IPE DAQ for TRISTAN

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

KIT TRISTAN lab: characterising the IPE4 DAQ system

Till Bergmann

34th KATRIN Collaboration Meeting
February 2018

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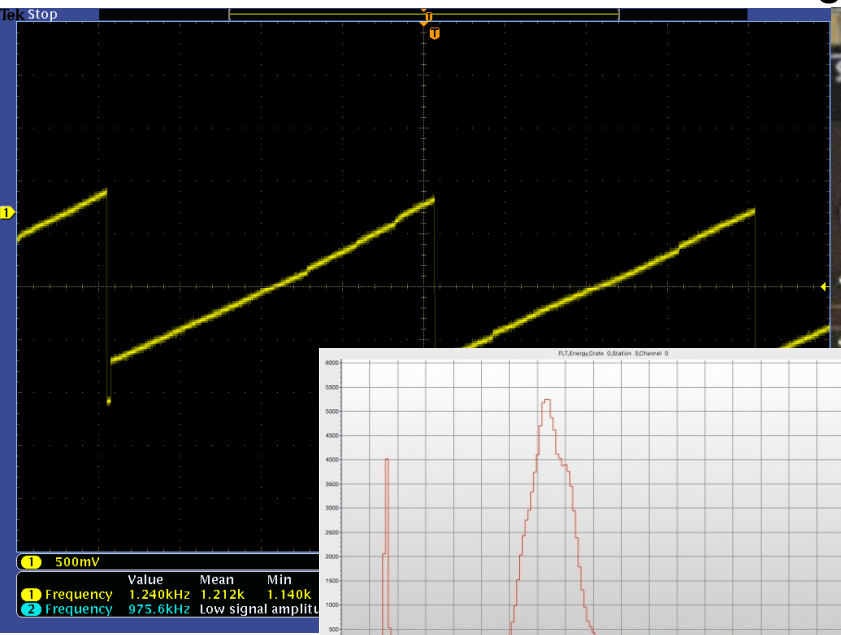
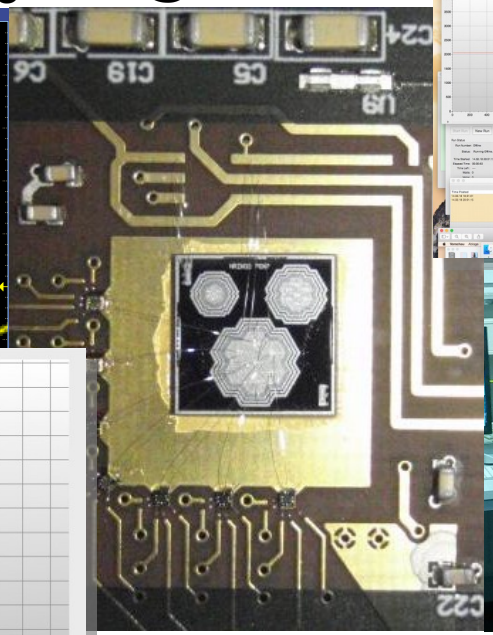
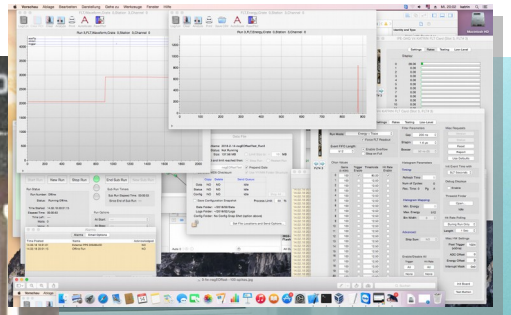
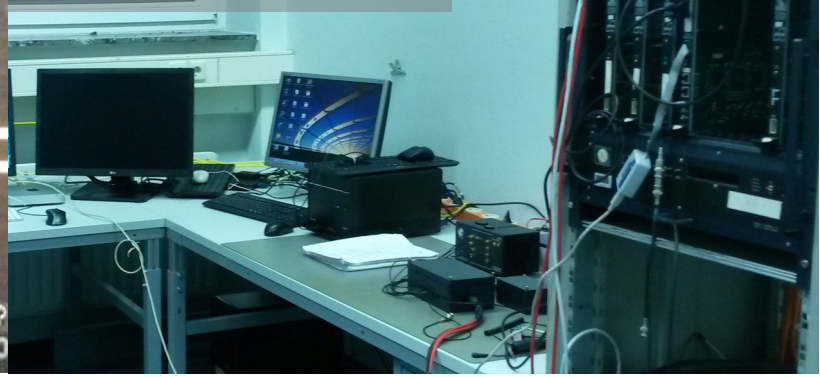








Tasks

- IPE4 crate + ORCA upgrade + recommissioning
- Data taking with IPE4+ORCA
- Investigate KATRIN trigger for TRISTAN signals
- Support TRISTAN MTCA crate development

TRISTAN Test Stand at KIT

Marc Korzeczek,
KIT, IKP

Crate PC
Linux

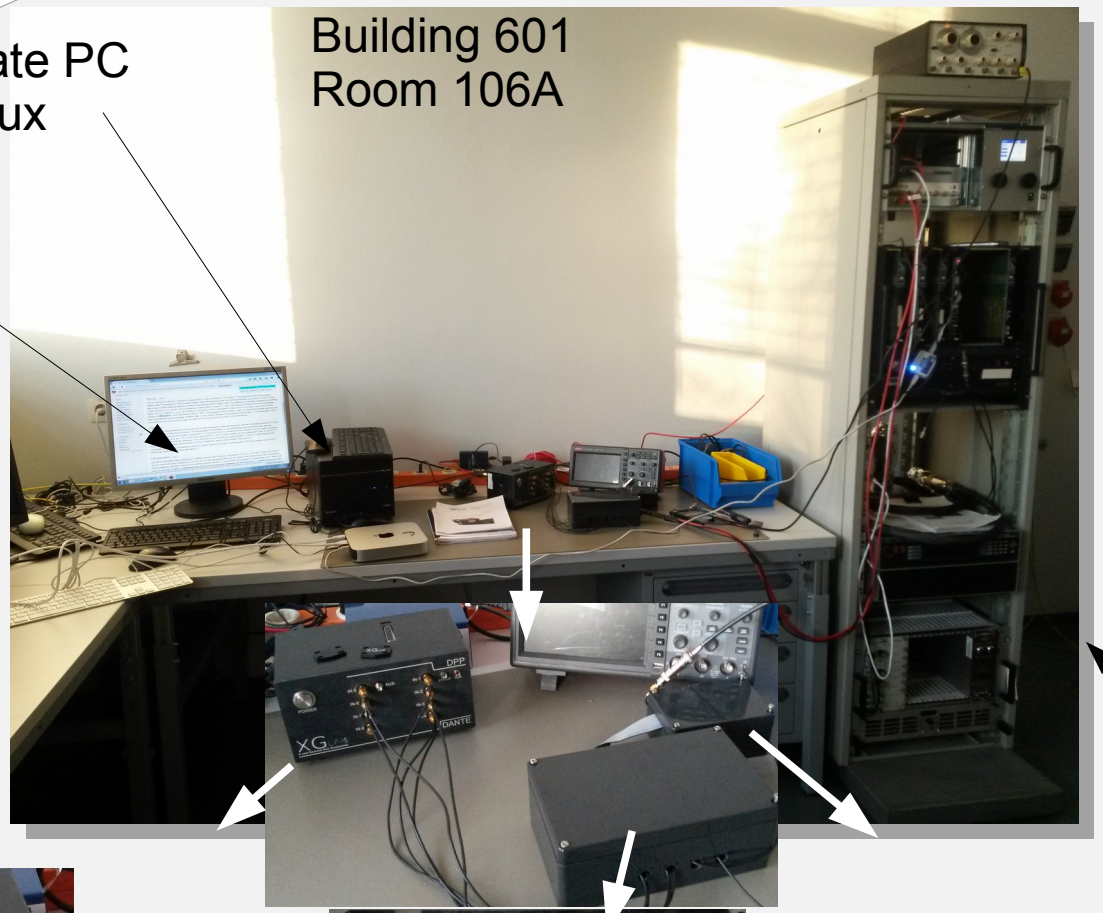
Building 601
Room 106A

Testpulser

Power Supply

PC + XGlab
software

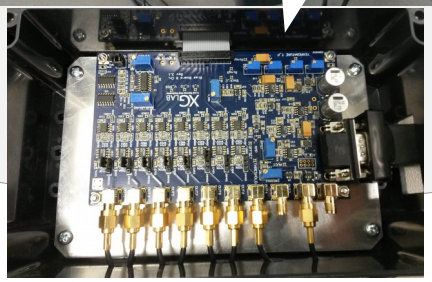
MacMini
ORCA



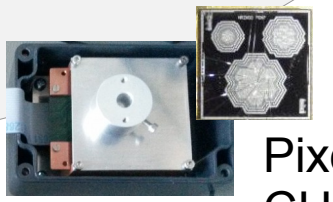
IPE4 Crate

E-Gun

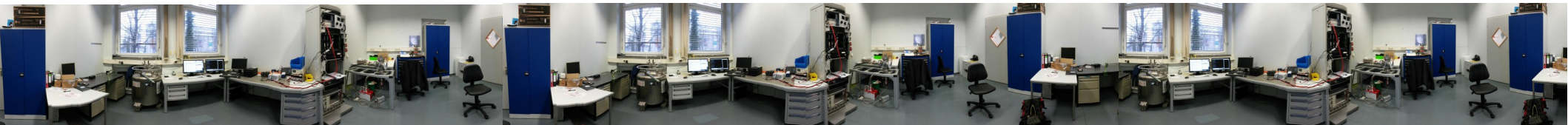
XGlab DANTE DAQ



XGlab Bias Board



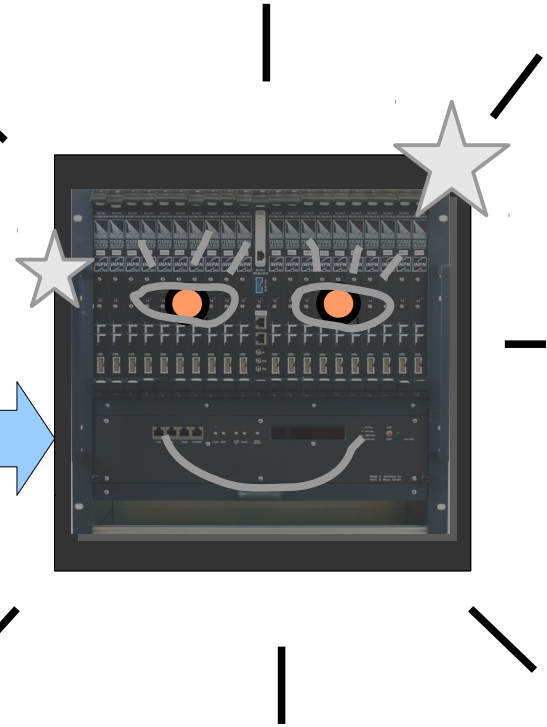
Pixel detector +
CUBE ASIC +
Fe55 source

