ECal Prototype for SPD

1. Sampling calorimeter essential property:
    1. Fine Scintillator – Lead structure with sampling fraction (SF) 20-30%
    2. Moliere Radius is about 3.3 – 3.4 cm
    3. Number of Radiation length 15-17 – depended from number of layers
    4. Granularity – rectangular cell size 4-5.5 cm – depended from particles occupancy
    5. Scintillator quality : composition, attenuation length
    6. Photo Sensor Photodetector Efficiency (PDE)
    7. Long time stability (essential from temperature)
    8. WLS fibers quality : diameter, attenuation length
    9. Time resolution -

The possible prototypes options:

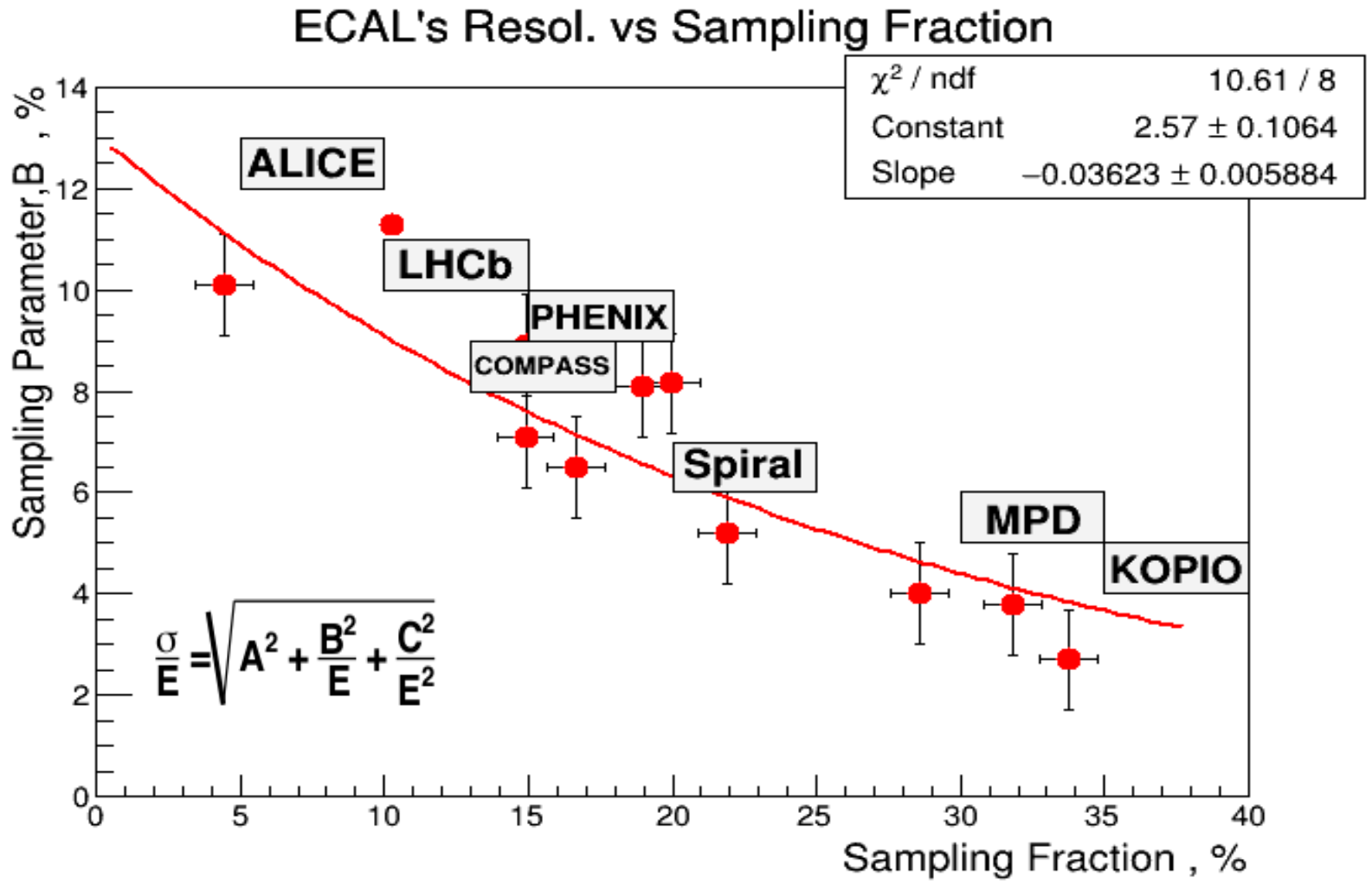
1. KOPIO – the best result was achieved in energy resolution
2. MPD – design under investigation
3. COMPASS – was completed for MPD as BM&N option

