PETRA III Operation & PETRA IV Status

ESLS Workshop 2025

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on behalf of the PETRA III Operations Team

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PETRA IV Project Team: R. Bartolini, H. Reichert et al.

HELMHOLTZ

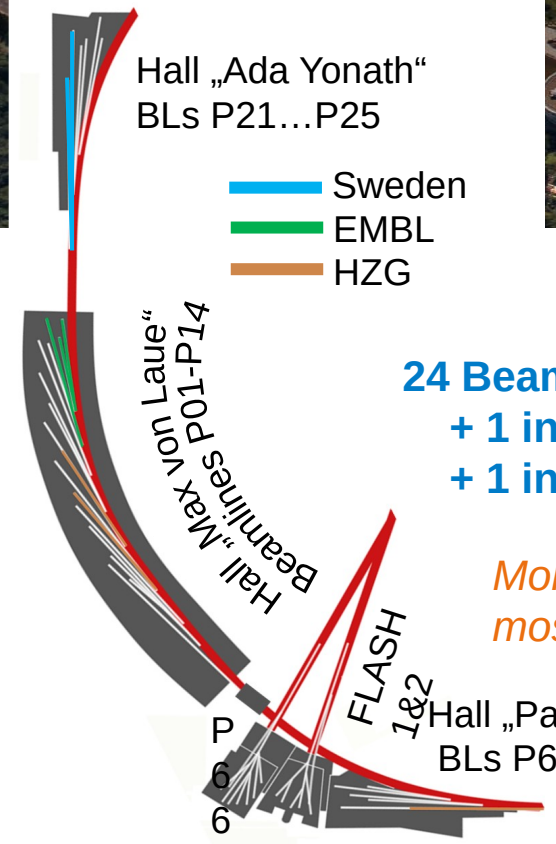
DESY.

Ada Yonath Hall
Extension Hall East

Max von Laue Hall

PETRA III
is one of DESY's core facilities

Paul P. Ewald Hall
Extension Hall North



24 Beamlines are in operation
+ 1 in commissioning
+ 1 in preparation

More than 50 experiments covering most relevant methods

The world's biggest storage ring light source

Parameter	PETRA III
Energy / GeV	6
Circumference /m	2304
Emittance (horz. / vert.) /nm	1.3 / 0.013
Number of bunches	40 or 480
Total current / mA	100 or 120

Content

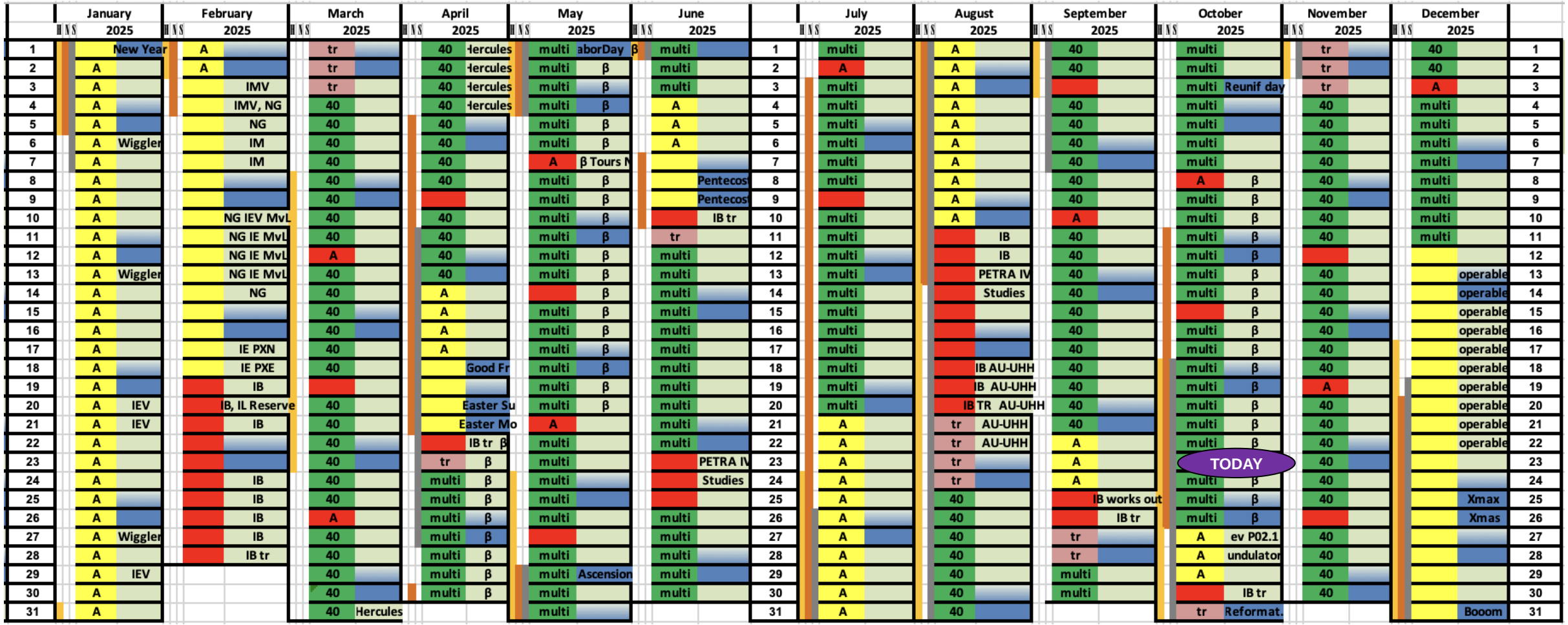
PETRA III Operation in 2025

Plans for the Long Shutdown from Sept. 2026

Status of the PETRA IV Project

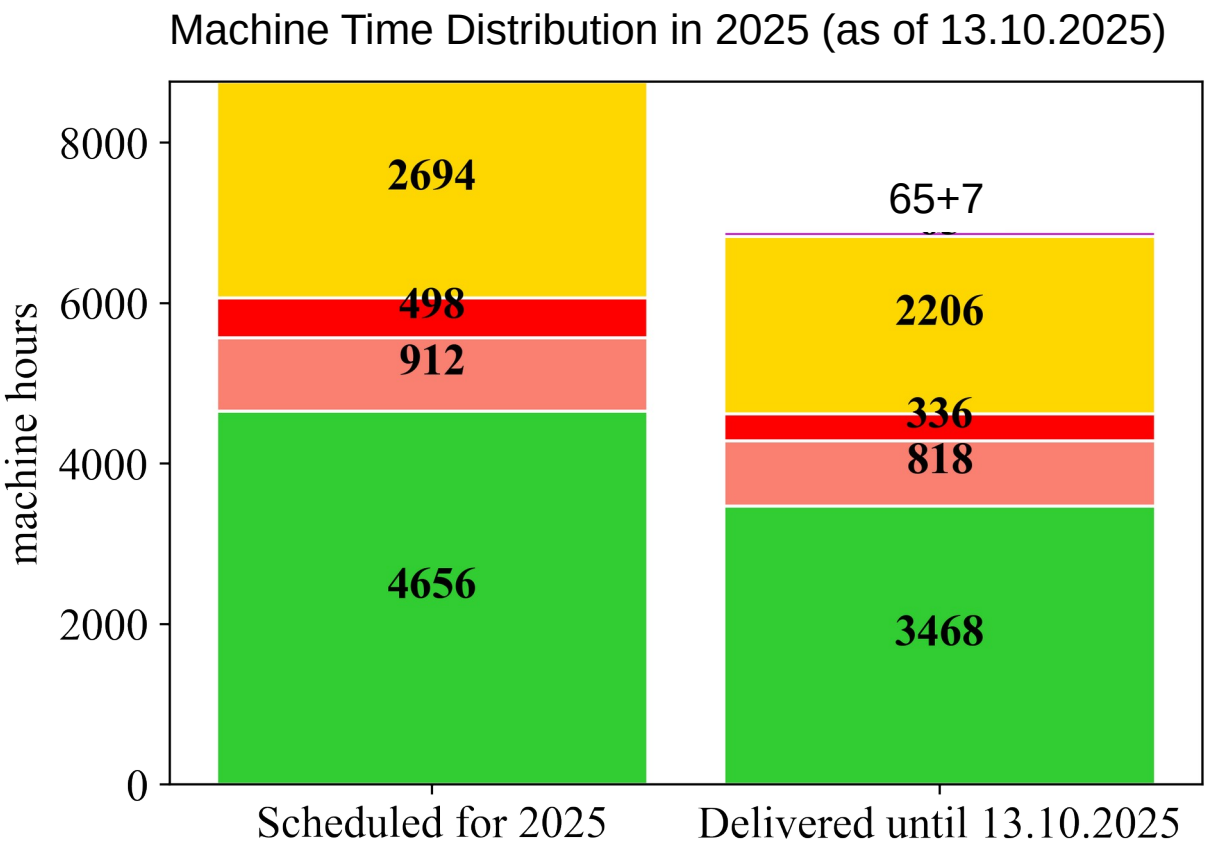
4656 user hours are scheduled for 2025

Two-week “operable” period in December to support energy management at DESY



Already delivered 75% of user time scheduled for 2025 with 98.2% availability

MTBF of ~65h thanks to low general fault rate – in total 54 faults during user run



