

ZDC Simulation Study

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Introduction

- ◆ 神戸大の大隅くんの仕事を引き継いだ。

“Evaluation of the radiation dose at the Zero Degree Calorimeter using g4e simulation”

→ 彼の結果(3月2日)を再現できるか？

- ◆ Simulation Setup

- ZDC: 大隅くんの内容から変更なし

Ohsumi-kun's slide
on 2/Mar.

- ZDC size 30
5 × 5 × 5 cm cell, 12 × 12 × 15 cells
→ total 60 × 60 × 150 cm
- position : x = 960, y = 0, z = 37500 mm
(Ref: yellow report page 638)
- Material : tungsten only
- aperture 4mrad

- Neutronを打ち込む
 - General Particle Source (GPS)
 - E = 50 GeV, $\sigma_E=0.3$ GeV (Gaussian)
 - Beam from a point (0,0,0)
 - Direction is set to hit (x,y,z) = (960,0,37500)
 - Angular distribution:

2D gaussian with $\sigma_x = 6$ mrad, $\sigma_y = 6$ mrad, (corr. to $p_{x,y}=0.3$ GeV)
(backup: 1D gaussian with $\sigma_r = 6$ mrad)

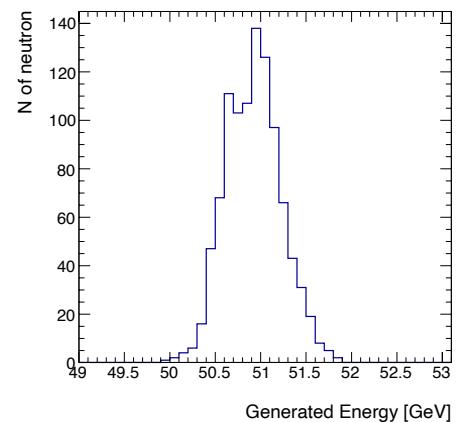
My setup

```
/generator/select particleGun
/gps/verbose 1
/gps/particle neutron
/gps/pos/type Beam
/gps/energy 50 GeV
/gps/ene/type Gauss
/gps/ene/sigma 300 MeV
/gps/pos/centre 0. 0. 0. m
/gps/ang/rot1 37500. 0 -960.
/gps/ang/rot2 0 -1 0
/gps/ang/type beam2d
/gps/ang/sigma_x 0.006 rad
/gps/ang/sigma_y 0.006 rad
```

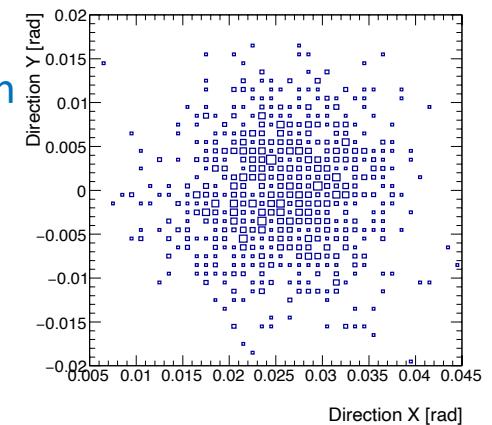
Neutron 50 GeV, 1000 events

- Distributions of generated neutrons:

Energy



Angular distribution

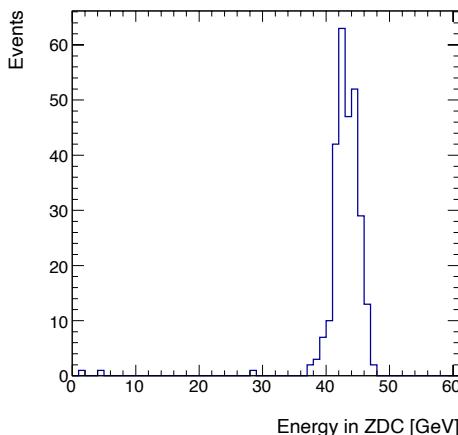


- Events with energy in the ZDC: **273 events**
 - Seems OK.

