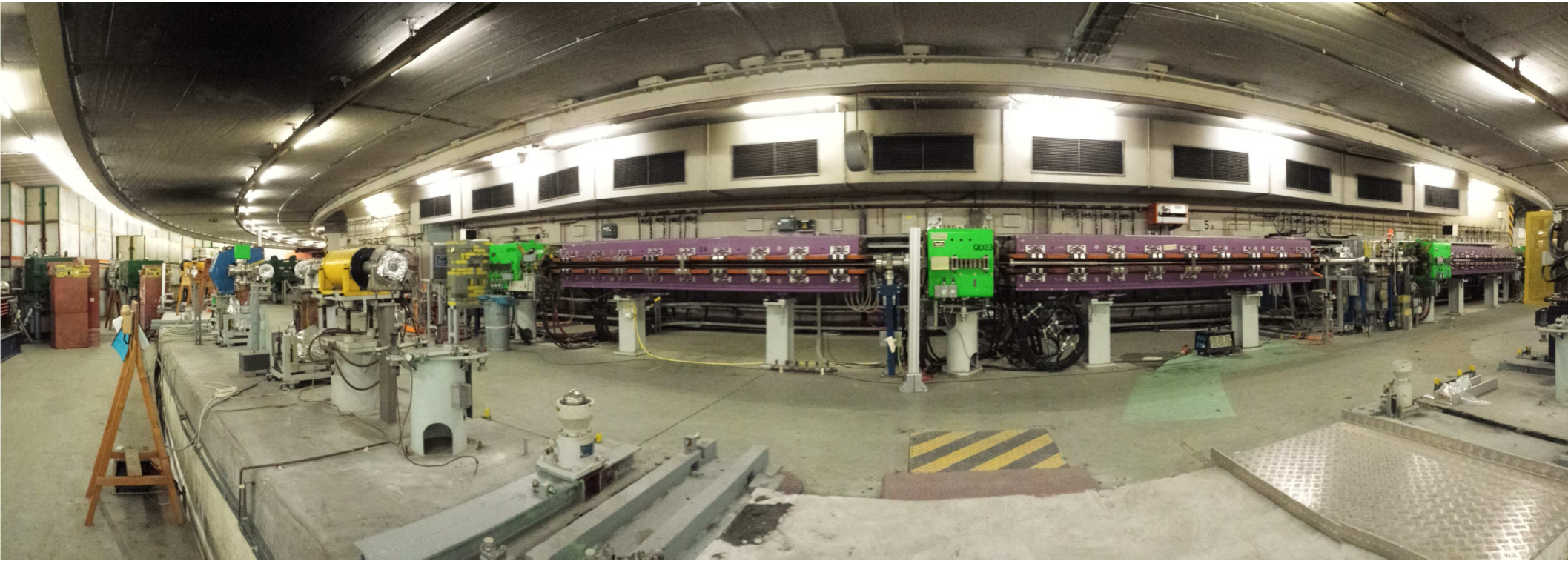
WP15: Upgrade of test beam infrastructure

Task 15.3 Improvements of the DESY test beam infrastructure

AIDA 2020

Kickoff Meeting



Dimitra Tsionou

DESY

WP15 – What is it ?

- WP15: Upgrade of test beam and irradiation infrastructure
  - WP managers Federico Ravotti (CERN), Marcel Stanitzki (DESY)
- Structure/Tasks
  - WP 15.1 - Scientific Coordination / Management
  - WP 15.2 - Improvements of test beam infrastructure for high precision tracking
    - Two sub-tasks
  - WP 15.3 - Improvements of the DESY test beam infrastructure
    - Two sub-tasks
  - WP 15.4 - Improvements of the test beam infrastructure at INFN-LNF
    - Two sub-tasks
  - WP 15.5 - Irradiation facilities
    - Four sub-tasks

WP15.3 at a glance

- WP15.3.1 Silicon strip telescope for 1 T magnet in the DESY test beam line
  - Milestone May 2017 (M24): Hardware assembled
  - Deliverable May 2018 (M36): Installed & Commissioned

