

# The DESY II Test Beam Facility



DRD6 Meeting 10.04.2024

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# Facility

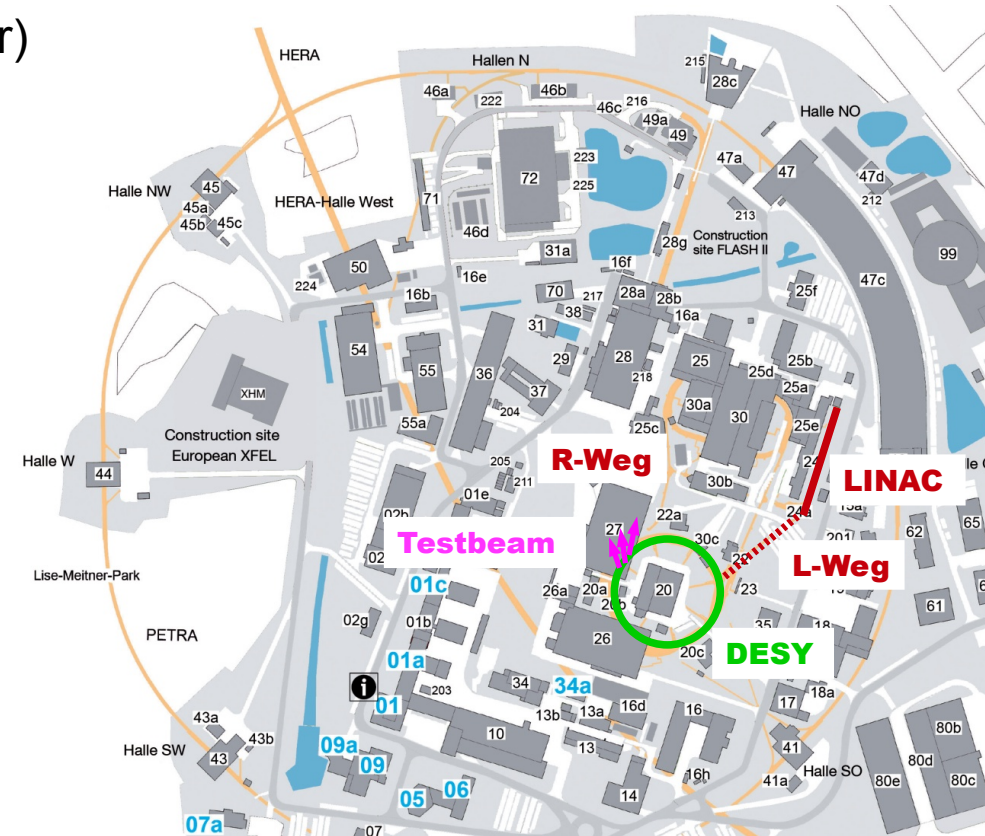
## Overview and Beam Generation



# Facility

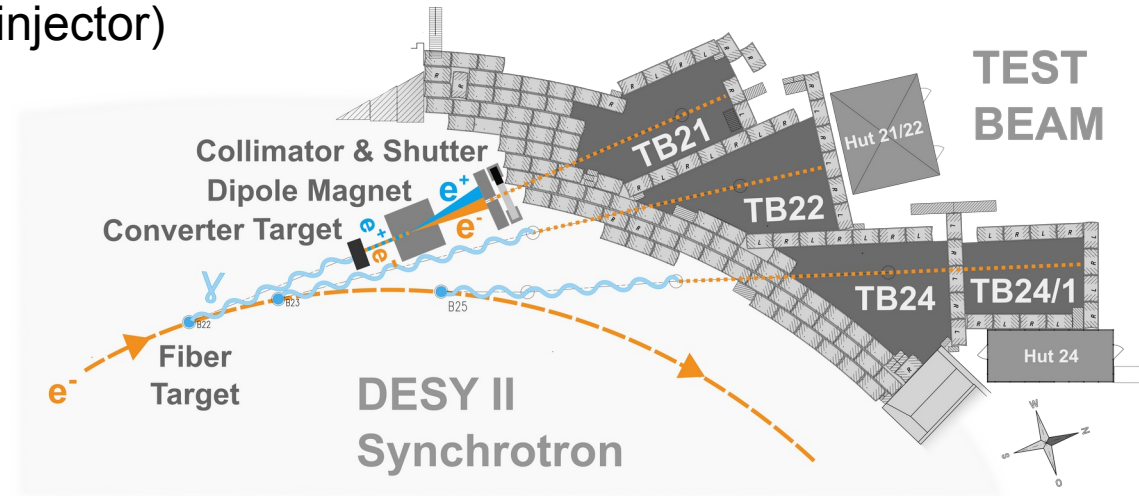
## Overview and Beam Generation

- Facility parasitically fed by DESY II synchrotron (PETRA III injector)
  - 1 bunch per fill
  - 1 MHz circulation frequency
  - Energy ramps sinusoidal @ 12.5 Hz between 0.45 and 6.3 GeV
  - Very high availability (~ 99 % uptime)



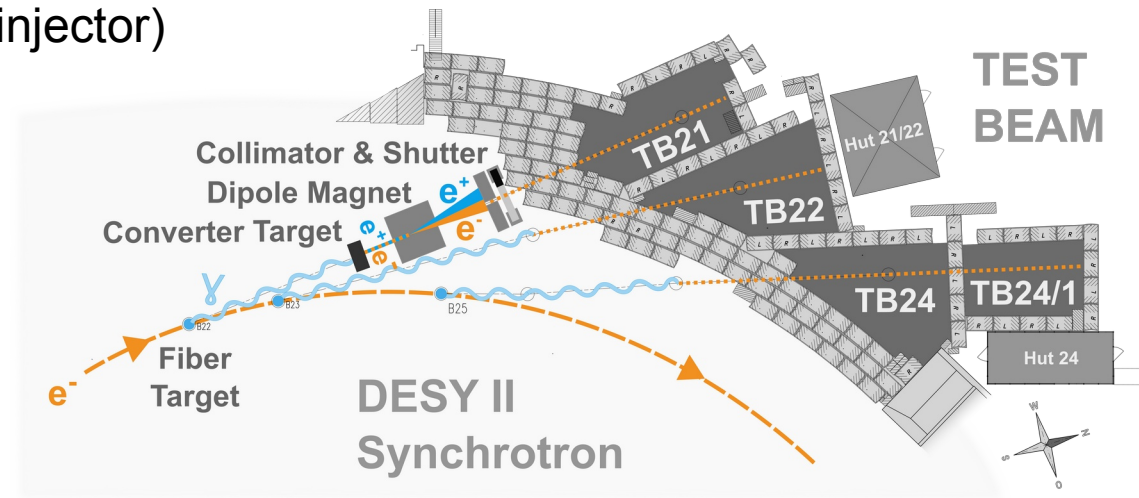
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- Test beam generation:
  - 3 primary carbon fiber targets generate bremsstrahlung photons
  - Conversion at secondary target to  $e^+/e^-$  up to 6 GeV
  - Energy selected with dipole / collimator



