Status PETRA III and PETRA IV project

Hans-Christian Wille on behalf of the PETRA III Team

Workshop on Targeted Challenge-Driven Proposals, Hamburg, 5th of October 2023

HELMHOLTZ

DESY.

PETRA III

DESY's Brilliant Synchrotron Radiation Source

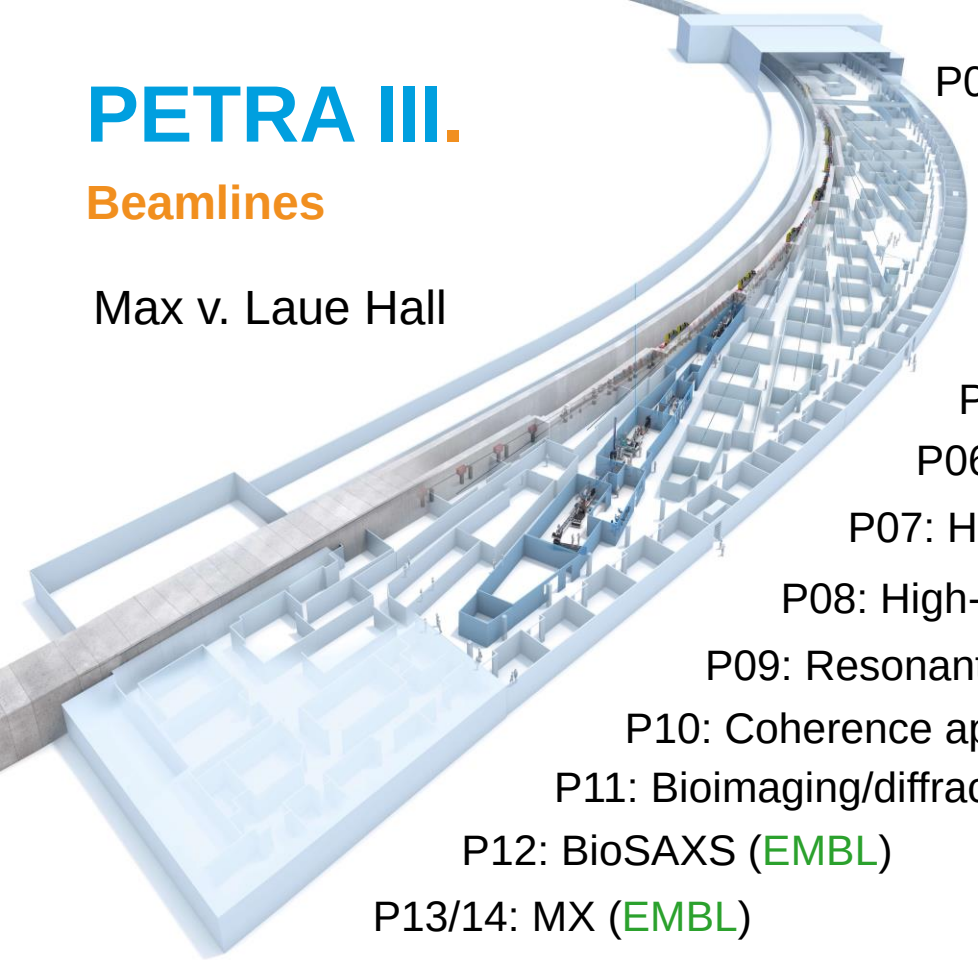
History of PETRA:

- 1978 built for high-energy physics, first direct observation of the gluon, since 1988 pre-accelerator for HERA
- starting July 2007: rebuilding PETRA as a synchrotron radiation source (PETRA III)
- Sept. 2010: **start of user operation** with the first three beamlines
- End of 2013: all 15 beamlines fully operational in Max v. Laue Hall
- Mar. 2014 - Apr. 2015: **Shutdown for extension project** after the DORIS III shutdown
- 2016: First two beamlines in the extension operational
- 2021: PETRA III extension project complete
- **planned for end of 2026:** shutdown of PETRA III as part of PETRA IV upgrade

> electron energy:	6 GeV
> stored current:	100 / 120 mA (top-up)
> emittance (h × v):	**1.3 nmrad × 10 pmrad**
> circumference:	**2304 m**
> photon energy range:	250 eV — 150 keV
> beamlines in operation:	**25**
> beamlines under construction:	**1.5** (P25 & P23-KIT)
> beamlines in planning:	**1** (P63)
> user operation (hours/year):	5000 h (4000 h)
> bunch separation:	192 ns / 16 ns

PETRA III.

Beamlines



Max v. Laue Hall

P01: Dynamics beamline, IXS, NRS

P02.1: Powder diffraction & total scattering

P02.2: Extreme conditions

P03: Micro-, nano-SAXS, WAXS (DESY, Hereon)

P04: Variable polarisation XUV

P05: Micro-, nano-tomography (Hereon)

P06: Hard X-ray micro-, nanoprobe

P07: High-energy materials sci. (Hereon, DESY)

P08: High-resolution diffraction

P09: Resonant elastic scattering/diffraction

P10: Coherence applications

P11: Bioimaging/diffraction

P12: BioSAXS (EMBL)

P13/14: MX (EMBL)

P21: Swedish materials science beamline

- P21.1 High-energy broad band diffraction
- P21.2 High-energy diffraction and imaging

P22: Hard X-ray photoelectron spectroscopy

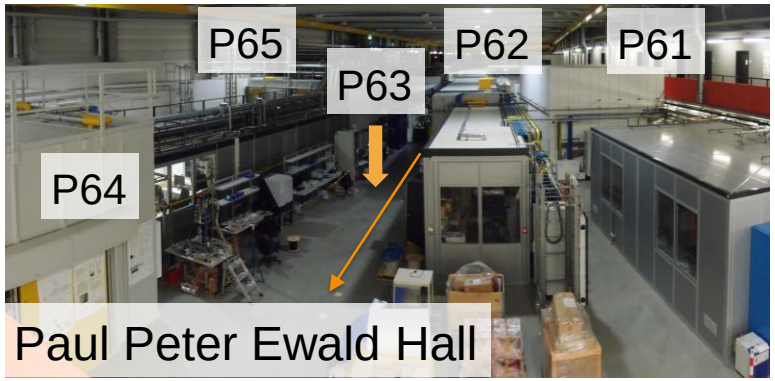
P23: In-situ and nano diffraction **/ HIKA** (DESY, KIT)

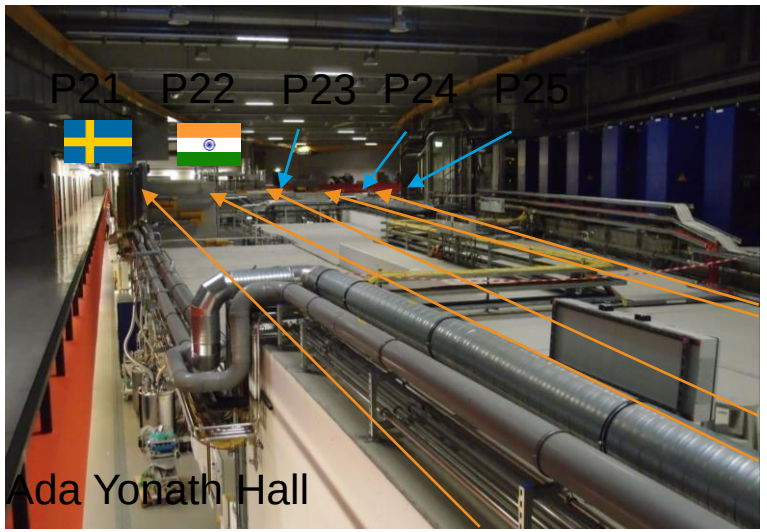
P24: Chemical crystallography

P25: Bio-med. imaging, Powder XRD, Innovation

ErUM Pro, ErUM Data

Federal Ministry of Education and Research





P61: High-energy wiggler beamline (Hereon, DESY)

P62: Small-angle X-ray scattering

P63: OperandoCat (MPG) (in planning)

P64: Advanced XAFS

P65: Applied XAFS

P66: Time-resolved luminescence spectroscopy

PETRA III

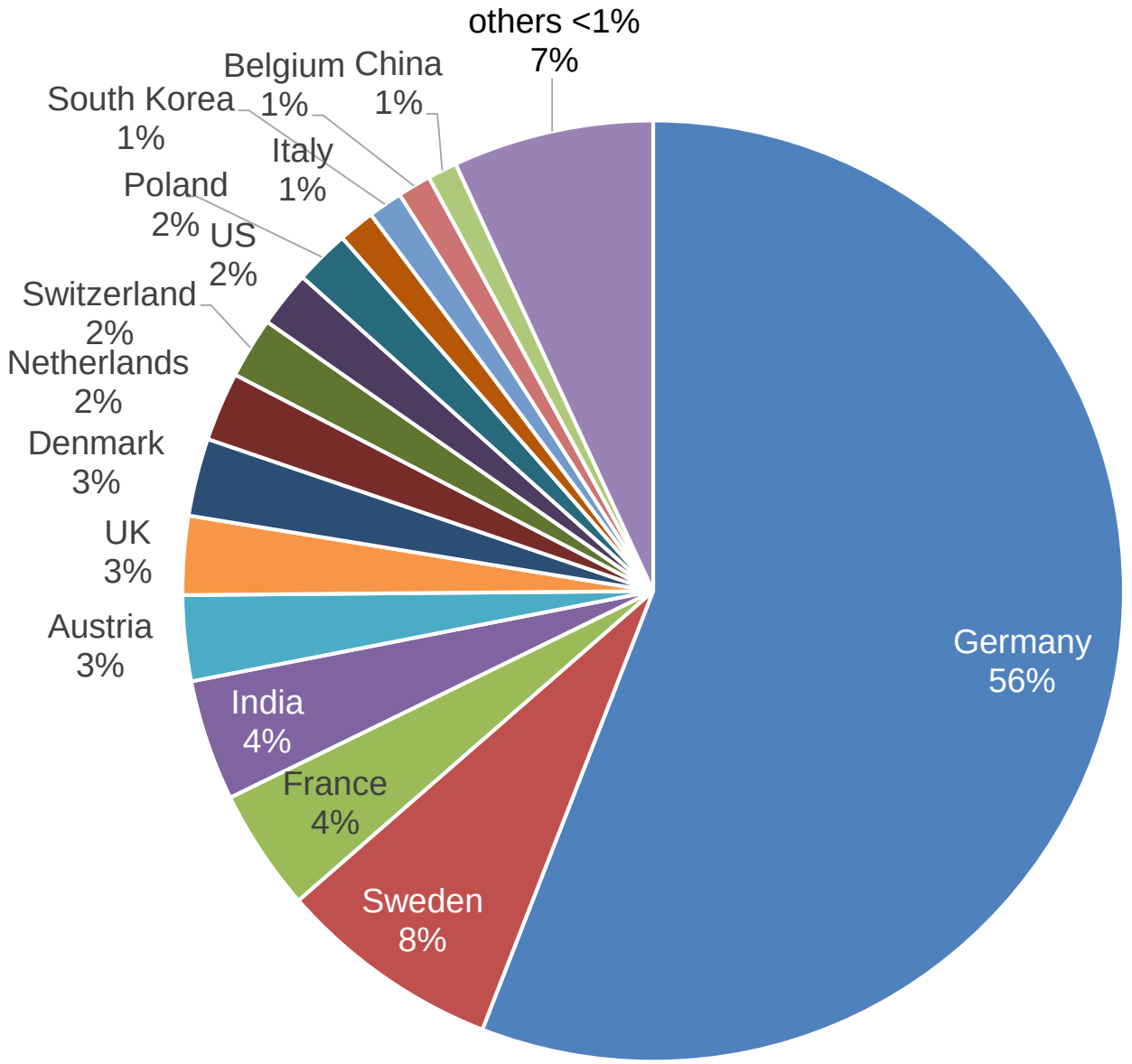
User Statistics 2022

PETRA III
Users: 3350
User visits: 7500

Return to normal user operation

Numbers include:

> on-site visits
> mail-in services
> remote access



PETRA III Schedule for 2023

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
winter		A	multi	40	multi	40	A	multi	40	A	40
shut down		multi	multi	40	multi	40	A	multi	40	multi	40
A		multi	service	A	multi	40		multi	40	multi	40
A		multi	week	40	multi	40		multi		multi	40
A		multi	A	40	multi			multi	40	multi	40
A		multi	A	40	multi	40		A	40	multi	A
A		multi		40		40		multi	40	multi	40
A				40	multi	40		multi	40		40
A		multi		40	multi	40	tr	multi	40	multi	40
A		multi			multi	40	multi	multi	40	multi	40
A		multi		40	multi	40	multi	service	A	multi	40
A		multi	tr	40	multi		multi	week	40	multi	40
A		multi	40	40	multi	40	multi	A	40	multi	A
A		multi	40	40	A	40	multi		40	multi	40
A	A	A	40	40	multi	40	multi		40	A	40
A		multi	40	A	multi	40		tr	service	multi	40
A		multi	40	40	multi	summer	multi	tr	week	multi	40
A	tr	multi	40	40	multi	shut down	multi	tr PIV	A	multi	40
A	tr	multi	A	40	multi	A	multi	40		multi	40
A		multi	40	40	multi	A	multi	40		service	winter
	tr	multi	40	40		A	multi	40	tr	week	shut down
	multi		40	service	40	A	tr PIV	40	tr	A	
	multi	multi	40	week	40	A	A	40	tr PIV		
	multi	multi	40	A	40	A	multi	40	multi		
	multi	multi	40	A	40	A	multi	40	multi	tr	
	multi	multi		A	40	A	multi	40	multi	tr	
	multi	multi	40		40	A	multi	A	multi	tr PIV	
	multi	multi	40		A	A	multi	40	multi	40	
		A	40		40	A	multi	40	multi	40	
		multi	40		40	A		40	multi	40	
		multi		tr		A	multi		multi		

Operation:
4776 h user service

- set-up / test run
- service week
- user run
- machine development time

4 days of test run for
PETRA IV

P25 hutches were built during summer shutdown

Covid-19 pandemic overcome

Inflation issues:

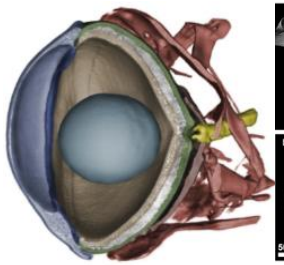
Electricity issue solved by federal state financial umbrella

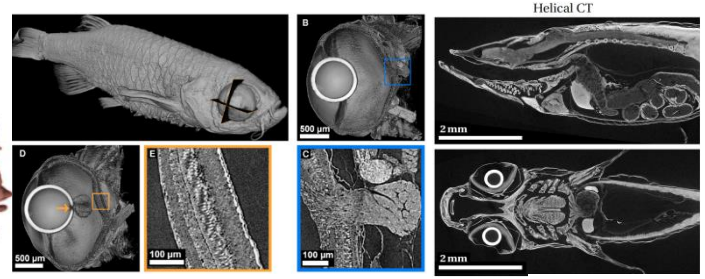
Helium shortage lead to a reduction of corresponding experiments and/or reduction of the accessible T range in run 1 (to about 40%), with some investment run 2 will be better of

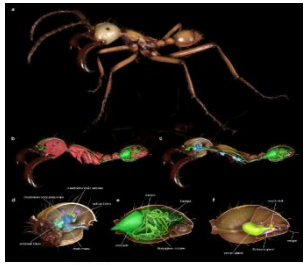
The HIKa Hierarchical Imaging Karlsruhe Station at P23

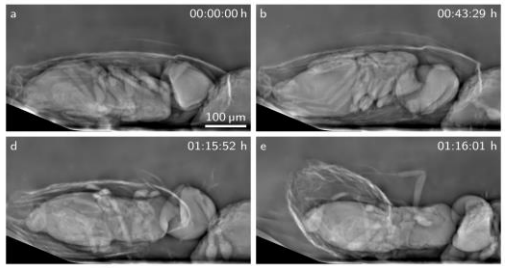
Aim: Morphological imaging

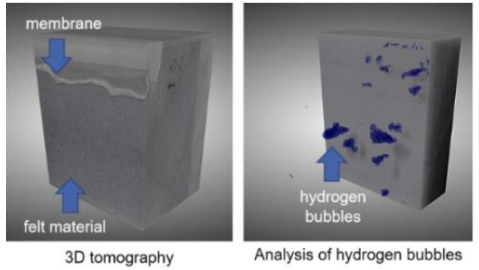
- combined parallel beam and X-ray microscopic imaging methods → multiscale / hierarchical morphological studies
- micro tomography & laminography → 3D morphology & morphometrics
- high-throughput up to serial CT → large comparative studies
- dose efficient up to *in vivo* imaging → morphodynamics
- multiple X-ray contrasts and light microscopy → correlated imaging

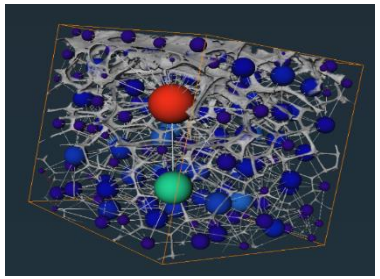


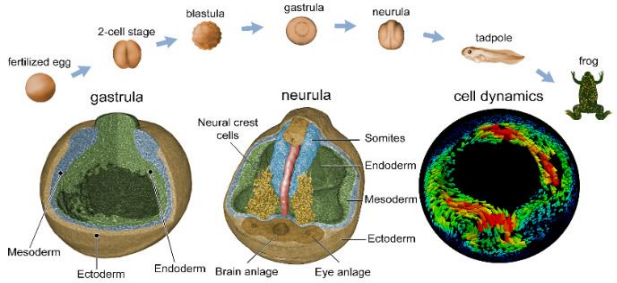


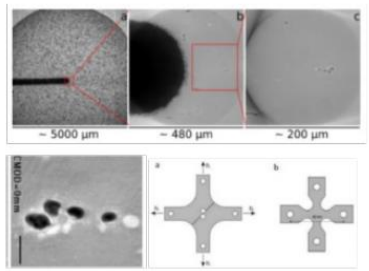


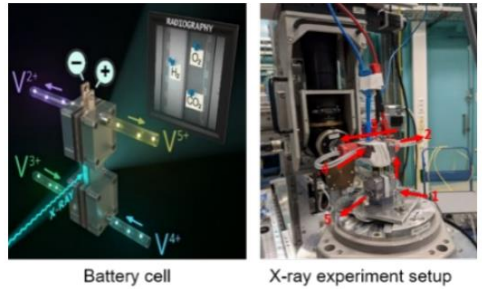












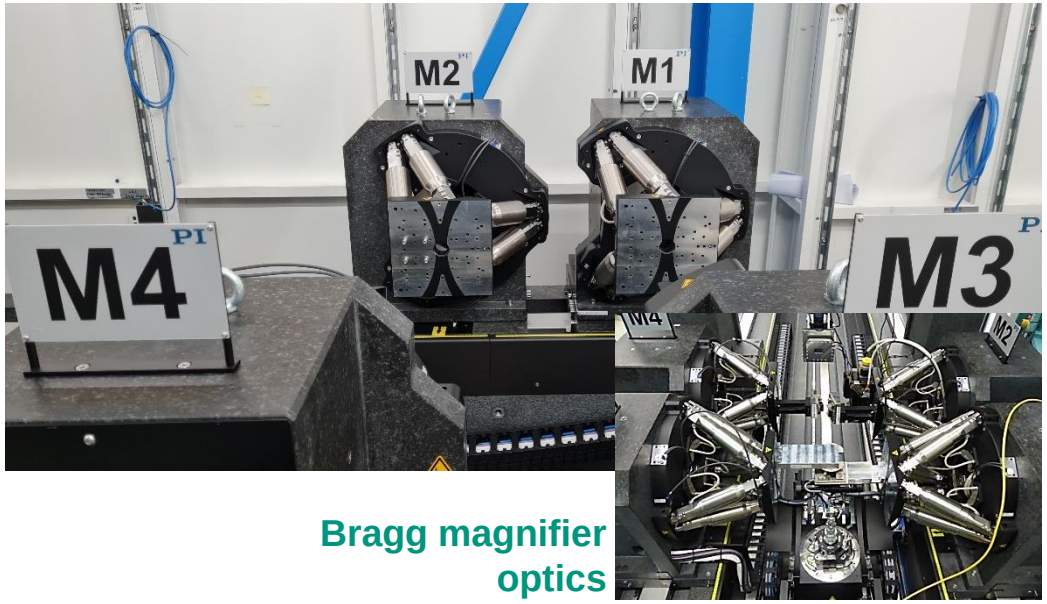
The HIKa Hierarchical Imaging Karlsruhe Station at P23

Major milestones

- **Parallel beam imaging**: absorption, phase contrasts (grating interferometry, propagation-based up to 4 m)
- **Bragg Magnifier optics:** bragg magnifiers for large FOV, bragg magnifier microscope (dose efficient imaging)
- **Microscopy: full-field X-ray in line holography & Scanning X-ray Microscopy** (STXM and SXFM)
- **3D imaging modes:** high resolution **Laminography & Tomography** (all imaging modalities)
- **Beamline automation: high-throughput experiments**, automatic sample handling, massive data analysis (all imaging modalities)

MiQA (September 2023)

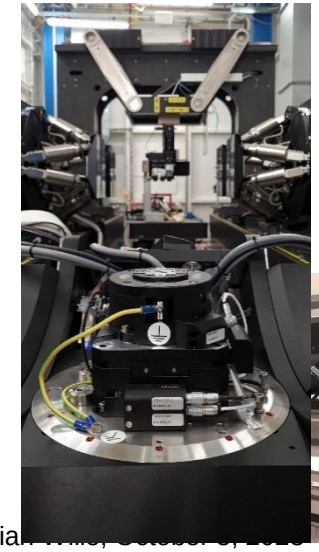
High precision under load sample hexapod



