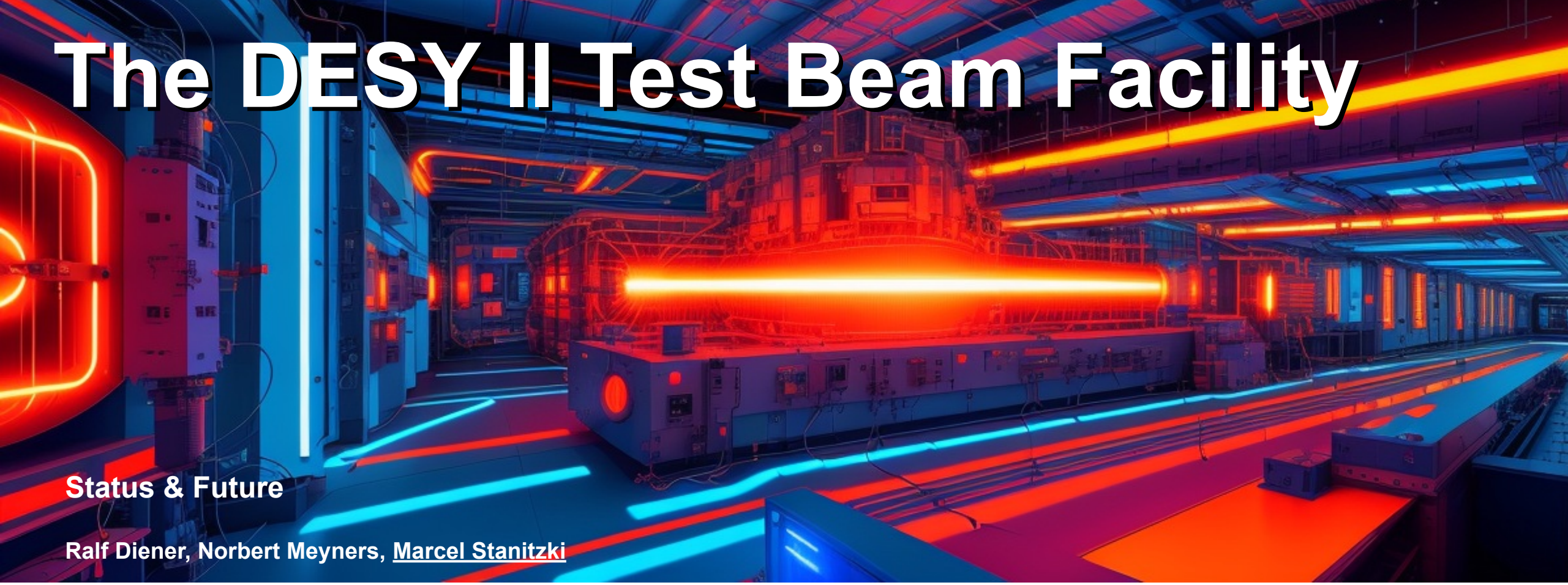
The DESY II Test Beam Facility



Status & Future

Ralf Diener, Norbert Meyners, Marcel Stanitzki

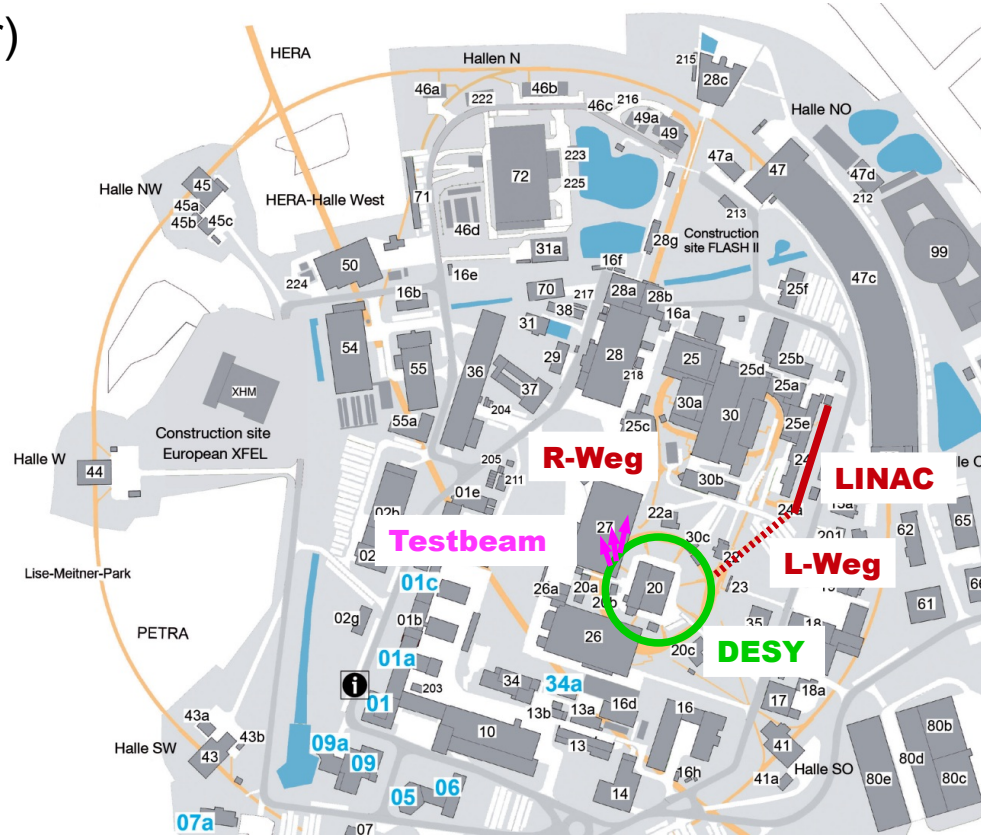
HELMHOLTZ

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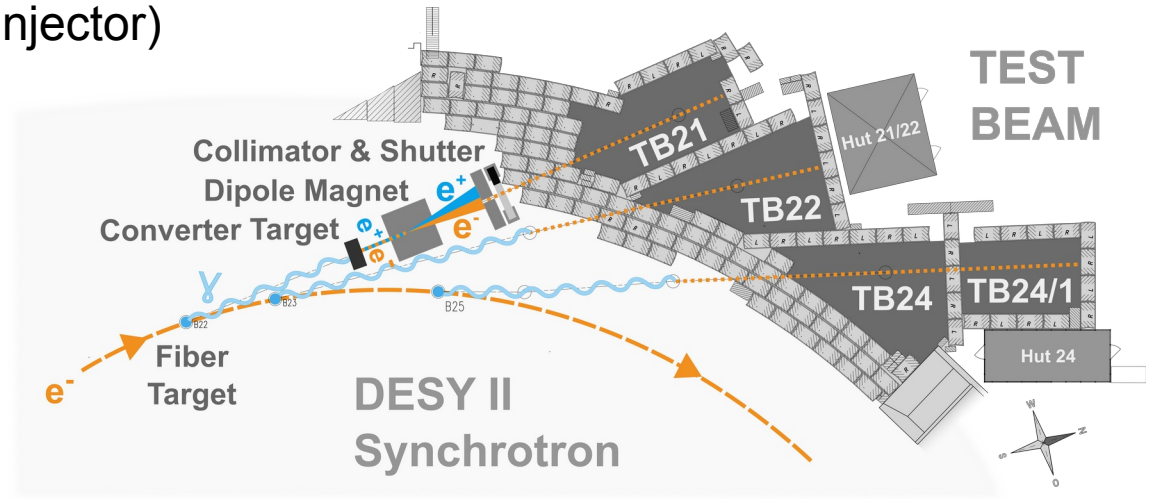
  - 3 primary carbon fiber targets generate bremsstrahlung photons
  - Conversion at secondary target to e^+/e^- up to 6 GeV
  - Energy selected with dipole / collimator



