Test Beams at DESY
Status and Plans

Sven Ackermann, Ralf Diener, Norbert Meyners, Marcel Stanitzki

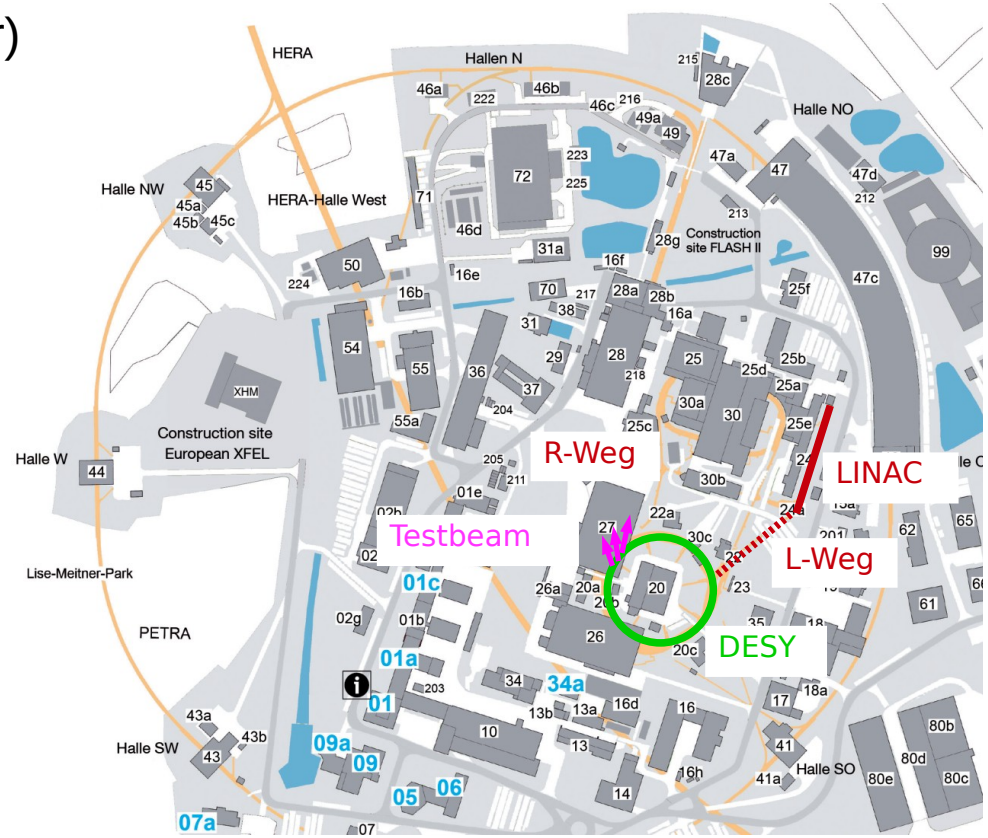
HELMHOLTZ

DESY.

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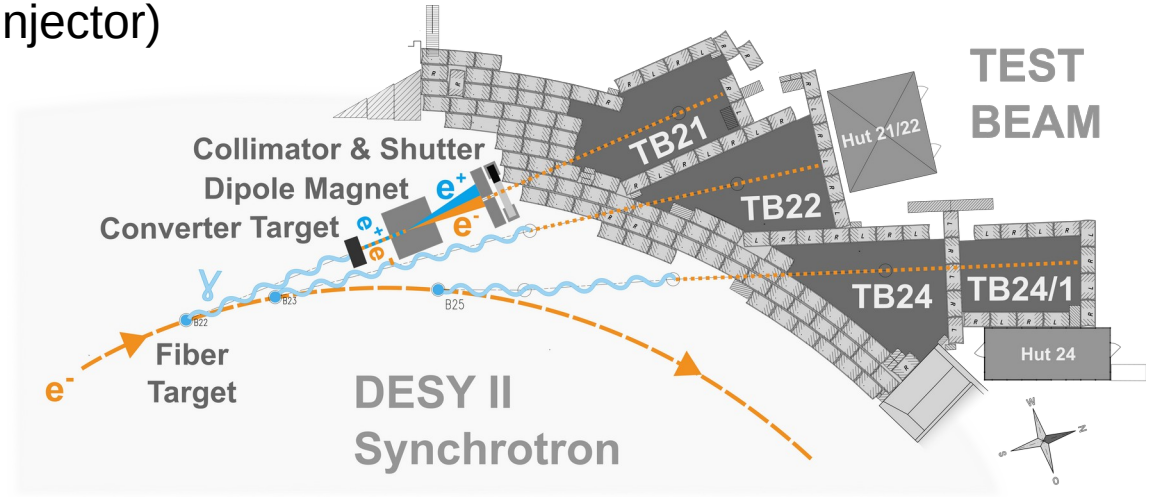
  - 3 primary carbon fiber targets generate bremsstrahlung photons
  - Conversion at secondary target to e^+/e^- up to 6 GeV
  - Energy selected with dipole / collimator



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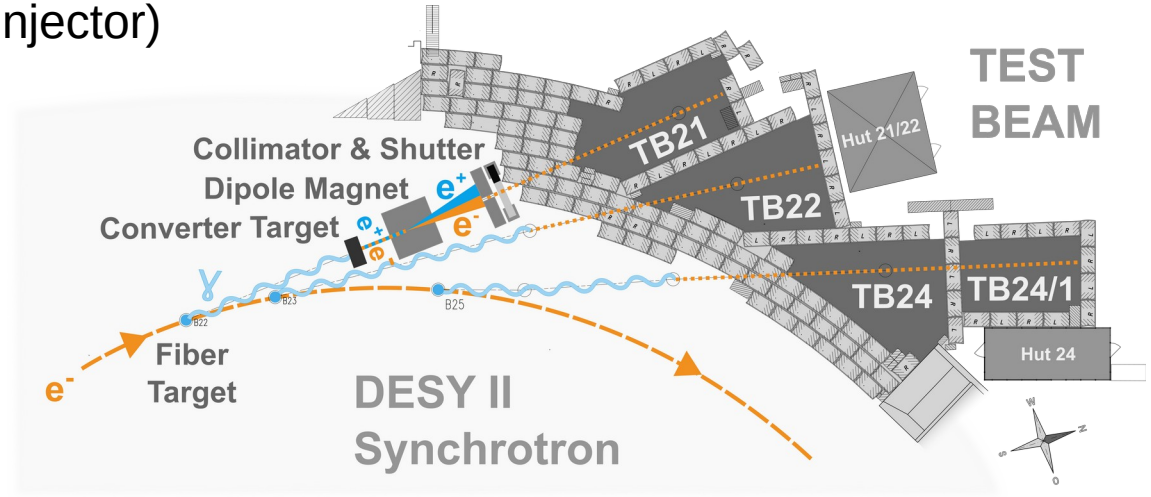
  → Single electrons, rates *O*(10k particles s^{-1} cm^{-2}) depending on beam line, energy, converter target, collimation
- Three individual beam lines, controlled by the user: shutter, area interlock, converter, momentum + collimation



