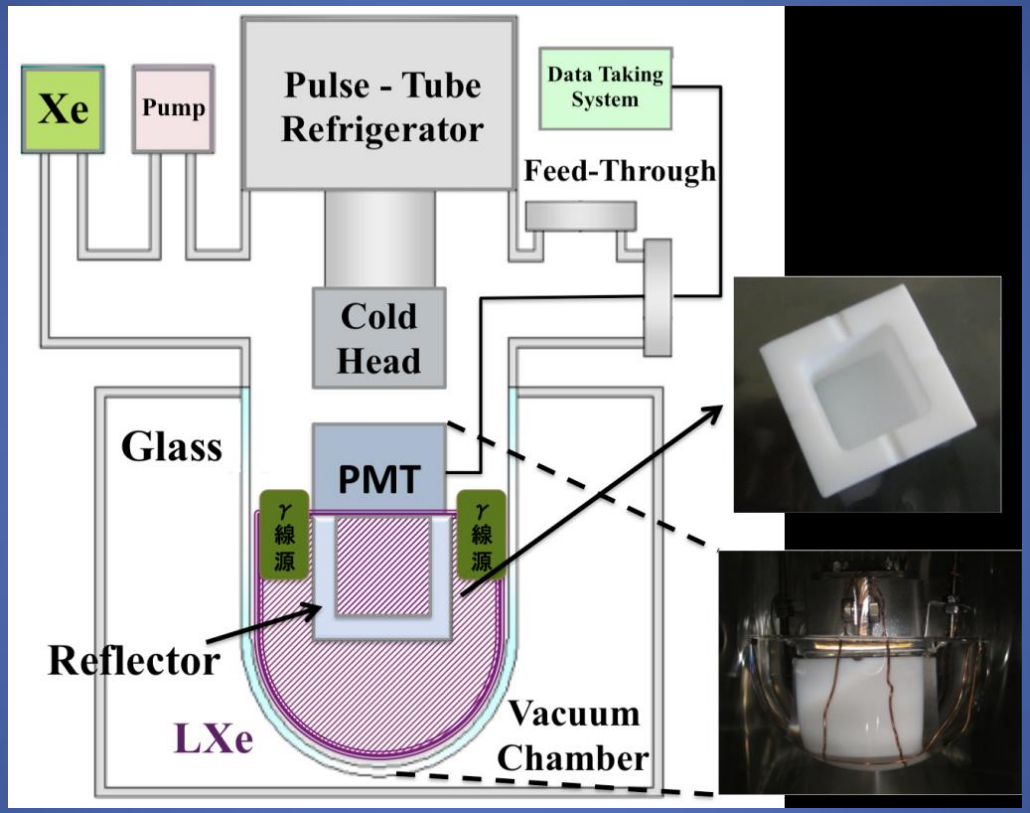
Geant4 (Geometry and Tracking 4)

- Simulating reaction and behavior of proton, electron, and gamma-ray, etc.
- Decide probability of interaction by random numbers
- Define what physical phenomenon is induced when particles(gamma) interact with Lxe
- If particles disappear or go out space defined by user, simulation is stopped

