March 03 2016

Scintillator tiles with SiPM readout for calorimetry and fast timing in SuperKEKB commissioning

Outline

- Setup and DAQ for Scintillator and SiPM Studies
- Scintillator Studies
- Application in the SuperKEKB accelerator
- Outlook

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

Frühjahrstagung der DPG - Hamburg 2016

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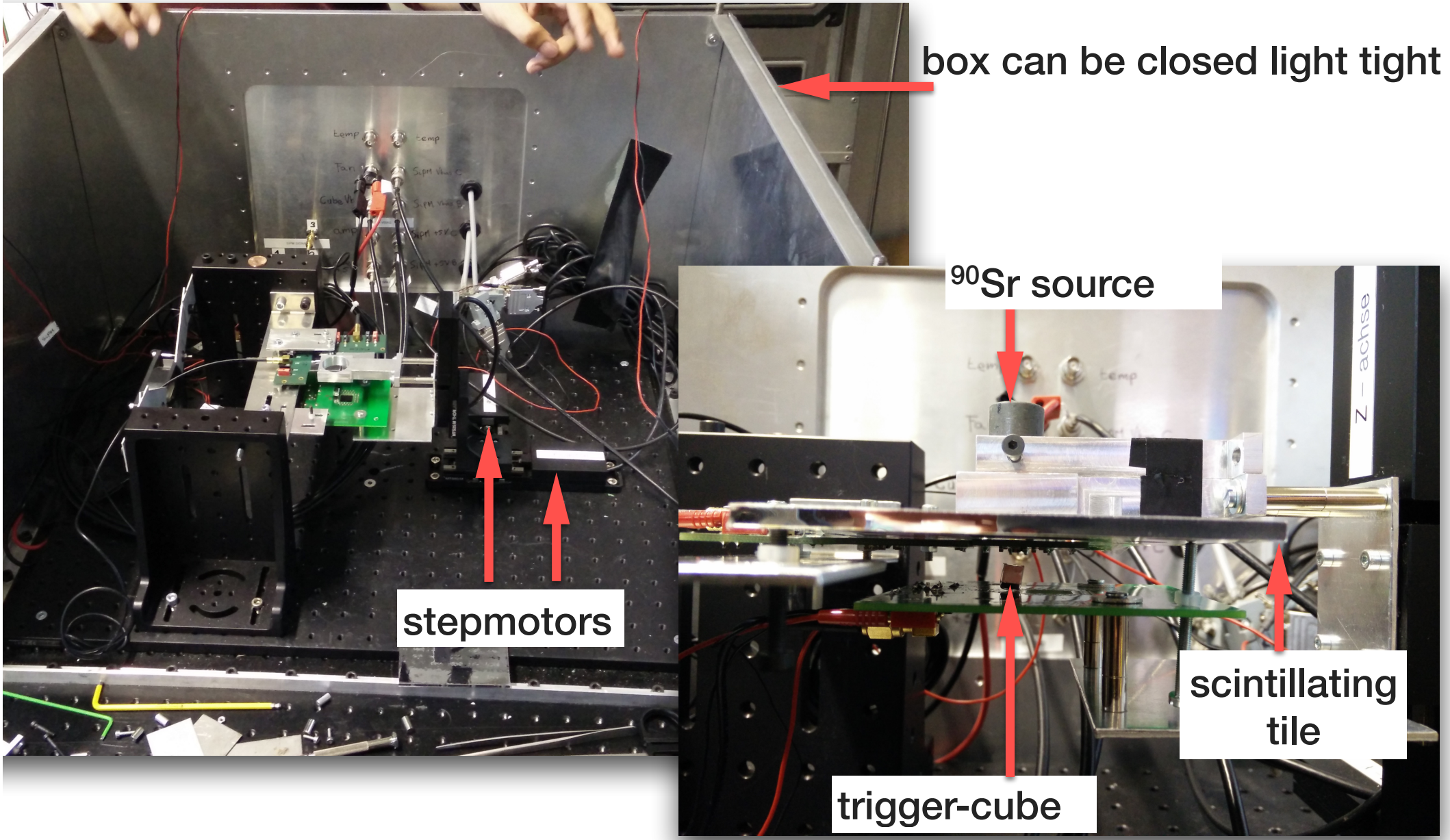
Motivation

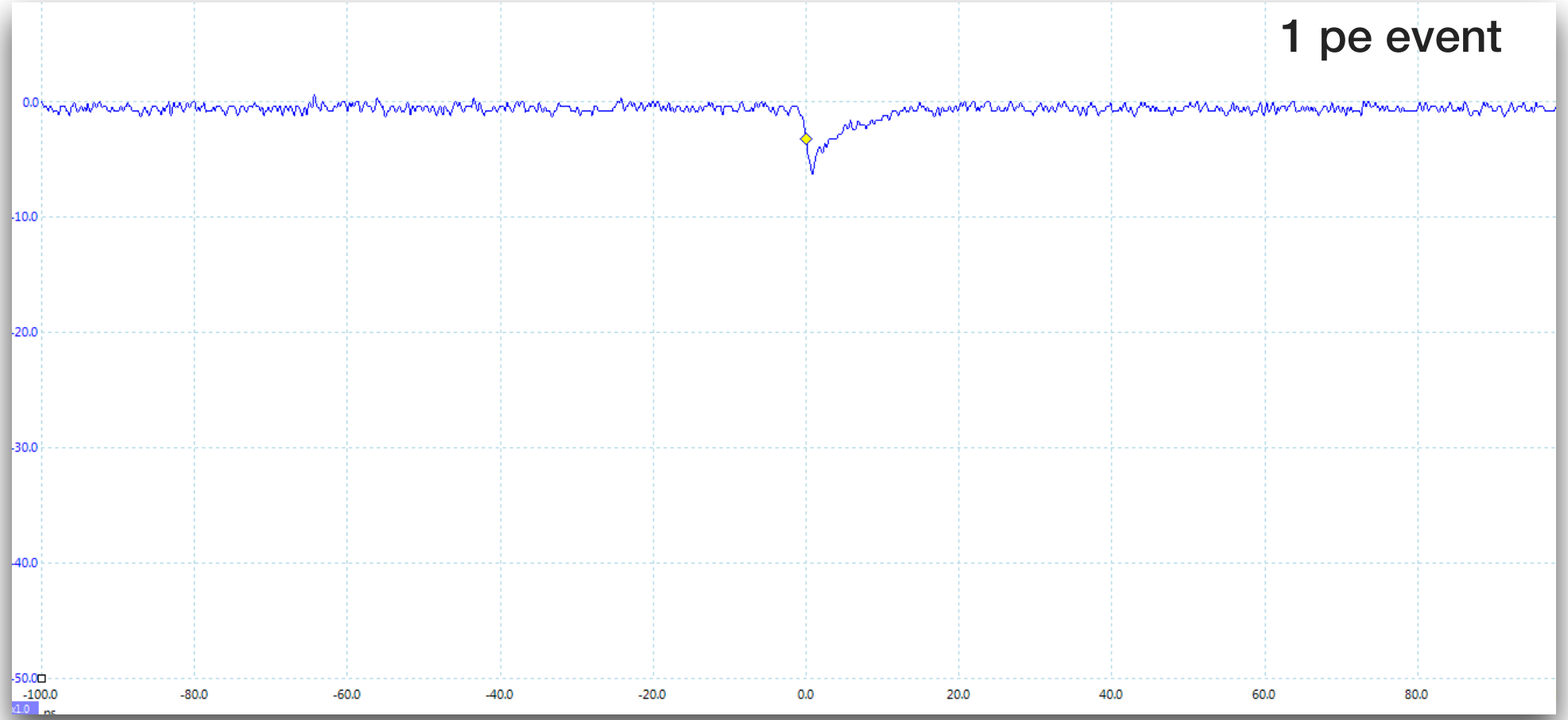
Study of different plastic scintillator designs and SiPMs as one option for HCAL for future linear collider detectors

