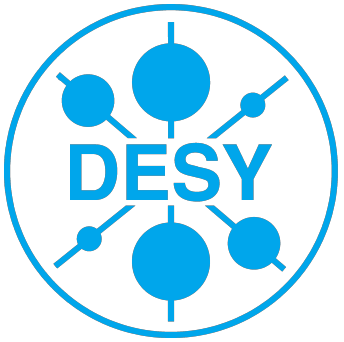


Integration and characterization of the vertex detector in SuperKEKB commissioning Phase 2

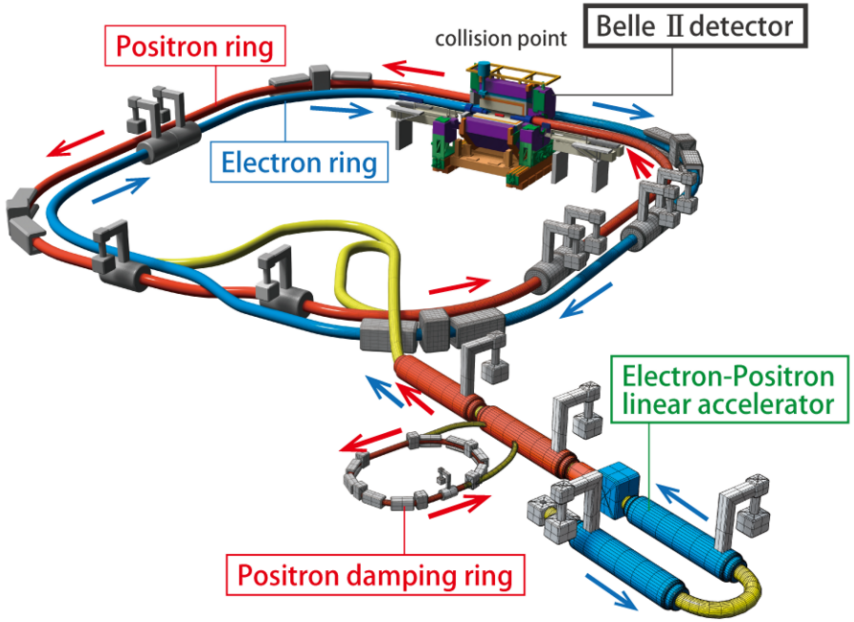
H. Ye (DESY)

