Electron Muon Ranger (EMR)
Preparations for Step IV

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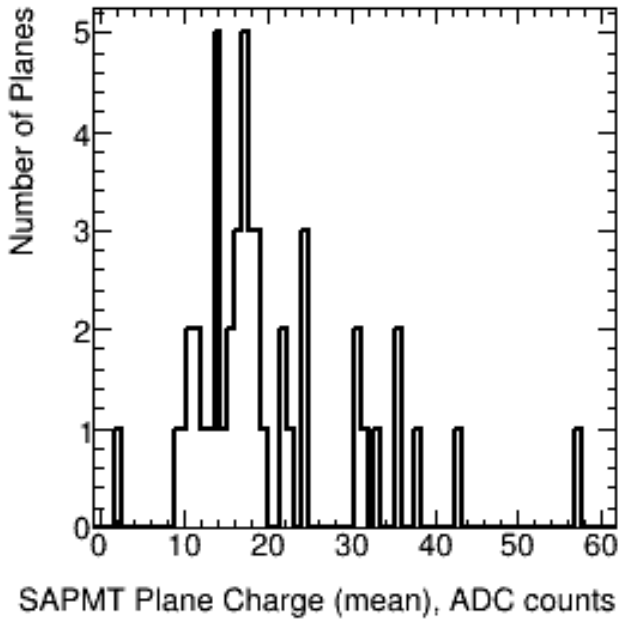
Single Anode PMT replacement (1)

Ageing **Philips XP2972** manufacturer characteristics:

- Useful diameter: Ø 23 mm
- Maximum response: 400 nm
- Sensitivity: ~ 65 μA/lm
- Gain: 3×10^6
- Time spread: ~ 800 ps
- QE: 14.5 %

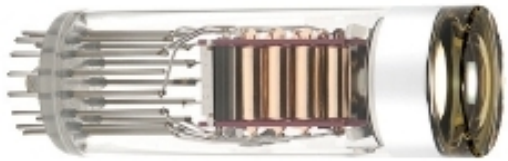
$\rightarrow$ 30 years old
$\rightarrow$ Degraded photocathode
$\rightarrow$ Reduction of secondary emissions
$\rightarrow$ Gain loss
$\rightarrow$ Spurious pulses

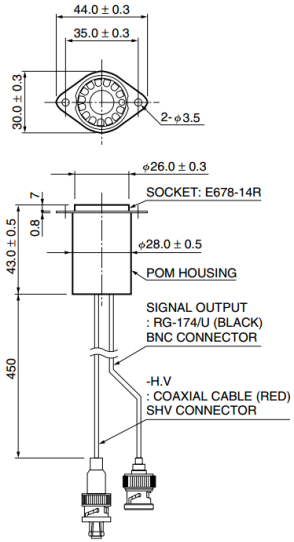


Single-Anode PMT replacement (2)

New **Hamamatsu R6427** manufacturer characteristics:

- Useful diameter: Ø 25 mm
- Maximum response: 420 nm
- Sensitivity: ~ 100 μA/lm
- Gain: 5×10^6
- Time pread: ~ 500 ps
- QE: 24 %





New voltage divider
$\rightarrow$ 55 PMTs and 55 VDs (7 spares)
$\rightarrow$ Characterization tests at CERN in September (noise, dark current, response to MIP like signal)
$\rightarrow$ Change done by UniGe technicians at RAL at the beginning of October 2014 (few days work), Necessary

New Control Rack Installation

New elements:

- 47 U rack to replace current one
- AC fan system
- Remote controlled AC power supply
- HVPSU (photomultipliers)
- LVPSU (trigger distribution boards, LED driver, fans)
- New VME and NIM crates

Figure: Remote controlled PSU

Implementation:

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

PMT High Voltage Optimization

Situation after the SAPMT change:

- Fully commissioned SAPMTs
- All the Multi-anode PMs set to the same voltage
- The PMTs are non-uniform and their response can vary significantly