The Setup

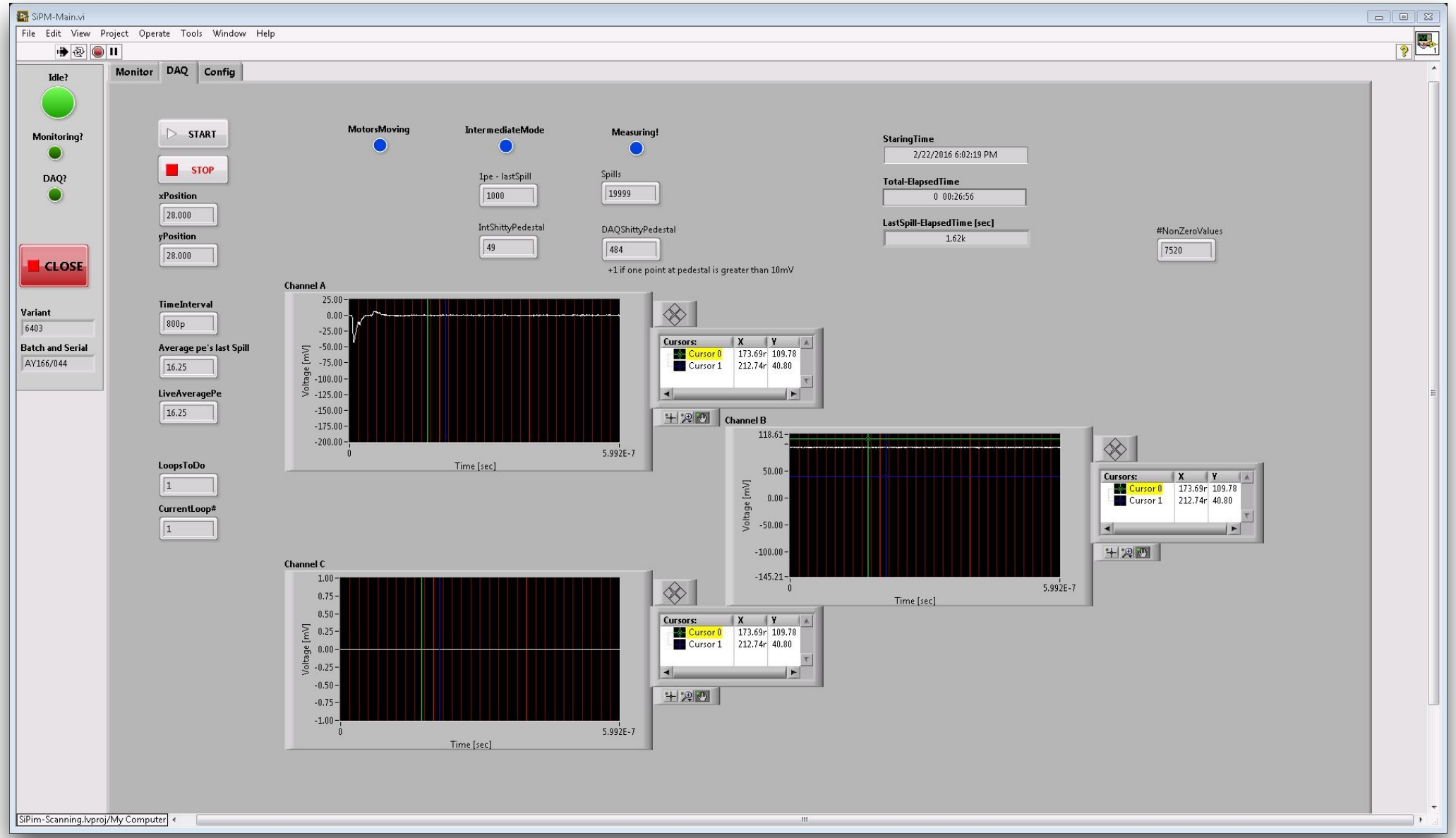

box can be closed light tight
^{90}Sr source
stepmotors
scintillating tile
trigger-cube
z – achse

The Signal

- SiPM readout with USB connected oscilloscopes with 800 ps time resolution and 8 bit voltage resolution



LabView based DAQ System



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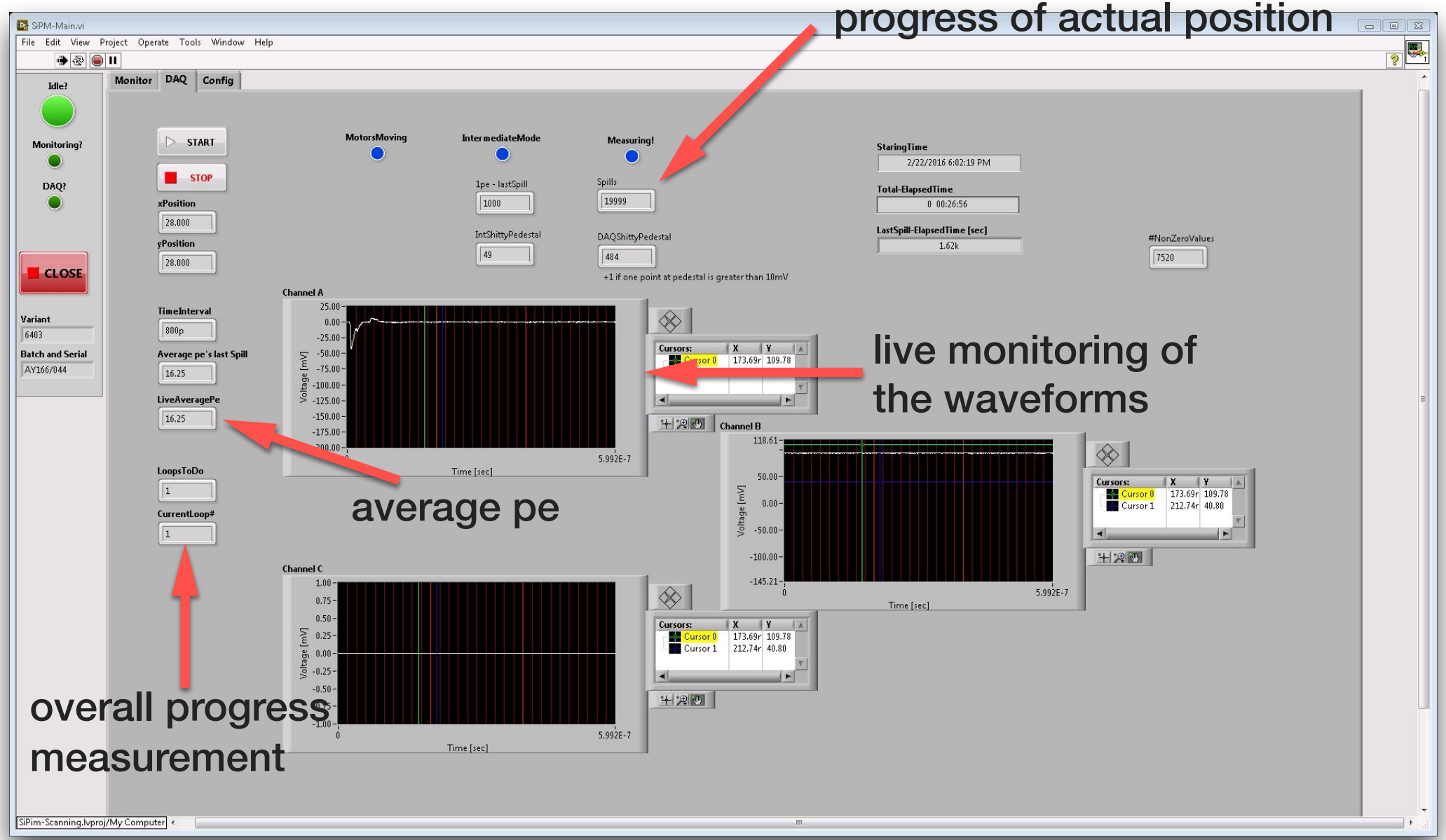

Scintillator Studies

- Test of different scintillator materials such as BC-408 or PEN and various SiPMs

