CLAWS - T3B Technology for SuperKEKB

CALICE Collaboration Meeting
Munich
September 2015

Image taken from:
http://orig08.deviantart.net/6e17/f/2014/164/c/a/godzilla_2014_wallpaper_1920x1080_by_sachso74-d7m69cc.jpg

Introduction

1. Upgrade to SuperKEKB Accelerator and Belle II Experiment

KEKB quest for CPV kekb.jp ⇨ Super KEKB

BELLE ⇨ Belle II

2. Commissioning of the SuperKEKB Accelerator

SuperKEKB Commissioning Detector — BEAST II — Belle II Collaboration

For Beam Diagnostics:

- **Phase I** (without Belle II)
- **Phase II** (with Belle II, but no VXD)
- **Phase III** (full detector)

3. Scintillation Light And Waveform Sensors (CLAWS)

SuperKEKB Commissioning Detector — CLAWS — Belle II Collaboration

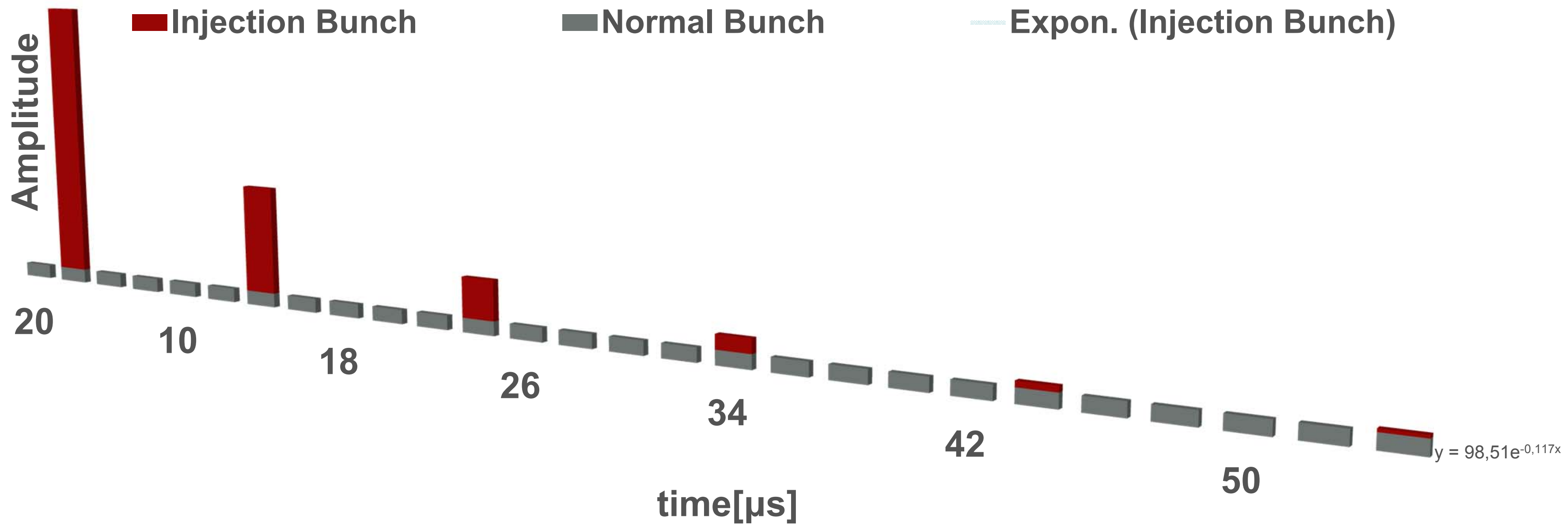
- Different small detectors in Phase I&II
- **Fast system** with capability of sampling over **extend times**

⇨ **CALICE Technology in SuperKEKB commissioning**

4. Timeline and Outlook

Image taken from:

Phase I: Goals



Bunch Scheme:

- Bunch spacing of 4 ns
- Circulation time of 10 µs
- Two injection bunches per 2500 bunches
- Two injection bunches 100 ns apart

Goals of Phase 1:

- Decay time of noise from injection bunches
  - ▷ Sample over extended times
- Measure exact trigger delay
  - ▷ Fast timing
- Verify timing structure in KEKB
  - ▷ Fast timing

The Problems:
No idea what background to expect + System needs to be ready yesterday

