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Undulator perspectives

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on behalf of WP5

XLS WP leaders meeting CERN 03-04 December 2019

Outline

Afterburner

HTS first results

III. Undulator plus after-burner(AB)

a) Fixed (e.g. SCU with circular) polarization

b) Afterburner with variable polarization (e.g. in-vacuum PM)

λ_U = 13mm
K = 1.85 ... 0.85

Soft x-ray:		Hard x-ray:	
GeV / keV			
0.95	1.95	2.75	5.5
243	2041	2038	16233

circular sc undulator mature technology
but

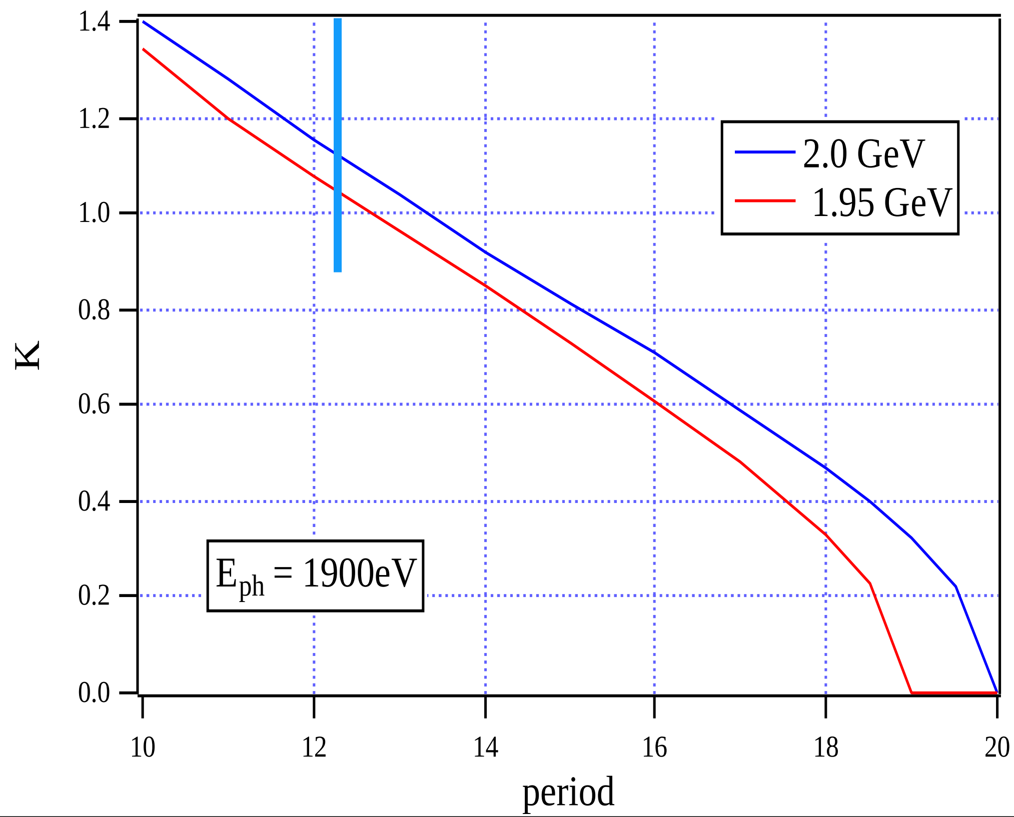
single units -> series
short intersections -> long cryostat?
quadrupoles, BPMs integrated?

Afterburner

- full polarisation control in soft x-ray and hard x-ray
  - APPLE type undulators are ppm and therefore weaker compared to hybrid or sc
  - needs to be compatible with FEL undulator

(λ_U = 13mm, K = 0.85 – 1.85)

$$\lambda_{\mathrm{AB}}(1+\frac{K_{\mathrm{AB}}^2}{2}) = \lambda_{\mathrm{U}}(1+\frac{K_{\mathrm{U}}^2}{2})$$



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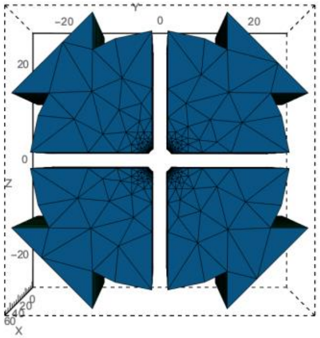
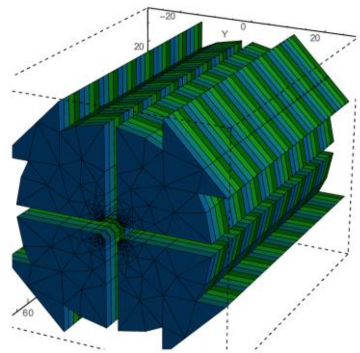
Afterburner





APPLE X / APPLE III options:

out of vacuum: newest material: B_r = 1.37T — 18mm
8 magnets / period
5 mm vacuum chamber
very low minimum K

in vacuum: intermediate step

cryogenic: strongest material: B_r = 1.7T
LN_2 — 4 magnets / period
higher radiation hardness — 16mm
minimum K about 0.5

Note:
periods are not integers

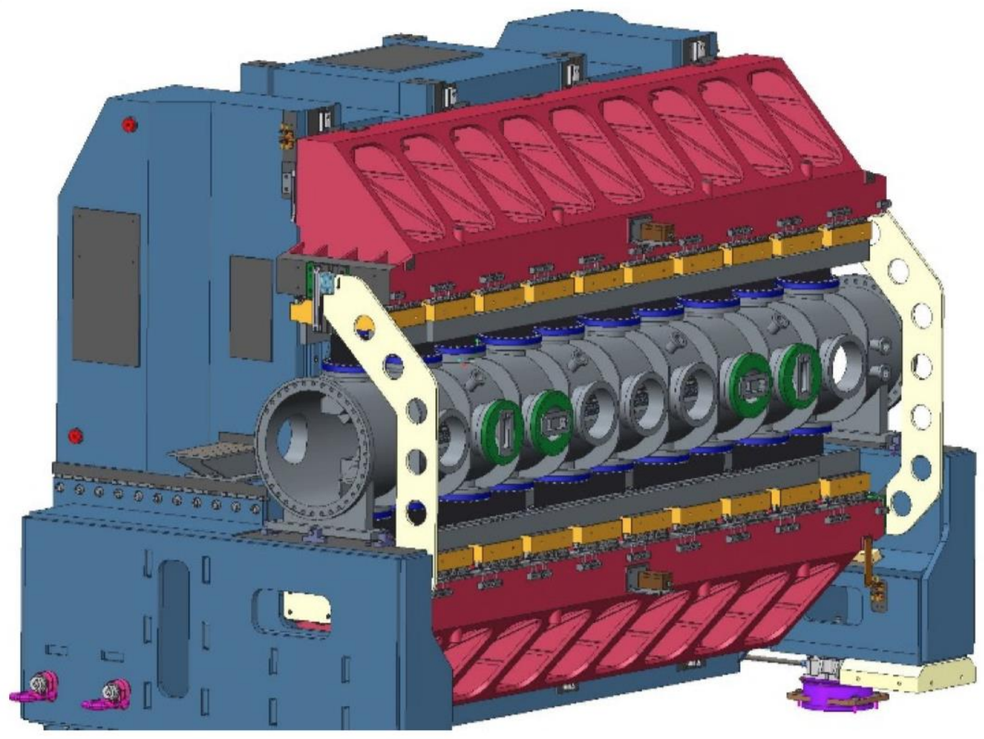
FEL Undulator			Afterburner		
per	Kmax	Kmin	per	Kmax	Kmin
13	1.85	0.85	13	1.85	0.85
13	1.85	0.85	14	1.74	0.73
13	1.85	0.85	15	1.64	0.60
13	1.85	0.85	16	1.55	0.46
13	1.85	0.85	17	1.47	0.29
13	1.85	0.85	18	1.38	#ZAHL!
13	1.85	0.85	19	1.31	#ZAHL!
13	1.85	0.85	20	1.23	#ZAHL!

