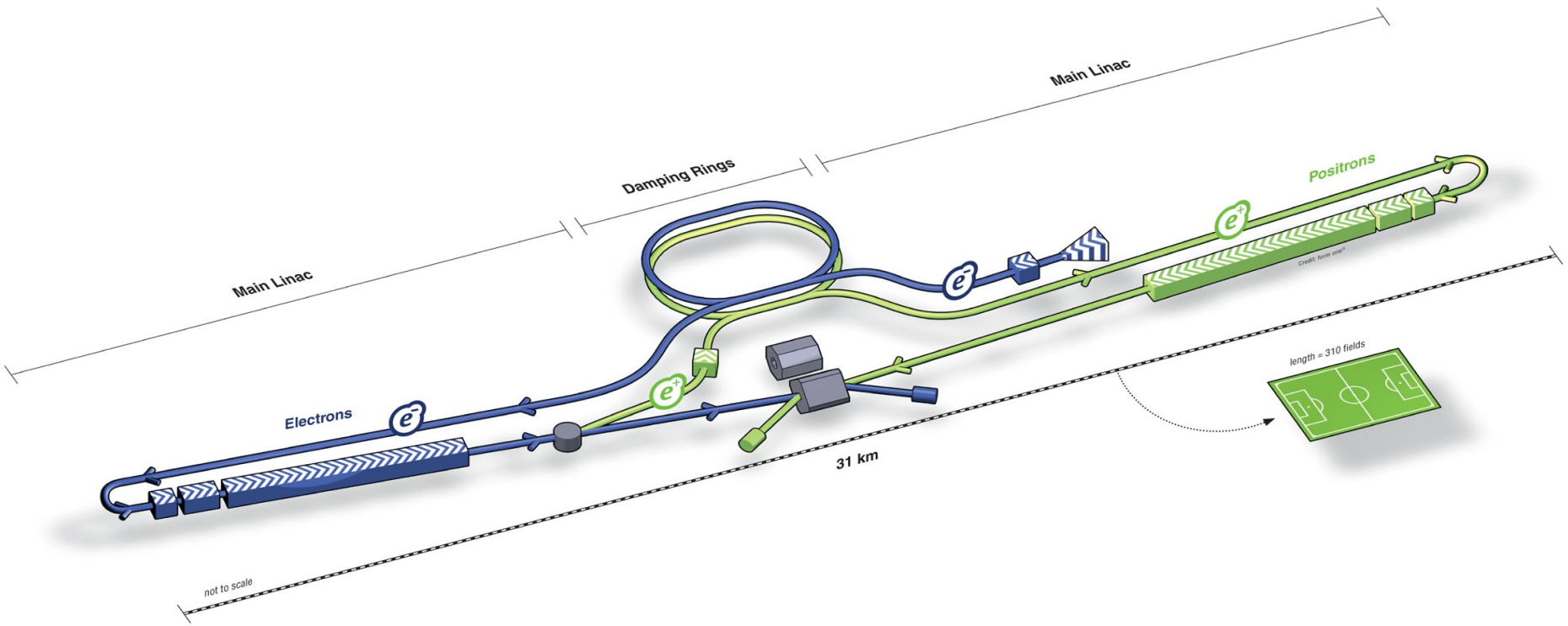
The study of uniformity in direct readout SiPM tiles

