THE CBM ECAL

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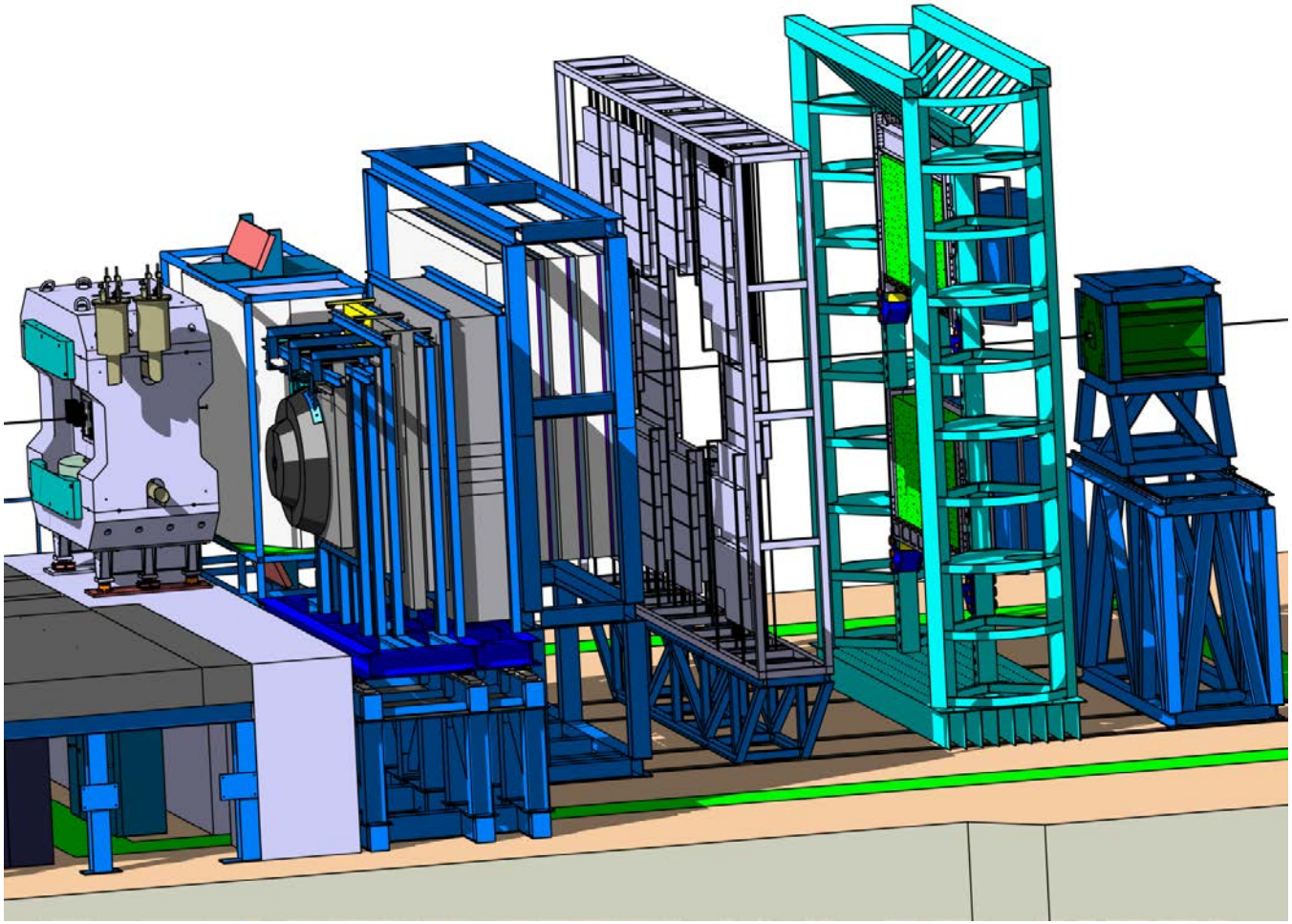
The CBM detector



Designed to study Compressed Barionic Mater – P.Senger talk
key feature – very high occupancies, free streaming data taking

Electromagnetic calorimeter

Long history – more than 14 years of optimization studies

"Shashlik" technology was chosen – relatively chip

Fast response, easy choice of granularity

Developed in Russia in 20th century

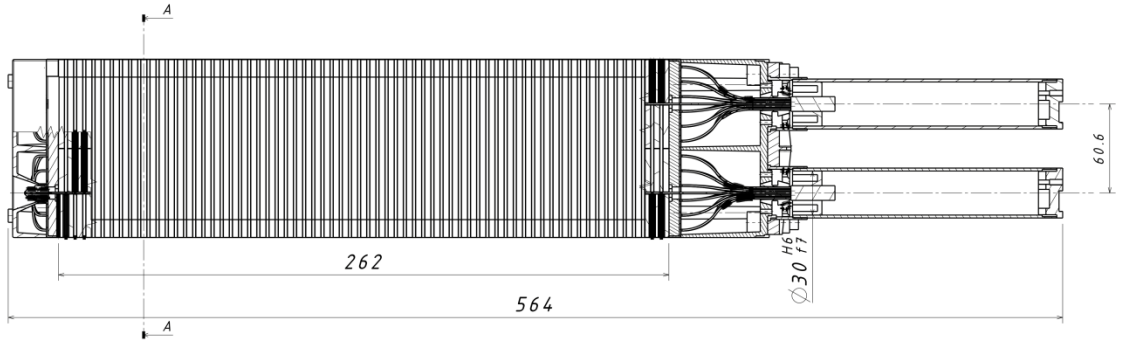
Calorimeters in PHENIX, HERA-B, LHCb (and other)

Full technology chain in hands – a lot of experience

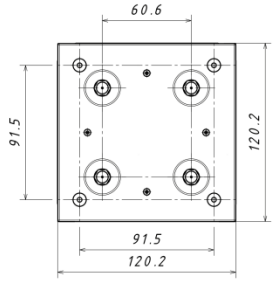
ECAL for the CBM:

- energy resolution (5-6)%/$\sqrt{E}$
- small Moliere radius – thin plastic plates
- main limiting factor - price