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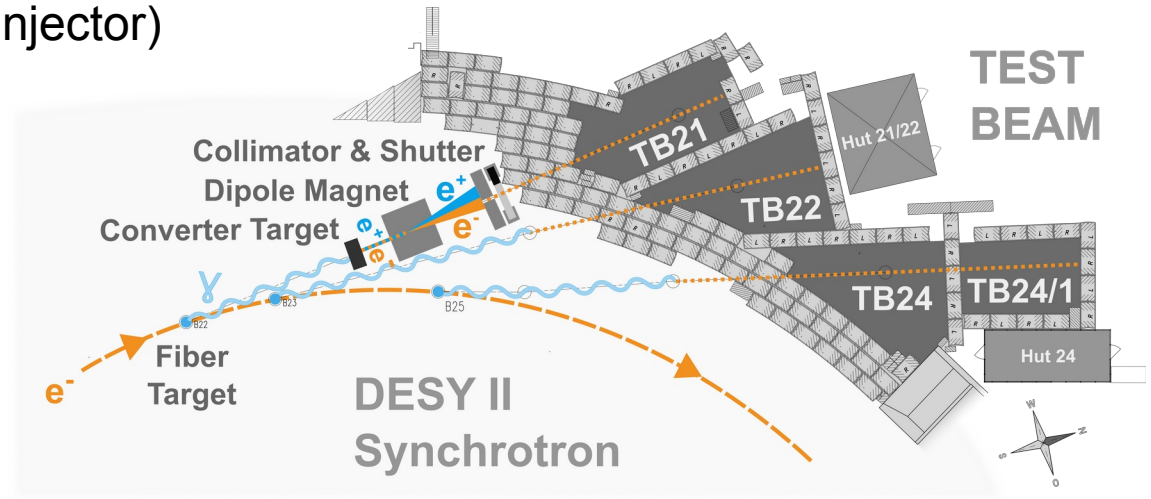
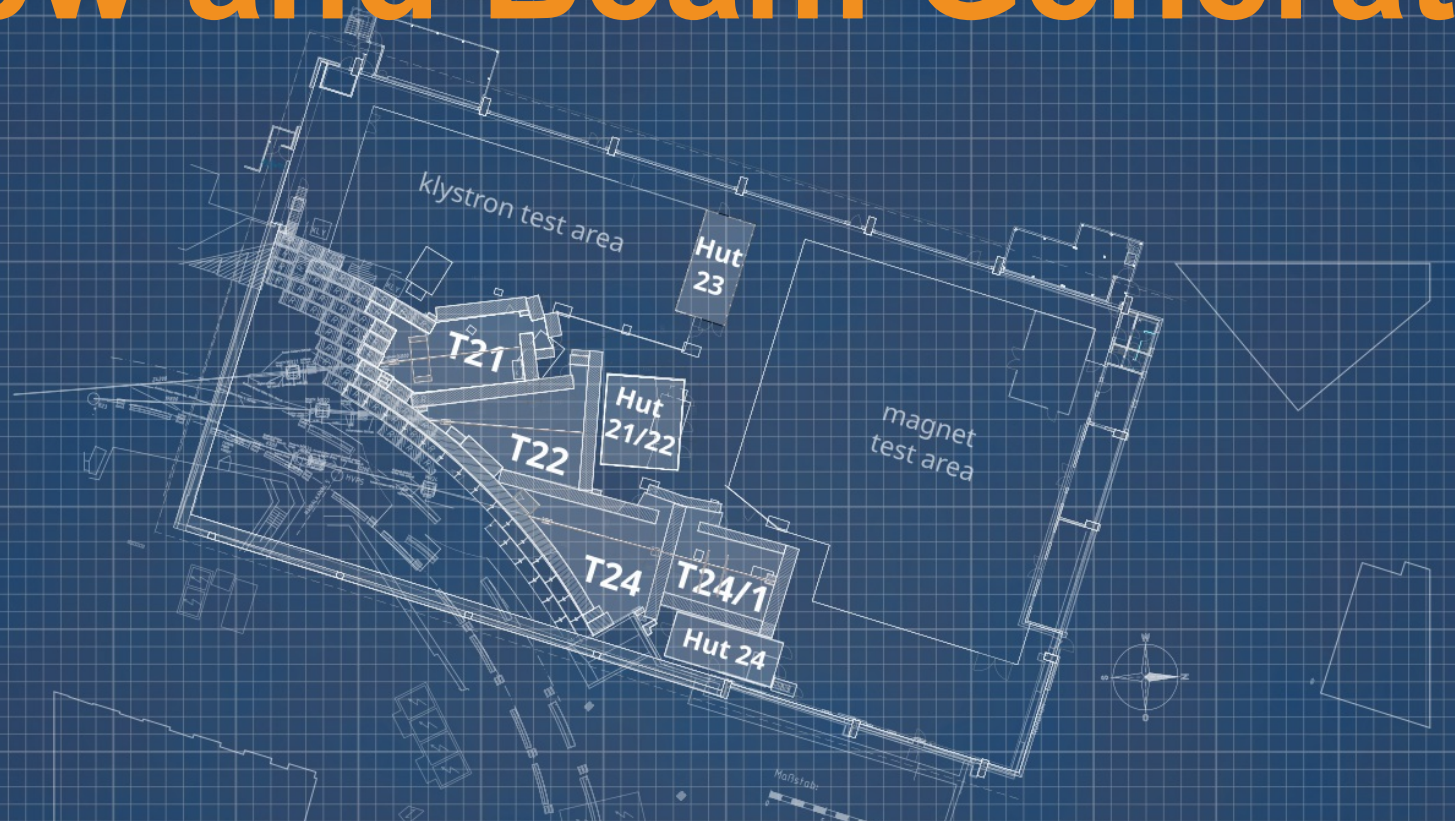
  → Single electrons, rates *O*(10k particles s^{-1} cm^{-2}) depending on beam line, energy, converter target, collimation
- Three individual beam lines, controlled by the user: shutter, area interlock, converter, momentum + collimation