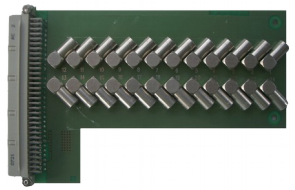


IPE4 Crate Upgrade

Former Myon Panel DAQ, unused for ~ 2 years

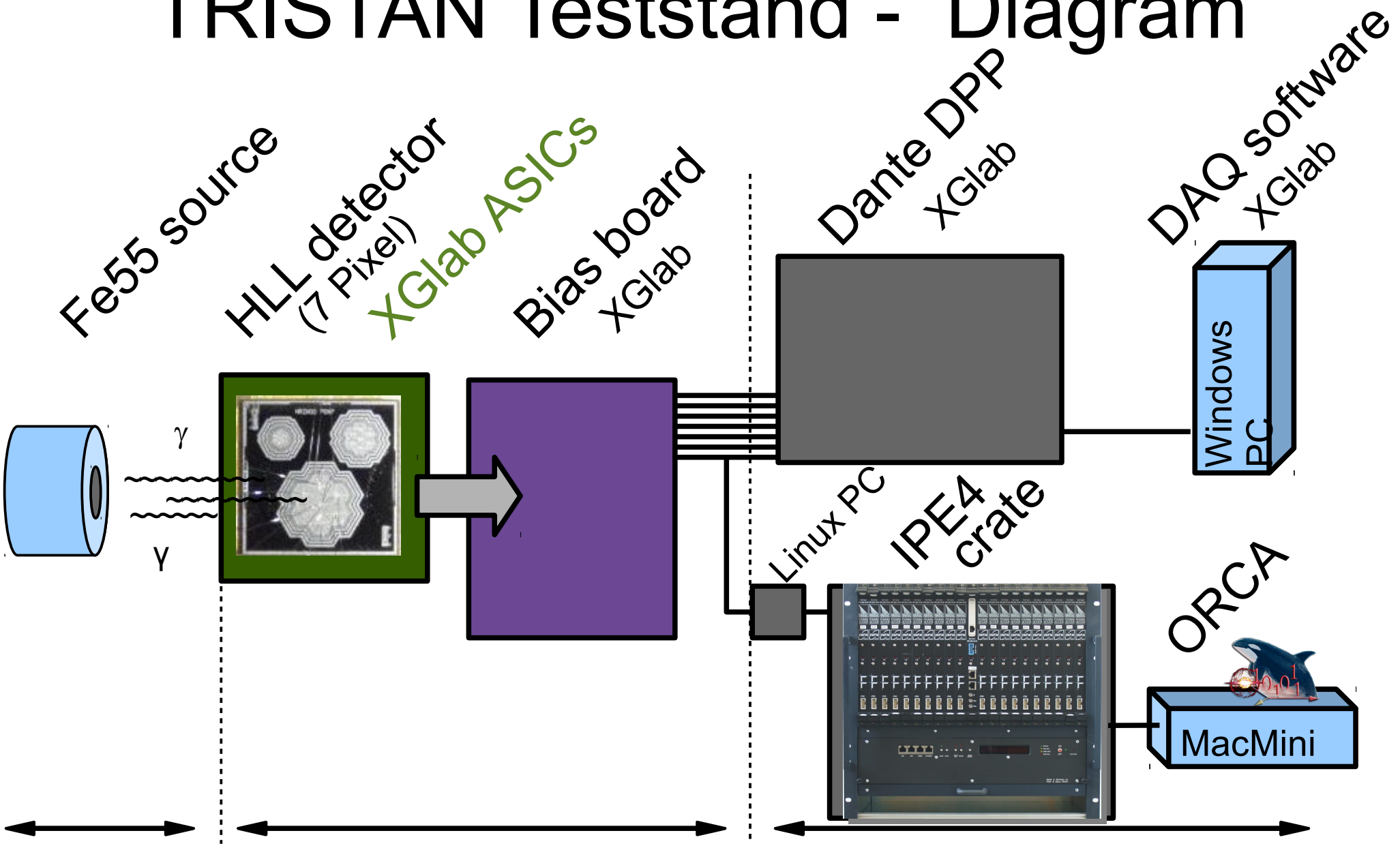
- PrPMC Replacement → PCIexpress Link + Crate PC
- Firmware (FPGA)
- SLT driver
- Crate PC: Linux + hardware library
- MacMini setup
- Orca
- OrcaRoot
- Router (local LAN)
- modified Lemo Adapter (Sascha Wüstling)





ch 1-8: polarity reversed

TRISTAN Teststand - Diagram

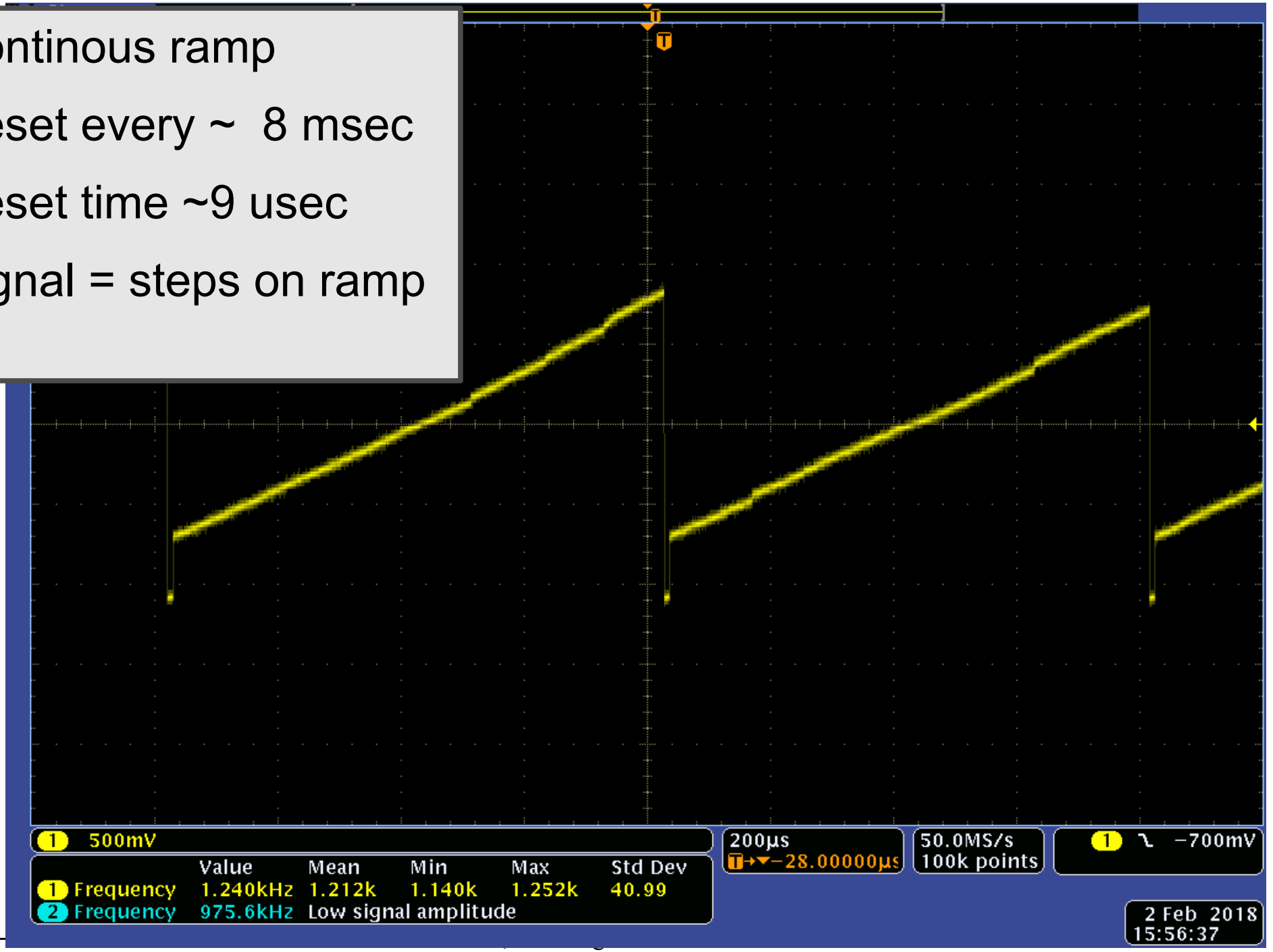


Data taking with IPE4+ORCA

- Details of the detector signal using a Fe55 source
- Compare DANTE and IPE4 data
- Issues

Signal from Fe55 source

- Continous ramp
- Reset every ~ 8 msec
- Reset time ~9 usec
- Signal = steps on ramp



Signal from Fe55 source

- Continous ramp
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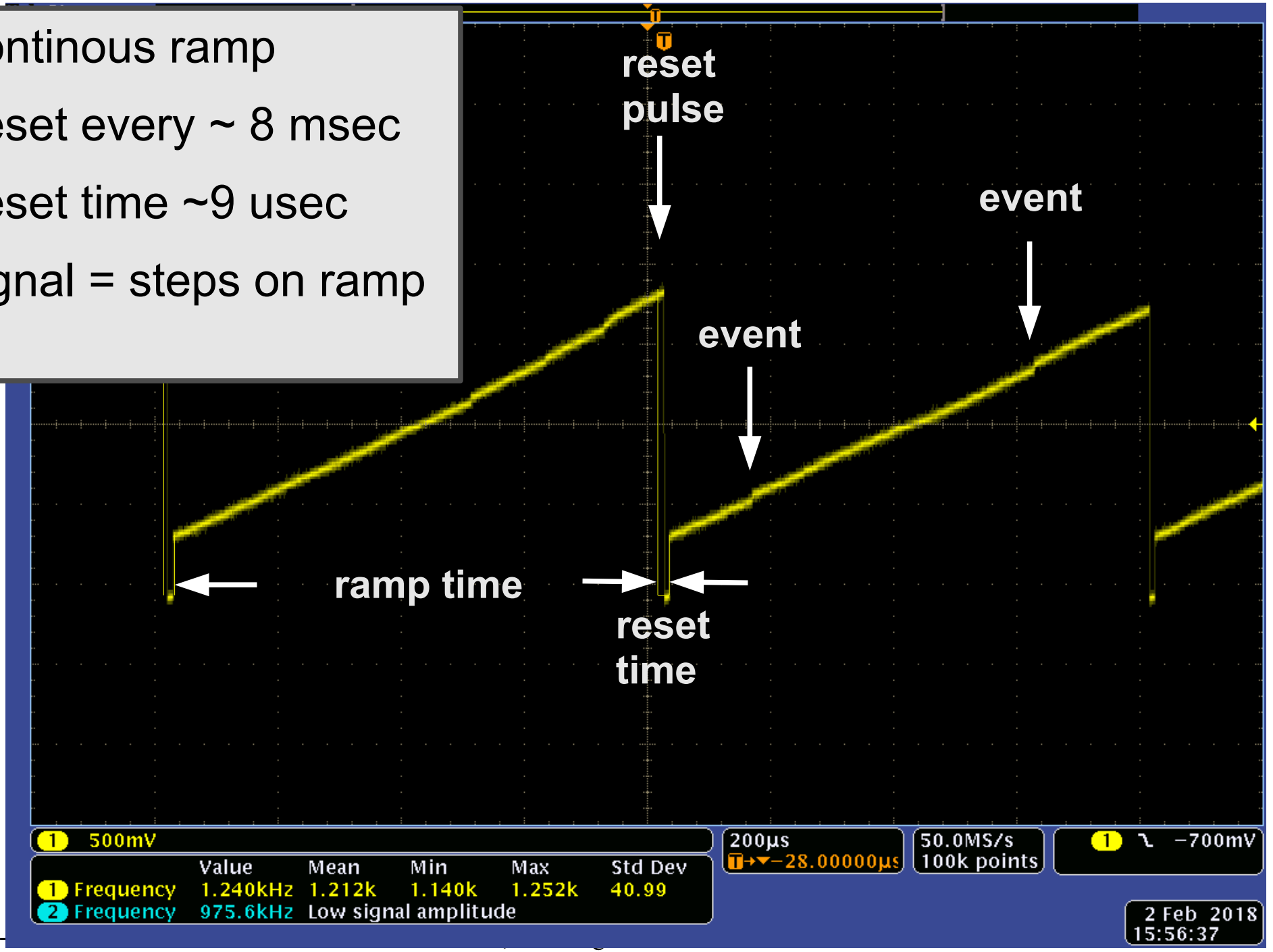
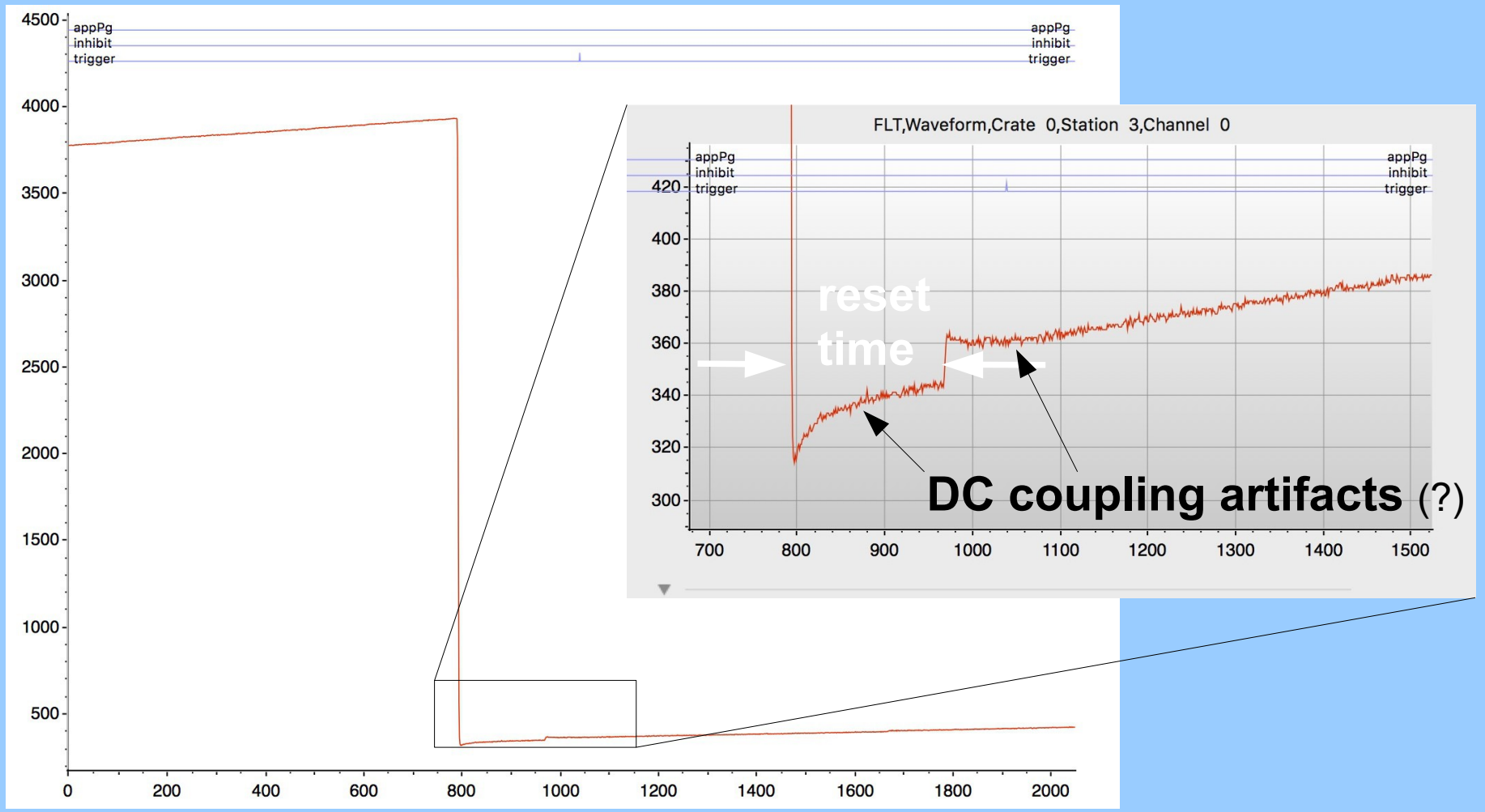
- Signal = steps on ramp