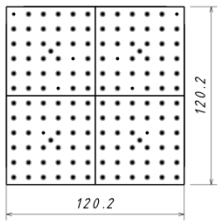
“Shashlik” module



Front view
Scale: 1:2

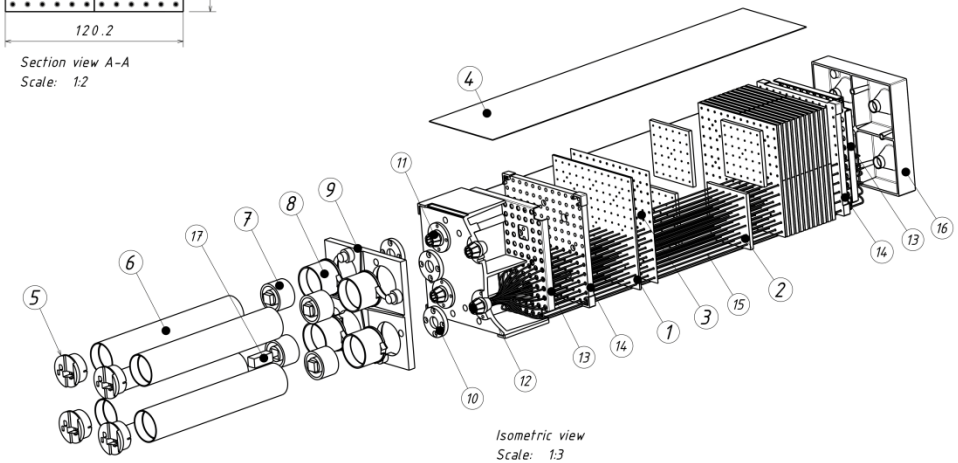


Left view
Scale: 1:2



Section view A-A
Scale: 1:2

Stack of modules	Pb	Sc
Dimension (mm)	120x120	59.9x59.9
Thickness (mm)	1	1
Weight (kg)	0,163	0,0043
Total weight (kg)	20,2	2,1



Isometric view
Scale: 1:3

QUANT	DESCRIPTION	POS	MAT.	OBSERVATIONS
	ENS/ASS		S.ENS/S.ASS	
4	LIGHT MIXER	17	GLASS	
1	LOOP COVER_4	16		CBME__0038
76	WLS FIBER CURVED R=15 MM	15	Kuraray WLS	CBME__0037
2	SPACER FOR GRATING_4x36	14		CBME__0036
2	PRESSING GRATING_4X36	13	Stainless steel	CBME__0035
1	FIBER HOUSING_4	12	ABS	CBME__0034
4	GRIP_37	11		CBME__0033
4	GRIP MOUNT_37	10	Aluminum	CBME__0032
1	PLASTIC PLATE_4	9	ABS	CBME__0031
4	FERRULE FOR PM MUFF	8		CBME__0030
4	LIGHT MIXER HOLDER	7		CBME__0029
4	MUFF FOR PM	6		CBME__0028
4	SHANK FOR PM	5		CBME__0023
4	STEEL BAND	4	Stainless steel	CBME__0022
123	TYVEK	3	TYVEK	CBME__0017
500	SCINTILATOR TILE_36	2	Polystyrene+Sc	CBME__0004
124	PB PLATE	1	Pb99.1+Sb5+Sn0.3	CBME__0002

CBM ECAL DETECTOR

MIDDLE MODULE

SCALE

DES/DRA. A. SEMENNIKOV 2014-12-20
CONTROLLED
RELEASED
APPROVED

REPLACES

ITEP NOT VALID FOR EXECUTION Q.AC - CBME__0039 SIZE 2 IND.

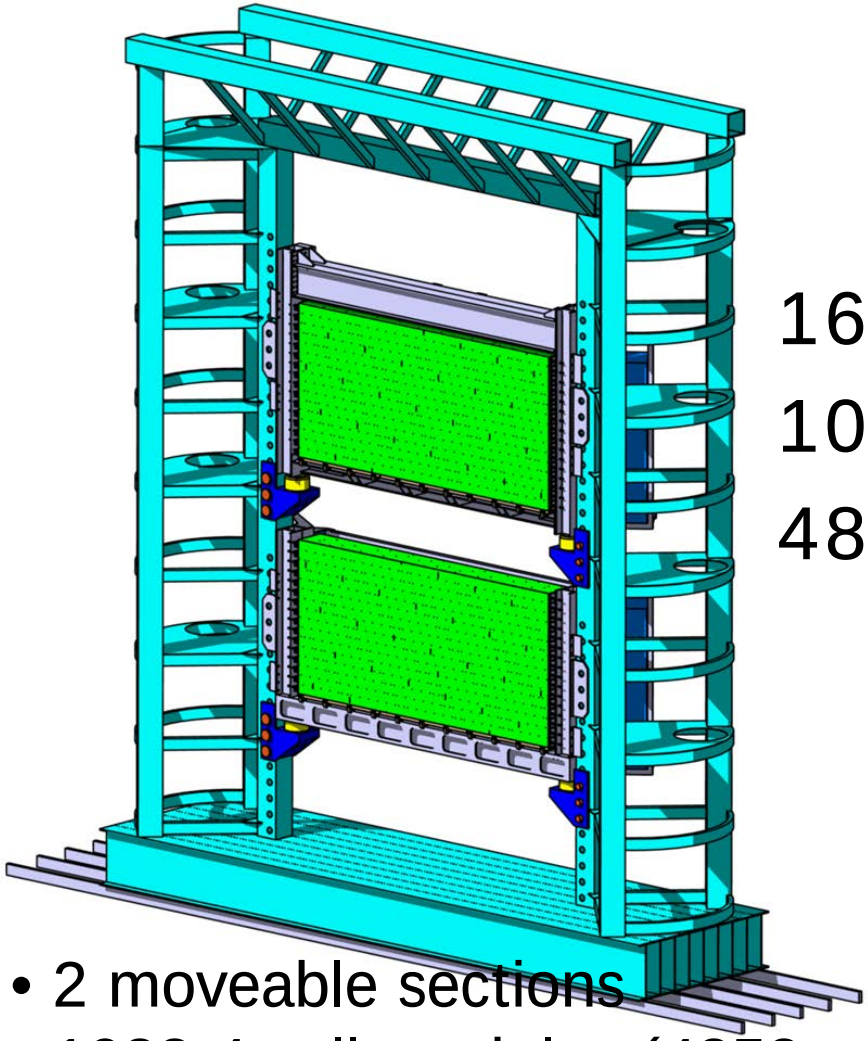
DRAWING RIGIDITY TOLERANCES ACCORDING TO GOST STANDARDS