Sampling calorimeters could be used as prototype for SPD ECal

Module design:

1. KOPIO – 4 cells of 5.5x5.5 cm^2 rectangular shape
2. MPD – 16 cells of 4x4 cm^2 ***trapezoidal*** shape (~ 1 degree)
3. COMPASS – 9 cells of 4x4 cm^2

Ecal's sampling resolution in experiments of last 20 years



Sampling calorimeters summary table

	N	Sc	Pb	N	Num	X0	mm	Pb	Scint	Pb	Sc	Samp.	Sampl.	Const	Noise	Res %
	Tiles	mm	mm	layers	Fibers	n	Length	mm	mm	X0	X0	Fract.	B%	A%	C%	1 GeV
Compass	40x40	1,50	0,80	109	16	15,9	256	87	164	15,5	0,4	14,90	8,9	1,1	1,0	9,02
BMN	40x40	1,50	0,30	220	16	12,6	407	66	330	11,8	0,8	31,83	7,1	2,0	1,0	7,44
MPD	40x40	1,50	0,30	220	16	12,6	407	66	330	11,8	0,8	31,83	3,8	1,0	1,0	4,05
SPD	55x55	1,50	0,30	250	16	14,3	463	75	375	13,4	0,9	31,83	3,8	1,0	1,0	4,05
spiral	38x38	1,50	0,70	170	16	21,8	383	119	255	21,2	0,6	16,68	6,5	1,0	1,0	6,65
phenix	55x55	4,00	1,50	66	36	18,3	366	99	264	17,6	0,6	19,94	8,2	2,1	0,0	8,42
KOPIO	110x110	1,50	0,28	300	144	15,8	548	83	450	14,7	1,1	33,75	2,7	1,9	0,0	3,30
VES	28x38	1,50	0,60	224	16	24,8	482	134	336	23,9	0,8	18,93	8,1	2,0	0,0	8,34
solid	6.25 hex	1,50	0,50	194		18,0	398	97	291	17,3	0,7	21,89	5,2	2,0	0,0	5,57
Alice EMCal	56x6	1,76	1,44	77	36	20,1	256	111	136	19,8	0,3	10,25	11,3	1,7	4,8	12,38
LHCb ECAL	40x40	2,00	4,00	66	16	47,4	399	264	132	47,0	0,3	4,46	10,1	0,9	0,0	10,14
LHCb ECAL	40x40	1,50	0,35	230	16	15,2	449	81	345	14,3	0,8	28,58	4,0	1,0	1,0	4,24
COMPASS	150x150	5,00	20,00	40	1	143,0	1000	800	200	142,6	0,5	2,28	35,0	1,0	0,0	35,01
HCAL_BM&N	150x150	5,00	10,00	64	1	114,8	966	640	320	114,0	0,8	4,46	30,0	1,0	0,0	30,02
HCAL_ALPOM	150x150	10,00	10,00	50	1	90,3	1000	500	500	89,1	1,2	8,54	20,0	1,0	0,0	20,02

Ecal of KOPIO

- The best resolution for the "shashlyk" type calorimeter has been achieved by the KOPIO collaboration. A quadratic fit to KOPIO experimental data gives

