

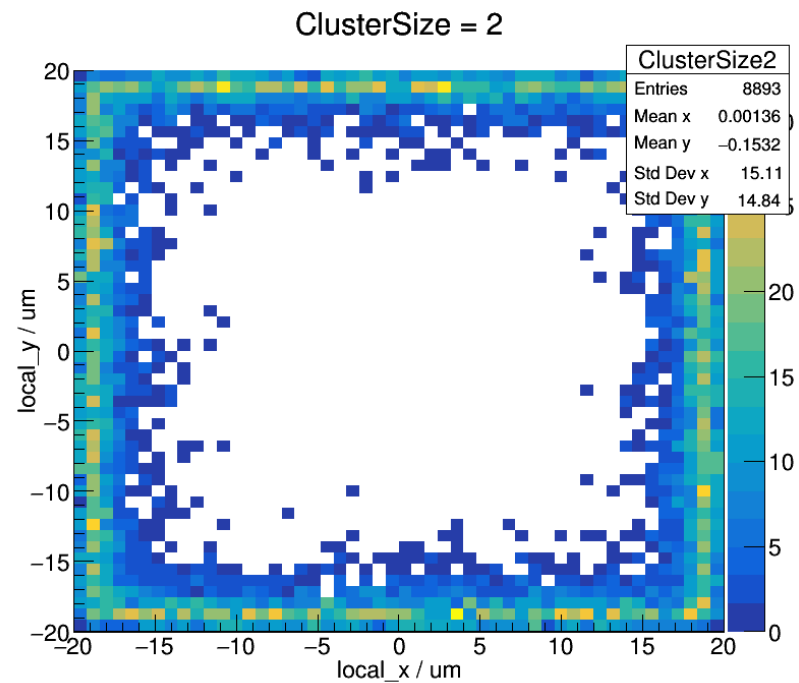
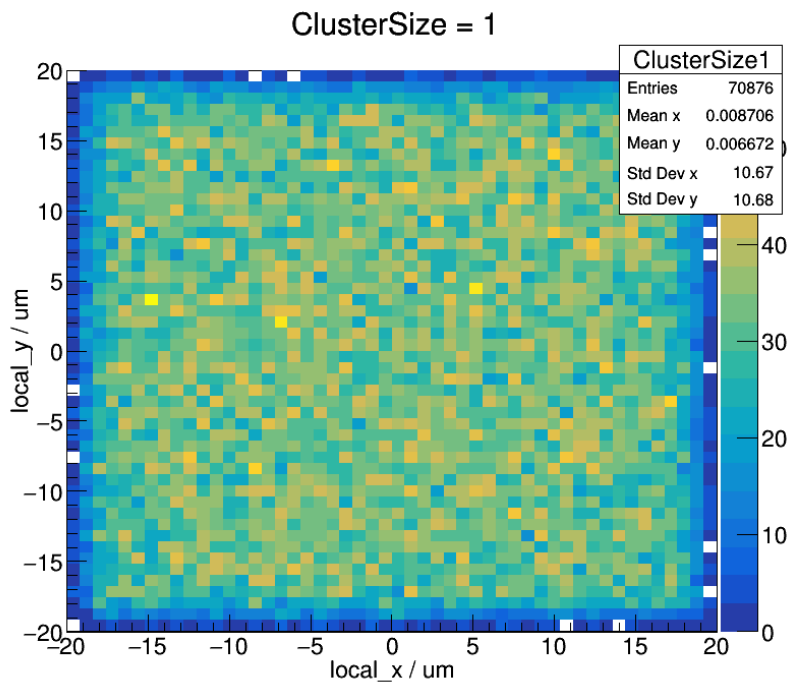


