Electron Muon Ranger (EMR) Commissioning

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EMR commissioning time line

$\leq$ September 2013

$\rightarrow$ Construction of the detector in Geneva

$\rightarrow$ Commissioned with cosmic data, no dead channels

End of September 2013

$\rightarrow$ Installation of the EMR in the MICE

$\rightarrow$ Hardware and software integrity tested with cosmic DAQ

October 2013

$\rightarrow$ 3-4 weeks Step I beam DAQ

March 2014

$\rightarrow$ Detector's 2832 channels fully calibrated with cosmics (Step I)

October 2014

$\rightarrow$ EMR readout hardware extensively upgraded

$\rightarrow$ Commissioning of the detector after the upgrade (Step IV)

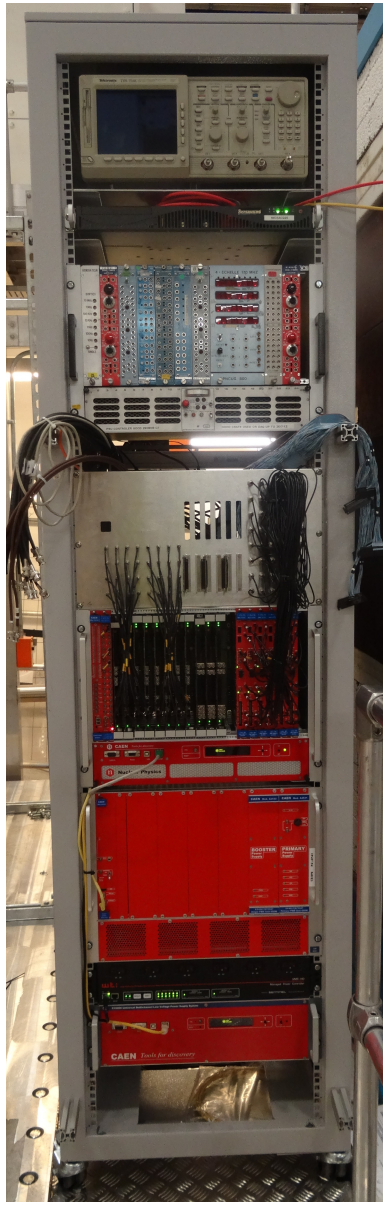
Issues fixed since the October 2014 update

PROBLEM	SOLUTION
1 VHDC fails to configure its FEBs	Spare cable used (✓)
New HVPSU won't start	Controller fixed by CAEN (✓)
LED LV channel malfunctioning	Channel fixed, spare received (✓)
Cosmic DAQ code bugging	Fixed on site (✓)
2 noisy MAPMTs (in planes 9, 10)	Not overflowing * (✓)
1 of the new SAPMT down	Replaced, fixed (✓)

EMR Rack Elements

Controls and power supplies:

- 47 U rack
- AC fan system (back of the rack, top of the rack, EMR box)
- Remote controlled AC power supply
  → general switch, needs update for individual
- HVPSU (photomultipliers)
- LVPSU (trigger distribution boards, LED driver, fans)
  → new LVPSU arrived and installed
- New VME (and NIM) crate(s)
  → VME crate remote controlled through `telnet`



EMR Hardware: LVPSUs

LVPSU 1

- 1 channel for the LED driver
- 1 channel for the fans
- 1 channel for the fan-out boards

→ Fully operational, LED channel fixed since April

New LVPSU 2

- 2 channels for 48 FEBs ($\sim$ 35 A)
- 1 channel for 48 DBBs ($\sim$ 25 A)

