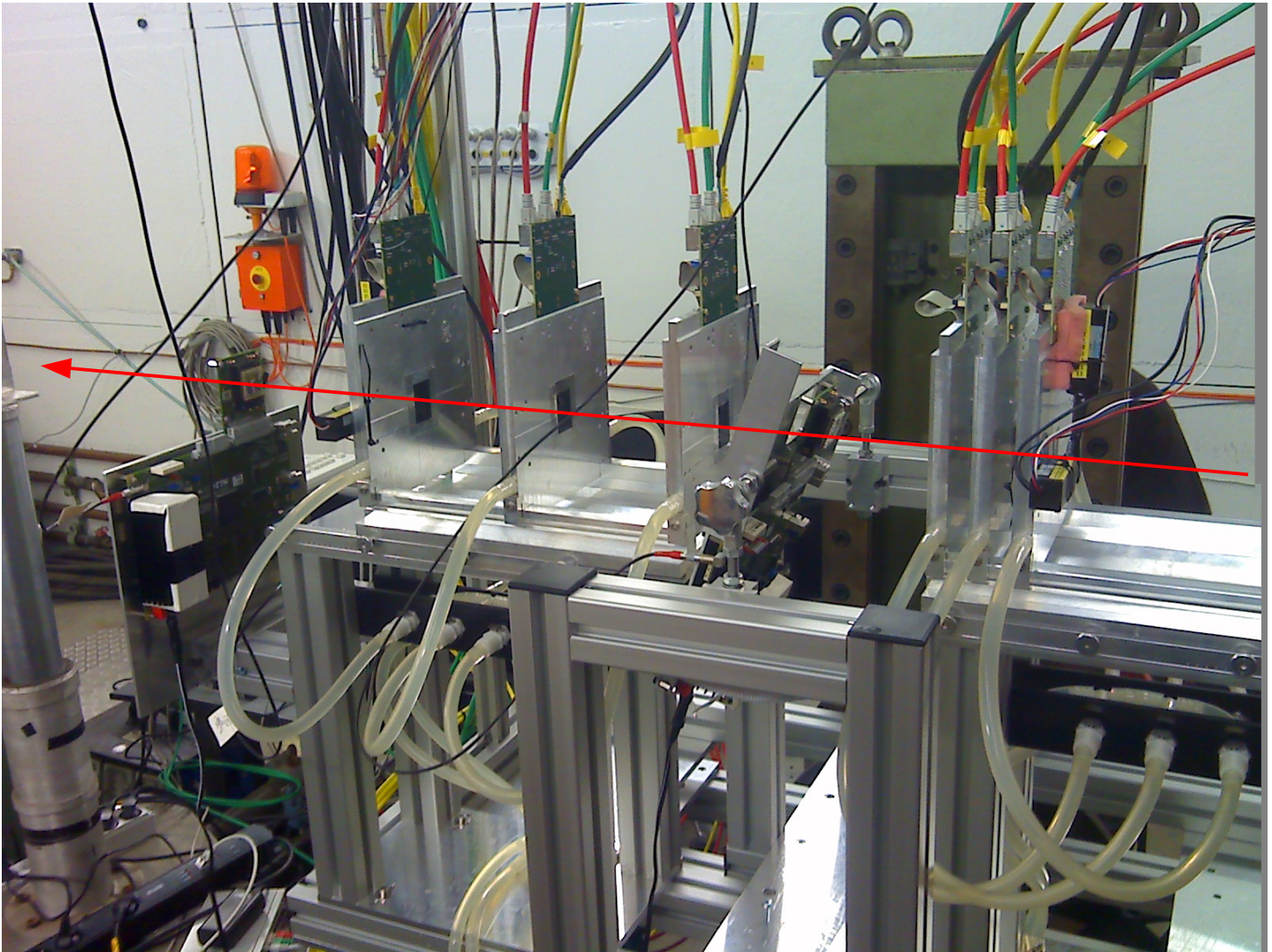
Preparations for Pixel beam test April 2012

Armin Burgmeier, Luigi Calligaris, Thomas Eichhorn
Shiraz Habib, Alexey Petrukhin, Hanno Perrey,Daniel Pitzl
DESY CMS Pixel upgrade, 20.4.2012

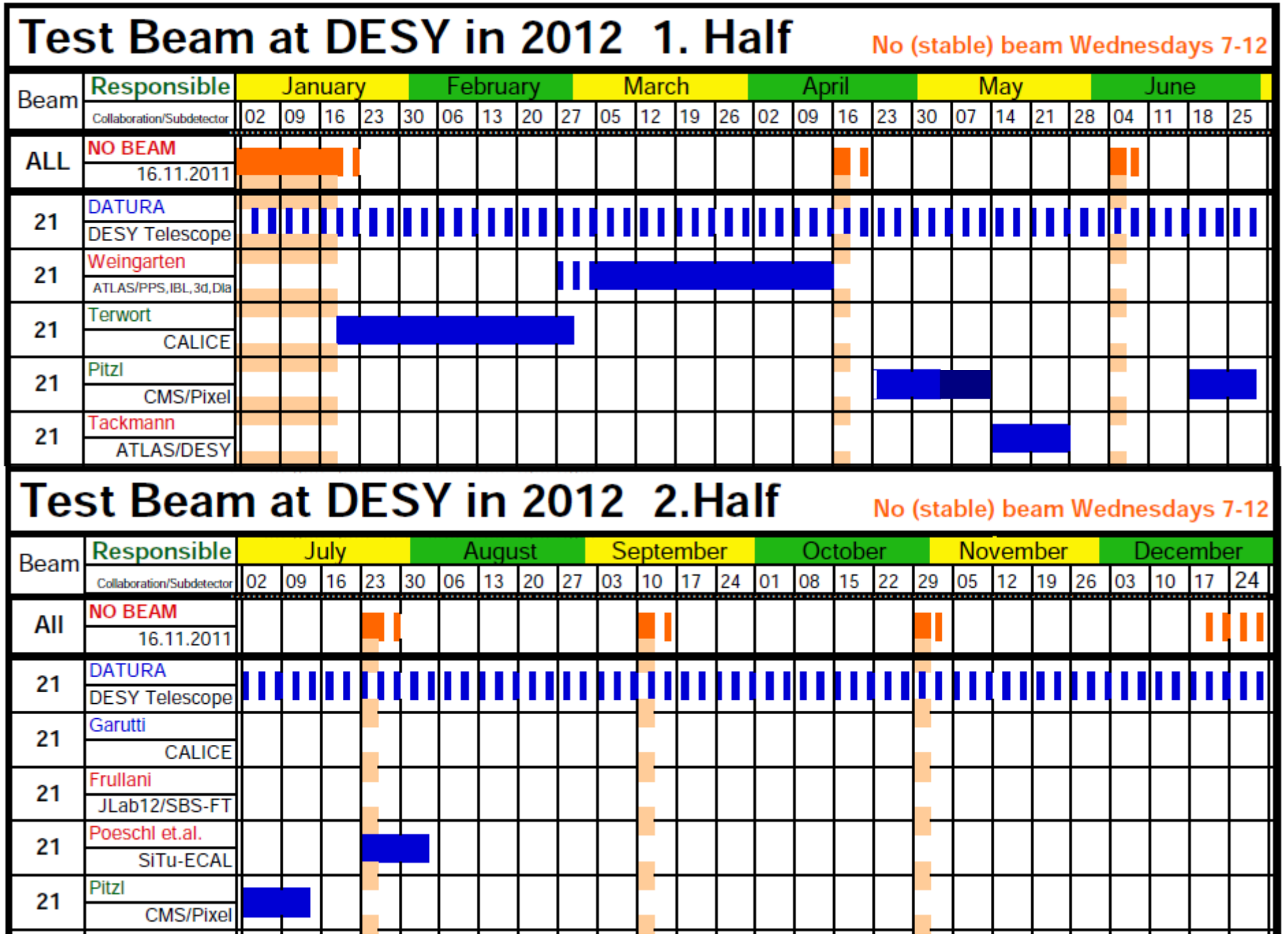


- goals: resolution and efficiency for present ROC
- preparations

CMS Pixel in the DESY test beam

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

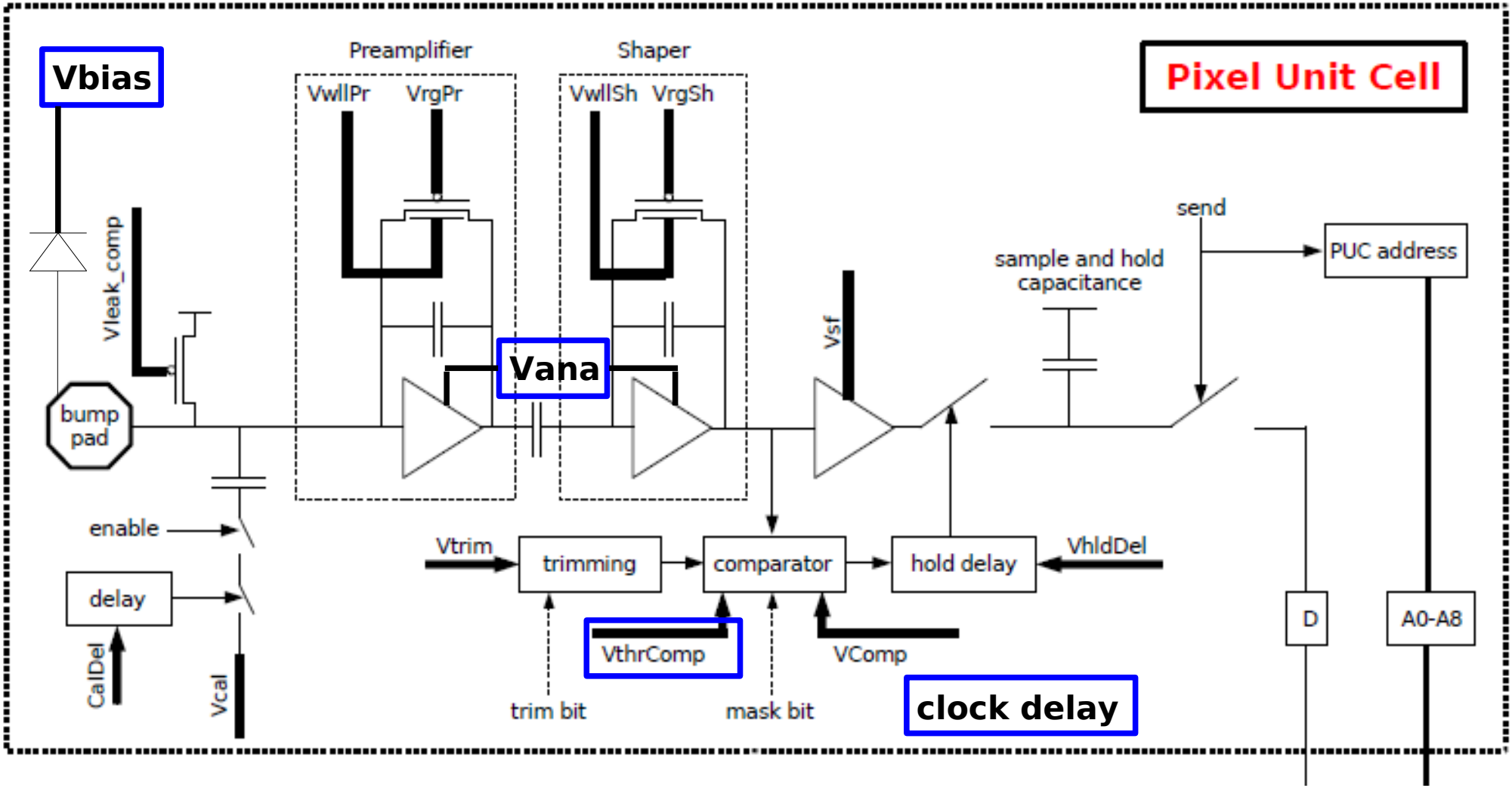
20.01.2012



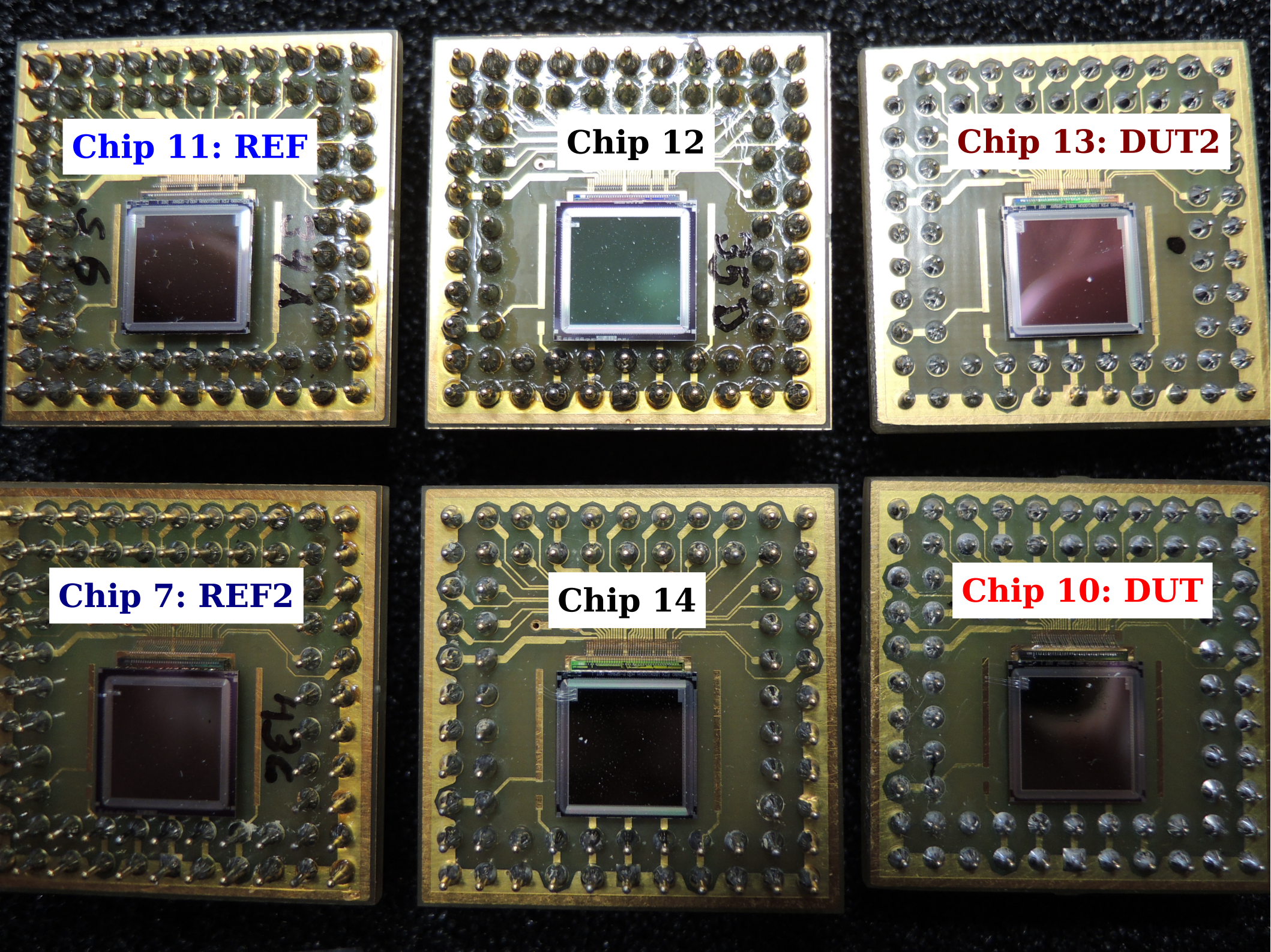
Goals for the April 2012 beam test

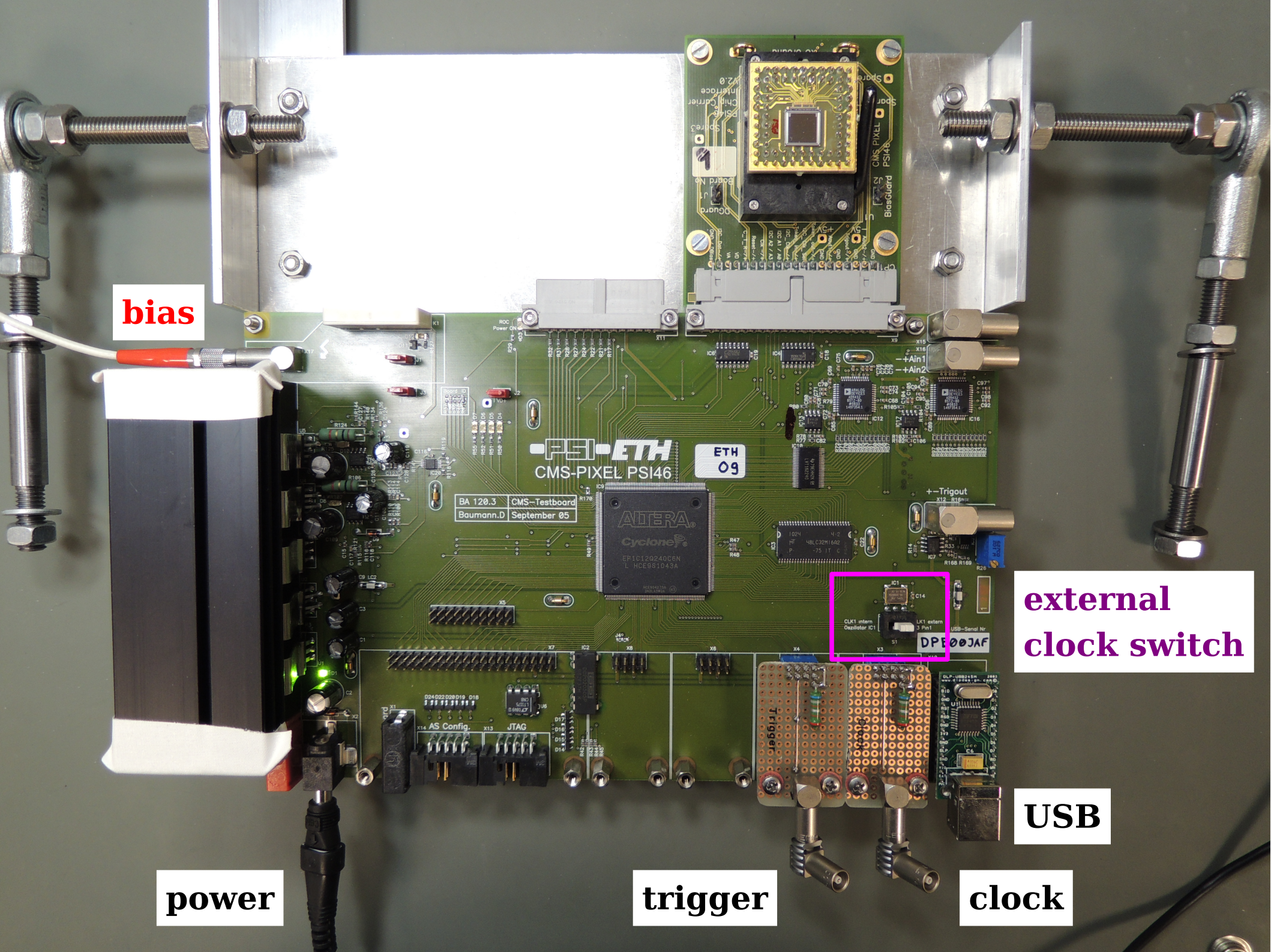
- Take reference data with the present Pixel ROC PSI46 v2.3
  - large statistics
- measure efficiency and resolution:
  - vs clock delay (0..25 ns)
  - vs bias voltage (up to 150 V with new Keithley, need Triax adapter)
  - vs threshold (soft to hard, cutting small pulses)
  - vs tilt angle (0 to 30 deg, mimic Lorentz angle)
- Procedure established:
  - operate 2 single chip modules
  - clock synchronized with the DESY II beam
  - parallel DAQ with 2 PSI46 test boards and the EUDET telescope
  - analyze with modified/extended EUTelescope software
- 2nd beam test with new PSI46xdb in summer