Facility

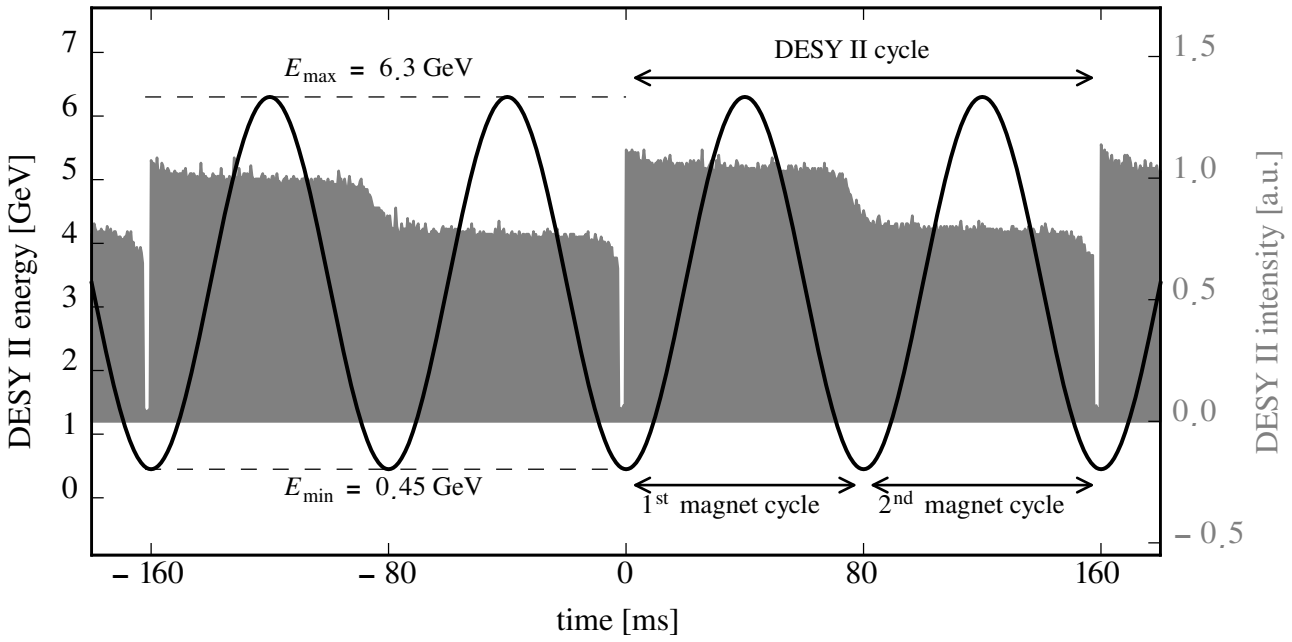
Overview and Beam Generation



Accelerating the Beam

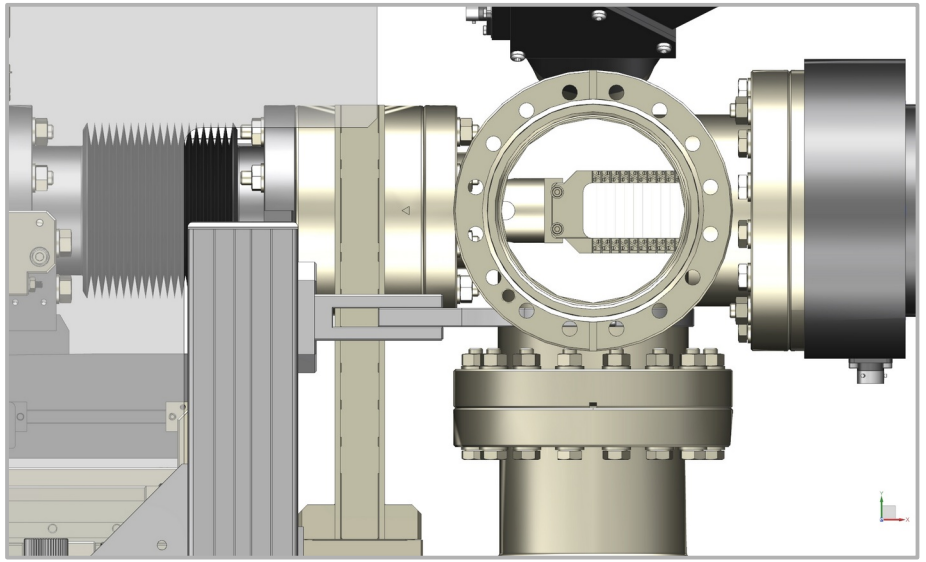
The DESY II Synchrotron

- 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

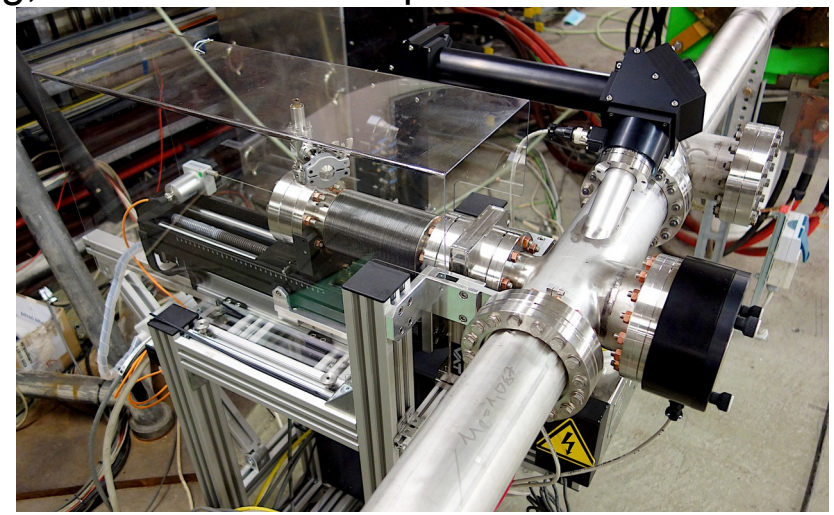


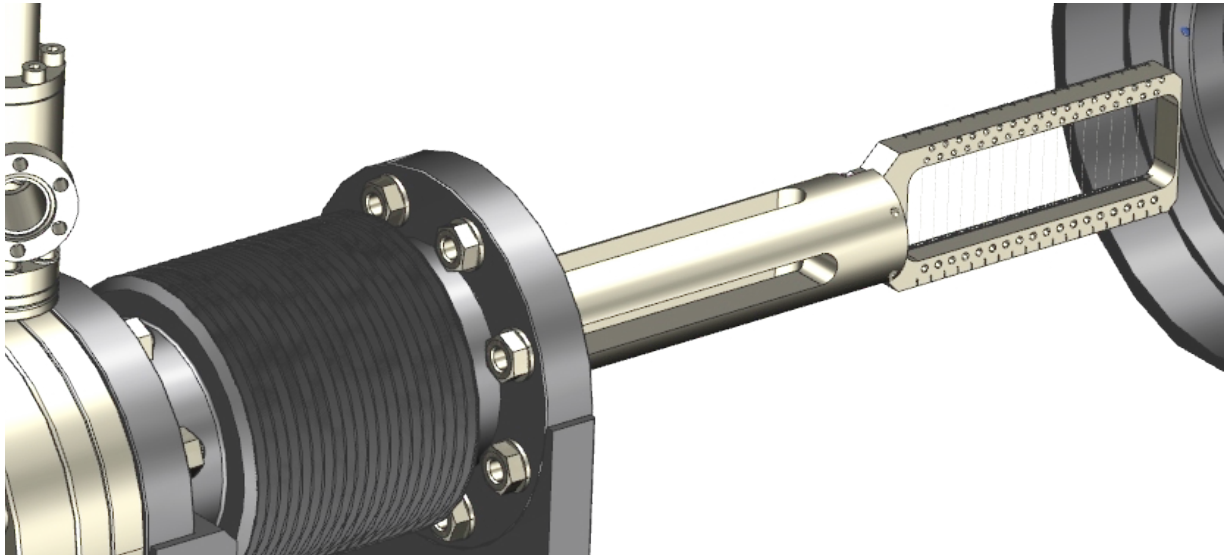
Facility and Beam Generation

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

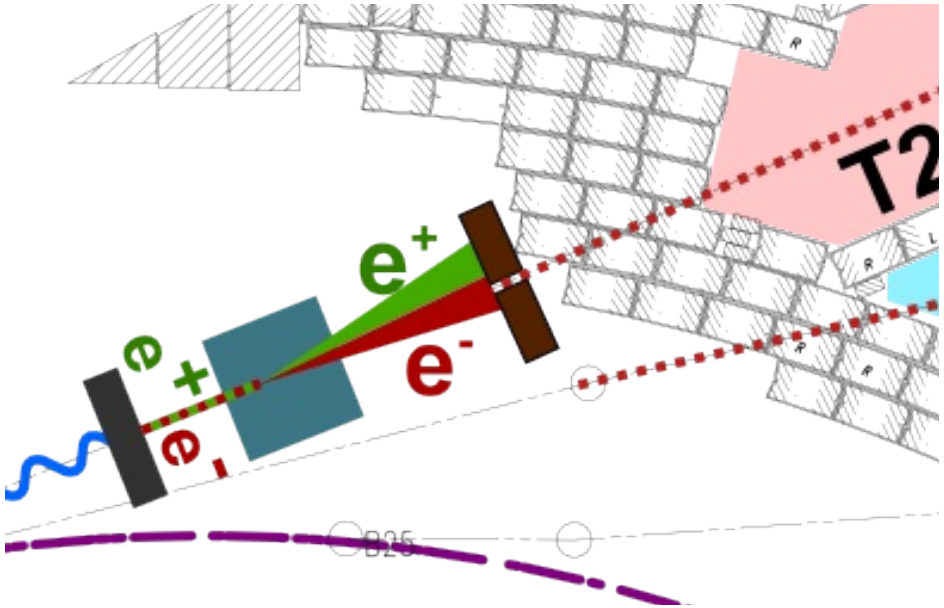


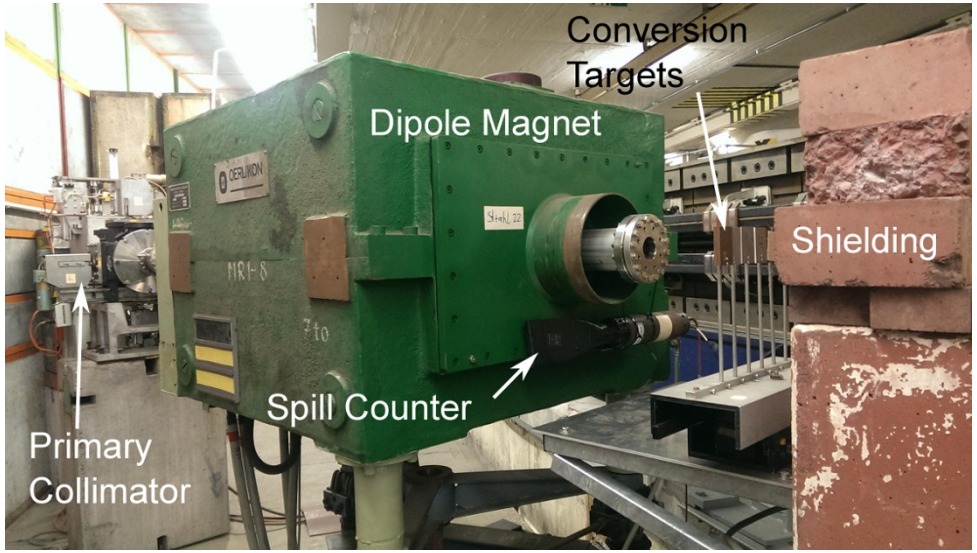


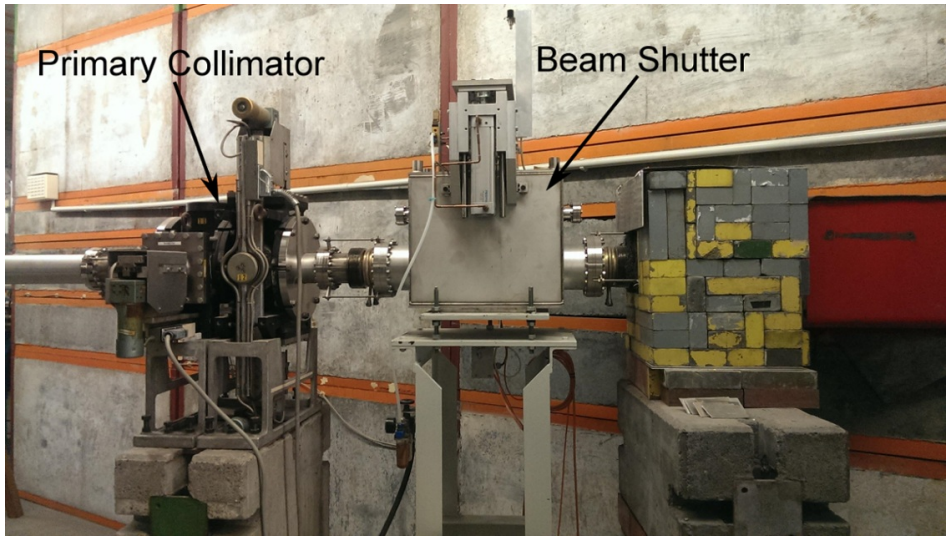
Facility and Beam Generation

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



