The DESY II Test Beam Facility

Status and Future Developments

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4th annual meeting of the programme "Matter and Technologies"
Berlin, 13.06.2018

DESY TEST BEAM.

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

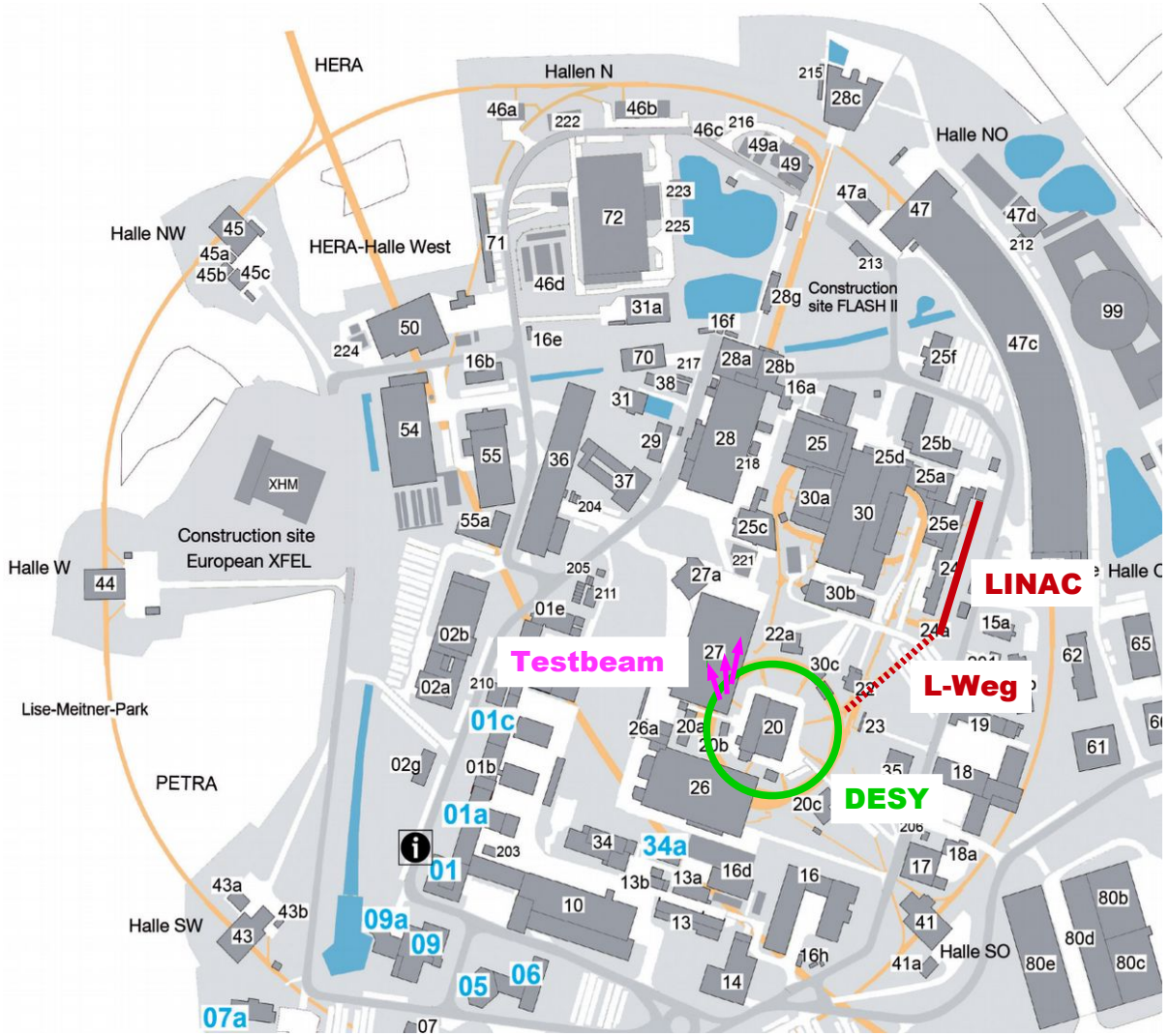
MTDTS

DESY.