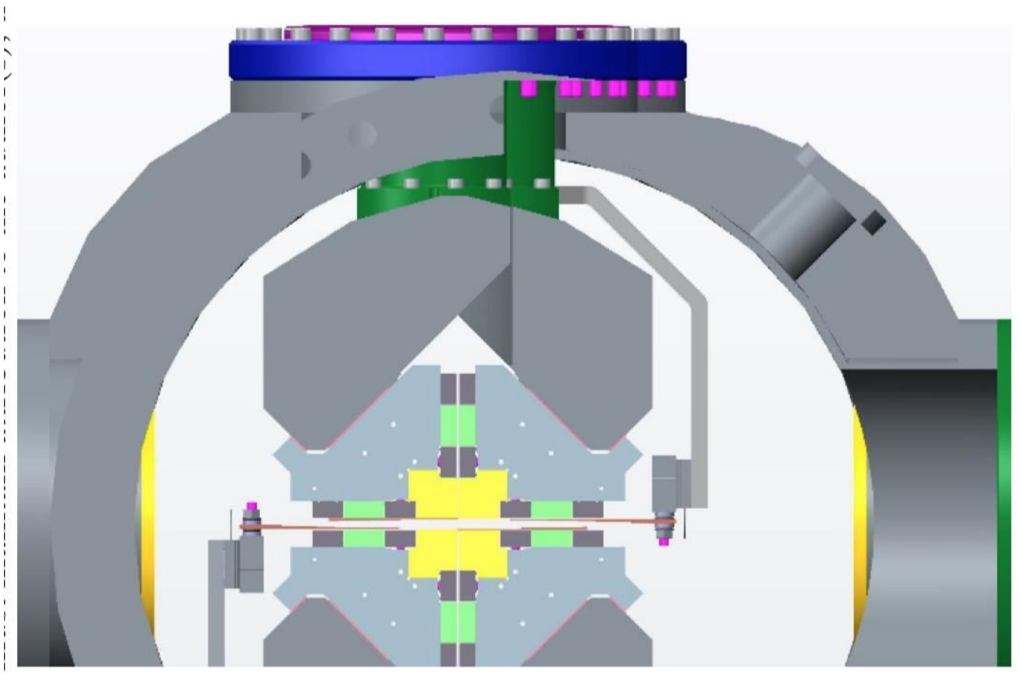
	CPMU APPLE X		Apple X	
	Br = 1.7T		Br = 1.37T	
gap / slit	6.5 / 2.5	5.5 / 2.5	6.5 / 2.5	6.5 / 2.5
per = 13			# magnets	
14			4 / period	8 / period
15		1.33		
16	1.34	1.52	1.08	1.17
17	1.53	1.73	1.24	1.32
18			1.4	1.52

Afterburner

Courtesy Johannes Bahrdt

In-Vacuum APPLE III under construction at BESSY
Cryogenic in-vac APPLE prototype part of LEAPS LIDs work package!





challenges:
3D force compensation to reduce momentums on feedthroughs
rf finger for gap and shift drive
in this design no movebal parts inside vacuum

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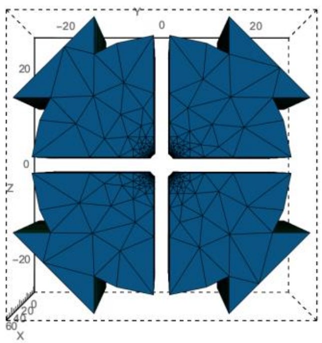
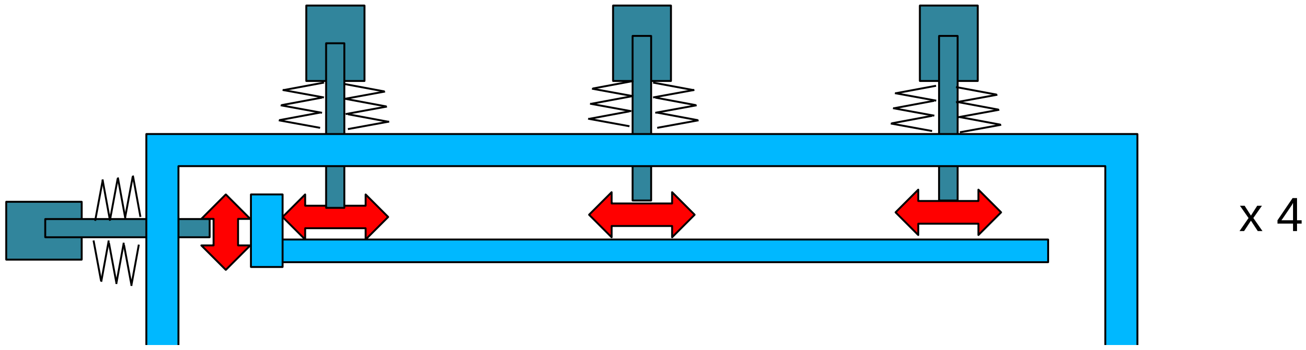
Afterburner





possible layout for in-vac or cryo Apple with
bearings inside of vacuum

APPLE X has benefit of reduced momentums for inclined modes
can bearings help simplifiying design?

Cryogenic in-vac APPLE prototype part of LEAPS LIDs work package!

next steps:

performance study by Hector Maurice

with „out of vacuum“ 18mm K_{min} = 0.2

versus CPMU 16mm with K_{min} = 0.46

for soft x-ray regime and hard x-ray regime to define what is the baseline

-> Extra Task 2

APPLE X in SwissFEL with 5mm vacuum chamber just started this week
spontaneous radiation with 2 out of 16 undulator modules.