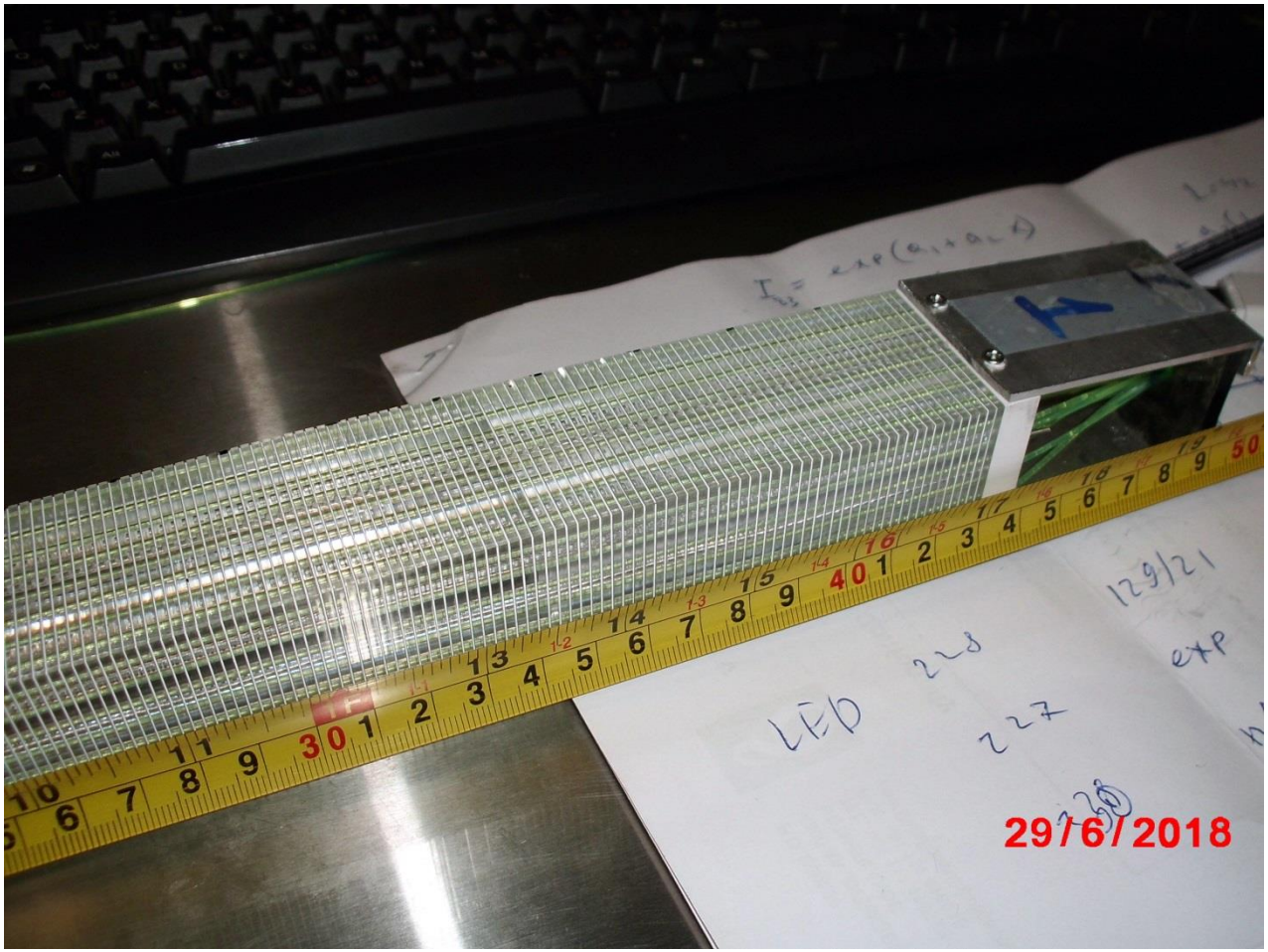
  $$\mathbf{\sigma(E)/E = (1.96 \pm 0.1)\% \otimes (2.74 \pm 0.05)\%/p(E)(GeV),}$$

  where $\otimes$ means quadratic summation.
- photo statistics and no uniformity of light collections add to the total energy resolution $2.1\%/\sqrt{E}$ and $1.8\%/\sqrt{E}$, respectively.
- Attention should be paid to improving the quality of scintillator, optical and mechanical, and to selecting the photo-detector with higher quantum efficiency.

