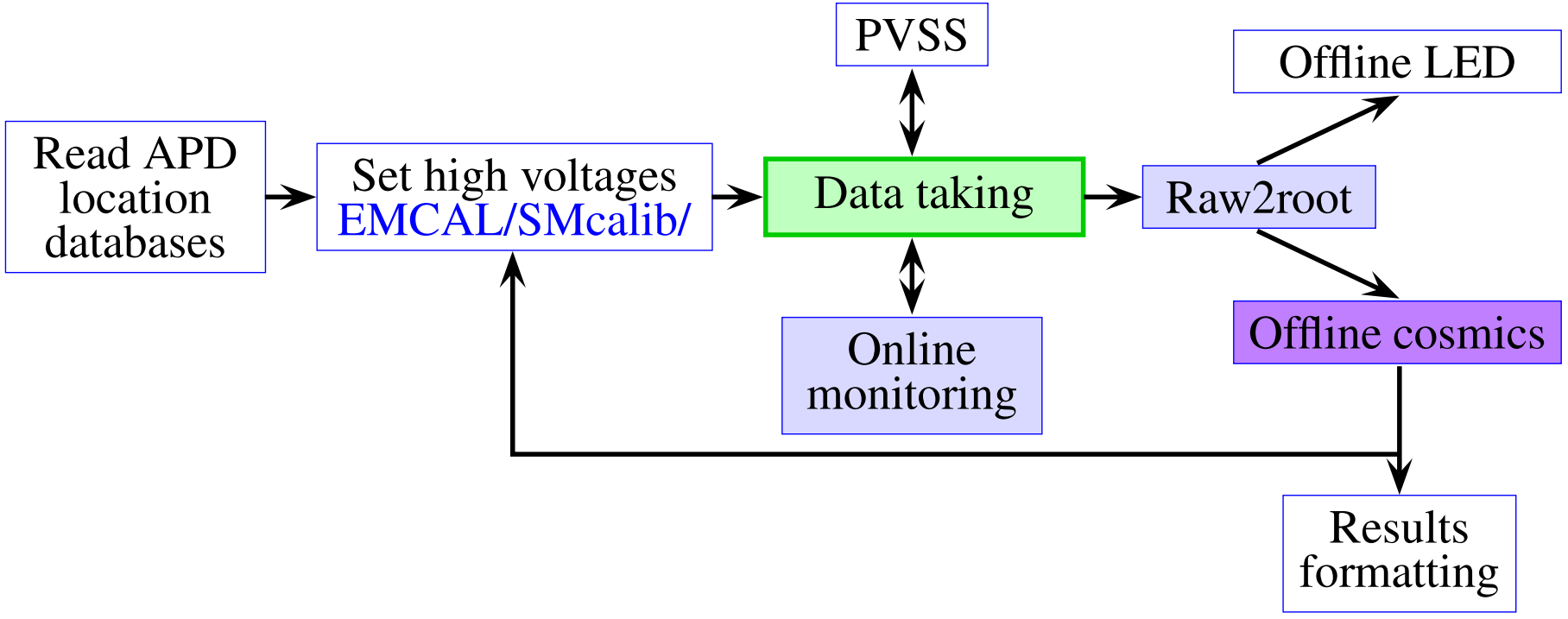
EMCAL calibration with cosmics at Grenoble : Current software tools :

- **Aims :**
  - → Get average signal amplitude for cosmic muons for each tower with nominal high voltages (Catania's APD V30)
  - → Calibration : get uniform response for whole SM (identical average amplitudes)
    - ◇ Tune each tower's high voltage to change tower gain
    - ◇ Dispersion of towers average amplitudes after calibration should be < 10 %
- **How : method :**
  - → Trigger on cosmic muons which cross the EMCAL (scintillator paddles)
    - ◇ Ensure EMCAL signal looked at is due to trig'd μ ("time of flight" cut)
    - ◇ Ensure the muon has crossed only 1 tower (isolation cut)
  - → For each tower : get average signal amplitude
  - → Tune APD high voltage
    - ⇒ Change tower gain
    - ⇒ Move average signal amplitude to desired value
- **How : software tools...**

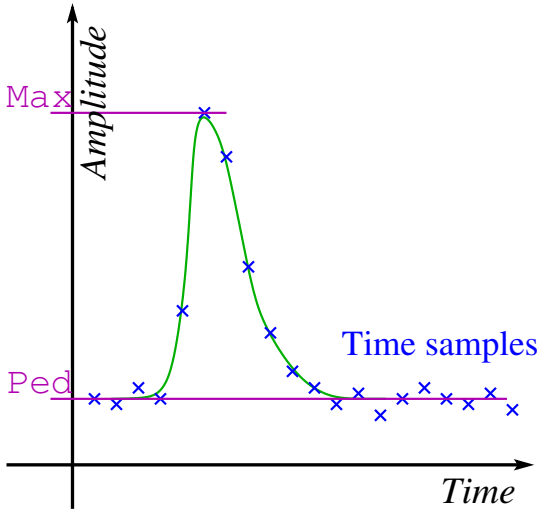
Current software tools :

- **How : software tools :**
  - → Read APD location (row;col) databases
  - → Get APD high voltages in database / tune HV, write them to DCS
  - → Slow-control through PVSS (temperatures, low and high voltages)
  - → Offline LED : e.g. identify weak towers
  - → Writes average signal amplitudes and APD high voltages to some database