→ Need for a high voltage scan

→ Planned in October after rack and SAPMTs installation, Important

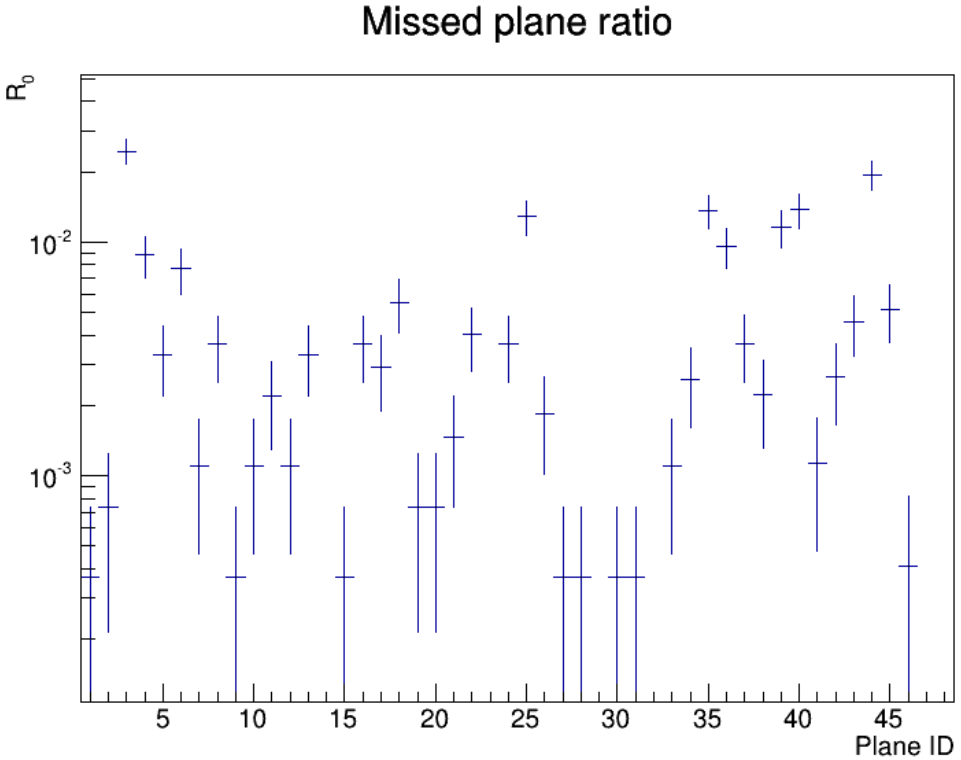
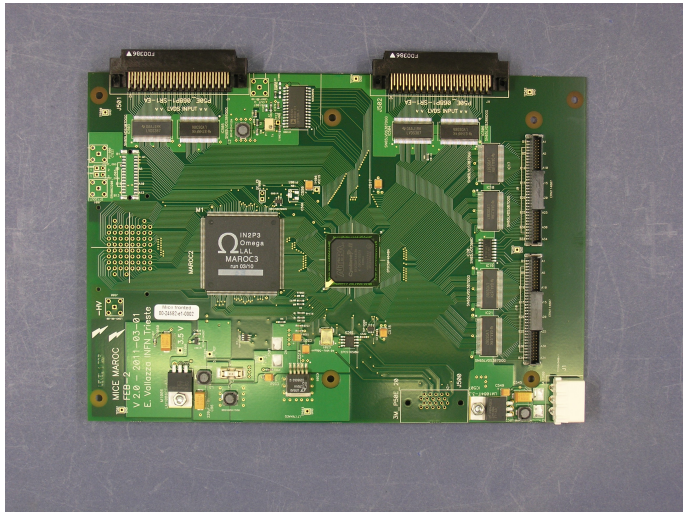


Fig: Probability of given plane to not record a single signal in the MAPMT when a 350 MeV/c muon goes through it. Some of the planes have an efficiency under 99 %; their voltage needs to be adjusted.

