

DESY II Test Beam Facility

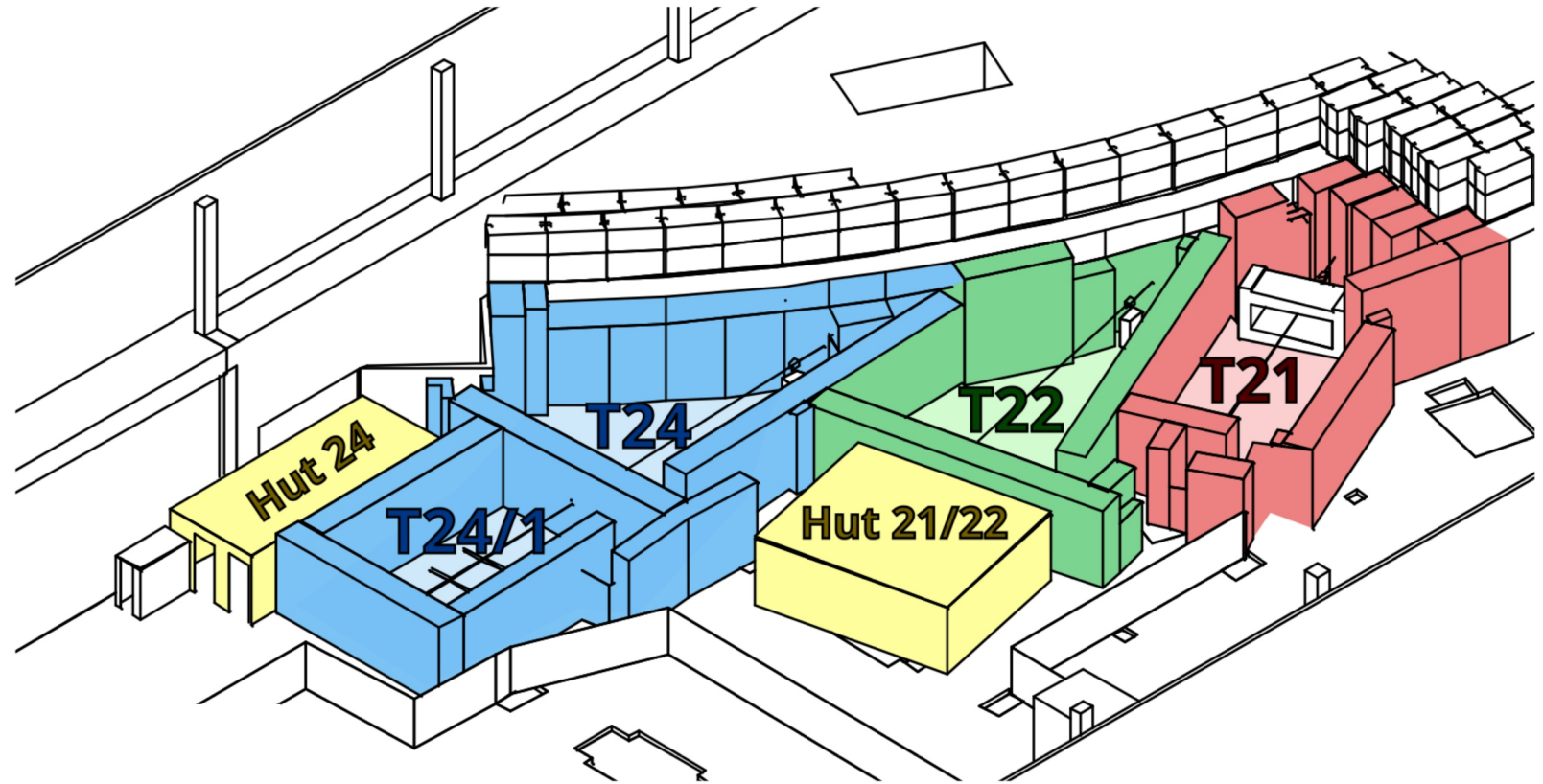
Tests Beam at DESY

Coordinators:

Ralf Diener

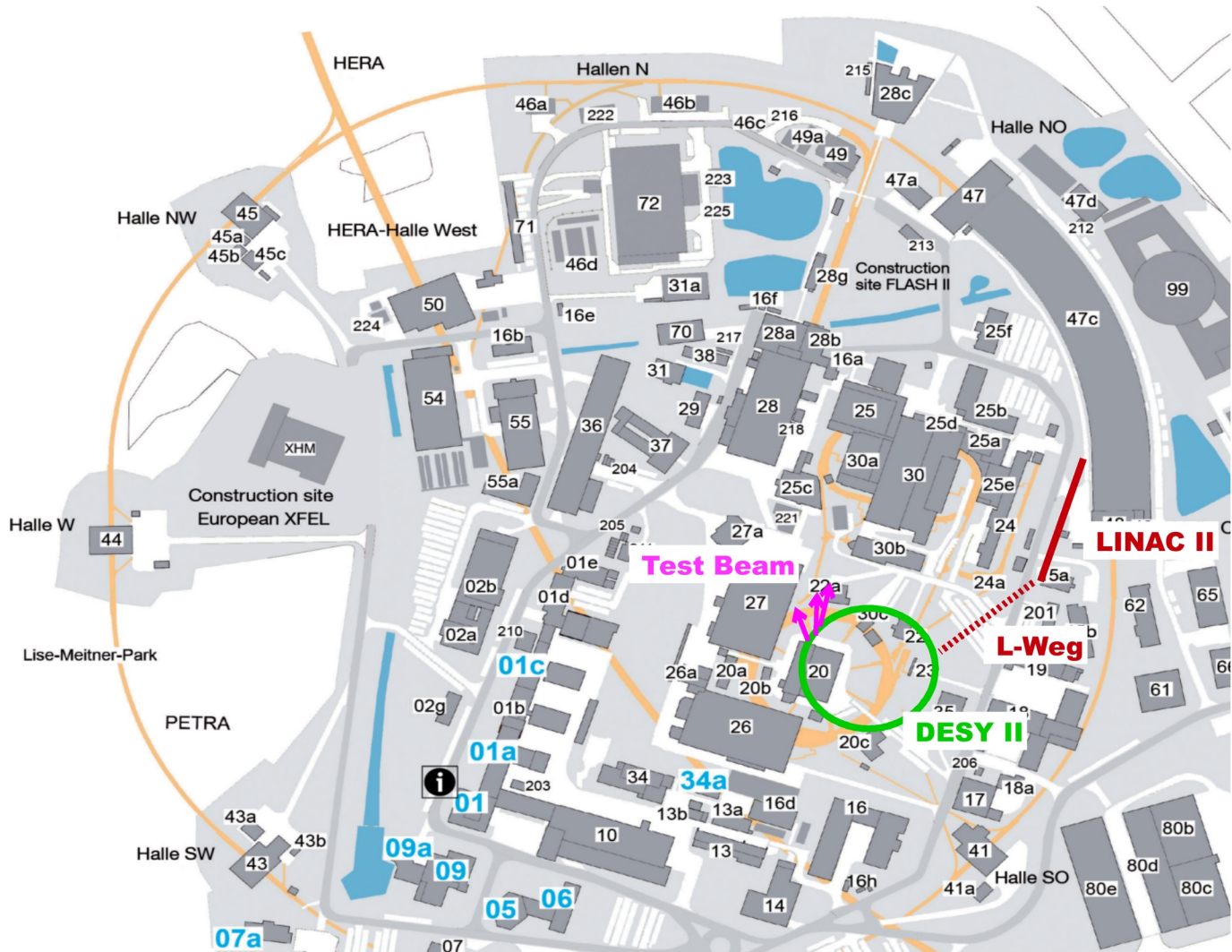
Norbert Meyners

Marcel Stanitzki



Introduction

- The basics
 - Some very quick recap
- DESY II
 - Beam Generation
 - Linac2 & PIA
 - DESY II Synchrotron
- The Test Beams
 - Generation
 - Properties



How does one become a Test Beam Coordinator ?