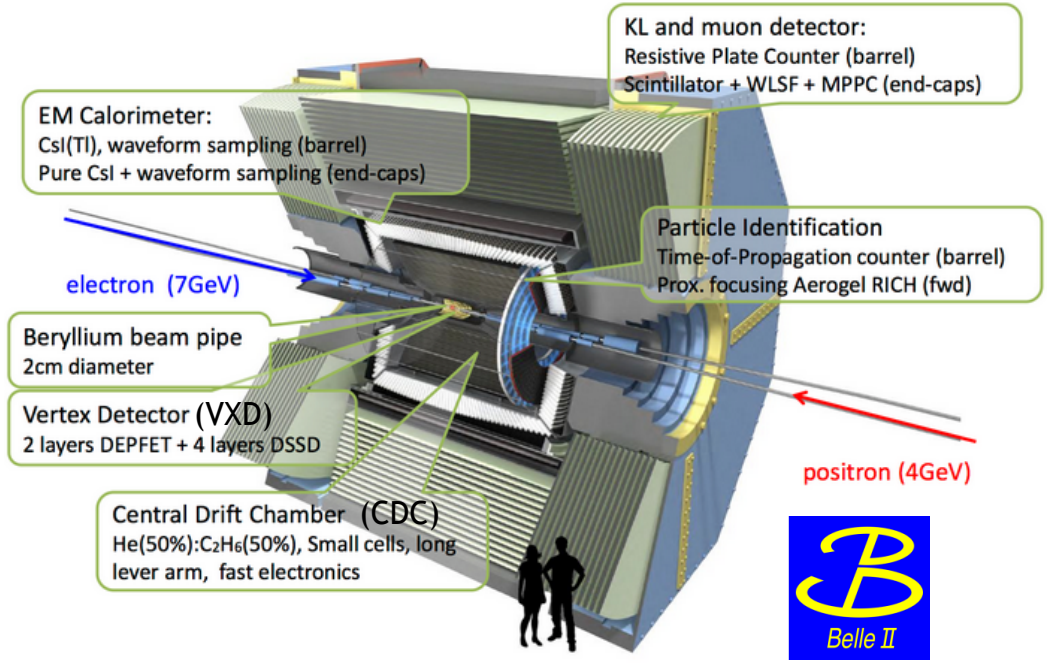
On behalf of the BEAST2 Collaboration

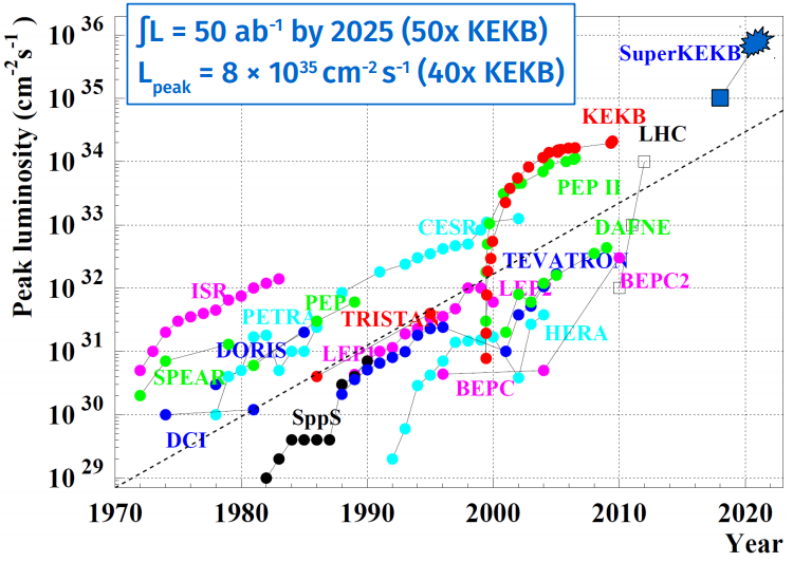
TIPP17
May 22-26, 2017 Beijing

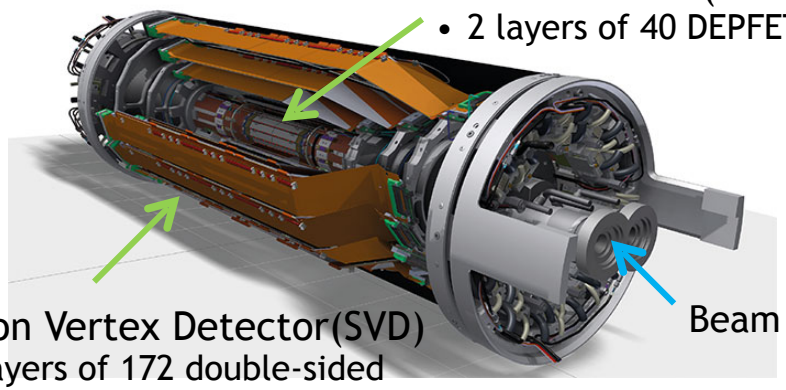
hua.ye@desy.de

SuperKEKB and Belle II



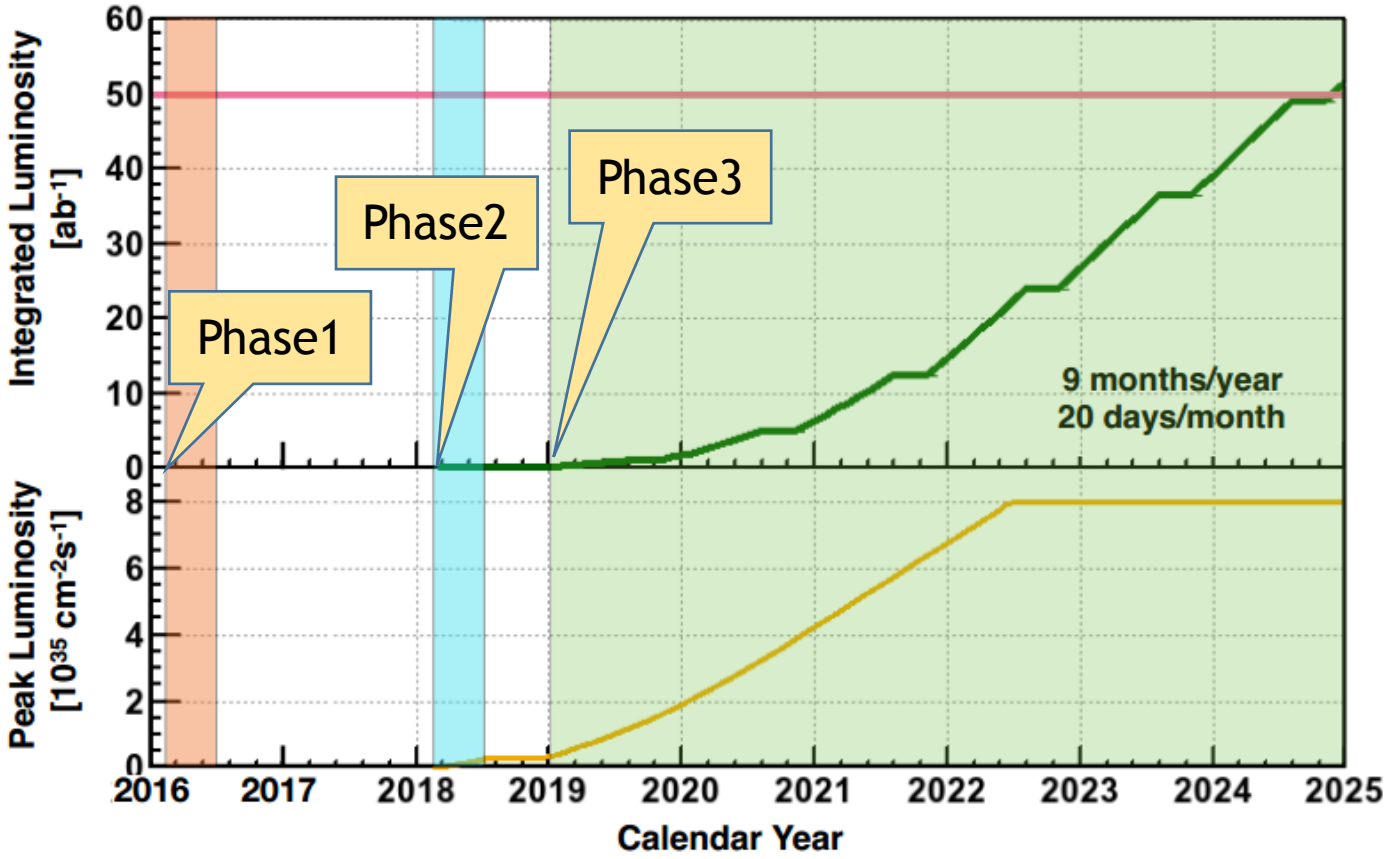




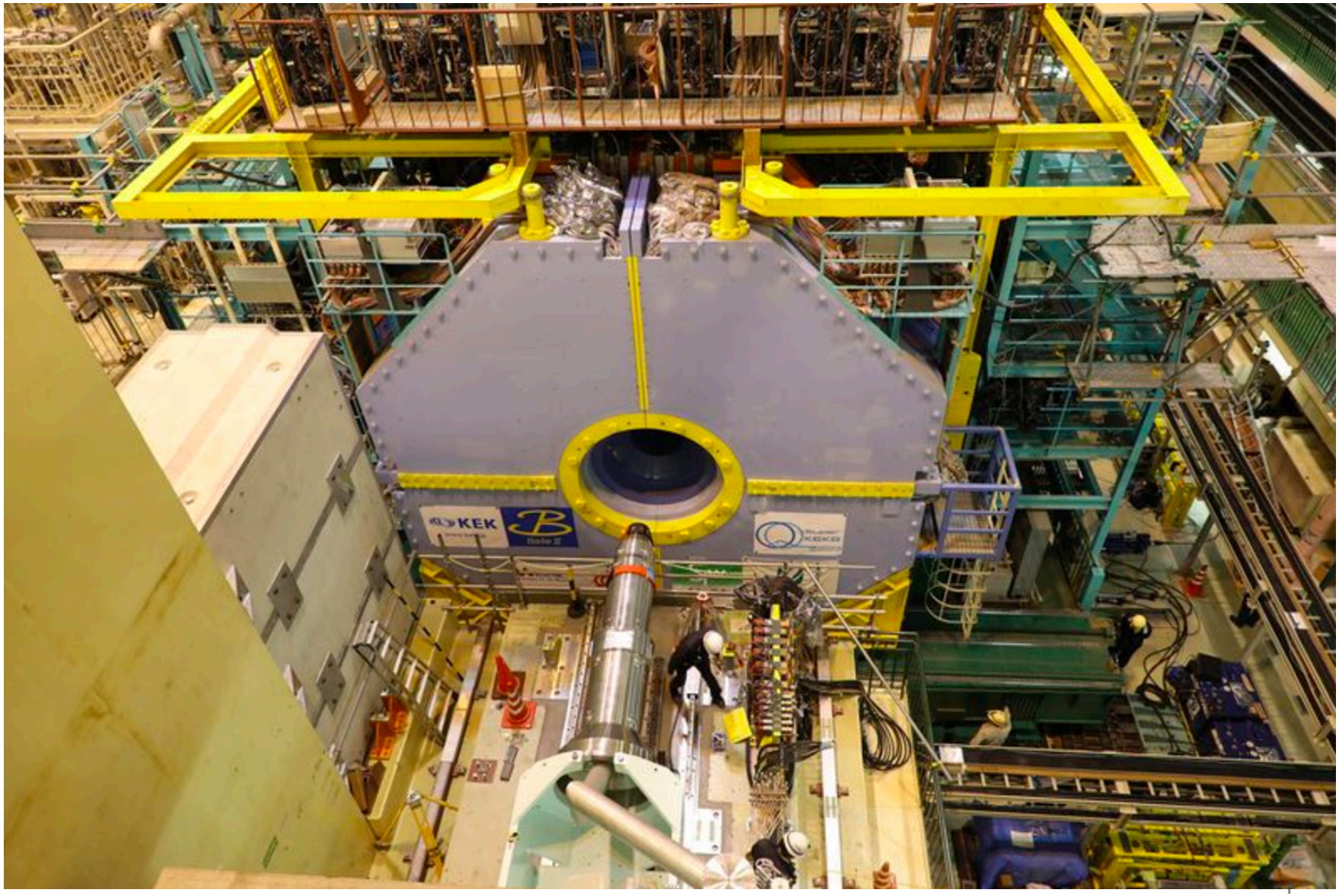


SuperKEKB Commissioning Schedule

- Phase 1: Beam commissioning, without collisions & Belle II (Successfully finished in Jun.2016) *M. Gabriel's TIPP17 talk*
- Phase 2: partial Belle II is rolled in (without full VXD) in Apr.2017, collision tuning will start.
- Phase 3 – Physics Run: Full Belle II with VXD

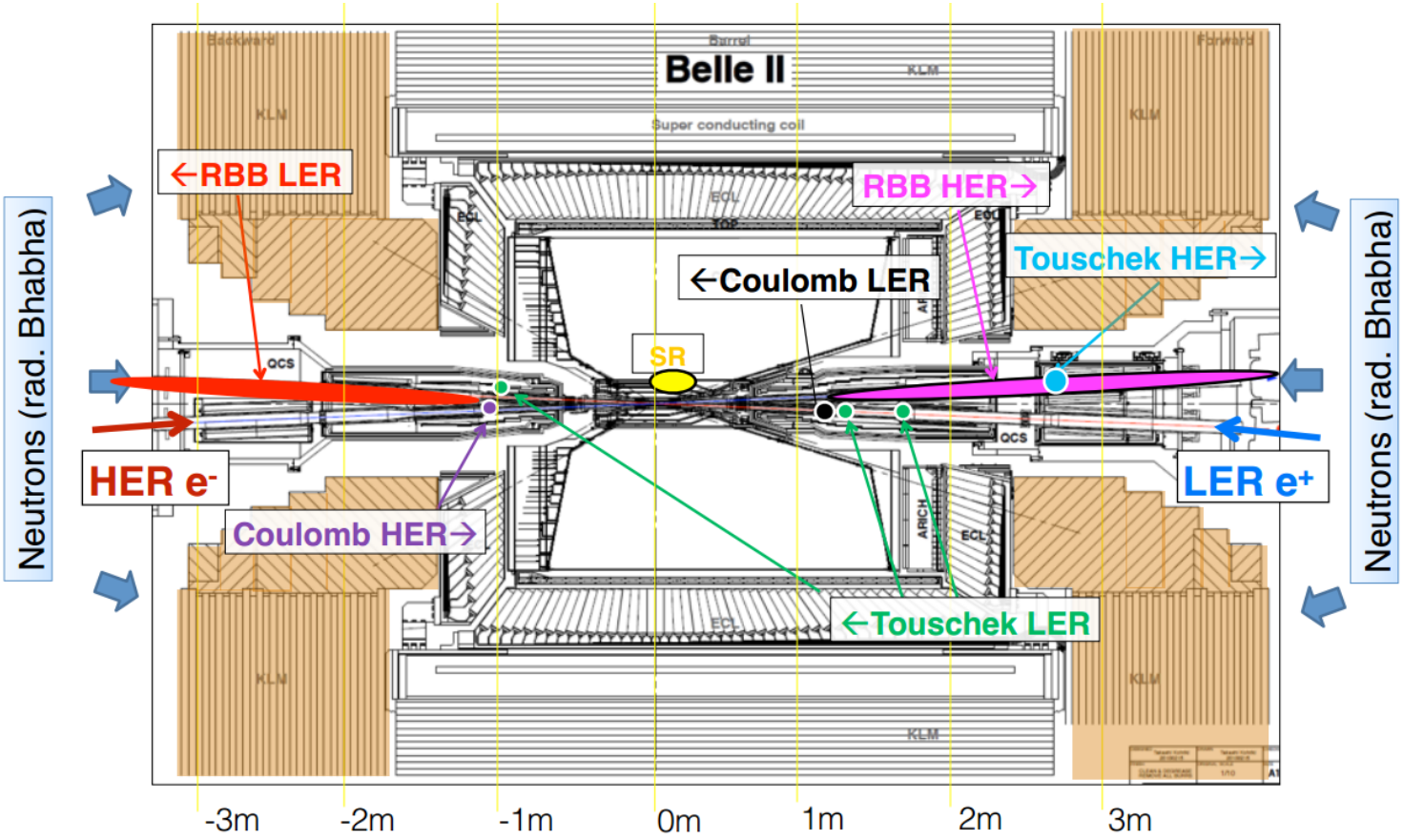


Belle II detector occupies its place



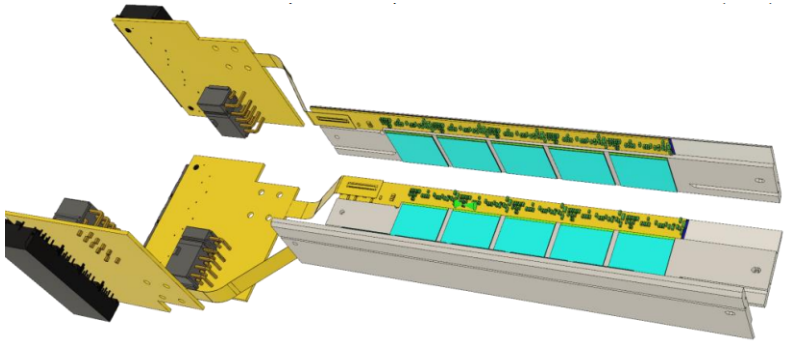
Beam Induced Background

40X instantaneous luminosity is expected to lead to significantly higher background levels in all Belle II subdetectors.