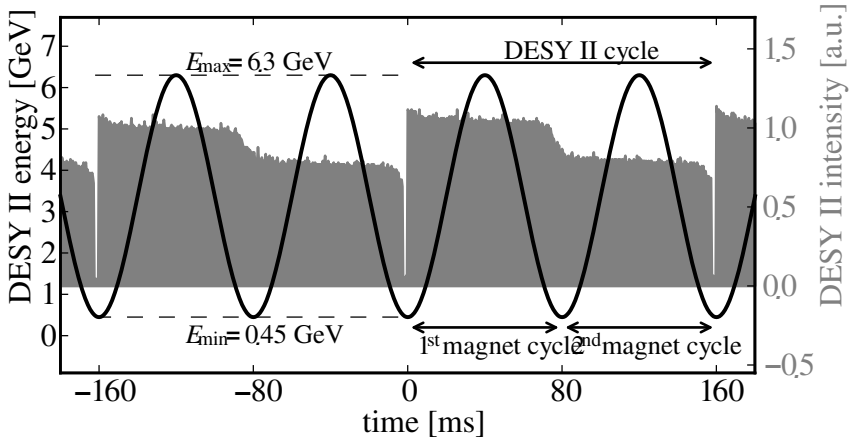


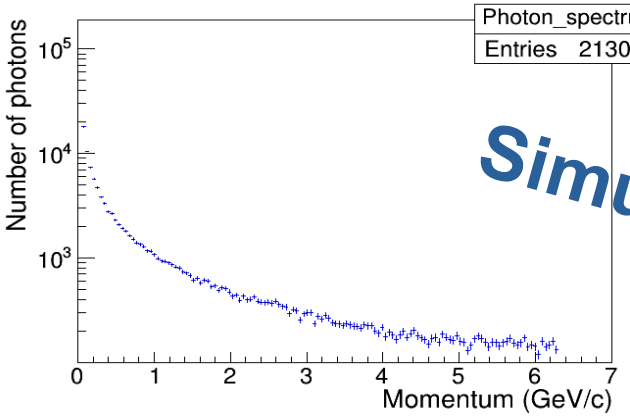


Beam Generation

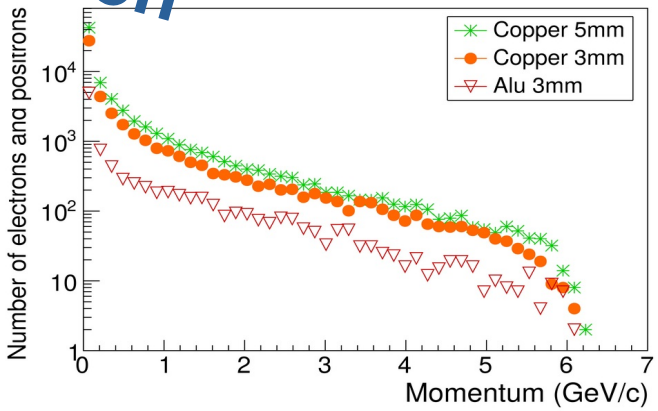
Beam Properties

- 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





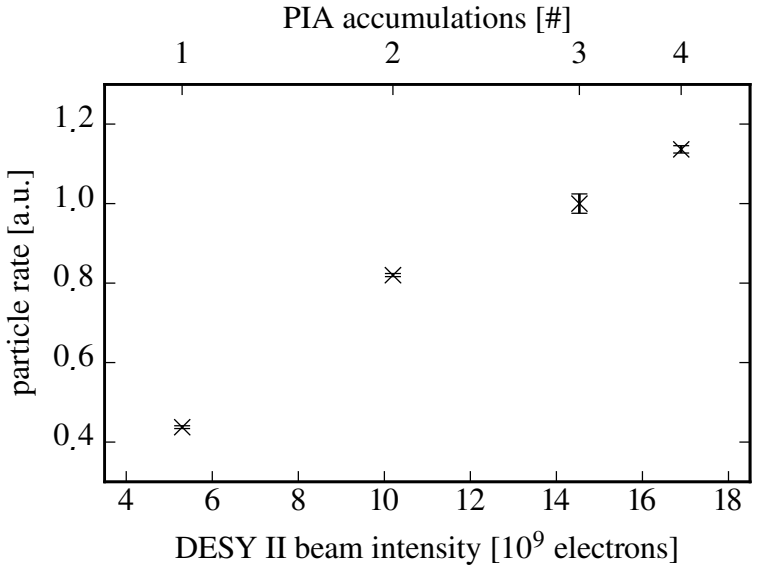
Simulation

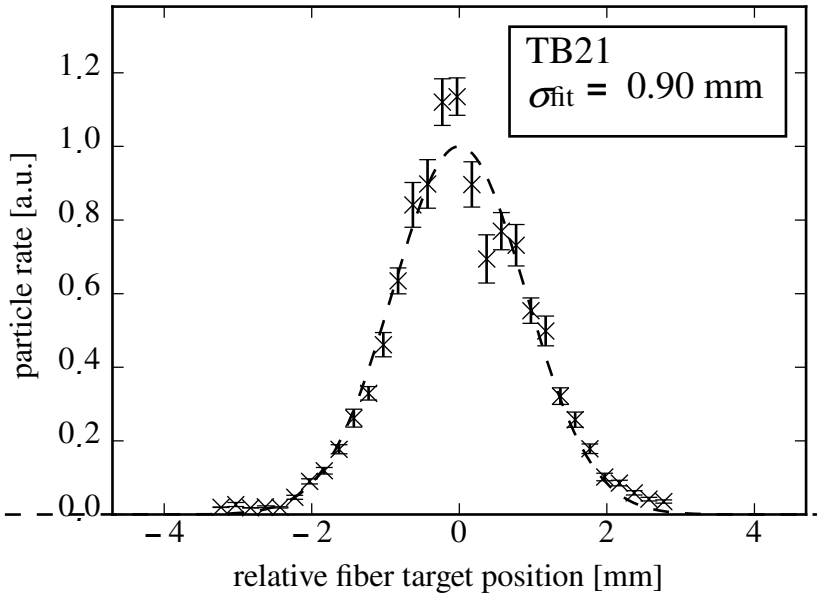


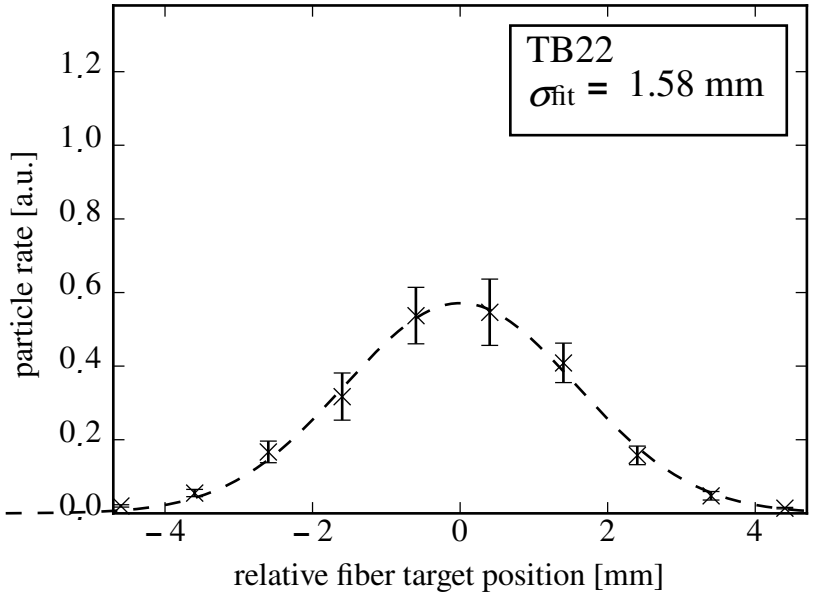
Some numbers

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



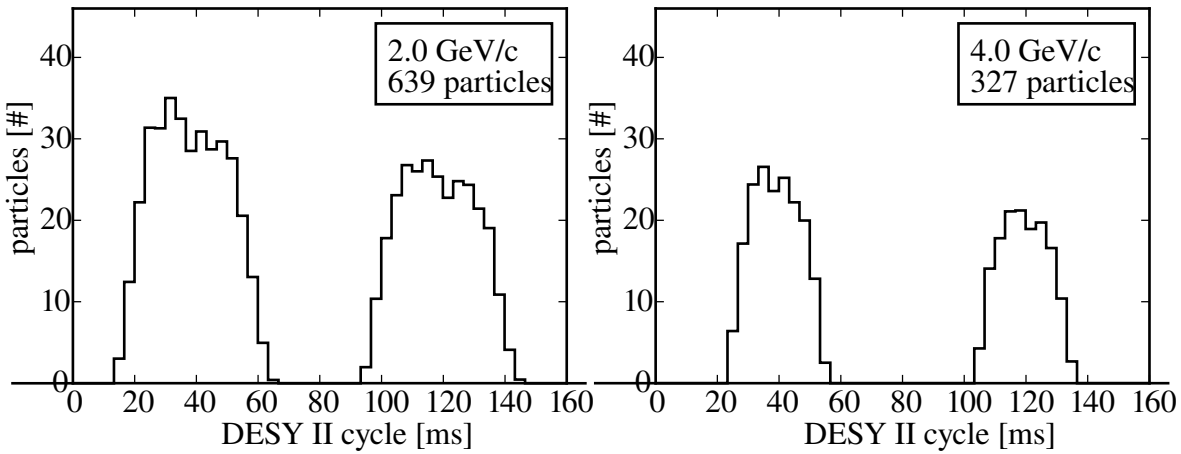


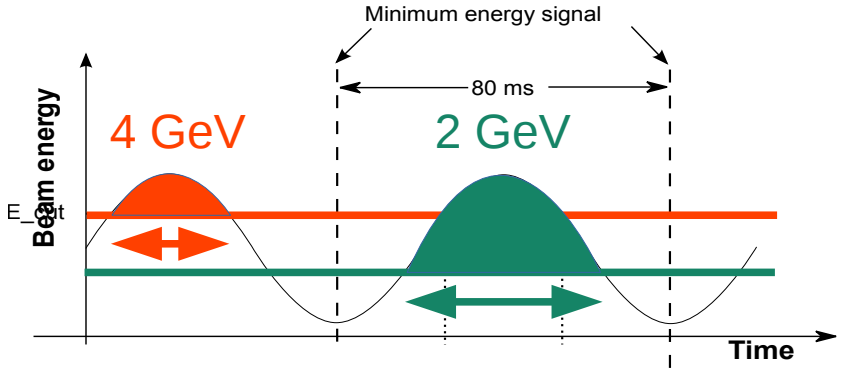


Some numbers

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

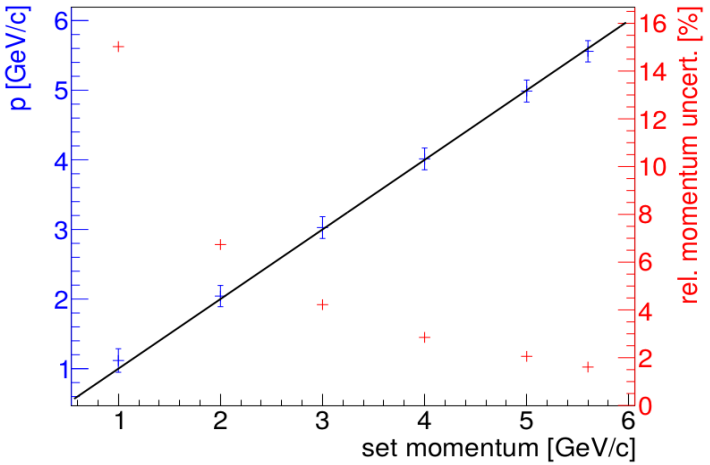