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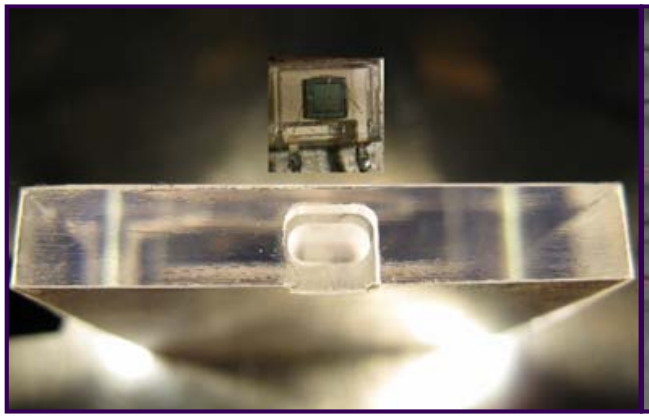
Phase I: Hardware

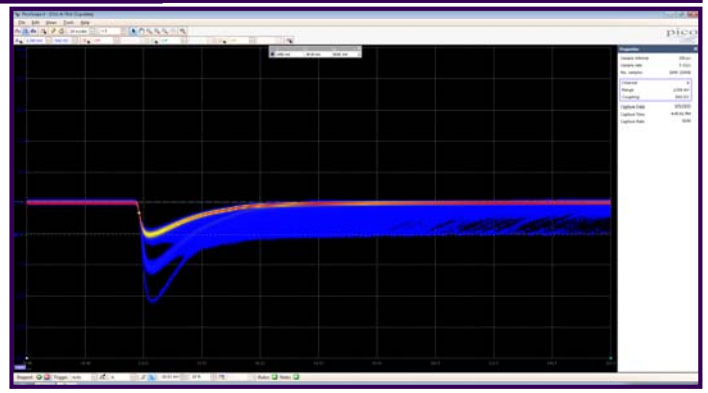
Narrow timing in Phase I calls for hardware basically ready to go:

▹ **System based on T3B Technology**



T3B Sensors & Boards:

- MPPC 50 Silicon PMs from Hamamatsu as sensors
- 30 x 30 mm^2 Scintillators
- Integrated pre amp
- Wrapped in reflective foil
- Dynamic range up to 15 MIPs

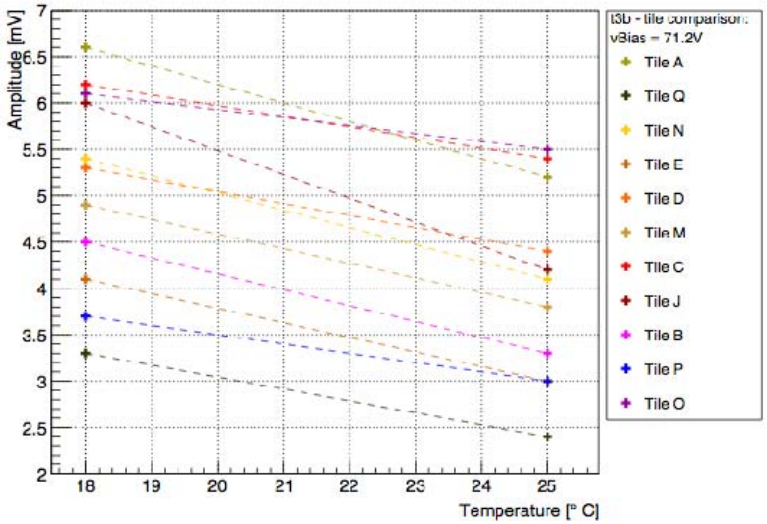


Distance of 37m between *IP* and hut (Scopes):

- Additional amplification stage (Mini circuits ZF-L 500)

Phase I: Hardware

11 T3B Boards at hand, each with slightly different amplitude:



The Idea:

- Identify two Groups of 4 boards each (Similar gain for same voltage, ± 10 %)
- One V_{bias} - line per group
- Per Board/Channel:
  - 3m coax cable
  - ZF-I 500 Amplifier (located near boards)
  - 45 m BNC (Signal)
  - 45 m Supply voltage (V_{bias} + $V_{pre\ amp}$, 4 wires, TP, shielded)
- Distribute voltages to cables with common box

45 m BNC-Signal

45 m PreAmp+Bias Volt.