Fault in Test Run (7h)
Fault in User Run (65h)

Shutdown/
Maintenance

Machine Development

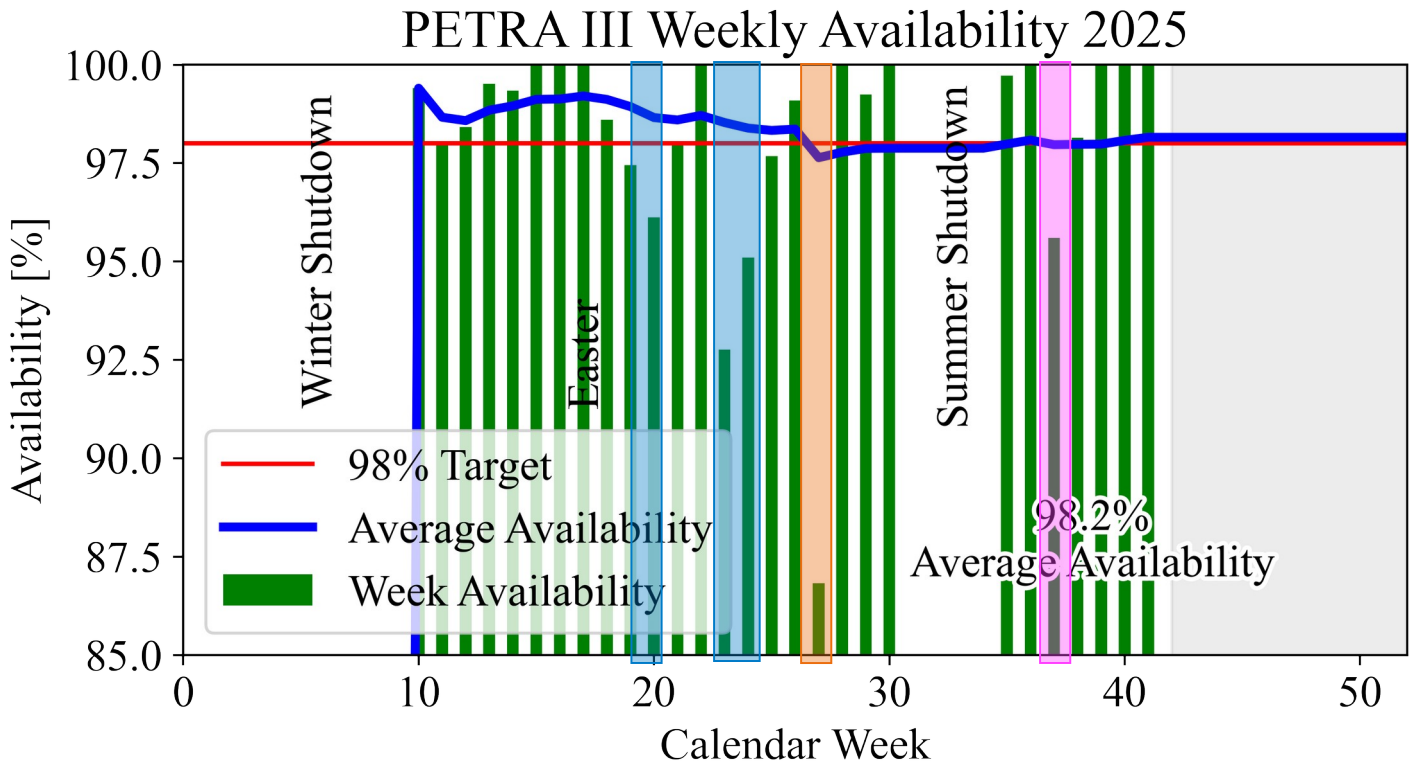
Test Run

User Run

	Done	Target
Availability	**98.2%**	98%
MTBF	**65 h**	60 h
MTTR	**1.2 h**	-

Stable availability around 98%

Major source of faults in 2025 were issues around the cooling water infrastructure



KW20/23/24

→ 3 punctured water hoses of the same type

KW27

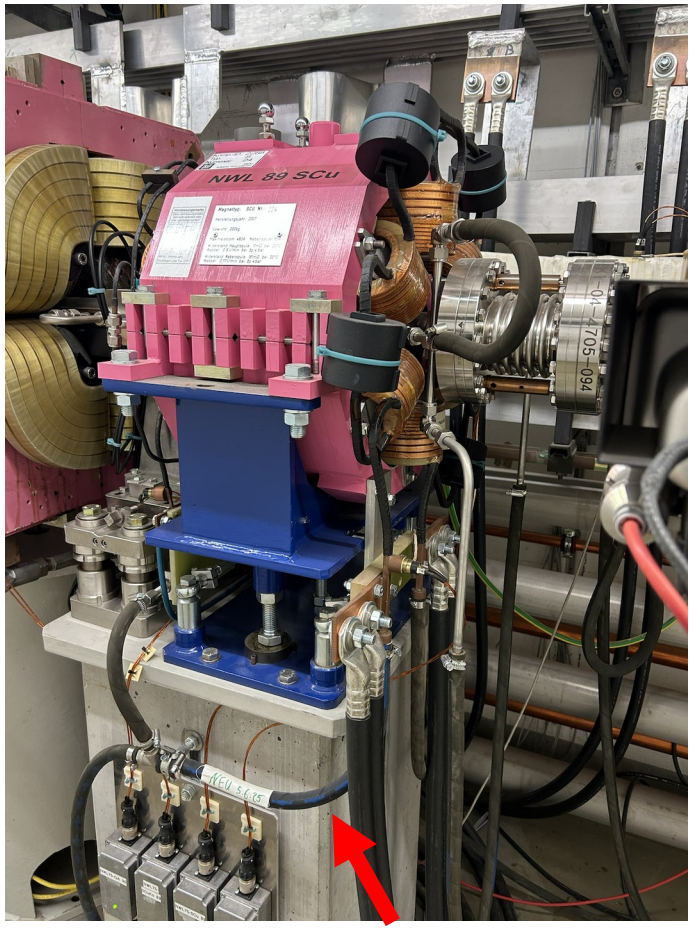
→ defect water filter polluted cooling water system around the whole ring

KW37

→ radiation damaged temperature sensor caused frequent beam dumps

Series of broken water hoses – faster ageing due to higher water temperature

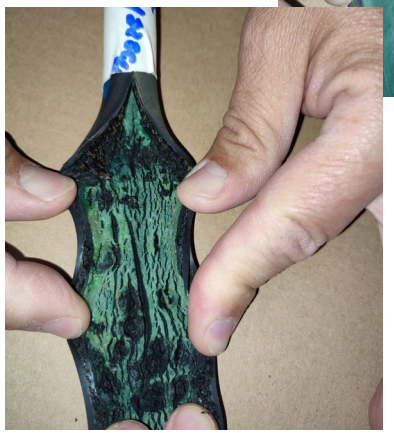
Water hoses on a particular position at all sextupoles in the copper-water circuit have been exchanged



Always same piece of hose connecting the sextupole coils to the Cu-water circuit.

- 3x water leaks during user run
- **All hoses** of this position **exchanged** during summer shutdown

→ *Most found to have the same symptoms*



Inside covered by copper rust, point-like holes and cracked defects

- Sextupoles of SCu type are operated at higher current

→ higher water temperature

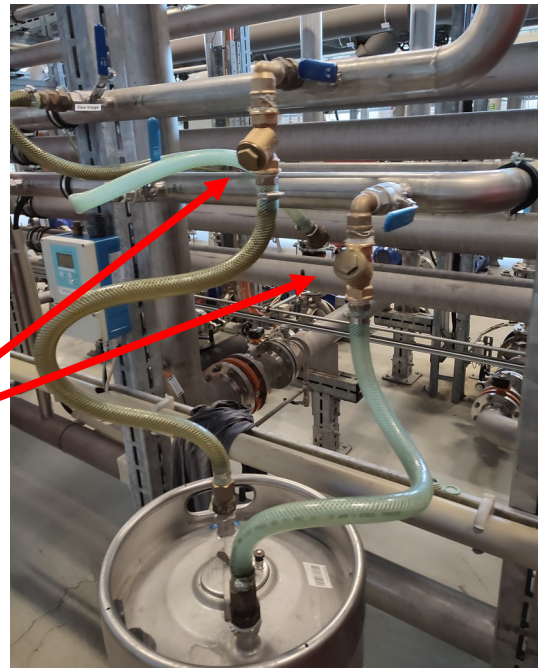
→ higher stress on material

- **Samples of other locations** on “hose tree” of SCu and SAl show **good condition**.