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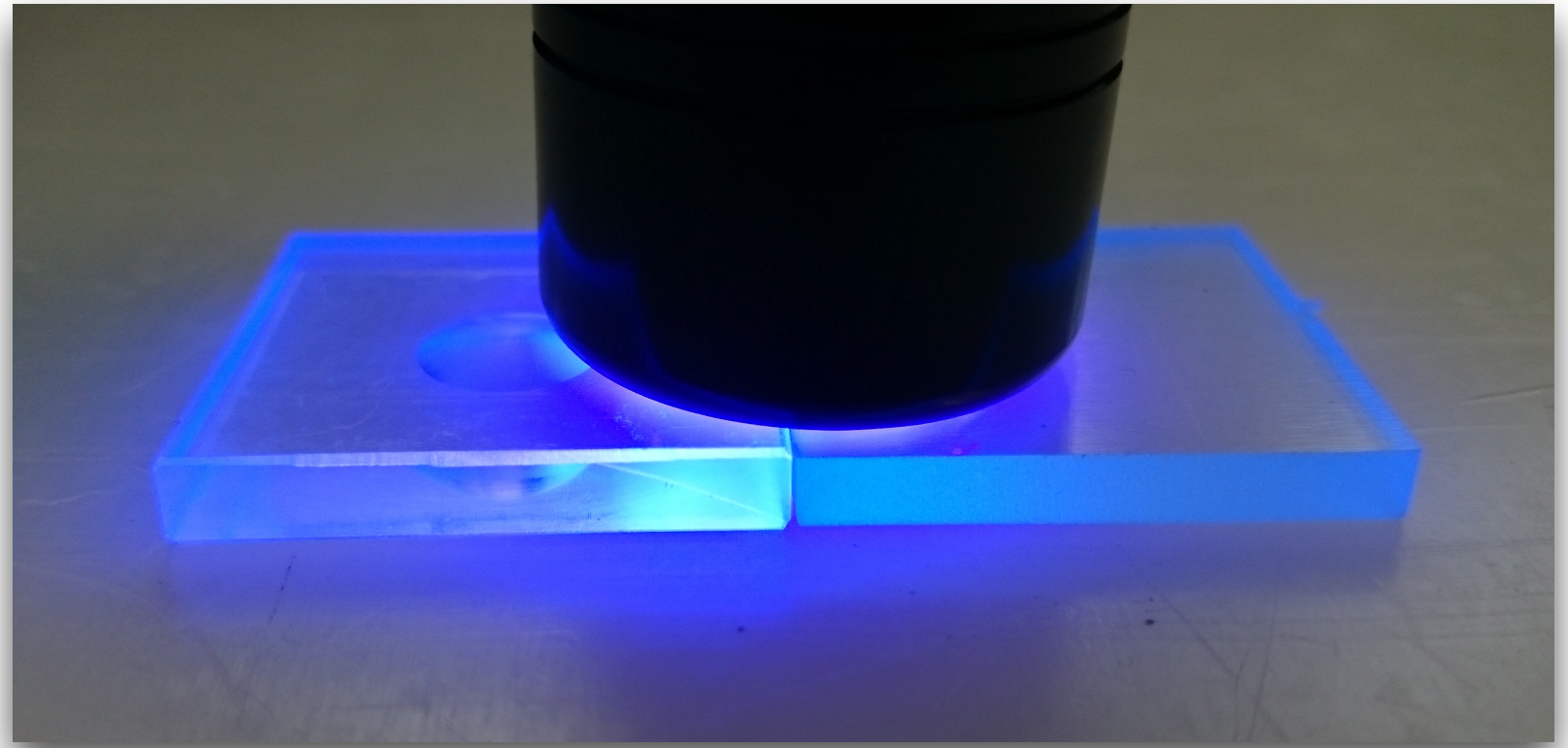

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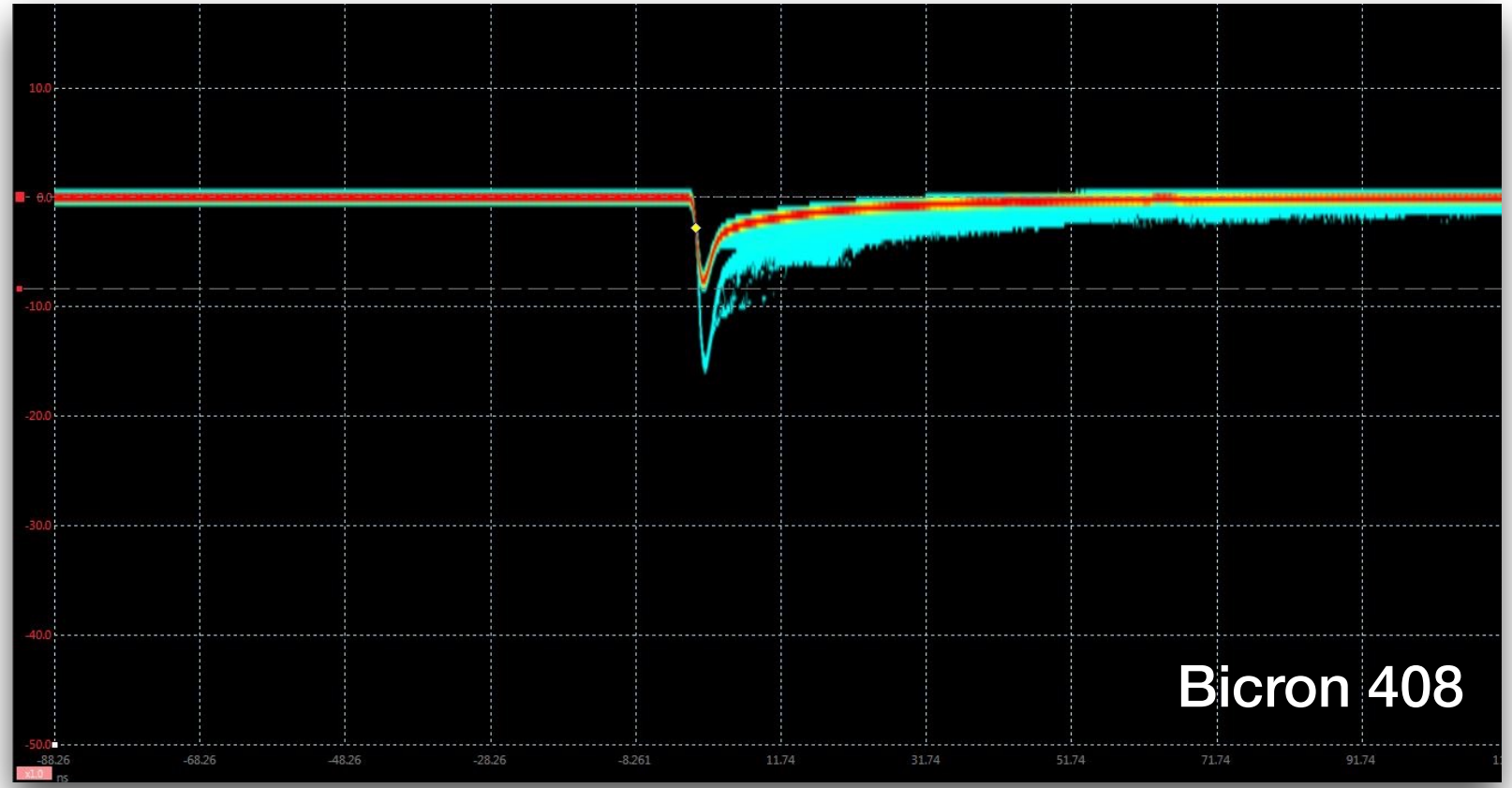

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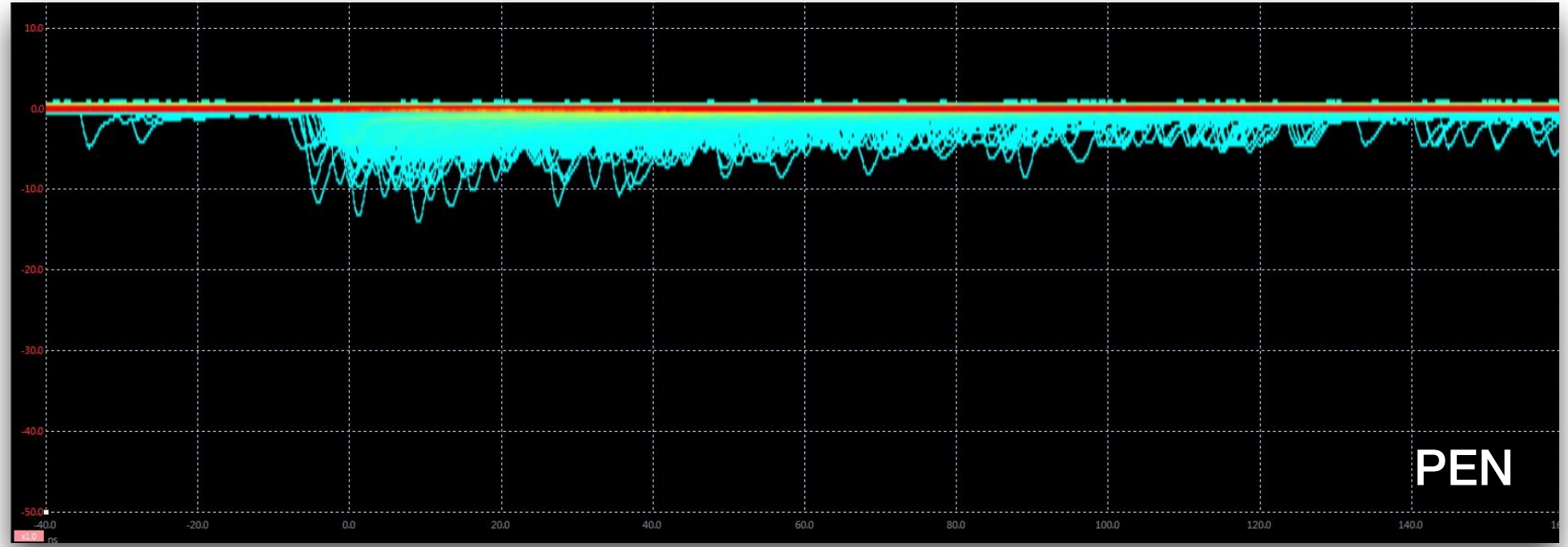

