40 Years of DESY II – A Review

13th Beam Telescopes and Test Beams Workshop,
Valencia, Spain, 19.May.2025

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HELMHOLTZ

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Introduction

Introduction

Start

What is the lowest injection energy of DESY II?

200MeV

Found:

- **March 22nd, 1985: 1. beam in DESY II**
- **Nov. 1984 - Feb. 85 Installation (4 Month)**
- **Winter '85/'86 Connect Transfer Lines**

- **DESY I is serving DORIS, PETRA and test beam users**

Another date:

- **Sept. 10th, 1990** My first day at DESY
  - Support for ZEUS detector assembly
    - 1. project: ZEUS concrete shielding
  - **Responsible for the technical equipment at the test beams**

G. Hemmie, "Status Report on the DESY II Synchrotron,"
PAC 1985; doi: 10.1109/TNS.1985.4333677
IEEE Transactions on Nuclear Science,
vol. 32, no. 5, pp. 1641-1643, Oct. 1985,

STATUS REPORT ON THE DESY II SYNCHROTRON

The DESY II Collaboration*
presented by G. Hemmie
Deutsches Elektronen-Synchrotron DESY
Notkestraße 85, 2000 Hamburg 52, W.-Germany

Abstract

After approval of the construction of the new separated function electron synchrotron, DESY II, in May 1983, the design and fabrication of all components was completed and the new machine fully installed during a four month winter shutdown from Nov. 84 until Feb. 85. The new machine will be tested in parallel with normal operation of the old 7 GeV synchrotron, DESY I, by using 200 MeV electrons injected from the upgraded Linac I. Provisional power supplies run the magnets up to 1 GeV. During a second shutdown in winter 85/86 it is planned to install full magnet- and rf-power and to connect all beam transfer lines to PETRA and DORIS. DESY I will then be turned off and most of the components will be used to form a new proton synchrotron (DESY III) for the HERA e^--p project.

An updated parameter list and first results from the initial tests of DESY II will be presented.

Introduction

On March 22, 1985 the first electron beam was injected from Linac I into the new electron synchrotron DESY II. The captured beam revolved several thousands of turns in the machine. A construction period of less than two years had elapsed since May 1983 when the project was authorized. Further beam-tests have been carried out up to the present time (April 85). Since the old synchrotron DESY I is still serving the two storage rings DORIS and PETRA and test beam users, these DESY II tests have to be carried out between the filling procedures and do not interfere with the high energy physics program at DESY. The upgraded Linac I is switched back and forth from DESY I 55 MeV injection to DESY II 200 MeV injection.

Parameter list:

repetition frequency	12.5 Hz
max. energy (for magnet design)	10 GeV
1st completion stage	8 GeV
injection	
e^- single bunch 5×10^9 particles	200 MeV
e^+ " " 8×10^9 "	450 MeV
circumference	292.8 m
lattice sep. function 8 superperiods	
6 BM + 3 QF + 3 QD + 2 SD + 1 SF	
acceptance ($\Delta p/p$) = ± 1 %) $A_{x,z}$	= 10 mradmm
max. horiz. beta	21.8 m
" vert. "	21.8 m
momentum compaction	.243
rf harmonic number	488
frequency	499.65 MHz
no. of cavities (7-cell type)	8
total shunt impedance	168 MOhm
peak power	900 kW
magnets (rating refer to 10 GeV/c excitation)	
dipoles length	3.55 m
gap	160x45 mm²
good field region ($\Delta B/B$ 5×10^{-4})	± 40 mm
bending radius	27.12 m
max. field	1.23 T
peak current	1147 A
inductance	33.2 mH
power losses	30 kW
quadrupoles length	.58 m
max. field	14.7 T/m
peak current	1350 A
power losses	6 kW
sextupoles core length	.18 m
max. field	77.8 T/m²
power losses	∿ 1.1 kW

Fig. 1 shows details of the dipole and fig. 2 the results of measurements of the field homogenity.

Deutsches Elektronensynchroton DESY

How it began

DESY Laboratory

How it began

1955 Germany was allowed to do Nuclear Research

1956 Willibald Jentschke ➔ Prof. @ Hamburg University
Proposing a laboratory with a particle accelerator
(Electron, not Proton; Synchrotron, not a LINAC, Hamburg: empty site)

1957 Start Preparation

1959 Foundation of DESY (Deutsches Elektronensynchrotron) as a national institute

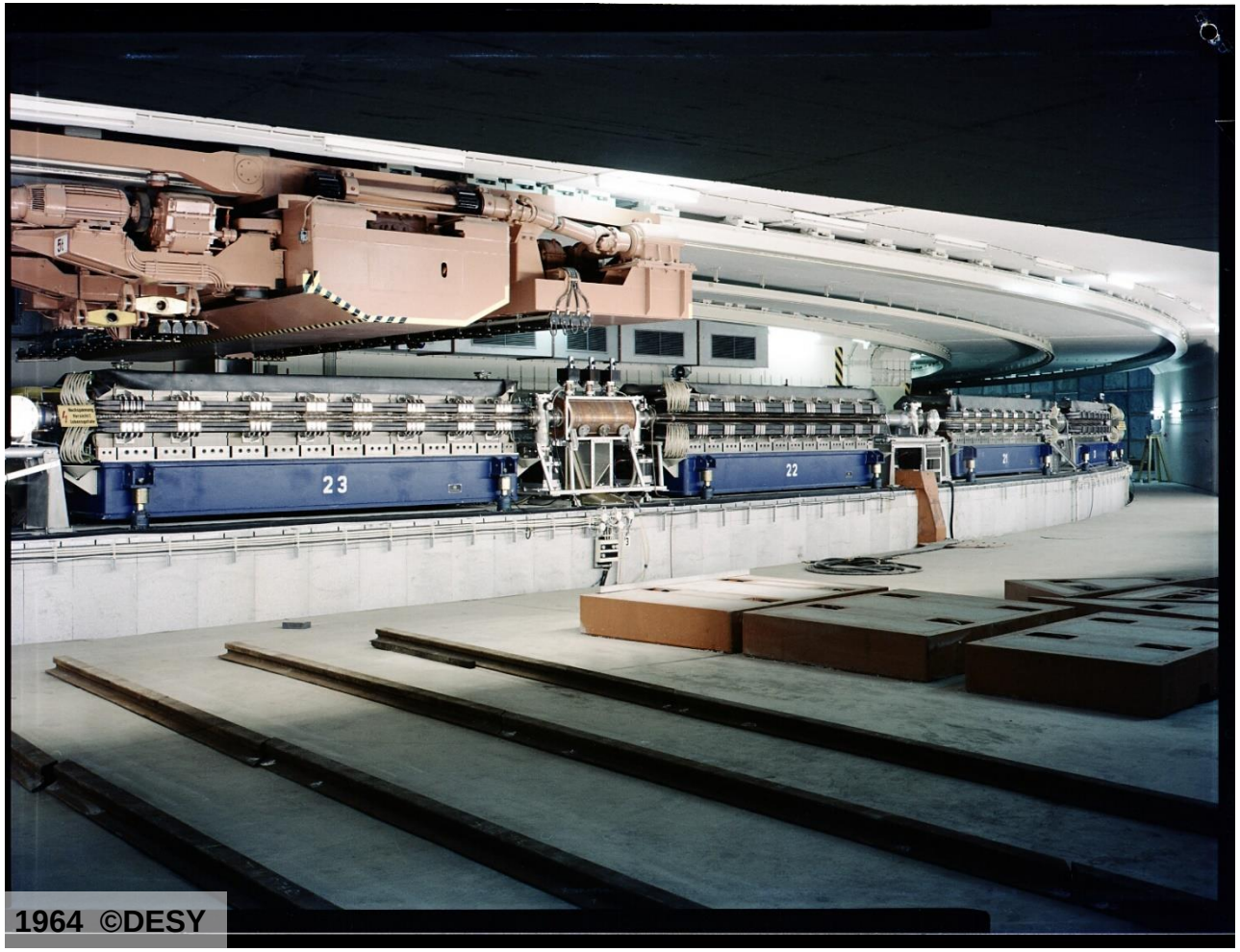
1930 ©DESY

1963 © DESY

1965 ©DESY

DESY I

How it began



1964 ©DESY

DESY I:

- Improved Copy of Cambridge Electron Accelerator (CEA) Cooperation Harvard & MIT (1952-1974)
- 300m Circumference
- 7.5 GeV Electrons
- Alternating Gradient Synchrotron
  with 48 Combined Function Magnets
  i.e. FODO Lattice (Focussing-Defocussing Lattice)
  plus Kickers, Septa, Cavities, Targets etc.
- 50 Hz White-Circuit Power Supply

Other Synchrotrons: (first operation)

- AGS, Brookhaven; (1960) 33 GeV Protons
- PS, CERN; (1960) 30 GeV Protons
- CEA, Cambridge; (1962) 6 GeV Electrons
- DESY, Hamburg; (1964) 7.5 GeV Electrons

1. Mayor of Hamburg visiting DESY

1964

Experimental Hall I & II 1965-1977

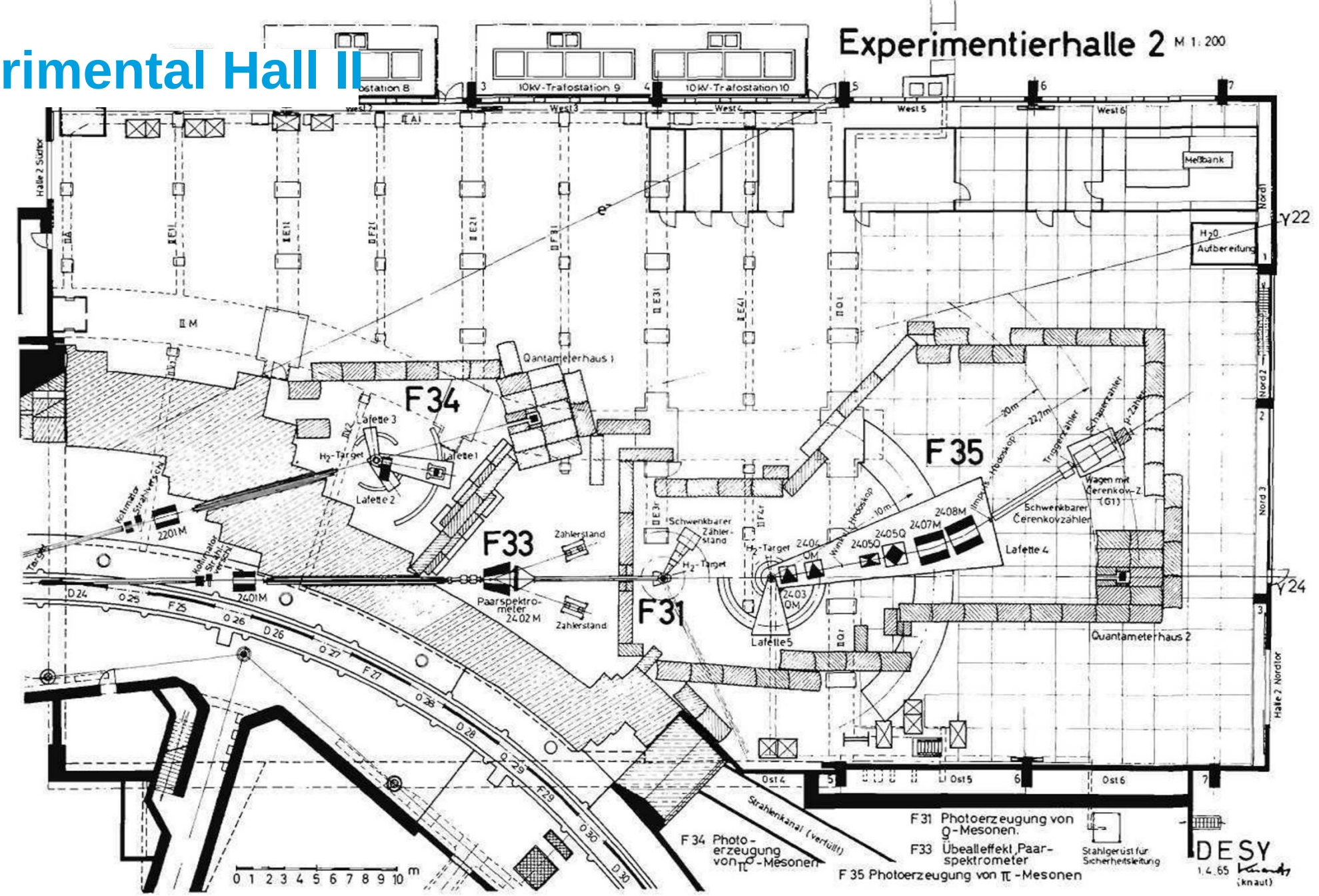
Drawings from Annual Reports “Wissenschaftlicher Jahresbericht”
Photos from DESY Archive

Layout Experimental Hall II

1965

- System of channels under the floor (Dashed Lines)
- Sophisticated set of Shielding Blocks
- Modular Interlock System
- Switch Board for Magnet Power
- …

➔ **Flexible Setups**



New Beam Line Installation

05.03.1964 Quantameter, Aufbau Halle 1 Dr. Ladage KB-Film E5

- Beam Height 1700mm

Standard Shielding Blocks:

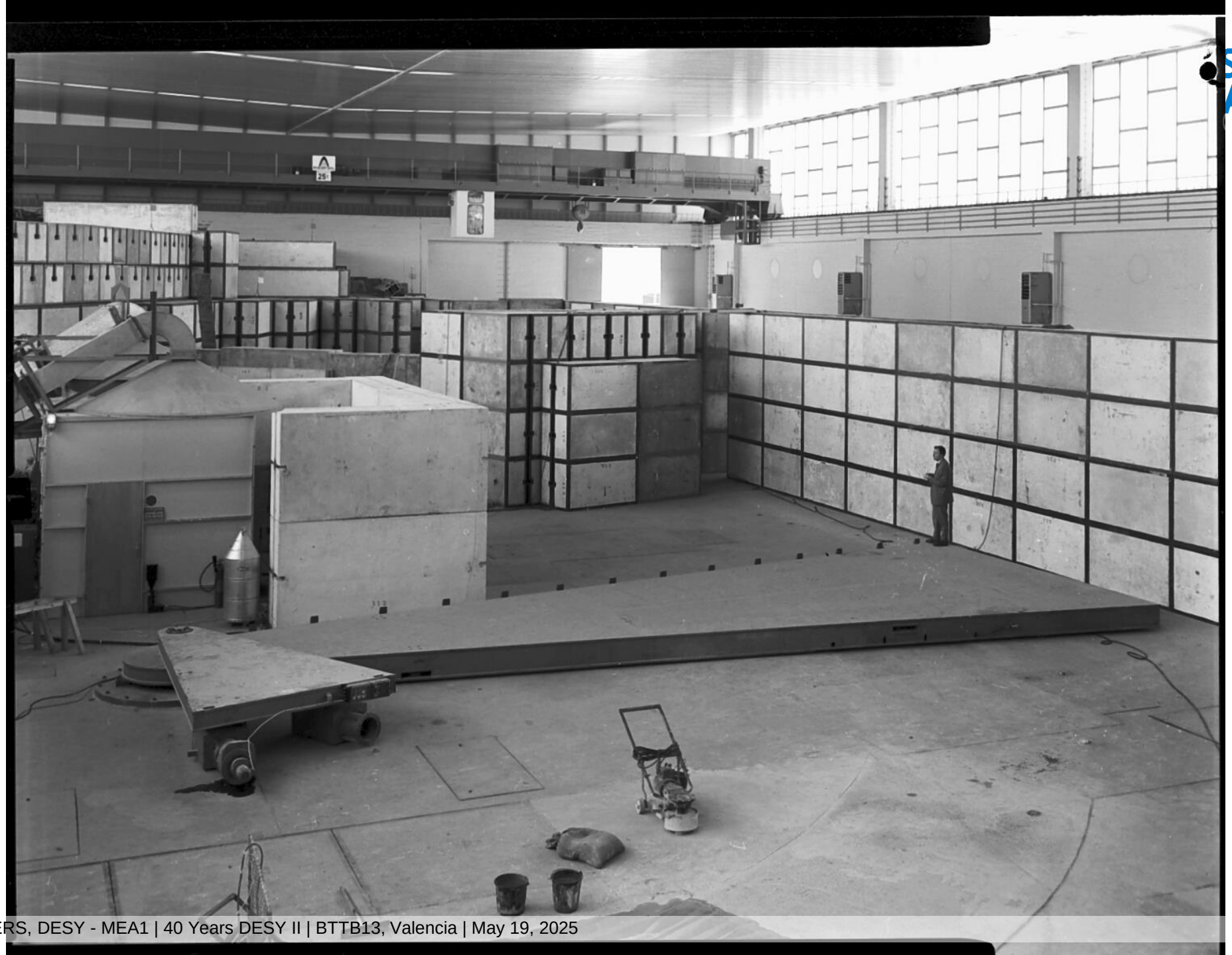
- Normal Height: 1090mm
- Special Height1: 400mm
- Special Height2: 290mm
- Thickness: 1130mm
- Length (Trapezoid): 2000/1960mm

Experimental Hall II 1964

25.05.1964 Halle 2, Ring u. Exp. Absch. M

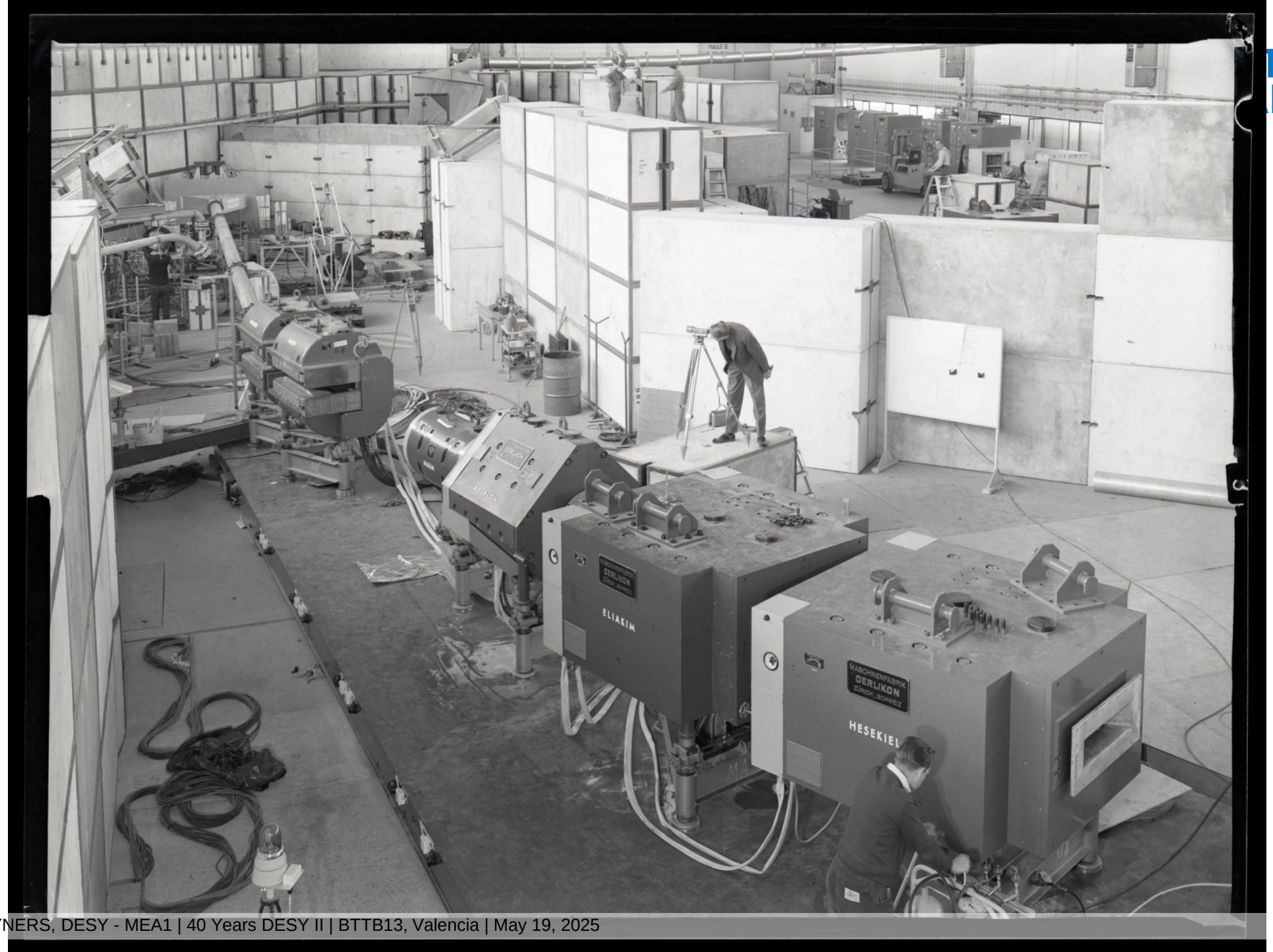
Experimental Hall II 1964

14.09.1964 Atlas, Lafette in Halle 2 (leer) W



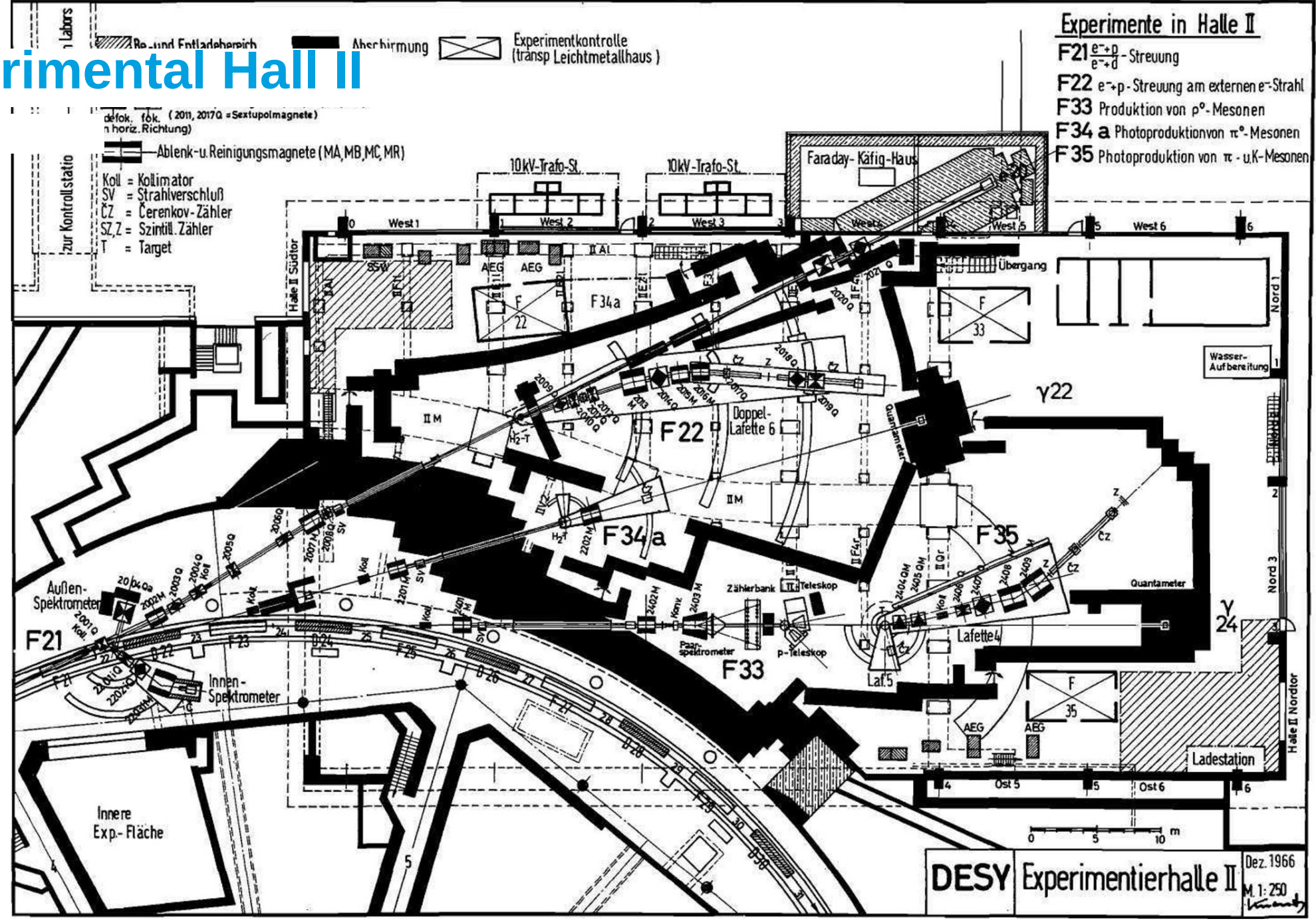
Hall II 1965

2696 24.06.1965 Halle 2 (Atlas, Spektrometer) Dr. Wuster R/SD



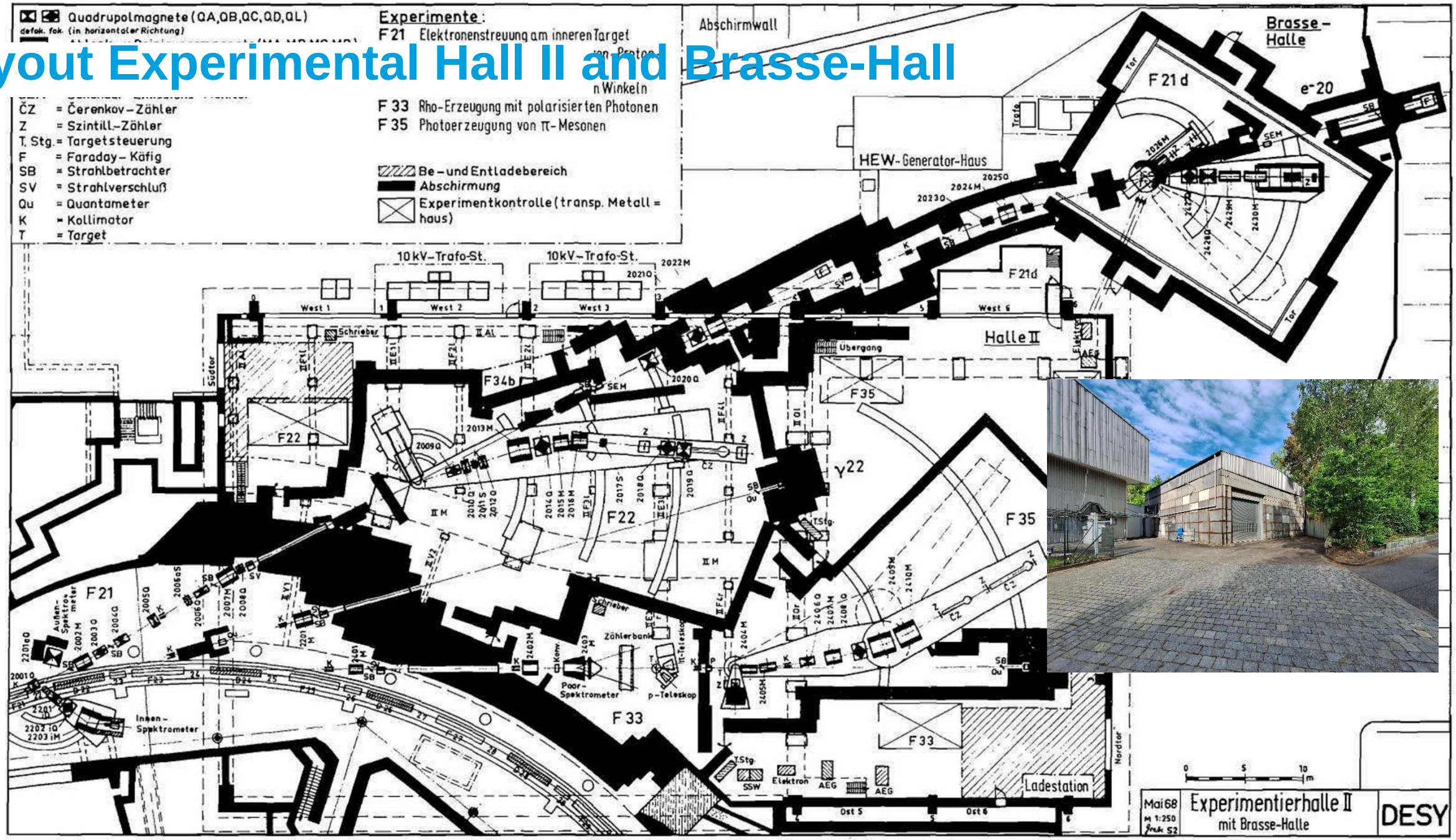
Layout Experimental Hall II

1966



Layout Experimental Hall II and Brasse-Hall

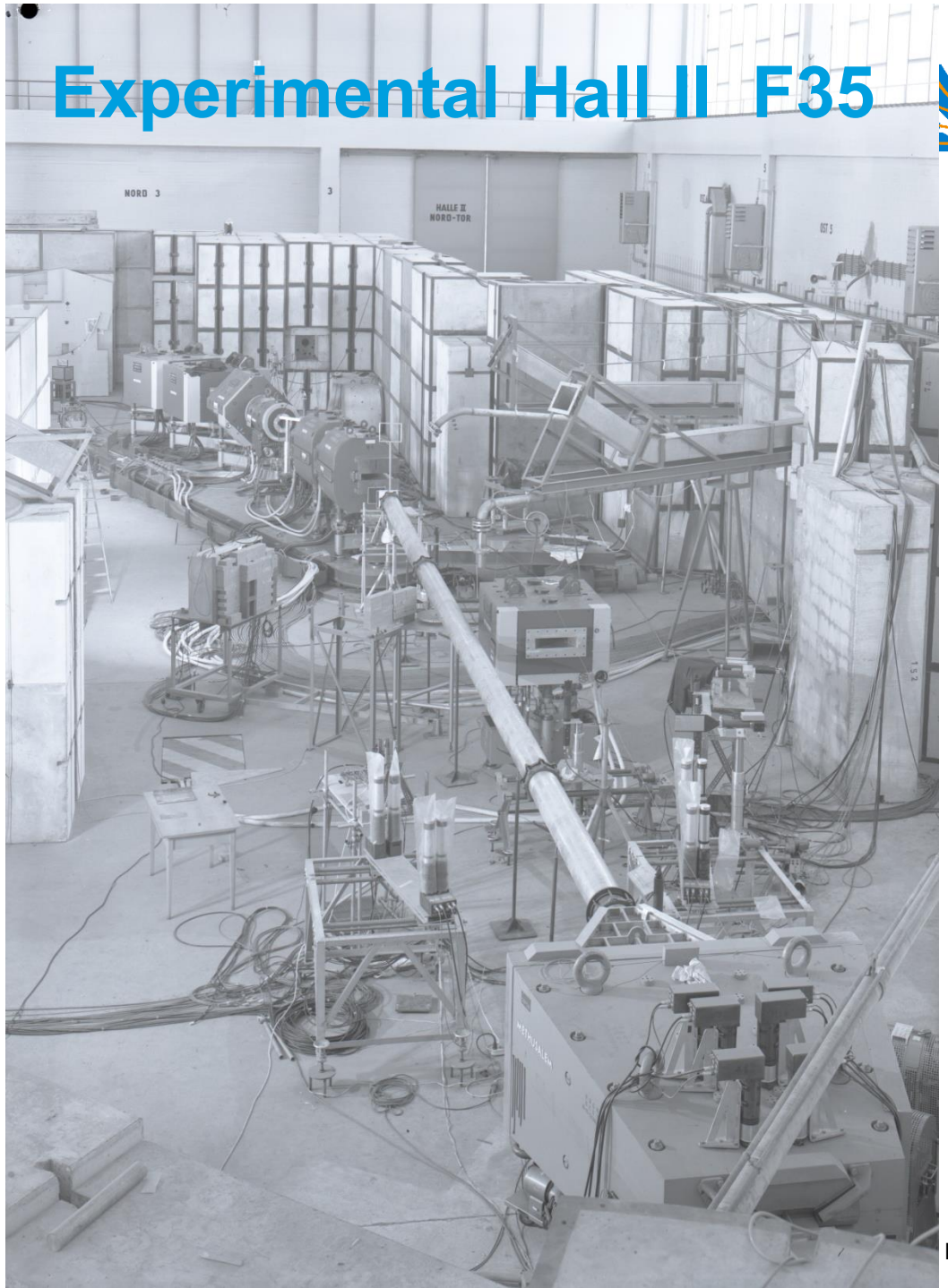
1967



“beam Shutter for ext. e-beam”

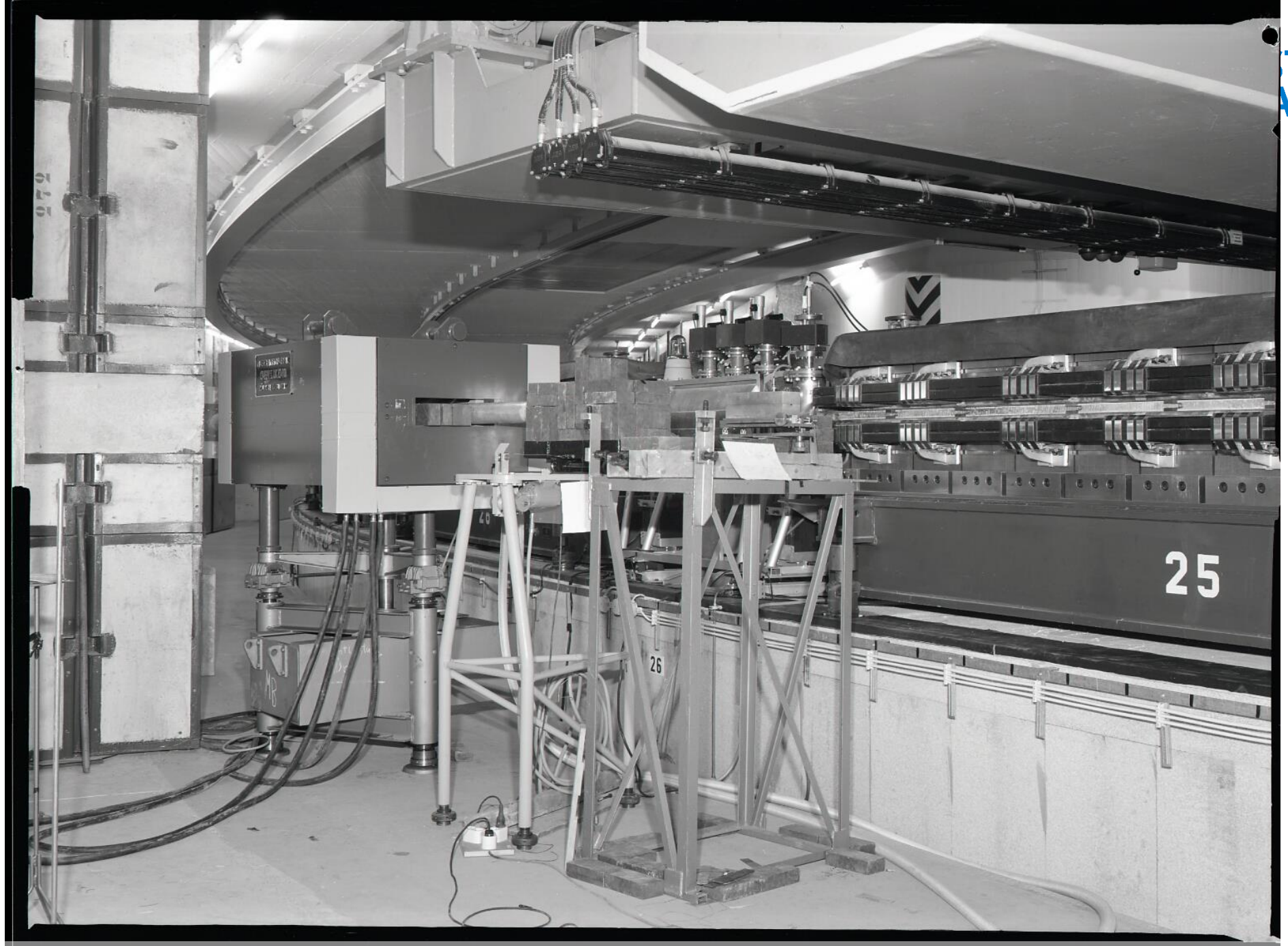
1965

Experimental Hall II F35



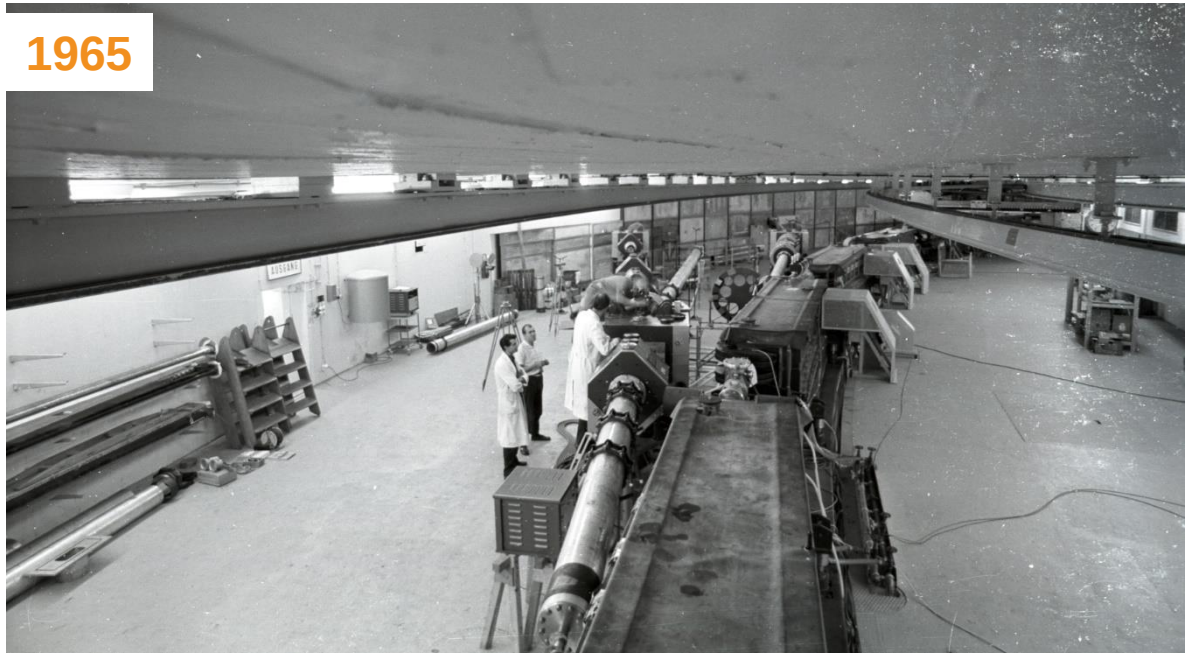
Bending Magnet befor Hall II 1964

25.05.1964 Ablenkmagnet i. Ring vor Halle 2 SD

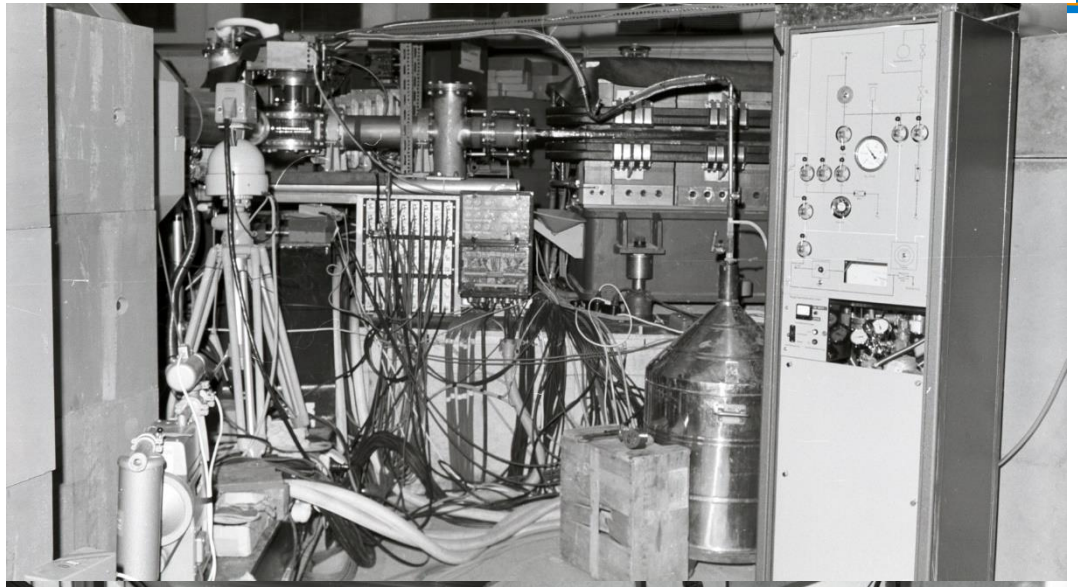


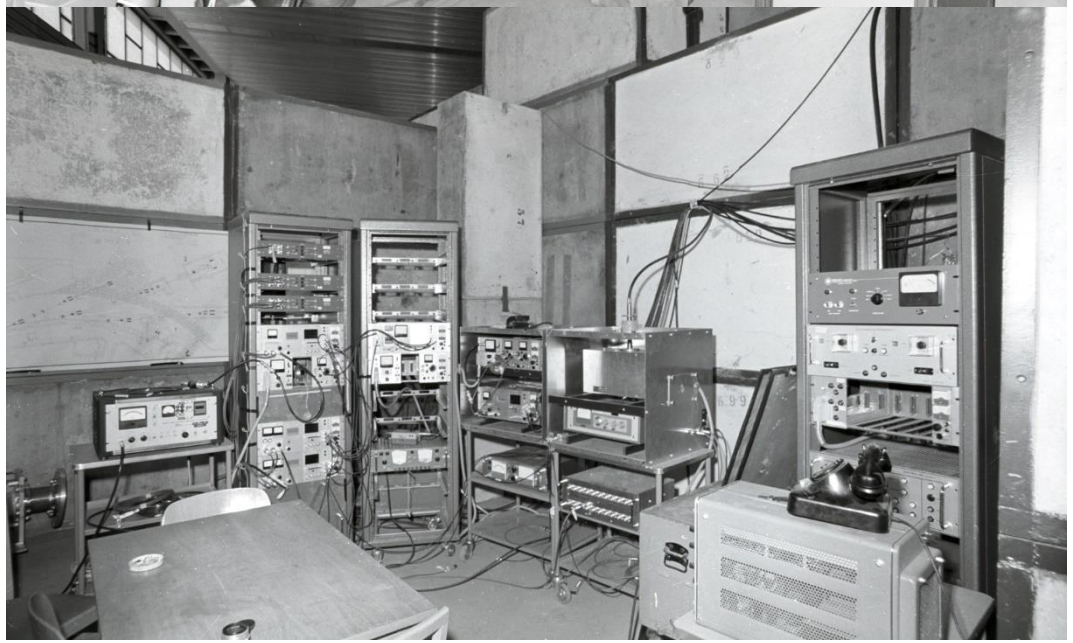
“Ext. e- beam” (A2/F22)

1965



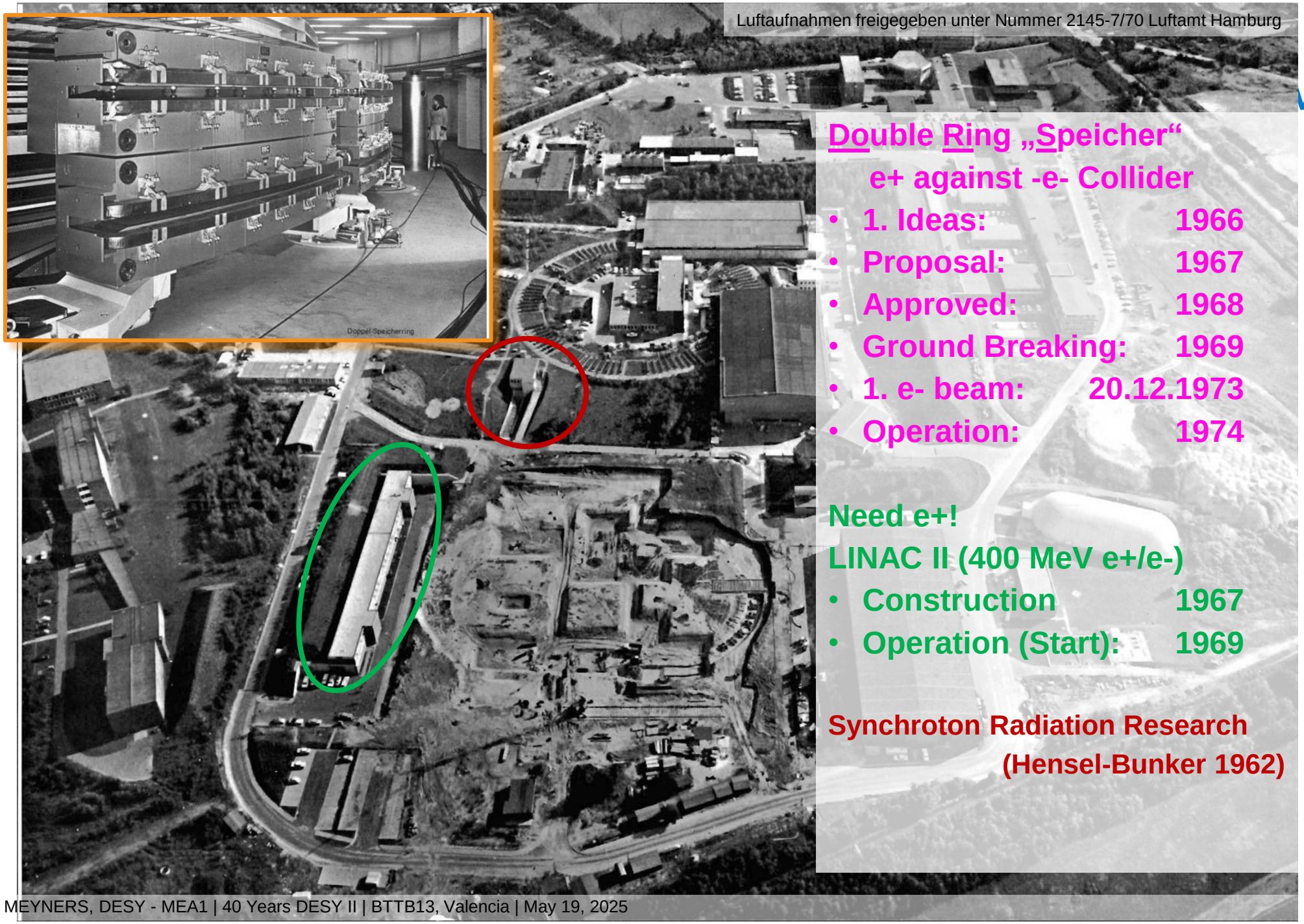
Hydrogen Target (F21)





DESY Site 1970

Foreground DORIS Construction Site



Luftaufnahmen freigegeben unter Nummer 2145-7/70 Luftamt Hamburg

Double Ring „Speicher“

e+ against -e- Collider

- 1. Ideas: 1966
- Proposal: 1967
- Approved: 1968
- Ground Breaking: 1969
- 1. e- beam: 20.12.1973
- Operation: 1974

Need e+!

