

PETRA IV Planning & Opportunities

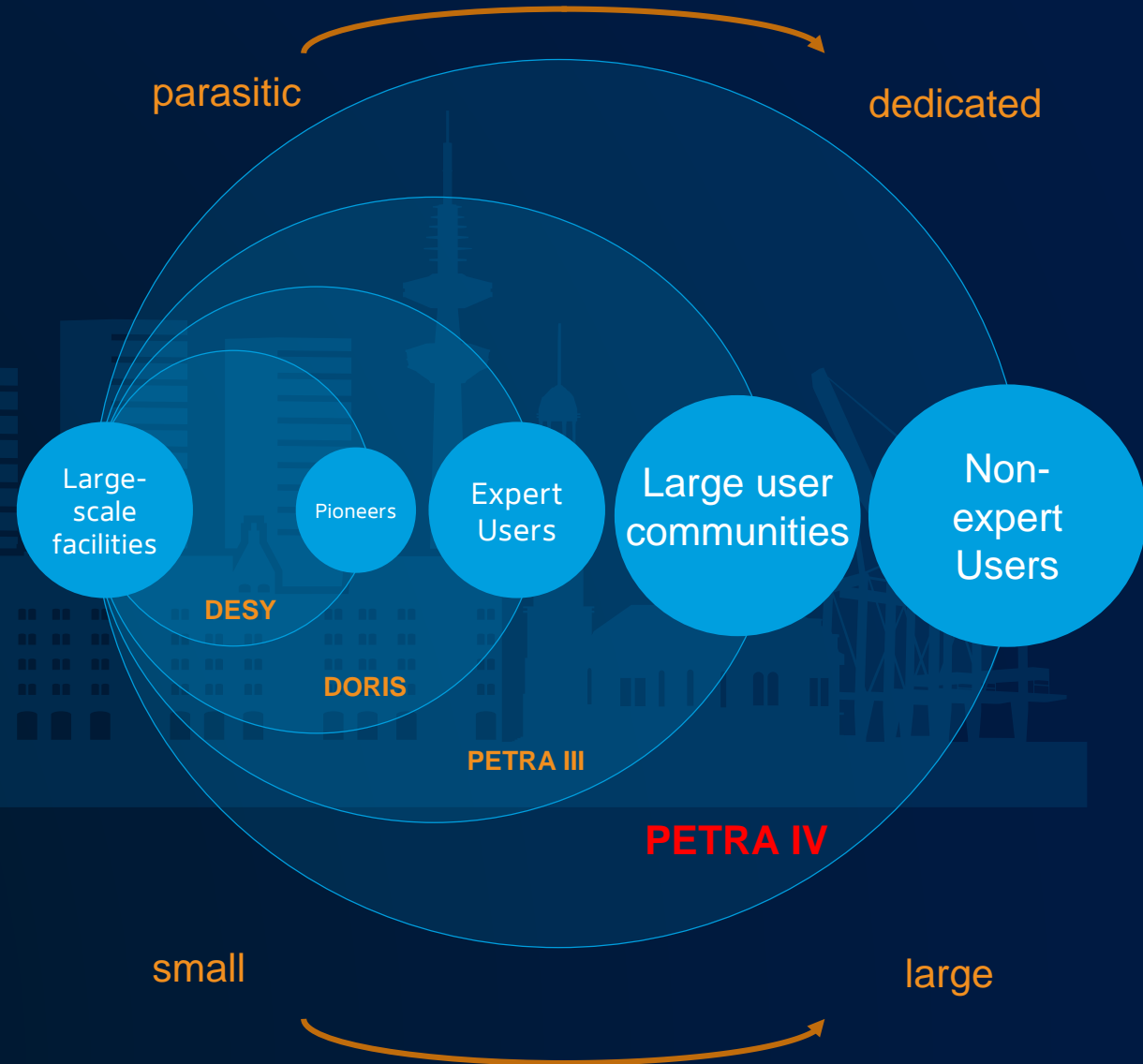
Industry opportunities at light source infrastructures , LEAPS Big Science Supplier Forum, 1 December 2023

Harald Reichert

Project Leader PETRA IV

The Evolution of Synchrotron Radiation Sources at DESY

From basic science to broad application – crucial backbone infrastructure

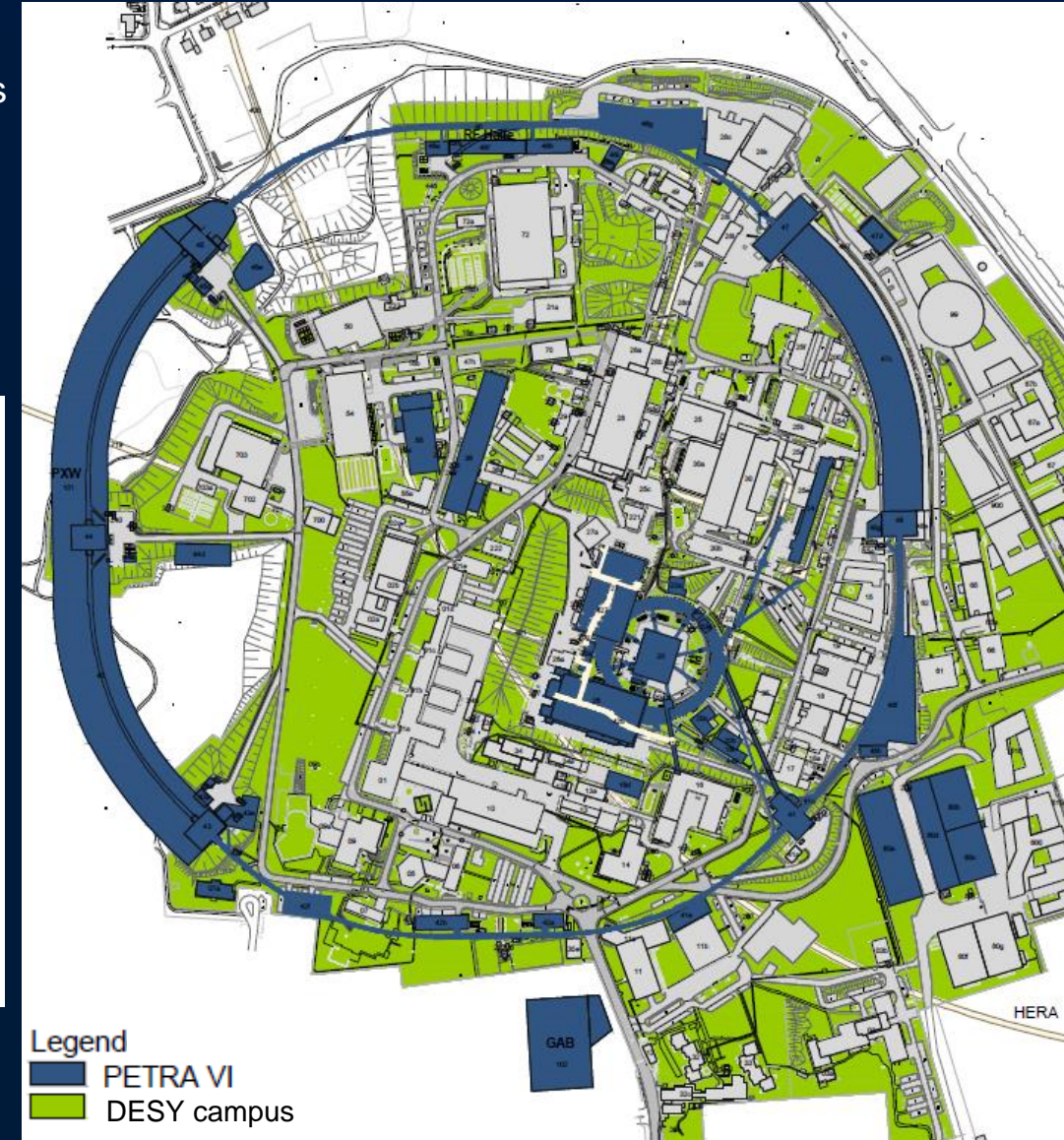
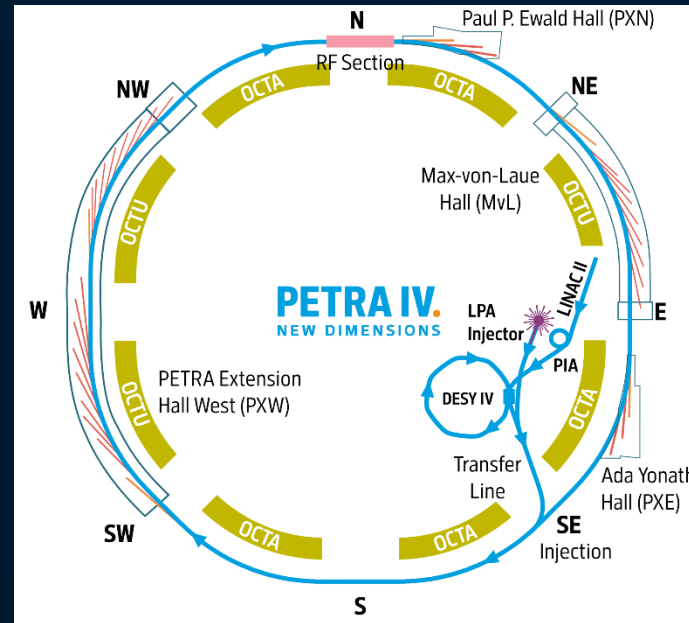
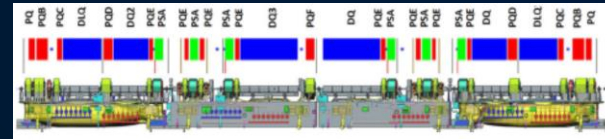


PETRA IV Project

Extension/Refurbishment of the existing infrastructure, accelerator complex, and experimental facilities

Baseline design is fixed and costs have been assessed and reviewed on that basis

Increase in performance by a factor of 500



PETRA IV – Civil Construction

Civil construction programme (status end of March 2023)

organised in 11 packages

- **GAB**
- **PXW, Tunnel NWN, RF Sector**
- **DESY Complex**
- **Supply Buildings**
- **Building Refurbishments**
- **Tunnel refurbishment (old sections)**
- **Underground Networks (Heating, Cooling, IT, etc.)**

+ Works under the responsibility of the City

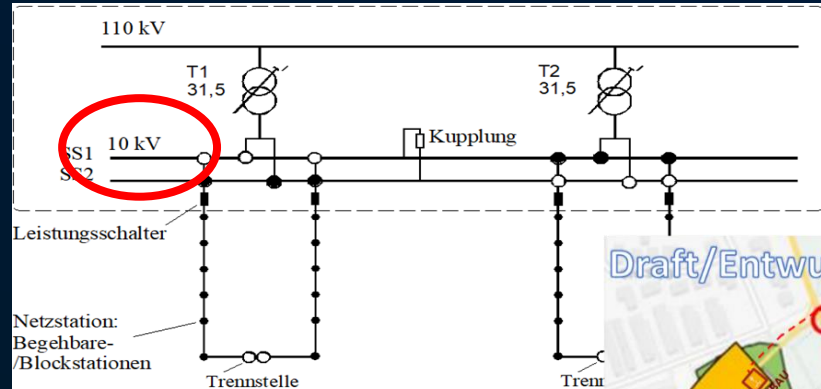
- **Relocation of the biotopes**
- **Replacement of sports facilities**
- **Reconstruction Lise-Meitner-Park**



