CMS-ECAL timing studies with laser

- **Study purpose:**
  - **Explore timing performances of ECAL with laser system**
  - **Local (in time and in space) performances**
    - ► **Crystal intercalibration within a light monitoring region**
  - **Global performances**
    - ► **Crystal incalibration in whole ECAL**
  - **Stability**

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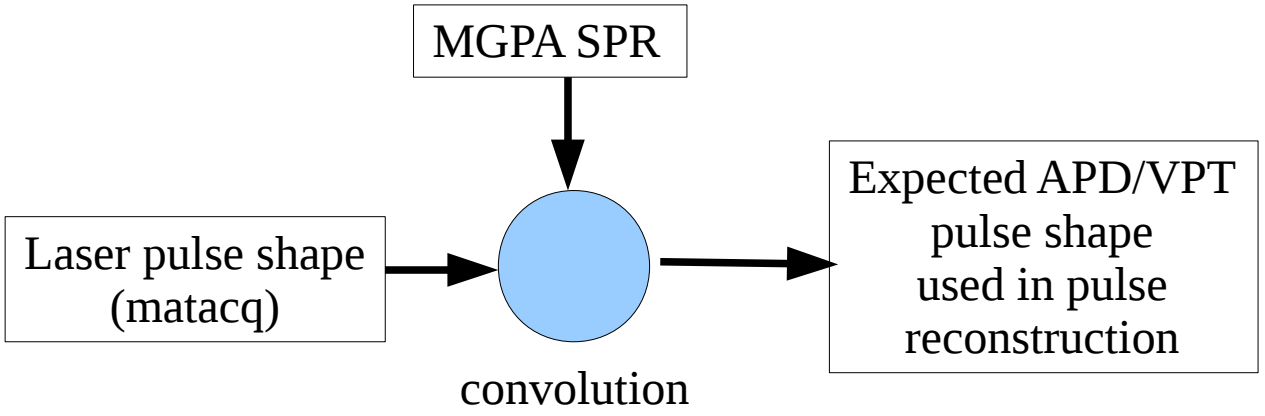
Timing with light injection system

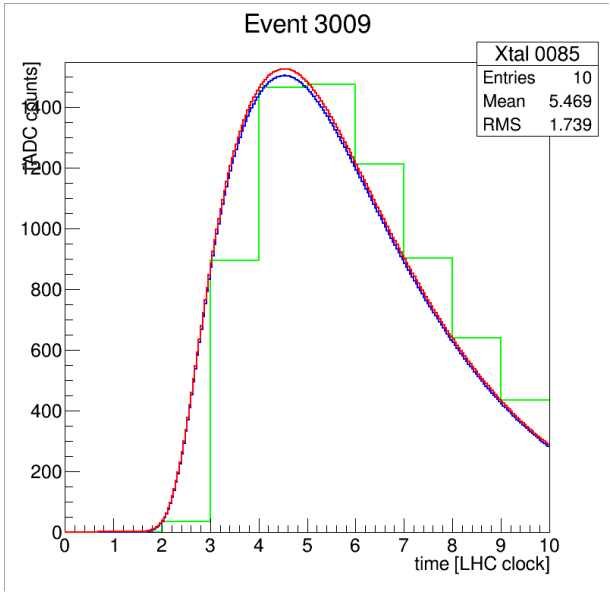
- **Within a monitoring region**
  - **All crystals see the same light pulse**
  - **Assume no jitter added in light distribution paths**
    - **Where ?**
- **Within a monitoring sequence**
  - **600 events/monitoring region in a raw**
    - **6 seconds**
- **Local timing stability**
  - **In space**
    - **Half a super-module, EE sector**
  - **In time**
    - **6 seconds**

Timing measurement

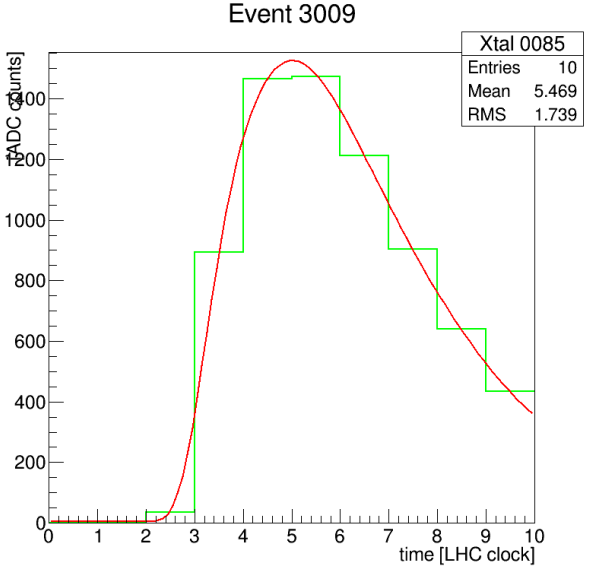
- **Standard monitoring analysis :**
  - **Pulse reconstruction with shapes template**