Broken water filter distributed resin particles over the full copper-water circuit

529 dirt traps had to be cleaned before machine operation could continue

Cleaning of all dirt traps in the tunnel and the power supplies that are connected to the Cu water circuit.



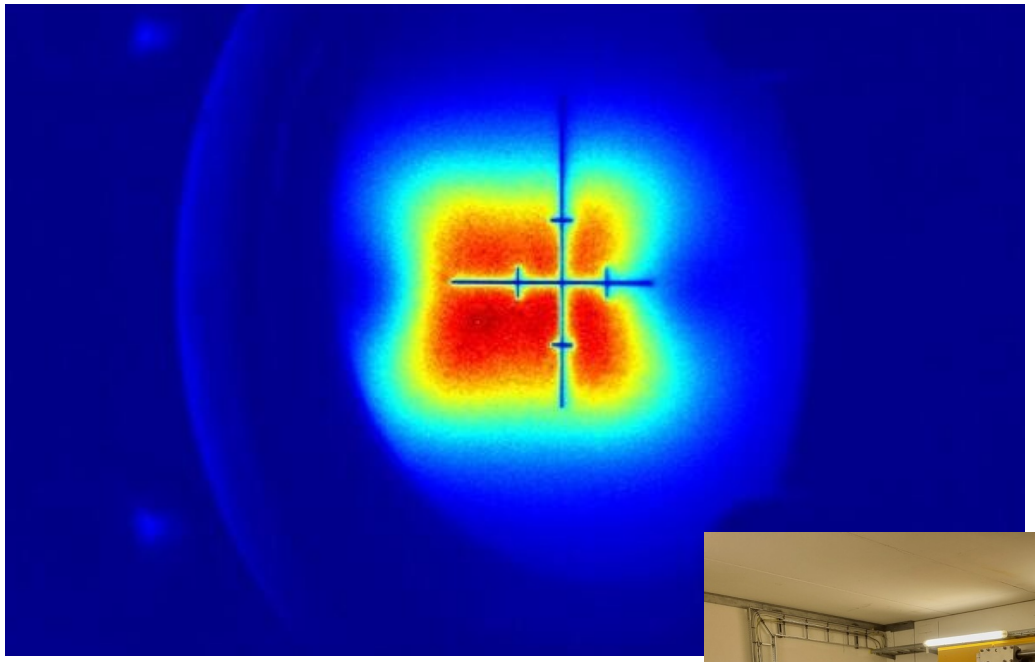
Installation of dirt traps on connections to filter.

Filter exchanged. Root cause analysis showed that mesh keeping the particles inside the filter had detached.

Triggered further discussions on dirt trap concept for PETRA IV

First light from PU25 undulator

The commissioning of the PU25 Undulator is finished – Beamline P25 is getting ready for first light

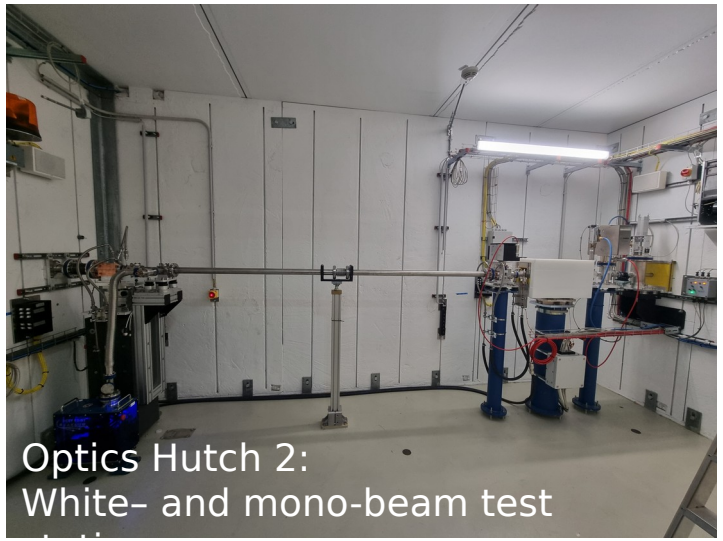


Partnership of industry and DESY
Innovation and Technology Transfer (ITT)
& Photon Science

