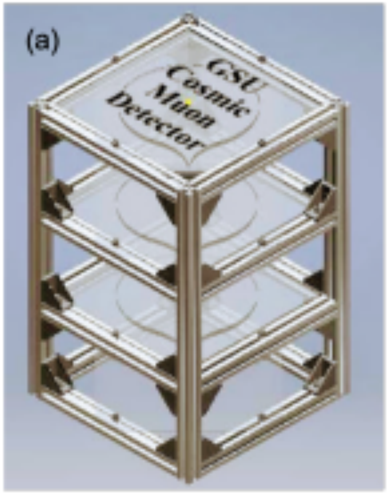


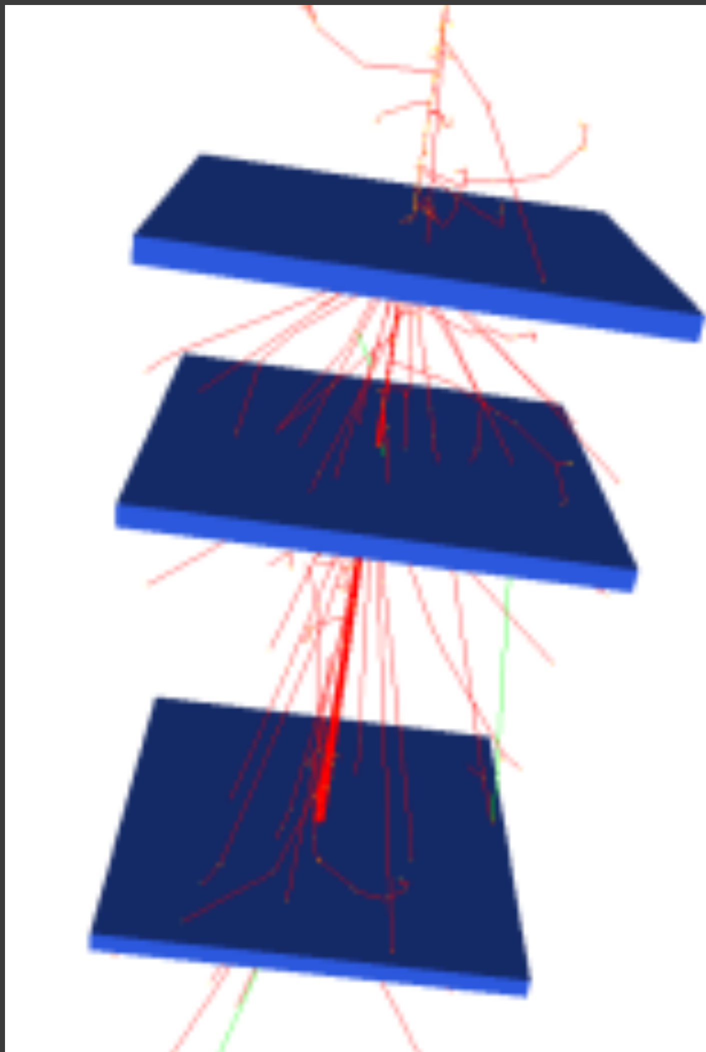
Muon telescope

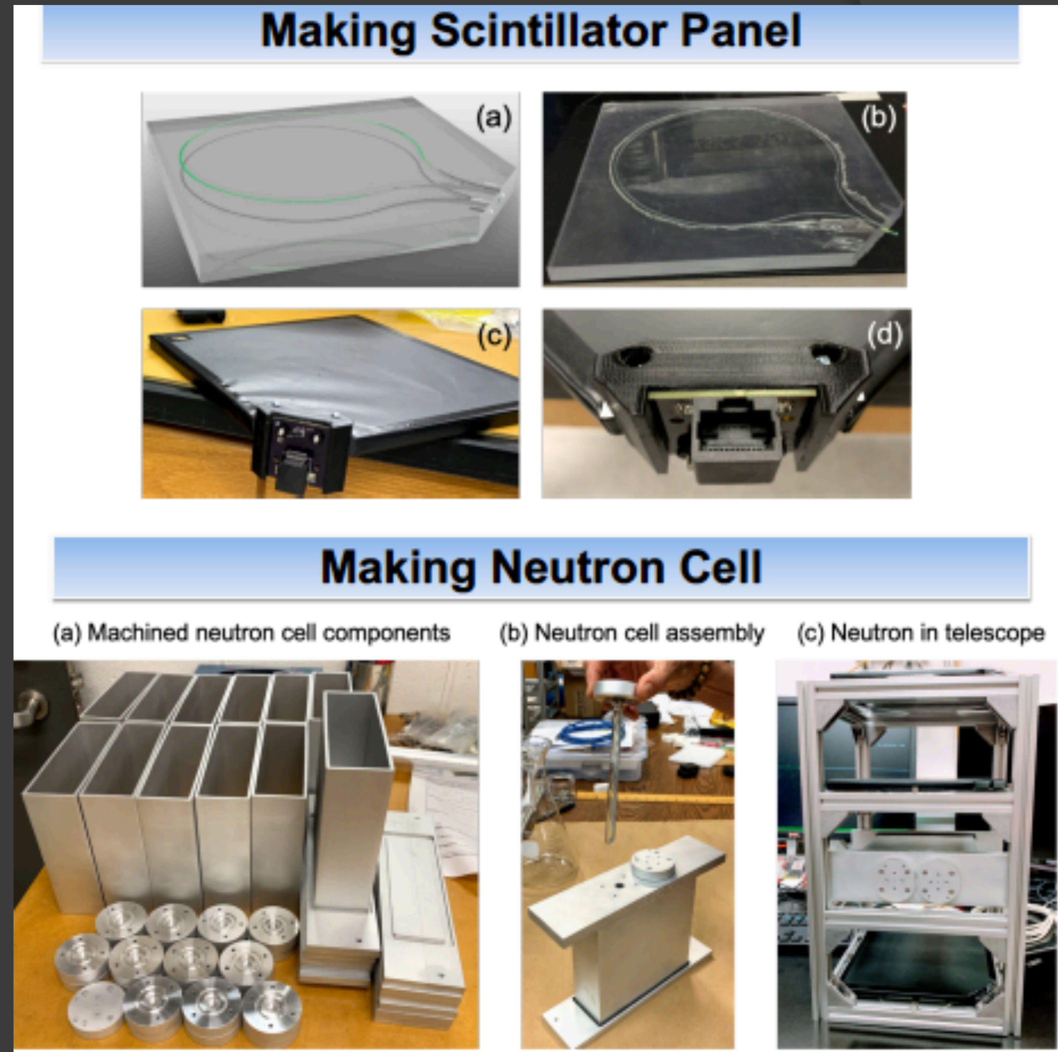
Large Area Scintillators for Cosmic Ray Studies