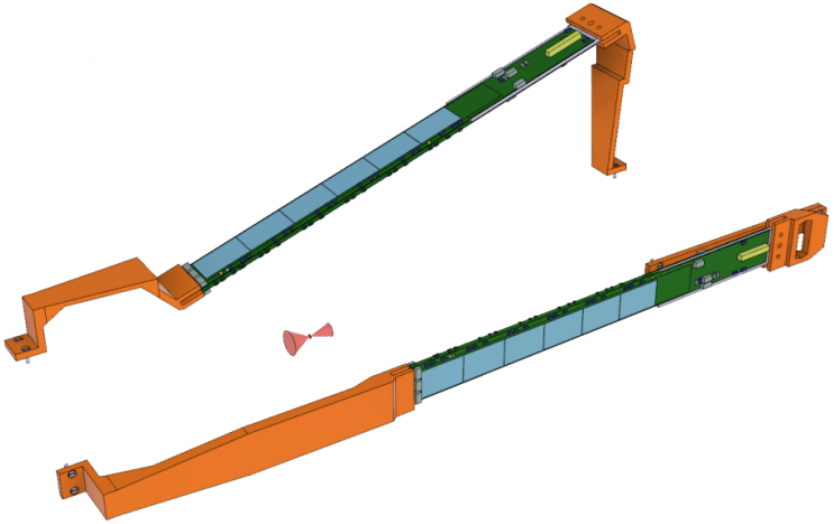


FANGS, CLAWS and PLUME

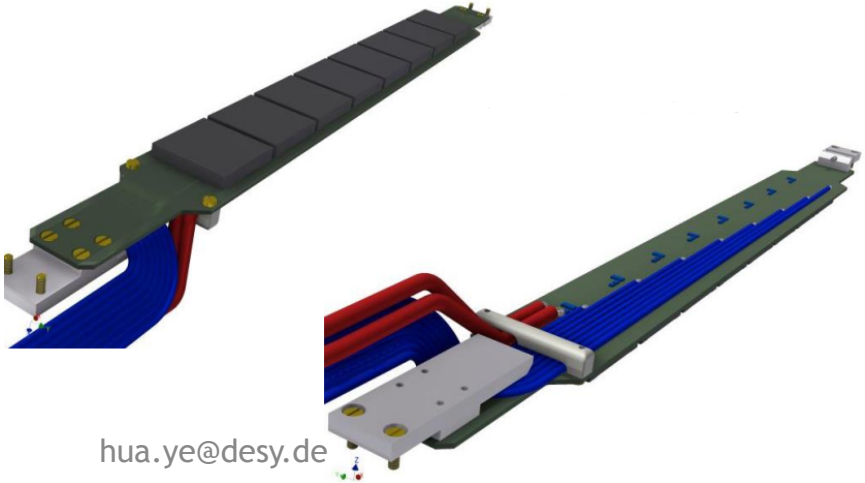
FANGS: planar pixel with ATLAS IBL readout (FE-I4)
To investigate the Synchrotron Radiation (SR) and deposited energy spectrum of background.



PLUME: double-layer MIMOSA pixels
To study the spatial distribution and direction information of the beam injected background.



CLAWS: Plastic scintillators with SiPM readout
To study the time evolution of beam injected background and its decay constant



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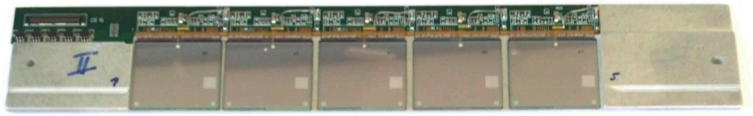

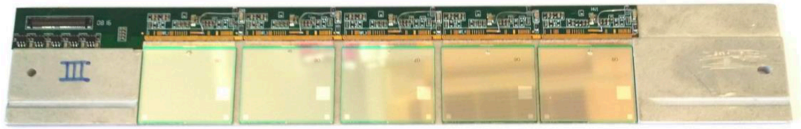

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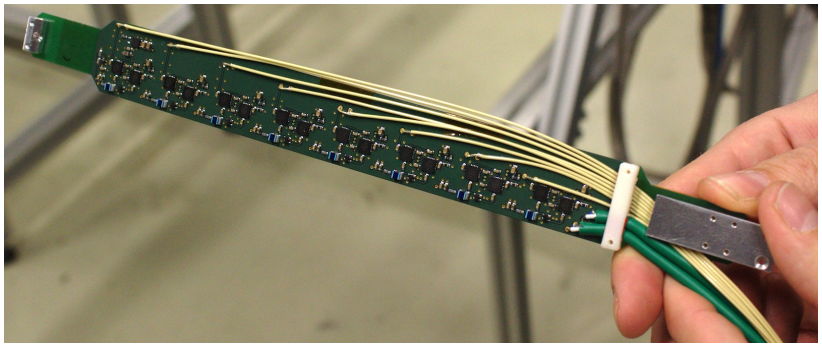


SuperKEKB Commissioning Phase II

Beam Exorcism for A STable experiment (BEAST II) :

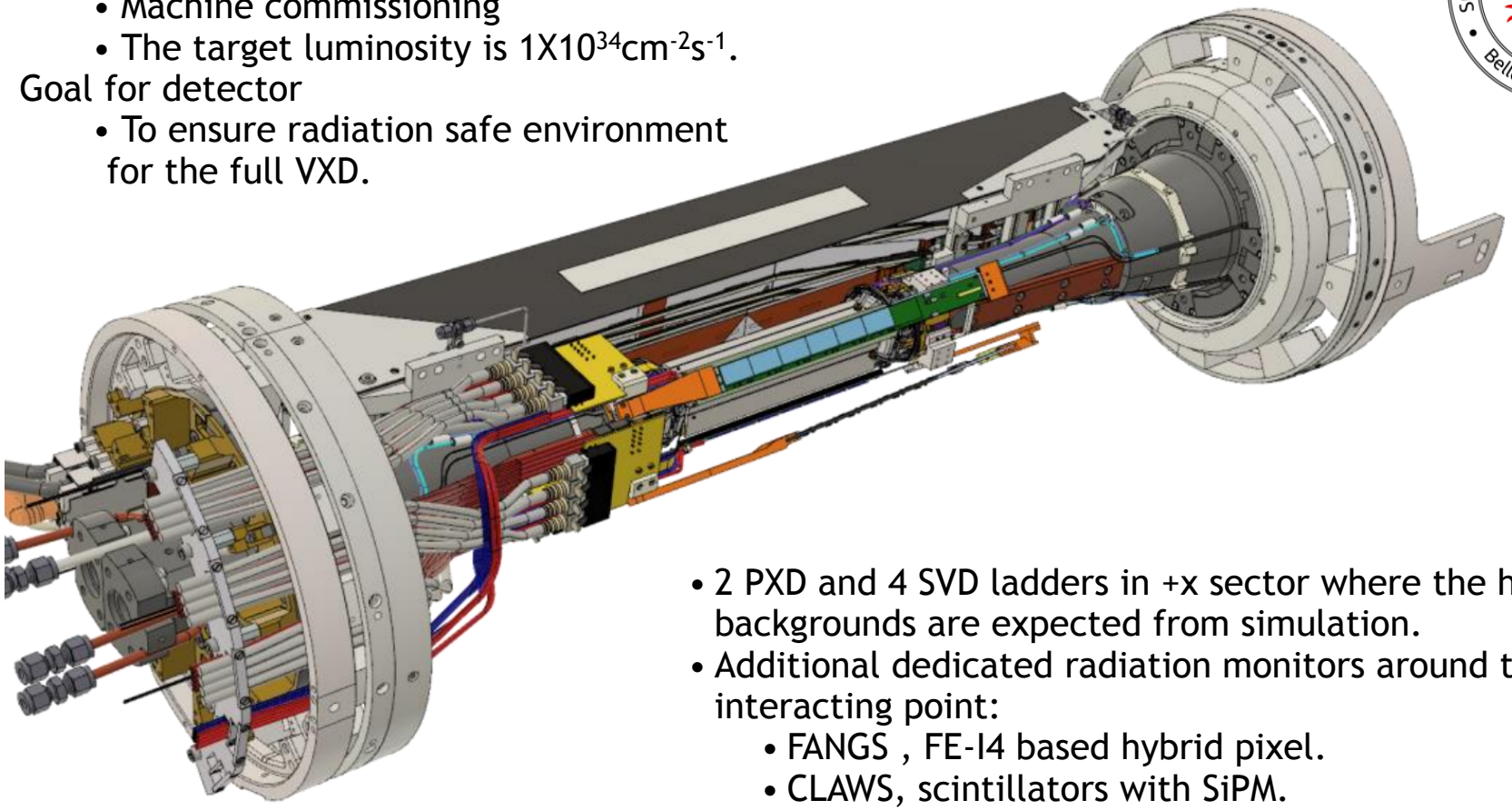
To characterise the beam-induced backgrounds near the interaction point (IP)

Goal for accelerator

- Machine commissioning
- The target luminosity is $1X10^{34}cm^{-2}s^{-1}$.

Goal for detector

- To ensure radiation safe environment for the full VXD.

