

PETRA IV.
NEW DIMENSIONS

PETRA IV and its booster

Future machines on a campus rich in tradition

Sven Sievers

GFA Seminar, PSI, January 2023

HELMHOLTZ



01 DESY

- What was?
- What is?
- What will be?

02 PETRA IV

- From the idea to the concept

03 DESY IV

- A new booster synchrotron for PETRA IV

04 Old meets new

- A new accelerator in a historical building

05 Summary

DESY

What was?

What is?

What will be?

DESY timeline

Some history (with a focus on PETRA)



Quick Facts

- 1959 Foundation of Deutsches Elektronen-Synchrotron

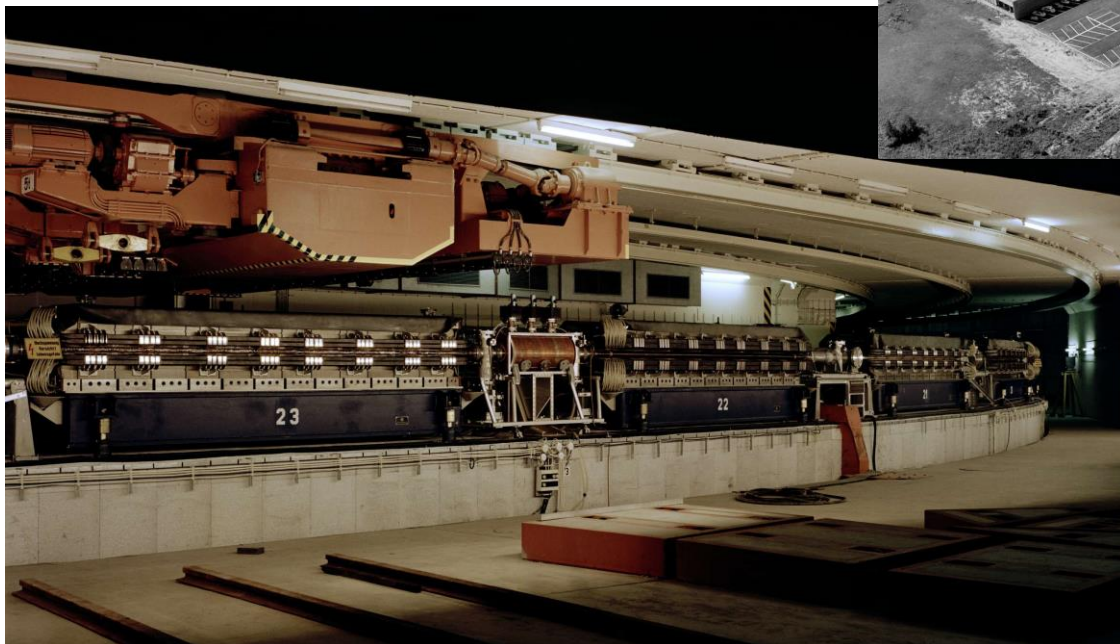


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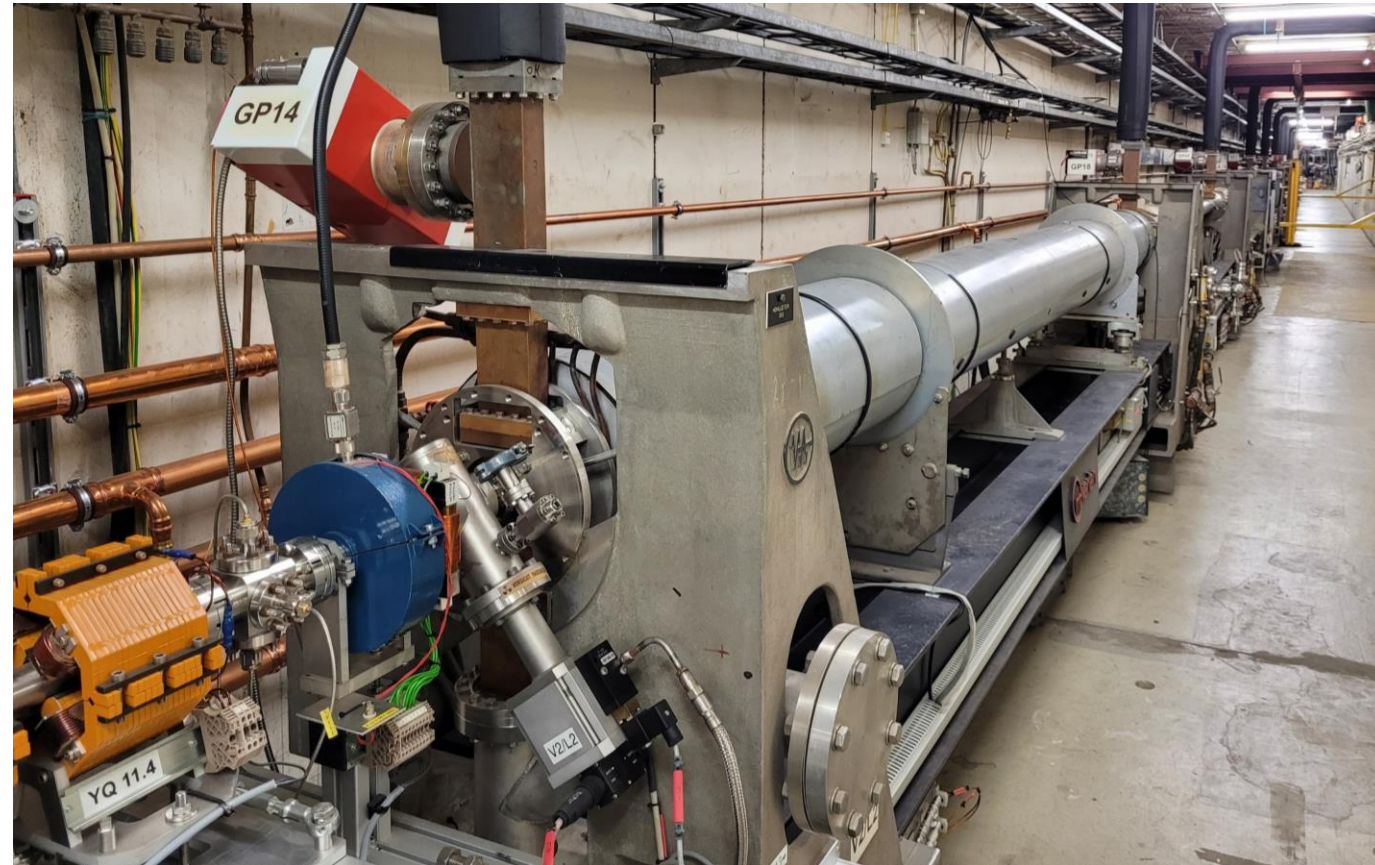


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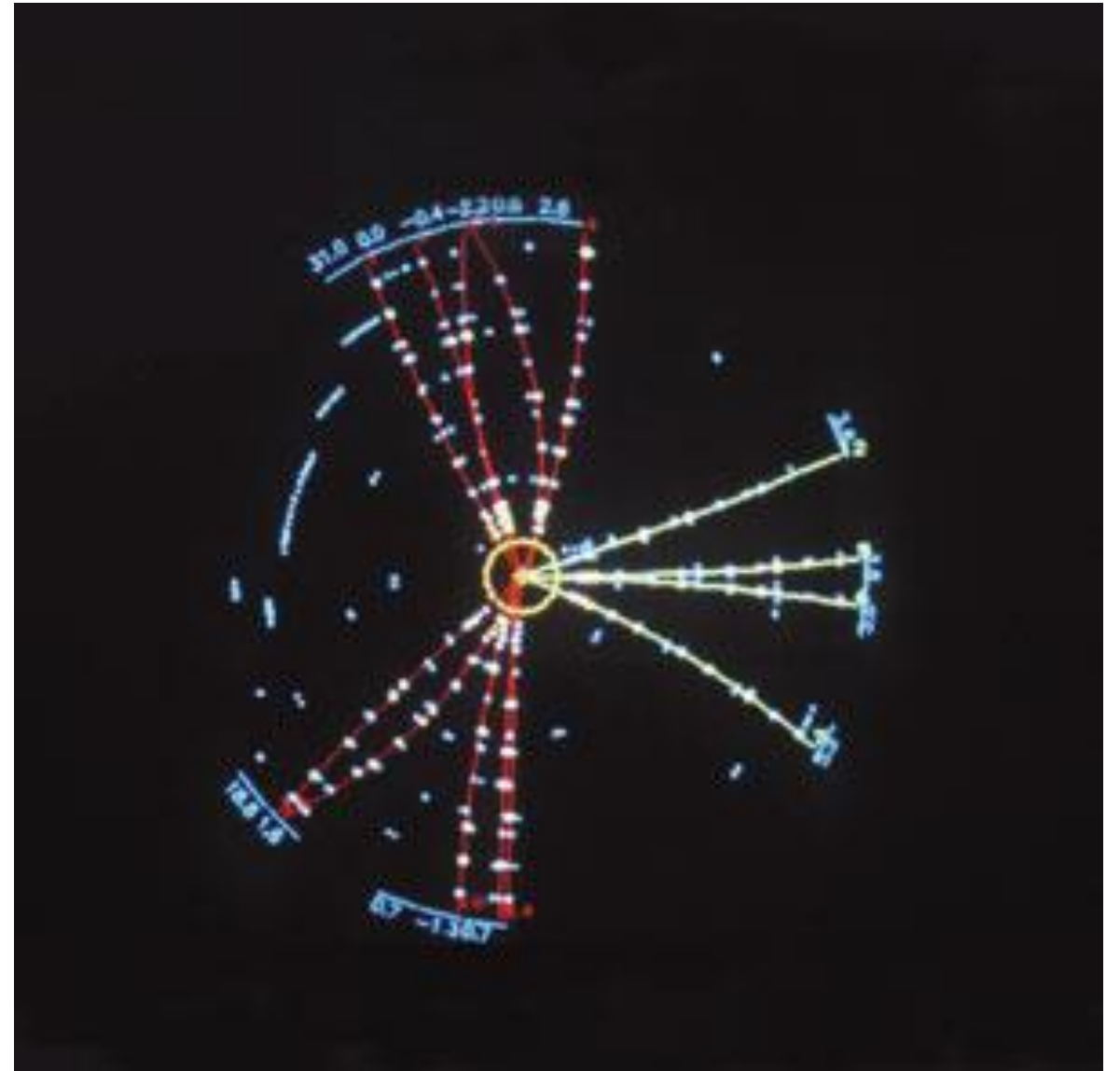


