



KoALICE

Study on Reciprocal Scattering of Low Energy Alpha Source Using Silicon Pixel Detector

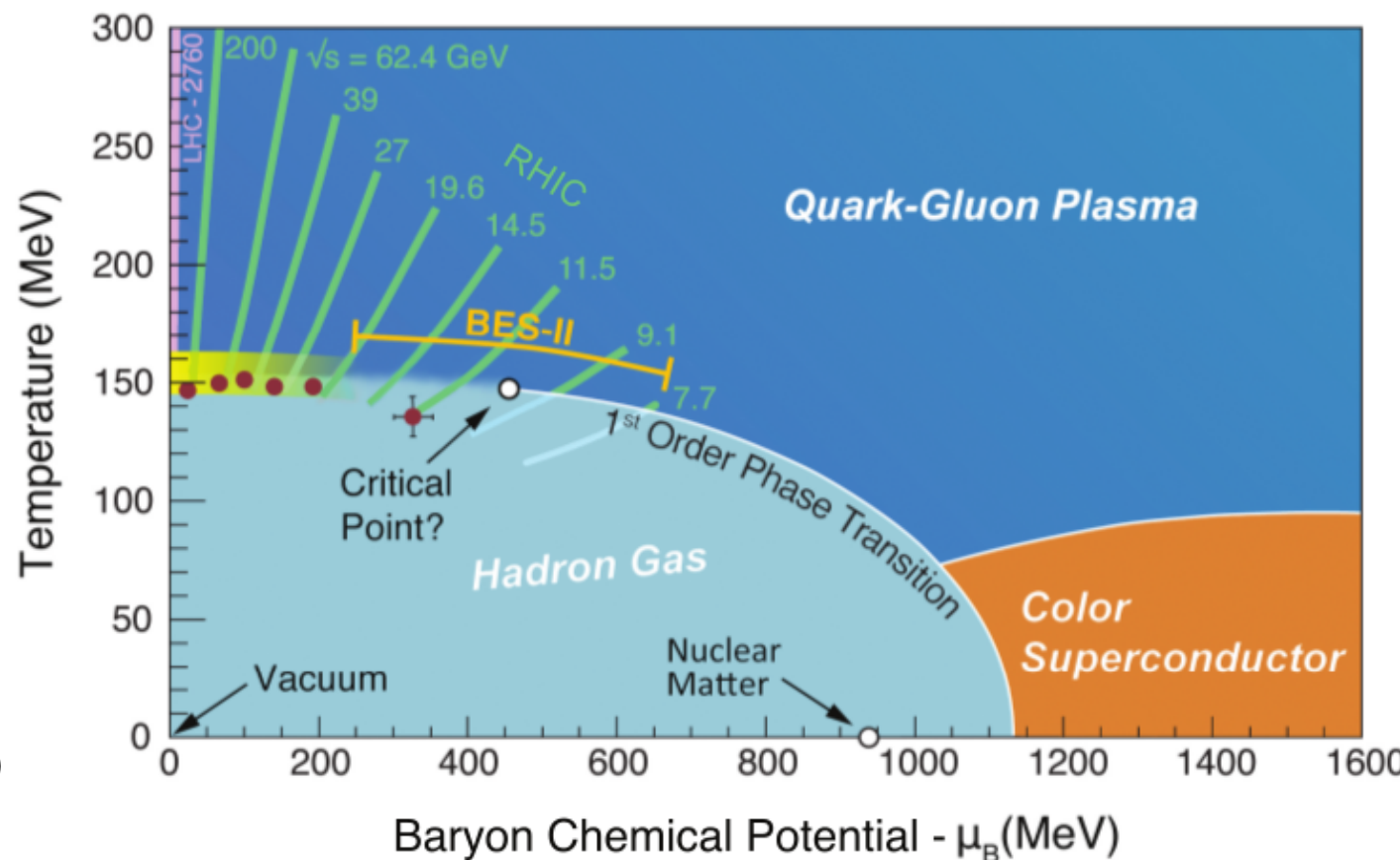
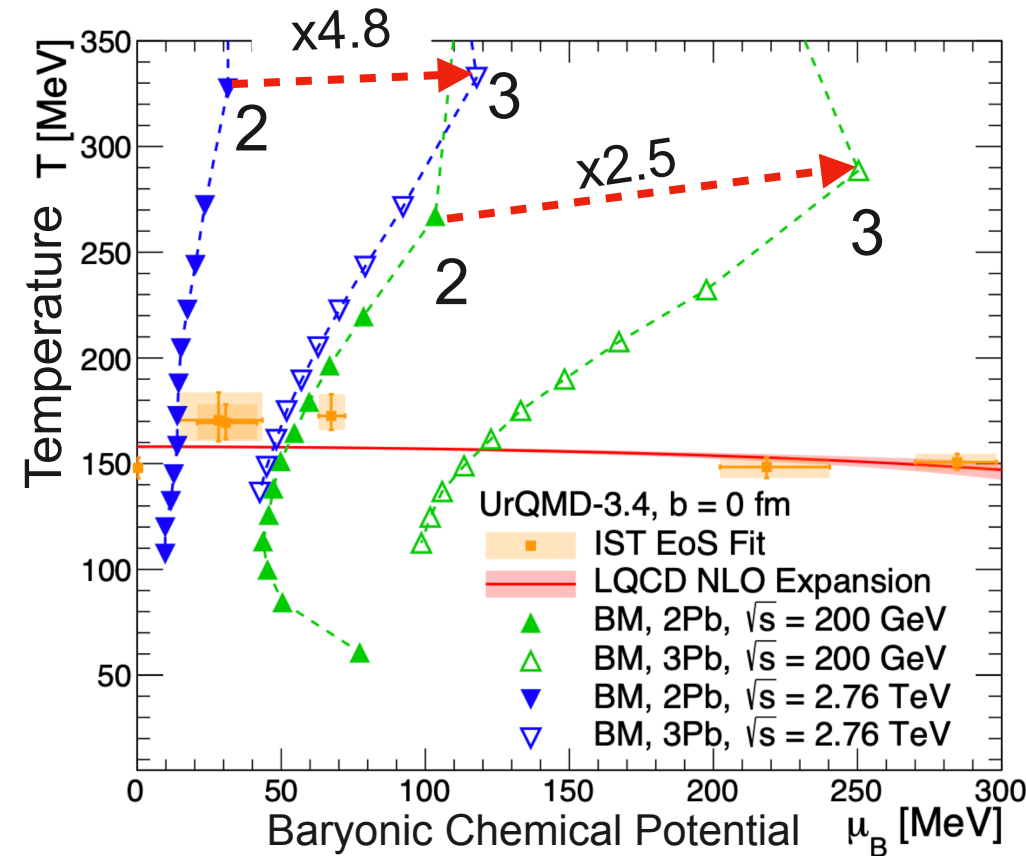
실리콘 픽셀 검출기를 이용한 저에너지 알파 선원의 상호 산란 연구

KoALICE National Workshop 2021, 2022.01.05, MINJAE ISAAC KWON

Ultra Short Summary of 2021

- Robust PID of α and γ particle from ^{241}Am
- Measure reciprocal scattering with 2 of ^{241}Am sources.
- On-call shift for ITS2 on ALICE-Commissioning 2021
- M.S Defense (15 Dec. 2021)
Thesis Title: Study on Reciprocal Scattering of Low Energy Alpha Source Using Silicon Pixel Detector
Referee: Prof.Dr. Sanghoon Lim, Prof.Dr. Minjung Kweon, Prof.Dr. In-Kwon Yoo

Tri- Nuclear Collision

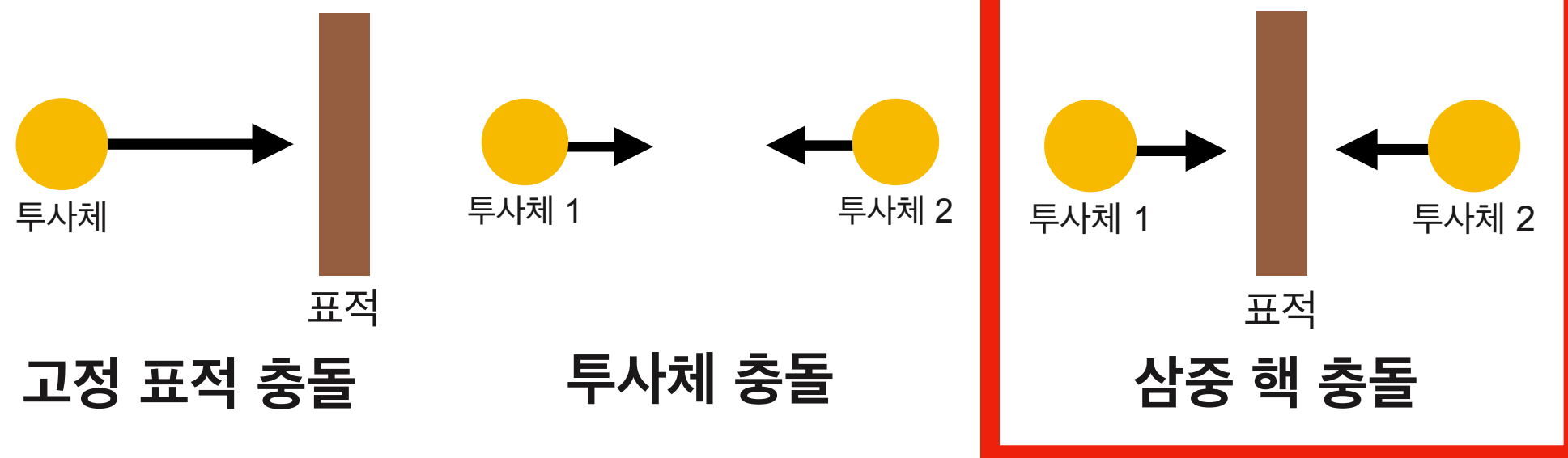


QCD Phase Diagram 2)

Comparison of Baryonic Chemical and temperature between 2 and 3 nuclear collisions¹⁾ (Theory)

- New experimental scheme for nuclear colliding experiment.

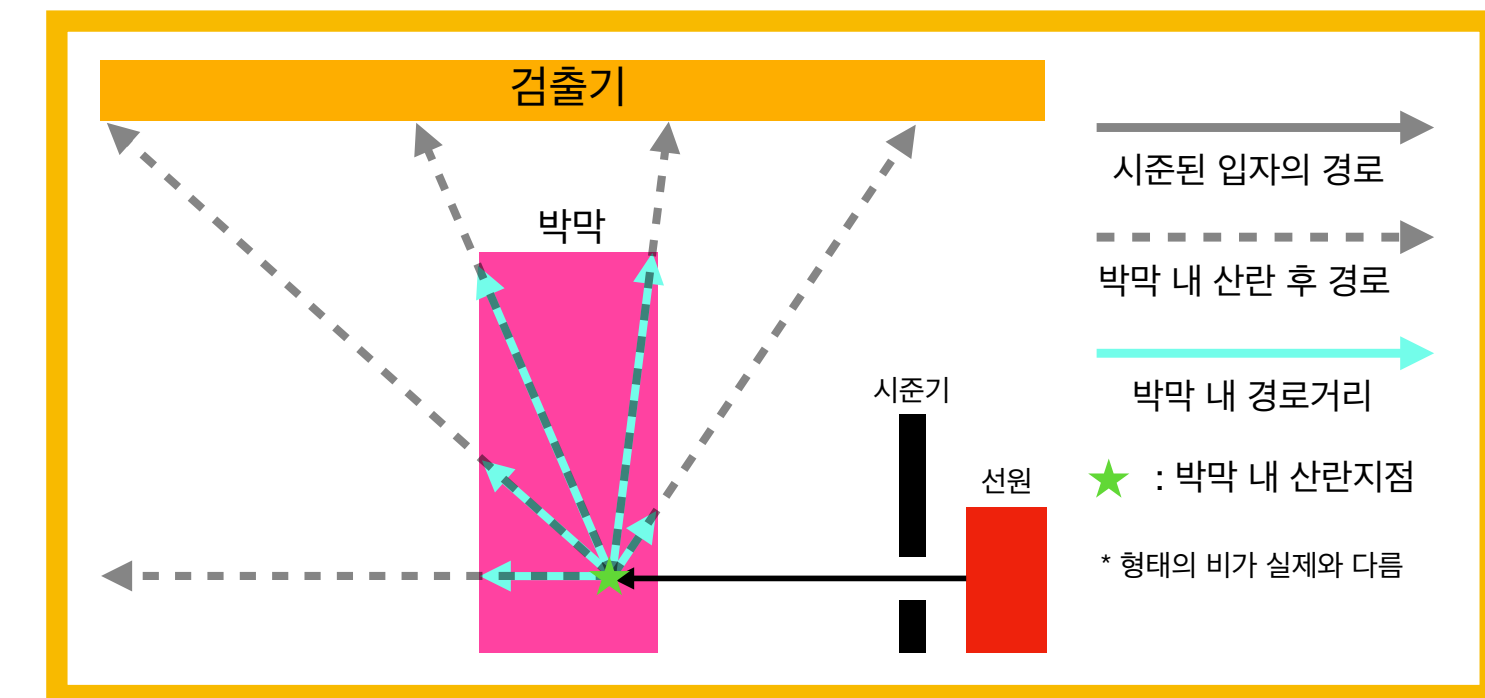
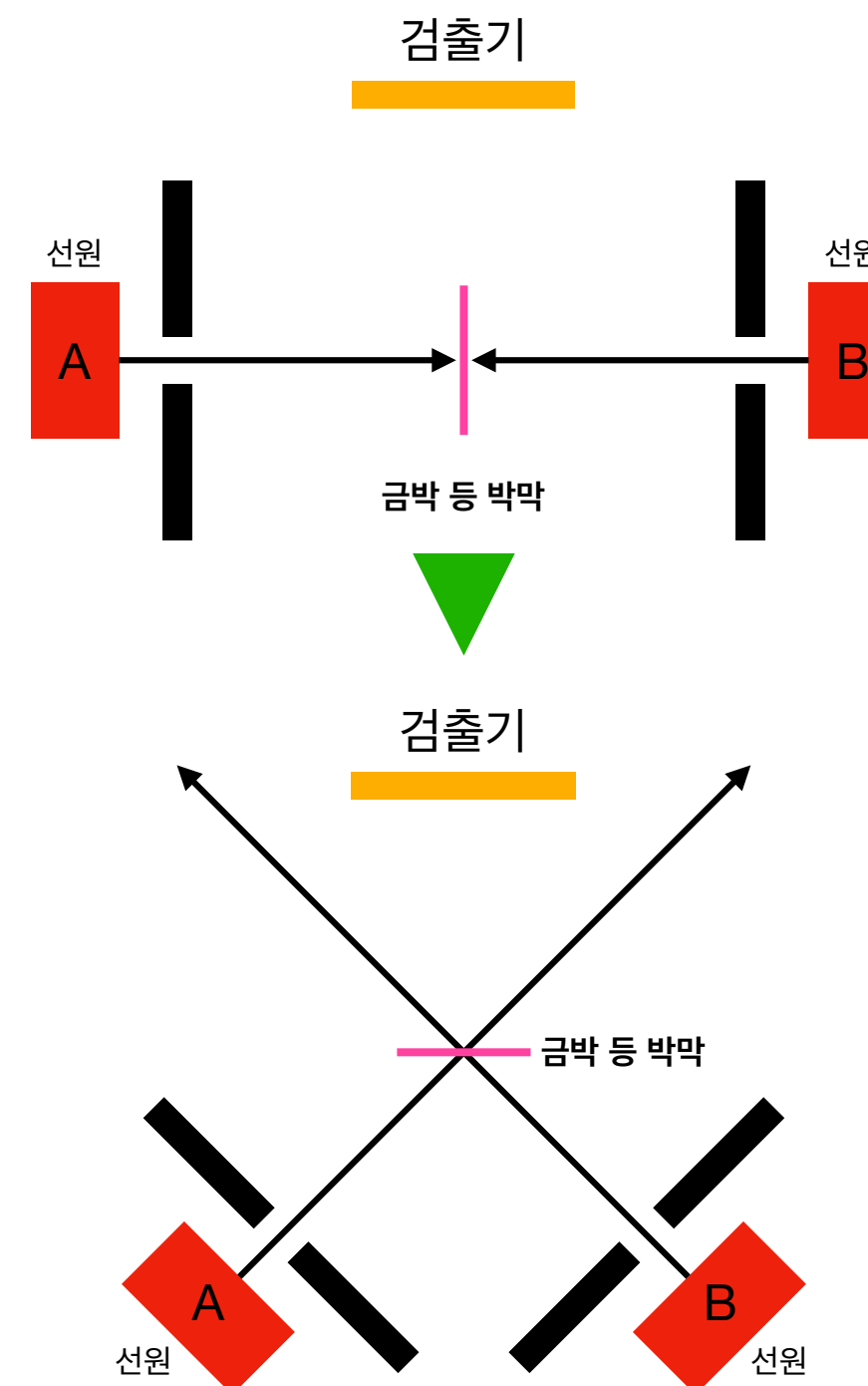
실험적 구현 방법?



Elastic Scattering

- Experiment to prove observability
- Using low energy radioactive source
- Similar method with Geiger-Marsden Experiment.

Detail Scheme



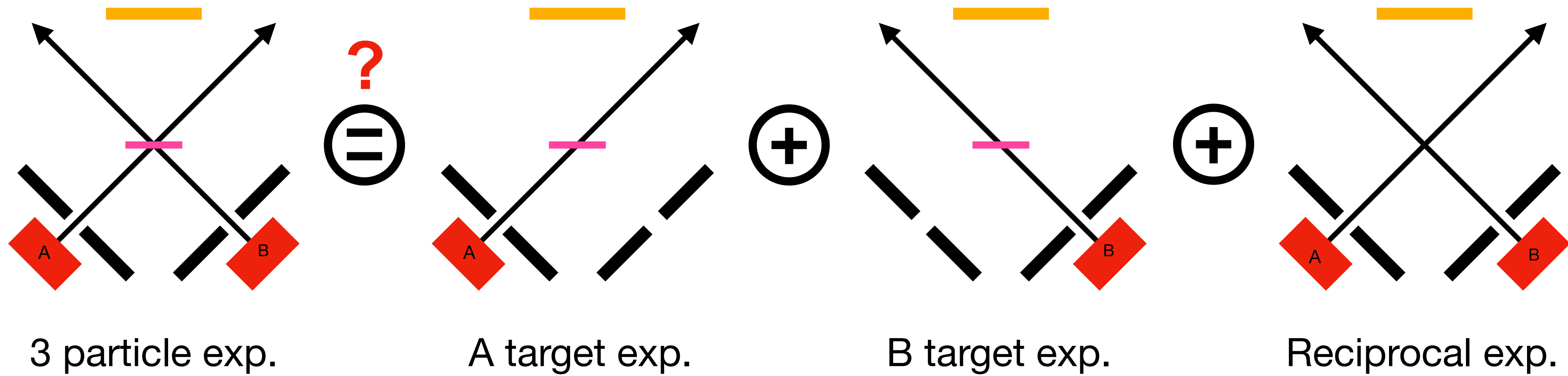
- Acceptance is dependent on scattering angle.
- Scattering Angle $\rightarrow 90^\circ$, Acceptance \searrow

물질명	밀도 (g/cm ³)	투과범위 (mg/cm ²)	투과거리
공기(1기압)	1.20479×10^{-3}	4.990	4.142 cm
물	1.00	4.301	43.01 μm
실리콘	2.33	6.376	27.36 μm
금	19.32	18.06	9.34 μm

Penetration depth of 5.486MeV α particle in materials ³⁾

1) K. Bugaev and O. Vitiuk
 2) USQCD
 3) M. Berger, J. Coursey, M. Zucker, and J. Chang

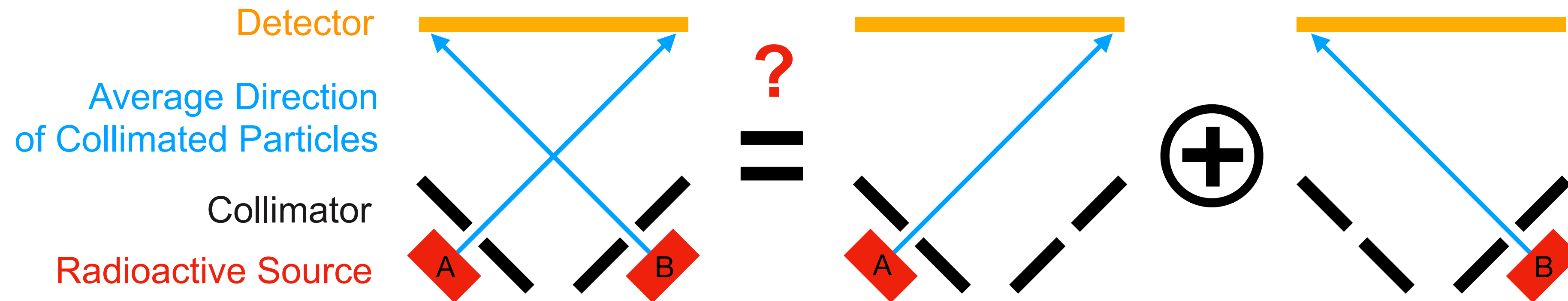
3 Particle Elastic Scattering in REAL WORLD



: Detector : Thin film target : Thin film target
 : Source : Particle Direction

Measurement?
Hitmap of alpha particle

Reciprocal Scattering

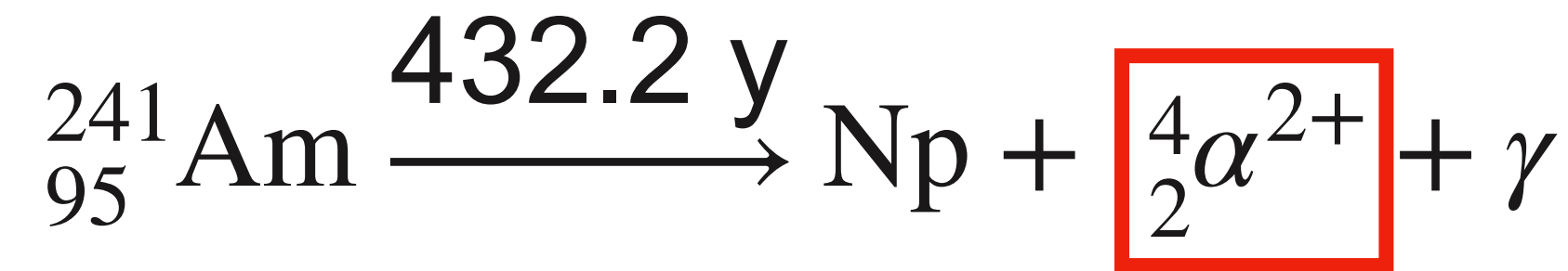


- A part of three particle elastic scattering.
- Experiment of measurement of overlapping.

Robust PID low E α and γ on SPD

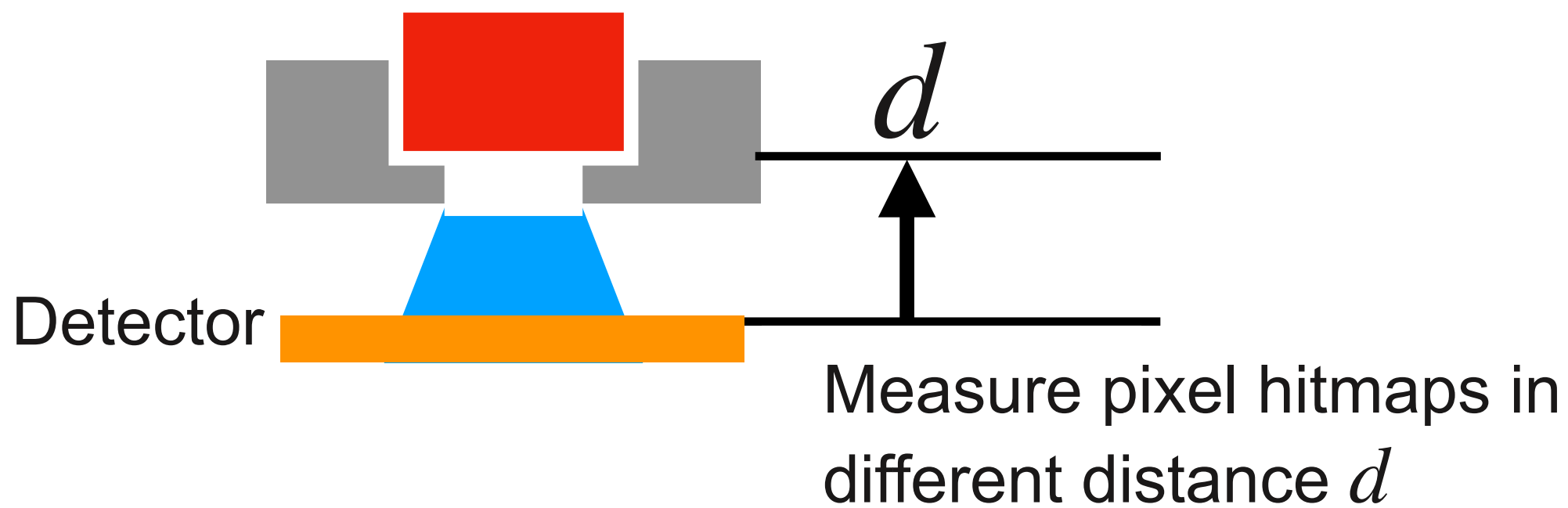
Motivation

- Measurement of characteristics of signal from ^{241}Am is needed.

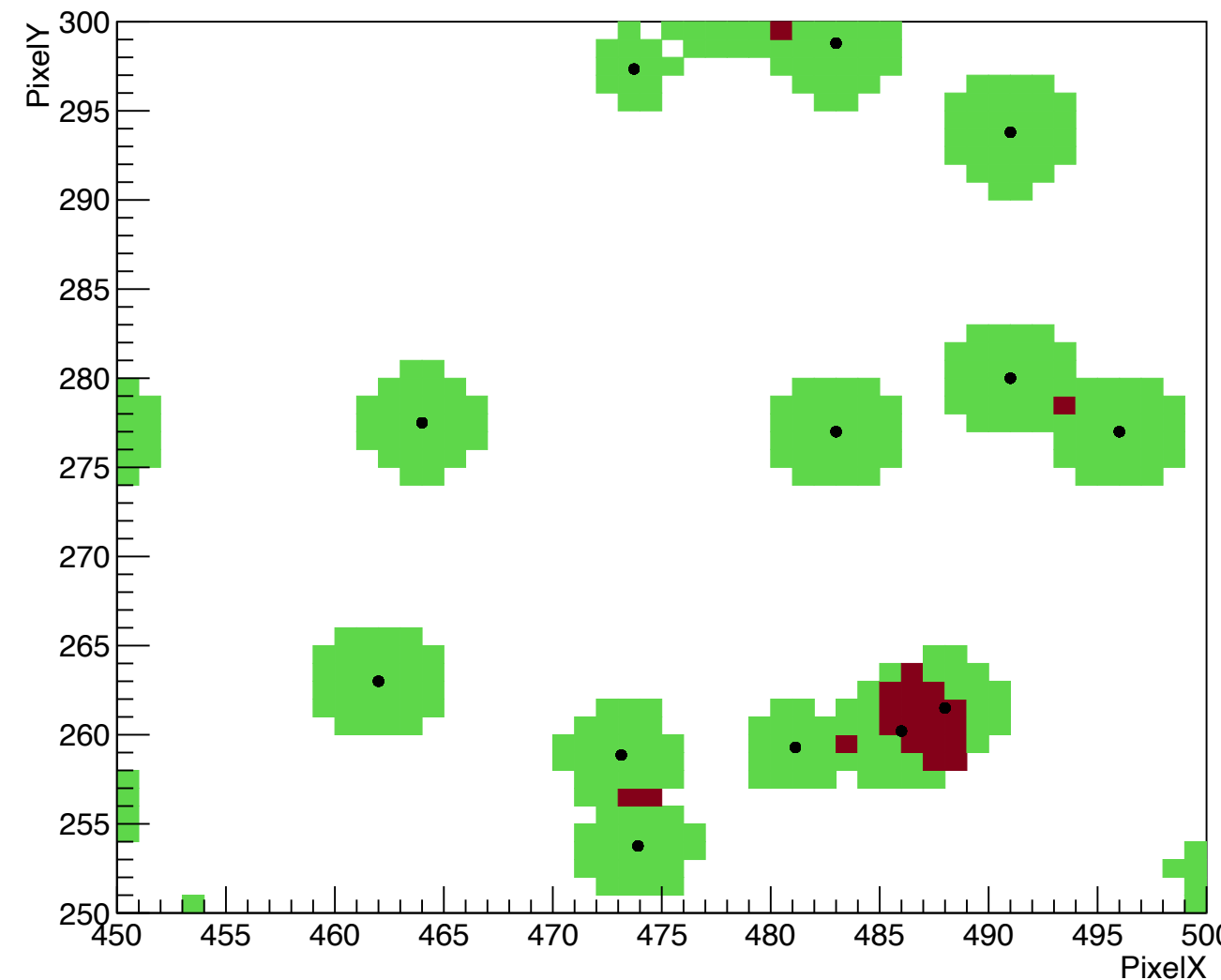


활용하는 알파 입자 감마 입자 (노이즈?)

Exp. is done in 2020!



Analysis



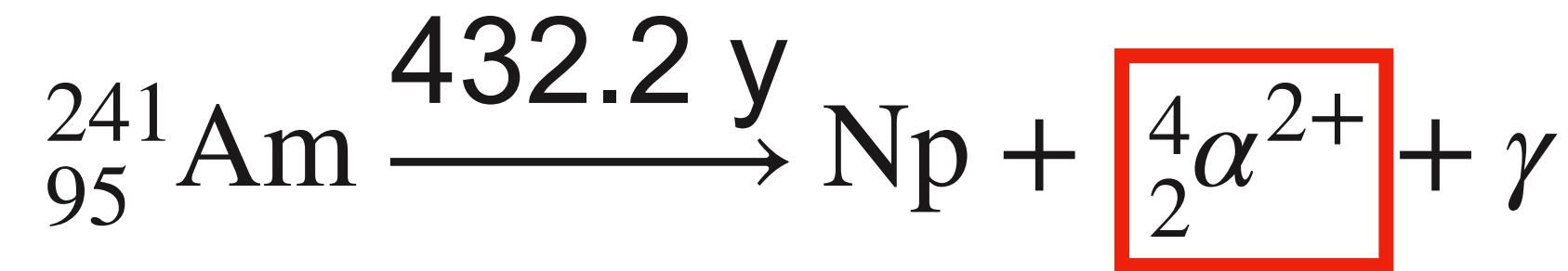
1. Clustering
2. Measure characteristics of each cluster
3. Get Statistics!

Cluster Characteristics?

