



Adrian Herkert on behalf of the DESY Test Beam group

Vertex Detector Workshop @ QMUL

London, 8 Nov 2023

HELMHOLTZ

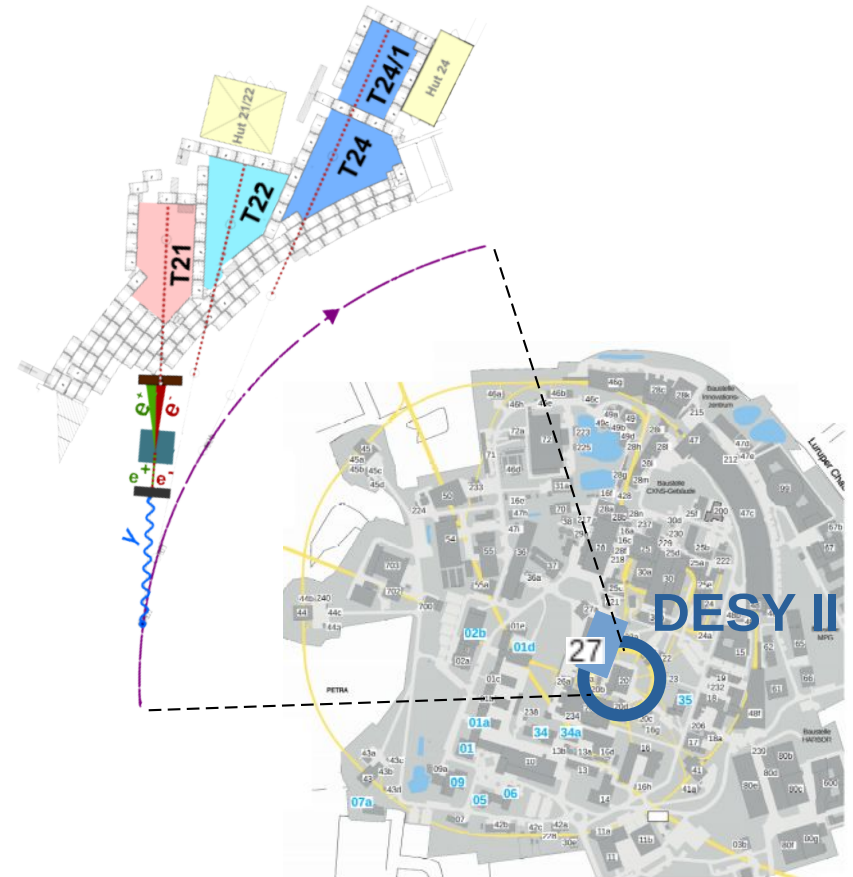


The DESY II Test Beam facility



Overview

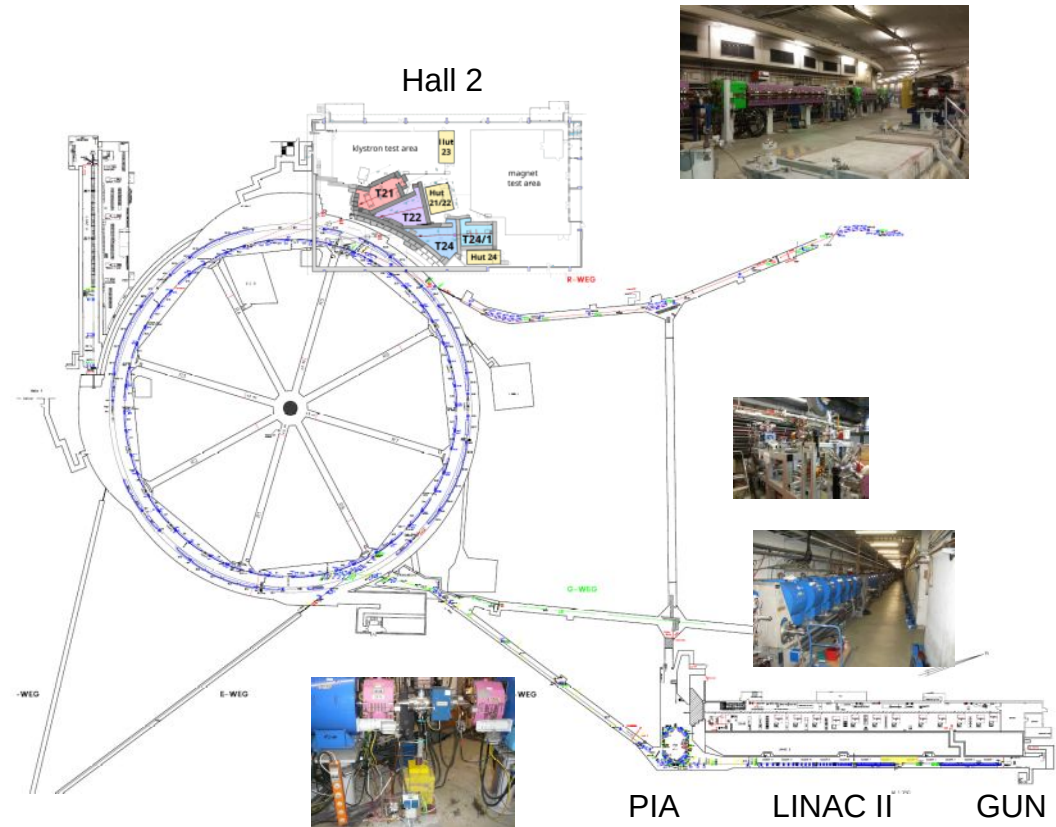
- Located on DESY campus Hamburg-Bahrenfeld
- Operates parasitically at PETRA III injector: DESY II
- Provides electron beams to user groups
 - ~ 40 weeks per year
 - @ 3 independent beam lines
- Beam energies between 1 and 6 GeV (adjustable by users)
- Particle rates up to $O(10,000 \text{ particles s}^{-1} \text{ cm}^{-2})$ depending on set energy