ITEP, MEPhI, MIPT

Dima Mironov, 2013

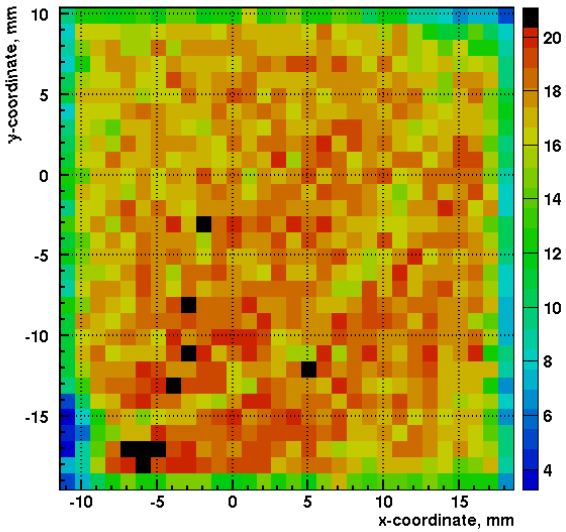
International Linear Collider

- To study the Higgs Boson properties
- To be build in Japan in 2027

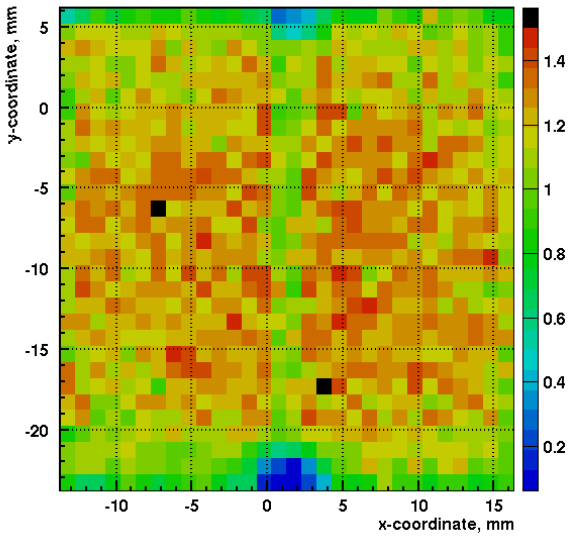


Fiber readout

30x30x5 mm3 tile



30x30x3 mm3 tile



RMS/Mean with 1mm precision

7% 10%

RMS/Mean with 2mm precision

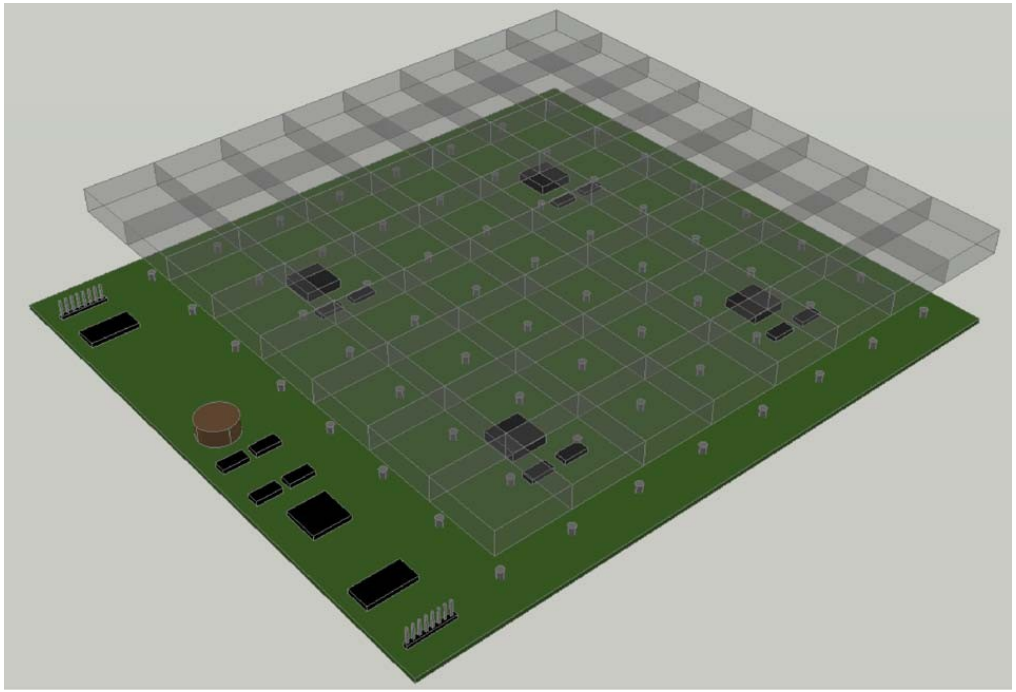
6% 7%

Direct readout

- ~3 000 000 tiles are needed
- Wavelength shifting fiber is prepared and installed manually. This is expensive and time consuming
- An attempt of direct readout is made

Hadron Calorimeter Configuration

- Introduced by Northern Illinois University
- With the direct readout we can combine electronic planes and scintillator planes in the latest stage



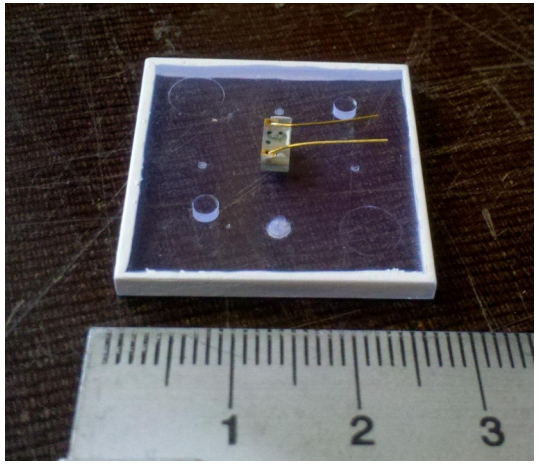
Picture from NIU work

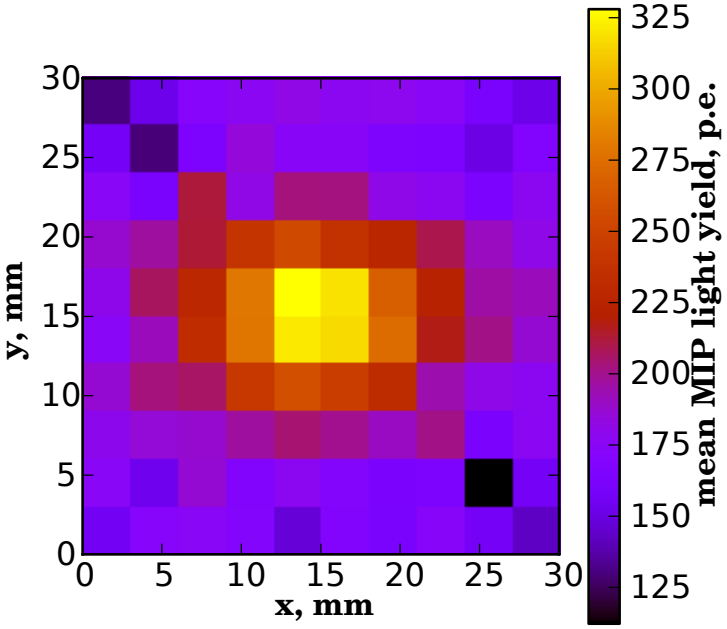
Uniformity

- The key concern when using direct readout is light collection uniformity
- The central value is 3 times bigger, than others.