## Overview and Beam Generation

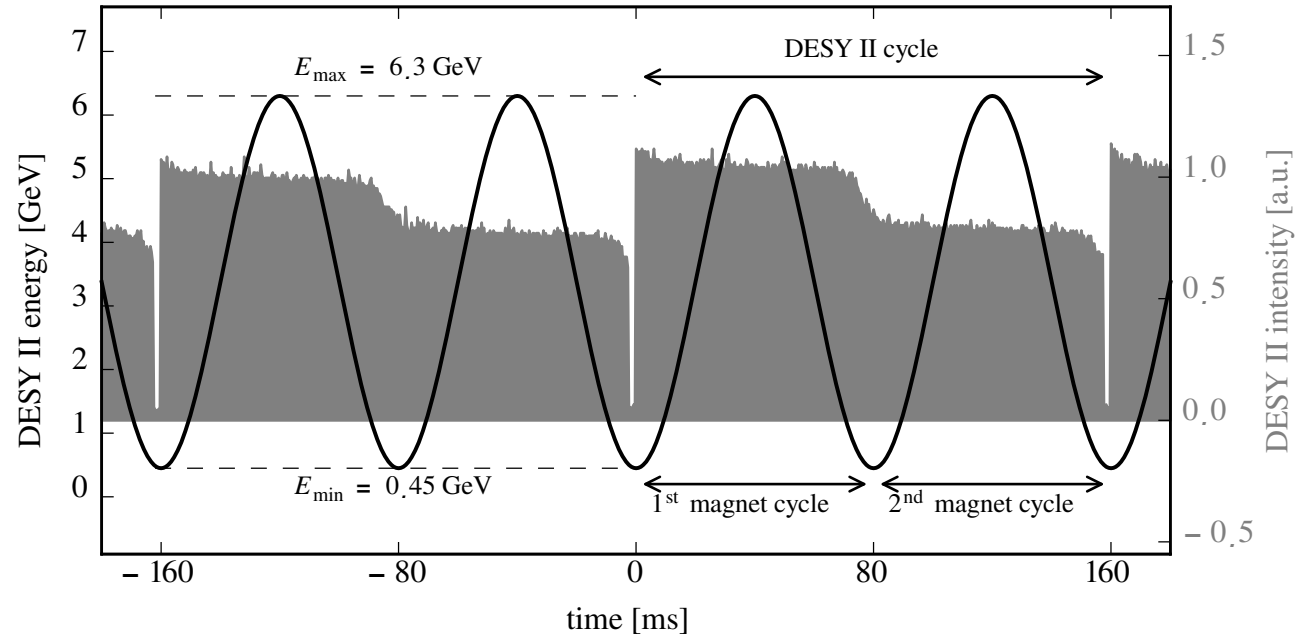
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  - Energy selected with dipole / collimator
    - Single electrons, rates  $O(10k \text{ particles s}^{-1} \text{ cm}^{-2})$  depending on beam line, energy, converter target, collimation
- Three individual beam lines, controlled by the user: shutter,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



# Accelerating the Beam

## The DESY II Synchrotron

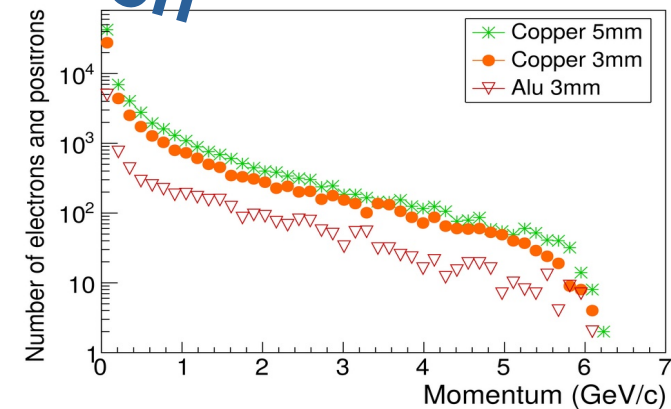
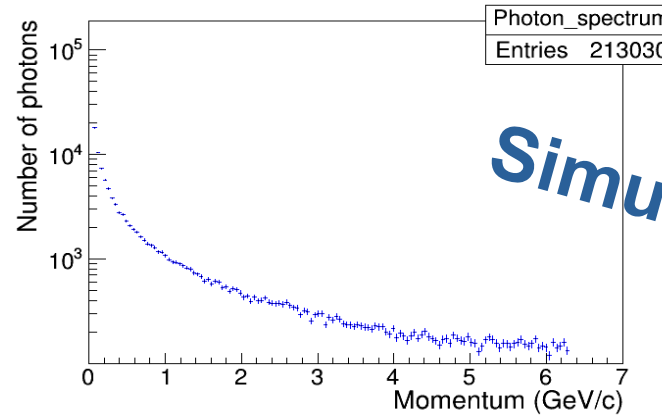
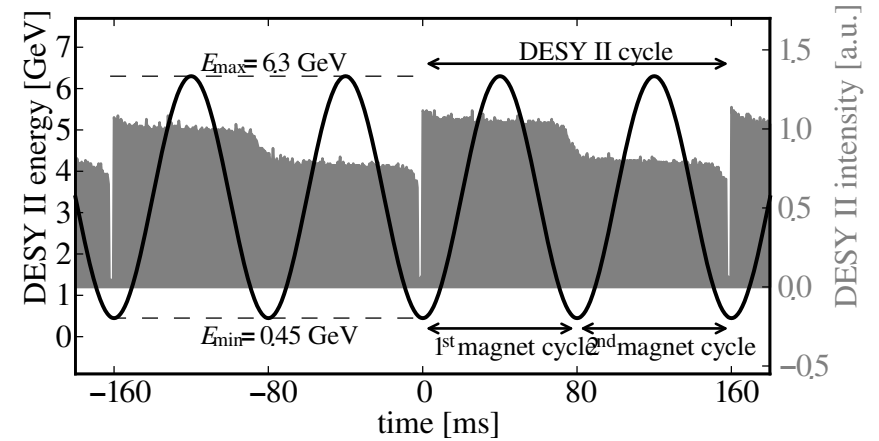
- Circumference: 292.8m
- Continuously cycling at 12.5 Hz (a quarter of the power grid frequency of 50 Hz) this means all magnets ramp up and down with this frequency (80 ms magnet cycle)
- Extraction at any time and any energy
  - e.g. 3 or 6 GeV particles for PETRA
  - 4.5 GeV particle for DORIS (when it still existed)
- Injection at 450 MeV from the L-Weg (PIA) happens usually every second cycle
- Very flexible ... but
  - The beam quality suffers after the deceleration (increased multiple scattering at lower energies)
  - Can't run stable at a certain energy