Recorded with IPE4+Orca

Waveforms/signals



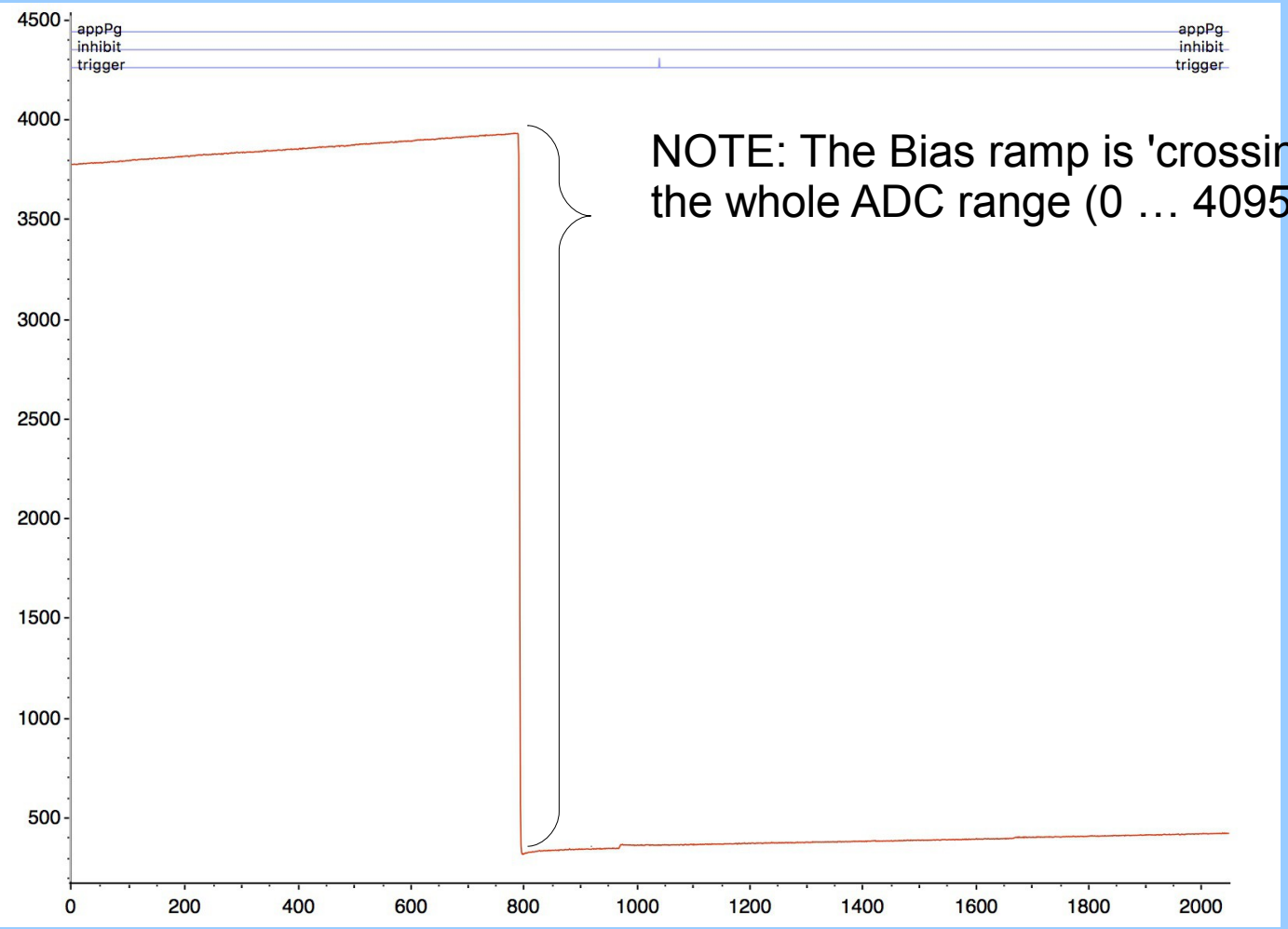
Reset Pulse

ADC units

t/50 nsec

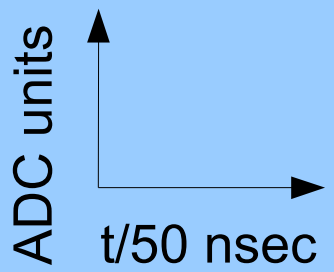
Recorded with IPE4+Orca

Waveforms/signals



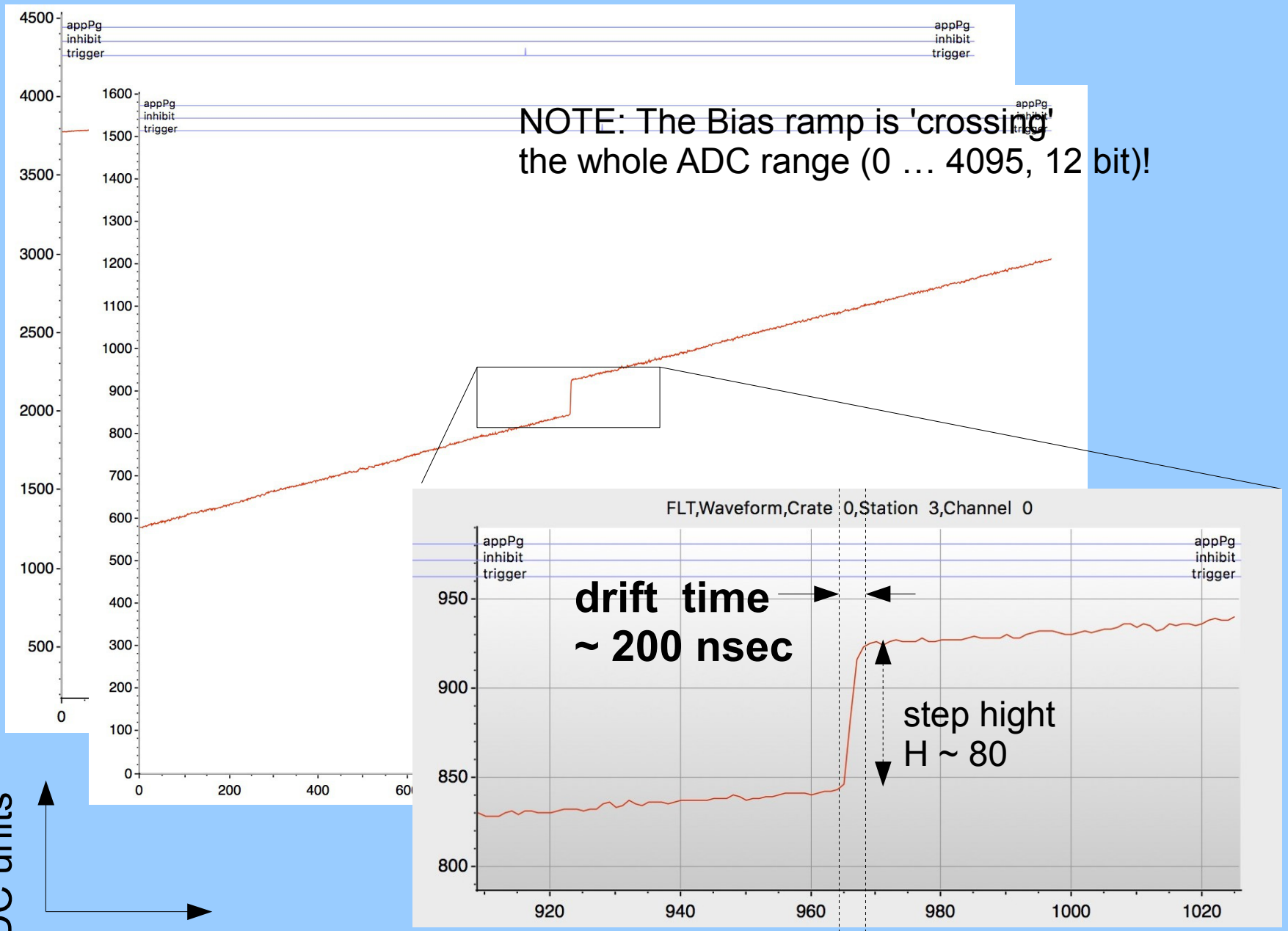
NOTE: The Bias ramp is 'crossing' the whole ADC range (0 … 4095)!

