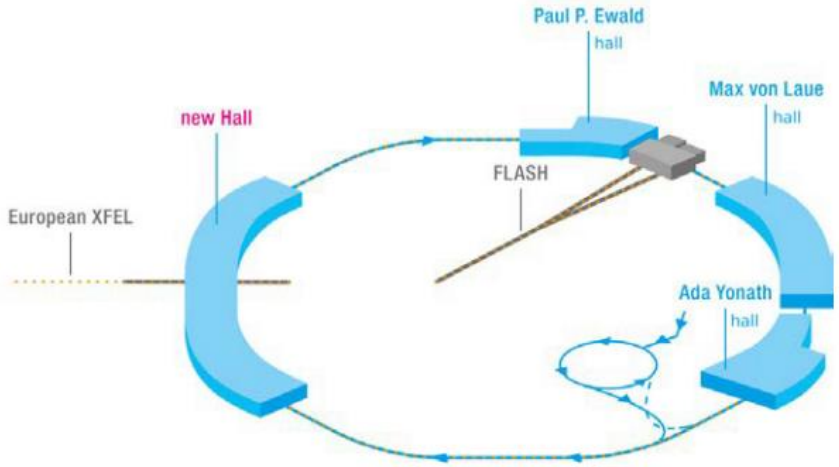

PETRA IV.
NEW DIMENSIONS

PETRA IV planning

Timeline (updated)



Targeted submission of roadmap proposal

01'2023: Kickoff PETRA IV project

01'2027 Start construction work
End PETRA III operation

01'2028 Start up PETRA IV

LEAPS, HGF-FIS

PETRA IV project phase

PETRA IV operation

PETRA IV TDR Phase

PETRA IV CDR Phase

12'2019: CDR

2023 - proposal submission to the Government

Today

Shutdown

2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028

Beamline portfolio complete

PETRA IV *In situ* Large Volume Press Beamline

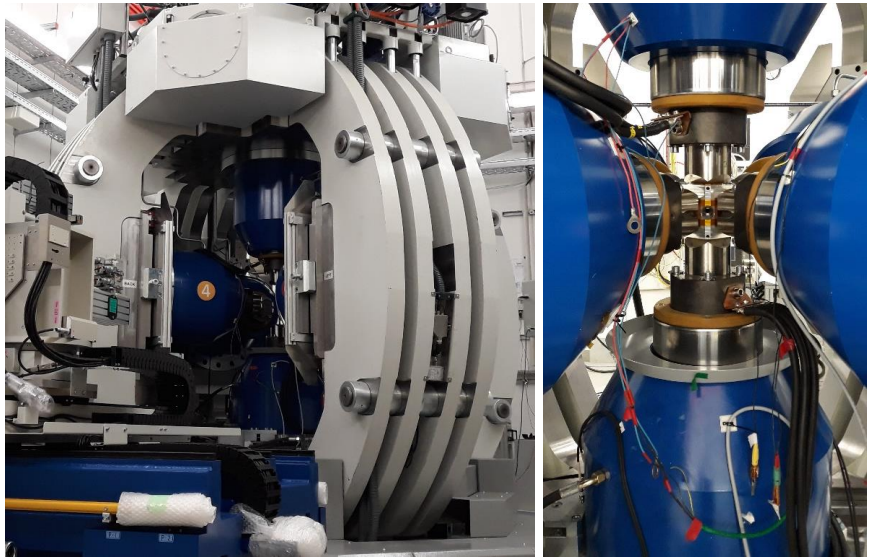
PETRA IV statement

Keywords: high flux/brilliance, high-resolution, large time/length scales, beam focus/expansion

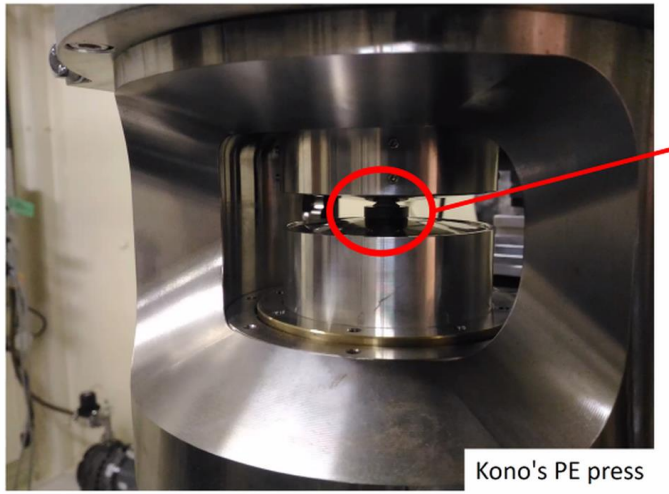
The new '*In situ* Large Volume Press Beamline' at PETRA IV will accommodate **multiple LVPs** for *in situ* studies at extreme pressures and temperatures.