- PhD Karlsruhe Germany 2003
 - DELPHI Experiment at LEP, CERN
 - Searching for Higgs Bosons



- PostDoc Yale, US 2004-2006
 - CDF Experiment at Fermilab
 - Responsible for the CDF Silicon Detector



- Staff Scientist, Rutherford Appleton Laboratory, Oxfordshire, UK 2006-2011
 - Silicon Pixel R&D
 - International Linear Collider

What does he actually do ?

- According to the directorate
 - Responsible for the Safety and the Operation of the facility
- What we actually do
 - Keep the facilities running & Make sure everything is safe
 - Make all the planning
 - Liase with the M division experts
 - Convince people to give us funding
 - Deal will all kind of user requests
 - Supervise students
 - Do “what needs to be done”
- If we have some time left
 - Organize Teacher Programmes
 - Do BL4S



- To first order
 - Acceleration with electric fields
 - Bending the beam with Lorentz Force

$$F = q \cdot U$$

$$F = q v \times B$$

- Of course there some (minor details)
 - Relativity
 - Resonances
 - Hystereses
 - Real and not ideal fields
- But we'll happily ignore this for now



Wikipedia



tesla

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DESY II Synchrotron

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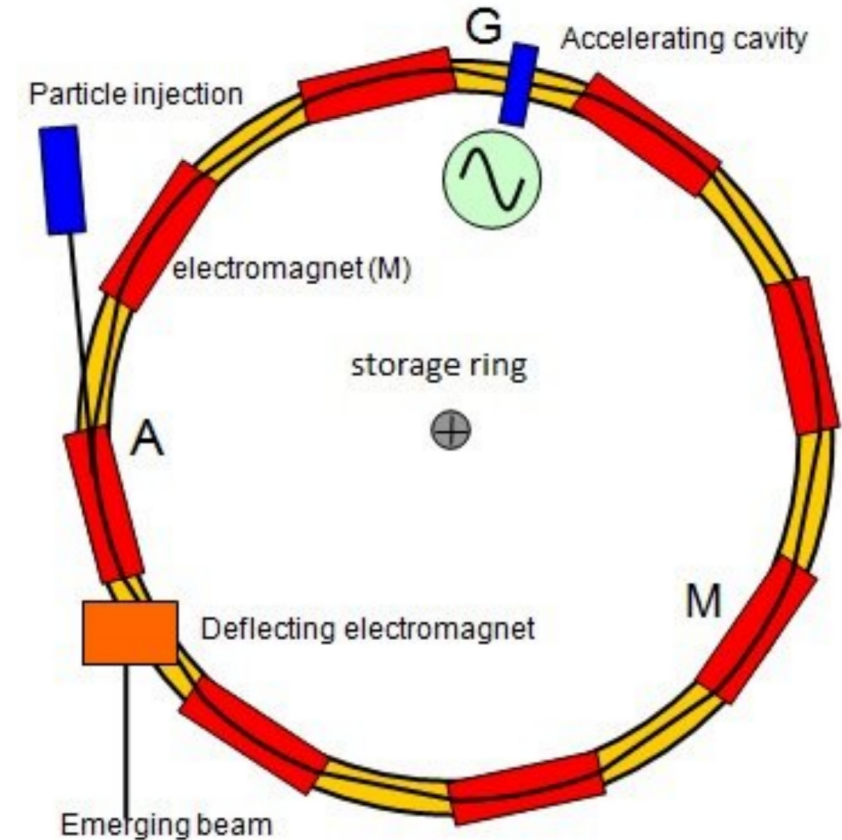
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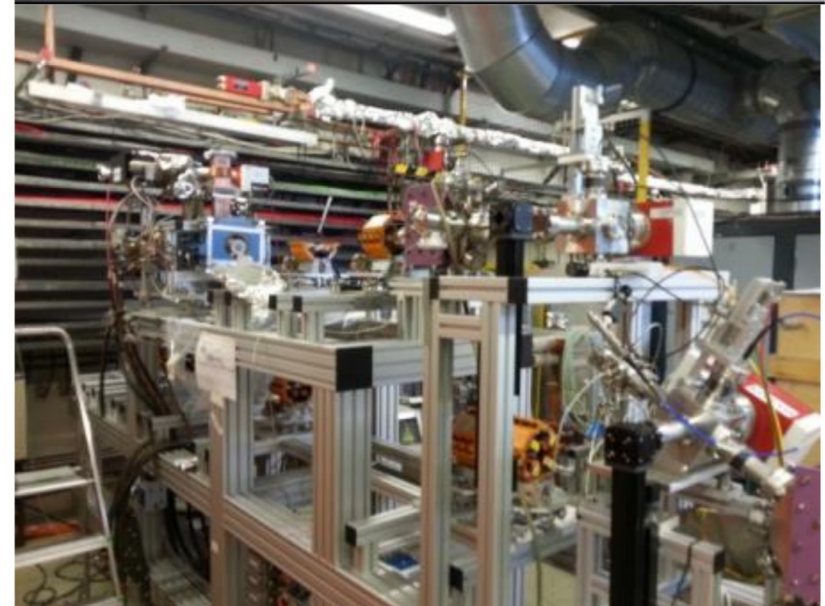
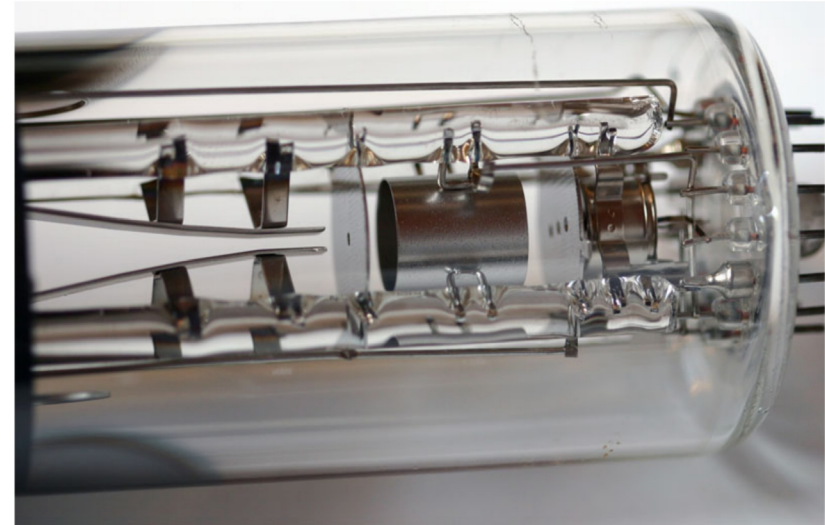
What is a synchrotron ?