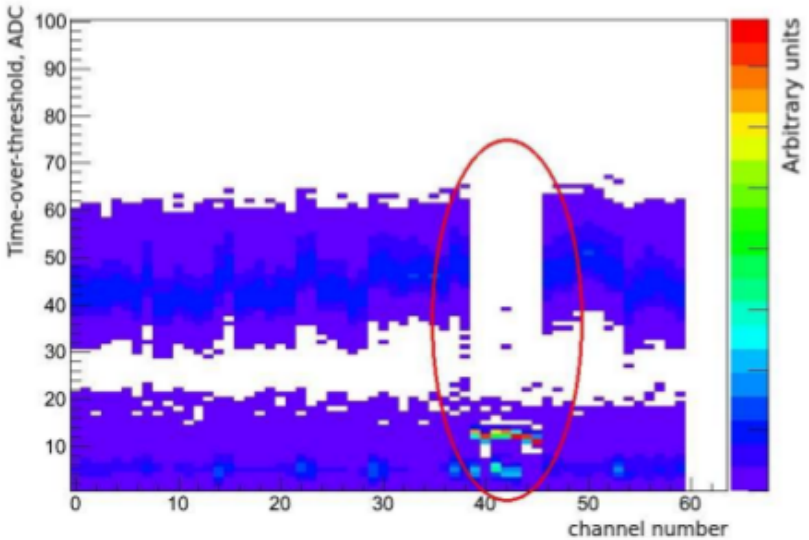
Faulty Front End Boards Investigation

Some of the dedicated FEBs exhibit faulty behaviours:

- High levels of noise
- No signal recorded at the right Time over Threshold
- Electronics flaw



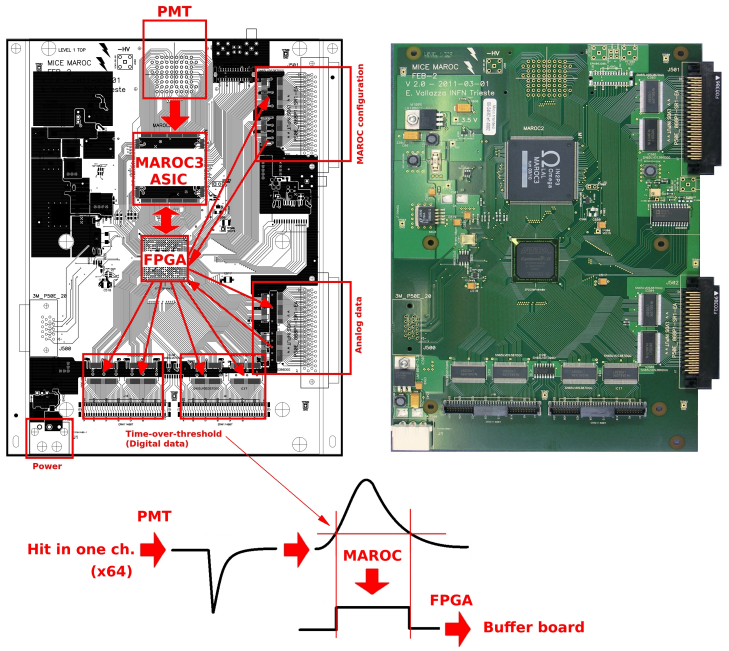
→ Needs to be investigated to see at which stage the signal is lost
→ Fixing them will provide much required additional spares
→ 1 month work, Important



Front End Board ASIC Optimization

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



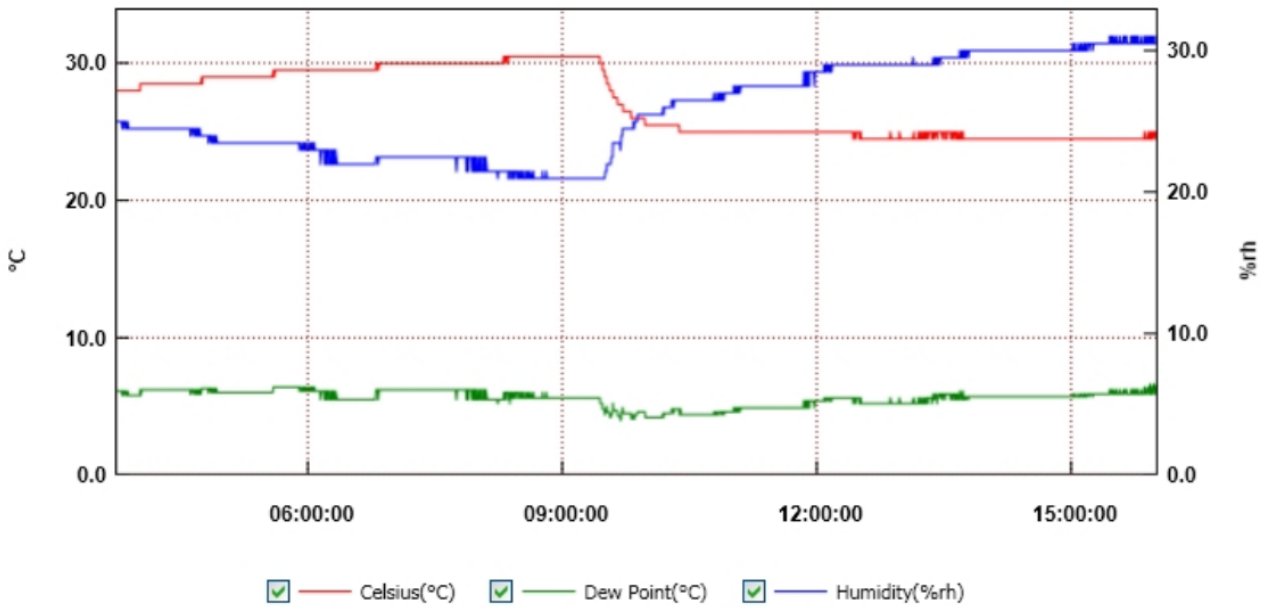
→ Hasn't been studied extensively
→ Study of the threshold influence to increase acceptance
→ Correction of the MAPMT non-uniformity using the pre-amp
→ 2 month work with a test bench at CERN, Secondary