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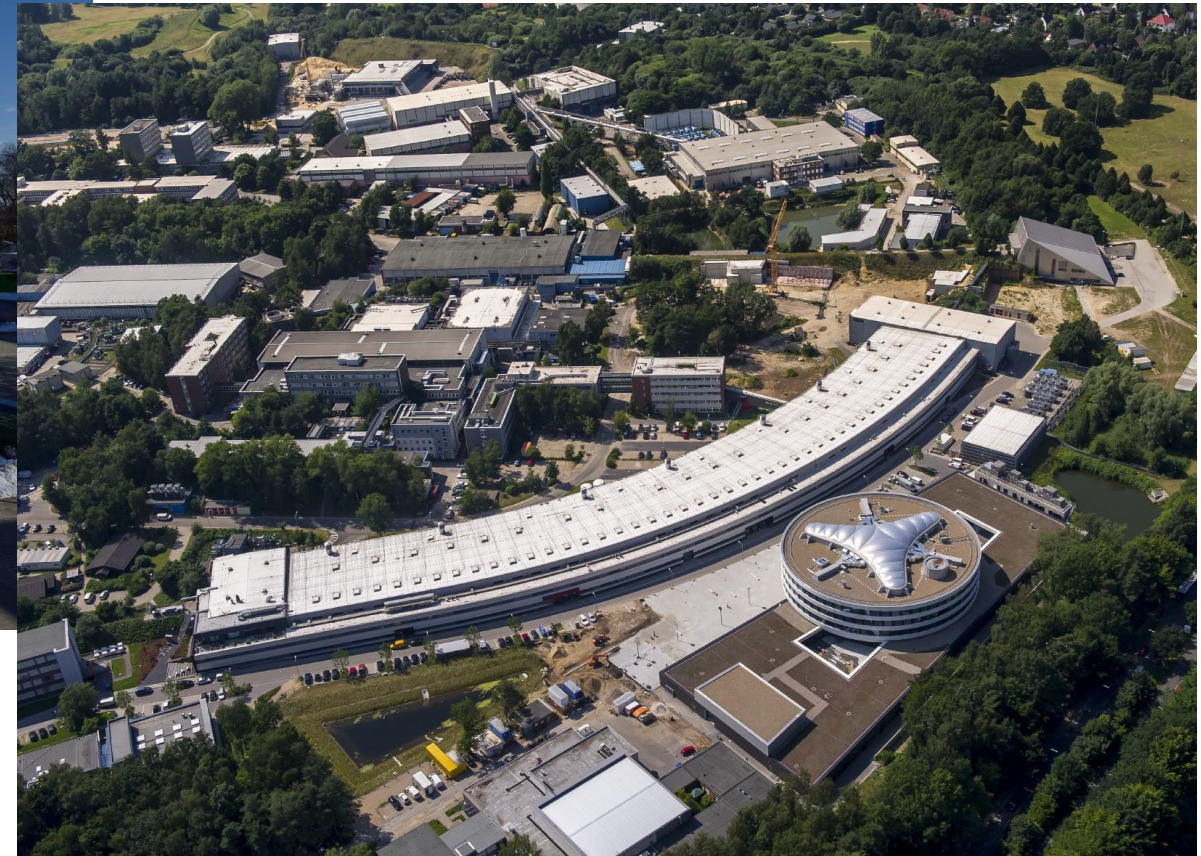
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- 1987 (and 1988) DESY II (and DESY III for protons) start operation as pre-accelerators for HERA
- 1990 PETRA II starts operation as pre-accelerator for HERA



DESY timeline

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- 2010 PETRA III is commissioned as dedicated light source

DESY timeline

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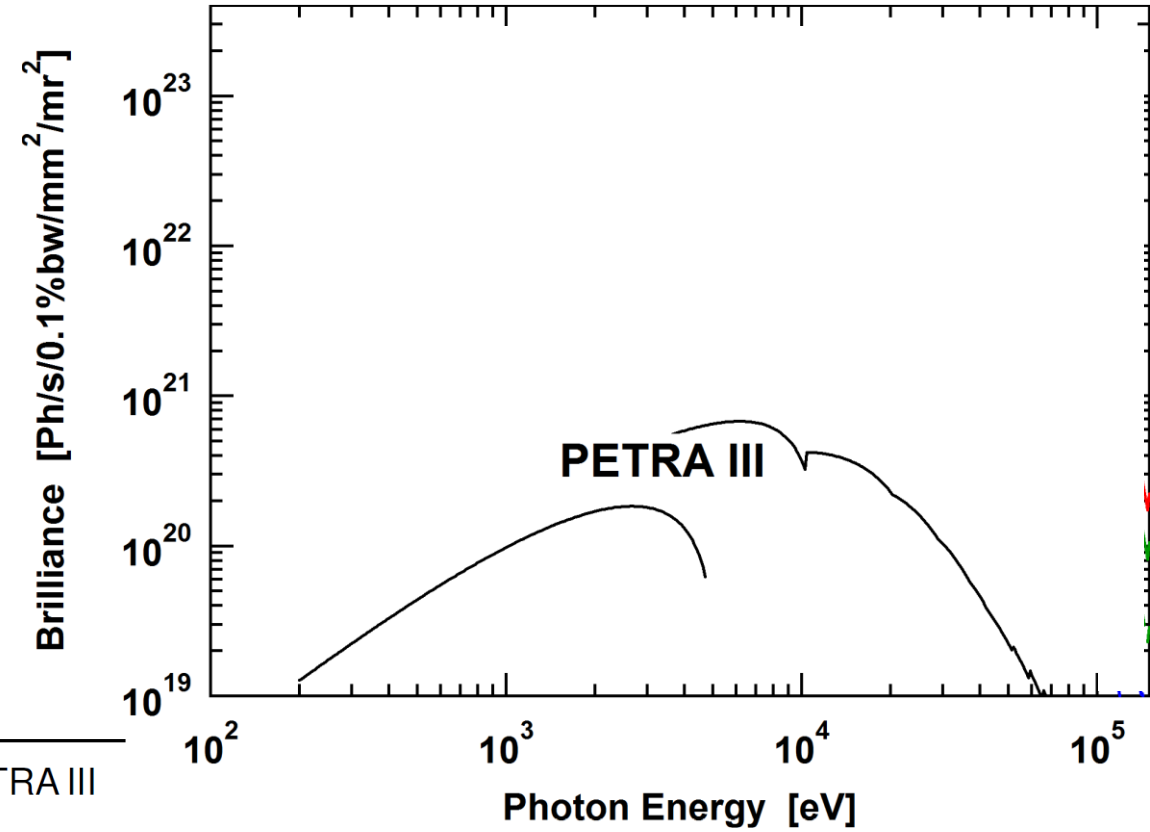
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- 1990 PETRA II starts operation as pre-accelerator for HERA
- 2010 PETRA III is commissioned as dedicated light source
- 2023 PETRA III still up and running... with LINAC II and DESY II as pre-accelerators

PETRA IV

... looking into a bright future

Quick Facts

- 2023 PETRA III still up and running...



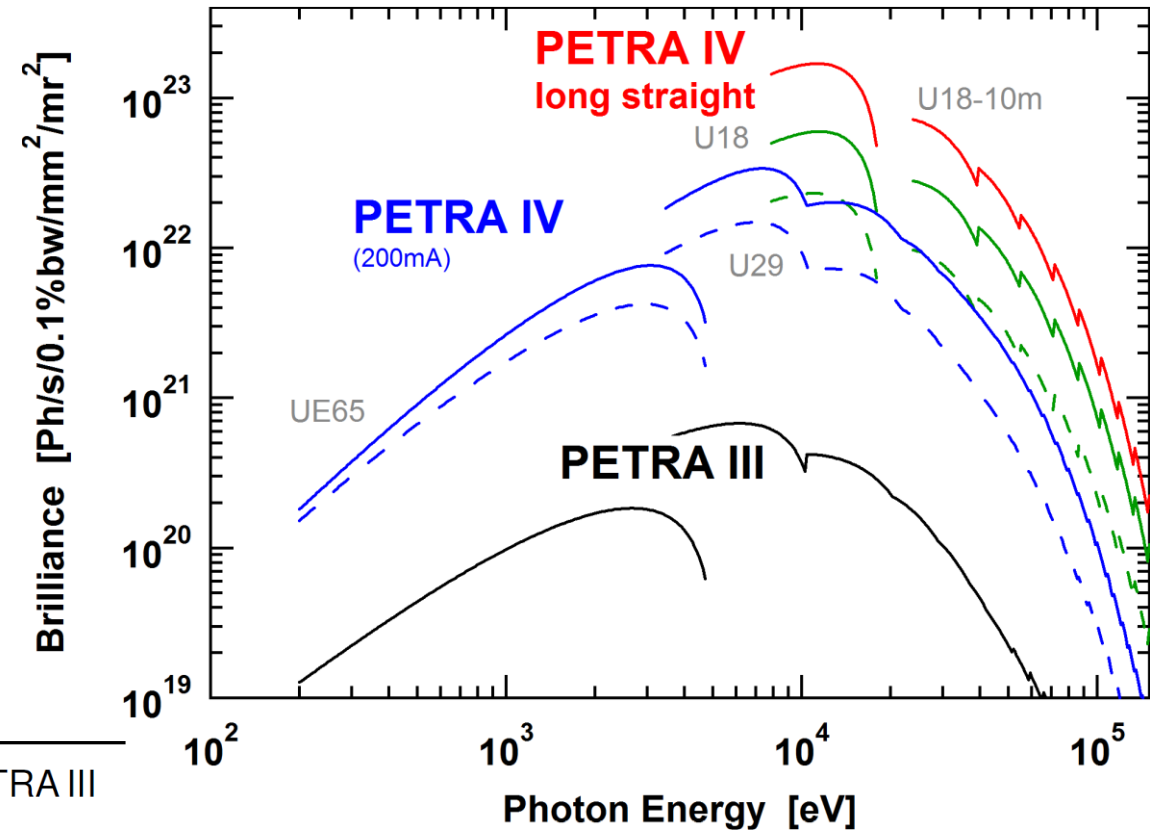
Parameter	PETRA III
Energy / GeV	6
Circumference / m	2304
Total current / mA	100
Number of bunches	40 ... 960
Emittance	
Horiz. ϵ_x / pm rad	1300
Vert. ϵ_y / pm rad	10
Number of undulator beamlines	21(26)