- Classic “design” for a circular machine
 - Cavities driven by microwaves for acceleration
 - Dipole magnets for bending the beam
 - Quadrupoles for focusing
 - Bunched operation
 - Works with electrons, positrons, protons...
- Most frequently used
 - DESY II, PETRA, LHC, Tevatron are all synchrotrons
- Drawbacks
 - As magnets cannot cycle very well from 0 to several T field
 - Synchrotrons need an “injector chain”



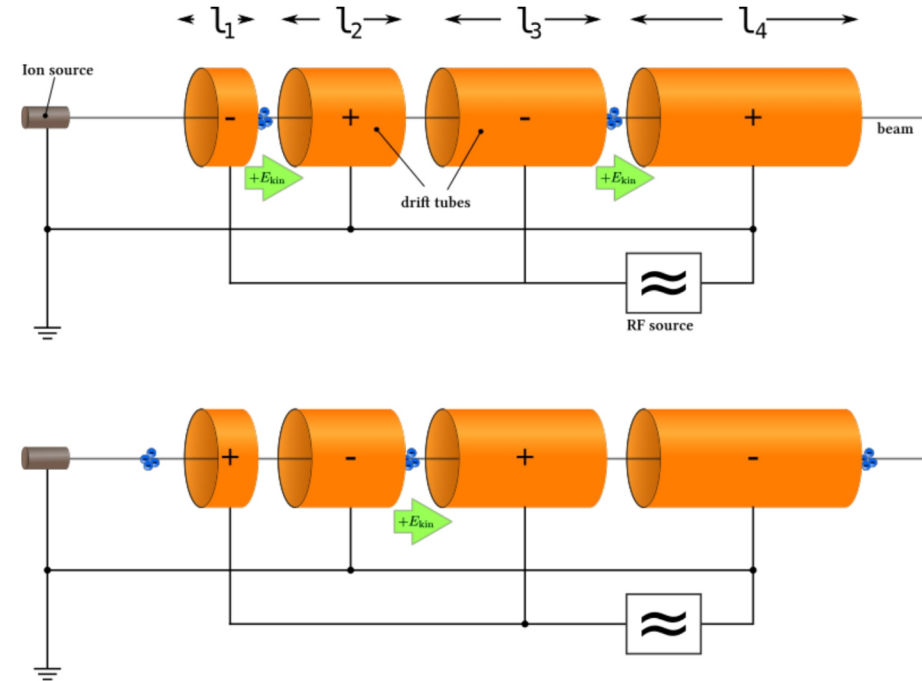
Beam Generation

- If we'd like to accelerate electrons, we need a source ?
 - What to do ?
- Most commonly used
 - An "Electron Gun"
 - Most well-known is the Cathode Ray Tube
 - Thermionic emission of electrons
 - Emitter size mm^2
- The guns at DESY
 - Just a "bit" bigger and stronger
 - 28 cm^2
 - Each pulse is 20 ns long with several 10^9 electrons
 - Electrons leave the gun section with 150 keV

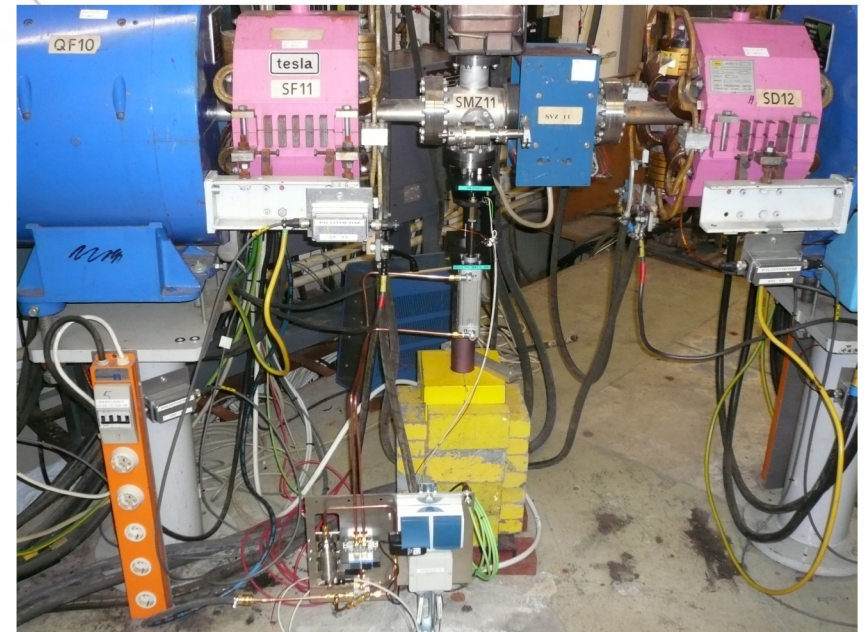
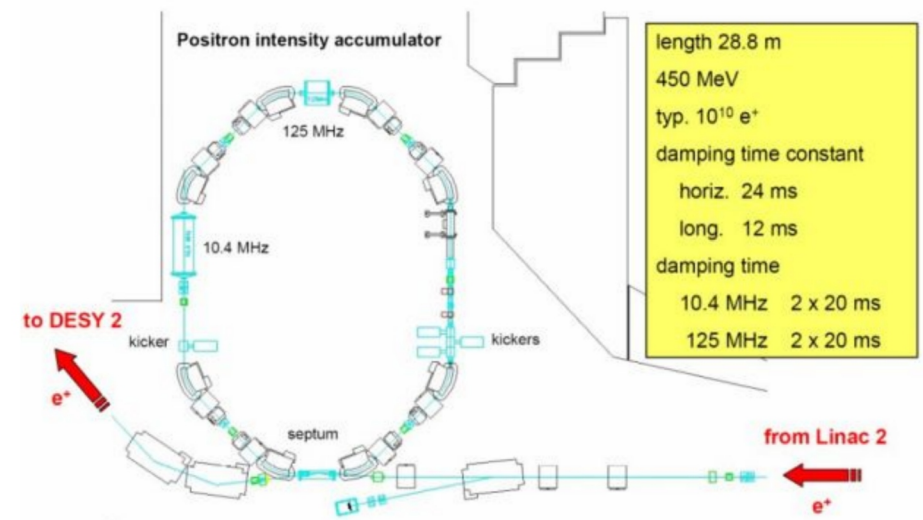


LINAC II

- The LINAC II is the first step in the injector chain
- Principle of all linacs
 - Particle ride on the “wave”
- LINAC II
 - 12 Accelerator modules running with 3 GHz RF
 - 70 meters in total
 - Gradient 17 MV/m
 - LINAC II inject particles in PIA at 450 MeV
- LINAC II can also be used to generate Positrons ..
 - If we want to run Positrons in DESY II

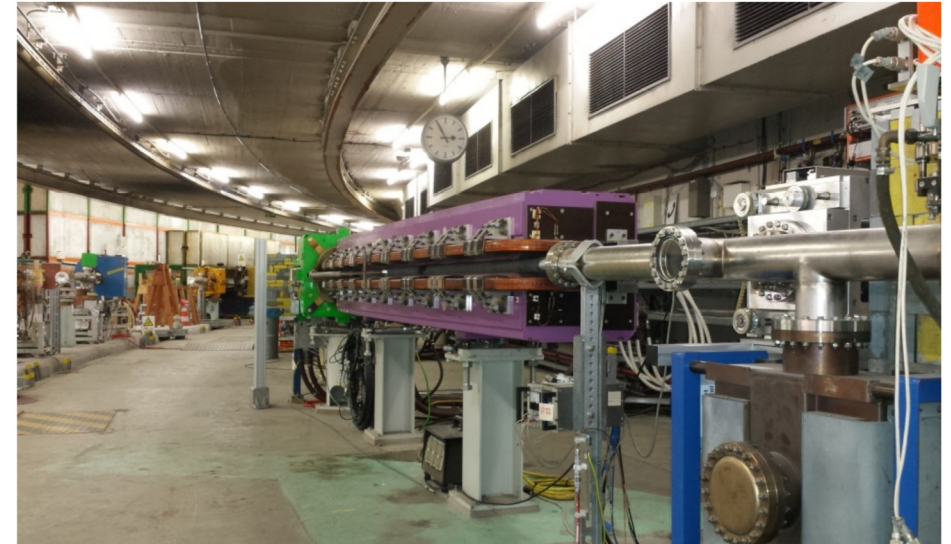


- Positron Intensity Accumulator
 - Tiny synchrotron (length of 28 meters)
- Accumulator
 - Takes several shots from LINAC II and merges them
 - Converts 3 GHz bunch structure (LINAC II) to 500 MHz (Required for DESY II)
- Extraction into the L-Weg (Linac Path)
 - Transfer line to DESY II