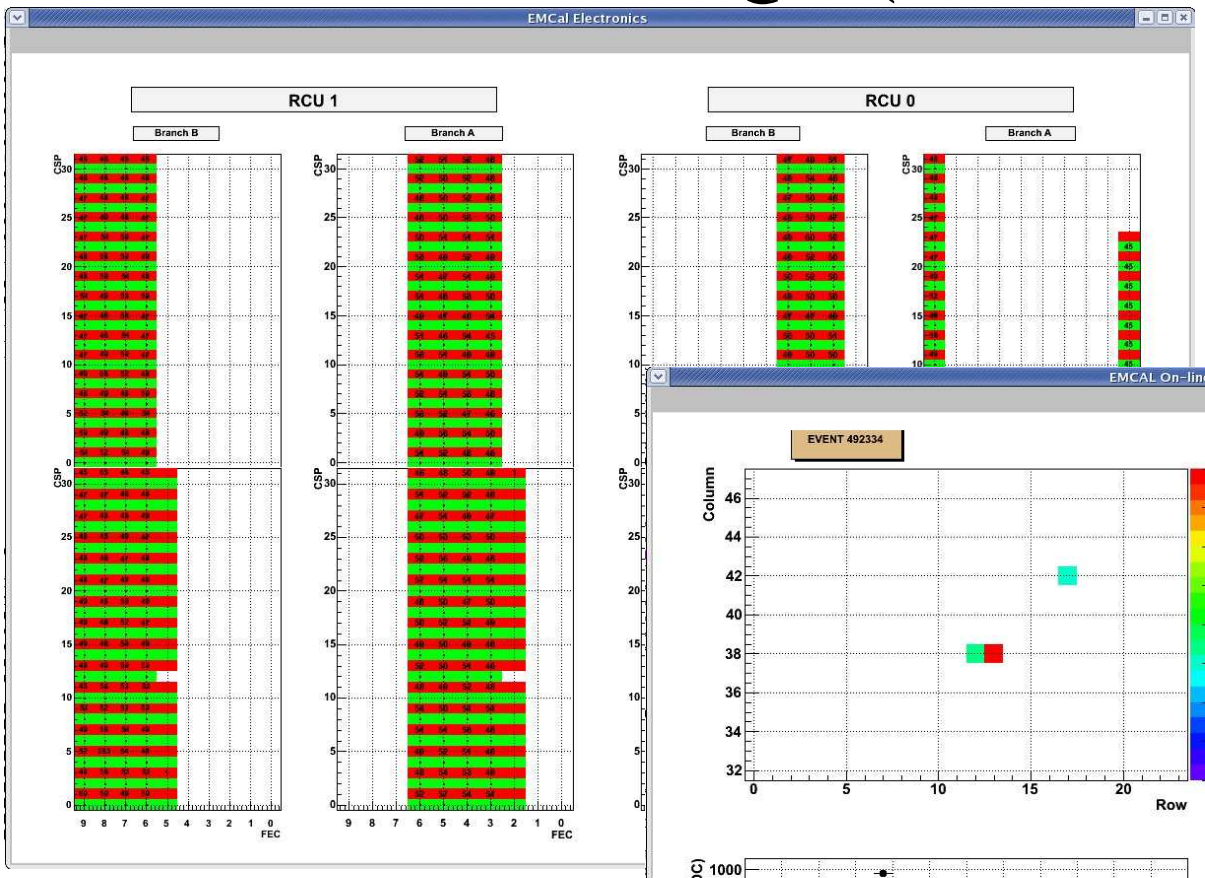
Data processing, online monitoring :

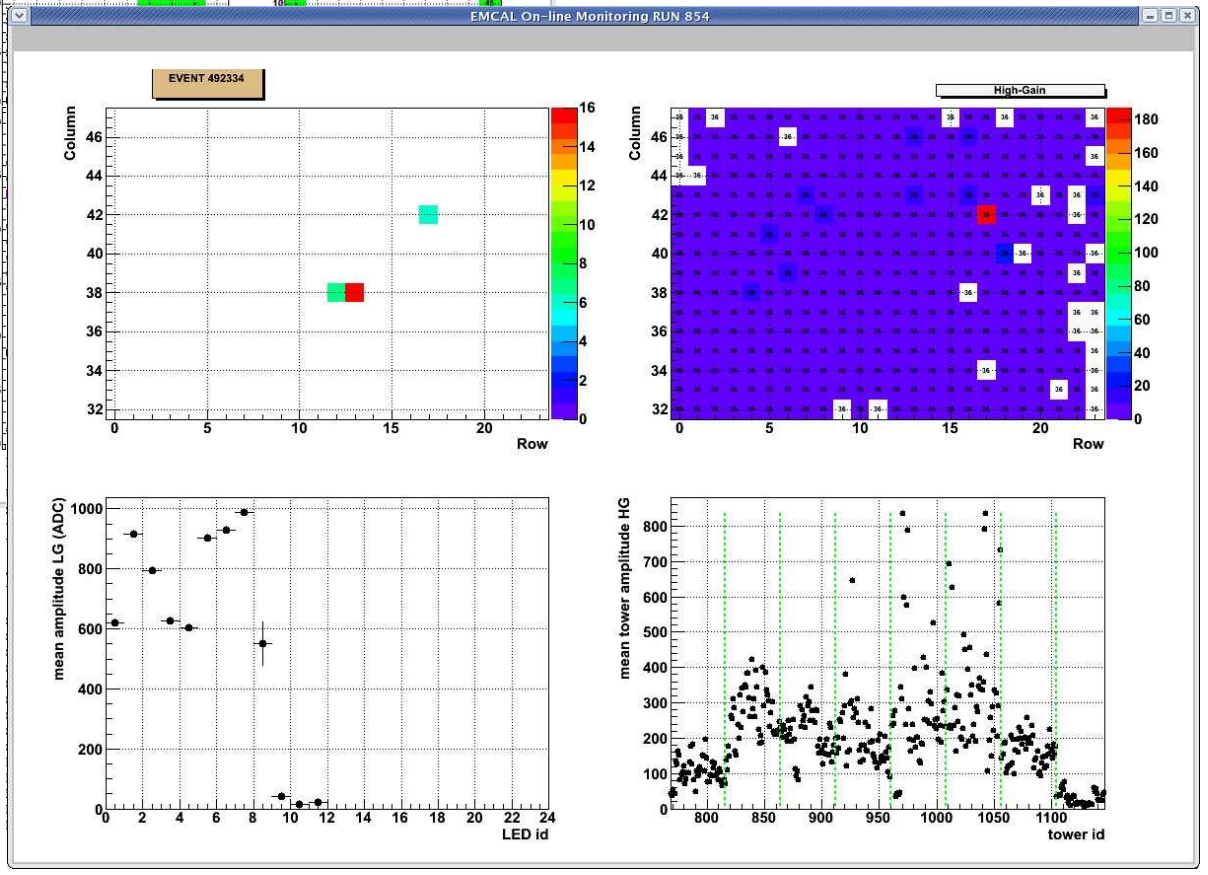
- **Data processing (raw2root) :**
  - → If (max-pedestal > 5) : Fit the time samples by some function
    Store fit parameters
  - → Else : store only max and pedestal level