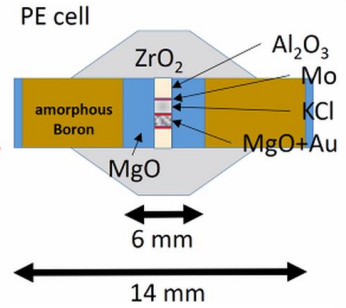
X-ray diffraction (PXRD), Absorption & Contrast imaging, μ-tomography, & other techniques (e.g. time-resolved)

1. Aster-15 LVP: 6-ram press at P61B for isotropic and anisotropic, high-pressure generation (at high T).



2. Purchase of new PE press: moderate pressures (15 GPa) on liquid/solid samples.





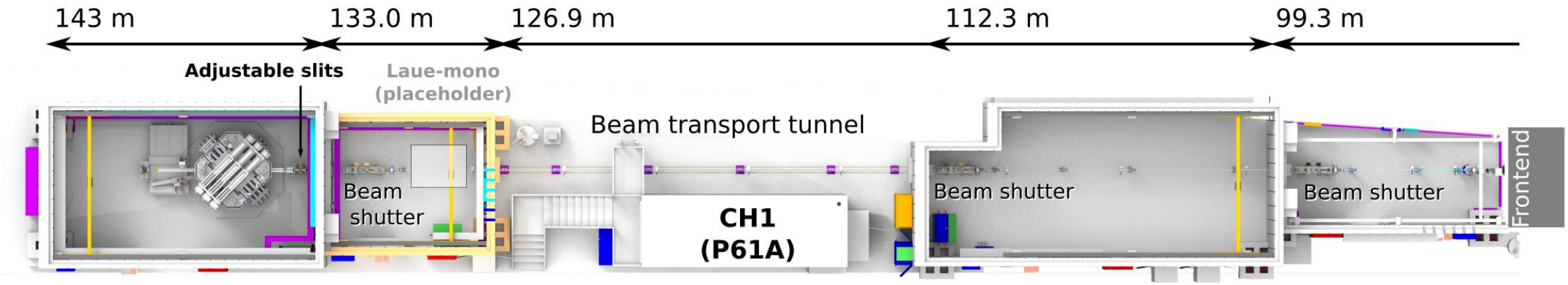
Tomography in the PE press
Photo of the ROTOPEC (J.P. Perrillat)

