SHIP calorimeters at test beam

I. Korolko February 2016

2015 test beam:

SPS - ECAL (response uniformity)

PS - HCAL (comparison with GEANT)

2016+ test beam:

SPS - ECAL (response uniformity)

(energy resolution, photodetectors, FEE)

PS - HCAL (comparison with GEANT)

(as for ECAL + μ and π identification)

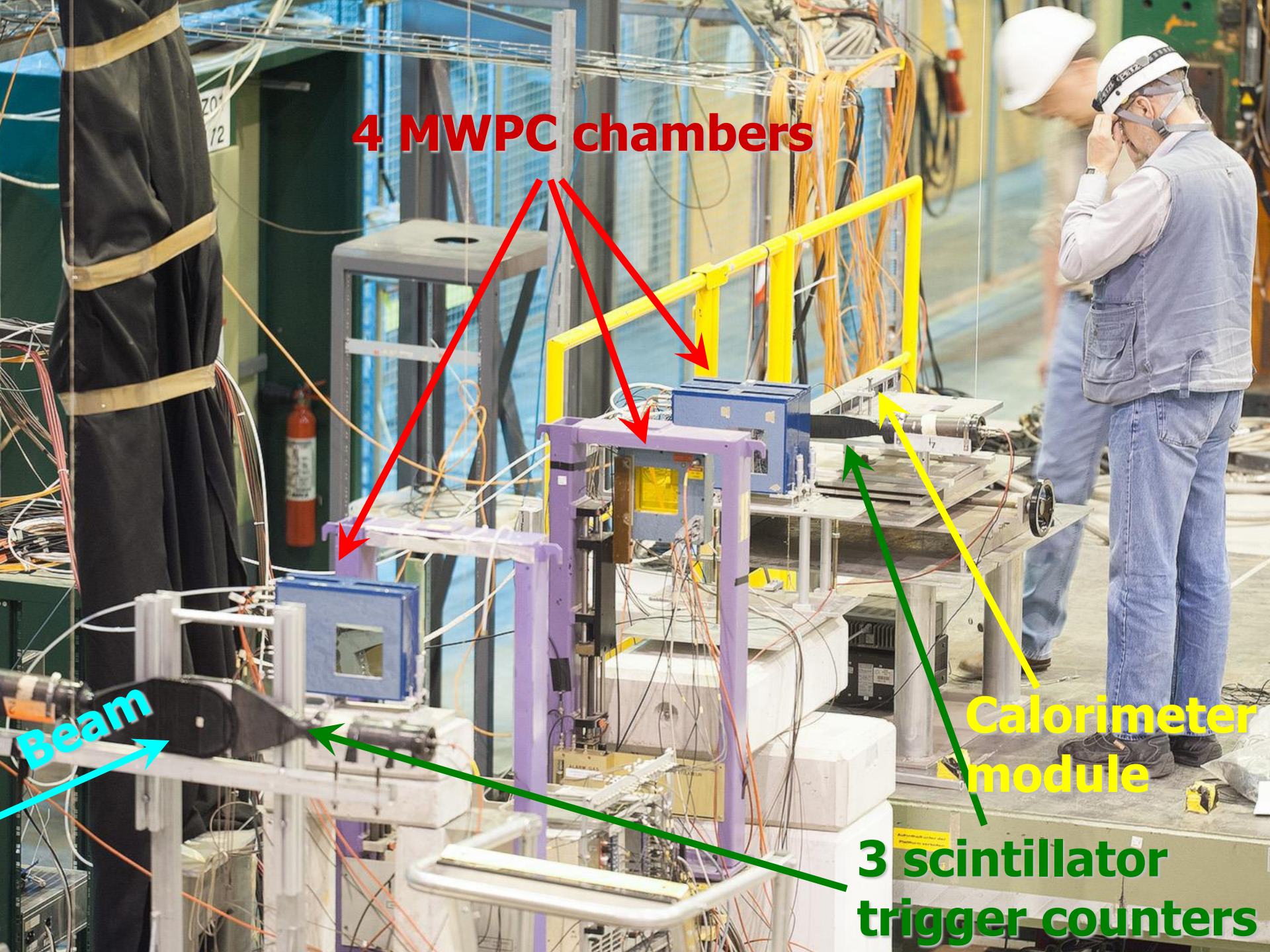
need to work with many channels (16-25)

ITEP and IHEP groups are participating

(new groups, new technologies ?)

SPS test beam ECAL
(reminder from October meeting)

- Measure calorimeter response with high energy muons as a function of impact point in module
    - good coordinate measurement is crucial
    - we used 4 MWPC with cathode delayed readout
        - one chamber from CERN H2 beamline facility
        - tree chambers from ITEP provided by Pavel Shatalov
  - for module with spiral fibers
  - for module with straight fibers
- Add knowledge gained during LHCb test beams
- Try to choose the best production technology

