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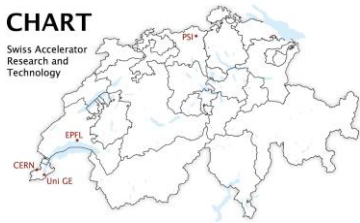
Marco Calvi:: IDs :: Paul Scherrer Institute

Superconducting Undulator for Porthos

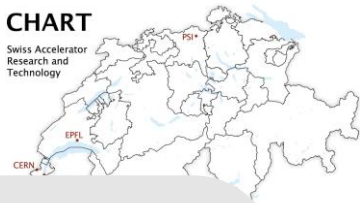
August 23, 2017, Geneva, SPS

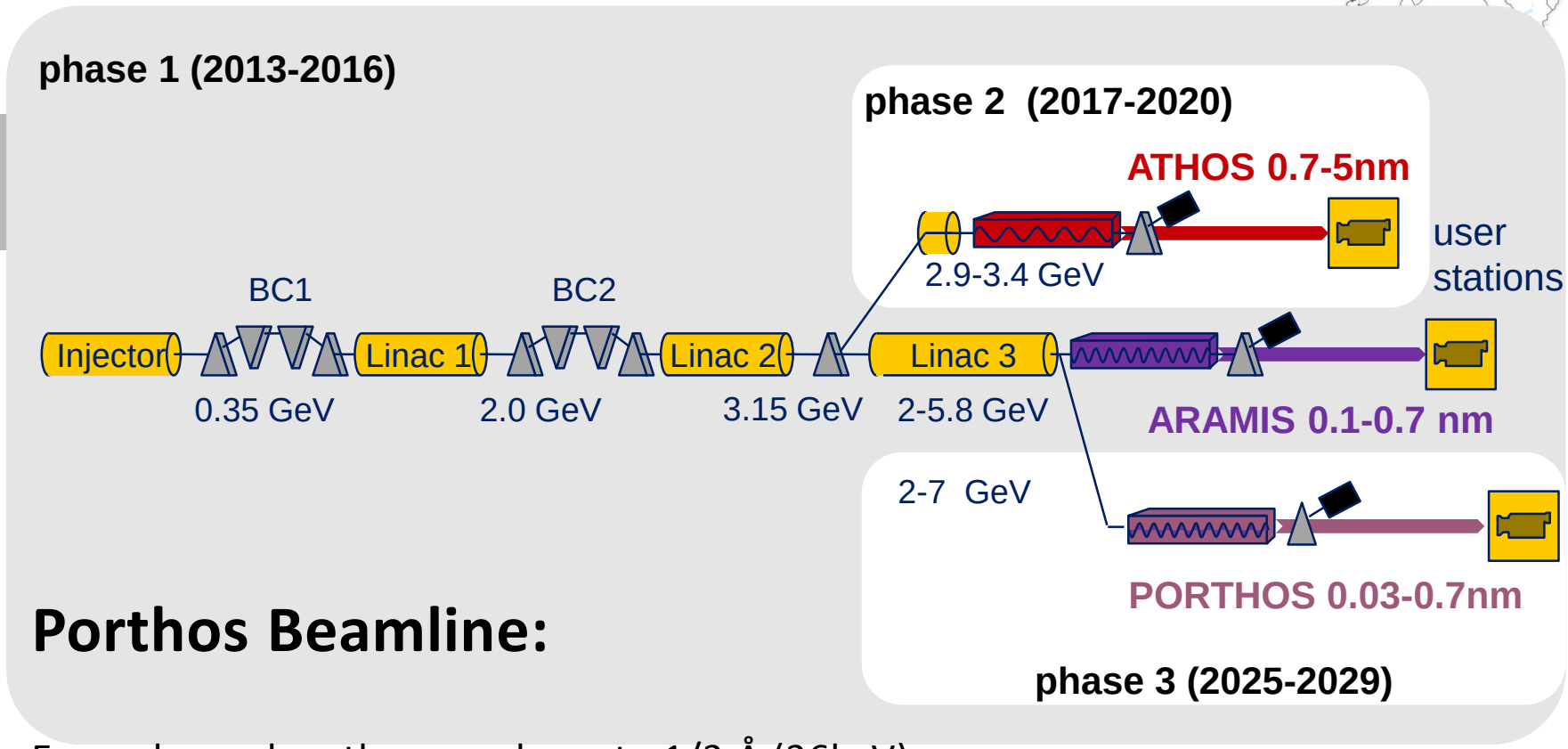
Outline



- SwissFEL Project
- Porthos Beamline
- Harmonic Lasing
- Superconducting undulators
- Conclusions

SwissFEL Project





Porthos Beamline:

Expand wavelength range down to 1/3 Å (36keV)

Better performance at 1 Å

Adapt CHIC modes to hard X-rays
(no polarisation control)

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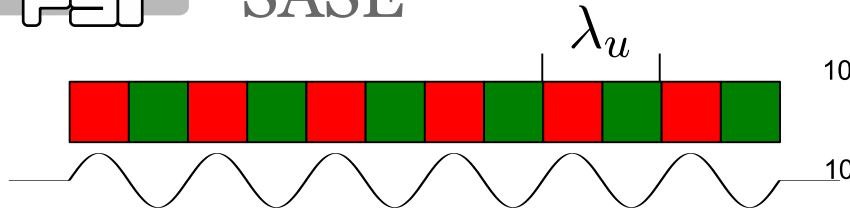
SASE

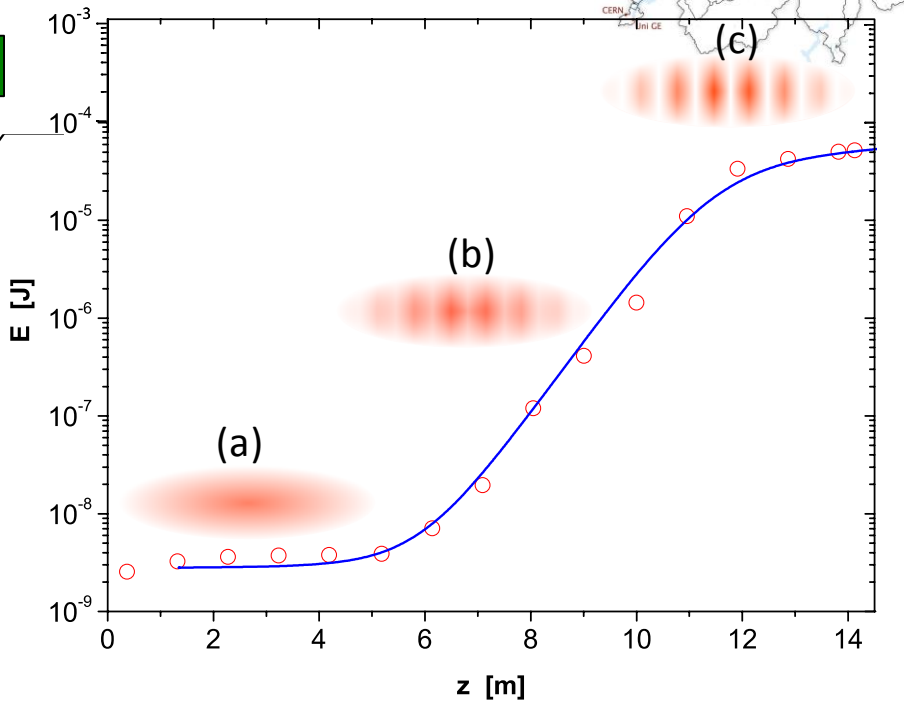


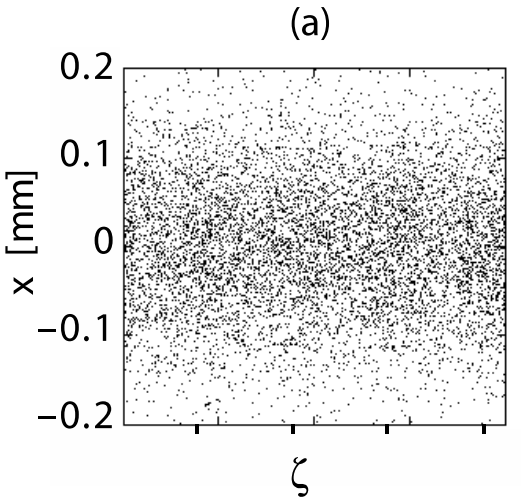
$$\lambda = \frac{\lambda_u}{2n\gamma^2}\left(1+\frac{1}{2}K^2\right)$$

$$K = 0.93B[T]\lambda_u[cm]$$

$$\Gamma = \left[\frac{\mu_0 \hat{K}^2 e^2 k_u n_e}{4\gamma^3 m}\right]^{1/3}$$

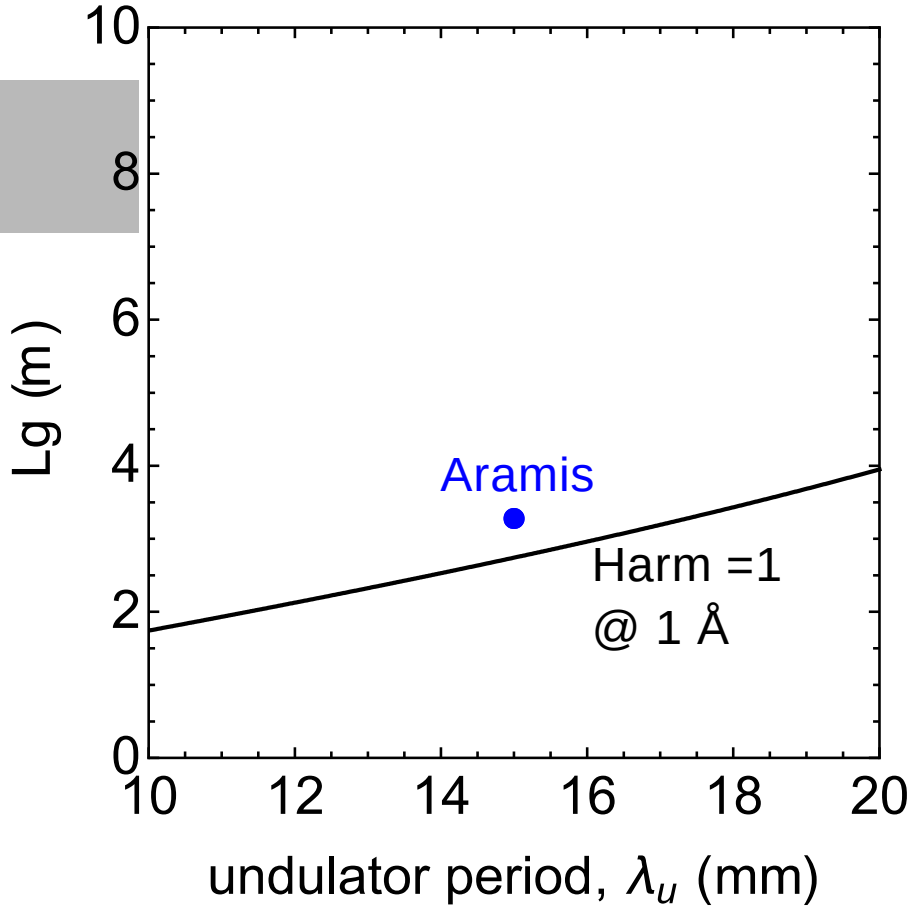
$$L_g = \frac{1}{\sqrt{3}\Gamma} \qquad L_s \approx 20 L_g$$





