Report on the analysis of the ion test of CHD paddles to study effects of quenching and delta rays

TAMURA Tadahisa for T&C in Japan

（Yuko OKADA is now analyzing the CHD paddle data.）

Motivation to study effects of quenching and delta rays of CHD plastic scintillator

Tarle's equiation for quenching effect:

$$\frac{dL}{dx} = A\left((1-f)C + f\right)\frac{dE}{dx} \qquad C = \frac{1}{1+B}(1-f)\frac{dE}{dx}$$

We use this formula in our simulation for the CHD output signals.
However, experimental data is affected by delta rays from upstream and backscatters.

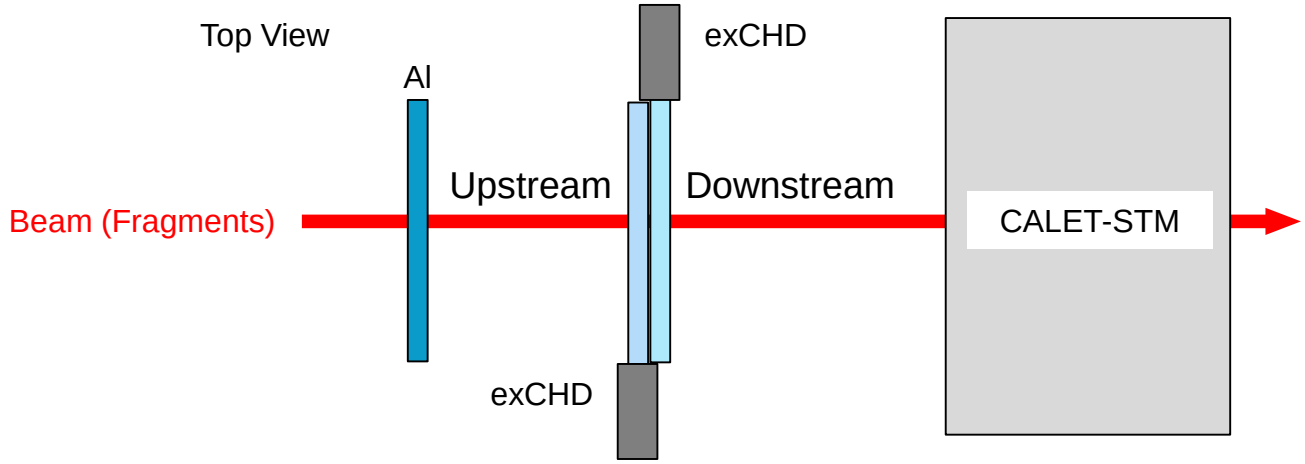
$$\frac{dL}{dx} = A\left[a\left((1-f)C + f\right)\frac{dE_h}{dx} + \frac{dE_s}{dx}\right] \qquad C = \frac{1}{1+B}(1-f)\frac{dE_h}{dx}$$

dE_h : Energy deposit by nuclei
dE_s : Energy deposit by particles with Z=1

We would like to verify appropriate parameters in our simulation to explain experimental data.
⇒ It is desirable to use same parameters for both the upstream and downstream paddles.
⇒ We would like to study an effect of pass length on the light yield.

Experimental setups

	Upstream	Downstream	Incident angle
①	exCHD No.1	exCHD No.2	Vertical (0 deg.)
②	exCHD No.2	exCHD No.1	Vertical (0 deg.)
③	exCHD No.1	exCHD No.2	0, 15, 30, 45 , 60 deg.



Two CHD paddles (exCHD No.1 and No.2) were set closely at upstream and downstream in the beam line.

① Upstream exCHD No.1
Downstream exCHD No.2 (Vertical)