E.Kistenev, BNL

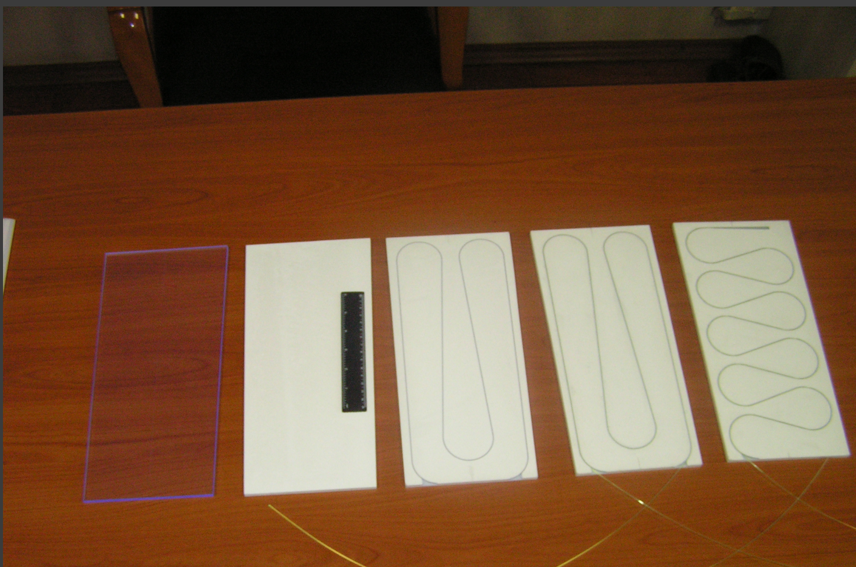
October 4, 2019

What we already can do



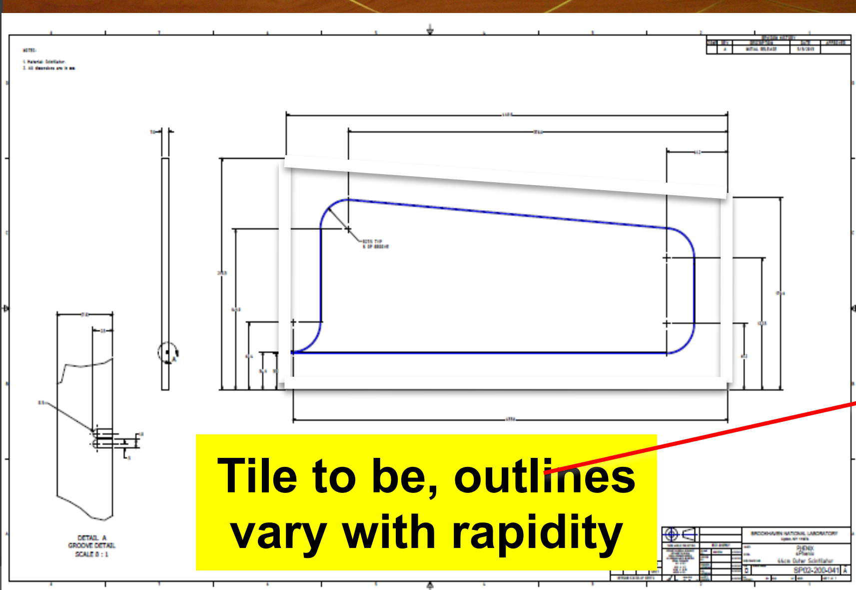


sPHENIX Tile Design

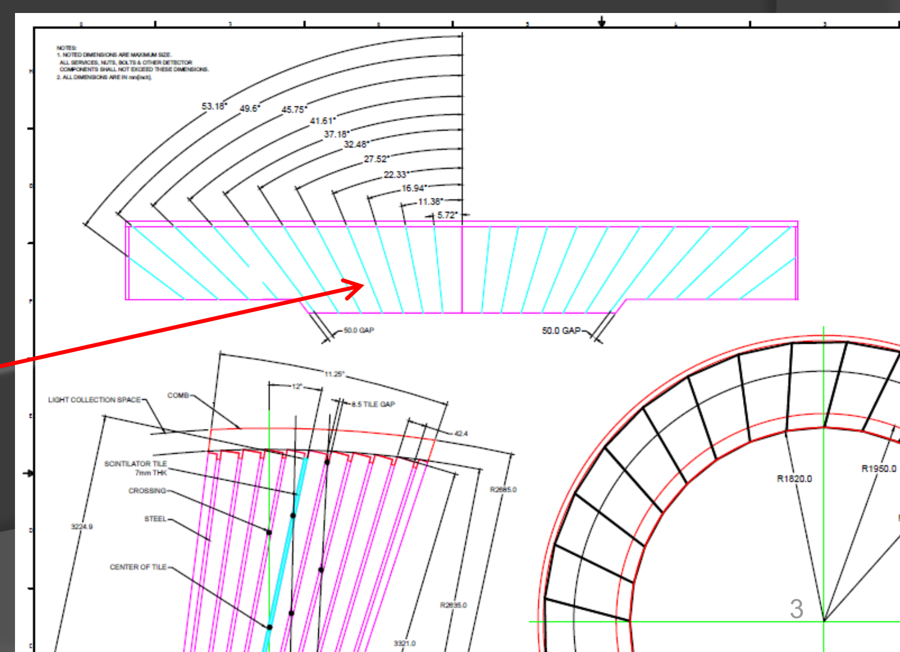


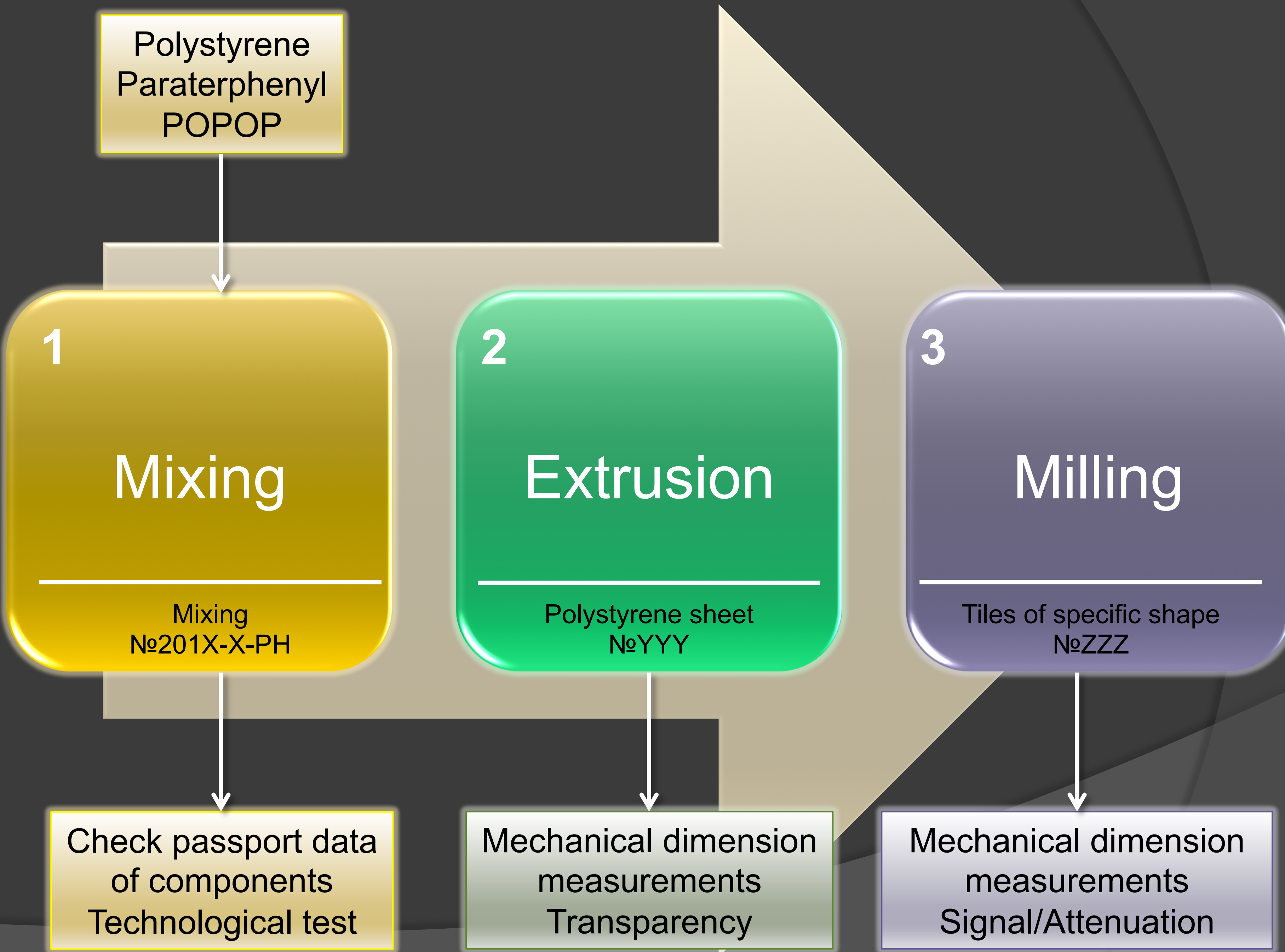
Prototype tiles

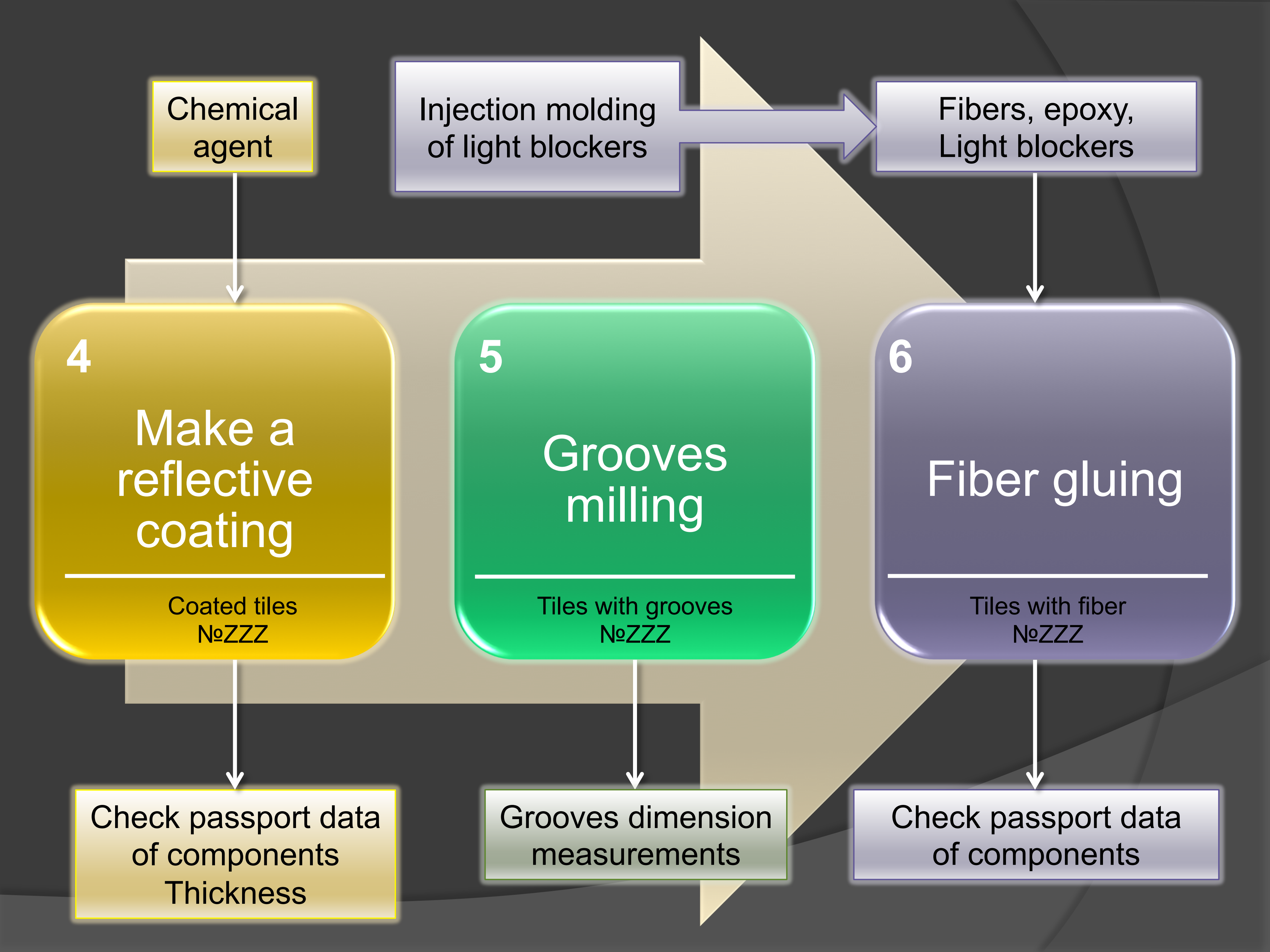
- -Fiber bending diameter >5cm
- -Light path to nearest fiber <2.5cm everywhere