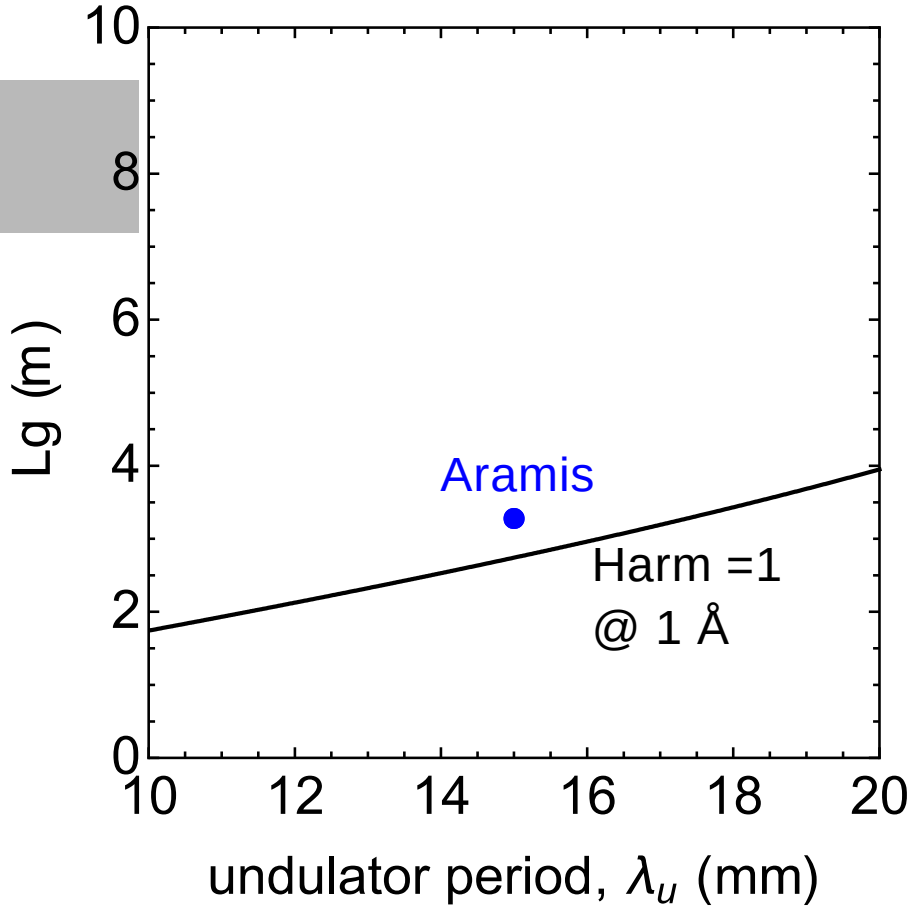
Courtesy of Sven Reiche

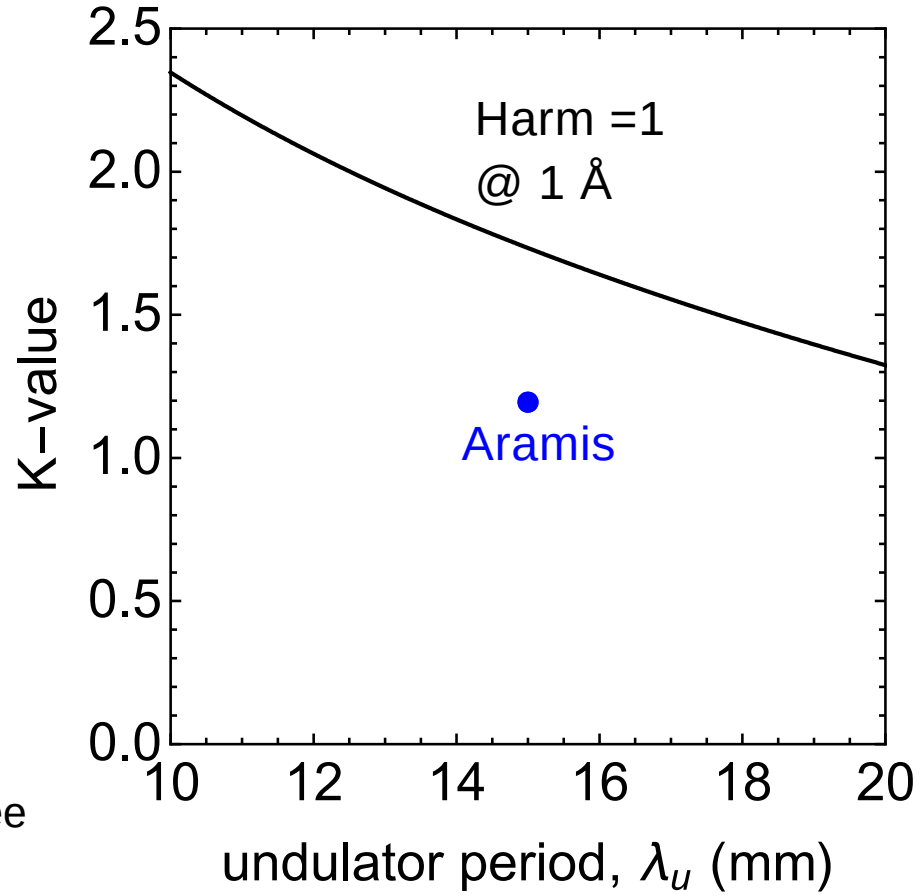
Porthos – Harmonic lasing



Schneidmiller E, Yurkov M, Harmonic lasing in free electron lasers, Physical Review Special Topics - Accelerators and Beams 15, 080702, (2012)

Porthos – Harmonic lasing





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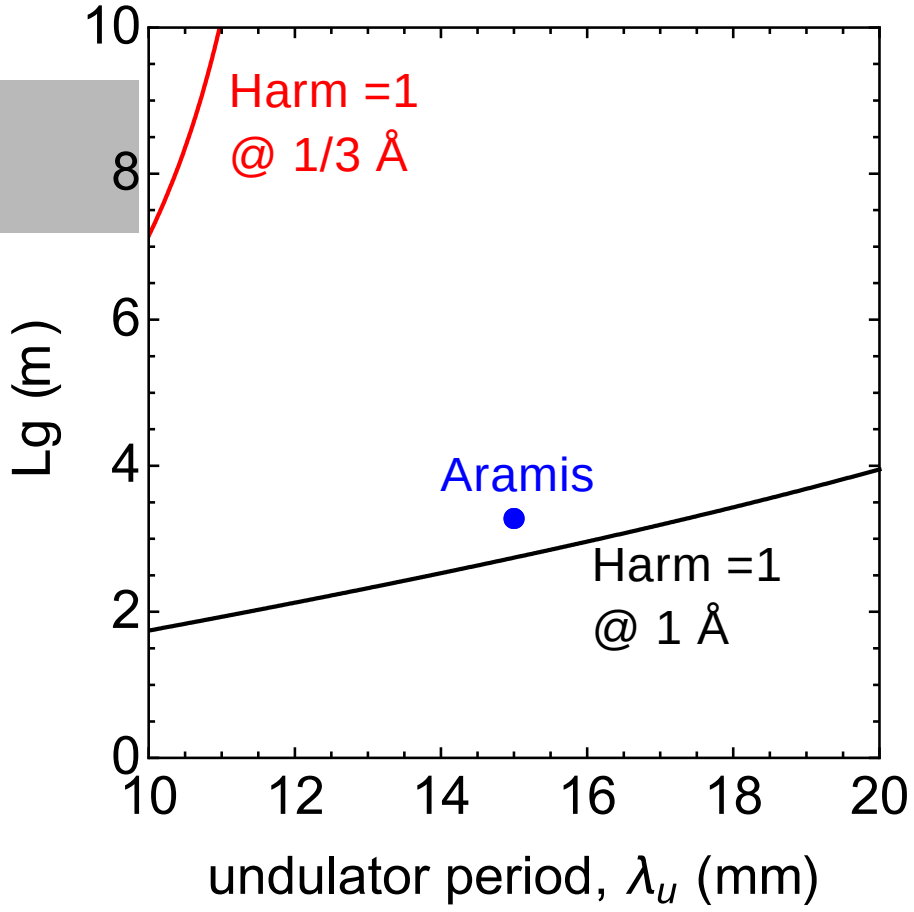
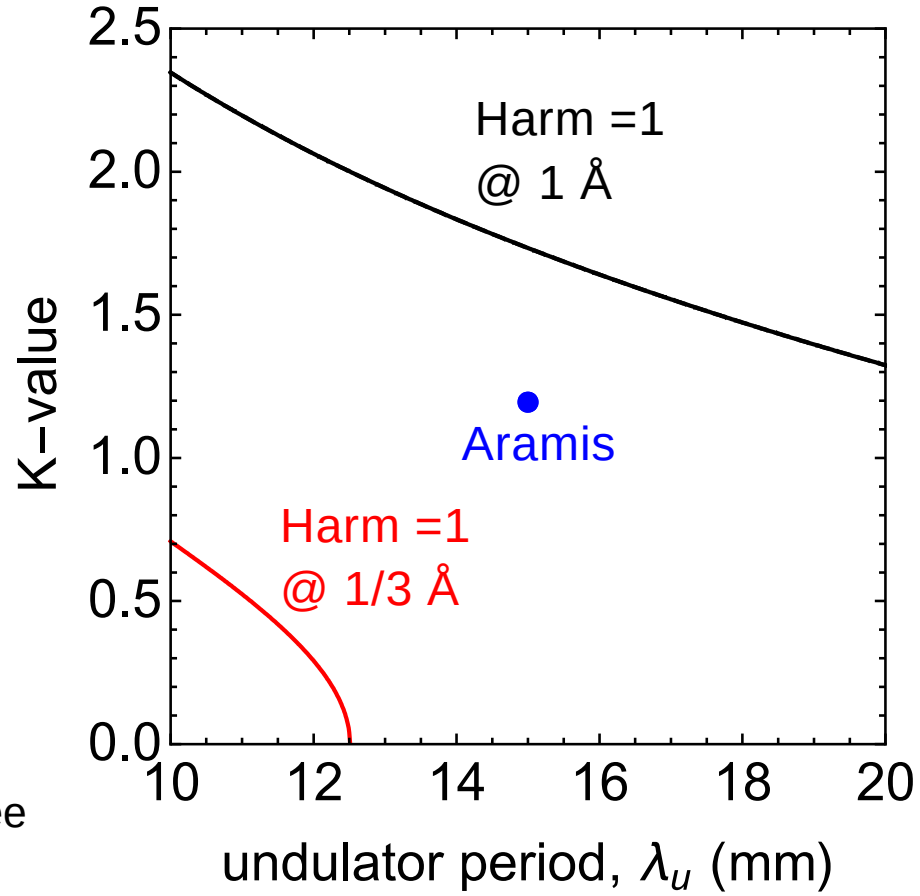
Porthos – Harmonic lasing





