Check CsI Calorimeter with Cosmic Ray

Osaka Univ.
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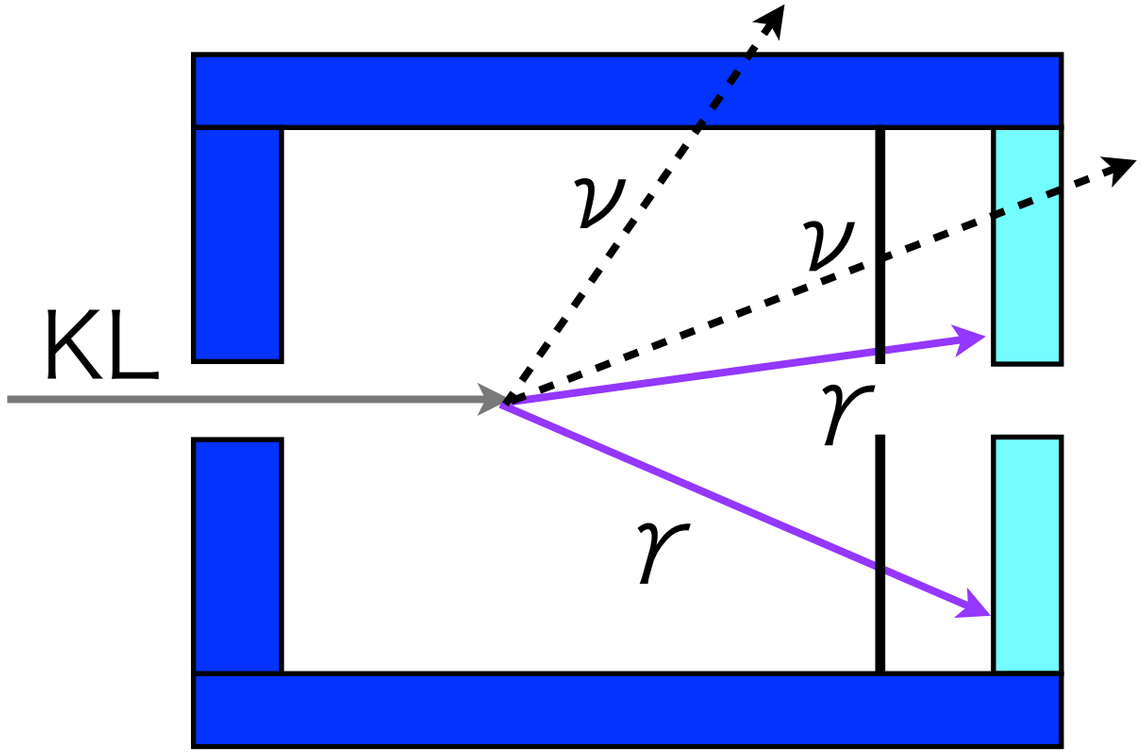
KOTO experiment

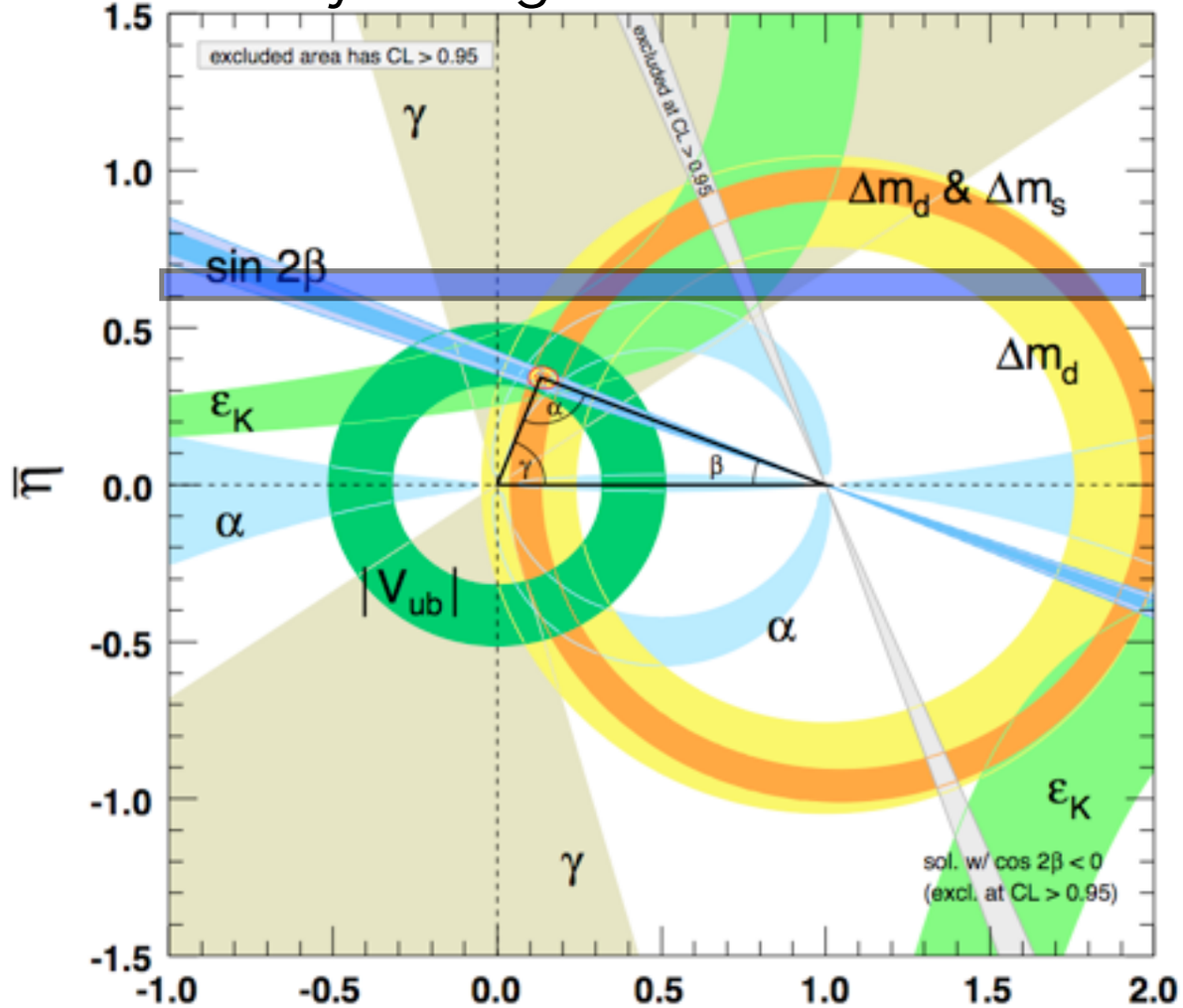
Search for rare decay of K-long (KL→$\pi^0 \nu\ \nu$)

Measure CP-Violation Factor η

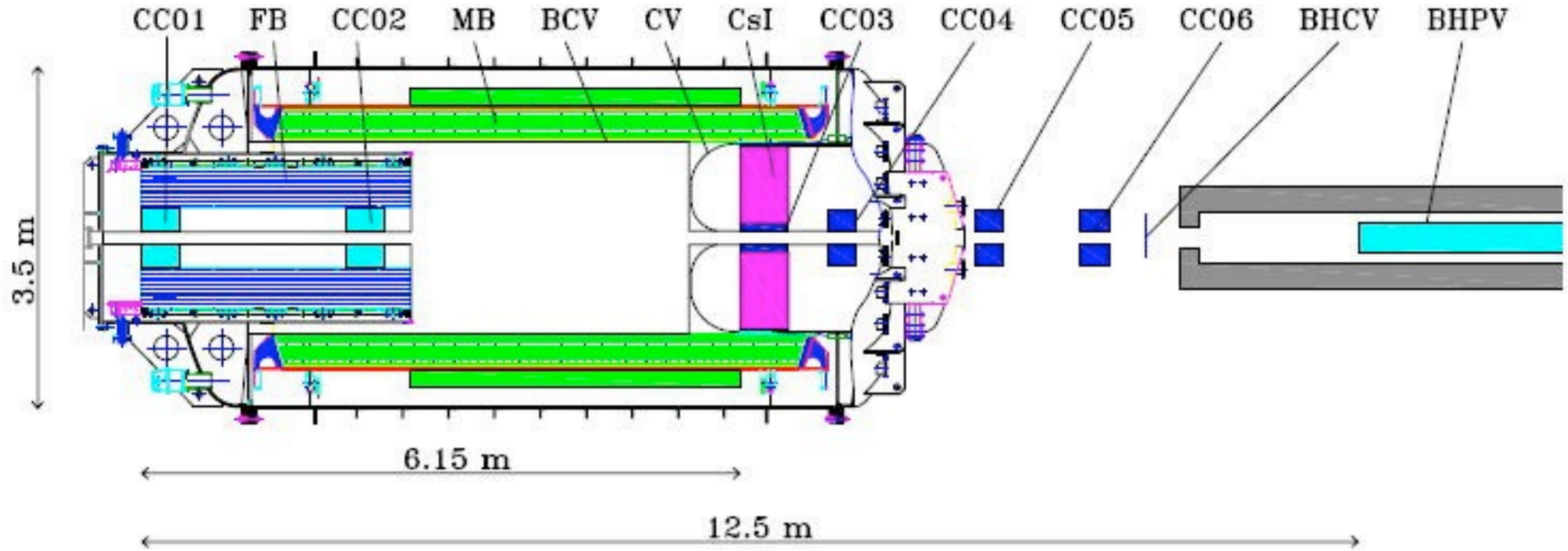
Searching for New? Uncovered physics.



