PSI46xdb pixel chip in the DESY test beam: the first 3 days

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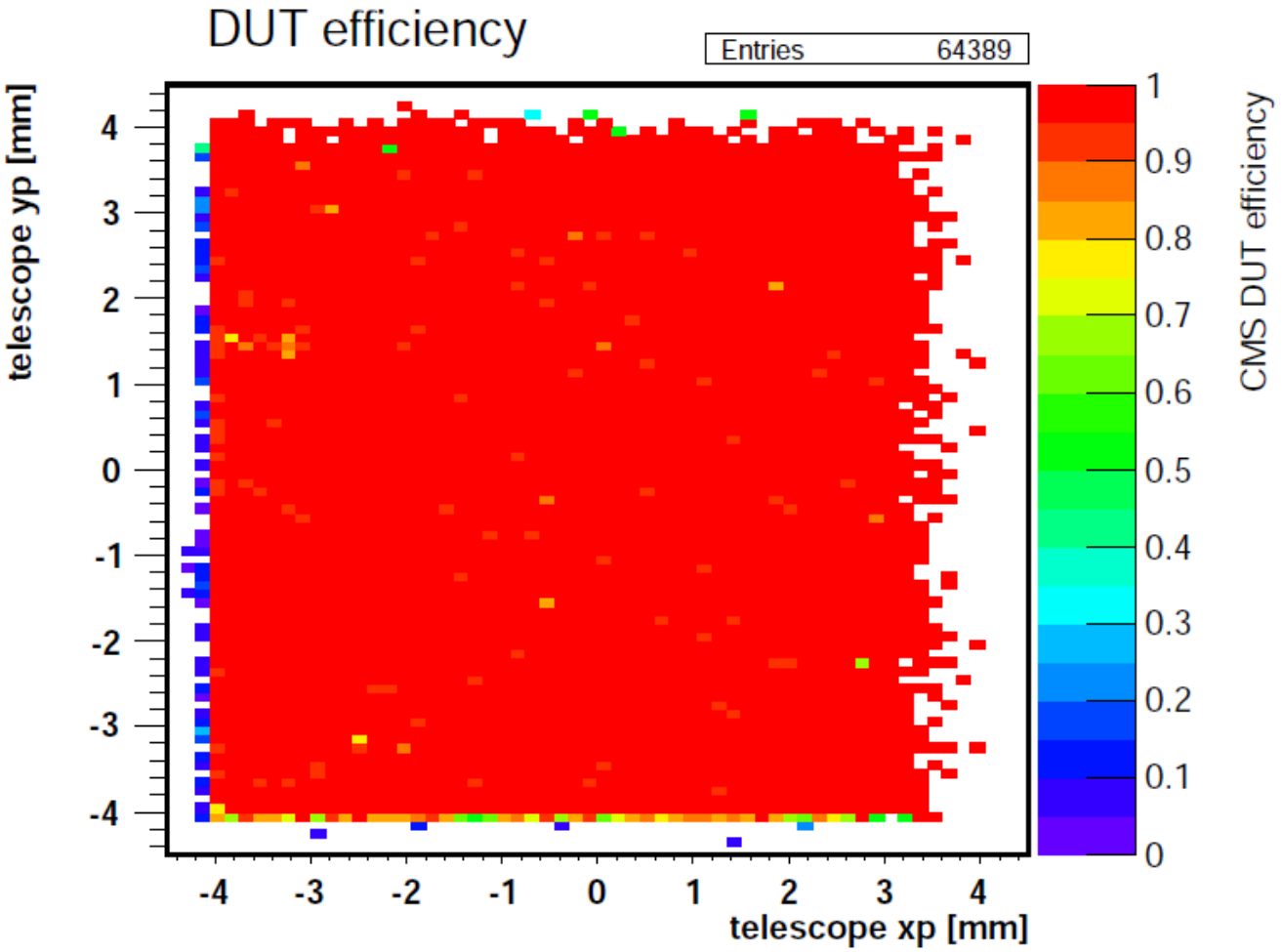
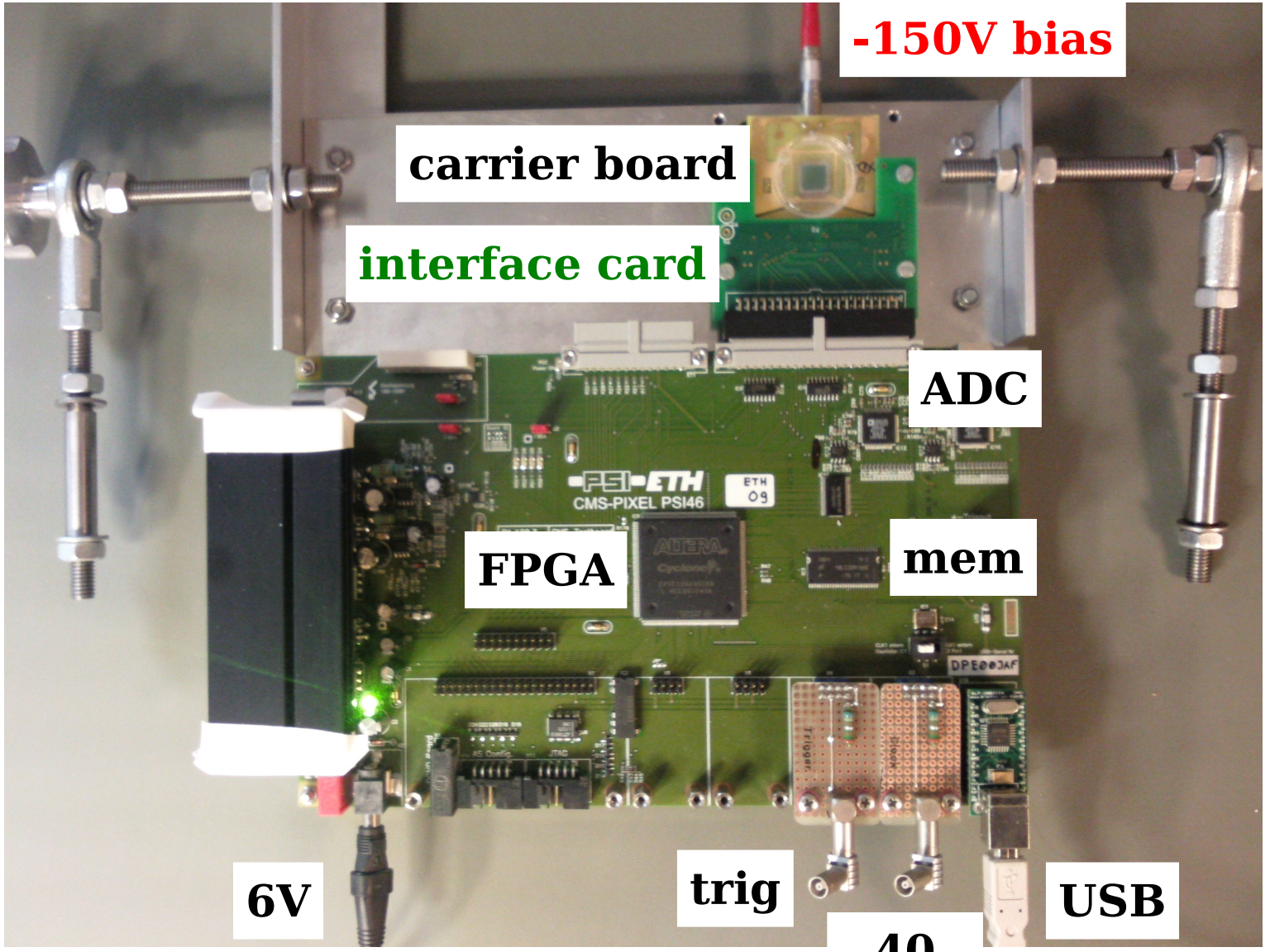
DESY CMS Phase I pixel upgrade, 29.6.2012



- PSI46xdb
- setup and plan
- first results

psi46xdb and test board at DESY



- Single chip module:
  - Indium bump bonded at PSI
  - Glued and wire bonded to carrier printed circuit board
  - Interface card to test board
  - xdb 2 arrived 25.6.
- Use the same board, firmware, software as for psi46

PSI46xdb

Data Rate, Efficiency:

- Extended data buffer 32 → 80 cells
- Extended time stamp buffer 16 → 24

Crosstalk, threshold uniformity:

- 6 metal layer (process option)
- Thick top metal (LM instead of MZ process option, +37%)
  → better power and ground distribution (lower resistance)
  → better threshold uniformity
- New routing for calibrate signal → less crosstalk of calibrate signal
- Better decoupling of comparator and digital voltage → less crosstalk
- Different other minor layout changes to reduce crosstalk