Resolution Limit and $\text{pitch}/\sqrt{12}$

Fuyue Wang

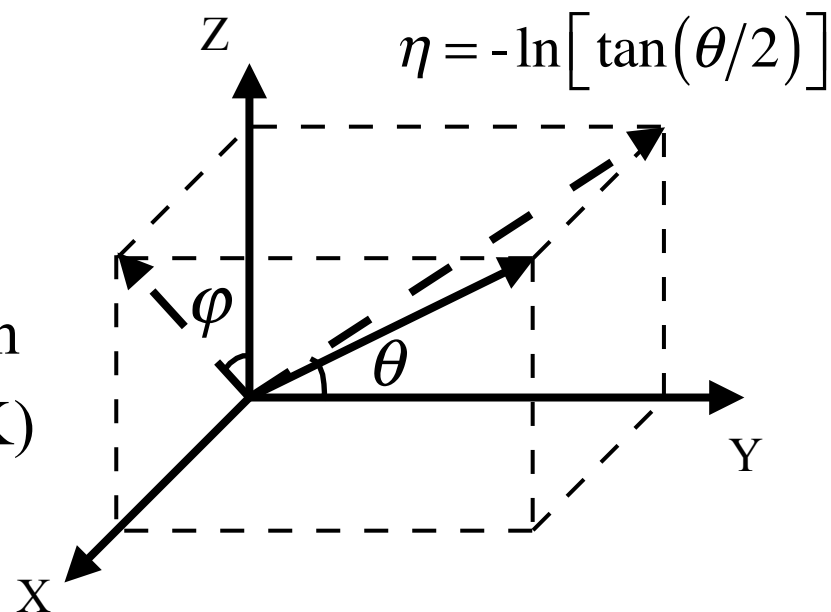
The limit of standard deviation

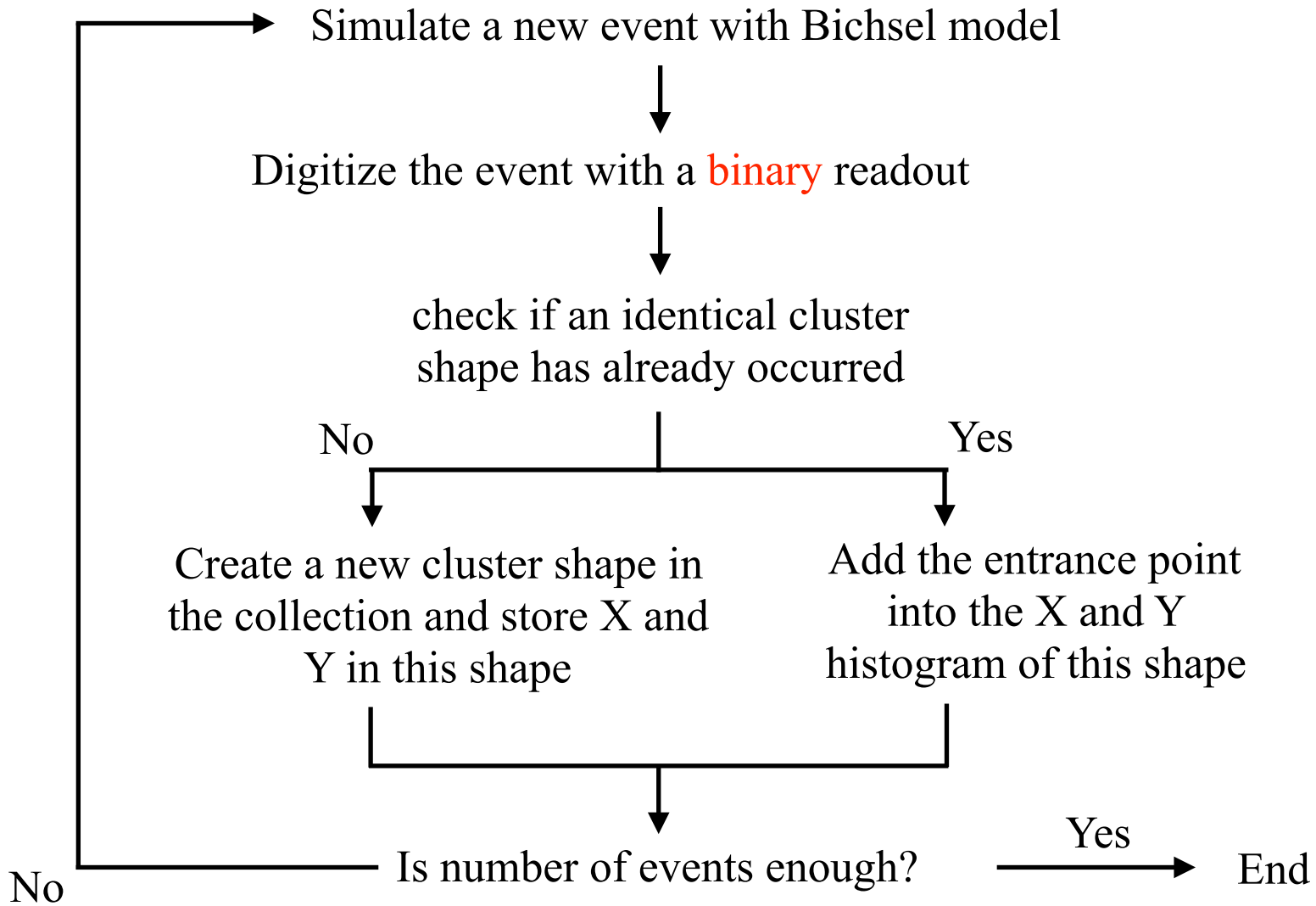
- Spatial resolution: charge distribution in pixels
- **Upper limit standard deviation**: binary readout
- Estimate limit for a single pixel hit is $\text{pitch}/\sqrt{12}$



Simulation

- 1 layer pixel detector with different pixel size
- Source position: 39 mm away from detector
uniformly smeared by the pixel dimension
- 20 GeV muons
- Angle: $0 < \eta < 2$, $0 < \varphi < 50^\circ$
1 mrad smear
- Bichsel model
- Diffusion length: 2.5 μm /300 μm
(1 V/ μm , 263K)