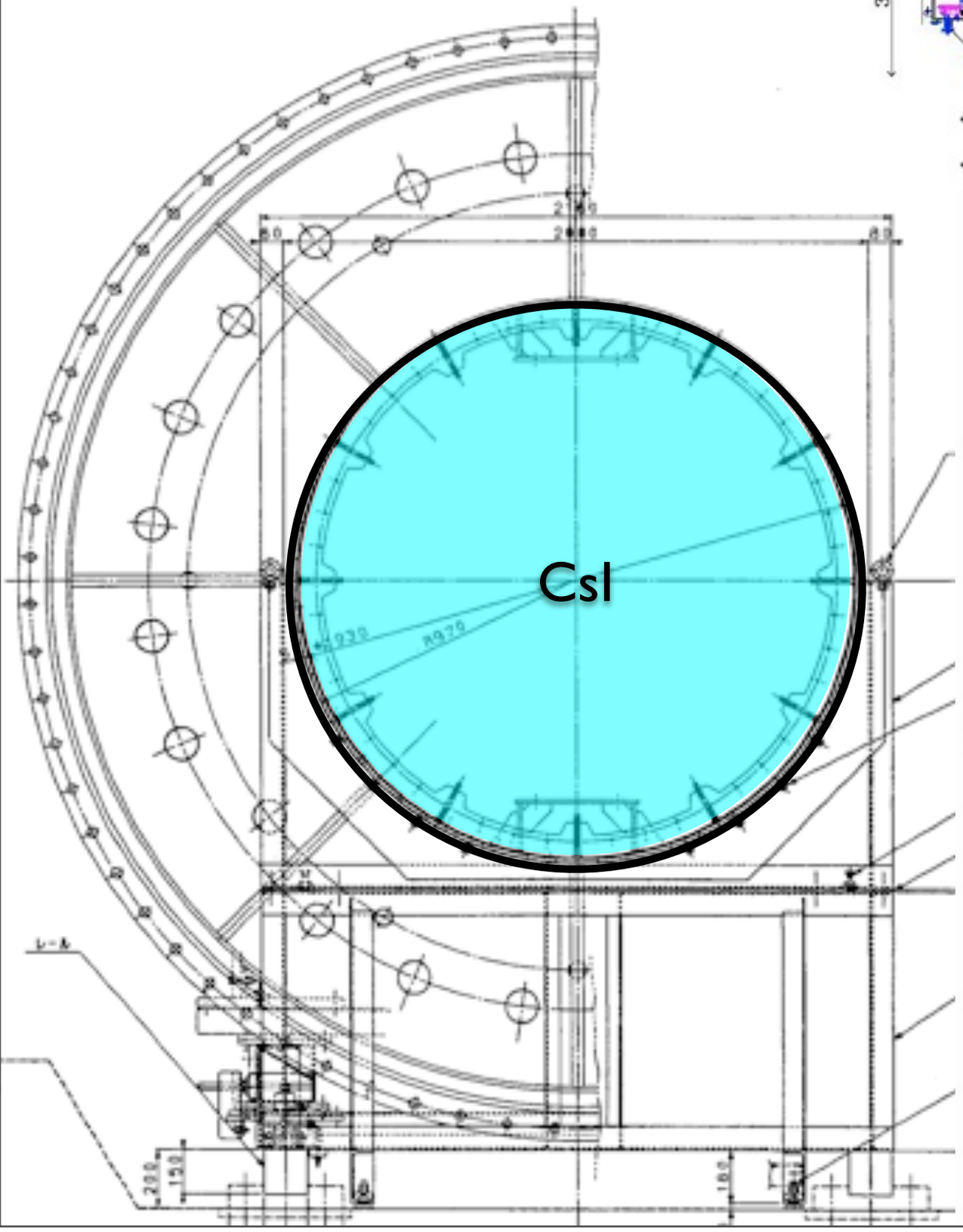
Unitarity triangle

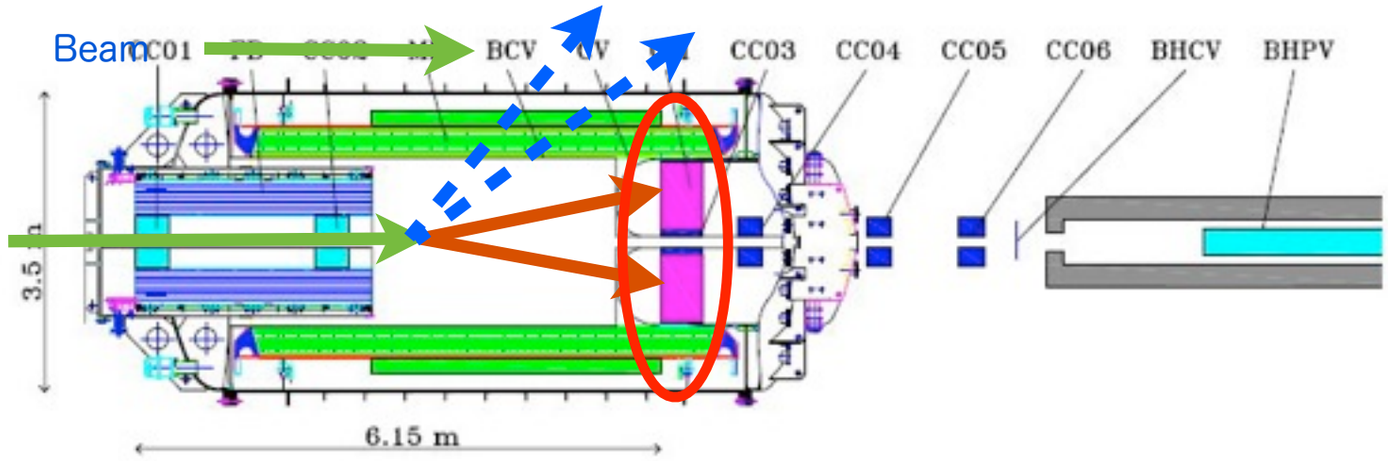


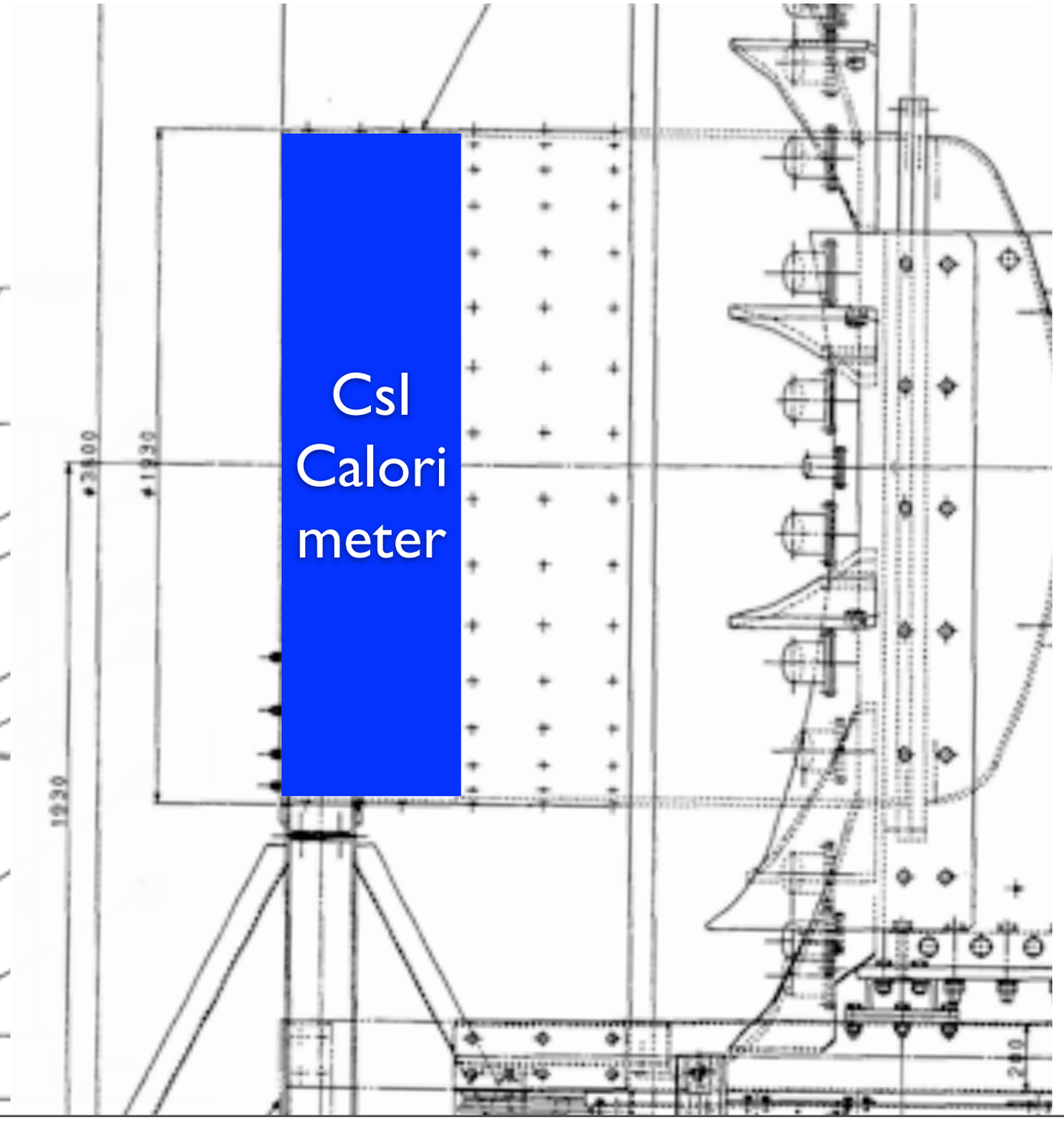
KOTO Detector



CsI Calorimeter

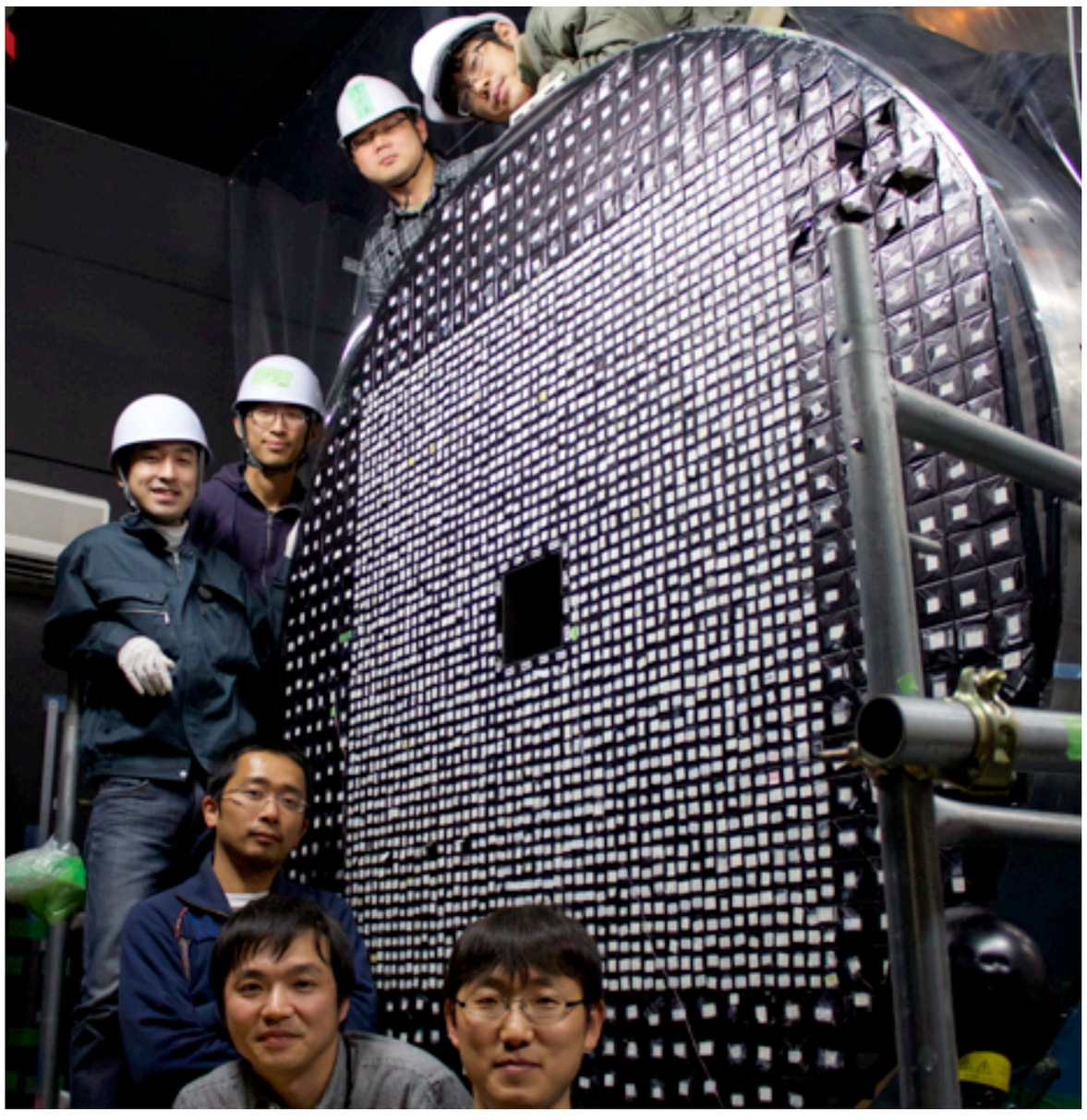


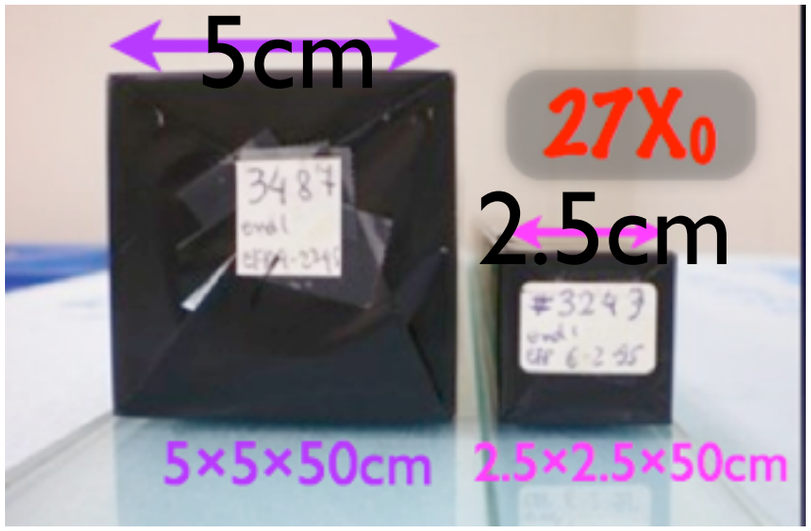




CsI Calorimeter

Before earth quake(Mar. 8th)



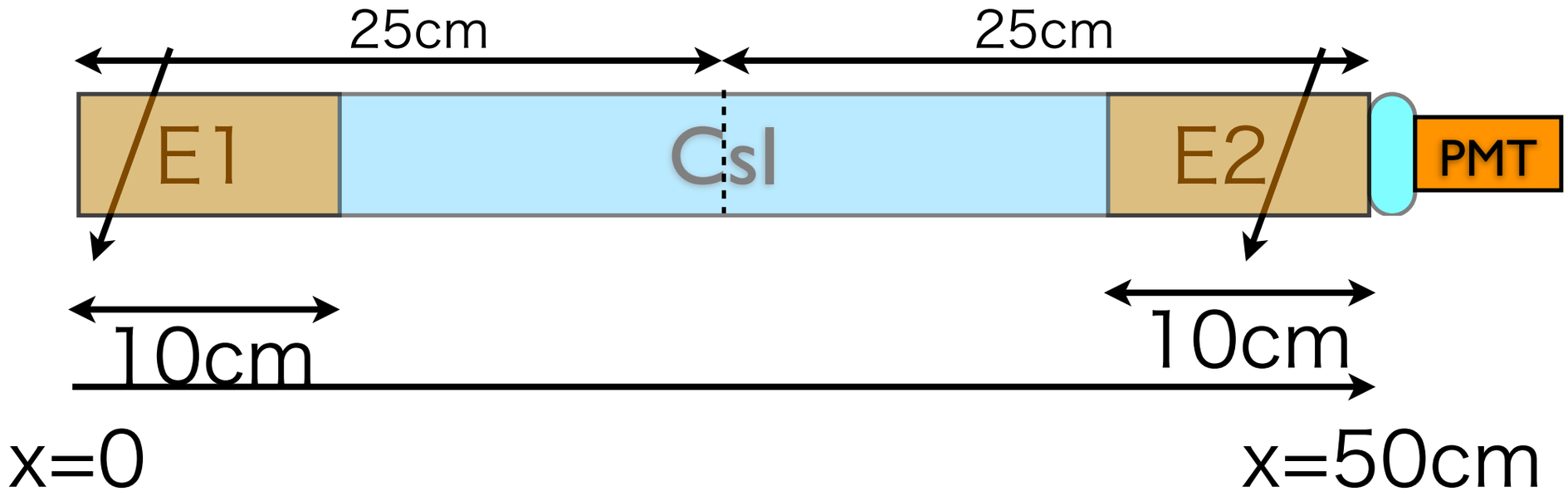


Large Crystal(5cmX5cm)x376ch
Small Cryatal(2.5cmX2.5cm)x2240ch
2716ch in total.

Stack up CsI crystal was ended
@Feb. 8th

The installation of PMT&Base was almost end.

Light Yield Uniformity



LY = LY(x) : x = Position of Cosmic Ray injected.

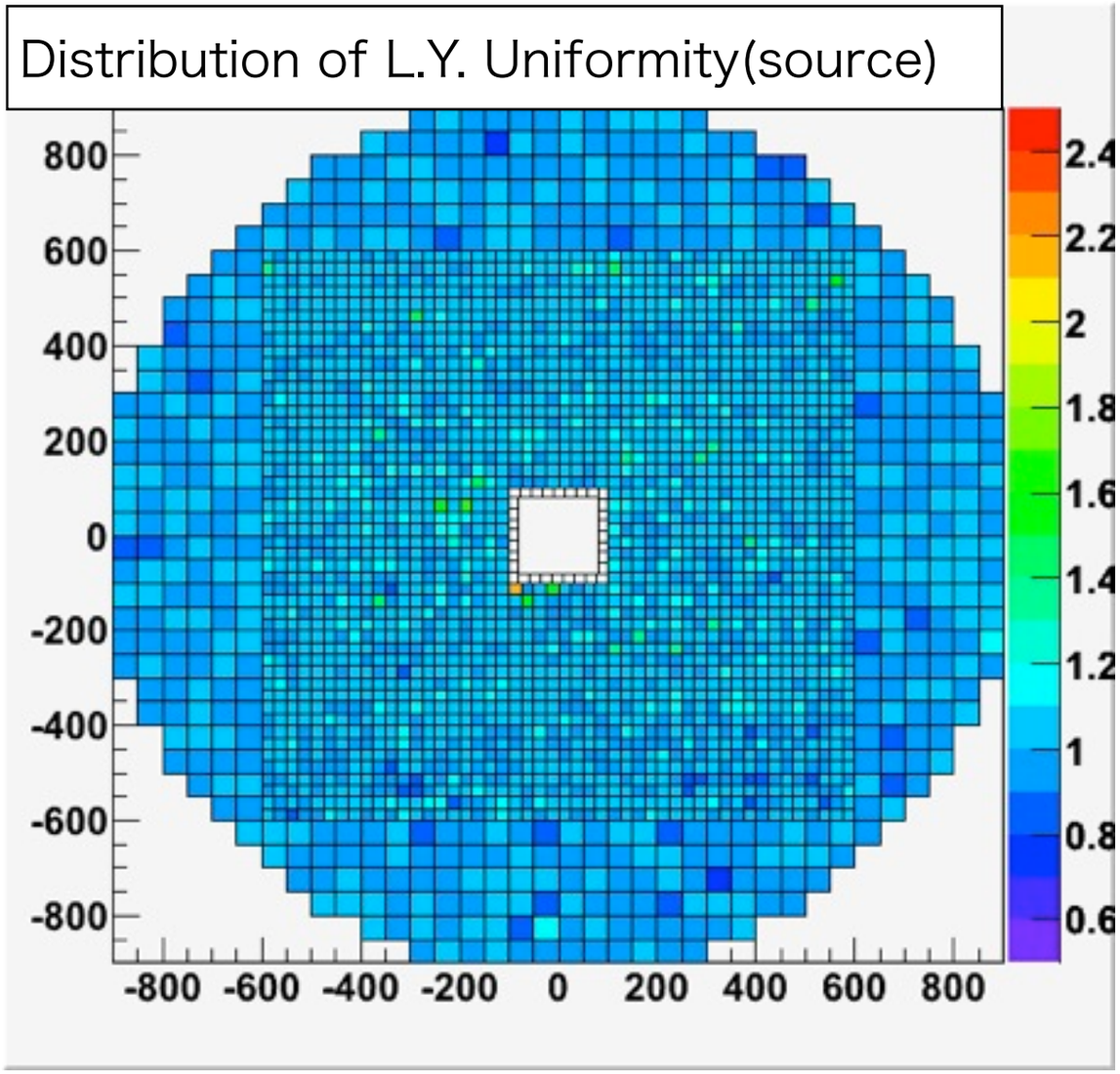
Definition of LY Uniformity

E1=output peak Up Stream(x < 10cm)

E2=output peak Down Stream(x > 40cm)

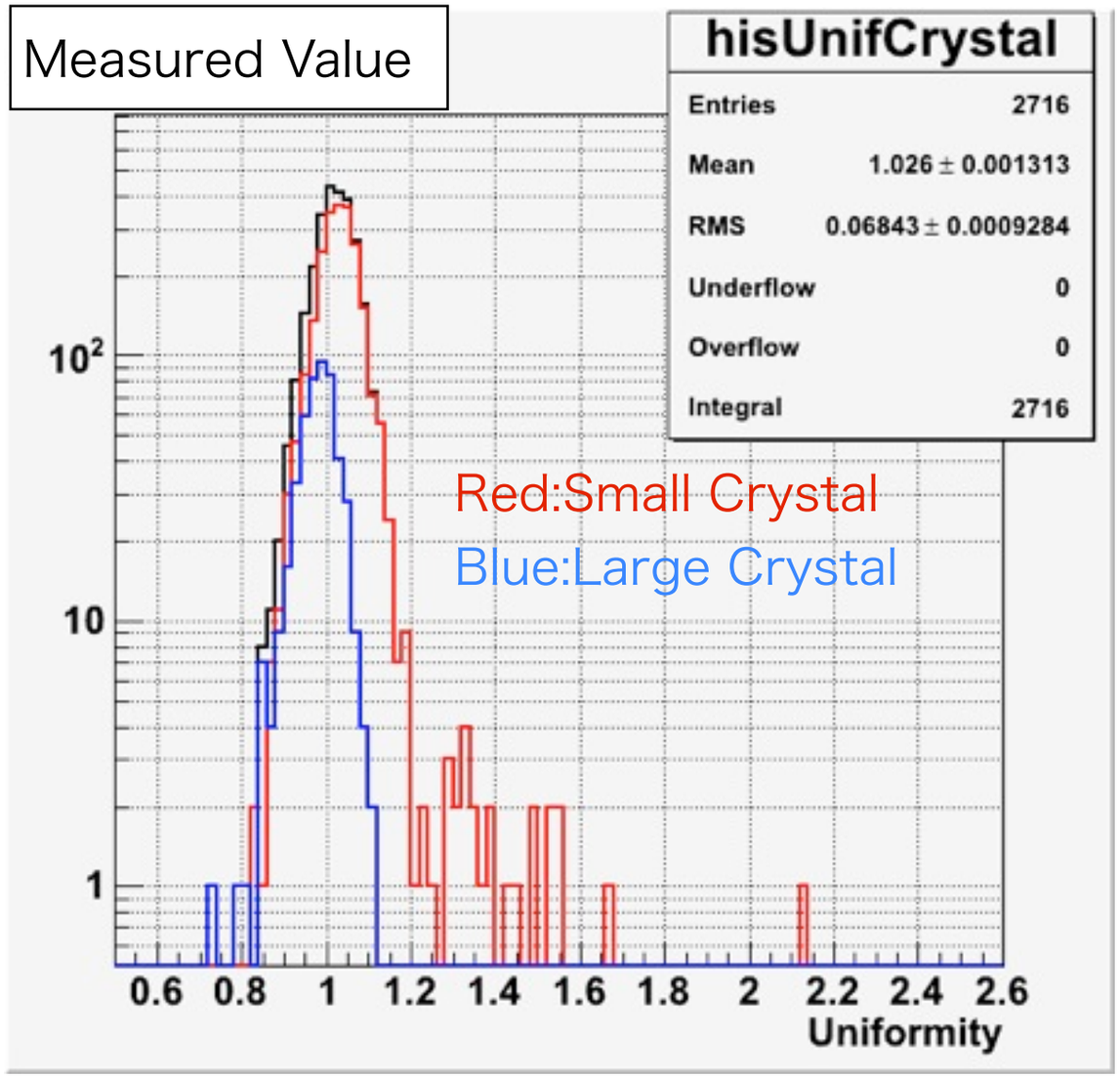
L.Y. Uniformity := E2/E1~1 is expected in ideal.