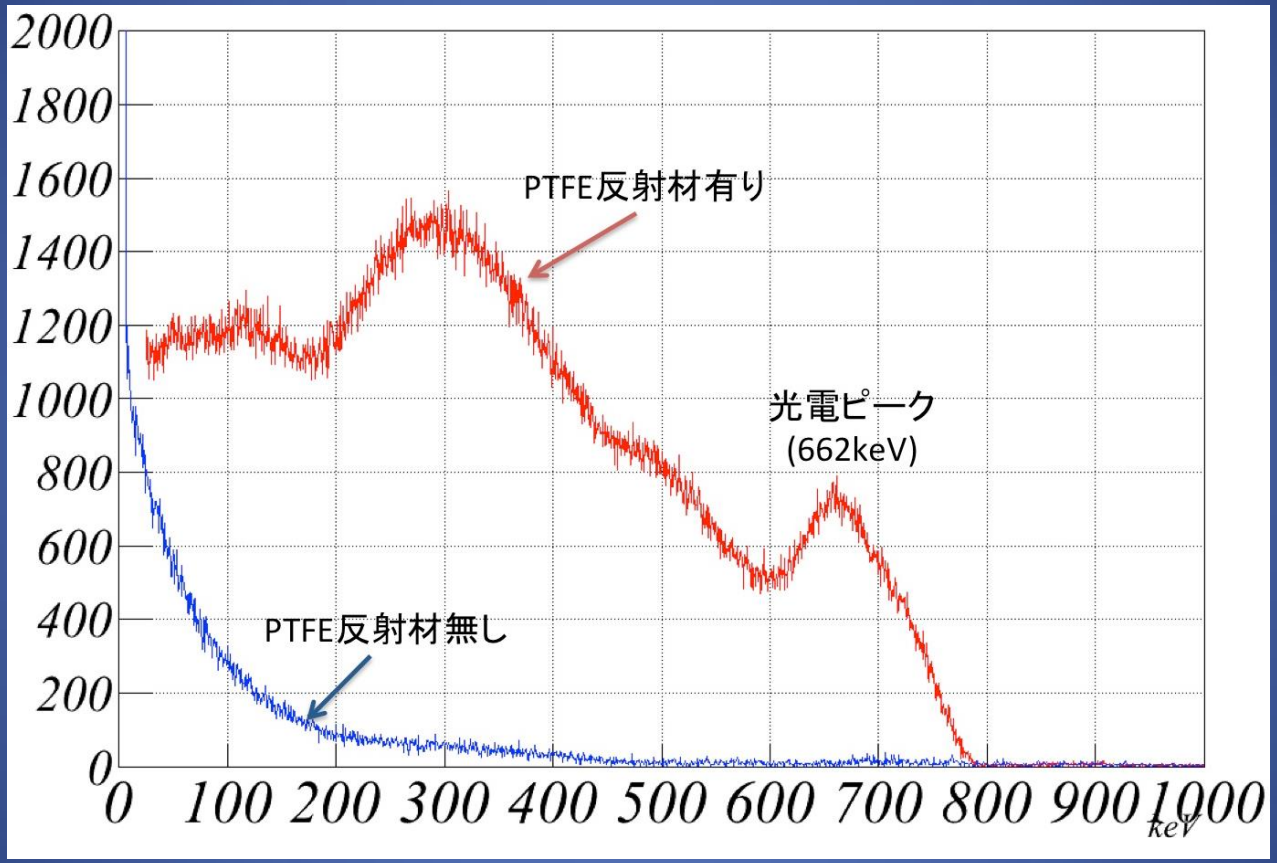
Setting of Experiment



PMT → Amp → K102

10 times Amplification
(Voltage)

Results of Experiment

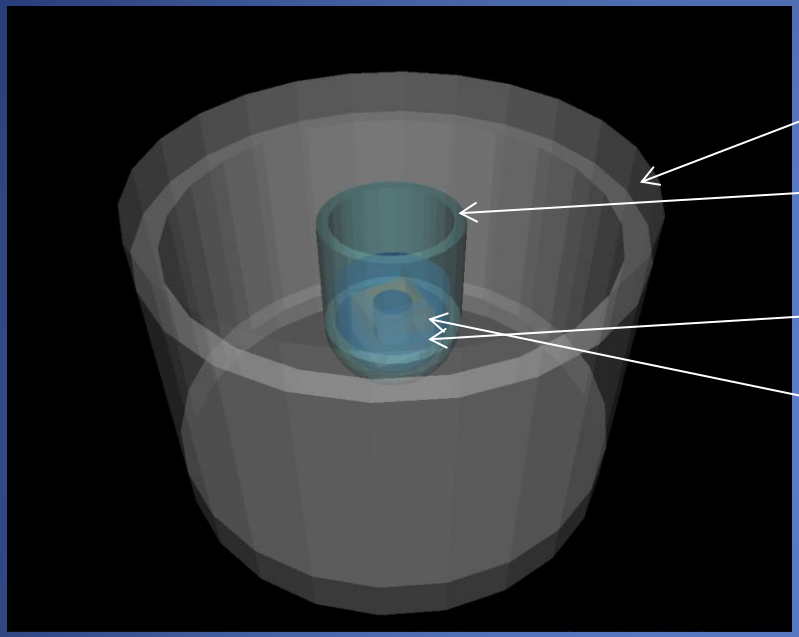


We can not measure gamma-ray spectrum without PTFE reflector.

Define of System in Geant4

- DetectorConstruction
  - position and size of experimental tools
- PrimaryGeneratorAction
  - first physical information of experiment
- PhysicsList
  - physical process of each particle
- SensitiveDetector
  - responses of detector (ex. Lxe, PMT)
  - get information of interaction in Hit class