Bragg magnifier optics

Three magnification X-ray camera and detector portal

Grating interferometry



High-precision sample rotation

The HIKa Hierarchical Imaging Karlsruhe Station

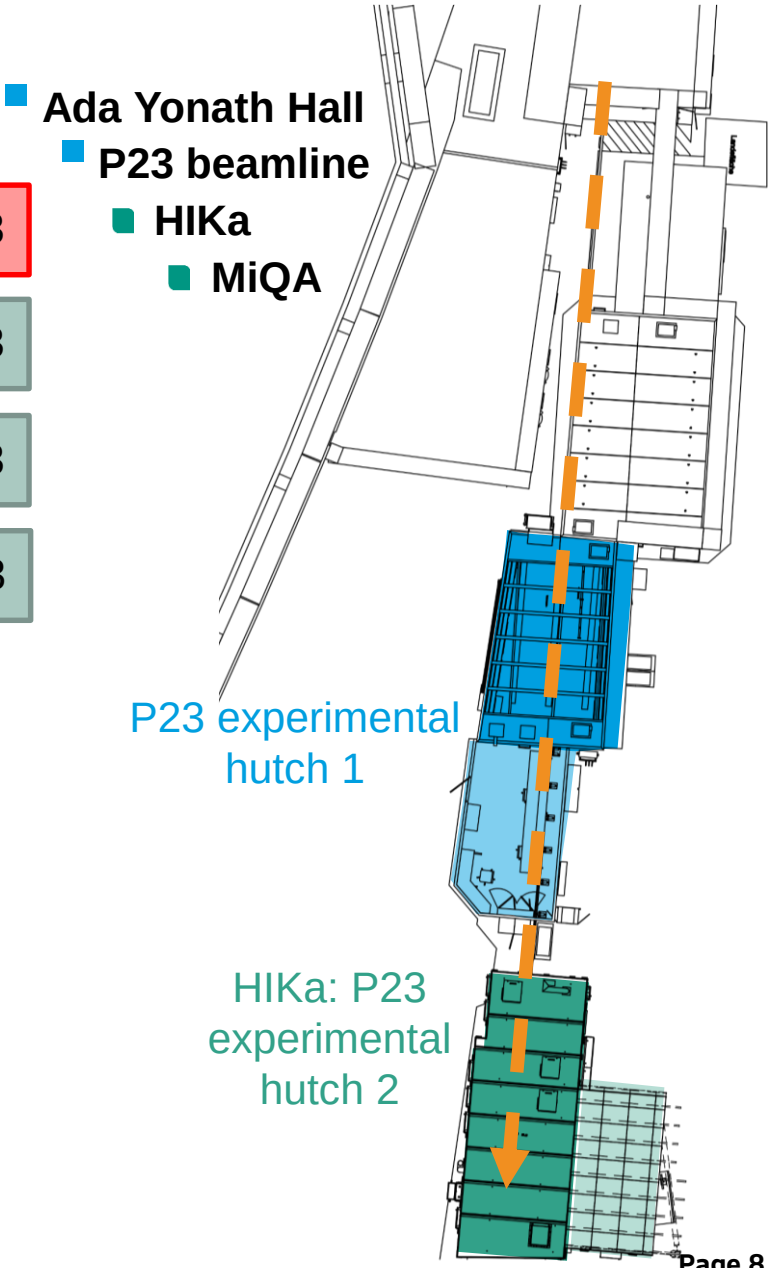
at the P23 Beamline at PETRA III

Construction of the Preparation and Control Hutches	Q1/2023
Technical infrastructure	Q2/2023
Commissioning of MIQA and further HIKA components	Q3/2023
TÜV, HIKA operation in parallel beam geometry	Q4/2023

Ada Yonath (HIKa roof top view)

HIKa CH and cabinet

HIKa EH and CH

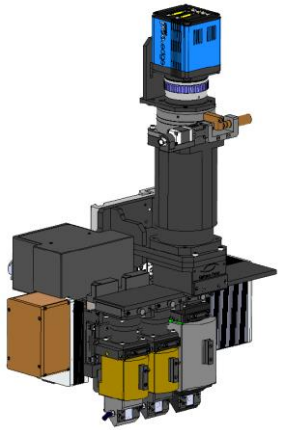


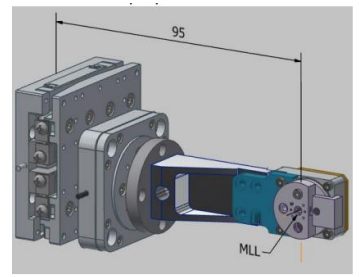
The HIKa Hierarchical Imaging Karlsruhe Station

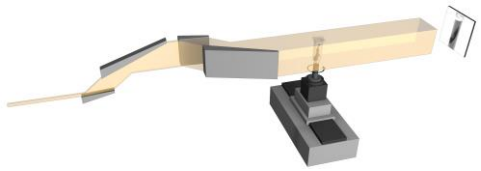
at the P23 Beamline at PETRA III / IV

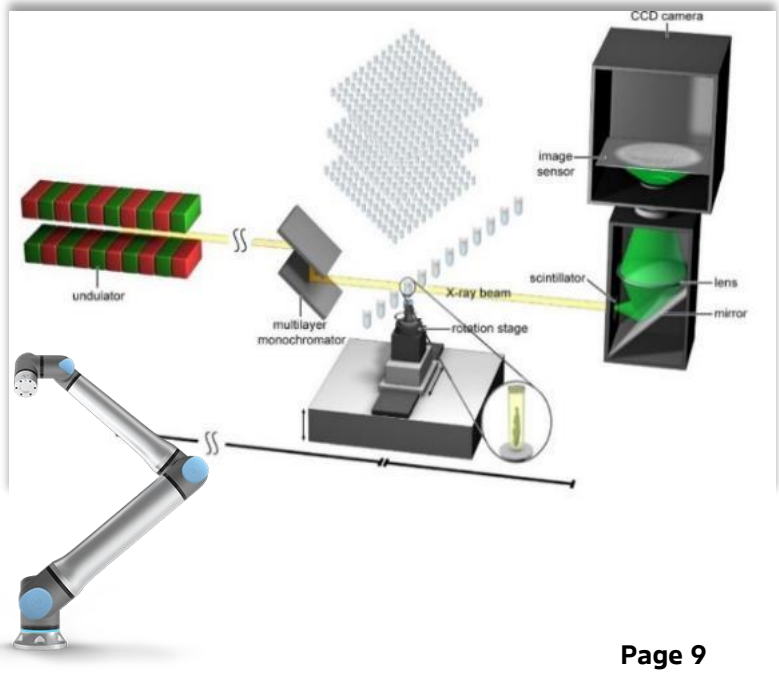
HIKa has taken part in the call for proposals 2023_II

Construction of the Preparation and Control Hutches	Q1/2023
Technical infrastructure	Q2/2023
Commissioning of MIQA and further HIKA components	Q3/2023
TÜV, HIKA operation in parallel beam geometry	Q4/2023
Implementation of hierarchical and in vivo imaging	Q2/2024
Implementation of hard X-ray microscopy	Q4/2024
Towards PETRA IV: SERIAL CT, BMBF ErUM pro SMART-Morph, BMBF ErUM data KI-Morph, KI4D4E	Q2/2026
Towards PETRA IV: MorphoSphere	2027









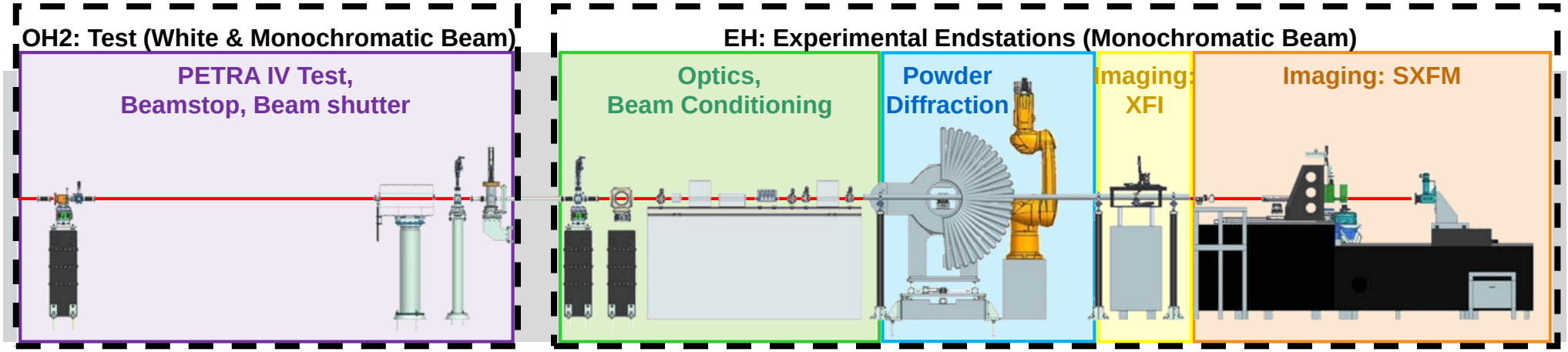
PETRA III

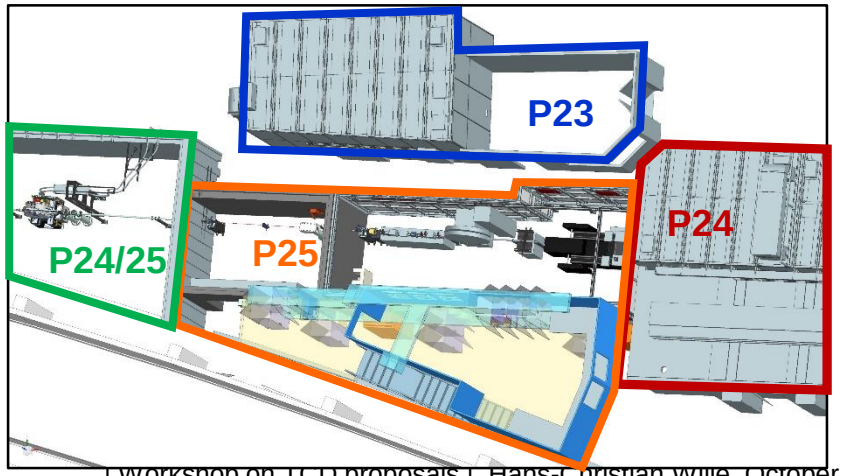
Beamline for Applied Bio-Medical Imaging, Powder Diffraction and Innovation P25

Beamline staff: Kathryn Spiers (manager), Niklas Thielen, Jackey (Canrong) Qiu.
In cooperation with ITT (A. Burkhardt), P06 (G. Falkenberg) and P02.1 (M. Etter, A. Schökel, V. Baran et.al).

User target groups: Industrial users
Impact-driven projects
Applied bio-medical research

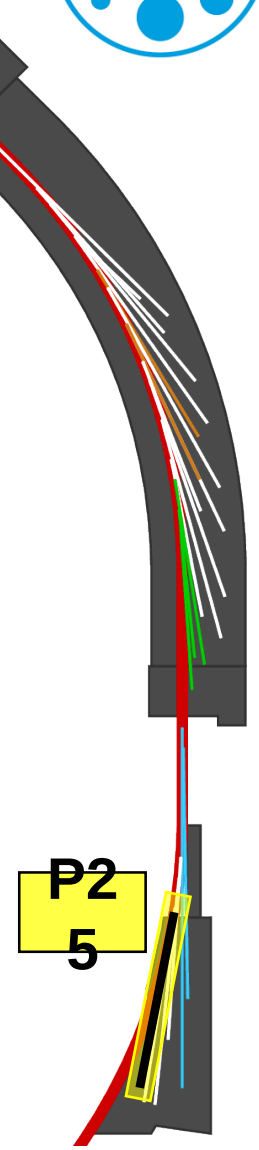
A joint ITT – FS Project under the umbrella of the DESY INNOVATION FACTORY





	Test	PD	XFI	SXFM
Energy	White & Mono	15 – 35 keV	50 – 60 keV	10 – 40 keV
Beamsize		50 µm² to 1.5 x 0.5 mm²	0.2 - 1 mm²	~1 µm²

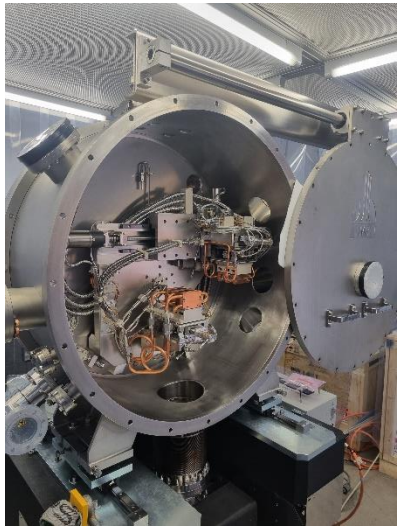
DCM Installation:	Q1 2024
Control Hutch Construction:	Q1 2024
Technical Infrastructure:	Q2 2024
First beam (OH2):	Q2 2024
First beam (EH):	Q3 2024



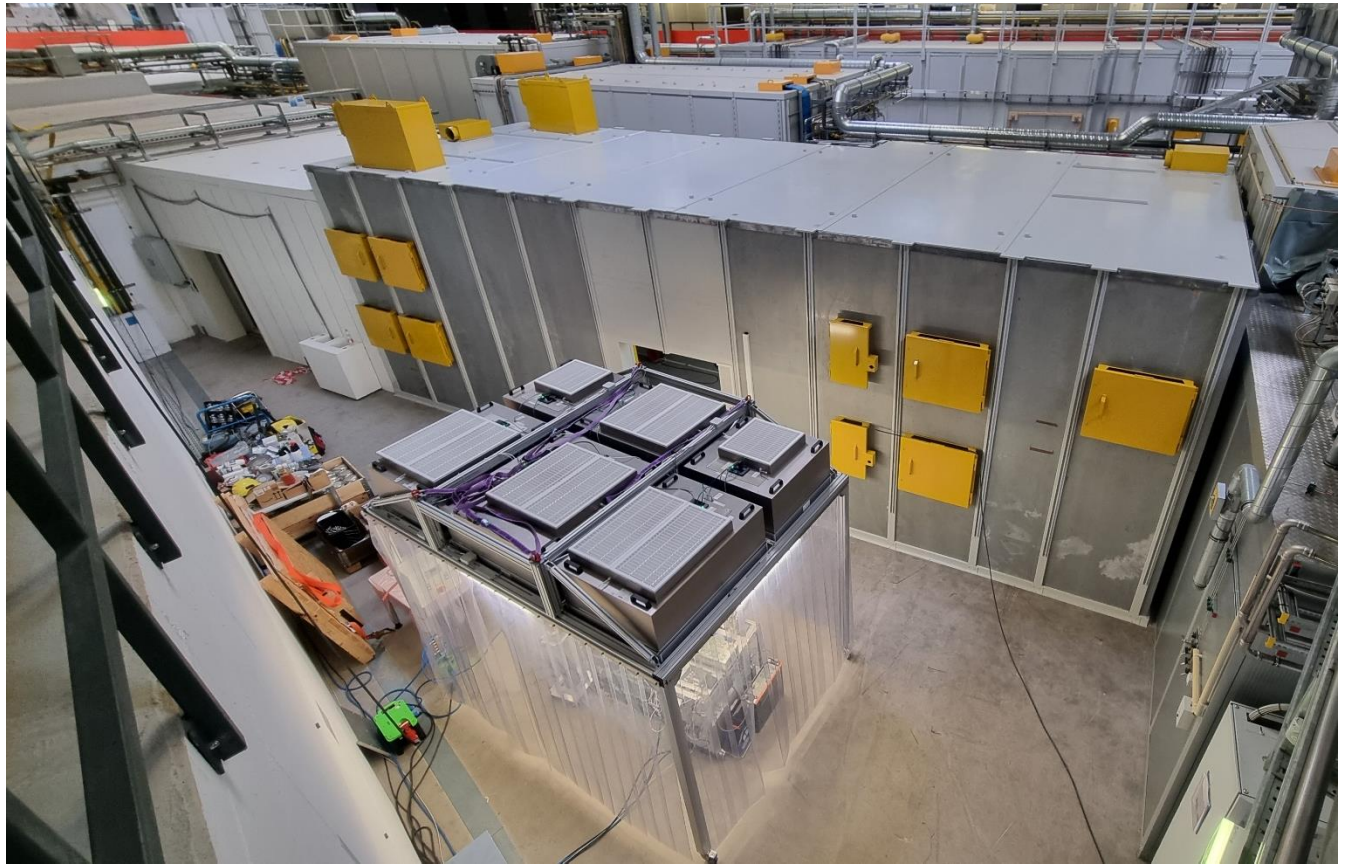
PETRA III

Beamline for Applied Bio-Medical Imaging, Powder Diffraction and Innovation P25

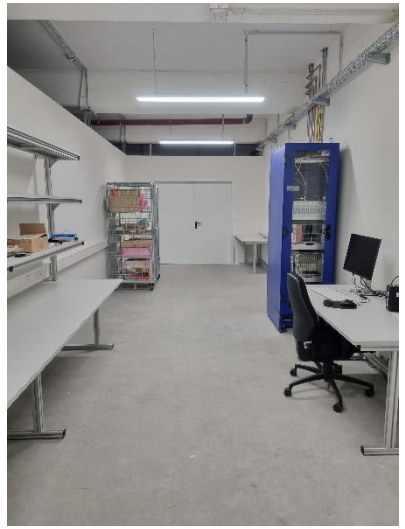
P25 Undulator installed



DCM delivered, leak-tested



P25 Optics Hutch 2 and Experimental Hutch
(DCM in Clean Room Tent in foreground).



P25 Integration Room

Mythen detectors for P25
under test at P02.1

PETRA III — Future Developments

Beamline P63: OperandoCat — Combined XAS/XRD/SAXS for Operando Studies of Energy Materials

Motivation:

> strong science case
> large user community
> P64/P65 strongly overbooked 2…4

Boundary conditions:

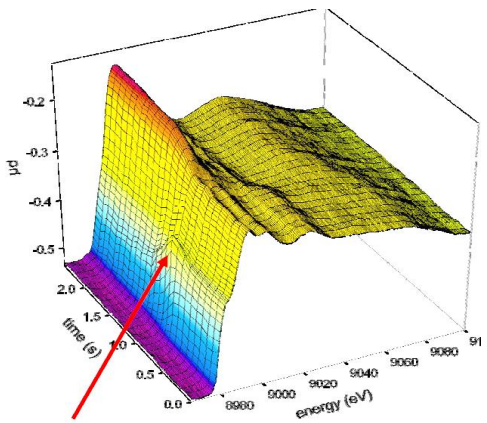
> PETRA III shutdown according to new schedule by end of 2026 ✓
> Beamline can persist at PETRA IV ✓
> Partners have full funds available ✓

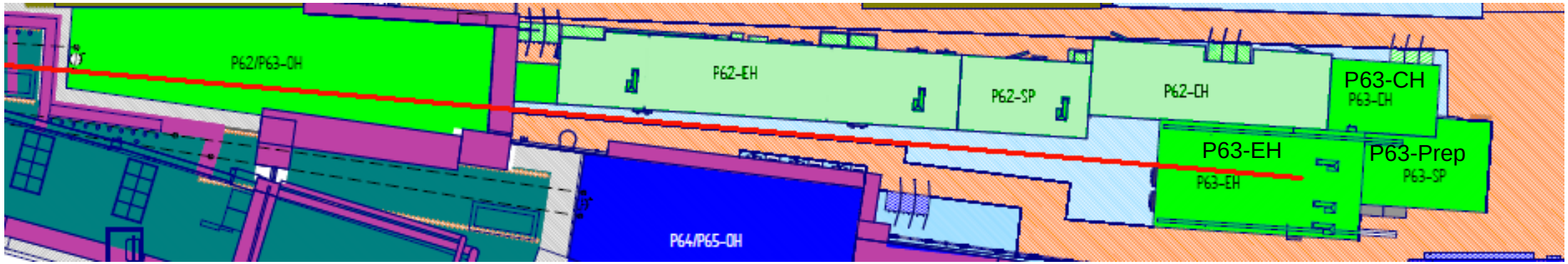
Planning by P64/P65 with MPG
Beamline manager: Wolfgang Caliebe
Engineer: Marcel Görlitz

Partners

FRITZ-HABER-INSTITUT
MAX-PLANCK-GESELLSCHAFT
Prof. Dr. Beatriz Roldan

MAX-PLANCK-INSTITUT FÜR CHEMISCHE ENERGIEKONVERSION
Prof. Dr. Serena deBeer



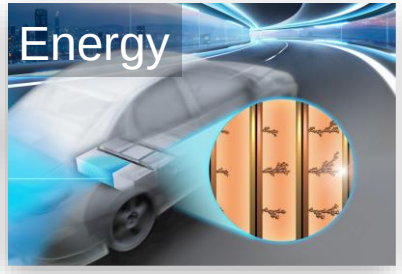


- Contract between MPG & DESY ready t.b.s.
- Construction in 2024
- EH Design ready call for tender out soon
- First beam end 2024/early 2025