# Beam Generation

## Beam Properties

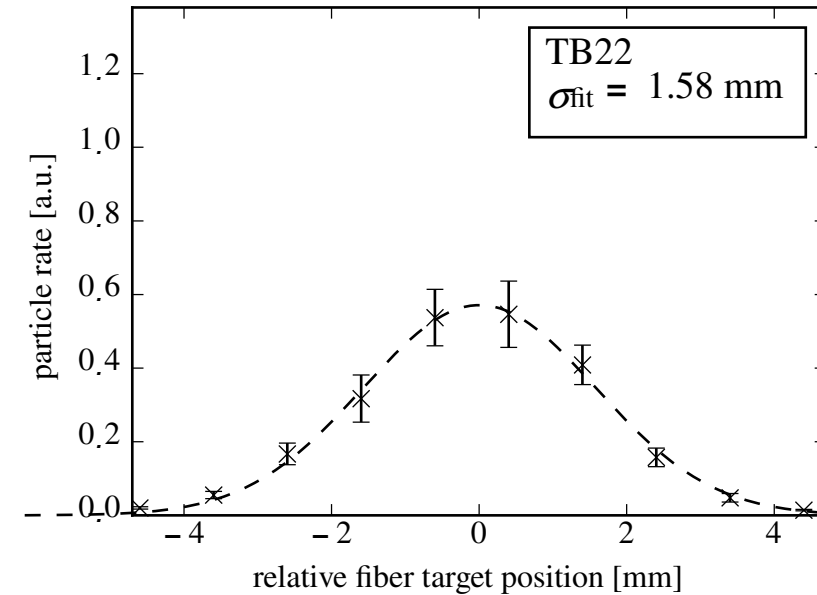
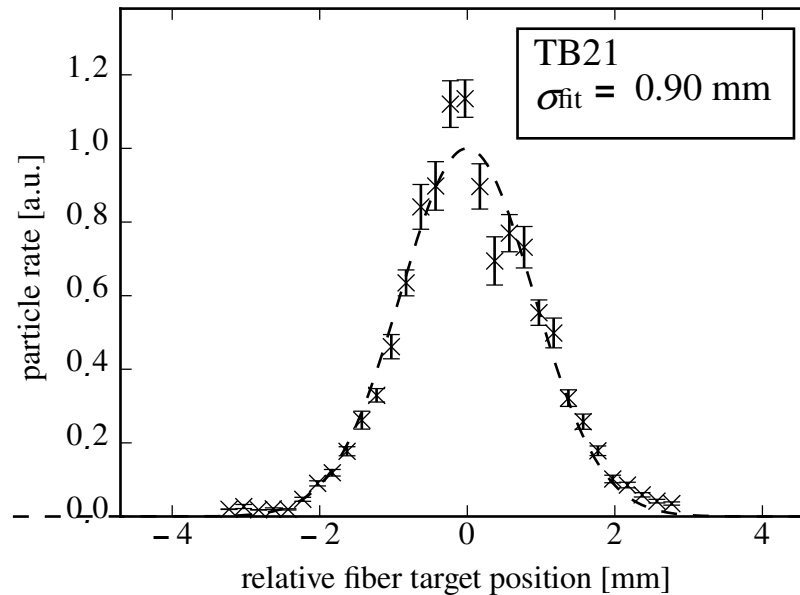
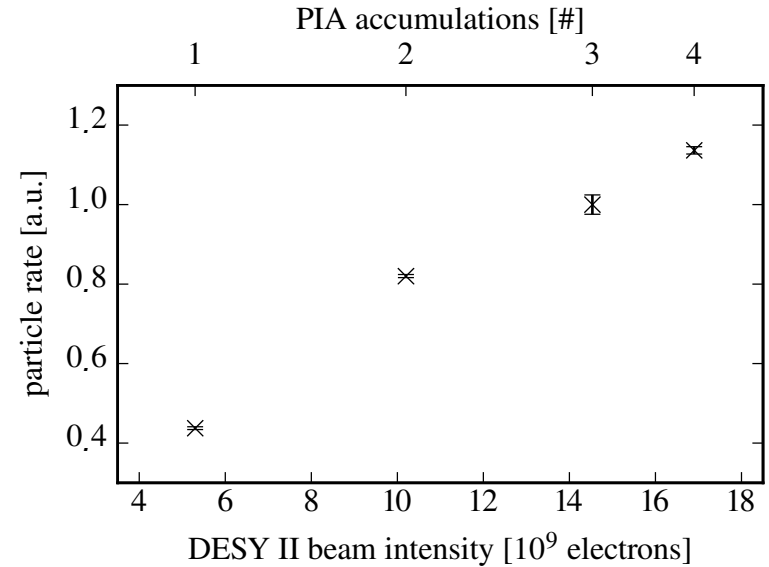
- What users are usually interested in: rate, energy (precision)
- Tricky to determine:
  - DESY II synchrotron cycles energy, intensity can vary
  - Bremsstrahlung spectrum (energy dependent) also depends how well the target is positioned in the beam (which is also not 100% stable) and the resulting photon beam has some divergence
  - Pair production spectrum (energy dependent)
  - Which energy is chosen
  - Collimator opening



# Some numbers

## Beam Properties

- A few measurements to get an idea of the dependencies
  - DESY II synchrotron beam intensity
  - How well the target is positioned in the beam
    - + which beamline + how many targets are in overall

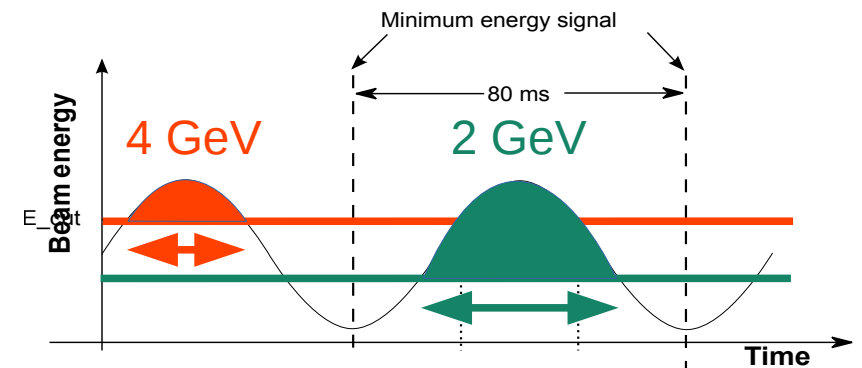
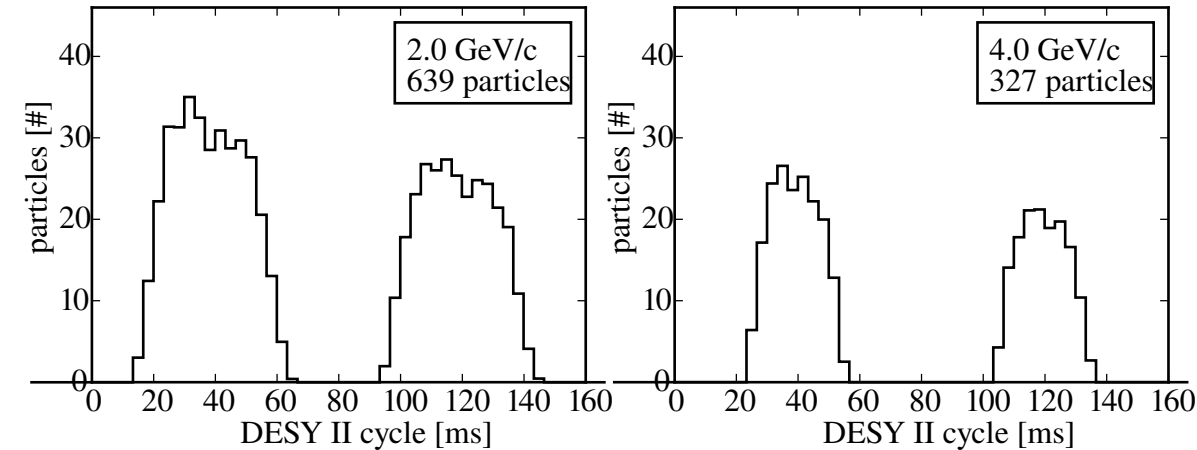




# Some numbers

## Beam Properties

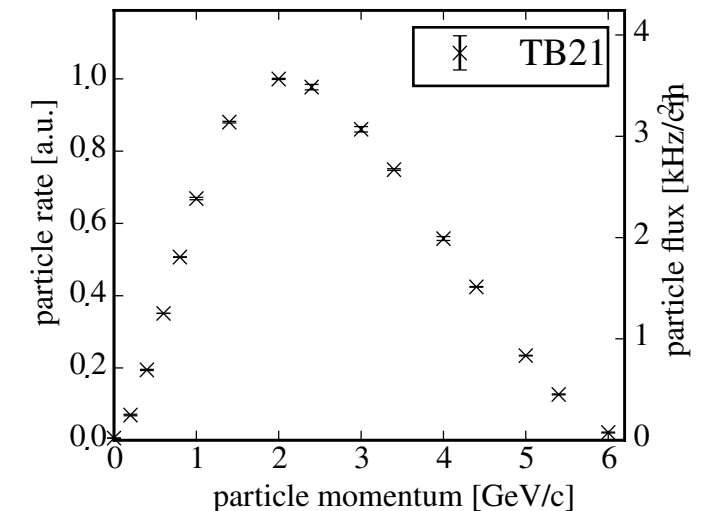
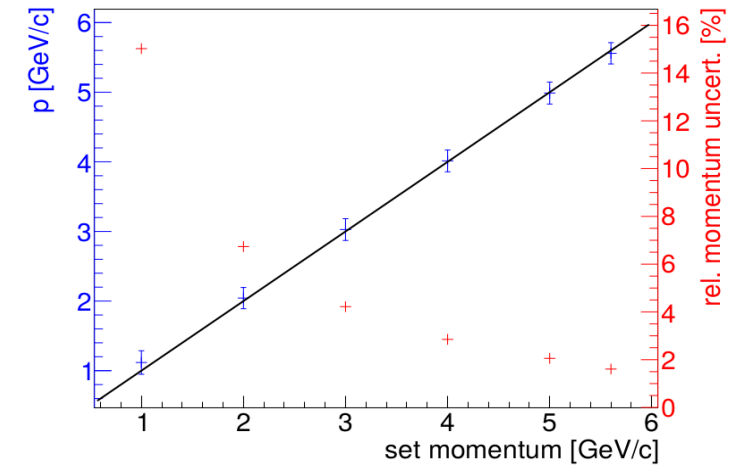
- A few measurements to get an idea of the dependencies
  - DESY II synchrotron intensity
  - How well the target is positioned in the beam + which beamline + how many targets are in overall
  - Energy dependence