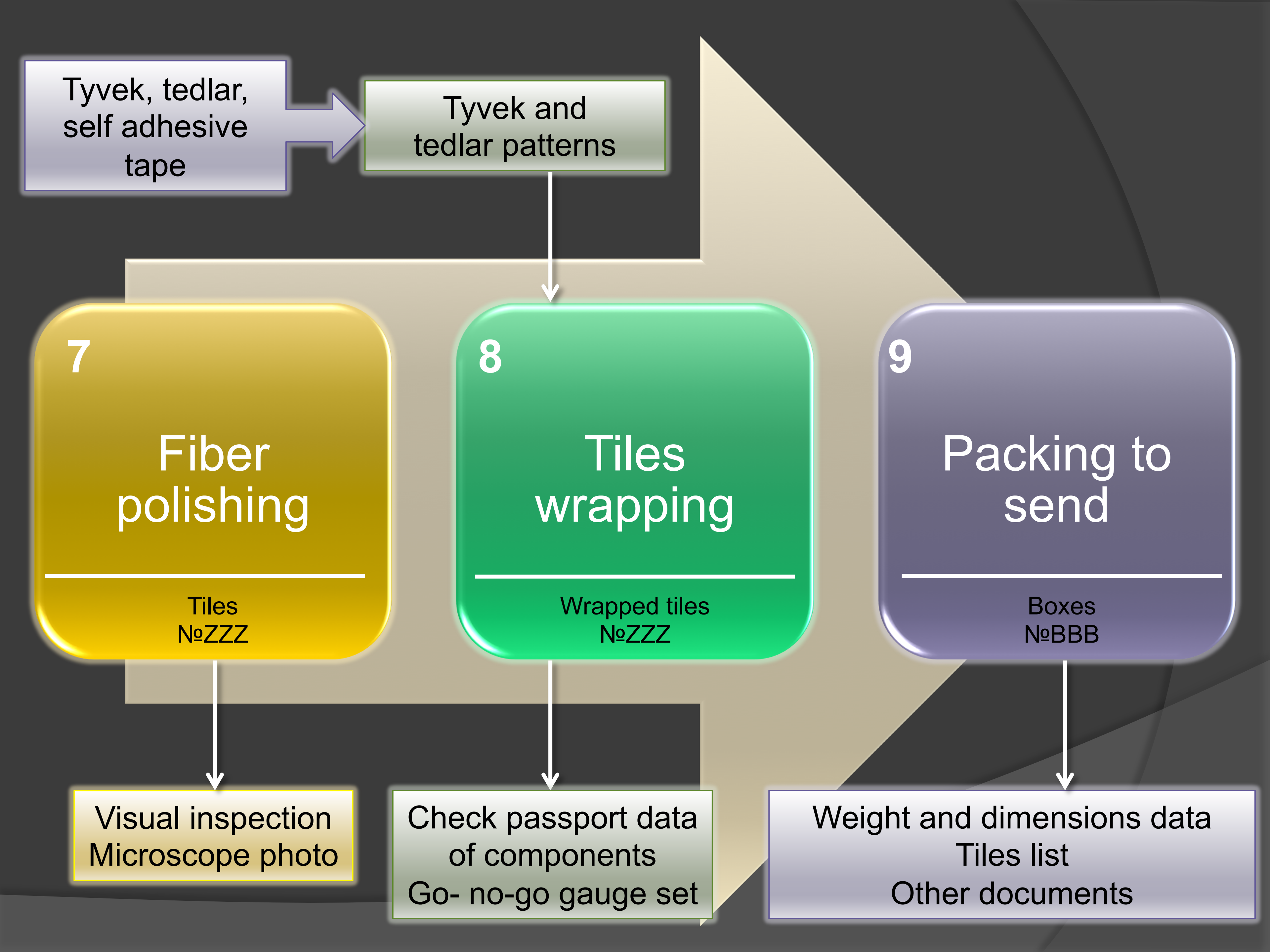


Tile to be, outlines vary with rapidity



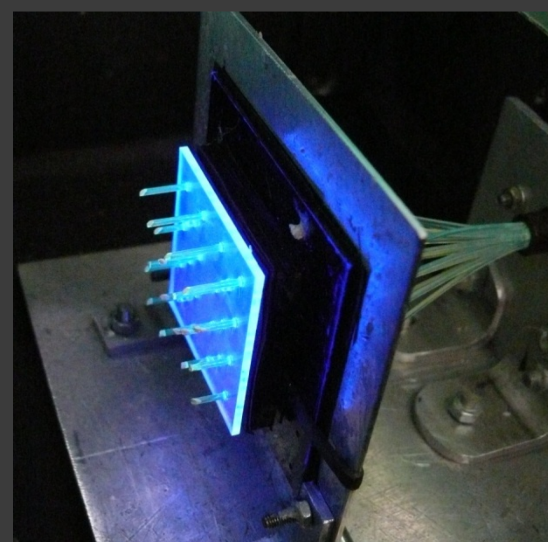

Polystyrene
Paraterphenyl
POPOP
1
Mixing
Mixing
№201X-X-PH
2
Extrusion
Polystyrene sheet
№YYY
3
Milling
Tiles of specific shape
№ZZZ
Check passport data of components
Technological test
Mechanical dimension measurements
Transparency
Mechanical dimension measurements
Signal/Attenuation

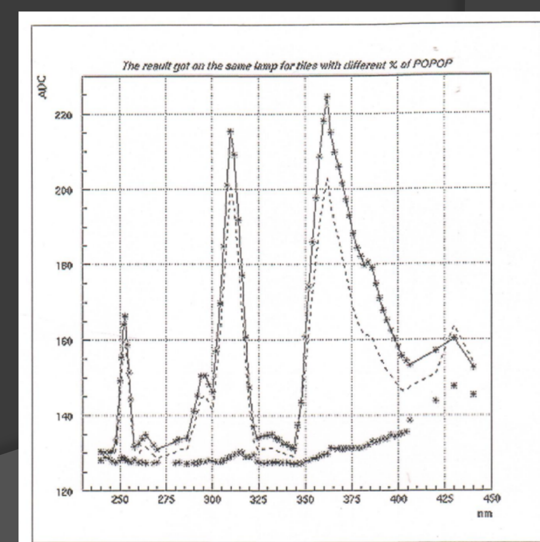

Chemical agent
Injection molding of light blockers
Fibers, epoxy, Light blockers
4
Make a reflective coating
Coated tiles №ZZZ
5
Grooves milling
Tiles with grooves №ZZZ
6
Fiber gluing
Tiles with fiber №ZZZ
Check passport data of components Thickness
Grooves dimension measurements
Check passport data of components


Tyvek, tedlar, self adhesive tape
Tyvek and tedlar patterns
7
Fiber polishing
Tiles
№ZZZ
8
Tiles wrapping
Wrapped tiles
№ZZZ
9
Packing to send
Boxes
№BBB
Visual inspection
Microscope photo
Check passport data of components
Go- no-go gauge set
Weight and dimensions data
Tiles list
Other documents

Raw Materials Testing

- Check passport data of components
- Making test party of scintillation tiles (press-form for NICA project)
- Measurement of the light output by the spectrophotometer
- Light output must be at least 97% of the reference tile





Extrusion

Polystyrene sheets are produced by extrusion from the composition of polystyrene (98.46%) + paraterphenyl (1.5%)+ POPOP (0.04%).

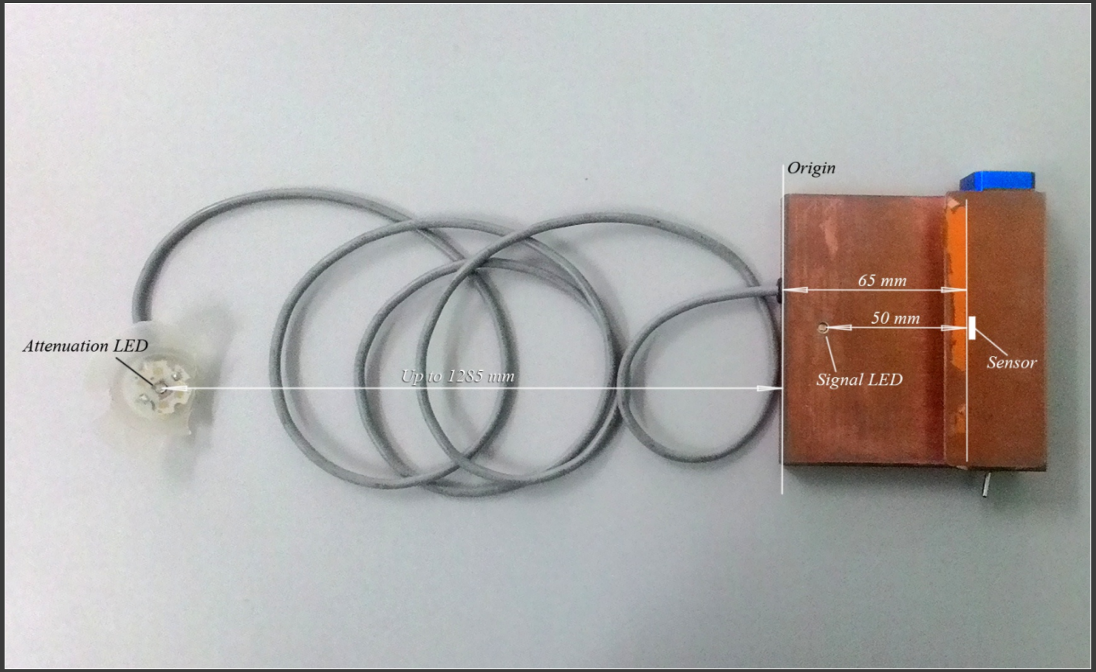
Thickness accuracy – 0.1 mm

The width and thickness of extruded sheets are controlled by a caliper and thickness gauge.

The transparency of the plastic is controlled by LEDs.

Quality control of scintillation plastic

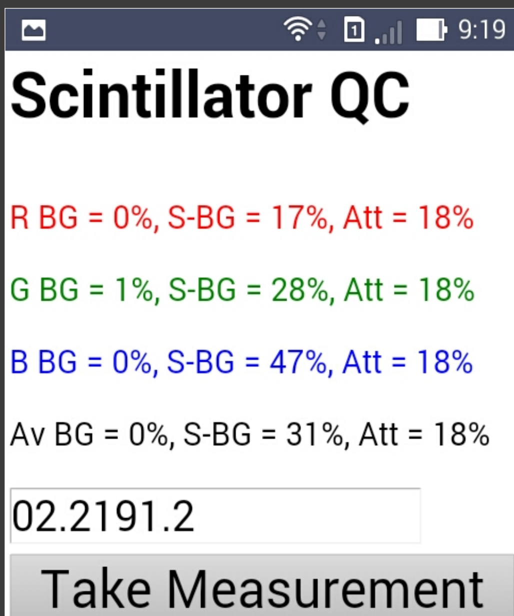
Quality control of scintillation plastic is made with Scintillator Quality Meter (Laboratory for High Energy Physics – University of Bern).
Scintillator Quality Meter is a compact device (100x100x20 mm) with two LEDs and a photosensor. Arduino platform is used for signal processing.