PETRA IV – Power Supply

Main power lines

3 110 kV power lines supply the DESY Campus



PETRA IV / PXW Erschließung/ development

HST A Geb. 16 110/10kV-Hauptstation
HST B Geb. 16a 110/10kV-Hauptstation
HST C Geb. 16b 110/10kV-Hauptstation

Unterstationen „PETRA IV 10kV-Ring“

— 10 kV Kabeltrasse
— 10 kV Kabeltrasse (PXW-Ringversorgung)
- - 10 kV Kabeltrasse im Tunnel
— 0,4 kV Kabeltrasse

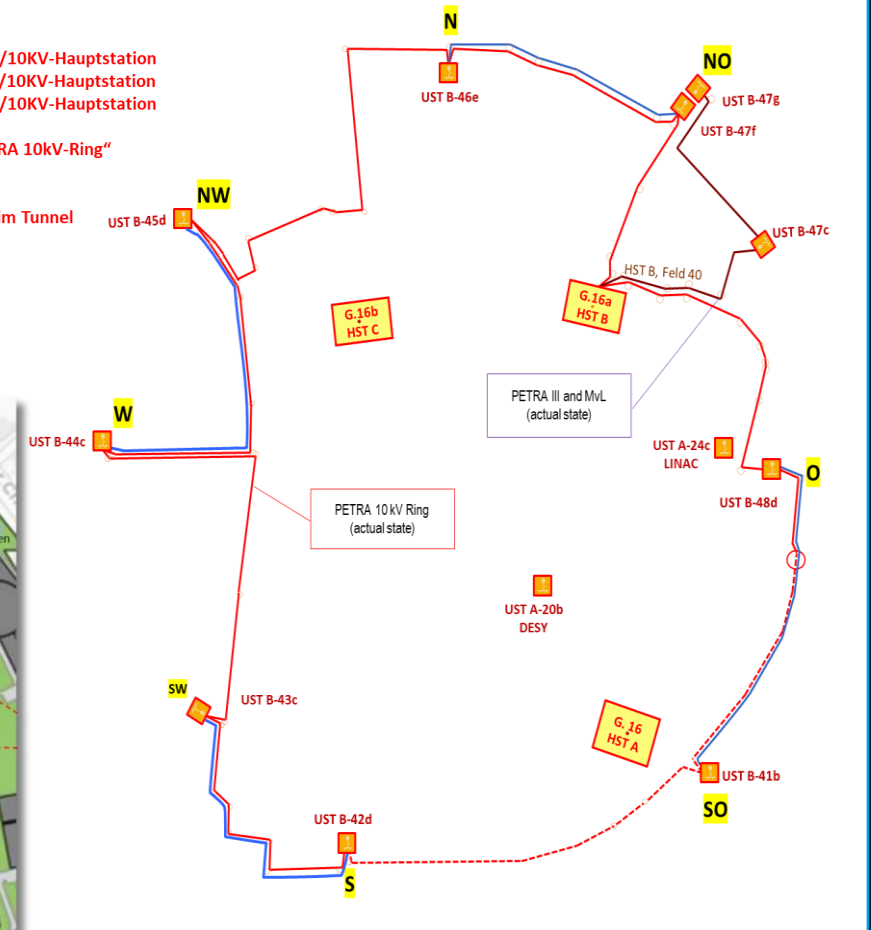
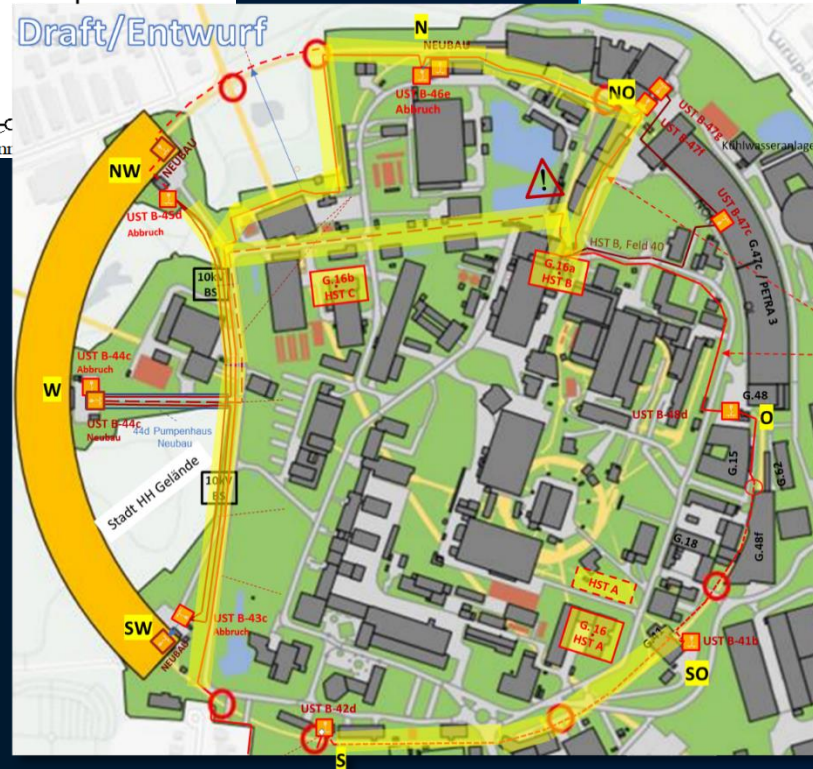
Power supply via 10 kV Ringleitung

Legende

HST A Geb. 16 110/10kV-Hauptstation
HST B Geb. 16a 110/10kV-Hauptstation
HST C Geb. 16b 110/10kV-Hauptstation

Unterstationen „PETRA 10kV-Ring“

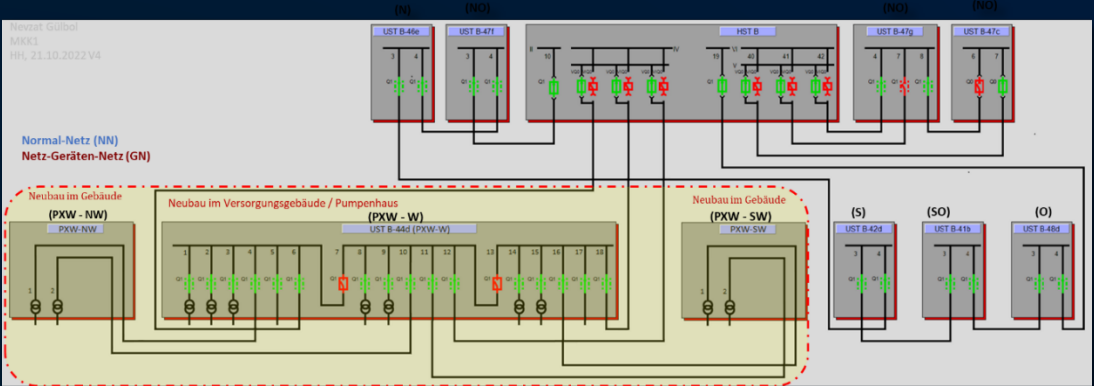
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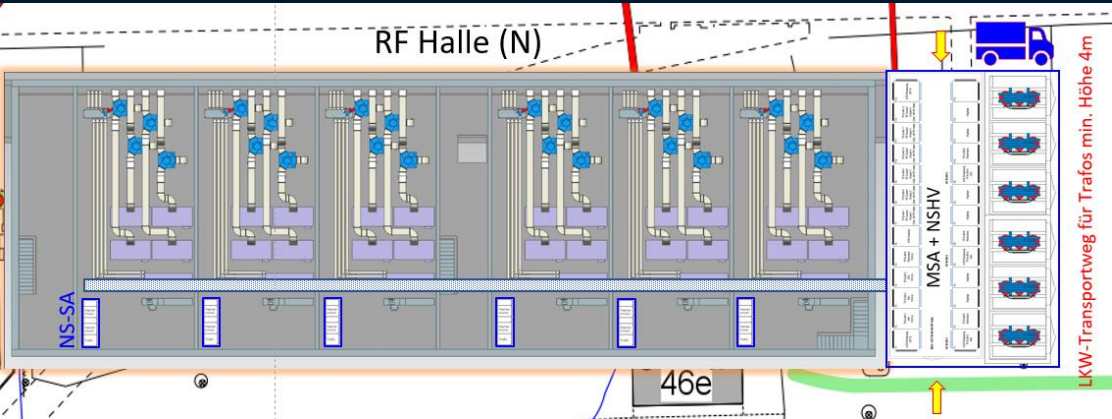
PETRA IV – Power Supply

Main supply areas

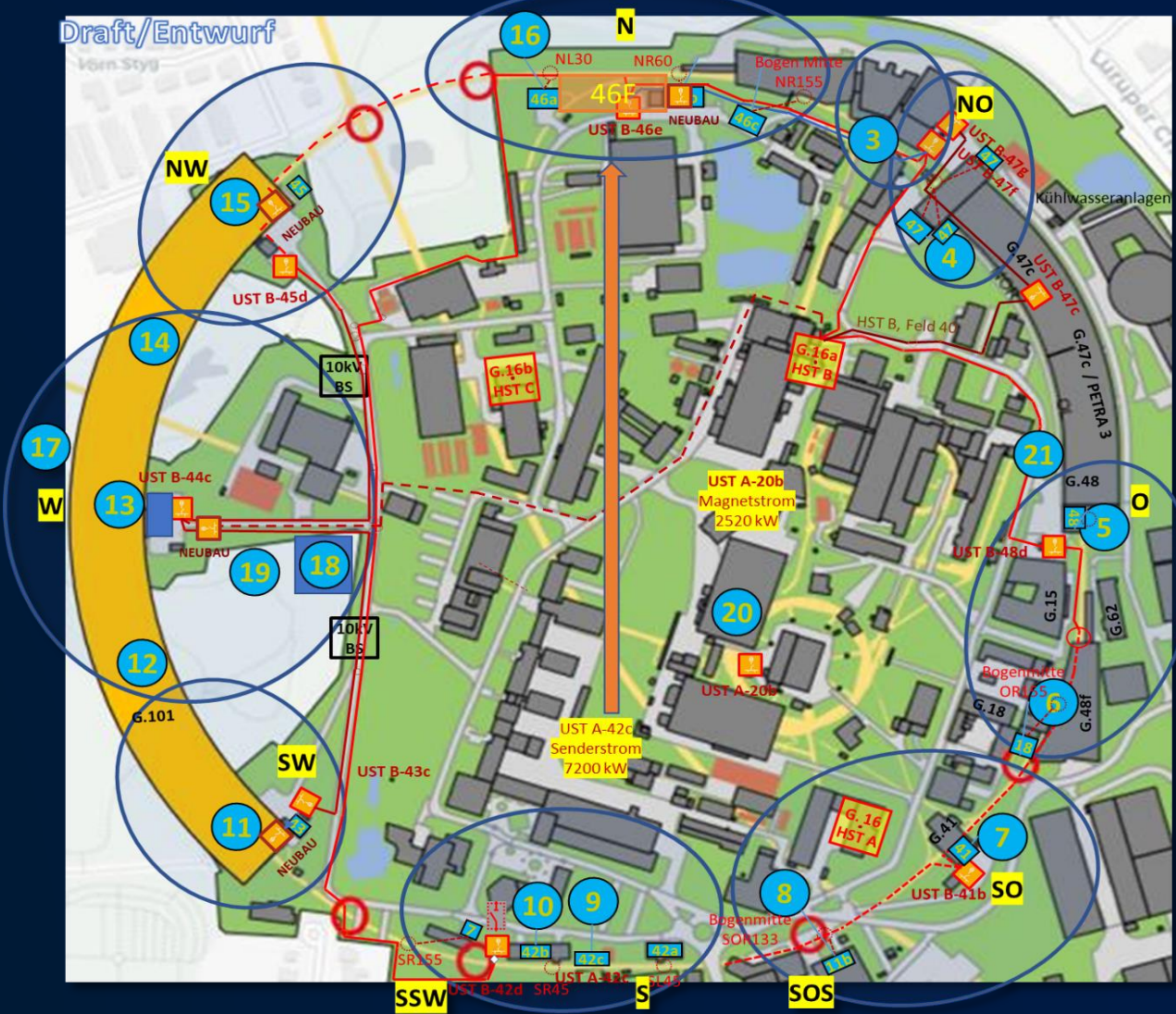
PETRA IV PXW sub-station



Power supply for the RF-System



Power supply organised aggregated supply areas



PETRA IV – Power Supply

New Installations & Refurbishments

Power consumption (peak power)

