

Detector Simulation Using GEANT4

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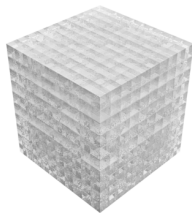
School of Physics


Outline

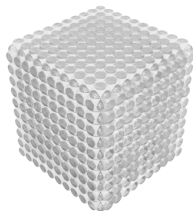
- ① Brief Introduction
- ② physcis and scoring
- ③ simulation output
- ④ summary


Priliminary Geometry Design

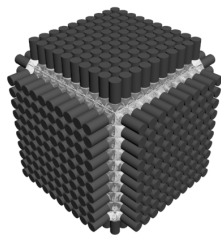
- 1 scintillator cubes $10 \times 10 \times 10$
- 2 flat film as neutron detector: 4layers
- 3 six light guide arrays
- 4 six PMT [SiPM] arrays



: scintillator cube



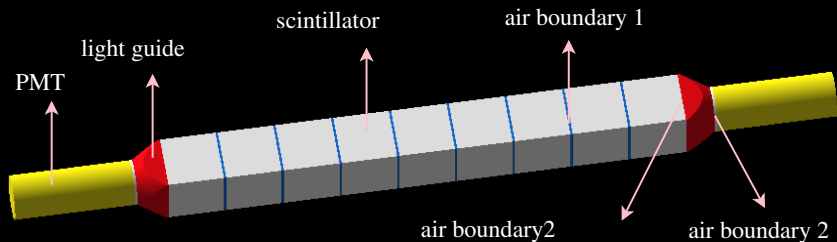
: scintillator cube+light guide




: scintillator cube+light guide+PMT

Details about the Geometry Set-up

The structure of one dimension detector:



 Geometry structure: PMT-lightguide-scintillator-air boundary between [scintillators; scintillator and lightguide; lightguide and PMT cathode]

Details about the Geometry Set-up

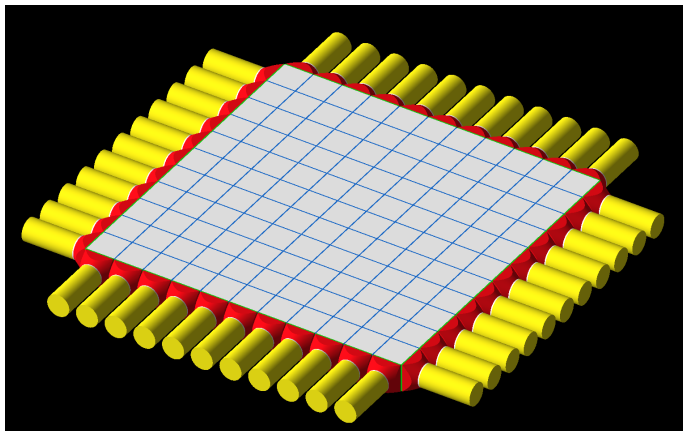


图: two dimation detector layout

Details about the Geometry Set-up

Not finished yet.

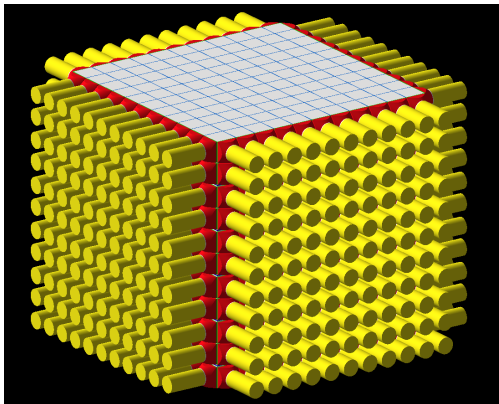
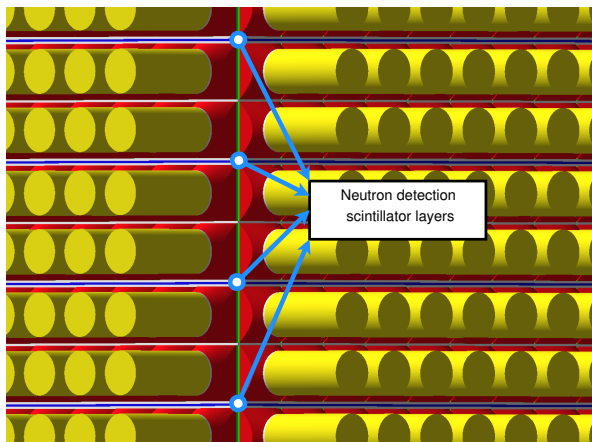