PROJECTION

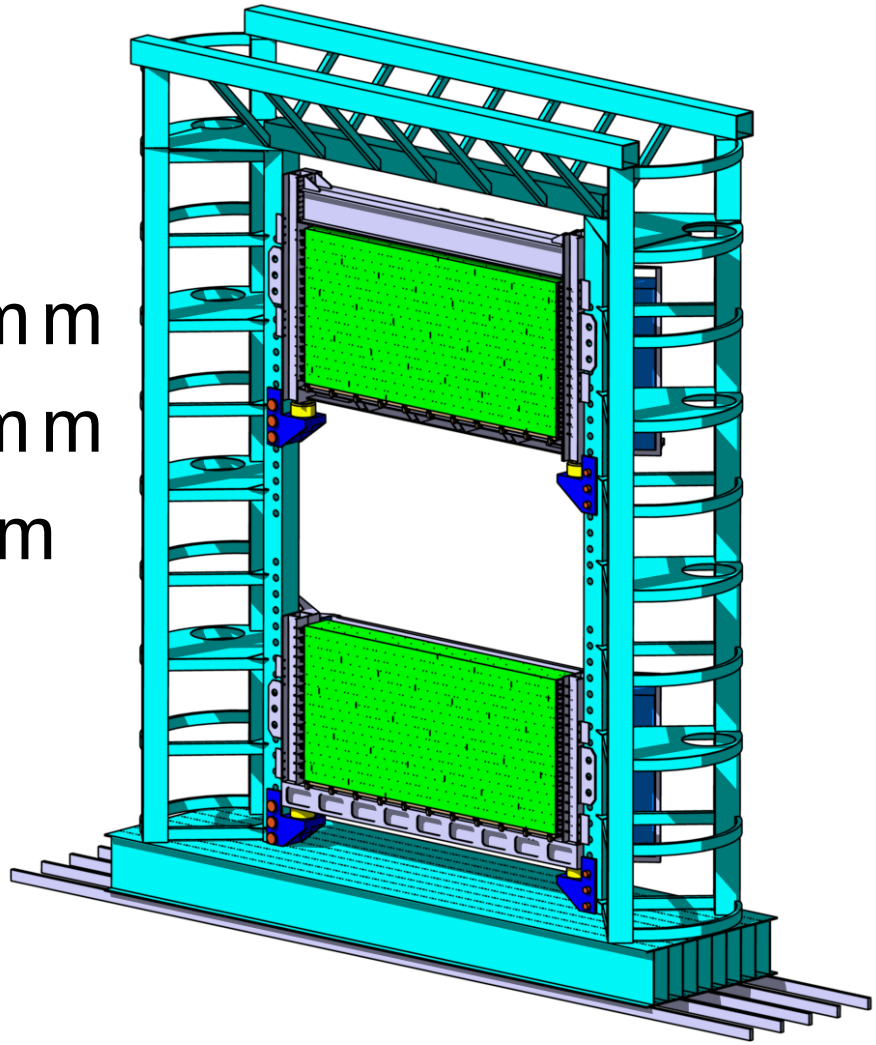
ITEP

This drawing may not be used for commercial purposes without written authorization

The CBM ECAL



1680 mm
1080 mm
480 mm



- 2 moveable sections
- 1088 4 cell modules (4352 cells)
- 6x6 cm^2 cells
- weight ~28 tons

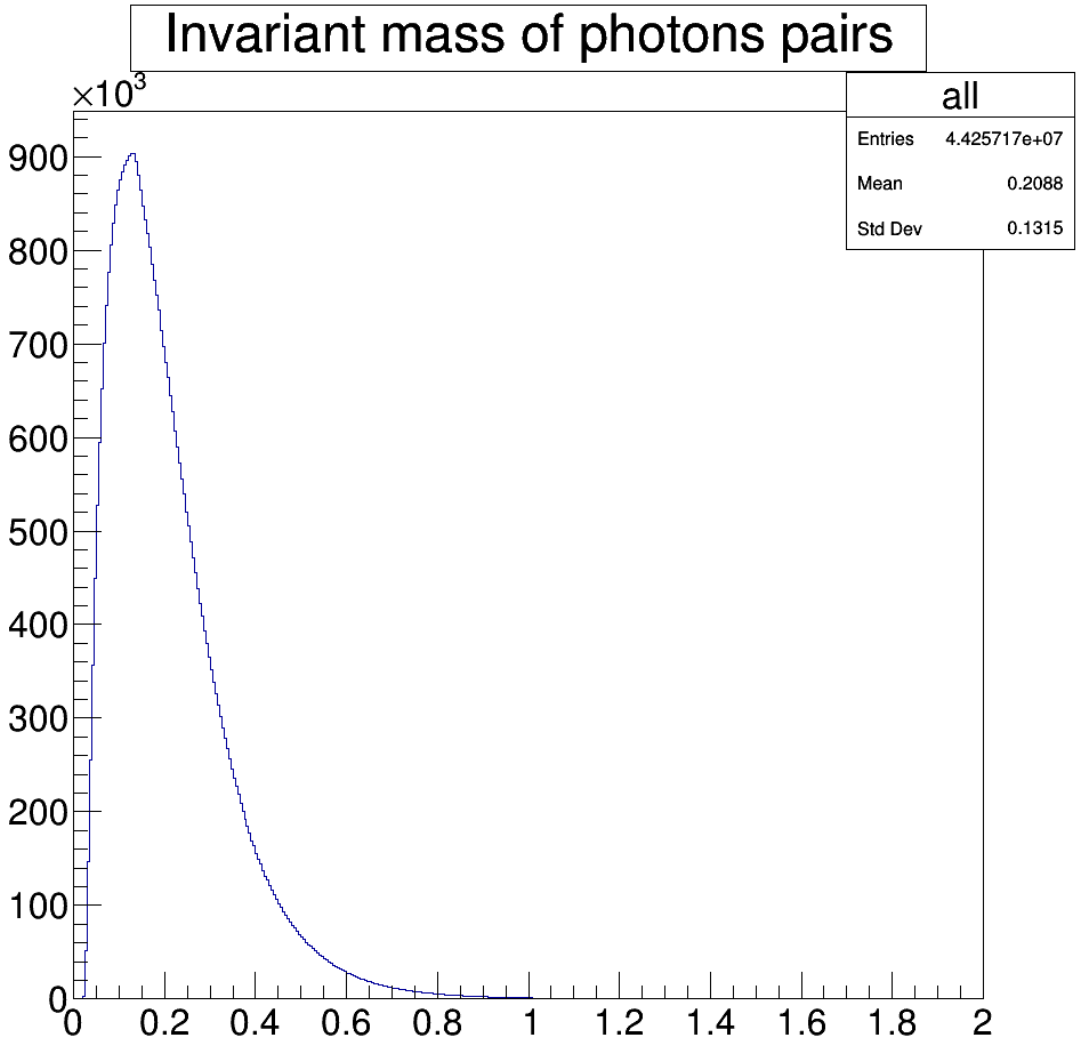
Reduced ECAL acceptance to minimize the price.

