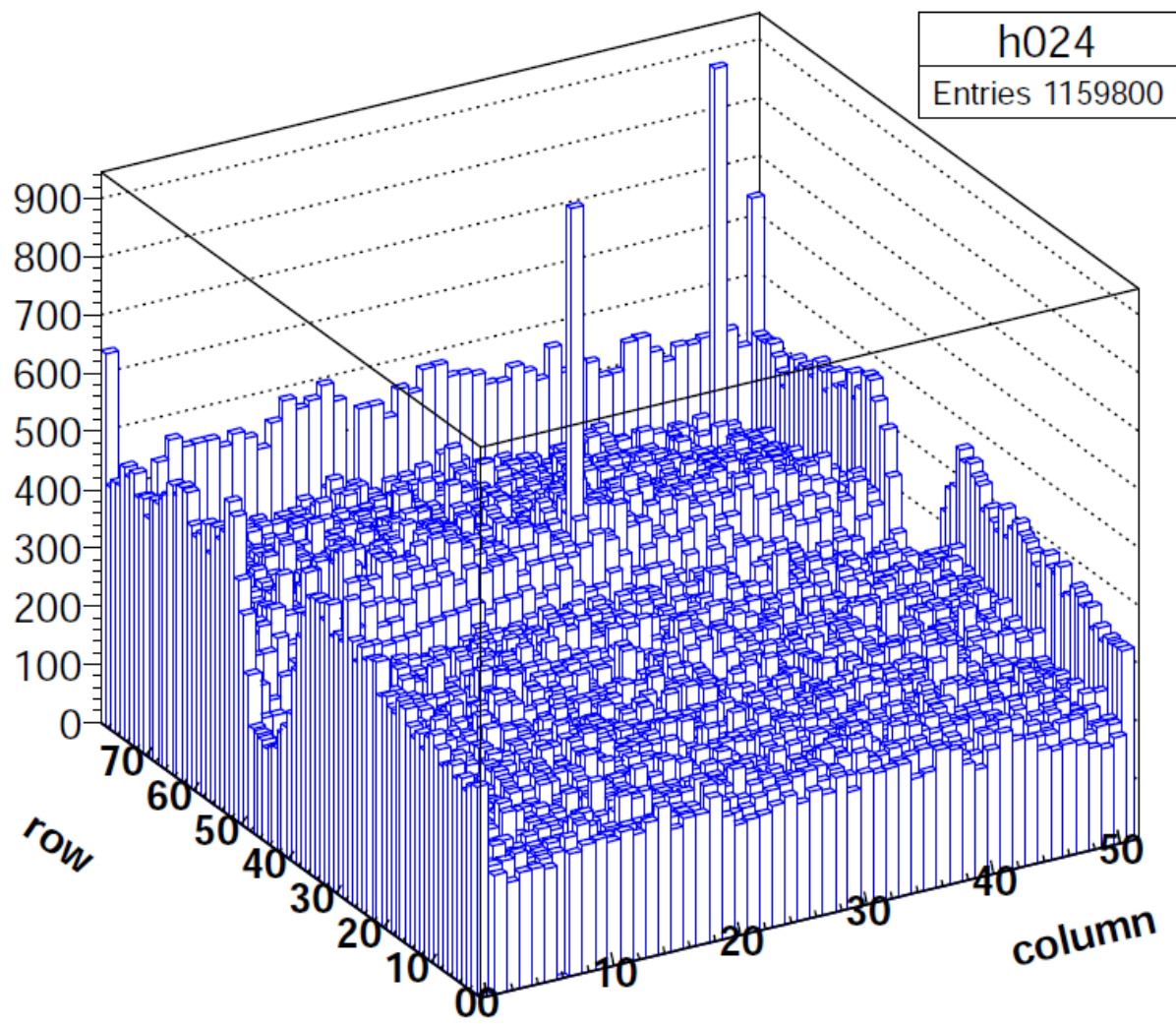


Source test setup for pixel single chip detectors

Daniel Pitzl, DESY

Aleksander Gajos, Cracow

DESY CMS tracker upgrade meeting, 9.8.2011



- Ru source
- PSI46 test board
- trigger modes
- takeData
- first results
- next steps