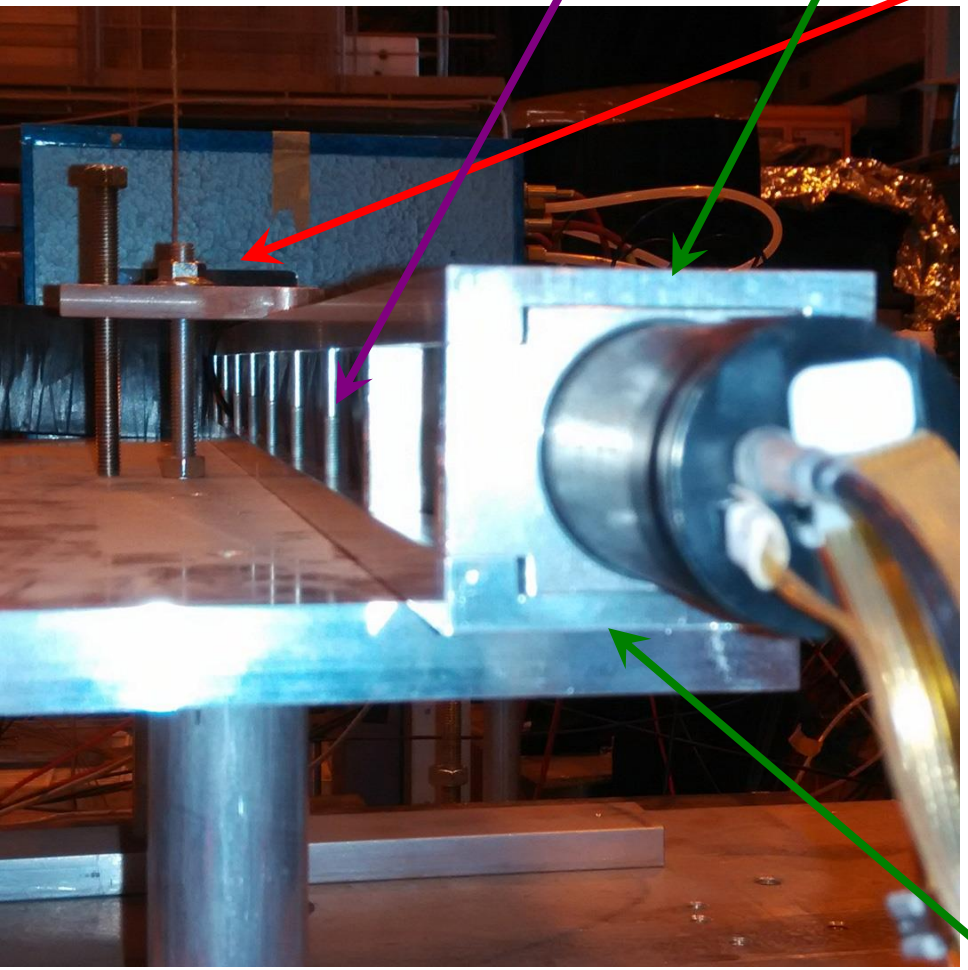

4 MWPC chambers
Beam
Calorimeter module
3 scintillator trigger counters

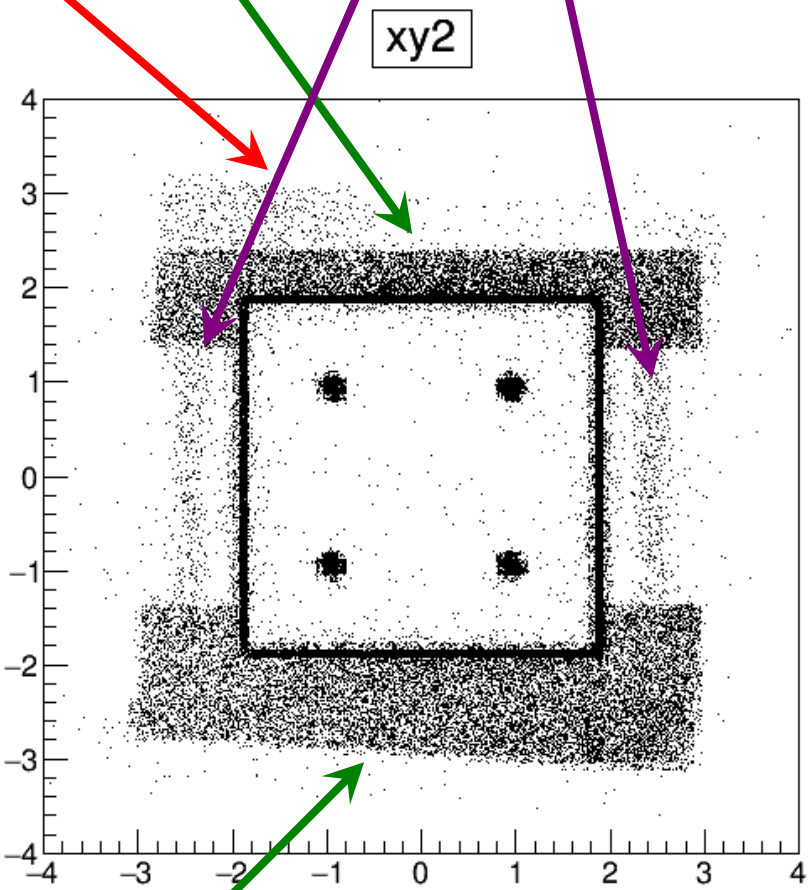
Nuts and bolts which tighten module housing

Delta electrons
from nearby objects!!!

Module housing

Clamp



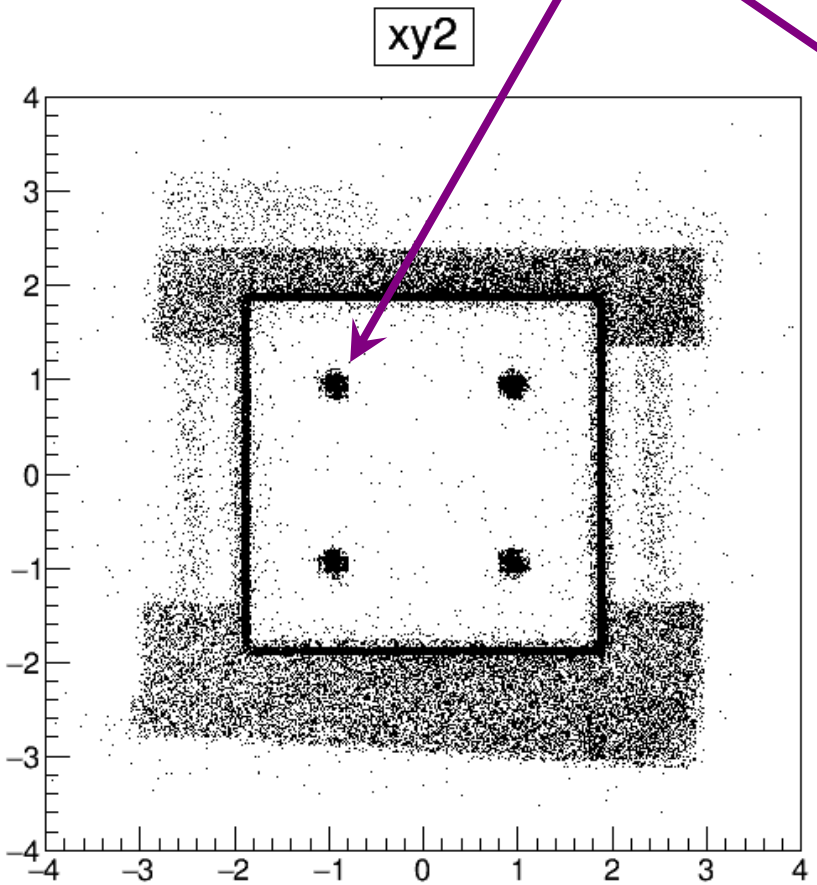


Module housing and rotating table

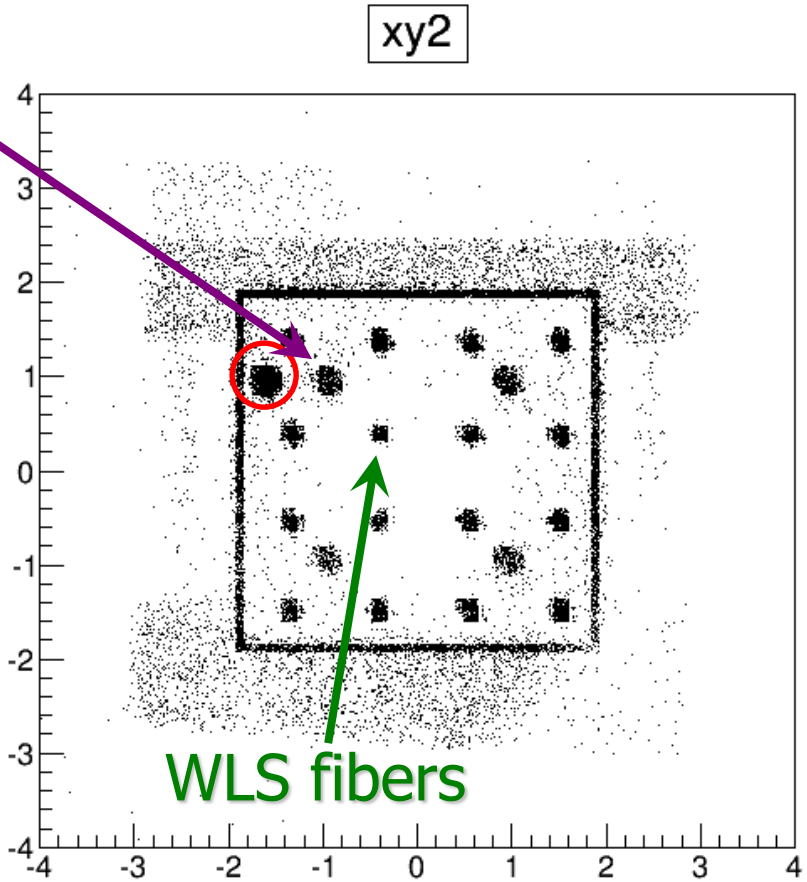
Different modules

Steel needles fixing stack structure (tapes in LHCb)

Spiral fibers



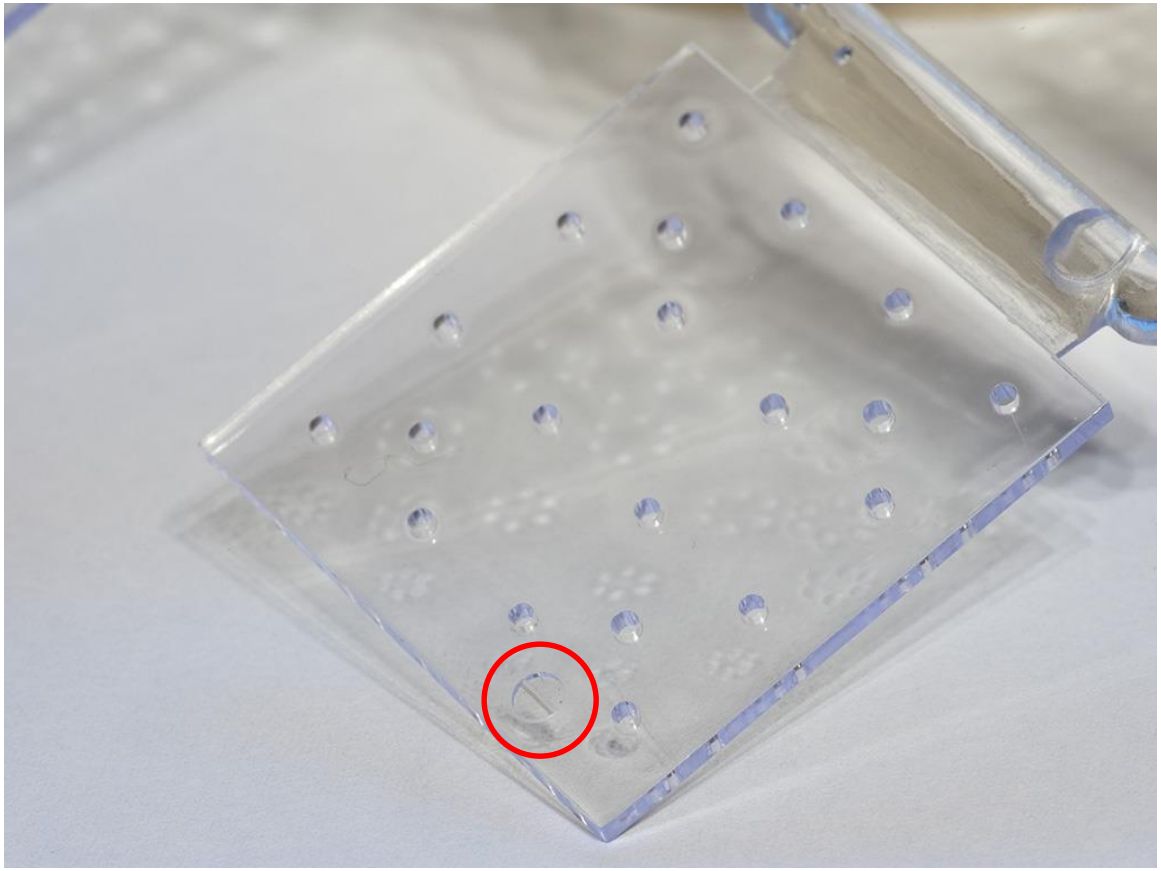
Straight fibers



Fibers are clearly seen in modules with straight fibers.