The CBM ECAL

Physics tasks for the ECAL:

- reconstruct photons
- reconstruct π0 and η mesons
- identify electrons

π0 and η reconstruction

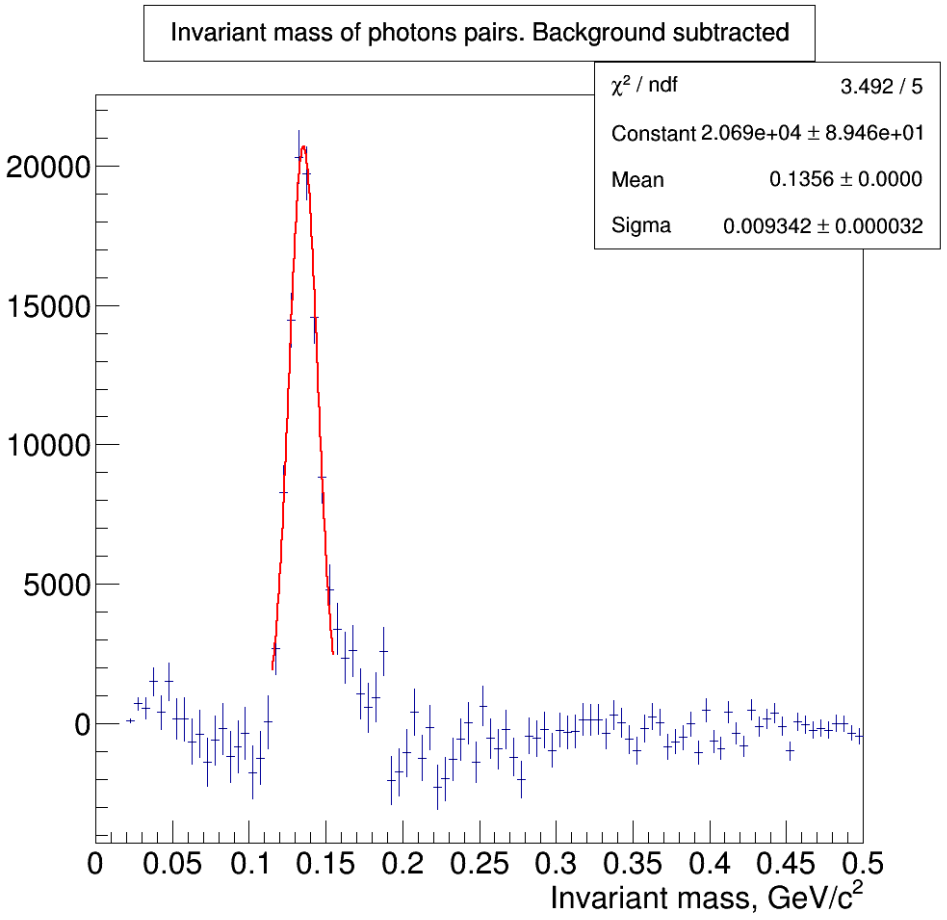


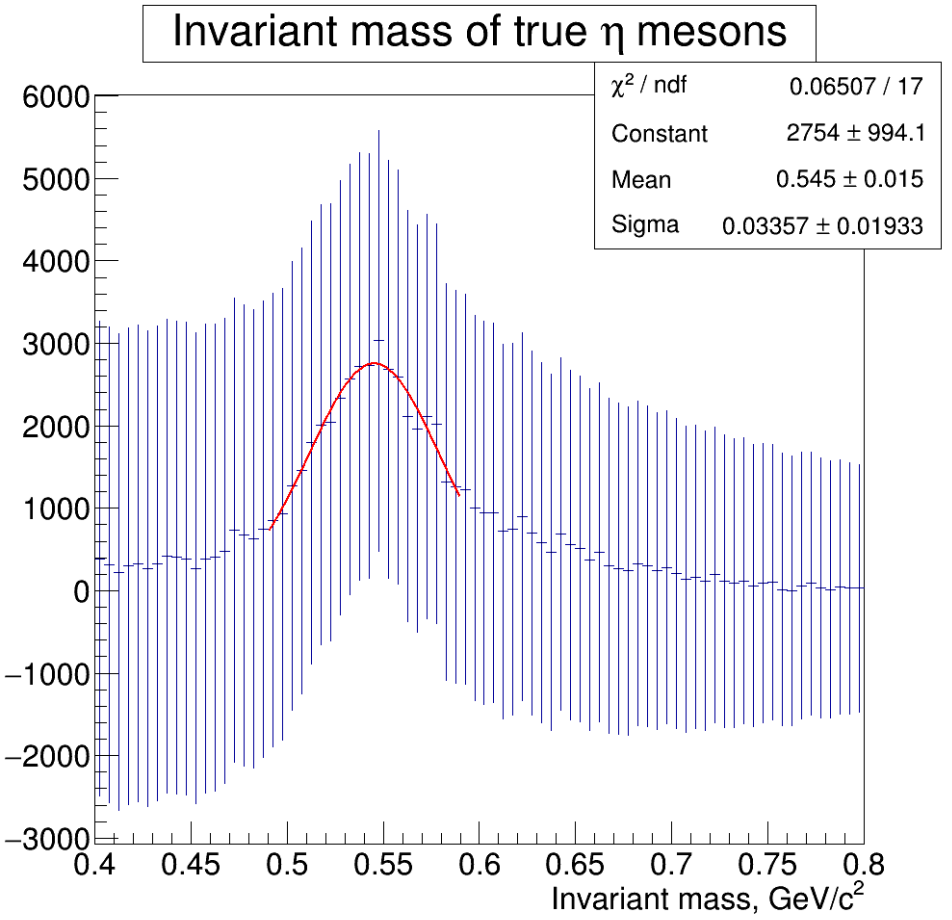
AuAu MC

Combinatorial background is huge – special methods are required

π0 and η reconstruction

Background subtracted signals in Au+Au collisions (1.5M events)





