

Status Report on the The DESY II Test Beam Facility and the EUDET/AIDA Beam Telescopes

Adrian Herkert
on behalf of the
DESY Test Beam crew

9th BTTB Workshop

8 February 2021



HELMHOLTZ RESEARCH FOR
GRAND CHALLENGES

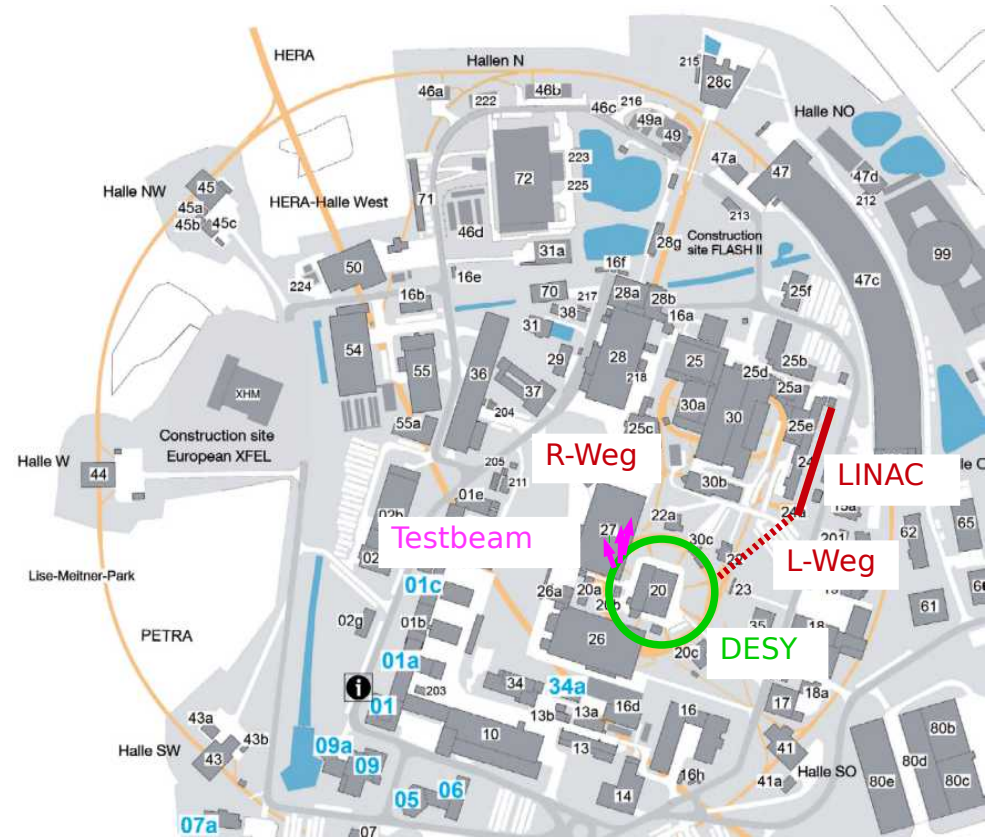


The DESY II Test Beam Facility



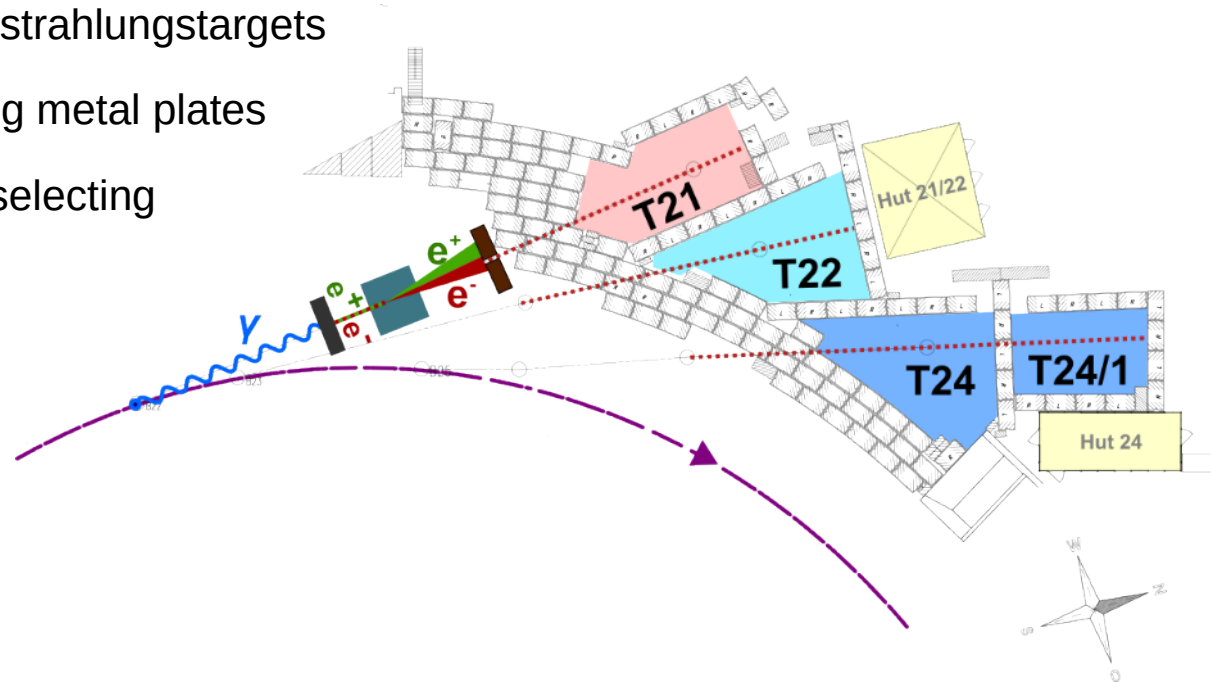
DESY II

- Electron storage ring
- Main purpose: PETRA III injector
 - Test Beam operates parasitically
- One electron bunch per fill
(~ 30 ps long, ~ 1 μ s circulation period)
- Energy ramps continuously between 0.45 and 6.3 GeV at 12.5 Hz



Beam lines

- 3 beam lines (21, 22, 24)
- Extracted independently via Bremsstrahlungstargets
- Photons converted to e^+e^- -pairs using metal plates