L.Y. Uniformity Distribution(source)



Uniformity of crystal was measured at Osaka Univ with RI source.

The uniformity of each crystal was adjusted to 1.



If...

If, there was some damage on crystal by earth quake, How survey it?

->Uniformity is useful tool to survey damage

Because ...

If there is some damage on the crystal, the output of upstream place in crystal decrease (E1->e1).

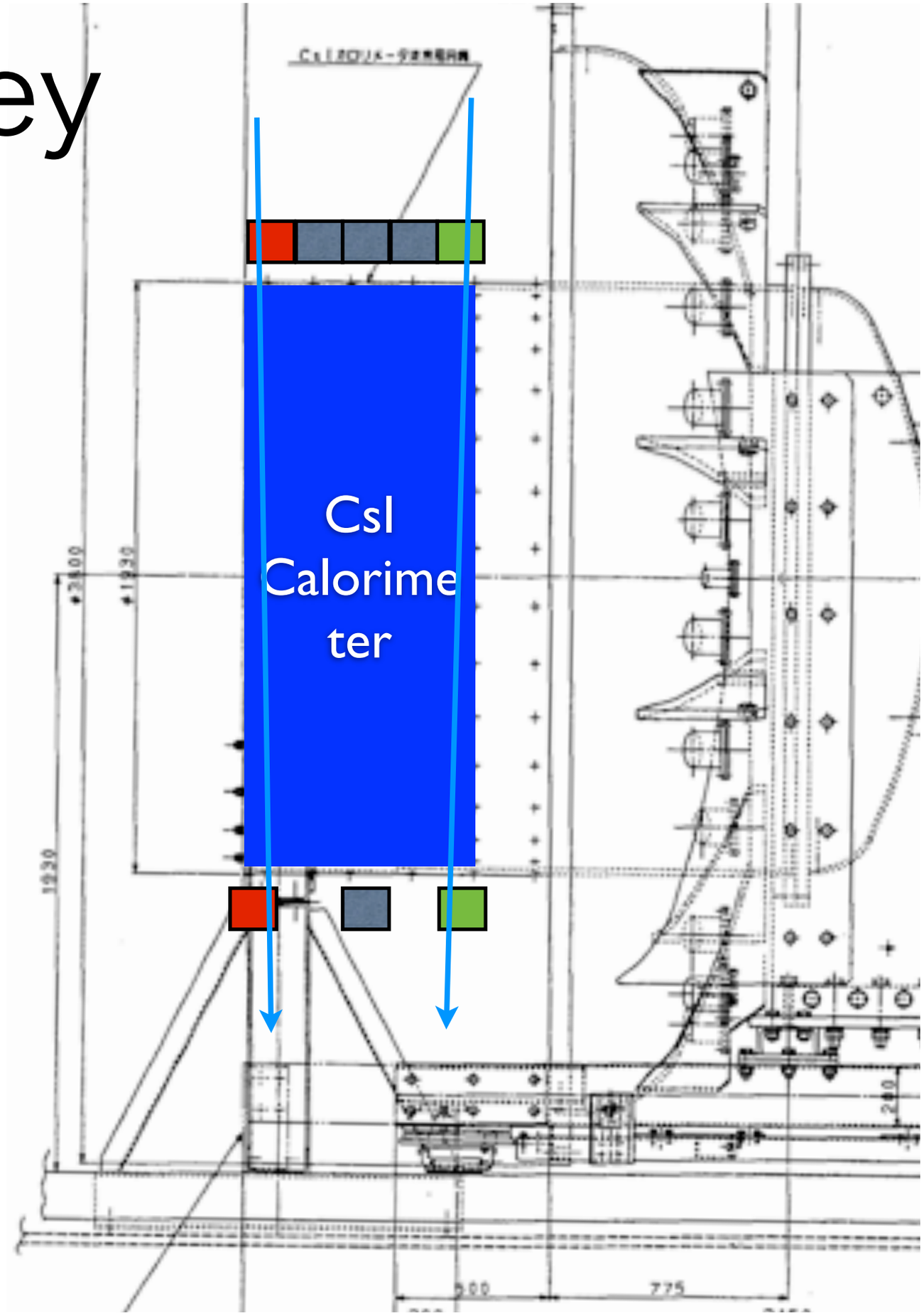
In definition of L.Y.(:=E2/E1), L.Y. is increase when crystal taken damage.

Setup of Survey

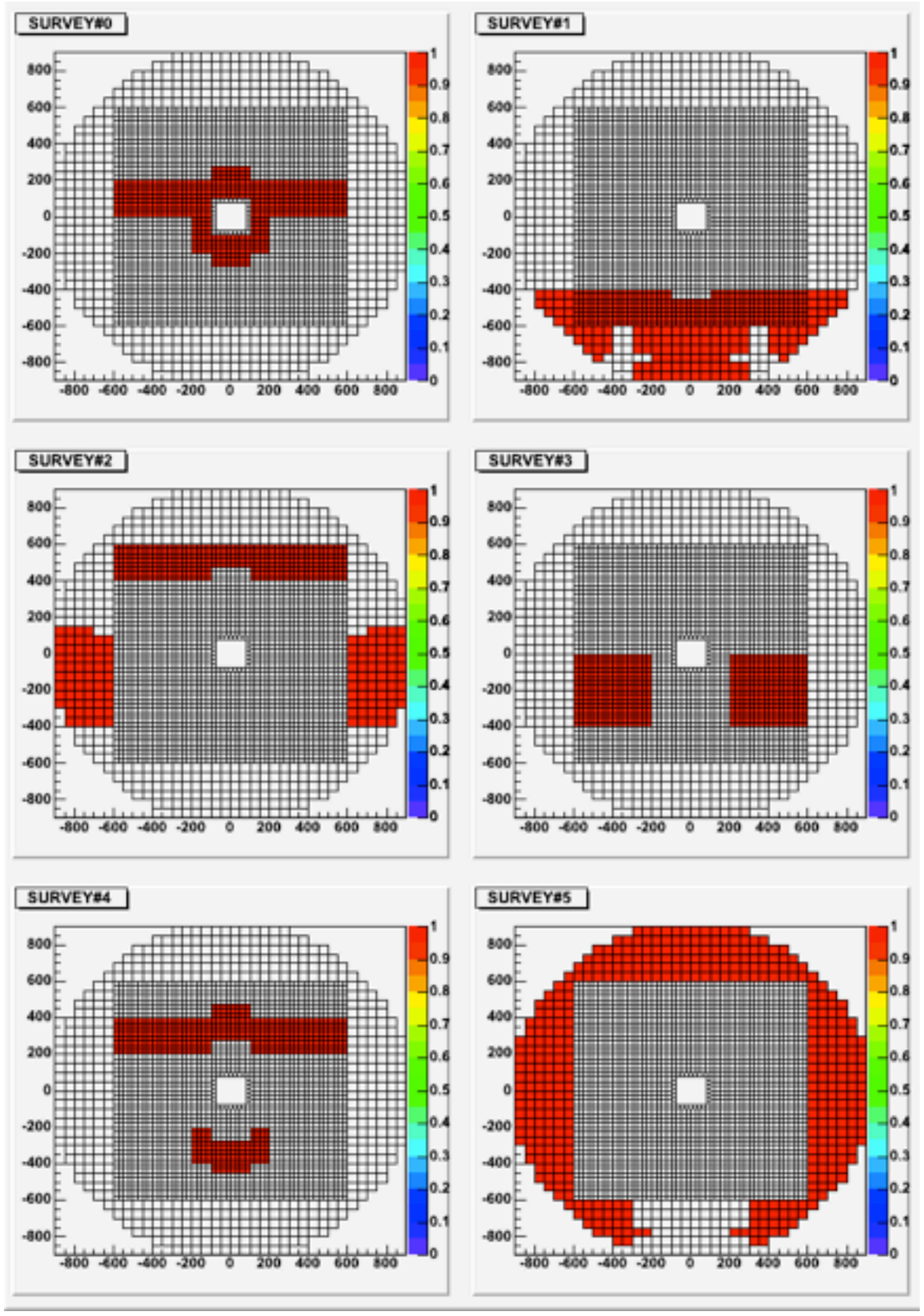
- Setup 8 cosmic trigger over(5) and below(3) of CsI calorimeter.

- measure output @15 point of crystal(the measure points at each crystals change by it's vertical position.)

- Compare with old data, measured with RI source and cosmic ray.

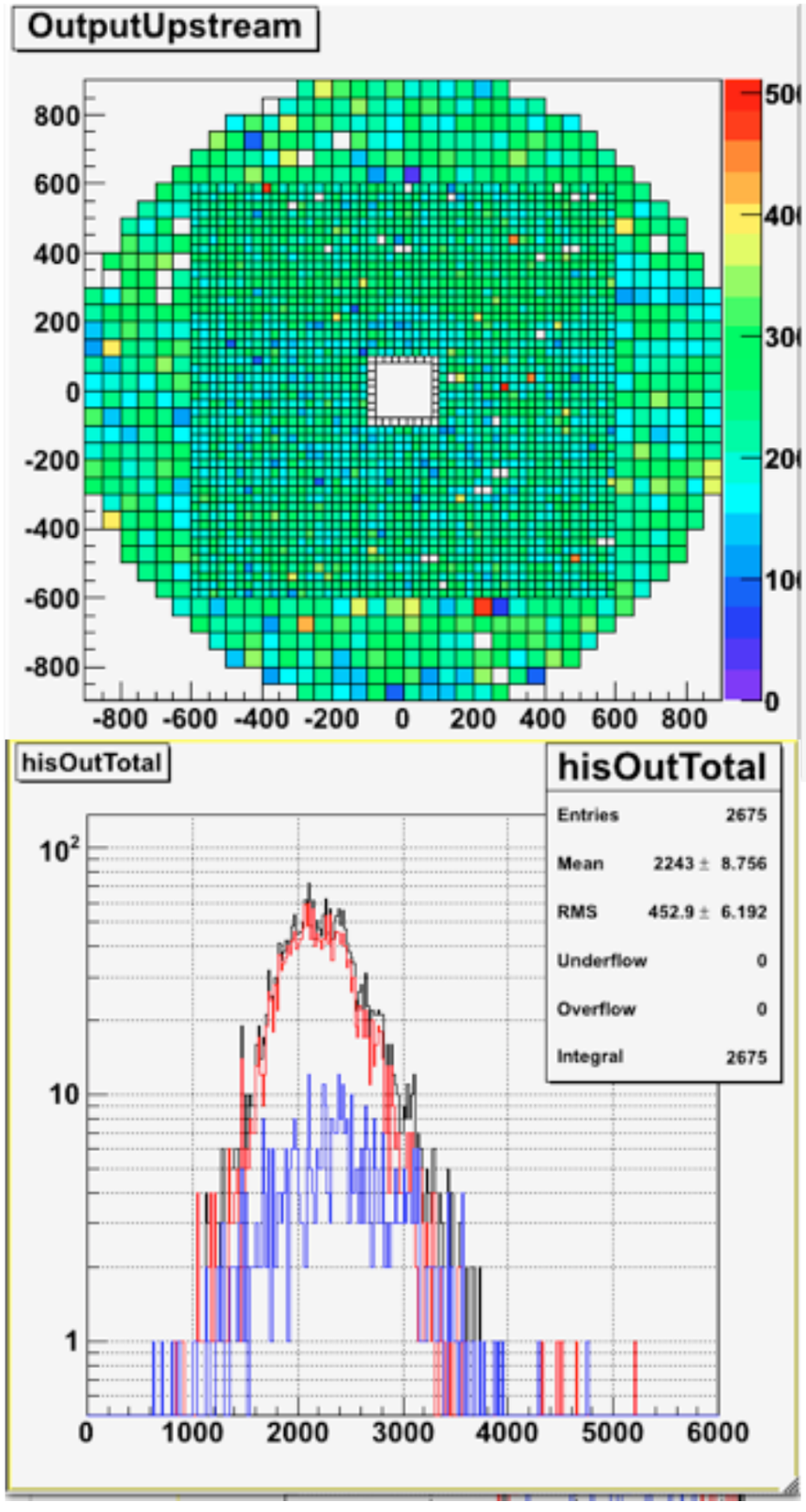


Collect Cosmic Ray Event



- From DC power supply problem, total # of survey CH per one survey is restricted to ~500ch.
- We read (all) channels of CsI calorimeter for the first time.

Result of measurement



- Number of read out channel: 2675/2716
- Mean Output of Small crystal: 2215 ADC count
- Mean Output of Large crystal : 2378 ADC count
- Ideal output of crystal~2200

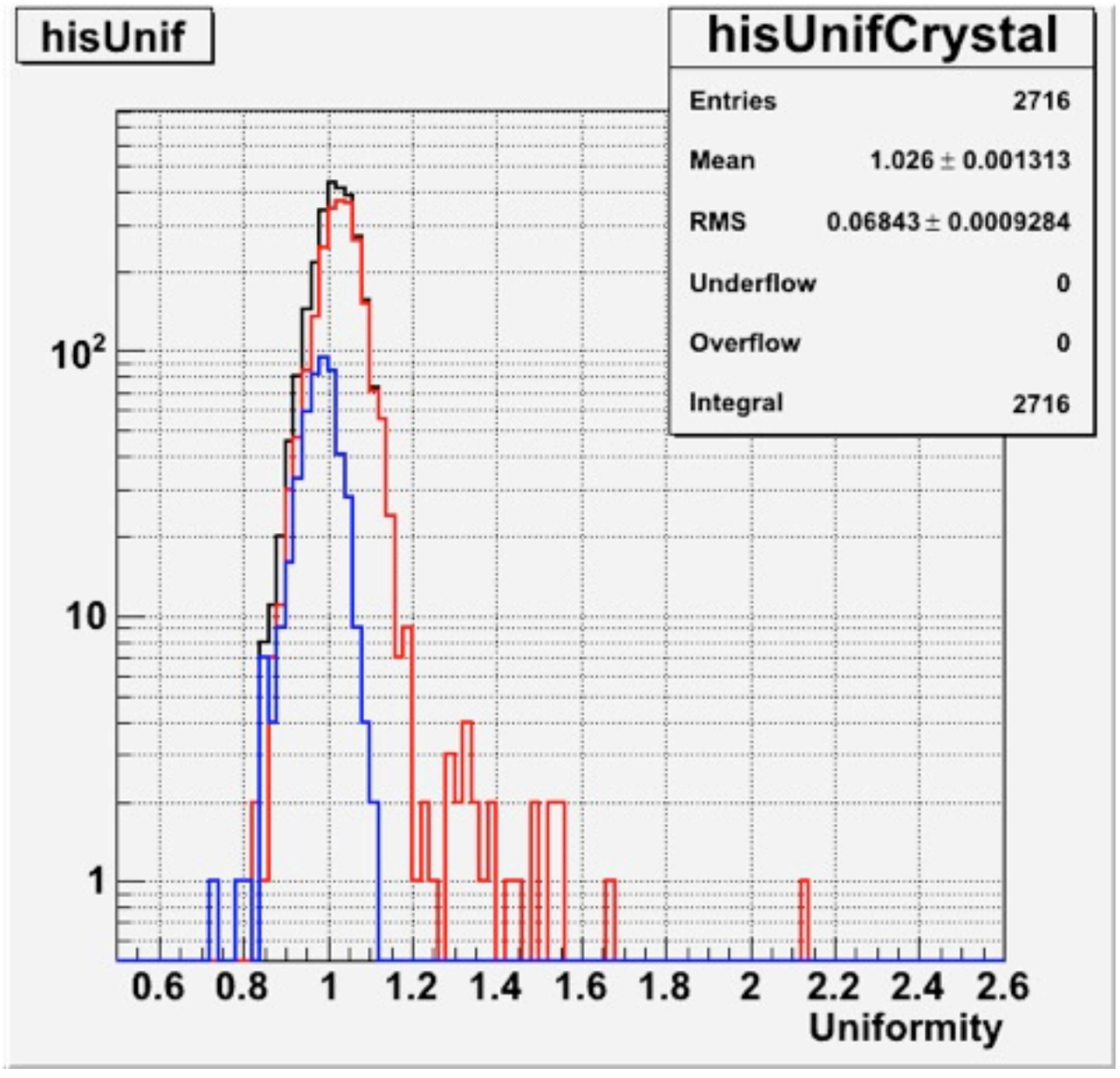
Compare Data sets.