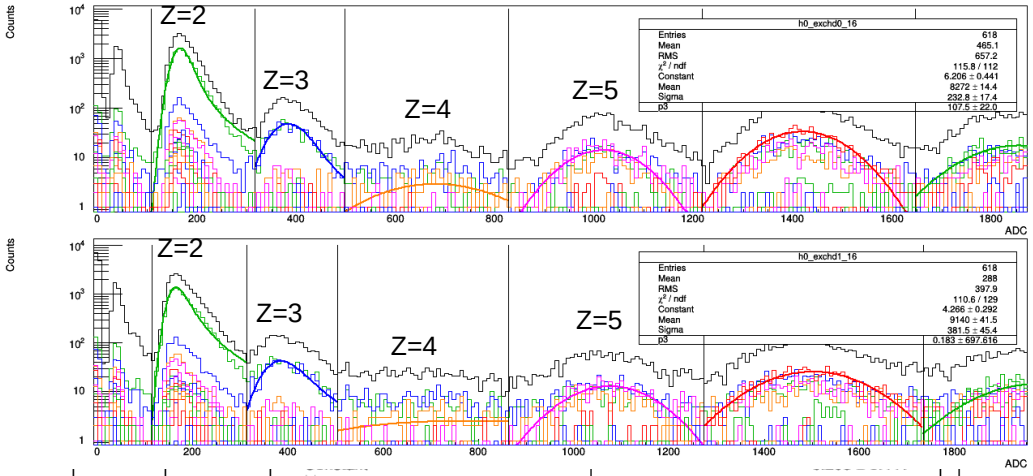
- 10k events in total

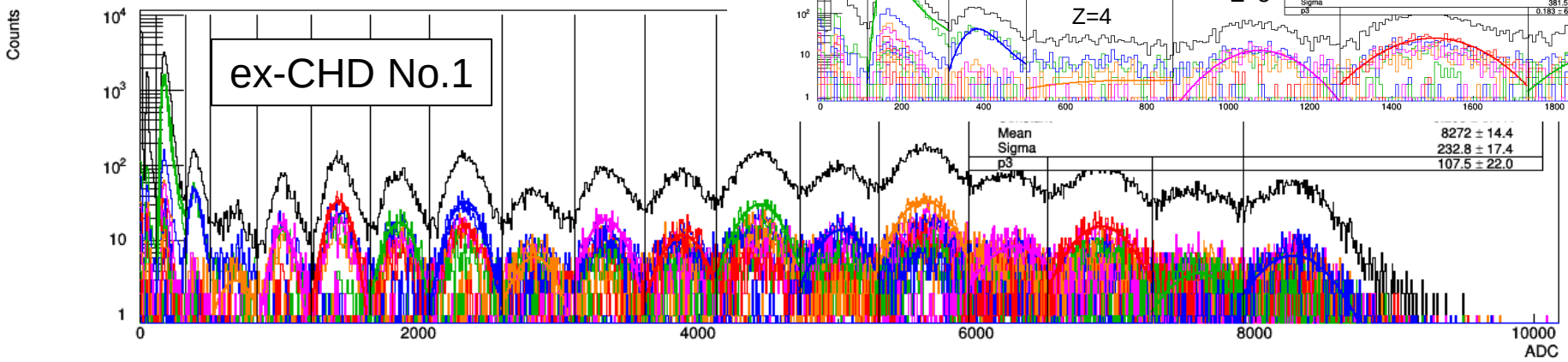
Black：all events

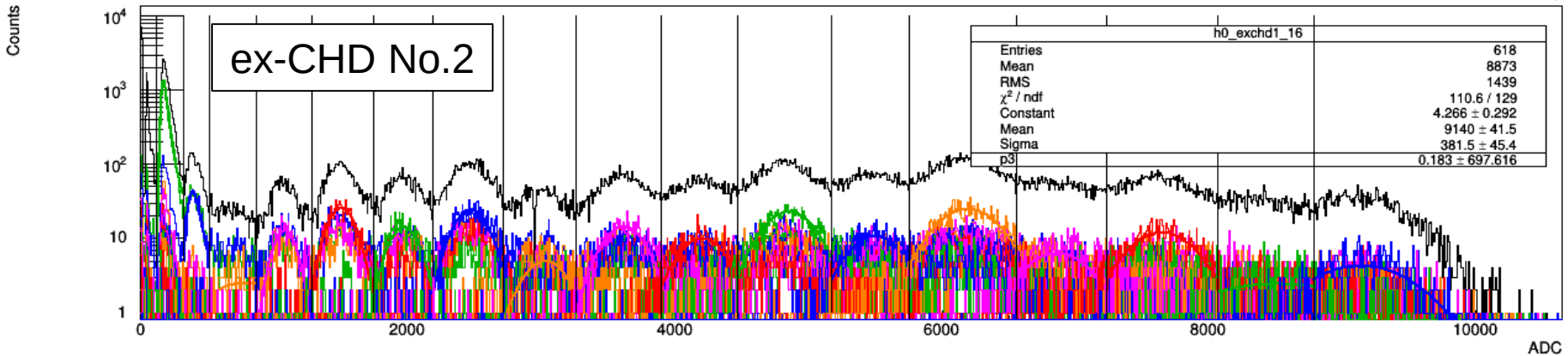
Colored: Events tagged by CALET-CHD

Peak Fitted by

- Z≦4 Landau & Gauss convolution
- Z＞4 Gauss

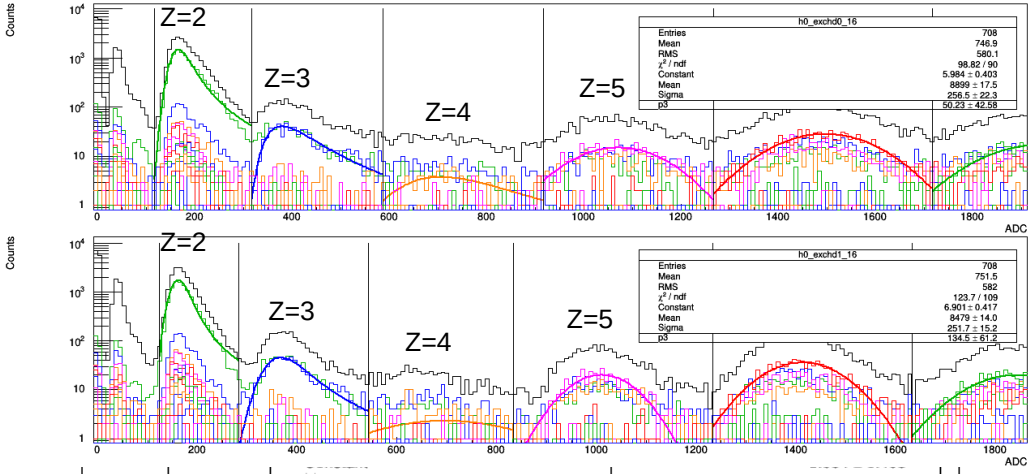


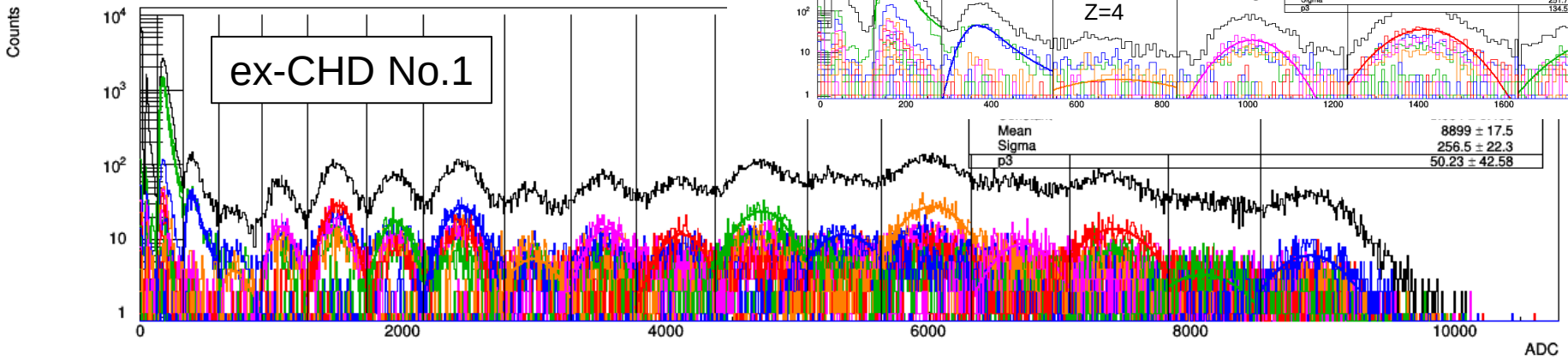


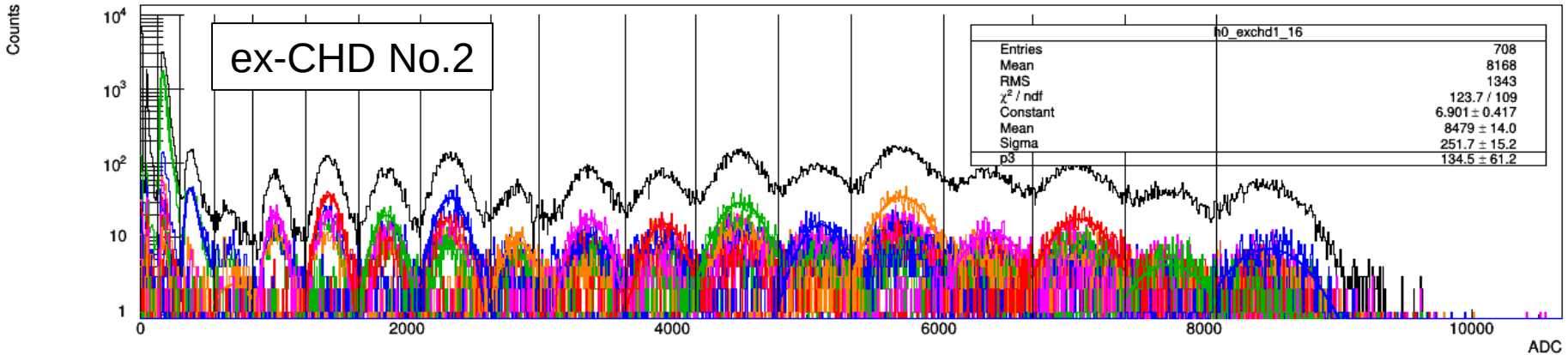


② Upstream exCHD No.2
Downstream exCHD No.1 (Vertical)

- 10 k events in total







① Nuclei peaks in the He MIP unit

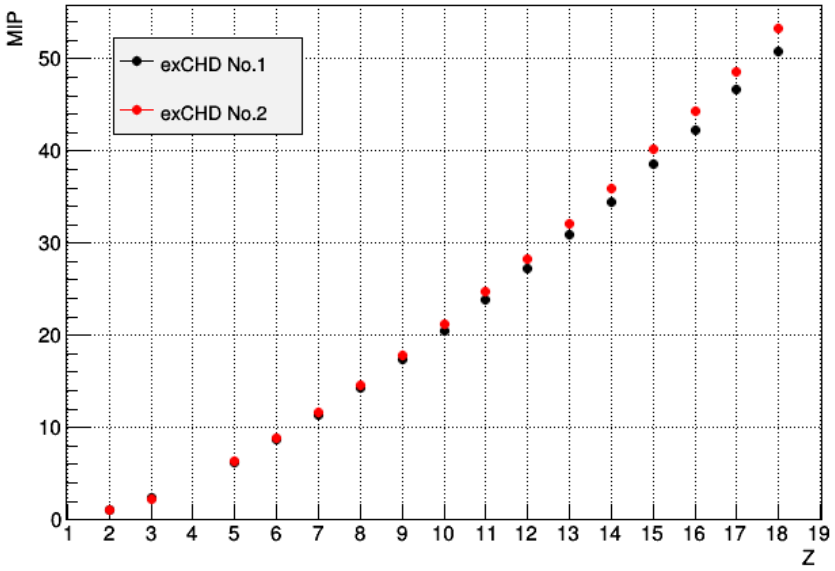
- Helium MIP of each exCHD set at upstream was calibrated.
- We use the Helium MIP as a unit of light output here.

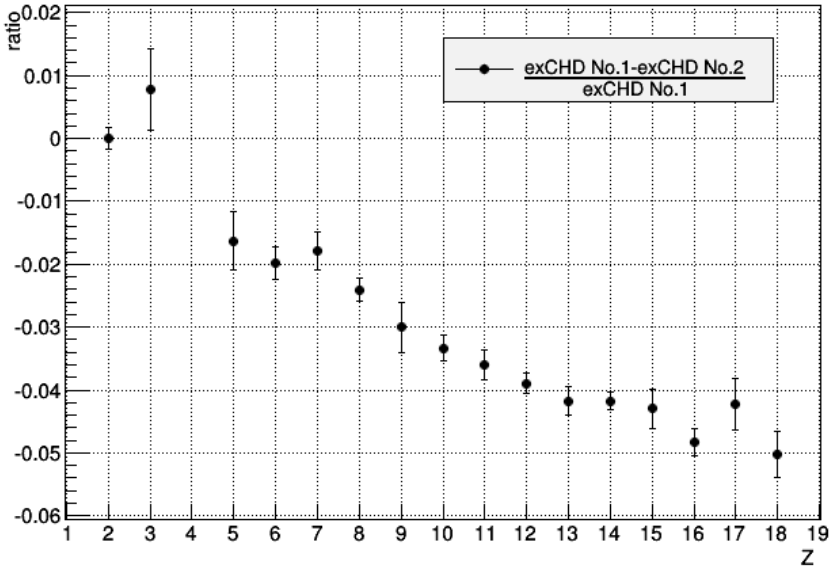
● He-MIP

Each nuclear peak is shown in the Helium MIP unit.