- Size
- Position
- Eccentricity
- ...

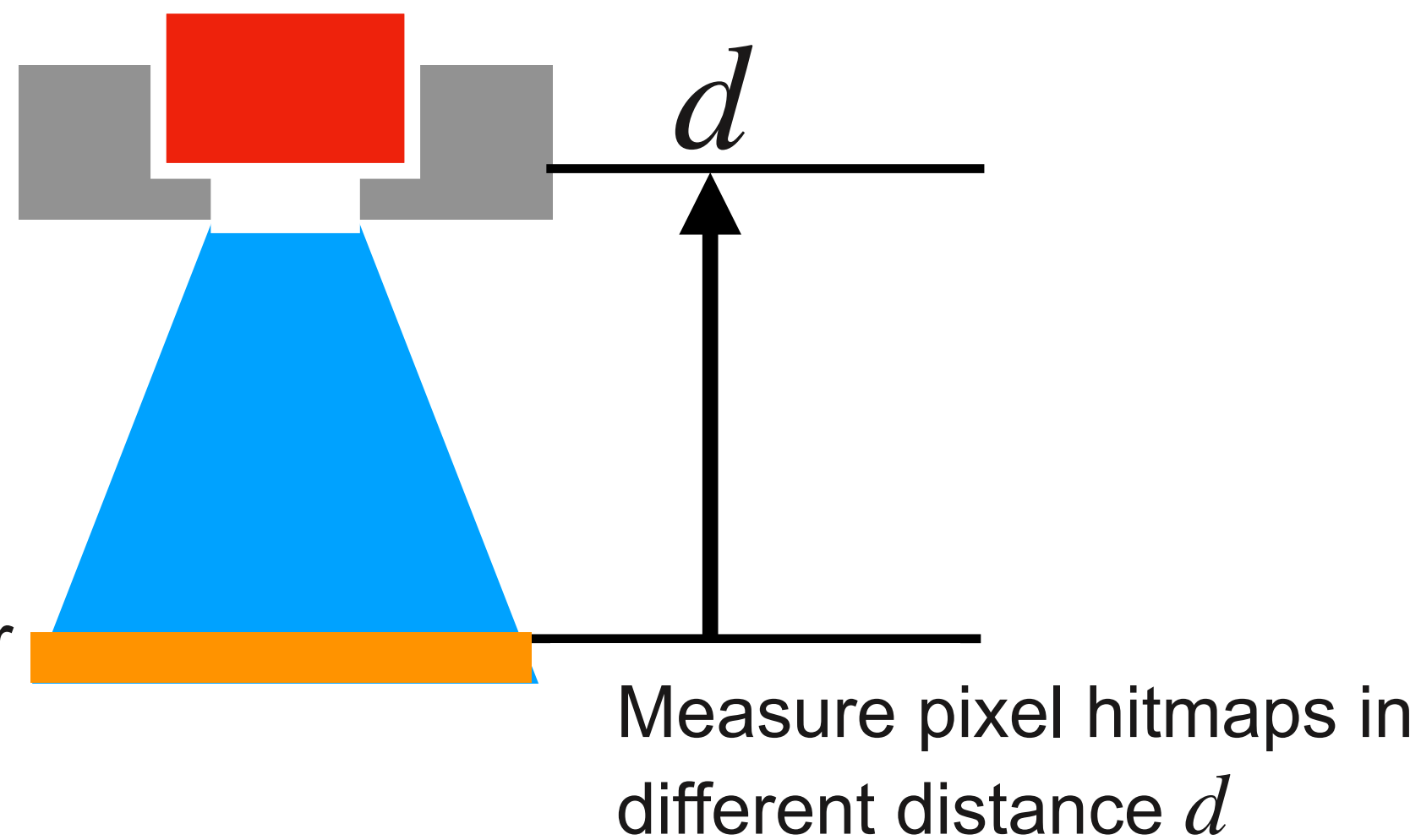
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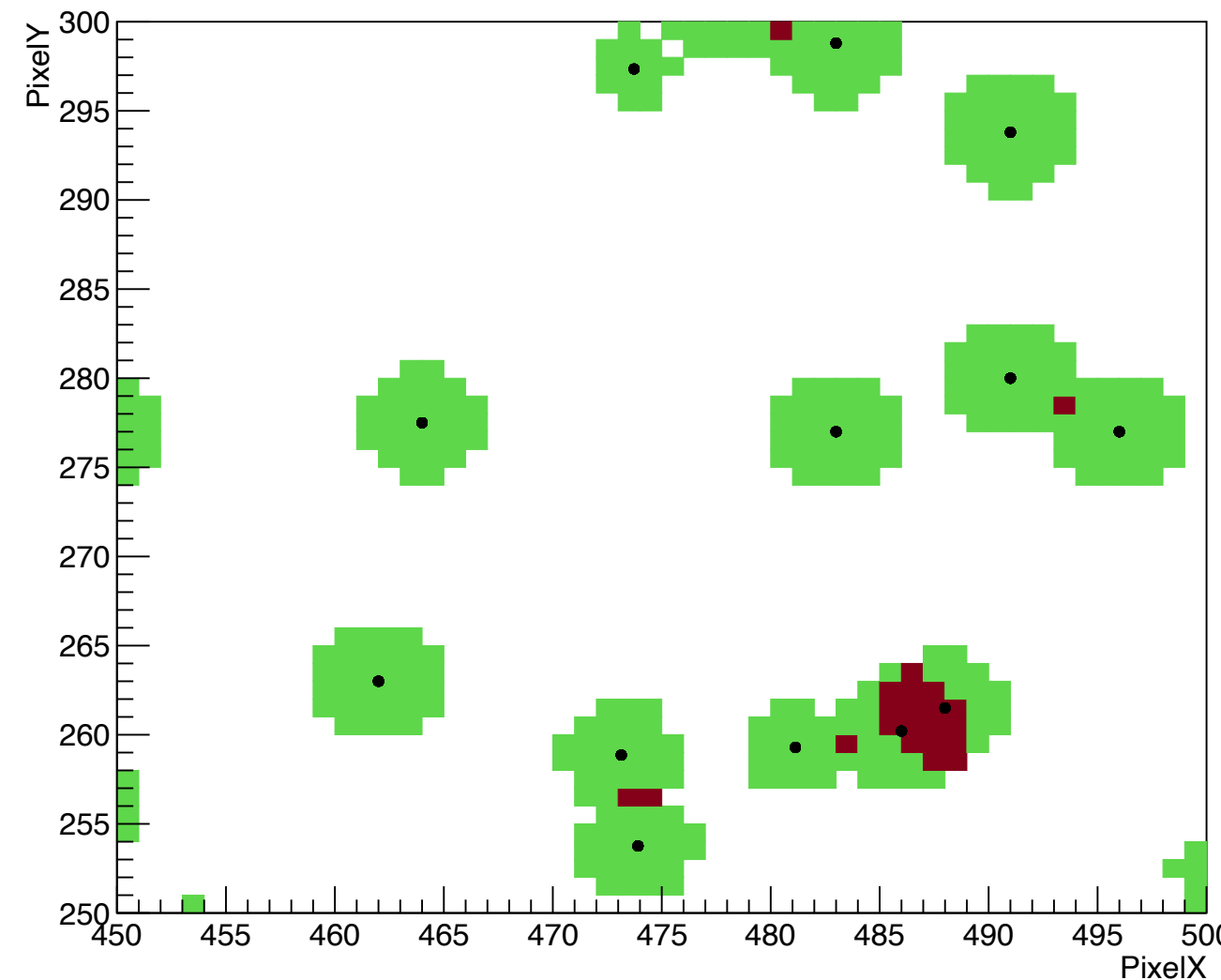


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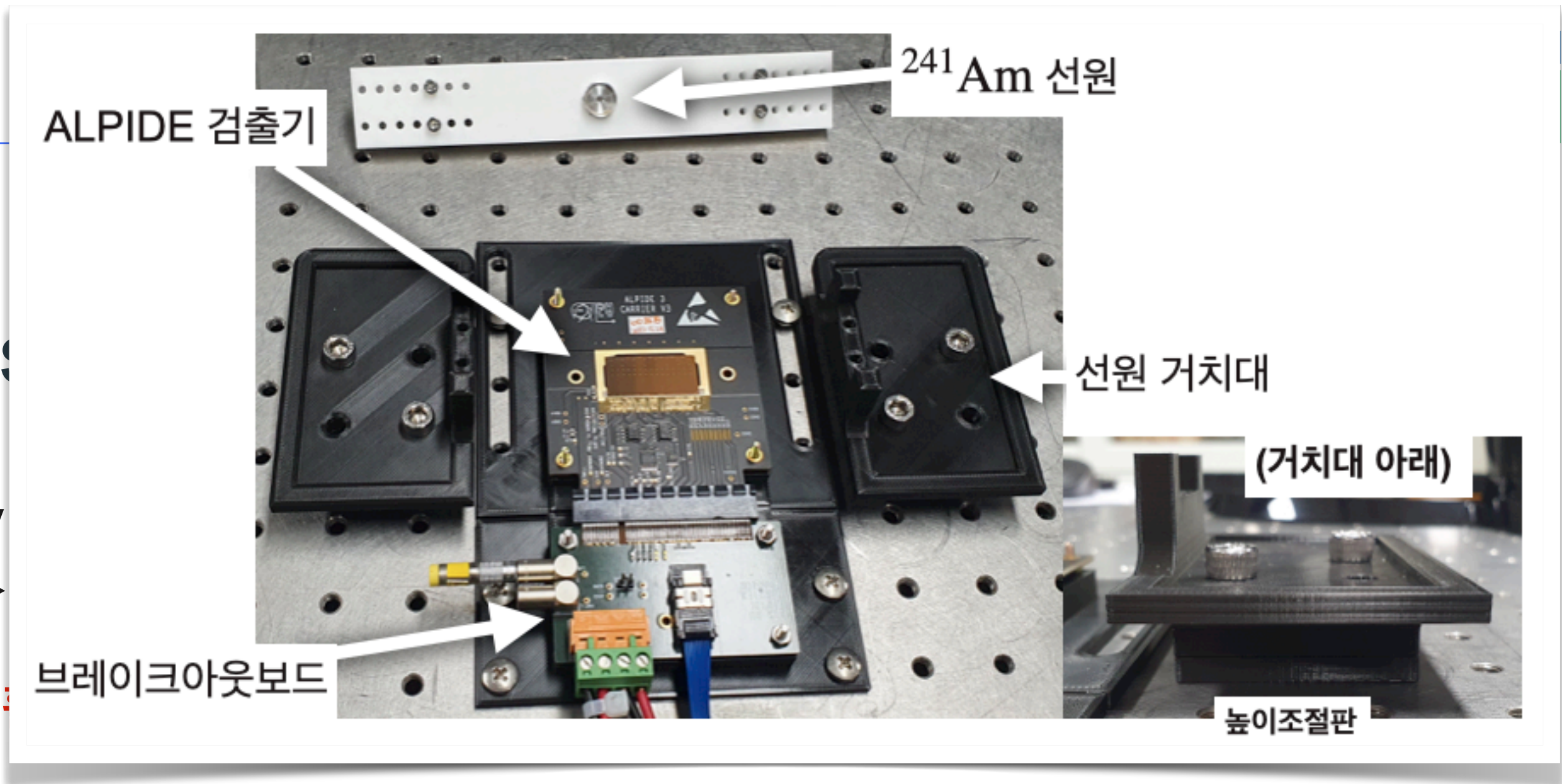
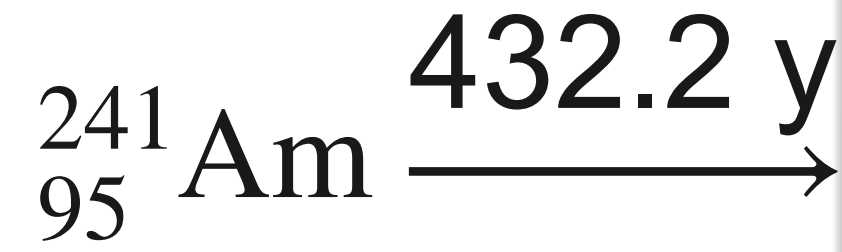
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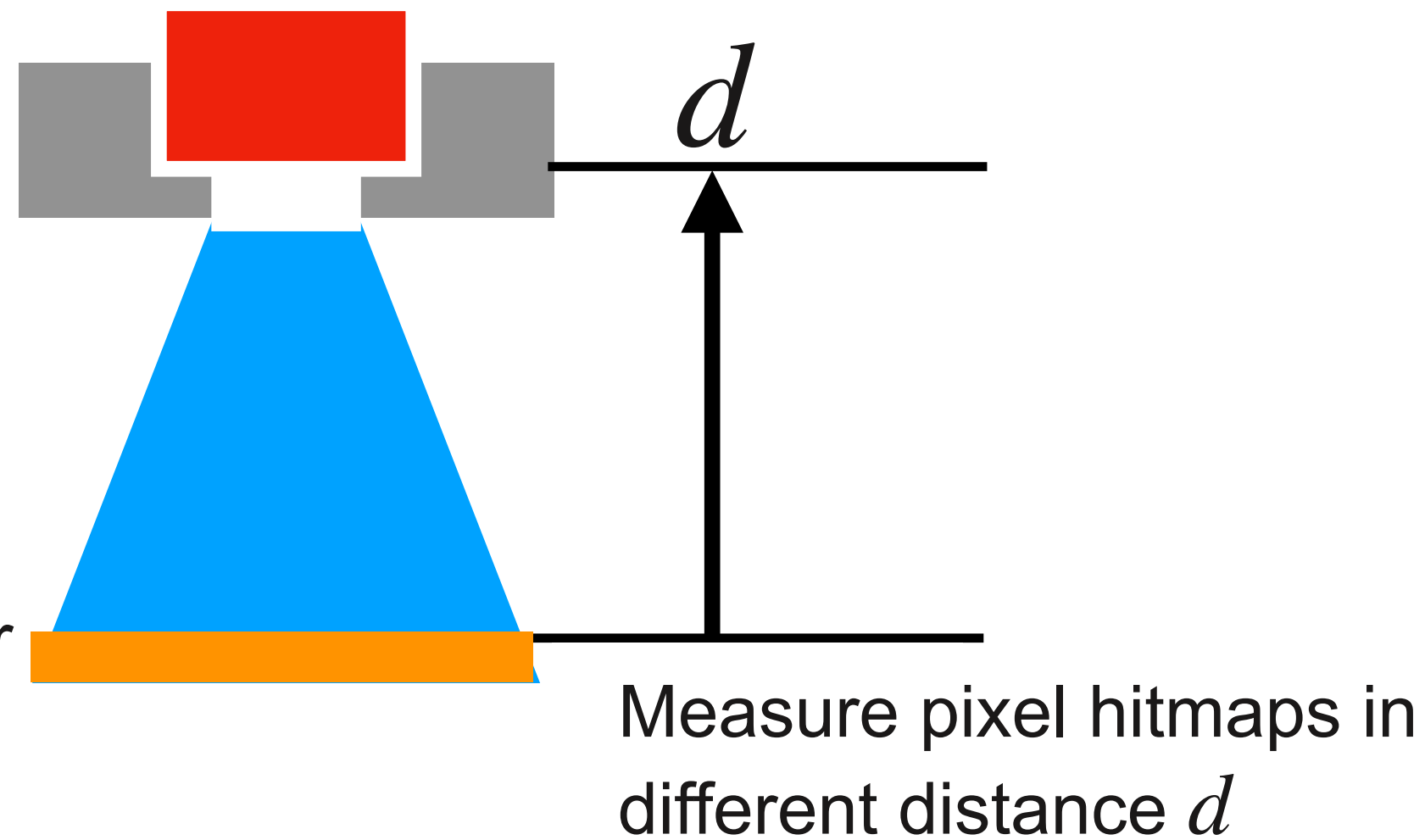
- Size
- Position
- Eccentricity
- ...

Motivation

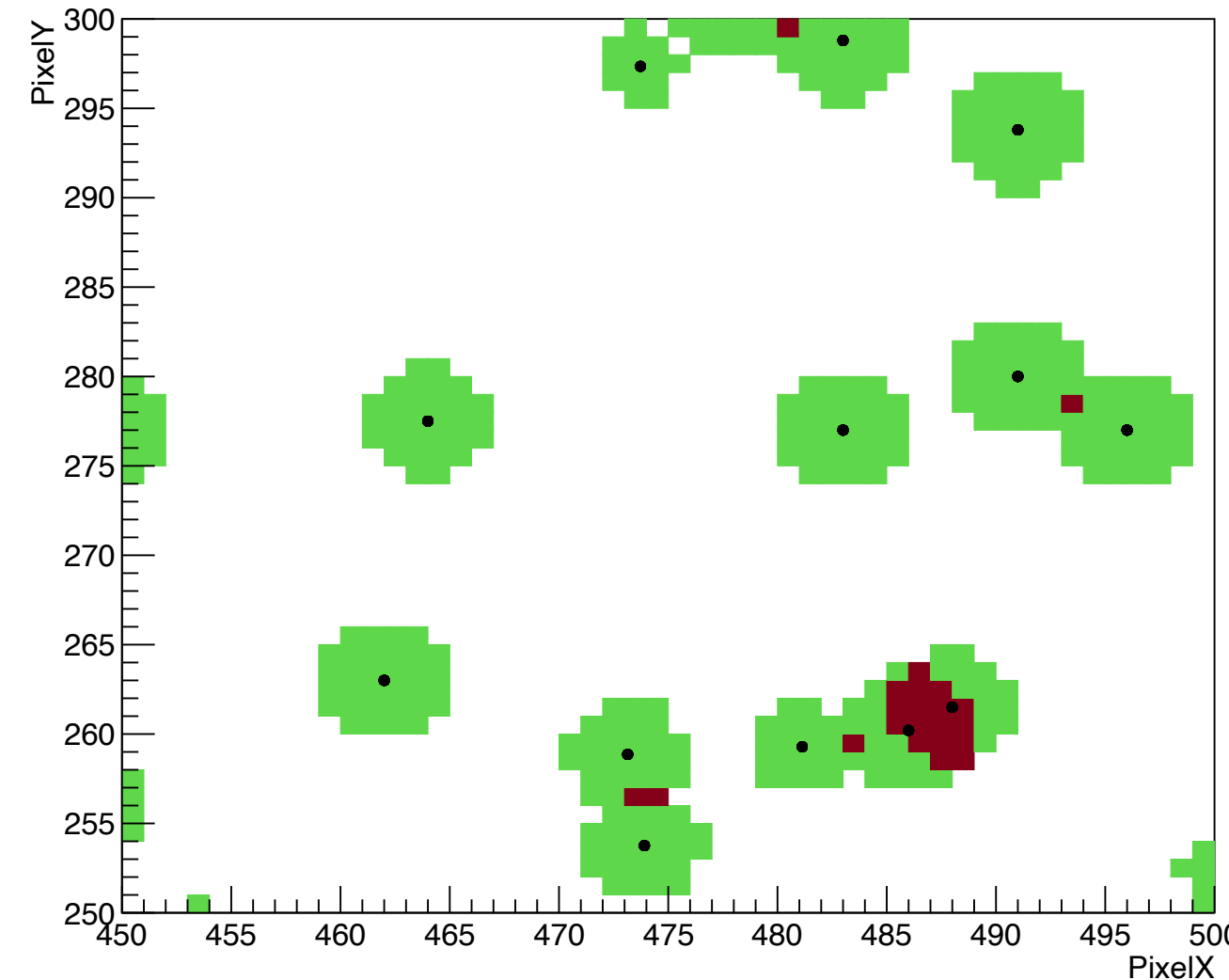
- Measurement of characteristics



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Analysis



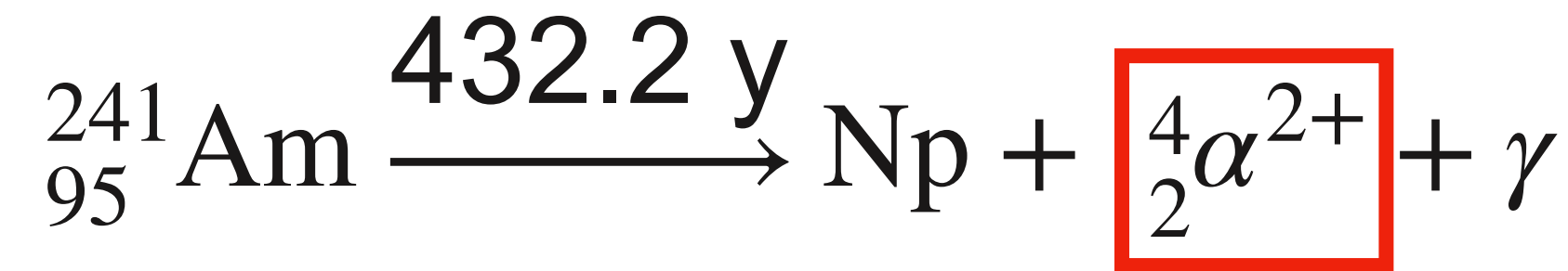
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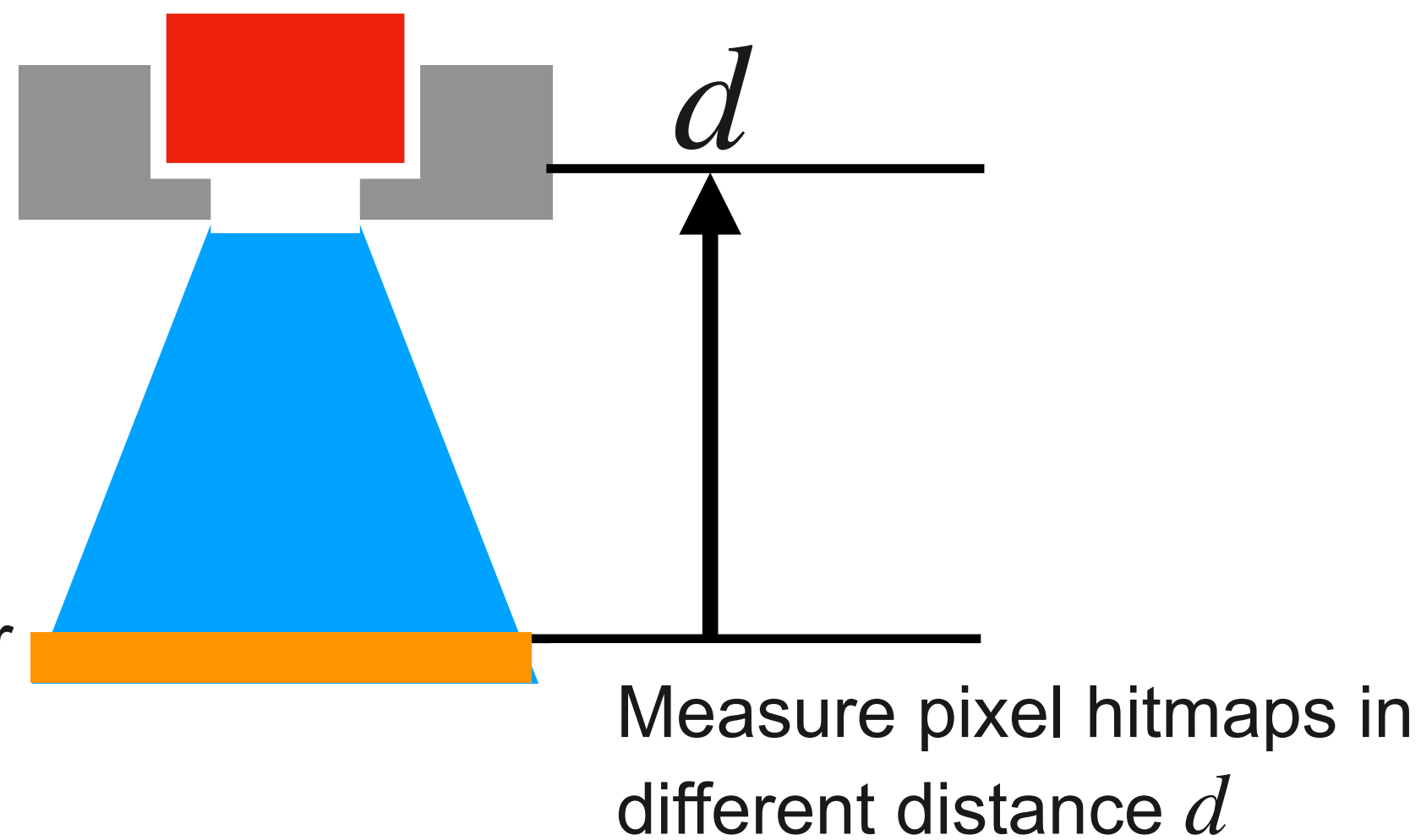
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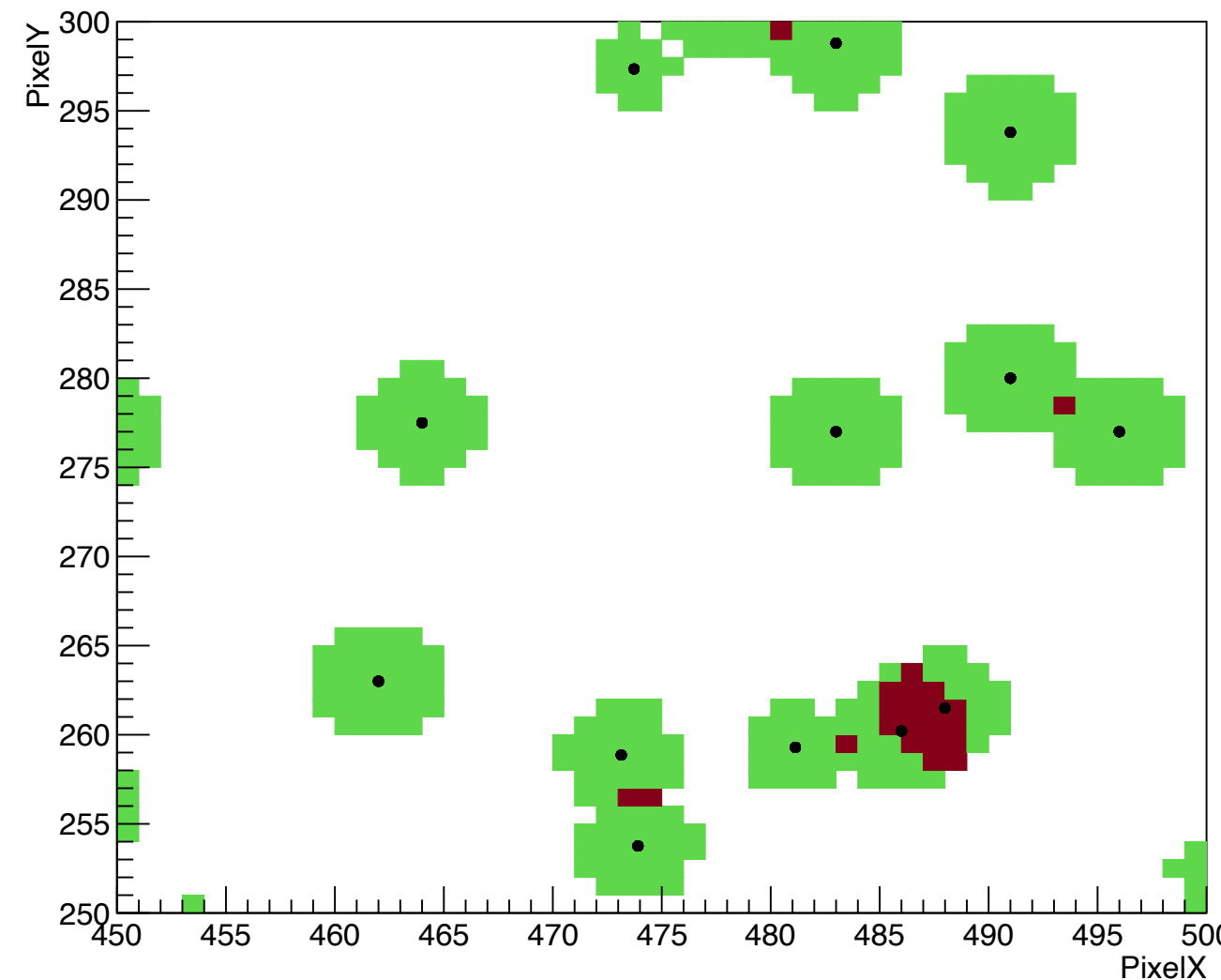


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Analysis



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Cluster Characteristics?

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- Position
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- ...