- Dipole magnets and collimators for selecting charge and momentum (1 – 6 GeV)
- Particle rate $O(1 \text{ kiloelectron/s})$
(depends on beam line, target, and momentum)



Infrastructure

- 30 kg and 1 t stages, 25 t crane
- Superconducting 1 T solenoid (T24/1)
- ~ 1.5 T dipole magnet (T21)
- EUDET-type beam telescope in each area
(see [second part of this talk](#))
- Moveable high-res camera in each area
- Dry nitrogen, cooling water, gas cabinets
- Beam monitor
- Patch panels
- ...

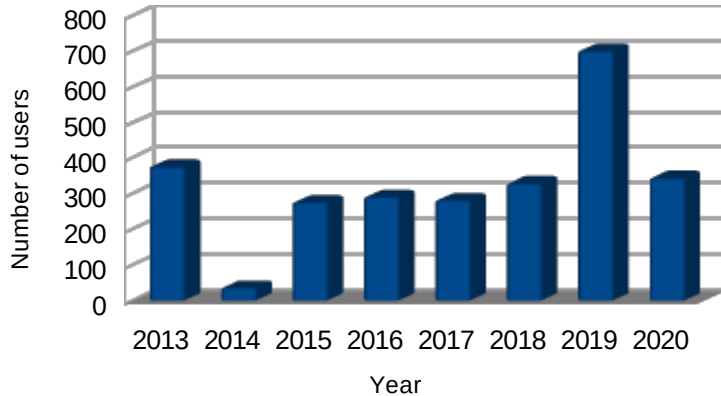


Test beam operations 2020



Users / schedule 2020

- 84 weeks available
- 81% used
(not counting some DESY-internal users)
- 345 users
from institutes in 27 different countries

