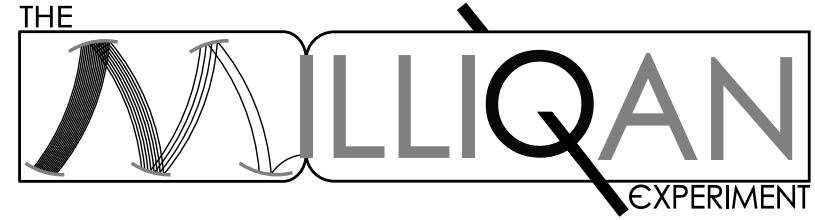




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BRUSSEL



# Background Measurements for the milliQan experiment: preliminary results

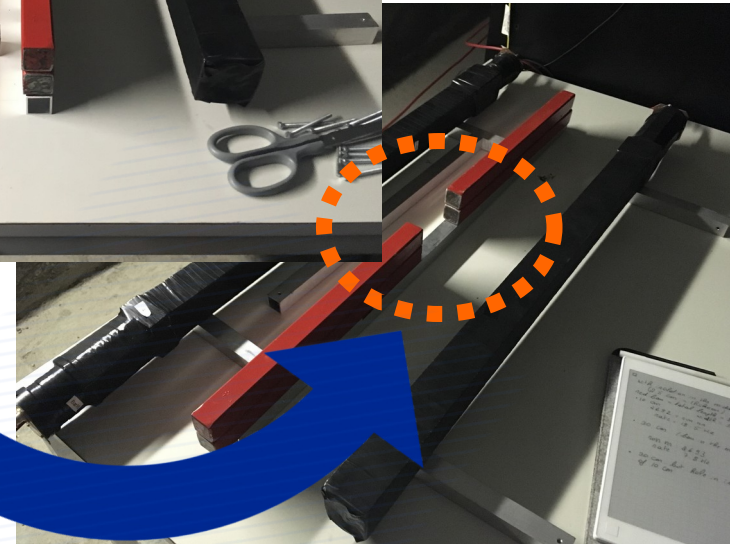
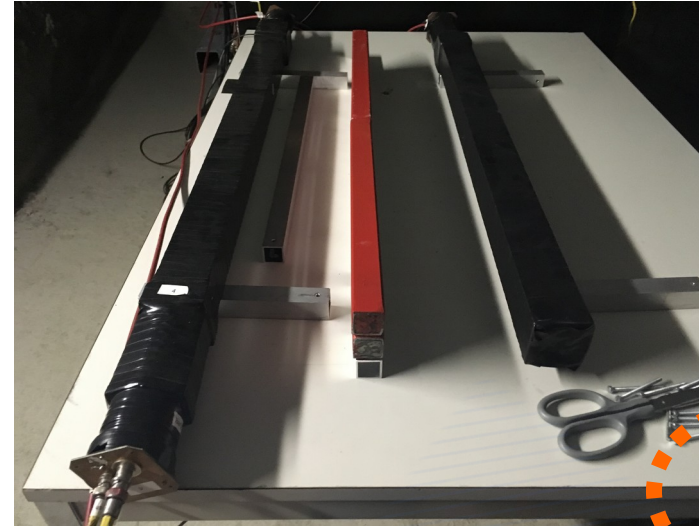
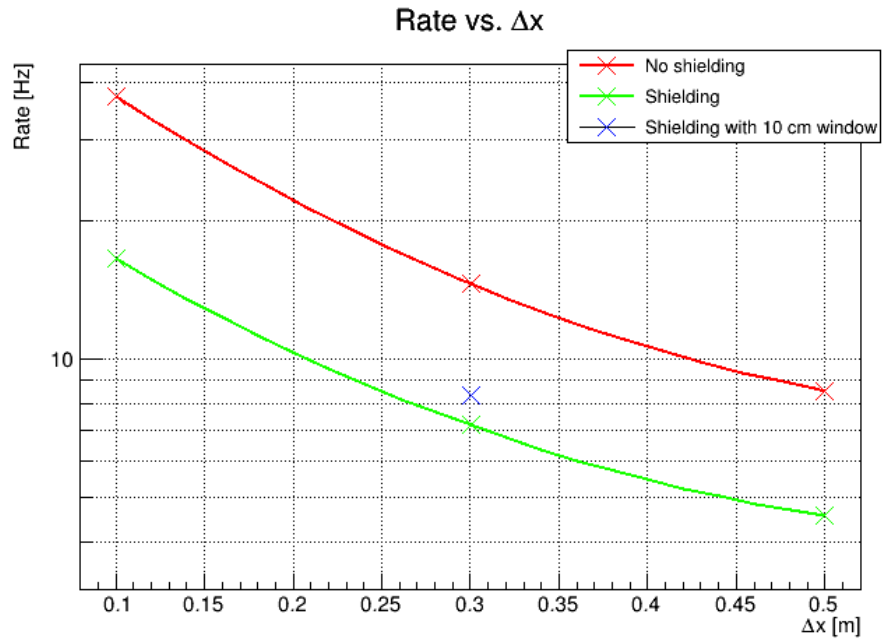
Yens Elskens

[Yens.Elskens@vub.be](mailto:Yens.Elskens@vub.be)

Supervised by prof. dr. Steven Lowette

# In situ measurements

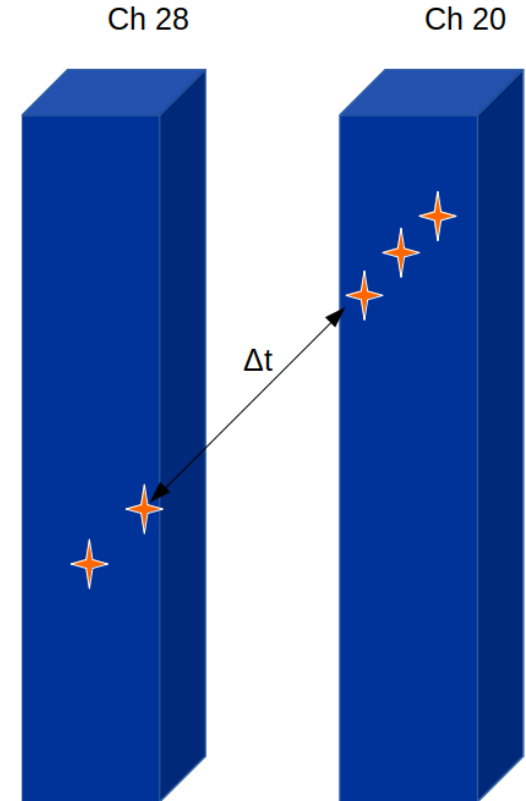
## Rate vs. distance



# In situ measurements

## Time difference between Ch 20 & Ch 28

- 1 Event,  $\neq$  pulses
- Possible afterpulses
  - Consider largest pulse
- Expect normal distribution around 0

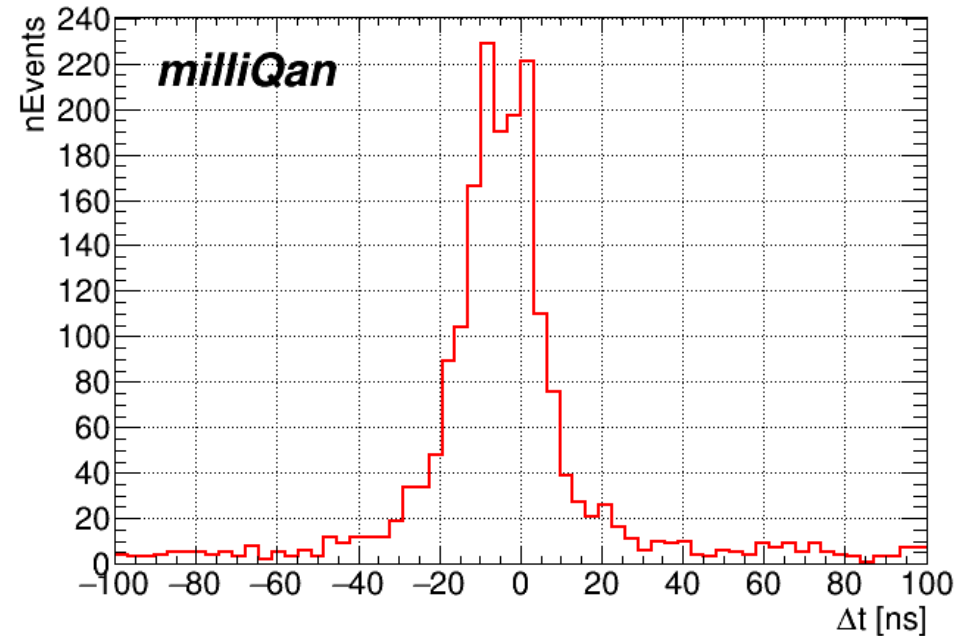
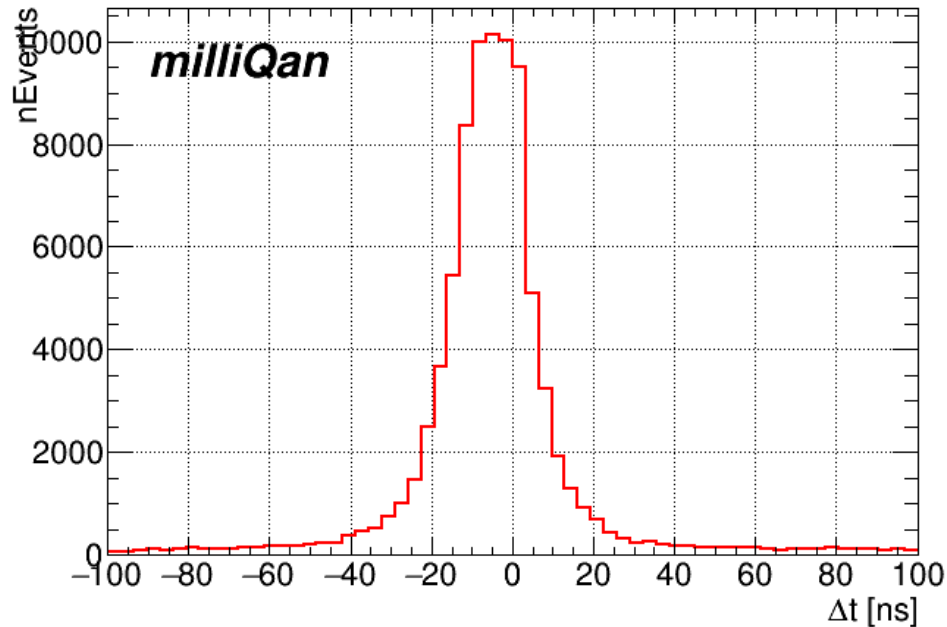