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SC variable polarization

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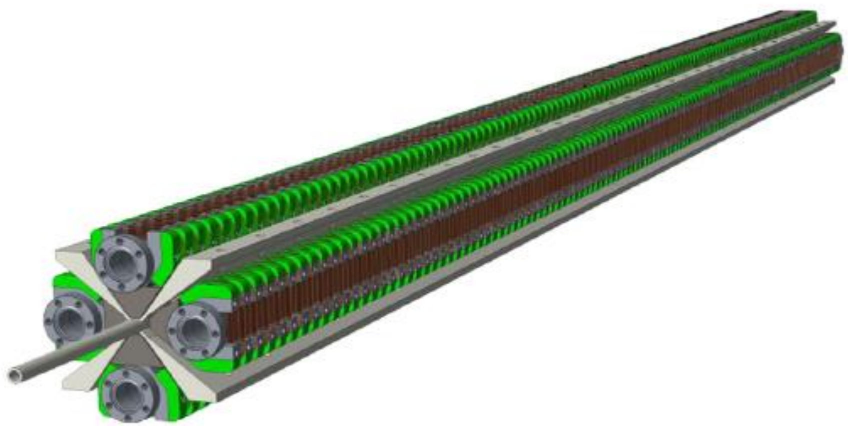
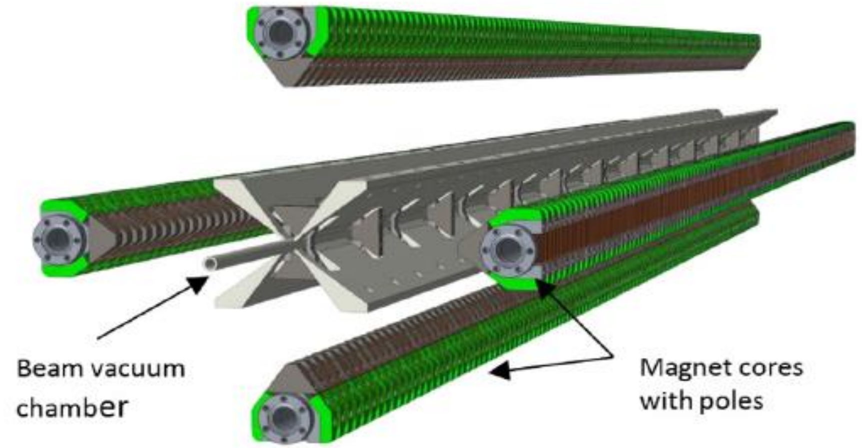
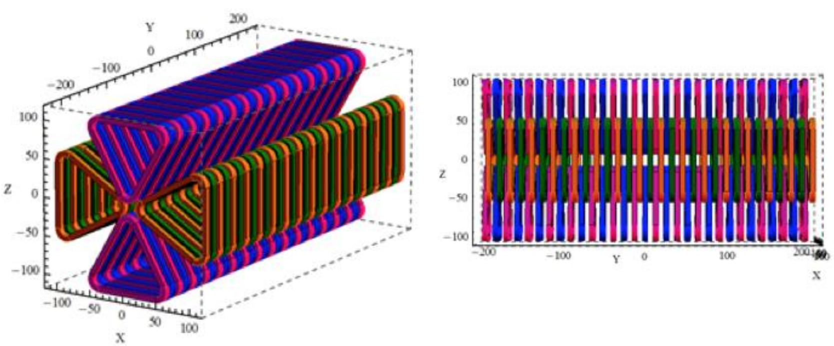
SCAPE - SuperConducting Arbitrary Polarization Emitter
proposed and 30cm prototype at APS
planned to be studied at KIT