→ OVC fixed, fully functional since April

(✓) Both LVPSUs are controllable remotely using `telnet`

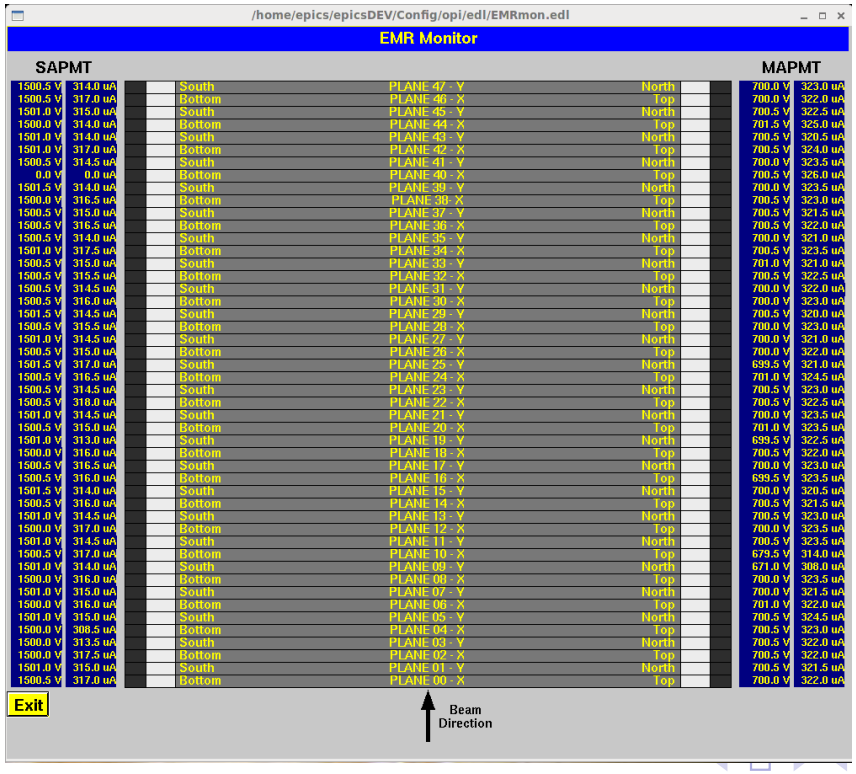
EMR Hardware: HVPSU

120 channels HVPSU

- 48 channels for the SAPMTs (1500V)
- 48 channels for the MAPMTs (700V)
- 1 dead channel, 23 spares left

$\rightarrow$ Fully operational and stable

(✓) Accessible remotely, first pass at the controls (Hanlet)



EMR electronics: new SAPMTs since October 2014

Measured mean charge for MIP signals:

- acquisition of 150k MIP-like signals in the range (1100-1900)V
- measurement of the mean charge for each setting

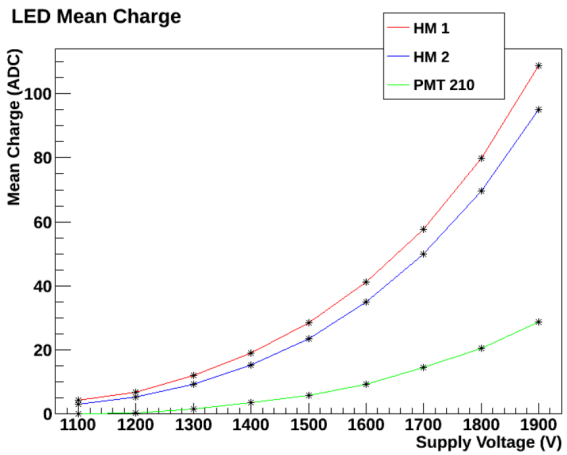
$\rightarrow \overline{Q_{Hm}} \gg \overline{Q_{Ph}}$ over the whole range

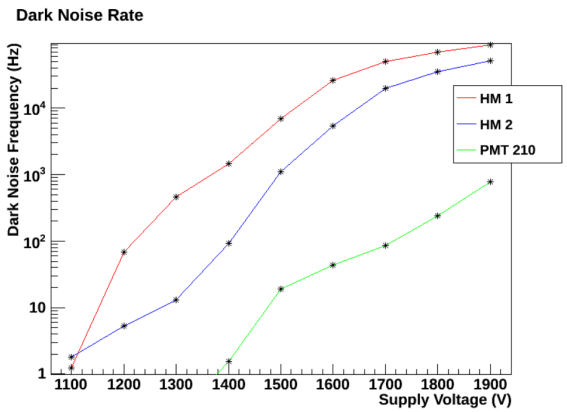
Measured level of dark noise:

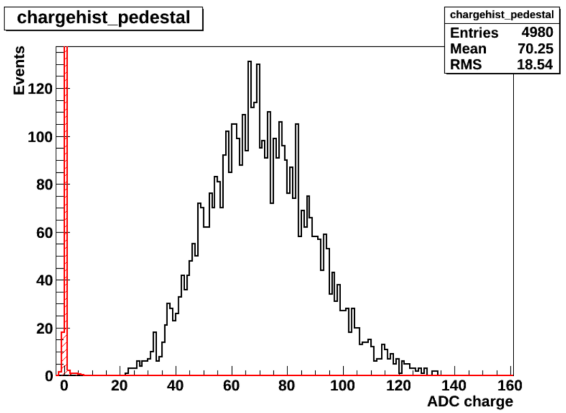
- recording of the DN frequency over 5 minutes in the same range
- measurement of the average DN frequency for each setting