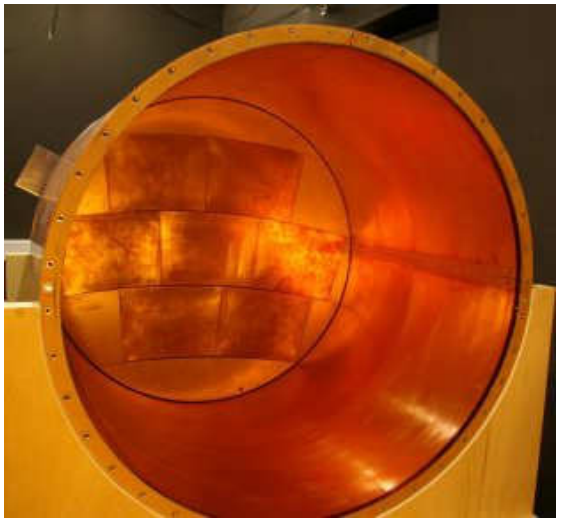
- WP15.3.2 Environmental parameter monitoring system for the DESY test beam areas (J. Dreyling-Eschweiler)
  - Milestone November 2016 (M18): Hardware installed
  - Deliverable November 2017 (M36): Commissioned

External Silicon Tracker

- DESY test beam infrastructure T24/1
  - Supported by EUDET, AIDA, Terascale Alliance
  - 1T PCMAG magnet including cosmic trigger scintillator setup mounted on a lifting stage that can move in 3 axes
- This infrastructure has been used for different purposes
  - Belle II
  - ILD vertex detector
  - LCTPC → TPC prototype for ILD
- Need to provide time stamping of events and reference hits at entry and exit position (reference tracks) → Si telescope to be introduced in this infrastructure

TPC usecase

- For the time being, the characteristics are mainly driven by the TPC usecase
  - Used by different groups testing different/improving different technologies: GEMs, Micromegas, InGrid

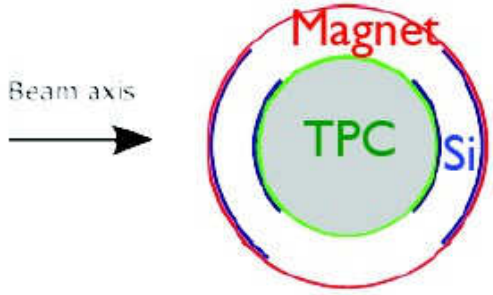


- Studies on different characteristics of the sensors
  - Desired sensor spatial resolution
  - Number of layers
  - Geometry and coverage
  - Material budget

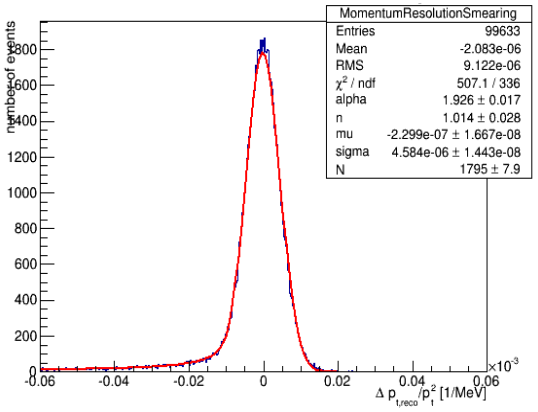
- Exploring what is currently available in terms of sensors/chips

TPC usecase Introduction

- Large Prototype of TPC installed at the DESY test beam area
- Simulation of this prototype and addition of Si sensors at the entrance and exit of the TPC



- The momentum resolution of the standalone Si sensors needs to be at least as good as the TPC one
  - TPC standalone momentum resolution → $4.58 \cdot 10^{-6}$ 1/MeV



Si Simulation Studies for LCTPC

- Momentum resolution for standalone Si sensors (10^{-6} 1/MeV)
  - Assuming 4 layers of sensors and varying the distance between the pair