Beam generation (1/2)

Up to DESY II

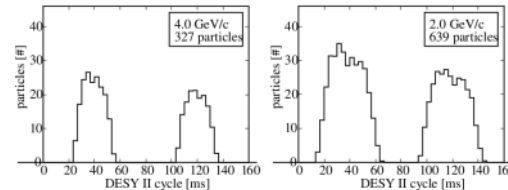
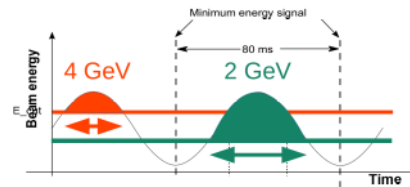
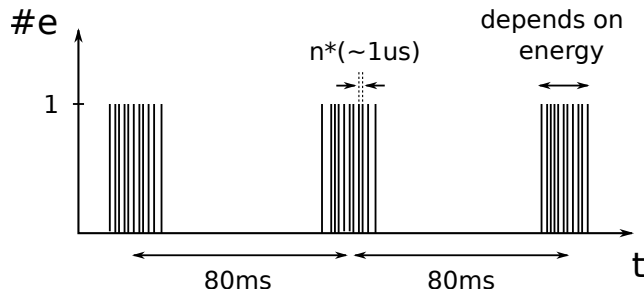
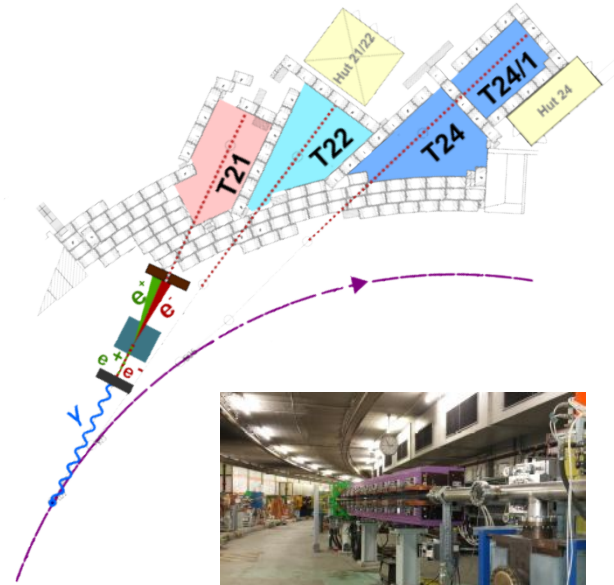
- Electron gun, LINAC II ...
- PIA: “Positron Intensity Accumulator”
 - Accumulates ~ 10 bunches from Linac II and compensates for fluctuations, adjusts pulse length
- DESY II:
 - 1 bunch at a time (ca. 10^{10} electrons)
 - 1 MHz circulation frequency
 - Energy ramps sinusoidally between 0.45 and 6.3 GeV with frequency of 12.5 Hz
 - Every two cycles bunch is dumped and new one filled
 - Every couple of minutes PETRA III top-up