honest background subtraction

MC truth usage

photons, π0 and η reconstruction

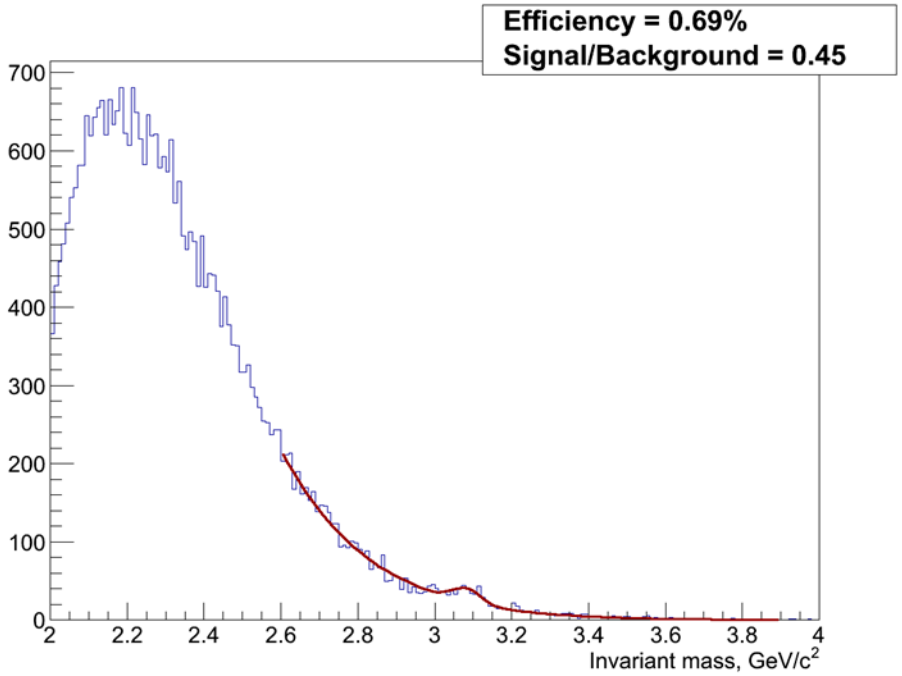
Summary table (for J/ψ optimized setup)

	Photons	π^0	η
pC 30 GeV	Eff=19.9%	Eff=5.27% S/(S+B)=0.66	Eff=2.95% S/(S+B)=0.035
NiNi 10 AGeV	Eff=20.9%	Eff=6.40% S/(S+B)=0.071	Eff=3.62% S/(S+B)=0.0012
AuAu 10 AGeV	Eff=14.0%	Eff=3.54% S/(S+B)=0.014	Eff=1.83% S/(S+B)=0.00022

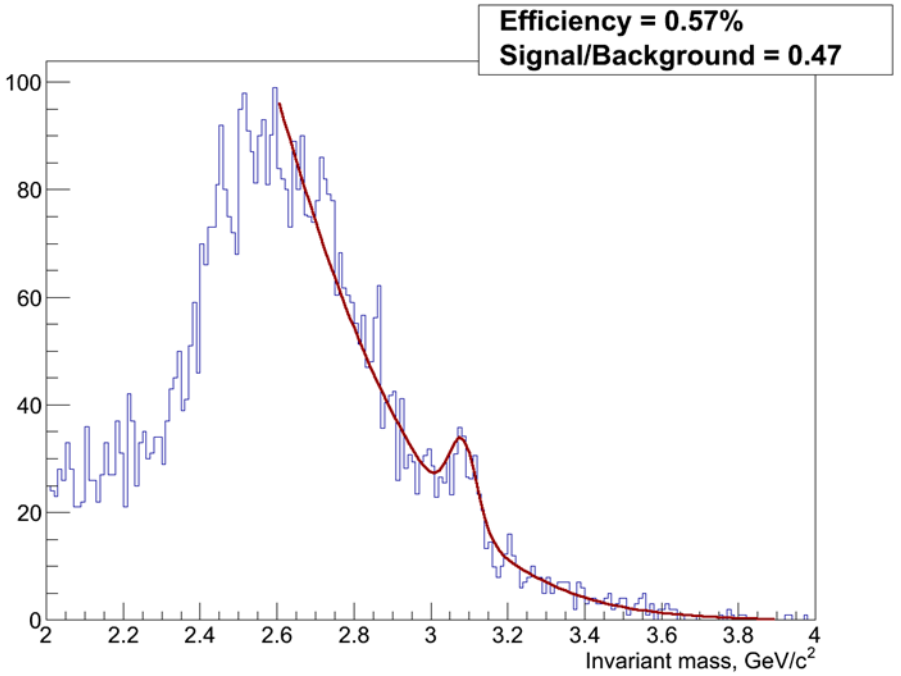
Different angular distributions for pC 30 GeV and NiNi 10 AGeV.
Difference between NiNi 10 AGeV and AuAu 10 AGeV is due to occupancy.