Setup in 1d EG 408

Keithley 617
-90 V sensor bias

HP Pulse Generator
NIM → TTL trigger

Linux PC
takeData

Ru 106
source

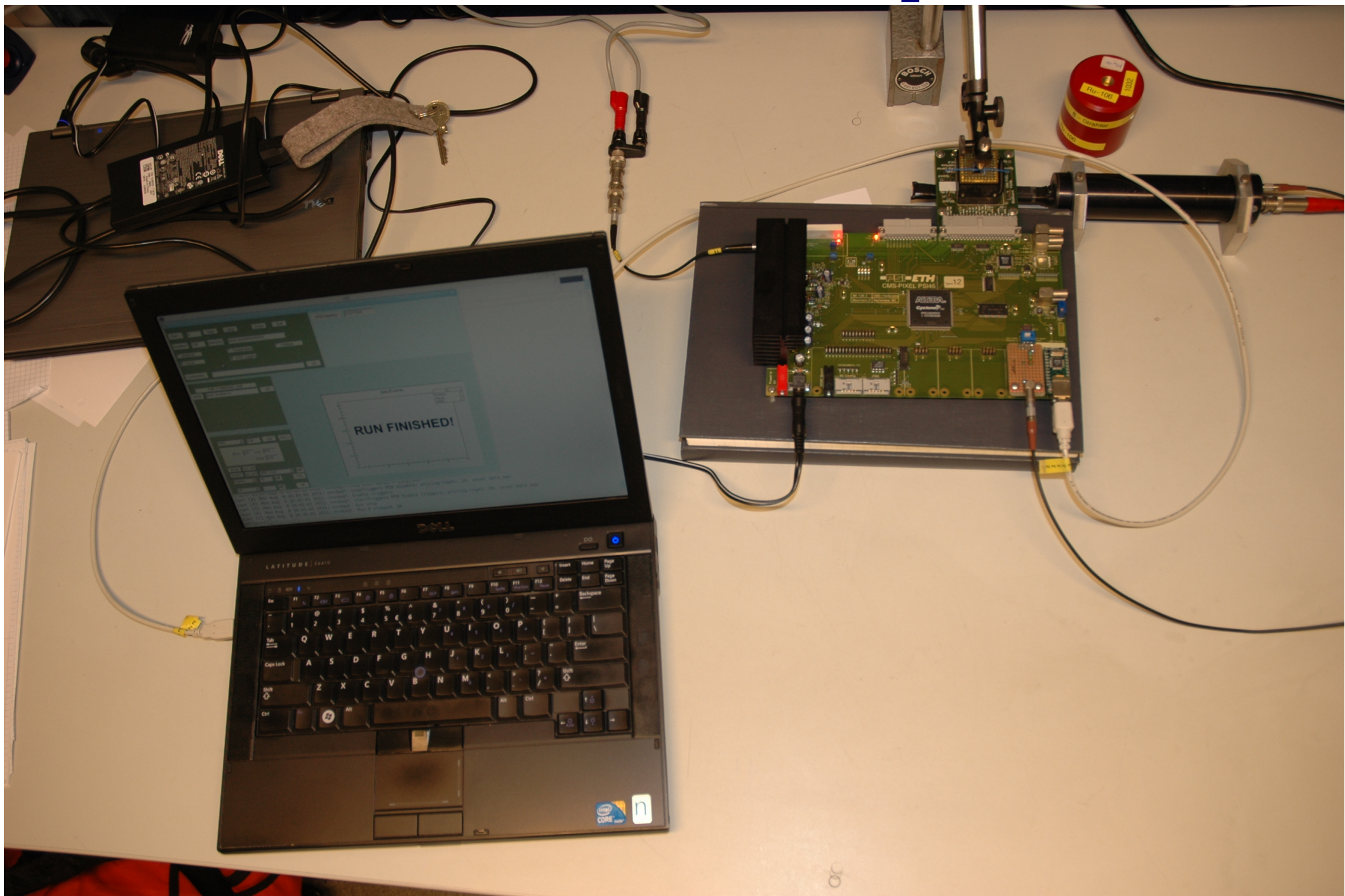
scintillator
+ PM

PM HV
-1600 V

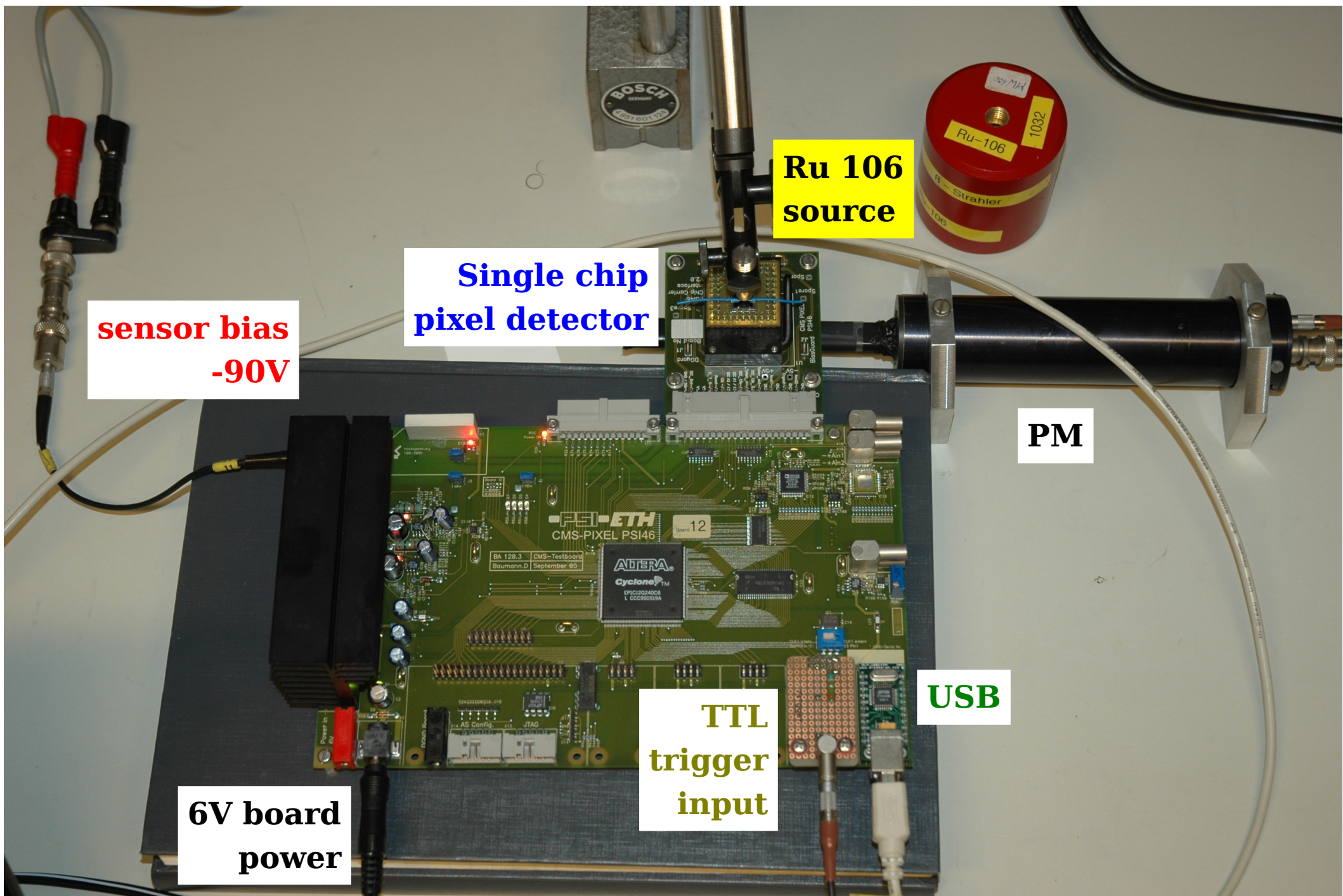
PM
discriminator
→ trigger

PSI46
test board

Source test setup



Source test setup



**Ru 106
source**

**Single chip
pixel detector**

**sensor bias
-90V**

PM

USB

**TTL
trigger
input**

**6V board
power**

Source and detector

- $\text{Ru}^{106} \rightarrow \text{Rh}^{106} \rightarrow \text{Pd}^{106}$:
 - pure beta emitter,
 - $E_{\text{max}} 3.54 \text{ MeV}$,
 - half life 1.02 y,
 - DESY Ru source #1032 has $\sim 15 \text{ kHz}$ activity today (scintillator).
- PSI46 ROC (v 2.4) from 2005 (chip 6)
 - bump bonded at PSI to a baby pixel sensor.

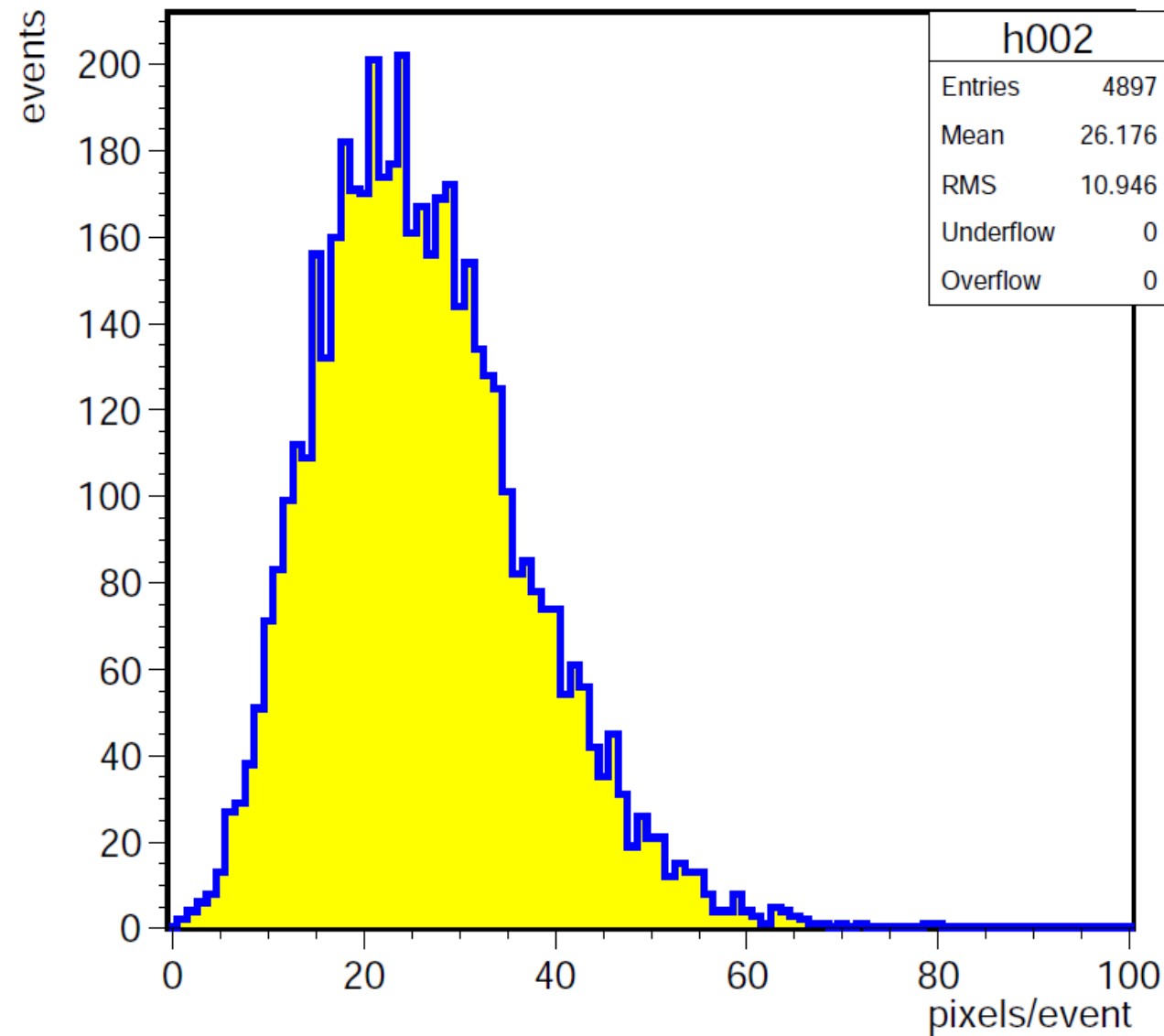
PSI46 test board trigger modes

- External trigger:
 - used in CMS
 - needed for test beam
 - source test with penetrating beta rays
- Internal trigger:
 - generated on the test board
 - needed for X-ray source test
 - allows stretching of the clock by up to $2^{16} \times 25 \text{ ns} = 1.64 \text{ ms}$ for increased efficiency
 - reached up to 89% duty cycle: 890 Hz with 1 ms clock stretch.
- Timing:
 - board trigger delay tct = 103 BC after stretched clock cycle.
 - ROC bunch crossing pointer WBC = 100.