addition spot – special technological mark on scintillator

Technological mark

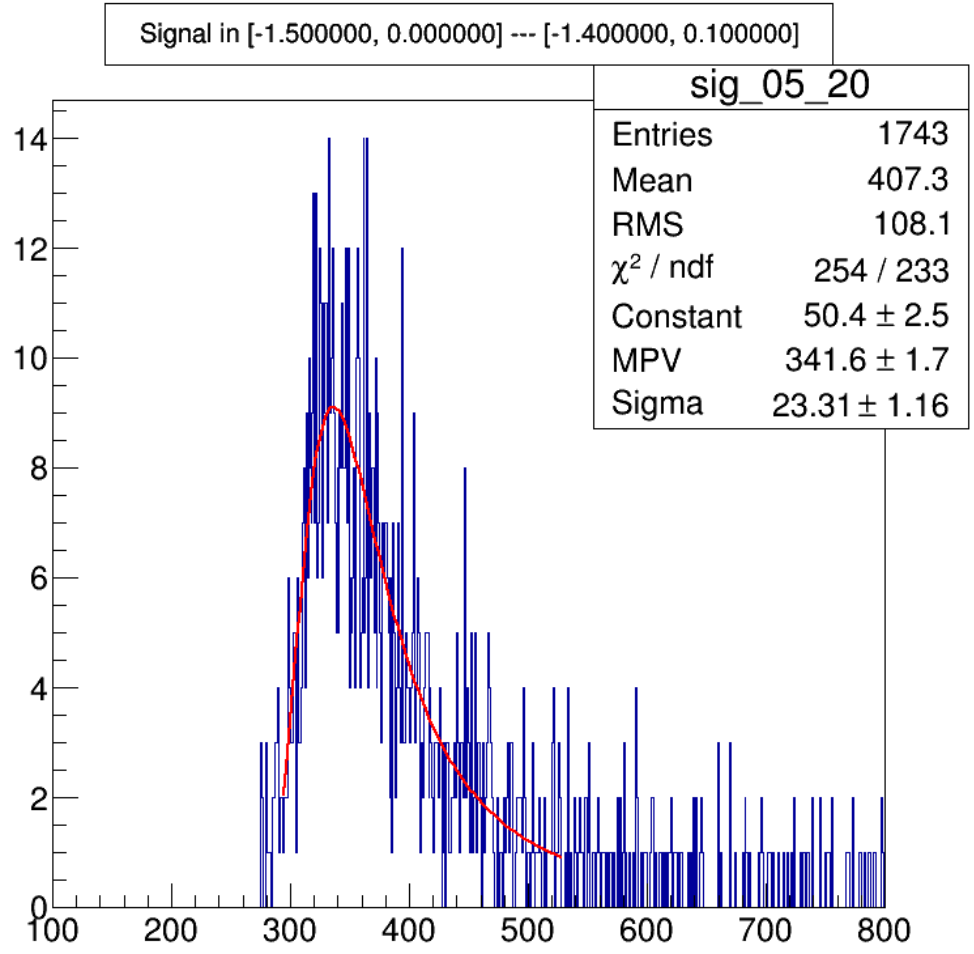


Marks ensures correct order of different tiles (4) for module with spiral fibers.

Tiles of only one type are used in module with straight fibers.

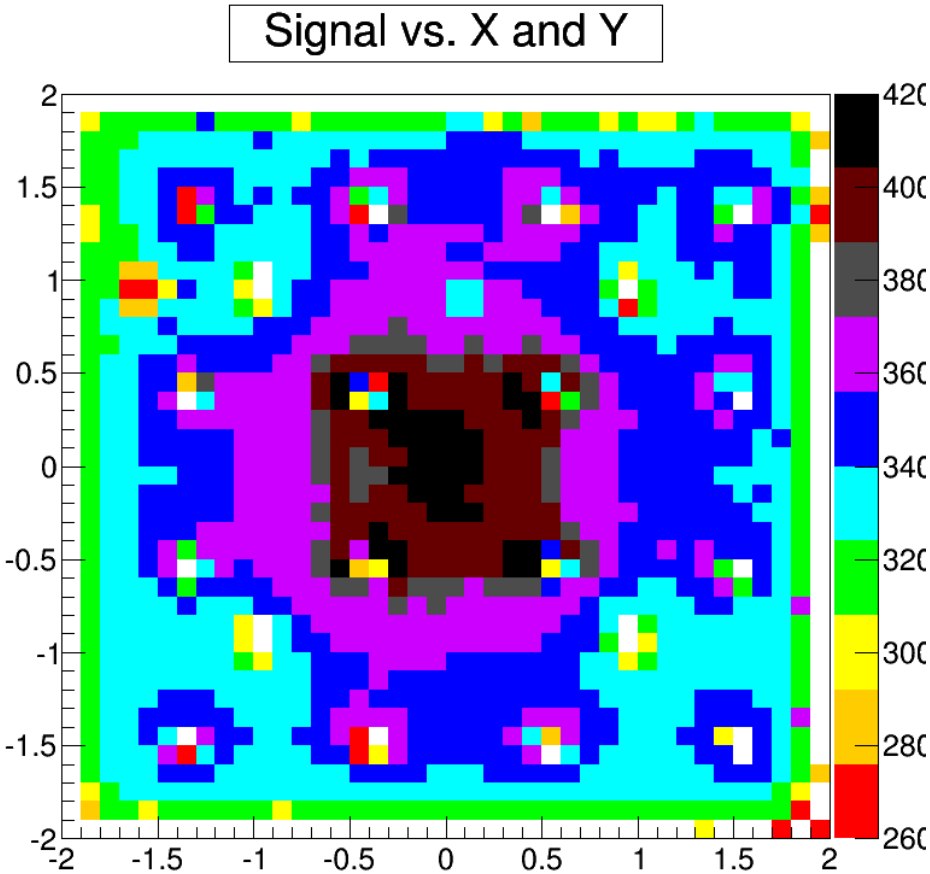
Procedure

- Collect signal in 1x1 mm^2 regions into histograms
- Fit histograms with Landau distribution
- Plot MPV of the fits as a function of coordinates