Temperature and Humidity Sensors

Temperature and Humidity sensors are to be installed in the EMR box and the electronics and PSUs rack and should be used to

- Monitor the stability of these variables
- Study the influence they have on the front end electronics (FEBs are known to trip above a certain value of temperature)
- Study the influence of the PMT gain or their readout and adjust their parameters according to the measured values

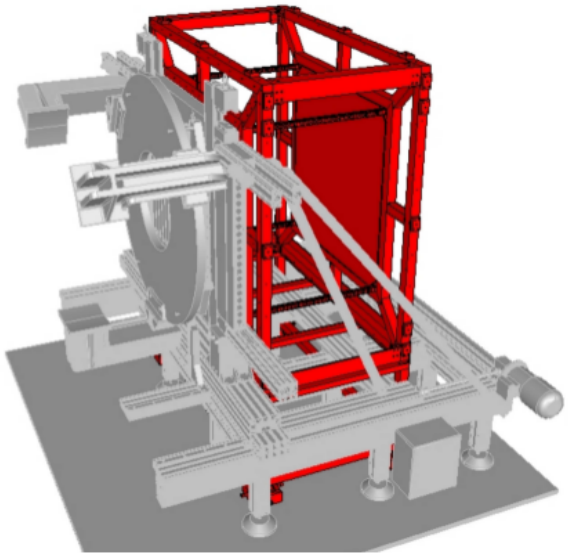
$\rightarrow$ Secondary

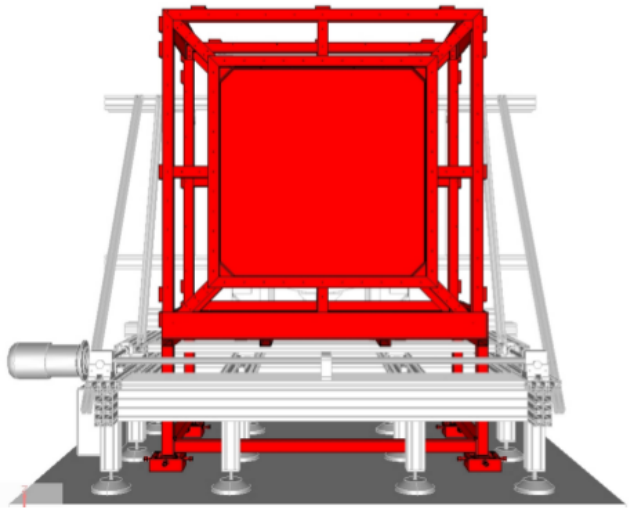


EMR Frame

- The front panel of the EMR consists of 800kg of steel
- What will be the magnetic field at the level of the EMR?
- Should the structure be reinforced?

→ Necessary





Code integration into MAUS

What has been done:

- **MC Digitization** entirely in MAUS (version 1.1)
- Modication of the **data structure** implemented
- **Data Processors, tests** adapted

What needs to be done:

- Modification of the **EMRPlaneHits** map to accommodate two additional reconEvents (noise+decay particles) and fill them
- Integrate the **reconstruction code** (already exists)

$\rightarrow$ functional by the end of summer, Necessary.