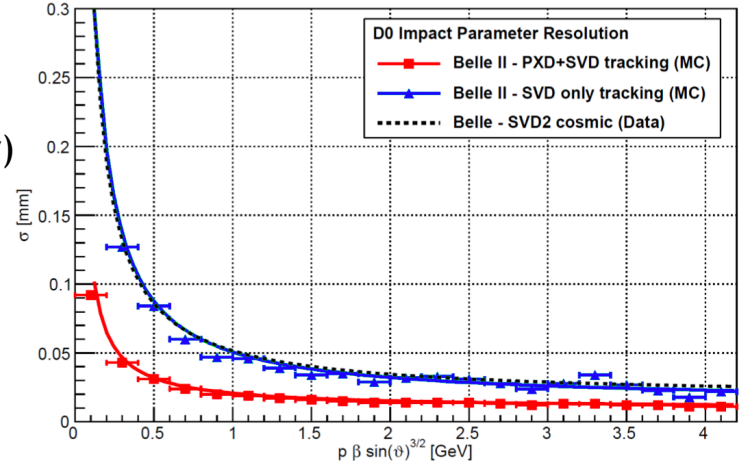


- 2 PXD and 4 SVD ladders in +x sector where the highest backgrounds are expected from simulation.
- Additional dedicated radiation monitors around the interacting point:
  - FANGS , FE-I4 based hybrid pixel.
  - CLAWS, scintillators with SiPM.
  - PLUME, double-sided high granularity MIMOSA pixels

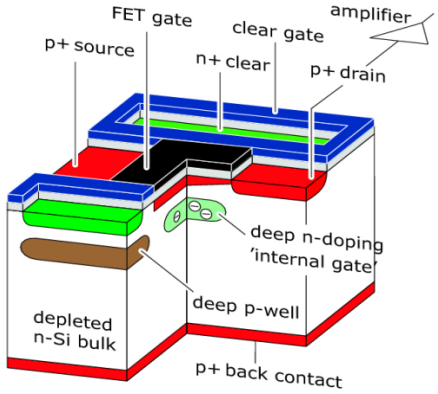
DEPFET Pixel Sensor

2 layers @14(22) mm
Pixel size: 50 x 55-85 μm²
Occupancy: 0.4 hits/μm²/s (3% max)
Integration time: 20 μs (rolling shutter)
Thickness: 75 μm, 0.21% X_0 per layer

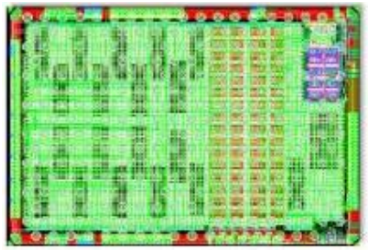
Simulated resolution for track impact parameter

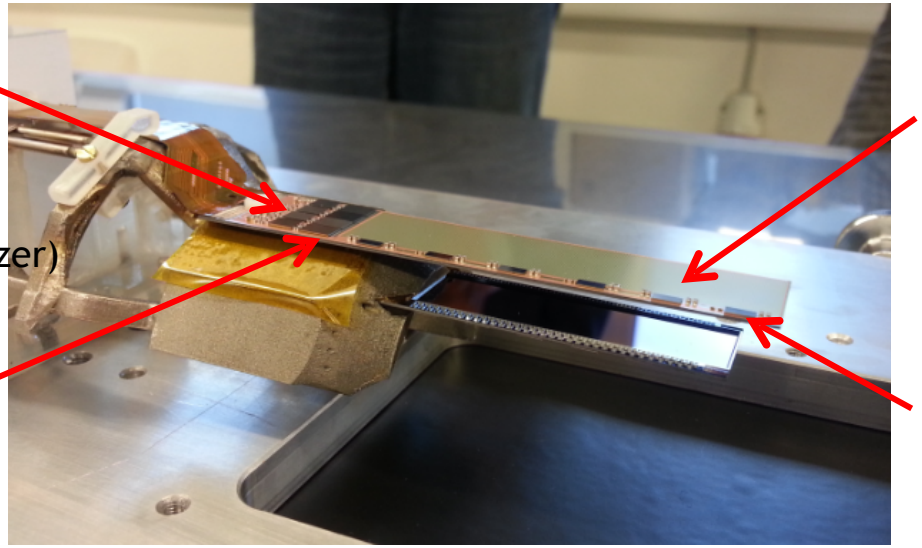


Depleted P-channel Field-Effect Transistor (DEPFET)

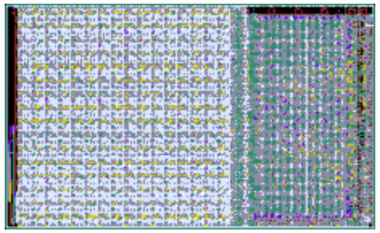


DHP (Data Handling Processor)
First data compression

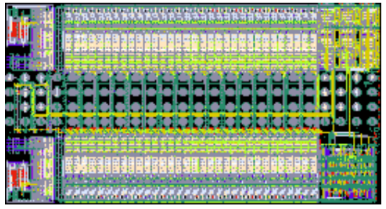




DCDB (Drain Current Digitizer)
Analog frontend



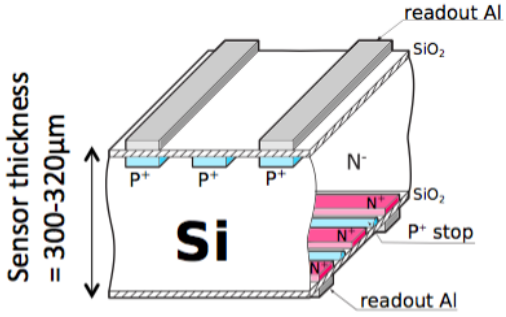
SwitcherB
Row control, Gate and Clear signal



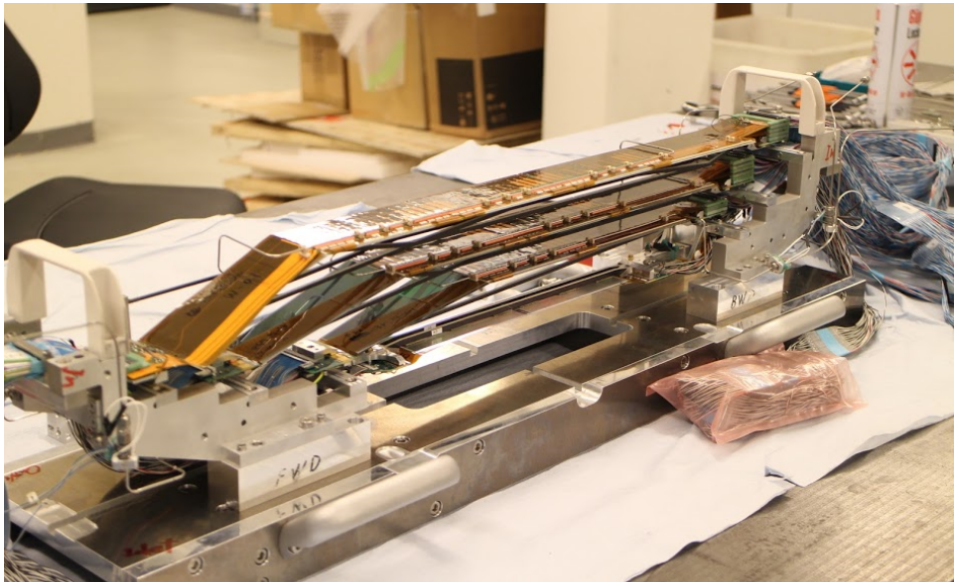
Belle II SVD

DSSD (Double-sided Si strip detector)

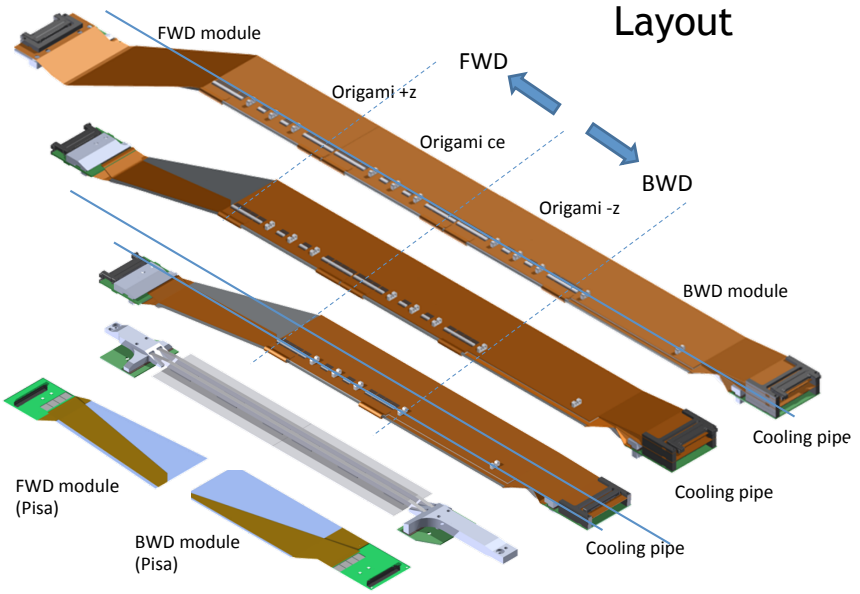
- Four-layer (numbered 3-6) of ladders with up to five DSSD sensors in a row.
- p-strip pitch: 50(75)μm
- n-strip pitch: 160(240)μm
- APV25 front end ASICs are thinned down to 100μm



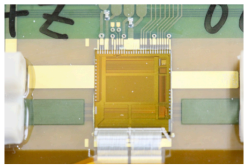
- Slanted shapes in FWD region for the material budget reduction. Average 0.7% X_0 per layer.