Reset Pulse

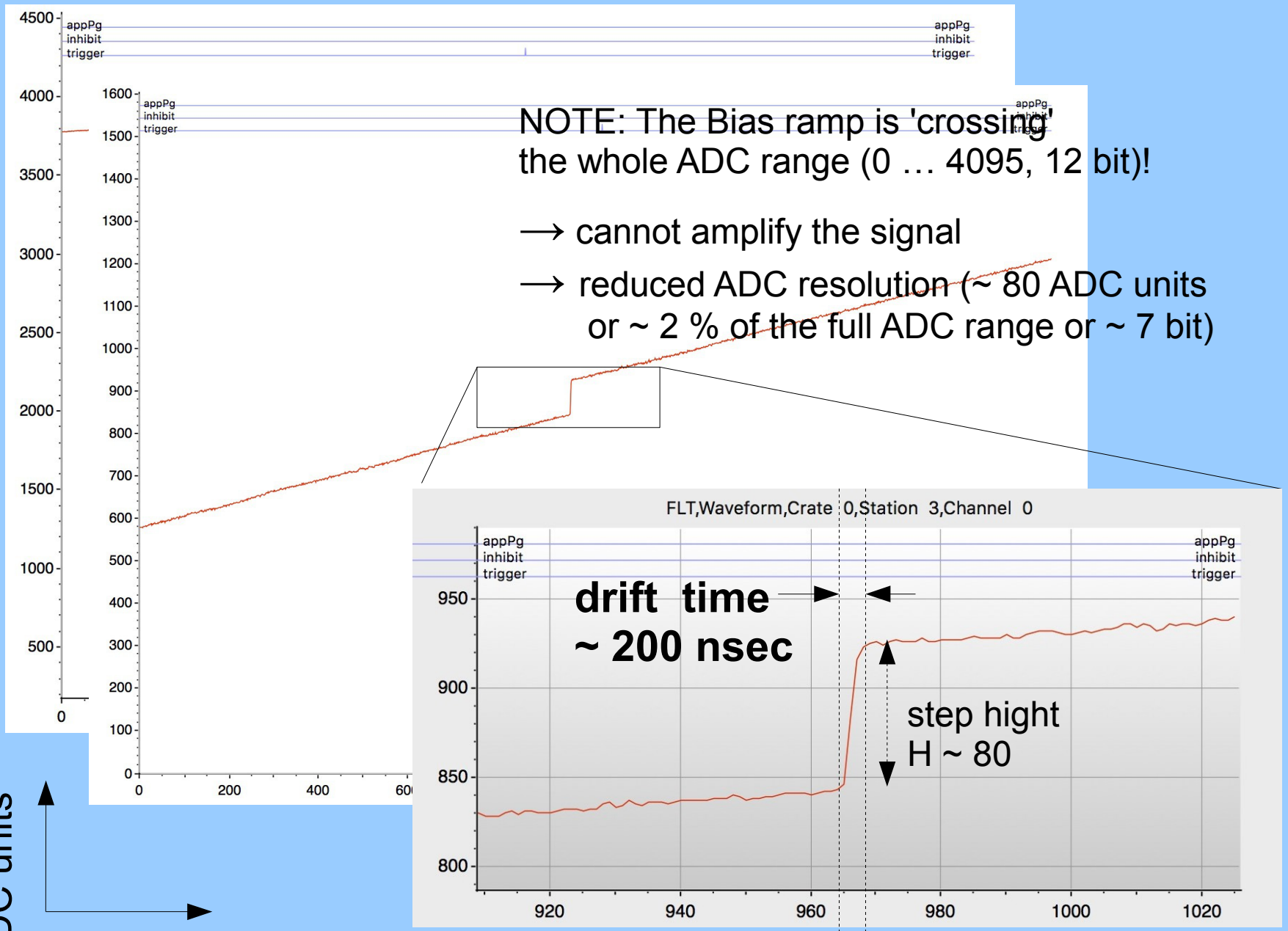


Recorded with IPE4+Orca

Waveforms/signals

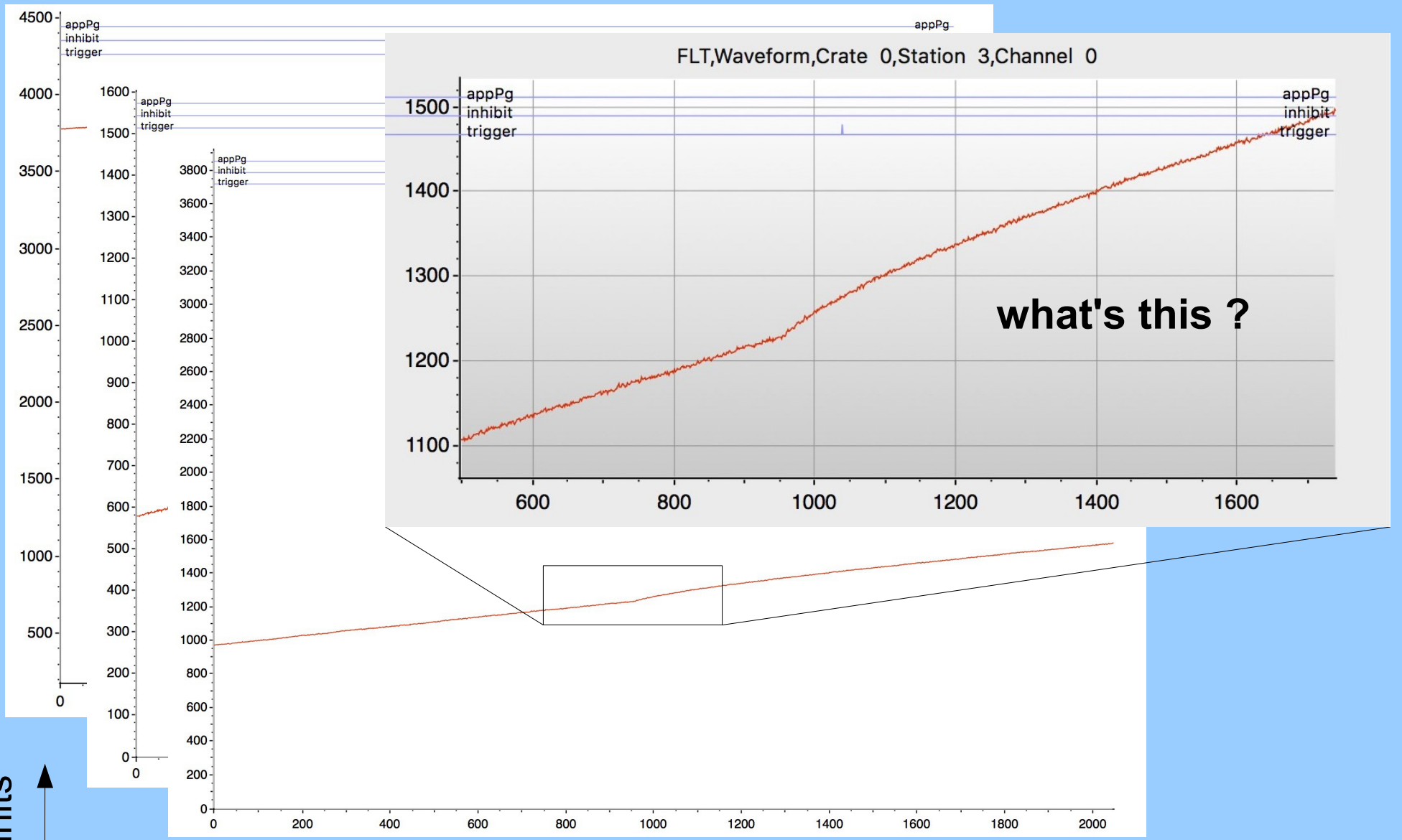


Waveforms/signals



Recorded with IPE4+Orca

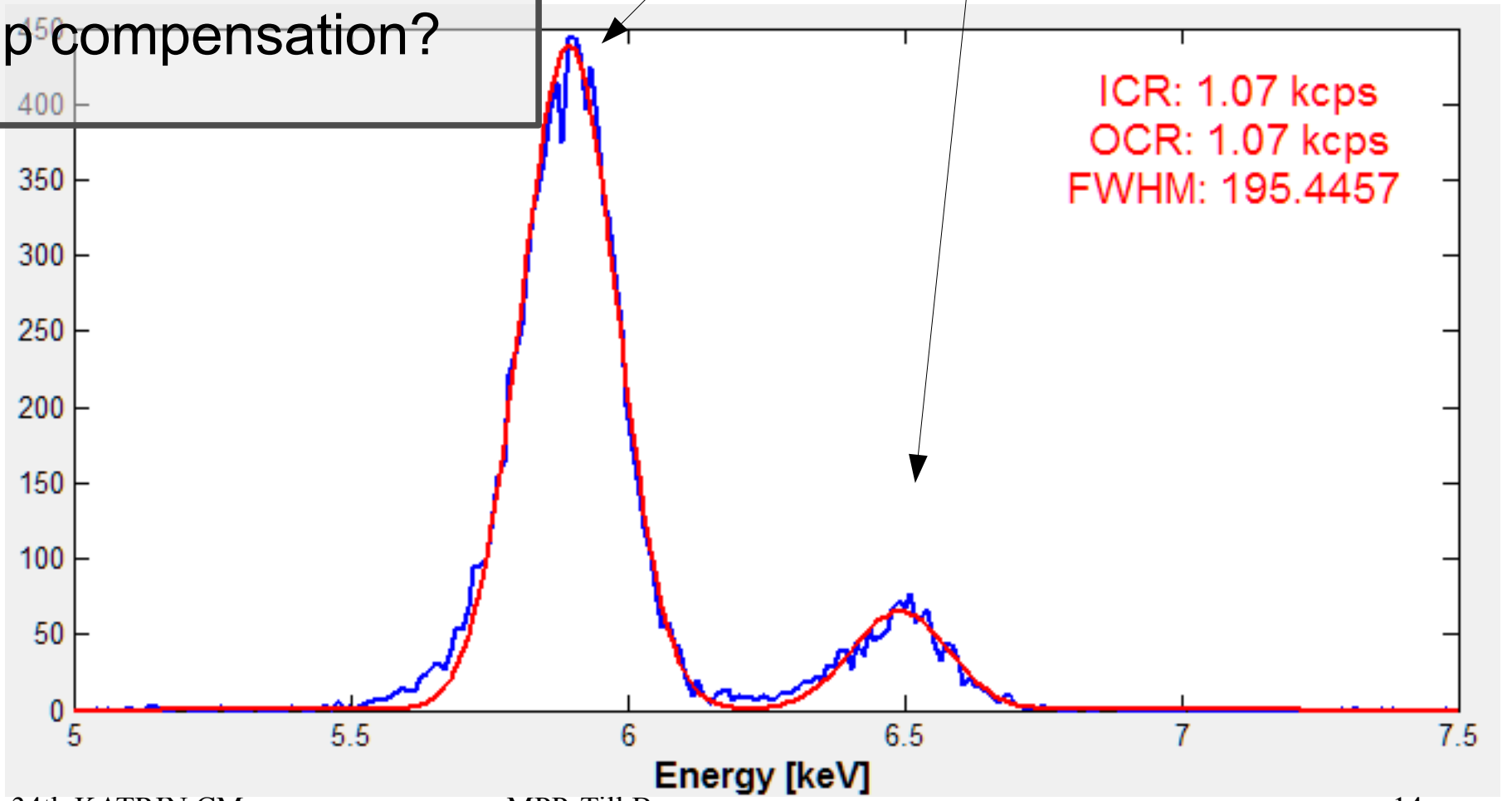
Waveforms/signals



Energy spectrum Dante

- ADC: 16 bit, 62.5 MHz (?)
- Complex trigger (shaper, pileup detection, edge detection)
- Ramp compensation?

