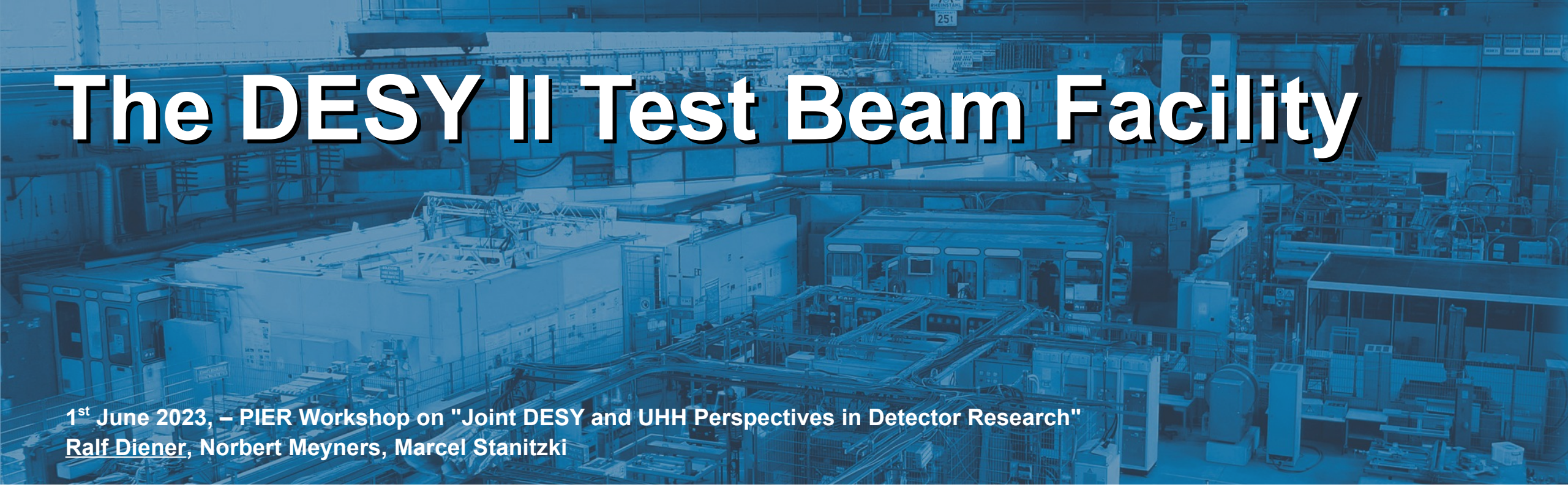


The DESY II Test Beam Facility

1st June 2023, – PIER Workshop on "Joint DESY and UHH Perspectives in Detector Research"

Ralf Diener, Norbert Meyners, Marcel Stanitzki

HELMHOLTZ

PIER

Partnership of
Universität Hamburg and DESY

DESY.

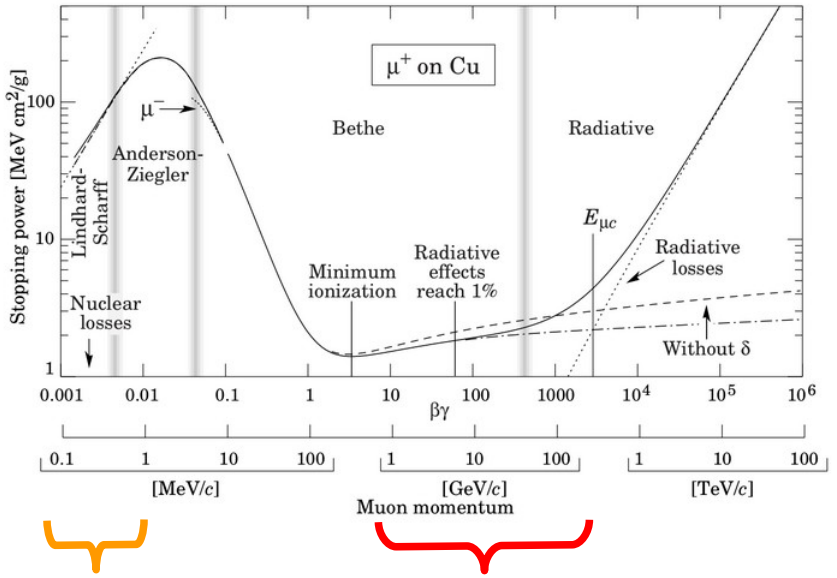
Introduction - Motivation

Why a Test Beam?

- Typical steps in detector R&D:
  - Proof-of-principle
  - Protoypes (iterations from tiny/small to large)
  - System tests
  - Production/installation
  - Operation

- In all above steps tests and evaluations are necessary of:
  - Performance: efficiency, noise, rate capability, stability …
  - Resolution: position, energy, time, … (particle identification)

- Energy has to be in the GeV range



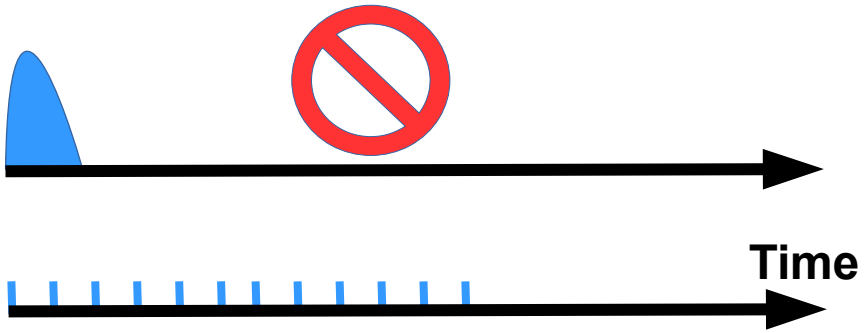
Sources **Particles from collisions**

- Sources: not enough energy
- Comics: too low rate per area (1/cm²/min)

Introduction - What Users Need

The Ideal Test Beam Facility

- Monochromatic beam < few percent
- Rates from 1 kHz up to 100 kHz
- Multiplicity ~ one/few particle/bunch/mm^2