# In situ measurements

## Time difference between Ch 20 & Ch 28

50 cm, no shielding

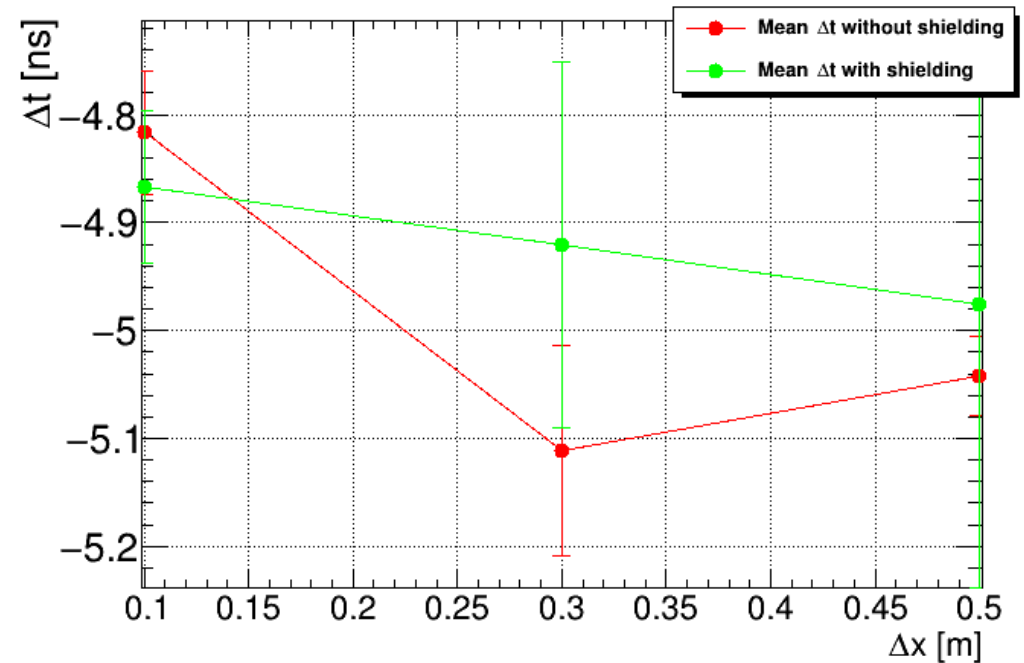
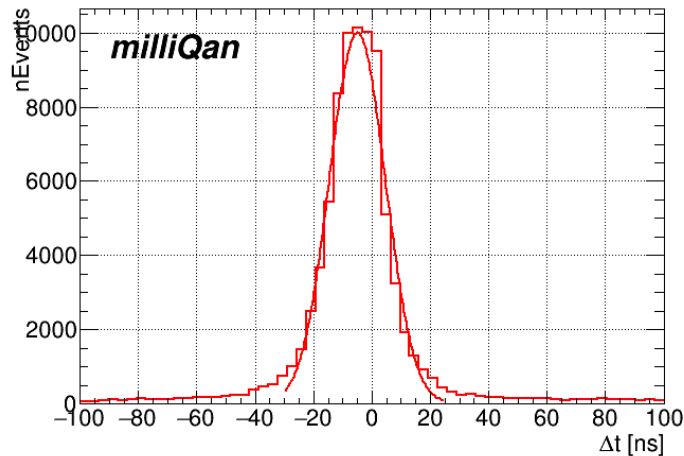
50 cm, shielding



# In situ measurements

## Mean time difference between Ch 20 & Ch 28

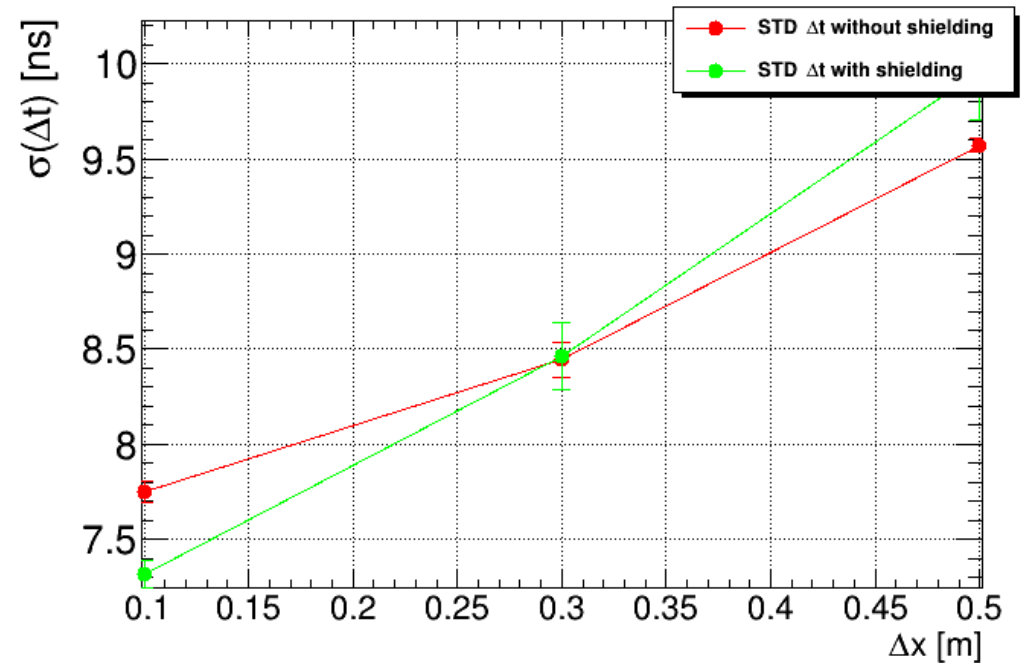
- Fitted peak with Gaussian
- Retrieve fitted parameters with errors.



# In situ measurements

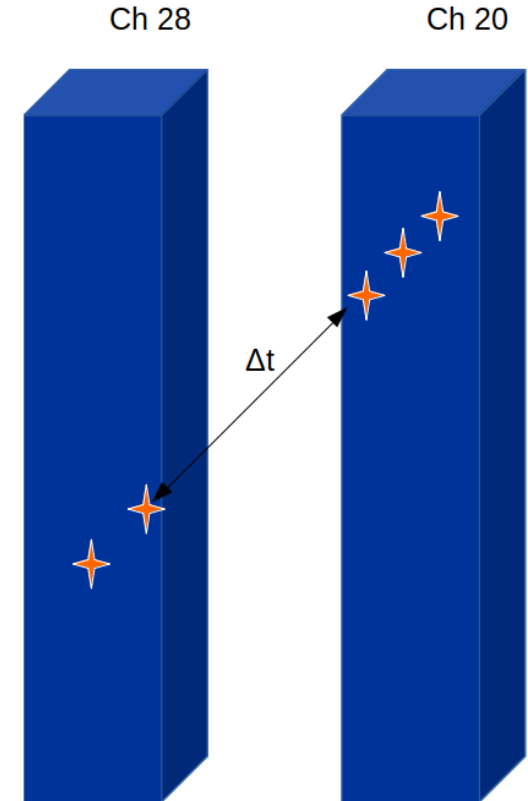
## Mean time difference between Ch 20 & Ch 28

- Fitted peak with Gaussian
- Retrieve fitted parameters with errors.
- Time spread increases with separation.



# Preliminary conclusions

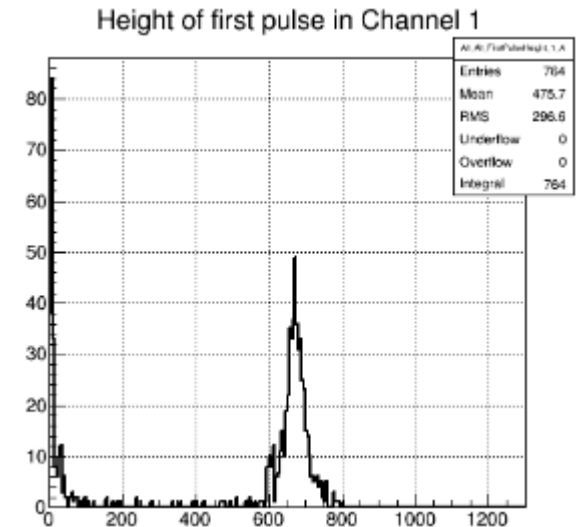
- Event rate decreases with separation (in similar ways with and without shielding).
- No real difference in mean time difference.
- Spread time difference increases with separation



# In situ measurements

## Cosmic vs. non-cosmic

- Found peak in “first pulse height” in other channels than 20 & 28
- e.g.: Channel 1 (similar for other channels)
- First pulse height  $> 600$