DESY II Test Beam Facility

Accelerator

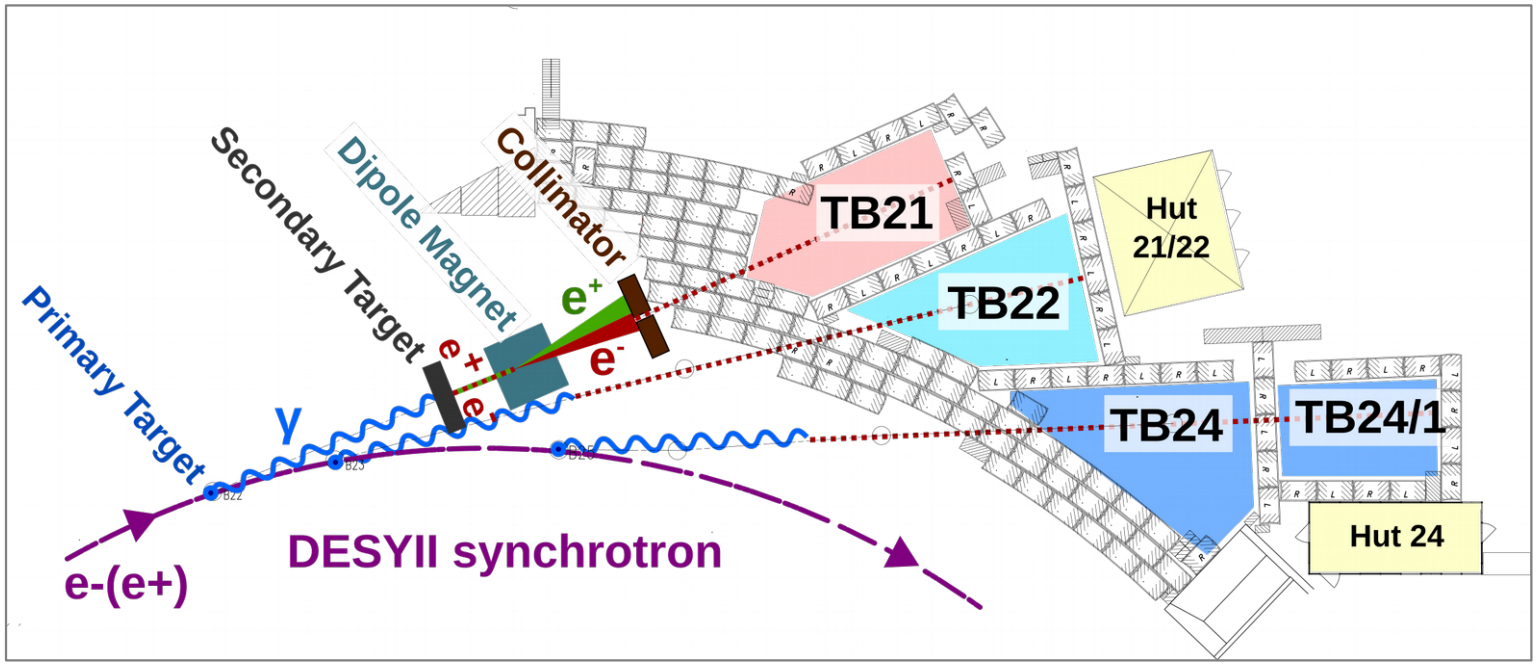
- Facility runs parasitically,
  fed by DESY II synchrotron (PETRA III injector)
  - 1 bunch per fill, 30 ps, 1 MHz
  - Sinusoidal cycle: 0.45 to 6.3 GeV @ 12.5 Hz
  - Very high availability: ~ 99 % uptime



DESY II Test Beam Facility

Beam Generation

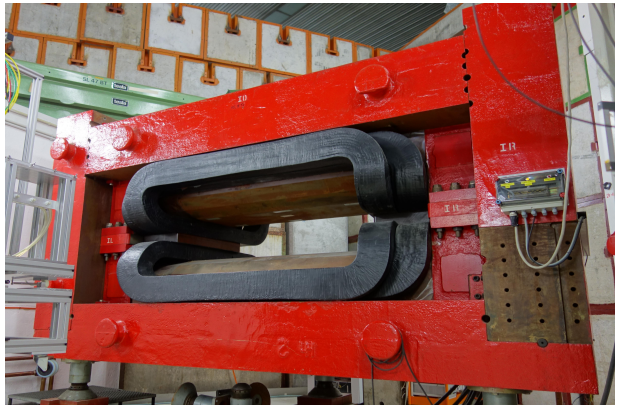
- Carbon fiber targets in the electron beam generate bremsstrahlung photons
- Conversion at thin metal plate target to e+/e- with momenta up to 6 GeV
- Momentum selection by dipole + collimator
- Single electrons, rates depend on: beam line, energy, target, collimation
- Three individual beam lines
  - Controlled by the user:
    - Area interlock
    - Shutter
    - Momentum
    - Collimation