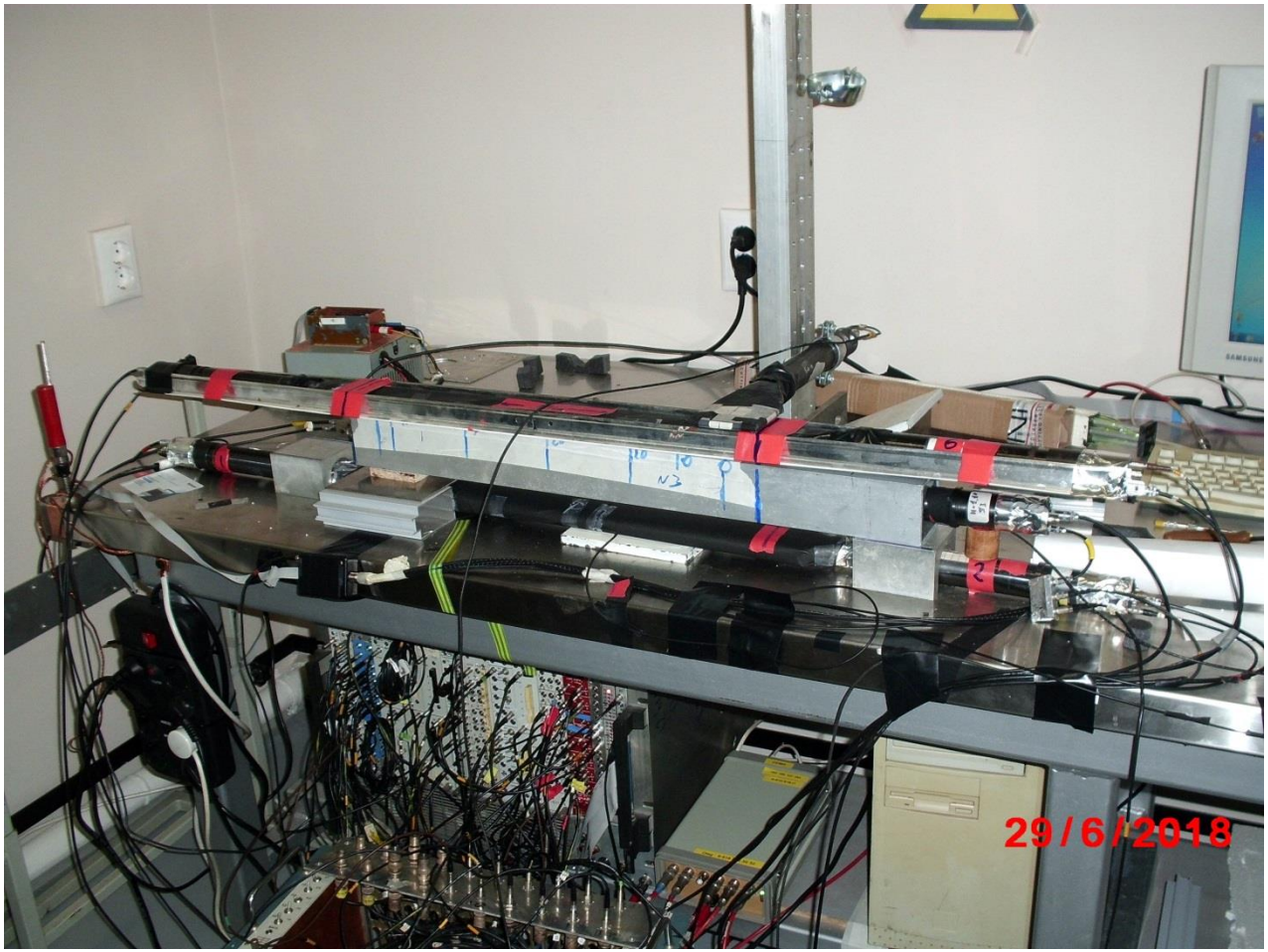
The table of shashlik modules types and where energy resolution