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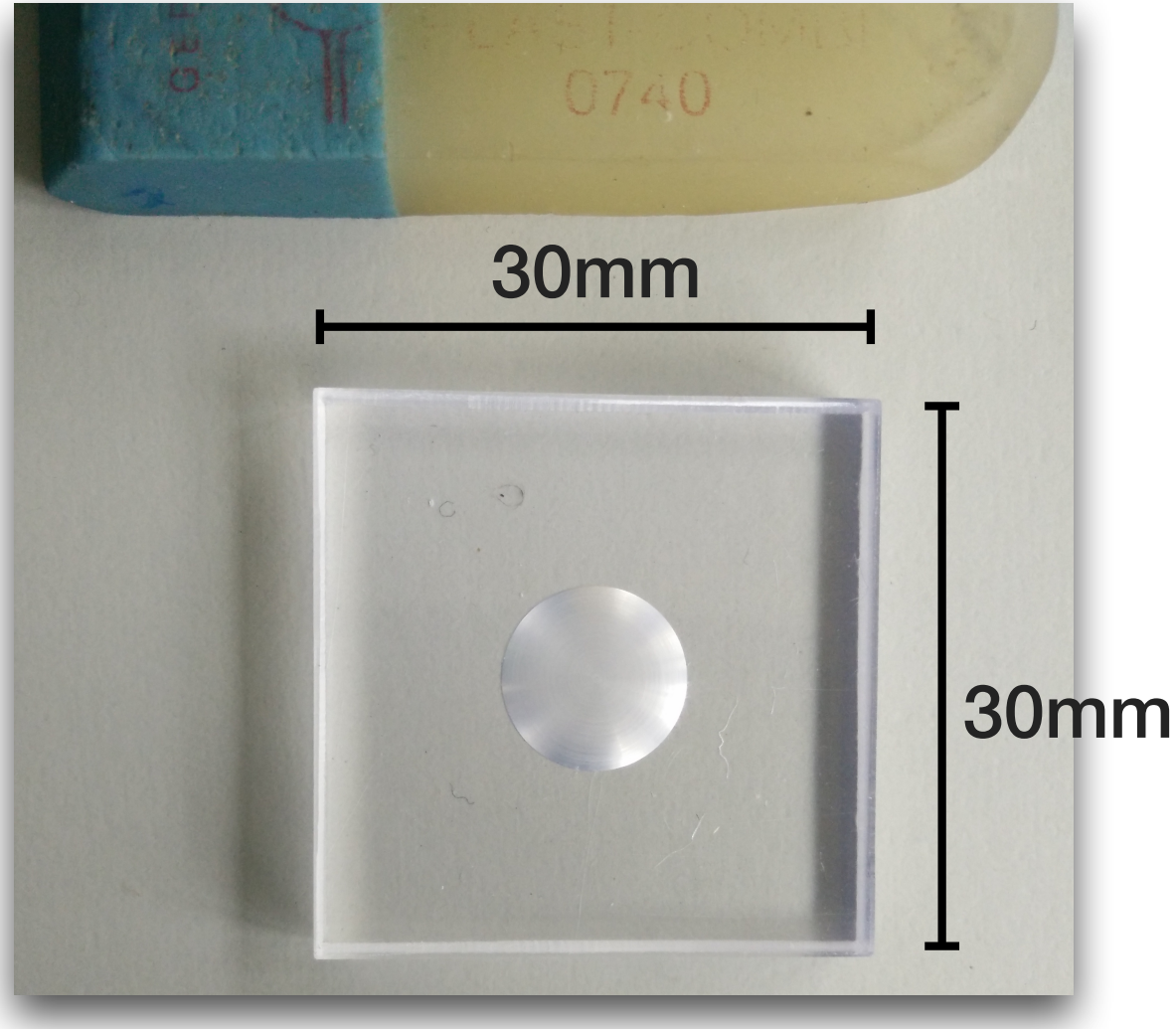
- Test of different tile geometries to steer the photons for high light yields



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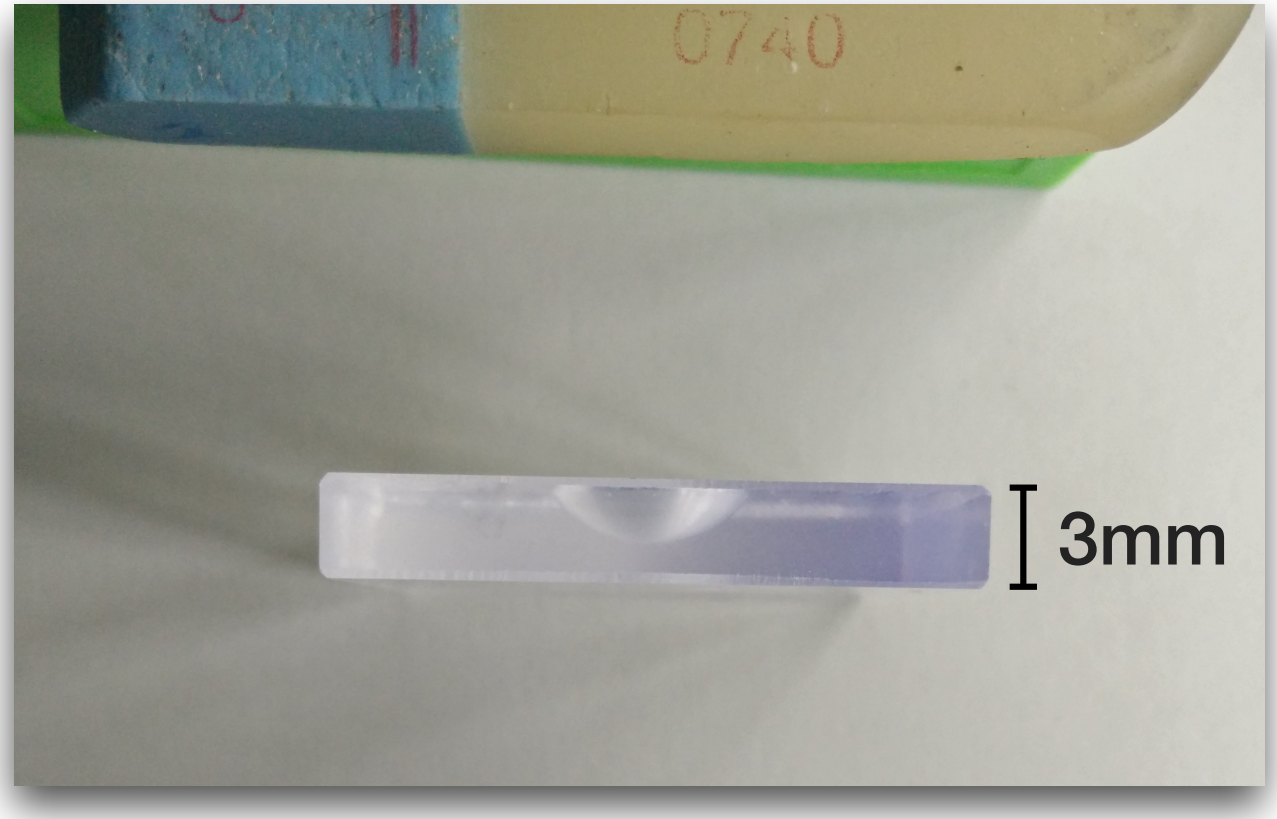
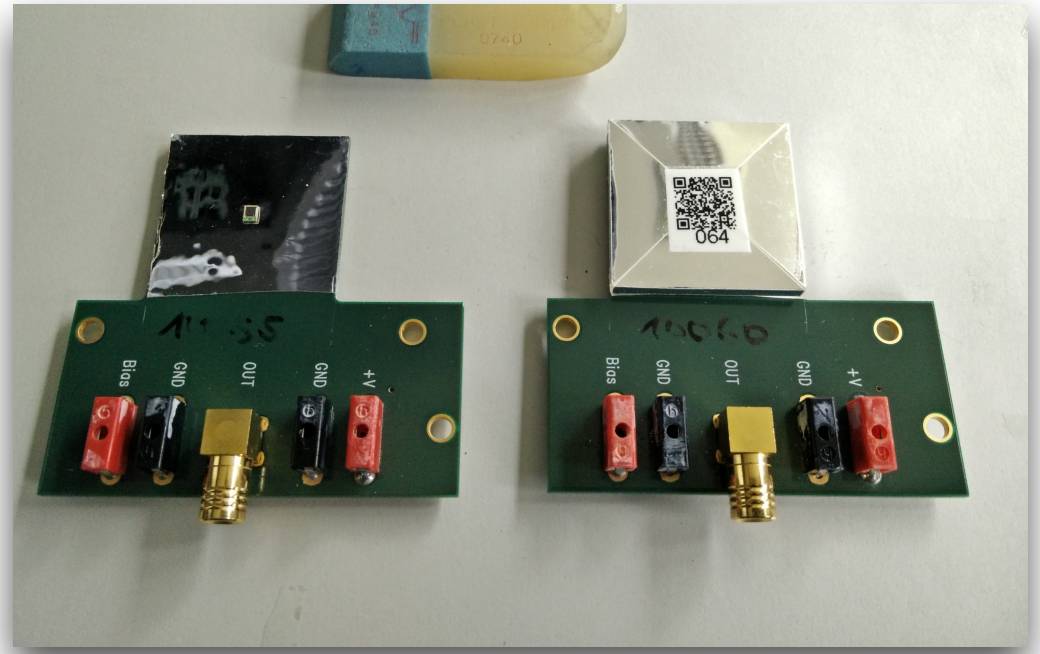