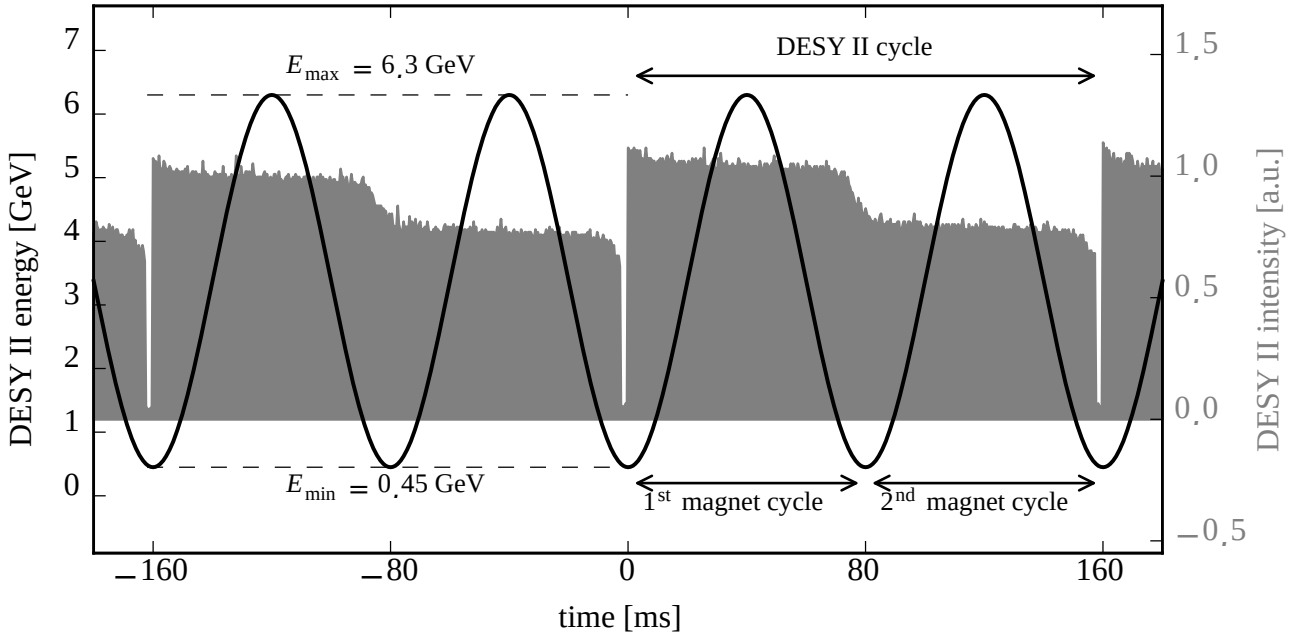
Facility

Overview and Beam Generation

Accelerating the Beam

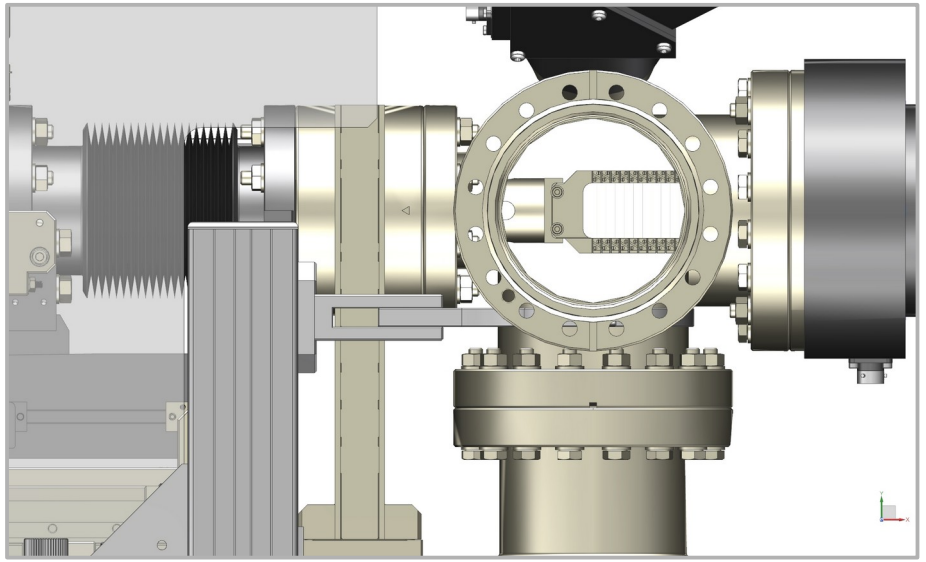
The DESY II Synchrotron

- 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

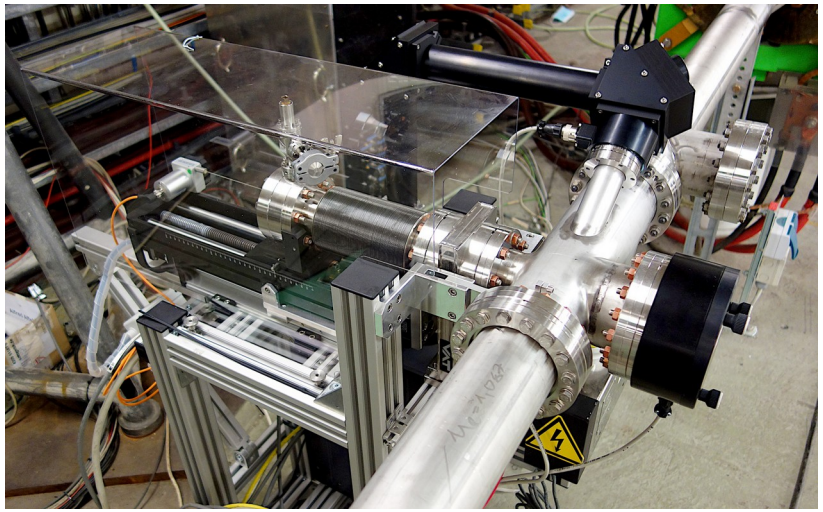


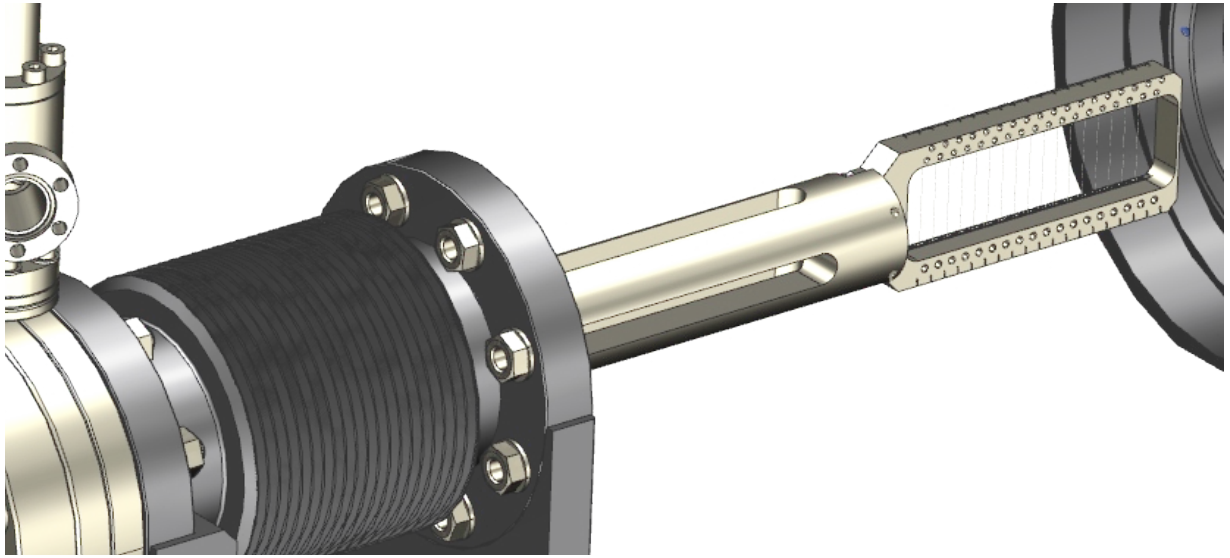
Facility and Beam Generation

Primary Target



- In the primary target station there's a "harp" with ten carbon fibers, 7 µm thick
- One the these is driven into the electron beam in DESY II
- Bremsstrahlung spectrum
  - Steeply falling of … but still lots of photons per bunch hitting the secondary target.
