# “X-talk” in the ND

## an update

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**OUTLINE**

- **Motivation – First Results**
- **“Single-Muon” MC**
- **Far Detector**
- **X-talk results (CR & LI)**
- **Conclusions - Plans**

# A Short Revision

MOTIVATION: CR Data in the ND "look noisy":

-Incorporated pixel # info in the standard ntuples: We expect x-talk to come –mainly- from neighbor pixels

RESULTS:

-Most hits accompanying CR reconstructed tracks in the ND come from neighboring strips in the same plane, and NOT from neighboring pixels on the same PMT.

Pixel Number

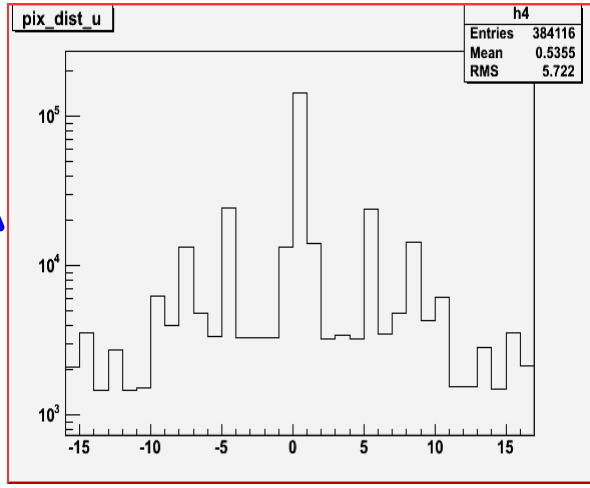
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 |
| 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 |
| 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 |
| 40 | 39 | 38 | 37 | 36 | 35 | 34 | 33 |
| 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 |
| 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 |
| 64 | 63 | 62 | 61 | 60 | 59 | 58 | 57 |

Box Fiber Number

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 28 | 15 | 2 | 53 | 40 | 27 | 14 | 1 |
| 4 | 55 | 42 | 29 | 16 | 3 | 54 | 41 |
| 44 | 31 | 18 | 5 | 56 | 43 | 30 | 17 |
| 20 | 7 | 58 | 45 | 32 | 19 | 6 | 57 |
| 60 | 47 | 34 | 21 | 8 | 59 | 46 | 33 |
| 36 | 23 | 10 | 61 | 48 | 35 | 22 | 9 |
| 12 | 63 | 50 | 37 | 24 | 11 | 62 | 49 |
| 52 | 39 | 26 | 13 | 64 | 51 | 38 | 25 |

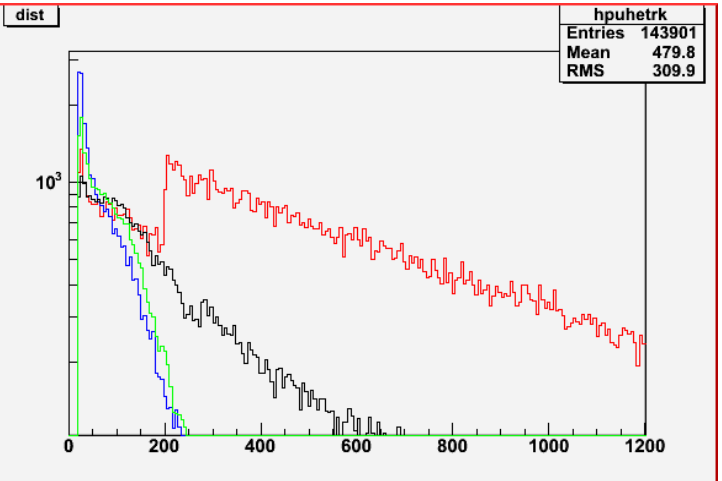
Plane Strip Number

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 54 | 41 | 11 | 35 | 22 | 53 | 40 |
| 43 | 9 | 37 | 24 | 55 | 42 | 10 | 36 |
| 39 | 26 | 57 | 44 | 8 | 38 | 25 | 56 |
| 59 | 46 | 6 | 19 | 27 | 58 | 45 | 7 |
| 4 | 17 | 29 | 60 | 47 | 5 | 18 | 28 |
| 31 | 62 | 49 | 3 | 16 | 30 | 61 | 48 |
| 51 | 1 | 14 | 32 | 63 | 50 | 2 | 15 |
| 12 | 34 | 21 | 52 | 0 | 13 | 33 | 20 |




Distance from "track hit" in pixel space: Peaks at
+/-1,+/-8 (x-talk)
+/-5,+/-10,+/-15(neighbor strips)
+/-13(x-talk to neighbor strips!)

-Neighbor-to-track-hit strips have high pulseheight – sometimes higher than the track hit
-Neighbor-to-track-hit pixels have ~1pe pulseheight, as expected.




Pulseheight distributions:
Red: "Track" Hits
Blue, Green: "Neighbor" pixels
Black: "Neighbor" strips

ALSO:
-These hits have the same "time spread" as the track hits. (They do not seem to come earlier or later than the "track hit")
-Neighboring strips map into nearby MENU's, so we cannot disentangle electronics x-talk. (Improbable at this level, though…).