J/ψ reconstruction

P_T>1.0 GeV



P_T>1.2 GeV



- Efficiency 0.69%
- S/B 0.45
- ~60 reconstructed J/ψ per day at 10 MHz

AuAu 10 AGeV central events

HSD J/ψ multiplicity 1.74×10^{-7}

“Radiative” decays of other particles

- $\omega \to \pi^+\pi^-\pi^0$ (eff=5.0%, S/B=0.02)
- $\eta' \to \gamma\gamma$ (eff=1.0%, S/B=0.01)
- $\Sigma^+ \to p\pi^o$ (eff=0.35%, S/B=0.08)
- $\Sigma^o \to \Lambda\gamma$ (eff=1.0%, S/B=0.09)

	$\omega \to \pi^+\pi^-\pi^0$	$\eta' \to \pi^+\pi^-\eta$	$\Sigma^+ \to p\,\pi^0$	$\Sigma^0 \to \Lambda\,\gamma$
Yield/event	0.028	0.009	0.017	0.029
For “closed” ECAL sections				
acceptance %	2.9	1.2	1.4	3.1
total efficiency %	1.5	0.57	0.17	0.33
S/B ratio	0.024	0.008	0.05	0.09
for “opened” ECAL sections				
acceptance %	0.8	0.4	0.4	2.0
total efficiency %	0.4	0.1	0.04	0.16
S/B ratio	0.024	0.01	0.05	0.11

ECAL performance is limited by acceptance.

electronics

Work of I.Alekseev, D.Svirida and KI group

Typical PMT signal:

rise time	6ns
fall time	36ns
average occ.	25%
average rate	2.5 MHz
Overlap prob.	13%

250 MHz sampling rate

Digitization - Texas Instruments flash ADC ADS62P19 (cheap)

Processing - field programmable gate array XC7K160T (8 ch)

bus control and communication - Xilinx XC7K160T

electronics

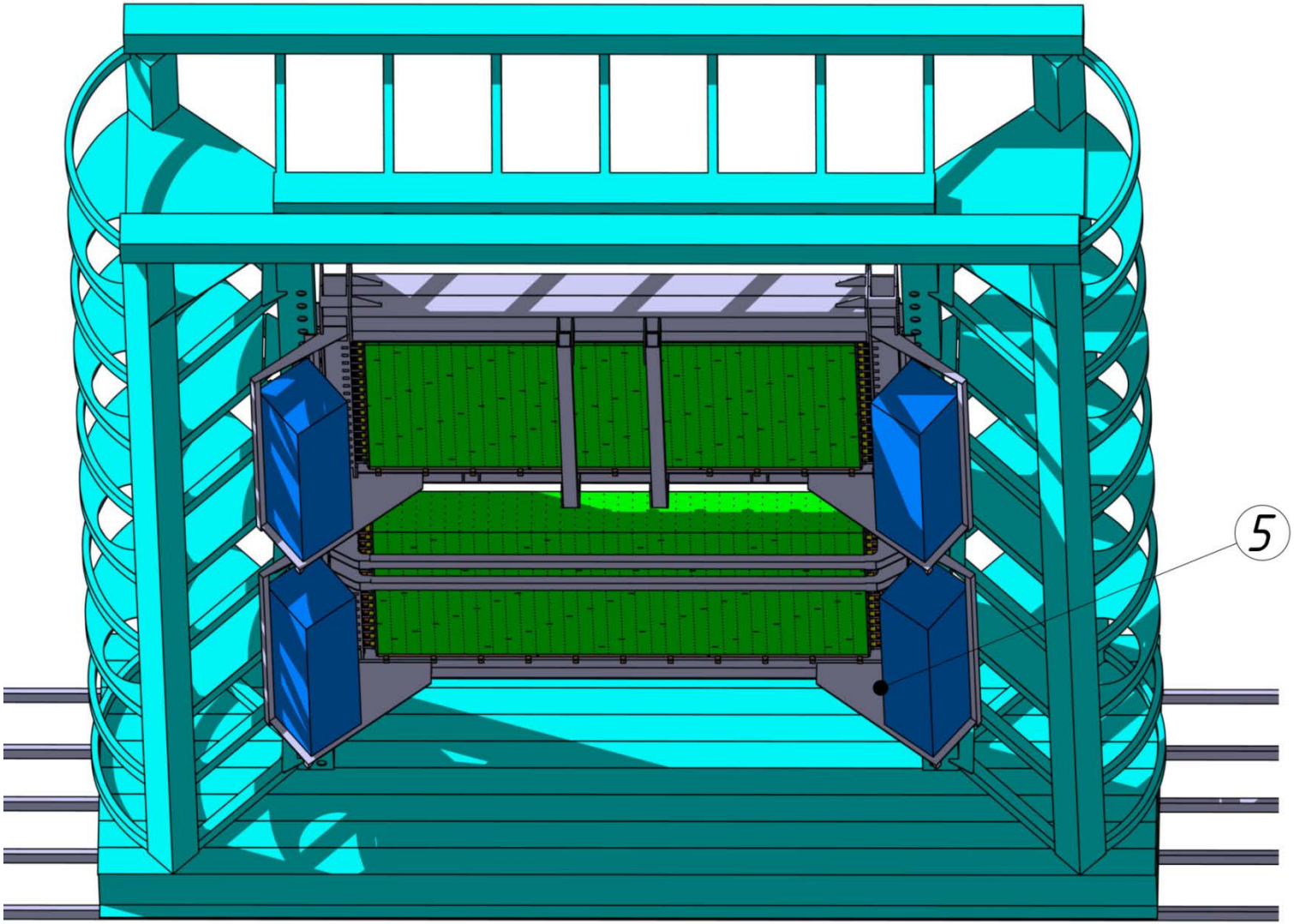
UWFD VME64 module:

- Serves 32 channels
- Process signals (resolve overlapping signals)
- Send data to DAQ via 10 Gbit optical link

4352 ECAL cells + 68 PiN monitoring – 160 modules

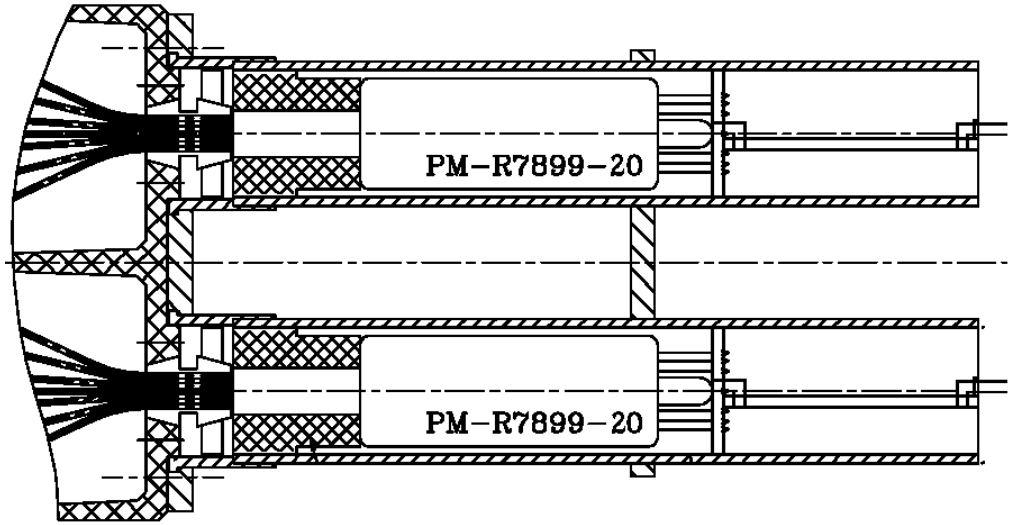
(some reserve for the central region with high occ.)