Result

class 1

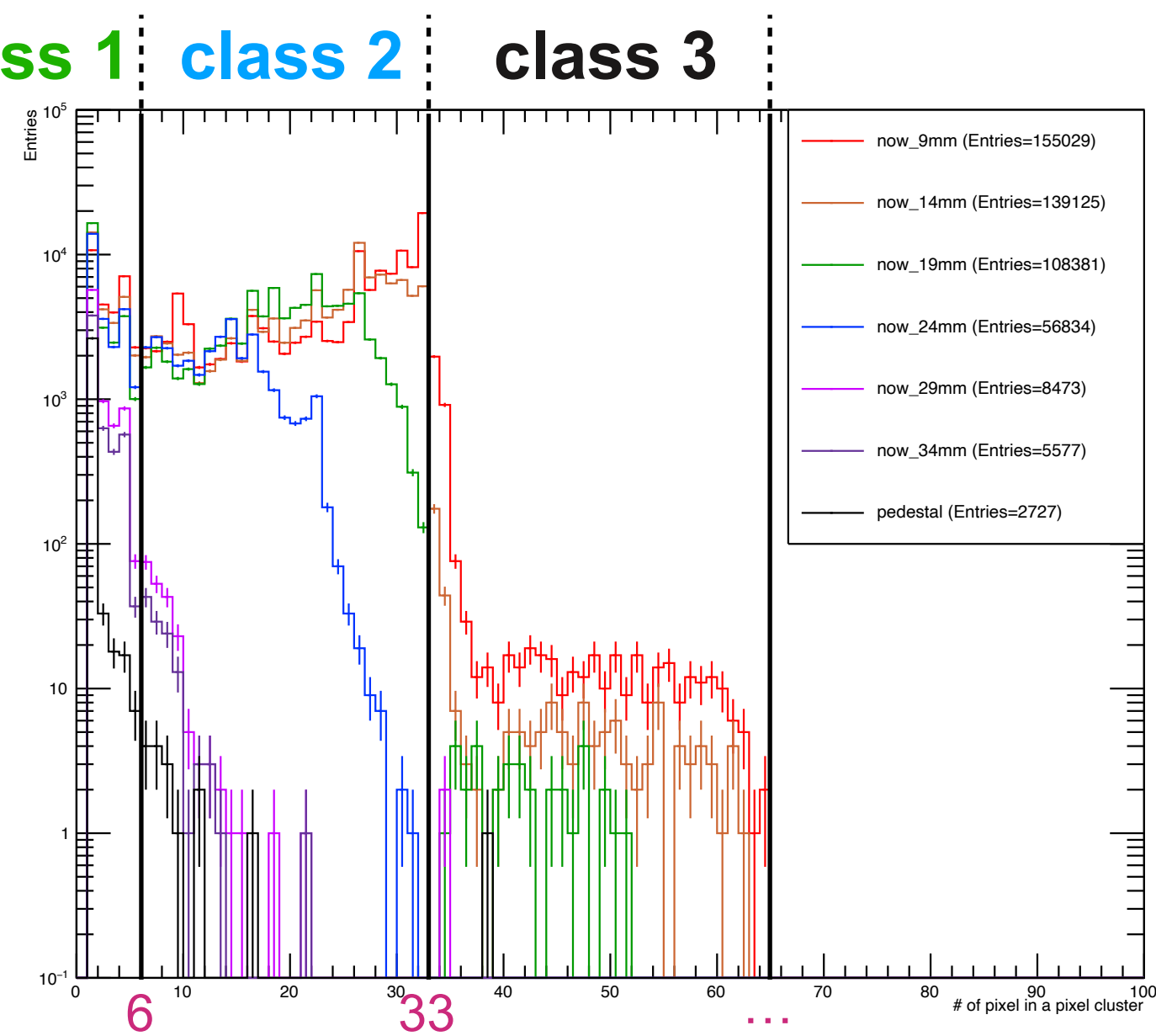
class 2

class 1

class 2

class 3

class 3

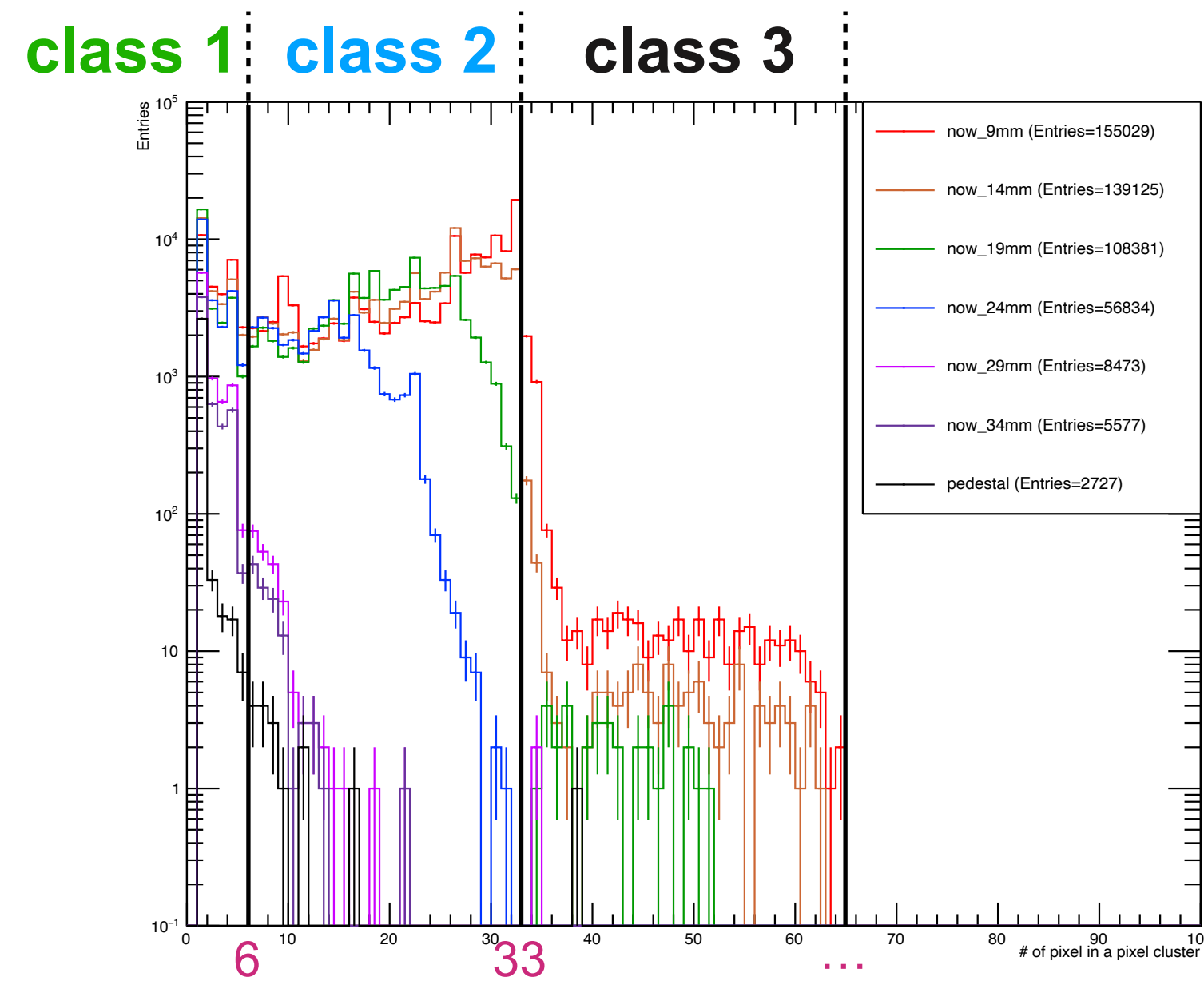


Histogram of # of Pixels in a cluster
(Each color: different distance d)

Result

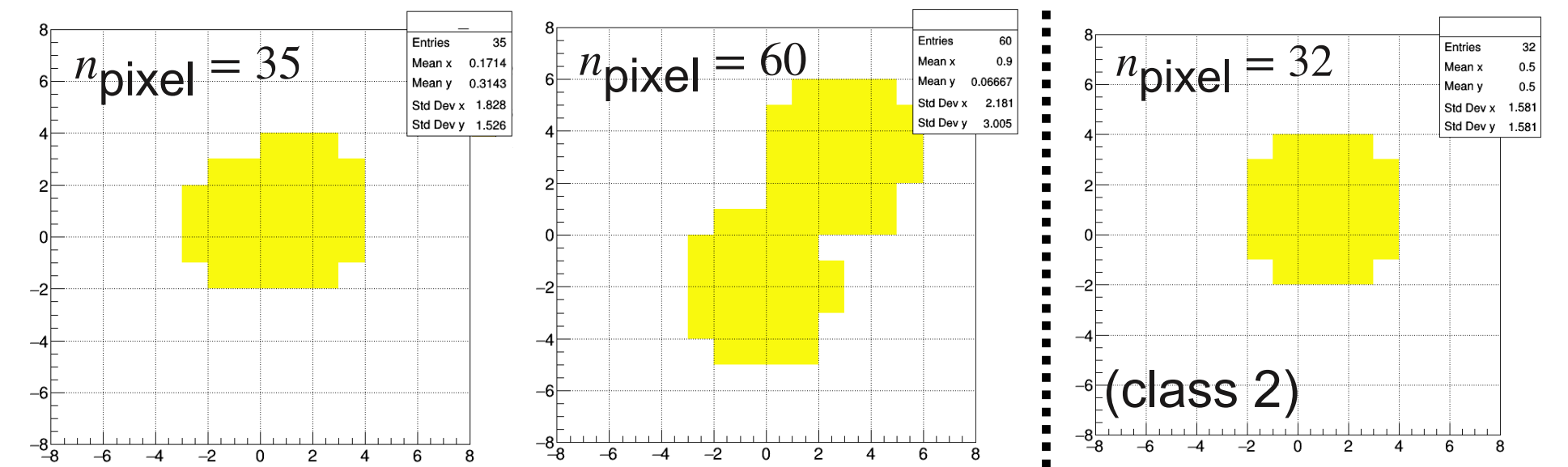
class 1

class 2



Histogram of # of Pixels in a cluster
(Each color: different distance d)

class 3



Unsymmetrical Clusters

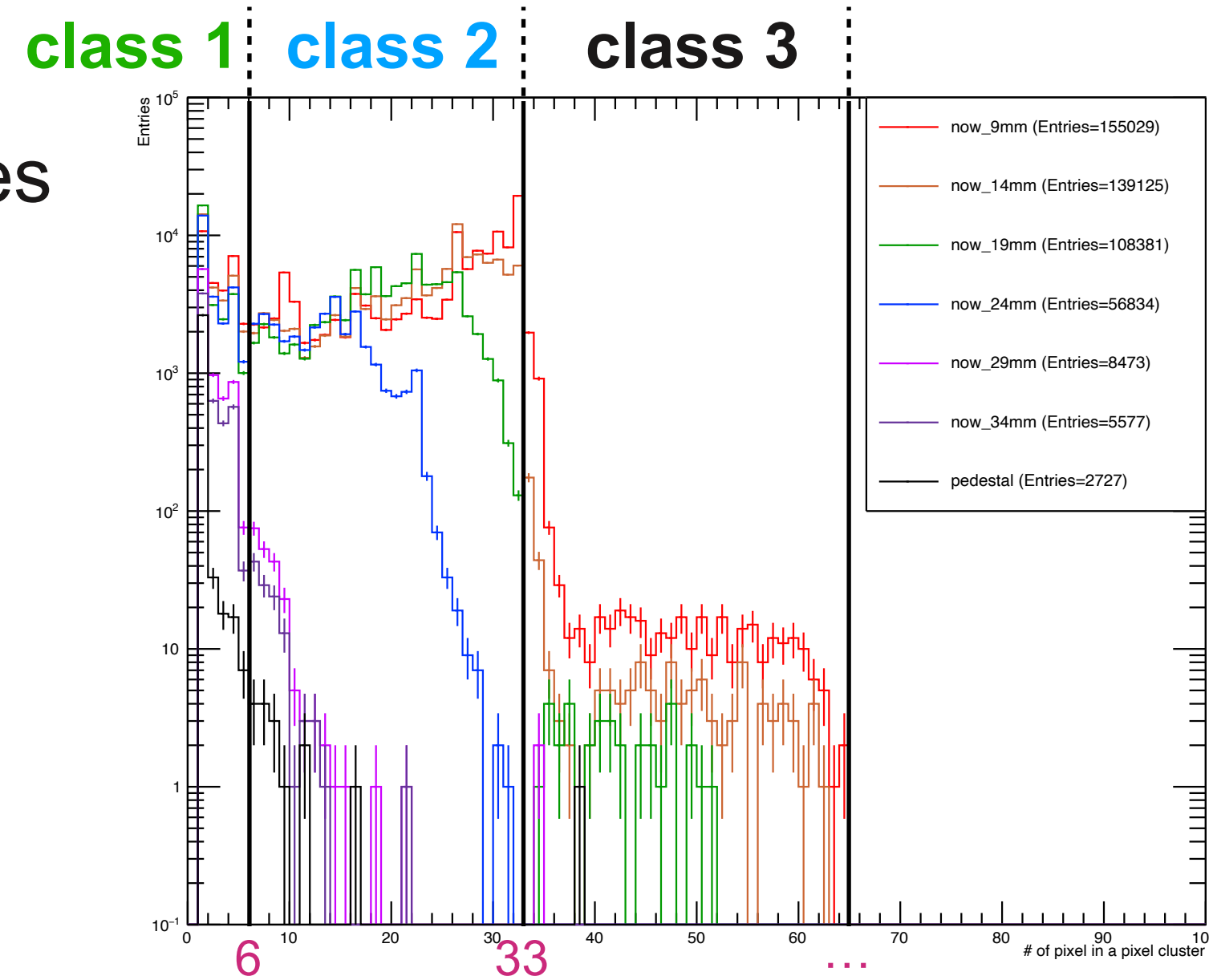
→ 2 or more cluster generated nearby.

Result

class 1

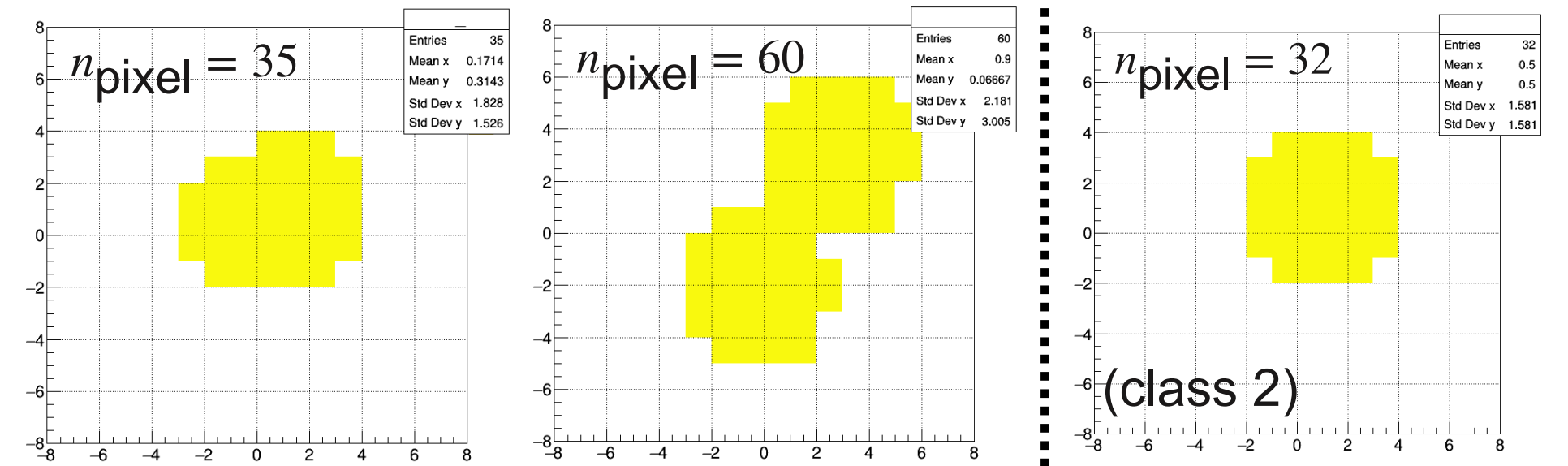
No shape different but entries
 → No effect on char. of signals

class 2



Histogram of # of Pixels in a cluster
 (Each color: different distance d)

class 3



Unsymmetrical Clusters

→ 2 or more cluster generated nearby.

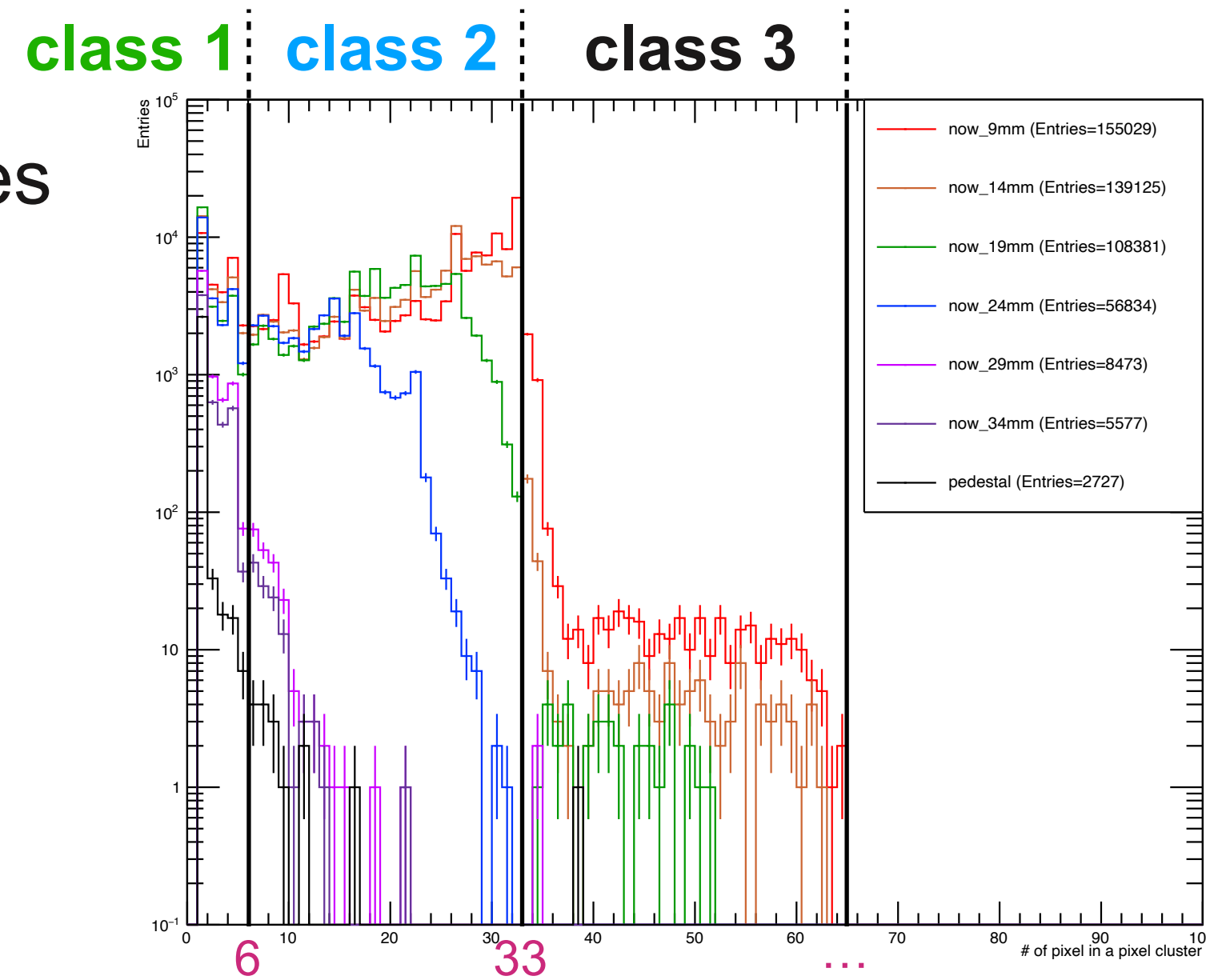
Result

class 1

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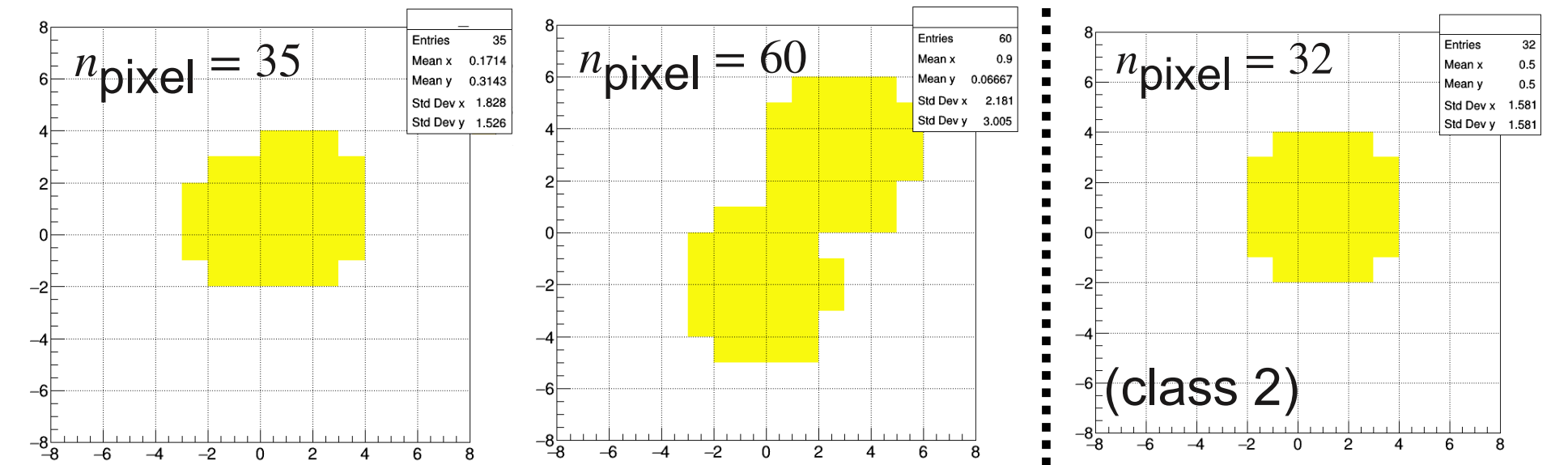
class 2

Shape differs on distance d
 → Effect on char. of signals exists



Histogram of # of Pixels in a cluster
 (Each color: different distance d)

class 3



Unsymmetrical Clusters

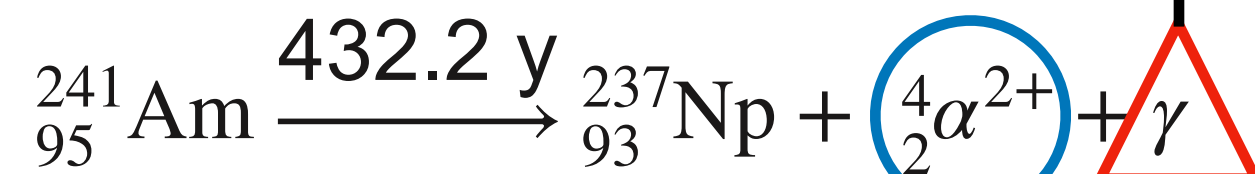
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Result

class 1

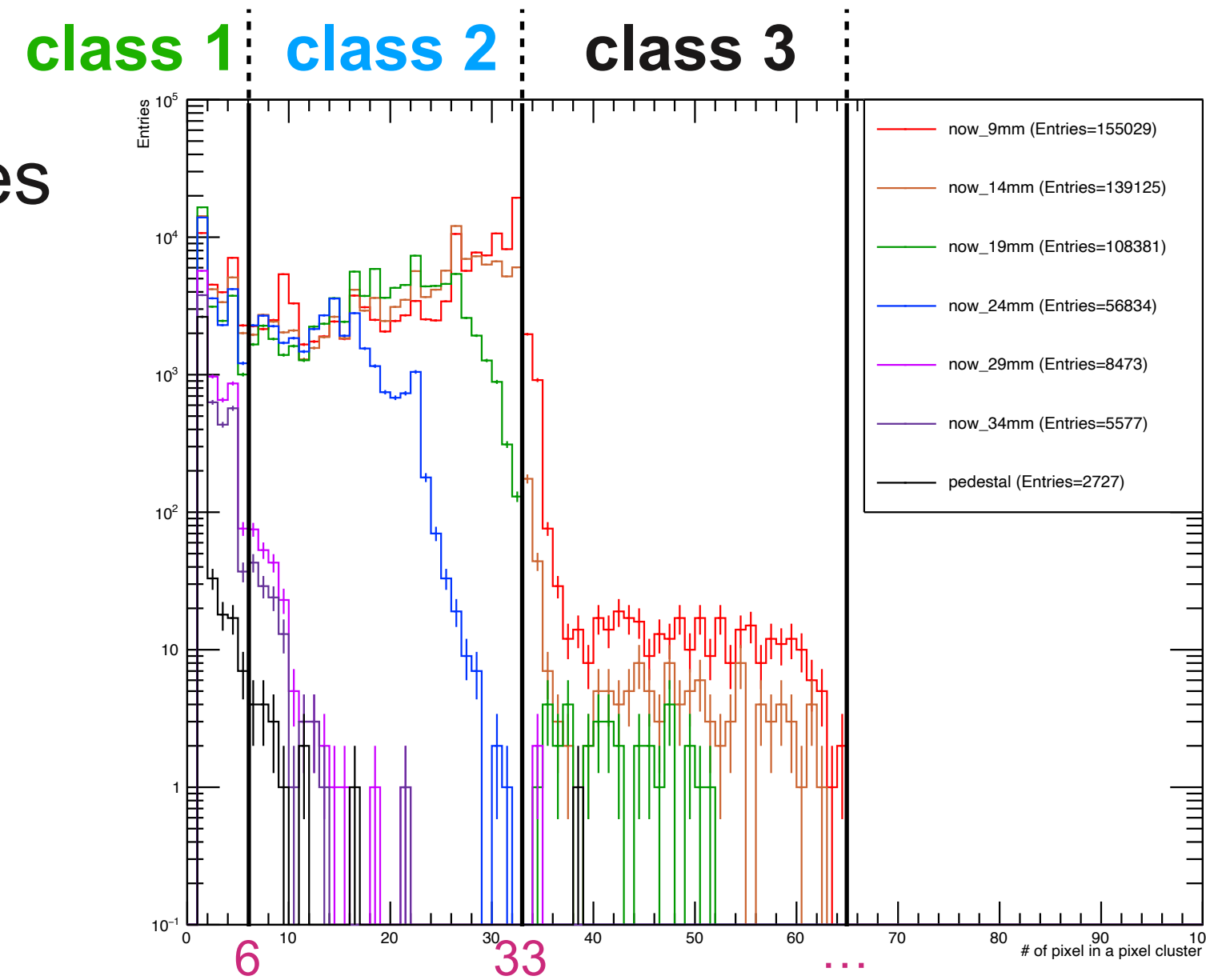
No shape different but entries
 → No effect on char. of signals

(γ : almost no material interaction)



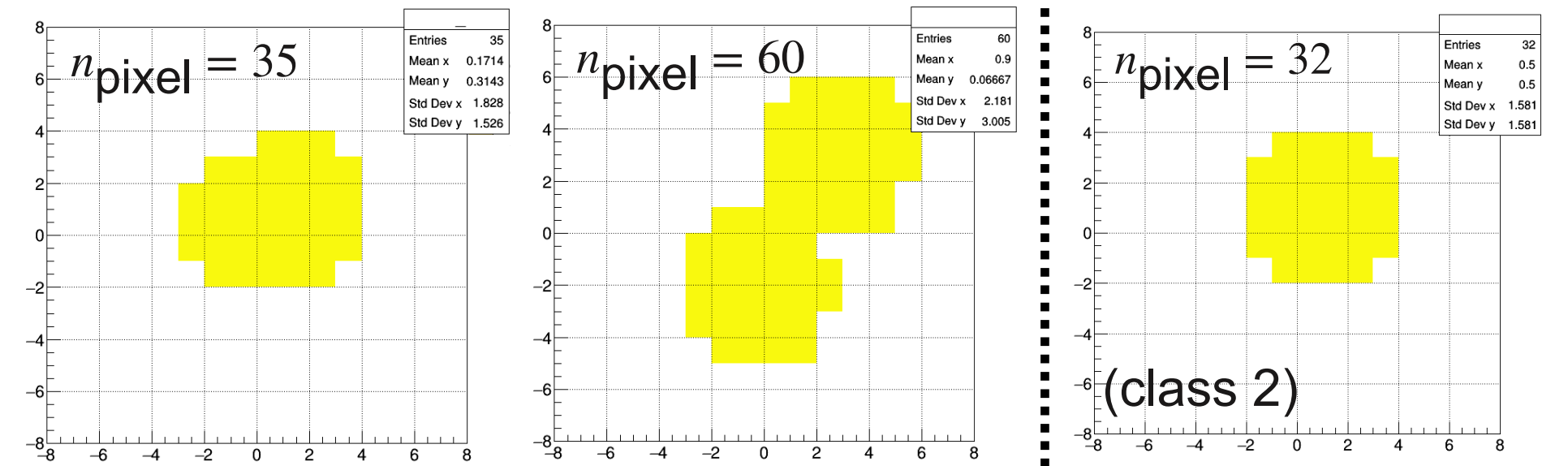
class 2

Shape differs on distance d
 → Effect on char. of signals exists
 (α : Lots of material interaction)



Histogram of # of Pixels in a cluster
 (Each color: different distance d)

class 3



Unsymmetrical Clusters

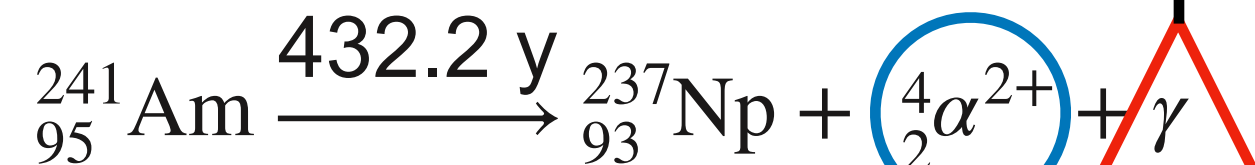
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Result

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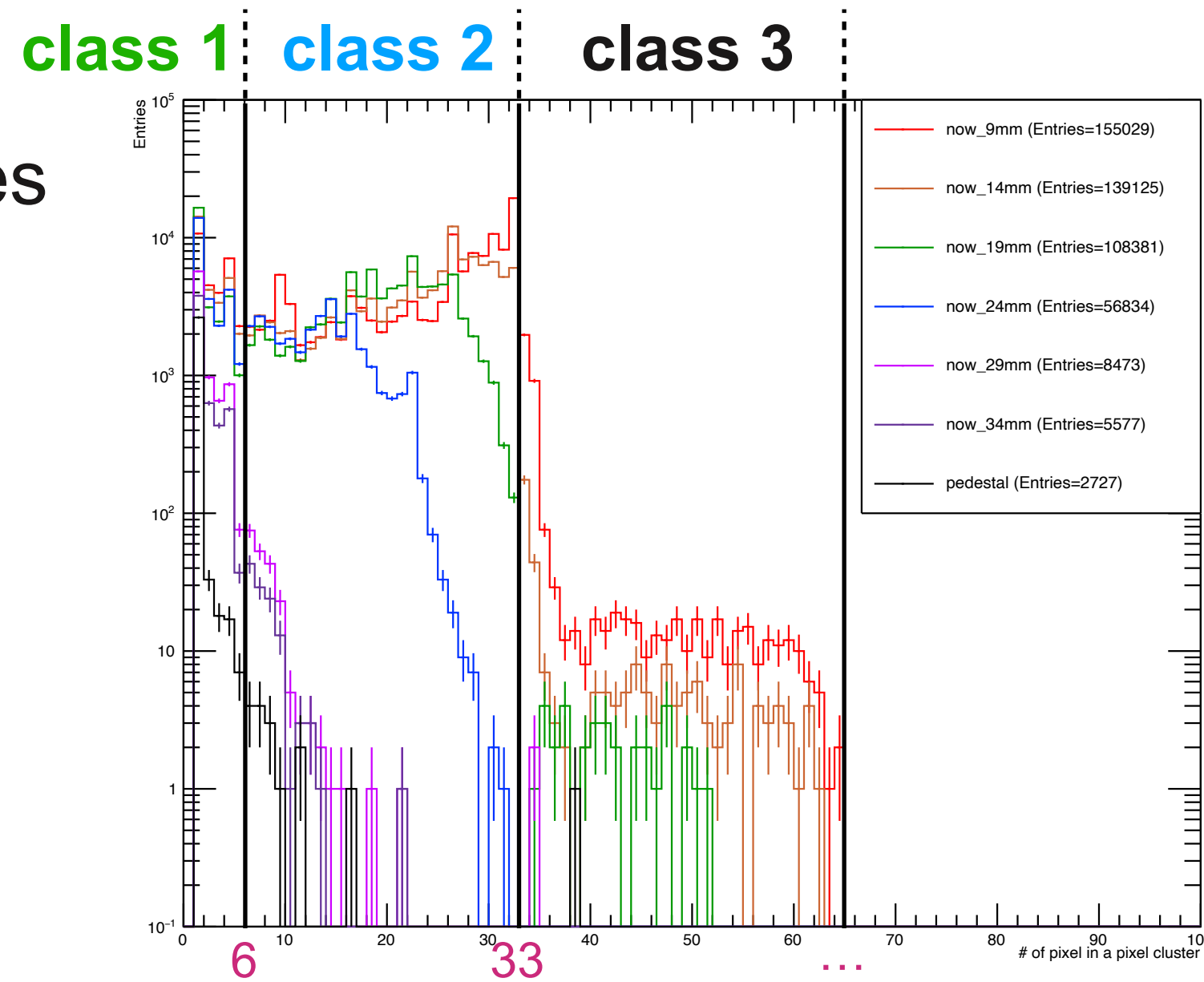
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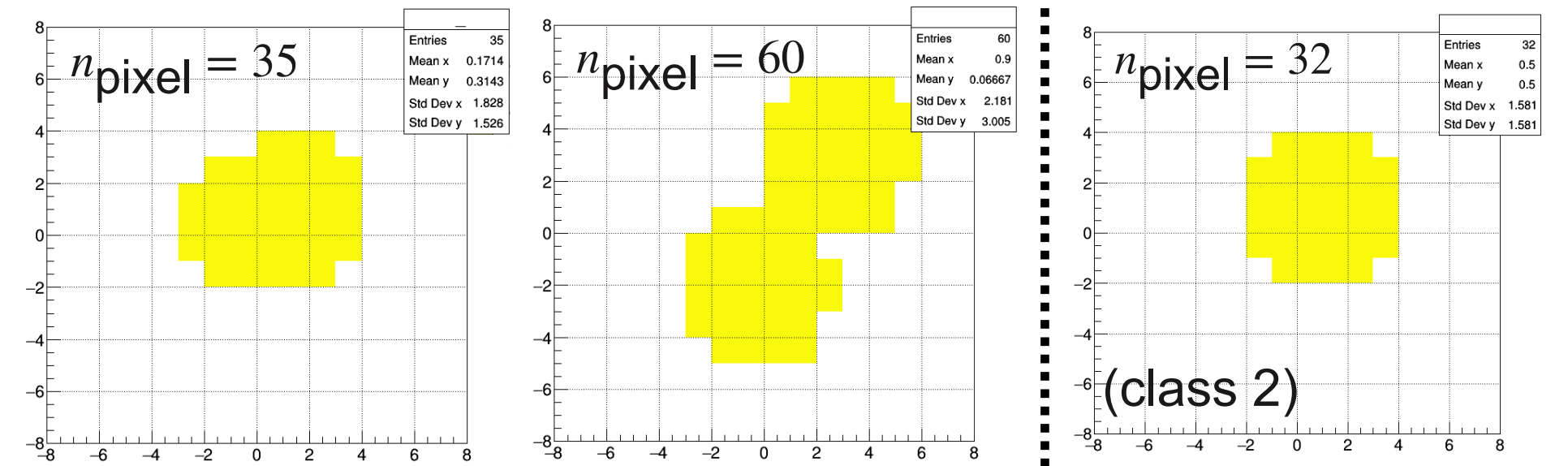
class 2

Shape differs on distance d
 → Effect on char. of signals exists
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Histogram of # of Pixels in a cluster
 (Each color: different distance d)

class 3



Unsymmetrical Clusters

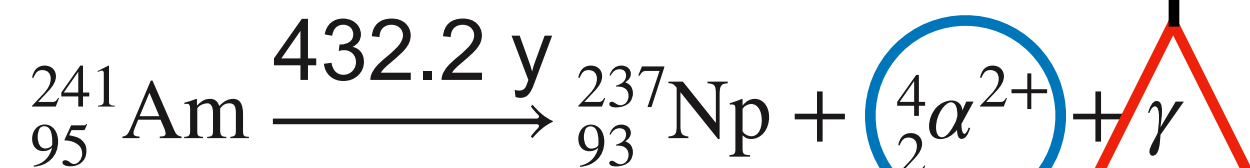
→ 2 or more cluster generated nearby.