PETRA IV

... looking into a bright future

Quick Facts

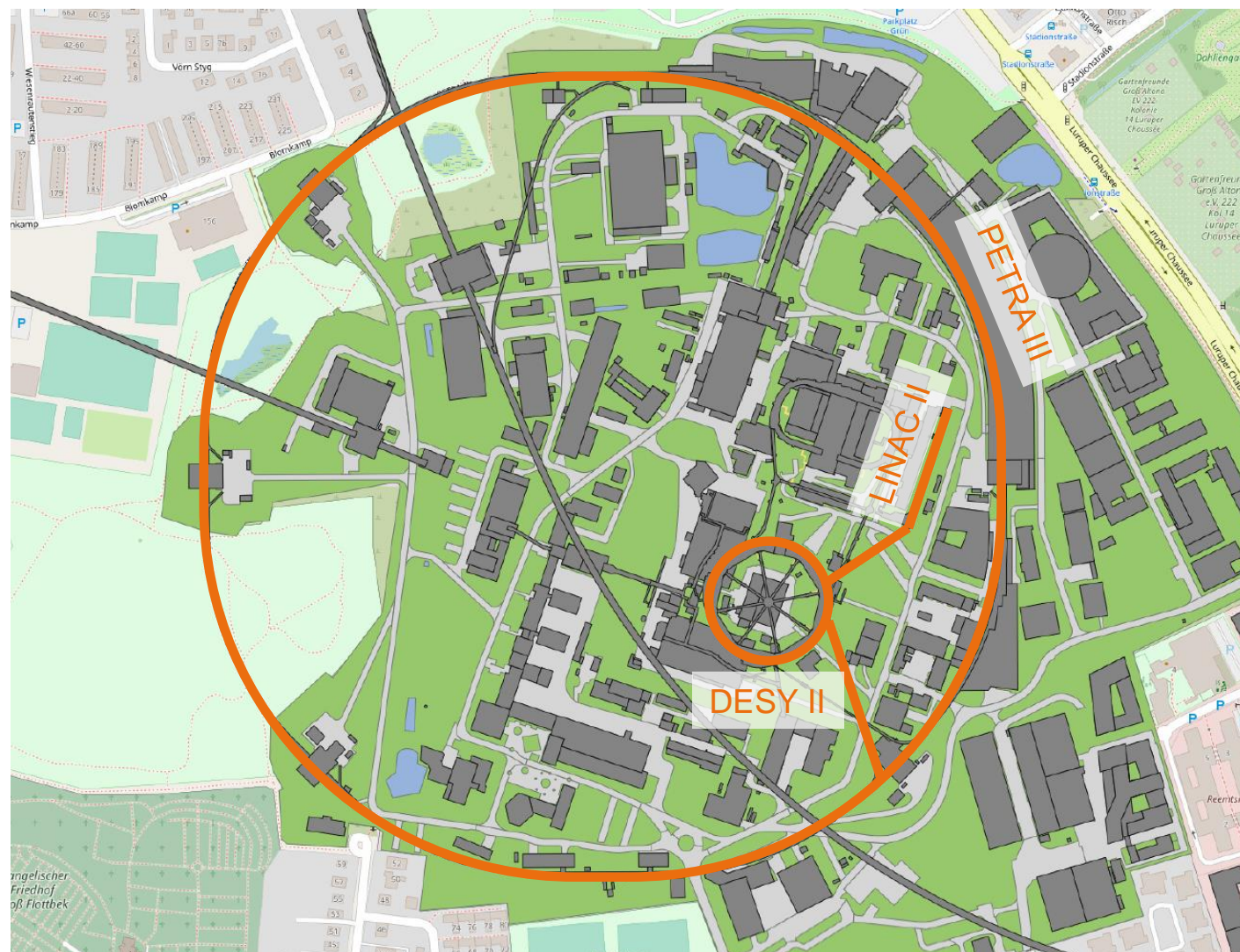
- 2023 PETRA III still up and running...
- ... but PETRA IV is on the horizon



Parameter	PETRA IV		PETRA III
	Brightness mode	Timing mode	
Energy / GeV	6	6	6
Circumference / m	2304	2304	2304
Total current / mA	200	80	100
Number of bunches	1600	80	40 ... 960
Emittance			
Horiz. ϵ_x / pm rad	< 20	< 40	1300
Vert. ϵ_y / pm rad	2 - 10	5 - 20	10
Number of undulator beamlines	30		21(26)