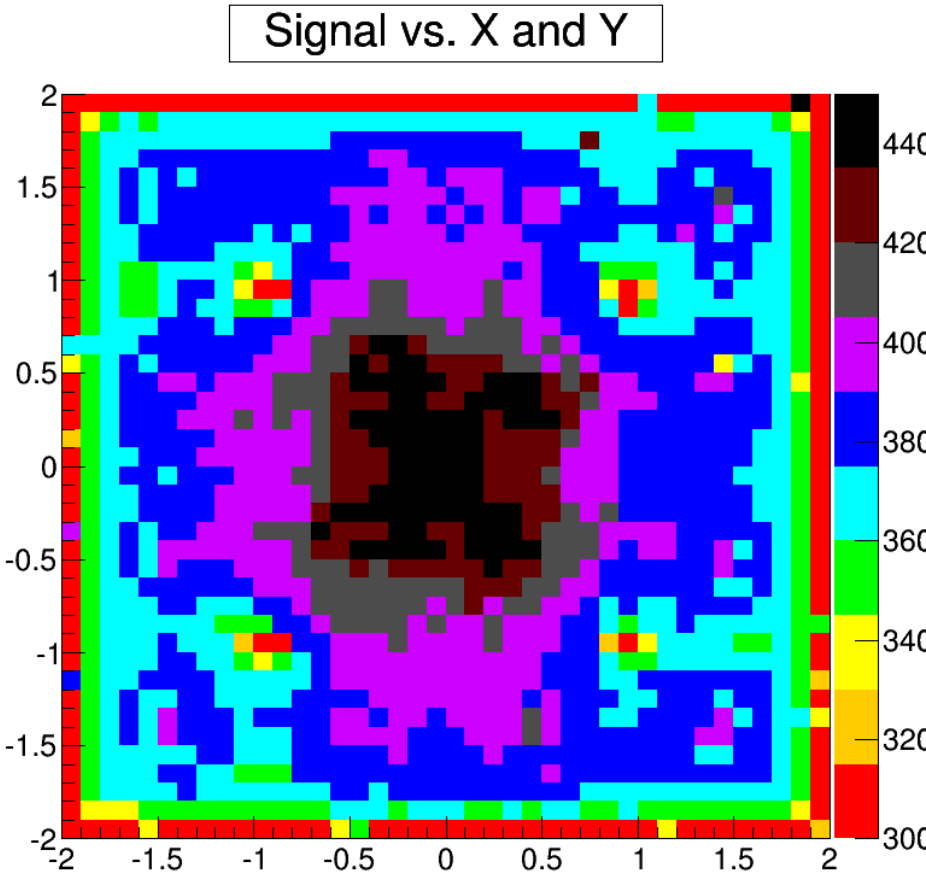


Results

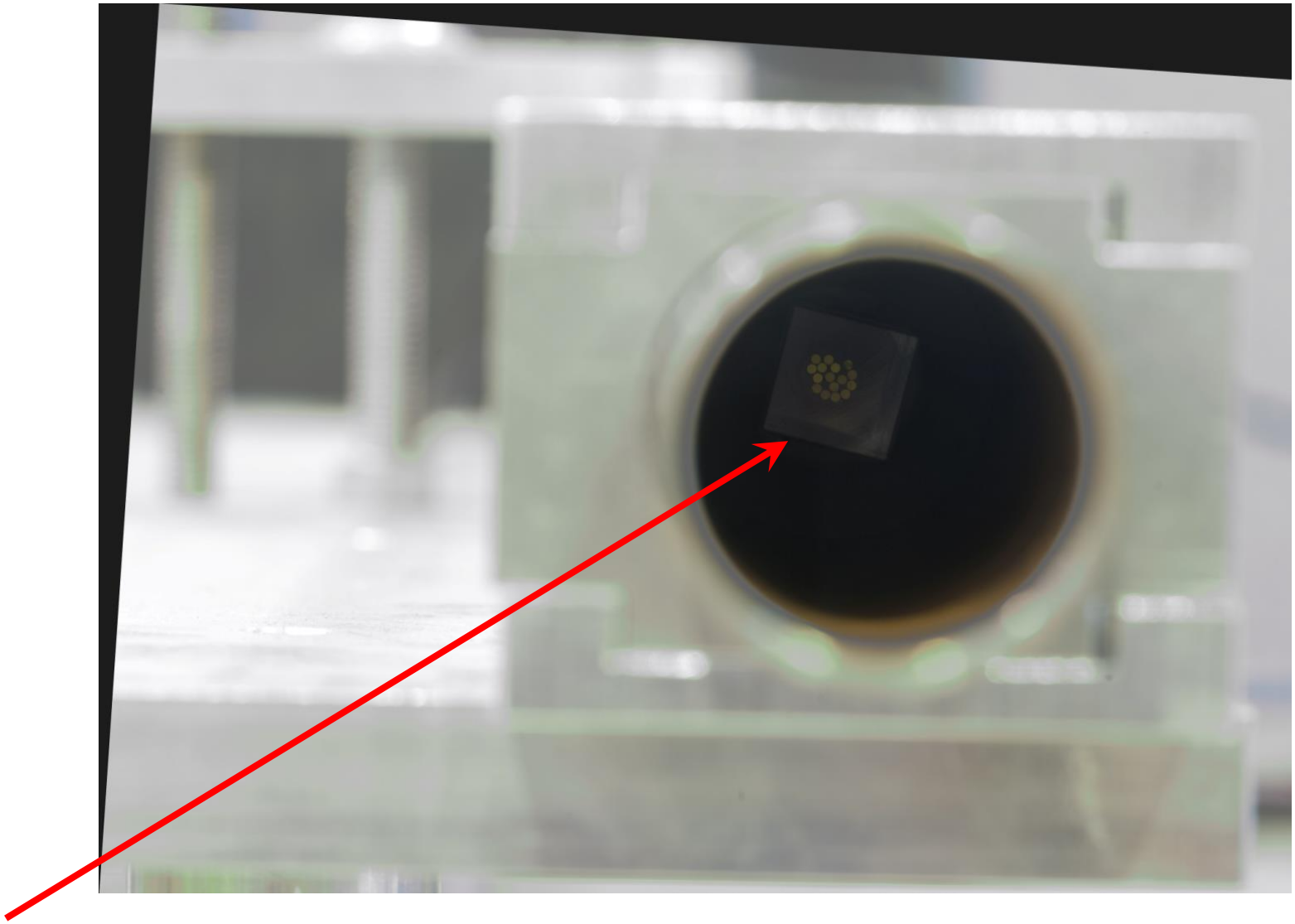
Straight fibers



Spiral fibers



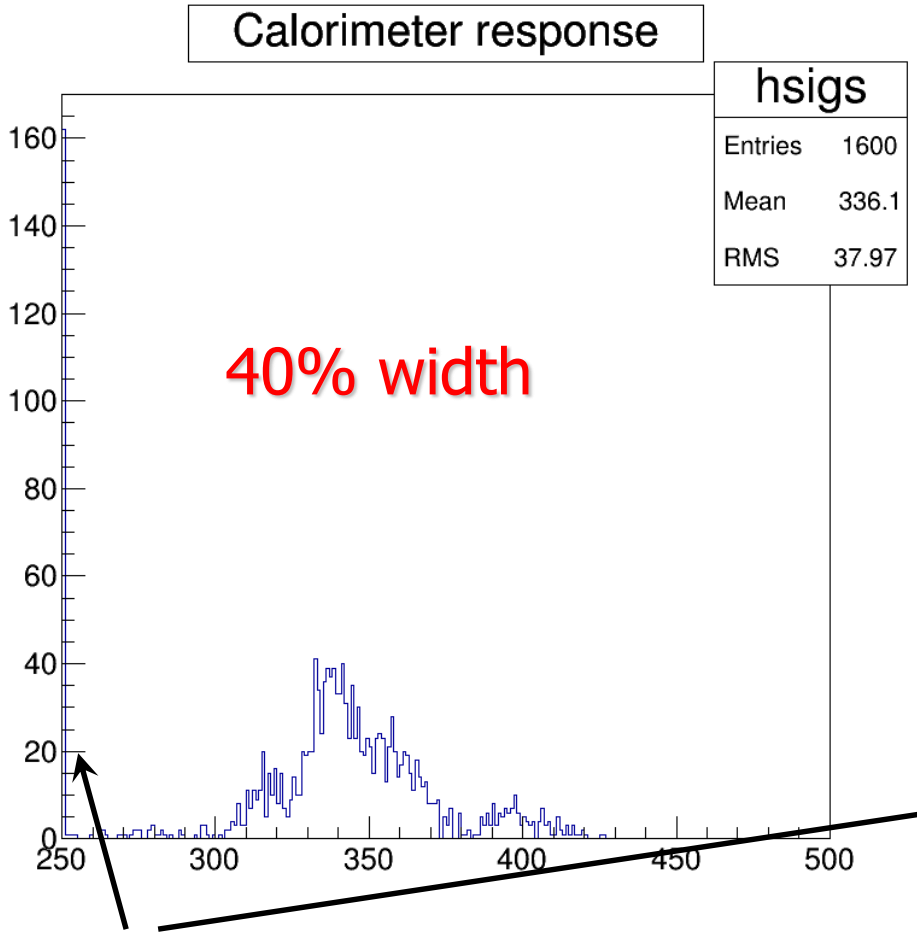
Central bumps - light mixers



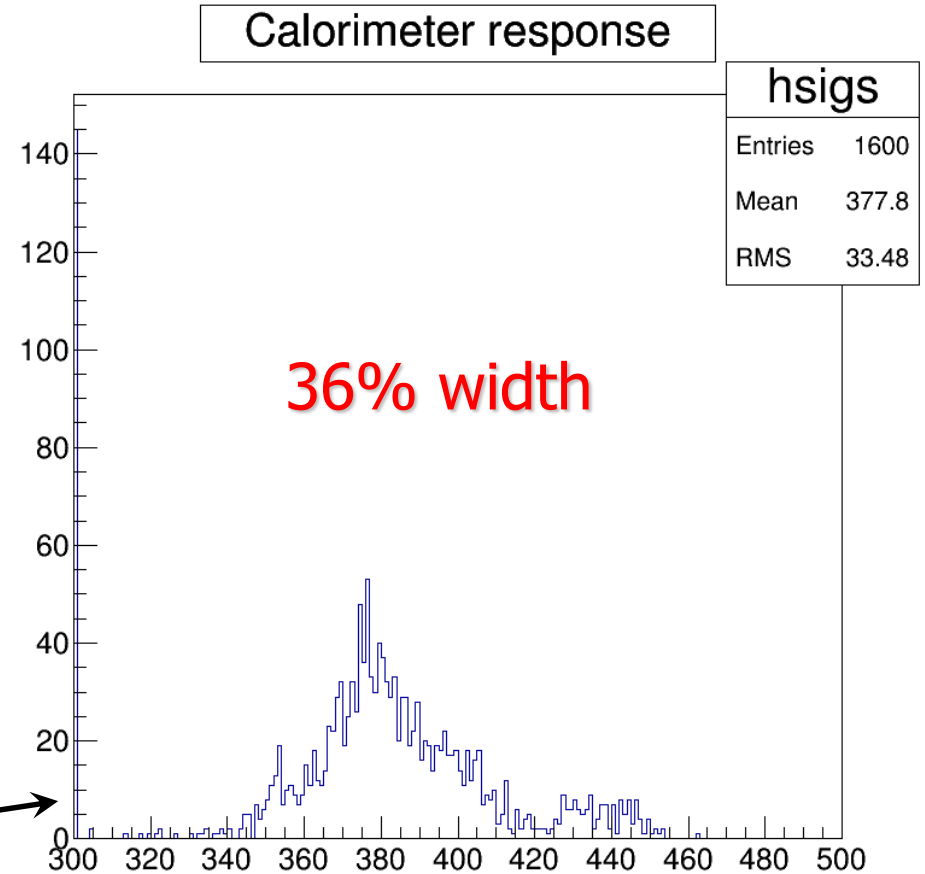
Light mixer – do we really need them ?

Results. Response distributions

Straight fibers



Spiral fibers



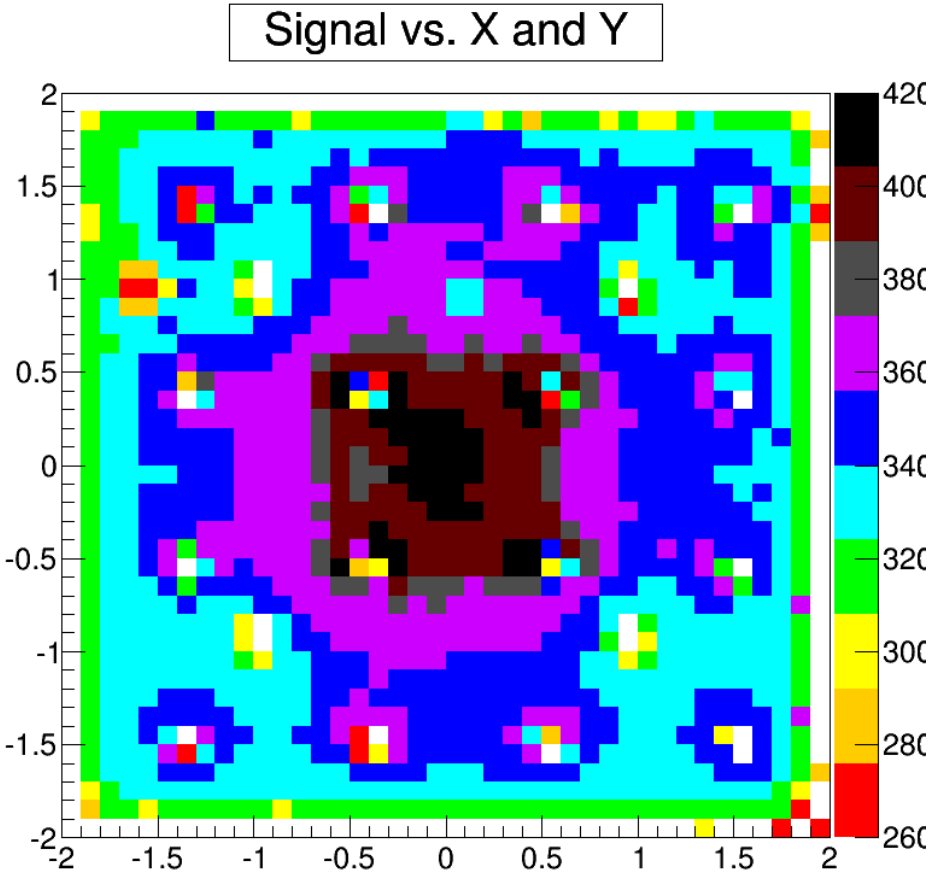
Failed fits: boundaries, needles and fibers (in case of straight fibers).