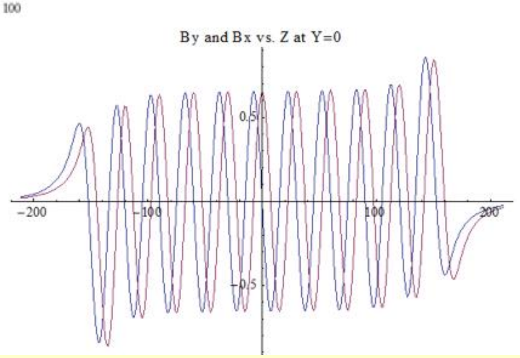
Courtesy Efim Gluskin

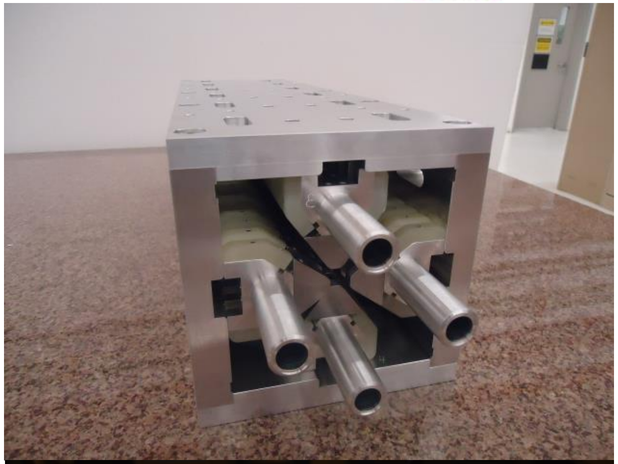


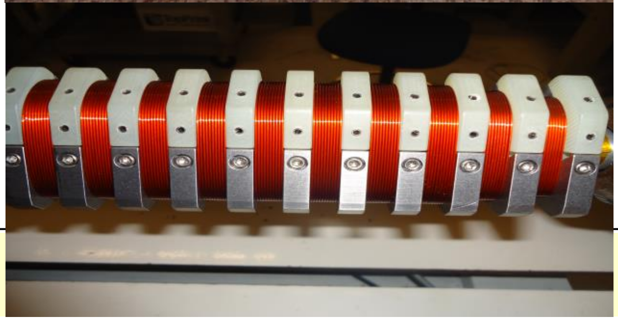


Radia model of SCAPE

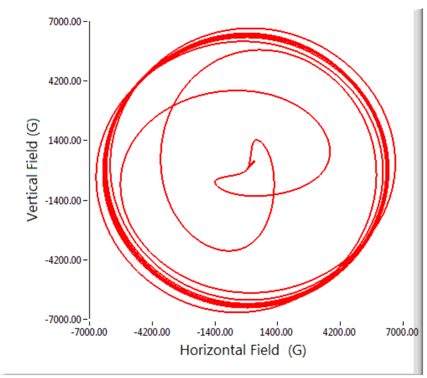