  RMS/Mean is ~80%

  ↑ — nonuniformity

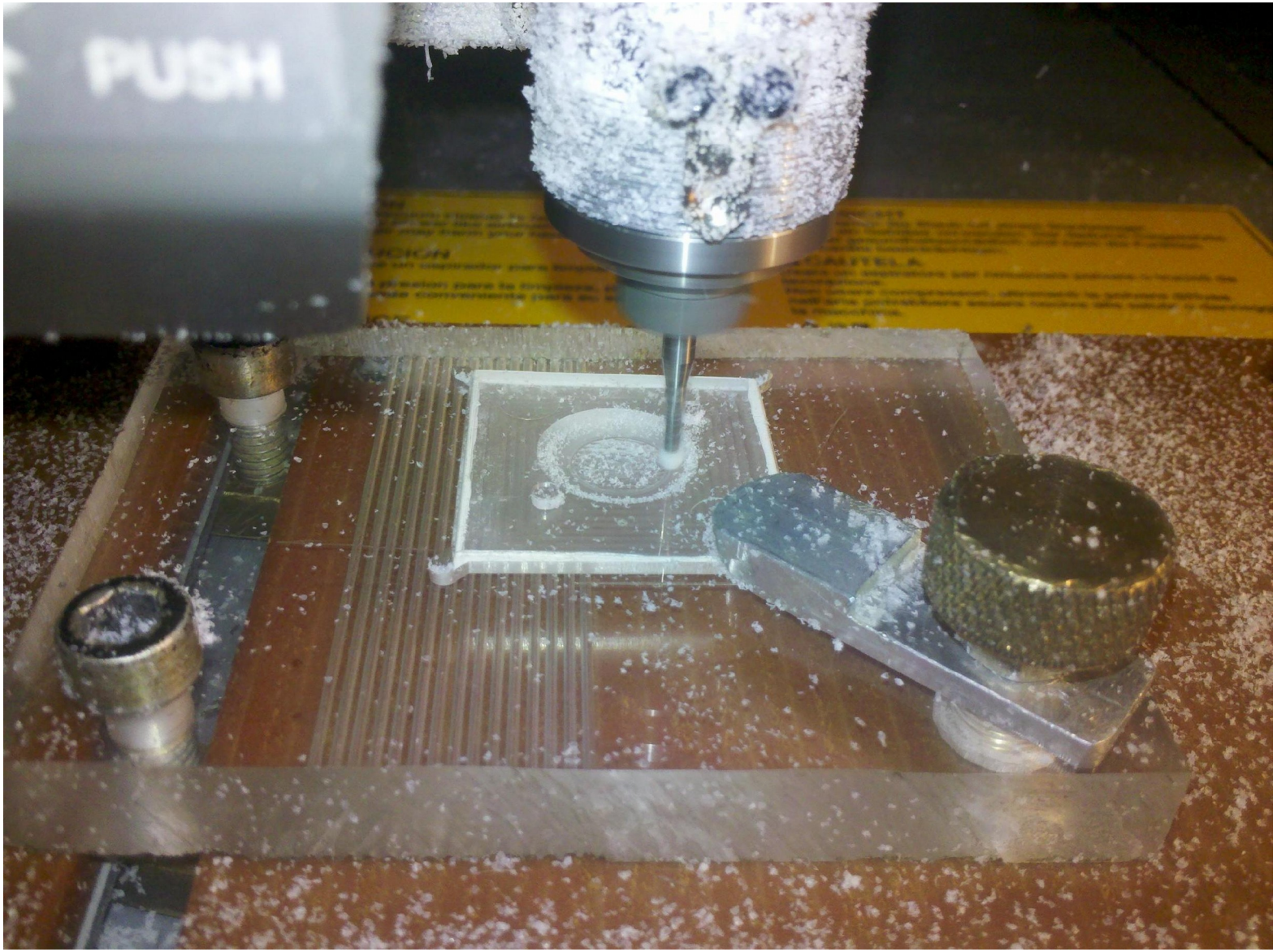




The setup

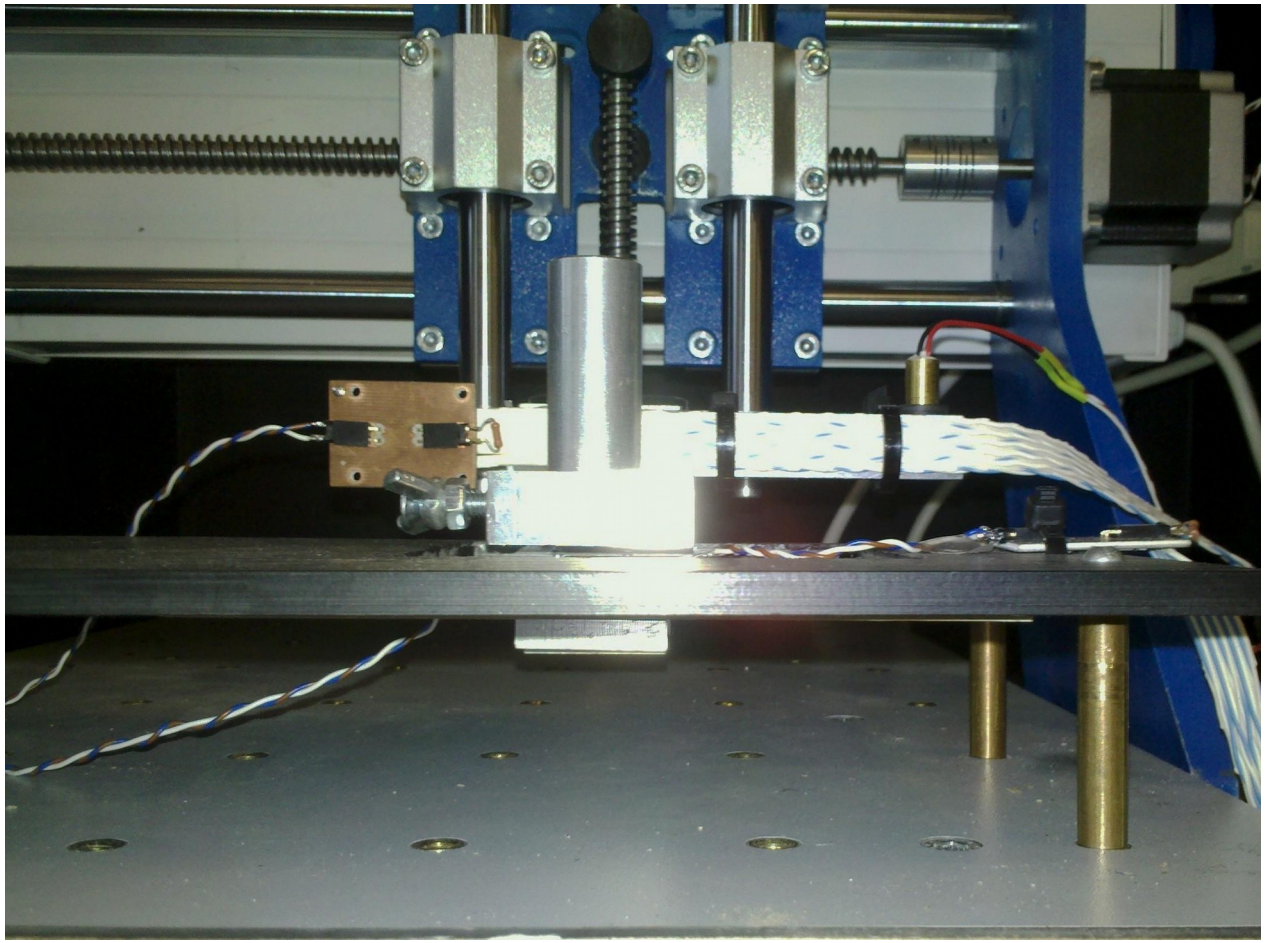
- 2 parts
  - Programmable milling machine with the software modified to be able to mill a generic shape hole in a tile
  - The automated uniformity measurement setup, consisting from 3 axis cartesian manipulator with a radioactive source and software for control and results processing.