- **Online monitoring :**
  - → FEE cards monitoring
  - → Reference LED amplitude (averaged over time)
  - → LED amplitude per tower (averaged over time)
  - → Number of cosmics & of LED events per tower (per event & integrated)

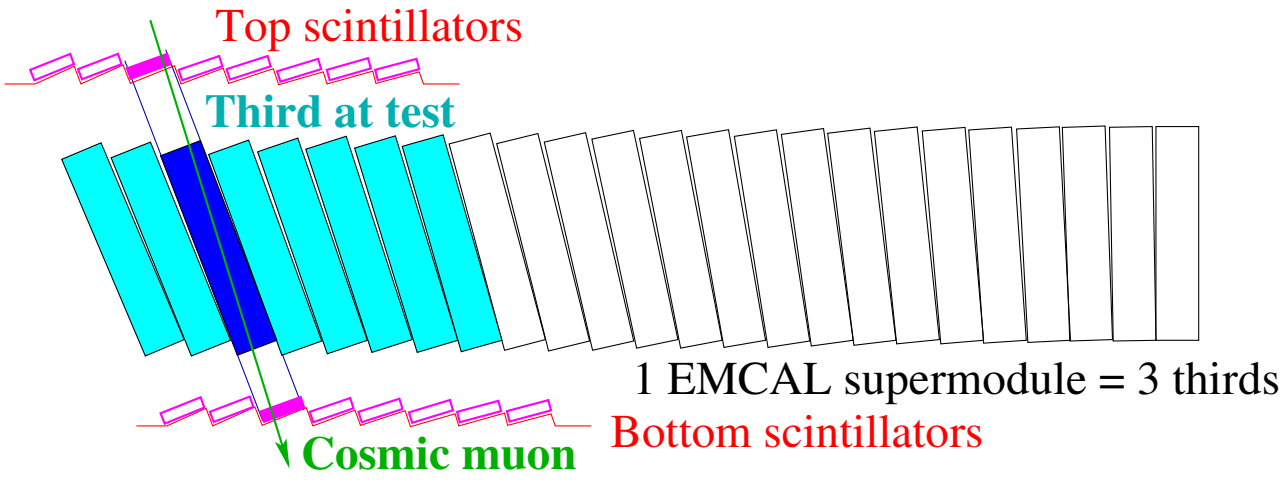
Online QA (screenshots) :

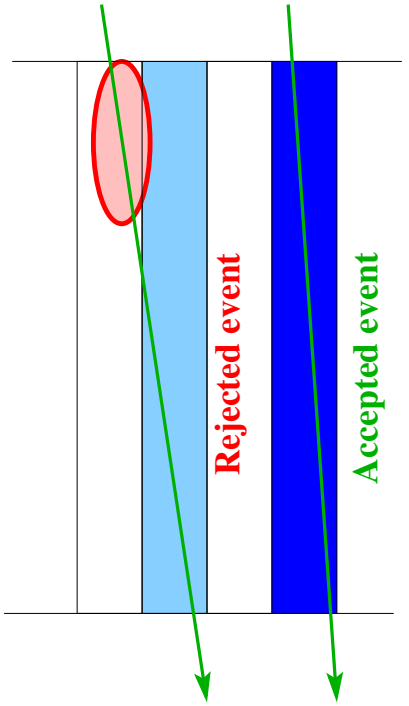




Isolation cut :

- Experimental bench (side view) :