(See CMS DN-2008/001)



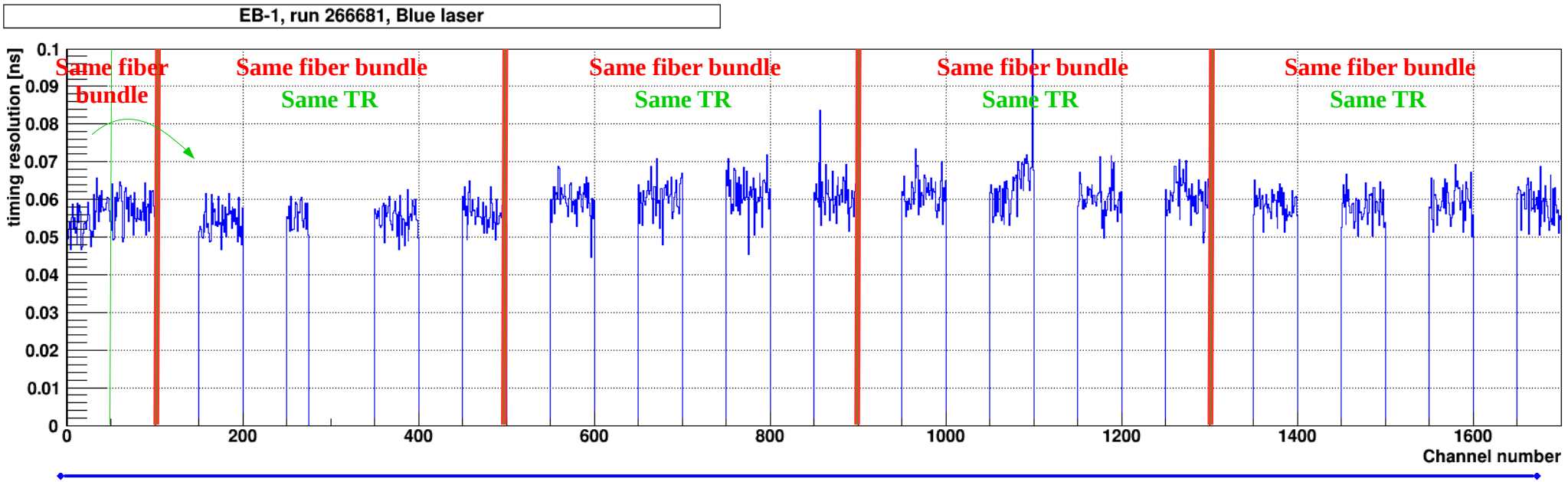
  - **Use SPR library and MATACQ information on sequence by sequence basis**
  - **Analytic computation of pedestal, amplitude and phase after linearisation (iterative process)**



- **This analysis**
  - **Use of Minuit : TH1->Fit()**
    - ► **Expect better resolution**