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- Rates from 1 kHz up to 100 kHz
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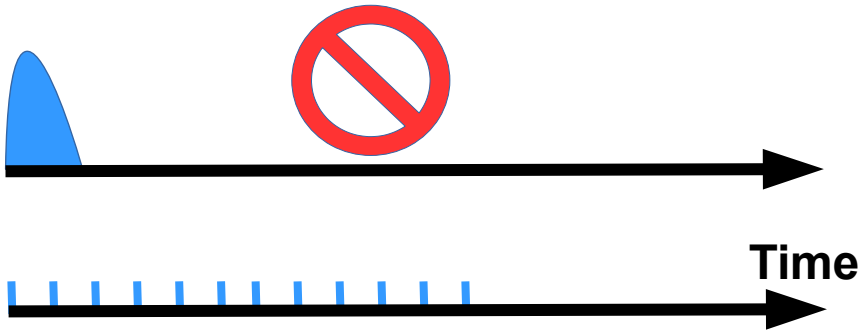
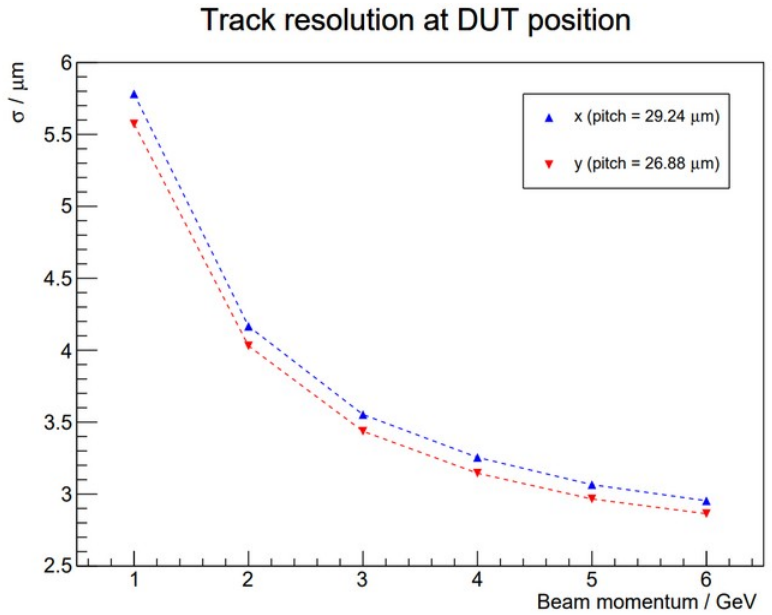
- Energy range between 1-100 GeV
- For tracking detectors: highest energy possible
  → reduce the scattering (limits the resolution)
- For calorimeters: adjustable energy
  (+ different particle types)
- PiD: As many particle flavors as possible
- Reliable beam 24/7 + Independent & user-controlled beamlines





Achievable resolution for tracks using the telescopes at the test beam depending on the beam momentum

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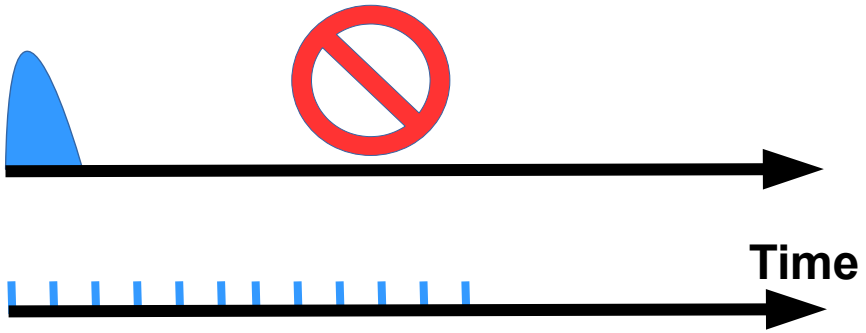
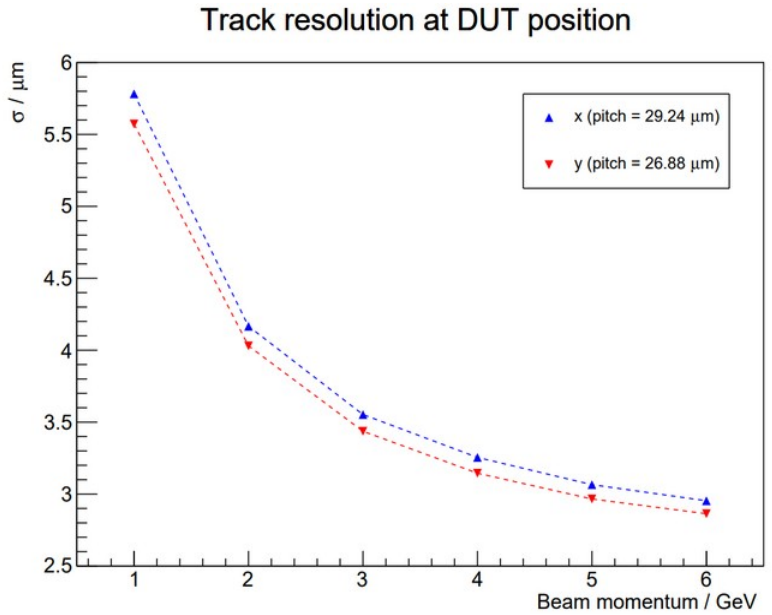
- Only few facilities in the world deliver this kind of GeV test beams:
  - US: Fermilab, (SLAC) - EU: CERN, DESY, (ELSA) - Japan: KEK

  (no facility delivers all of the above wish list at once)





