



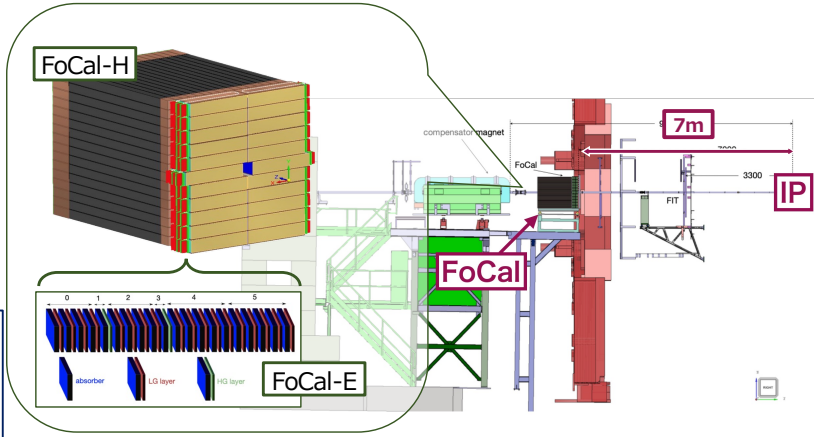
# Estimation of Neutron Irradiation of p-type Silicon Sensor for ALICE FoCal detector

Nara Women's University, Japan : Yuka SASAKI

Co-Author : M. INABA, T. CHUJO, Y. GOTO, T. KOBAYASHI, Y. WAKABAYASHI, J. PARK, T. INUKAI, K. OKUI, S. ITO, K. YODA, A. TAKETANI, S. SAKAI, T. HACHIYA, M. HATSUDA

## 1. FoCal(Forward Calorimeter)

- Newly developed to measure CGC in LHC-ALICE
  - FoCal-E : measure photon energy
  - FoCal-H : measure hadron energy
- Will be installed in forward region from the point of the collision
  - Due to high neutron exposure, p-type silicon sensor will be used which are known for high radiation tolerance



The more exposed to radiation, the more their characteristics change rapidly.  
 →Need to know what happens if they are exposed to the amount planned for the experiment

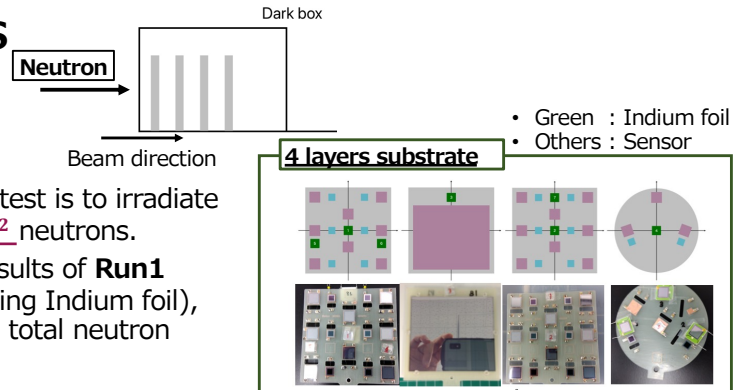
## 2. Neutron Irradiation test at RANS

- Neutron irradiation was performed in 9 runs.
- Irradiation amount[C] = current[μA] × time[sec]

Run No.	1	2~9
time[sec]	3634	25676
current[μA]	6.470	34.222
irradiation amount[C]	0.0186	0.8437

Total value

- The goal in this test is to irradiate around  $10^{14}/\text{cm}^2$  neutrons.
- Based on the results of **Run1** analysis(containing Indium foil), we estimate the total neutron dose.



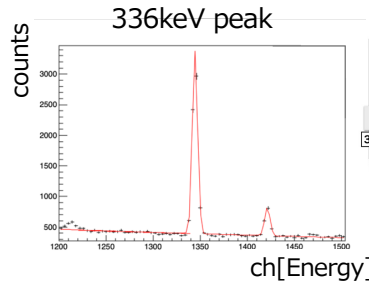
## 3. Evaluation of Neutron dose

- The neutrons strike indium foil, which moves to the excited state and then to the ground state by emitting γ-rays at 336 keV. (isomeric transition)
- The neutron dose is proportional to the γ dose.

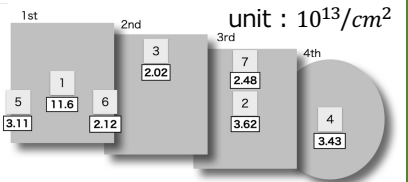
**Number of neutron : N**

$$N = \frac{1}{\sigma} \cdot \frac{\lambda M t_i}{m R N_A B_f \epsilon_{cap} (1 - e^{-\lambda t_i}) e^{-\lambda t_c} (1 - e^{-\lambda t_m})} \cdot A$$

A : number of γ-rays



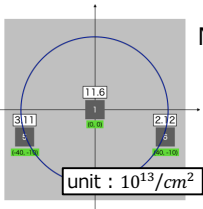
Result : Total Neutron dose



- The result of total neutron dose achieved target value.  $10^{14}/\text{cm}^2$

## 4. Result : Neutron dose(sensor)

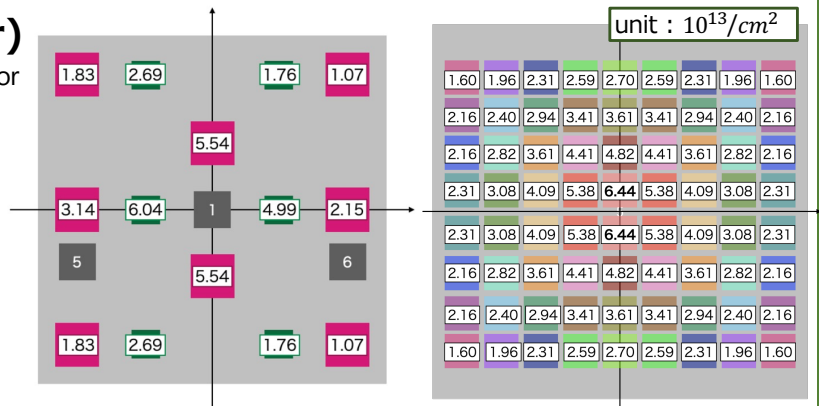
- Calculated the amount of Neutron dose of the sensor from the Total Neutron dose for exponentially decreasing.



Neutron dose of the sensor :  $N_{sen}$

$$N_{sen} = N_c \cdot \exp\left(\frac{1}{L_{In}} \ln\left(\frac{N_{In}}{N_c}\right) \times L_{sen}\right)$$

$L_{sen}$  : Distance of sensor  
 $L_{In}$  : Distance of Indium foil (center and corner)



## 5. Summary

- In order to evaluate the performance of p-type Si sensor, Neutron irradiation test was conducted at Riken RANS.
- The result of the total neutron dose achieved target value ( $10^{14}/\text{cm}^2$ ), which is assumed in the ALICE experiment.
- The irradiated neutron dose of sensors could also be estimated.
- There are some differences in neutron dose of sensors depending on location of the sensors.