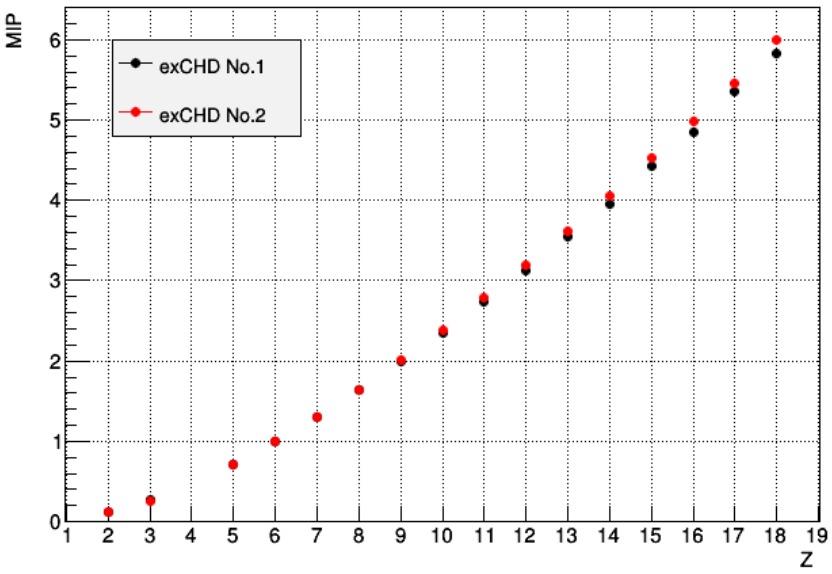
Ratio of Difference to light output

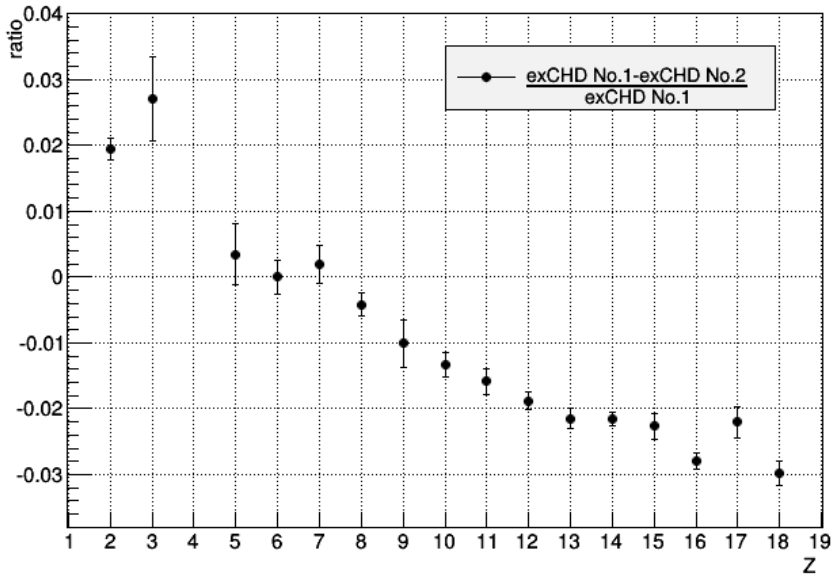
$$\frac{\text{exCHD No.1} - \text{exCHD No.2}}{\text{exCHD No.1}}$$