Area	PETRA III	PETRA IV
Offices	100 kW	150 kW
Laboratories	150 kW	300 kW
Experimental Floor	400 kW	800 kW
Air Cooling	500 kW	1.700 kW
Water Cooling	6.000 kW	11.600 kW
Magnets	3.000 kW	3.200 kW
RF	3.000 kW	3.300 kW
DESY, PIA, LINAC	2.000 kW	2.000 kW
Diagnostic	250 kW	700 kW
Vacuum Systems	200 kW	600 kW
Total	15.650 kW	24.350 kW

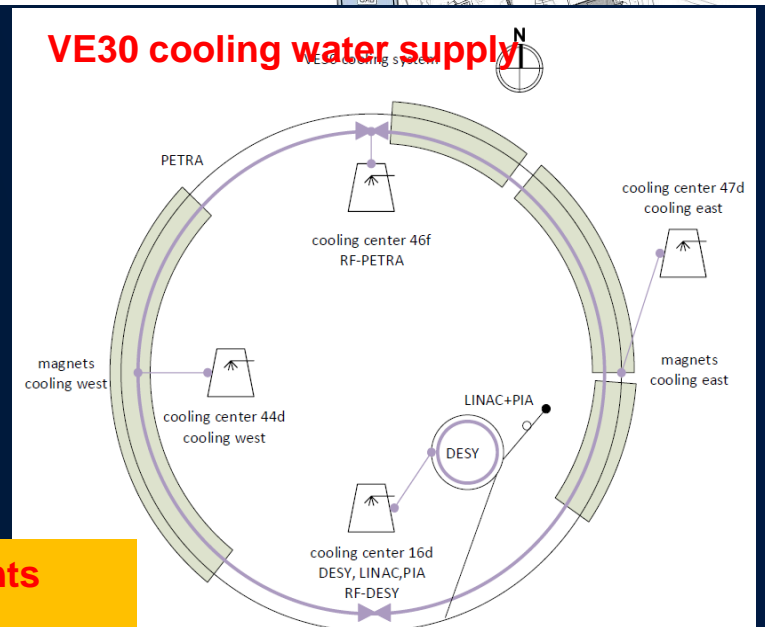
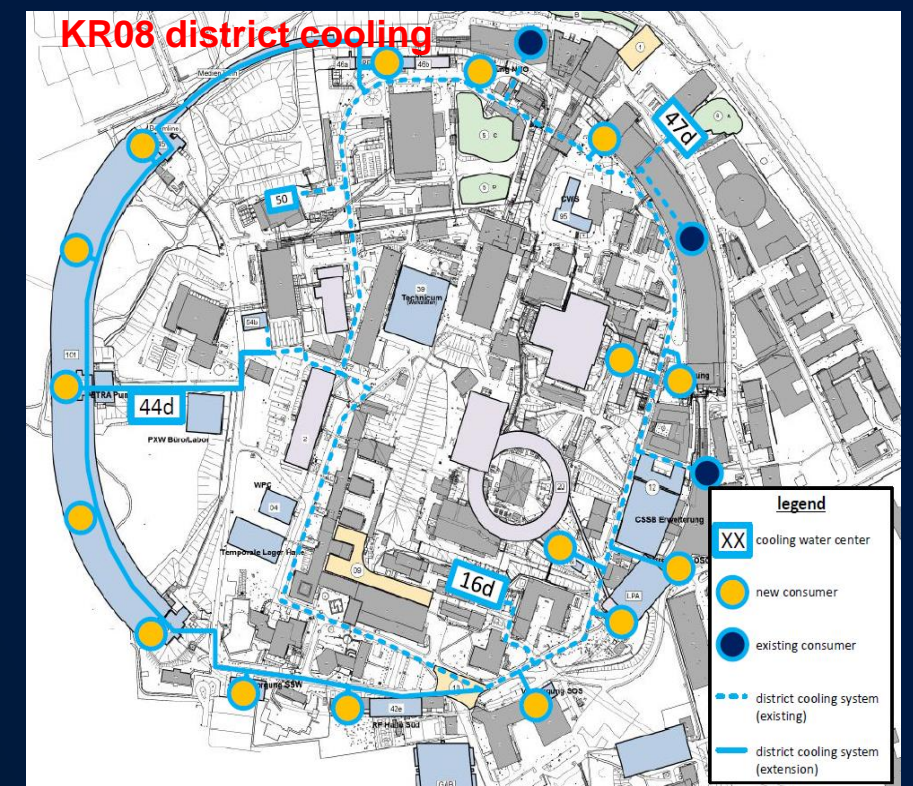
Electricity supply units and their condition

Equipment	Year	Quantity	Condition	Action
Substations (MVSB)	1995 – 2008	2	acceptable	replace later, modifications
Diesel Generator	1998	1	acceptable	replace later, modifications
Transformers	1962 – 1969	10	not ok	replace now
	1977 – 1996	4	acceptable	replace later, modifications
	2020 – 2021	4	ok	replace later, modifications
Main Distribution (LVSB)	2008	9	ok	Small modifications
Sub Distribution (LVSB)	1966	73	not ok	replace now
	2008 – 2022	24	ok	Small modifications

PETRA IV – Water Cooling

Povision of 6 different cooling water qualities

water type acronym	consumer stakeholder	temperature (inlet)	water quality	pipng materials
cooling water VE30	magnets, RF, magnet power supplies, vacuum system	30 °C	deionized water electr. conductance: < 1 µS/cm BTGA 3.003	stainless steel copper red brass
chilled water ALU25	Undulators	25 °C	deionized water electr. conductance: < 1 µS/cm BTGA 3.003	stainless steel aluminum
chilled water KW20	server racks	20 °C	BTGA 3.003	stainless steel copper red brass
chilled water VE20	laboratories experiments	20 °C	deionized water electr. conductance: < 1 µS/cm BTGA 3.003	stainless steel copper red brass
chilled water RLT KW09	AC units	9 °C	BTGA 3.003	stainless steel copper red brass
district cooling KR08	district cooling/ campus distribution	8 °C	BTGA 3.003	carbon steel copper red brass