Scintillator Studies

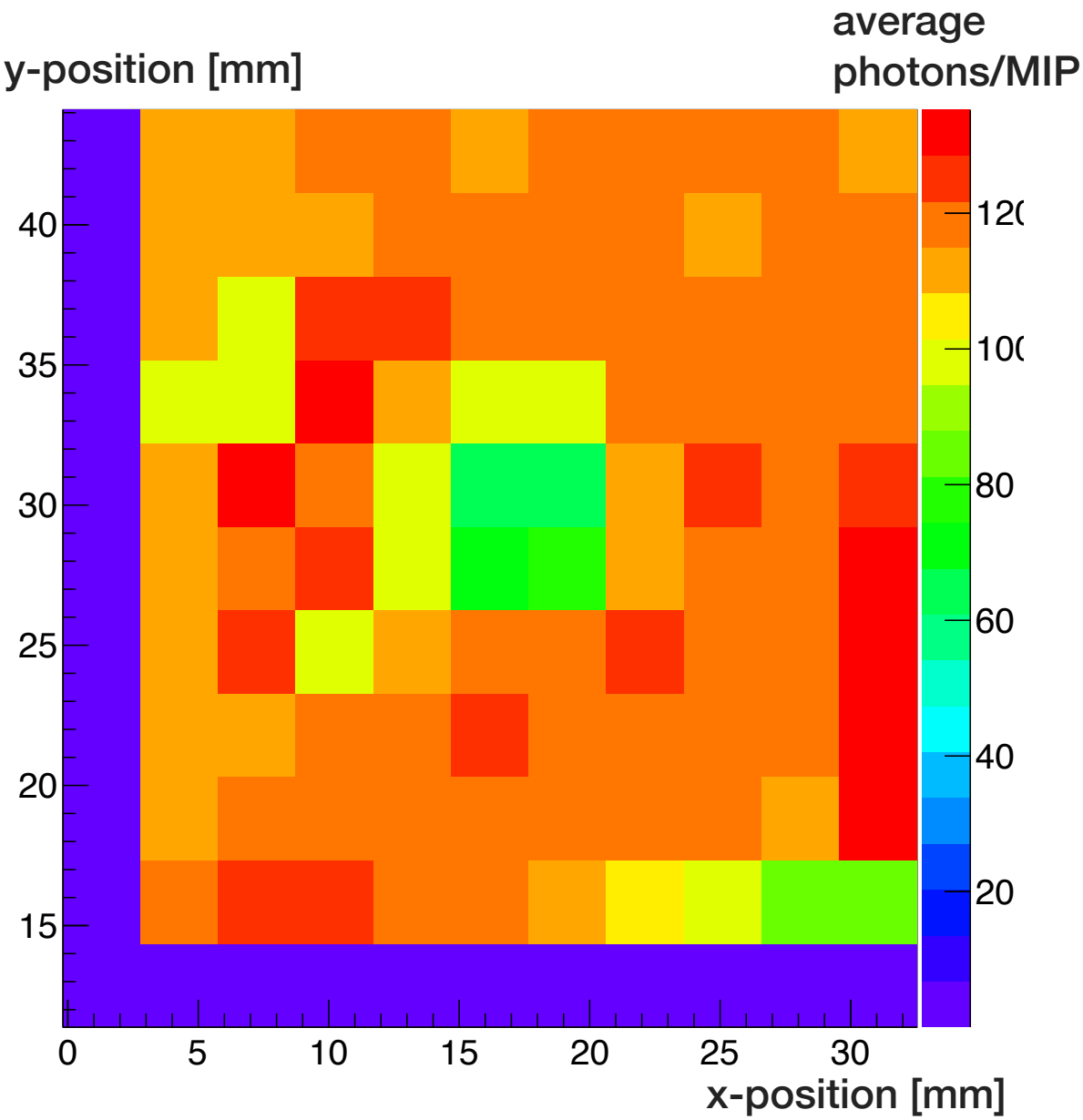
- Tiles are wrapped in reflecting foil for better light yield

- Mounted on a PCB
  - Reflecting foil additionally on PCB for higher light yield around the SiPM
  - Preamplifier included



Scintillator Studies: Uniformity

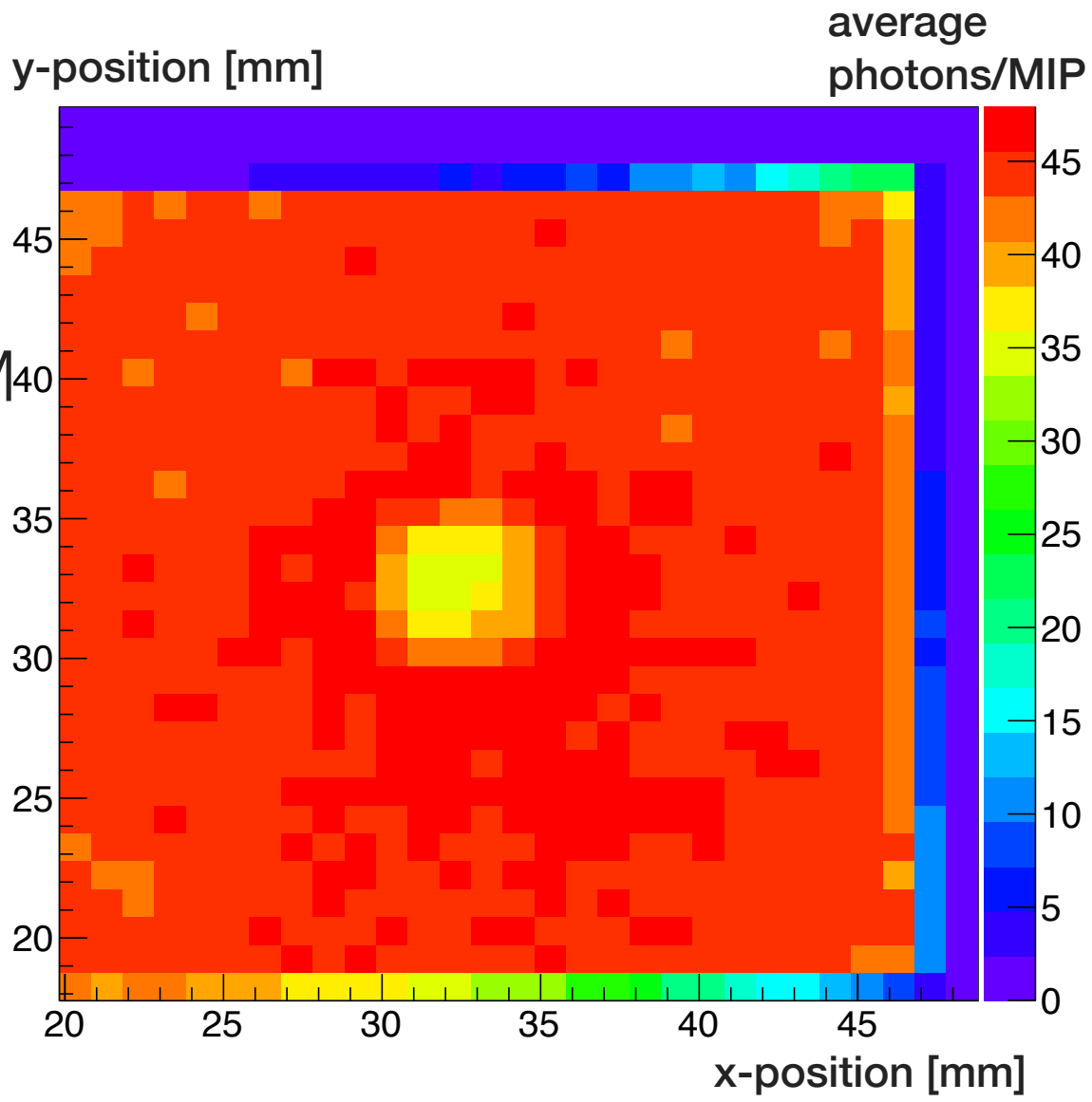
- 2D histogram is the result of a uniformity scan
- Tile not perfectly aligned
- Neighboring bins differ up to ~30 photons/MIP