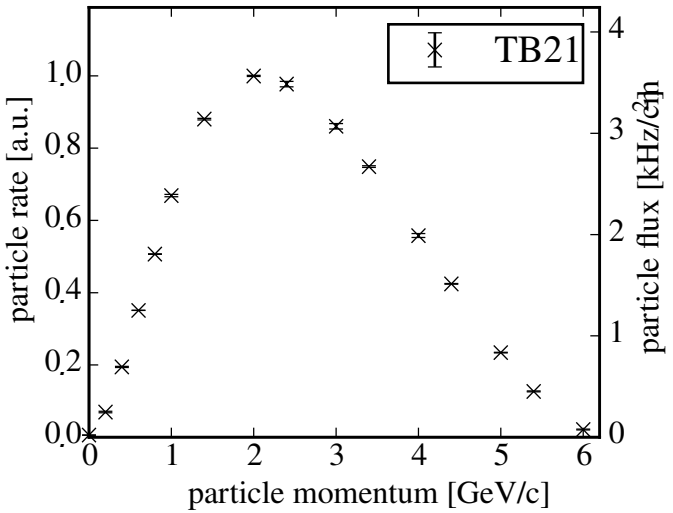


Some numbers

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)

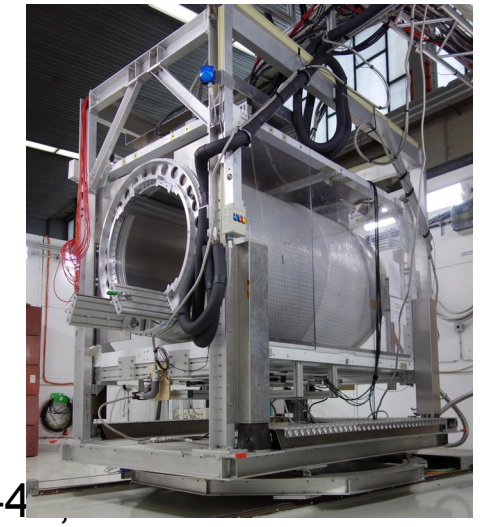


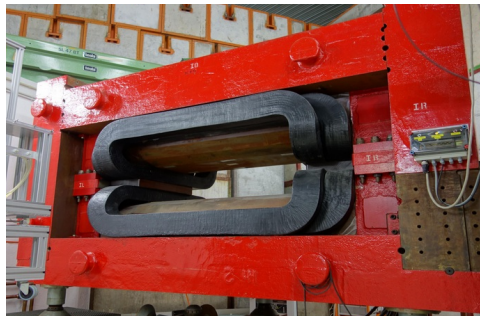


Facility

Infrastructure

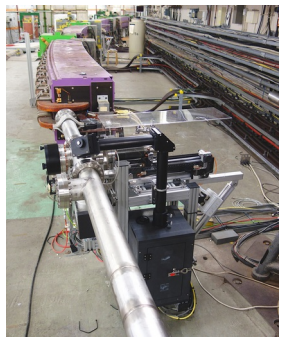
- Remote controlled 1 t and 30 kg stages
- Hall crane, up to 25 t
- Test magnets: SC 1 T solenoid (TB24/1), 1.35 T dipole (TB21)
- EUDET-type beam telescope in two areas,
  ALPIDE based telescope prototype in one
- Remote controlled IP cameras in each area
- Dry nitrogen, cooling water in each area
-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