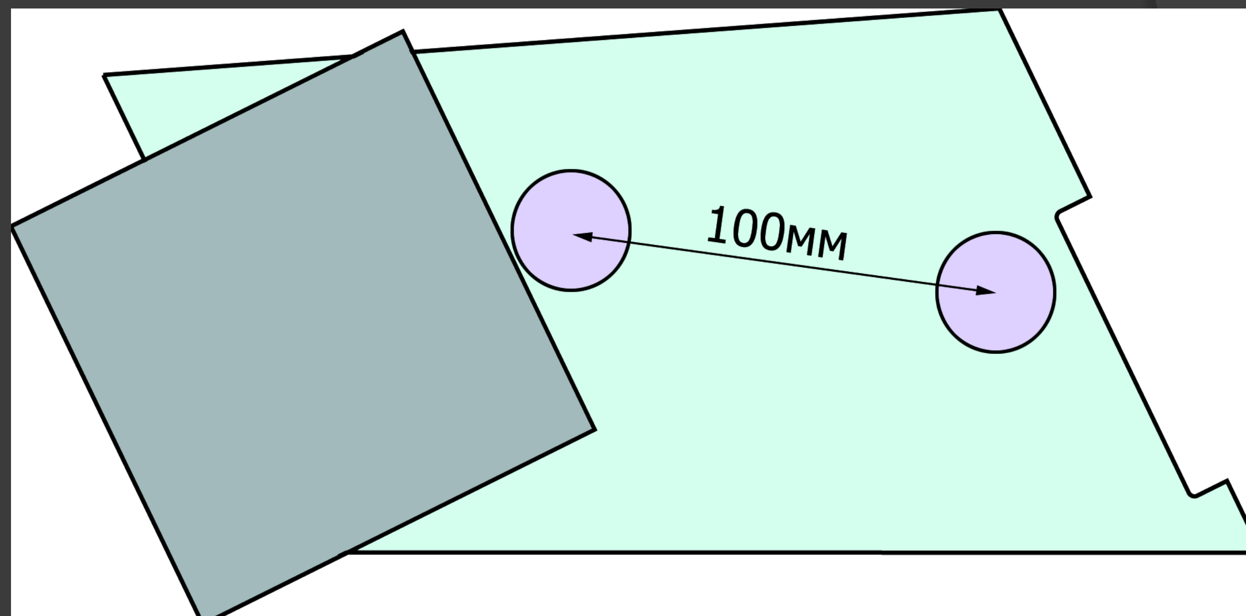


LEDs emit near-ultraviolet (365 nm), the photosensor measures the signal levels, compares them and gives the results of the comparison.

Quality control of scintillation plastic

The results are light output from short distance (50 mm) and attenuation on selected distance (100 mm for small tiles, 300 mm for big tiles).

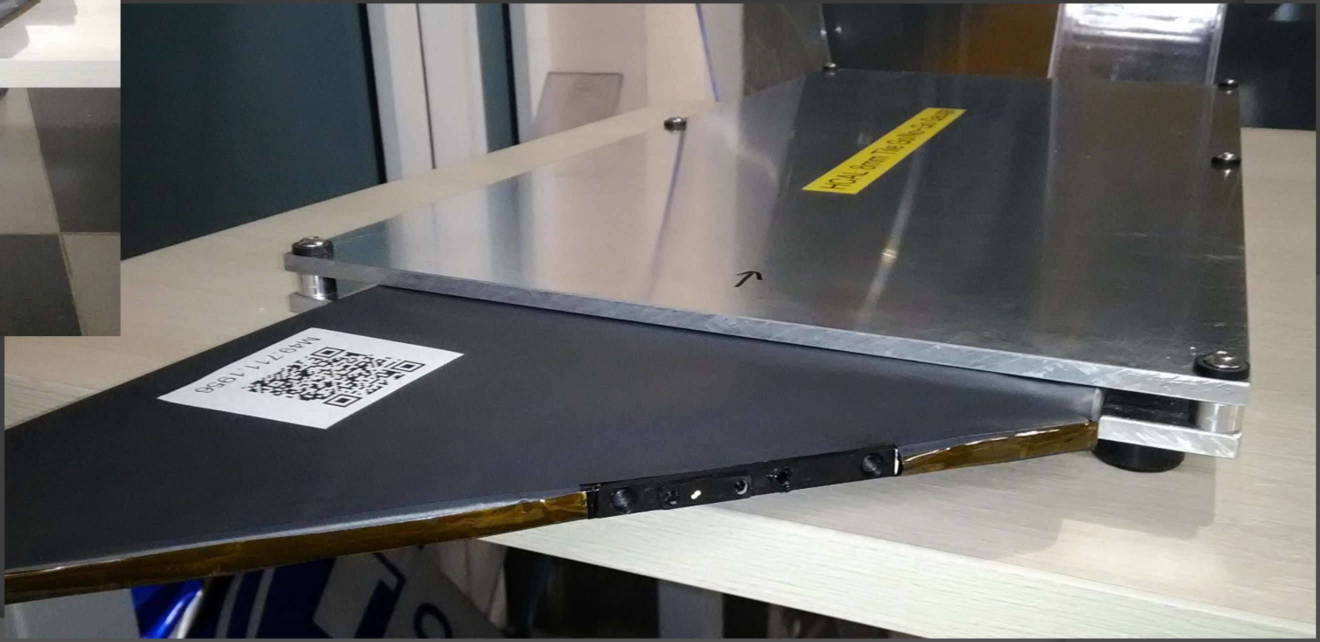




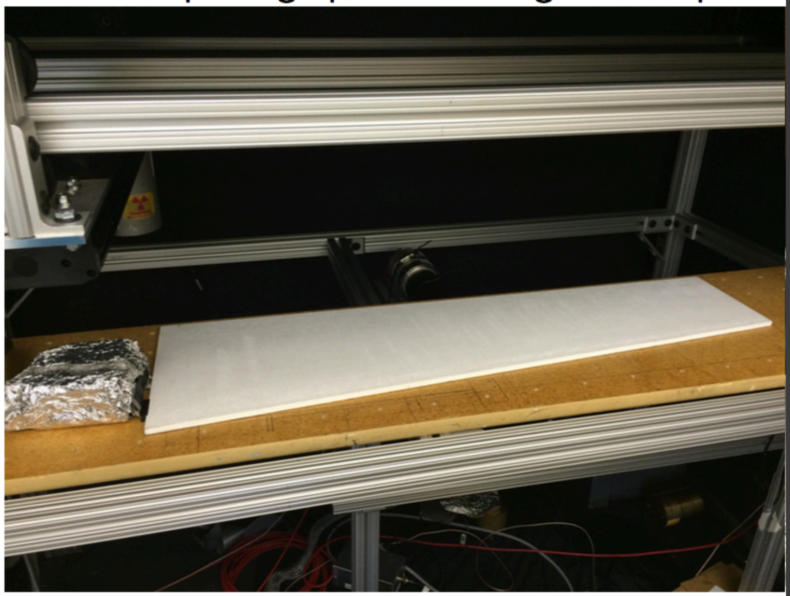
Reading and saving results is done using a smartphone or tablet via Wi-Fi.

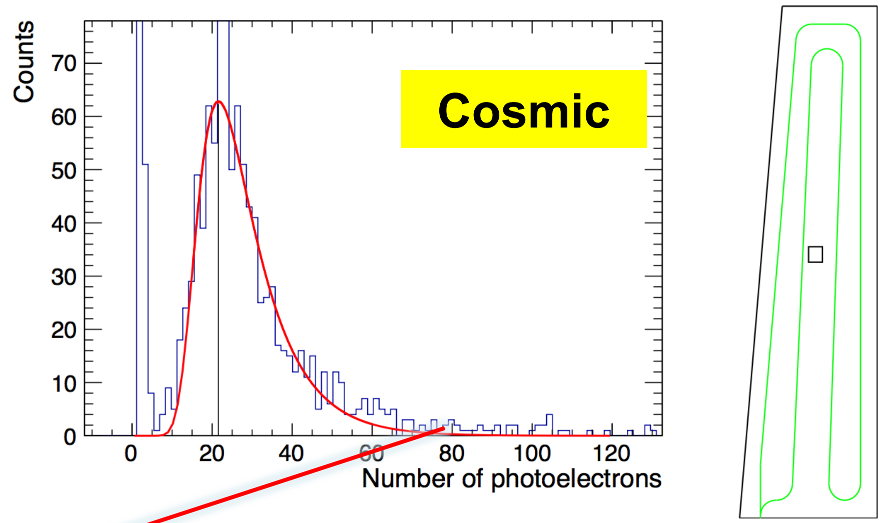
Go- No-go Gauge Set Control

Finished wrapped-tile shall pass insertion test in a go- no-go gauge set at 8.0 mm, maximum.



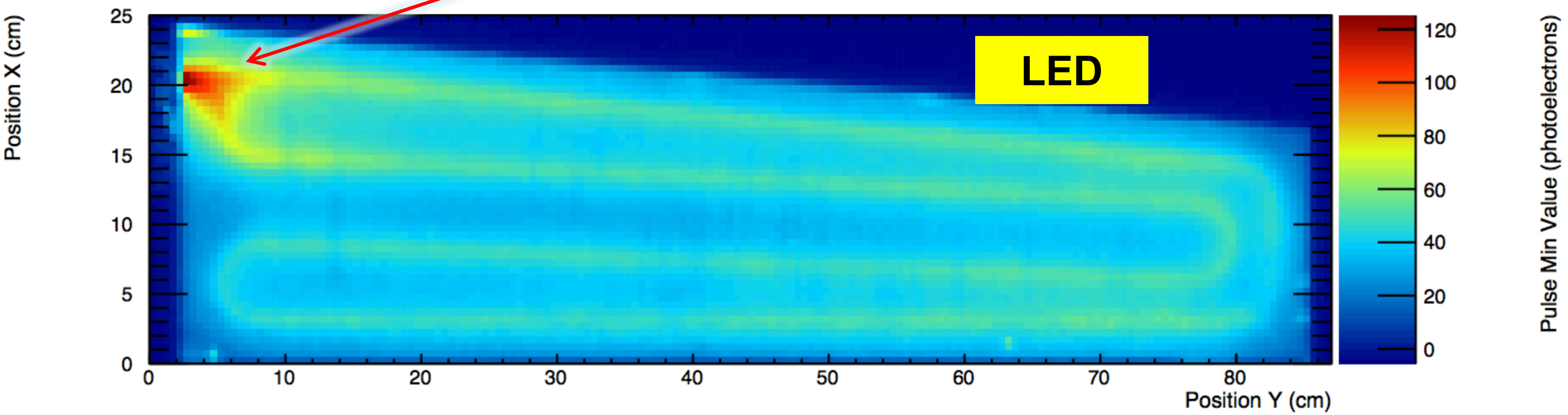
Prooving that tile behaves

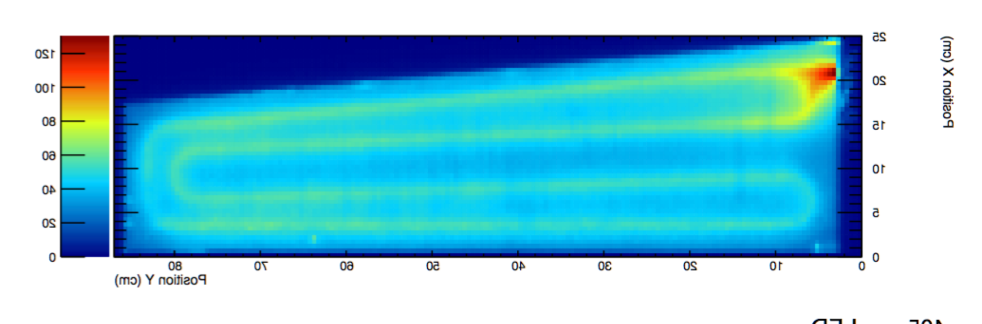




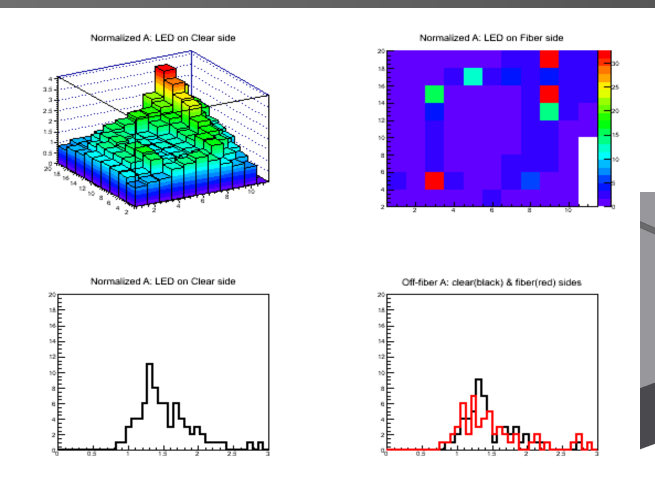
$[\Delta E]_{MPV} = 21.6\pm0.5$ photoelectrons and $\xi = 5.0\pm0.3$ photoelectrons

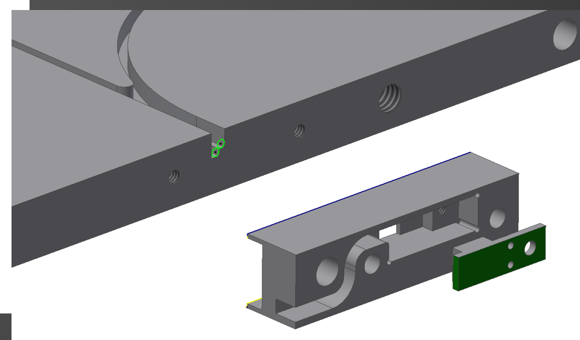
: Colorado

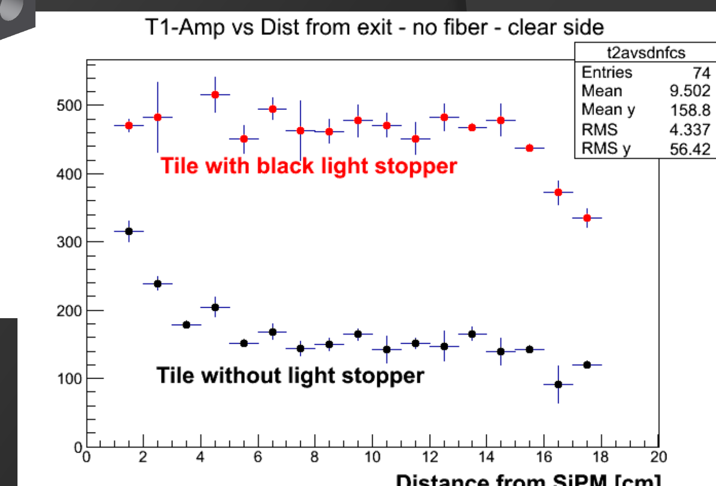




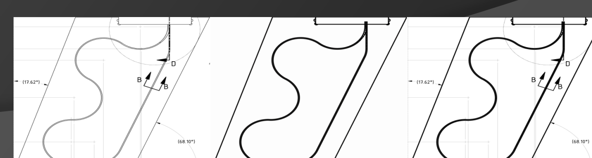
Prompted by large nonuniformities in light collection measured with LED light source at CSU (confirmed at UTFSM)



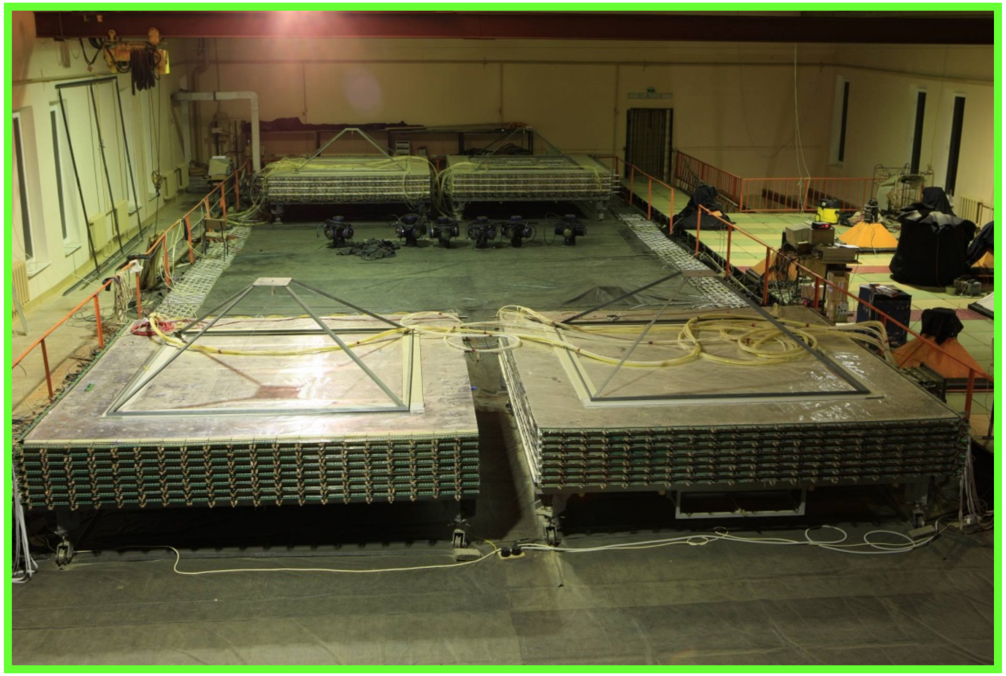




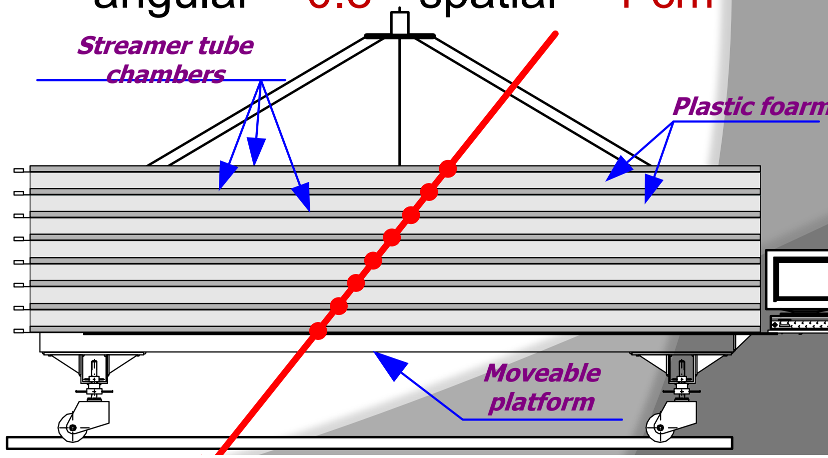
✓Positioning of the fiber exit at the edge center helps somewhat. Symmetrical fiber configuration improves response symmetry;