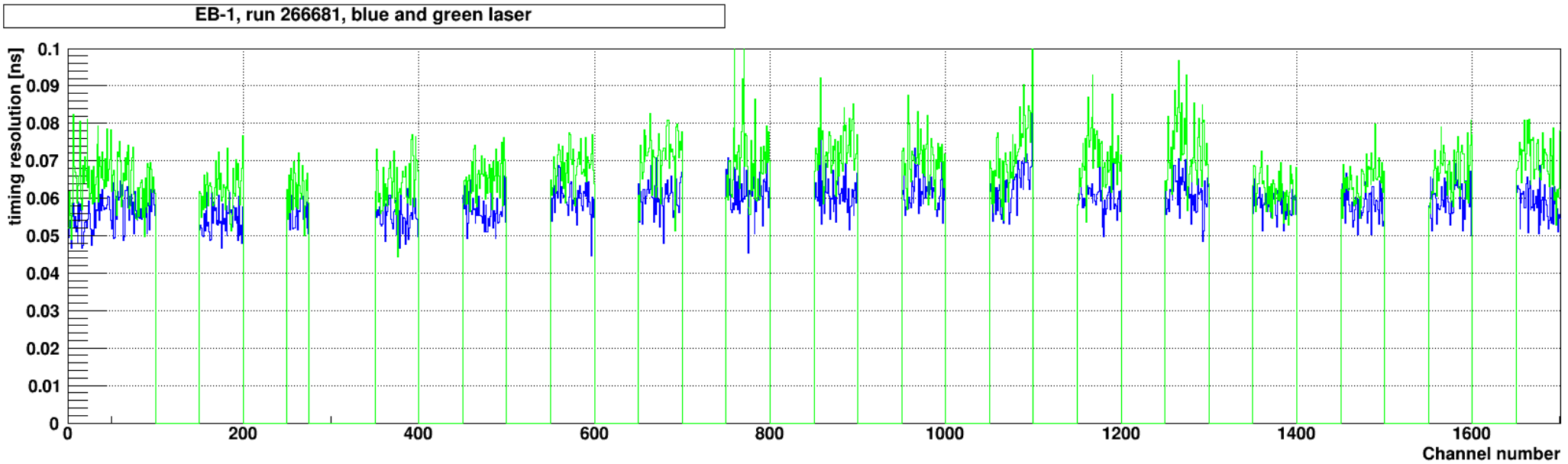
Local timing performances

- 600 events within a monitoring region
  - Use channel 0 as reference
  - Measure jitter of all channels with respect to channel 0
  - Assume channel 0 and 1 with same performances
    - jitter(0)=jitter(1)/sqrt(2)
    - jitter(i)=sqrt(jitter(i)**2-jitter(0)**2)
- Average timing resolution : 60 ps