Beam generation (2/2)

Test beams

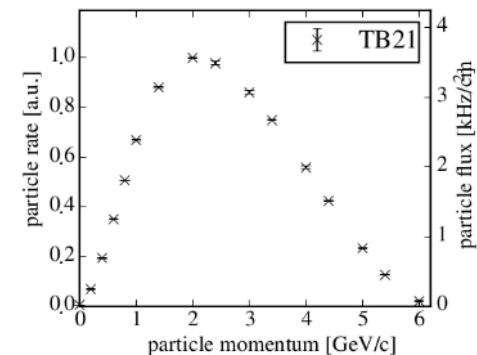
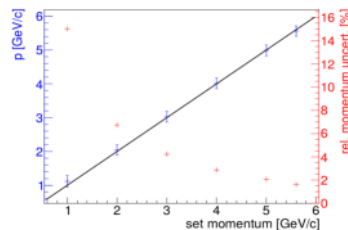
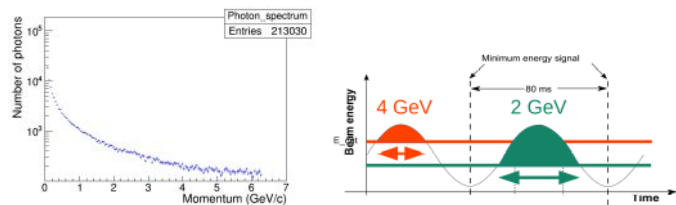
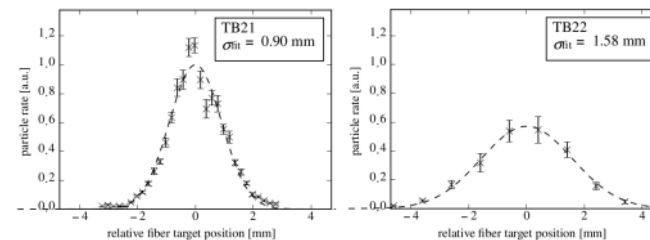
- 1 carbon fiber ($7\mu\text{m}$) target per beam line inside accelerator
- Secondary target (copper plate) converts photons to e^+/e^- pairs
- Momentum selection via dipole and primary collimator



Particle rates

Depend on several factors

- More or less fixed: prim. and sec. target (thickness and material), PIA accumulation, PETRA operation
- Maximum $O(10,000 \text{ particles s}^{-1} \text{ cm}^{-2})$
- Beamline: T21 & T22 have higher rates than T24 (double dipole chicane)
- Energy: Bremsstrahlung spectrum + “duty cycle” + dipole/collimator
- Primary collimator settings



Schedule 2023



Almost back to normal

- Usually startup beginning of February
- This year we saved some energy:
 - Prolonged winter shutdown
 - Tried to avoid weeks with only one single area occupied
- Running until Christmas as usual
- 33 ½ weeks of beam for user operations
- ~ ¾ full
- > 300 users (ca. 40% international)