See Philippe *et al. HPR* 2016

PETRA IV proposed beamline layout

PETRA III – P61

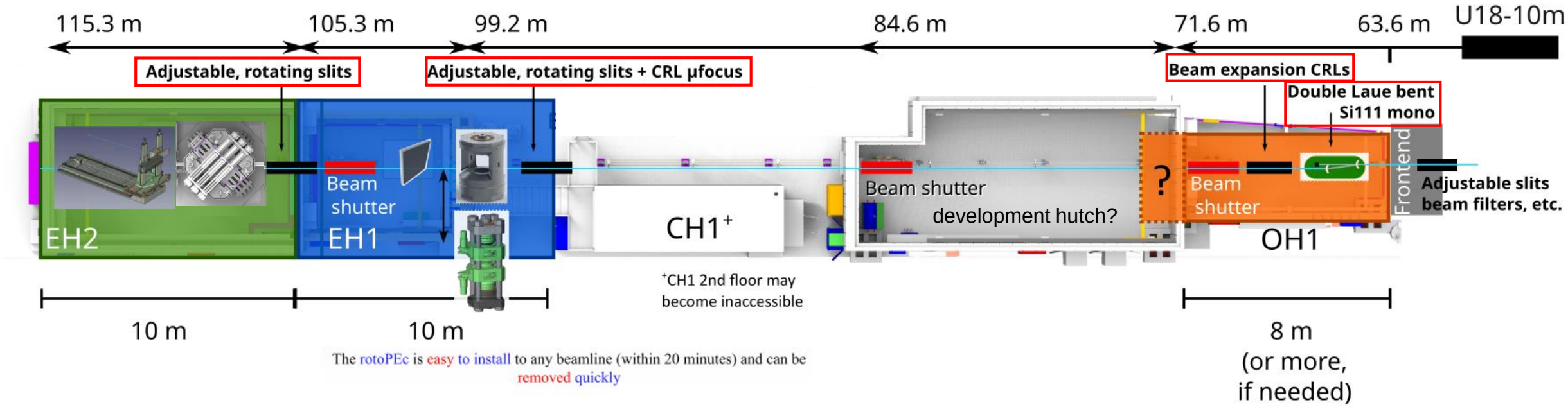
PXN hall
Sector 1



PETRA IV proposed beamline layout

PETRA IV – *In Situ* LVP beamline concept

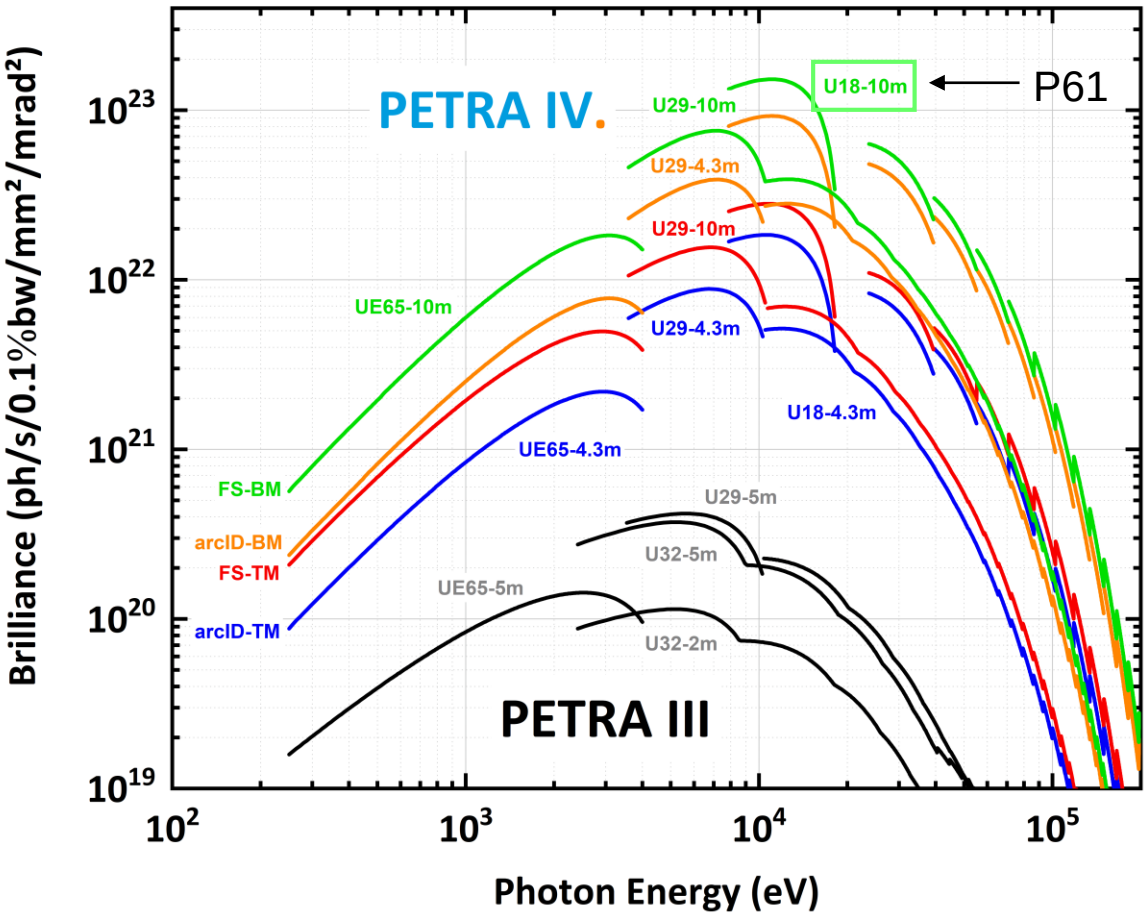
PXN hall
Sector 1



The new U10 source will be closer to Aster-15 (~110 m) than the current PETRA III 10 wiggler array (~136 m)