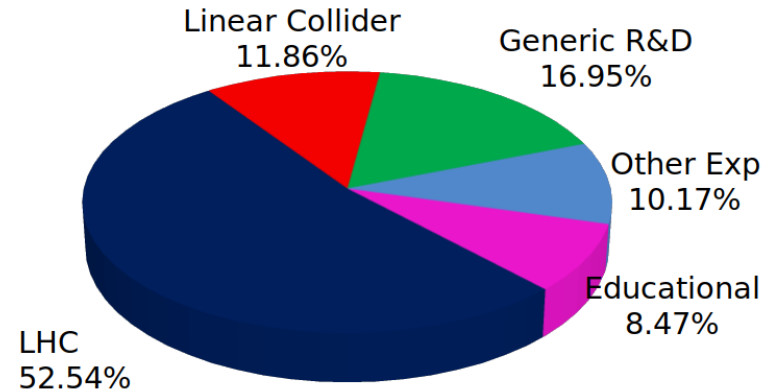


Week	TB21		TB22		TB24/1		TB24			
	STARTUP	DURANTA	STARTUP	DURANTA	PC/MAG	TELESCOPE / FCAL	PC/MAG	AZURA		
6-Jan-20	Shutdown									
13-Jan-20	Shutdown									
20-Jan-20	Shutdown									
27-Jan-20	Shutdown									
3-Feb-20	Shutdown									
10-Feb-20	Shutdown									
17-Feb-20	Start-up		Start-up		Start-up		Start-up		Announced	
24-Feb-20	EDIT-2020	X	ALICE-mTower	X	EDIT-2020		Mu3e	X		
2-Mar-20	EDIT-2020	X	CLIC Pixel	X	EDIT-2020		CMS-Pixel-Phase2	X		
9-Mar-20	FCAL	X	Belle-II PXD	X			CMS-Pixel-Phase2	X		
16-Mar-20	FCAL	X	Bonn-SILAB	X	Lycoris					
23-Mar-20	Shutdown									
30-Mar-20	Shutdown									
6-Apr-20	Shutdown									
13-Apr-20	Shutdown									
20-Apr-20	Shutdown									
27-Apr-20	Shutdown									
4-May-20	Shutdown									
11-May-20	Shutdown									
18-May-20	Shutdown									
25-May-20	Shutdown									
1-Jun-20			Setup Time						Rescheduled & Announced	
8-Jun-20	CMS-Pixel-Phase2	X	MBI	X			Telescope-Dev	X		
15-Jun-20	CMS Outer Tracker	X	Telescope-Dev	X			ALICE-ITS3	X		
22-Jun-20	CMS-Pixel-Phase2	X	Telescope-Dev	X			CMS-Pixel-Phase1			
29-Jun-20	CMS-Pixel-Phase2	X	ATLAS-ITk-Pixel	X			Mu3e	X		
6-Jul-20	Shutdown									
13-Jul-20	Shutdown									
20-Jul-20	Shutdown									
27-Jul-20	BL4S	X	Belle-II PXD	X			CLIC Pixel	X		
3-Aug-20	MBI	X	Belle-II PXD	X			Lycoris	X		
10-Aug-20	CMS Outer Tracker	X								
17-Aug-20	CALICE AHCAL	X	CMS-Pixel-Phase1				CMS-HGAL-Sci	X		
24-Aug-20	CLIC Pixel	X					ALICE-ITS3	X		
31-Aug-20	CMS-Pixel-Phase2	X					AFP-TOF			
7-Sep-20	CMS-Pixel-Phase2	X					AFP-TOF			
14-Sep-20	Shutdown									
21-Sep-20	BL4S	X					LHCb-Luminometer			
28-Sep-20	BL4S	X	ATLAS-HGTD	X			CMS-Pixel-Phase2	X		
5-Oct-20	ATLAS-ITk-Pixel	X	ATLAS-HGTD	X						
12-Oct-20	ATLAS-ITk-Pixel	X	Mu3e	X						
19-Oct-20	LHCb-MightyPix	X	CALICE AHCAL	X			HEP for Teachers			
26-Oct-20	CMS OT 2S	X								
2-Nov-20	Shutdown									
9-Nov-20			Setup Time							
16-Nov-20			ATLAS-ITk-Strips	X			LHCb-ECAL	X		
23-Nov-20	CMS OT 2S	X	ATLAS-ITk-Strips	X			LHCb-ECAL	X		
30-Nov-20	CMS-Pixel-Phase2	X					LHCb-ECAL	X		
7-Dec-20	MBI	X	Belle-II VXD	X						
14-Dec-20	MBI	X	Belle-II VXD	X			ALICE-ITS3	X		
21-Dec-20	Shutdown									
28-Dec-20	Shutdown									

User projects

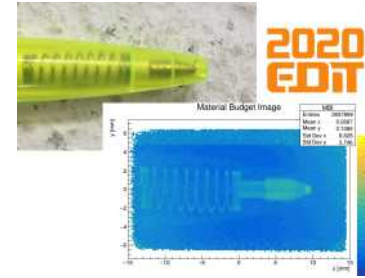
- ~ 50% of TB weeks 2020 used by LHC experiments
- Some linear collider R&D
 - CLiC, CALICE, FCAL
- Detector R&D for ‘other’ experiments
 - Belle II, Mu3e, ...
- Generic R&D
 - Telescope development, MBI, ...
- Outreach & education