Measured magnetic field



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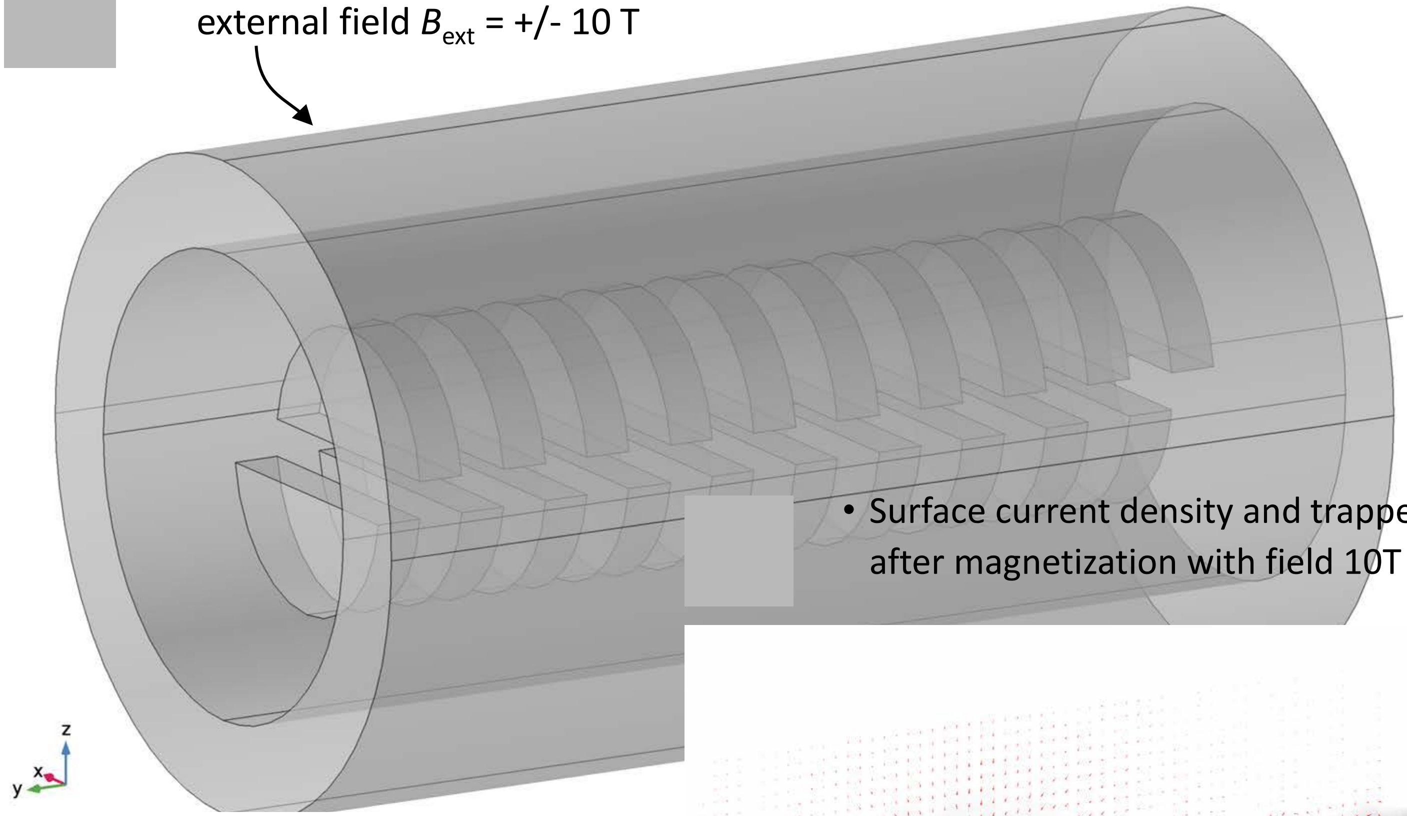
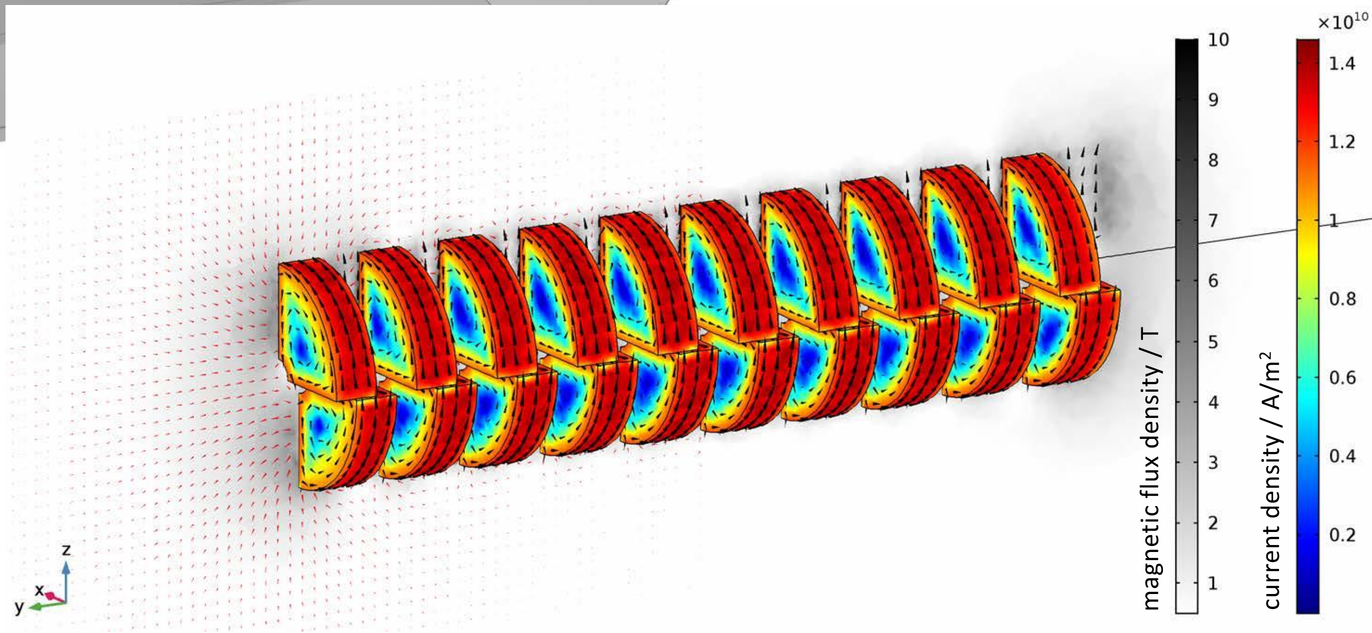
HTS circular

