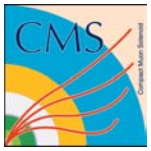

Dec'04 CMS Week

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Universidad Autónoma de Madrid

Bunched Beam Test of the DT Track-Finder Trigger

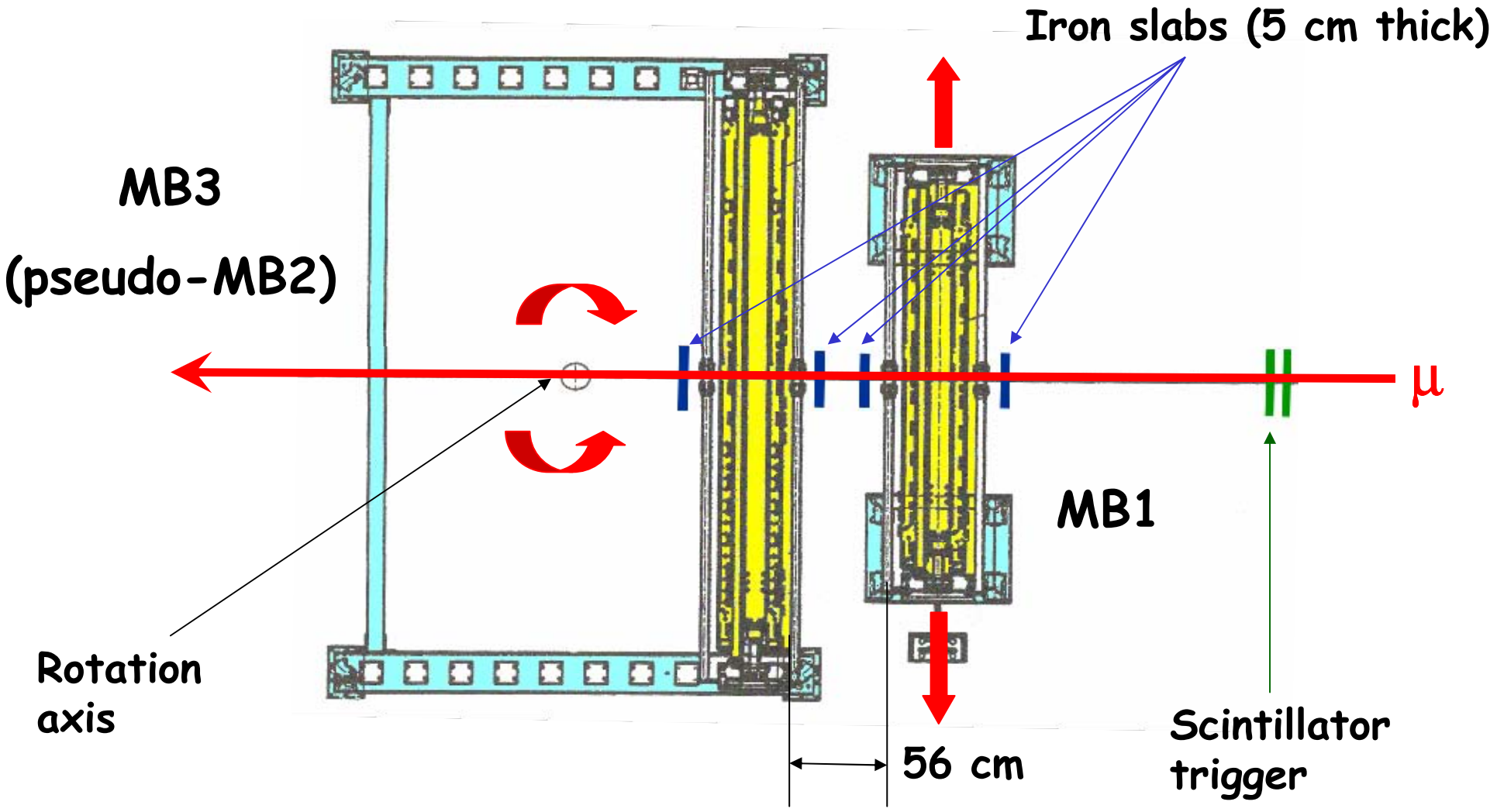
INFN - Bologna, U. A. - Madrid, HEPHY - Vienna

Bunched Beam Test of DT Trigger

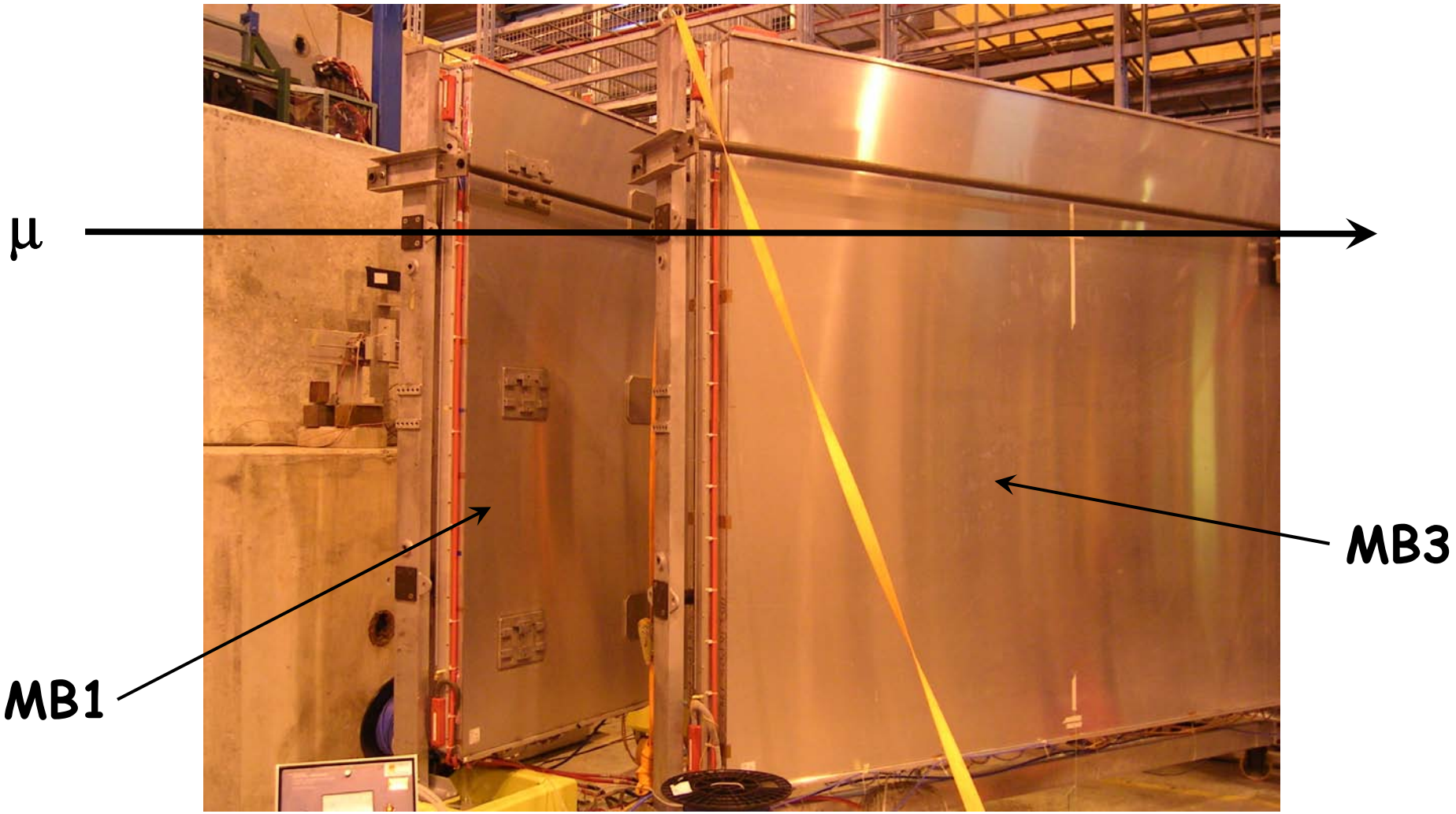
(Aachen, Bologna, Legnaro, Madrid, Padova, Torino, Vienna)

- Two chambers, equipped with front-end electronics for readout and trigger, and connected to prototypes of the ROS-master and of the DT Track-Finder (PHTF and WS), were exposed to the muon 40 MHz bunched beam @ H2 in 6-10 October 04.
- This beam test was intended as a benchmark for the DT trigger electronics together with all the hardware and software tools for configuration, synchronization and operation.
- The chamber configuration reproduced the trigger conditions of a MB1 and a (pseudo-) MB2 at Wheel 0 in CMS, including slabs of iron in front and between the chambers.