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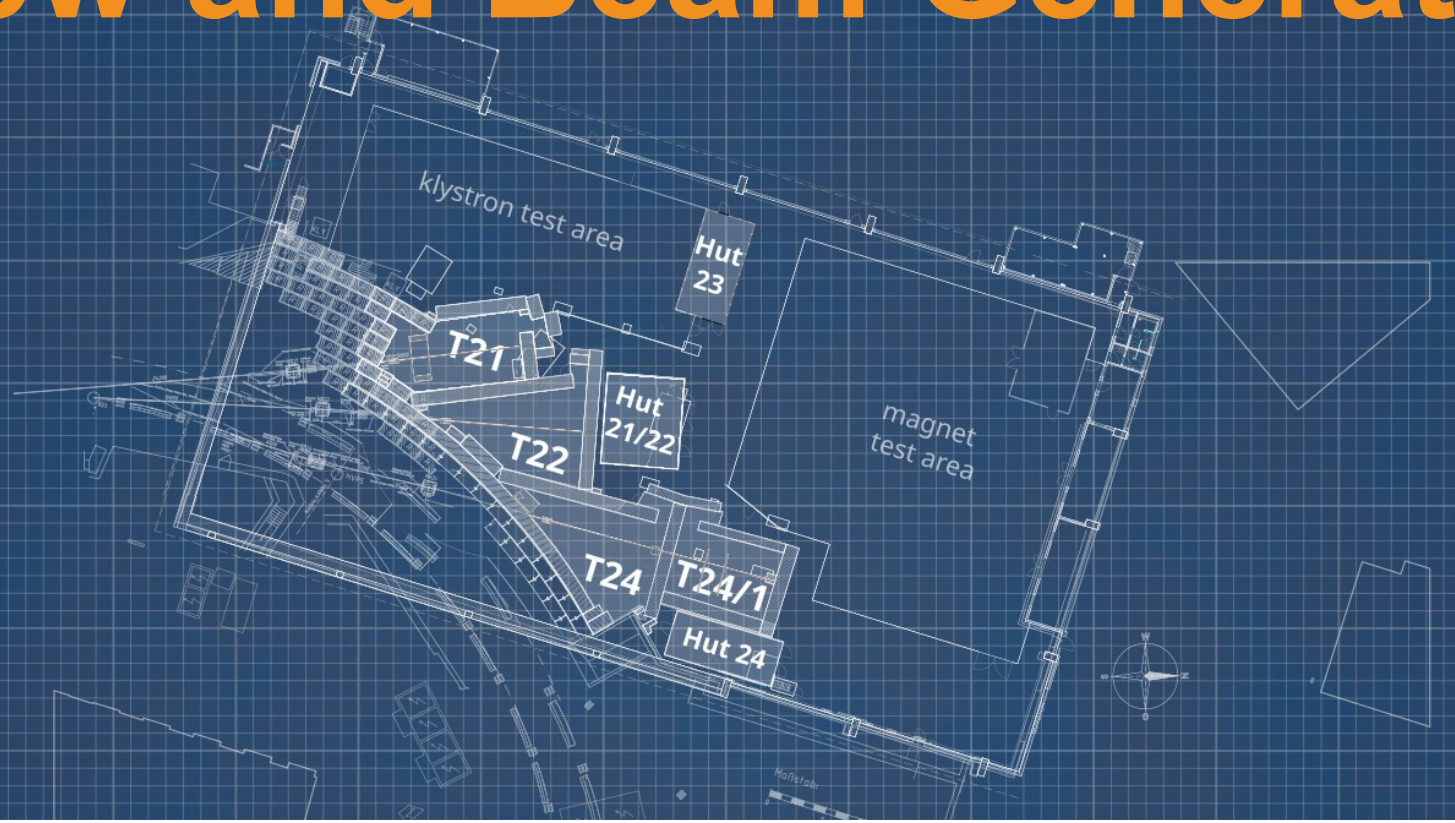
Facility

Overview and Beam Generation



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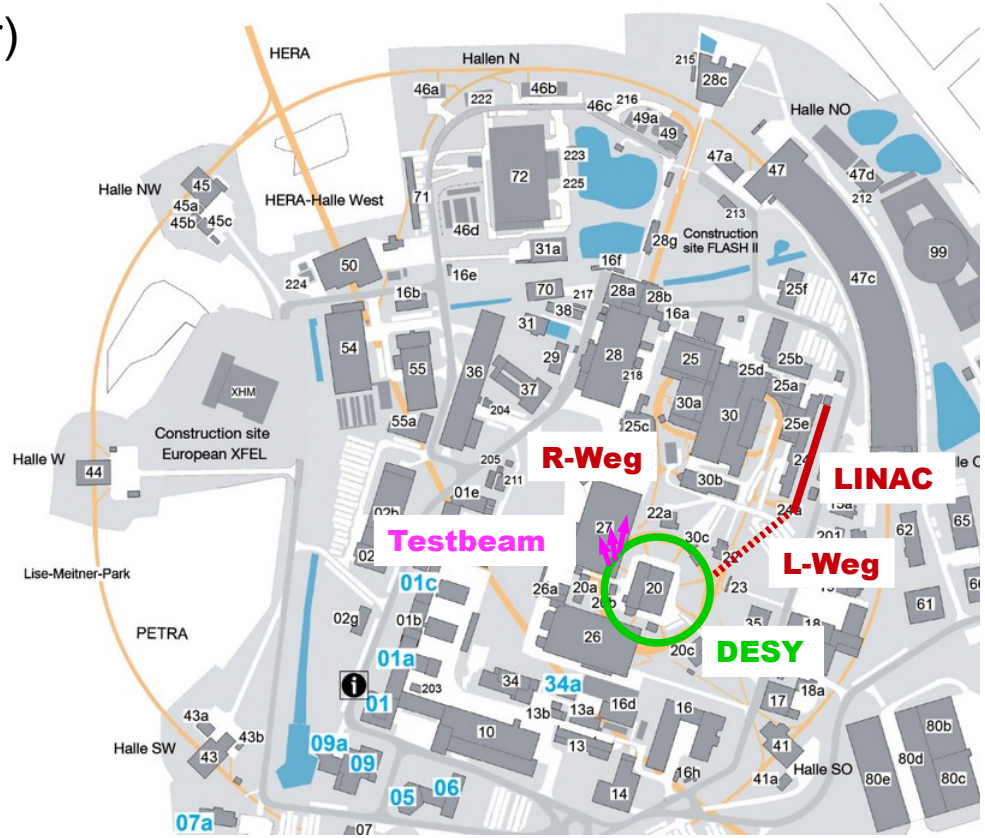
- Facility parasitically fed by DESY II synchrotron (PETRA III injector)
  - 1 bunch per fill
  - 1 MHz circulation frequency
  - Very high availability (~ 99 % uptime)