Simulation



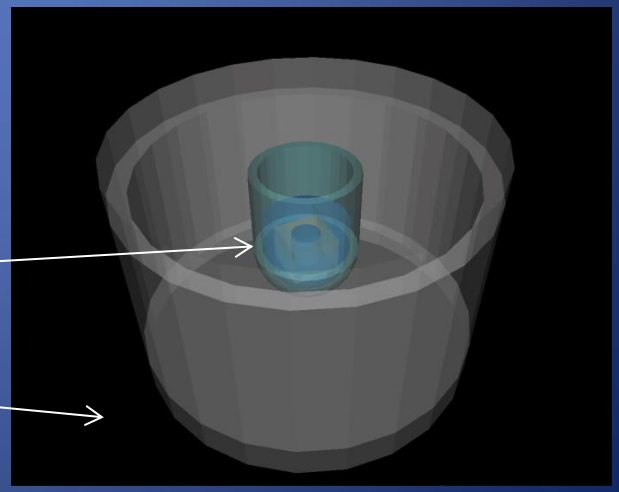
- Measure about energy spectrum of ^{137}Cs, ^{22}Na and ^{60}Co
- Change position of gamma source and parameter of reflectance of PTFE reflector
- Count optical photon being incident on detector

Energy Deposit

- Gamma source
  - ^{137}Cs ; 662 [keV] gamma-ray
  - ^{22}Na ; 511 [keV] and 1275 [keV] 5:9 gamma-ray
  - ^{60}Co ; 1170 [keV] and 1330 [keV] 1:1 gamma-ray
- Position of gamma source
  - inside and outside of chamber