**4 separate refrigeration plants
(16d, 44d, 46f, 47d)**

PETRA IV – HVAC

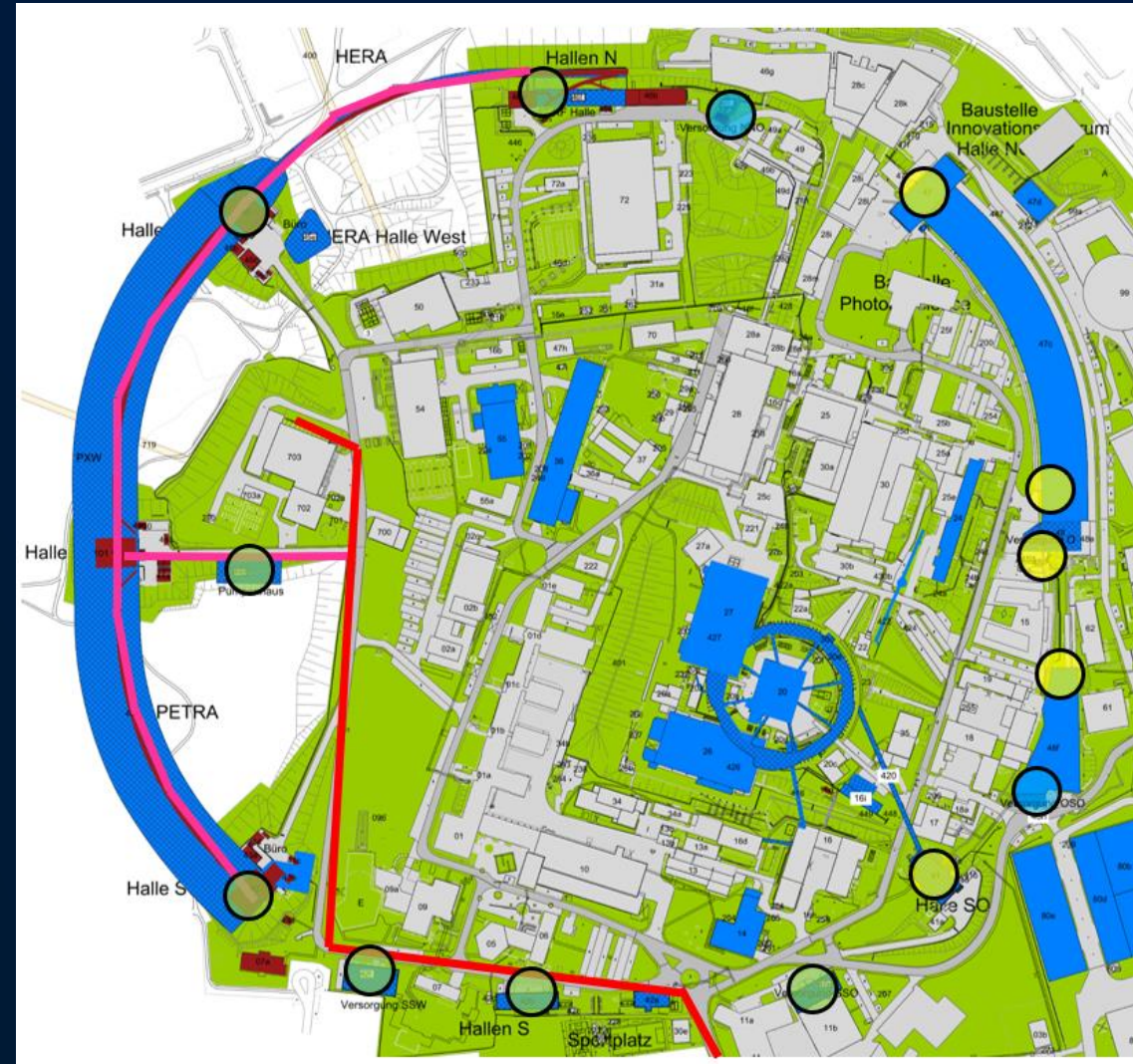
District heating

Connection to the external district heating network

DESY local district heating supply

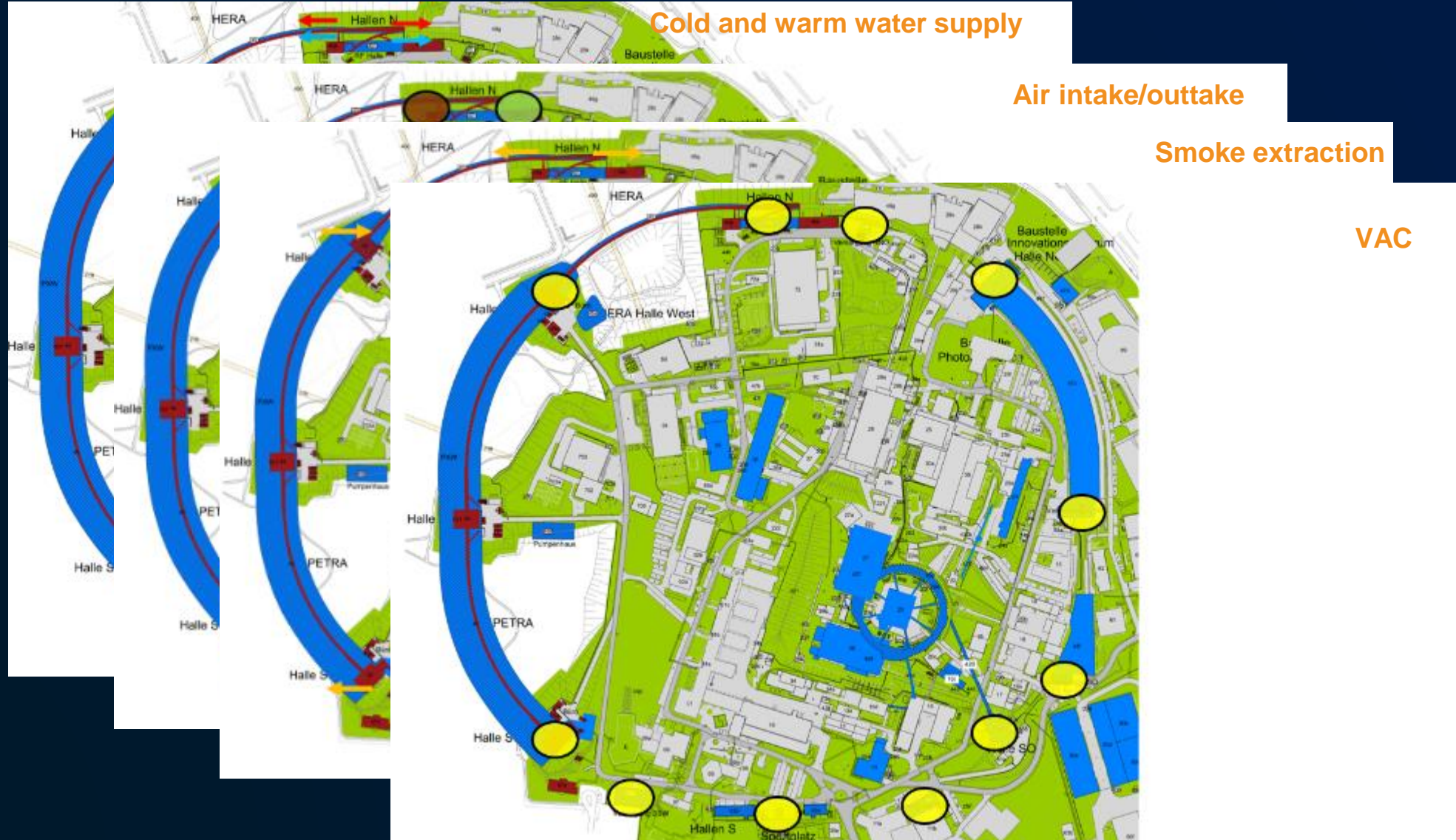
- Primary district heating circuit (55 to 105 °C)
- Secondary district heating circuits (50 °C)

- Existing district heating distribution – available for PETRA IV
- New district heating connections for PETRA IV (low-T)
- New district heating circuits für PETRA IV (high-T)
- Extension of the low-T network
- District heating connection from XFEL to Campus South



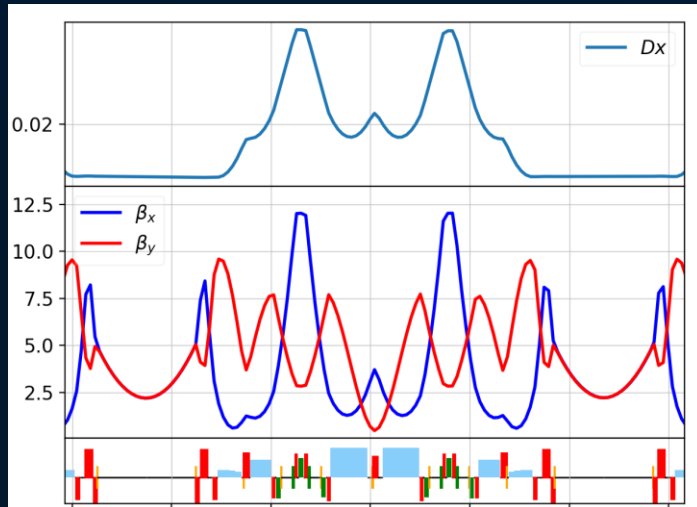
PETRA IV – HVAC

Water and fresh air supply

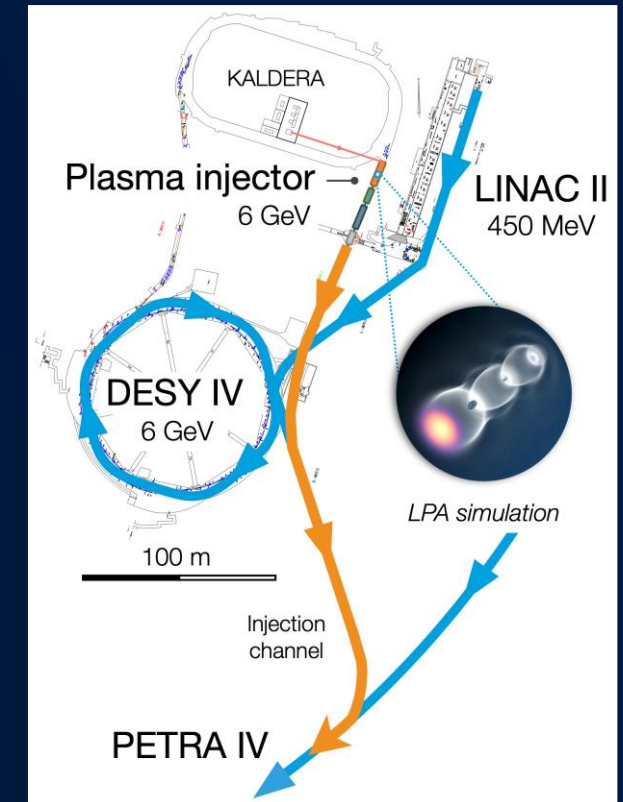
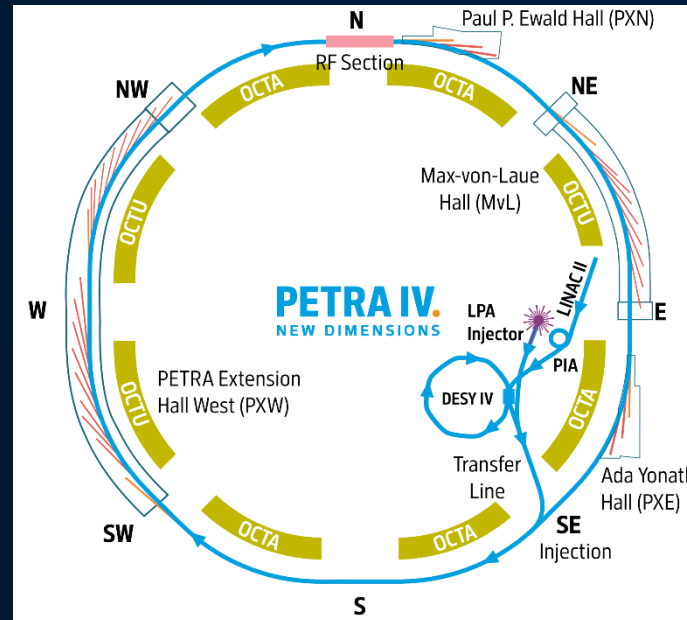


Accelerator Complex – PETRA IV Lattice Design in Place

Lattice with novel H6BA unit cell (design frozen) that is replicated identical across all octants (72 cells)