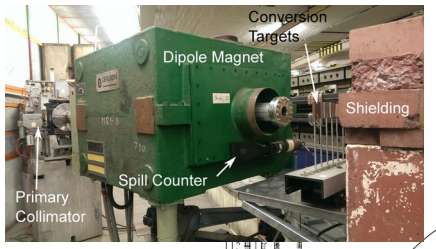




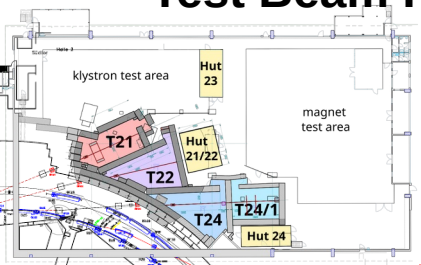
A

The entire accelerator chain

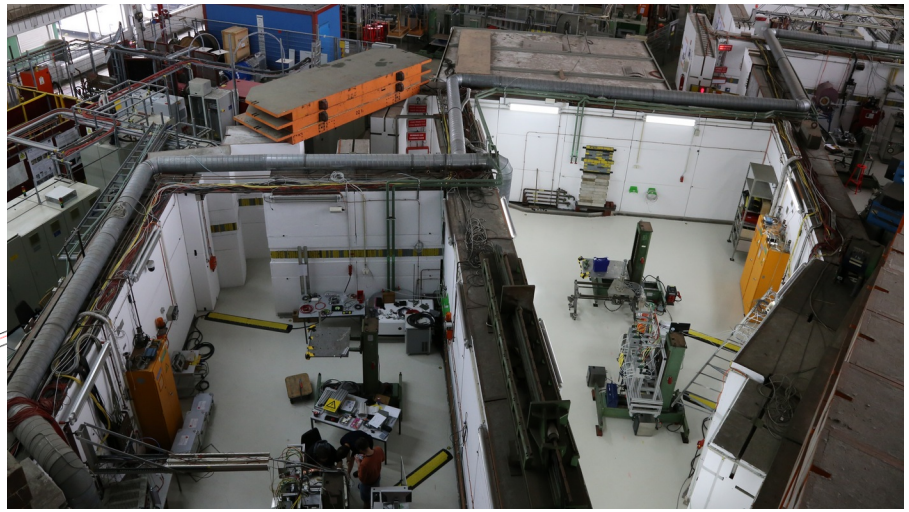




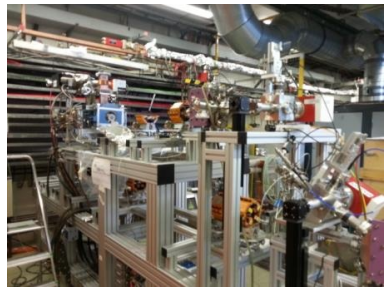
Test Beam Hall



Test Beam Generation



DESY II



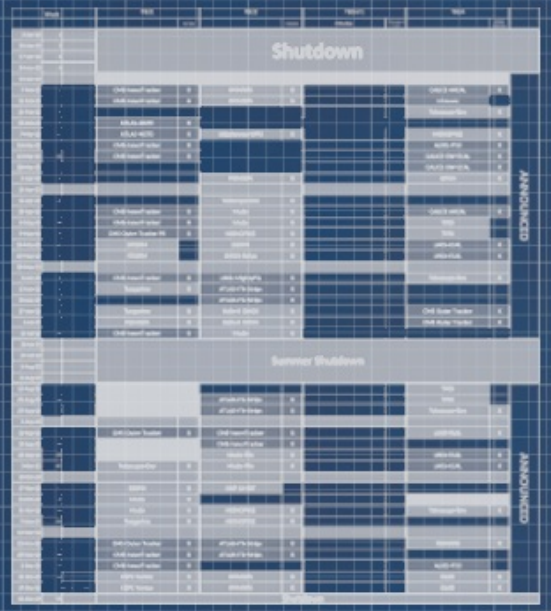
Electron “Gun”

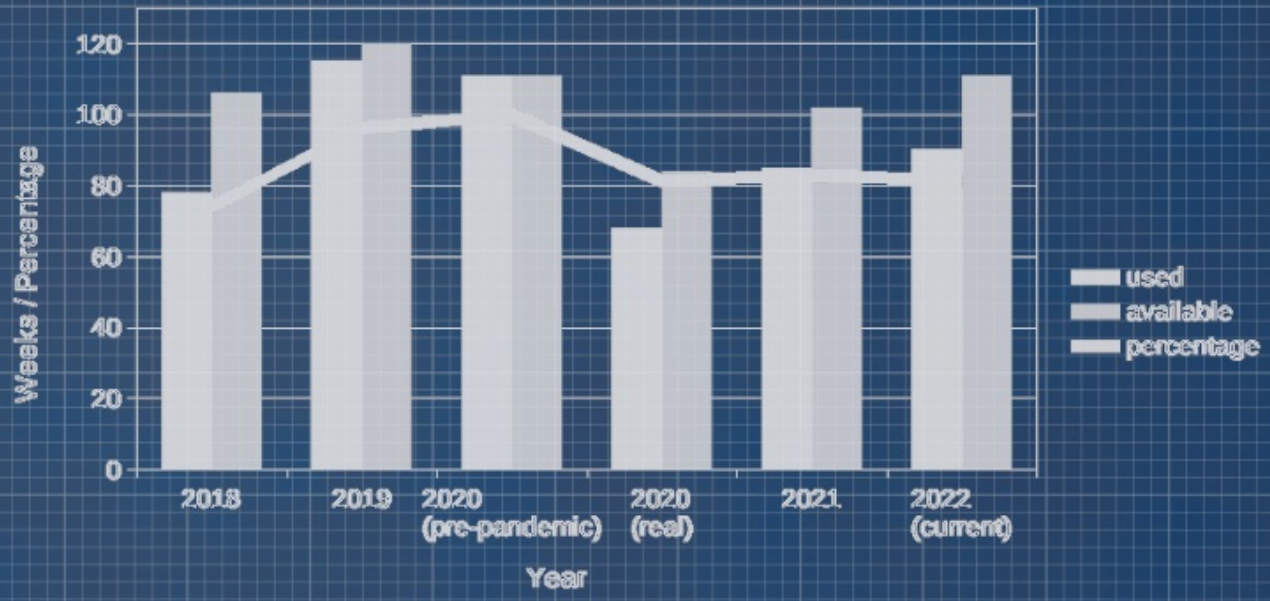
PIA

LINAC II

Schedule

Booking, User Statistics, Outreach





Schedule 2023 - ongoing

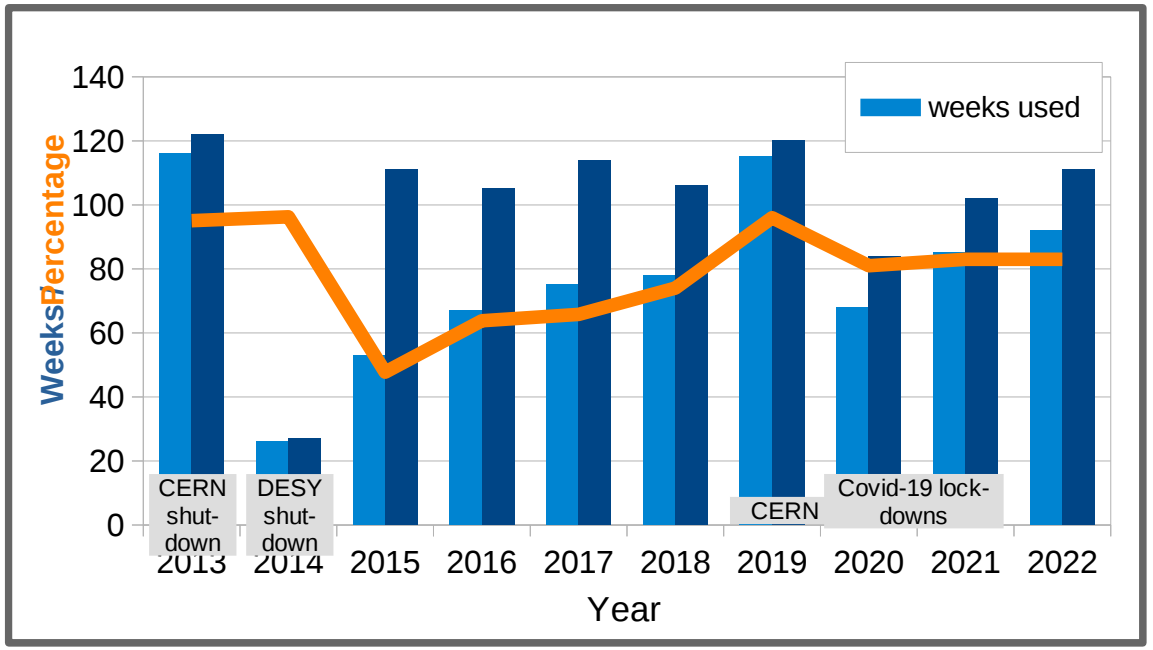
Preliminary Numbers after 9 month

- Energy saving:
  - No beam time allocated first 3 weeks + 1 week start-up (no urgent bookings)
  - Avoid weeks with only one single beamline booked
- We are running till Christmas (December, 20th) as usual
  - Well booked – ~ 80% usage
- Currently
  - 314 users from 13 Countries