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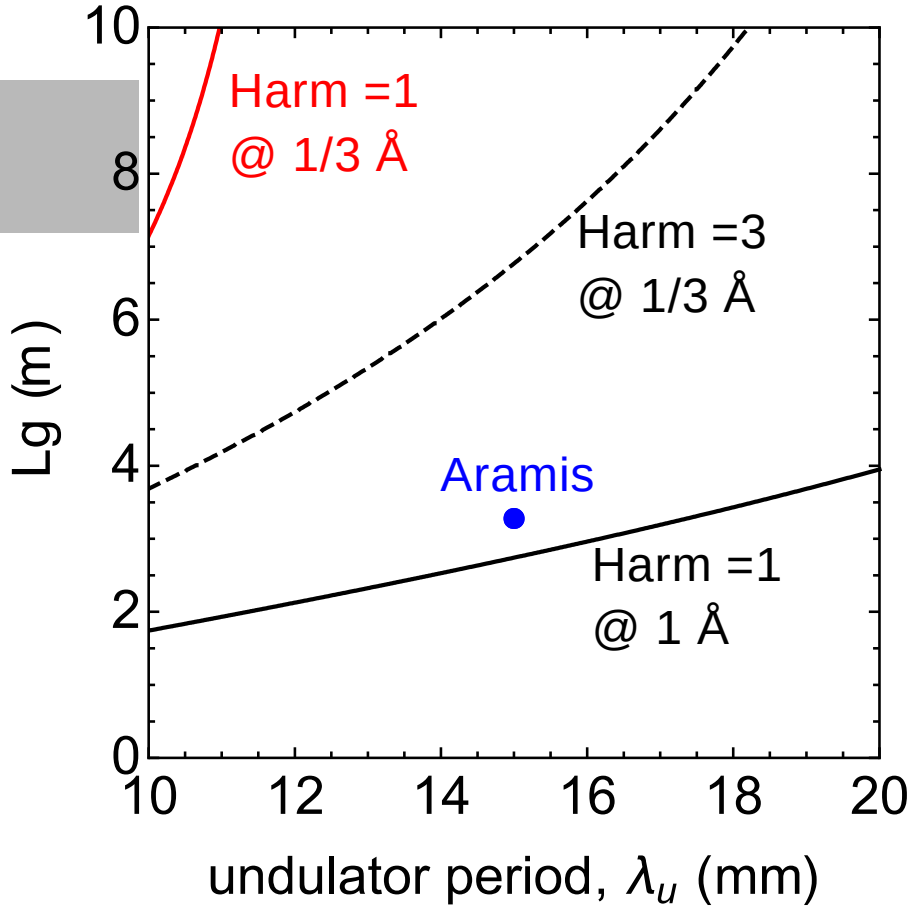
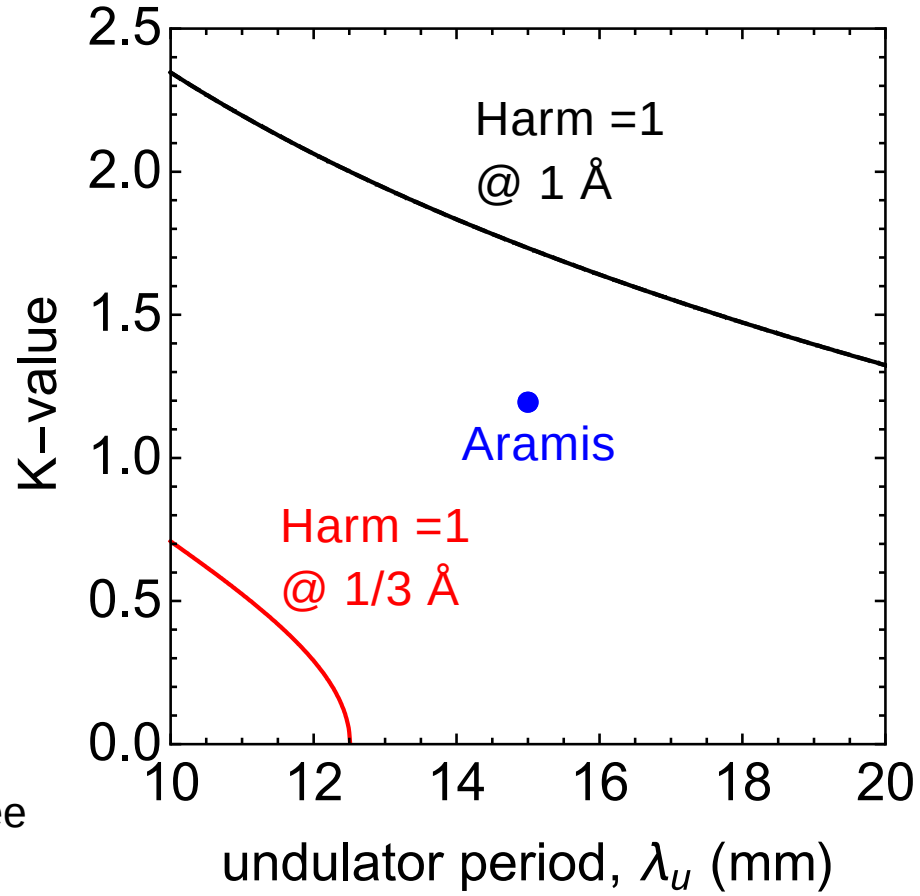
Porthos – Harmonic lasing





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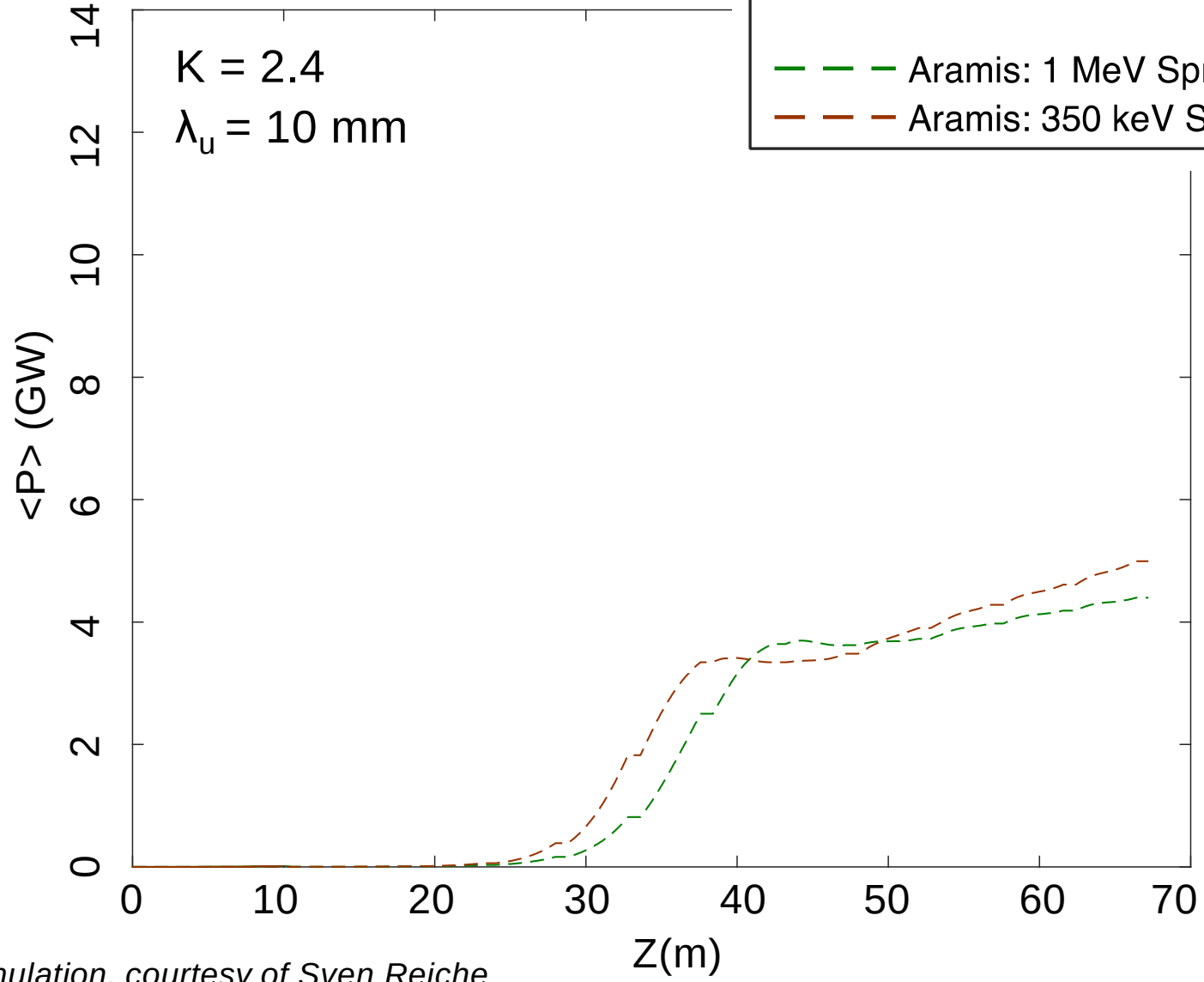
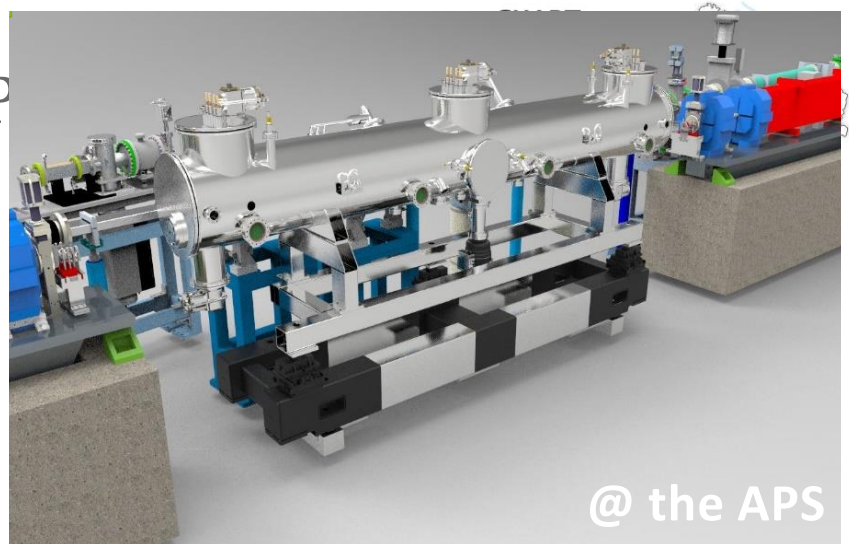
Porthos @ 1 Å



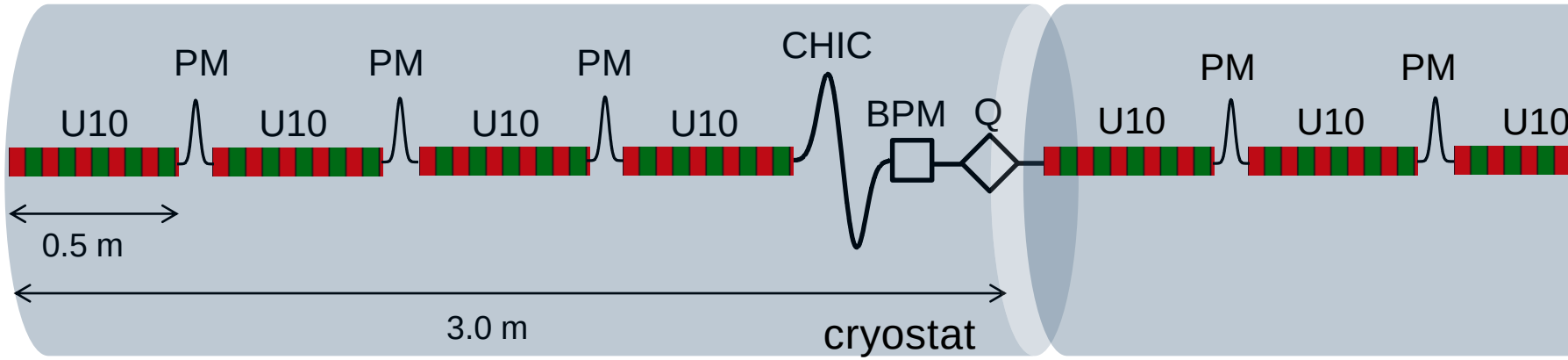
Genesis simulation, courtesy of Sven Reiche

Porthos Preliminary P



- Beam energy: 7.0 GeV
- Slice emittance: 300nm
- Peak current: 3kA
- CHIC modes
- Harmonic lasing:

→ Every half Lg a phase matcher is needed to suppress the fundamental



λ_U = 10 mm β = 3-4 m

K = 2.4 tunnel: 120m

gap = 4 mm

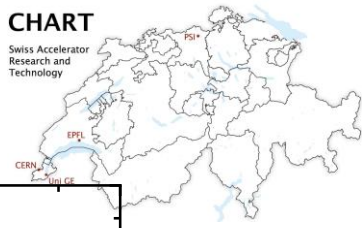


CHART
Swiss Accelerator
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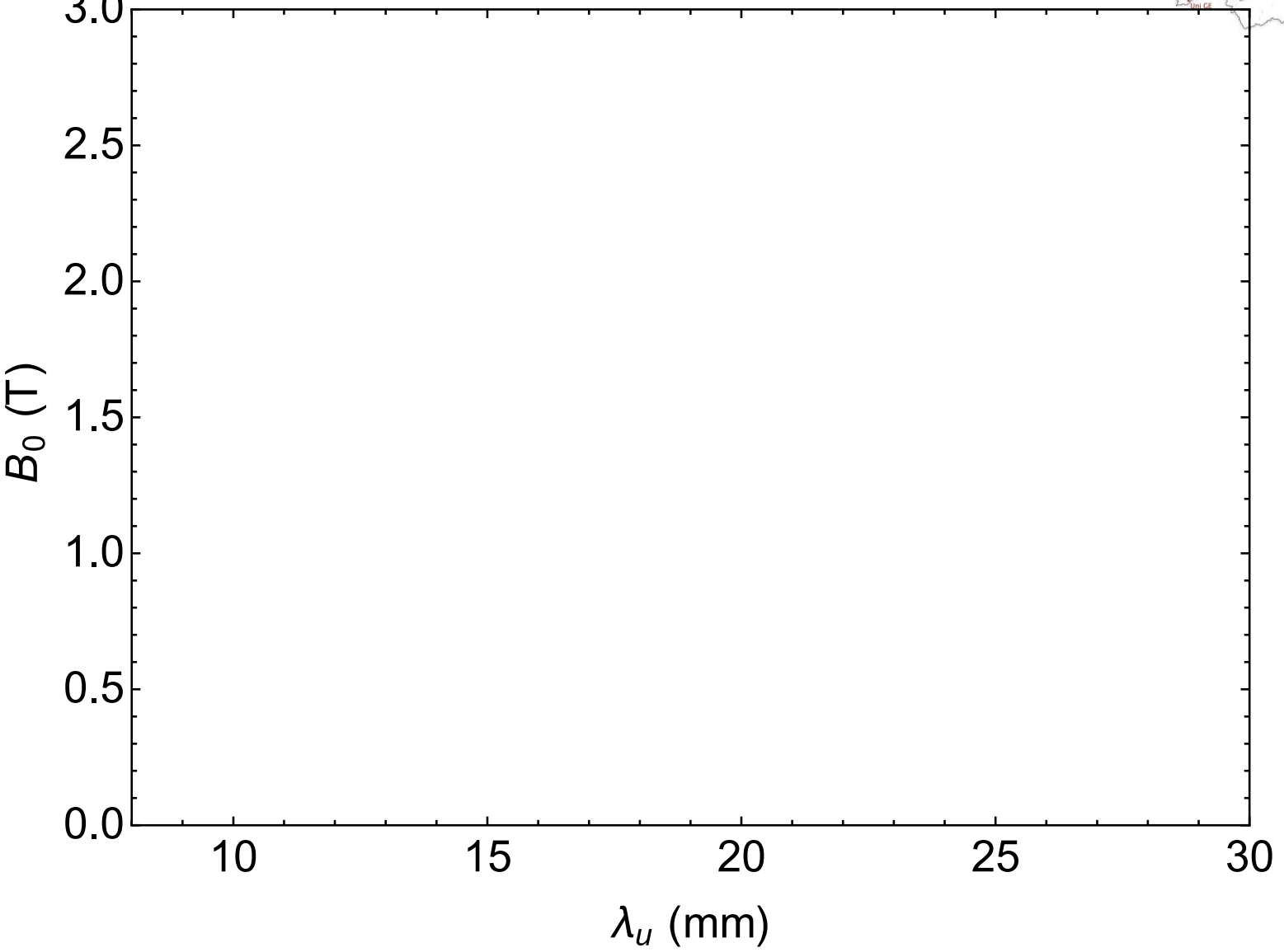
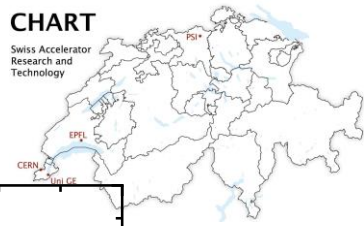

3.0
2.5
2.0
1.5
1.0
0.5
0.0
B_0 (T)
10
15
20
25
30
λ_u (mm)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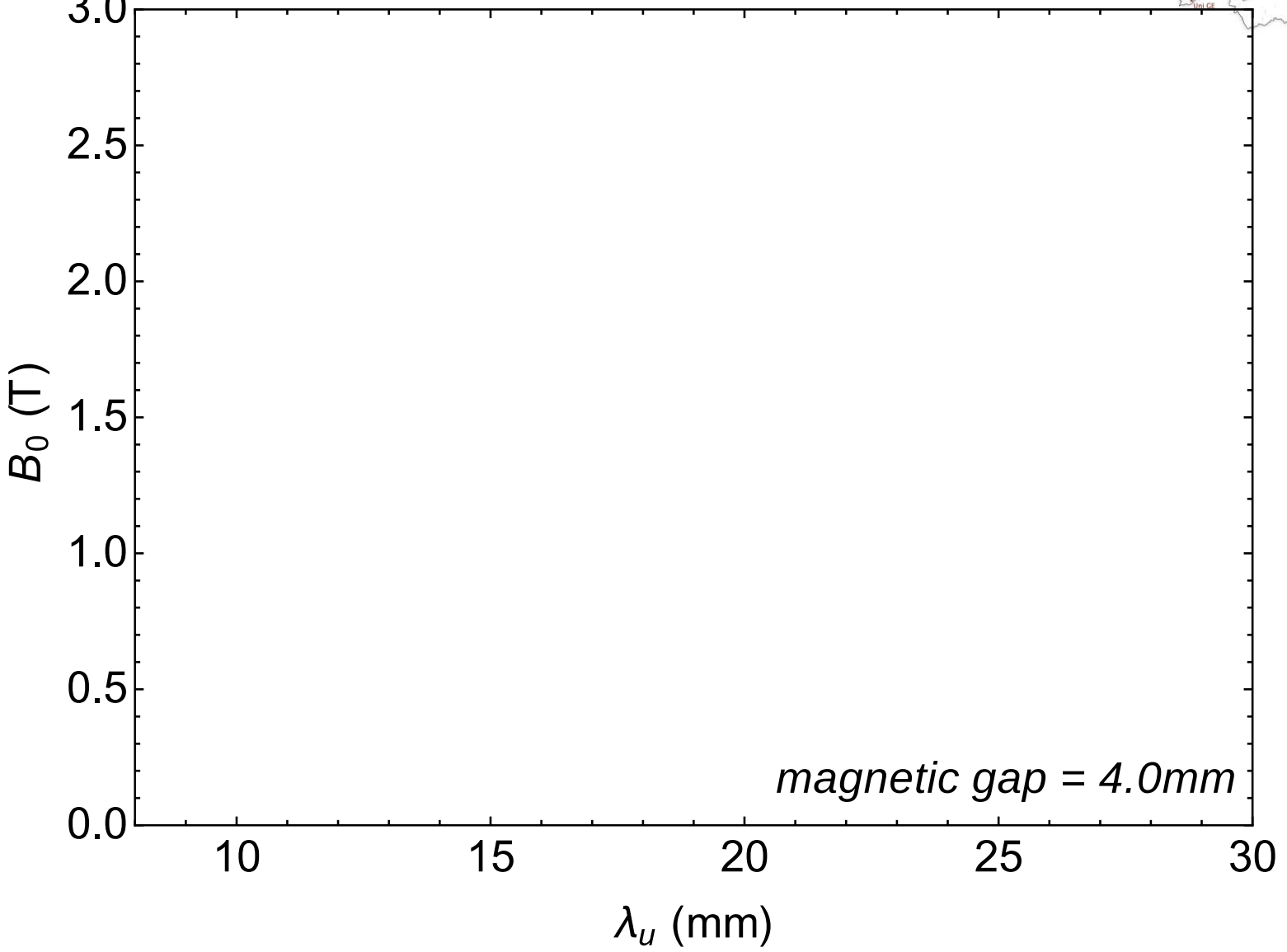
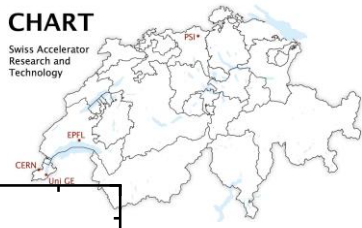

3.0
2.5
2.0
1.5
1.0
0.5
0.0
B_0 (T)
10
15
20
25
30
λ_u (mm)
magnetic gap = 4.0mm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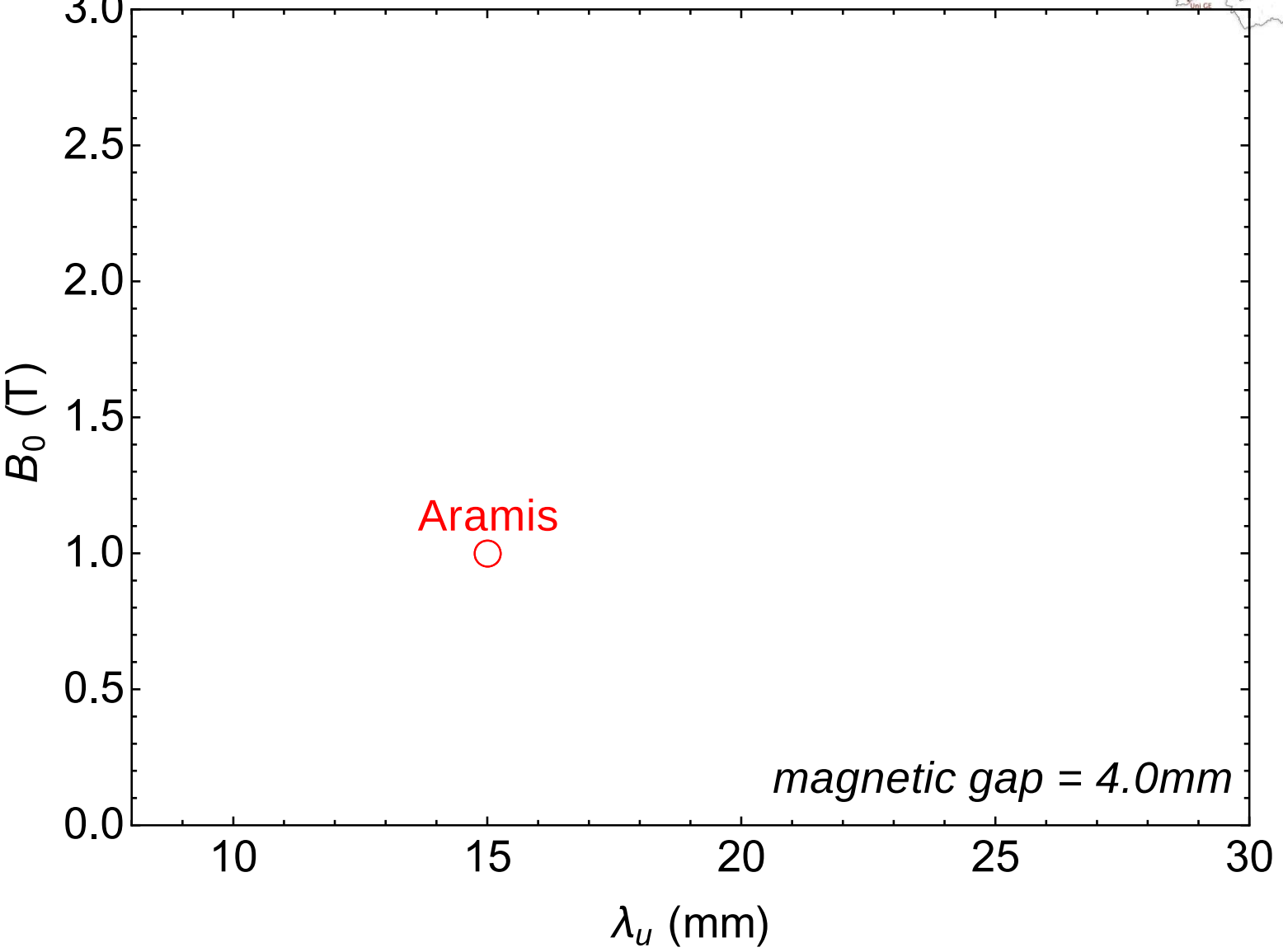
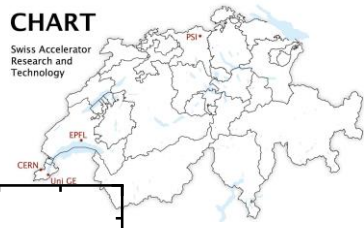