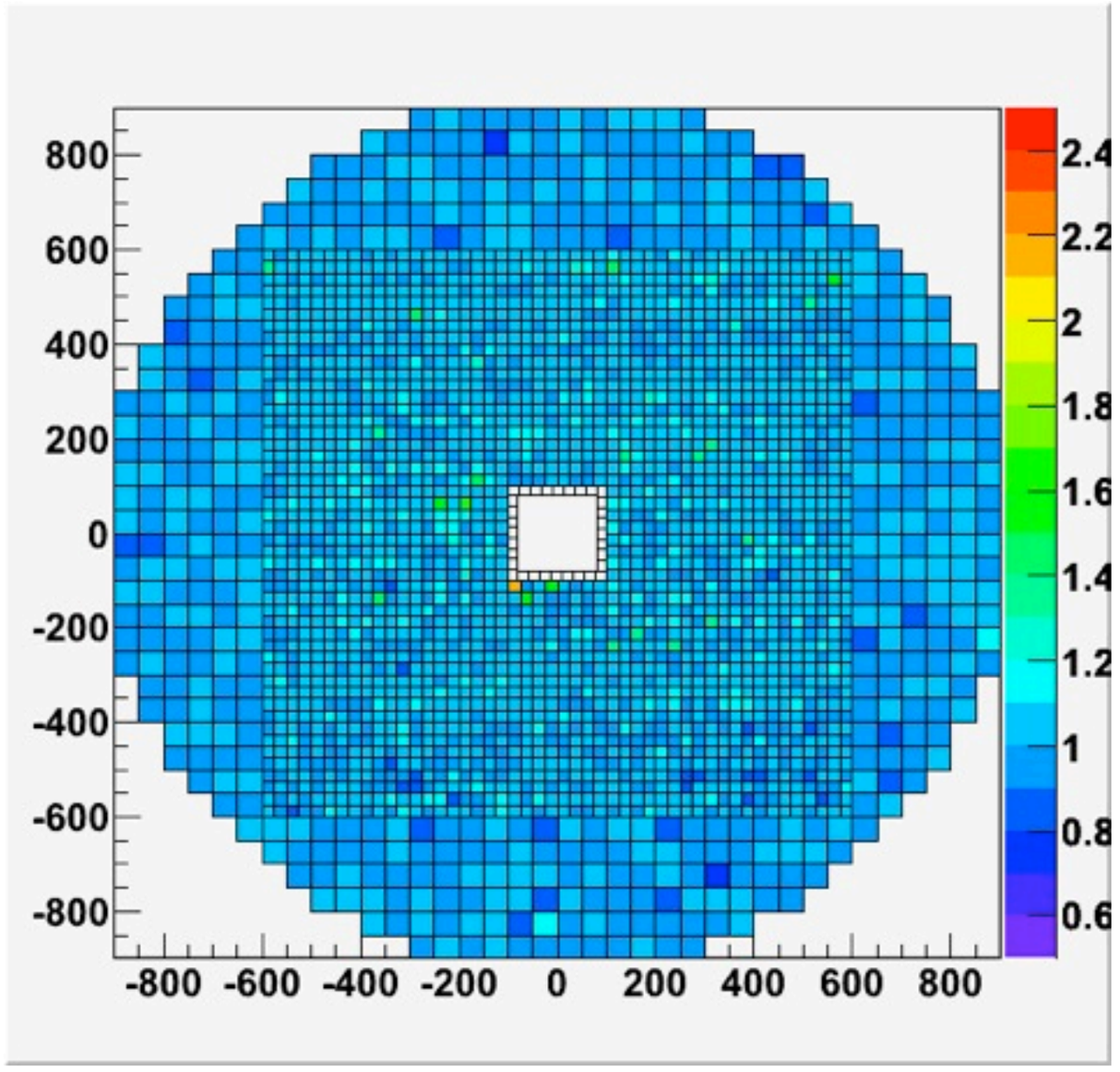
There is three Uniformity data sets.

- Before earthquake, using RI source
- Before earthquake, using Cosmic Ray.
- After earthquake, using Cosmic Ray.

Uniformity(R.I. Source)

- Uniformities(Light yields) of crystals measured with R.I. source 2009~2010 at Osaka Univ.(before build CsI Calorimeter)

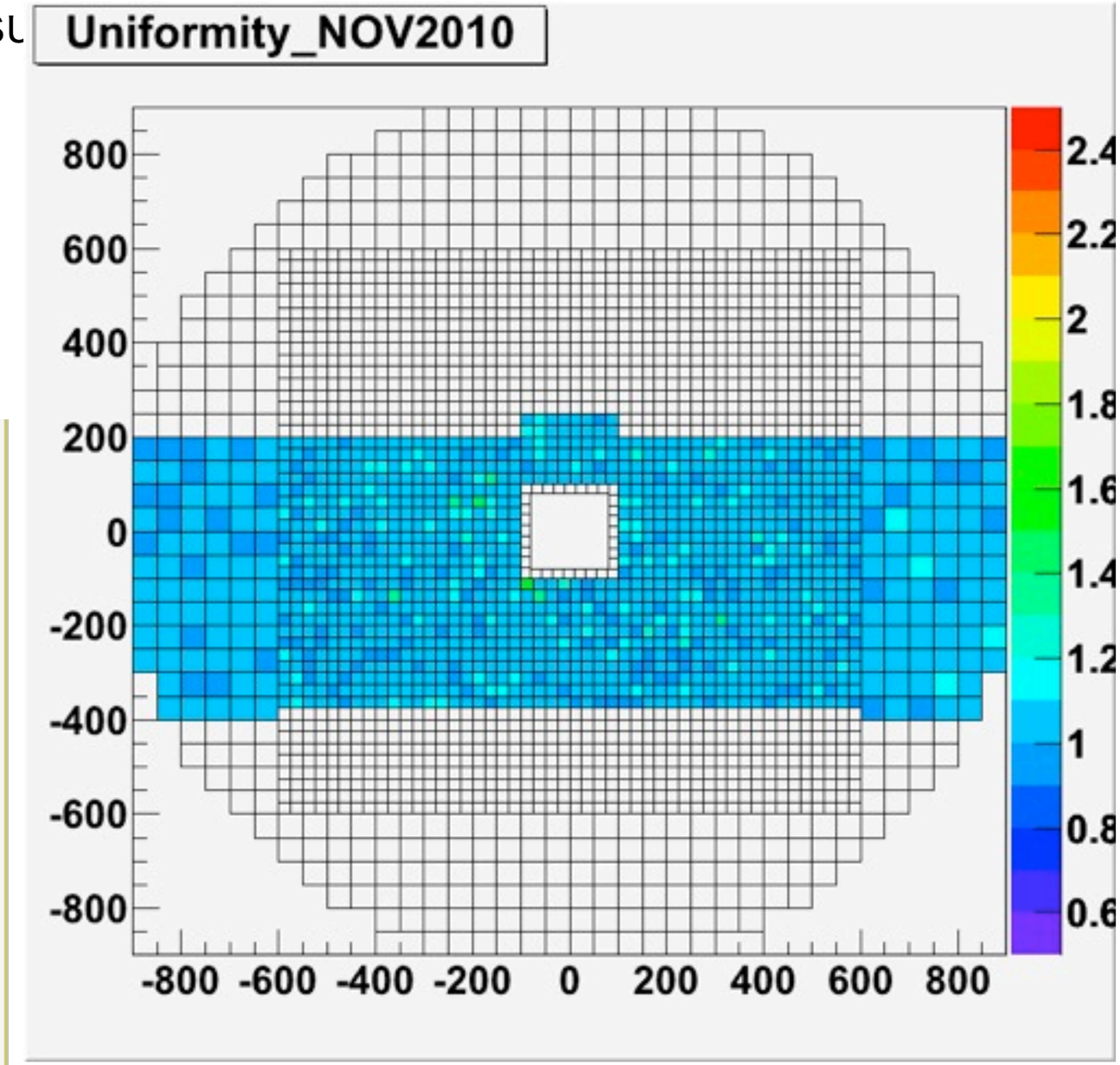


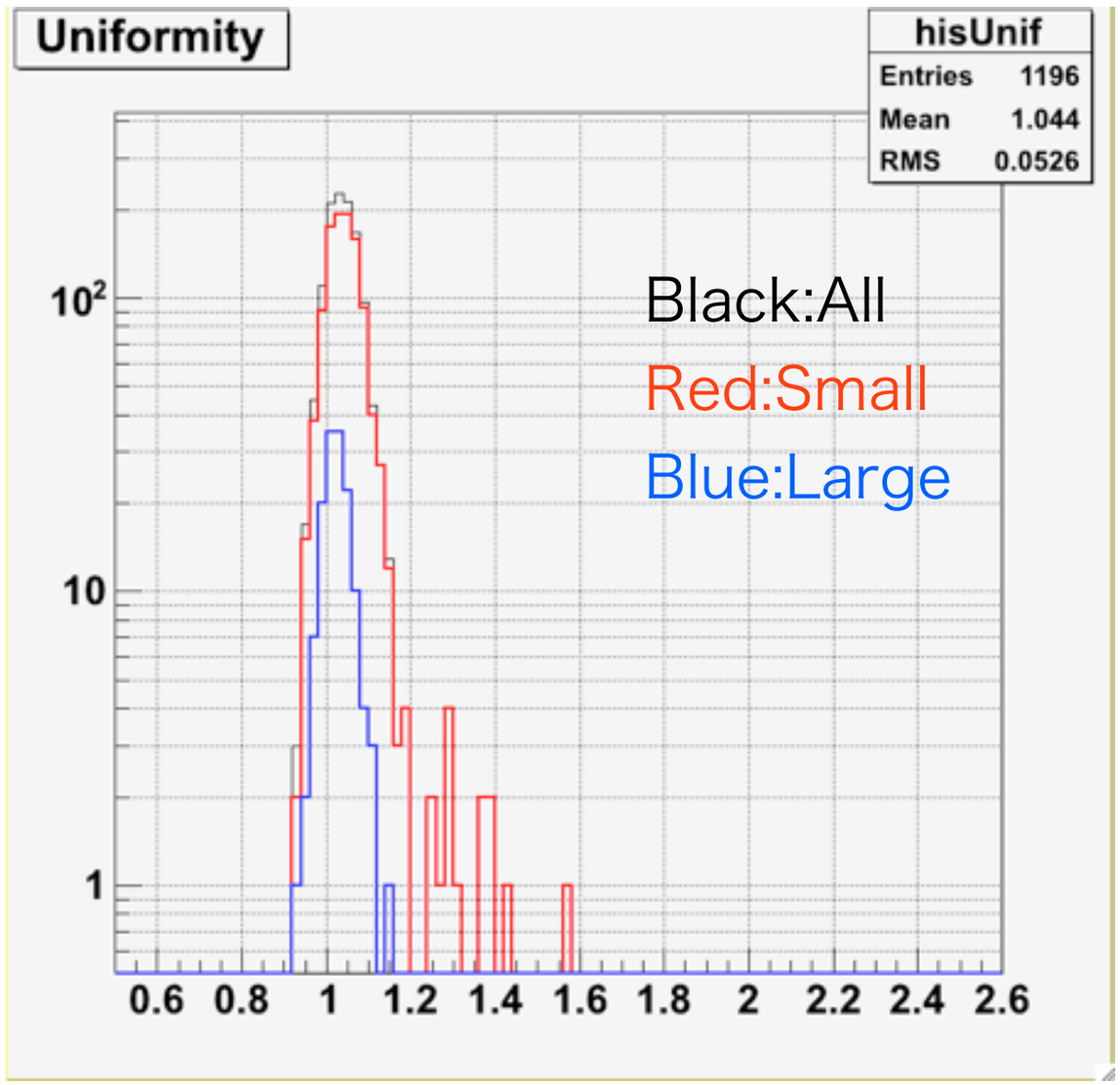


*Uniformity:=
average L.Y. of (z>400mm)/
average L.Y. of (z<100mm)

Uniformity(C.R.:Nov,2010)

- Uniformities of Crystals were measu after beam test at Nov. 2010.
- Cosmic ray trigger position was different from now.