Beamline for Applied Bio-Medical Imaging,
Powder Diffraction and Innovation

DESY
INNOVATION
FACTORY

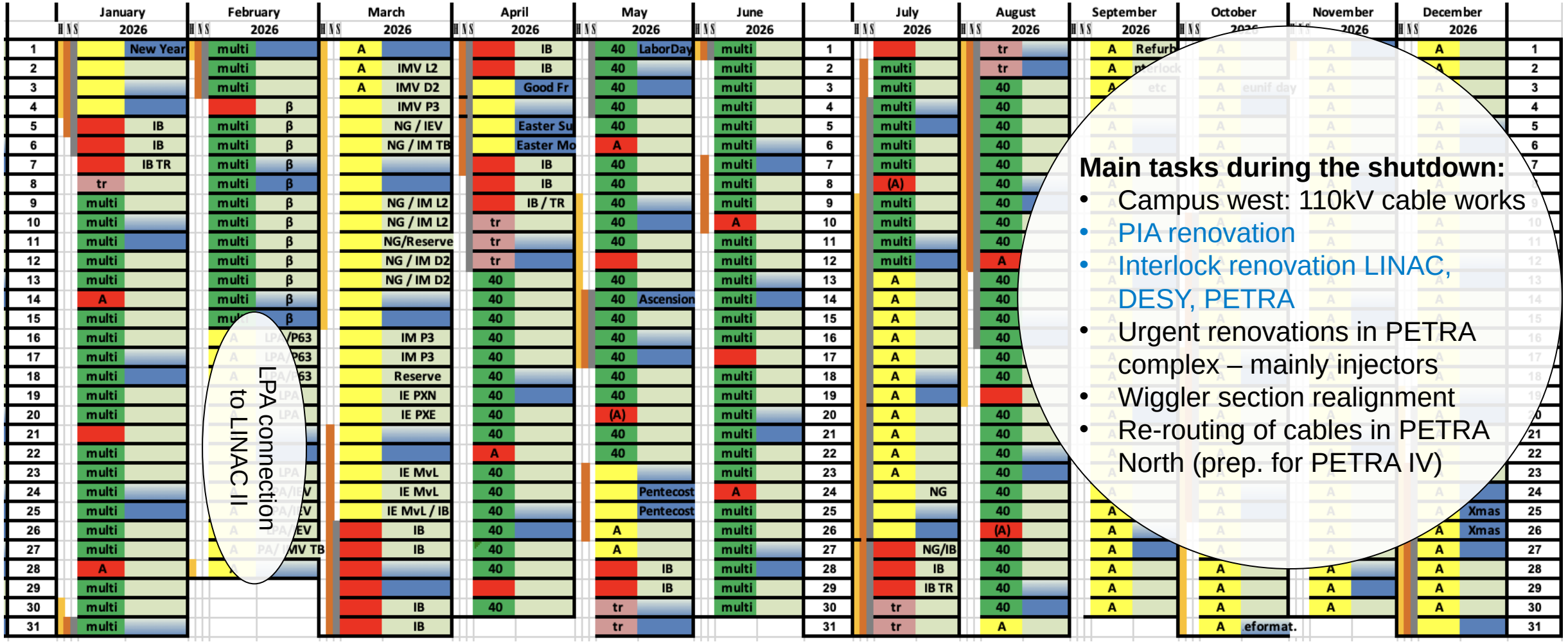
Optics Hutch 1:
P25 Double Crystal



Optics Hutch 2:
White– and mono-beam test

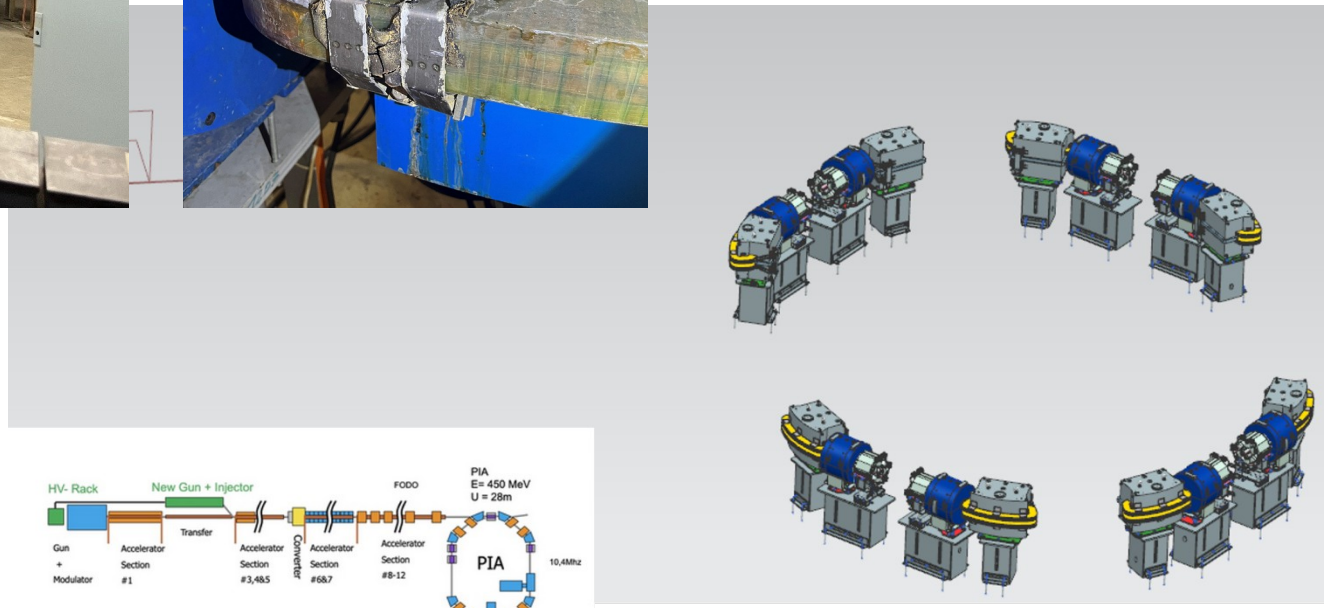
Approved schedule for 2026 with long shutdown and 3144 h user run

Many external boundary conditions influenced the scheduling



PIA refurbishment in long shutdown from Sept. 2026

Project long due, but delayed due to delivery issues



Core items to be renewed

- New **sextupoles** and **quadrupoles**
- **Dipoles** will be equipped with new coils
- New **BPM electronics**
- New **vacuum chambers**
- General refurbishment of the **hall**

Refurbishment of the interlock system from Sept. 2026

Ensure continued safe operation of the PETRA III complex in compliance with current standards

Key safety components reach end of 20-year mission time in 2027

→ Demand to continue operation of PETRA III and the pre-accelerators until 2029

→ The **personnel safety systems** (PSS) at **LINAC II, DESY II** and **RF safety interlock** at **PETRA III** will undergo a **comprehensive refurbishment**.

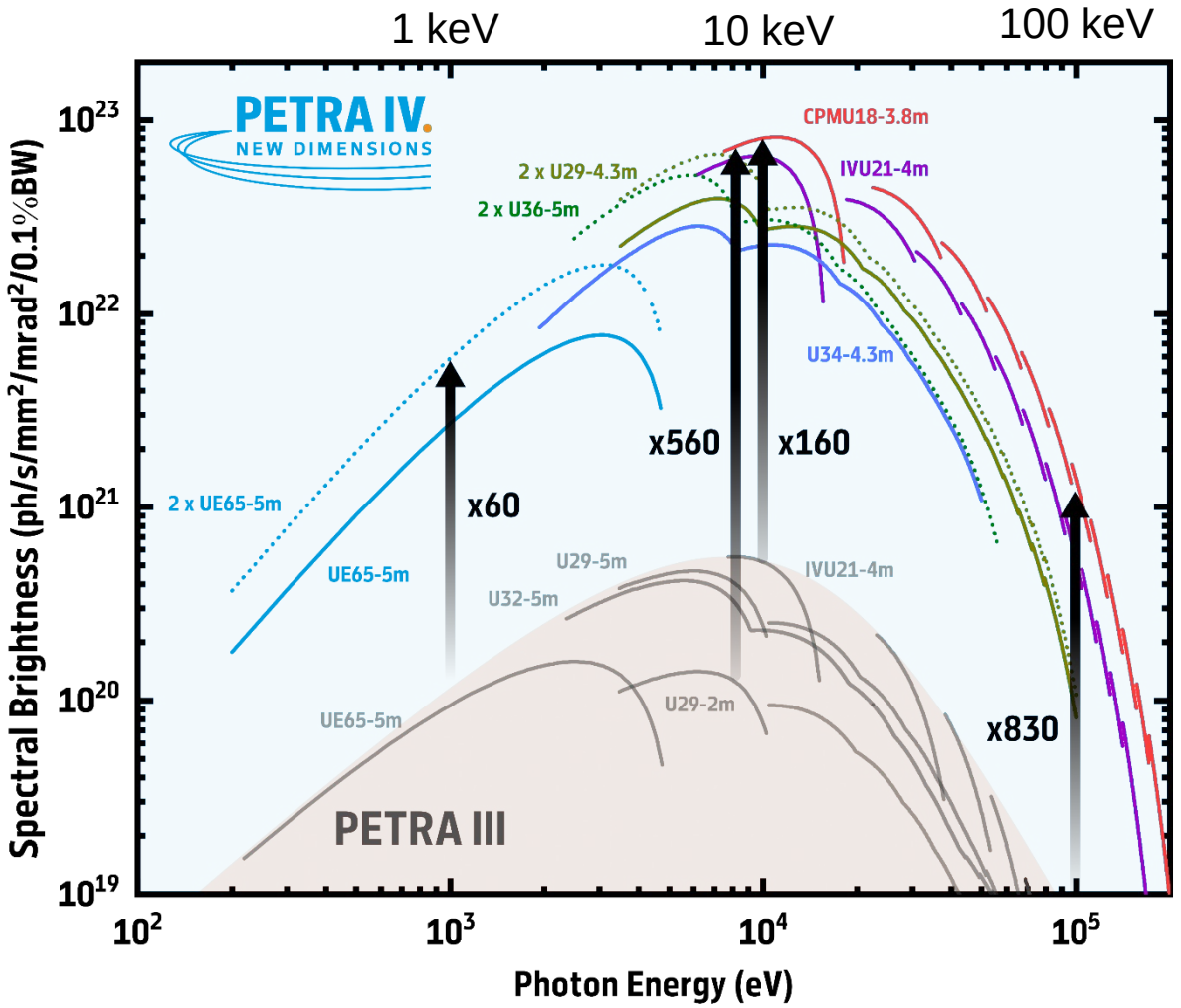
Safety Interlock System

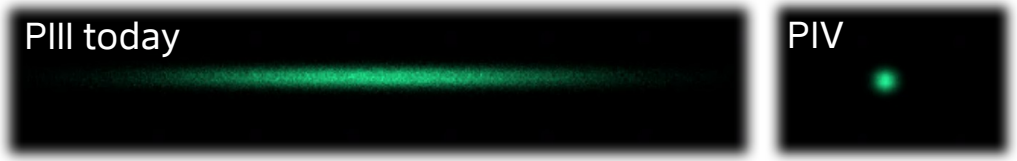
Ensuring fast switching off of the hazard source (electron beam, RF) in emergency situations.


PETRA IV.
NEW DIMENSIONS

High-energy x-rays will be up to 800x brighter than at PETRA III

PETRA IV will run with round beams in full coupling operation





Photon source size – ideal imaging capabilities

Standard operation: ***full coupling***

12	**x 12**	**(pm·rad)²**	**emittance**
5	**x 5**	**μm²**	**source size**
2.4	**x 2.4**	**μrad²**	**source divergence**

PETRA IV brightness mode

1900 bunches , 4 ns spacing, 200 mA (1 nC per bunch)

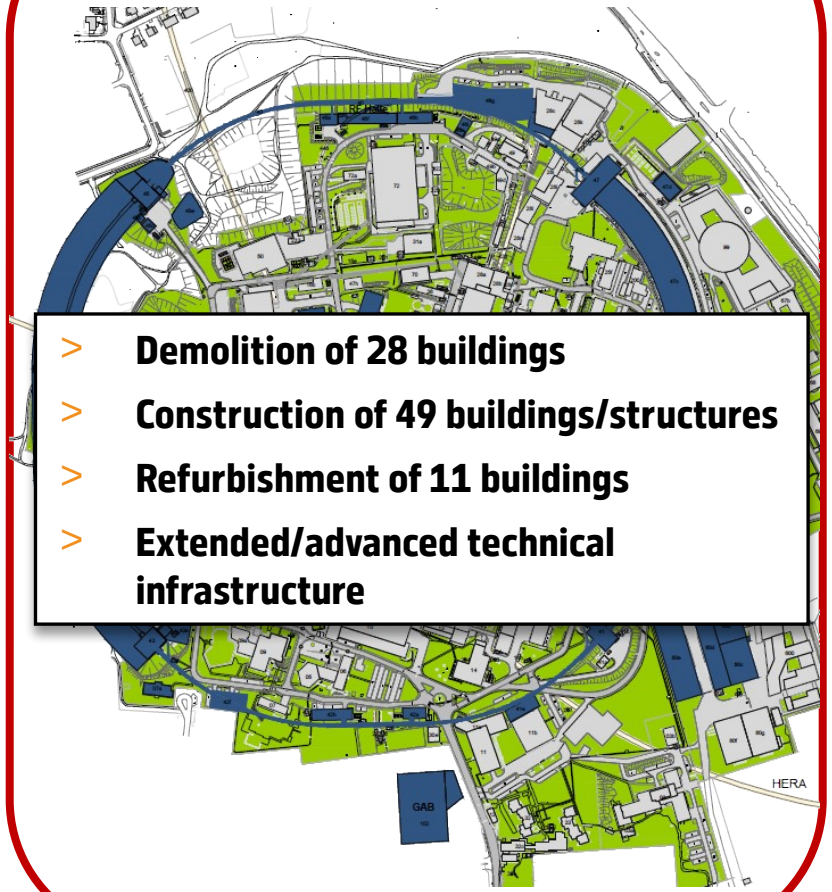
PETRA IV brightness at 100 keV
higher than for 10 keV at PETRA III today!!