Software

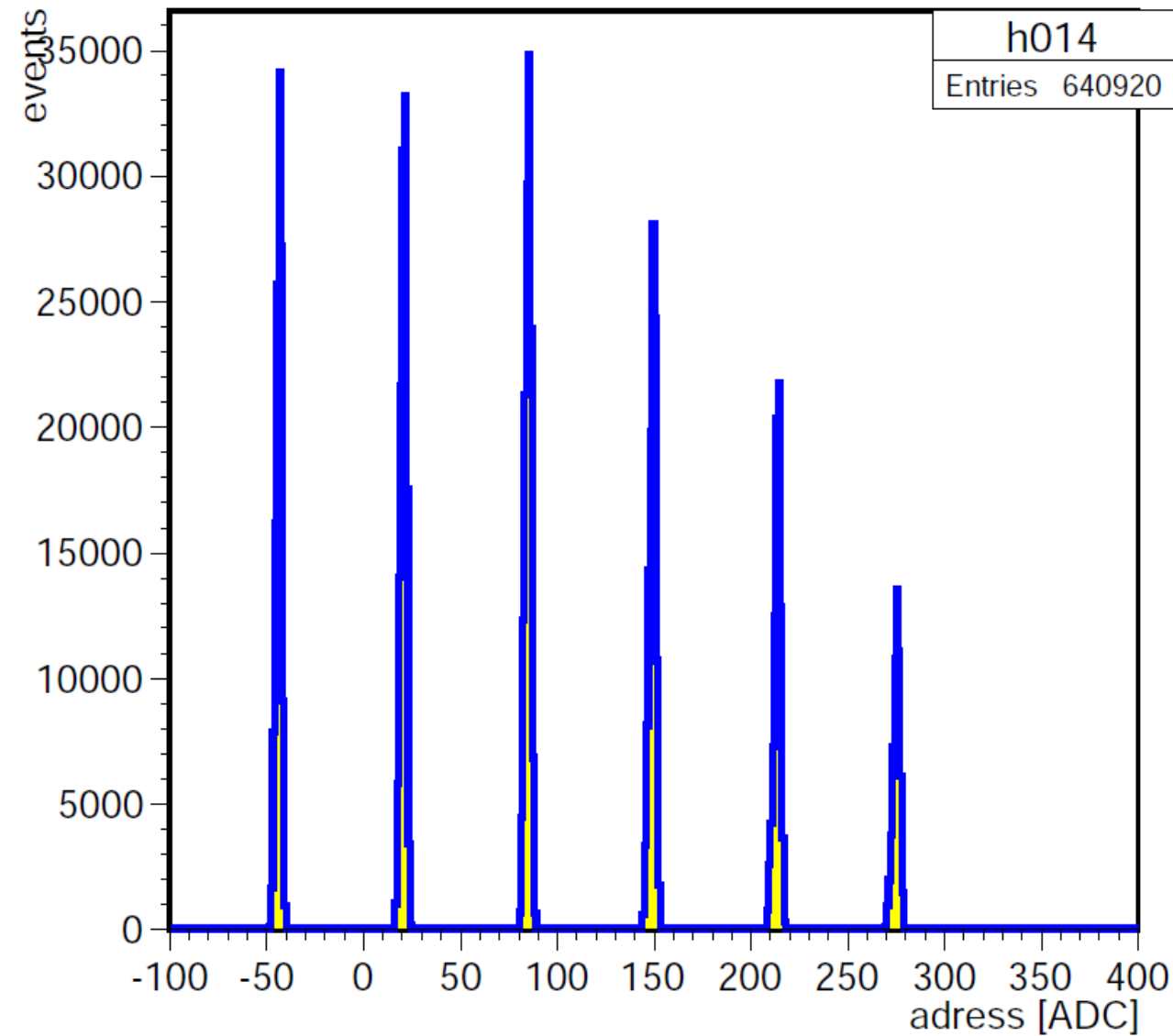
- PSI test board with Aug 2010 FPGA firmware (v 6.1)
- Single ROC (no TBM emulator)
 - settings for the 28 ROC DACs determined by A. Petrukhin.
- takeData code from PSI under 64 bit Linux:
 - Run for up to 300 seconds (memory limit).
 - FPGA generates reset – clock stretch – trigger – token sequence at up to 1 kHz.
 - Raw data from ROC are stored in 64 MB memory.
 - transfer memory via USB (0.44 MB/s), store as binary file.
- Process binary file:
 - decode raw data: header, pixel address, pulse height.
 - (cluster finding code to be written...).
 - fill ROOT histograms.

Multiplicity



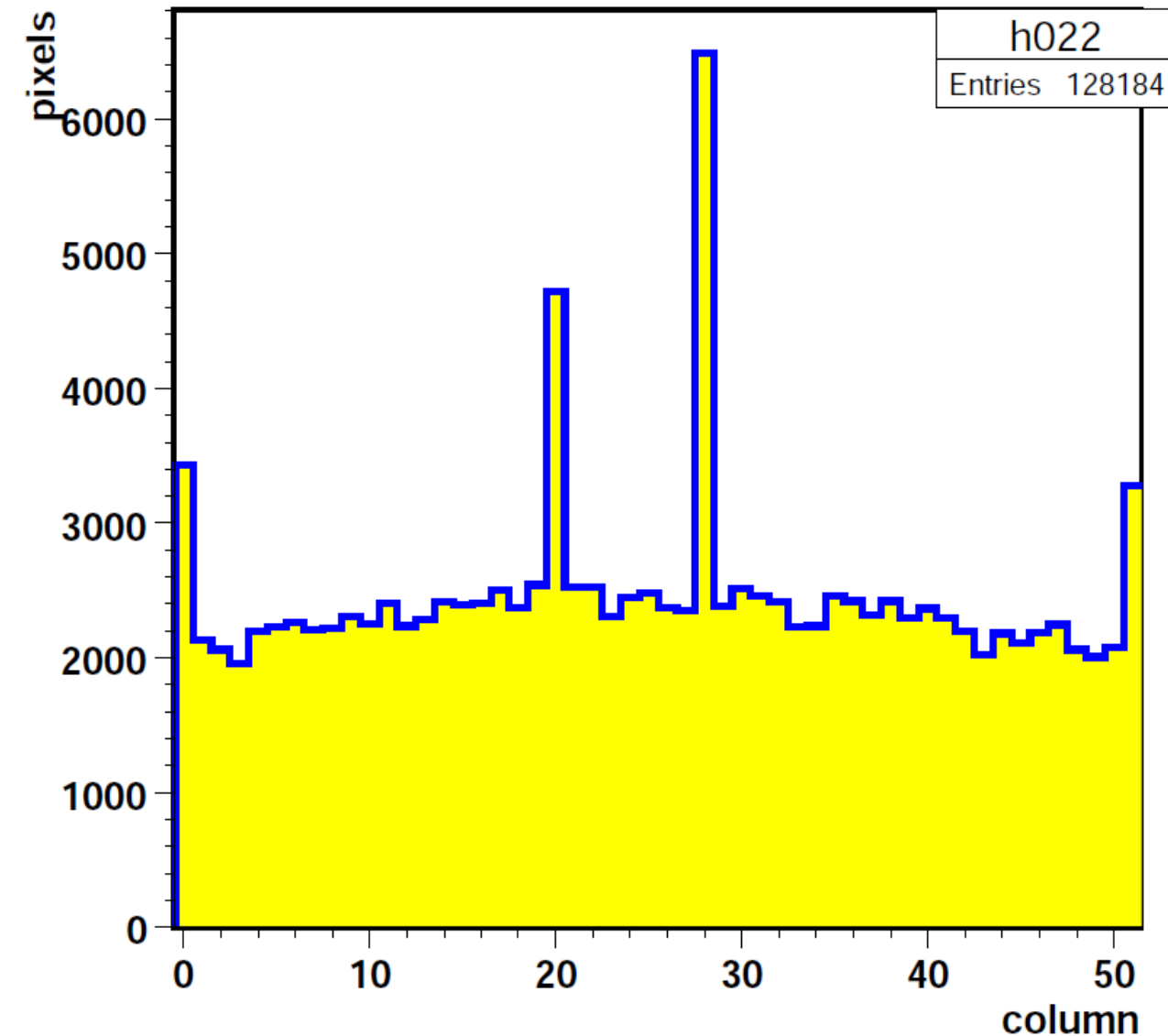
- Ru source (15 kHz), 10s.
- 1.64 ms clock stretch:
 - expect up to 25 hits/event.
 - Caveat: pixel threshold (~ 3000 e) higher than scintillator threshold.