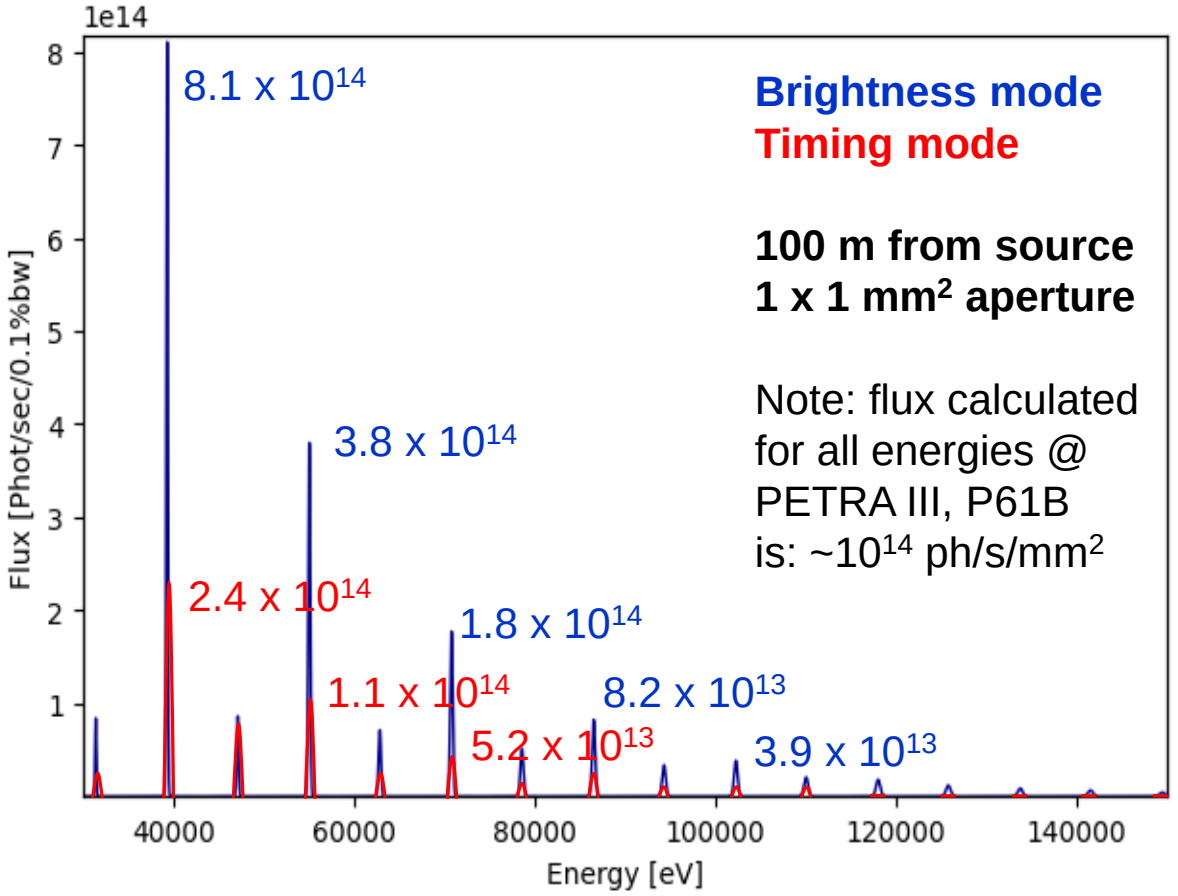
PETRA IV source flux

Brilliance and flux curves

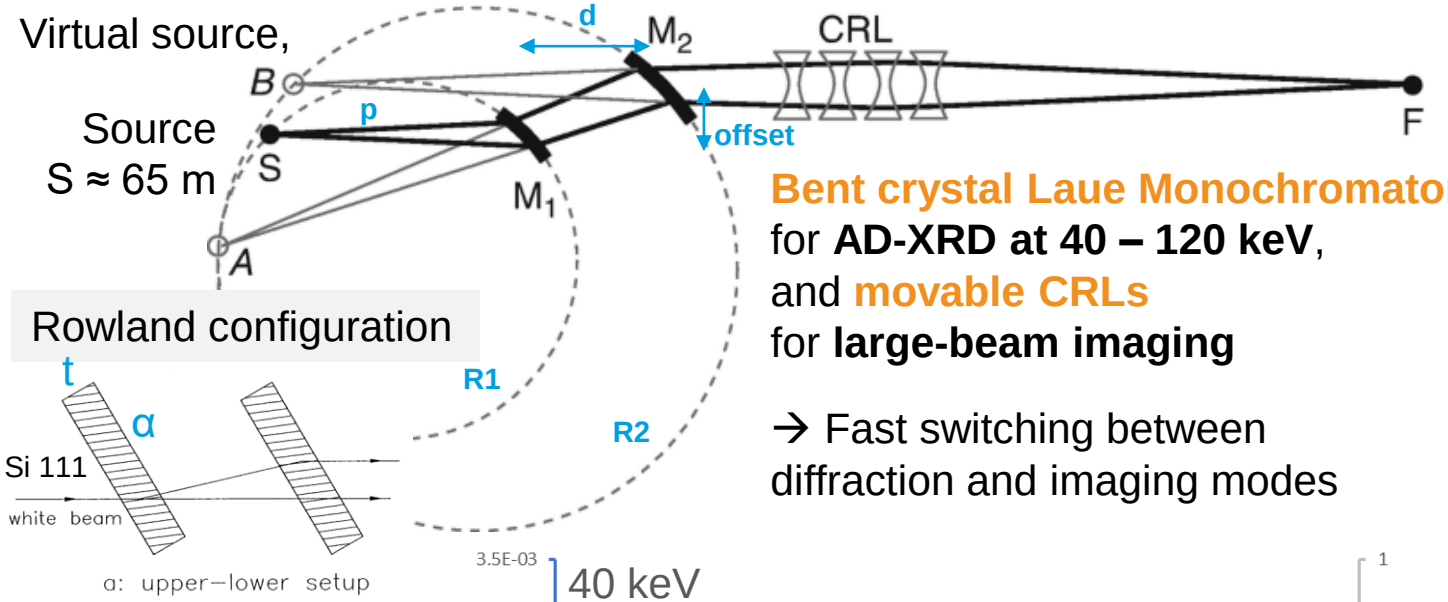


At PXN (P.P. Ewald hall) – Sector 1, P61

U18 – 10 m cryogenically cooled undulator