PSI46xdb

DAC:

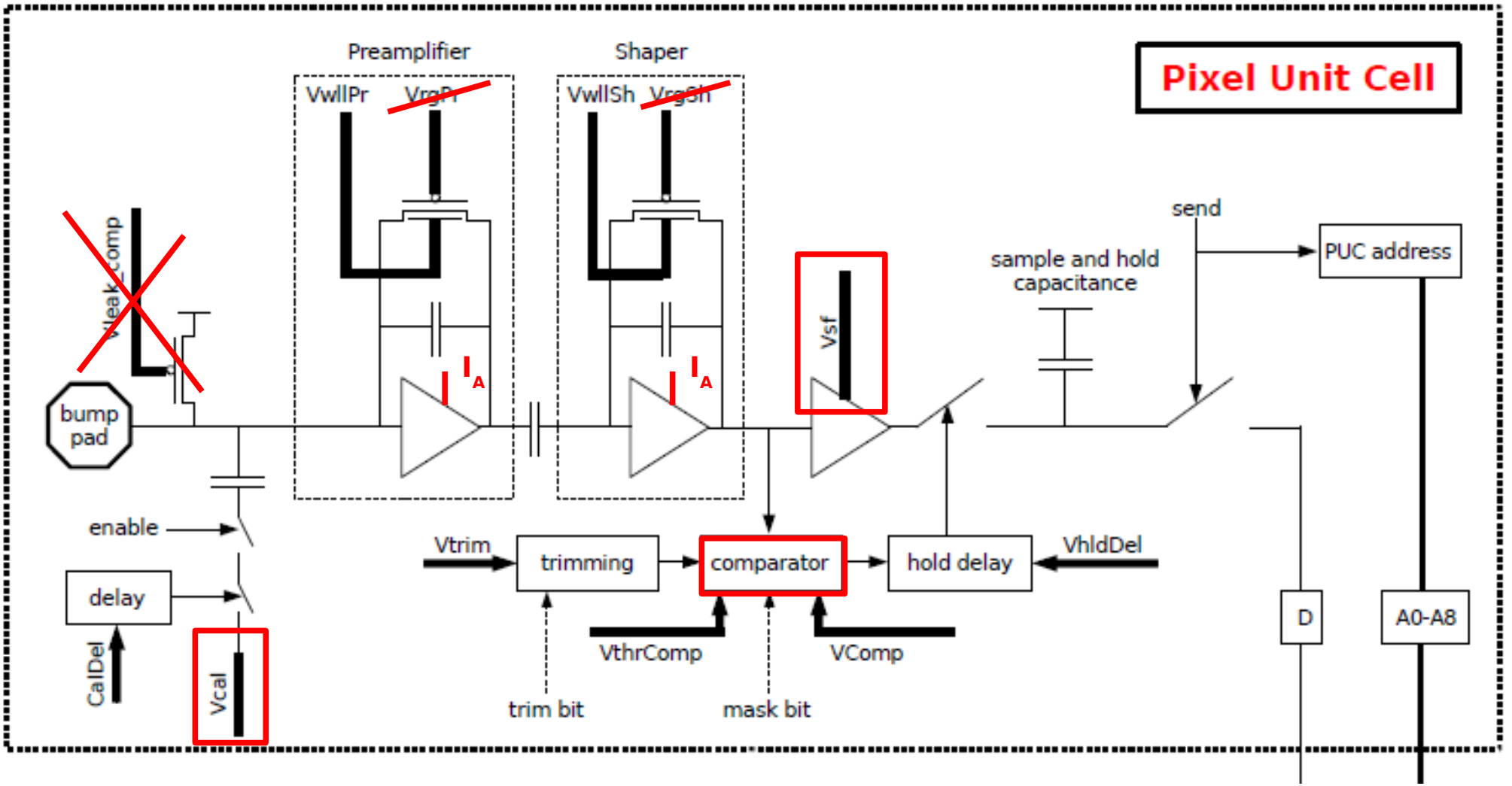
- 3 DACs removed: VRGPR, VRGSH and Vleakage
- All DAC's with power on reset for low power ROC configuration
- Current control instead of voltage control for S&H and analog power supply → easier and independent setup

Timing:

- Small performance optimization in column drain mechanism (timing)
- Modified comparator with reduced timewalk

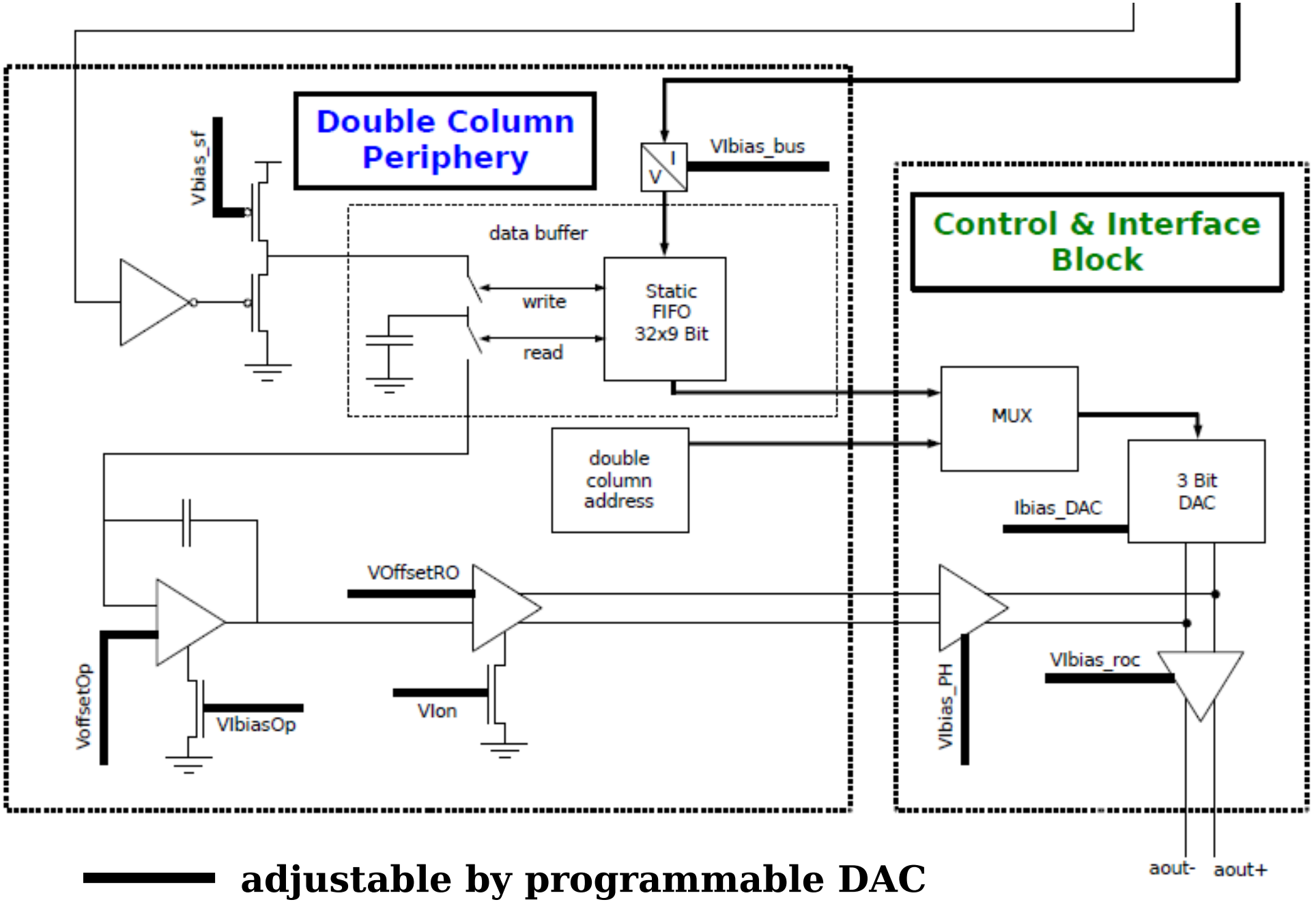
- Same analog read out as PSI46 → same test board
- Comparison possible between PSI46 and PSI46xdb