- Superconducting solenoid providing external field B_{ext} = +/- 10 T



- Surface current density and trapped magnetic field after magnetization with field 10T → 0T:



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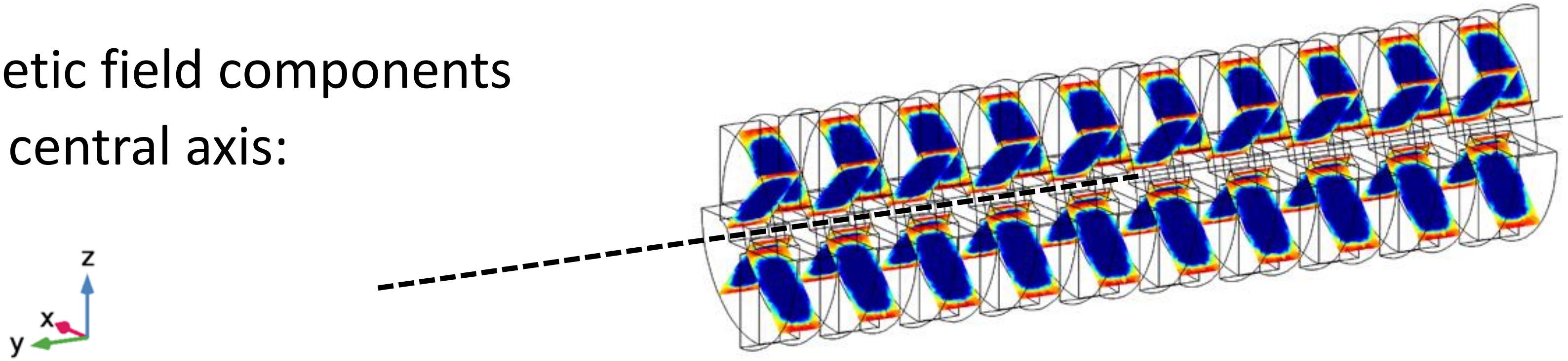
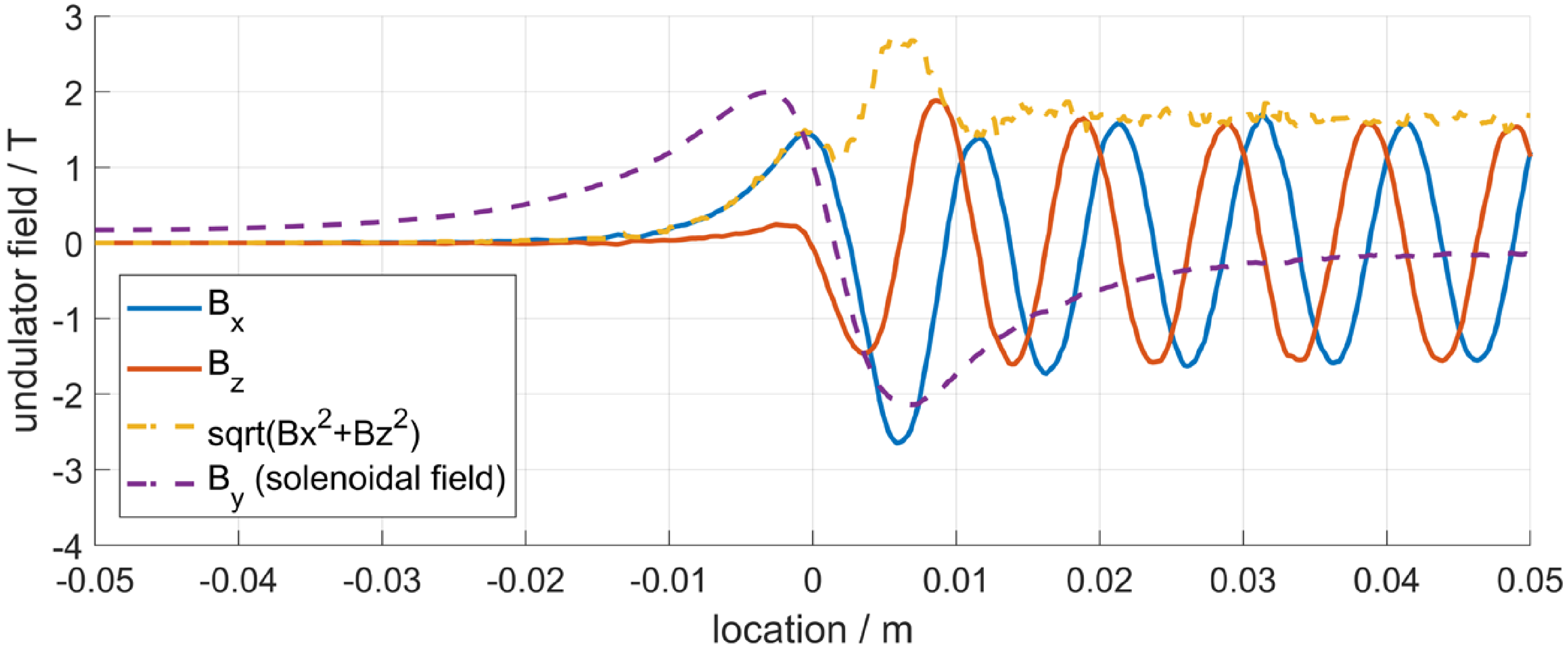
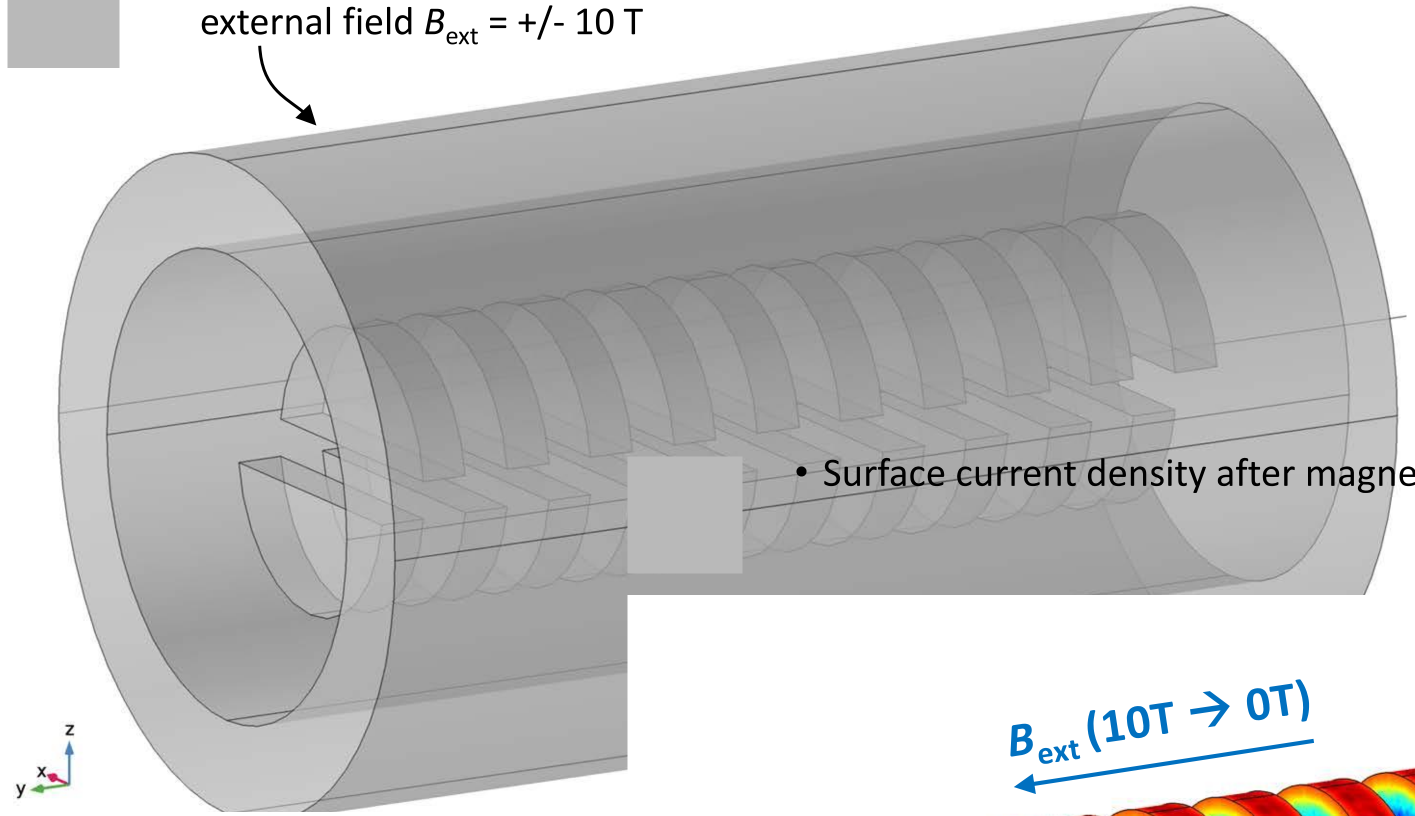
- Magnetic field components along central axis:



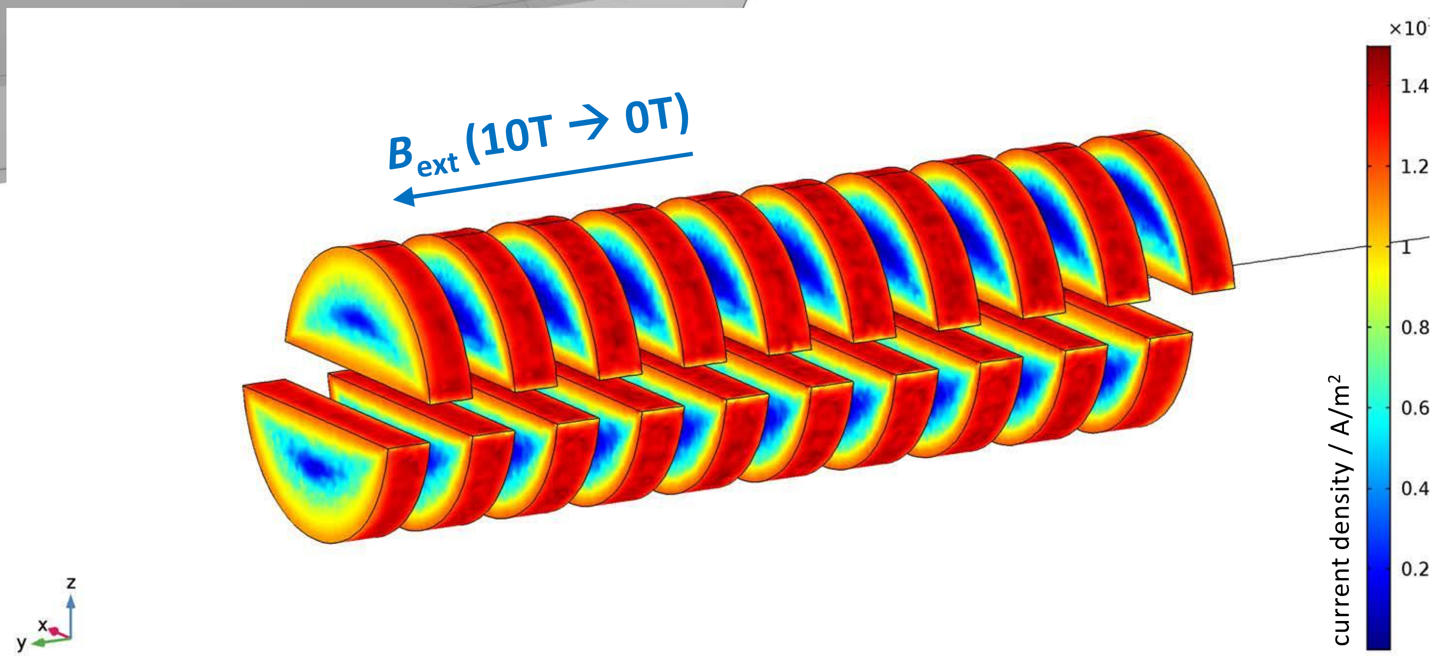


HTS 1st measurements

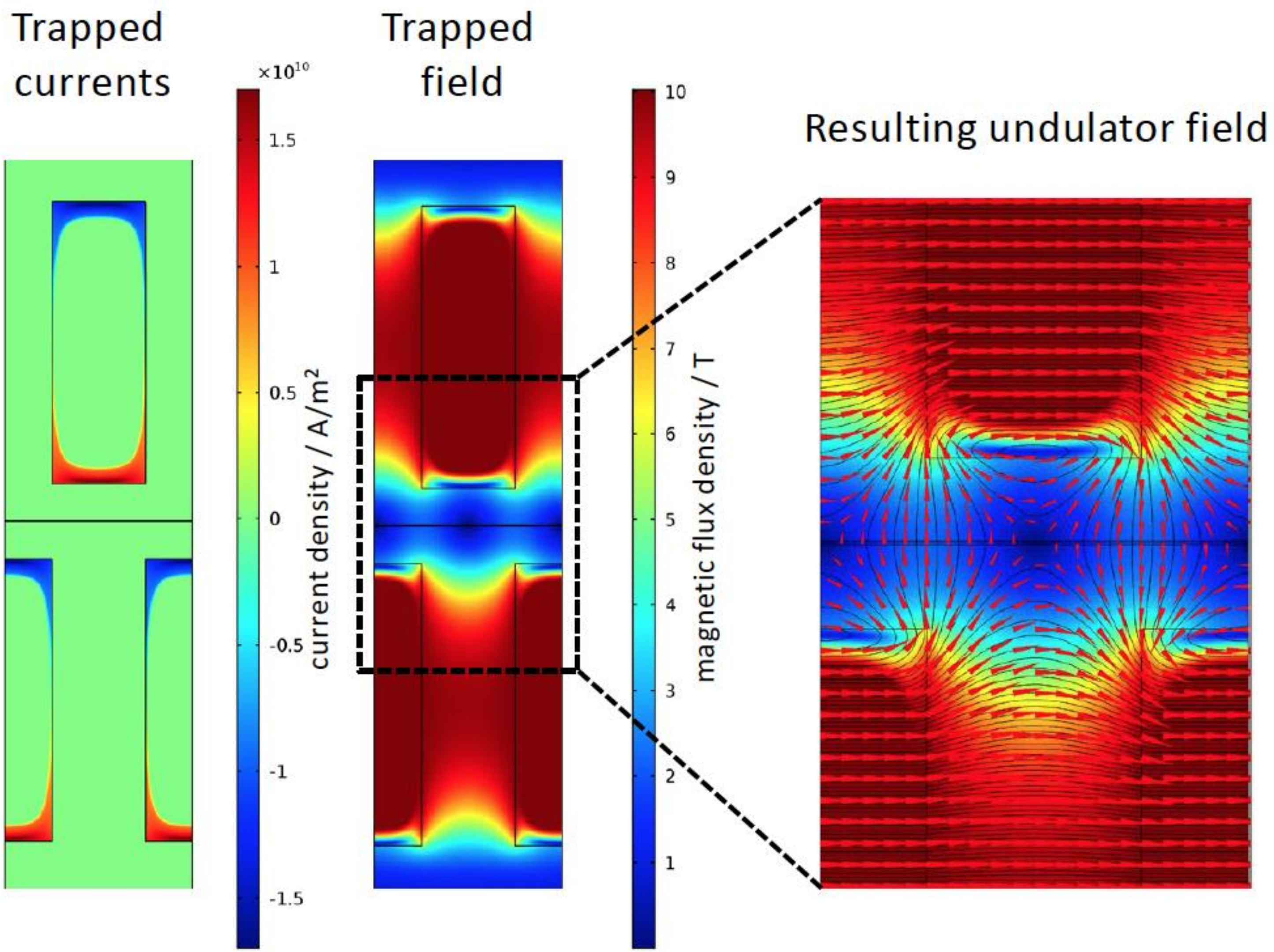
- Superconducting solenoid providing external field B_{ext} = +/- 10 T



- Surface current density after magnetization with field 10T → 0T:



HTS 1st measurements



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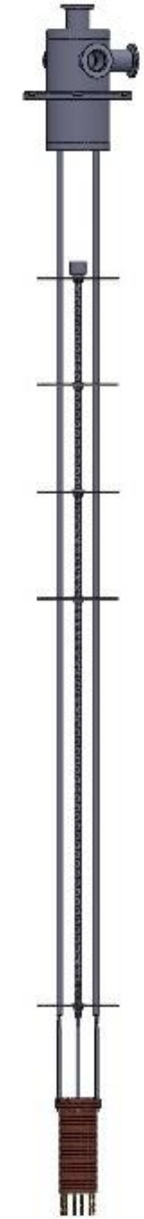
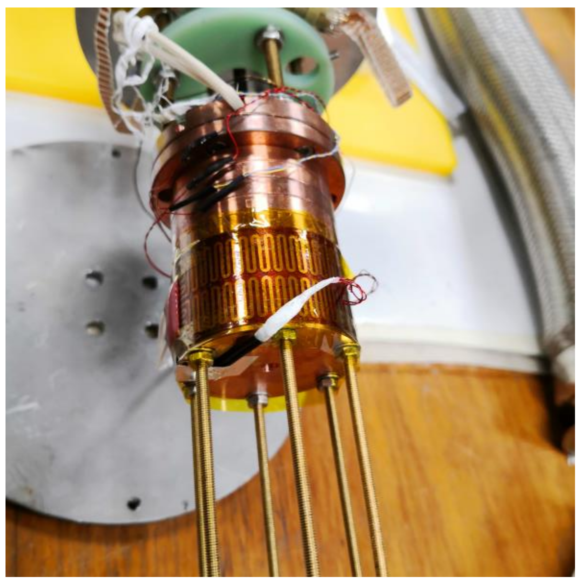
HTS 1st measurements

HTS staggered pair undulator
crystal growth and first tests at Cambridge University (John Durell)