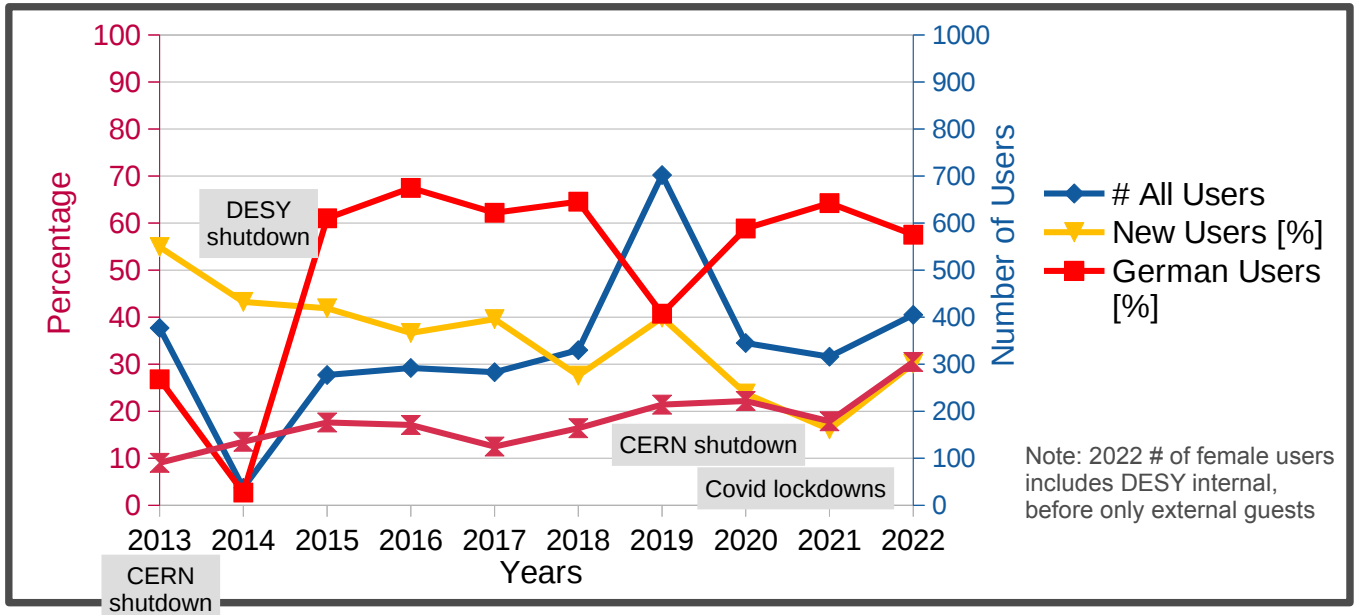
2-Jan-23	1		Shutdown										
9-Jan-23	2												
16-Jan-23	3												
23-Jan-23	4												
30-Jan-23	5												
6-Feb-23	6		Reserve/Energy Conservation										Announced
13-Feb-23	7												
20-Feb-23	8												
27-Feb-23	9		STARTUP										
6-Mar-23	10		CMS-HGCAL	X	CMOS Strips Detectors	X							
13-Mar-23	11		DSiPM	X	ATLAS-ITk-Strips	X			Telescope-Dev	X			
20-Mar-23	12		DSiPM	X	ATLAS-ITk-Strips	X							
27-Mar-23	13		MONOPIX2	X	CMS-ETL	X			RSD	X			
3-Apr-23	14												
10-Apr-23	15		CEPC Vertex	X	Tangerine	X							
17-Apr-23	16		CEPC Vertex	X	BTTB	X			BTTB	X			
24-Apr-23	17		CMS-InnerTracker	X	TelePix	X							
1-May-23	18		CMS-InnerTracker	X	TelePix	X							
8-May-23	19				Tangerine	X			LHCb-ECAL	X			
15-May-23	20		CMS-HGCAL	X	Tangerine	X			LHCb-ECAL	X			
22-May-23	21												
29-May-23	22												
5-Jun-23	23				ATLAS-ITk-Strips	X			LUXE LeadGlass	X			
12-Jun-23	24		CMS-InnerTracker	X	ATLAS-ITk-Strips	X							
19-Jun-23	25												
26-Jun-23	26		MONOPIX2	X	Telescope-Dev	X			PSI-MAPS	X			
3-Jul-23	27		CMS-InnerTracker	X	Belle-II CMOS	X							
10-Jul-23	28		CMS-InnerTracker	X	RD50-CMOS	X							
17-Jul-23	29		Summer Shutdown										
24-Jul-23	30												
31-Jul-23	31												
7-Aug-23	32		BL4S	X	Telescope-Dev	X			ATLAS-ITk-SystemTest	X			Announced
14-Aug-23	33												
21-Aug-23	34												
28-Aug-23	35								CMS-HGCAL	X			
4-Sep-23	36				Tangerine	X			CMS-HGCAL	X			
11-Sep-23	37												
18-Sep-23	38		BL4S	X	ATLAS-ITk-Strips	X			AIDAINNOVA WP6	X			
25-Sep-23	39		BL4S	X	ATLAS-ITk-Strips	X			AIDAINNOVA WP6	X			
2-Oct-23	40		CMS-OuterTracker	X	CALICE-Crystal	X			FAST3				
9-Oct-23	41		CMS-InnerTracker	X	CALICE-Crystal	X			Telescope-Dev	X			
16-Oct-23	42												
23-Oct-23	43		ATORCH		CMOS Strips Detectors	X			MONOPIX2	X			
30-Oct-23	44		MDI-2		CMOS Strips Detectors	X			MONOPIX2	X			
6-Nov-23	45		CMS-HGCAL	X	Tangerine	X			ATLAS-HGTD	X			
13-Nov-23	46		CMS-InnerTracker	X	Tangerine	X			ATLAS-HGTD	X			
20-Nov-23	47												
27-Nov-23	48		CMS-InnerTracker	X	ATLAS-ITk-Strips	X			MIMOSIS				
4-Dec-23	49		CMS ETL	X	ATLAS-ITk-Strips	X			LHCb-ECAL	X			
11-Dec-23	50		CMS ETL	X	Tangerine	X			LHCb-ECAL	X			
18-Dec-23	51	Beam till 20/12 0800			Tangerine	X							
25-Dec-23	52		Shutdown										

Statistics 2013 - 2022

Booking/Usage Statistics



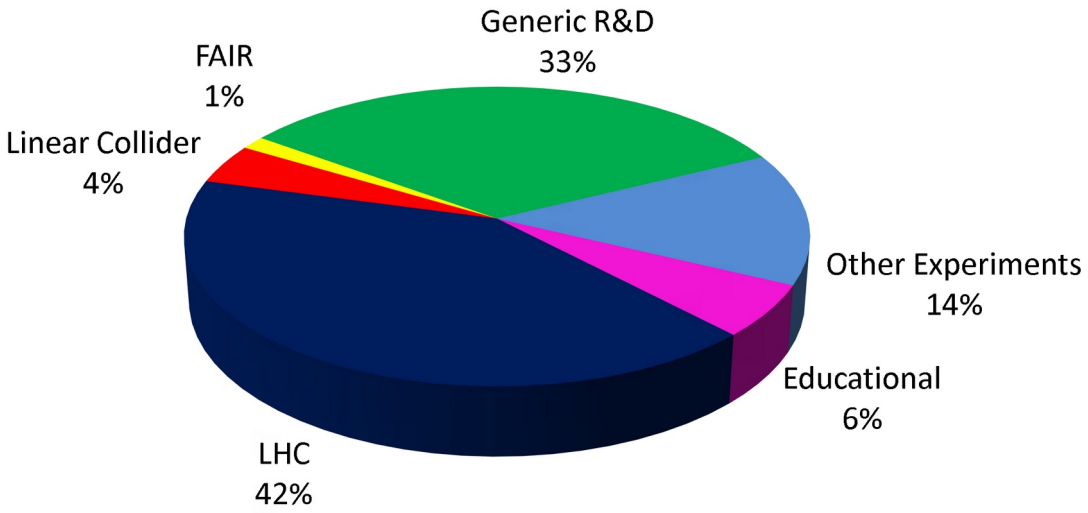
> 700 Users (2019)



