Vertex Detectors in D
Ideas of smaller Projects

DESY FH Detector Platform Retreat
12. June 2025

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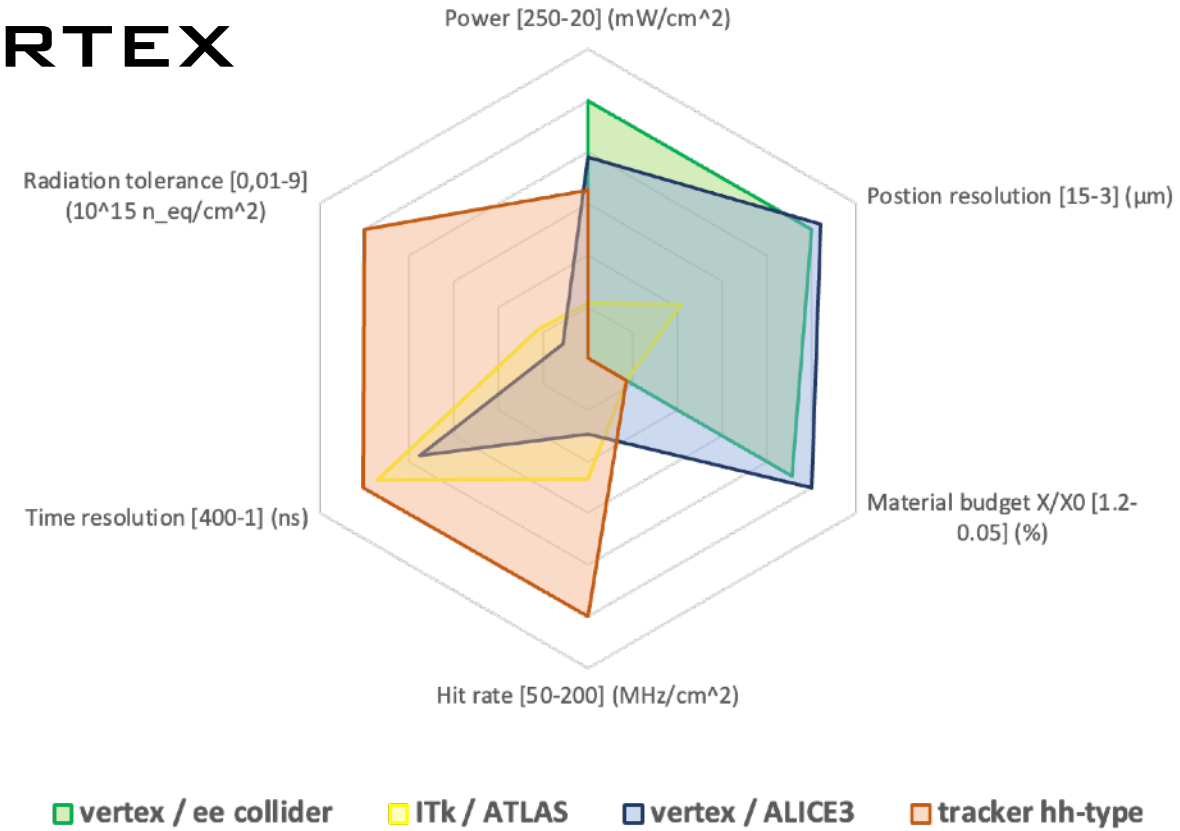
VERTEX



Jerome, Baudot, IPHC

Vertex detectors are always a challenge!
We want to play an important role in future projects: need to develop and maintain expertise NOW

German Silicon Consortium idea:

180nm nodes → Intermediate project such as Belle-II VXT Mu3e, CBM …

R&D Goals: Find solutions for very light mechanics, cooling etc.