Zoom to the energy peaks at 5.9 and 6.5 keV of Fe55

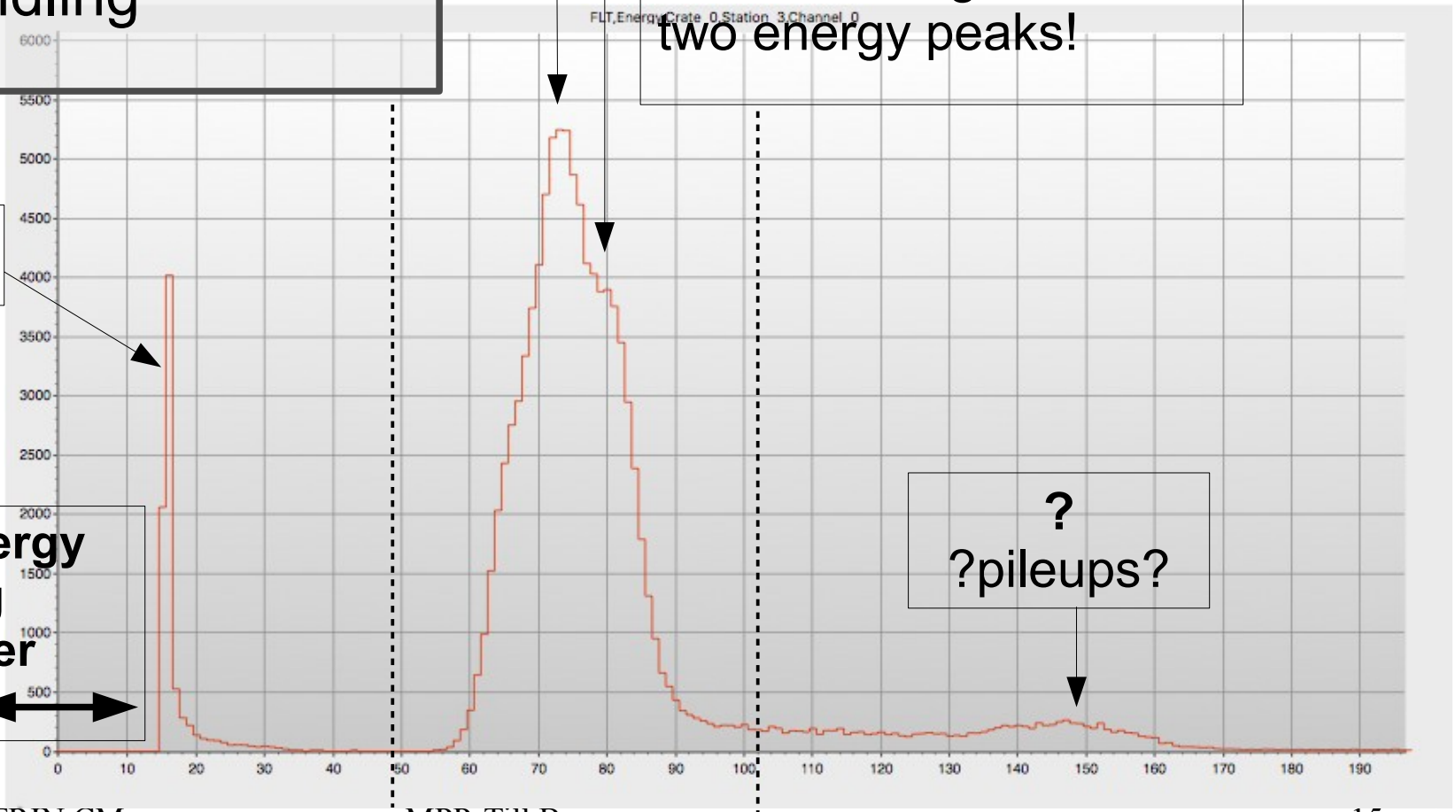


Energy spectrum IPE4

- ADC: 12 bit, 20 MHz
- KATRIN trigger (trapezoidal filter)
- No Ramp and Refresh Pulse handling

Two energy peaks?

cannot distinguish the two energy peaks!



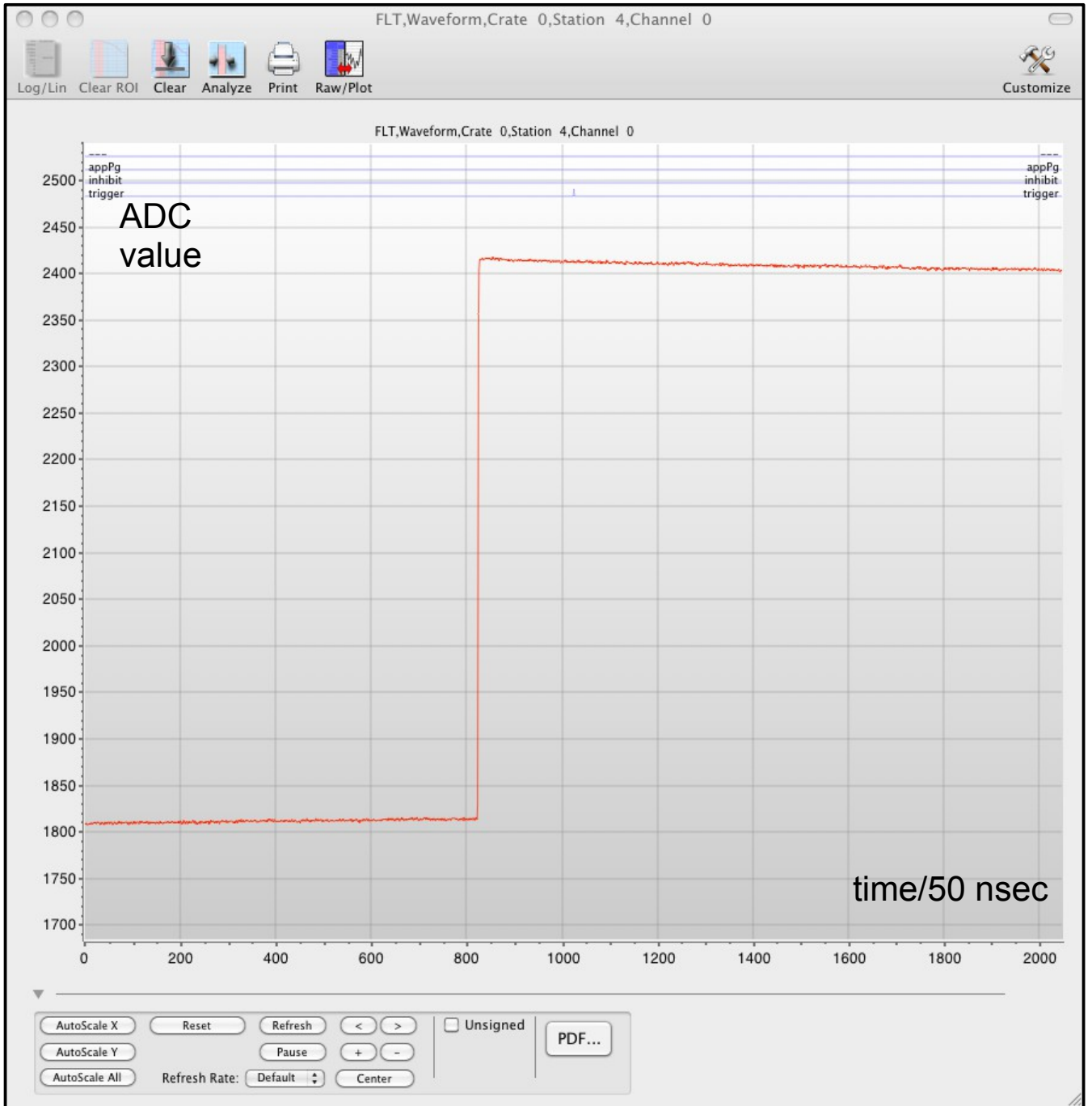
Reset pulse

Observation: energy shifts depending on KATRIN trigger settings

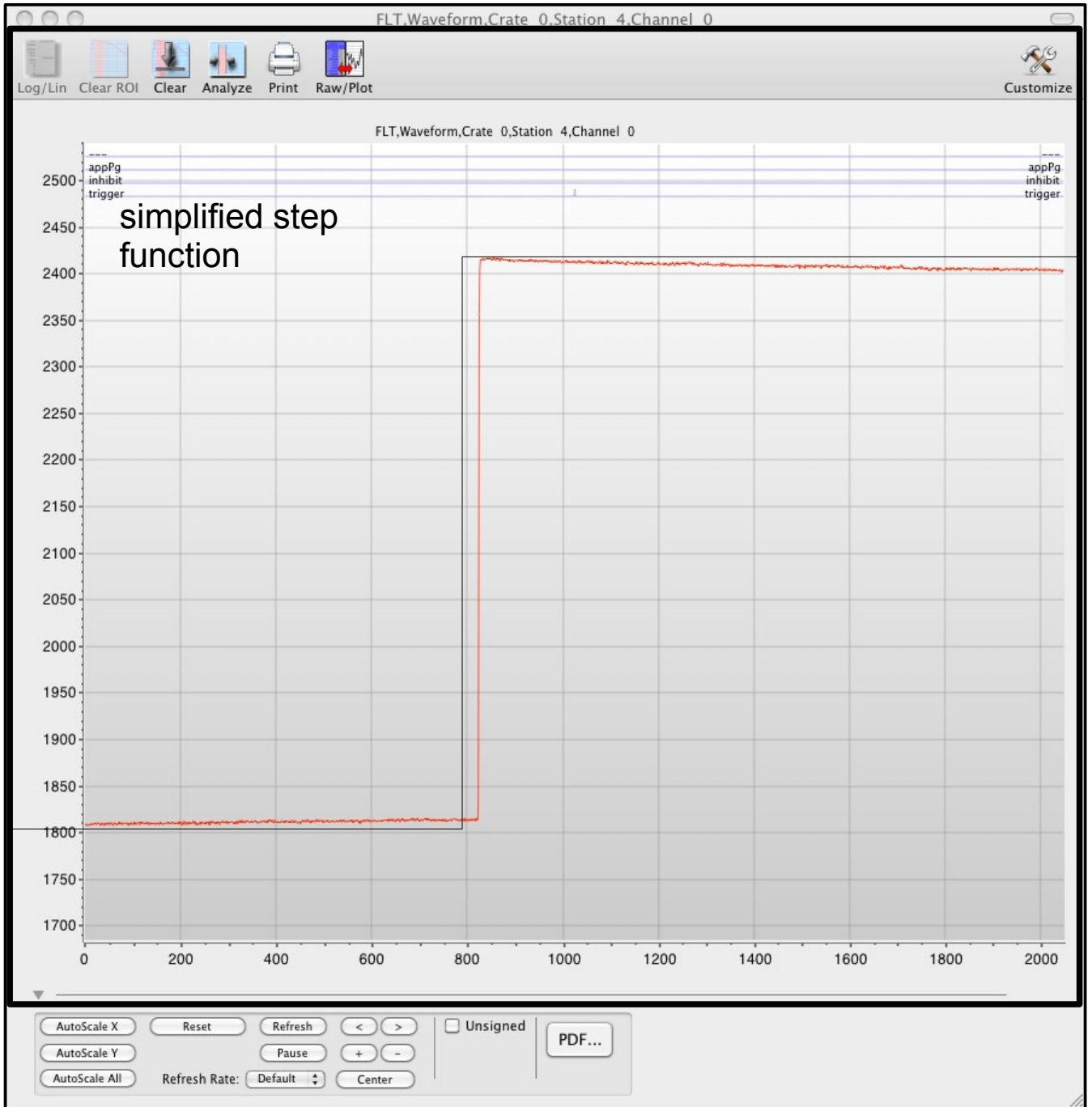
?
?pileups?