$\rightarrow$ DN 2 orders of magnitude higher for Hamamatsu PMTs

$\rightarrow$ Not to worry, as the DN/Signal separation is ensured



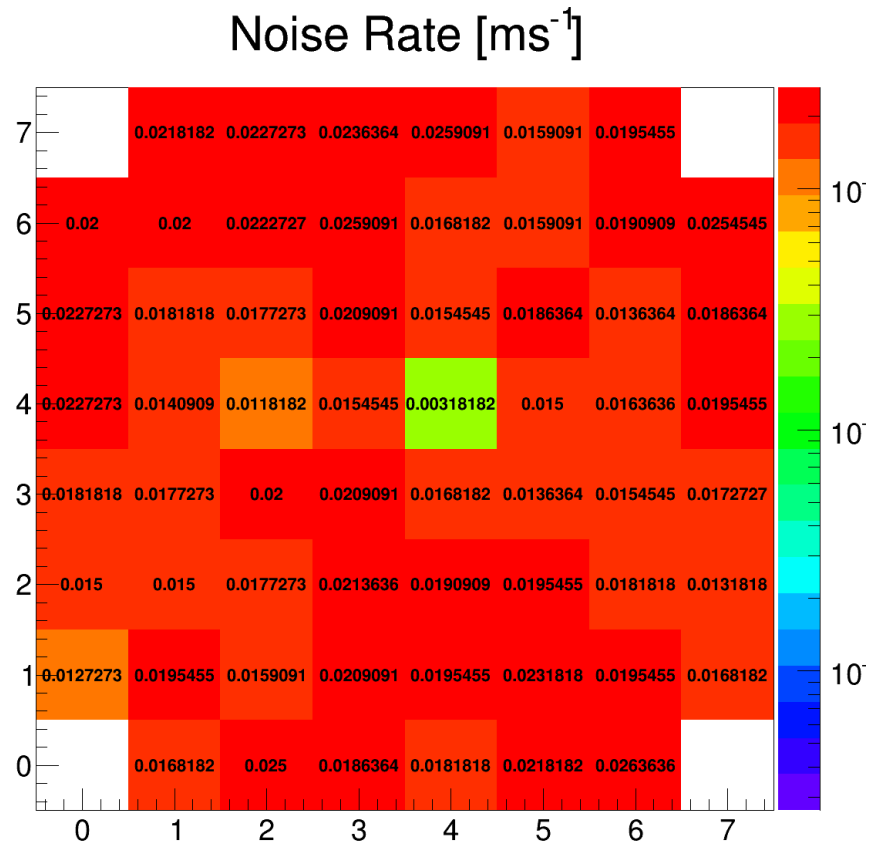


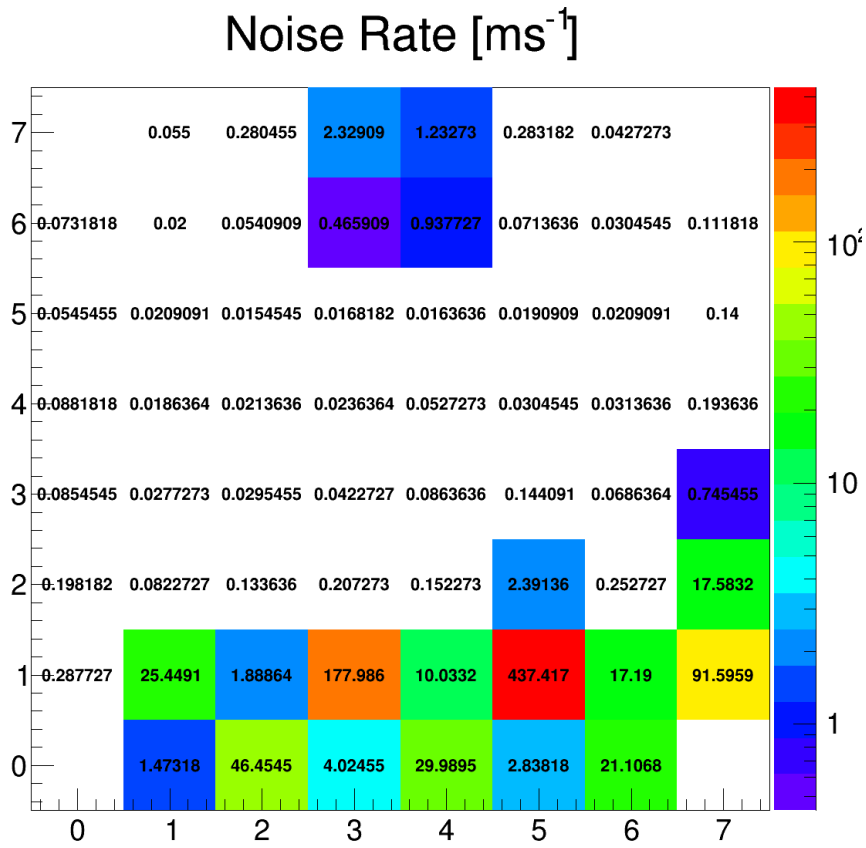


Preliminary Noise Analysis

Noise has been unveiled in several of the FEBs

- 39 practically noiseless planes (< 1 ms^{-1} in each channel)
- 7 mildly noisy planes (< 100 ms^{-1})
- 2 very noisy planes (> 100 ms^{-1}), overflow danger