3.0
2.5
2.0
1.5
1.0
0.5
0.0
B_0 (T)
Aramis
magnetic gap = 4.0mm
10
15
20
25
30
λ_u (mm)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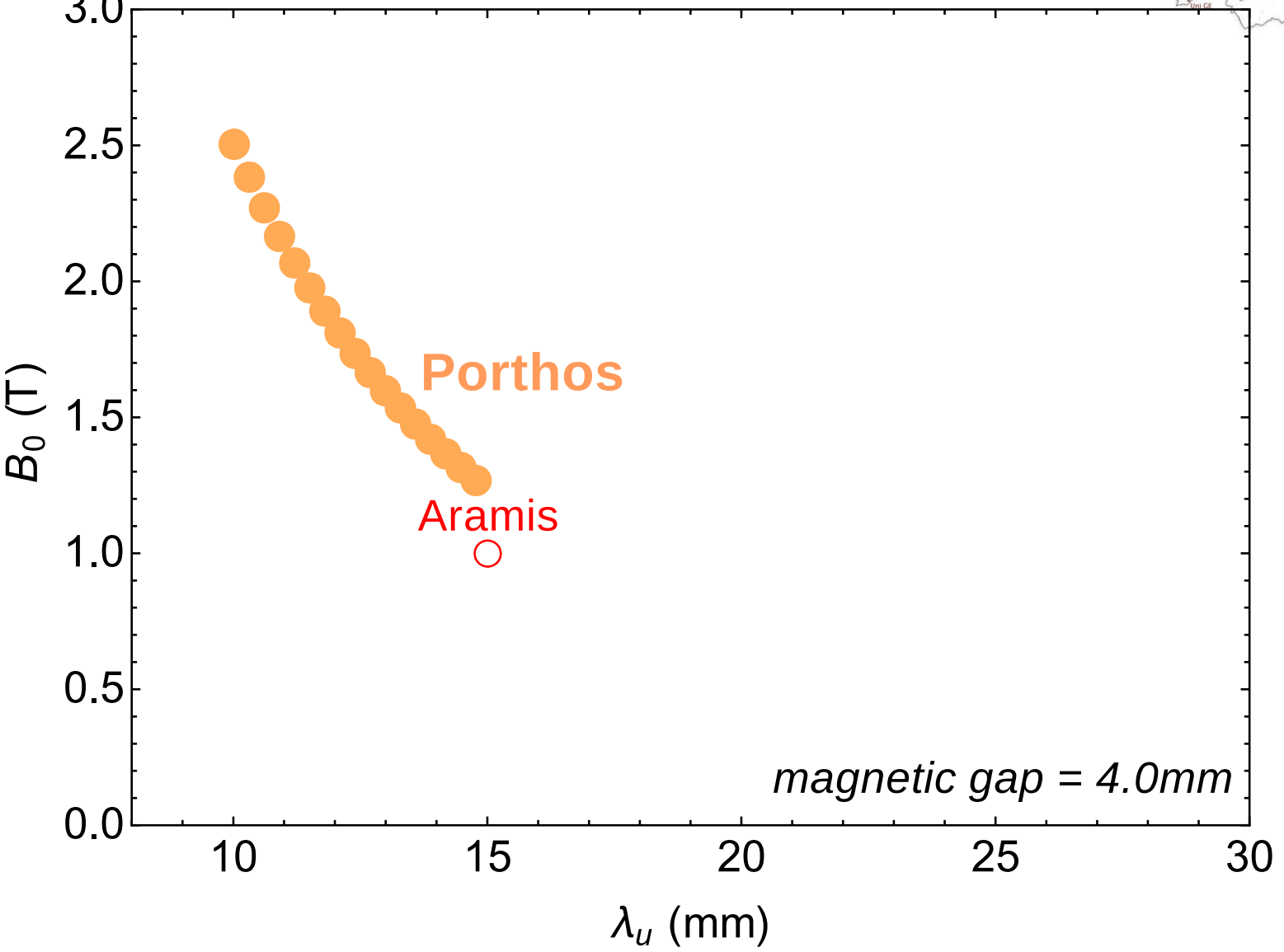
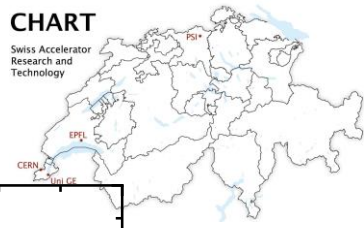
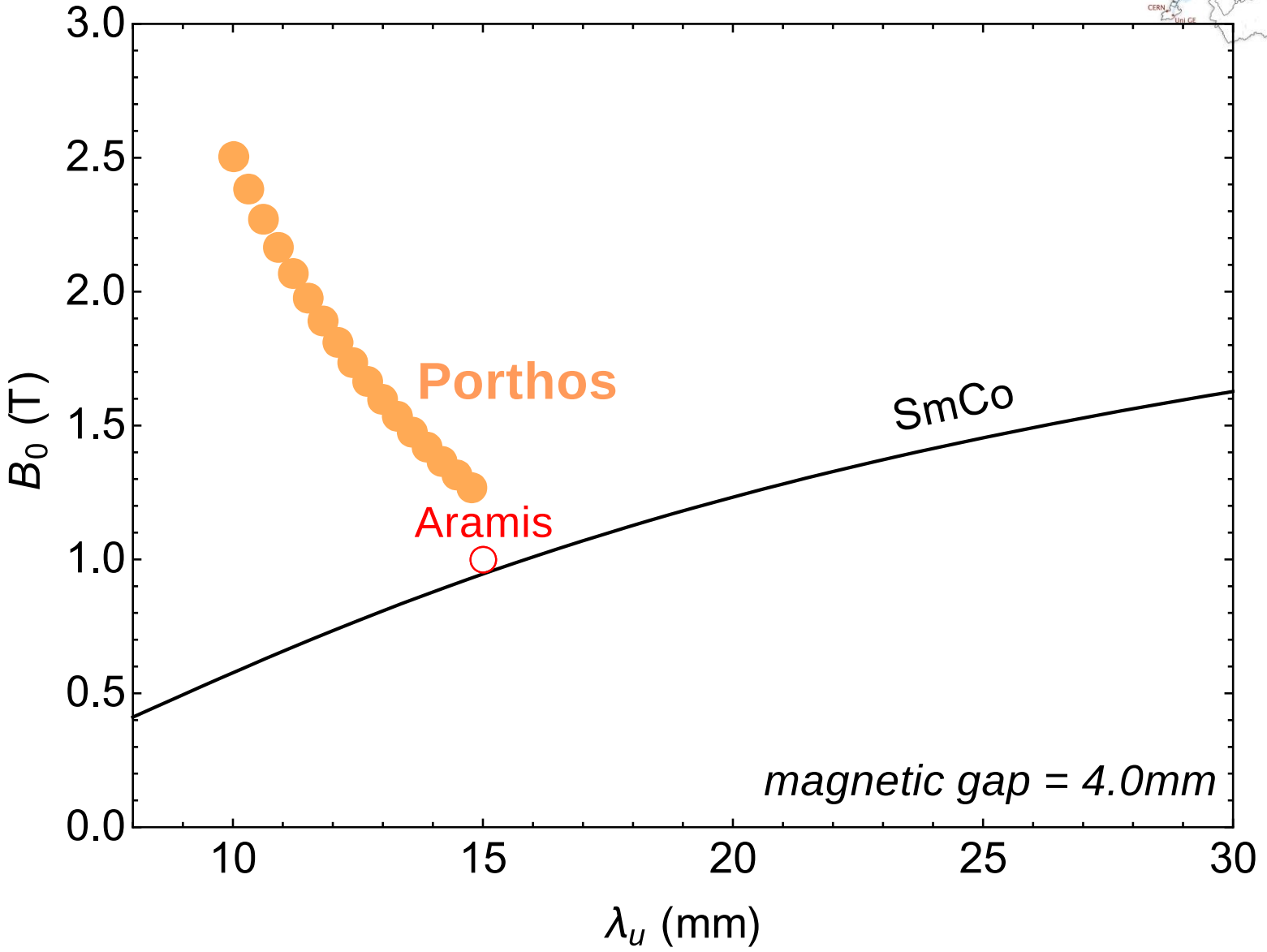
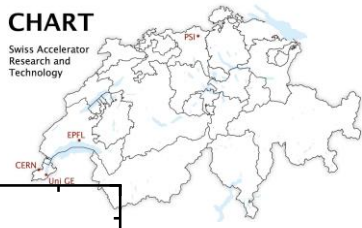
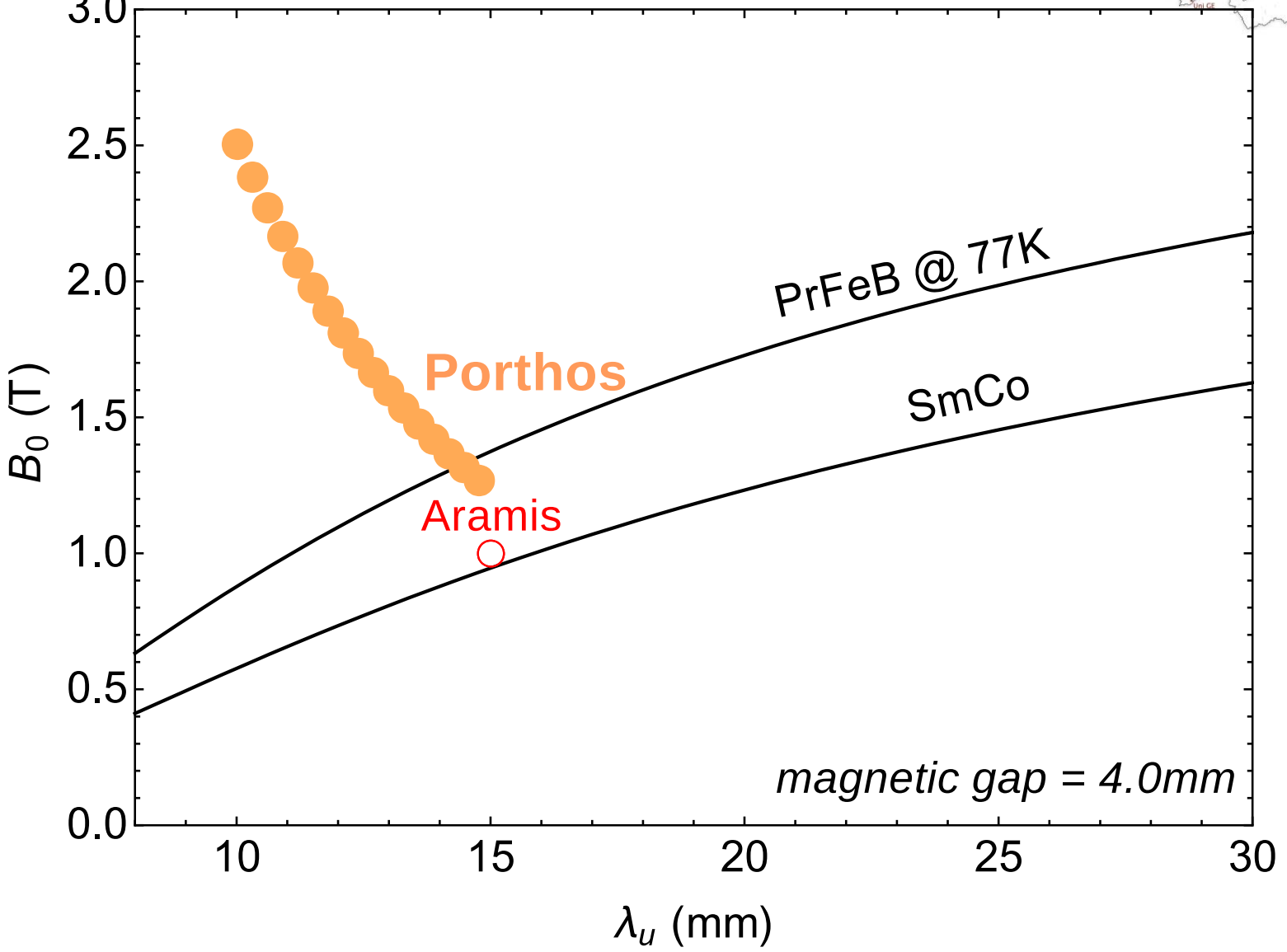

3.0
2.5
2.0
1.5
1.0
0.5
0.0
B_0 (T)
10
15
20
25
30
λ_u (mm)
Porthos
Aramis
magnetic gap = 4.0mm





E.R. Moog, R.J. Dejus, and S. Sasaki , Light Source Note: ANL/APS/LS-348





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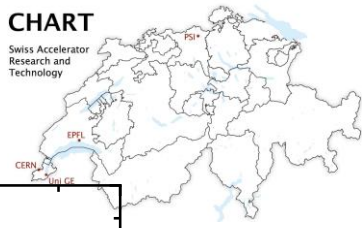