PSI46 pixel ROC

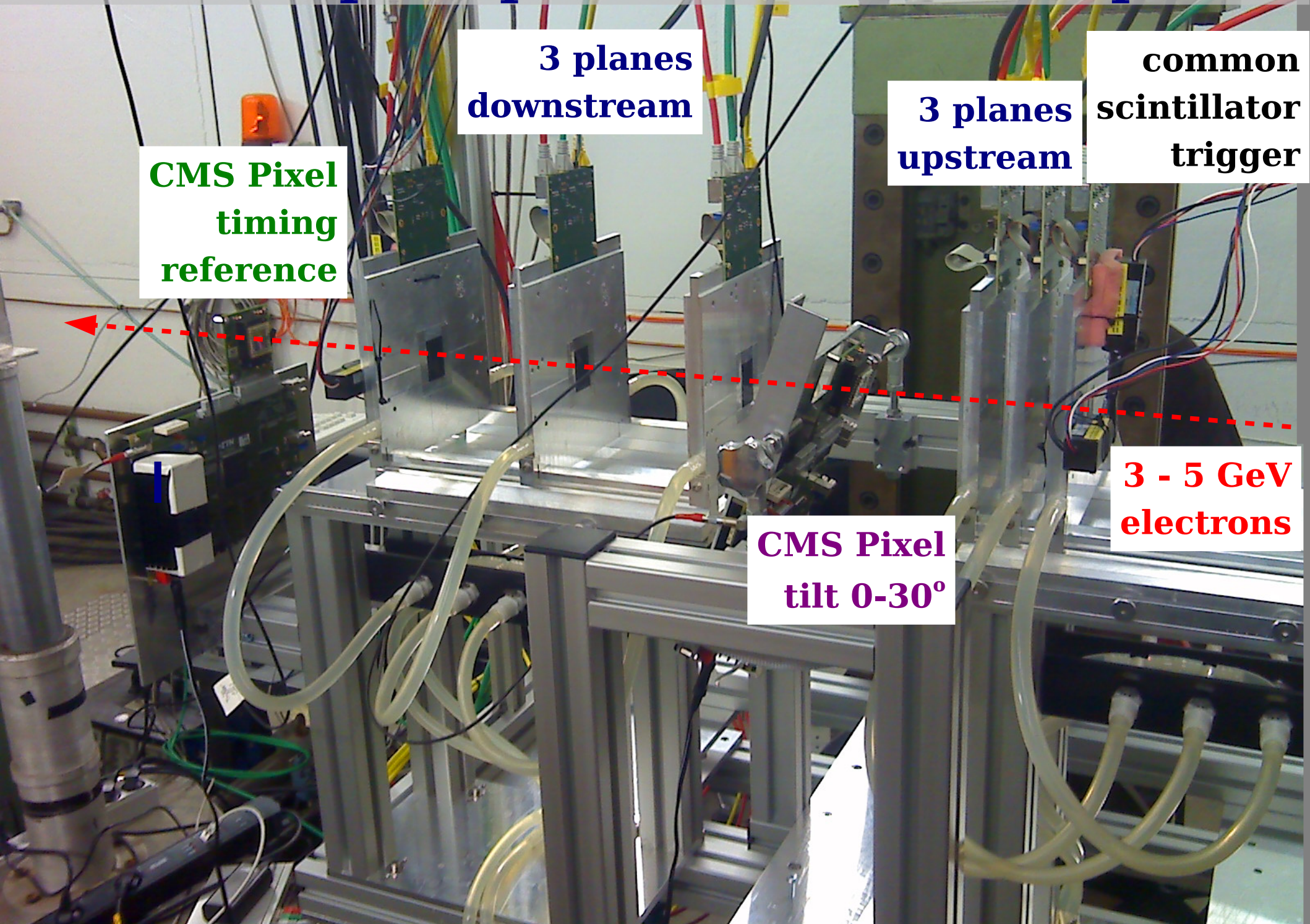


vary in beam test


Chip 11: REF
Chip 12
Chip 13: DUT2
Chip 7: REF2
Chip 14
Chip 10: DUT

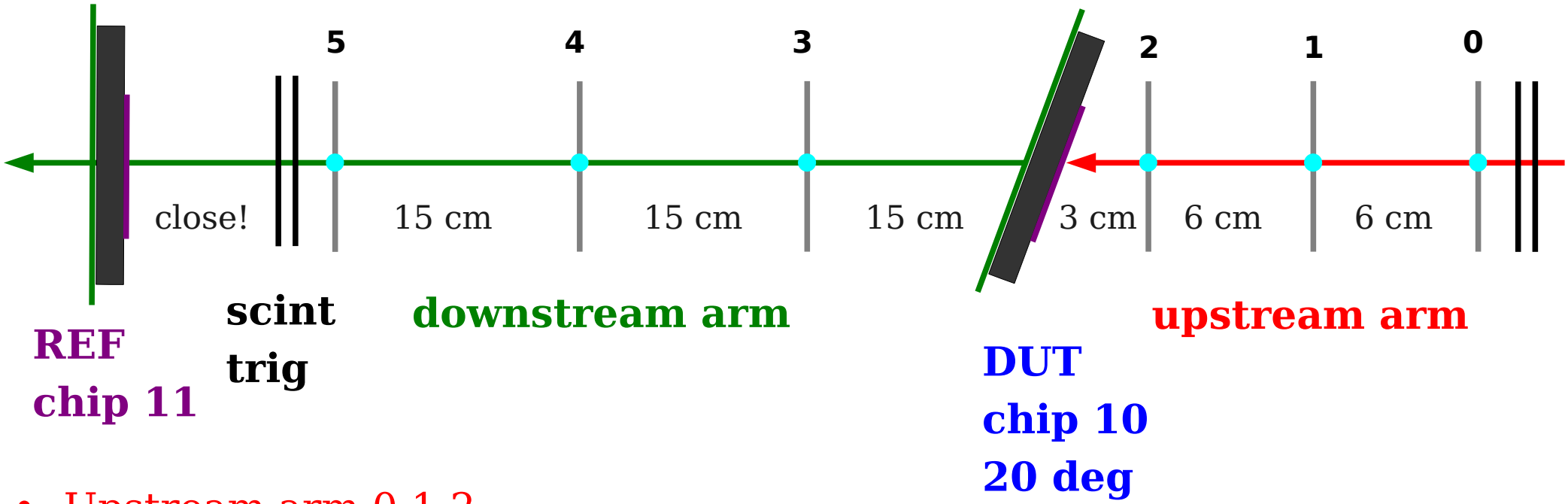

bias
external
clock switch
USB
power
trigger
clock
PSI-ETH
CMS-PIXEL PSI46
ETH
09
BA 120.3
CMS-Testboard
Baumann.D
September 05
ALTERA
Cyclone
AS Config.
JTAG
+-Trigout
-+Ain1
-+Ain2

2 CMS pixel planes in the telescope



new telescope

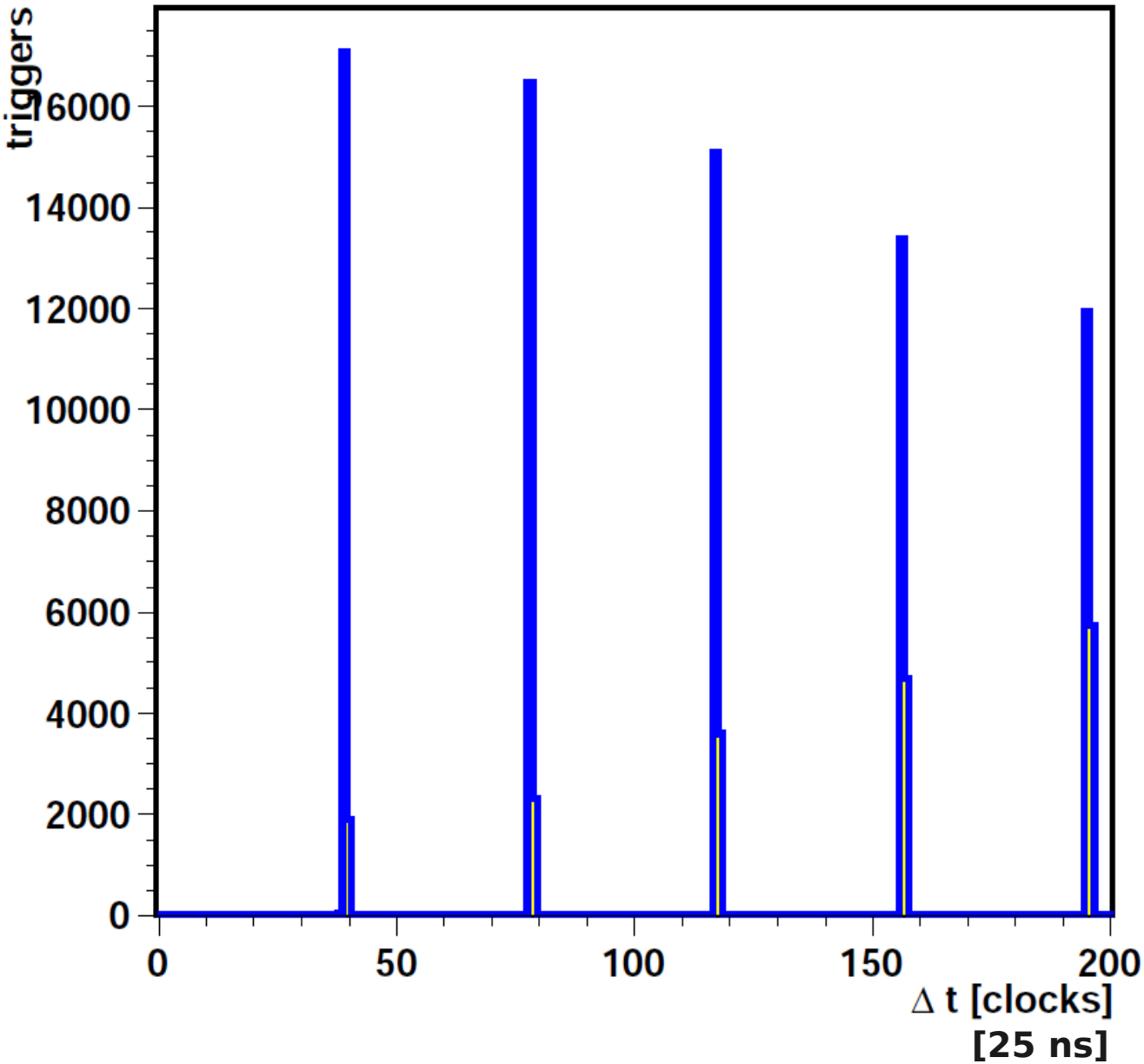
Default set up



- Upstream arm 0-1-2:
  - as close as possible to DUT, but allow for insertion and tilting
- 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: 4-fold coincidence (config: TLU AndMask 15)

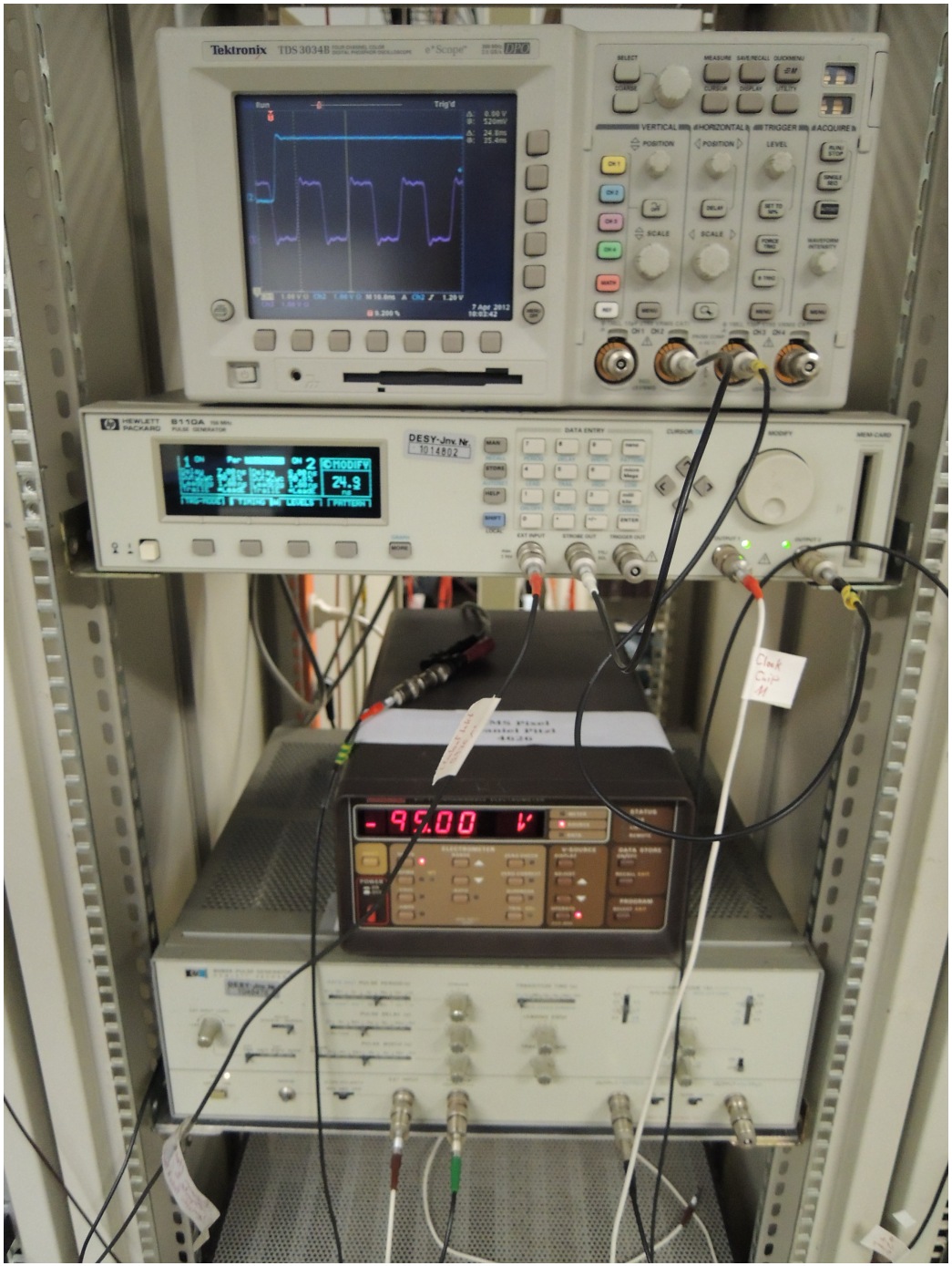
timing in DESY II

CMS pixel without telescope (fast) time between events:



- DESY II circumference is 292.8 m
- DESY II has one bunch:
  - repeats every 0.976 µs (1.024 MHz)
  - = 39 × 25 ns
  - hardware signal
- CMS operates with 40 MHz clock
  - synchronous to the beam
  - need to generate!