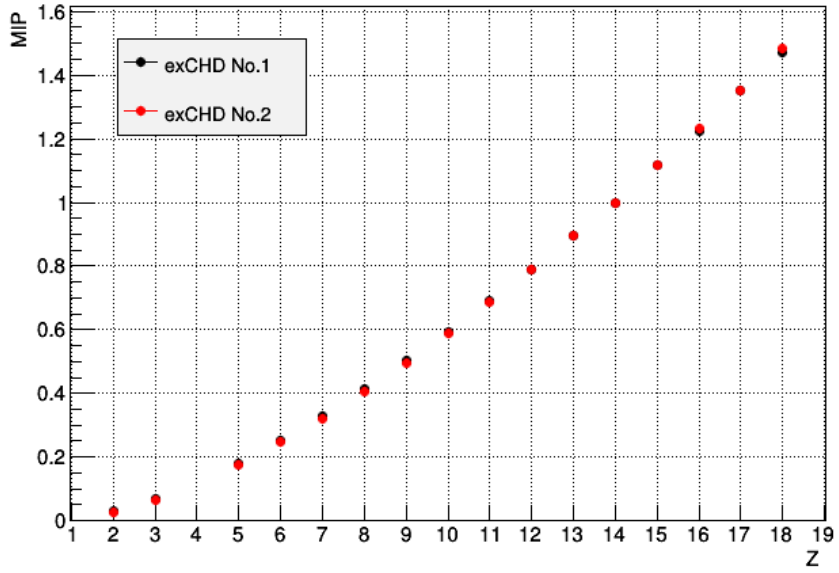


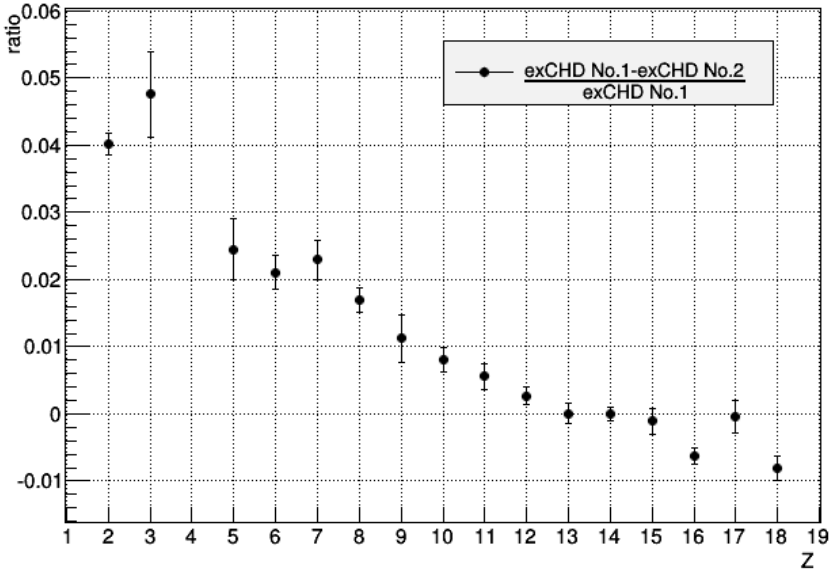
- In case of C-MIP unit



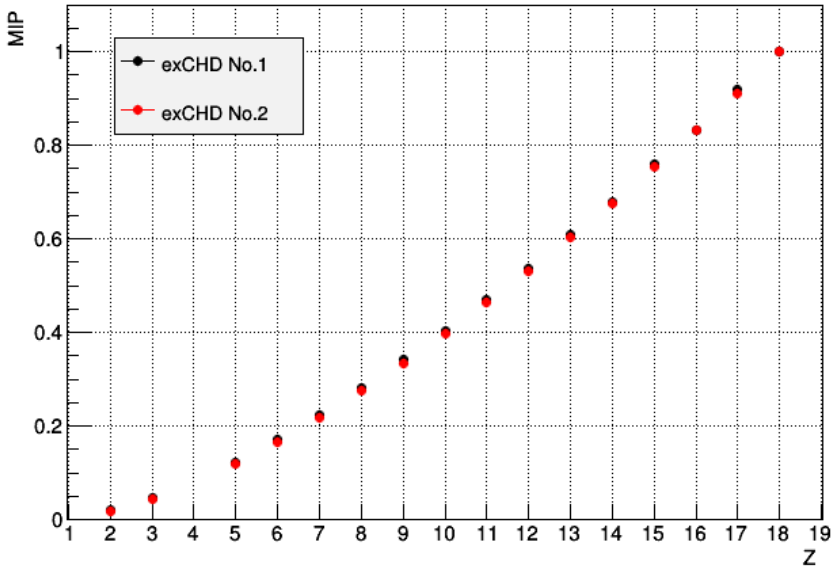


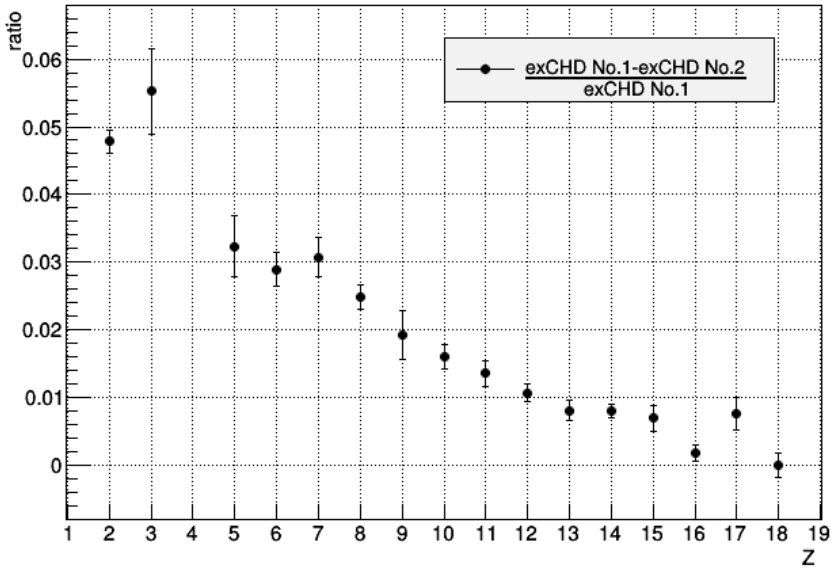
- In case of Si-MIP unit





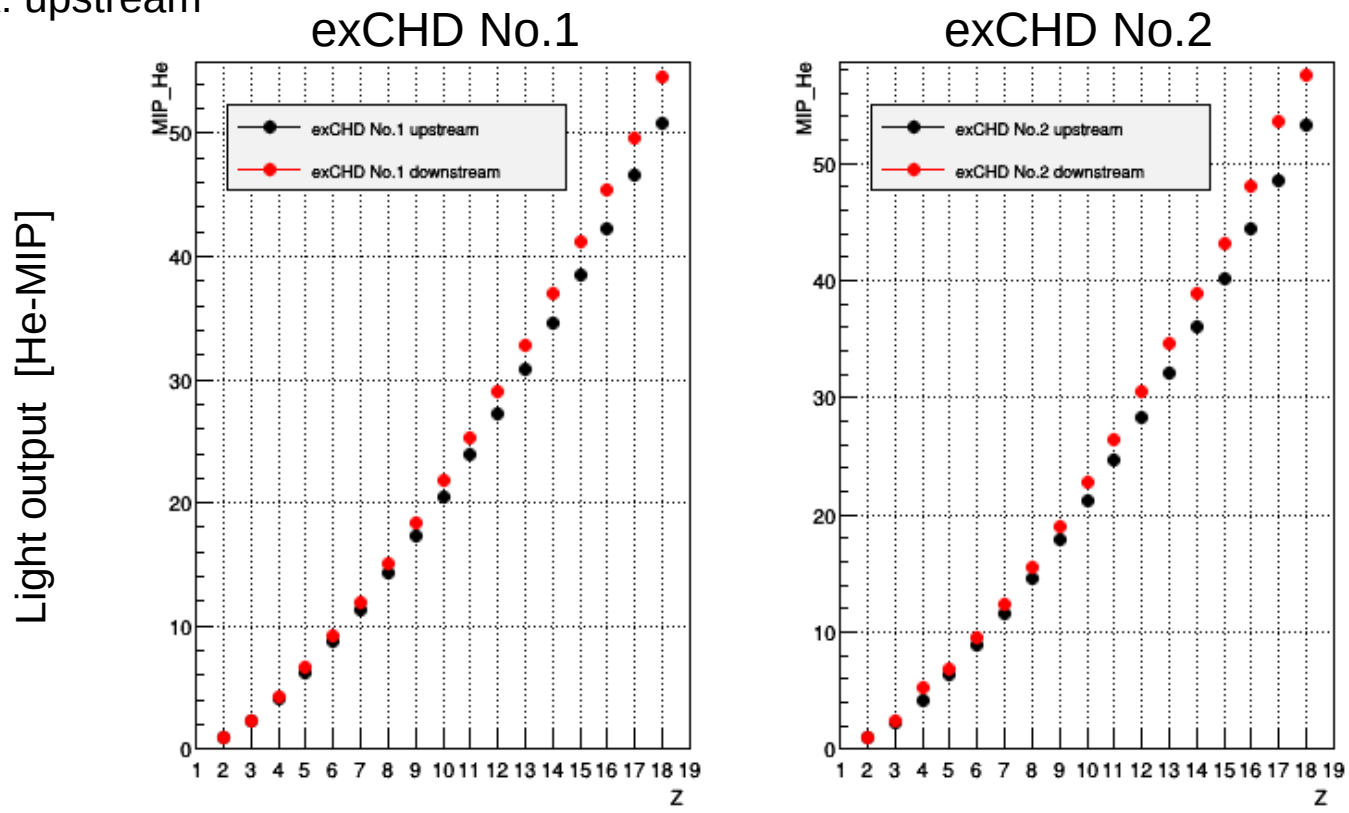
- In case of Ar-MIP unit





①② Difference of light output at upstream and downstream

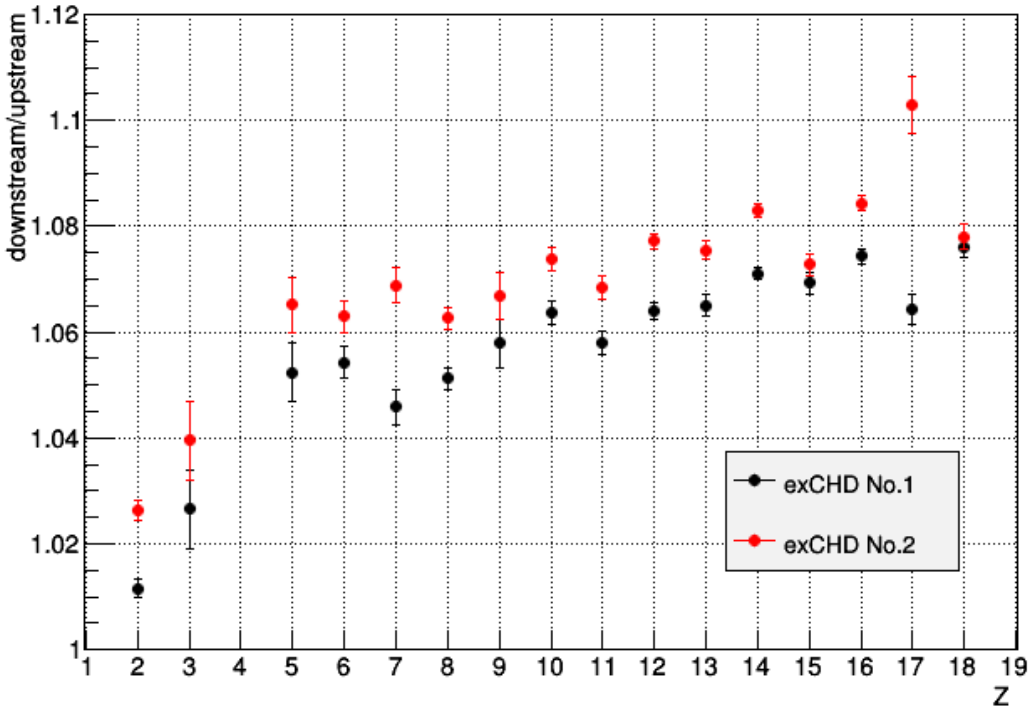
Red: downstream
Black: upstream



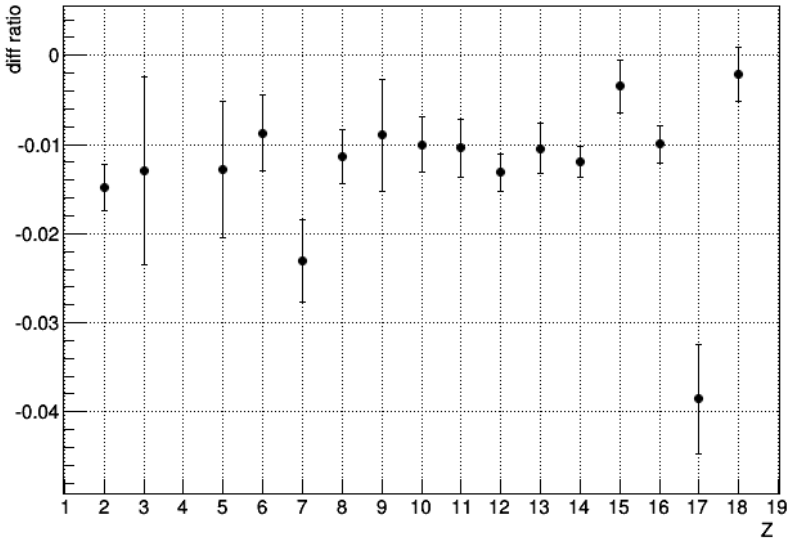
Light output at downstream is larger than that at upstream
⇒ It is expected to be an effect of delta rays from the upstream paddle to the downstream paddle.