Scintillator Studies: Uniformity

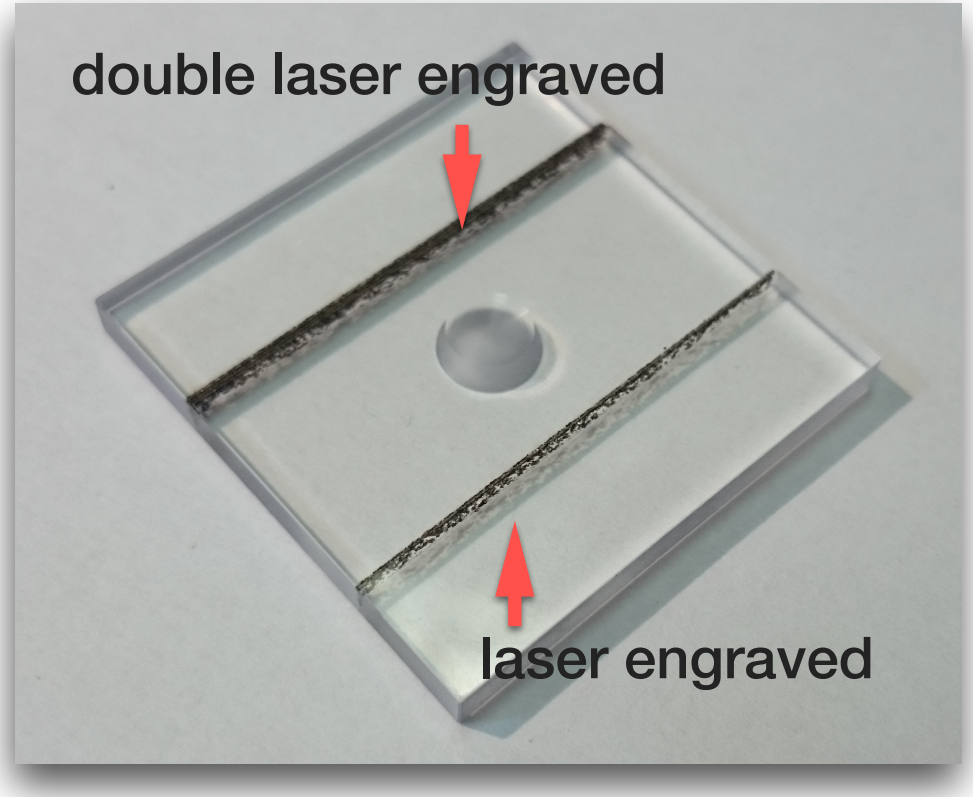
- Better result of a uniformity scan
- Low light yield around SiPM is expected due to less scintillating material
- Tile is could be aligned better

  ➡ Edges not clearly visible



Scintillator Studies

- More investigations in laser engraving could simplify the construction later on
  ➡ Real detector designs foresee up to 10 million channels



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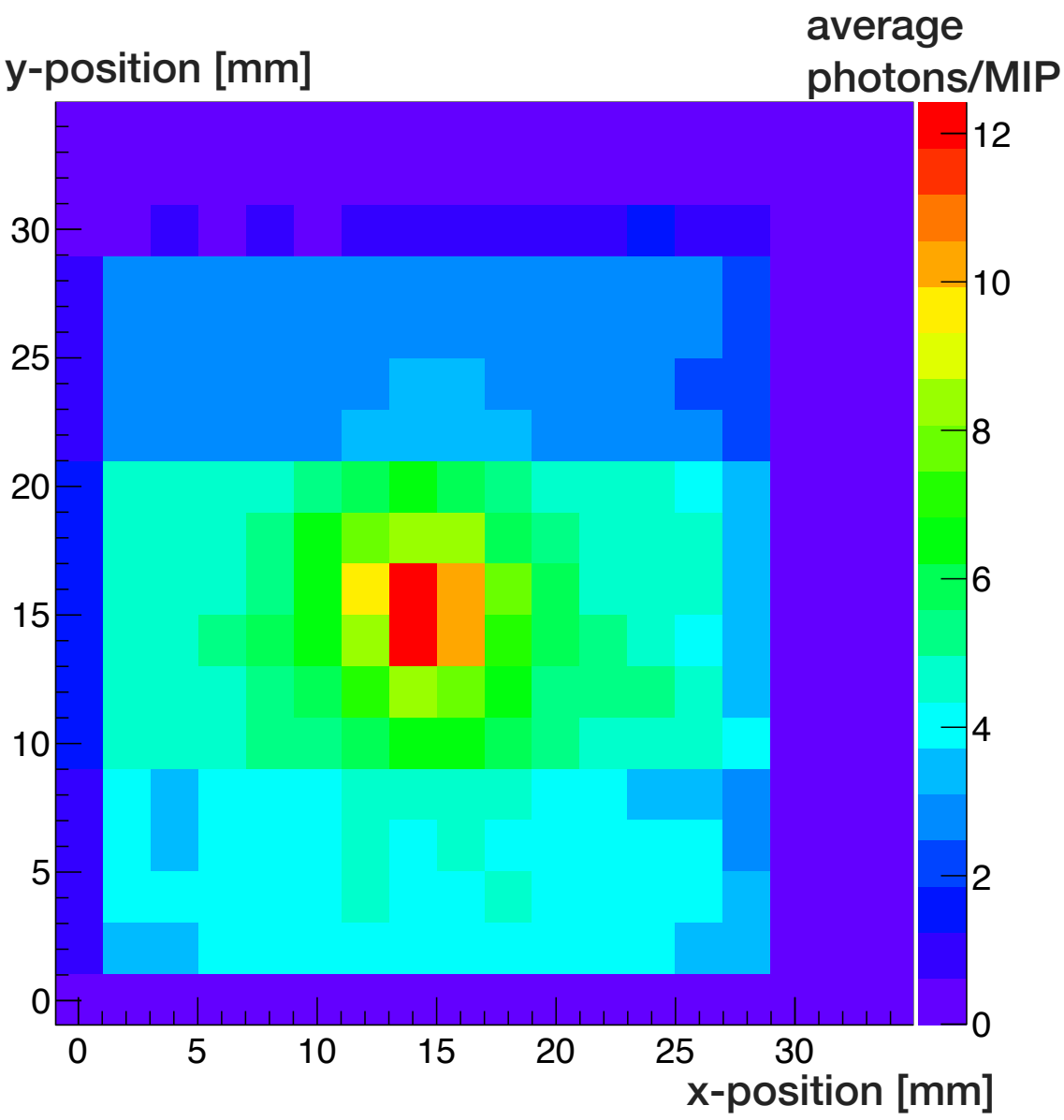