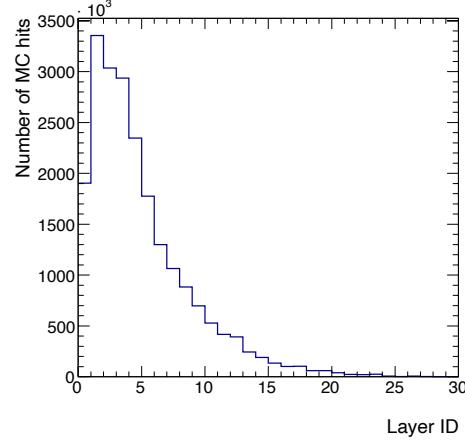
Ohsumi-kun's slide on 2/Mar.

- Events with energy in the ZDC (among 1000 events)
 - 20 GeV : 48 events
 - 50 GeV : 286 events

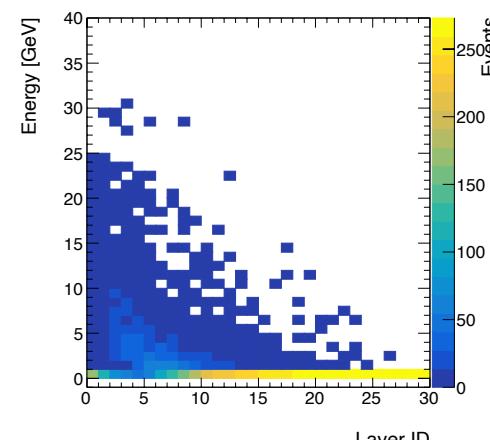
- Energy and hits in ZDC



Total energy deposited in ZDC



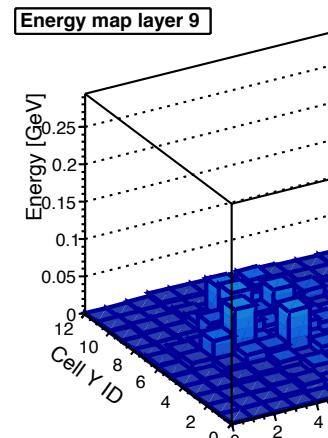
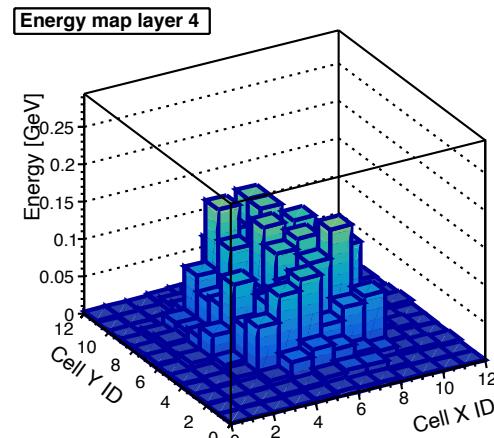
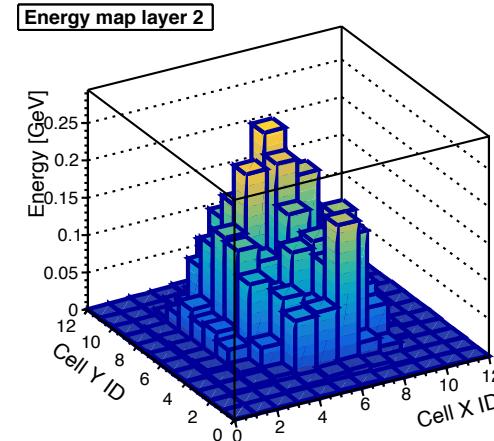
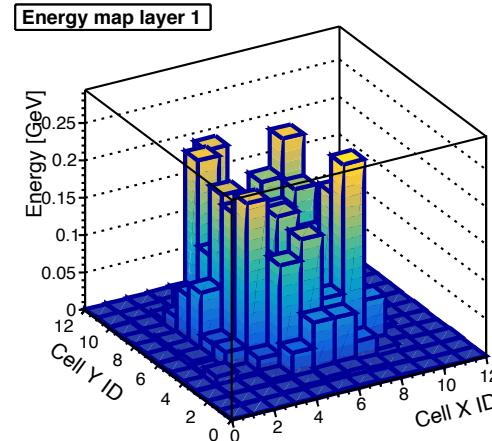
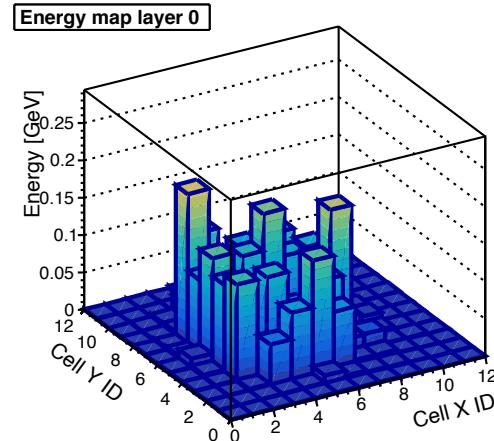
Number of MC hits per layer