Pixel address



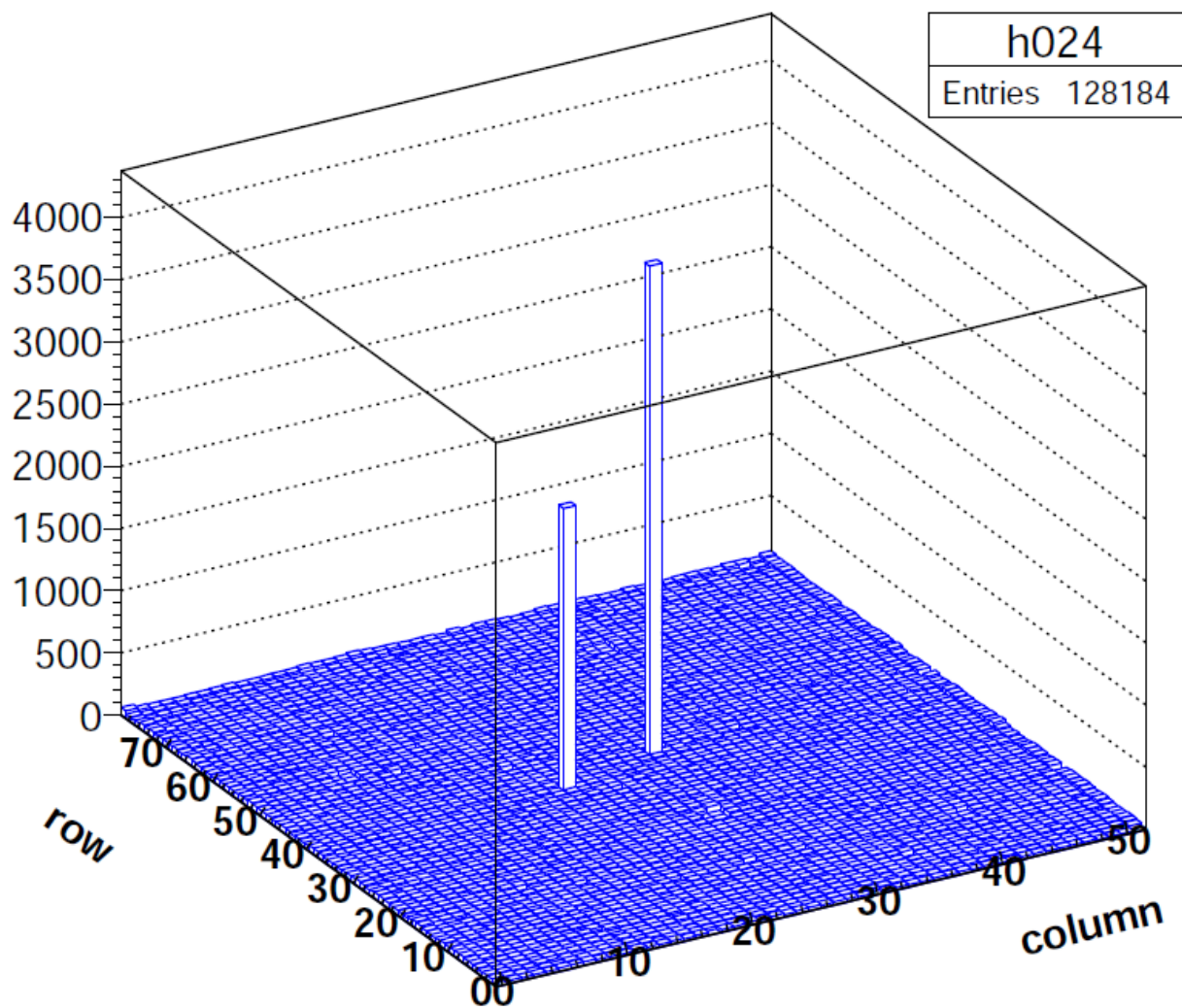
- Pixel column and row address transferred in 6-level code:
 - clean separation!
- Address decoding:
 - $6 C_1 + C_0 \rightarrow$ double column
 - $36 A_2 + 6 A_1 + A_0 \rightarrow$ row address.

Column map



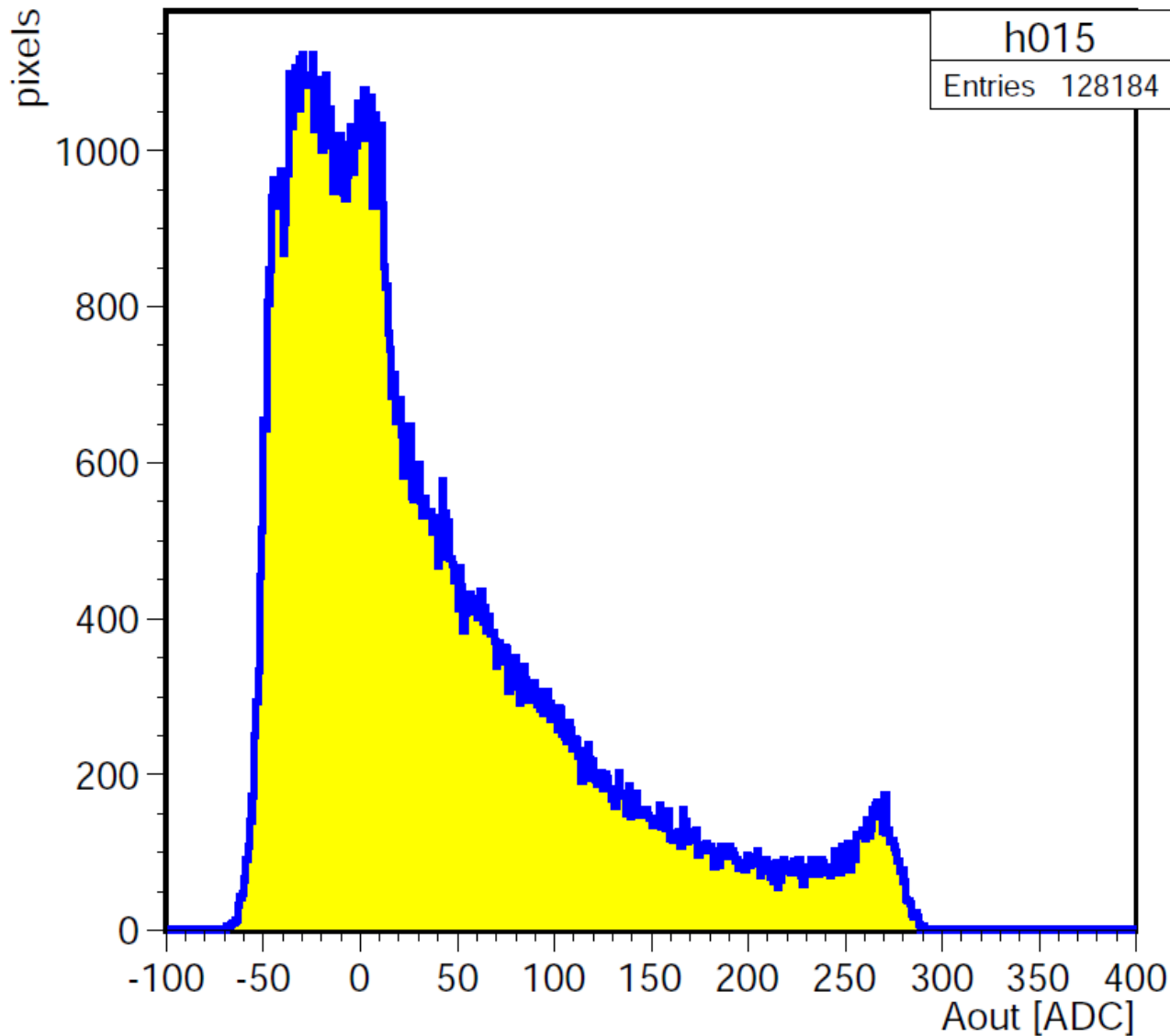
- Ru source, 10s.
- Chip 6.
- Column map (z):
 - quite uniform illumination.
 - 2 noisy pixels.
 - first and last columns have double length pixels (300 instead 150 μm).