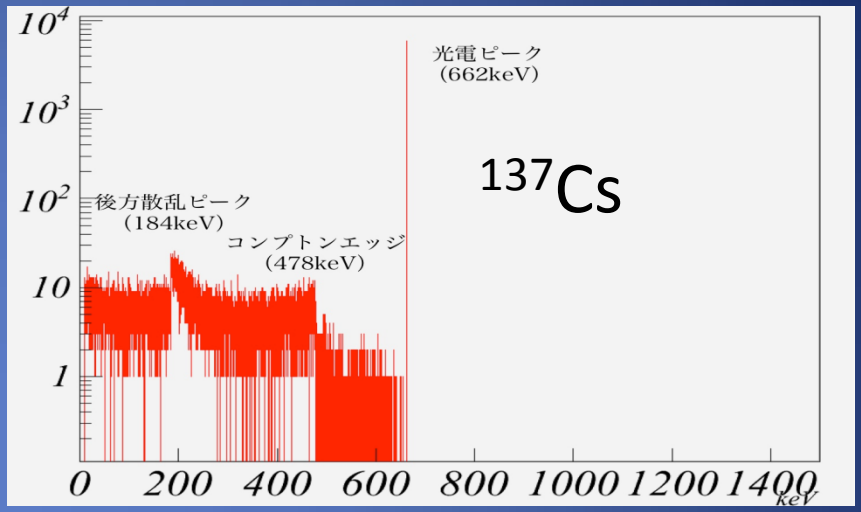
inside

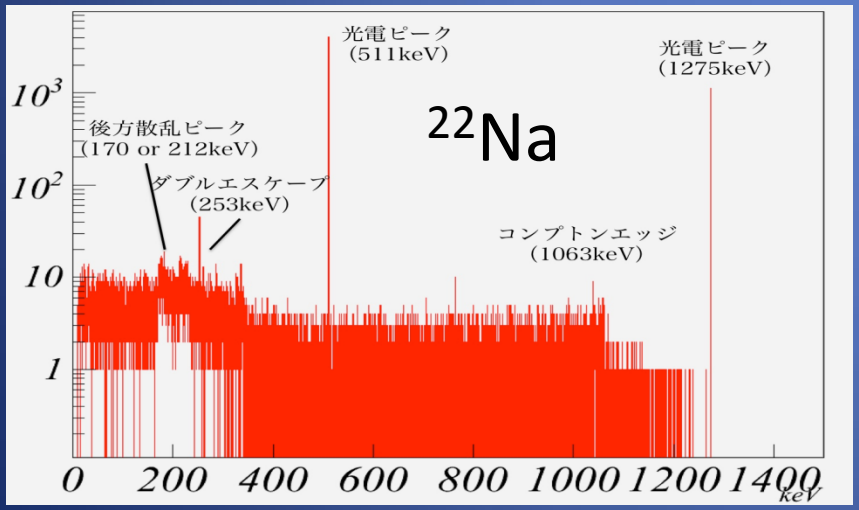
outside

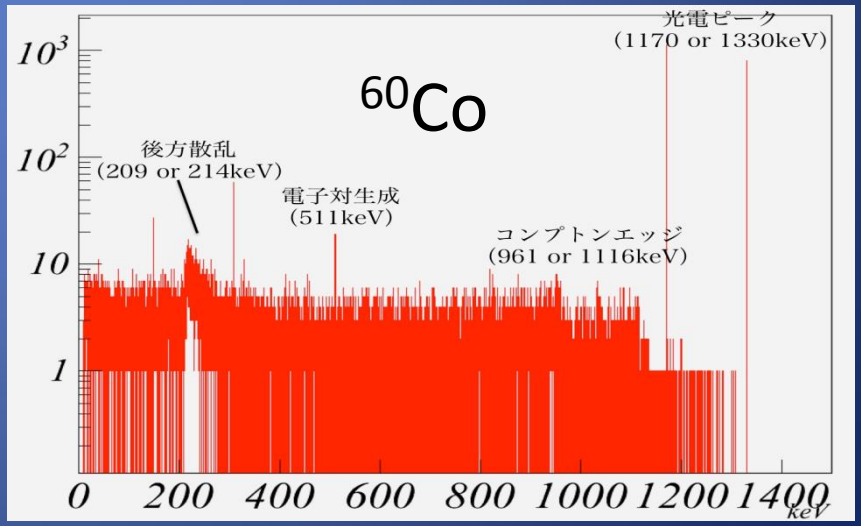


Results of Simulation (inside)

- Results when I put gamma source inside chamber

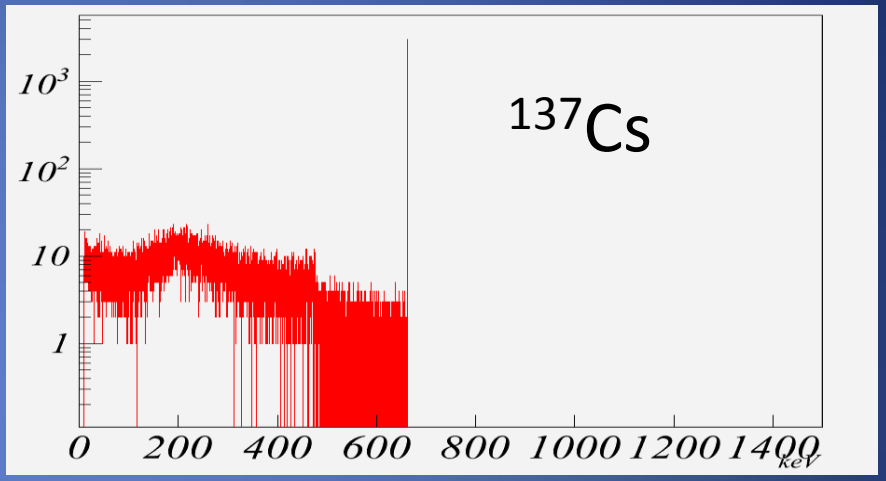


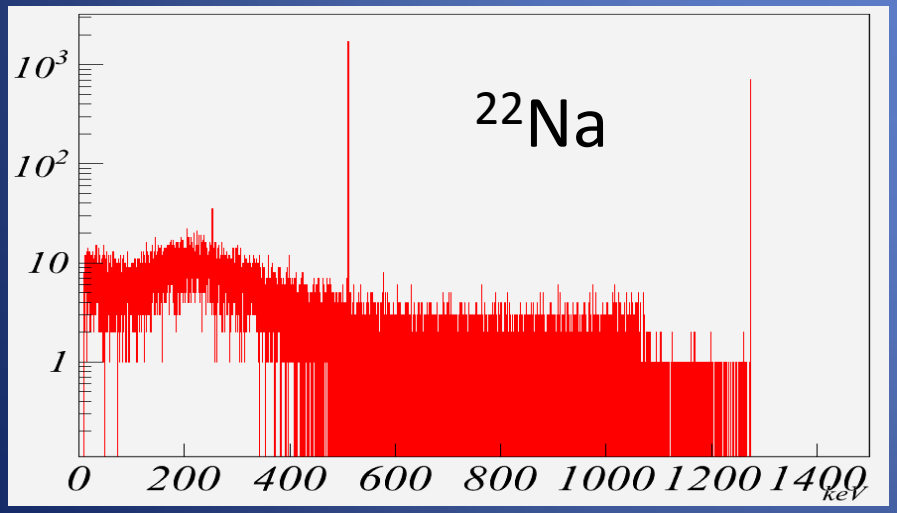


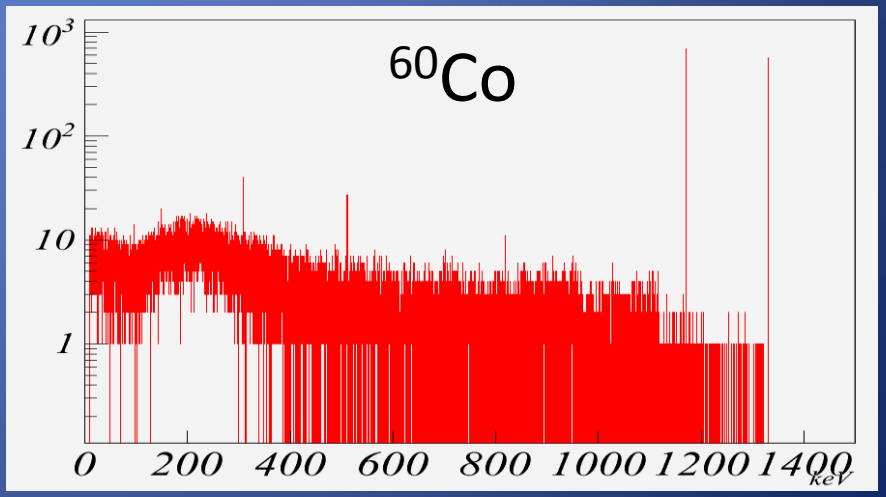


Results of Simulation (outside)