Digitization Parameters Study

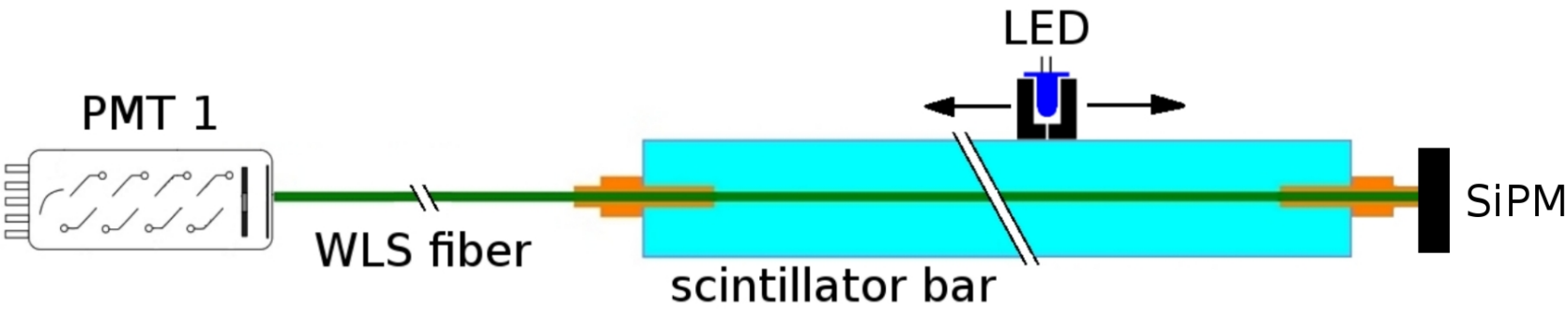
The MC digitization variables are currently based on the data sheets:

- Photoproduction and trapping efficiency in the bars
- Attenuation factors in the fibres
- Quantum Efficiency of the Multi and Single Anode PMTs
- PMT non-uniformity

Studies will be made for the parameters to reflect the detector specificities

- PMT non-uniformity adjusted through calibration
- Light output of the bars with SiPM
- Transport of the light in the fibres with SiPM

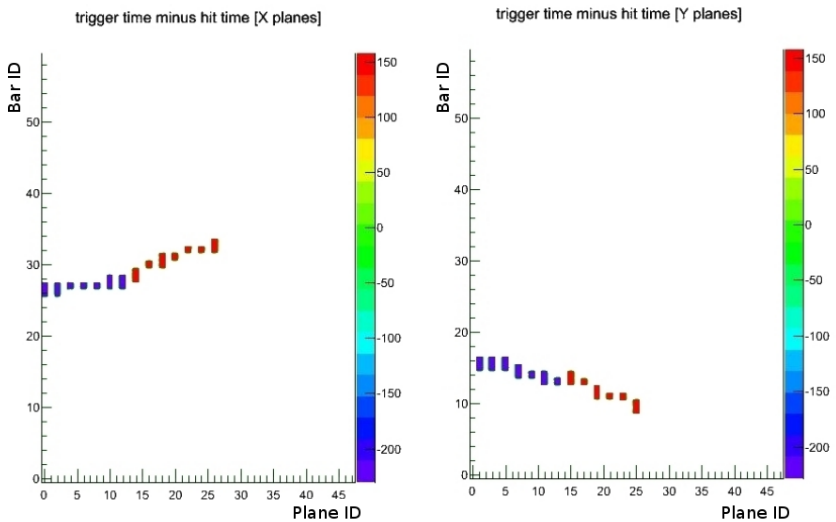
$\rightarrow$ 2 months work, Important.