PETRA IV key beamline components



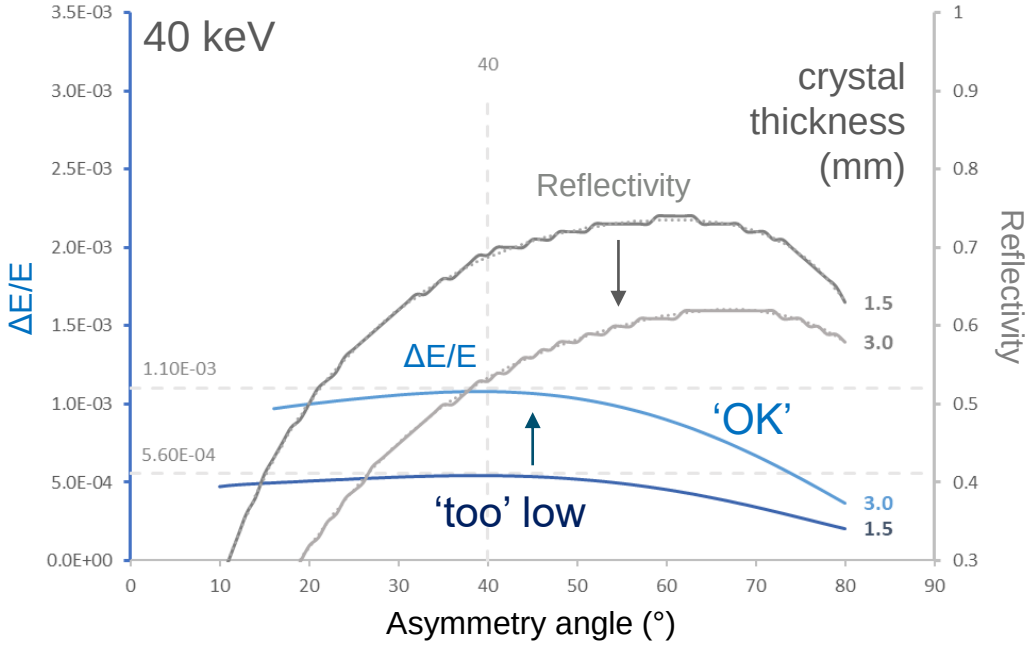
Bent crystal Laue Monochromator
for **AD-XRD at 40 – 120 keV**,
and **movable CRLs**
for **large-beam imaging**