electronics



Main requirement – to ensure immobility of all cables during movement of ECAL sections

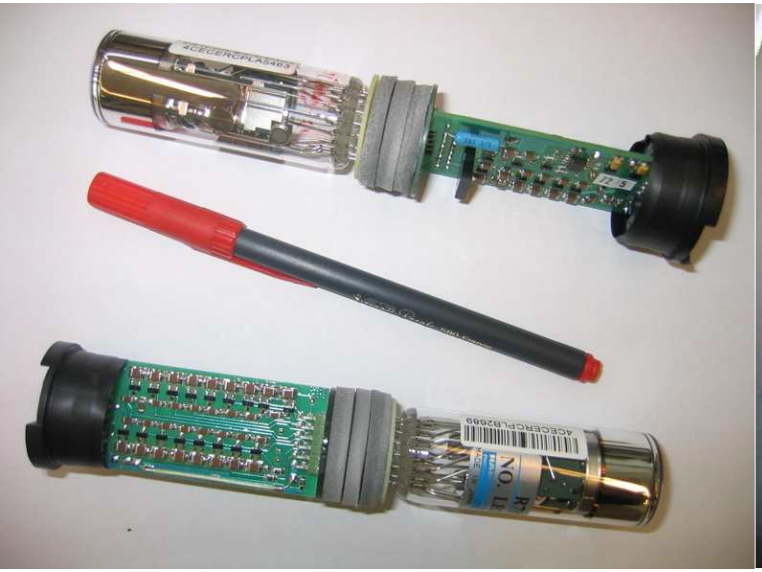
PMT and CW (as in LHCb)



Hamamatsu R7899-20

Cockcroft-Walton LHCb design

Proved to be very robust at the LHCb ECAL (higher radiation)



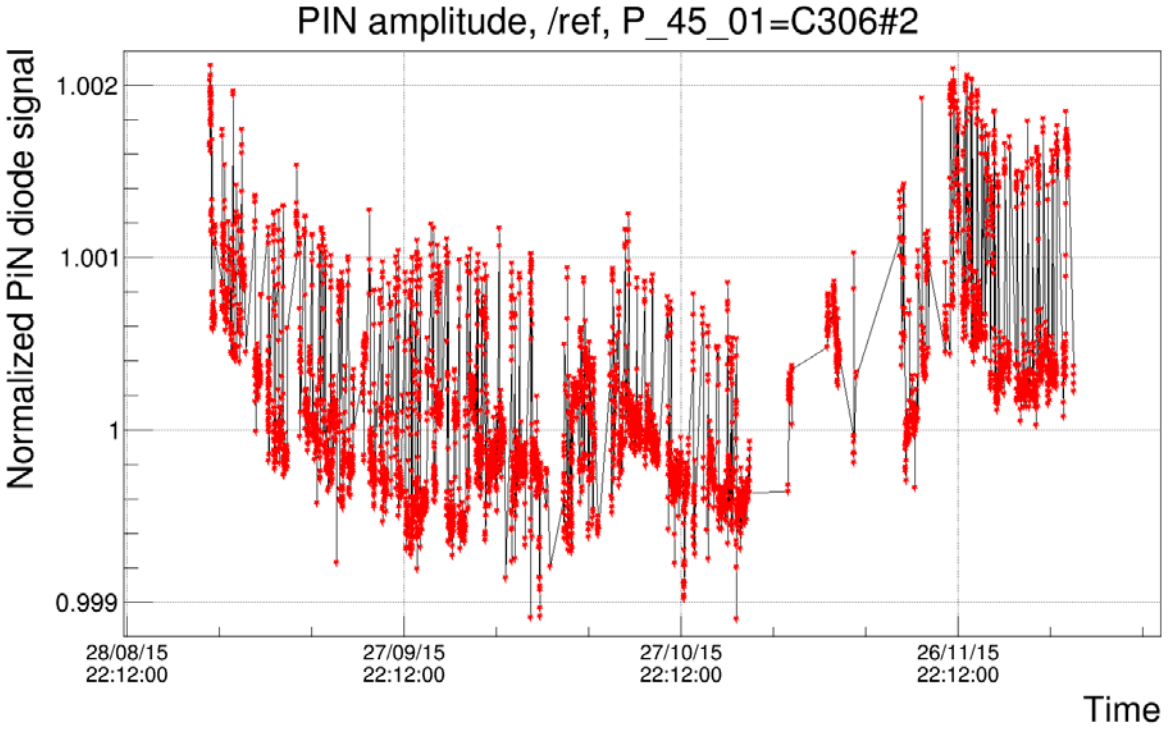
Monitoring system (as in LHCb)

Monitoring system has to provide gain control for all calorimeter phototubes with better than 0.5% accuracy

1 LED send light to 16 ECAL cells - 272 LEDs

1 PiN diode controls 4 LEDs - 68 PiN diodes

Quartz fibers are transporting light from LEDs to ECAL cells



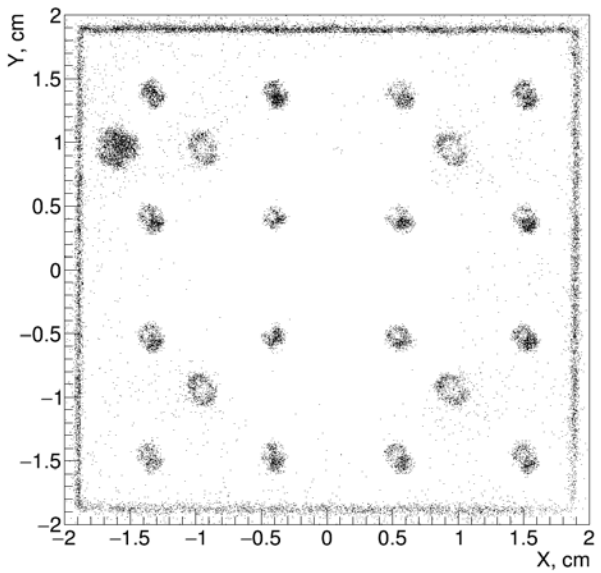
Stability of PiN diode during 3 months tests at CERN