Projects 2020



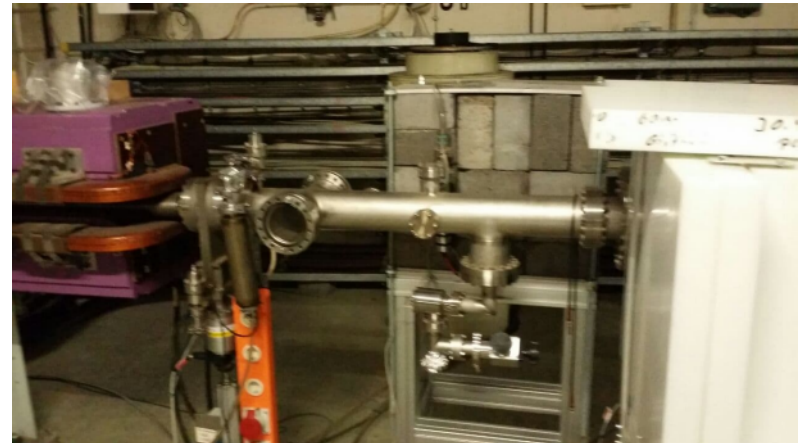
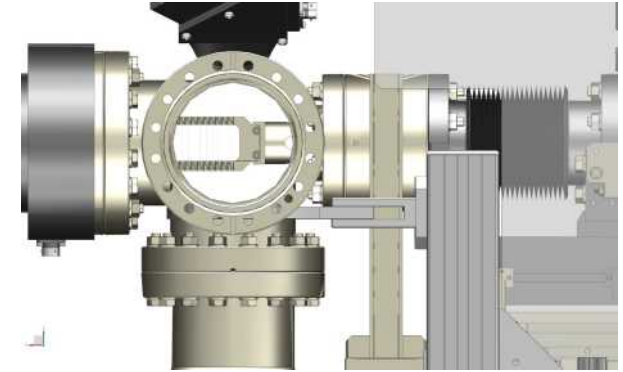
Outreach & education

- EDIT-2020
 - Detector and instrumentation school for grad students and young postdocs
- Beamline for Schools (BL4S)
 - Two teams of high school students get to perform their proposed experiment
 - Approved by CERN also for 2021
- Teachers education
 - Hands-on course for school teachers
 - Annual event, planned also for 2021



Maintenance / improvements (I)

- New target stations
 - Installed during winter shutdown
 - New design
 - Holds more fibres
 - Allows for exchange without breaking main vacuum of DESY II (venting time 48 h → 6 h)
- More fail-safe test beam operation
- Might open up possibilities, e.g. multi-bunch operation



Maintenance / improvements (II)

- Annex
 - Cleared & equipped with ethernet and furniture
 - More flexibility with room situation
- Further renovations of Hall 2:
 - New windows
 - New ceiling lights
 - Further refurbishment of power distribution
 - Air purifier in hut 21/22
 - Dish washer



Ongoing test beam projects



New office container

- For users
- Will replace the old blue container
- Offers twice as much space
- Has lots of windows
- Status:
 - Has been ordered
 - But delivery date is currently unknown



© 2020 HANSA BAUSTAHL



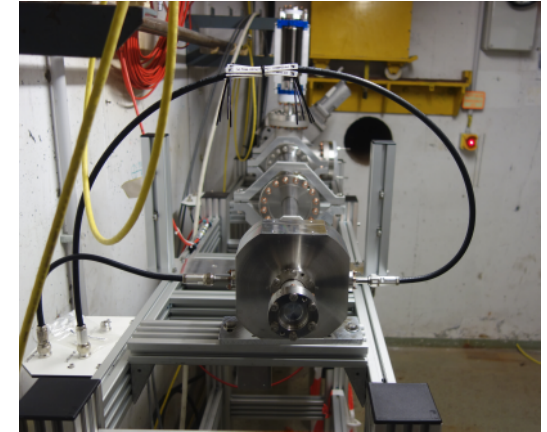
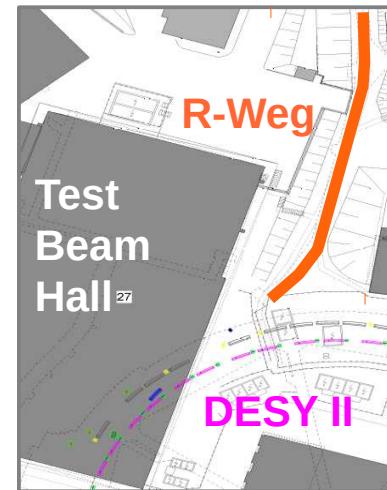
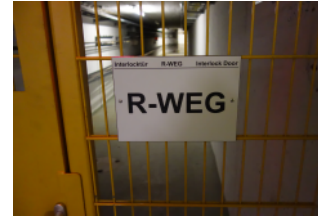
Environmental conditions monitoring