TPSCO 65 nm → Whatever comes

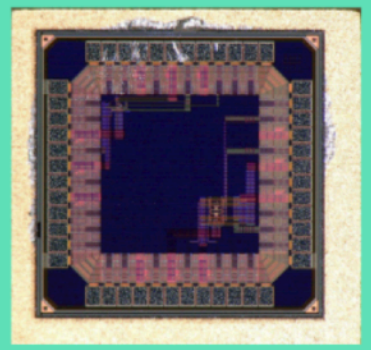
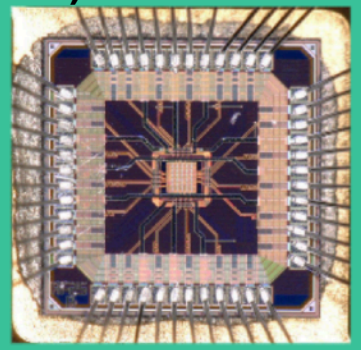
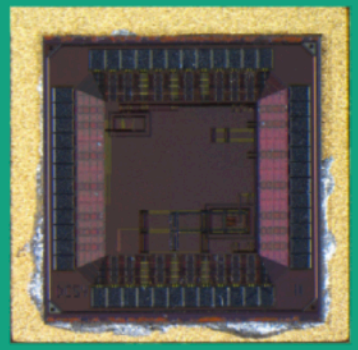
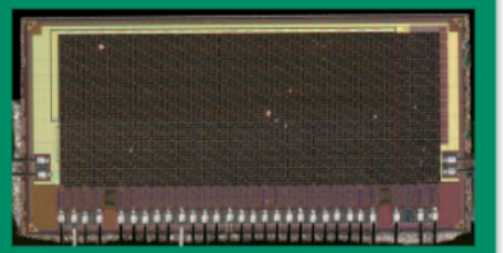
R&D Goals: Design the best vertex detector ever

Ongoing Activities

Tangerine in on Slide

International collaboration for common submissions to foundry with **65 nm CMOS imaging process**, coordinated by CERN.

MLR1 (2021) **ER1 (2023)**

DESY Chip V1

- ★ Designed at DESY
- ★ CSA test structures
- ★ 2 × 2 pixel matrix
- ★ 16 μm pitch
- ★ Analog output

APTS

W. Deng et al.

- ★ Analog Pixel Test Structure
- ★ Designed at CERN
- ★ 4 × 4 pixel matrix
- ★ 15 - 25 μm pitch
- ★ Analog output with source follower (SF)

DESY Chip V2

- ★ Designed at DESY
- ★ 2 × 2 pixel matrix
- ★ 35 × 25 μm^2 pitch
- ★ In-pixel amplifier and discriminator

H2M

- ★ Hybrid-to-Monolithic
- ★ Designed at DESY, CERN and IFAE
- ★ 64 × 16 pixel matrix
- ★ 35 μm pitch
- ★ 4 acquisition modes

Important tools we provide and maintain:

Established a leading role in this field

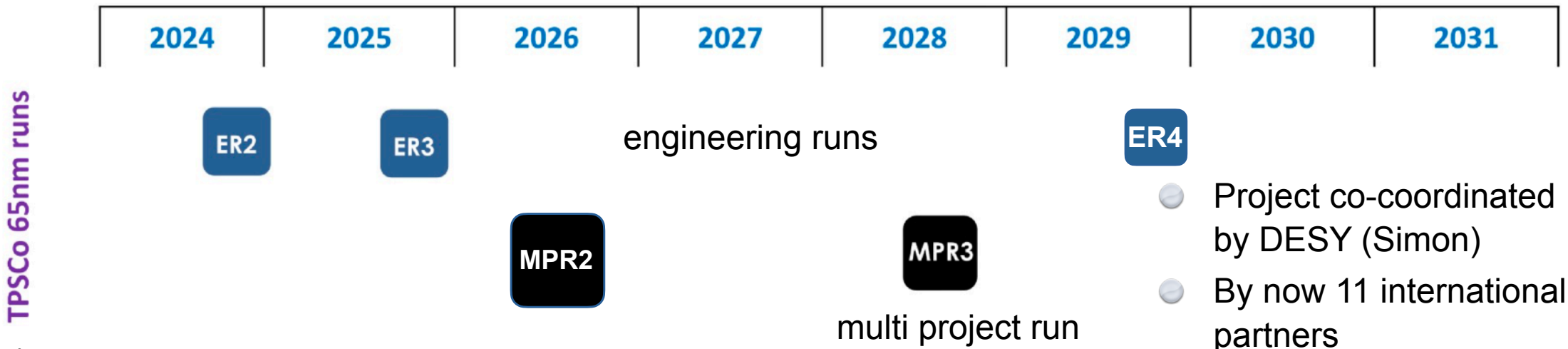
DRD3 Project: Octopus (now-2030)

Needs to be clearly reflected in the strategy!