Milling



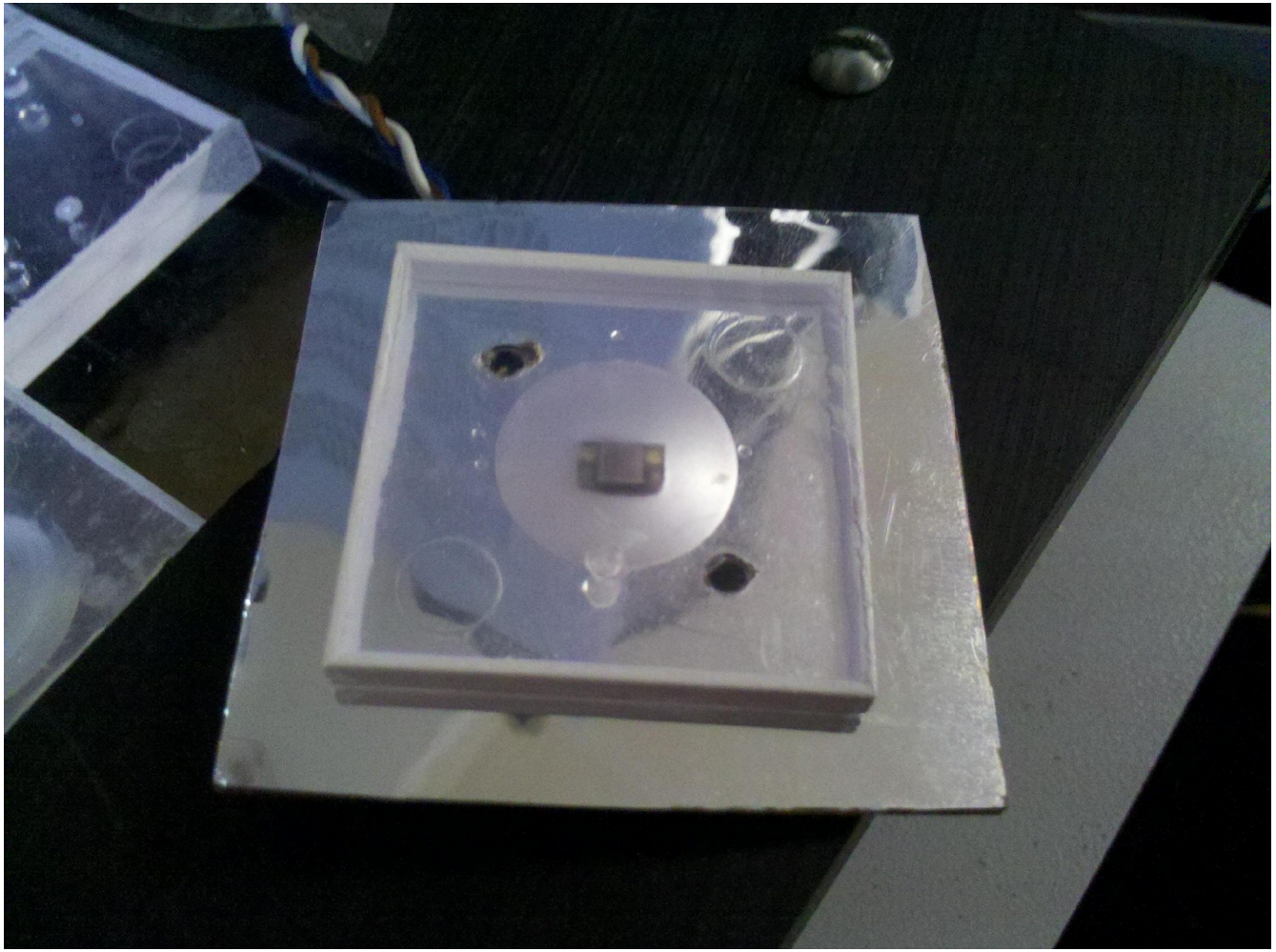
The setup

- Manipulator with mounted 90Sr beta-source and trigger tile. Collimator size is 1mm.