  - Maximum energy of the photon depends on the beam energy
  - Due to cycling, makes it a bit complicated

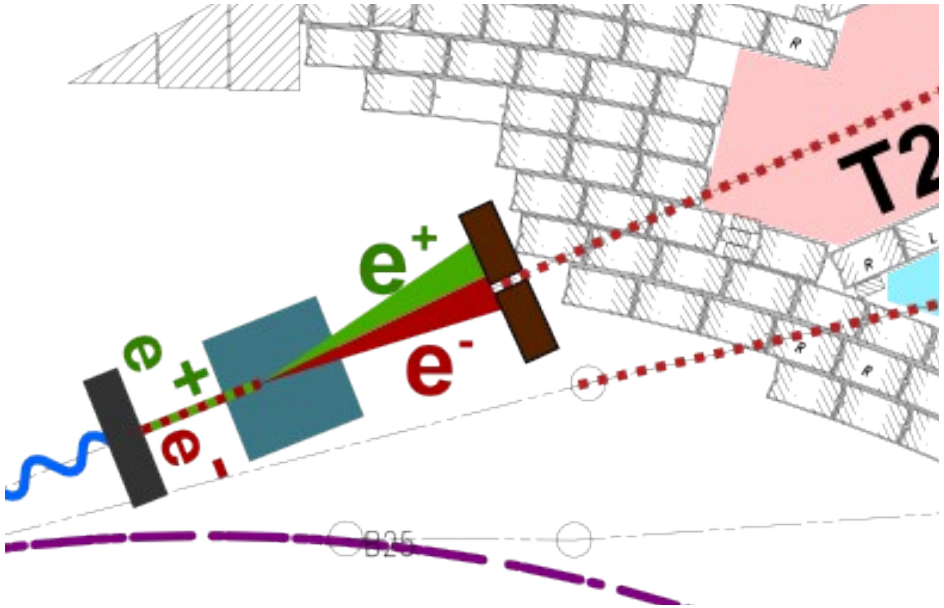


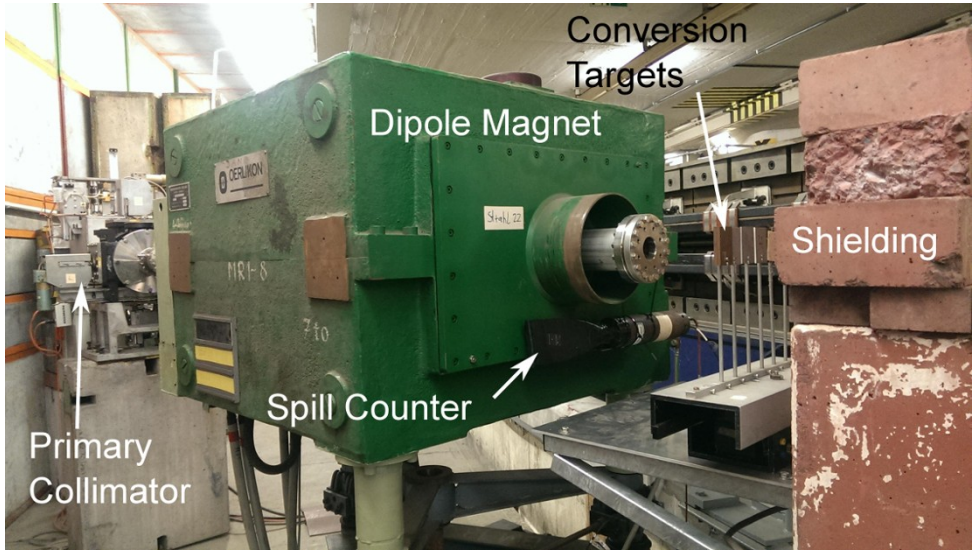


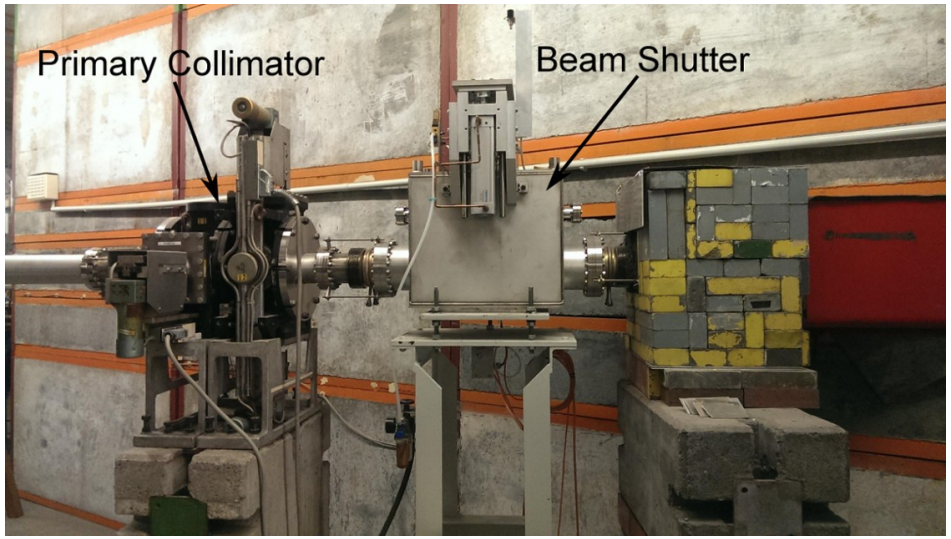
Facility and Beam Generation

Secondary Target

- Bremsstrahlung photons from the primary target hit a secondary target: thin metal plate
  - Here they can do pair production: $\gamma \rightarrow e^+e^-$
- The collimator is at a fixed position
- By adjusting the magnet power, we can select the electron postrion/energy