Distance between inner and outer Si layers

Sensor spatial resolution	4cm	3cm	2cm	1cm
2.5 μm	2.85	2.90	3.00	3.68
5 μm	3.05	3.21	3.63	5.52
7.5 μm	3.37	3.65	4.43	7.92
10 μm	3.68	4.16	5.33	9.90
15 μm	4.49	5.36	7.53	14.3

- Exploring configurations with
  - Different number of Si layers (4 or 2+1 layers)
  - Different distance between the Si layers of each pair
  - Reference momentum resolution from TPC $4.58 \cdot 10^{-6}$ 1/MeV

3 cm distance between the Si pair layers

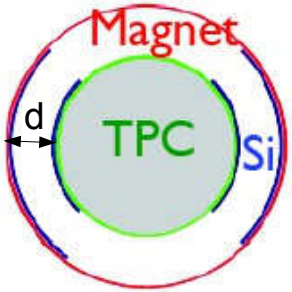
Spatial resolution	4 layers	2+1 layers
5 μm	3.21	4.17
7.5 μm	3.65	4.83
10 μm	4.16	5.61

2 cm distance between the Si pair layers

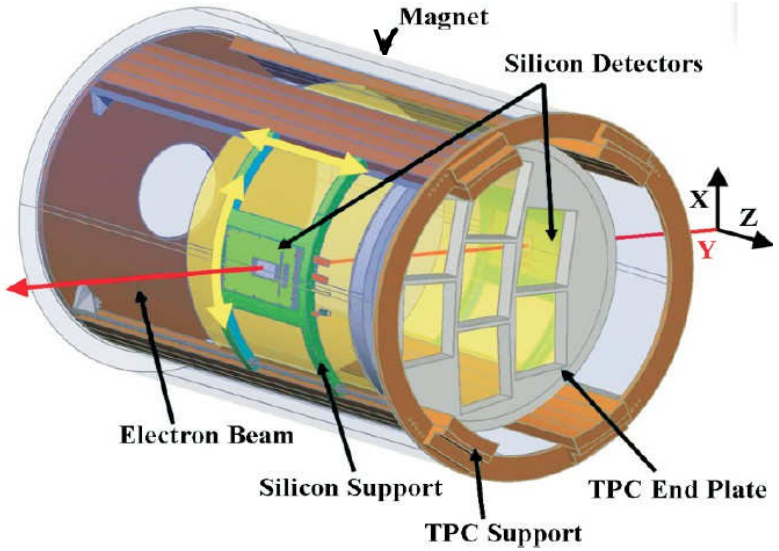
	4 layers	2+1 layers
5 μm	3.63	4.82
7.5 μm	4.43	6.03
10 μm	5.33	7.34

Geometry

- The available space to fit in the Si telescope is limited d~3.5 cm (rTPC=38.5 cm, rMagnet=42 cm)
- The distance between the 2 Si layers is important
- How big a device can we fit in while aiming for maximum width?



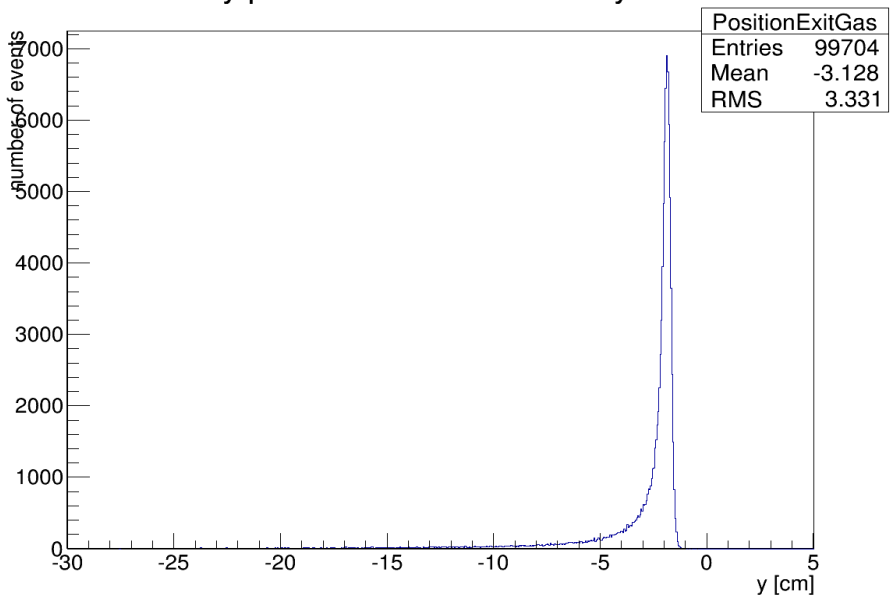
Thickness (cm)	Height (cm)
3	13
2	22
1	29