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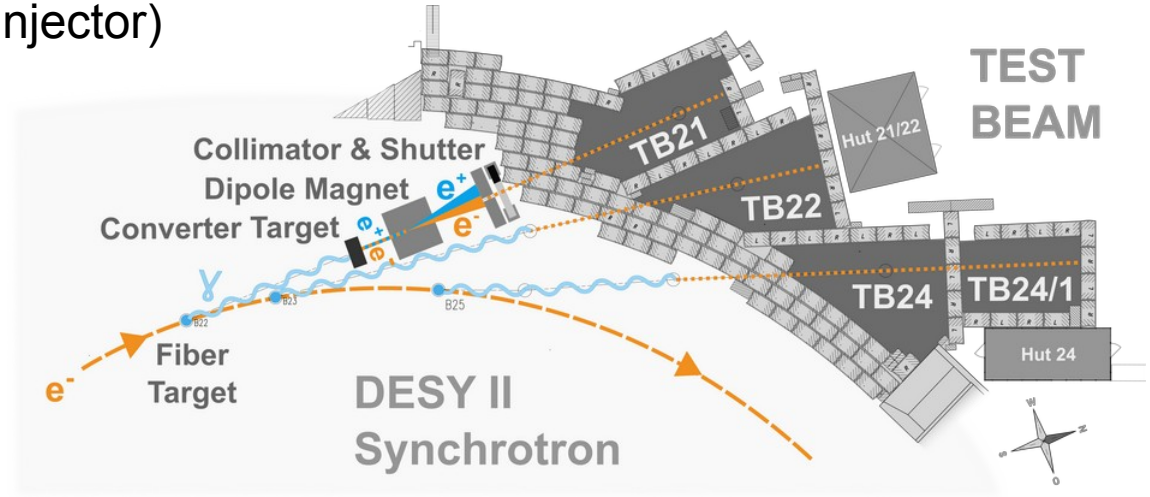
  - Energy selected with dipole / collimator



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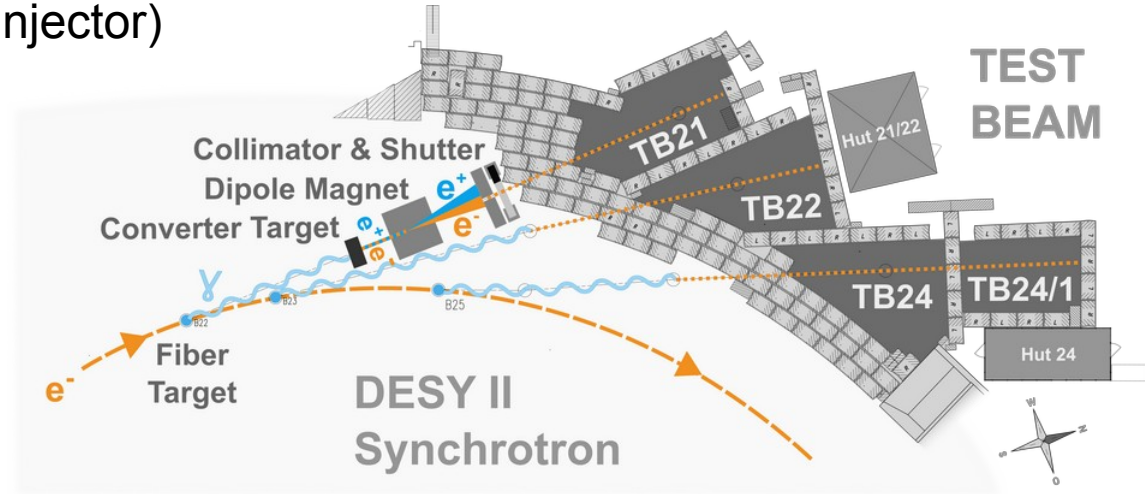
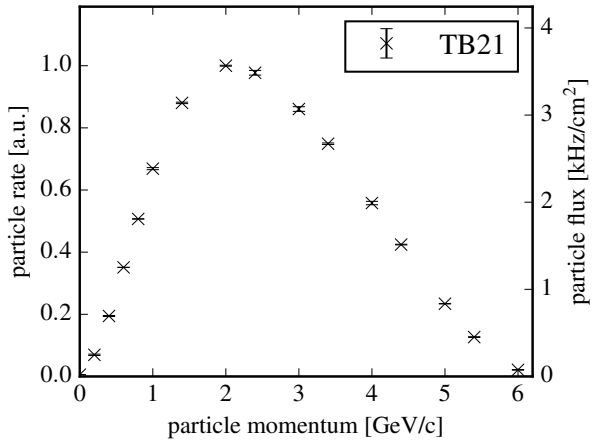
- Three individual beam lines, controlled by the user: shutter, area interlock, converter, momentum + collimator
- Single electrons, rates *O*(10k particles s^{-1} cm^{-2}) depending on beam line, energy, converter target, collimation





Facility

Overview and Beam Generation

Facility

Infrastructure

Facility Infrastructure

General Infrastructure

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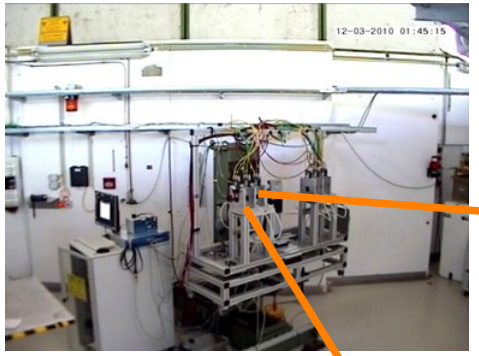
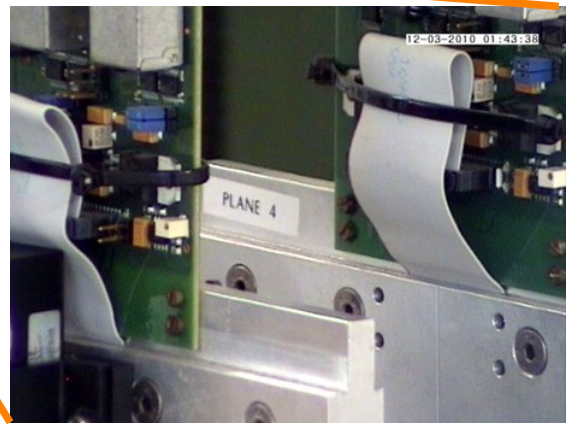
- Dry nitrogen, cooling water in each area
- Gas cabinets in TB22 and TB24, flammable gas possible