- Results when I put gamma source outside chamber

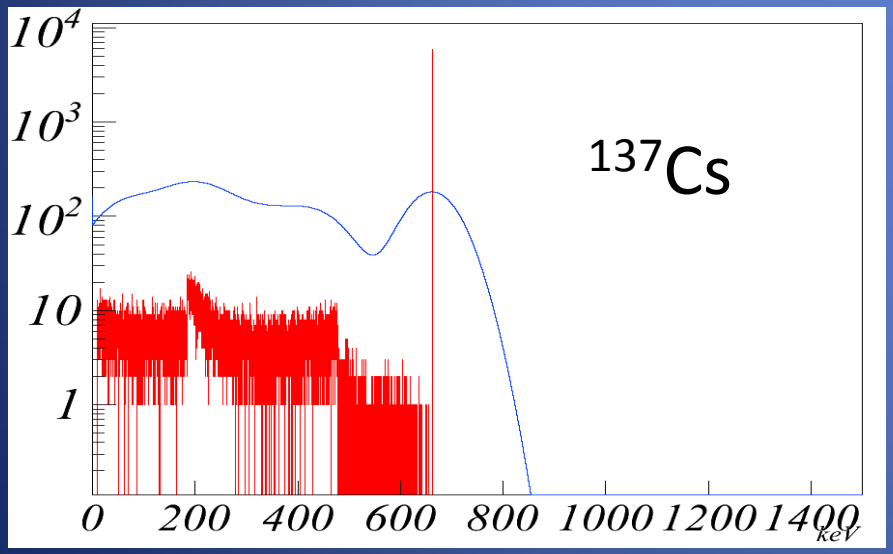


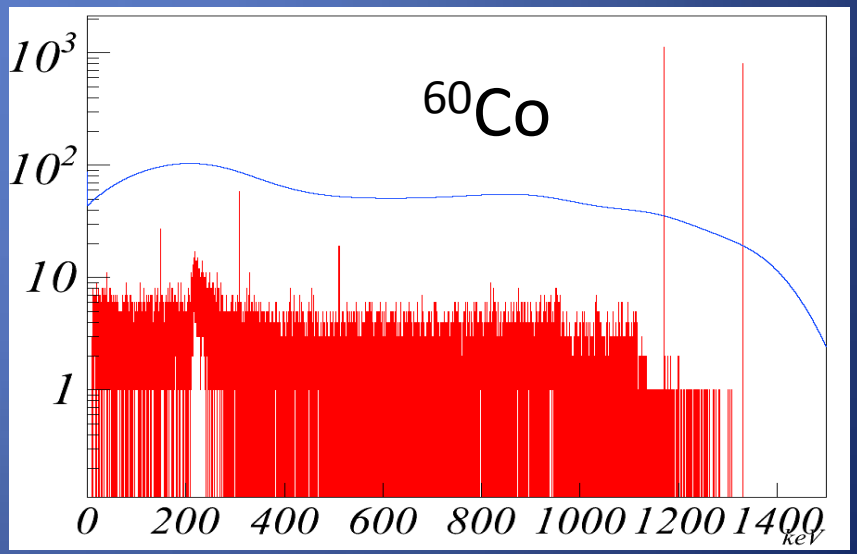




Convolution

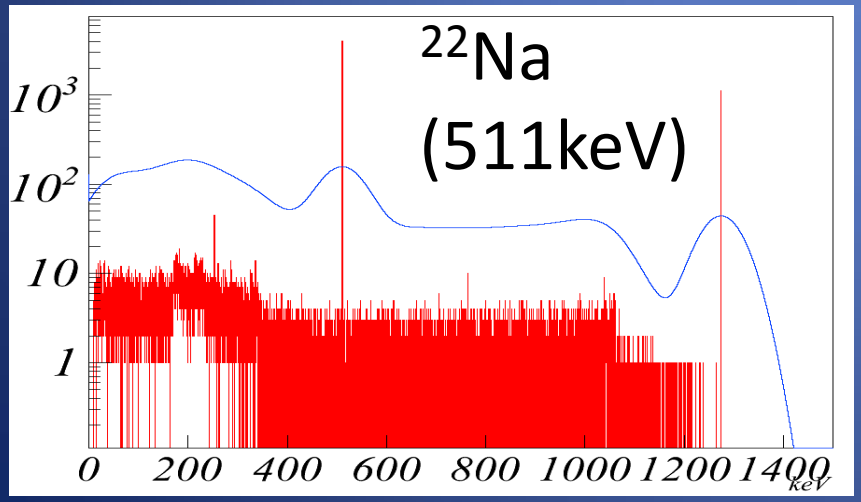
- Energy resolution is 18% (by experiment).
- Blue lines show results of convolution. (convolution to results of inside)