clock, bias, and trigger

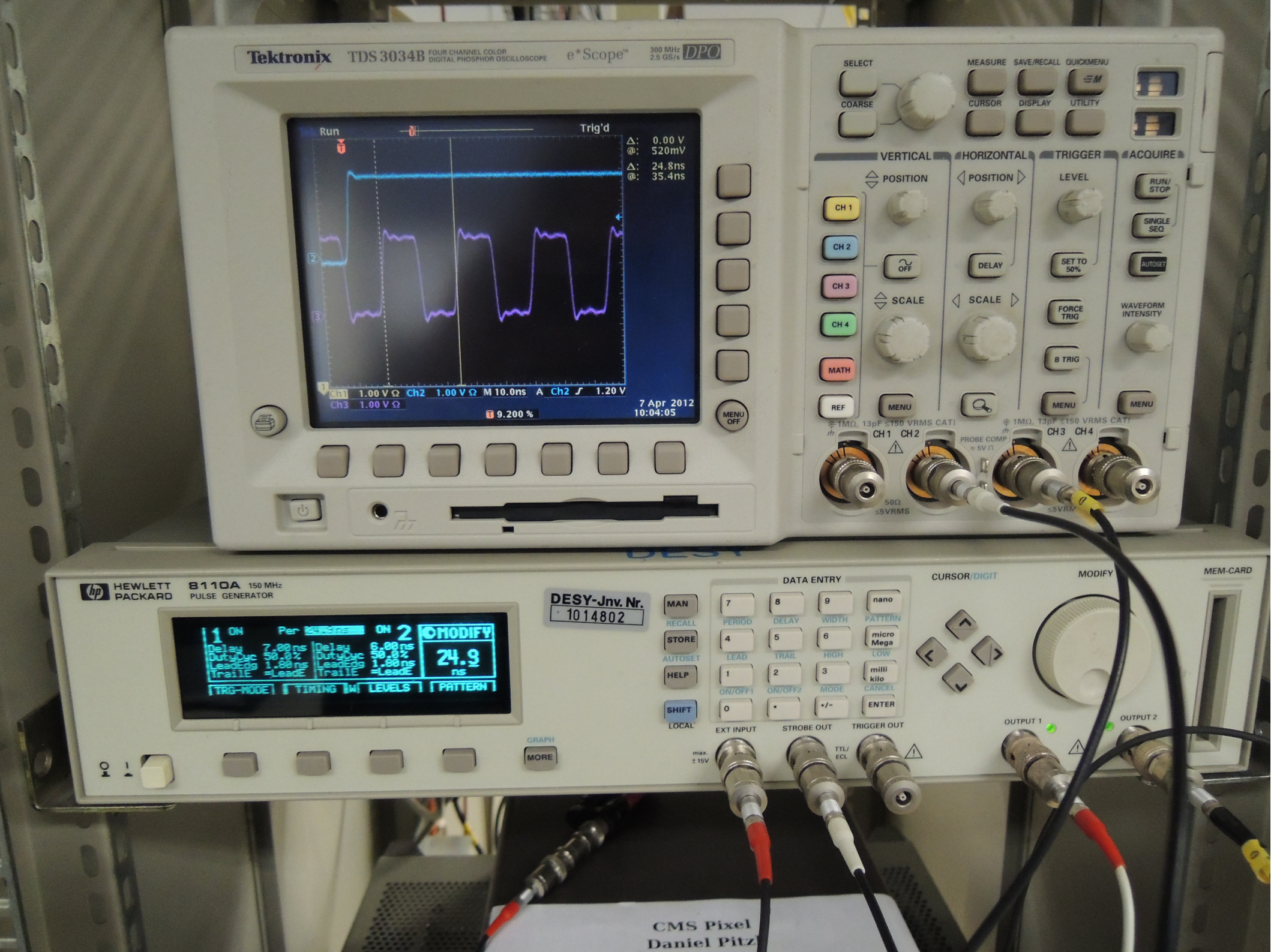


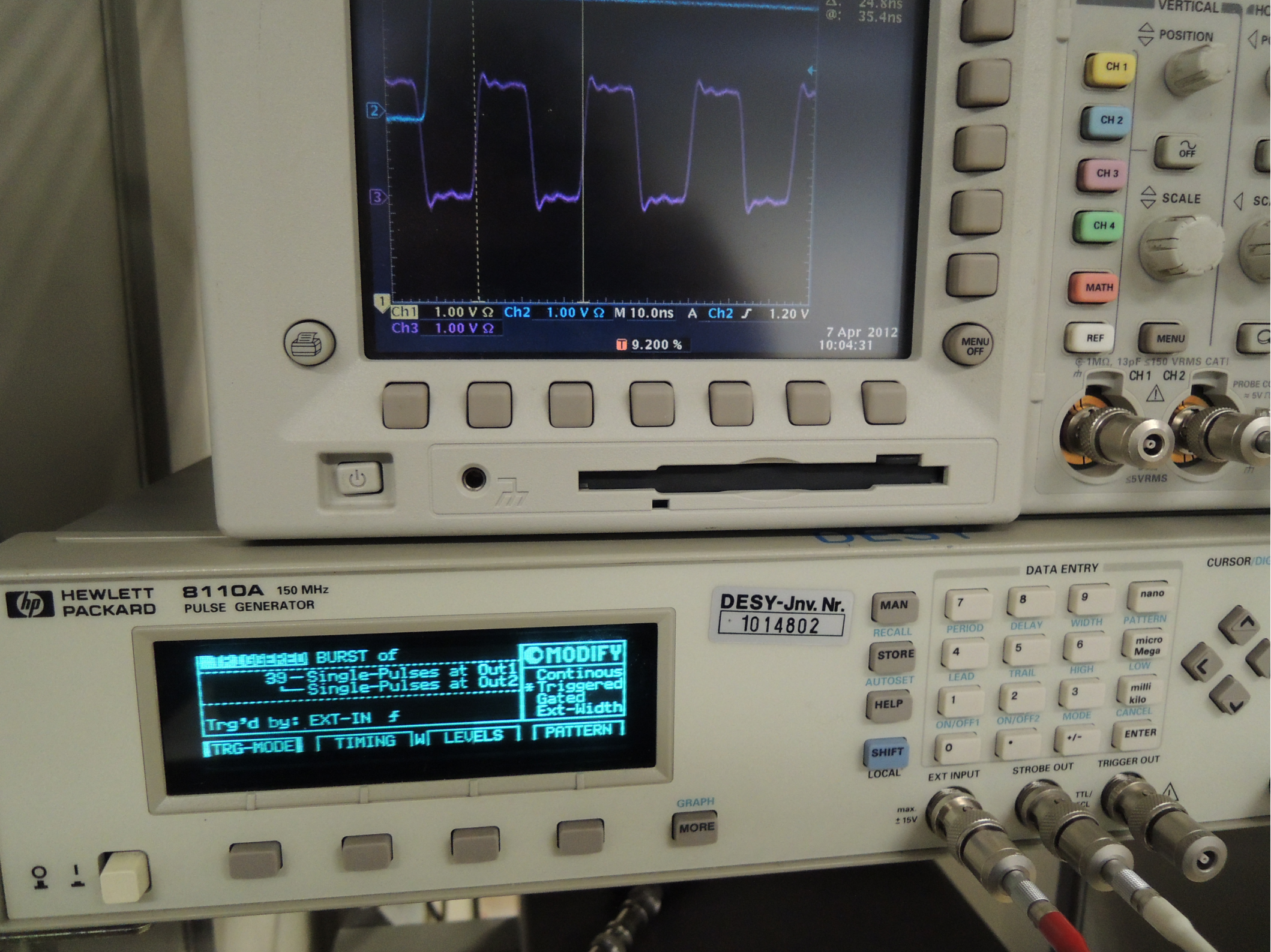
from U. Hurdelbrink (MHF): generate 39 pulses of 25 ns after every DESY bunch trigger

HP Agilent 8110A
pulse generator -> clock
(borrowed from U. Koetz, one more ordered)

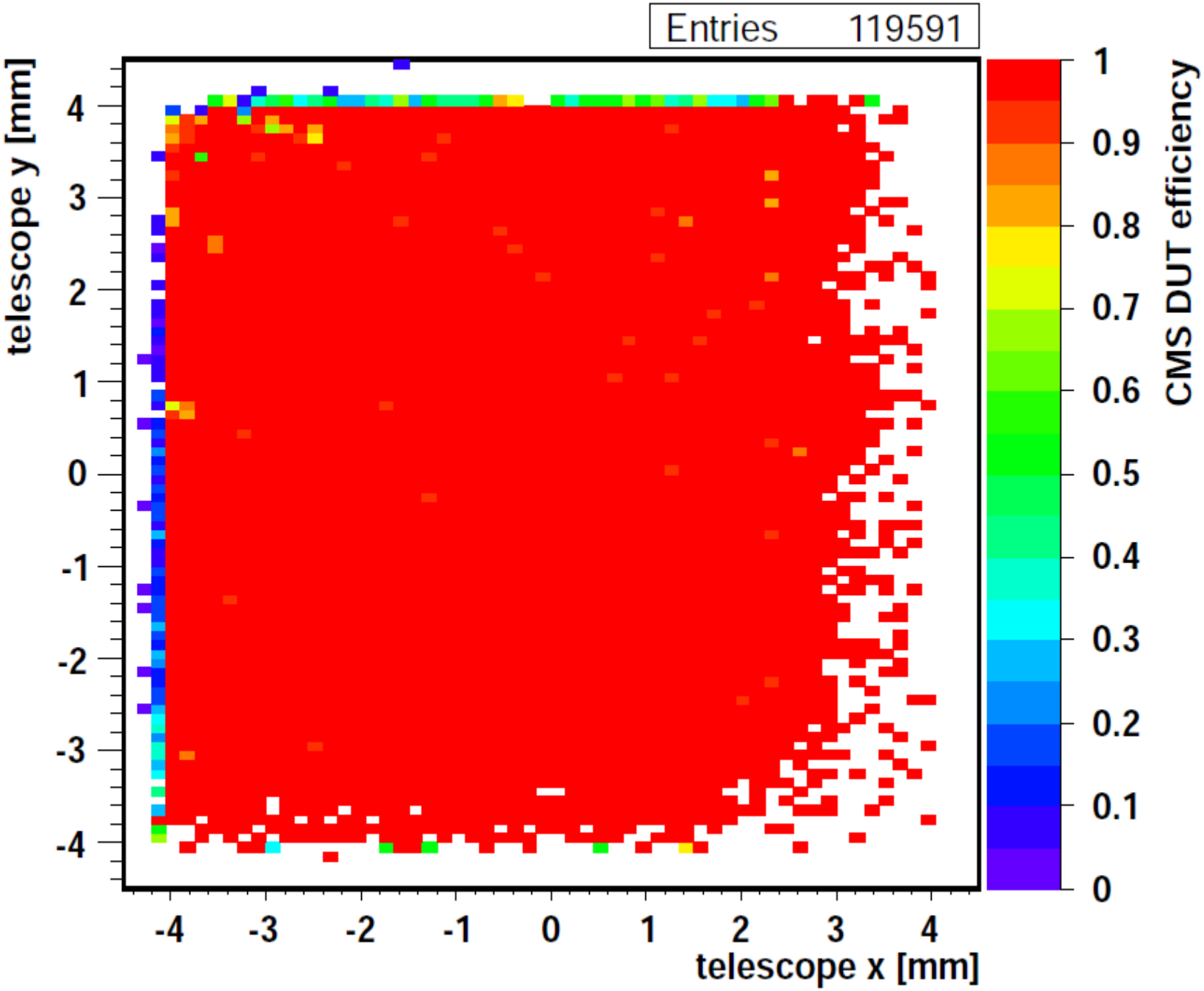
Keithley 617
bias voltage: -95V

HP pulse generator
-> trigger


Tektronix TDS 3034B FOUR CHANNEL COLOR DIGITAL PHOSPHOR OSCILLOSCOPE
e*Scope
300 MHz 2.5 GS/s DPO
Run
Trig'd
Δ: 0.00 V
@: 520mV
Δ: 24.8ns
@: 35.4ns
Ch1 1.00 V Ω Ch2 1.00 V Ω M 10.0ns A Ch2 1.20 V
Ch3 1.00 V Ω
9.200 %
7 Apr 2012
10:04:05
MENU OFF
SELECT
COARSE
MEASURE
SAVE/RECALL
QUICKMENU
CURSOR
DISPLAY
UTILITY
VERTICAL
HORIZONTAL
TRIGGER
ACQUIRE
POSITION
LEVEL
CH 1
CH 2
CH 3
CH 4
MATH
REF
OFF
SCALE
DELAY
SET TO 50%
FORCE TRIG
B TRIG
MENU
RUN/STOP
SINGLE SEQ
AUTOSET
WAVEFORM INTENSITY
CH1 CH2
CH3 CH4
PROBE COMP
50Ω ≤5VRMS
HEWLETT PACKARD 8110A 150 MHz PULSE GENERATOR
DESY-Jnv. Nr. 1014802
MODIFY
24.9 ns
TRG-MODE
TIMING
LEVELS
PATTERN
MAN
RECALL
STORE
AUTOSET
HELP
SHIFT
LOCAL
DATA ENTRY
PERIOD
DELAY
WIDTH
PATTERN
LEAD
TRAIL
HIGH
LOW
ON/OFF1
ON/OFF2
MODE
CANCEL
nano
micro Mega
milli kilo
ENTER
CURSOR/DIGIT
MODIFY
MEM-CARD
GRAPH
MORE
EXT INPUT
STROBE OUT
TRIGGER OUT
OUTPUT 1
OUTPUT 2
CMS Pixel
Daniel Pitz


Ch1 1.00 V Ω Ch2 1.00 V Ω M 10.0ns A Ch2 1.20 V
Ch3 1.00 V Ω
9.200 %
7 Apr 2012
10:04:31
MENU OFF
VERTICAL
POSITION
CH 1
CH 2
CH 3
CH 4
OFF
SCALE
MATH
REF
MENU
CH1 CH2
≤5VRMS
HEWLETT PACKARD
8110A 150 MHz
PULSE GENERATOR
DESY-Jnv. Nr.
1014802
BURST of
39—Single-Pulses at Out1
Single-Pulses at Out2
MODIFY
Continous
Triggered
Gated
Ext-Width
Trg'd by: EXT-IN
TRG-MODE
TIMING
LEVELS
PATTERN
GRAPH
MORE
MAN
RECALL
STORE
AUTOSET
HELP
SHIFT
LOCAL
DATA ENTRY
PERIOD
DELAY
WIDTH
PATTERN
LEAD
TRAIL
HIGH
LOW
ON/OFF1
ON/OFF2
MODE
CANCEL
EXT INPUT
STROBE OUT
TRIGGER OUT
ENTER
nano
micro
Mega
milli
kilo
max ±15V

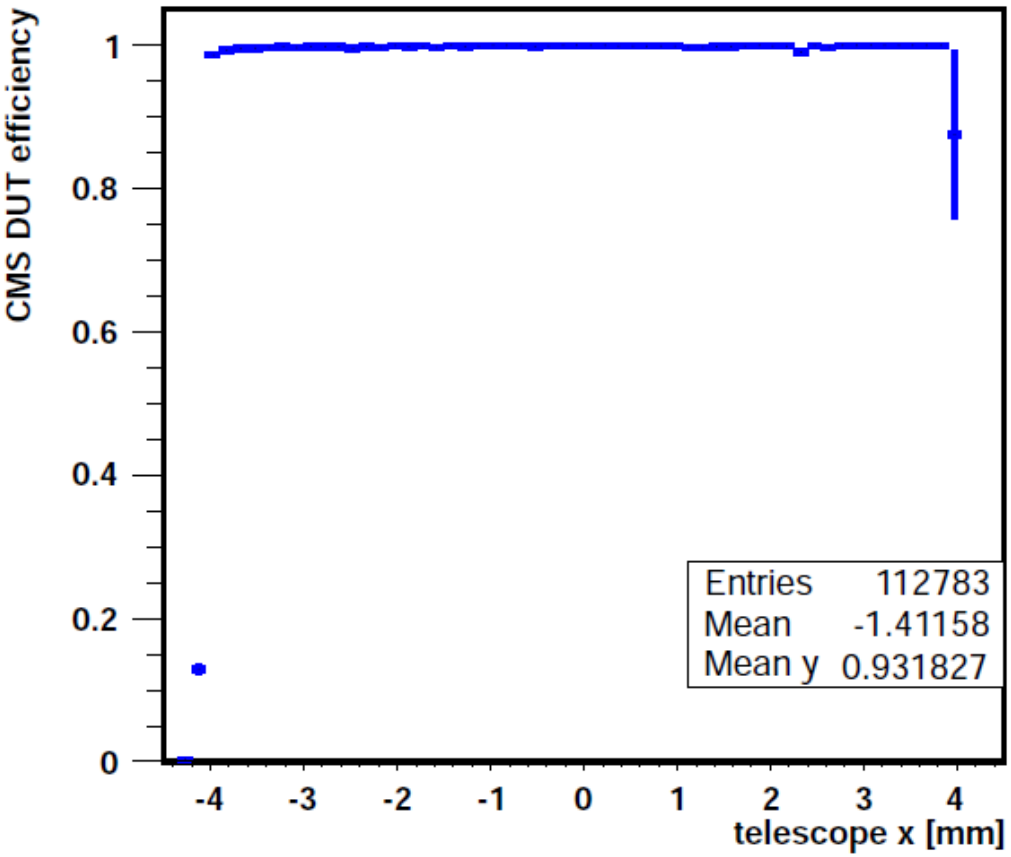
Efficiency map



- run 2880
  - 60 min
- 4.0 GeV
- chip 10
- tilt 20°
- clock delay 7 ns

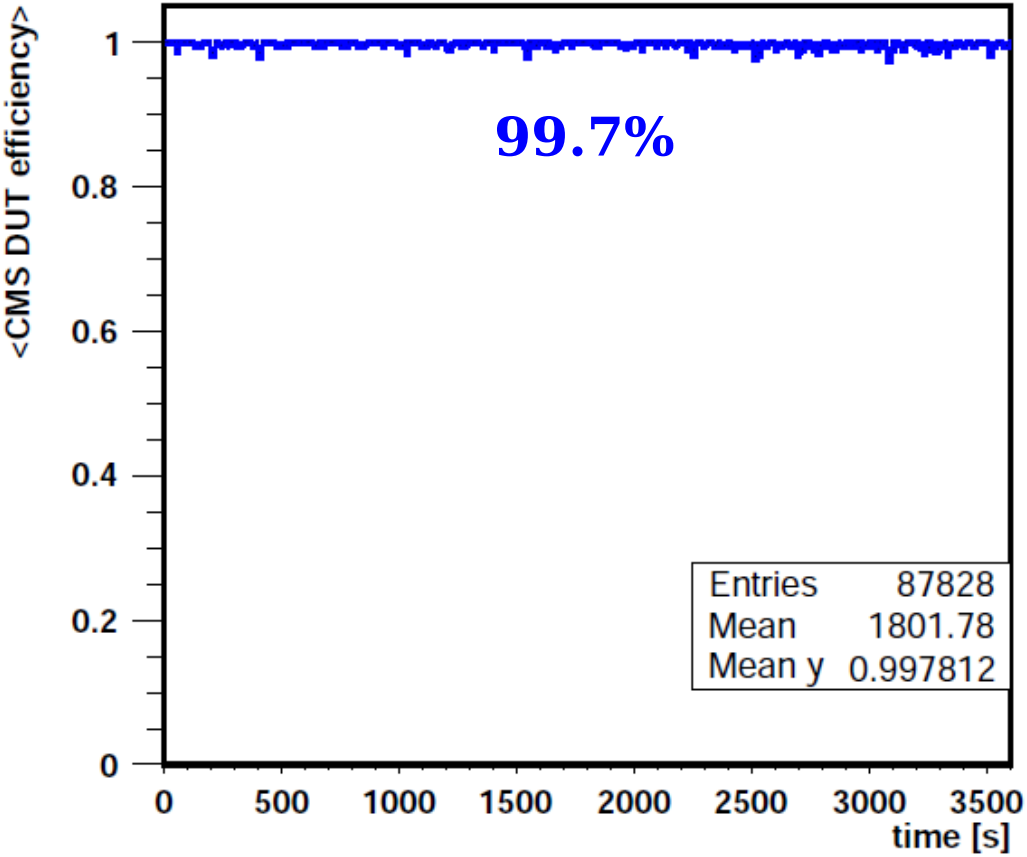
Efficiency profiles

fiducial cuts in *y*



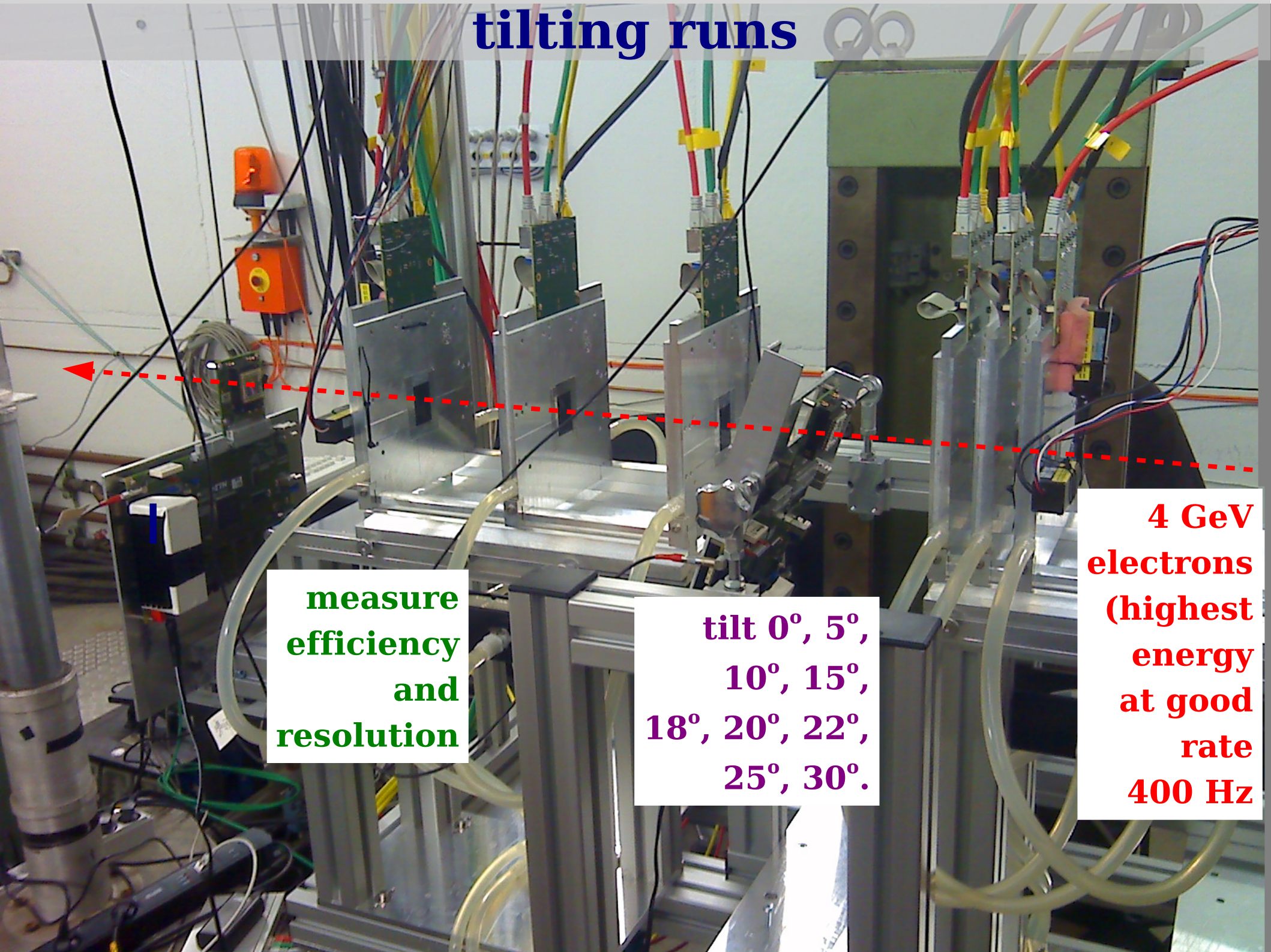
52 columns

fiducial cuts in *x* and *y*

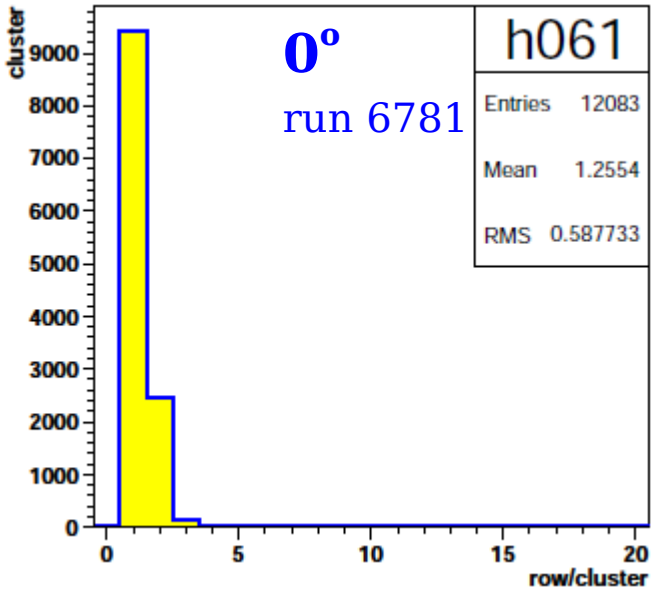


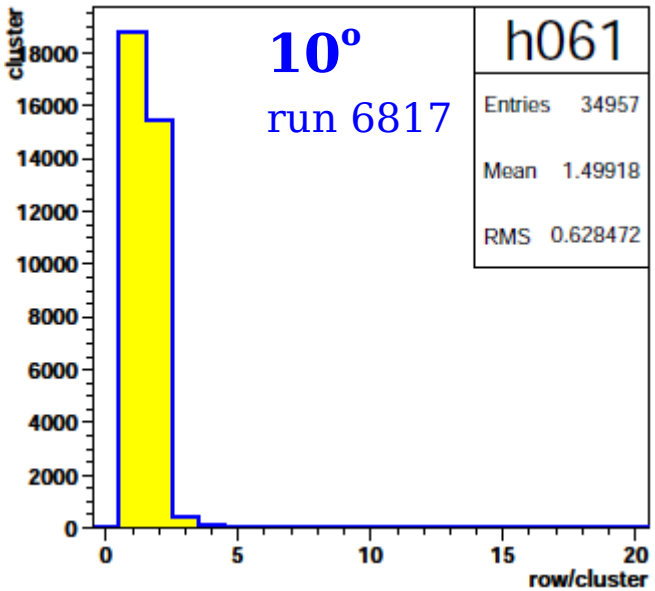
one hour

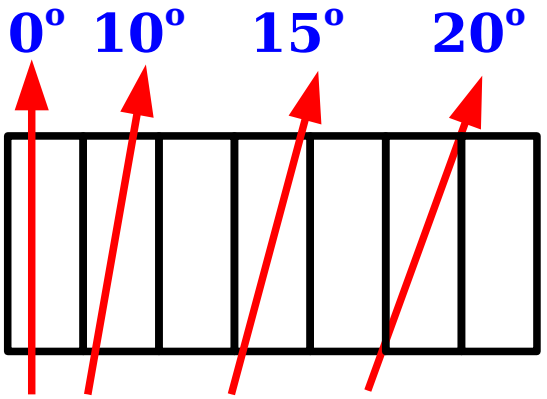
tilting runs



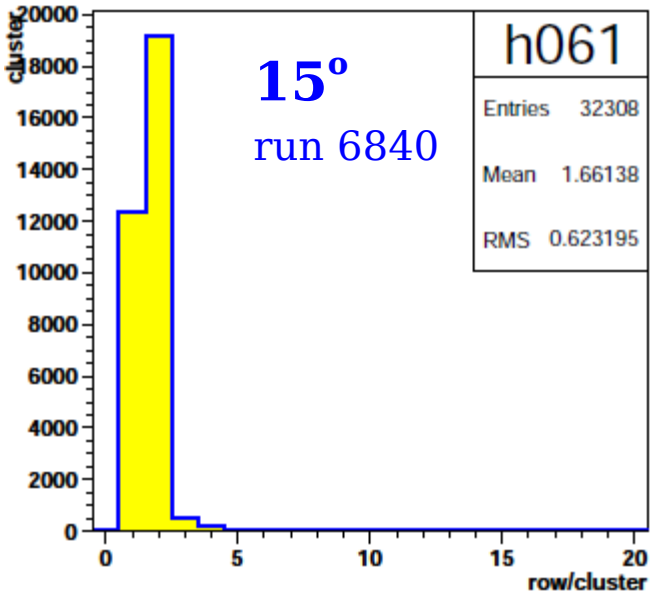
cluster size vs tilt angle

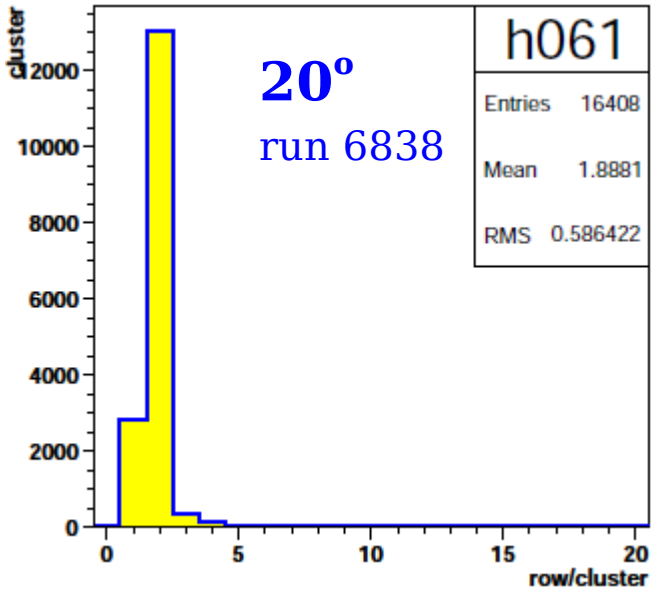


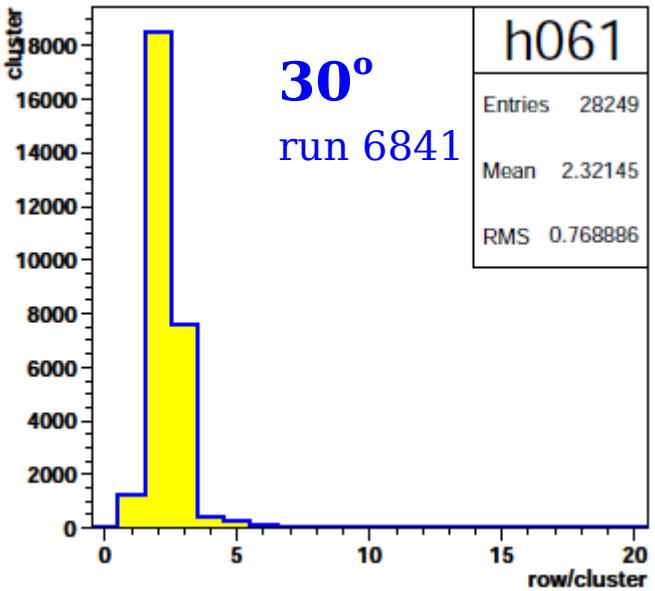




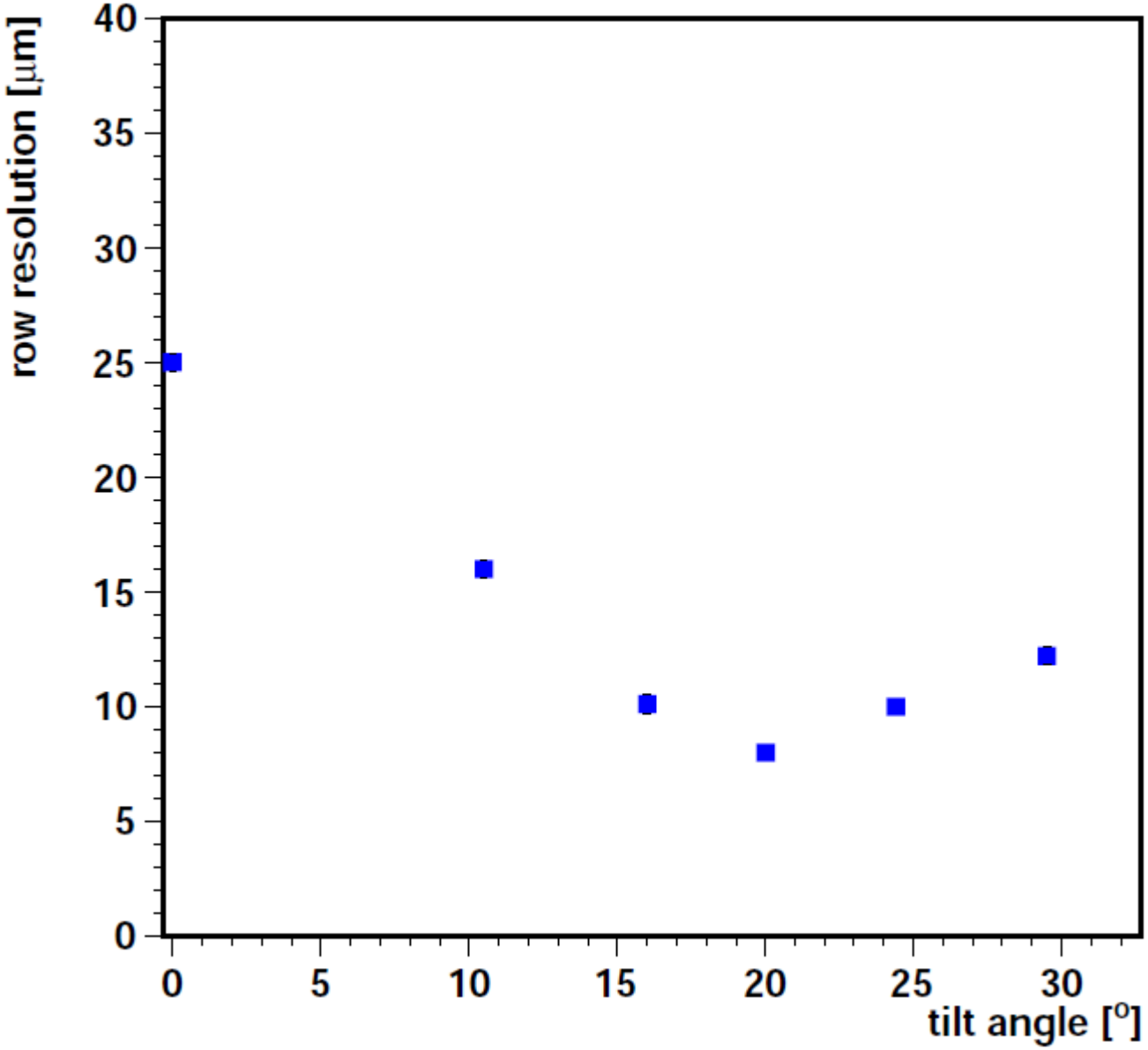
atan(100/285) = 19.3°

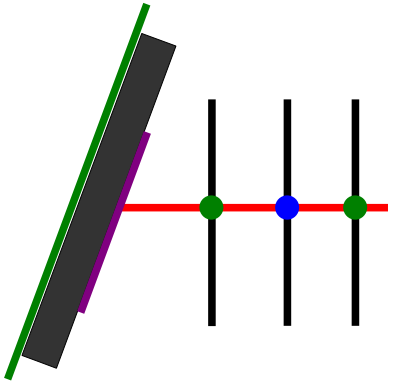






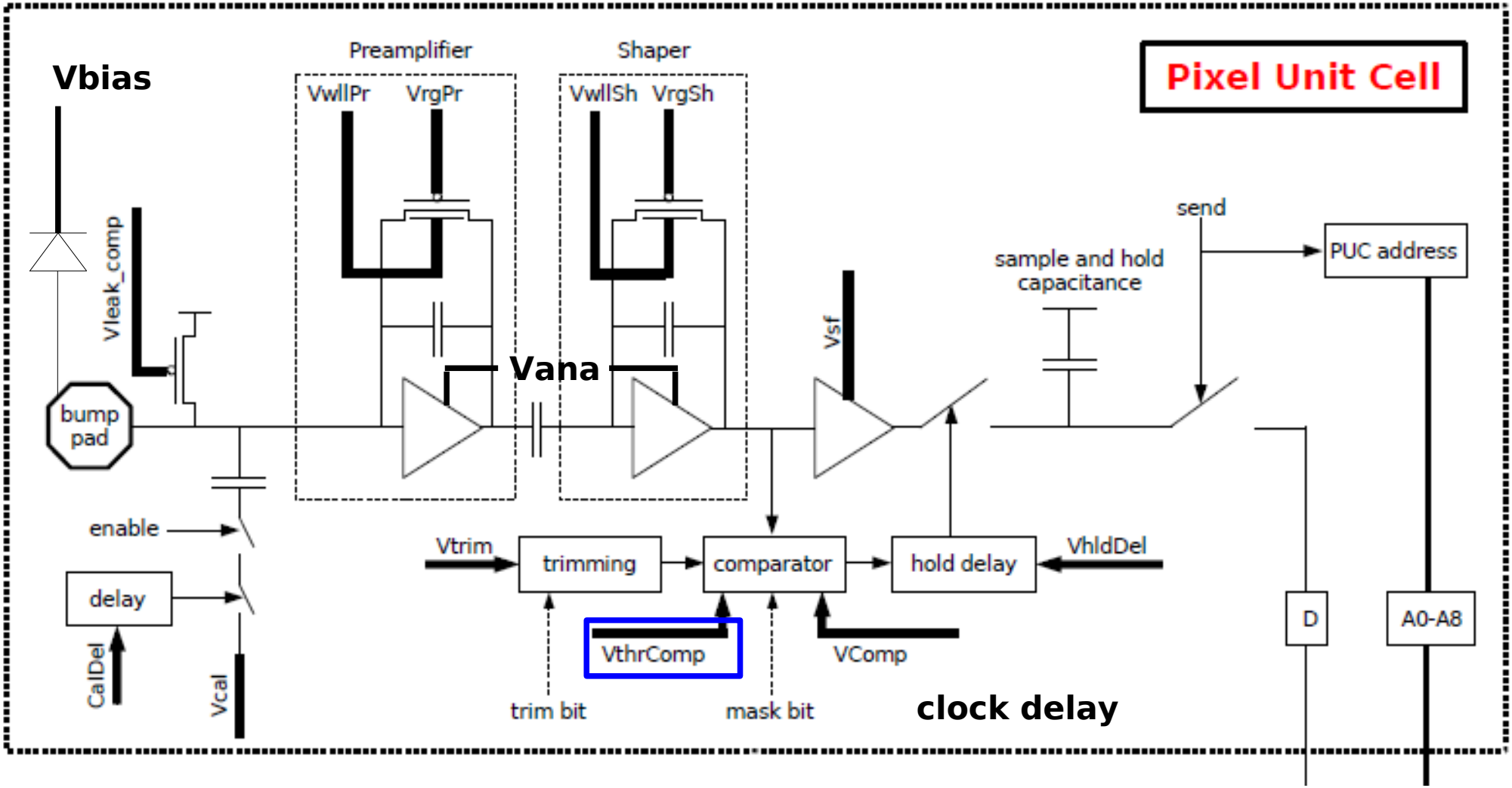
CMS pixel row resolution vs tilt angle





- 6 GeV, telescope extrapolation uncertainty subtracted.
- row pixels = 100 μm.
- Binary:
  - $\sigma = 100 / \sqrt{12} = 29$ μm
- Optimal angle 19°:
  - $\sigma = 8$ μm.

threshold scan

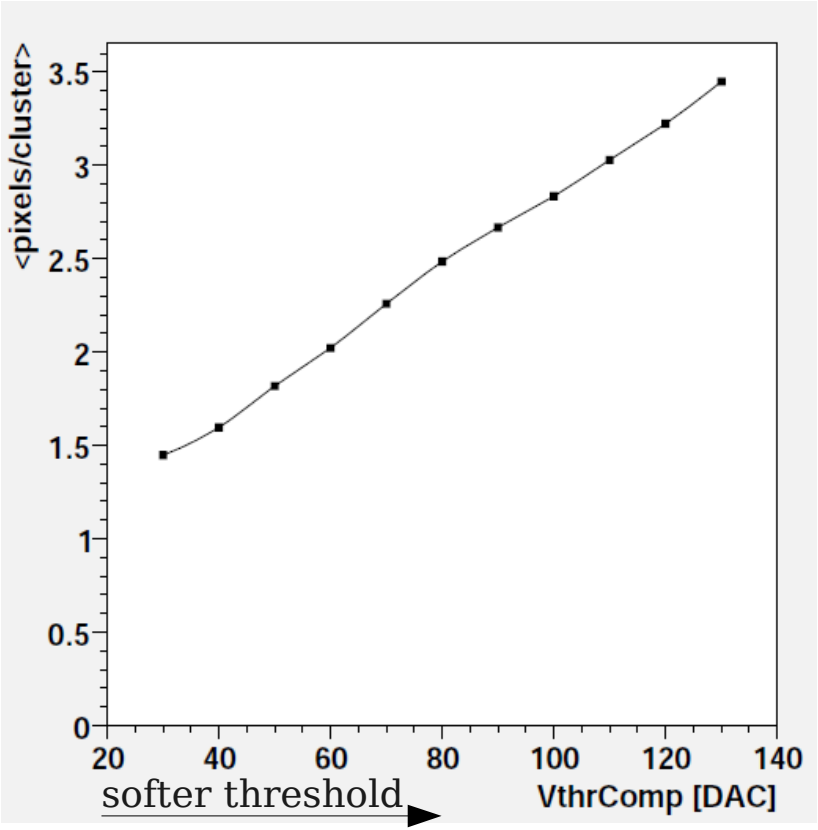


threshold from soft to hard: loose small pulses
simulates reduced charge collection
study cluster size, resolution, efficiency

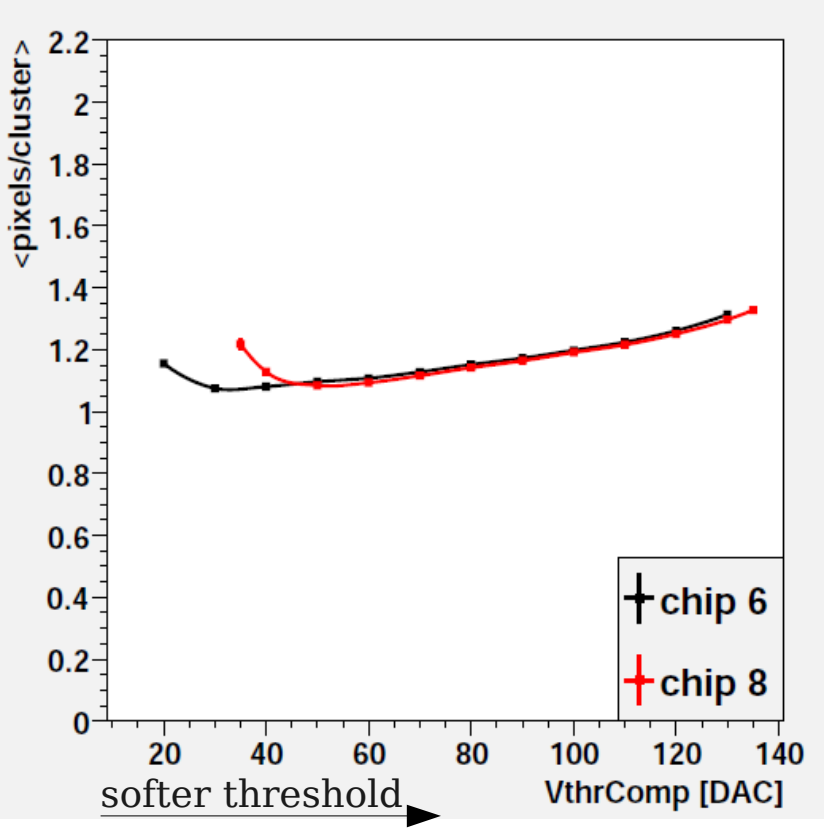
Cluster size vs. ROC threshold

A. Gajos, summer student, Sep 2011

Ru source: 3 MeV e



Test beam at 0°



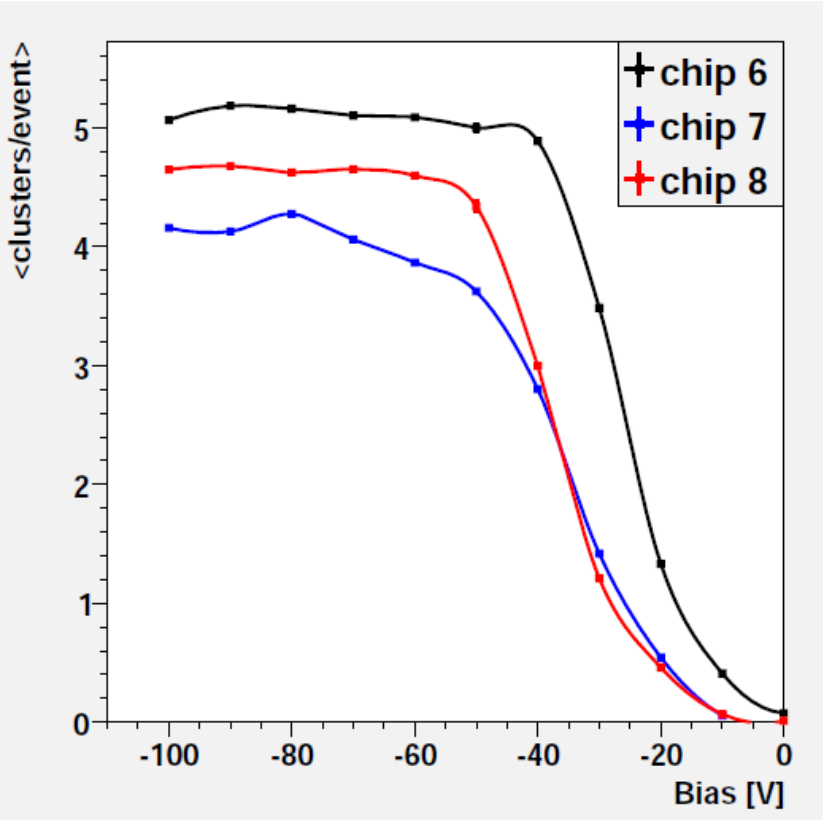
- strong effect:
  - all incident angles
  - lots of scsttering
  - makes large clusters

- weak effect:
  - mostly 1-pixel clusters at 0°
- repeat at 20°
  - expect larger effect

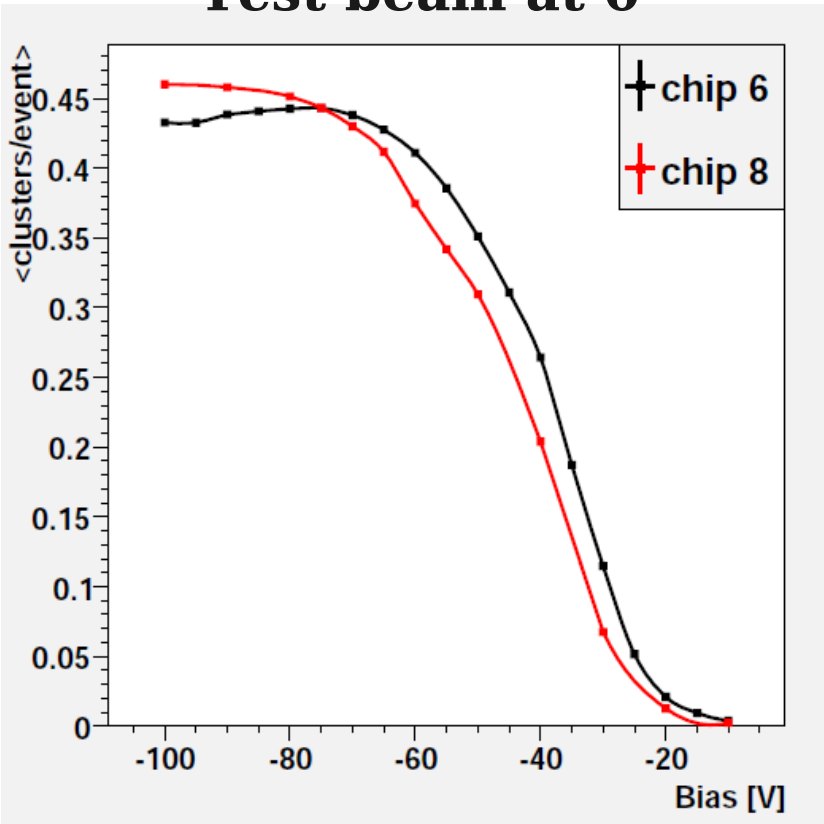
Cluster rate vs. sensor bias voltage

A. Gajos, summer student, Sep 2011

Ru source: 3 MeV e



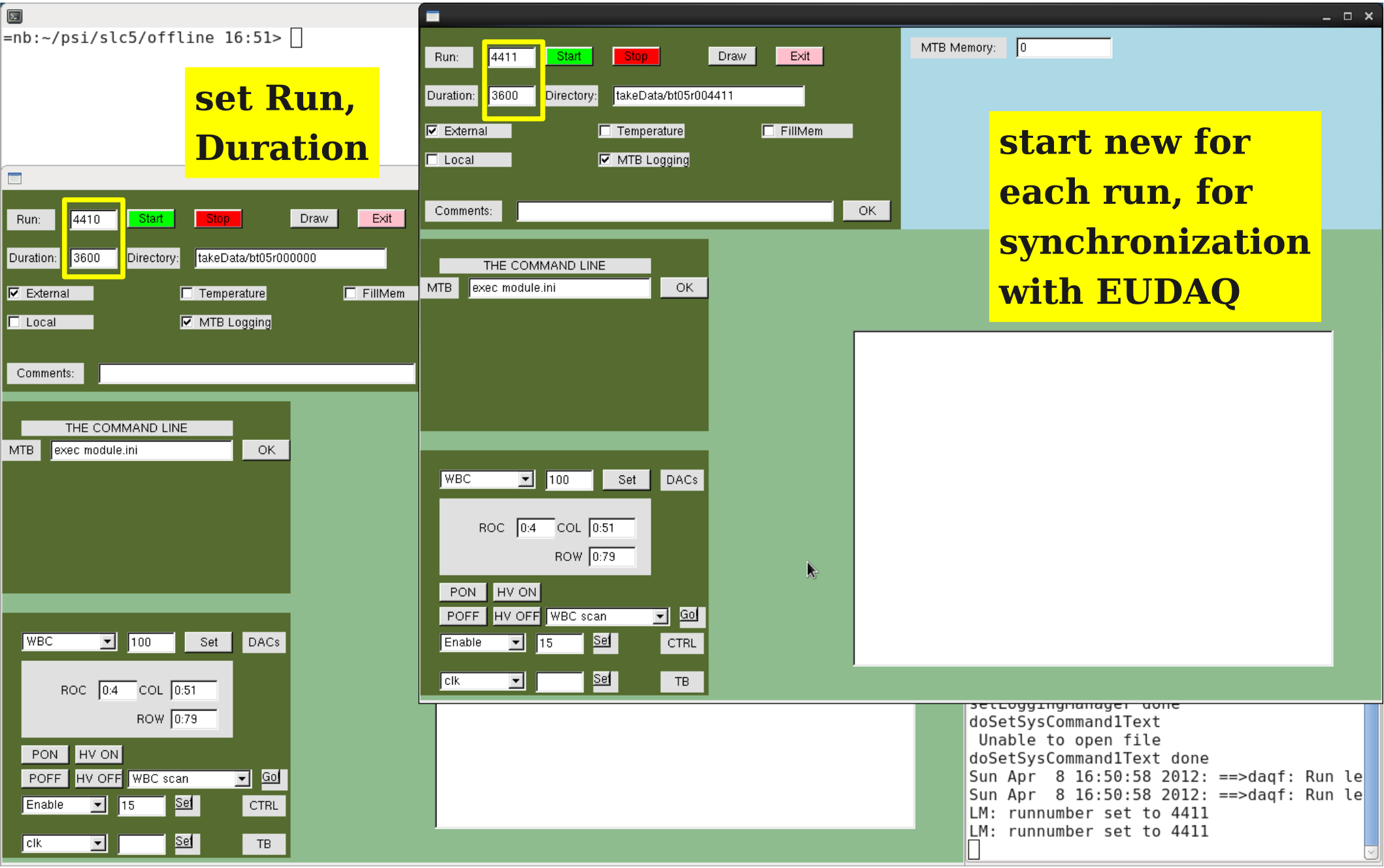
Test beam at 0º



- large pulses → cluster rate reaches plateau at –50V
- Chip variation: source alignment and threshold differences

- efficiency plateau at –80V when full charge is collected
- Chips similar: vertical incidence and optimized thresholds

CMS pixel DAQ



PC `hlantigua` prepared by Shiraz. Group account `cmspix`. Ready?

Data taking

- CMS pixel DAQ: from `psi46expert`
  - `../bin/takeData -dir chip10` (DUT), set run i, duration, start
  - `../bin/takeData -dir chip11` (REF), set run j, duration, start
- EUDAQ:
  - `./STARTRUN`
  - config
  - start
- check CMS pixel: from `takeData`
  - `../../offline/b2h -c 10 -r i | less`
  - `root -l data00i.root`
  - `root> .x data2ps.C`
  - `acroread data.pdf`
  - `repeat for chip 11 run j`

Logbook: Google spread sheet

Telescope Testbeam April/May 2012 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

google.com https://docs.google.com/spreadsheet/ccc?key=0AvwUuOG-G9SYdHNBSVhMVEtFVlZHQTZUbG1Ma0JpaGc#gid=0

datura

H1 pitzl pxl HistSci LHCC LHCp1 fills iCMS Google Wetter Radar Regen Radar

OP Vistars | DESY-CMS Tracker Upgrad... | Telescope Testbeam April/... | Weekly Tracker DPG Meeti...

Telescope Testbeam April/May 2012

Daniel Pitzl

Freigeben

Ihr Browser unterstützt nicht alle Funktionen von Google Docs. Steigen Sie auf Google Chrome um, falls Sie Schwierigkeiten haben. Schließen

Datei Bearbeiten Ansicht Einfügen Format Daten Tools Hilfe Alle Änderungen gespeichert

tho.eichhorn: hi

Alle Formeln anzeigen

Please sign up for shifts, at least two people per shift necessary

		23.04.2012	24.04.2012	25.04.2012	26.04.2012	27.04.2012	30.04.2012	(01.05.2012)	02.05.2012
		no telescope		machine studies	DESY PRC			May Day	machine studies
Armin Burgmeier	08:00 - 14:00			on shift		on shift			
Luigi Calligaris			on shift			on shift			
Thomas Eichhorn			on shift						
Shiraz Habib				on shift	on shift				
Hanno Perrey					on shift				on shift
Alexey Petrukhin							on shift		on shift
Daniel Pitzl		present	present	present	auditorium	present	on shift		present
Armin Burgmeier	14:00 - 20:00		on shift						
Luigi Calligaris				on shift	on shift				
Thomas Eichhorn				on shift			on shift		
Shiraz Habib			on shift				on shift		
Hanno Perrey									on shift
Alexey Petrukhin						on shift			
Daniel Pitzl		present			on shift	on shift			on shift

Shift List | Operations Log | Hardware Log | Geometry Setup | Problem List | Comments

Done

prepared by Thomas Eichhorn, registered users can read and modify

EuTelescope software in Marlin

step	output.format	constants
0. EUDAQ data taking	native.bin	
1. convert, find hot pixels	raw.lcio	hotpixel.db
2. clustering	clusters.lcio	offset.db
3. hits, coarse align	hits.lcio	pre-align.db
4. Millepede alignment with GBL	pede.bin	align.db
5a. read CMS, GBL tracks Millepede align	tracks.lcio	DUTal.txt
5b. re-run GBL track fit	final plots	

All steps produce ROOT histograms for monitoring

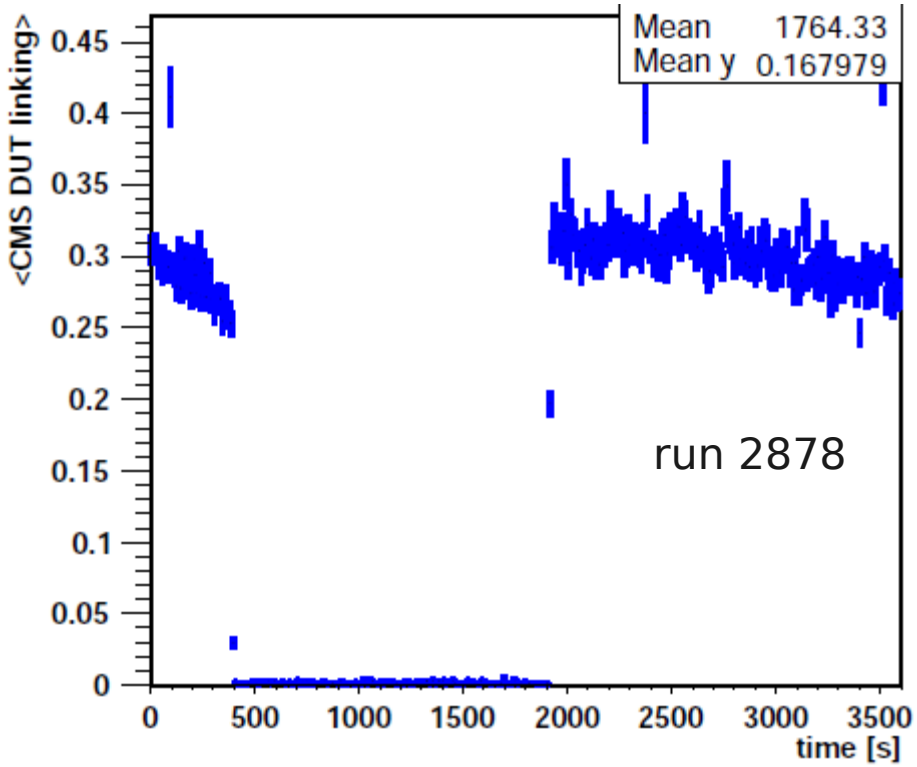
alignment of DUT and REF not yet fully automated **DP**

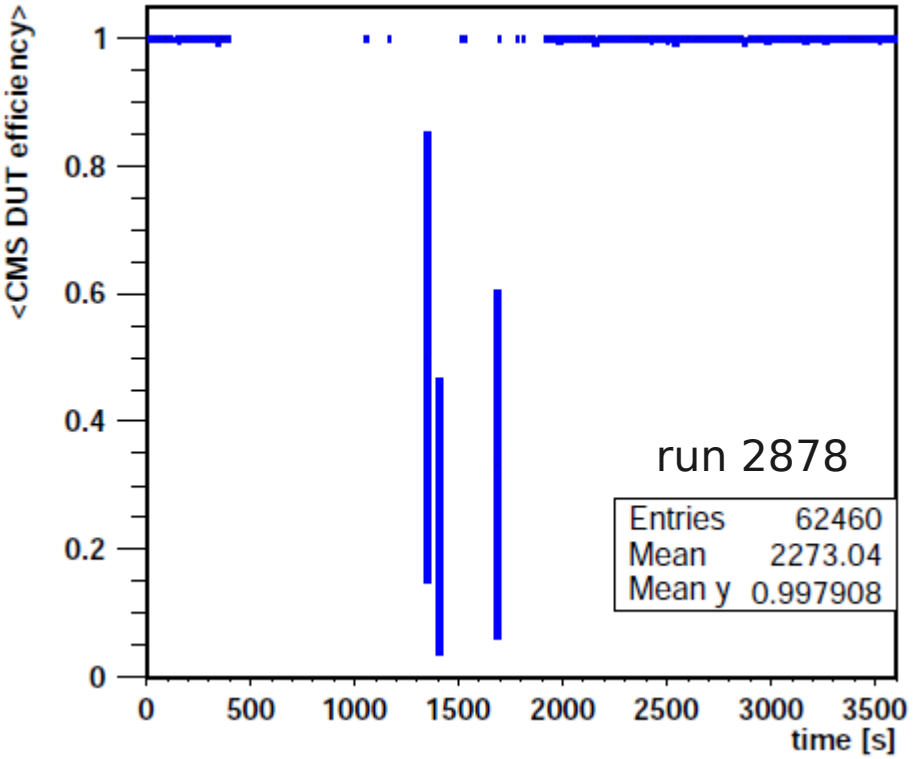
code: `desy-cms010:/data/group/pixel/software` **HP, LC**

data: `desy-cms010:/data/group/pixel/testbeam`

prompt offline feedback

- process EUTel runs on `desy-cms010` as soon as possible
  - convert, cluster, hits, align, fit
  - check histograms (macros available)
  - iterate TestFitter for CMS DUT and REF alignment
  - evaluate run quality: efficiency vs time stable?





documentation

- online logbook: Google spreadsheet
  - shift list
  - record date, time, run numbers
  - record settings (bias, delay, trigger, beam energy, tilt, threshold)
  - record interruptions and adjustments, access to beam area
- make fotos
- prompt analysis:
  - EUDAQ online monitoring: check correlations
  - b2h for CMS data: check hit maps, pulse height
  - EUTelescope full reconstruction: ROOT macros available

proposed programme

- 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

chip 10 DACs

1	Vdig	6
2	Vana	126
3	Vsf	170
4	Vcomp	10
5	Vleak_comp	0
6	VrgPr	0
7	VwllPr	35
8	VrgSh	0
9	VwllSh	35
10	VhldDel	150
11	Vtrim	113
12	VthrComp	97
253	CtrlReg	0
254	WBC	98

13	VIBias_Bus	30
14	Vbias_sf	10
15	VoffsetOp	27
16	VIbiasOp	115
17	VOffsetR0	120
18	VIon	130
19	VIbias_PH	130
20	Ibias_DAC	101
21	VIbias_roc	190
22	VIColOr	99
23	Vnpix	0
24	VSumCol	0
25	Vcal	200
26	CalDel	124
27	RangeTemp	0

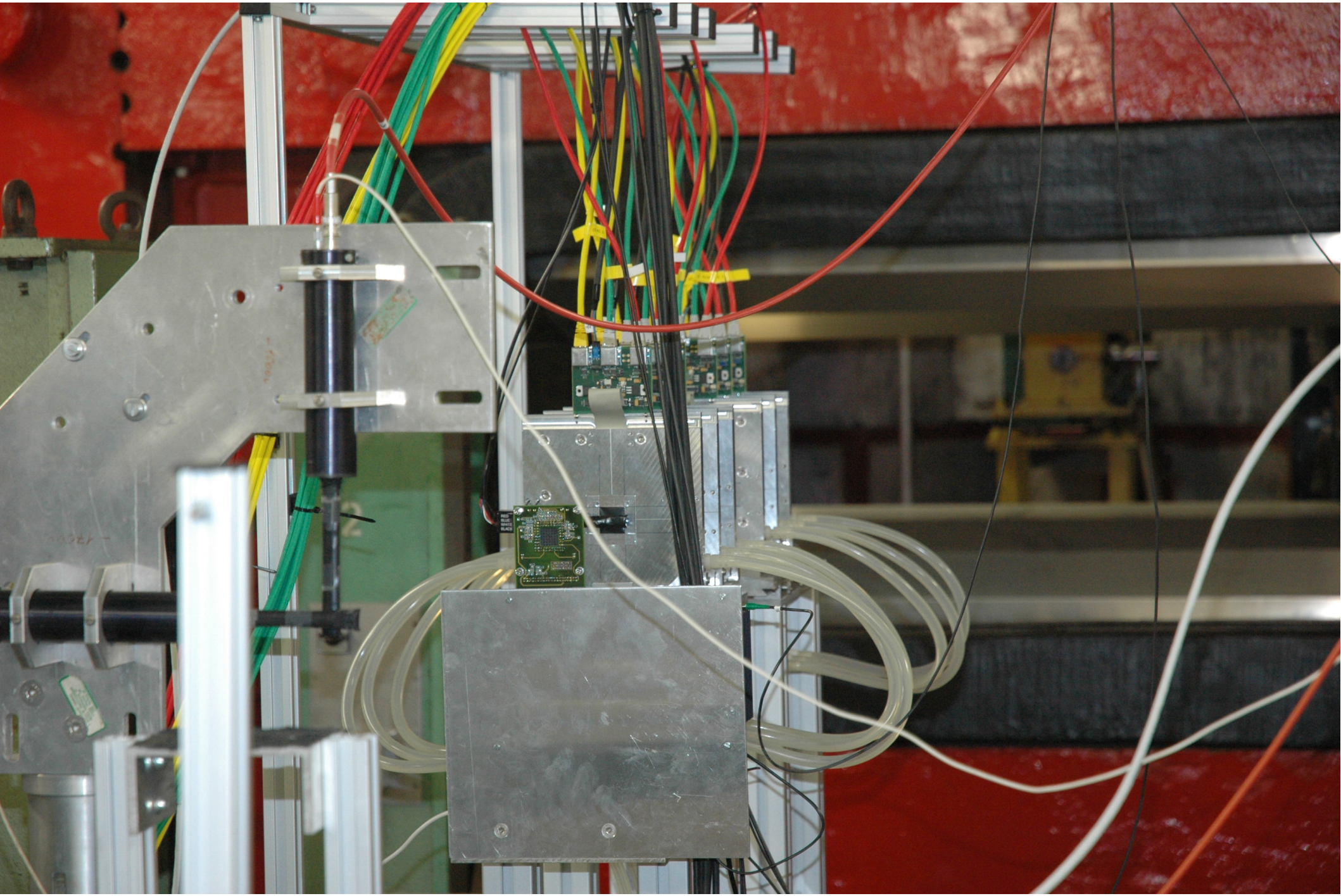
DAC settings and trim values for several VthrComp and a few Vana prepared by Alexey

Summary

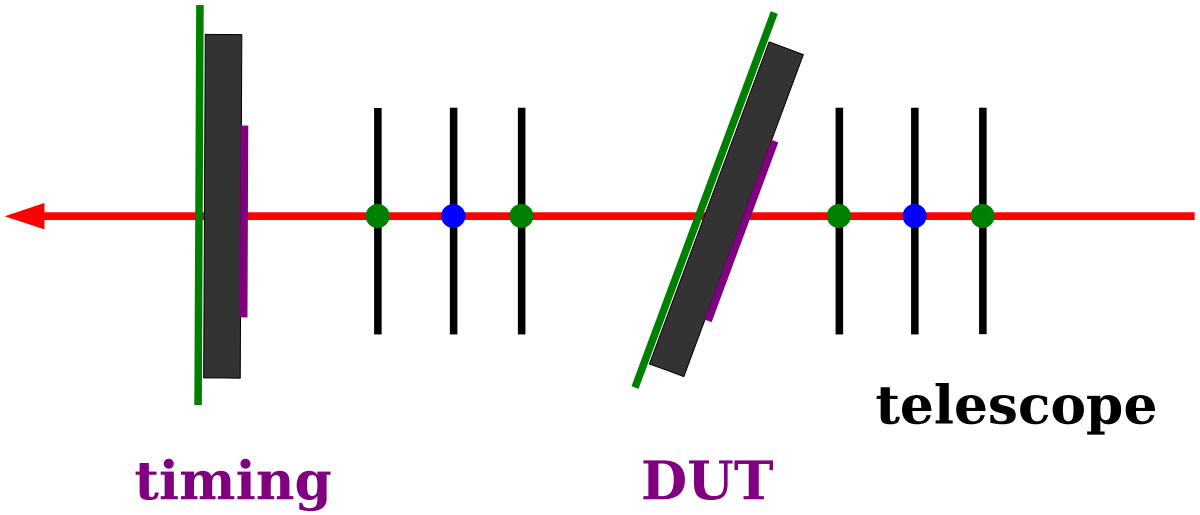
- Preparations for the April 2012 pixel beam test are well advanced:
  - hardware ready
  - offline software ready
  - measurement program defined
  - prepared DAC parameters for lower Vana and VthrComp scan
  - prepared chip 13 as backup
  - shifts assigned, may need to fill 3rd week
- to do:
  - finish `psi46expert` installation on `h1antigua`
  - get `EUTelescope` software running on `desy-cms010`
  - set up at TB21
  - triax adapter for Keithley bias voltage supply
  - temperature monitor with USB readout

Acknowledgements

- Ingrid Gregor, Artem Kravchenko, Igor Rubinskiy (all DESY ATLAS):
  - building the next telescope for TB21
- Adam Zuber, Holger Maser (DESY CMS):
  - improved the support frames for the test boards
- Torsten Külper (FH electronics lab):
  - made the trigger and clock adapters for the test board
- Beat Meier (PSI):
  - new test board firmware with external trigger input
- Ulrich Hurdelbrink (machine group):
  - developed the clock generation setup
- Claus Kleinwort (DESY CMS):
  - General Broken Lines code, advice on alignment

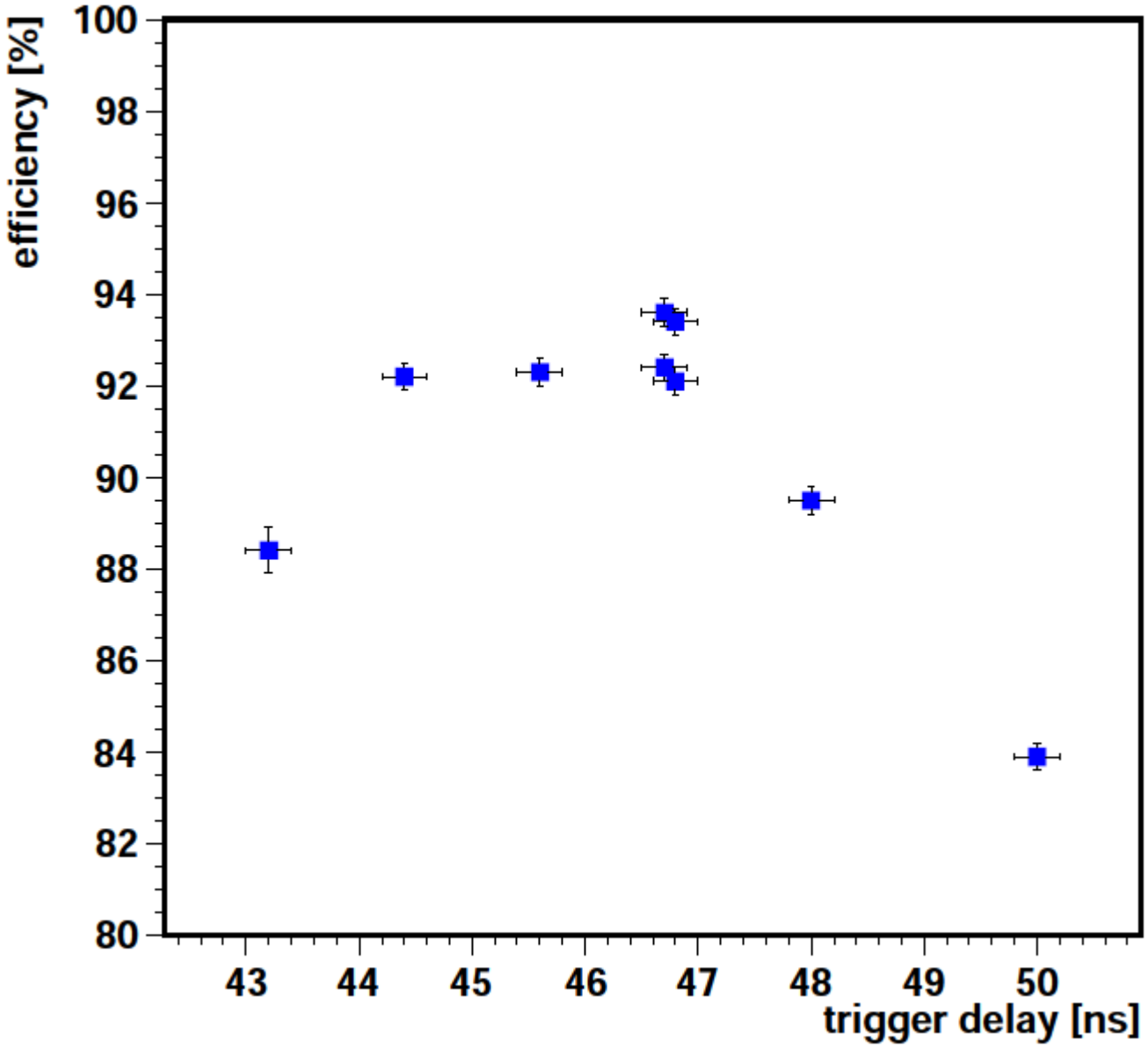


efficiency measurement



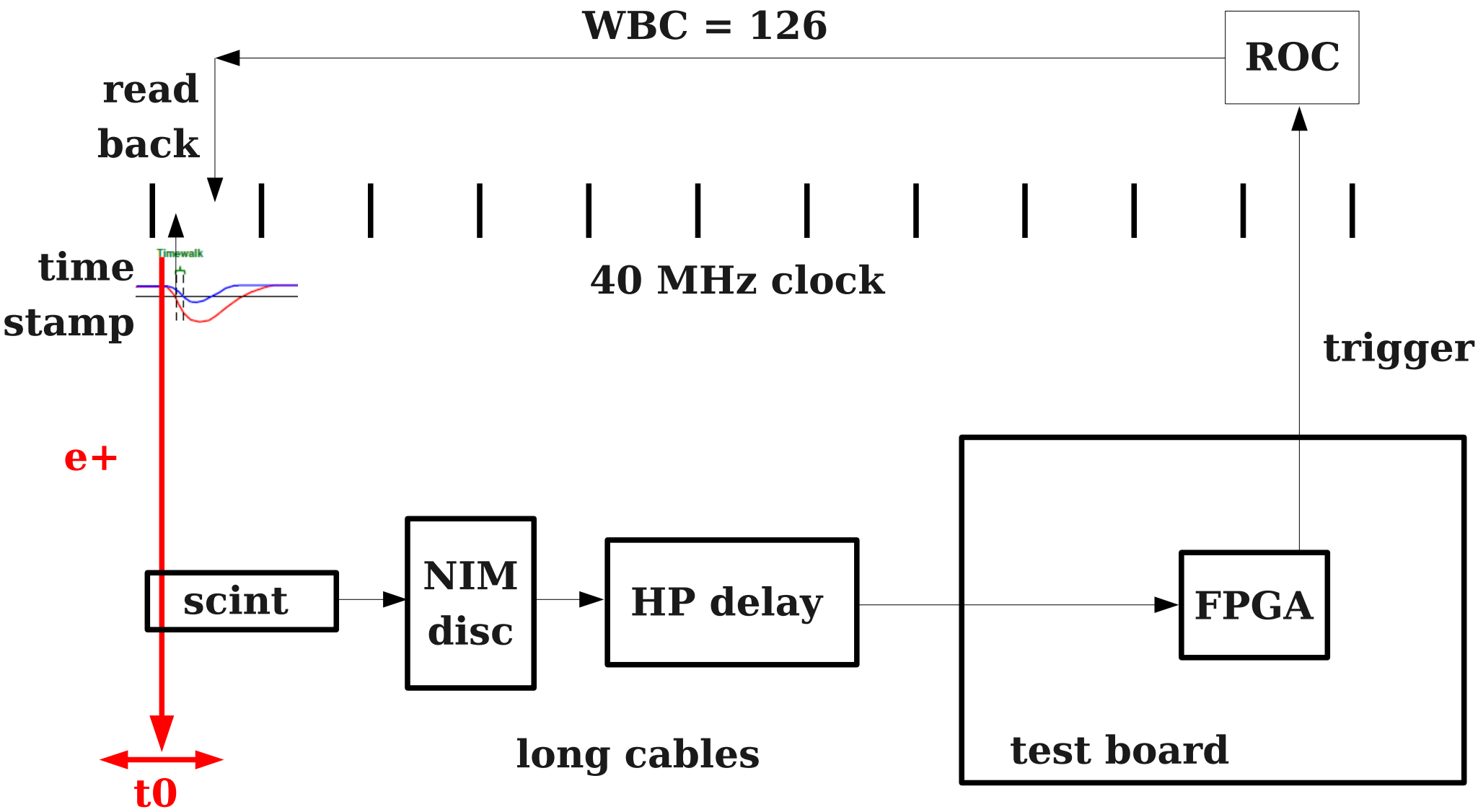
- Trigger and DAQ for 2 test boards and telescope established
- Software to be written:
  - link telescope track to hit in timing plane.
  - need General Broken Line fit, taking material into account,
  - with interface to MillePede II for common alignment.
- efficiency = DUT / (Telescope track && timing hit)
  - as function of position, angle, bias voltage, threshold, timing, ...

Efficiency vs timing delay



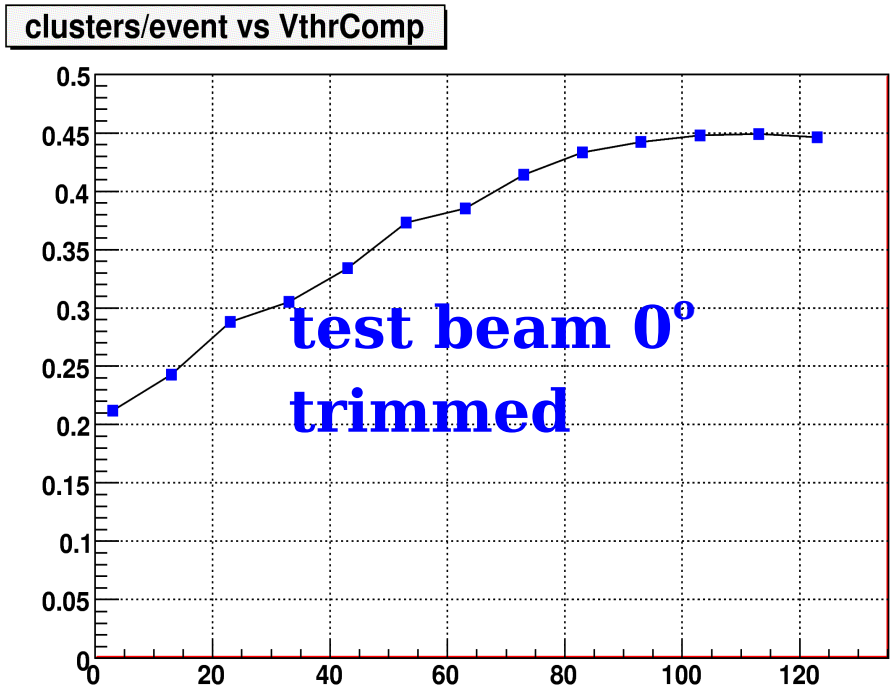
- old Runs 158 – 179
- efficiency plateau:
  - only ~3 ns wide
  - only 92 - 93%
- now much better: 99.7%
- scan clock delay (relative to beam)
  - 0..24 ns, step 4 ns, finer steps at edges of plateau

WBC timing needs scanning

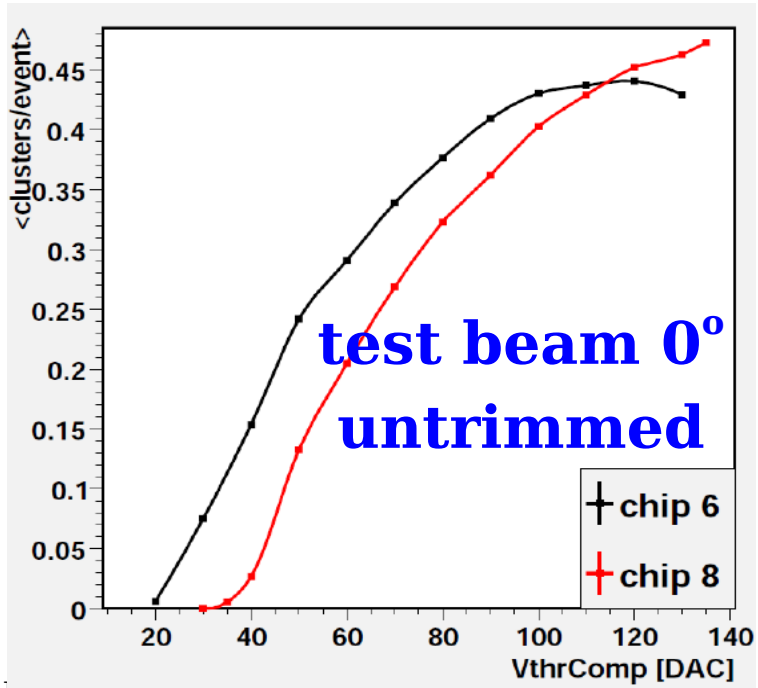


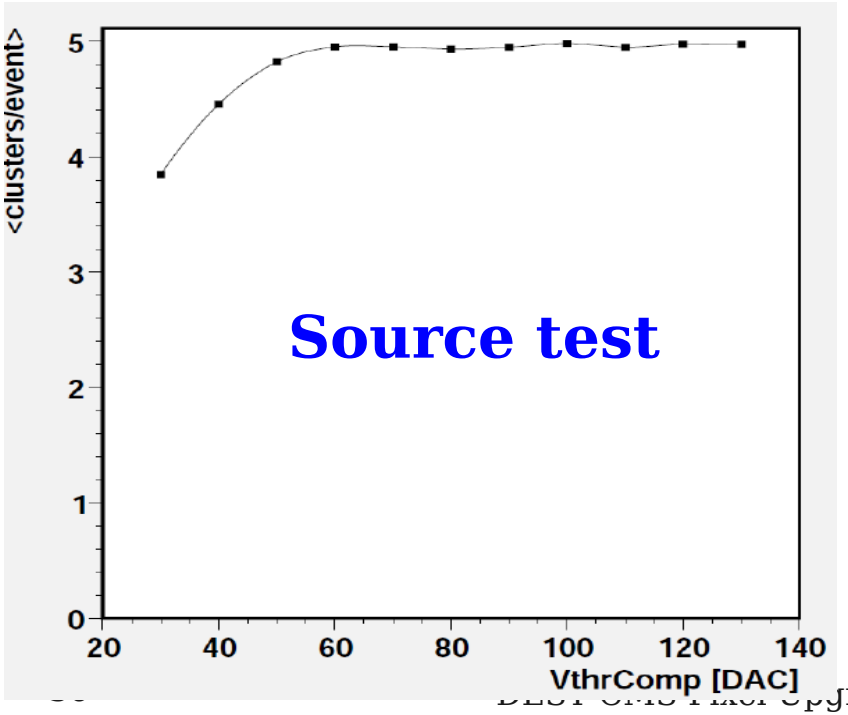
beam not synchronized to clock

Threshold Scan Results

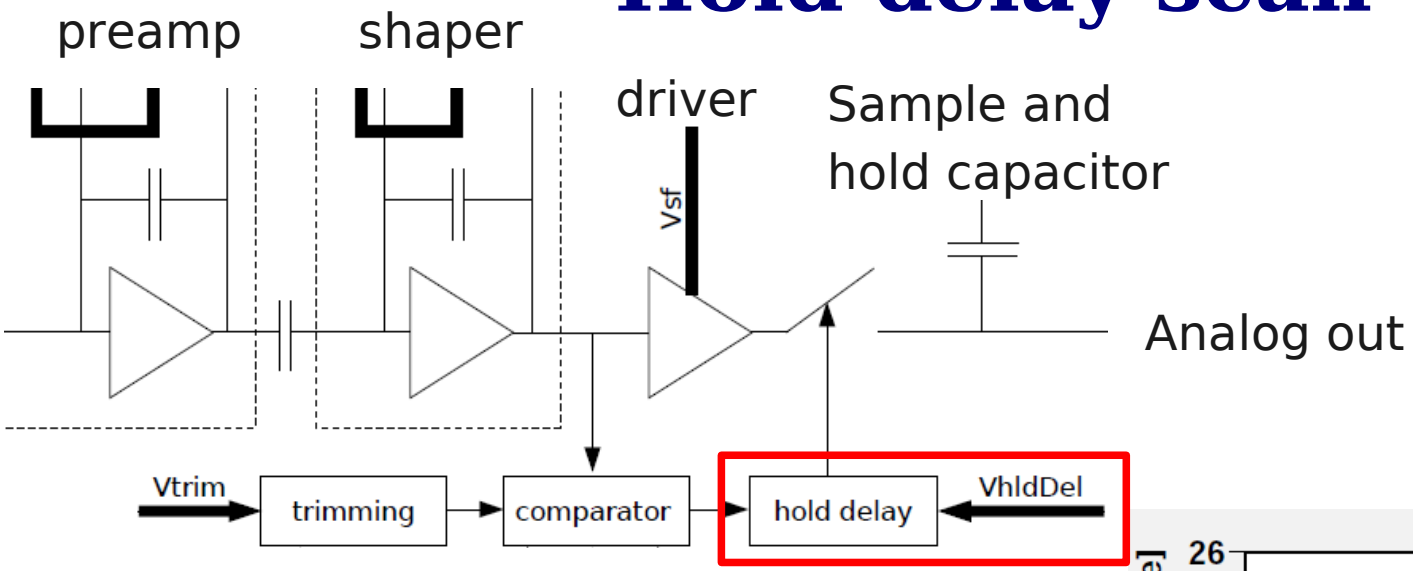


- Uniforming of pixel thresholds (trimming) makes an efficiency plateau visible
- More close to source test results now ?