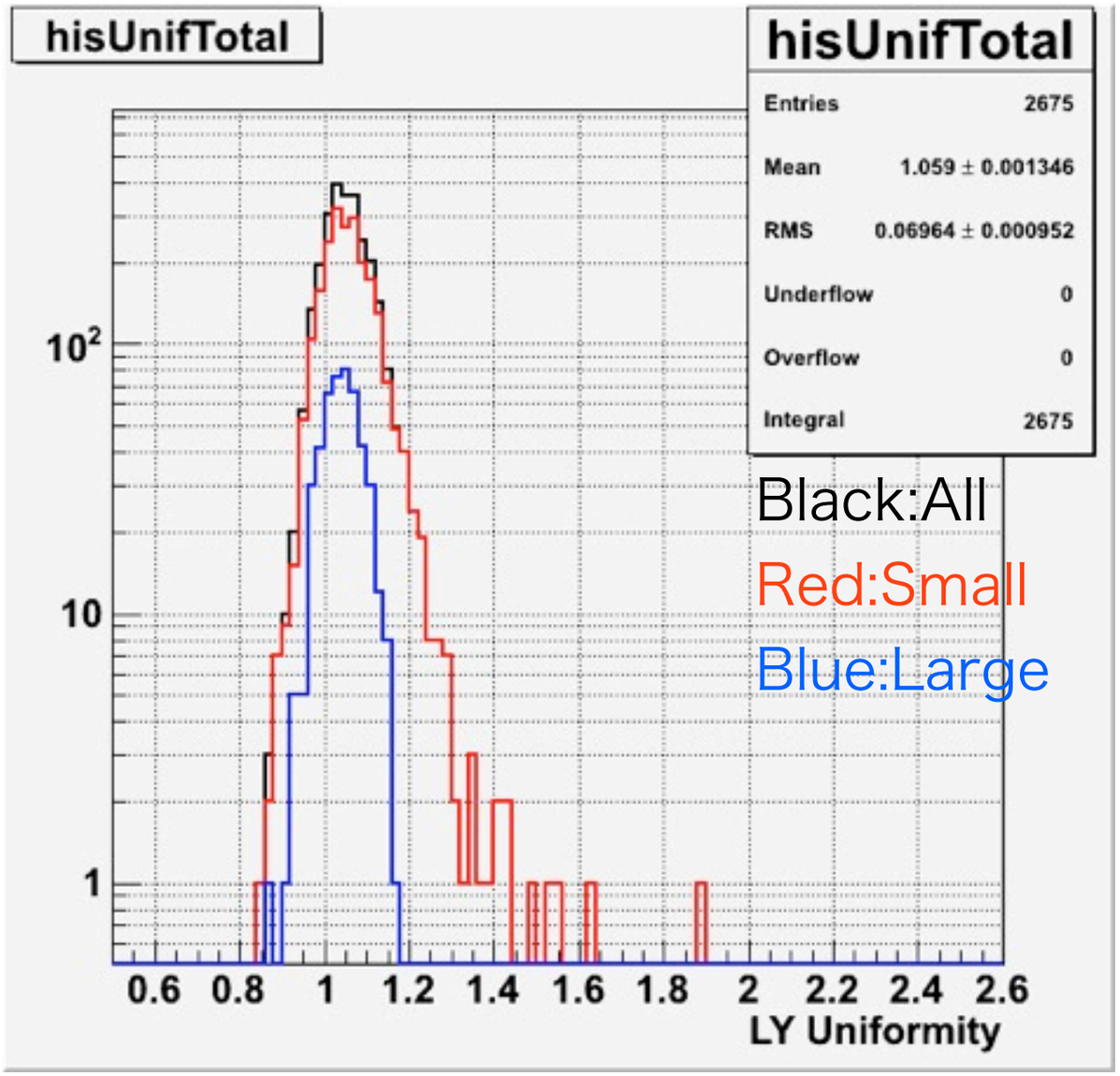


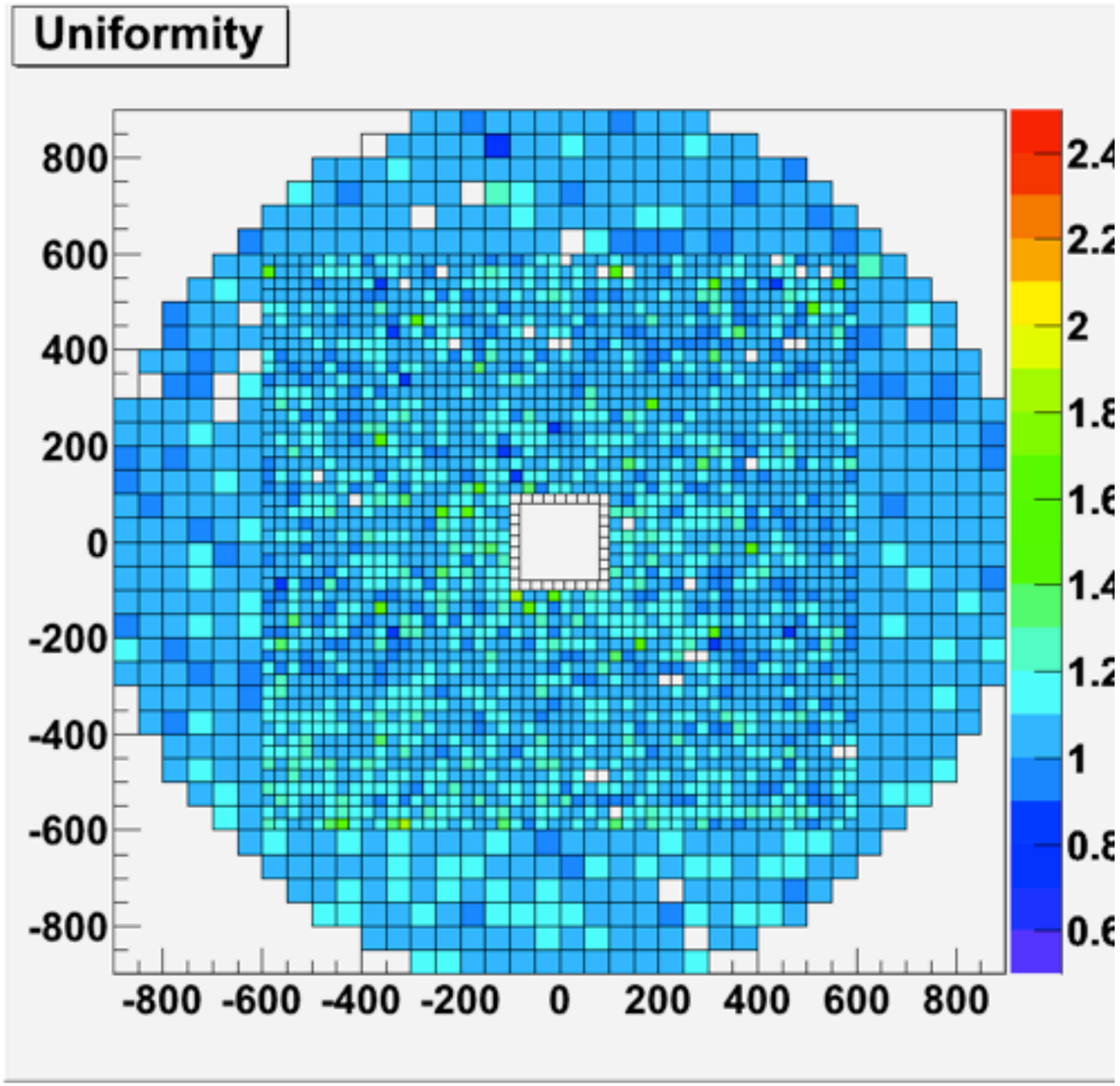


- LY Uniformity Small:0.9-1.6
- LY Uniformity Large:0.9-1.2

Uniformity(C.R.:May-Jul,2011)

- Uniformities of large crystals were 0.9~1.2.
- Uniformities of small crystals were 0.85~1.8.

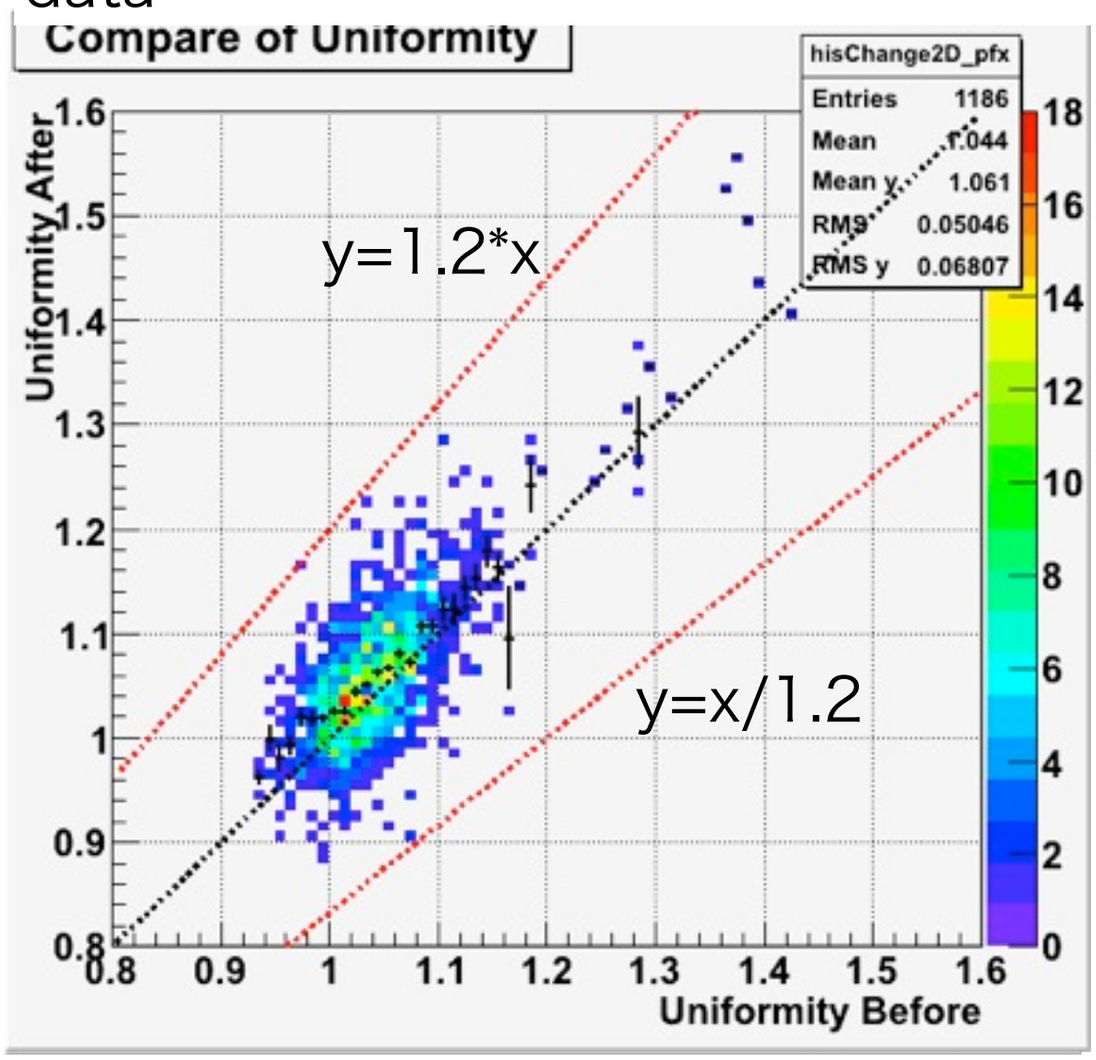




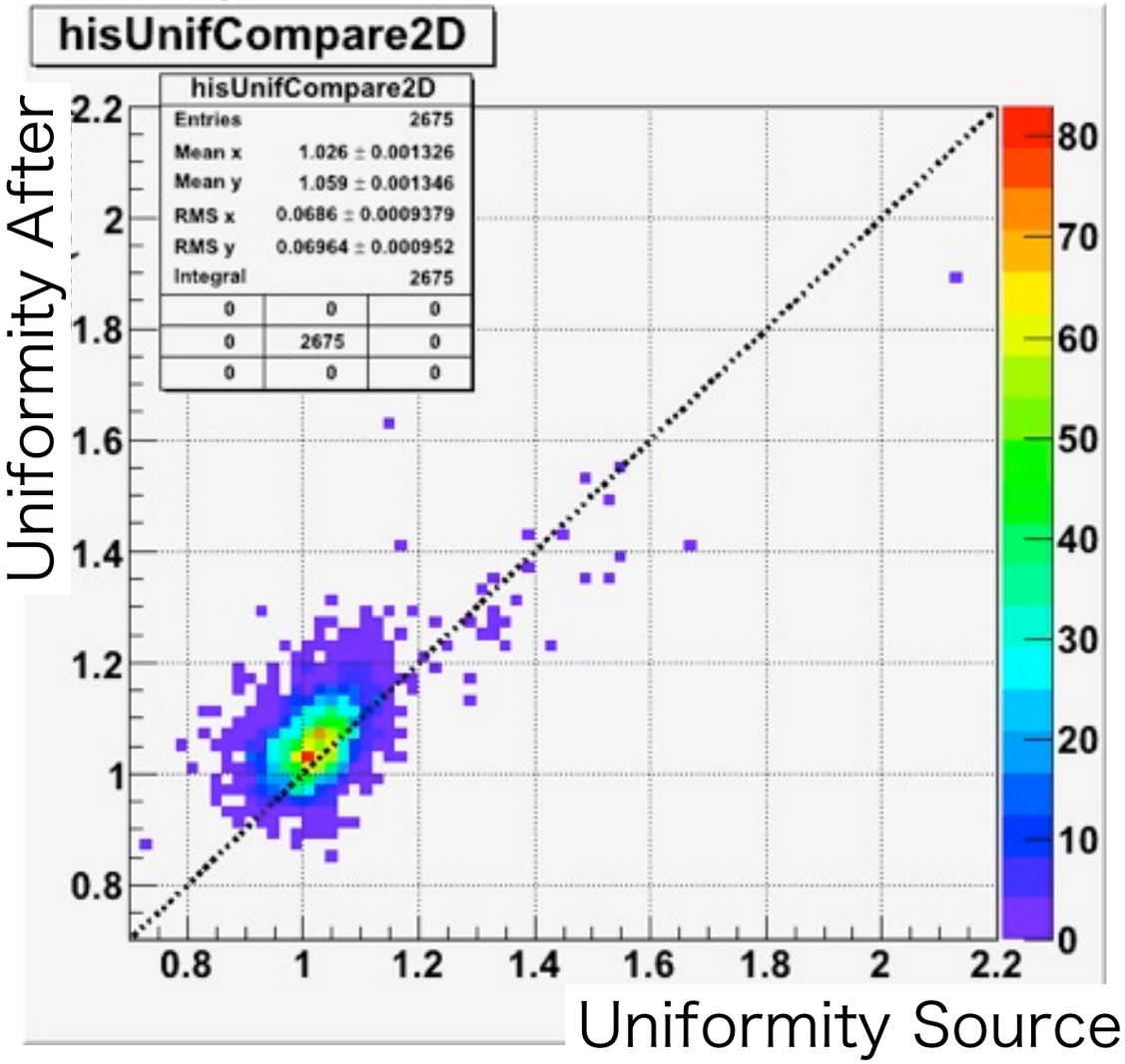
- Crystals(Uniformity > 1.5)-> Compare with other raw data.

Compare Uniformity

Compare with Before-Earthquake data

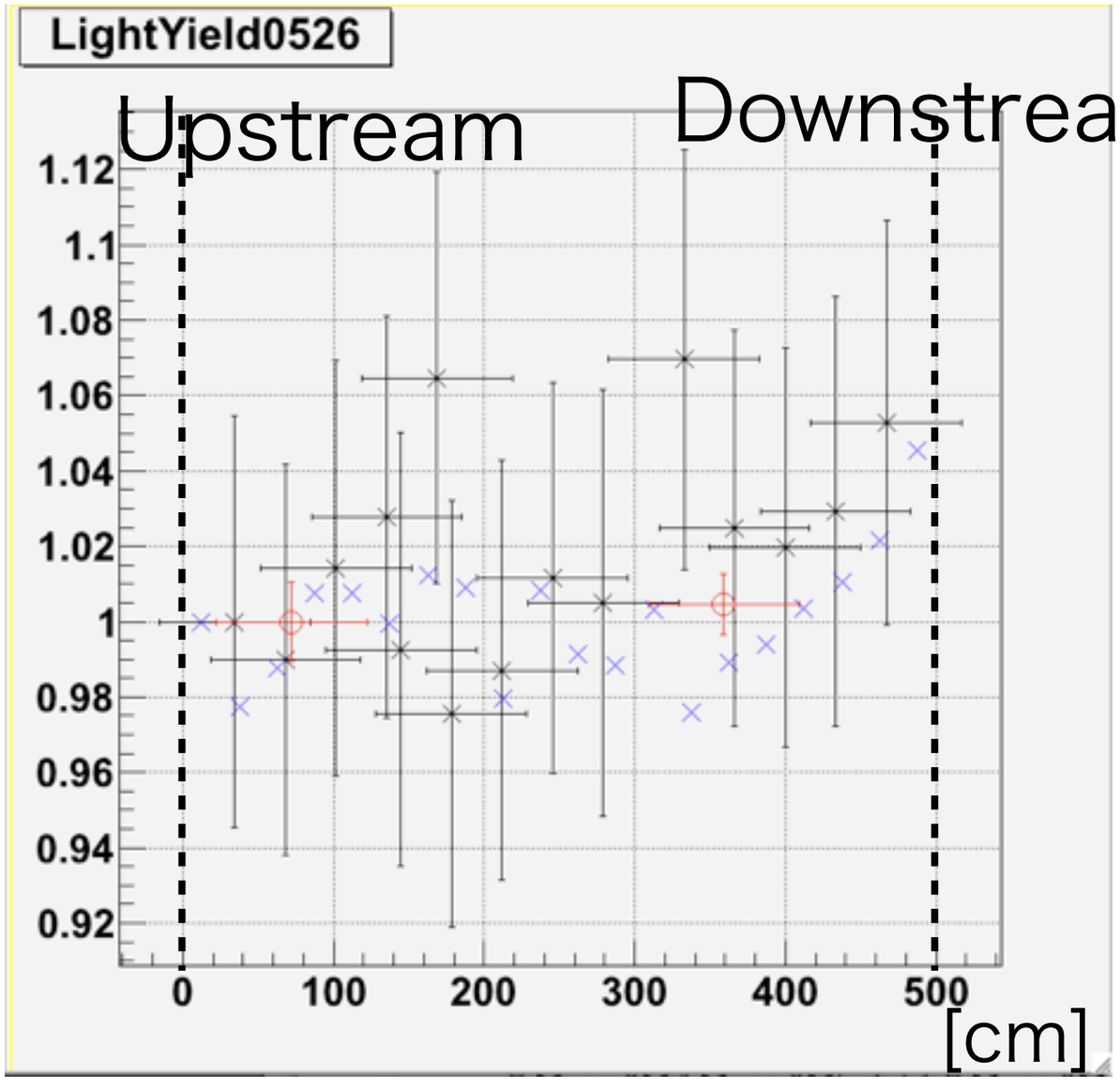


Compare with Source Data



- The influence of earth quake on CsI calorimeter was limited for output and Uniformity.
- Difference of Uniformities of each measurement are less than 20%.