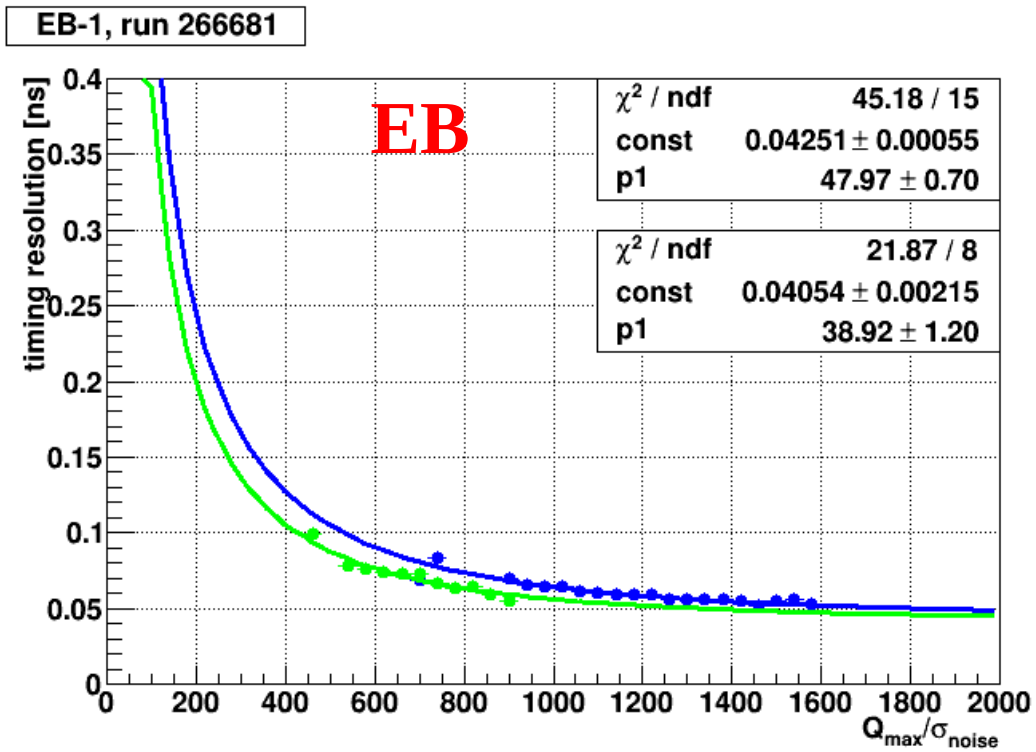
Timing performances vs wavelength

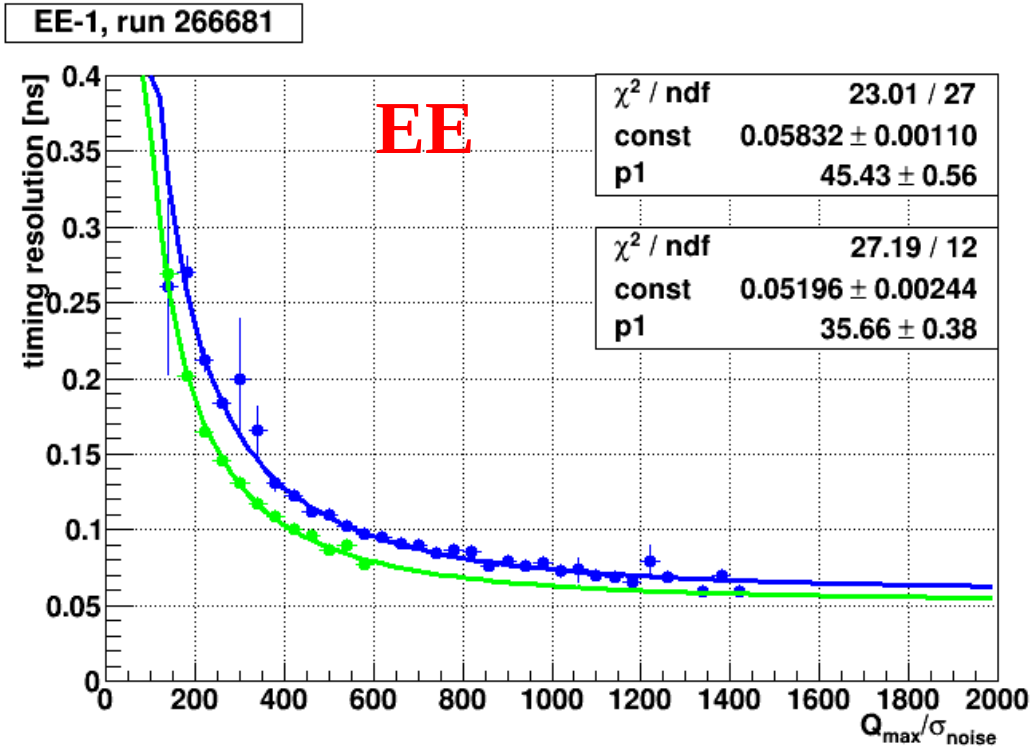
- **Compare DP2 and green laser**
  - **DP2 better than green but...**



Timing performances vs amplitude

- **Look at resolution vs amplitude/noise**
  - **Better resolution obtained with green laser**
    - ► **Shorter pulses**
  - **Constant term ~ 40 ps in EB, ~ 55 ps in EE**
    - ► **Include limits from fit method**