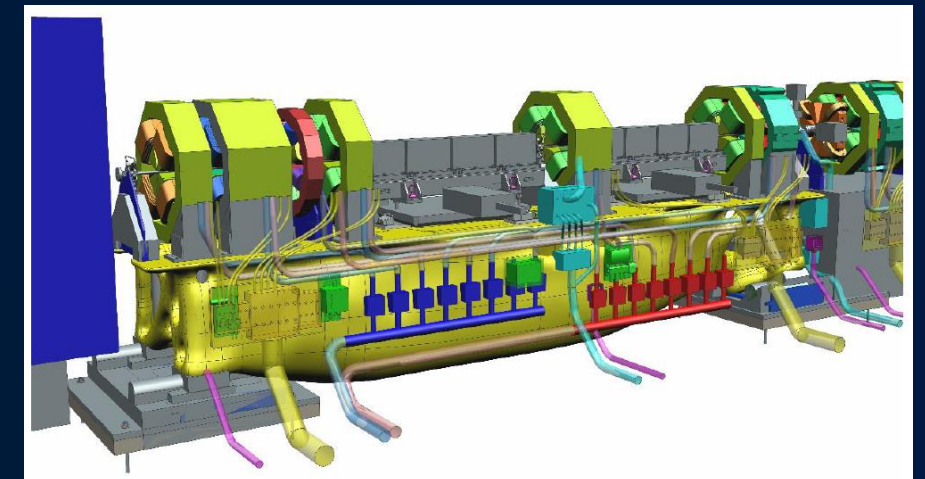
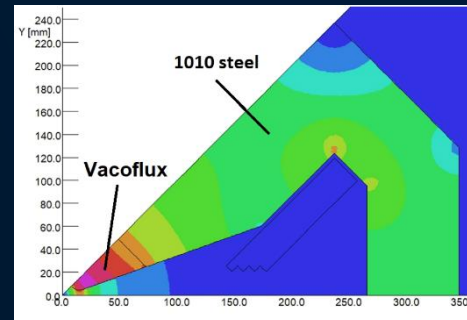
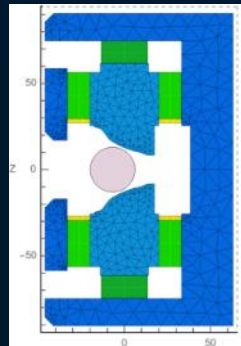
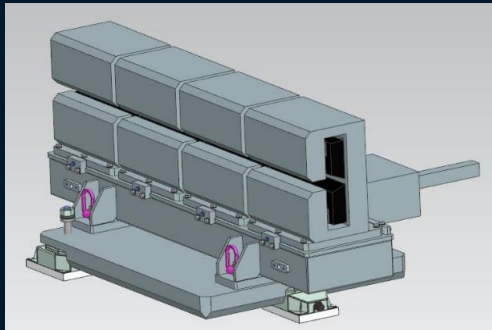
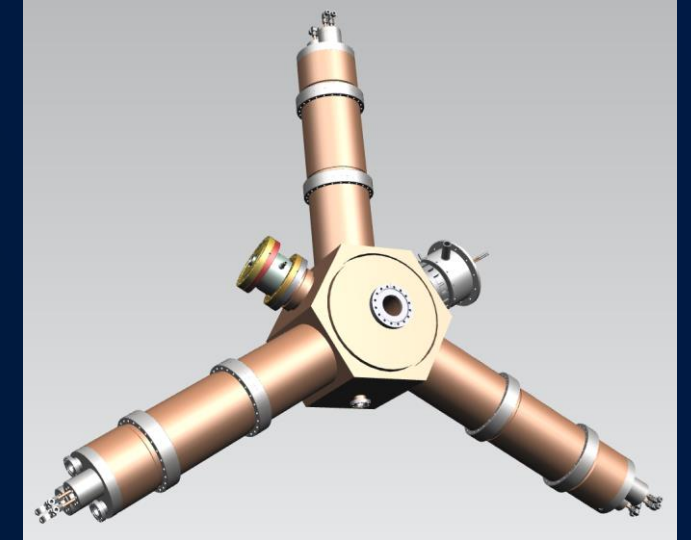
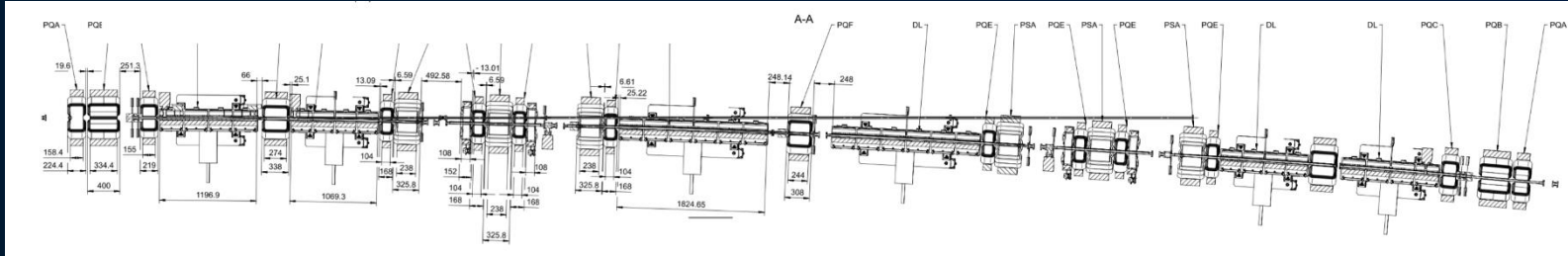


$20 \times 4 \text{ (pm}\cdot\text{rad)}^2$



Accelerator Engineering Design

Engineering design is progressing well and the prototyping/testing programme is ongoing

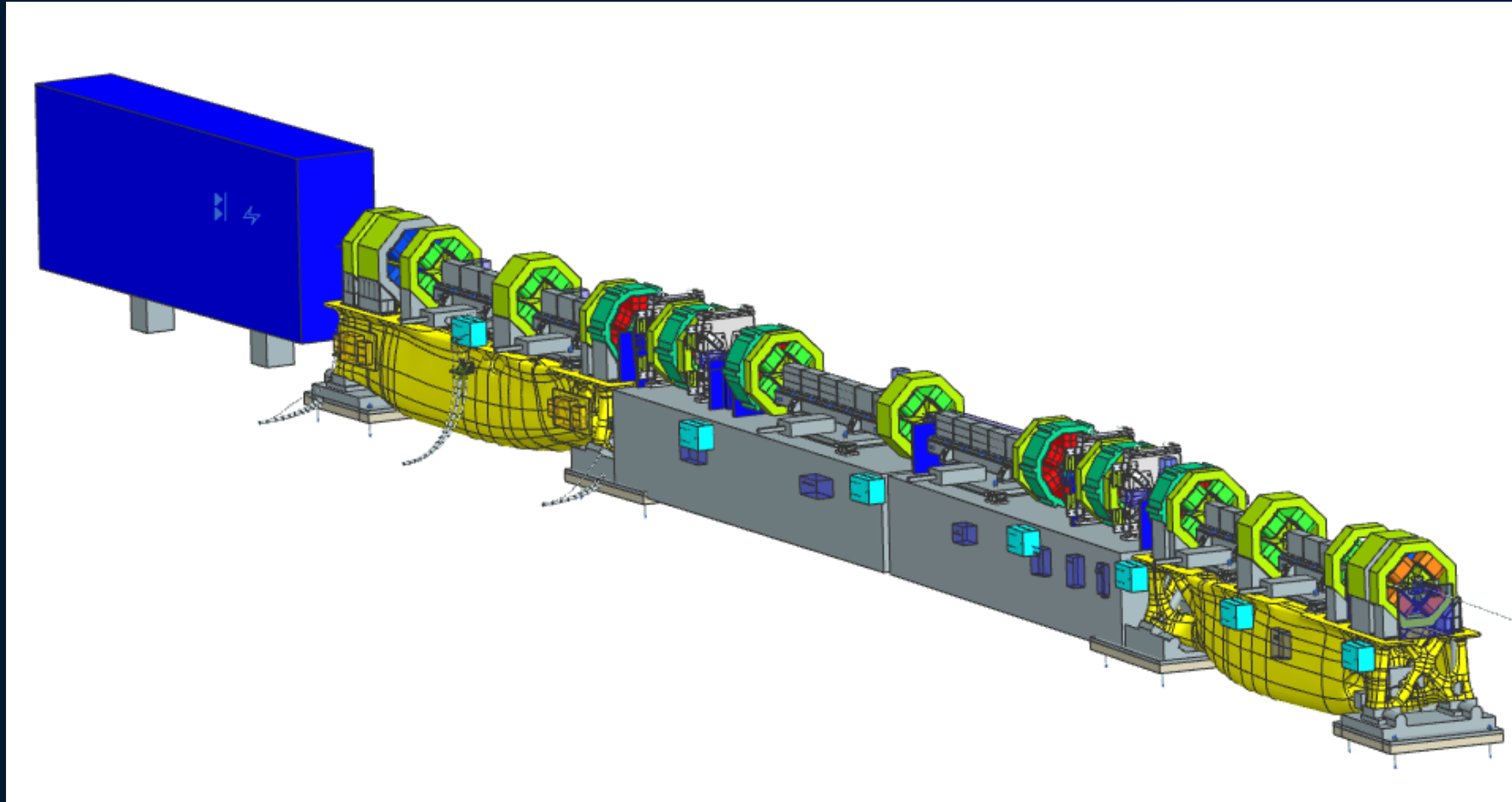


Accelerator Engineering Design

The accelerator components are mounted on girders

„Girder“ refers to the full assembly with magnets, vacuum string, cables, pipes and auxiliaries

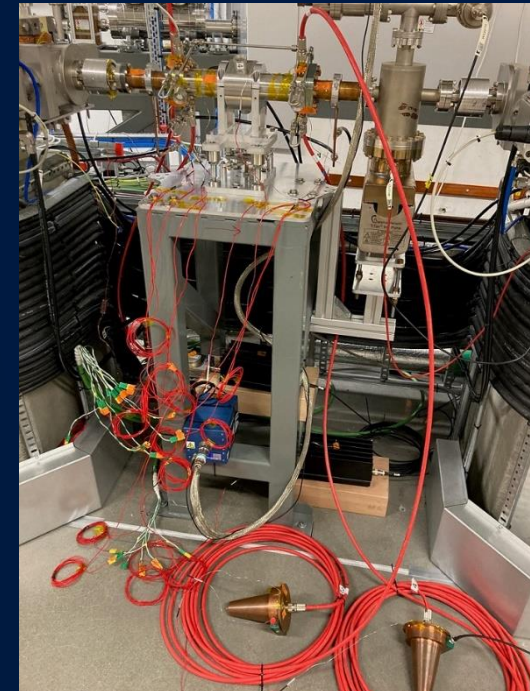
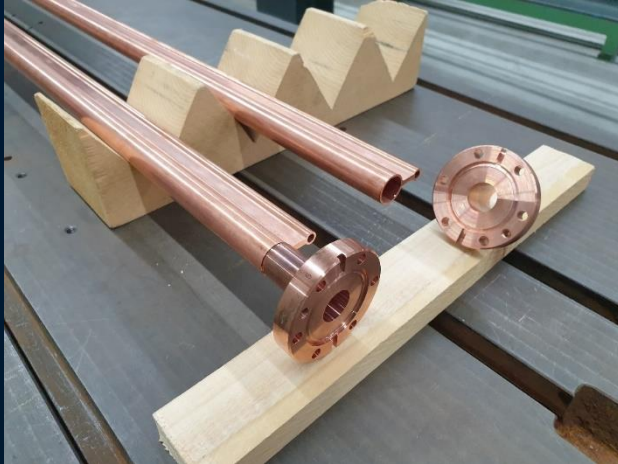
The total number of girders is $8 \times 9 \times 4 = 288$



Prototyping is underway

Very large number components:

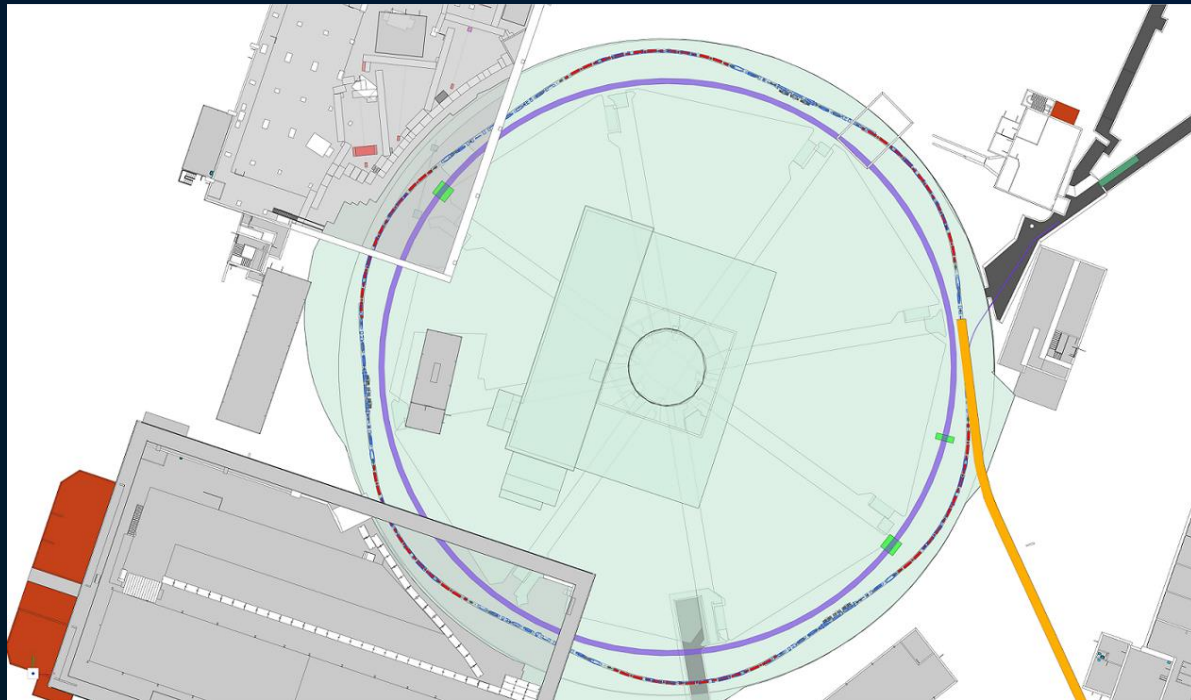
- ~ 4000 magnets & power supplies
- ~ 1000 vacuum chambers
- ~ 1000 pumps
- ~ 2400 racks
- 48 RF cavities



DESY IV Booster Synchrotron

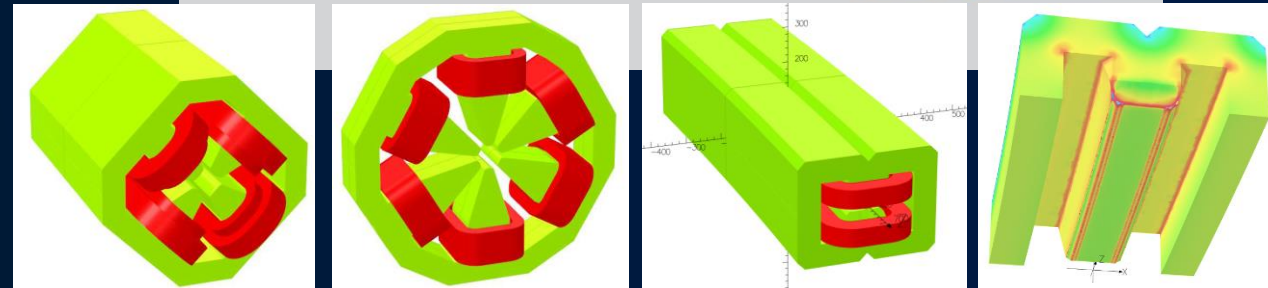
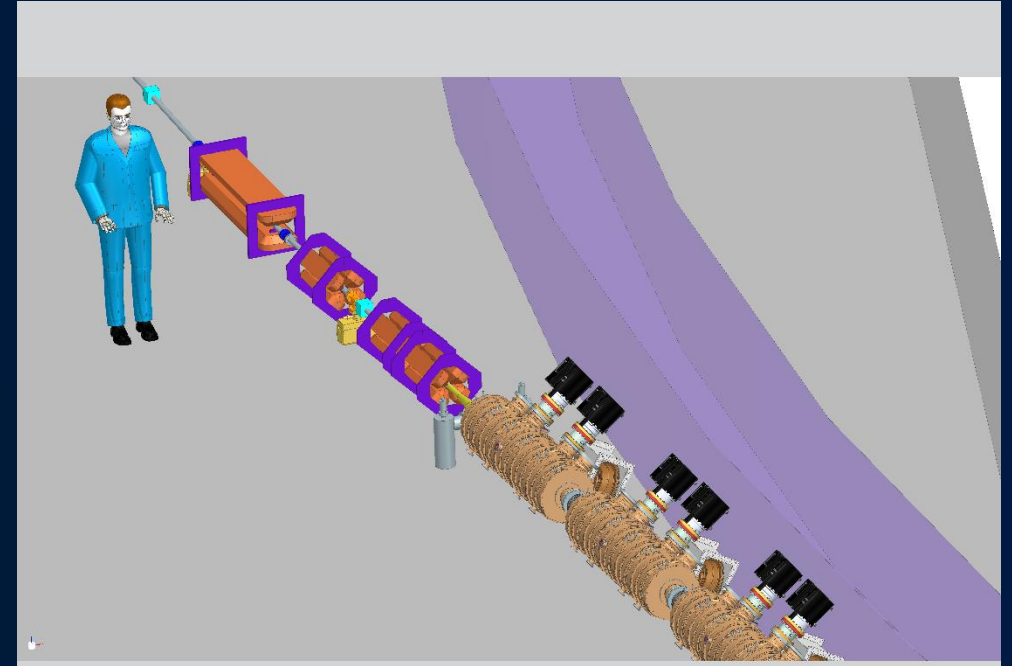
Construction of the new booster DESY IV for injection into PETRA IV

The lattice was frozen last year with a design delivering 20 nm – 1 nC single bunch operation reusing the LINAC-II and PIA ring

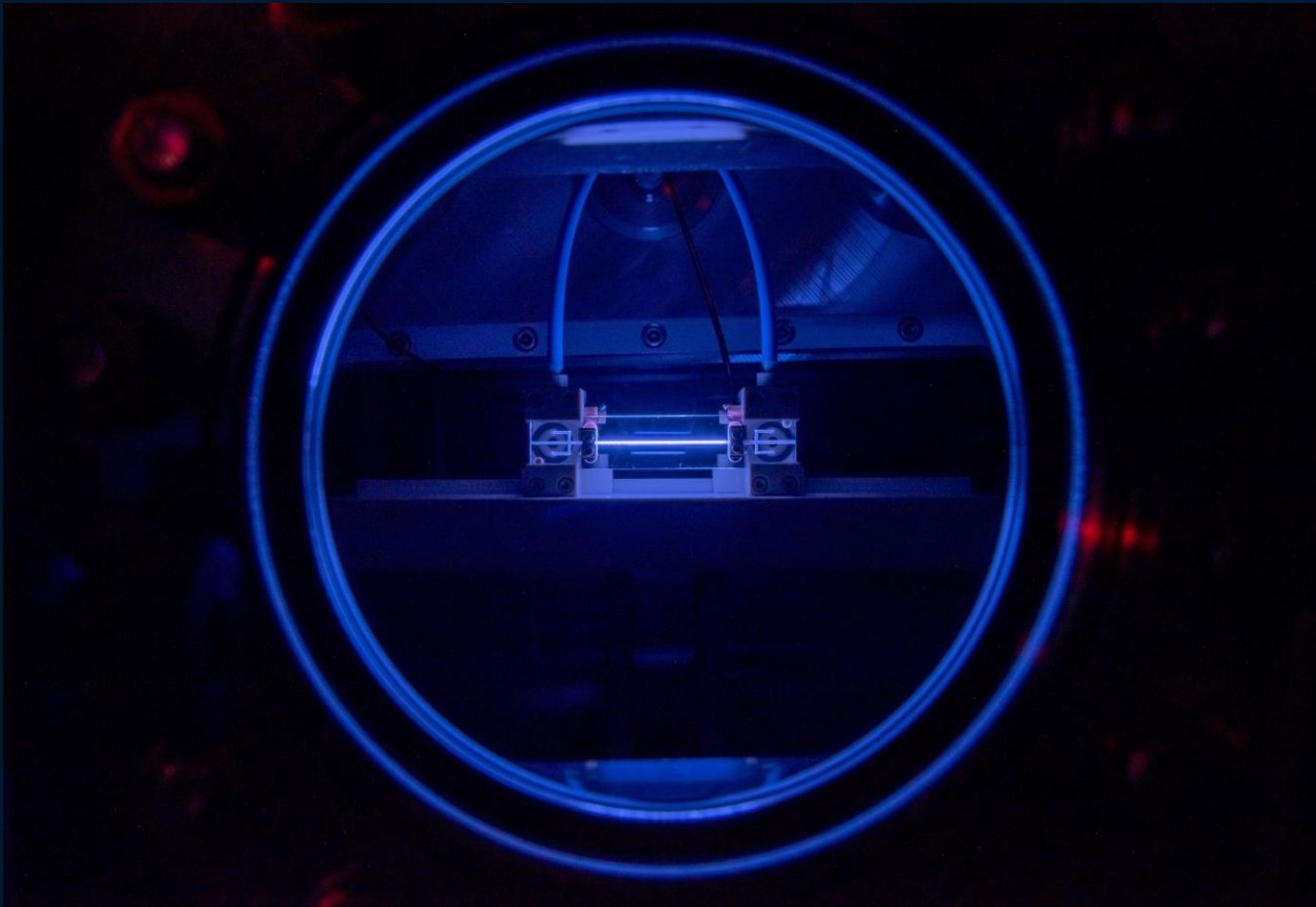


The DESY IV booster (316.8m) has 252 magnets and 9 RF cavities

System design and CAD integration



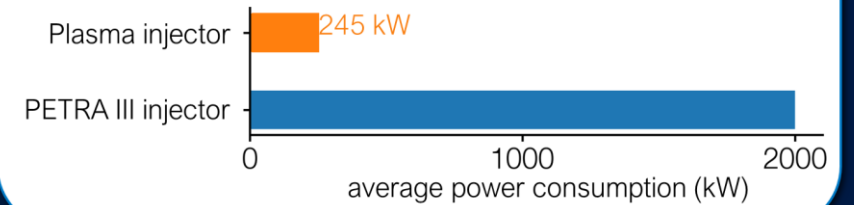
PIP4 – Laser Plasma Injector for PETRA IV



Why?