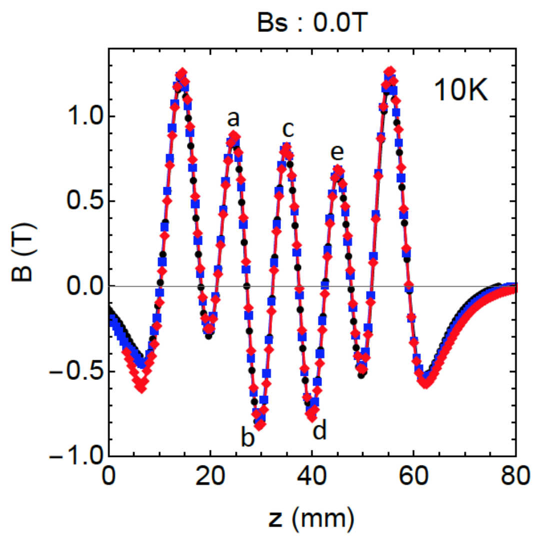


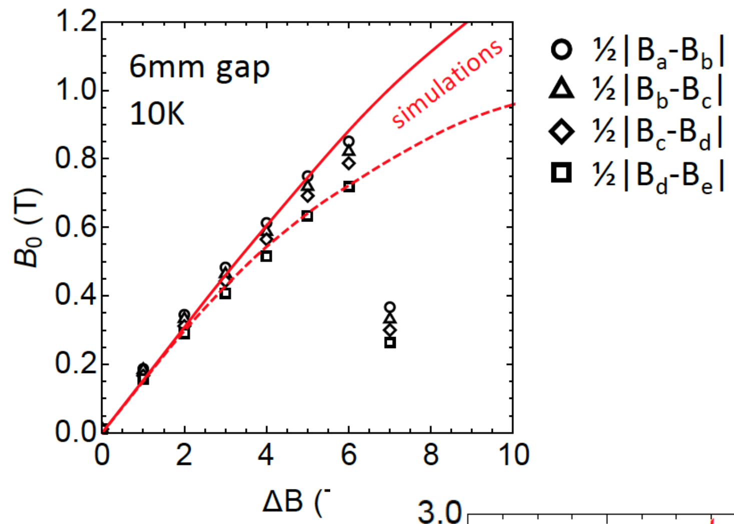
GdBCO
crystal



HTS 1st measurements

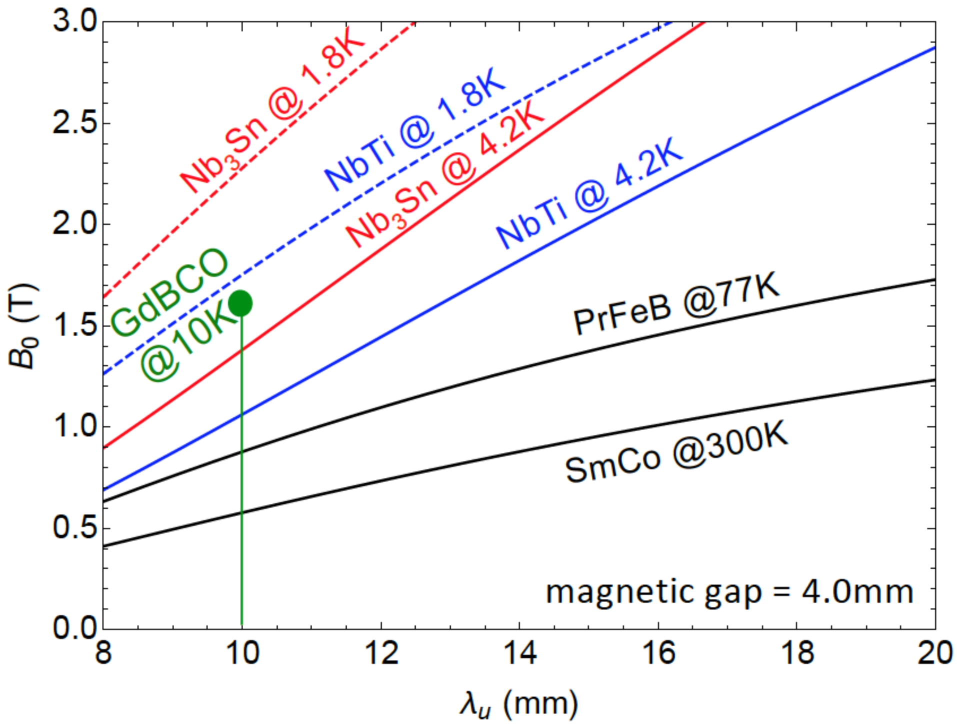
Courtesy Marco Calvi





next steps:

- 10 periods
- 4mm gap
- blocks stacked from tapes



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Thank you!

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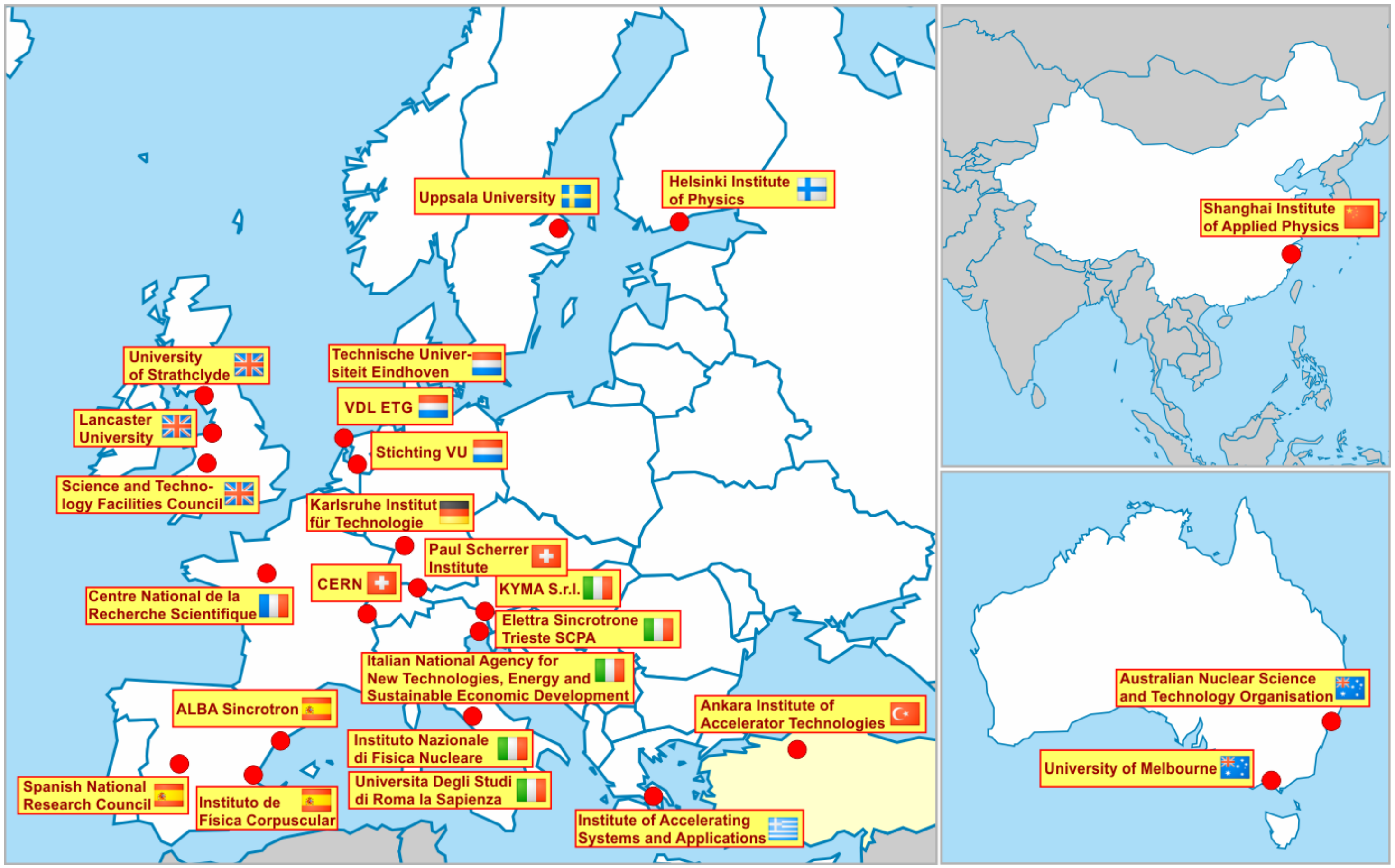

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