Courtesy of H. Reichert

A new accelerator complex in an extended & refurbished infrastructure

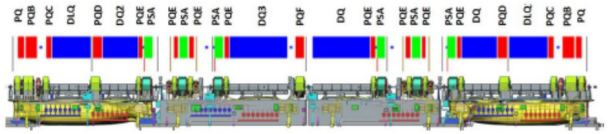
Project pillars are the civil construction, accelerator complex and experimental facilities

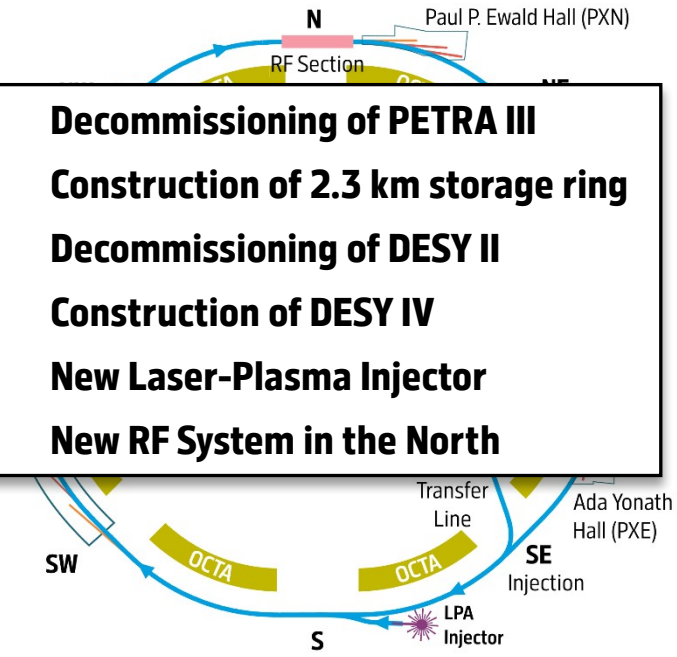
Civil Construction and Infrastructure



- Demolition of 28 buildings
- Construction of 49 buildings/structures
- Refurbishment of 11 buildings
- Extended/advanced technical infrastructure

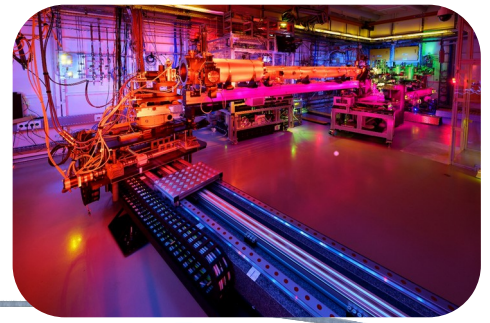
Accelerator Complex

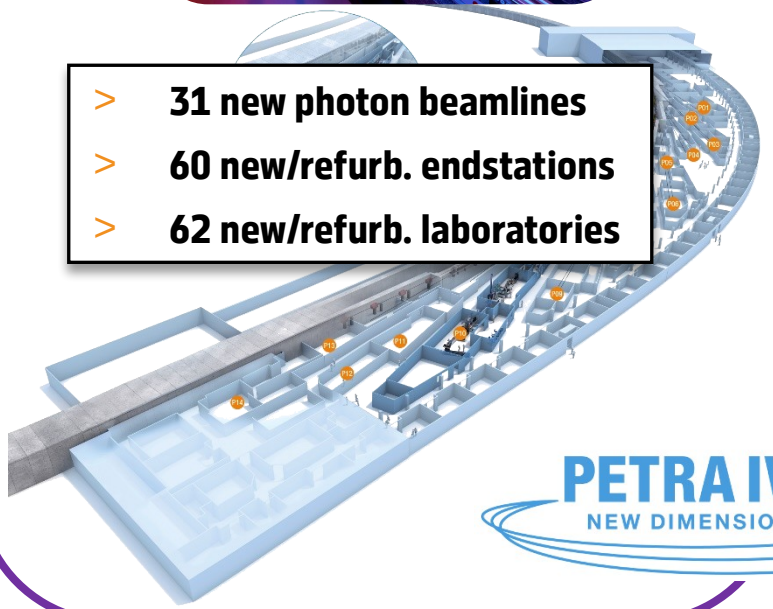




- Decommissioning of PETRA III
- Construction of 2.3 km storage ring
- Decommissioning of DESY II
- Construction of DESY IV
- New Laser-Plasma Injector
- New RF System in the North

Experimental Facilities





- 31 new photon beamlines
- 60 new/refurb. endstations
- 62 new/refurb. laboratories

PETRA IV. NEW DIMENSIONS

Courtesy of H. Reichert

Project timeline fixed by (external) boundary conditions

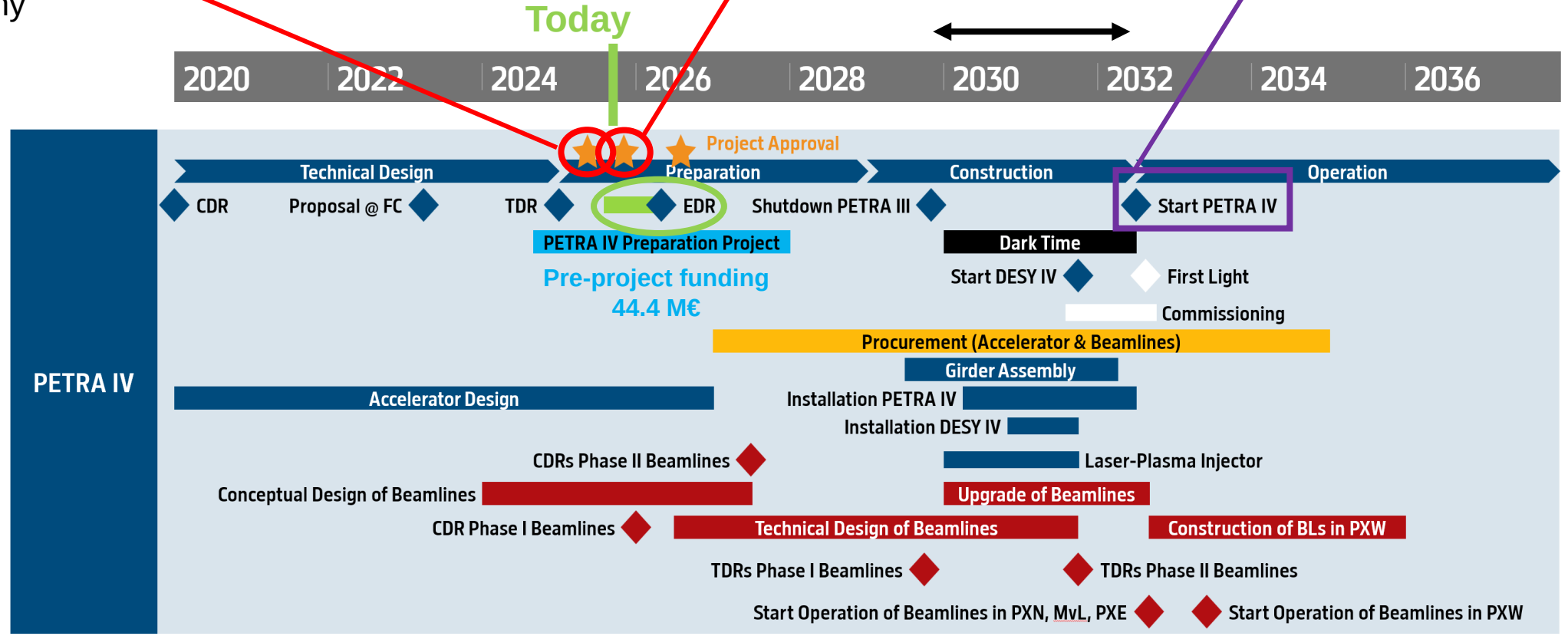
July 2025: PETRA IV was classified as ”Research Infrastructure of National Importance"

PETRA IV put on roadmap priority list for large-scale research infrastructures in Germany