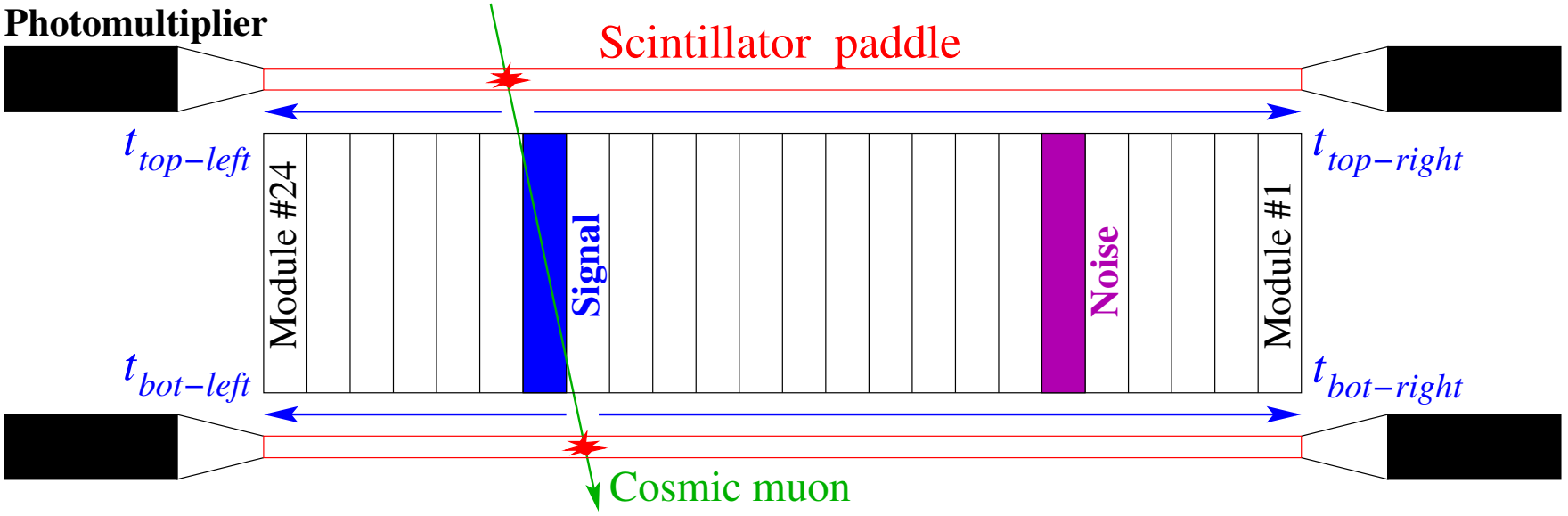




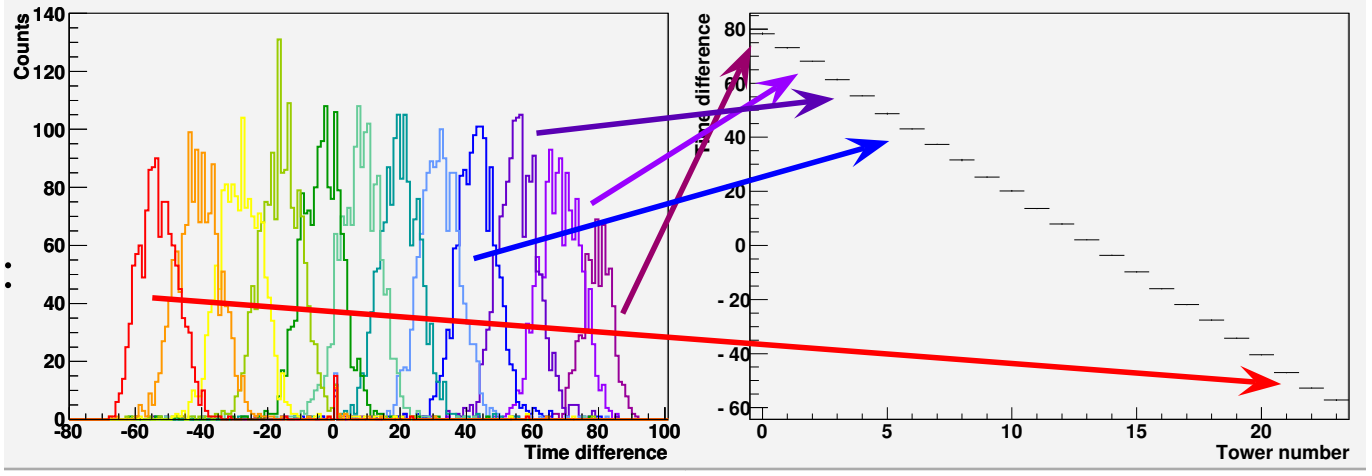
- Want narrow energy distribution
  $\Rightarrow$ discard cosmics which hit more than 1 tower
  $\Rightarrow$ discard event when a neighbor tower has some signal
  Isolation cut level limited by noise : 3 ADC

"Time of flight" cut :

- Experimental bench (front view) :



- Time difference between both photomultipliers :



Offline plots available :

- Statistics collected for each tower
  (distrib for each tower, $\int$ as a function of (col;row))
  - → Raw
  - → Isolation cut
  - → Isolation + ToF cuts

  } → Control time of flight
  → Spot hot and dead towers, influence on neighbor towers (isolation)
- Gaussian fit parameters for each tower
  (amplitude, width, mean, χ^2)
- Correlation between the 4 means
  (w/ or w/o ToF cut ; distrib mean vs fit mean)