DT Chamber Setup



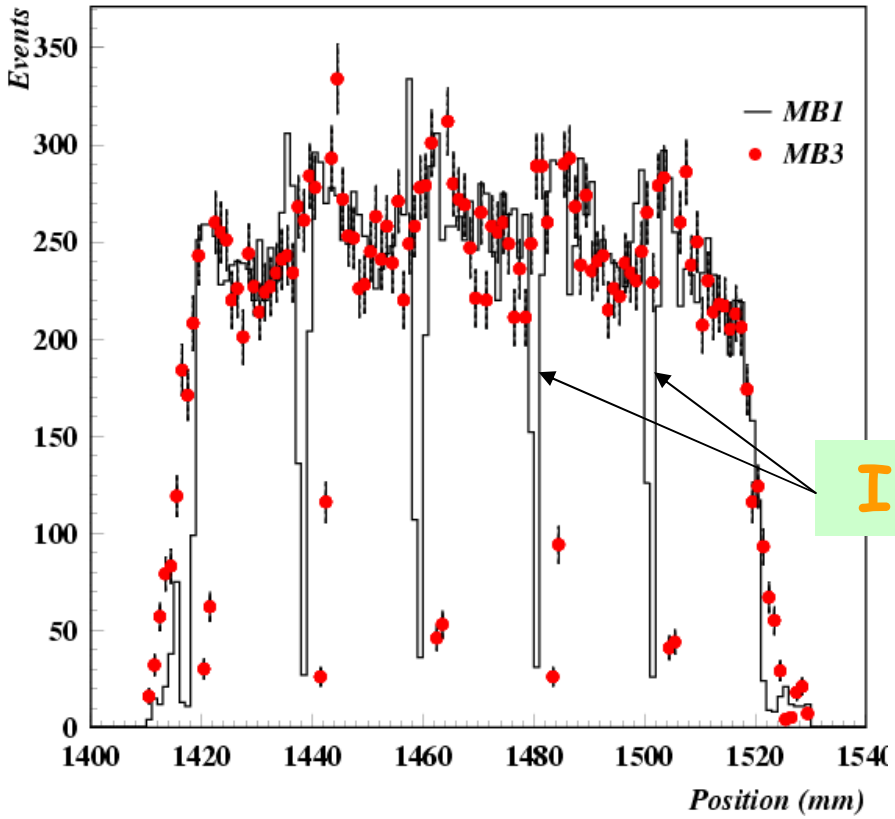
Experimental Area



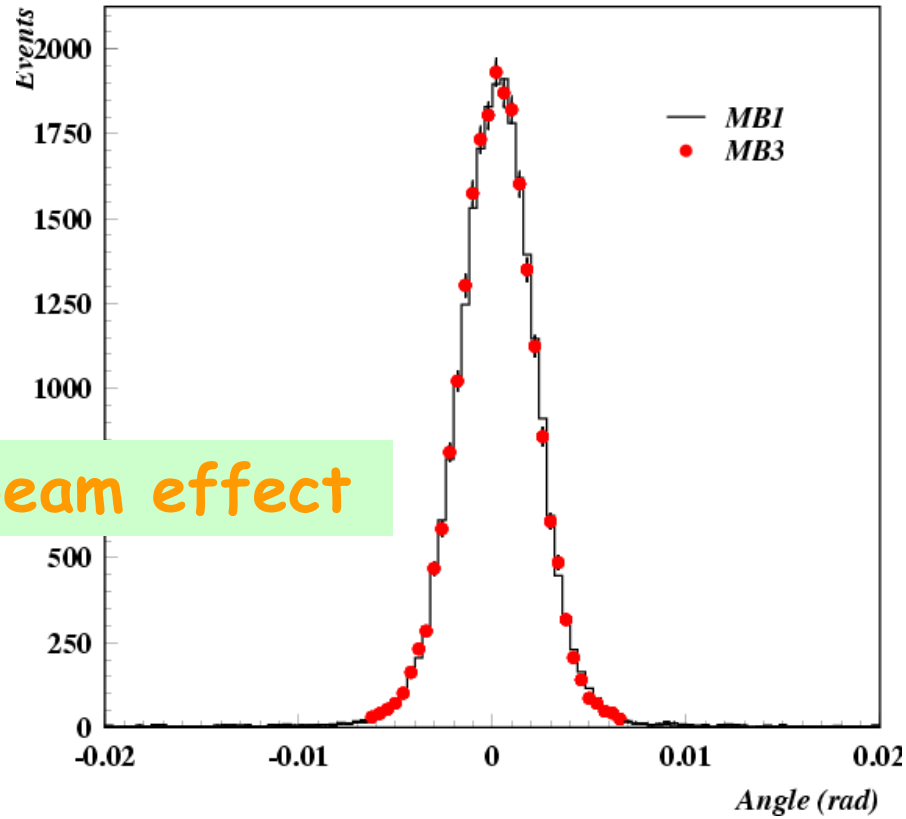
Beam Seen by the Chambers

4+4-hit events = good muons

Beam size: 10 cm (scint. trigger) Angular size: 2 mrad



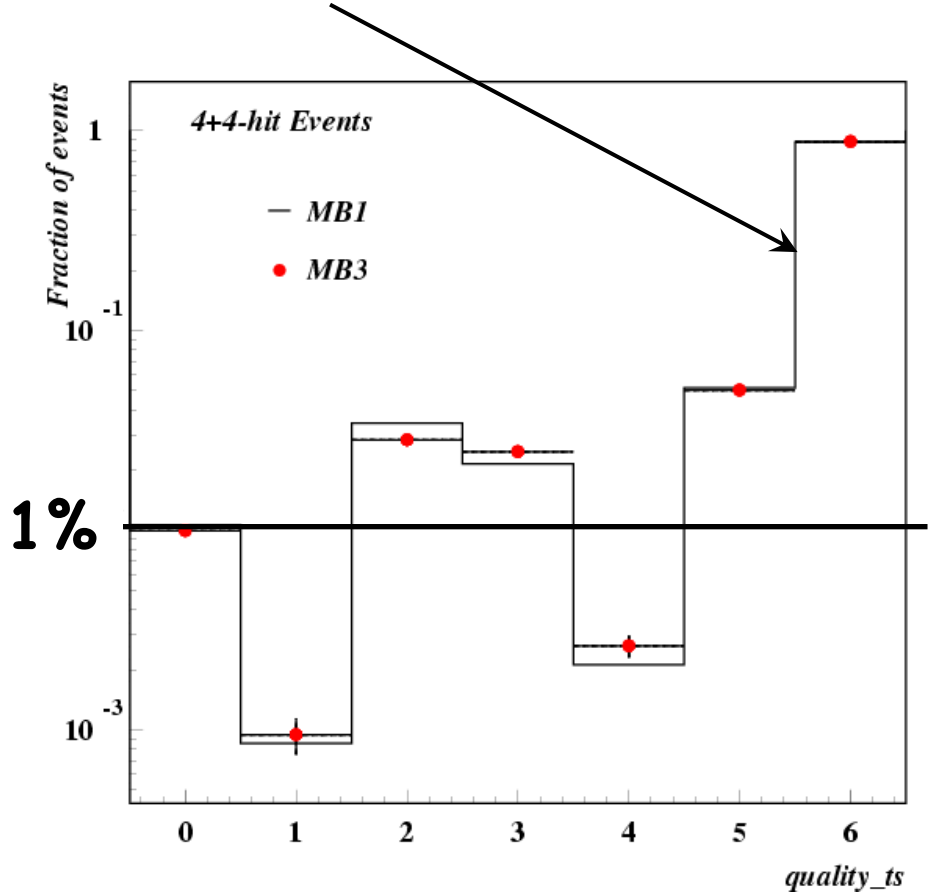
I-beam effect

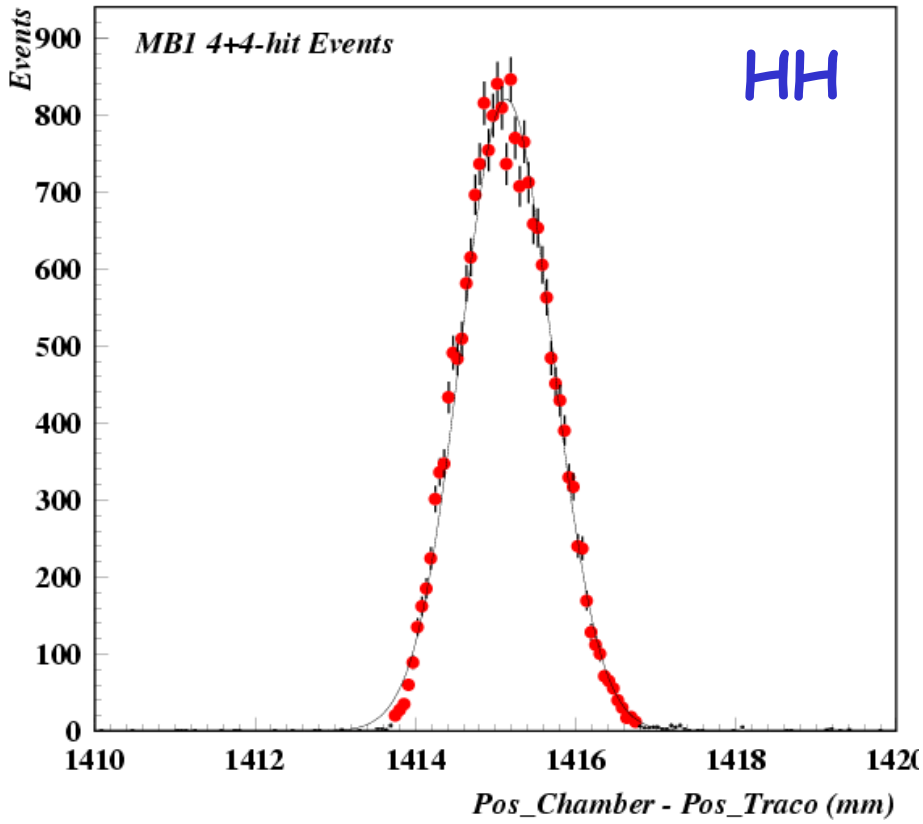


DT Local Trigger Performance

HH (qual=6) efficiency: 90%

Position resolution: 0.54 mm

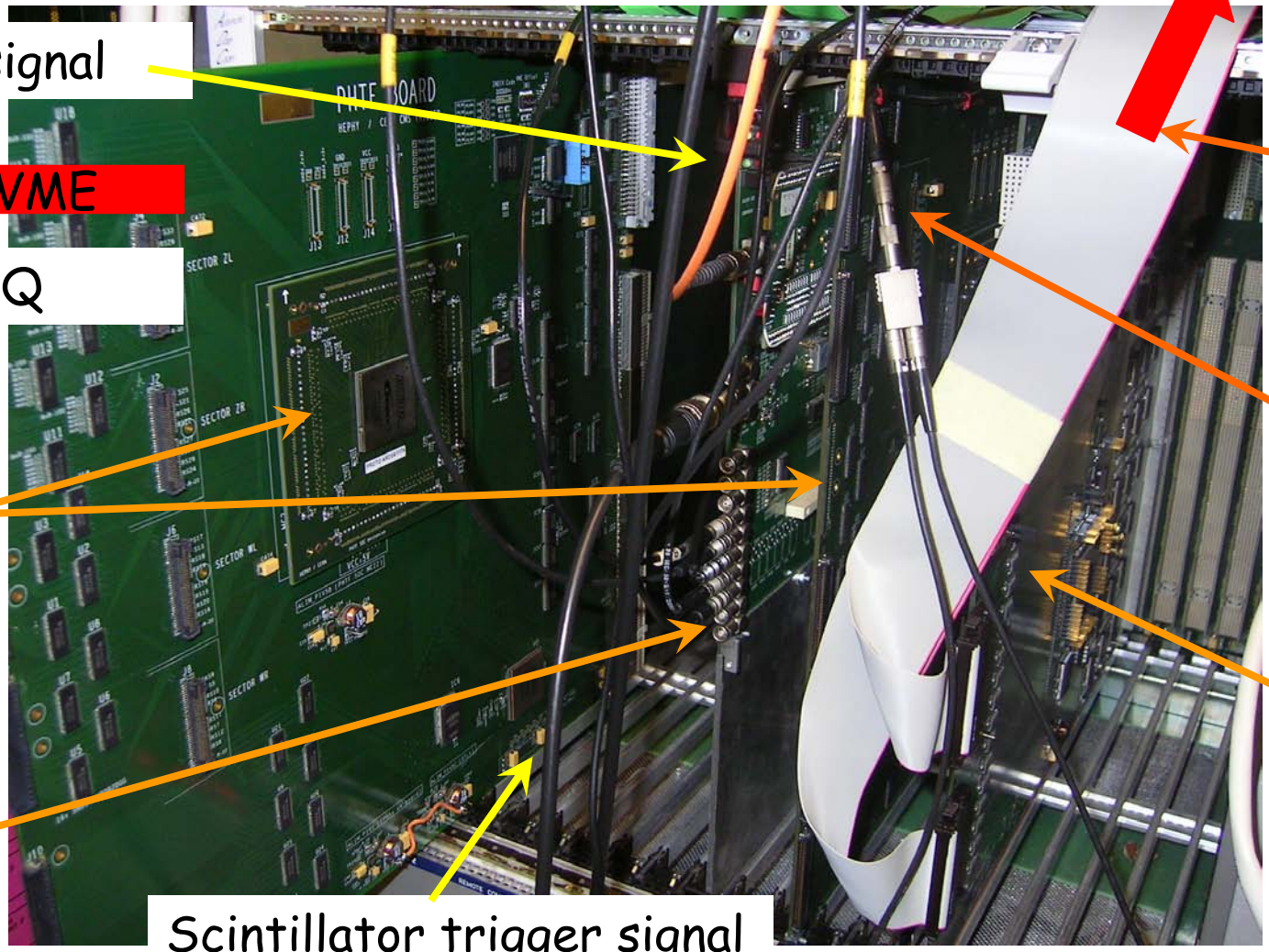




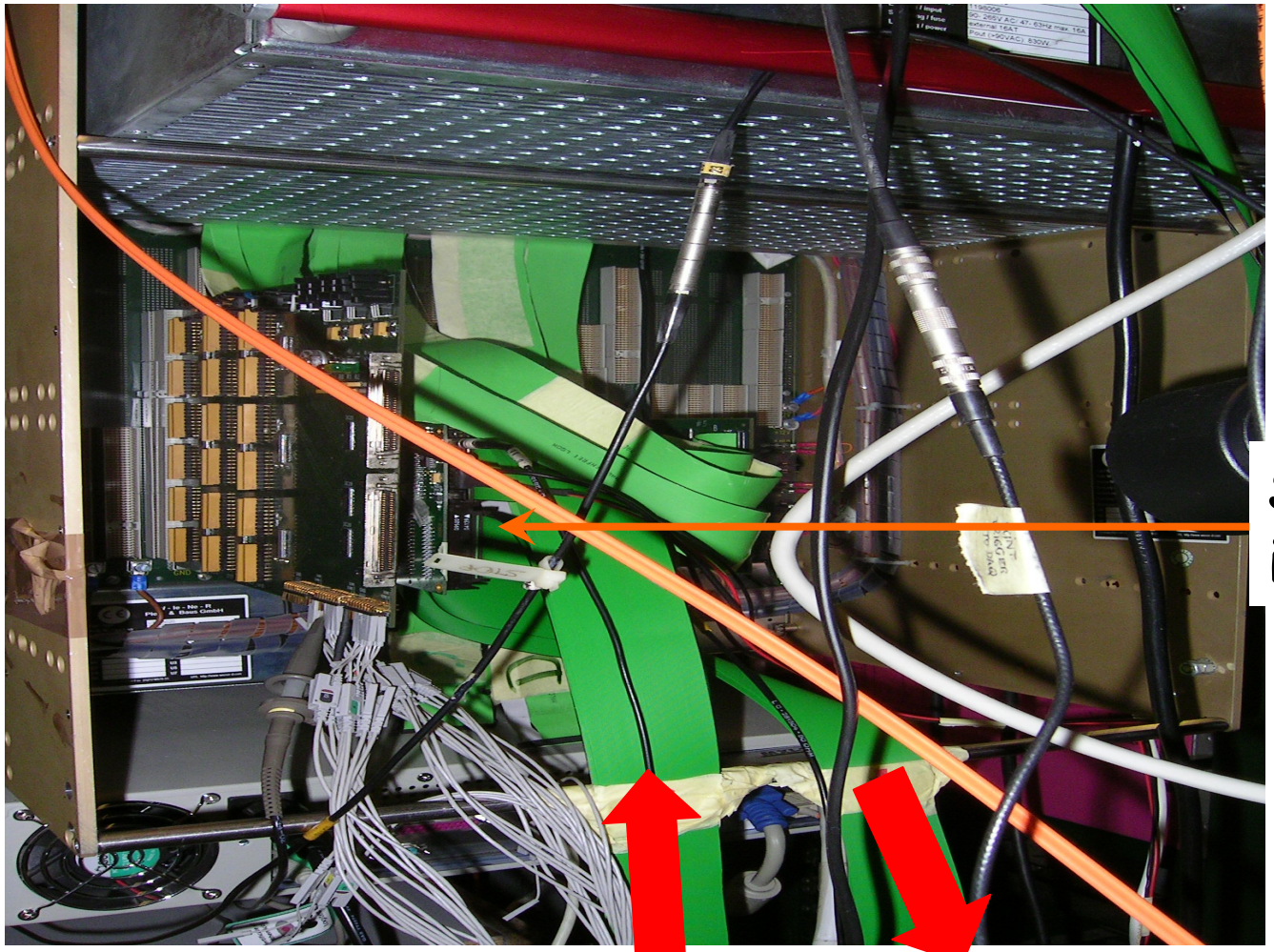
PHTF setup

- PHFT board arrived to CERN at the end of August.
- Test bench activities in September:
  - Cabling, new XDAQ software and basic tests (chip interconnectivity, Boundary Scan and Spy JTAG chains, etc) carried out.
  - Track-finder logic upgraded, and tested using single muon and dimuon ORCA events.
  - Spy system modified for integration with TB DAQ.
  - New set of extrapolation LUTs, adapted to TB geometry, calculated. Back-up solution (open LUTs) prepared.
  - Integration tests with Bologna boards (SC, WS) .
- At H2:
  - For configuration of the PHTF at TB, firmware (logic + LUTs) downloaded manually (Quartus): 3 times.
  - Setup for default configuration is automatic (at power up).
  - Turn on of alternative noise and ghost suppression schemes done using test bench software.

DTTF Crate (Front Side)



DTTF Crate (Back Side)



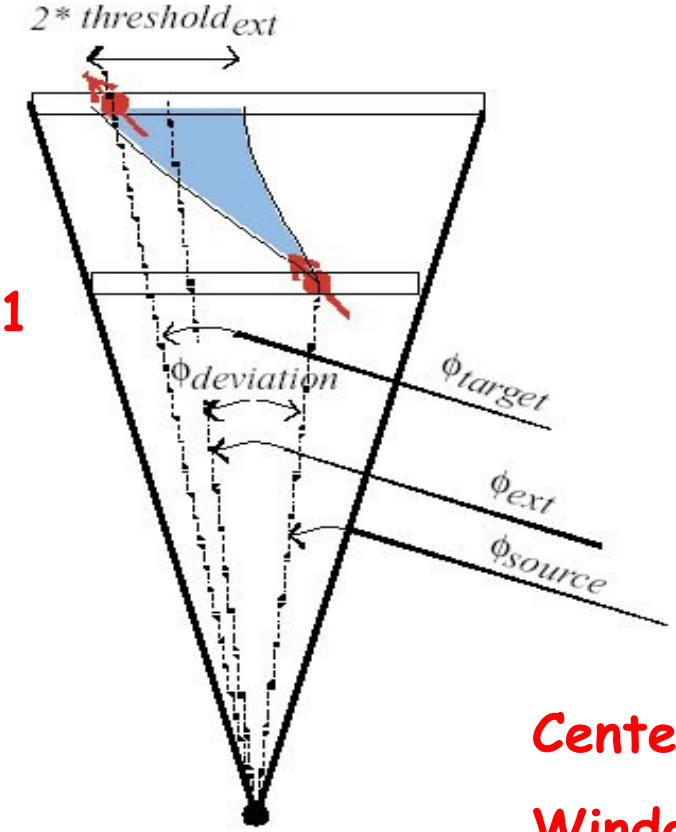
SC-to-PHTF interface board

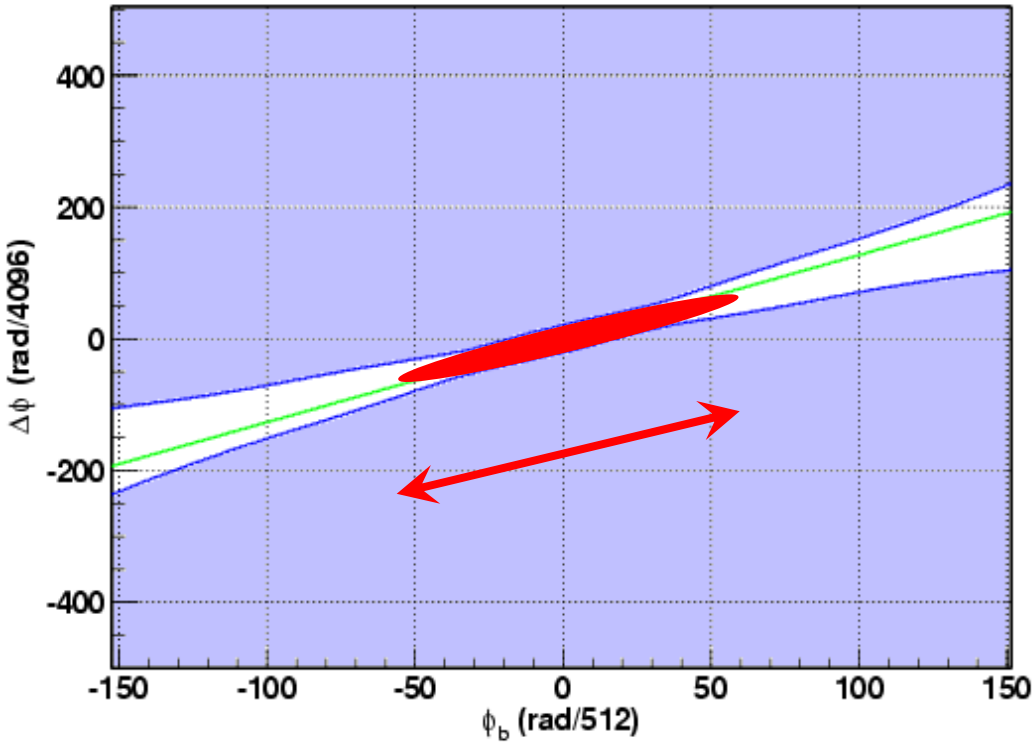
From SC

To PU1

Extrapolation LUTs

MB3 simulates MB2, with MB2 Traco LUTs





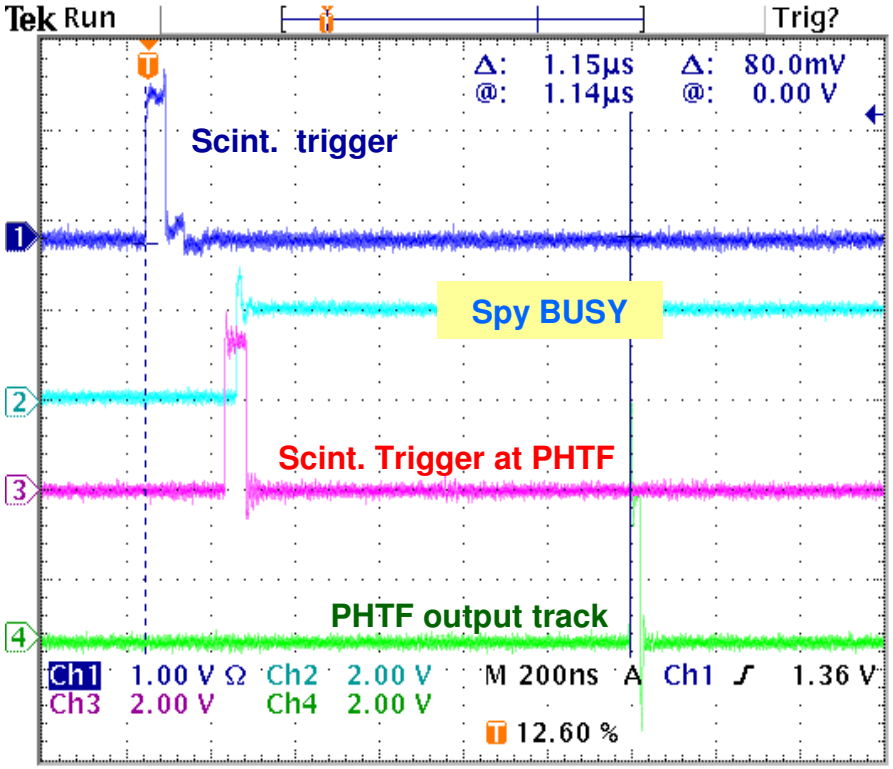
Center: Beam spread simulates different Pt values

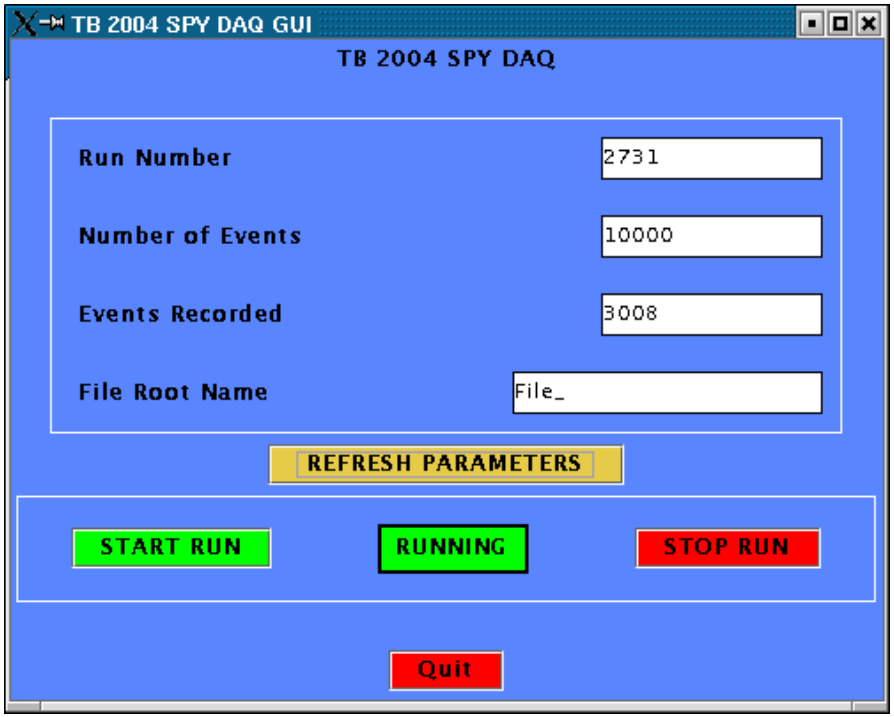
Windows: nominally 99% efficient (from ORCA)

DAQ

- Two systems reproducing the situation at the CMS Control Room: Central_DAQ and Local DAQ (TB_DAQ).
- Central_DAQ accessed full info about DTTF input (PU1) and output (PU2).
- TB_DAQ, based on SPY_DAQ (2nd JTAG), accessed directly PHTF information (bandwidth 150 Hz).
- Spy system was modified to be triggered by external L1A signal. SPY_BUSY signal allowed synchronization with Central_DAQ with full flexibility:
  - Central_DAQ standalone
  - Central_DAQ, TB_DAQ synchronized (event-by-event comparison)
  - Central_DAQ, TB_DAQ (5 times slower) running in parallel
- Relative delays of PHTF spied blocks determined and stability tested in September. Delay of Spy trigger w.r.t. scintillator trigger measured using early data.

From SPY_DAQ to TB_DAQ



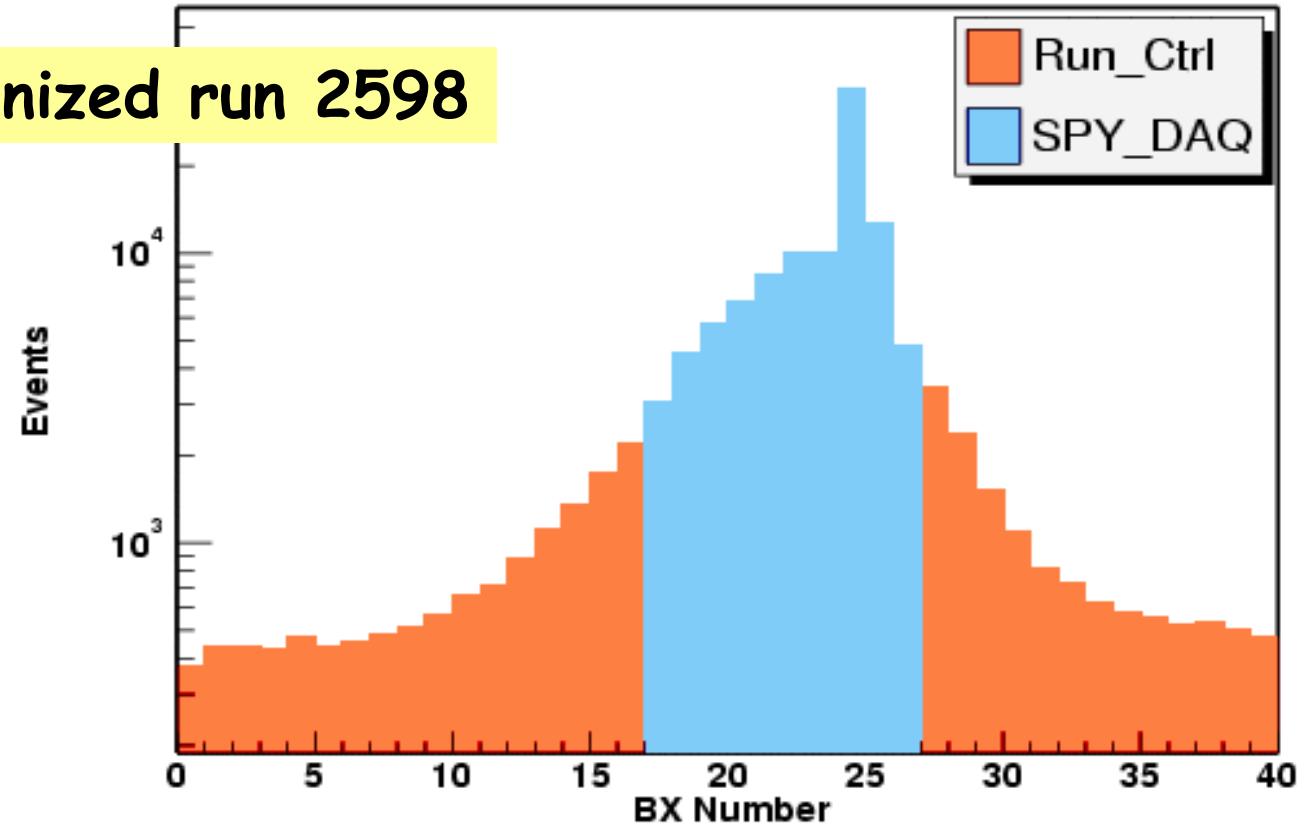


- Spy performance was excellent (perfect synchronization with scintillator trigger signal and Central_DAQ, no hang-ups), confirming SPY_DAQ as our preferred solution for future use and development.

Central_DAQ vs. SPY_DAQ

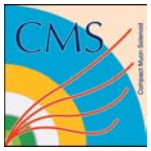
- Central_DAQ read 40 BXs (Trigger BX = 24). TB_DAQ concentrated on 10 BXs around trigger.

Synchronized run 2598



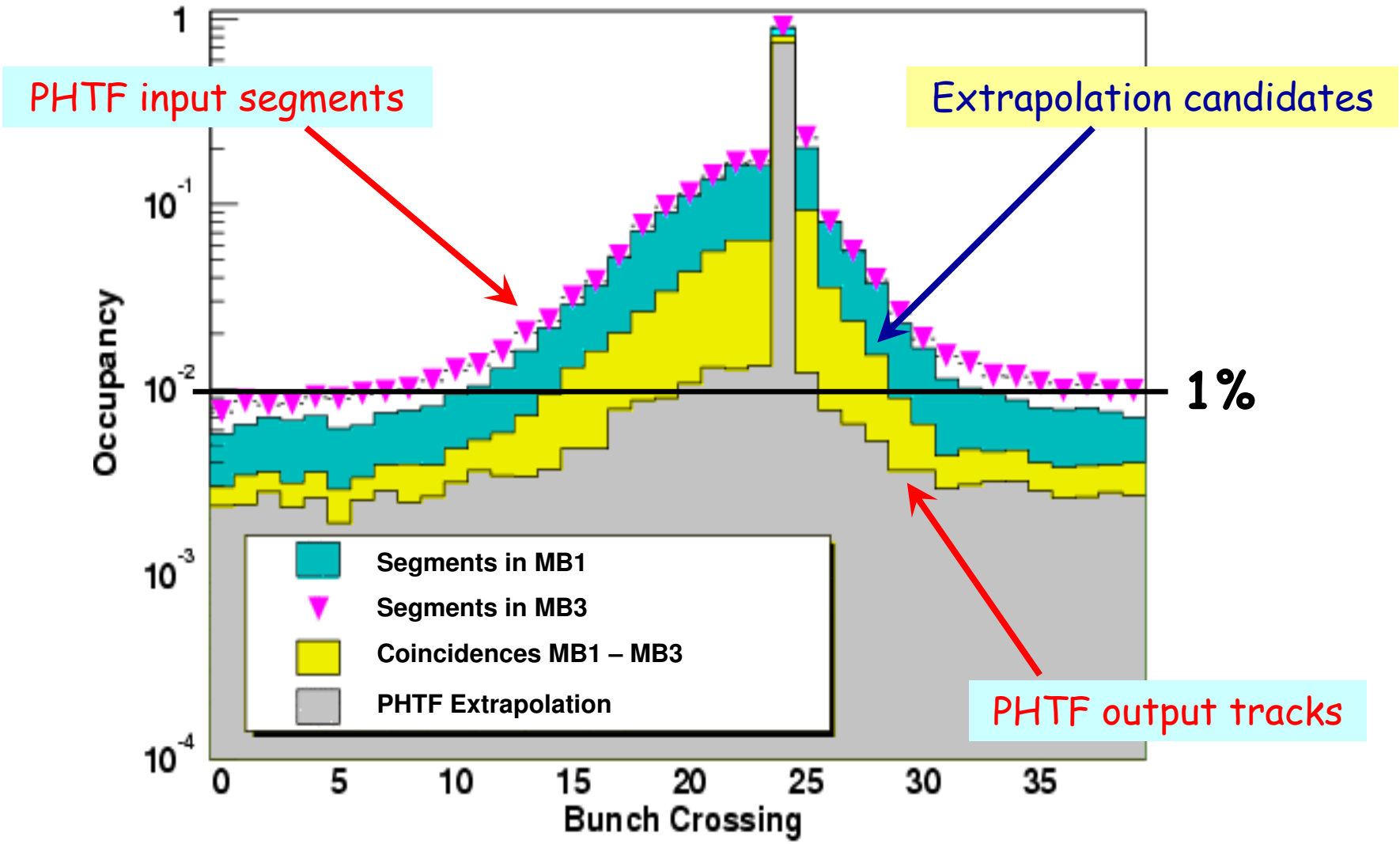
Data Taking Program

- All runs included by default DTTF information (PU2 in Central DAQ).
- From them, 50 runs (about 2 million triggers) specially devoted to DTTF studies:
  - **Energy scan** (50, 100, 150, 300 GeV) with and w/o iron
    - Since our test was parasitic of HCAL, no freedom to choose beam energy
  - **Pt scan:** 11 positions w/ and w/o iron covering full range of Pt assignment @ 100 GeV.
    - Since MB1 couldn't be rotated, different angles "simulated" by MB1 lateral displacement (with backup open LUTs)
  - **SPY_DAQ** tests
  - Alternative noise and ghost suppression schemes (**Q-cut, 2→1 extrapolation, H-filter**)

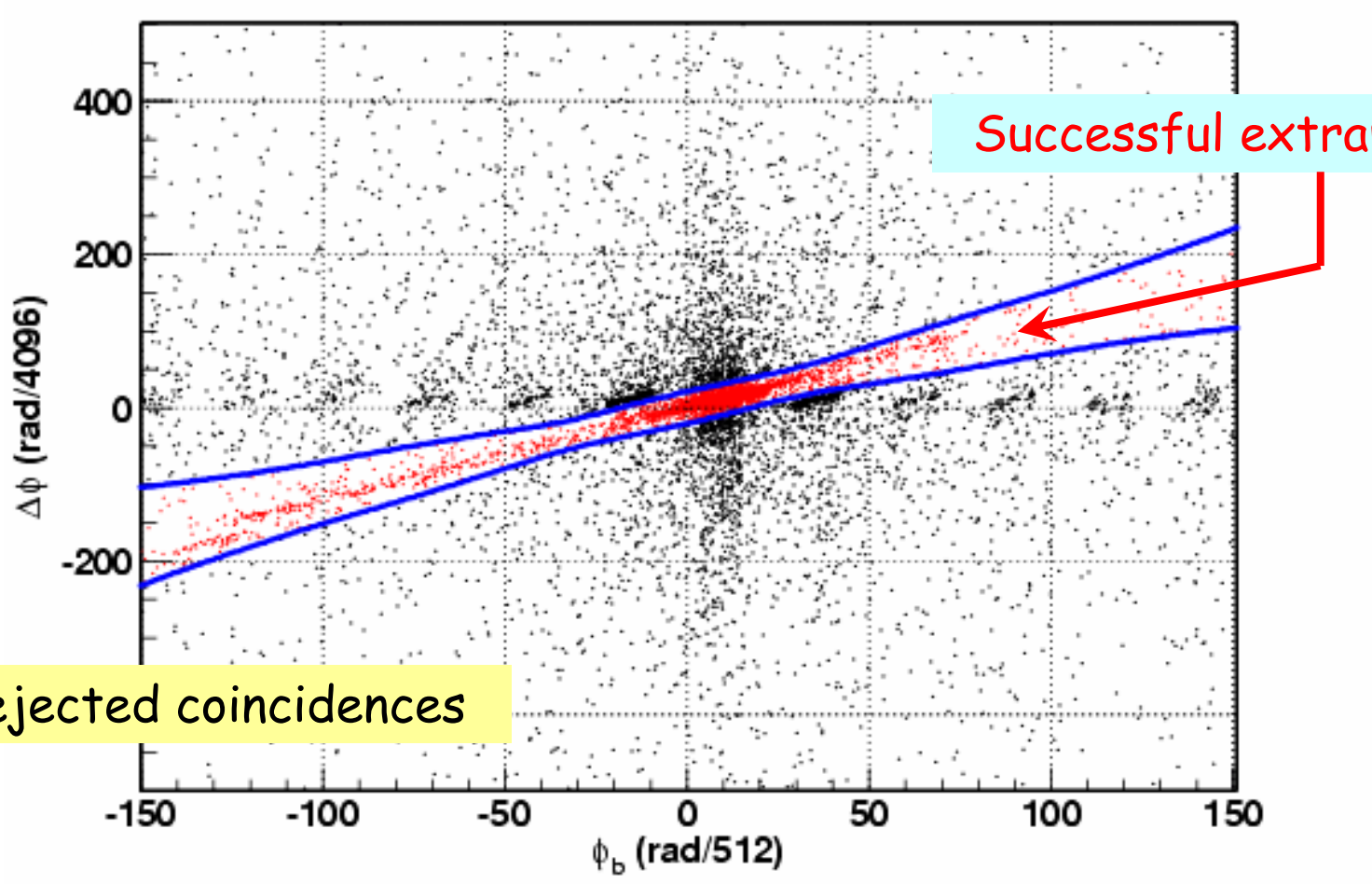


First look at the DTTF data

PHTF Performance: Occupancy

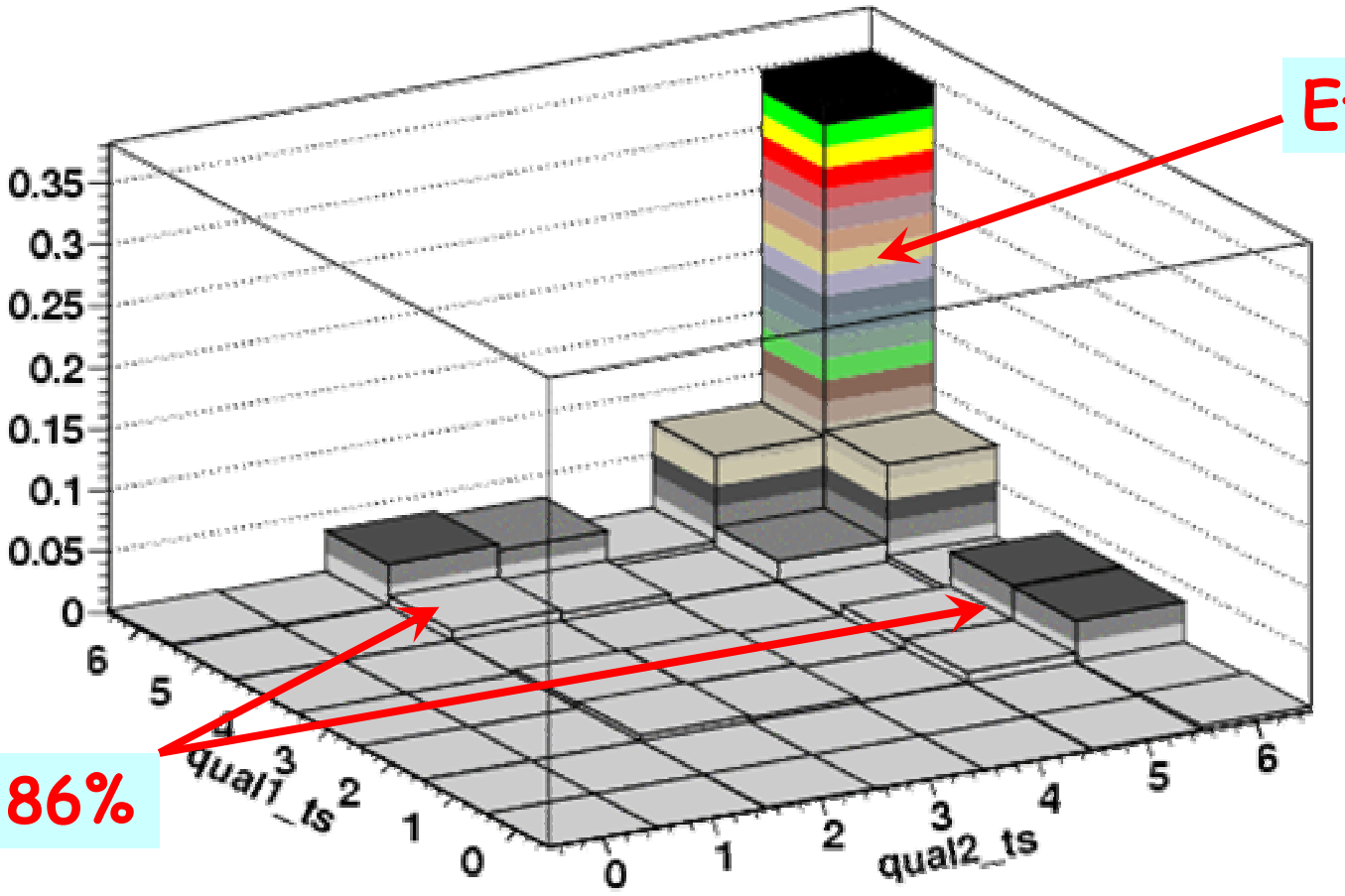


PHTF Performance: Extrapolation

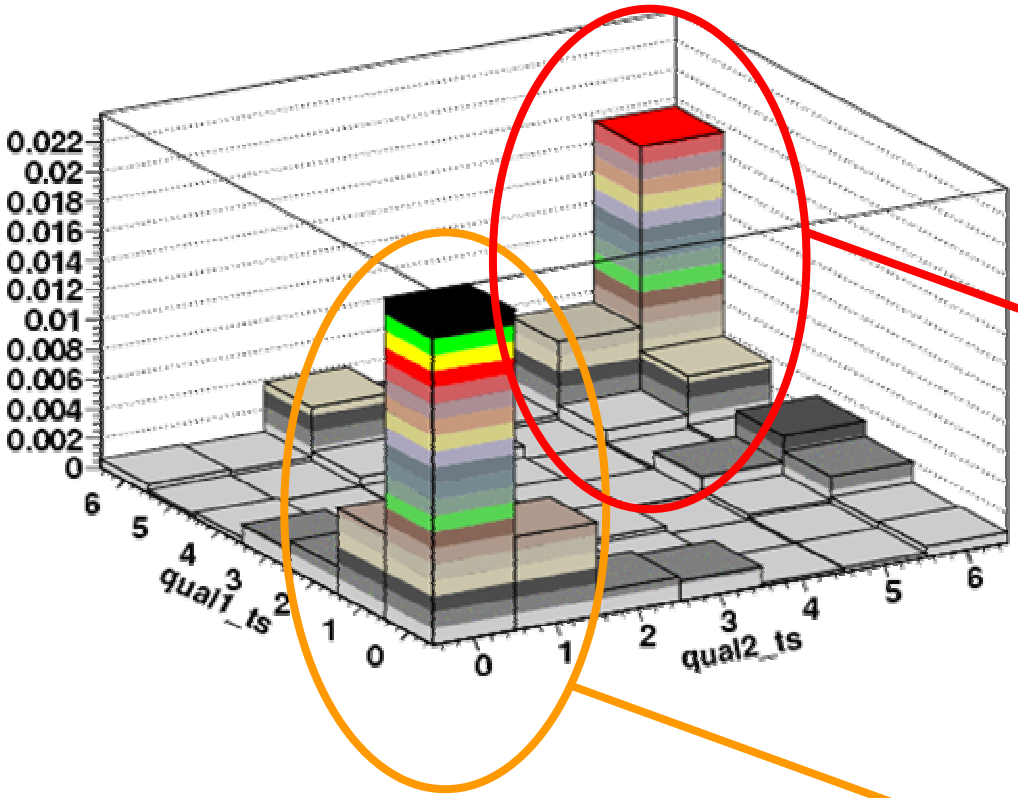


Trigger Muon Extrapolation (BX = 24)

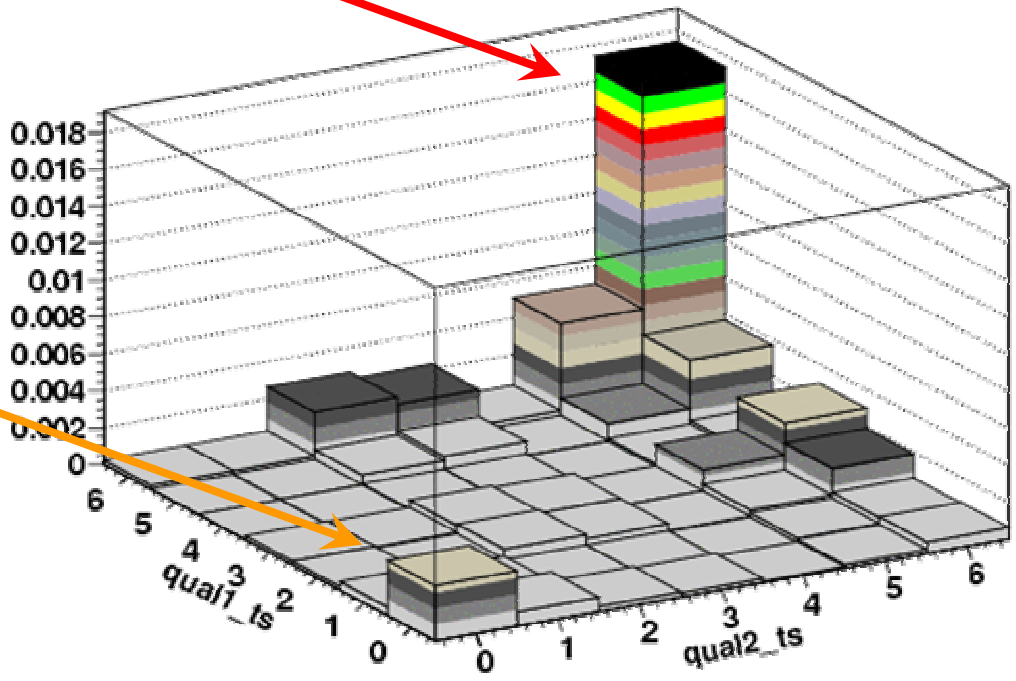
Inclusive efficiency = 94%



Out-of-time Extrapolation (BX < 17)