The KATRIN trigger in a nutshell

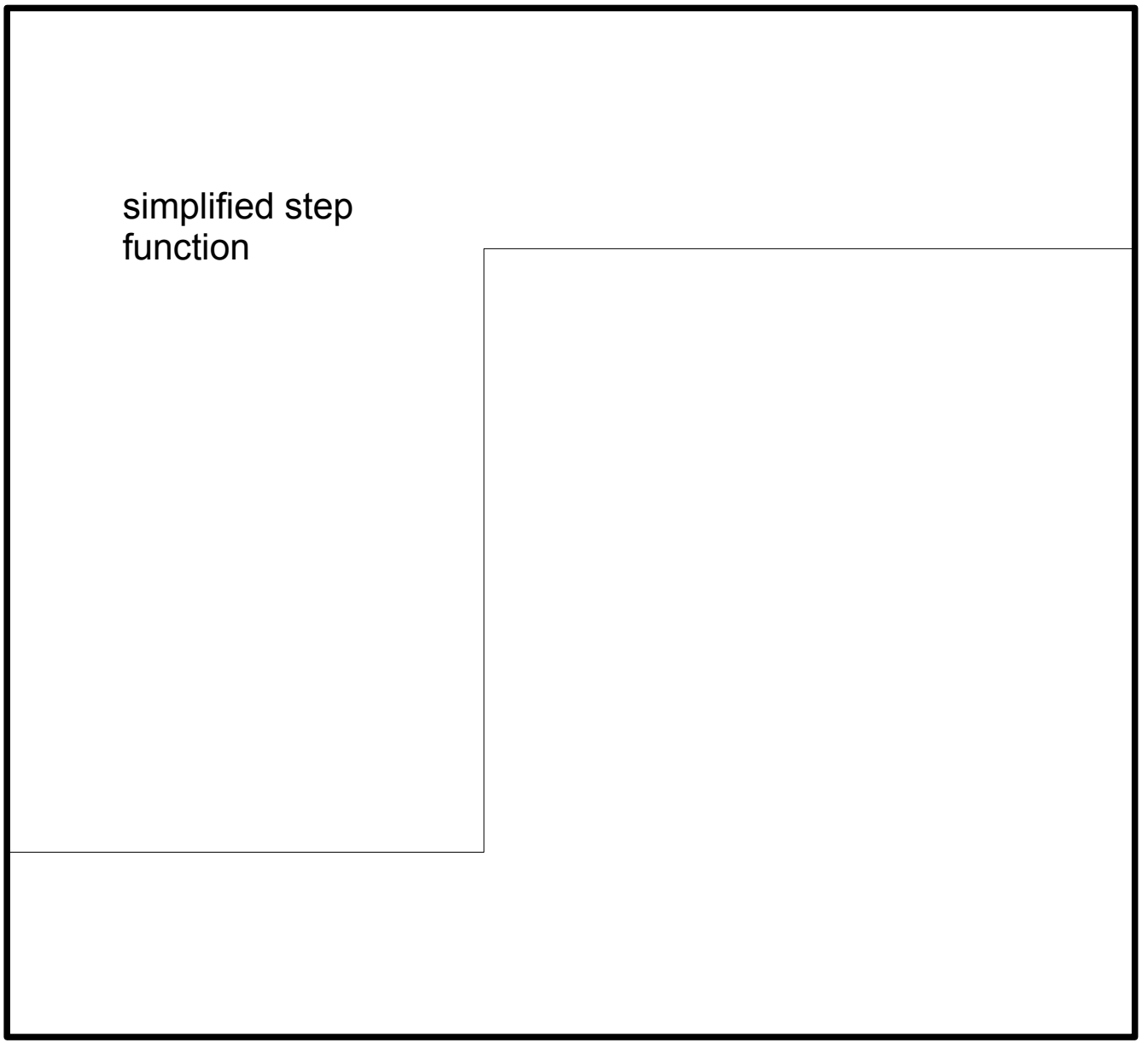
- observed energy shifts depending on KATRIN trigger settings
- → short excursion to KATRIN trigger



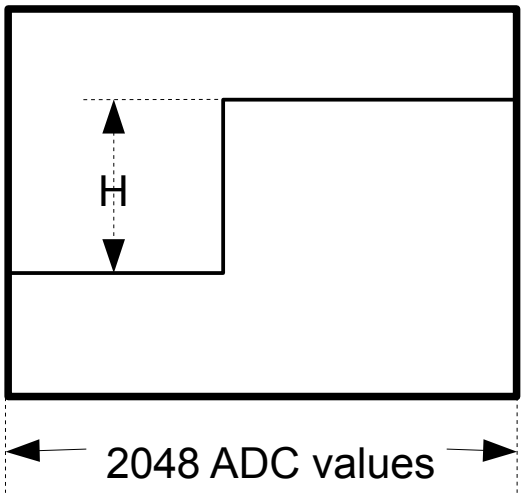
The KATRIN trigger in a nutshell



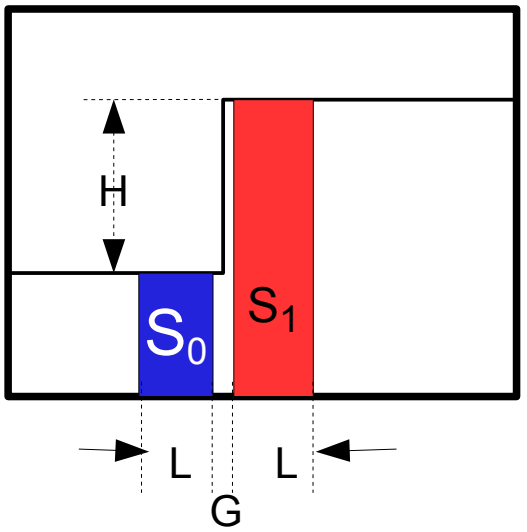
The KATRIN trigger in a nutshell



The KATRIN trigger in a nutshell

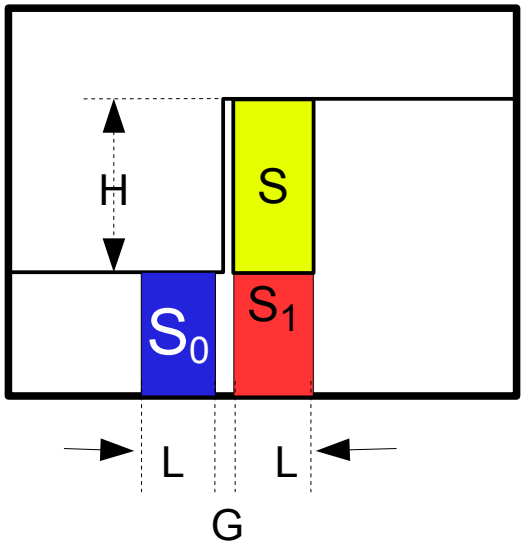


simplified step function with step height H

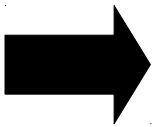


compute the sums S_0 and S_1

L: shaping length
G: gap

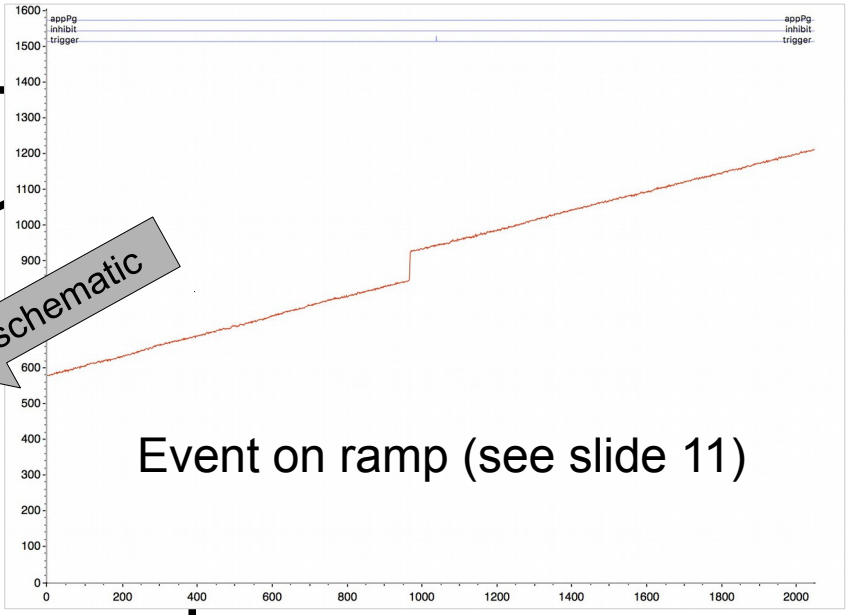


filter energy
$S := S_1 - S_0$



estimation for step height H (ADC energy) is
$H = S/L = (S_1 - S_0)/L$

The KATRIN trigger with Bias ramp



schematic

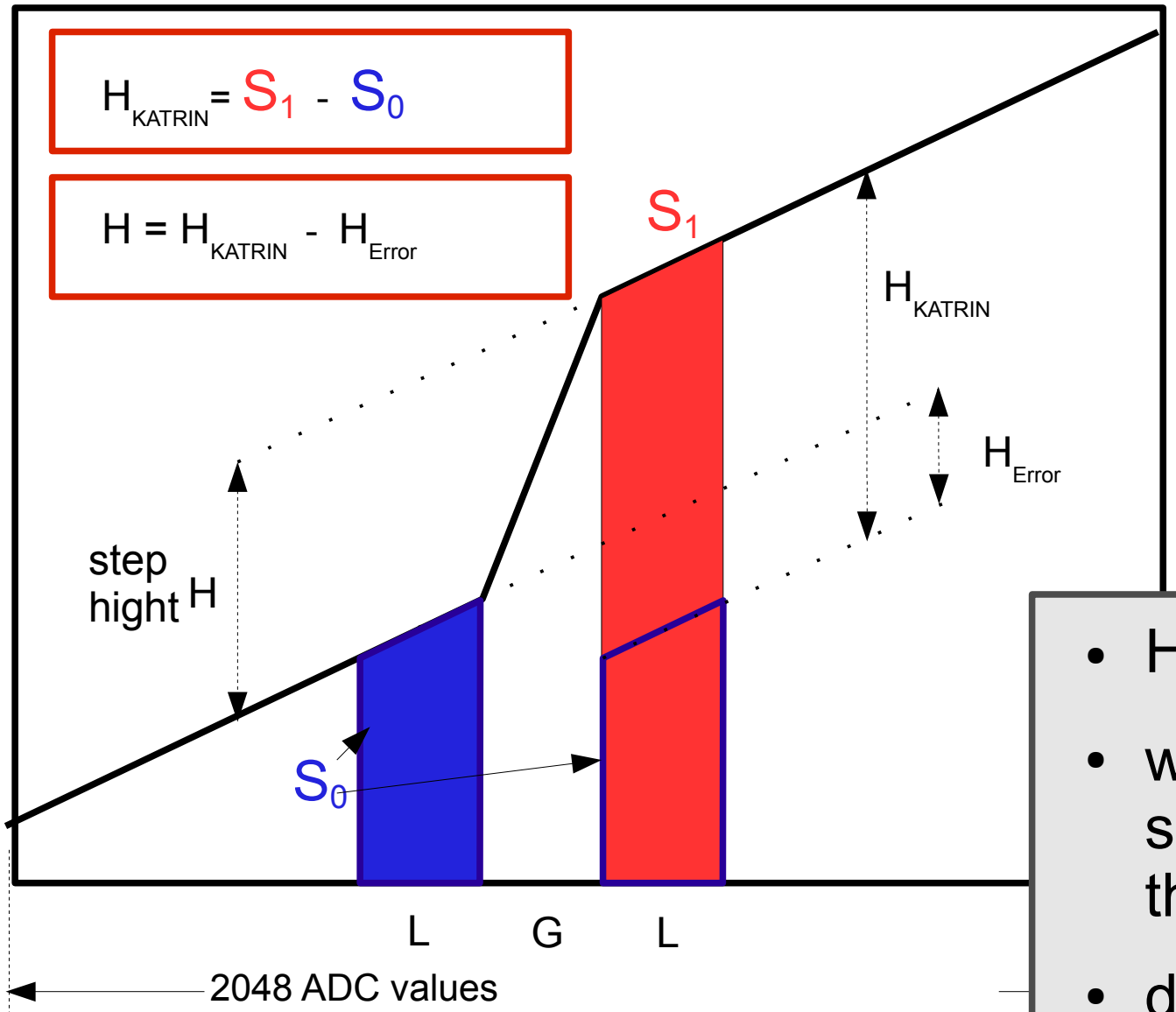
Event on ramp (see slide 11)