hit map



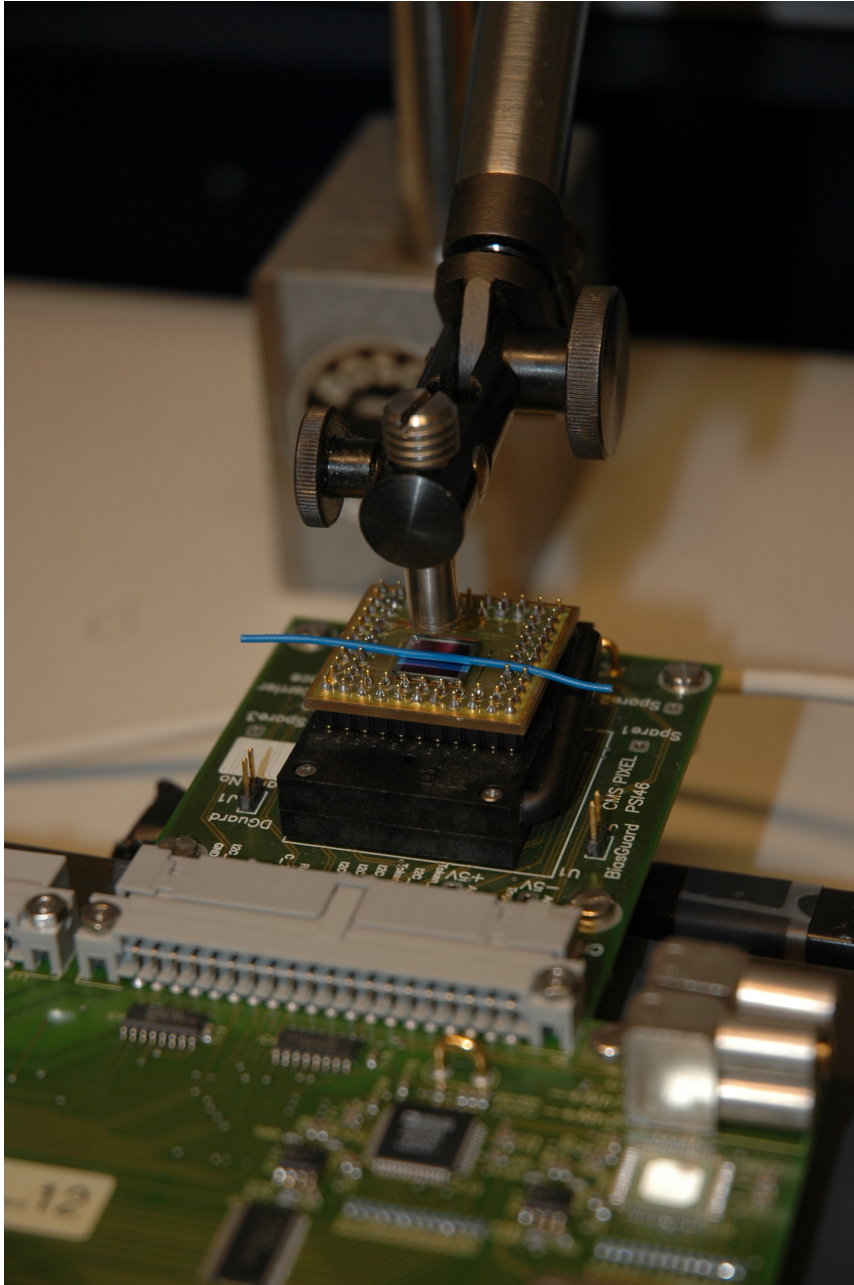
- Ru source, 10s.
- Chip 6, run 1000.
- 2 noisy pixels dominate:
 - need to be masked out...

Pixel pulse height

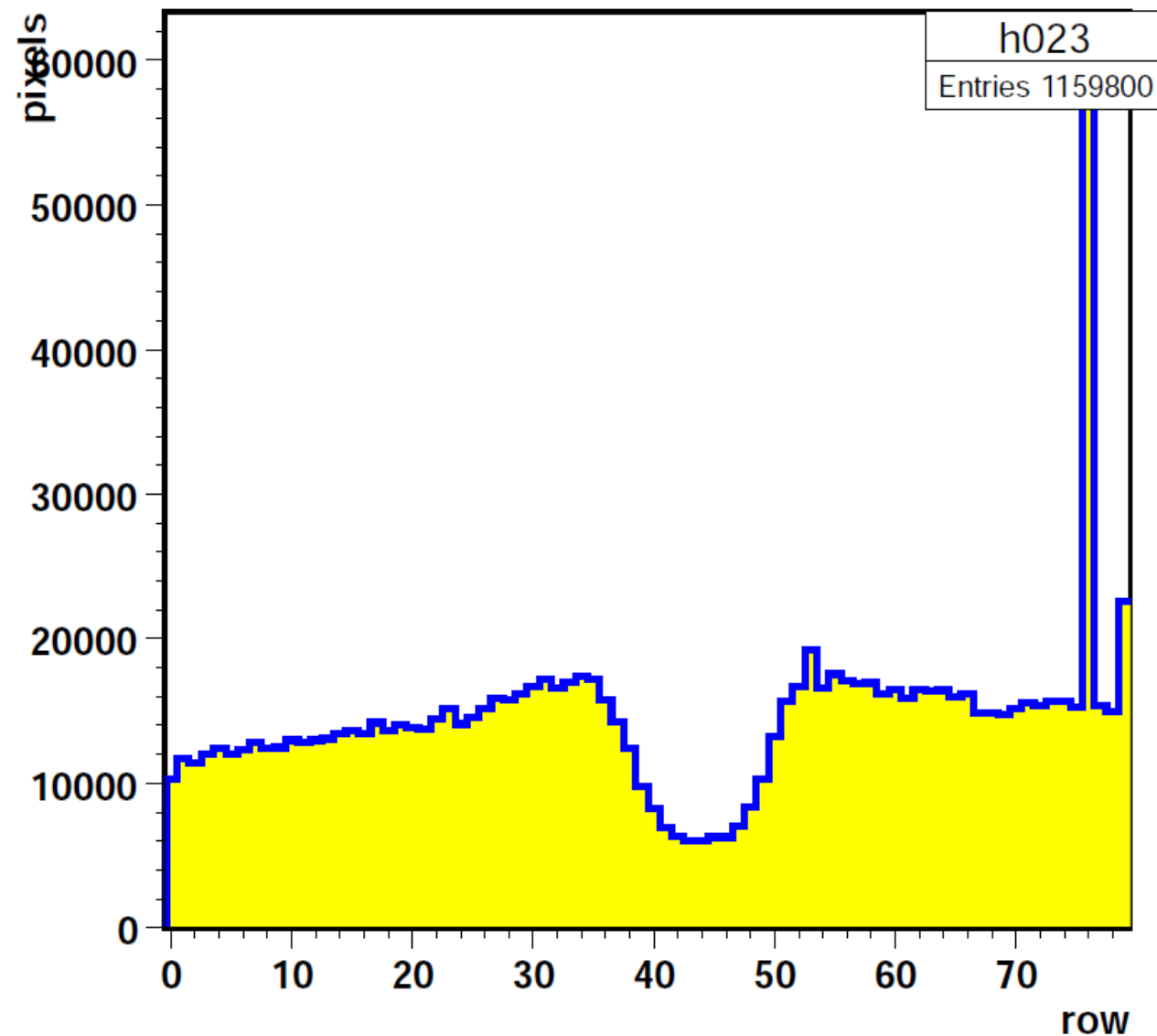


- Ru source, 10s.
- Pulse height per pixel:
 - no clustering,
 - no gain calibration.
 - ROC preamp saturation for large pulses.

