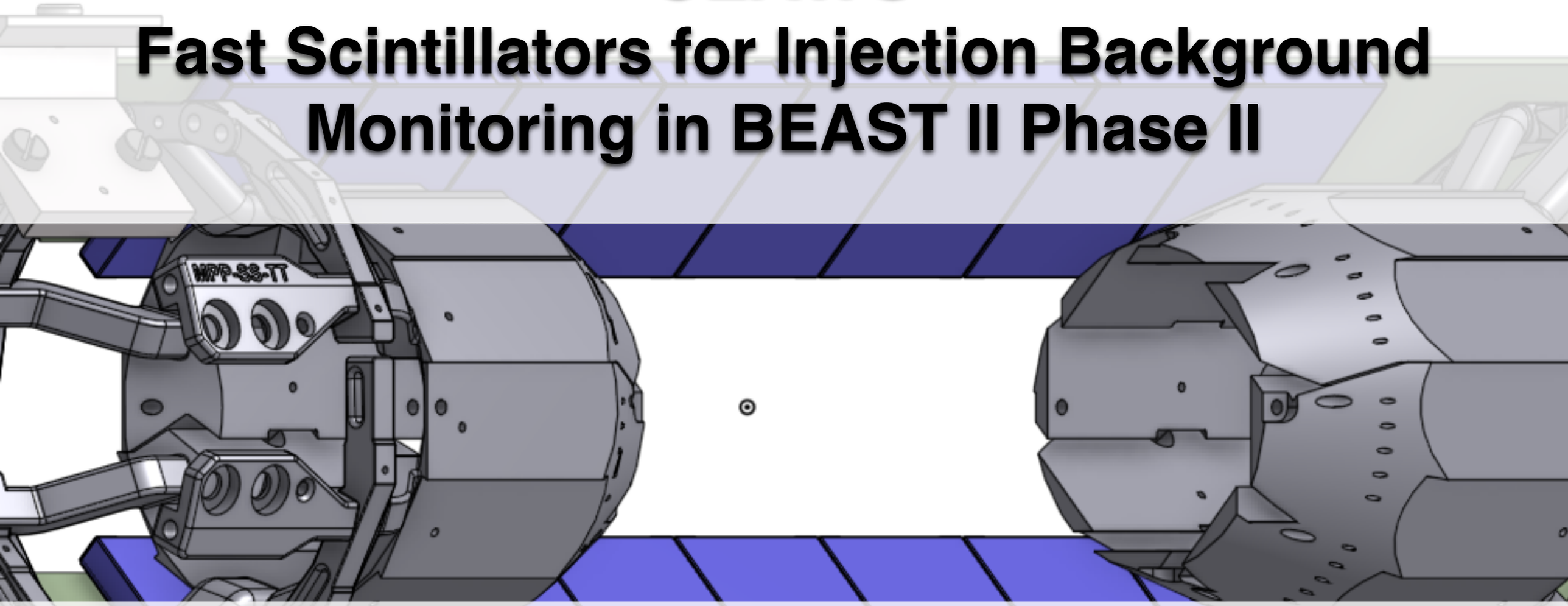
CLAWS
Fast Scintillators for Injection Background Monitoring in BEAST II Phase II



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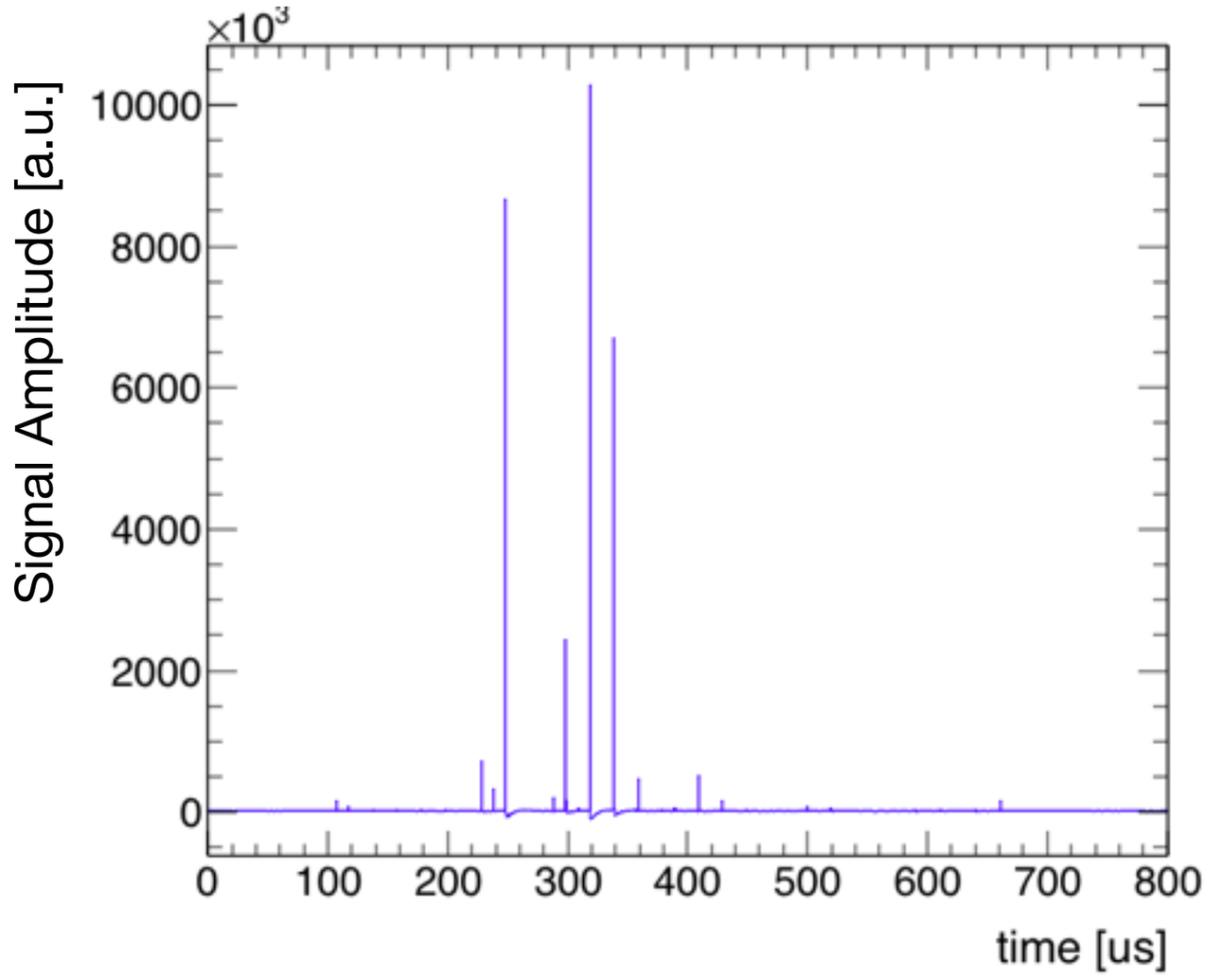
Scintillation *L*ight *A*nd *W*aveform Sensors (CLAWS)