Shape Collection: $(\eta, \varphi, pitch)$

shape1: Histogram X&Y σ_{x1}, σ_{y1}

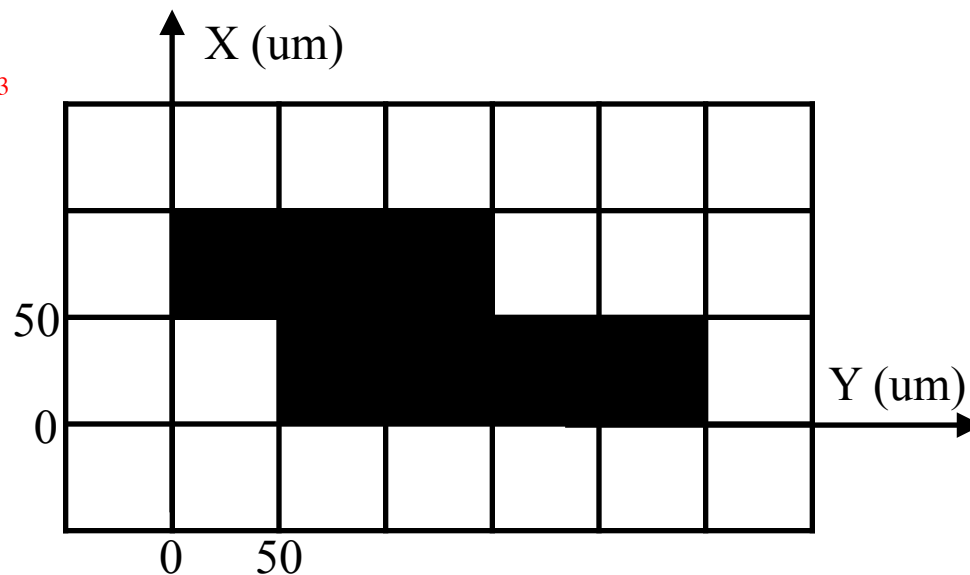
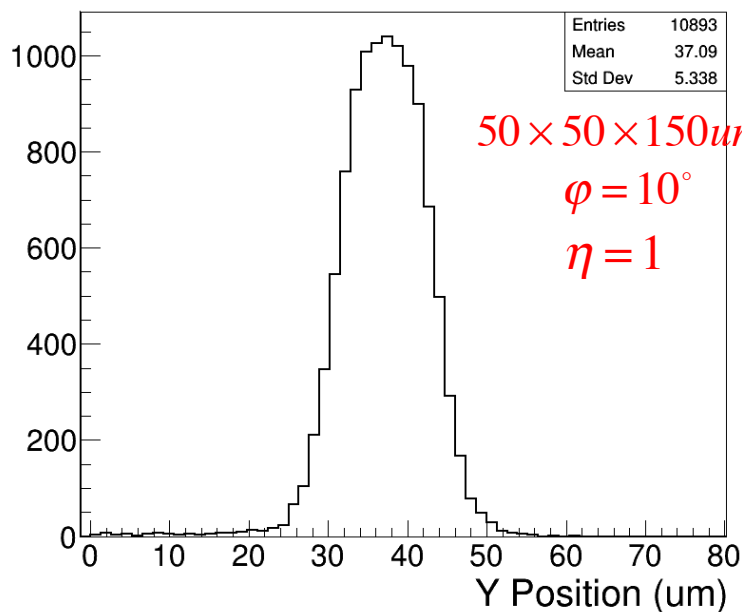
shape2: Histogram X&Y σ_{x2}, σ_{y2}

.....

shapeN: Histogram X&Y σ_{x3}, σ_{y3}

$$\sigma_{x(y)} = \sqrt{\frac{\sum_1^N \sigma_{x(y)i}^2 \cdot Entries_i}{NumberofEvent}}$$

Shapes that have no more than **10** entries do not contribute!