图: 3 dimension detector layout

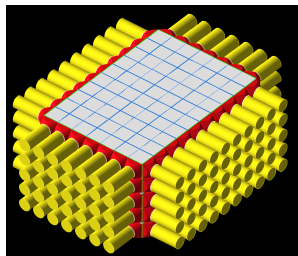
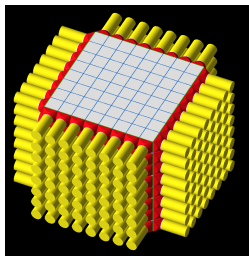
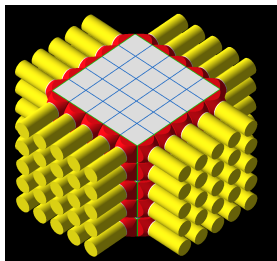
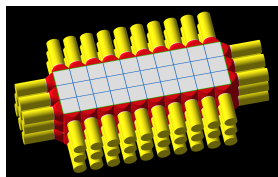
Details about the Geometry Set-up



: neutron detection scintillator layers in the y direction.

flexiable size adjustment

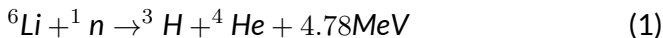
Easy to change the full detector size according to experimental requirements.



THERMAL NEUTRON DETECTOR

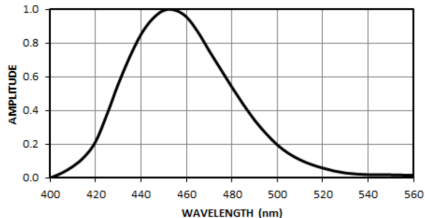
- the neutron detector EJ-426.
- flat white thin sheet, ${}^6\text{LiF} : (\text{ZnS:Ag})$

detection principle:



The resulting triton and alpha particle are detected by ZnS:Ag phosphor with the broad blue fluorescent spectrum.

EJ-426 EMISSION SPECTRUM



DETECTION PROPERTIES

DETECTION PROPERTIES			
Screen Type		EJ-426-0	EJ-426HD2
${}^6\text{LiF}:\text{ZnS}$ Mass Ratio		1:3	1:2
${}^6\text{Li}$ Density (atoms/cm ³)		8.81×10^{21}	1.39×10^{22}
Theoretical N TH Efficiency	0.32 mm thick	0.23	0.34
	0.50 mm thick	0.34	0.48

parameter adjustment

- ① choose the formula: EJ-426-0 or EJ-426HD2 ?
- ② switch the thickness: 0.32mm or 0.5mm?
- ③ sheet size: 60mm× 60mm?
- ④ do we need backing material?

BACKING		
MATERIAL TYPE	DESCRIPTION	SUFFIX
Aluminum Foil	50 μm thick foil	(none)
Clear Polyester Sheet	0.25 mm thick sheet	-PE
	Laminated between two 0.25 mm thick sheets	-PE2
Aluminized Mylar	0.12 mm thick sheet	-AM
Pure Aluminum	0.5mm thick plate	-PA
High Reflective Aluminum	0.4mm thick plate	-A

next to be done

- detector construction .
 - add remain geometry [lightguides and PMTs].
 - attach correct material to each logical volume.
 - other components
- adjustment of physics list
 - about scintillator material and their optical properties
 - optical performance of lightguides
 - response of PMT [SiPM]
 - optical boundaries
- add different primary particle sources
 - alter the particle type, position, momentum, energy etc.
 - use gps to control the particle source
- sensitive detector and scoring
- more user actions for output and analyze.