- The light output of each scintillator at downstream relative to that at upstream

$$\frac{\text{downstream[He-MIP]}}{\text{upstream[He-MIP]}}$$



Difference of light output (up – down) relative to light output at upstream

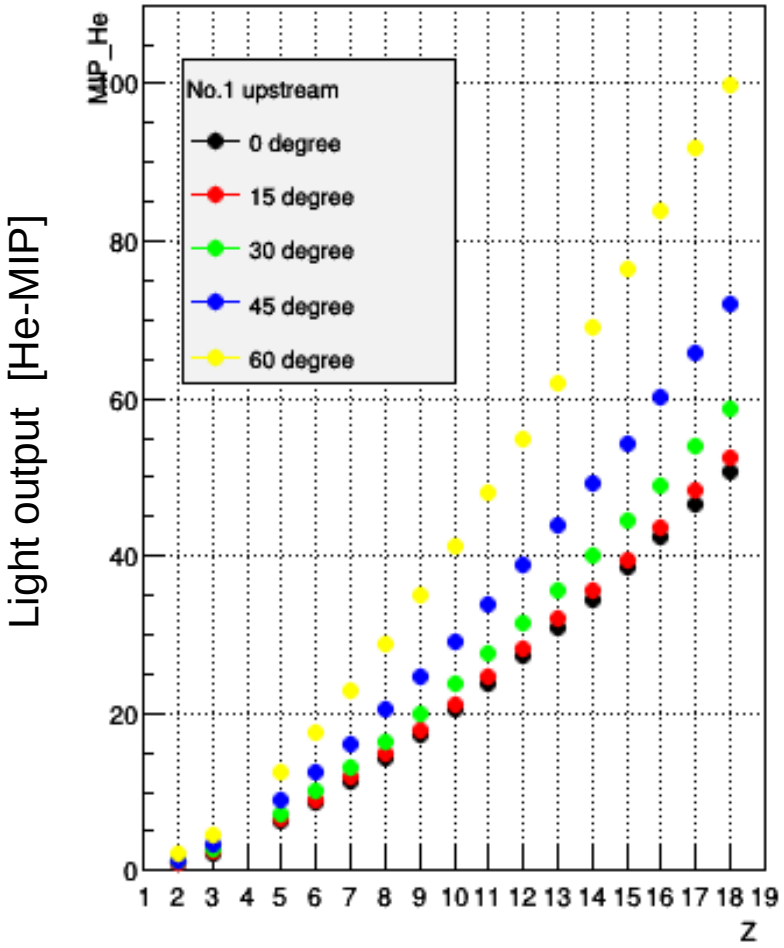


The ratio of No.2 is larger by about 1 % than that of No.1.

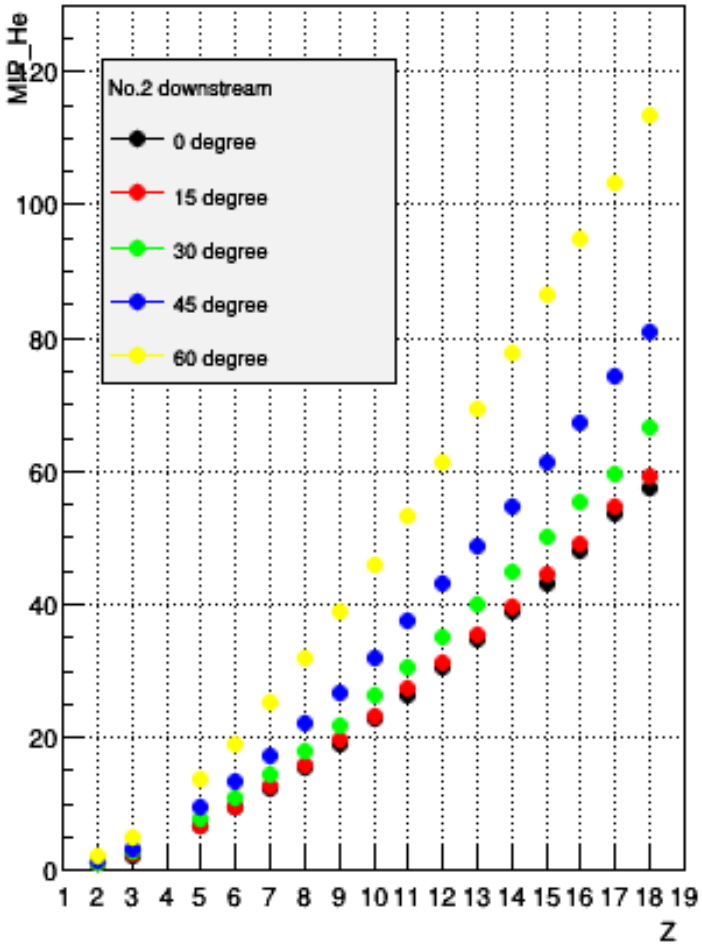
⇒ It should be same in the MIP unit. We need more consideration.