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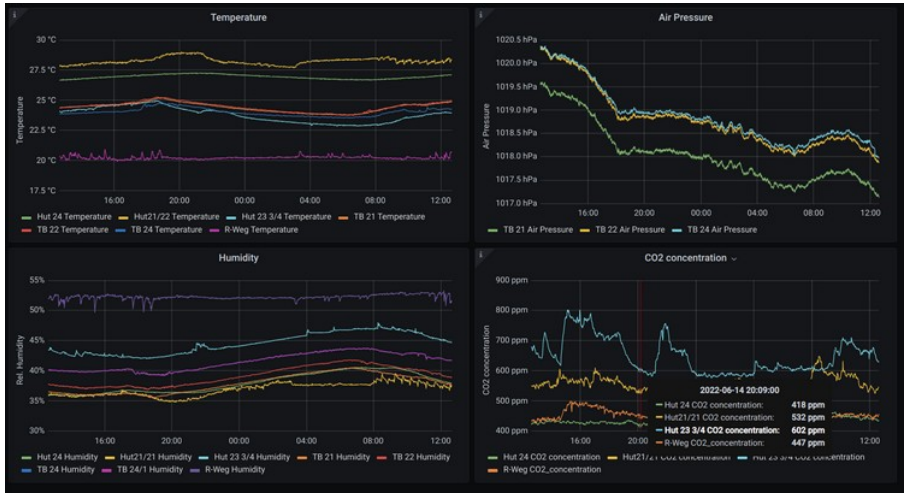
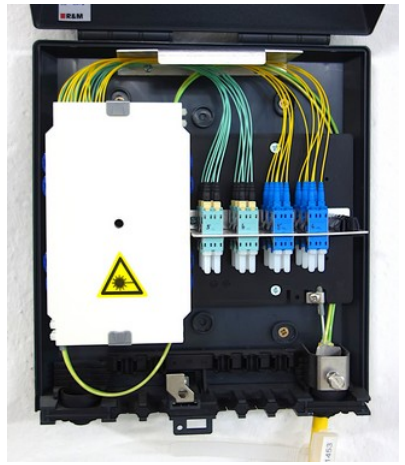
- Weather stations, slow control system, laser alignment
- Beam monitors
- Patch panels
  - Ethernet RJ-45, optical fiber (single and multi-mode)
  - High voltage SHV, BNC Coax





Facility Infrastructure

Large Test Magnets

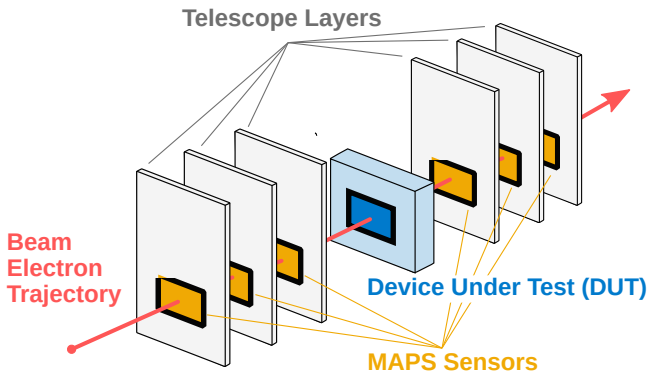
- PCMAG (superconducting solenoid, in TB24/1)
  - Magnetic field up to 1 T
  - Usable inner diameter: 75 cm
  - Mounted on movable stage
  - Material budget: 20 % of a radiation length
  - Complete gas detector setup available:
    Gas incl. slow control system, high voltage,
    beam & cosmic trigger, 2PCO$_2$ cooling

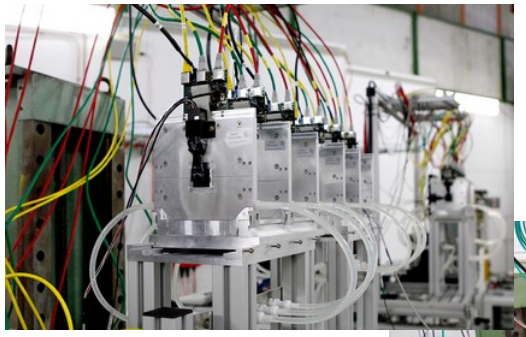
- "*Big Red Dipole*" (normal conducting - type: MD, in TB21)
  - Up to 1.35 T
  - Integrated length ~ 1 m
    Opening ~ 1.50 m wide and 0.35 m high

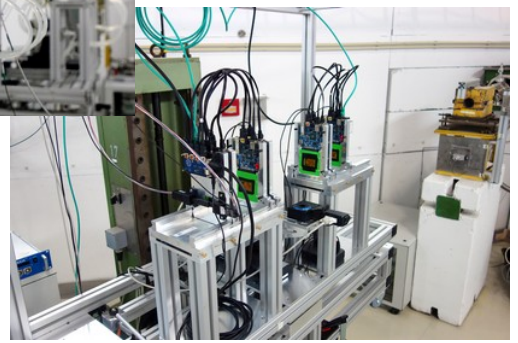
Facility Infrastructure

Beam Telescopes

- Beam telescopes (hodoscopes) are essential tools in detector testing
- Principle: several layers with tracking sensors to measure and extrapolate the beam particle trajectories
- Requested by > 80 % of the user groups
- 2 systems currently in use at DESY:
  - EUDET-type (Mimosa sensors): down to 2 µm resolution, 2 x 1 cm², 230 µs readout frame
  - Alpide-based prototype resolution down to ~3 µm, 3 x 1.5 cm², 10 x shorter readout frame
  - Additional timing layers in development
- Come as a package with a TLU (trigger logic unit), DAQ framework and standard software reconstruction
- Copies exit at test beams worldwide
- Active team and community for support and development