α and γ can be identified
 with size of cluster!

Result

class 1

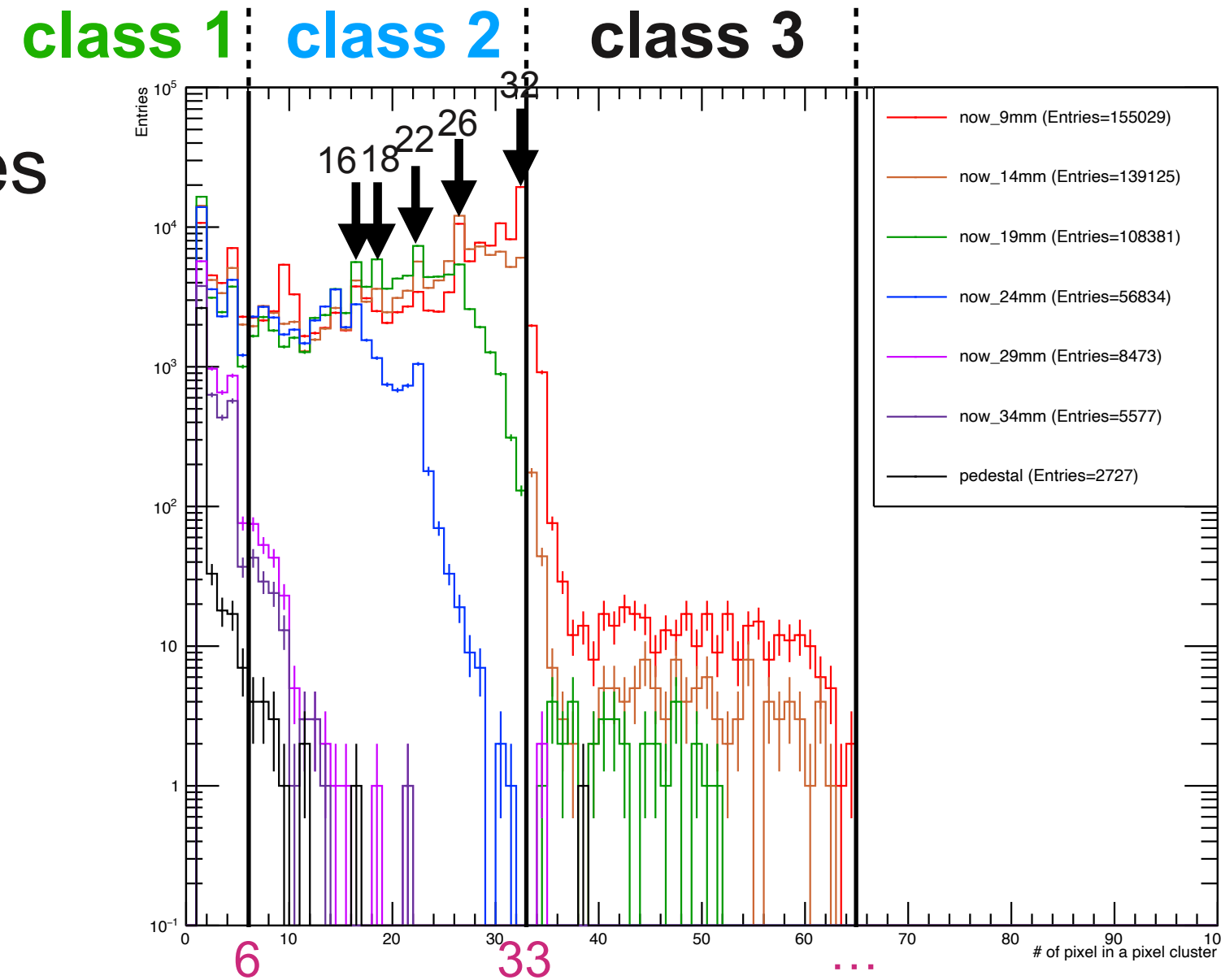
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class 2

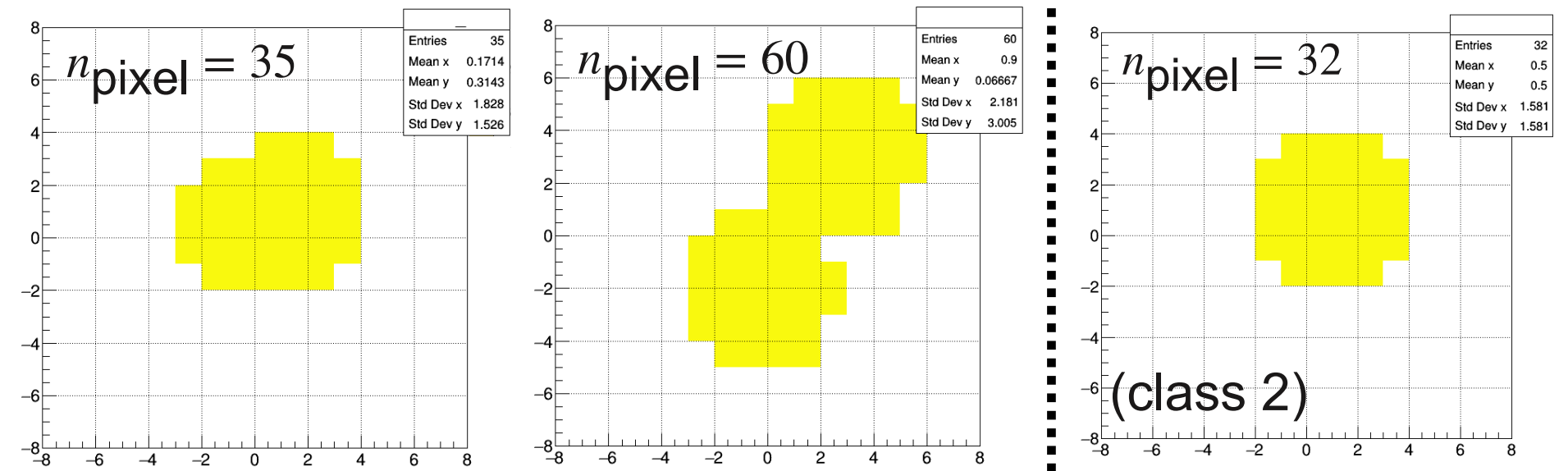
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α and γ can be identified with size of cluster!



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class 3

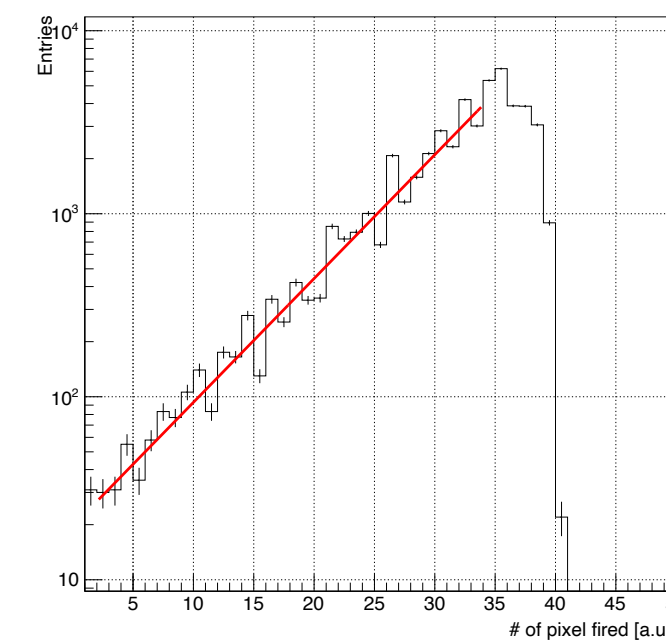


Unsymmetrical Clusters

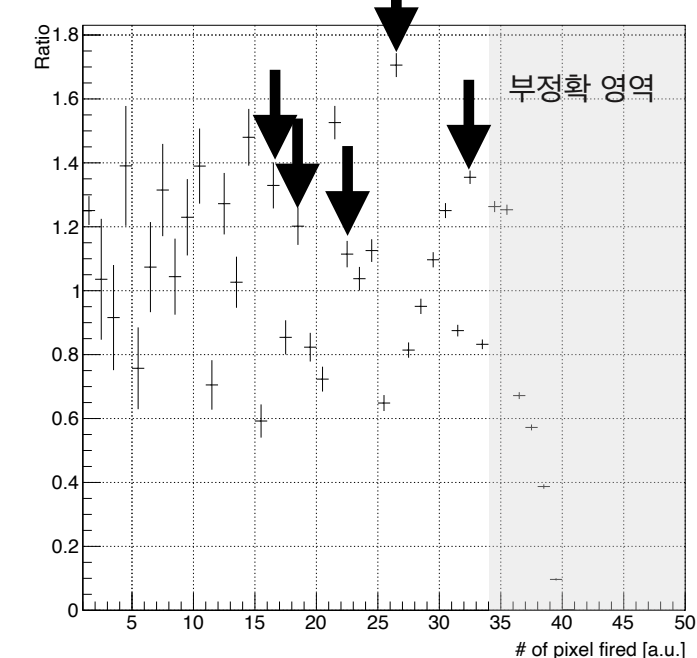
→ 2 or more cluster generated nearby.

Shape

Toy model simulation¹⁾



Data / simulation ratio



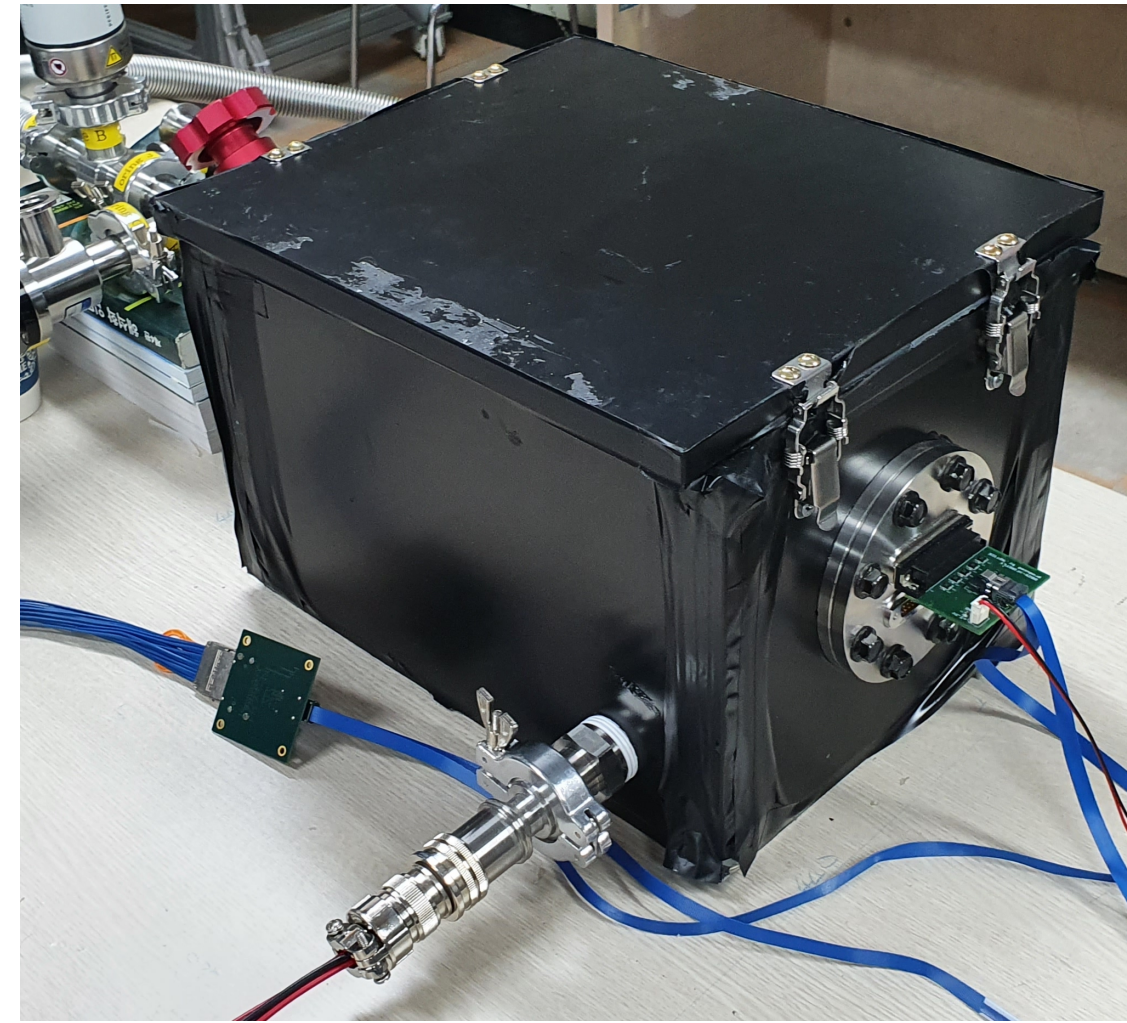
Signal on pixel geometry is simulated.
 It can explain local maxima.

1) Minjae Kwon. (2021). Isaac-Kwon/qupid

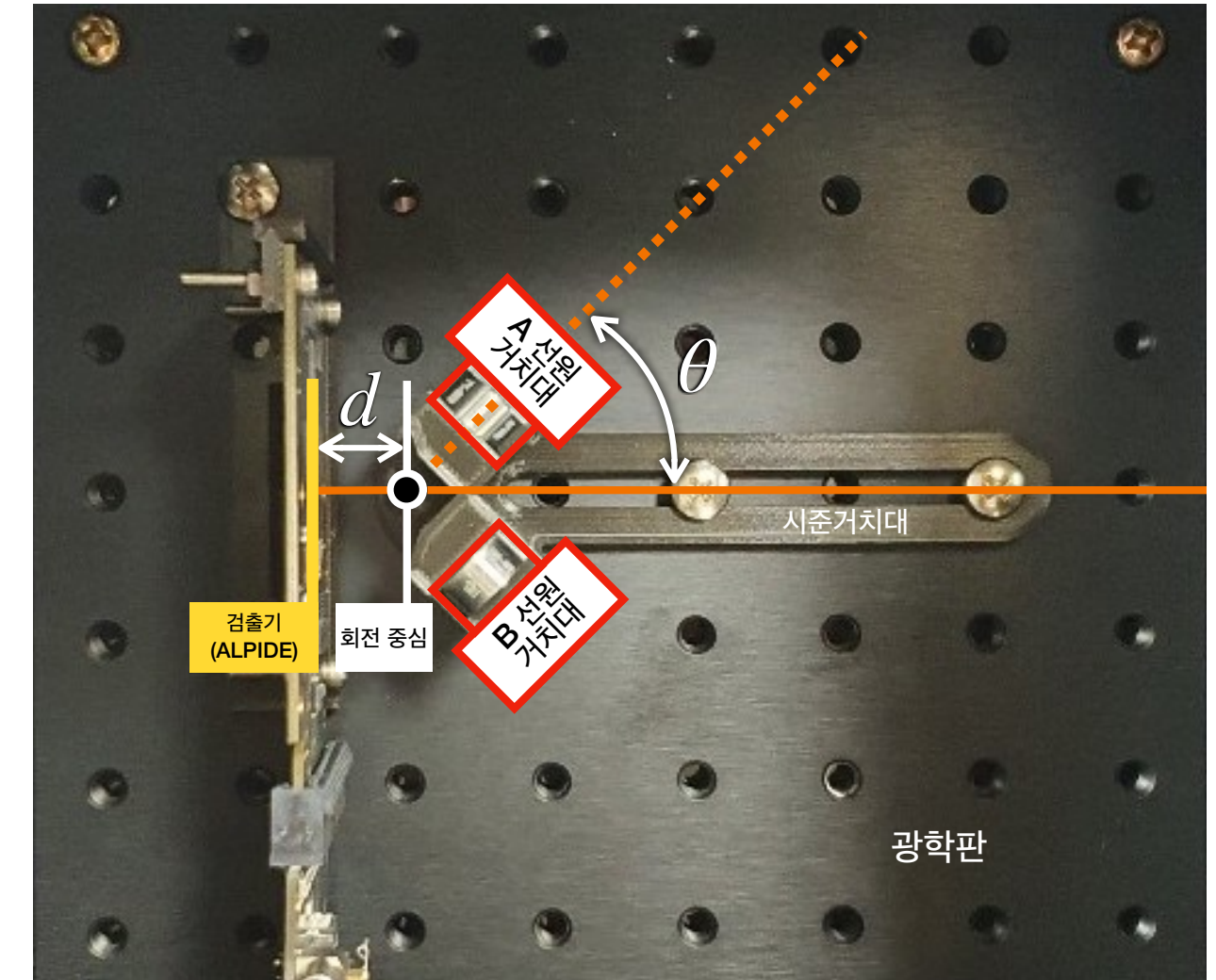
Measurement of reciprocal scattering with 2 of ^{241}Am sources.

Constructing Experiment

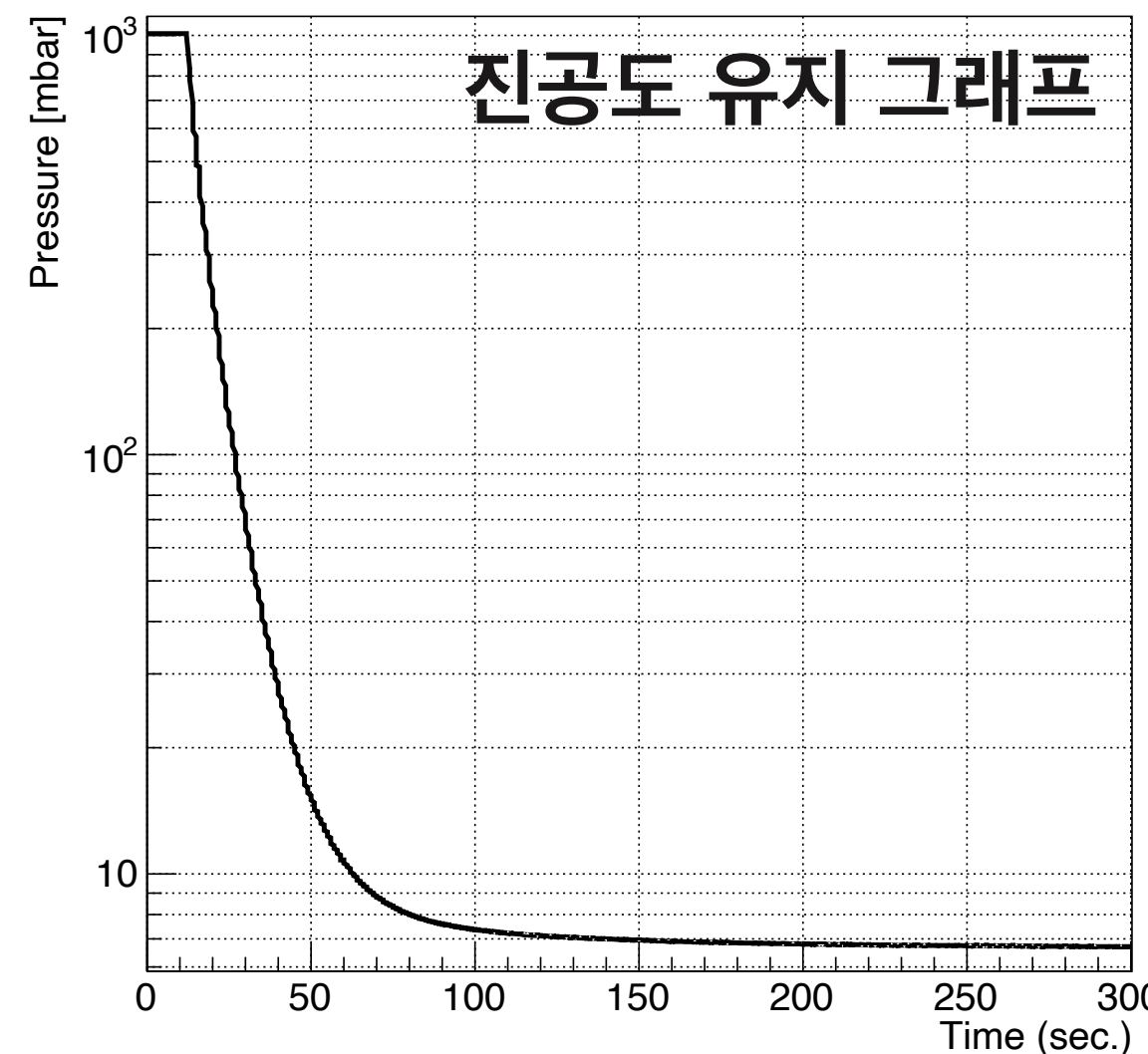
- Vacuum chamber
 - To prevent interaction with air for α
 - 1013mbar \rightarrow 7mbar in 5 min.
 - Includes data, power Feedthroughs.
- Collimating Stand
 - 2 Sources can be attached with 45 deg of interfering angle
 - Each parts of stand are named as "A", "B"
 - Can be rotated on the interaction center
 - d : Distance from interaction center to detector
- Experiment Monitoring System
 - Remote control and monitoring
 - Operating on TMUX



진공 상자



실험 구조



Every 2.0s: ls -lnt /data/ | head -n20 && echo && df -h .

```

total 170G
drwx----- 24 hipex hipex 4.0K Oct 29 17:14 .
-rw-r--r-- 1 hipex hipex 96M Oct 29 17:06 scan_cont_211029_165613.root
drwx-r-xr-x 6 hipex hipex 128K Oct 29 17:06
-rw-r--r-- 1 hipex hipex 102M Oct 29 16:56 scan_cont_211029_164601.root
-rw-r--r-- 1 hipex hipex 103M Oct 29 16:45 scan_cont_211029_163549.root
-rw-r--r-- 1 hipex hipex 94M Oct 29 16:35 scan_cont_211029_162537.root
-rw-r--r-- 1 hipex hipex 121M Oct 29 16:25 scan_cont_211029_161525.root
-rw-r--r-- 1 hipex hipex 92M Oct 29 16:15 scan_cont_211029_160513.root
-rw-r--r-- 1 hipex hipex 180M Oct 29 16:05 scan_cont_211029_155501.root
-rw-r--r-- 1 hipex hipex 96M Oct 29 15:54 scan_cont_211029_154449.root
-rw-r--r-- 1 hipex hipex 88M Oct 29 15:44 scan_cont_211029_153437.root
-rw-r--r-- 1 hipex hipex 111M Oct 29 15:24 scan_cont_211029_151415.root
-rw-r--r-- 1 hipex hipex 103M Oct 29 15:14 scan_cont_211029_150401.root
-rw-r--r-- 1 hipex hipex 109M Oct 29 15:03 scan_cont_211029_145349.root
-rw-r--r-- 1 hipex hipex 119M Oct 29 14:53 scan_cont_211029_144337.root
-rw-r--r-- 1 hipex hipex 117M Oct 29 14:43 scan_cont_211029_143324.root
-rw-r--r-- 1 hipex hipex 99M Oct 29 14:33 scan_cont_211029_142312.root
-rw-r--r-- 1 hipex hipex 94M Oct 29 14:23 scan_cont_211029_141300.root
                    
```

데이터 파일 목록

Fri Oct 29 17:15:12 2021

```

total 170G
drwx----- 24 hipex hipex 4.0K Oct 29 17:14 .
-rw-r--r-- 1 hipex hipex 96M Oct 29 17:06 scan_cont_211029_165613.root
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-rw-r--r-- 1 hipex hipex 119M Oct 29 14:53 scan_cont_211029_144337.root
-rw-r--r-- 1 hipex hipex 117M Oct 29 14:43 scan_cont_211029_143324.root
-rw-r--r-- 1 hipex hipex 99M Oct 29 14:33 scan_cont_211029_142312.root
-rw-r--r-- 1 hipex hipex 94M Oct 29 14:23 scan_cont_211029_141300.root
                    
```

진공 상자 내부의 기압 현황

Filesystem

```

/dev/mapper/cc-home 407G 207G 200G 51% /home
                    
```

저장 공간 용량현황

```

1 [|||||] 7.3% Tasks: 158, 527 thr: 2 running
2 [|||||] 3.3% Load average: 0.04 0.10 0.15
3 [||] 2.1% Uptime: 57 days, 06:00:17
4 [|||||] 7.9%
Mem[|||||] 112.37G/7.61G
Swap[|] 244M/7.87G
                    
```

실험 기기의 자원 (CPU, 메모리) 사용 현황

```

CreateHistogram: generated map with 1 elements
Chip id 0, token = 1, previous = 0
Board 0, found 1 enabled chips
Enabling receiver 3
MOSAIC ResetReceiver: reset the TranReceiver n.0
MOSAIC ResetReceiver: reset the TranReceiver n.1
MOSAIC ResetReceiver: reset the TranReceiver n.2
MOSAIC ResetReceiver: reset the TranReceiver n.3
MOSAIC ResetReceiver: reset the TranReceiver n.4
MOSAIC ResetReceiver: reset the TranReceiver n.5
MOSAIC ResetReceiver: reset the TranReceiver n.6
MOSAIC ResetReceiver: reset the TranReceiver n.7
MOSAIC ResetReceiver: reset the TranReceiver n.8
MOSAIC ResetReceiver: reset the TranReceiver n.9
Saved the conditions
Warning (CScanAnalysis::CreateResult): hic list is empty, doing nothing
[ 48(0), 676, 25 ] is now masked: '48 676 25'
EventTaking: ConfigMaskFile - total 1 pixels are masked
EventTaking: ApplyMask - Starting Mask
EventTaking: ApplyMask - Mapping pixels for each chips 0
ChipID: 0
EventTaking: ApplyMask - Masking chipid=0, pixel=0, pixel=[676,25]
EventAnalysis: Run - Sleeping for Data
EventAnalysis: Run - Run for Events
                    
```