PETRA IV

X-Ray Microscope for Chemical, Biological, and Physical Processes

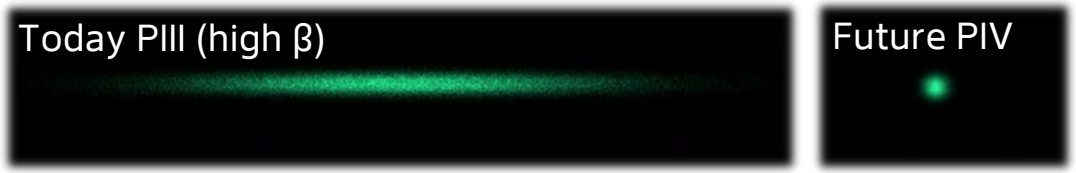
Cross-scale view of structure and function of complex systems in nature and technology:



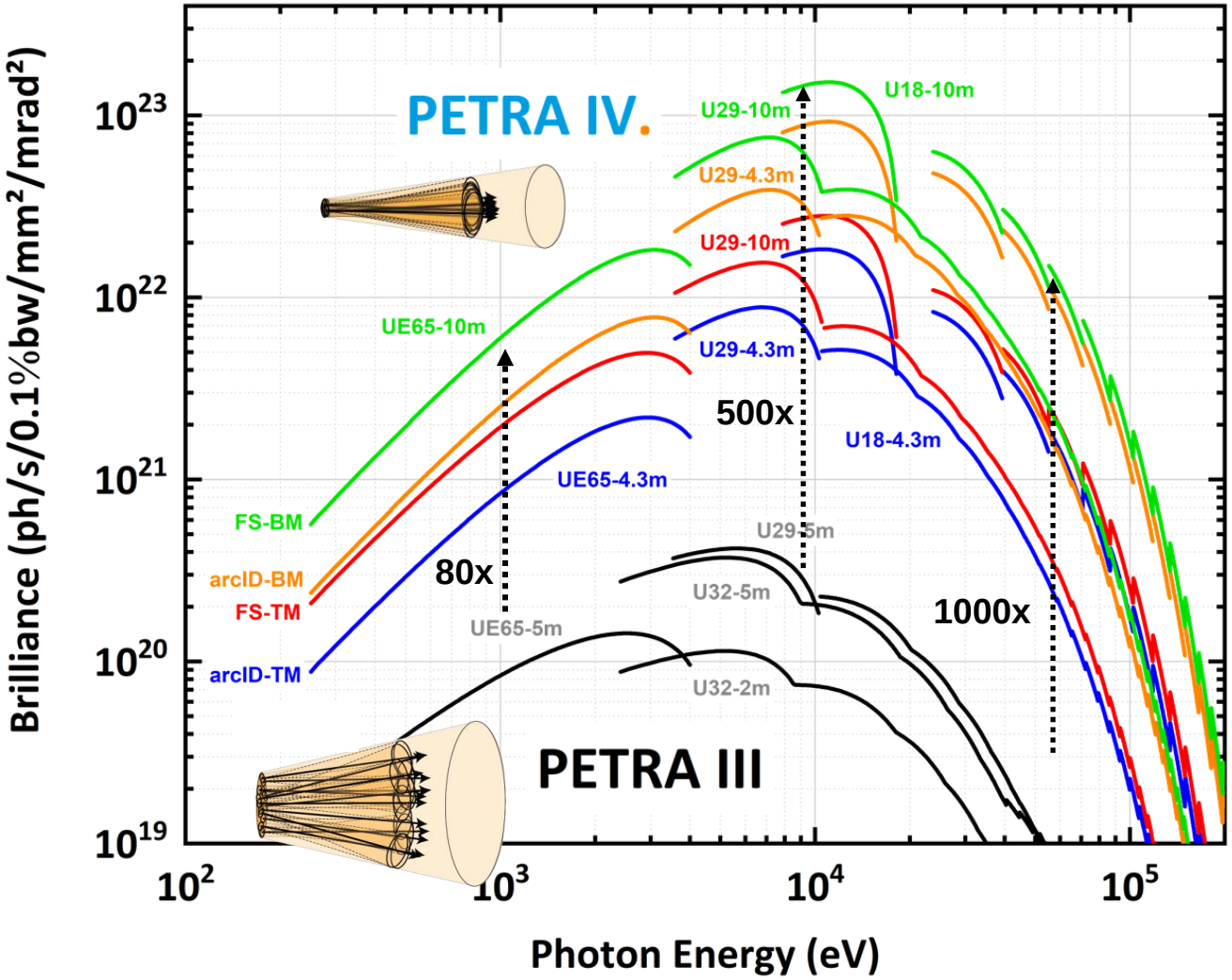
- contributions to grand challenges
- all fields of science
- academia and industry
- planned budget ~1.5 Billion €

Photon Science Experiments at PETRA IV

From PETRA III to PETRA IV



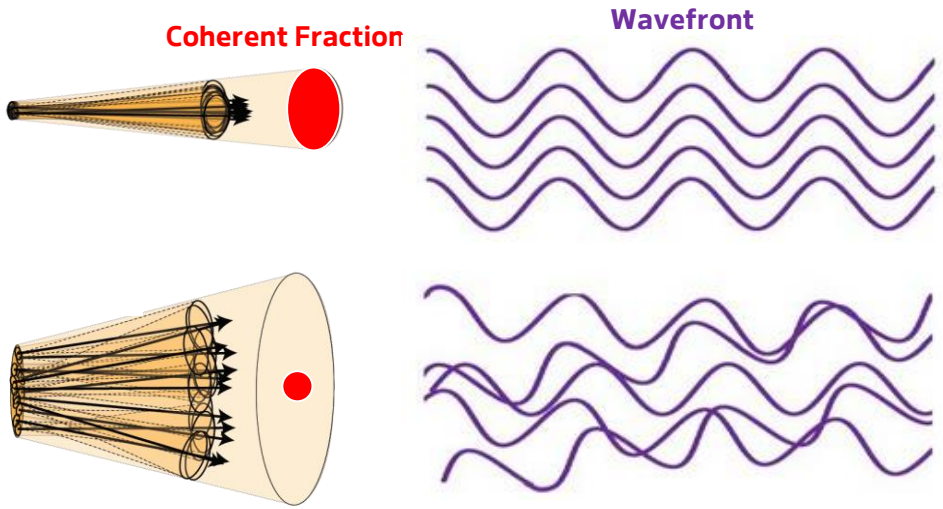
Photon source size – ideal imaging capabilities



Brilliance increase by

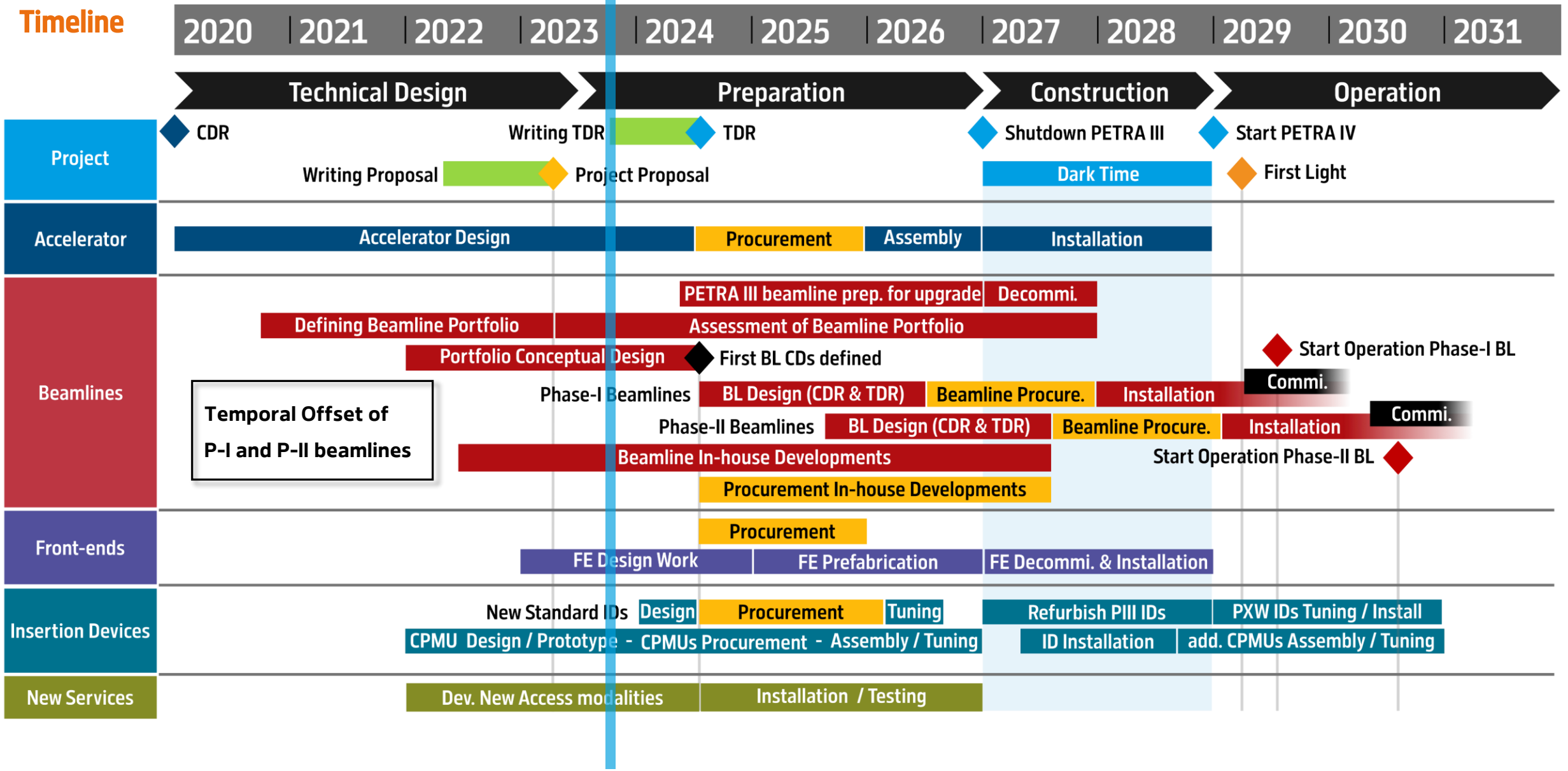
- ➔ 500 x (hard X-rays)
- ➔ 1000 x (high-energy X-rays)

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



Photon Beamlines at PETRA IV.

Timeline

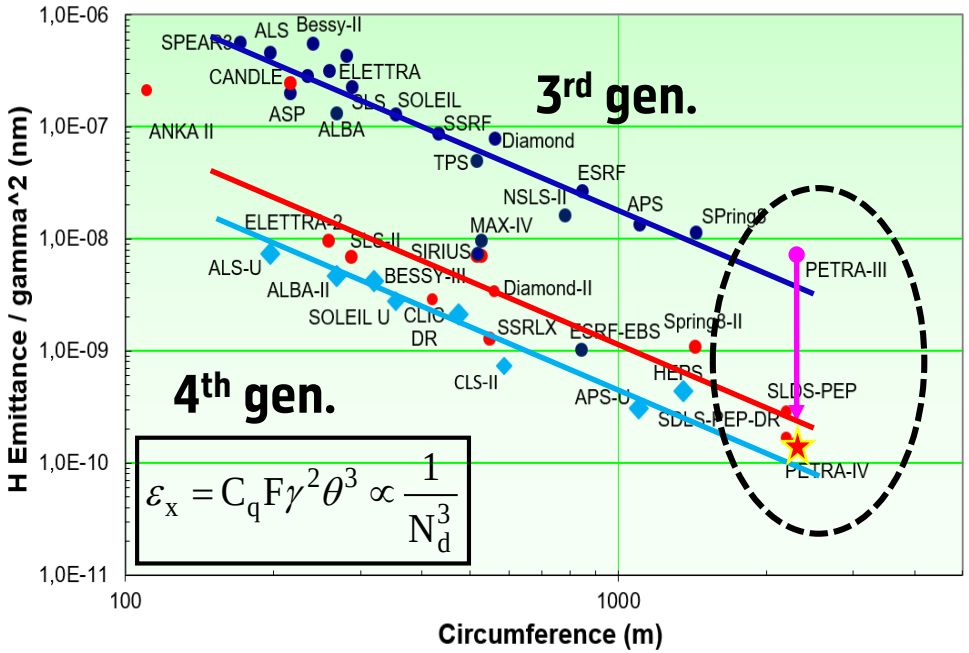


PETRA III and PETRA IV in Numbers

Recap - The H6BA machine lattice – PETRA IV will be world leading

	H6BA Technology (PETRA IV)		DBA Technology (PETRA III)	
Mode of Operation	brightness mode	timing mode	continuous	timing mode
Number of Bunches	1600 - 1920	80 (40)	480 - 960	40
Total current [mA] Bunch current [mA]	200 0.125	80 (80) 1.0 (2.0)	120 0.25 - 0.125	100 2.5
Arc ID β_x/β_y [m] long ID β_x/β_y [m]	2.2 / 2.2 4.0 / 4.0		high β: 20.0 / 4.0 low β: 1.4 / 4.0	
Hor. Emittance ε_x [pmrad] Vert. Emittance ε_y [pmrad]	20 5	35 (38) 7 (8)	1300 10	
Bunch length σ_z [ps] Bunch separation [ns]	30 4	65 (75) 96 (192)	40 16 - 8	43 192
Energy spread σ_p [10^{-3}] Touschek lifetime τ [h]	0.9 > 10	1.2 (1.5) > 5	1.3 9 - 13	1.3 1.5
Number of beamlines	29 + 5 + 1 VUV		26 + 1 VUV	

Global Competitors



At PETRA III: timing mode and brightness mode have same brilliance parameter ➔ 50% timing vs. 50% brilliance
At PETRA IV: This is NOT the case ➔ careful scheduling of modes, other bunch patterns useful ?

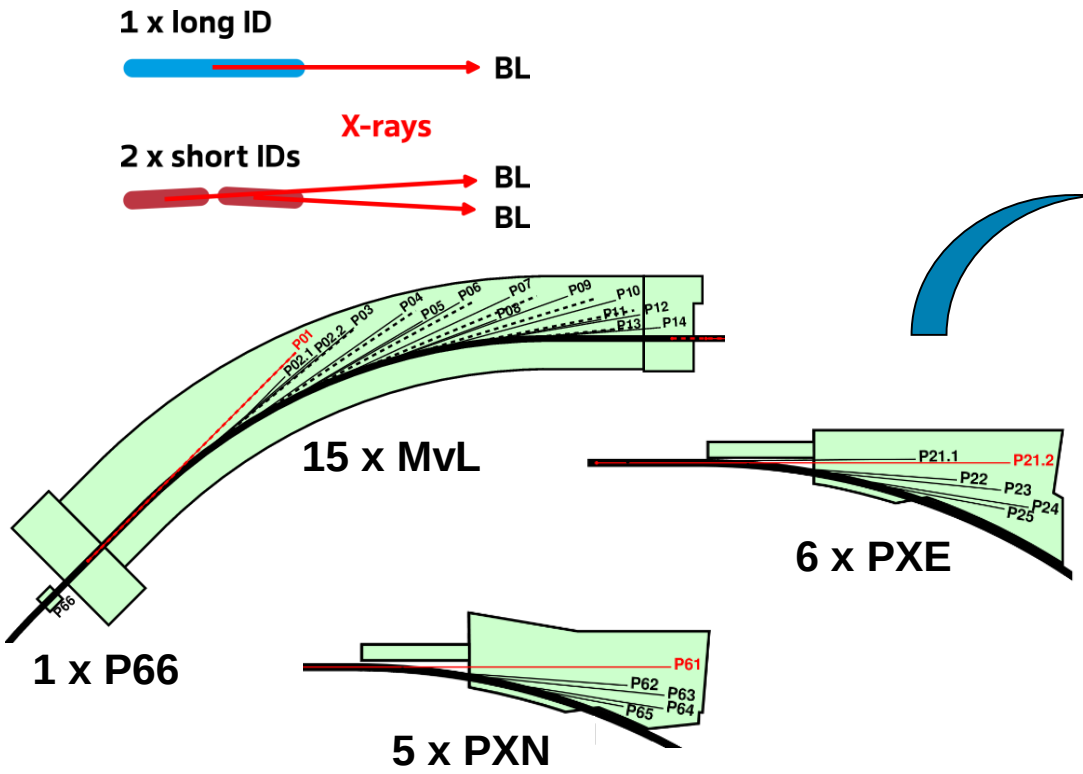
Beamlines at PETRA III and PETRA IV

Number and Distribution of Beamlines

With New Hall

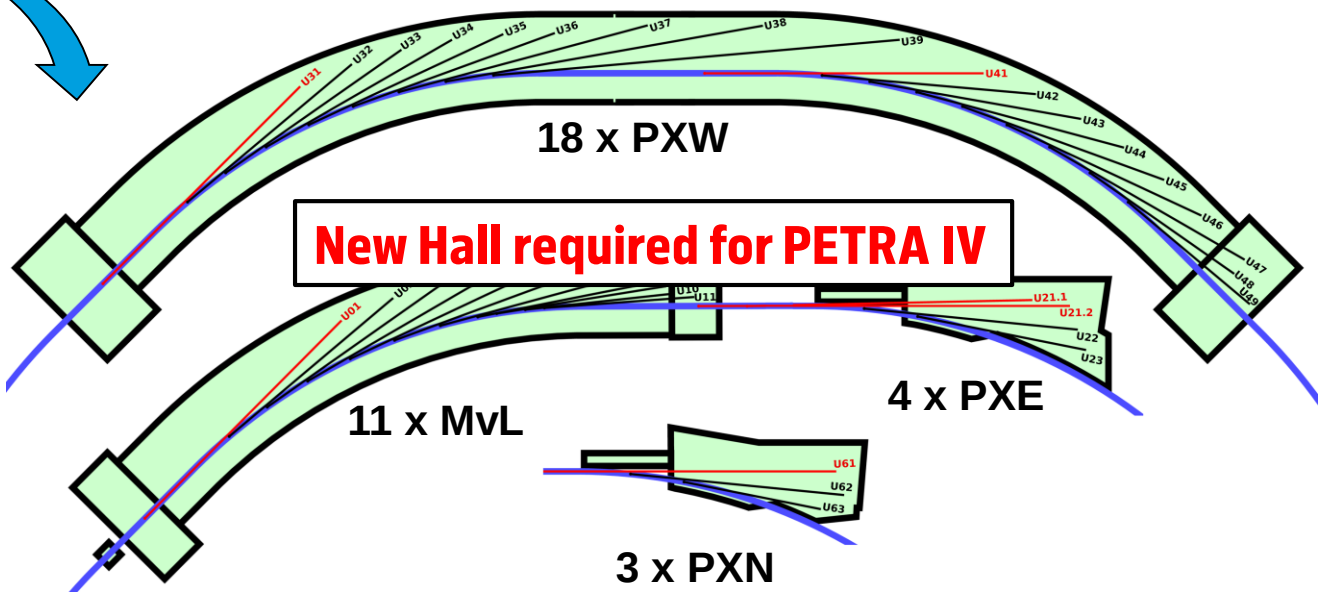
PETRA III Beamlines: Total 25 (+2)

- 25 beamlines in operation (3 experimental halls)
- Many canted sectors (2 m and 5 m IDs)



PETRA IV Beamlines with PXW hall: Total 37

- Canting only possible in a few exceptions!
- **10 beamlines more than today**
- **Strategic buffer for future expansion**
- **Dedicated areas for new services (more space)**
- Additional diagnostics beamlines (reliable operation)



The PETRA IV Beamline Portfolio

A Truly User-tailored Set of Beamlines

"Bottom-Up" approach to define beamlines (SIP Process)

- Scientific Instrumentation Proposals (SIPs) from users form the basis of the beamline portfolio
- Unique snapshot of scientific program, needs and requirements
- Allocation of SIPs define beamline specifications

Further continuous exchange is needed to adapt the portfolio to the evolving requirements!

PETRA IV Beamlines

- Large set of experimental capabilities and analytical methodologies (**multi-scale**)
- Wide range of contrasts, sensitivities, and resolutions (**multi-modal**)
- Balanced high-brightness and high-throughput experiments
- Extended imaging capabilities
- **Unique opportunities** for users
- Beamlines for **targeted use** (science & industry)!