PSI46xdb pixel unit cell



modified in PSI46xdb

psi46 pixel readout chip



adjustable by programmable DAC

psi46xdb DACs

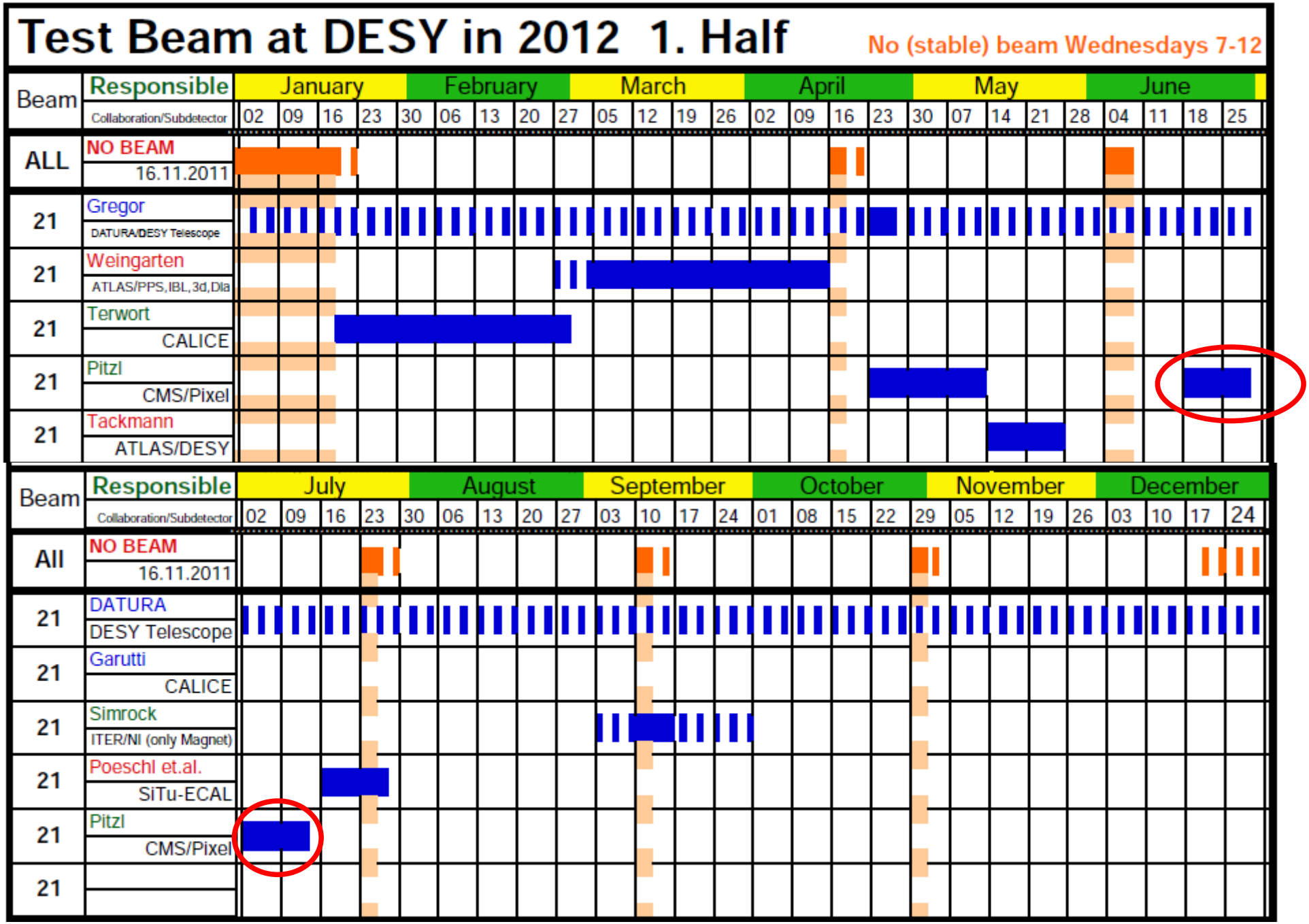
1	Vdig	6
2	Vana	166
3	Vsf	30
4	Vcomp	10
7	VwllPr	60
9	VwllSh	60
10	VhldDel	250
11	Vtrim	130
12	VthrComp	74
253	CtrlReg	0
254	WBC	20

13	VIBias_Bus	30
14	Vbias_sf	10
15	VoffsetOp	57
16	VIbiasOp	115
17	VOffsetR0	120
18	VIon	115
19	VIbias_PH	130
20	Ibias_DAC	83
21	VIbias_roc	190
25	Vcal	200
26	CalDel	155
27	RangeTemp	0