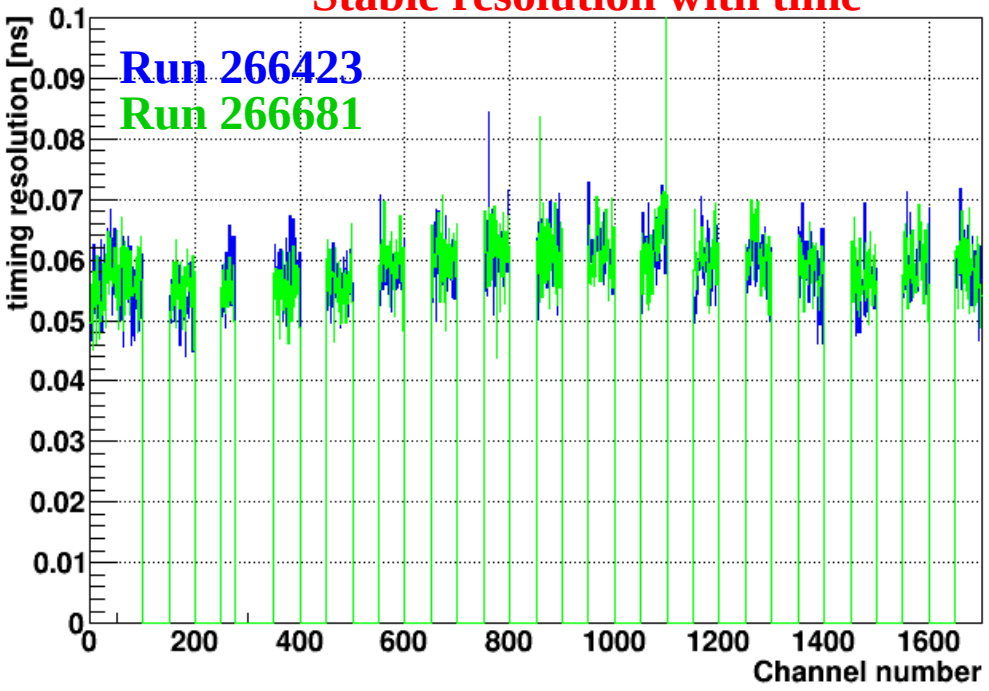




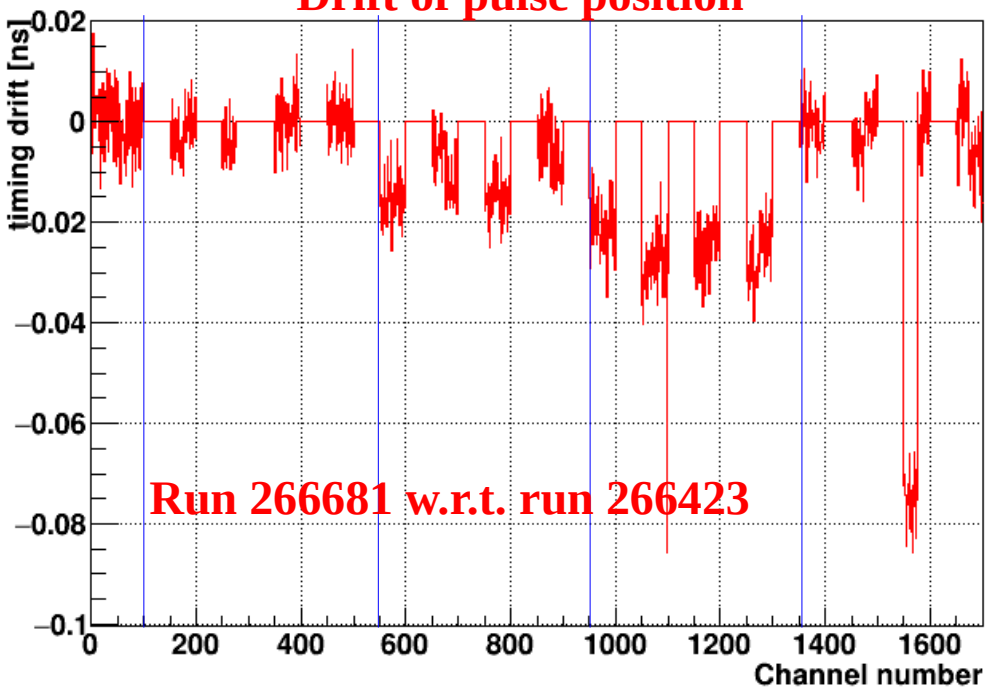
Timing performances vs time

- Look at pulse position for each channel for 2 monitoring measurements, referenced to channel 0
  - Peak precision ~ 60 ps/sqrt(600) = 2.5 ps
- Plot difference between both
  - Stable timing resolution
  - Drift of mean values, vs TR, vs TT

Stable resolution with time

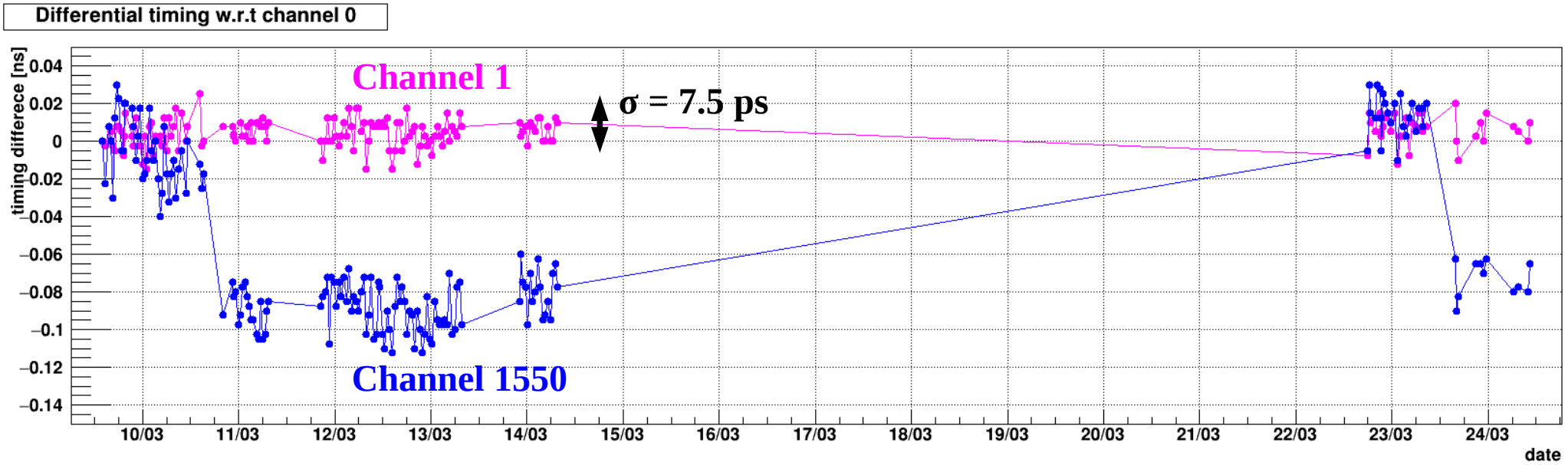


Drift of pulse position



Timing performances vs time : details

- **Look at 2 channels (1 and 1550) w.r.t to channel 0 with time**
  - **Timing measurement with legacy monitoring fit (CPU--)**