실험 현황

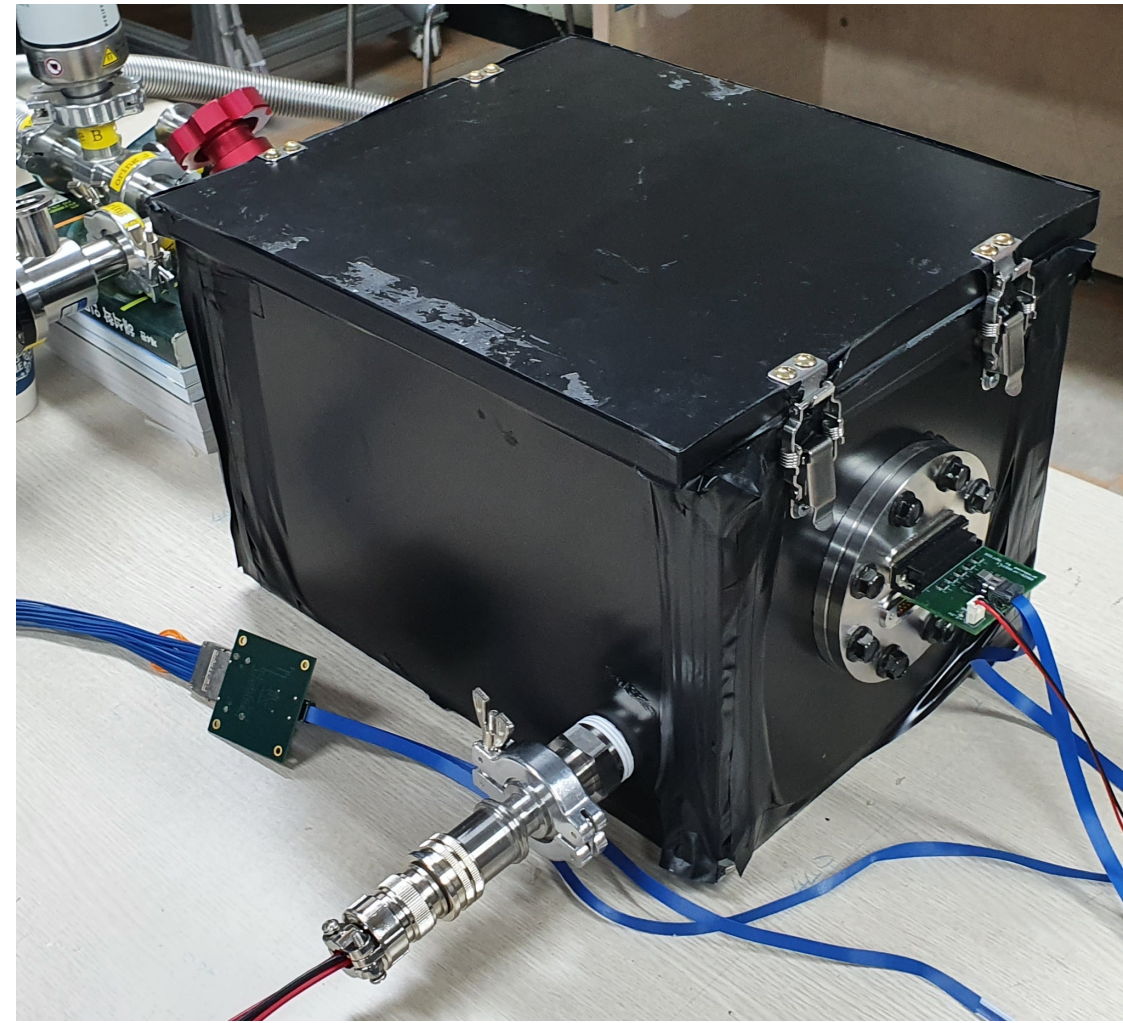
```

hipex 20 0 601M 223M 52548 S 18.2 2.9 1:33.23 /test_myscan -c /Data/Config/9/Config_myscan
hipex 20 0 601M 223M 52548 S 16.1 2.9 1:16.14 /test_myscan -c /Data/Config/9/Config_myscan
hipex 20 0 120M 2820 888 R 2.0 0.0 20:32:58 http
hipex 20 0 120M 1312 1152 R 1.3 0.0 14:46:41 http
hipex 20 0 325M 311M 94324 S 0.7 4.0 0:33.28 /usr/lib64/firefox/firefox
hipex 20 0 722M 20764 1716 S 0.0 0.3 2:46:02 /usr/libexec/gsd-color
hipex 20 0 743M 26816 7524 S 0.0 0.3 3:41:20 /usr/libexec/gnome-terminal-server
root 20 0 90688 32 0 S 0.0 0.0 37:35:07 /sbin/rmtd -F
hipex 20 0 1984 1792 788 S 0.0 0.1 56:14.94 tmux new-session -s exp
hipex 20 0 3235M 311M 94324 S 0.0 4.0 10:36.00 /usr/lib64/firefox/firefox
hipex 20 0 2697M 49408 23604 S 0.0 0.6 0:26.36 /usr/lib64/firefox/firefox -contentproc -child
hipex 20 0 2915M 239M 40180 S 0.0 3.7 0:40.78 /usr/lib64/firefox/firefox -contentproc -child
hipex 20 0 2657M 52844 22704 S 0.0 3.7 0:10.59 /usr/lib64/firefox/firefox -contentproc -child
hipex 20 0 2915M 289M 40180 S 0.0 3.7 0:02.37 /usr/lib64/firefox/firefox -contentproc -child
                    
```

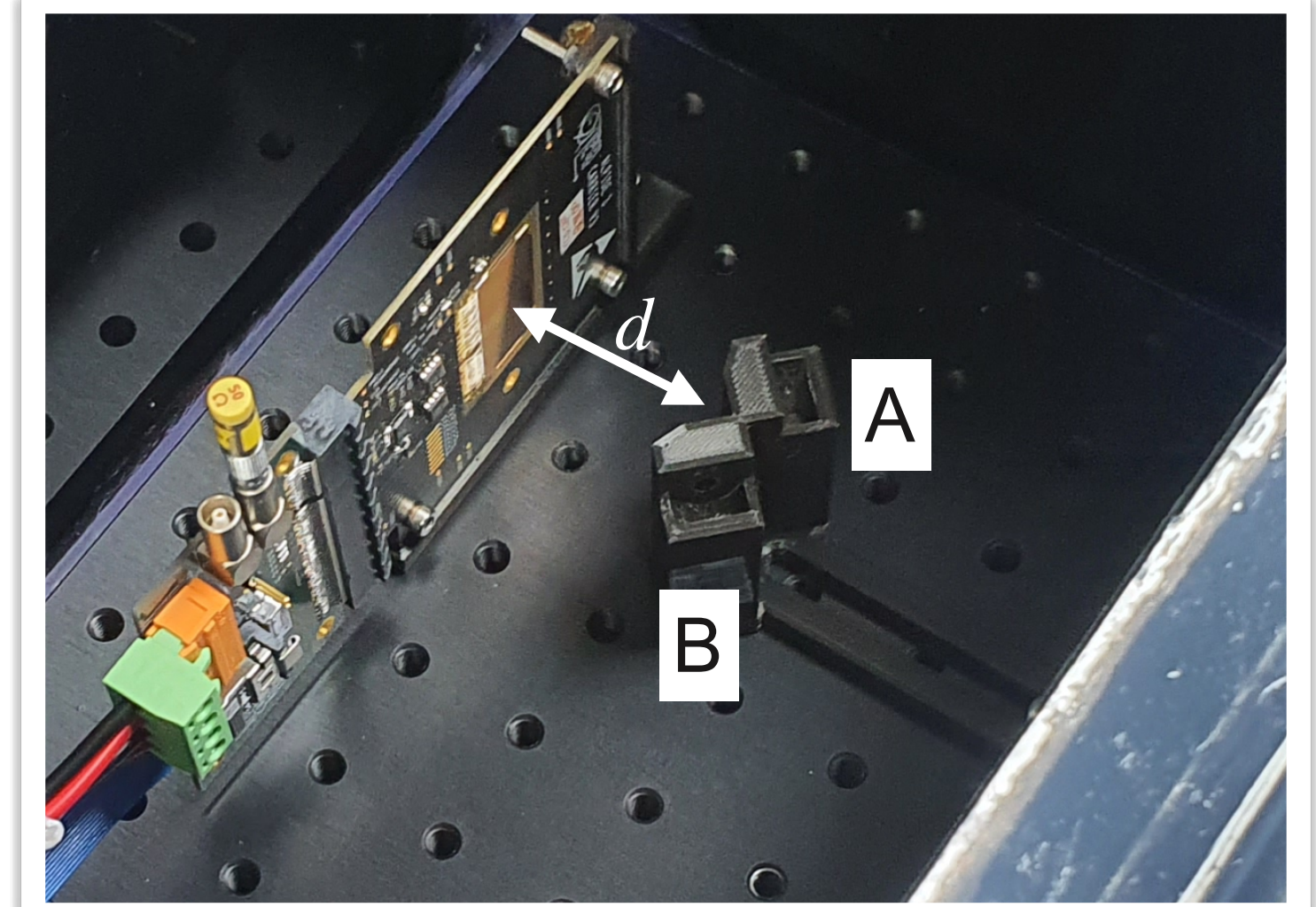
실험 모니터링 시스템

Constructing Experiment

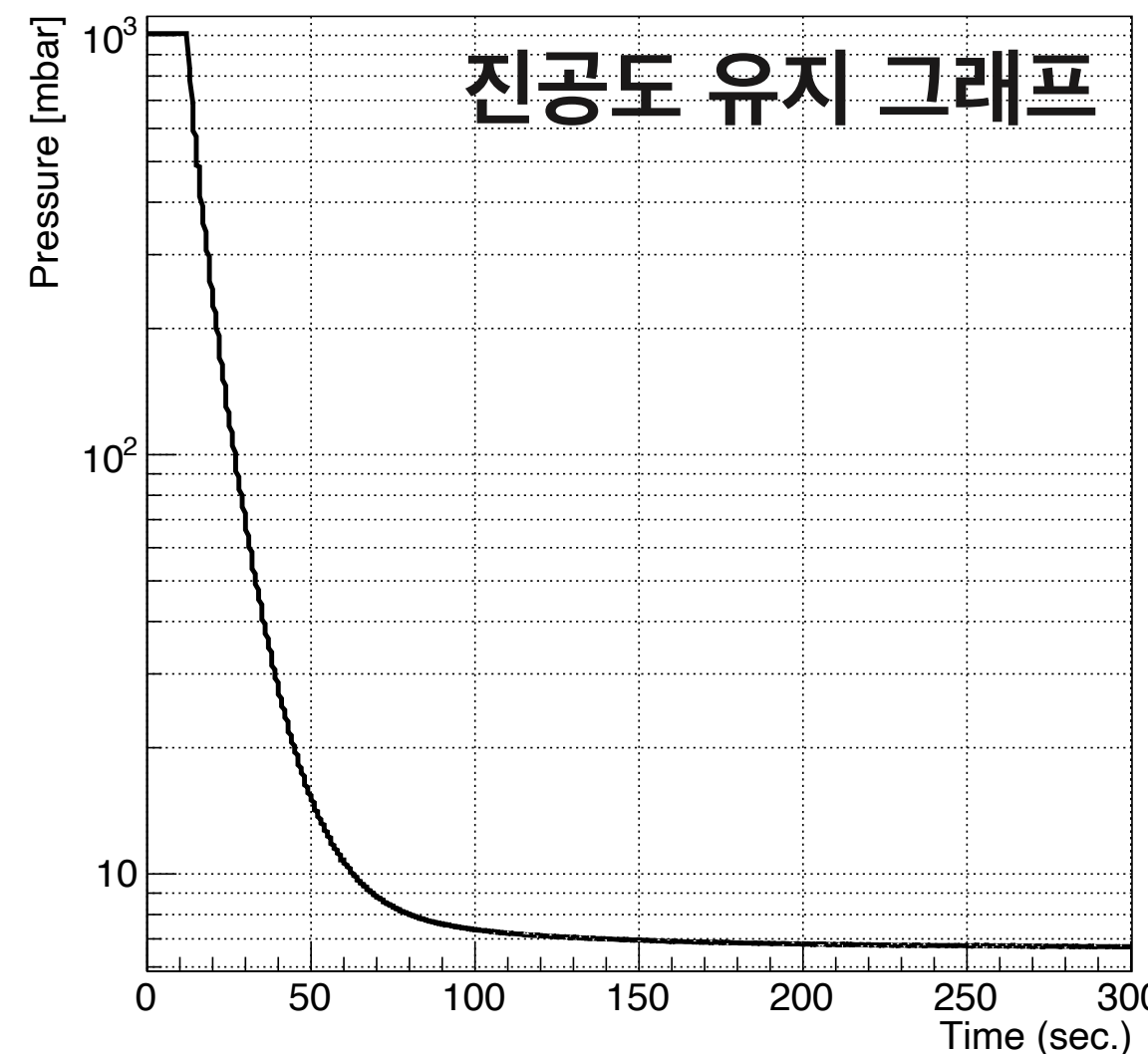
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- Experiment Monitoring System
 - Remote control and monitoring
 - Operating on TMUX



진공 상자



실험 구조



Every 2.0s: ls -lht /data/ | head -n20 && echo && df -h .

```

total 170G
drwx----- 24 hipex hipex 4.0K Oct 29 17:14 .
-rw-r--r-- 1 hipex hipex 90M Oct 29 17:06 scan_cont_211029_165613.root
drwx-r-x- 6 hipex hipex 128K Oct 29 17:06
-rw-r--r-- 1 hipex hipex 102M Oct 29 16:56 scan_cont_211029_164601.root
-rw-r--r-- 1 hipex hipex 103M Oct 29 16:45 scan_cont_211029_163549.root
-rw-r--r-- 1 hipex hipex 94M Oct 29 16:35 scan_cont_211029_162537.root
-rw-r--r-- 1 hipex hipex 121M Oct 29 16:25 scan_cont_211029_161525.root
-rw-r--r-- 1 hipex hipex 92M Oct 29 16:15 scan_cont_211029_160513.root
-rw-r--r-- 1 hipex hipex 180M Oct 29 16:05 scan_cont_211029_155501.root
-rw-r--r-- 1 hipex hipex 90M Oct 29 15:54 scan_cont_211029_154449.root
-rw-r--r-- 1 hipex hipex 88M Oct 29 15:44 scan_cont_211029_153437.root
-rw-r--r-- 1 hipex hipex 111M Oct 29 15:24 scan_cont_211029_151413.root
-rw-r--r-- 1 hipex hipex 103M Oct 29 15:14 scan_cont_211029_150401.root
-rw-r--r-- 1 hipex hipex 119M Oct 29 15:03 scan_cont_211029_145349.root
-rw-r--r-- 1 hipex hipex 119M Oct 29 14:53 scan_cont_211029_144337.root
-rw-r--r-- 1 hipex hipex 117M Oct 29 14:43 scan_cont_211029_143324.root
-rw-r--r-- 1 hipex hipex 99M Oct 29 14:33 scan_cont_211029_142312.root
-rw-r--r-- 1 hipex hipex 94M Oct 29 14:23 scan_cont_211029_141300.root
                
```

Filesystem Size Used Avail Use% Mounted on
/dev/mapper/cc-home 407G 207G 200G 51% /home

CreateHistogram: generated map with 1 elements
Chip id 0, token = 1, previous = 0
Board 0, found 1 enabled chips
Enabling receiver 3
MOSAIC ResetReceiver : reset the TranReceiver n.0
MOSAIC ResetReceiver : reset the TranReceiver n.1
MOSAIC ResetReceiver : reset the TranReceiver n.2
MOSAIC ResetReceiver : reset the TranReceiver n.3
MOSAIC ResetReceiver : reset the TranReceiver n.4
MOSAIC ResetReceiver : reset the TranReceiver n.5
MOSAIC ResetReceiver : reset the TranReceiver n.6
MOSAIC ResetReceiver : reset the TranReceiver n.7
MOSAIC ResetReceiver : reset the TranReceiver n.8
MOSAIC ResetReceiver : reset the TranReceiver n.9
Saved the conditions
Warning (CScanAnalysis::CreateResult): hic list is empty, doing nothing
[480], 676, 25] is now masked : '48 676 25'
EventTaking:ConfigureMaskFile - total 1 pixels are masked
EventTaking:ApplyMask - Starting Mask
EventTaking:ApplyMask - Mapping pixels for each chips 0
ChipID: 0
EventTaking:ApplyMask - Masking chipid=0, pixel=0, pixel=[676,25]
EventAnalysis:Run - Sleeping For Data
EventAnalysis:Run - Run For Events

Fri Oct 29 17:15:12 2021

```

Every 2.0s: tail -n 20 vacuumlog_20211025_180910.log
                
```

데이터 파일 목록

진공 상자 내부의 기압 현황

저장 공간 용량현황

실험 현황

실험 기기의 자원 (CPU, 메모리) 사용 현황

```

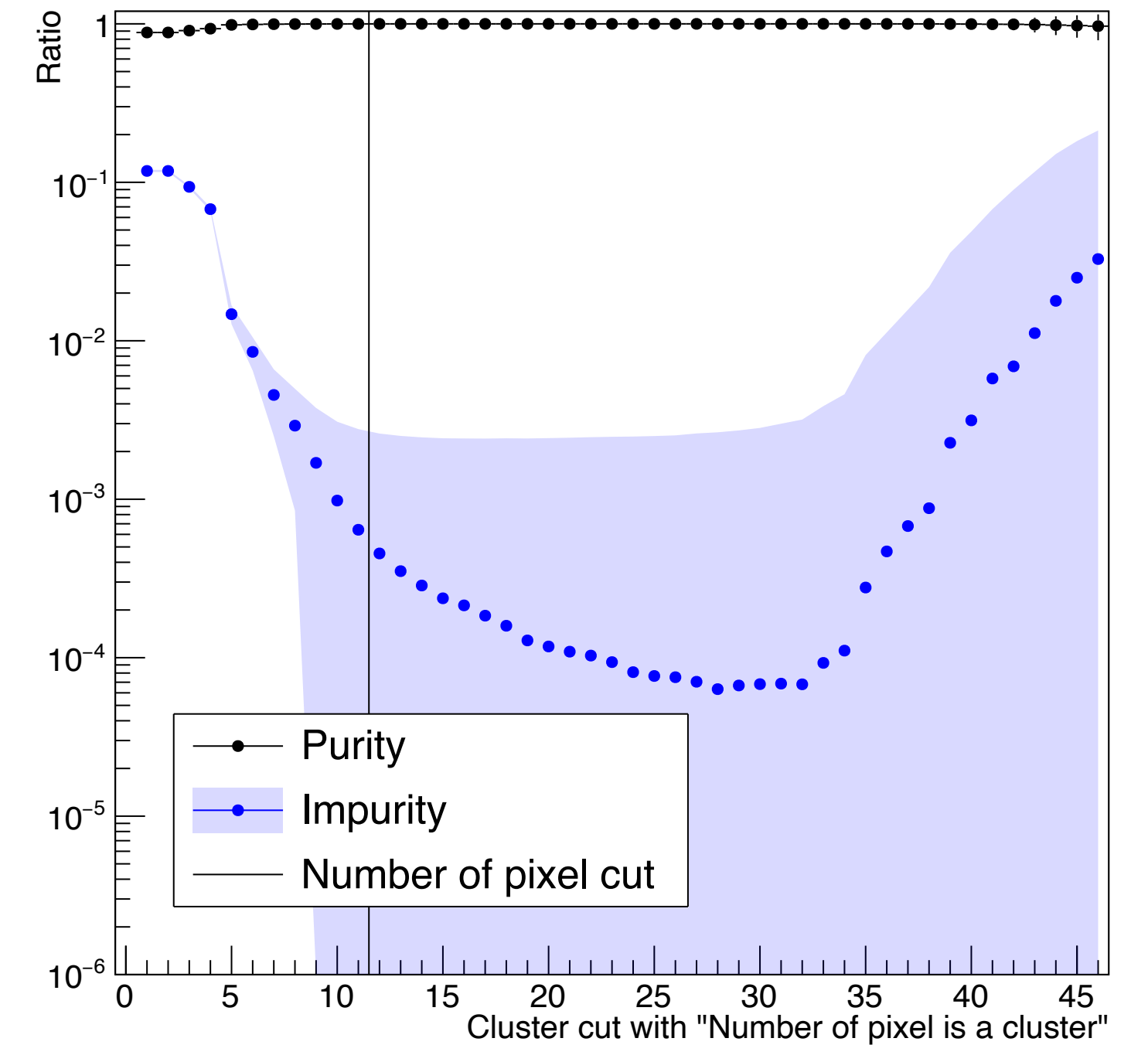
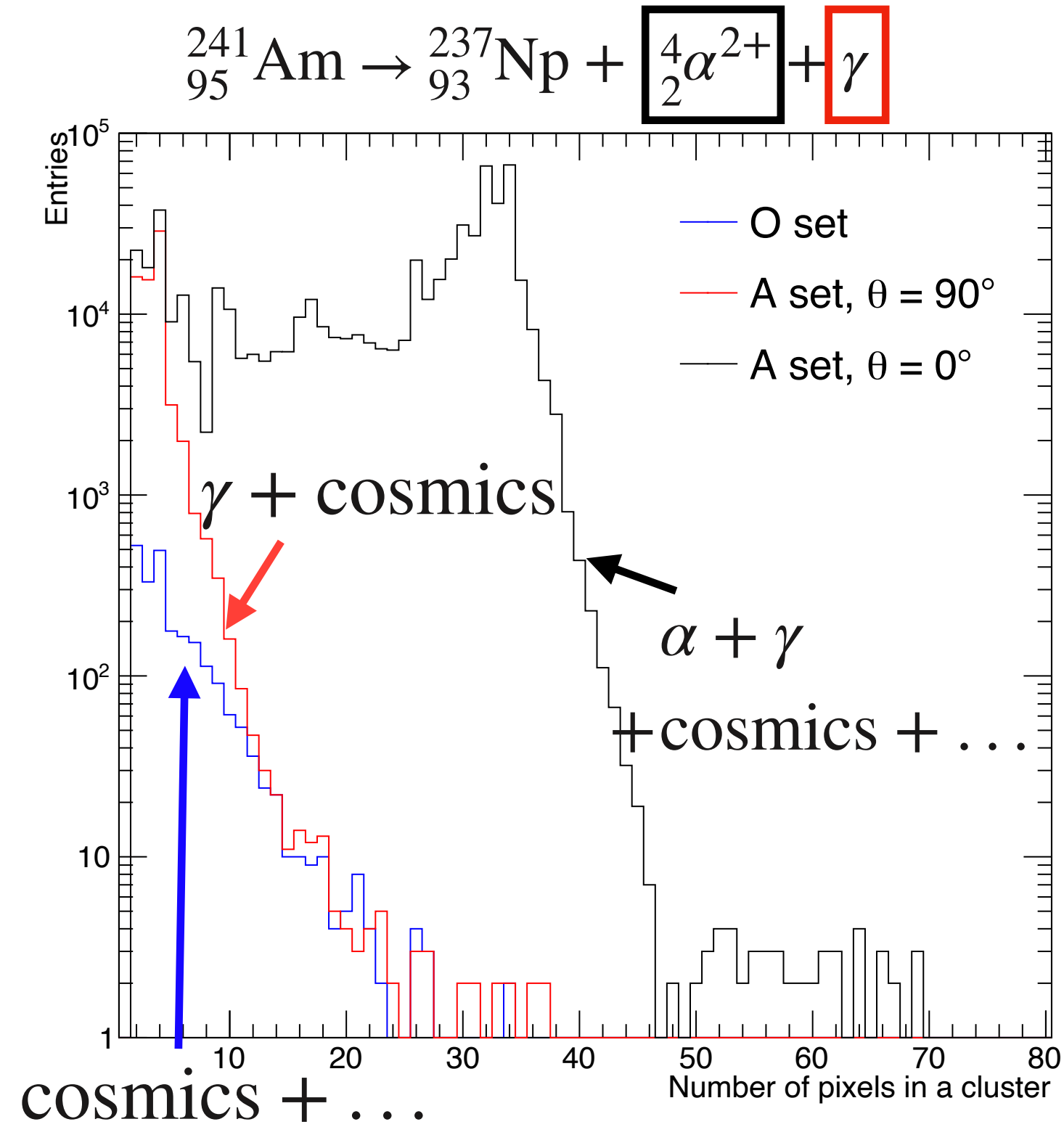
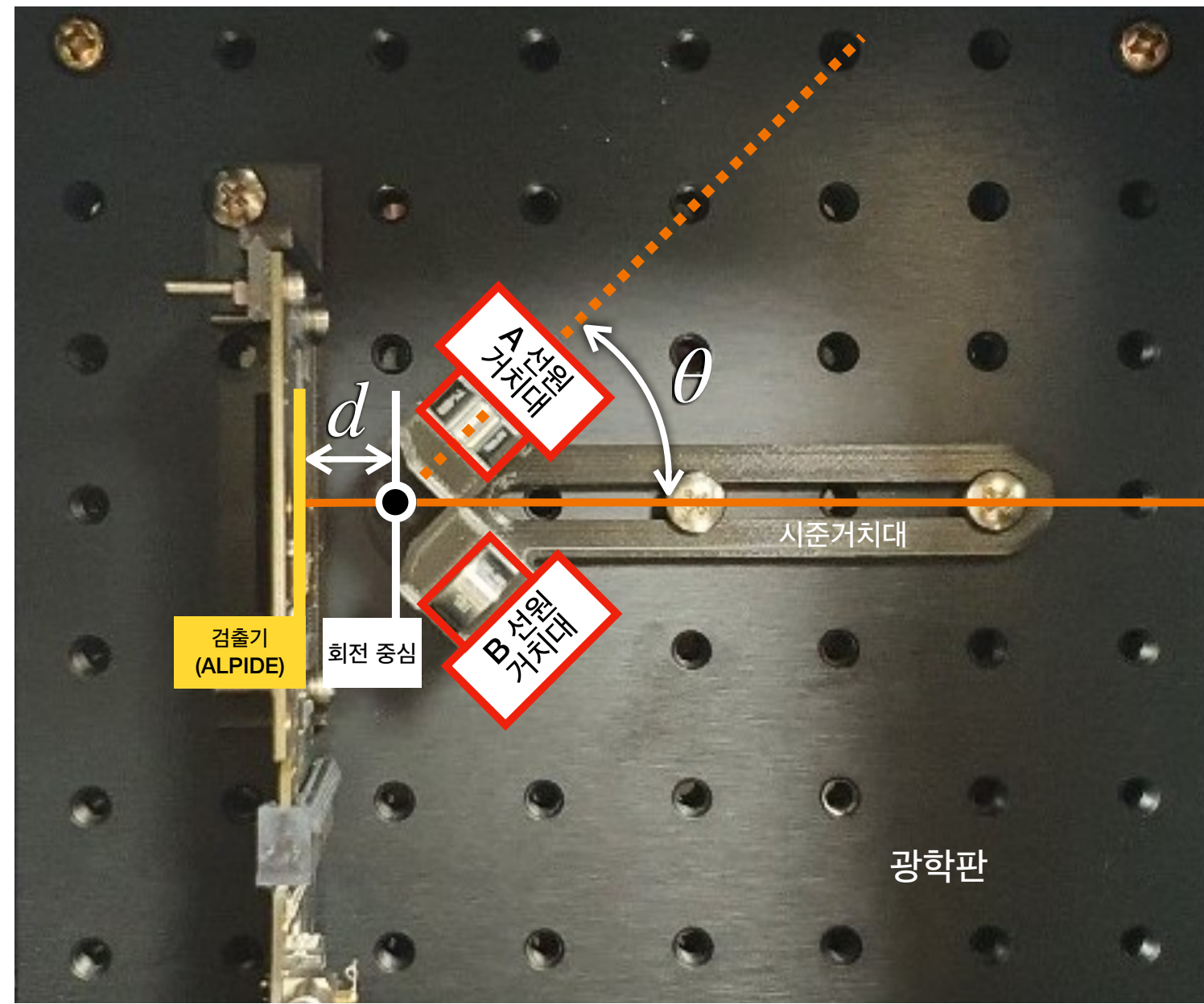
1 [|||||] 7.3% Tasks: 158, 527 thr: 2 running
2 [|||||] 3.3% Load average: 0.04 0.10 0.15
3 [||] 2.1% Uptime: 57 days, 06:00:17
4 [|||||] 7.9%
Mem[|||||] 112.37G/7.61G
Swap[|] 244M/7.87G
                
```

```

hipex 20 0 601M 223M 52548 S 18.2 2.9 1:33.23 /test_myscan -c /Data/Config9/Config_myscan
hipex 20 0 601M 223M 52548 S 16.1 2.9 1:16.14 /test_myscan -c /Data/Config9/Config_myscan
hipex 20 0 601M 223M 52548 S 2.7 2.9 0:16.25 /test_myscan -c /Data/Config9/Config_myscan
hipex 20 0 120M 2820 888 R 2.0 0.0 20:32:58 http
hipex 20 0 120M 1312 1152 R 1.3 0.0 14:46:41 http
hipex 20 0 3255M 311M 94324 S 0.7 4.0 0:33.38 /usr/lib64/firefox/firefox
hipex 20 0 722M 20764 1716 S 0.0 0.3 0:46:02 /usr/libexec/gsd-color
hipex 20 0 743M 26816 7524 S 0.0 0.3 30:11:20 /usr/libexec/gnome-terminal-server
root 20 0 9068 32 0 S 0.0 0.0 0:37:35.07 /sbin/rngd -F
hipex 20 0 1984 1092 788 S 0.0 0.1 56:14.94 tmux new-session -s exp
hipex 20 0 3235M 311M 94324 S 0.0 4.0 10:36.00 /usr/lib64/firefox/firefox
hipex 20 0 2679M 49406 23604 S 0.0 0.6 0:26.36 /usr/lib64/firefox/firefox -contentproc -child
hipex 20 0 2915M 2399 40180 S 0.0 3.7 0:40.78 /usr/lib64/firefox/firefox -contentproc -child
hipex 20 0 2657M 52844 22704 S 0.0 0.7 0:10.59 /usr/lib64/firefox/firefox -contentproc -child
hipex 20 0 2915M 2899 40180 S 0.0 3.7 0:02:37 /usr/lib64/firefox/firefox -contentproc -child
                
```