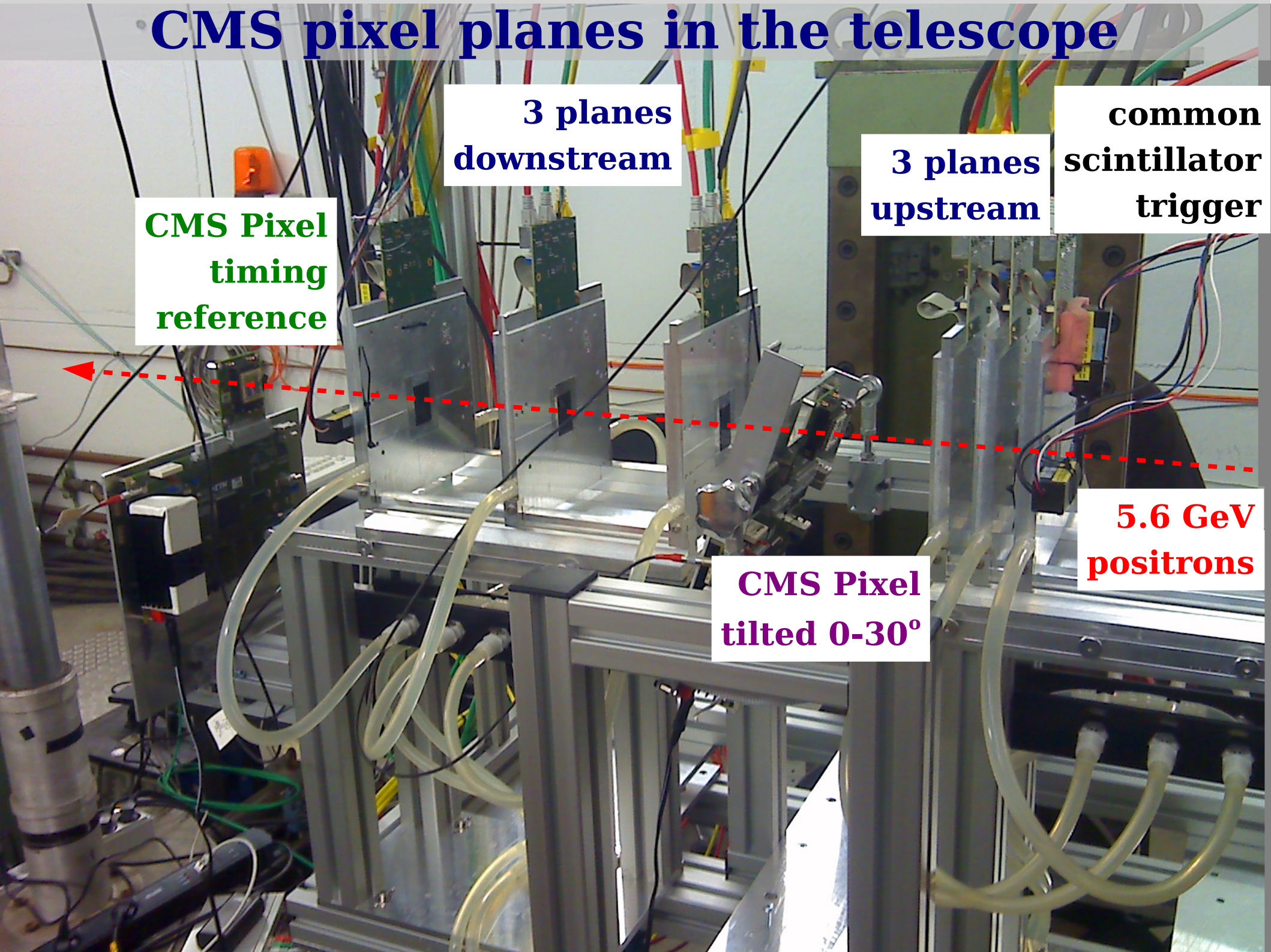
CMS Pixel in the DESY test beam

http://adweb.desy.de/~testbeam/

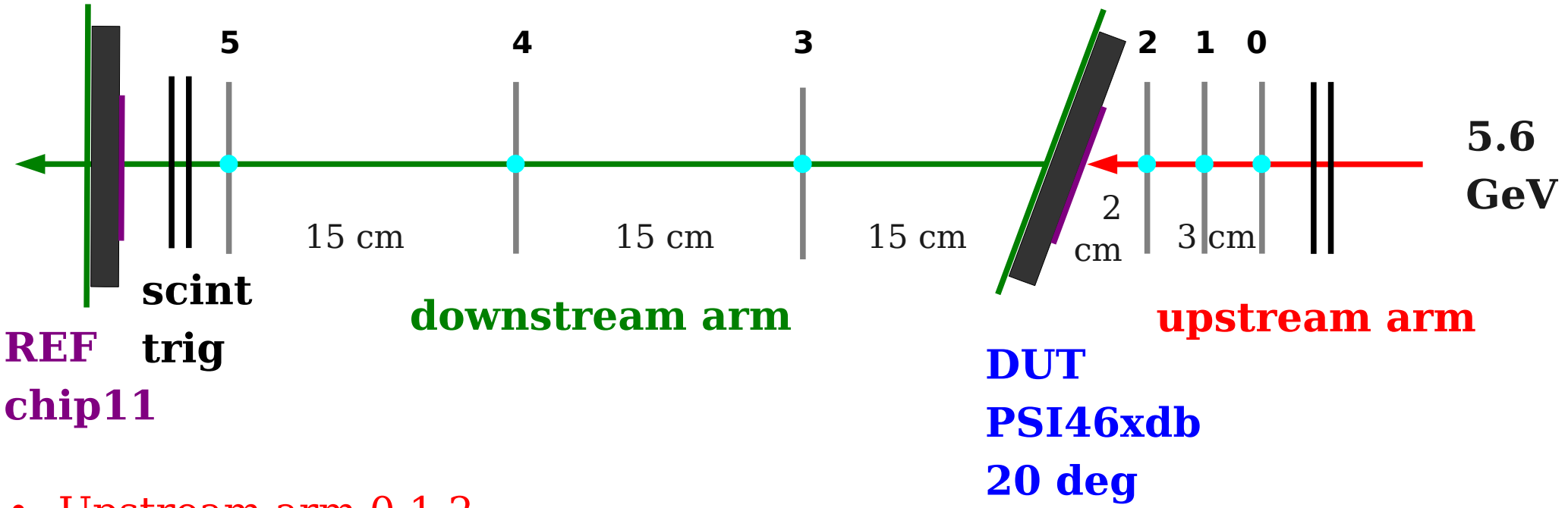
29.05.2012



CMS pixel planes in the telescope



Default set up

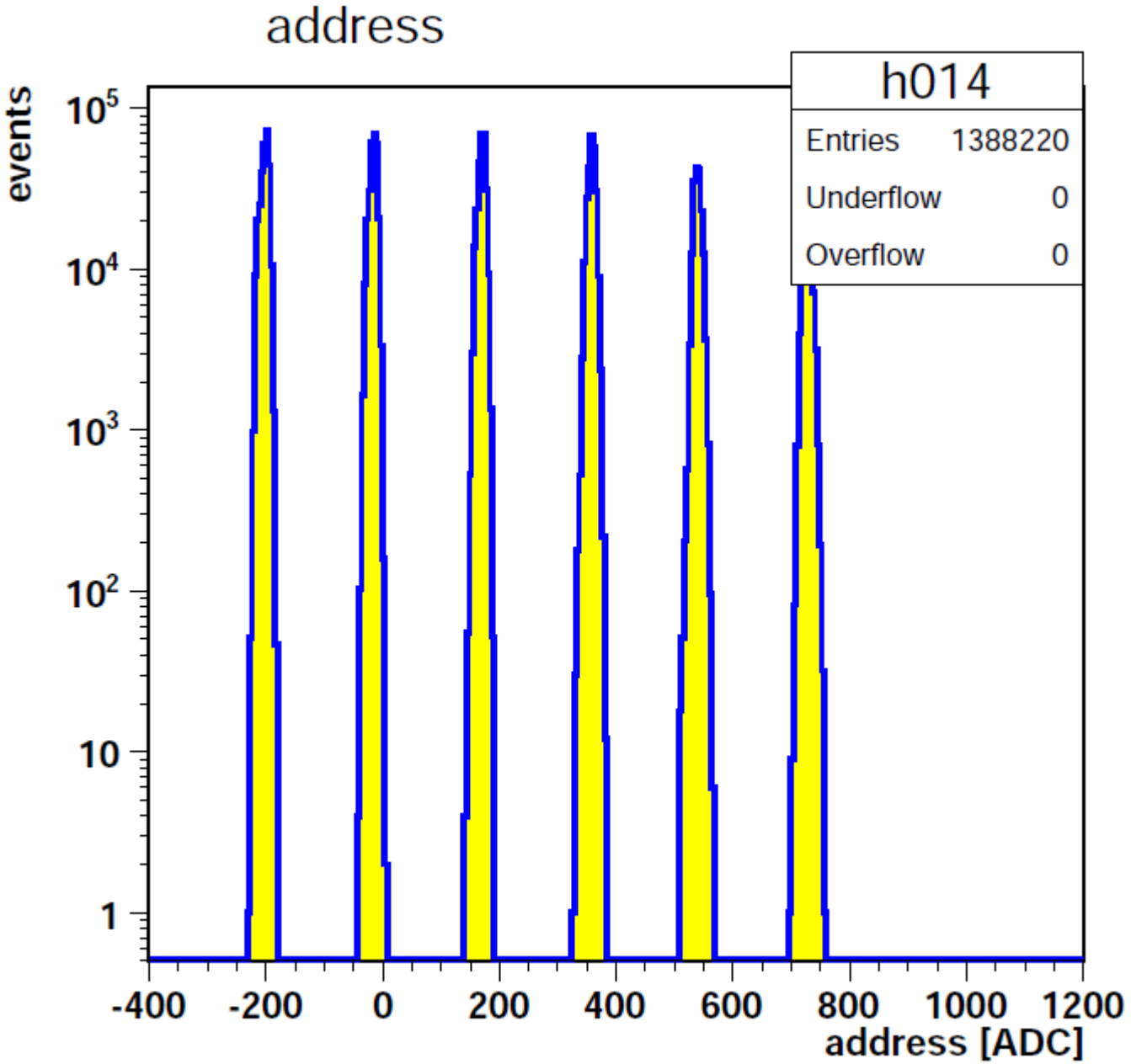


- Upstream arm 0-1-2:
  - as close as possible to DUT, but allow for tilting (open for insertion)
- DUT = single chip module, tilted by up to 30°,
- Downstream arm 3-4-5:
  - equally spaced between DUT and REF, allow for DUT tilting
- REF = single chip module for timing, as close as possible behind scint
- trigger: 2-fold coincidence (config: TLU AndMask 12)