Without failed fits. Straight fibers: Mean: 345.8, RMS: 25.81 (7.5%)

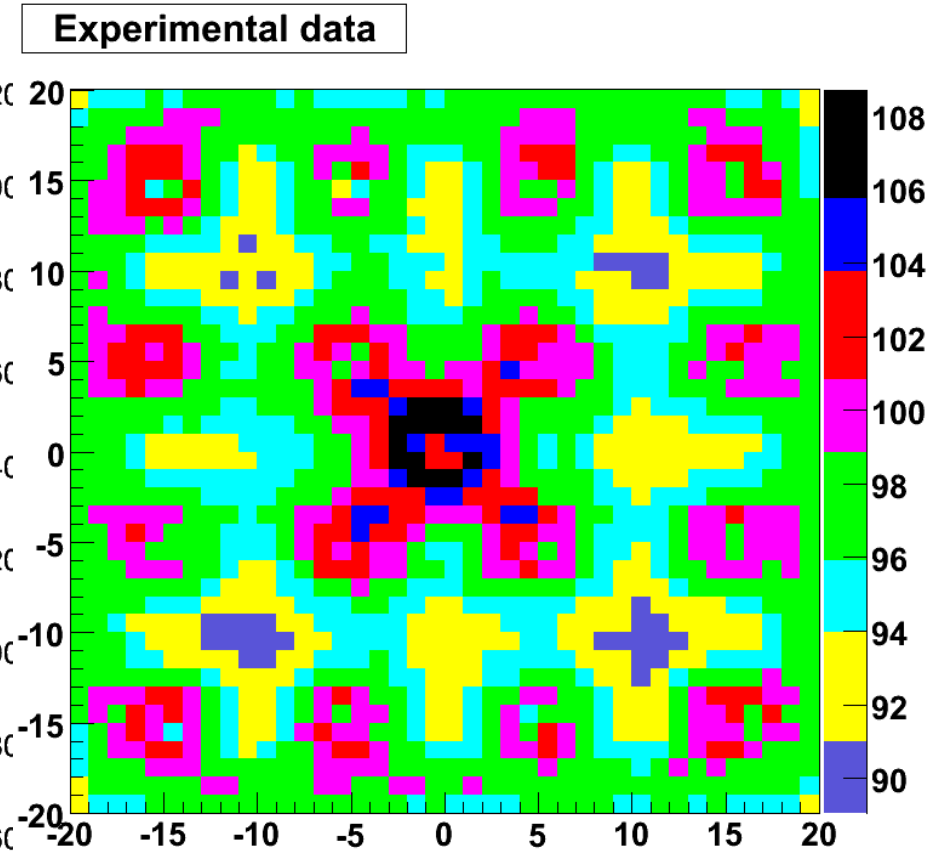
Spiral fibers: Mean: 385.5, RMS: 23.85 (6.2%)

Comparison with LHCb results

Straight fibers



LHCb inner module scanned with muons.
3 CERN chambers for tracking.



Response on edge of two modules are completely different!

Edge treatment of LHCb module plates makes the response much more uniform.