Project evaluation for final funding approval 2./3. Dec 2025

Shutdown max. 2.5 year (2030-32)

Start of operation 7/2032 with 19 beamlines

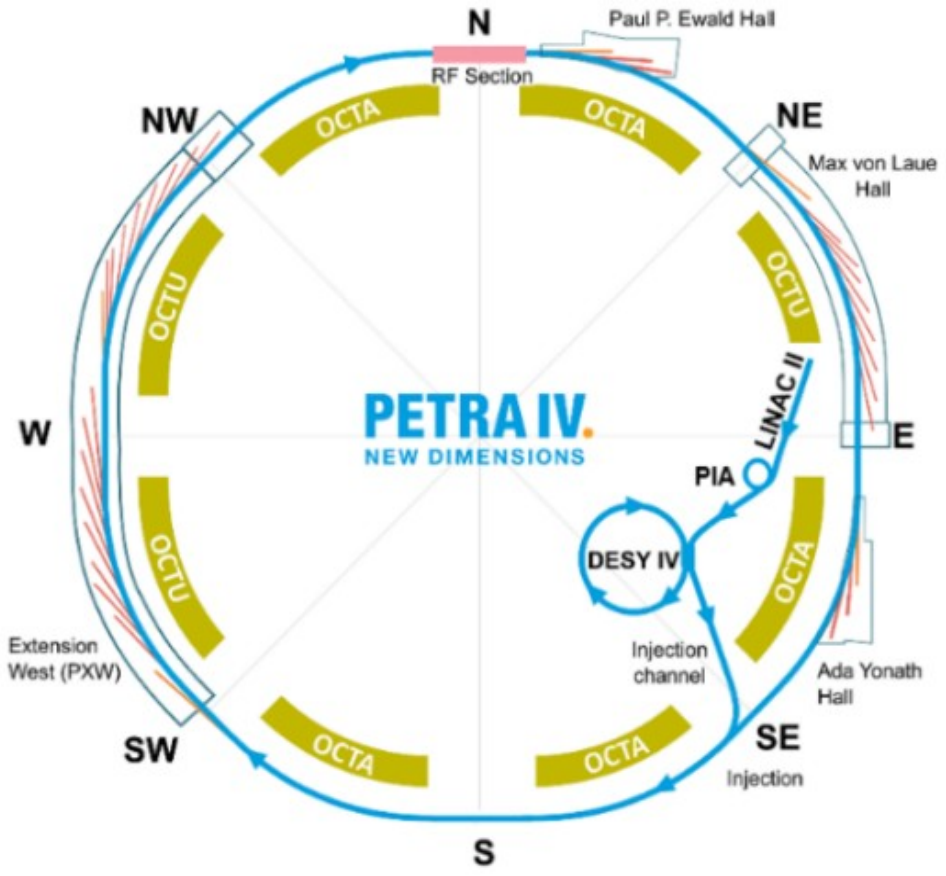


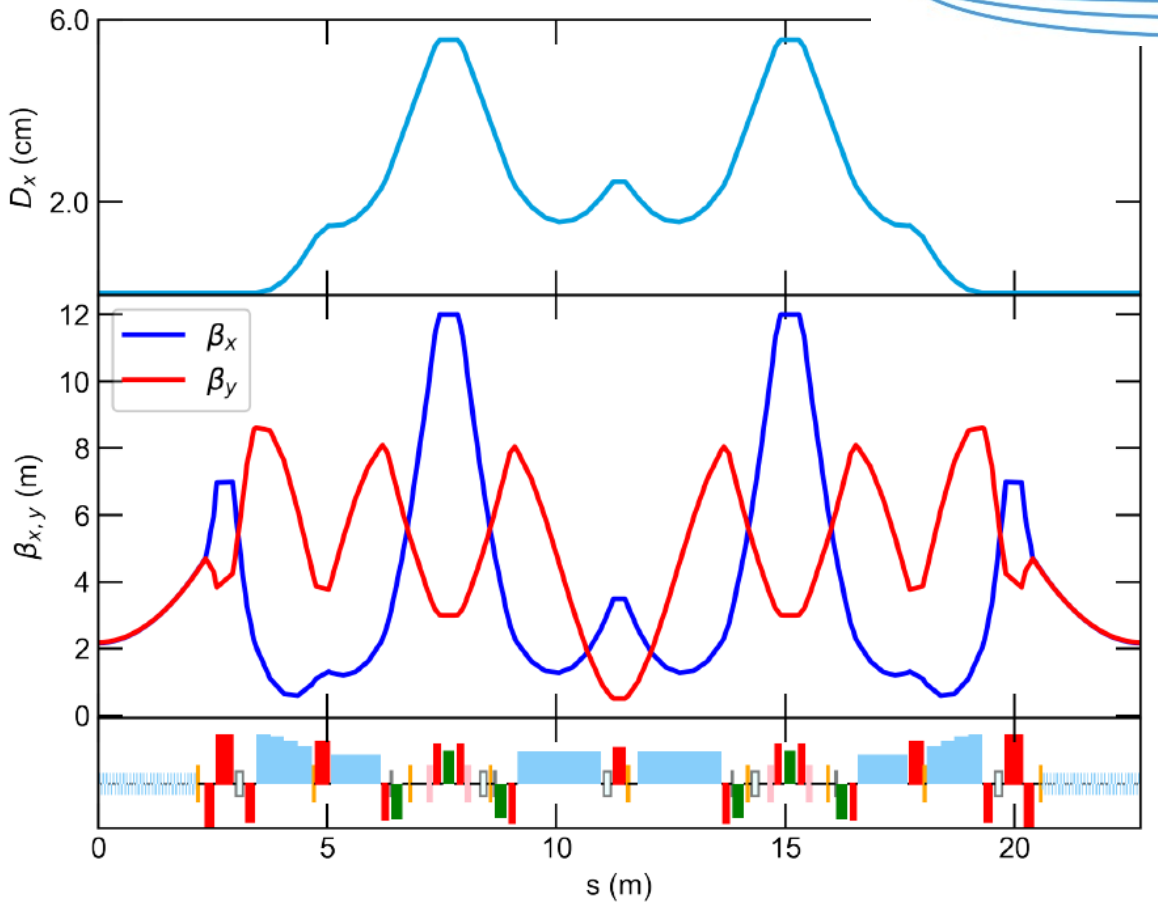
Courtesy of H. Reichert

Fully symmetric 8-fold H6BA cell structure with 72 cells over 2.3km

Dynamic aperture sufficient for off axis injection (~8mm with errors – 6mm at injection point)

Momentum aperture sufficient for beam lifetime >10h (brightness mode)