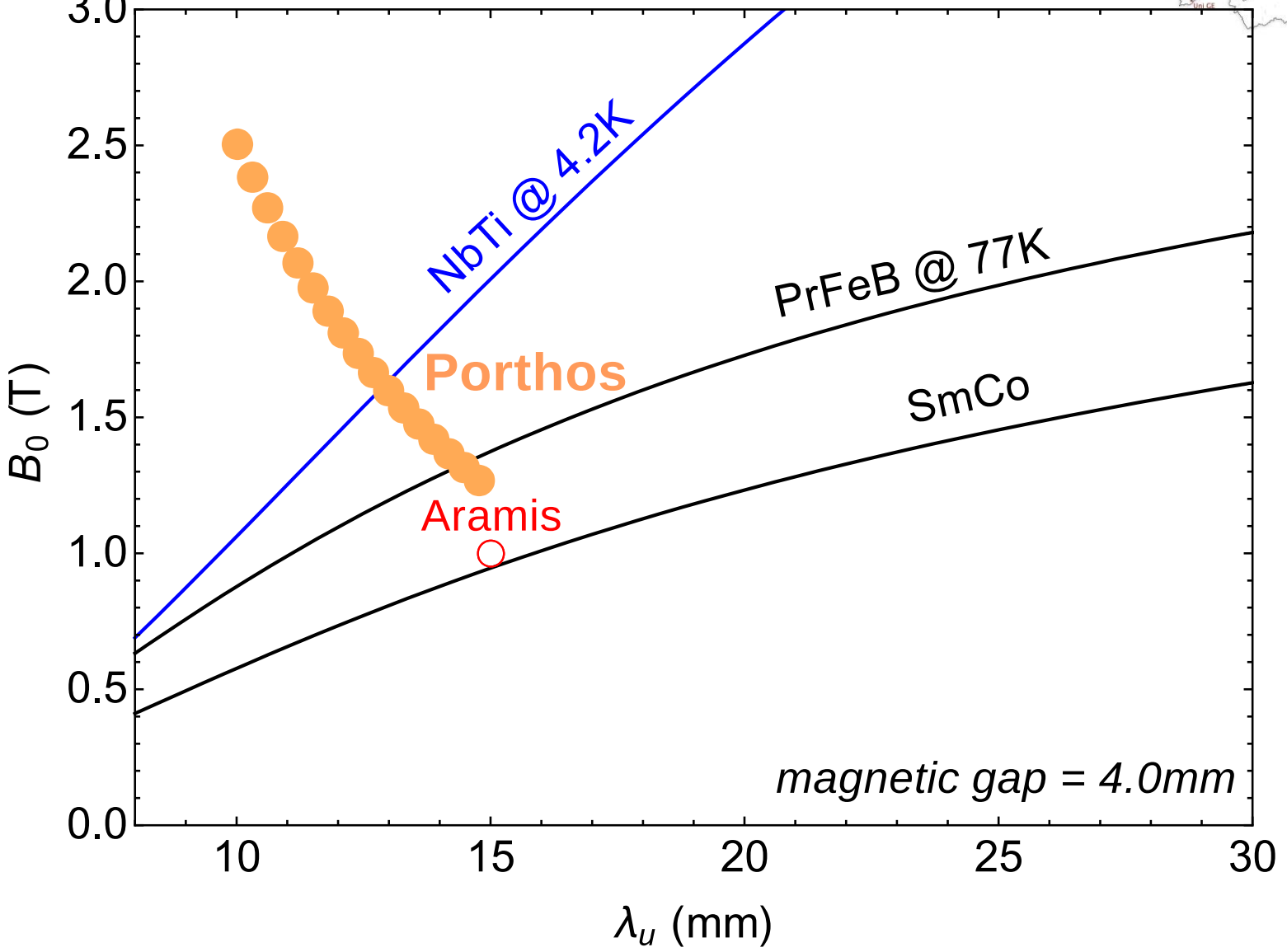

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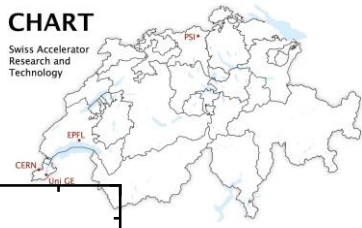

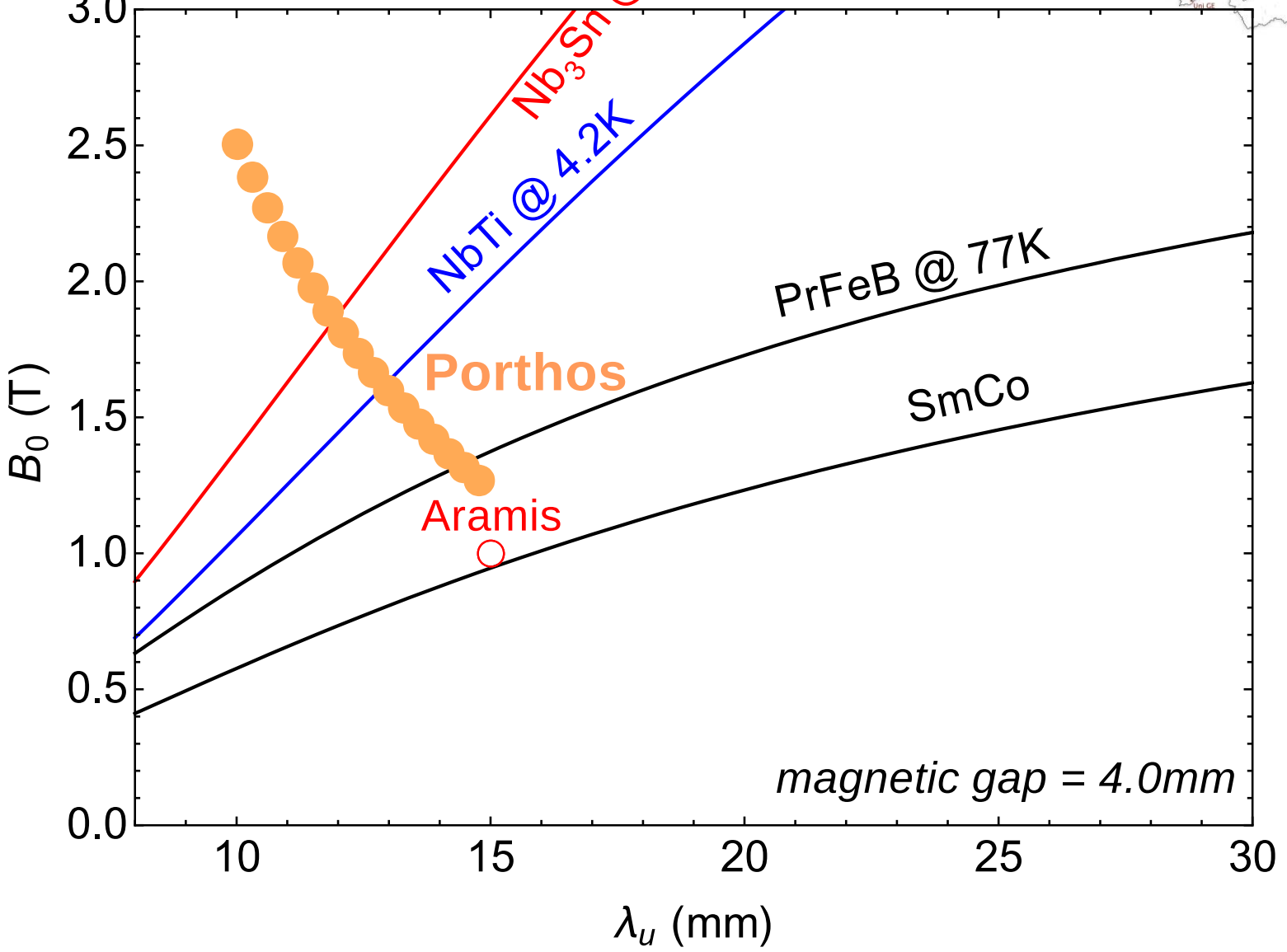

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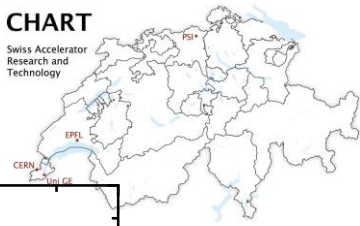