45 m Amp Voltage

Voltage Distribution

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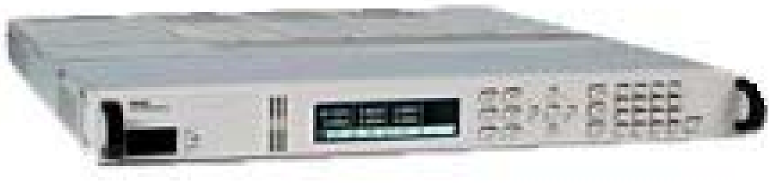
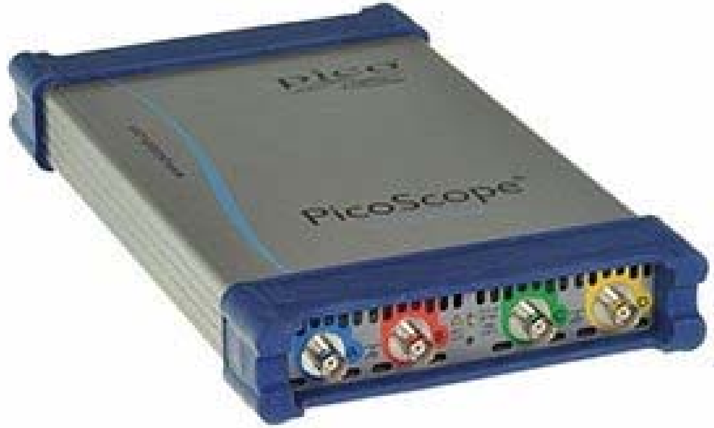
Image taken from:

Phase I: Hardware





Keysight 6700B Modular Powersupply:

- 2 **L**ow **V**olt. modules (V_{Amps}+$V_{Pre\ Amps}$ up to 20 V)
- 2 **H**igh **V**olt. modules (V_{bias} up to 100 V)
- Rack mountable
- Operated via Labview

Readout out for CLAWS Phase I:

- Picked up updated version of T3B solution
  - ▷ Picotech picoscope 6404D
- 8 bit resolution
- 5 Gs/s (1.25 Gs/s per channel)
- 2 GS Ultra deep memory
- Up to 400 ms of one continuous waveform
- Labview integration possible (under study)

Hardware safely arrived at KEK:

- 0.5 Kg of SiPM boards
- 60 Kg of cables
- Total of 110 Kg were shipped to Japan

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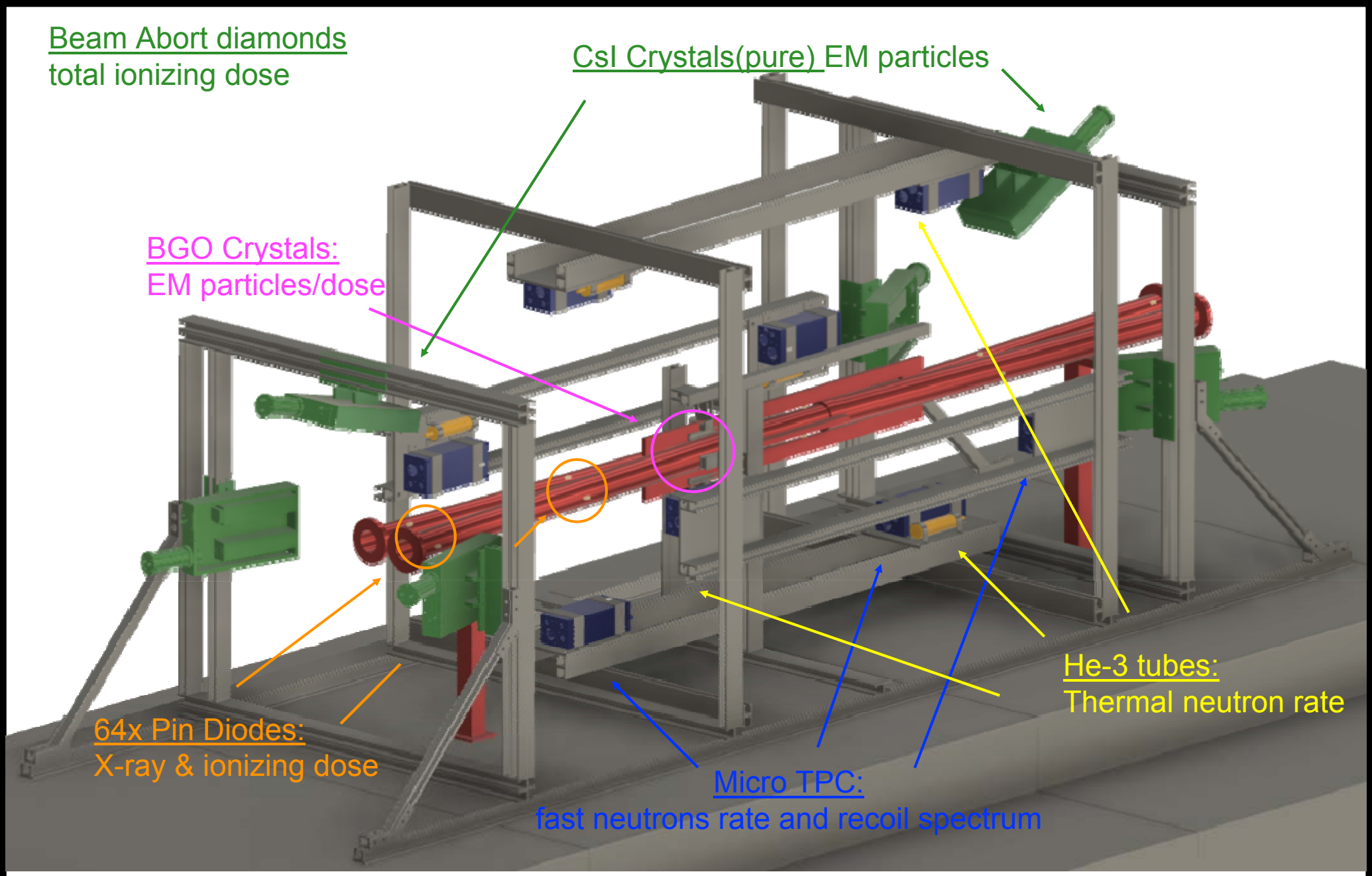
Image taken from:

Phase I: Installation



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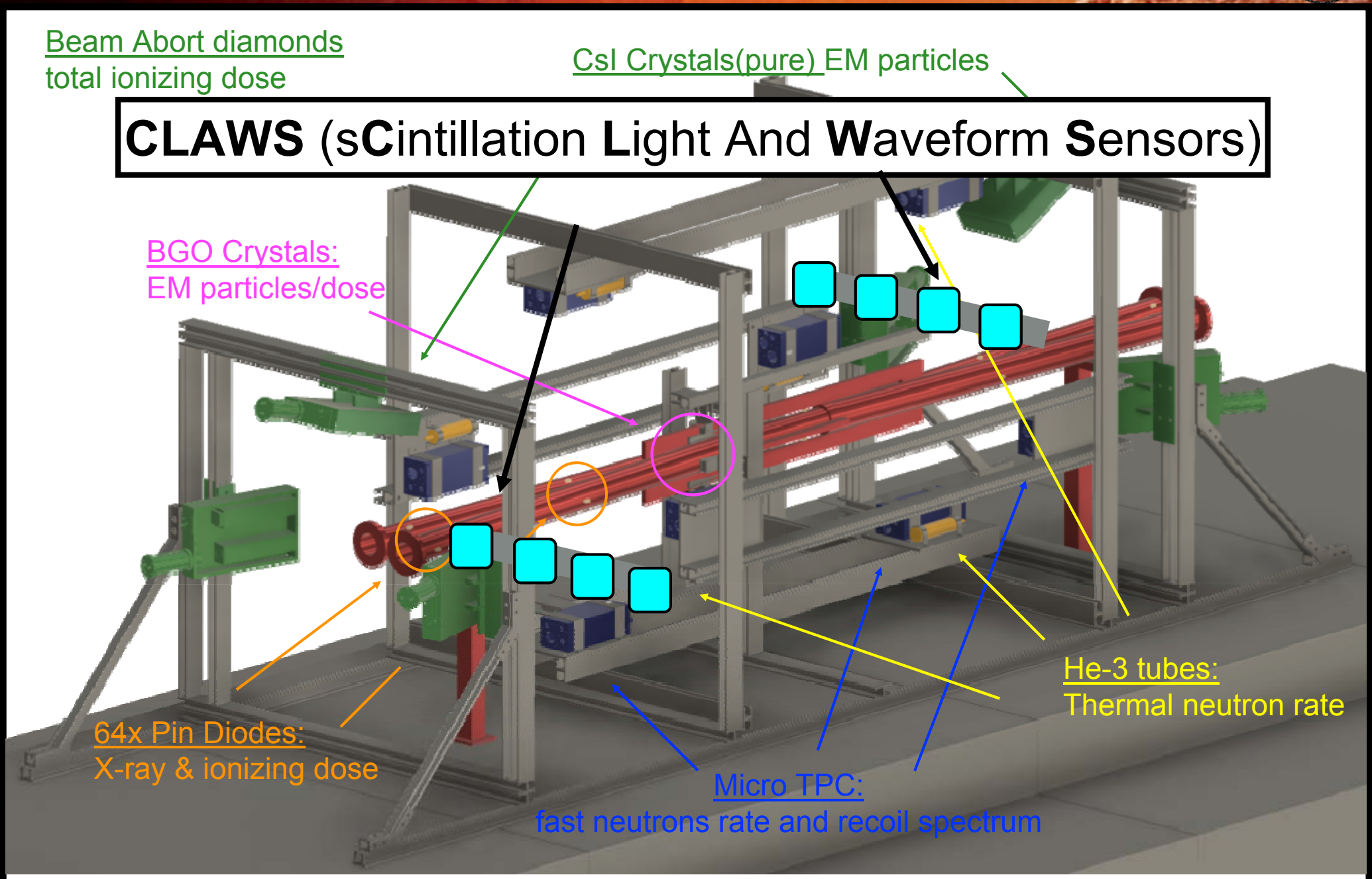