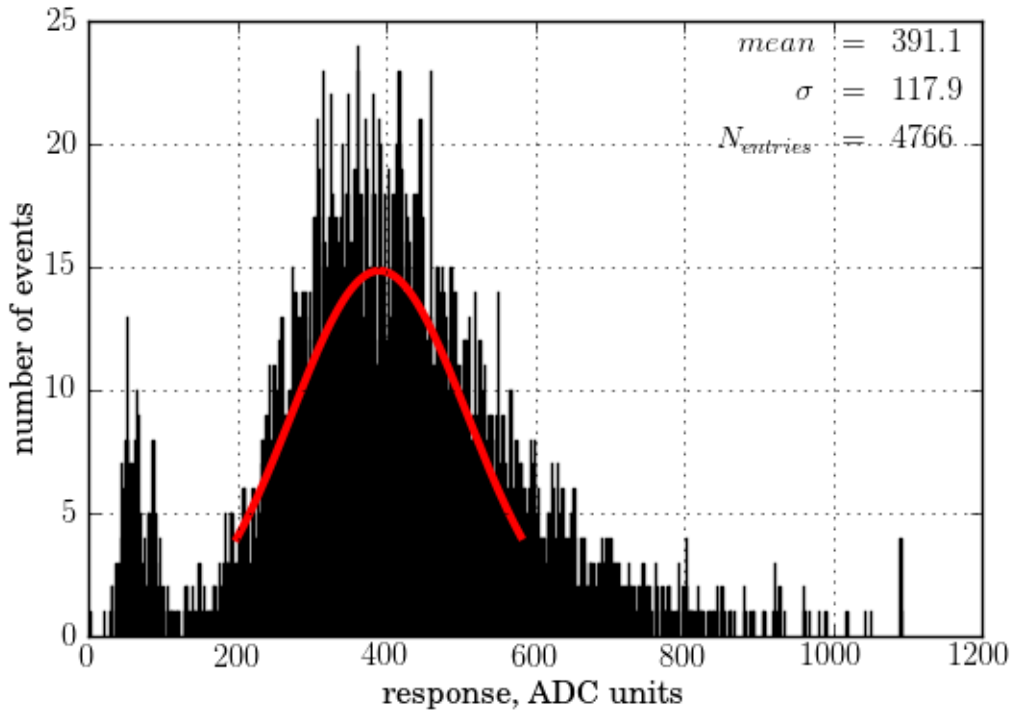
The setup

- SiPM in the upper mirror



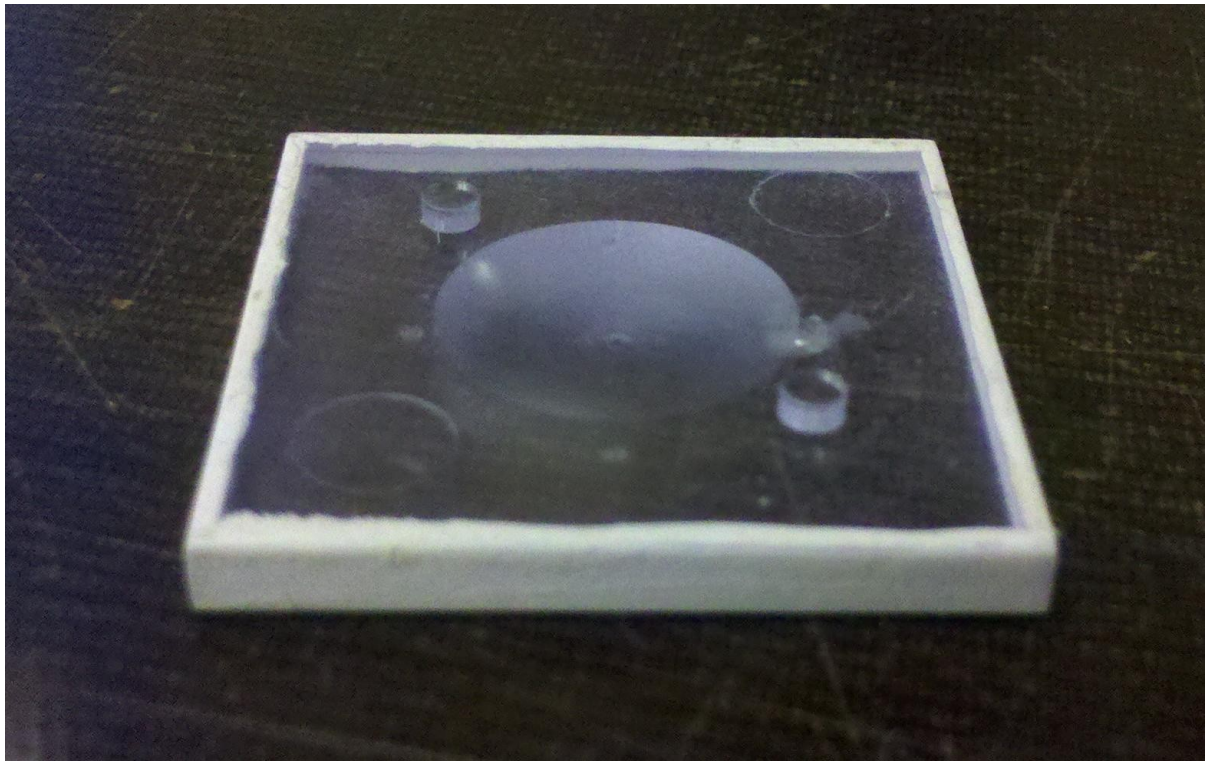
Measurements

- Only particles passed through the studied tile are used (with the signal in trigger tile)
- The spectrum of signals from their passes is considered (number of particles with vs ADC from SiPM)
- Fit it with gaussian



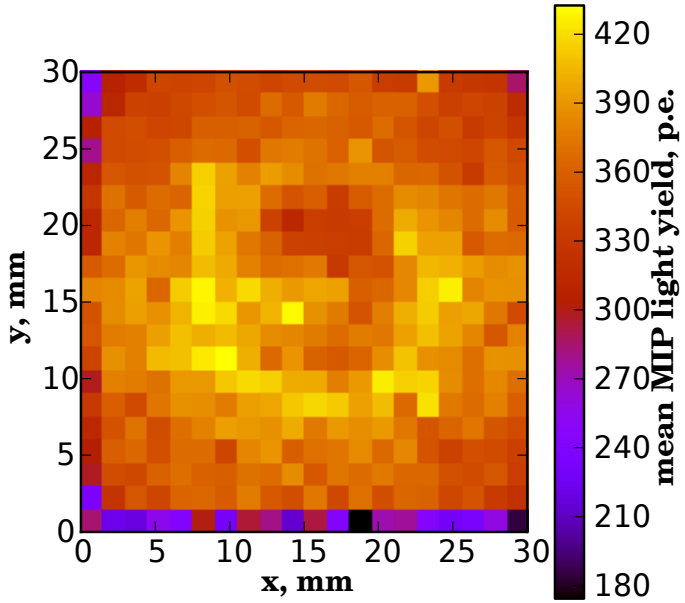
Tile shape

- Parallelepiped with the hole in the center of the flat face in the form of paraboloid. It has two parameters - the depth and radius of the hole on the surface.