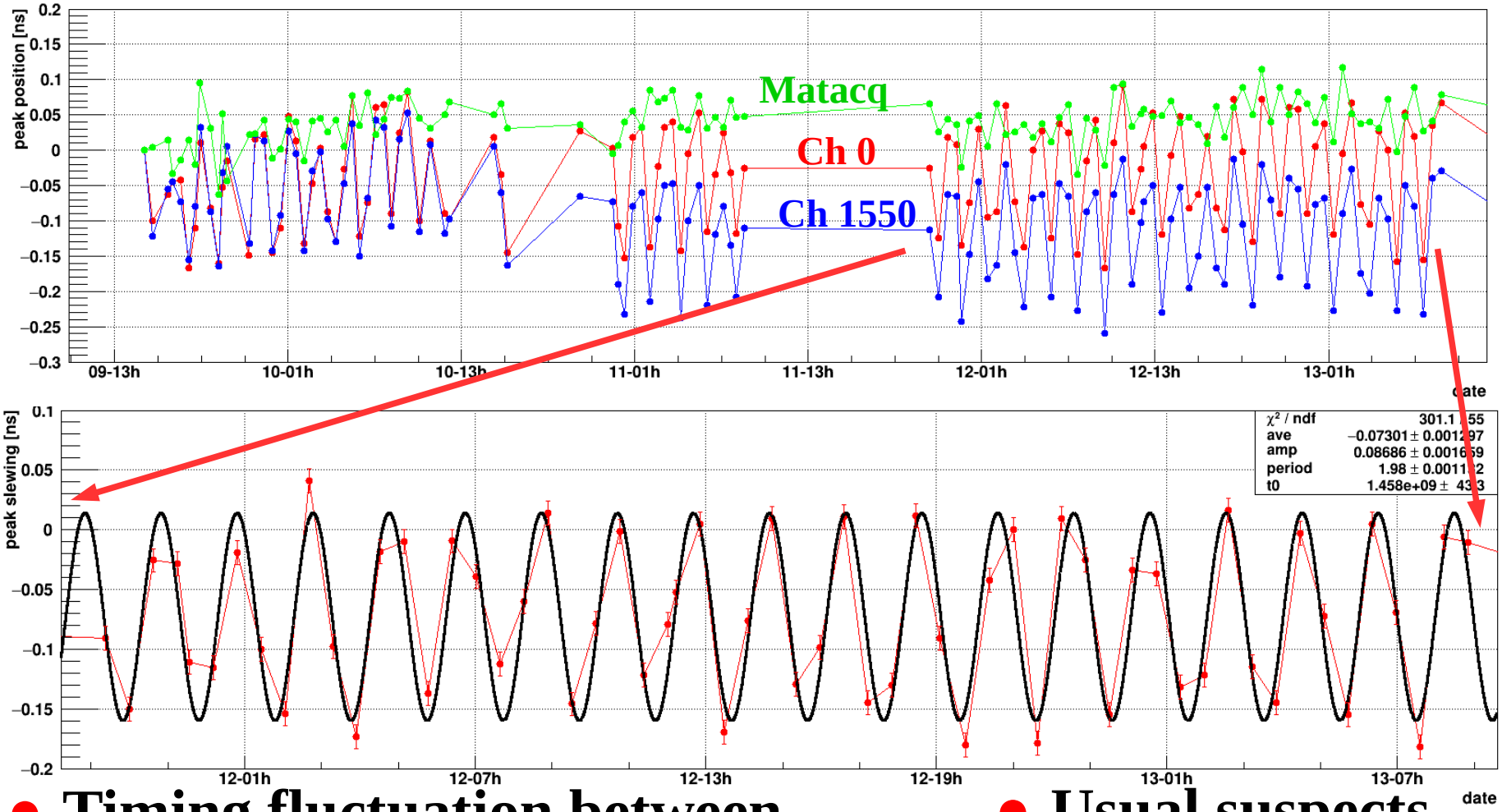
Local conclusion

- **Clock distribution in CMS ECAL**
  - **jitter less than 40 ps within a supermodule**
  - **No jitter increase across TT and/or TR**
- **Differential clock phase unstable between TT and TR**
  - **Phase steps occurrences ~O(100 ps)**
- **Laser monitoring system**
  - **Could recover VFE phase stability within a monitoring region with a precision of 10 ps**
  - **Calibration every ~40 mn**
- **Can we go further : Stable phase in full ECAL ?**
  - **Need to measure laser phase between monitoring region**
  - **Look at matacq data**