Conclusions for SPS test beam

- Module response as a function of coordinates has been measured
- We got knowledge which would help us to chose the module manufacturing technology.
- questions for shashlik technology:
  1. Tapes or needles
  2. Straight or spiral fibers
  3. Tile edge treatment
  4. Tile sickness
  5. Light mixers

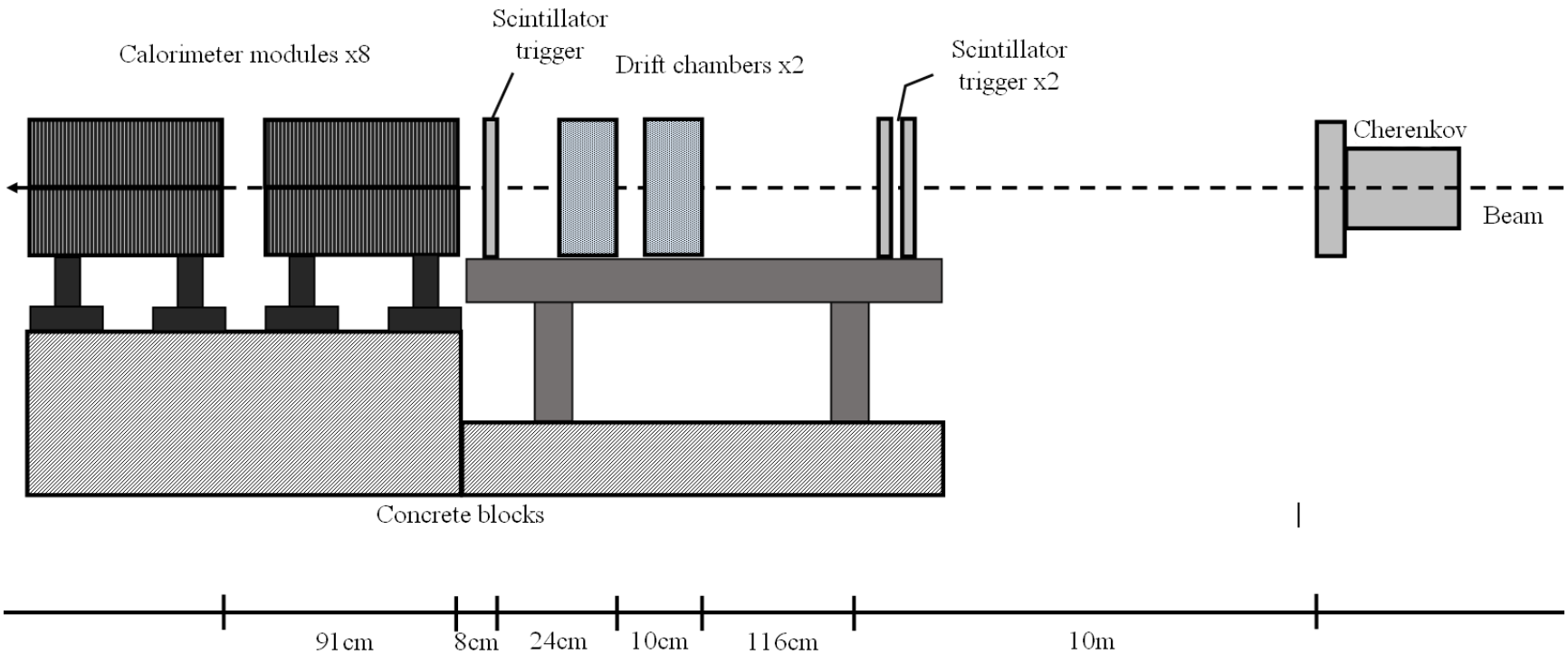
Plans for 2016+

- Response uniformity of new module:
  1. need 3 MWPC chambers from Pavel
  2. with and without light mixer
  3. try to get 2nd modules with matted tiles
- Prepare to work with electrons:
  1. in ideal case 25 channels (16 minimum)
  2. update DAQ (currently 1500 Hz with few channels)
  3. much more cables, PMTs, CWs. Dedicated monitoring
- New ideas:
  1. Choice of PMT for the SHIP CALO, New photodetectors ?
  2. Any new ideas from new people…

PS test beam (HCAL)

- Study calorimeter response with low energy pions (muons and electrons)
  - tune MC
  - better understand capability of calorimeter to identify particles
- Use two calorimeter sections
    - LHCb 12x12 outer modules (single cell)
- PS “pion” beam used
  - 1, 2, 3, 5 and 10 GeV particles

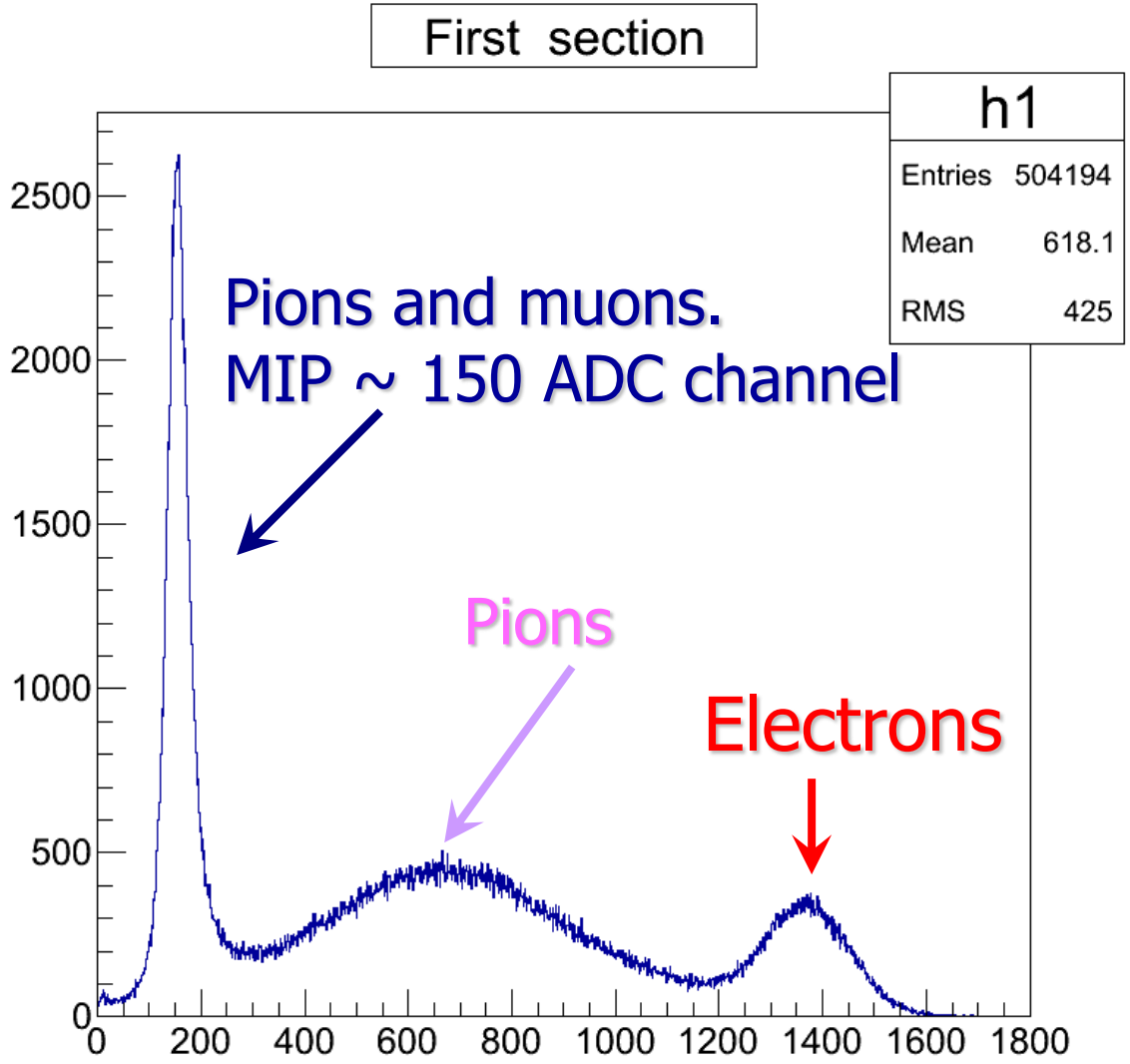
PS test beam (HCAL)