PETRA IV Beamline Portfolio

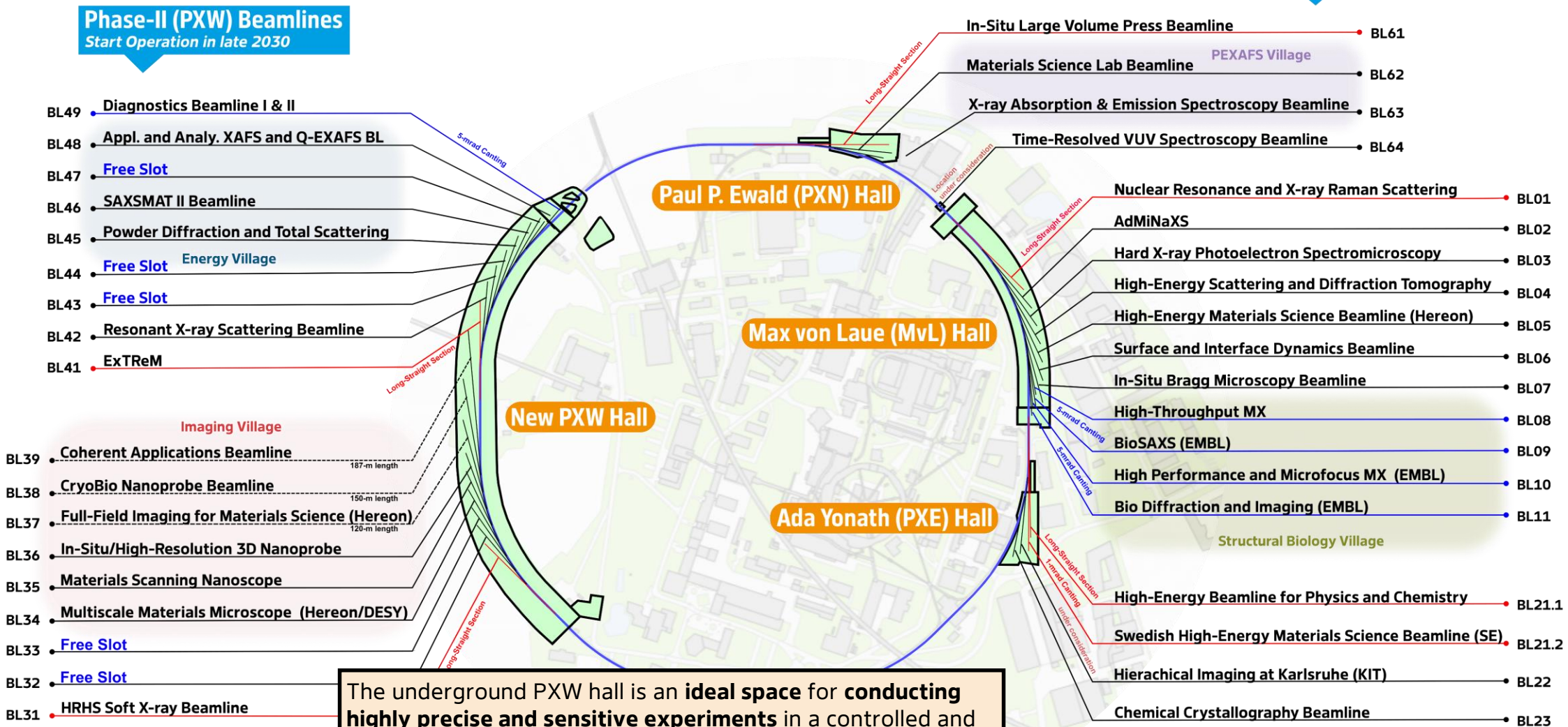
Beamline	Techniques	Energy range
01 Powder Diffraction and Total Scattering	PXRD, TS	15 - 80 keV
02 Swedish High-Energy Mater. Sci. Beamline (SE)	WAXS/3DXRD, SAXS, Imaging	38 - 150 keV
03 High-Energy Scatt. and Diff. Tomography	**High-Energy Beamlines**	40 - 120 keV
04 High-Energy Mater. Sci. Beamline (HEREON)		30 - 200 keV
05 ExTReM	XRD, PDF, PCI, CDI	25 - 58 keV
06 *In-situ* Large Volume Press Beamline	AD-/ED-XRD, PXRD, A/PCI	40 - 130 keV
07 AdMiNaXS Beamline	GI/T/SAXS/WAXS, CoGISAXS	7 - 30 keV
08 SAXSMAT II Beamline	**Scattering and Diffraction**	5 - 60 keV
09 Surface and Interface Dynamics Beamline		8 - 40 keV
10 Chemical Crystallography Beamline	PXRD, Crystallography	15 - 50 keV
11 Coherent Applications Beamline	XPCS, XCCA, Holotomo.	7 - 25 keV
12 Materials Scanning Nanoscope	XRF, XRD, XBIC, XEOL, Ptycho.	2.4 - 50 keV
13 In-Situ/High-Resolution 3D Nanoprobe	XRF, XRD, XBIC, XANES, Ptycho	4 - 100 keV
14 CryoBio Nanoprobe Beamline	**Imaging and Coherence**	17 - 60 keV
15 *In-situ* Bragg Microscopy Beamline		7 - 40 keV
16 Full-Field Imaging for Mater. Sci. (HEREON)	Tomography, Radiography	10 - 200 keV
17 Multiscale Mater. Microscope (DESY/HEREON)	Holotomo., Radiography	60 - 200 keV
18 HIKA Beamline (KIT)	Tomography, Laminography	10 - 60 keV
19 X-ray Absorption & Emission Spec. Beamline	HR-XES/XAS, TR-XES/XAS	4 - 25 keV
20 Materials Science Lab Beamline (MPG)	XAFS, XRD/PDF, Tomography	2 - 100 keV
21 Applied Analytical XAFS and Q-EXAFS Beamline	**Spectroscopy Beamlines**	4 - 45 keV
22 Nuclear Resonance and X-ray Raman Scattering		6.5 - 73 keV
23 Resonant X-ray Scattering Beamline (MPG)	RIXS, REXS	2.4 - 14 keV
24 Hard X-ray Photoelectron Spectromicroscopy	HAXPES(ARPES, PEEM, XPD), CDI	2.4 - 15 keV
25 High-Thru. MX	MX, SSX	6 - 30 keV
26 BioSAXS Beamline (EMBL)	BioSA **MX Beamlines**	6 - 20 keV
27 High Performance and Microfocus MX (EMBL)	SSX,	5 - 30 keV
28 Bio Diffraction and Imaging (EMBL)	HT-MX, HiTT	6 - 30 keV
29 HRHS Soft X-ray Beamline	**Soft and VUV Beamlines**	0.25 - 4 keV
30 Time-Resolved VUV Spectroscopy Beamline		004 - 0.04 keV

+ 2 new BL

PETRA IV. Beamlines

Distribution of Beamlines on Experimental Halls

Extensive **re-use** of existing infrastructure in existing halls (minimise construction work)



The underground PXW hall is an **ideal space** for **conducting highly precise and sensitive experiments** in a controlled and stable environment.

PETRA IV. Beamlines

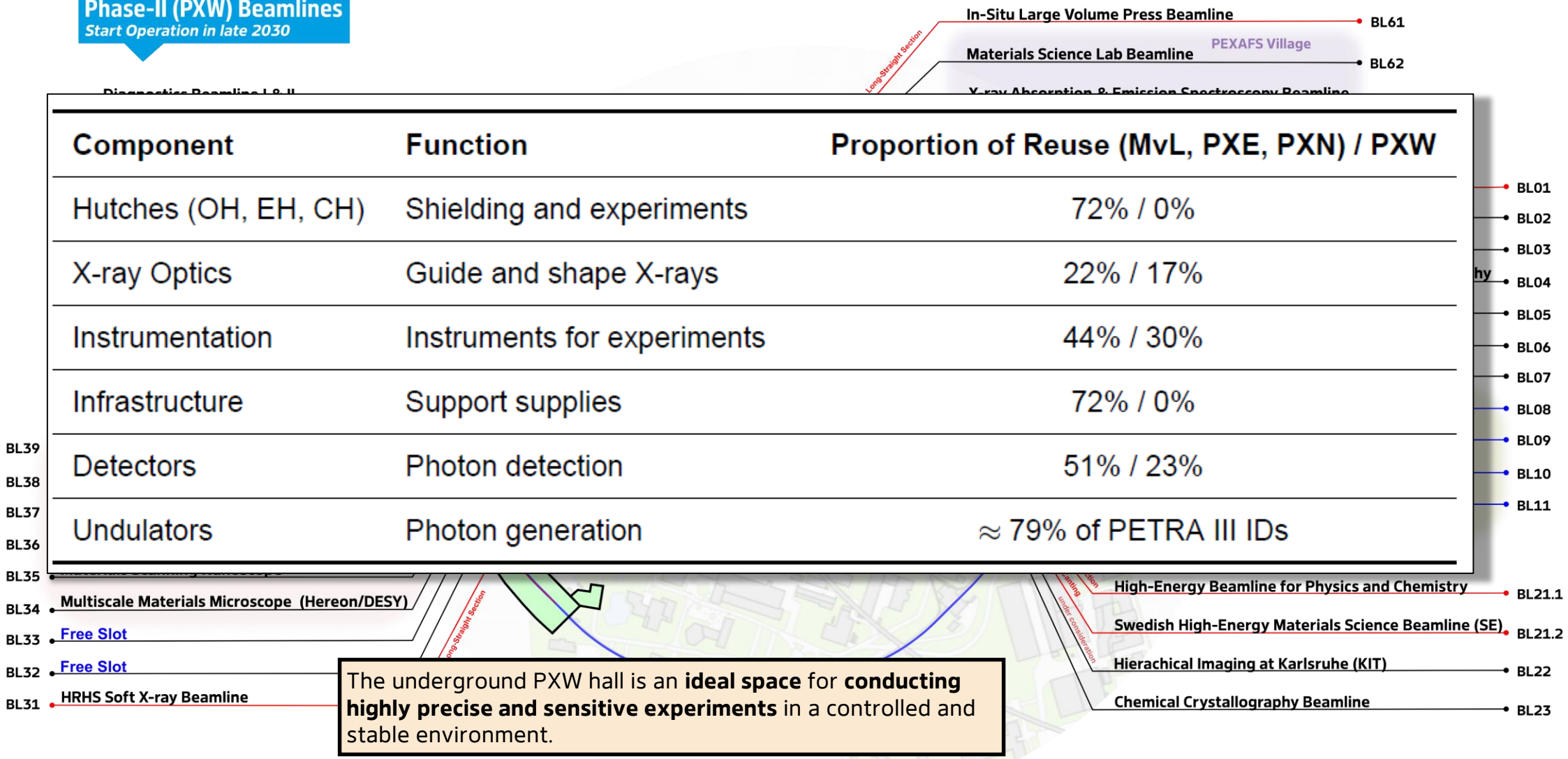
Distribution of Beamlines on Experimental Halls

Extensive **re-use** of existing infrastructure in existing halls (minimise construction work)

Phase-I Beamlines
Start Operation in 2029

Phase-II (PXW) Beamlines
Start Operation in late 2030

Component	Function	Proportion of Reuse (MvL, PXE, PXN) / PXW
Hutches (OH, EH, CH)	Shielding and experiments	72% / 0%
X-ray Optics	Guide and shape X-rays	22% / 17%
Instrumentation	Instruments for experiments	44% / 30%
Infrastructure	Support supplies	72% / 0%
Detectors	Photon detection	51% / 23%
Undulators	Photon generation	≈ 79% of PETRA III IDs



The underground PXW hall is an **ideal space** for **conducting highly precise and sensitive experiments** in a controlled and stable environment.

Beamline Conceptual Designs

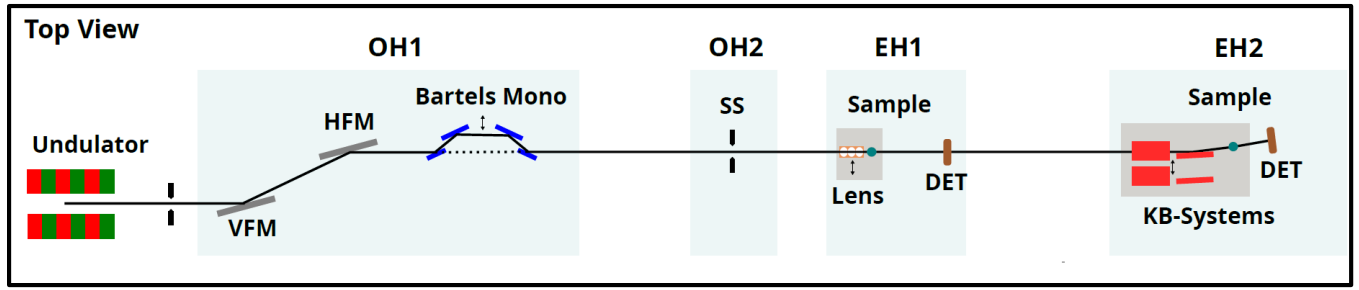
Bring the Excellent Source Properties to the User Experiments and More

- Beamline layouts based on SIP requirements (user demands)
- Refurbishment of existing optical components (costs, sustainability, …)
- Spatial coherence tuning and preservation (e. g., sec. sources, …)
- Optics with higher angular stability (e. g., hor. deflecting optics, …)
- In-house developments (enhance beamline capabilities and operation)

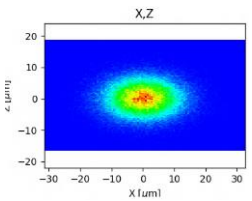
Beamline designs and portfolio not fixed!

Will be continuously assessed, refined and revised in the coming years!

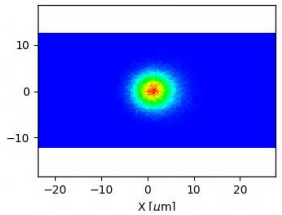
Example: CryoBio Nanoprobe Beamline



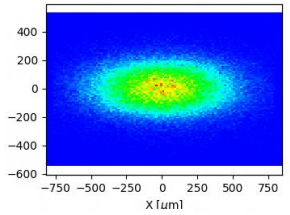
16 x 8.8 µm² (FWHM)
Coherence 15 x 43 %



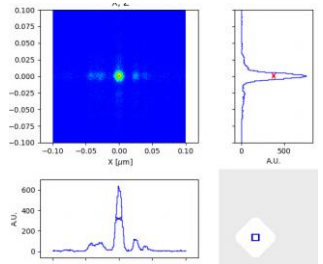
5.9 x 5.4 µm² (FWHM)



667 x 280 µm² (FWHM)
85 x 110 µm² Cohlen



8 x 10 nm² (FWHM)



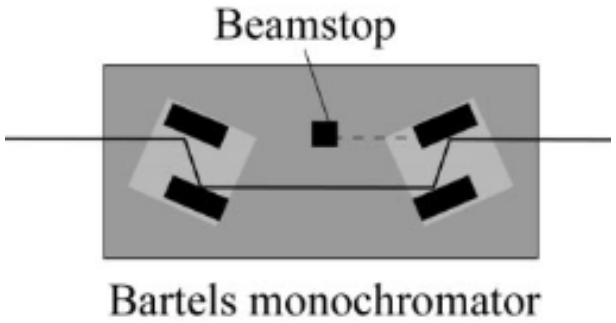
Supporting Simulations

Ray-tracing and wave propagation tools to support the beamline development (Xrt, OASYS, SRW)

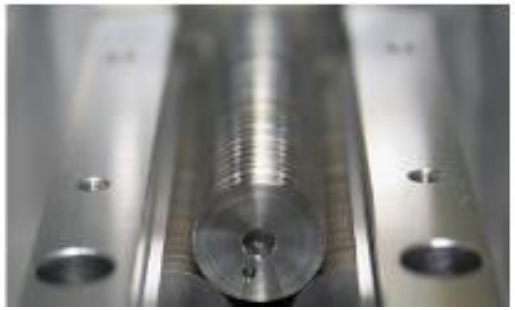
TechTask and PETRA IV.

In-House Developments

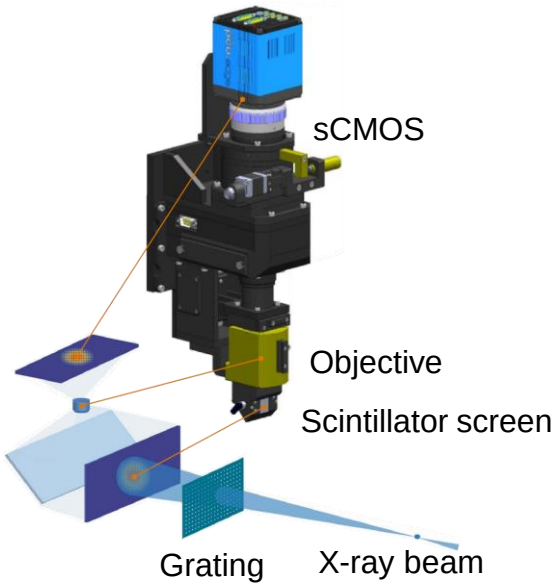
4-bounce monochromator



Diamond CRLs and Lens changer



Wavefront Sensor



High Heat Load Mirror

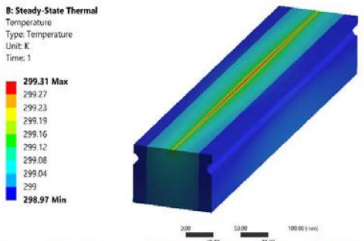
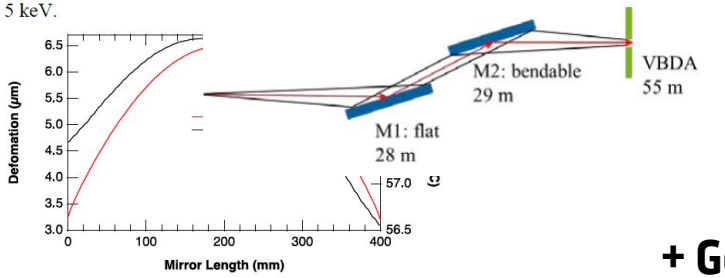
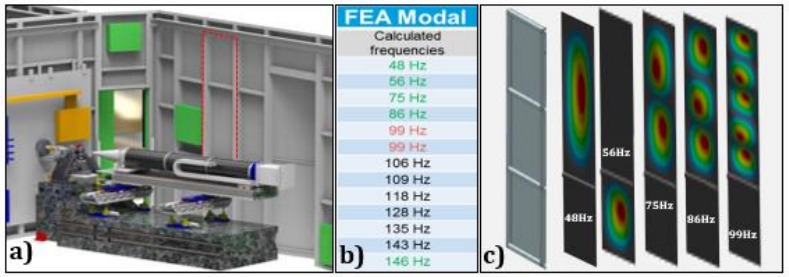


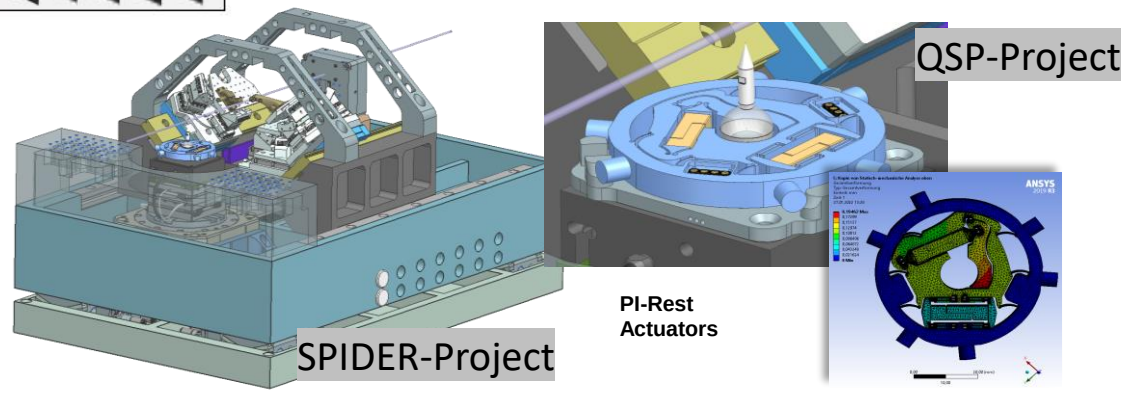
Figure 3: ANSYS model and temperature of M1 Mirror at 5 keV.



Low-Vibration Hutch



Scanning Platform for Imaging and Diffraction with Extreme Resolution



+ Generic Components (FS-BT)

(Monos, Hios mirrors, …)

Thank you

Questions?