Infrastructure

Common and Magnets

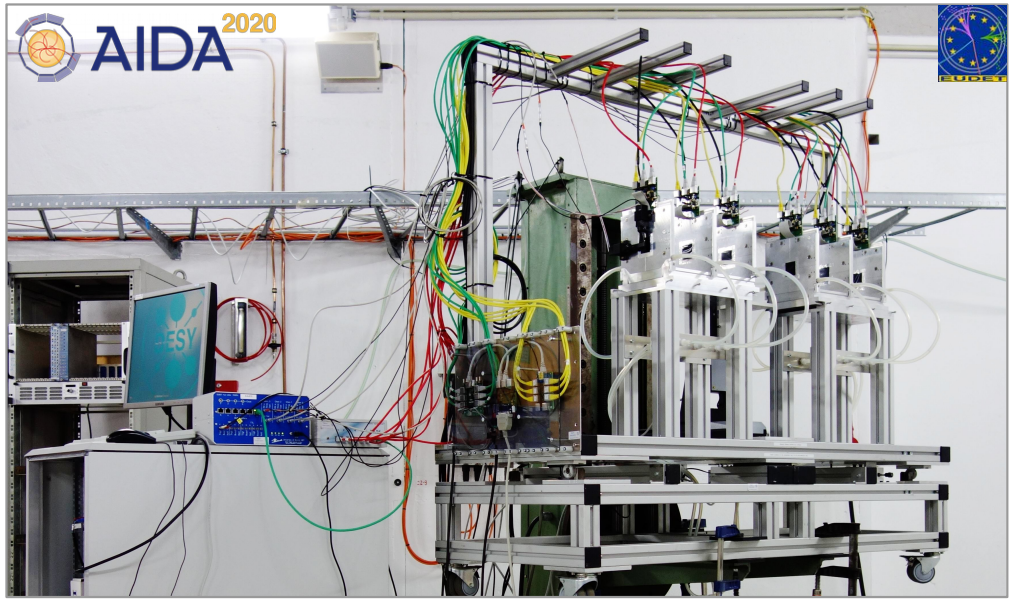
- All the useful things:
  - 30 kg and 1 ton stages, 25 t crane
  - Patch panels: Gb Ethernet, optical fiber, BNC, S-HV
  - High resolution IP cameras
  - Dry nitrogen, cooling water
  - Gas setup (2 areas, system recently modernized)
  - Beam monitor
  - Common slow control system
- Dipole magnet in TB 21 (~1.35 T)
  - Opening height ~35 cm
- Superconducting 1 T solenoid on movable stage
  - Usable diameter ~75 cm

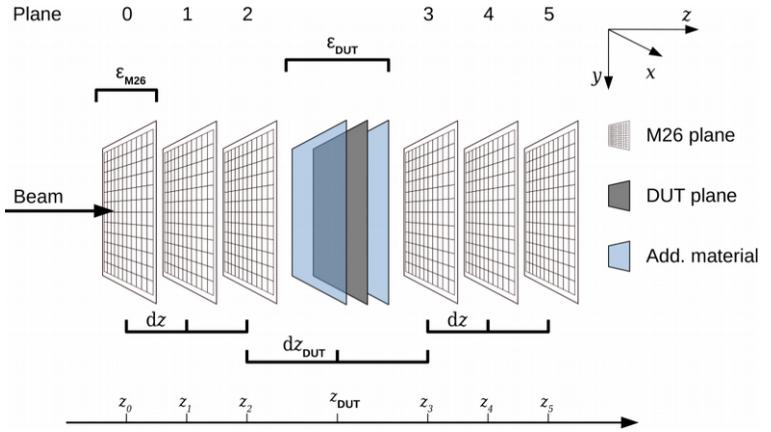


Infrastructure

Pixel Beam Telescopes

- EUDET-type Beam Telescopes
  - Complete Package:
    - Hardware, trigger, software
    - Dedicated support crew
  - The telescope in numbers
    - Six pixel planes: 2x1 cm^2, 18.4 µm pitch
    - Trigger rates up to 3 kHz
    - Few micron tracking resolution
  - Seven copies around the world
  - Common DAQ Package EUDAQ/EUDAQ2
  - Allows for easy integration with User DAQ