# Some numbers

## Beam Properties

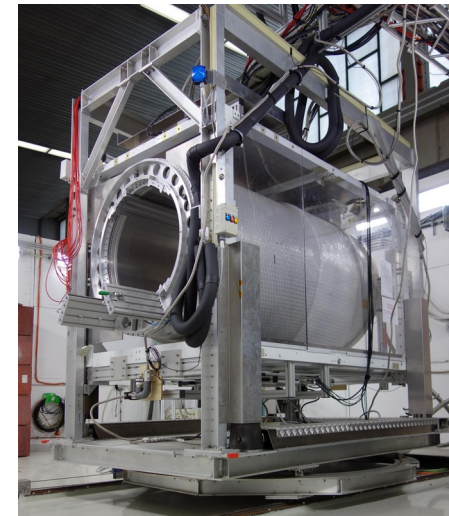
- A few measurements to get an idea of the dependencies
  - DESY II synchrotron intensity
  - How well the target is positioned in the beam + which beamline + how many targets are in overall
  - Energy dependence
  - Energy precision: Offset very small
    - Absolute spread rather independent of energy → relative spread smaller at higher energies
  - Can be influenced by the collimator setting (but less spread also means less rate, so you need to decide what's more important)



# Facility

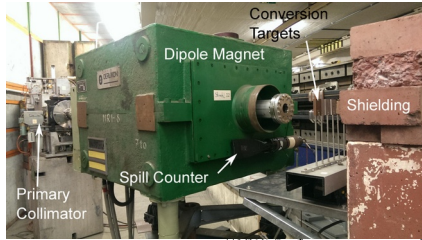
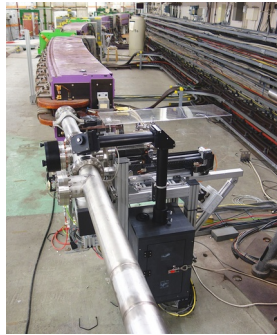
## Infrastructure

- Remote controlled 1 t and 30 kg stages
- Hall crane, up to 25 t
- Test magnets: SC 1 T solenoid (TB24/1), 1.35 T dipole (TB21)
- EUDET-type beam telescope in two areas, ALPIDE based telescope prototype in one
- Remote controlled IP cameras in each area
- Dry nitrogen, cooling water in each area
- Gas cabinets in TB22 and TB24, flammable gas possible
- Weather stations, slow control system, laser alignment
- Beam monitors
- Patch panels with High voltage SHV, BNC Coax, Ethernet RJ-45, optical fiber (single and multi-mode)

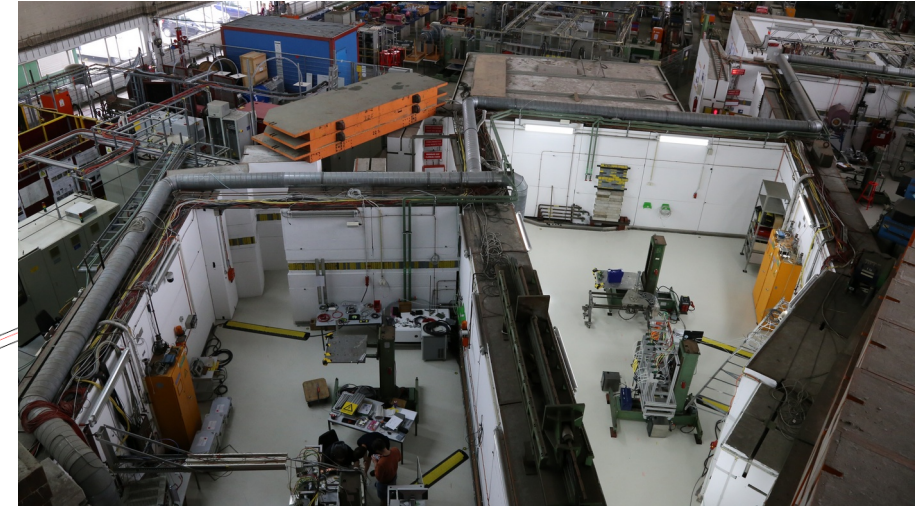
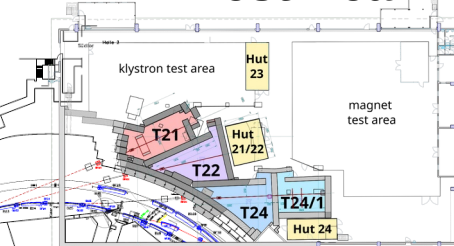