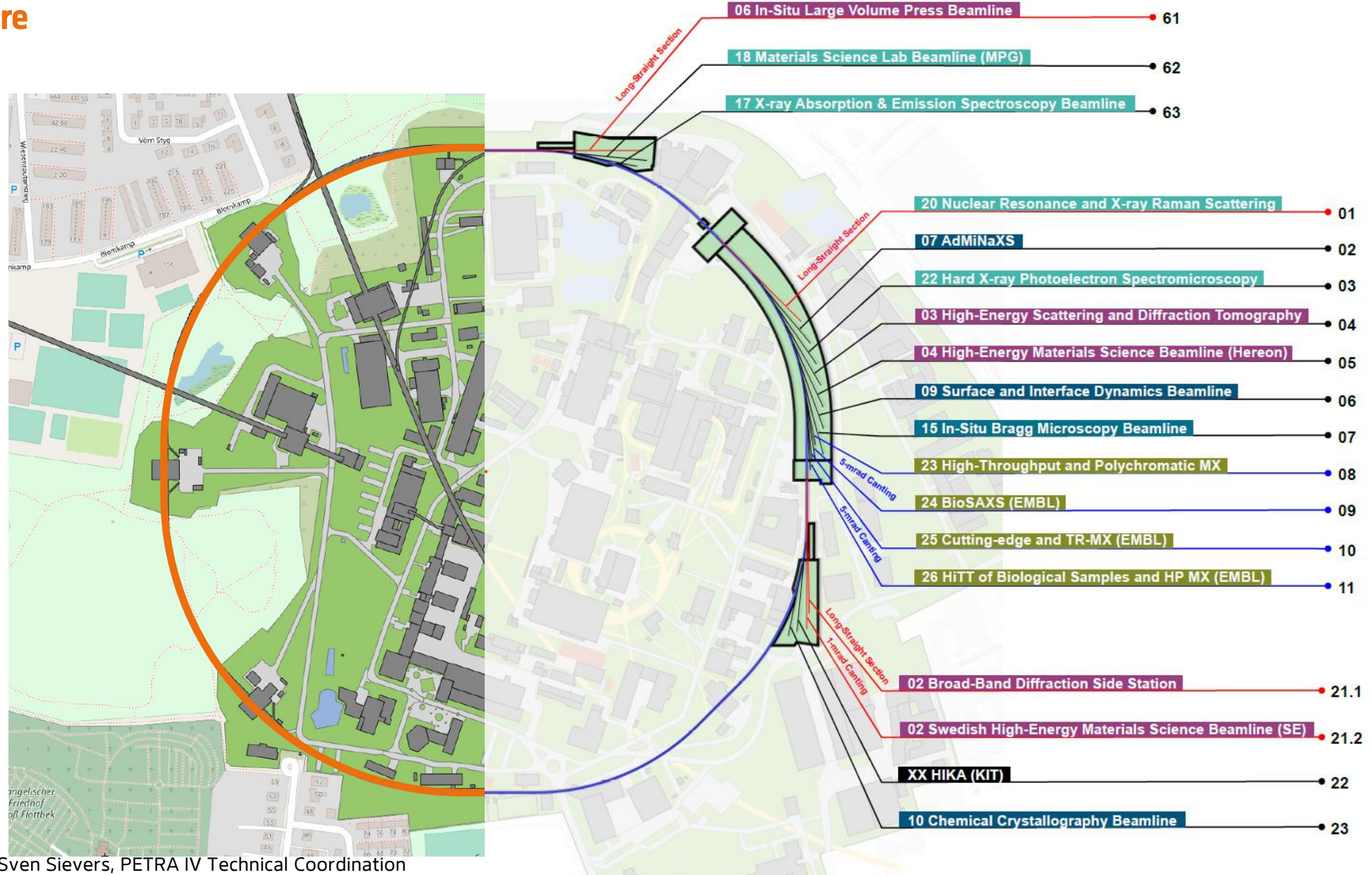
PETRA IV

... looking into a bright future



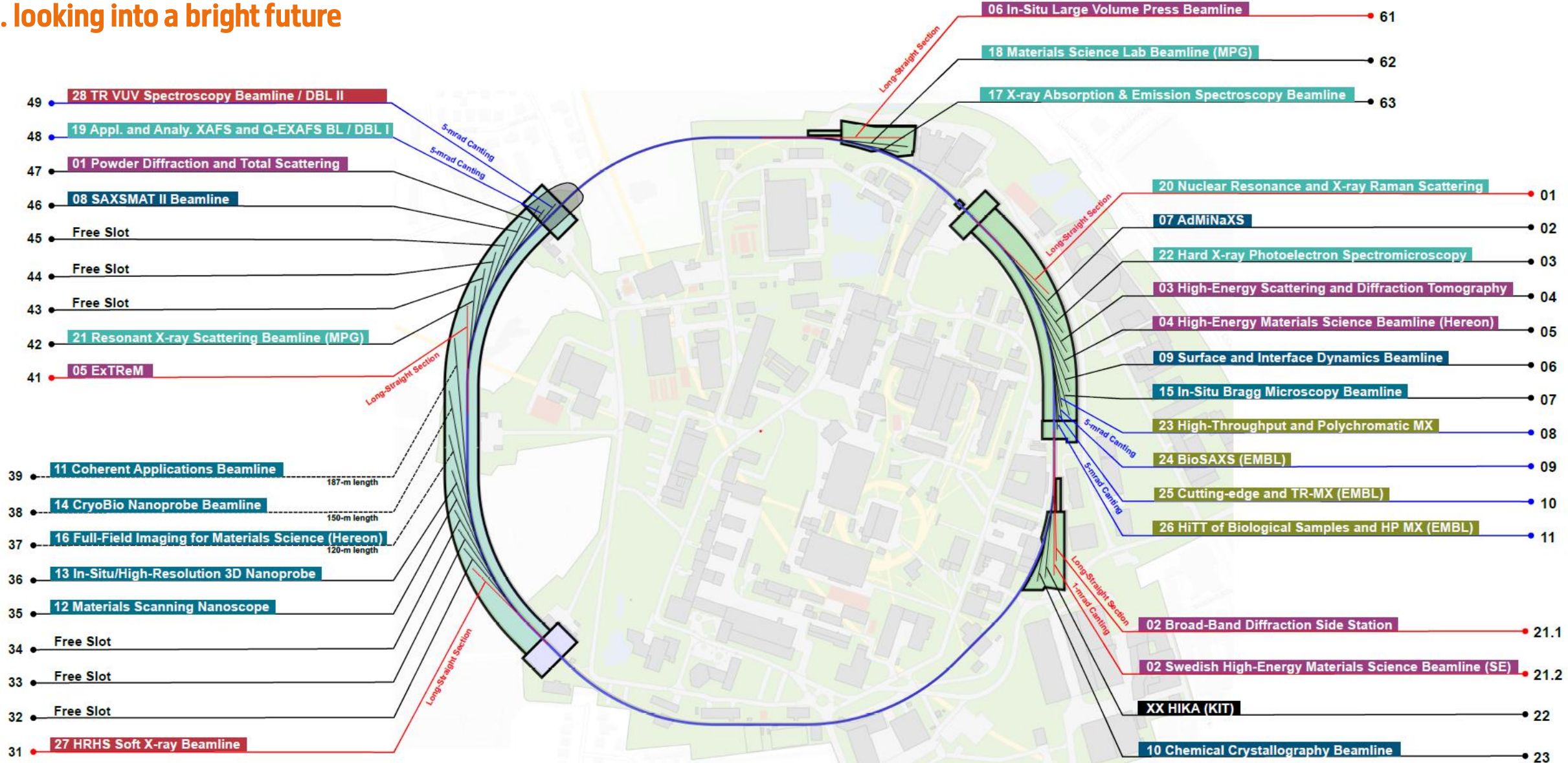
PETRA IV

... looking into a bright future



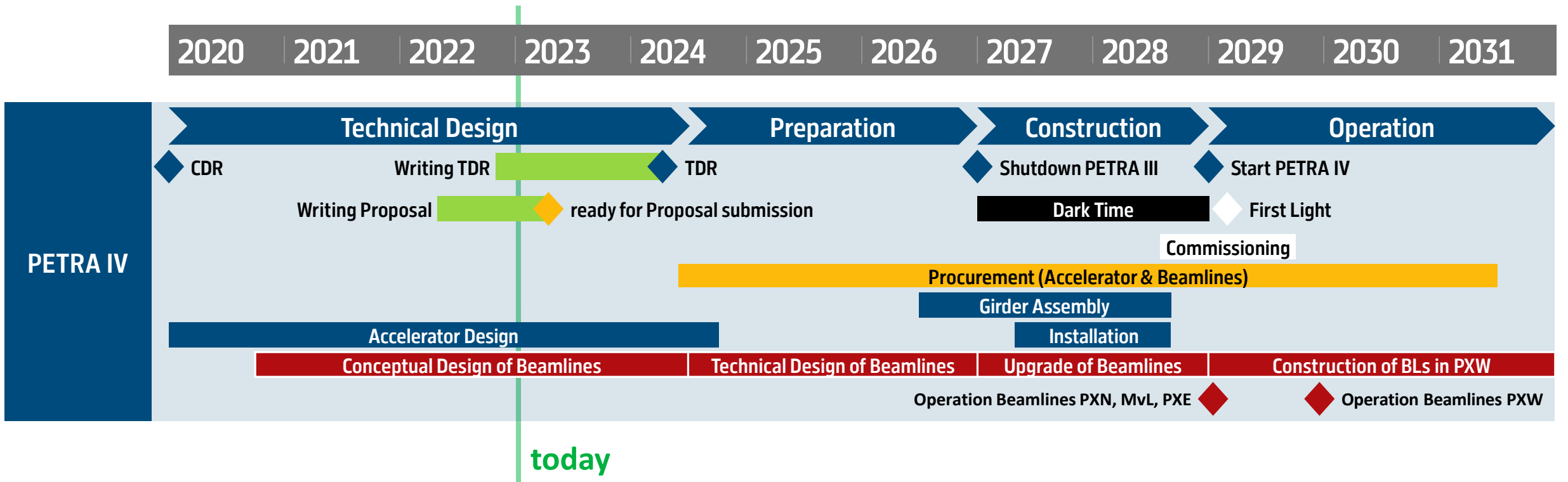
PETRA IV

... looking into a bright future



PETRA IV

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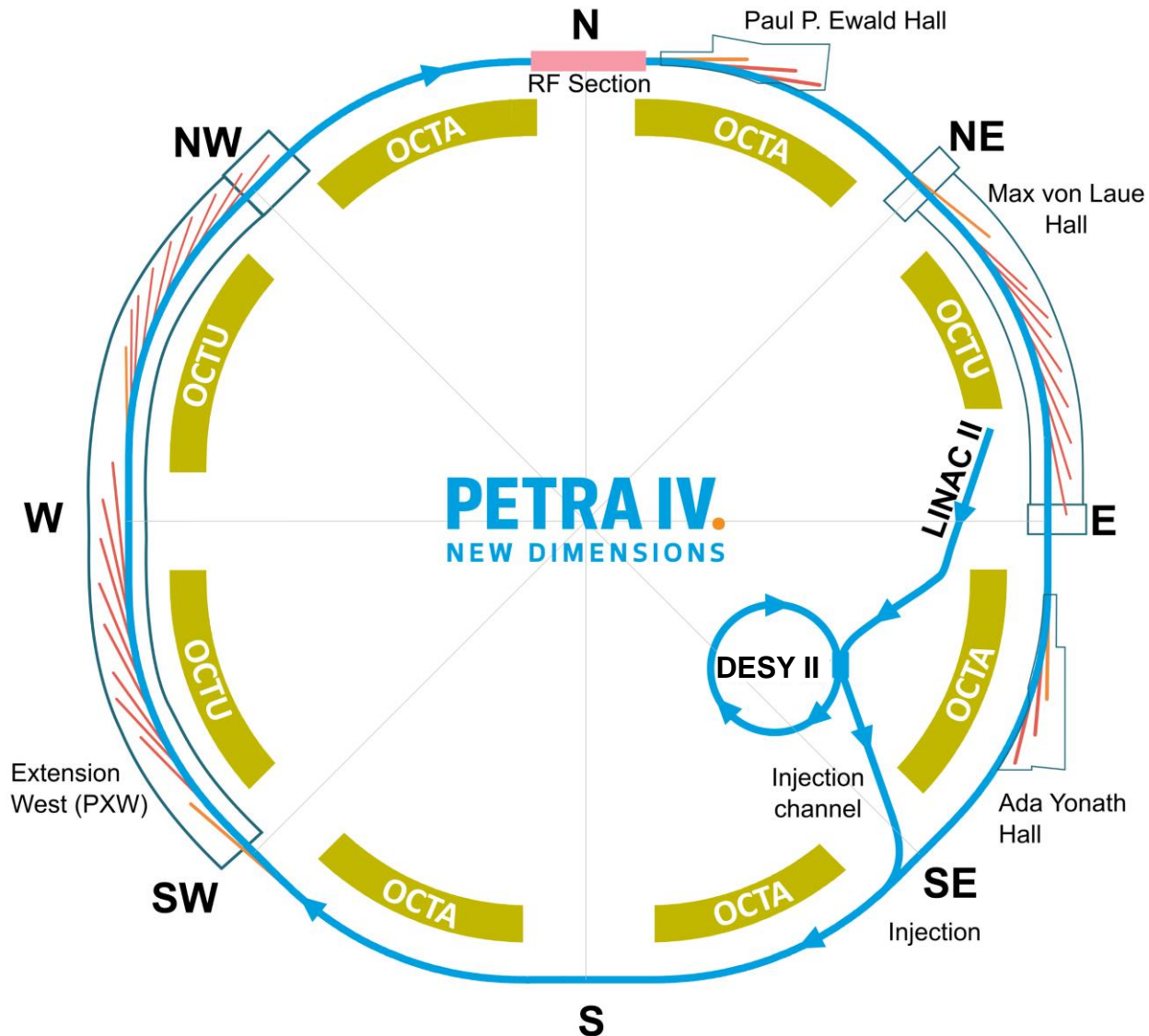
PETRA IV facility

From the idea...

... to the concept.

PETRA IV facility layout

How will the new facility look like?

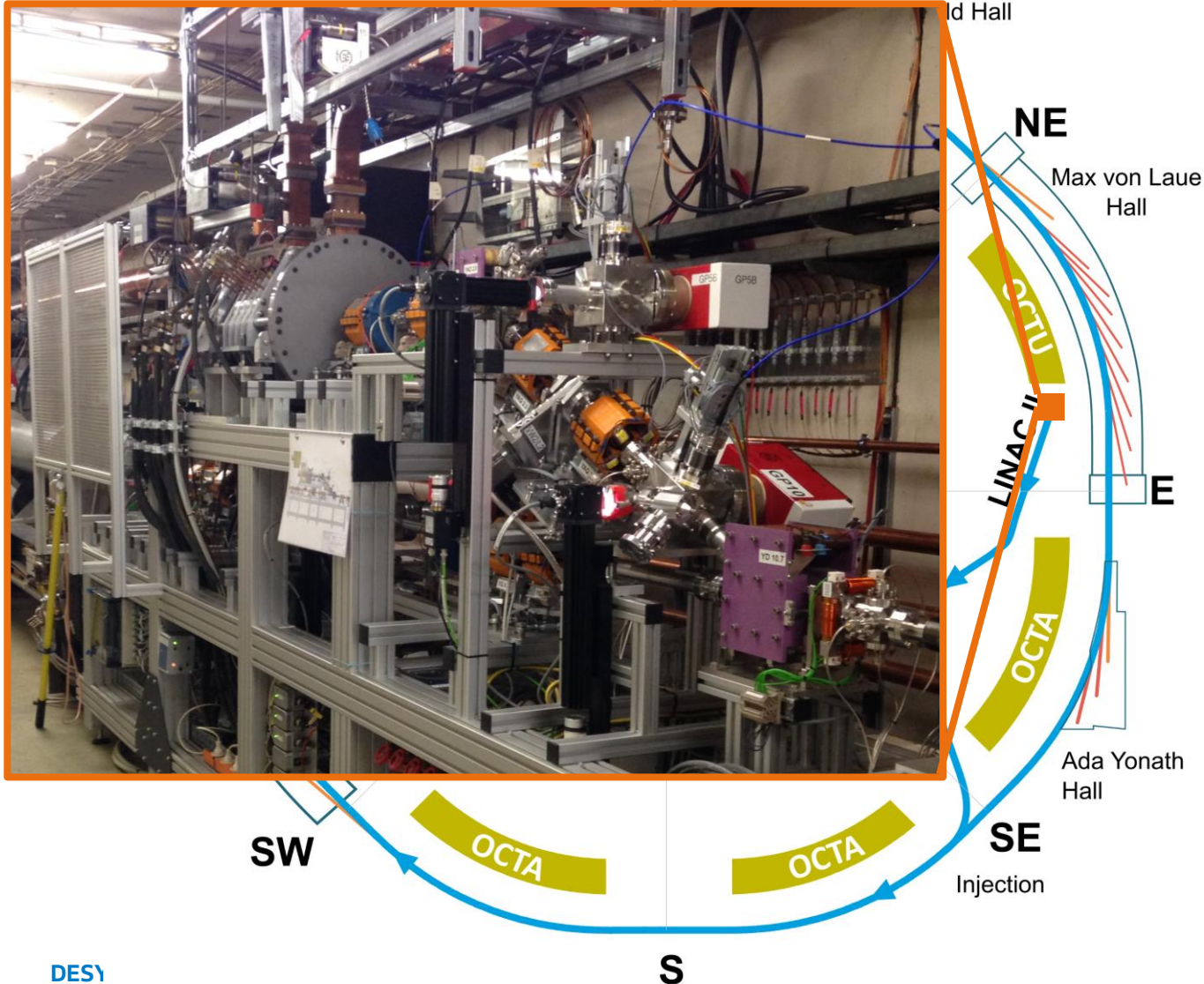


Make it great... but make it cheap!