Goals of CLAWS in Phase II:

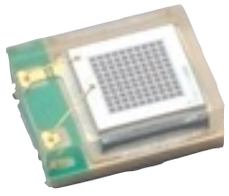
- Measurement of background time dependence in PXD region
  - Decay behaviour from injection bunches relative to normal bunches
- Change in injection conditions: Phase I vs Phase II
- Evolution over several BXs & many turns
  - Requires sampling over extended times - up to multiple *ms*



Background averaged over 3 channels and multiple injections (phase I)

Setup & Readout Chain

Sensors | **Dock Box** | **Scope & PSU** | **DAQ**



Setup & Readout Chain

Sensors

Two Sensor Ladders - 8 Channels Each:

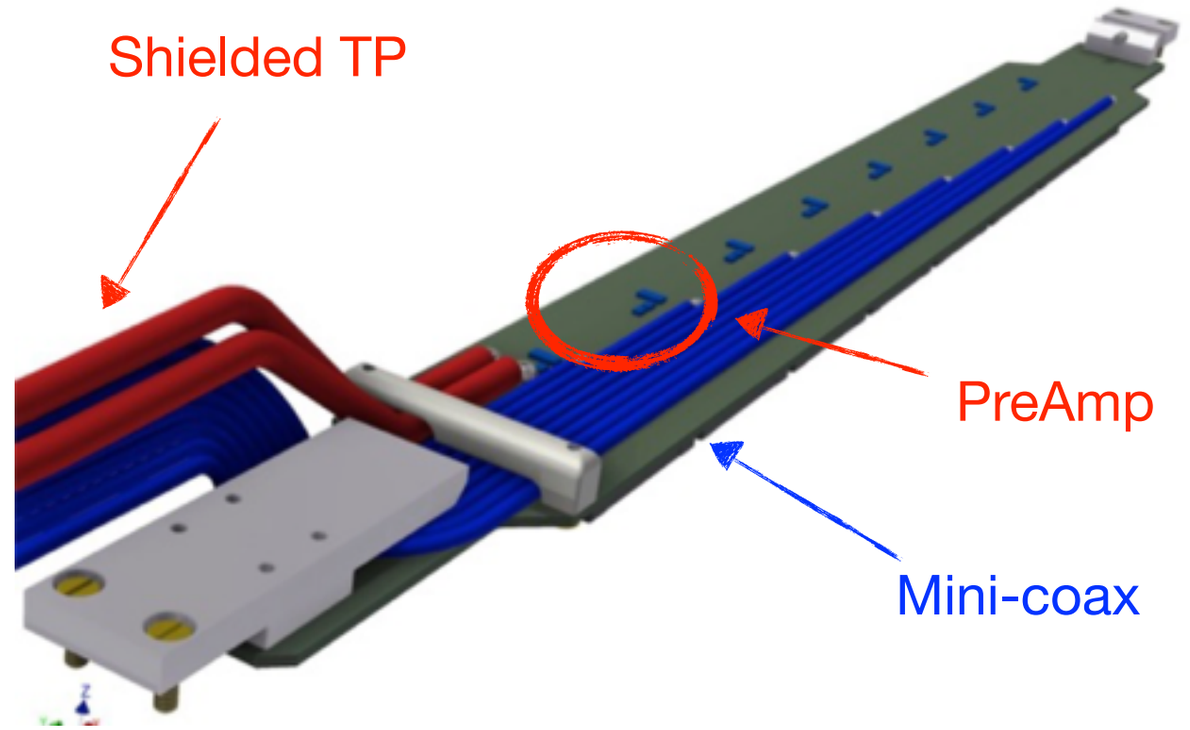
- Mechanical support entirely by PCB
- Channel composition:
  - Scintillating tile: 20x20x3 mm^3 BC-408
  - SiPM: MPPC S13360 1325PE
  - PreAmp: 20 dB ~ factor 10

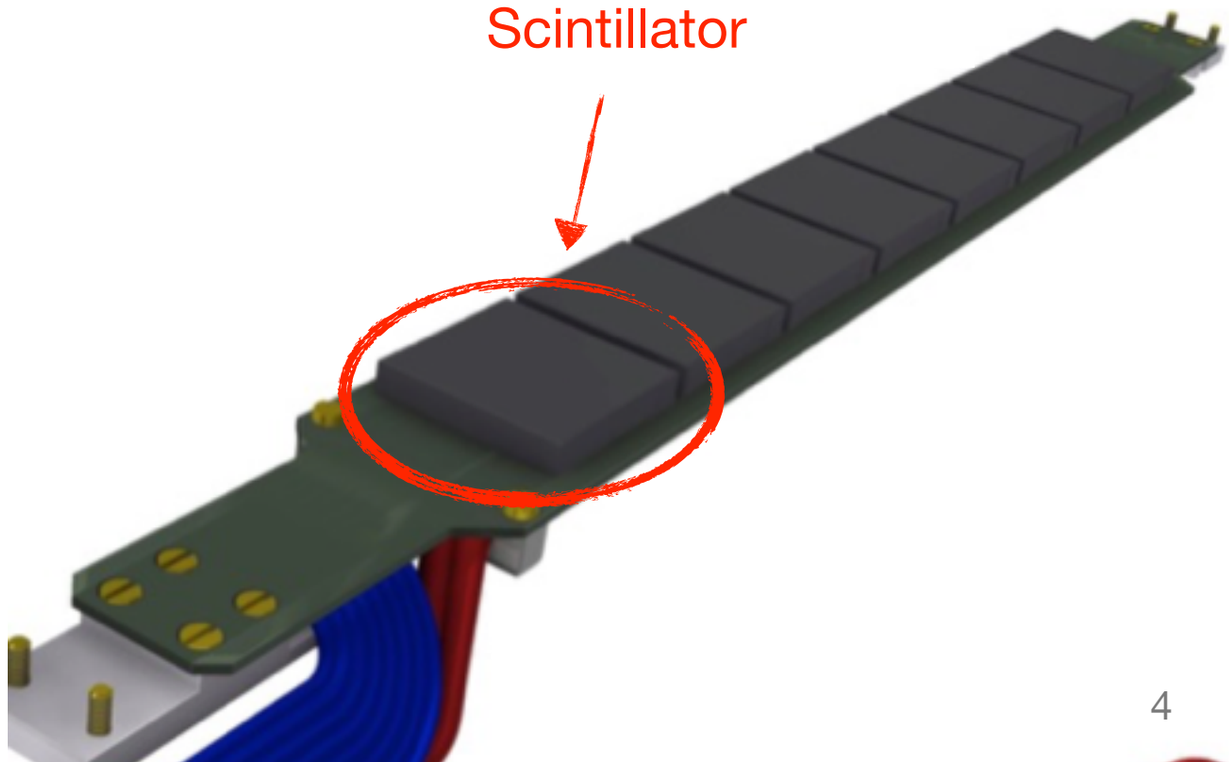
New High-Gain/Low-Gain Settings:

- Bypass PreAmp - switchable from remote O(1 min)

Power Consumption:

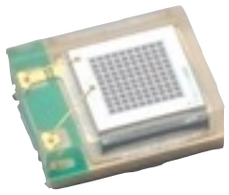
- Major power consumer: PreAmps ~ 40 mA @ 5 V (rest negligible)
- Total: ~2 W / ladder





SiPMs: Temperature & Noise Rate

Sensors



Hamamatsu MPPC-S13360-1325PE

SiPMs:

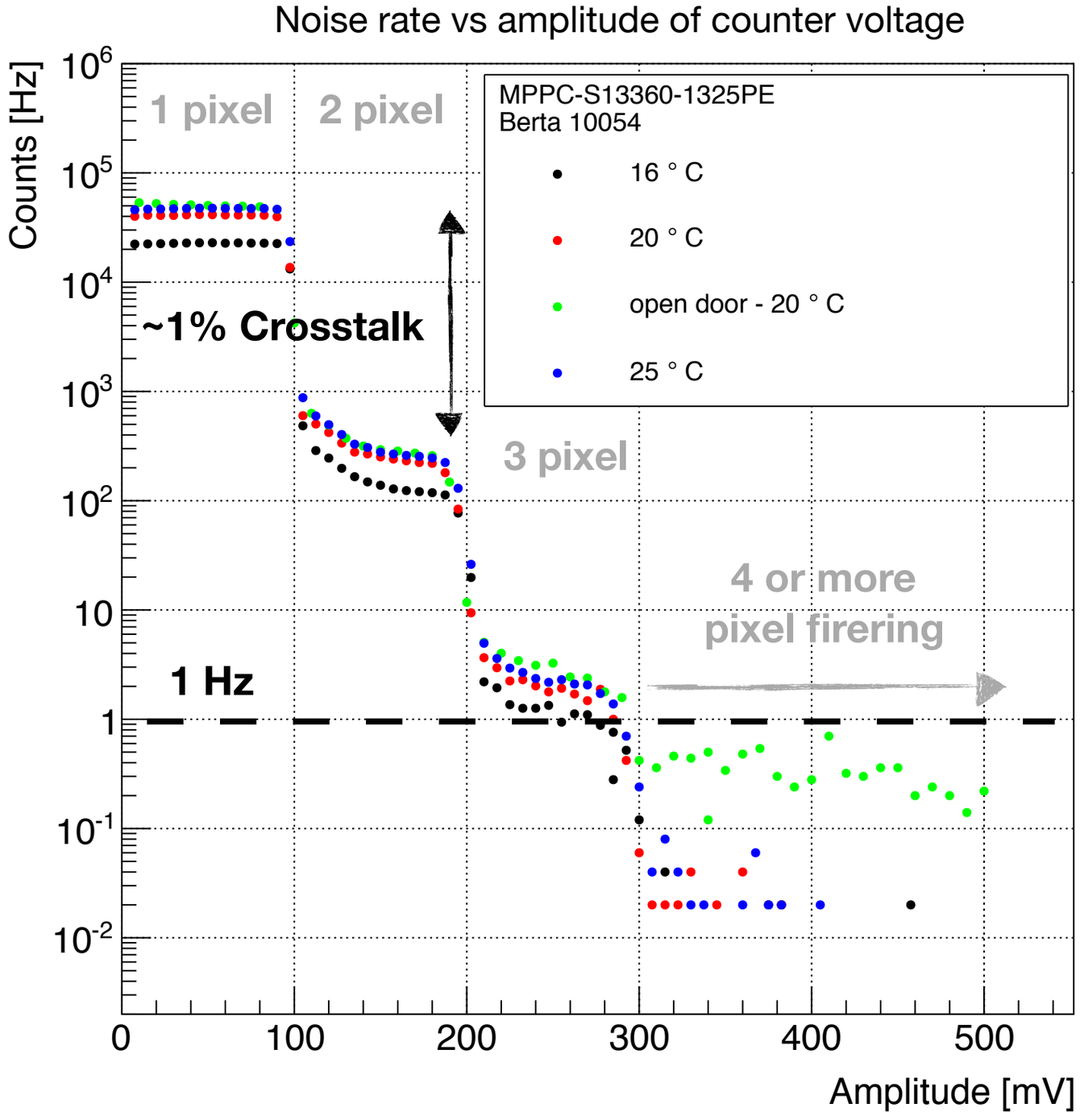
- Active area 1.3x1.3 mm^2
- Large dynamic range - 2668 Pixel

Sensor Noise:

- 1 photon event noise rate < 100 kHz
- 4 photon event noise rate < 1 Hz
- Expected MIP response: ~15 photons
- Cut on 4 photons - **basically no noise**

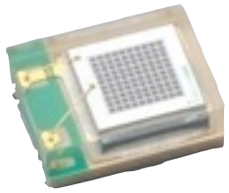
Impact of Temperature Change:

- Higher noise rate: **no issue**



SiPMs: Temperature & Amplitude

Sensors



Sensor Amplitude:

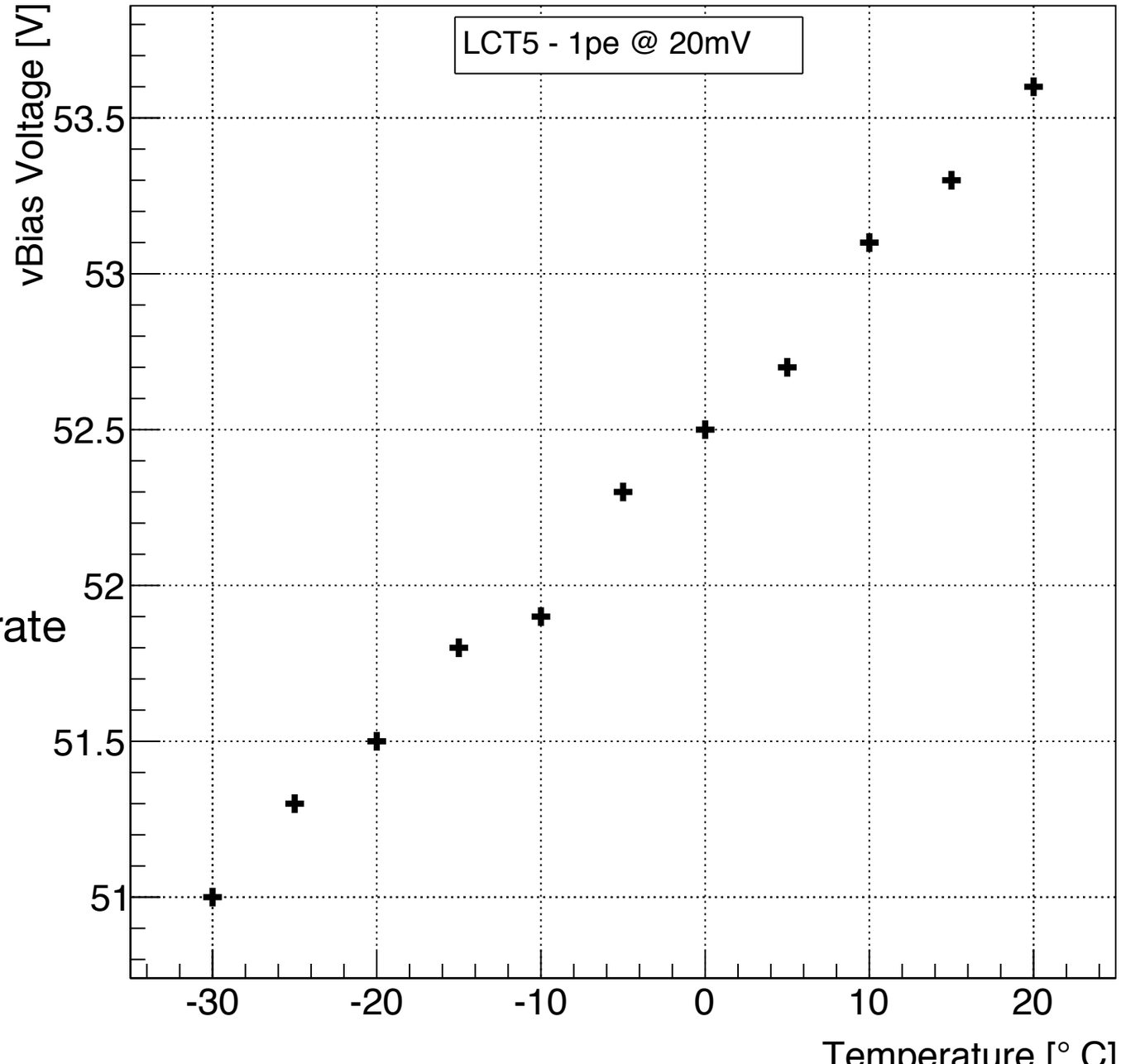
- Constant V_{Bias} but change in temperature:
  - Signal amplitude changes
- Calibration run (O(2 min)) every ~ 30 minutes:
  - Measure amplitude change - calibrate temperature effect

Impact of Temperature Change:

- Slow change: **No issue**
- Change ~ few degrees: **No issue**

V_{Bias} needed for 1 pixel/photon amplitude of 20 mV

LCT5 - similar 1325PE



Setup & Readout Chain

Dock Box

Dock Box Design:

- Box in box: aluminium box coated with capton inside Dock Box - electrically isolated
- 16 Amplifiers inside box: 1 per channel - ~ 20 dB amplification
- Minor cable patching

Power Consumption:

- 16 Amps: 80 mA @ 15 V
- Total: 20 W peak consumption

Setup & Readout Chain

Scope & PSU

4 Picoscope 6404D Oscilloscopes for Signal Digitization (2 from phase I, 2 new):

- 4 full channels + ext. trigger / scope
- 8 bit vertical resolution
- 5 Gs/s (1.25 Gs/s per channel) sampling rate - fast timing
- 2 GS Ultra deep memory - extended sampling
- 50 ms “waveform” successfully taken in phase I
- Control & Readout via USB 3.0 - 4 oscilloscopes connected to DAQ workstation
- Only 2 scopes available at DESY test beam

Keysight N6700 PSU:

- 4 channels: 1xVPreAmp, 1xVAmps, 1xVBiasLadder1, 1xVBiasLadder2
- Reused from Phase I - no problems encountered
- Control & Readout via DAQ workstation

Setup & Readout Chain

DAQ

CLAWS Phase II Workstation & DAQ:

- Same workstation as in phase I - possible ram and storage upgrade
- DAQ: Modification of phase I DAQ based on LabVIEW - extended to 4 scopes
- Communication with other systems via Experimental Physics and Industrial Control System (EPICS)

Triggering & Timestamping:

- Trigger via external signal connected to ext. trigger of each scope
- Phase I: Timestamp via common Beast time server - accurate to ~ 10 ms
- CLAWS trigger in phase II is a remaining an issue!

Cabling & Rack Space

Cables - Ladder to Dock Box:

- Signal micro-coax: made from Peek, 2 m (?), outer diameter = 1mm
- V_{Bias} : shielded Twisted Pair, 2 m (?) , outer diameter 3.5mm
- V_{PreAmp} : shielded same

Cables - Dock Box to Electronic Hut:

- 16x RG174: 30m, like RG174 but LSZH, outer diameter = 2.6 mm
- 3xTP: 30m, 2x8 cores, outer diameter = 15mm
- 2xTP: 30m 2x2 cores, outer diameter = 8mm

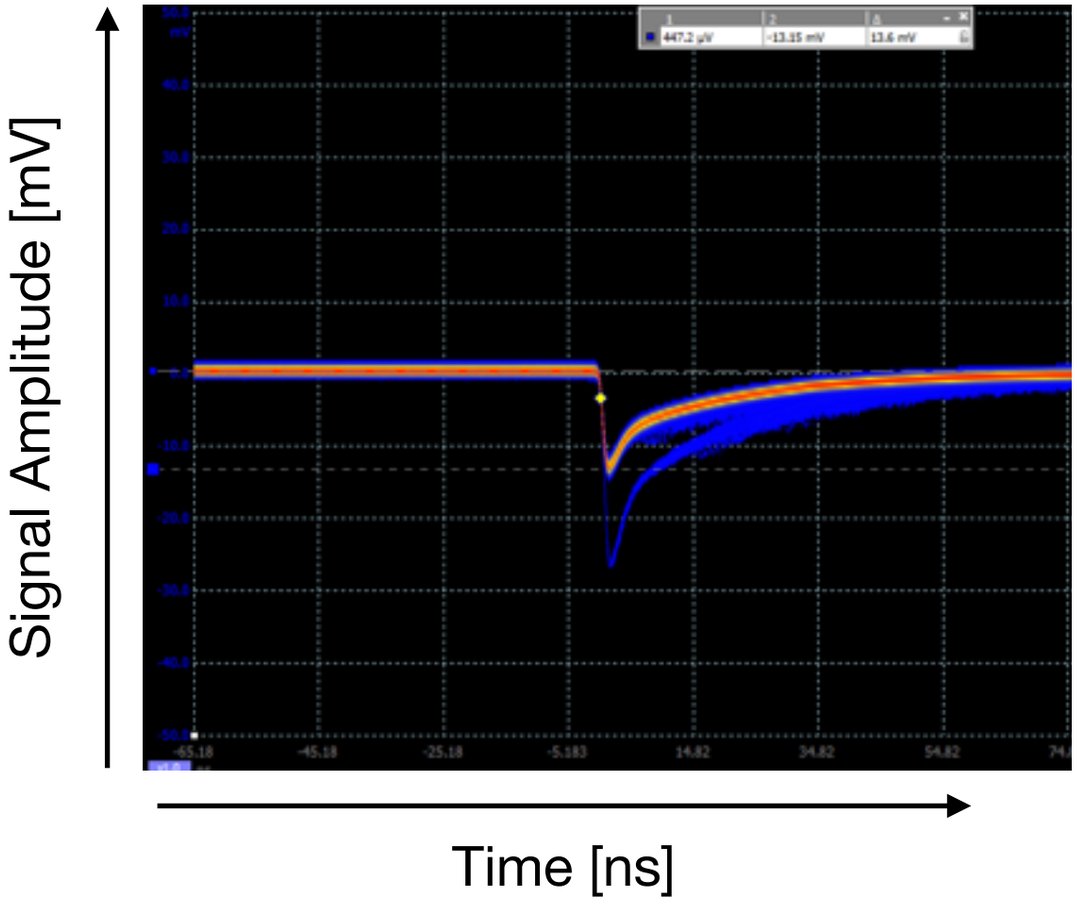
All cables will be LSZH!