# A short summary

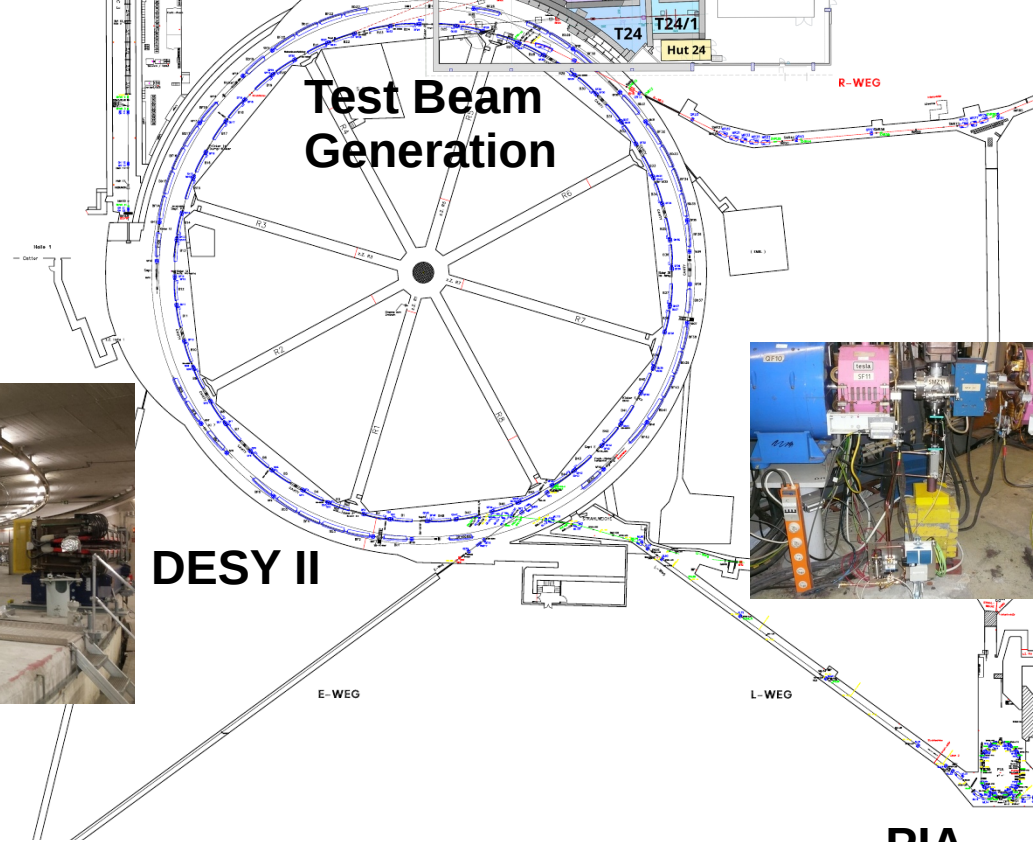
## The entire accelerator chain



### Test Beam Hall



### Test Beam Generation

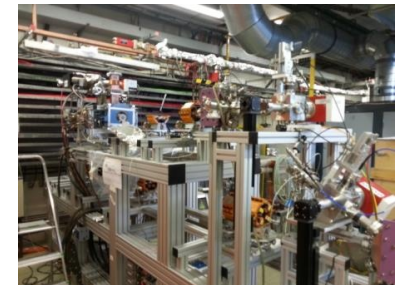


### DESY II



### PIA

### LINAC II

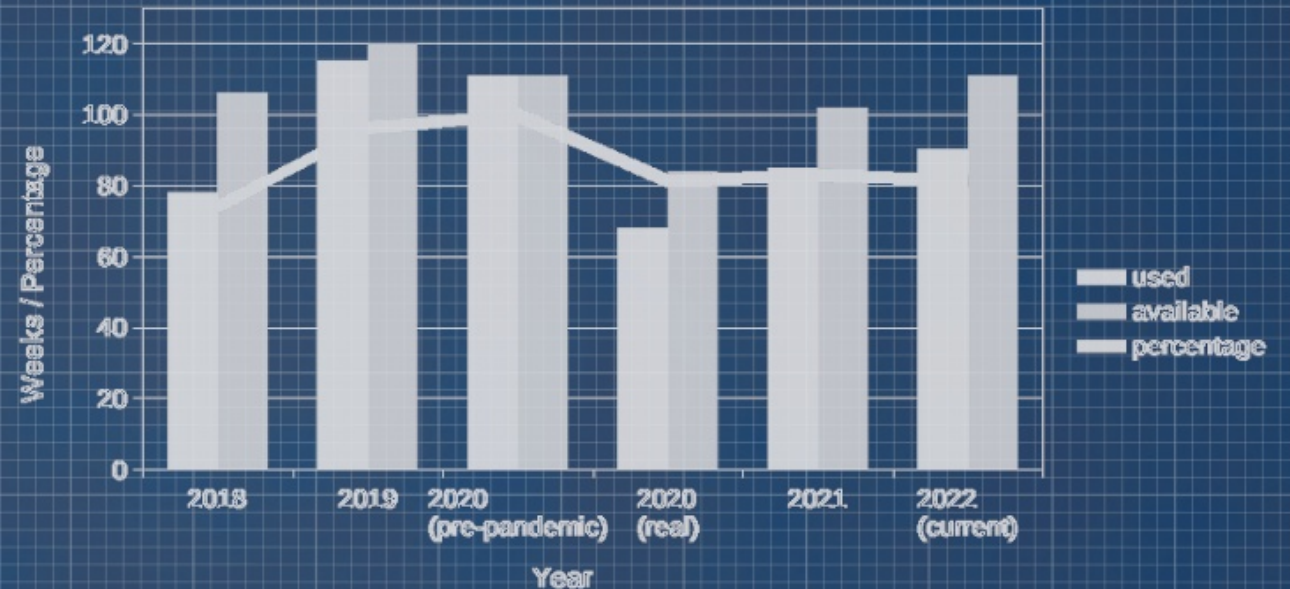


### Electron "Gun"

# Schedule

## Booking, User Statistics, Outreach

The Gantt chart displays a detailed schedule with two main sections: 'Shutdown' and 'Summer Shutdown'. Each section contains multiple rows of tasks, represented by horizontal bars of varying lengths and colors (dark blue, light blue, grey). The tasks are organized into columns, likely representing different phases or activities. The 'Shutdown' section is at the top, and the 'Summer Shutdown' section is below it. The chart is set against a grid background.



# Schedule 2023



## Booking/Usage Statistics

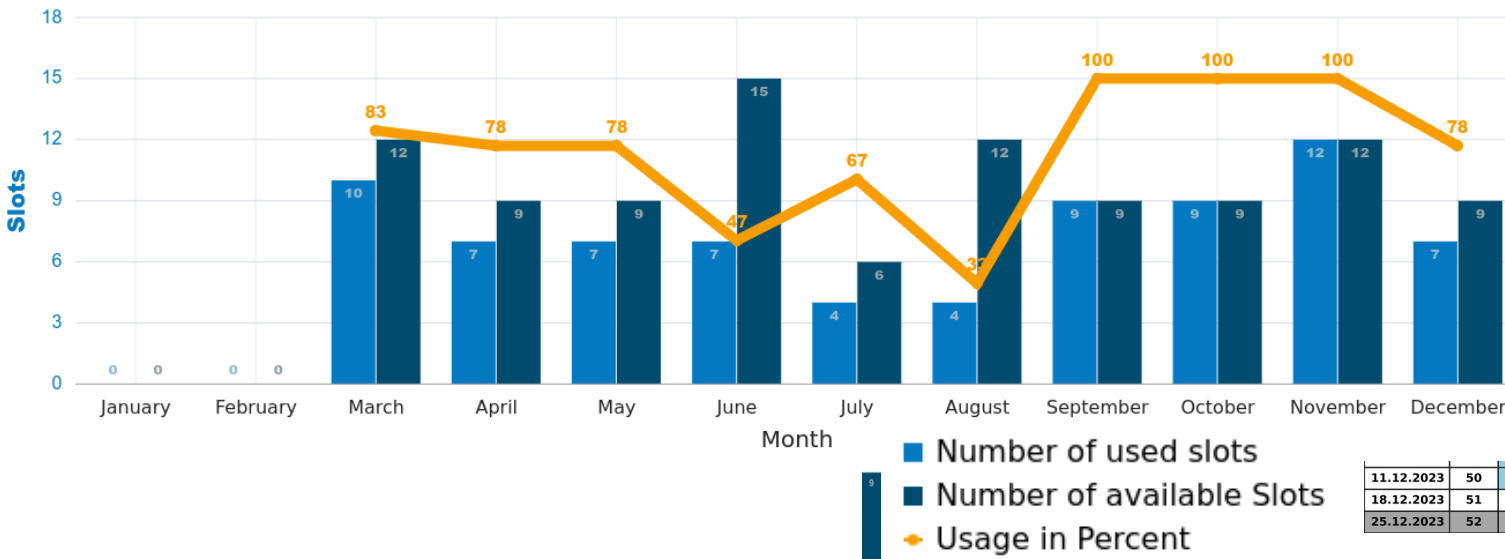
- Typical year
- ... except starting with 3 weeks downtime for energy conservation

Startdate	Week	TB21	T	TB22	T	TB241	T	TB24	T
02.01.2023	1	Shutdown		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	CMS-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	CMS ETL	X			RSD	X
03.04.2023	14	Maintenance		Maintenance		Maintenance		Maintenance	
10.04.2023	15	CEPC Vertex	X	Tangerine	X				
17.04.2023	16	CEPC Vertex	X	BTTB	X			BTTB	X
24.04.2023	17	CMS Inner Tracker	X	TelePix	X				
01.05.2023	18	CMS Inner Tracker	X	TelePix	X				
08.05.2023	19			Tangerine	X			LHCb-ECAL	X
15.05.2023	20	CMS-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	CMS 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	CMS Inner Tracker	X	Belle-II CMOS	X				
10.07.2023	28	CMS Inner Tracker	X	RD50-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	BL4S	X	Telescope-Dev	X			ATLAS-ITk-SystemTest	
14.08.2023	33								
21.08.2023	34								
28.08.2023	35							CMS-HGCAL	X
04.09.2023	36	BL4S		Tangerine	X			CMS-HGCAL	X
11.09.2023	37	Maintenance		Maintenance		Maintenance		Maintenance	
18.09.2023	38	BL4S	X	ATLAS-ITk-Strips	X			LUXE LeadGlass	X
25.09.2023	39	BL4S	X	ATLAS-ITk-Strips	X			Telescope-Dev	X
02.10.2023	40	TelePix	X	CALICE-Crystal	X			FAST3	X
09.10.2023	41	CMS Inner Tracker	X	CALICE-Crystal	X			ATLAS-HGTD	X
16.10.2023	42	Maintenance		TelePix		Maintenance		Maintenance	
23.10.2023	43	MDI-2		CMOS Strips Detectors	X			MONOPIX2	X
30.10.2023	44	MDI-2		CMOS Strips Detectors	X			MONOPIX2	X
06.11.2023	45	CMS Outer Tracker PS	X	Tangerine	X			ATLAS-HGTD	X
13.11.2023	46	CMS Inner Tracker	X	Tangerine	X			ATLAS-HGTD	X
20.11.2023	47	Maintenance		Maintenance		Maintenance		Maintenance	
27.11.2023	48	CMS Inner Tracker	X	ATLAS-ITk-Strips	X			IPHC-CE65_v2	
04.12.2023	49	CMS ETL ETROC	X	ATLAS-ITk-Strips	X			LHCb-ECAL	
11.12.2023	50	CMS ETL ETROC	X	Tangerine	X			LHCb-ECAL	
18.12.2023	51			Tangerine	X				
25.12.2023	52	Shutdown		Shutdown		Shutdown		Shutdown	