- Accumulation in the storage ring seems feasible!
- ⇒ First idea: Reuse the pre-accelerator complex

PETRA IV facility layout

How will the new facility look like?

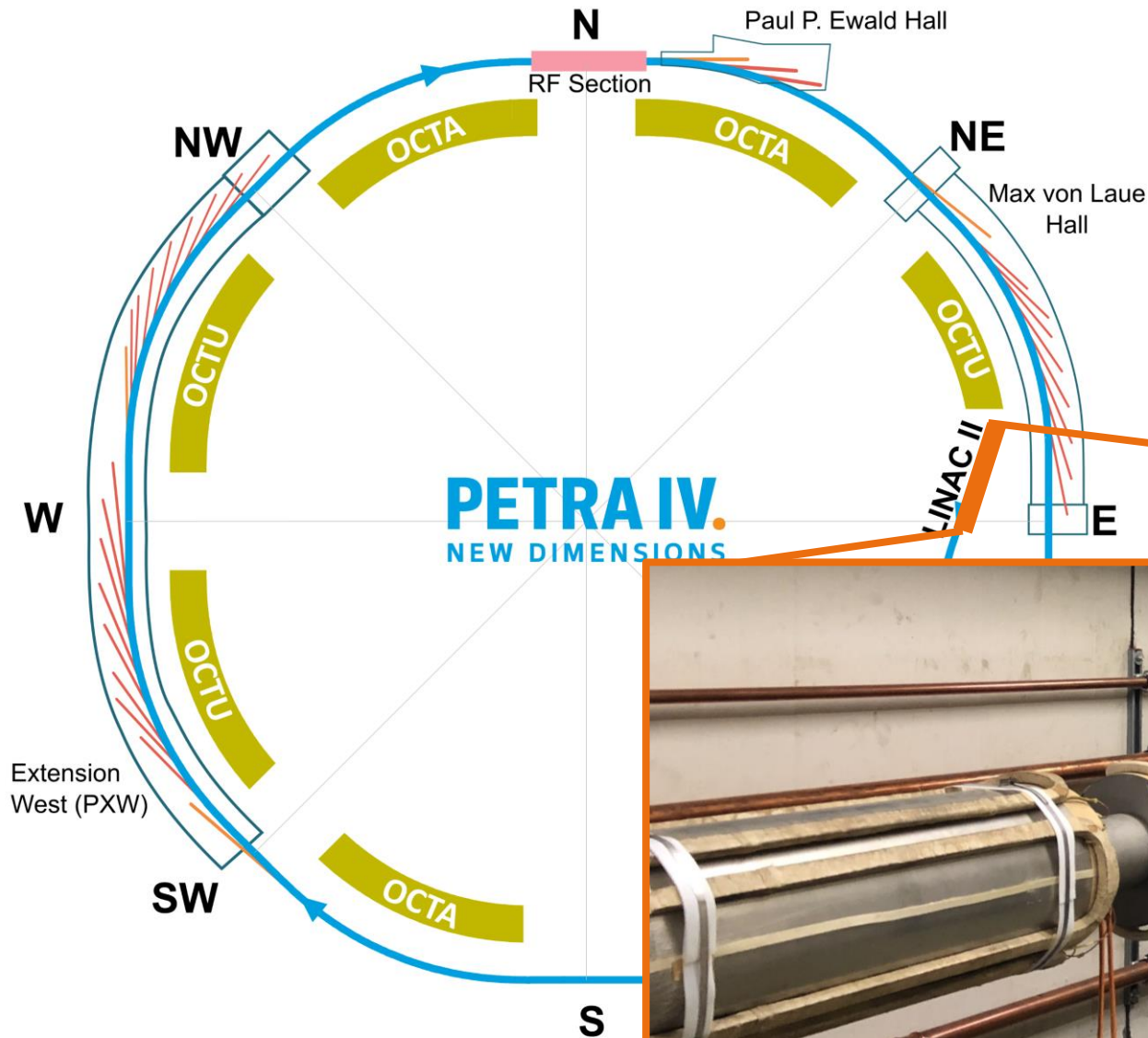


Make it great... but make it cheap!

- Accumulation in the storage ring seems feasible!
 - ⇒ First idea: Reuse the pre-accelerator complex
 - ⇒ Check Electron Source ✓
 - ⇒ Gun delivers
 - ~ 10^{10} e^-
 - in 50 ns pulses
 - with 50 Hz repetition rate

PETRA IV facility layout

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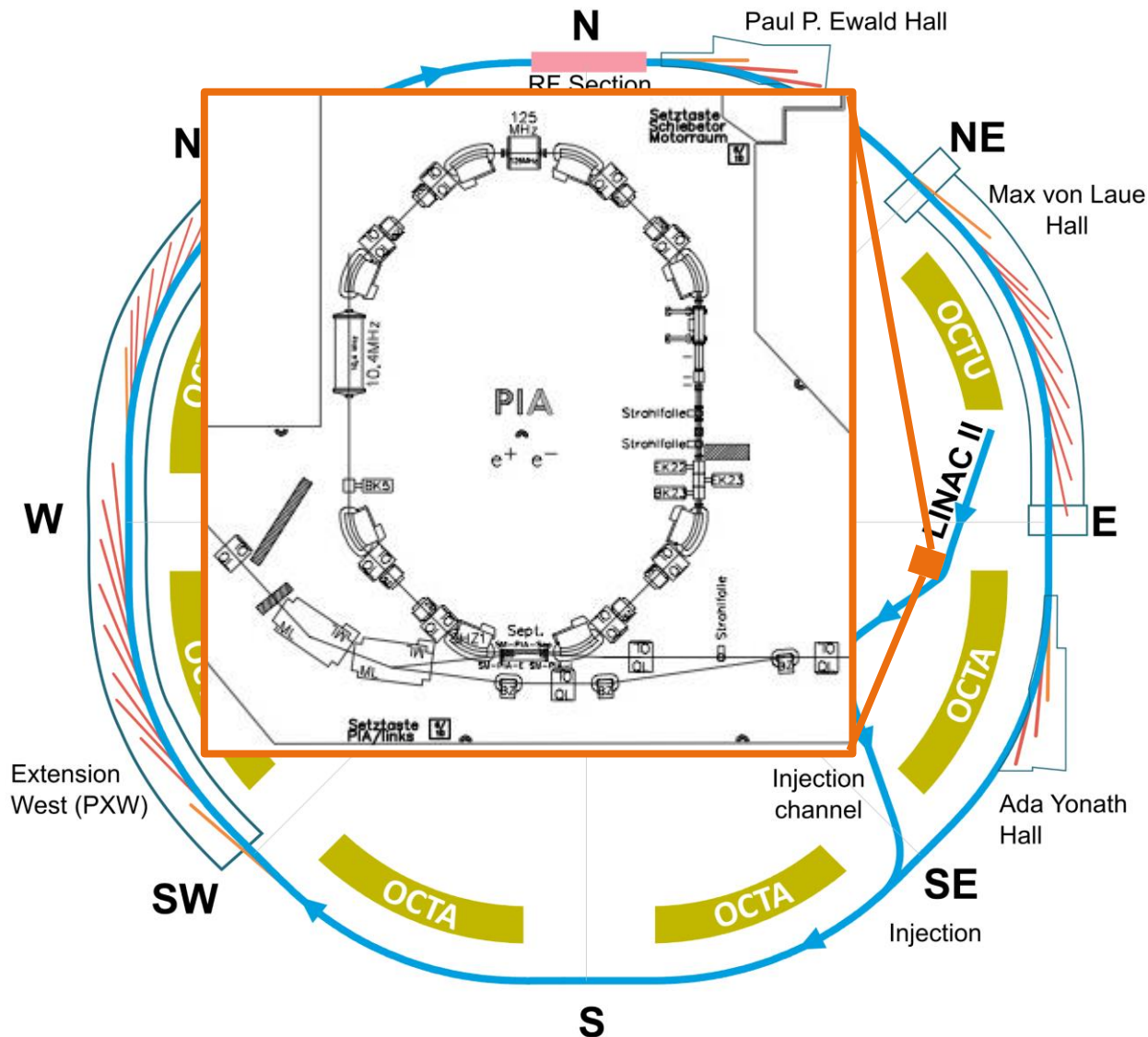
Make it great... but make it cheap!

- Accumulation in the storage ring seems feasible!
- ⇒ First idea: Reuse the pre-accelerator complex
- ⇒ Check Electron Source ✓
- ⇒ Check Linac ✓
- ⇒ S-band Linac up to 450 MeV



PETRA IV facility layout

How will the new facility look like?



Make it great... but make it cheap!