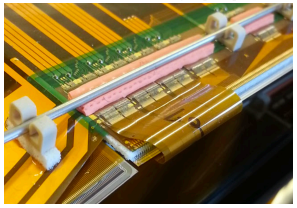
Layout



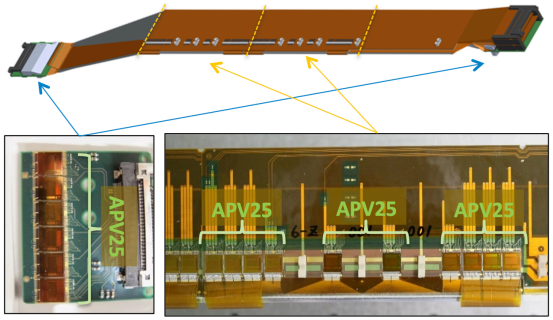
APV25 chips



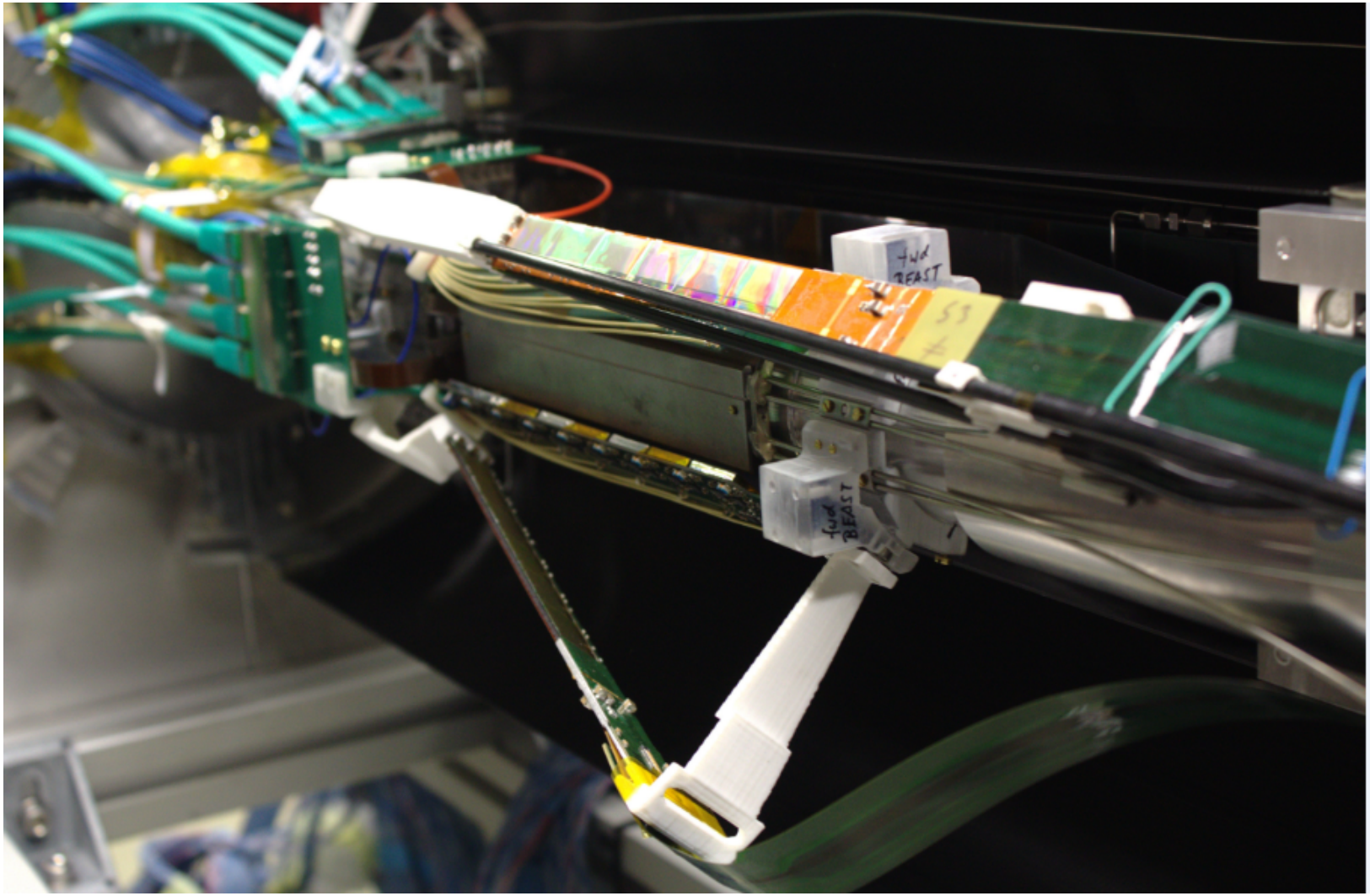
Origami flex and CO2 cooling pipe



APV25s in ladder



BEAST II Integration test at DESY

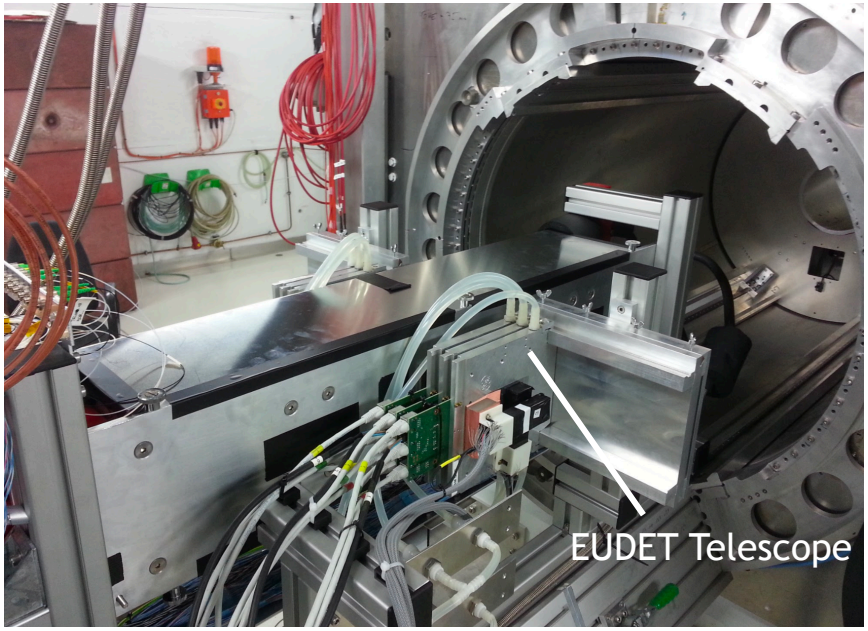


Belle II VXD beam tests at DESY

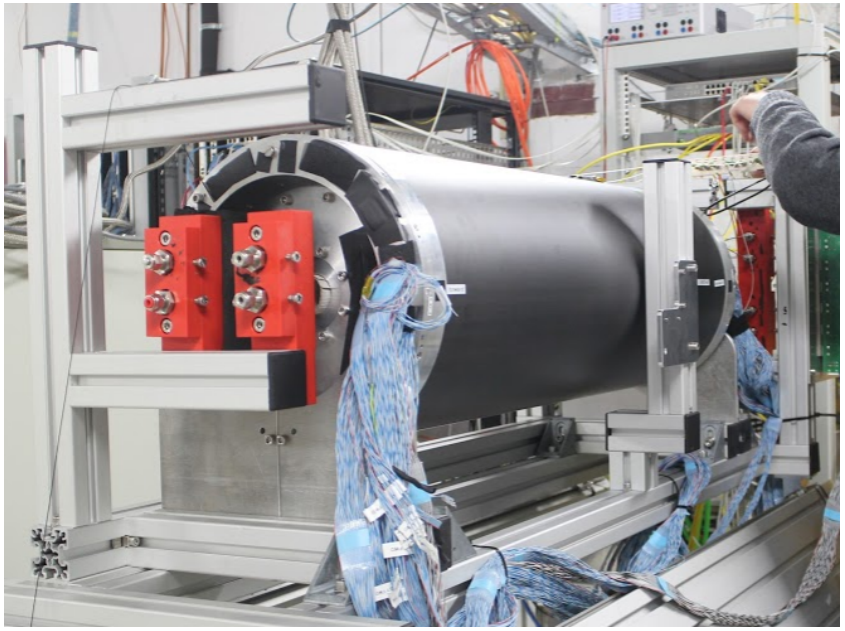
DESY provides the infrastructure and facilities for these critical beam tests

- Complete VXD readout chain: HLT, ROI, monitoring, event building, pocketDAQ, CO2 cooling, slow control, environmental sensors.
- FANGS and CLAWS joined in 2017.
- Illumination with (up to) 6 GeV e^- in solenoid magnetic field up to 1T (PCMAG)

Test beam in Apr.2016
PXD and SVD were tested



Test beam in Feb.2017
Up to 4 PXD modules were tested with beam, FANGS and CLAWS were involved.