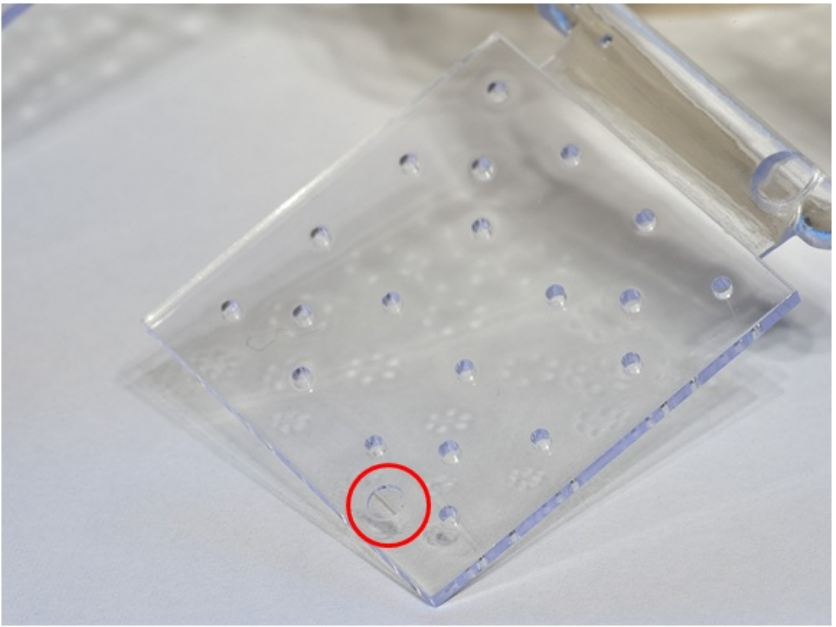
Tests of prototypes (CERN SPS)

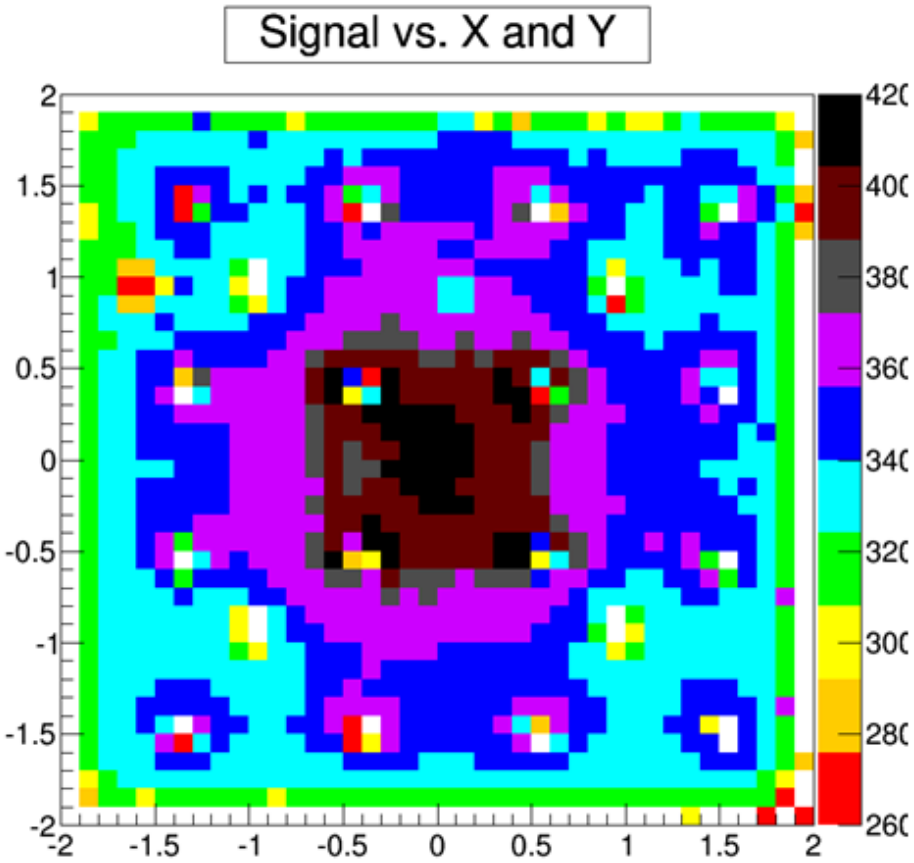
Measuring:

- transverse light collection uniformity with muons (need for MC)
- absolute light yield

Tests of prototypes (CERN SPS)







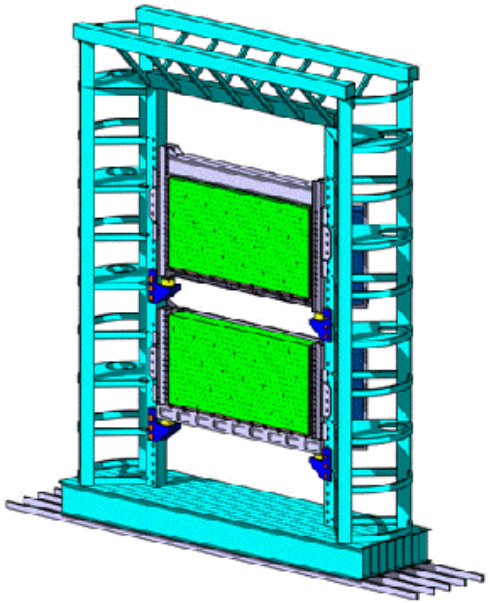
Light yield – 2060 +/- 95 p.h.e. per GeV

Compressed Baryonic Matter Experiment

Technical Design Report for the CBM

Electromagnetic Calorimeter (ECAL)

The CBM Collaboration



March 2016

TDR has been sent to collaboration management on April 9.

Got questions from collaboration

Now we are working on a final version

Looking for interested groups to collaborate