Rack Space:

- Workstation: rack mountable 1U
- PSU: rack mountable 1U
- 4x scopes: on top of workstation, 3-4 U

Calibration & Analysis

1 Pixel noise signal - 1 photon equivalent



Dedicated calibration runs every ~ 30 minutes:

- 1 photon events from noise
- 1000 events / channel: O(2 mins)
- Extract average 1 photon waveform for each channel

Channel wise reconstruction:

- Iterative subtraction on raw waveform yields total amplitude & timing

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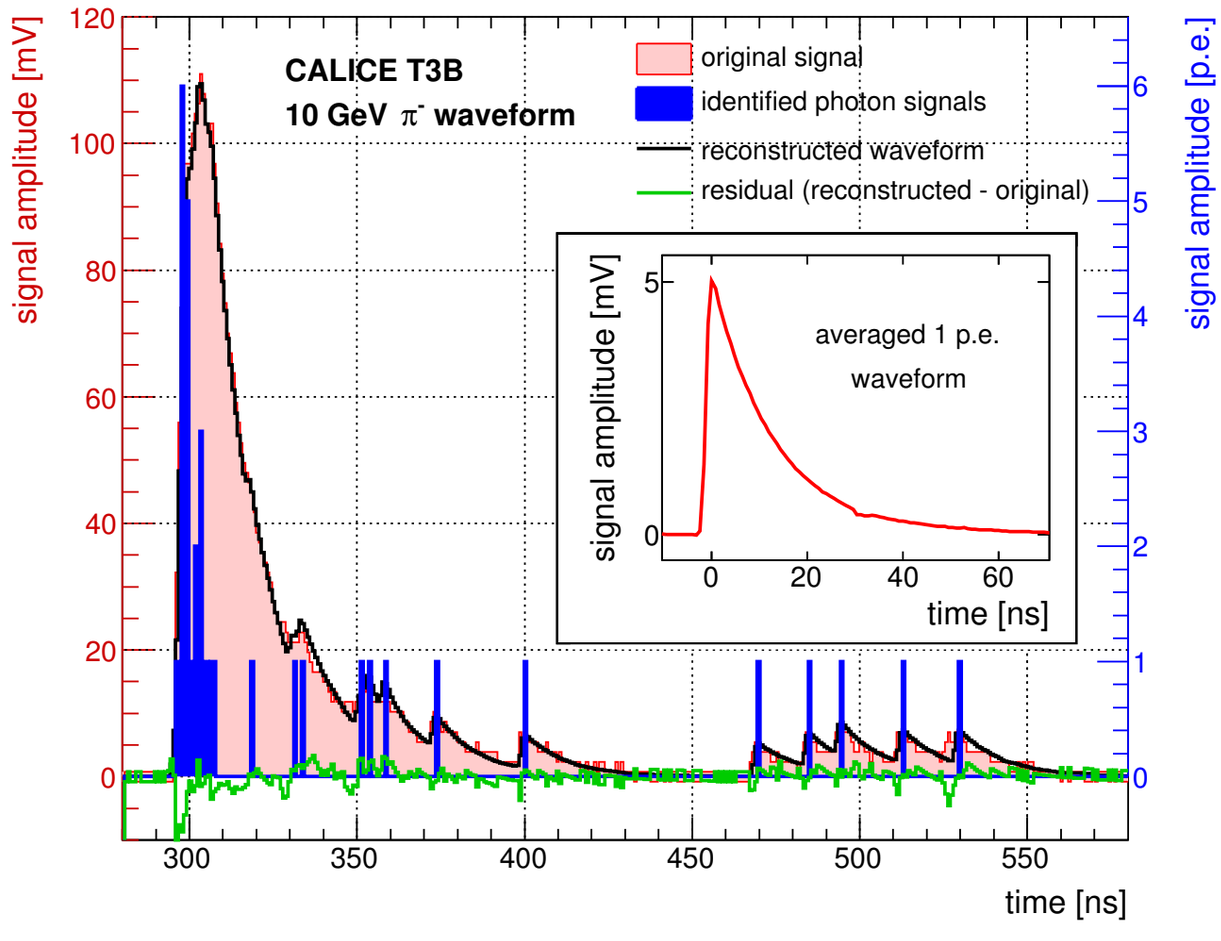


Hardware Status

Sensor Ladders:

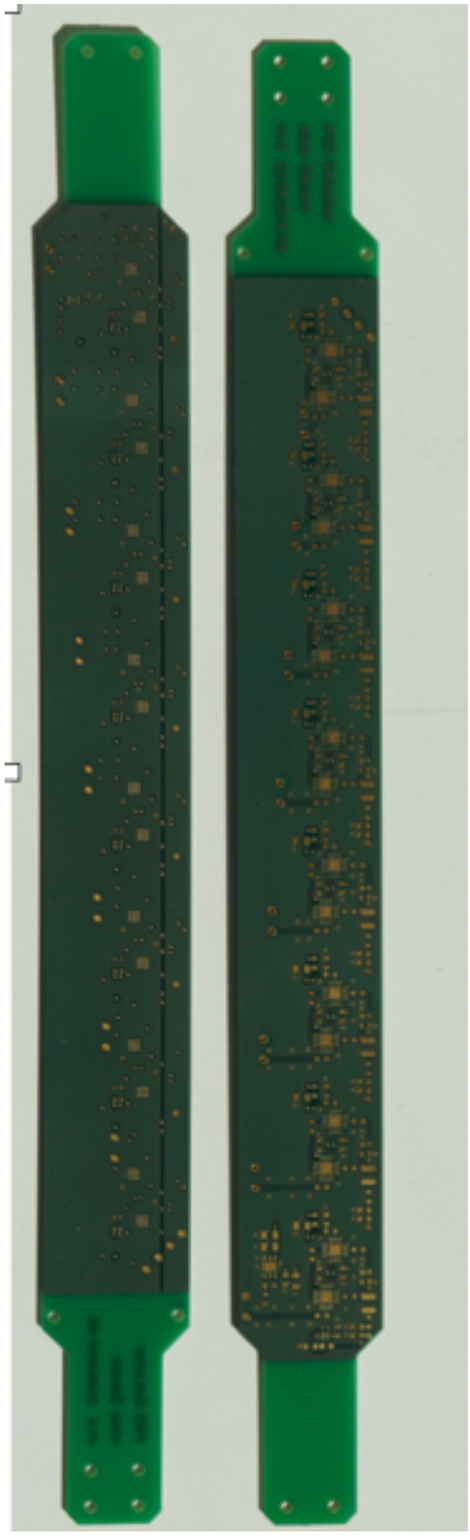
- PCB: manufactured and delivered
- SiMPs + Elect. Parts: delivered
- Scintillators: manufacturing - ready until mid October
- First board ready by end of this week - begin commissioning next week

Cables:

- Dock Box to E-Hut:
  - LSZH signal cables order: delivery this week
  - Signal cables for DESY: ready
  - Power cables: partially ready/ being manufactured
- Sensors to Dock Box:
  - Mini-coax: cable at the institute - SMA connectors minor issue
  - Power cables: searching for supplier - in contact with several suppliers

Dock Box:

- Amplifiers: delivered
- Box, connectors & inside patch panels: being designed - focus hardware efforts



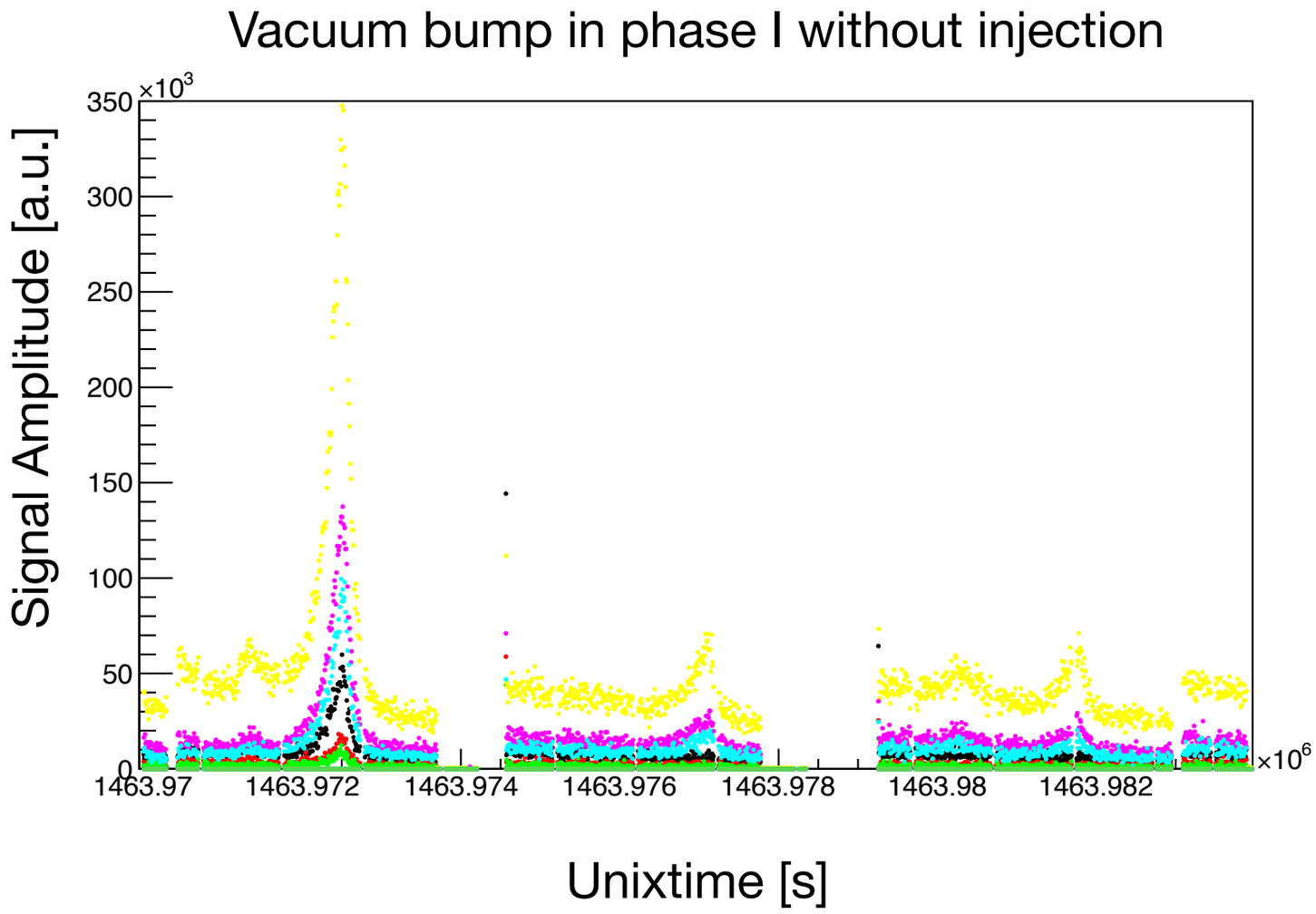
Summary & Outlook

Hardware:

- Hardware processing well
- Almost all cables at hand/ awaiting delivery
- Hardware focus on finalising design inside Dock Box & commissioning

Triggering & Timestamping:

- Open issue

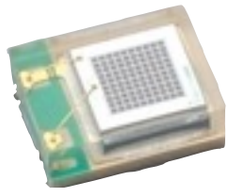


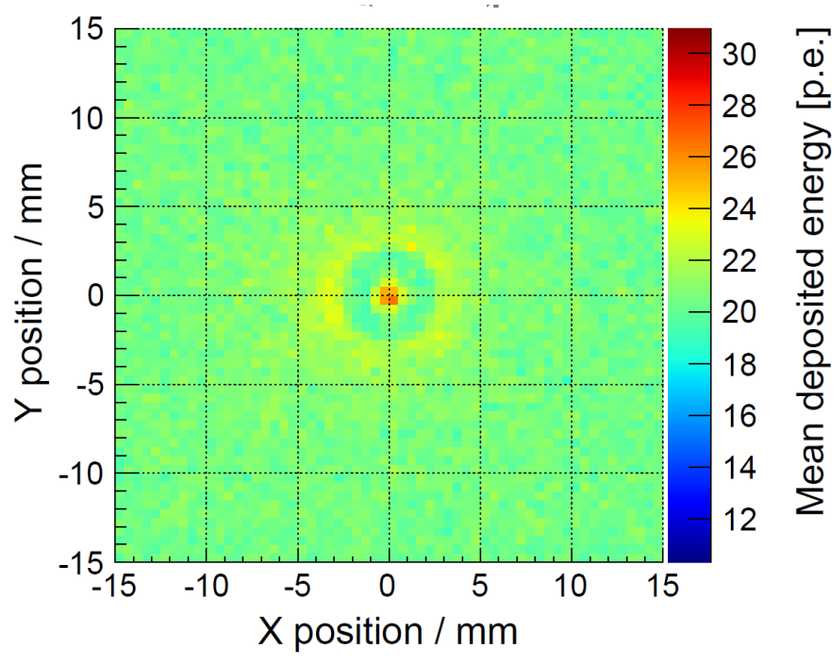
Backup

Backup

Silicon Photomultipliers: Temperature Stability

Sensors

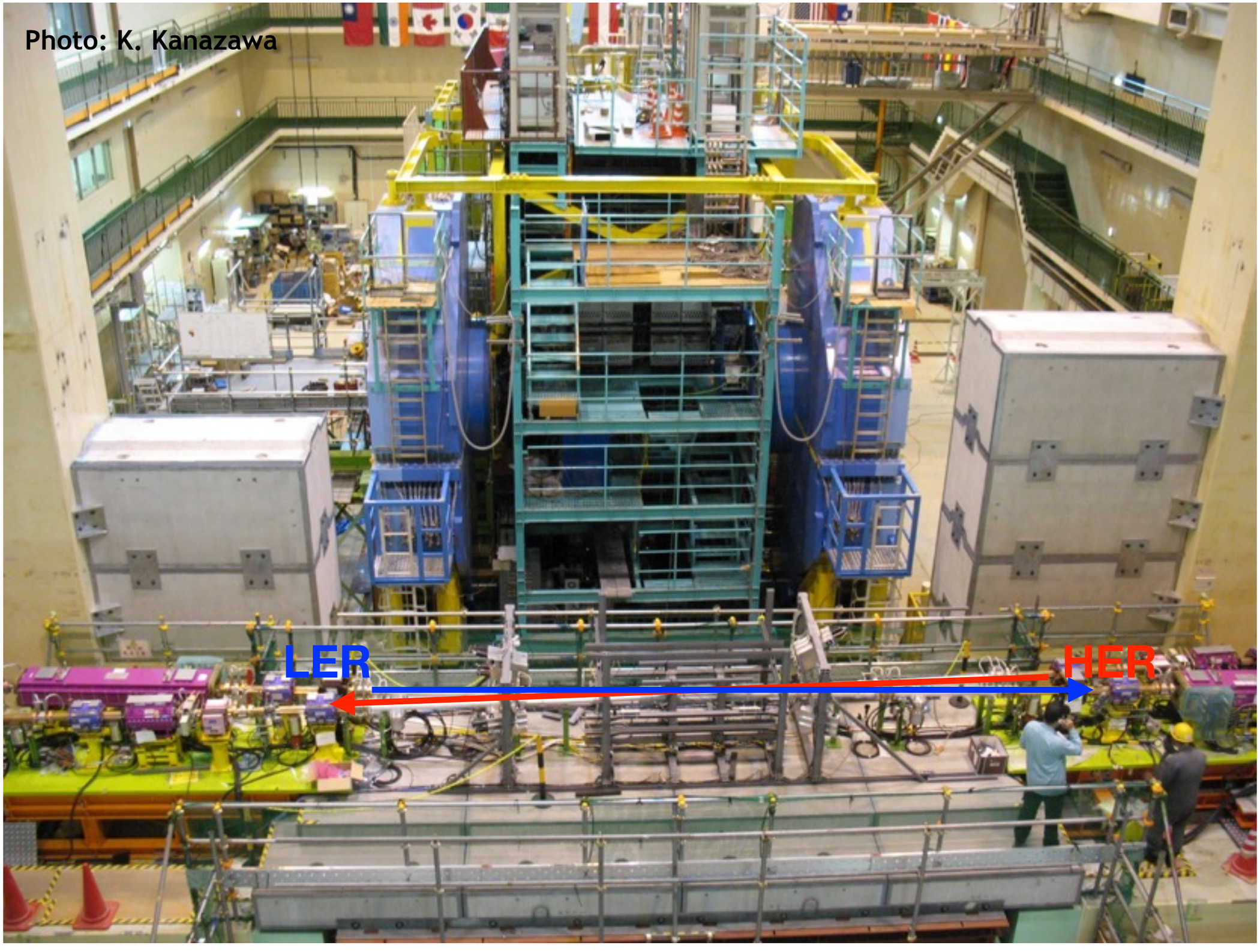




Hamamatsu MPPC-S13360-1325PE SiPMs:

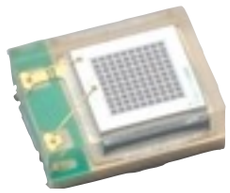
- Active area 1.3x1.3 mm^2
- Dramatically reduced noise :
  - 1 photon event < 100 kHz
  - 4 photon event at the same time < 1 Hz
- Substantially larger dynamic range (2668 Pixel)
- Overall very good uniformity of gain of detectors when operated with same bias voltage

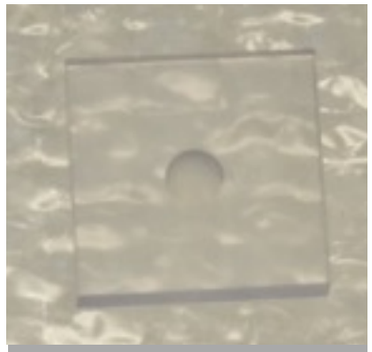
Beast II



Silicon Photomultipliers & Scintillating Tiles

Sensors





Unpackaged Scintillator

Pre-Amplifier Board

Packaging Material

Fully Packaged

Hamamatsu MPPC-S13360-1325PE SiPMs:

- Active area 1.3x1.3 mm^2, 2668 pixel
- Ultra low noise rate (1 photon rate < 100 kHz, 4 photon rate < 1 Hz)