- Optimised CMOS Technology for Precision in Ultra-thin Silicon
- Goals:
  - Simulation, development and evaluation of MAPS
  - Development of a vertex detector sensor prototype in 65nm TPSCo CIS process
  - Targeting the requirements of future Lepton Colliders
  - Intermediate target: Development of high-resolution sensors for beam telescopes
  - Staged approach: further refinement of performance targets after next strategy update

not trivial

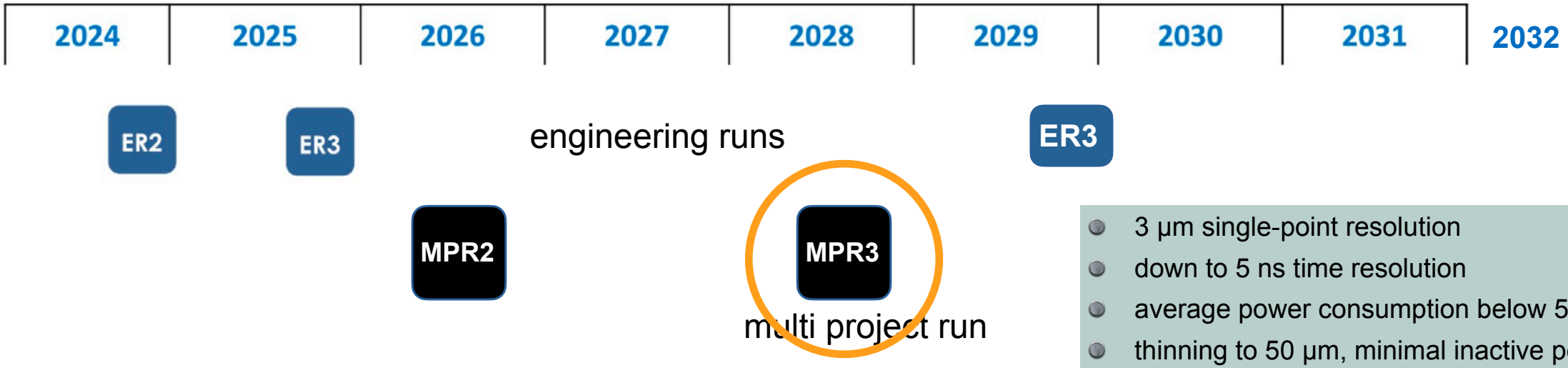
- 3 µm single-point resolution
- down to 5 ns time resolution
- average power consumption below 50 mW/cm2
- thinning to 50 µm, minimal inactive periphery area
- sensor architecture scalable to a large-area detector system



- Project co-coordinated by DESY (Simon)
- By now 11 international partners

OCTOPUS++ (BEYOND 2030)

Needs to be clearly reflected in the strategy!



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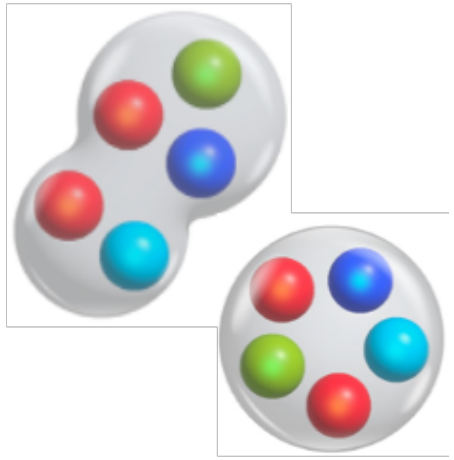
- **Staged approach:** further refinement of performance targets after next strategy update
- Based on development of OCTOPUS
  - Sensors development in the project WILL be used for applications
  - Concrete prototypes can be build

Possible Future Activities

Insight Vertex Detector @ELSA

- Structure formation in the strong interaction: How does the strong interaction produce ist massive bound states from almost massless quarks?