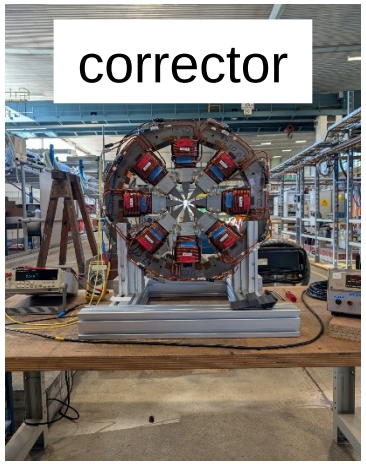


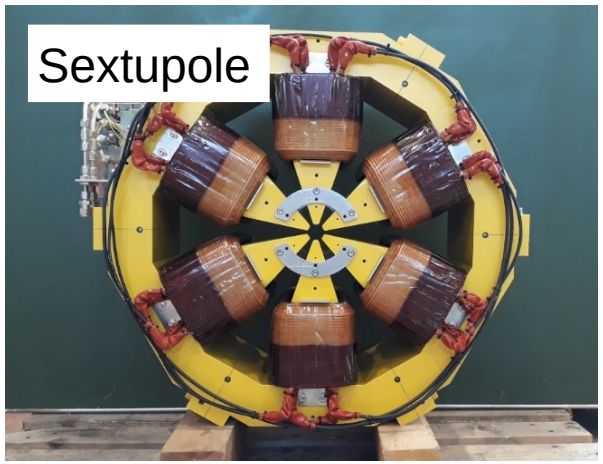


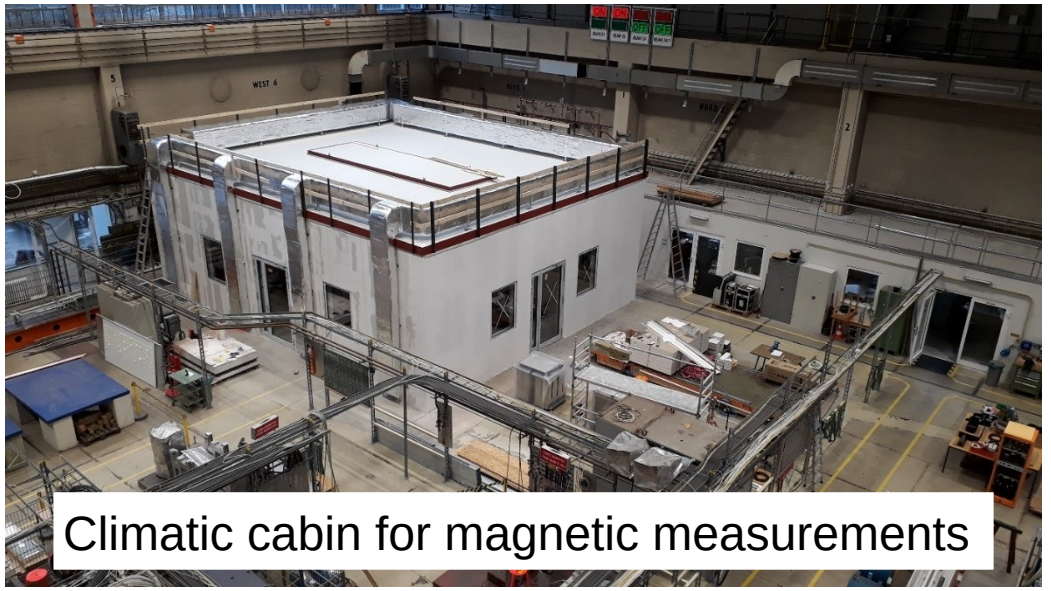
Courtesy of R. Bartolini

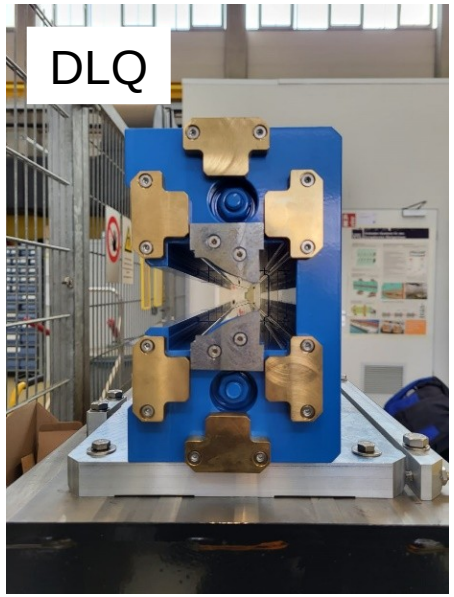
Prototypes for the main critical components are on site

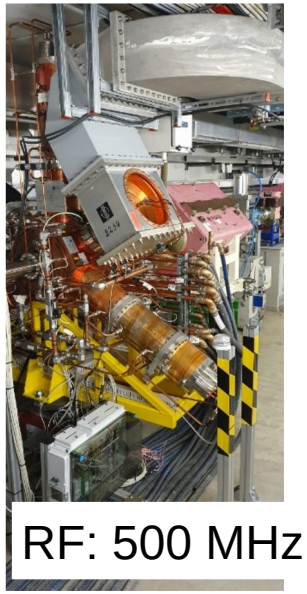
A mock-up girder is been assembled with prototypes and dummy magnets









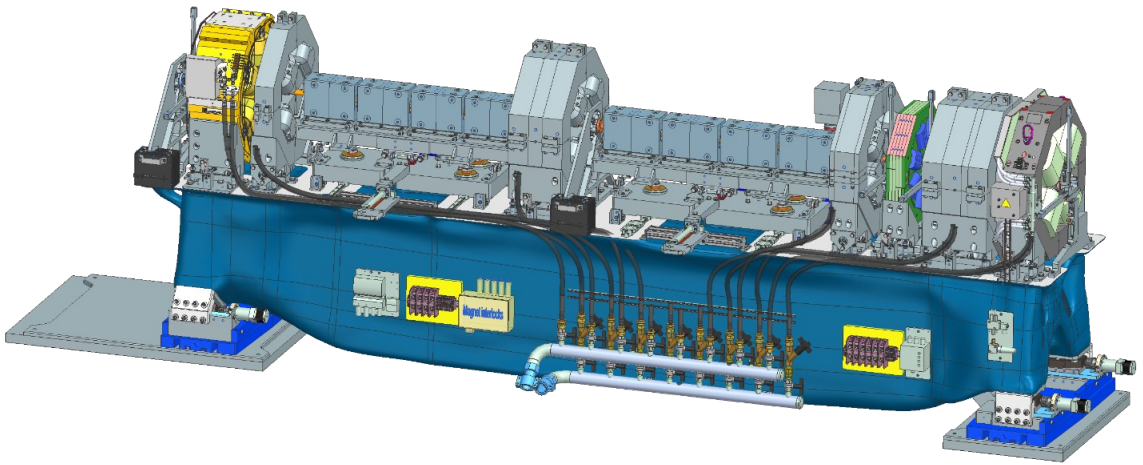


Courtesy of R. Bartolini

Mock-up girder is been assembled with prototypes and dummy magnets

Prototype girder is now in the testing phase

Magnets, vacuum equipment, diagnostics will be assembled, aligned and tested on girders