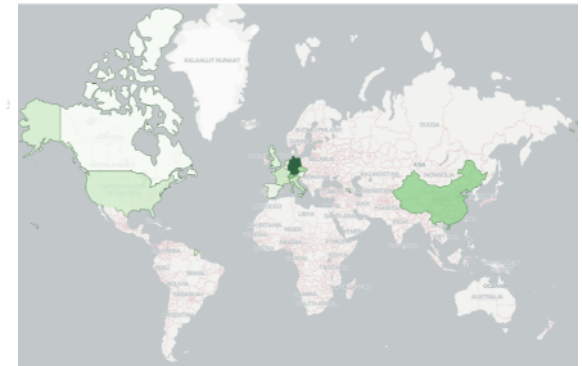
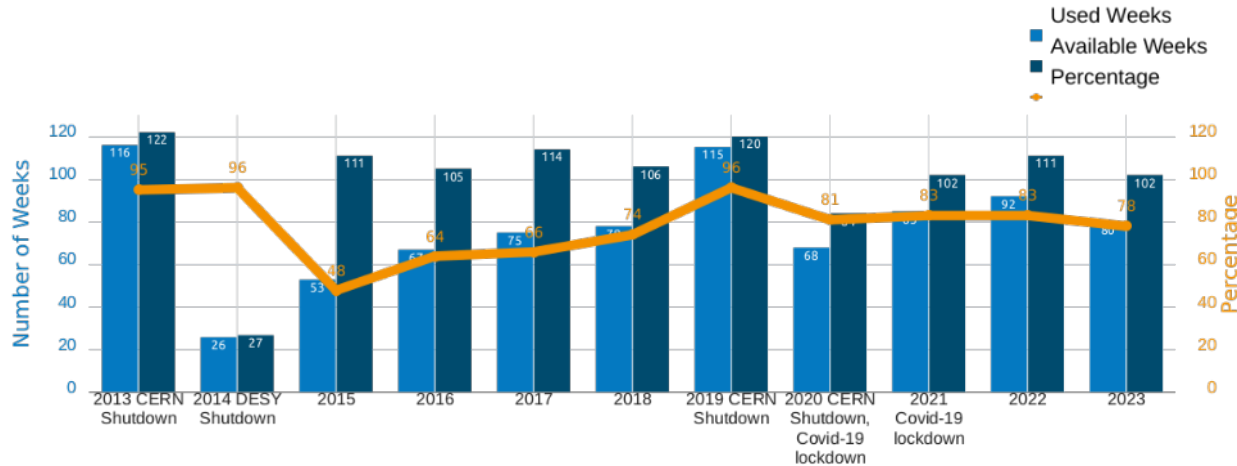
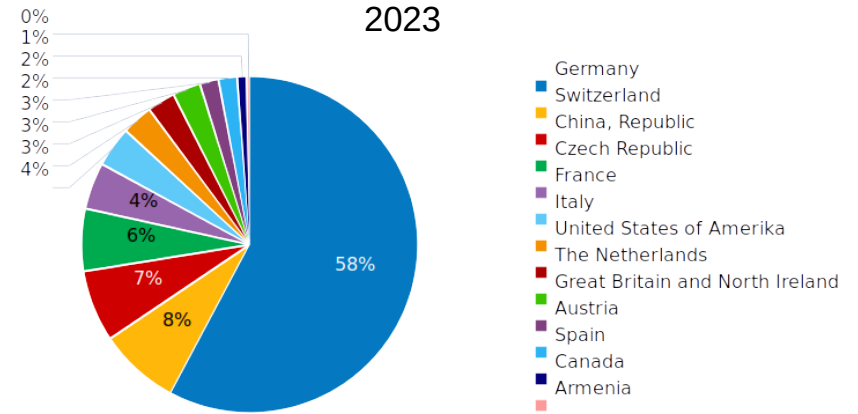
Startdate	Week	TB21	T	TB22	T	TB241	T	TB24	T
02.01.2023	1	Shutdown				Shutdown		Shutdown	
09.01.2023	2	Shutdown		Shutdown		Shutdown		Shutdown	
16.01.2023	3	Shutdown		Shutdown		Shutdown		Shutdown	
23.01.2023	4	Shutdown		Shutdown		Shutdown		Shutdown	
30.01.2023	5	Shutdown		Shutdown		Shutdown		Shutdown	
06.02.2023	6	Energy Conservation		Energy Conservation		Energy Conservation		Energy Conservation	
13.02.2023	7	Energy Conservation		Energy Conservation		Energy Conservation		Energy Conservation	
20.02.2023	8	Energy Conservation		Energy Conservation		Energy Conservation		Energy Conservation	
27.02.2023	9	Startup		Startup		Startup		Startup	
06.03.2023	10	CMOS Strips Detectors	X	CM5-HGCAL					
13.03.2023	11	DSIPM	X	ATLAS-ITk-Strips	X			Telescope-Dev	X
20.03.2023	12	DSIPM	X	ATLAS-ITk-Strips	X				
27.03.2023	13	MONOPIX2	X	CM5 FTI	X			RFSD	X
03.04.2023	14	Maintenance		Maintenance		Maintenance		Maintenance	
10.04.2023	15								
17.04.2023	16	CEPC Vertex	X	BTTB	X			BTTB	X
24.04.2023	17	CM5 Inner Tracker	X	TelePix	X				
01.05.2023	18	CM5 Inner Tracker	X	TelePix	X				
08.05.2023	19			Tangerine	X			LHCb-ECAL	X
15.05.2023	20	CM5-HGCAL	X	Tangerine	X			LHCb-ECAL	X
22.05.2023	21	Maintenance		Maintenance		Maintenance		Maintenance	
29.05.2023	22								
05.06.2023	23			ATLAS-ITk-Strips	X			LUXE LeadGlass	X
12.06.2023	24	CM5 Inner Tracker	X	ATLAS-ITk-Strips	X				
19.06.2023	25								
26.06.2023	26	MONOPIX2	X	Telescope-Dev	X			PSI-MAPS	X
03.07.2023	27	CM5 Inner Tracker	X	Belle-II CMOS	X				
10.07.2023	28	CM5 Inner Tracker	X	RDSO-CMOS	X				
17.07.2023	29	Shutdown		ATLAS-ITk-Strip-DAQ		Shutdown		Shutdown	
24.07.2023	30	Shutdown		Shutdown		Shutdown		Shutdown	
31.07.2023	31	ATLAS-ITk-Strip-Magnet		ATLAS-ITk-Strips		Shutdown		Shutdown	
07.08.2023	32	BL45	X	Telescope-Dev	X			ATLAS-ITk-SystemTest	
14.08.2023	33								
21.08.2023	34								
28.08.2023	35							CM5-HGCAL	X
04.09.2023	36	BL45	X	Tangerine	X			CM5-HGCAL	X
11.09.2023	37	Maintenance		Maintenance		Maintenance		Maintenance	
18.09.2023	38	BL45	X	ATLAS-ITk-Strips	X			LUXE LeadGlass	X
25.09.2023	39	BL45	X	ATLAS-ITk-Strips	X			Telescope-Dev	X
02.10.2023	40	TelePix	X	CALICE-Crystal	X			FAST3	X
09.10.2023	41	CM5 Inner Tracker	X	CALICE-Crystal	X			ATLAS-HGTD	X
16.10.2023	42	Maintenance		TelePix		Maintenance		Maintenance	
23.10.2023	43	ATORCH	X	CMOS Strips Detectors	X			MONOPIX2	X
30.10.2023	44	MDI-2		CMOS Strips Detectors	X			MONOPIX2	X
06.11.2023	45	CM5-HGCAL		Tangerine	X			ATLAS-HGTD	
13.11.2023	46	CM5 Inner Tracker	X	Tangerine	X			ATLAS-HGTD	
20.11.2023	47	Maintenance		Maintenance		Maintenance		Maintenance	
27.11.2023	48	CM5 Inner Tracker	X	ATLAS-ITk-Strips	X			IPHC-CE65_v2	
04.12.2023	49	CM5 ETL	X	ATLAS-ITk-Strips	X			LHCb-ECAL	
11.12.2023	50	CM5 ETL	X	Tangerine	X			LHCb-ECAL	
18.12.2023	51			Tangerine	X				
25.12.2023	52	Shutdown		Shutdown		Shutdown		Shutdown	