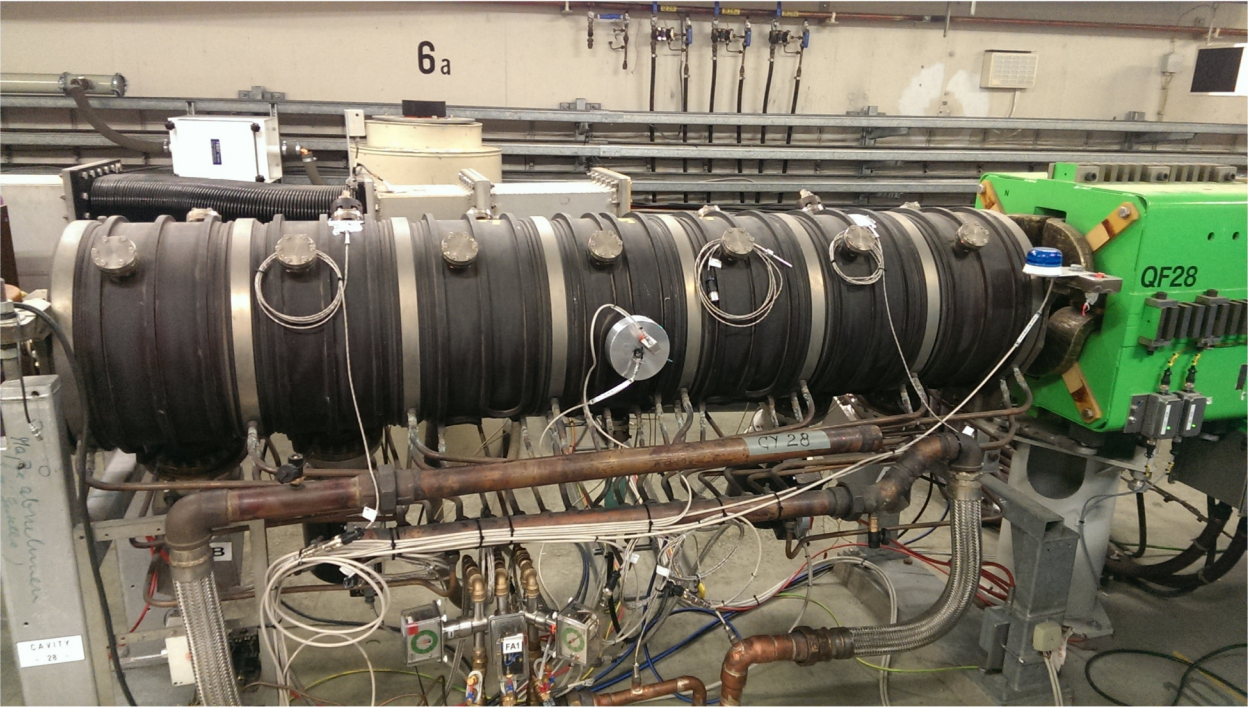


Finally, BEAM in DESY II

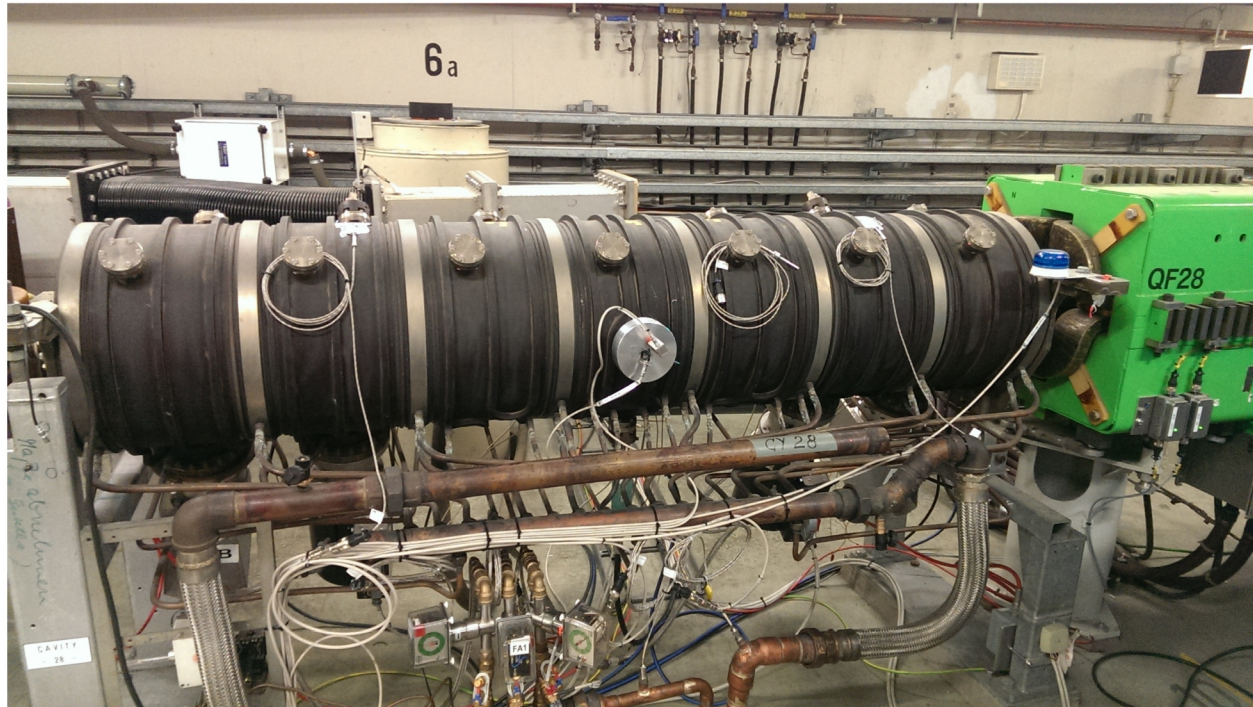
- DESY II
 - Workhorse of the DESY accelerator complex
 - Feeds beam to PETRA III and the test beam
- Details
 - Electron Synchrotron with 292.8 m circumference
 - Injection energy 450 MeV, maximum energy 6.3 GeV
 - 500 MHz RF, 1 μ s per turn
 - Specialty: Continuously ramping with 12.5 Hz
 - Typically with a single bunch with 10-15 10^9 electrons, 30 ps length
- In operation since 1988