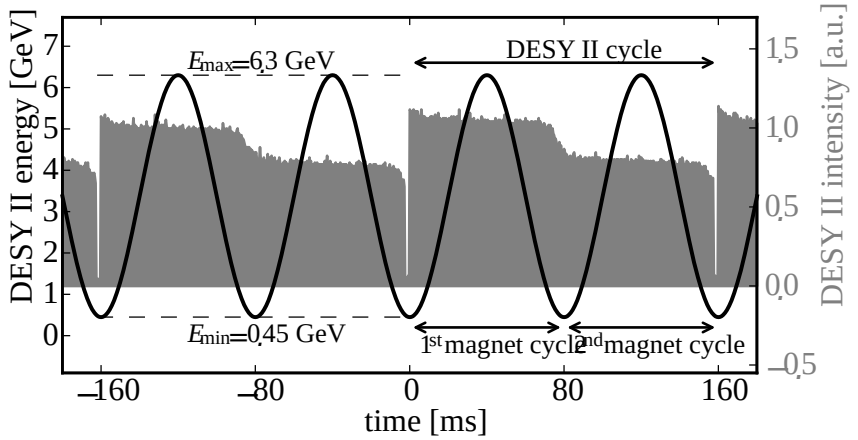


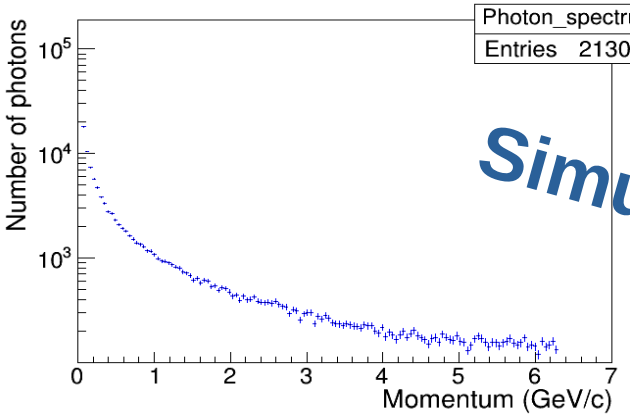


Beam Generation

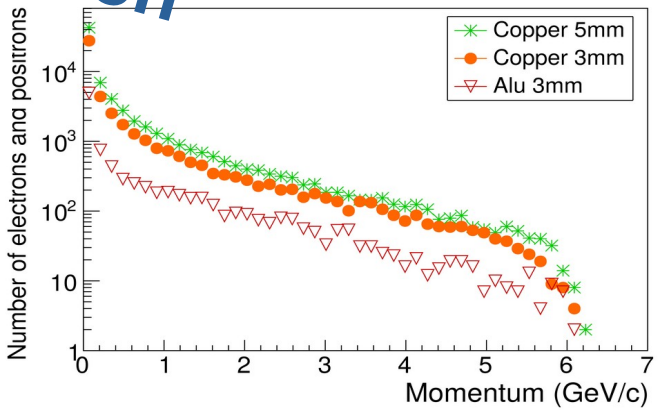
Beam Properties

- What users are usually interested in: rate, energy (precision)
- Tricky to determine as it depends on many parameters:
  - DESY II synchrotron cycles energy,
  - Beam 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