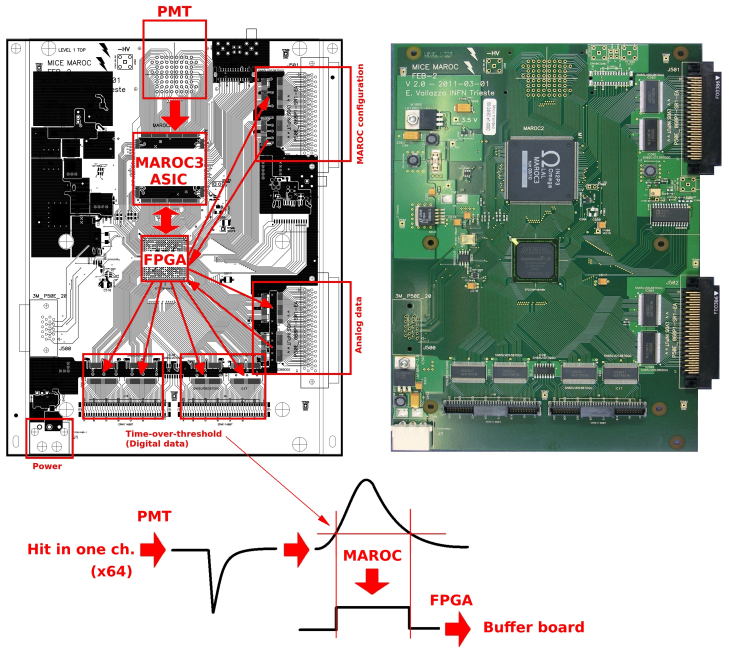




Front End Board ASIC

The ASIC used in the EMR is a Multi-Anode ReadOut Chip (MAROC):

- 64 inputs/outputs
- Shapes the signal and measures a Time over Threshold
- Fast response
- Tunable pre-amplifier gain up to a factor 4 with 6 % accuracy
- Tunable threshold value



→ Hasn't been studied extensively
→ Study of the threshold influence on acceptance
→ Correction of the MAPMT non-uniformity and reject noise