User statistics (1/2)



User origins and demand over the years

- In the past general upwards trend
- Most busy during CERN shutdowns
- 2019: Record year with over 700 users
- After 2019: You know what happened ...

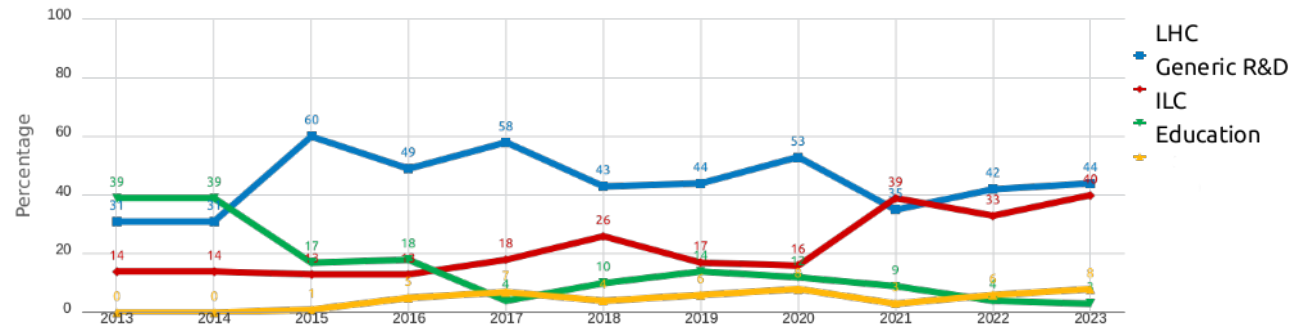
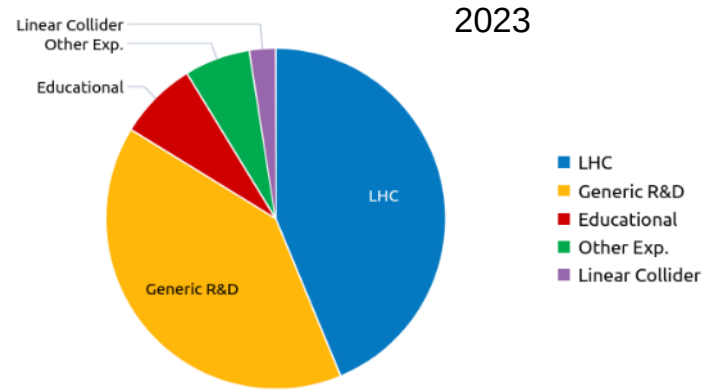