DESY II Tunnel

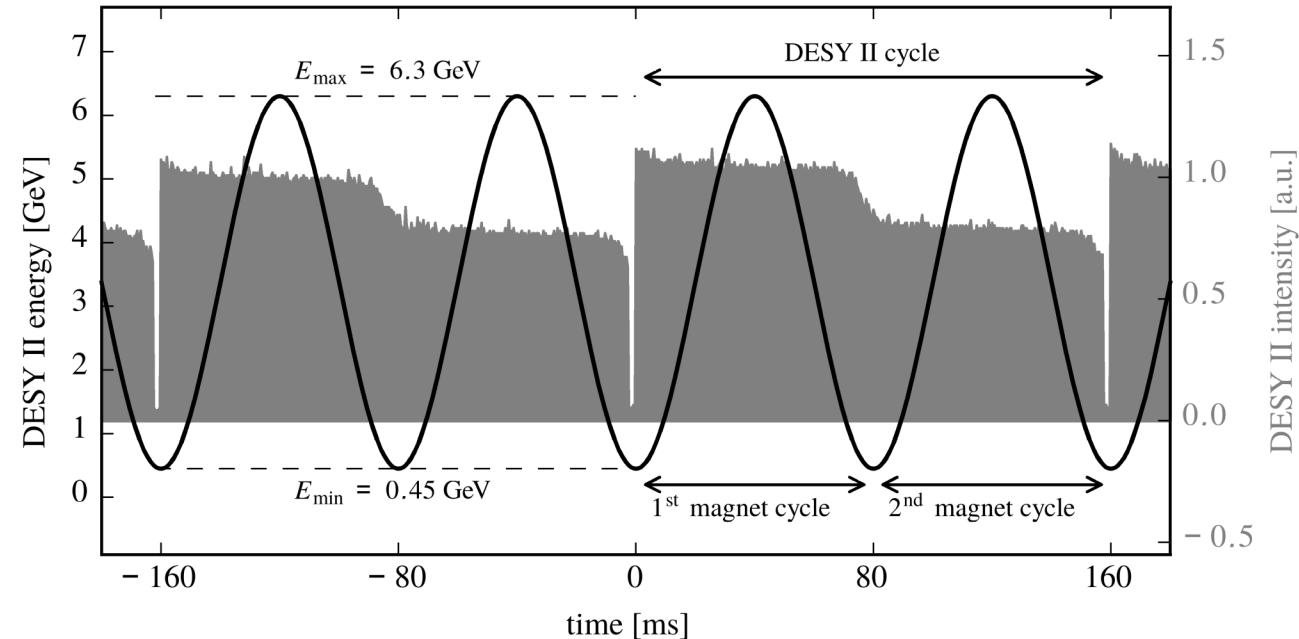



Finally, BEAM in DESY II



The famous 12.5 Hz cycle

- DESY II
 - Continuously cycling at 12.5 HZ
- Injection at 450 MeV from the L-Weg
 - Every second cycle
- Extraction at any time and any energy
 - e.g. 3 or 6 GeV particles for PETRA
 - 4.5 GeV particle for DORIS (not decommissioned)
- Very flexible ... but
 - The beam quality suffers after the deceleration
 - Can't run at a certain energy

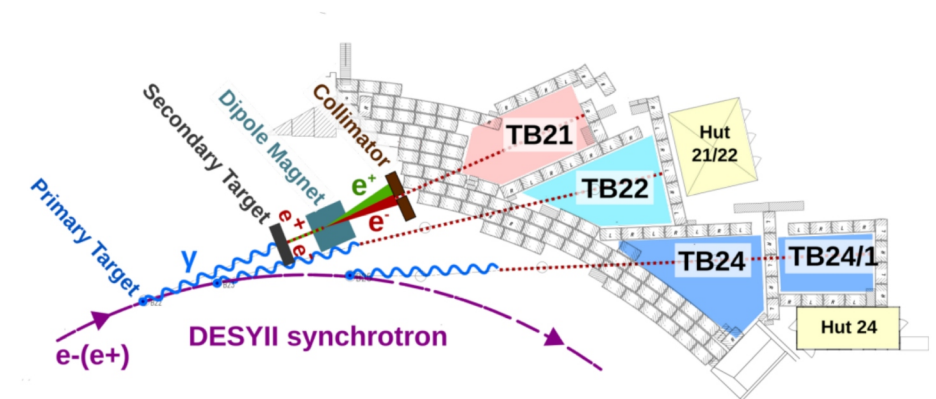
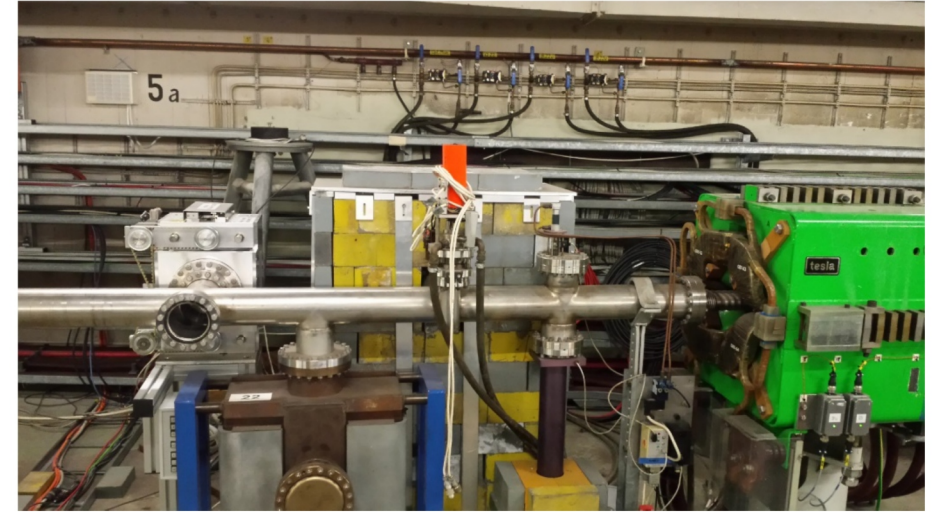