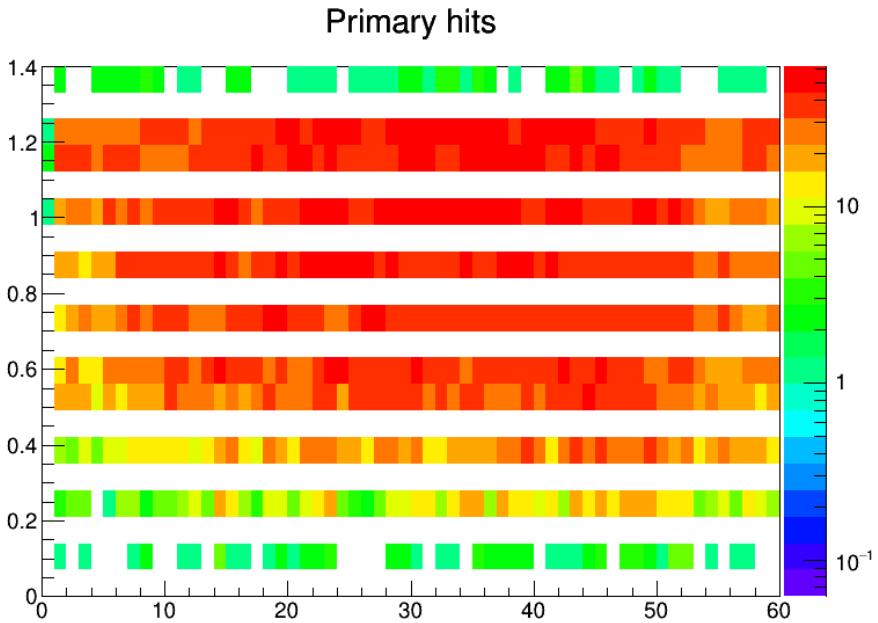
Pre-amplifier gain tuning

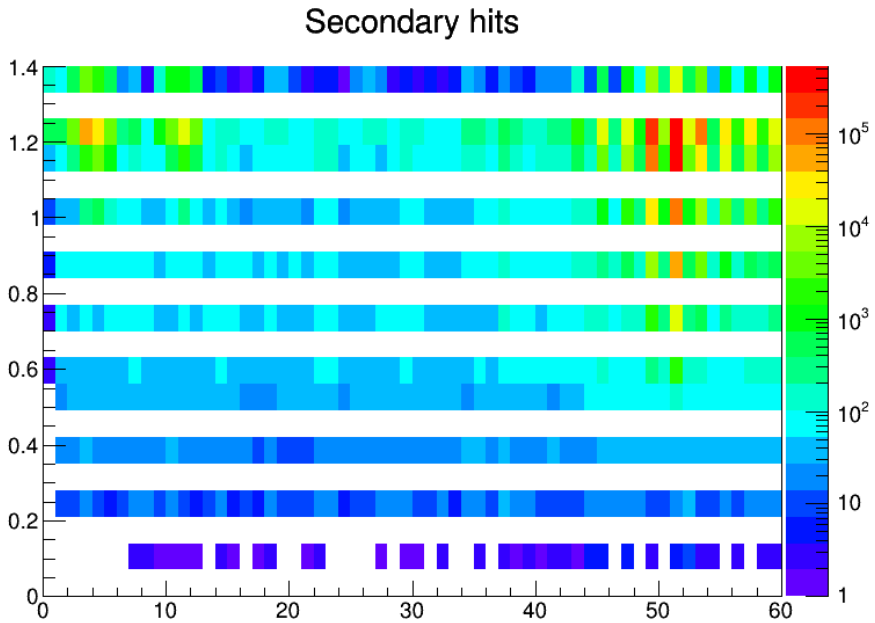
2000 cosmics acquired for gains ranging from 0 to 2 (8 bits)

- number of hits measured within the primary (useful)
- number of hits measured outside (should be as close to 0 as possible)

$\rightarrow$ Default setting is x1, going down to x.75 does no deprecate the amount of hits but would reduce the energy resolution (smaller ToTs)

$\rightarrow$ The noise would be reduced by 1 order of magnitude to $\sim$ 50 hits ms^{-1}





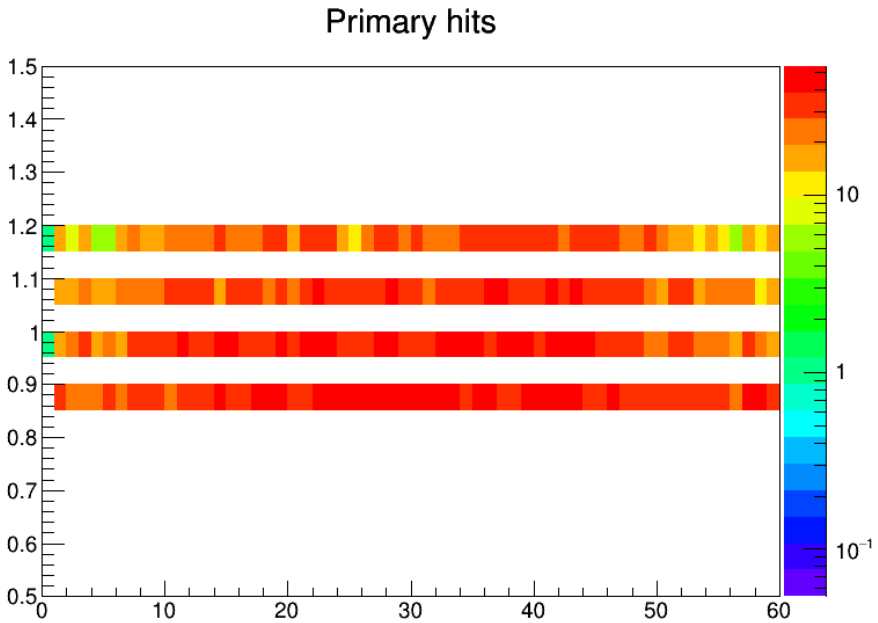
Threshold gain tuning

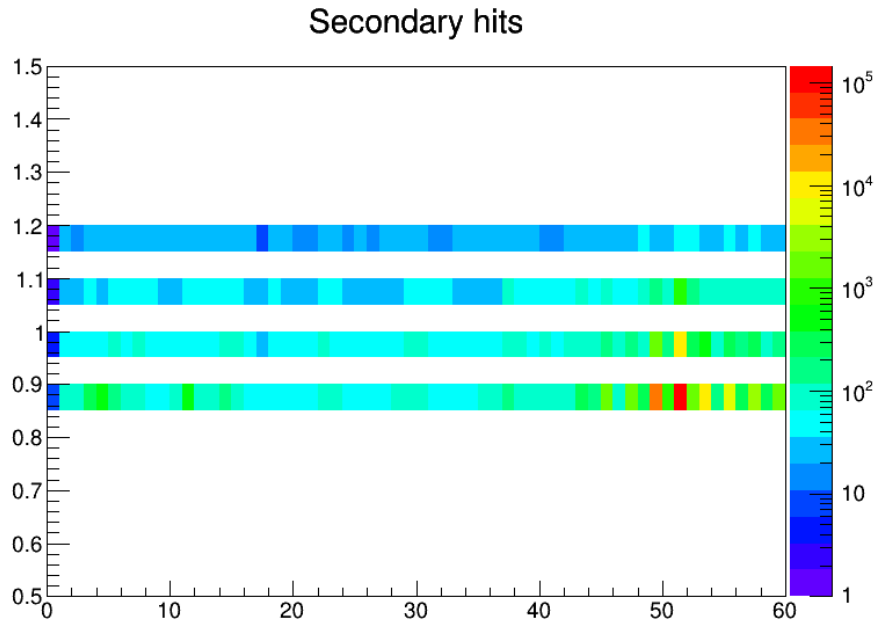
2000 cosmics acquired for threshold ranging from 0 to 2V (10 bits)