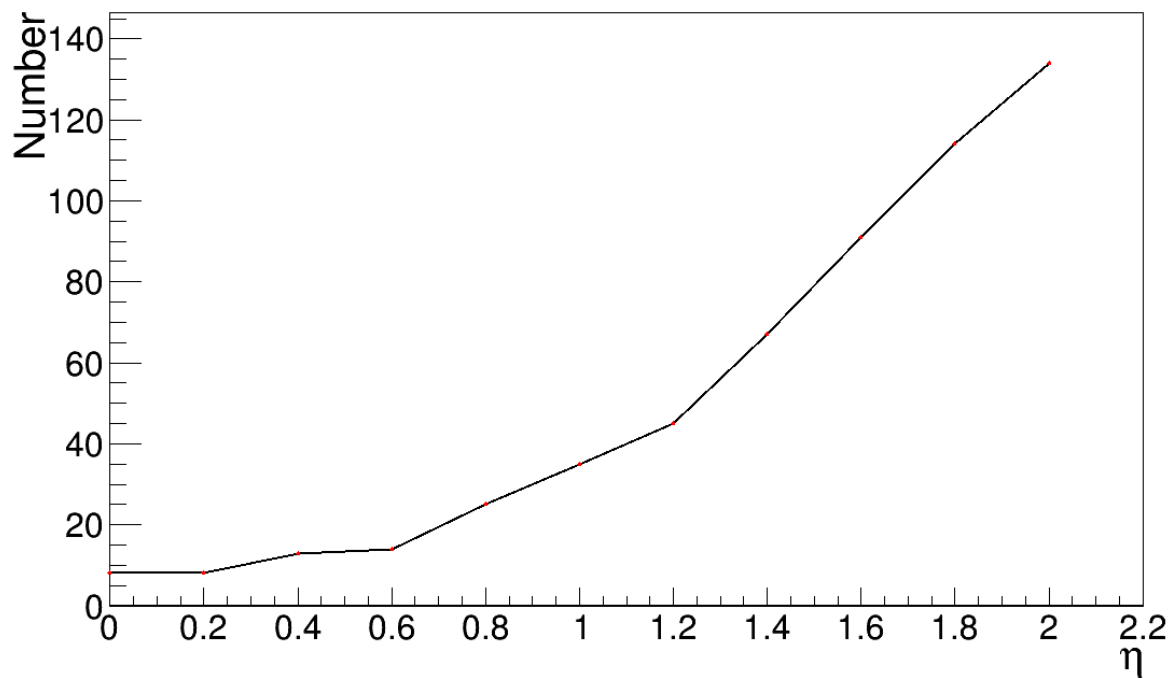




Better spatial resolution

1. More # shapes
2. Evenly occurrence probability of shapes

Number of shapes $\phi=0$



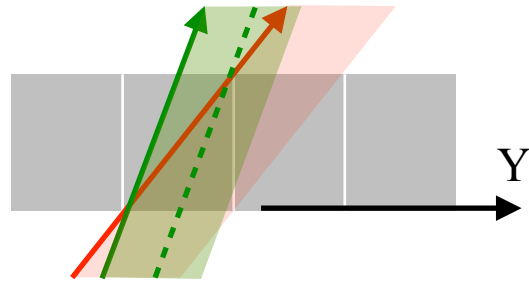
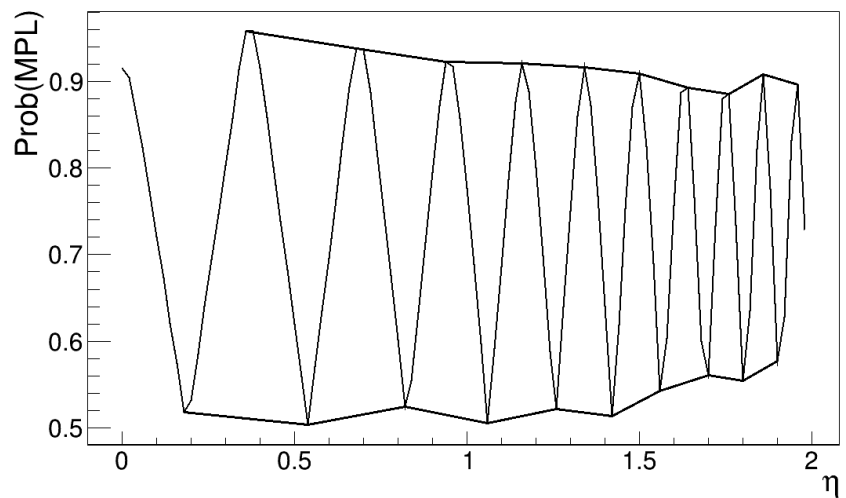


Oscillation and boundaries

- For any η : 1 or 2 possible length in Y (**without** diffusion)
- Most probable length(MPL): the length that occurs the most
- Low Prob(MPL): events are divided more evenly into different shapes
 - small spread
 - small std