③ Dependency of light output on beam incident angles

exCHD No.1 @upstream

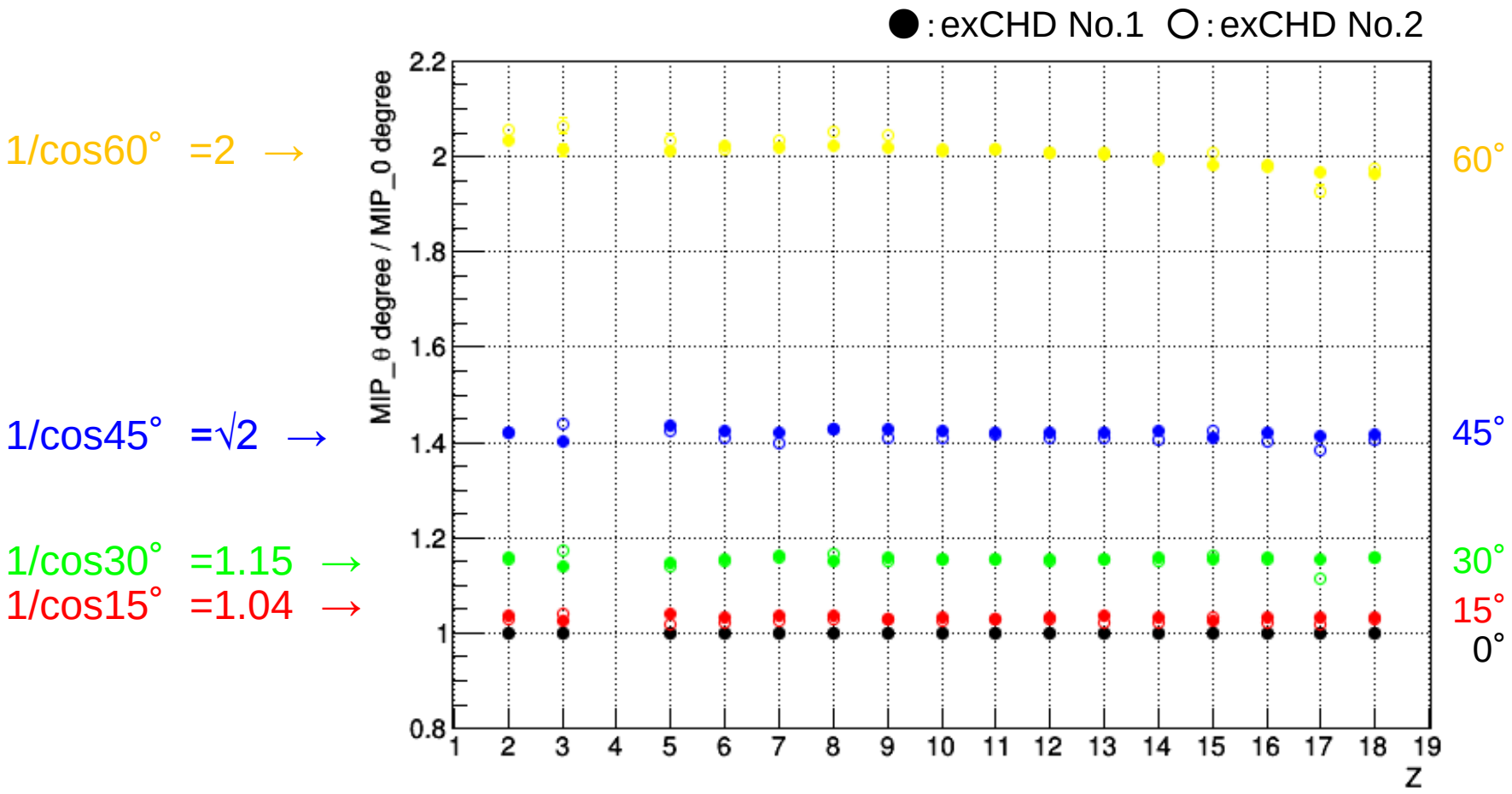


exCHD No.1 @downstream



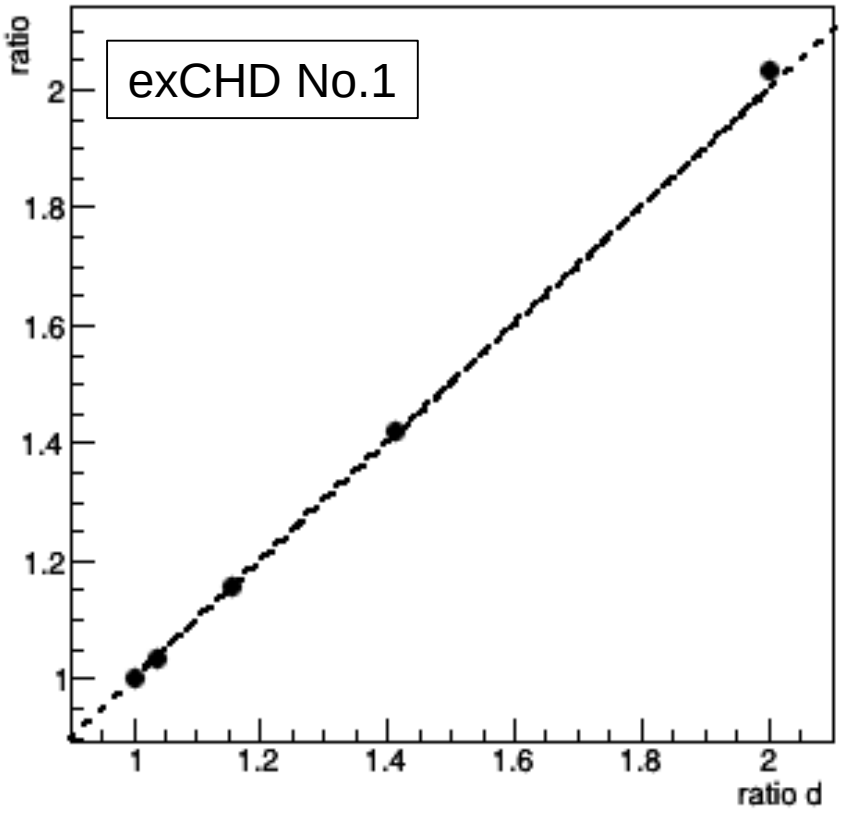
- Light outputs at each angle relative to that at 0 deg.

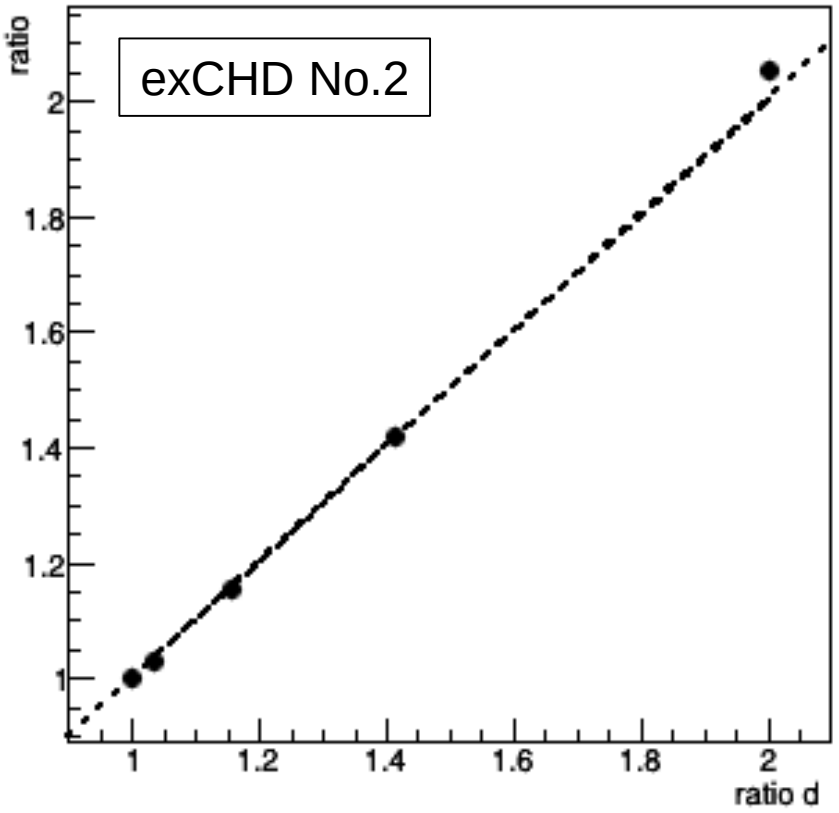
$$\frac{\text{Light Output (Z,}\theta\text{) [He-MIP]}}{\text{Light Output (Z,0) [He-MIP]}}$$