User statistics (2/2)



Types of usage

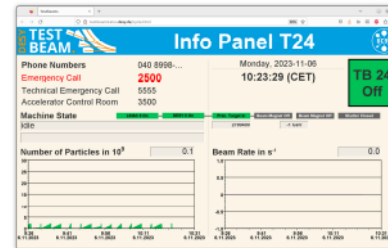
- Largest category over many years: LHC experiments
 - Upgrade R&D, final characterization, module testing, ...
- Generic R&D catching up
- Linear collider R&D keeps decreasing



Provided infrastructure

Some examples

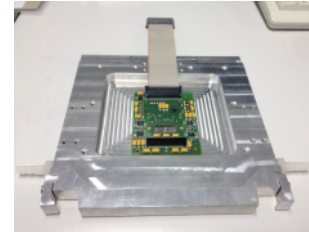
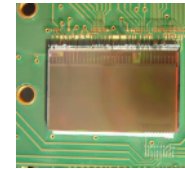
- 25t hall crane
- 1t XY-stages
- Laser alignment system
- Variable collimators
- Convenient interlock procedure
- Magnets (1T solenoid, 1.35T dipole)
- Rate monitors
- Remote-controlled cameras
- ...
- One beam telescope per area



EUDET-type beam telescopes

Longer than 10 years in operation

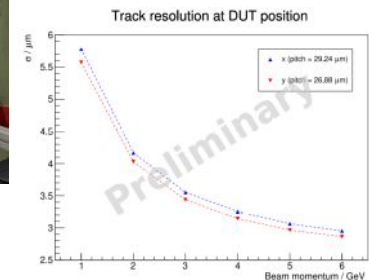
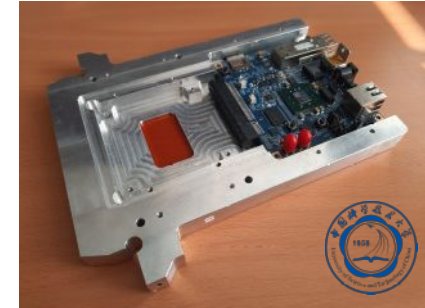
- 2 copies at DESY
(5 more at CERN, Bonn, SLAC)
- Large user base
- 6 layers of MIMOSA26 MAPS (thinned to 50 μm)
 - Active area: 2 cm x 1 cm
 - Pixel size: 18.4 μm x 18.4 μm
(2 μm track resolution possible)
 - Rolling-shutter RO (115 μs per cycle,
2 cycles read out per trigger)
 - Other than that no hit time information
- Deeply integrated with TLU and EUDAQ
- Unfortunately, few spare parts left



New third beam telescope at DESY (1/2)

Adenium - an ALPIDE-based prototype

- In the scope of AIDAInnova, DESY has committed to developing next generation of EUDET-type telescopes
 - Will be ALPIDE-based
 - High efficiency, little noise, 10 μs readout
 - End-user license required
- First Prototype:
 - Designed and produced by Y. Liu and USTC (<https://arxiv.org/abs/2102.11138>)
 - Again very integrated with (AIDA) TLU and EUDAQ2 (operation very similar to M26 telescopes)
 - Well received by users
 - Now in permanent operation in T22



Future of test beams at DESY (1/3)



Most likely change will come

- Reminder: DESY II TB operates parasitically at PETRA III injector
- Upgrade PETRA III → IV planned
 - not finally approved, but ...
 - ... official timeline: shutdown 2027 – 2029
- PETRA IV:
 - Upgraded synchrotron X-ray source
 - Used for non-destructive imaging of nanoscale processes under realistic conditions in
 - Renewable material research
 - Battery research
 - Medical research
 - ...