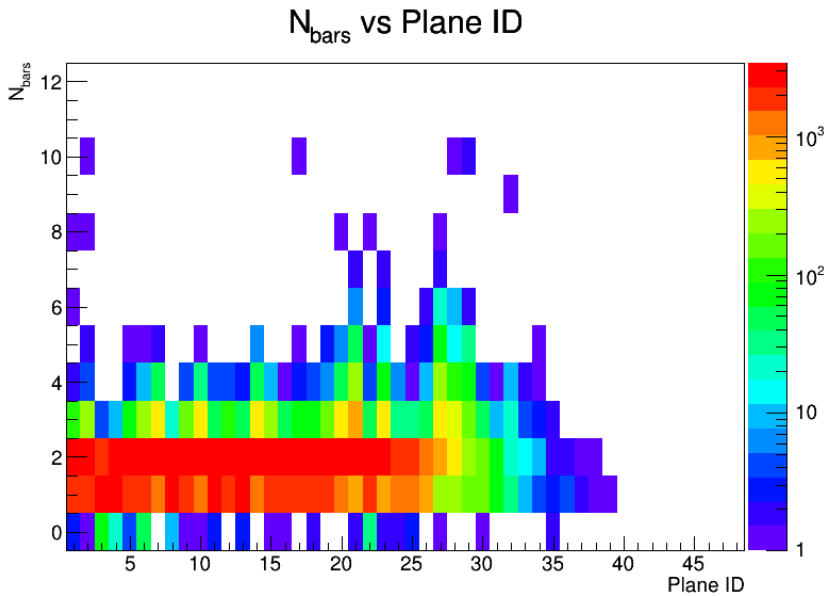


Improve Track Reconstruction

- The coordinate in each plane as a weighted average of the position of the bars hit and their ToT measurements
- Include the triangular geometry in the range measurement
- Redefine the end point of the primary track using bar multiplicity
- New parameters to tag muons (eDep pattern for instance)

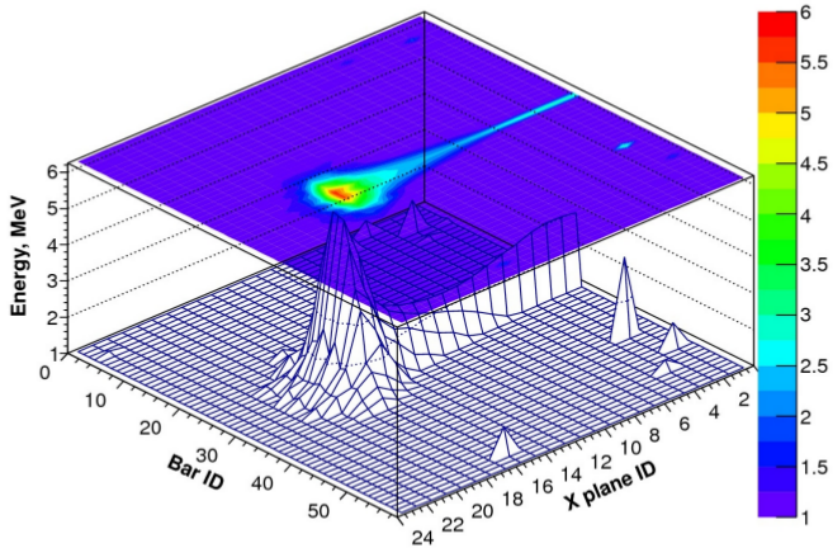
$\rightarrow$ 1 month work, Secondary.





Software Advanced Prospects

- Use Monte Carlo digitization as a tool to reconstruct the energy deposition pattern of muons from the measured charge and ToT
  $\rightarrow$ 1 month work, Secondary.



- Implement multivariate algorithm for particle identification
  $\rightarrow$ 1 month work, Secondary.

EMR DAQ

A few standalone features of the EMR need to be integrated in the DAQ

- Calibration of the fADC pedestal before each run (DONE)
- MAROC configuration before each run
- Use LED monitoring to adjust PMT gains (analogue devices are sensitive to temperature changed, magnetic fields, power cycles, etc.)
- Calibration Run (3 weeks of cosmic data taking after major hardware updates, finely tuned by LED monitoring)
- 3 distinct modes of DAQ
  - Beam
  - Cosmic
  - LED pulser

$\rightarrow$ Possibility to include the EMR in every run, Necessary.

EMR Operations

- Write EMR operation instructions
- Write EMR technical note
  - Cable tags, patch panels map
  - Hardware IDs
  - High Voltage mapping
  - DAQ configurations

  $\rightarrow$ 1 month work, Important
- Set-up LED monitoring of the PMT gain

  $\rightarrow$ 1 week work, Important.