Additional Feature: Fast Timing

- The same hardware (light tight packaging) with a slightly modified software is used in the commissioning phase of the **SuperKEKB** accelerator in Tsukuba, Japan
  - ➡ give information about the timing of the beam

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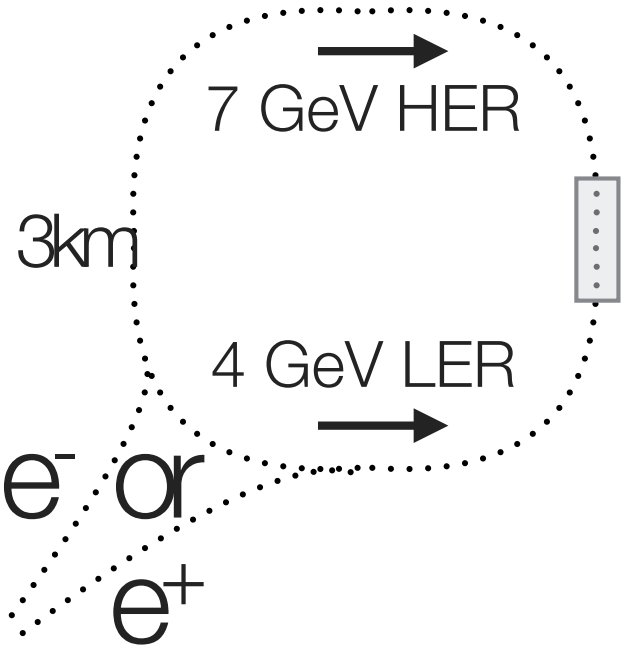
SCINTILLATION LIGHT AND WAVEFORM SENSORS

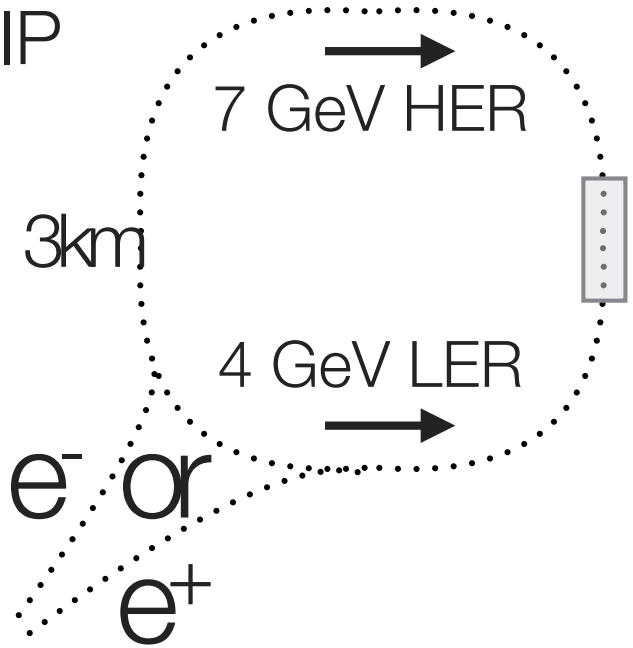


Upgrade from KEKB to SuperKEKB with a new LER

Commissioning SuperKEKB

Injection of either e^- or e^+:

- Scrub beam pipe with cm-beam
- Background at IP was unknown



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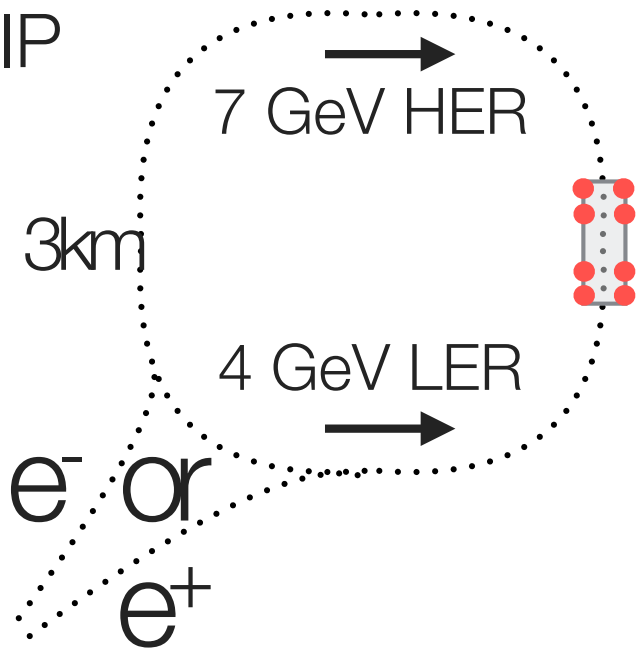

Interaction point:

- 8 scintillator tiles
- no detector
- no beam optics for focusing

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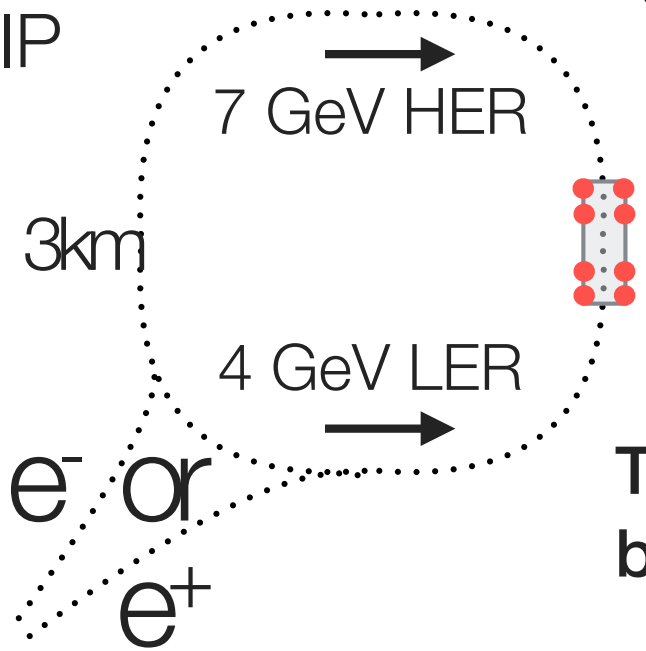

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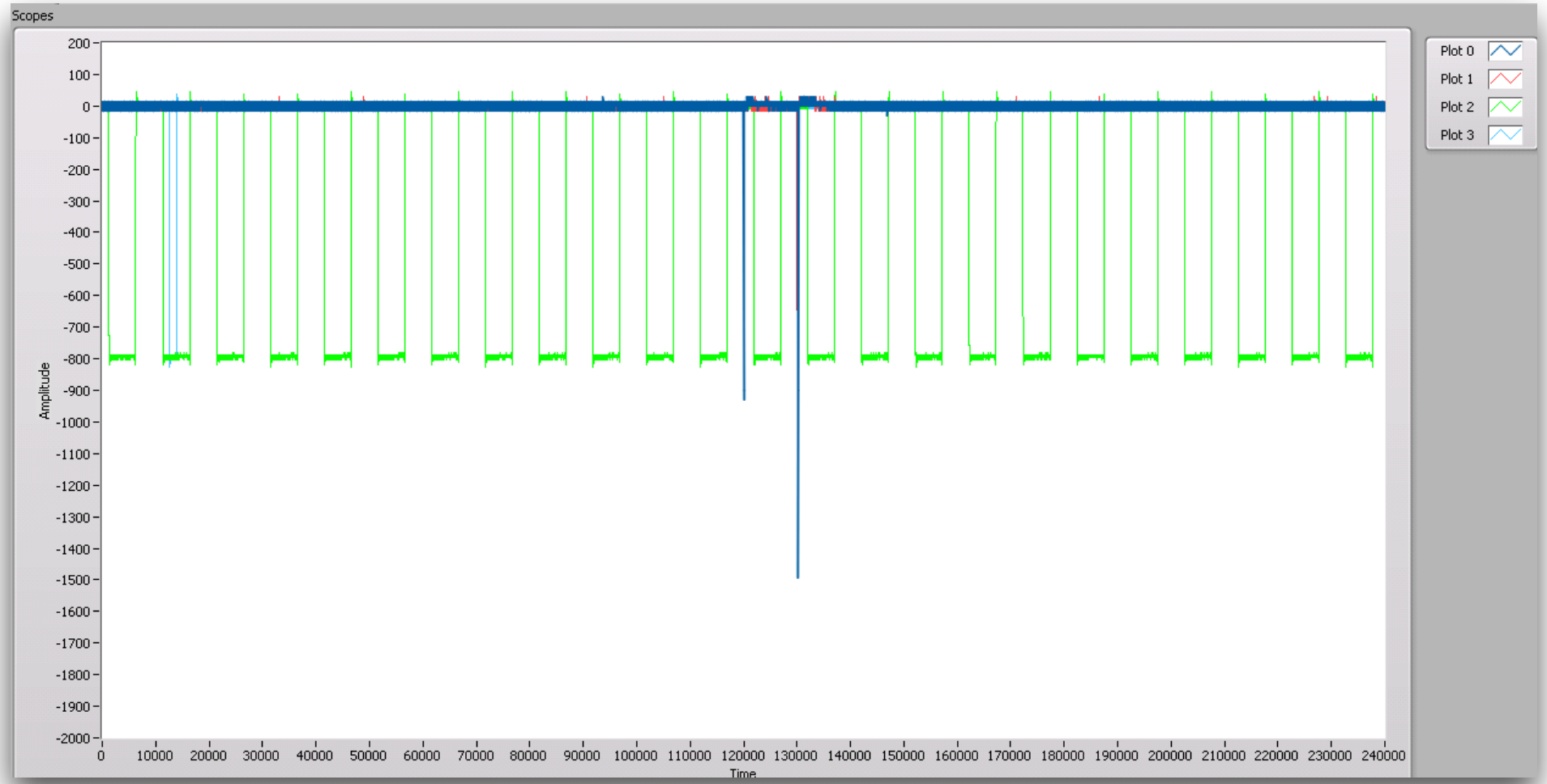
Trigger signal 30-50 µs before bunch arrives at IP:

- Demand for fast timing and sampling over extended times

Upgrade from KEKB to SuperKEKB with a new LER

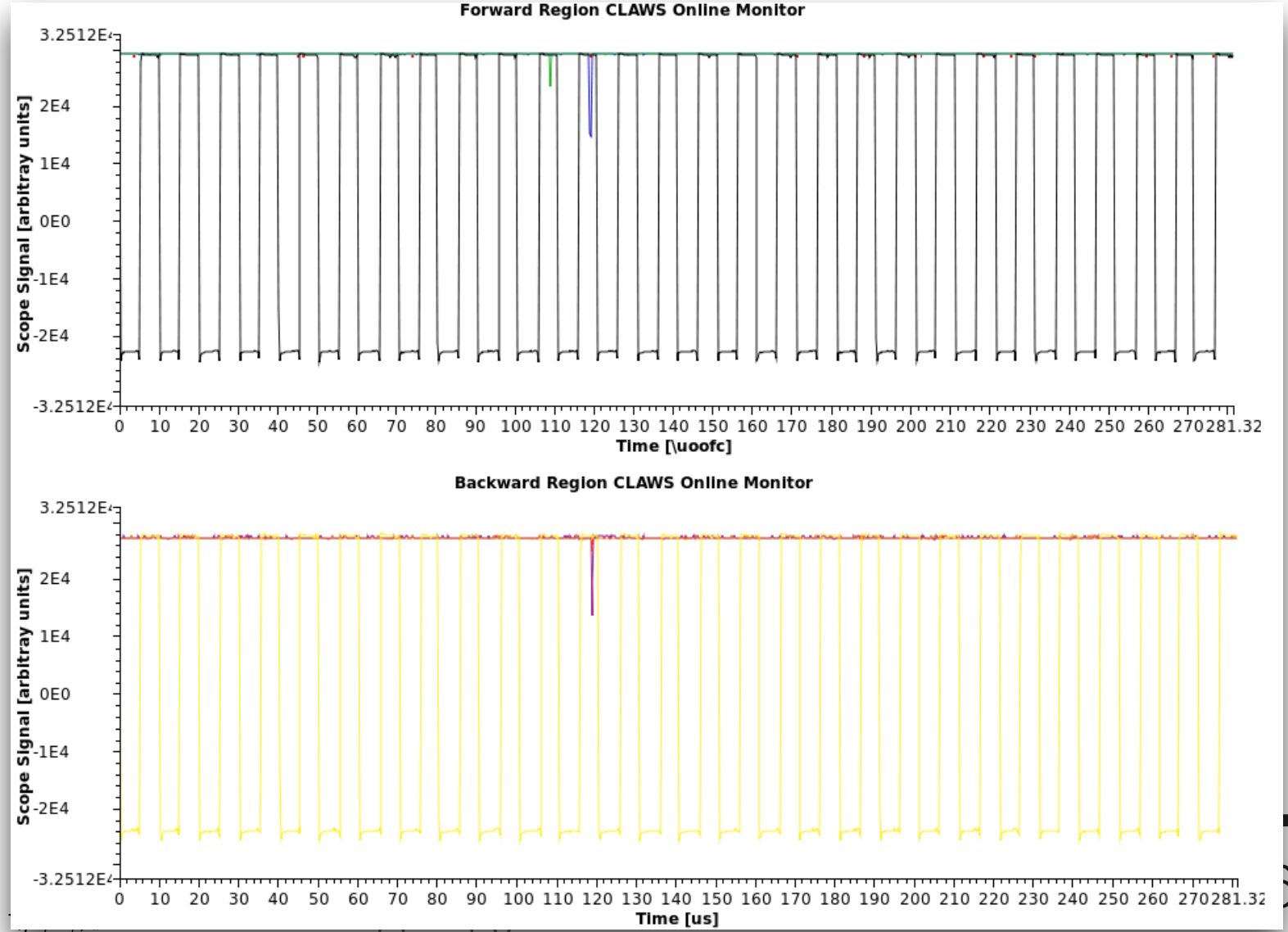
CLAWS: First Turns

First particles from LER:
8 am JST on Feb 08 2016



CLAWS: First Turns

First particle from HER:
8 am JST on Feb 22 2016



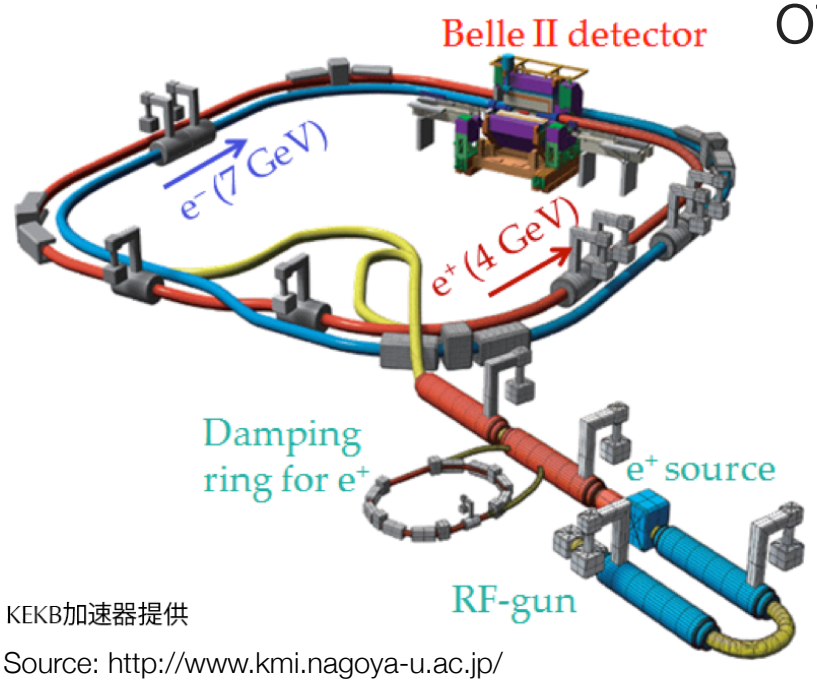
Outlook

- Further investigations in scintillator studies needed
  - test of more materials and their assembly

- Further application in second phase of the commissioning phase of SuperKEKB are planned
  - more modes for data taking are needed

BACKUP

SuperKEKB



KEKB加速器提供

Source: http://www.kmi.nagoya-u.ac.jp/jpn/spotlight/kekb_belle2.png

Asymmetric e^+e^- collider for investigation of B-Meson decays (B-Factory):

- ***HER*** (7 GeV electrons)
- ***LER*** (4 GeV positrons)
  - ➡ E_{cms} = 10.58 GeV - Y(4s)
- Target Luminosity ~ $8 \times 10^{35} cm^{-2} s^{-1}$
  - ➡ 40 times KEKB
- Positron Ring completely new
- Nano Beam Scheme
- Increased Beam Current (factor ~2)