Absolute calibration - 1

- **Goal : calibrate differential time drifts between monitoring regions**
- **Need to follow the laser pulse timing**
  - **Use Matacq as TDC**
- **Look at absolute VFE peak position and compare with laser pulse timing**

Absolute calibration - 2



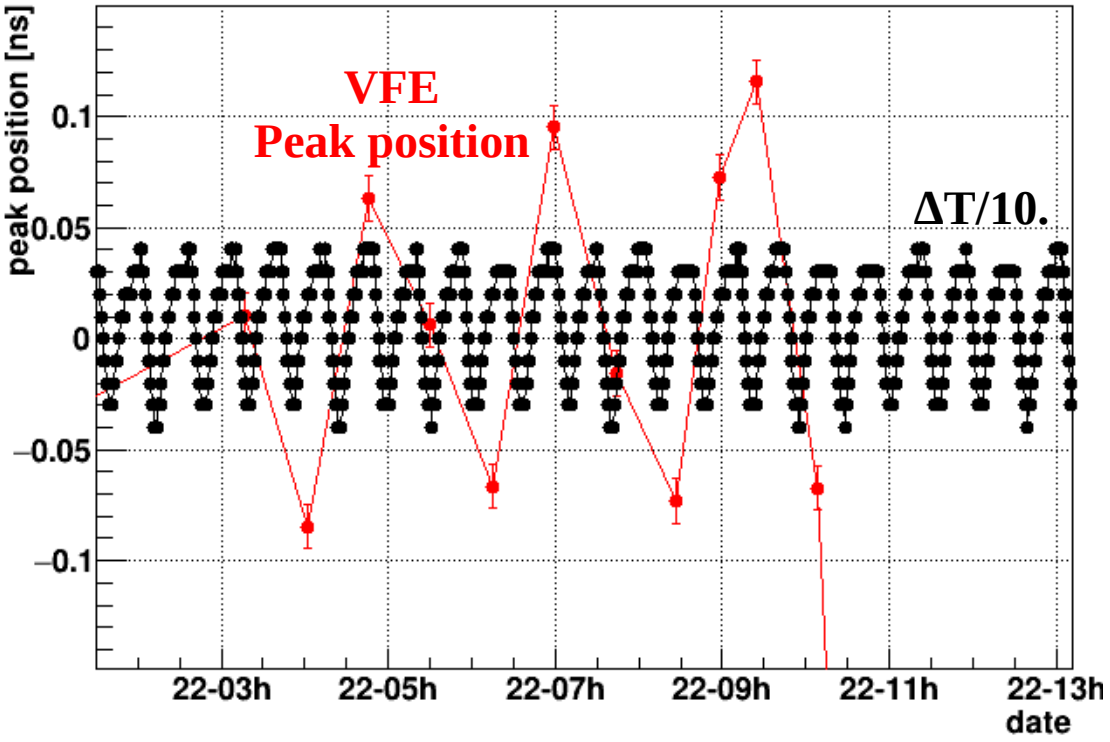
- **Timing fluctuation between matacq and VFE**
  - **180 ps peak-to-peak**
  - **~2 h period**
- **Usual suspects**
  - **PLL**
  - **Temperature**

PLL - clocks - etc

- **Laser and Matacq start signals:**
  - **Built in EMTC**
  - **Synchronized with the same clock**
  - **Clock from partition 4 (EE+)**
- **Compare VFE-matacq timing in different partitions**
  - **Same oscillations for EE-, EB-, EB+ and EE+**
    - ► **Not a problem of clocks across partitions**
- **EMTC signal building**
  - **Use internal FPGA DLL for signal generation**
    - ► **DLL slewing ?**
  - **Modify EMTC firmware to synchronize with QPLL clock**
    - ► **Parasitic test done on March 22.**
    - ► **First indication tends to exclude this cause**
    - ► **To be redone properly**

Temperature

- **Compare timing fluctuations and laser barrack temp**
  - **Laser barrack probe not accessible in DCS**
  - **Compare with laser temperature**
    - ► **No corrrelation (30 min vs 2 hours)**
  - **To be redone once laser barrack ambiance temperature accessible**