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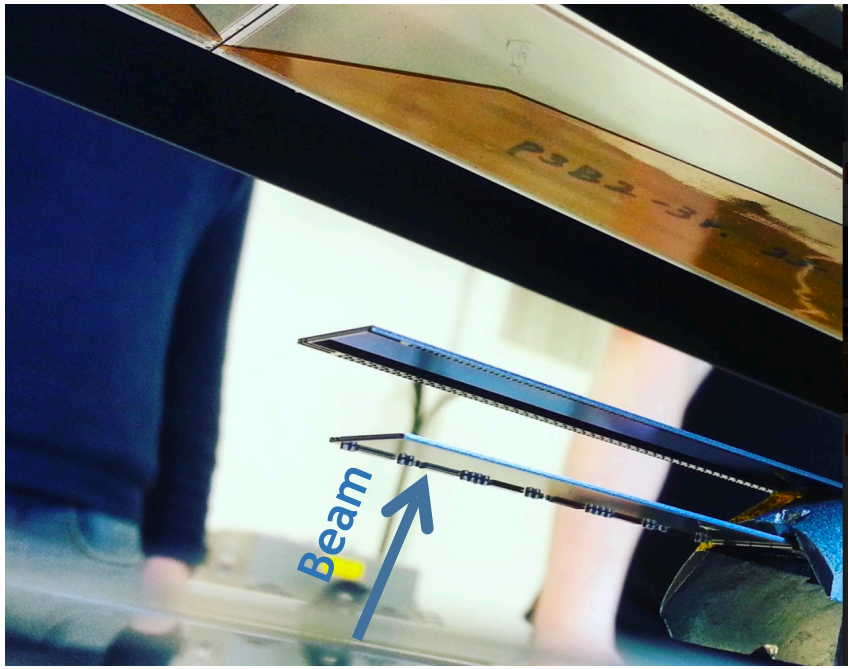
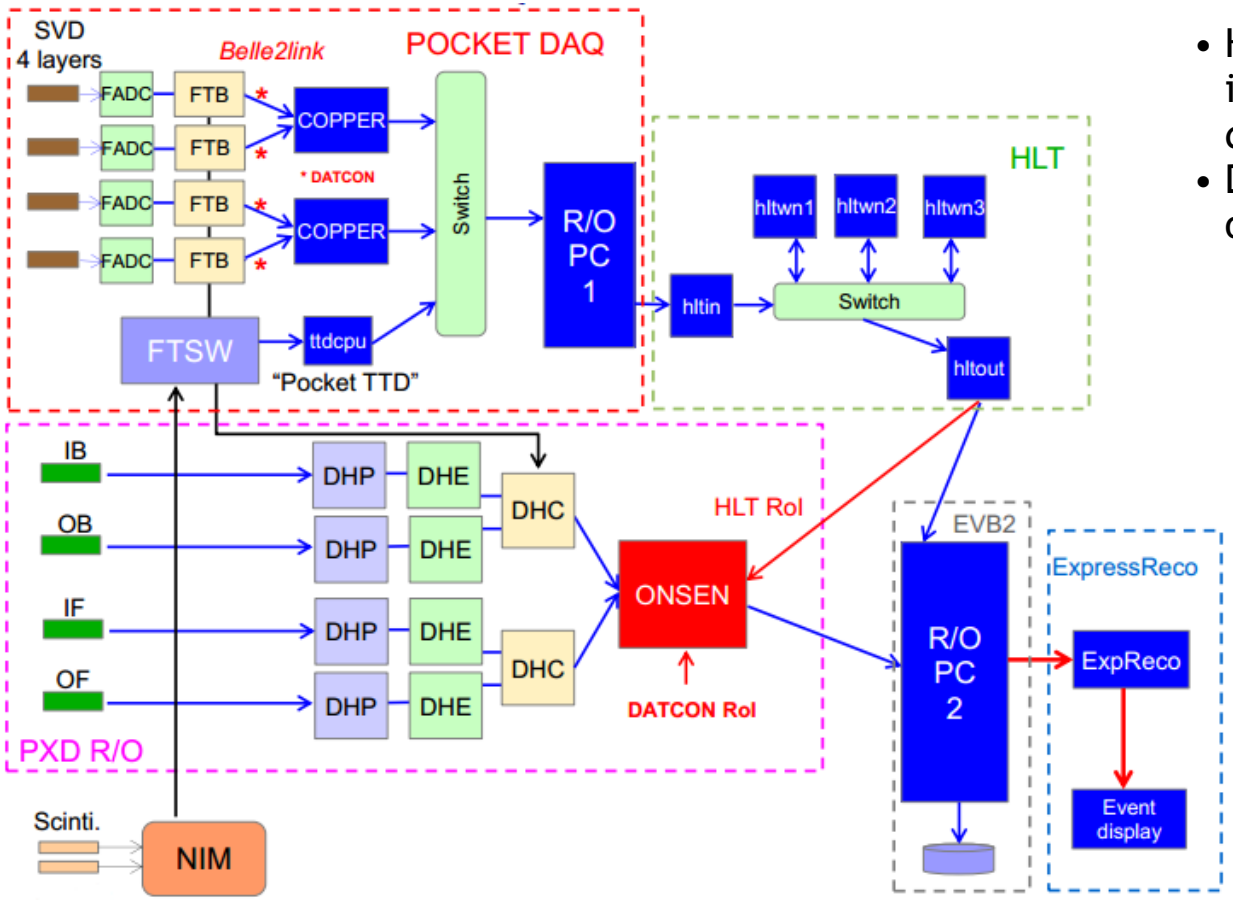


Test beam in Feb.2017
Up to 4 PXD modules were tested with beam, FANGS and CLAWS were involved.

VXD Test Beam DAQ Structure

- PXD data output rate of about 30 GB/s after zero suppression.
- DAQ system aims to reduce the background data by a factor of 30.
- A set of ROIs on PXD sensors are determined, Onsen buffers the output data and records just the data from the pixels inside the ROIs.

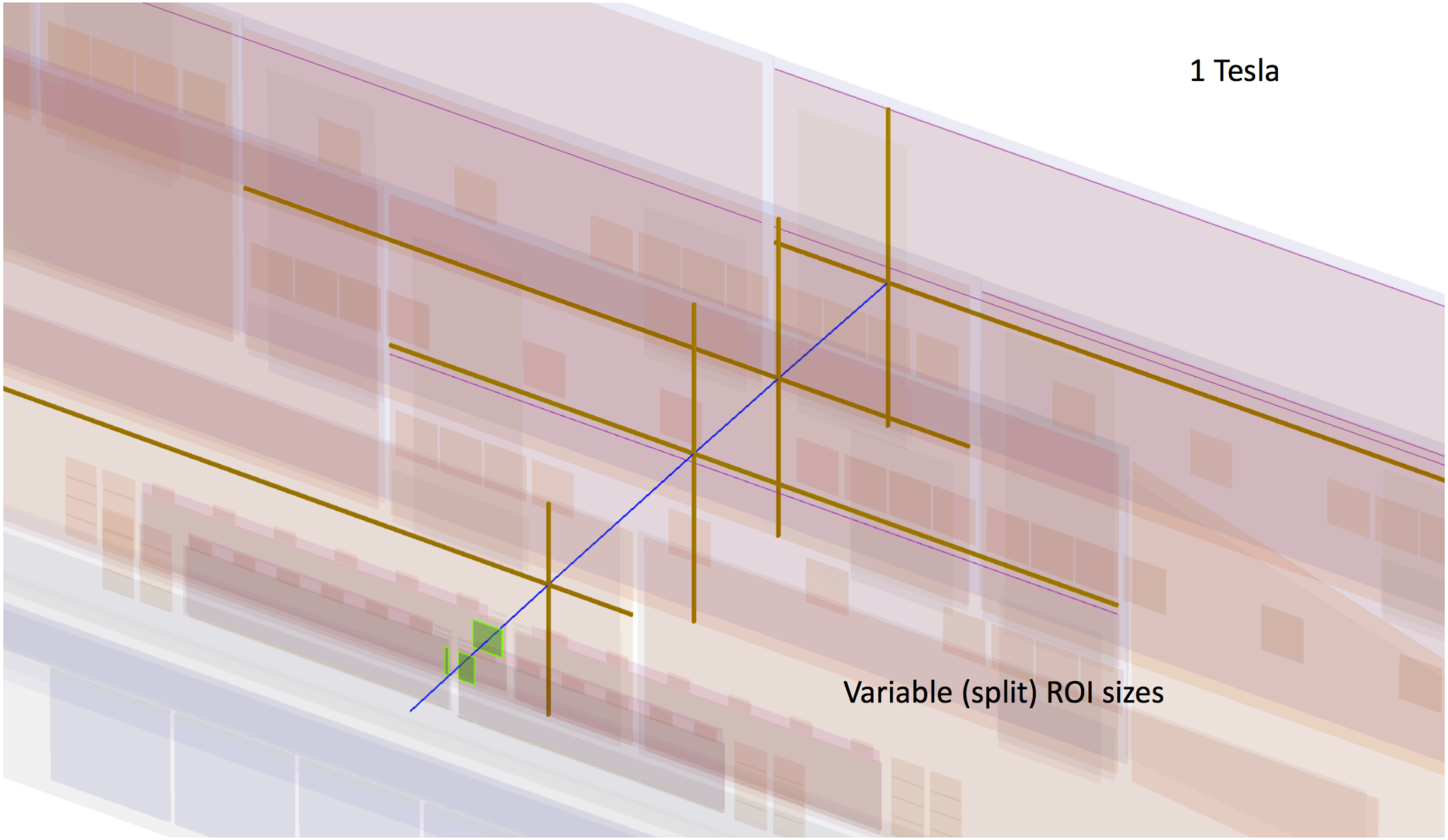


- HLT defines ROIs using the information of SVD and central drift chamber (CDC)
- DATCON defines ROIs using only SVD hits

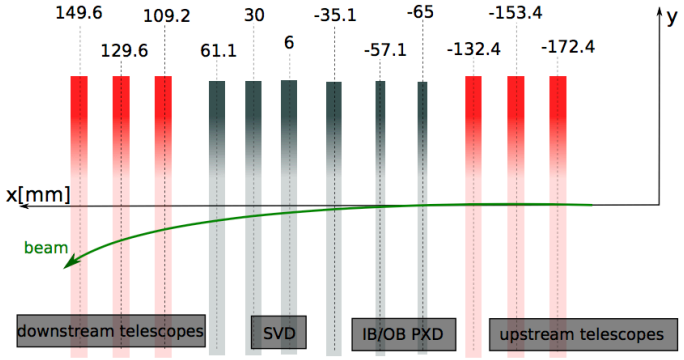
ROI: region of interest
HLT: High level trigger
DATCON: Data concentrator
ONSEN: Online Selection Nodes
EVB: Event builder
DHE: Data handling engine
DHH: Data handling hub
…