2016: MEPHI, Moscow, Muon hodoscope URAGAN

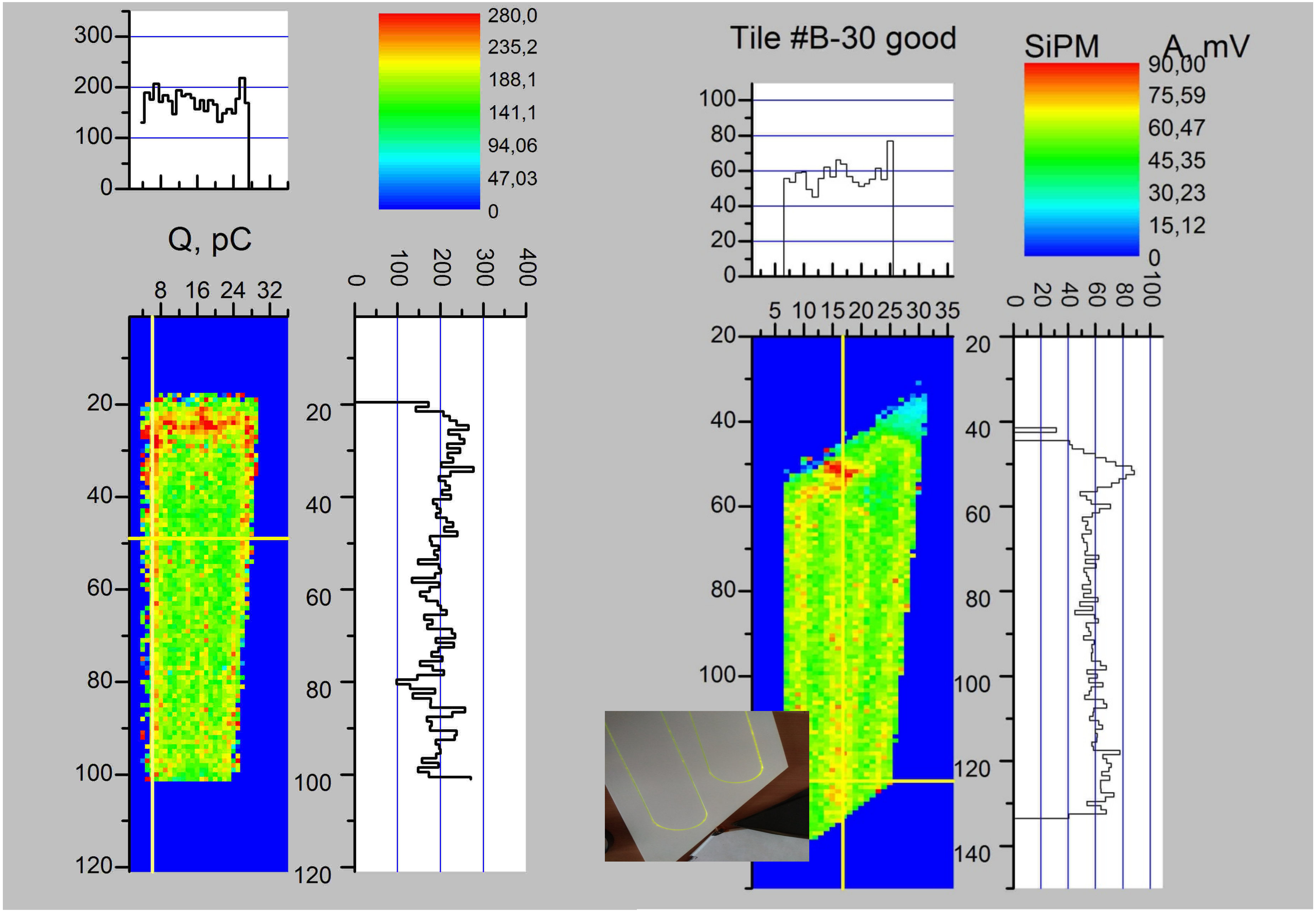


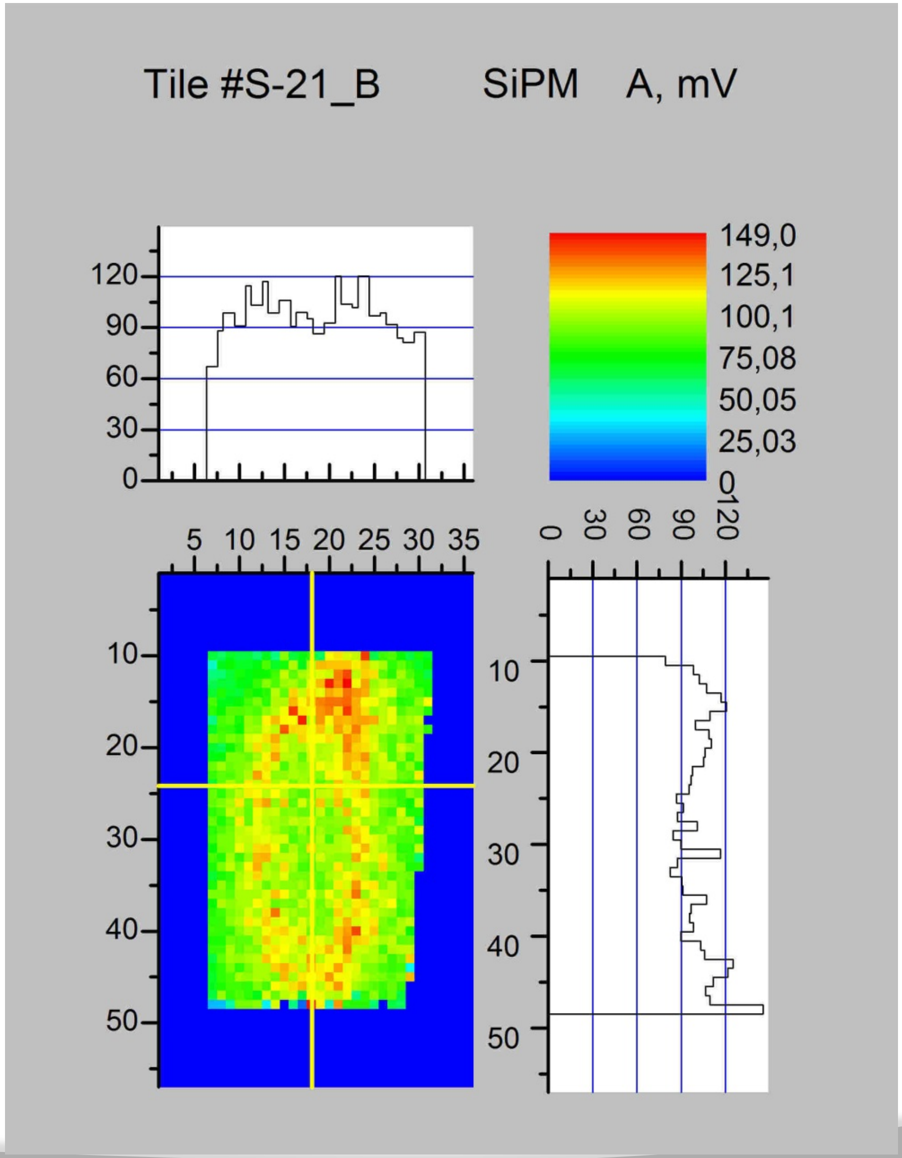
- 4 independent supermodules (SM)
- SM 8 planes of streamer tube chambers with external strip read-out (8×[320-X & 288-Y] chan.). SM area ~11 m^2
- SM trigger coincidence of signals from ≥ 4 X-planes within time gate 250 ns.
- Resolution: angular 0.8°, spatial – 1 cm

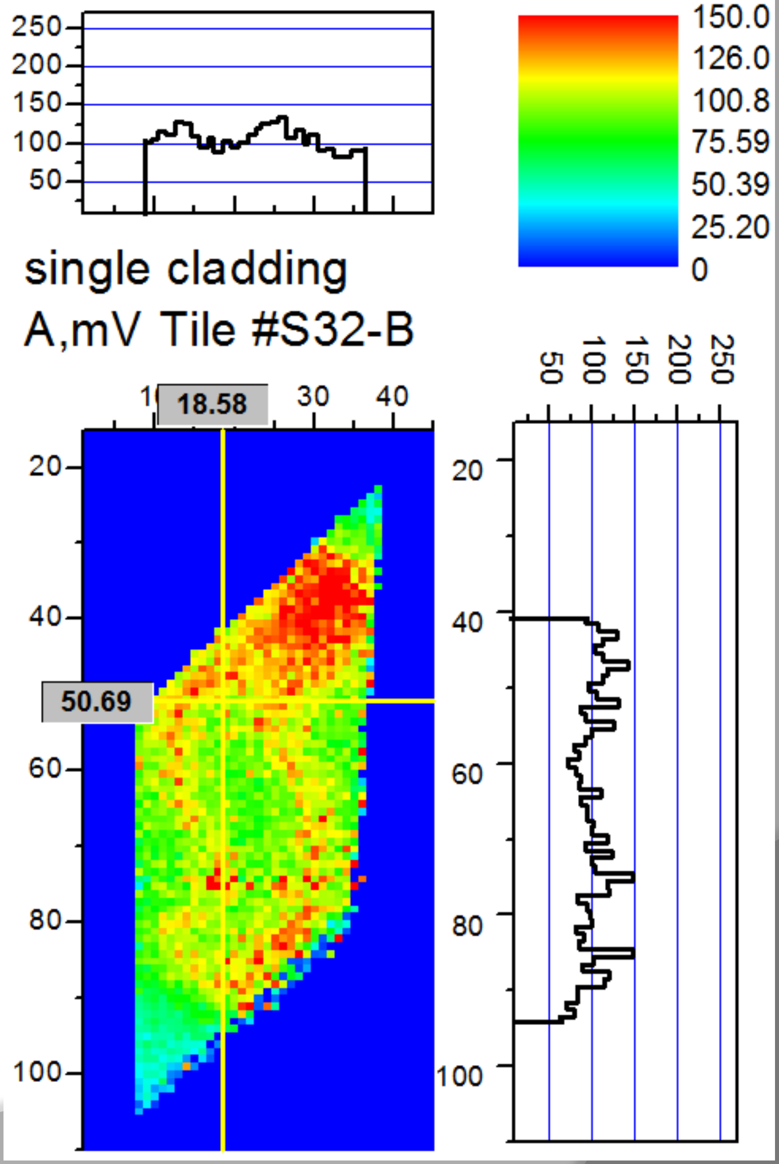


URAGAN:

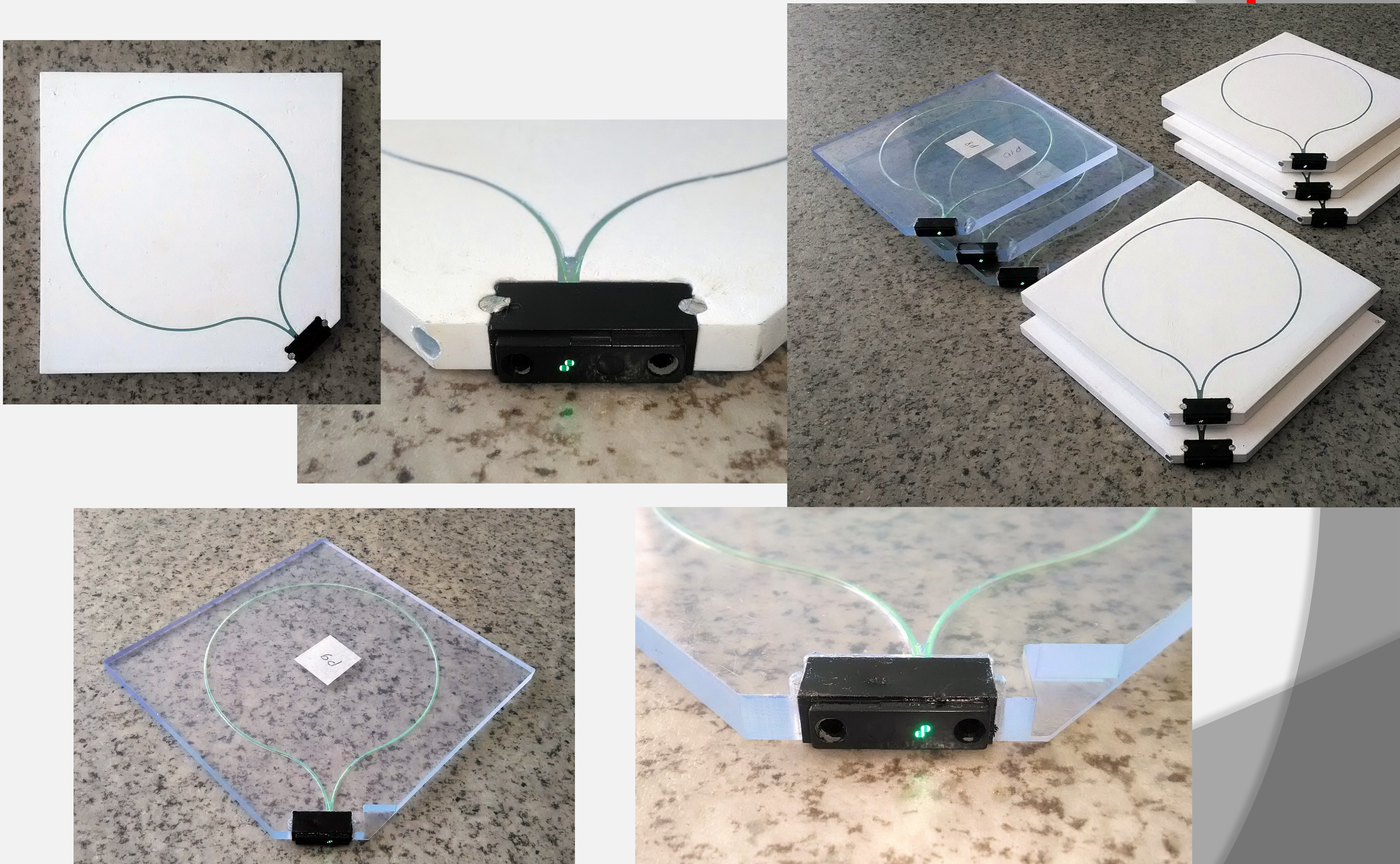
- Detection of muons simultaneously from all directions of the upper hemisphere.
- The study characteristics of muon flux variations related with various processes of CR modulation in the Earth's atmosphere and extraterrestrial space


Q, pC
280,0
235,2
188,1
141,1
94,06
47,03
0
Tile #B-30 good
SiPM
A, mV
90,00
75,59
60,47
45,35
30,23
15,12
0


Tile #S-21_B
SiPM
A, mV
149,0
125,1
100,1
75,08
50,05
25,03
0


150.0
126.0
100.8
75.59
50.39
25.20
0
single cladding
A,mV Tile #S32-B
18.58
50.69

Tested tiles for muon telescopes



7-mm prototype tiles testing results

Position	Channel №	Trigger	Tile ID	MPV	Sig
1	0	Yes	B24.245.641	1263	27
2	2	No	B24.378.1037	1304	28
3	3	No	P4	1848	41
4	8	No	B24.378.1038	1168	25
5	9	No	P3	2122	42
6	10	No	B24.379.1039	1354	29
7	11	No	P2	2024	44
8	12	No	B24.381.1047	1358	29
9	13	No	P1	1947	40
10	1	Yes	B24.382.1048	1411	29

May 27, 2019. All tiles are coated. Test duration 4 hours.

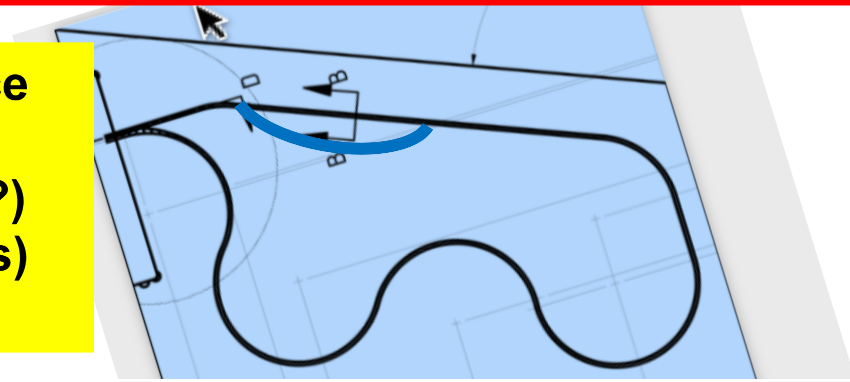
Diffuse reflector (coating)

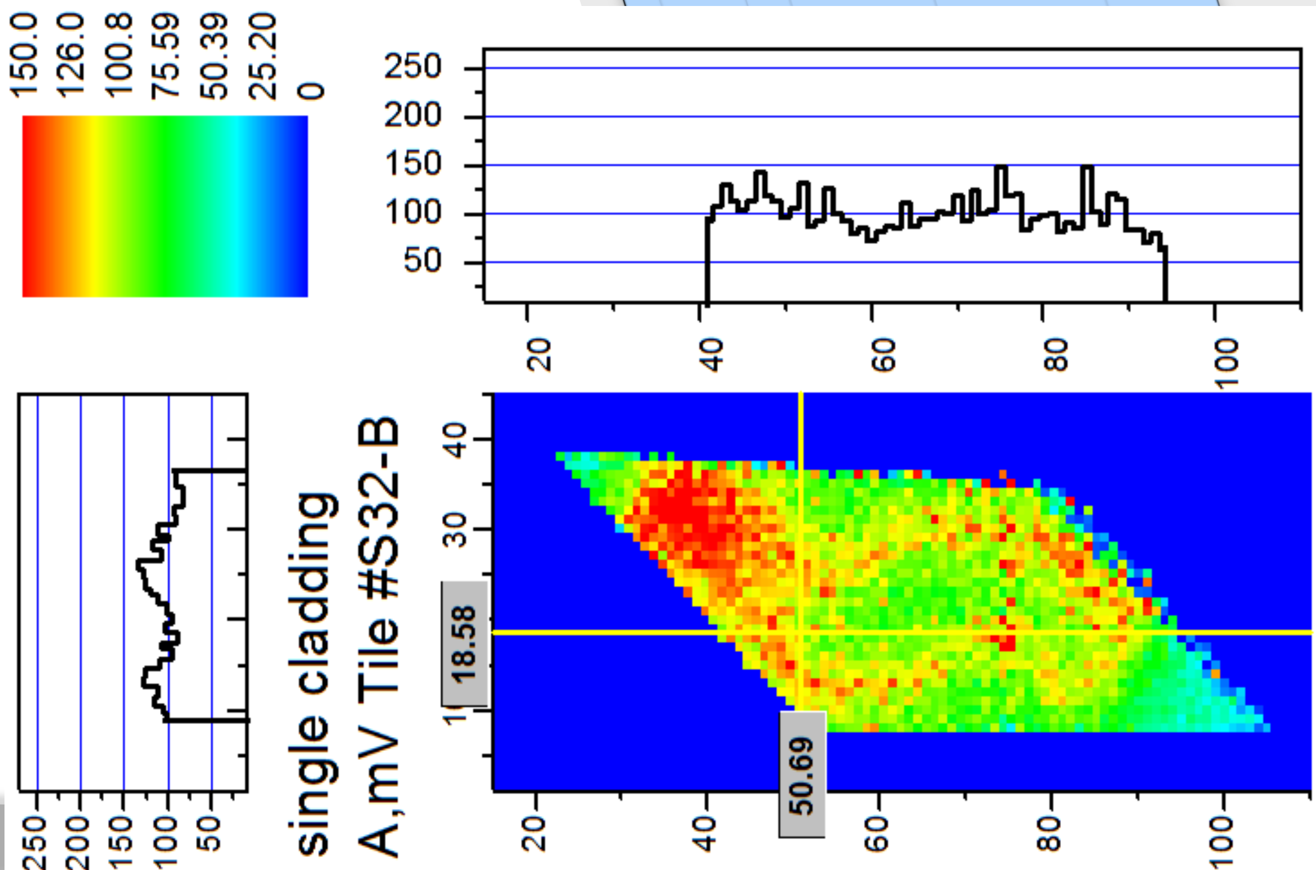
Position	Channel №	Trigge r	Tile ID	MPV	Sigma
1	0	Yes	B24.245.641	1150	243
2	2	No	B24.378.1037	1231	254
3	3	No	P1 (coated)	1682	340
4	8	No	B24.378.1038	1069	228
5	9	No	P8 (not coated)	667	124
6	10	No	B24.382.1048	1289	268
7	11	No	P2 (coated)	1707	357
8	12	No	B24.379.1039	1197	254
9	13	No	P9 (not coated)	606	107S
10	1	Yes	B24.381.1047	1250	250

June 2, 2019. Coated and not coated tiles. Test duration 6 hours.