LINAC II (400 MeV e+/e-)

- Construction 1967
- Operation (Start): 1969

Synchroton Radiation Research

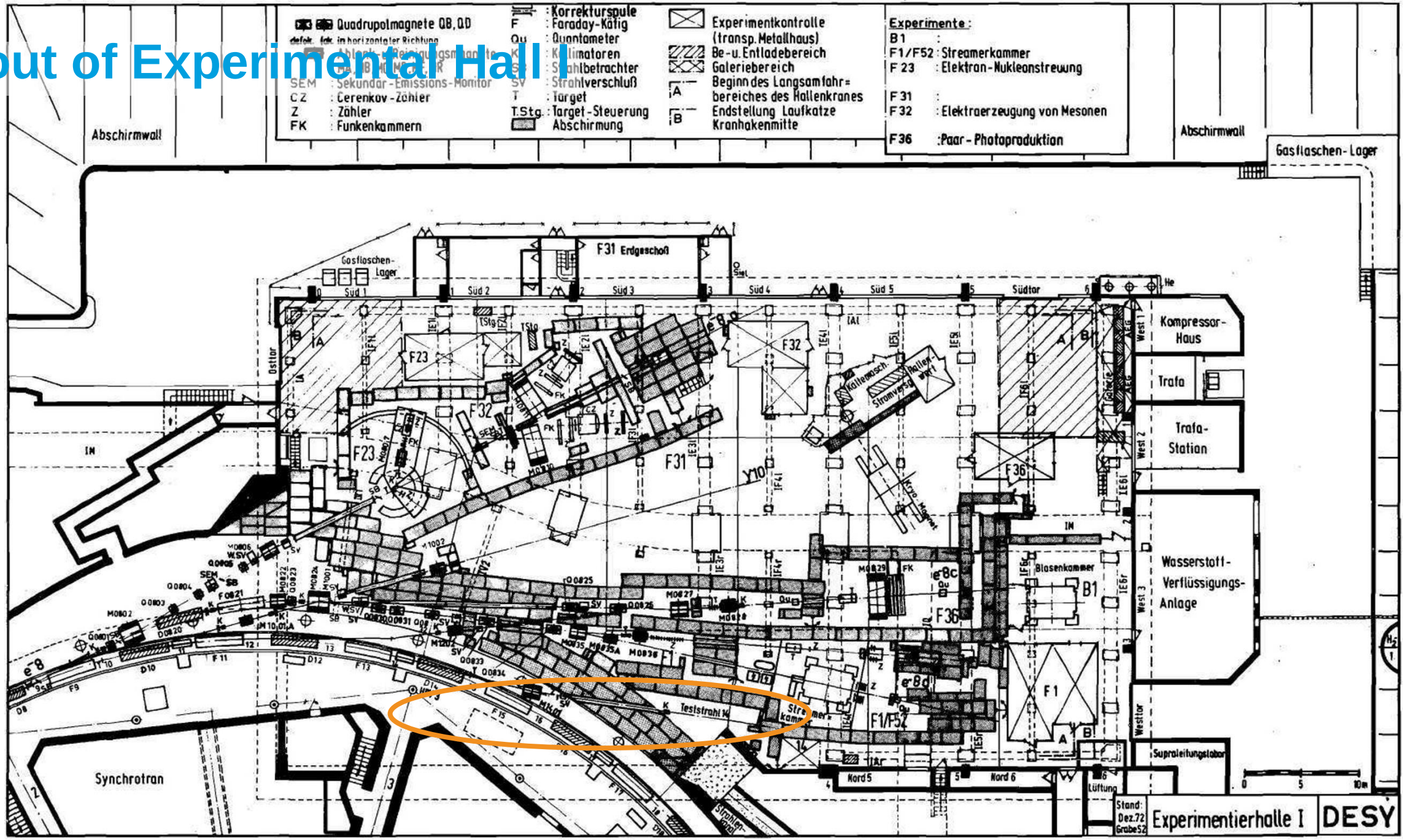
(Hensel-Bunker 1962)

Eine Luftaufnahme der Anlagen von DESY. Im Vordergrund die Baugrube des Speicherrings, im mittleren Teil die Kreisbahn des Synchrotrons mit den beiden Experimentierhallen.

(Alle in diesem Bericht verwendeten Luftaufnahmen sind freigegeben unter der Nummer 2145-7/70 Luftamt Hamburg)

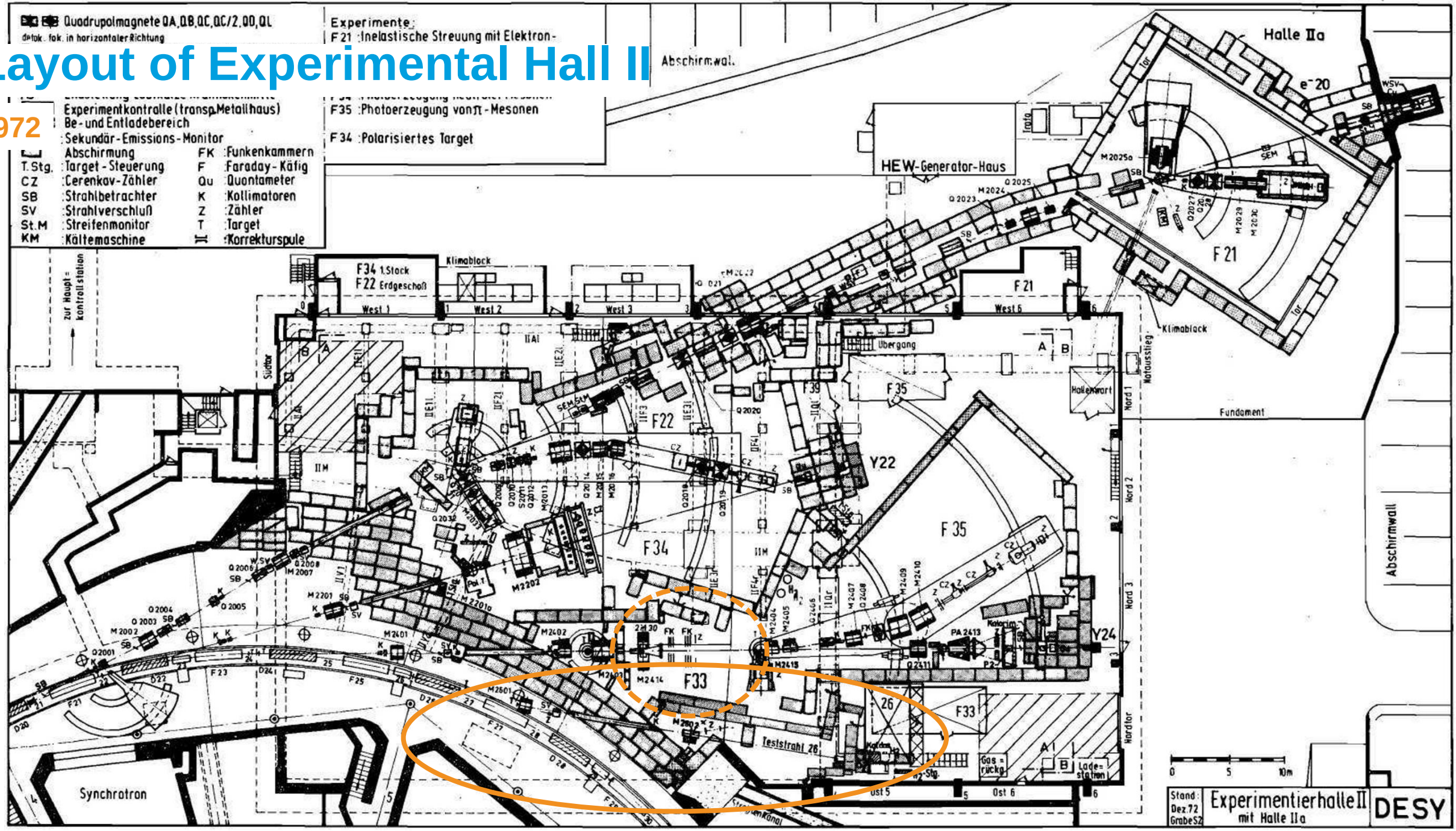
Layout of Experimental Hall I

1972



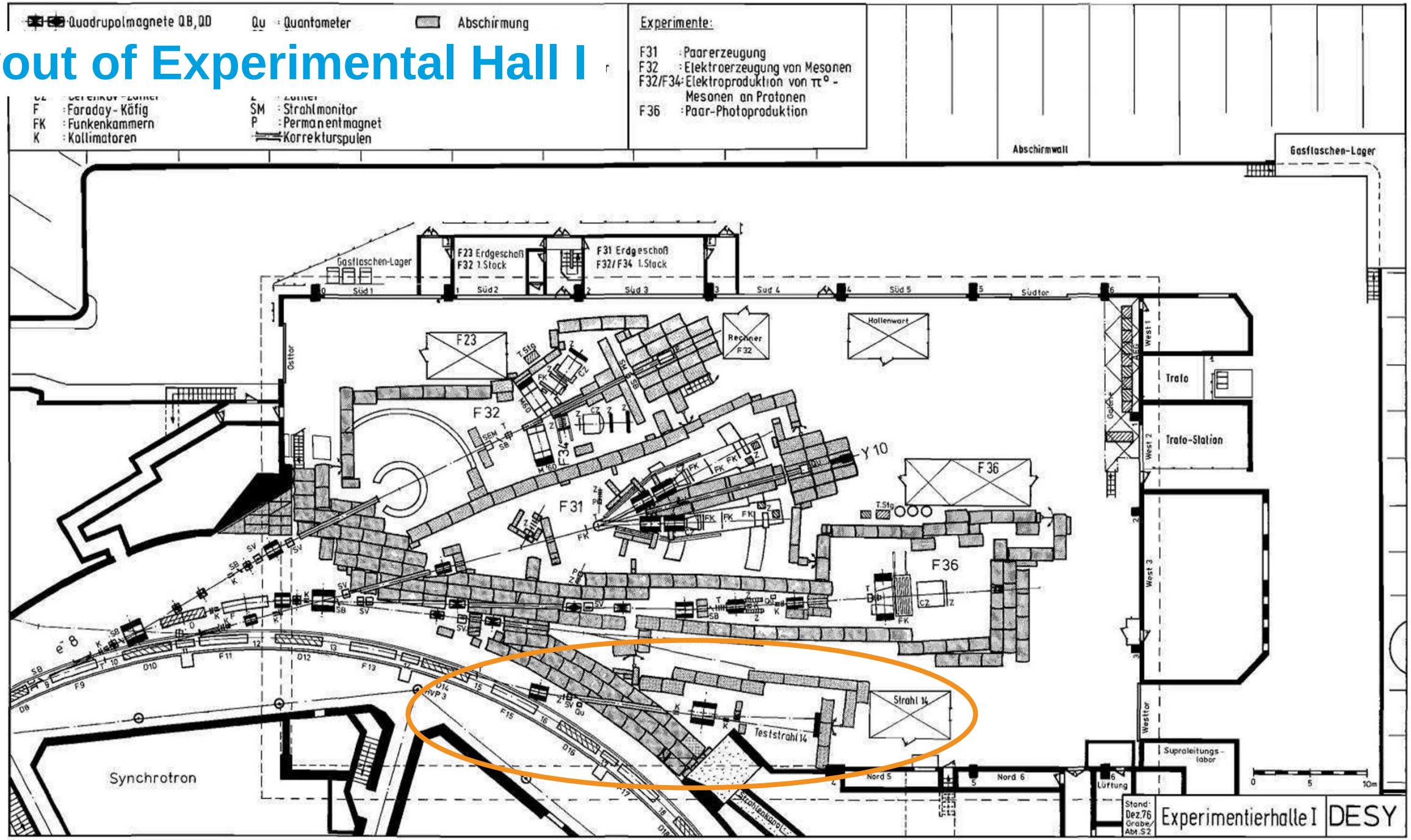
Layout of Experimental Hall II

1972



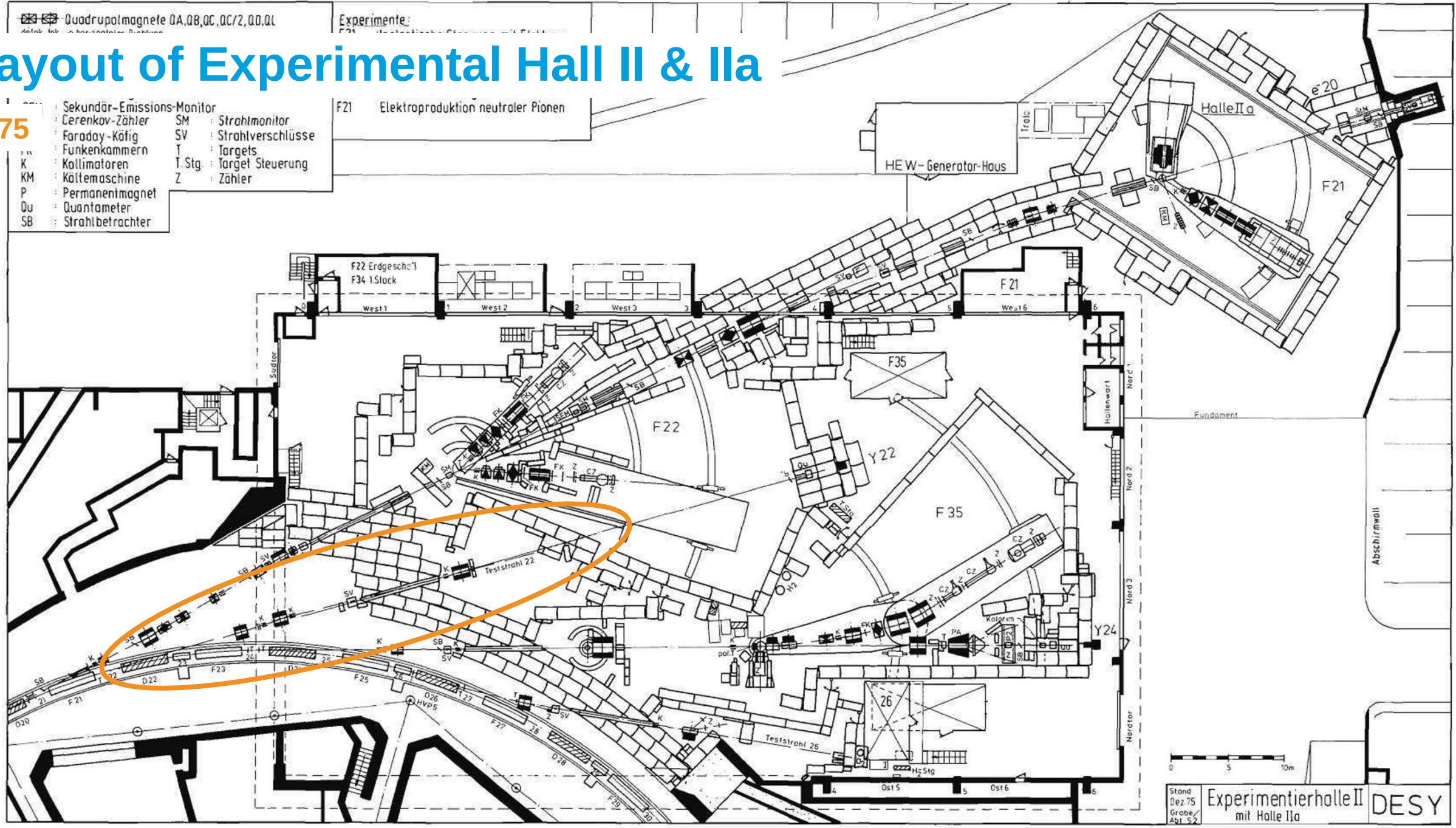
Layout of Experimental Hall I

1976



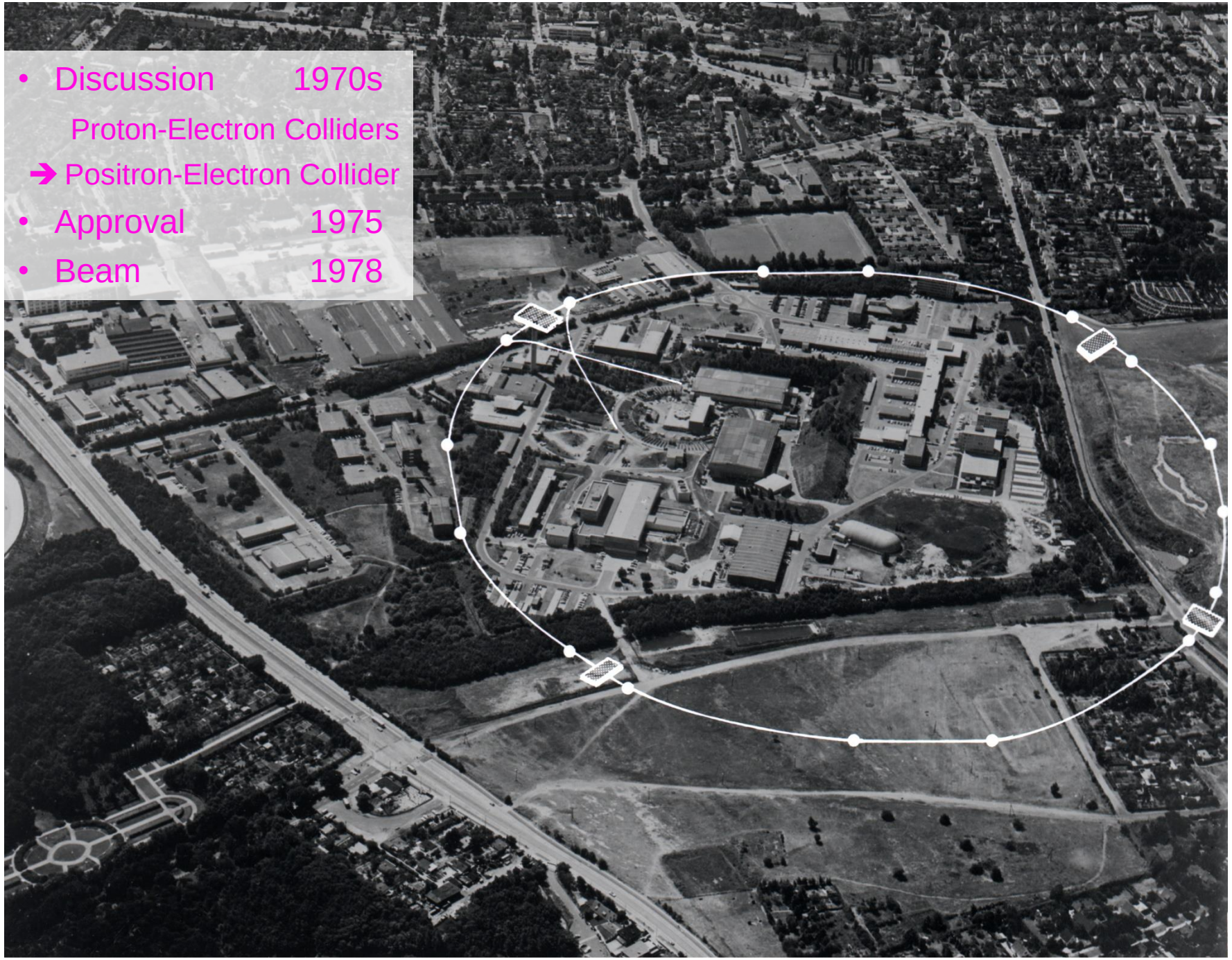
Layout of Experimental Hall II & IIa

1975



PETRA Planning 1975

15.09.1975 Repro Luftbild mit “Petra” D4



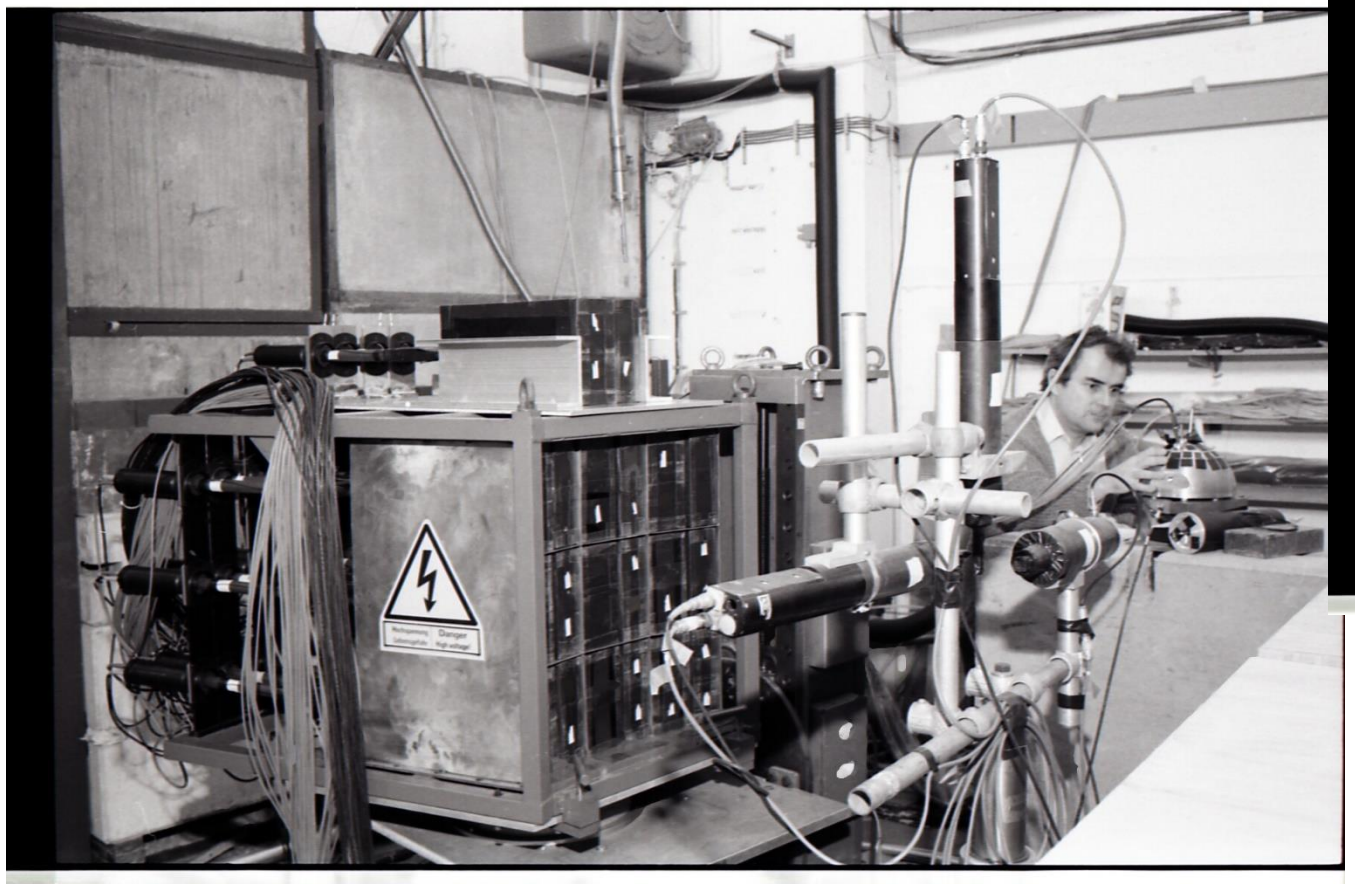
- Discussion 1970s
  Proton-Electron Colliders
  ➔ Positron-Electron Collider
- Approval 1975
- Beam 1978

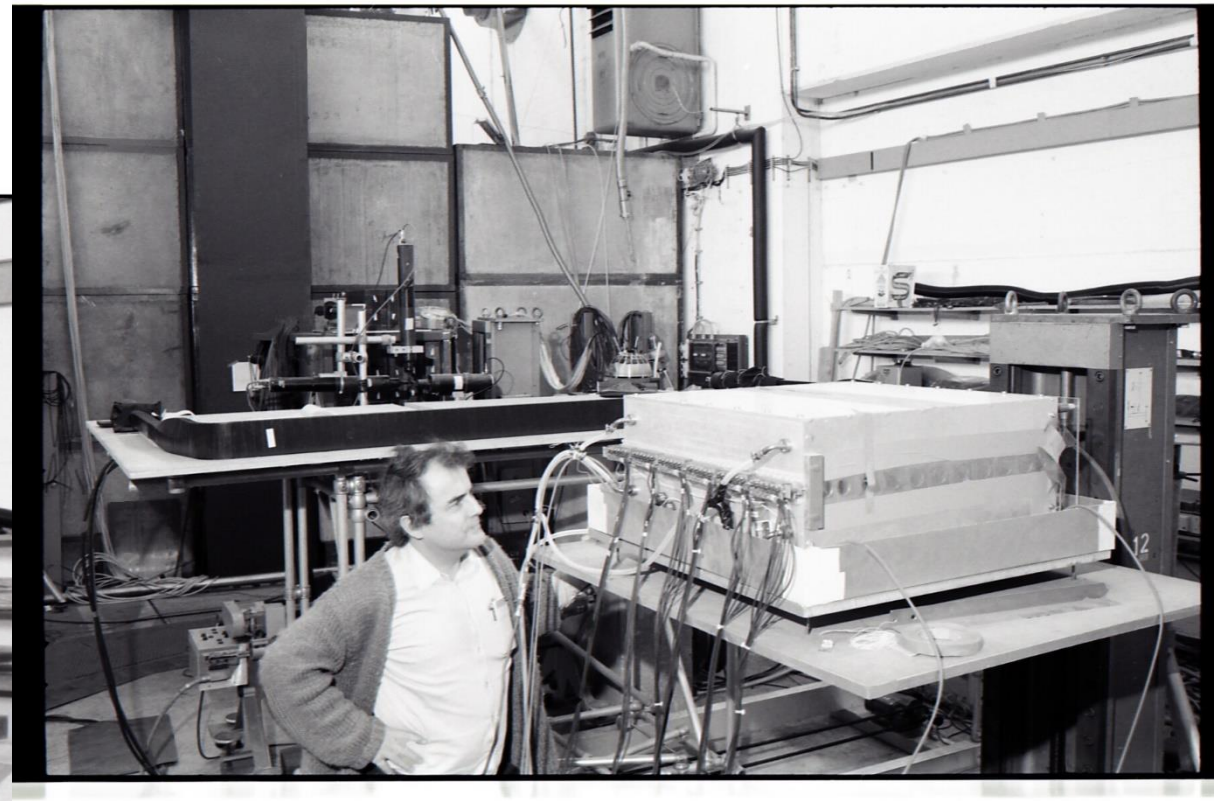
Test Beam @ DESY I

1982 for ARGUS(?)

Test Beam 1982

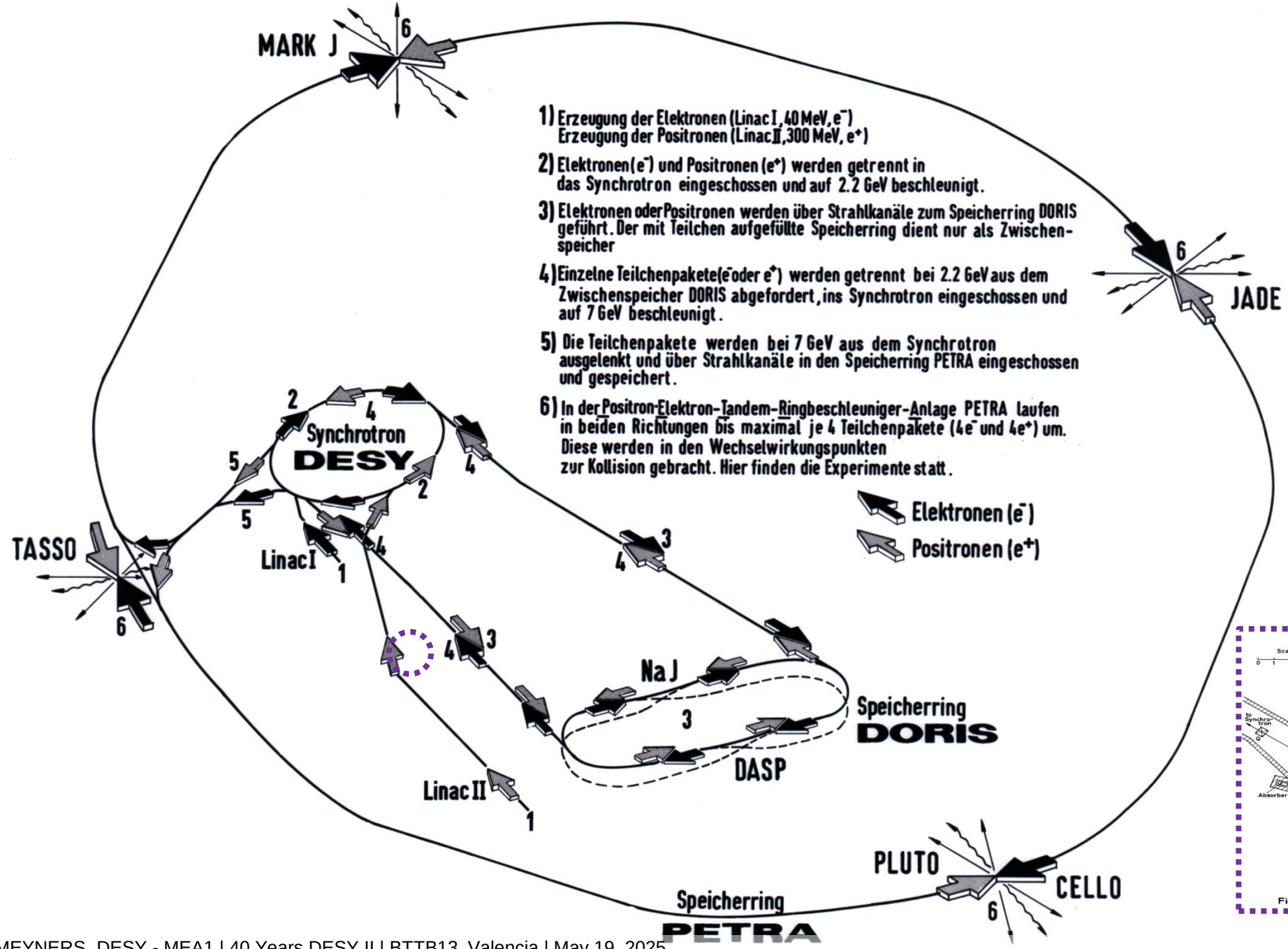
ARGUS Detektor Components (?)





DORIS as Accumulator @ 2.2GeV

1978



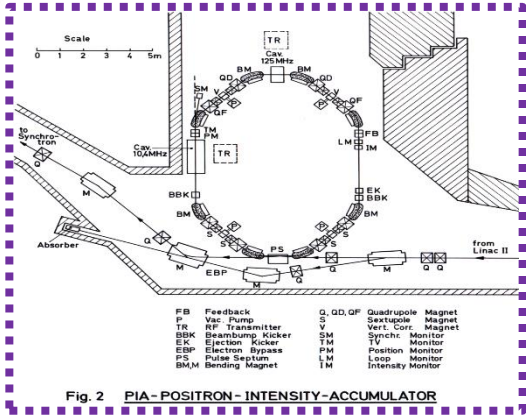


Fig. 2 PIA-POSITRON-INTENSITY-ACCUMULATOR

DESY II

DESY II in DESY Tunnel

1982 Concept

- 9.2 GeV, Single Bunch
- up to 16 7-cell Cavities (RF-Power 1.2 MW)
- FODO Lattice: Separate Function Magnets
  48 Dipole, 48 Quadrupole, 12 Sextupole,
  plus Kicker, Septum Magnets, Fiber targets etc.
- 12.5Hz cycle, White-circuit
  (modified & reuse from DESY I)

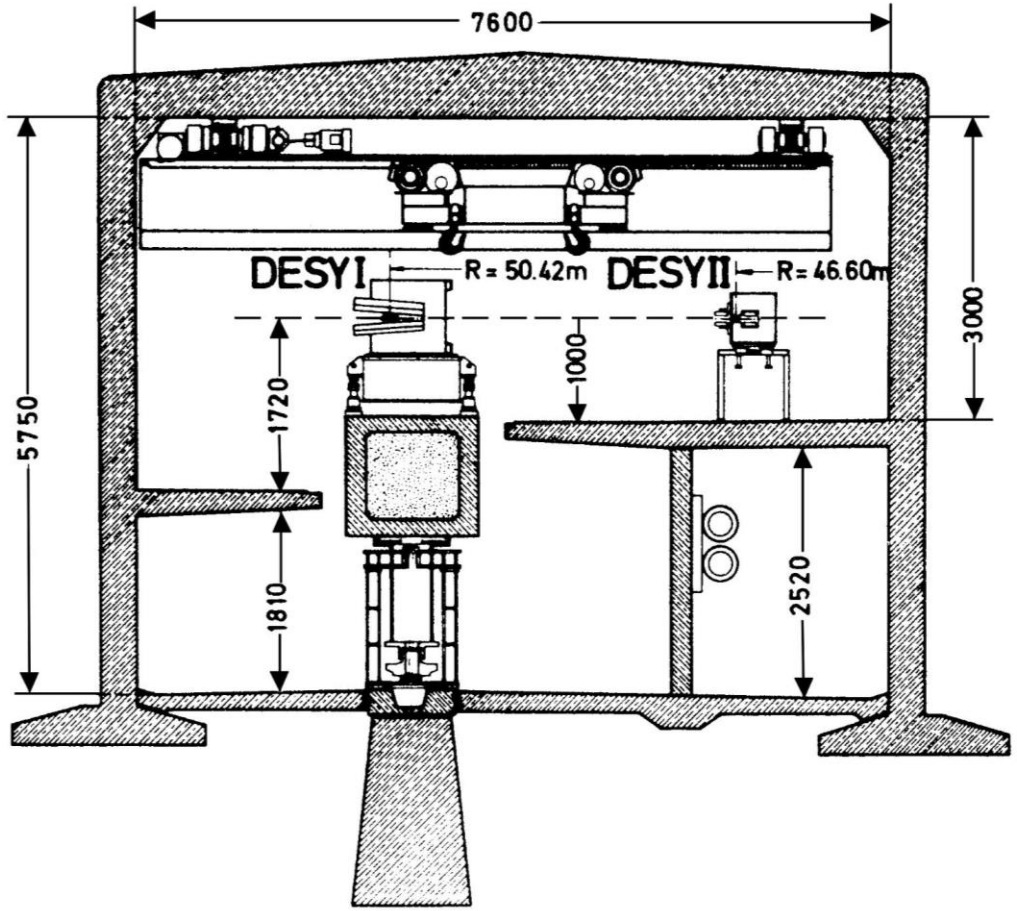


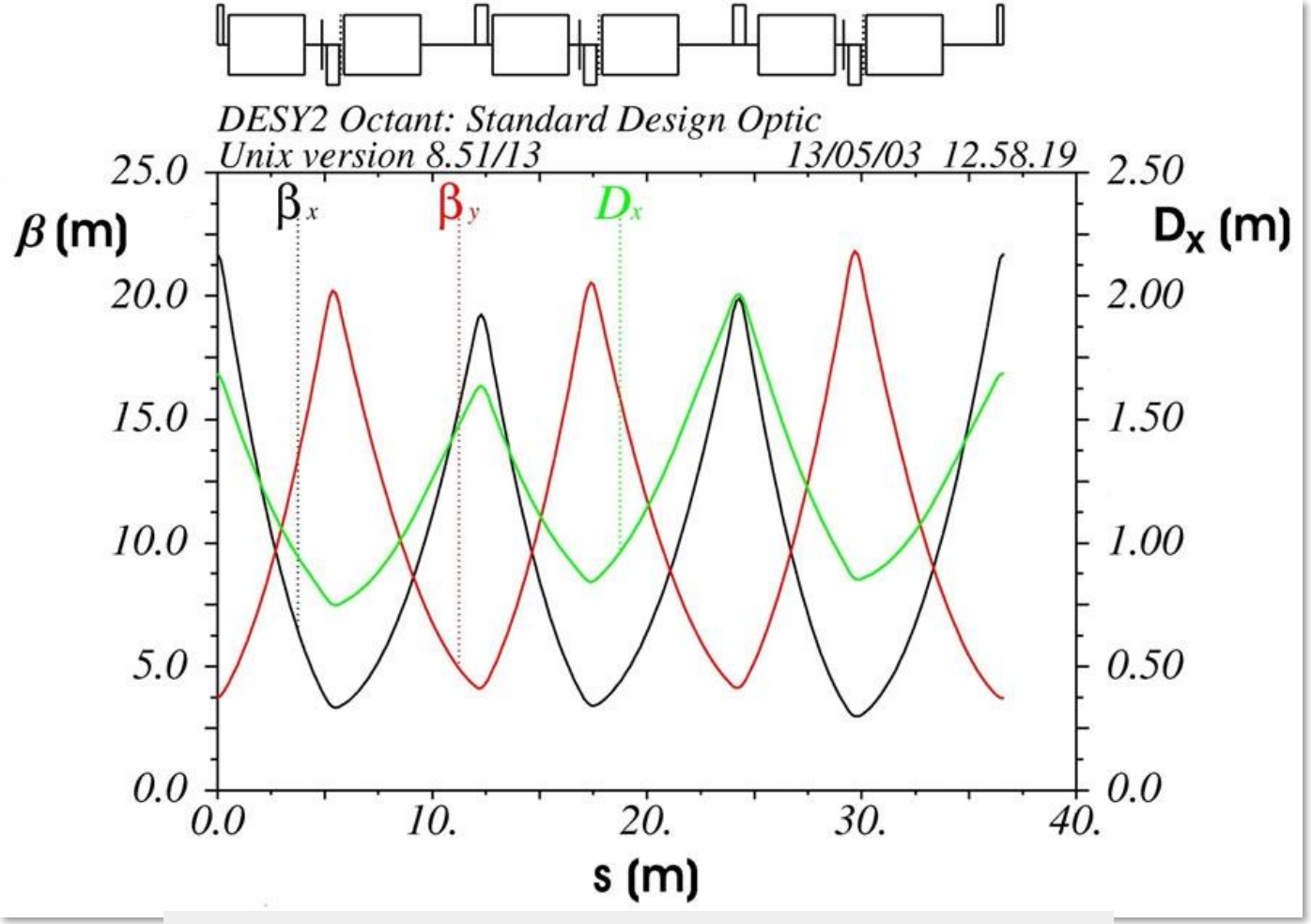
Figure 2 Cross section of the DESY tunnel (from 1983 [1]). Today, the DESY II lepton accelerator is located as shown while the DESY III proton accelerator has taken the place of DESY I.