Generation of Shashlyk module	Sampling		N, layers	X_0, cm	WLS fiber		Photo Detector	$N_{p.e.}$, muon	$N_{p.e.}$, 1 GeV photon	Energy resolution, %					
	Sc, mm	Lead, mm			Type	D, mm				Sampling term	Photo statistic term	Constant term 1)	Noise term 2)	Instability of P. D. 3)	Total (1 GeV photon)
1	4.0	1.40	60	2.2	BCF-92, SC	1.2	PMT FEU-85	320*	1200**	5.6	2.9	3.2	0.0	3.2	7.9**
2	1.5	0.35	240	3.1	Y11(200)M, DC	1.0	PMT EMI-9903B	1080*	3600**	2.7	1.7	2.1	0.0	1.1	4.0**
3	2.0	0.35	240	3.8	Y11(200)M, DC, S-type	1.0	PMT EMI-9903B	1860*	6200	2.5	1.3	2.1	0.0	1.1	3.7
3	2.0	0.35	240	3.8	Y11(200)M, DC, S-type	1.2	PMT EMI-9106B	2300	7600	2.5	1.1	2.1	0.0	0.3	3.5
4	1.5	0.25	320	3.8	Y11(200)M, DC, S-type	1.2	PMT EMI-9106B	1900	6300	2.1	1.2	2.1	0.0	0.3	3.3
3	2.0	0.35	240	3.8	Y11(200)M, DC, S-type	1.0	PIN diode 18x18 mm²	17,700*	59,000	2.5	0.4	2.1	4.0	0.0	5.2
3	2.0	0.35	240	3.8	Y11(200)M, DC, S-type	1.0	Drift PIN diode C_{pd} = 0 pF	16,000	52,000	2.5	0.4	2.1	1.7	0.0	3.7
3	2.0	0.35	240	3.8	Y11(200)M, DC, S-type	1.0	APD 10x10 mm² M = 50	16,000	40,000	2.5	0.5	2.1	0.1	0.0	3.3
5	1.5	0.25	320	3.8	Y11(200)M, DC, S-type	1.0	APD 10x10 mm² M = 50	10,000	32,000	2.1	0.6	2.1	0.1	0.0	3.0

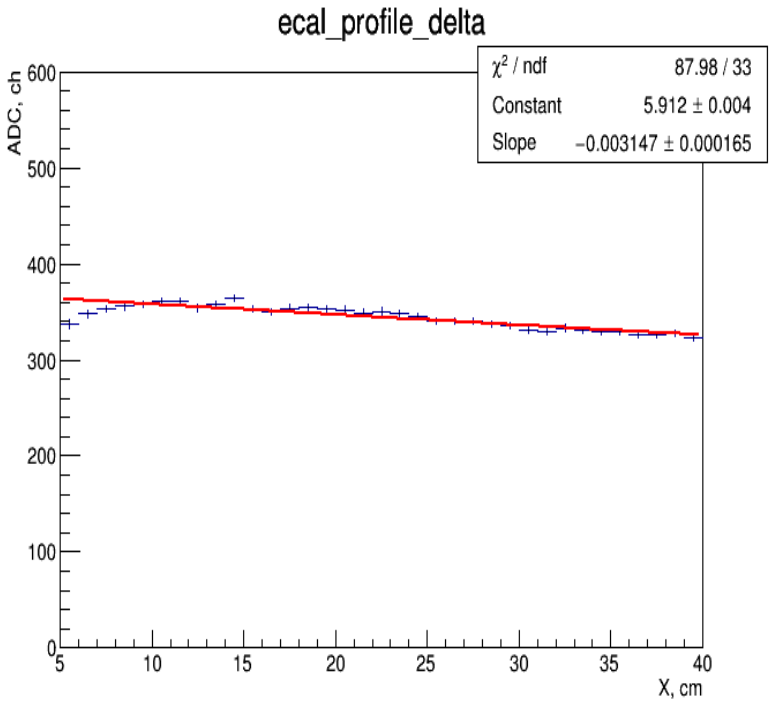
MPD first module assembling to tesr wrapping and mirror conditions