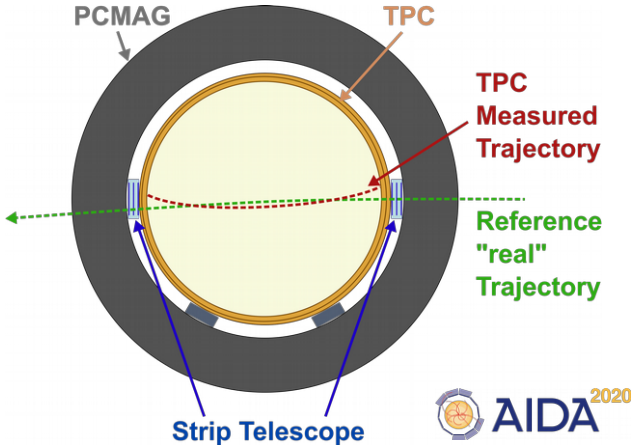
Ongoing Projects

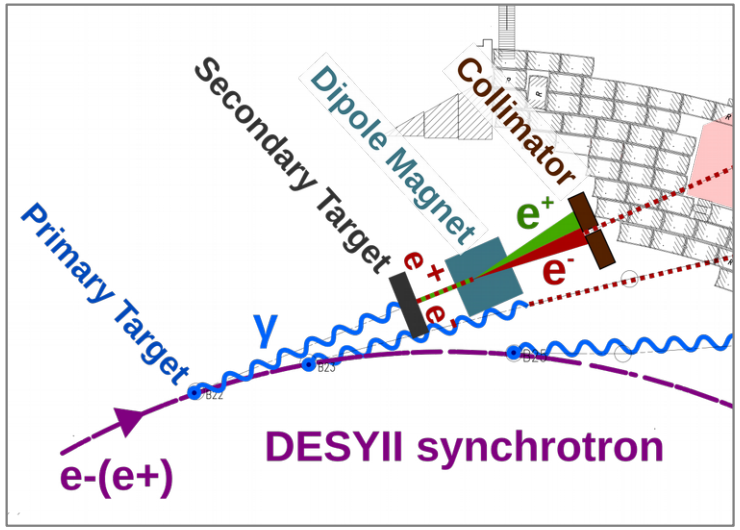
From Infrastructure to Facility Improvements

- Large area silicon strip telescope in 1 T solenoid
- New interlock system installation
  - Improved safety and reliability
- Work on new primary target system has started
  - Reduce maintenance and access needs
  - Common components with other systems
- Maintenance and continuous upgrades of beam telescopes
  - EUDAQ version 2 for decentralized data taking
  - New trigger logic unit providing a common clock for data synchronization