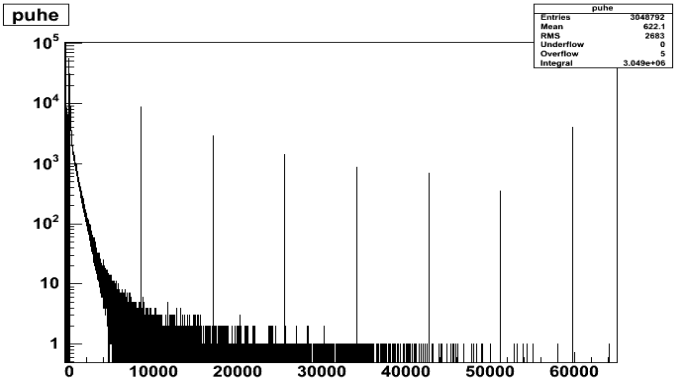
# Two Caveats:

-"Rogue" Channels

Channels that give strange values of pulseheight: Either negative/below sparsification level, or clustered around some (usually unreasonably high) ph values.

I filtered the strips that were behaving oddly in the real data, and kept this filter on in MC.

When processed more recent data → Different "rogue" channels showed up! (Now solved at the Strip Maker level).




Pulseheight distribution: Notice the peaks (Range errors/ Miscalibrations?)

With the new Digit Filter, all CapID errors show up as "readout holes" , but the peaks remain! (8-10 menus still with this problem)

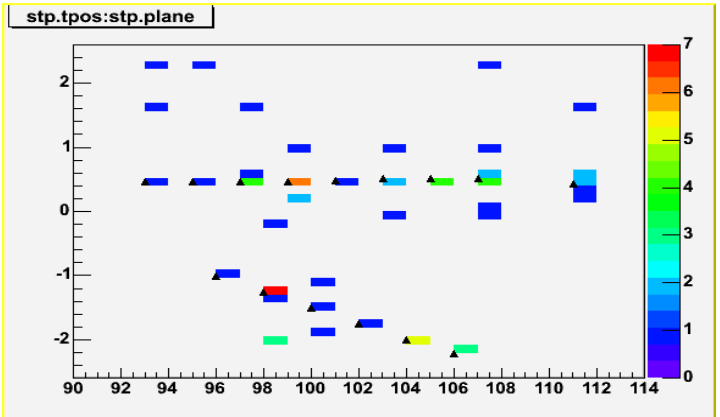
-"Many strips per strip" (!)

Pulseheight-weighted timing of hits, results in multiple reconstructed strips with the same (plane-strip) coordinates for one snarl.

So, in the following, hit's pulseheight is defined as the sum of pulseheights for reconstructed strips with the same coordinates over the whole snarl…

A CR muon (both views):
Color code: # of strips reconstructed for each physical strip – NOT a binning effect!

TRK.STP array points to just one of them



# Single Muon Monte-Carlo

Created "single muon" StdHEP format files (*thanks Robert H.*), which were fed through the GMINOS Near Detector full Monte-Carlo.

During the creation of the files, I selected

-Energy 70-200GeV, (the bulk of the CR muons that reach ND)

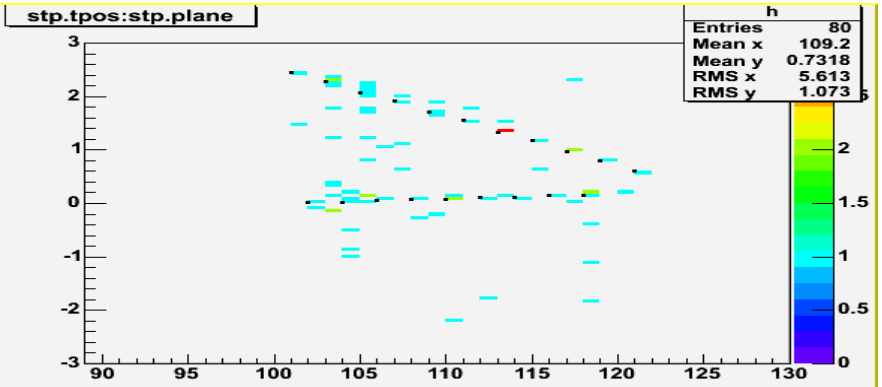
-Angle of incidence:

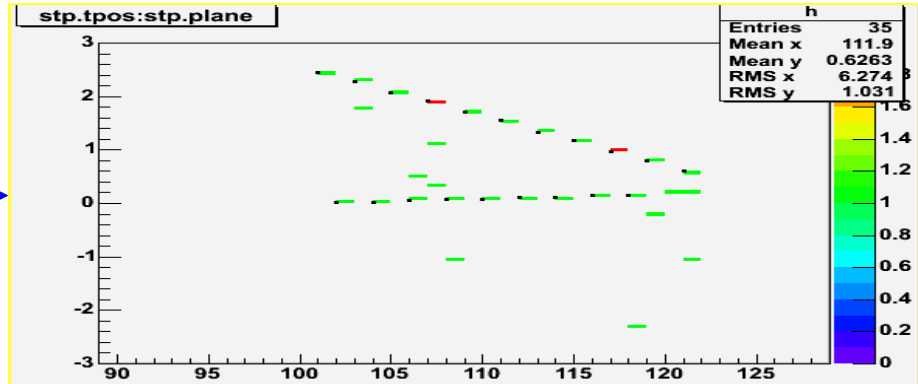
0-150mrad wrt "beam" axis ("Horizontal" Files) OR 170-1400mrad wrt "beam" axis ("Vertical" Files)