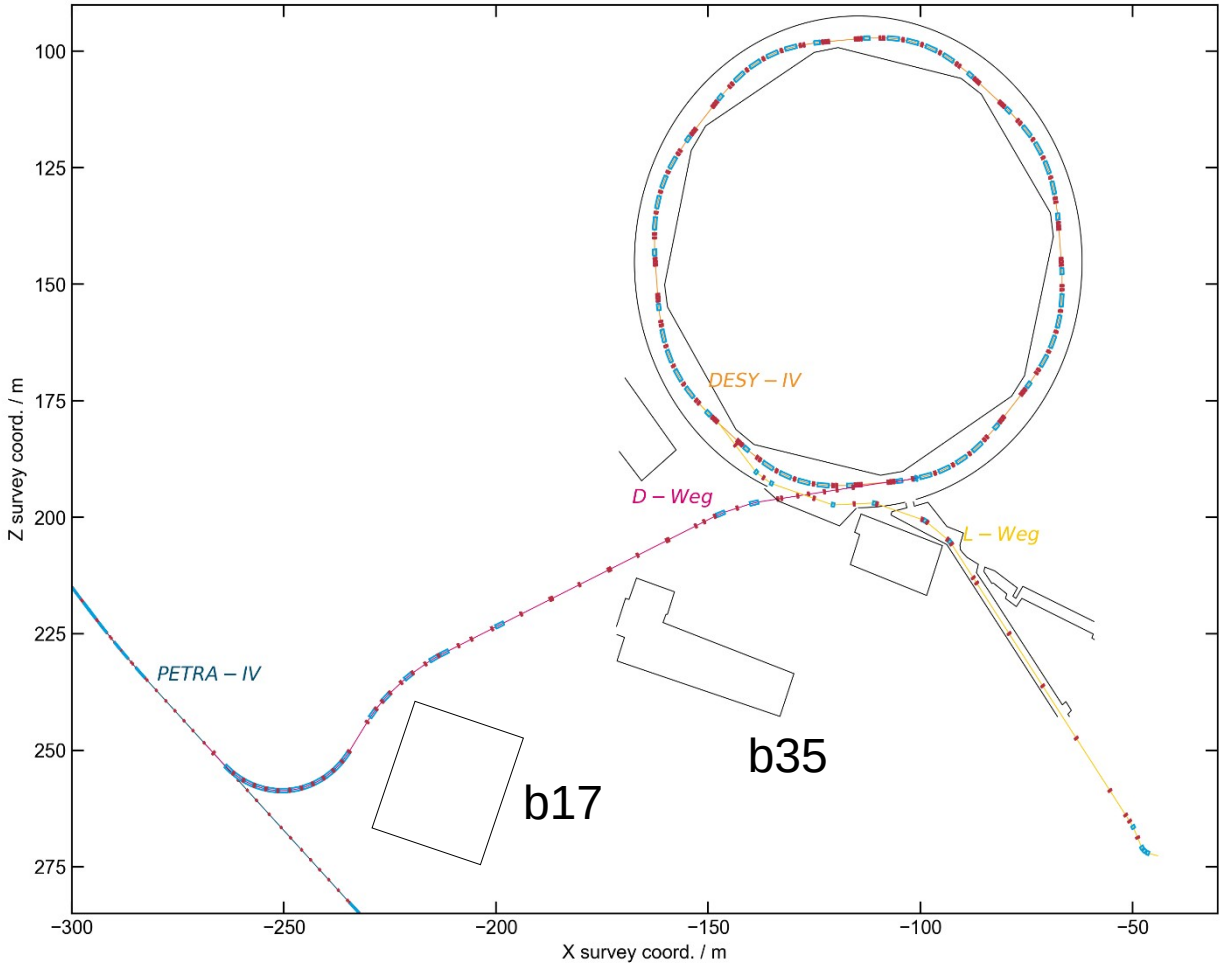


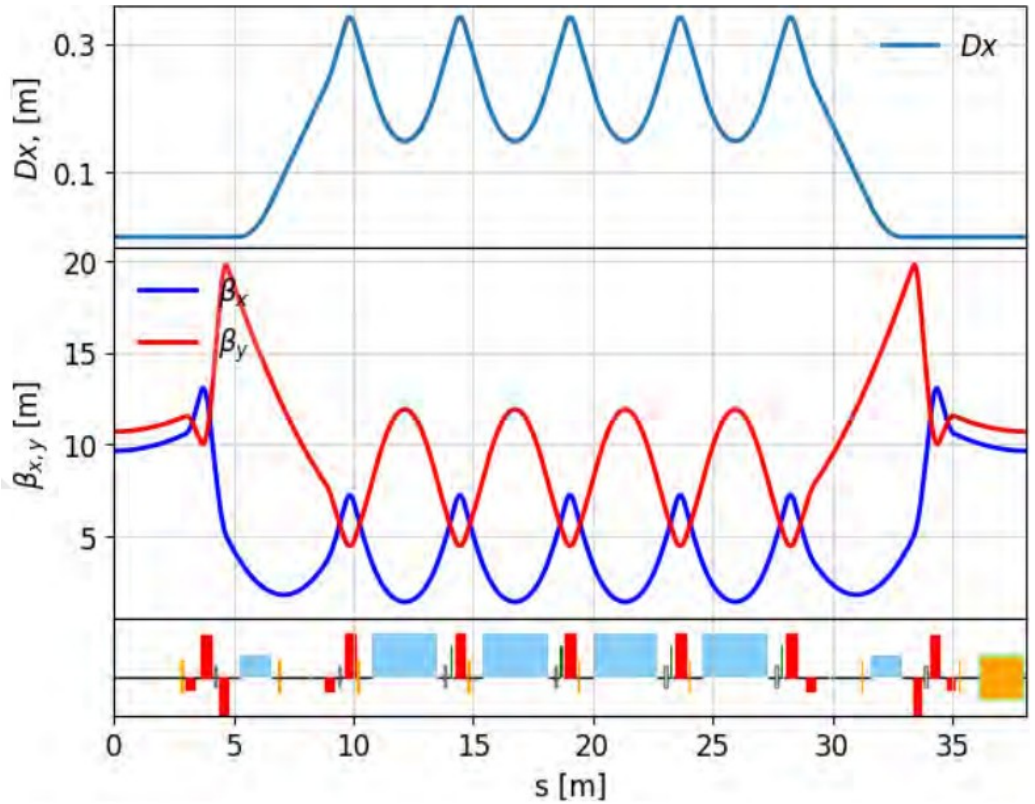
PETRA IV will have 288 girders

Courtesy of R. Bartolini

Injector baseline: construction of a new booster - DESY IV

with lower emittance than the existing DESY II (from 335 nm to 20 nm)



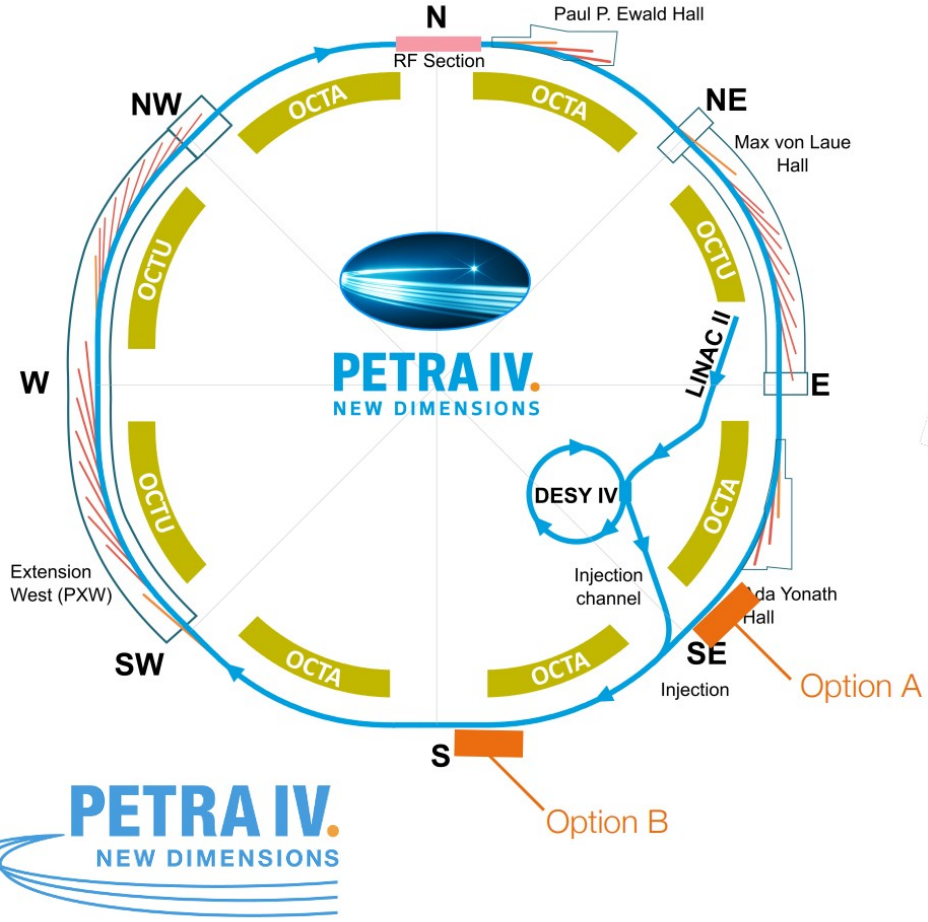


Courtesy of R. Bartolini

Laser Plasma Accelerator (LPA) as alternative injector option

Integration of the LPA into the storage ring straight sections is been studied

The LPA injector can sustain filling the ring and top-up operation with a charge of 250 pC at 10 Hz rep rate

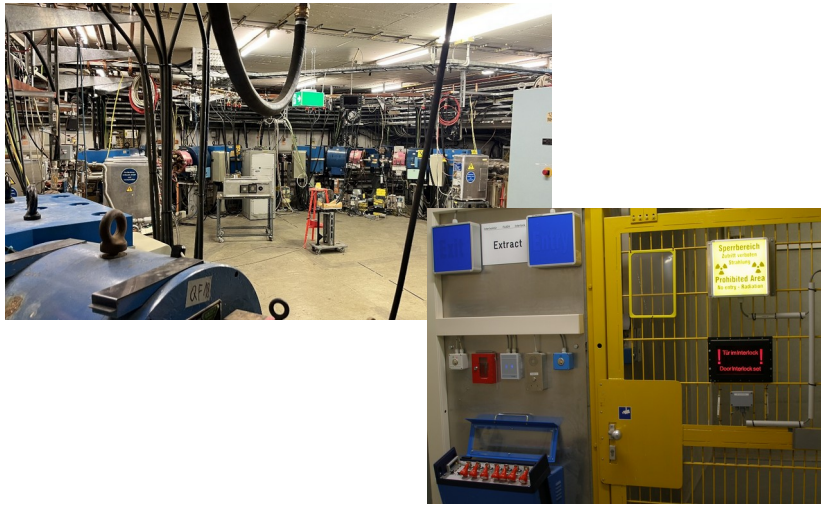


Bird view of Option B

Courtesy of R. Bartolini

Conclusion

The PETRA III complex operates with an **availability of 98%,** while aging effects become more and more noticeable.



A **6-month long shutdown** is planned to start in September 2026, with the major task to refurbish PIA and the interlock system in the injector chain.

PETRA IV got accepted for the national roadmap priority list

→ Evaluation for final funding approval in December 2025

→ Project start 2027 – with 2.5 years of dark time in 2030-2032

Thank you for your attention

Full Coupling: new PETRA IV standard operating mode

PETRA IV brightness mode

1900 bunches 4 ns spacing 200 mA (1 nC per bunch)

standard mode: emittance 20 pm; 20% coupling (**17pm/3pm**); energy spread 0.1 %

	β_x (m)	β_y (m)	σ_x (μm)	σ_x' (μrad)	σ_y (μm)	σ_y' (μrad)
Standard straights	2.2	2.2	6.1	2.8	2.7	1.2
Long straights	4.0	4.0	8.2	2.0	3.7	0.9
Long straight north	5.0	5.0	9.1	1.8	4.1	0.8

All other optics functions are zero: $\alpha_x = \alpha_y = D_x = D_x' = D_y = D_y' = 0$

full coupling mode: emittance 20 pm; 100% coupling (**12pm/12pm**); energy spread 0.1 %

	β_x (m)	β_y (m)	σ_x (μm)	σ_x' (μrad)	σ_y (μm)	σ_y' (μrad)
Standard straights	2.2	2.2	5.1	2.3	5.1	2.3
Long straights	4.0	4.0	6.9	1.7	6.9	1.7
Long straight north	5.0	5.0	7.7	1.5	7.7	1.5

Contact

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