AIDA 2020

- Reference paper on DESY II Test Beam Facility

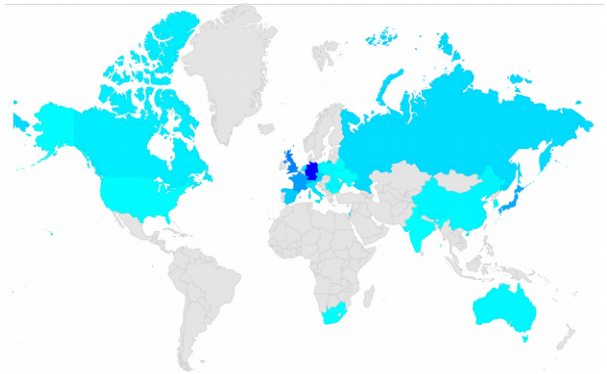


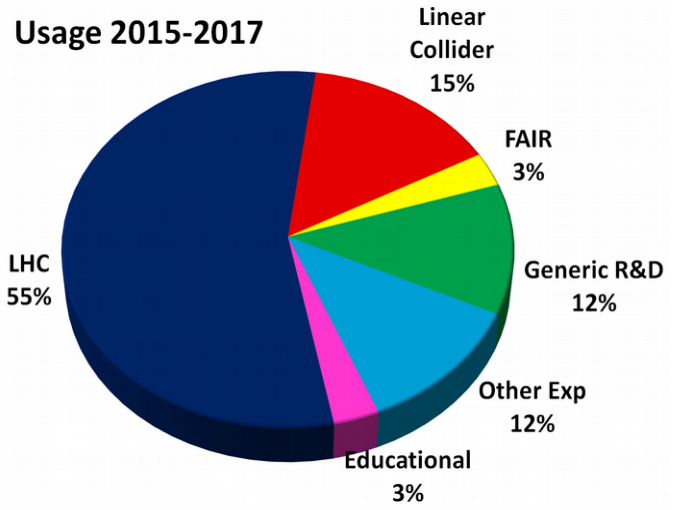


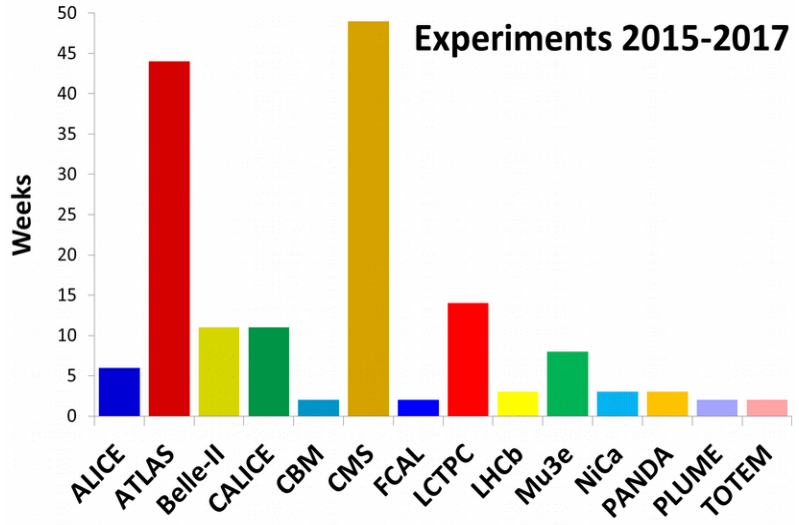
Operation 2015-2017

Some Stats

- Key facts
  - 200 weeks delivered
  - Availability of DESY II > 99 %
- Users
  - 800 users from 26 countries
  - About 50% are students
- European support: AIDA 2020
  - Transnational Access has supported many user groups





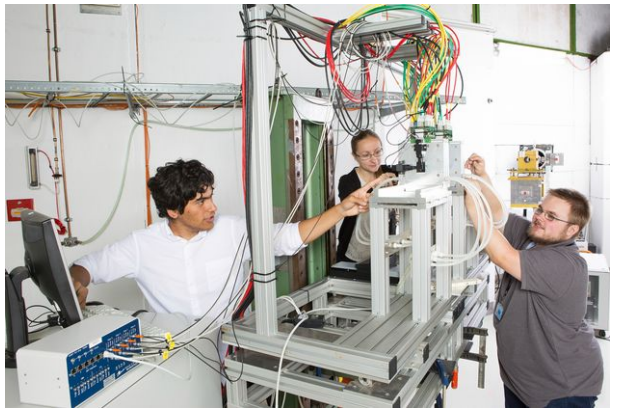


Outreach

Education at the Test Beam

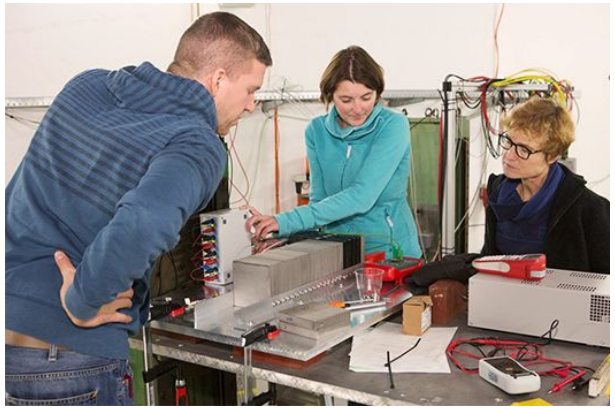
Summer Students

- Since several years very successful
- Full life-cycle: setup → data taking → analysis