- Raspberry Pi based expandable system measuring at different locations:
 - Temperature
 - Humidity
 - Air pressure
 - Air quality, CO₂ (to be implemented)
- Status: One device running as server:
 - Database
 - Web interface
 - Tine server (accelerator control system)



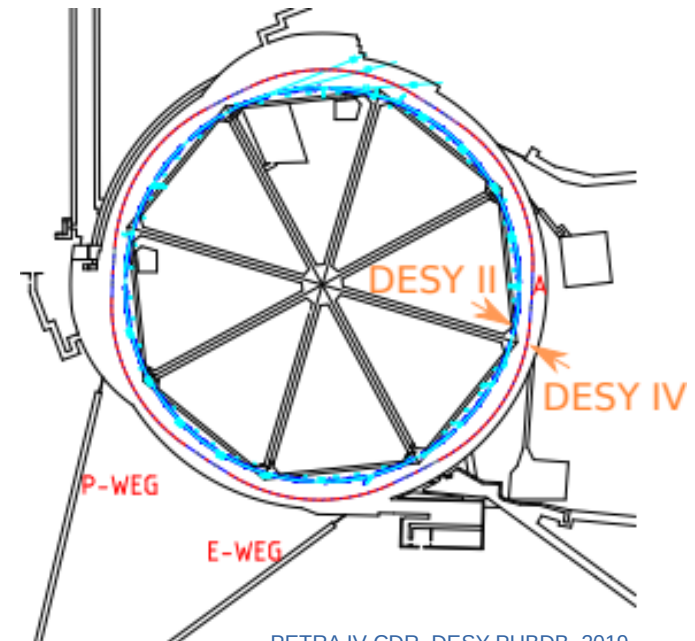
“R-Weg”

- Test area for 4th beam line that uses the dumped DESY II beam
 - Intensity: 1×10^8 - 2×10^{10} particles / bunch
 - Energy: 0.45 GeV - 6.3 GeV
 - Repetition rate: 12.5 Hz
- Area not suited for user operations → if tests successful, we need to find new location
- Status:
 - Beampipe and Interlock system installed
 - Start of commissioning planned for the upcoming months