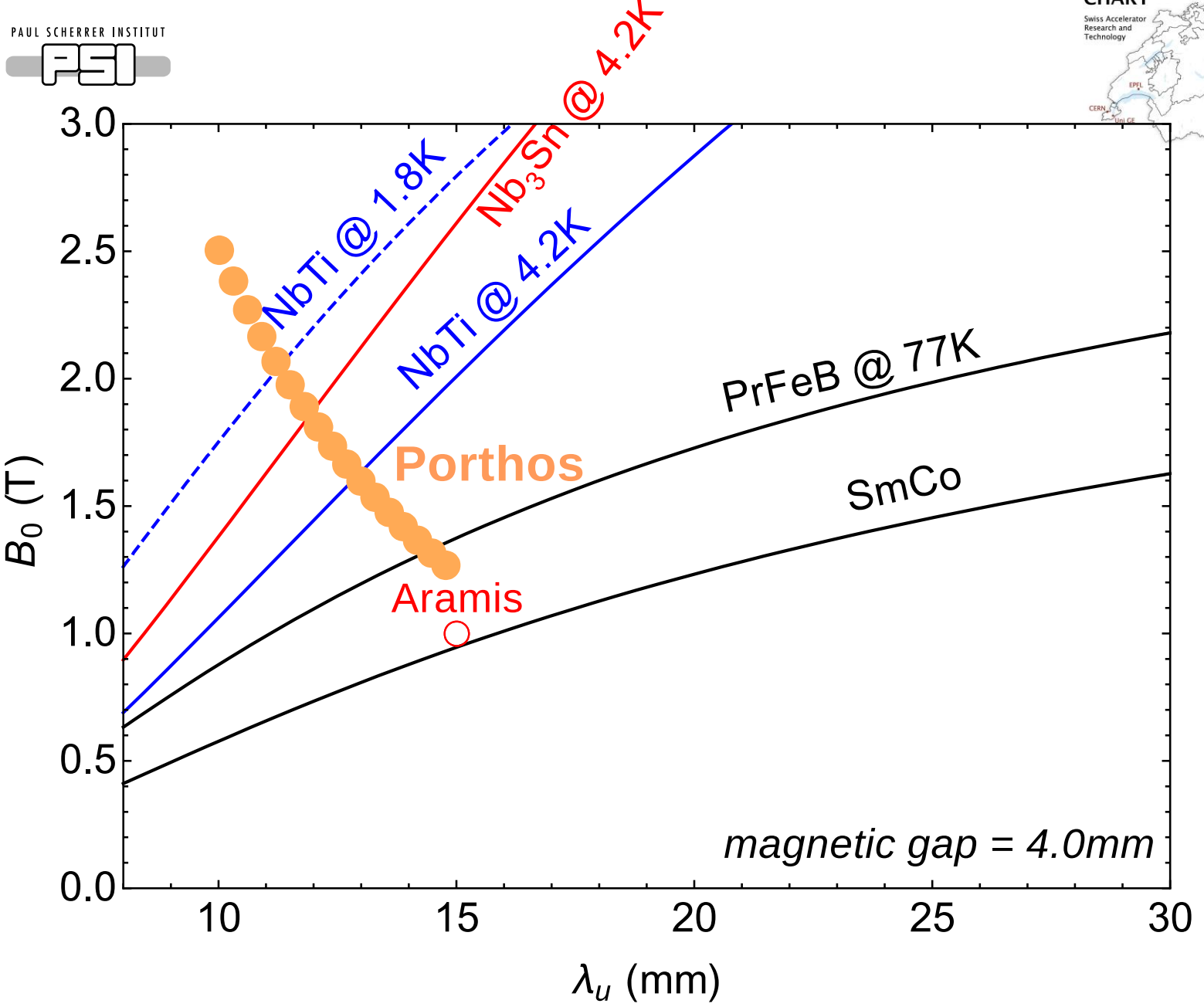

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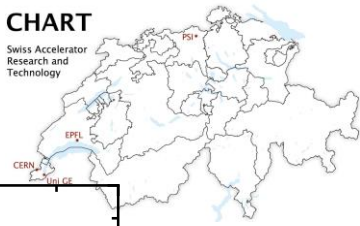
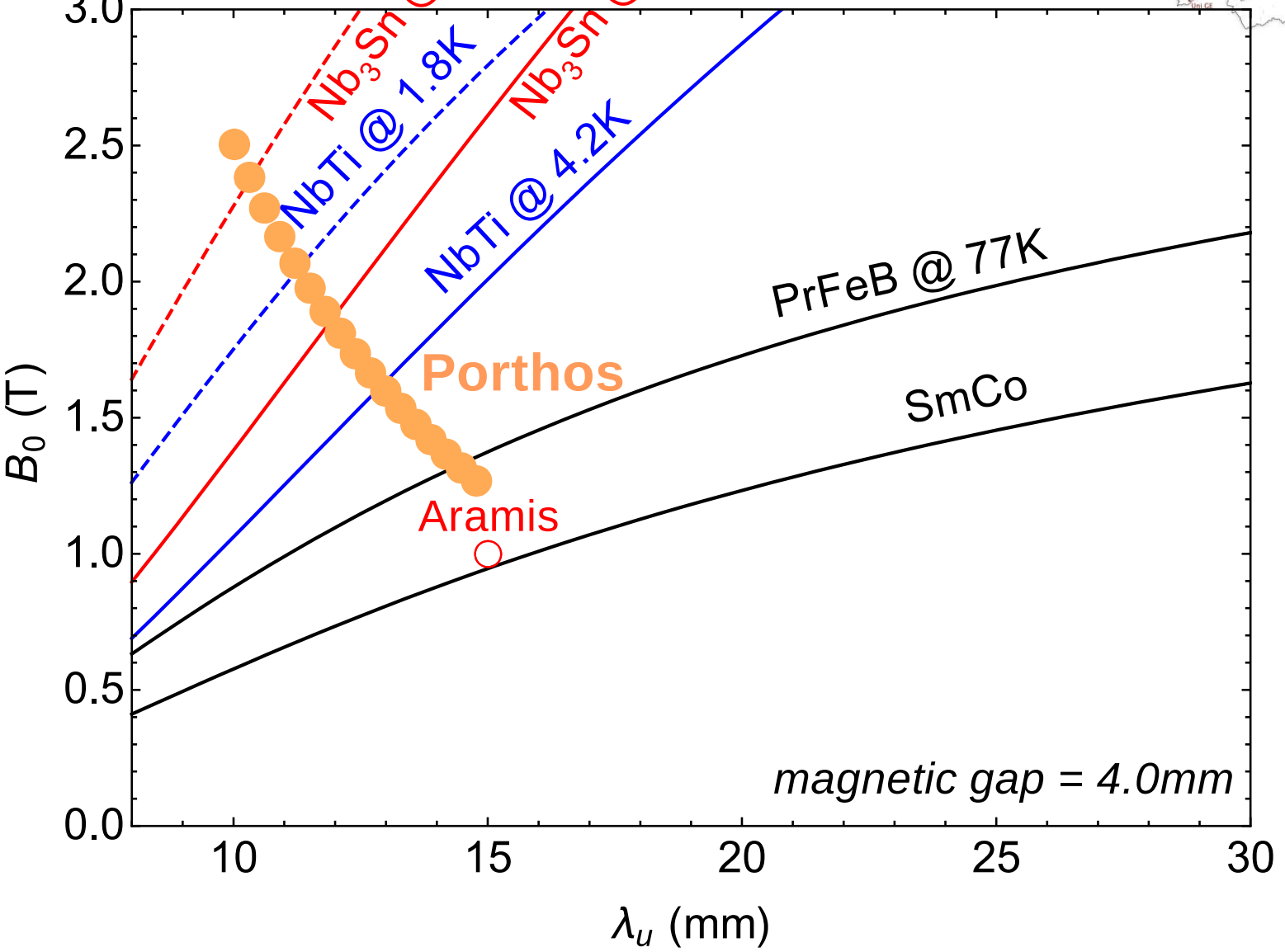
James Clarke, FLS 2012, March 2012





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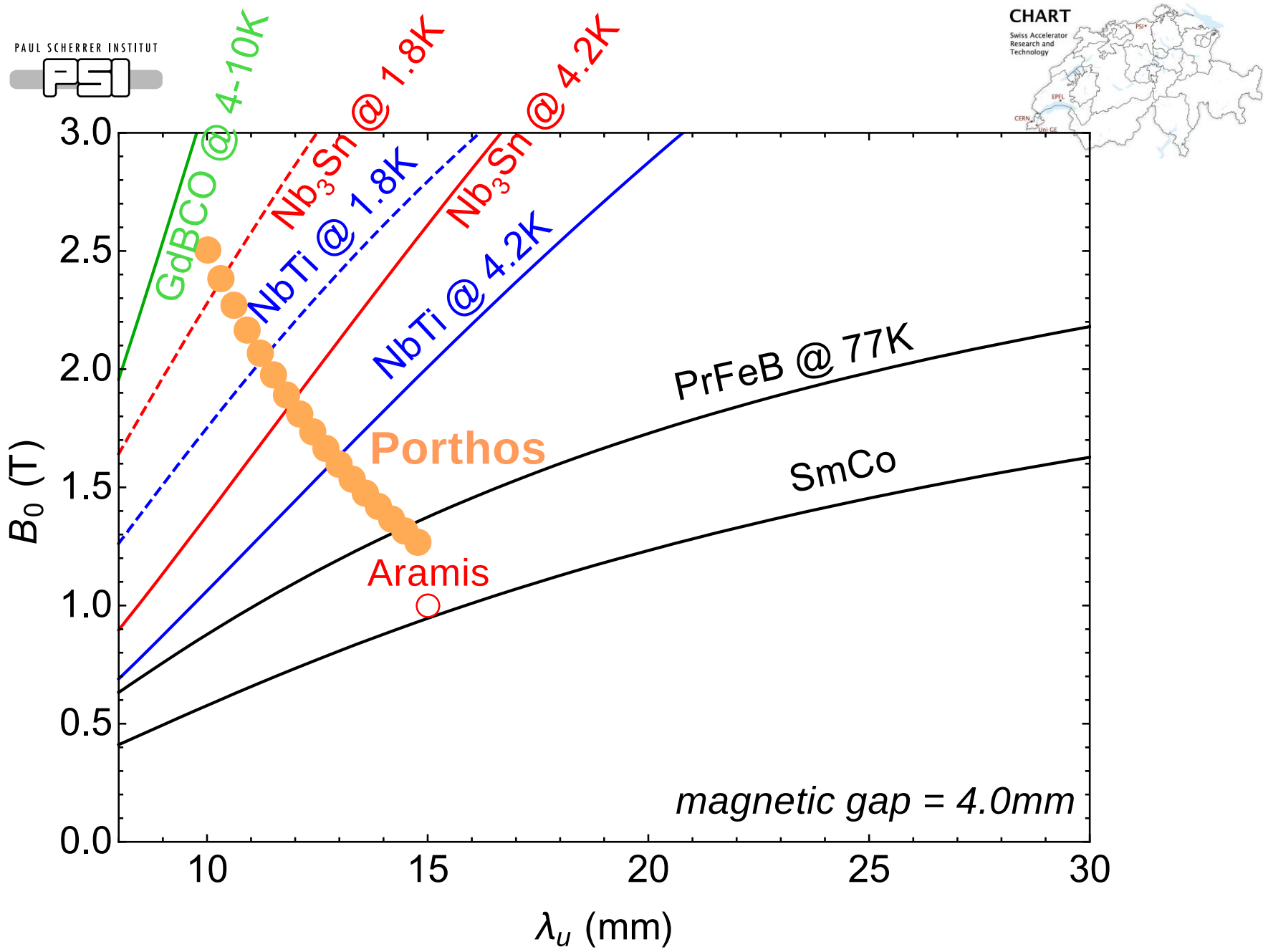

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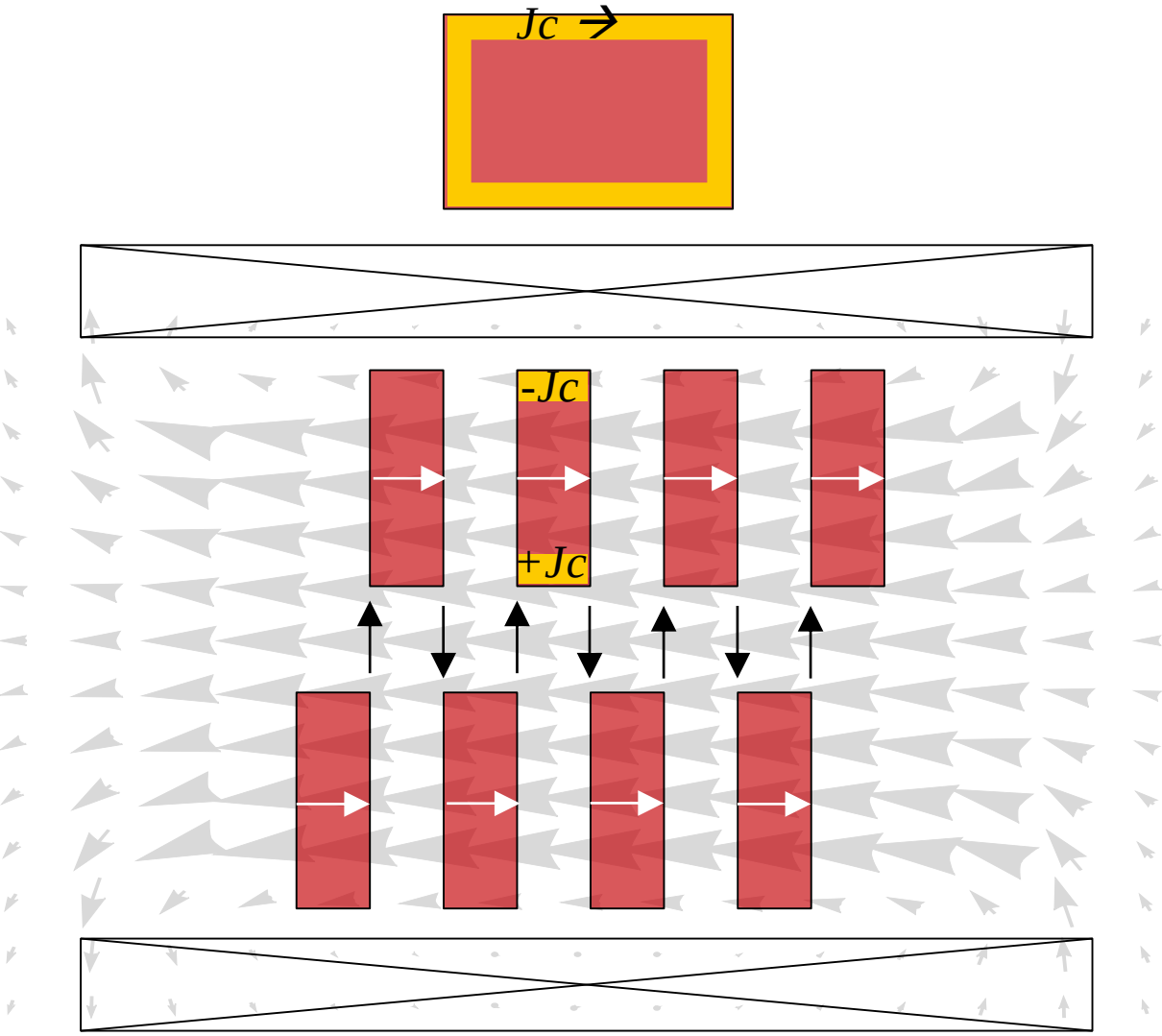
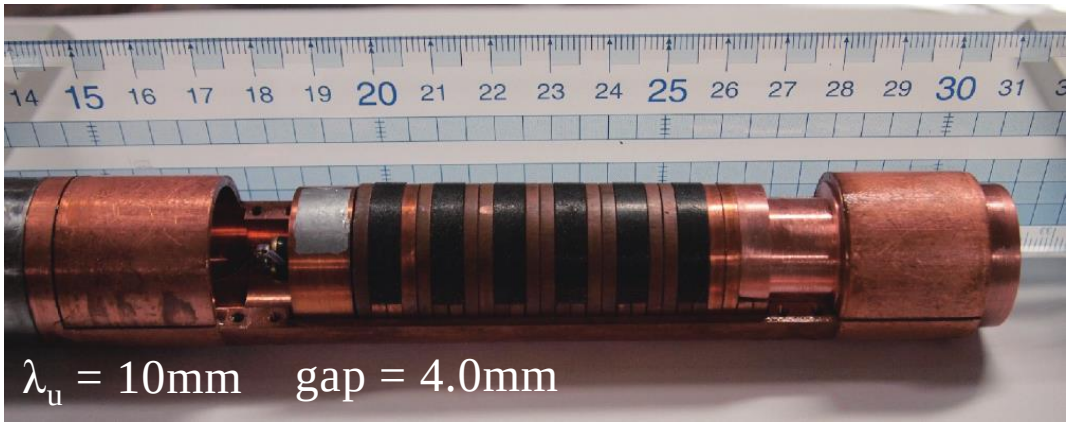
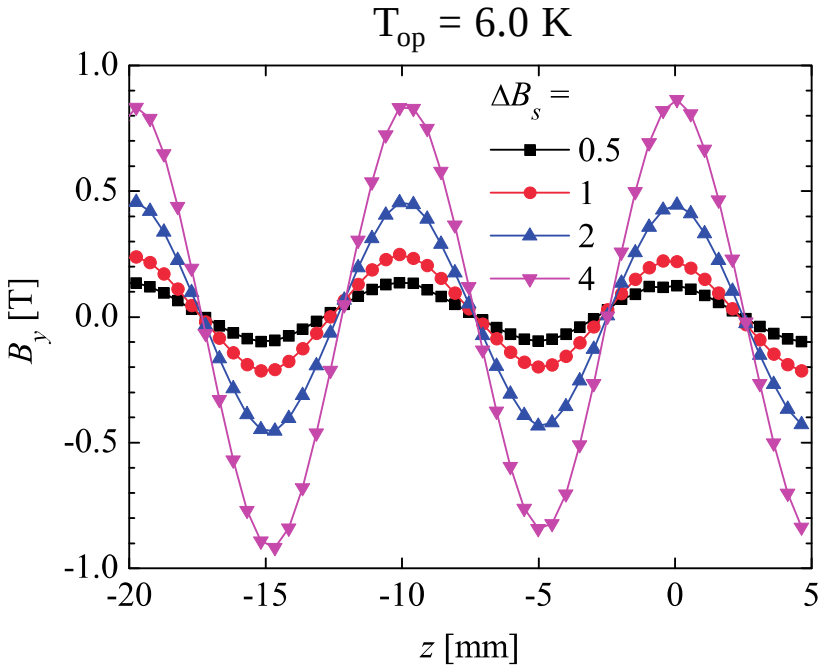
Staggered array with HTS bulks