G.Hemmie, “DESY II, a new injector for the DESY storage rings PETRA and DORIS”, DESY M-83-10; PAC 1983, Santa Fe, New Mexico IEEE Transactions on Nuclear Science 30 (4) (1983) 2028–2030. doi:10.1109/TNS.1983.4332706.

Minty, Michiko. (2015). Overview of the DESY-2 and DESY-3 accelerators (from 2003). 10.13140/RG.2.1.2610.0323.

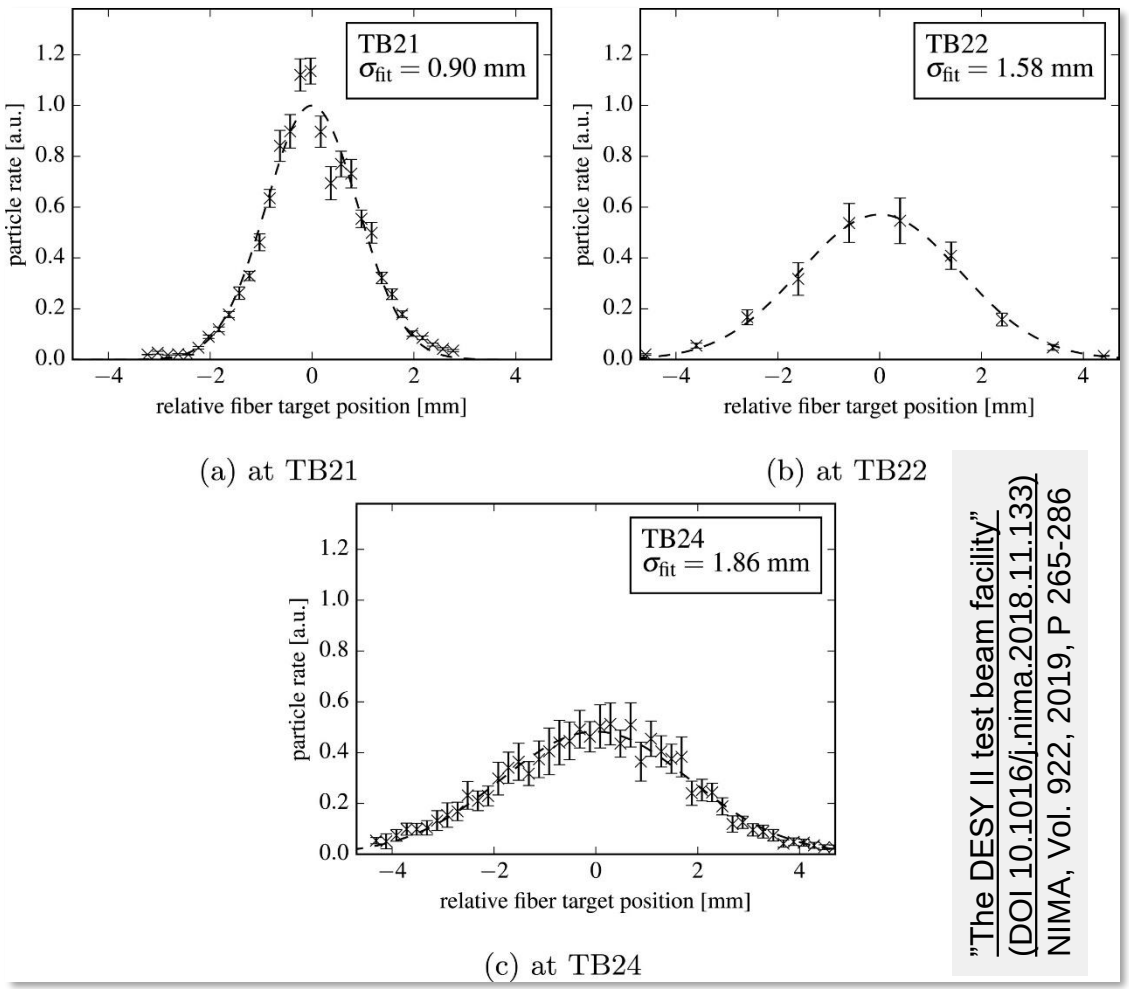
DESY II FODO Optics

Beta Function ~ Beam Size (+ dispersion$_x$)



From: Minty, Michiko. (2015). Overview of the DESY-2 and DESY-3 accelerators (from 2003). 10.13140/RG.2.1.2610.0323.

Rate dependence from primary Target Position



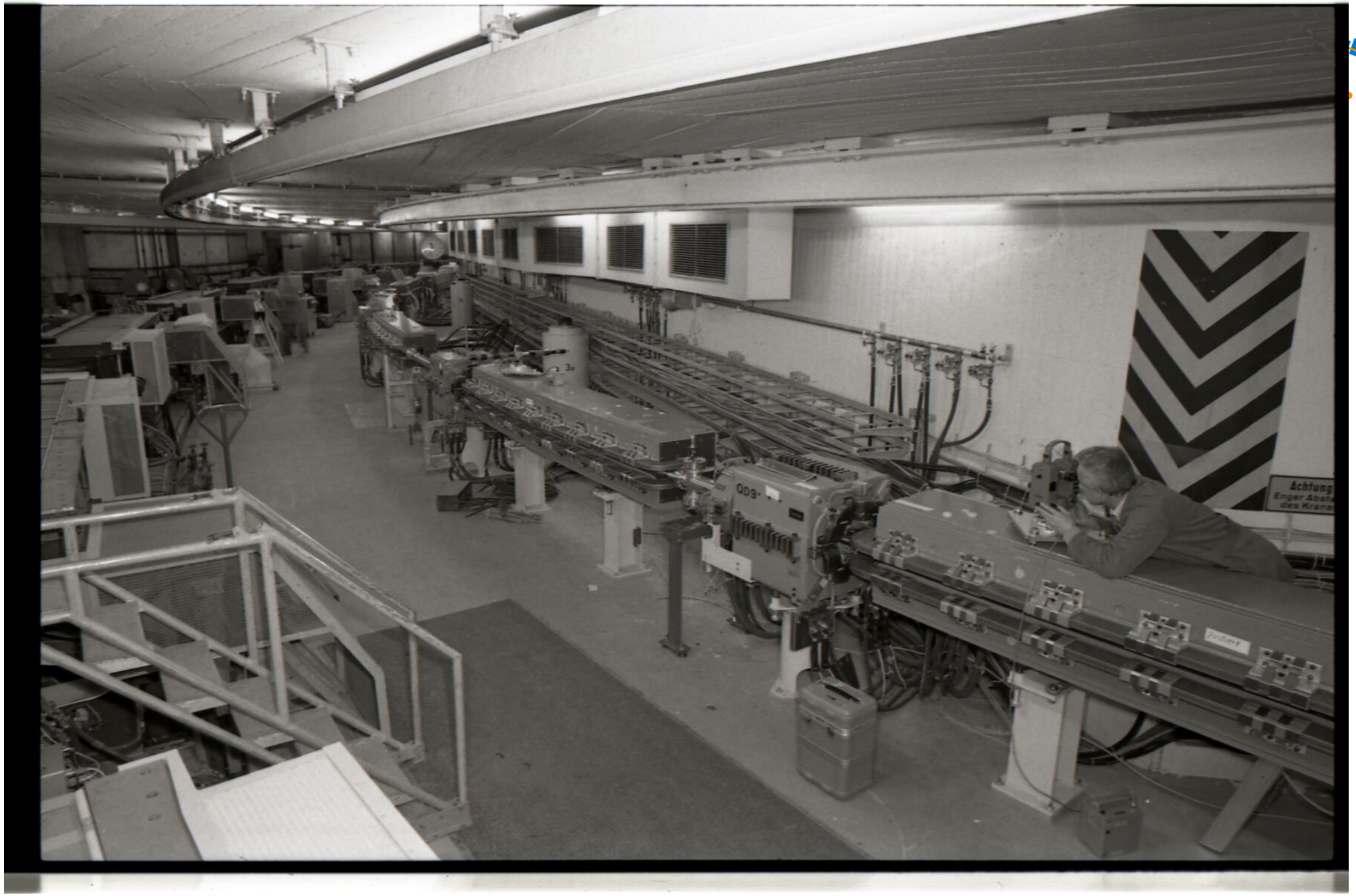
(a) at TB21 (b) at TB22

(c) at TB24

"The DESY II test beam facility"
(DOI 10.1016/j.nima.2018.11.133)
NIMA, Vol. 922, 2019, P 265-286

DESY I and DESY II 1985

Alignment



DESY II and DESY III

2003 Additional Quadrupols (Sextupoles etc.)

DESY II and DESY III

2003 Extraction to PETRA

DESY 1990

DESY 1990

- Job offer on a microfiche @ Job Center

- MEA (Machine & Experiment Assembly) is a service group
  - Before “Hallendienst” resp. S2
  - MEA1 Project Engineers
  - MEA2 Survey and Alignment
  - MEA3 Safety System (Interlock & Gas)
  - MEA4 Assembly Group + Workshop
  - MEA5 Riggers

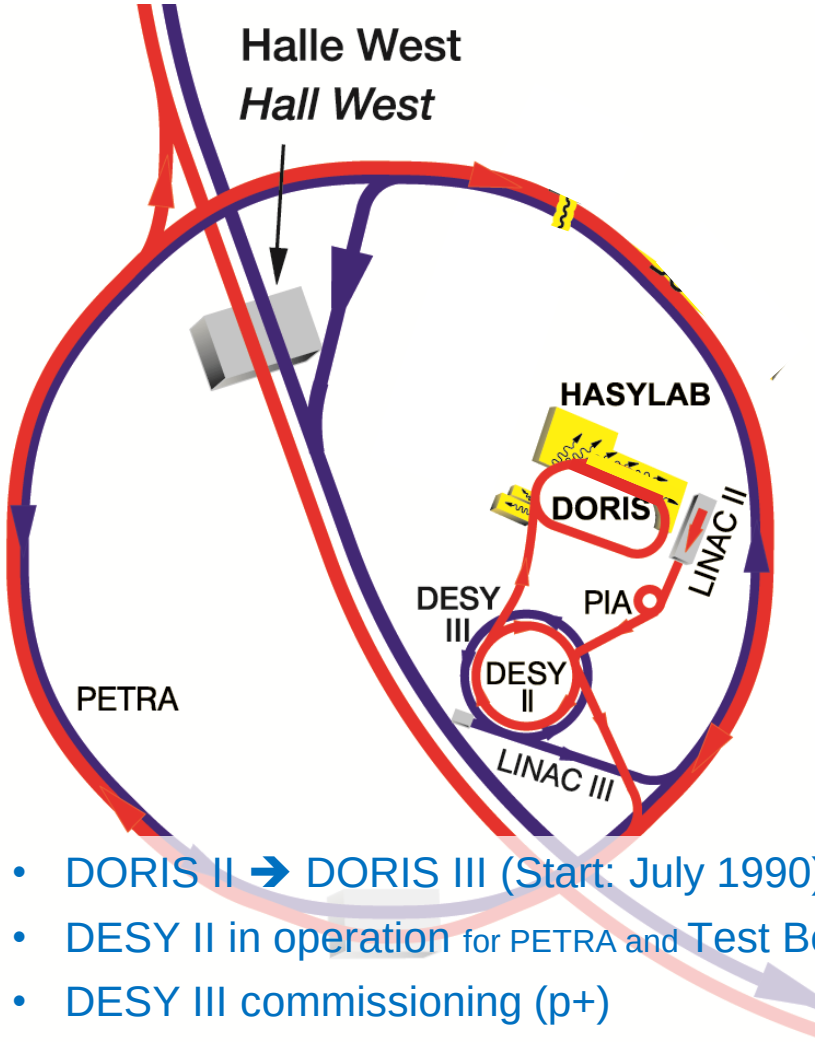
- *I am Physicist and Radio & TV Technician*
  - *Videos were on VHS tape cassettes*
  - *TV-sets used a cathode-ray tube*
  - *Photos with films or Polaroid*

Infrastructure:

- IBM 3090 main frame (TSO operation system)
  - Terminals all over the site
  - 6 letter account name, meamey@DSYIBM.DESY.de
- VAX cluster
- 2d-CAD system (technovision on Norsk Data workstation)
- Pager System DESY wide (4-digits)
- Accelerator Control System based on Norsk Data computer (Serial Bus via BNC cable: SEDAC)
- Accelerator Status distributed via TV broadcast
- ……

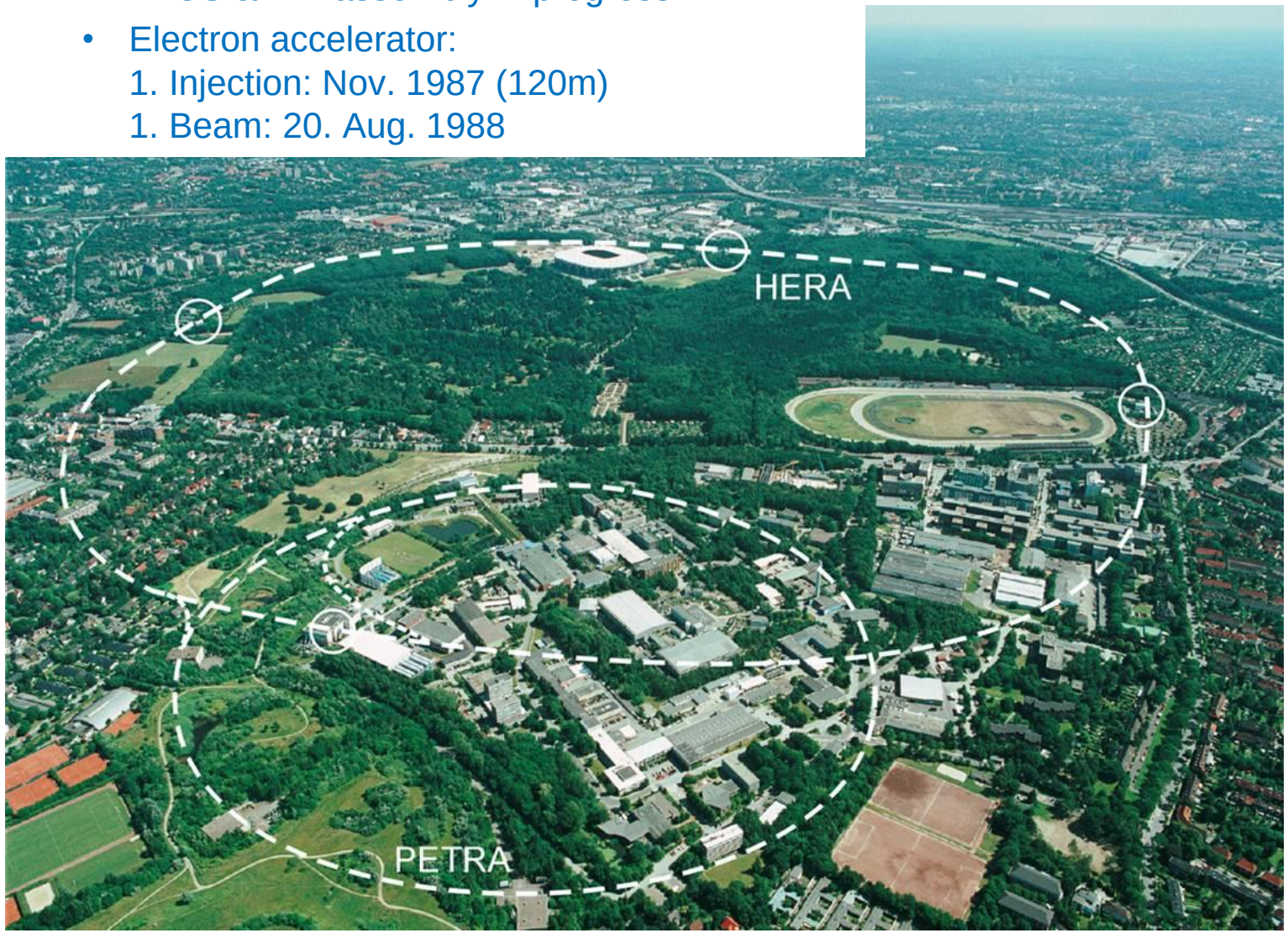
DESY 1990

Accelerator:



- DORIS II ➔ DORIS III (Start: July 1990)
- DESY II in operation for PETRA and Test Beam
- DESY III commissioning (p+)
- PETRA II commissioning with p+

- **HERA** under construction
  - 19. Sept.1990 last proton magnet installed
  - ZEUS & H1: assembly in progress
  - Electron accelerator:
    1. Injection: Nov. 1987 (120m)
    1. Beam: 20. Aug. 1988



Test Beam 1990

Test Beam 1990

DESY Tunnel

3 beam shutter

3 collimator

4 momentum defining dipole magnets
(3 Type MR, 1 MB)

3 Carriages for converter targets

4 Vacuum Pipes, 1 Vacuum Pump

3 Spill Scintilators with PMT (~1993)

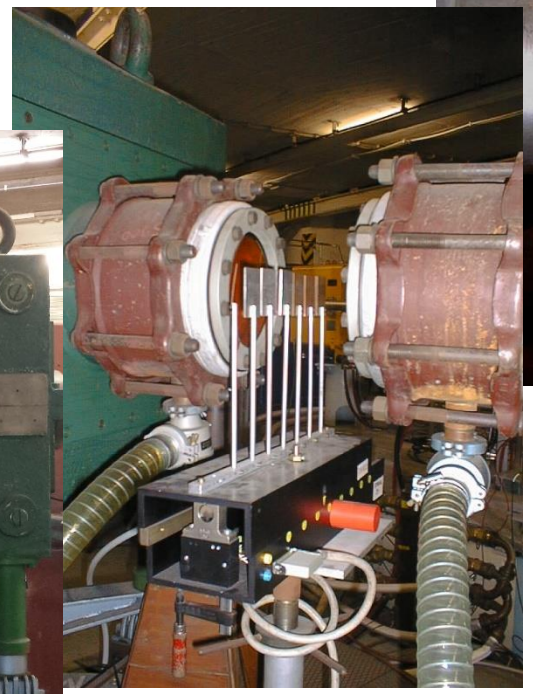
3 fiber targets provided by MDI (Machine Diagnostic and Instrumentation)

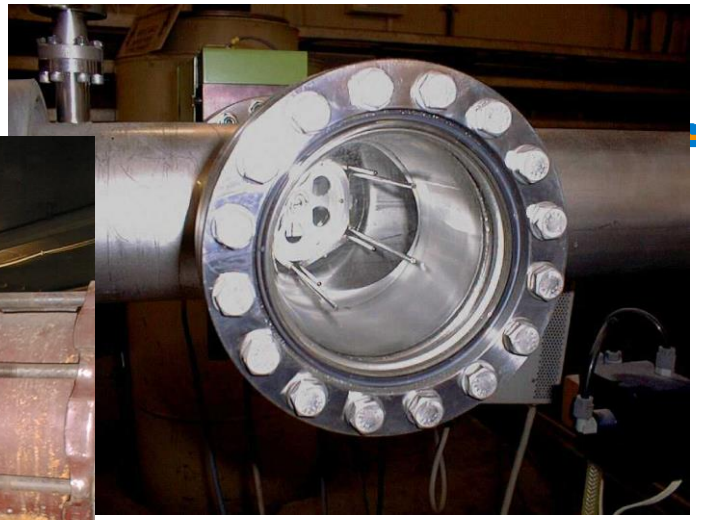
DESY II vacuum system including extraction chamber maintained by MVA (Machine Vacuum)

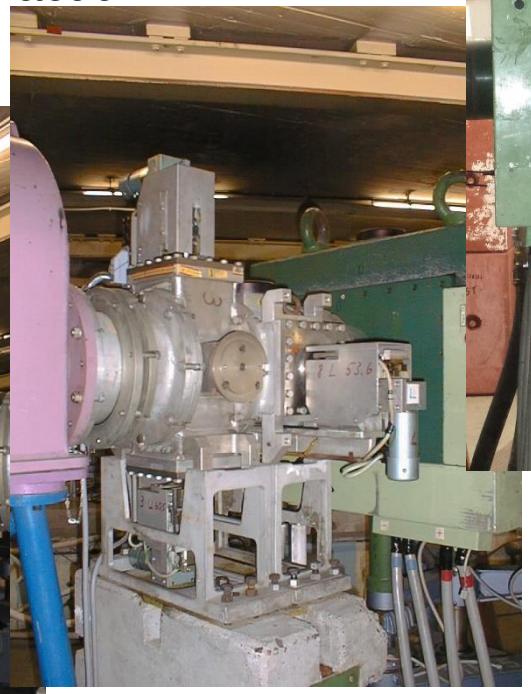
DESY III vacuum and cross chambers maintained by PVAK (Proton Vacuum)

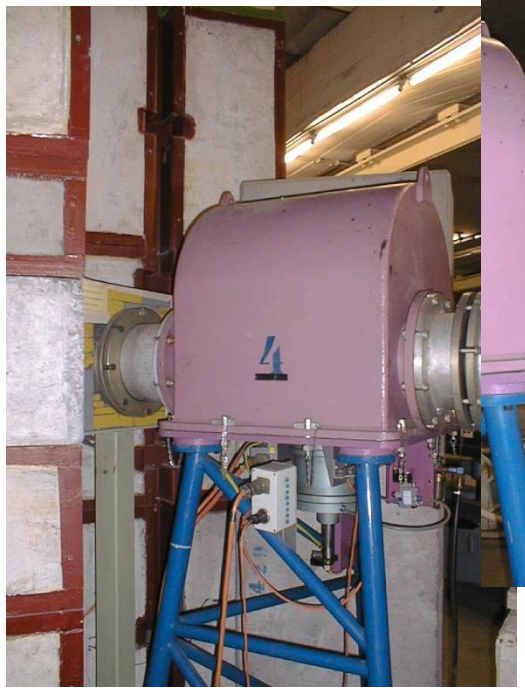
Test Beam Elements

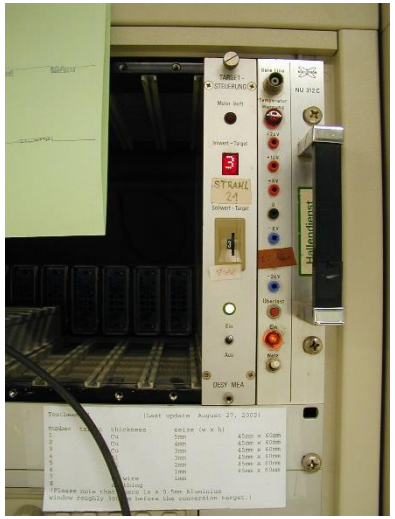
- Huge Vacuum Pipes
- Kapton Windows
- Magnet under Vacuum











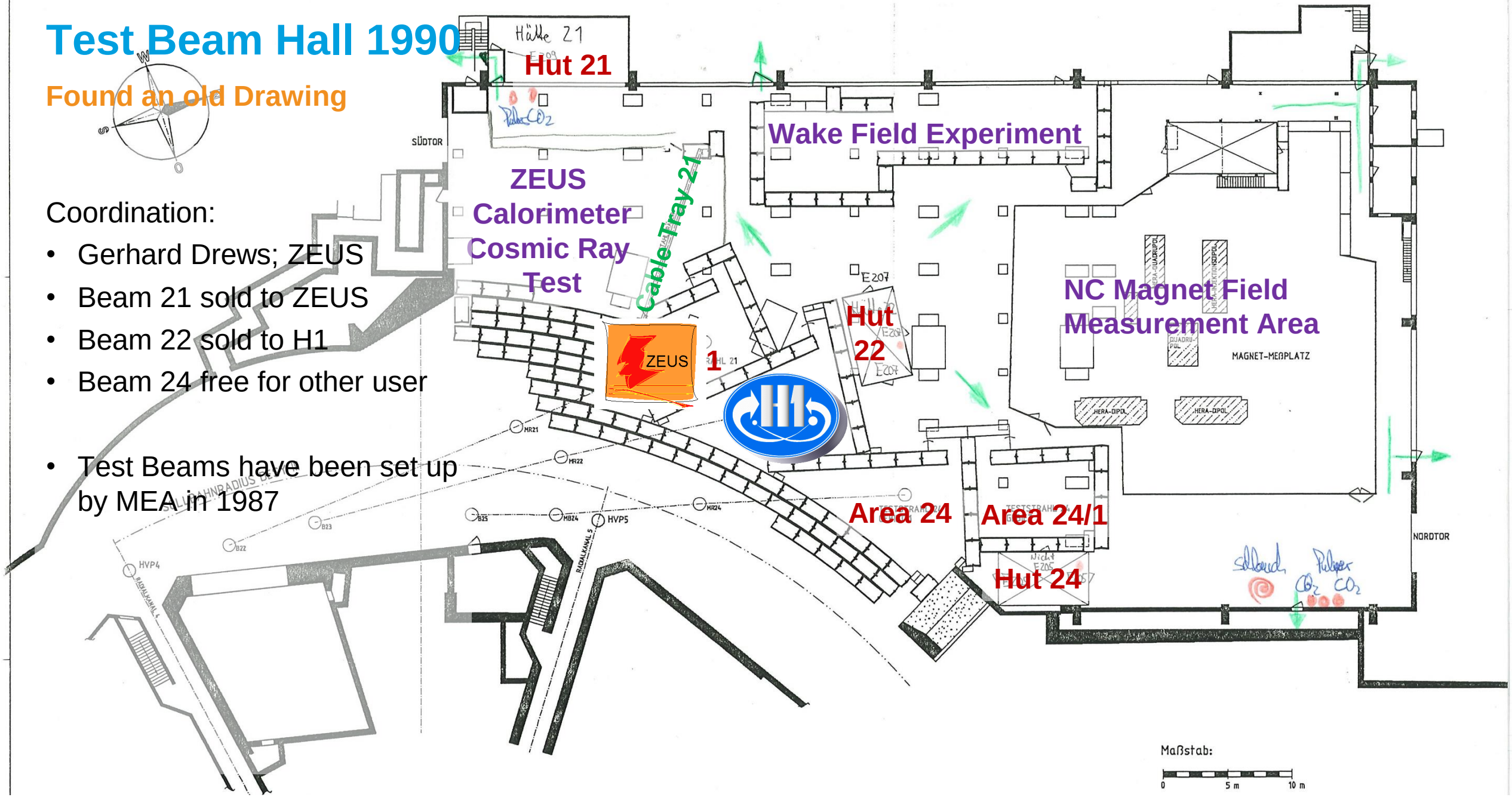
Test Beam Hall 1990

Found an old Drawing

Coordination:

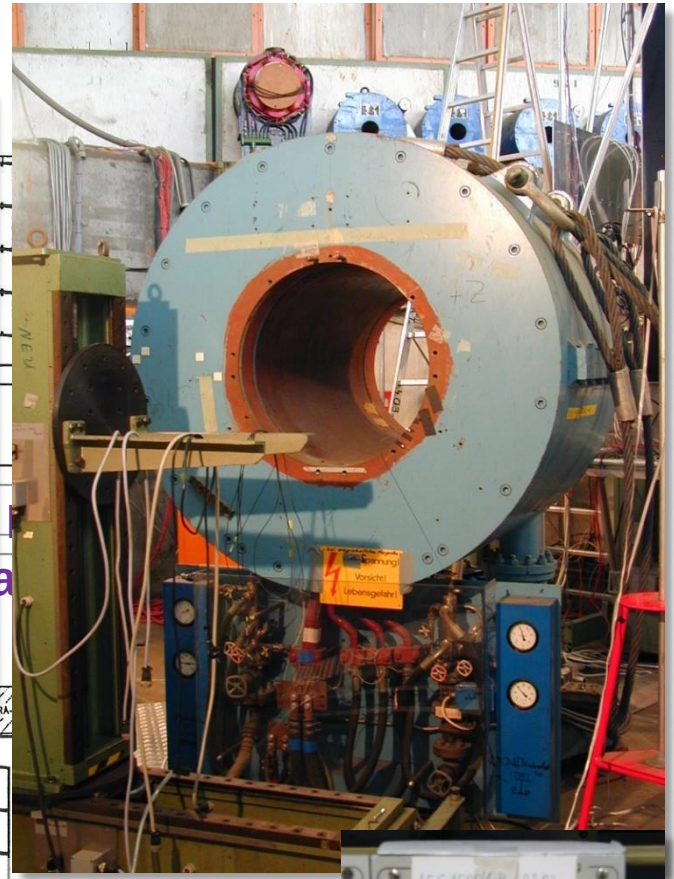
- Gerhard Drews; ZEUS
- Beam 21 sold to ZEUS
- Beam 22 sold to H1
- Beam 24 free for other user

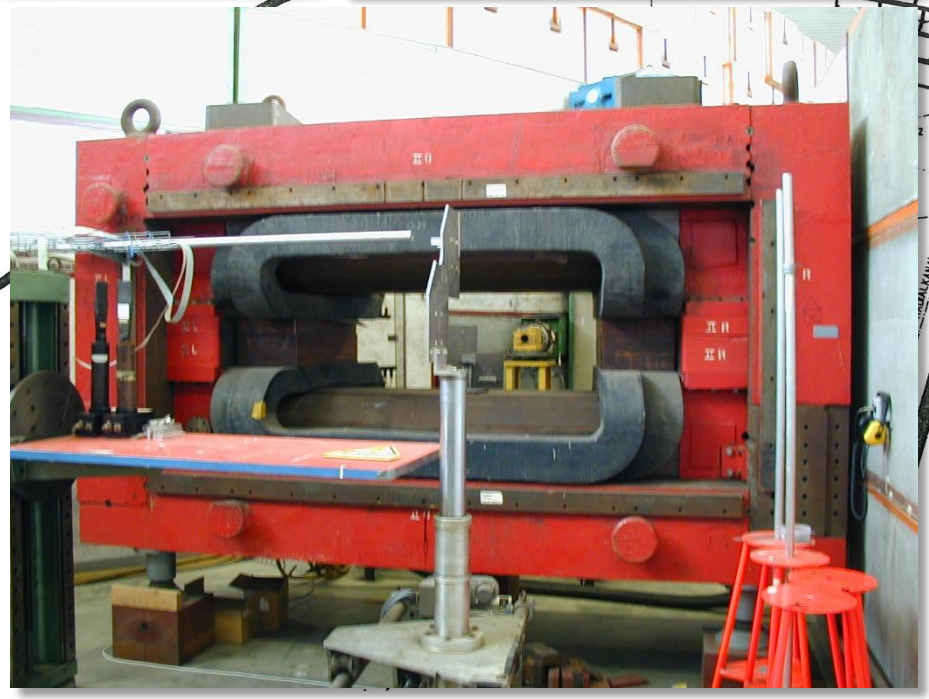
- Test Beams have been set up by MEA in 1987



Test Beam Hall 1990

Equipment



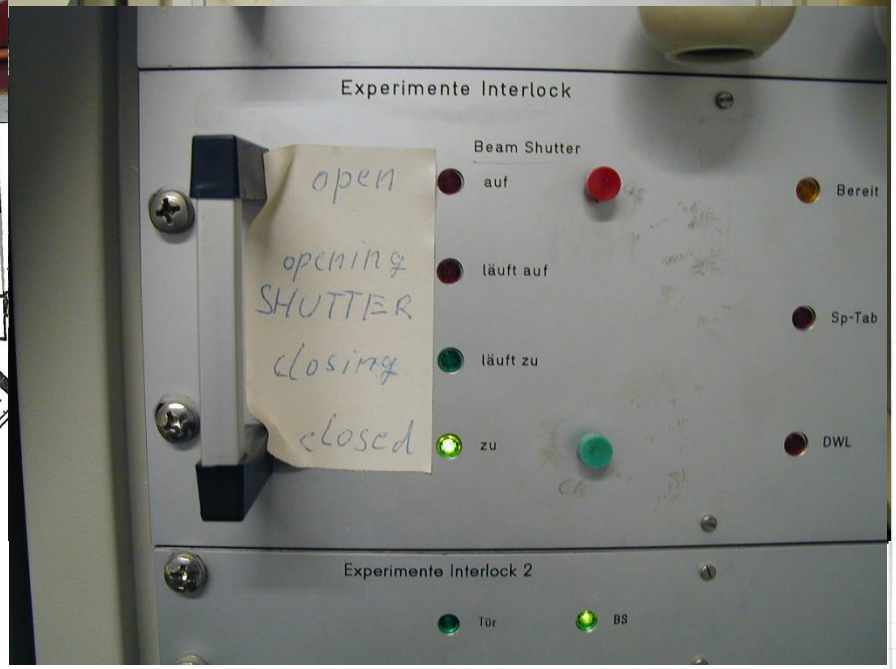


Test Beam Hall 1990

Gas Safety

Test Beam Hall 1990

Radiation Safety System (Interlock)



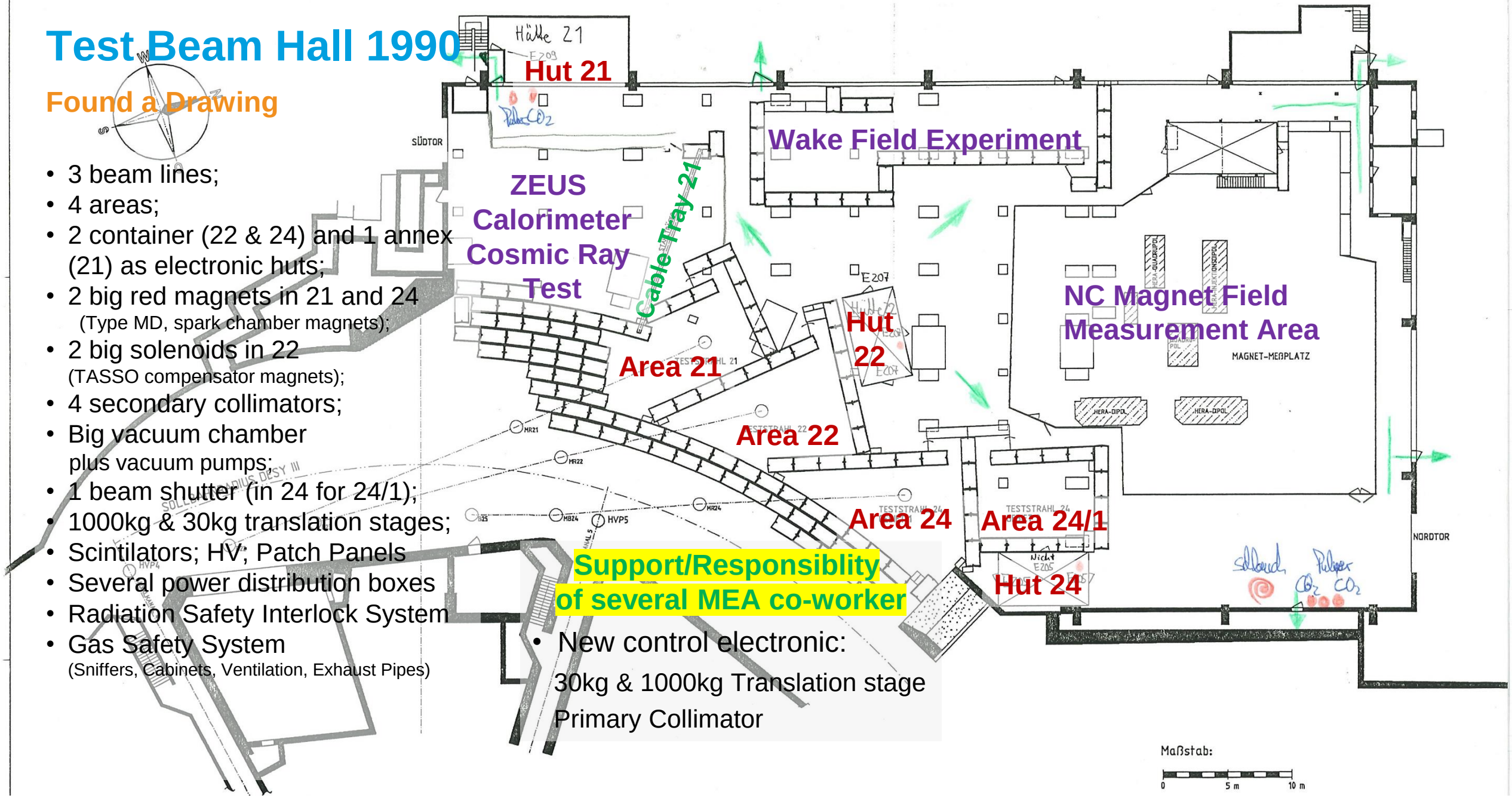
Inside a Collimator

2019

Test Beam Hall 1990

Found a Drawing

- 3 beam lines;
- 4 areas;
- 2 container (22 & 24) and 1 annex (21) as electronic huts;
- 2 big red magnets in 21 and 24 (Type MD, spark chamber magnets);
- 2 big solenoids in 22 (TASSO compensator magnets);
- 4 secondary collimators;
- Big vacuum chamber plus vacuum pumps;
- 1 beam shutter (in 24 for 24/1);
- 1000kg & 30kg translation stages;
- Scintilators; HV; Patch Panels
- Several power distribution boxes
- Radiation Safety Interlock System
- Gas Safety System (Sniffers, Cabinets, Ventilation, Exhaust Pipes)



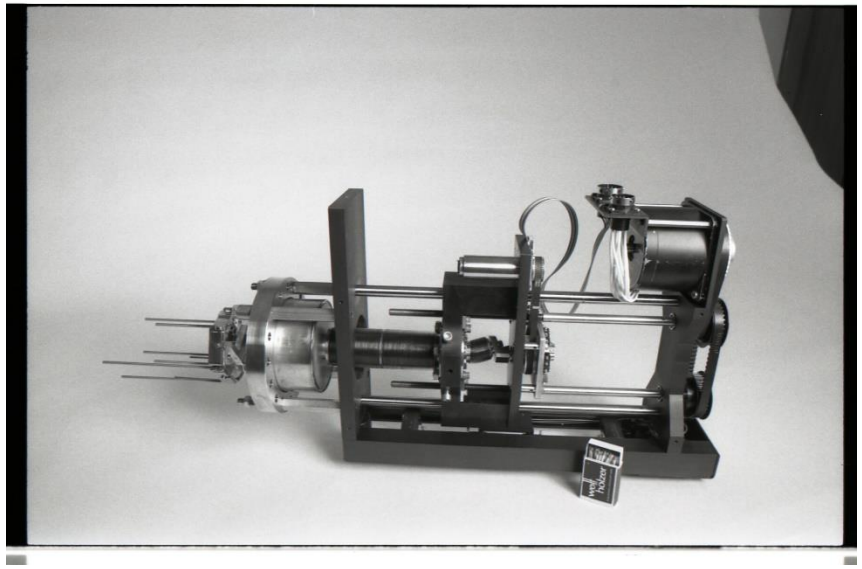
Support/Responsiblity of several MEA co-worker

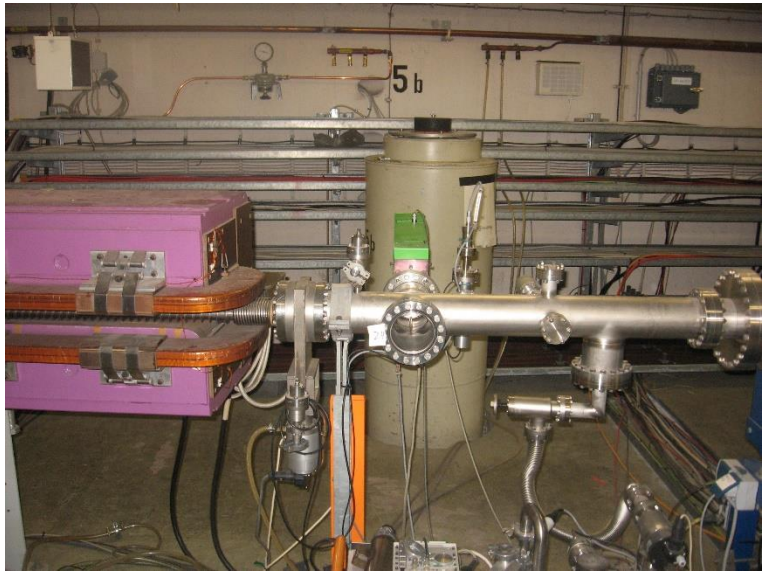
- New control electronic:
  30kg & 1000kg Translation stage
  Primary Collimator