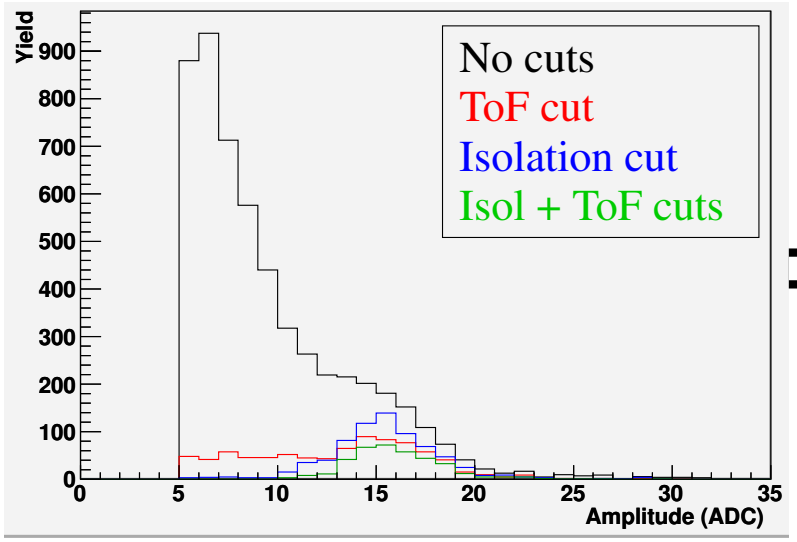
  } → Check fits quality
- These 4 means as a function of (col;row)
- Average signal amplitudes distributions
- High voltages distributions (V30 and tuned)

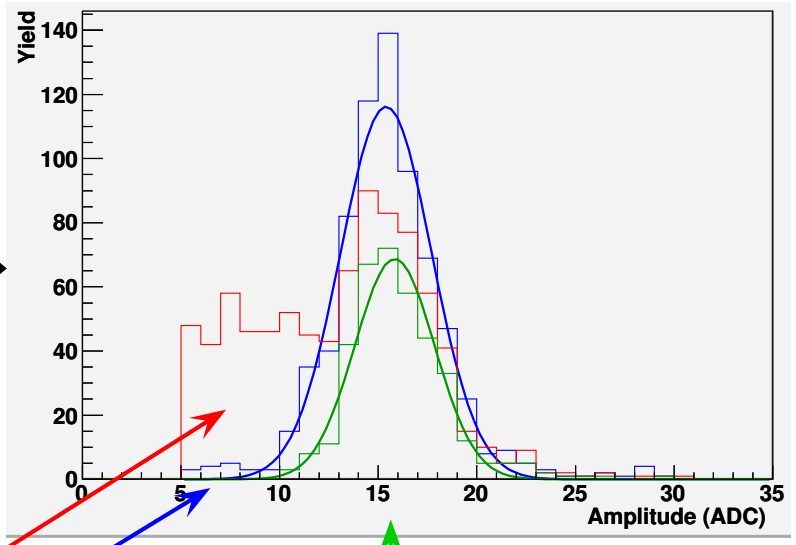
  } → Check uniformity or correlation with voltage map

- Time-dependent plots (single- and multi-runs) :
  - → Tower statistics (integral) w/o and w/ cuts
  - → Average signal amplitudes

- Statistical error for each tower

Average signal amplitude :





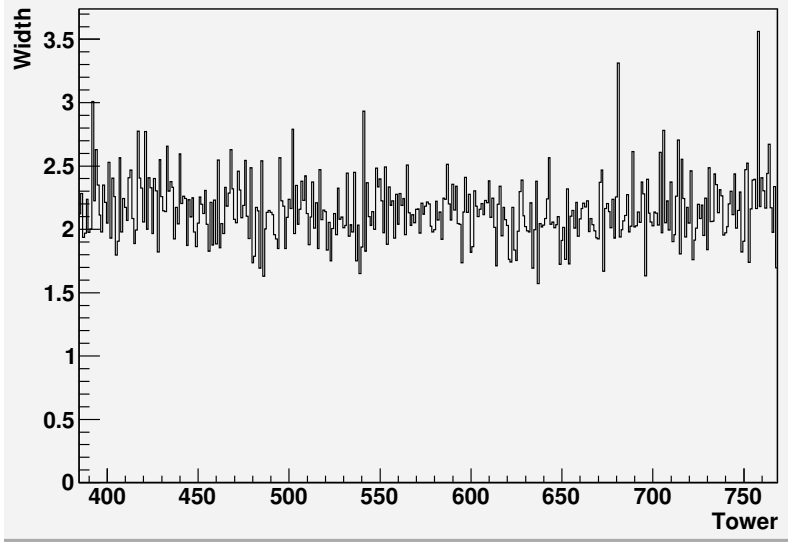
No isolation

No ToF

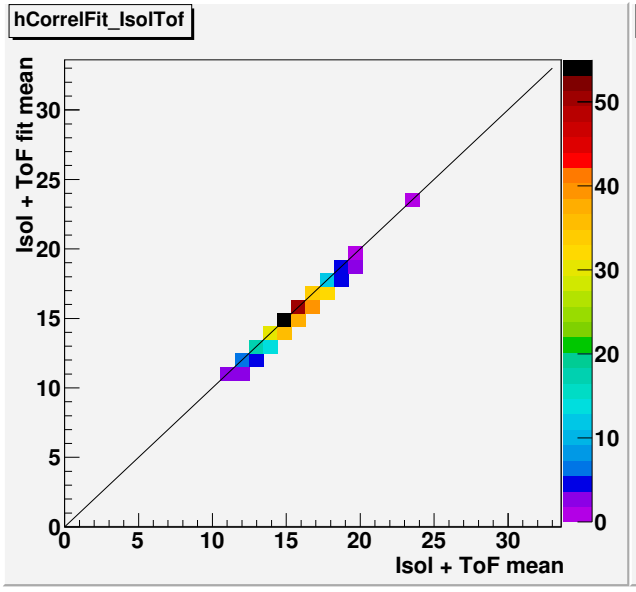
- $>$ 8 bins used for the fits (fit range still to be studied)
- Mean used : fit over isol+ToF cut distributions
  → **average signal amplitude**