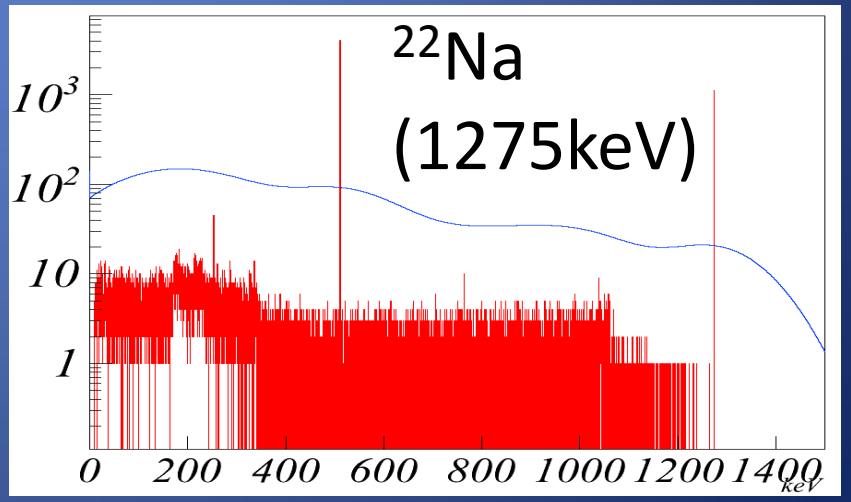




Convolution

- These are results of convolution to Na spectrum.
- Left one is convolution at 511 [keV] peak.
- Right one is convolution at 1275 [keV] peak.





Count Optical Photon

- Count optical photon being incident on PMT
- ResolutionScale due to fluctuation of optical photon number
- Fluctuation follows Gaussian distribution

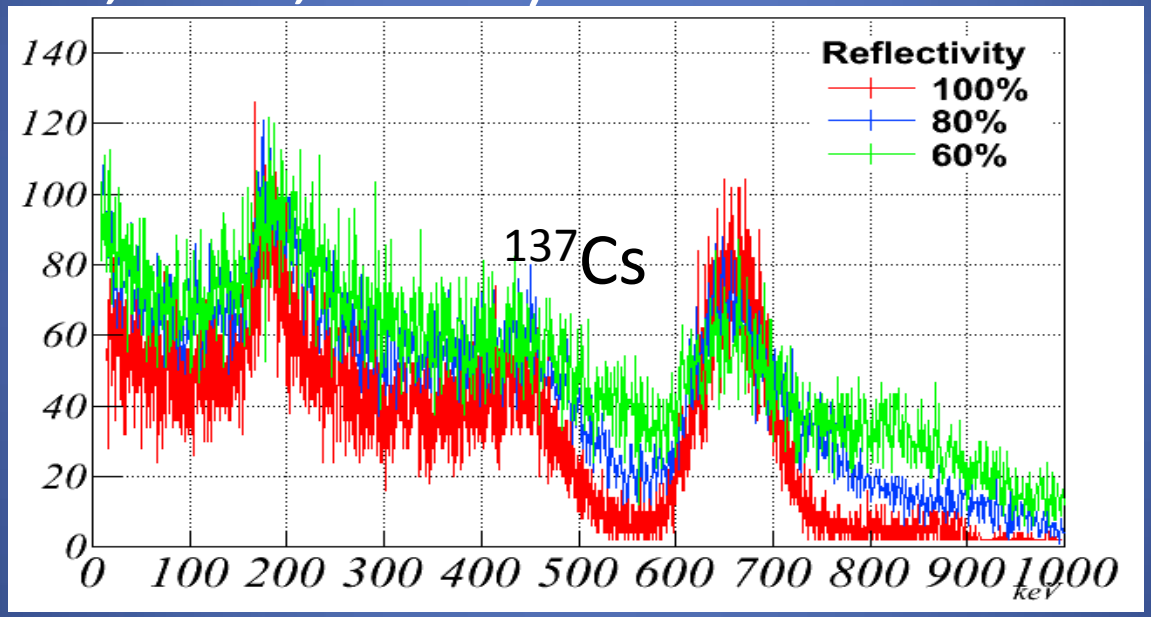
$$\sigma = ResolutionScale/\sqrt{E \times ScintillationYield}$$