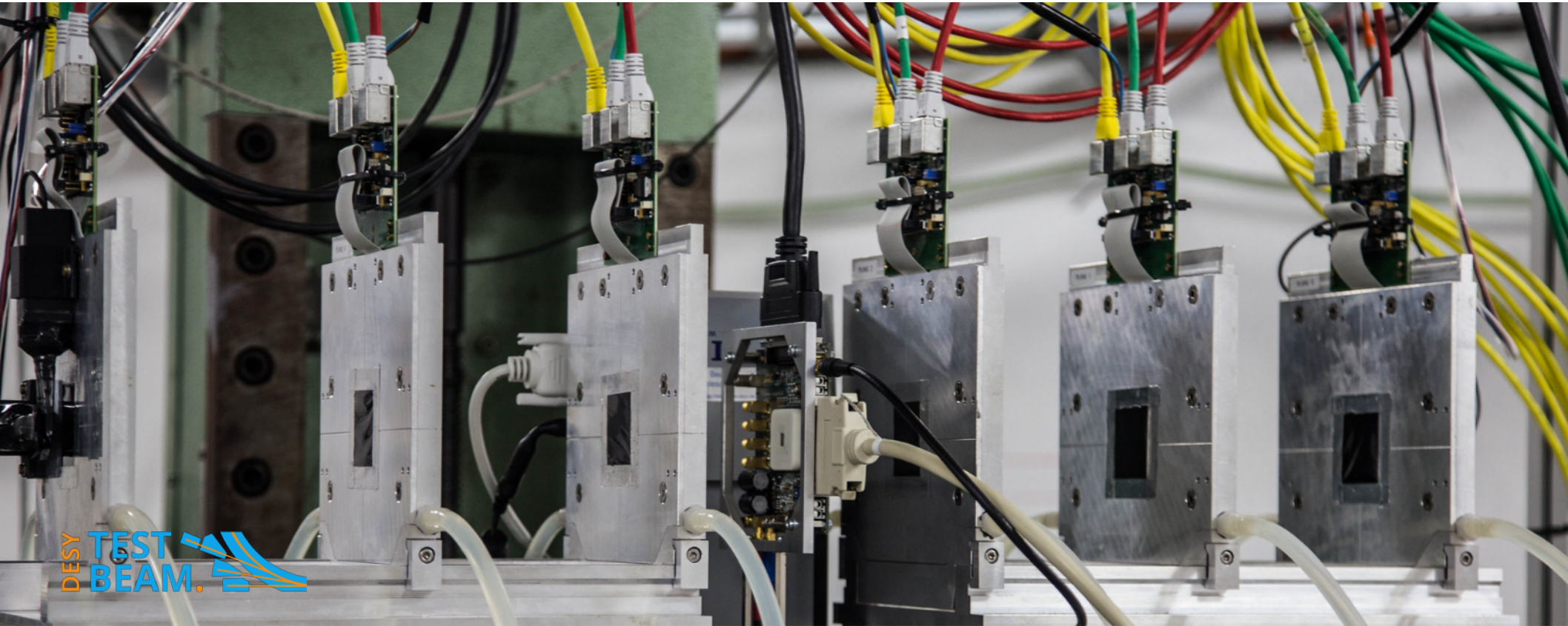
DESY TB Facility & PETRA IV

- Upgrade PETRA III → PETRA IV (until 2027) includes new booster synchrotron DESY IV
- What will happen to DESY II TB facility?
- Situation has not changed since last BTTB
- PETRA IV CDR (2019) includes statement:
“Due to their central role for detector development in particle physics, nuclear physics, photon science and beyond, the availability of electron/positron test beams is essential. [...] The future PETRA IV complex should be able to provide test beams in a similar fashion to DESY II today.”
- Strategy how to keep TB facility to be decided until end of technical design phase (end of 2022)



PETRA IV CDR, DESY PUBDB, 2019.

EUDET-type beam telescopes



EUDET-type beam telescopes

- 6 layers of MIMOSA26 pixel sensors
 - Sensor size: 2 cm x 1 cm
 - Pixel size: ca. 18 μm x 18 μm
 - Rolling-shutter RO (115 μs / cycle)
- DAQ system uses AIDA(EUDET) TLU and it is integrated in EUDAQ2(1) software
- Common mechanical setup
- Located at CERN, Bonn, and DESY (Hamburg)
- Successful operation since ~ 10 years!



Status (I)

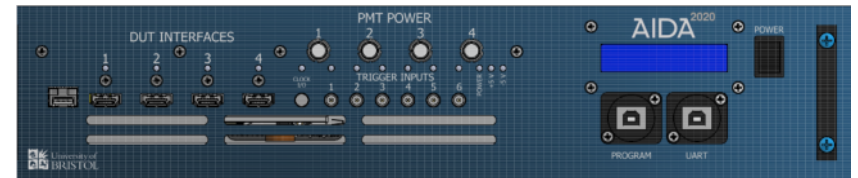
- Currently, still 3 telescopes at DESY
 - 1 installed at each beamline
 - Equipped with 2 trigger scintillators each
 - Planned to go back to 4
 - 1 FEI4-based timing layer available to users
 - Timepix3 has been used successfully as timing layer before
 - Planned to be made available to users
 - 2020 recap:
 - Operation stable, no major issues reported
 - Telescope requested for ~ 90% of the used TB weeks
- **Telescopes are integral part of the TB infrastructure**

A few words on TLU & EUDAQ

- The AIDA TLU and EUDAQ2 were released 2 years ago
- The EUDET TLU and EUDAQ1 are legacy products by now and regarding their functionality there is no reason to keep using them
- At DESY there are 3 EUDET TLUs left
 - One of them already has broken channels
- EUDAQ1 installations on TB machines will no longer be maintained



If you haven't already,
please consider
switching!



The same goes for EUDAQ

Status (II) (in a wider context ...)

IL BUONO

- ✓ Small pixel size
- ✓ Thin sensors
- ✓ Robust setup
- ✓ Stable operation since many years

