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)

Single Anode PMT replacement

Ageing **Philips XP2972** :

- Sensitivity: $\sim 65\ \mu$A/lm
- Gain: 3×10^6
- Time spread: ~ 800 ps
- QE: 14.5 %

$\rightarrow$ 30 years old
$\rightarrow$ Degraded photocathode
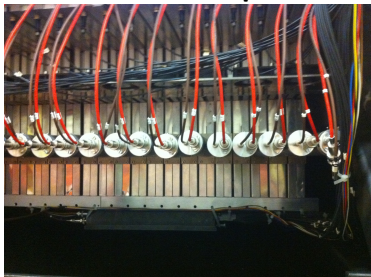$\rightarrow$ Reduction of secondary emissions
$\rightarrow$ Gain loss
$\rightarrow$ Spurious pulses

New **Hamamatsu R6427** :

- Sensitivity: $\sim 100\ \mu$A/lm
- Gain: 5×10^6
- Time pread: ~ 500 ps
- QE: 24 %

$\rightarrow$ 56 PMTs (8 spares)
$\rightarrow$ Change done by UniGe technicians at RAL at the beginning of October 2014 (two days work)
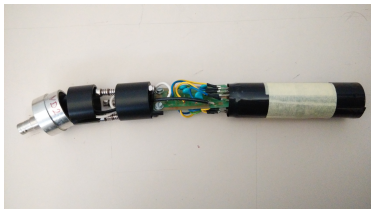
SAPMT implementation

Old set up

New set up

Comparaison between old and new SAPMTs

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

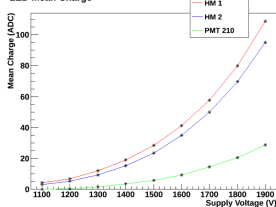$\rightarrow \overline{Q_{Hm}} \gg \overline{Q_{Ph}}$ over the whole range

Measured level of dark noise:

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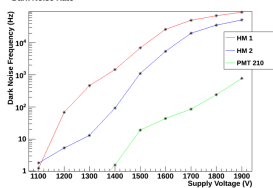- measurement of the average DN frequency for each setting

$\rightarrow$ DN 2 orders of magnitude higher for Hamamatsu PMTs
$\rightarrow$ Not to worry, as the DN/Signal separation is ensured
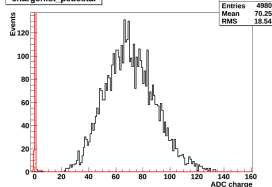
New EMR Elements Installation

New elements:

- 47 U rack to replace current one
- AC fan system (back of the rack, top of the rack, EMR box)
- Remote controlled AC power supply
- HVPSU (photomultipliers)
- LVPSU (trigger distribution boards, LED driver, fans)
- New VME (and NIM) crate(s)

Implementation:

- New design and layout approval (RAL) (✓)
- Installation of remote control switch, connection to grid (RAL) (✓)
- Rack repackaging (UniGe) (✓)
- Cables rewiring (UniGe) (✓)
- Test and commissioning (UniGe) (✓)
  $\rightarrow$ Finalized after the upgrade of the SAPMT

Issues encountered after restarting

| 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	New LVPSU ordered (✗)
Cosmic DAQ code bugging	Fixed on site (✓)
2 very noisy FEBs (planes 9, 10)	HV tuned down (✓/✗)
1 of the new SAPMT down	Needs to be replaced (✗)

Cosmic data taking

After fixing the issues encountered after restarting, a first round a cosmic data was taken in January. The following configuration was used:

- All the boards, fans and crates were on at nominal voltage
- All the SAPMT set to 1500V
- All the MAPMT set to 700V, except 2 at 680V
  $\rightarrow$ 2 noisy FEBs
- Spill generated by the software, every 2.5ms, for 2ms
  $\rightarrow \sim 1$ in 10 spill has a trigger
- Particle trigger generated by a pair of coincidences between two adjacent planes (14&&15) || (30&&31)
  $\rightarrow$ 4 trigger planes record no charge information
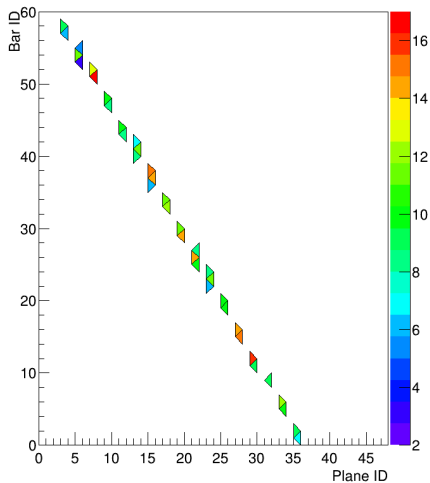- 100k events recorded to check stability

Cosmic muon event
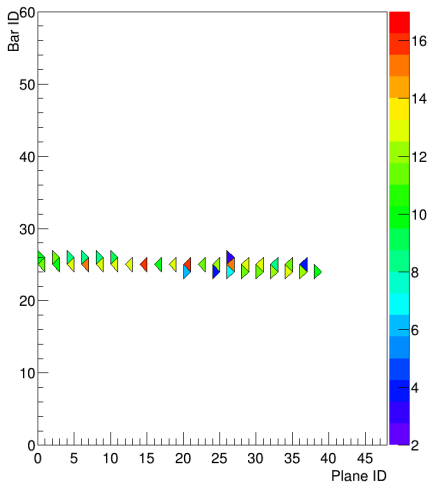
New SAPMT performance
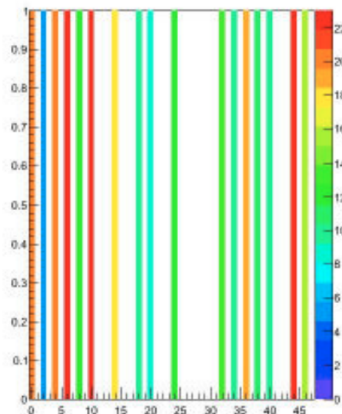

Old SAPMT
plane charge [X planes]

New SAPMT
plane charge [X planes]
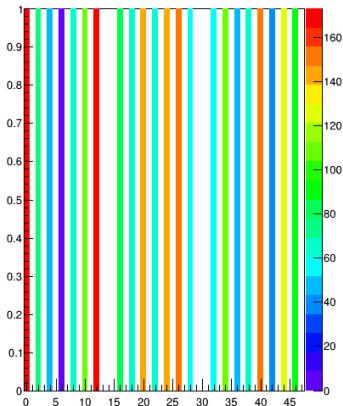
$\rightarrow$ Much higher signals recorded in the new SAPMTs

$\rightarrow$ No more charge losses as we had before (no signal in some planes)

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 after the SAPMT replacement (no beam time required to produce the calibration constants)
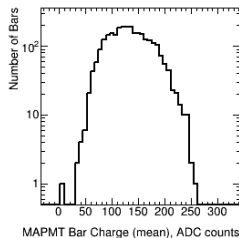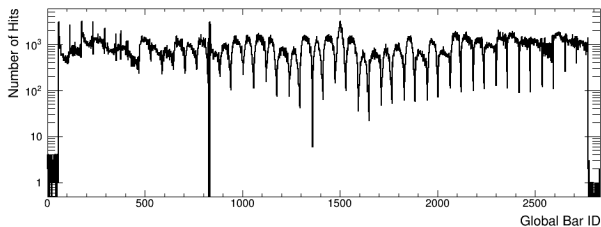
EMR status summary

EMR hardware upgrade **completed**

- SAPMT commissioned, upcoming MICE-DET-NOTE (✓)
- New 47U rack, network operated power switch → functional (✓)
- New HVPSU → controller fixed by CAEN (✓)
- New LVPSU → functional with the exception of the LED driver (✓)
- New CAEN VME crate → functional (✓)
- VHDC replacement → operational configuration (✓)
- New patch panel and environmental sensors → functional (✓)

Outstanding issues

- Investigate the noisy FEBs, make some spares (✗)
- Replace the faulty SAPMT (✗) → this week
- Take enough data and produce the calibration constants ϵ_{ij} (✗)

Step IV readiness? No problem in sight.