- ScintilaltionYield is

  (number of optical photon)/MeV

Change Reflectance of PTFE Reflector

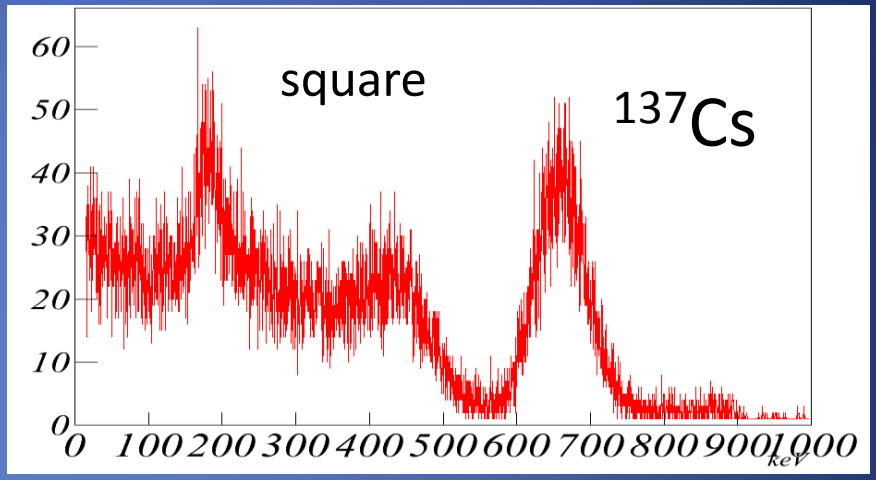
- Change reflectance of PTFE reflector (60%, 80%, 100%)

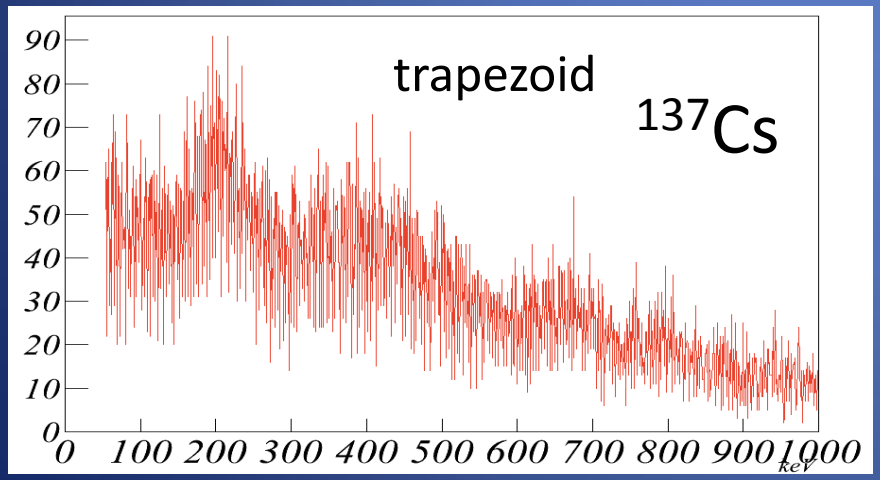


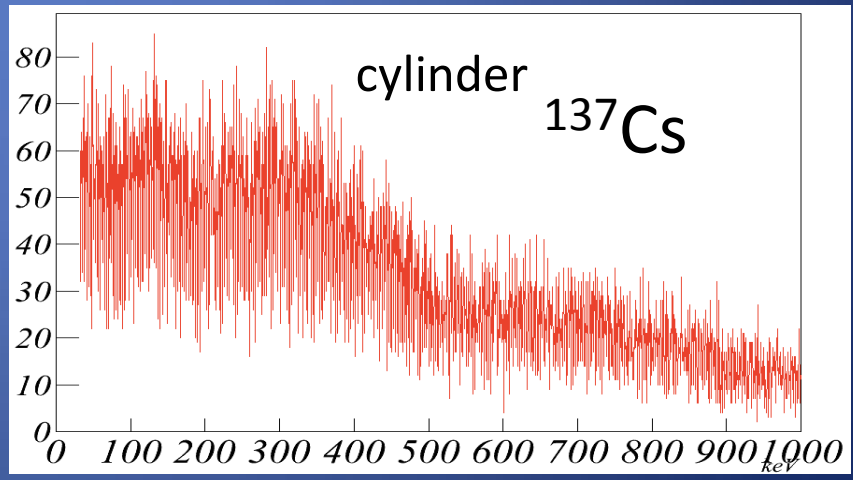
Reflectance [%]	Energy resolution [%]
100	14
80	16
60	18