sensor: $50 \times 50 \times 150 \mu m^3$ $\phi = 0^\circ$

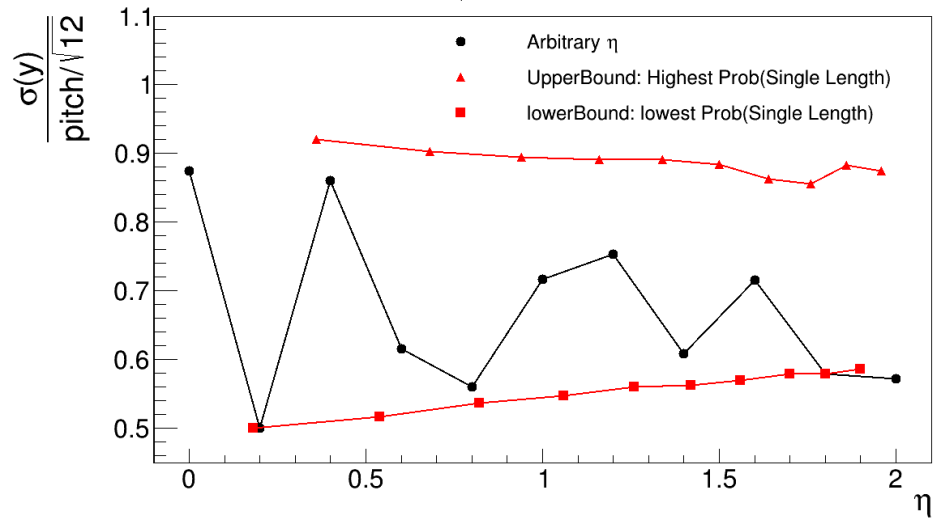
$\phi=0$



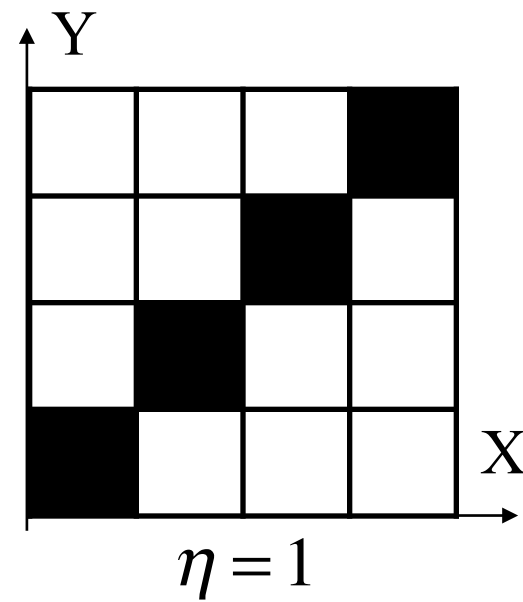
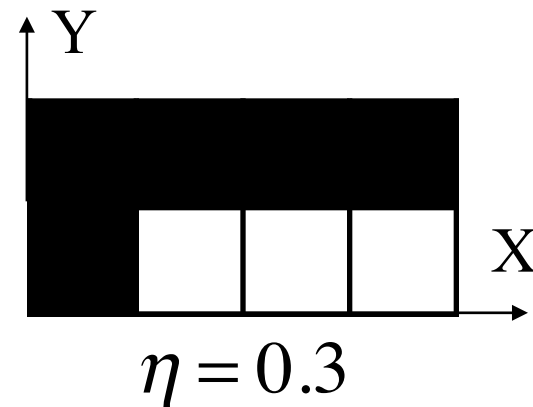
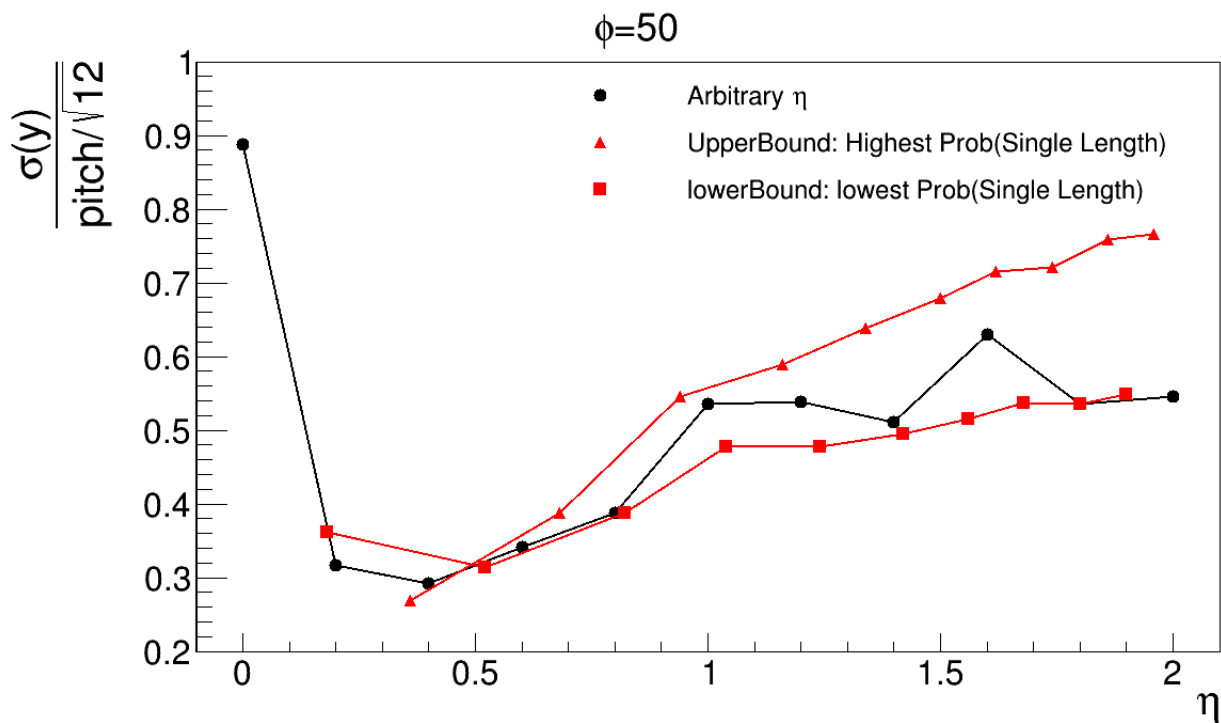
Length=2
Prob=1