- number of hits measured within the primary (useful)
- number of hits measured outside (should be as close to 0 as possible)

$\rightarrow$ Default setting is .9, going up to 1 does no deprecate the amount of hits but would reduce the energy resolution (smaller ToTs)

$\rightarrow$ The noise would be reduced by 1 order of magnitude to $\sim$ 50 hits ms^{-1}





Noise: current status

Potential sources of noise

- Noisy Front-end boards (FEBs)
- Noisy MAPMT (can be replaced, tricky)

Front-end electronics

- Gain study under way (each channel can be tuned individually)
- Threshold study under way (each board can be tuned individually)

$\rightarrow$ Tuning down the MAPMT reduces the level of the noise

$\rightarrow$ Noise could be reduced to acceptable levels by tuning down the gain or raising the threshold of the MAROC

$\rightarrow$ New FEBs under production, MAPMTs spares available for swapping

$\rightarrow$ **Noise does not seem to overflow the DBB buffer at the moment**

EMR code integration into MAUS

Essential parts of the EMR code are integrated in MAUS

- MC fully functional
- MC Digitization complete, data unpacking working
- Advanced reconstruction fully operational
  - → Range, charge, matching, PID variables
- Tests developed for the mappers
- Step I calibration and geometry in the CDB
- Cartesian output integrated with errors
- Reducer and data quality flags under production

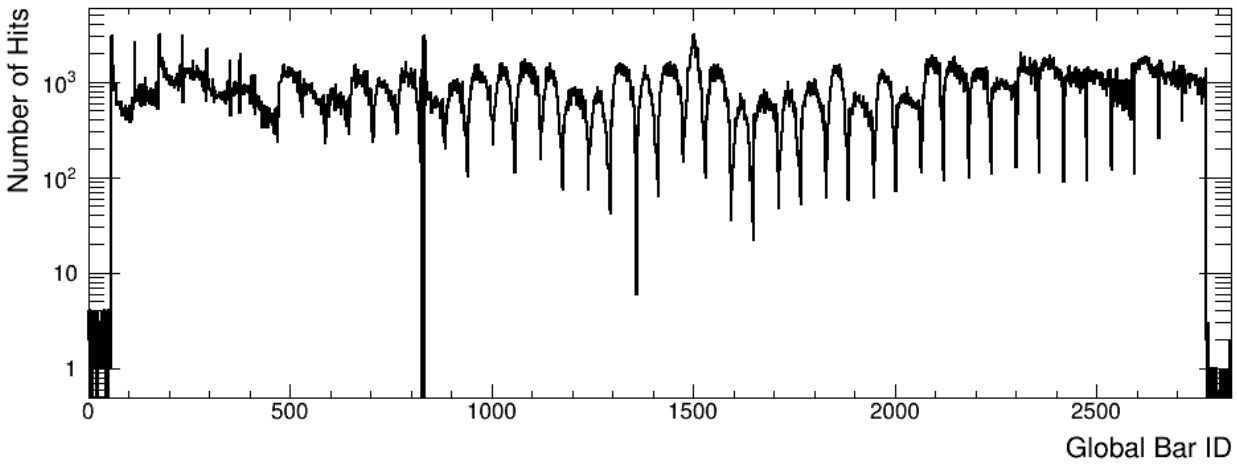
→ **Fully functional as is, requires improvements**

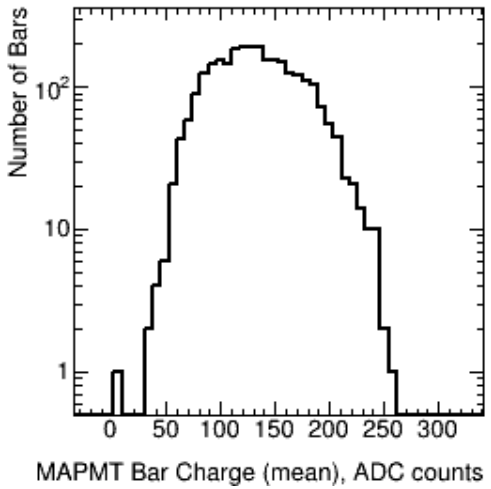
EMR charge calibration

A calibration program exists and need enough cosmic data:

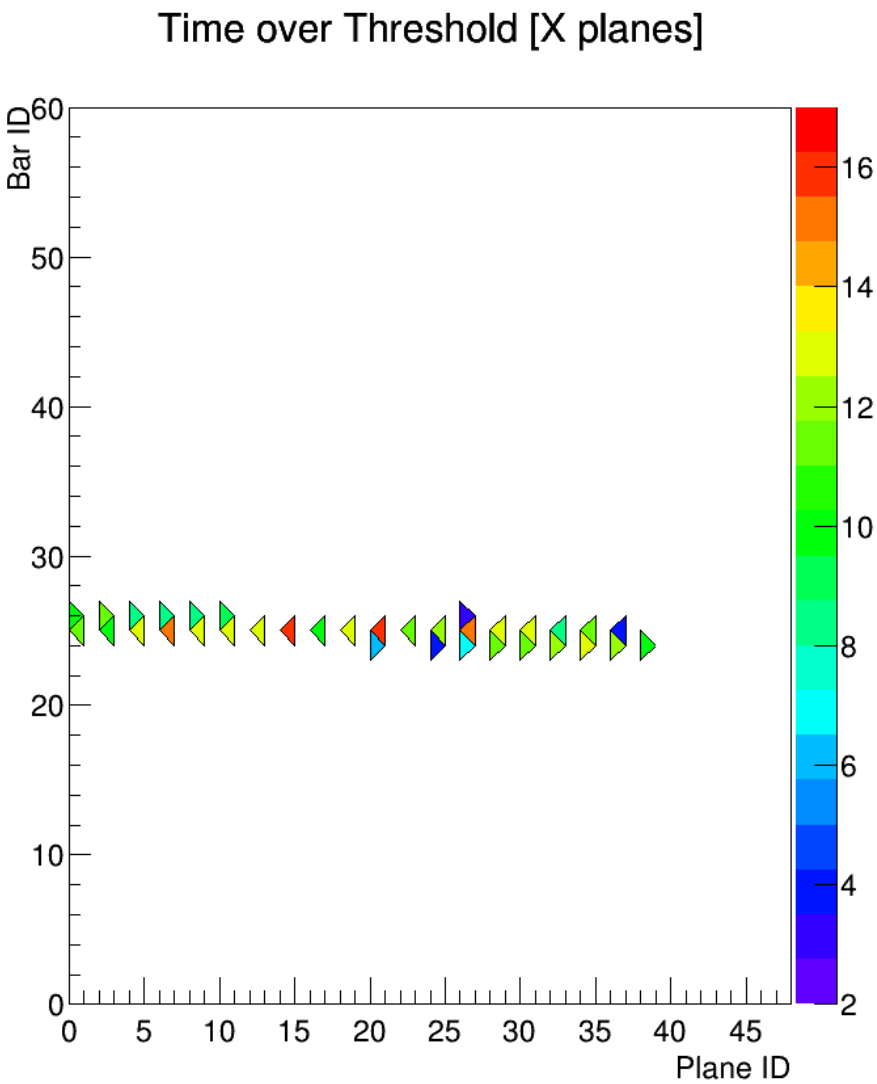
- **calibration** uses cosmic data to evaluate the photomultipliers irregularities and give a parameter for each channel
  - ran in March 2014 and correction map included in MAUS (Step I)
  - 300k (~ 1 week) cosmic trigger needed in the EMR
  - Measurement of the mean charge for each bar i in a plane j, $\overline{Q_{ij}}$
  - Calculation of the correction factor $\epsilon_{ij} = \overline{Q_{ij}}/\overline{Q}$, with $\overline{Q}$ global average