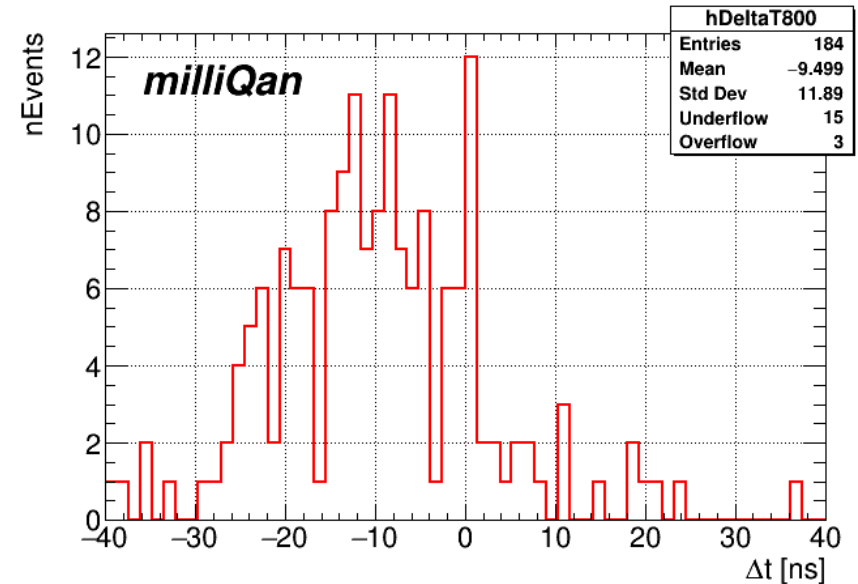
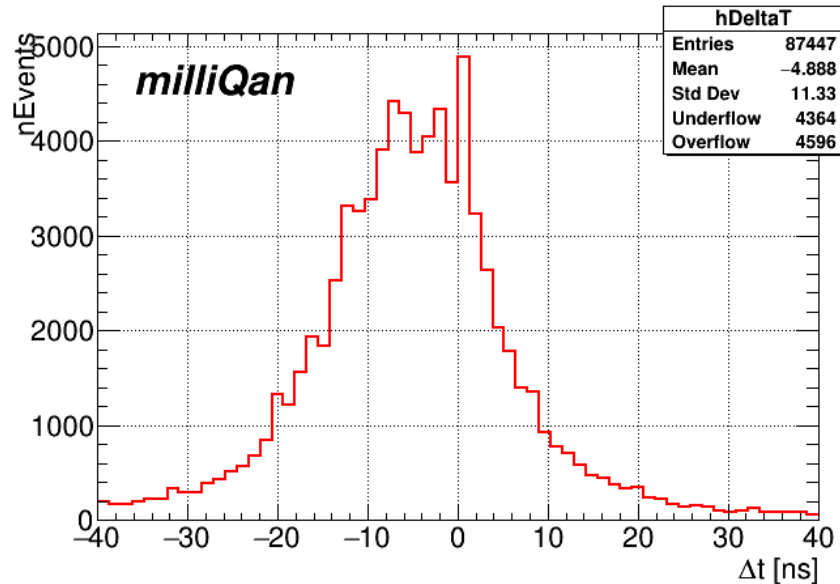




# In situ measurements

## Non-cosmic vs. cosmic

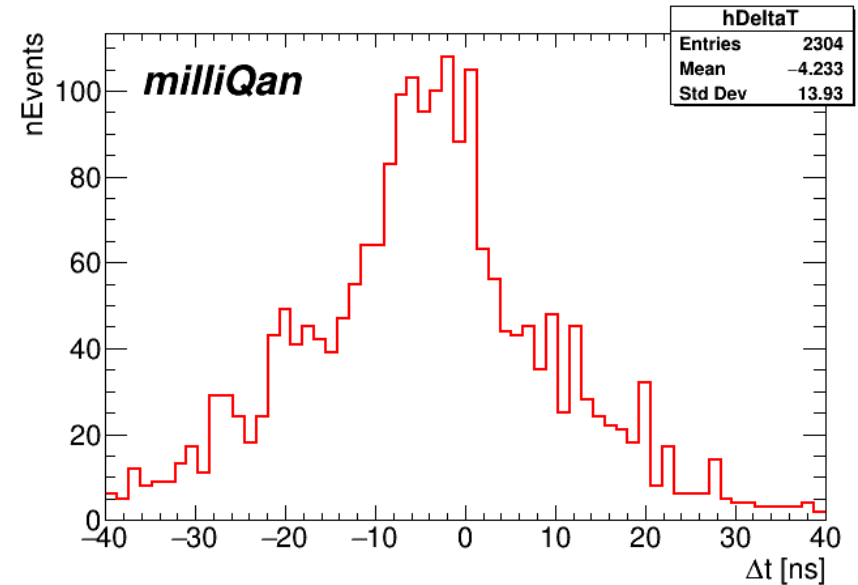
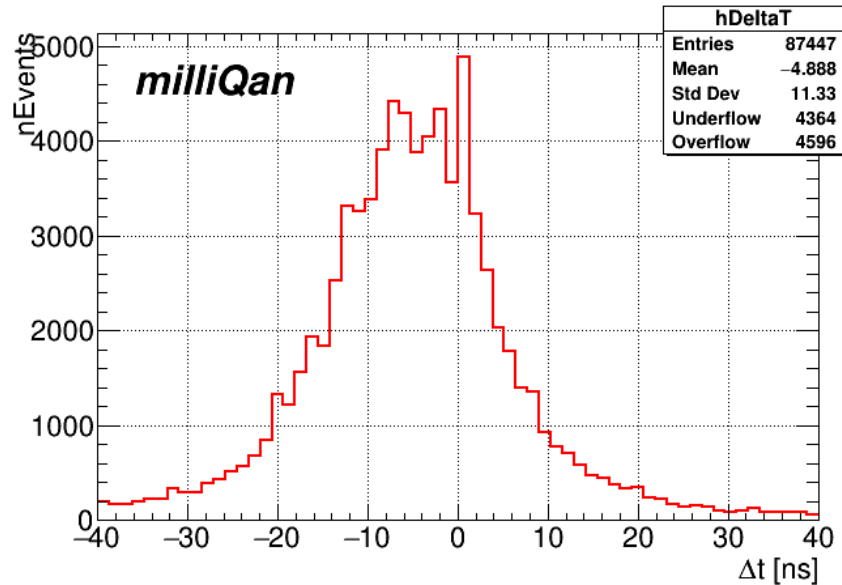
- 50 cm, no shielding (600 firstPulseHeight-cut)



# In situ measurements

## Non-cosmic vs. cosmic

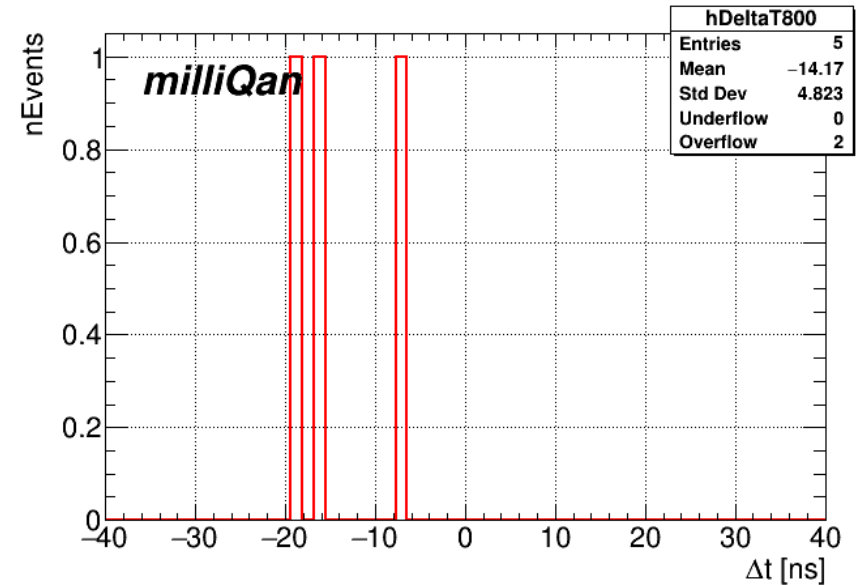
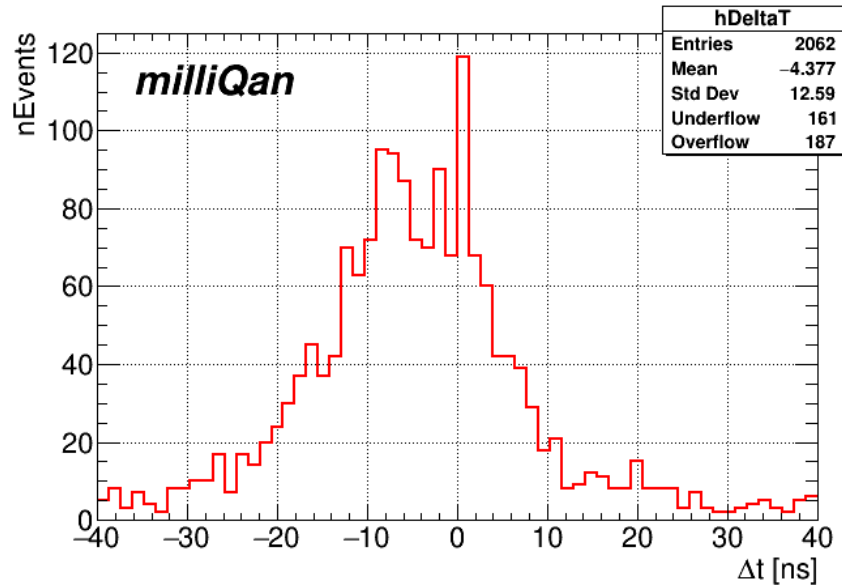
- 50 cm, no shielding (run 2689 vs. run 2711)