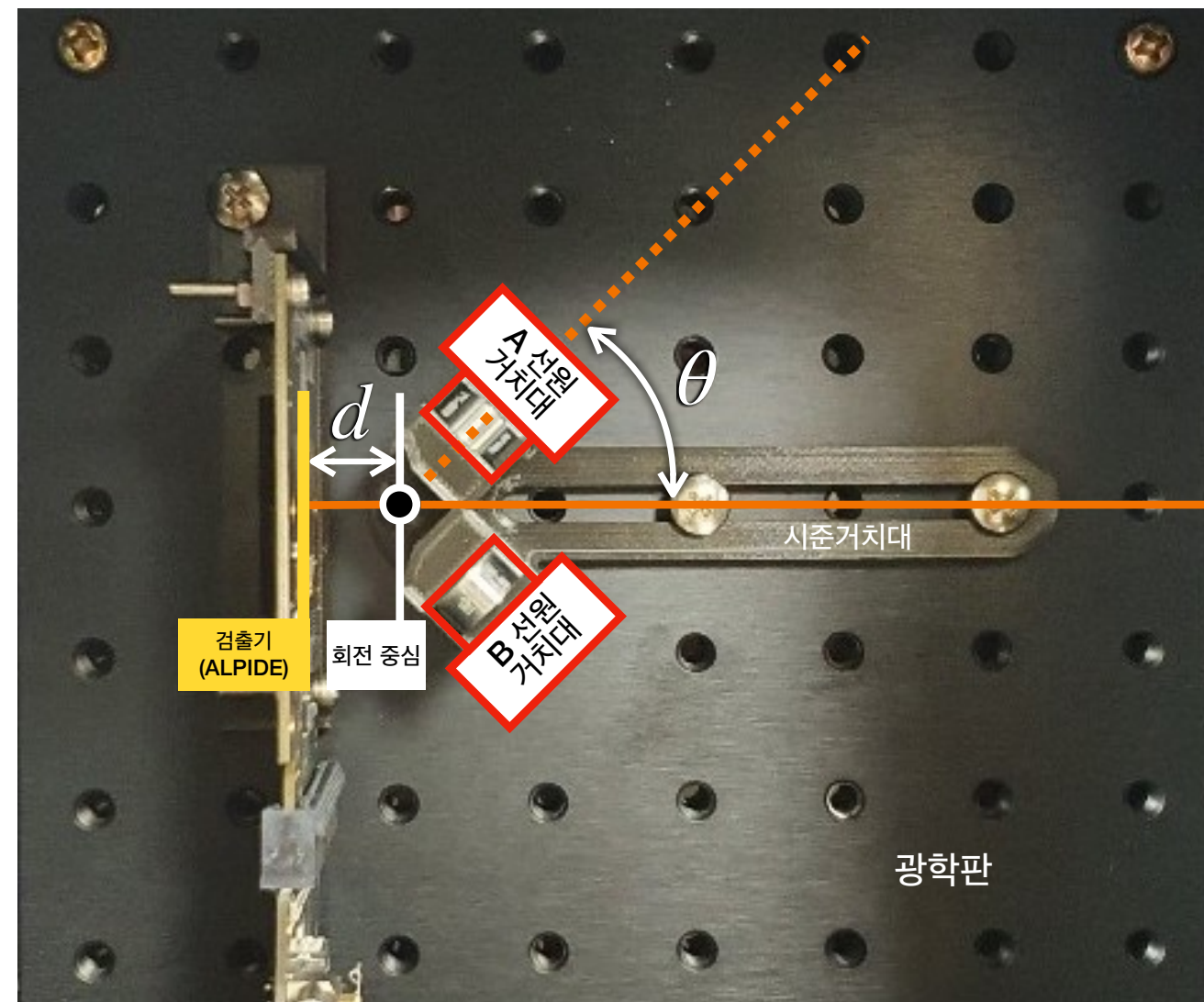
실험 모니터링 시스템

Pre-exp.) Noise ID



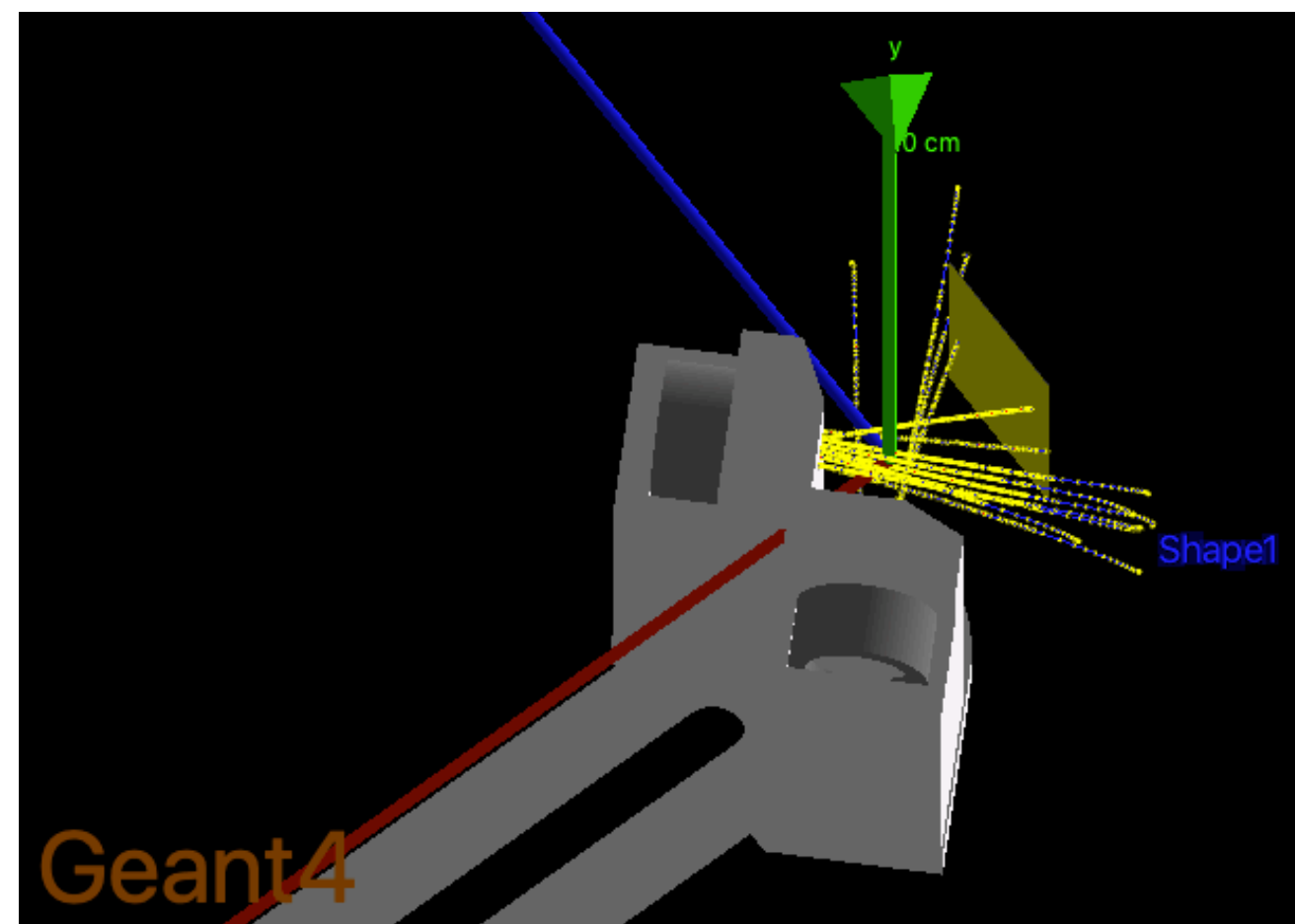
- Noise rather than $\alpha : \gamma$, Cosmics
- $n_{\text{pixel}} > 9$: Purity's uncertainty includes 0
- Set the n-pixel cut to take α : $n_{\text{pixel}} > 11$

Main exp.) Is there different on distance d about recip. scattering?



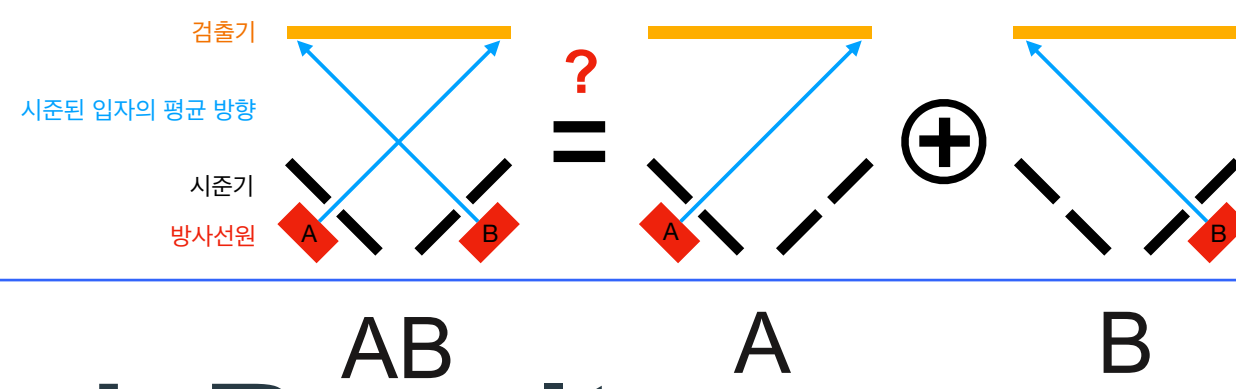
Real World

- $d = 7\text{mm}, 12.4\text{mm}, 17.0\text{mm}$
- Experiments are done with A, A and B, B source.
 - Never re-attach source!
- 1 Experiment = 6 hrs.



GEANT4 World

- **No interaction between α particles**
 - The interference can be watched by comparison.
- Same geometrical, source conditions
- Done with equivalent number of particles on time on real world

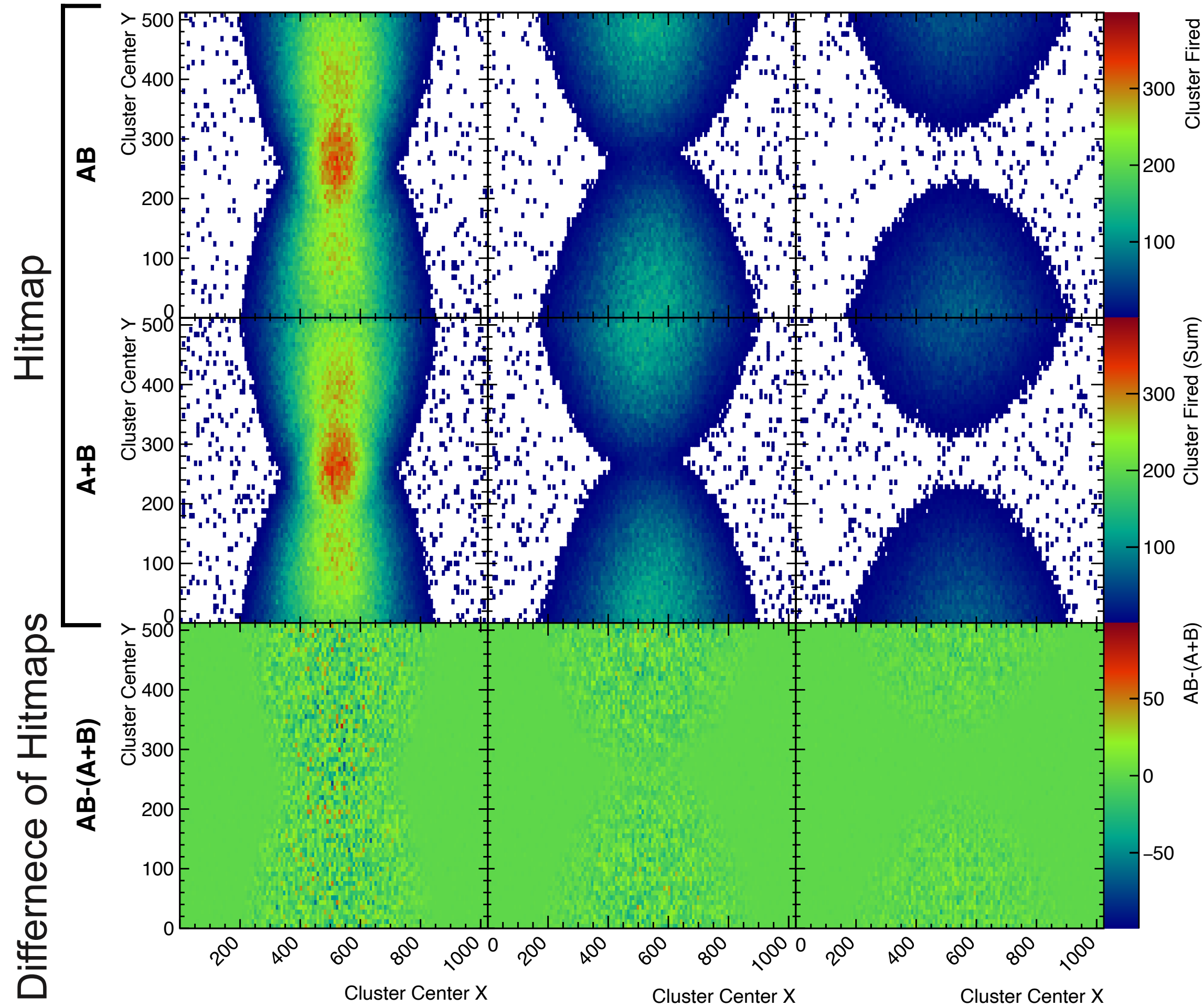


Analysis Method, Result

d = 7.0mm

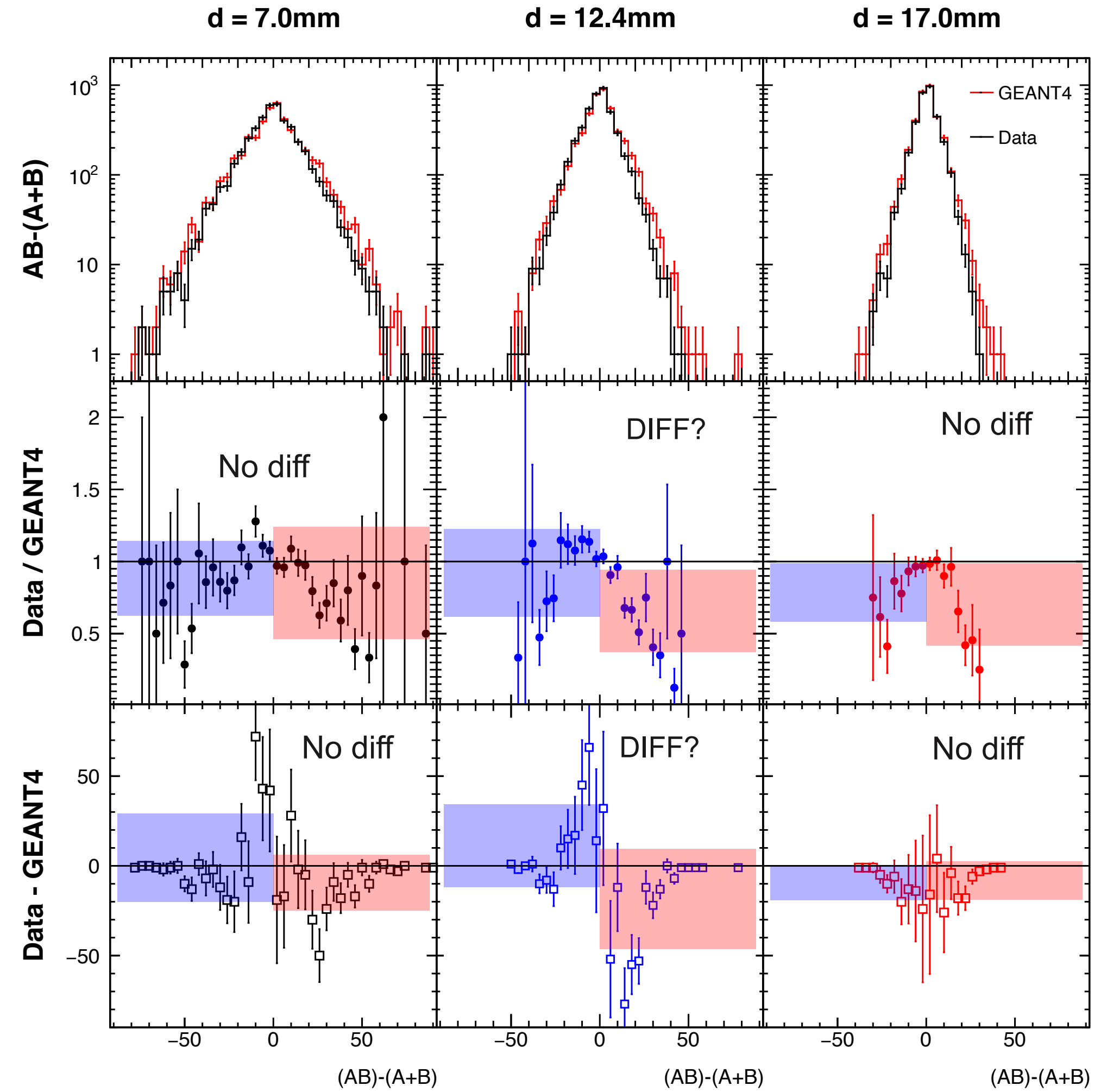
d = 12.4mm

d = 17.0mm



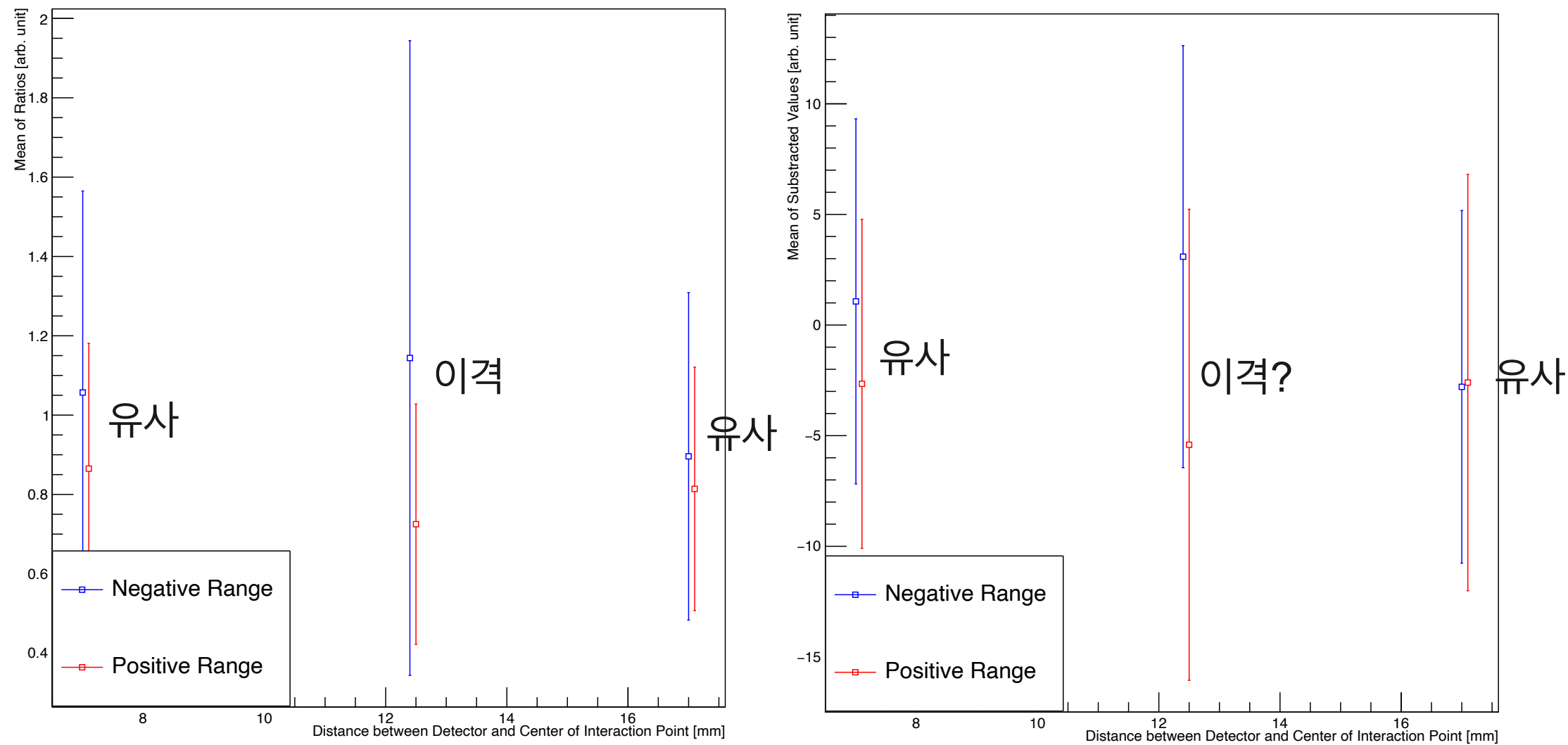
Difference of Entries
in each bins

Red: Mean Value in Positive Range
Blue: Mean Value in Negative Range



The part, AB is less than A+B and larger than A+B

Result / Possibility



수집된 클러스터의 갯수 일람

$d(\text{mm})$	A	B	A+B	AB
7.0	31000 ± 600	285700 ± 500	595700 ± 800	591600 ± 800
12.4	107300 ± 300	118500 ± 300	225800 ± 500	220500 ± 500
17.0	34900 ± 200	45900 ± 200	80800 ± 300	81300 ± 300
$d(\text{mm})$	AB-(A+B)		$(AB-(A+B))/AB$	
7.0	-4200 ± 1100		-0.0070 ± 0.0018	
12.4	-5400 ± 700		-0.024 ± 0.003	
17.0	500 ± 400		0.006 ± 0.005	

- If, # of AB's incident particle is less than A or B(With any other reasons)?
 - Same effect!
- Analysis about systematic uncertainty?

Summary & Outlook

- PID for low energy α particle **with SPD**_(ALPIDE) is done
- The first reciprocal scattering using 2 of ^{241}Am is done
- The result is compared with GEANT4 which doesn't have reciprocal effect.

- The experiment is done in distance $d = 7\text{mm}, 12.4\text{mm}, 17.0\text{mm}$
 - In case of $d = 12.4\text{mm}$, the result is different with other d .
 - It can be from lack of incident of particles because of other reasons.
 - Analysis about systematic uncertainty is needed.

Reference

1. K. Bugaev and O. Vitiuk, “Triple nuclear collisions – a new method to explore the matter properties under new extreme conditions”, Online Strangeness in Quark Matter Conference 2021. New York, NY, May, 2021. <https://indico.cern.ch/event/985652/contributions/4302192/>.
2. USQCD, <https://www.usqcd.org/extreme.html>
3. M. Berger, J. Coursey, M. Zucker, and J. Chang, “Estar, pstar, and astar: Computer programs for calculating stopping-power and range tables for electrons, protons, and helium ions (version 1.2.3). [online]”,. <http://physics.nist.gov/Star>. Last Updated at July 2017, Accessed at 20 October 2021. Originally published as: Berger, M.J., NISTIR 4999, National Institute of Standards and Technology, Gaithersburg, MD (1993).
4. M. Kwon, “Isaac-kwon/qupid”, Sept., 2021. <https://doi.org/10.5281/zenodo.5519749>.
5. S. Agostinelli, J. Allison, K. Amako, J. Apostolakis, H. Araujo and et al. “Geant4—a simulation toolkit”, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 506 no. 3, (2003) 250–303. <https://www.sciencedirect.com/science/article/pii/S0168900203013688>.
6. C. M. Poole, I. Cornelius, J. V. Trapp, and C. M. Langton, “A cad interface for geant4”, Australasian Physical & Engineering Sciences in Medicine 35 no. 3, (2012) 329–334. <https://doi.org/10.1007/s13246-012-0159-8>.

Thank You!



Ultra Short Summary of Years

2020

- Development frameworks for data-taking and analysis are done.
 - Source measurement with ^{241}Am on ALPIDE.
- Concept for elastic low-energy scattering is designed.

2021

- Robust PID of α and γ particle from ^{241}Am
- Measure reciprocal scattering with 2 of ^{241}Am sources.
- On-call shift for ITS2 on ALICE-Commissioning 2021

Qupid model

Quasi-Signal Generation Model for *P*ixelized *D*etector

Objective

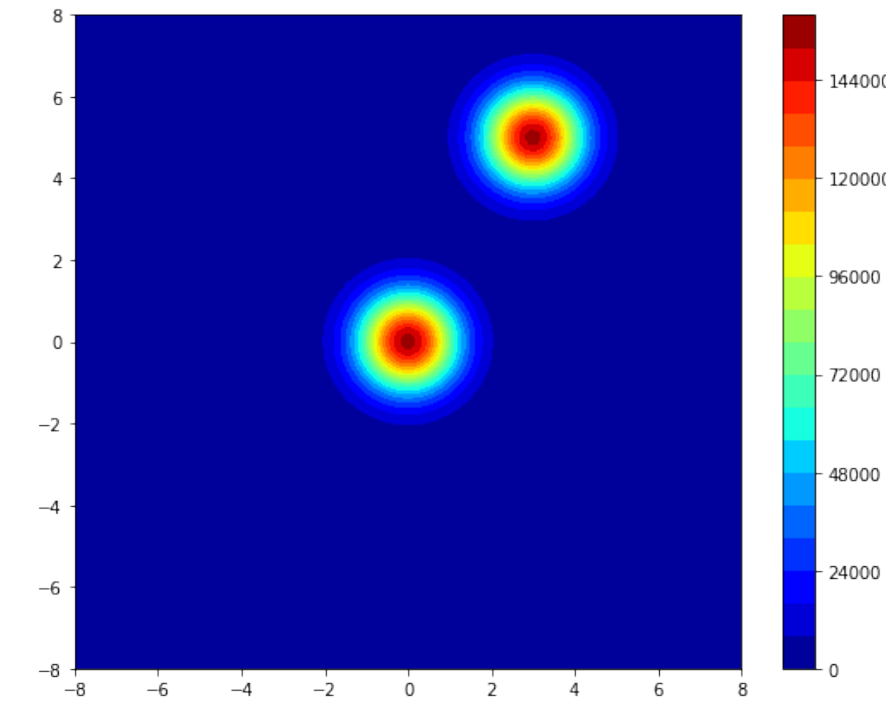
Fired pixel cluster shape generation to use for machine learning

- Based on Python3 (numpy, scipy)
- Procedure
 - Define signal amplitude distribution function (ADF) on detector plane
 - Calculate signal in pixel with integrating ADF with for each pixel.
 - Find pixel which has signal over threshold.

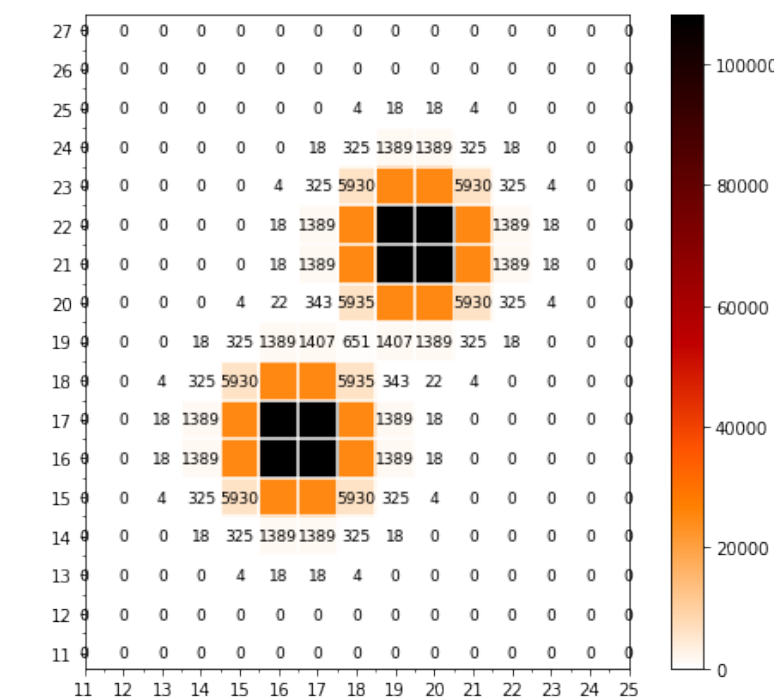
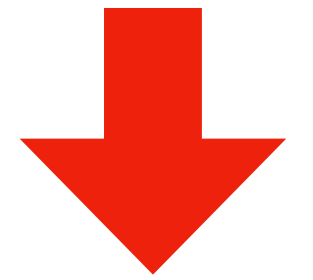
Github Repository: <https://github.com/Isaac-Kwon/qupid>

Documentation : <https://isaac-kwon.github.io/qupid>

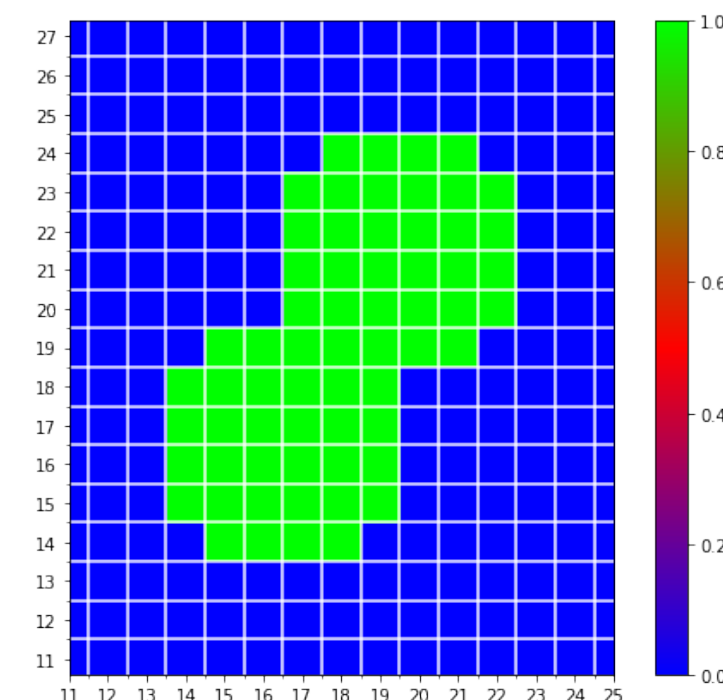
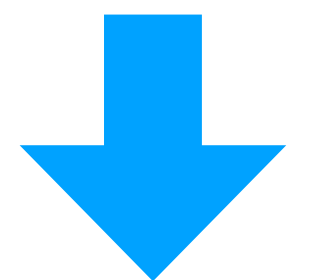
Now Generation is on-going...