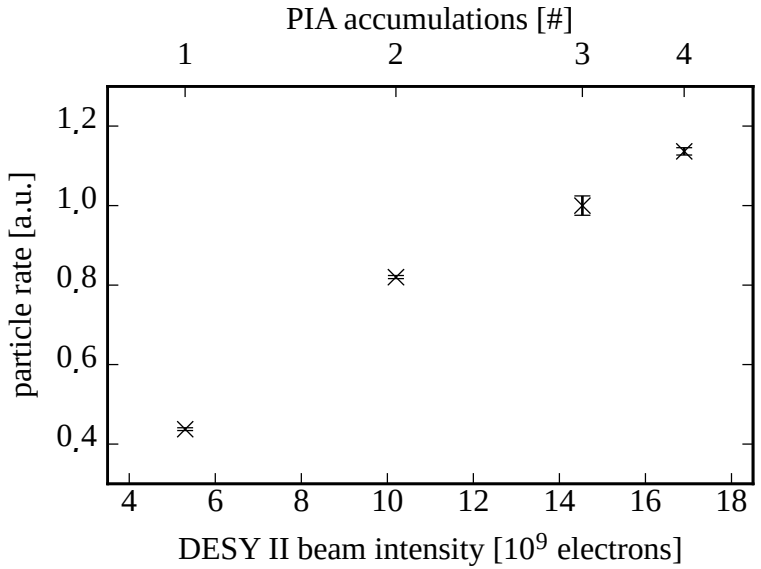
Simulation

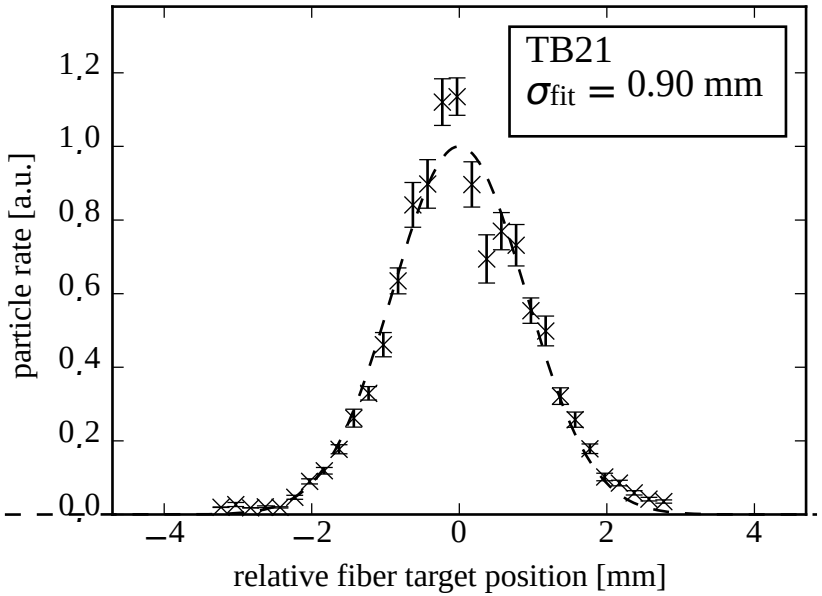


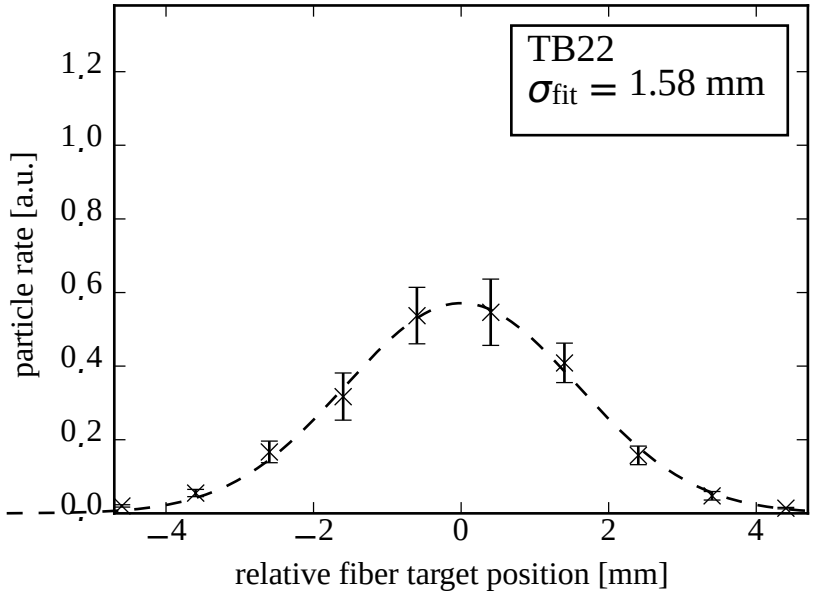
Some numbers

Beam Properties

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







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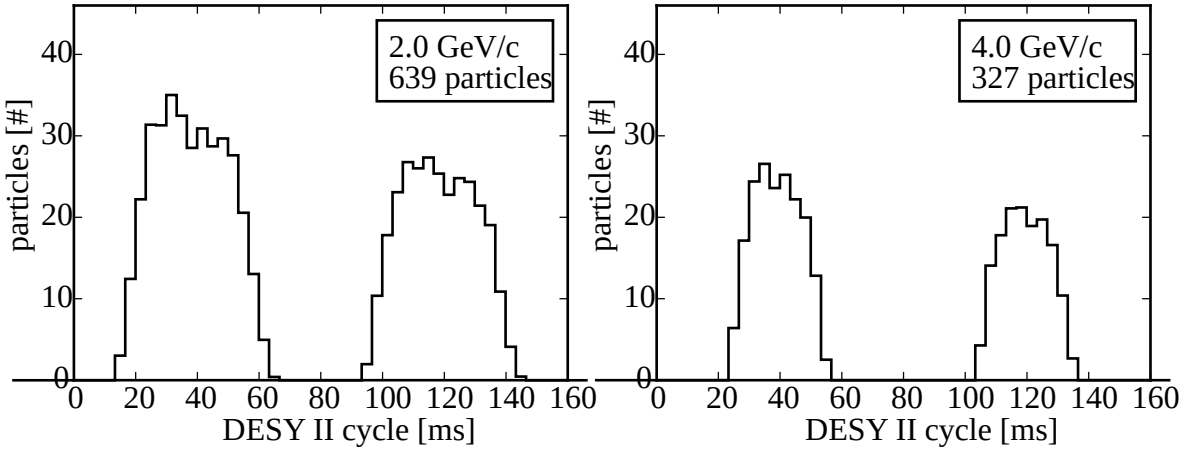
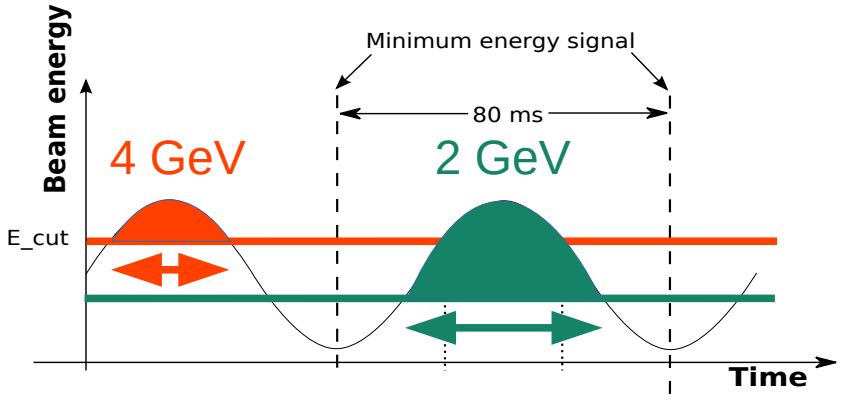
Beam Properties

- 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

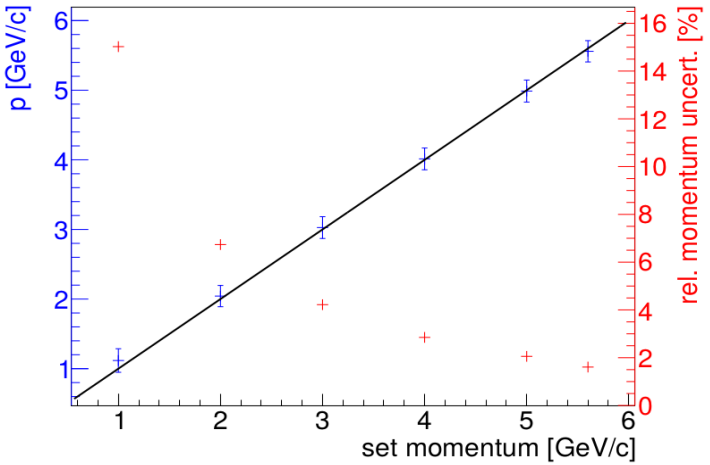


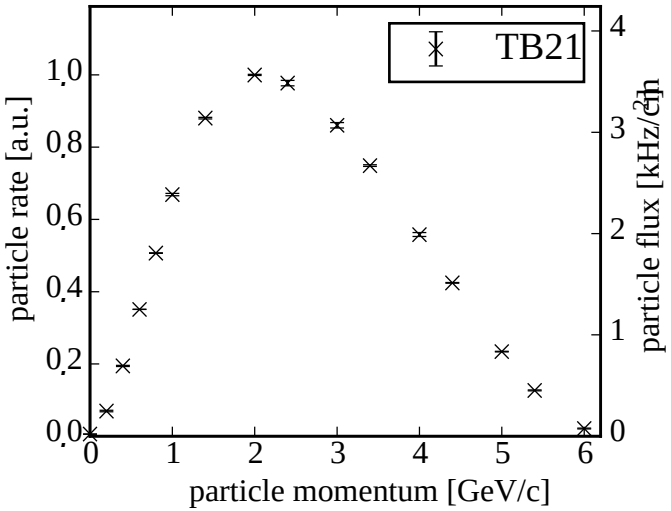


Some numbers

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)

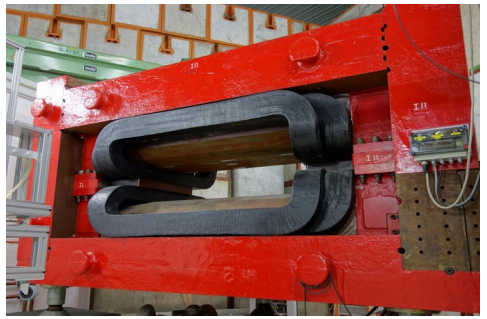




Facility

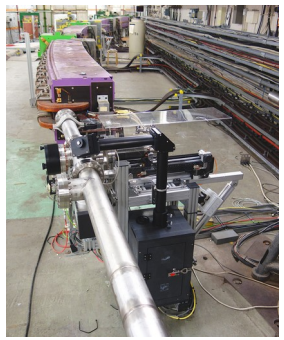
Infrastructure

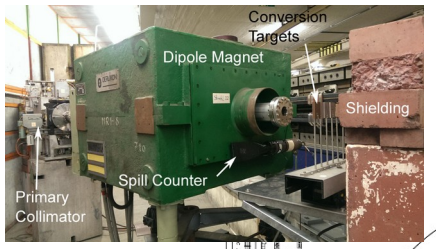
- Remote controlled 1 t and 30 kg stages
- Hall crane, up to 25 t
- Test magnets: SC 1 T solenoid (TB24/1), 1.35 T dipole (TB21)
- EUDET-type beam telescope in two areas,
  ALPIDE based telescope prototype in one
- Remote controlled IP cameras in each area
- Dry nitrogen, cooling water in each area
- 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-4
  optical fiber (single and multi-mode)