# In situ measurements

## Non-cosmic vs. cosmic

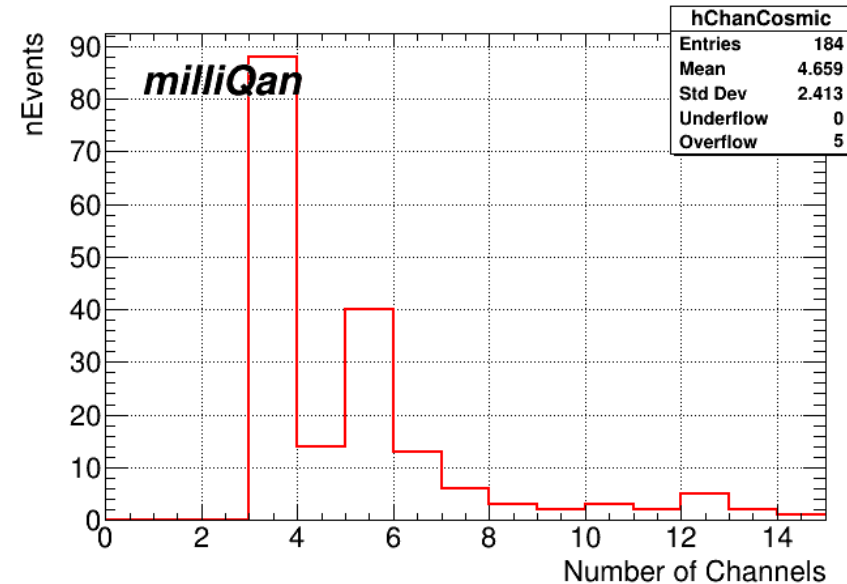
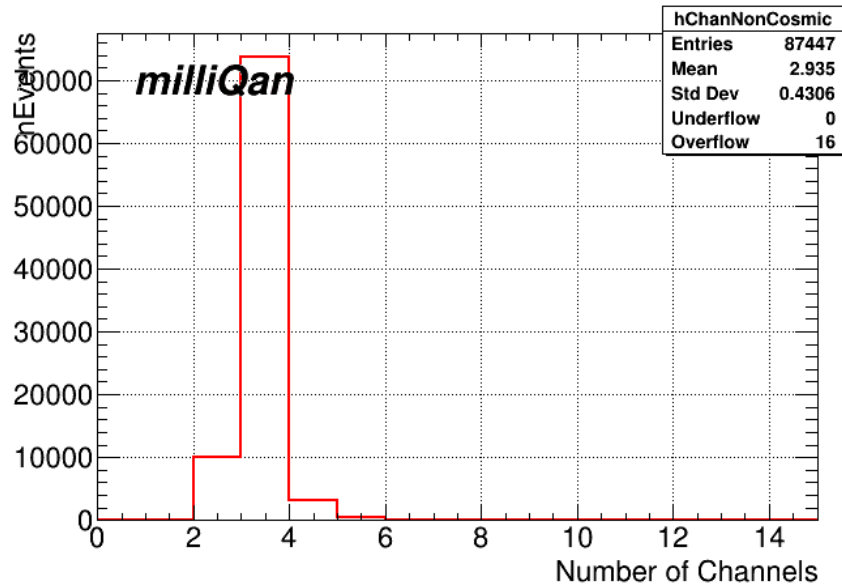
- 50 cm, shielding



# In situ measurements

## Non-cosmic vs. cosmic

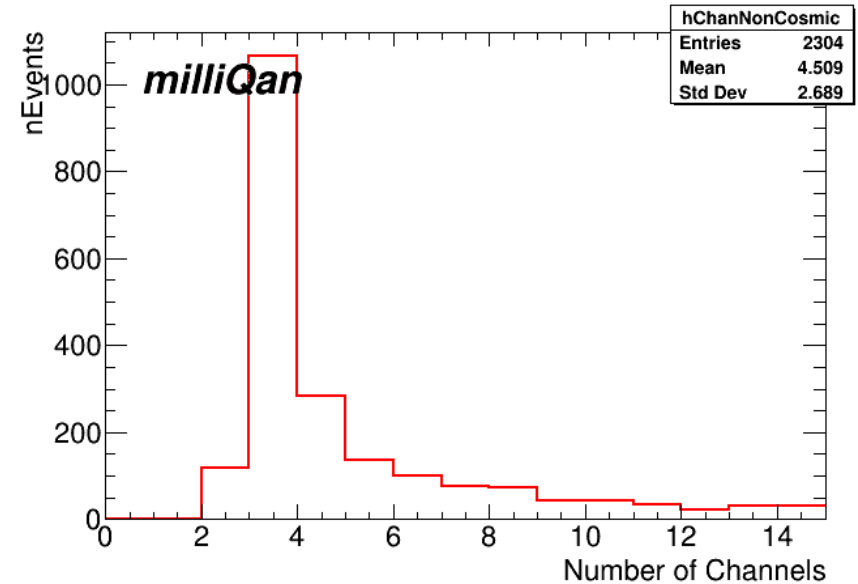
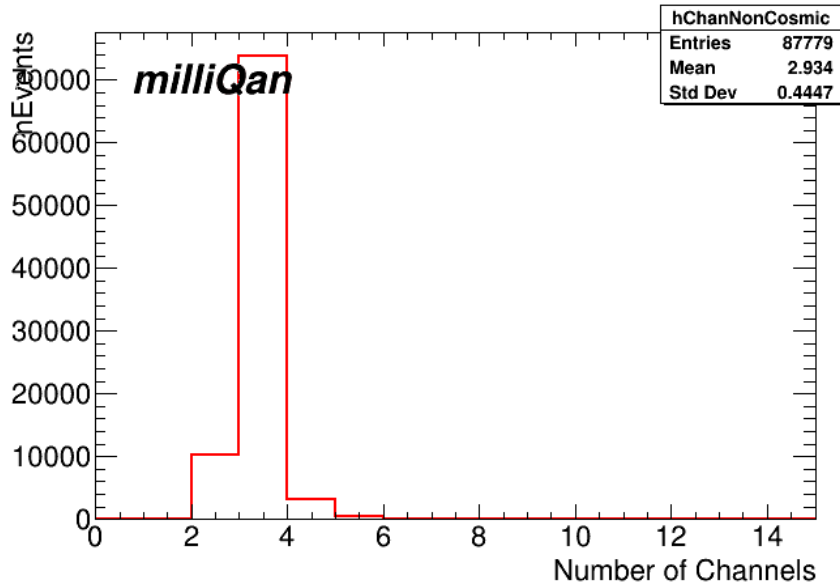
- 50 cm, no shielding (both run 2689)



# In situ measurements

## Non-cosmic vs. cosmic

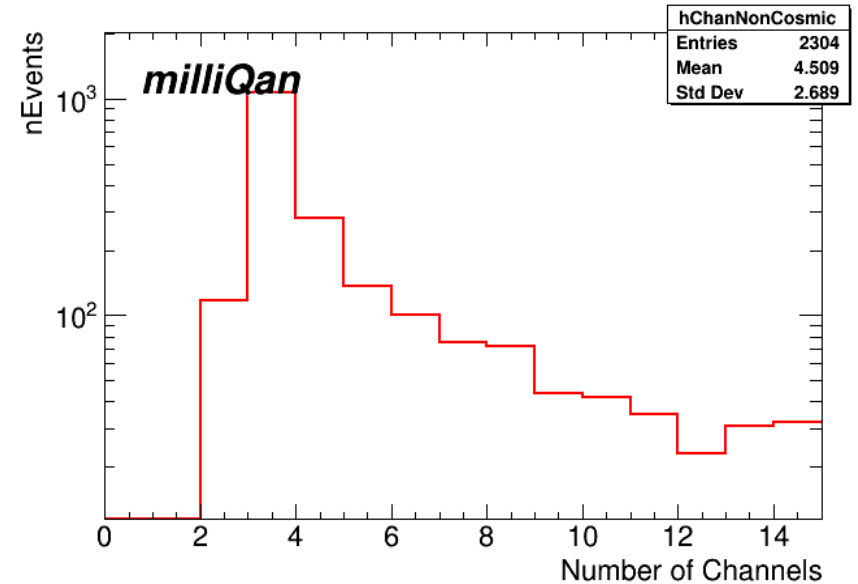
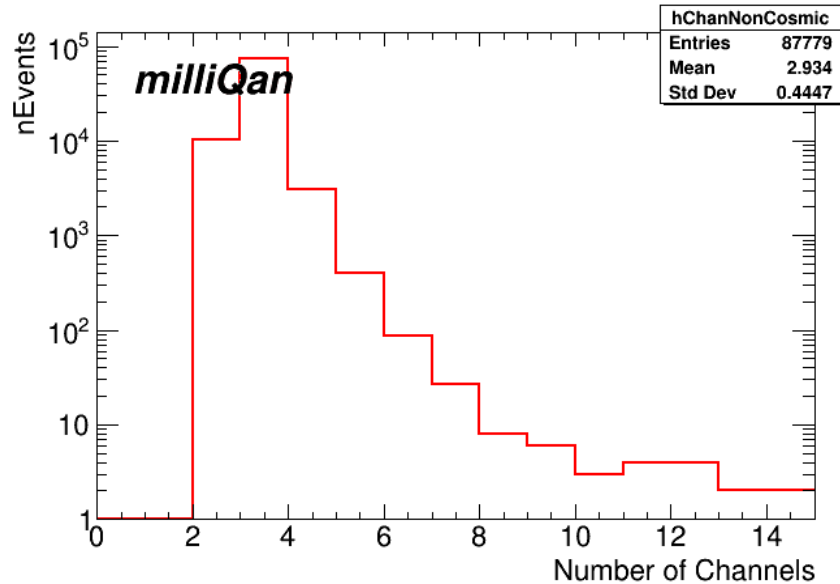
- 50 cm, no shielding (run 2689 vs. 2711)



# In situ measurements

## Non-cosmic vs. cosmic

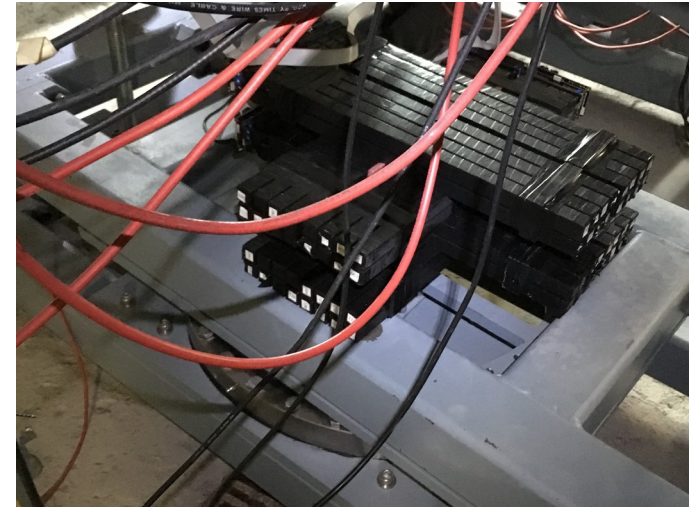
- 50 cm, no shielding (run 2689 vs. 2711)



# Data hodoscope pile

## Set up

- Hodoscope packs from demonstrator placed in “Jenga pile”.
- Data taken in strings of zeros (“finger not hit”) and ones (“finger hit”).

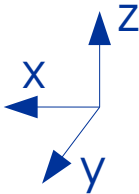
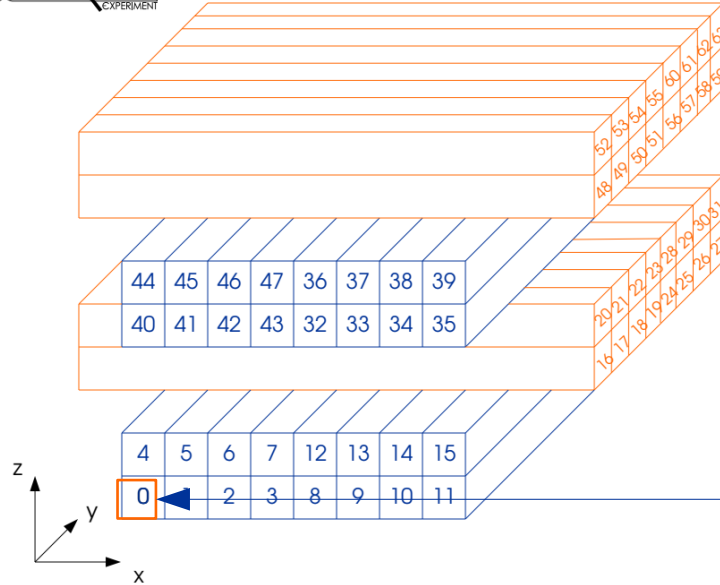


Data format (1 event)

1547157601 2019:01:10:22:00:01:237400 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
0  
0  
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1111 0.236922 308035170

# Data hodoscope pile

## Set up



### Data form

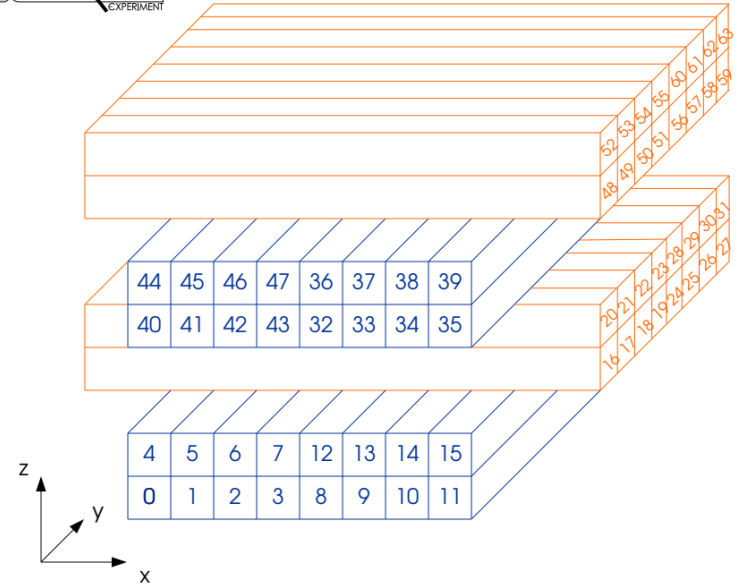
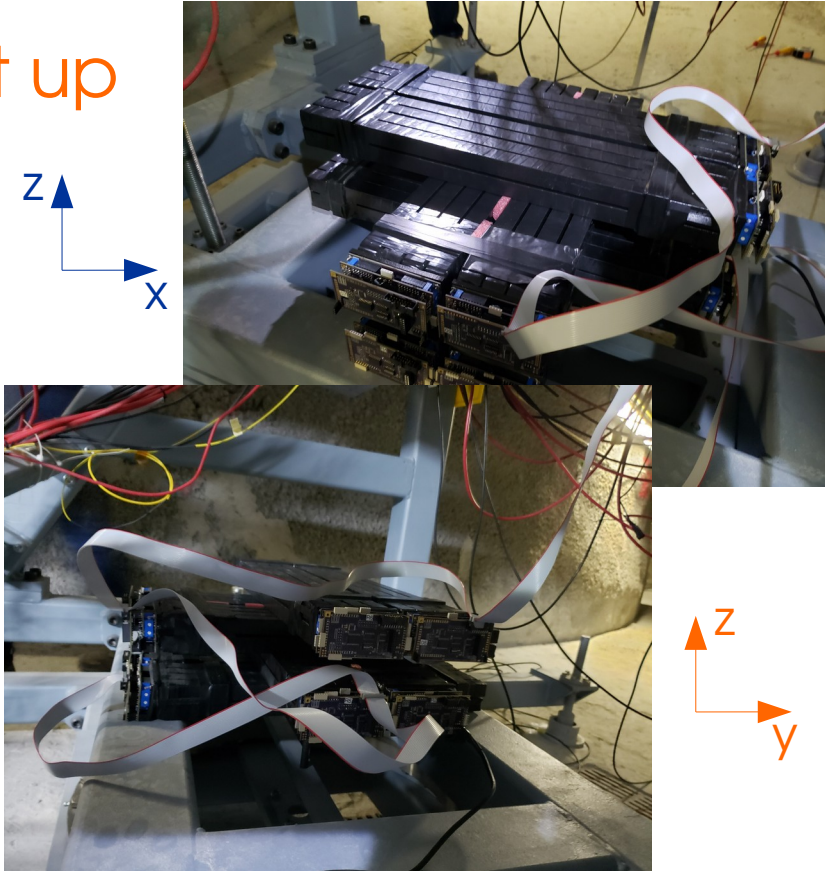
```

1547157601 2019:01:10:22:00:01:237400 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
    
```



# Data hodoscope pile

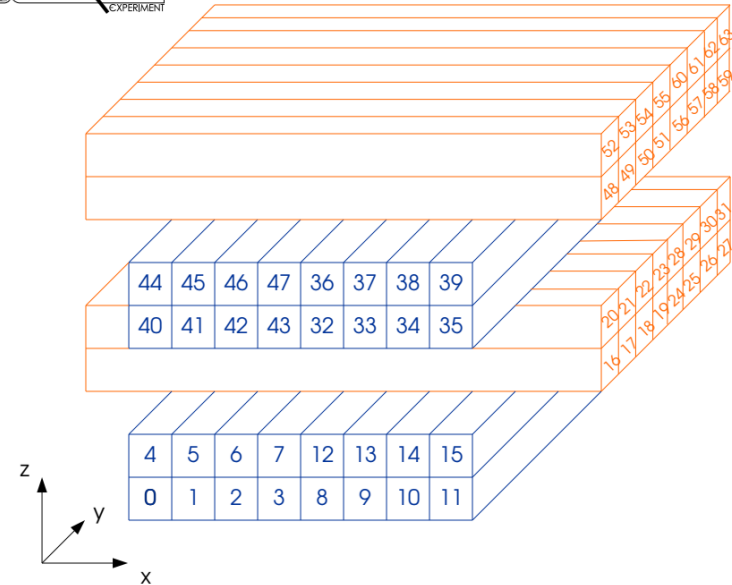
Set up



# Data hodoscope pile

## Assumptions

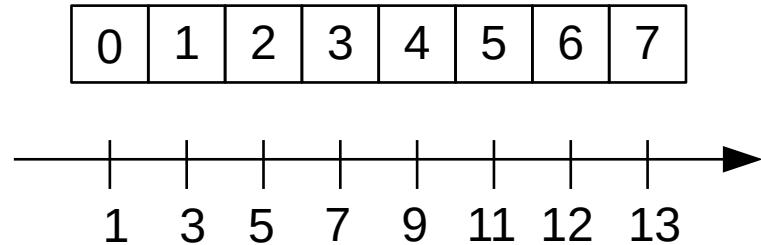
- No space between fingers
- Each finger: 2 x 2 (chosen unit)
- Hit happens in centre of finger.



# Data hodoscope pile

## Structure

- 8 layers ( $i=0-7$ ) of 8 fingers ( $j=0-7$ )
- Horizontal position (x or y):  $j \rightarrow x=2j+1$
- Vertical position (z):  $i \rightarrow z=2i+1$
- If two hits next to each other:  
hit=middle of two channels



# Data hodoscope pile

## Event selection

Which events are interesting?

- Total # events (from Nov. 7-27 2019): 3 517 078
- # events **internally triggered**: 559 132 (externally triggered ones almost always empty)
- From these, only look at events that triggered either **7** (11 662) or **8 layers** (6 998) so that we can we have enough to fit in both directions.

# Data hodoscope pile



## Event selection

Which events are interesting?

- Then there were still layers that were triggered like this:

→ only consider **max one cluster of max 2 ones next to each other** (5397 events left)

-----	11110000
-----	11110000
00000100	-----
00000100	-----
-----	00001100
-----	00000100
①000①000	-----
00010000	-----

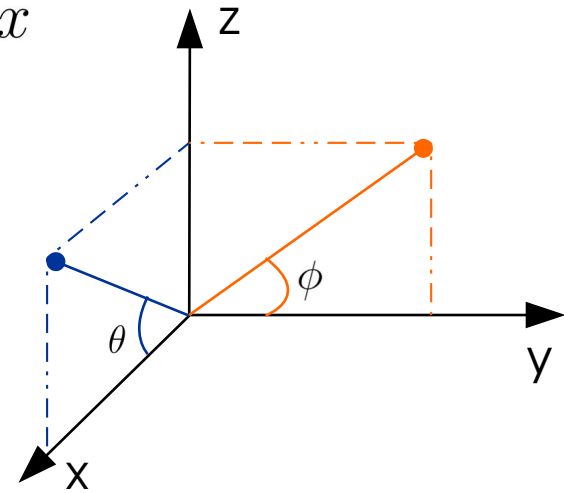
# Data hodoscope pile

## Data analysis

- Create TGraphs with  $(x,z)$  and  $(y,z)$  positions and fit linear:  $z = a_x \cdot x + b_x$
- Get angles from slope:

$$\theta = \arctan(a_x)$$

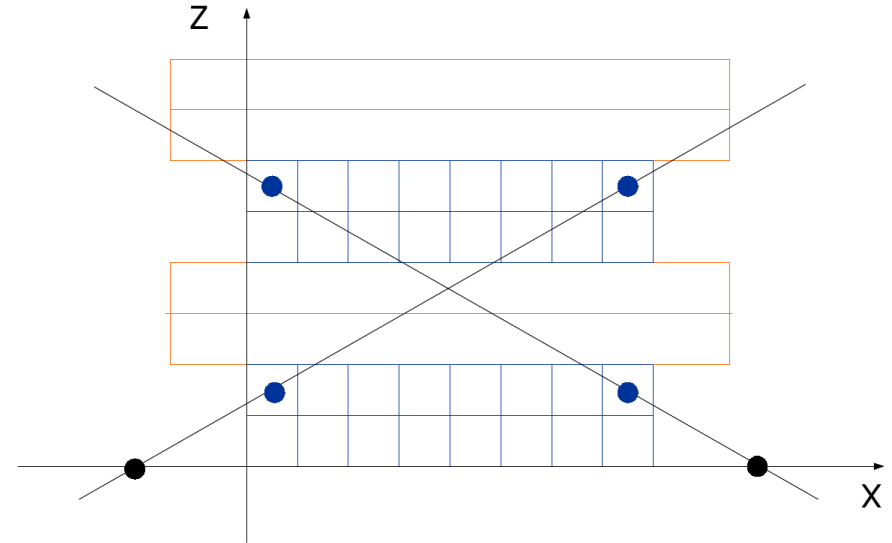
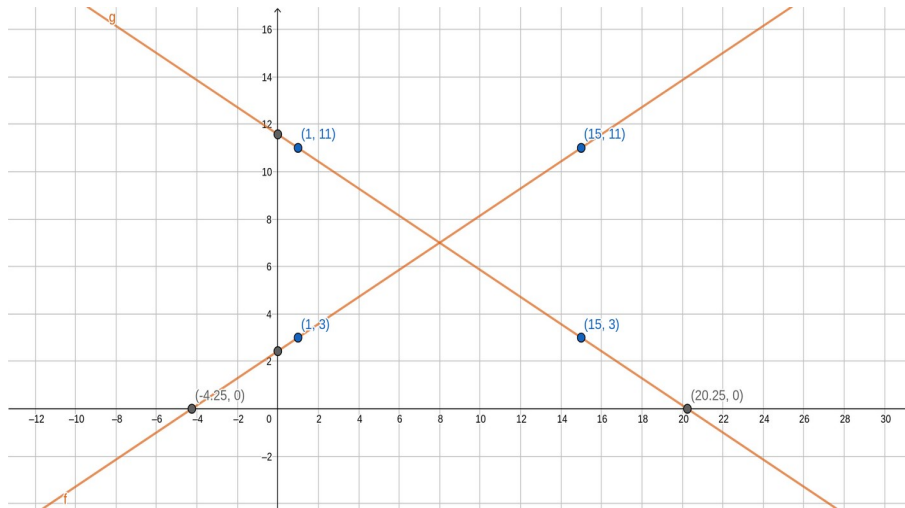
$$\phi = \arctan(a_y)$$



# Data hodoscope pile

## Data analysis

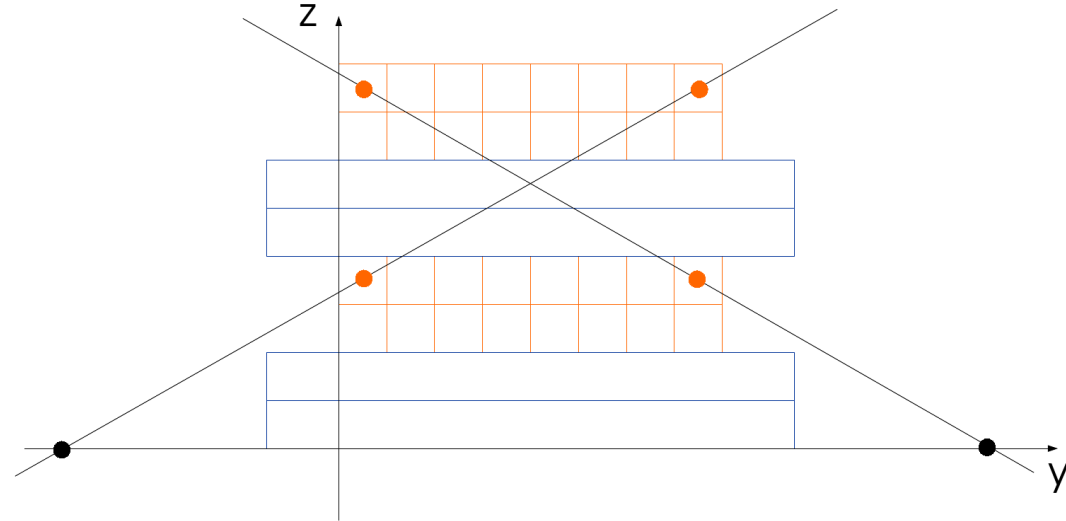
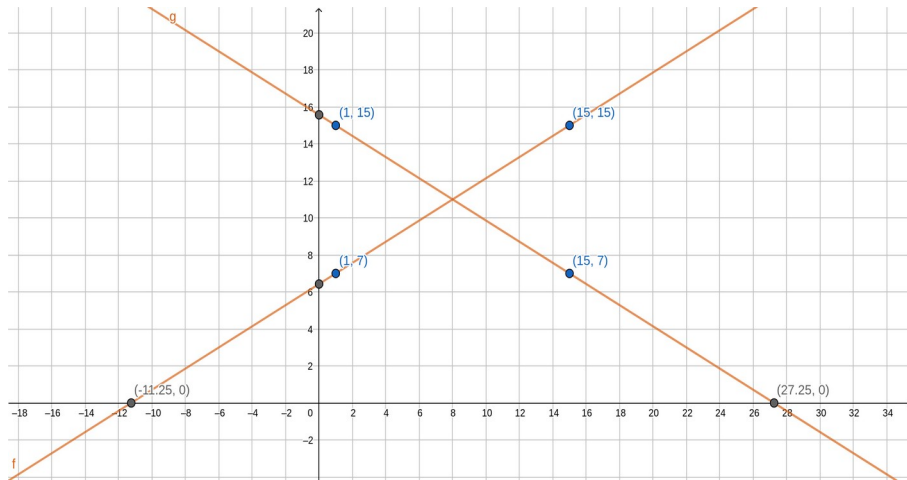
What are the possible values in the x-direction?



# Data hodoscope pile

## Data analysis

What are the possible values in the y-direction?





# Data hodoscope pile

## Data analysis

What kind of data do we expect?

Variable	Minimum	Maximum
$\theta, \phi$	$29.7^\circ$	$150.3^\circ$
Root $x$	$\sim -5$	$\sim 21$
Root $y$	$\sim -12$	$\sim 28$

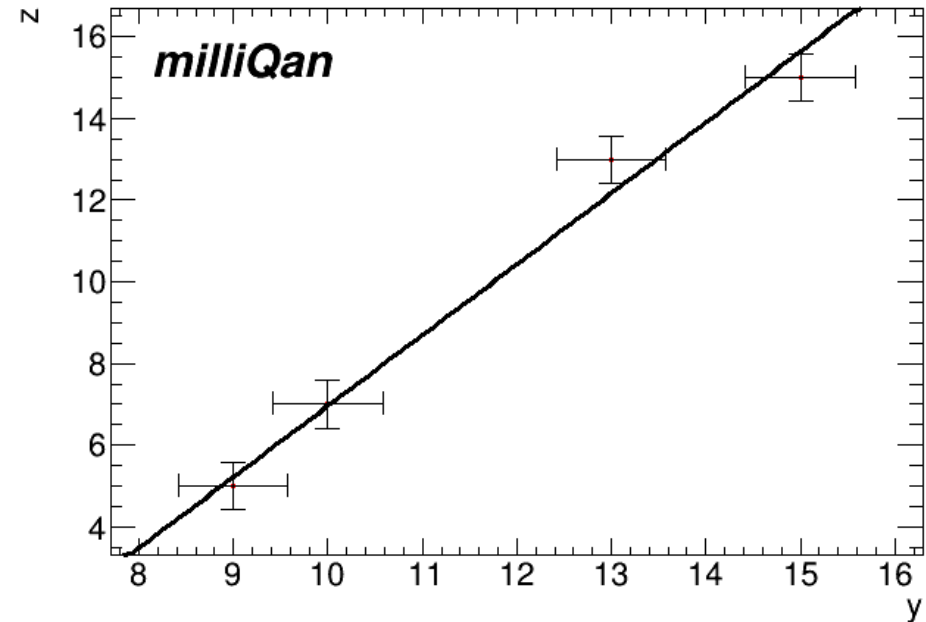
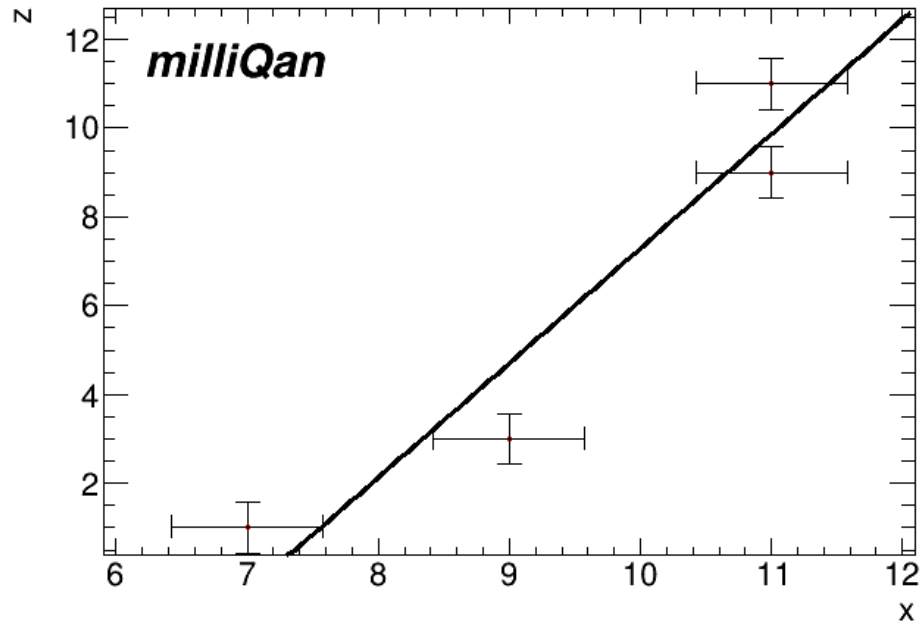
Knowing this allows us to eliminate other “bad” events, i.e. events that lie outside these extrema (now only 5 249 events remain).

```
----- 00001000
----- 00001000
00000001 -----
10000000 -----
----- 00001000
----- 00001000
00000001 -----
00000000 -----

theta=169.374
phi=89.9906
```

# Data hodoscope pile

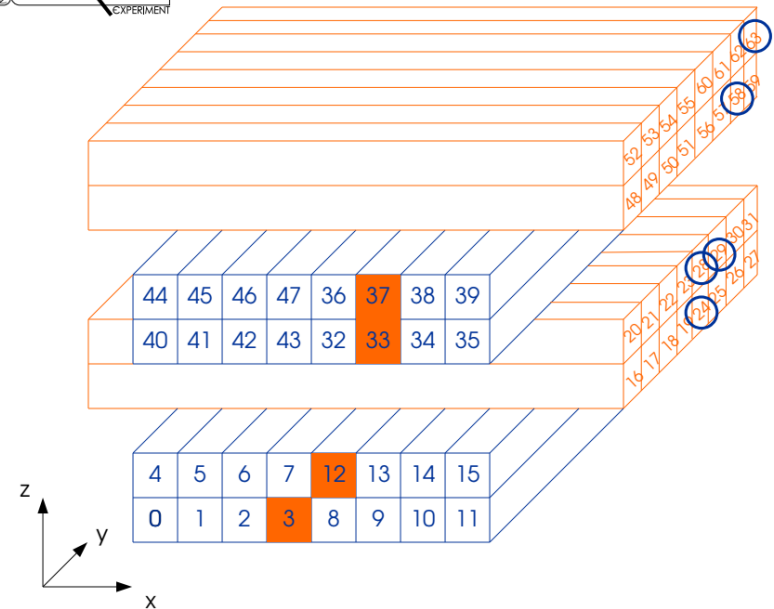
## Data analysis: example



# Data hodoscope pile

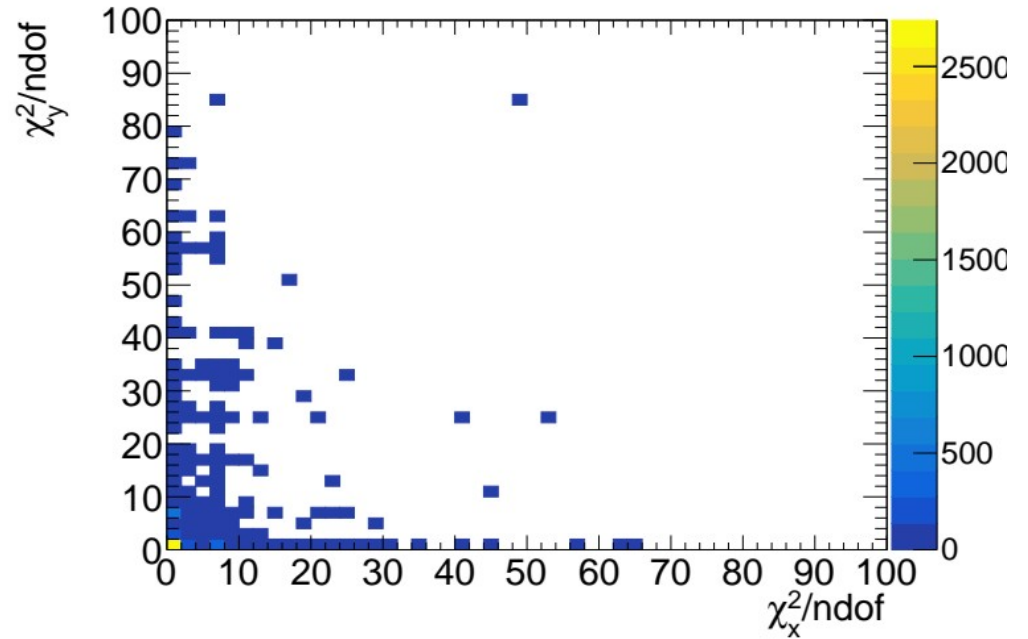
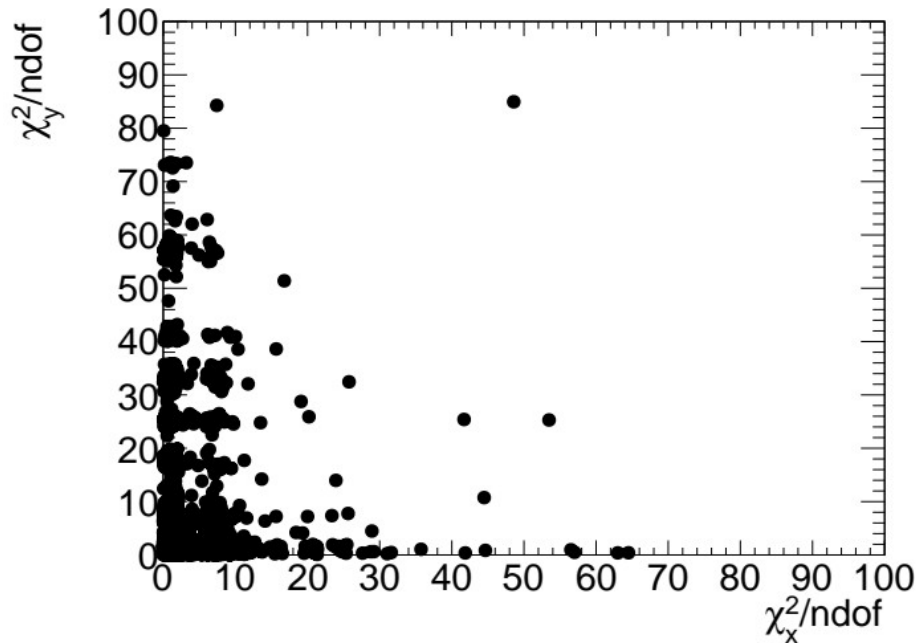
## Data analysis: example

-----	00000001
-----	00000010
00000100	-----
00000100	-----
-----	00001100
-----	00001000
00001000	-----
00010000	-----
theta=68.8135	
phi=60.0596	



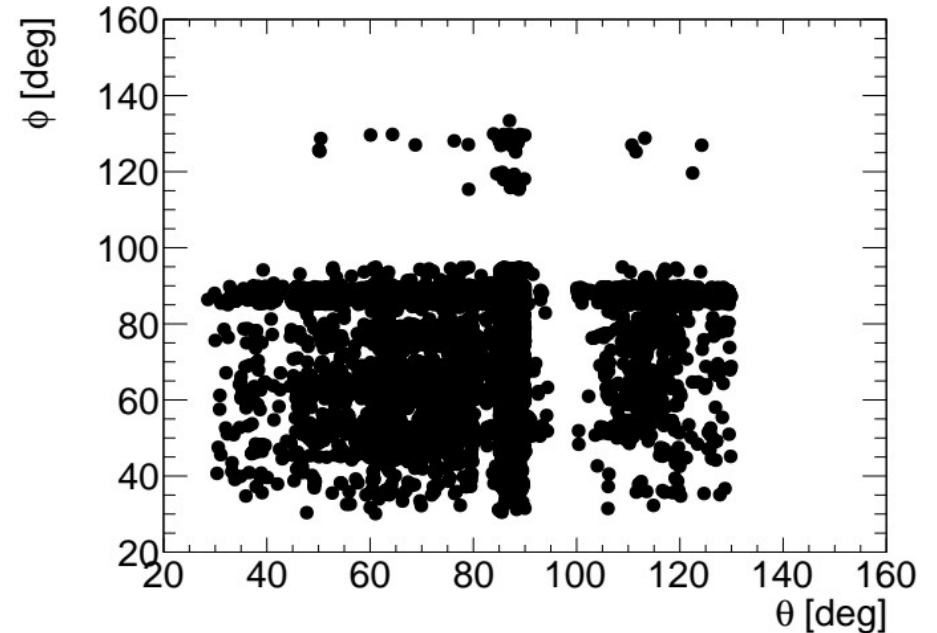
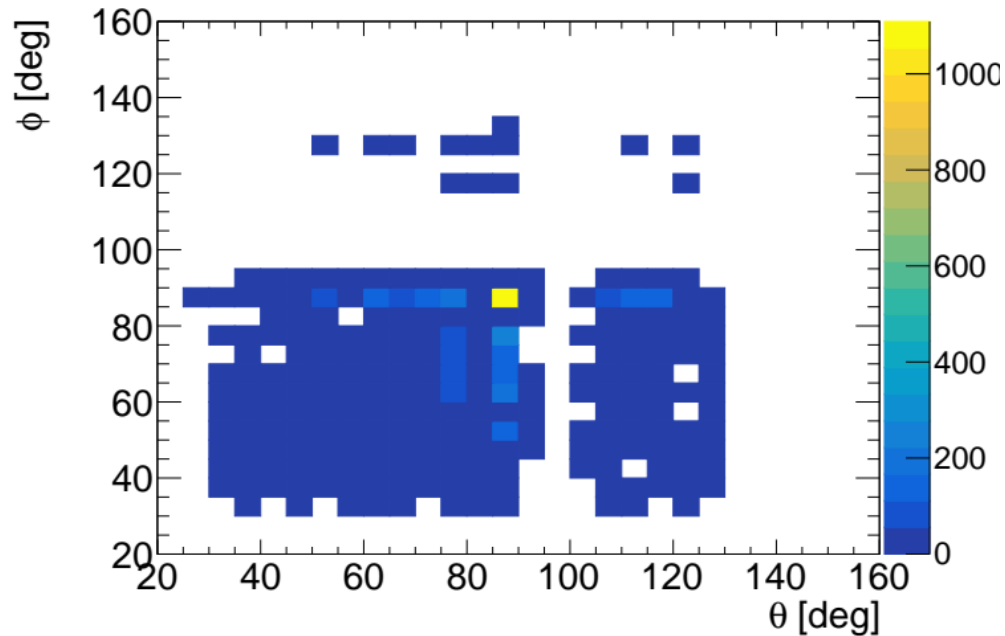
# Data hodoscope pile

Data analysis: goodness of fit  
(Chi2 method)



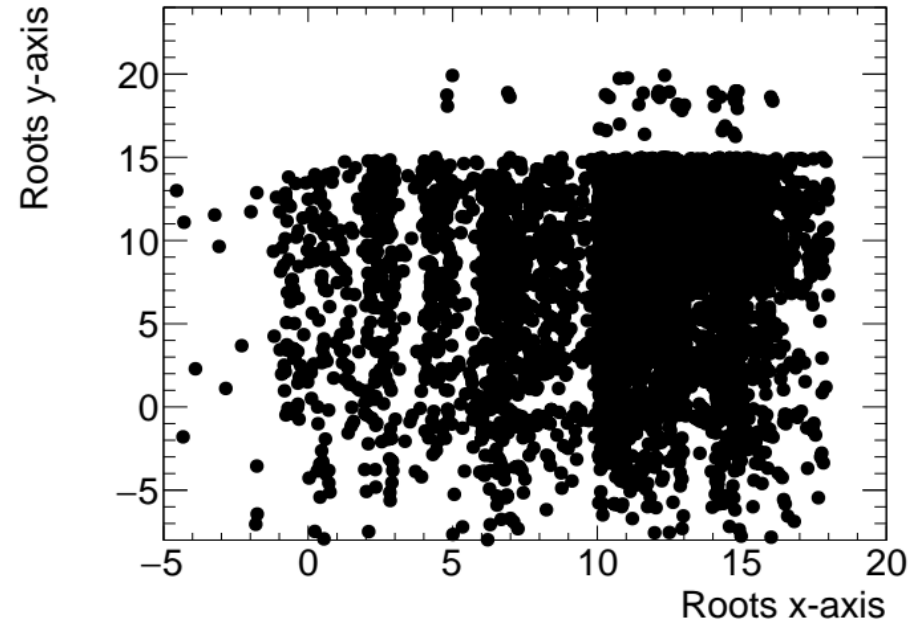
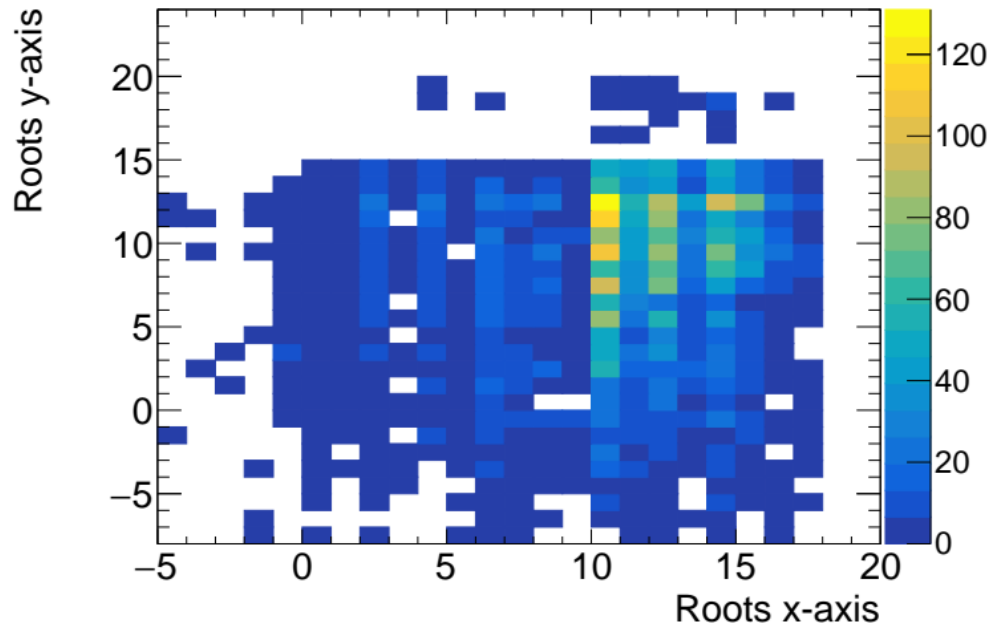
# Data hodoscope pile

## Data analysis: angular distributions



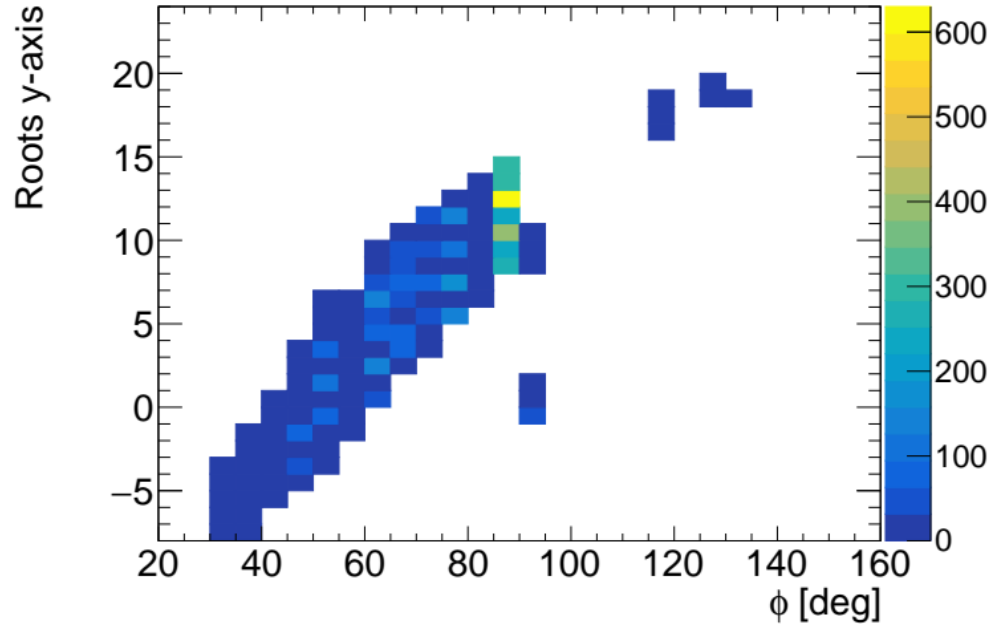
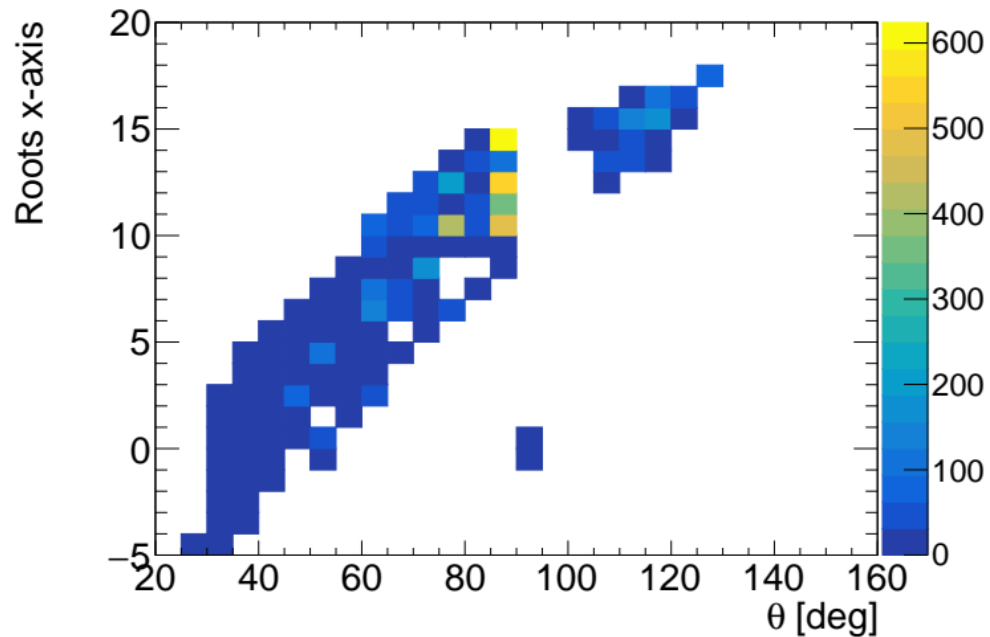
# Data hodoscope pile

## Data analysis: root distributions



# Data hodoscope pile

## Data analysis: Angles vs. roots

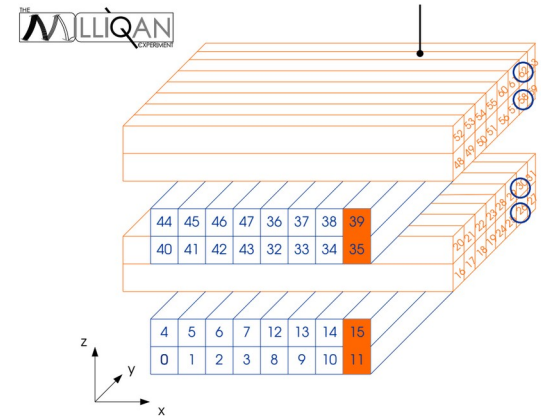


# Data hodoscope pile

## Data analysis: Angles vs. roots

- Most events have an angle of  $90^\circ$
- These are often even on the same spot
- Most events have  $\text{Chi}^2 \sim 0$  since the positioning is discrete and most events are at  $90^\circ$ . In this case  $z$  is for every point equal to the fit:

$$\chi^2 = \sum_{i=0}^n \left( \frac{z_i - f(x_i|a, b)}{\sigma_i} \right)^2$$





# Data hodoscope pile

## Data analysis: Questions

These histograms create some confusion:

- Most events at  $90^\circ \rightarrow$  why?
- They appear to mostly hit one point at  $90^\circ$ , unclear why.
- Clear asymmetry in the angular distributions  $\rightarrow$  why?
- Perhaps we could compare this to simulations of the cosmos?

# frameTitle

## frameSubtitle



Hodoscope info: <http://stuart.physics.ucsb.edu/Lgbk/pub/E40712.dir/E40712.html>