Length=1 or 2
Prob=0.5

$\phi=50$

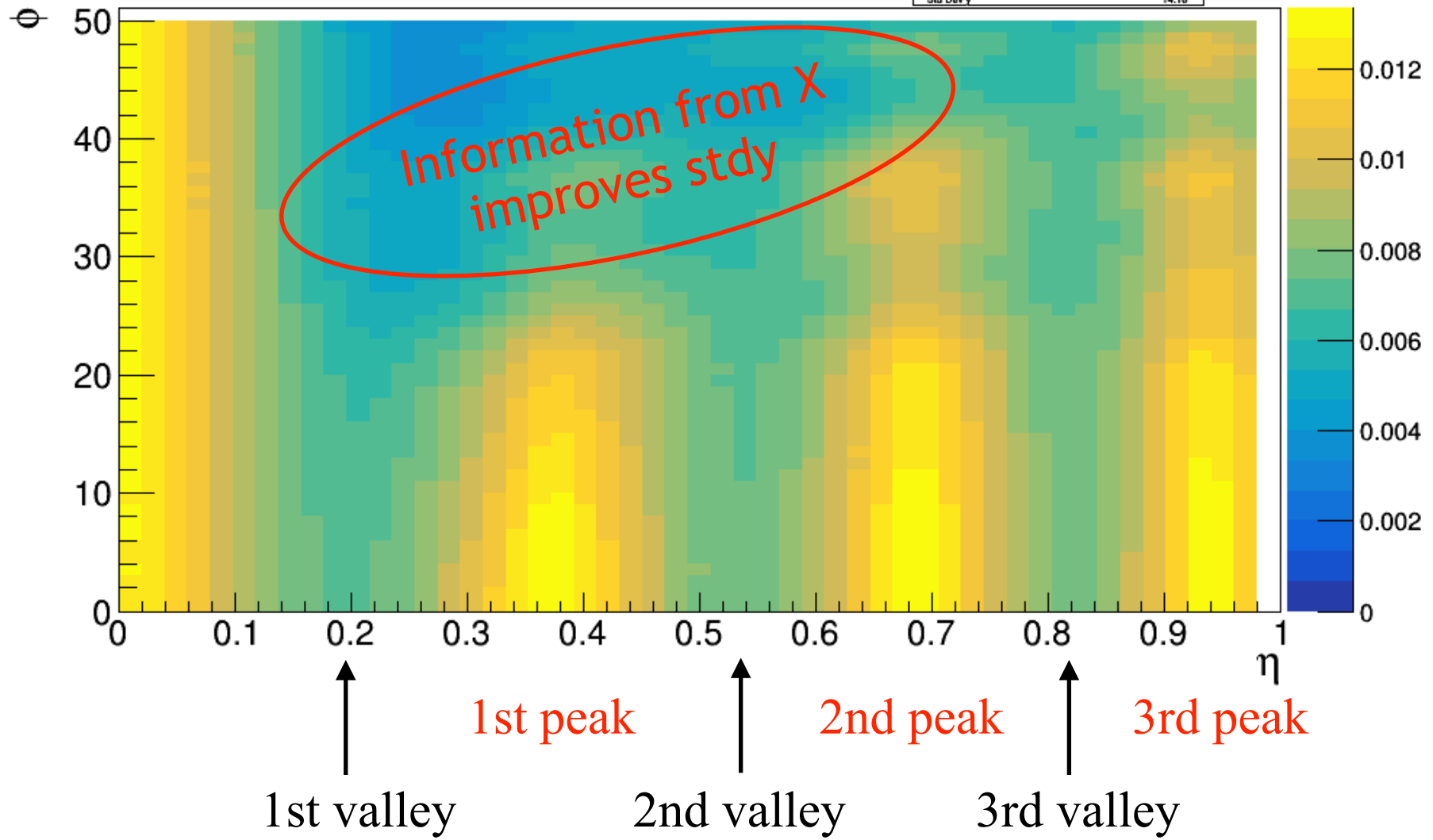


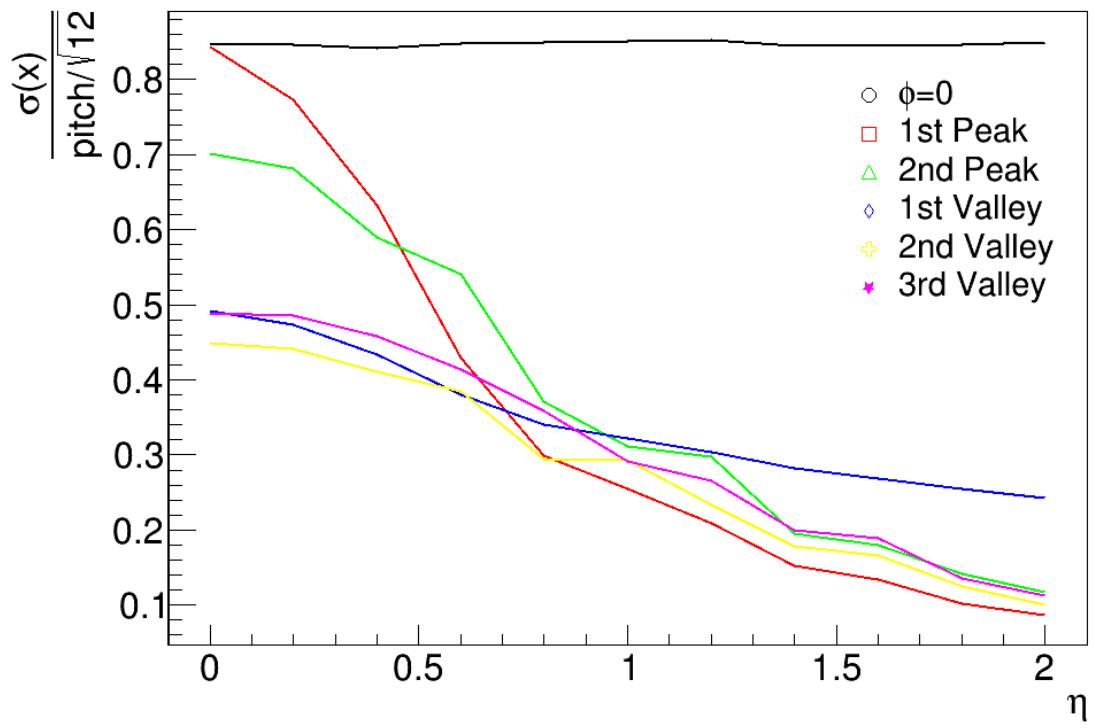
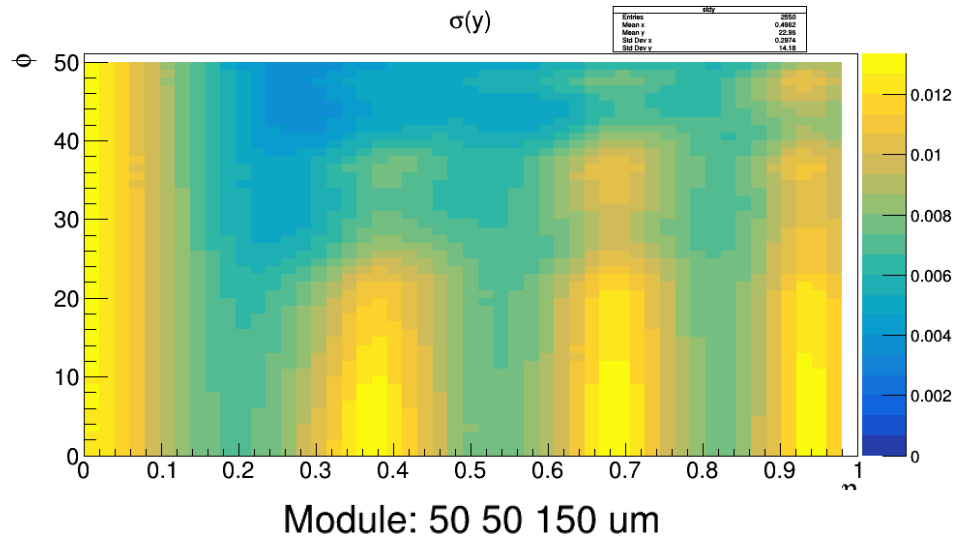
Effects of the perpendicular direction φ