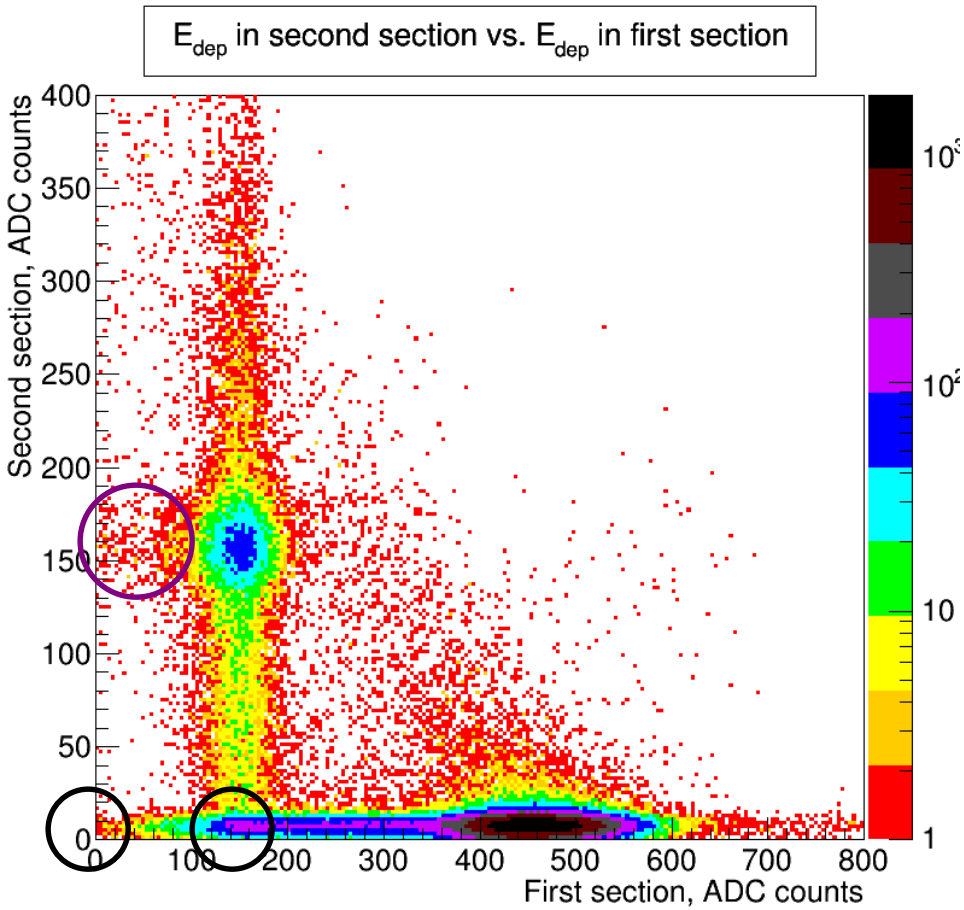
Dedicated MC description of beam line and test setup
Analyzing data trying to understand “tricky” things

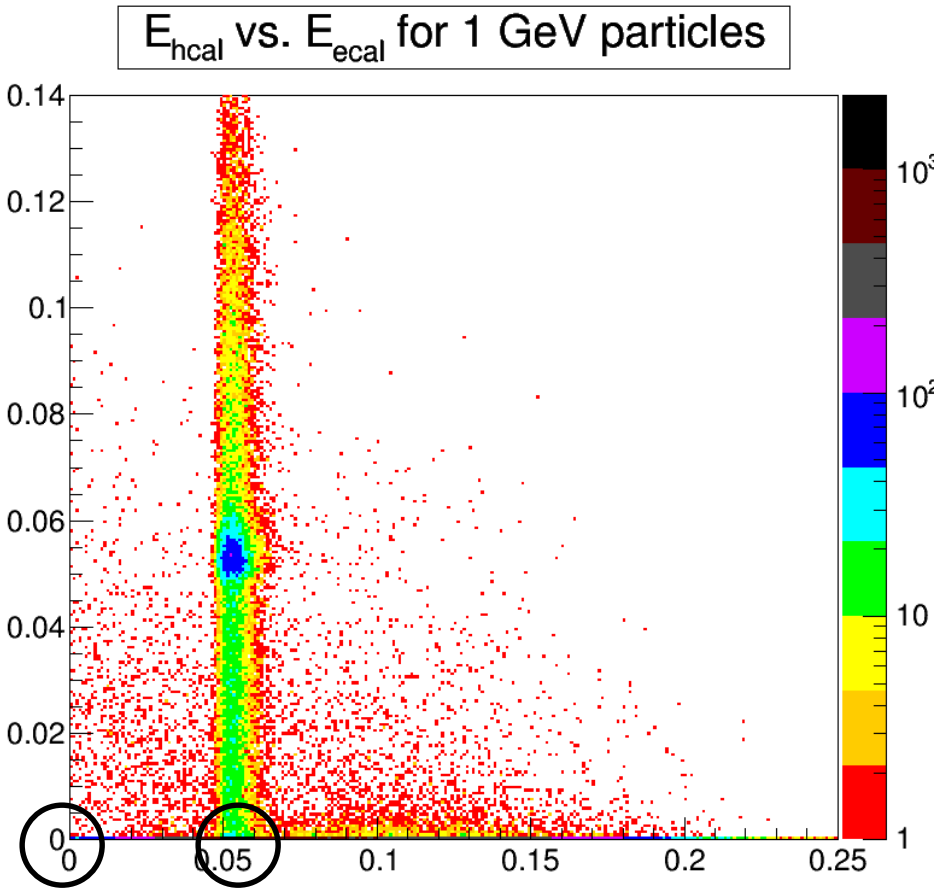
HCAL 1st section response

- First calorimeter section.
- 3 GeV beam
- See electrons in the beam
  - Cherenkov counter
- Mixture of pions and muons



1 GeV Data vs. pion simulation





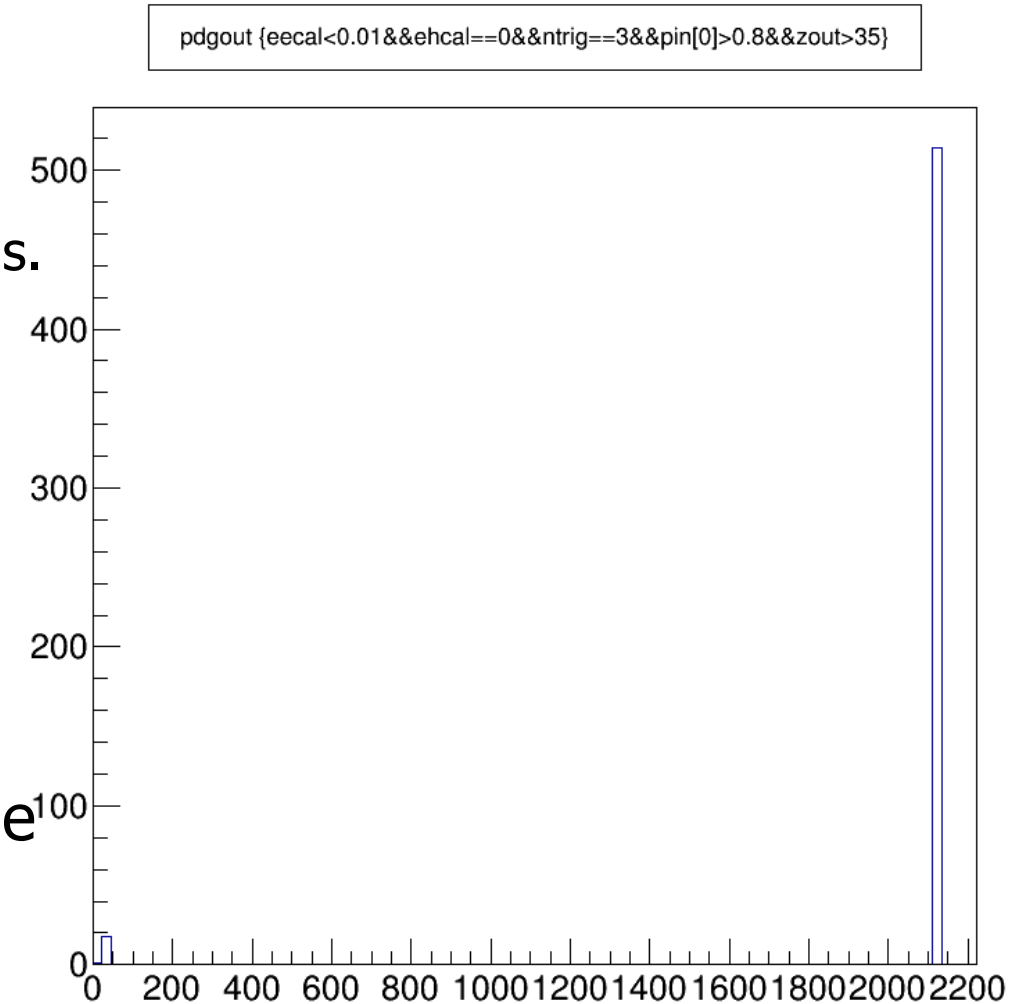
Closer look: there are some difference (dead material?).

Two interesting regions on both data and MC: trigger but almost no energy in both sections, MIP in first section and almost nothing in second.