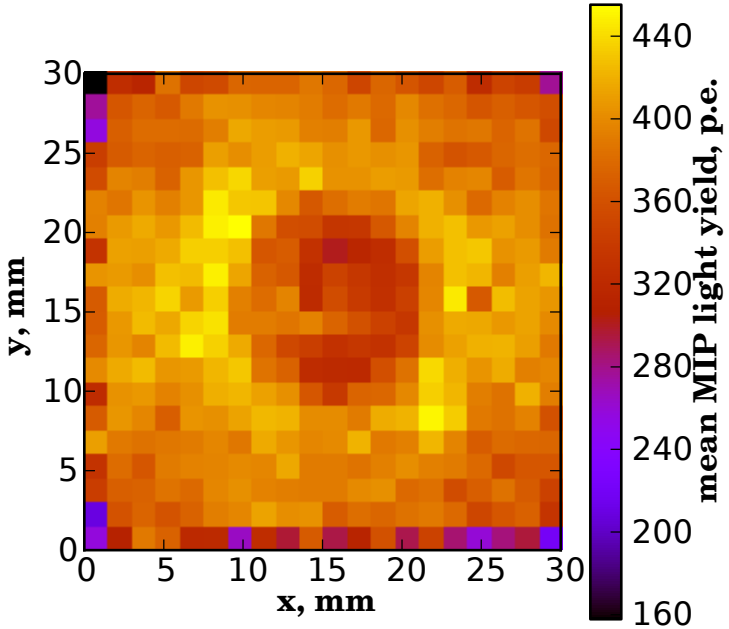


2d scans

0 on z-axis on the plots is placed in the minimum of the distribution.
The scan precision is 3mm.

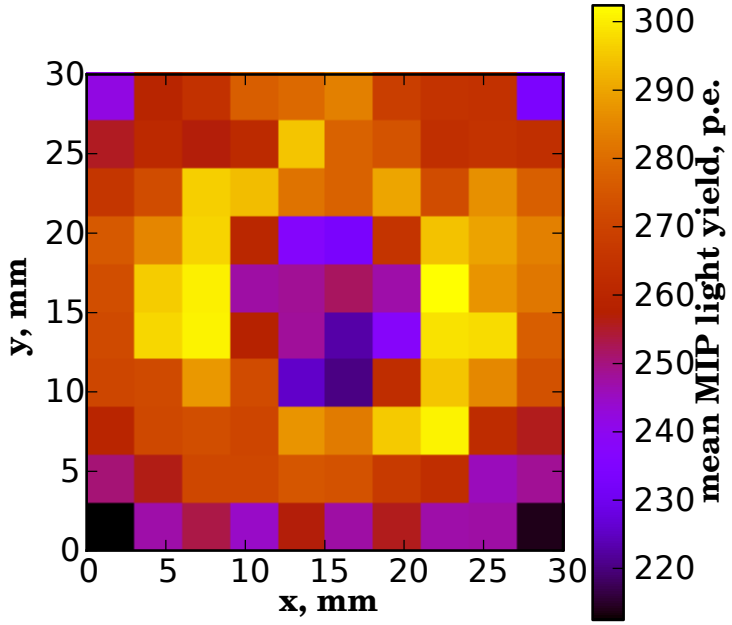


Depth 1.7mm
Radius 8mm
Mean 246
RMS/Mean 10%



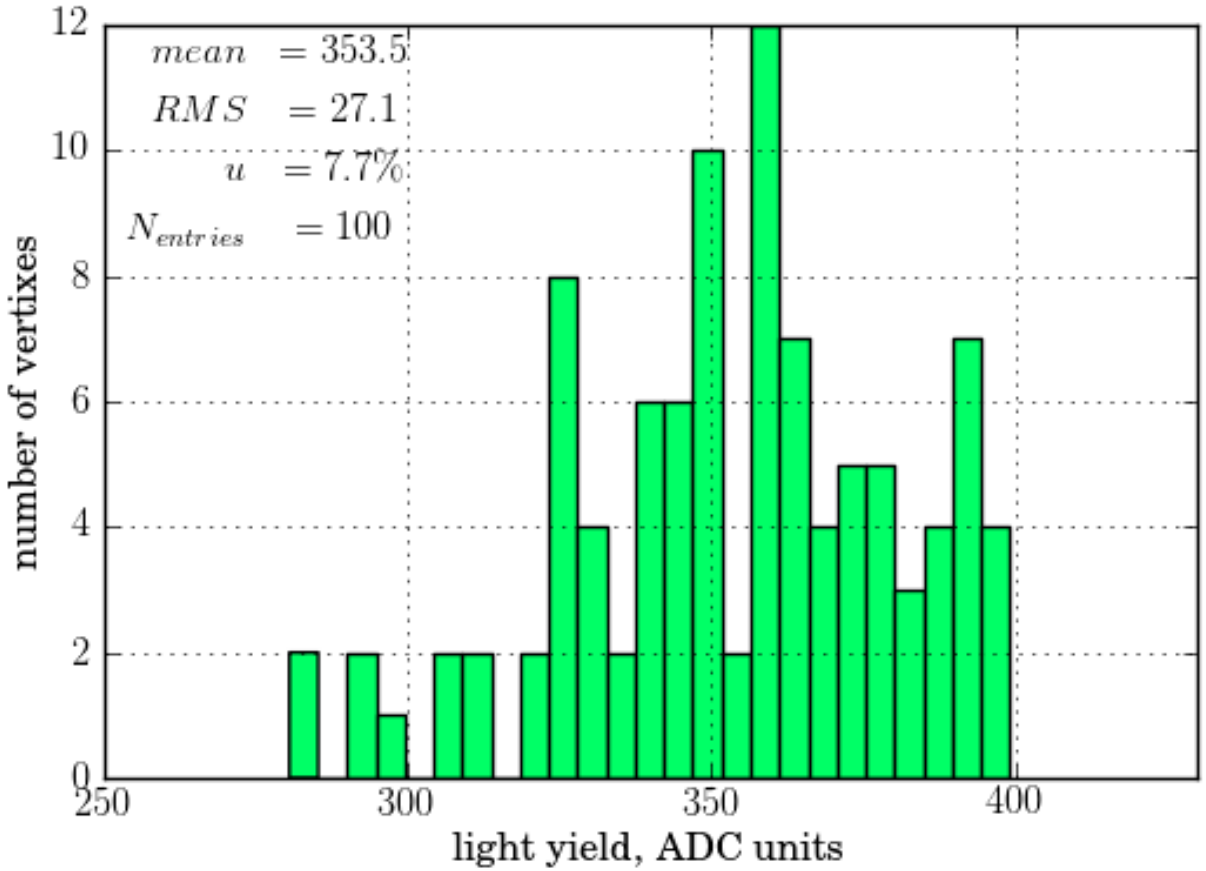
Depth 1.9mm
Radius 8mm
Mean 262
RMS/Mean 10%