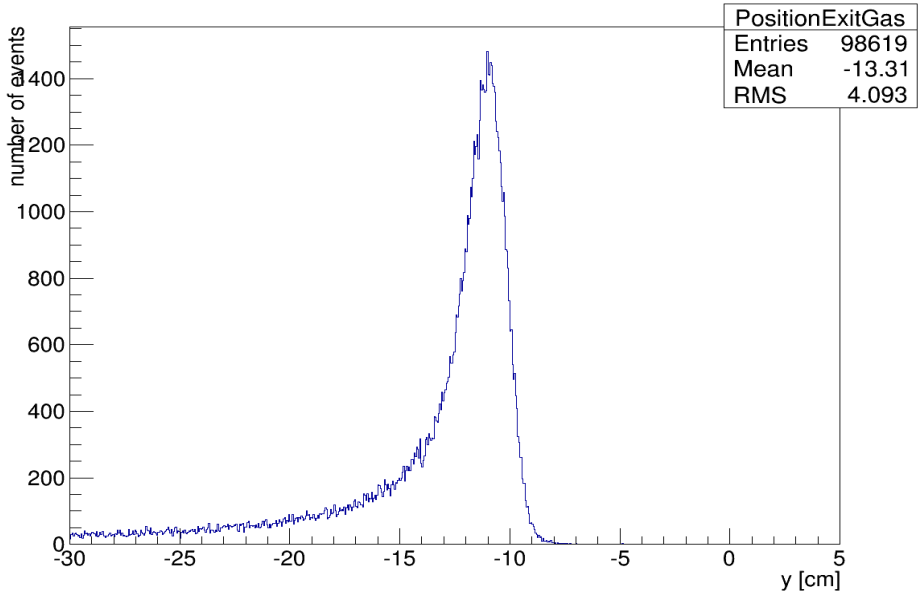
Coverage

- What sensor size do we need / What area do we need to cover?
  - Simulation assuming 4 layers of 1mm thick sensors (→ more material → more bending)
- For the sensors in the front, the possible minimum size is 1x1 cm2
- For the sensors at the exit position and size depend on beam energy
- Obviously, we would like larger coverage area than the minimum
  - Alignment, angle scan,...

6 GeV beam



1 GeV beam



Material Budget

- Studies up to now were using simply Si sensors of 250μm
- In reality more material will be present... → Mimick dead material effects (ie support) by increasing the Si sensor thickness

- Table shows the Si standalone momentum resolution in units of 10^{-6} 1/MeV
  - 4 Si layers used here
  - Reminder: TPC only → $4.5 \cdot 10^{-6}$ 1/MeV

Sensor spatial resolution	Sensor thickness	Distance between Si layers	
		3 cm	2 cm
5 um	250 μm	3.20	3.62
	500 μm	3.37	3.82
	750 μm	3.50	3.93
	1000 μm	3.62	4.10
10 um	250 μm	4.14	5.33
	500 μm	4.34	5.56
	750 μm	4.47	5.70
	1000 μm	4.58	5.91