Important input for the Precision search of BSM-Physics at CERN and KEK

color meets flavor

UNIVERSITÄT BONN

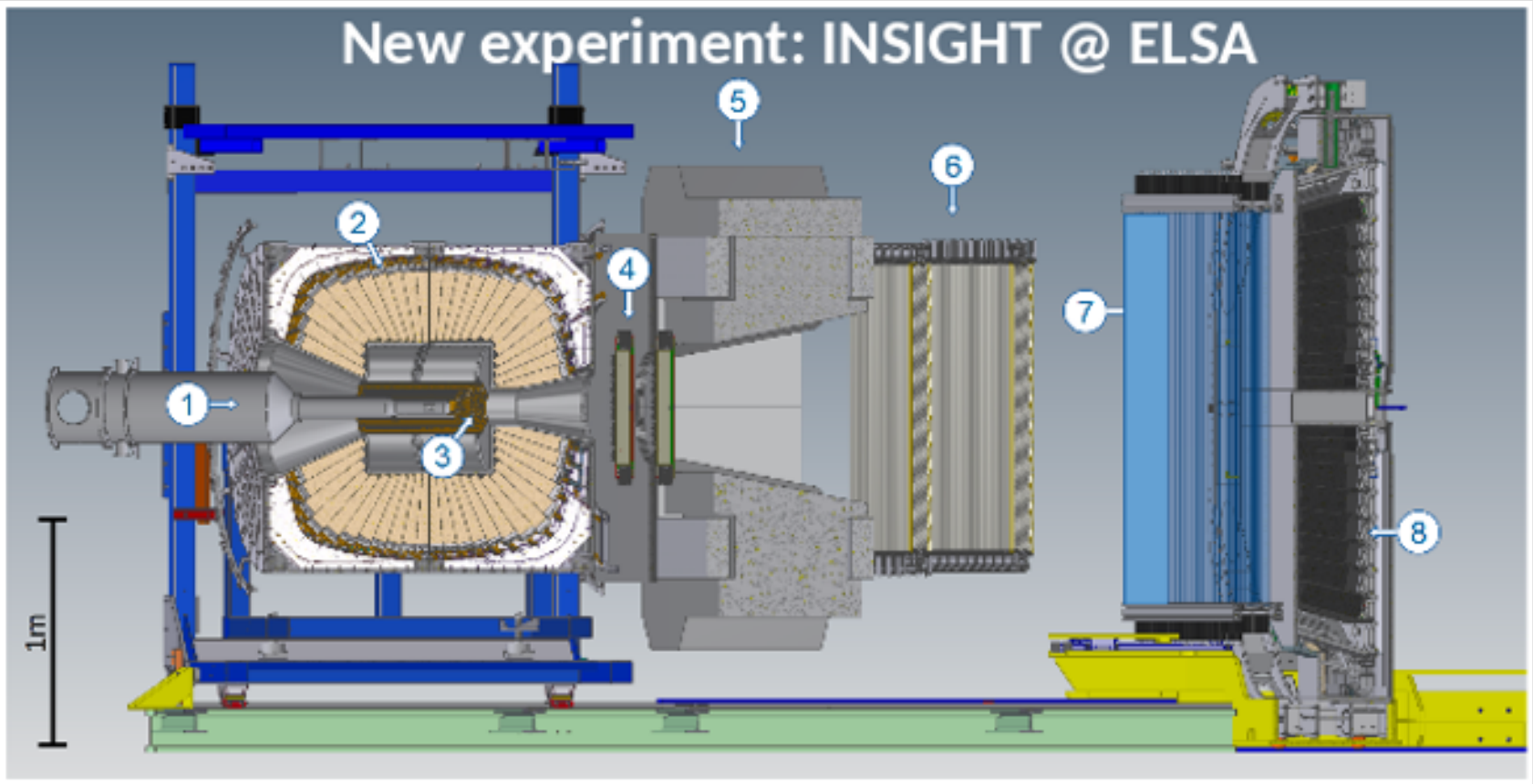
technische universität dortmund

UNIVERSITÄT SIEGEN

JÜLICH Forschungszentrum

DESY.