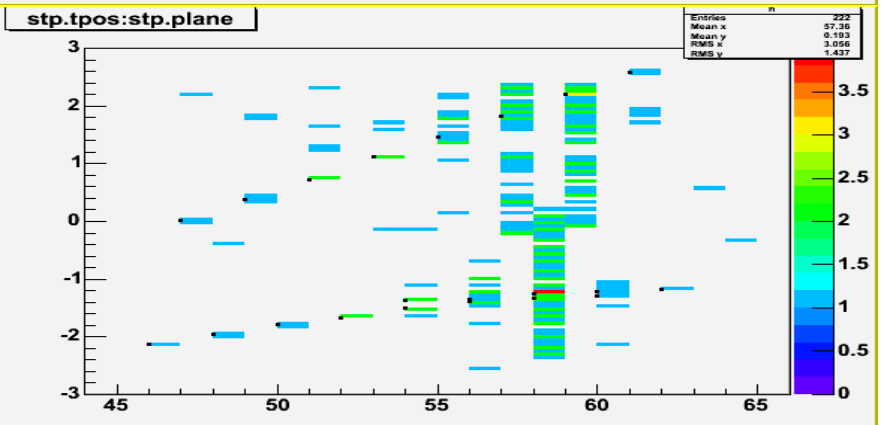
-Vertex position (anywhere in the ND → Inefficiency in reconstruction)