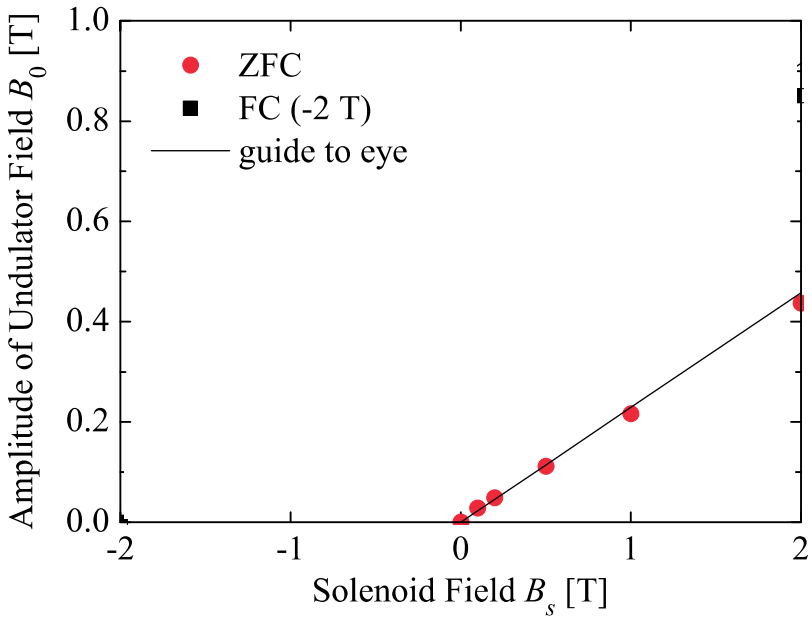


C.P.Bean, Rev. Mod. Phys. 36 (1964) 31.

GdBCO short prototype

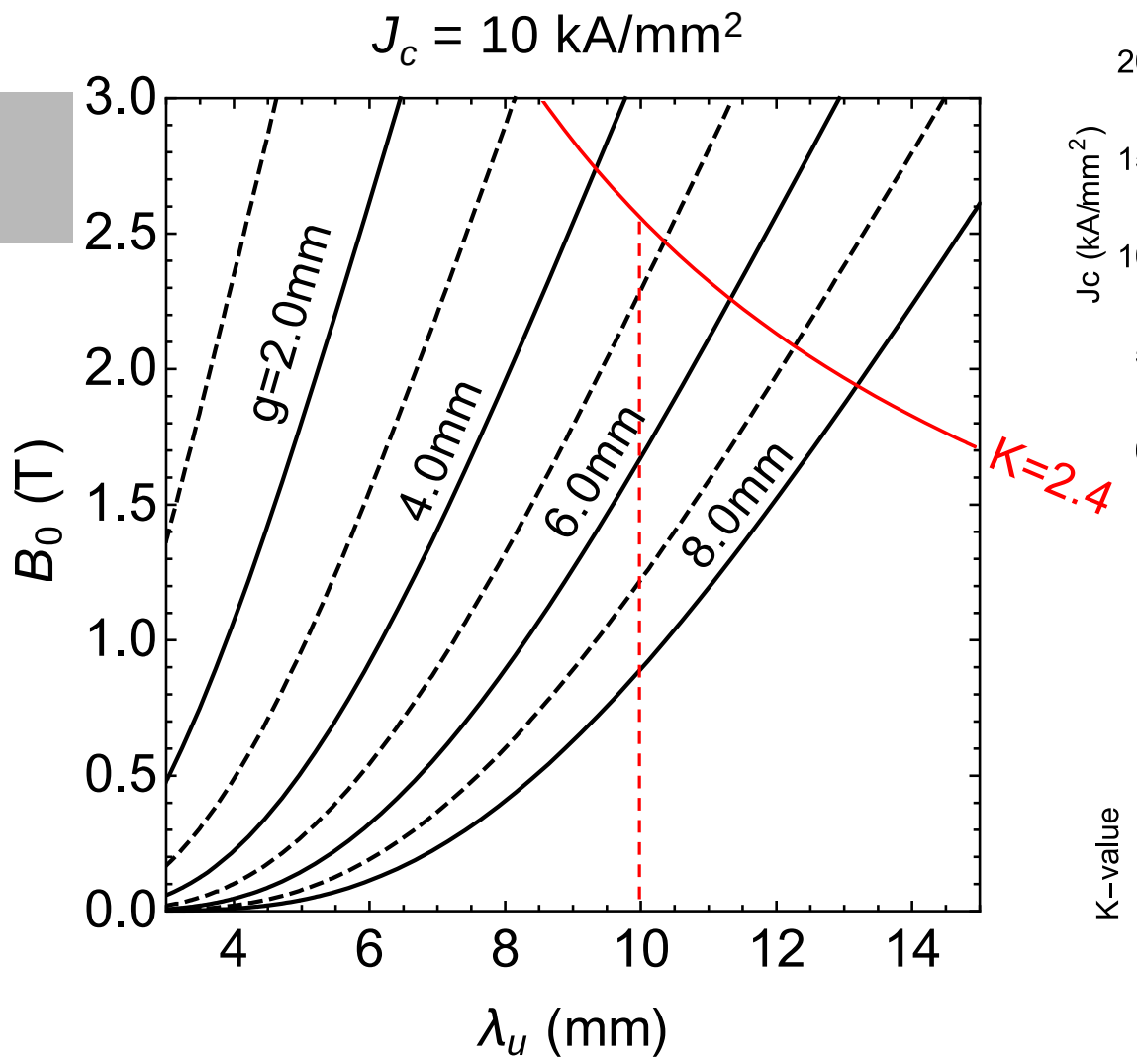


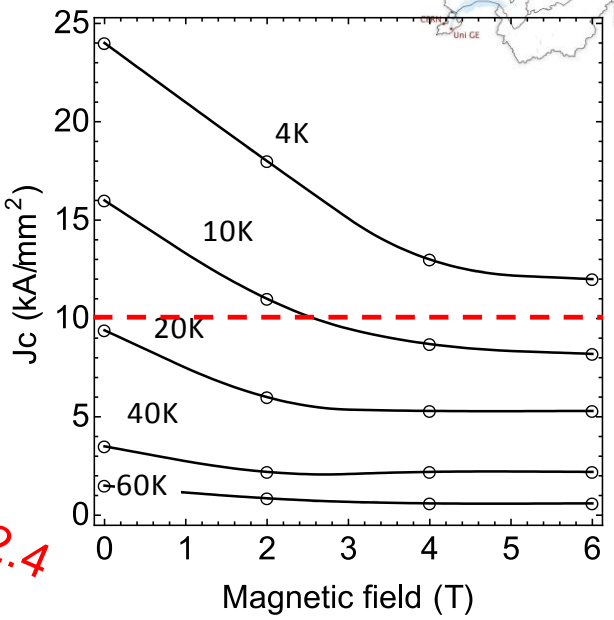


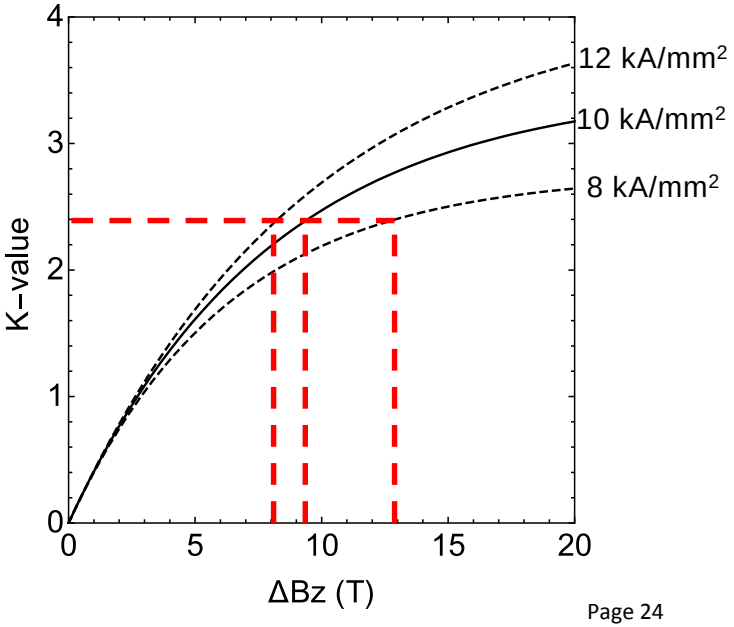


R.Kinjo et al., Applied Physics Express 6 (2013) 04270

GdBCO scaling laws

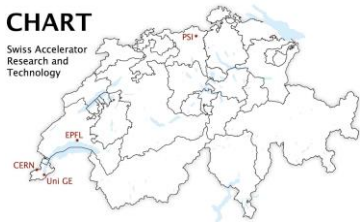






R.Kinjo et al., Physical Review Special Topics, Accelerator and Beams 17, 022401 (2014)

Conclusions



- NbTi electromagnetic undulators are a mature technology, used on a regular base at the APS to enhance the brilliance and energy of their beamlines
- Techniques for measuring the field at cryogenic temperature as well as shimming to achieve compatible phase errors have been demonstrated
- Recently Nb_3Sn has been successfully implemented by Berkeley team and tested at the APS: training behaviour to be understood
- Pioneering work on GdBCO bulk superconductor has been recently carried out at the university of Kyoto, this technique shows high potential to further reduce the period length but it requires a serious R&D program to build a full scale prototype with low phase error <10°.

My thanks go to

- S. Reiche, PSI
- S. Prestemon, D. Arbelaez, S. Caspi, LBNL
- J. Clarke, Daresbury
- R. Dejus, APS