- Accumulation in the storage ring seems feasible!
 - ⇒ First idea: Reuse the pre-accelerator complex
 - ⇒ Check Electron Source ✓
 - ⇒ Check Linac ✓
 - ⇒ PIA Positron-Intensity Accumulator ✓
 - ⇒ Used as damping ring

PETRA IV facility layout



cheap!

storage ring seems feasible!

e-accelerator complex

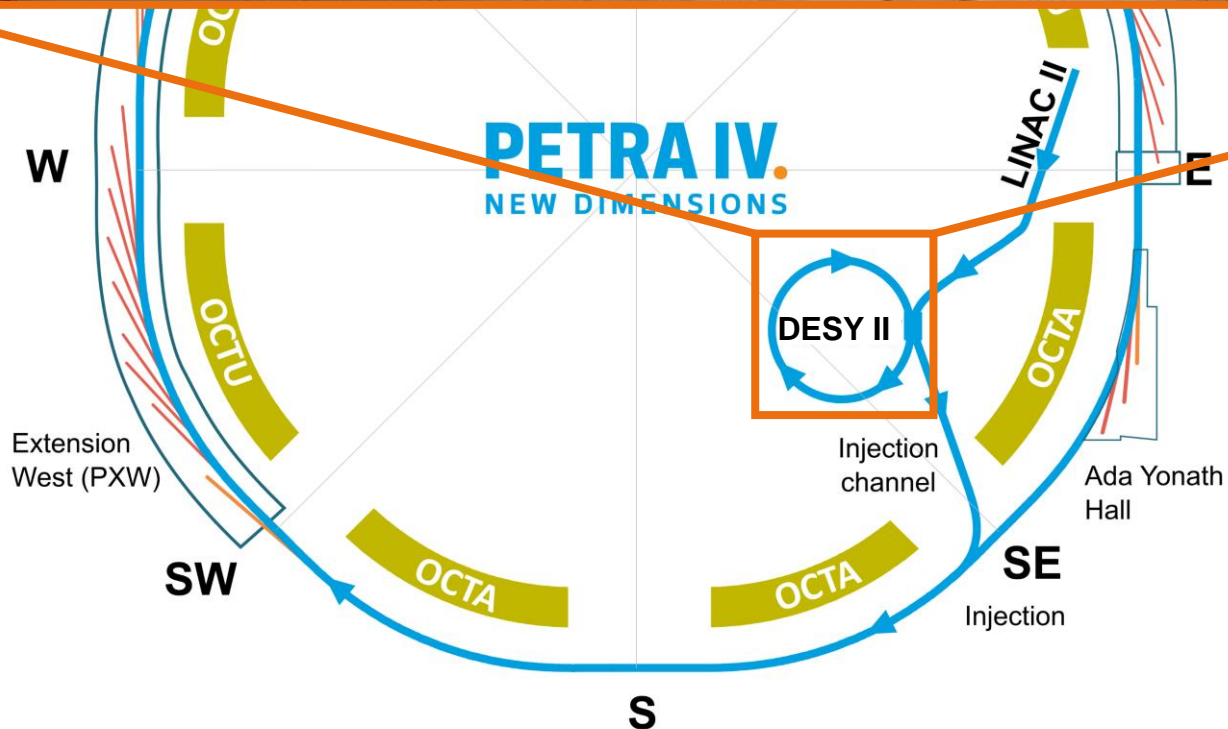


⇒ PIA Positron-Intensity Accumulator ✓

⇒ Check Booster-Synchrotron

⇒ Intensity: typical $\sim 10^{10} e^-$ ✓

⇒ 450 MeV → 7 GeV ✓

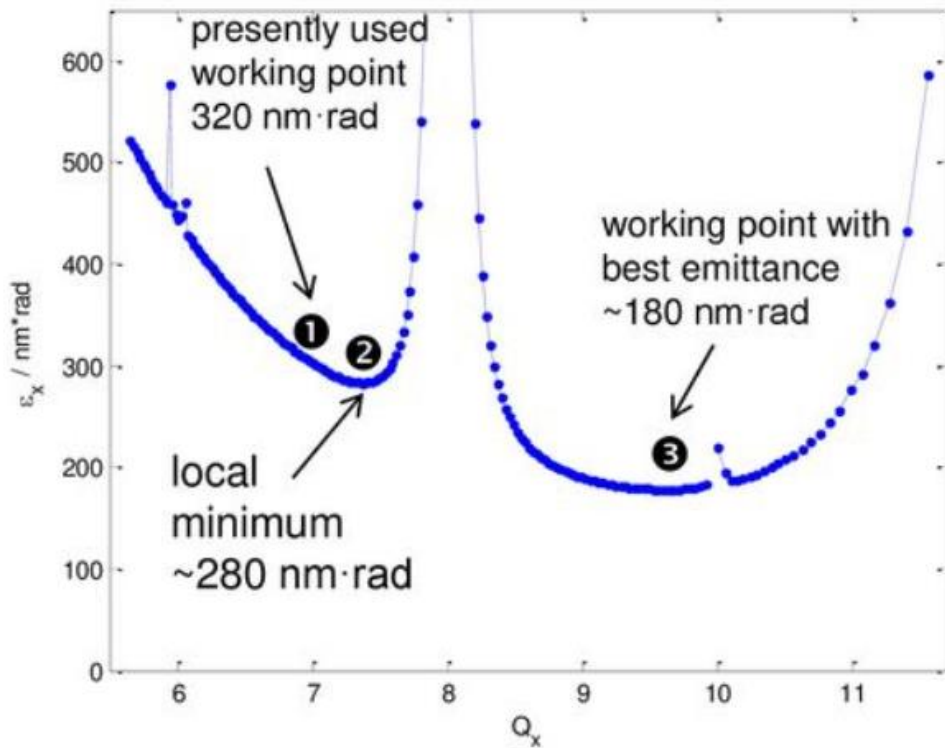
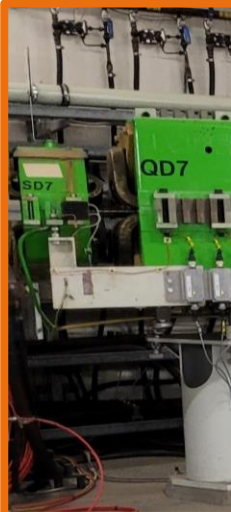


PETRA IV facility layout

DESY II

(different working points)

The ejection scheme is optimized for working point 1



The presently installed quad power supplies do not allow an operation at working point 3 with full energy.



cheap!
storage ring seems feasible!
e-accelerator complex

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- ⇒ PIA Positron-Intensity Accumulator ✓
- ⇒ Check Booster-Synchrotron ✓
- ⇒ Intensity: typical $\sim 10^{10} e^-$ ✓
- ⇒ 450 MeV → 7 GeV ✓
- ⇒ new storage ring needs low emittance beam for injection!
- ⇒ Emittance of extracted beam to high! ✗
- ⇒ New booster Design needed!

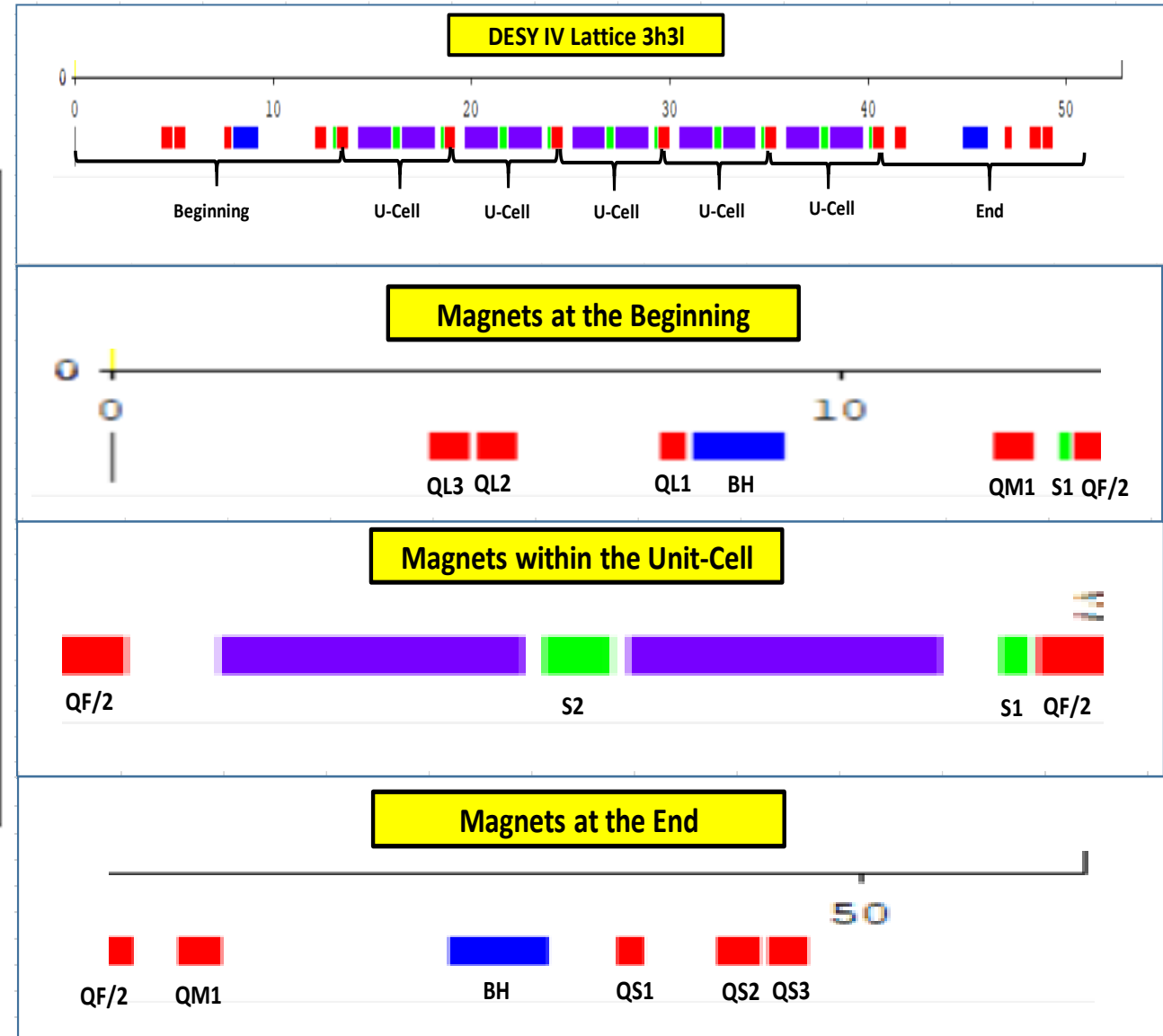
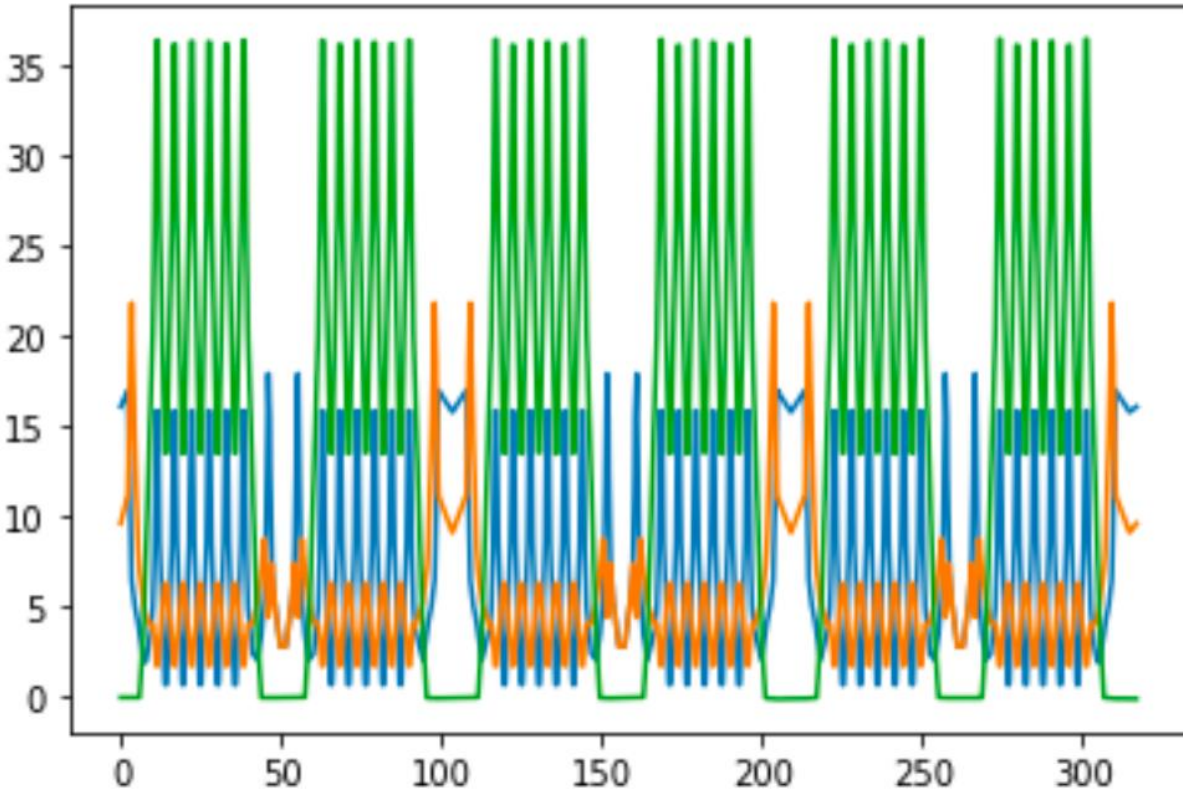
DESY IV