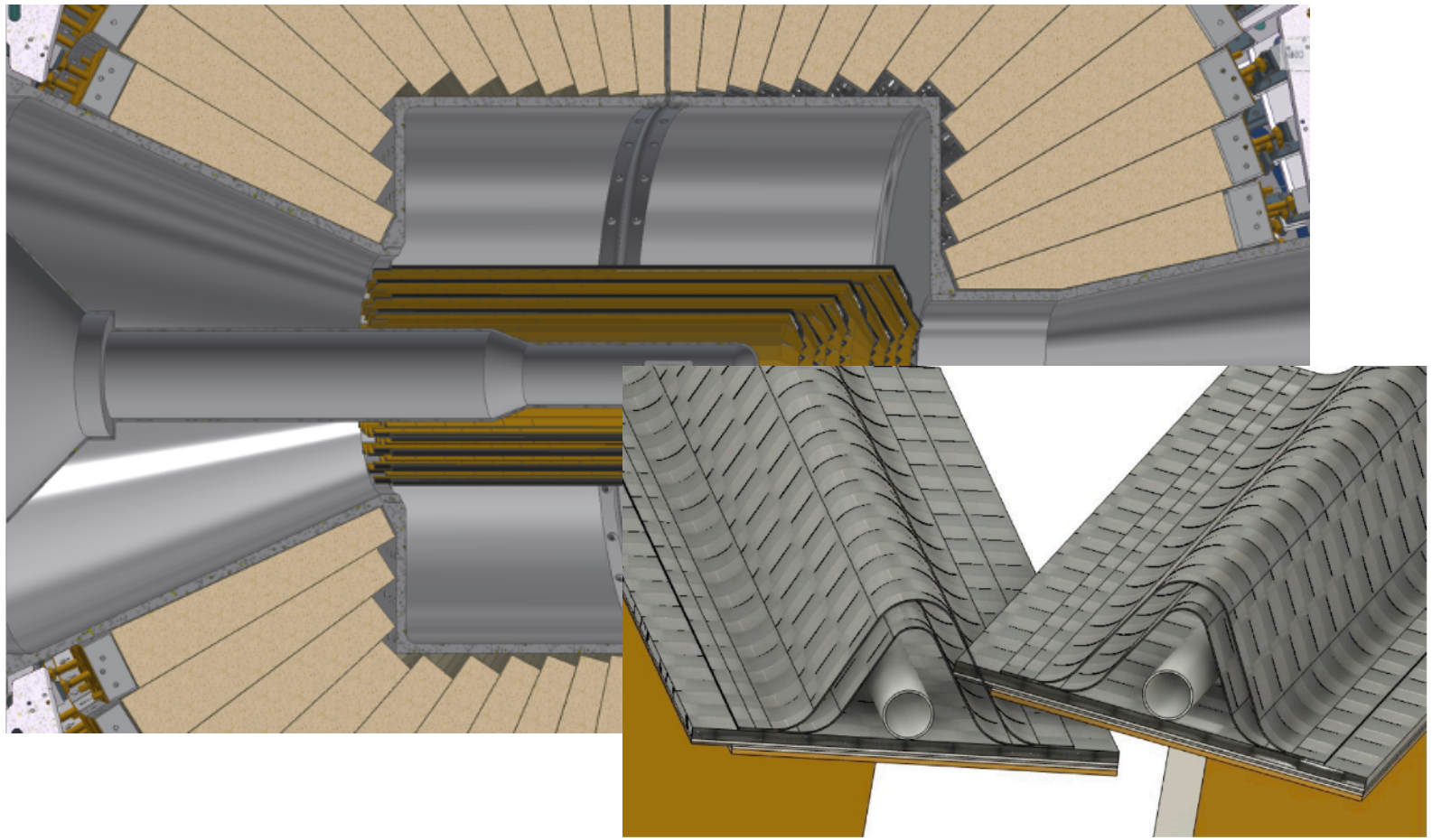
Insight Vertex Detector @ELSA



Detector and microelectronics development & construction of new experiment:
Worldwide unique sensitivity for baryon spectroscopy Polarized beam and polarized target

New experiment: will be build independently of Excellence cluster decisions
On the hunt for collaborators!!

Insight Vertex Detector



Current idea for sensor: use **Obelix** chip (development for Belle II)

Backup considered: **P2Pix**

Large overlap with Belle II ideas!