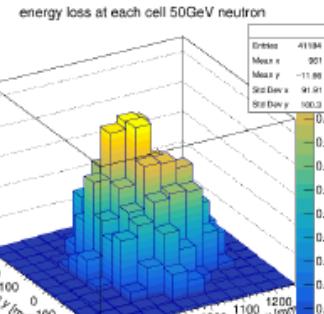
Energy deposition per layer

Energy Maps on ZDC layers

Energy map averaged per event,
shown for 1st, 2nd, 3rd, 5th layers.



- Deposited energy at each cell ($5 \times 5 \times 5 \text{ cm}$) at second layer (average per event)



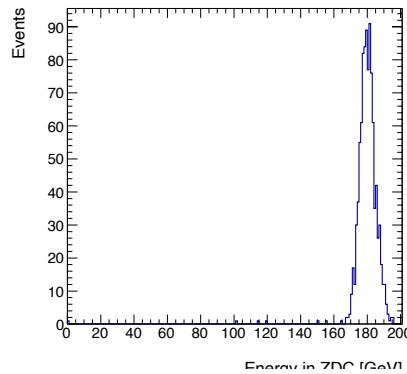
Ohsumi-kun's
slide on 2/Mar.

- ◆ Cell Energy: ~0.25 GeV @ 2nd and 3rd layers
- ◆ Seems OK, comparing to Ohsumi-kun's result.

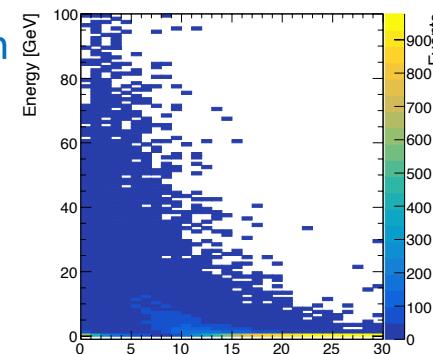
Neutron 200 GeV

- $E = 200 \text{ GeV}$, $\sigma_E = 0.3 \text{ GeV}$ (Gaussian)
- Angular distribution:
2D gaussian with $\sigma_x = 1.5 \text{ mrad}$, $\sigma_y = 1.5 \text{ mrad}$, (corr. to $p_{x,y} = 0.3 \text{ GeV}$)
→ **984/1000 events** has energy in ZDC. (cf. 988 events by Ohsumi-kun)