- ▶ **Compact**
 - plasma injector + beamline: < 50 m

- ▶ **Cost-effective**

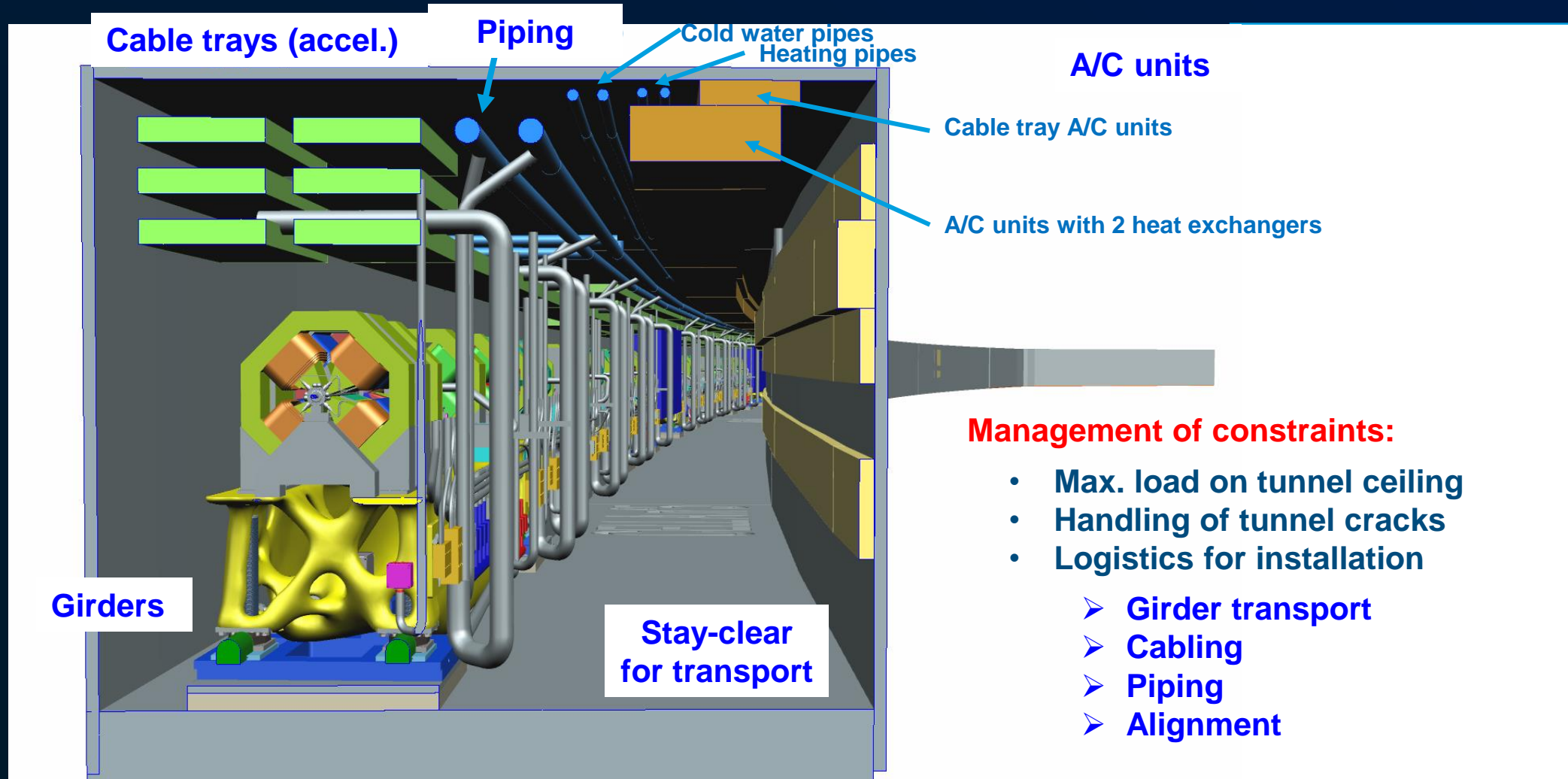


Key challenges

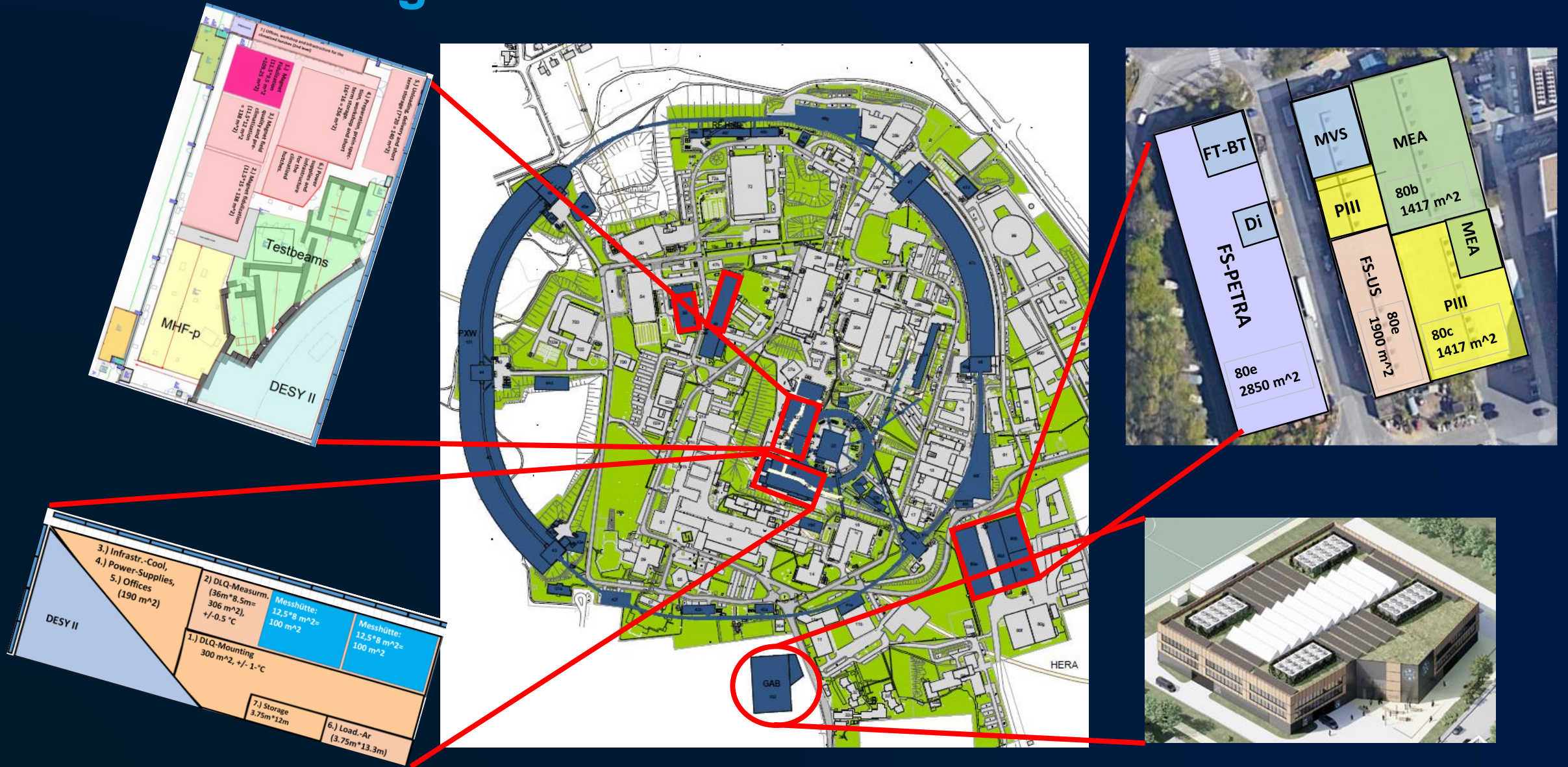
- ▶ 6 GeV injection energy
- ▶ Energy spread acceptance $\pm 1\%$ including all jitters
- ▶ Average current 2.7 nC/s for filling the ring in 10 minutes
- ▶ 99%+ uptime for user happiness

View into the PETRA tunnel

very crowded environment



PETRA IV – Logistics

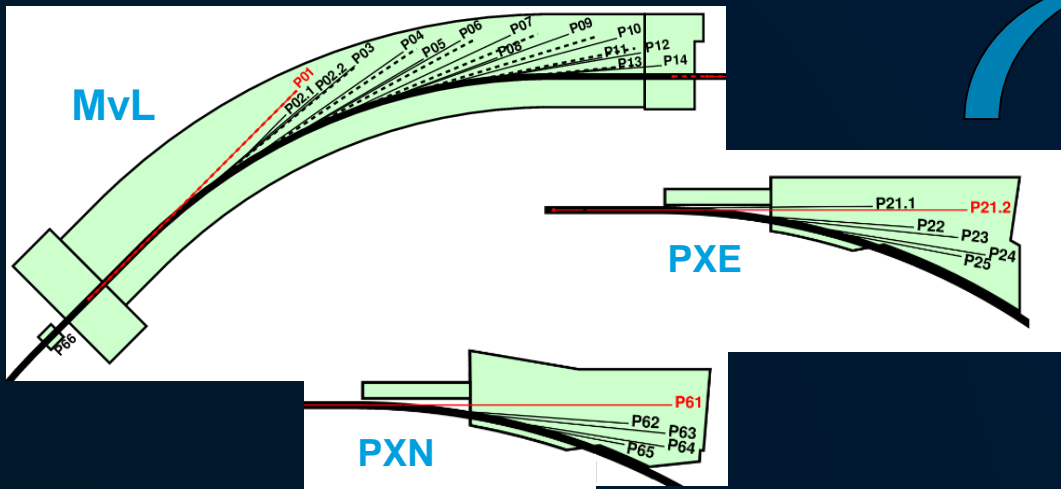


PETRA IV – Experiments

Number and Distribution of Beamlines

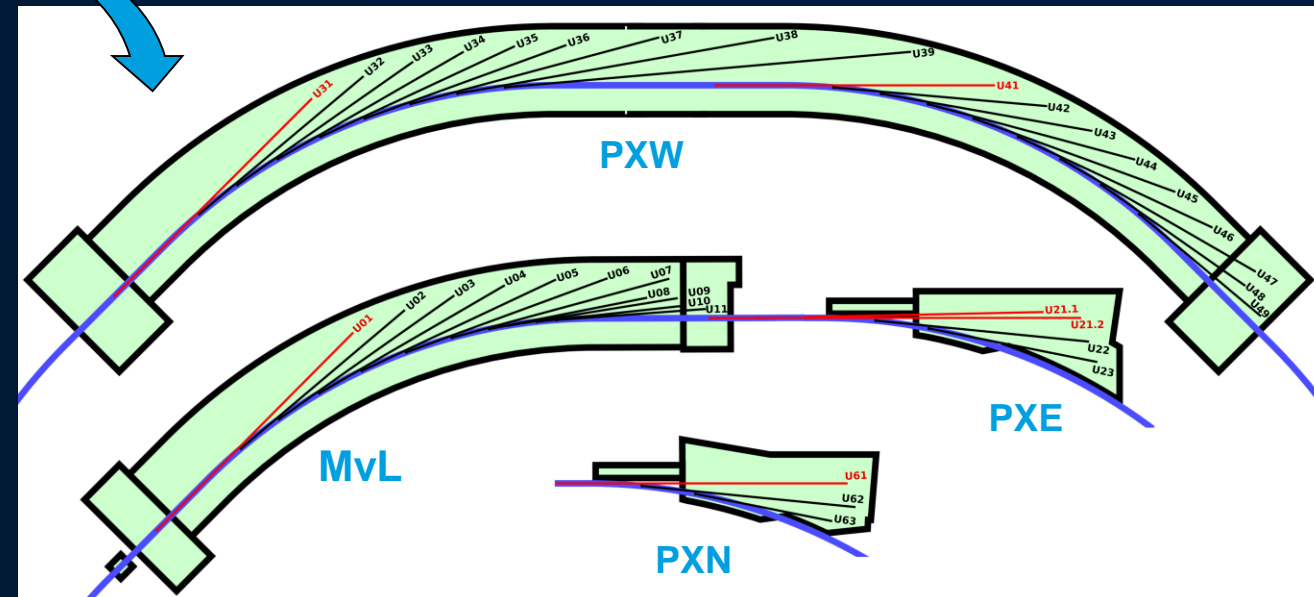
PETRA III Beamlines (max): 26 + 1 VUV

- 25 beamlines in operation (3 experimental halls)
- Many canted sectors (2 m and 5 m IDs)
- Partners: 3 EMBL, 2.5 Hereon, 1.3 India (virtual), Sweden, MPG



PETRA IV Beamlines (max): 35 + 1 VUV

- 31 ID project beamlines (4 experimental halls)
- Preservation of BL infrastructure in existing halls possible
- Canting very limited (1 – 5 mrad only, 4.3 m IDs)
- 5 high-brightness beamlines (10 m IDs)
- Partners: EMBL, Hereon, India, Sweden, MPG, ...