Almost no energy in both sections

- Primary pion (89%)
  - Neutrons leaving the calorimeter from both sides
    - some times a few low energy photons/electrons.
    - rarely some framents
  - nuclear reaction
- Some low momentum particles (11%)
  - protons and photons
  - nuclear reaction in air/scintillator before the calorimeter?
- Black magic of GEANT

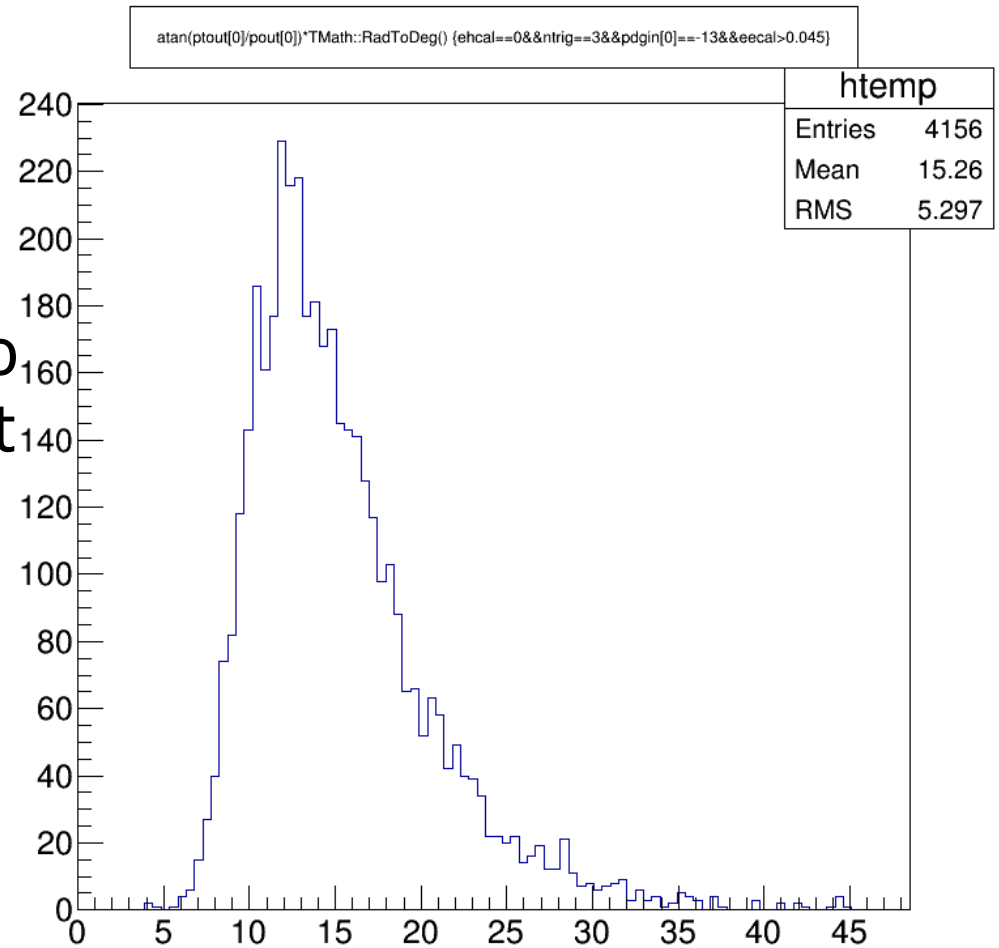
PDG of particles leaving the first calorimeter from back side.



MIP in the first section. Nothing in the second section.

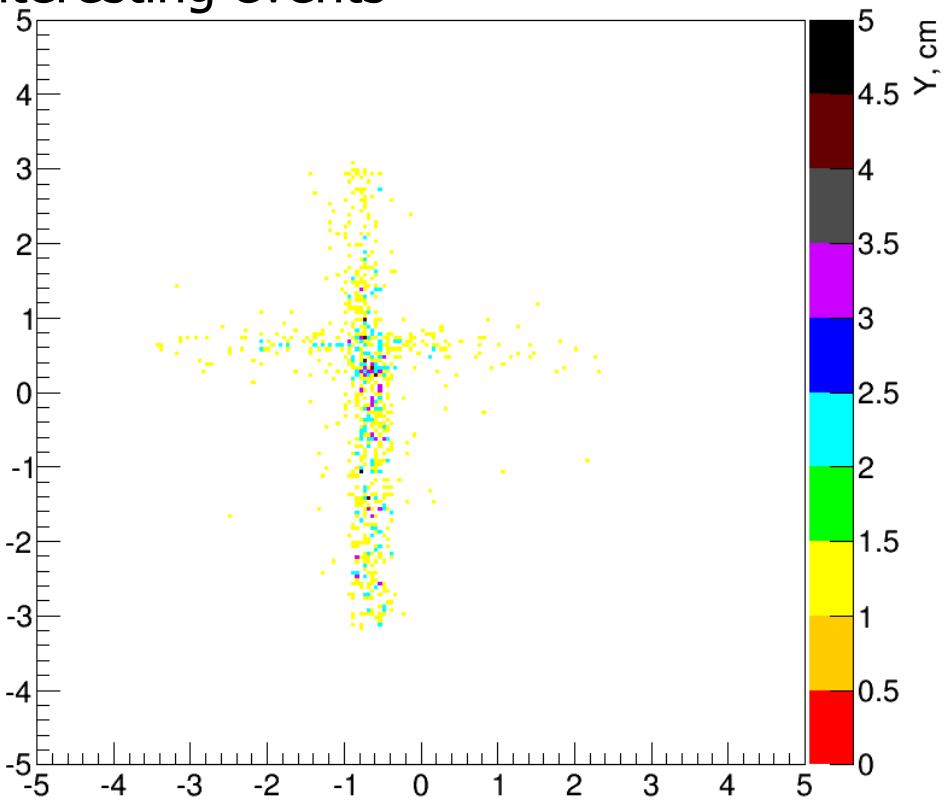
- Muon or pion hits the first section
- Muon (~20%)
  - Multiple scattering
  - Scattering angle can be so large that muon do not hit the second section
  - Effect disappears if one uses large (i.e. 20x20 modules) second section in simulation.

Muon scattering angle.

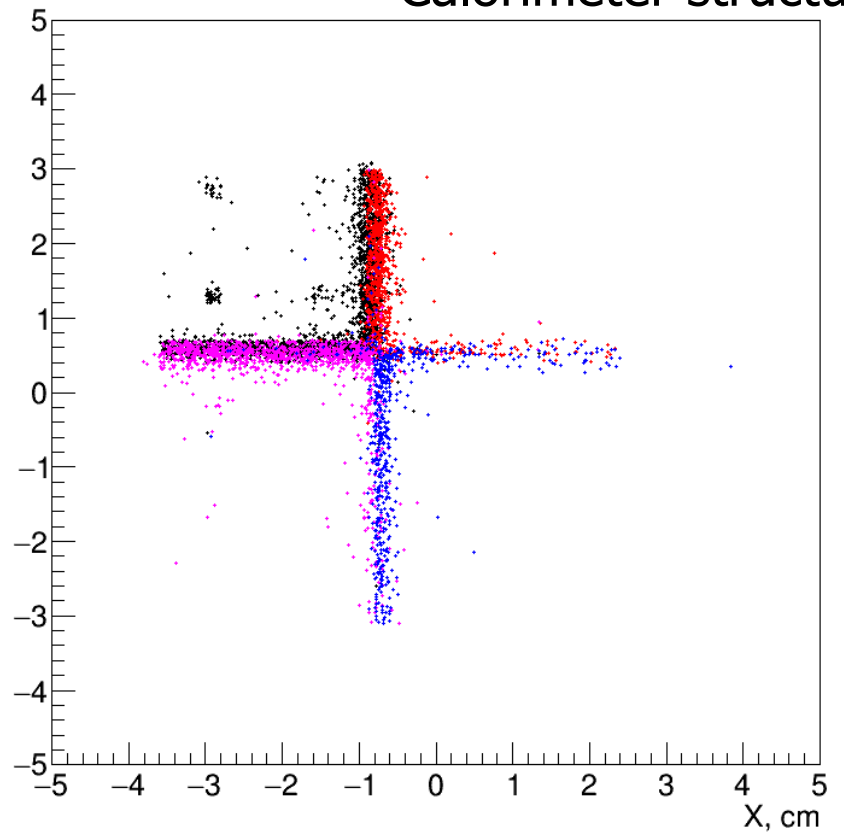


Nothing in first section.
MIP in the second section.

Interesting events



Calorimeter structure



We see particles flying between modules.
Left and right columns are not tightened to each other (think about tile HCAL)
MC model was upgraded to describe this effect (0.1mm tape +0.3 mm of air)

Plans for 2016+

- Continue with 2 section setup:
  1. need 2-3 MWPC chambers from Pavel
  2. Additional scintillator counter to be placed behind HCAL
- Hadron showers are wide – more modules:
  1. two 4x4 sections – 8 modules
  2. update DAQ (currently 1500 Hz with few channels)
  3. much more cables, PMTs, CWs. Dedicated monitoring
- Test better (cheaper) technologies for HCAL
- New ideas:
  1. Choice of PMT for the SHIP CALO, New photodetectors ?