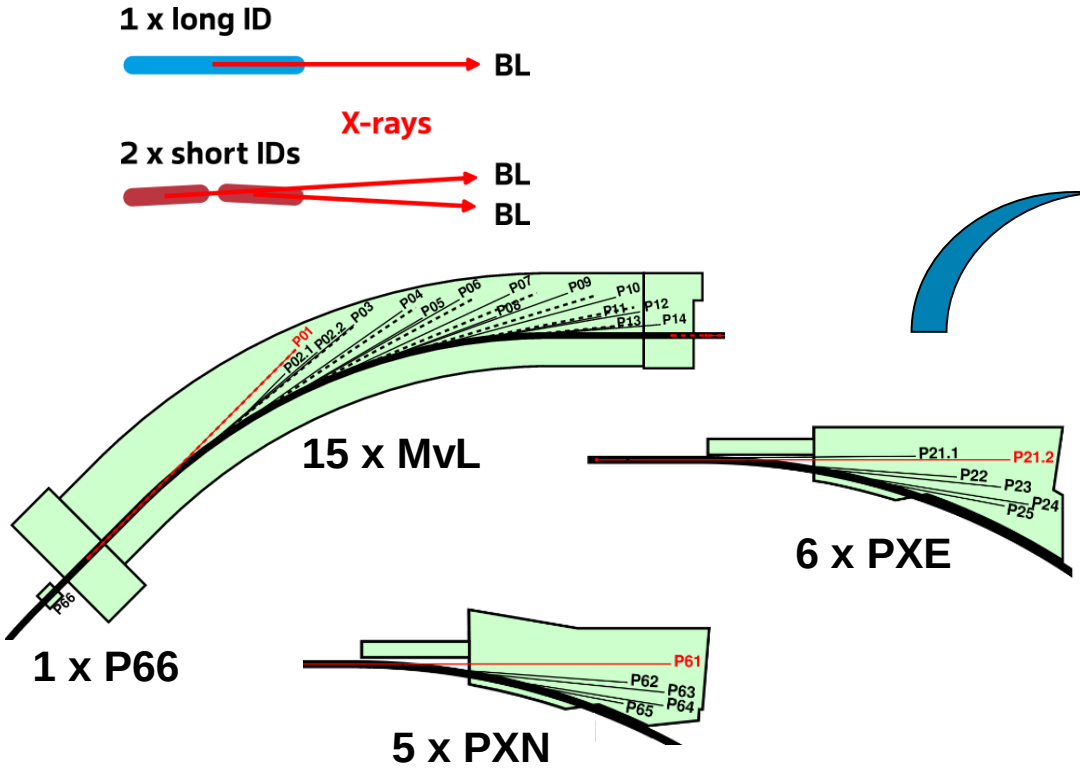
Beamlines at PETRA III and PETRA IV

Number and Distribution of Beamlines

Without New Hall

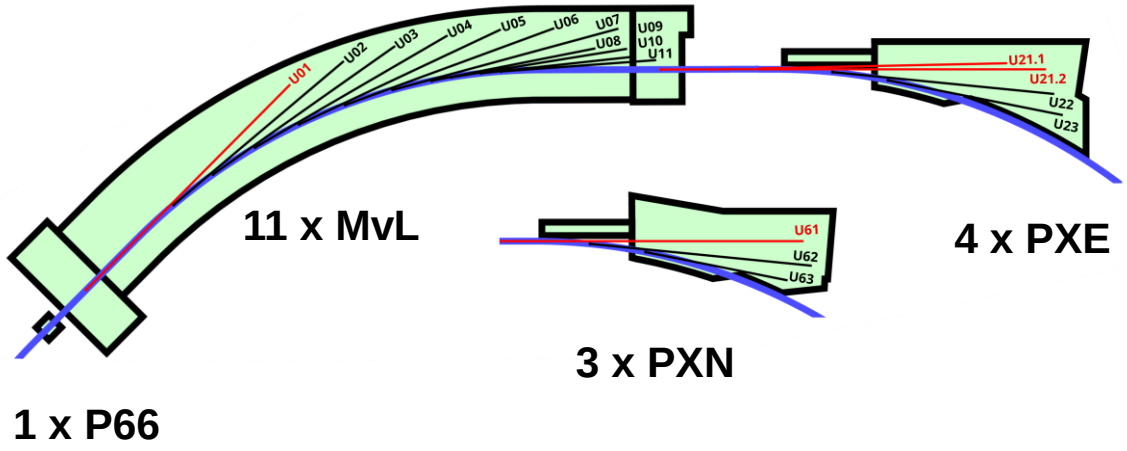
PETRA III Beamlines: Total 25 (+2)

- 25 beamlines in operation (3 experimental halls)
- Many canted sectors (2 m and 5 m IDs)



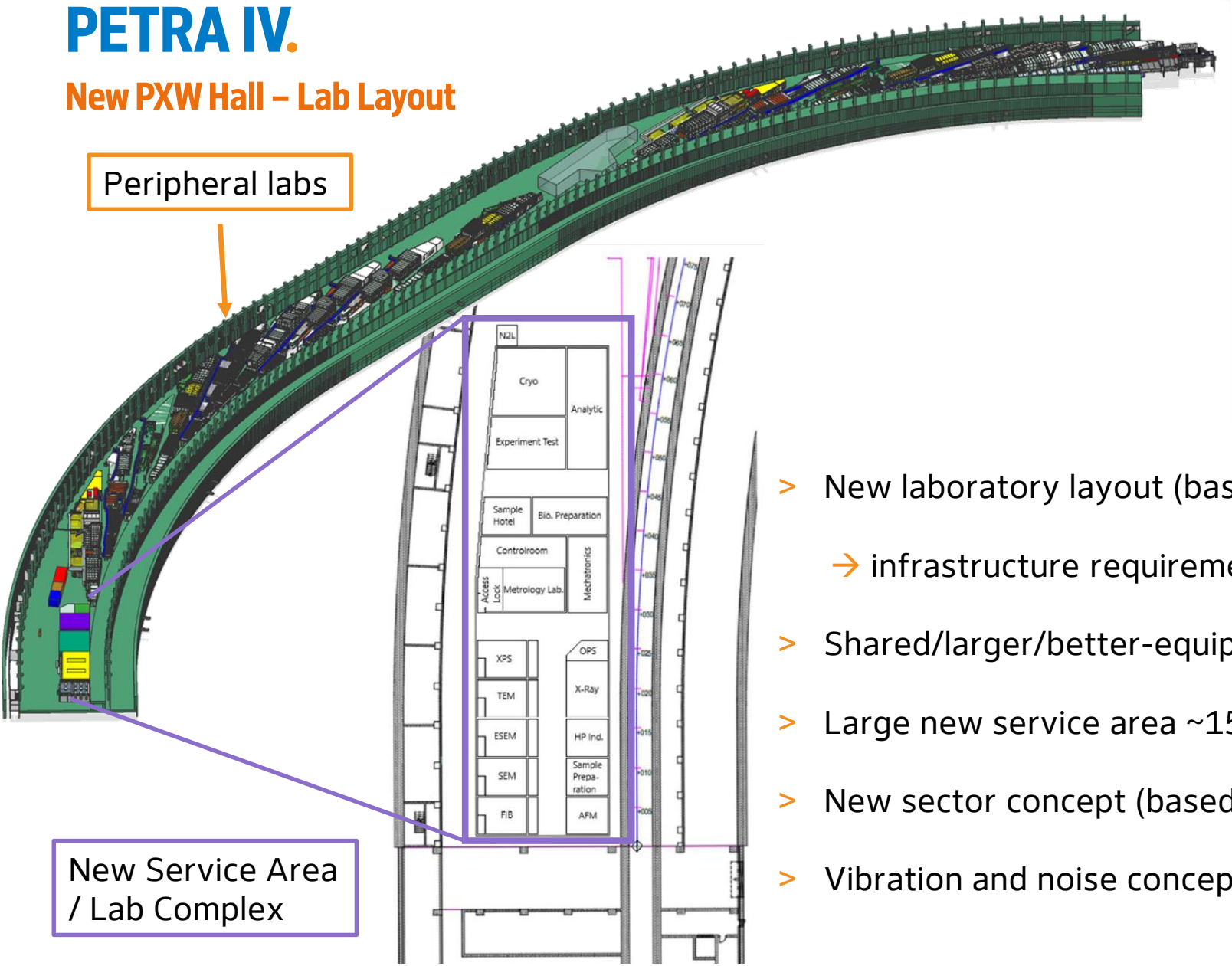
PETRA IV Beamlines w/o PXW hall: Total 19

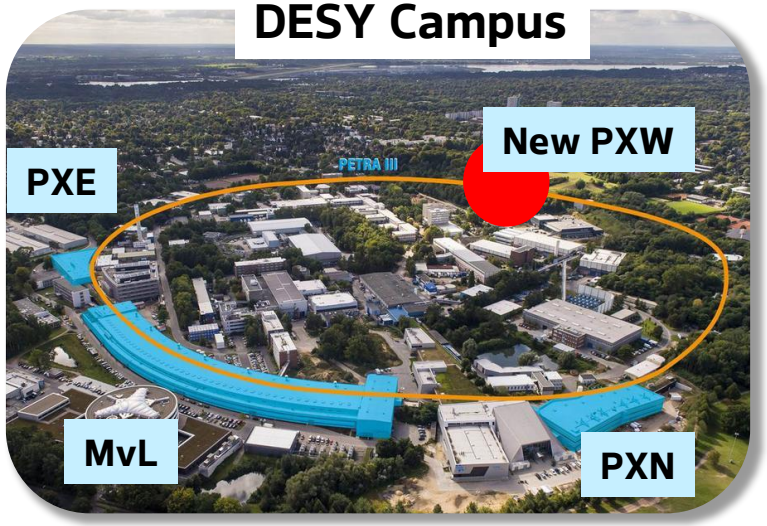
- Canting only possible in a few exceptions!
- **8 beamlines less than today**
- **Significantly reduced user/science program**
- Preservation of a few beamlines possible



PETRA IV.

New PXW Hall – Lab Layout

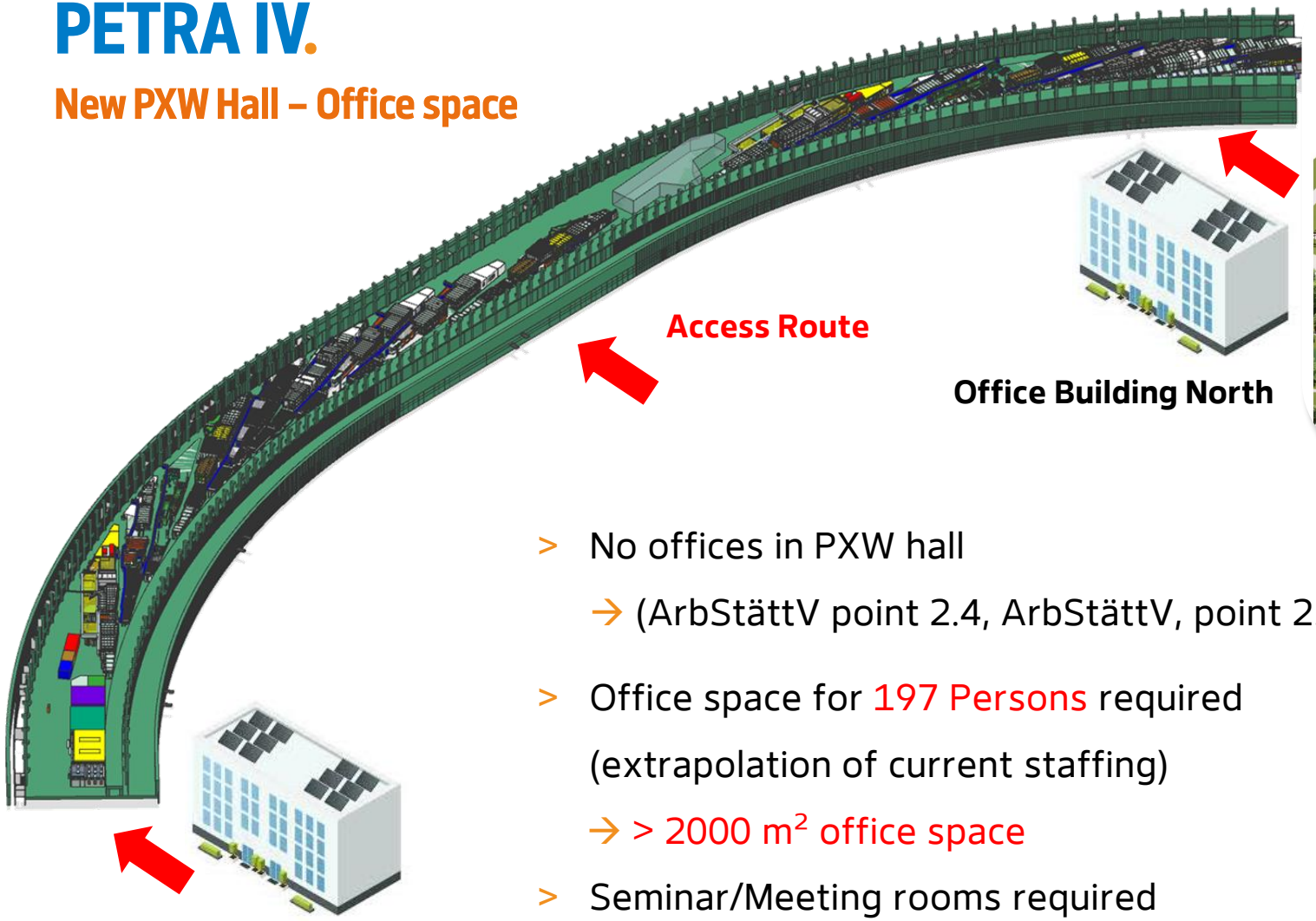




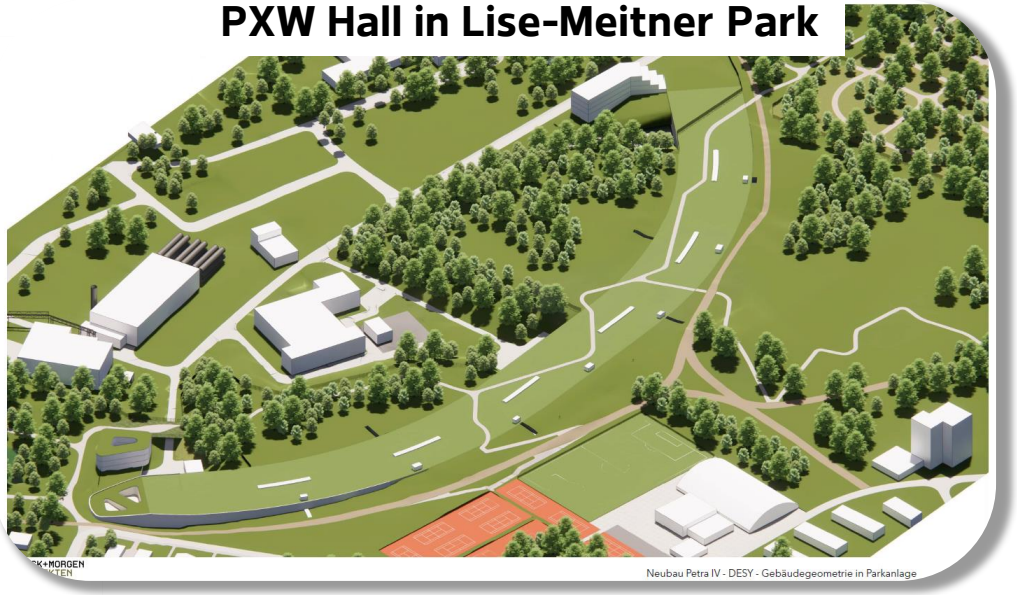
- New laboratory layout (based on user requirements)
  - → infrastructure requirements in room book (power, gases, water, …)
- Shared/larger/better-equipped ChemLabs (improved services)
- Large new service area ~1500 m^2 (SEM, TEM, eSEM, Analytics Lab, ….)
- New sector concept (based on beamline demands)
- Vibration and noise concept (in planning)

PETRA IV.

New PXW Hall – Office space



PXW Hall in Lise-Meitner Park



- No offices in PXW hall
  → (ArbStättV point 2.4, ArbStättV, point 2.)
- Office space for 197 Persons required
  (extrapolation of current staffing)
  → > 2000 m^2 office space
- Seminar/Meeting rooms required
- Short ways to beamlines and labs required

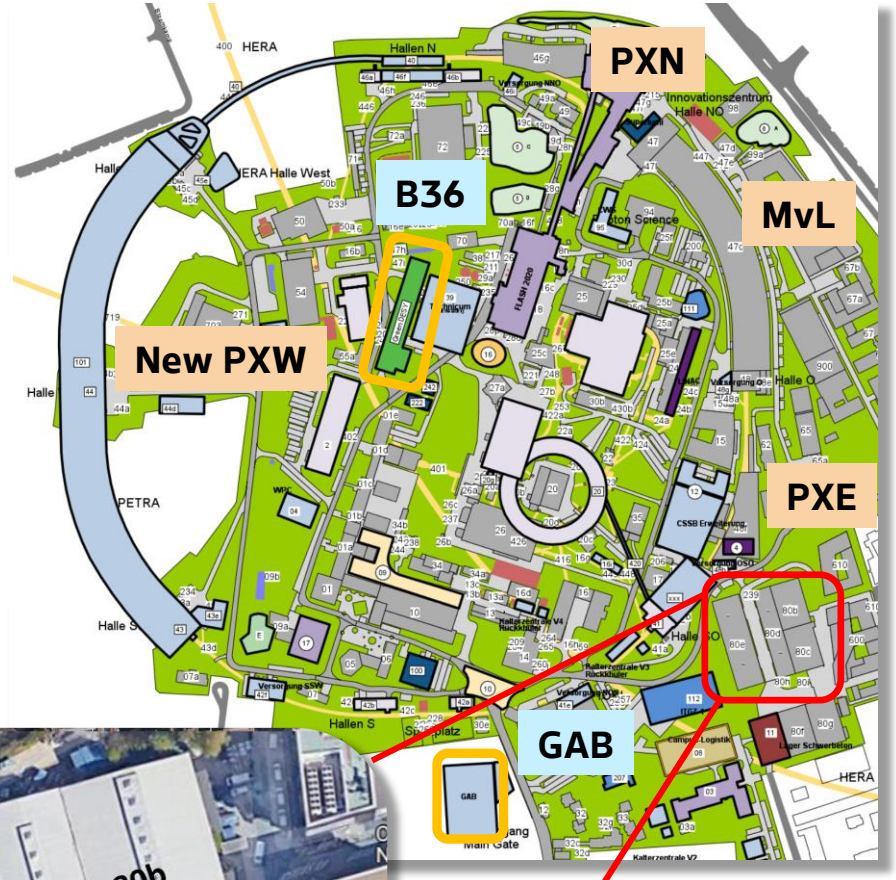
PETRA IV.

Storage and assembly space – Beamlines, Front-ends, IDs

Beamline	Storage (m²)	Small part (15% of Storage)	Total (m²)
P01	100.43	15.06	115.50
P02.1	49.32	7.40	56.72
P02.2	222.20	33.33	255.53
P03	84.39	12.66	97.05
P04	193.94	29.09	223.03
P05	70.07	10.51	80.58
P06	86.14	12.92	99.06
P07	126.78	19.02	145.80
P08	38.64	5.80	44.44
P09	42.04	6.31	48.35
P10	103.60	15.54	119.14
P11	53.81	8.07	61.88
P12	40.66	6.10	46.76
P13	20.27	3.04	23.30
P14	33.12	4.97	38.09
			1455.2
P21.1	32.83	4.92	37.75
P21.2	158.13	23.72	181.85
P22	40.62	6.09	46.71
P23 (estimate)	50.00	7.50	57.50
P61A	44.80	6.72	51.52
P61B	49.89	7.48	57.37
P62	43.84	6.58	50.42
P64	20.04	3.01	23.04
P65	14.39	2.16	16.55
P66	20.70	3.11	23.81
			222.71
		Total	2059.24 m²

Based on inventory list of all large components

- FE & Mono refurbishment and assembly in GAB
- ID refurbishment and assembly in B36



- Storage of existing/refurbished BL components
- Storage of new BL components

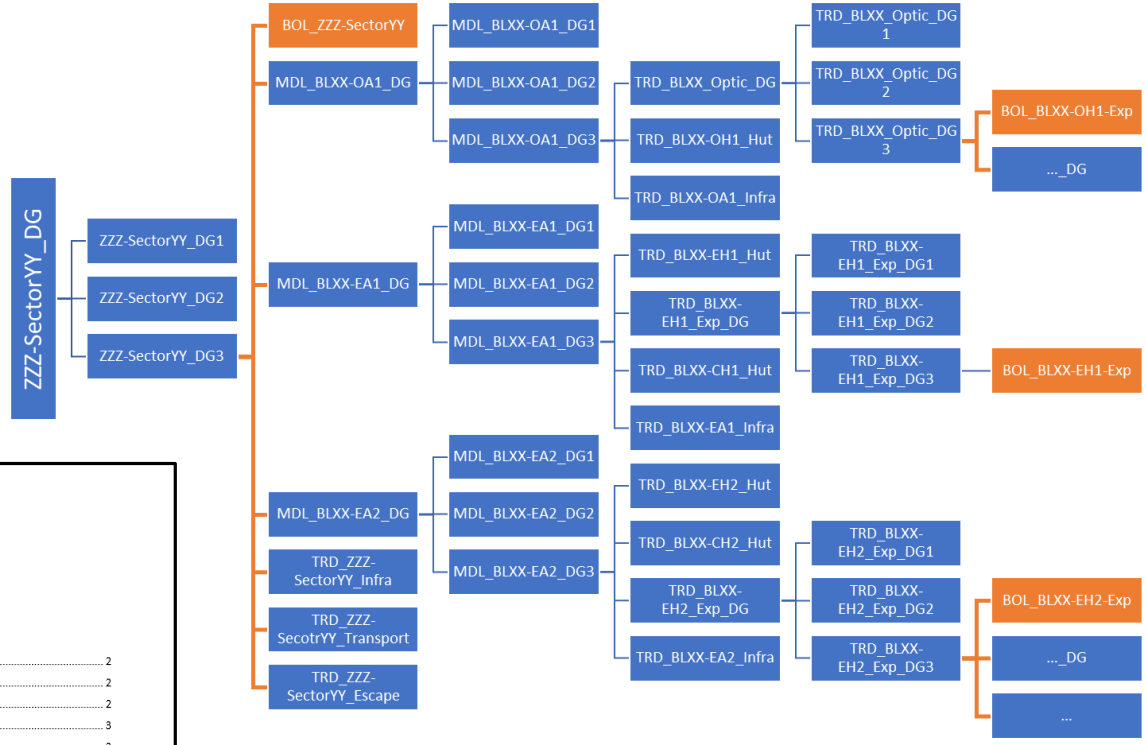
TechTask and PETRA IV.

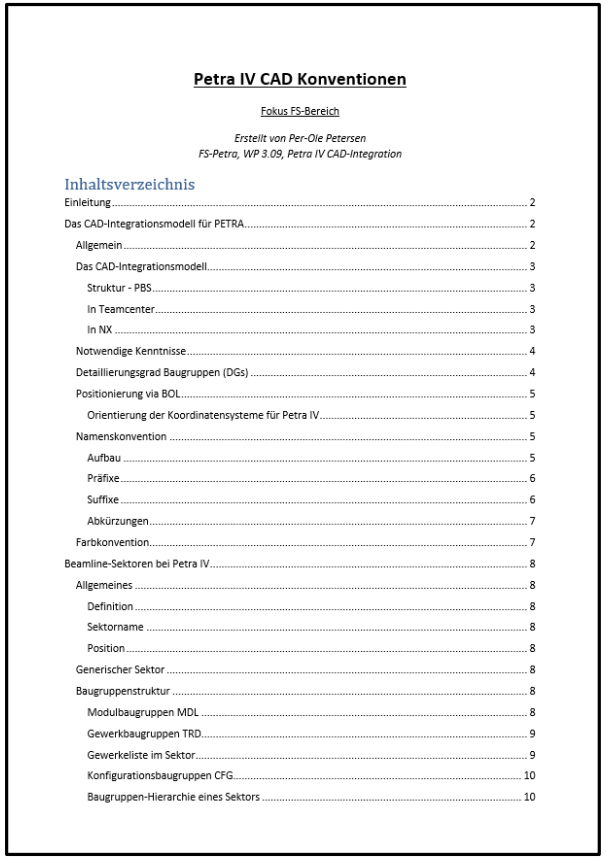
Construction Guidelines for PETRA IV

Document in preparation by Per-Ole

- Naming / BOL conventions
- DG assemblies
- ....