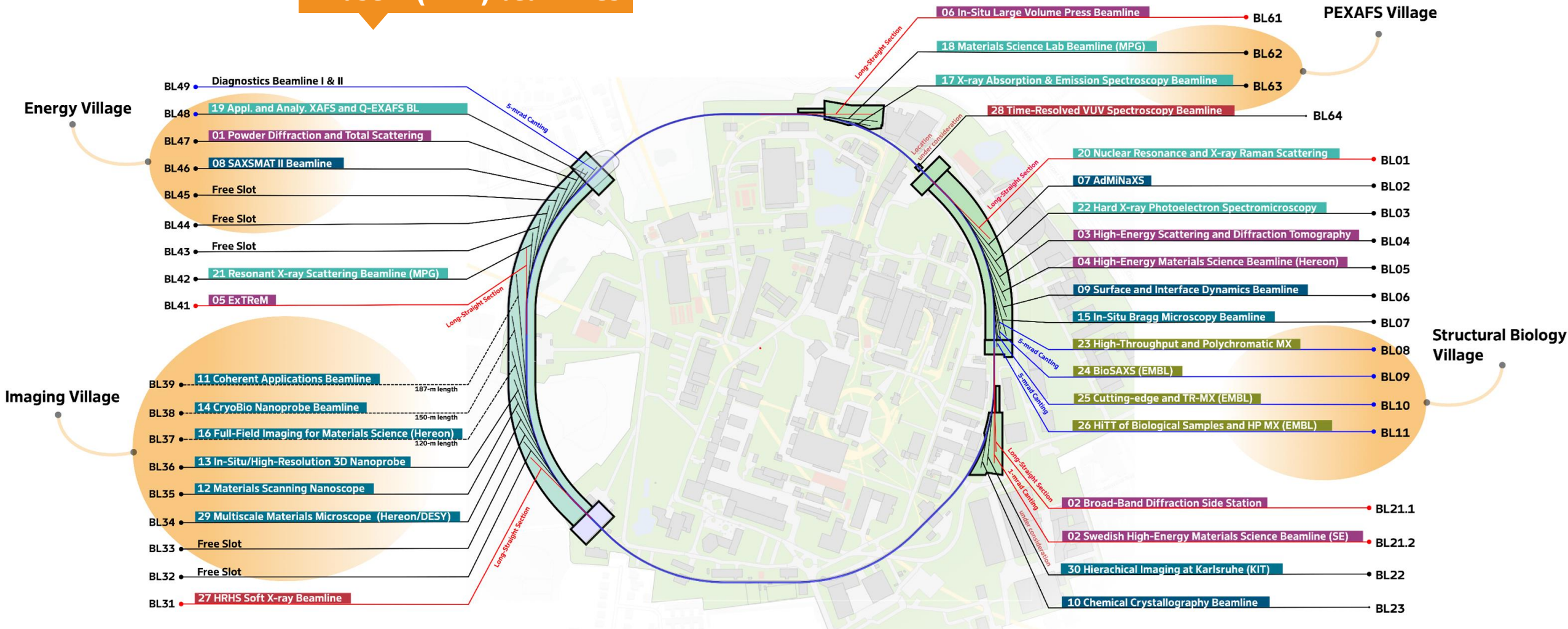


PETRA IV – Beamline Portfolio

Beamline Villages

Phase-II (PXW) beamlines

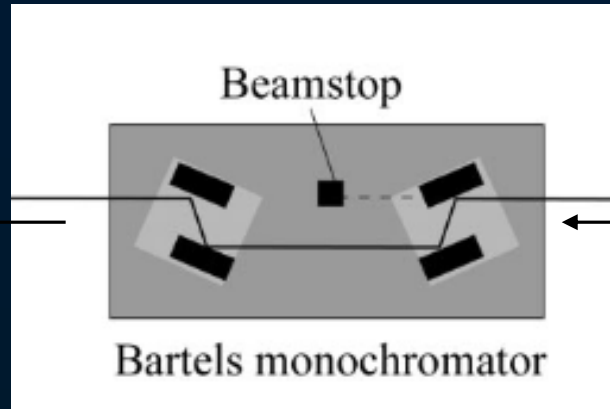
Phase-I beamlines



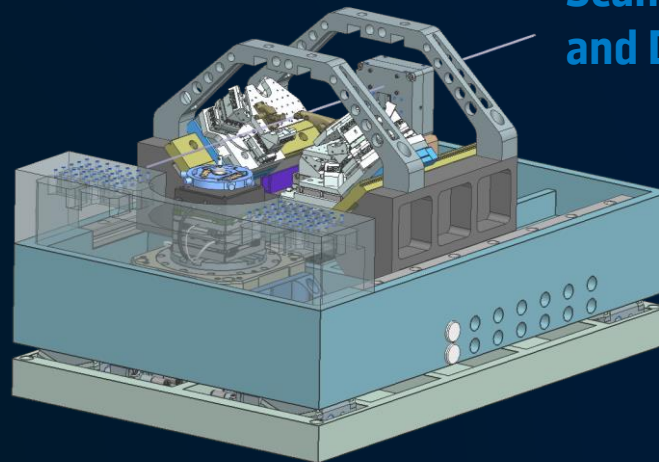
PETRA IV – Beamline Technology

Enhanced Beamline Capabilities

4-bounce monochromator

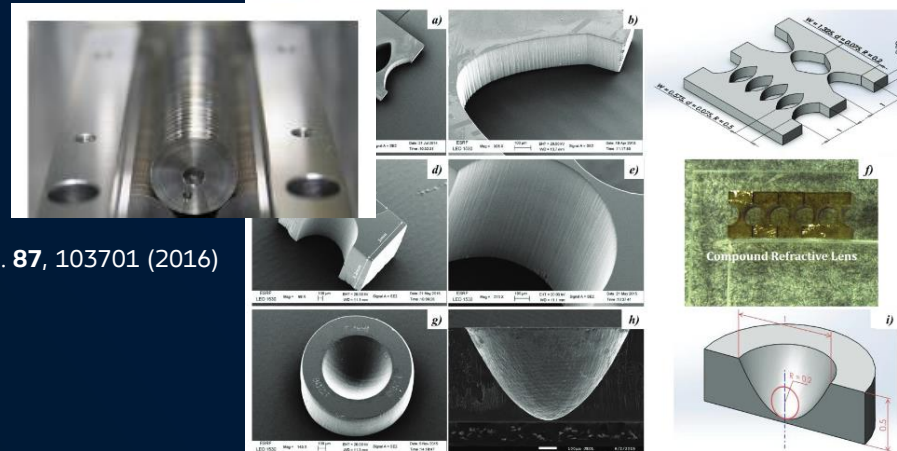


D. Lübbert et al., Acta Cryst. (2004). D60, 987-998



SPIDER-Project

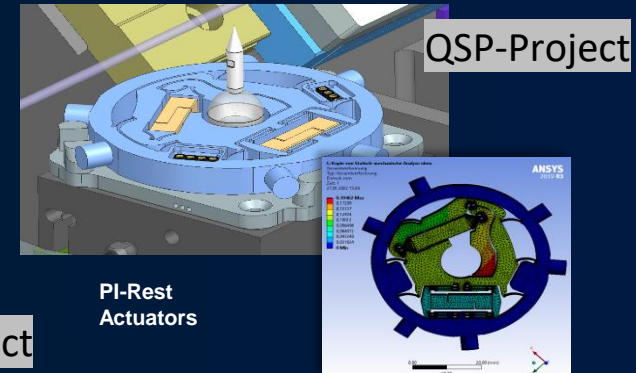
Diamond CRLs and Lens changer



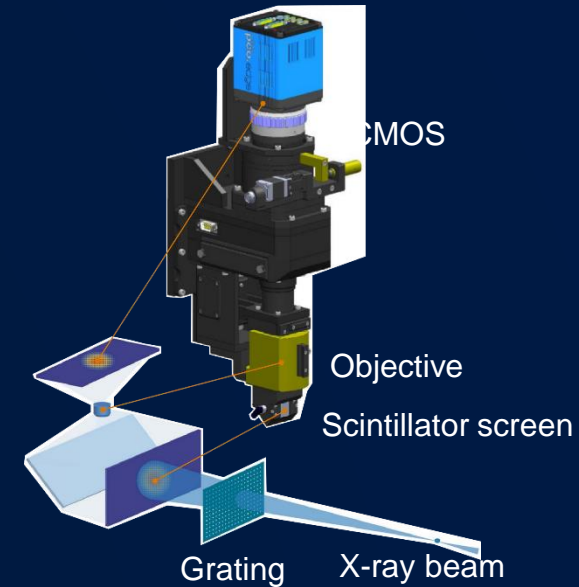
B. Nagler et al.
Rev. Sci. Instrum. **87**, 103701 (2016)

M. Polikarpov et al., Physics Procedia **84** (2016) 213 – 220

Scanning Platform for Imaging and Diffraction with Extreme Resolution



Wavefront Sensor



PETRA IV – List of Major Items

Buildings/Infrastructure

Experimental Hall West (PXW)

Supply Buildings

RF Hall

Refurbishment of a large number of Buildings

- 39 New buildings & building extensions
- 11 Existing buildings to be refurbished
- 28 Buildings to be demolished
- 4 refrigeration plants (13 MW)
water cooling
- Air handling systems (8 MW)
- Expansion of power supply network
- Renewal and/or expansion of IT networks
- 2400 Electronic racks

New Accelerator structures

LPA injector

DESY IV Booster synchrotron

H6BA PETRA IV storage ring

Transfer lines

- 2300 Resistive magnets (SR)
- 300 Resistive magnets (Booster)
- 432 Permanent magnet dipoles
- 288+6 Girders
- 48 RF cavities
- 48 (SR) + 9 (Booster) SSAs
- 1250 Vacuum chambers
- 1000 Vacuum pumps
- 5000 power supplies
- 10 Kickers & HV pulsers
- 10 septa
- BPMs, Diagnostics, etc.

Experiments

16 new beamlines

10 completely refurbished beamlines

5 partially refurbished beamlines

- 102 Hutches
- 20 Monochromators
- 41 Transfocators
- 26 Mirror systems
- 22 KB systems
- 39 Pixel detectors
- 35 Other detectors
- 62 Endstations
- 445 BL control electronics elements
(ZMX, MicroTCA, Timer, NIM, ADC)
- Large amount of IT hardware

PETRA IV – Schedule

Project fixed by (external) boundary conditions

- Start of operation 1/2030 with 19 beamlines
- Shutdown of max. 2 years (2028/2029)
- Overall project duration to full project delivery: 8 years (2025-2032)