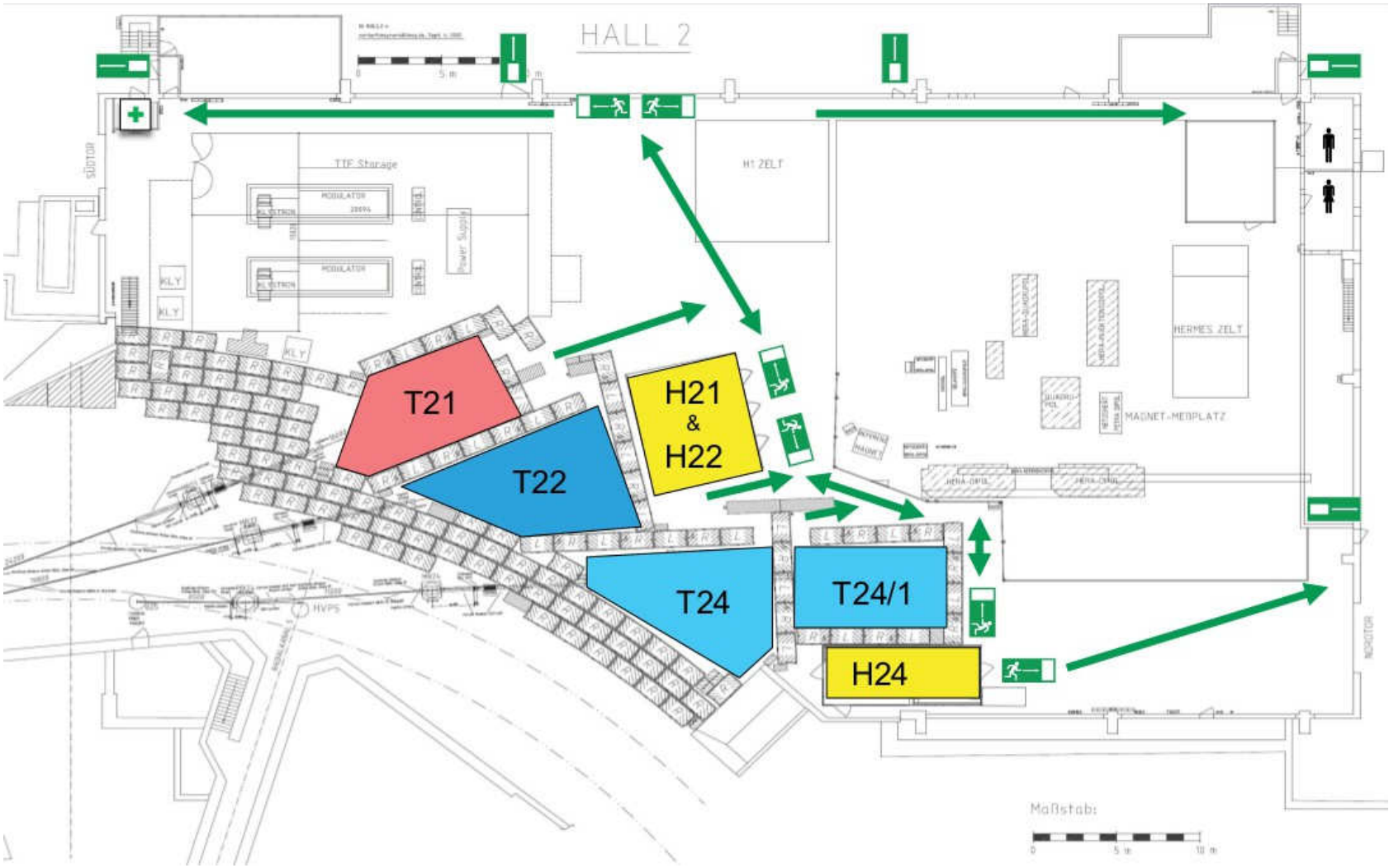
Exploring Available Options

- Possible “realistic” configurations summarising the previous slides

Distance between layers	Spatial sensor resolution for 4 Si layers	Spatial sensor resolution for 3 Si layers	Maximum height of box apparatus
3 cm	< 10 μm	< 5 μm	13 cm
2 cm	< 5 μm	---	22 cm

- We have received some sensors from Th. Bergauer (Vienna)
  - Strip sensors with 50μm pitch
  - Used previously for a Si external tracker prototype for TPC. Now implemented in a telescope at CERN
- Due to the stringent spatial resolution requirements we have started thinking the possibility of using pixel sensors
  - Mimosa sensors ~4μm spatial resolution