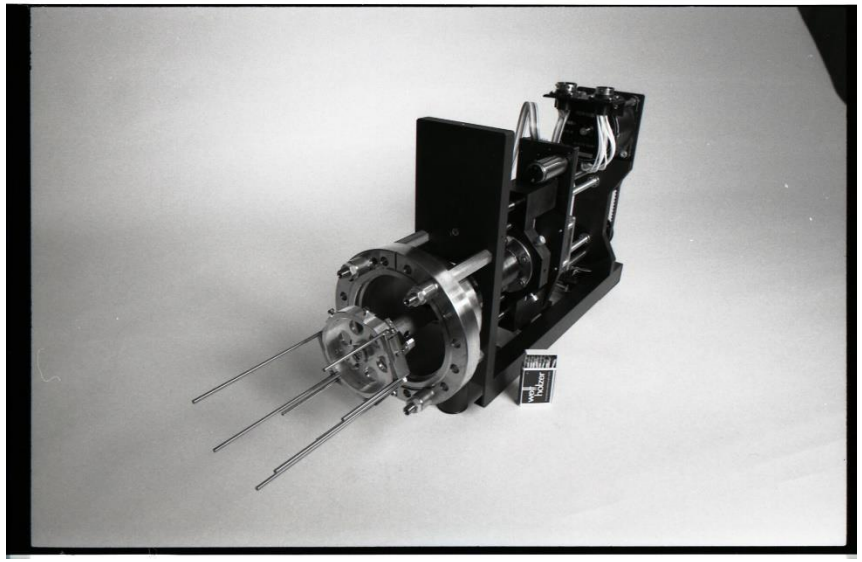
Breaking Carbon Fibers Small Apertures

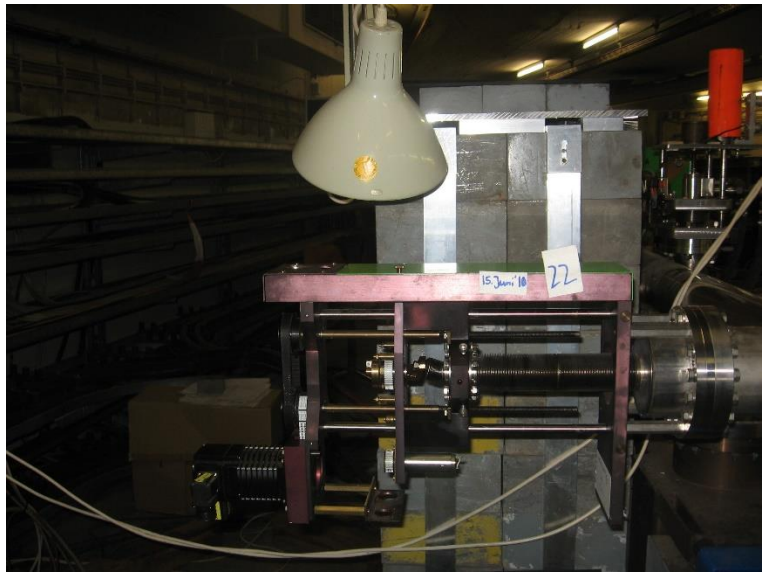
With High Bunch Currents

Fiber Target Stations



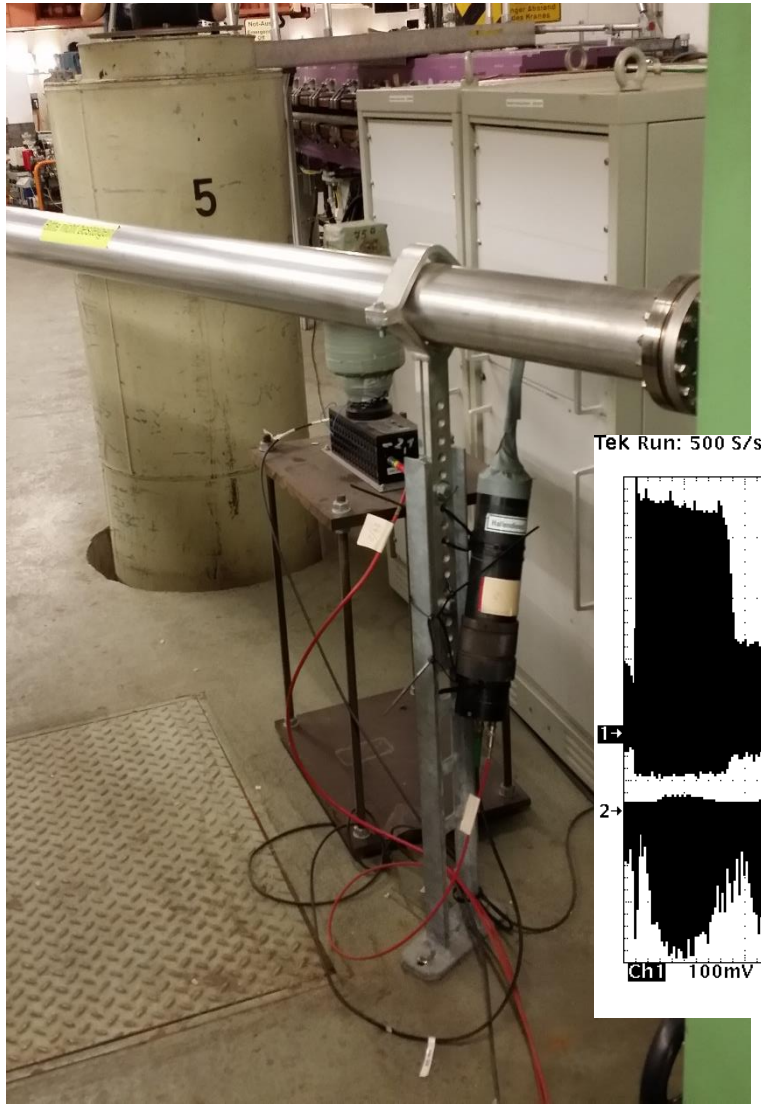


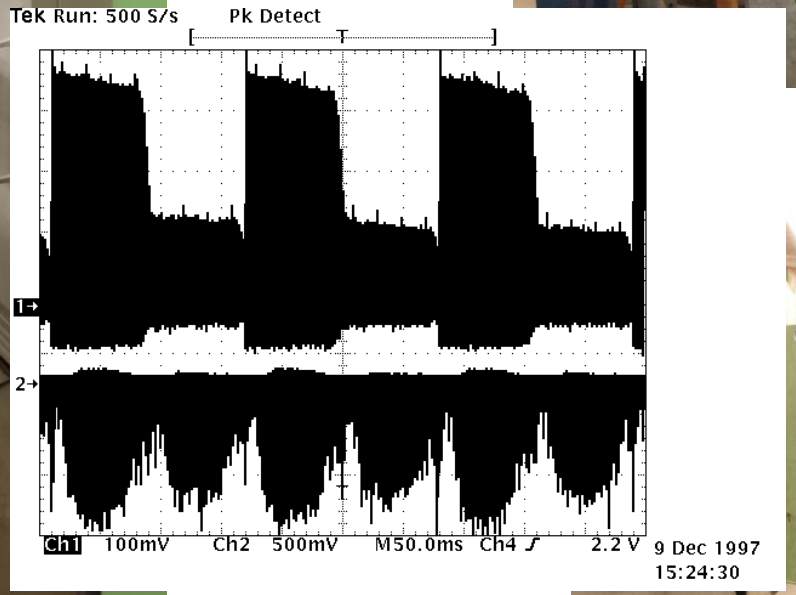




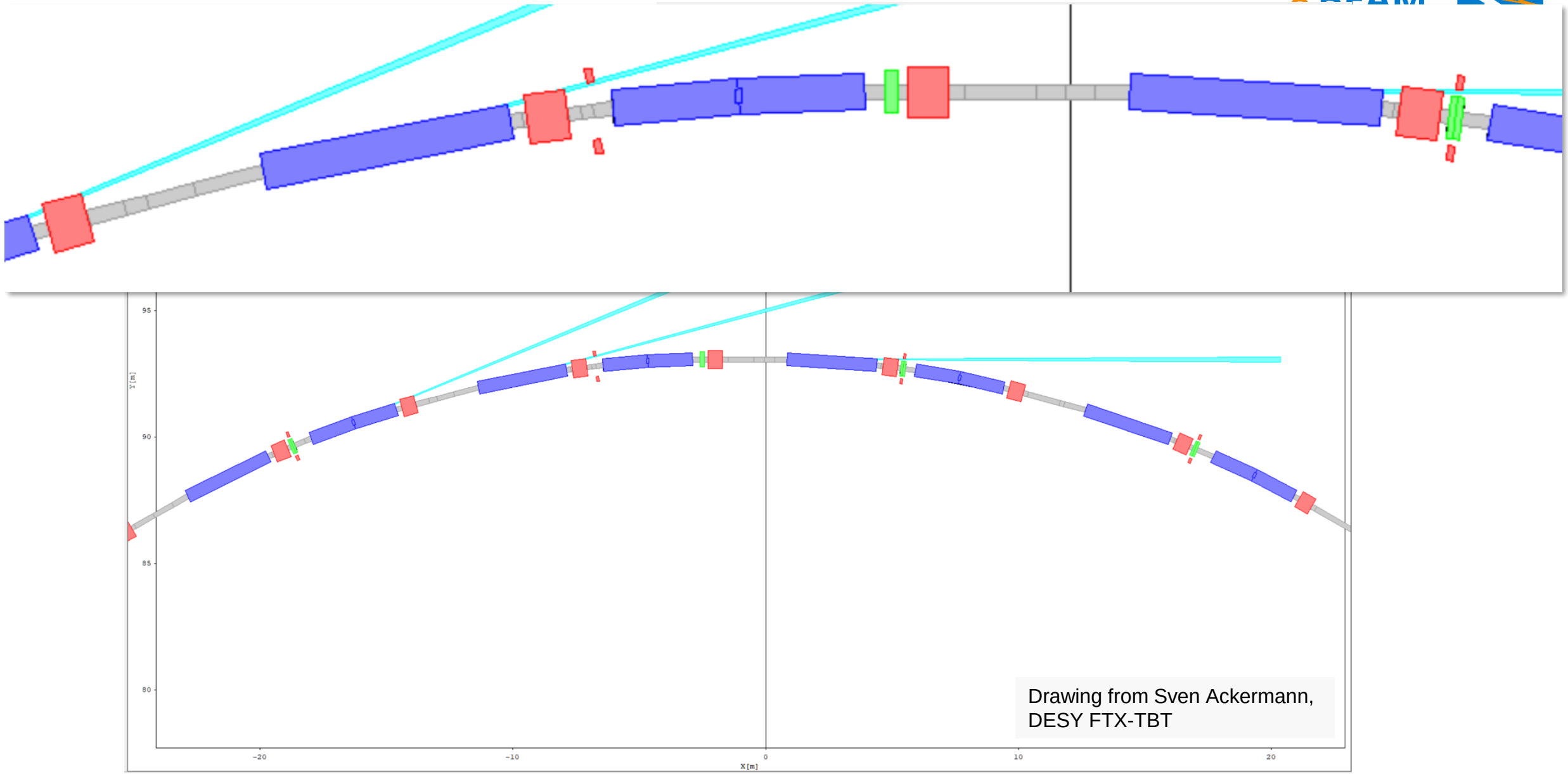
Spill Counter

Top right 21, down right 22, left 24





Aperture in Quadrupoles



Drawing from Sven Ackermann, DESY FTX-TBT

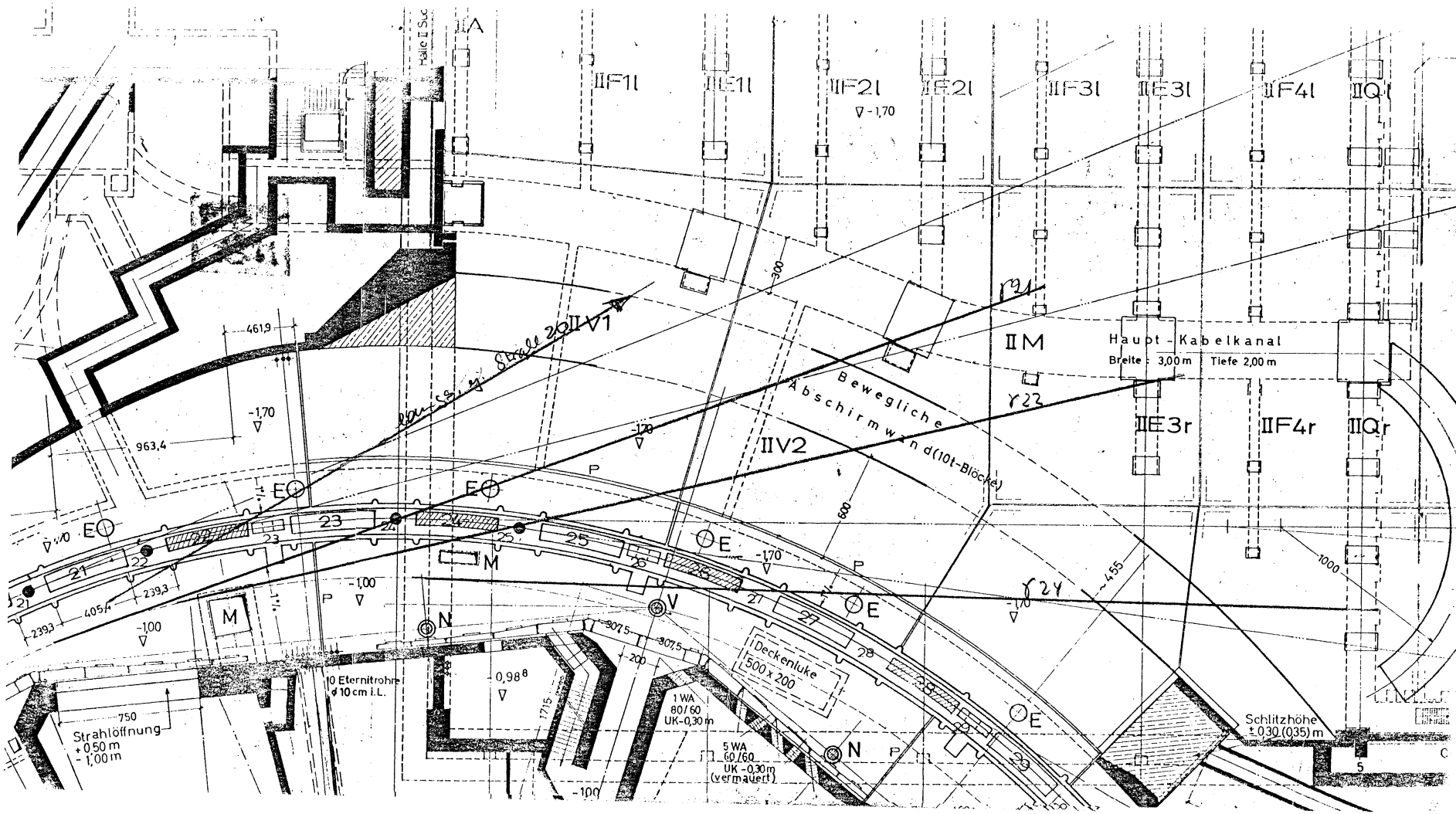
Aperture Limit in Extraction Beam Pipe and Quadrupole

2010

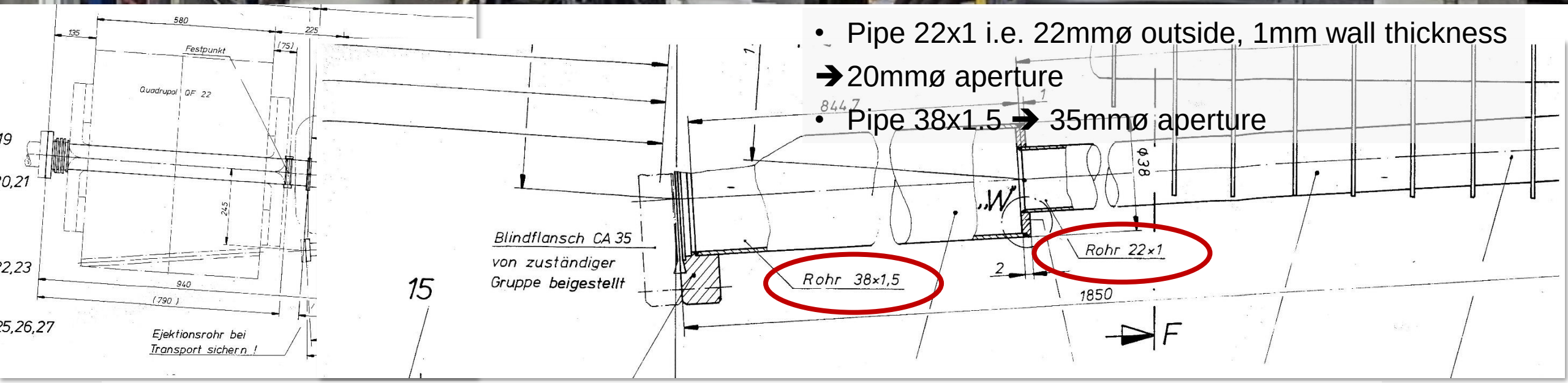
Plans for Test Beam @ DESY II

2. 2. 1984

- A hole of 30mmø in the quadrupole is sufficient!
- 25mmø would be okay too.



Aperture & Extraction Pipe Dimensions



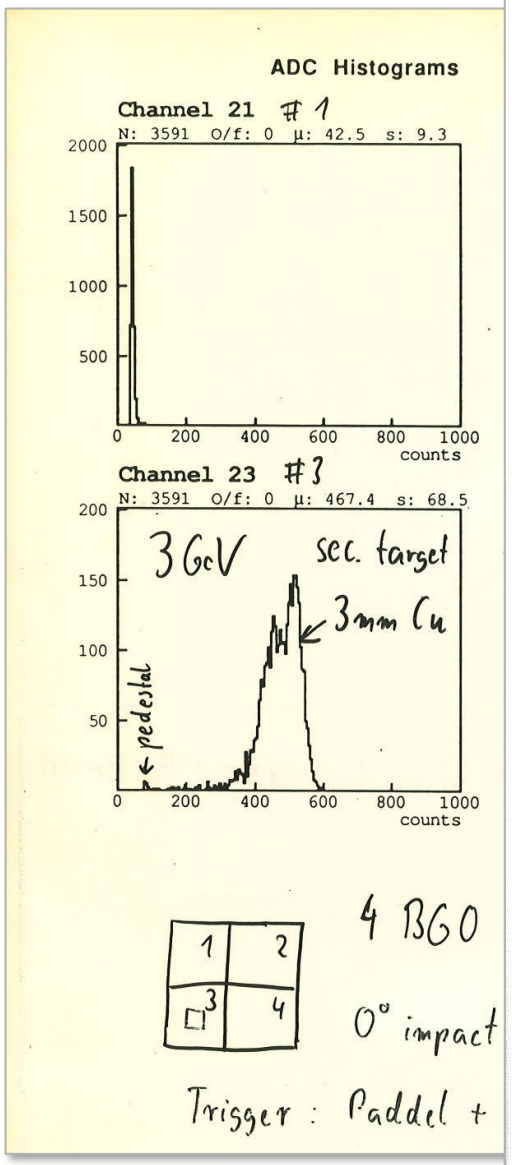
- Pipe 22x1 i.e. 22mmø outside, 1mm wall thickness
  ➔20mmø aperture
- Pipe 38x1.5 ➔ 35mmø aperture

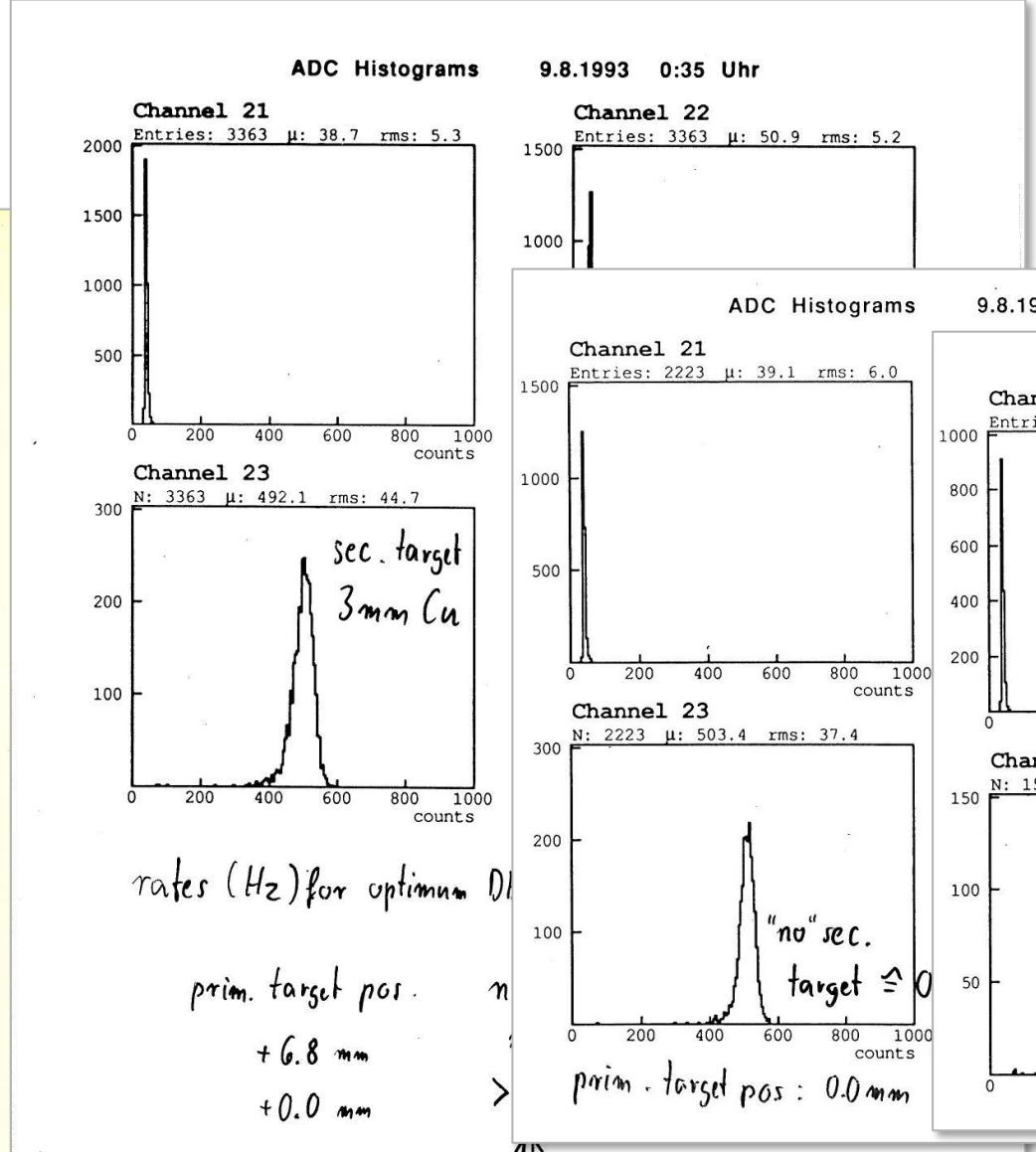
Aperture Limit in Extraction Beam Pipe and Quadrupole

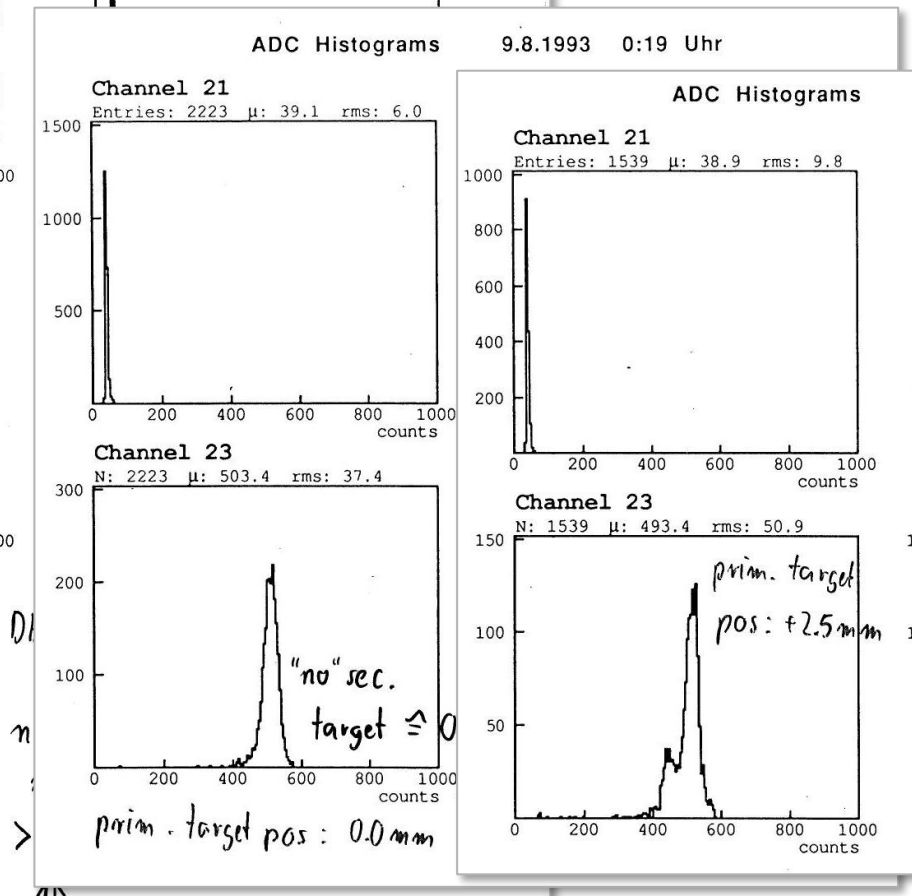
2010

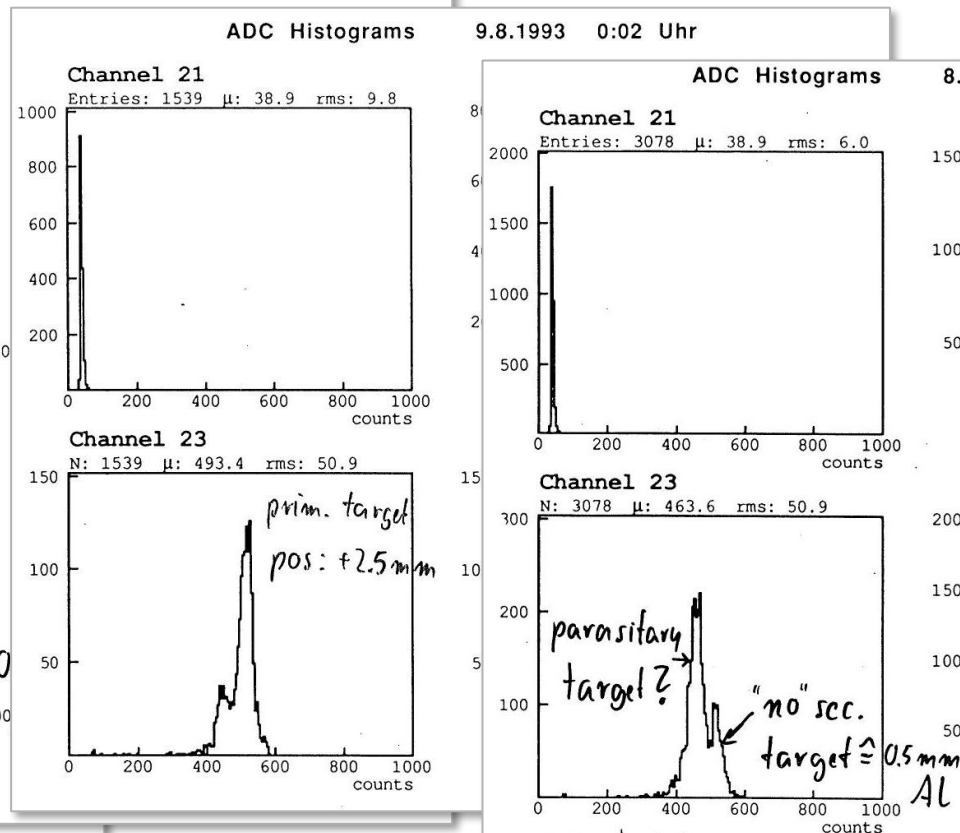
Effect of off axis carbon fibers

1993







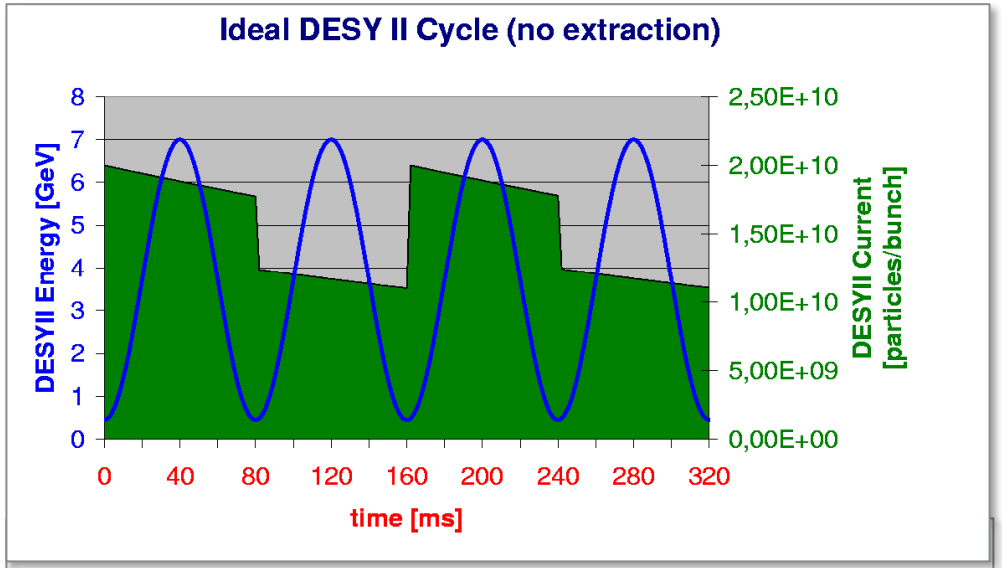


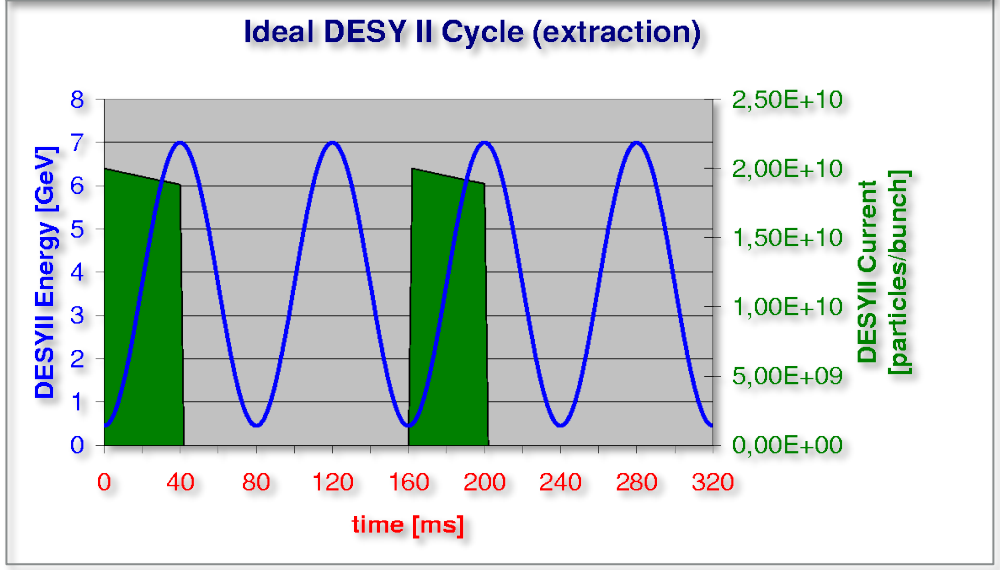
Test Beam @ DESY
1990 – 2006/2007

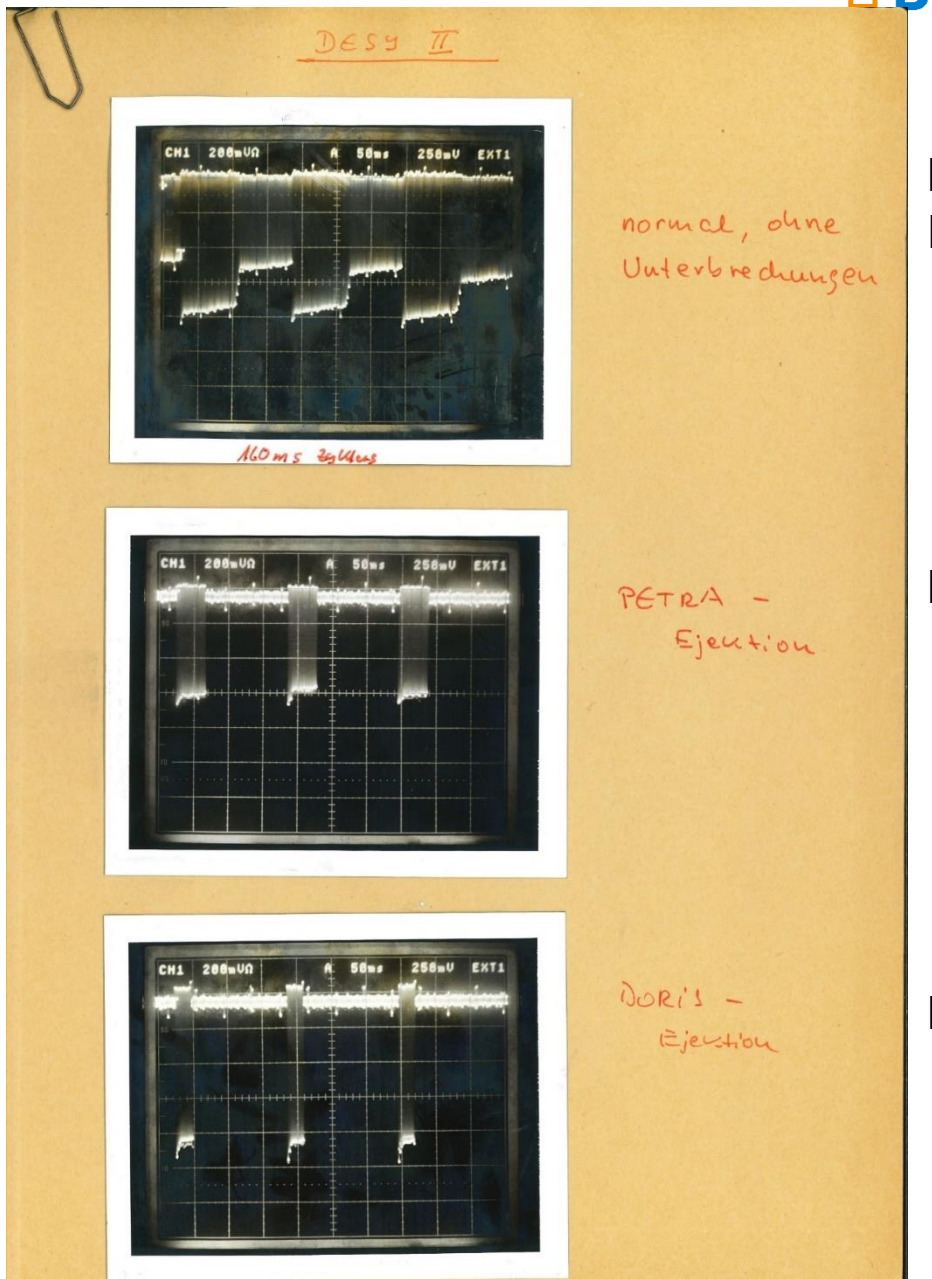
~~“Quiet”~~ Interesting Years

Particles via PETRA for HERA and for DORIS Filling

From 1. Test Beam Web Page (1993/1994)







Normal, w/o Interruptions

PETRA – Ejection

DORIS – Ejection

User Meeting 1994

Minutes of a User Meeting for DESY-Testbeams on July 14, 1994

Participants:

B. Racky (D3), W. Ebeling (MDE), A. Schwind (HERMES), N. Meyners (MEA), A. Wagner (F), V. Bachkirov (ZEUS), R. Appuhn (H1), T. Hamacher (HERA-B), V. Schröder (H1), M. Amarian (HERMES), J. Spengler (HERA-B), H. Sindt (D5), A. Fantoni (HERMES), G. Drews

1. Review of the past run period

The revised rules for using the testbeams („Benutzerordnung") seem to work well; there were no complaints from radiation protection, general safety or MEA.

HERMES started their calibration measurements of leadglass modules. In view of the rather low availability of the beam (around 30% efficiency, which is realistic) they think now that they will need some 21 weeks for the calibration of all 1000 blocks, i. e. three times as much as originally requested.

The groups from H1 (Appuhn) and HERA-B (Hamacher) were rather content with the counting rates and (after the HERA run-in period) also with the beam efficiency. However, they would find it very helpful, if more information about the status of the beam from the control room could be displayed in the beam hut.

- Beam availability ~30% ➔ HERMES 3x more time (21 weeks) for 1000 lead glass calorimeter

H1 & HERA-B

- Rather content with the counting rates
- Want status display/information for efficient use of TB

2. Future Testbeam Conditions

W. Ebeling pointed out that going from electrons to positrons (HERA is scheduled to run with e+ in a few weeks) will mean a factor of 2 to 3 less particles accelerated in DESY II. An extension of the accumulation time in PIA, which would increase our intensities, seems to be ruled out, since that will impair HERA. Some improvement may be expected from a careful optimization of the target positions.

Some of the bearings on the testbeams were addressed which come from switching to DORIS filling, proton acceleration and machine studies. Again it was stressed that the testbeams could be used more efficiently, if the appropriate information from the control room would be made available at the testbeams.

A proposal about technical improvements of the testbeams is expected to be made by N. Meyners, M. Amarian, T. Hamacher and G. Drews by mid-September.

3. Further Beam Schedule

The appended distribution of the requests for testbeams until the end of the year was approved. Shut-down is expected to happen around December 1st.

DESY, July 18, 1994

G. Drews

To: Wagner, Sindt, Tesch, Goerlach, Meyners, Sinram, Schröder, Köpke, Hamacher, Spengler, Henkes, Schwind, Krizan, Appuhn, Ebeling, Bachkirov, Amarian, Bähr

- e+ operation ➔ 2-3 lower rate
- Proposal about technical improvements
- Shutdown **around** Dec. 1st

Test Beam Schedule 1994 2. Half & Rules

Application Form

Request for Test Beam at DESY II

Name / Group / Institute:
collaborating with DESY group:

Address:

Telephone/E-Mail:

Person responsible for the test:

Tested Object:
Part of a larger project?
Name of project or collaboration:

Dimensions

Weight (kg):

Length along beam (m):

Easily movable into/out of beam?
e.g. remotely controlled or without re-surveying

Magnetic field needed (if yes, specify)?

Flammable gases to be used:
(specify kind and quantity)

Hazardous materials to be used:
(like radioactive sources; quantify)

Number of mechanical support tables needed:

Crane and floor services needed?

Further specifications or remarks:

Requested period(s):

Preferred beam (T21, T22, T24a or b):

Date: Signature: .....

Return this form to the DESY test beam coordinator.

DESY-Teststrahlen

Anmeldungen für die Zeit Juli bis Dezember 1994

#	Woche	T21	T22	T24a	T24b
26	27.6.–3.7.				
27	4.7.–10.7.	HERMES Henkes Jul, Aug ≤ 7 weeks			Hera-B Krizan ?
28	11.7.–17.7..				
29	18.7.–24.7.		H1		
30	25.7.–31.7.				
31	1.8.–7.8.		Appuhn + 18.7.–15.12.		
32	8.8.–14.8.				
33	15.8.–21.8.	HERMES Schwind 12.8.–25.9.			
34	22.8.–28.8.			ZEUS Bachkirov	
35	29.8.–4.9.				
36	5.9.–11.9.				
37	12.9.–18.9.				
38	19.9.–25.9.				(Hera-B)
39	26.9.–2.10.				
40	3.10.–9.10.	(Henkes)			
41	10.10.–16.10.				
42	17.10.–23.10.	(Schwind) etc.			
43	24.10.–30.10.				
44	31.10.–6.11.		H1 Bähr 31.10.–18.11.		
45	7.11.–13.11.	(HERMES)			
46	14.11.–20.11.				
47	21.11.–27.11.				
48	28.11.–4.12.		shut-down ~ Dec. 1st		
49	5.12.–11.12.				
50	12.12.–18.12.				
51	19.12.–25.12.				
52	26.12.–1.1.95				

Stand: 13.7.94

Rules for Using the DESY Test Beams

The parasitic test beams at DESY II are not only available to DESY groups but also to anyone interested from outside. Experiments at the test beams are approved and scheduled by a coordinator at DESY (at present Gerhard Drews, F01DRE@DHHDESY3. BITNET, tel. 040-8998-3531), to whom requests for test beam should be directed.

In an application form ("Request for Test Beam at DESY II", available from the coordinator) the desired test periods and some details about the planned experimental setup have to be specified. The information about the apparatus is needed to facilitate [illegible] Experimenten"), which supervises the test beam areas in Hall 2. It is important to note, that this group can support the installation of the measuring electronics (e.g. with crates) only to a very limited extent.

Before an experiment starts taking data at the test beams, the group has to know the safety [illegible] supervisors for radiation protection ("Aufsichtsperson für den Strahlenschutz") and general safety [illegible] has to be inspected ("Technische Abnahme") by MEA (Herr Meyners, tel. 3321/3327) and D5 (DESY [illegible] Lindt, tel. 3585 or Herr Kirfel, tel. 3185). If flammable gases are used, a safety inspection by MEA and D5 has to happen even before taking data. [illegible]

The fulfillment of these safety requirements has to be documented by the signatures of the above [illegible] Test Beam Experiment at DESY II"), which will also show the alloted test periods. A copy of this sheet must be posted at the [illegible] for the duration of the experiment. In this way the personnel of the [illegible] and the safety institutions are kept informed about the ongoing activities at the test beams.

Only after the radiation protection supervisor has given his signature, the person responsible for the experiment can receive a safety key for the interlock system from MEA (tel. 3327). With this key the experimenter takes over the responsibility for the radiation protection until he returns the key to MEA; he may not simply pass the key to the next group. In case of two groups measuring in parallel, the leader of one group has to take over the responsibility for the whole.

All participants of the experiment have to learn how to use the test beams and the interlock system in time. It is advisable to contact the people in the DESY Accelerator Controlroom (BKR, tel. 3500) for the machine schedules and details of beam parameters.

Hamburg, April 18, 1994

G. Drews, DESY

- Application form
- Safety Supervisors have to be named
- Door sheet
- Responsible Person gets the interlock key after Radiation Safety Supervisor has signed!
- Technical acceptance by MEA and Safety Department etc.
- Training required

1994

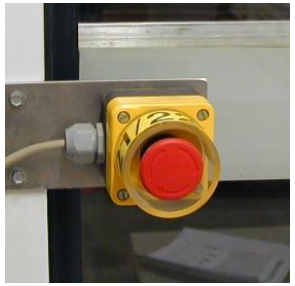
Improving Safety!

- Master Key in special Key Box
- Better Control of Usage
- Responsible User can stop operation
- Door Sheets

  For Emergency Service

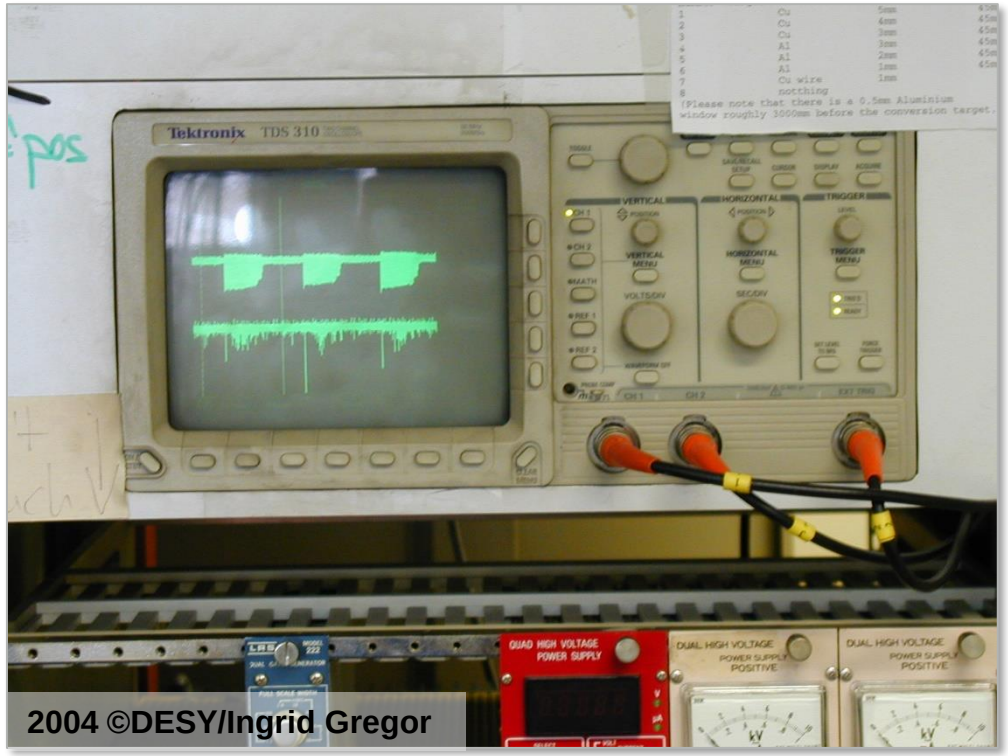
  Accelerator Control Room etc.