DESY II
Test Beam Facility

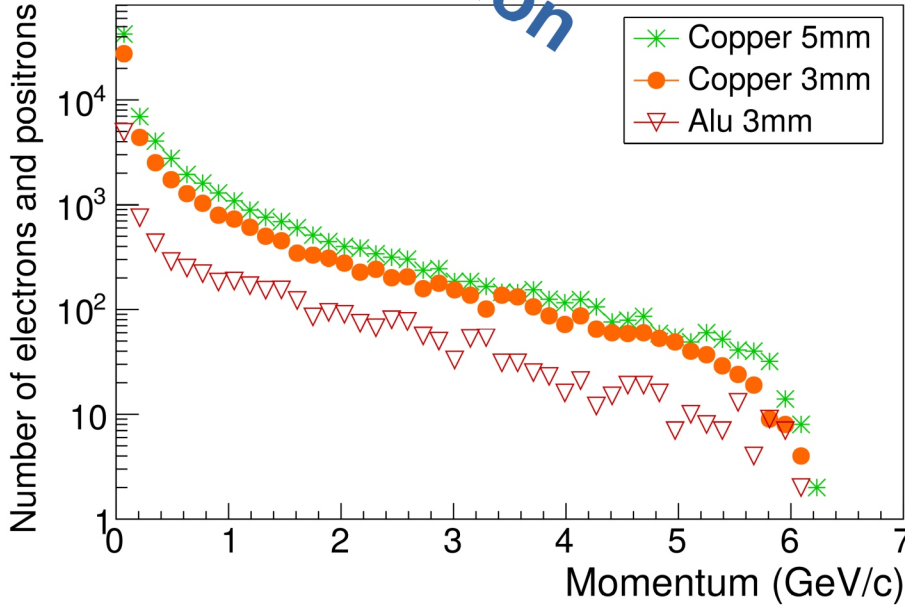
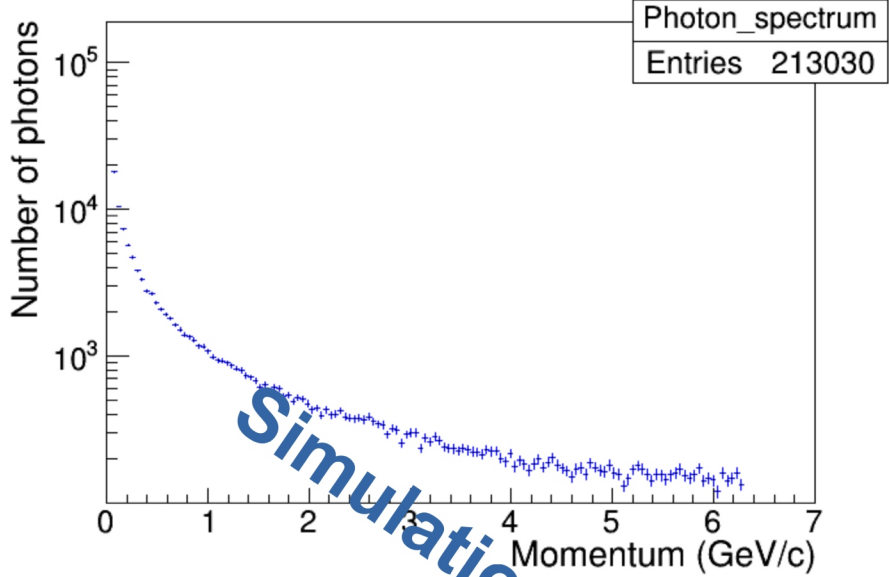
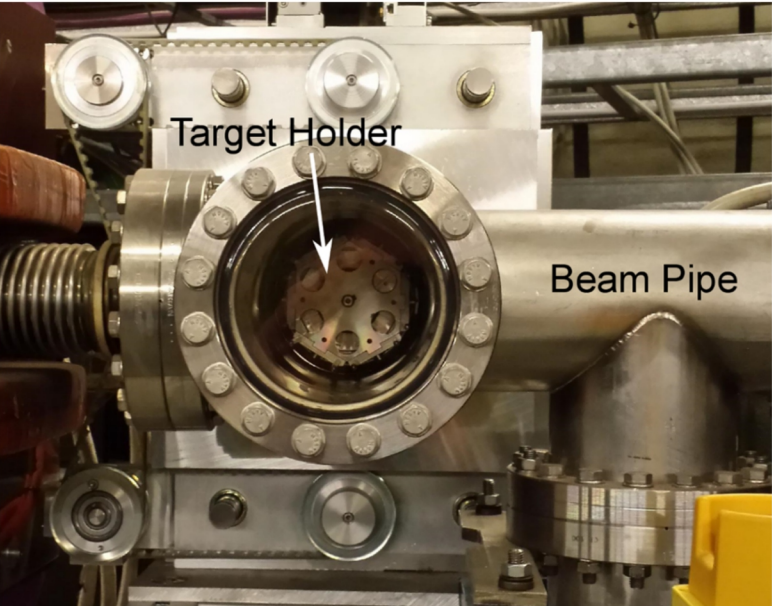
DESY II Test Beam Generation

- Test beam at DESY
 - No extraction of primary beam!
 - Fully parasitic
- Secondary beam generation
 - 3 Carbon-fibre targets inserted into the DESY II primary beam
 - Bremsstrahlung photons hits secondary target (copper or aluminum) to produce electron/positron pairs
 - Magnet selects the desired momentum and electrons/positrons entering the beam line
 - Primary Collimator to shape the beam
 - If shutter is open, beam enters the respective area

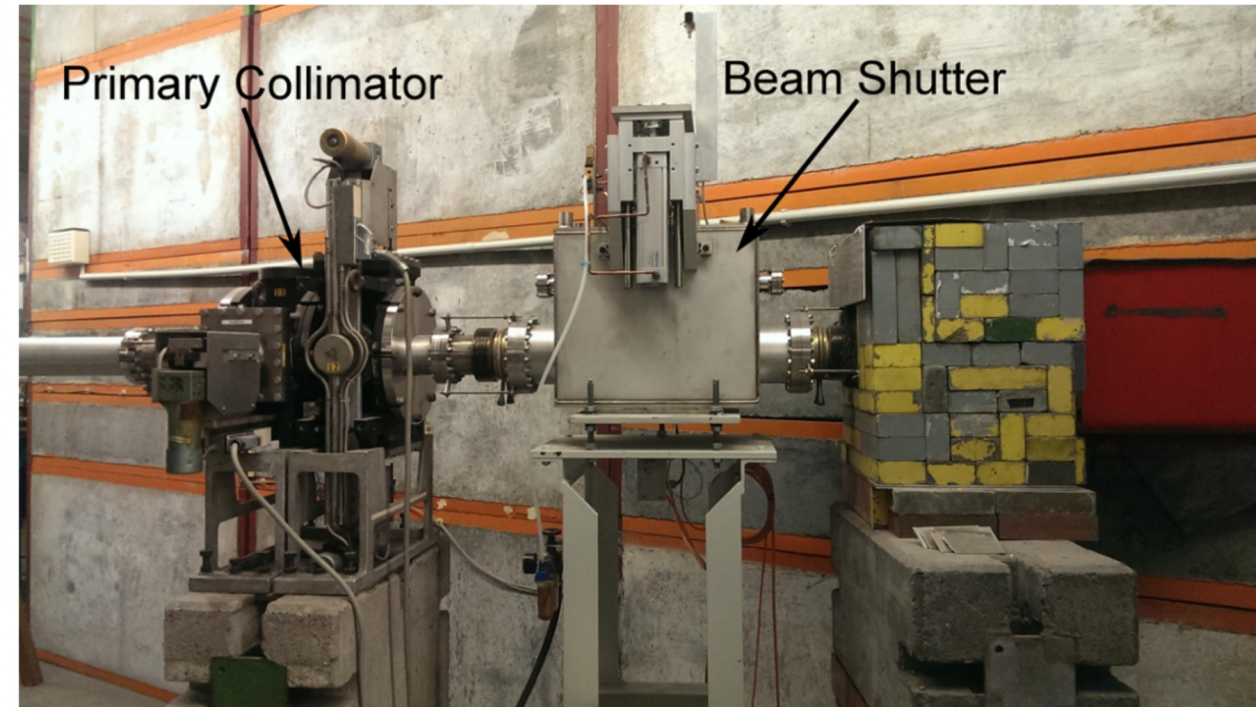
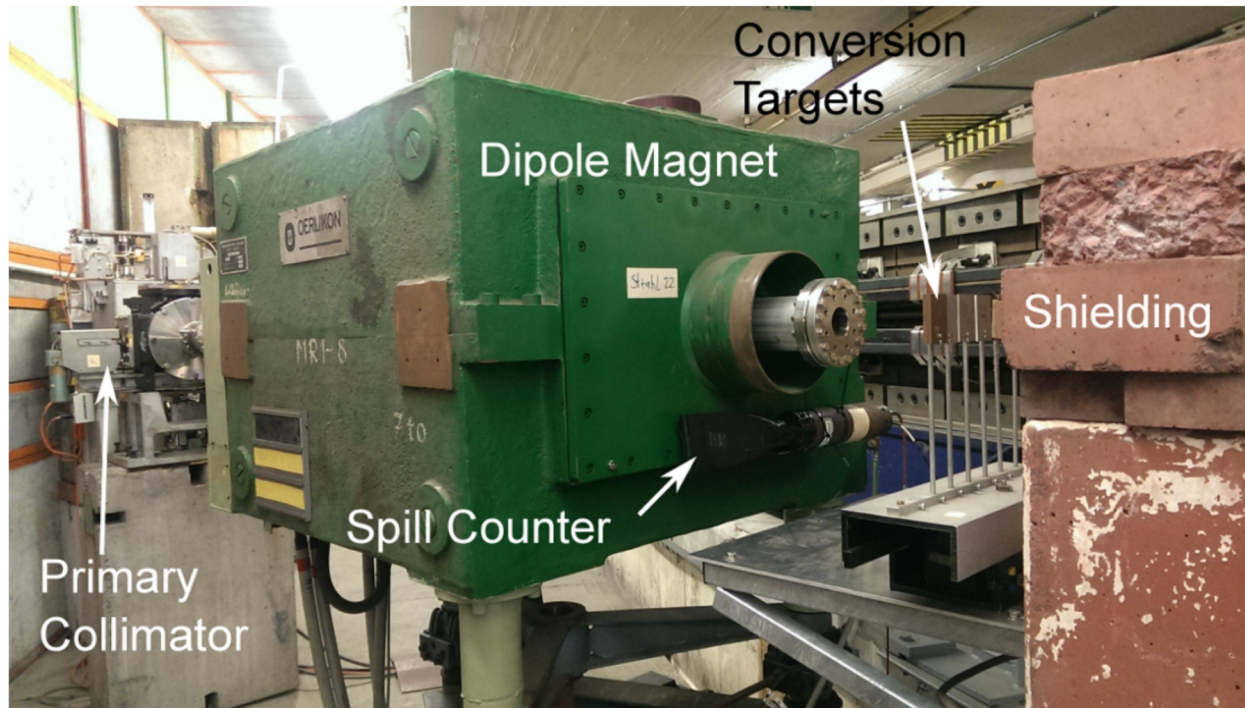