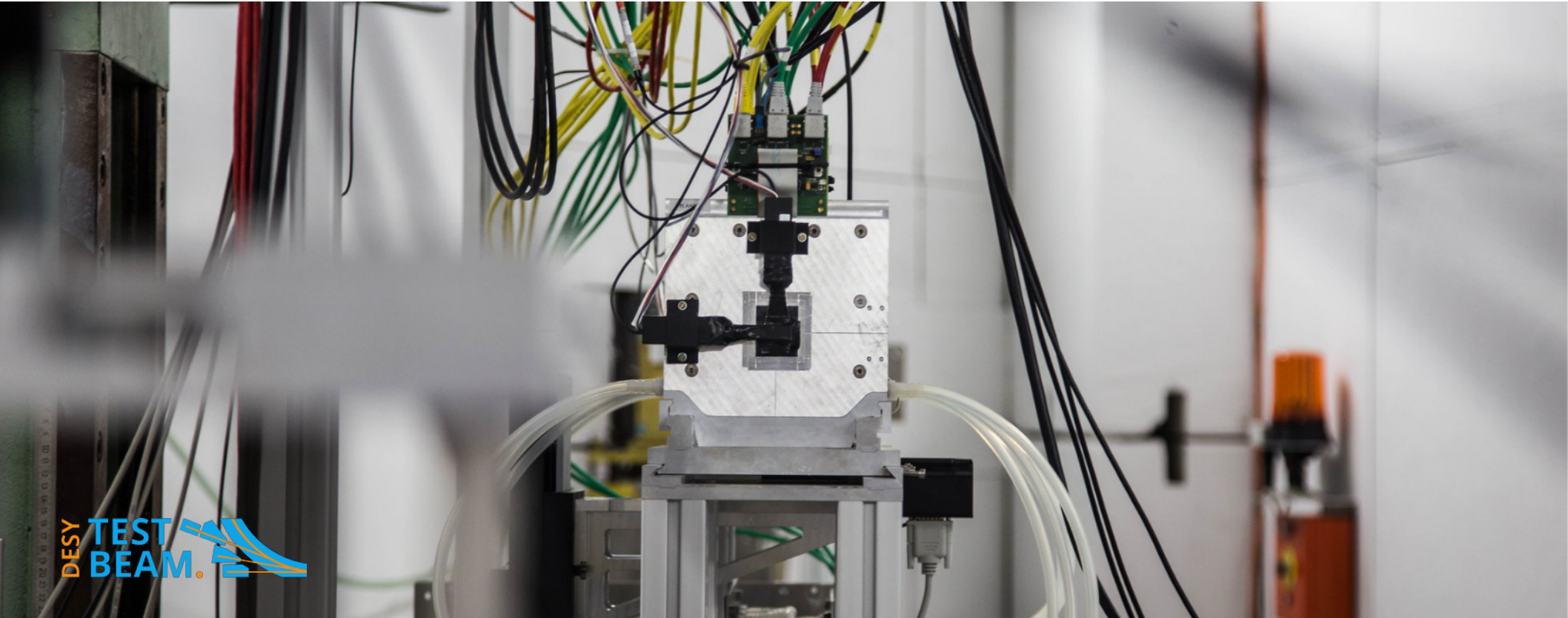
IL BRUTTO

- ✗ DAQ runs on legacy system
- ✗ No spares left

IL CATTIVO

- ✗ Signs of deterioration
- ✗ No hit time stamps
- ✗ (Slow charge collection)

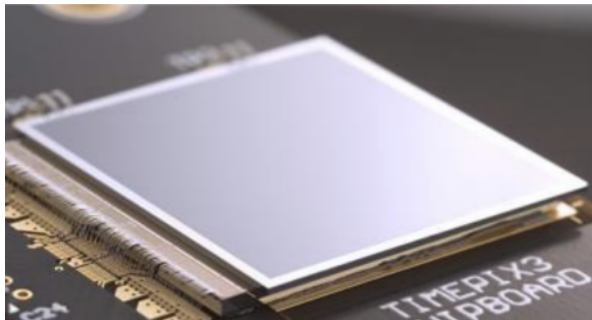
Beam telescope development



Timing layer

- Timepix3

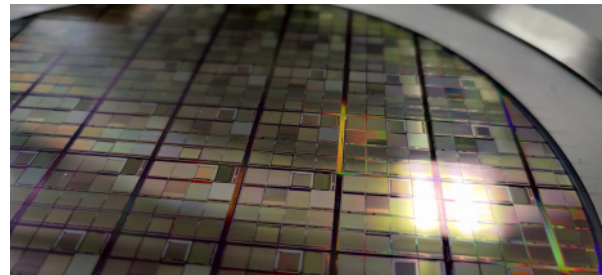
- Multi-purpose hybrid pixel ASIC
- $\sigma_t \approx 1$ ns
- Already working