Review and feedback by TechTask





Petra IV CAD Konventionen

Fokus FS-Bereich

Erstellt von Per-Ole Petersen
FS-Petra, WP 3.09, Petra IV CAD-Integration

Inhaltsverzeichnis

How to build a beamline

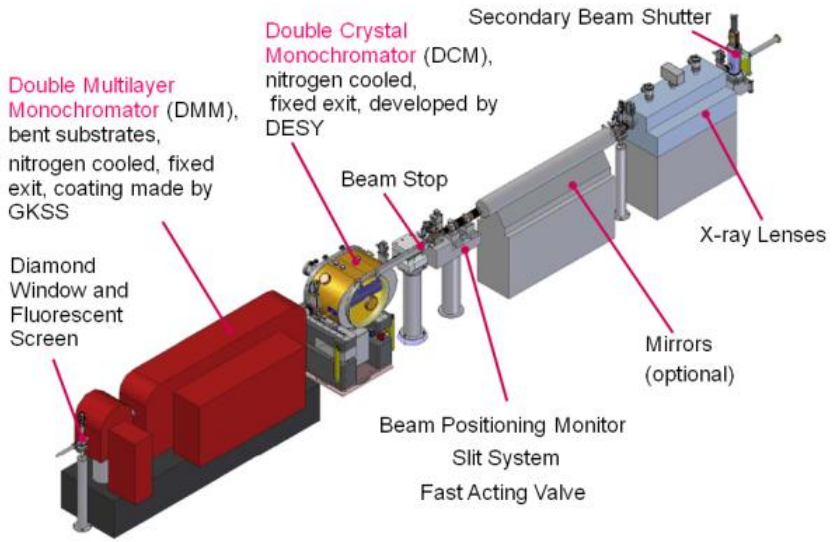
- Construction Guidelines
- Interfaces with other service groups
- Responsibilities

TechTask and PETRA IV.

Status of Components in NX

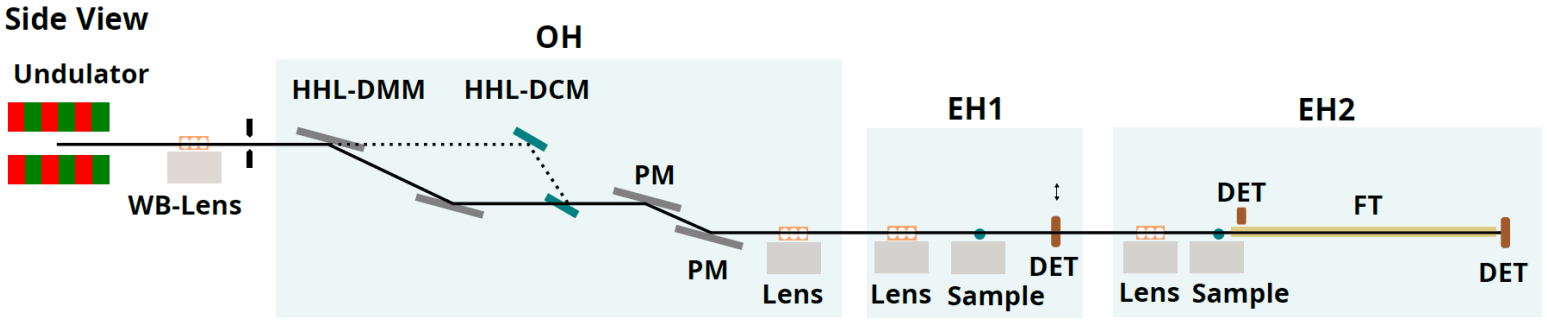
PETRA IV Beamlines

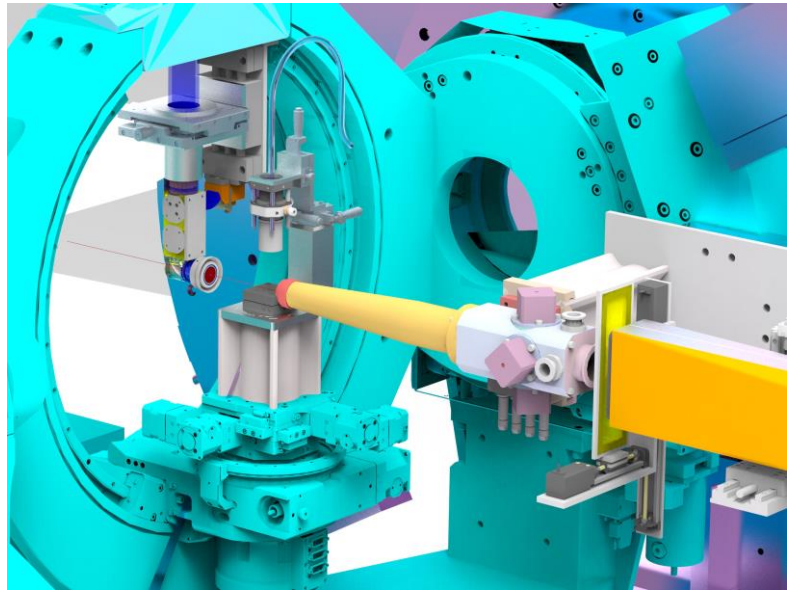
First basic optical layouts exist + identification of reused components



Idea:

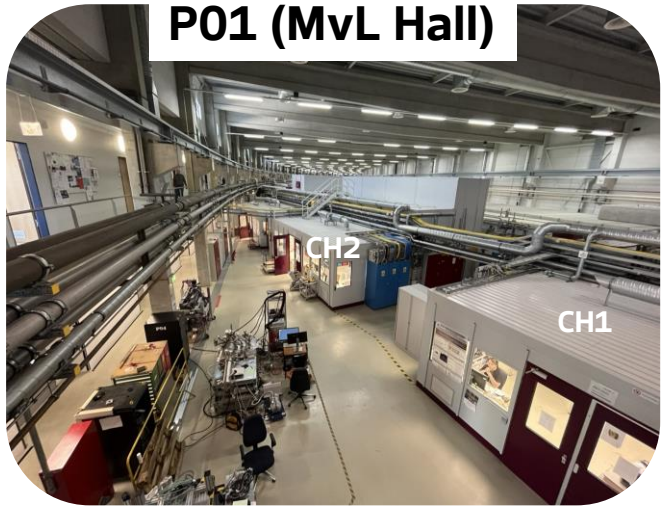
- Beamline Engineers need to check status of reused components in NX after SE to NX migration
- Identify problems and discuss with TechTask
- Work out in next years

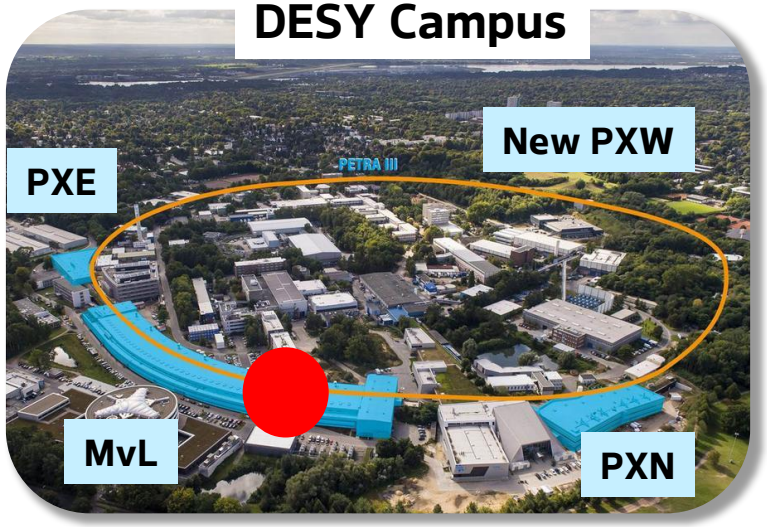


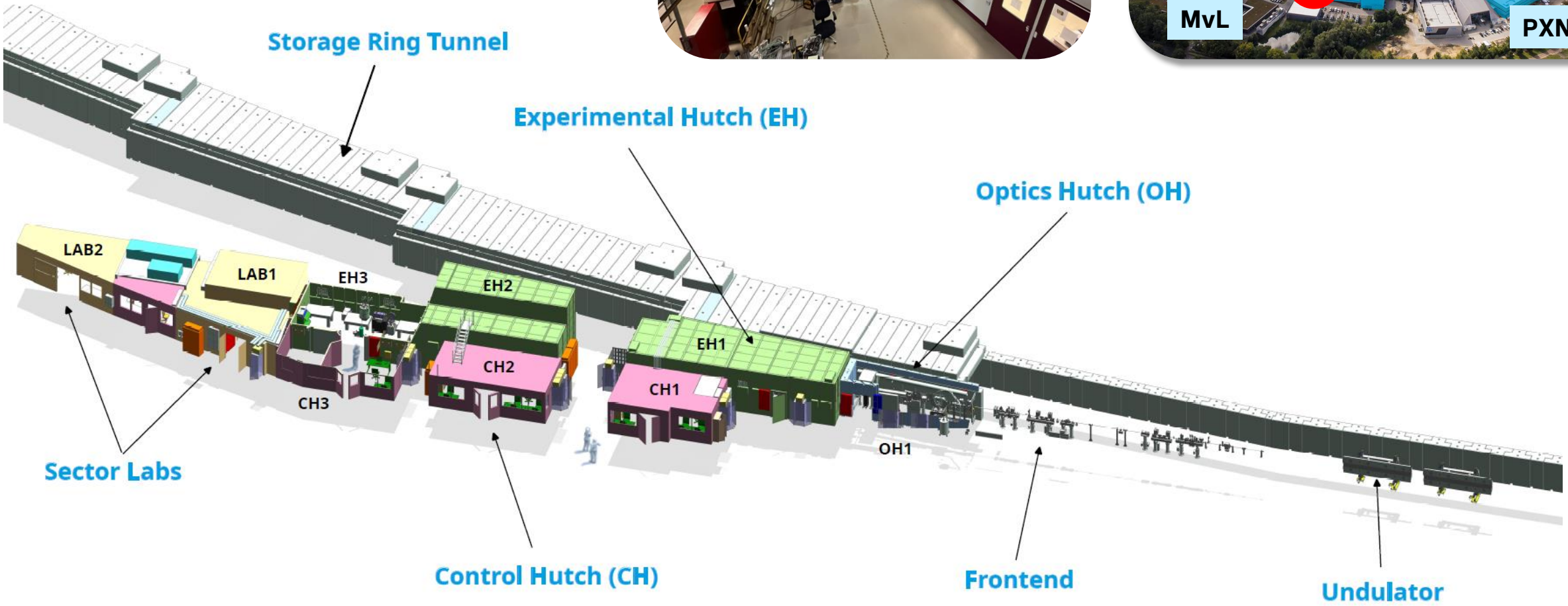


Photon Beamlines at PETRA

Example: P01 Beamline at PETRA III today





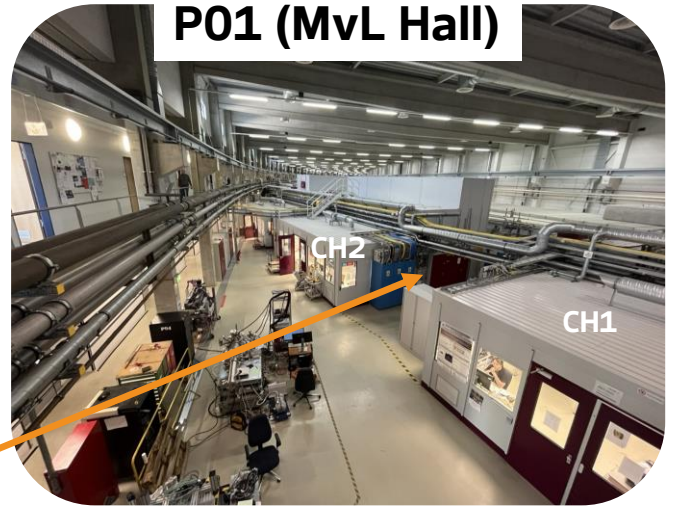


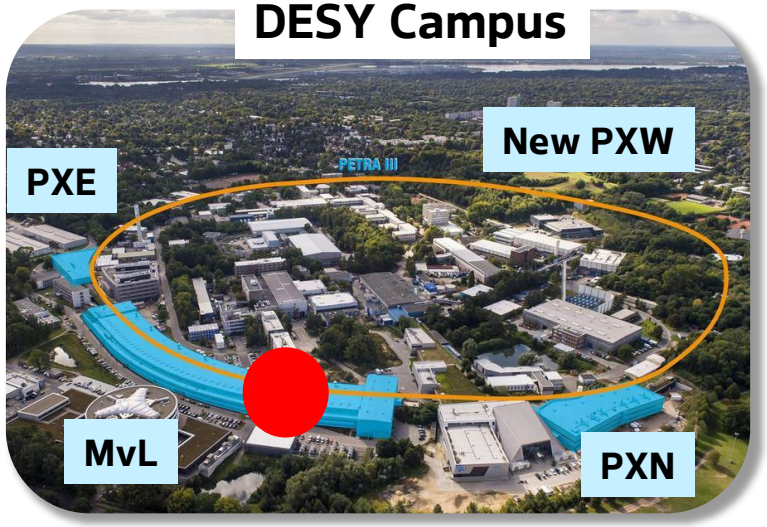
Photon Beamlines at PETRA

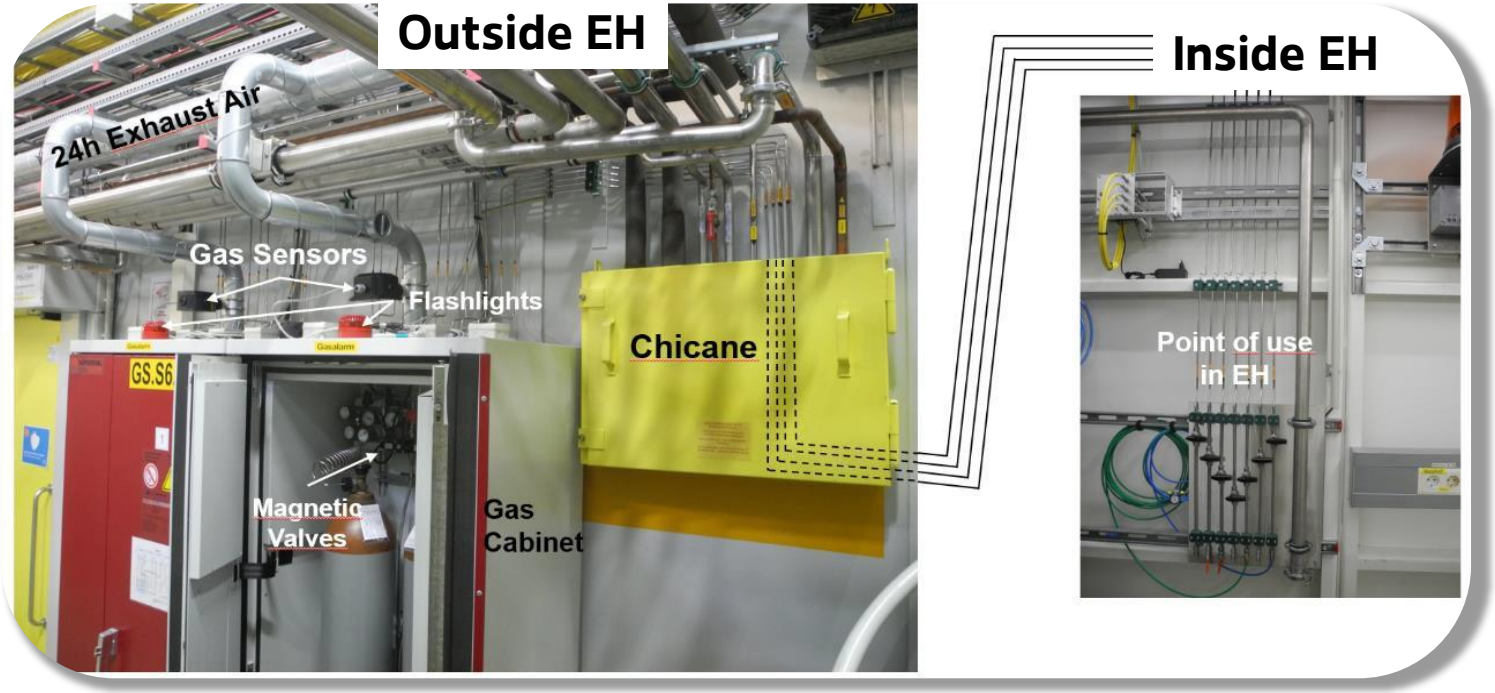
Example: P01 Beamline at PETRA III today

Required temperature stability in EHs:

> **±0.1 - ±0.01K (for nano beams)**







Infrastructure:

> **Hutches (radiation shielding)**
> **Safety Systems (warning, fire, ..)**
> **Power, signal, IT cables (along sector)**
> **Gas pipelines/supply (air, N2, Helium, ...)**
> **LN2/water cooling of components**
> **HVAC systems**

PETRA IV.

