Combined, Mized and ZS data analysis

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on behalf and with the help of all the
members of the analysis group

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Please come to the analysis session!

- In view of making more and more people able to do analysis using our software, we organized an hands-on tutorial. From scratch to tracks!
- Other results, in particular temperature dependent variations and time dependent telescope resolution will be also presented (Philipp)
- Very recent improvements (Emlyn):
  – Inclusion of Mimosa18 in the converter
  – Capability of decode RAW2 data
  – Capability to write LCIO files directly from the DAQ

Combined data

Objectives

- Offer to DUT users the possibility to use our analysis and reconstruction software combining their data with the telescope reference tracks.

Maximum flexibility for the user

If they use Marlin + LCIO:

- Use JoinEvents to merge the LCIO files and synchronize events.
- Use EUTelDUTHistograms to make standard resolution / efficiency and fake rate analysis for the DUT

If they DON'T use Marlin:

- Use EUTelFitTuple to produce a ROOT TTree (ntuple) with fit results in a very trivial format.
- Add their data as friend branches to our TTree and to the rest by themselves

The DEPFET case

- The have their analysis code, but they want to move to the ILC framework, so they started from EUTelescope.
  - Prepare a DataReader to convert their data into LCIO
  - Use EUTelescope for pedestal / clustering and space point transformation
  - Merge the telescope reference file with their one using: **JoinEvents**
    - This was developed upon our request in LCIO and requires the generation of an event look up table to overcome the serial I/O limitation
- This is successfully working!

Mixed data

Mixed mode

- Main goal: test the performance and the quality of the ZS
- Data taken last year in DESY with 6 GeV electrons
- Two sensors were working in ZS mode (threshold ~ 1 sigma) and sandwiched by the RAW detectors

RAW ZS RAW ZS RAW

4 3 2 1 0

Beam
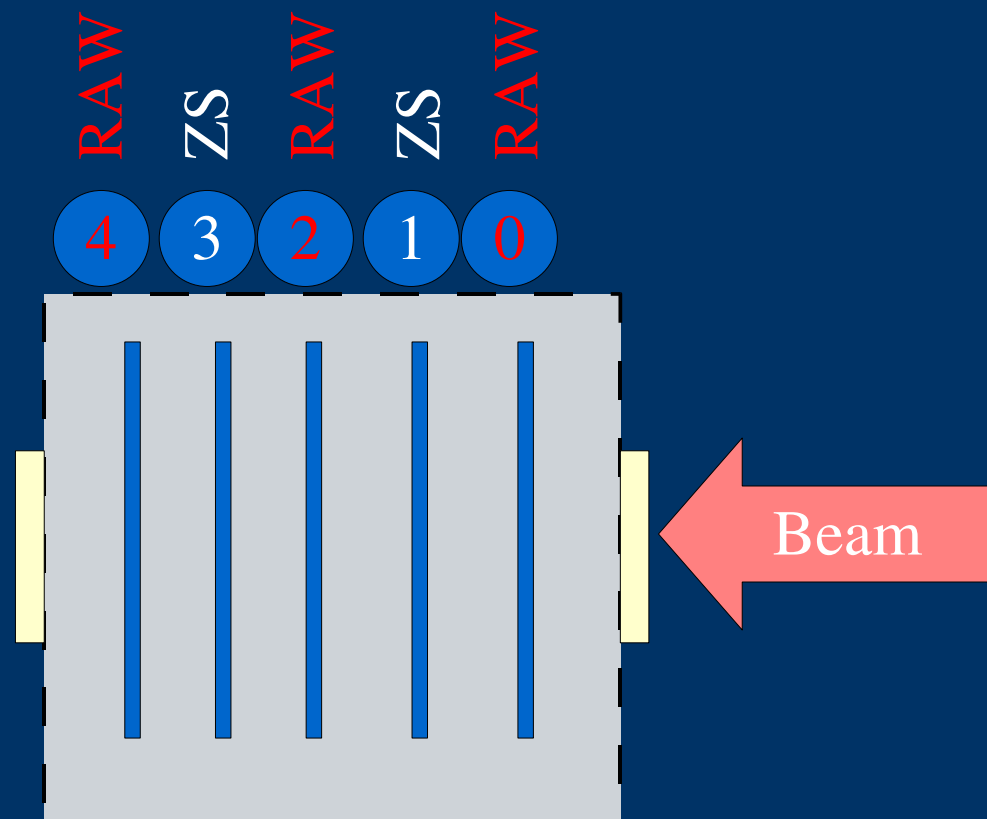
Ideal configuration for debugging:

- Fitting using the RAW planes
- Interpolating on the ZS one used as DUTs
- Comparison of sensor 1 and 3 with normal runs.

Mixed data handling

- The EUDAQ software is labeling how each sensor is readout: either in RAW mode or in ZS
- The analysis software checks this label and treats the corresponding output data differently:
  - In case of RAW data, it calculates the CDS and stores all pixel signals for clustering.
  - In case of ZS data, for each pixel over threshold three numbers are recorded: x, y and signal.
    - No need to calculate the CDS since this is internally done in the EUDRB
  - For all modalities, we have access also to the Pivot Pixel corresponding to the one being readout while trigger arrived.
- Maximum frame rate similar to full RAW mode, because the raw planes are the bottle neck.

ZS re-clustering

- ZS pixels are eventually clustered in standard groups of 5x5 pixel having the one with the highest signal in the middle.
- Differently from RAW data some pixels into a 5x5 frame may be missing because below the primary threshold, nevertheless...

Sensor 0 not displayed because of different epi thickness.

Sensor 3 (green) is the noisy one lots of single pixel clusters

Cluster SNR (3x3) for 6 GeV e⁻

- Sensor 1 (ZS)
- Sensor 2 (RAW)
- Sensor 3 (ZS)
- Sensor 4 (RAW)

SNR
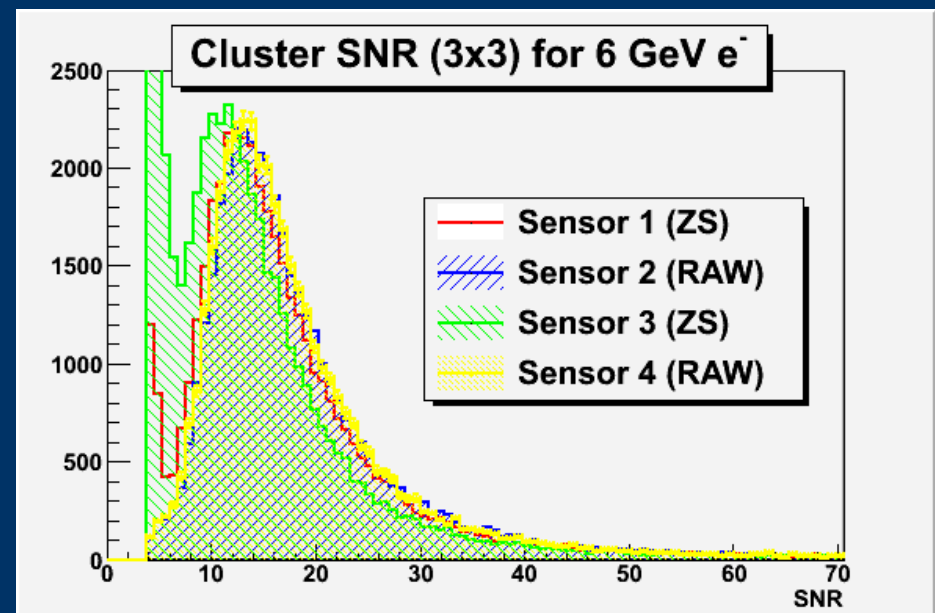
*Fitting the reference planes**

- First step is to validate the RAW planes to be used as reference.
- Planes readout in RAW should have the same residuals as on a full RAW run

		S0	S3	S5
RAW	**ResX [um]**	0.9397	1.8147	0.8972
	ResY [um]	0.9623	1.8630	0.9215
MIXED	**ResX [um]**	0.9316	1.8040	0.8953
	ResY [um]	0.9562	1.8502	0.9153

(*) We never used the Eta correction in this analysis, for two main reasons:
- The way we store the Eta function is not actually compatible with the organization of mixed data. Technicality that may be solved.
- Can you calculate Eta functions from ZS clusters?

Using the ZS as DUTs

		S1	S4
RAW	**ResX [um]**	5.1334	5.2754
	ResY [um]	5.2017	5.3500
MIXED	**ResX [um]**	4.9906	5.1684
	ResY [um]	5.0507	5.2468
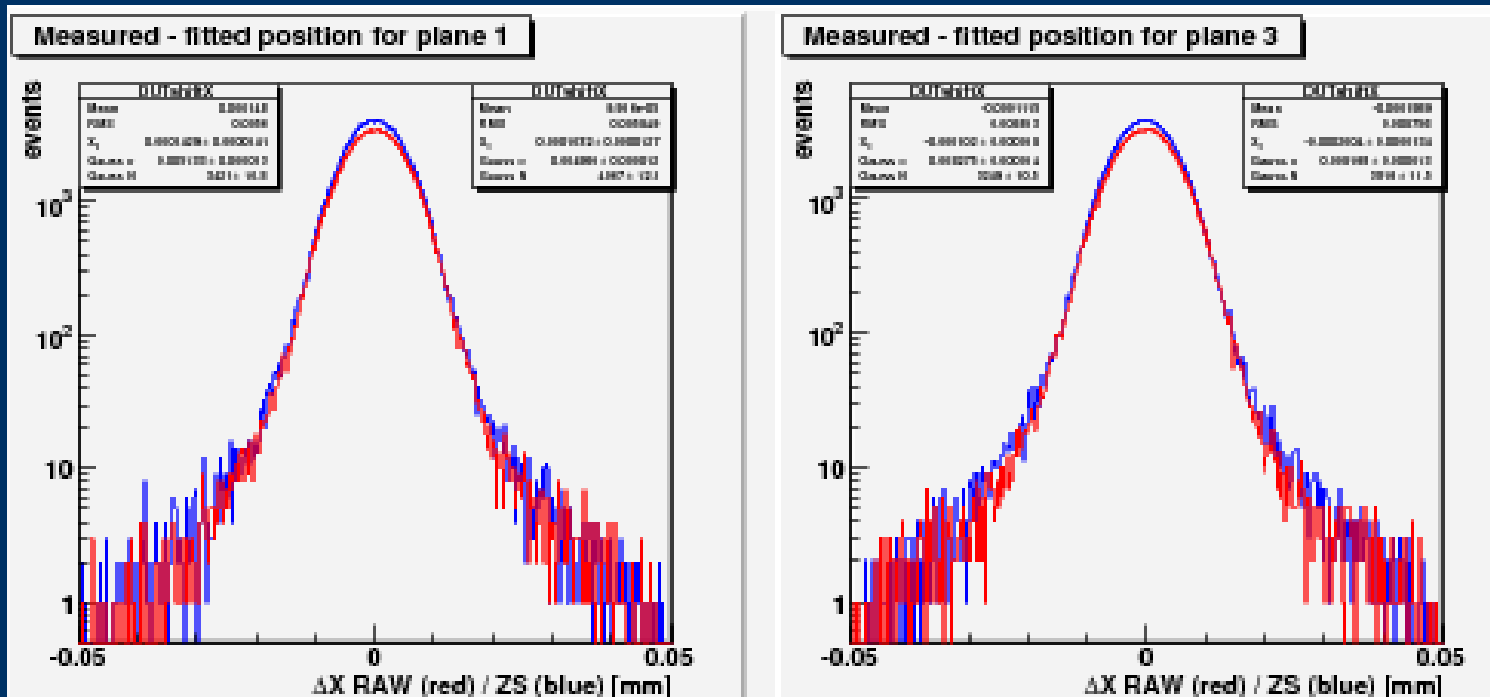
Conclusion on Mixed

- The use of a mixed readout setup was a great idea for debugging the system.
- As expected the planes readout in RAW mode are behaving as in the case of a full RAW run
- ZS planes are well behaving both:
  - In terms of collected charge and SNR
  - In terms of resolution
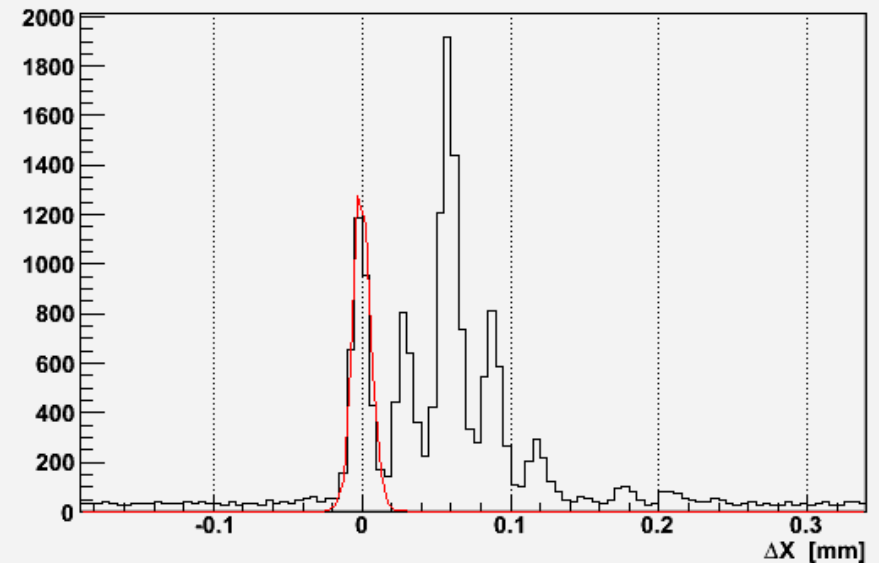- This is proving that ZS is working properly...

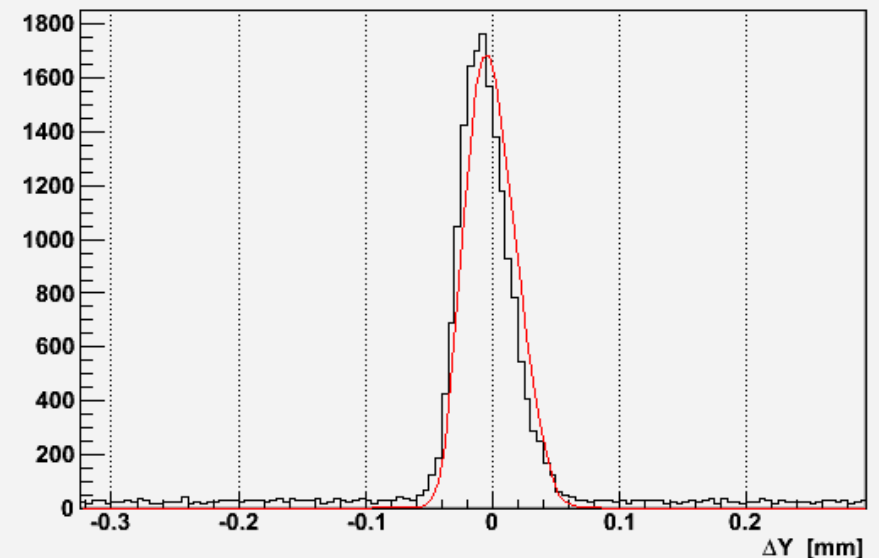But...

ZS data and problems

The first symptom: the alignment

- It was impossible to get a proper alignment!
- Multipeaked distribution for the x direction
- Slightly larger for the y.

- We simply assumed that the telescope didn't move and used the previous alignment constants

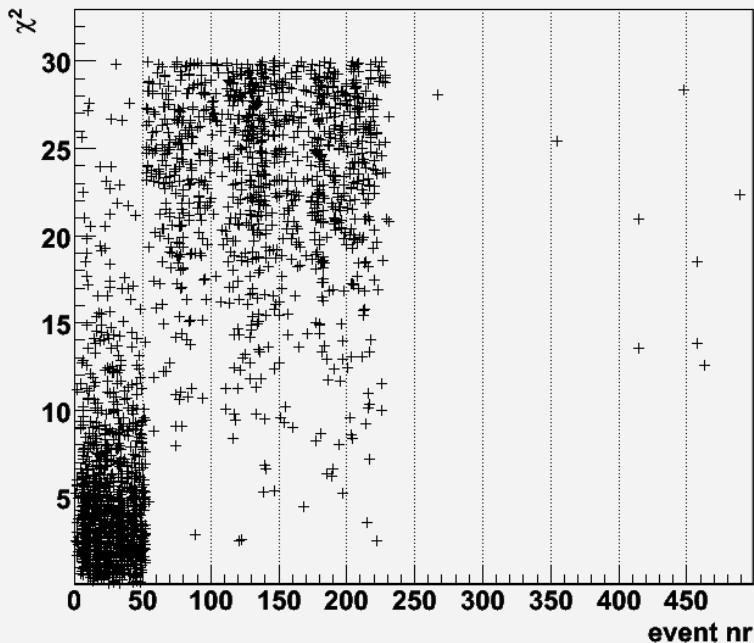Beam alignment shift in X for plane 1 w.r.t. plane 0

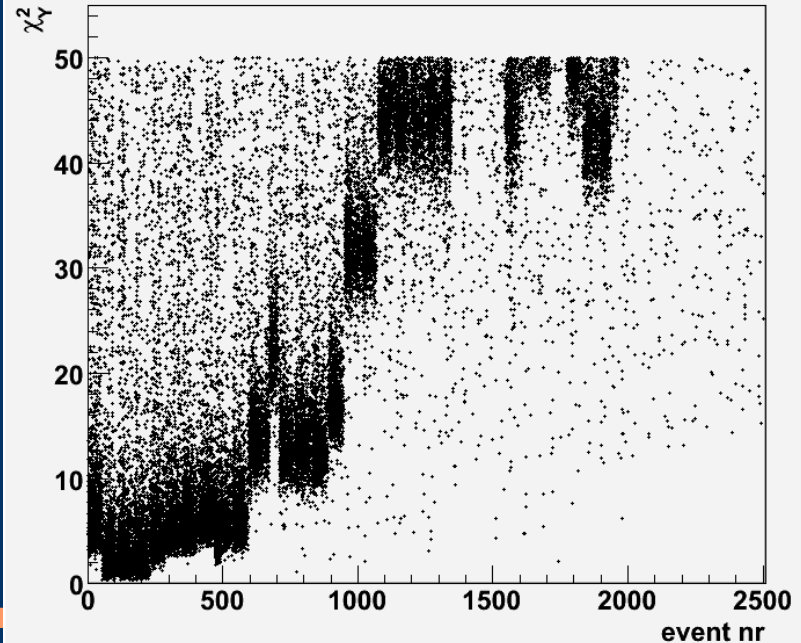Beam alignment shift in Y for plane 1 w.r.t. plane 0

The second sign: the χ²

- The fitting procedure is failing after the first ~ 50 events along x
- Along y the situation is a bit better, but it is just a question of time... (~ 500 events)

Run 1801, fit excluding second plane
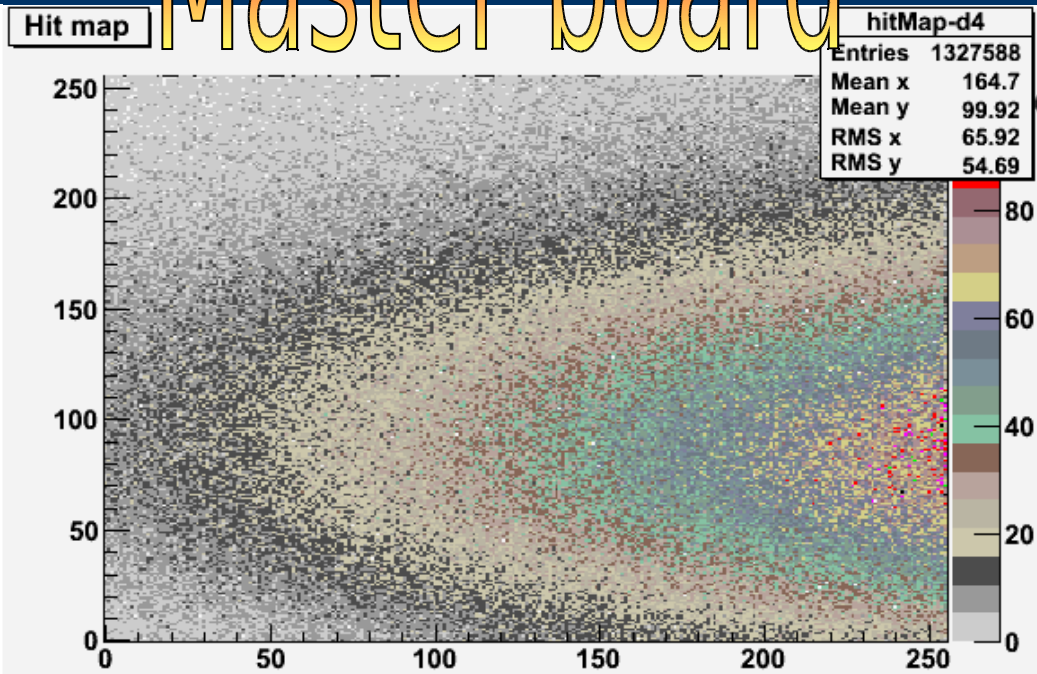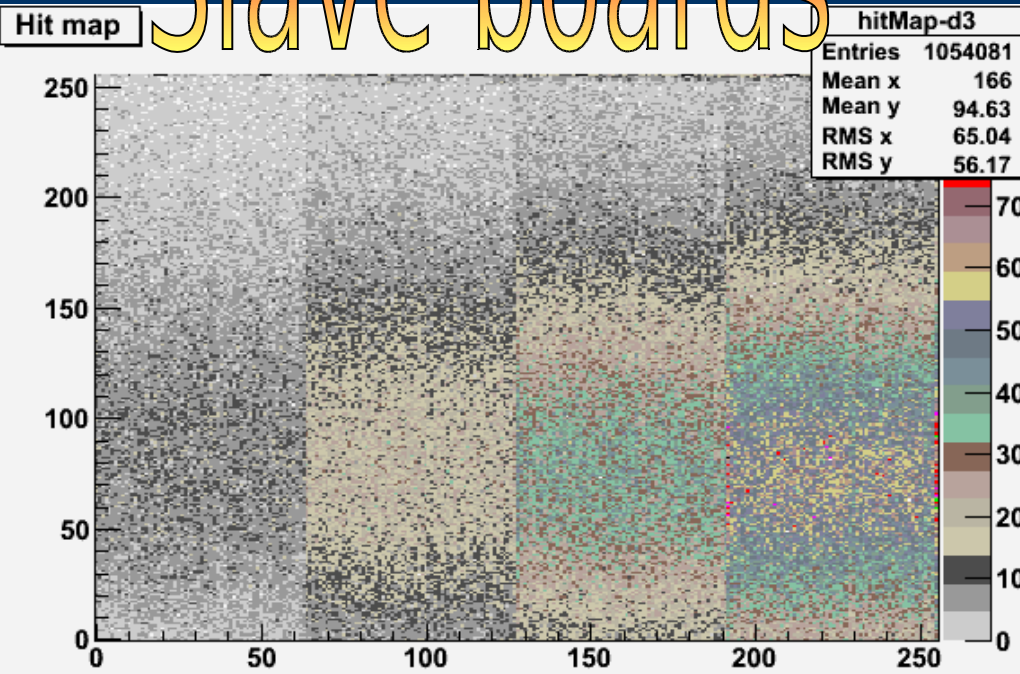

Run 1801, 5 plane fit in Y only

The last one: the hitmap

- The beam footprint appears as it should only on the Master board, while it is deformed on all the others.

Slave boards

Master board

Diagnosis / 1

- It **CANNOT be the software** (EUTelescope) because it doesn't know which is the master board and all the data treated in the same way.
- From the hardware point of view: it **CANNOT be the logic of the ZS** algorithm implemented into the FPGA because on the master board is working

Open questions:

- Why was it working perfectly in MIXED mode? There are just two differences:
  - Speed
  - Reset frequency (boards are reset at the end of each events even if this is not due)
- Why is it deteriorating with time?
  - It looks like there is something critical that we can't recover from
  - **De-synchronization? But of what?**

De-synchronization

- Boards are synchronized and clock is distributed from the master board. This should assure that the pivot pixel address is the same on all the boards ± 1 because of trigger latency.
- In principle a de-synch of the pivot pixel shouldn't affect the reconstruction of the hit position, but only the calculation of the CDS.
- We analyzed the pivot pixel address and we conclude that
  - Pivot pixel de-synch is sporadically observed in RAW and MIXED data, but **it affects great part of ZS data.**
  - While in RAW / MIXED data the system seems to recover from this loss of synch automatically, in ZS the loss of synch is getting worse event by event

Is the pivot pixel out of synch the guilty guy?

- No. We remove from a huge run all events out of synch (max difference > 2) but this didn't fixed the problem!

Is it possible that the scanning clock gets de-synch from the master clock?

- In principle no, but there is no simple way to test it

Is this problem still there?

- We don't know, but probably not! The firmware has been completely refurbished and made stronger against critical paths in view of Cadarache tests. So it maybe gone already

Do we loose a lot of data?

- Not a lot. The great part of the data collected last year was taken in RAW mode to test the telescope. We know that the ZS is working from MIXED runs, but we can't go in full ZS mode with users until this problem will be fixed.

Can we debug the new firmware?

- Yes, we can! And this is the strategy we have in mind:

    – The best way is to go on a high momentum particle beam (in two weeks)
    – In the mean time we can have a look at the hitmaps with sources running the system in ZS mode
        - Set up a system with at least two EUDRBs and two sensors
        - Run the TLU in free running
        - Place the source on top of a shaped collimator and shine it onto the master board (→ we should see a nice hitmap)
        - Place the source with the collimator on a slave sensor and if we don't see any deformation we have good chances the problem is fixed.

Open discussion

- Your comments and suggestions are very much appreciated!!!