<https://kt.cern/technologies/timepix3>

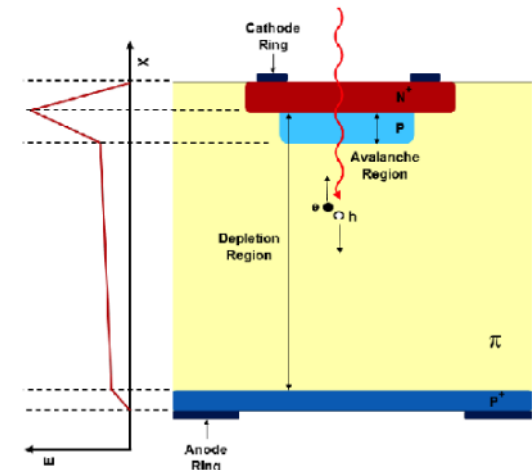
- TelePix

- HV-MAPS
- $\sigma_t \lesssim 10$ ns
- Fast (ROI) trigger out
- Being tested



- LGAD

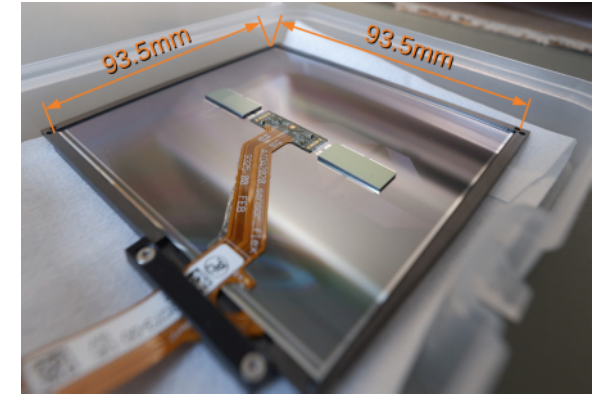
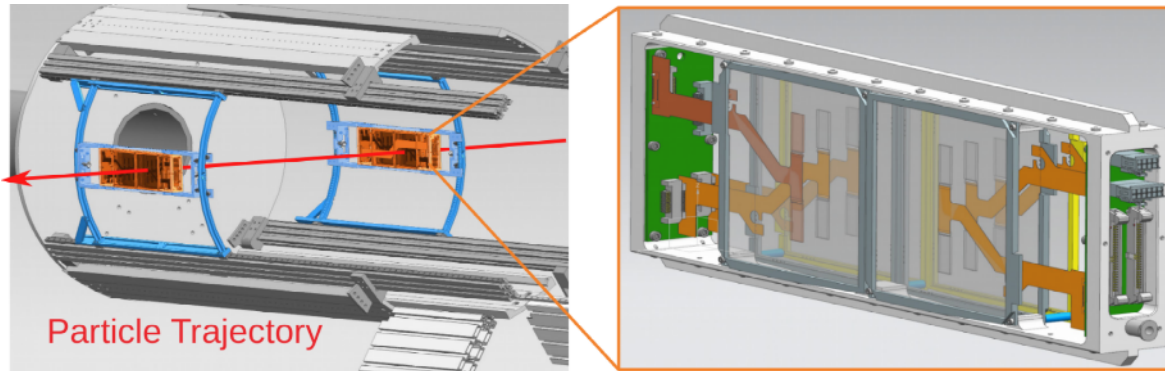
- Potential candidate
- $\sigma_t \approx O(10$ ps)
- Not yet at hand



DOI: 10.1016/j.nima.2018.02.018

LYCORIS

- Large area silicon strip telescope
- PhD project of U. Kraemer (thesis: 2020)
- Can be operated inside solenoid in T24/1
- Could be made available to users in 2021



- Sensor and ASIC (KPiX) designed for ILC
- 3680 strips per module
 - Pitch: 25 μm
 - Length: 92 mm

Next generation?

- No existing pixel sensor ticks all the boxes for next generation beam telescopes

(small pixels, large total size, thin (full system-on-chip), short integration times, high-rate capability, hit time stamping, ...)

- Developing such a sensor takes its time
- Strategy has to be to follow two approaches simultaneously:

- Develop telescope based on an existing sensor as intermediate solution

- Develop next generation sensor
 - Included in AIDAinnova (both CMOS and TB/DAQ WPs)
 - Also closely related to Tangerine (Towards Next Generation Silicon Detectors) project
 - Ideally, DAQ based on some common system (e.g. Caribou)

Conclusions



DESY II Test Beam Facility

- 2020 was a successful year, especially regarding the circumstances
- Facility is in an overall good state
- Hall infrastructure is still constantly improving
- Details on long term future are still to be decided
- Schedule 2021 will be updated as soon as possible

Beam telescope @ DESY

- EUDET-type telescopes are still doing their job
- Strategy for near and far future is clear
- Funding has been approved

Acknowledgement

The excellent performance of the DESY II Test Beam Facility would not be possible without the great support from the FH and M divisions and the DESY management.

Test beam schedule 2021



- Will be updated as soon as possible!
- Please, stay tuned ...

Call for your support



- We have to justify keeping the test beam facility
- So please always include the following **acknowledgement statement** in all publications, presentations, and posters based on data taken at the DESY II Test Beam:

“The measurements leading to these results have been performed at the Test Beam Facility at DESY Hamburg (Germany), a member of the Helmholtz Association (HGF).”

- Also, please don't forget the **AIDA(2020) acknowledgement** where applicable:

“This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168.”

Or the short version:

“Supported by the H2020 project AIDA-2020, GA no. 654168.”