MvL Hall Construction

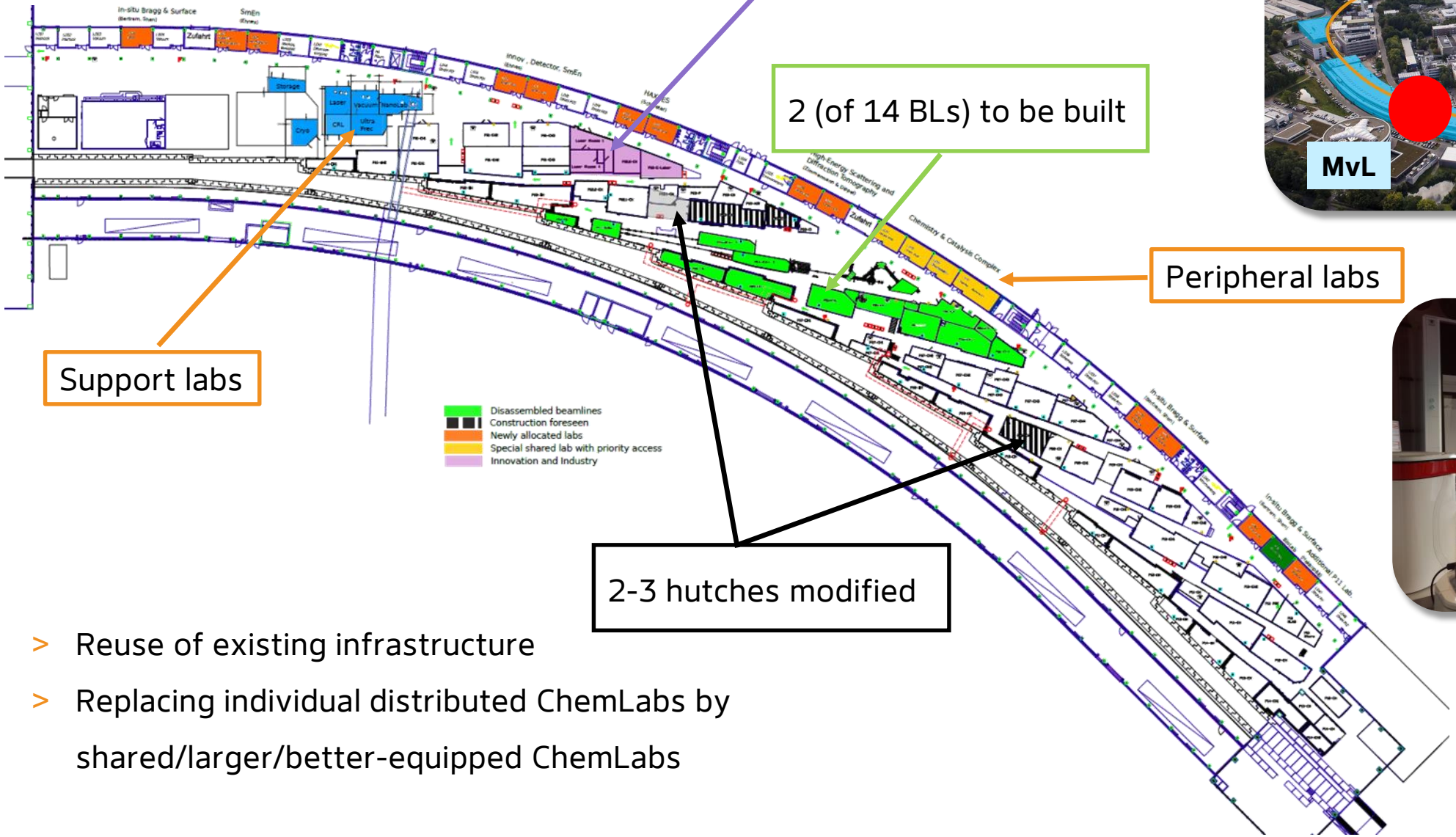
Dedicated area for new services

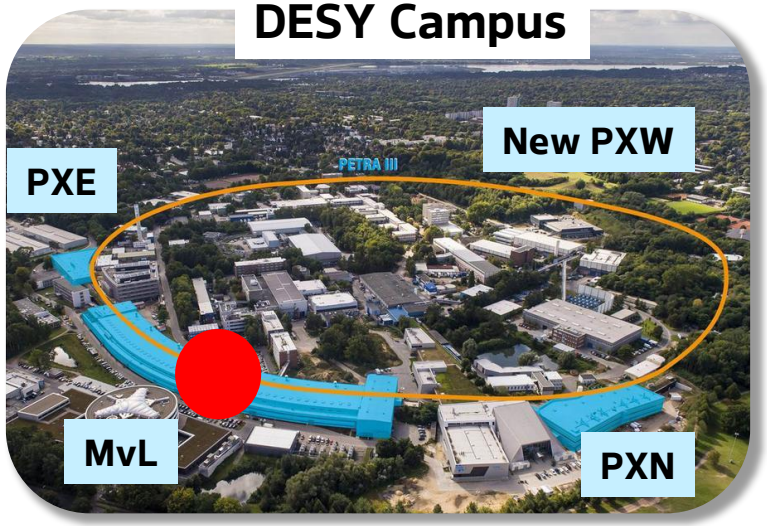
2 (of 14 BLs) to be built

Support labs

Peripheral labs

2-3 hutches modified





- Fume hoods
- Sink
- …

> Reuse of existing infrastructure

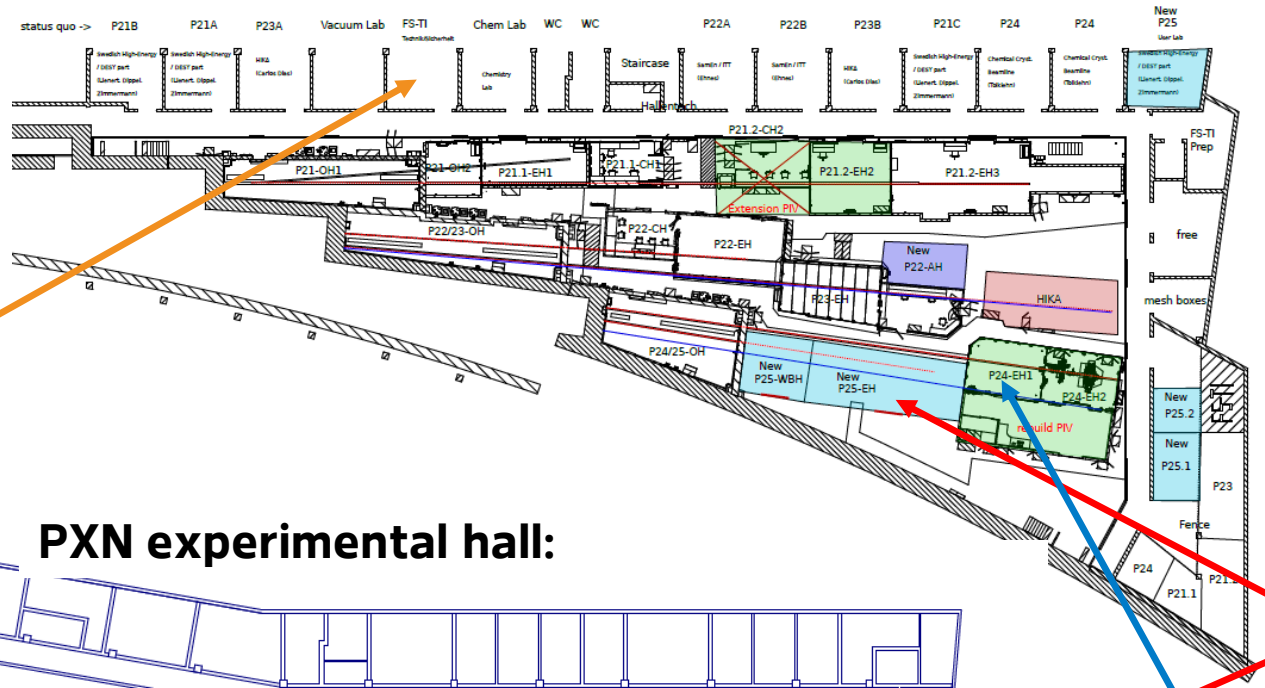
> Replacing individual distributed ChemLabs by shared/larger/better-equipped ChemLabs

PETRA IV.

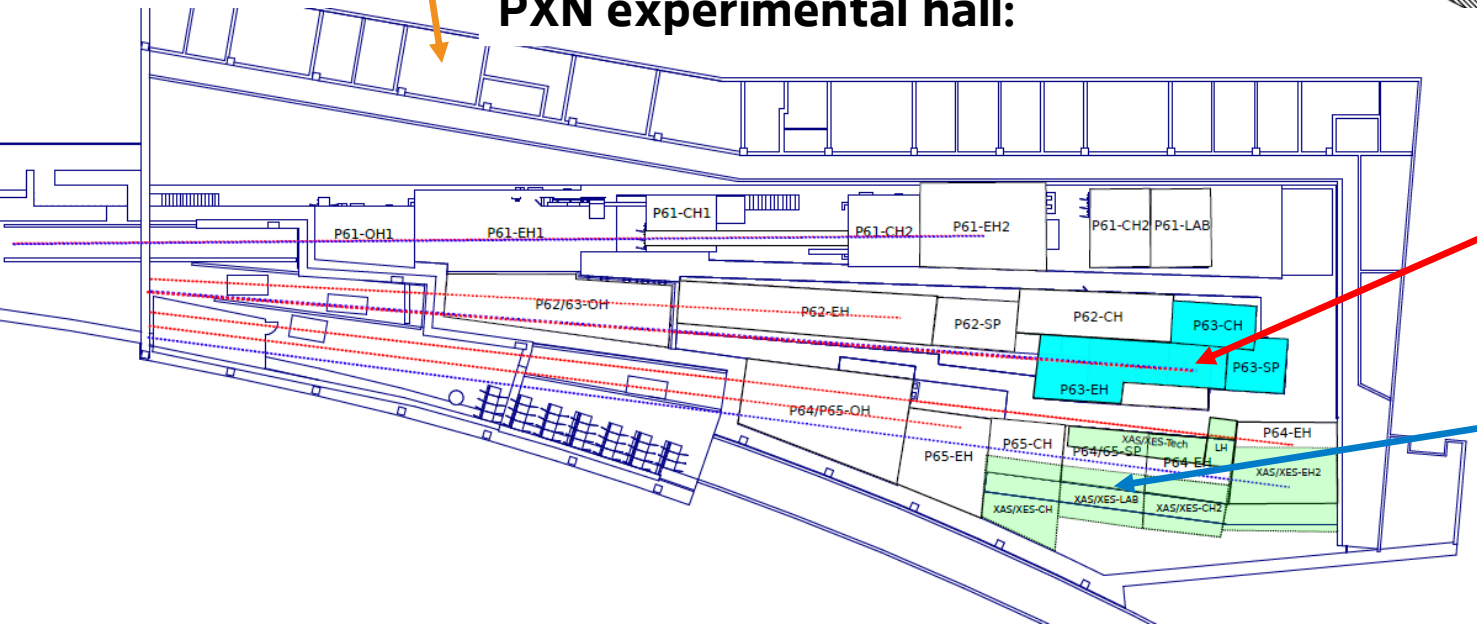
PXE + PXN

Peripheral labs

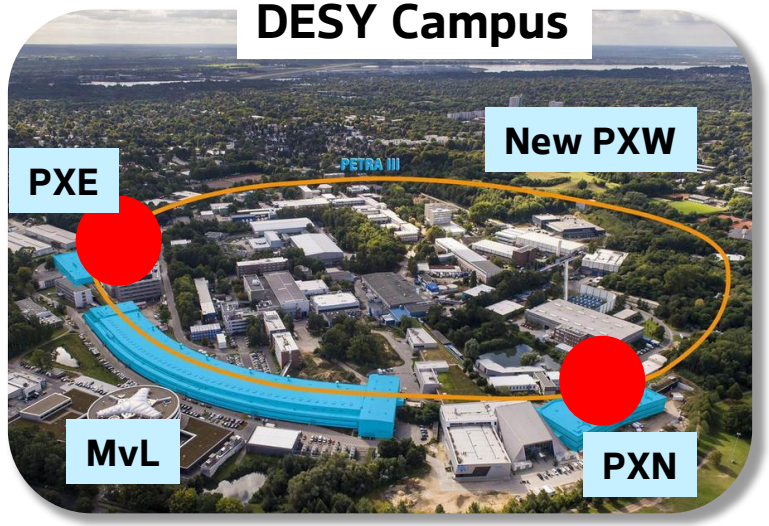
PXE experimental hall:



PXN experimental hall:



DESY Campus



> BLs currently planned or under construction at PETRA III can be reused for PETRA IV with minimal effort.

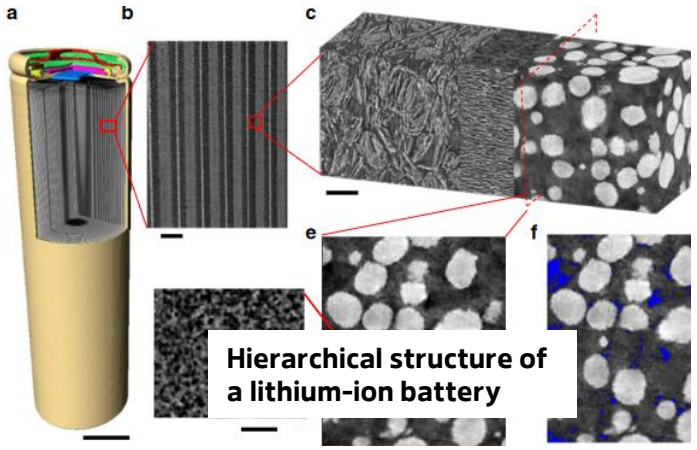
> Reconstruction of hutches due to new photon beam axis

Photon Science Experiments at PETRA IV

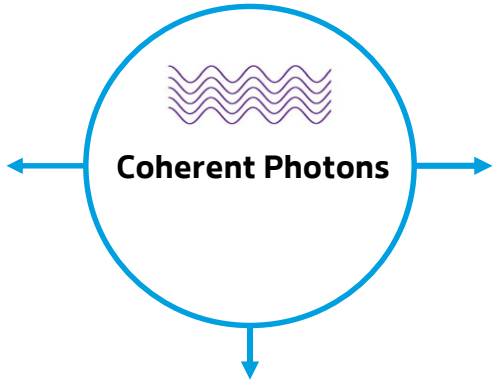
Why we need the new machine – much more "useful" photons

Coherent Scattering and Imaging

- Single-digit nanometer spatial resolution
- Routine 3D visualization
- Operando 3D maps of chemical and structural heterogeneity with nanometer resolution (holy grail)



Hierarchical structure of a lithium-ion battery

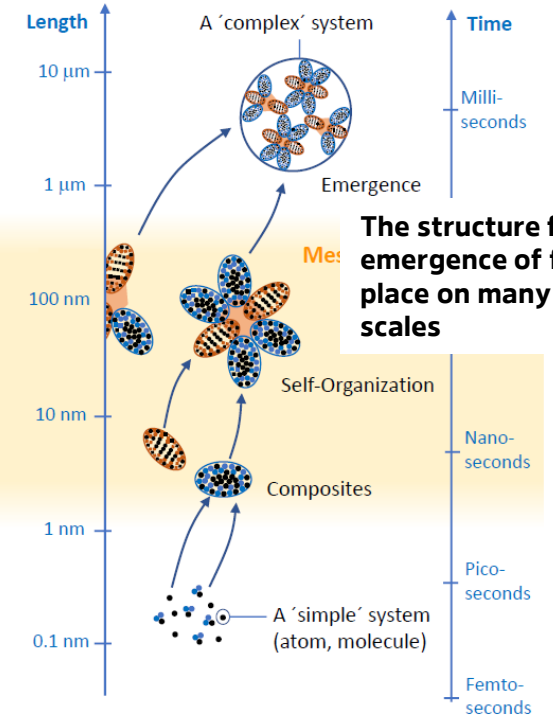


High resolution at high speed

- Following and detecting rare events
- Increase data rate to complete experiments (from week to min)
- Multiscale view – formation, structure and dynamics of complex systems in nature and technology

Coherent High-Energy X-rays

- Nano focusing becomes accessible
- Coherent techniques – imaging individual grains deep within bulk polycrystalline structural materials



The structure formation and emergence of functionalities take place on many length and time scales

TechTask and PETRA IV.

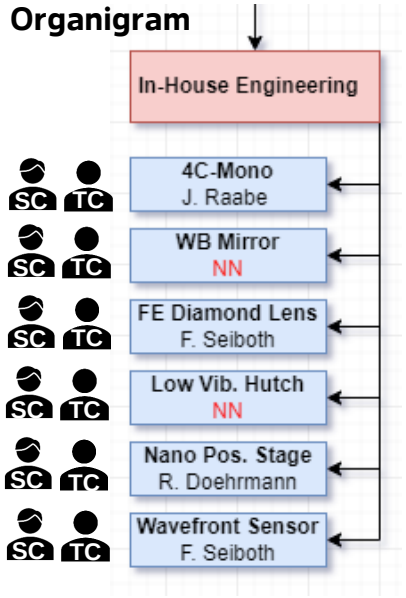
In-House Developments – 4-C Monochromator Pilot project

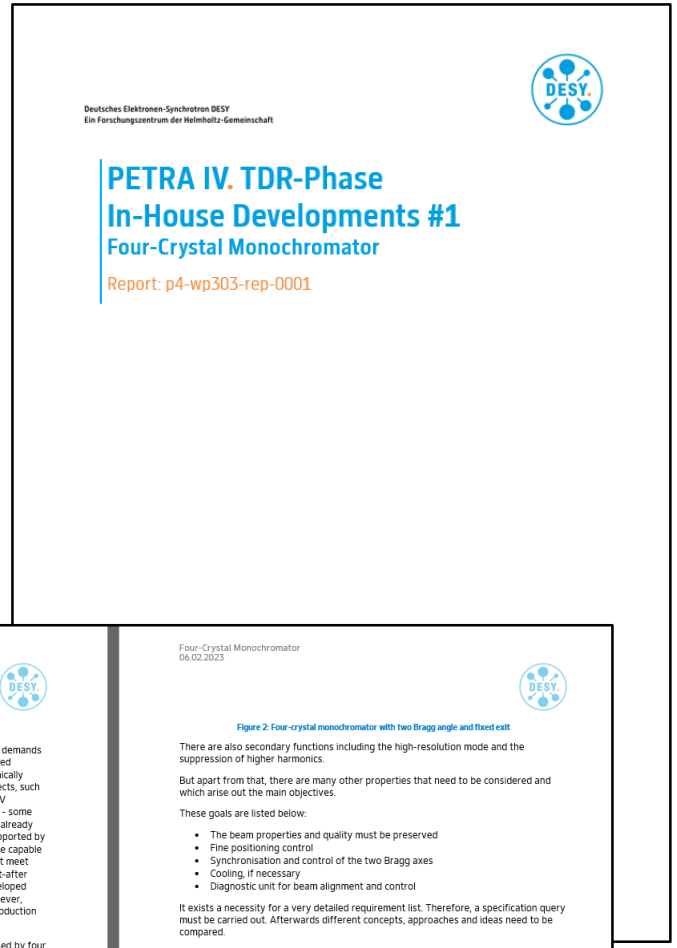
In-House Projects: (engineering project work)

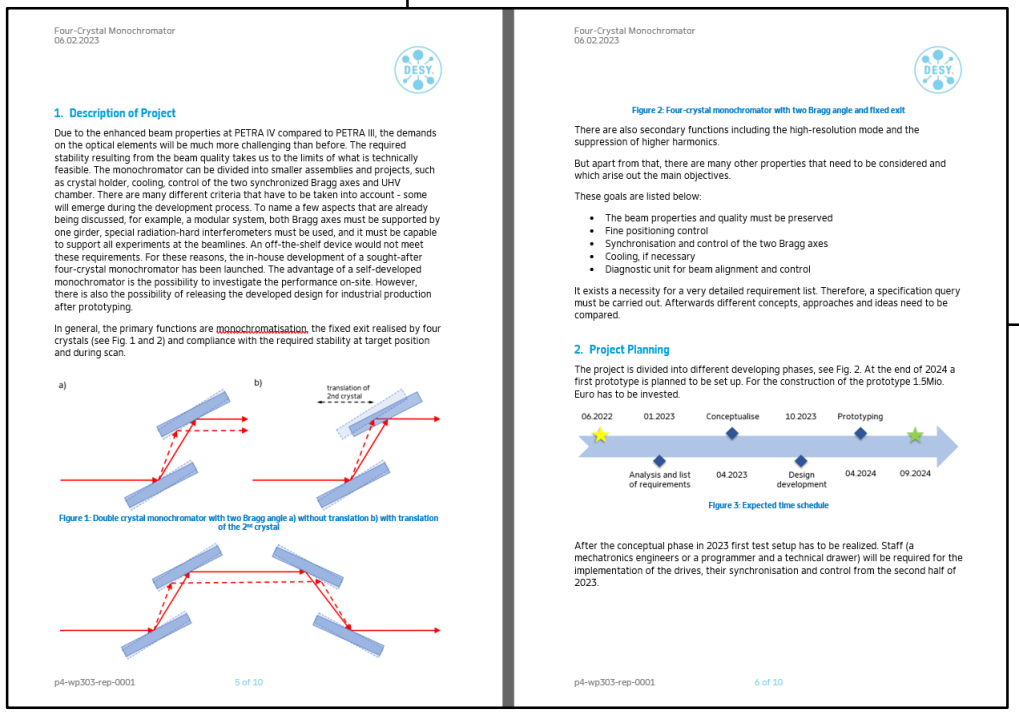
- Project description of each in-house development (timeline, resources needed,….)
- Project responsible and team of engineers, technicians, and scientists (mostly PETRA III staff and later new staff)
- Tandem of scientific and technical coordinator for each project
- Visibility within PETRA IV project structure (Organigram)
- Definition and identification of staff for In-House Engineering support by TechTask based on project requirements

Additional PETRA IV Technical Staff requested in project proposal:

- 3 Engineers + 2 Technicians







TechTask and PETRA IV.

Technical Coordination and Organization

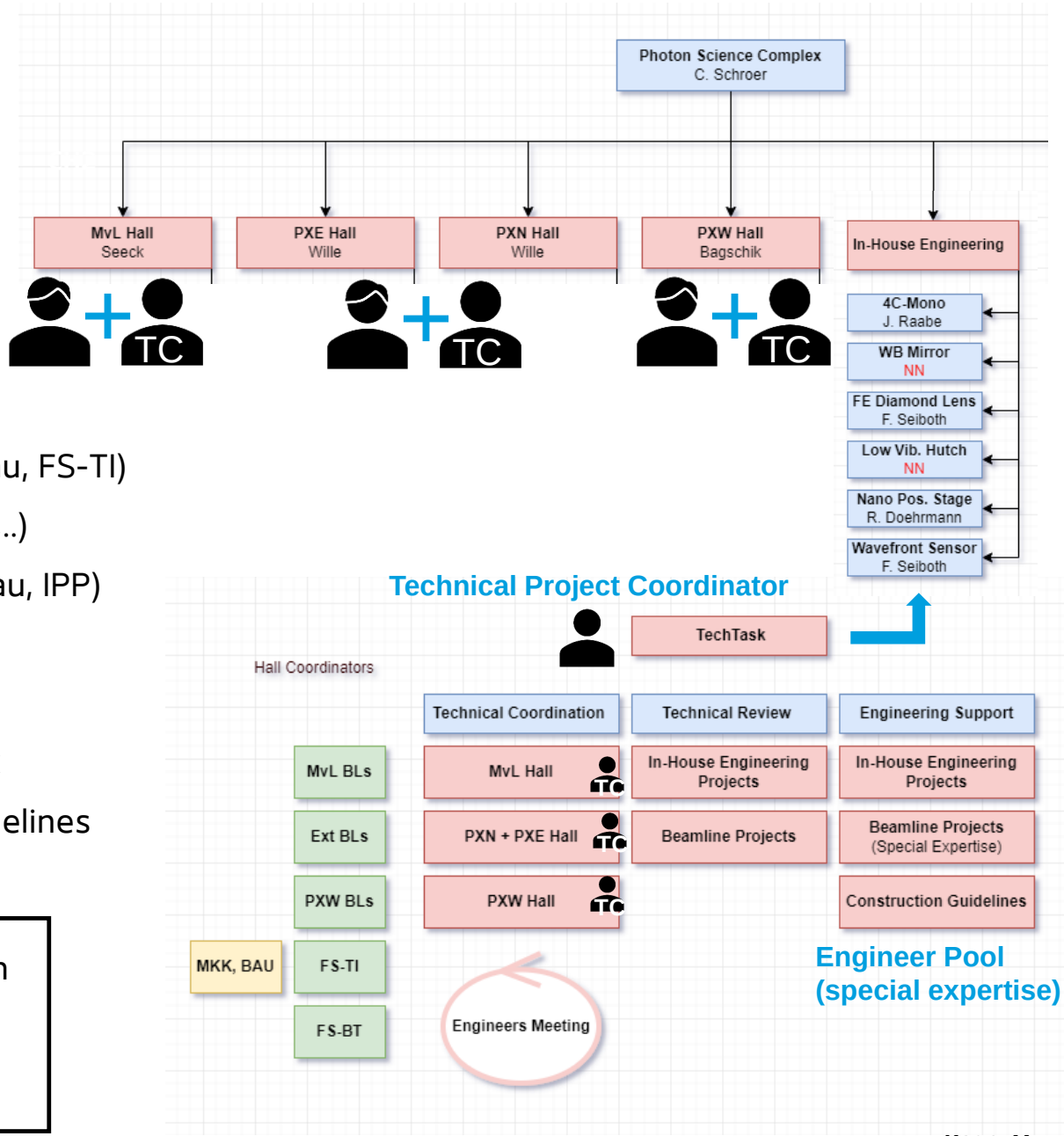
Ideas:

- Technical Coordinator for each Hall
  - → Support for hall project lead (Oliver, HC, Kai)
  - → Coordination of Hall CAD model (overview, across beamlines, Bau, FS-TI)
  - → Contact Person for Beamline Engineers (Guidelines, Information,..)
  - → Contact Person for Technical Groups (e. g. FS-TI, maybe MKK, Bau, IPP)
  - → Control Hutch & sector Labs tenders (centralized coordination)
  - → Trained during PIII operation (~20% of time)
- Technical review of in-house/beamline developments by TechTask
- Responsibles for organization of reviews and development of guidelines

Small workshop by FS-TI about roombook and important information for planning of beamline technical Infrastructure

→ TI developed in NX (exchange with TC and BL Engineers)

New Organigram will be set up (Project Leader for each Hall)



PETRA IV.