A new booster synchrotron for PETRA IV

Low emittance booster

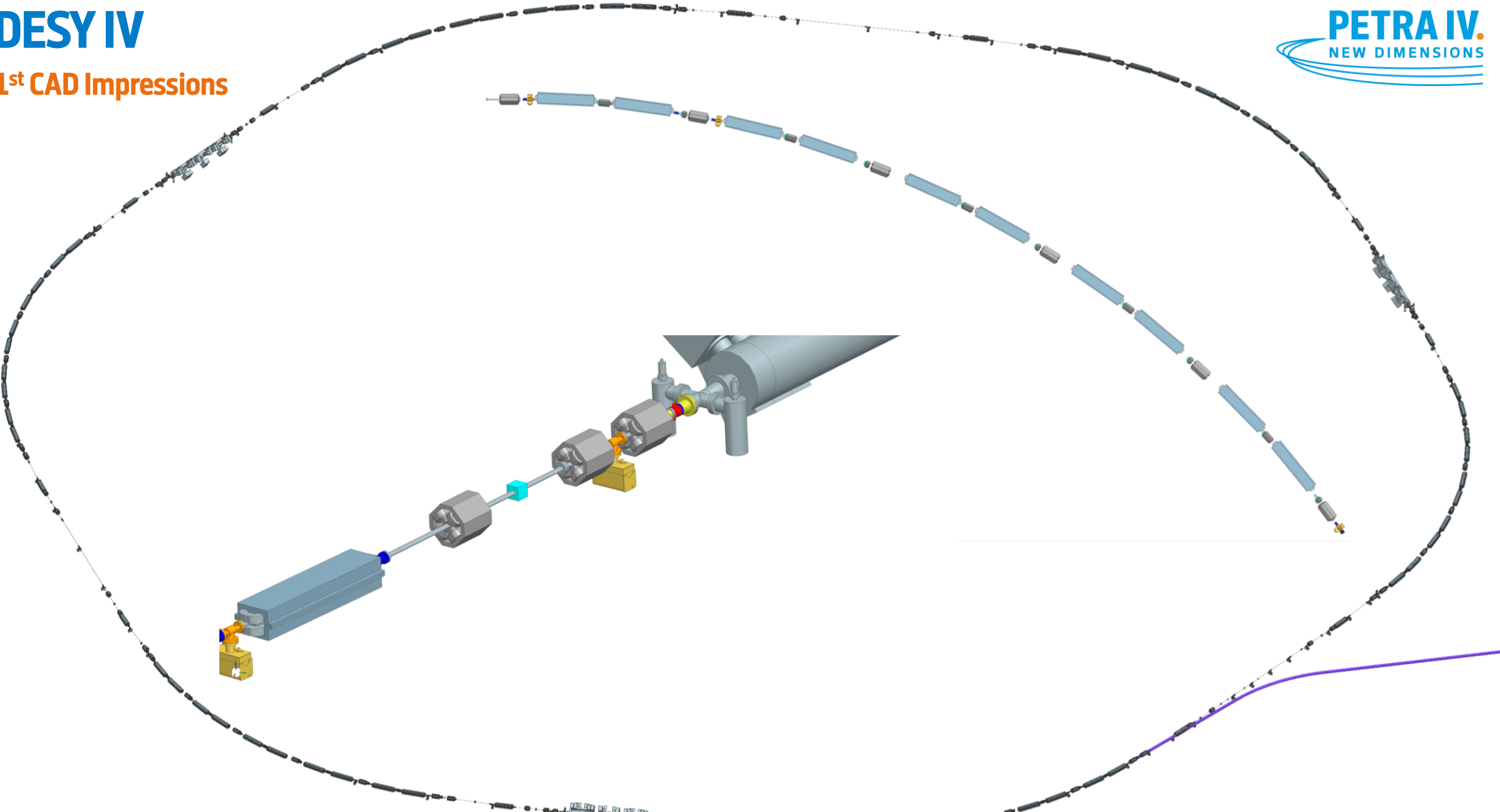
Booster (DESY IV) parameters

<i>Parameter</i>	<i>Value</i>	<i>Comment</i>
Energy	450MeV - 6 GeV	
Rep. rate	5 Hz	Determined by initial fill speed
Inj. Energy	450 MeV – 1 GeV	450 MeV is nominal
No. bunches	1	Possibly 1-5 low-charge bunches for commissioning
Bunch charge	0.1 - 1 nC	Top-up mode: 0.1nC brightness, 1 nC timing (ca. 10% bunch charge); Fill mode: 1nC both timing and brightness
Top-up freq.	$\sim 5 \text{ min}^{-1}$	Could vary slightly depending on lifetime
Bunch parameters at injection (450 MeV)	$\epsilon_x = 0.8 \text{ } \mu\text{m rad}$ $\sigma_\epsilon = 0.03\%$ $\sigma_\tau = 0.37 \text{ ns rms (11 cm)}$	
Bunch parameters at extraction	$\epsilon_x = 20 \text{ nm rad}$ $\sigma_\epsilon = 0.26\%$ $\sigma_\tau = 60 \text{ ps rms (2 cm)}$	