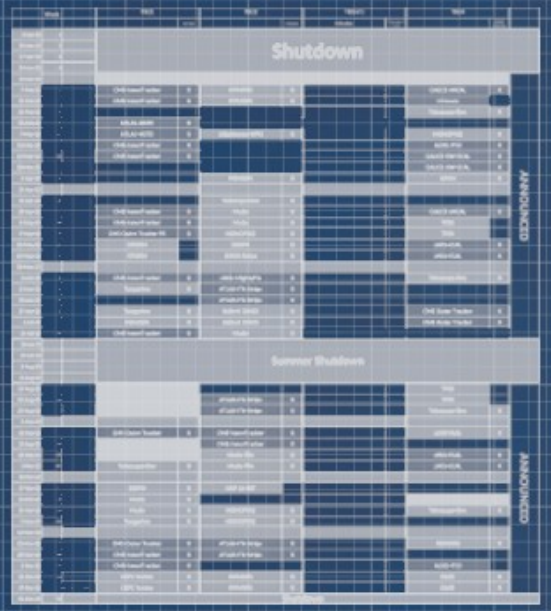


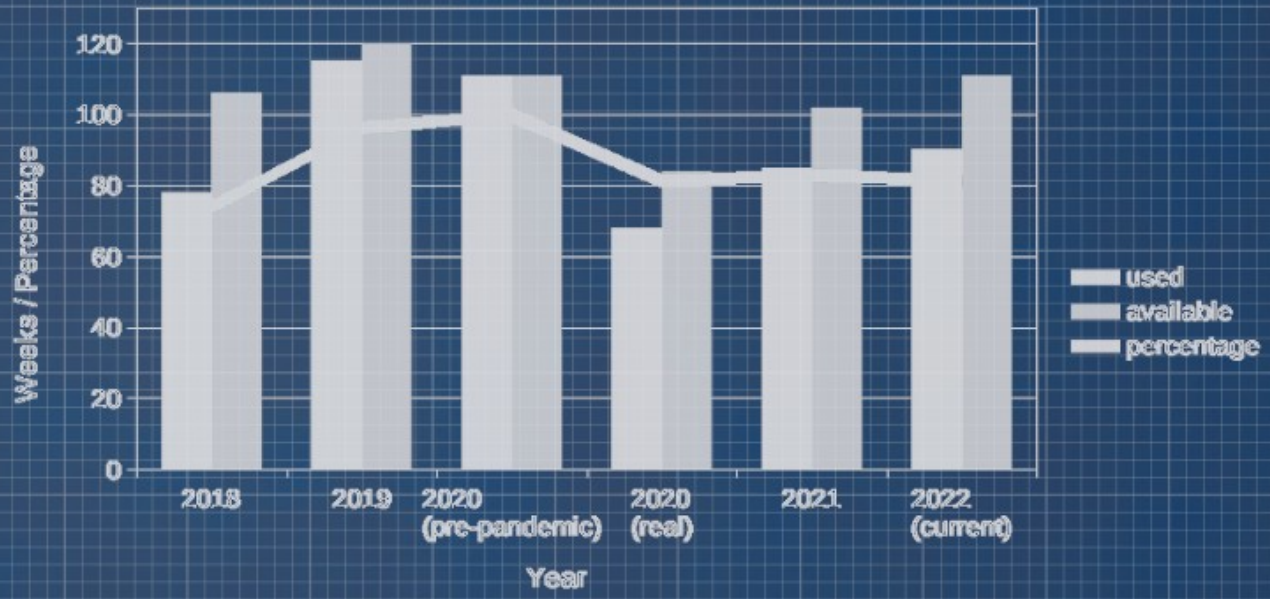




Schedule

Booking & Usage Statistics





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- Example: 2022
  (after Corona back to normal operations)
  - 91 of 111 weeks used = 82 %

	Week		TB21		TB22		TB24/1		TB24		
			DATURA		DURANTA		PCMAG	Telescope in PCMAG		AZALEA ADENIUM	
3-Jan-22	1		Shutdown								
10-Jan-22	2										
17-Jan-22	3										
24-Jan-22	4										
31-Jan-22	5		Startup		Startup		Startup		Startup		ANNOUNCED
7-Feb-22	6		CMS-InnerTracker	X	HVMAPS	X			CALICE AHCAL	X	
14-Feb-22	7		CMS-InnerTracker	X	HVMAPS	X			Mimosis		
21-Feb-22	8								Telescope-Dev	X	
28-Feb-22	9		ATLAS-HGTD	X							
7-Mar-22	10		ATLAS-HGTD	X	AidaInnova-WP3	X			MONOPIX2	X	
14-Mar-22	11		CMS-InnerTracker	X					ALICE-ITS3	X	
21-Mar-22	12		CMS-InnerTracker	X					CALICE-SiW-ECAL	X	
28-Mar-22	13								CALICE-SiW-ECAL	X	
4-Apr-22	14				PSIMAPS	X			APIX3	X	
11-Apr-22	15										
18-Apr-22	16				Telescope-Dev	X					
25-Apr-22	17		CMS-InnerTracker	X	Mu3e	X			CALICE AHCAL	X	
2-May-22	18		CMS-InnerTracker	X	Mu3e	X			TPEX		
9-May-22	19		CMS Outer Tracker PS	X	MONOPIX2	X			TPEX		
16-May-22	20		STORM		DSiPM	X			LHCb-ECAL	X	
23-May-22	21		STORM		CMOS-Strips	X			LHCb-ECAL	X	
30-May-22	22										
6-Jun-22	23		CMS-InnerTracker	X	LHCb-MightyPix	X			Telescope-Dev	X	
13-Jun-22	24		Tangerine	X	ATLAS-ITk-Strips	X					
20-Jun-22	25				ATLAS-ITk-Strips	X					
27-Jun-22	26		Tangerine	X	Belle-II CMOS	X			CMS Outer Tracker	X	
4-Jul-22	27		PSIMAPS	X	Belle-II CMOS	X			CMS Outer Tracker	X	
11-Jul-22	28		CMS-InnerTracker	X	Mu3e	X					
18-Jul-22	29		Summer Shutdown								
25-Jul-22	30										
1-Aug-22	31										
8-Aug-22	32										
15-Aug-22	33		BL4S	X	CMS-HGCAL						ANNOUNCED
22-Aug-22	34		Summer Students	X	ATLAS-ITk-Strips	X					
29-Aug-22	35		Summer Students	X	ATLAS-ITk-Strips	X			Telescope-Dev	X	
5-Sep-22	36										
12-Sep-22	37		CMS Outer Tracker	X	CMS-InnerTracker	X			LUXE-ECAL	X	
19-Sep-22	38		BL4S	X	CMS-InnerTracker	X			CMS ETL	X	
26-Sep-22	39		BL4S	X	Mu3e-Tile	X	ATLAS-ITk-Wirebonds				
3-Oct-22	40		Telescope-Dev	X	Mu3e-Tile	X					
10-Oct-22	41										
17-Oct-22	42		RSD-EXFLU	X	SHiP LS-SBT						
24-Oct-22	43		Mu3e	X	DSiPM	X			HEP for Teachers	X	
31-Oct-22	44		Mu3e	X	MONOPIX2	X			Telescope-Dev	X	
7-Nov-22	45		Tangerine	X	MONOPIX2	X			CMS ETL	X	
14-Nov-22	46										
21-Nov-22	47		CMS Outer Tracker	X	ATLAS-ITk-Strips	X			PSIMAPS	X	
28-Nov-22	48		CMS-InnerTracker	X	ATLAS-ITk-Strips	X			LHCb-ECAL	X	
5-Dec-22	49		CMS-InnerTracker	X	ALICE-ITS3				LUXE-LeadGlass	X	
12-Dec-22	50		CEPC Vertex	X	HVMAPS	X			LHCb-MightyPix	X	
19-Dec-22	51	Beam till 22/12 0900	CEPC Vertex	X	HVMAPS	X			LHCb-MightyPix	X	
26-Dec-22	52		Shutdown								