Analogue Signal Distribution



Digital Signal Distribution (Integrated Signal)



Fired Pixel Distribution

Qupid model

Quasi-Signal Generation Model for *Pixelized Detector*

Objective

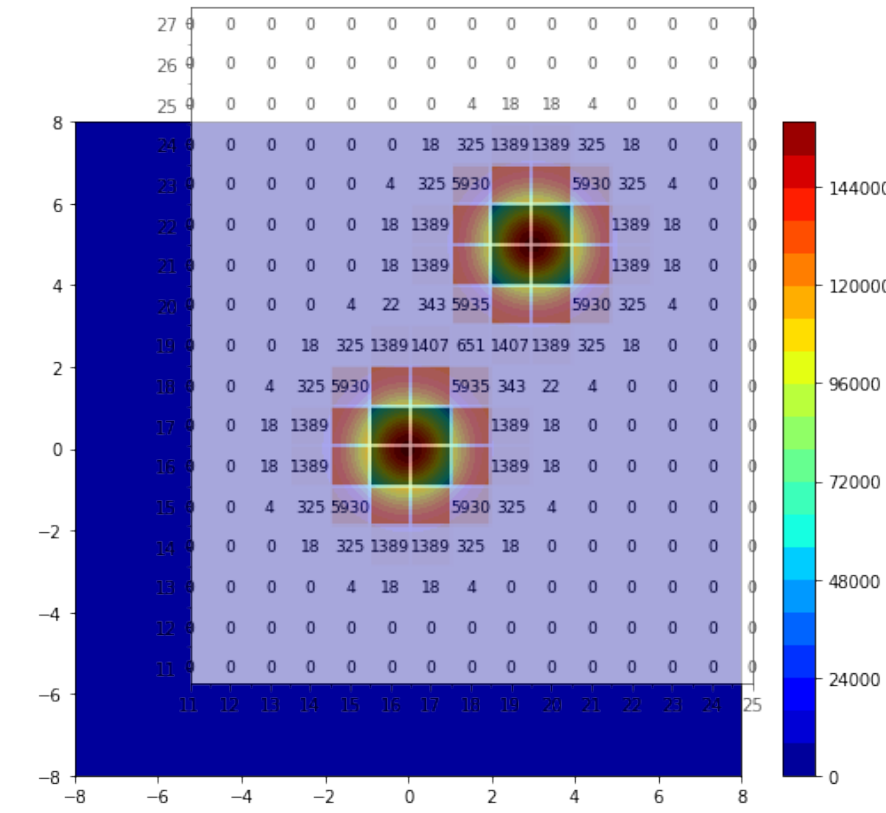
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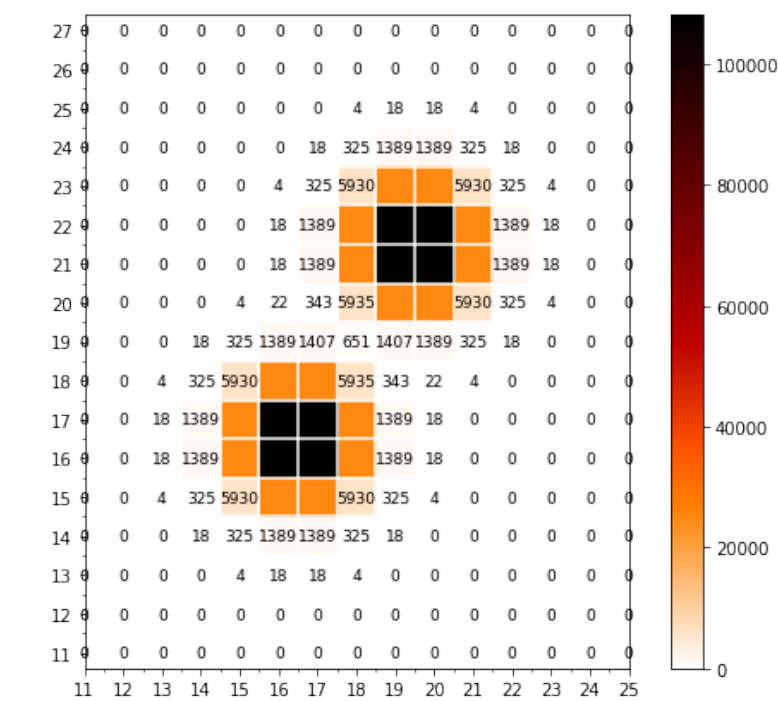
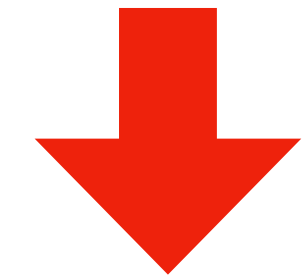
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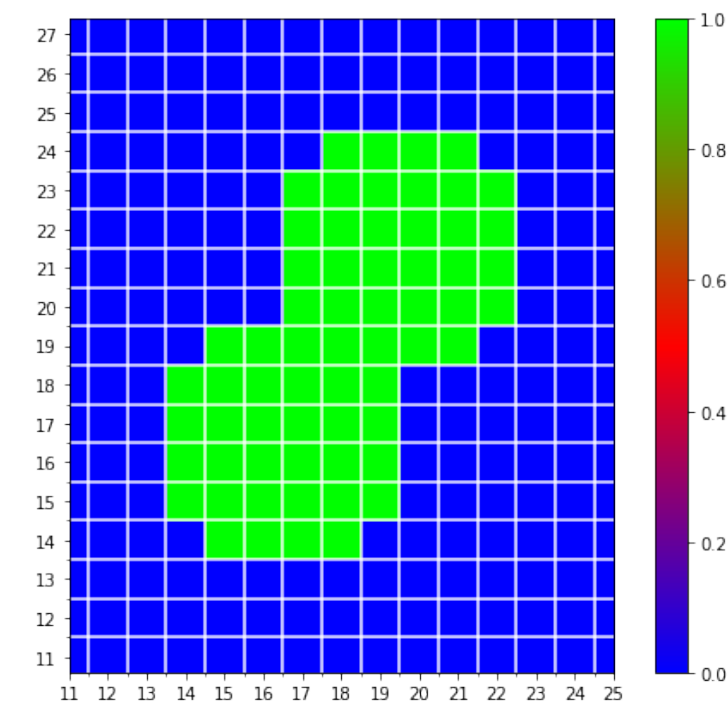
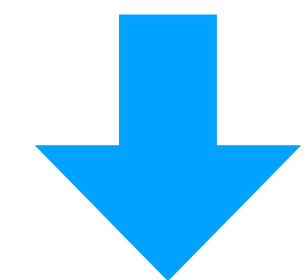
Now Generation is on-going...



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Digital Signal Distribution (Integrated Signal)



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Qupid model

Quasi-Signal Generation Model for *Pixelized Detector*

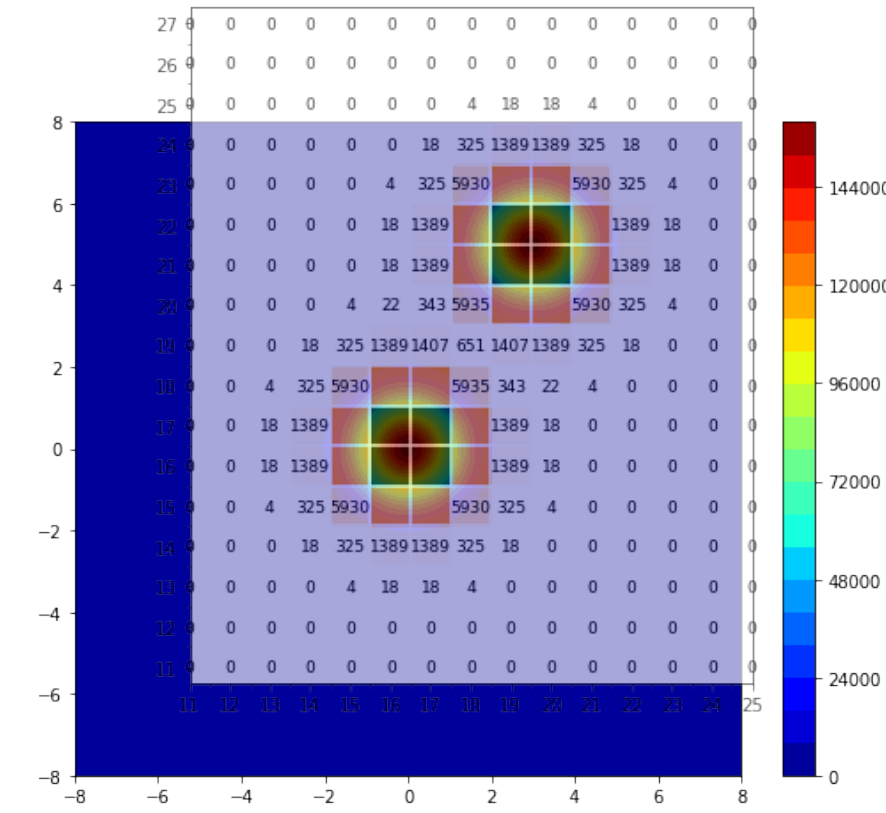
Objective

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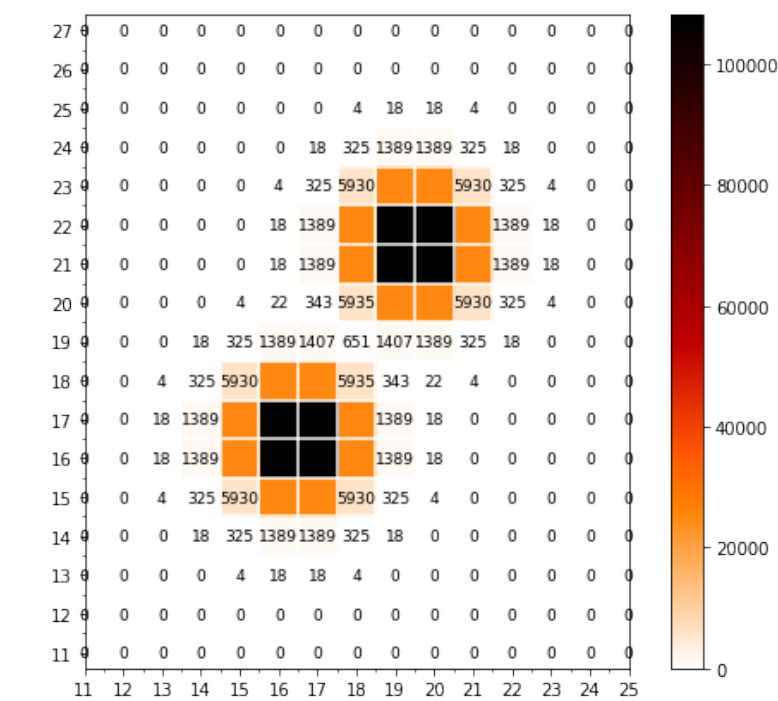
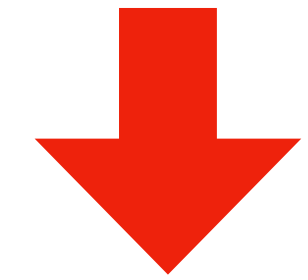
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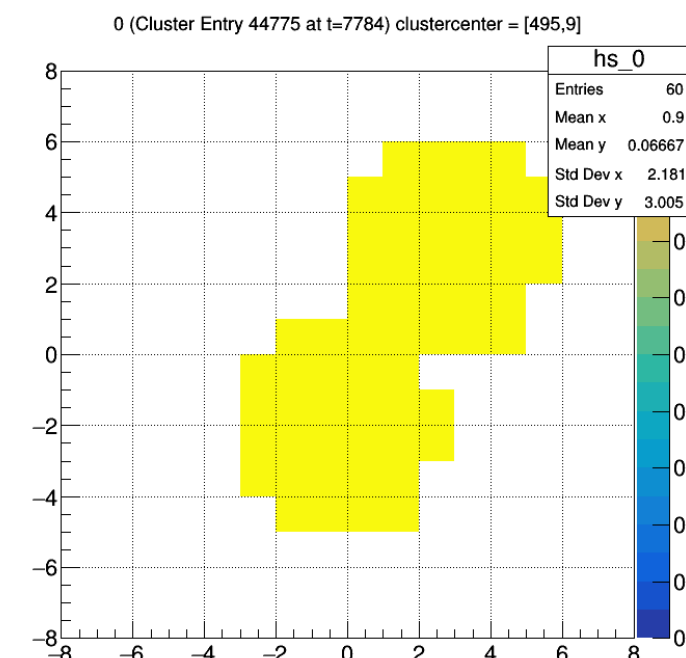
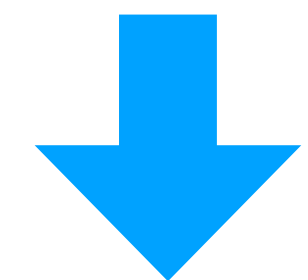
Now Generation is on-going...



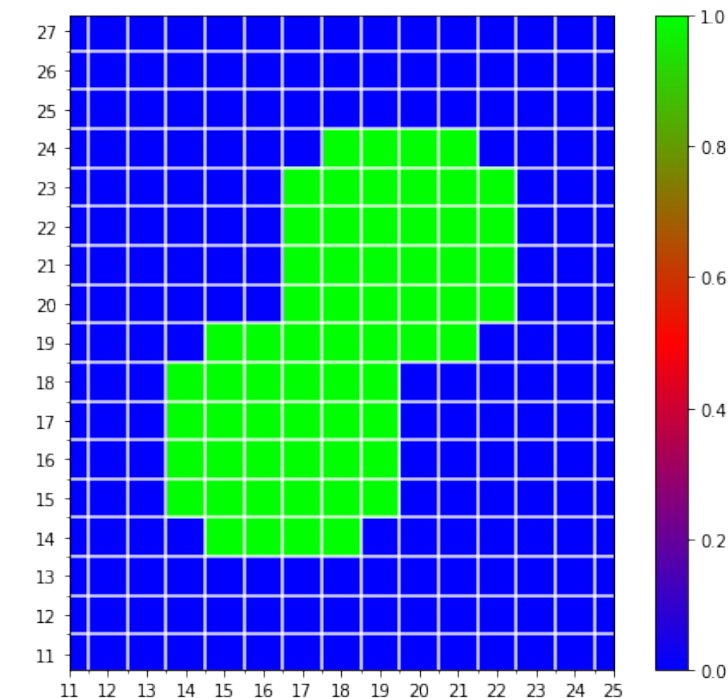
Analogue Signal Distribution



Digital Signal Distribution (Integrated Signal)

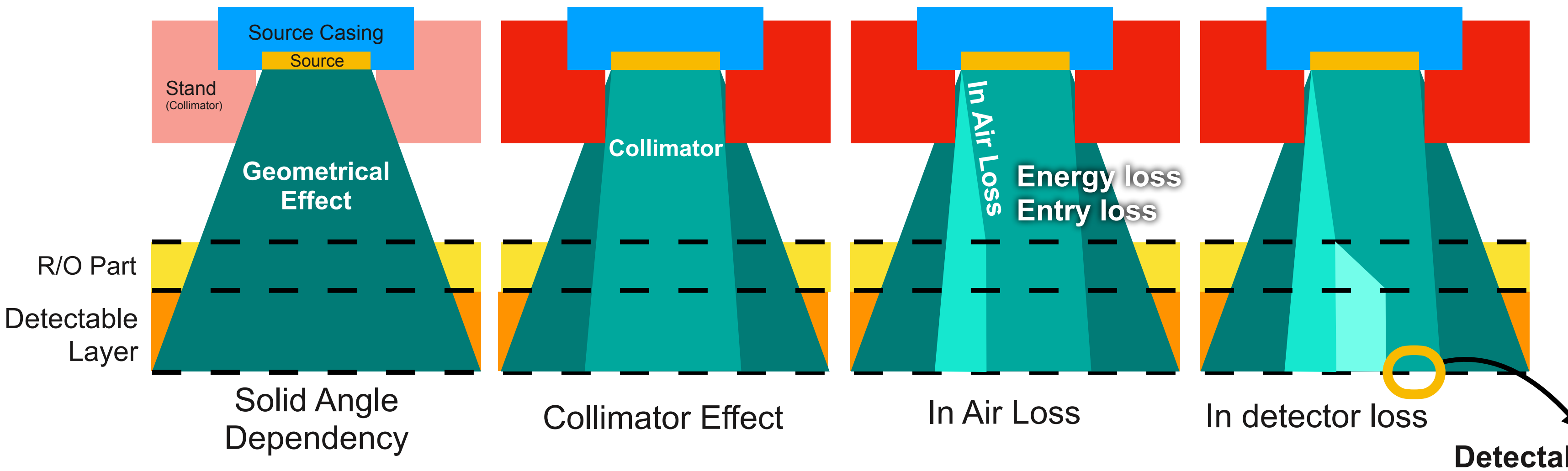
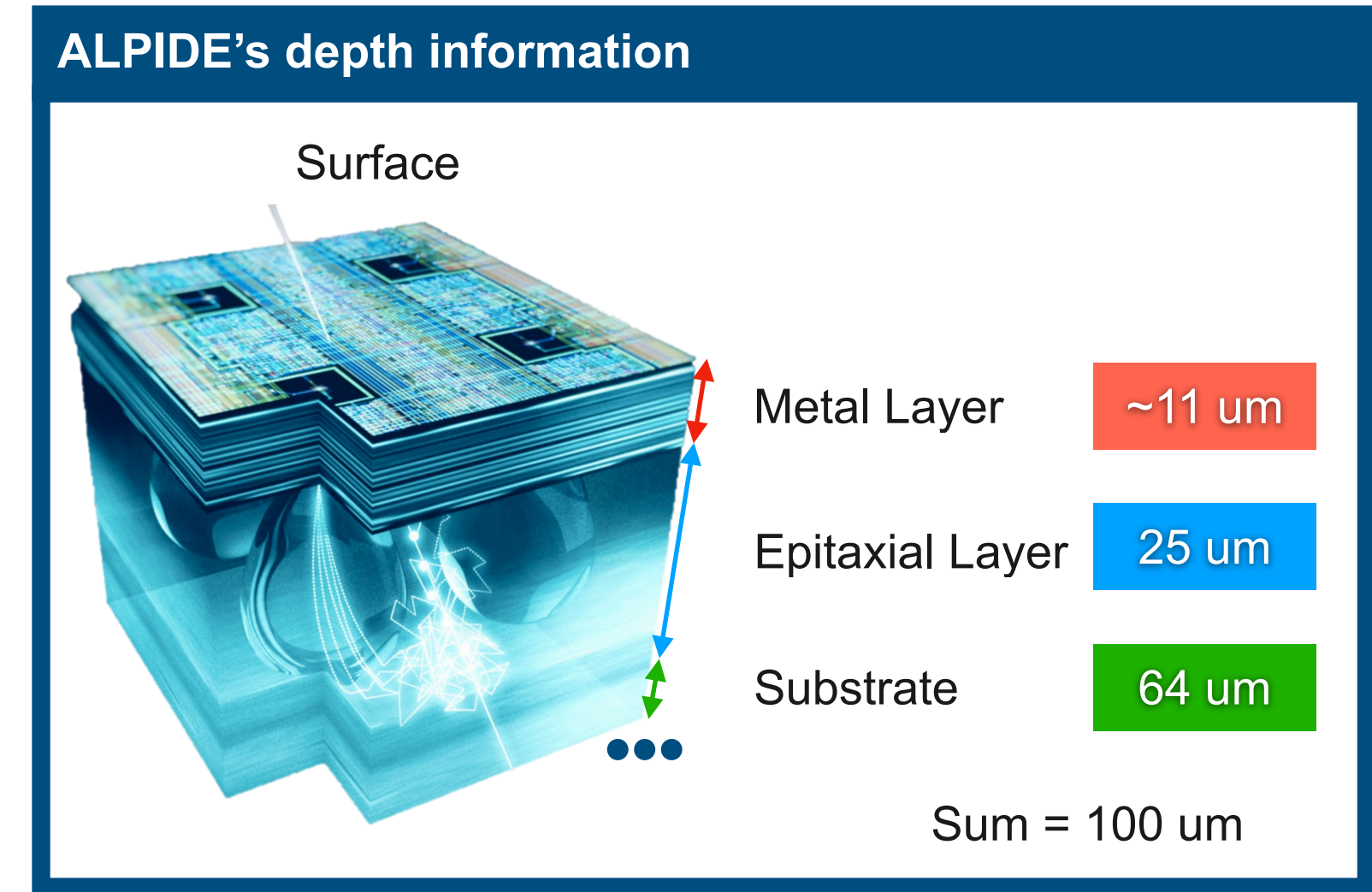
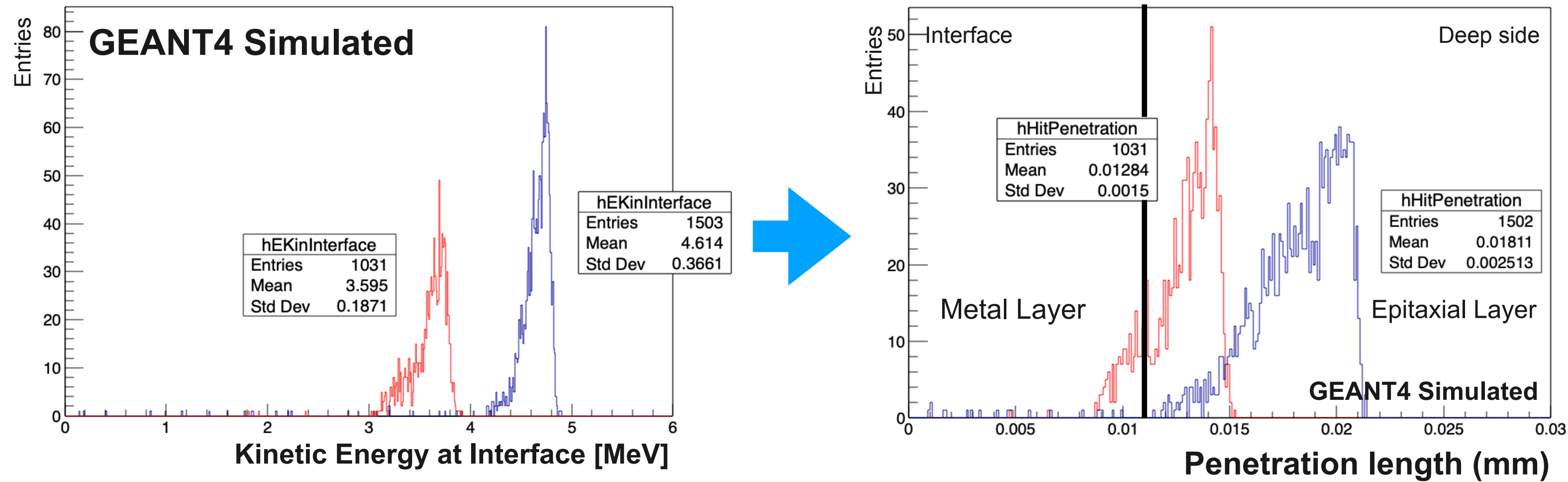


One of cluster in real data



Fired Pixel Distribution

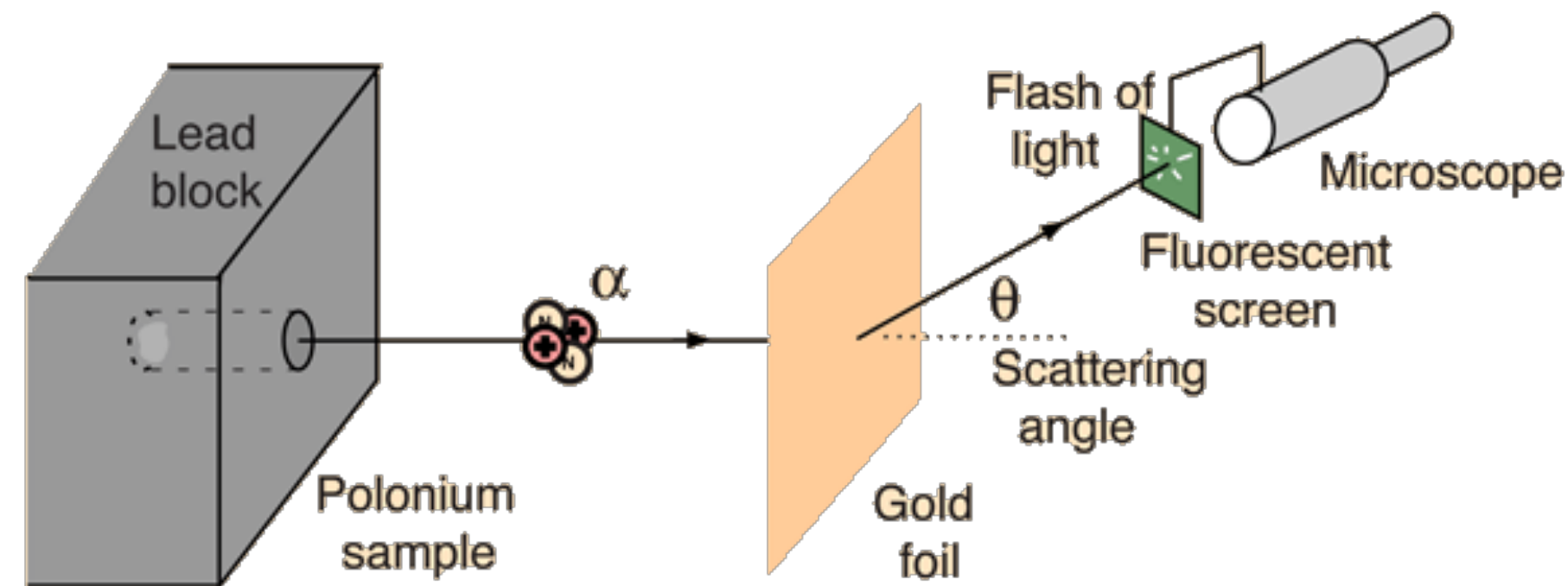
On chip penetration length dependency



- ALPIDE can detect α particle with energy dependent efficiency.
 - Because of R/O part layer.
- In real experiment data, anonymous loss part existed. (simple calculation is in backup; 16p, 17p)

Elastic Scattering Experiment - more

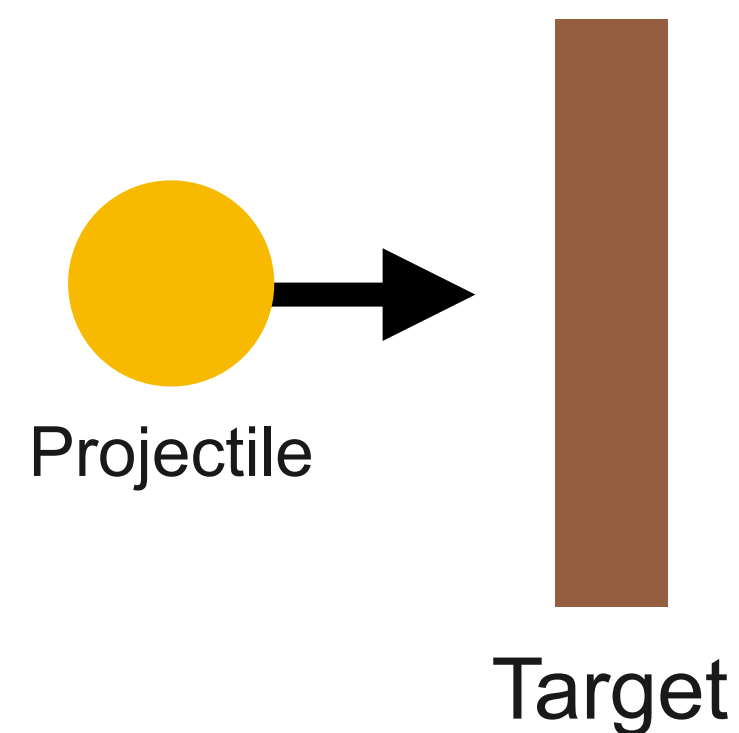
Rutherford's experimental condition



Inspired from Rutherford Scattering ...