- Power OFF for Hut (inside & outside) & Area (outside)



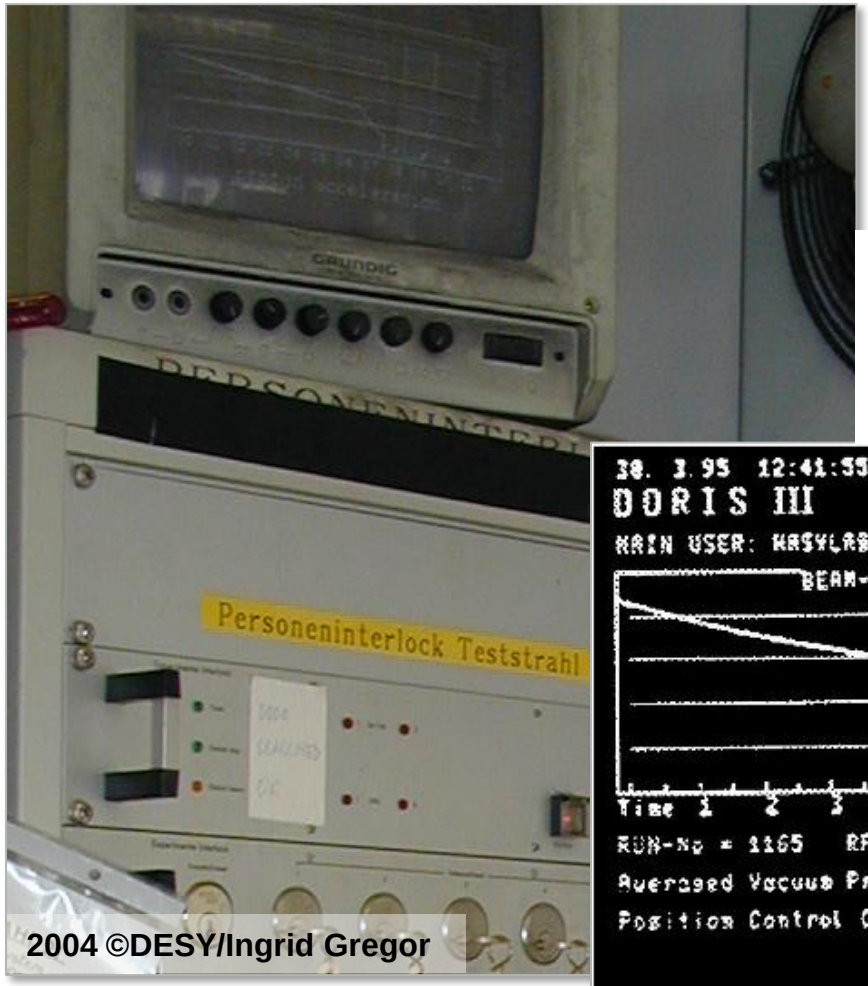
Improving Information (~1994)

DESY II Beam Current & Spill Signal



2004 ©DESY/Ingrid Gregor

Status TV



2004 ©DESY/Ingrid Gregor

TV Screen Pictures taken from:
H. Nesemann, W. Brefeld, F. Brinker, W. Decking, O. Kaul and B. Sarau, "DORIS III as a dedicated source for synchrotron radiation," Proceedings Particle Accelerator Conference, Dallas, TX, USA, 1995, pp. 195-197 vol.1, doi: 10.1109/PAC.1995.504607

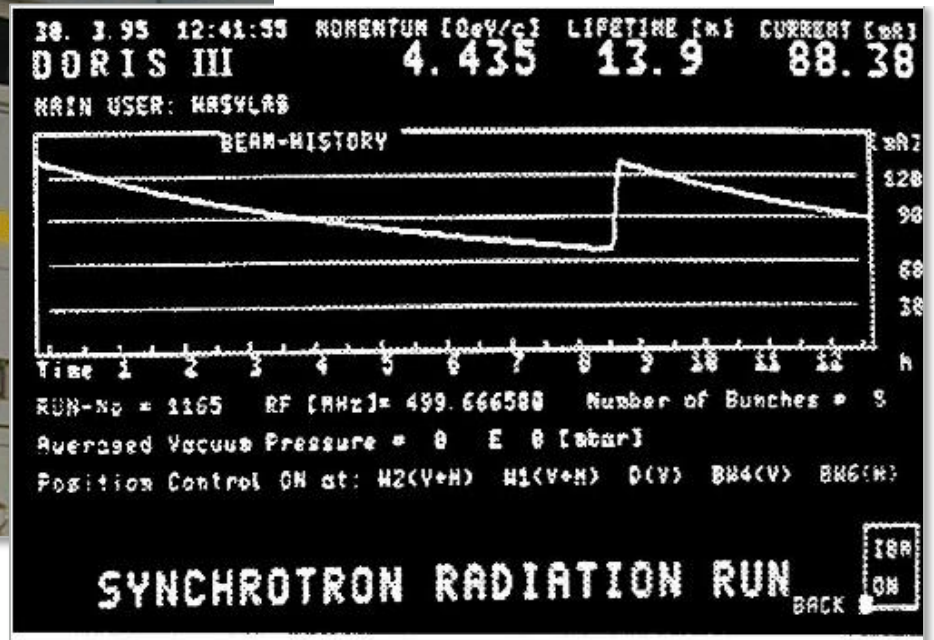
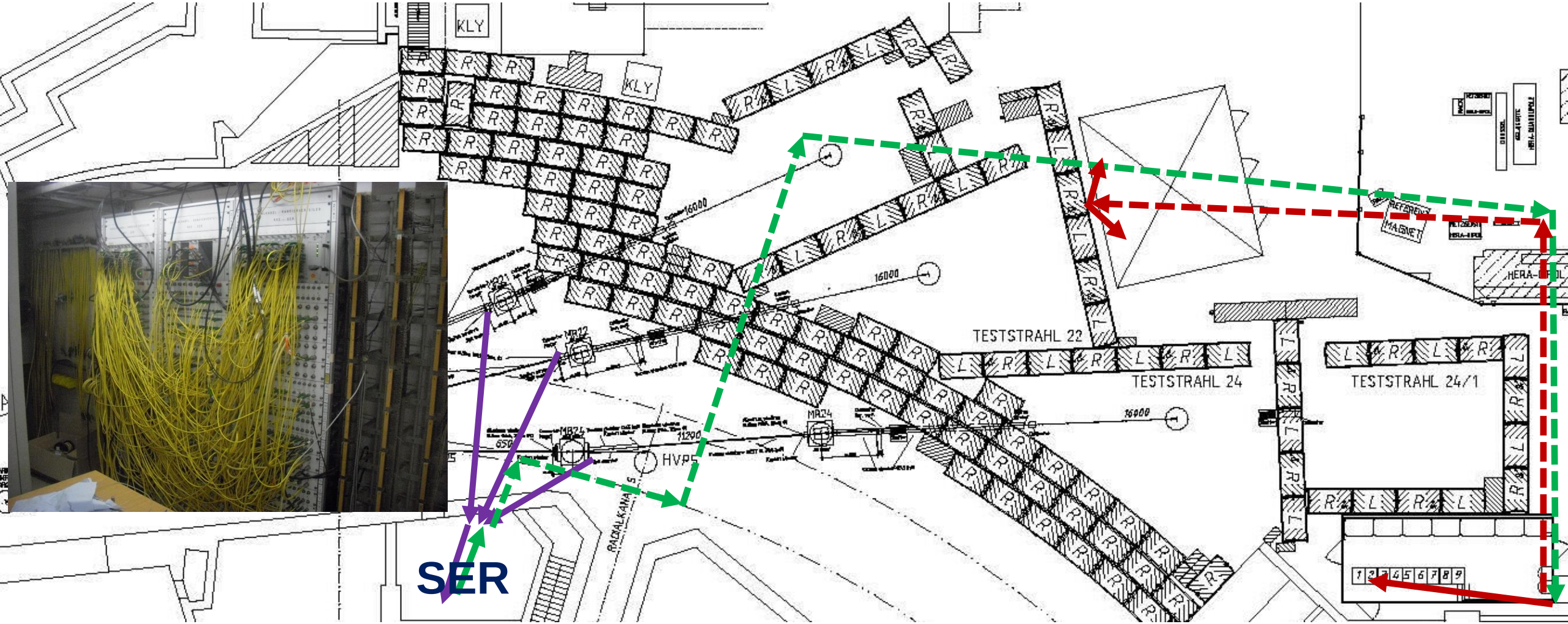


Figure 2. Positron current versus time

Cable Routing to SER and Huts

Picture: Patch Panel in SER (Synchrotron Electronic Room)



1. Description 1. Webpage

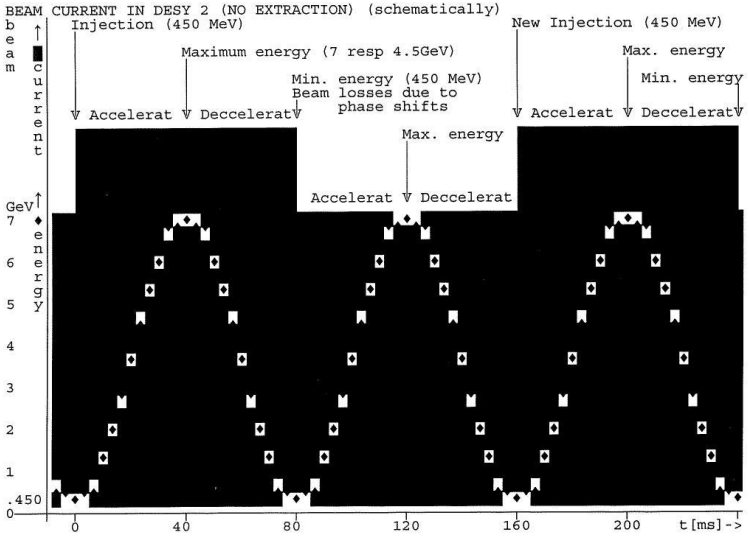
"The DESY II test beam facility"
(DOI 10.1016/j.nima.2018.11.133)
NIMA, Vol. 922, 2019, P 265-286

Norbert Meyners, MEA (3321, MEAMEY@DSYIBM) remarks.txt page 1 18. Juli 1994 17:22

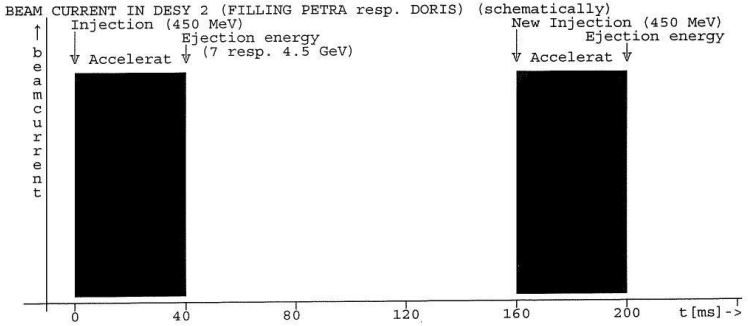
DESY II

The electron synchrotron DESY 2 accelerates and decelerates one bunch of $6*10^9$ positrons in sinuodale mode with a frequency of 12.5 Hz (= 50 Hz/4 = 1/80 ms) from 450 MeV up to 7 GeV (for HERA via PETRA) resp. to 4.5 GeV (for DORIS). The revolution frequency is 1 MHz, the RF frequency 500 MHz, the bunch length around 30 ps. The average radius is 46.601 m (So the circumference is 292.8 m).
In 1994 every second cycle new particles are injected. If the particles are not extracted for DORIS resp. PETRA the beam monitor signal (with a appropriate time base) showes a stairlike picture. When DORIS resp. PETRA are filled you see only spikes of 40 ms.

BEAM CURRENT IN DESY 2 (NO EXTRACTION) (schematically)



BEAM CURRENT IN DESY 2 (FILLING PETRA resp. DORIS) (schematically)



Description

Introduction

DESY provides three test beam lines (21, 22 and 24). These electron or positron beams are converted bremsstrahlung beams from carbon fibre targets in the lepton synchrotron DESY II with up to 1000 particles per cm² and second, energies from 1 to 6 GeV, an energy spread of ~5% and a divergence of ~2mrad.

A detailed description of the beam generation, the operation, infrastructure and equipment and safety aspects can be found in the web.

The time schedule is made after the requests by test beam coordinator (Email: testbeam-coor@DESY.de). At the moment the co-ordination is done by Ingrid Gregor, F1 and Norbert Meyners, MEA1. Beam time can be requested via a request form or by email according to the points of the form.

(Please report the attendees via this list (Excel) before you come. Be aware that the German and DESY regulation forces all participants to attend a briefing about general, special and radiation safety before you can start to work at the test beam. All important information have to be collected on this door sheet (PDF/ doc).)

The EU-funded AIDA project has been approved to improve the Detector R&D for detectors at accelerators. As a part of it, support for travel expense can be given for European, non-German DESY test beam user.

Brief Description

The counting rooms for beam 24 and 21/22 are close to the areas. The entire control are located devices in these huts. There is space for electronics and data acquisition, but it is also possible to place it in the area. The huts have 100MBit and wireless Ethernet connections and there are BNC and HV cables connections to the areas. Cycle trigger and bunch trigger signals from the accelerator are also available in the huts. *(The network now uses DHCP (Dynamic Host Configuration Protocol). So internal users can just bring their computers, and external users will be in the guest network not protected by the DESY firewall. If they need to be in the DESY network they have to fulfill the DESY regulations (PDF) for computers - most important an up-to-date virus scanner - to get one or more IP numbers.)*

The beams areas are surrounded by shielding blocks and are equipped such that flammable gases could be used in the tests. *(All sorts of gas also premixed can be supplied by the DESY gas group MEA6. The use of flammable gas or other hazard materials needs special precautions. Please discuss this well before.)*

The areas can be equipped with translation stages. The large one can carry up to 1000kg and move the load 1m horizontal and vertical. The smaller one can take 30kg and is mainly used to carry the trigger counter.

Authors: Isabell Melzer-Pellmann, Norbert Meyners; Last change: 04.04.2012, Imprint

Beam Generation

A bremsstrahlung beam is generated by a carbon fibre in the circulating beam of the electron/positron synchrotron DESY II. The photons are converted to electron/positron pairs with a metal plate (converter). Then the beam is spread out into a horizontal fan with a dipole magnet. Like a slice, the final beam is cut out of this fan with a collimator.

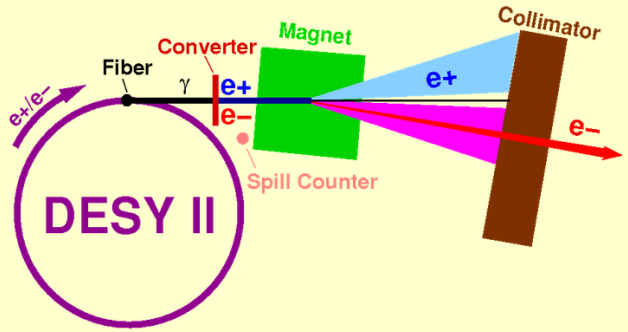


Fig. 1: Schematic Layout of a Test Beam at DESY (pdf, ps)

Therefore, the physics is simple. The bremsstrahlung spectrum has a 1/E dependence. The energy distribution of the electron/positron pair is nearly flat, the geometry is fixed by the beam pipe and setting the magnet current chooses the beam momentum.
The real situation is more complicated because the energy of the synchrotron varies with time, i.e. the bremsstrahlung edge of the photon spectrum changes in time with cycles of the accelerator. The beam particles can reach the area obviously only when the accelerator energy/c is above the chosen momentum.

DESY II

The electron/positron synchrotron DESY II is mainly an injector for DORIS and PETRA (picture of the beam lines in the DESY tunnel as they were in 2006). The average radius of the DESY II ring is 46.601 m (so the circumference is 292.8 m).

It accelerates and decelerates in sinusoidal mode with a frequency of 12.5 Hz (= 50 Hz/4 = 1/80 ms). Therefore one DESY II magnet cycle takes 80 ms (see Fig. 2). The revolution frequency is 1 MHz, the RF frequency 500 MHz, and the bunch length around 30 ps.

In theory, particles could be injected into the synchrotron every cycle. But typically, when running in DORIS mode, DESY II injects every second cycle (160 ms) single bunches with about $3*10^9$ positrons at 4.5 GeV/c into DORIS. For PETRA it injects every fourth cycle (320 ms) single bunches with up to $3*10^{10}$ ($1*10^{10}$ positrons) at 7 GeV/c. The ejection to DORIS and PETRA happens at maximum energy 40 ms after injection. Therefore, a burst of 40 ms can be seen every 160 or 320 ms (see Fig. 3).

On the beam current scope this looks like Fig. 4 and 5 if the particles are not extracted or like Fig. 6 if they are extracted.

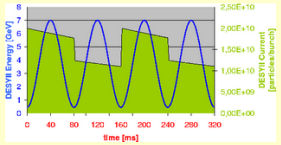


Fig. 2: Ideal DESY II cycle; No Extraction

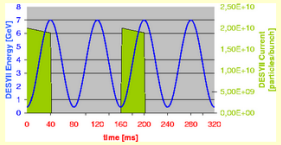


Fig. 3: Ideal DESY II cycle; Extraction

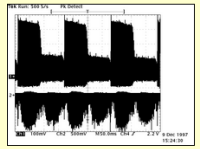


Fig. 4: Beam current scope picture:
Electrons, No Extraction
Upper signal: Beam Current;
Lower signal: Spill Counter Signal

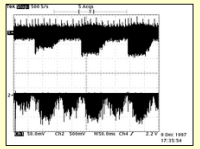


Fig. 5: Beam current scope picture:
Positrons; No Extraction
Upper signal: Beam Current;
Lower signal: Spill Counter Signal

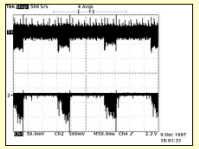


Fig. 6: Beam current scope picture:
Positrons; Extraction
Upper signal: Beam Current;
Lower signal: Spill Counter Signal

Rates

In table 1 you can find a rough estimate of the rates.

Figures 7 and 8 show the rates vs momentum for Testbeam 21 and 24, with 6 GeV Electrons or Positrons in DESYII. Figure 9 shows a comparison of the rates for 6 GeV and 7 GeV in DESY II (measurements done 10/2008).

The rates are influenced by many parameters. In practice, the maximum rate is around 5 kHz (3 GeV, 3mm Cu convert, Collimator ca. 5mm x 5mm, DESY II maximum energy at 7 GeV, no beam extraction, no DESY III ramp, single carbon wire).

Rates	Target	
Energy	3mm Cu	1mm Cu
1 GeV	~3 kHz	~1 kHz
2 GeV	~5 kHz	~1.5 kHz
3 GeV	~4.5 kHz	~1.2 kHz
5 GeV	~15Hz (6GeV in DESY II) - 600 Hz (7GeV in DESY II)	~3Hz (6GeV in DESY II) - 200 Hz (7GeV in DESY II)
6 GeV	~3 Hz (7GeV in DESY II)	~1 Hz (7GeV in DESY II)

Table 1: Estimated Rates

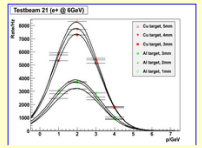


Fig. 7: Rate vs p for Testbeam 21:
about 7*10e6 positrons @ 6 GeV,
more than one carbon wire,
different targets.

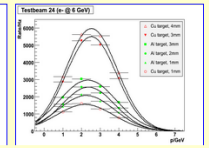


Fig. 8: Rate vs p for Testbeam 24:
about 14*10e6 electrons @ 6 GeV,
one carbon wire,
different targets.

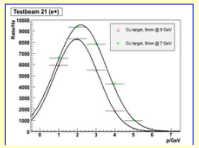
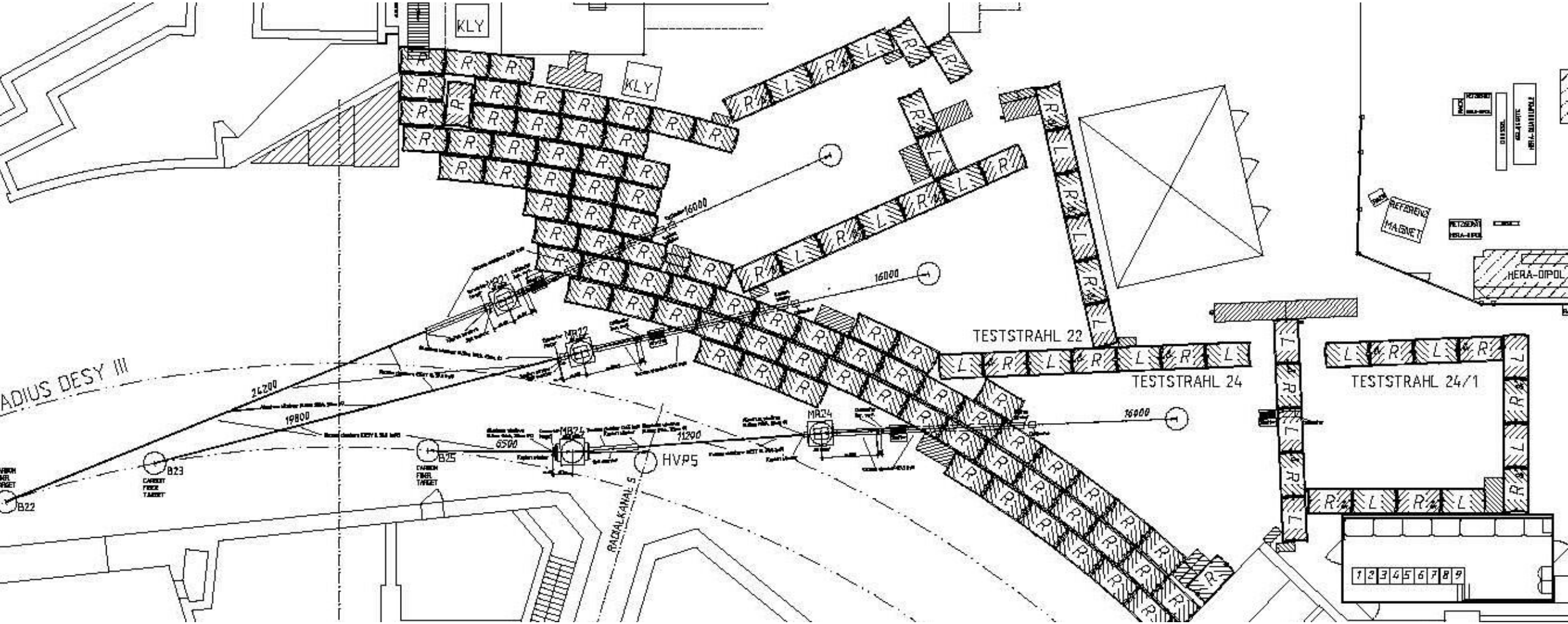


Fig. 9: Rate vs p for Testbeam 21:
about 7*10e6 positrons @ 6 and 7 GeV,
more than one carbon wire
5mm Cu target

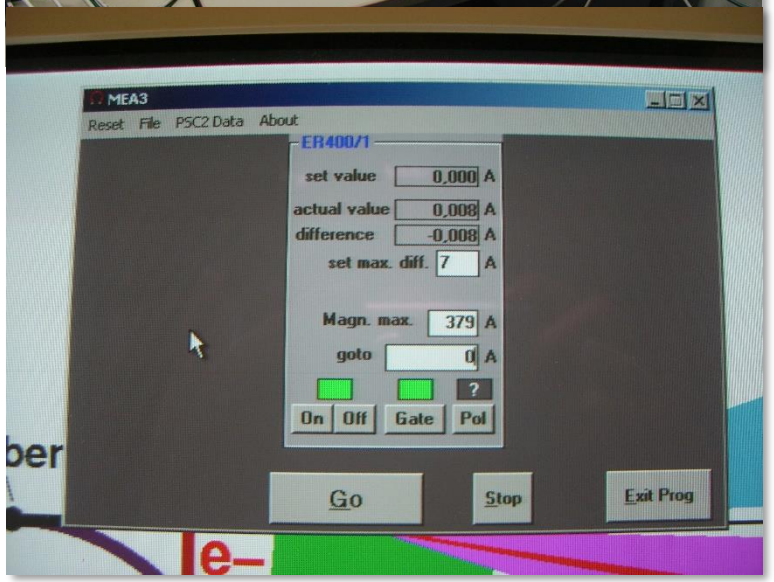
Description:

Detailed Beam Equipment



Power Supply Control

~1995 from Kontrave Switches to SEDAC

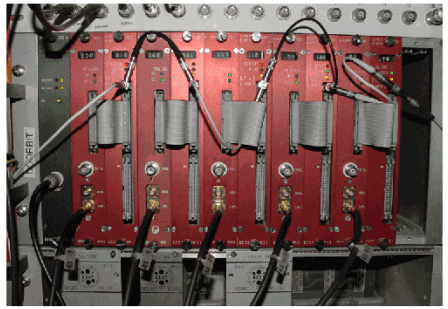


MDI | Maschine, Diagnose und Instrumentierung

MDI Home / MDI 1 / SEDAC-Komponenten /

SEDAC-Komponenten

SEDAC-Komponenten bei DESY



SEDAC "**SE**rial **D**ata **AC**quisition" ist ein Feldbus, der 1976 bei DESY entwickelt wurde, um den Beschleuniger PETRA auf wirtschaftliche Weise zu steuern.
Zur Zeit werden bei DESY ca. 140 Crates mit ungefähr 1100 Modulen über SEDAC betrieben. (Stand 02.2025)

2008 New Vacuum System & Beam Shutter

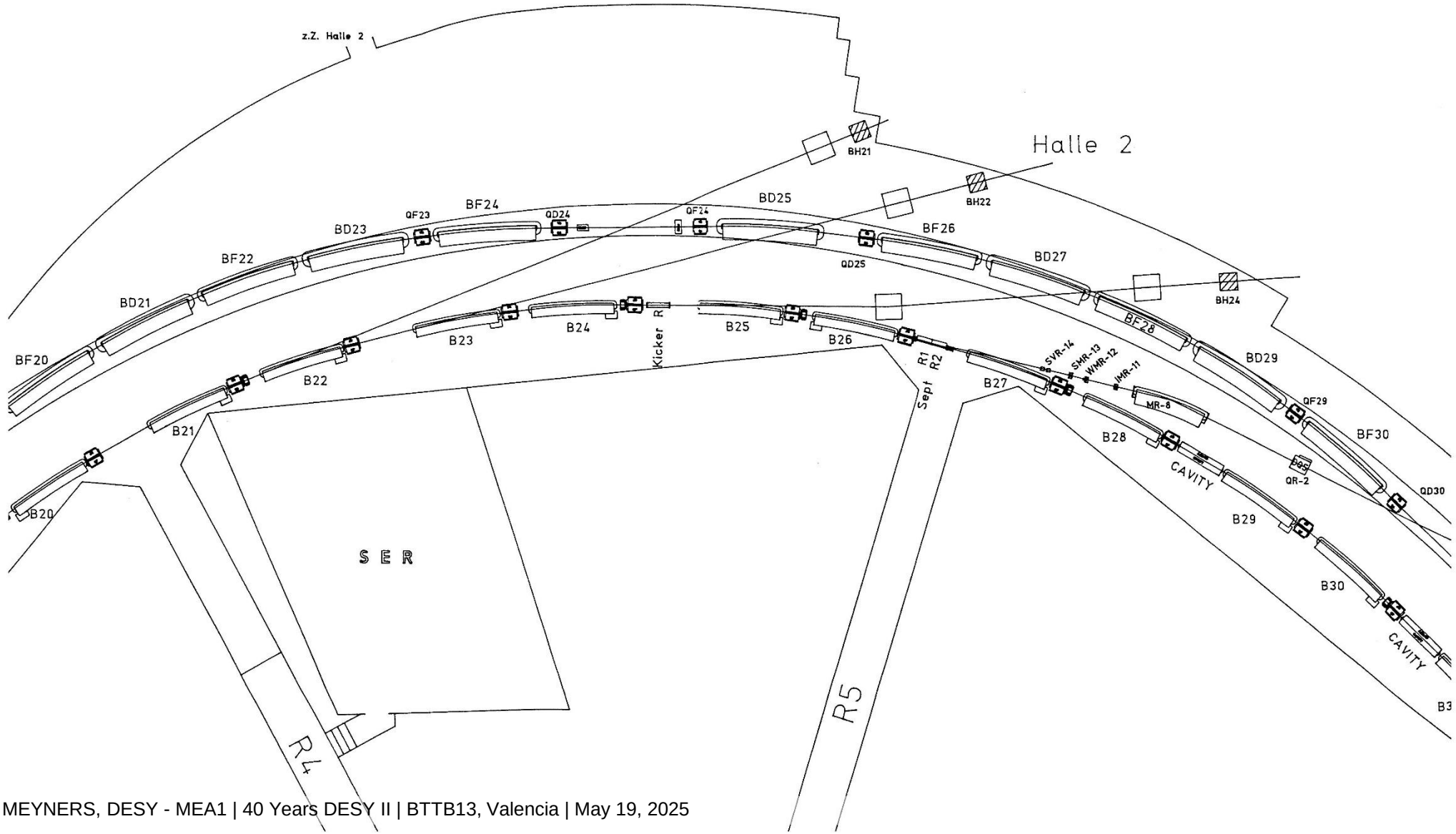
Smaller Beam Shutter ➔ Lead Collar necessary

Beam Pipe in Magnet

Parasitic Mode

DESY II & III injecting to HERA and DORIS

Test Beams Crossing DESY III

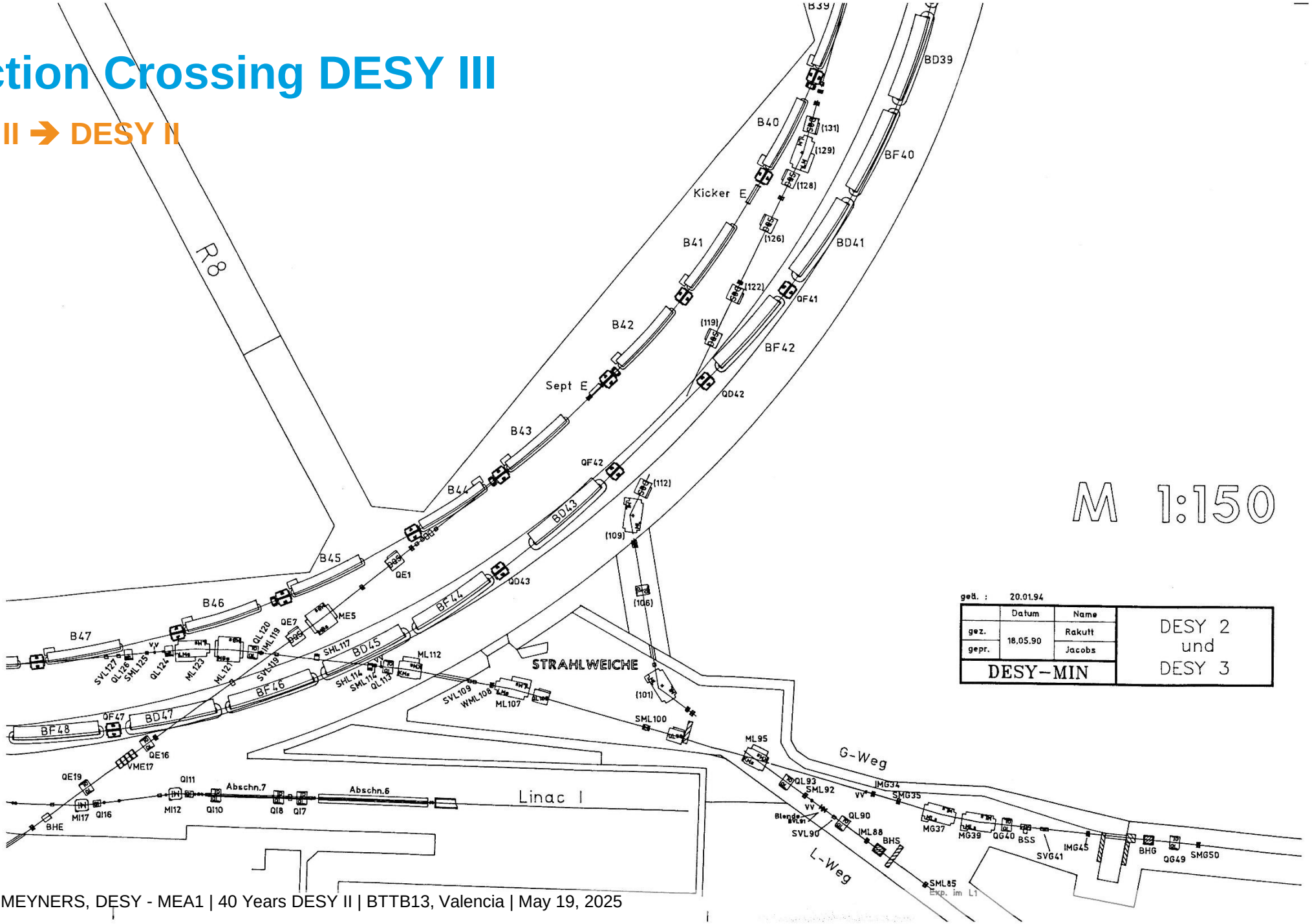


Transfer beam lines crossing DESY III

2003 Extraction to DORIS (Beam Line 21 similar)

Injection Crossing DESY III

LINAC II ➔ DESY II



Transfer beam lines crossing DESY III through a sector magnet

2003 Extraction to PETRA (Beam 22 & 24 and Injection!)

➔ Injection to DESY II only when DESY III at E_{min}

- DESY III ramping:
  1sec E_{min}; 2sec Ramp; 1sec E_{max}

- i.e. if DESY III on
  (filling HERA via PETRA; ~1h plus)
  ¼ rate

HERA & DORIS Filling

Hera fill ~12h, DORIS fill:e-: 3h /e+~8h

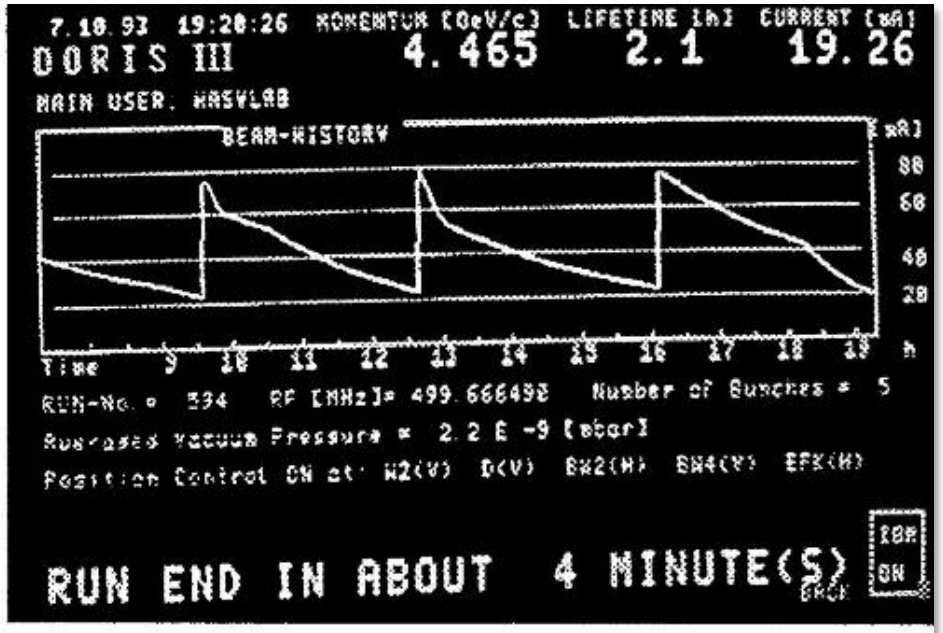


Figure 1. Electron current versus time

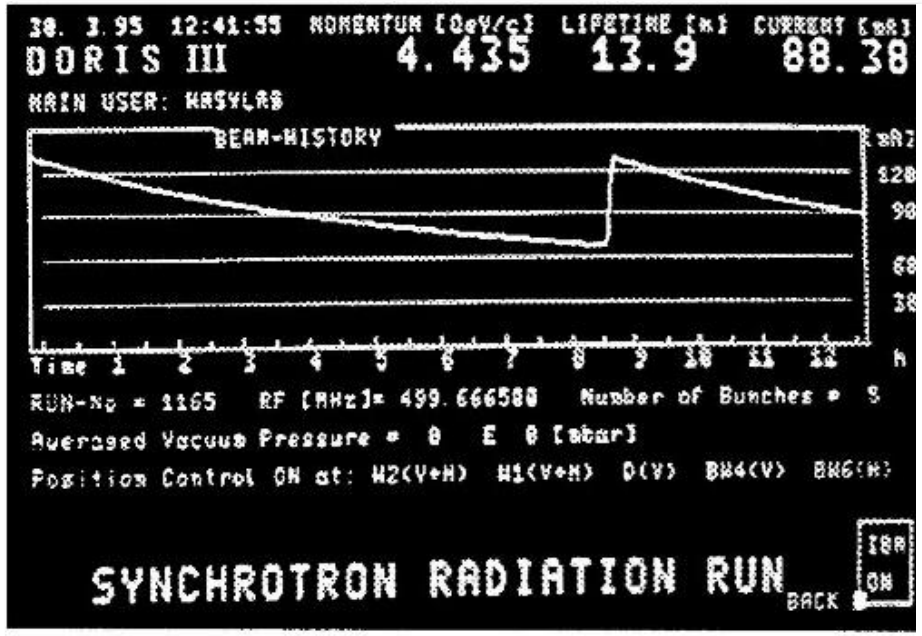
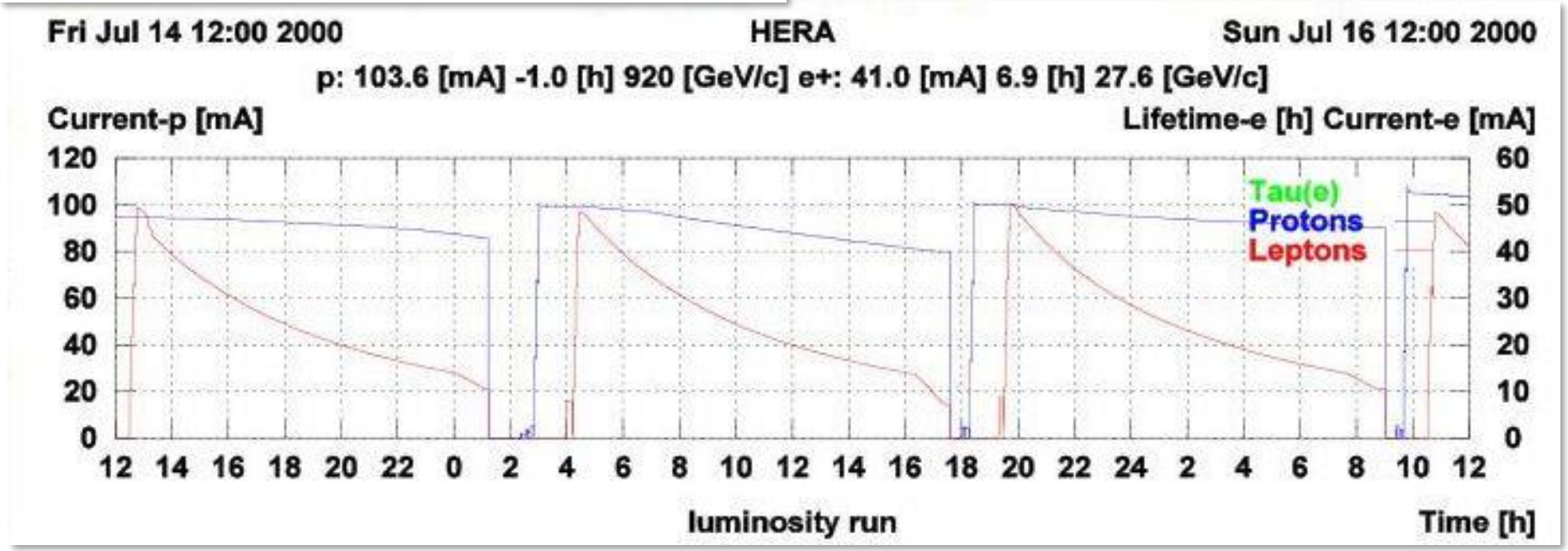


Figure 2. Positron current versus time

TV Screen Pictures taken from:
H. Nesemann, W. Brefeld, F. Brinker, W. Decking, O. Kaul and B. Sarau, "DORIS III as a dedicated source for synchrotron radiation," Proceedings Particle Accelerator Conference, Dallas, TX, USA, 1995, pp. 195-197 vol.1, doi: 10.1109/PAC.1995.504607



Graph taken from: Jim Stewart @ Jefferson Lab "HERMES – Selected Highlights" (https://slideplayer.com/slide/9854556/)