# Schedule 2023

## Booking/Usage Statistics

- Typical year
  - ... except starting with 3 weeks downtime for energy conservation
  - 80 of 102 slots booked ( 78 % )
  - LHC 44 % , generic R&D 40 %
  - 400 users, about 30 % first time at the DESY test beam



Startdate	Week	TB21	T	TB22	T	TB241	T	TB24	T
02.01.2023	1	Shutdown		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	CMS-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	CMS ETL	X			RSD	X
03.04.2023	14	Maintenance		Maintenance		Maintenance		Maintenance	
10.04.2023	15	CEPC Vertex	X	Tangerine	X				
17.04.2023	16	CEPC Vertex	X	BTTB	X			BTTB	X
24.04.2023	17	CMS Inner Tracker	X	TelePix	X				
01.05.2023	18	CMS Inner Tracker	X	TelePix	X				
08.05.2023	19			Tangerine	X			LHCb-ECAL	X
15.05.2023	20	CMS-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	CMS 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	CMS Inner Tracker	X	Belle-II CMOS	X				
10.07.2023	28	CMS Inner Tracker	X	RD50-CMOS	X				
		own		ATLAS-ITk-Strip-DAQ		Shutdown		Shutdown	
		own		Shutdown		Shutdown		Shutdown	
		rip-Magnet		ATLAS-ITk-Strips		Shutdown		Shutdown	
		S	X	Telescope-Dev	X			ATLAS-ITk-SystemTest	
		S		Tangerine	X			CMS-HGCAL	X
		ance		Maintenance		Maintenance		Maintenance	
		S	X	ATLAS-ITk-Strips	X			LUXE LeadGlass	X
		S	X	ATLAS-ITk-Strips	X			Telescope-Dev	X
		Pix	X	CALICE-Crystal	X			FAST3	X
		Tracker	X	CALICE-Crystal	X			ATLAS-HGTD	X
		ance		TelePix		Maintenance		Maintenance	
		-2		CMOS Strips Detectors	X			MONOPIX2	X
		-2		CMOS Strips Detectors	X			MONOPIX2	X
		Tracker PS	X	Tangerine	X			ATLAS-HGTD	X
		Tracker	X	Tangerine	X			ATLAS-HGTD	X
		ance		Maintenance		Maintenance		Maintenance	
		Tracker	X	ATLAS-ITk-Strips	X			IPHC-CE65_v2	
		ETROC	X	ATLAS-ITk-Strips	X			LHCb-ECAL	
								LHCb-ECAL	
11.12.2023	50	CMS ETL ETROC	X	Tangerine	X				
18.12.2023	51			Tangerine	X				
25.12.2023	52	Shutdown		Shutdown		Shutdown		Shutdown	

# Schedule 2024



## Booking/Usage Statistics

- First half year
  - February to April fully booked
  - Overall 59 of 66 available slots ( 90 % )
  - Still a few slots before the summer break available on a first-come first-served basis

Startdate	Week	TB21	T	TB22	T	TB241	T	TB24	T
01.01.2024	1	Shutdown		Shutdown		Shutdown		Shutdown	
08.01.2024	2	Shutdown		Shutdown		Shutdown		Shutdown	
15.01.2024	3	Shutdown		Shutdown		Shutdown		Shutdown	
22.01.2024	4	Shutdown		Shutdown		Shutdown		Shutdown	
29.01.2024	5	Startup		Startup		Startup		Startup	
05.02.2024	6	CMS Outer Tracker	X	dSIPM	X			CMS-HGCAL	X
12.02.2024	7	CMS Outer Tracker	X	Mu3e	X			Aidainnova-WP6	X
19.02.2024	8	CMS ETL ETROC	X	Mu3e	X			Aidainnova-WP6	X
26.02.2024	9	CMS ETL ETROC	X	TelePix	X			ATLAS HGTD	
04.03.2024	10	ITk Pixel Dortmund	X	ATLAS-ITk-Strips	X			ATLAS HGTD	
11.03.2024	11	CMS Inner Tracker	X	LHCb-MightyPix	X			CMS ETL	X
18.03.2024	12	CMS Inner Tracker	X	LHCb-MightyPix	X			SHIP-SHADOWS-ECAL	X
25.03.2024	13	Maintenance		Maintenance		Maintenance		Maintenance	
01.04.2024	14	Maintenance		Maintenance		Maintenance		Maintenance	
08.04.2024	15	DESY Heidelberg TB School	X	Tangerine	X			DESY Heidelberg TB School	
15.04.2024	16	Schwartz-Reisman School		Tangerine	X			ALICE-ITS3	
22.04.2024	17	MDI-2		RD50-MPW4	X			CaIVision	X
29.04.2024	18	CMS ETL ETROC	X	CMOS Strips Detectors	X			Telescope-Dev	X
06.05.2024	19	CMS ETL ETROC	X	CMOS Strips Detectors	X			IPHC-CE65_v2	
13.05.2024	20	Maintenance		Maintenance		Maintenance		Maintenance	
20.05.2024	21	MDI-2		dSIPM	X				
27.05.2024	22	ATORCH		Tangerine	X			LHCb-ECAL	X
03.06.2024	23	CMS ETL ETROC	X	Tangerine	X			LHCb-ECAL	X
10.06.2024	24	CMS ETL ETROC	X	Telescope-Dev					
17.06.2024	25	CMS ETL ETROC	X	DCRSD	X			CMS ETL	X
24.06.2024	26	CMS Inner Tracker	X	ATLAS-ITk-Strips	X			DDR6-CALICE SIW-ECAL	X
01.07.2024	27	Maintenance		Maintenance		Maintenance		Maintenance	
08.07.2024	28	MONOPIX2	X					CMS-HGCAL	X
15.07.2024	29	Belle-II CMOS	X					MIMOSIS	
22.07.2024	30								
29.07.2024	31	BL4S preparation		TelePix	X			EIC AC-LGAD	
05.08.2024	32	Shutdown		Shutdown		Shutdown		EIC AC-LGAD	
12.08.2024	33	Shutdown		Shutdown		Shutdown		Shutdown	
19.08.2024	34	Shutdown		Shutdown		Shutdown		Shutdown	
26.08.2024	35								
02.09.2024	36								
09.09.2024	37								
16.09.2024	38								
23.09.2024	39								
30.09.2024	40								
07.10.2024	41	Maintenance		Maintenance		Maintenance		Maintenance	
14.10.2024	42								
21.10.2024	43								
28.10.2024	44								
04.11.2024	45								
11.11.2024	46	Maintenance		Maintenance		Maintenance		Maintenance	
18.11.2024	47								
25.11.2024	48								
02.12.2024	49								
09.12.2024	50								
16.12.2024	51								
23.12.2024	52	Shutdown		Shutdown		Shutdown		Shutdown	



