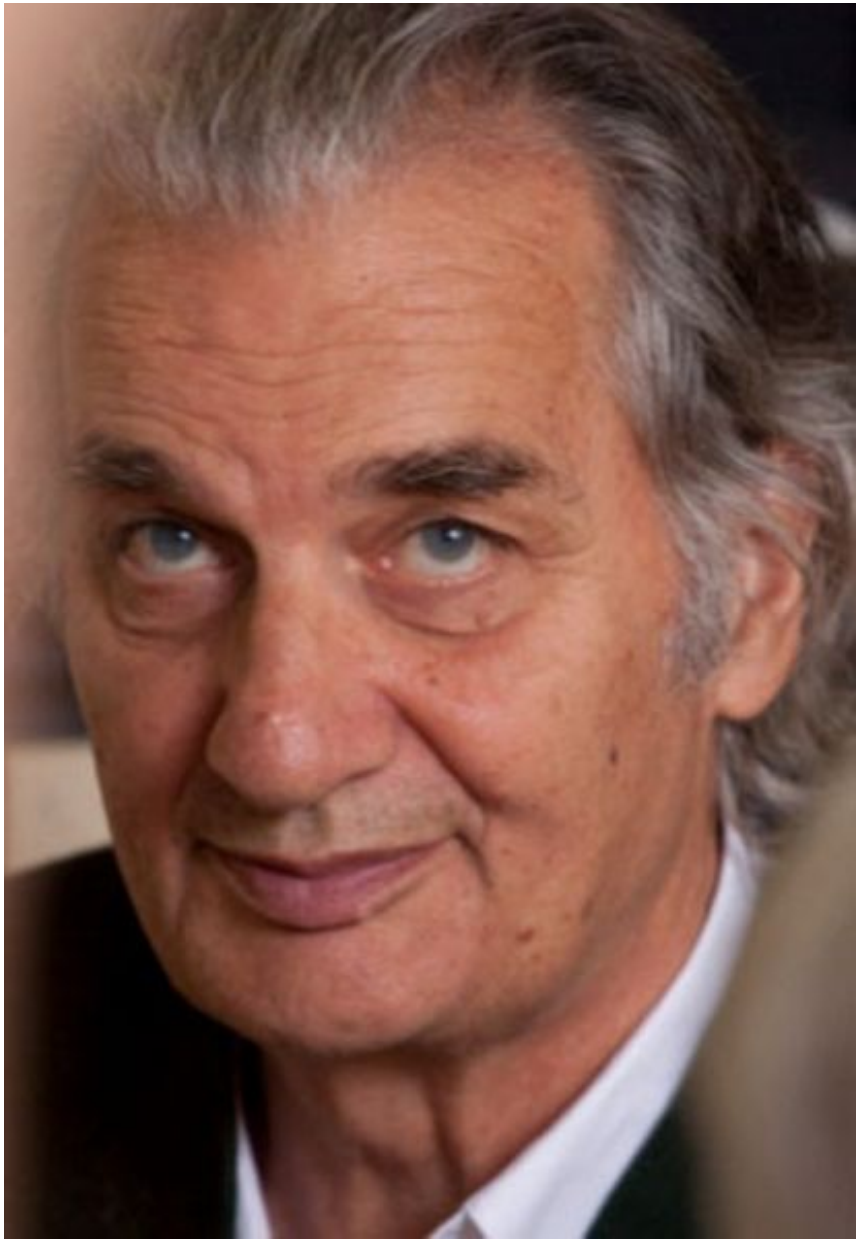
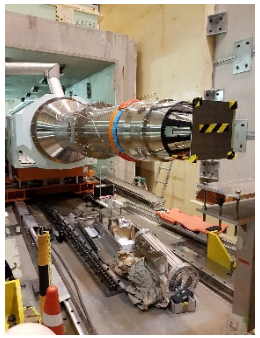


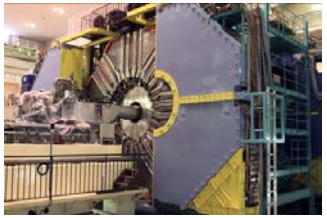
Dr. Gerhard Lutz (1939 – 2017)

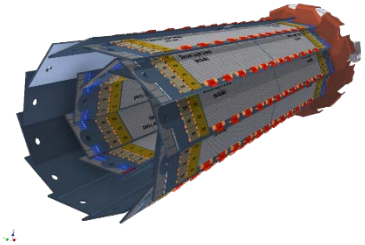
21st International Workshop on DEPFET Detectors and Applications Introductory Remarks

Christian Kiesling
MPI Munich

- Status of SuperKEKB
- Status of Belle II
- Status of the PXD
- Issues of the Meeting



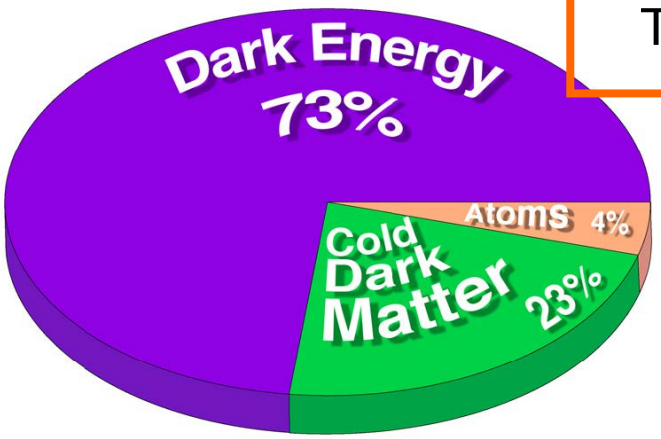




Why SuperKEKB ?

The Standard Model $SU_3 \times SU_2 \times U_1$ (SM) describes all data so far

yet: cannot be the correct theory, SM only a „low energy“ approximation



There is Physics beyond the Standard Model !

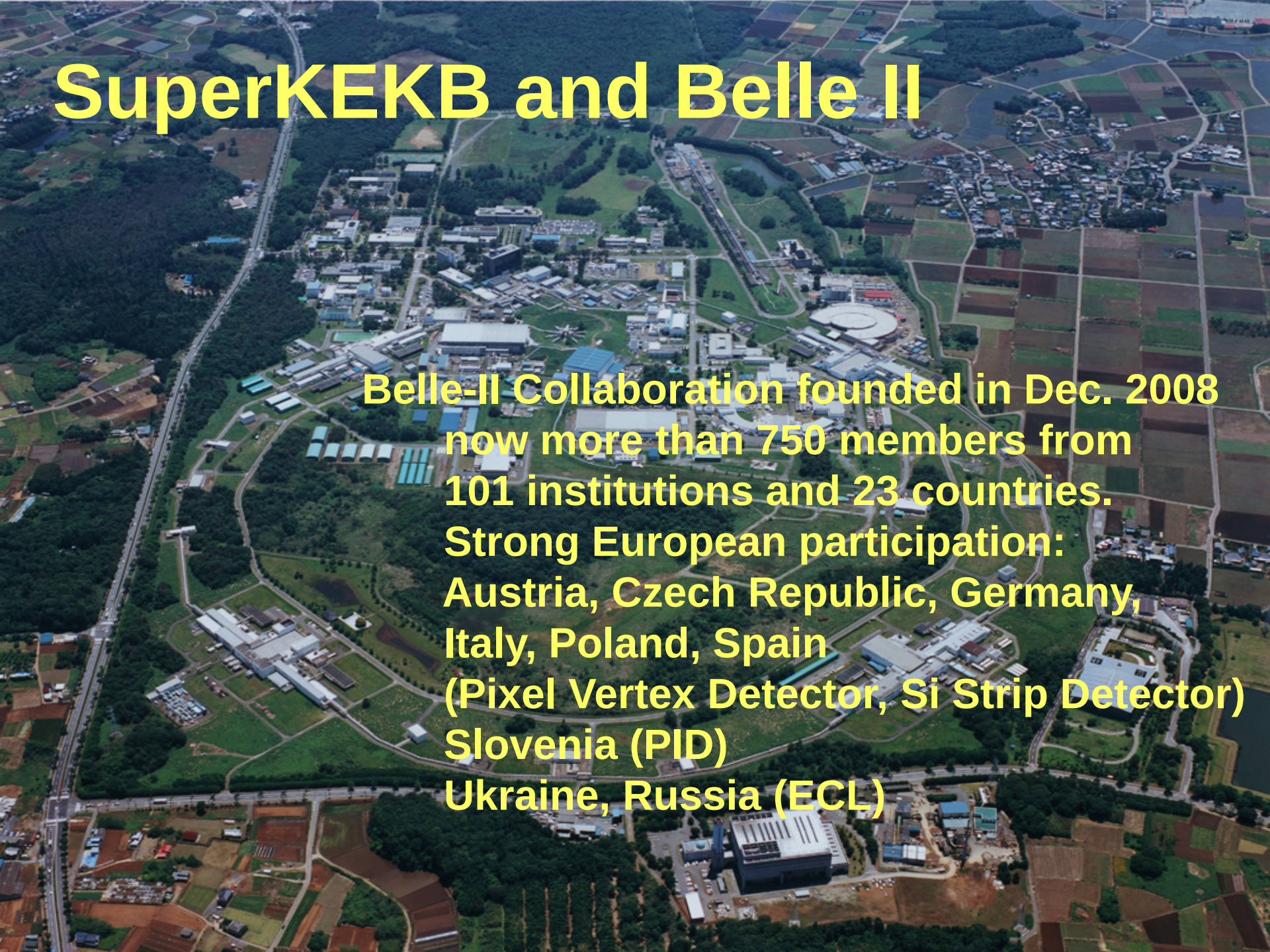
- Neutrinos have mass (Dirac, Majorana?)
- Evidence for Dark Matter & Dark Energy (only 4% of the Universe accounted for by SM)
- Baryon Asymmetry in the Universe is much too large (by 10 orders of magnitude)

need
very high energy
(LHC) or
v. high precision
(**SuperKEKB**)

At least two of them have to do with CP Violation

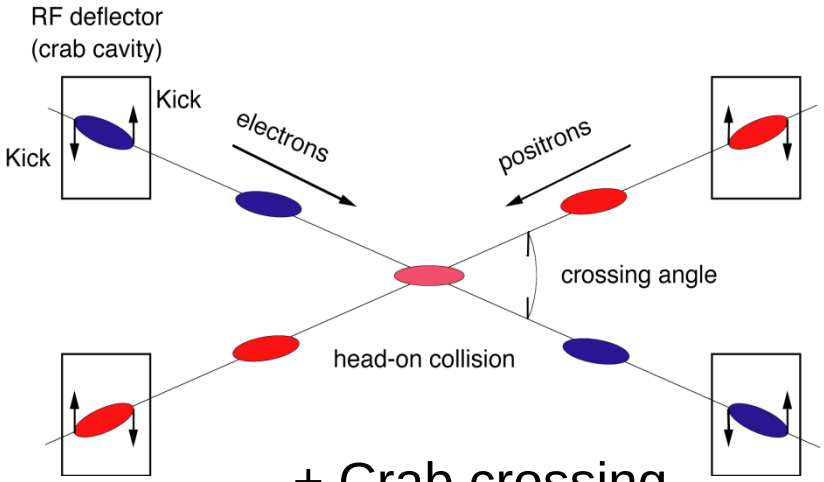
$\not{C}P$: One of the so-called Sakharov-conditions

SuperKEKB and Belle II



Belle-II Collaboration founded in Dec. 2008
now more than 750 members from
101 institutions and 23 countries.
Strong European participation:
Austria, Czech Republic, Germany,
Italy, Poland, Spain
(Pixel Vertex Detector, Si Strip Detector)
Slovenia (PID)
Ukraine, Russia (ECL)

Strategies for High Luminosity



$$\mathcal{L} = \frac{N_+ N_- f}{4\pi\sigma_x\sigma_y} R$$

R : reduction factor (geometrical)

$\sigma_{x,y}$: beam spot size at IP

$$\sigma_{x,y} = \sqrt{\varepsilon_{x,y}\beta_{x,y}}$$

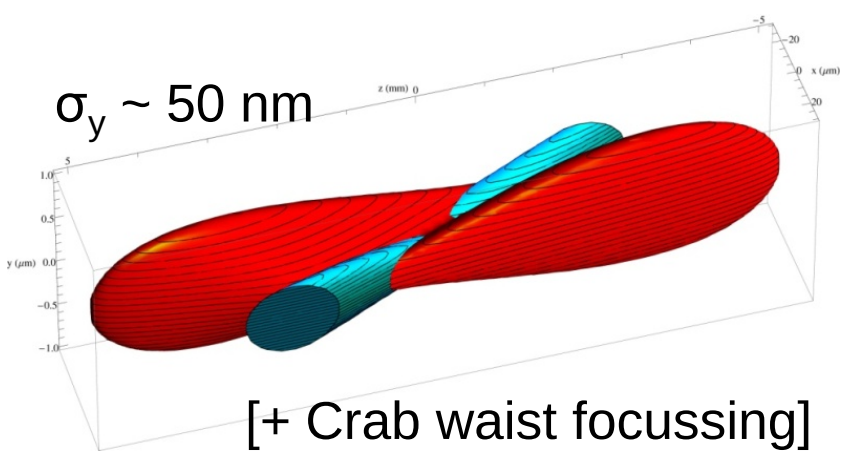
emittance
(e^- : l.e. gun
e^+ : damping ring)

β function
(focussing
s.c. quads)