update of work

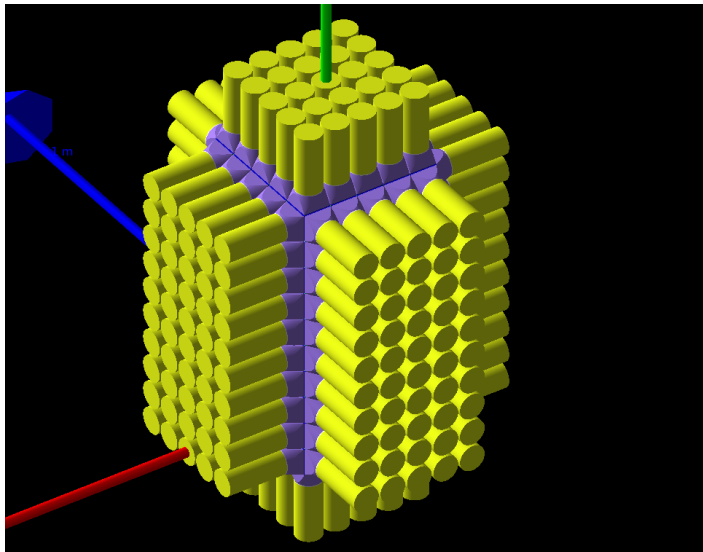
finished

- finish the geometry.
 - finish the material
 - add GPS
 - add sensitive detector (SD)
 - priliminary analyze codes
-

next to be done

- more details about the optical photons(optical properties and optical boundaries)
- update the analyzing class

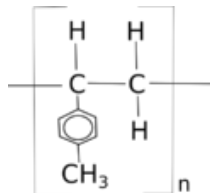
current geometry set-up



material of detector components

● gamma scintillator:EJ-200

Base: Polyvinyl toluene formula : $[\text{CH}_2\text{CH}(\text{C}_6\text{H}_4\text{CH}_3)]_n$



Density: 1.023 g/cm^3

Refraction Index: 1.58

Light Output: No change from -60°C to 20°C

● thermal neutron scintillator:EJ-426HD2

^6LiF : $\text{ZnS MassRatio} 1 : 3$

^6Li Density(atoms/ cm^3) : 1.39×10^{22}

^6Li enriched to minimum of 95 atom percent.

details about detector components

- 1 material of lightguide: H-K9L
- 2 material of gaps between scintillators: air
- 3 PMTs around the scintillators as sensitive detectors
- 4 currently PMTs work as ideal detectors with 100% PDE

density of EJ-426

formula: (^6LiF)(ZnS:Ag) density of ^6Li : 1.39×10^{22} atoms/cm³

atomic mass of ^6Li : 6.0151amu

atomic mass of ^7Li : 7.0160amu

atomic mass of Fluorine : 18.9984amu

^6LiF :ZnS Mass Ratio: 1:2

density: $(6.0151 \times 0.95 + 7.0160 \times 0.05 + 18.9984) \times 3 \times 0.139 / 6.022 = 1.7355/\text{cm}^3$

sensitive detector

- ① optical photon with single wavelength(energy)
- ② PMT record the time and count of photon hits.
- ③ do I need to attach SD to scintillators inside?

optical simulation part

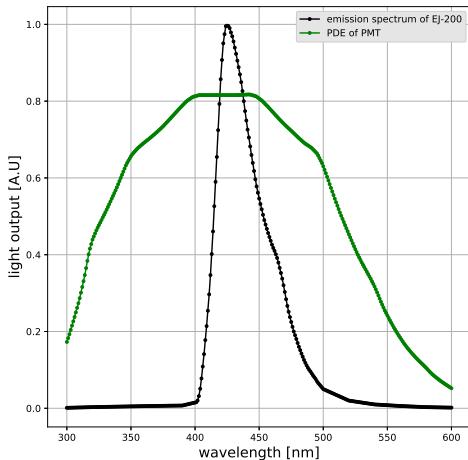
response curve v.s photon energy(wavelength)

- scintillator emission spectrum
- reflectivity of materials
- refractive index
- attenuation length
- PMT detection efficiency

wave length range:350nm ,650nm,step 1nm. active the rise time. the scintillation process. absorption and re-emission of photons; Boundary Process

spectrum

EJ-200 Emission Spectrum and PMT Response



suppose the relectivity, refractive index and attenuation length to be constants for different wavelength.

The main sensitive wavelength region is about 400nm-550nm.

the 2D case

summary

- almost finish simple detector geometry.
- other parts of simulation program still in progress.

BEHUP