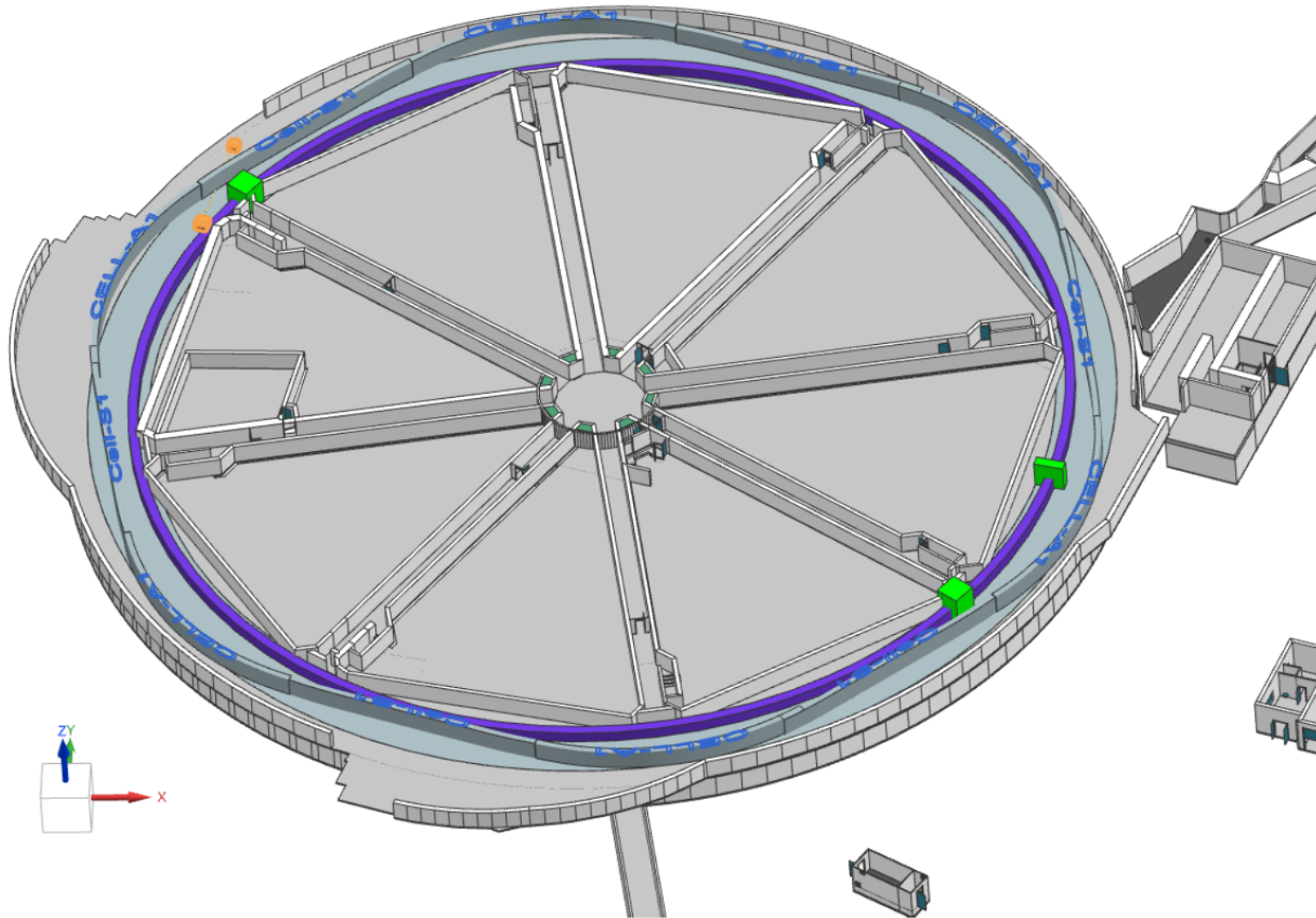
DESY IV

1st CAD Impressions



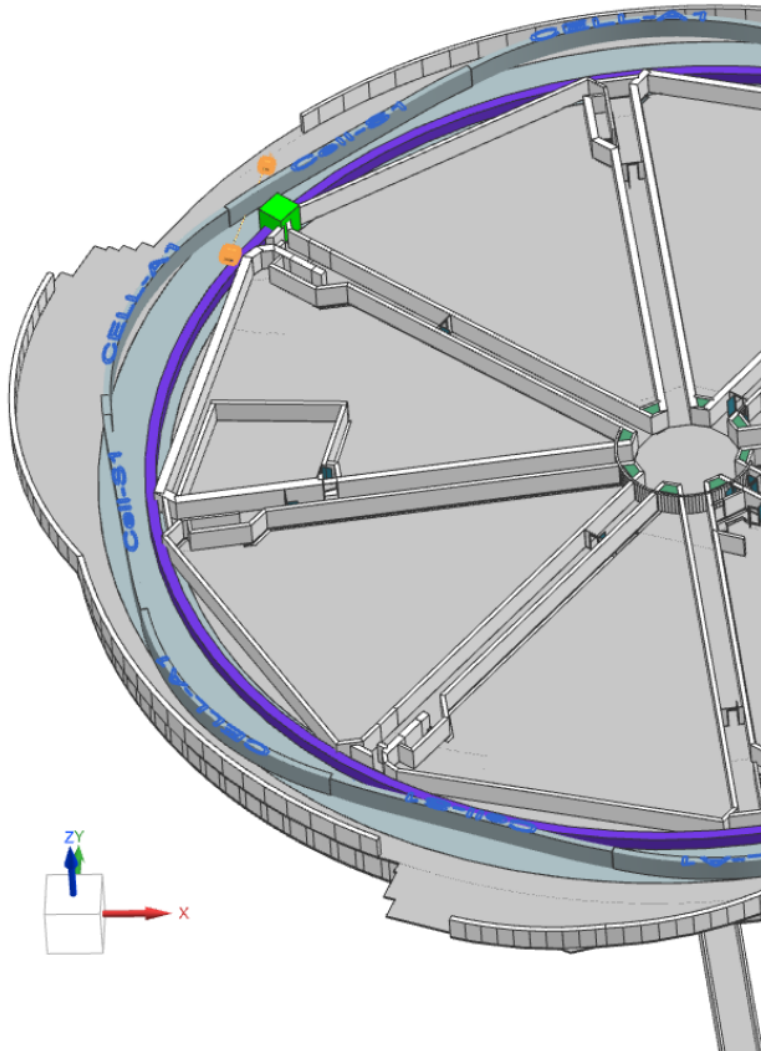
DESY Tunnel Layout

How to treat DESY I Legacy



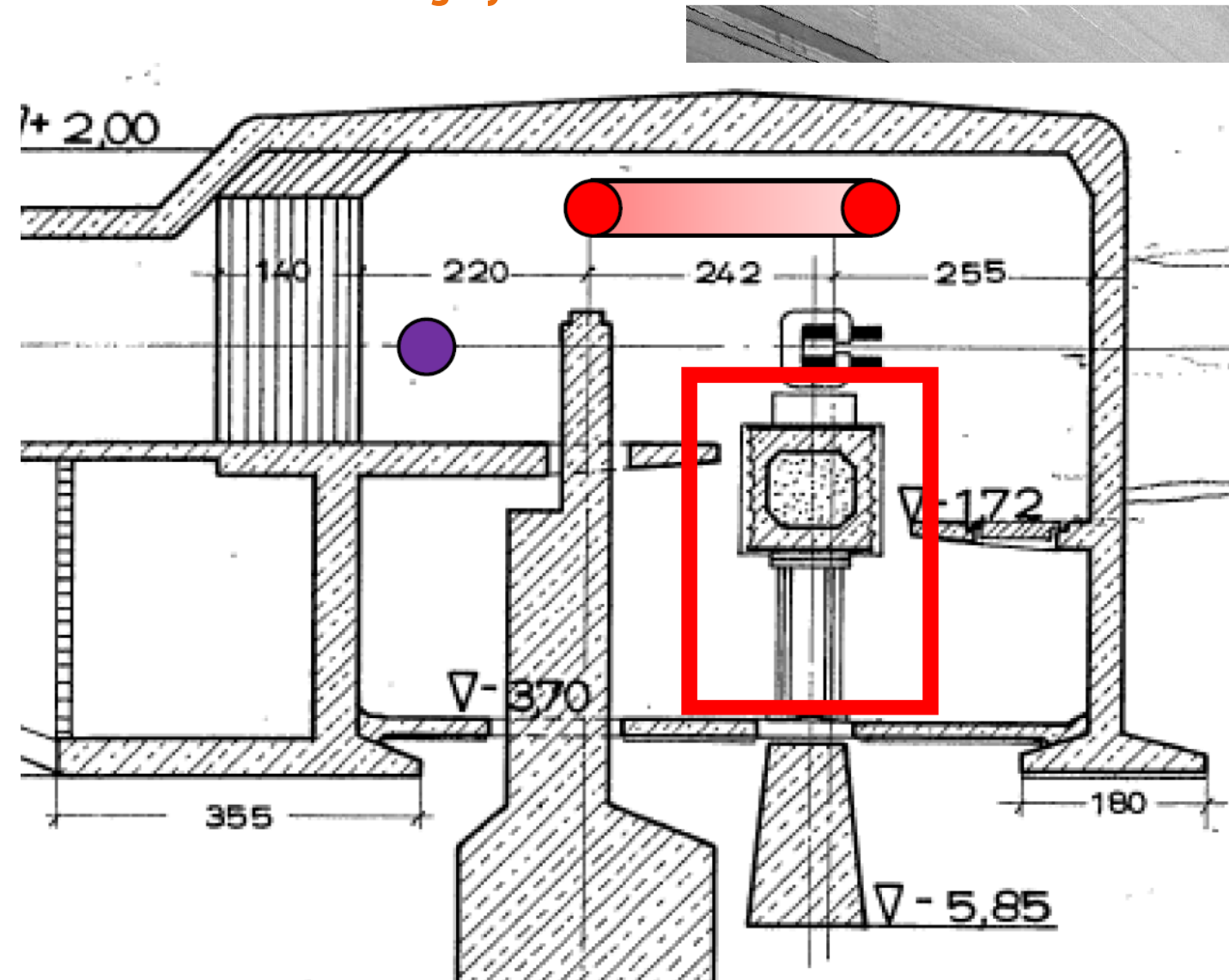
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DESY Tunnel Layout

How to treat DESY I Legacy



Old meets new

A new accelerator in a historical building

DESY IV on the ceiling

What are the challenges?

If the booster is on the ceiling,

⇒ the crane has to be removed!



DESY IV on the ceiling

What are the challenges?

If the booster is on the ceiling,

- ⇒ the crane has to be removed!
- ⇒ Floor based transport and installation equipment required
- ⇒ Floor must be stable, smooth and flat



DESY IV on the ceiling

What are the challenges?

If the booster is on the ceiling,

- ⇒ the crane has to be removed!
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- ⇒ Floor must be stable, smooth and flat
- ⇒ Should the "Ringträger" be removed?



DESY IV on the ceiling

What are the challenges?

If the booster is on the ceiling,

- ⇒ the crane has to be removed!
- ⇒ Floor based transport and installation equipment required
- ⇒ Floor must be stable, smooth and flat
- ⇒ Should the "Ringträger" be removed?
- ⇒ Whatever we do with it... 1st take care of the asbestos!

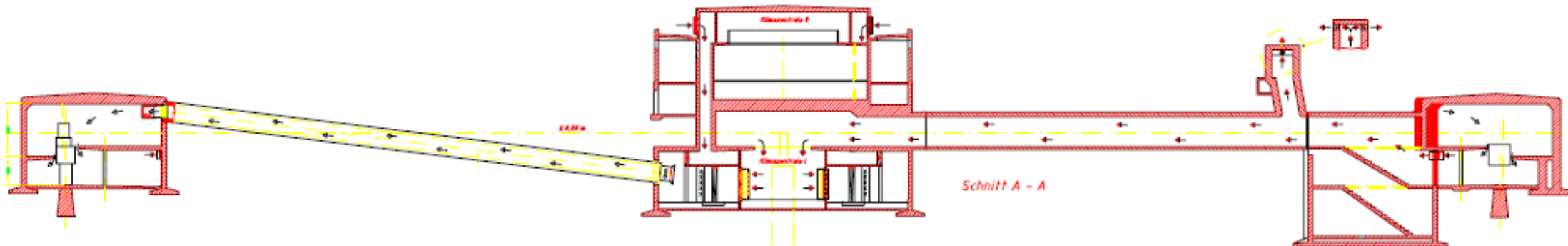


DESY IV in the original DESY I ring tunnel

Might any regulations have changes in the past 60 years?

Occupational safety and fire protection

- New concept is being developed.
 - Emergency escape routes must get shorter
- ⇒ New fire compartments must be separated
- ⇒ Ventilation system must be adapted



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 - ⇒ New fire compartments must be separated
 - ⇒ Ventilation system must be adapted
- Reduce fire loads by removing old cables...



Summary

To make a long story short...

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- With PETRA IV DESY aims to built the largest 4th generation light source in the world.
- To benefit from the existing infrastructure many parts of the PETRA III complex will be refurbished and reused.
- However, a new booster synchrotron has to be built to meet the requirements of PETRA IV.
- Installing this booster in the existing accelerator tunnel poses some challenges.
- In addition to the development of a new logistics concept, the cleanup of hazardous materials and the modernization of the fire protection concept are also necessary.



Thank you

Contact

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