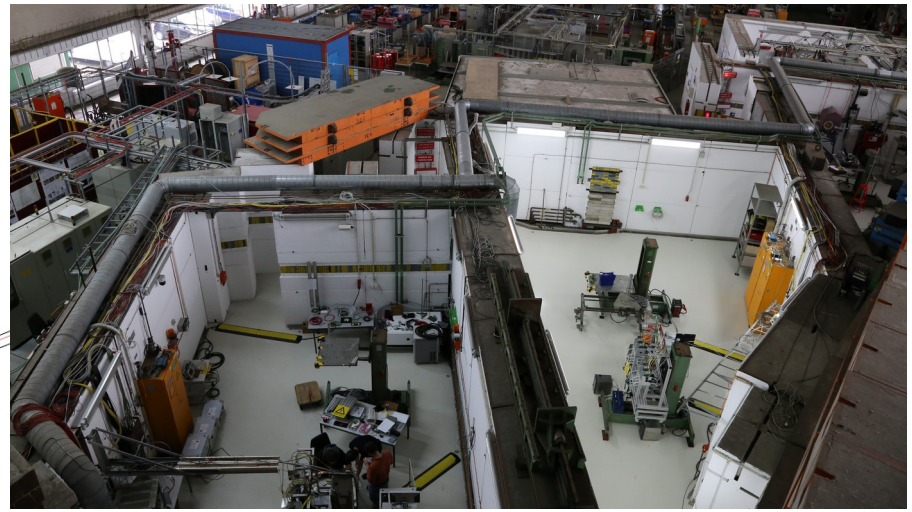
A

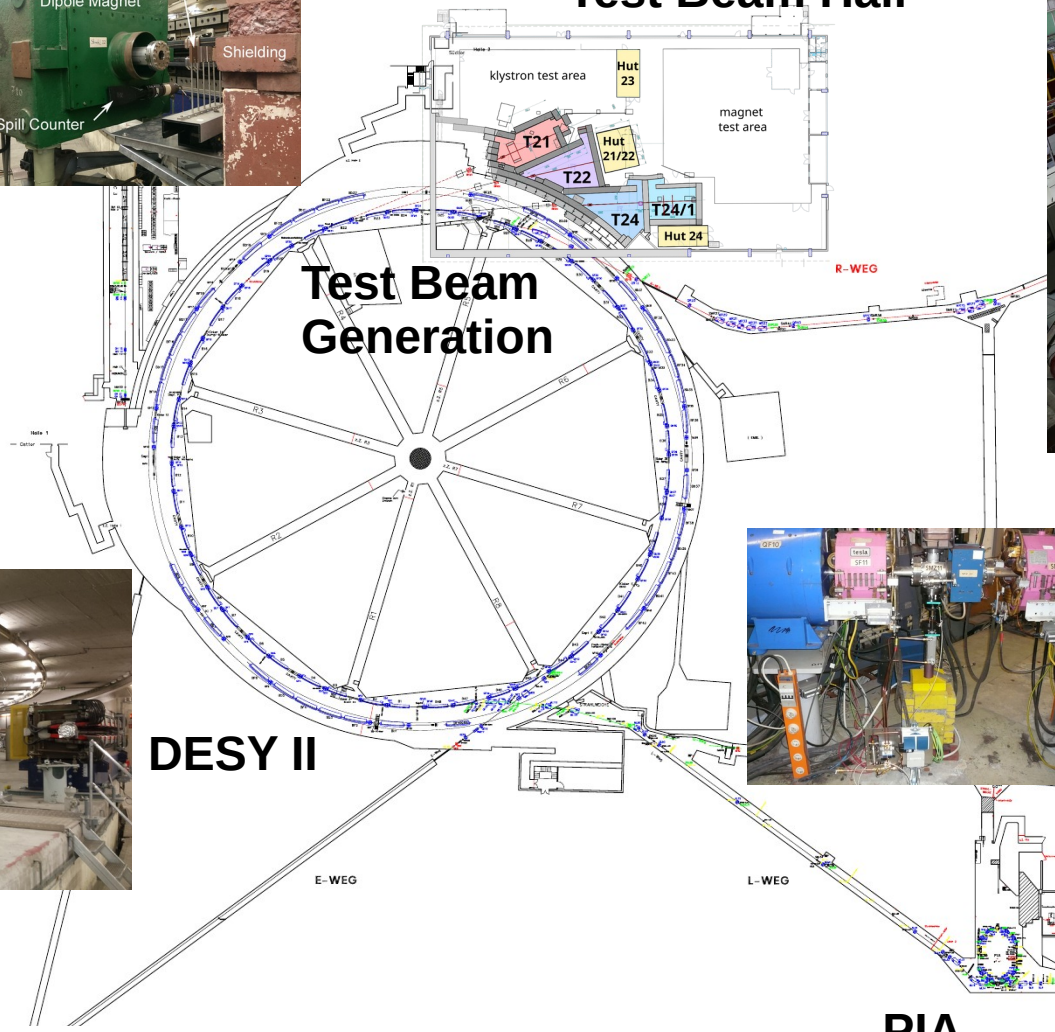
The entire accelerator chain





Test Beam Hall



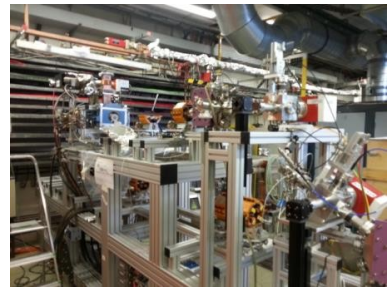


Test Beam Generation

DESY II

PIA

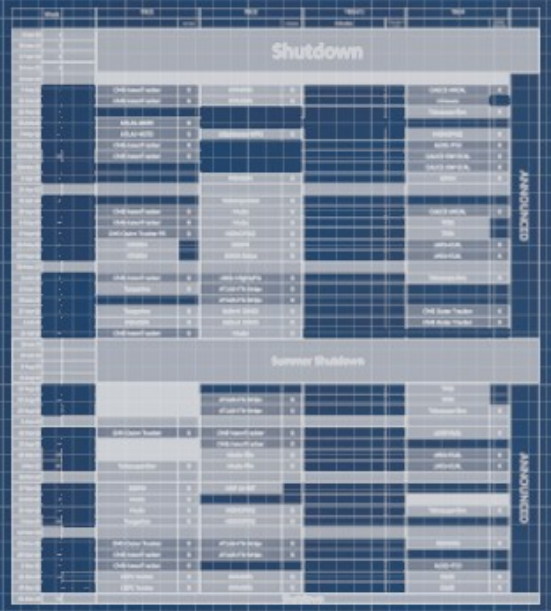
LINAC II

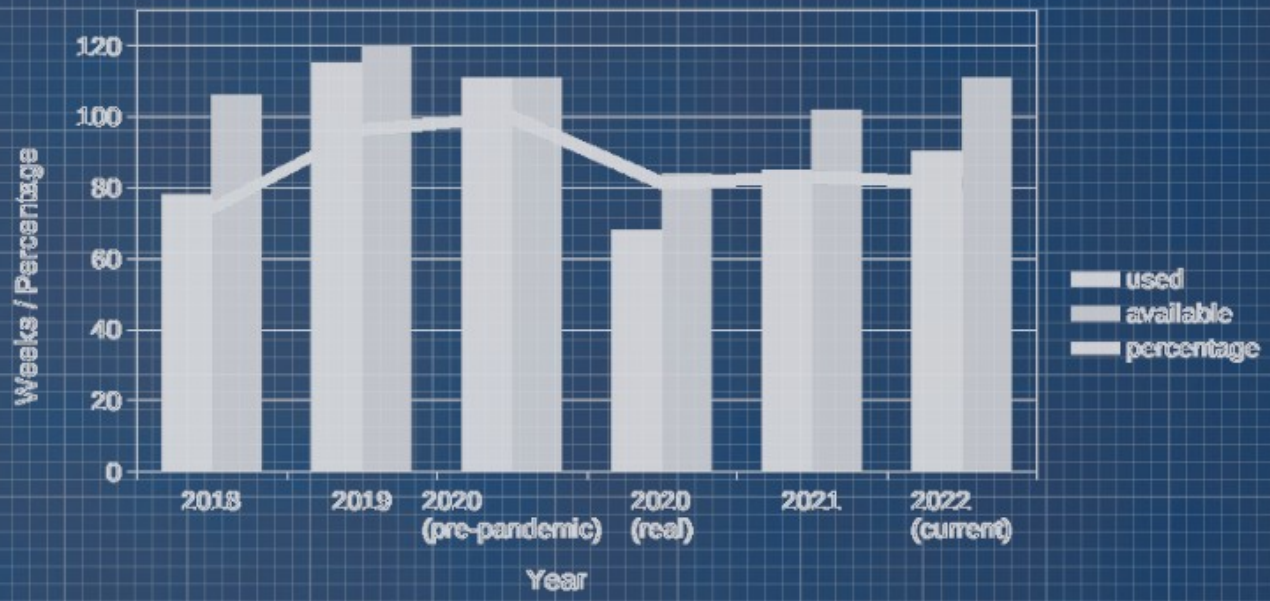


Electron “Gun”

Schedule

Booking, User Statistics, Outreach





Schedule 2024 - ongoing

Preliminary Numbers after 6 month

- We are running till Christmas (December, 20th) as usual
  - Well booked – ~ 80% usage
- Currently
  - 321 users from 16 Countries so far

DESY 2 Test Beam Schedule 2024 - Status from 19/JUN/2024

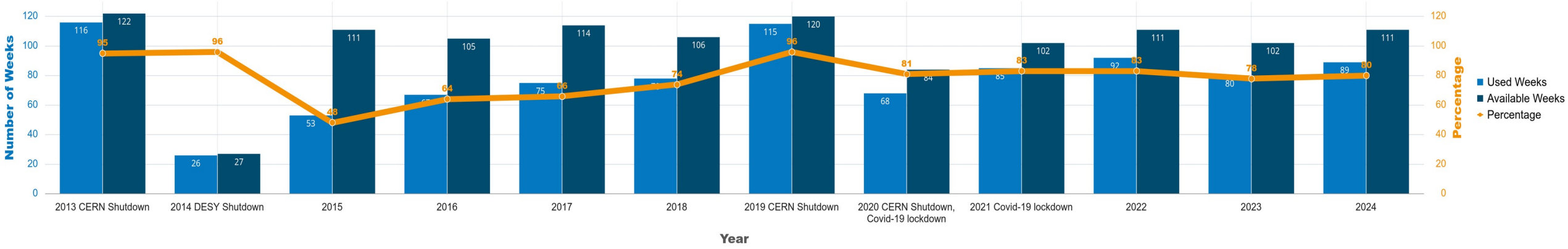
DESY 2 Test Beam Coordinators: Ralf Diener, Norbert Meyners, Marcel Stanitzki

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			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	HD HV-MAPS	X			IPHC-CE65_v2	
13.05.2024	20	Maintenance		Maintenance		Maintenance		Maintenance	
20.05.2024	21	MDI-2		dSiPM	X			CMS HGCAL	
27.05.2024	22	ATORCH		Tangerine	X			CMS HGCAL	
03.06.2024	23	CMS ETL ETROC	X	Tangerine	X				
10.06.2024	24	CMS ETL ETROC	X						
17.06.2024	25	CMS ETL ETROC	X	DCRSD	X				
24.06.2024	26	CMS Inner Tracker	X	ATLAS-ITk-Strips	X				