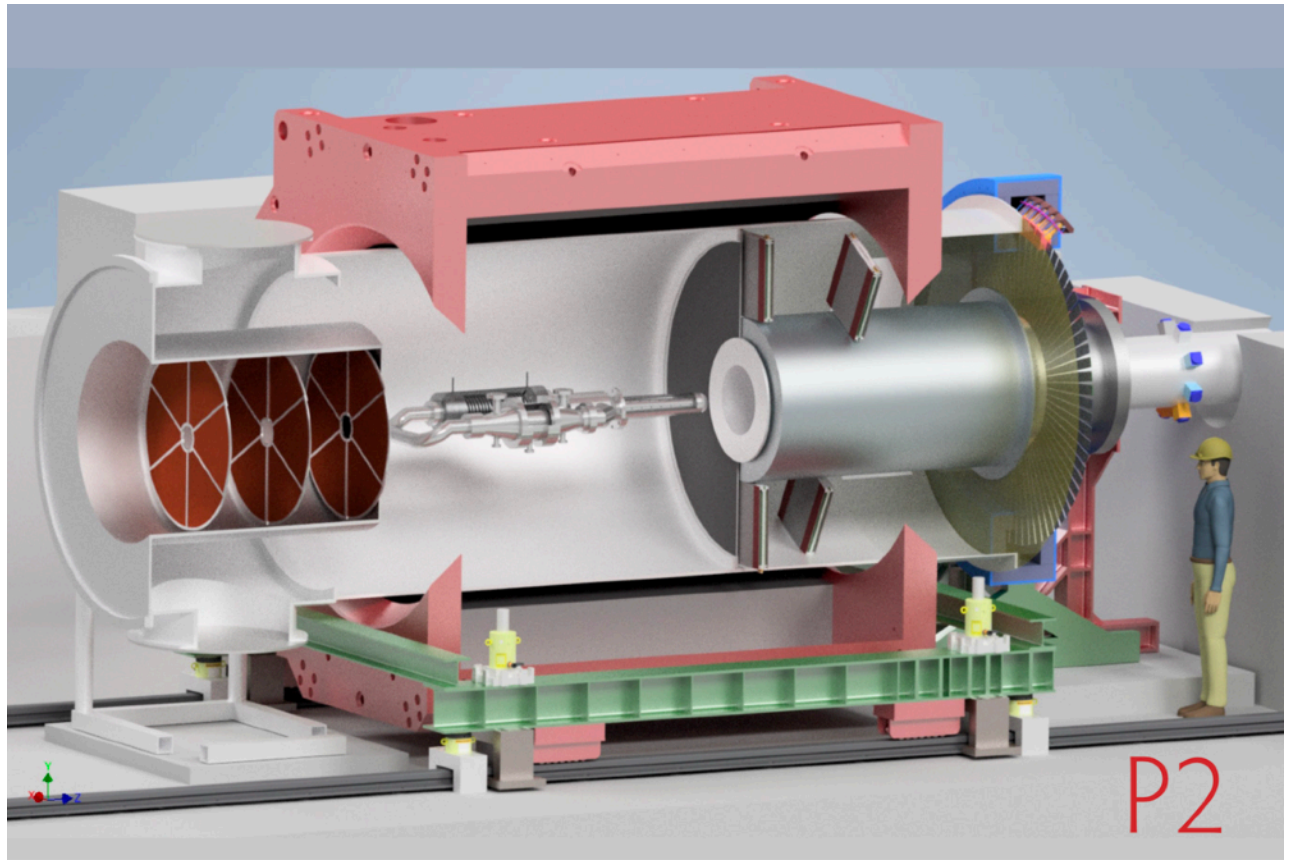
requirements

- precise track measurement
  $\Rightarrow$ vertex resolution
- high acceptance
  $\Rightarrow 12\,^\circ \leq \vartheta \leq 156\,^\circ$, full φ
- low material budget
  $\Rightarrow$ photon conversion low
- available space:
  minimal $r = 5.2\,\mathrm{cm}$,
  maximal $r = 11.5\,\mathrm{cm}$
- ...

Our possible role:

- study sensors in lab and test beam
- support light weight construction
- system aspects
- to be started SOON