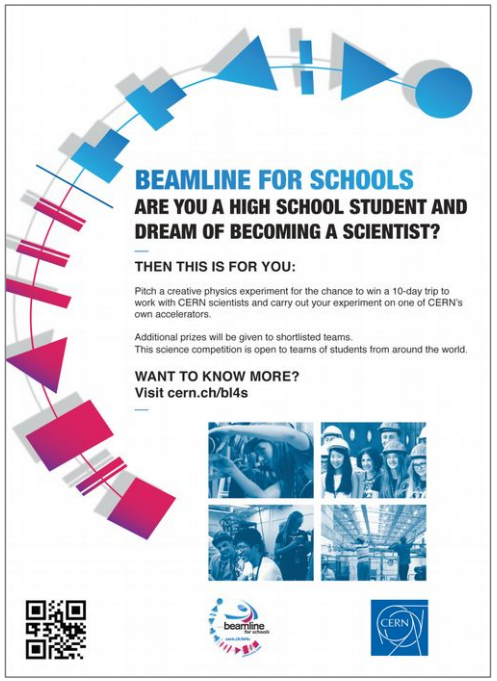
Teacher Education

- Nation-wide and going in its third year
- Test Beam as one of the “lab experiments”



Beam Line for Schools (BL4S)

- Very successful project at CERN
- Teams of high school students can propose experiments at a beam line
- 2 winning teams can perform their experiments supported by scientists
- Long Shutdown 2 at CERN: DESY is going to host



User Workshop

Future Opportunities for Test Beams at DESY

Workshop in October 2017

- With representatives of nearly all user communities
  - Very fruitful discussions and feedback
  - DESY rated a very good place to do test beams
- Two main wishes formulated by the community
  - Electrons with max. energy and/or high intensity
    - High Intensities (100 kHz or more)
    - Studies with 6.3 GeV monochromatic beam
- Pion/Muon Beam (Secondaries)
  - Improved testing capabilities
    e.g. particle-identification (PID)
- Write-Up available: http://arxiv.org/pdf/1802.00412.pdf

Attending Communities

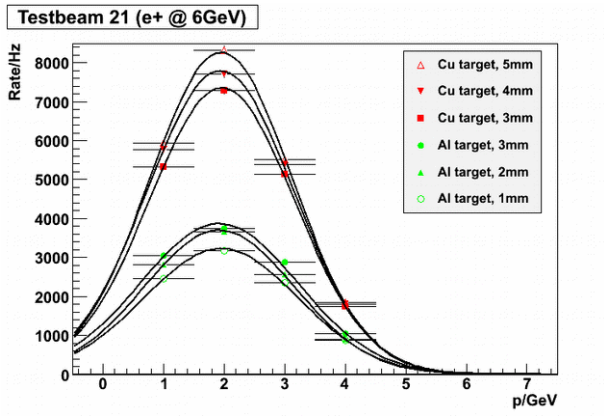
- LHC: Atlas, CMS, Alice, LHCb
- LC: Calice, LCTPC, CLIC
- Belle II
- Mu3e
- Dune
- GSI/FAIR: CBM / HADES, Panda

Future Beam Rate Improvements

Limits and Solutions

Limiting Factors Today

- Maximum Beam Rate is at ~2 GeV
  - With a few kHz rate
- Best Compromise for tracking studies is 5.4 GeV
  - Rates are O(100) Hz



- For tracking studies
  - Rates are becoming the limiting factor
  - Followed by the energy spread…