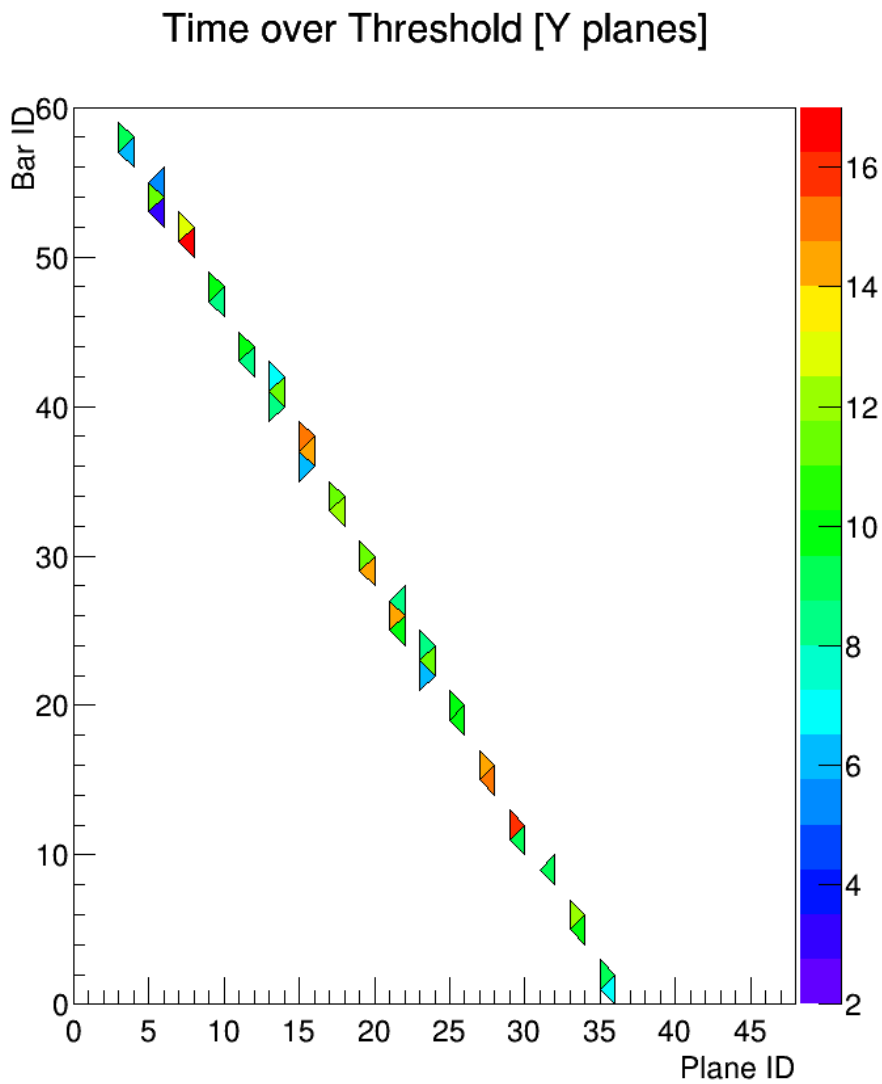
$\rightarrow$ More cosmic data needs to be taken in **August 2015** to account for the SAPMT replacement (no beam time required)





Cosmic muon event





Step IV commisionning

The EMR Step IV commissioning will happen in October 2015

→ Timing calibration (primary hits to trigger time)

→ PID consistency check (pion, positron beams)

→ Muon beams

	positive	momentum							momentum	total triggers
run	beam	at target	at D2	at Q9	spills	triggers at TOF1	rate at TOF1	proton absorber	at Q9	at TOF1
5435	e+	277	230	143	563	6289	11	83		
5436	e+	277	230	143	1616	18558	11	83		
					total triggers:	24847			*230.1*	*24847*
5433	e+	289	240	150	2362	33914	14	83		
5434	e+	289	240	150	2657	40000	15	83		
					total triggers:	73914			*240.26*	*73914*
5430	e+	325	271	172	826	18980	23	83		
5431	e+	325	271	172	322	7023	22	83		
5432	e+	325	271	172	2199	51451	23	83		
					total triggers:	77454			*270.75*	*77454*
5428	e+	360	300	193	1564	60511	39	83		
5429	e+	360	300	193	630	21860	35	83		
					total triggers:	82371			*300.38*	*82371*
5423	e+	400	334	217	3234	100000	31	83		
5424	e+	400	334	217	202	8000	40	0		
					total triggers:	108000			*334.24*	*108000*
5421	e+	431	360	235	1637	89092	54	83		
					total triggers:	89092			*360.48*	*89092*
5451	pi+	275	269	243	2321	50427	22	83		
					total triggers:	50427			*268.59*	*50427*
5418	e+	466	390	256	814	46751	57	83		
5419	e+	466	390	256	498	29410	59	83		
5420	e+	466	390	256	381	26640	70	83		
					total triggers:	102801			*390.11*	*102801*

EMR status summary

EMR hardware upgrade **completed** and **commissioned**

- SAPMT commissioned, 48 of them working and efficient (✓)
- HVPSU → fully operational, first control interface produced (✓)
- 2 LVPSUs → fully functional and in final state (✓)
- CAEN VME crate → functional (✓)

EMR software

- Completely functional MC and reconstruction (new data structure)

Outstanding tasks

- Investigate the MAROC on the FEBs further (✗)
- Try replacing the MAPMTs on the noisy plane (✗)
- Produce a reducer and data quality flags (✗)
- Calibrate the detector and output the ϵ_{ij} (1 or 2 week(s) in August)

Ready for Step IV