+ Crab crossing

world record luminosity of
2.11×10^{34} cm^{-2} s^{-1}

$\sigma_y \sim 50$ nm



[+ Crab waist focussing]

Nano Beam Option

Proposal by P. Raimondi *et al.*
for the Italian Super B Factory:
Primarily reduce beam size at the IP

Nano-Beam Option for SuperKEKB

$\sigma_y \sim 50$ nm

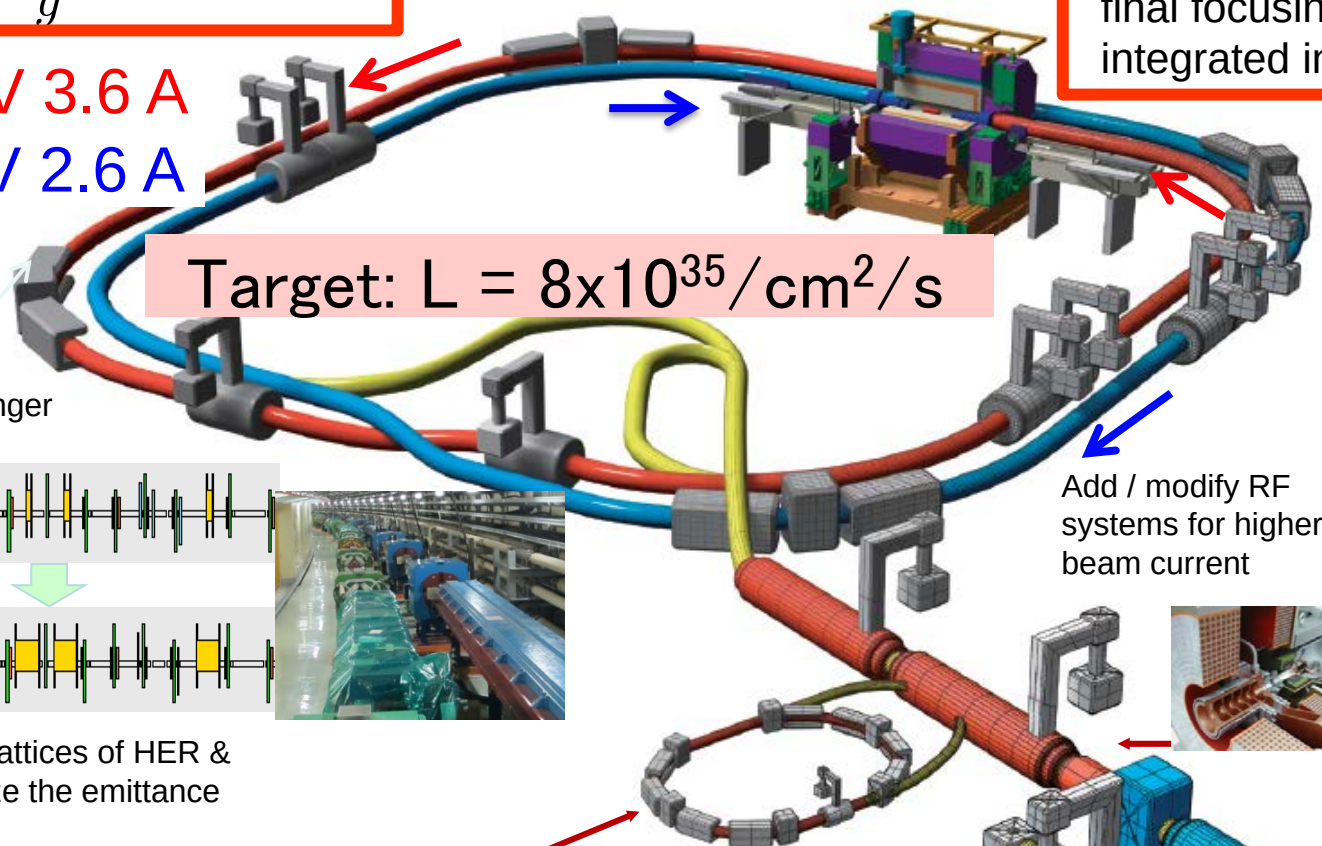
e^+ 4GeV 3.6 A

e^- 7GeV 2.6 A

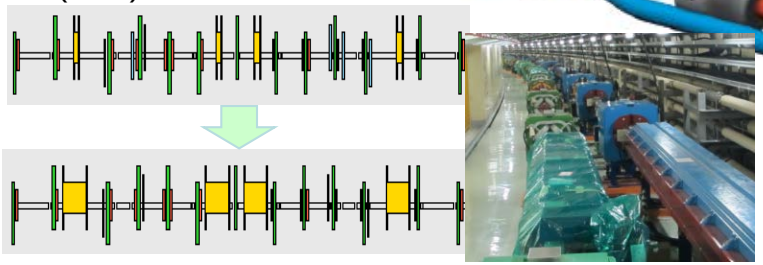
smaller boost !

Target: L = $8 \times 10^{35}/cm^2/s$

New superconducting final focusing quads integrated into detector

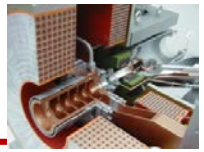


Replace short dipoles with longer ones (LER)



Redesign the lattices of HER & LER to squeeze the emittance

Add / modify RF systems for higher beam current



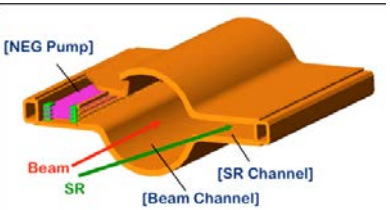
Positron source

New positron target / capture section

Damping ring for positrons

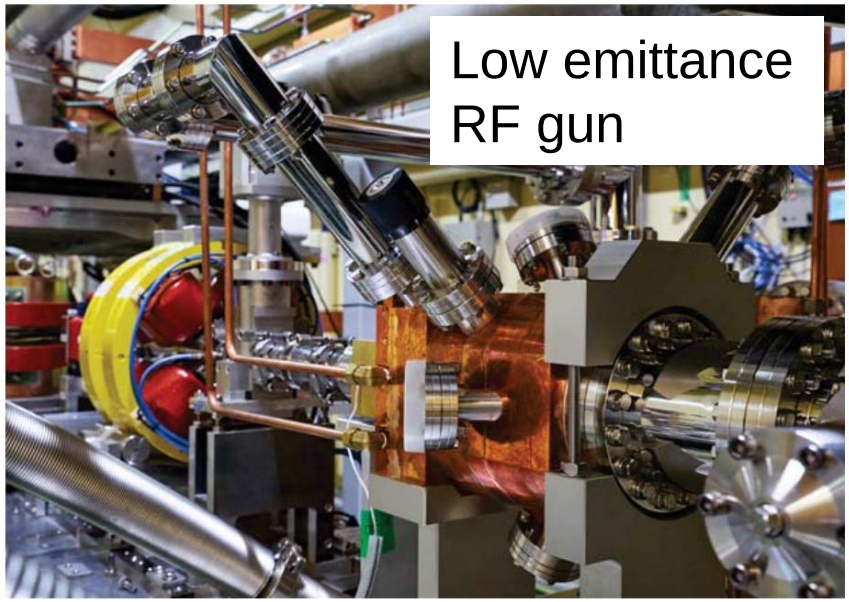
Low emittance gun for electrons

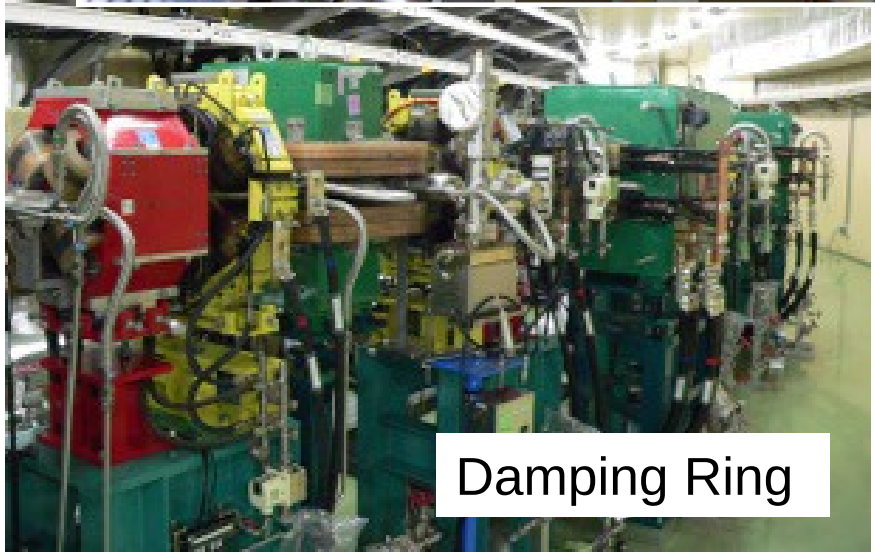
TiN-coated beam pipe with antechambers



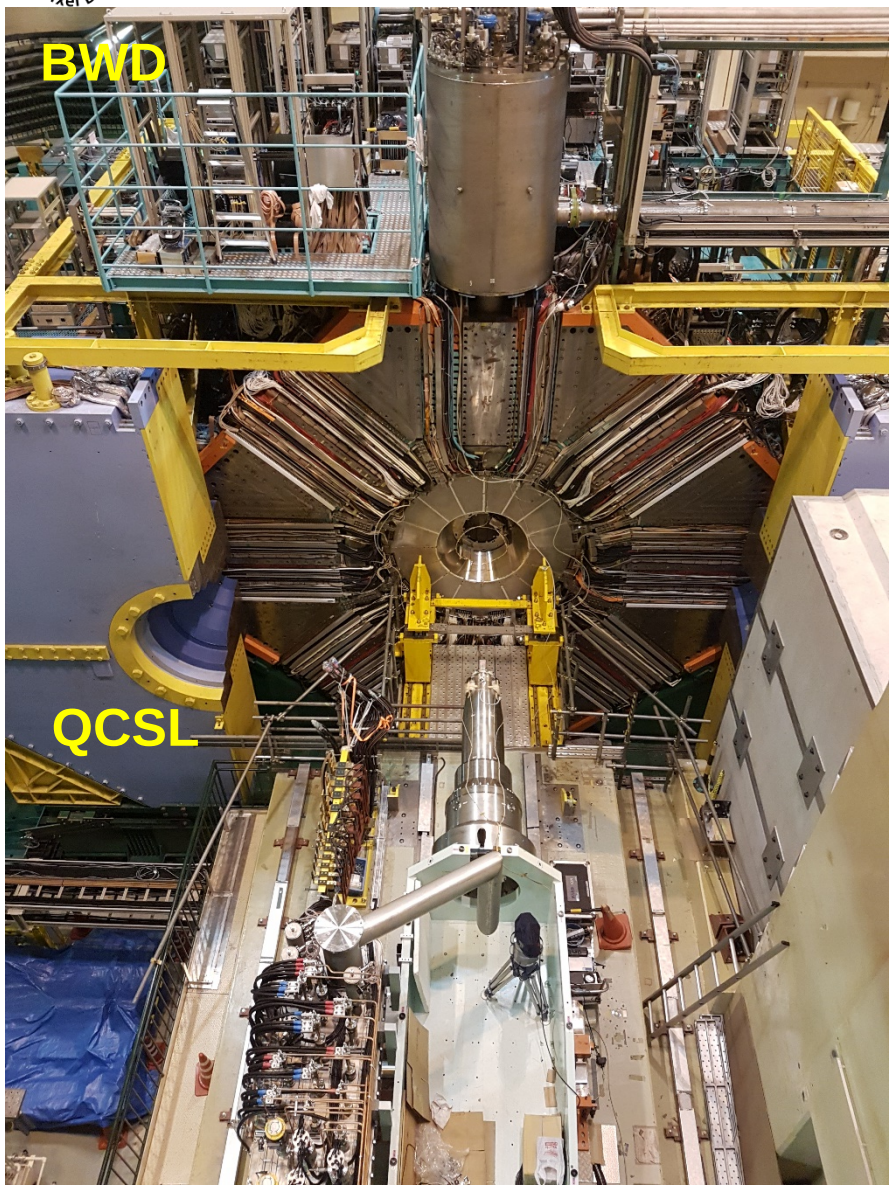
SuperKEKB Hardware almost ready …

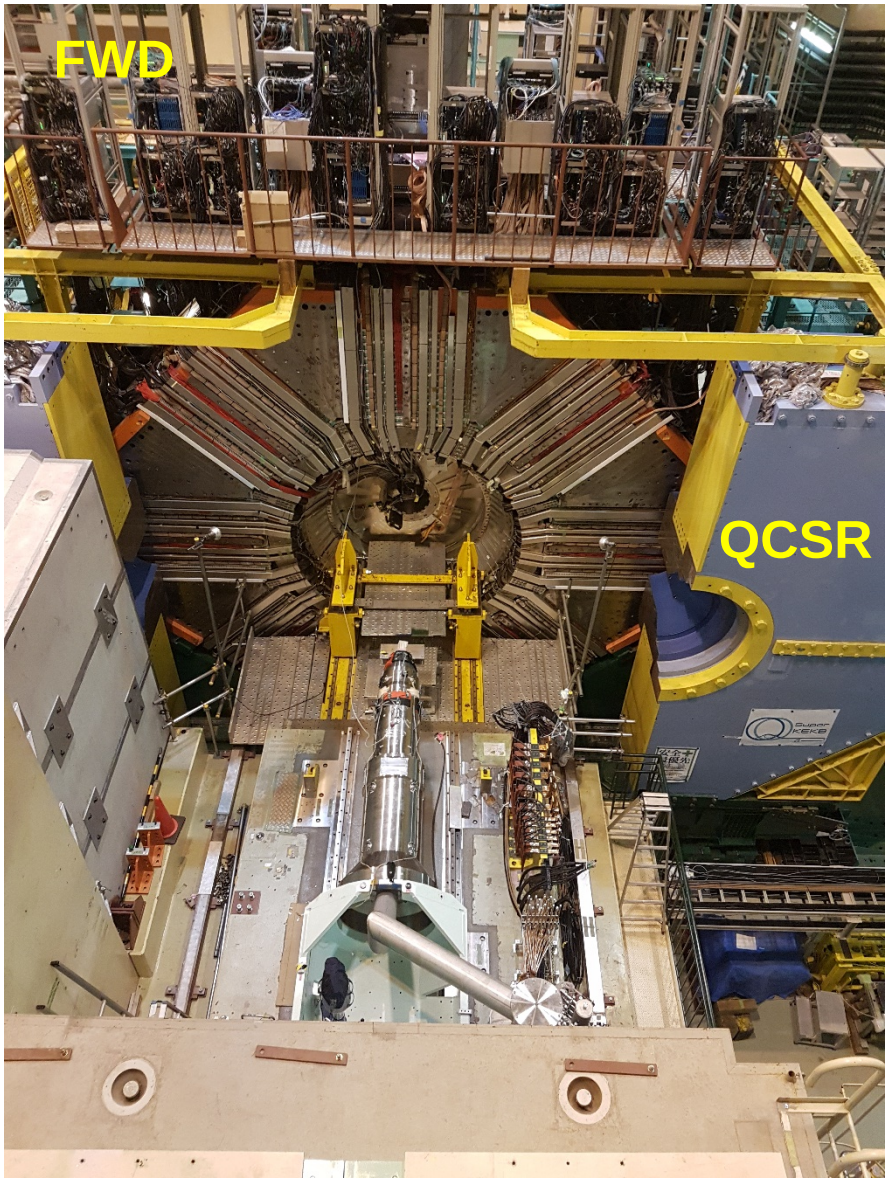
Both rings have been commissioned („Phase 1“)



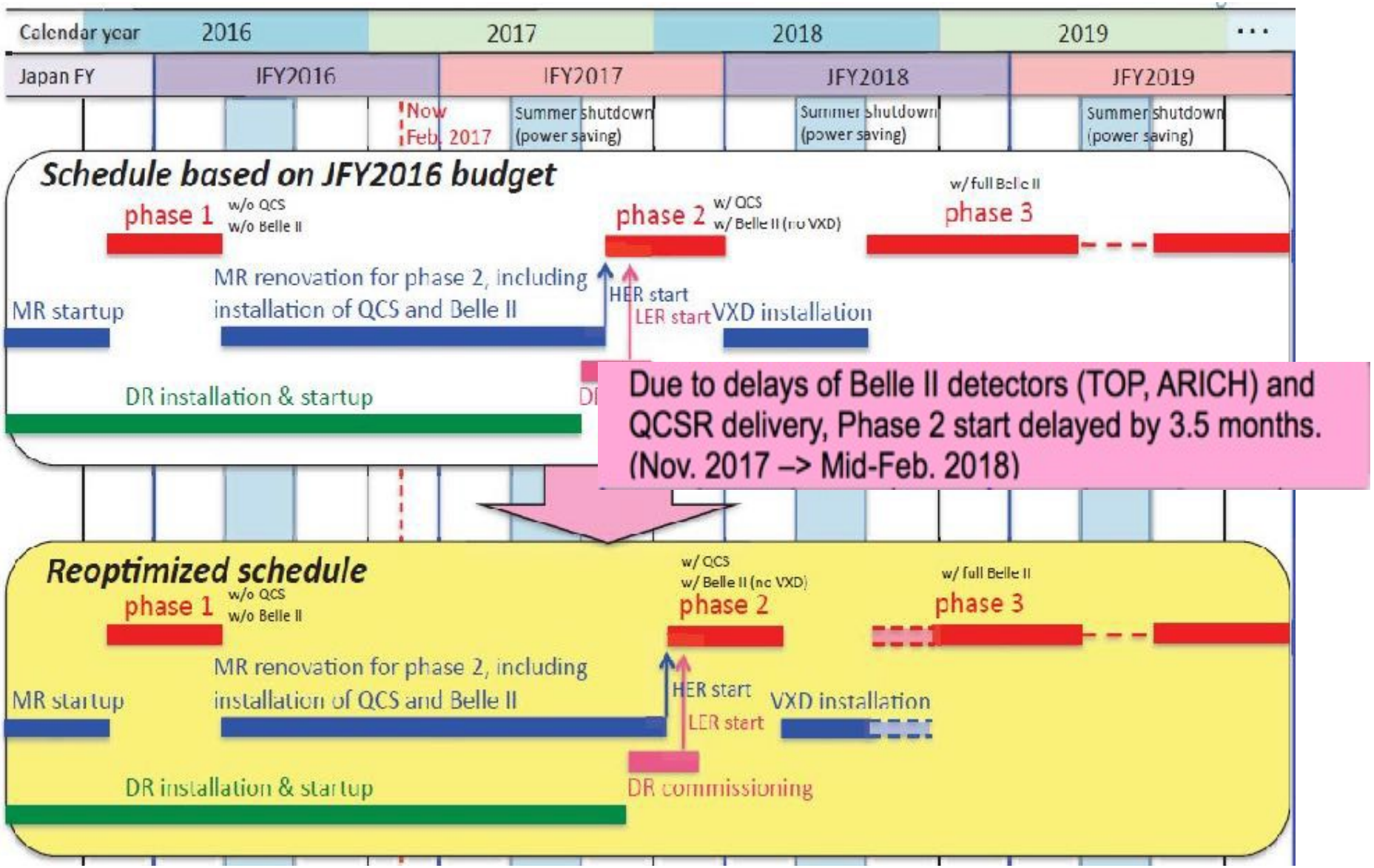


SuperKEKB Hardware almost ready …

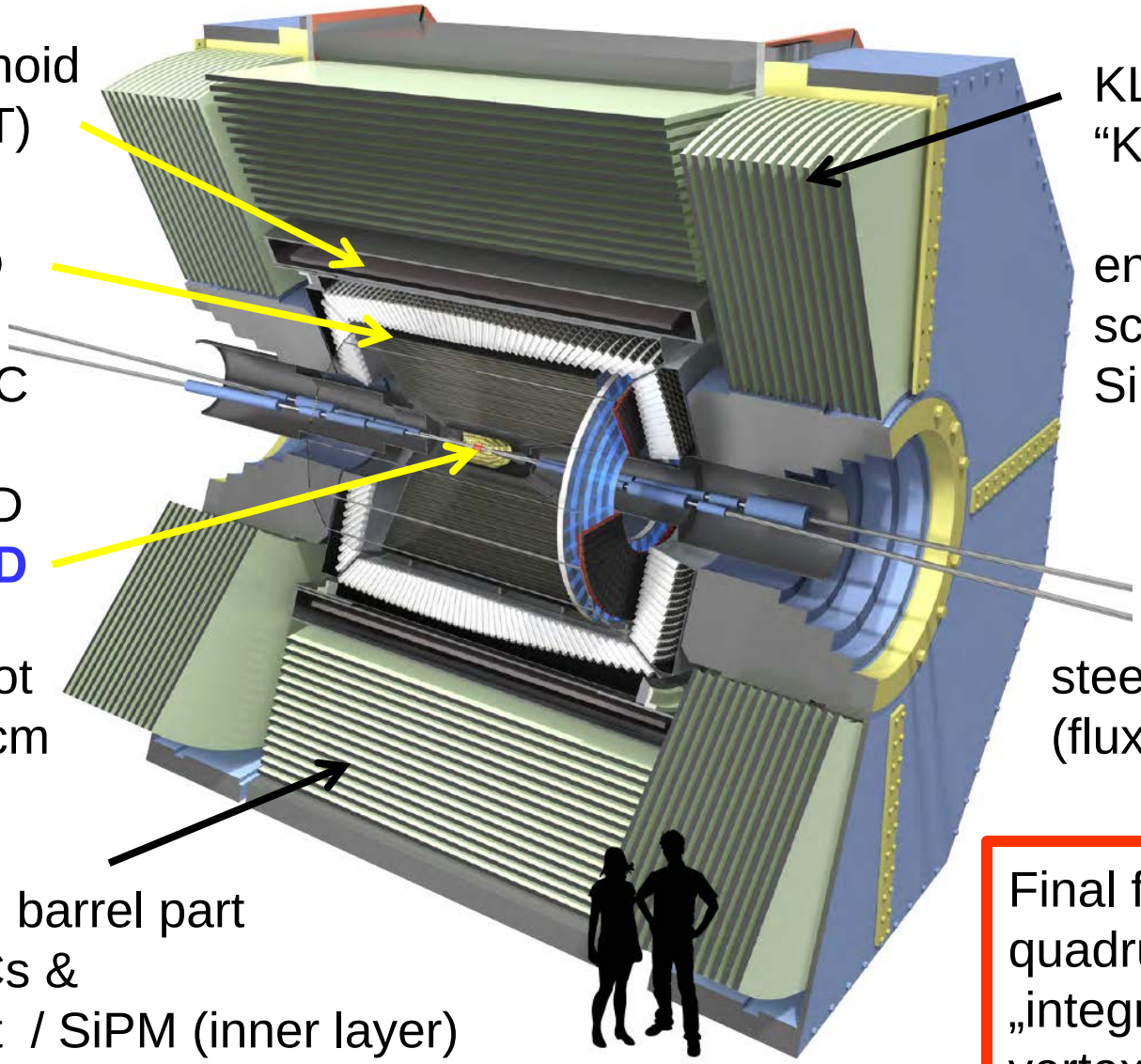




Revised Schedule for SuperKEKB



The Belle II Detector



Solenoid
(1.5 T)

new PID

new CDC

new SVD
new PXD

(strips will not work @1.4 cm radius)

KLM barrel part
RPCs &
scint / SiPM (inner layer)

KLM
"K_L and muon"

end cap:
scinillator &
SiPM

steel plates
(flux return yoke)

Final focus quadrupoles „integrated" into vertex detector

Belle (II) in Tsukuba Hall

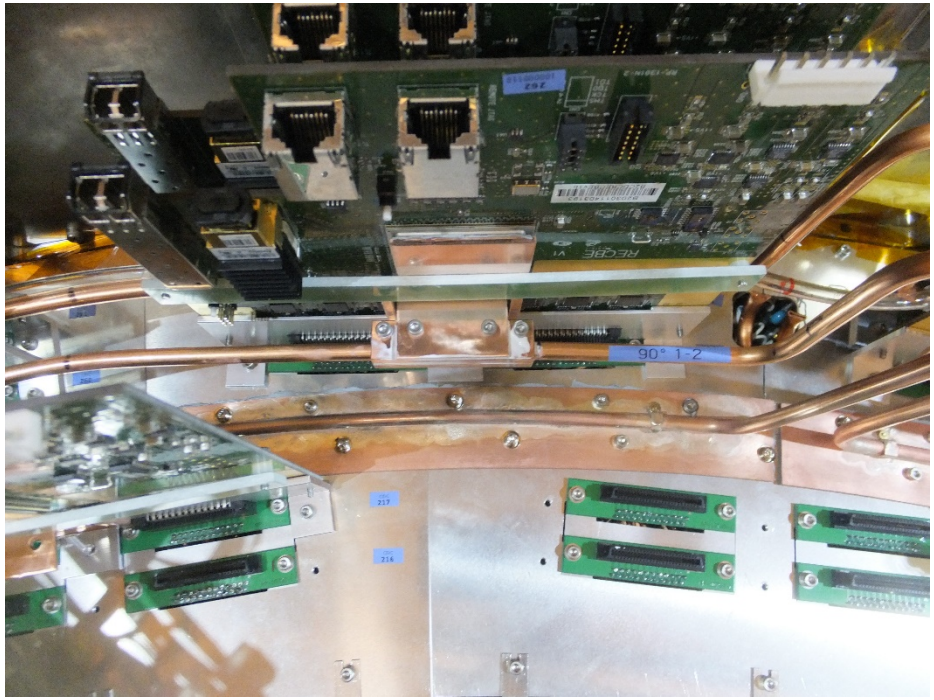
TOP counters installed during the summer of 2016 (PMT rotation issue not fully solved)

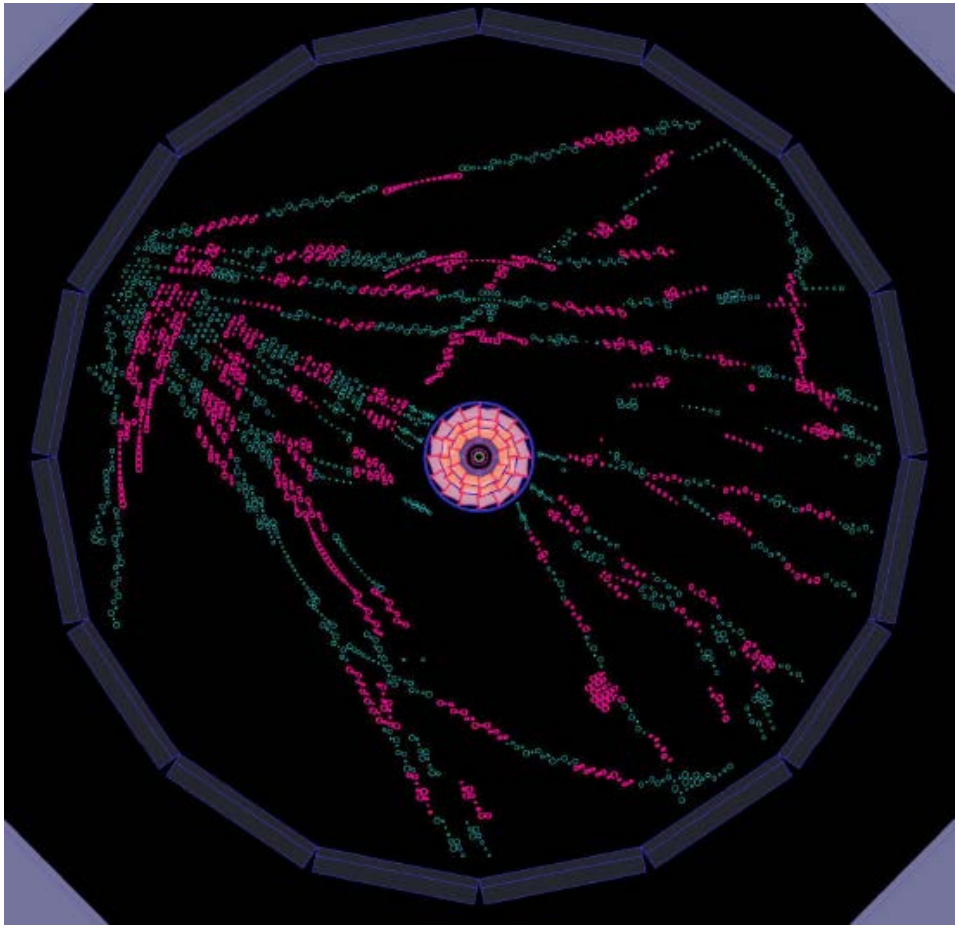
Installation of the Central Drift Chamber

Commissioning of the CDC

Dec. 16: after installation and cabling cooling of FPGAs was found inadequate.

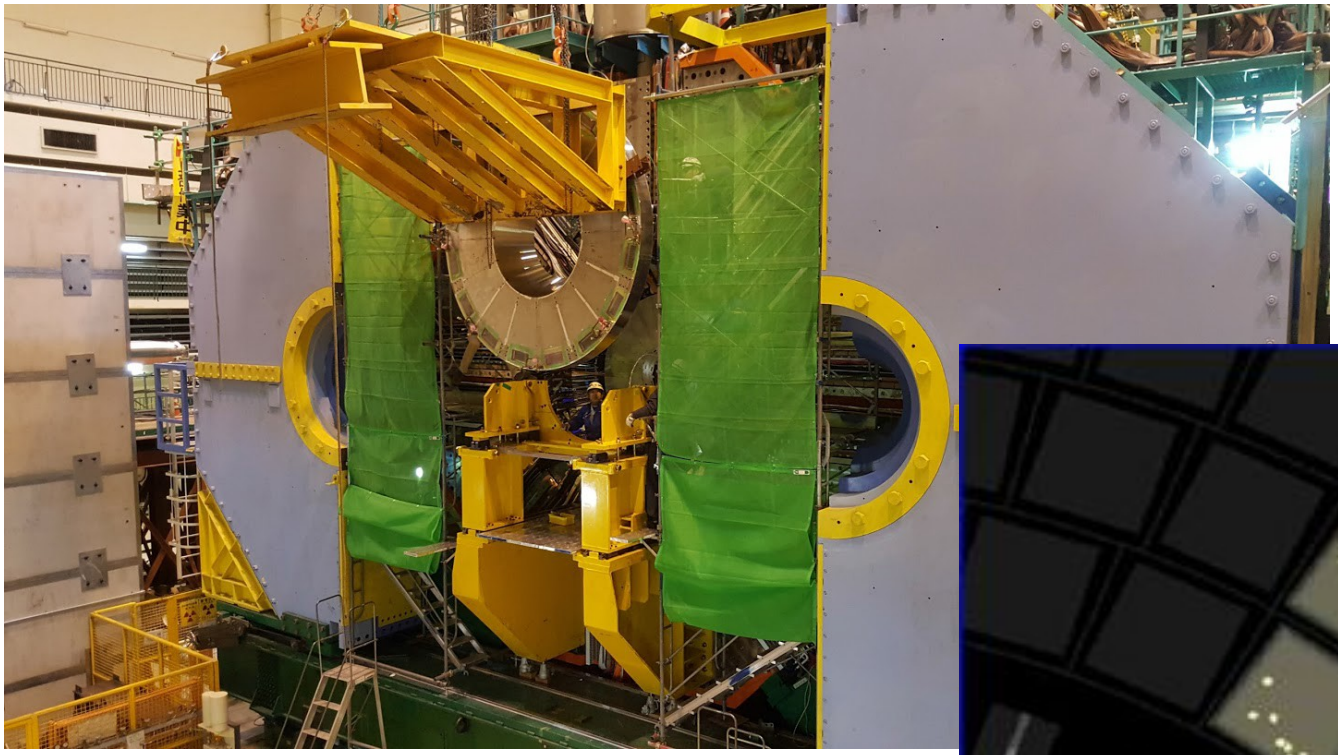
New cooling blocks and H_2O pipes close to FPGAs: now OK





Cosmic shower event in CDC, full electronics readout

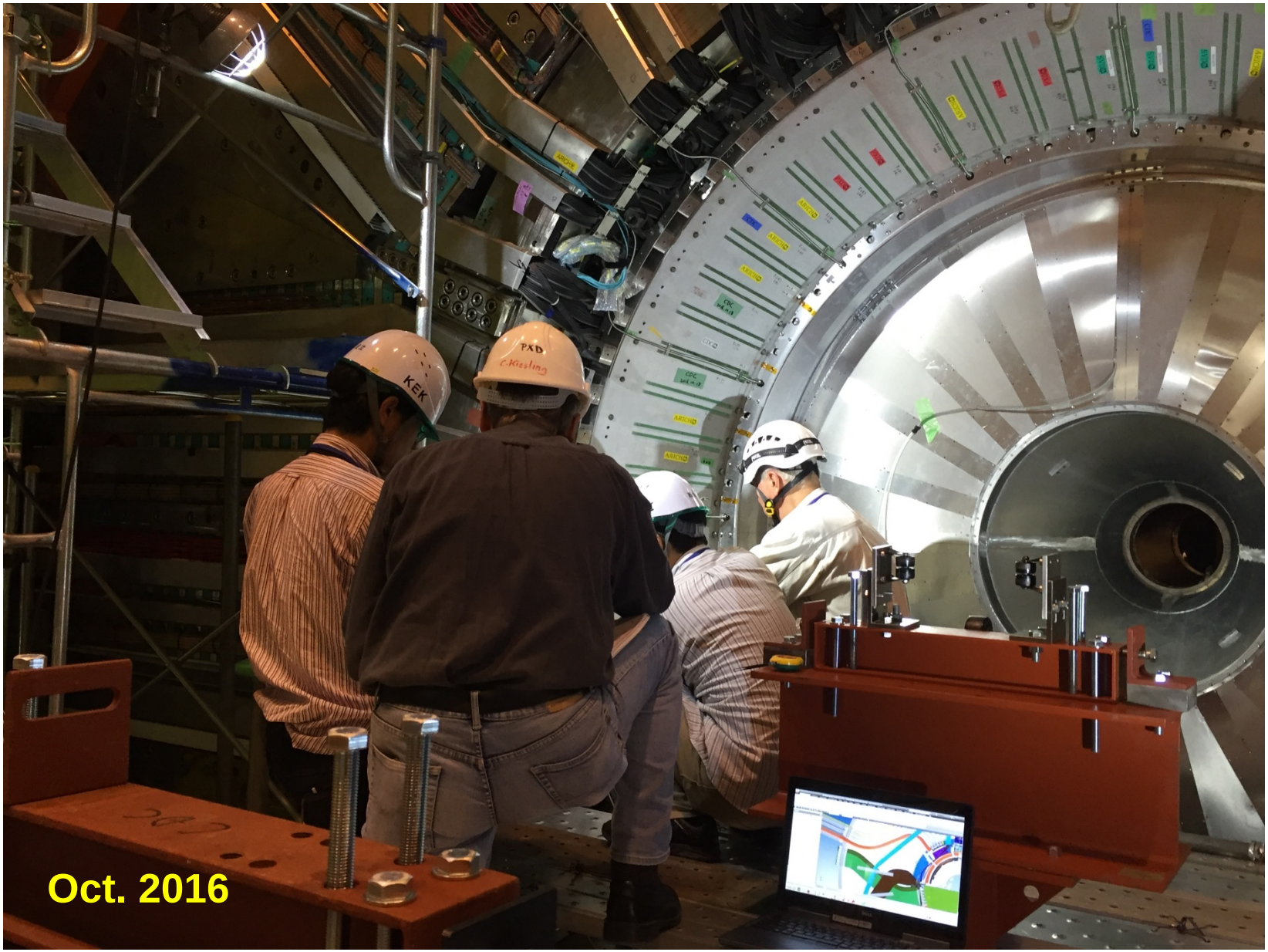
ECL Endcaps and ARICH



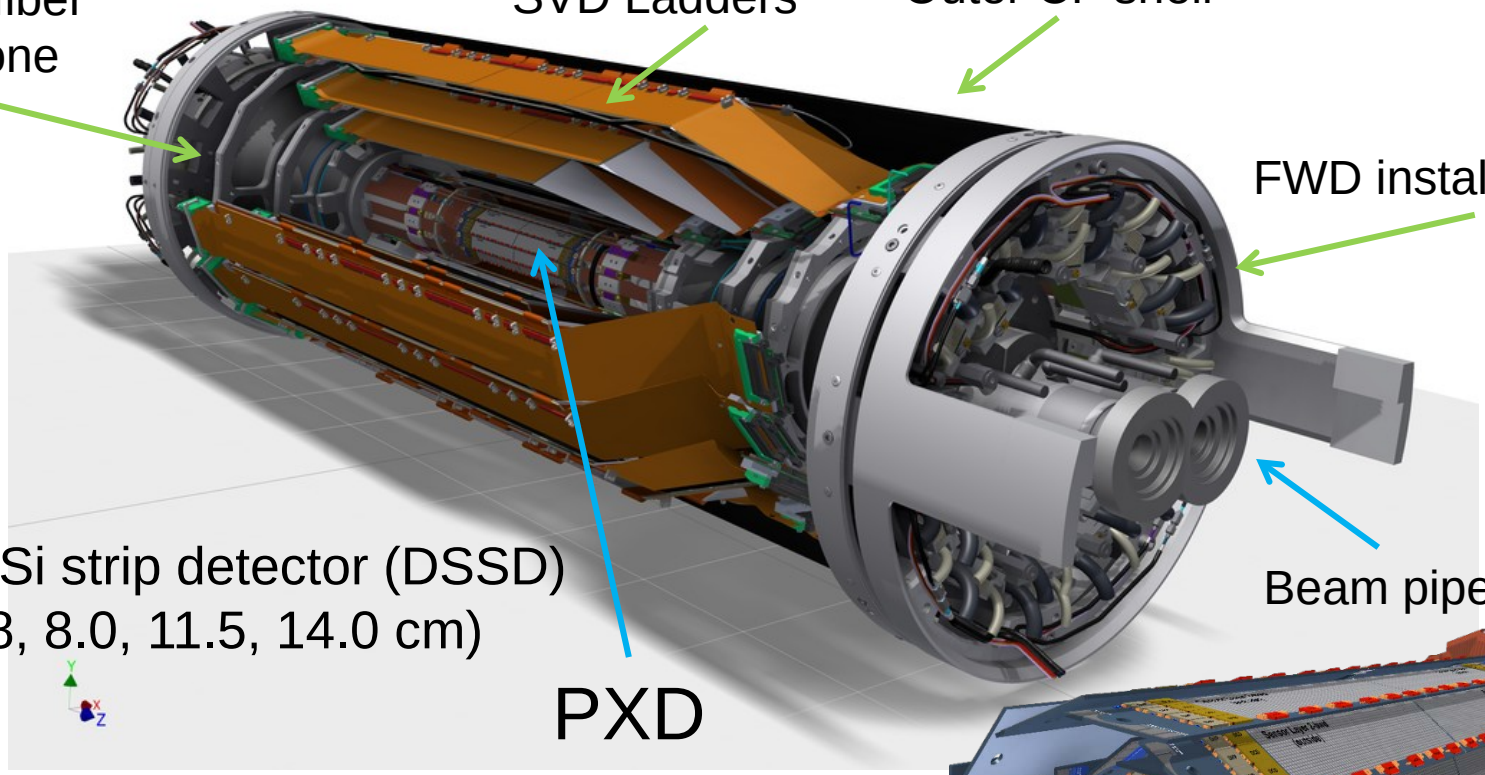
BWD ECL endcap being installed

First cosmic in sector 1 of ARICH counter (installation scheduled for Sept. 2017)

… only the Vertex Detector is missing …

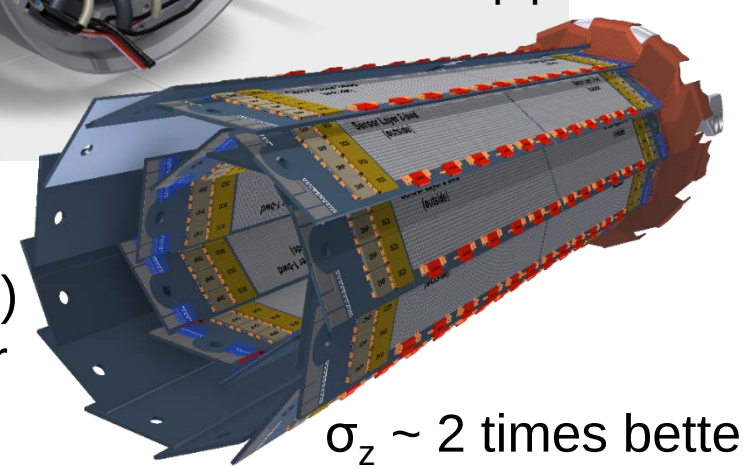


Vertexing: Silicon Tracking System @ Belle II



SVD:
4 layer Si strip detector (DSSD)
(R = 3.8, 8.0, 11.5, 14.0 cm)

PXD:
2 layer Si pixel detector (DEPFET technology)
(R = 1.4, 2.2 cm) monolithic sensor
thickness 75 µm, pixel size ~50 x 60 µm²



σ_z ~ 2 times better than Belle

PXD System Overview

Total of 0.2% of X_0 2 layers: @1.4(2.2) cm Pixels: 50 x 60(75) µm

Half ladder

768 x 250 px

HLL

~50µm

~75µm

Switcher

KIT/HD

DCD

DHP

BN

Thickness:
75 µm
total of 8 Mpx
readout: 20 µs

Important contributions (test/ software) from Göttingen, Krakow, Prague and Valencia

TUM

GIE/BN

Kapton flex

Patch Panel Data

Patch Panel Power

45 cm

2 m

Slow Control

Data

Power cables

Docks

15 m

Slow Control

Data

Power cables

Data Handling Hub DHE + DHC

Optical

Optical

JTAG

DAQ, data reduction, ROI selection

DHH Controler, Trigger/Timing

Slow Control

Power Supply System

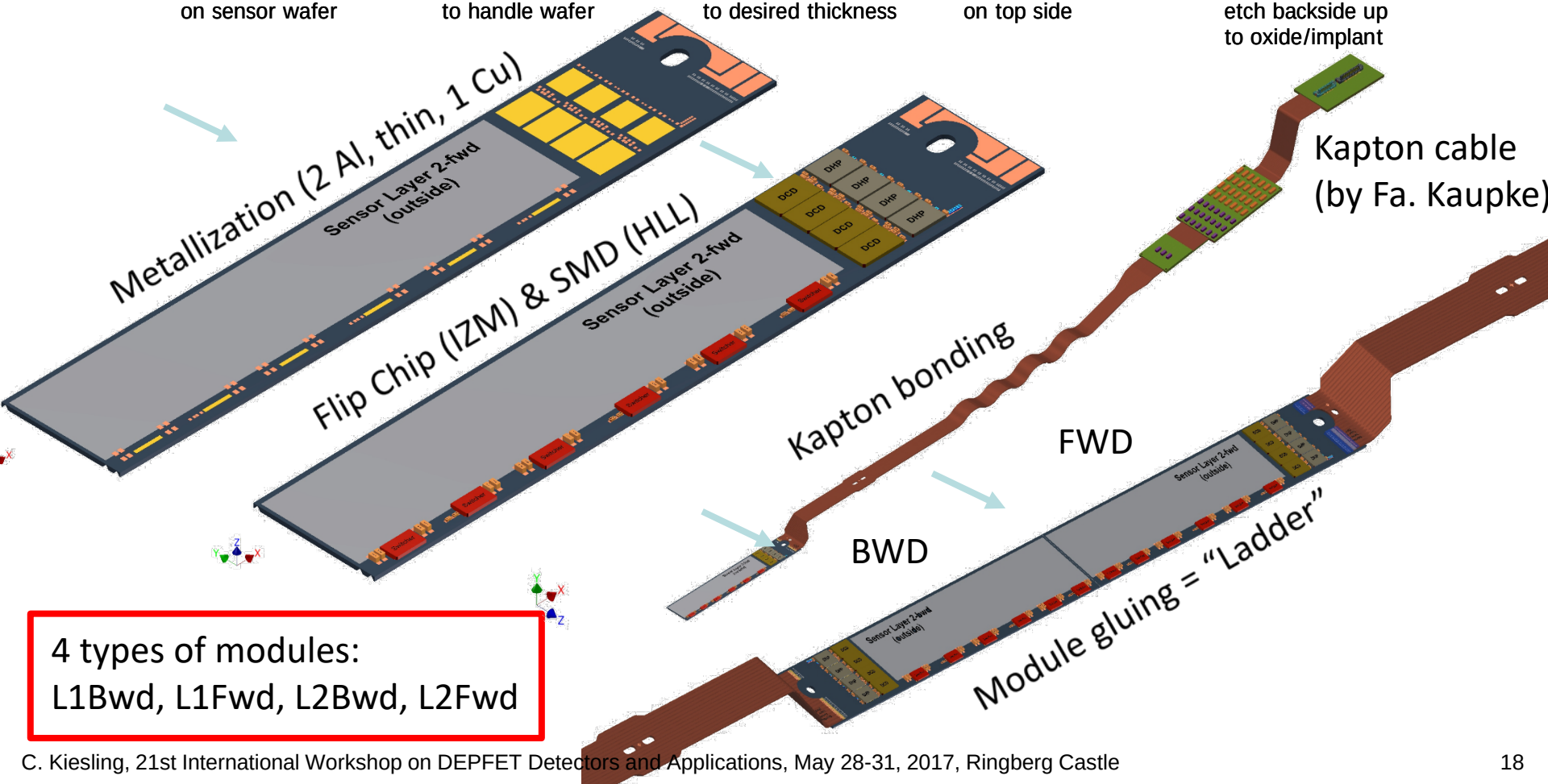
Mainz / HD

LMU/MPI

LMU/TUM (inf)

Production Steps of PXD Ladders

1. implant backside on sensor wafer
2. bond sensor wafer to handle wafer
3. thin sensor side to desired thickness
4. process DEPFETs on top side
5. structure resist, etch backside up to oxide/implant



4 types of modules:
L1Bwd, L1Fwd, L2Bwd, L2Fwd

PXD Production Status - Overview

Sensor production ~ completed

4 Batches: PXD9-7 (4), PXD9-8 (9), PXD9-9 (6),
PXD9-10 (7: contingency, last 4 are under needle test)
About 1.5 to 2 times more prime grade sensors (>99%) than needed,
plus medium class sensors (>98%)

ASICs

DCDB4.2, DHPT1.2b **final versions**

Chips fully functional

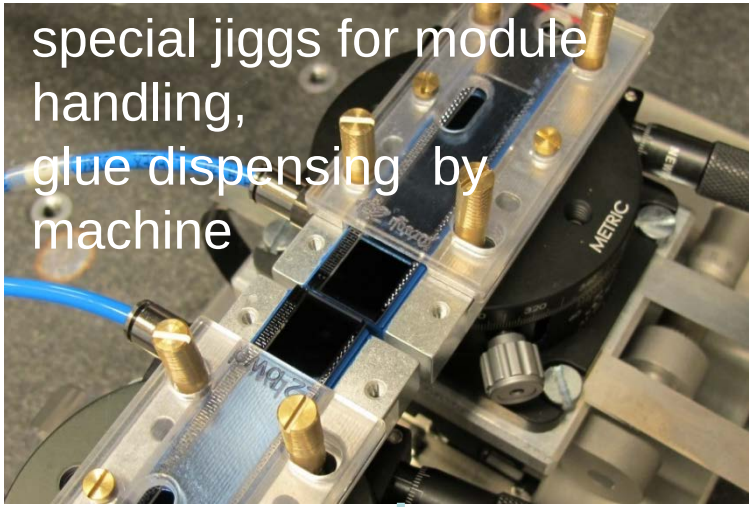
SwitcherBv2.1 – **final version**

Chip fully functional, bumping established, mass production ongoing

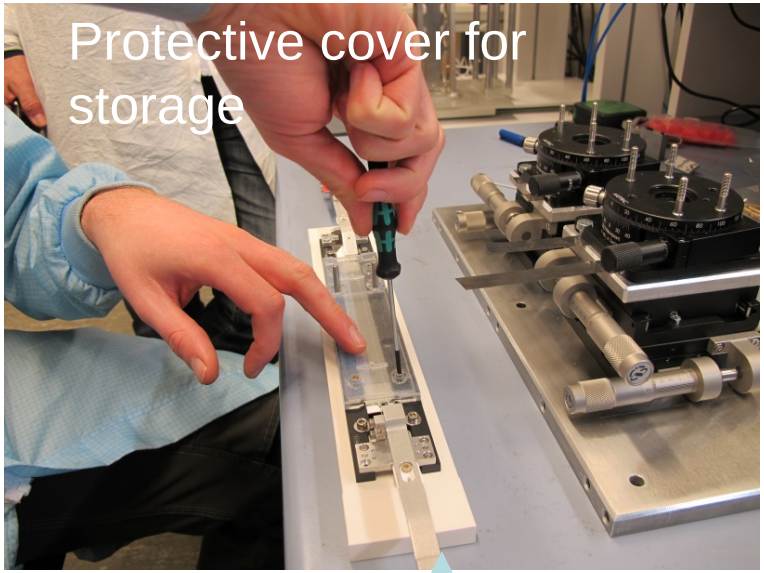
Modules

Pre-producton (10 modules) done at IZM (flip chipping, some issues)
Production of Phase 2 modules (1 set) done (some issues, under test),
2nd set launched, SMD @ HLL, Kapton, Test and ladder gluing @ MPI
Main production not yet started

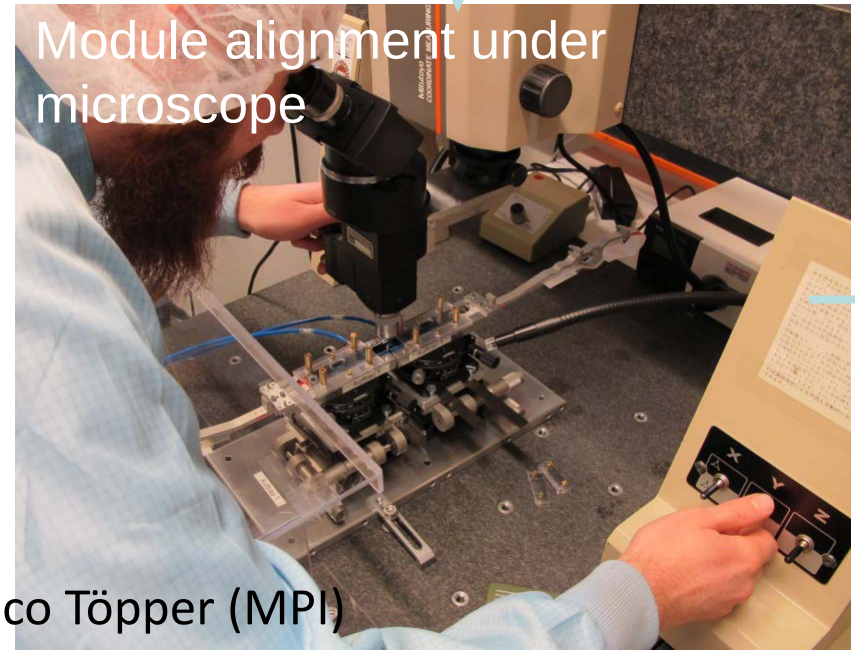
Ladder Gluing



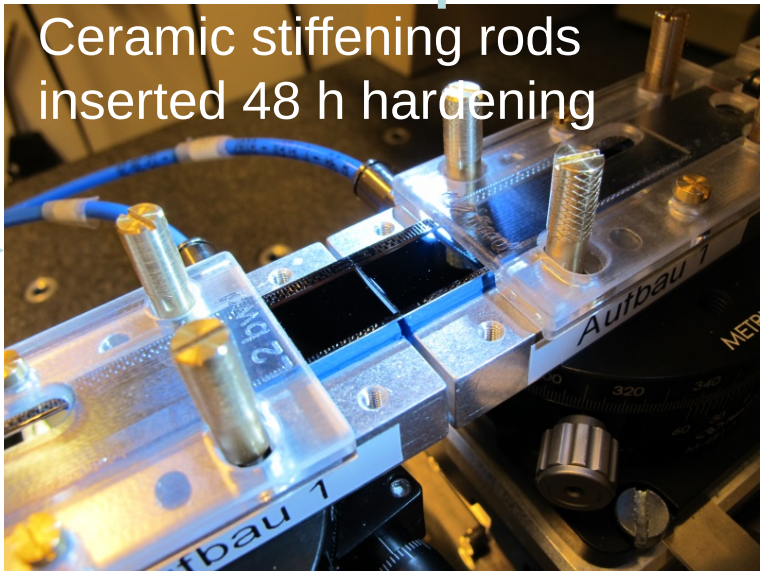
special jiggs for module handling,
glue dispensing by machine



Protective cover for storage



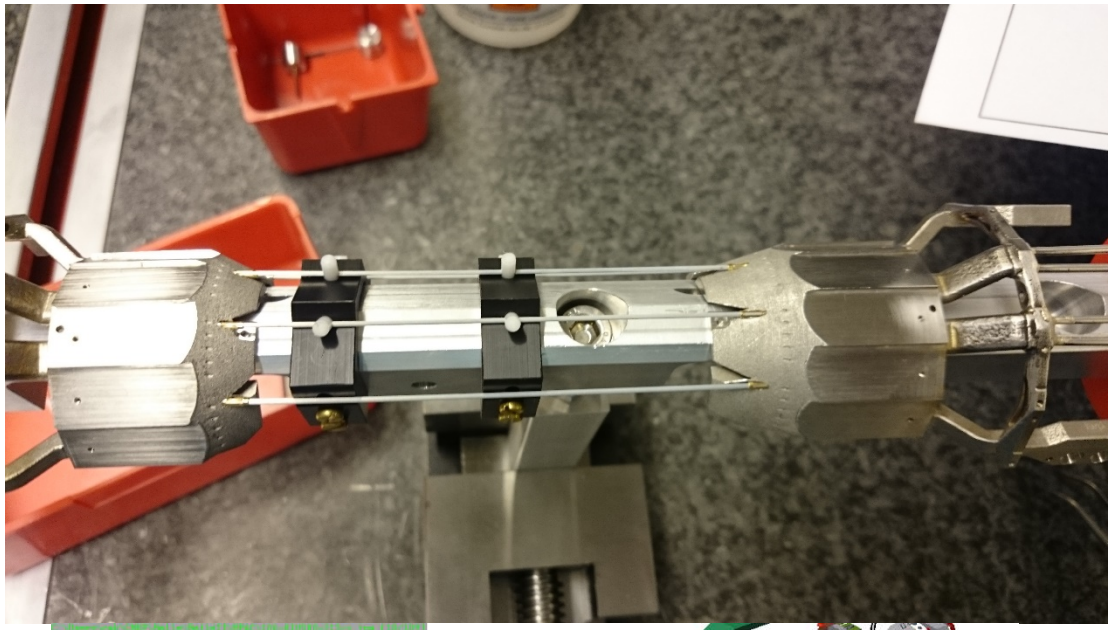
Module alignment under microscope

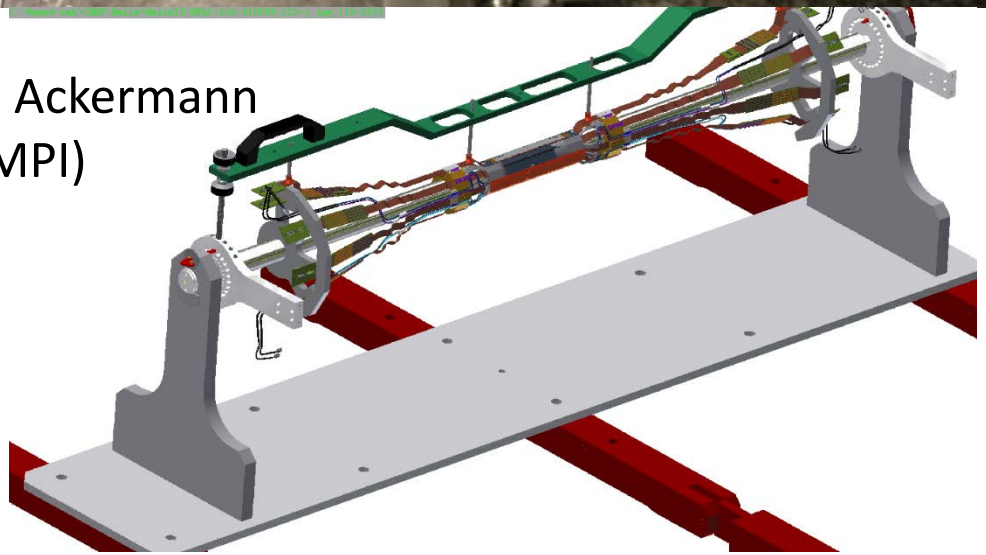


Ceramic stiffening rods inserted 48 h hardening

Enrico Töpper (MPI)

Half Shell Assembly





T. Ackermann (MPI)

SCB assembly („half shell“) is prepared for mounting tests of full ladders.

Mounting will proceed from top, using a support structure for the ladder, picked up at the Kapton by mechanical fixtures

Design of rotatable mounting stage is ongoing, first tests by early summer (~ June 2017)

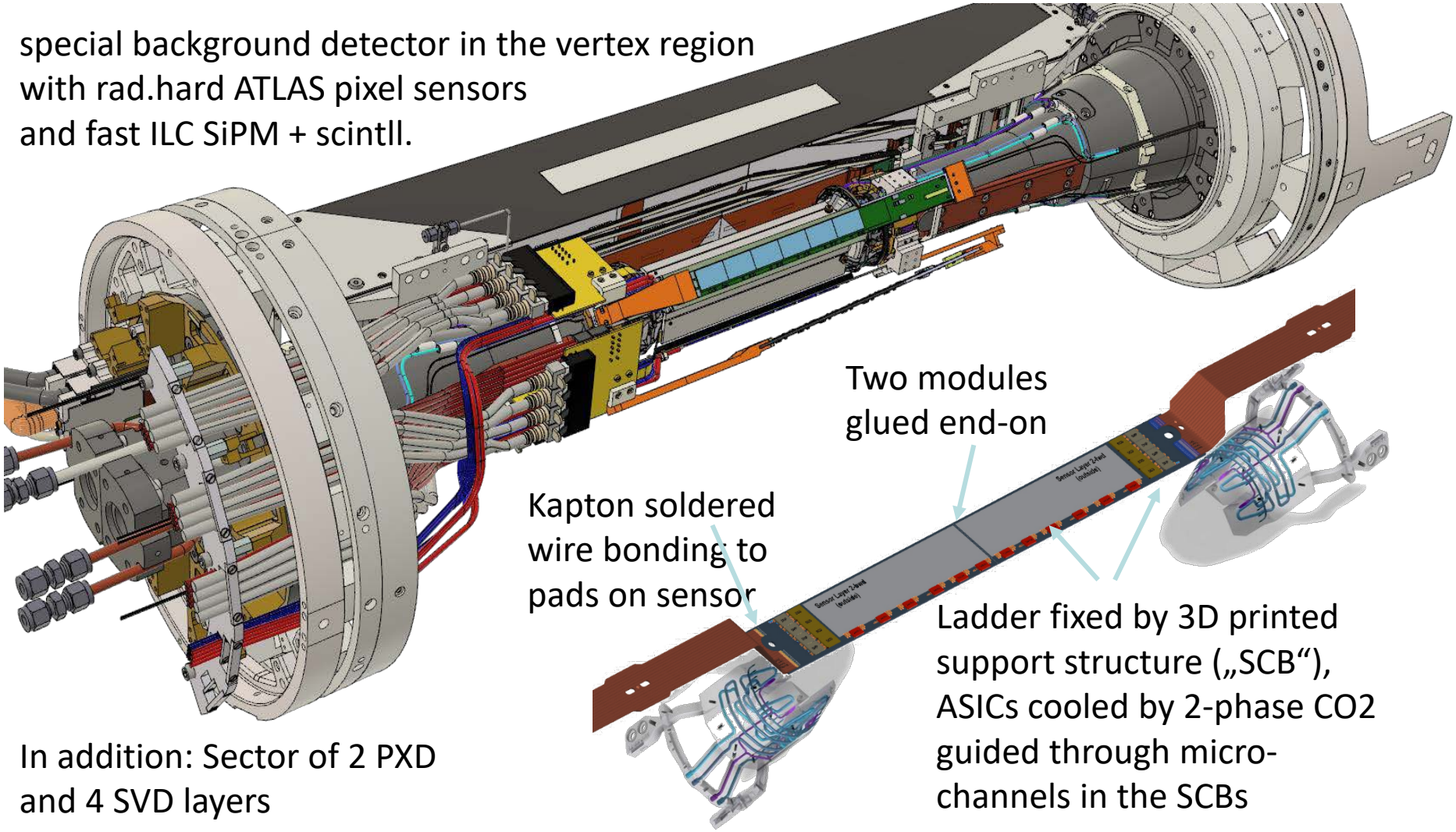
Mounting stage will also be used to lower half-shell onto beam pipe

Phase 2 Detector: BEAST

First nano-beam collisions during Phase 2

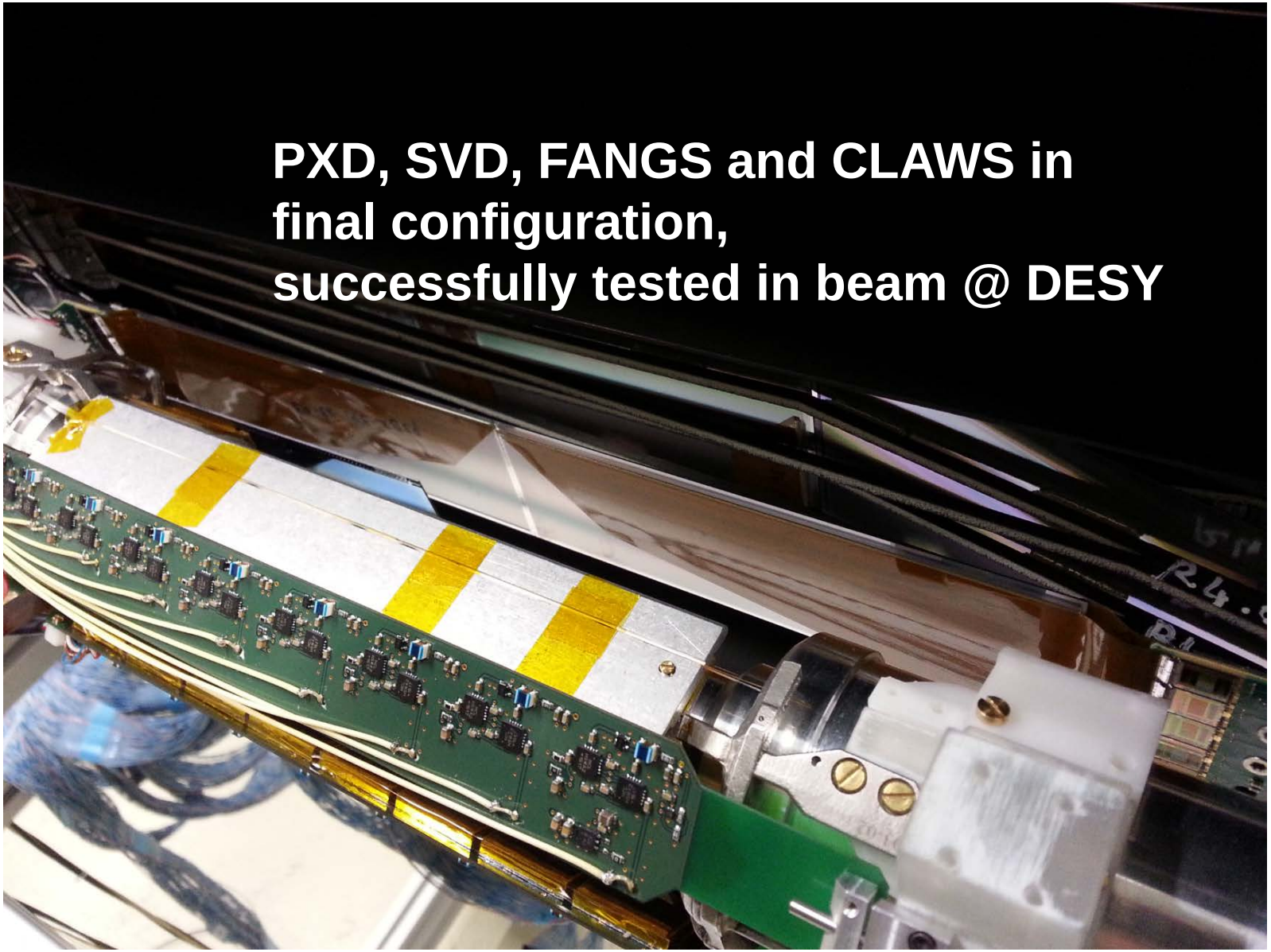
Vertex detector mounted on the beam pipe

special background detector in the vertex region with rad.hard ATLAS pixel sensors and fast ILC SiPM + scintll.



In addition: Sector of 2 PXD and 4 SVD layers

Preparation for Phase 2: BEAST



CO2 Cooling

IBBelle installed in Tsukuba Hall, B1

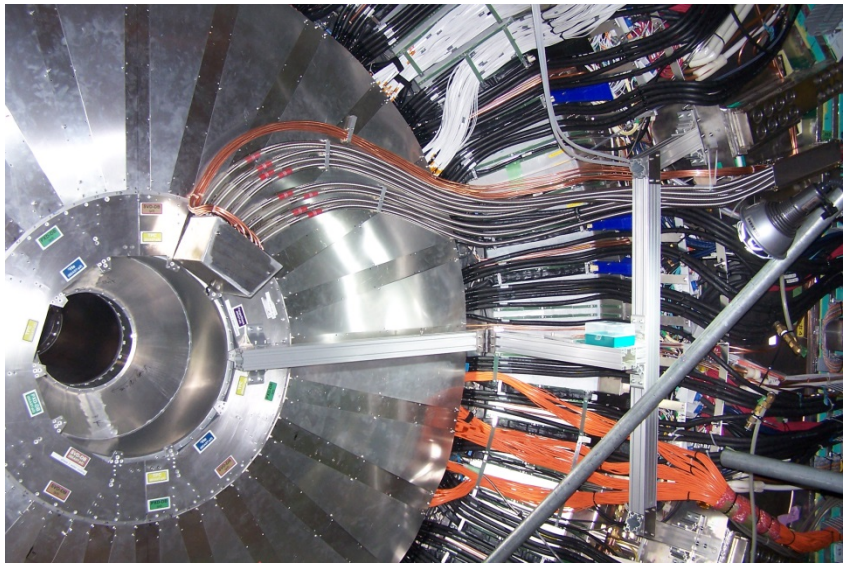
Arrival: Oct. 20, 2016

Junction Box and Manifolds installed (Oct. 28, 2016)

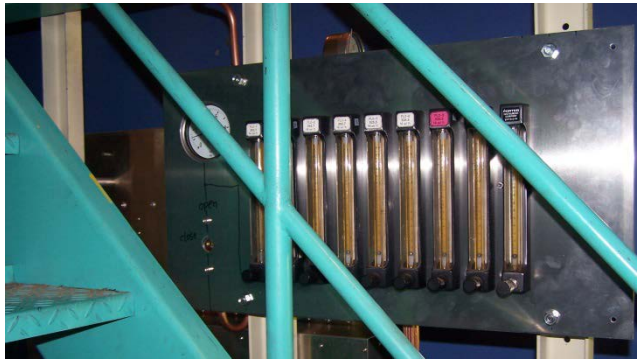
- Cold operation successful
- CO_2 circulated up to junction box (40m downstream from IBBelle)
- **IBBelle is able to cool >2500 W @ -30°C (required: 1100 W)**
- Recently transfer lines reconnected, Belle on beam position
- System tested after Belle roll-in, functional

CO2 Flex Line Installation

Dock Boxes, flex lines and N_2 manifolds installed by DESY Team
(K. Gadow, C. Camien, U. Packheiser) December 12-16, 2016

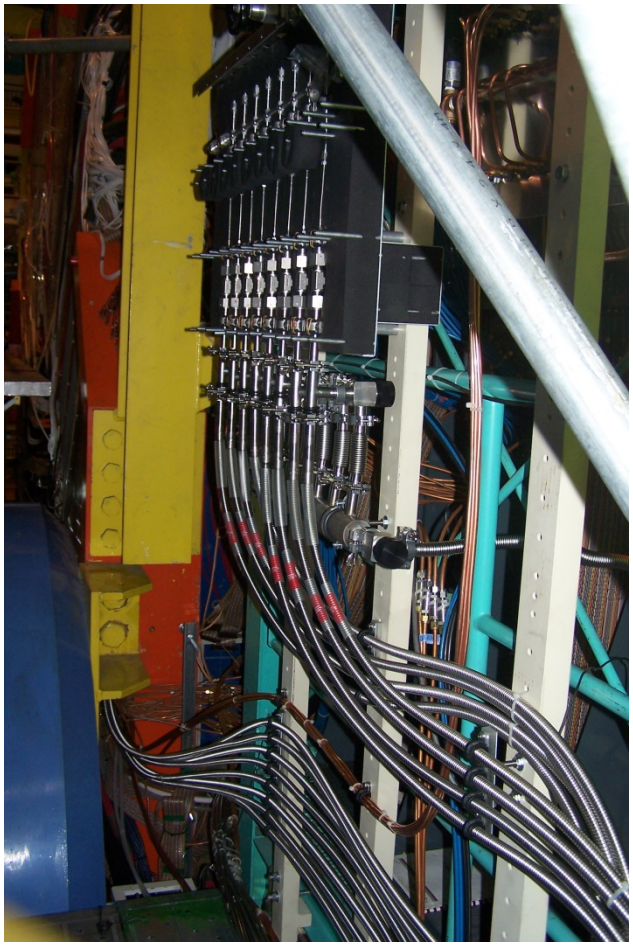


Dock box and flex lines (BWD)



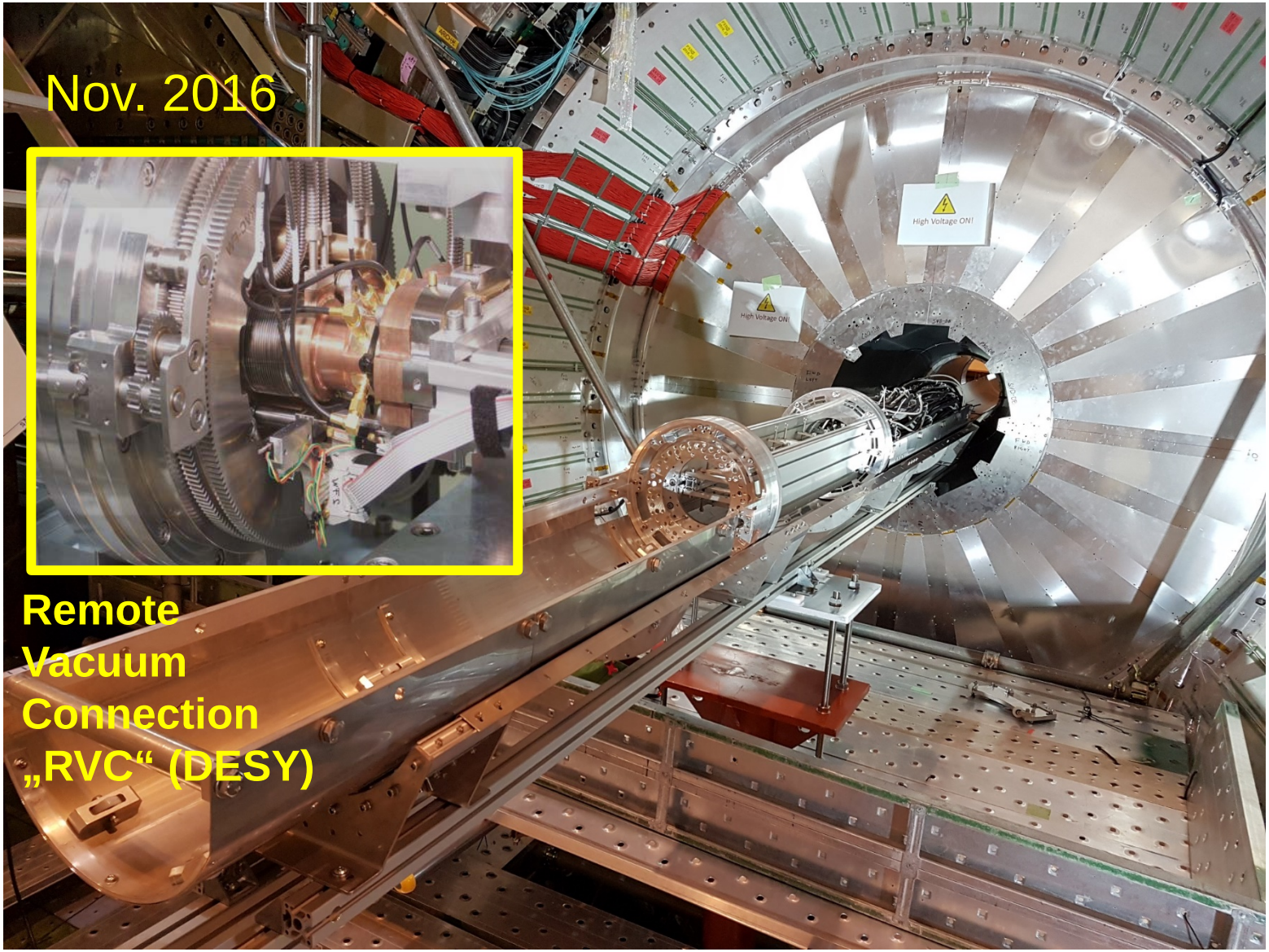
N_2 manifold (FWD)

All 12 lines (8 on BWD, 4 on FWD) are supplied with CO2 and are working

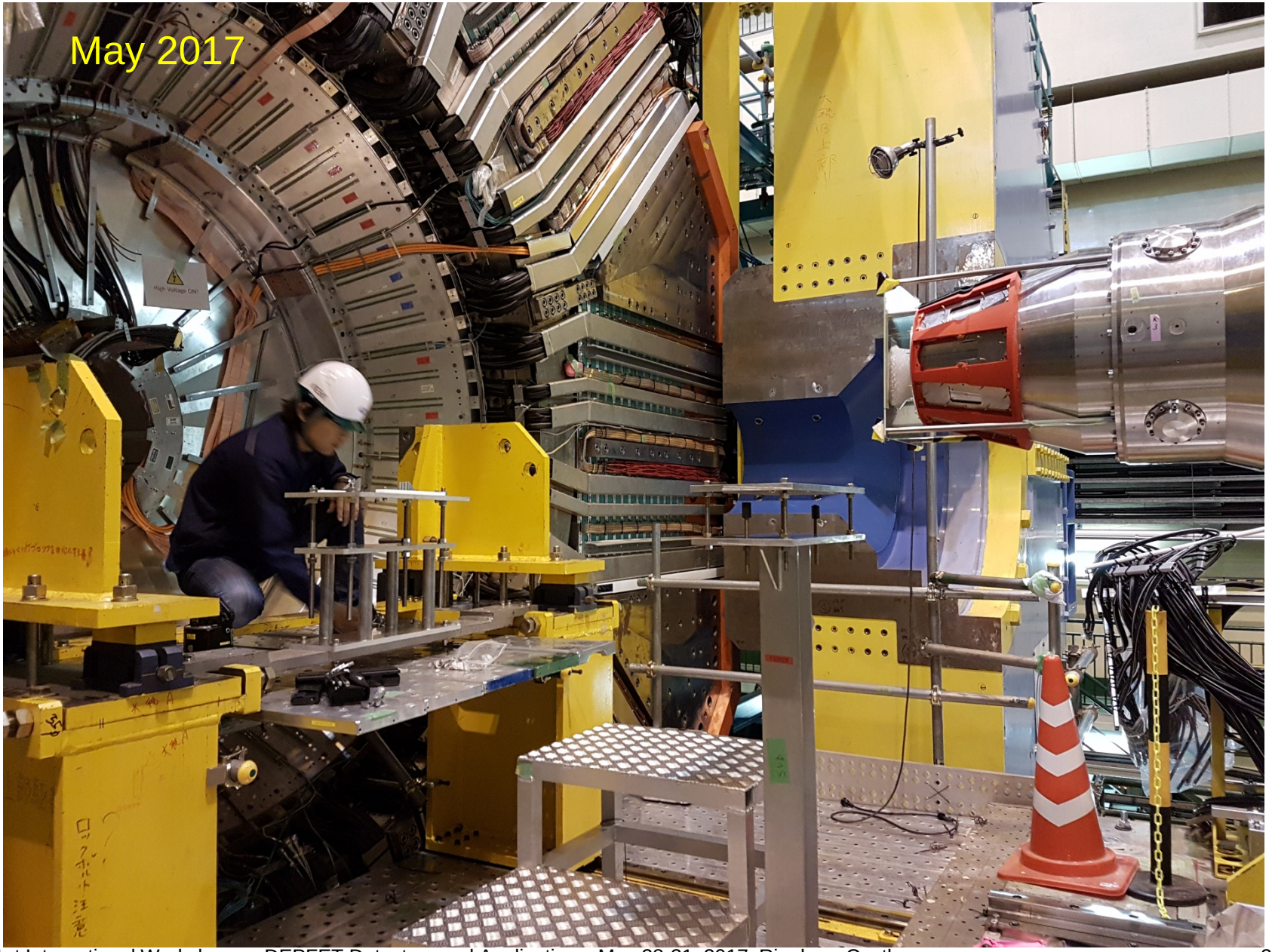


CO2 manifold (BWD)

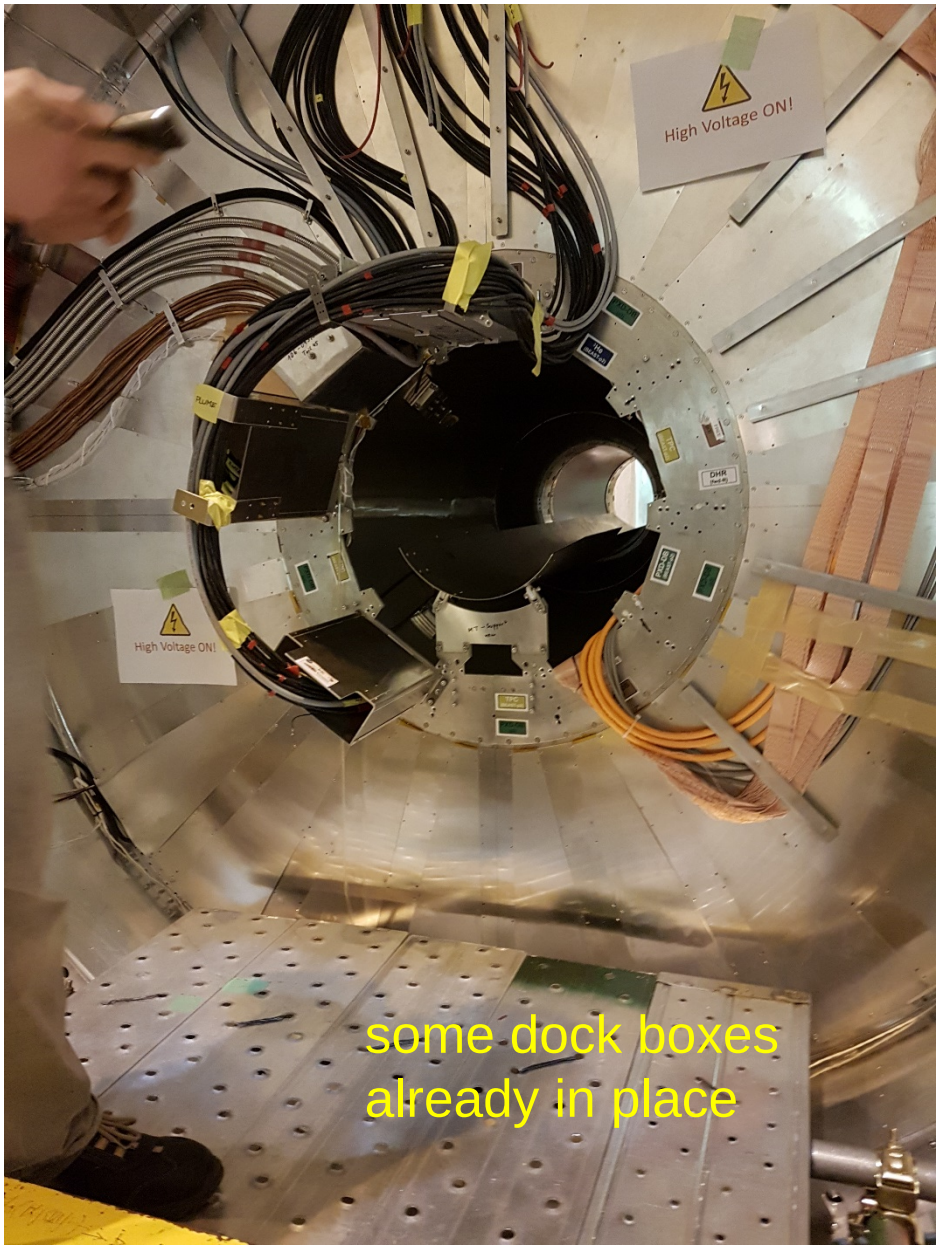
VXD Test Installation into Belle



VXD Test Installation After Roll-In



VXD Test Installation After Roll-In



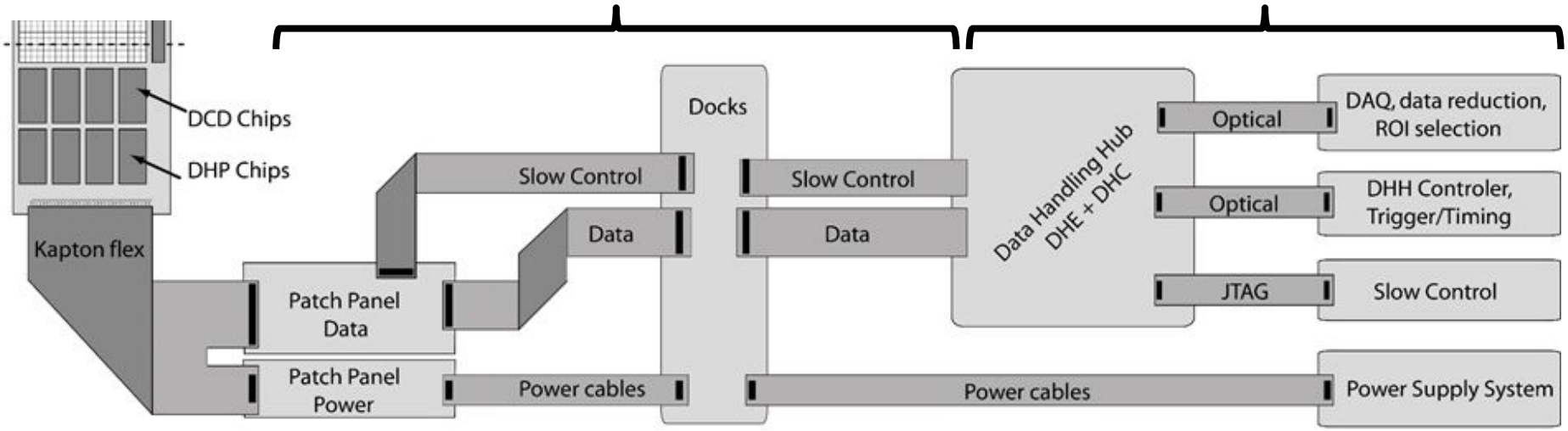
Issues of the Meeting

Next big milestones:

- produce the ladders for the BEAST detector
- assemble ladders on existing SCB half-shell
- test at DESY, SCBs CO2-cooled by MARCO (full system readout at full speed)

still under design / test

firmware being debugged

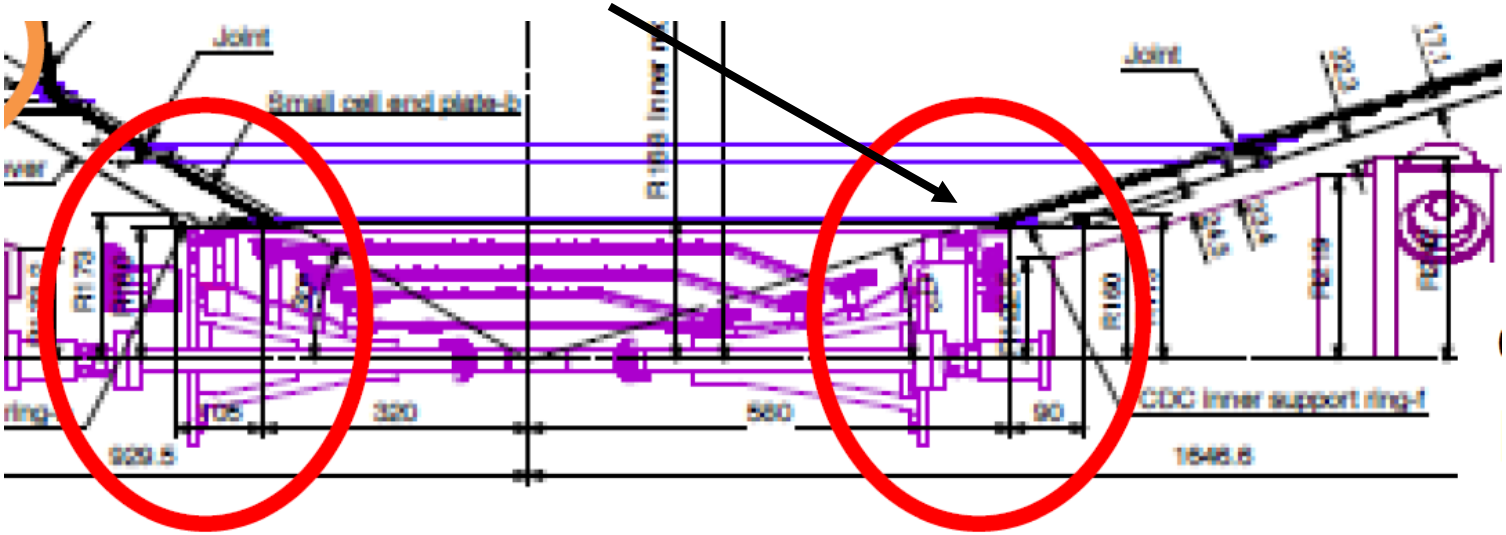


- Entire off-module DAQ chain must work before transport to KEK
- arrival at KEK in early September 2017 at the latest,
- installation planned for mid October 2017 (after ARICH/ECL)

Issues of the Meeting

Under design / discussion:

- tool for the ladder mounting on SCB half-shell (needed for BEAST)
- FWD: patch panel cable cage etc. (see mechanics session)

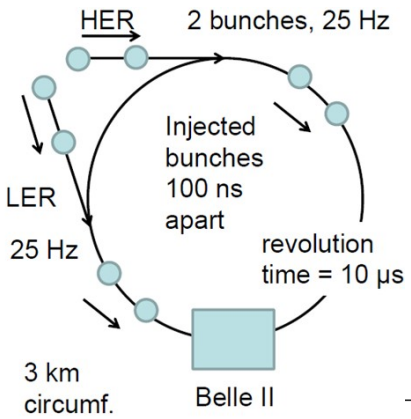


- at KEK: Clean room for BEAST (new booth in B4 @ CDC area)
- commissioning / assembly / test + installation of BEAST into Belle

Discussion for Phase 3 preparation:

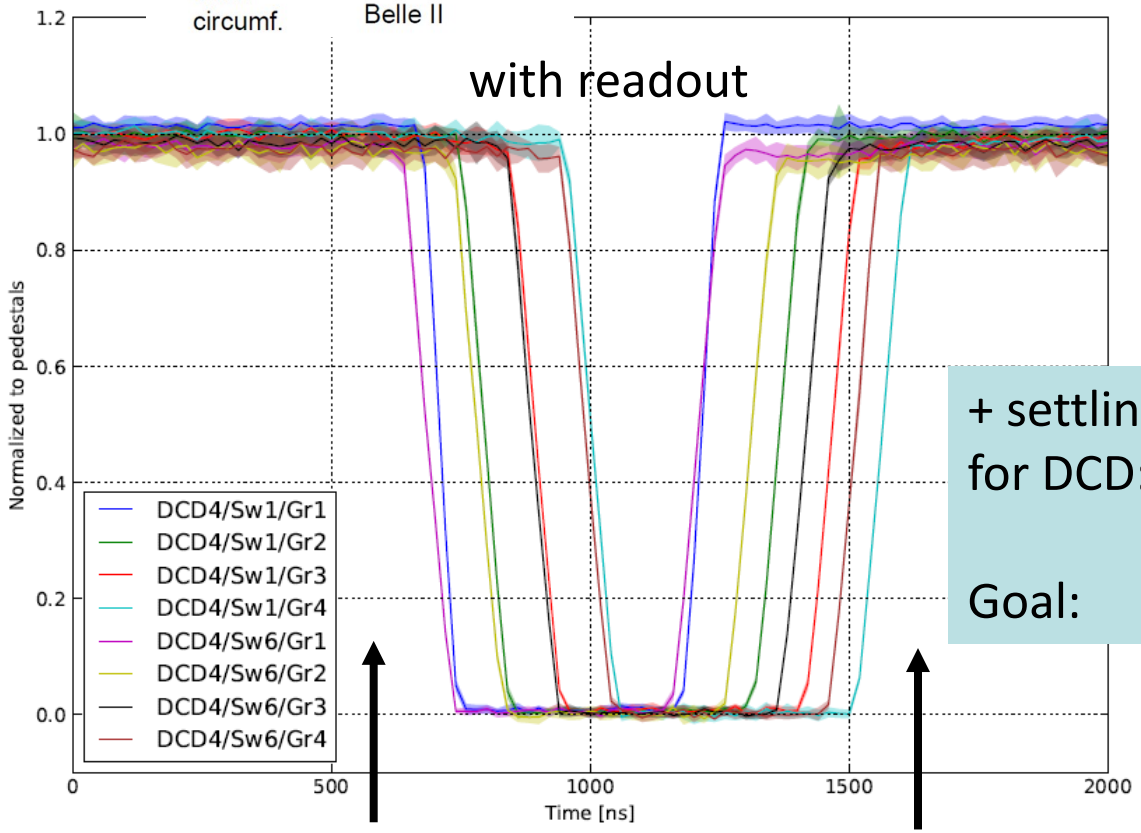
- production / assembly / test of full PXD (needs MARCO cooler)
- fallback solution if MARCO is not available in spring of 2018
- upgrade project for PXD (for ~2021)

Important Issue: Gated Mode



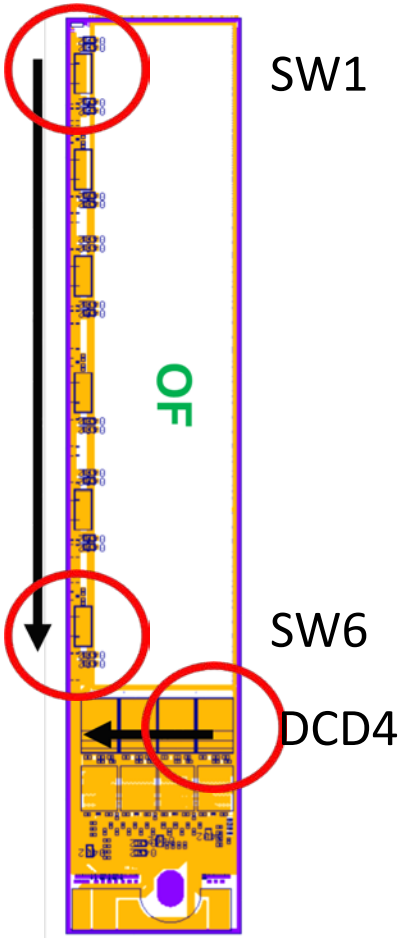
Imcreased width of substrate line on the module leads to substantial improvement of the Gated Mode operation

– Test with ASICs in worst case position



+ settling time for DCD: ~ 2µs

Goal: 1 µs



Felix Müller (MPI)
Christian Koffmane (HLL)

Summer 2017 Installation Details

I. Adachi, B2TB, May 17, 2017

Baseline plan

- (Removing cryogenic pipes and cables, QCS extracted : Sep. 1-9)
- ARICH and FWD-ECL combination : Sep. 6 - 8.
- Endcap installation : Sep. 11 - Oct. 13
  - Including/removing scaffoldings set-up.
- Beast2 installation : Oct. 16 - Nov. 30
  - Including the mapper extraction.

Dates should be confirmed by accelerator group.

Summary and Conclusions