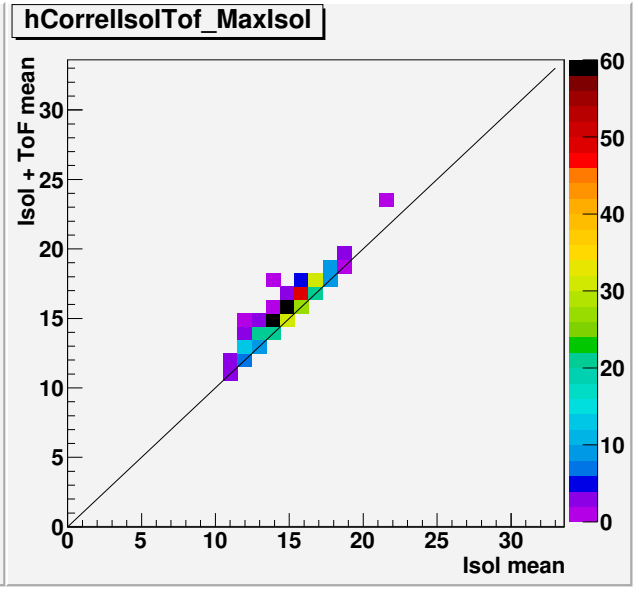
- Measure average signal amplitude for all towers, with V30 high voltage values
- Then iteratively tune high voltages to move all average signal amplitudes to e.g. 16 ADC (2 passes enough)

Some control plots :



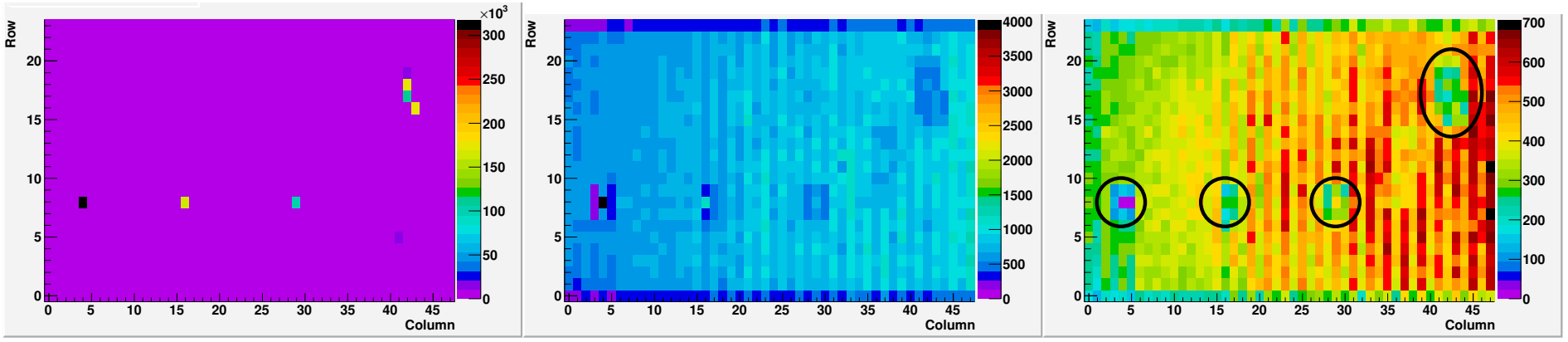
- Fit widths consistent
- Means correlations :
  - → Fit mean consistent with distrib. mean
  - → ToF cut necessary, otherwise mean underestimated



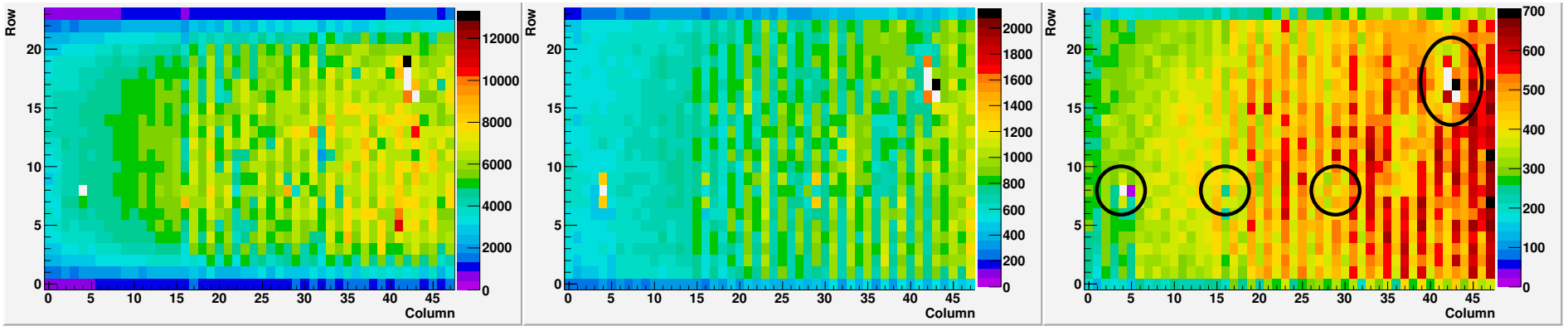


Statistics collected (1/2) :