# Schedule 2024

## Booking/Usage Statistics

- First half year
  - February to April fully booked
  - Overall 59 of 66 available slots ( 90 % )
  - Still a few slots before the summer break available on a first-come first-served basis
- Call for the 2<sup>nd</sup> half year running until May, 3rd 2024
- EURO-LABS Transnational Access
  - financial support for user travels
  - User groups can apply, where the team leader and the majority of the members are employed at an institution outside Germany
  - More details: [https://particle-physics.desy.de/test\\_beams\\_at\\_desy/euro\\_labs\\_ta/](https://particle-physics.desy.de/test_beams_at_desy/euro_labs_ta/)

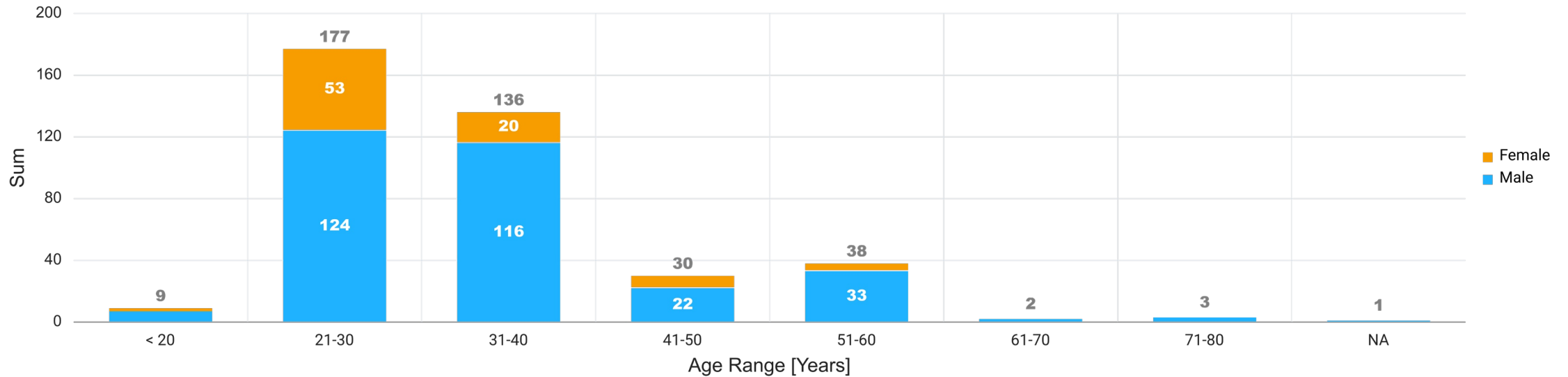


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05.02.2024	6	CMS Outer Tracker	X	dSIPM	X			CMS-HGCAL	X
12.02.2024	7	CMS Outer Tracker	X	Mu3e	X			Aidainnova-WP6	X
19.02.2024	8	CMS ETL ETROC	X	Mu3e	X			Aidainnova-WP6	X
26.02.2024	9	CMS ETL ETROC	X	TelePix	X			ATLAS HGTD	
04.03.2024	10	ITk Pixel Dortmund	X	ATLAS-ITk-Strips	X			ATLAS HGTD	
11.03.2024	11	CMS Inner Tracker	X	LHCb-MightyPix	X			CMS ETL	X
18.03.2024	12	CMS Inner Tracker	X	LHCb-MightyPix	X			SHIP-SHADOWS-ECAL	X
25.03.2024	13	Maintenance		Maintenance		Maintenance		Maintenance	
01.04.2024	14	Maintenance		Maintenance		Maintenance		Maintenance	
08.04.2024	15	DESY Heidelberg TB School	X	Tangerine	X			DESY Heidelberg TB School	
15.04.2024	16	Schwartz-Reisman School		Tangerine	X			ALICE-ITS3	
22.04.2024	17	MDI-2		RD50-MPW4	X			CalVision	X
29.04.2024	18	CMS ETL ETROC	X	CMOS Strips Detectors	X			Telescope-Dev	X
06.05.2024	19	CMS ETL ETROC	X	CMOS Strips Detectors	X			IPHC-CE65_v2	
13.05.2024	20	Maintenance		Maintenance		Maintenance		Maintenance	
20.05.2024	21	MDI-2		dSIPM	X				
27.05.2024	22	ATORCH		Tangerine	X			LHCb-ECAL	X
03.06.2024	23	CMS ETL ETROC	X	Tangerine	X			LHCb-ECAL	X
10.06.2024	24	CMS ETL ETROC	X	Telescope-Dev					
17.06.2024	25	CMS ETL ETROC	X	DCRSD	X			CMS ETL	X
24.06.2024	26	CMS Inner Tracker	X	ATLAS-ITk-Strips	X			DDR6-CALICE SIW-ECAL	X
01.07.2024	27	Maintenance		Maintenance		Maintenance		Maintenance	
08.07.2024	28	MONOPIX2	X					CMS-HGCAL	X
15.07.2024	29	Belle-II CMOS	X					MIMOSIS	
22.07.2024	30								
29.07.2024	31	BL4S preparation		TelePix	X			EIC AC-LGAD	
05.08.2024	32	Shutdown		Shutdown		Shutdown		EIC AC-LGAD	
12.08.2024	33	Shutdown		Shutdown		Shutdown		Shutdown	
19.08.2024	34	Shutdown		Shutdown		Shutdown		Shutdown	
26.08.2024	35								
02.09.2024	36								
09.09.2024	37								
16.09.2024	38								
23.09.2024	39								
30.09.2024	40								
07.10.2024	41	Maintenance		Maintenance		Maintenance		Maintenance	
14.10.2024	42								
21.10.2024	43								
28.10.2024	44								
04.11.2024	45								
11.11.2024	46	Maintenance		Maintenance		Maintenance		Maintenance	
18.11.2024	47								
25.11.2024	48								
02.12.2024	49								
09.12.2024	50								
16.12.2024	51								
23.12.2024	52	Shutdown		Shutdown		Shutdown		Shutdown	

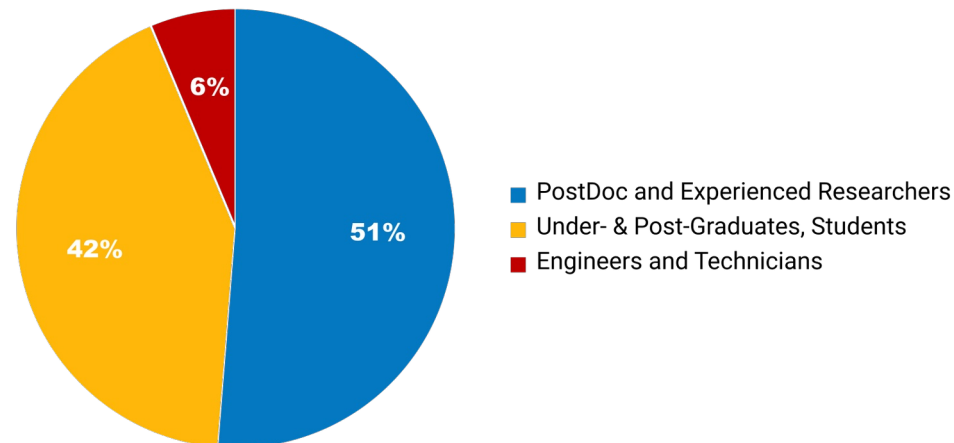
# Outreach and Education

## Test Beam Users

- Age distribution: it's a young people's game (close to 50 % 30 years or younger; 70% under 35 years)