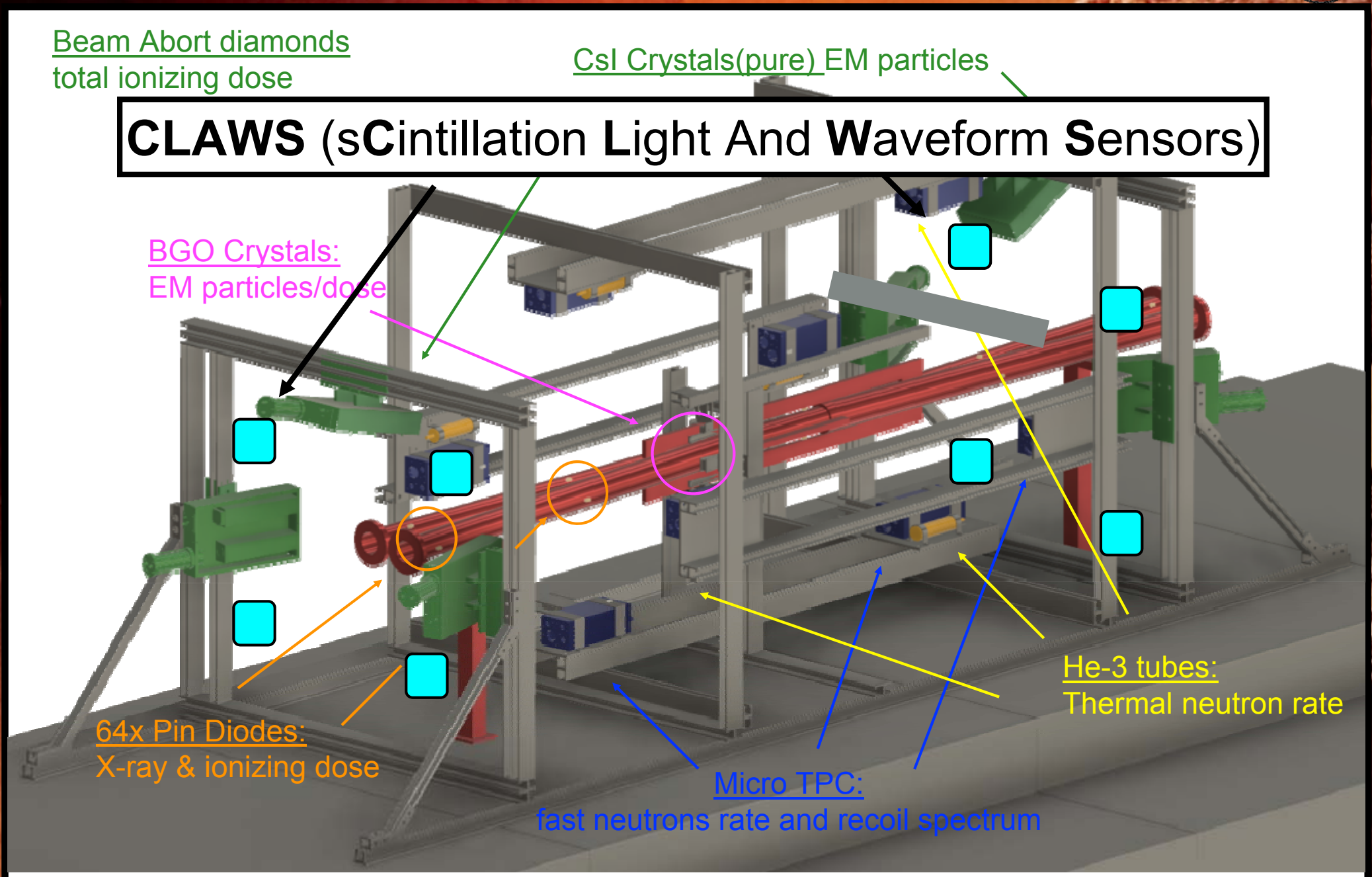
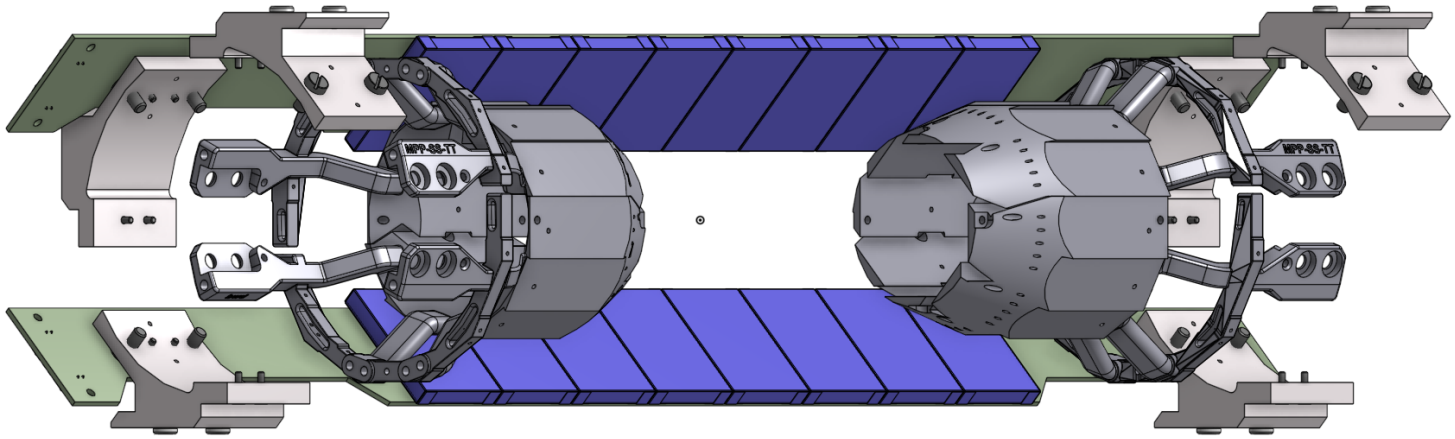
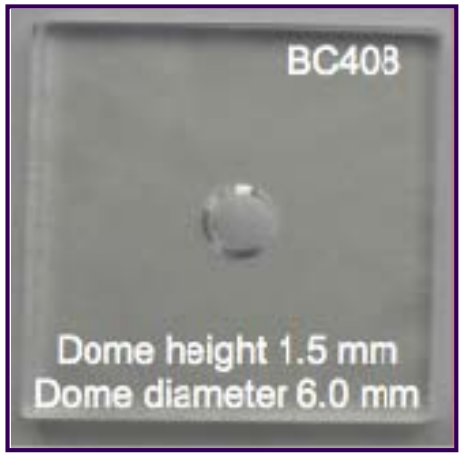