Fiber Target Station

1. Fiber Target Stations

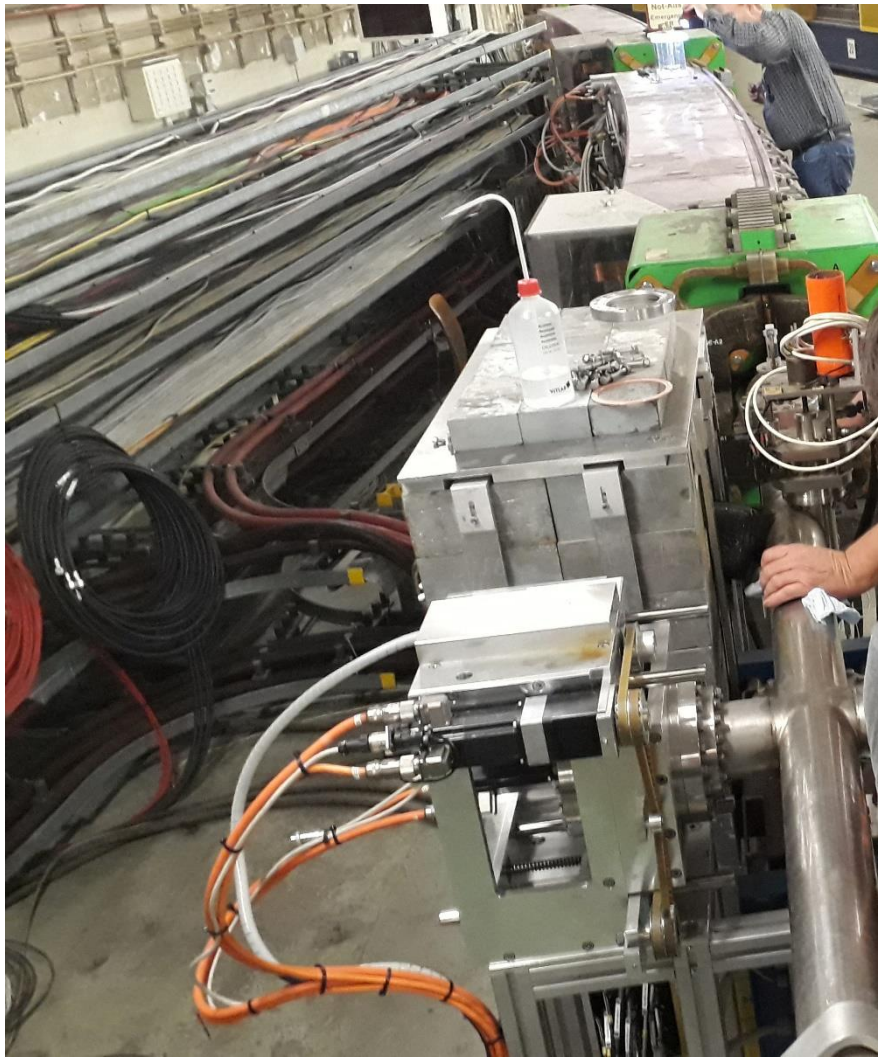
Incident May 2010

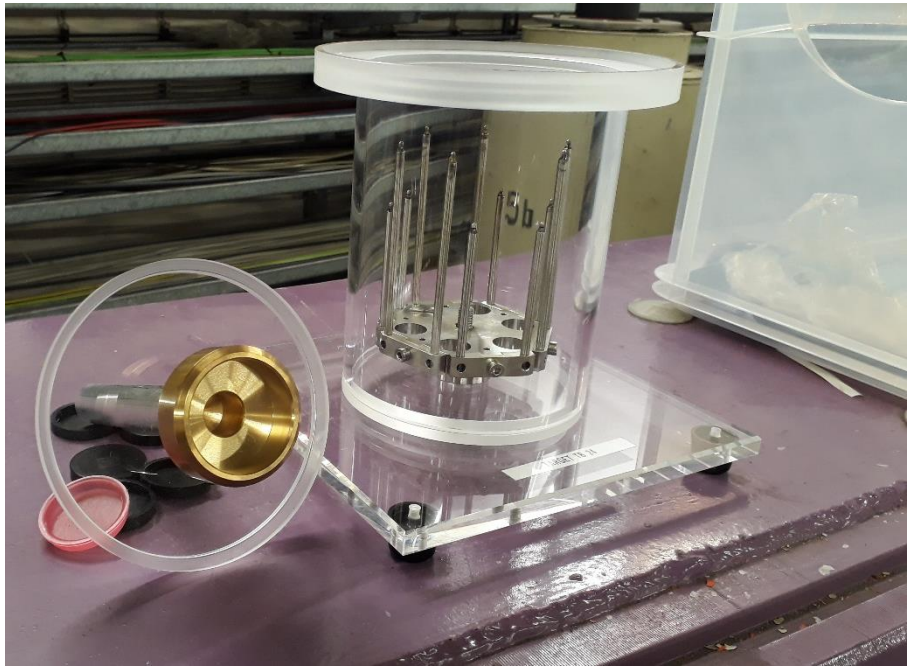
- Inclined Bellow for rotating the fiber holder is critical.
- Avoid unnecessary turning!!!
- Expert retired
- May 2010 new expert work on the targets
- After ~17h of permanent running bellow failed
- Accelerator vented
- Wrong target station dismounted, then right on
- Lost 2 beam lines for 5 weeks
- Squeezed all user in 24

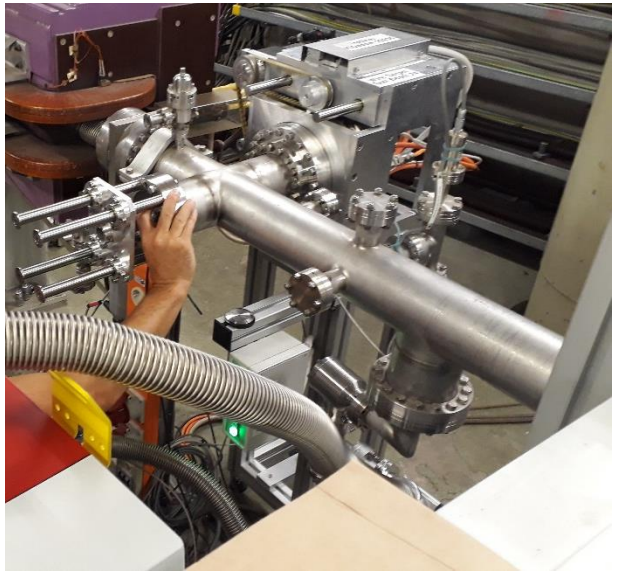
➔ Build new target stations

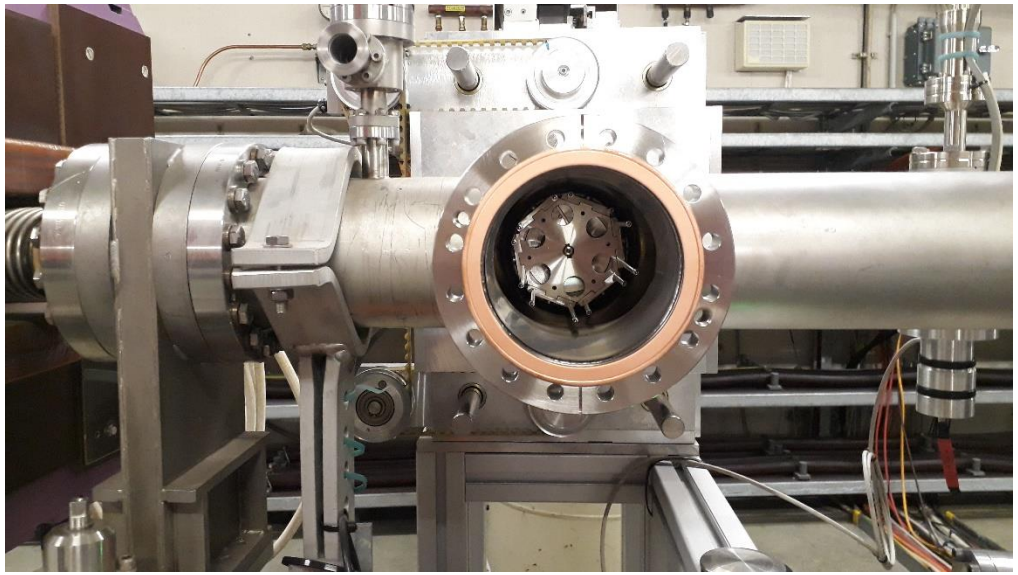
New Fiber Target Mount

Installed 2012 (Target Exchange 2018)









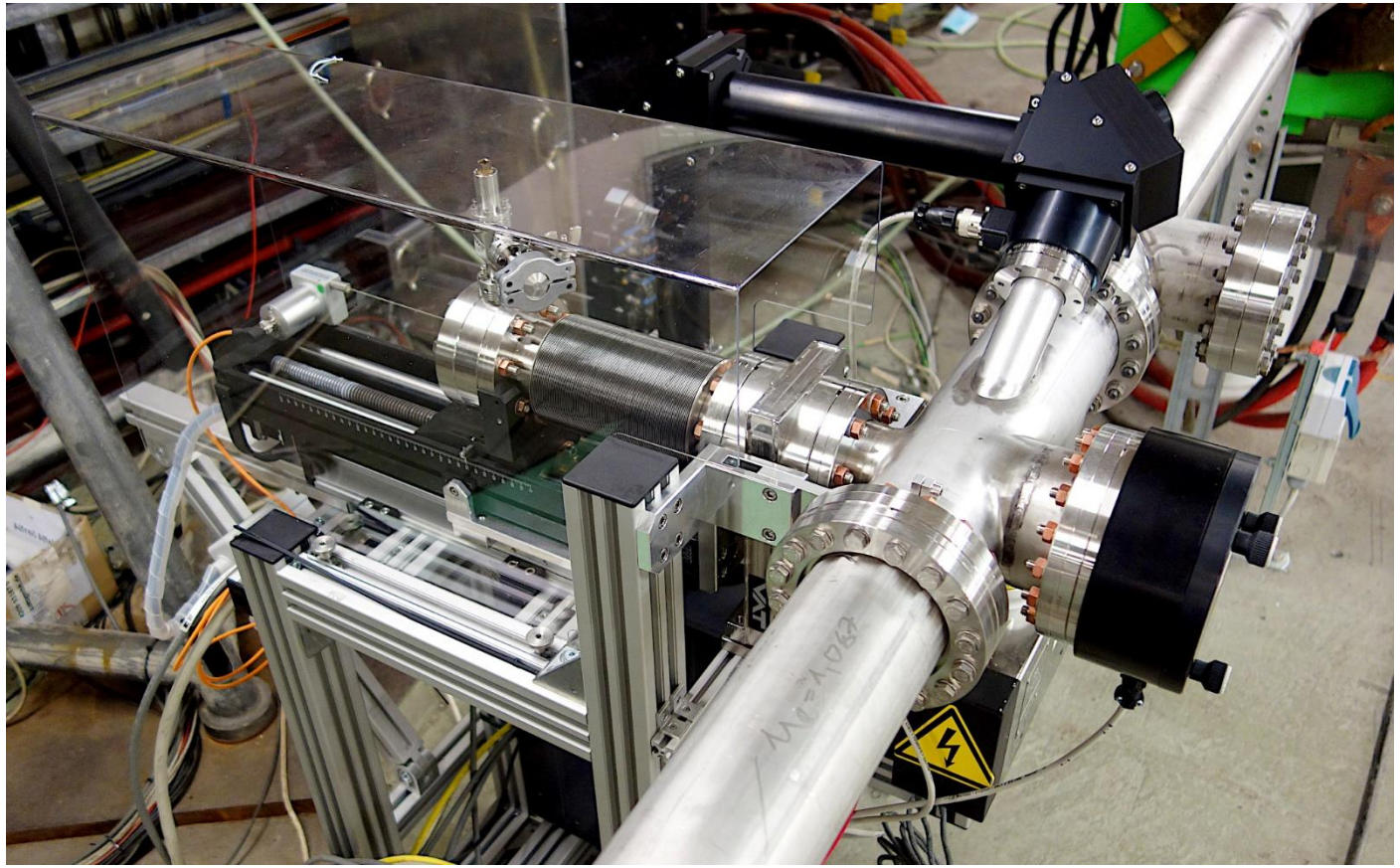
- Support much more stable
- Similar broken fiber rate

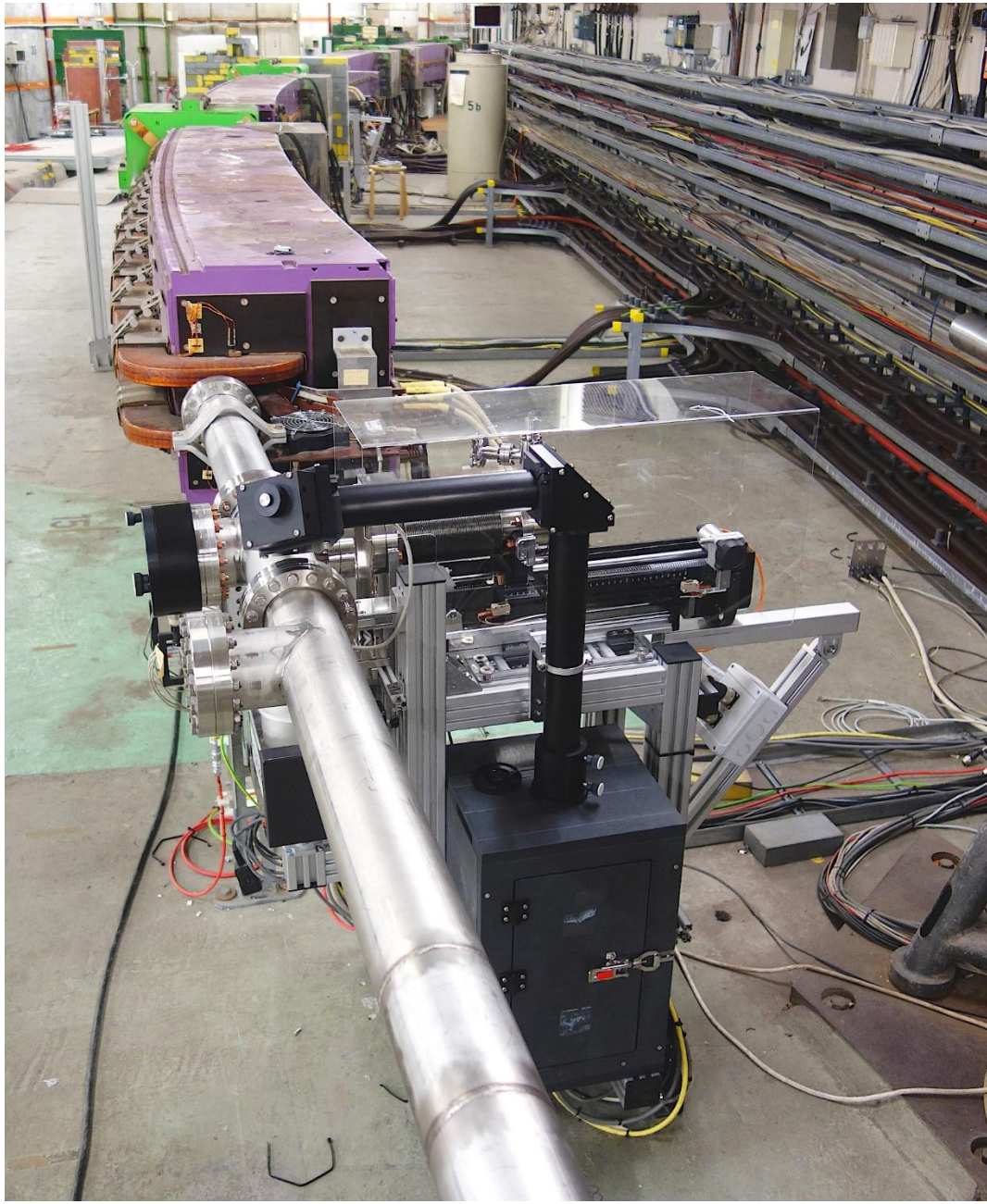
➔ Roots to thin?

➔ **Change to modified OTR station from MDI**
(Developed For XFEL)

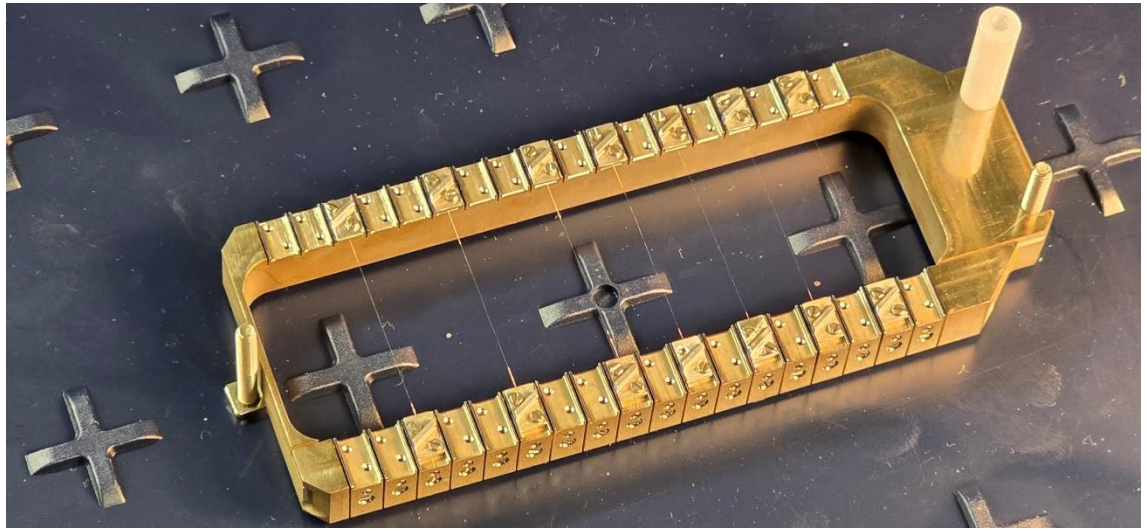
New Carbon Fiber Mount

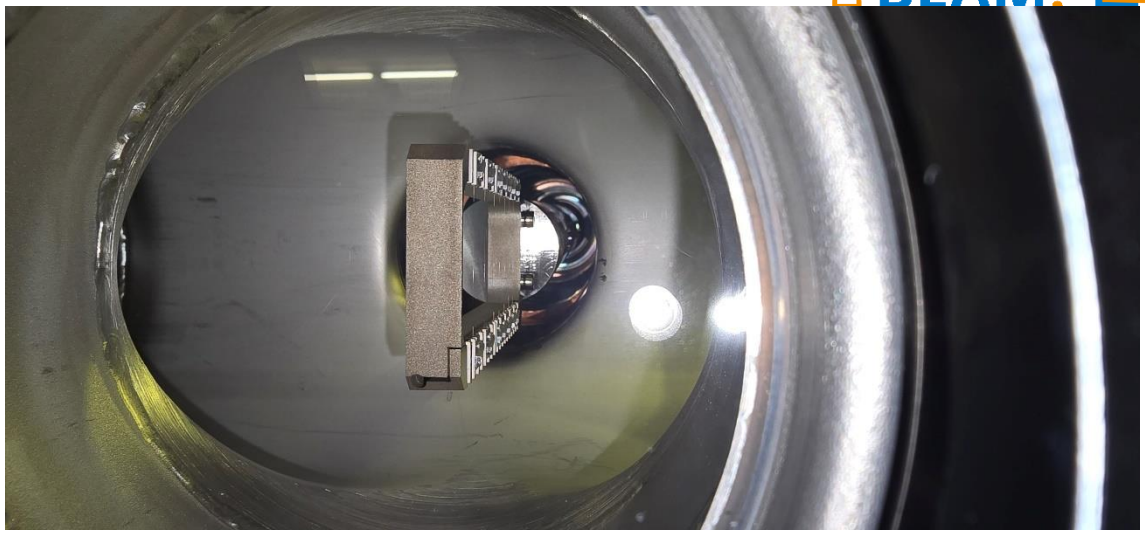
Installed 2020

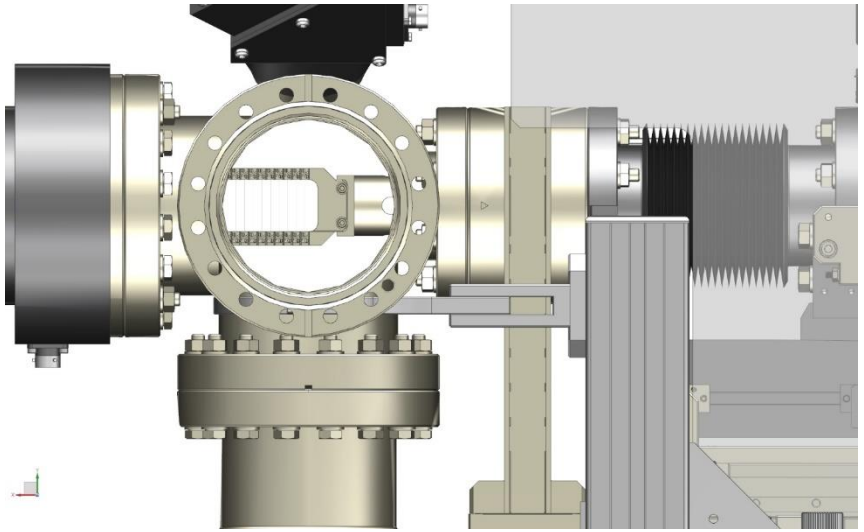




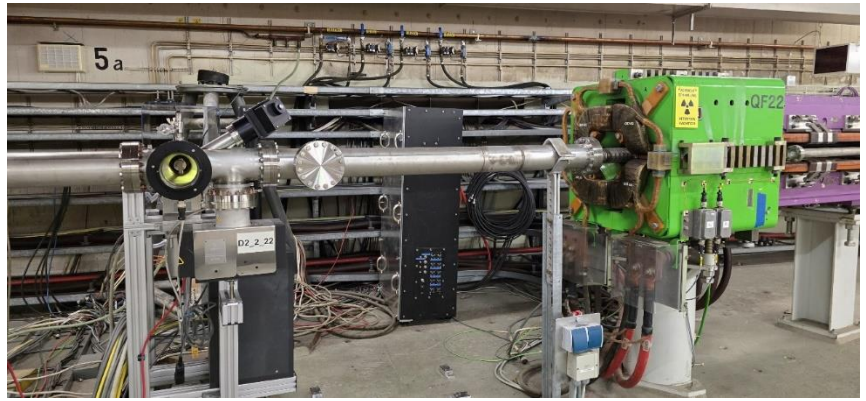
New Carbon Fiber Mount 2020







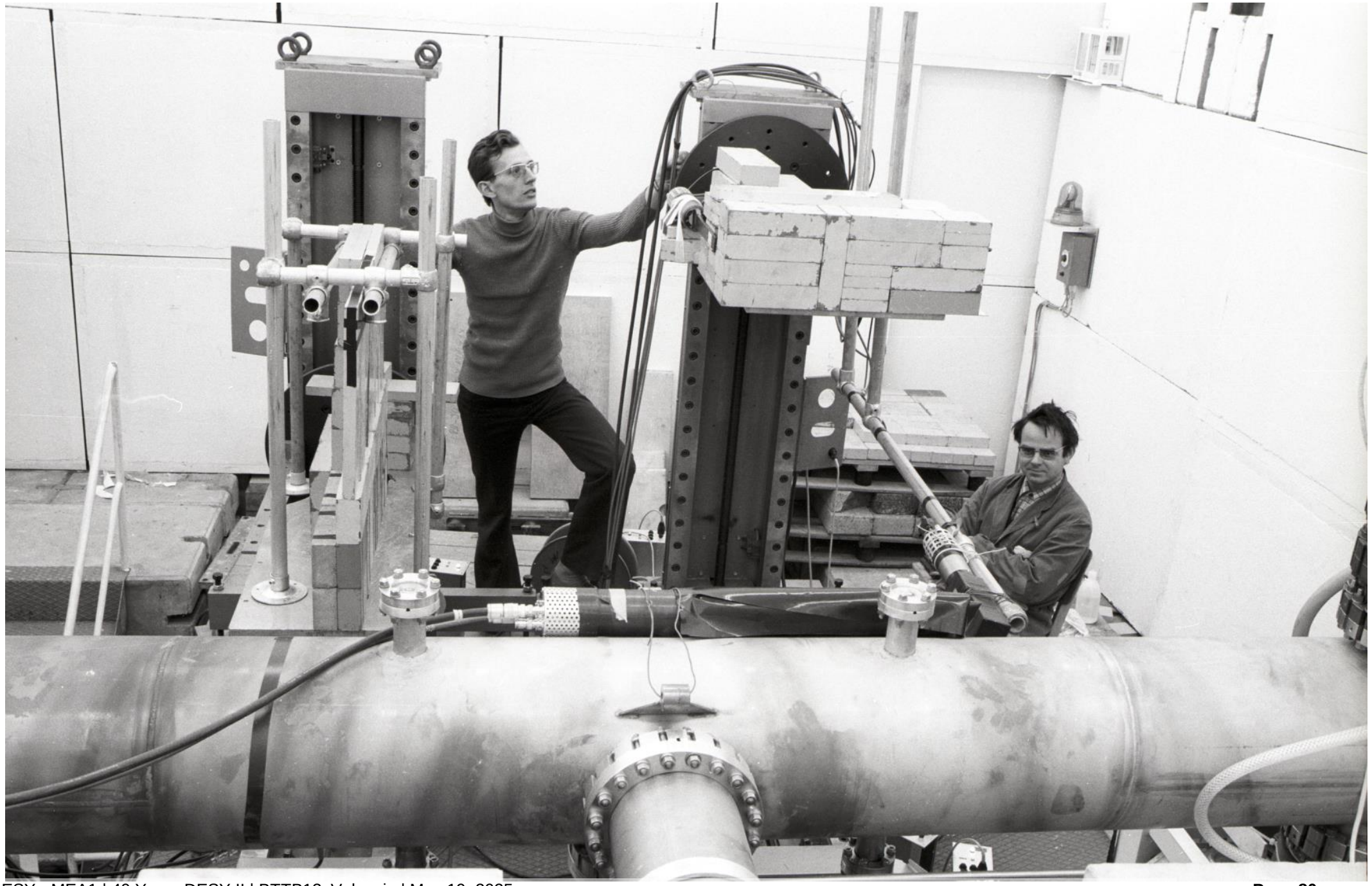
- Massive Copper Harp
- Fiber Ends coated with Copper



Green 1000kg Stages /DESY tables

Green Stages @ PETRA IP (PLUTO)

21584 28.03.1974 KB Aufbau Pluto-WW-Zone Hr. Bartel F11



Green 1000kg Stages / DESY tables

“Zählerstände”

At CERN:

- **~1988: 2**
- **2009: 4** (MOU June 16, 2009)
- **2016: 6**
  (Loan Contract April 20, 2016, prolonged 2021)
  CERN build own control box
- Now request from ELSA Test Beam (University Bonn)

Control Box

Control Box w/ TTY interface

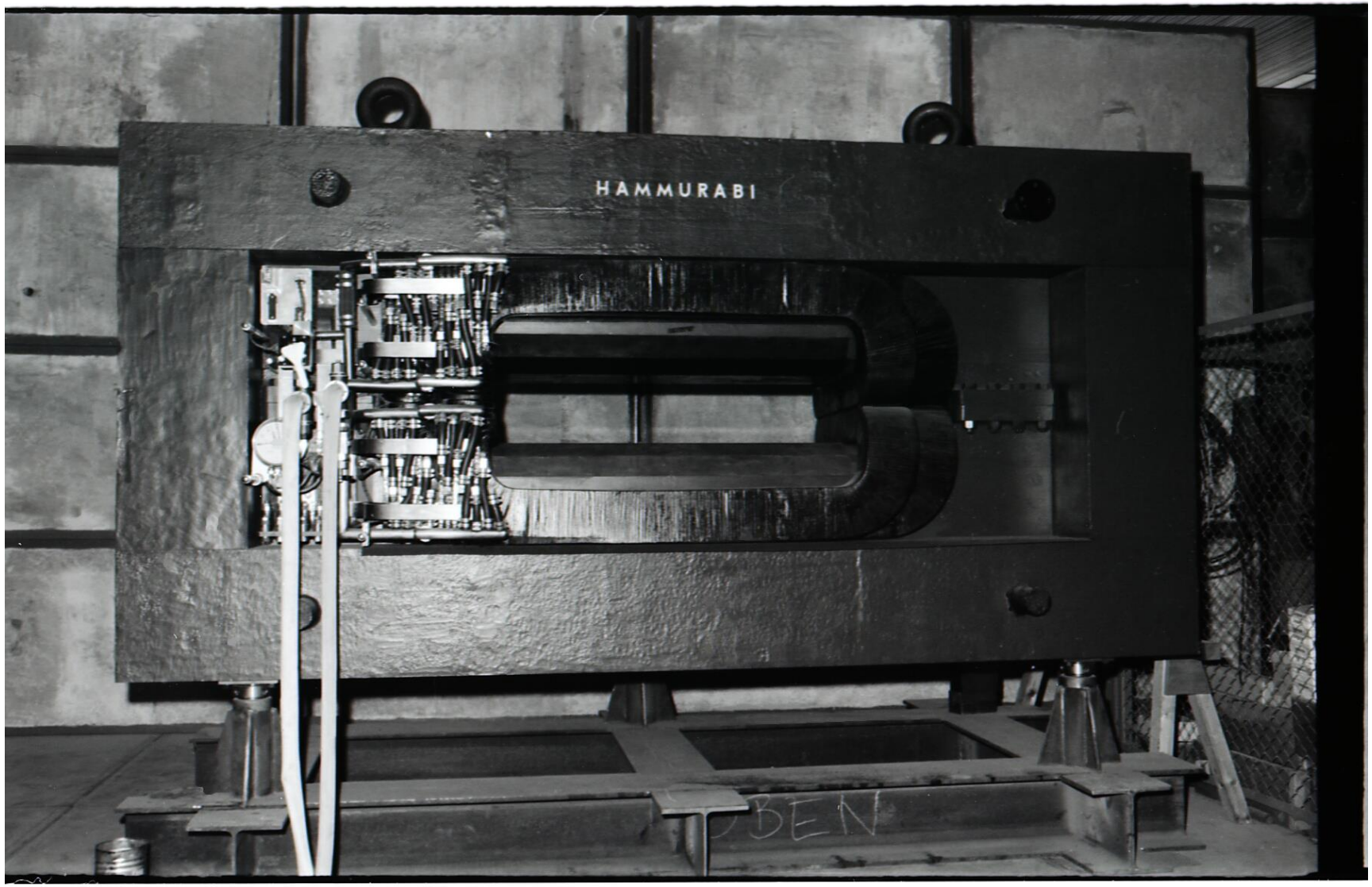
TTY-RS232 converter

Big Red Magnet

Spark Chamber Magnet (Type MD)

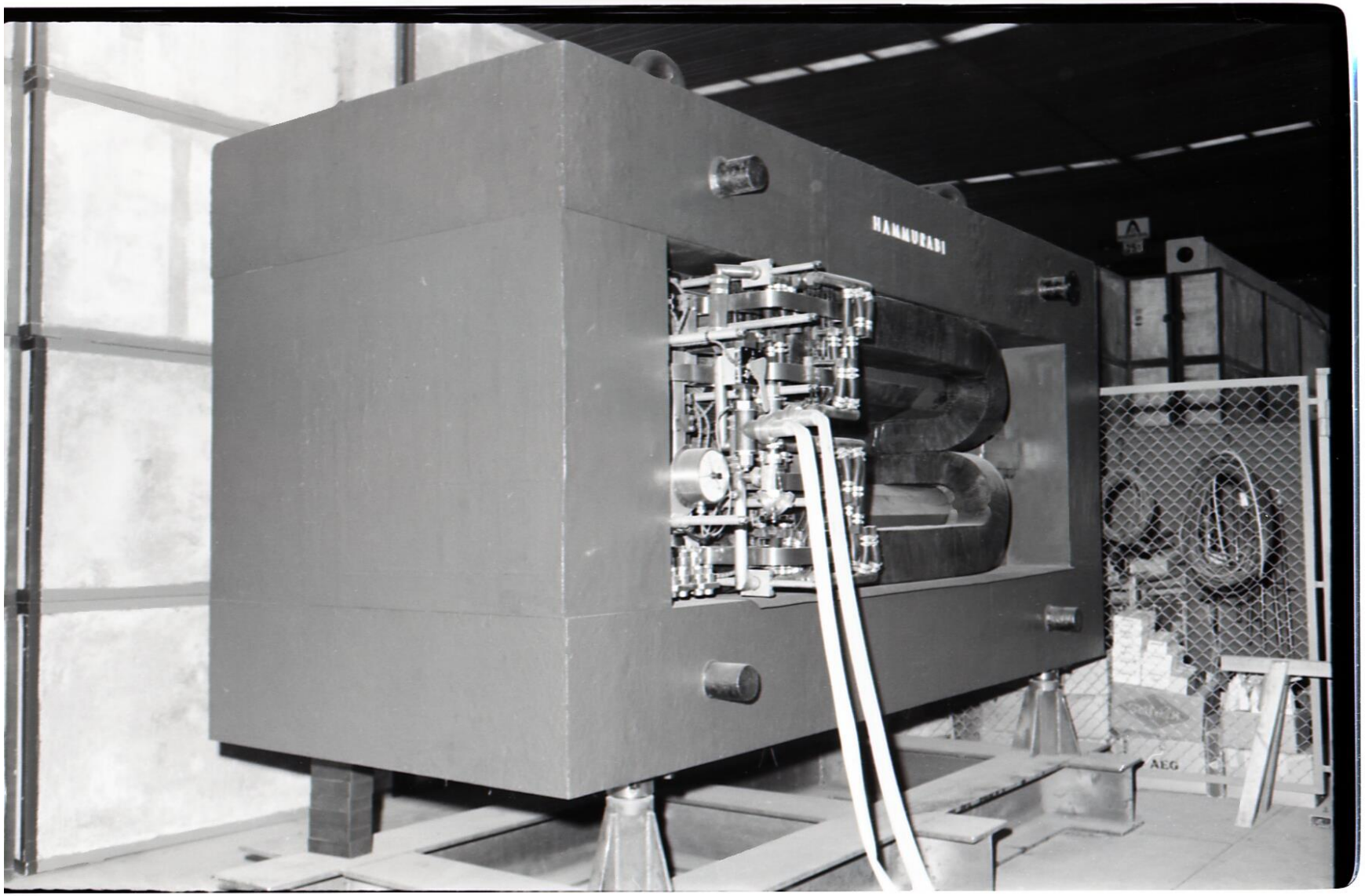
Spark Chamber Magnet “Hammurabi”

1964



Spark Chamber Magnet “Hammurabi”

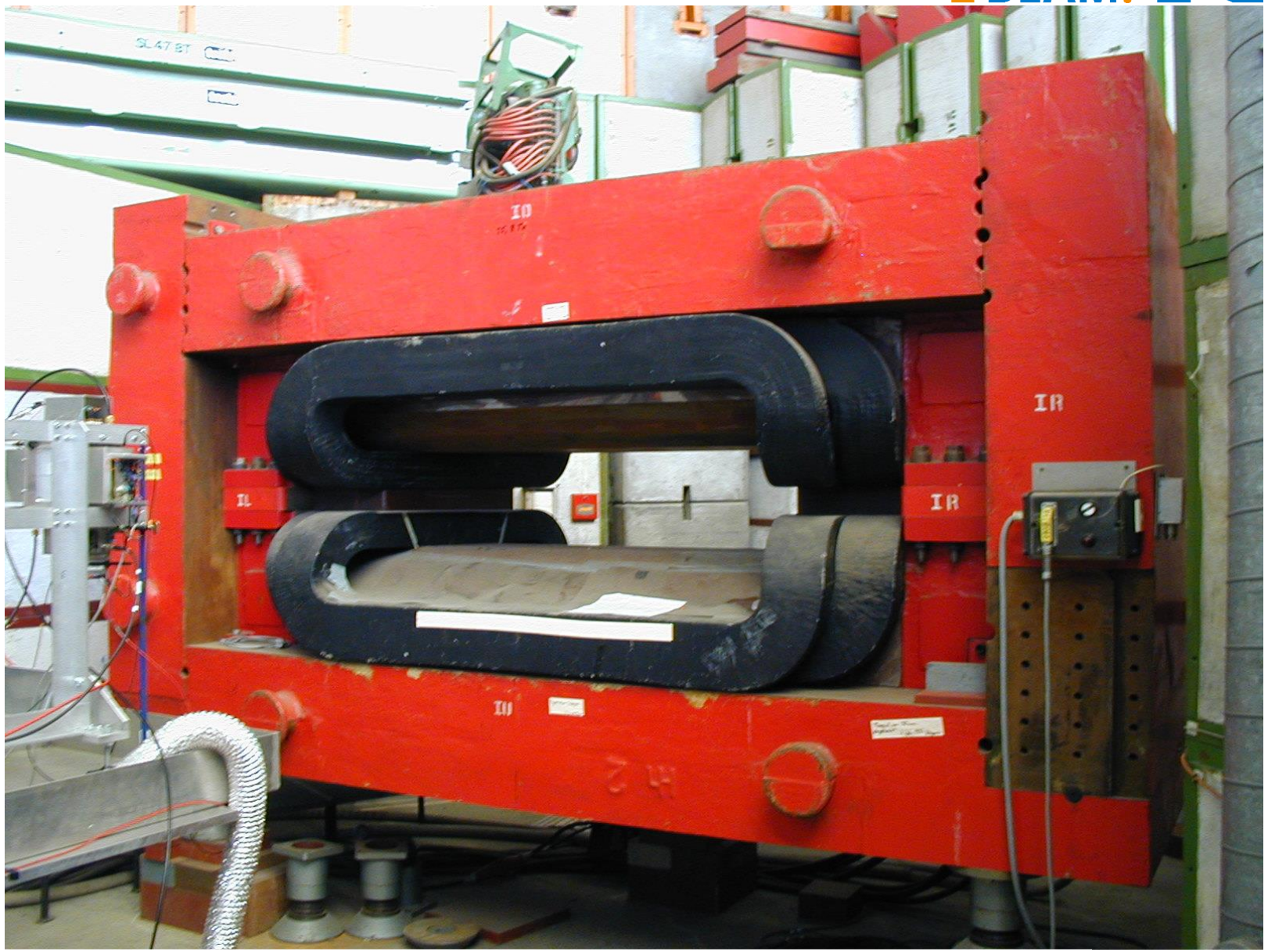
1964



Spark Chamber Magnet MD

Second Life of Hammurabi

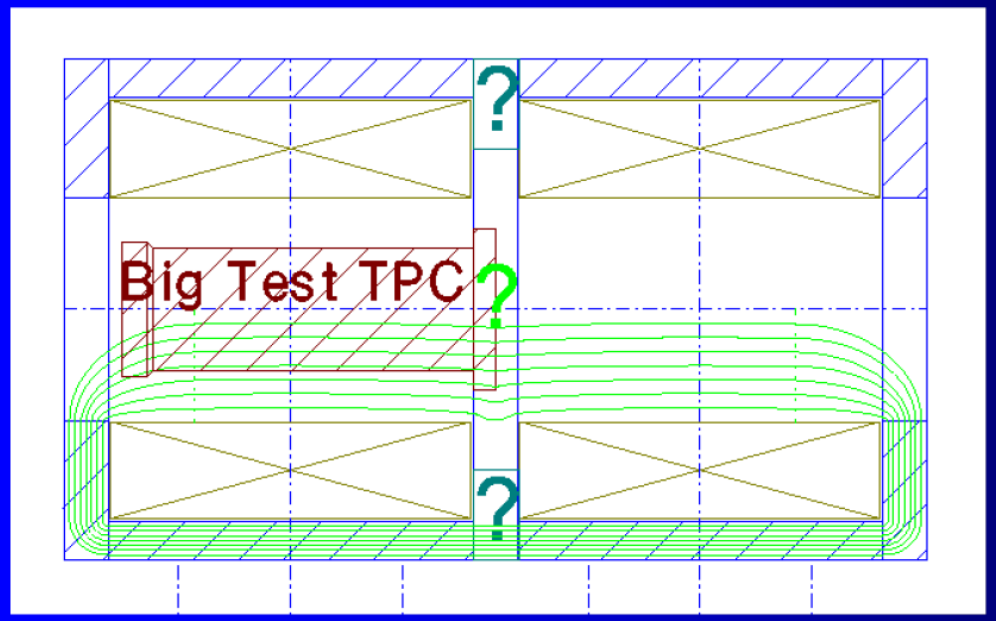
- Now gap height changeable!
- Twin (from 24) lent to Bonn Crystal Barrel @ ELSA (University Bonn) as forward spectrometer magnet
- Use for
  - wire chamber test,
  - electronic test in B-field 3x ITER (Safety electronic, National Instruments electronic, Company Schneider Electric),
  - Spectrometer magnet
  - Cleaning magnet



Solenoid for TPC Tests

Possible Solenoid for TPC Beam Test

Old TASSO Compensating Solenoids for the Test TPC Test Beam Test



This has been done for the H1 LAr calorimeter test without removing the inner end caps.

Also requested for the HCAL test by V.Korbel

- Third idea:
  Place both solenoids in a line and remove the inner end caps
  - Field should be much more homogenius
  - Field not reduced

But:
- Big forces
- Bigger effort
- Will take time (~month)
- Bad Access (Cables?)

➔ This version will anyhow be calculated.