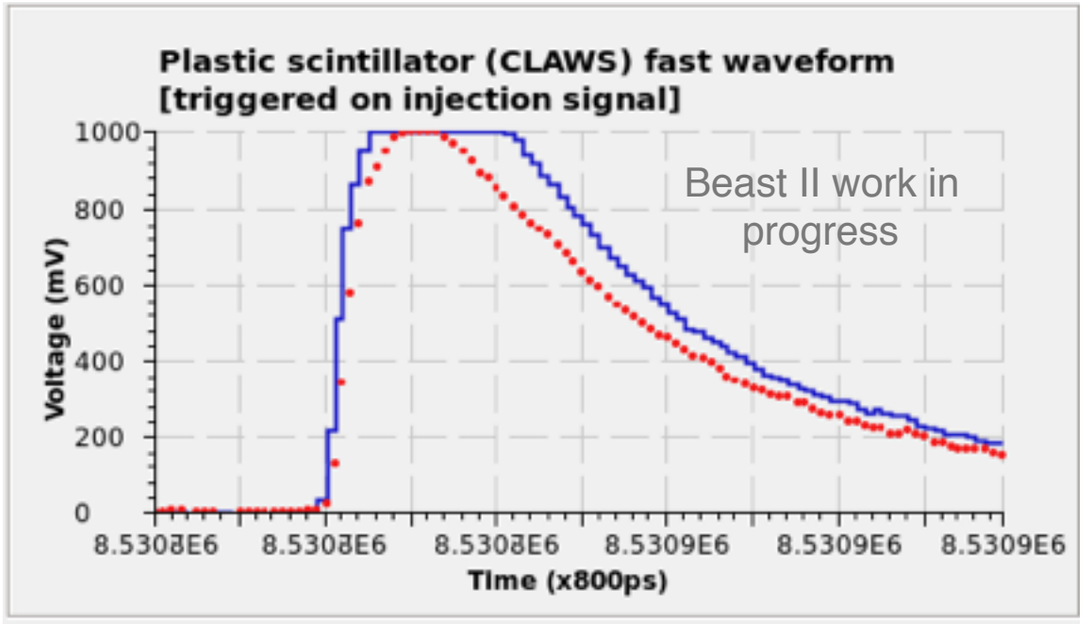
Polystyrene Scintillator Tiles:

- 30x30x3 mm^3 + half sphere
- Radiation hardness > 1MRad
- ~18 photons/MIP (^{90}Sr & cosmic tests)

Pre-Amplifier :

- Closest possible mounting to SiPM (improved S/N)

SuperKEKb LER Commissioning: First Signals



~ 200 ns

Feb 1st:

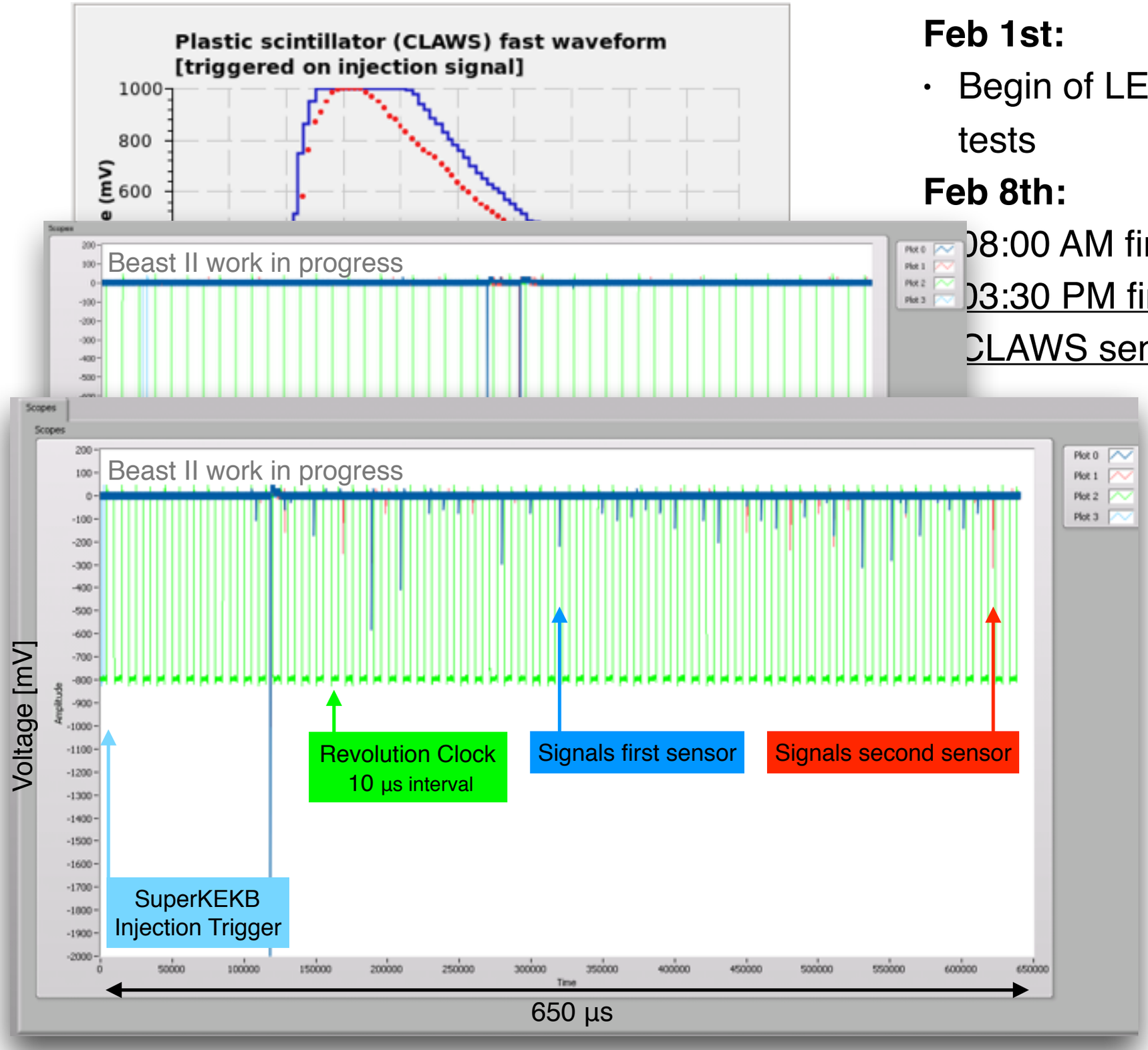
- Begin of LER commissioning with linac tests

Feb 8th:

- 08:00 AM first positron injections into LER
- 03:30 PM first coincidental signals in two CLAWS sensors

First Particles at the IP of SuperKEKb!

SuperKEKb LER Commissioning: First Turns



Feb 1st:

- Begin of LER commissioning with linac tests

Feb 8th:

08:00 AM first positron injections into LER

03:30 PM first coincidental signals in two CLAWS sensors

Feb 9th:

- 05:20 PM First turns can be seen in SuperKEKb
- 05:30 4 Turns
- End of the day more than 50 have been reached