2048 ADC values

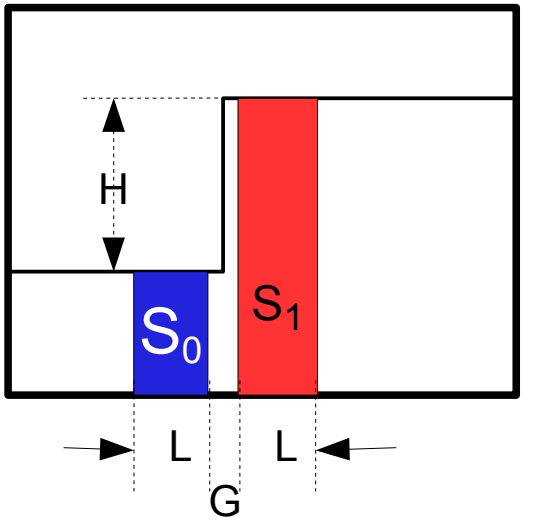
The KATRIN trigger with Bias ramp

$H_{KATRIN} = S_1 - S_0$

$H = H_{KATRIN} - H_{Error}$



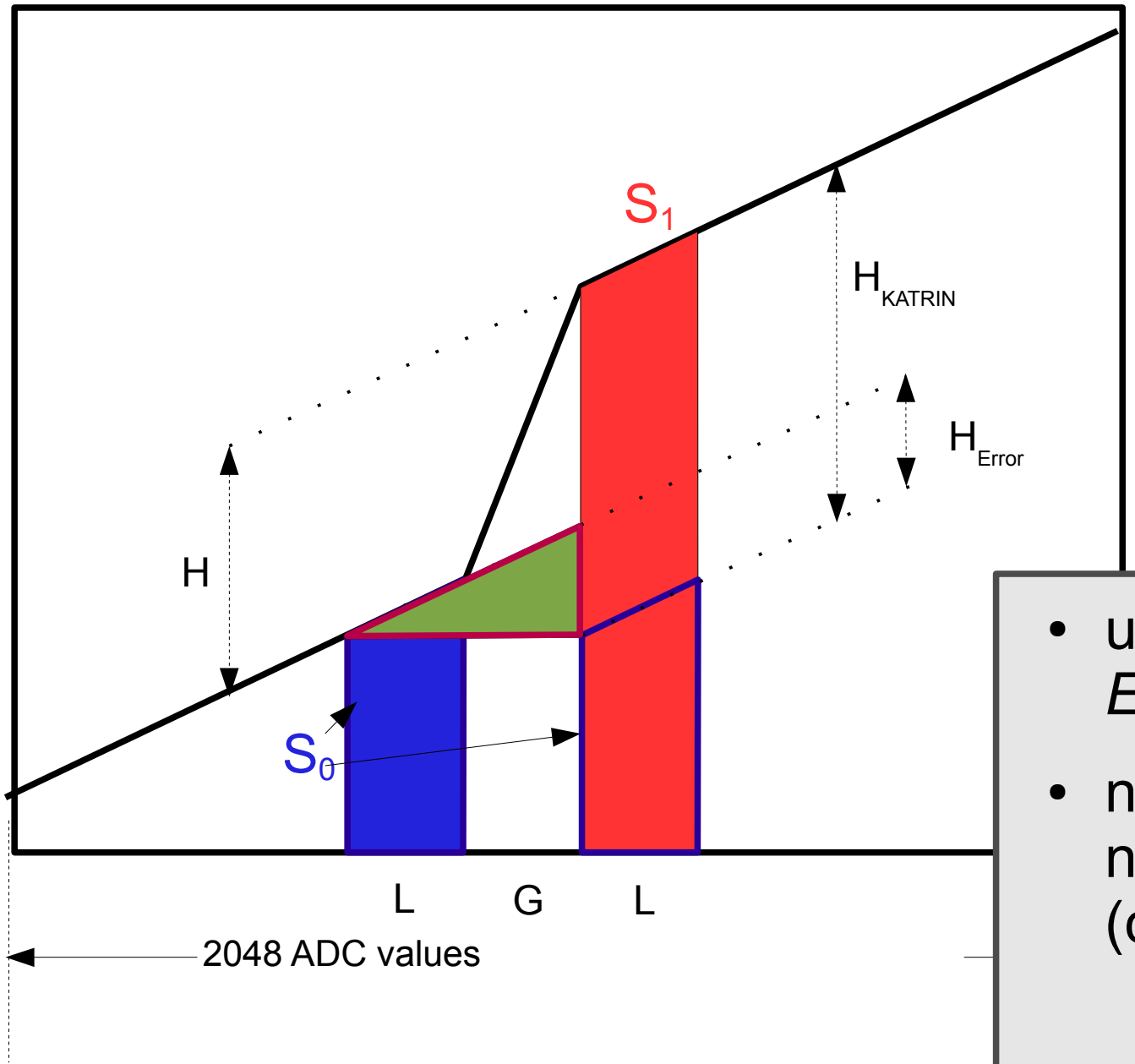
Reminder: without ramp

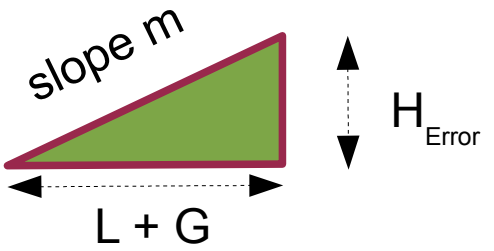


L: shaping length
G: gap

- H_{KATRIN} is larger than H
- will trigger on smaller thresholds than specified!
- depends on L and G! (see next slide)

The KATRIN trigger with Bias ramp





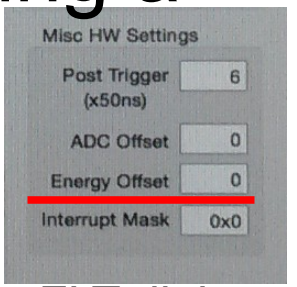
$$H_{Error} = m * (L + G)$$

$$H = H_{KATRIN} - H_{Error}$$
$$= H_{KATRIN} - m * (L + G)$$

- use FLT parameter *EnergyOffset*
- new firmware with negative values (currently testing)

Issues with IPE4 recording and solution

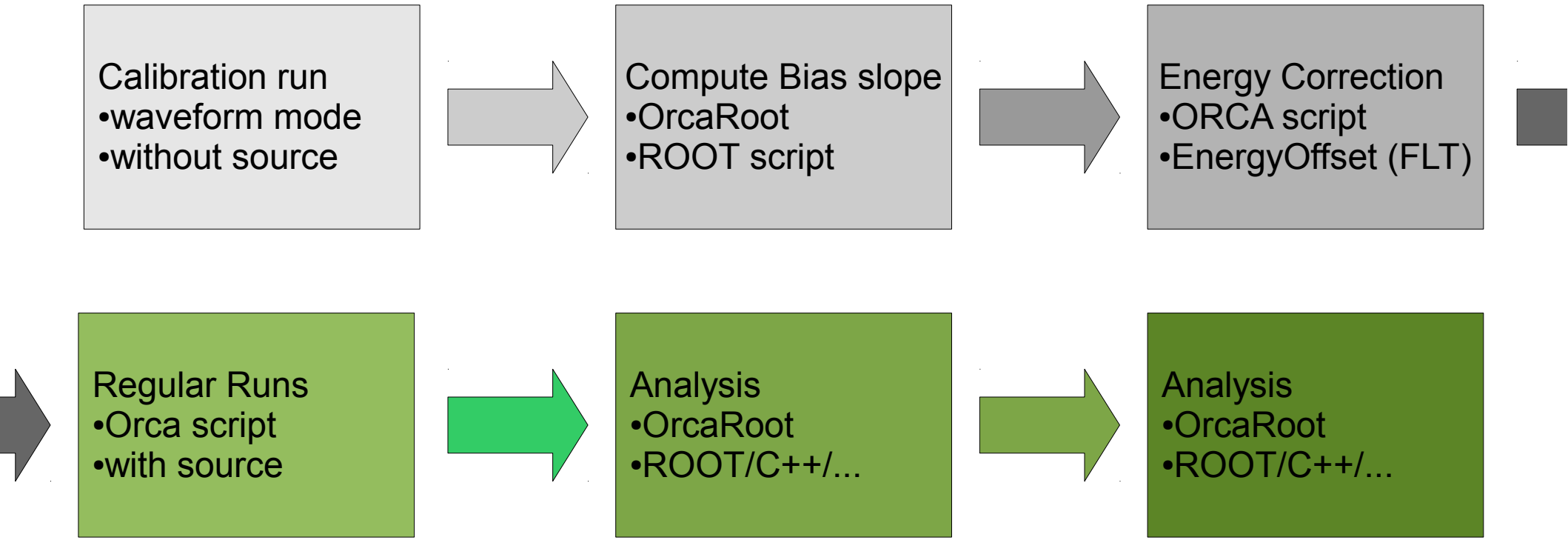
- Bias ramp exhausting the ADC range
  → effectively using only 7-8 bits of the 12 bit ADC
- KATRIN energy trigger: Bias ramp producing a constant energy offset
  → calibration and correction (FPGA level)



FLT dialog

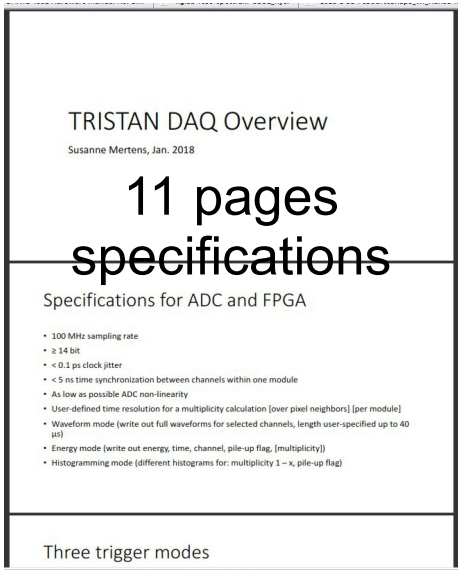
- Reset pulse (not critical, recorded as event with sharp energy distribution)
  → use analog inhibit signal (SLT lemo input)

Suggested DAQ Workflow



MTCA based TRISTAN DAQ ("IPE5 DAQ")

- MTCA = new DAQ standard (successor of VME etc.)
- Kickoff meeting 2018-02-02 in TRISTAN lab: Matthias Balzer, Denis Tcherniakhovski, Oliver Sanders (all KIT/IPE); Marc Korzeczek (KIT/IKP); Till Bergmann (MPP)
- Discussion of tech. specifications (11 pages, Susanne Mertens) and experience from test stand
- Plan: first prototype (7/32 chan?) April 2018, 168 channel prototype end of 2018



Conclusion

- IPE4 DAQ system upgrade
- Bias ramp: calibration, energy correction (new firmware). Inhibit during reset.
- Suggestions for MTCA development
  (Bias ramp: cancel out, 16 bit ADC or modified AC coupling?)
- Outlook: IPE4 calibration with Egun

Thank you for your attention!