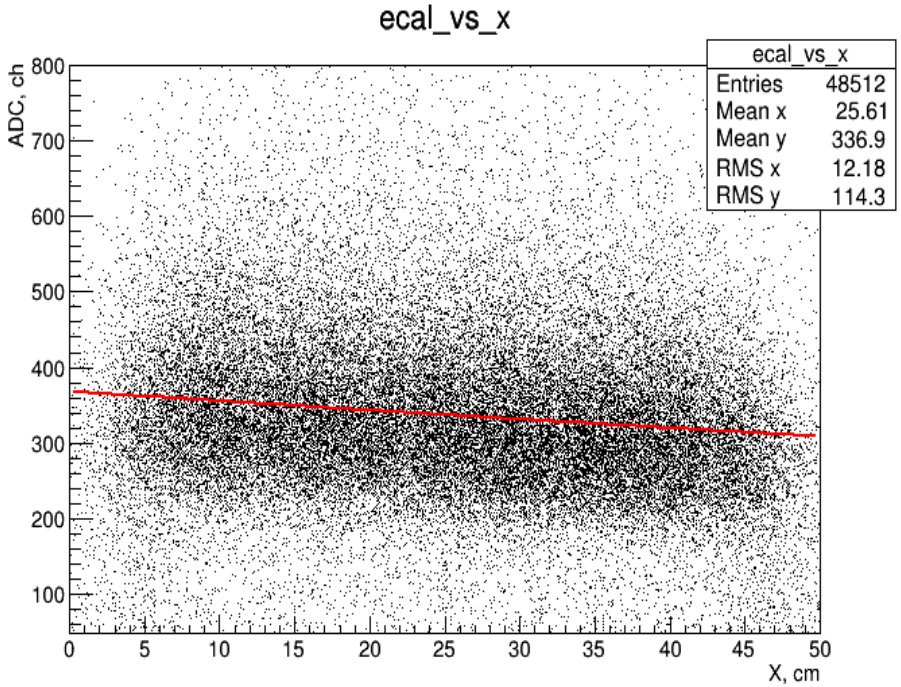


Experimental setup for module uniformity measurement by time of flight method



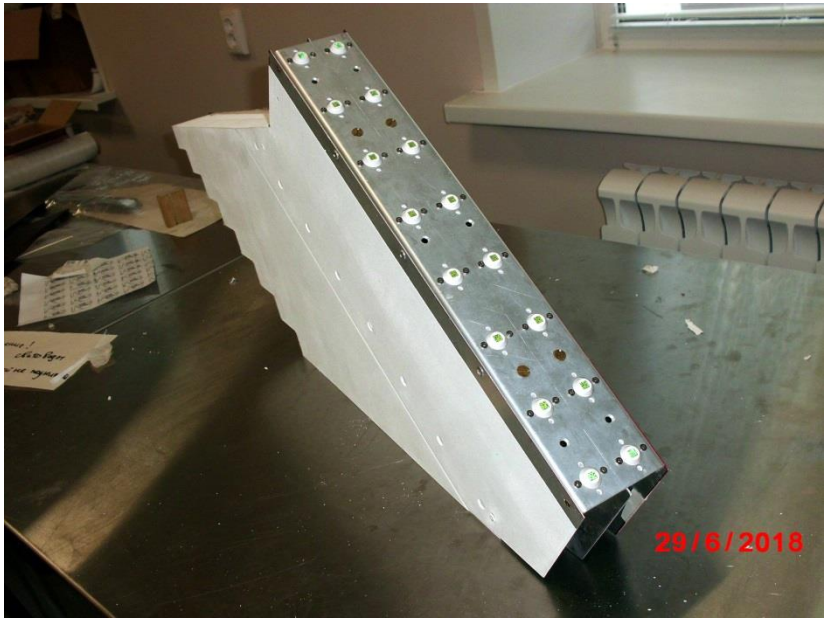
The results of uniformity measurements