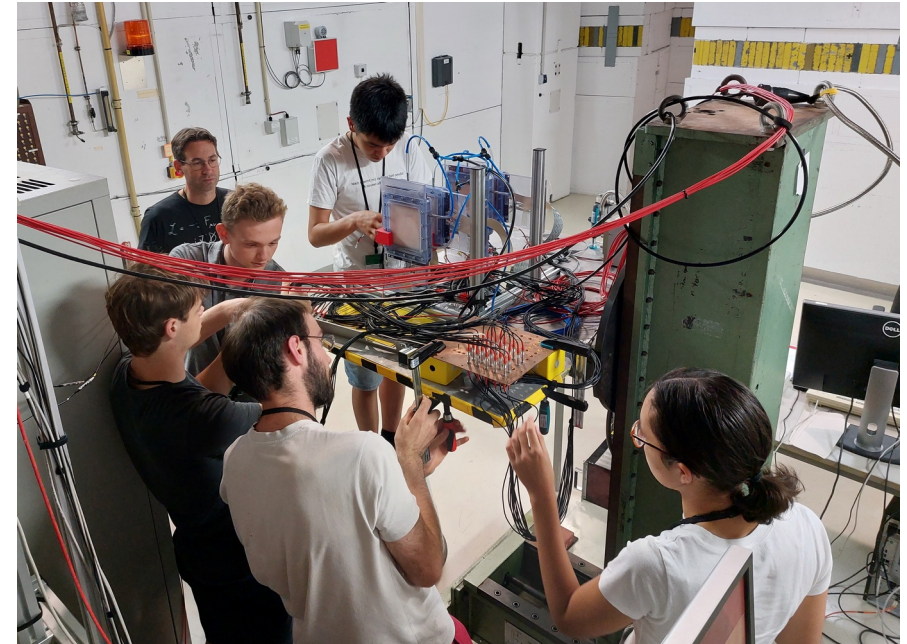
- Most of our users are students or early-career postdocs



# Outreach and Education

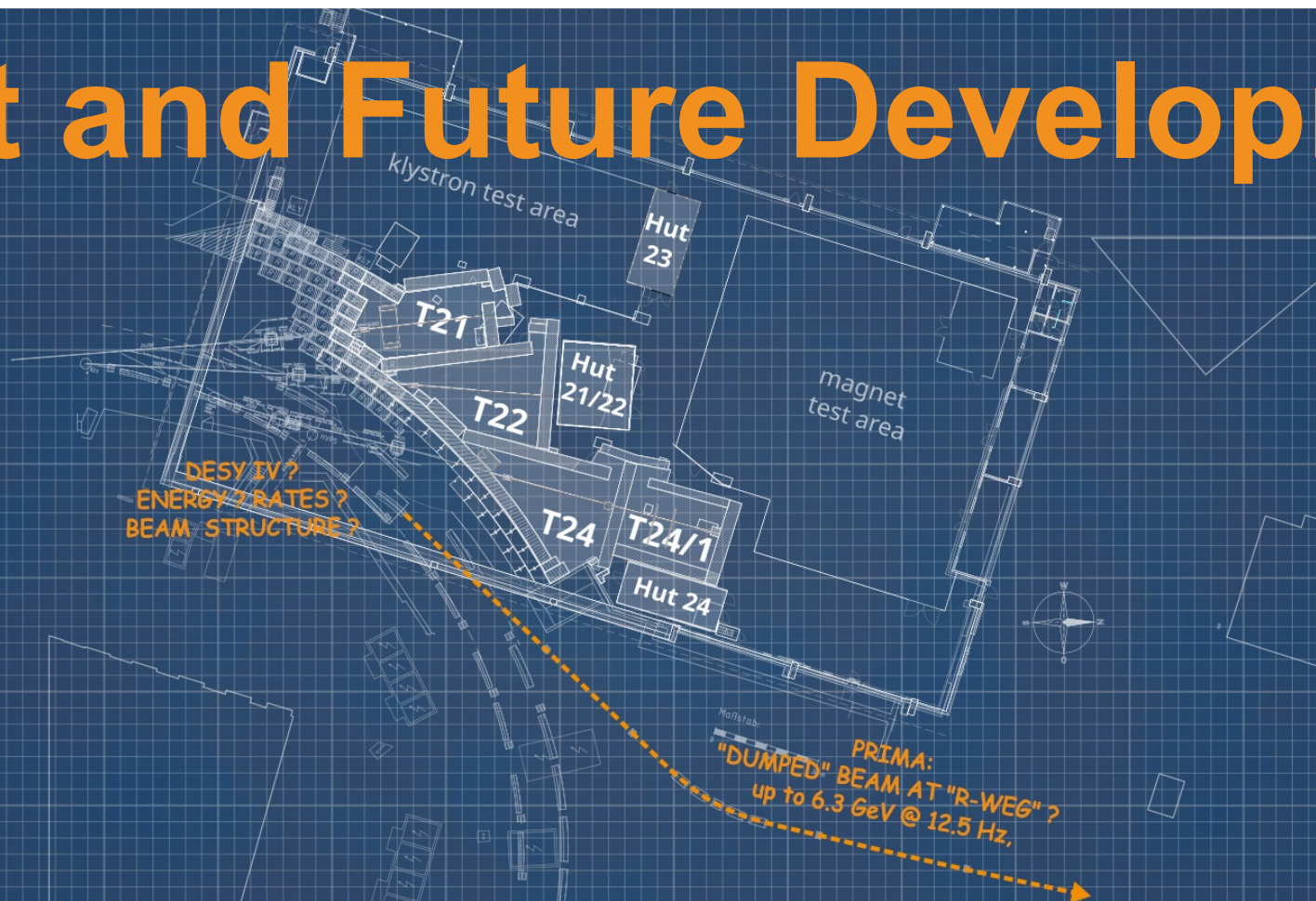
## On-site Activities

- BTTB 11 in 2023 with hands-on tutorial at 2 beam lines
- DESY Summer Student Program
  - Undergraduate students join day-to-day work
  - In 2023: TelePix2 studies; foreseen for this year again
- Beamline 4 Schools
  - Competition for high school students, in parallel at beam lines at CERN and DESY
  - In 2023, at DESY “Wire Wizards” with self-build wire chambers → see [presentation on Thursday](#)
  - Proposal submission for 2024 ended 10 April
- HighRR Testbeam School @ DESY – last week
  - Hands-on course at DESY with silicon devices, timing detectors and calorimetry incl. introductory lectures



# Outlook

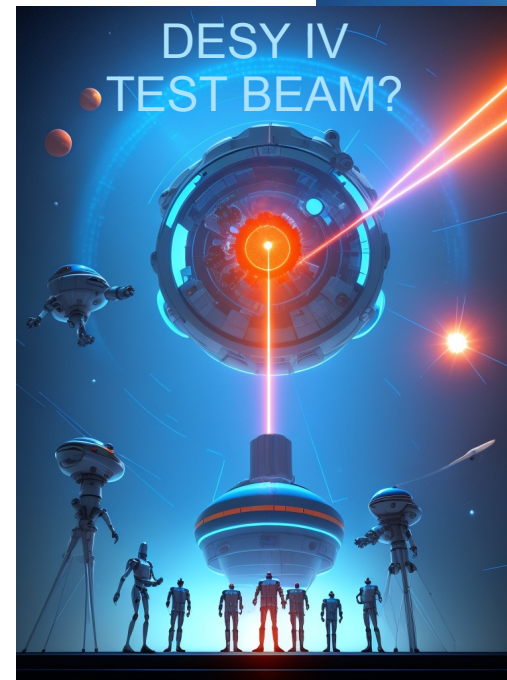
## Current and Future Developments



# 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 this is not a done deal
  - Implementation of test beam lines in DESY IV has still to be designed
- Petra IV project currently undergoing review
  - official timeline: shutdown 2027 → 2028/2029



# Closing Remarks

## Web, Publication, Acknowledgments, Contact

- More information can be found on our web page: [testbeam.desy.de](https://testbeam.desy.de)
- And in the reference publication: *"The DESY II test beam facility"* <https://doi.org/10.1016/j.nima.2018.11.133> ,  
*NIMA, Volume 922, 1.4.2019, Pages 265-286*
- Please include this acknowledgment in publications, presentations etc. based on data from DESY 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, don't forget the AIDA and EURO-LABS acknowledgments where applicable:
    - AIDA 2020: *"This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168."* 
    - AIDA Innova: *"This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101004761."* 
    - EURO-LABS: *"The research leading to these results has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101057511."* 
- Contact: [testbeam-coor@desy.de](mailto:testbeam-coor@desy.de)