Change shape of PTFE reflector

- Shape was set square , cylinder and trapezoid.
- Reflectance is 100%

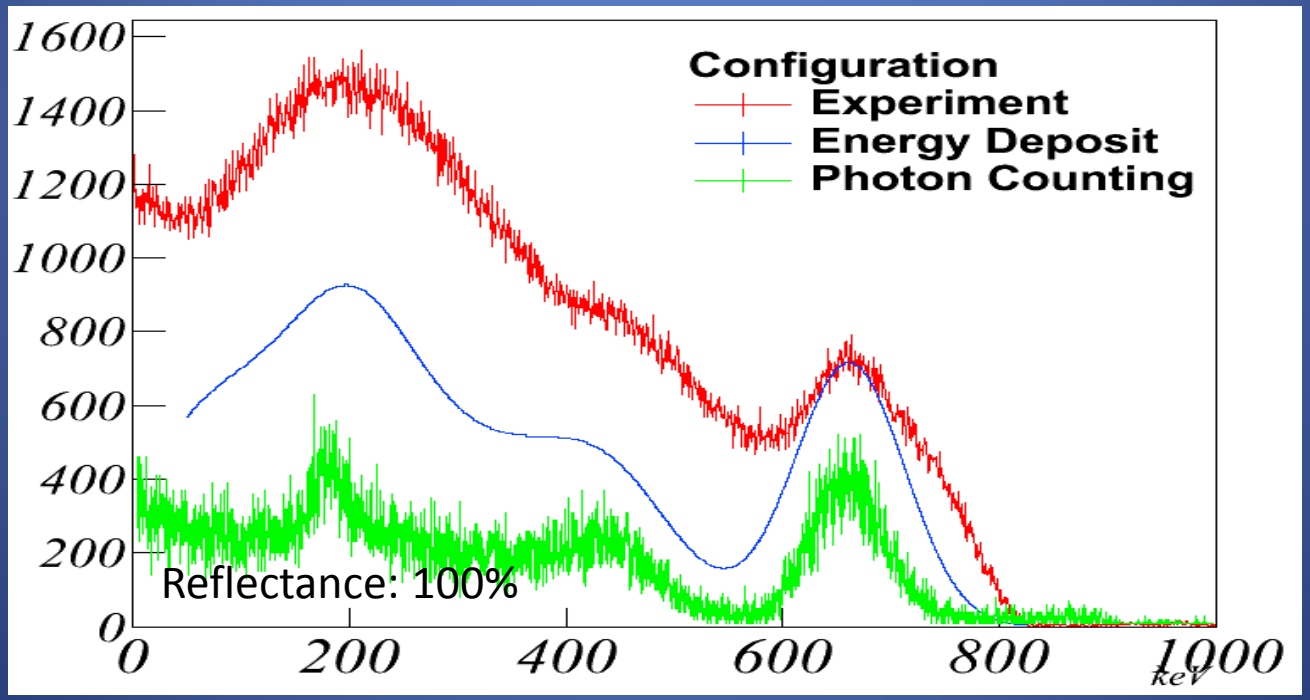






Compare

- Shape of PTFE reflector is square.



My Study

- Improve development environment
  - incorporate ROOT option into CMake
- Change viewer (most useful viewer)
  - openGL (default Geant4 viewer) to VRML or DAWN
- Remort system
  - connect my PC to our laboratory PC from remote

Next

- Input PTFE parameter and gamma source parameter more exactly
- Consider energy deposit of optical photon in LXe

```
for(size_t i=0;i<pmtHit.size();i++)
{
   op= pmtHit[i]-> GetOp();
   if(op>10){     G4cout << "RunAction:     " <<op << "counts" << G4endl;
    h1 = (TH1D*)gROOT-> FindObject("Scintilation");
    h1-> Fill(op);
   }
 }
 for(size_t i=0;i<photonHit.size();i++)
{
   if(op>10)
{
    G4double effi =(G4double)op/(photonHit[i]->GetPhoton());
    h1 = (TH1D*)gROOT -> FindObject("Efficiency");
     h1 -> Fill(effi);      G4cout << "Efficiency:   " <<effi*100 <<"perCent" << G4endl;
  }
 }
 for(size_t i=0;i<scintiHit.size();i++)
{
    G4double edep = scintiHit[i]->GetEdep();
     h1 = (TH1D*)gROOT-> FindObject("Energy Spectrum");
     h1-> Fill(edep/keV);
     if(/*edep/keV==661*/op>3500)
                    {
                       G4double posy=scintiHit[i]->GetY();
                       G4cout << "High Photons Detect: y = "<< posy << G4endl;
                       h1 = (TH1D*)gROOT-> FindObject("YPosition");
                       h1-> Fill(posy/mm);//,op);
                    }
 }
```