PSI46xdb test beam goals

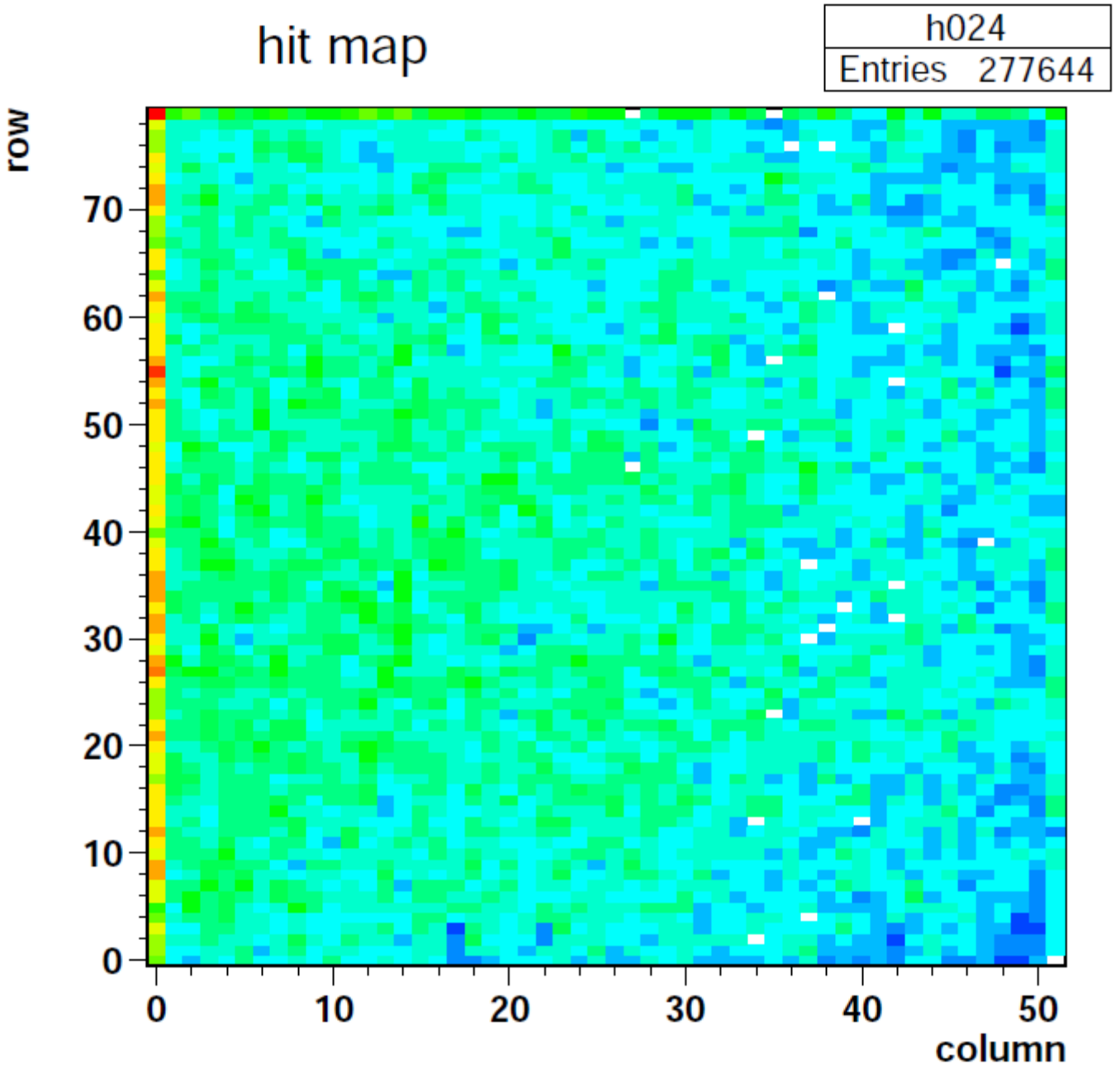
- Measure efficiency
  - present ROC reached 99.9%
- Measure resolution
  - present ROC reached 7 µm at 20^{o} tilt
  - new ROC might be better with lower thresholds
- Measure gain:
  - calibration from Landau peak vs tilt angle
- Study any problems
- Give feedback to chip designers at PSI
- Present results in CMS meetings and at conferences
- Publish

xdb2 address levels



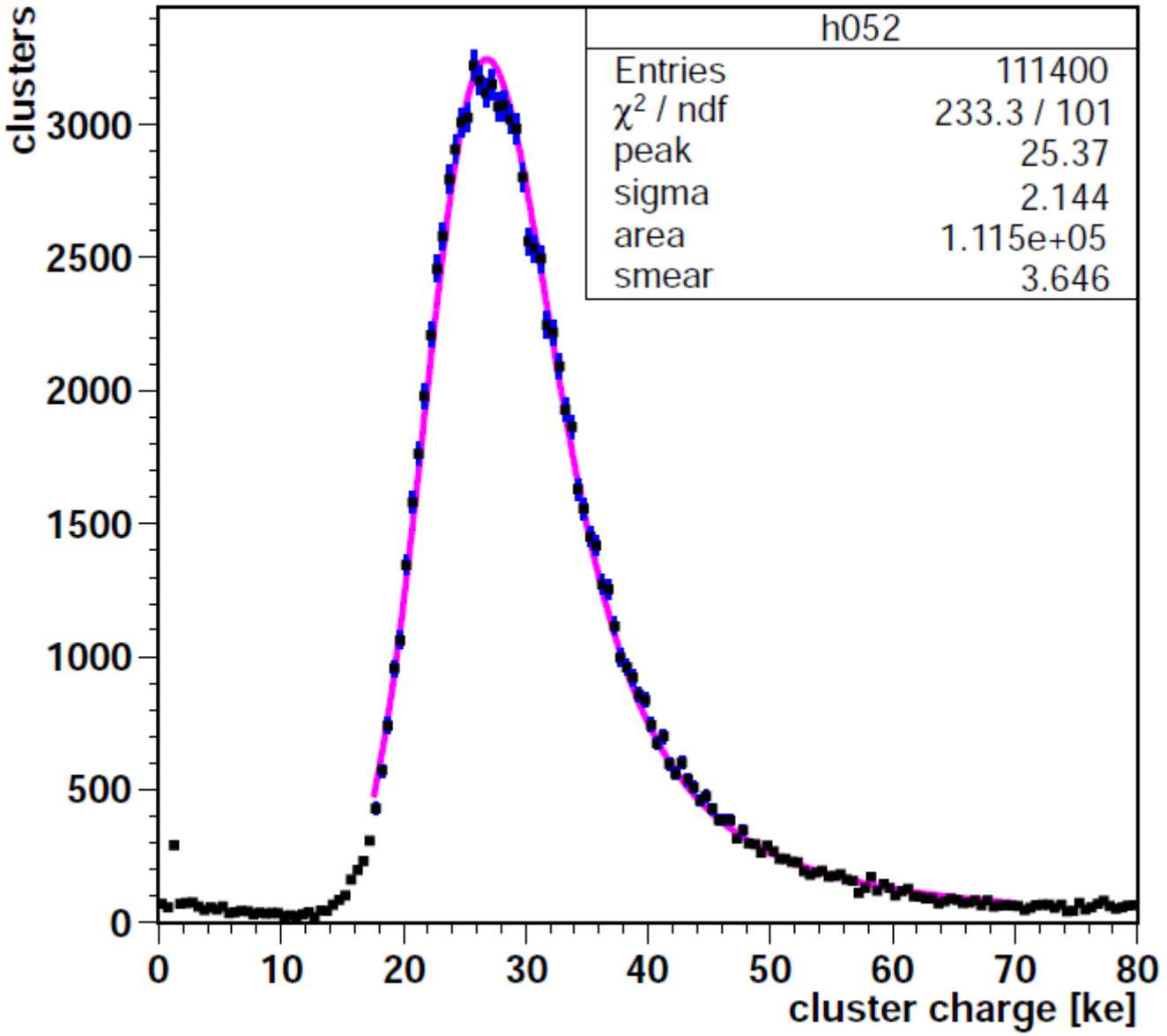
- analog transfer of pixel column and row address:
  - hexal encoding
- 6 levels clearly separated
- no noise
- perfect

xdb2 hit map in beam



- xdb2
- run 2392:
  - 600 s
  - 5.6 GeV
  - tilt 22°
- beam profile from left to right
- some dead pixels in the right half:
  - thresholds?
  - bumps?