Out-of-time muons: efficiency



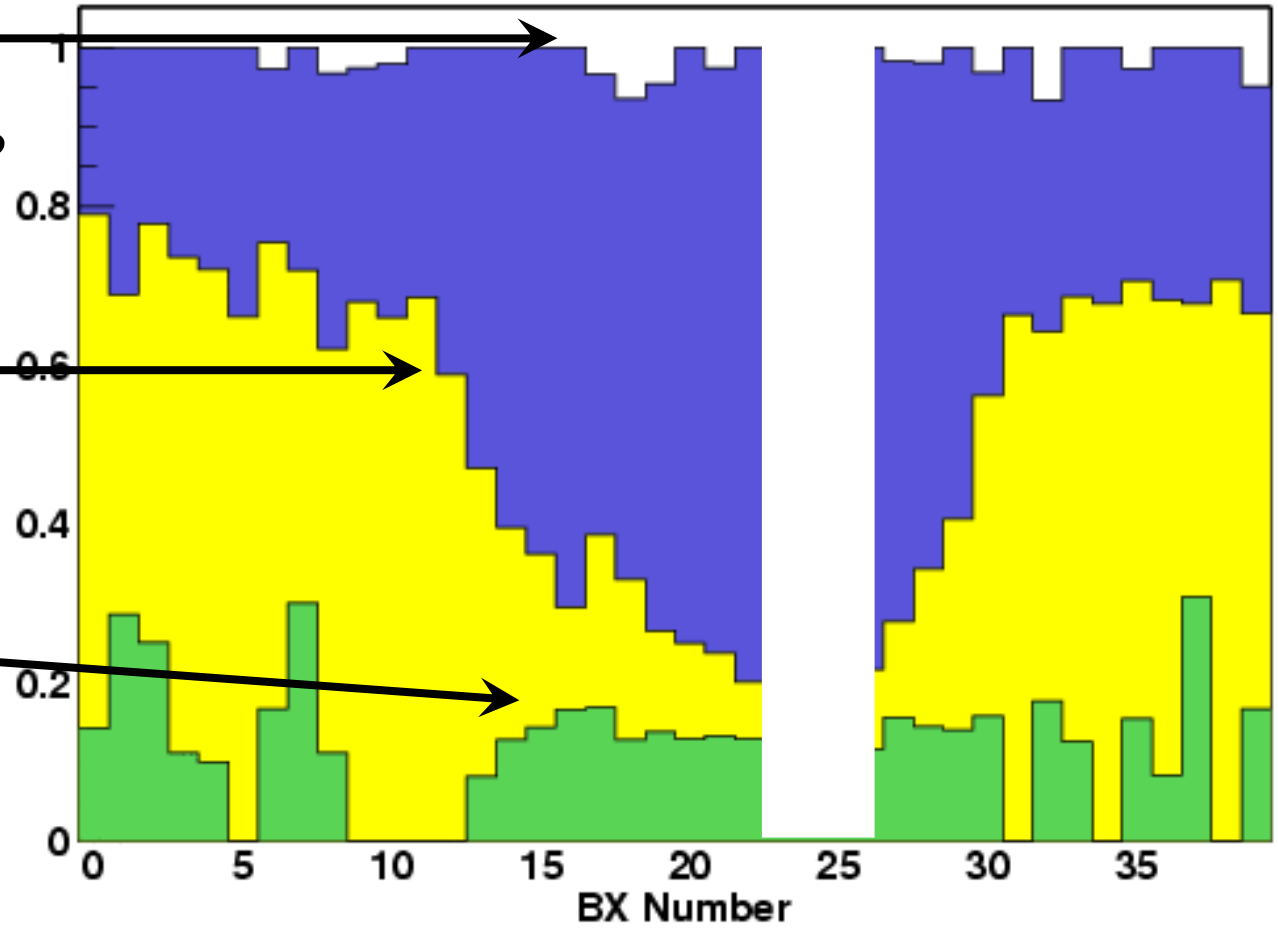
Low-quality Ghosts: rejection power

PHTF Performance: Extrapolation

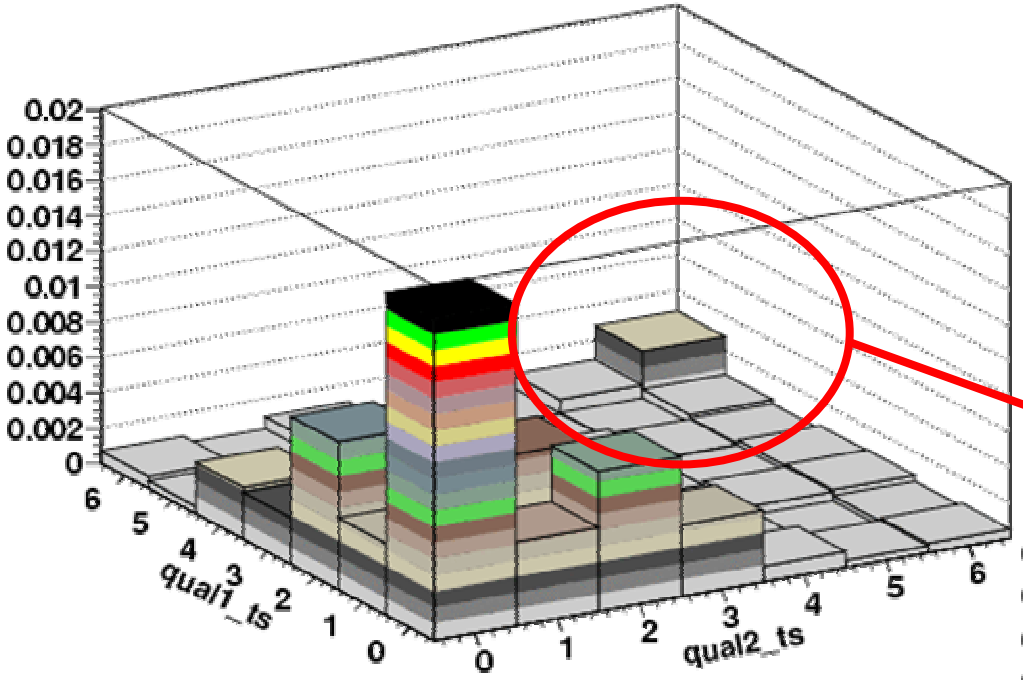
High quality:
efficiency > 99%

All events

Low quality:
ghost rejection
power up to 8

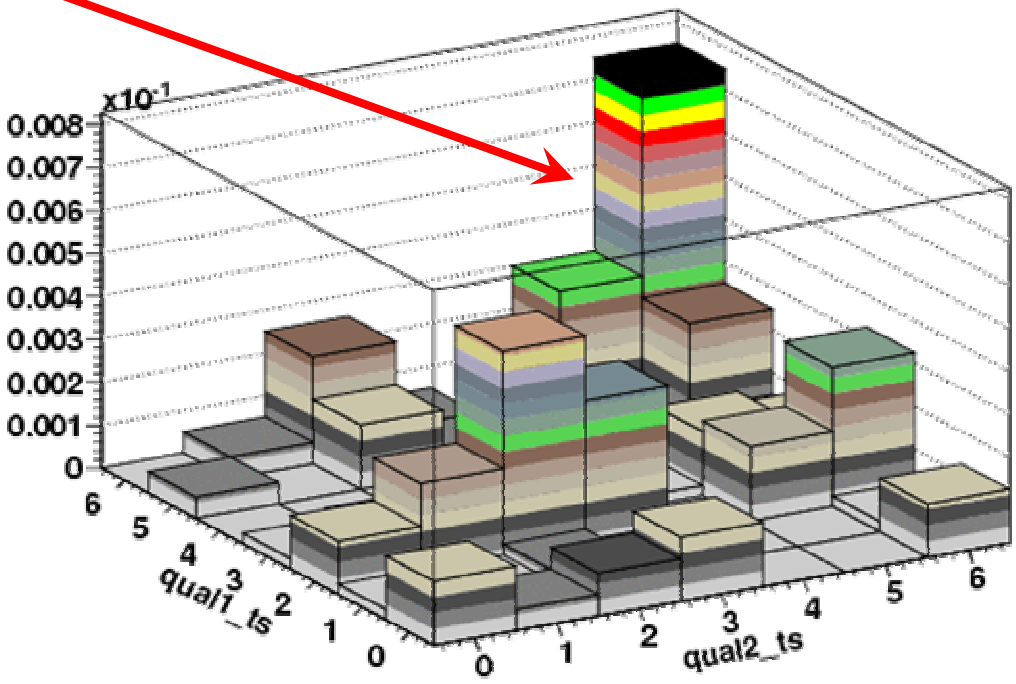


2nd muon extrapolation (BX = 25)



Found by PHTF:

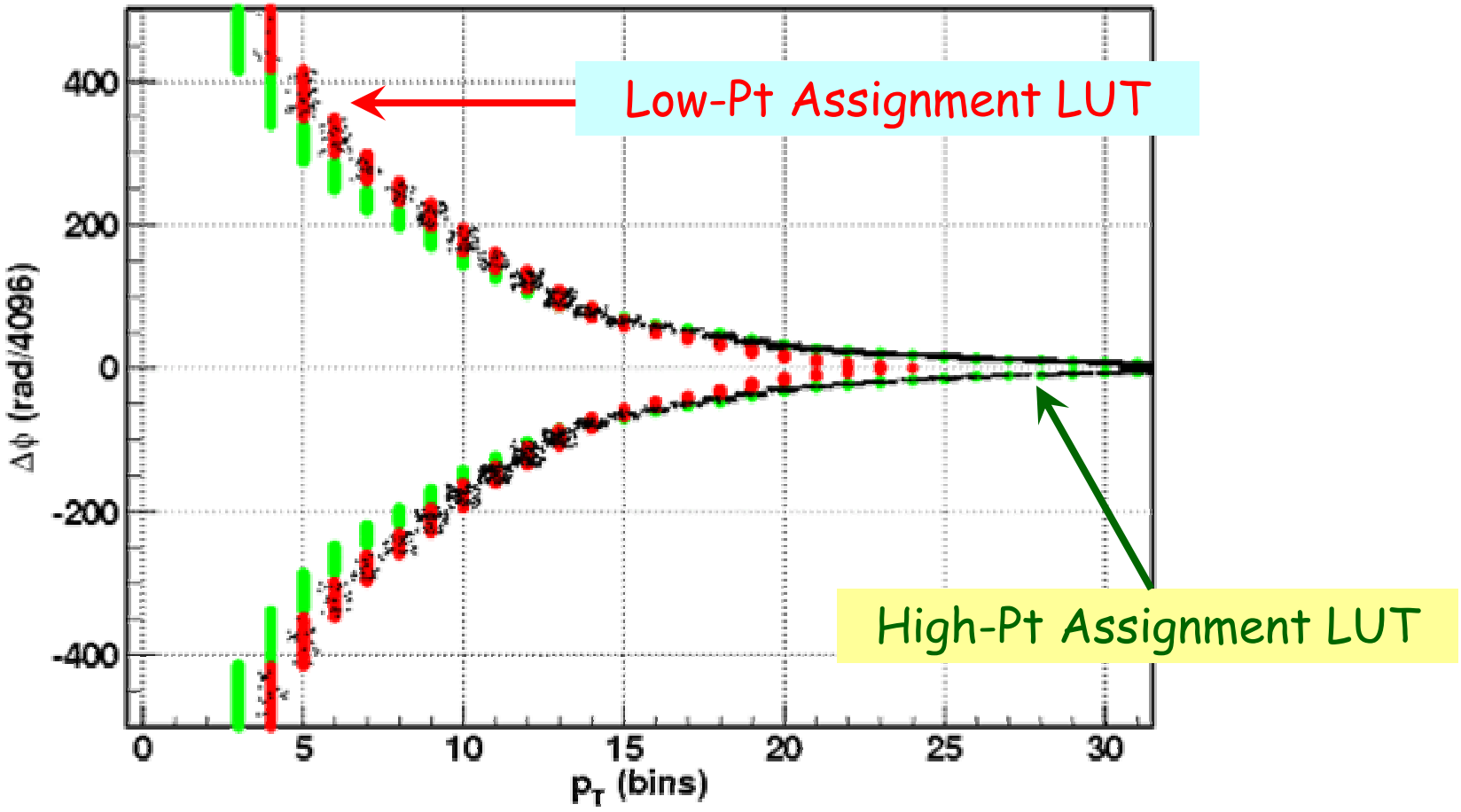
2nd muon



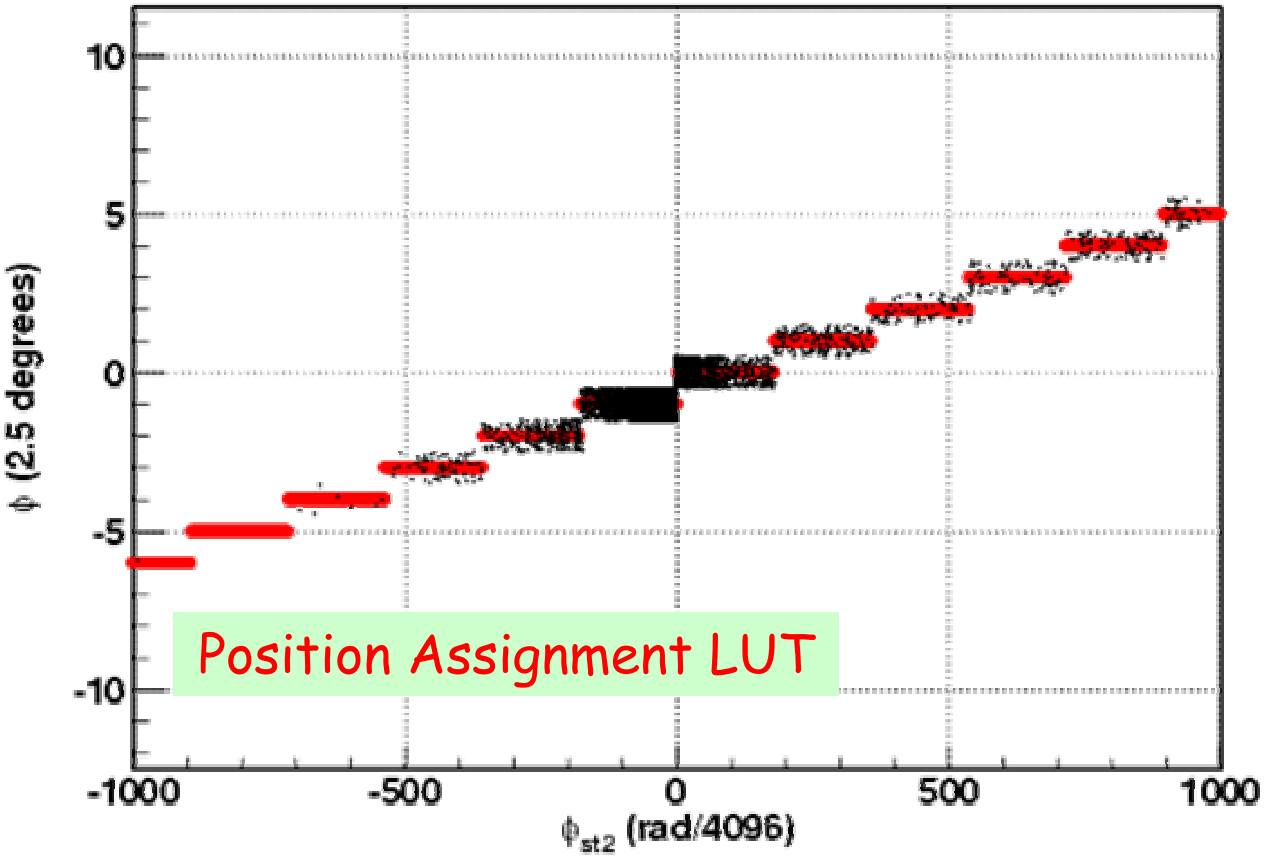
All segments Bx+1:

very low quality

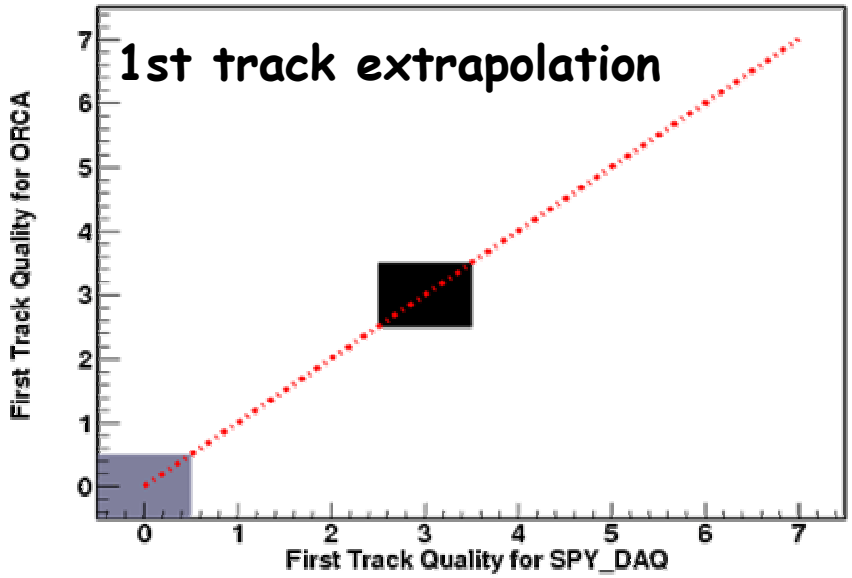
PHTF Performance: Pt Assignment

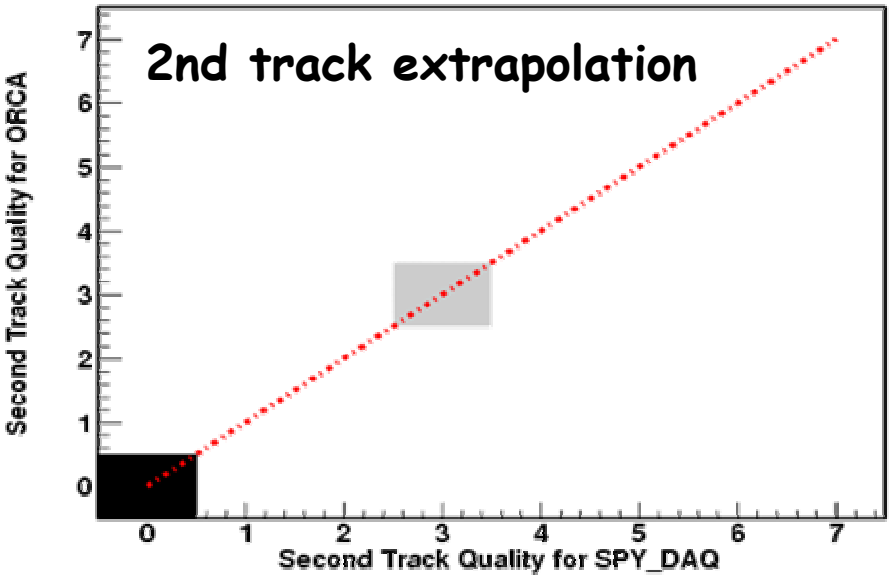


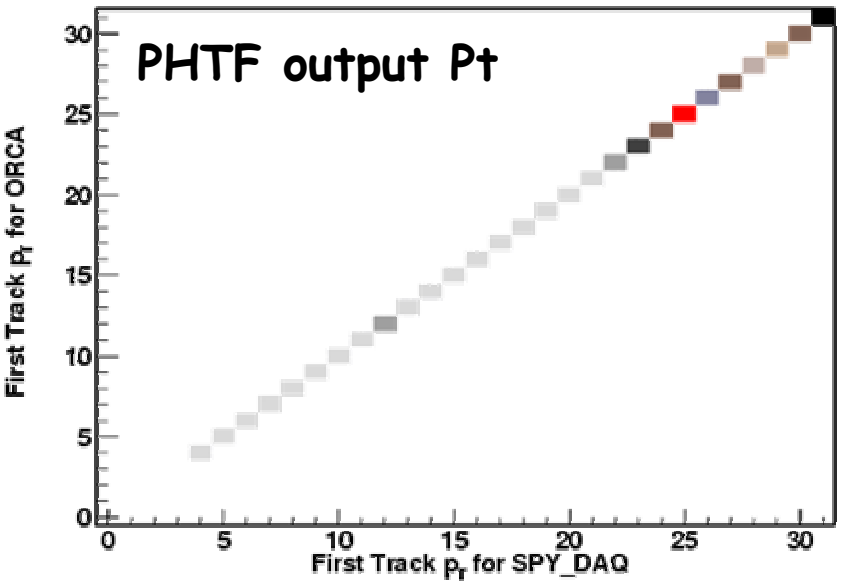
PHTF Performance: Position Assignment



ORCA vs. Hardware Check







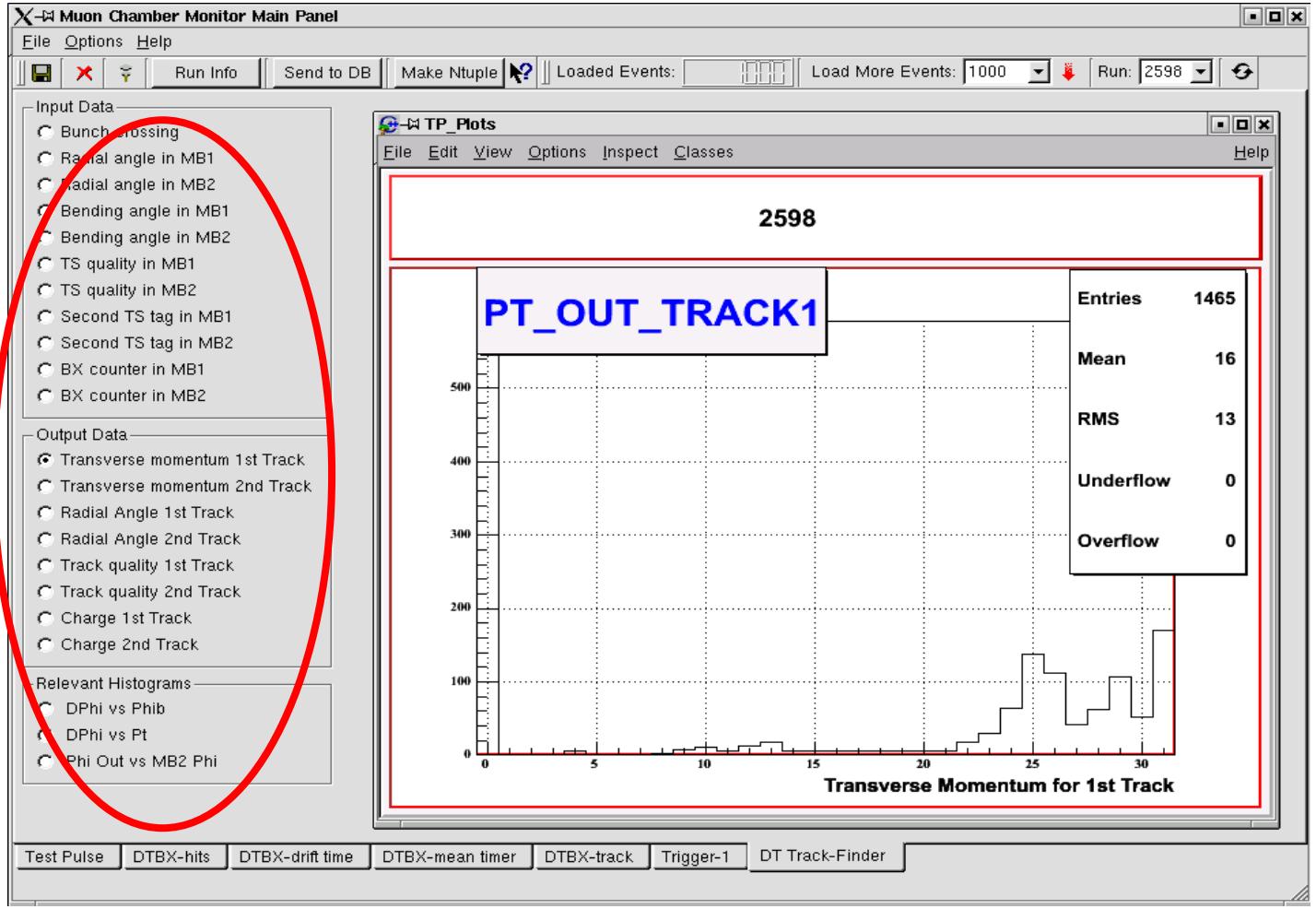
- Check PHTF logged outputs with ORCA emulation based on inputs.
- 1st and 2nd track extrapolation results, Pt and ϕ values assigned, agree perfectly (40k events).

Problems

- Not everything was perfect… (but almost).
- In run 2598 (40K triggers):
  - One event had apparently a 2nd MB1 TS segment without the 1st one. Apart of this, the muon extrapolated properly in PHTF.
  - In 9 events, the PHTF extrapolated from one good segment in MB1 to a MB3 segment located in a neighbor sector. Neighbor sector and next wheel inputs were found noisy at the testbench, but segments were explicitly disabled. Must be a rare kind of noisy input not found in September. Still, no problem when all boards in a crate connected.

“On-line” Monitor

“Standard” set of PHTF histograms

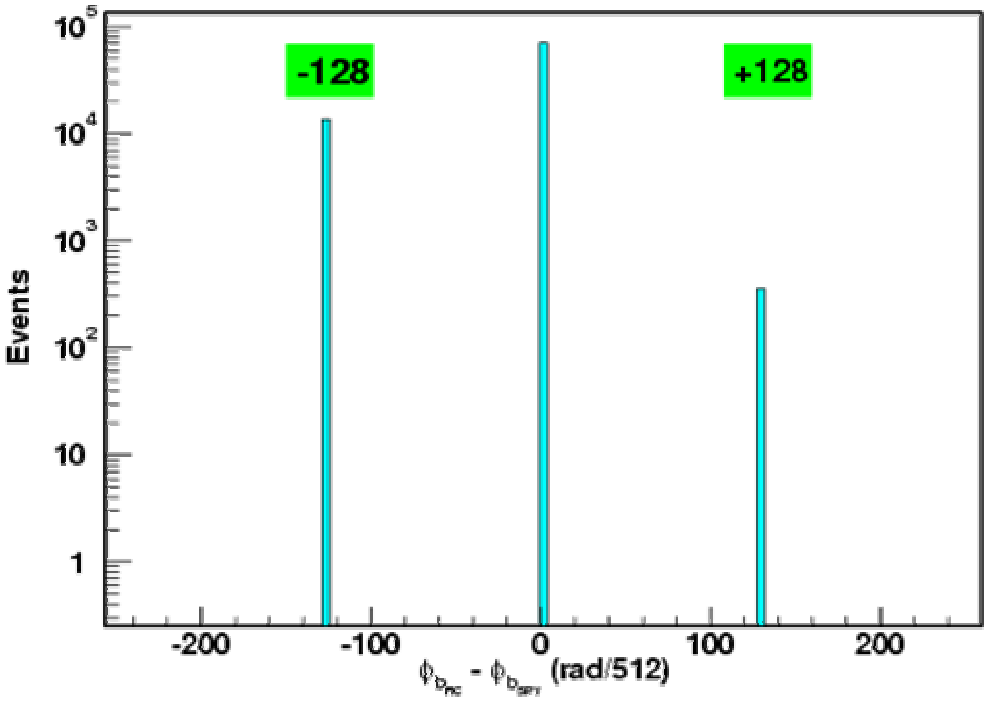


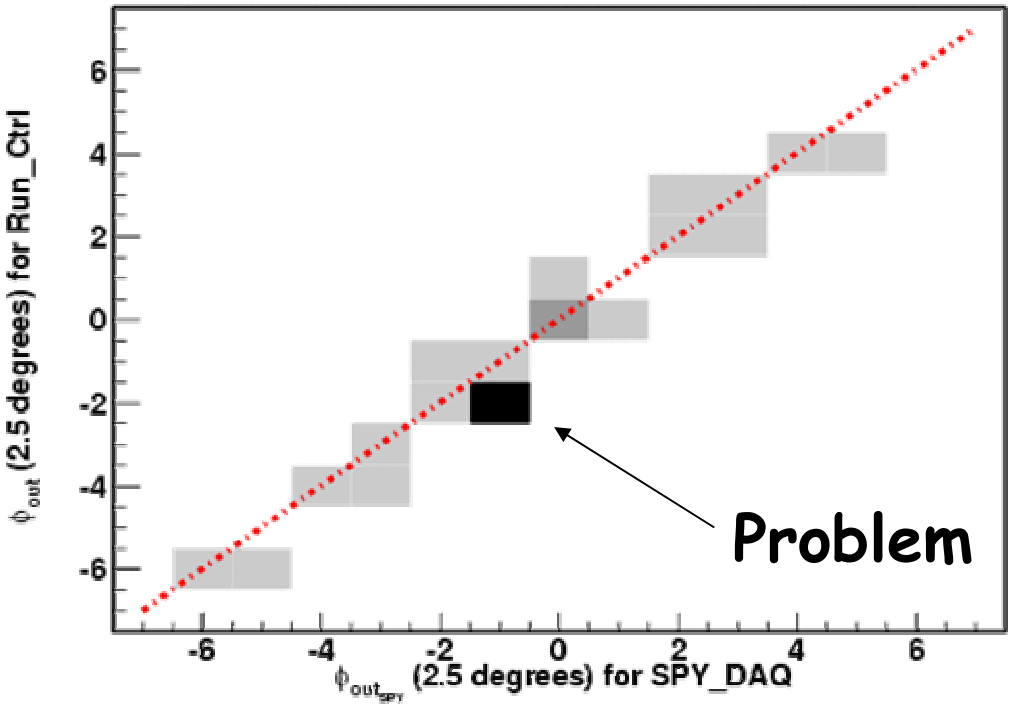
Prepared by P. Ronchese and I. Jimenez

Troubleshooting using SPY_DAQ

Comparing Run_Ctrl to SPY_DAQ:

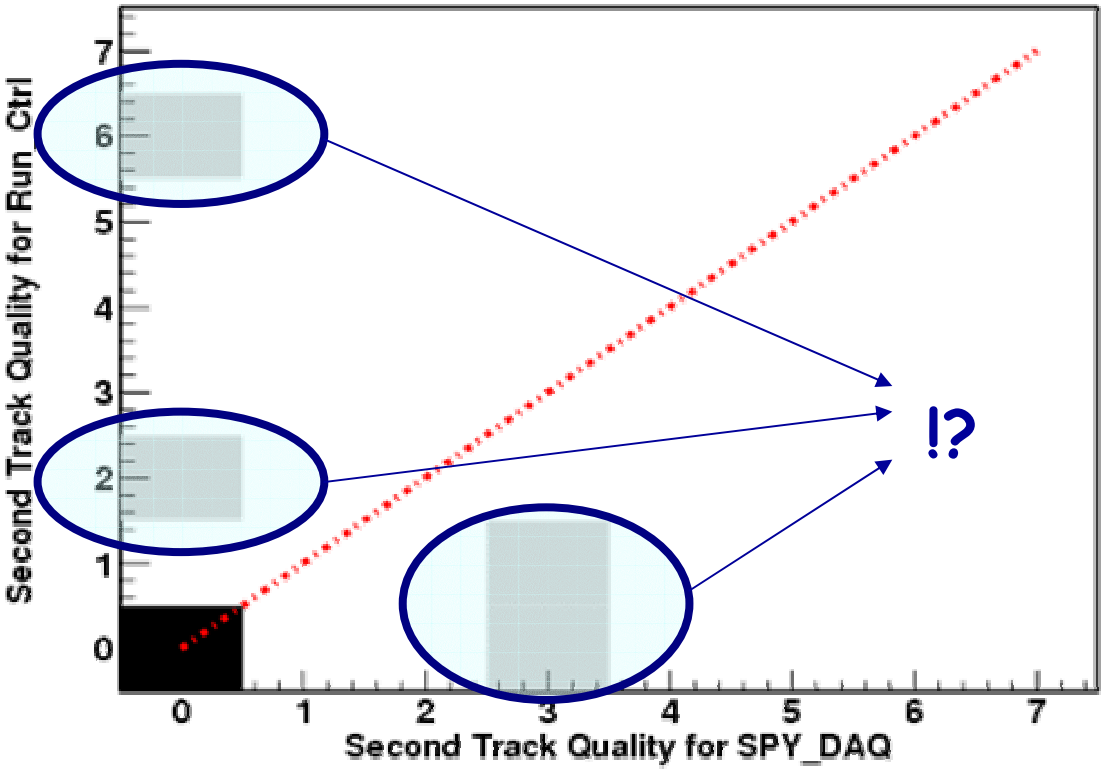
Example 1) Stuck bits in Pattern Units





Troubleshooting using SPY_DAQ

Example 2) Quality of 2nd DTTF track wrong



Conclusions

- The DTTF faces the data for the first time.

- Everything (trigger electronics, hardware/software tools, data quality, performance) as expected.
- More detailed analysis will follow.