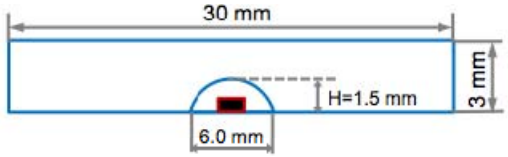
Phase I: Installation



Phase II: Hardware

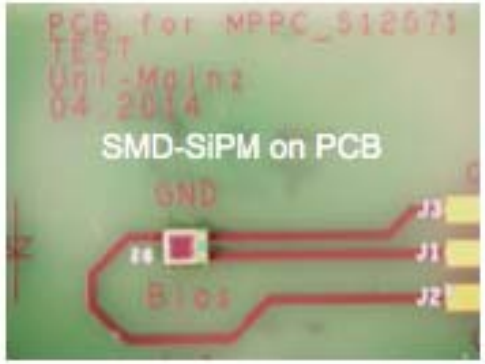






Sensors arranged in two PCB boards in *PXD* location with 8 SiPM-tile combinations each (~ 31 mm from *IP*):

- 20 x 20 x 3 mm^3 scintillator tiles with Mainz dimple wrapped in reflective foil
- New low noise SMD SiPMs (LCT4/5 with trenches)
  - 50 µm pixels
  - 1 mm^2 active area ~ 20 keV/photon
    - ▷ for ~ 5 keV SR photons go for 3x3 mm^2
- SiPMs directly mounted on PCB
- Pre amps, LV and HV supply and micro-coax signal cables all integrated in PCB
- ~ 2 W per ladder
- Maybe integration of LED calibration system