→ Fast switching between diffraction and imaging modes

Trade off between:

- Beam energy (keV)
- crystal thickness (t)
- asymmetry angle (α)
- bending radius (R)
- source distance (p)
- beam power (W)

for optimal throughput with reasonable energy resolution ΔE/E ~ 10^{-3}



For example,

- Large source distance → larger bending radius → thicker crystals → more (heat) absorption at lower E (e.g. 40 keV).
- Low asymmetry angle → increased X-ray path length in crystal → more (heat) absorption at lower E.

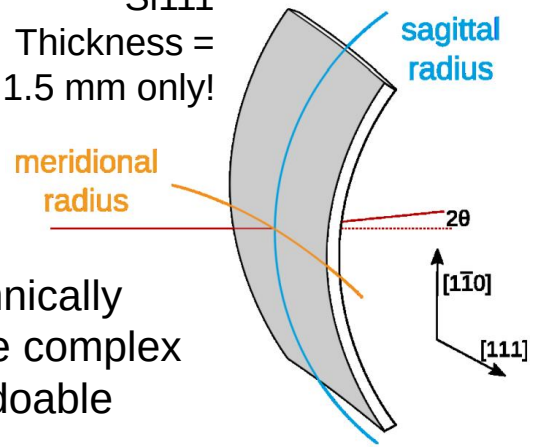
In both cases, access to low E can be restrictive, which could be a challenge…

Meridional bending could be insufficient, maybe try **Sagittal 'mediated-meridional' bending**

At P21

U. Lienert
→ source distance is 100 m

Si111
Thickness = 1.5 mm only!