Thank you for your attentior

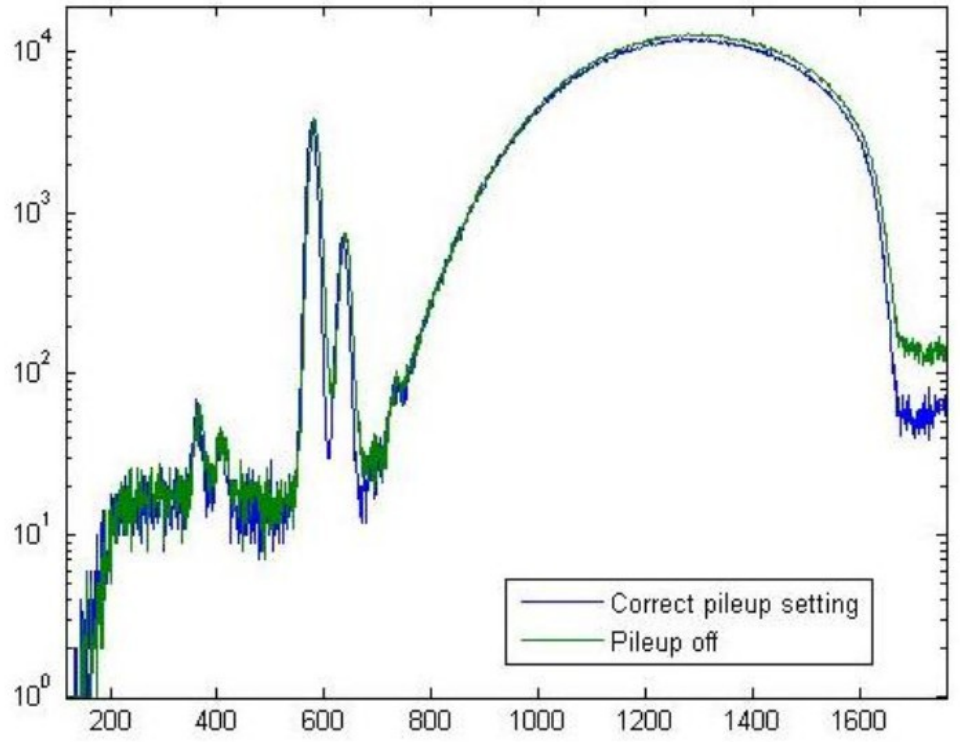
The END


Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

ENDE

BACKUP SLIDES

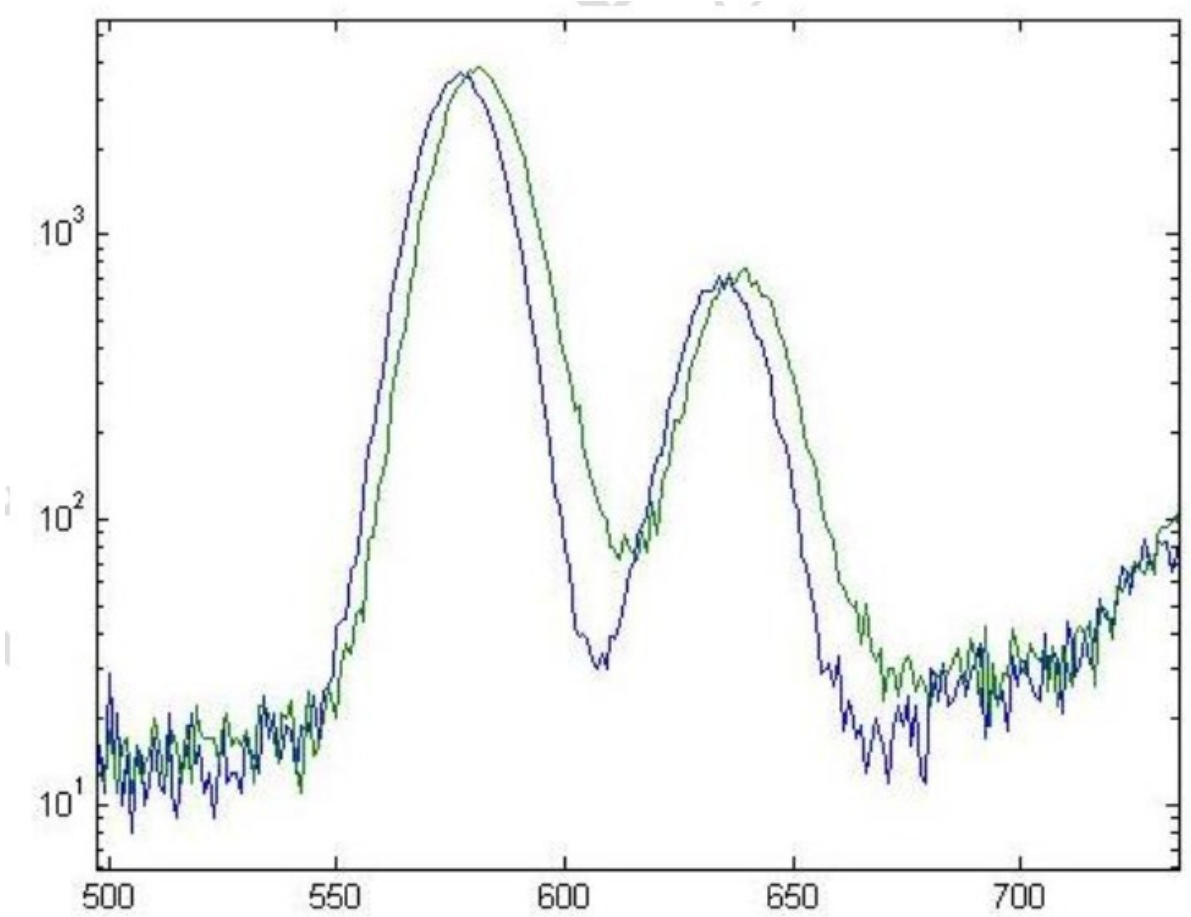
XGlab DANTE DAQ example



This measures has been taken with a Ketek 20mm^2 detector, a Fe55 source and an X-Ray Tube producing about 2.2 Mcps of ICR. The flattop was 224 ns and the peaking time 32 ns.

from the DANTE manual ...

XGlab DANTE DAQ example

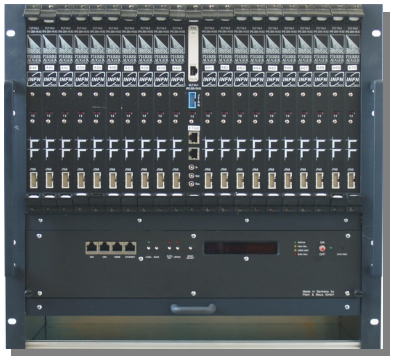


As you can see better from this figure there is an energy shift between the two and it is about 40 eV and also the resolution worsen of about 10 eV.

from the DANTE manual …
pileup detection ...

TRISTAN Test Stand at KIT

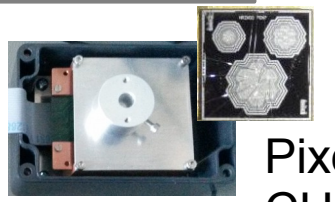
MacMini
ORCA



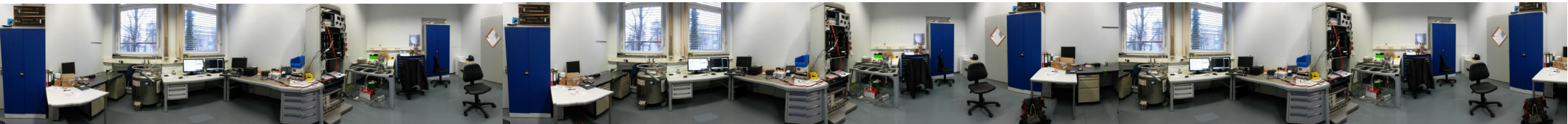
IPE4 Crate

DANTE DAQ

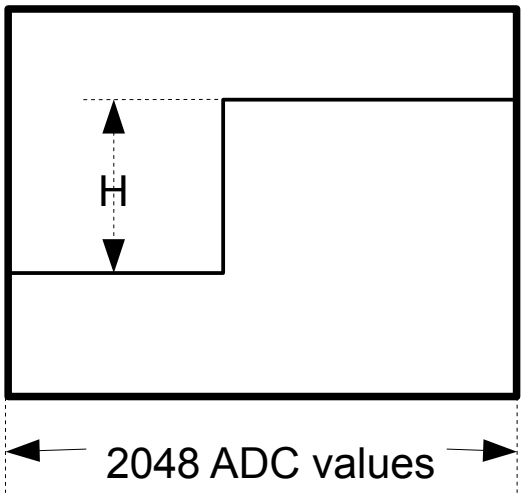
Bias Board



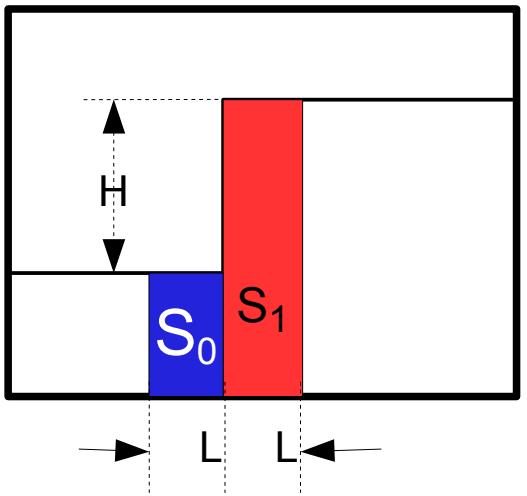
Pixel detector +
CUBE ASIC +
Fe55 source



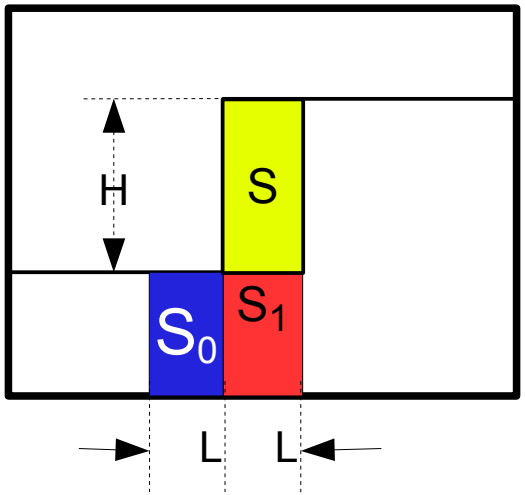
The KATRIN trigger in a nutshell



simplified step function with step height H



compute the sums S_0 and S_1

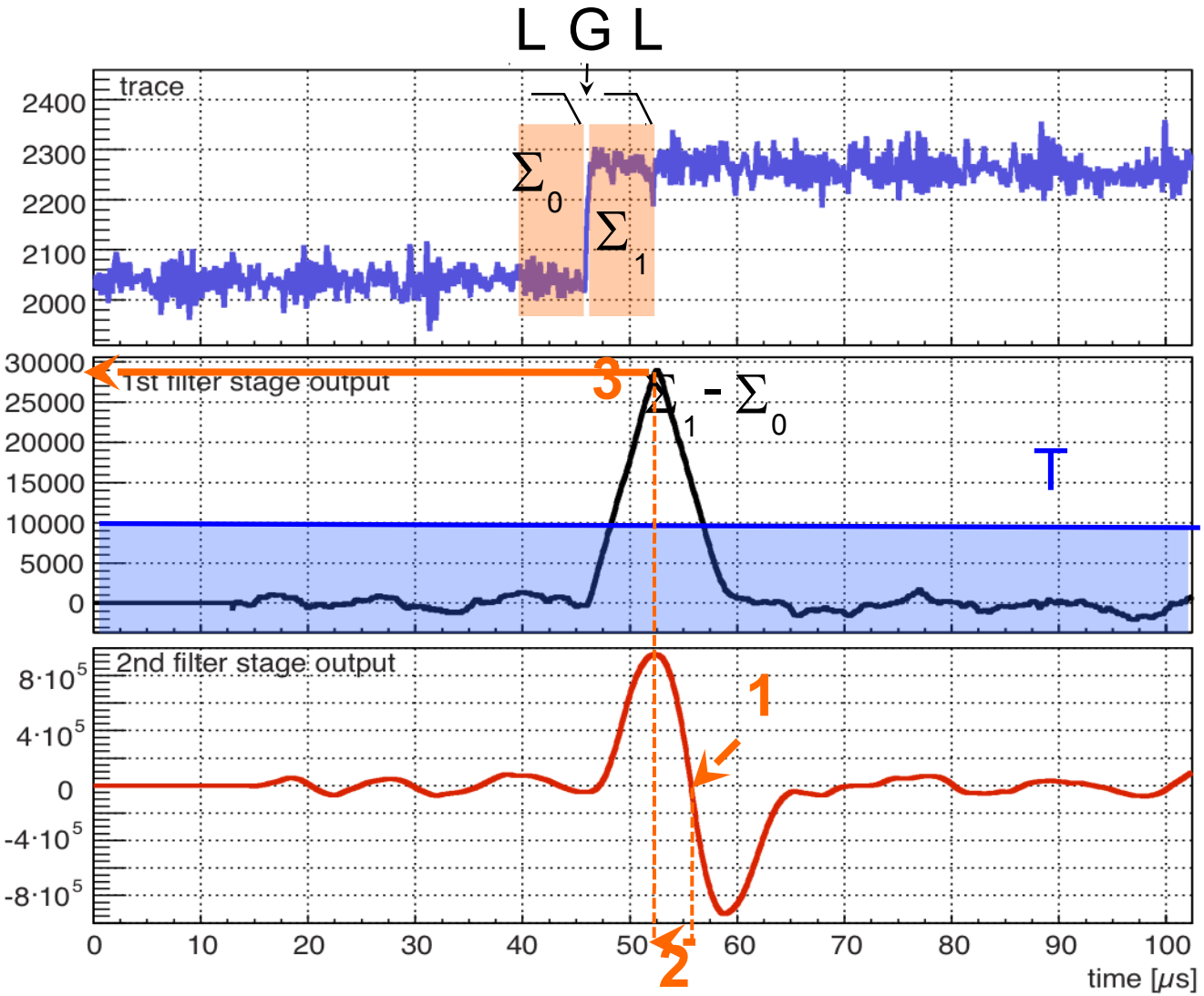


filter energy
$S := S_1 - S_0$

estimation for step height H (ADC energy) is
$H = S/L = (S_1 - S_0)/L$

KATRIN trigger example

(without bipolar extension)



L: shaping length

G: gap length

T: threshold

1 determine zero-crossing

2 go back L/2

3 determine energy