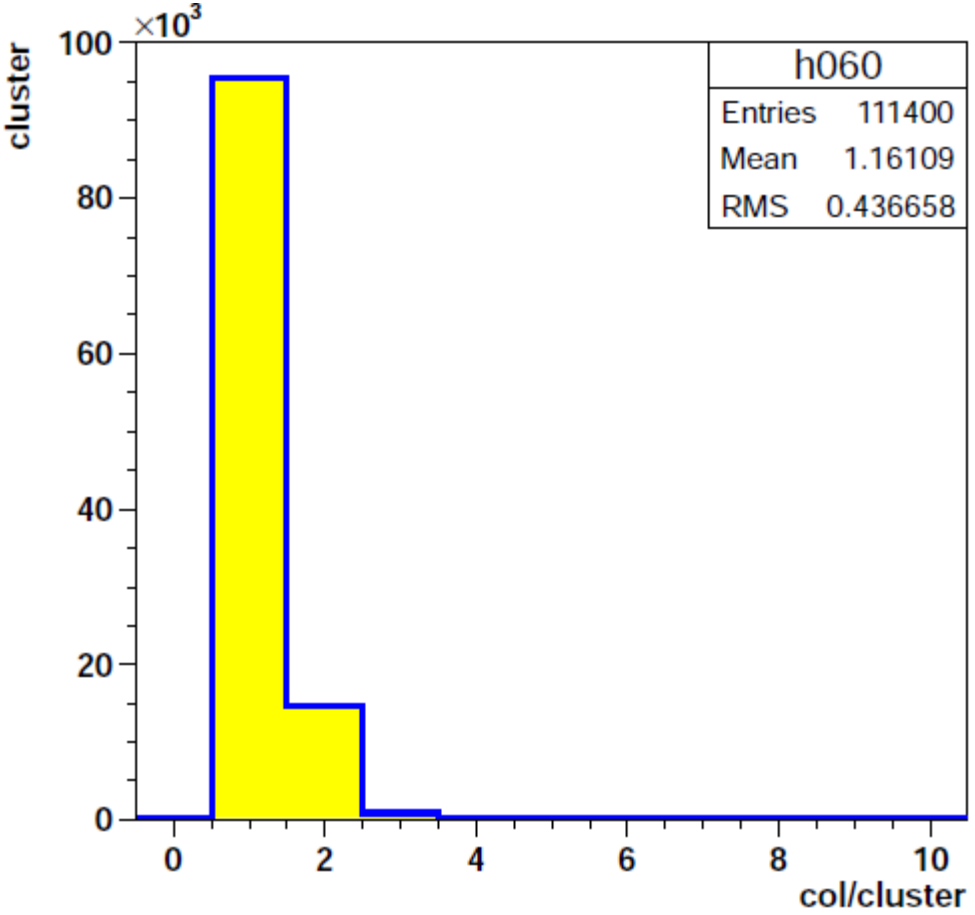
xdb2 Landau distribution



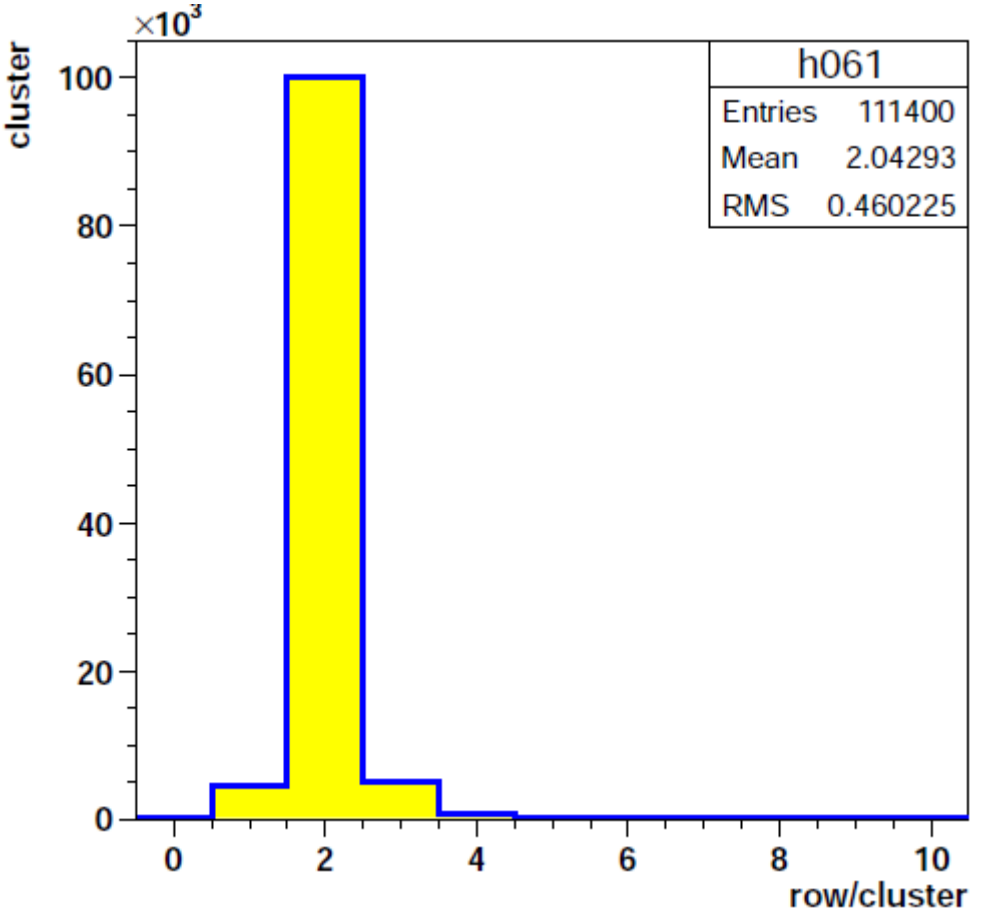
- xdb2
- run 2392:
  - tilt 22°
- Weibull gain calibration applied
- Cluster charge distribution fit by Landau ⊗ Gauss
  - peak position and width OK
  - too much Gaussian smearing needed

xdb2 cluster size

column direction:
no tilt
mostly 1-col clusters

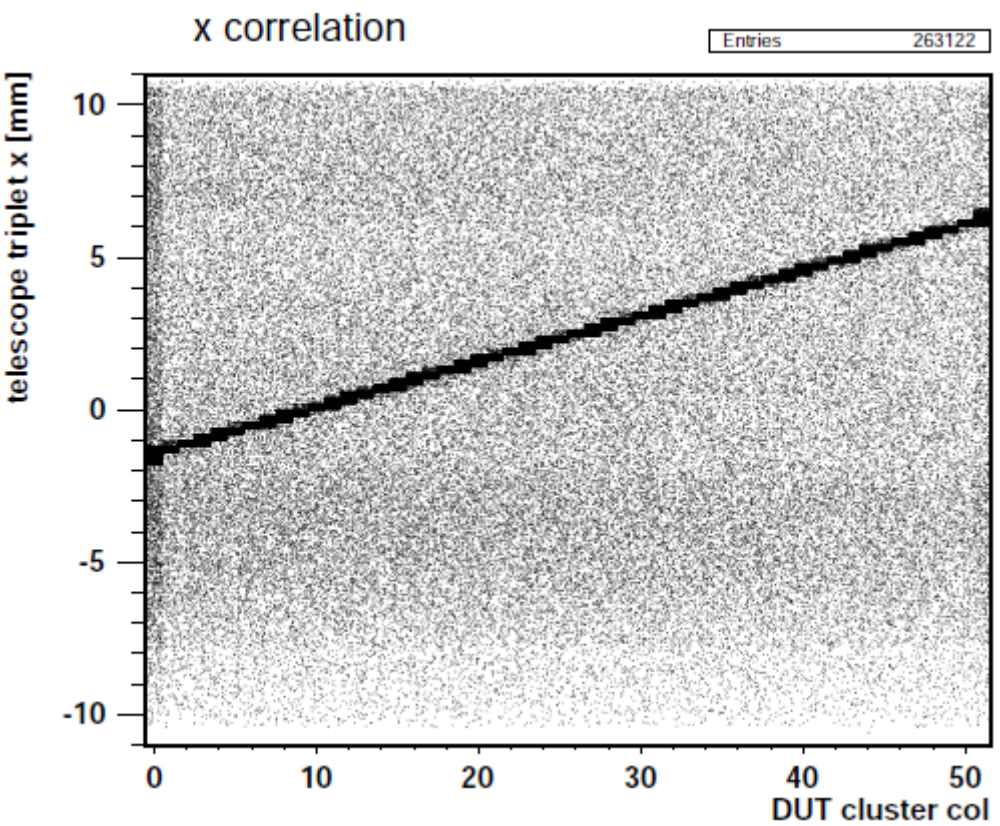


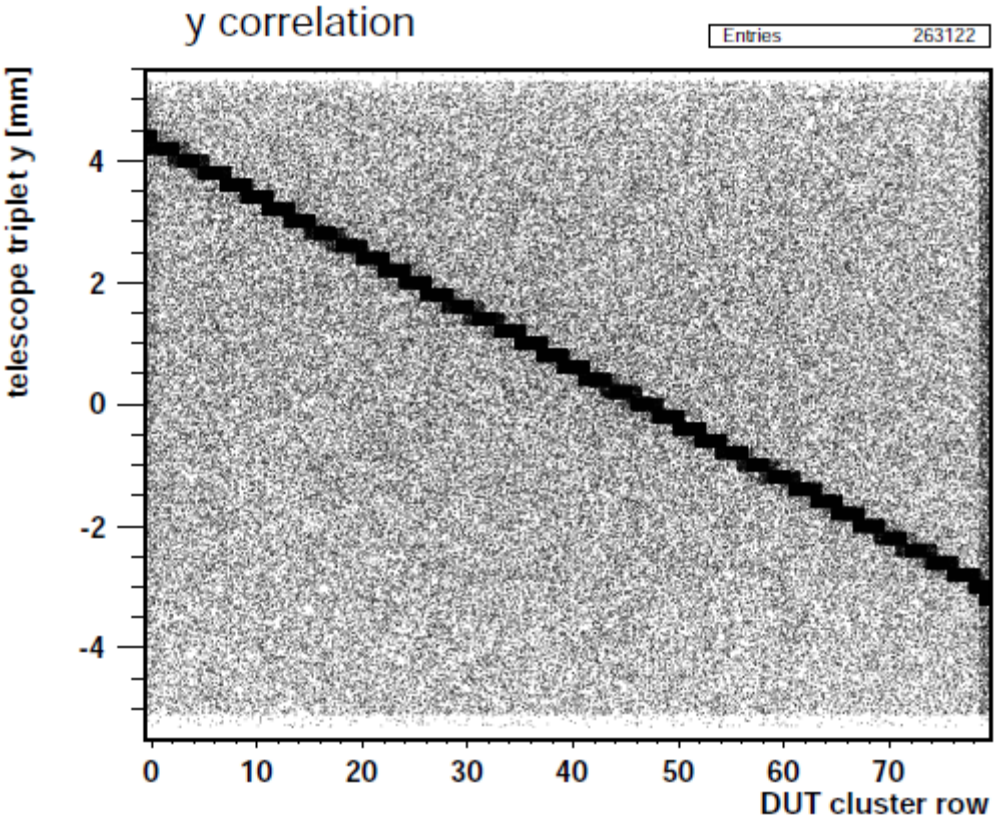
row direction:
22° tilt
mostly 2-row clusters



xdb2 clusters vs telescope tracks

correlations!