- Statistics collected in 23 hours : no cuts, isolation cut, isol+ToF cuts

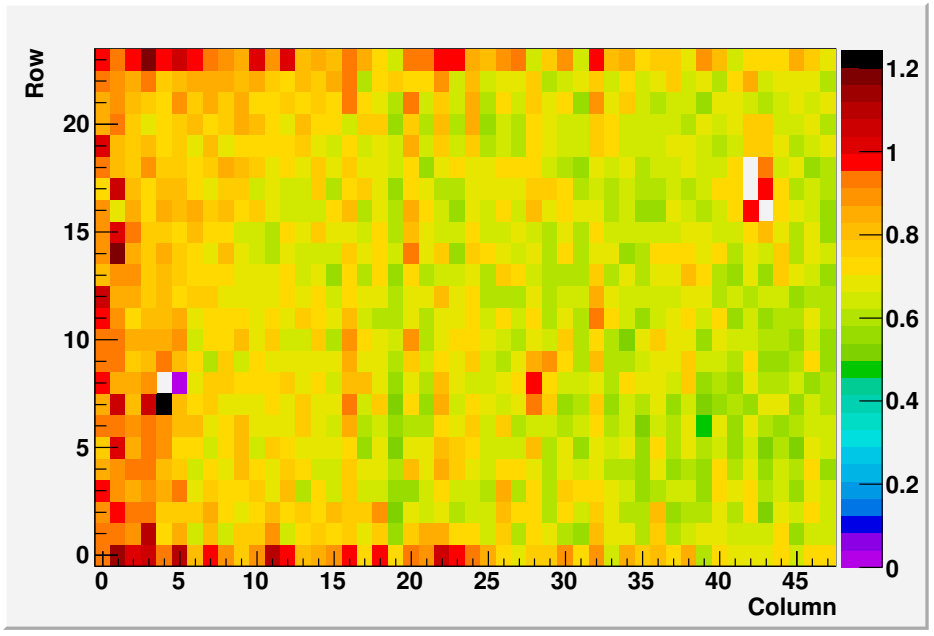


- Now discarding noisy tower (loosen isolation cut) : neighboring towers'statistics $\times 2$



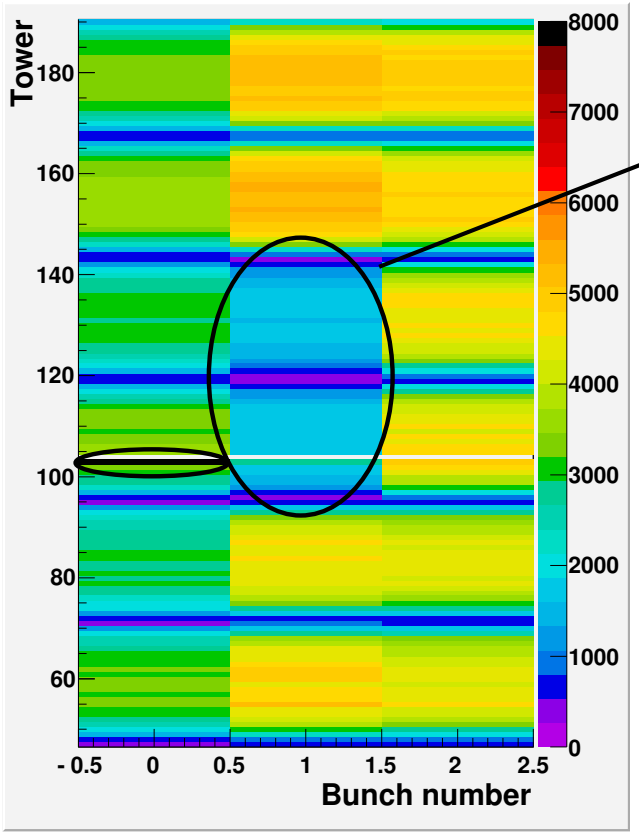
Statistics collected (2/2) :

- Typical statistical relative uncertainty on the average signal amplitude for a 23-hour run (in %)
  → Below the 1 % level