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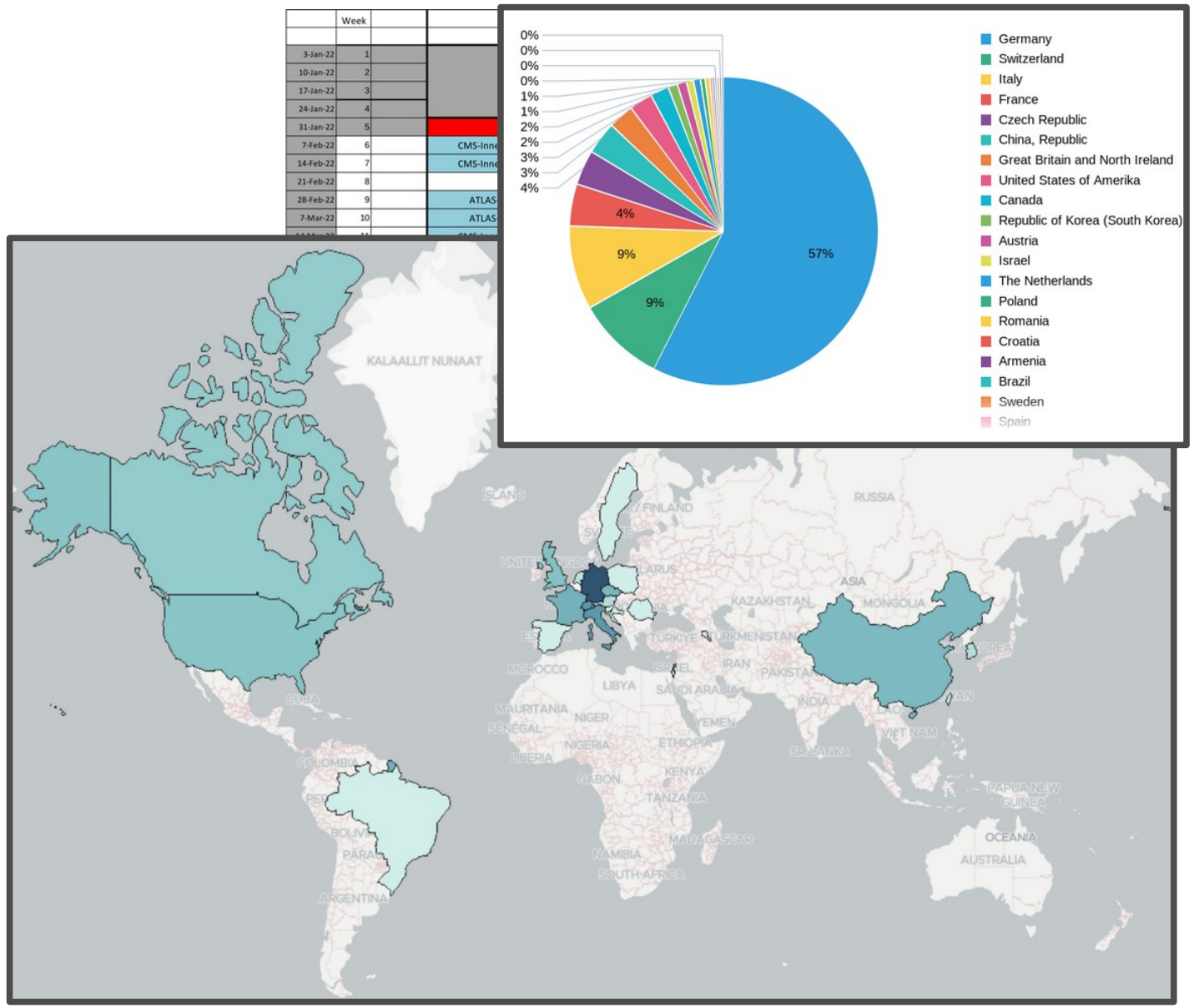
  - 91 of 111 weeks used = 82 %
  - 409 users in 66 groups



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  - 409 users in 66 groups
  - Majority of beam tests for LHC experiment upgrades
  - Generic detector development catching up

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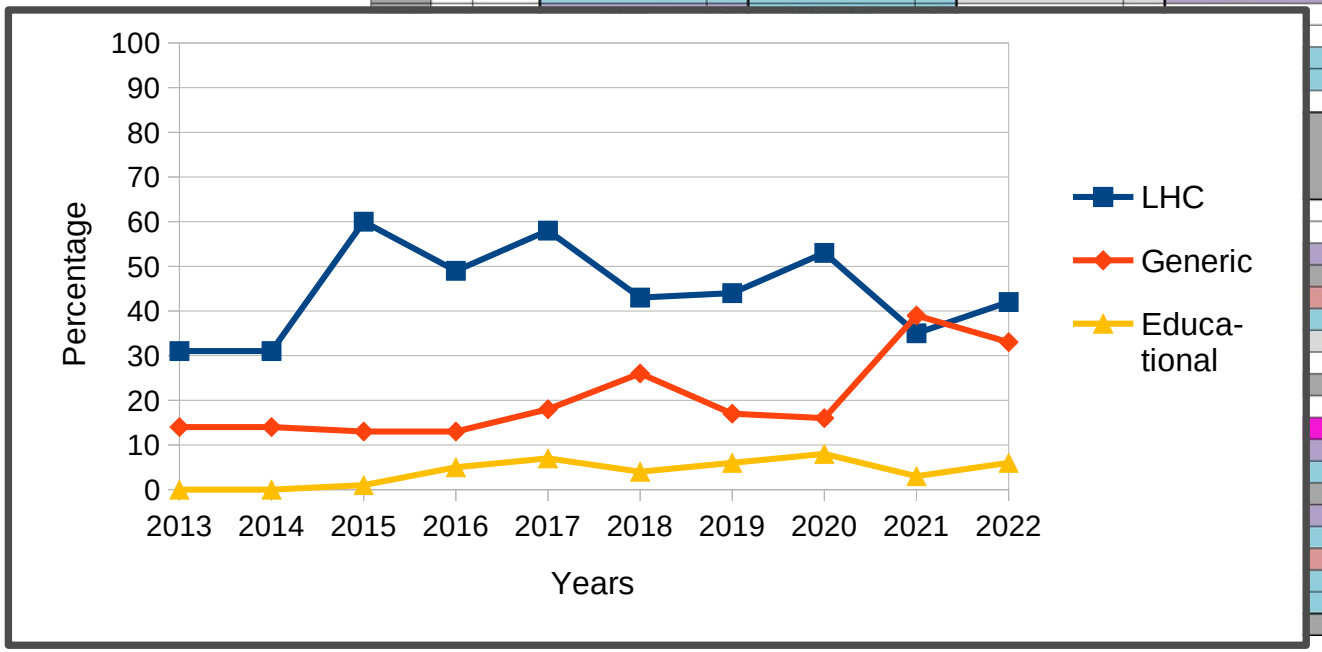
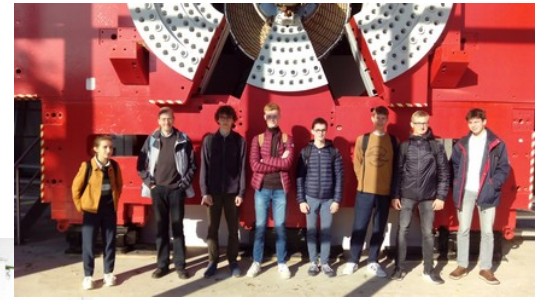
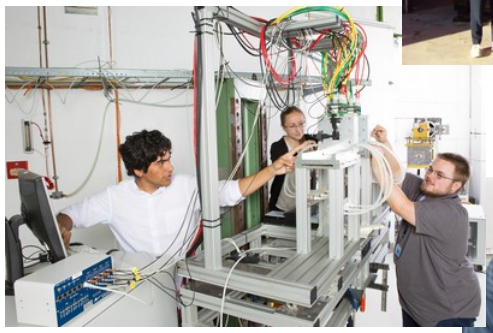