Timeline and Outlook

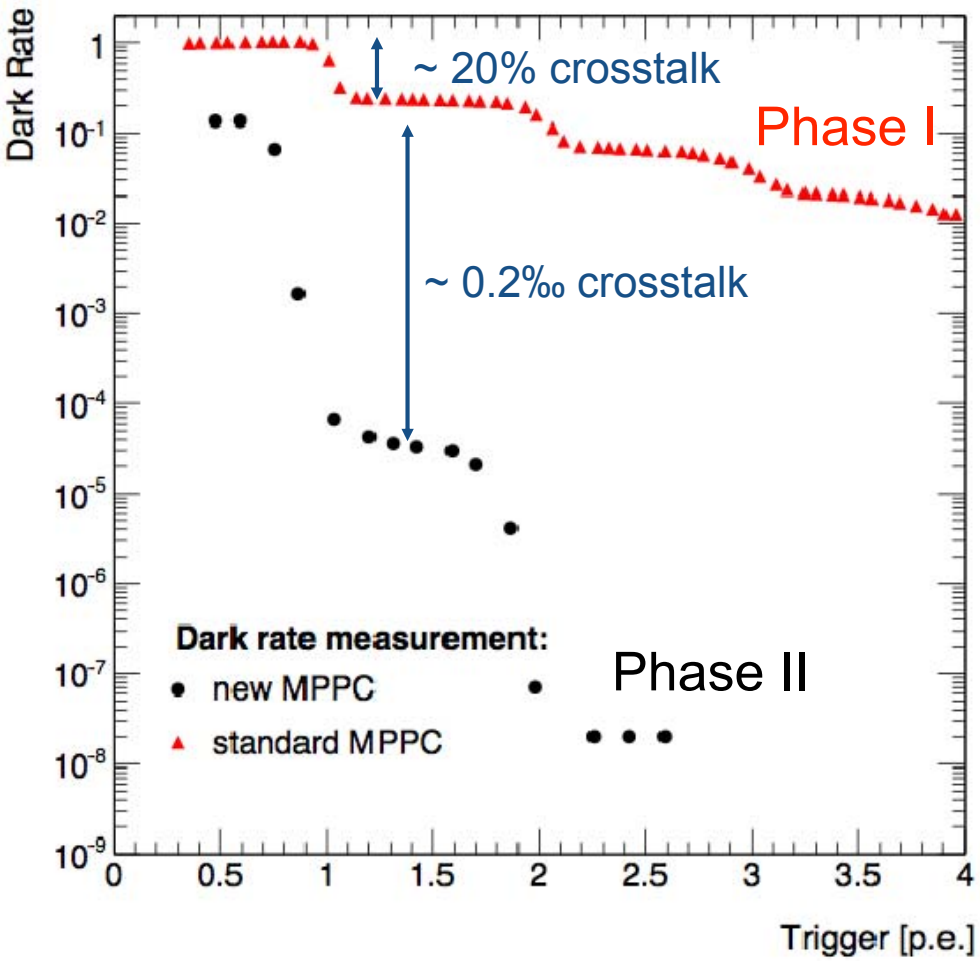
CALICE Technology is part of Belle II commissioning experiment at SuperKEKB:

- **Phase I:**
  - In spite of time constraints, find system with fast timing + sampling over extended times - T3B technology based on SiPM and scintillators
  - Transport setup to KEK - arrived
  - Installing of CLAWS - scheduled for third week of September
  - Get working DAQ - to do, but on good way
  - Begin taking data - February 2016