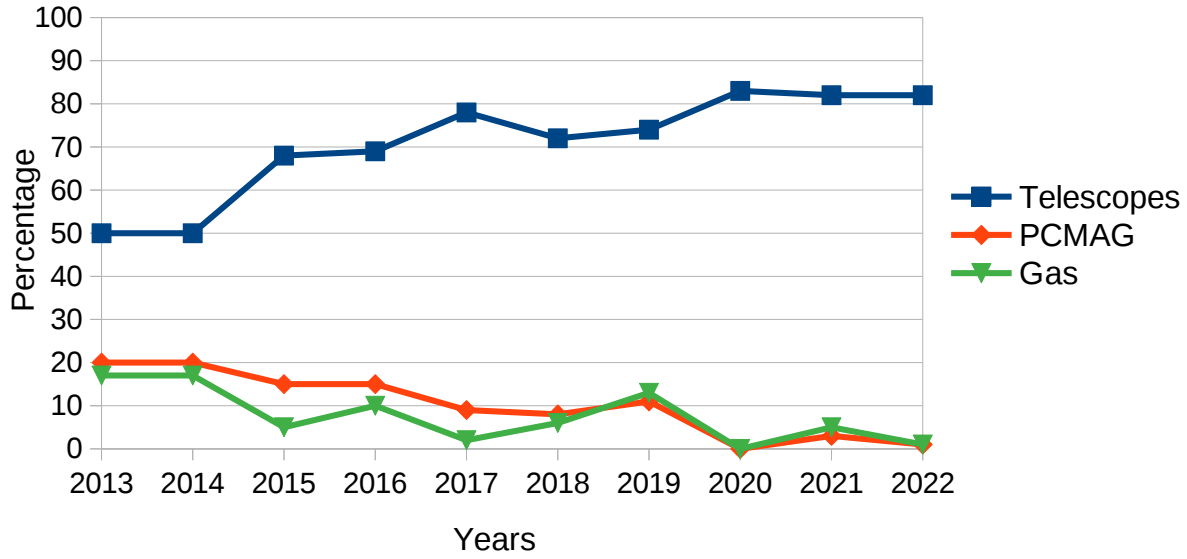
Statistics 2022

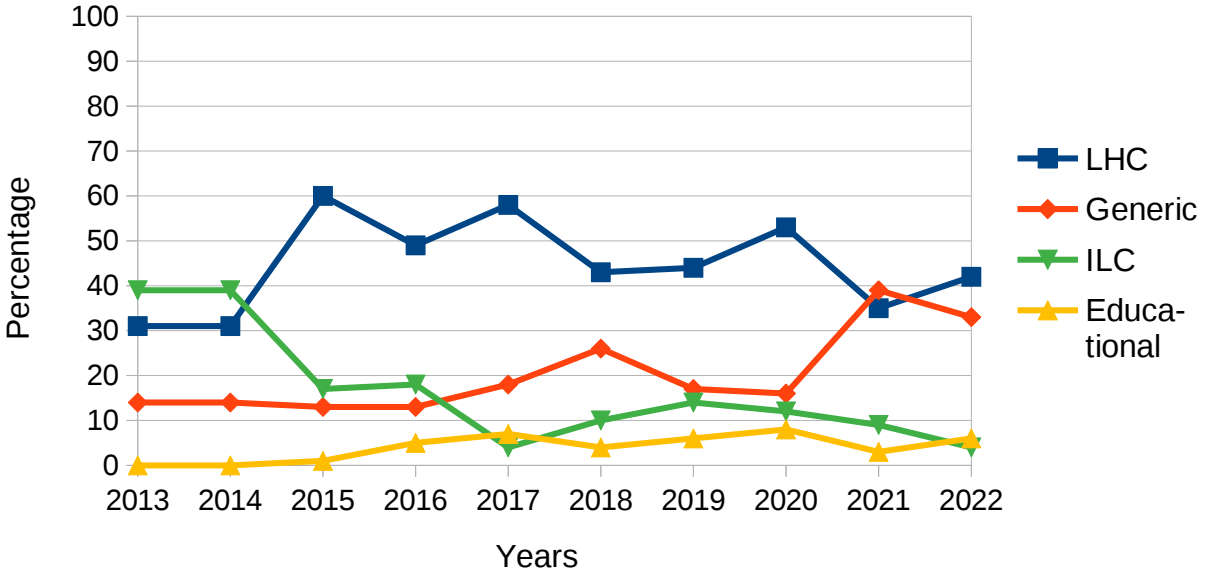
Infrastructure and Experiments

- Beam Telescopes still the most requested infrastructure:
  - 1 T PCMAG and gas detectors on a low level: 1 %
    (infrastructure calculated for 2013/14 together → same numbers)
- In 2022, majority of beam tests for LHC



- Generic detector development catching up
  - ILC-related experiments continue declining

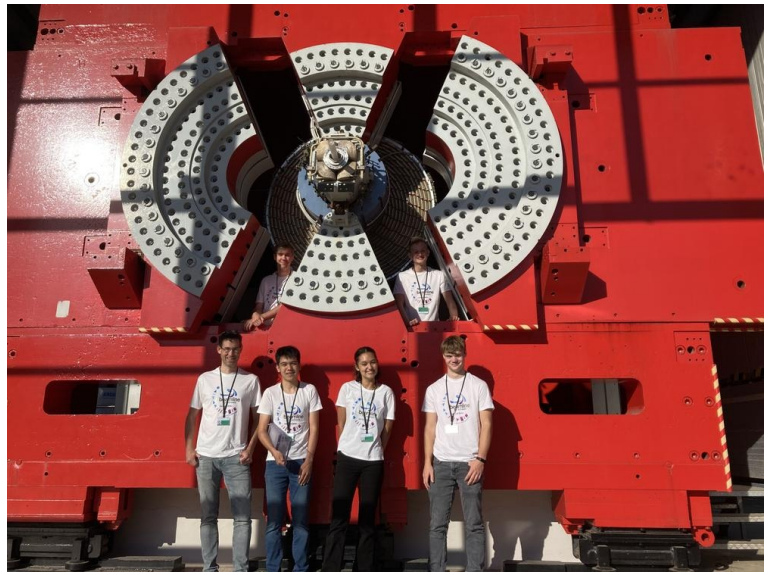




Outreach and Education

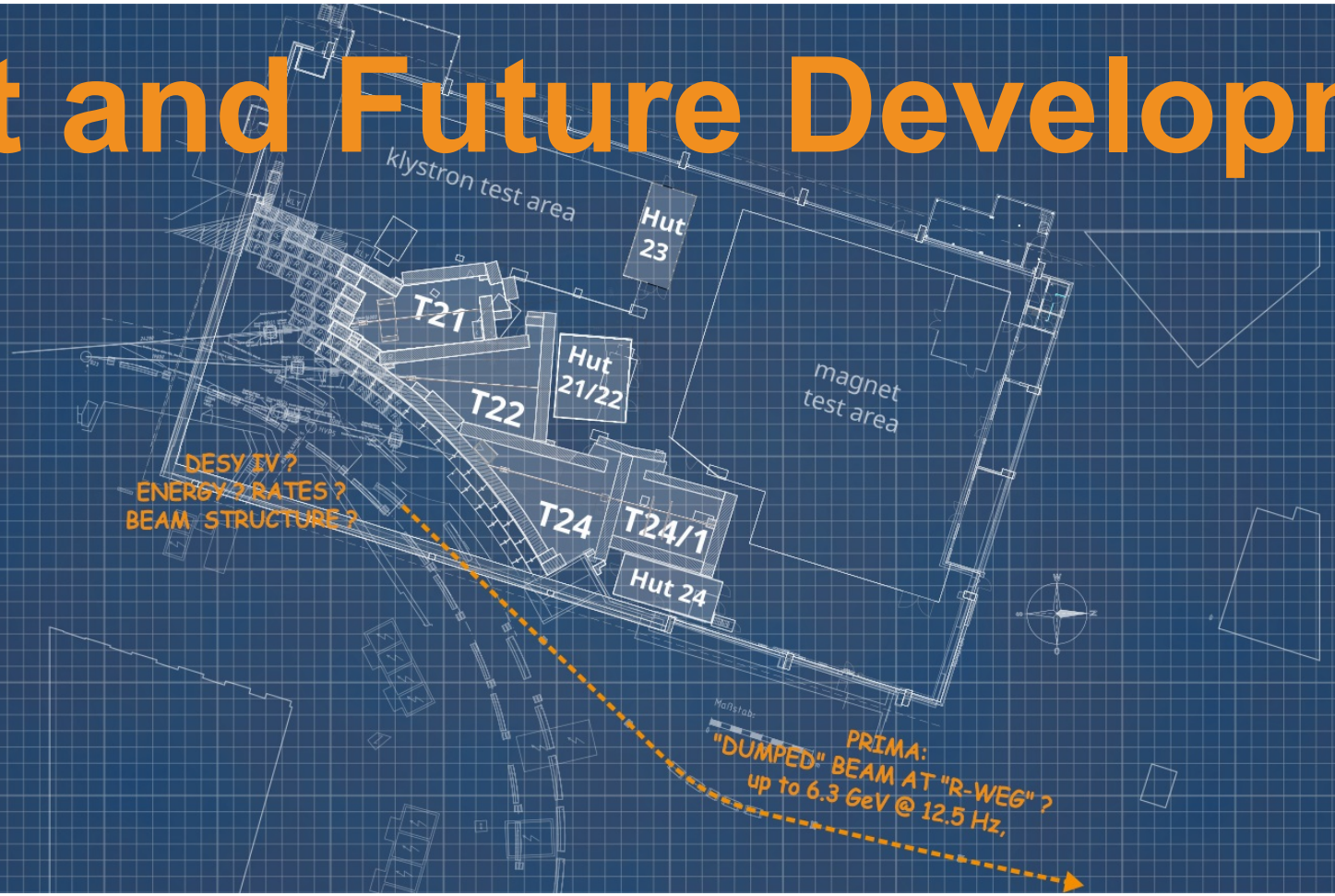
Beam Line 4 Schools

- 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*

- 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 not yet approved;
  - official timeline: shutdown 2027 → 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