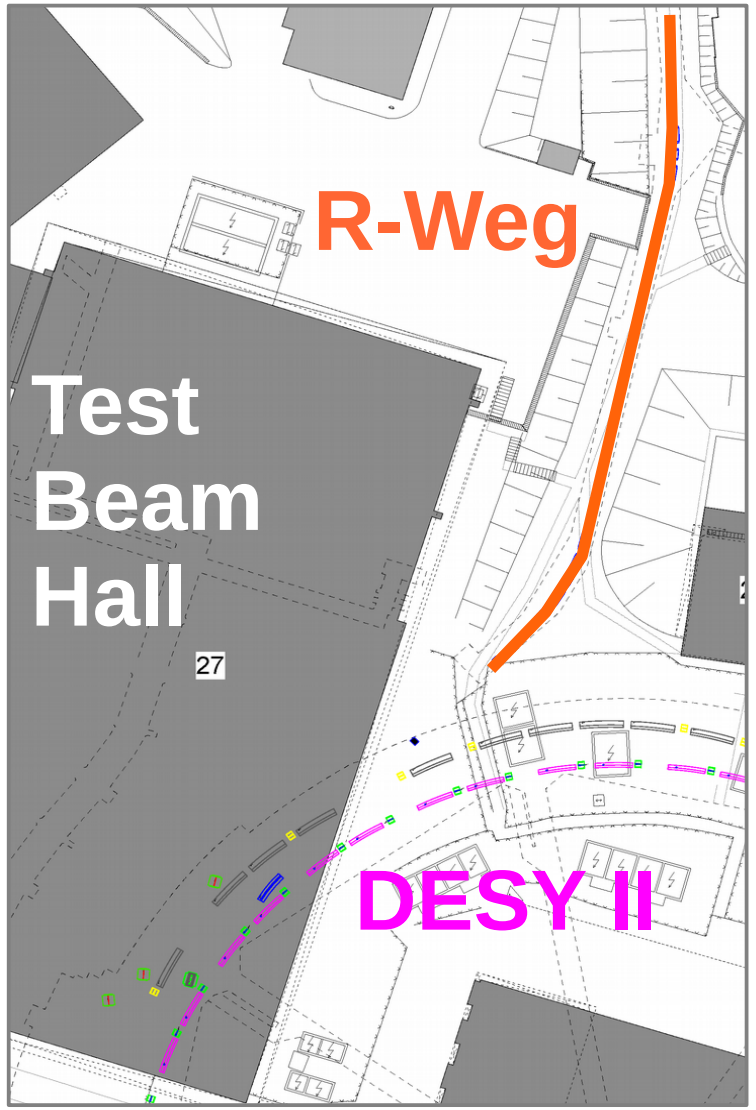
Possible Solutions

- DESY II Multi-bunch operation
  - Very welcome improvement, higher rates for the entire energy range
  - Strongly requested by the user communities
  - First tests started
- Using DESY II beam
  - @ 6.3 GeV with ~ 100 kHz particle rate
  - Will enable completely new studies
  - Unique facility worldwide

4th Beam Line

Extraction of DESY II Beam

- Using the “dumped” beam
  - Repetition rate up to 12.5Hz
  - Intensity max/min $2x10^{10}$ > $1x10^{8}$ particles/bunch
  - Extraction energy 456 MeV - 6.3 GeV (7 GeV)
- First test in “R-Weg”: former transfer line from DESY II to DORIS
- Current Status
  - Magnets and services old or defunct → being cleaned up
- Next steps
  - Proof-of-principle test
    - Planned for next year, preparations started
    - Discussion with involved groups revealed no show-stoppers
  - If successful: site discussion



Further Future

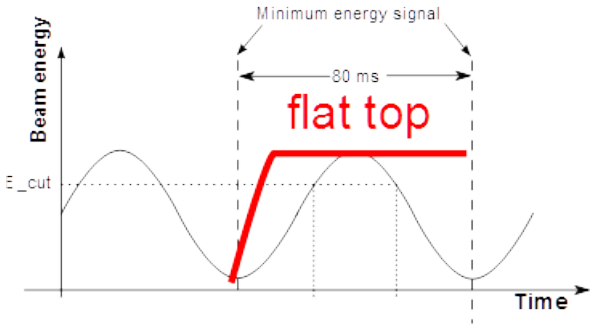
Ideas and Possibilities

PETRA IV

- “Ultimate” light source for photon science
- Timescale ~ mid-twenties
- Initial approach: Use DESY II as-is as injector
  - DESY II well over 30 years old
  - Refurbishment of the majority of components
  - Effort probably nearly as high as for a new injector
- Other Options
  - 6 GeV linac
  - 3 km booster ring in PETRA IV tunnel
  - DESY IV in existing tunnel

DESY IV

- Current beam generation would still work
- Interesting opportunities for the test beam facility
  - Flat-top mode → higher rates



  - Resonant extraction of primary beam
    - Energy independent rates & structured beam
- Strong interest of the user community to have test beam at DESY in the PETRA IV age

Conclusion

- DESY II Test Beam Facility provides 3 beam lines with electrons/positrons from 1-6 GeV
  - Open to the whole community
  - Selection of useful infrastructure for detector prototype tests available and being extended
  - Contact: http://testbeam.desy.de, testbeam-coor@desy.de

- User requirements from recent user workshop: Higher rates / higher beam energies
  - DESY II multi-bunch operation / 4th high-rate beam line using direct DESY II beam

- Outreach Activities
  - Summer student and teacher education established
  - Beam Line 4 Schools at DESY in 2019/2020

Acknowledgements
The excellent performance of the DESY II Test Beam Facility would not be possible without the great support from the FH and M divisions and the DESY management

Highlights and Users

Impressions from the Test Beam