May 29; 2002 Norbert.Meyners@DESY.de 5

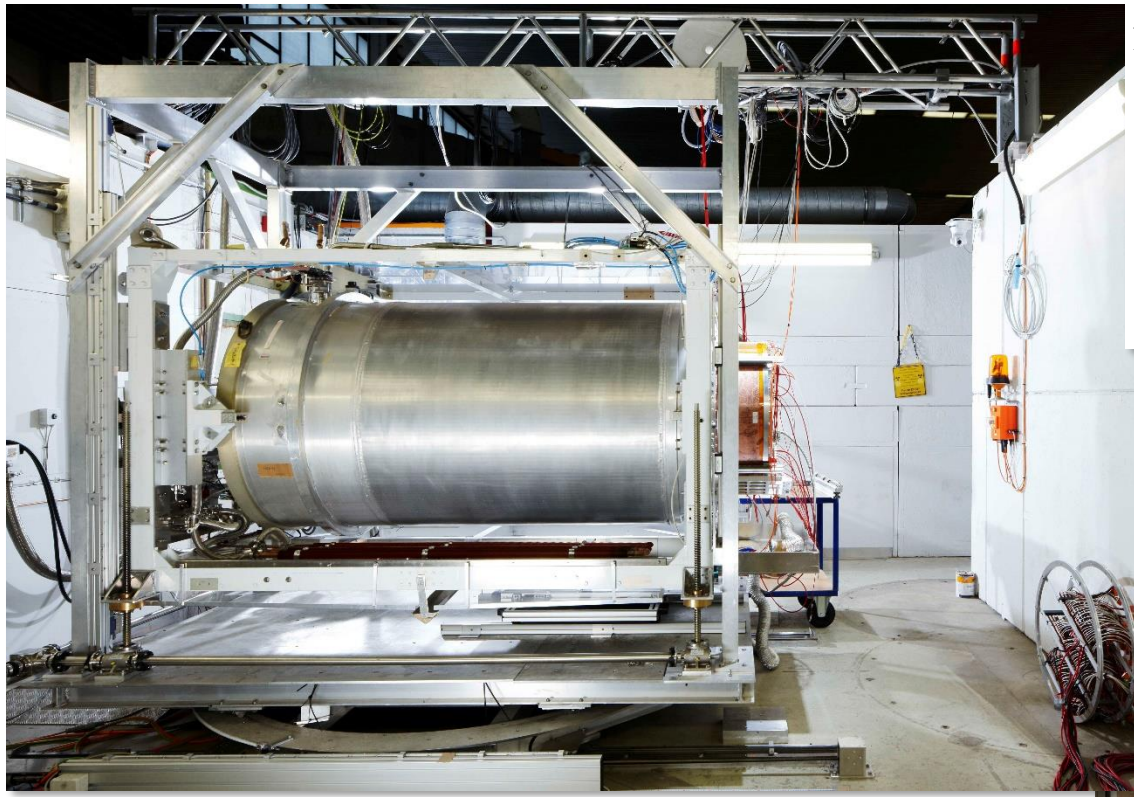
PCmag Arrival 2006

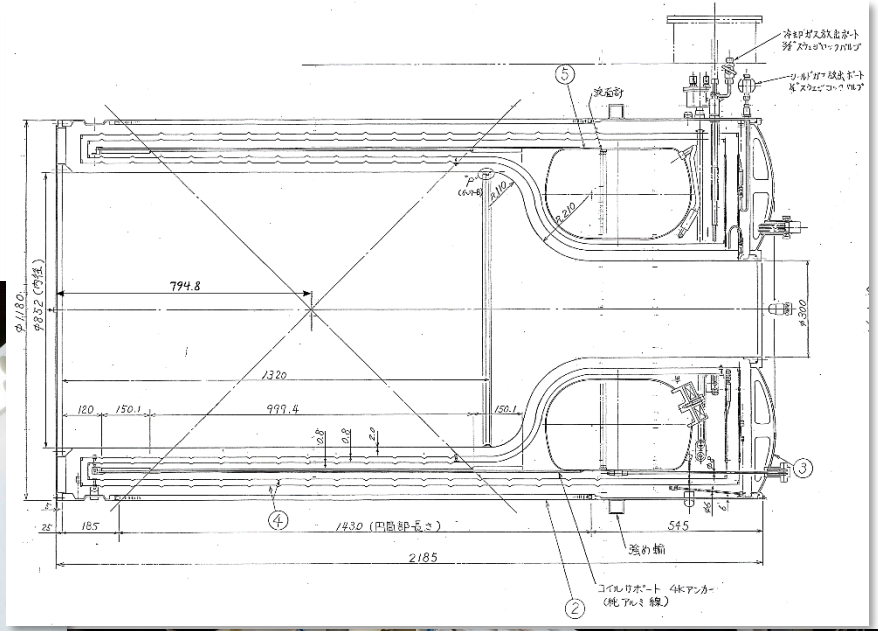
A Solenoid flew in

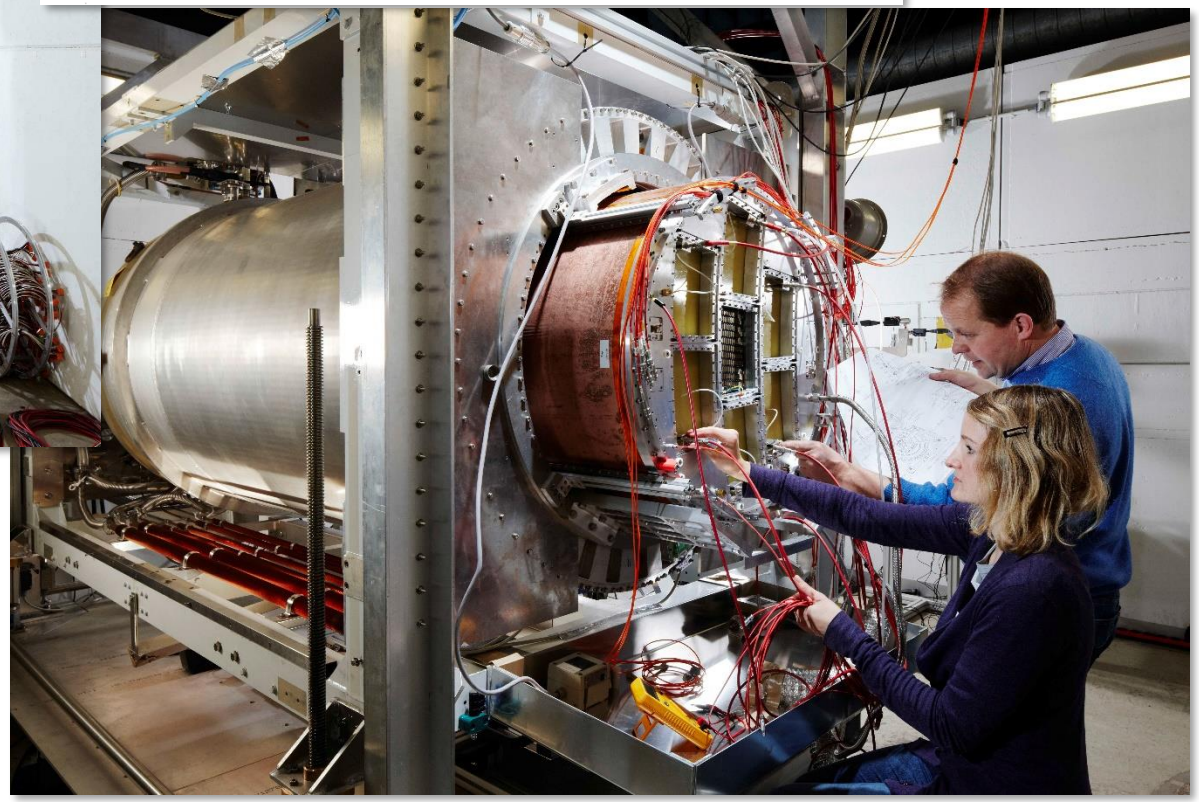
At least the twin

PCmag in Area 24/1

1T B-Field, 850mmø inner radius, 1.3m length







Coordination and Schedules

Coordination & Schedule

1997, 2008, 2012, 2015, 2025

Norbert Meyners, MEA (3321B), Norbert.Meyr

Nr.	Vorgangsname	Vera
1	DESY II Betrieb	W. E
2	HERA Wartungstage	R. B
13	DORIS Servicewochen	O. K
20	Strahl 21 (Tel. 3721)	ZEU
21	ZEUS BPC III (HH1)	U. H
24	HERA-B (Zeuthen)	R. N
25	HERA-B (Uni Heidelberg)	M. H
26	HERA-B (Rich)	R. E
27	ZEUS FPC prototype	Y. Y
28	HERA-B (Zeuthen)	J. Ba
29	ZEUS Crystal Polarimeter	K. P
30	ZEUS Photon Calorimeter	Z. D
31	Strahl 22 (Tel. 3723)	H1:
32	ZEUS FPC prototype	Y. Y
37	ZEUS Lumi	Z. D
38	H1 Si-Pad	M. K
43	H1 VLQ Calo	W. E
48	H1 MSGC	S. R
51	Strahl 24 (Tel. 3728)	HER
52	HERA-B div. Tracker	Ch.
53	Strahl 24/1 (Tel. 3728)	HER
54	HERA-B RICH	Ch.

Stand: Mit 27. Aug '97; Druck: Mit 27. Aug '97

Testbeam at DESY in 20

Beam	Responsible / Collaboration/Subdetector	January 07	14	21	28	February 04	11	18
21	Garutti/Sefkow ILC/HCAL							
21								
21								
21								
21	SHUTDOWN							
22	Gregor/ Kötz Telescope							
22								
22								
22								
22	SHUTDOWN							
24	Gregor EUDET/Telescope							
24								
24								
24								
24	SHUTDOWN							

Testbeam at DESY in 20

Beam	Responsible / Collaboration/Subdetector	July 07	14	21	28	August 04	11	18
21	Gregor EUDET Telescope							
21								
21								
21	NO BEAM							
21	SHUTDOWN							
22	Gregor/ Kötz MVD Telescope							
22	Ciborowski Warsaw/Mimosa5							
22	Airapetian Giessen/PANDA							
22	Ti SiPM							
22	SHUTDOWN							
24	Dehmelt ILC/TPC							
24	PCmag Cool down/Cooled							
24								
24	NO BEAM							
24	SHUTDOWN							

Legende Priority: high , standard , low Option: (Equipment in area, Tests possible)

Ingrid Gregor, Norbert Meyners testbeam-coor@desy.de schedule-200

DESY Testbeam Schedule 2013 - version11 of March 11th 2013

Ingrid-Maria Gregor, Norbert Meyners, Marcel Stanitzki - DESY Test Beam Coordinators

	Week		TB21	
			DATURA	none
	2		---	---
14-Jan-13	3		---	ITER
21-Jan-13	4		X0	
28-Jan-13	5		CMS Pix-irrad	---
4-Feb-13	6		CMS Pix-fwd	---
11-Feb-13	7		CLICpix	---
18-Feb-13	8		---	SiW ECAL
25-Feb-13	9		---	Sc ECAL
4-Mar-13	10			
11-Mar-13	11		ALICE ITS	---
18-Mar-13	12		CMS Pix-irrad	---
25-Mar-13	13		CMS Pix-KA	---
1-Apr-13	14		CMS Pix-ro	---
8-Apr-13	15		X0	---
15-Apr-13	16		ITER	
22-Apr-13	17			
29-Apr-13	18			
6-May-13	19		DEPFET	---
13-May-13	20		FE-I4	---
20-May-13	21		CMS Pix-ro	---
27-May-13	22		X0	
3-Jun-13	23		CLICpix	---
10-Jun-13	24		CLICpix	---
17-Jun-13	25		ALICE ITS	---
24-Jun-13	26		CMS Trk II	---
1-Jul-13	27		---	SiW ECAL
8-Jul-13	28		---	SC ECAL
15-Jul-13	29		APD	---
22-Jul-13	30		CMS TRK II	---
29-Jul-13	31		ATLAS Lucid	---
5-Aug-13	32		LHCb VELO	---
12-Aug-13	33		LHCb VELO	---
19-Aug-13	34		CLICpix	---
26-Aug-13	35		CLICpix	---
SHUTDOWN	36-52			
6-Jan-14	2		FCAL	---
13-Jan-13	3		FCAL	---
20-Jan-13	4		SBS GEM	---
27-Jan-13	5		SBS GEM	---
3-Feb-14	6		LHCb VELO	---
10-Feb-13	7		LHCb VELO	---
	8			
	9			
	10			
	30			
	90			

DESY Testbeam Schedule 2015 - Vers

Ralf Diener, Norbert Meyners, Marcel Stanitzki - DESY Test Beam Coordinators

	Week		TB21	
			DATURA	none
5-Jan-15	2			
12-Jan-15	3		Startup	Startup
19-Jan-15	4		CMS-Pixel-Ph1	
26-Jan-15	5			
2-Feb-15	6			TOTE
9-Feb-15	7		ALICE-ITS	
16-Feb-15	8			
23-Feb-15	9		CMS-Pixel-Ph1	
2-Mar-15	10			Mu3e
9-Mar-15	11		ATLAS-Strip-CMOS	TOTE
16-Mar-15	12			ATLAS ITK
23-Mar-15	13		Bonn-CMOS	ATLAS ITK
30-Mar-15	14			ATLAS ITK
6-Apr-15	15		CMS-Pixel-Ph1	
13-Apr-15	16			
20-Apr-15	17		CMS-Pixel-KA	
27-Apr-15	18		CMS-Pixel-KA	
4-May-15	19		ATLAS-Strip-Module	
11-May-15	20		ATLAS-Strip-Module	
18-May-15	21		CMS-Pixel-Ph1	
25-May-15	22			
1-Jun-15	23		CMS-TRK-EPi	
8-Jun-15	24		CMS-TRK-EPi	
15-Jun-15	25		CMS-Pixel-Ph1	
22-Jun-15	26		CMS-Pixel-Ph2	
29-Jun-15	27			
6-Jul-15	28		CMS-Pixel-Ph2	
13-Jul-15	29		Telescope R&D	
20-Jul-15	30			
27-Jul-15	31			
3-Aug-15	32			
10-Aug-15	33			
17-Aug-15	34		Summer Students	
24-Aug-15	35			
31-Aug-15	36			
7-Sep-15	37			
14-Sep-15	38			Du
21-Sep-15	39		ATLAS-Strip-Glue	
28-Sep-15	40		CMS-Pixel-Ph2	
5-Oct-15	41			
12-Oct-15	42		FCAL	
19-Oct-15	43		CMS-Pixel-Ph2	ATLAS-ITK
26-Oct-15	44		Mu3e	ATLAS-ITK
2-Nov-15	45		DEPFET	Goettingen
9-Nov-15	46	Beam 18 11/11 0800	DEPFET	
16-Nov-15	47			
23-Nov-15	48			
30-Nov-15	49			
7-Dec-15	50			
14-Dec-15	51			
21-Dec-15	52			

DESY TEST BEAM.

DESY 2 Test Beam Schedule 2025 - Status from 17/MAY/2025

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

Switch to High Contrast Schedule

Startdate	Week..	TB21	T	TB22	T	TB241	T	TB24	T
30.12.2024	1	Shutdown		Shutdown		Shutdown		Shutdown	
06.01.2025	2	Shutdown		Shutdown		Shutdown		Shutdown	
13.01.2025	3	Shutdown		Shutdown		Shutdown		Shutdown	
20.01.2025	4	Shutdown		Shutdown		Shutdown		Shutdown	
27.01.2025	5	Shutdown		Shutdown		Shutdown		Shutdown	
03.02.2025	6	Shutdown		Shutdown		Shutdown		Shutdown	
10.02.2025	7	Startup		Telescope-Dev	X	Startup		Startup	
17.02.2025	8	MONOPIX2	X	Tangerine	X			EEEMCAL	
24.02.2025	9	MONOPIX2	X	ATLAS HGTD	X			EEEMCAL	
03.03.2025	10	CMS HGCAL	X	ATLAS HGTD	X			DRD6 SiW ECAL AIDAinnova	X
10.03.2025	11	Telescope-Dev	X	DCRSD	X			CMOS LGAD	X
17.03.2025	12	CMS ETL ETROC	X	Tangerine	X			IPHC-Mimosis2.1	
24.03.2025	13	CMS ETL ETROC	X	ATLAS-ITk-Strips	X			EEEMCAL	
31.03.2025	14	Belle II CMOS	X	CMS ETL	X			EEEMCAL	
07.04.2025	15	Belle II CMOS	X					UHH-LGAD	X
14.04.2025	16	Maintenance		Maintenance		Maintenance		Maintenance	
21.04.2025	17	Telescope-Dev		ALICE 3 OT				ALICE 3 OT	X
28.04.2025	18			ALICE 3 OT				CalVision	X
05.05.2025	19	CMS ETL ETROC	X					CalVision	X
12.05.2025	20	CMS ETL ETROC	X	AIDAinnova-WP8.4.1					
19.05.2025	21								
26.05.2025	22			TelePix					
02.06.2025	23	Maintenance		Maintenance		Maintenance		Maintenance	
09.06.2025	24							LUXE ECAL and DRD6	X
16.06.2025	25	MDI-2		Tangerine	X			LUXE ECAL and DRD6	X
23.06.2025	26	MONOPIX2	X	Tangerine	X			TJ-Monopix DESY	X
30.06.2025	27	ATORCH		RD50 HV-CMOS	X			Telescope-Dev	
07.07.2025	28	ATORCH		ATLAS-ITk-Strips	X				
14.07.2025	29	BL4S preparation	X	ATLAS-ITk-Strips				EPIC BTOF FCFD	X
21.07.2025	30	Shutdown		Shutdown		Shutdown		Shutdown	
28.07.2025	31	Shutdown		Shutdown		Shutdown		Shutdown	
04.08.2025	32	Shutdown		Shutdown		Shutdown		Shutdown	
11.08.2025	33	Startup		Startup		Startup		Startup	
18.08.2025	34	Startup		Startup		Startup		Startup	
25.08.2025	35								
01.09.2025	36								
08.09.2025	37								
15.09.2025	38								
22.09.2025	39	Maintenance		Maintenance		Maintenance		Maintenance	
29.09.2025	40								
06.10.2025	41								
13.10.2025	42								
20.10.2025	43								
27.10.2025	44	Maintenance		Maintenance		Maintenance		Maintenance	
03.11.2025	45								
10.11.2025	46								
17.11.2025	47								
24.11.2025	48								
01.12.2025	49								
08.12.2025	50								
15.12.2025	51								
22.12.2025	52	Shutdown		Shutdown		Shutdown		Shutdown	

DESY II with PETRA III (e-) and DORIS (e+)

2010 Top Up Mode

PETRA III in Top Up Mode

Reduction of Heat Load Changes on Photon Optics

- Modern synchrotron light sources are operated in top-up-mode i. e beam current kept constant
- This requires permanently injection to compensate the losses

➔ Injection chain (LINAC II, DESY II) always on

➔ **always test beam possible**

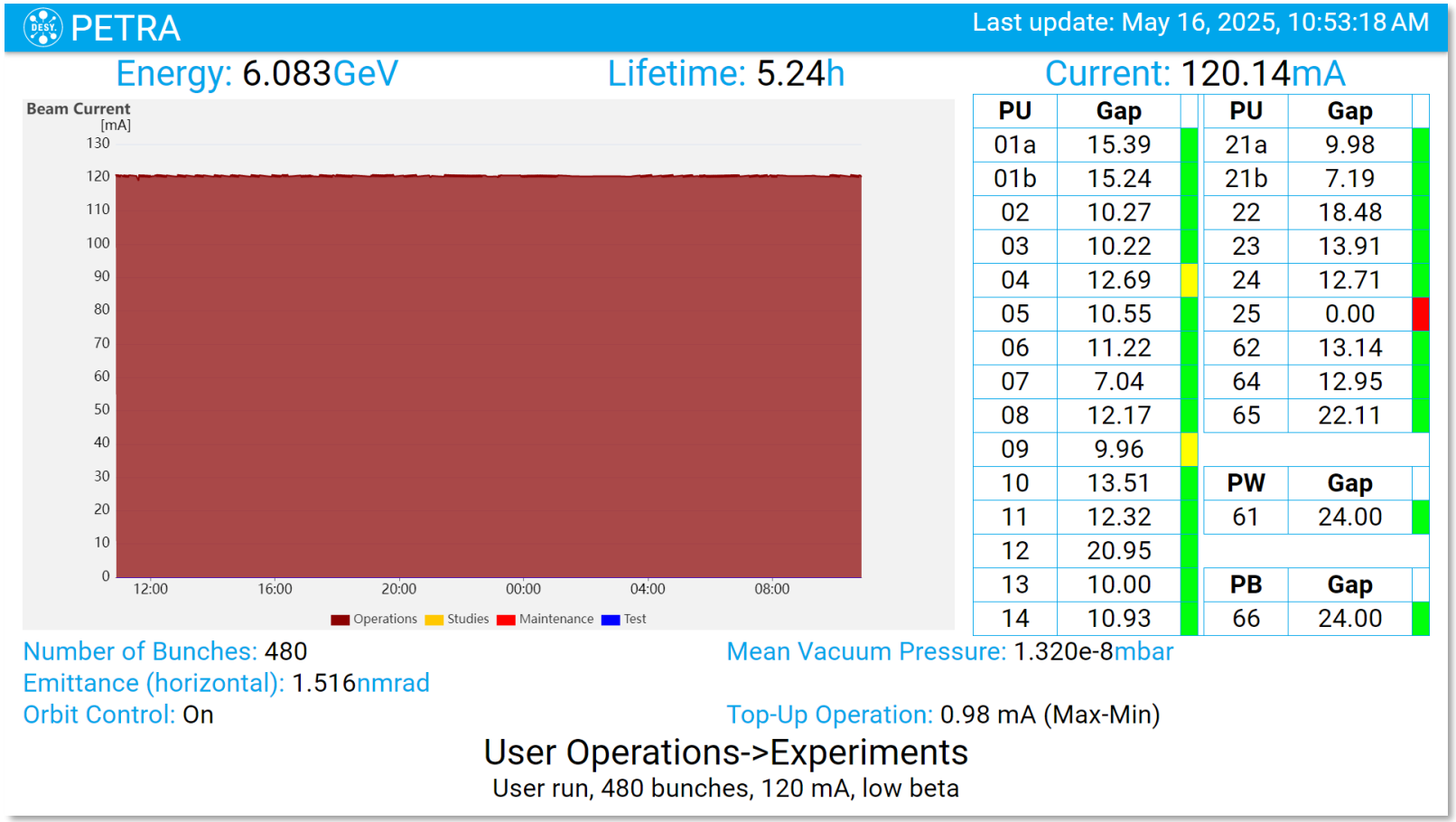
- Modern synchrotron light sources demand a very high availability >98% (User slots: 24h)

➔ **DESY II: New Power Supplies (2008-2009)**

- **DORIS End 2012 (no e+switching)**

➔ **Even more time for test beam**

PETRA III Live Display



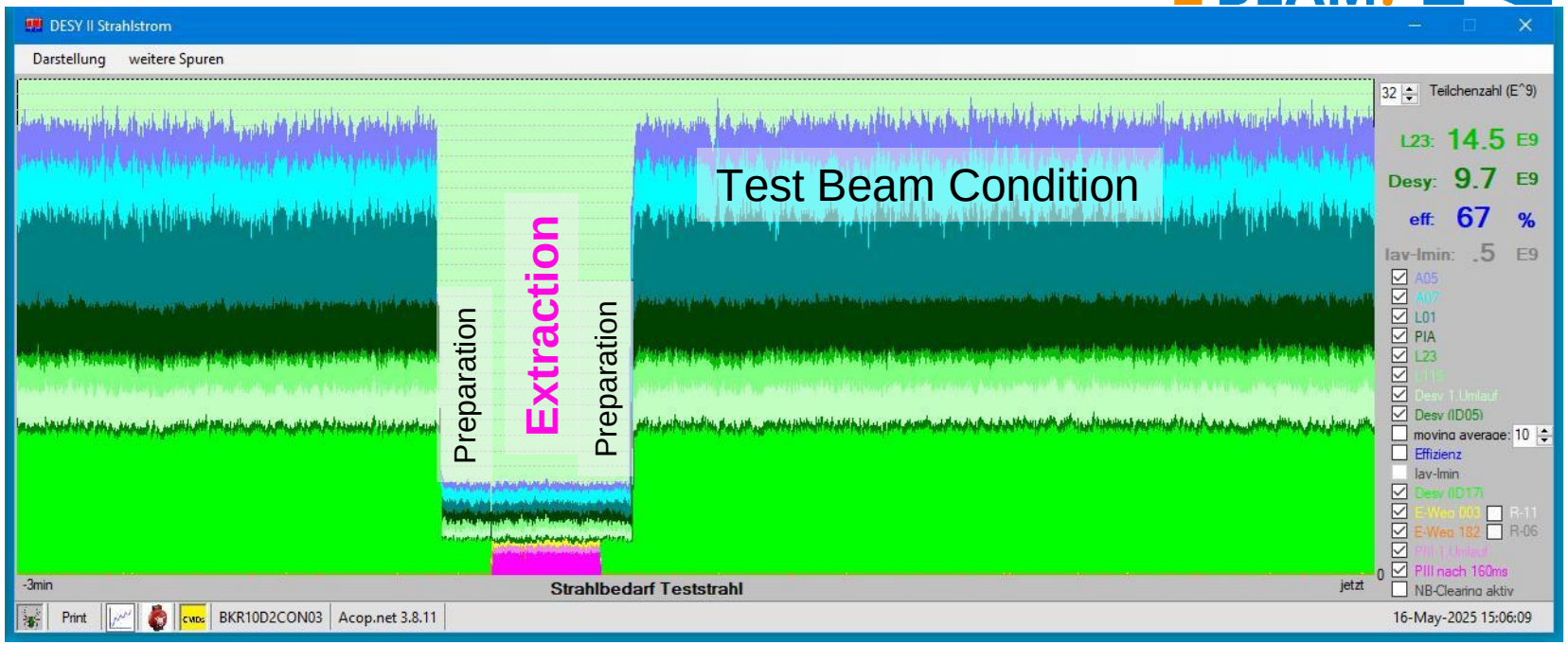
DESY Current

With PETRA Top Up

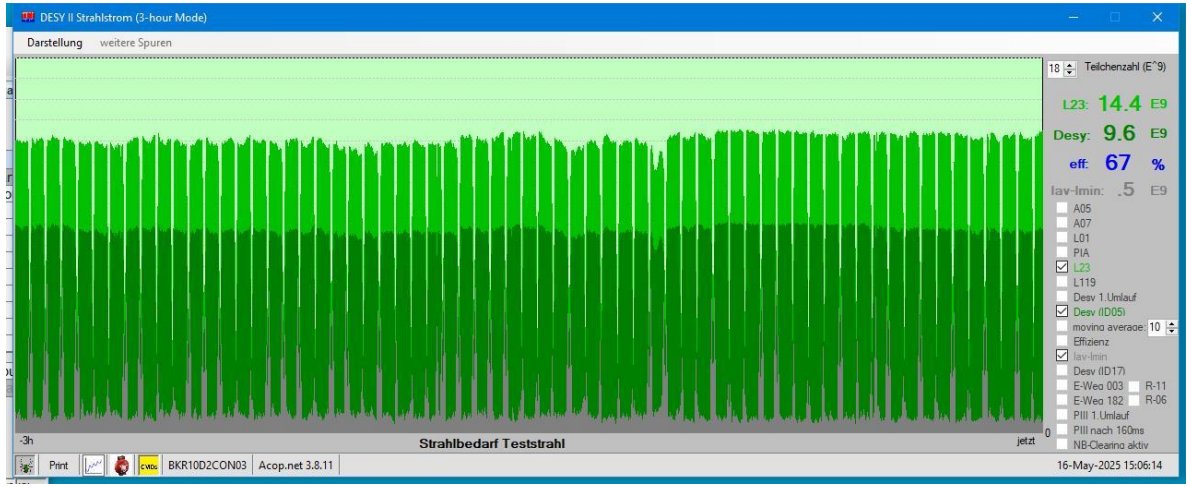
- ~30sec
- often in 3 hours

  depends on the
  e- lifetime @ PETRA
  i.e. operation condition

3 min



3 hours



Fully automated Procedure

DESY II

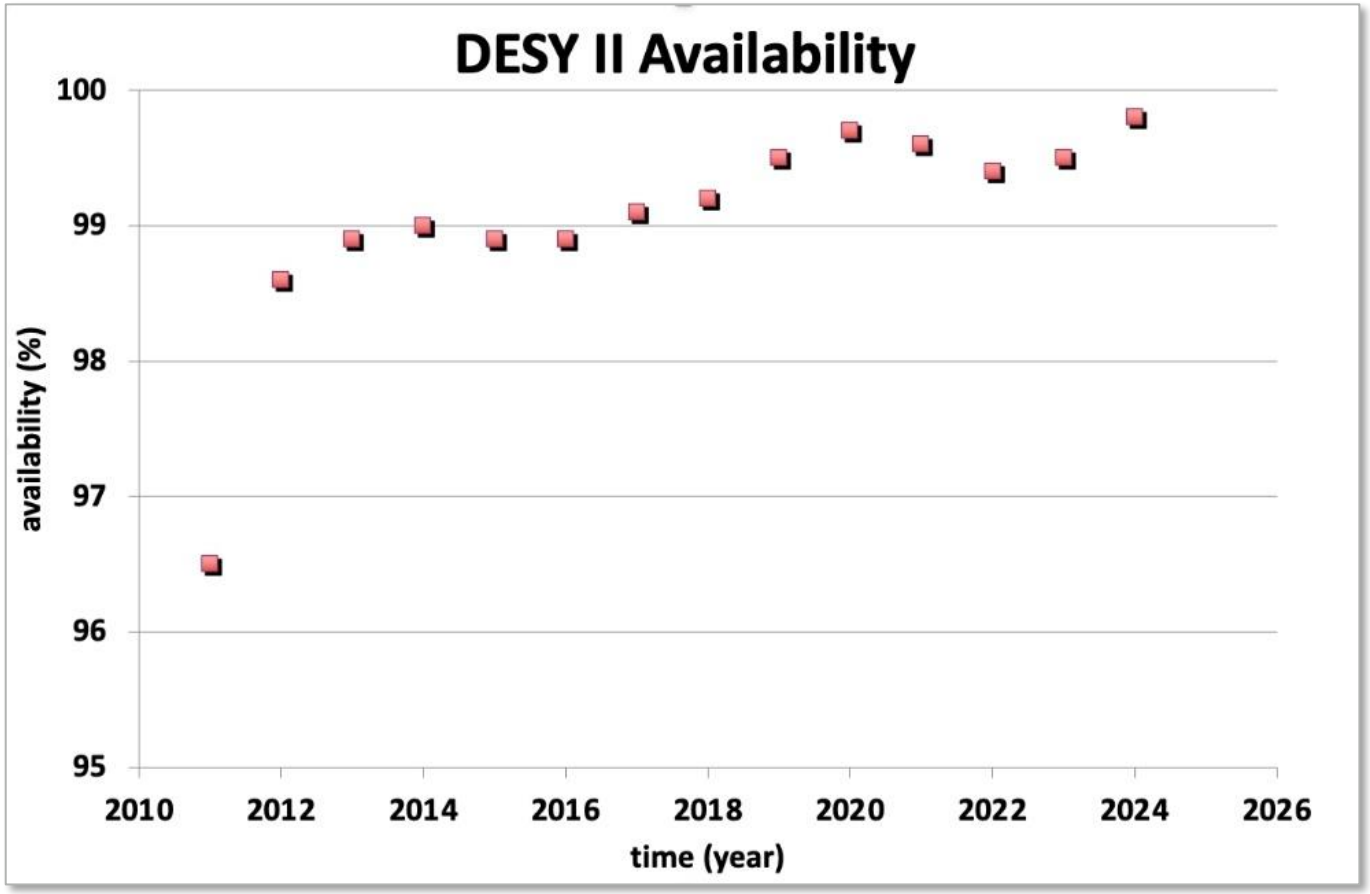
2010

DESY II 2025

DESY TEST BEAM.

DESY II

Availability



Publications

Berichte und Veröffentlichungen

Hier ist eine Liste von Berichten und Veröffentlichungen zu finden, die sich mit DESYII beschäftigen:

G. Hemmie, "Die Zukunft des Synchrotrons (DESY II)", DESY M-82-18 (1982)

J. Rossbach and F. Willeke, "DESY II opticial design of a new 10 GeV electron-positron synchrotron", DESY M-83-03 (1983)

G. Hemmie, "Desy II, a new injector for the DESY storage rings PETRA and DORIS II", DESY M-83-10 (1983)

G. Hemmie and J. Rossbach, "Eddy current effects in the DESY II dipole vacuum chambers", DESY M-84-05 (1984)

G. Hemmie, "Status report on the DESY II synchrotron", IEEE NS-32 (1985)

G. Hemmie et al, "Design, construction, and performance of the DESY II magnets", IEEE NS-32 (1985)

W. Bothe and P. Pillat, "Magnet excitation circuits for DESY II", IEEE NS-32 (1985)

U. Berghaus, W. Kriens and S. Pätzold, "Magnetic field measuerements of the DESY II magnets", IEEE NS-32 (1985)

J. Kouptsidis, R. Banthau, H. Hartwig, "A novel fabrication technique for thin metallic vacuum chambers with low eddy current losses", IEEE NS-32 (1985)

The DESY II collaboration, "Status of the DESY II Project", DESY M-87-08 (1987)

W. Bothe, "Resonant excitation of synchrotron magnets", DESY M-90-01 (1990)

W. Ebeling, "DESY Status und Pläne", DESY HERA 99-04 (Sept., 1999)

Conclusion

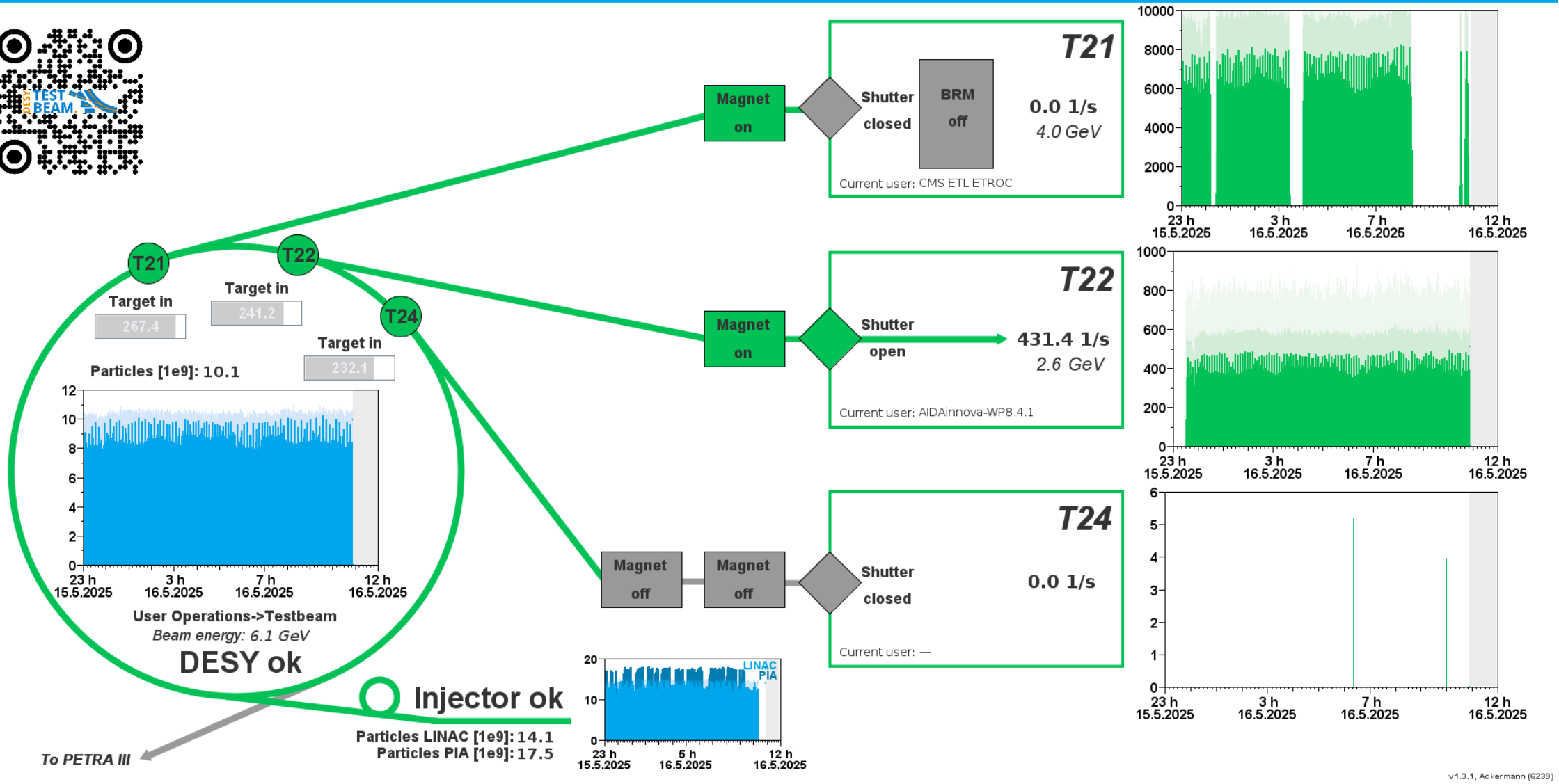
Test Beam today

Mostly under control ➔ Sven's Talk

DESY II Test Beam Facility.

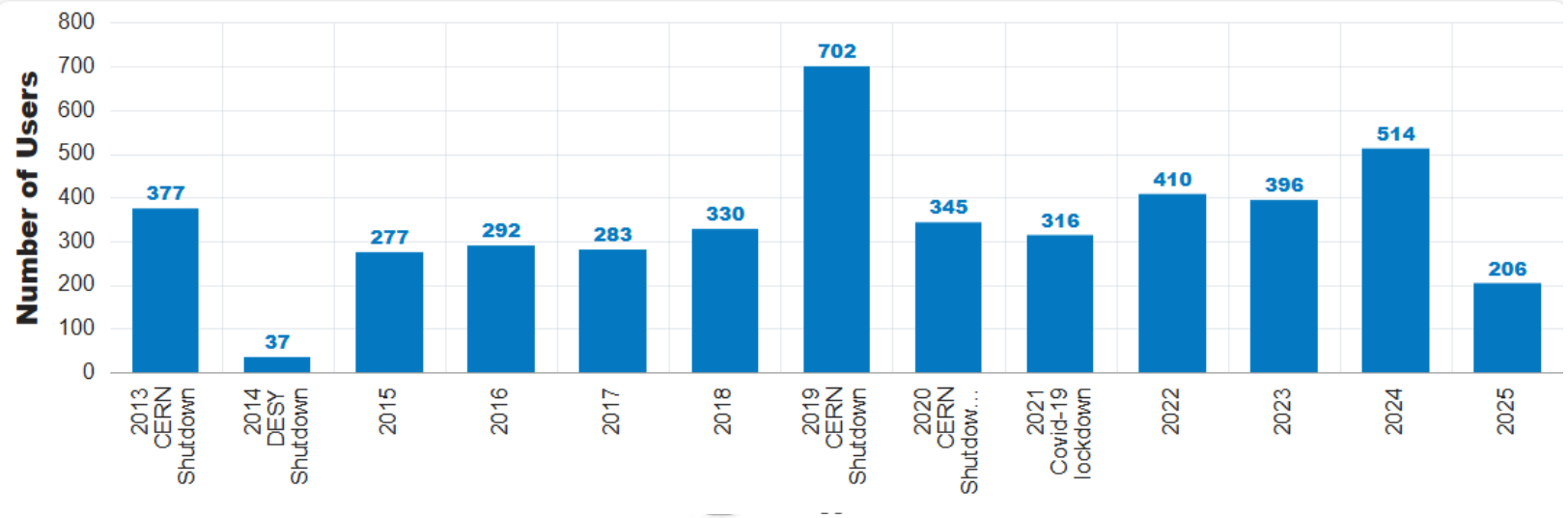
State: User Operation

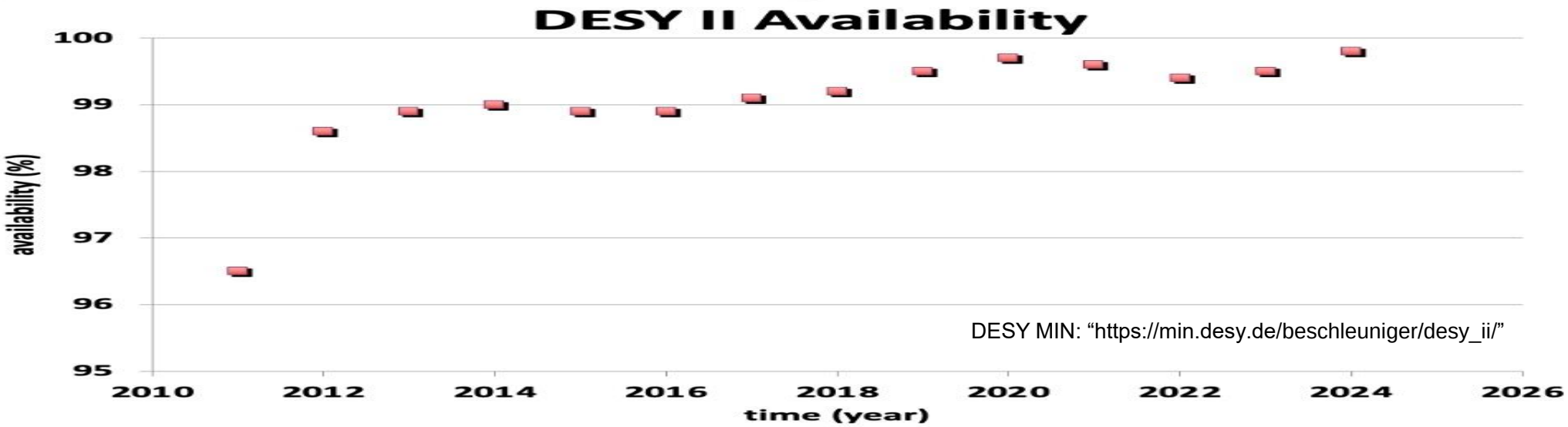
2025-05-16 10:54:47



Number of Test Beam User + DESY II Availability

Conclusion





DESY MIN: “https://min.desy.de/beschleuniger/desy_ii/”

Conclusion

Happy Birthday DESY II!

It’s an impressing story!

Thank you for delivering always
test beam
through the ages

All the best for the future!

Thank you.

for your attention and interest

Contact

DESY. Deutsches Elektronen-Synchrotron

www.desy.de

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References / Links

References / Links:

I used for this talk

- DESY Jahresberichte
- DESY PR Photo Archive
- DESY TB Photo Archive
- E.Lohrmann/P.Söding: Von schnellen Teichen und hellem Licht
- R. Diener, J. Dreyling-Eschweiler, H. Ehrlichmann, I.M. Gregor, U. Kötz, U. Krämer, N. Meyners, N. Potylitsina-Kube, A. Schütz, P. Schütze, M. Stanitzki, **The DESY II test beam facility,** Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 922, 2019, Pages 265-286, ISSN 0168-9002, https://doi.org/10.1016/j.nima.2018.11.133.
- DESY accelerator Logbook

Other links:

- Norsk Data: Technovision:
  https://www.ndwiki.org/wiki/Technovision
  https://www.youtube.com/watch?v=KyBzQI7x5Ck
  https://link.springer.com/chapter/10.1007/978-3-642-83997-9_13
- IBM 3090:
  S. G. Tucker, "The IBM 3090 system: An overview," in IBM Systems Journal, vol. 25, no. 1, pp. 4-19, 1986, doi: 10.1147/sj.251.0004.

G.Hemmie, “DESY II, a new injector for the DESY storage rings PETRA and DORIS”, DESY M-83-10; PAC 1983, Santa Fe, New Mexico IEEE Transactions on Nuclear Science 30 (4) (1983) 2028–2030. doi:10.1109/TNS.1983.4332706.

G. Hemmie, "Status Report on the DESY II Synchrotron,“ PAC 1985; doi: 10.1109/TNS.1985.4333677 IEEE Transactions on Nuclear Science, vol. 32, no. 5, pp. 1641-1643, Oct. 1985,

Minty, Michiko. (2015). Overview of the DESY-2 and DESY-3 accelerators (from 2003). 10.13140/RG.2.1.2610.0323.