Compare Uniformity



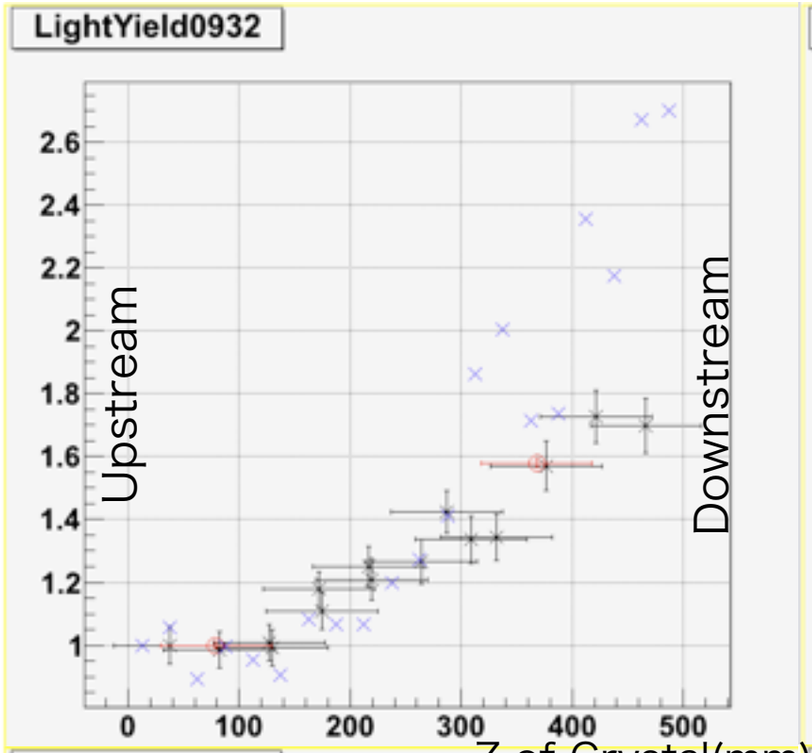
In the case of most of crystals, three data set of Uniformity agreed in each data set.

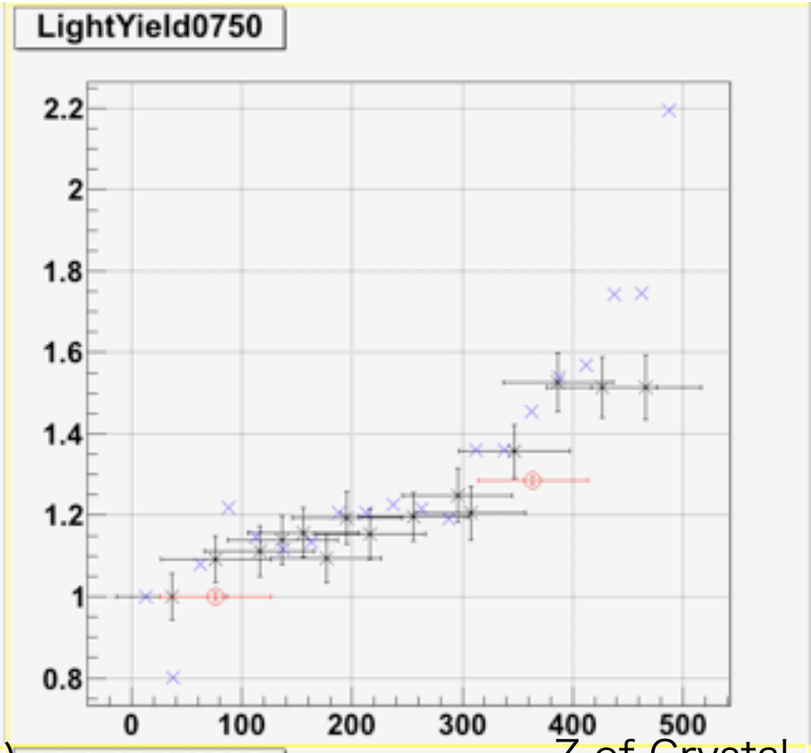
->Crystals didn't damaged.

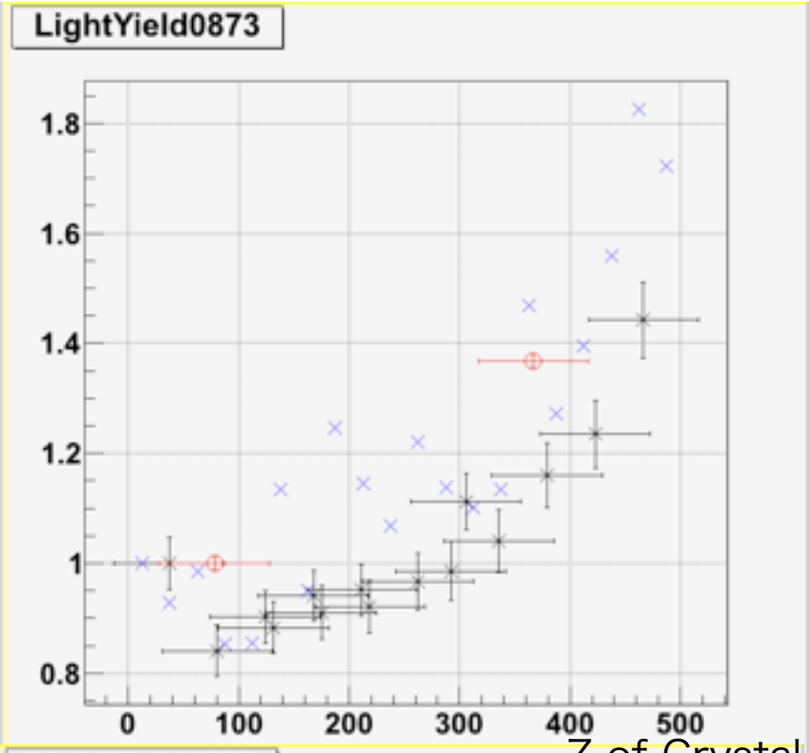
Black:After earthquake(cosmic)

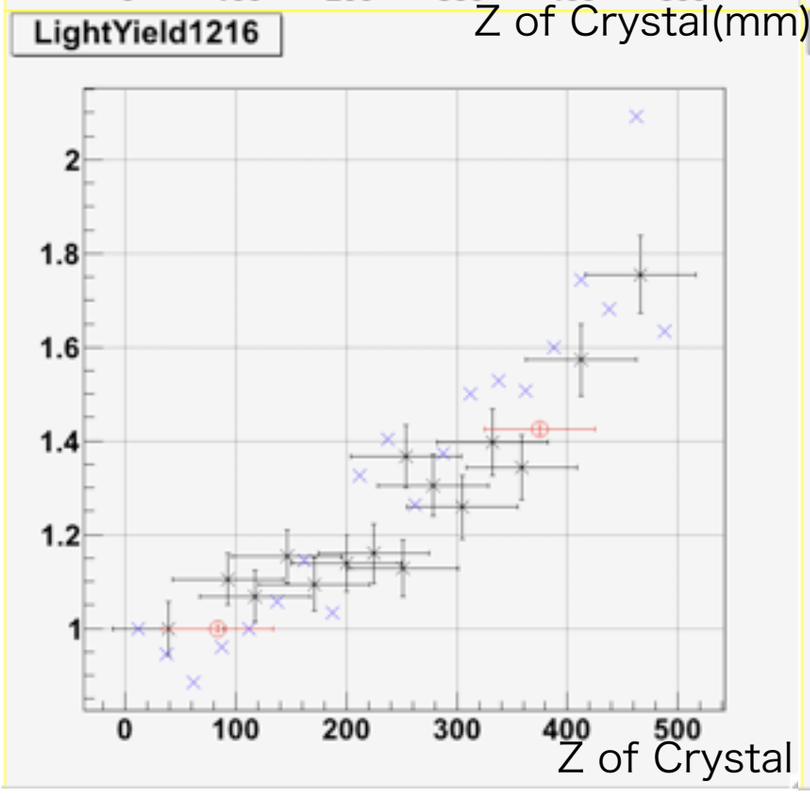
Red:Before earthquake(cosmic)

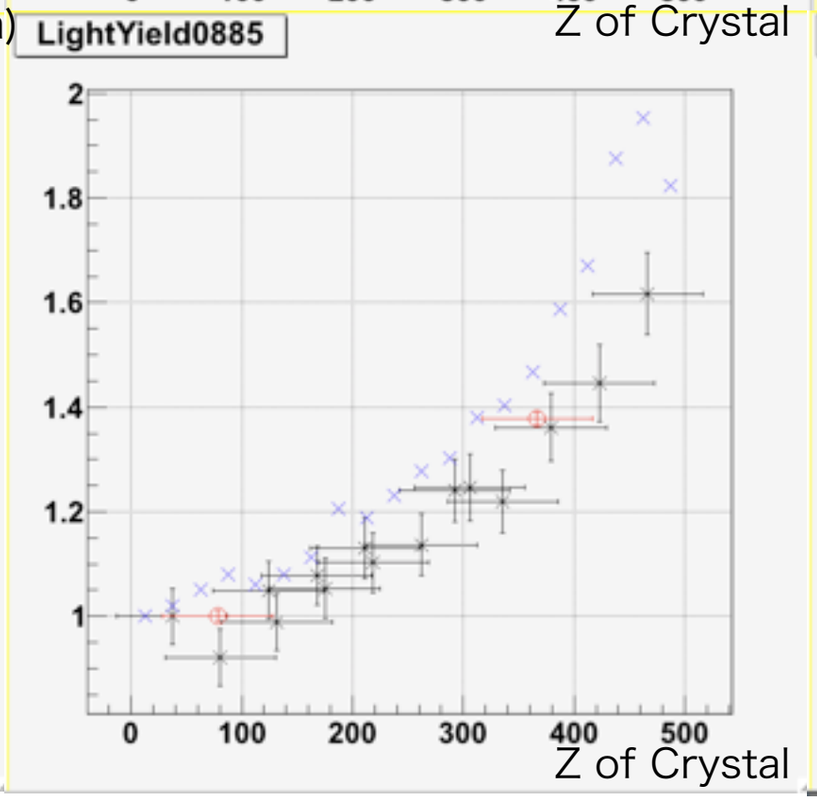
Blue:Before earthquake(source)

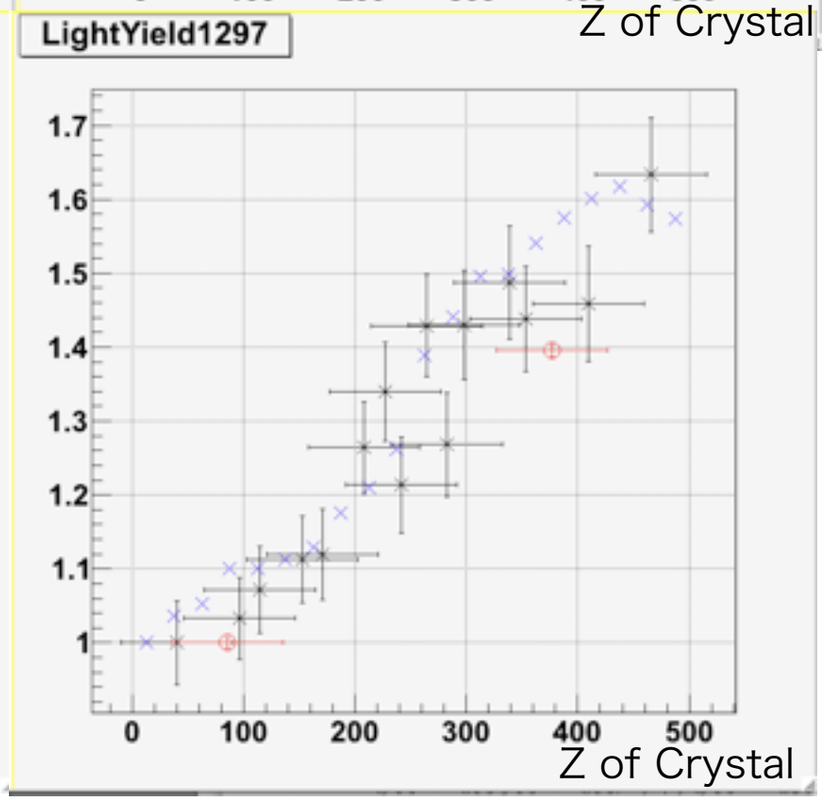












Black:Cosmic,Apr-Jun,2011
Red:Cosmic,Nov,2010
Blue:Source2009/2010

Compare raw uniformity result for each case.
Displayed Graphs are Uniformity > 1.5 @ survey in 2011

Measurements of uniformity are consistent among R.I. source, C.R. (before earthquake) and C.R. (after earthquake)

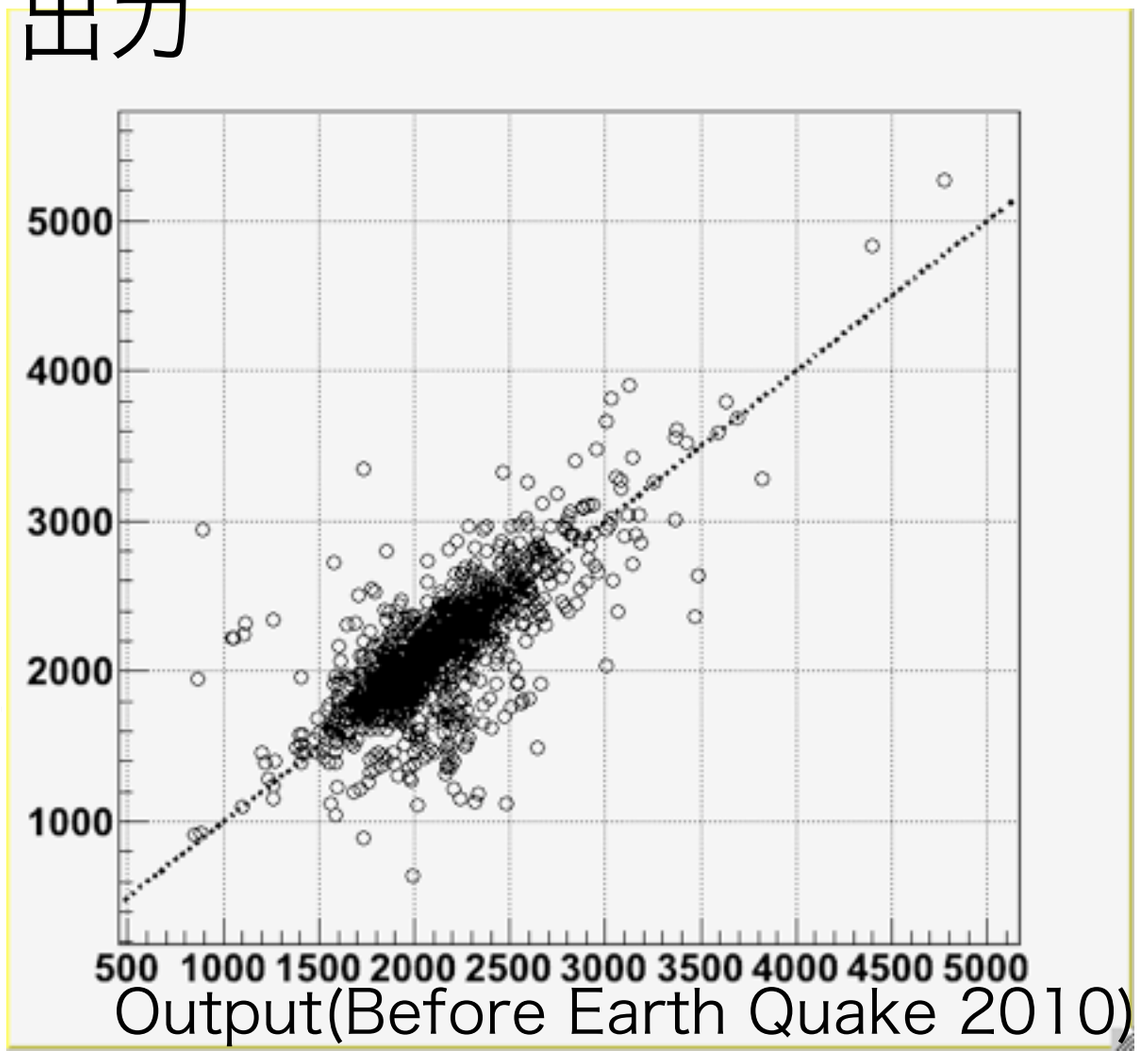
-> No significant damage on CsI crystal due to earthquake