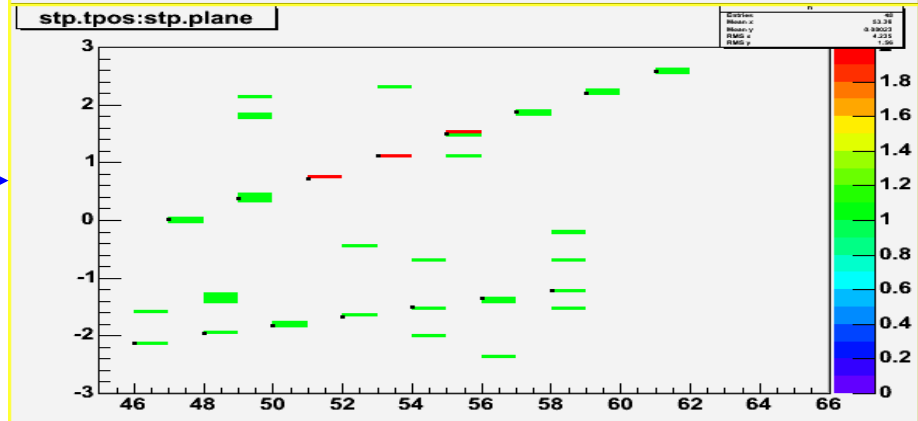
-Physics processes

all physics ON OR Delta-ray, brem., Pair production OFF



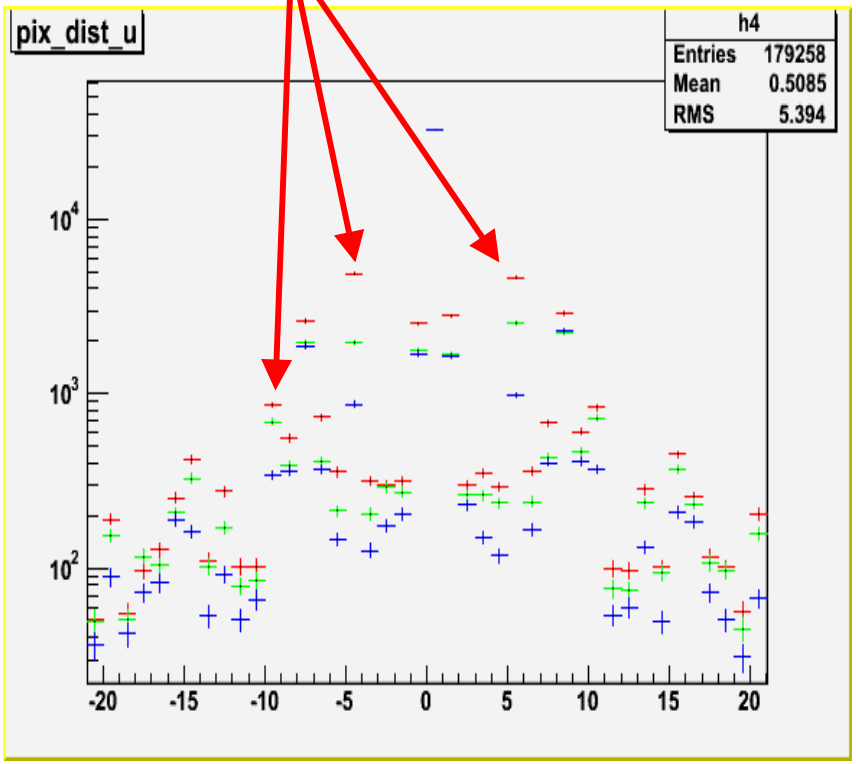



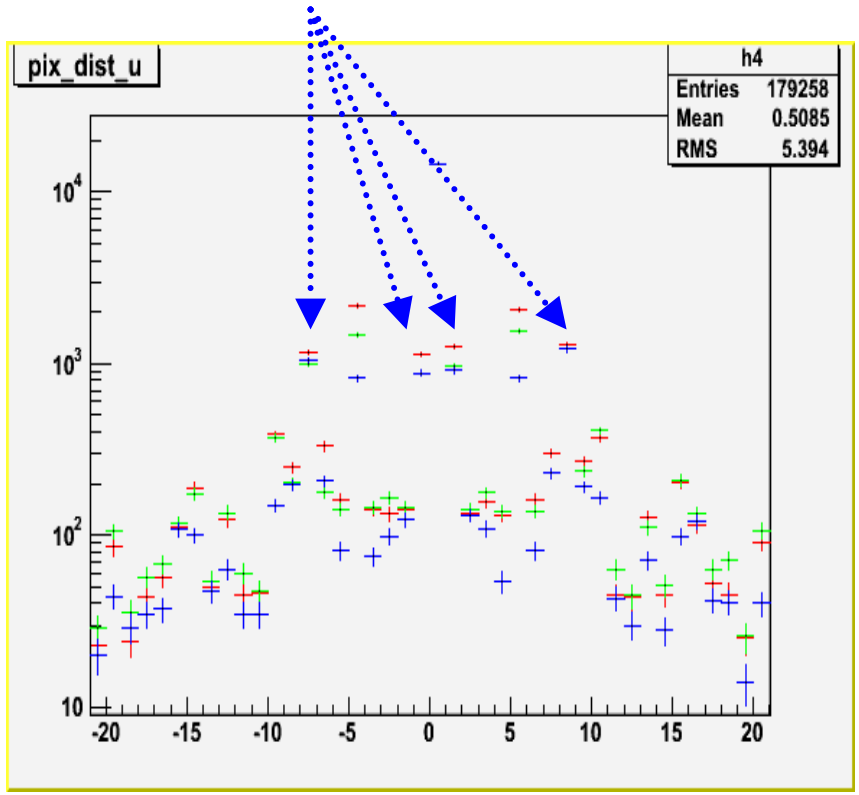
# Results for the MC 1

Neighbor strips




Real data with “MC1” & “MC3”

Neighbor pixels



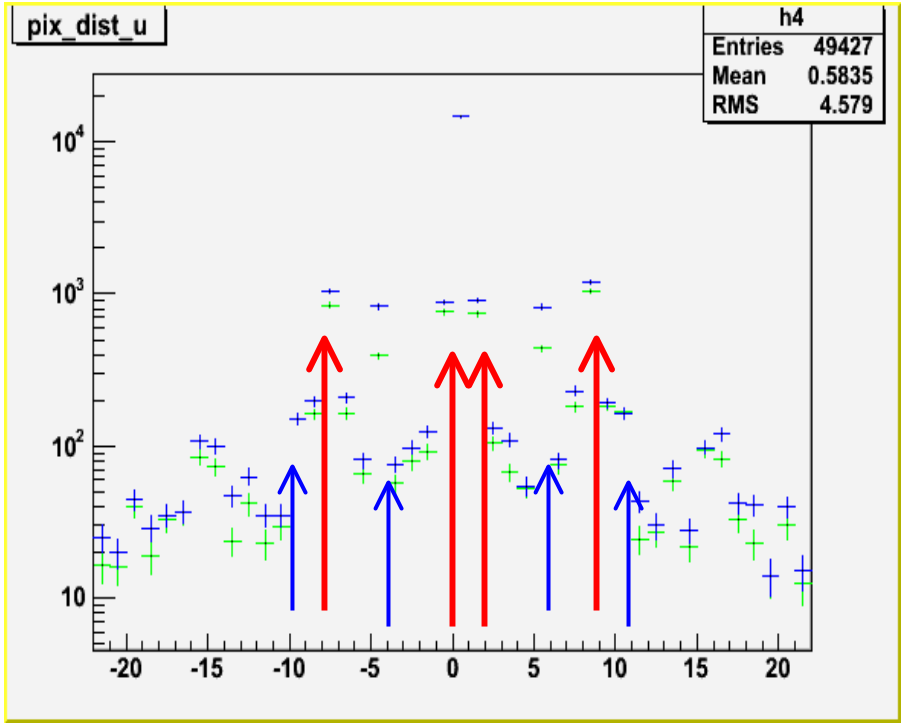

Real data with “VM1” & “VM3”