01.07.2024	27	Maintenance		Maintenance		Maintenance		Maintenance	
08.07.2024	28	MONOPIX2	X	Telescope-Dev				CMS-HGCAL	X
15.07.2024	29	Belle-II CMOS	X					MIMOSIS	
22.07.2024	30								
29.07.2024	31	BL4S preparation		TelePix	X				
05.08.2024	32	Shutdown		Shutdown		Shutdown		Shutdown	
12.08.2024	33	Shutdown		Shutdown		Shutdown		Shutdown	
19.08.2024	34	Shutdown		Shutdown		Shutdown		Shutdown	
26.08.2024	35			Telescope-Dev				CMS HGCAL	X
02.09.2024	36								
09.09.2024	37	BL4S	X						
16.09.2024	38	BL4S	X						
23.09.2024	39			Tangerine	X			UHH-LGAD	X
30.09.2024	40			RD50-MPW4				CalVision	
07.10.2024	41	Maintenance		Maintenance		Maintenance		Maintenance	
14.10.2024	42	ATORCH		ATLAS-ITk-Strips	X			DDR6-CALICE SiW-ECAL	X
21.10.2024	43			Tangerine	X				
28.10.2024	44	MONOPIX2	X	Tangerine	X			EEEMCAL	
04.11.2024	45	MONOPIX2	X	UHH-LGAD	X			EEEMCAL	
11.11.2024	46	Maintenance		Maintenance		Maintenance		Maintenance	
18.11.2024	47	CMS HGCAL	X	ATLAS HGTD	X			LHCb-ECAL	
25.11.2024	48	CMS Inner Tracker	X	ATLAS HGTD	X			LHCb-ECAL	
02.12.2024	49	CMS Inner Tracker	X	ATLAS-ITk-Strips	X			CMS ETL ETROC	X
09.12.2024	50	LHCb-MightyPix	X	DCRSD	X			CMS ETL ETROC	X
16.12.2024	51	LHCb-MightyPix	X	Telescope-Dev	X			EXFLU	
23.12.2024	52	Shutdown		Shutdown		Shutdown		Shutdown	