- "WP15.3.2 Environmental parameter monitoring system for the DESY test beam areas" or just
  slow control for TB21, 22, 24, 24/1



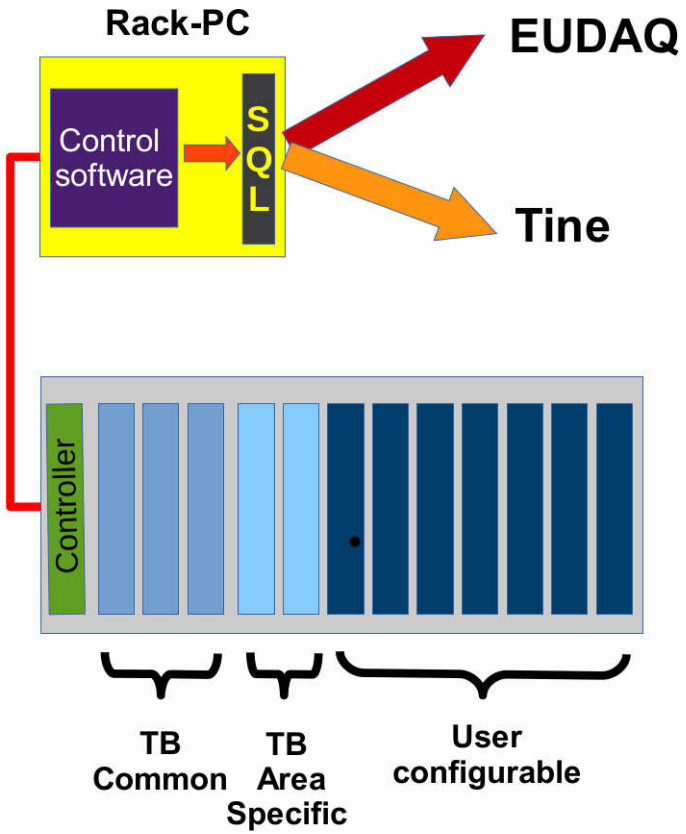
Slow control

- **Goal** of common slow control system
  - easily configurable and usable
  - network integration
- General **considerations**
  - up to 100 channels
  - read-out speed: > 0.1 Hz
  - rack-based
- **Proposal** of commercial Ahlborn system
  - Readout: Win OS, data logged in SQL (ODBC)
    → interfaces and integrations (EUDAQ, …) ?
- **Sensors** needed

  1) Common sensors: temp., hum., press., gas, ...

  2) Area-specific sensors: magnetic field (?), ...

  3) User-configurable: temp., flow., … ?

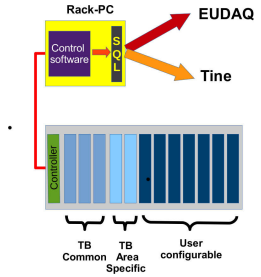


Summary (15.3.1)

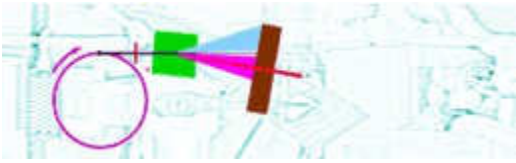
- Simulation studies on Si telescope requirements have already started
  - Sensor spatial resolution <10 μm
- Started to explore the hardware possibilities already available
  - Strip or pixel sensors? Chip? DAQ?
- Additional studies to follow soon
  - Number of sensors layers, Geometry of the system, ...
- Need to start exploring movable support for different beam energies, magnetic fields, different beam angles
- Additional requirements other users would like?

Summary (15.3.2)

- Common slow control system with **permanent** and **user** sensors



- **Suggestions/requests** are welcome until end of June to **marcel.stanitzki@desy.de** (DESY testbeam coordinator)



- **Milestones**
  - From now: Details of Ahlborn system and requests
  - Milestone November 2016 (M18): Hardware installed
  - Deliverable November 2017 (M36): Commissioned