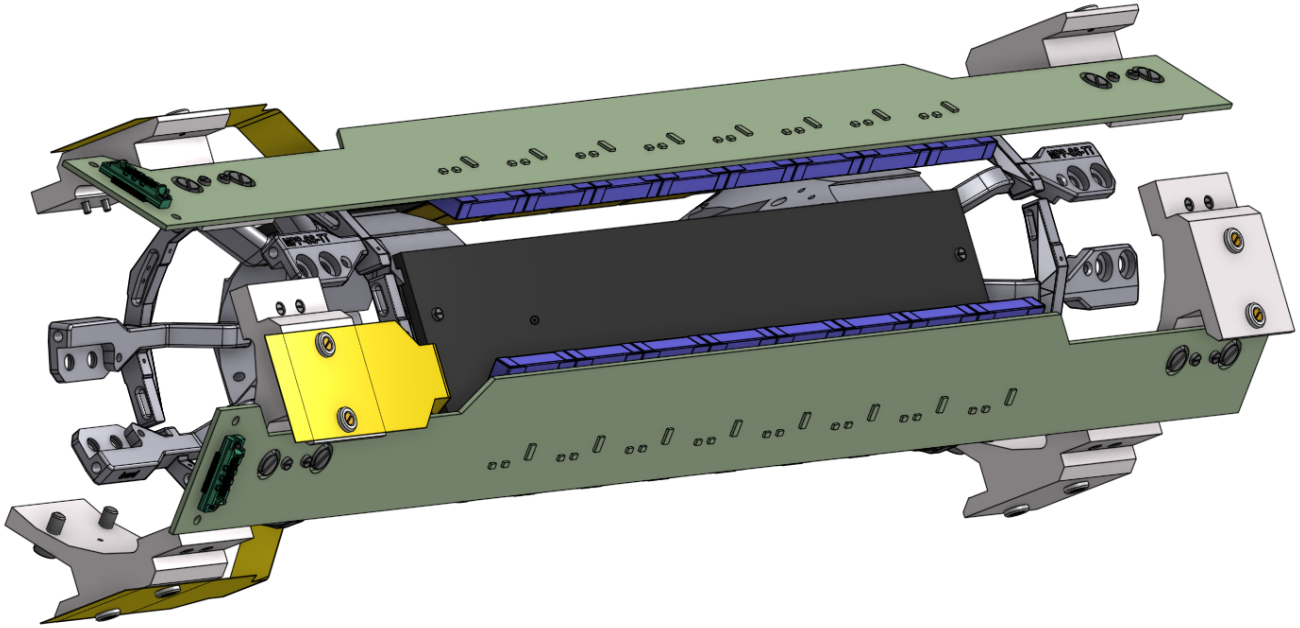
- **Phase II:**
  - Finalize hardware design - to do
  - Order and build hardware - several parts already at hand/to do
  - Extend DAQ to phase II - to do
  - Install and take data - end of 2016/beginning of 2017

Backup

SiPM Characteristics

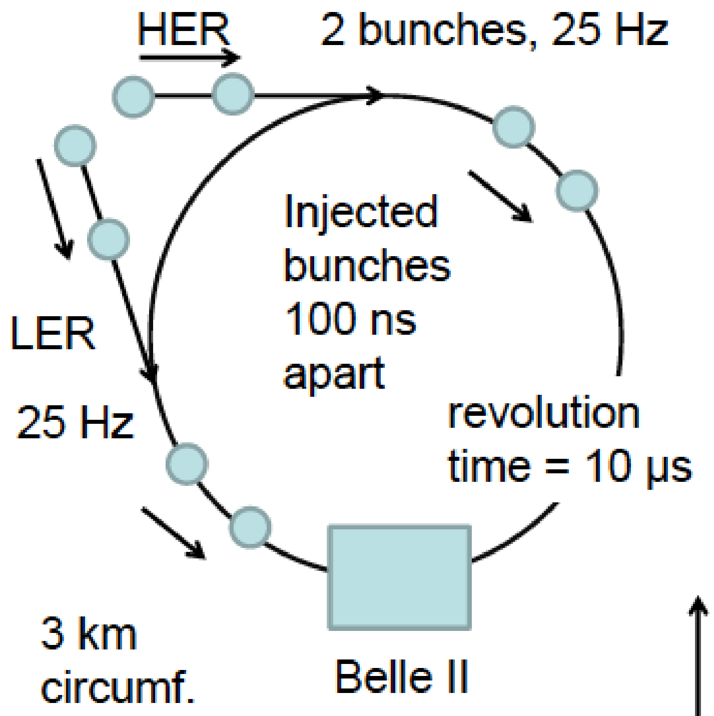


Phase II Mechanics



Borrowed from C. Kiesling

Problem: Injection Noise



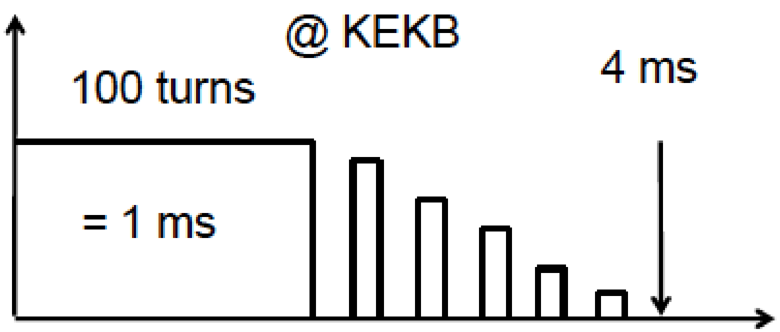
Total rate: 50 Hz

20 % deadtime for PXD

Principle:

continuous injection, developed by KEKB machine physicists

Liouville theorem:
bunches cannot be injected into same phase space volume
-> „cooling“ by synchroton radiation
-> particle loss -> „noisy bunches“



SuperKEKB: same damping assumed

C. Kiesling, Project Review 2011, MPI, Dec. 19-20, 2011 28

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