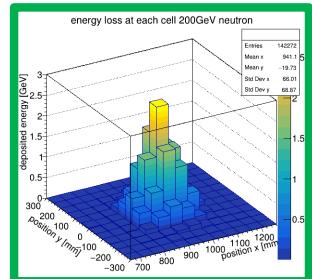
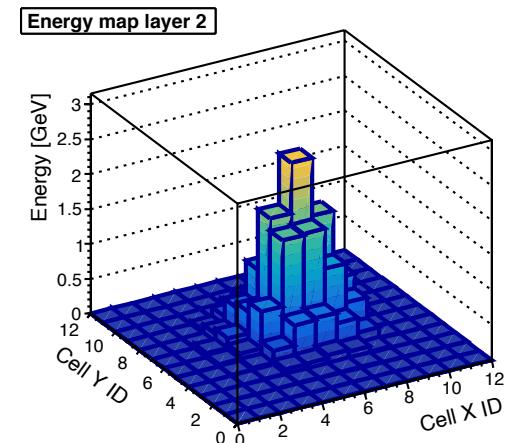
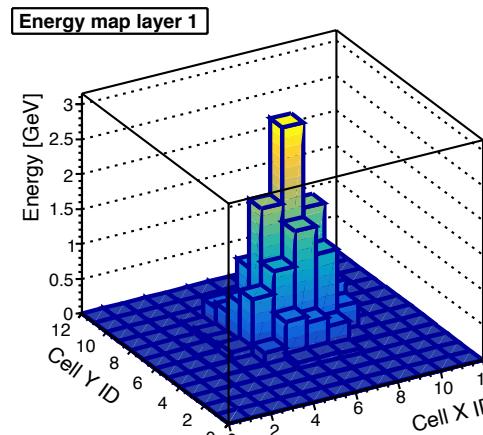
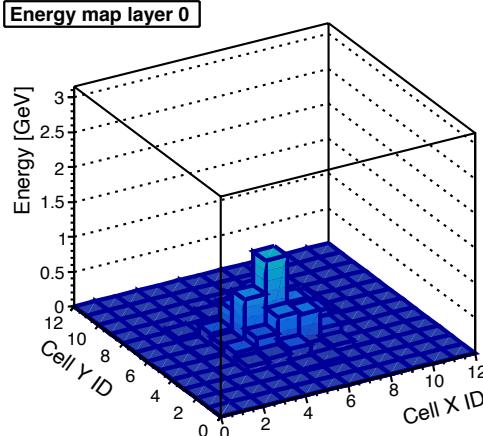
Total energy deposited in ZDC



Energy deposition per layer



Energy map averaged per event, shown for 1st, 2nd, 3rd layers.



Ohsumi-kun's slide on 2/Mar.

Cell Energy ~3 GeV on 2nd layer

まとめ

Neutronを使った場合、Cell でのEnergyは

50 GeV sample: $\lesssim 0.25 \text{ GeV} \sim 0.4 \times 10^{-10} \text{ J}$

200 GeV sample: $\lesssim 3 \text{ GeV} \sim 4.8 \times 10^{-10} \text{ J}$

(Cell: $5 \times 5 \times 5 \text{ cm}^3$ Tungsten $\approx 2.5\text{kg}$ なので $1 \times 10^{-10} \text{ J per cell} \rightarrow 4 \times 10^{-11} \text{ Gy}$)

→ 大隅くんの結果は(多分)再現できた。

Ohsumi-kun's slide on 2/Mar.

neutron energy	20 GeV	50 GeV	100 GeV	200 GeV
deposited energy $\times 10^{-10} [\text{J}]$	0.3	0.4	1.0	2.7
Radiation dose $\times 10^{-11} [\text{Gy/event}]$	1.1	1.7	4.0	18.2

今後

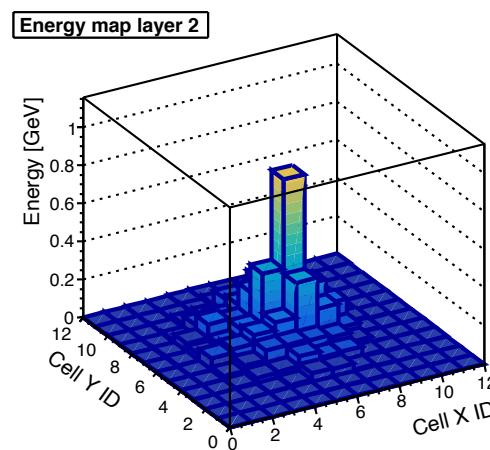
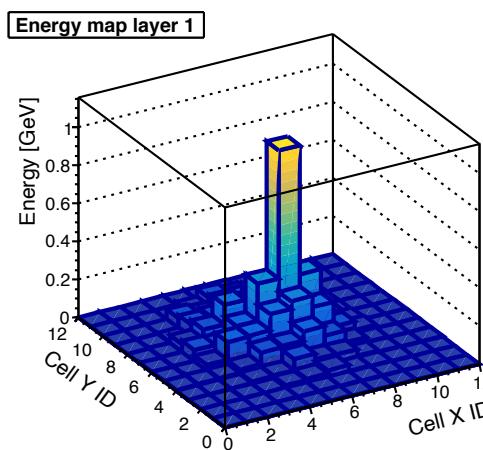
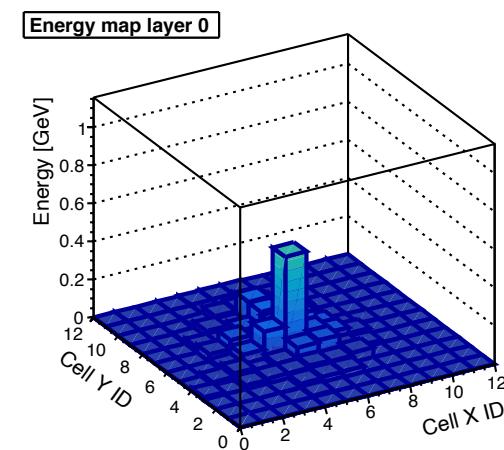
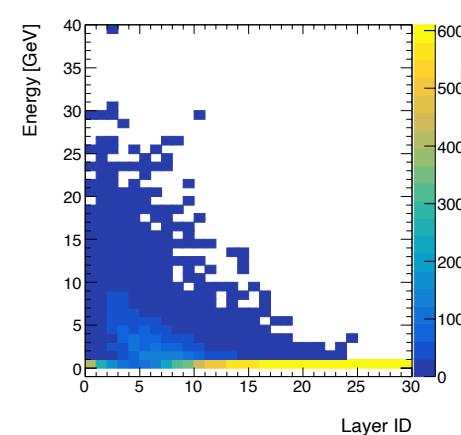
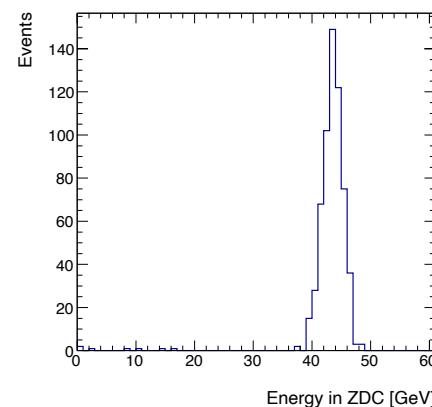
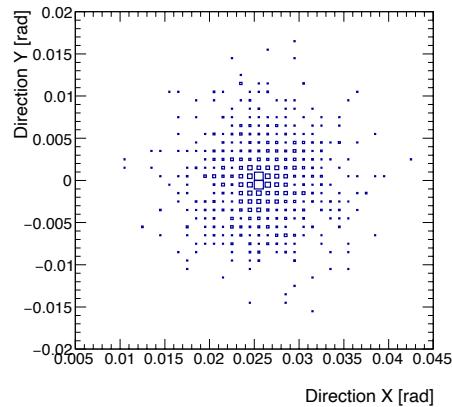
いくつかの方向性:

- 他の粒子を当てる。
- ZDCの構造のアップデート。
 - シリコン/シンチレーターを挟む？
 - FoCalのGeometryをもらってくる？
- ECCEとのつながり
 - ECCE内でどんな議論がなされているのか把握していない。（誰がどこで？）
 - BNLアカウントリクエスト中。

Backup

50 GeV neutron, with angular distribution of
1D gaussian with $\sigma_r = 6$ mrad
→ 610/1000 events has energy in ZDC.

```
/generator/select particleGun
/gps/verbose 1
/gps/particle neutron
/gps/pos/type Beam
/gps/energy 50 GeV
/gps/ene/type Gauss
/gps/ene/sigma 300 MeV
/gps/pos/centre 0. 0. 0. m
/gps/ang/rot1 37500. 0 -960.
/gps/ang/rot2 0 -1 0
/gps/ang/type beam1d
/gps/ang/sigma_r 0.006 rad
```



- ◆ Neutronがだいぶ中心に集中する。
- ◆ Cell Energy ~1 GeV on 2nd layer