Parameter	PETRA IV		PETRA III
	Brightness mode	Timing mode	
Energy / GeV	6	6	6
Circumference / m	2304	2304	2304
Total current / mA	200	80	100
Number of bunches	1600	80	40 ... 960
Emittance			
Horiz. ϵ_x / pm rad	< 20	< 50	1300
Vert. ϵ_y / pm rad	< 4	< 10	10
Number of undulator beamlines		30	21(26)

[PETRA IV CDR, 2019.](#)

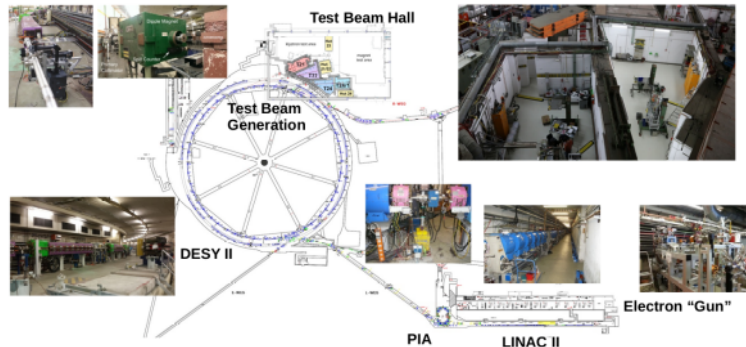
- Spectral brightness of X-ray beams $O(100)$ times better than today
- → Spatial resolution down to $O(1\text{nm})$

Future of test beams at DESY (2/3)



What does the PETRA upgrade mean for test beams?

- All of this:



- needs to go!

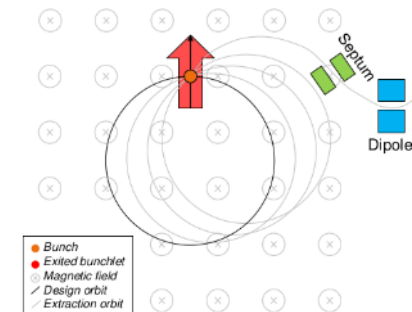
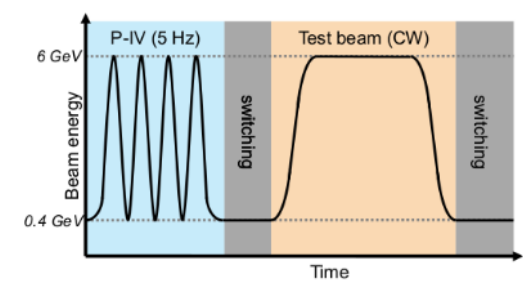
- BUT new PETRA IV injector:
Booster synchrotron DESY IV (in DESY tunnel)
- Possible new TB facility must be compatible with new requirements on beam quality for PETRA IV
→ Current extraction method won't work
- FS (photon science) department doesn't have any interest in having a test beam facility at DESY IV
 - Our department has to make this happen
 - DESY directorate generally in favor
 - But we need all the support we can get including yours!
- Specific concept for implementing test beam lines at DESY IV is being developed
(design for DESY IV itself is also not finalized yet)

Future of test beams at DESY (3/3)



Where do we currently stand?

- Studies have recently taken up speed
- One machine expert now working in our group to plan TB at DESY IV
 - manpower, expertise, and direct contact to the people designing DESY IV
- First conclusions:
 - No show stoppers for both
 - new target-based option
 - resonant extraction
 - Costs negligible compared to PETRA IV
 - Latest DESY IV ring design geometrically compatible



Beam time at DESY



How to apply

- Application periods of ~ 3 weeks twice a year
 - The one for 1st half year 2024 just ended
- Call for beam time applications sent out to testbeam-info@desy.de
 - Subscription via testbeam.desy.de
- Application via online form (This is new!)
- When applying for several beam times, please make one application per slot
- In between application periods, open slots can still be filled upon request

The screenshot shows a web browser window with the URL <https://ias-intern.desy.de/ias/opens/?p=099:148:111:06672991290...>. The page title is "DESY 2 Test Beam Controlling" and the user is logged in as "HERKERT". The main content is the "Test Beam Slot Application" form.