Backup Slides

From Catalogue of High Energy Accelerators

DESY I 1965? DESY II 1992

NAME OF MACHINE DESY
INSTITUTION Deutsches Elektronen-Synchrotron
LOCATION Hamburg, Germany

PERSON IN CHARGE H. Schopper
DATA SUPPLIED BY H. Kumpfert
DATE January 1974

HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1959
FIRST BEAM OBTAINED, OR GOAL (date) February 1964
TOTAL COST OF FACILITY 110 MDM (orig.constr.costs)
FUNDED BY Federal Government, City of Hamburg
TOTAL ACCELERATOR STAFF (now) 80
ANNUAL OPERATING BUDGET 6 MDM

ACCELERATOR PARAMETERS

Physical Dimensions (Mean)
RING DIAM. 100.84 m; Tunnel sect. 3.7 x 8.8 m
MAGNET 0.77/0.69 m; Mag. Gap 5.6(8.8) x 14.4 (9.0) cm
"DONUT" x cm; Aperture 3.8(7.0) x 10(10.0) cm

Injector System
TYPE Electron/Positron* Linacs**
OUTPUT (max) 200 mA(e^-) at 300 - 500 MeV
BEAM EMITTANCE 2 π mm-mrad
INJECTION PERIOD 1 μsec, or 1 turns
INFLECTOR TYPE septum + fast kicker magnet

Magnet System
FOCUSING TYPE AG Field Index n 69.51 (F) 70.16 (D)
No. MAG. UNITS 48 Length (ea) 4.15 m
STRAIGHT SECT. 48 Total S.S. Length 117.6 m
FOCUSING ORDER FODO
BETATRON OSC. FREQ. ν_H 6.29 ν_V 6.23
FIELD, AT INJ. 315(42) G, at max 7.9 kG
RISE TIME 9×10^{-3} sec; Flat-top time max. 3.1×10^{-3} sec
MAG. WEIGHT (tons) Fe 570, Cu 77
POWER INPUT (MW) PEAK MEAN 1.7

Acceleration System
HARMONIC No. 528 No. Cavities 16
RF RANGE 499.666 to 499.645 MHz
ORBIT FREQ. 0.9463
ENERGY GAIN max. 1250 keV/turn
RADIATION LOSS max. 8830 keV/turn
RF POWER INPUT (kW) PEAK 1000 mean 700

Other Relevant Parameters or Notable Features
*Positron Data: 1.6 mA ($|\frac{\Delta E}{E}| \leq \frac{1}{2}$ %) at 380 MeV
**The old 40 MeV-Electron Linac (140 mA max.) is still in use

Published Articles Describing Machine
Die Atomwirtschaft, July 1964
Proc. 1973 US Particle Accelerator Conference, San Francisco, (Improvements)
DESY Annual Reports

ACCELERATOR PERFORMANCE

	Normal (or Goal)	Maximum Achieved
ENERGY (GeV)	7.4	7.5
RESOLUTION ΔE/E (%)	± 0.25	± 0.25
REPET. RATE (pulse/sec)	50	50
PULSE WIDTH	3.1	3.1
DUTY FACTOR, macroscopic (%)	15.4	15.4
INTERNAL BEAM (part/pulse)	4×10^{11}	5×10^{11}
(part/sec)	2×10^{13}	2.5×10^{13}
average CURRENT (mA)	64	80
BEAM EMITTANCE (mm-mrad)		
SCHEDULED OPERATION (hr/wk)	168	

"ON BEAM" 90 - 95 % OF SCHEDULED TIME

Some Typical External and Secondary Beams

PARTICLE	FLUX (part/sec)	BEAM AREA (cm^2)	ENERGY (GeV)	ΔE/E (%)
2 x e^-	5×10^{12}		1-7.25	± 0.25
	$\varepsilon_z \approx 0.1\pi$ x mm x mrad			
or	$\varepsilon_r \approx 0.5\pi$ x mm x mrad			
	50 % < η < 85 %			
2 x e^+	10^{11}		1-7.25	± 0.25
3 x γ				
3 x converted γ (test beams)				
2 x Synchrotron Radiation				

RESEARCH PROGRAM

TOTAL EXPERIMENTAL AREA 6400 m^2
BEAM LINES TO 17 Stations
STATIONS SERVED AT SAME TIME 6 x e^- or γ + test&synchr. rad.beams
BEAM SEPARATORS SPECTROMETERS 11
ON-LINE COMPUTERS WITH 20 Inputs
BUBBLE CHAMBERS, in-house Users'
TOTAL POWER INSTALLED FOR RESEARCH 23 MW
No. USER GROUPS: in-house :3 outside :2 mixed :9
TOTAL RESEARCH STAFF, ~~in-house~~ ~~outside~~ 275
ANNUAL RESEARCH BUDGET, in-house 7.5 MDM
SCHEDULED RESEARCH TIME, hours/week 136

RECENT IMPROVEMENTS OR MODIFICATIONS TO MACHINE

- flat top operation (duty factor 15.4 %)
- 2 e^+/e^- beams (fast extraction) for DORIS
- max. circulating currents (e^-) up to 80 mA average as compared to 30 mA
- e^+ beams (slow extraction) for use in normal e^--experimental areas
- additional p^+-acceleration capability expected for 1975

NAME OF SYNCHROTRON DESY II
INJECTOR FOR DORIS and PETRA electrons and positrons
LOCATION DESY, Hamburg, West Germany
PERSON IN CHARGE G. Hemmie DATE Nov. 1992
DATA SUPPLIED BY G. Hemmie

HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1983
FIRST BEAM OBTAINED, or GOAL (date) March 22, 1985
TOTAL COST OF FACILITY 14 MDM
TOTAL ACCELERATOR STAFF (now) see below
ANN. OPERAT. BUDGET see below (without salaries)
ANN. OPERATING TIME 7500 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES e-; e+ : 3.5x 10^{10}
ENERGY 7.0 .. 8.0 GeV
RING DIAM. 93.2 m; TUNNEL SECT. (W x H) 8.8x3.7 m

Injector
TYPE e+/ e- accumulator PIA
OUTPUT (max) 6×10^{10} e-; e+ at 450 MeV
EMITTANCE* 1 (hor); .2 (vert) πmm-mrad
INJECTION PERIOD 1 μs, or 1 turns
INFLECTOR TYPE septum + full aperture kicker

Magnet System
FOCUSING TYPE sept. funct. FIELD INDEX n = 0
FOCUSING ORDER FODO 8x (6BH + 3QF + 3QD + 2SD + 1SE)
BETATRON FREQUENCY ν_H 6.575 ν_V 5.623
No. MAGNETS 48 LENGTH (ea) 3.55 m
BENDING FIELD at inj. 0.0246 T; at max 0.984 (8GeV) T
No. QUADS 48 LENGTH (ea) .58 m
GRAD. at inj. .294 T/m; at max 11.7 T/m
No. SHORT STRAIGHT SECT. 8 LENGTH .93 m
No. LONG STRAIGHT SECT. 24 LENGTH 2.22 m
RISE TIME 40 m s; FLAT-TOP TIME -sinusoidal- s
POWER INPUT PEAK - MW; MEAN 1.7 MW

Acceleration System
No. CAVITIES 8 LENGTH (ea) 2.10 m
HARMONIC NUMBER 488
RF RANGE 499.667 to 499.600 MHz
ENERGY GAIN max. 314 KeV/turn
RADIATION LOSS max. 1318 KeV/turn
RF POWER INPUT PEAK 750 kW; MEAN 200 kW

Vacuum System
MATERIAL OF VAC. CHAMBER stainless steel
APERTURE OF VAC. CHAMBER 80x40 mm
AVERAGE PRESSURE 1×10^{-9} torr

Extraction System
TYPE i) 4* beam bump, septum, kicker
ii)
iii)
LENGTH OF SPILL i) to μs
ii) to μs
iii) to μs

ACCELERATOR PERFORMANCE

	Normal (or Goal)	Maximum achieved
ENERGY (GeV)	7	8
RESOLUTION ΔE/E (%)	0.1	0.1
REPET. RATE (pulse/s)	12.5	12.5
PULSE WIDTH AT PEAK E	1μs (single bunch e)	
INTERNAL BEAM (part/pulse)	3.5×10^{10} e-; e+	5×10^{10} e-; e+
(part/s)	1×10^{11} e-	1.5×10^{11} e-
EMITTANCE* AT PEAK E	E_y = 1, E_z = .5 (7GeV)	πmrad-mm

Other Relevant Parameters, Recent Improvements, etc.

* without buildings and components already in existence for DESY I

Since early 1992, the LINAC I (200 MeV) is shut down and replaced by LINAC II PIA (450 MeV), which can be switched from e+ to e- operation within one minute. Transfer sequence of single bunches from the accumulator PIA to DESY is 320 ms (e-) and 640 ms (e+).

The DESY accelerator complex consisting of LINAC II with PIA (450 MeV), LINAC III (50 MeV p+), DESY II, DESY III, DORIS, PETRA and HERA is operated by the accelerator dicision, including also the electrical power, cooling, centilation and heating facilities for the entire institute and the cryogenics group.

Total staff now: 430
Ann. Oper. Budget without salaries and electrical power, but including R&D and current investments for the accelerators already in existence: 30 MDM

Catalogue of High Energy Accelerators

* Emittance measured for 1 st. deviation

25 years of DESY II beam operation.

A pre-accelerator running at the highest duty cycle ever

The first electron beam circulated in the DESY II synchrotron more than 25 years ago, on 22 March 1985. Since then, DESY II has been the central machine within the accelerator complex at DESY for delivering electron or positron beams of up to 7 GeV with high stability and reliability to the user facilities.

History

DESY's first accelerator, DESY I, started operation in 1964. It was first used for high-energy experiments, which took place directly at the synchrotron (until 1979), and then also for delivering beam to the new electron-positron storage rings DORIS (1974) and PETRA (1977). With the HERA electron-proton storage ring coming up as a new project, it became clear 30 years ago that electron beams would be needed at DESY for decades to come. Because DESY I featured a combined-function lattice resulting in a horizontally anti-damped beam with a correspondingly large emittance, it was decided to split the upcoming needs for electron and proton pre-acceleration.

A new separated-function synchrotron – DESY II – for electron beams of up to 10 GeV was thus constructed in the same tunnel (Fig. 1, 2), using much of the existing DESY I infrastructure. In parallel to the DESY I routine operation in 1985, first beam tests with provisional power connection were performed. With the end of the PETRA collider programme at the end of 1986, DESY I was irrevocably switched off and converted into the proton synchrotron DESY III. After the final connection of all transport lines and magnet circuits, from spring 1987 on, DESY II delivered beam to DORIS, PETRA and detector test areas.

DESY II

The magnet system of DESY II consists of five circuits: one dipole, two quadrupole and two sextupole circuits, all synchronously oscillating with 12.5 Hz. 24 horizontal and 24 vertical DC corrector coils allow some orbit manipulation at lower beam energies. The optical lattice is formed by 8 x 3 FODO cells. Eight 7-cell PETRA-type cavities are supplied by one 1 MW HF station. One bunch of about 10^{10} electrons or positrons is injected (on axis) at 450 MeV, shortly after the time of minimal fields, and accelerated to usually 6.3 GeV, maximum 7 GeV. For DORIS and PETRA, the beam is extracted during acceleration at 4.5 GeV or 6.0 GeV, respectively. Three thin internal targets generate bremsstrahlung photons which are converted back into charged particles for test beam purposes.

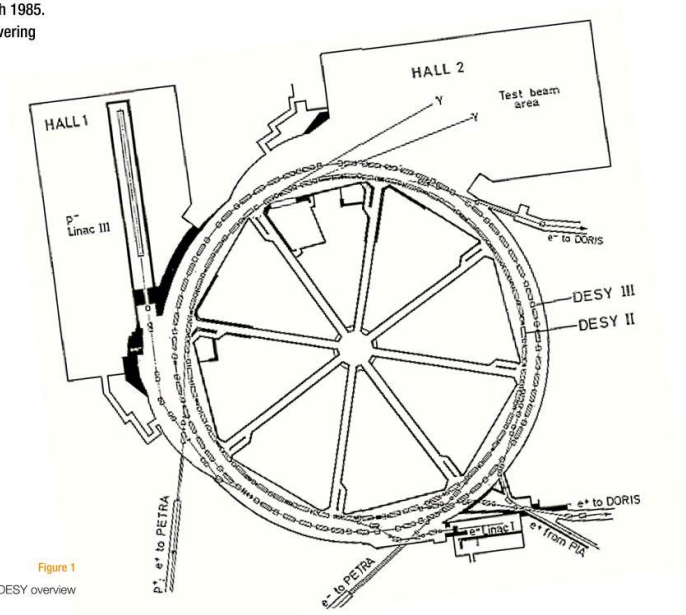


Figure 1
DESY overview

Figure 2
View of the DESY tunnel, DESY II is on the right.

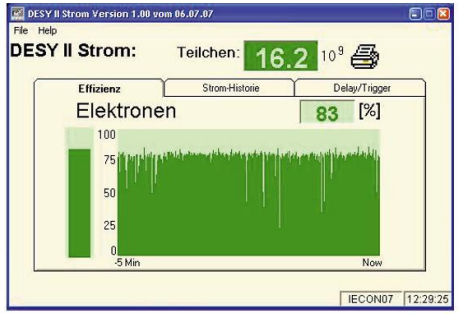


Figure 3
Snapshot of the beam intensity versus time in 2007 under optimal conditions, nevertheless with unavoidable intensity breakdowns

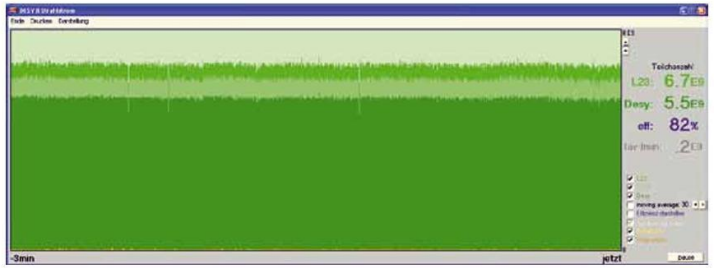


Figure 4
Beam intensity versus time for a typical situation today. The beam intensity in DESY II (dark green) follows the delivered intensity from LINAC II (light green) without breakdowns.

Status 2010/2011

With the constant-current ("top-up") operation mode of PETRA III, DESY II must deliver beam every few minutes. As a consequence DESY II has to run continuously. Maintenance periods are rather limited. At the same time, the reliability and operation stability must be very high.

As an important measure of infrastructure renovation, all six main power supplies (dipole DC, dipole AC, QD, QF, SD and SF) including the regulation concept were renewed during the past few years. The beam intensity variation could thus be significantly reduced, an overall efficiency of about 85-90% is typical (Fig. 3, 4). The availability usually reaches 99%.

For the last several years, DESY II has been running in a completely automated operation mode without manual actions by the operators. Beam requests from all users (DORIS, PETRA and test beams) are identified to set all necessary parameters for the requested operation mode.

DESY II is assigned to deliver beam quietly, without fanfare. This challenge has been completely and continuously fulfilled. To further reduce possible downtime, a second independent HF station is currently under construction. It will come into routine operation in summer 2011.

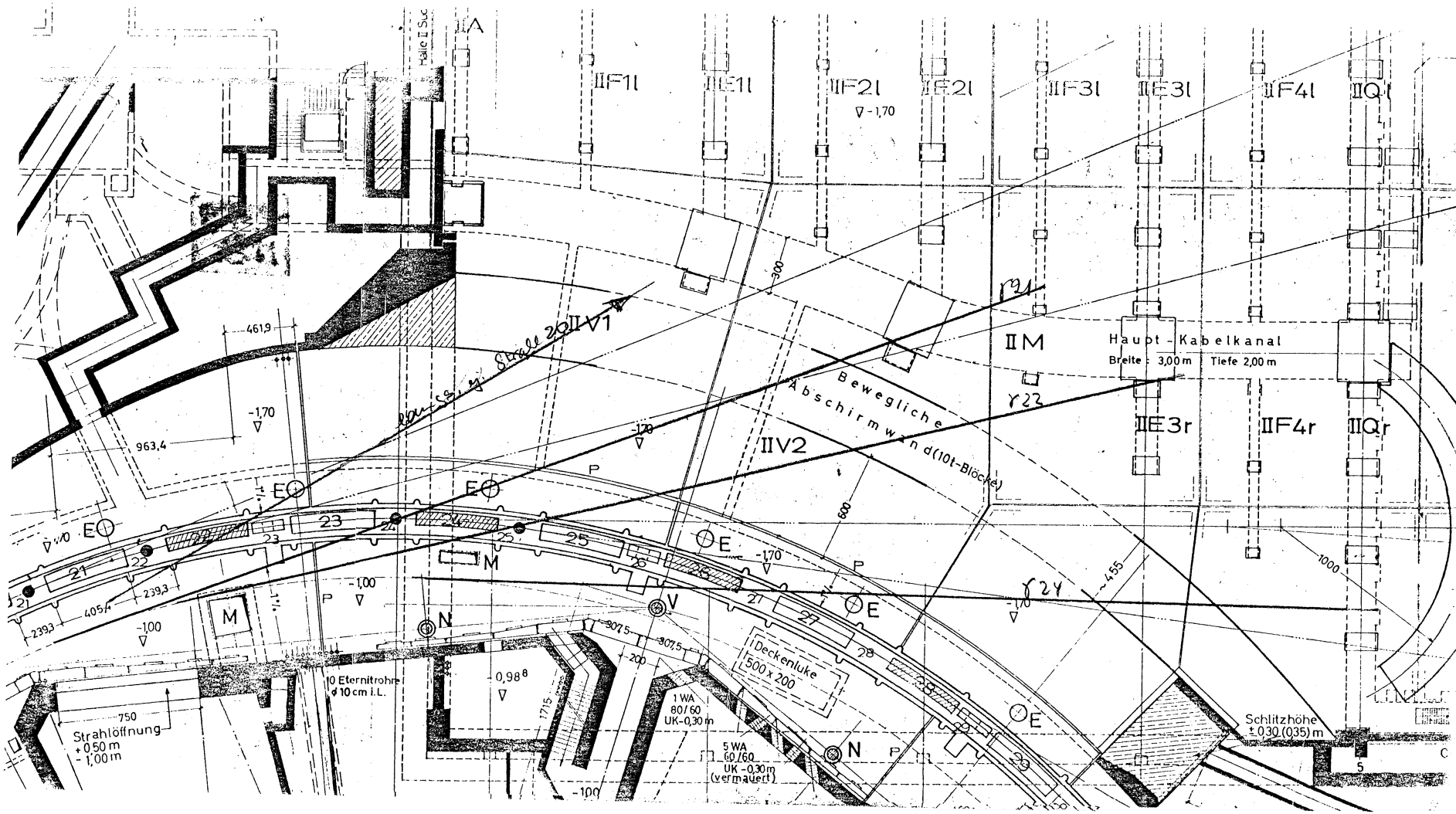
As a completely new activity at DESY, first tests for a dedicated beam dump experiment, HIPS (Hidden Particle Search), have recently been performed. For this experiment, the DESY II beam is extracted and directed onto a target inside the DESY II tunnel, parasitically to the pre-accelerator operation. The detector too will be located inside the tunnel. With this experiment, accelerator-based particle physics at DESY has returned home to the synchrotron.

Contact: Heiko Ehrlichmann, heiko.ehrlichmann@desy.de

Plans for Test Beam @ DESY II

2. 2. 1984

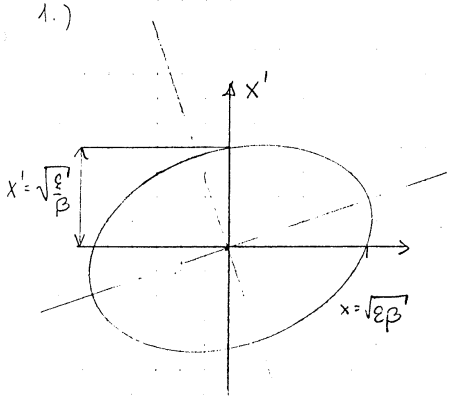
- A hole of 30mmø in the quadrupole is sufficient!
- 25mmø would be okay too.



Die notwendige Apertur ergibt sich aus:

1. der Divergenz des e^--Strahls am Ort des Targets
2. der Vielfachstreuung im Target
3. der eventuellen Orbitverbiegung während der Ejektion (R-Weg)

1.)



Für E = 1 GeV soll gelten:

$\varepsilon_x = 1\pi \times 10^{-6}$ rad m

$\varepsilon_z = 0.2\pi \times 10^{-6}$ rad m

	T21	T22	T24
β_x[m]	4.3	21	19.2
β_z[m]	17.5	3.8	4.2

Der Abstand Target – Quadrupol ist s

$s = 4$ m.

Dann ist

$$a = \sqrt{\varepsilon/\beta}\, s \; .$$

Wir untersuchen 3 Energiebereiche.

E = 300 MeV (ohne Orbitverbiegung)

E = 1000 MeV

E = 7000 MeV (maximale Orbitverbiegung)

E = 300 MeV

$\varepsilon_x = 3.33\pi \times 10^{-5}$ rad m

$\varepsilon_z = .66\pi \times 10^{-5}$ rad m

E = 300 MeV	T21	T22	T24
a_x[mm]	11	5	5.2
a_z[mm]	2.4	5.2	5.0

Vielfachstreuung

$$\Theta_V = \frac{21}{E}\sqrt{t_0}\quad E[\mathrm{MeV}]$$

t: Targetdicke in Strahlungslängen

Für Kohlenstoff gilt

$X_0 = 42.4$ g/cm^2 $\qquad L_0 = X_0/\rho = 19.27$ cm

$\rho = 2.2$ g/cm^3

$t_0 = d/L_0$

Targetdicke $d = 10\,\mu m = 10^{-5}$ m $= 10^{-3}$ cm

$t_0 = 5.2 \times 10^{-5}$

$\Theta_V = 5.048 \times 10^{-4}$

$a_V = 2\,\Theta_V \cdot s = 4$ mm

$A_x = 2a_x + a_V \qquad A_z = 2a_z + a_V$

E = 300 MeV	T21	T22	T24
A_x [mm]	26	14	14.4
A_z [mm]	8.8	14.2	14

E = 1 GeV

$\varepsilon_x = 1\pi\, 10^{-5}$ rad m

$\varepsilon_z = 2\pi\, 10^{-6}$ rad m

	T21	T22	T24
a_x[mm]	6.1	2.7	2.9
a_z[mm]	1.3	2.9	2.7

Vielfachstreuung:

$a_V = 1.2$ mm

$A_x = 2a_x + a_V \;,\; A_z = 2a_z + a_V$

E = 1 GeV	T21	T22	T24
A_x[mm]	13.4	6.6	7.0
A_z[mm]	3.8	7.1	6.6

E = 7 GeV

$\varepsilon_x = 1.4 \times 10^{-6}\pi$ rad m

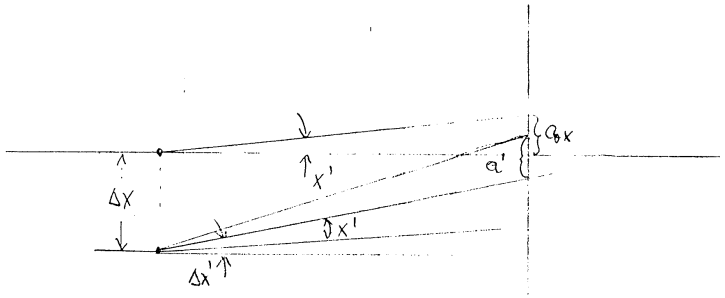
$\varepsilon_z = .28 \times 10^{-6}\pi$ rad m

Durch die Ejektion R-Weg ergeben sich folgende Orbitänderungen

	Δx[mm]	$\Delta x'$[mrad]
T21	−2.8	+1.3
T22	−14	+2.11
T24	−.95	−.66

	T21	T22	T24
a_x [mm]	2.28	1	1.1
a_z [mm]	.5	1.1	1.0

Durch die Orbitverbiegung:



$$a_{0_x} = |\Delta x + \Delta x' \cdot s|$$

	T21	T22	T24
a_{0x} [mm]	2.4	5.5	3.6

Vielfachstreuung

$$a_v = 0.17\,mm$$

Gesamtaperturbedarf

$$A_x = 2a_x + a_{0x}, \quad A_z = 2a_z$$

E = 7GeV	T21	T22	T24
A_x [mm]	6.8	6.5	4.7
A_z [mm]	1.0	2.2	2.0

Die Maximalforderung kommt aus dem 300 MeV-Betrieb

Eine Bohrung von 30mm ϕ ist ausreichend, wenn Aussen aber auch noch 25mm ϕ vertreten.

Photonenausbeute:

Die Targetdicke in Strahlungslängen ausgedrückt ist gerade das Verhältnis von entstehenden γ-Quanten zur Zahl der auftreffenden Elektronen.

$$t_0 = \frac{n_\gamma}{N_e}$$

$$n_\gamma = N_e \cdot t_0$$

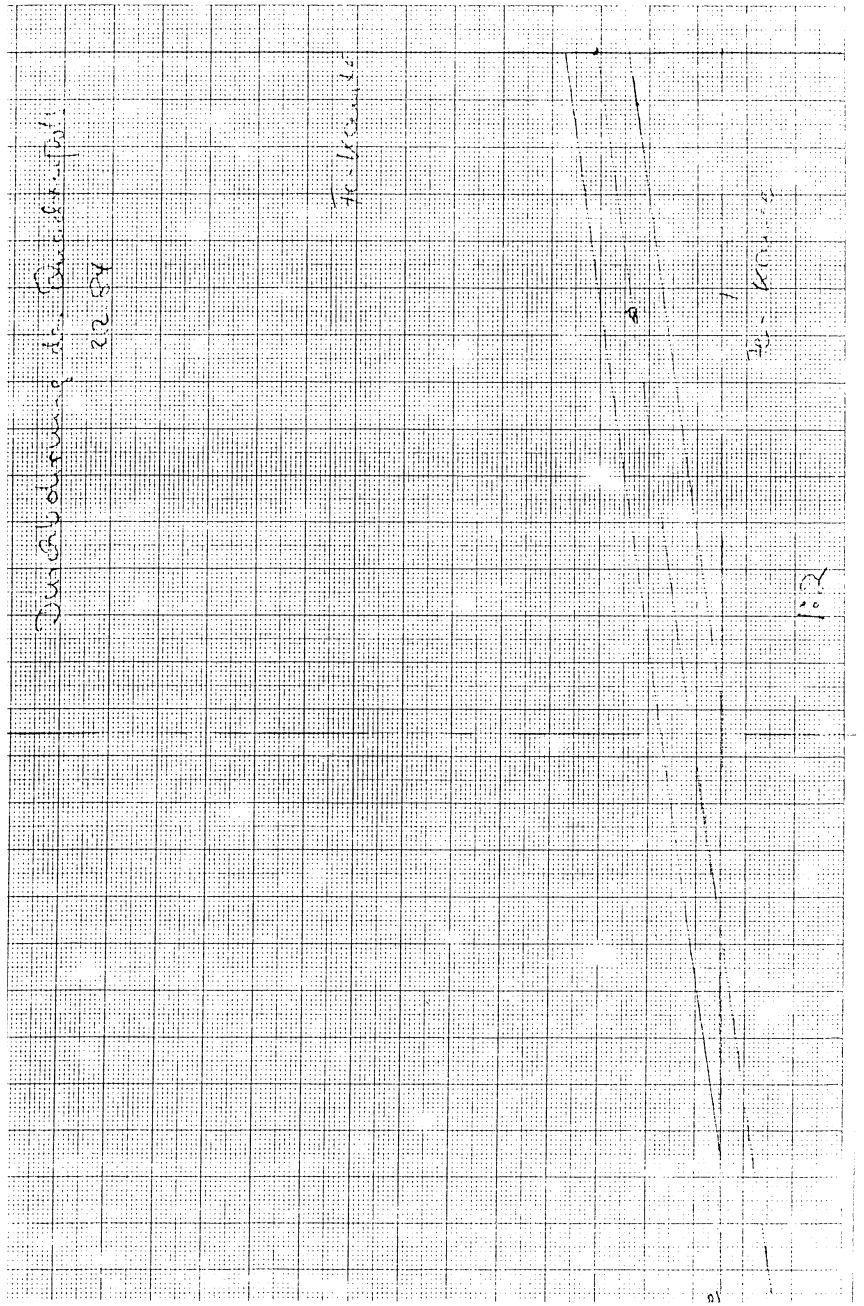
Wenn die Wiederholfrequenz der Pulse gerade 12.5 Hz ist, so ist der Photonenstrom je sec

$$n_\gamma = N_e \cdot t_0 \cdot 12.5\,sec^{-1}$$

Für $N_e = 4 \times 10^9$ ist

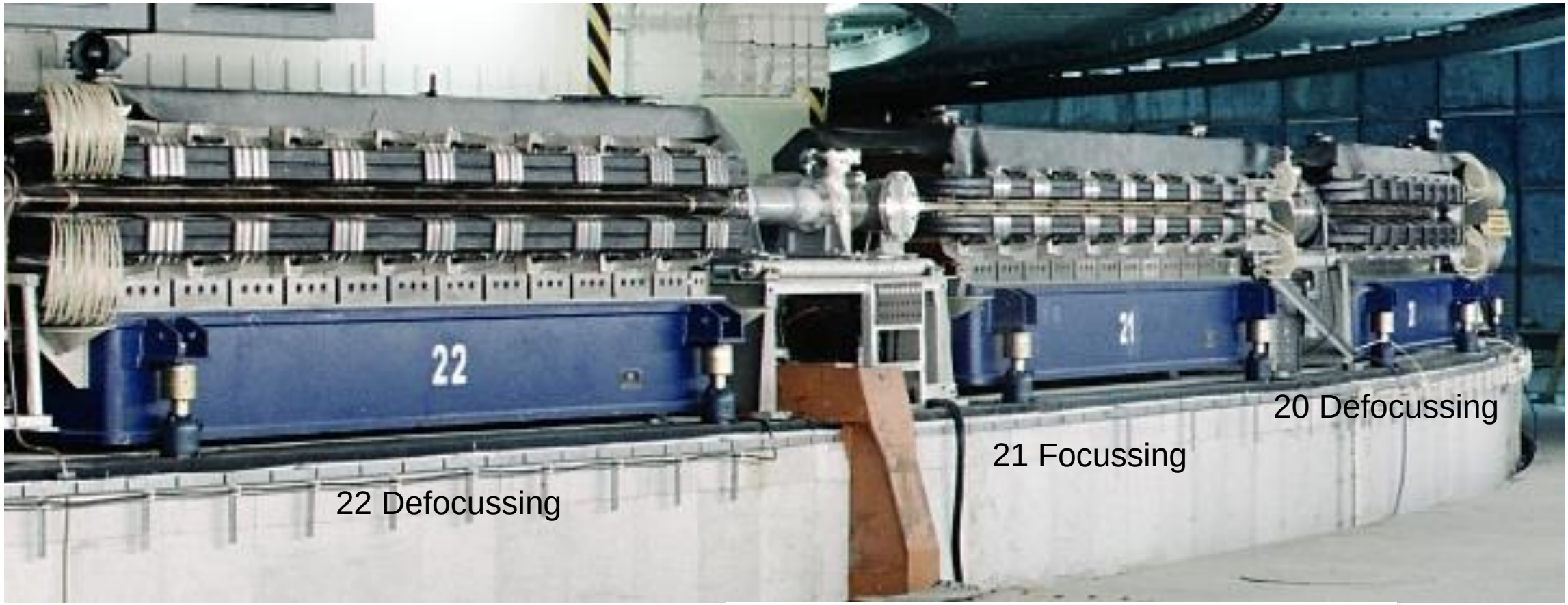
$$n_\gamma = 2.6 \times 10^6 \frac{Phot}{sec}$$

Dies ist der theoretisch maximal mögliche Wert.



DESY I F- and D-Magnets

25.05.1964 Ring v. Halle 2 innen M



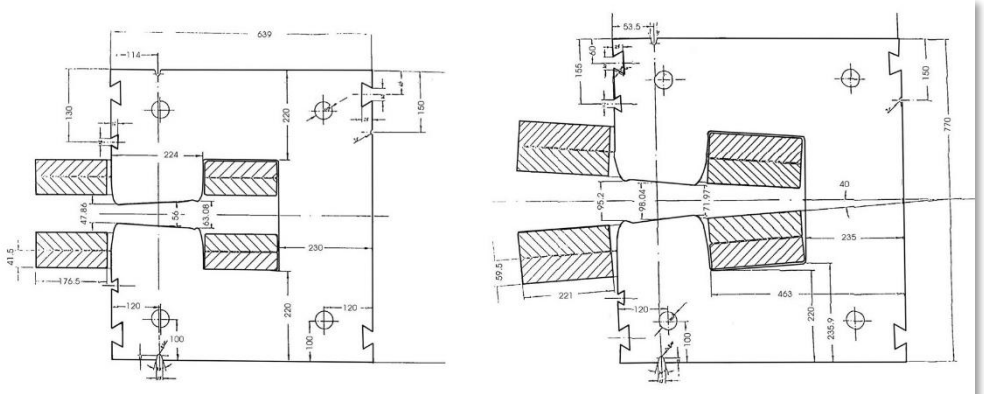


Fig 11 Cross sections of the DESY III combined function dipoles: focussing (left) and defocusing (right).

Minty, Michiko. (2015). Overview of the DEST-2 and DESY-3 accelerators (from 2003). 10.13140/RG.2.1.2610.0323.

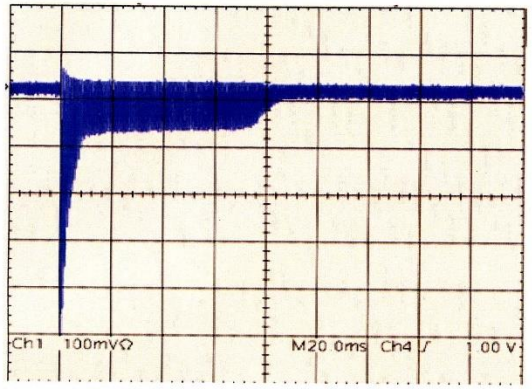
MDE

Feb 2009

Beam loss from "thick" test beam targets

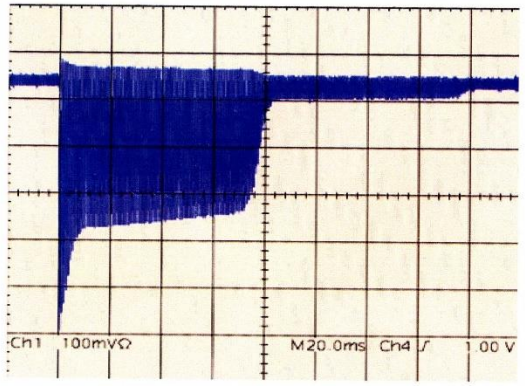
The "thick" targets installed in the 2008 shutdown cause significant beam loss.
For the record at each target station individually the thick target was driven in to produce maximum spill signal at peak beam energy
Approximately 10e10 positrons were injected and accelerated to 6 GeV

The resulting intensity versus time was captured and the traces included below.
All have 20 mS per div timescale so that peak energy is reached in 2 divisions



tb21

loss to 6 GeV ~90%



tb22

loss to 6 GeV ~50%

User Setups

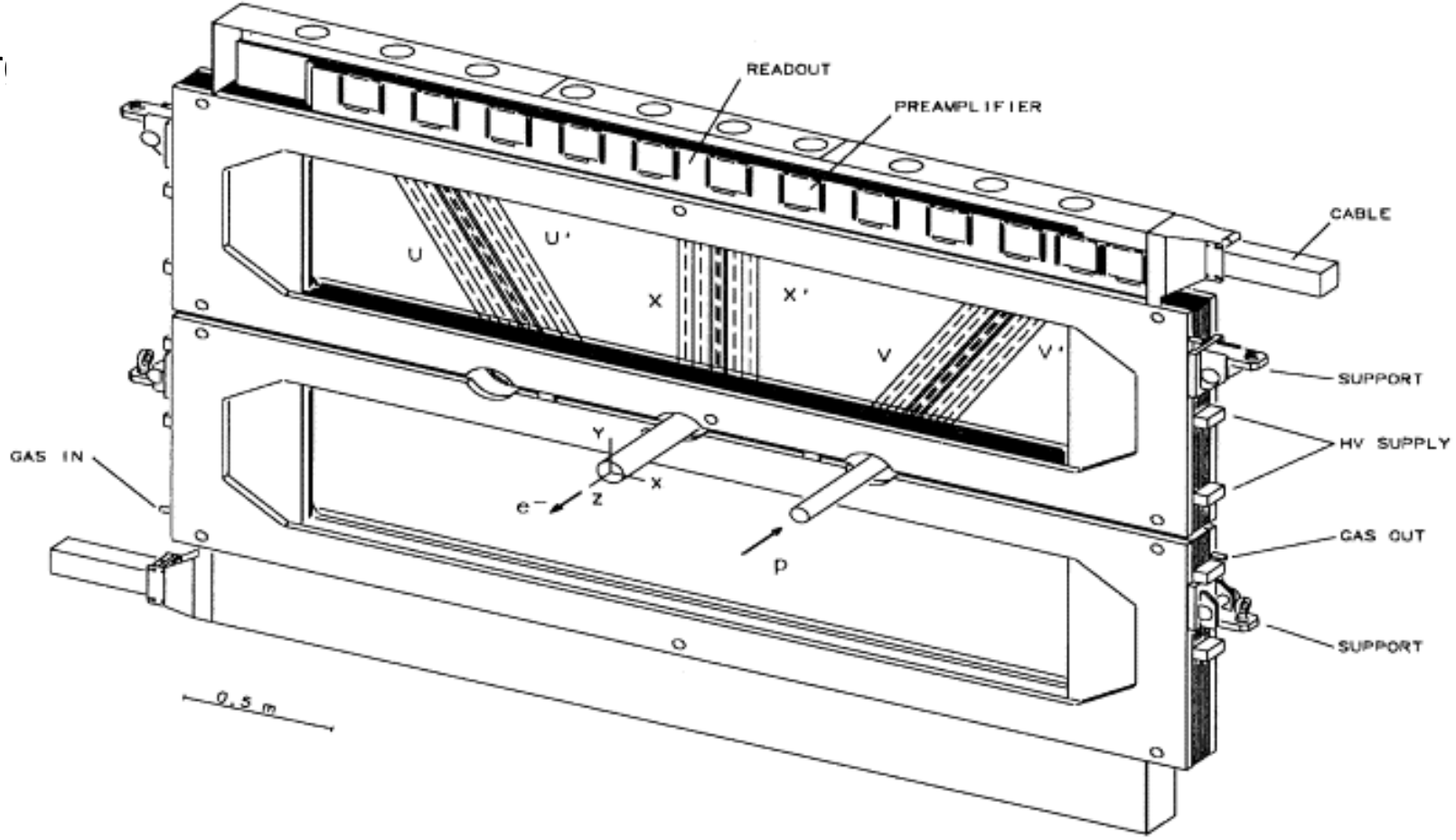
Fuji et.al., MVD Telescope, LHCb

HERMES BC Chamber

1992 – 1994 (Final Chambers)

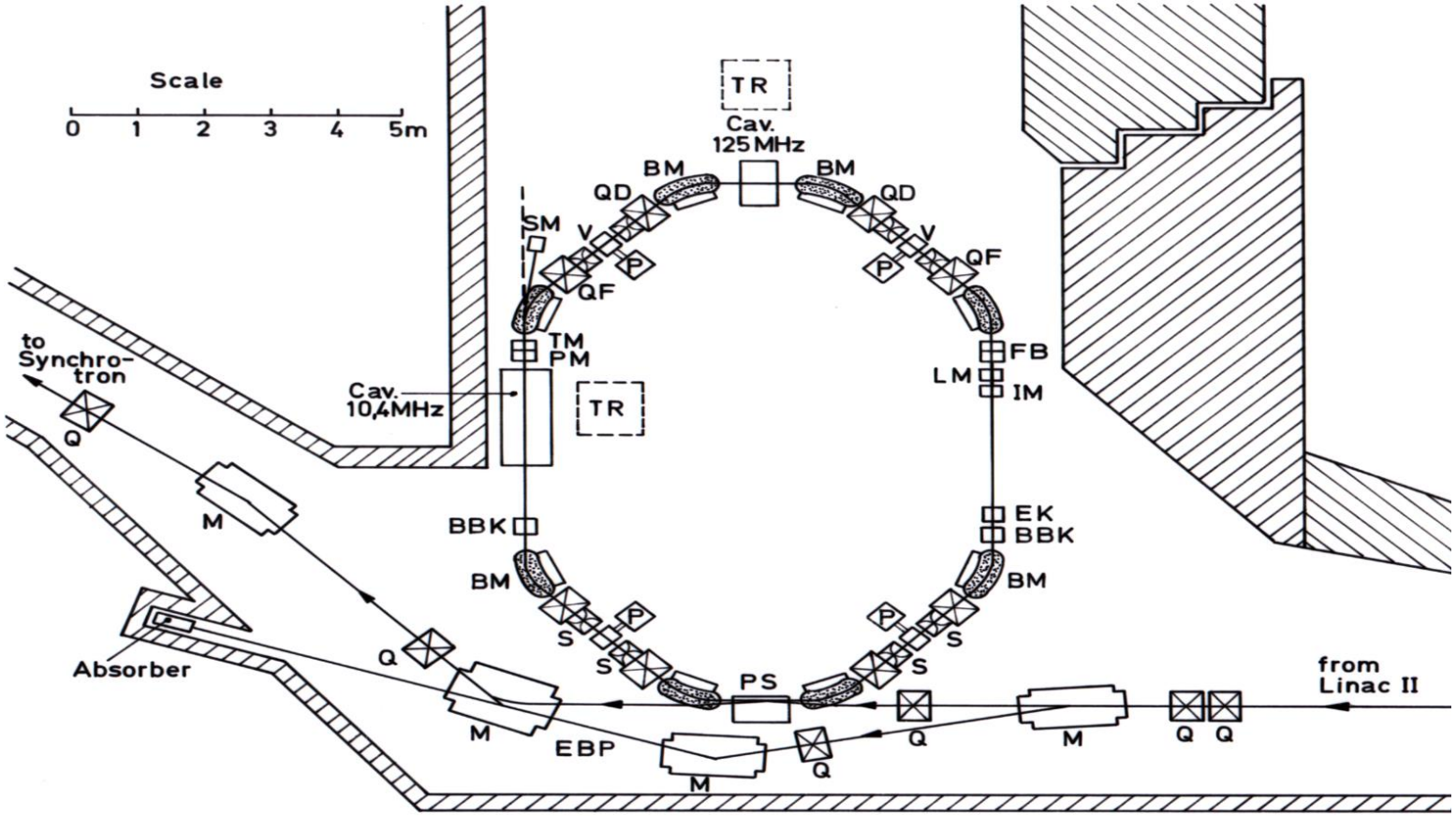
From:
The HERMES back drift chambers, S. Bernreuther et.al.
Design and performance of the lar chambers
S. Bernreuther et.al.,

Width ~3.4m, Height >2m



BC–PLANE

Positron Intensity Accumulator PIA



FB	Feedback	Q, QD, QF	Quadrupole	Magnet
P	Vac. Pump	S	Sextupole	Magnet
TR	RF Transmitter	V	Vert. Corr.	Magnet
BBK	Beambump Kicker	SM	Synchr.	Monitor
EK	Ejection Kicker	TM	TV	Monitor
EBP	Electron Bypass	PM	Position	Monitor
PS	Pulse Septum	LM	Loop	Monitor
BM,M	Bending Magnet	IM	Intensity	Monitor

Fig. 2 PIA-POSITRON-INTENSITY-ACCUMULATOR

Taken out