P2 Spectrometer@MESA

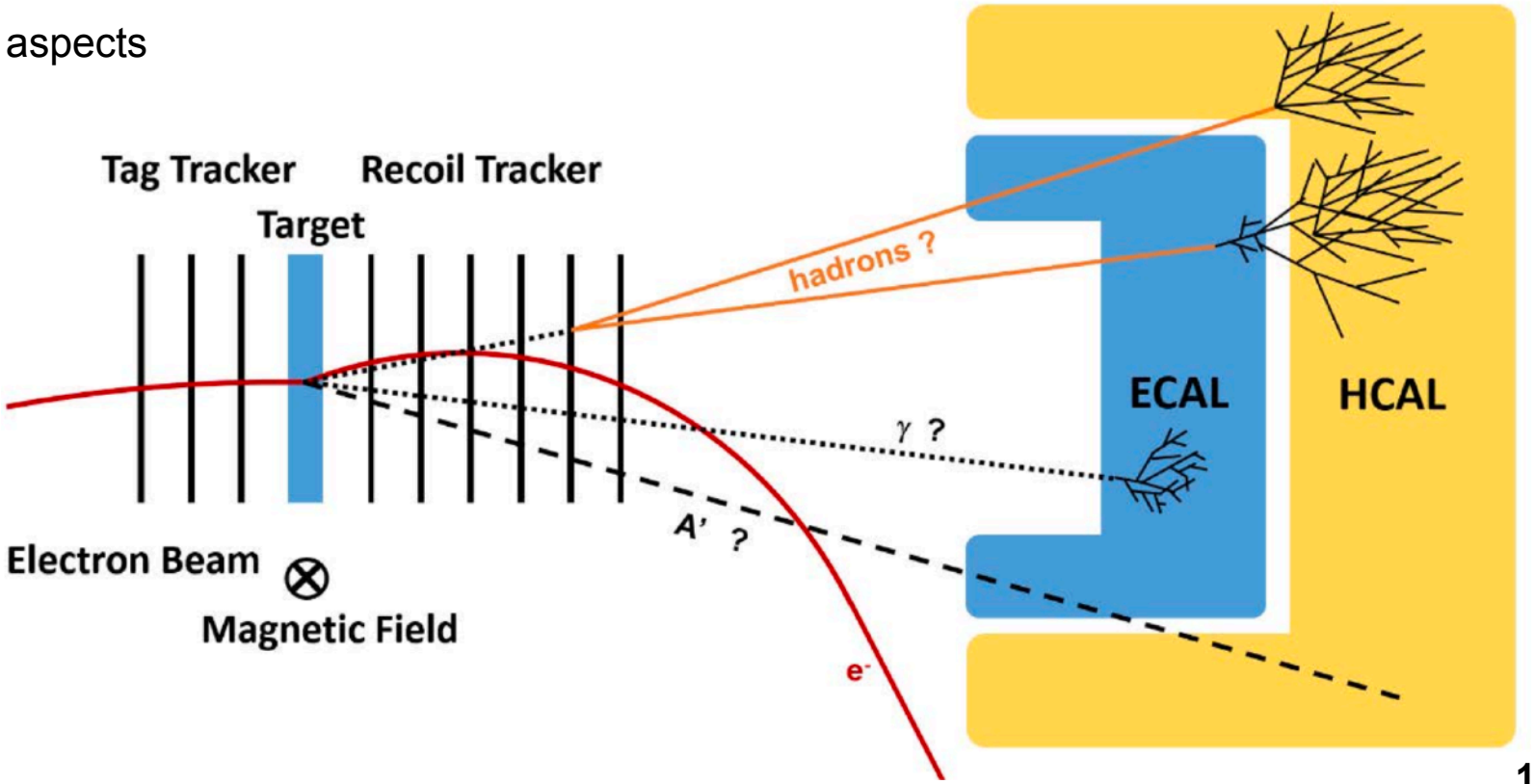


- Determining weak charge of the proton and thus weak mixing angle
  - Improving the existing results by factors of 3 to 4.
- Requires a precise knowledge of momentum transfer Q^2 of the electrons
- Tracking detector built from ultra-thin high-voltage monolithic active pixel sensos
  - P2Pix main candidate
- Expressed interest in support from DESY
  - sensor characterisation
  - system aspects

LOHENGRIN@ELSA

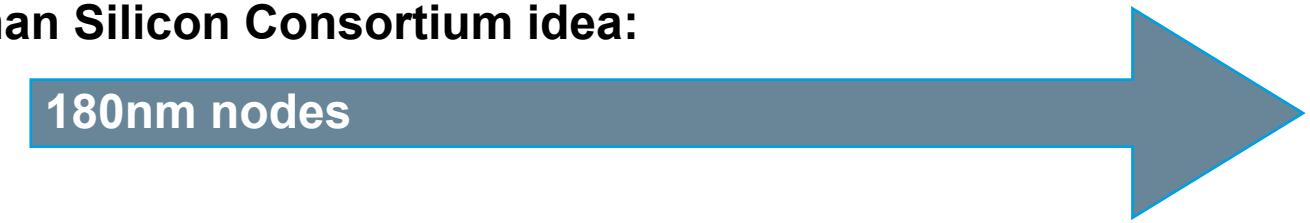
- Production of dark photons through dark bremsstrahlung (3.2 GeV electron beam on fixed target)
- Two ultrafast, low X_0 silicon pixel trackers needed
  - Each layer based on **TJ MonoPix2** DMAPS: 33.04 µm pitch, 512x512 pixels
  - Candidate layout: 3 tag layers, 6 recoil layers, each 2x2 ASICs
  - Fast Hit-or signal for triggering
- Early in the planning - Bonn very much interested in DESY contributions
  - Explicitly were asked about system aspects

also considering the P2Pix now



Conclusion

German Silicon Consortium idea:



Intermediate project such as
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Mu3e, CBM …