Red : Real Data

Green : Monte – Carlo, all physics included

Blue : Monte – Carlo, no explicit delta-ray production

# Results for the MC 2

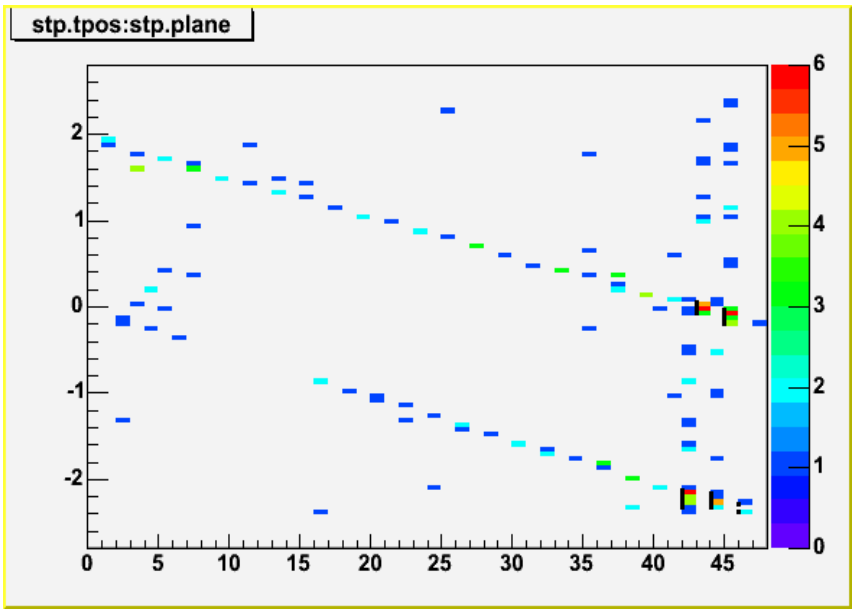


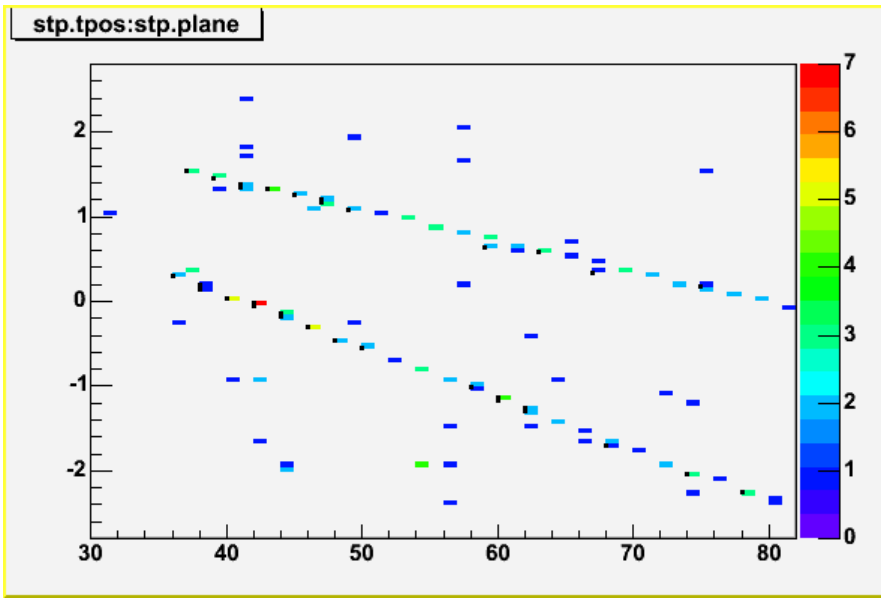

Red: Neighbor pixels
Blue:Neighbor strips

"Horizontal" and "Vertical" muons **without** delta-ray production

# Trying to validate the physics

Ok, we got a hint: Part of the problem are the δ's …
How can we prove they are deltas in real data?
➔Try to see the characteristic T^(-2) spectrum of deltas. (T: Kinetic energy of electrons)
Tried various shower finders:
-SR shower finder in CR data: A disaster story (expected, it was not built for that kind of data).
-CandShowerEM package (Chris Smith, Hai Zheng):
--Works on CandClustersSR
--Tries to find Clusters that "resemble" electrons
Quite sophisticated, but also not built for this purpose.
Comes along with a bunch of configurable parameters, though!
After a lot of tweaking on a trial and error basis, and valuable suggestions by the authors (HZ),
I still cannot rely on that for delta-ray finding in CR data: WORK IN PROGRESS!



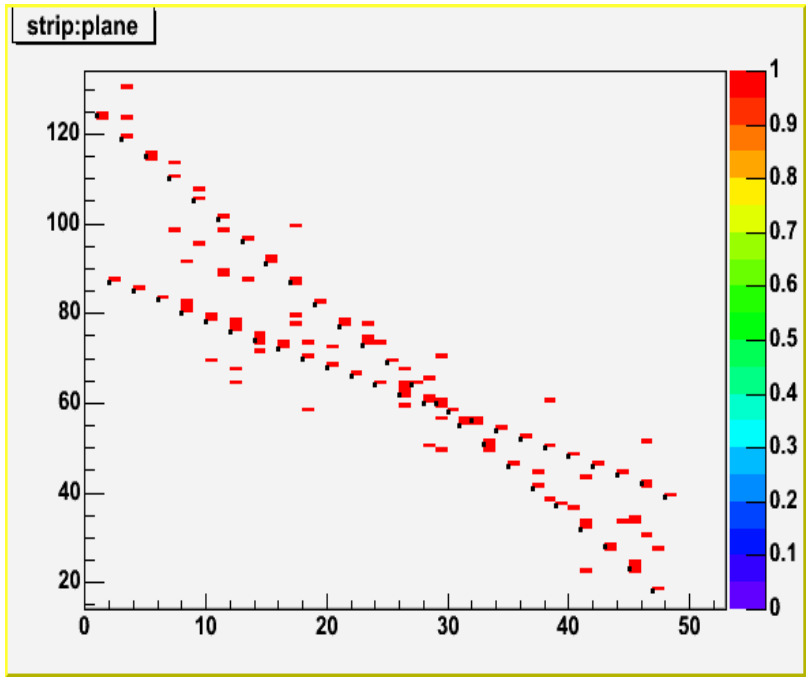




"Acceptable" and "not acceptable" shower examples

Authors' comments: Wait for improvements…(Last Nue meeting – Code still not public)