2d scans



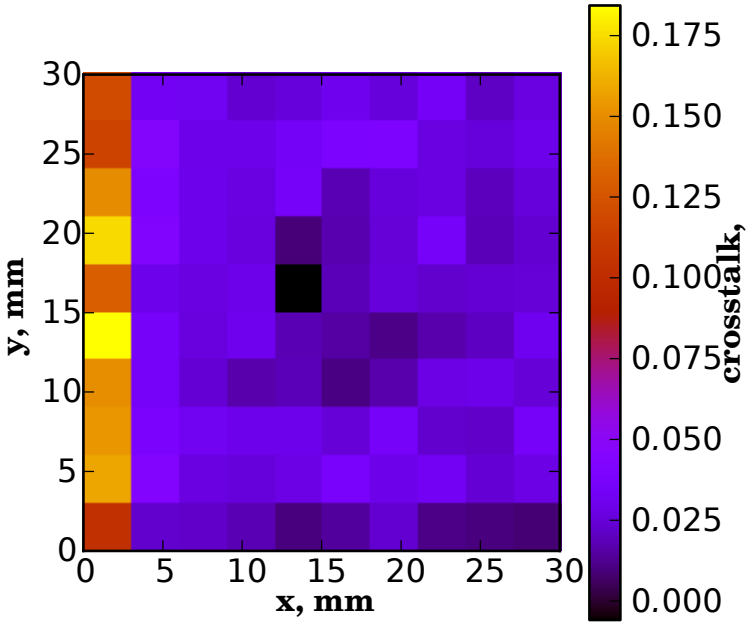
Depth 1.8mm
Radius 8mm
Mean 272
RMS/Mean 8%

Uniformity characterization

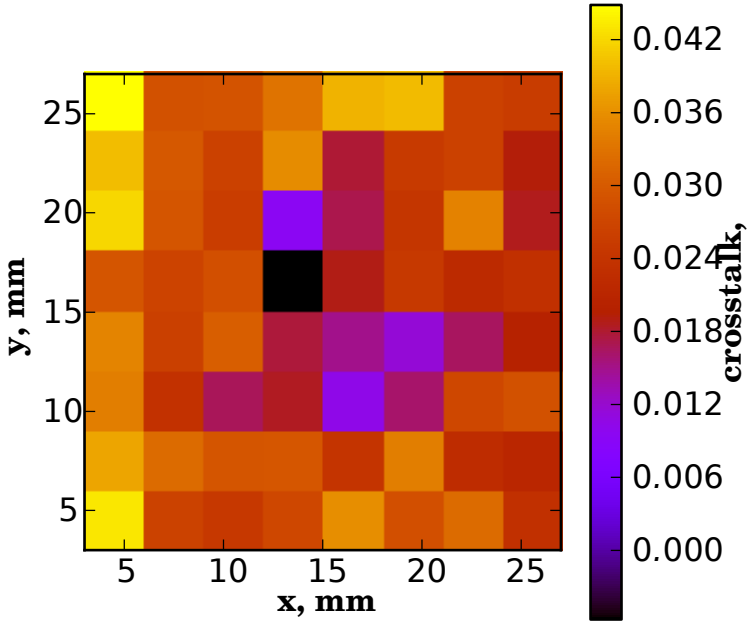


Distribution of MP values from MIP over tile

Optical crosstalk between tiles



3.8%



2.4%

Distribution of MP values from MIP over tile

Another investigations

- Mating and polishing of the surface in front of the SiPM have no effect
- Some light focusing exists — signal is not proportional to the SiPM surface area

Conclusions

- It is possible to achieve ~10% RMS/Mean in direct readout with 1.5 mm scan precision
- The configuration with the separate electronics assembly and SMD SiPM's is enabled
- The selected shape can be easily reproduced with injection molding

Thank you for your attention!