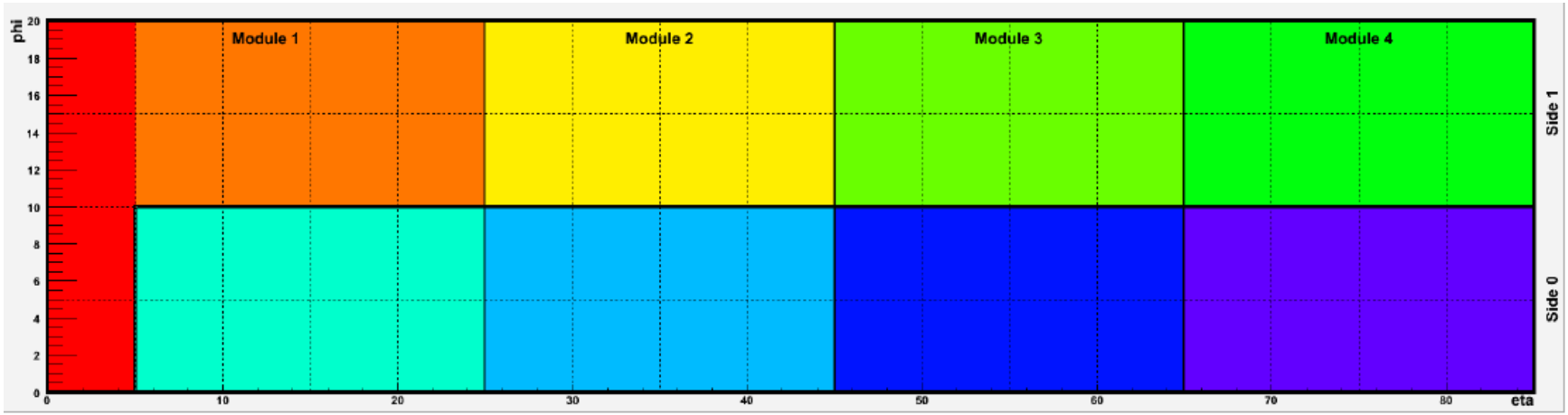


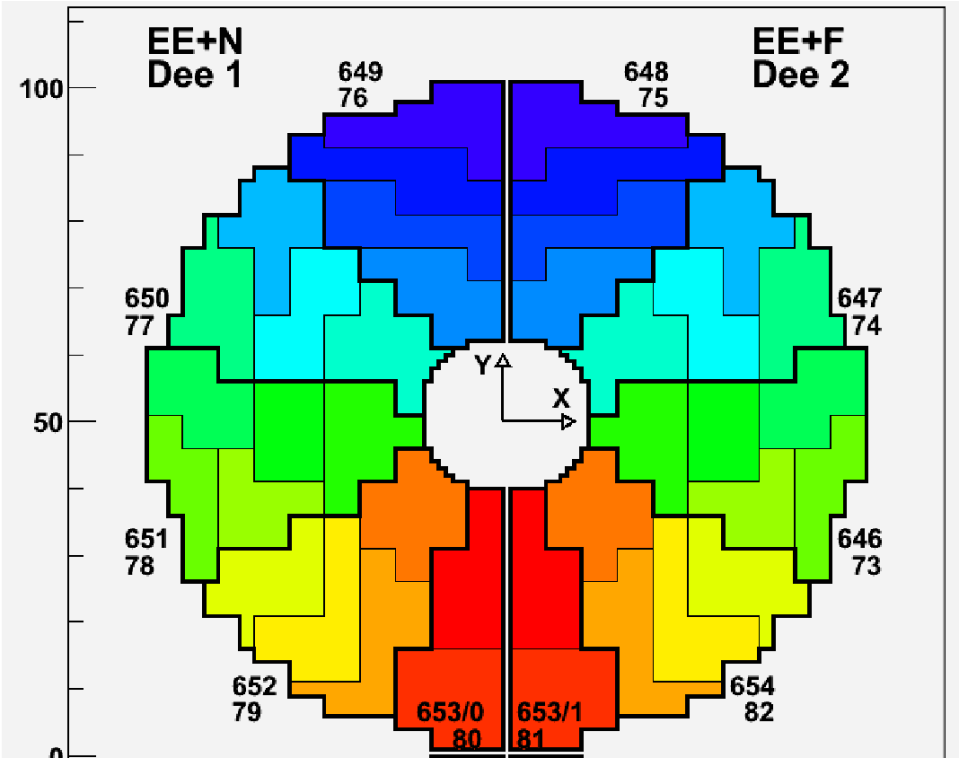
Conclusion

- **Present CMS ECAL has potential for good timing measurements**
  - **Constant term due to clock system <~40 ps**
- **Present laser monitoring system can intercalibrate crystal timing within a monitoring region with a precision of ~10 ps every 40 minutes**
- **Absolute timing calibration of ECAL**
  - **Requires understanding of matacq-VFE timing discrepancy**
  - **Ideas are welcome**
    - ► **Something which moves matacq trigger and laser pulse the same way**
      - **Not seen by matacq**
      - **Seen by VFE**
    - ► **Need to refresh our views of signal distribution in EMTC, matacq, laser, etc.**
      - **System cabling is 8 years old and my memory ...**

Backup

Laser monitoring geometry





Signals path