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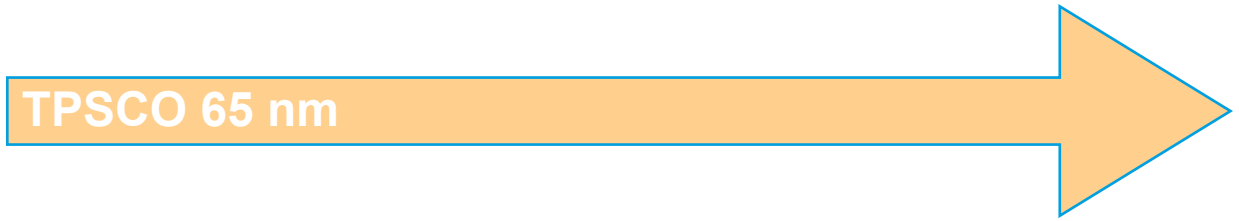
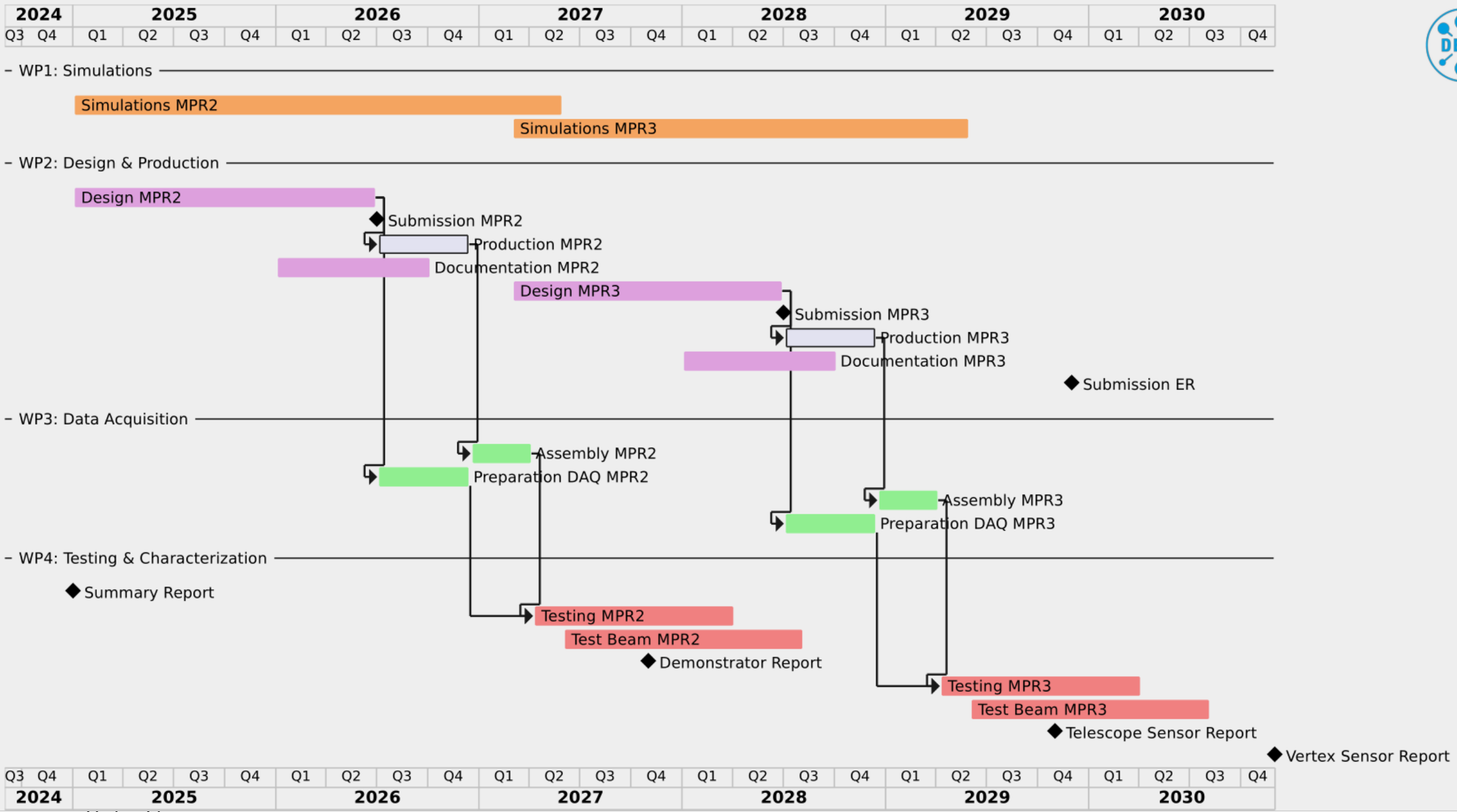


Whatever comes

R&D Goals:
Design the best vertex detector ever

- German colleagues very much interested in DESY joining smaller projects based on MAPS
  - Looks a lot, but very often using the same or similar technology
- Confirming our established role in this
- If we reduce our efforts in **any** area, we will quickly loose this position


2024
2025
2026
2027
2028
2029
2030
Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
WP1: Simulations
Simulations MPR2
Simulations MPR3
WP2: Design & Production
Design MPR2
Submission MPR2
Production MPR2
Documentation MPR2
Design MPR3
Submission MPR3
Production MPR3
Documentation MPR3
Submission ER
WP3: Data Acquisition
Assembly MPR2
Preparation DAQ MPR2
Assembly MPR3
Preparation DAQ MPR3
WP4: Testing & Characterization
Summary Report
Testing MPR2
Test Beam MPR2
Demonstrator Report
Testing MPR3
Test Beam MPR3
Telescope Sensor Report
Vertex Sensor Report