Making Photons, Electrons, Positrons

- 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 more complicated
- Choice of the secondary target impacts the rate

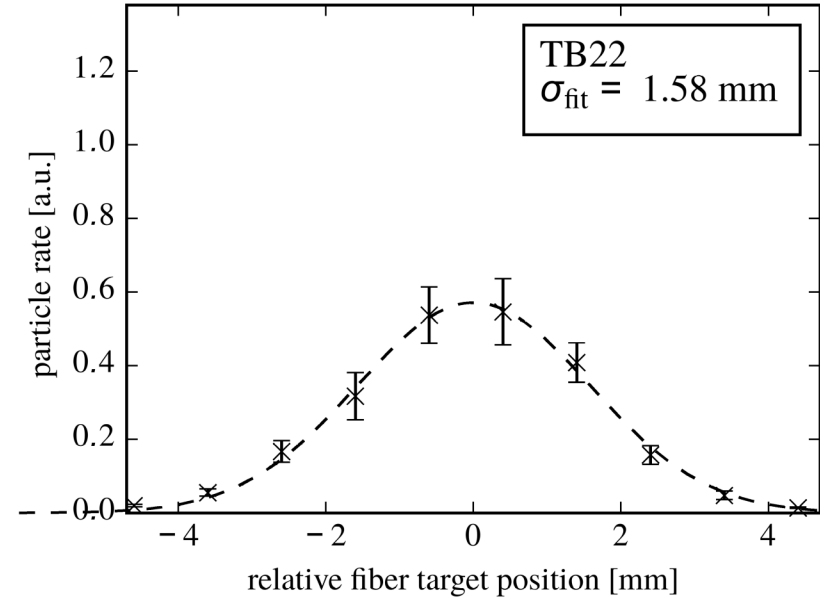
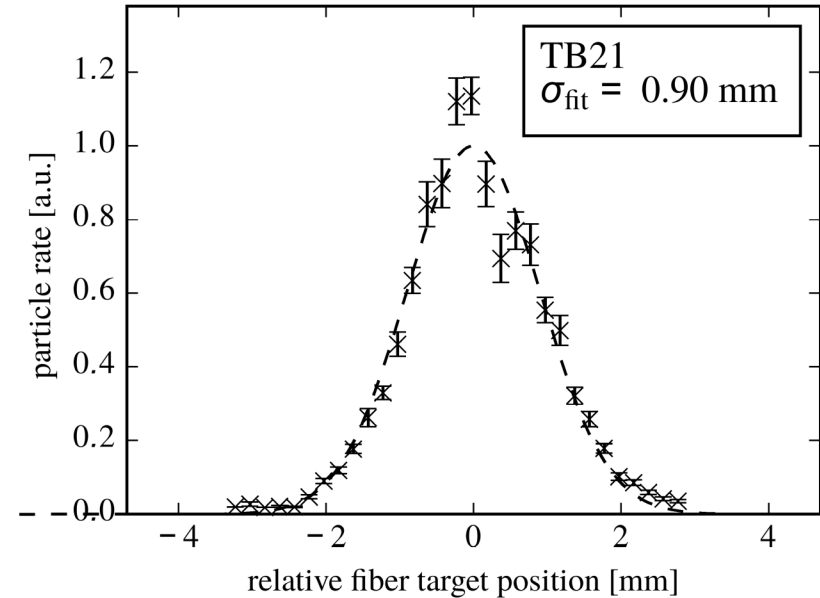
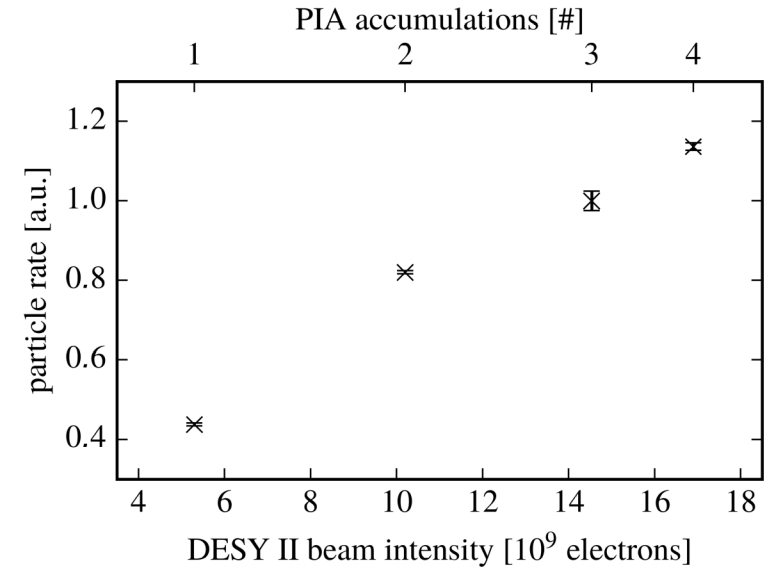