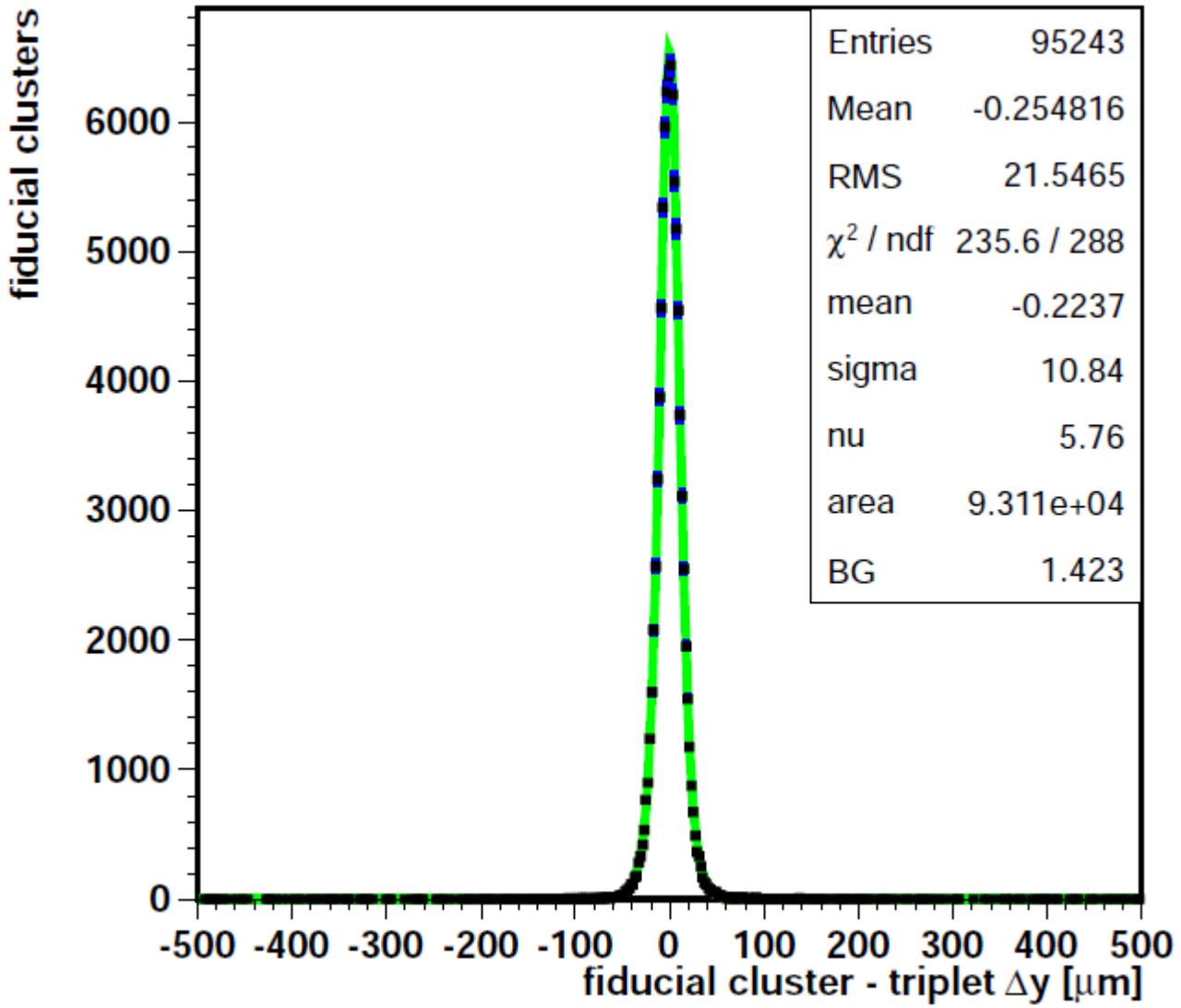


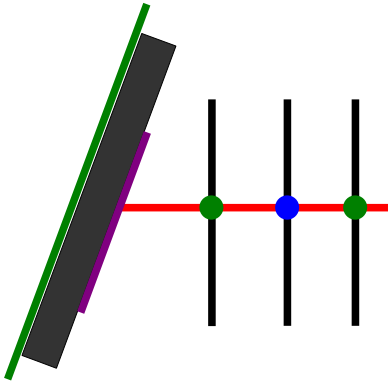


aligned in space and time

CMS pixel row resolution

run 3702, 5.6 GeV, 22° tilt

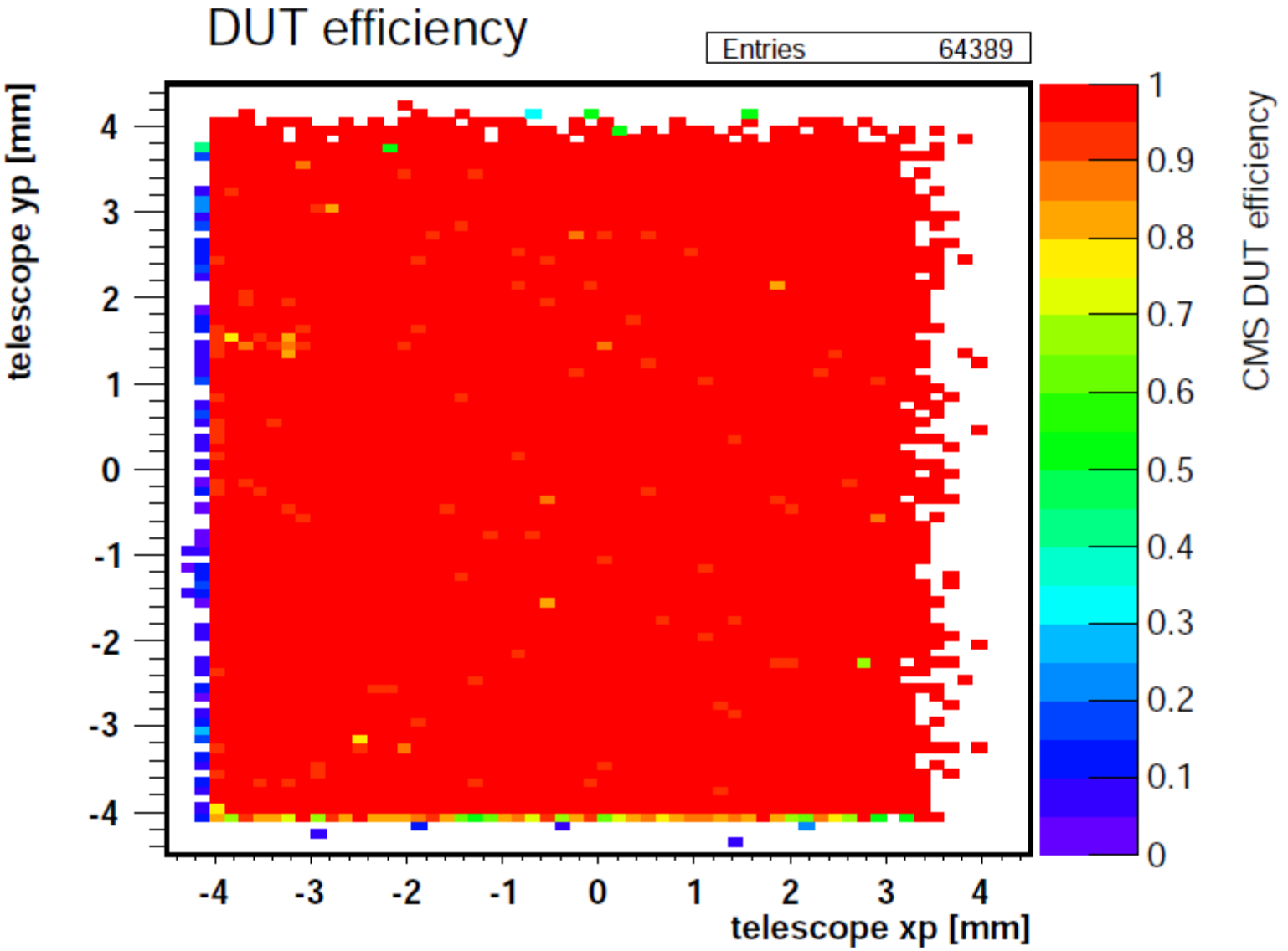




- Vertical = rows
  - CMS pixel = 100 µm.
- Residual:
  - σ = 10.8 µm,
  - telescope extrapolation: 4.5 µm,
  - **xdb resolution: 10 µm**
  - **previous: 7 µm**