wire obstacle

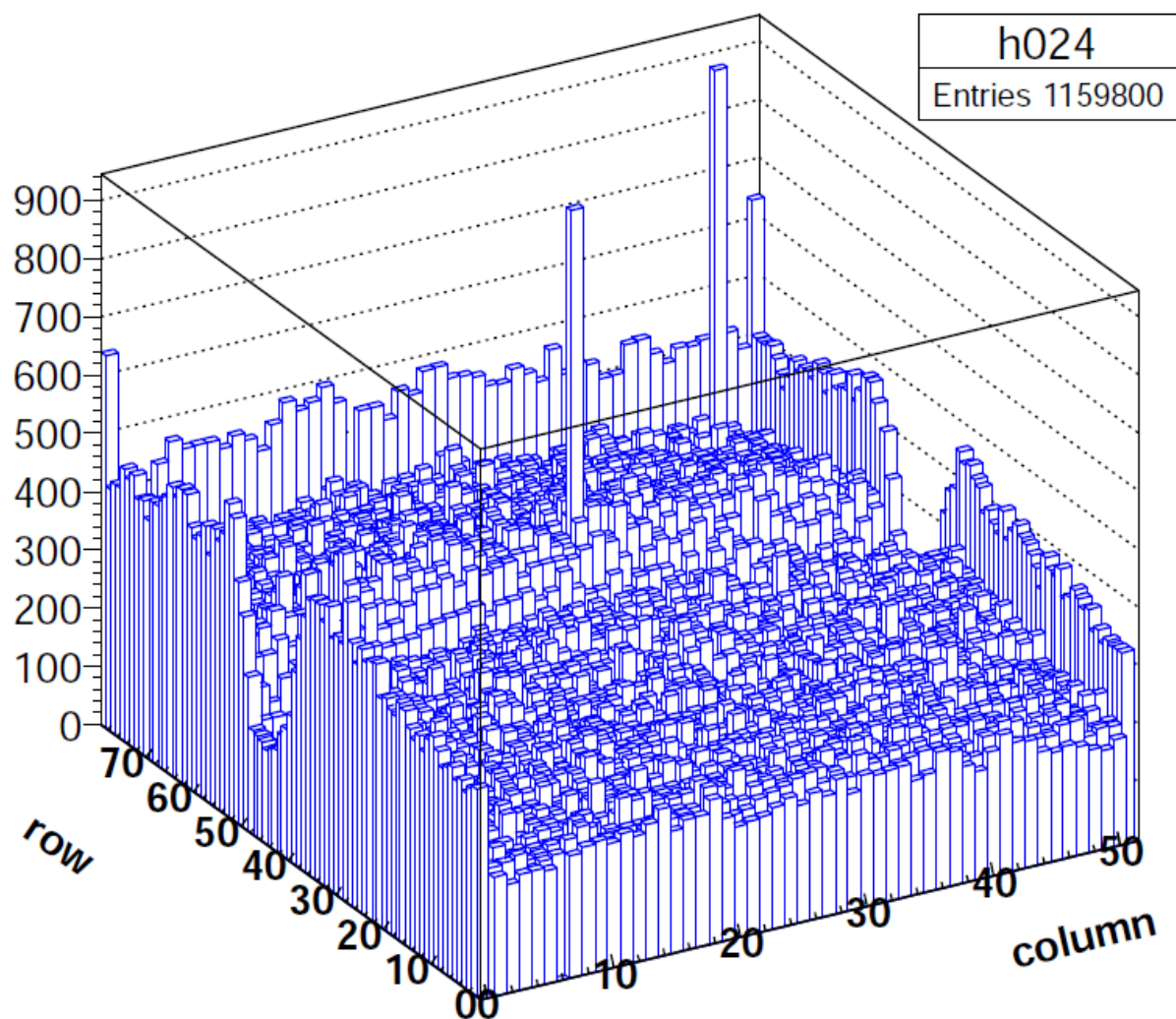


Row map with wire



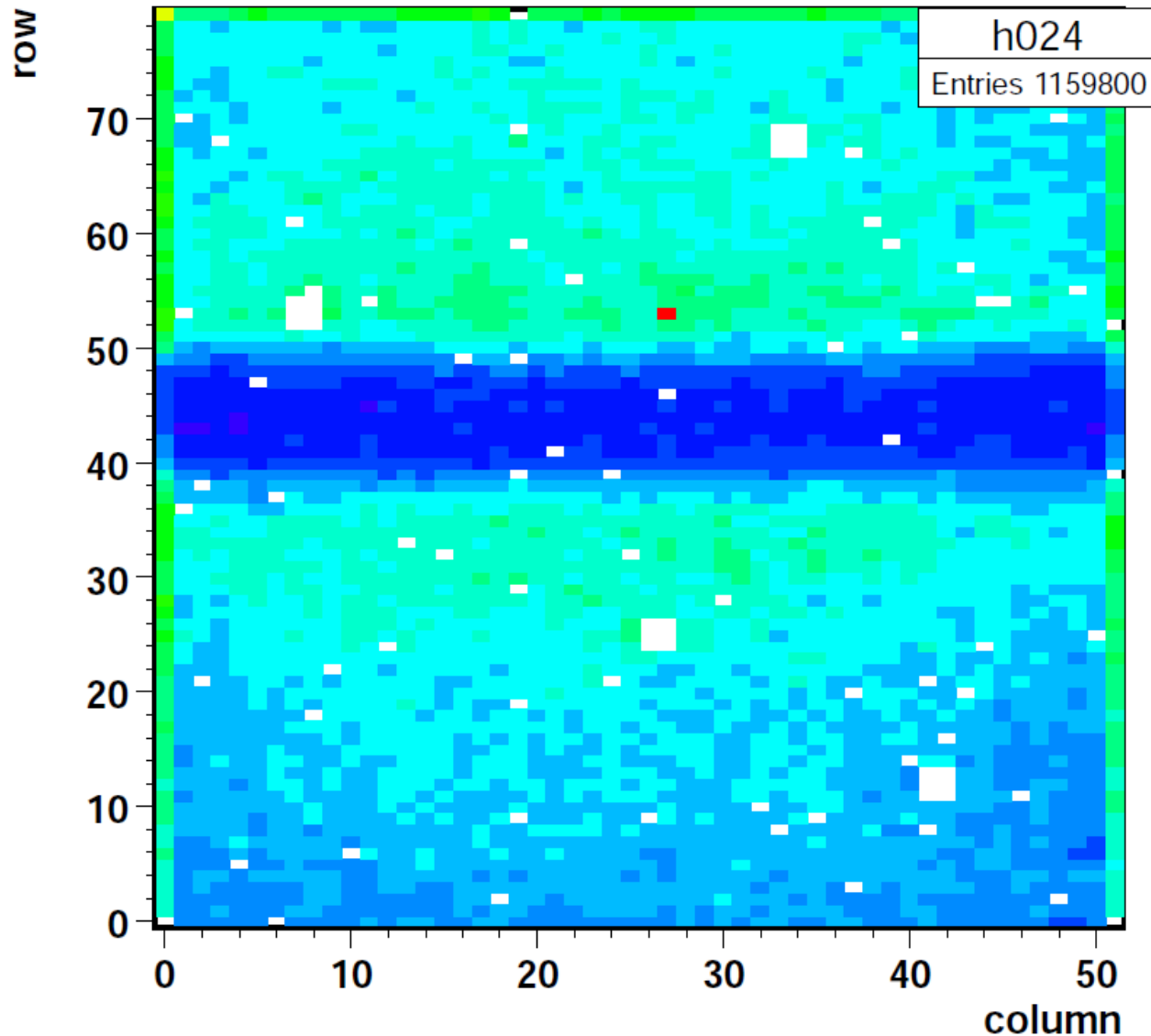
- Ru source, 100s.
- Chip 6, run 1004.
- Wire placed across the chip.
- Row map (φ):
 - shadow of the Fe wire
 - 1 noisy pixel (at a different place?).
 - last row has double width pixels (200 instead of 100 μm).

hit map



- Ru source, 100s.
- Chip 6.
- Wire placed across the chip.
- Pixel map (ϕ - z):
 - shadow of the Fe wire
 - 1 noisy pixel cut off.
 - long and/or wide pixels at 3 edges.

hit map



- Ru source, 100 s.
- Chip 6, run 1004.
- Wire placed across the chip.
- Pixel map (ϕ - z):
 - shadow of the Fe wire
 - 1 noisy pixel cut off.
 - long and/or wide pixels at 3 edges.
 - several holes (old chips, rejects?)

Status

- takeData code with Ru source taken into operation:
 - internal trigger timing adjusted (tct 103, wbc 100)
 - reached 89% duty cycle (890 Hz at 1ms clock stretch)
 - get 64 MB in 300 s data taking (+150 s USB transfer).
- Binary data:
 - decoding works (mode without TBM header/trailer),
 - clustering code to be adapted or written.
- More measurements:
 - efficiency vs bias voltage,
 - look at two more sensors (chip7 and 8), study uniformity,
 - study noisy pixels,
 - activate external (scintillator) trigger (penetrating beta rays),
 - DESY test beam?