Outreach and Education

Test Beam for Education

- Beamline for Schools (BL4S)
  - Woldwide competition in close collaboration with CERN for high school students to perform experiments at a real beamline
  - Job Advertisement: 6 months contract for a BL4S support scientist
- DESY Summer Student Program
  - Undergraduate students join day-to-day work of research groups
- HEP for Teachers
  - 5-day program for high school teachers
  - One part: beam tests with a sandwich calorimeter





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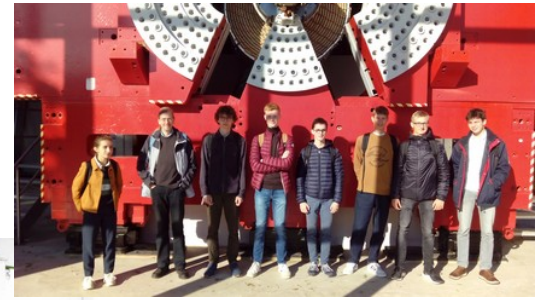
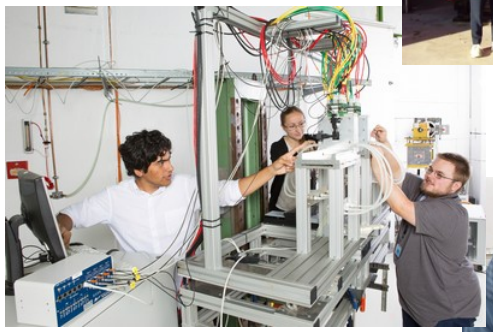
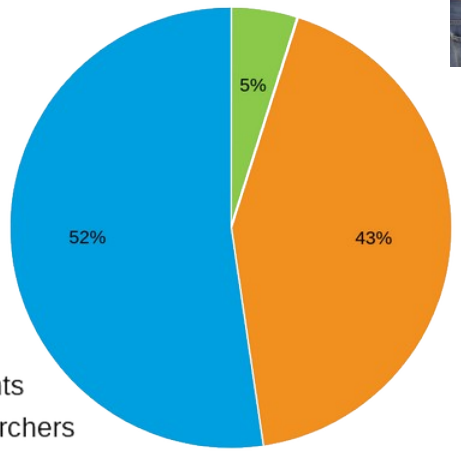
- Training place for the next generation of detector experts who can learn operating a detector under realistic conditions
  - Large part of the users are students and young postdocs







Outlook

Future Developments

Future

Test Beam Facility in Petra IV times

- Upgrade PETRA III → PETRA IV:
  - New booster synchrotron *DESY IV*

- What will happen to DESY test beam facility?
  - General support from the directorate:
    test beam facility is essential and should be preserved
  - But not a done deal
  - Implementation of test beam lines in DESY IV
    - 1 staff position from summer on to design
      future test beam generation
    - Ideally with additional support (postdoc)

- Petra IV project not yet approved; official timeline: shutdown 2027 → 2029

Closing Remarks

Additional Information and Contact

- More information can be found on our web page: testbeam.desy.de
- And in the reference publication: *"The DESY II test beam facility" NIMA, Volume 922, 1.4.2019, Pages 265-286*

- Contact:
  testbeam-coor@desy.de

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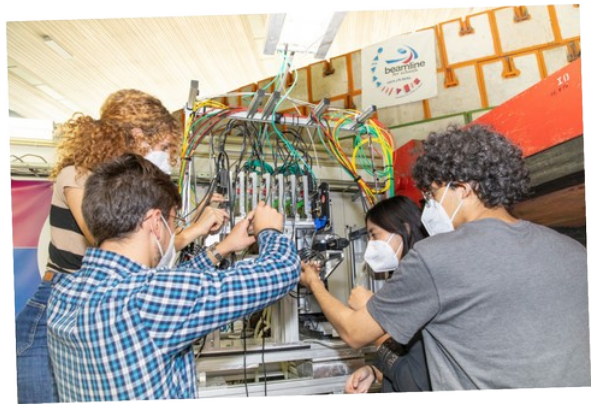




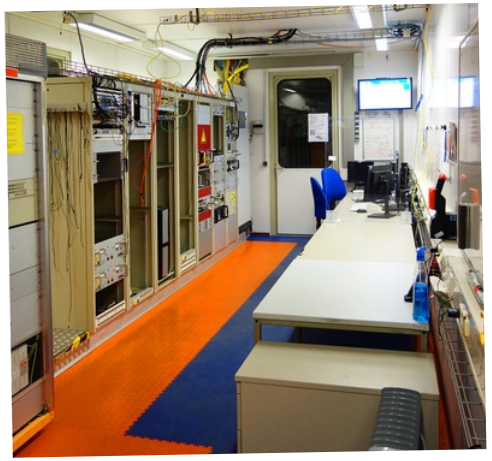

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