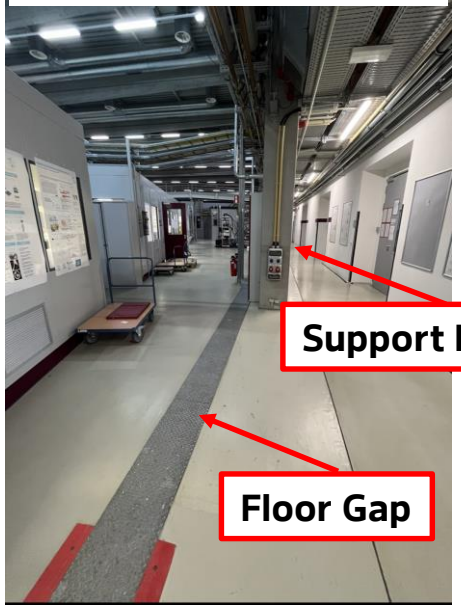
New PXW Hall – Experimental Floor Task Force

High demands on floor conditions:

- Area of > 15000 m^2
- Vibration criteria (Nano-E)
- Deformation max. 1 µm (1 kN load, distance 1 m)
- Surface flatness 4 mm / 10 m
- Slip resistant / waterproof
- Conductivity > 10^8 Ohm (grounding concept)

	Amplitude (µm/s)	Typical Usage	Accuracy
Nano-E	0,8 / 3,2	extremes Kriterium für REM der Nanotechnik für Auflösungen bis 2 Å bis 5 Å (10 Å = 1 nm), nur auf sehr massiven Bodenplatten und nur bei sehr günstigen Baugrundvoraussetzungen einhaltbar	(0,2...0,5) nm

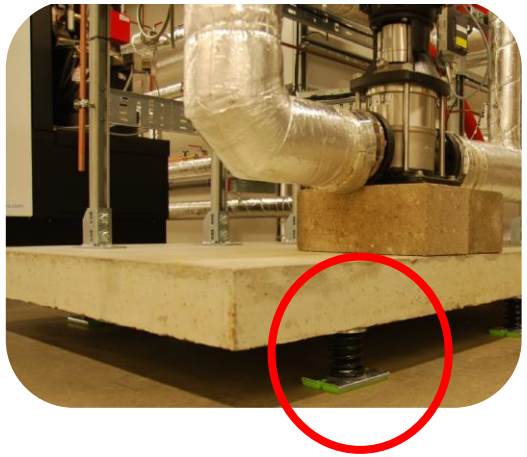
Decoupling in MvL Hall



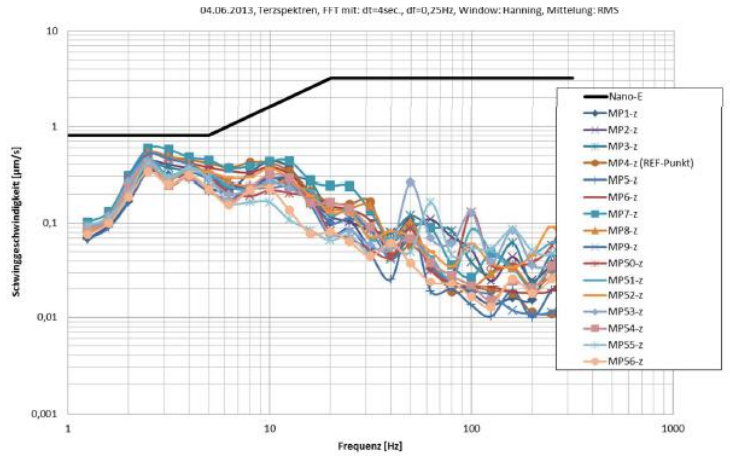
MvL Hall (April 2008)

Experimental Floor

Decoupling via springs MAX IV



Vibration spectrum XFEL hall



Distribution of Beamlines on Experimental Halls

Phase-I and Phase-II (PXW) Beamlines

The new storage ring can only accommodate a very limited number of canted sectors
(severely compromising target emittance and brilliance)

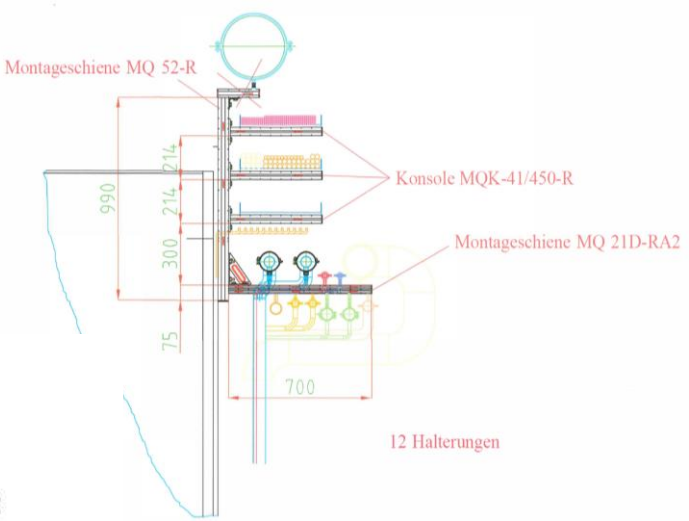
→ **New PXW hall to compensate for reduced number of beamlines (in total 33 straight sections available)**

Technical Boundary Conditions

- Reuse much of existing infrastructure
- Preserve existing laboratories
- Preserve beamline locations if possible
- Shielding of existing hutches
- Canted sectors and PIII/PIV beam axis
- ID length 4.3 m instead of 5 m (arcs)
- Reuse existing IDs
- 5 long straight sections (10 m IDs)
- Currently planned P25 and P63

Strategic Aspects

- As many Phase-I beamlines as possible
- Phase-I beamlines should cover most of user community and key experimental techniques
- Few beamline should show PETRA IV uniqueness
- EMBL beamlines and hub
- PXW beamlines start 1.5 years later
- In PXW less vibrations (underground)
- Extended beamline length in PXW hall
- In PXW tailored sector layout possible


Montageschiene MQ 52-R
Konsole MQK-41/450-R
Montageschiene MQ 21D-RA2
990
214
214
300
75
700
12 Halterungen

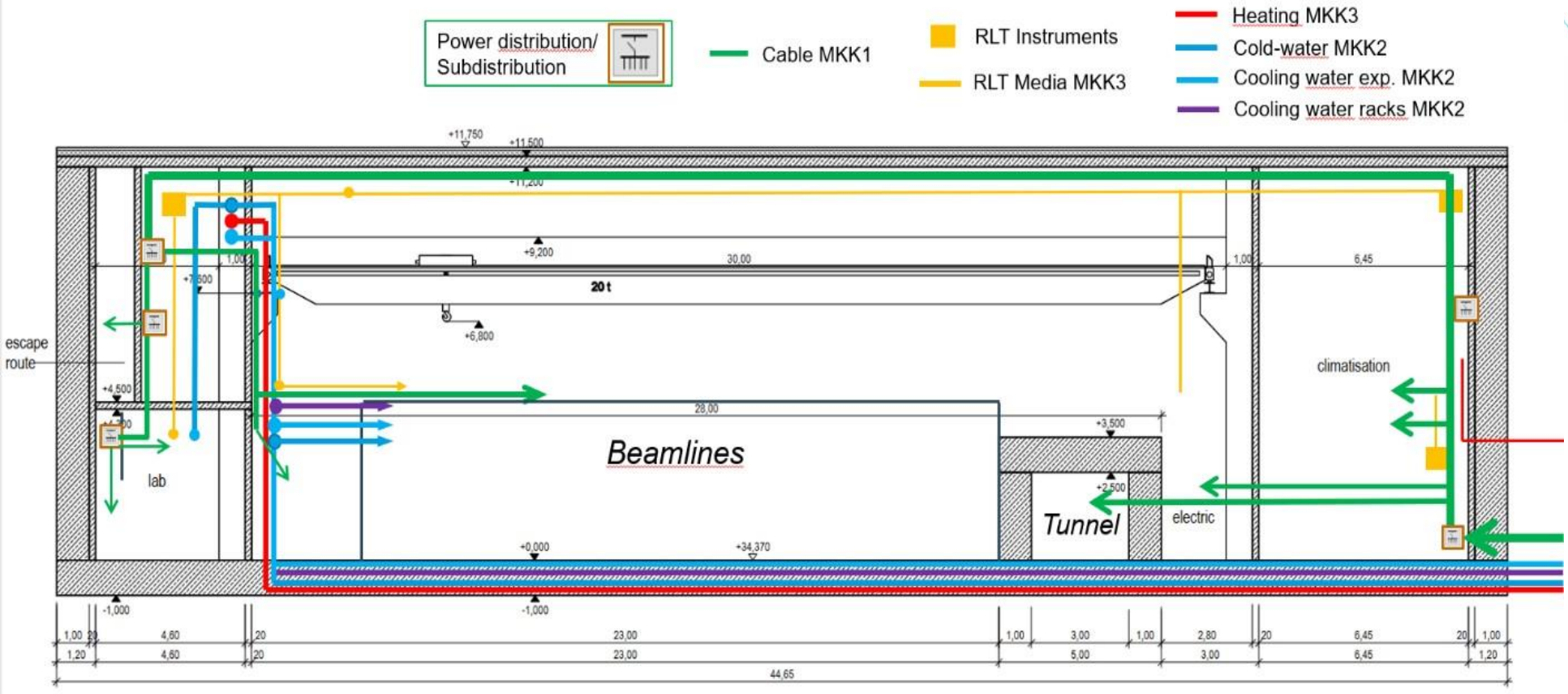

Power distribution/
Subdistribution
Cable MKK1
RLT Instruments
RLT Media MKK3
Heating MKK3
Cold-water MKK2
Cooling water exp. MKK2
Cooling water racks MKK2
+11,750
+11,500
+11,200
+9,200
30,00
1,00
6,45
20 t
+6,800
escape
route
+4,500
28,00
+3,500
Beamlines
lab
climatisation
+2,500
Tunnel
electric
+0,000
+34,370
-1,000
-1,000
1,00
20
4,60
20
23,00
1,00
3,00
1,00
2,80
20
6,45
20
1,00
1,20
4,60
20
23,00
5,00
3,00
6,45
1,20
44,65

Table 1: Overview Cooling Water

Water-typ	Acronym Layer	Consumer	Temperature (Inlet)	Water-Quality
Kühlwasser cooling water	KW_VE30	Magnete, Magnetnetzgeräte, Vakuumkomponenten	30 °C	Fully demineralized Electr. conductance: < 1 µS/cm BTGA 3.003
Kaltwasser ALU25	KW_ALU25	Undulatoren	25 °C	Fully demineralized Electr. conductance: < 1 µS/cm BTGA 3.003
Kaltwasser KW20	KW_KW20	Server Racks	18 °C	BTGA 3.003
Kaltwasser VE20	KW_VE20	Experimente Labore	18 °C	Fully demineralized Electr. conductance: < 1 µS/cm BTGA 3.003
Kaltwasser RLT	KW_RLT	RLT-Anlagen	9 °C	BTGA 3.003

XFEL TGA on top of EHs

Special Room in EHs for Pumps

PETRA IV ID Portfolio – First Draft

Result from beamline spectral requirements

ID Portfolio based on spectral requirements of individual PETRA IV beamlines

➔ **24 x IDs currently in operation at PETRA III**

15 x Reused refurbished IDs from PETRA III

4 x IDs with new magnet structure

16 x new IDs for PETRA IV (7 x new CPMU)

→ **ID Portfolio will be further developed and refined together with the beamline responsibles in the coming years.**

→ **Currently 6 mm gap for In-vacuum undulator and 9.5 mm gap for out-of-vacuum undulators. Will be further discussed with WPG2.**

Beamline	ID	K_{max} (Gap_{min})	type
Max von Laue (MvL) Experimental Hall:			
BL01 Nuclear Resonance and X-ray Raman Scattering	CPMU19~4.0m	1.95 (6 mm)	new
BL02 AdMiNaXS Beamline	2 x U29-2m	2.2 (9.5 mm)	refurbished
BL03 Hard X-ray Photoelectron Spectromicroscopy	U34-4.3m	2.2 (9.5 mm)	new
BL04 High-Energy Scatt. and Diff. Tomography	CPMU18~3.8m	1.76 (6 mm)	new
BL05 High-Energy Mater. Sci. Beamline (HEREON)	IVU21-4.0m	1.8 (6 mm)	refurbished
BL06 Surface and Interface Dynamics Beamline	2 x U29-2m	2.2 (9.5 mm)	refurbished
BL07 *In-situ* Bragg Microscopy Beamline	U30-4.3m	2.4 (9.5 mm)	new
BL08 High-Thru. MX	U29-2m	2.2 (9.5 mm)	refurbished
BL09 BioSAXS Beamline (EMBL)	U29-2m	2.2 (9.5 mm)	refurbished
BL10 High Performance and Microfocus MX (EMBL)	U23-2m	1.3 (9.5 mm)	ref./new mag.
BL11 Bio Diffraction and Imaging (EMBL)	U29-2m	2.2 (9.5 mm)	refurbished
Ada Yonath (PXE) Experimental Hall:			
BL21.1 High-Energy Beamline for Phys. and Chem.	U29-2m	2.2 (9.5 mm)	refurbished
BL21.2 Swedish High-Energy Mater. Sci. Beamline (SE)	IVU21-4m	1.8 (6 mm)	refurbished
BL22 HIKA Beamline (KIT)	tbd.	tbd.	tbd.
BL23 Chemical Crystallography Beamline	U25-4.3m	1.55 (9.5 mm)	new
New PXW Experimental Hall:			
BL31 HRHS Soft X-ray Beamline	UE65-5m	6.3 (11 mm)	refurbished
BL34 Multiscale Mater. Microscope (DESY/HEREON)	CPMU18~3.8m	1.76 (6 mm)	new
BL35 Materials Scanning Nanoscope	U34-4.3m	2.9 (9.5 mm)	new
BL36 In-Situ/High-Resolution 3D Nanoprobe	U32-4.3m	2.7 (9.5 mm)	new/ref. mag.
BL37 Full-Field Imaging for Mater. Sci. (HEREON)	U25-4.3m	1.55 (9.5 mm)	new
BL38 CryoBio Nanoprobe Beamline	CPMU18~3.8m	1.76 (6 mm)	new
BL39 Coherent Applications Beamline	CPMU18~3.8m	1.76 (6 mm)	new
BL41 ExTReM	CPMU18~4.0m	1.76 (6 mm)	new
BL42 Resonant X-ray Scattering Beamline (MPG)	2 x U32-2m	2.7 (9.5 mm)	refurbished
BL45 Powder Diffraction and Total Scattering	U25-4.3m	1.55 (9.5 mm)	new
BL46 SAXSMAT II Beamline	U30-4.3m	2.4 (9.5 mm)	new
BL48 Applied Analytical XAFS and Q-EXAFS Beamline	3PW	tbd.	new
Paul P. Ewald (PXN) Experimental Hall:			
BL61 *In-situ* Large Volume Press Beamline	CPMU18~4.0m	1.76 (6 mm)	new
BL62 Materials Science Lab Beamline (MPG)	U32-2m/U23-2m	2.7/1.3 (9.5 mm)	ref./new mag.
BL63 X-ray Absorption & Emission Spec. Beamline	U29-2m/U33-2m	2.2/2.7 (9.5 mm)	refurbished
BL64 Time-Resolved VUV Spectroscopy Beamline	3PW	tbd.	new

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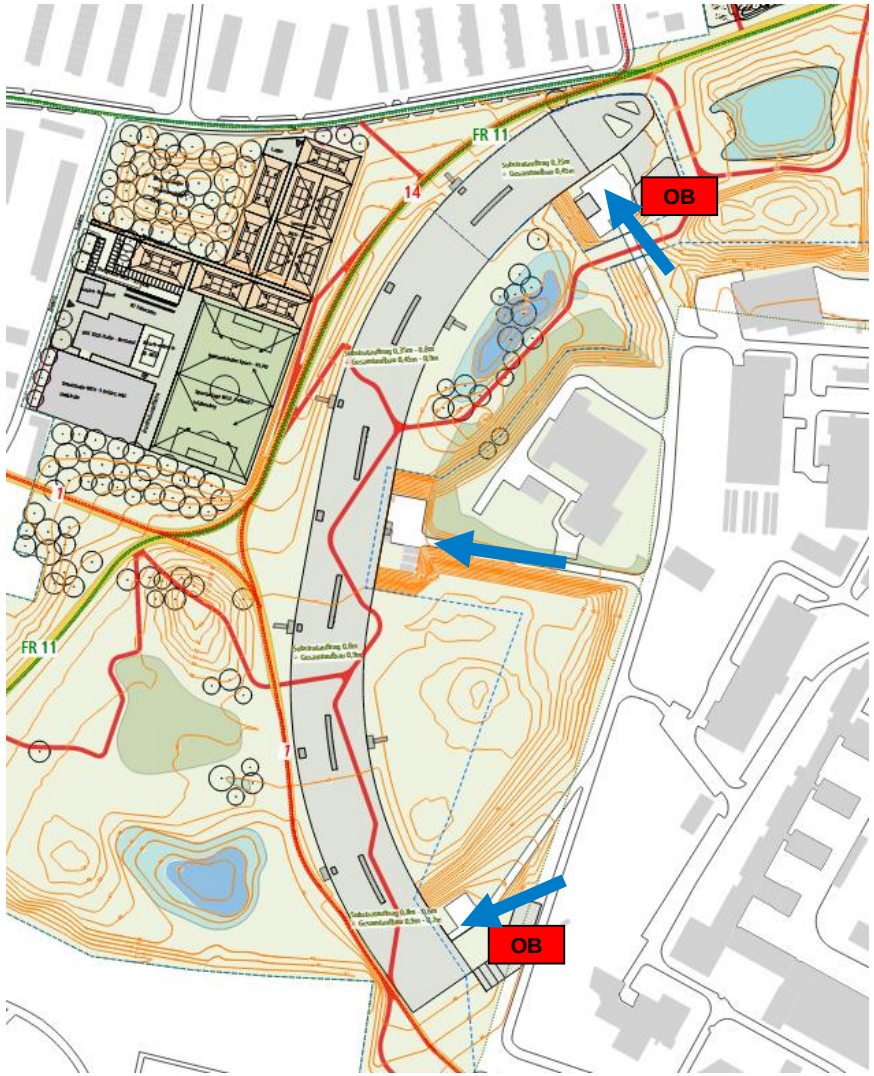
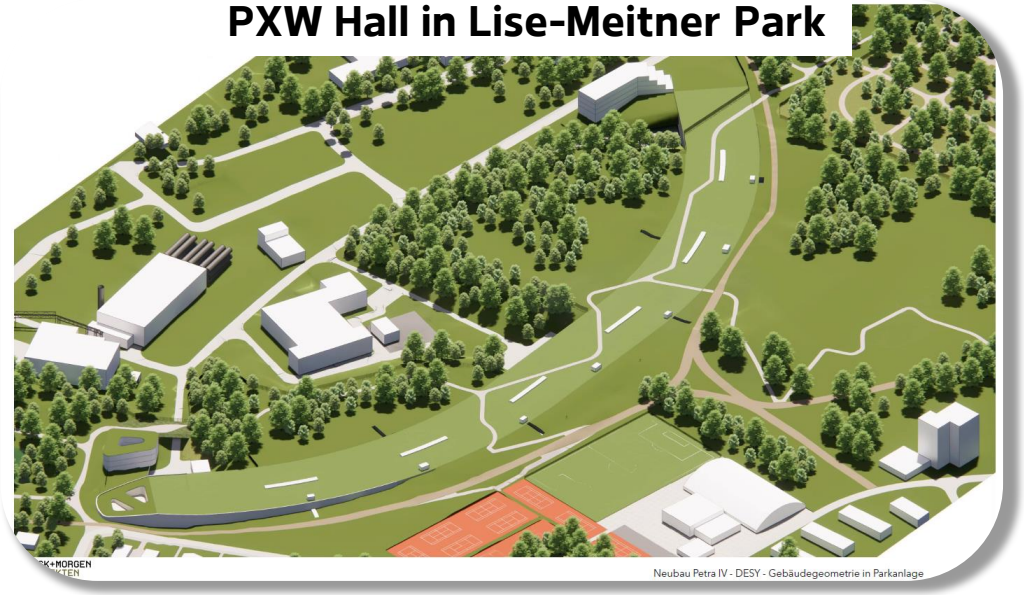
PETRA IV.

New PXW Hall – Office space



PXW Hall in Lise-Meitner Park



- No offices in PXW hall
  → (ArbStättV point 2.4, ArbStättV, point 2.)
- Office space for 197 Persons required
  (extrapolation of current staffing)
  → > 2000 m^2 office space
- Seminar/Meeting rooms required
- Short ways to beamlines and labs required