T.Konno's TIPP17 talk

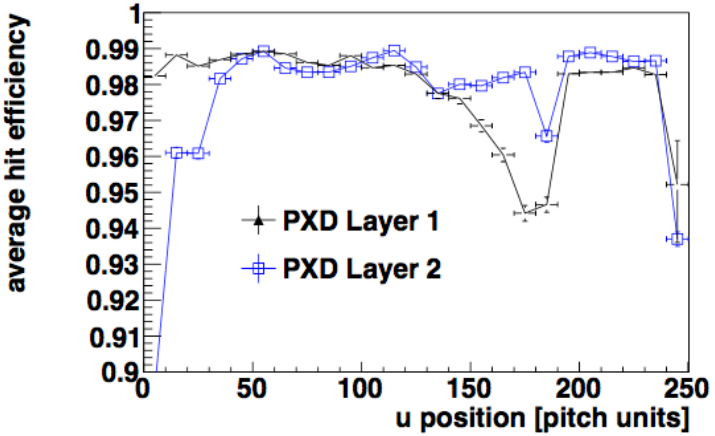
ROI selection



PXD resolution and hit efficiency

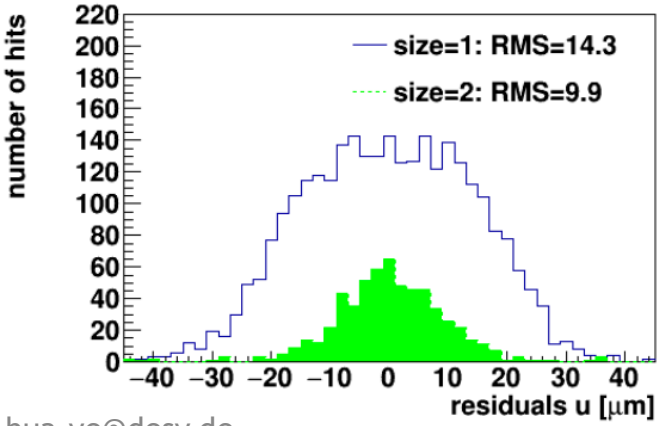


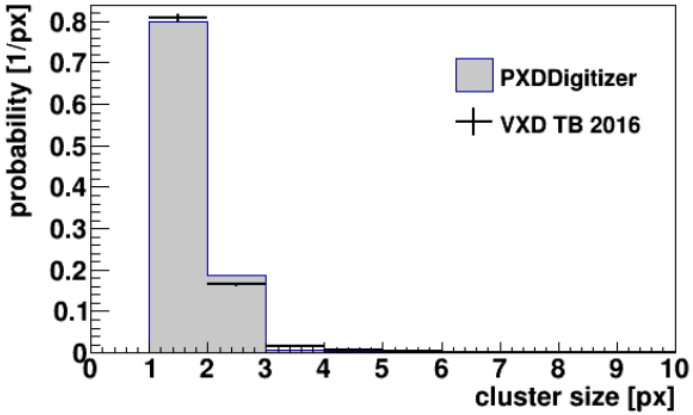
A track was counted as a pass when a PXD cluster was found in the ROI on the same sensor.



The spatial resolution

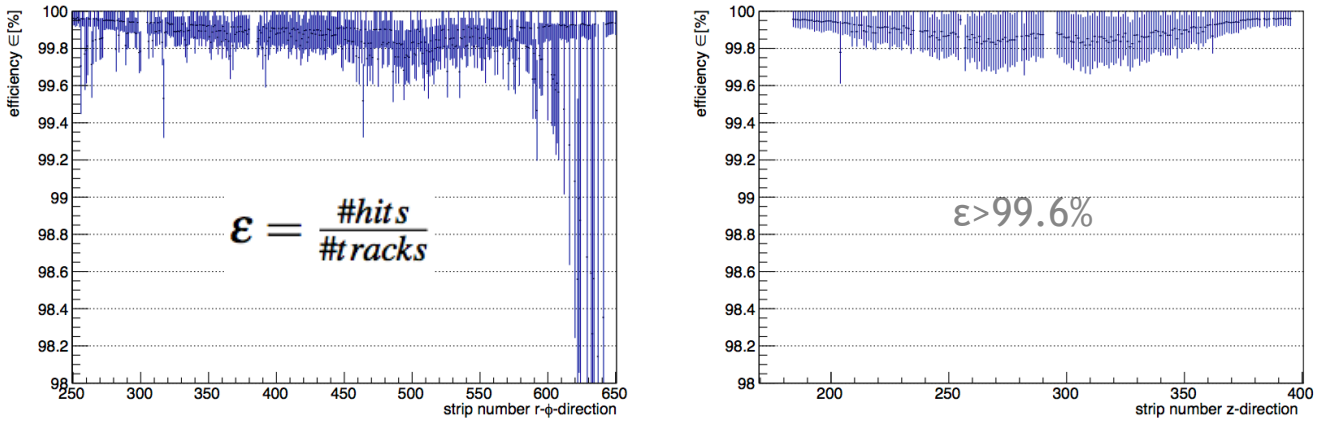
- The expected coordinate is estimated using the hits from at least 3 SVD planes and from the EUDET telescope.
- The residual RMS for single hit clusters agree with the digital resolution of Pitch.





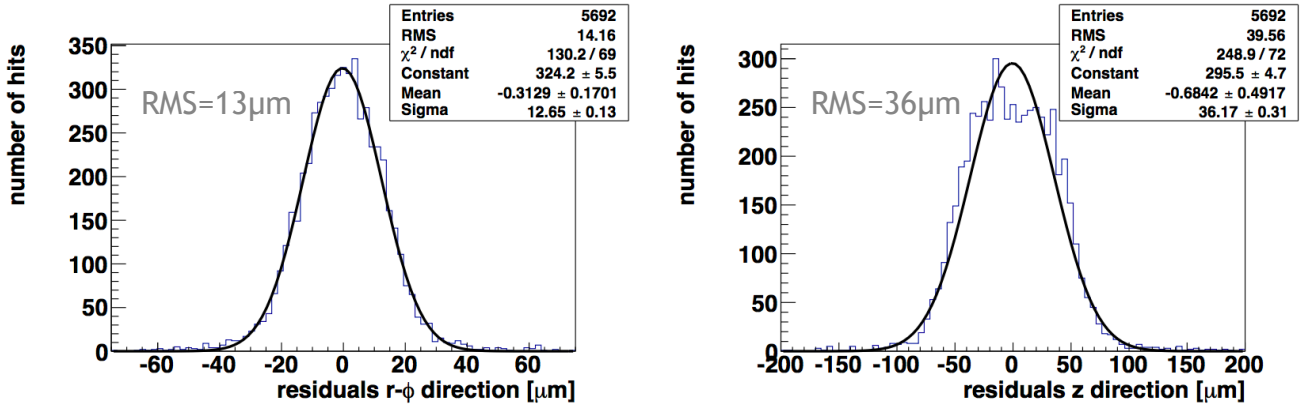
SVD efficiency and resolution

Hit efficiency is measured only using three out of the four SVD layers. The hits are counted when a signal is found within 300μm of the predicted track position.



Efficiency as function of the strip number for SVD layer.5

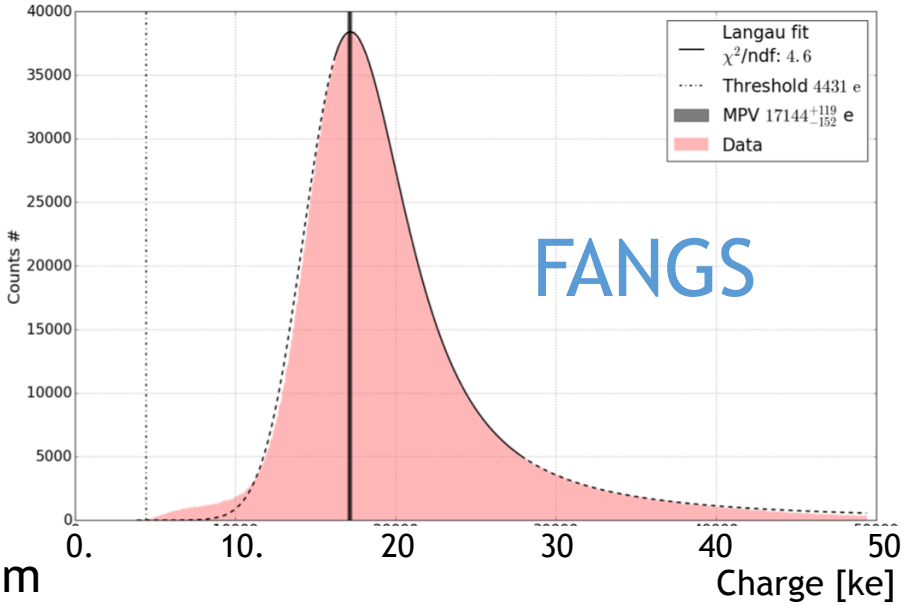
Telescope planes were used in the analysis to reduce the track extrapolation uncertainty.