Form Fields:

- Group Leader: Adrian Herkert
- Group Leader Email: adrian.herkert@desy.de
- Application...: 2023-10-13
- Name of the Test Beam Slot: (required; start typing for autocomplete options)
- Category: - Select Category - (required)
- Experiment: Select from this LIST (optional)
- Preferred Test Beam Area: - Any - (optional)
- Telescope: - None - (optional)
- Note: Testbeam slots always go from Monday to Sunday.
- Possible Period: Earliest Start: Mon, 2024-07-05 (Cw: 06) (required)
- Duration: 1 week (required)
- Possible Period: Latest End: Sun, 2024-08-04 (Cw: 31) (required)
- Project Description: - please insert description here - (required)
- Hardware (required):
 - FE4 reference plane
 - CMS-Pixel reference plane
 - Rotation stage
 - Translation Stages
 - AIDA2020 TLU
 - AIDA2020 Slow Control System
 - PCMag (persistent Current, superconducting MAG)
 - BRM (big red magnet / MD Dipole)
 - TeamViewer
 - Cx, please specify in the project description
 - Others, please specify in the project description
 - No hardware required-
- Safety Hazards (required):
 - Use of flammable gases **
 - Lasers brought by user group **
 - High voltage
 - Magnetic field
 - Radioactive sources **
 - Hazardous materials will be used **
 - Irradiated samples are considered as hazard **
 - Others, please specify in project description **
 - No Safety Hazards-
- Additional Comments: (optional)

Buttons: Cancel, Send Application, Send Application and Fill Another

Footnote: ** These materials need to be registered in advance. Please contact the test beam coordinators with the necessary details well in advance. Additional information can be found on the Test Beam Rules & Safety Instructions web page.

Transnational access

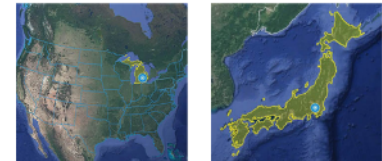
Travel funding via EURO-LABS



- EURO-LABS – EUROpean Laboratories for Accelerator Based Science
 - <https://web.infn.it/EURO-LABS>
 - European Union’s Horizon Europe research and innovation programme under grant agreement no. 101057511
 - Running Sep 2022 – Aug 2026
- Providing access to a network of 47 research infrastructures
 - financial support for user travels
- Who can apply for support via TA at the DESY test beam facility?
 - User groups where the team leader and the majority of the members are working at an institution outside Germany
- More details and how to apply → see our web page:
https://particle-physics.desy.de/test_beams_at_desy/euro_labs_ta/



Courtesy Google Earth



Final remarks



Contacts and additional information

- DESY Test Beam coordinators:
 - testbeam-coor@desy.de
- Contacts for all things telescope-related:
 - telescope-coor@desy.de
 - telescope-support@desy.de
- More information: testbeam.desy.de

Call for your support

- If you publish or present results based on data taken at the DESY II Test Beam, please include the following acknowledgment:

“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).”

- Reference paper:
<https://doi.org/10.1016/j.nima.2018.11.133>



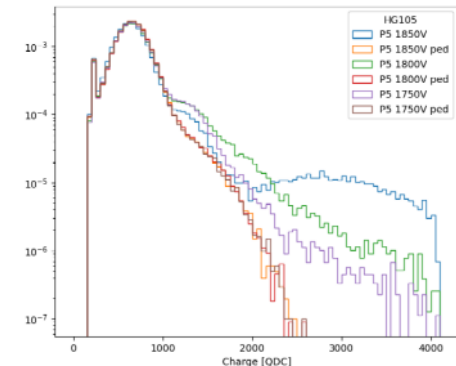
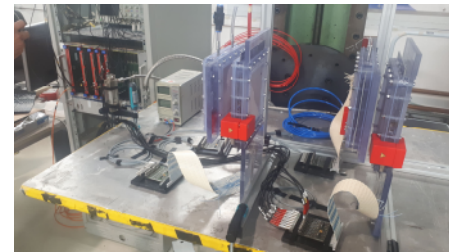
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA no 101004761.

Outreach and education



Beam Line 4 Schools (BL4S)

- Program of CERN and DESY
- Teams of high school students carry out their own experiment at a beam line
- ~ 400 applications
- 2023: 3 winning teams, 2 went to CERN, 1 to DESY
- Team at DESY:
 - 5 students from Eindhoven, Netherlands
 - Tested their self-developed wire chambers
 - Had two very busy and successful weeks
 - Thinking about coming back for test beam campaign



TLU and EUDAQ

Integrating DUTs with EUDET-type beam telescopes

- AIDA2020 TLU:
 - Hardware interface
 - Provides global trigger
 - Different sync modes possible (handshake, clock)
- EUDAQ2:
 - Software framework
 - Used for telescope run control and data formatting
 - DUT integration not necessary but practical!