Statistics 2013 - 2024

Booking/Usage Statistics

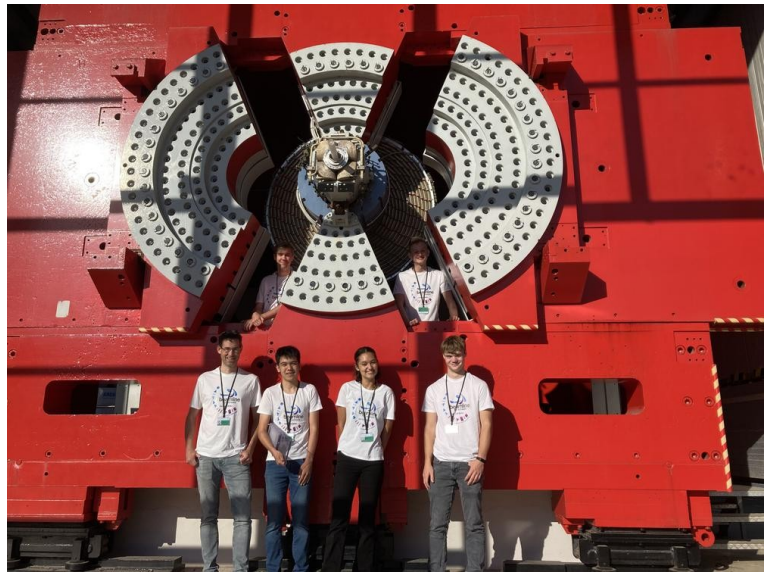
> 700 Users (2019)



Outreach and Education

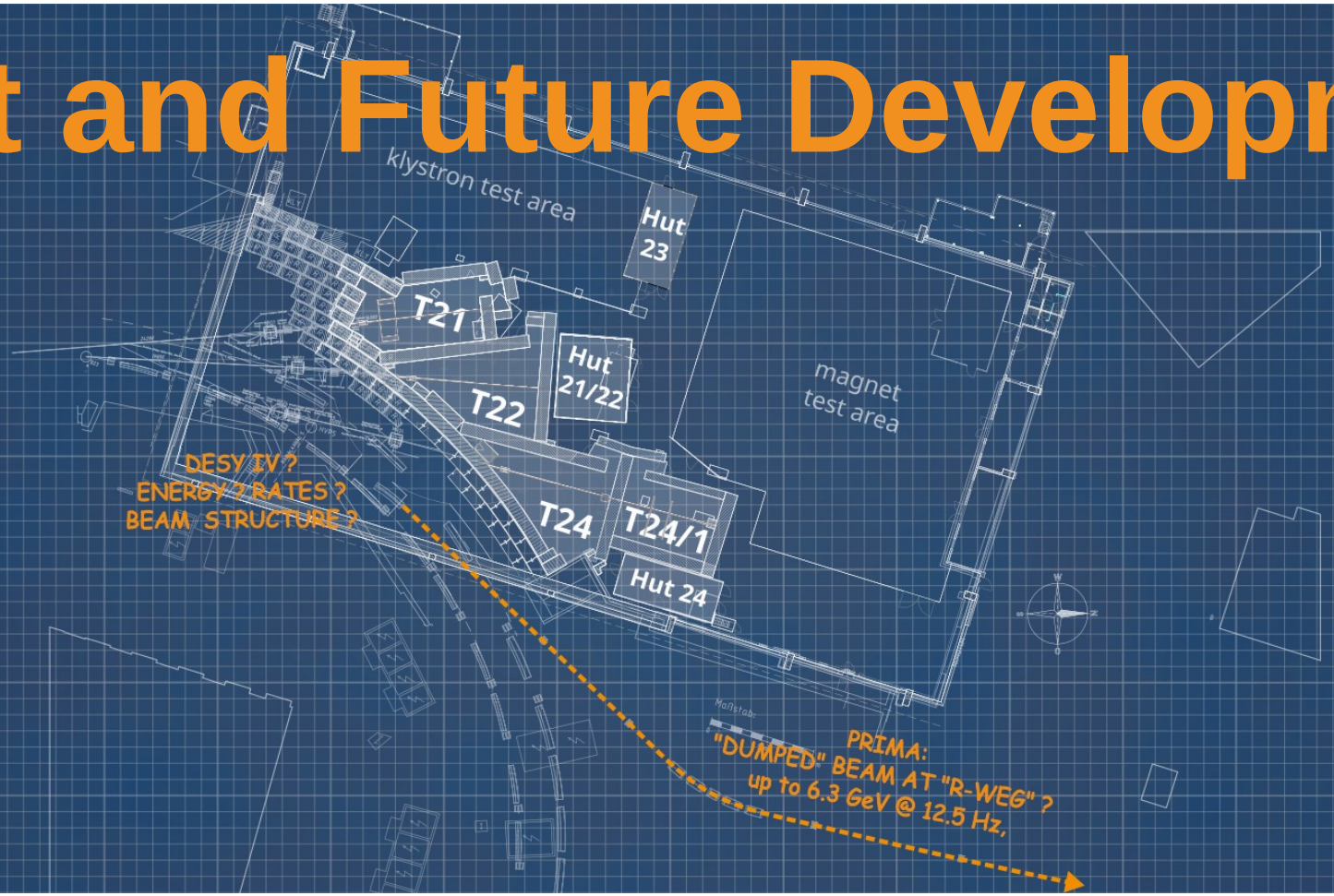
Beam Line 4 Schools

- In 2022, competition held for first time at CERN and DESY in parallel
  - Participation of 2000 high-school students in 304 teams from 58 countries
  - In 2023 running in the same mode
- CERN
  - Myriad Magnets - Phillips Exeter Academy, Exeter, NH, USA
  - Particular Perspective - 4 Schools from Pakistan
- DESY
  - The Wire Wizards – Augustinianum, Eindhoven Netherlands
- Finals currently at both CERN and DESY
  → lots of activities



Outlook

Current and Future Developments



Future

Test Beam Facility in Petra IV times

- Upgrade PETRA III → PETRA IV:
  - New booster synchrotron *DESY IV ?*
  - *Or Plasma Injector ?*

- 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
  - Work is ongoing to explore several options

- Petra IV project not yet approved;
  - official timeline: shutdown start end 2029

Why are we interested in crystals ?

For futre Test Beam s

- Upgrade PETRA III → PETRA IV:
  - New booster synchrotron *DESY IV*
  - Much brighter beam
- User needs
  - As high energy as possible → minimizes scattering
  - High rates of single particles, as number of channels will increase by O(100)
- We are discussing various test beam schemes
  - Targets 2.0 → needs some thought, current target would melt
  - Exciting third-order resonances → scrape off some particles each turn
  - Using a crystal to extract a few particles per turn
- This may be a really nice opportunity to use this for a user facility

Closing Remarks

Publication, Acknowledgments, Contact

- More information can be found on our web page: 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*
- Applying for beam-time
  - Subscribe to testbeam-info@desy.de for the bi-annual calls
  - After the calls- there is always the possibility to appply for still open slots on a first-come first serve basis
- Travel Support
- There is limited support available via the Eurolabs programme
  - See our web pages testbeam.desy.de
- Contact: testbeam-coor@desy.de