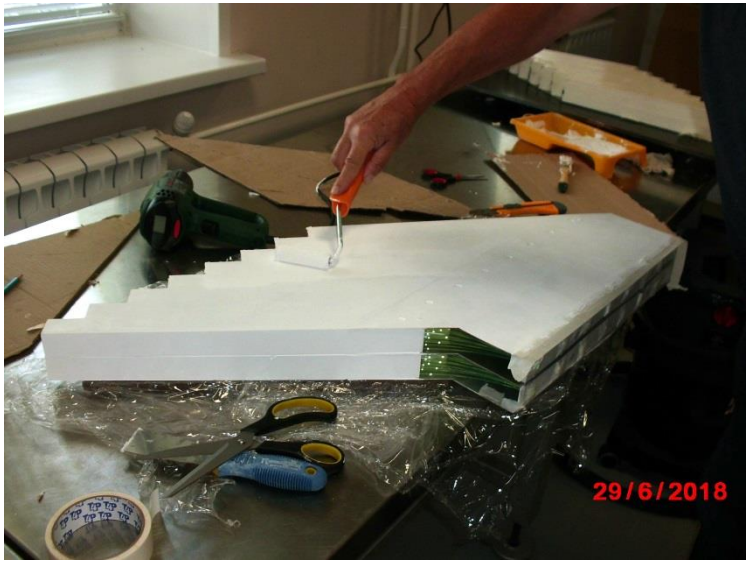


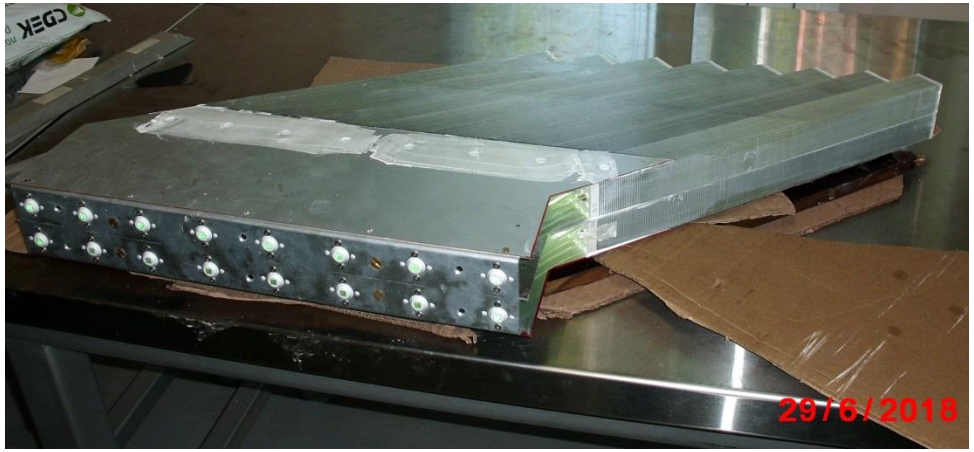


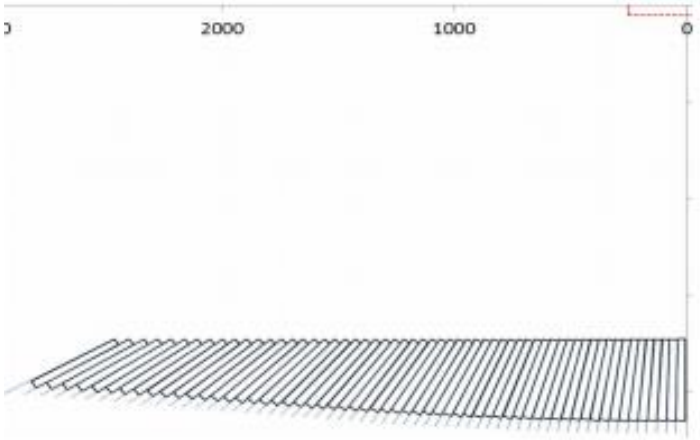
- Mirror : Silver paint : <A>=337, Slope: : L_0=318cm
- Tyvek wrapping
- Statistic taken during 12 hours.