Image is from hyperphysics

<http://hyperphysics.phy-astr.gsu.edu/hbase/rutsca.html>

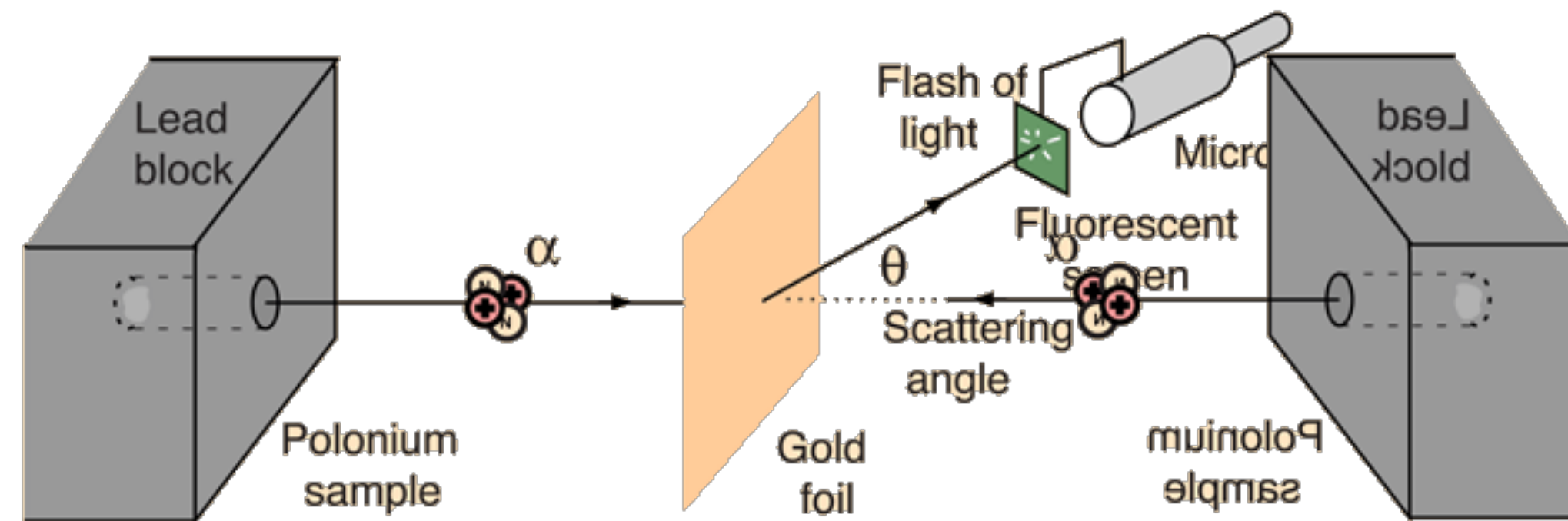


PNU's valid experimental condition

- Radiation Source
 - Am-241 Source x 2
 - α -particle with $E_k = 5.486\text{MeV}$
- Detector
 - ALPIDE100 Detector
- Additional Environment
 - Vacuum Chamber

Elastic Scattering Experiment - more

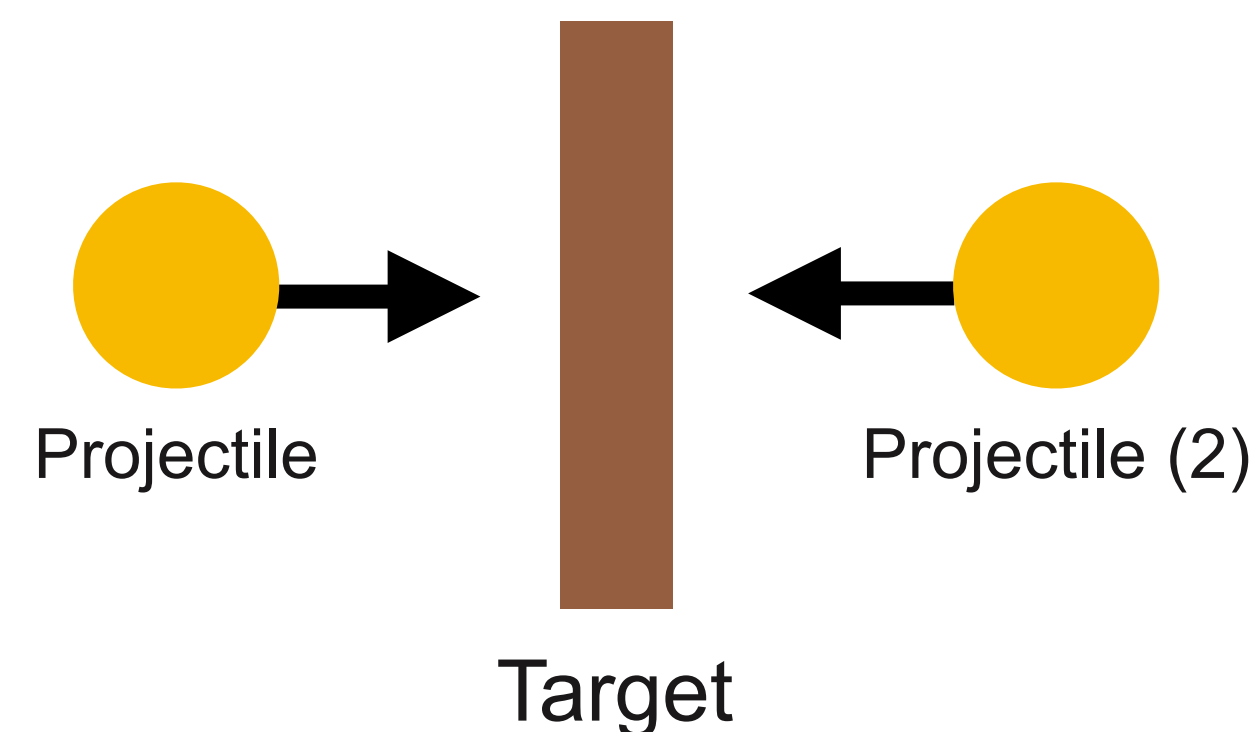
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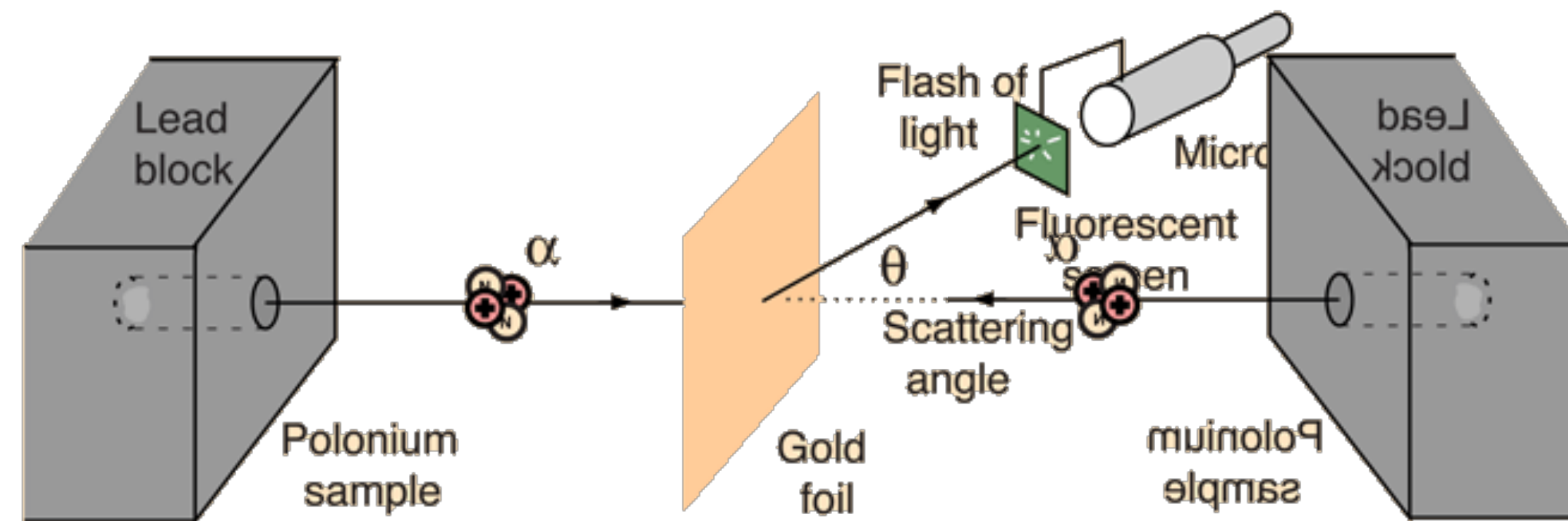


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Elastic Scattering Experiment - more

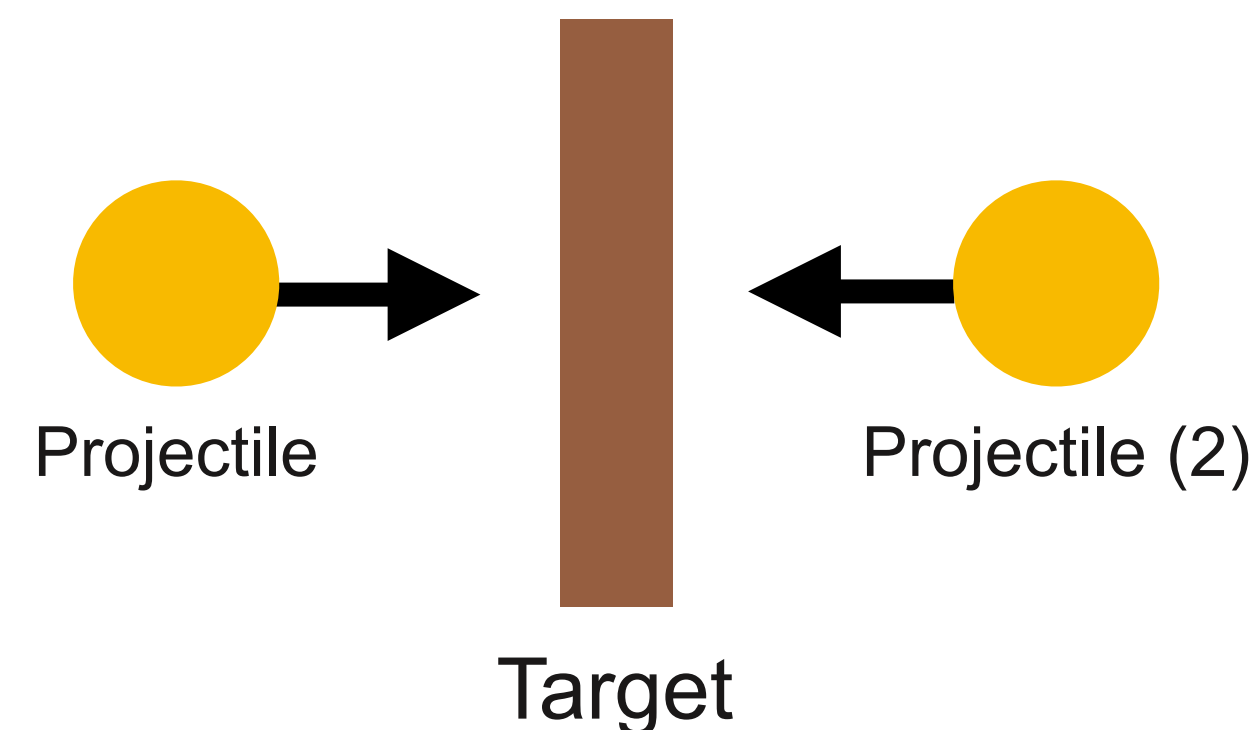
Rutherford's experimental condition



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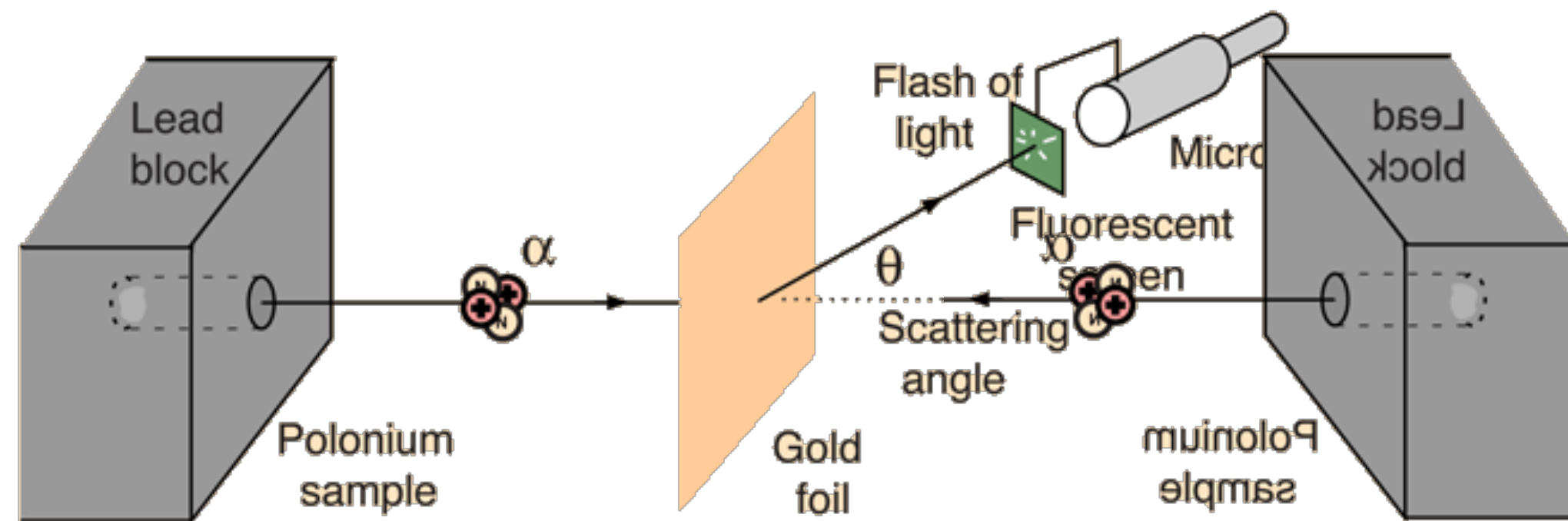


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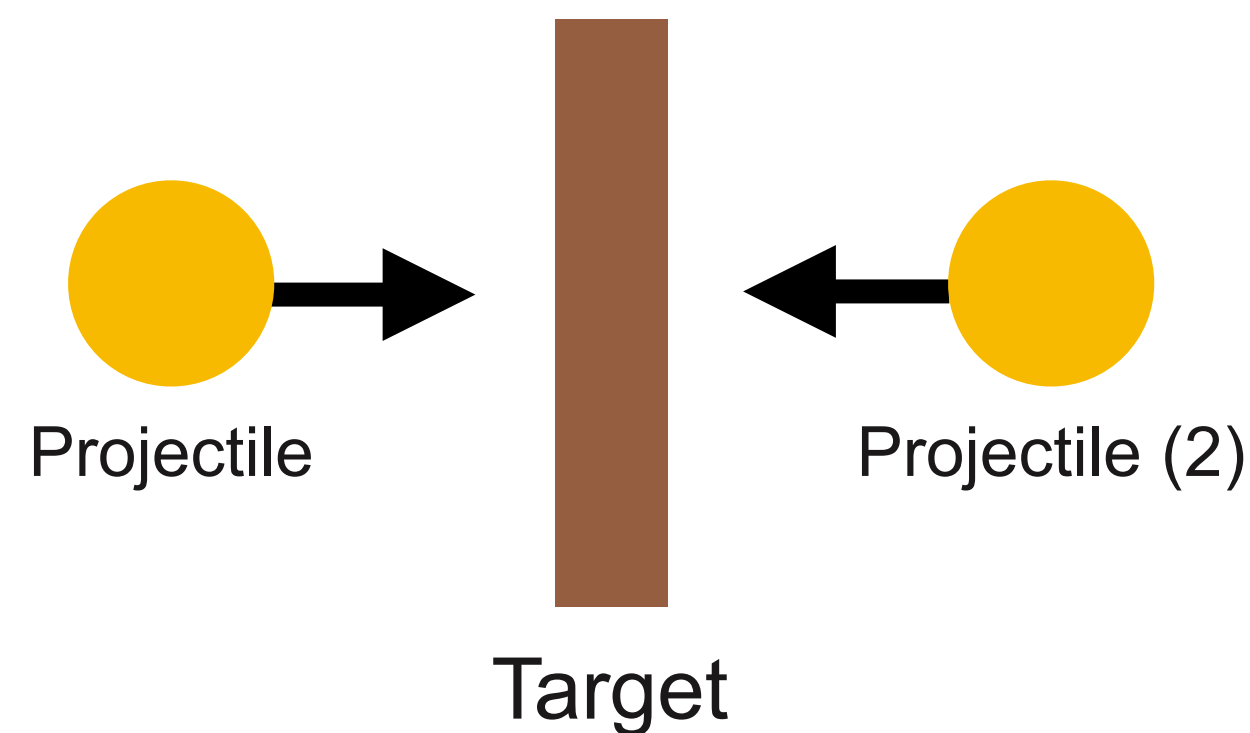
Elastic Scattering Experiment - more

Rutherford's experimental condition



Inspired from Rutherford Scattering ...

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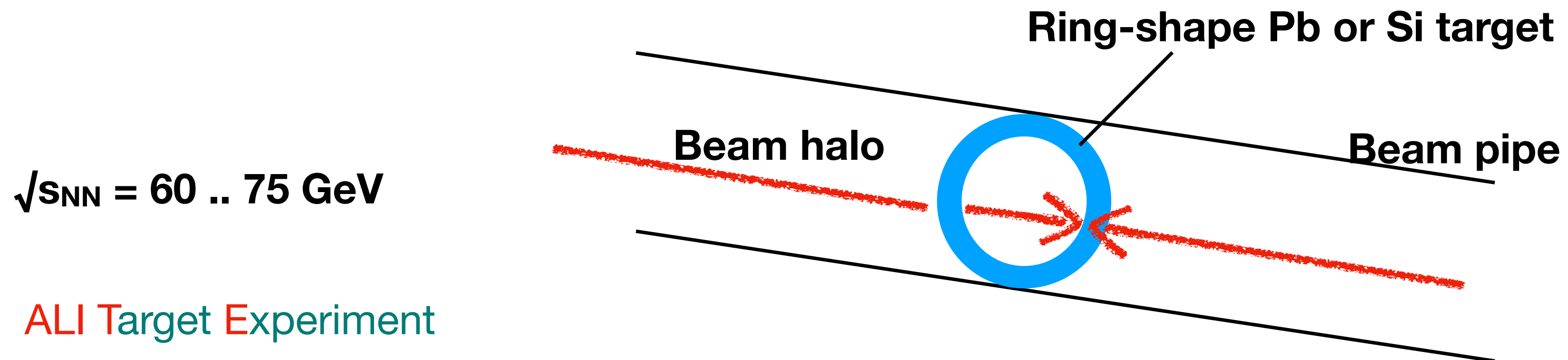


PNU's valid experimental condition

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- Detector
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- Additional Environment
 - Vacuum Chamber

ALITE in RUN4

KoALICE2030

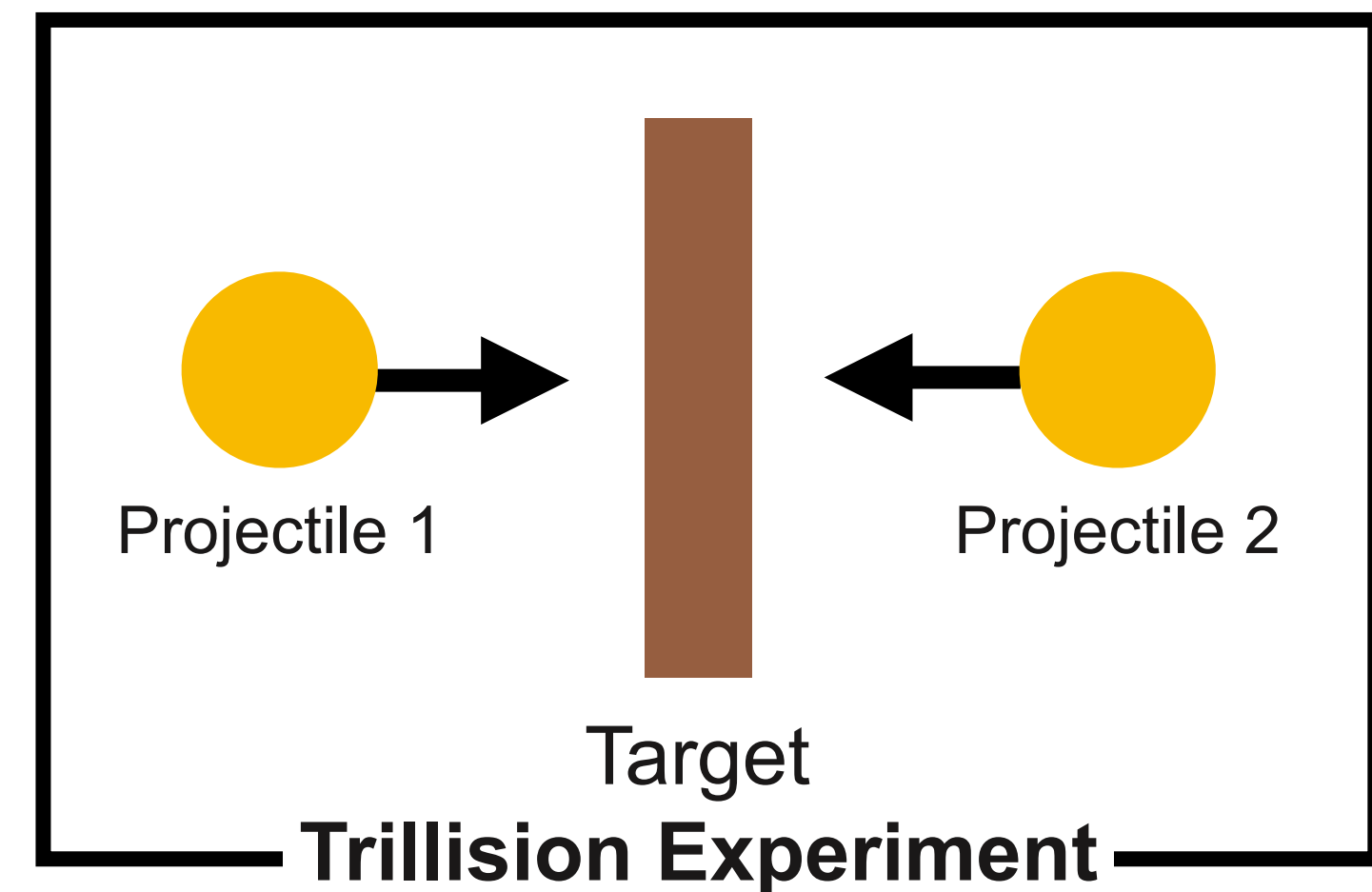
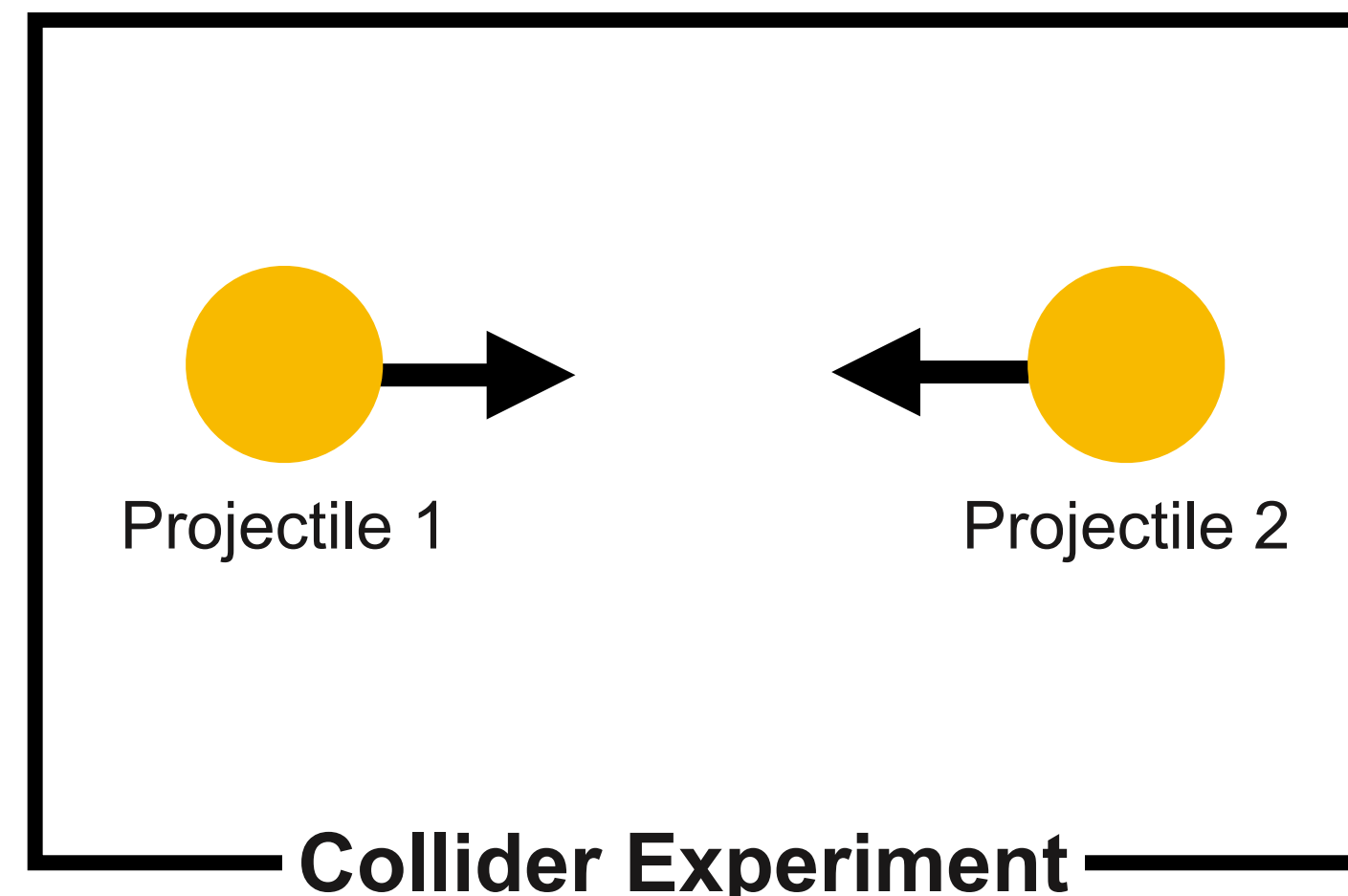
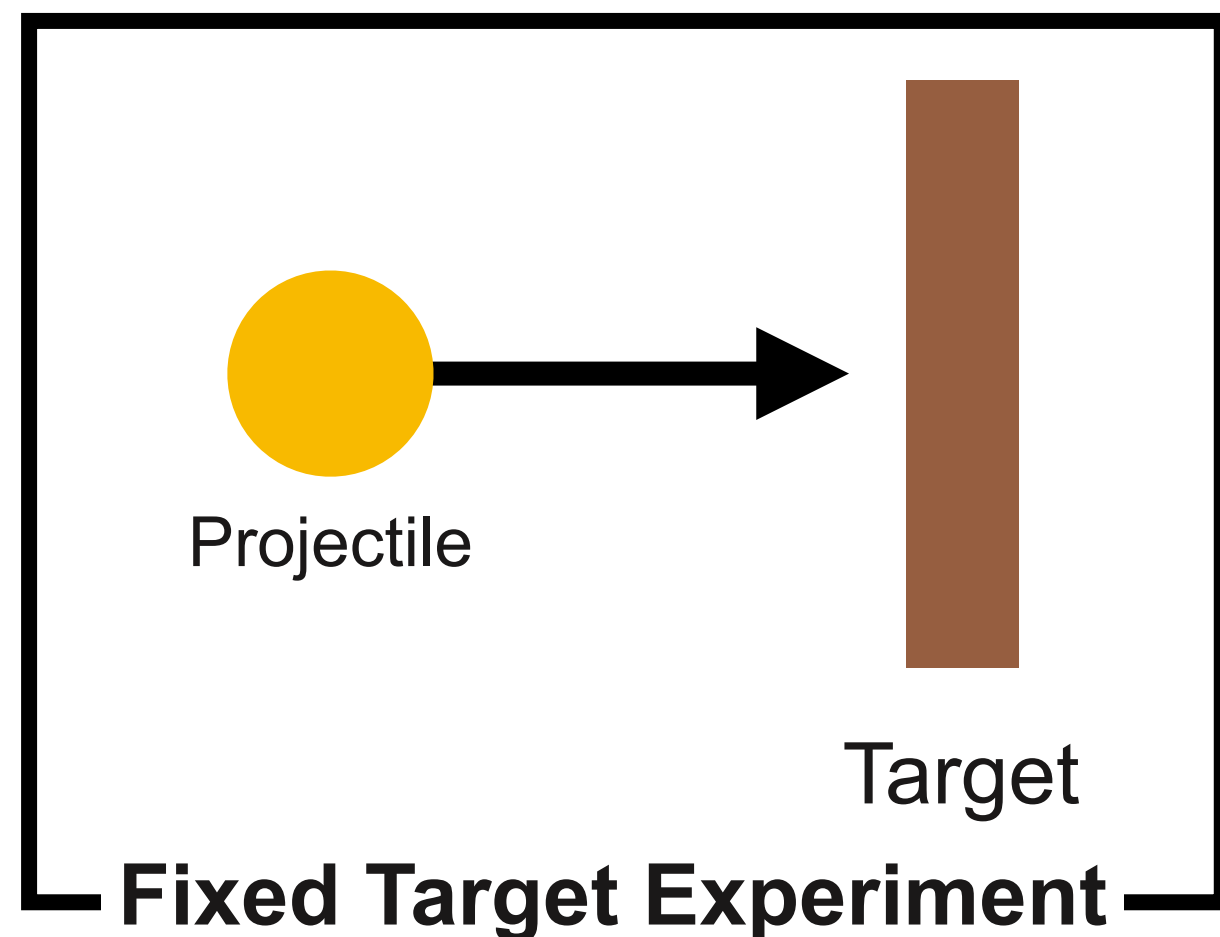
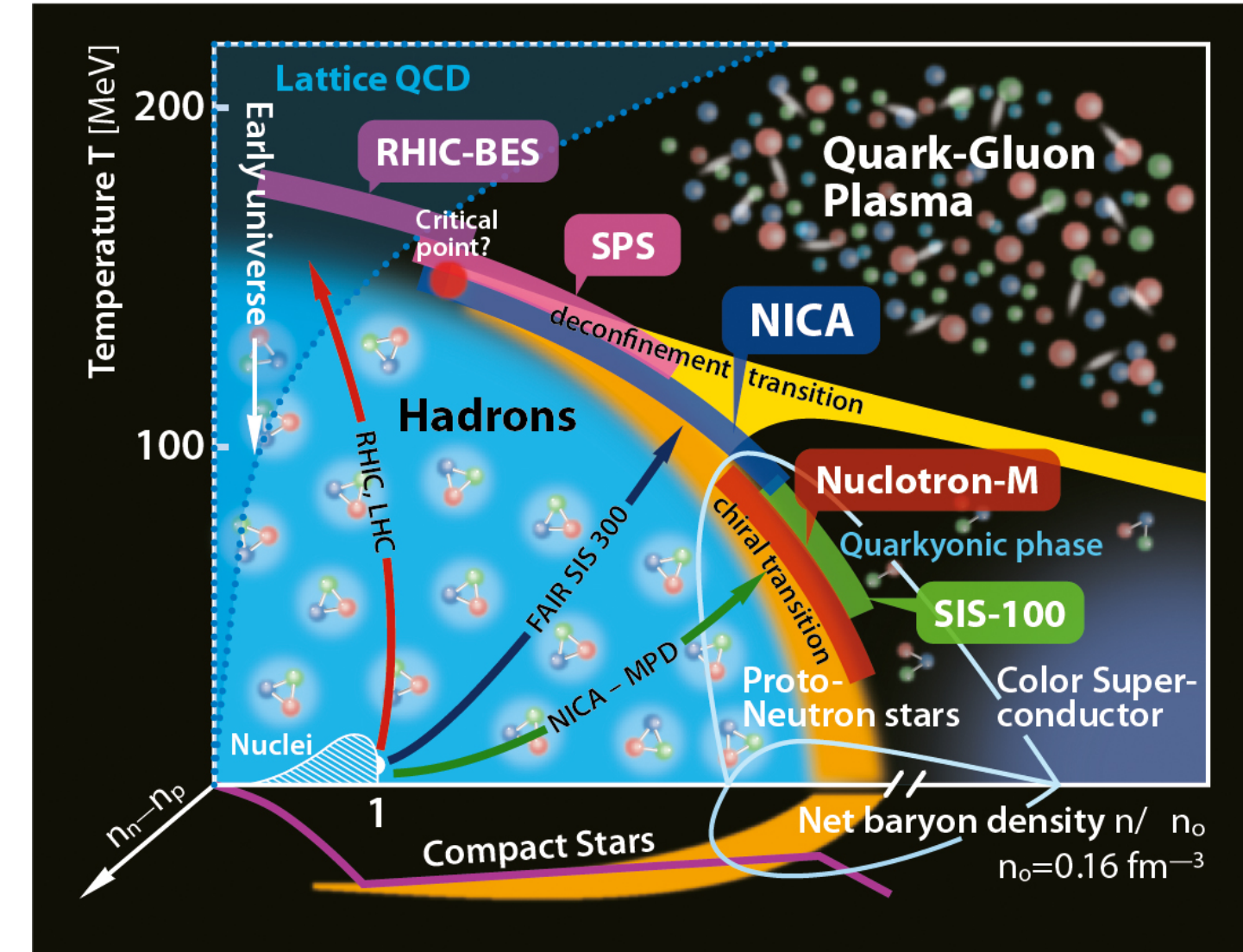


- **ALI Target Experiment**
 - A short period of Target (Test) Experiment (in RUN5-6 with ALICEs)
 - Higher Interaction rate at (little) lower $\sqrt{s_{NN}}$
 - Closer IP
 - Trillision (3 nuclei collision) event?
- Silicon R&D + Production for ALICEs in RUN5-6
 - ITS3 + 7 tracking barrel layers +
 - (Active Target Experiment at SPS)
- Exploring QCD diagram with Charm

3 Particle Collision

- *MORE DENSITY*: Trillision Experiment (3-body colliding)
- 2 particles and 1 target should be needed.
- ALITE is designed at run5-6 of ALICE.
ALICE Target Experiment
- Firstly, 3 particle elastic scattering experiment is on-going.

QCD Phase Diagram



3 Particle Collision

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QCD Phase Diagram