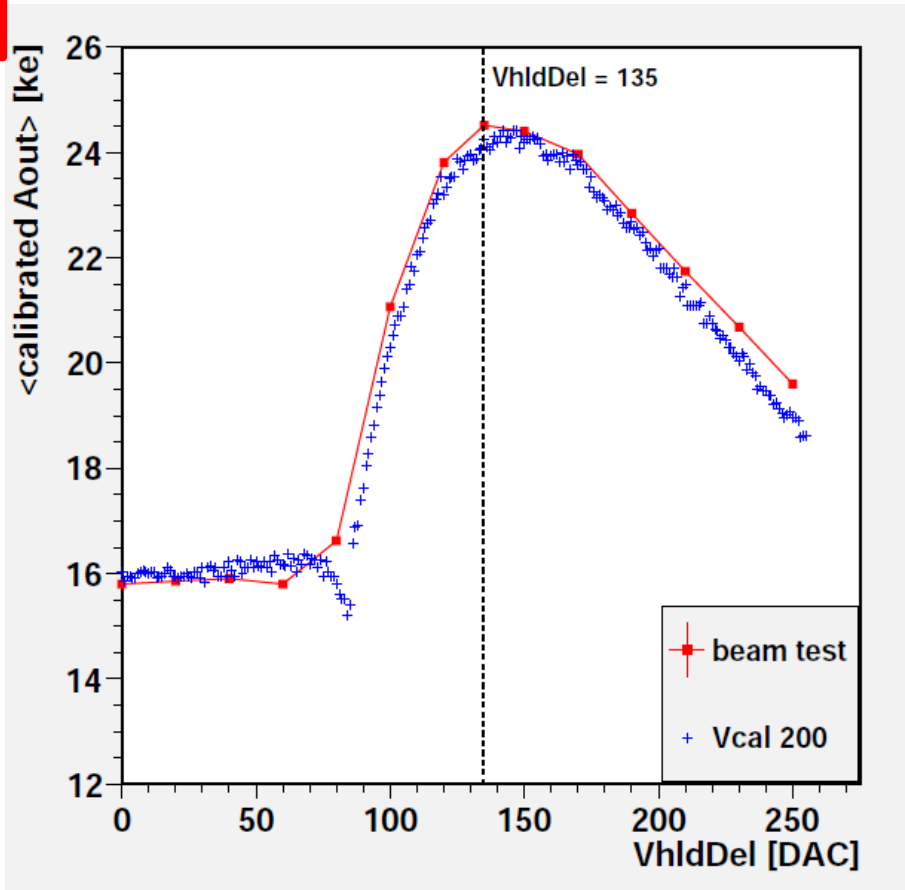




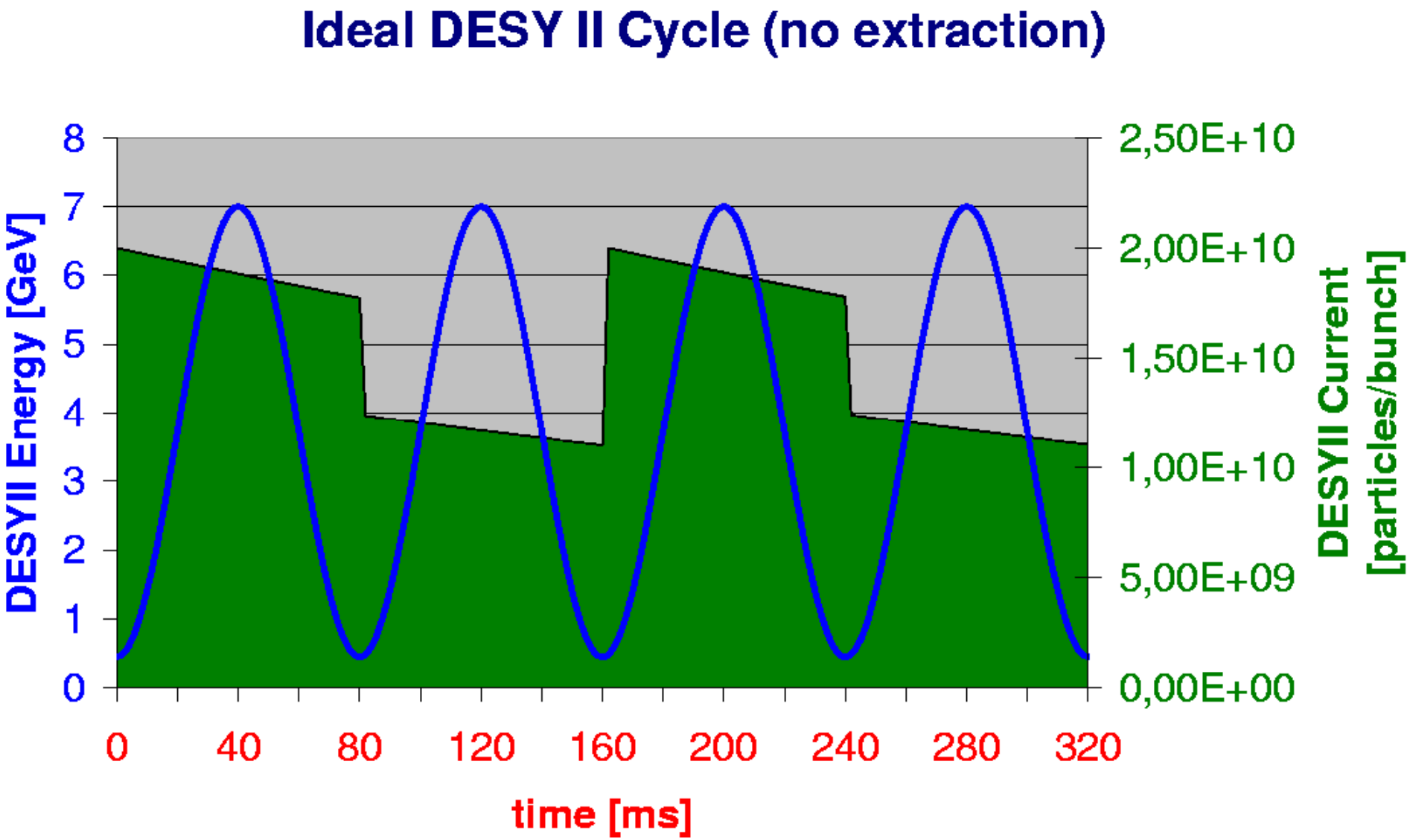
Hold delay scan

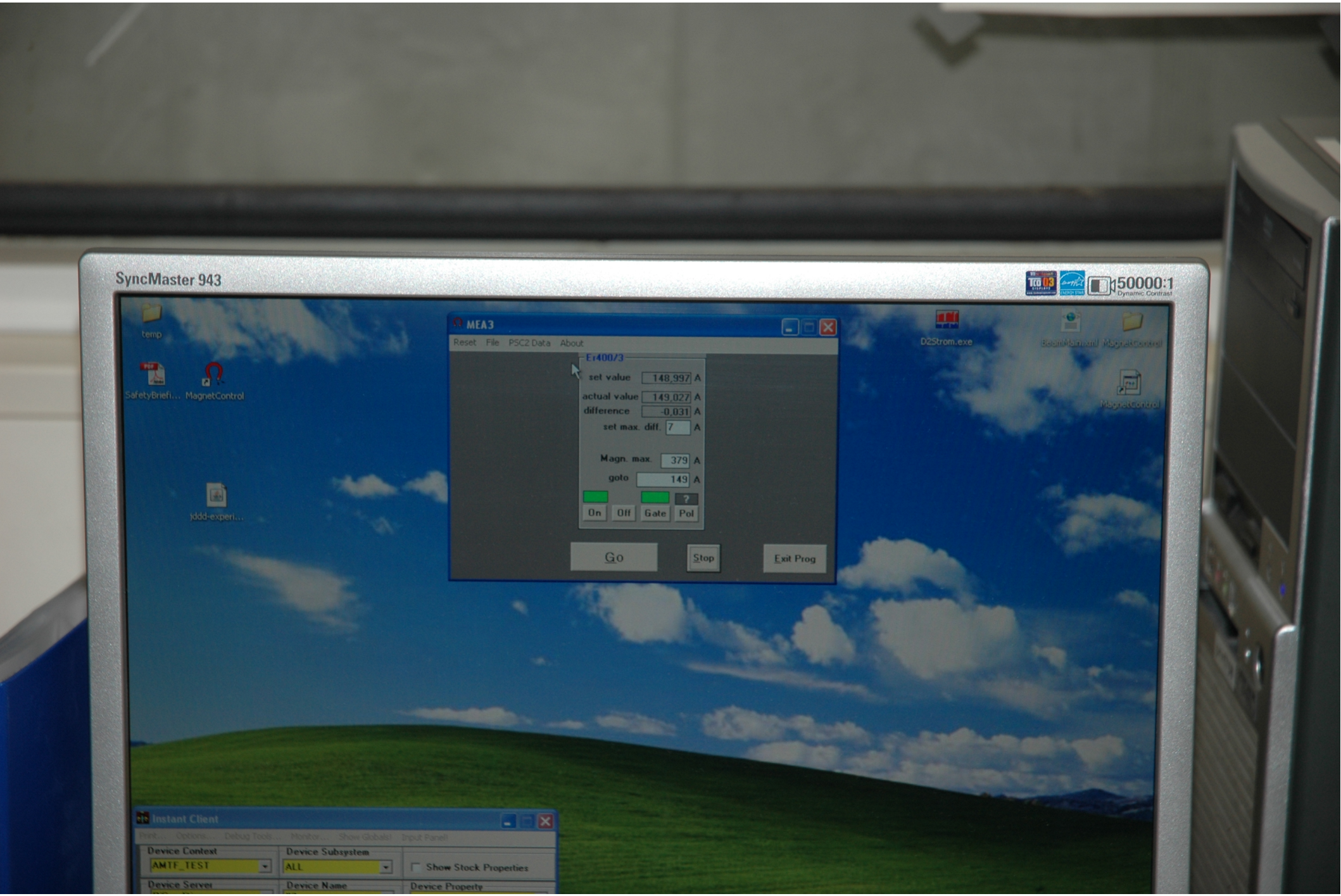


- VhldDel parameter was previously scanned with calibrate pulses generated by ROC
- Test beam results show very good conformity with Vcal scans
- VhldDel = 135 optimal for sampling maximal pulses



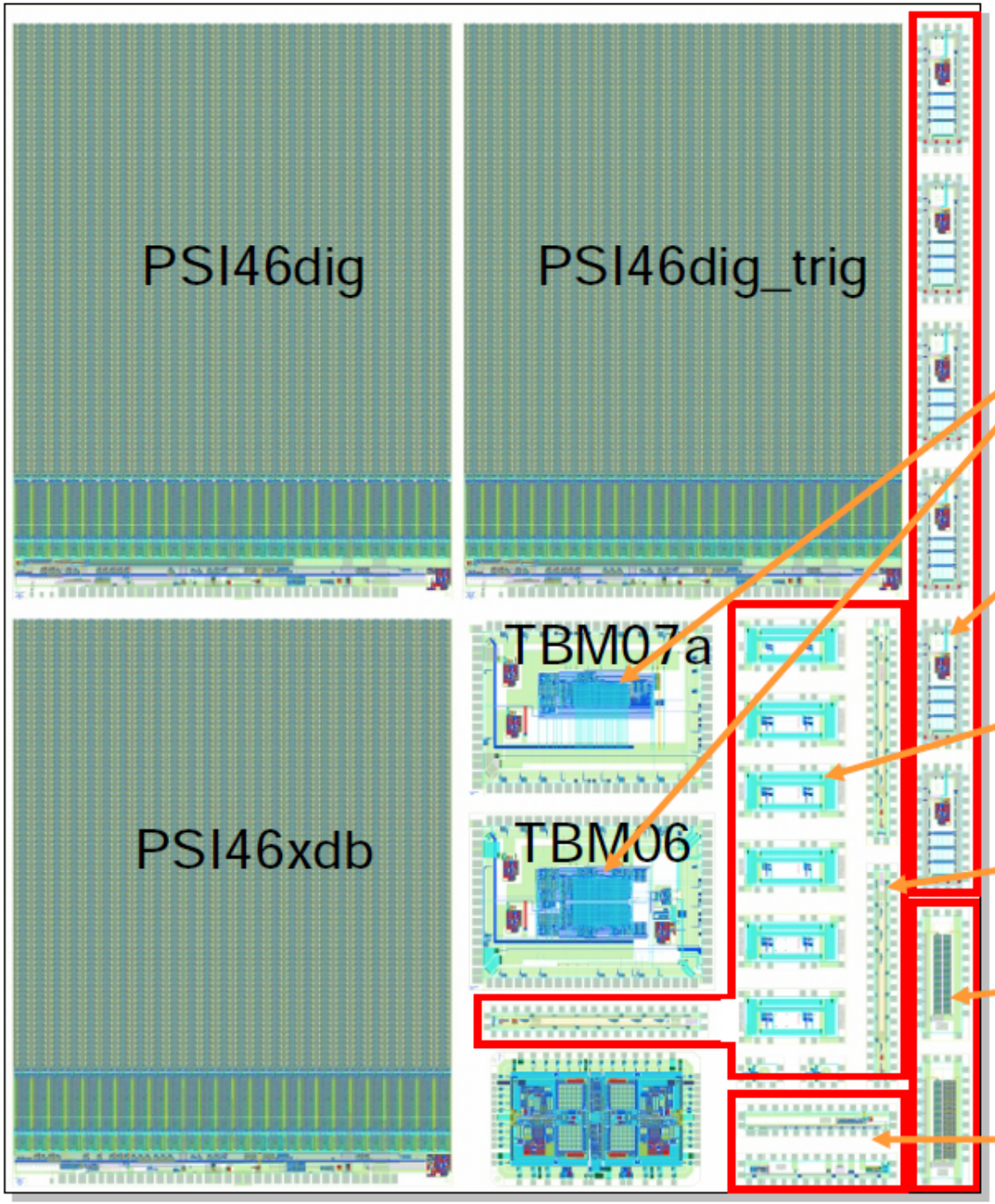
DESY II energy cycle




SyncMaster 943
50000:1
Dynamic Contrast
temp
SafetyBriefi...
MagnetControl
jddd-experi...
D2Strom.exe
MEA3
Reset File PSC2 Data About
Er400/3
set value 148,997 A
actual value 149,027 A
difference -0,031 A
set max. diff. 7 A
Magn. max. 379 A
goto 149 A
On Off Gate Pol
Go
Stop
Exit Prog
Instant Client
Device Context
AMTF_TEST
Device Subsystem
ALL
Show Stock Properties
Device Server
Device Name
Device Property


Gebiet bereit
1 DWL 2
Ein/Aus
Interlock 2 Hauptgebiet
DESY MEA
Erstfehler
Türen
Schlüsselkasten OK
Not-Aus OK
Gebiet OK
Σ BS ZU
LP
Schlüsselkasten
DESY MEA
Schlüssel vorhanden
1. System
2. System
verriegelt
verriegelt
Verriegelung
LP
Interlock 2 Teststrahl 21
DESY MEA
Erstfehler-speicher
HG
HG ok
HBS
HBS zu
LP
BEAM 21
STRAHL 21
Experimente Interlock
DESY MEA
Beam Shutter
auf
läuft auf
läuft zu
zu
Linac Freigabe
H-BS Netz
Interlock 2 gebrückt
DWL
Interlock 2 ok
Ansage
Baby Line
Interlock
Ein/Aus
LP

ROC submission 2012a



Size: 17.4 mm x 21.2 mm

60 recticles/wafer, 6 wafers

3 new ROC versions (PSI)

2 new TBM versions
Ed Bartz, Rudgers

LCDS cable drivers with bug fixed in read back (PSI)

Digital Level Translator DTL to replace the ALT chip (PSI)
Christoph Nägeli

LCDS/LVDS converter for test setups (PSI)

SEU resistent register test structures (PSI)

ADC, PLL and oscillator test structures (PSI)

Beat Meier (PSI): Pixel Upgrade plenary at CERN, 1.2.2012

ROC submission 2012a

- **PSI46xdb**: Enlarged data buffers, reduced crosstalk and better level distribution; - 3 DACs
- **PSI46dig_trig**: Digital readout added; - 4 DACs
- **PSI46dig**: Trigger mechanism removed; read back; - 7 DACs
- 2 **TBM** versions
- **DLT** Digital Level Translator for POH, replacing the ALT
- LCDS/LVDS level translator for test boards (LCDS not a standard)
- Other test structures (ADC, PLL)
- Tape out: January 2012 to IBM
- 6 wafers in April 2012, tested at PSI, problem with start-up mechanism

Beat Meier (PSI): Pixel Upgrade plenary at CERN, 1.2.2012

`https://indico.cern.ch/conferenceDisplay.py?confId=172930`

More news by Hans-Christian Kästli: Mon and Wed next week

ROC submission 2012a

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

Beat Meier (PSI): Pixel Upgrade plenary at CERN, 1.2.2012

ROC submission 2012a

DAC:

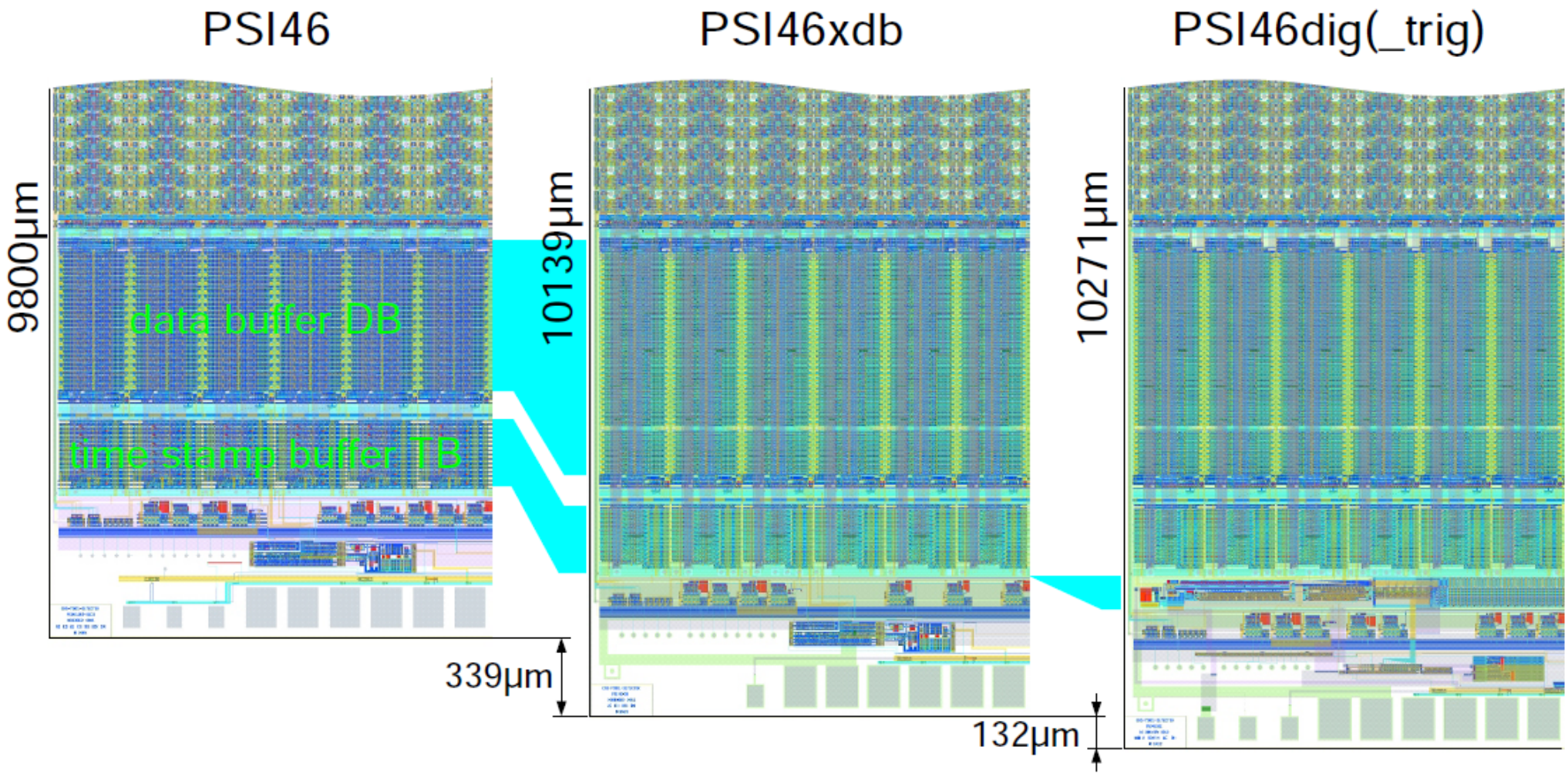
- 3 DACs removed: VRGPR, VRGSH and Vleakage
- All DAC's with power on reset for low power ROC configuration
- Current control instead of voltage control for S&H and analog power supply → easier and independent setup

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

ROC submission 2012a



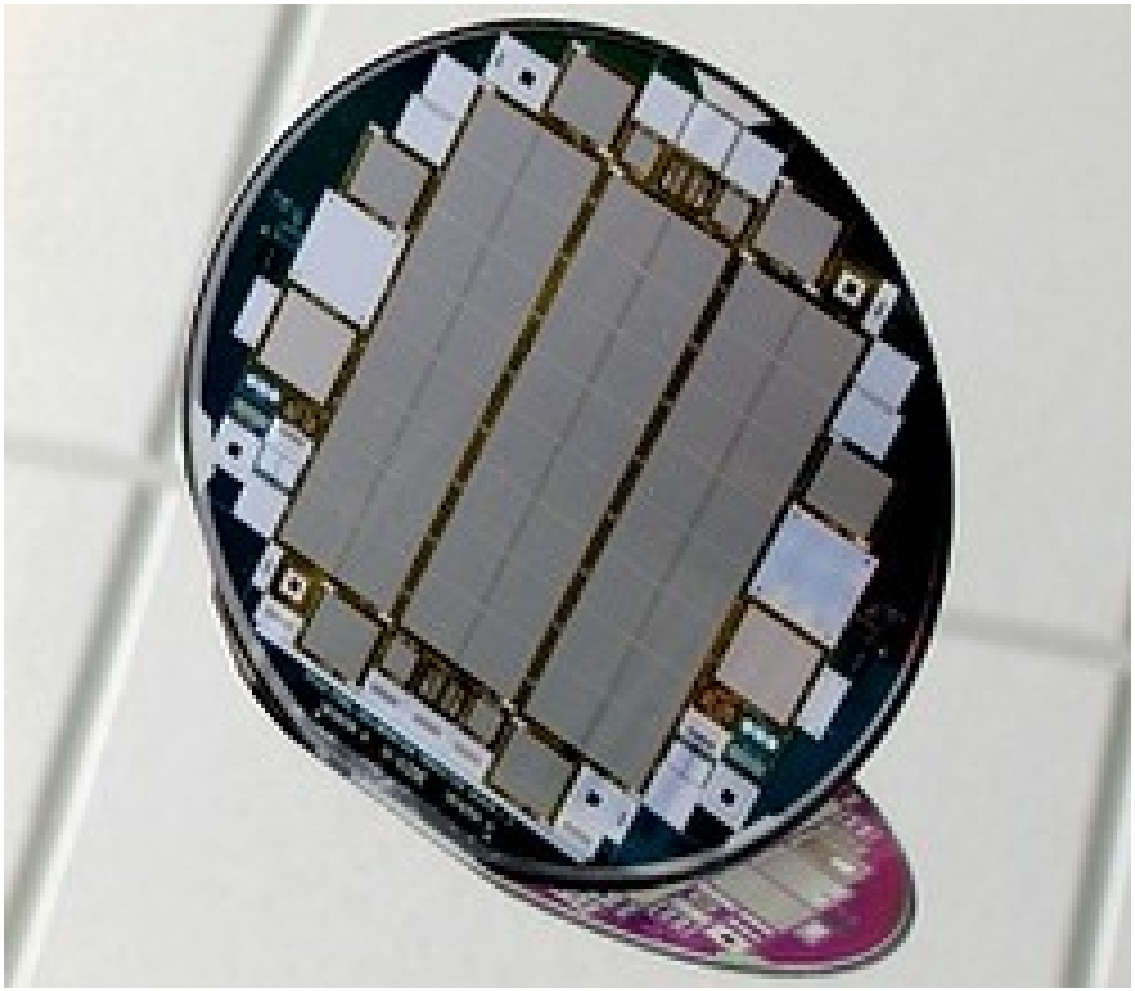
- DB 32
- TB 16

- DB 80
- TB 25

- DB 80
- TB 32

RB 64
8-bit ADC

CMS Pixel Sensors



design: Tilman Rohe, PSI

- 60 wafers under production at CIS (Erfurt)
  - standard CMS pixel sensor design (double sided, n-in-n, p-spray insulation).
  - for Karlsruhe, INFN, CERN/Taiwan, MRI, Purdue, DESY.
  - 5 wafers with increased bump pad passivation opening: 30 µm, for DESY.
  - Delivery in Mar 2012.
- Full sensors for first bump bondings.
- Single chip sensors for tests with new ROCs.