MPD module first assembling
file:///C:/Users/oleg/Documents/TDR_ECAL_v2.1%20(1).pdf

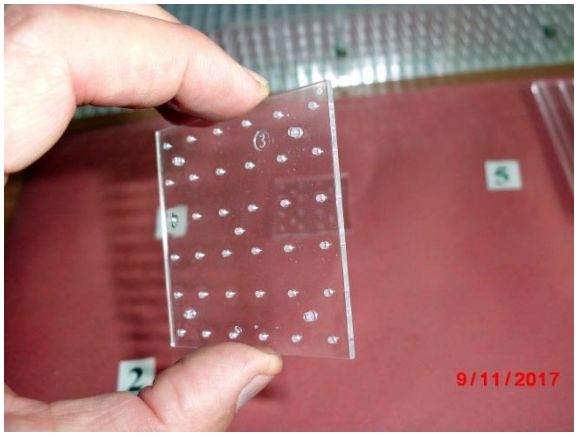


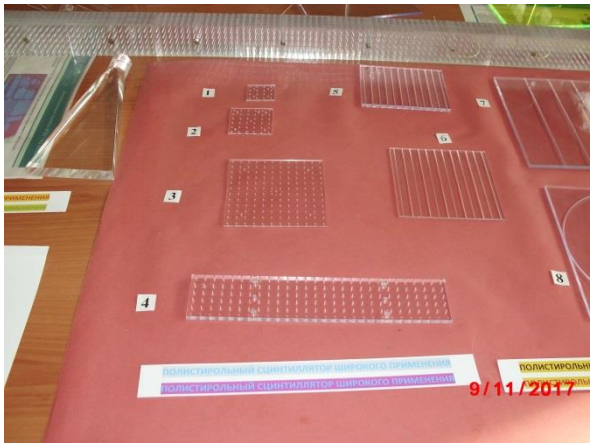






Molding machine and scintillator tiles examples



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KOPIO module design

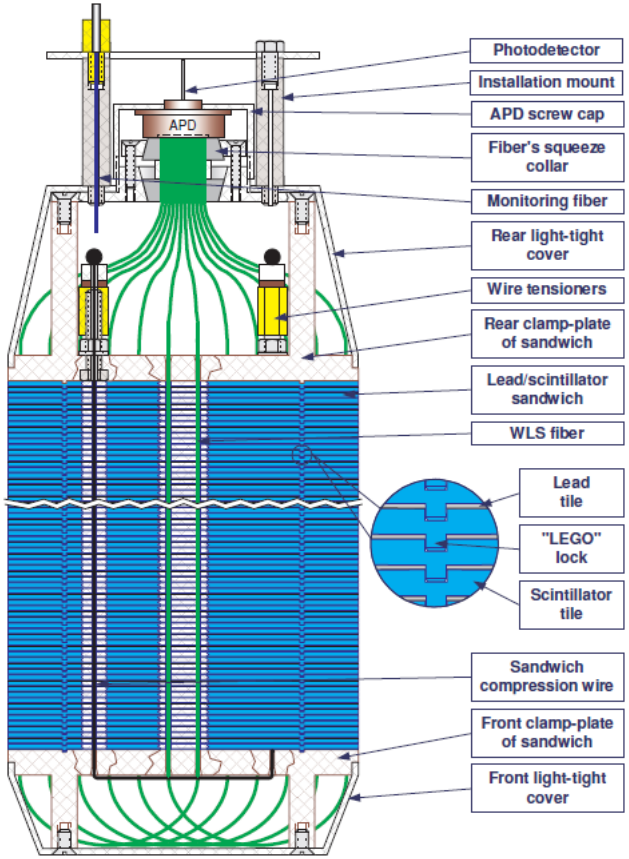

Fig. 1. The Shashlyk module design.

Prototype for SPD Ecal and front end electronic

ADC64 board used for signals digitizing

https://afi-project.jinr.ru/projects/adc64-sw/files

As a FE electronics unit we have designed and constructed ADC 64 channel. ADC board is a waveform digitizer. It quantize analogue input signal and samples it at fixed time intervals. Zero suppression logic is based on baseline estimation and threshold value. Signal shaping is performed in digital form with FIR filters. It allows to reduce the number of waveform points required for digital signal representation with minimum loss of accuracy. The ring type memory allows the read back of last 30 μs of waveforms.

Possible ECal prototype:
should be an optional KOPIO improved module

- **End of report**
- **Thanks all for attention**