Efficiency map

eff = (xdb linked hits) / (telescope tracks with REF hit)

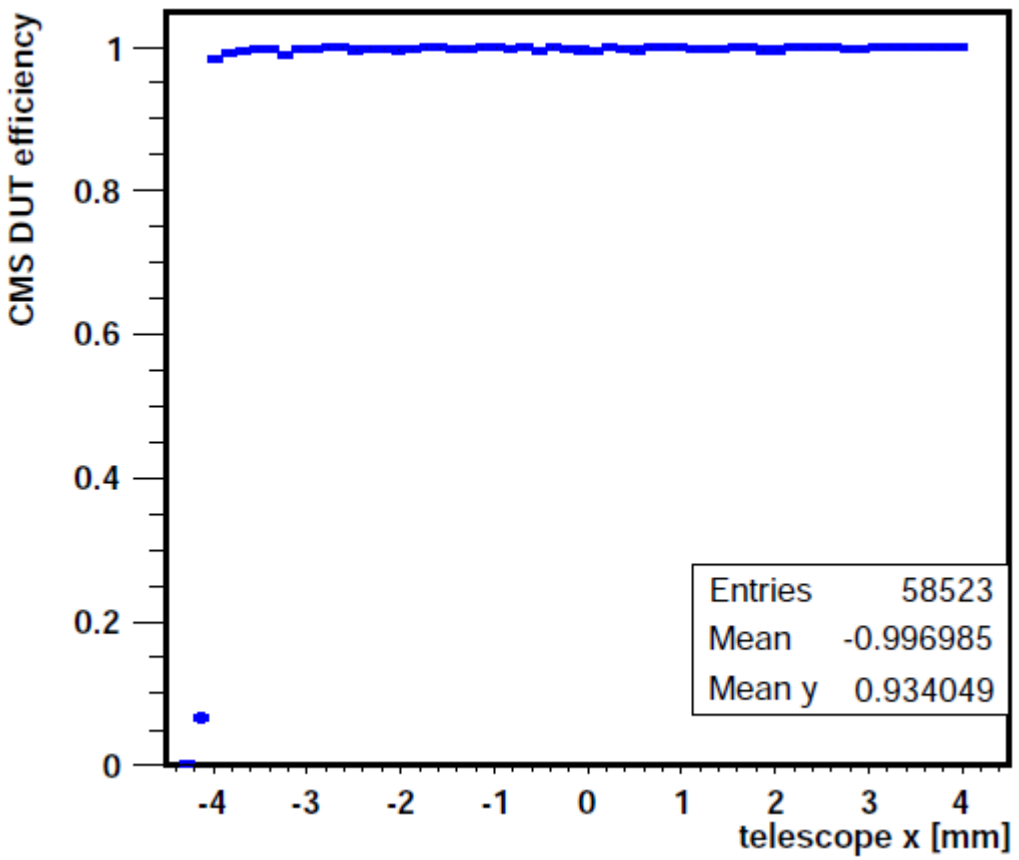


- xdb 2
- run 3702
  - first 350 s
- 5.6 GeV
- tilt 22°
- 99.7% in fiducial volume

Efficiency profiles

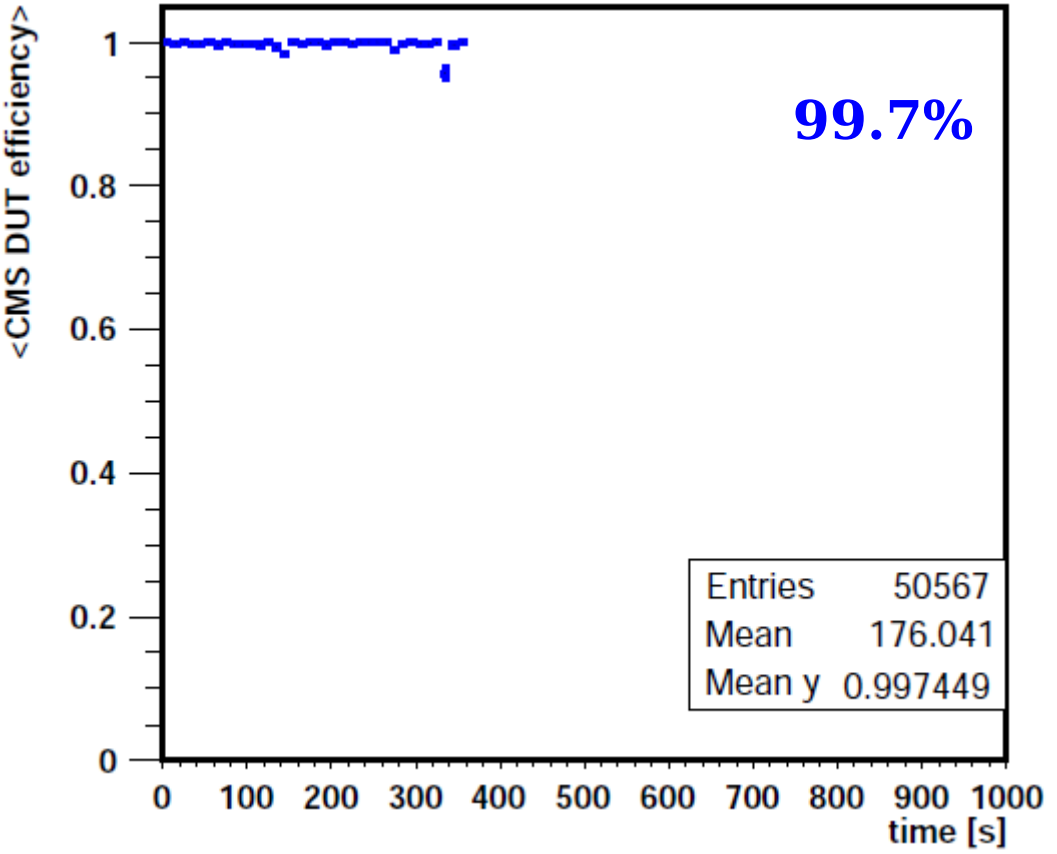
xdb 2, 22°, run 3702

efficiency vs *x* after fiducial cuts in *y*



x: 52 columns

Efficiency vs time after fiducial cuts in *x* and *y*



first 350 s (then drop)

Summary and outlook

- One analog PSI46xdb bump bonded to a single chip pixel sensor operated at the DESY test beam:
  - procedures established
  - efficiency good, resolution can be improved
- Improve:
  - Timing stability (Hanno)
- Next 2 weeks: efficiency and resolution scans:
  - vs threshold, vs analog current
  - vs tilt, vs bias voltage
- During Summer:
  - test PSI46dig

April TB program

- Defaults: DUT at 20°, bias -150 V, softest threshold, optimal delays
- Optimize rate in test beam by adjusting position ½ day
- Clock delay scan: 0..24 ns, 4 ns steps, finer at edges (~10 runs) ½ day
- Bias voltage scan: -150 to -10 V, 20 V steps (8 runs) ½ day
- DUT tilt scan: 0°, 5°, 10°, 15°, 18°, 20°, 22°, 25°, 30° (9 long runs) 1.5 day
- Threshold scan: `VthrComp` 97 to 7 step 10 (10 long runs) 1.5 day
- gain calibrations each day
- scan Vana (less power), always re-optimize other DACs 2 days
  - possibly repeat delay and threshold scans
- another chip as DUT 1 day
- repeat problematic runs 1 day
- reserve 1 day + weekends + extension week