Technically more complex but doable

PETRA IV detectors

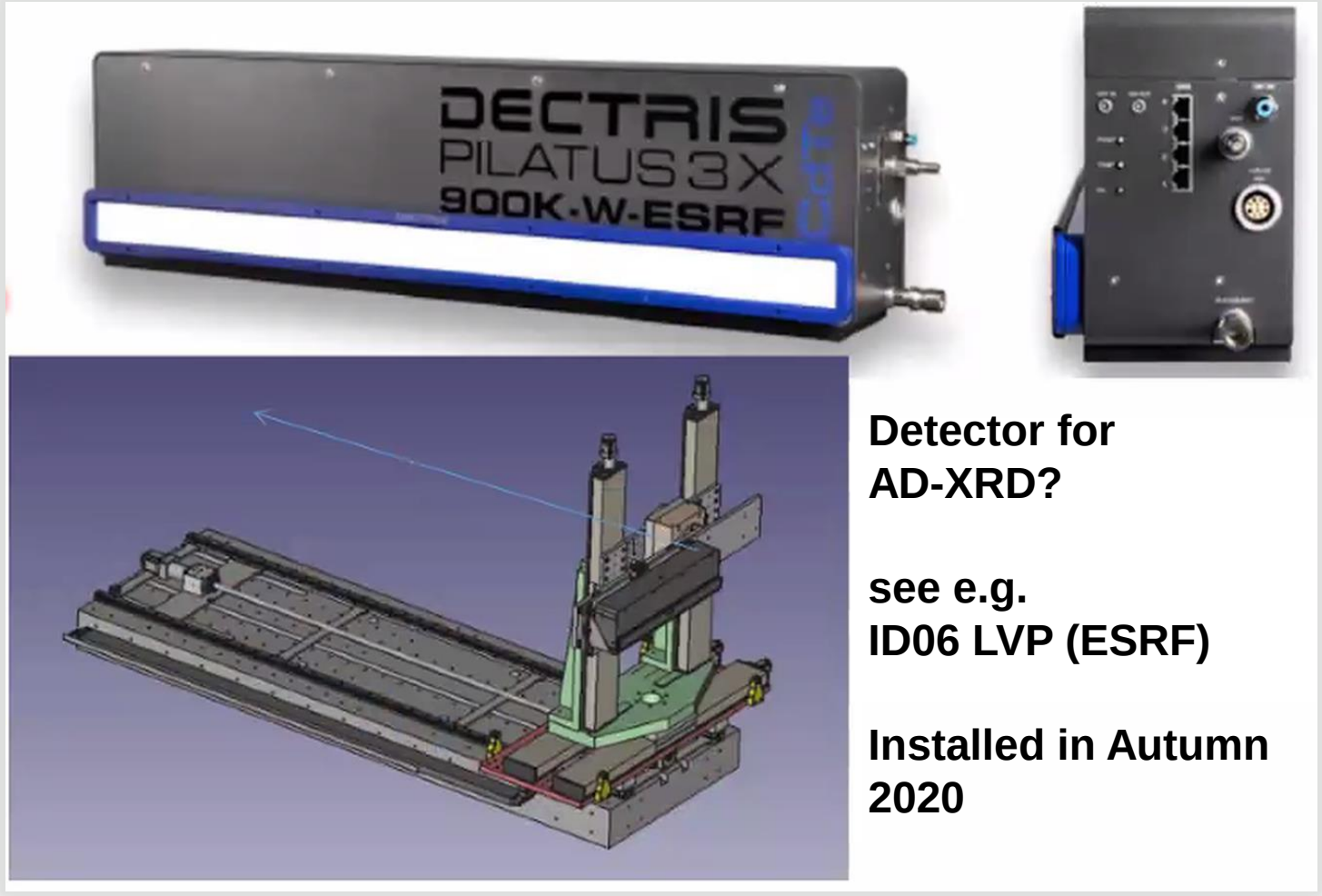
New detectors and stages/goniometers

Options for AD-XRD, DSCT, CDI

- A new large-radius linear detector for the Aster-15 LVP (see example on the right)
  - CdTe technology
  - Small pixel size (150 µm or less)
  - Gap-less (no gaps between modules)
  - High frame rate (> 1kHz)
  - Continuous readout/no deadtime
  - High quantum efficiency (>50%) at 100+ keV
  - High counting depth (20 bit)
  - Large size ≥ 800 mm
- Existing Varex 4343CT for smaller LVP

Options for Imaging (Abs/Phase contrast)

- Existing 2x obj. X-ray microscope
- New X-ray microscope with faster camera, optimized for PETRA IV beams



Detector for AD-XRD?

see e.g. ID06 LVP (ESRF)

Installed in Autumn 2020

Summary PETRA IV upgrade

PETRA IV is coming! (but timeline remains flexible)

- Full beamline with an additional experimental hutch in PXN = first light!
- Aster-15 LVP remains in place! Offline access still possible.
- Looking for support (you!) to buy a new LVP to take advantage of new and emerging imaging techniques under high P, T and stress
- Development of techniques and materials for AD-XRD in the LVP

New possibilities with AD-XRD

- Radial diffraction / fast timing (ms)
- Crystallography (Rietveld ref.)
- Single crystal XRD
- Enhanced rock deformation
- PDF on melts/glasses,
- Melt density measurements
- **New imaging techniques!**

(Phase Contrast, µCT tomography, DSCT, Bragg CDI)

Lets discuss your needs!

- What does the loss of ED-XRD mean to you? How can we adapt your experiment to AD-XRD geometry?
- What is the lowest required monochromatic energy (for you)?
- What detector requirements do you have for XRD and Imaging?
- What should a new (portable) LVP be able to do for you, Aster-15 cannot?
  → who is willing to write an ErUM-Pro (BMBF) proposal for one?

Many thanks to those who helped with the Scientific Instrumentation Proposals (SIPs) for the new *In Situ* LVP beamline at PETRA IV

In particular (in no specific order):

- Prof. Holzheid (Kiel)
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- Prof. Litasov (HPPI)
- Dr. Schwarz (Freiberg)
- Prof. Koch-Mueller (GFZ)
- Dr. Hilairet (Lille)
- Prof. Katsura (BGI)
- Dr. Wiehl (Darmstadt)
- Dr. Sieber (Potsdam)
- Prof. Perrillat (Lyon)

…and the wider high-pressure communities in Germany and around the world!

Thank You for Your Attention!