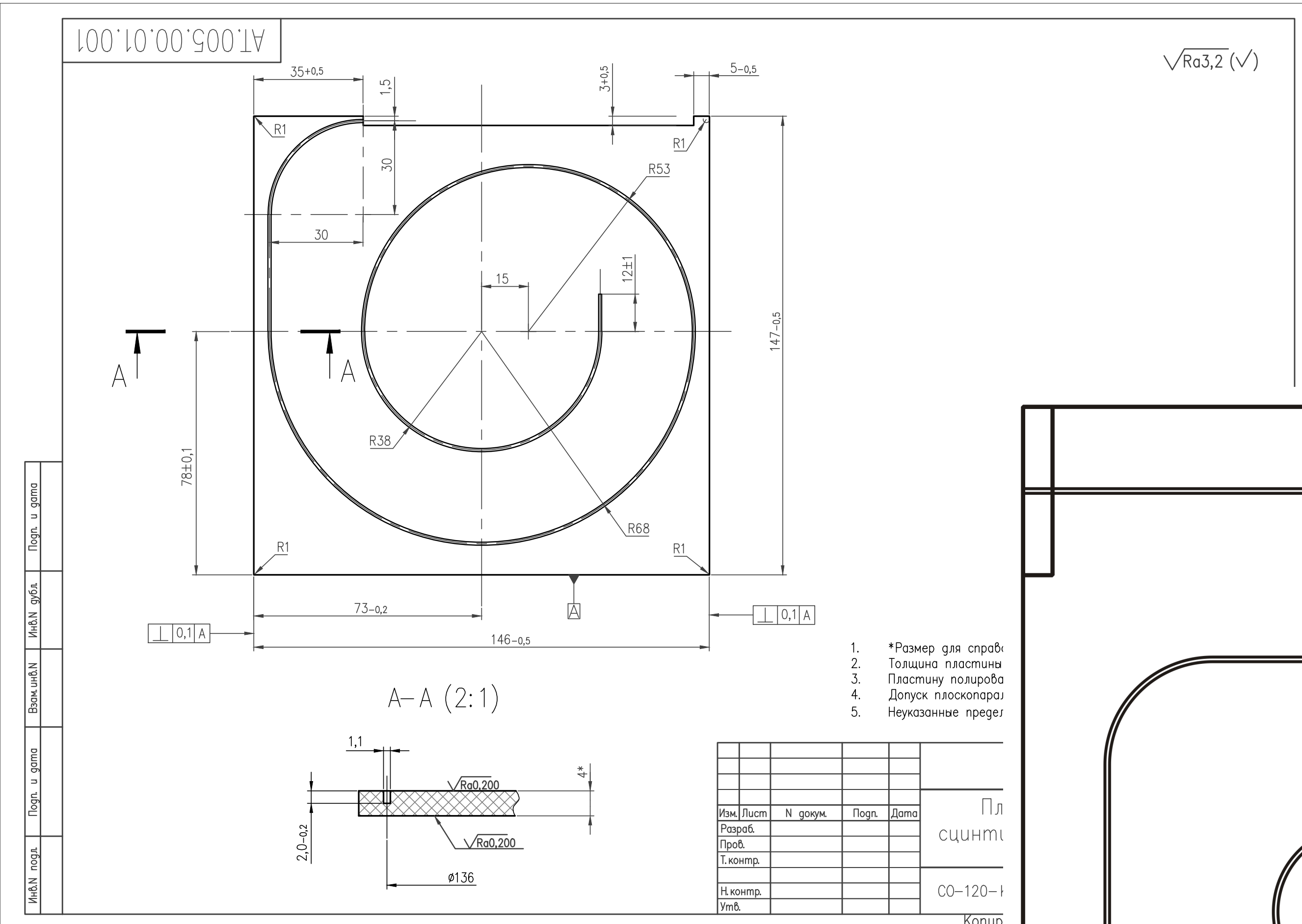
Battling the Nonuniformity

- **Fiber density per unit surface**
- **Edges (mirror or absorber)**
- **Empty corners (chamfer ???)**
- **Signal propagation (20cm/ns) and timing measurements**

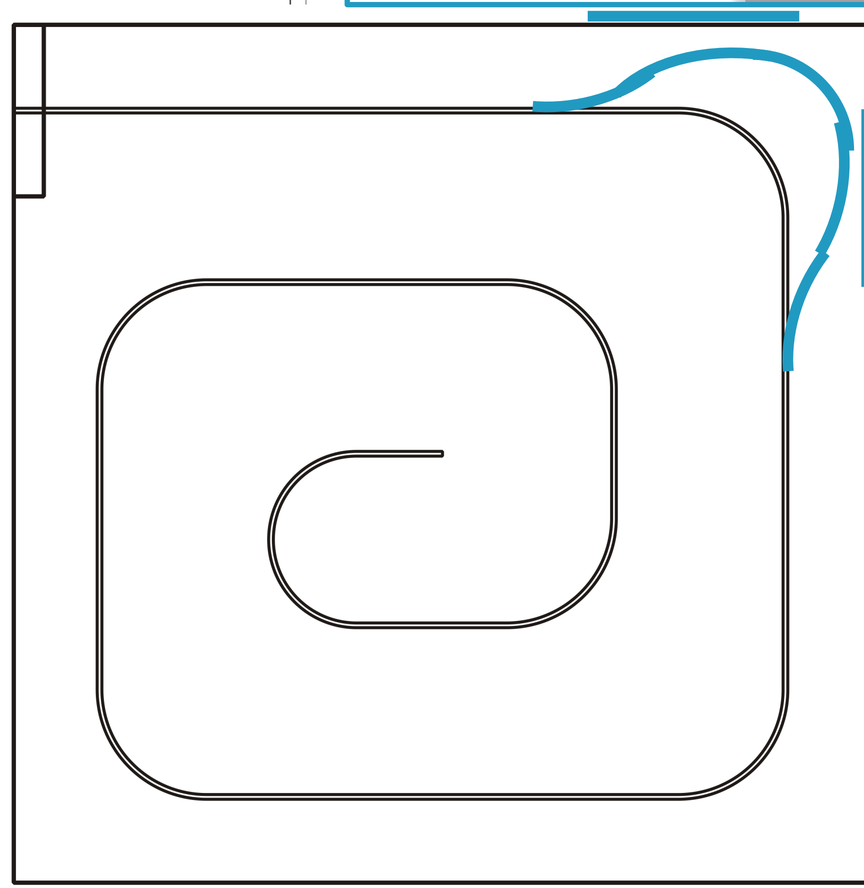




Competing options for Areal Muon Survey

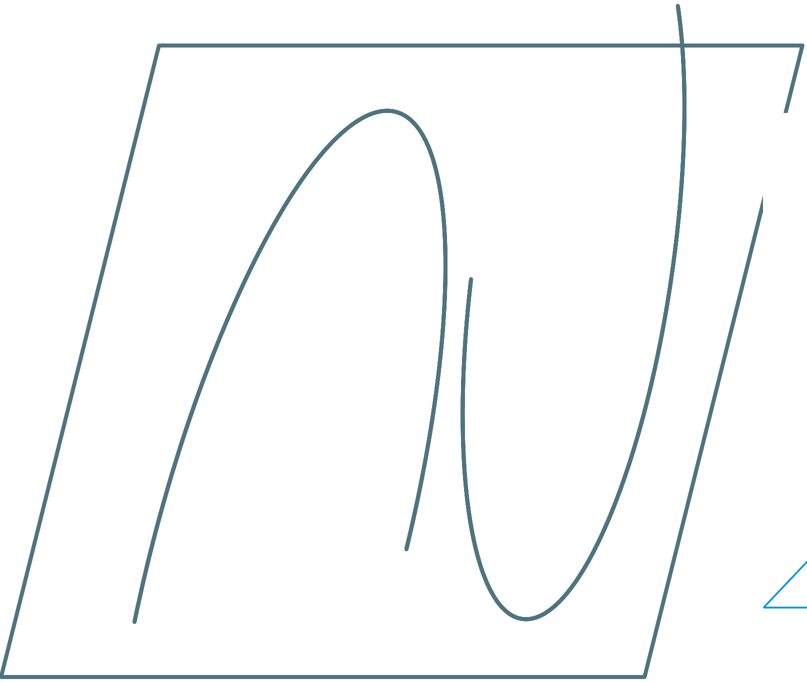


-Accessing remote corners may need coating locally removed from edges

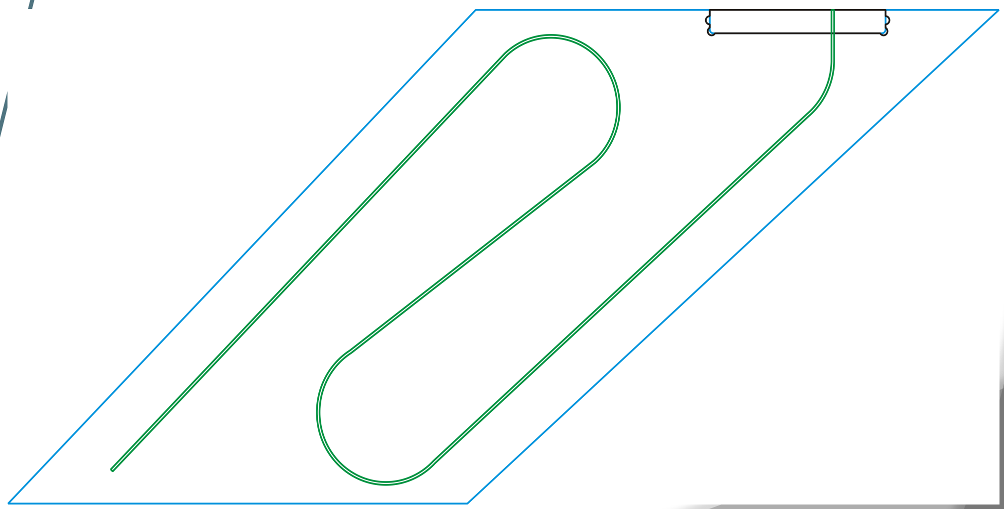


New sPHENIX inner calorimeter tile (option)

My “design”



Draft “professional” design

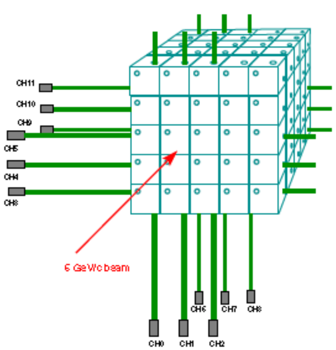


Early summary

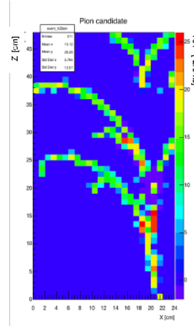
- Scuntillators for muon telescopes could be produced industrially, fast, in volumes and at a relatively modest price;

- Converting scintillation tiles into muon tracking and triggering physics detectors can be done at Universities (schools) by students;

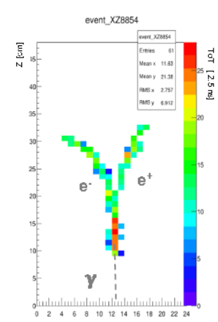
- It is not clear if scintillator can be loaded with neutron capturing substances (loosing transparency). But the coating which is 50 mkmm thick can be loaded with LiCl (50% by weight) or Li_2CO_3 (17-30% by weight). It adds up to 30 – 40 g of LiCl or 12 -20 g Li_2CO_3 per 1m2 of coated surface.



Pion (π⁻) candidate



γ conversion candidate



Stopping proton candidate