Acknowledgements

- Uli Koetz (DESY):
 - lab space, NIM crate and modules, scope
- Erika Garutti (DESY and Uni HH):
 - finger scintillator and PM.
- Torsten Külper:
 - TTL trigger adapter.
- Beat Meier (PSI), Thomas Weiler (KIT), Tilman Rohe (PSI):
 - code and advice.
- Carsten Niebuhr (DESY):
 - Strahlenschutzunterweisung
- Wladimir Hain (DESY):
 - source
- Carsten Muhl (DESY):
 - source holder

Universal pixel test board

Design and firmware
by Beat Meier, PSI

600 V
bias

psi46
chip

other
adapters
available

scope

ADC

trigger

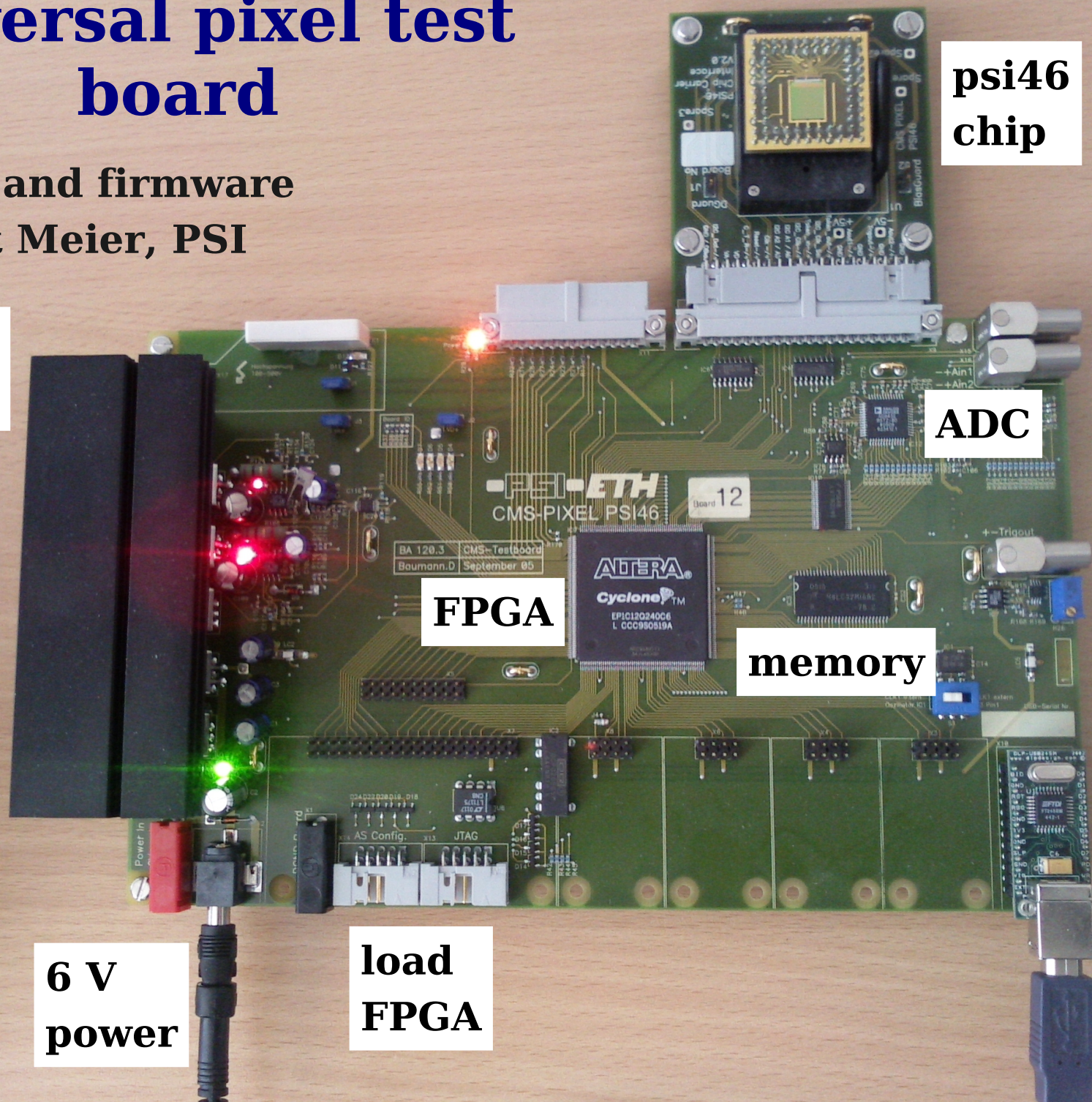
FPGA

memory

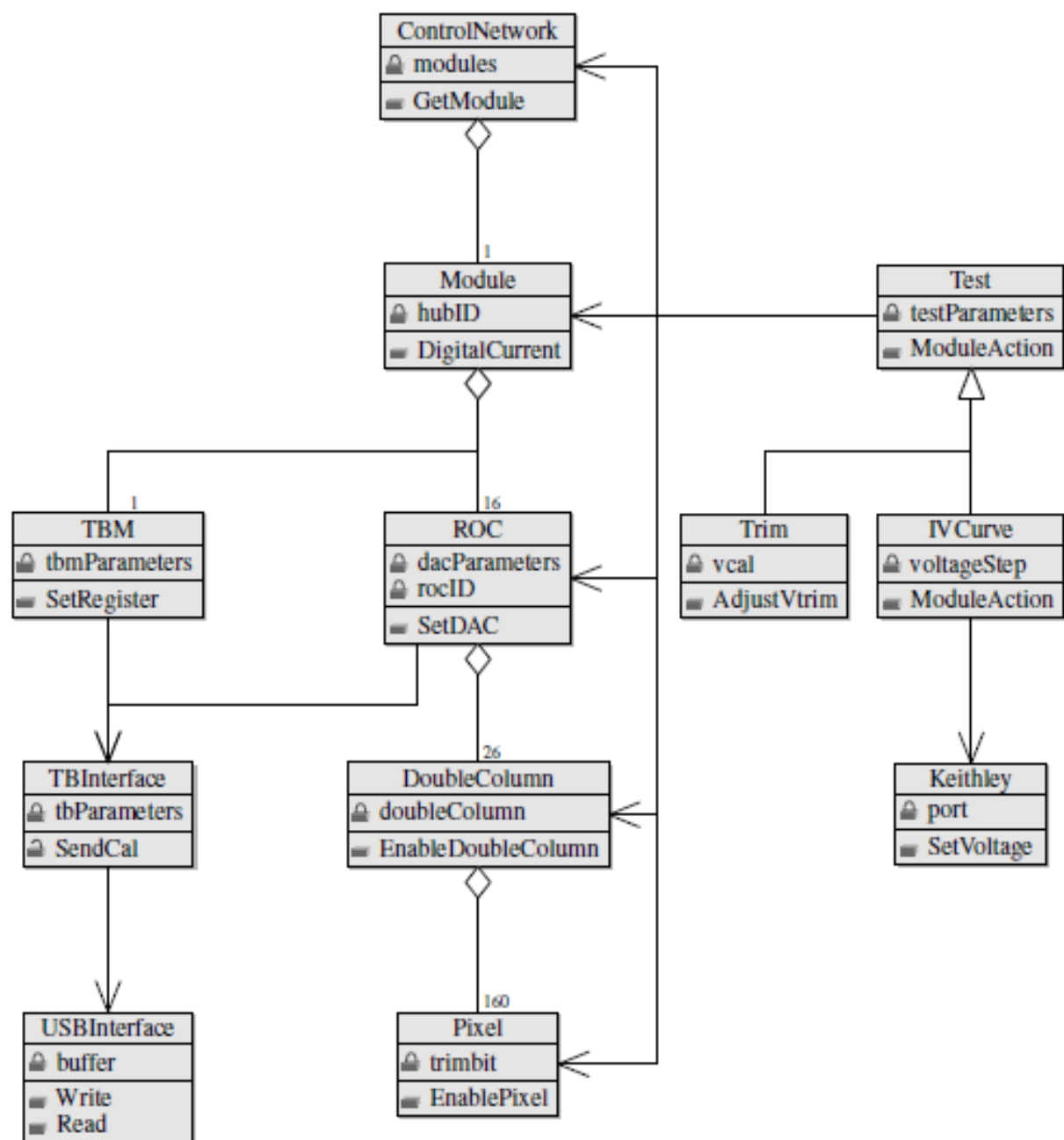
USB1
to
laptop

6 V
power

load
FPGA



psi46expert software



- C++ class library.
- Written by Peter Trüb (ETH, 2005-2007) for Scientific Linux (32 bit).
- Now compiled with g++ 4.4.5 under Ubuntu 10.10 (64 bit).
- USB interface required some changes (long → int).
- Lot's of code – only a small portion explored so far...