# What about the FD?

I looked into FD CR data the same way:
The data look as much as noisy (see below), if not worse, BUT:
The neighboring strip – neighboring pixel difference cannot be shown in full glory, because the M16 has smaller surface, so:
➔Neighboring strips end up in neighboring pixels (diagonal)
➔Different multiplexing in different strip-ends multi-plexes the picture

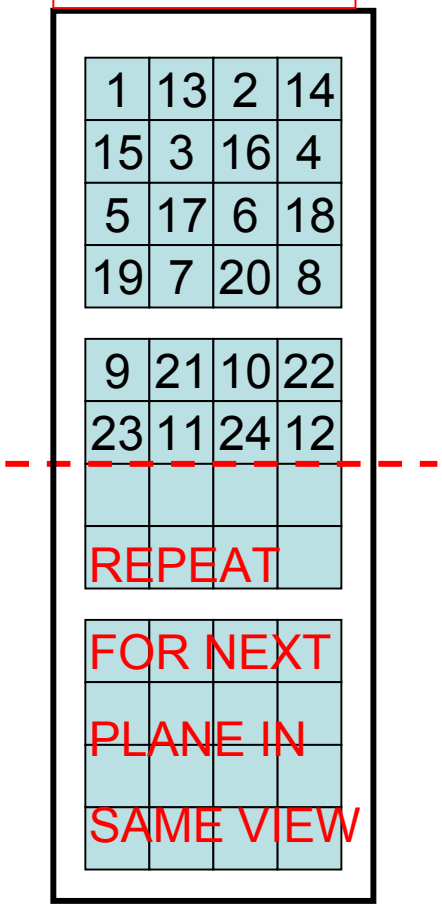



CR muon in the FD (both views in on picture) [Run 6030]

Extended the technique (writing out pixel info) to CalDet UberDSTs, but there is no tracker there (that I know of…), and the muon energies are quite lower.

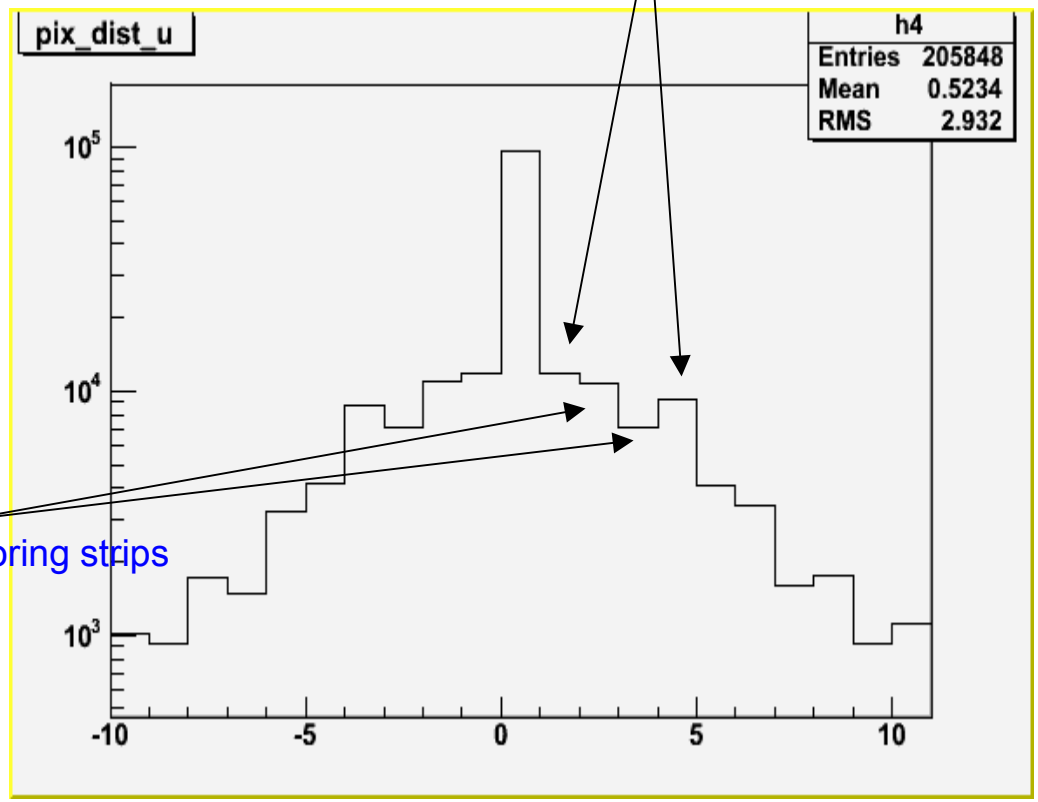
# The FD in pixel space:

Mux Box- FD style




"West" Strip-end Strip-to-Pixel Mapping in the Far Detector (schem.:B.Rebel)

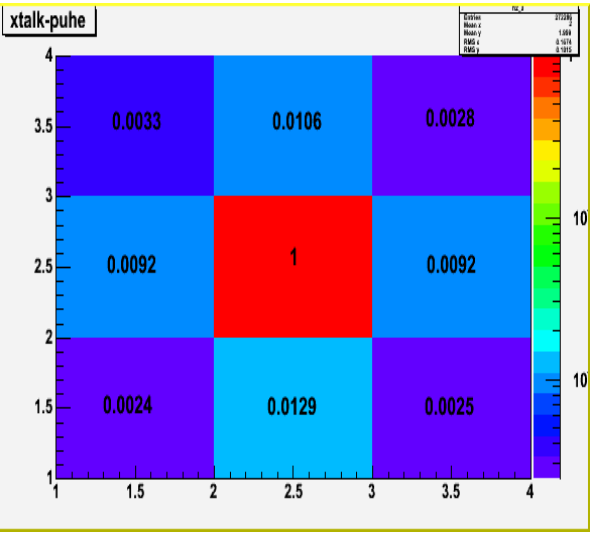
x-talk: neighboring pixels




physics:neighboring strips

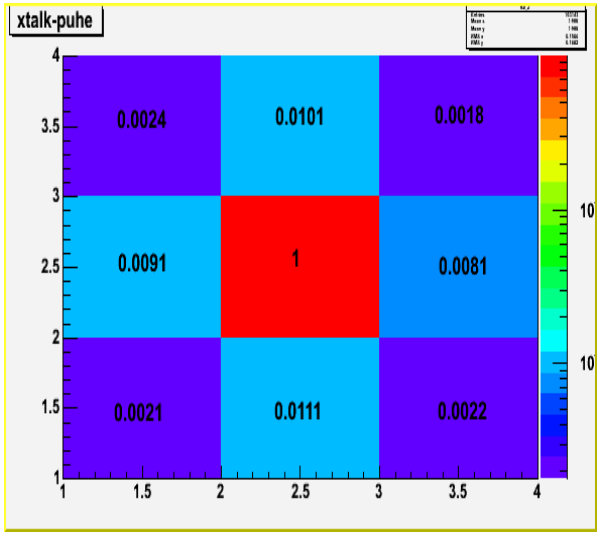
RUN 6030:No B-Field, only SM1 U planes, West End readout

# The real thing: “Final” results for x-talk



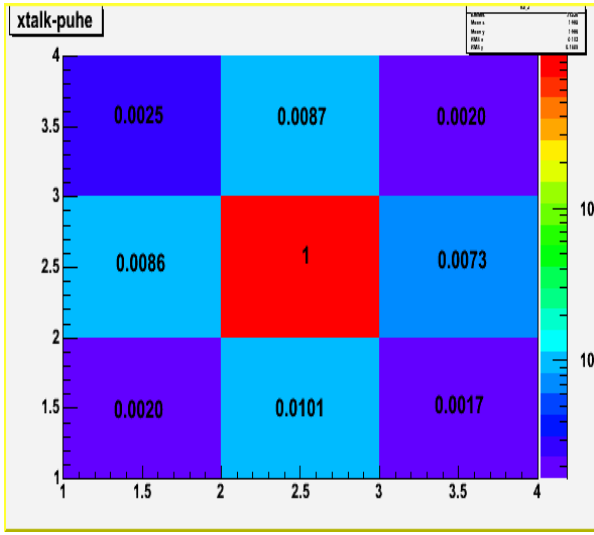

CR Data

87057 “track hits”




MC muons 1
(“Horizontal”)

32585 “track hits”




MC muons 2
(“Vertical”)

14766 “track hits”

x-talk percentage
(partial U planes:
1plane ==1 PMT)

$$x-talk_i = \frac{\sum_{\substack{\text{"hits with pixel distance } i \\ \text{from track hits"}}} ph.raw}{\sum_{\text{"track hits"}} ph.raw}$$

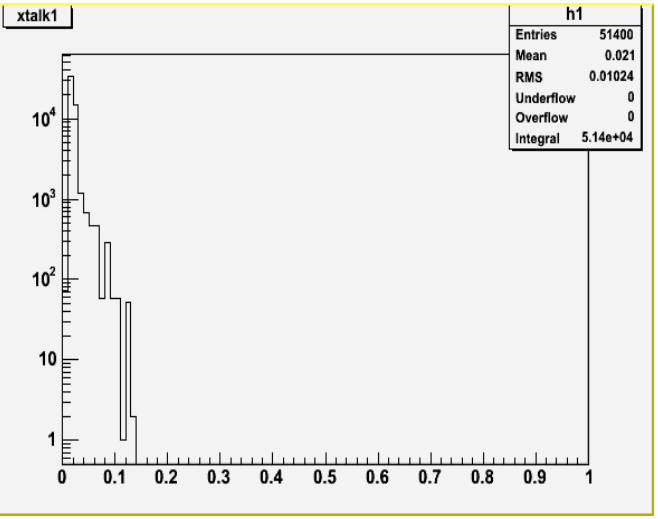
Oxford results
(NuMI-934)
(EXT+OXT)

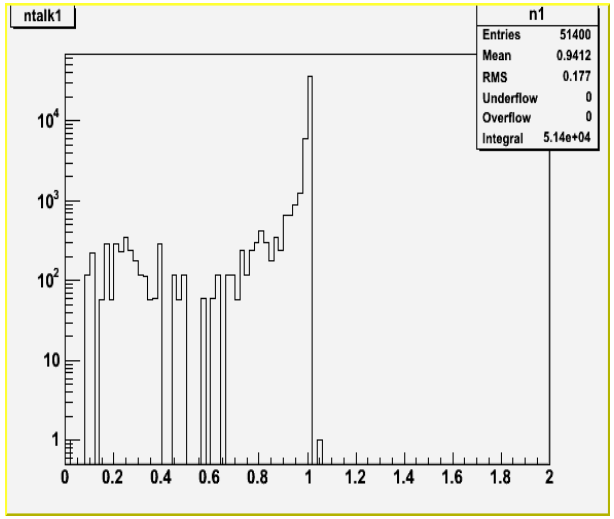
| | | | |
|---|---|---|---|
| | 0.0022 | 0.0090 | 0.0021 |
| S | 0.0086 | | 0.0090 |
| | 0.0022 | 0.0103 | 0.0020 |

E

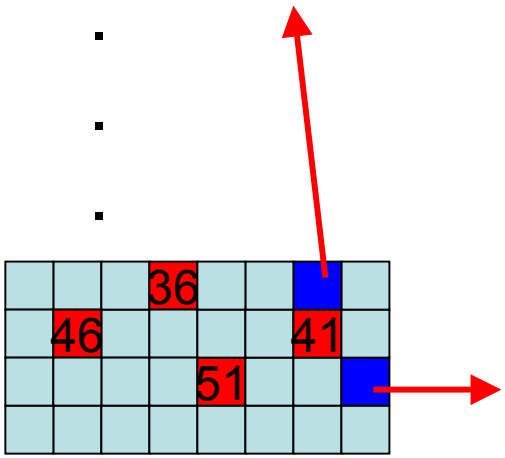
# x-check: LI x-talk

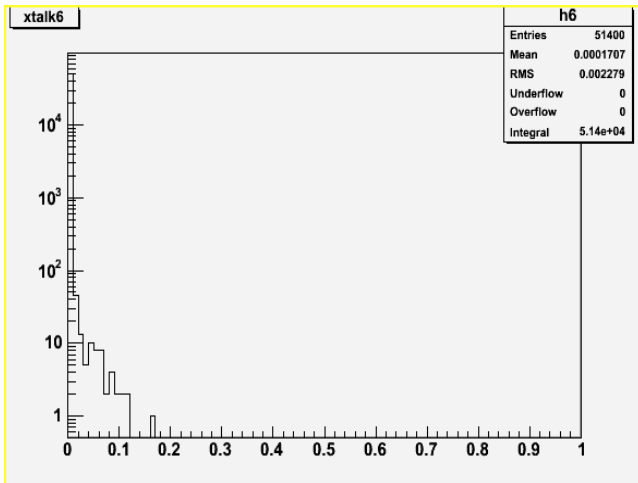
Most of the times, an LED shines on 10 fibers ➔ 10 pixels
Quite messy for x-talk studies…
I used one gain curve (Run 4450), where the led was shining on just 4 pixels:

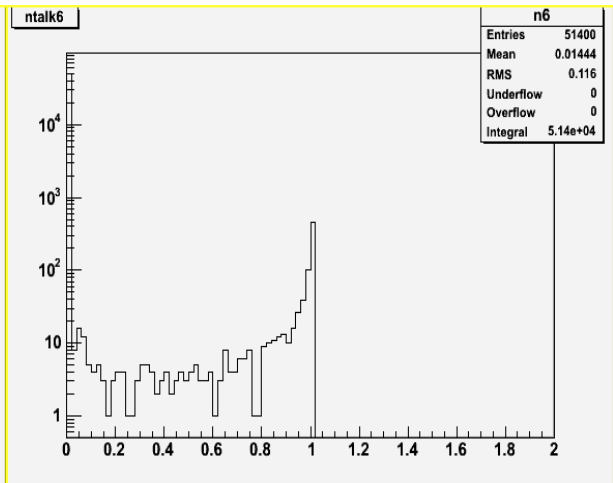



- Pulseheight ratios ~10% at most (side) (Very High Light Levels here!)
  Mean:1% for side
  0.2% for diagonal
  (VERIFY PREVIOUS METHOD!)
- X-talk **probability** up to 100%! (and more…)



# Conclusions - Plans

- We have better understanding of the “x-talk” in the ND:

1. x-talk levels as expected.
2. no big difference in MC-Real x-talk levels (as regards first neighbors).
3. neighboring strips due to:
   -Track angle (“corner clippers”).
   -Deltas produced. Bremmstrahlung, Mu pair production in higher energies.
4. Still a bit unclear, though…Need exactly representative MC.

- Probably need x-talk filtering before tracking, as is done in the FD (??).

(Tried the x-talk filter that is implemented for the ND: At first sight, no big difference, needs different parameters for different detectors).

- Is there something wrong with the LI?

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- Is pixel information important enough to be included in the standard Ntuples? (A few lines of code, ready)
- Extend the single-muon MC to other studies (realistic energy/zenith angle ranges, multiple scattering studies, rate studies (?)).
- Give up hope to measure delta-rays with this detector! (But: First try to see electrons in ND)
- It will be interesting to see any differences when the magnetic field is turned on…I can think of 2 contradictory schemes:

- The low-energy component of “showers” will be trapped inside the steel and never reach the scintillator (lower levels of “noise”).
- The medium-energy component of “showers” will have bent trajectories (helices) resulting in bigger pathlenght through the scintillator (higher levels of “noise”).

I can simulate this too, turning on and off the magnet in MC, but I know if the B-field is not correctly represented in the area outside the steel yet…