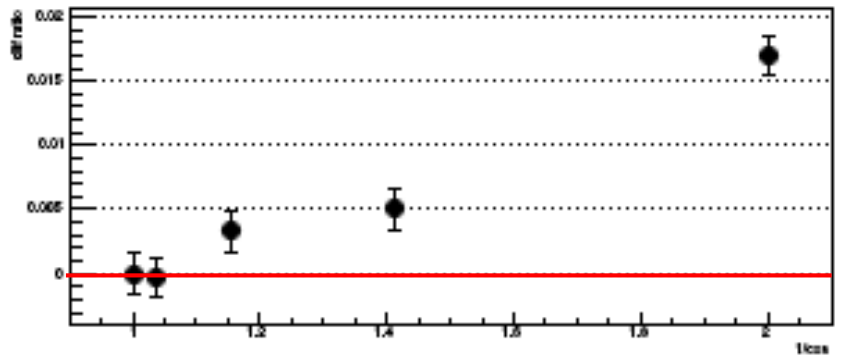


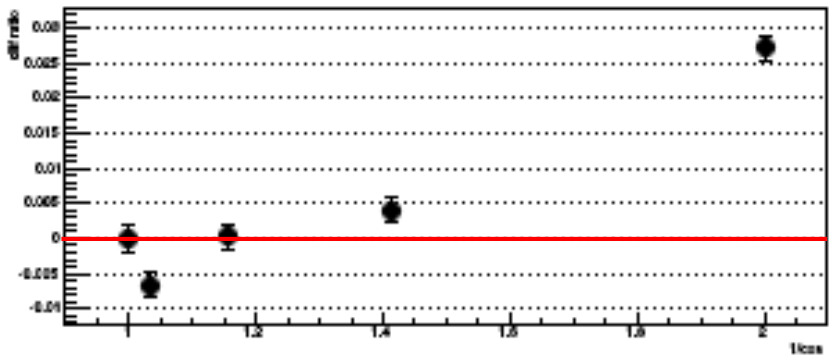
- **He**

Vertical: Ratio of light output
Horizontal：1/cosΘ



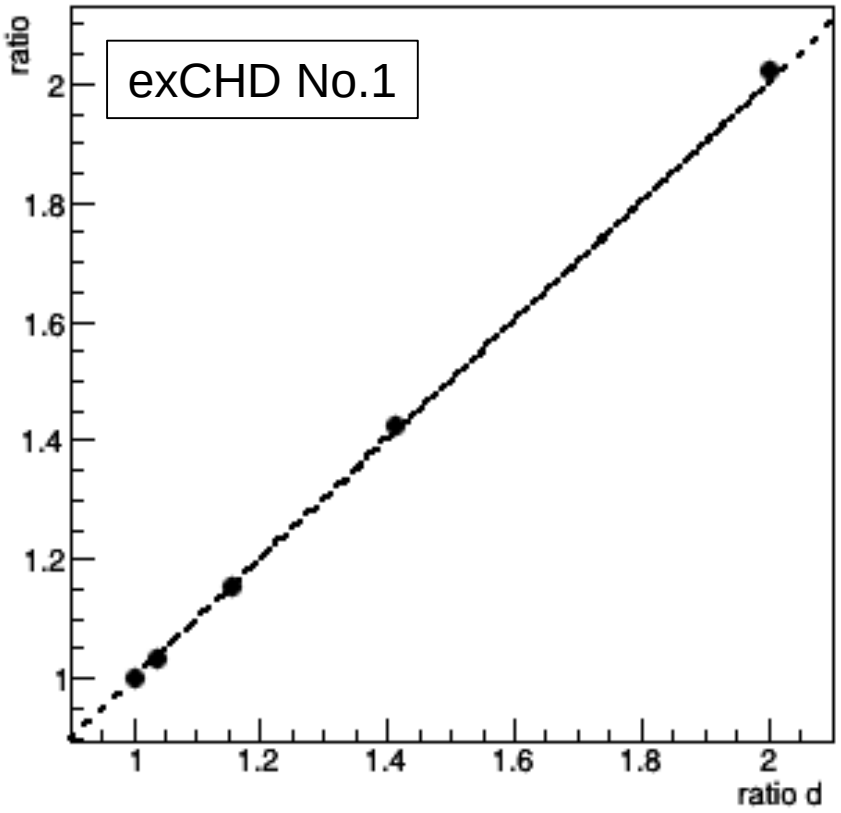


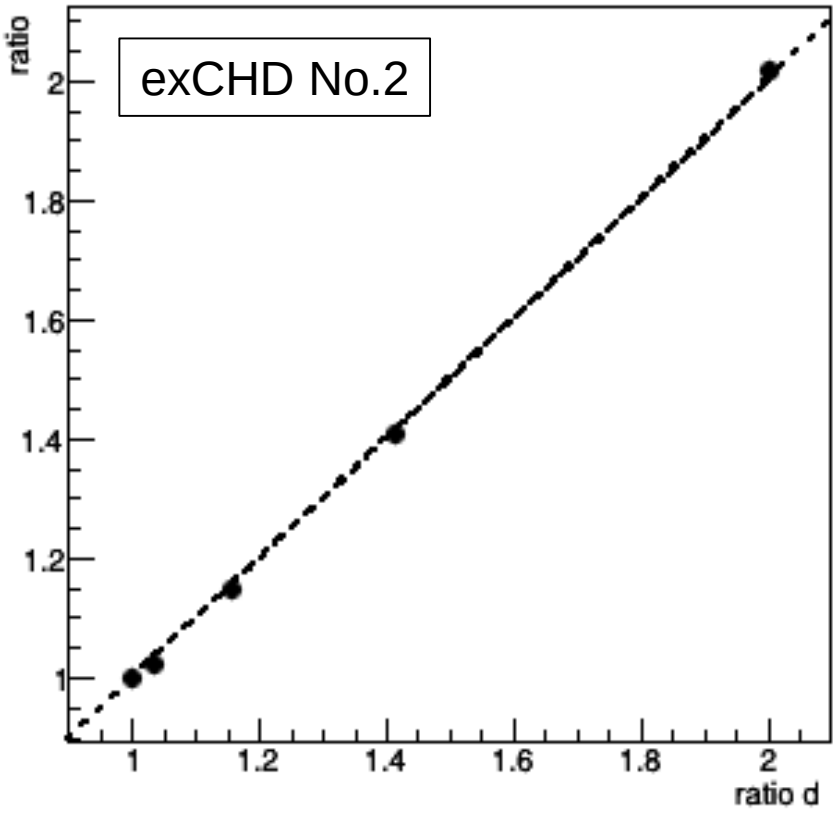


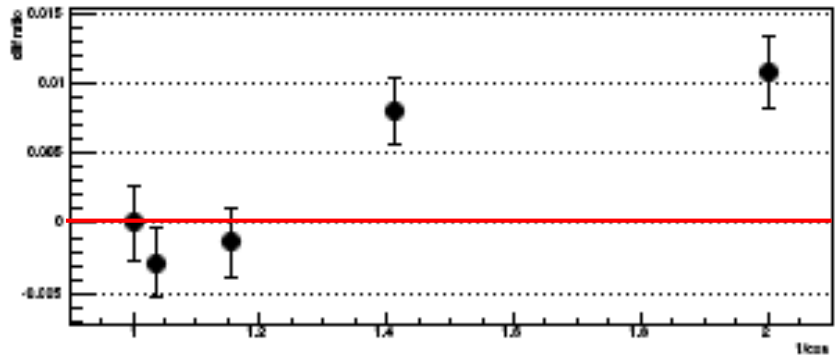


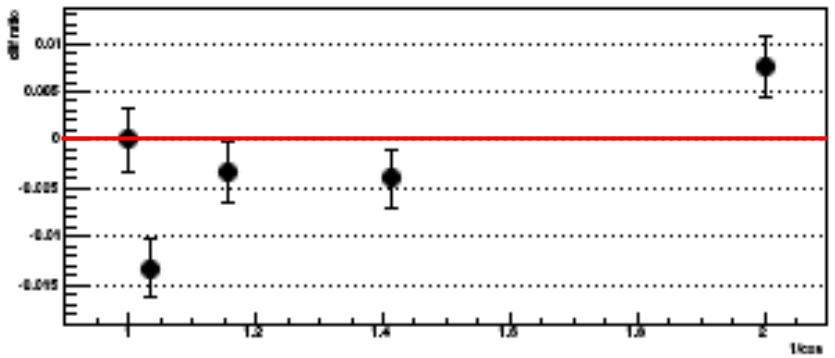
- C

Vertical: Ratio of light output
Horizontal：1/cosΘ



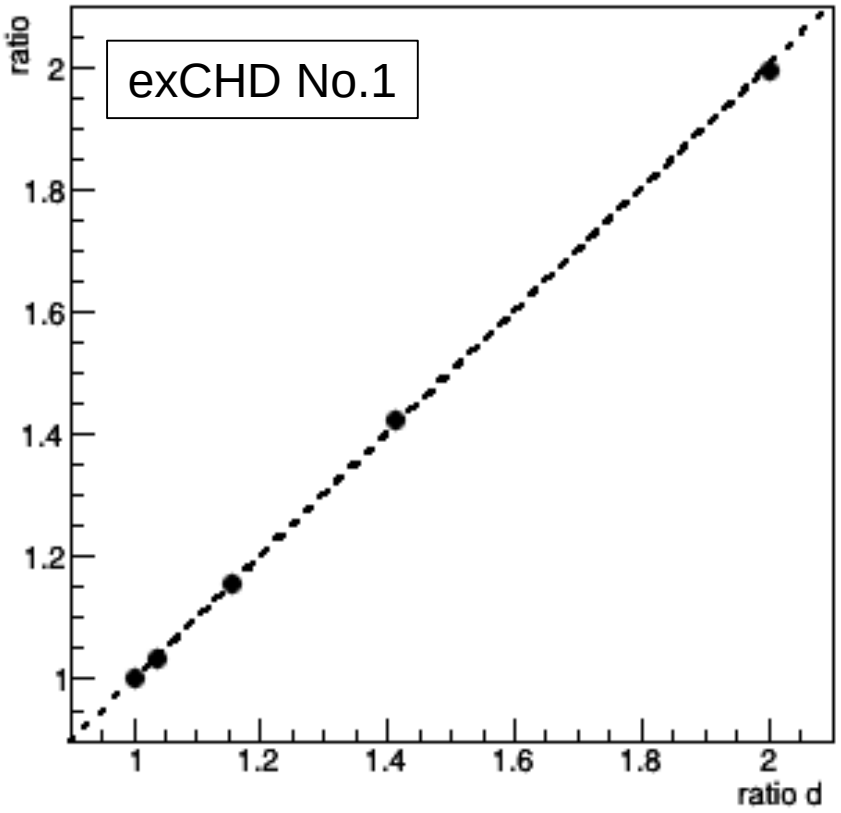


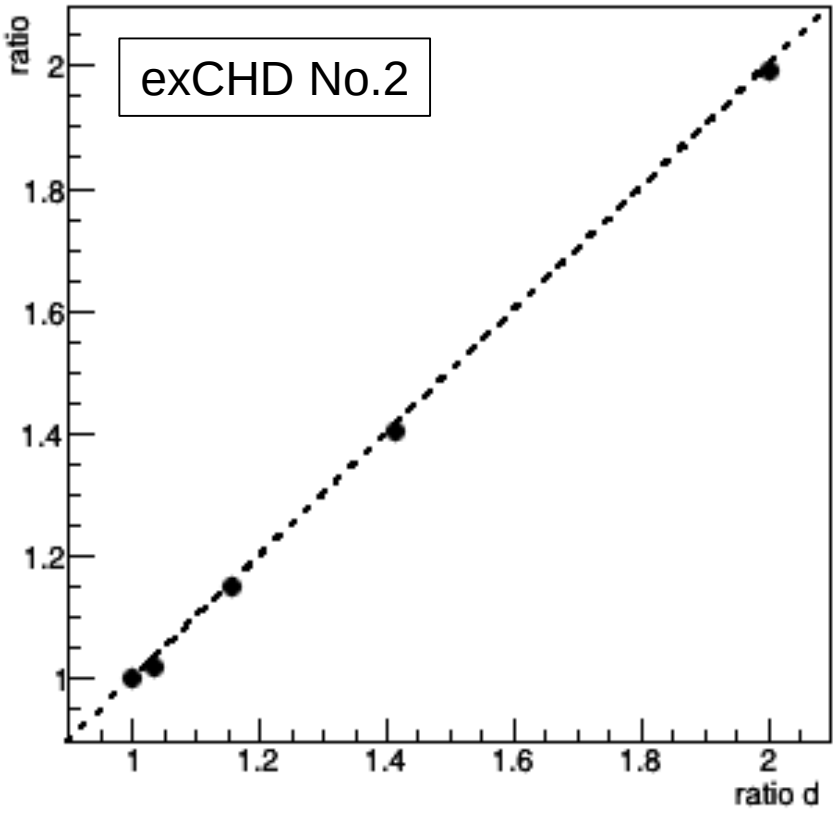


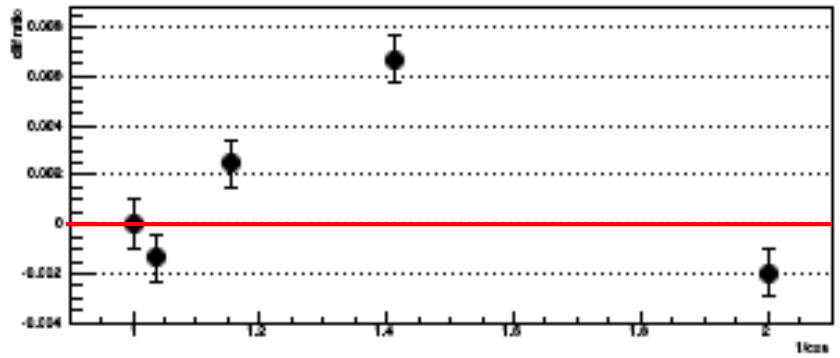


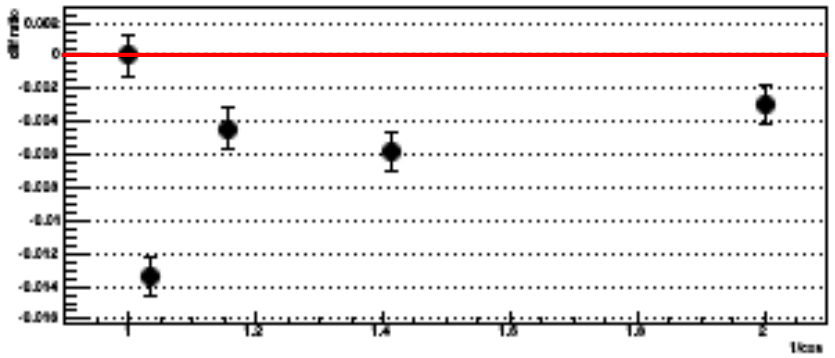
- **Si**

Vertical: Ratio of light output
Horizontal : 1/cosΘ