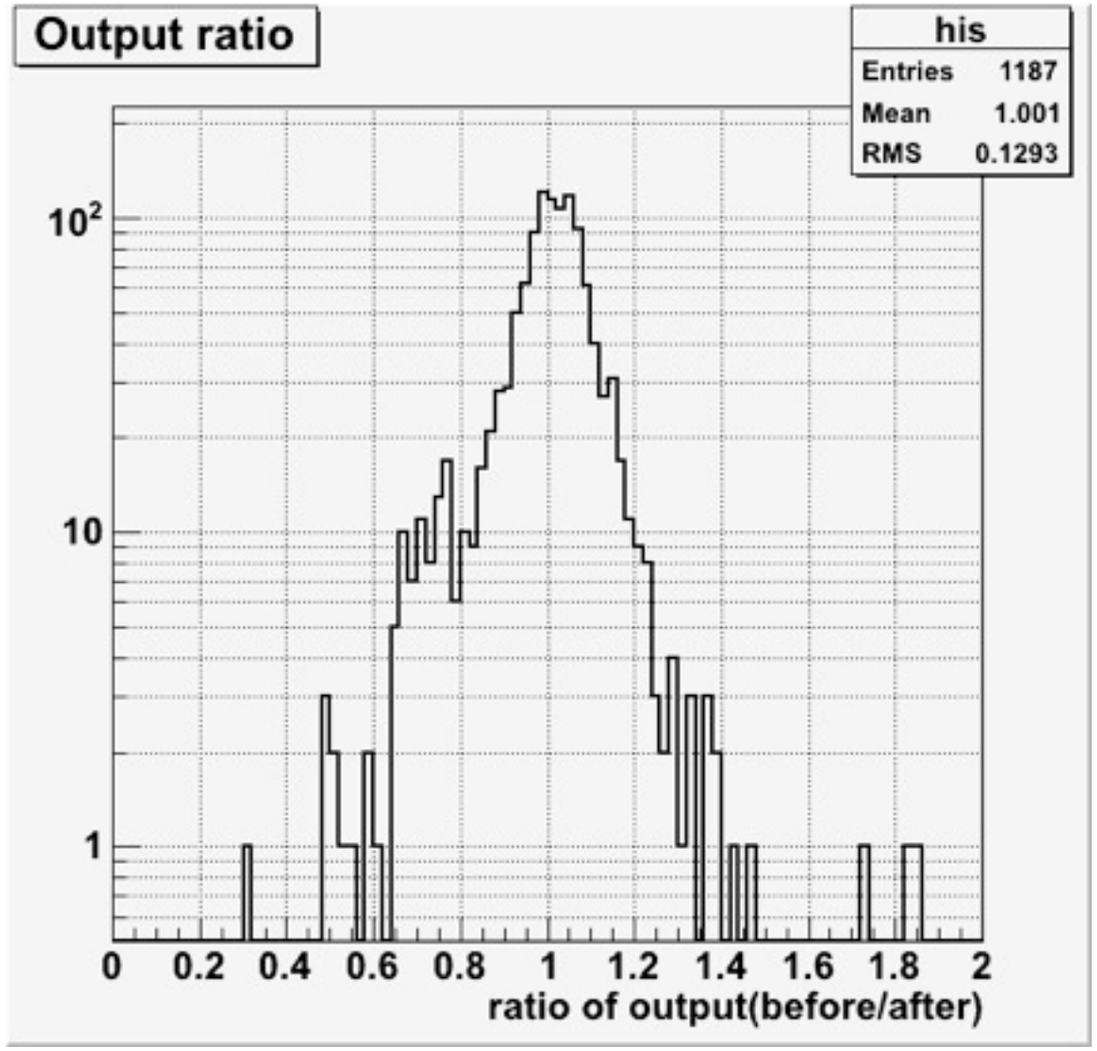
Summary

- We surveyed earth quake damage of CsI calorimeter by measure uniformities of all Crystals.
- Compared with other uniformity data.
- Result of survey, there is (no) significantly damaged crystal.

Back up

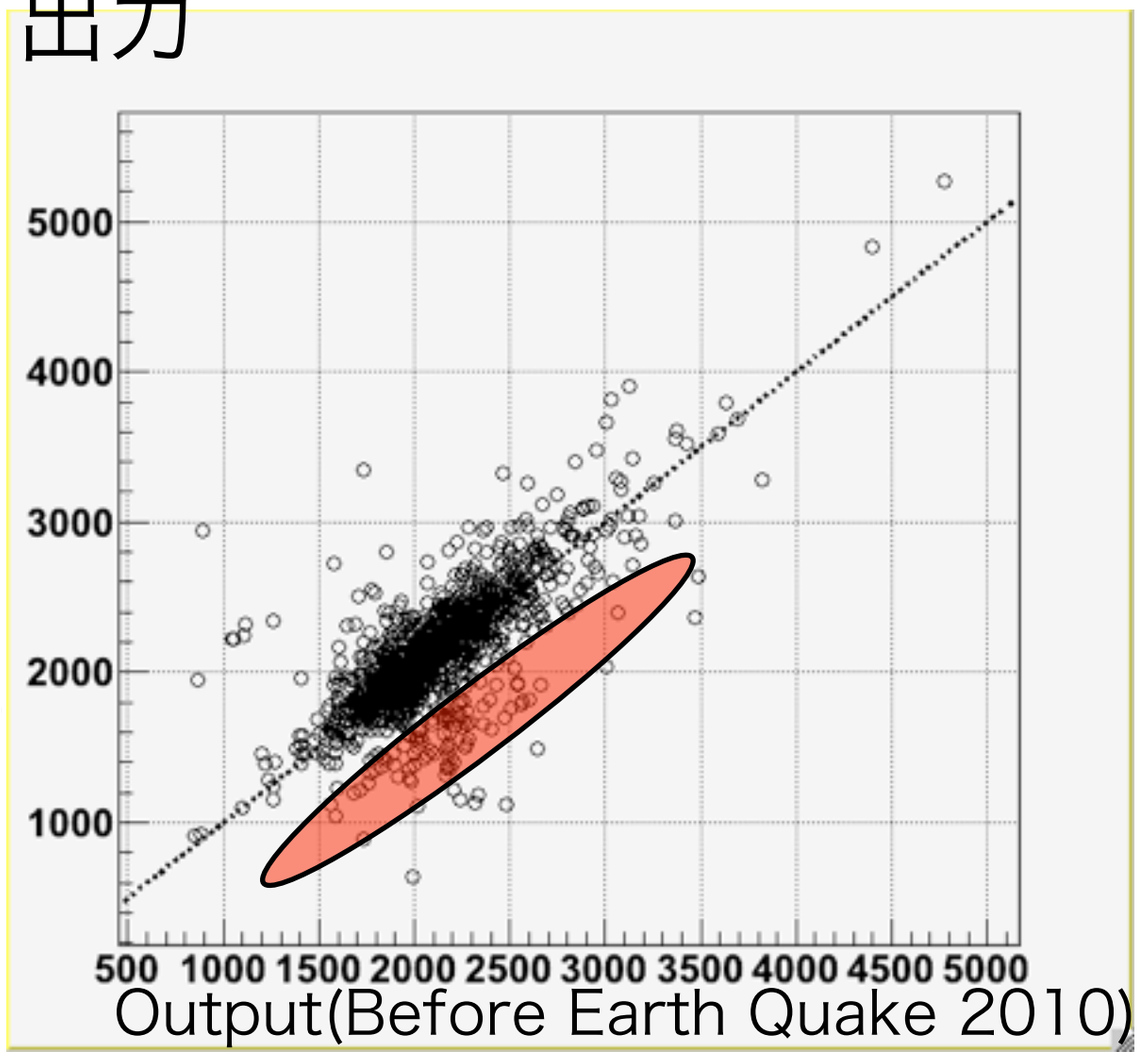
地震前後の出力の比較(宇宙線)

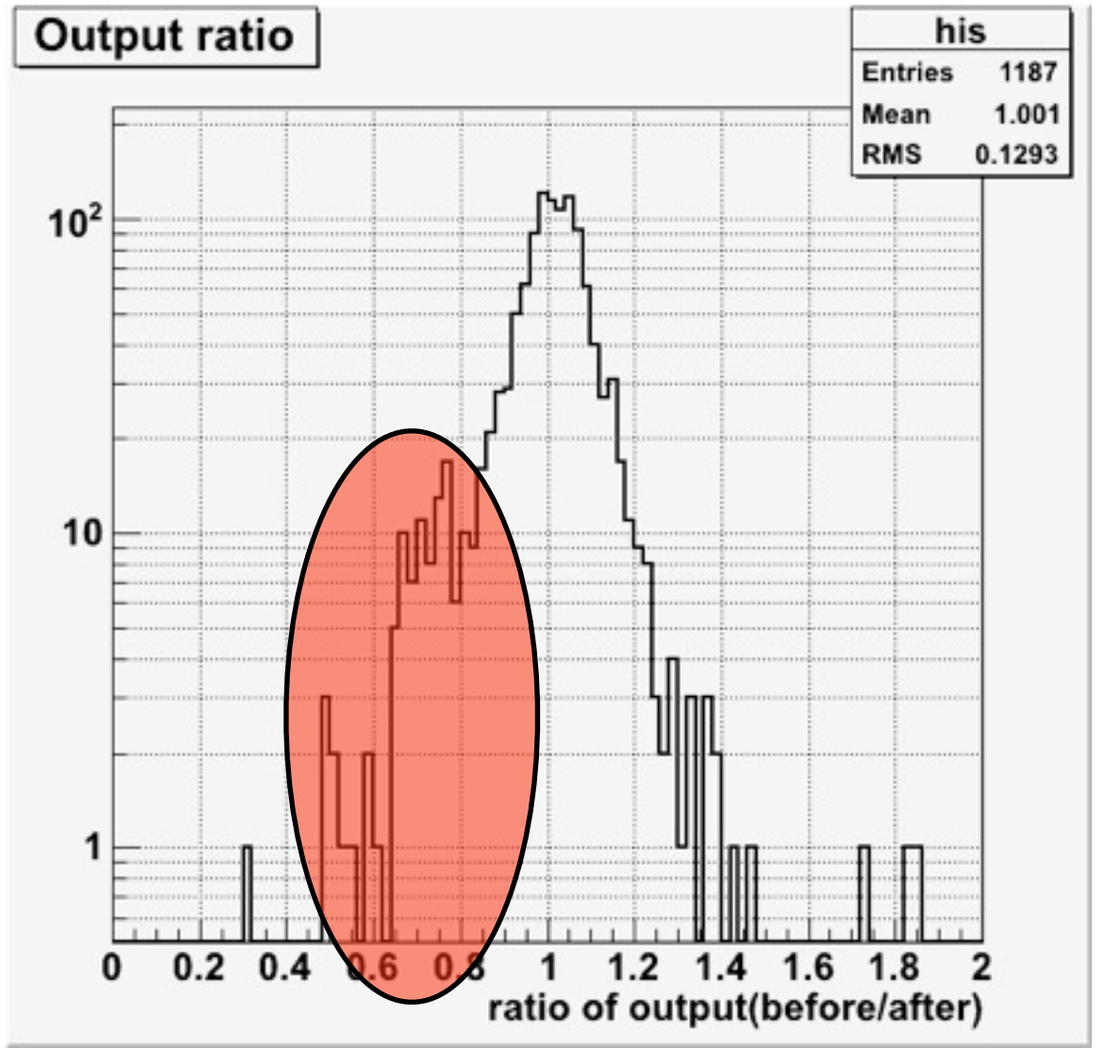




- 多くの結晶ではその出力は殆ど変化していない。
- 60ch程度が地震前より光量が30%程度落ちている。
- その原因は？ (結晶の白濁化？それ以外の理由？)

地震前後の出力の比較(宇宙線)





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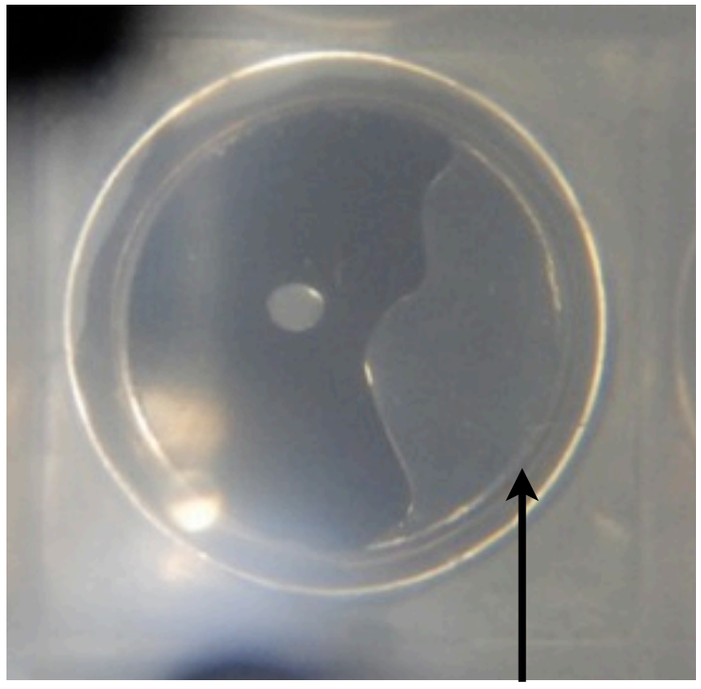
出力変化の原因