$\sigma(y)$

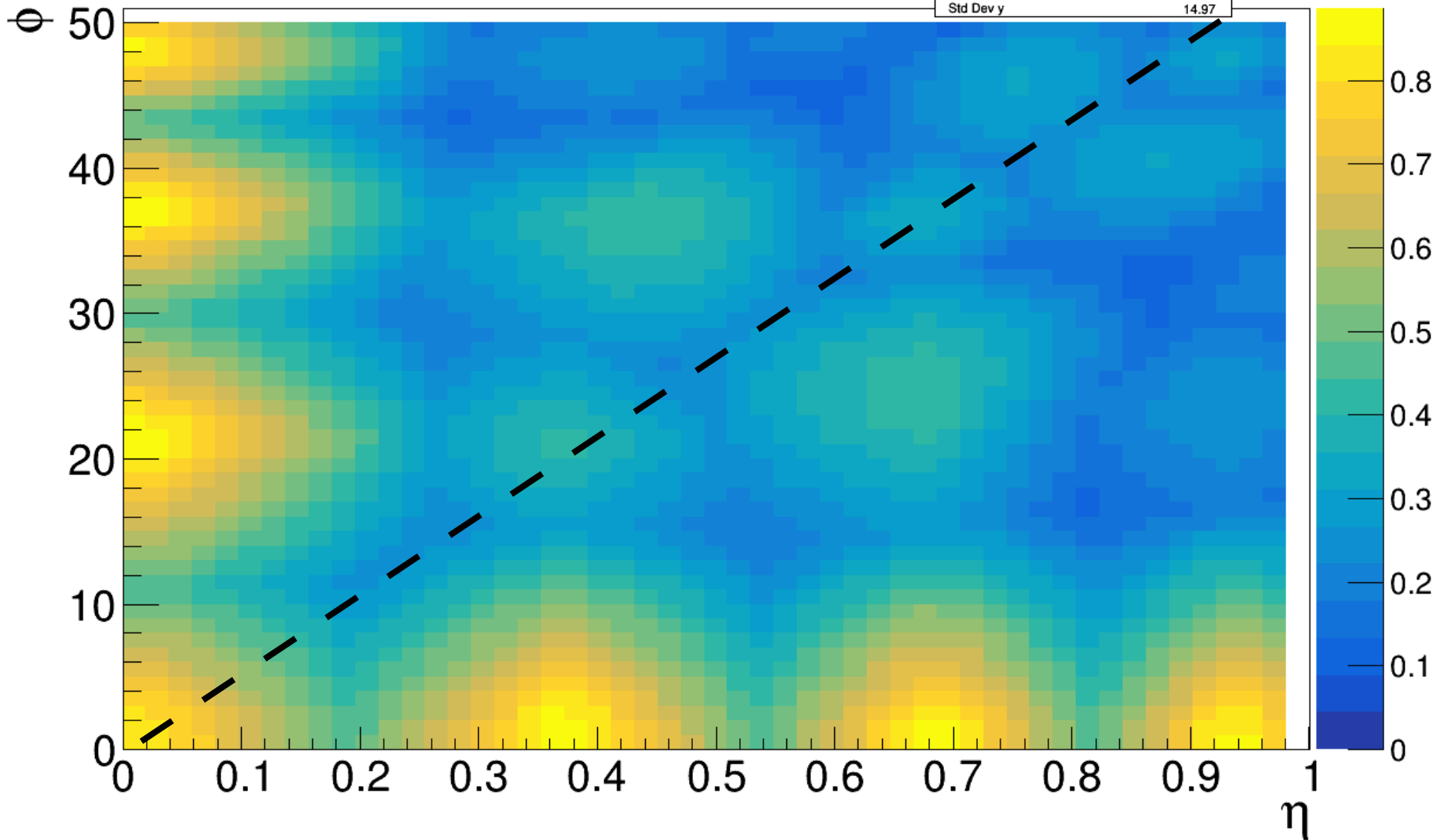
study	
Enines	2550
Mean x	0.4962
Mean y	22.96
Std Dev x	0.2974
Std Dev y	14.18