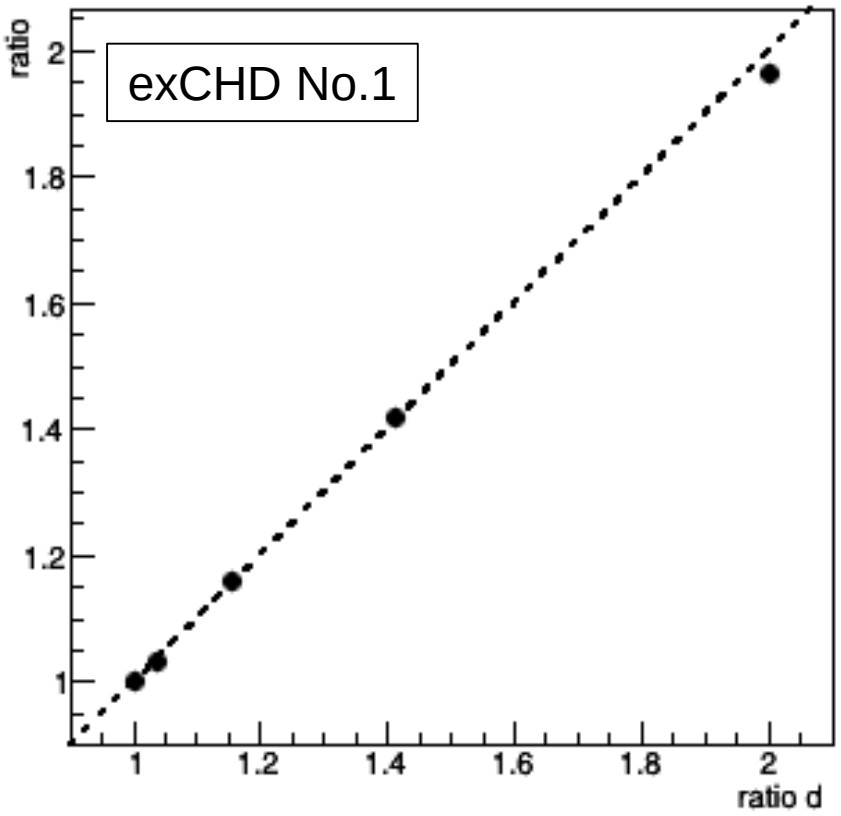


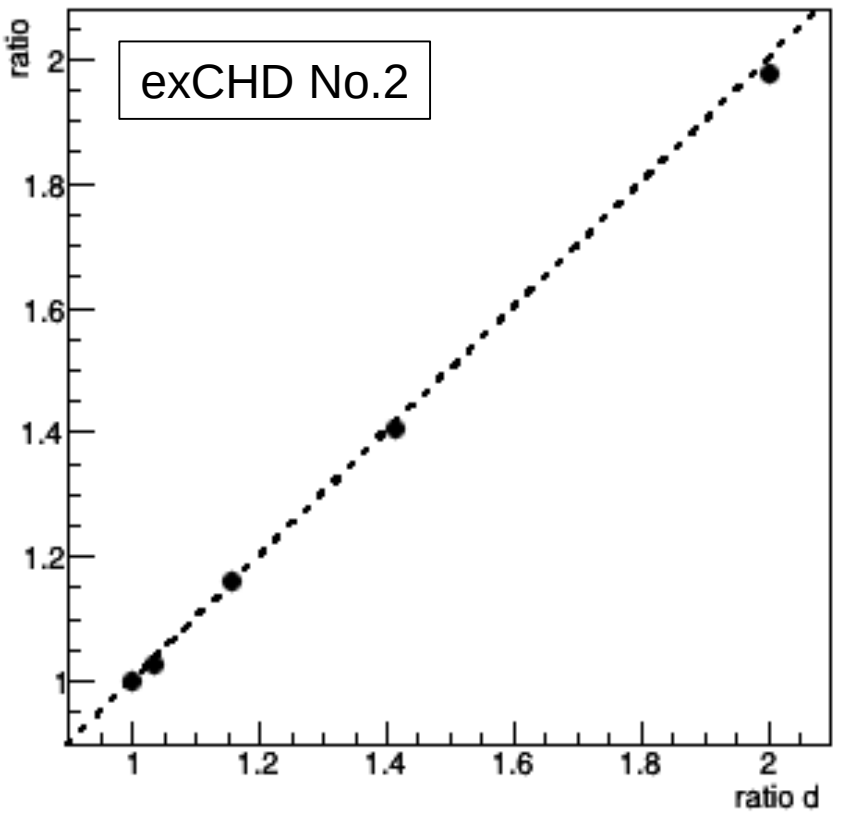


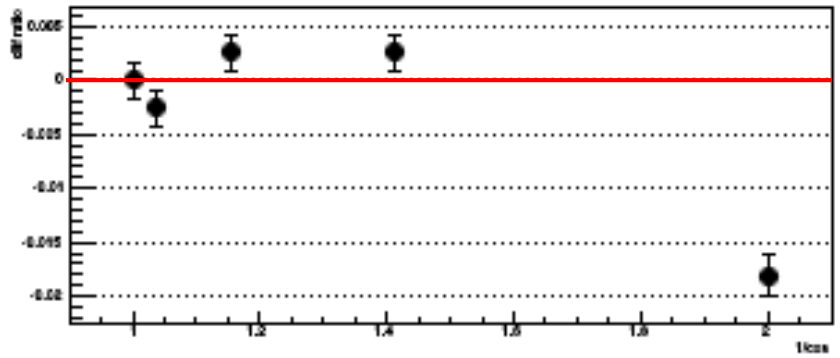


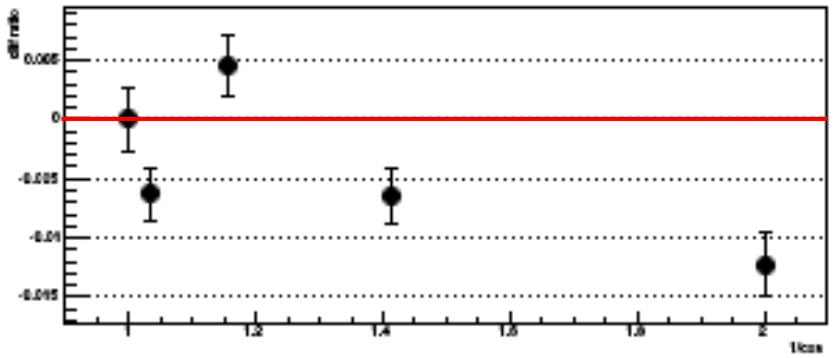
- **Ar**

Vertical: Ratio of light output
Horizontal：1/cosΘ









Summary

- Light output of the downstream paddle increases at about same ratio (6-7%) for all nuclei
- The Difference of 1 % between two paddles are to be considered more
- The light outputs are proportional to the pass length of the particles

Action Item

- We will make simulations to compare them with the experimental results to verify the effect of the delta rays