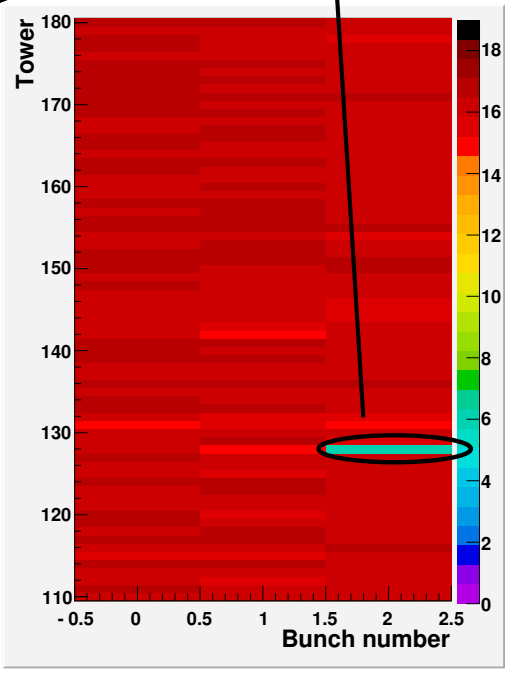


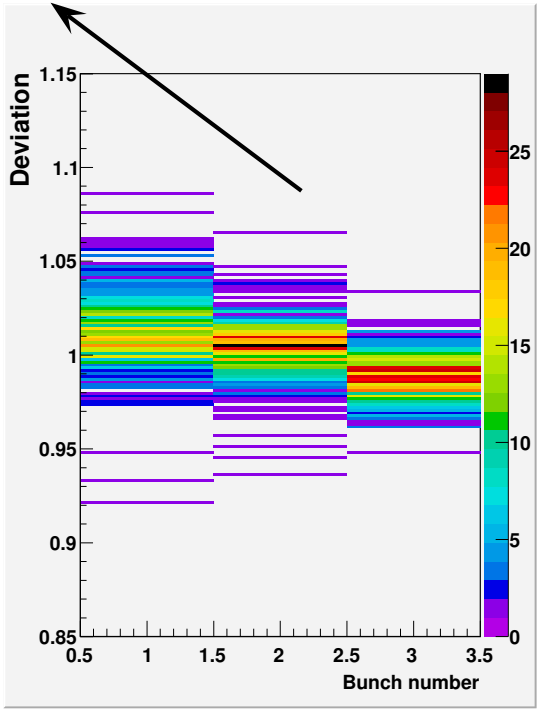
Time-dependence :

- Statistics collected, 1 run divided in bunches
- Statistics and average signal amplitudes, several runs
  $\Rightarrow$ check for which towers older runs can be used
- Check average signal amplitudes stability in time / results reproductibility



- Don't merge runs for these towers
- Wrong mean
- Temperature effect ?

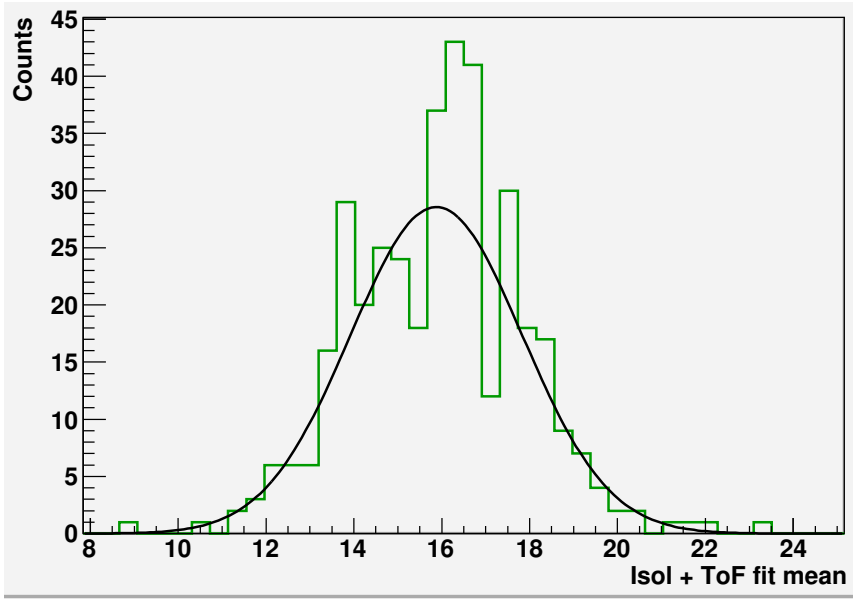


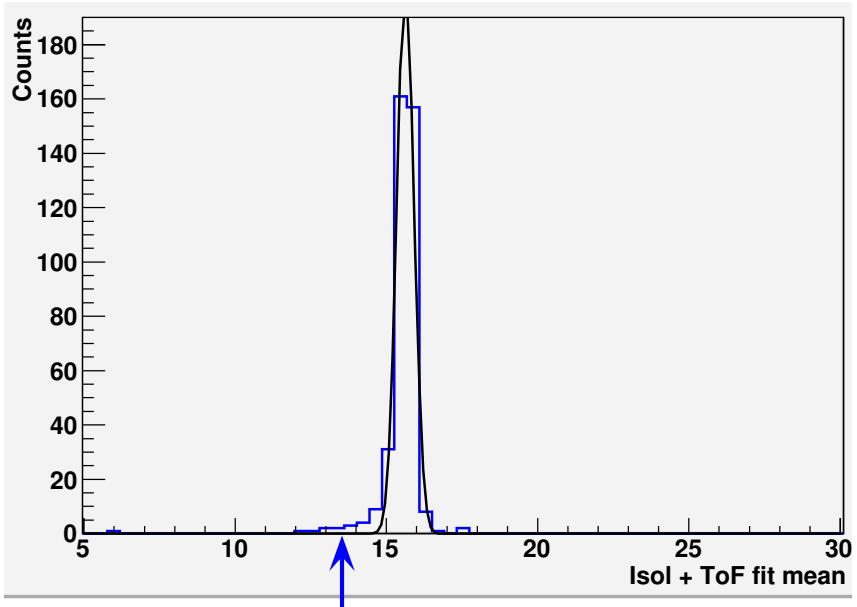


Average signal amplitudes distributions :

Example for 1/3 supermodule :

- **With V30 high voltages :**
  - → Mean = 15.9 ADC
  - → Sigma = 1.96 ADC
  - → Dispersion = 12 %
- **After 2 passes :**
  - → Mean = 15.6 ADC
  - → Sigma = 0.28 ADC
  - → Dispersion = 1.8 %





High voltage already at maximal voltage (385 V)

To-do and prospects :

- Study effect of looser isolation cut for noisy towers
- Pedestal runs analysis (just begun)
- Extract temperature from PVSS and plug it into cosmics analysis

- Finalize analysis of 1st European supermodule
  Store calibration results to file/database
- In June : 2 supermodules at test simultaneously !!
- Match average signal amplitudes to actual tower gains (numerical value)
- Get invested in further calibration of EMCAL
  (cosmics, charged tracks, π^0...)