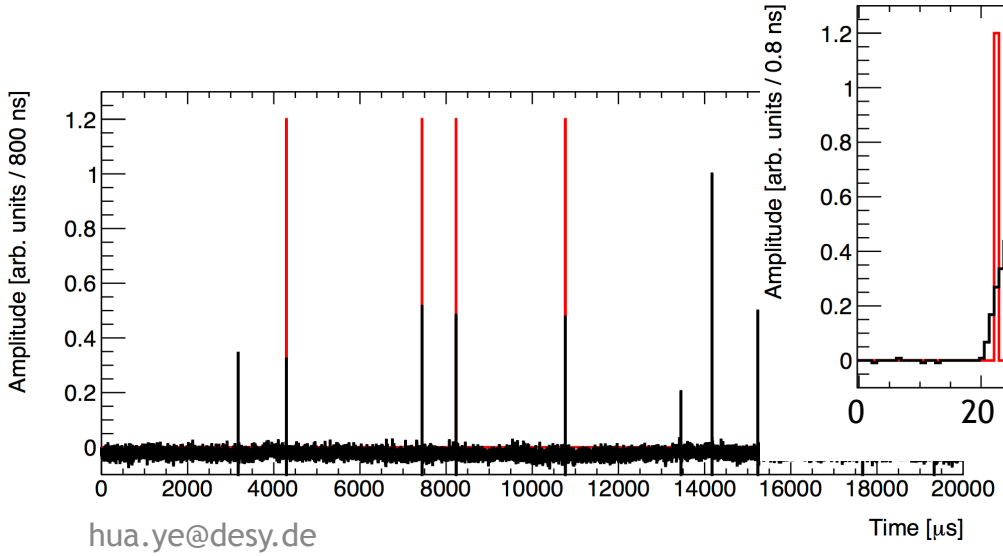
Residuals for the SVD layer.5

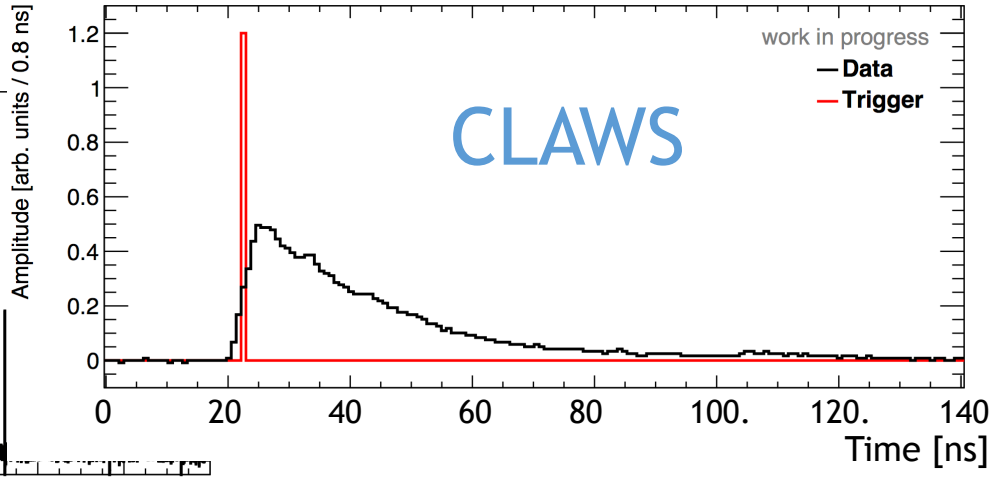
FANGS, CLAWS in Beam Tests

Calibrated charge deposition with TDC method, the fitted mean value (17.1ke) is consistent with the expected value, 18ke.



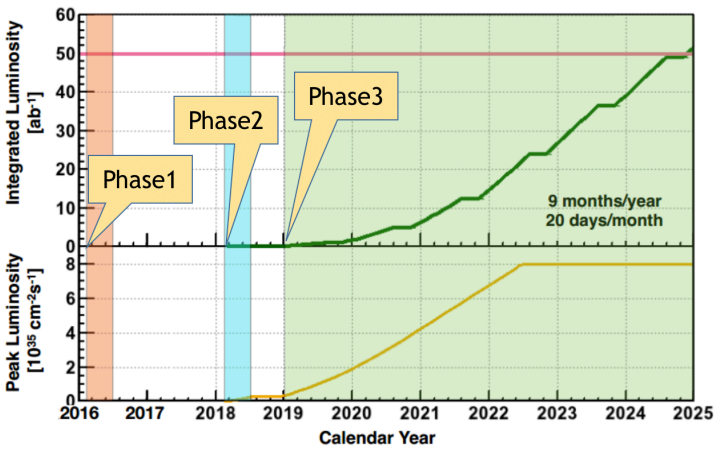
Typical CLAWS wave form in test beam





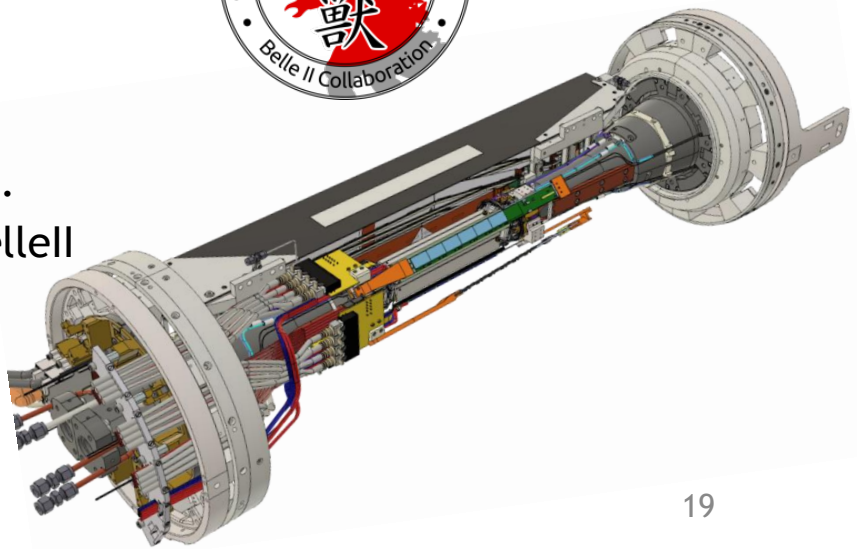
Summary and outlook

- SuperKEKB commissioning phase 2 will start in Feb. 2018, partial Belle II detector has been rolled in.
- The Phase 2 vertex detector includes a sector of PXD and SVD, as well as additional dedicated radiation monitors - FANGS, CLAWS, PLUME etc.
- Integration of the Phase 2 vertex detector is tested at DESY.
- The detector is characterized at DESY test beam. Full VXD read out chain was involved for the fist time in the test.



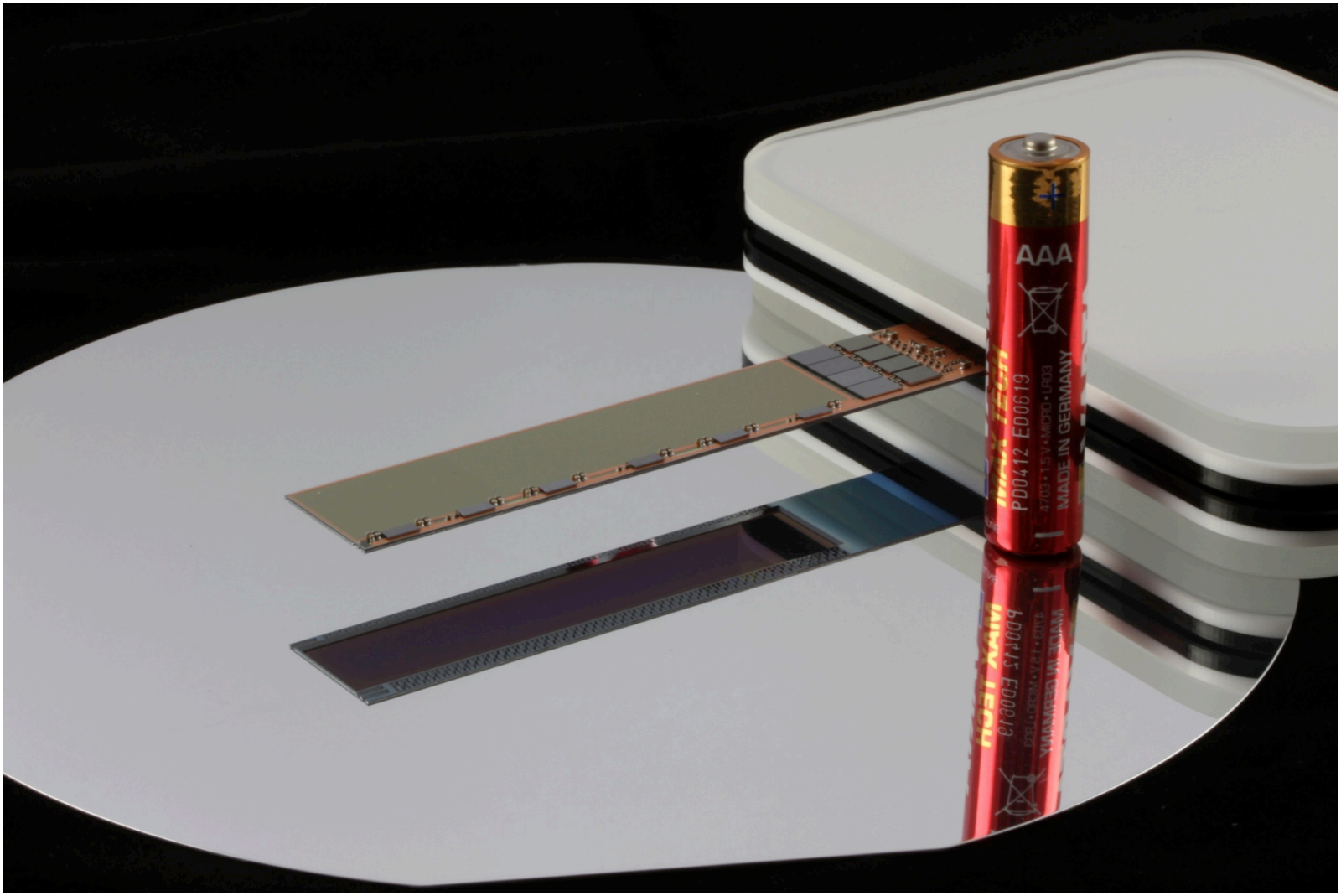
What is next?

- The subdetectors will be shipped to KEK in August.
- In parallel to phase 2, final PXD integration for BelleII physics run is under preparation at DESY.



Backup

DEPFET sensor



VXD beam test at DESY in April 2016