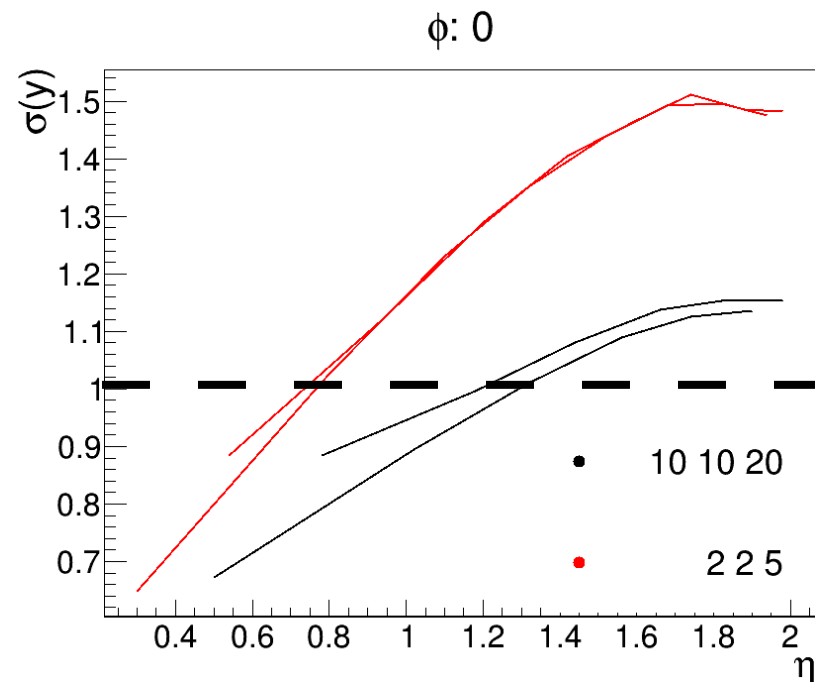
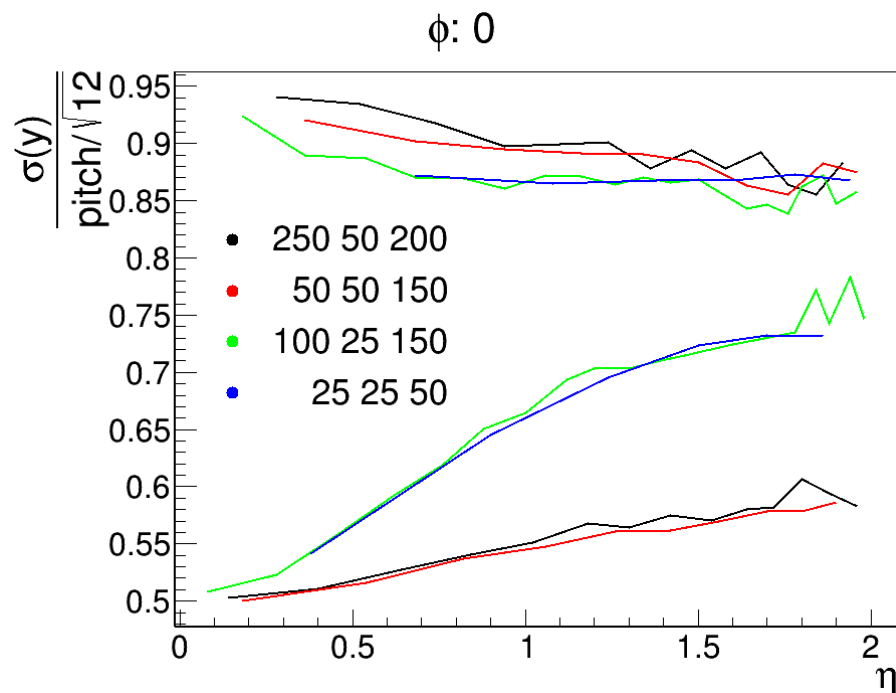


Prob(MPS)

MPS	
Entries	2550
Mean x	0.4331
Mean y	21.78
Std Dev x	0.2935
Std Dev y	14.97



Different pixel size



- For larger eta, the probability of losing the head and tail pixels is large
- Distance between two collisions will be larger than the pixel size



Summary

- Standard deviation of the binary readout is highly related with the cluster shape.
- $\text{Std}_y(x)$ oscillates with respect to $\eta(\varphi)$, but between two boundaries.
- $\text{Std}_y(x)$ always improves with $\varphi(\eta)$ — the perpendicular angle.
- More work needed for $\text{std}_y(x)$ of different module size.



Thank You!

Module: 50 50 150 um