Magnets, Collimators and Shutters



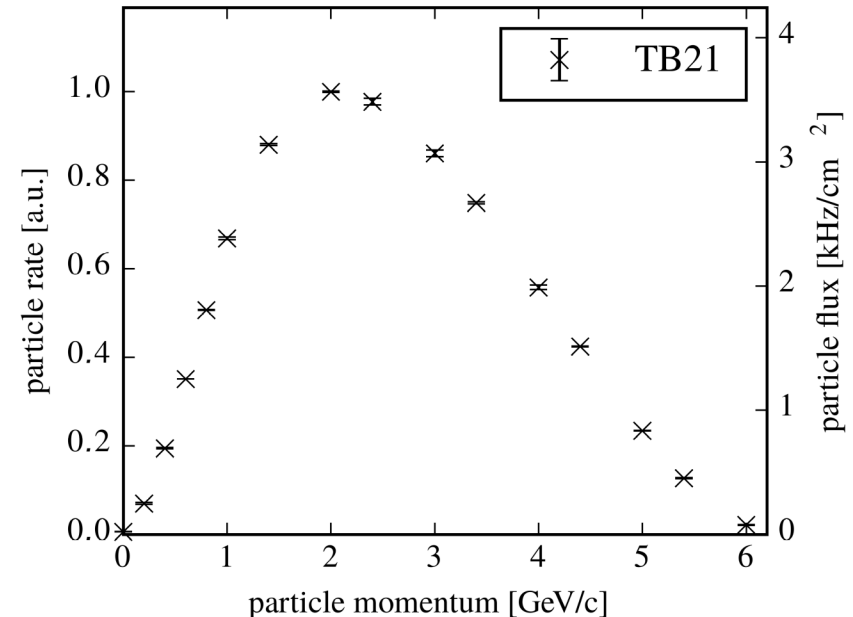
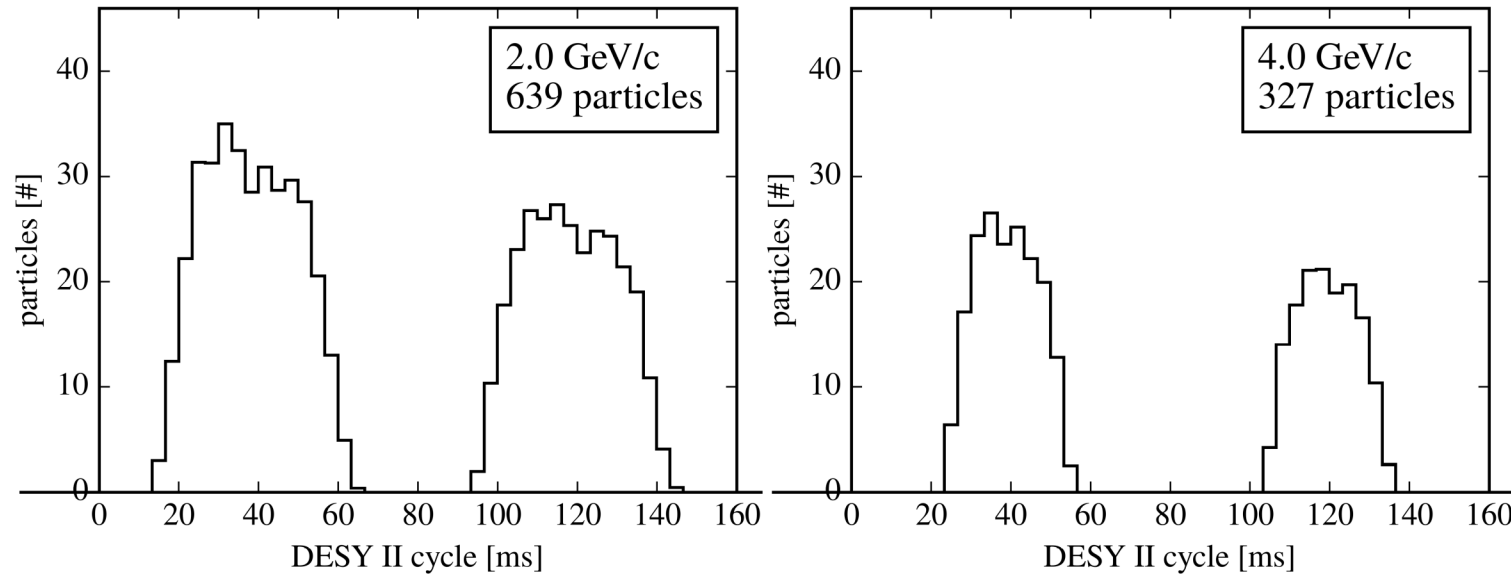
Performance → Basics

- The number of particles for your experiment depends on many parameters
 - DESY II and Operational status
 - Primary Target position
 - Selected Energy
 - Secondary target
 - Collimator size
- Hence
How many particles do I expect ?
is not as trivial as you may think



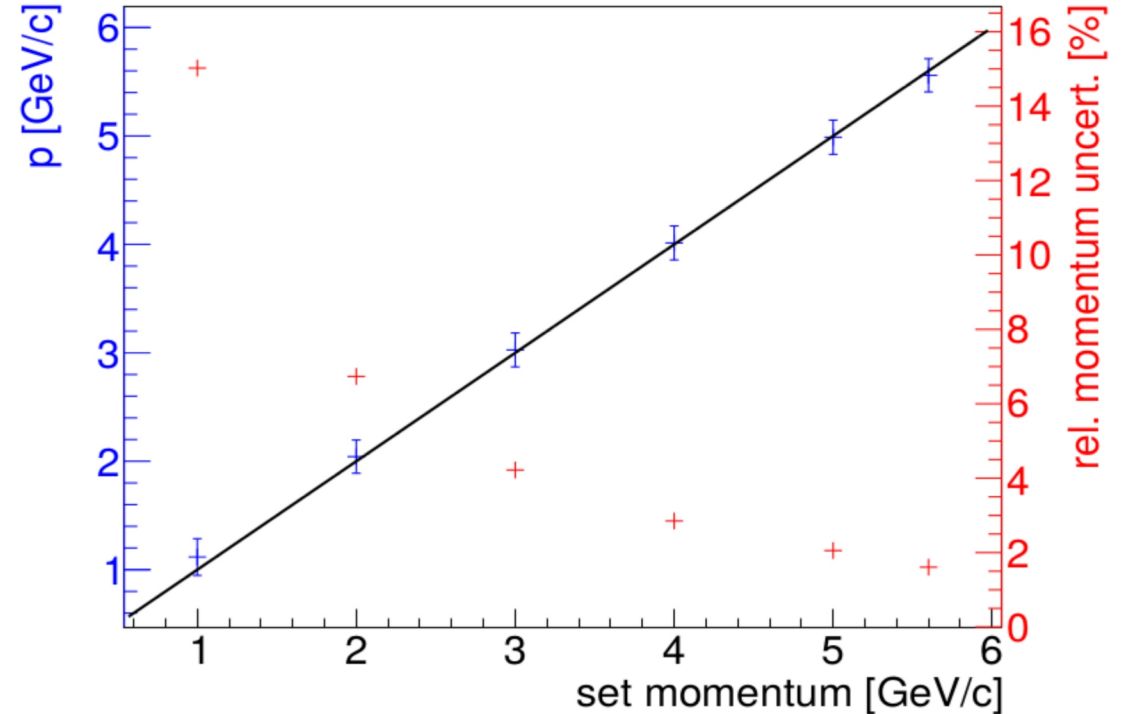
Performance → Particle Energy dependence

- This is a tricky one as there are several effects
 - The Bremsstrahlung spectrum is not flat
 - The DESY II cycle
 - Photon beam divergence
- E.g. Rate Dependence on the cycle
 - 2 GeV particles only possible if $E_{\text{DESY II}} > 2 \text{ GeV}$
 - No beam for certain periods



Performance → Momentum

- Quantity people are interested in
 - If I select 5 GeV particles, what is the offset and the spread ?
 - 1% 5 % ...
- Again not a trivial answer
 - But offset is very small
 - Rel momentum spread gets smaller with energy
 - Tight collimation will minimize spread but also the rate ...
- It all depends on user needs



Questions ?