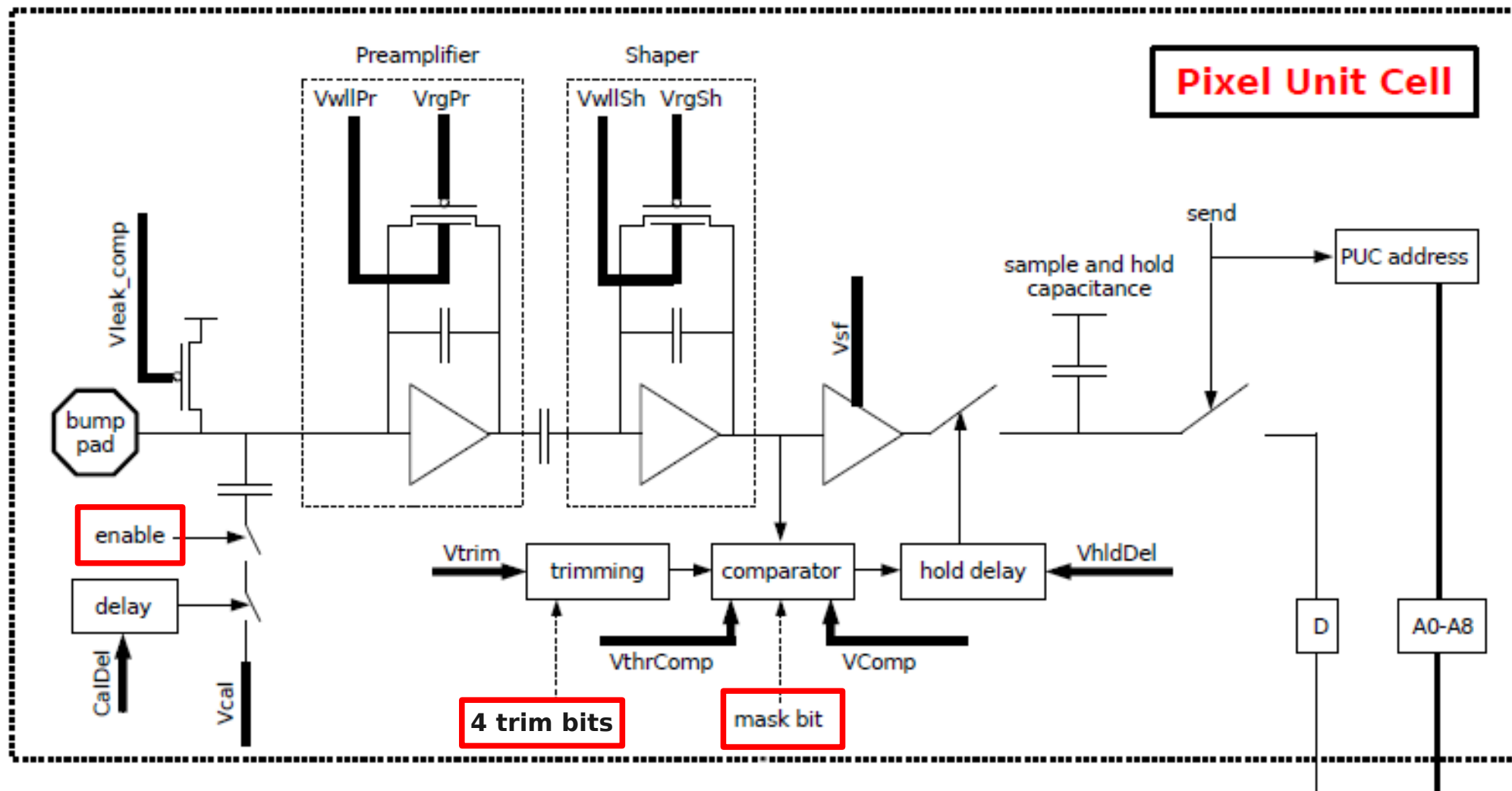
PSI46expert software at DESY

- Several new routines written:
 - DAC scans, noise maps, address decoding...
- Analysis in ROOT:
 - gain map, threshold map, noise map
- Steer psi46expert by command script instead of interactively:
 - faster, reproducible, self-documenting.
- DAC settings for 9 ROCs determined (3 with baby sensor).
- Fast efficiency determination on the FPGA does not work:
 - Configuration problem (single ROC test, no TBM)?
 - Not fixed by FPGA firmware update (Aug 2010 version).
 - Have to use slower USB access...

psi46 DACs

1	Vdig	6	13	VIBias_Bus	30
2	Vana	150	14	Vbias_sf	10
3	Vsf	160	15	Voffset0p	55
4	Vcomp	10	16	VIbias0p	115
5	Vleak_comp	0	17	VOffsetR0	120
6	VrgPr	0	18	VIon	115
7	VwllPr	35	19	VIbias_PH	130
8	VrgSh	0	20	Ibias_DAC	122
9	VwllSh	35	21	VIbias_roc	220
10	VhldDel	130	22	VIColor	100
11	Vtrim	7	23	Vnpix	0
12	VthrComp	124	24	VSumCol	0
253	CtrlReg	0	25	Vcal	200
254	WBC	20	26	CalDel	125
			27	RangeTemp	0

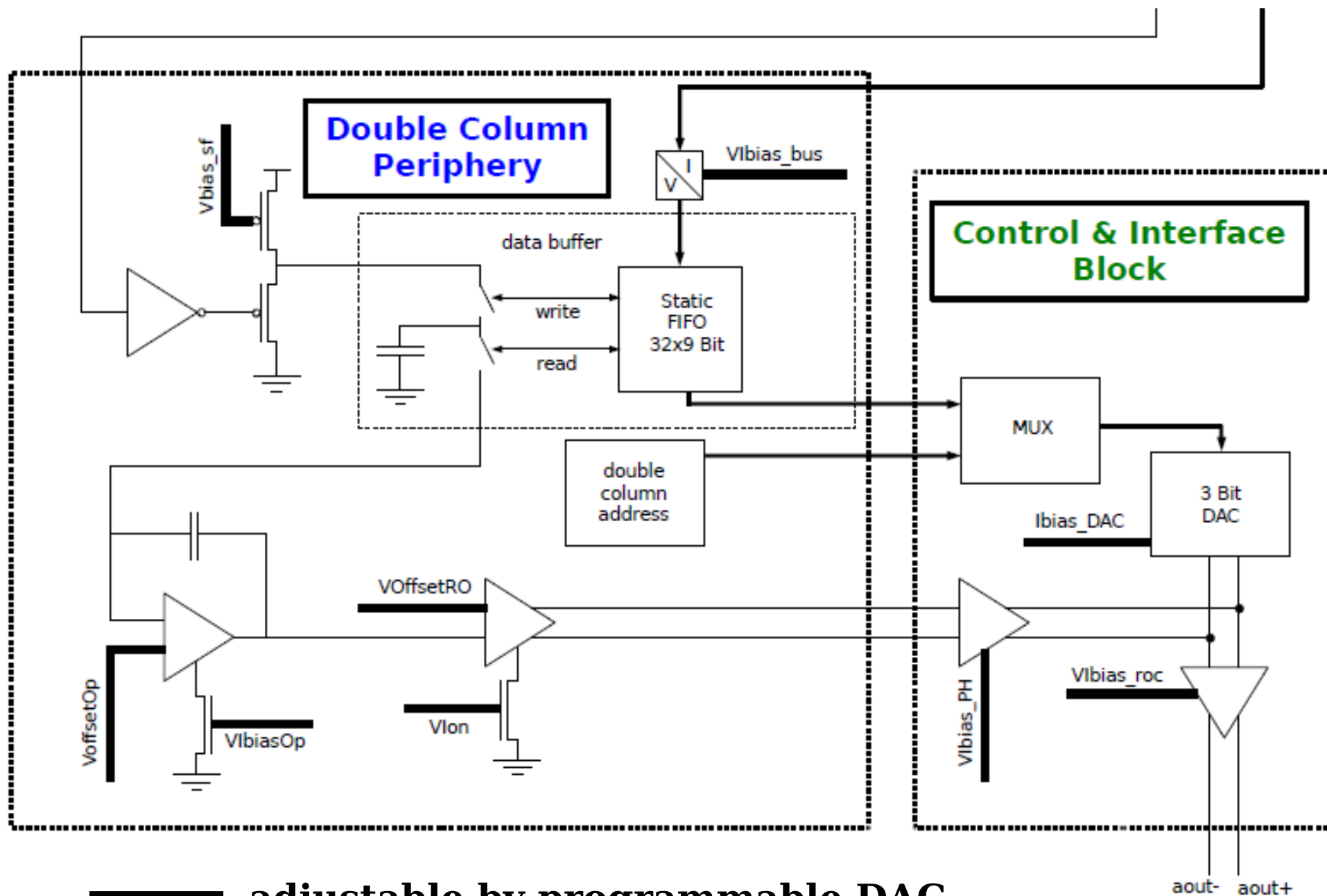
psi46 pixel readout chip



— adjustable by programmable DAC, per ROC

□ programmable register, per pixel

psi46 pixel readout chip



X-ray calibration at PSI

- ▶ Twofold purpose:
 - ▶ test module response to the injected charge into Si sensor
 - ▶ calibrate internal signal used for the trimming (setting threshold)
- ▶ X-ray source:
 - ▶ Primary source: Americium-241
 - ▶ Targets: Mo($4844 e^-$), Ag($6139 e^-$), Ba ($8906 e^-$)
 - ▶ Random trigger, stretched bunch-crossing
- ▶ Test setup:

