

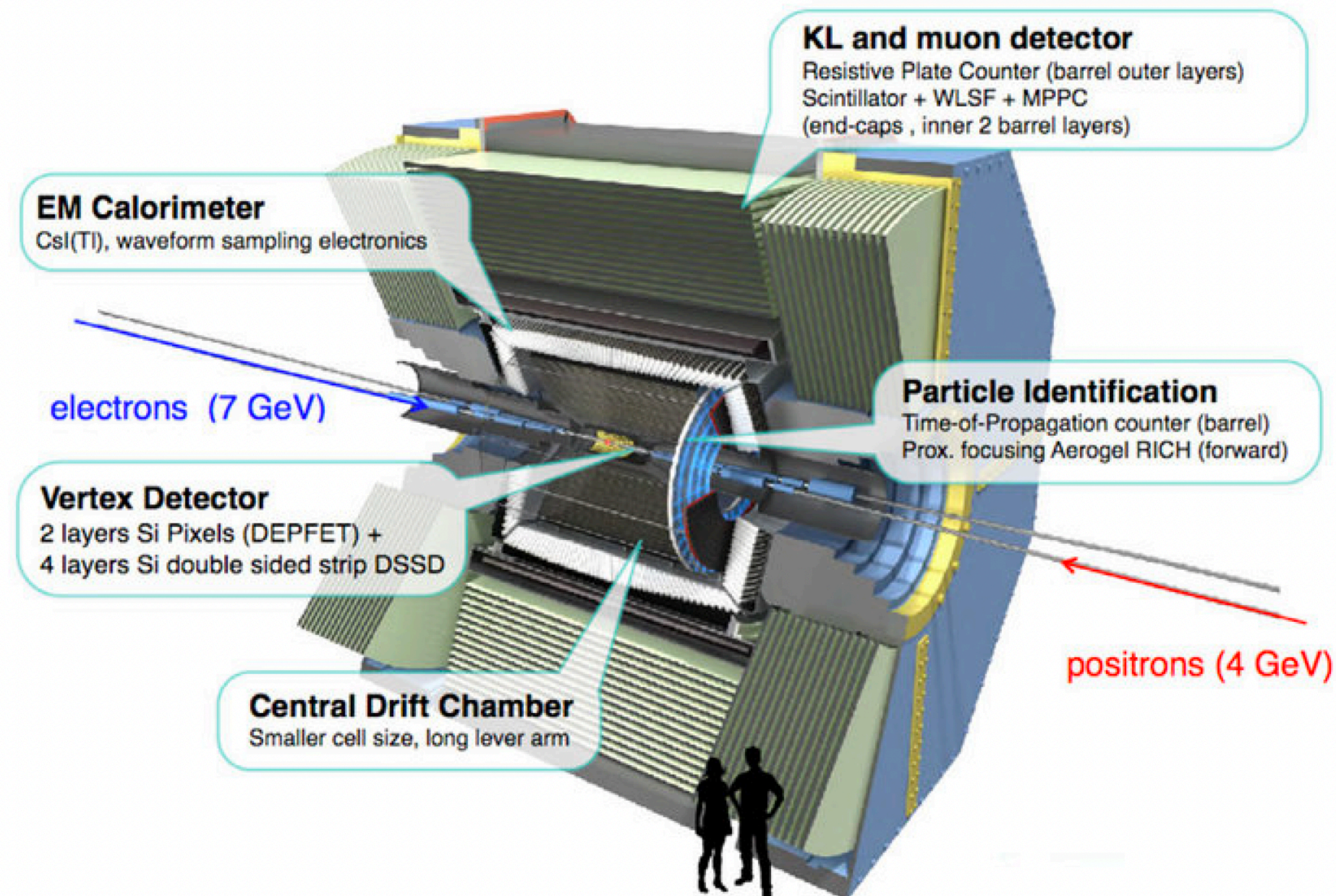
# Belle II Experiment at SuperKEKB

## SuperKEKB

- ▶ 2nd generation B-factory,  $e^+(4\text{GeV})$   $e^-(7\text{GeV})$  collider in Japan
- ▶ After some commissioning runs, physics runs with full detector started in 2019
- ▶ Peak luminosity so far:  $5.1 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

## Belle II detector and PXD

- ▶ DEPFET, 0.2%X0, 2 layers at 1.4cm & 2.2cm radii
- ▶ PXD2 with full layer-2 coverage installed during LS1 (2022–2023)





# Belle II Upgrade

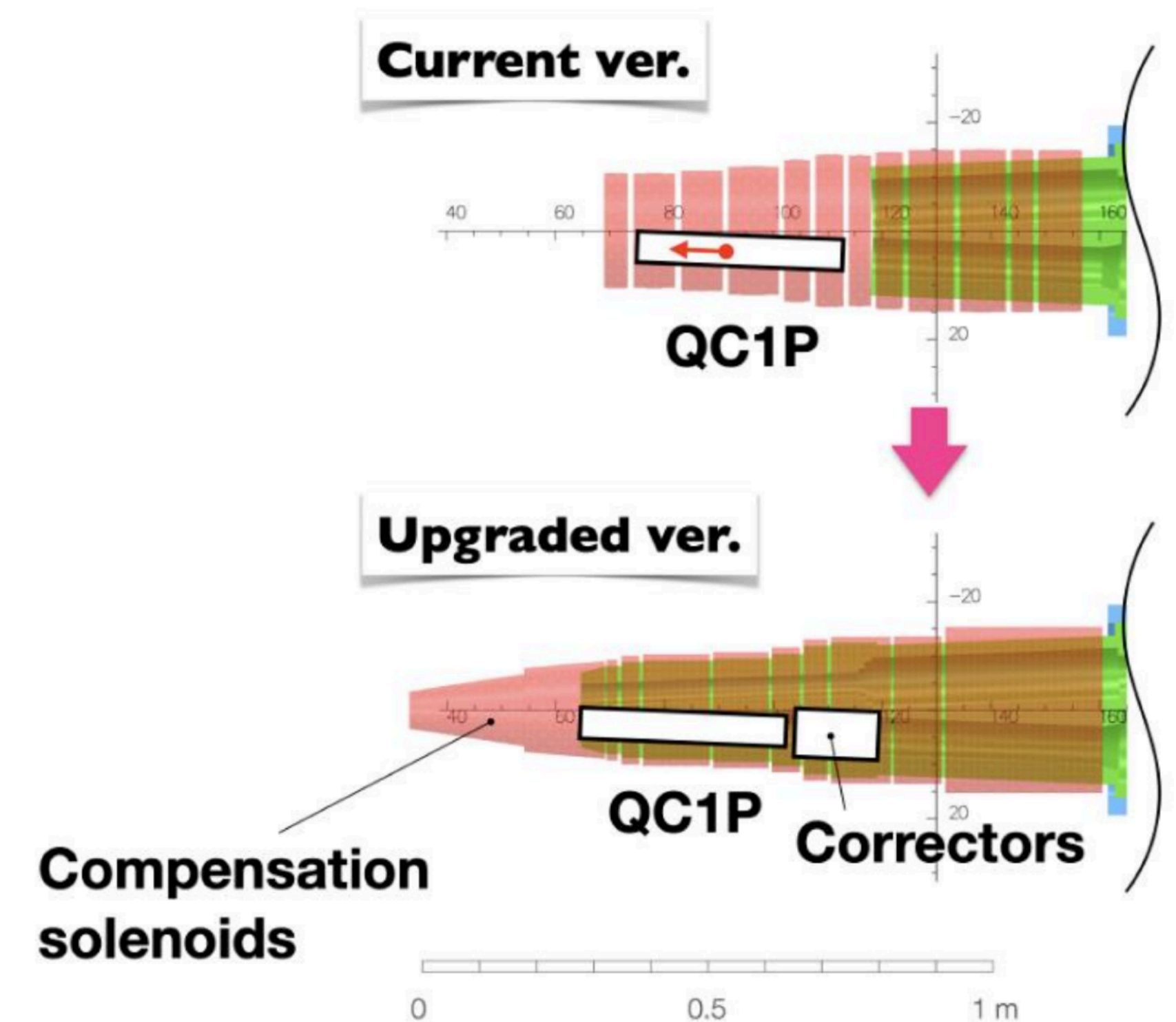
## Target (recently updated)

- ▶ Long Shutdown 2: 1.5 years starting **2032**
- ▶ ~10 years of operation after LS2
  - A. with final focus upgrade: peak luminosity  $\sim 6 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ , collect  $\sim 40/\text{ab}$
  - B. without final focus upgrade: peak luminosity  $\sim 3 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ , collect  $\sim 20/\text{ab}$

## Mile stones

- ▶ Conceptual Design Report: <https://arxiv.org/abs/2406.19421> July 2024  
→ several updates since incl. vertex detector (VTX) design
- ▶ Technical Design Report for both Interaction Region (IR) and detectors, 2027  
**N.B. design concept for final focus system to be finalised in the same time scale, with the possibility that it will NOT be upgraded**  
→ IR and VTX integration takes the current IR design as baseline, while keeping in mind the upgrade option

Upgrade possibility for final focus system  
significant change in  
geometrical constraints on IR/VTX



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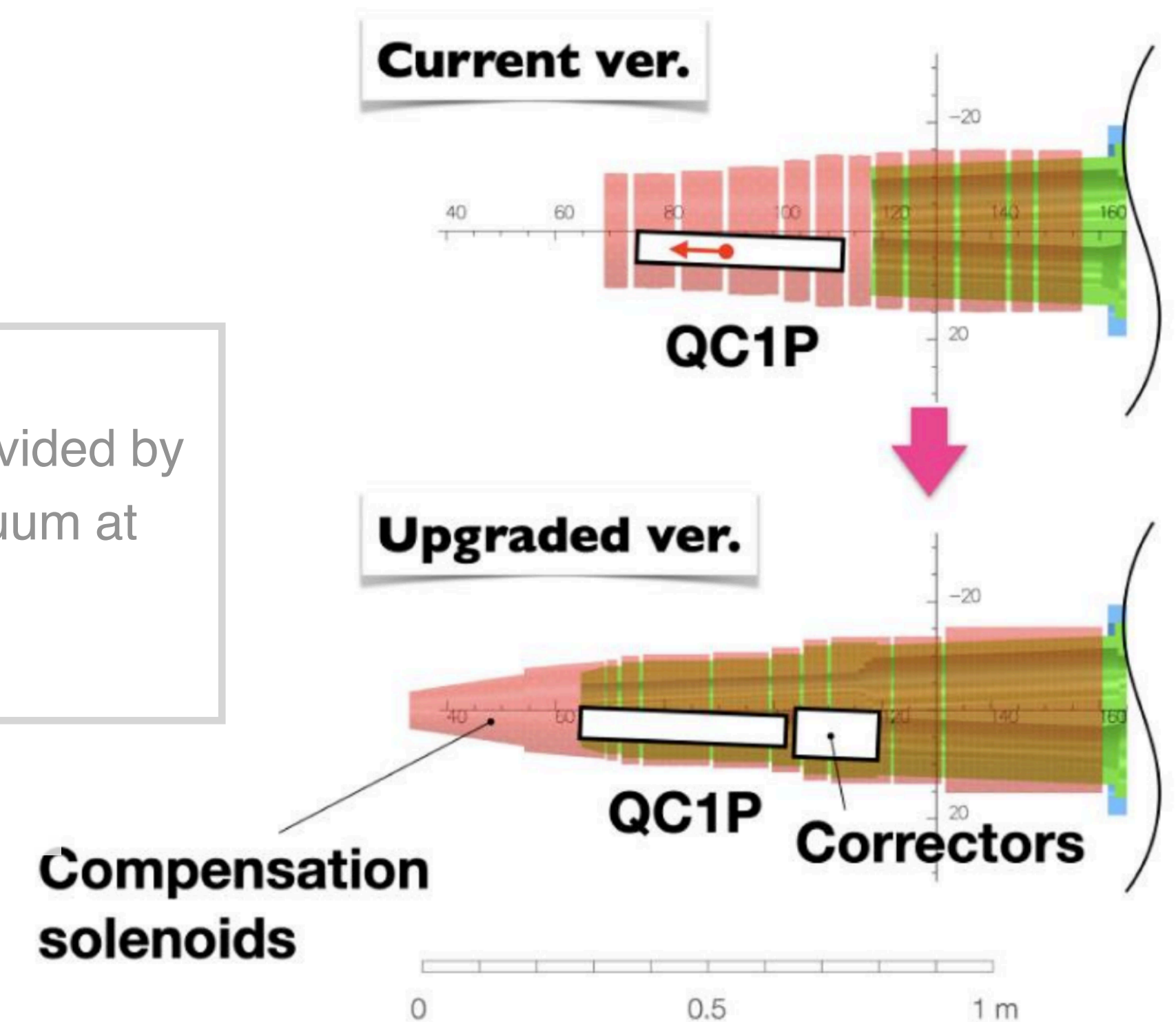
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### Challenges with tight space

“Remote Vacuum Connection” (previously provided by DESY, now continued at KEK) to seal the vacuum at the beam pipe joint from outside  
No space for background shields

Upgrade possibility for final focus system  
significant change in  
geometrical constraints on IR/VTX





# Belle II Upgrade Status

Last strategy discussion on Detector R&D (2025.03.06): <https://indico.desy.de/event/48014/>

## Main upgrades

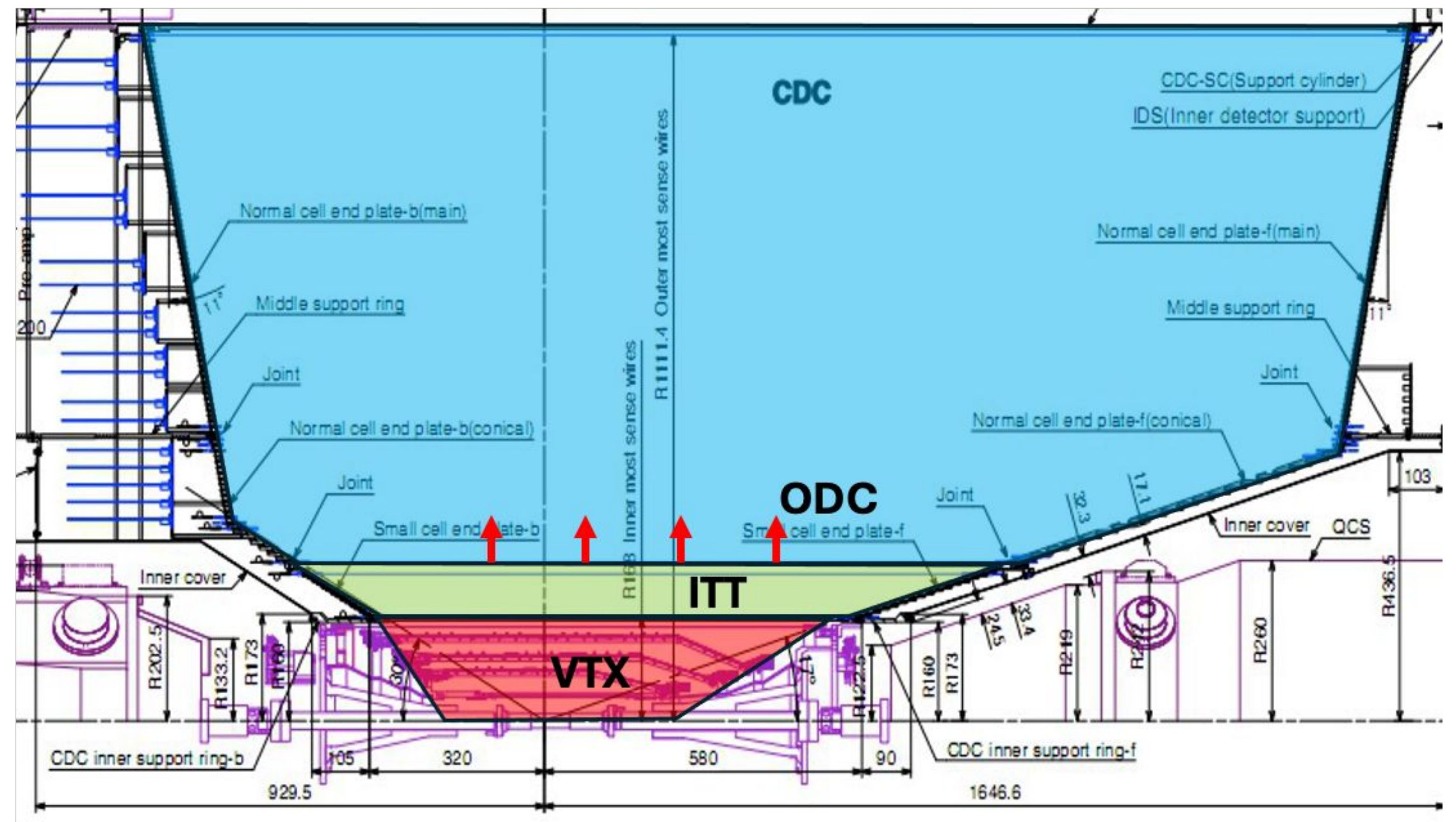
- ▶ Interaction Region (IR)
- ▶ Vertex detector (VTX) & Central Drift Chamber

## No change in official timeline

- ▶ LS2 for upgrade: 1.5 years starting 2032
- ▶ Decision on IR upgrade to be made in 2026
- ▶ Aim for TDR in 2027

## Current situation at SuperKEKB

- ▶ Next data-taking starts in Autumn 2025, plan to run through until May 2026
- ▶ Progress being made on understanding of Sudden Beam Losses & developments





# Replacement of Tracking System

# CDC Rescue Plan: Prospective Idea

Replace CDC small cell chamber with 2 layers of pixels with good timing capabilities for the high lumi part of the run after LS2

Simulations started

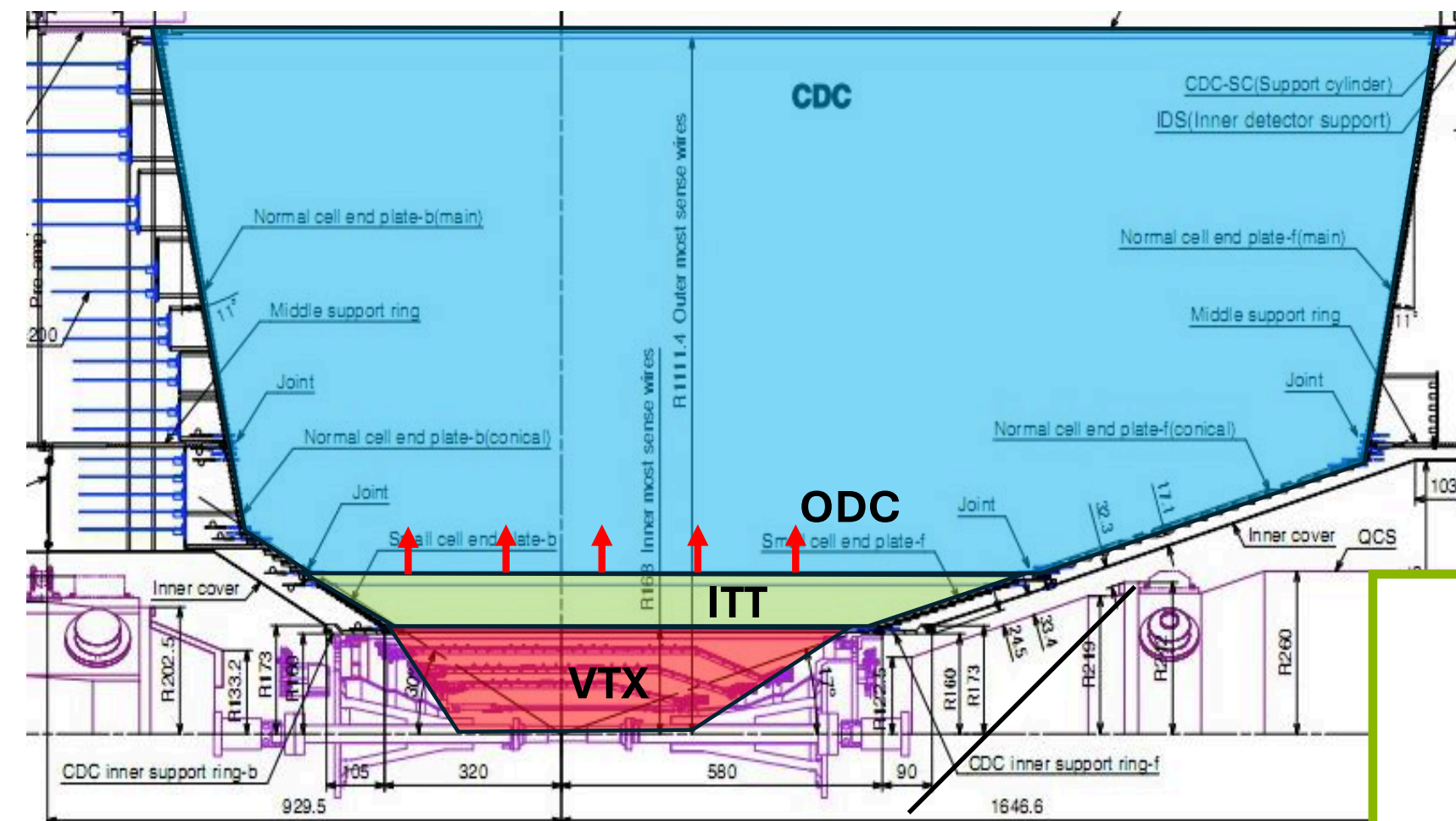
VTX: Spatial resolution, material budget  
ITT: Timing, power consumption

- **Main tracker upgrade (ITT)**

## Replace partially the CDC with DMAPS

Pitch 50x50  $\mu\text{m}^2$ 

1 ns time-stamping w. TRG capability



VTX (iVTX+oVTX): Vertex Detector

ITT: Inner Tracking and Timing

ODC: Outer Drift Chamber

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## ITT – Inner Tracking and Timing

Available space:

[ radius: 16cm – 25cm, length: 88cm – 135cm ]

## Technology considered:

LGAD (low gain avalanche detector)

Timing resolution ~30ps

## Simulation studies started

- Coverage at small radii improves particle-ID at low  $p_T$
- Evaluation of tracking performance needs re-optimisation of tracking software

## Shown last time

Idea to replace inner part of current drift chamber with silicon

Now, entire replacement of CDC is seriously considered

May be decoupled from VTX upgrade (may need sooner...)

CDC extraction and production procedure being reviewed

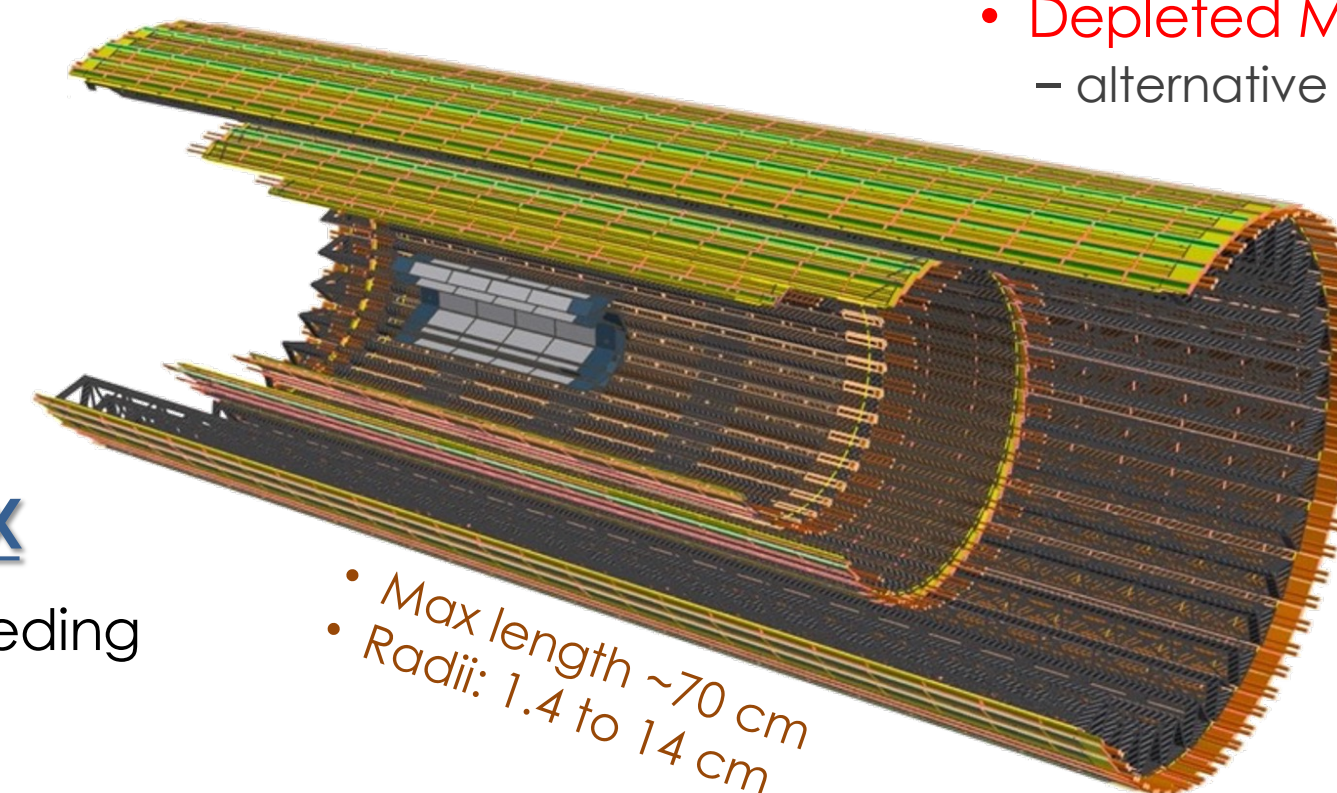


## 2 inner layers: **iVTX**

- “On” beam pipe for IP resolution
- Full-silicon concept:
  - material  $\lesssim 0.2\% X_0$  / layer
  - single-side connexion

## 3 to 4 outer layers: **oVTX**

- at least 3 points for track seeding
- Light & thin support:
  - material  $\lesssim 0.8\% X_0$  / layer
  - single-side connexion whenever possible
- Straight sections => adaptable to any IR



## Same sensor everywhere

- Space & time granularity  
=> occupancy  $\ll 1\%$
- **Depleted MAPS: OBELIX**
  - alternative SOI: DuTIP

## System

- Optical links asap

## Fast track reconstruction

- Full resolution for High Level Trigger
- Reduced granularity for L1 trigger

## VTX OBELIX sensor

→ connection to the

“Vertex detector projects” at DESY

(Ingrid et al.)

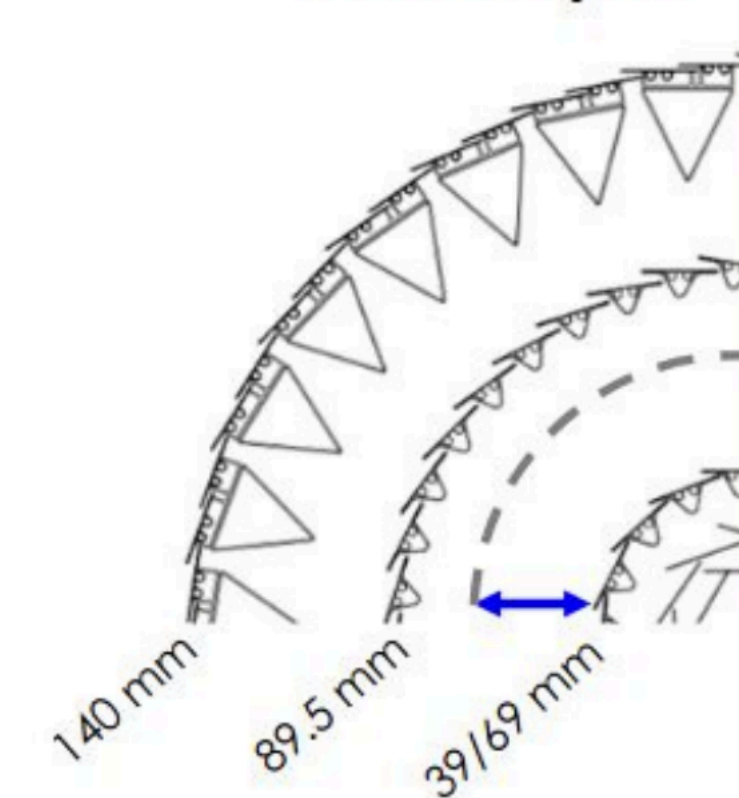
Framework Conceptual Design Report [arXiv:2406.19421](https://arxiv.org/abs/2406.19421) [hep-ex]

## VTX other aspects (2 relatively new efforts mentioned last time)

- ▶ System integration (organised by HEPHY):
  - work packages on electronics, power & cooling, monitoring & software, etc,
  - main interests from China and Spain, and Austria/France
- ▶ Demonstrator (OBELIX telescope at beamtest facility) → no news

## “Final” geometry

CDR 5 layers



New 6 layers