上流側から観察

シリコンCookie



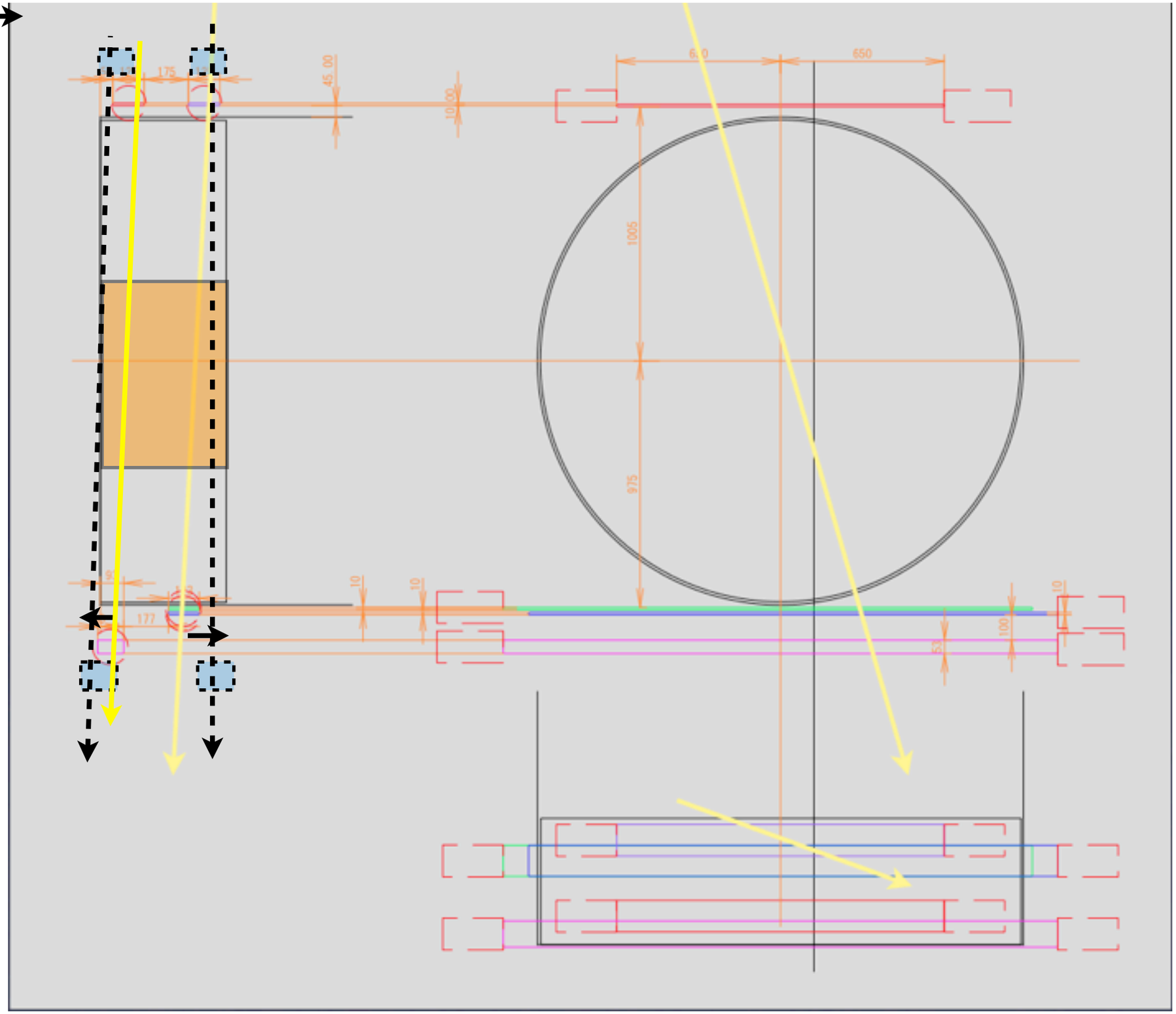
剥がれた部分

L:=地震前後の出力比

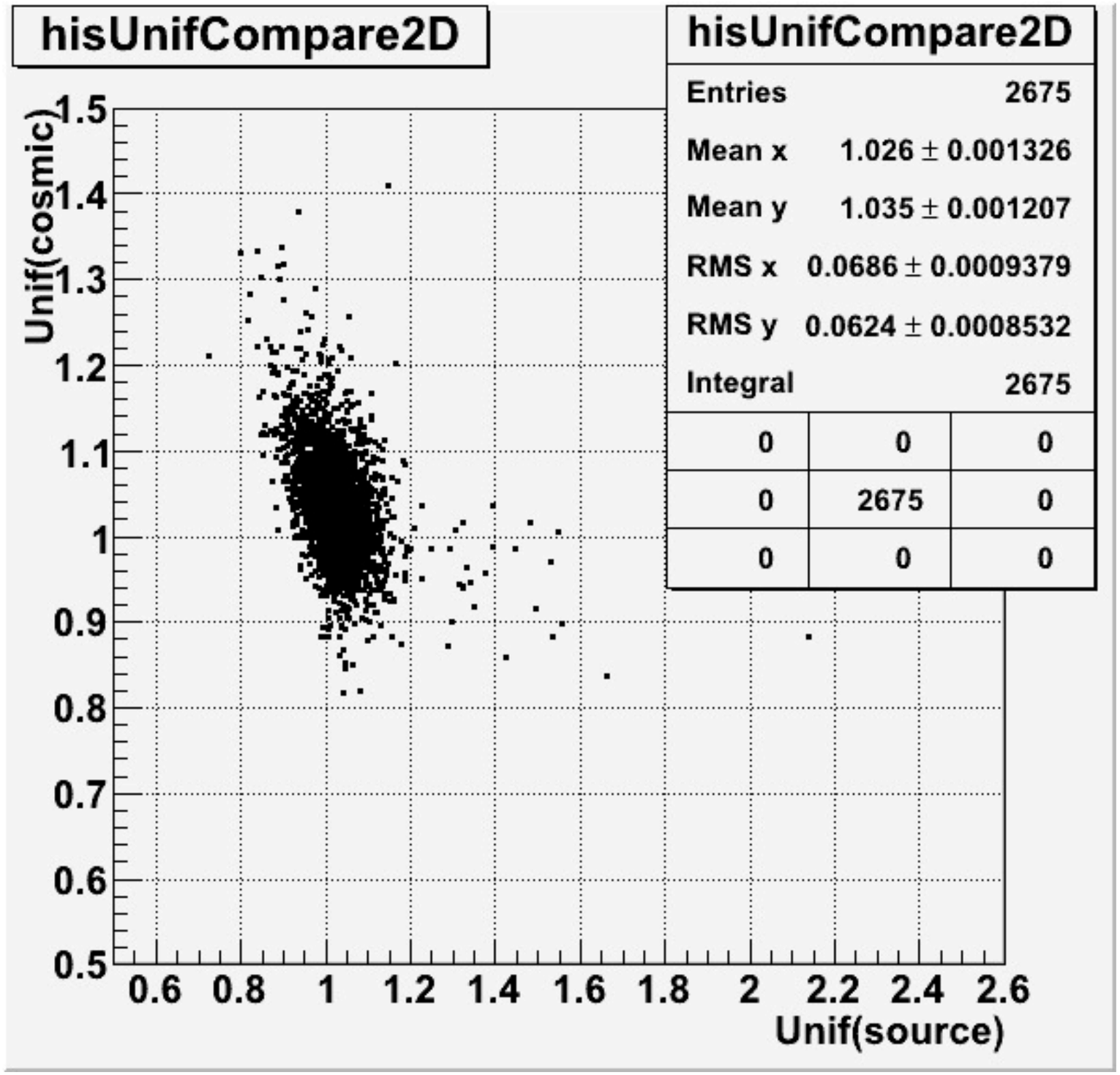
シリコンCookieの付着面積比率	L<0.75		L~1	
	Large	Small	Large	Small
0~30%	6	2	0	0
30~70%	0	8	6	2
70~100%	0	0	0	8

出力の変化の原因:~~結晶表面の自濁化~~→シリコンCookieの光学接続

Setup of Cosmic ray trigger Nov.2010

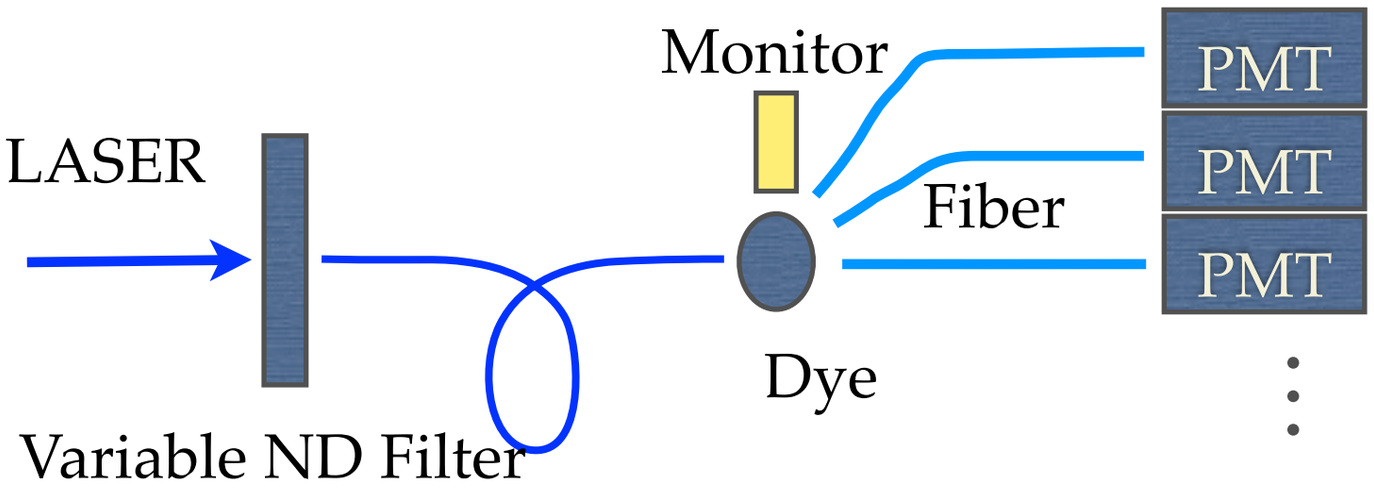


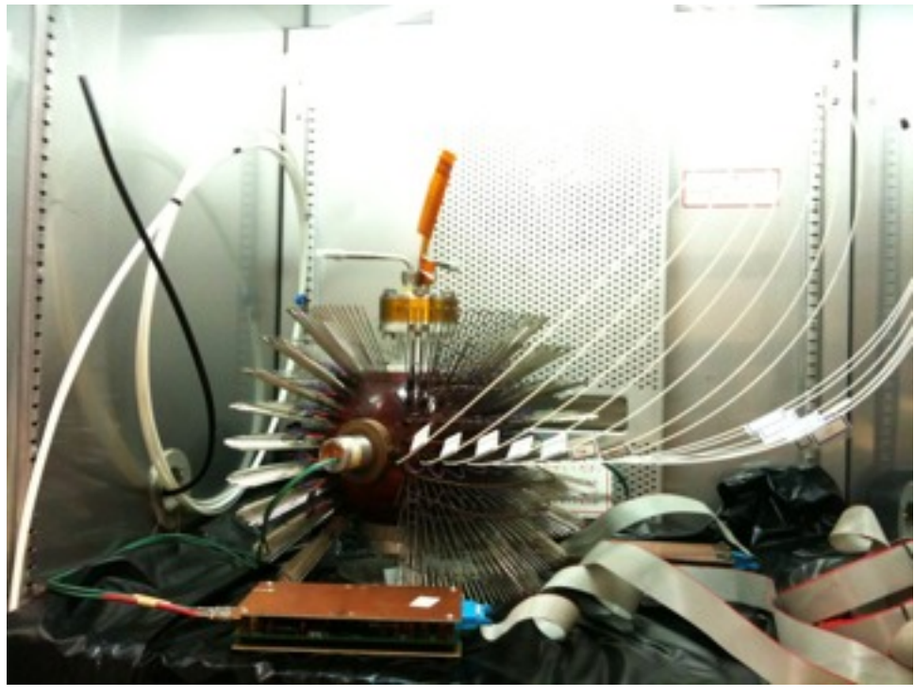
Uniformity source vs cosmic(2011)



PMT & CsI

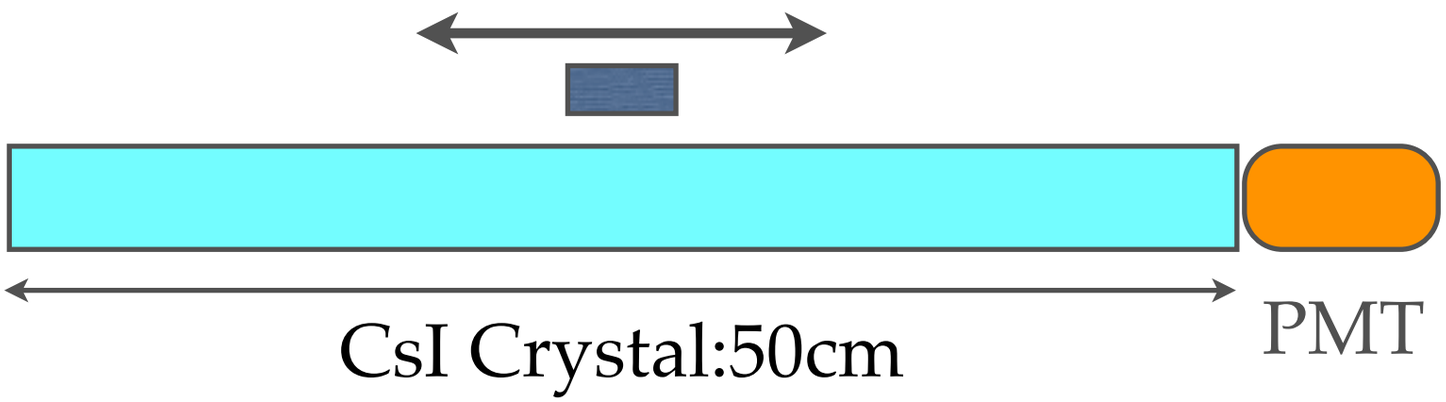
PMT Linearity measurement

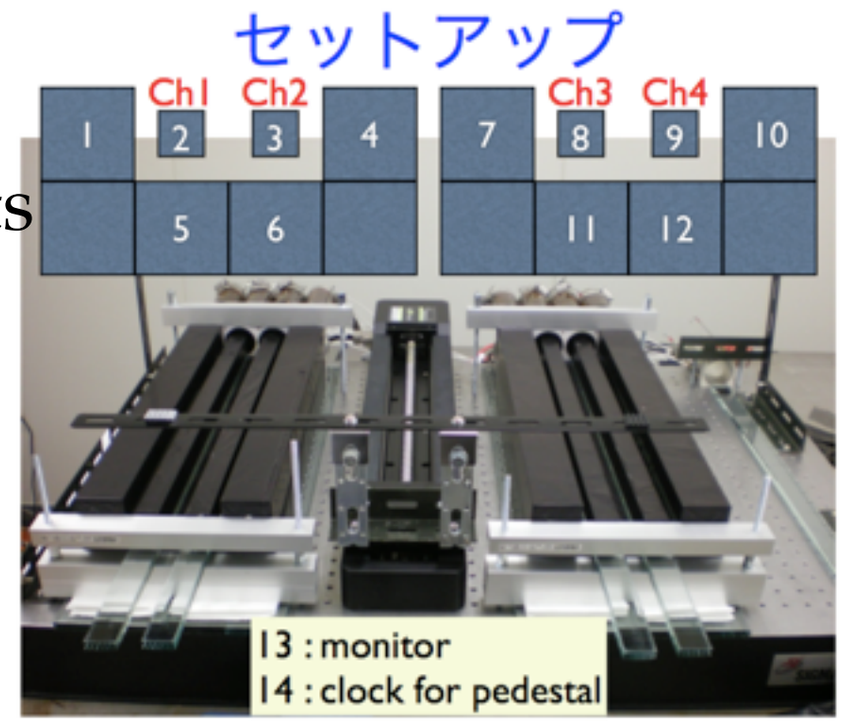




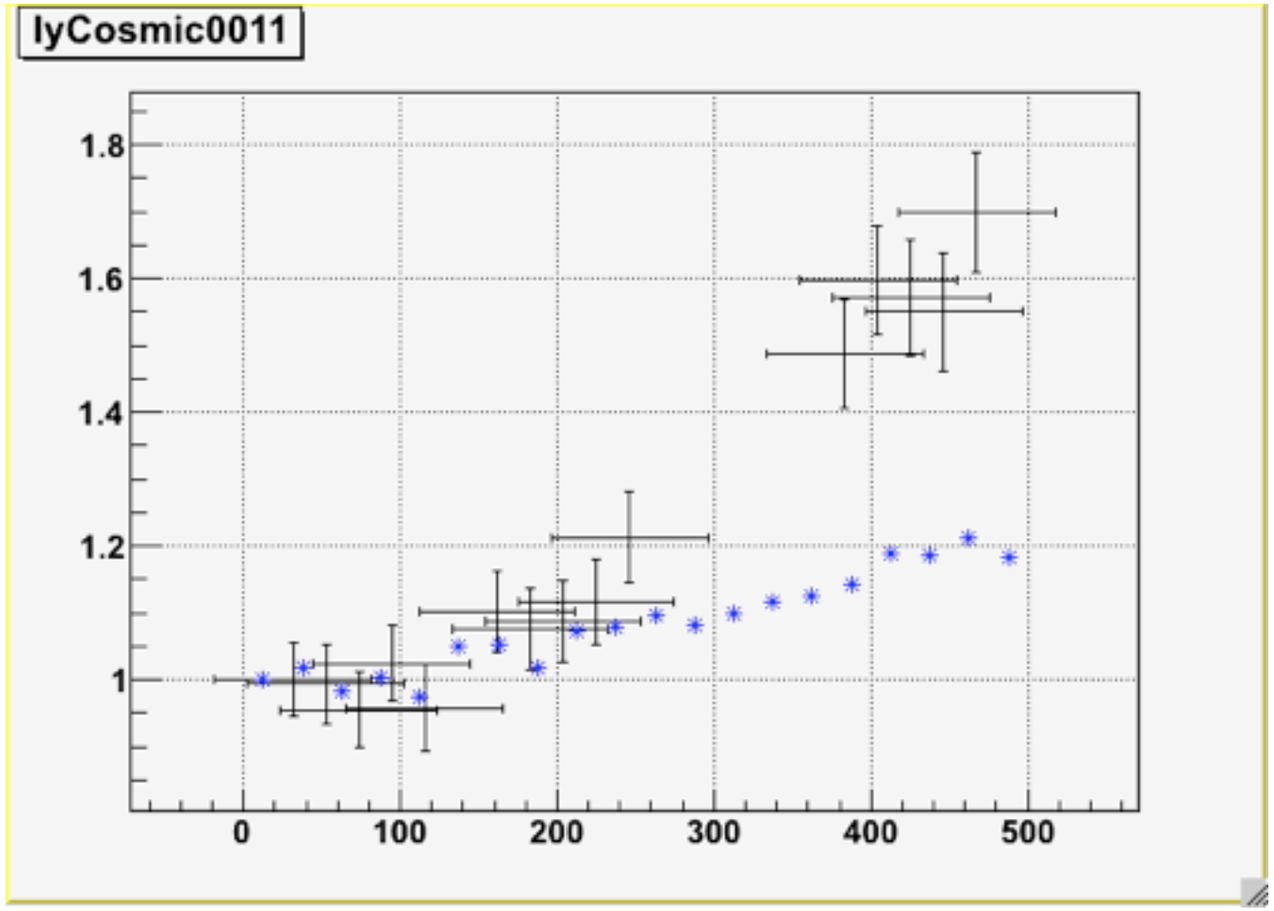
Uniformity Measurement with RI source

Move RI source with X stage, measure 20 Points





Uniformityの比較



- Light yield Uniformityが大きくずれている結晶が一つ存在する。
- この結晶について目視の確認をしたところ結晶に異常がなく、損傷はないと確認された。