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Marco Calvi :: ID group :: Paul Scherrer Institute

Porthos: ideas for the undulators

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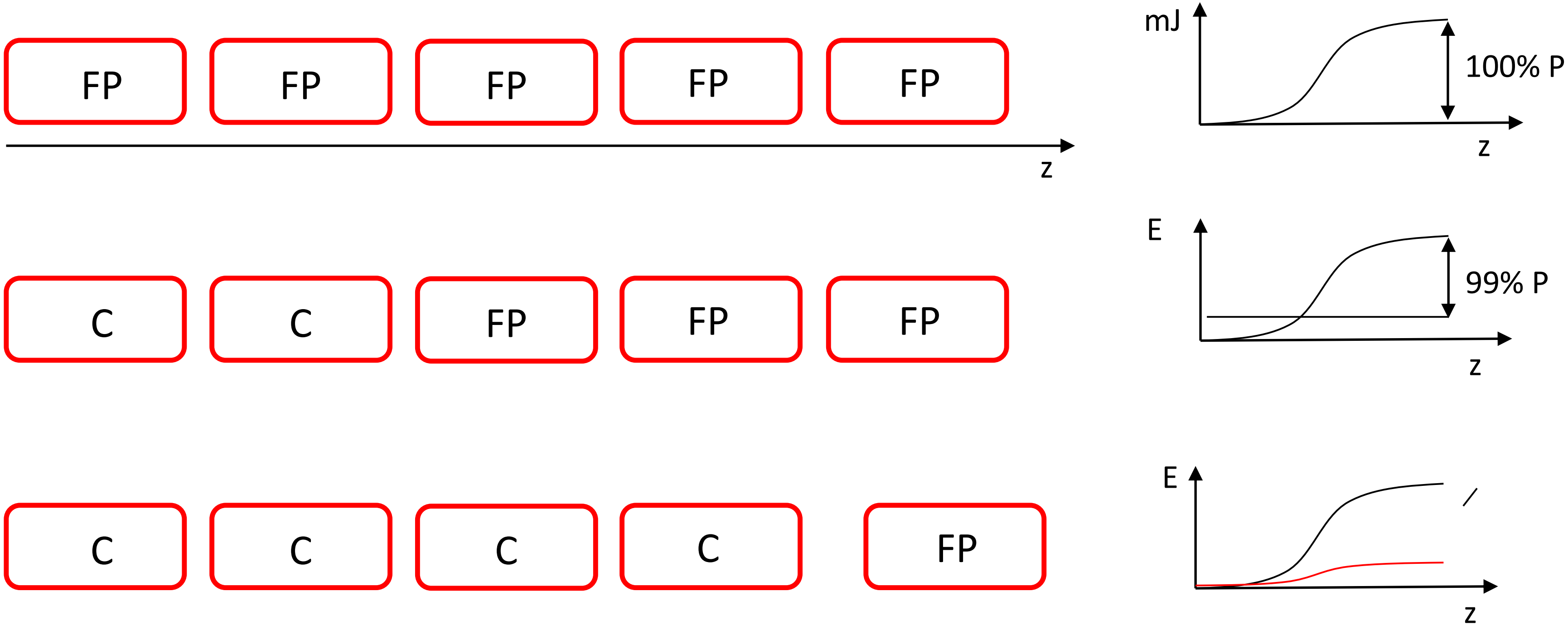
Discusions with:

T.Schmidt, K.Zhang, E.Gluskin, I.Kesgin, S.Casalbuoni, J.Bahrdt, E.Rial, B.Shepherd, C.Calzolaio, C.Boffo, C.Geiselhart, M.Valleau

Beamline

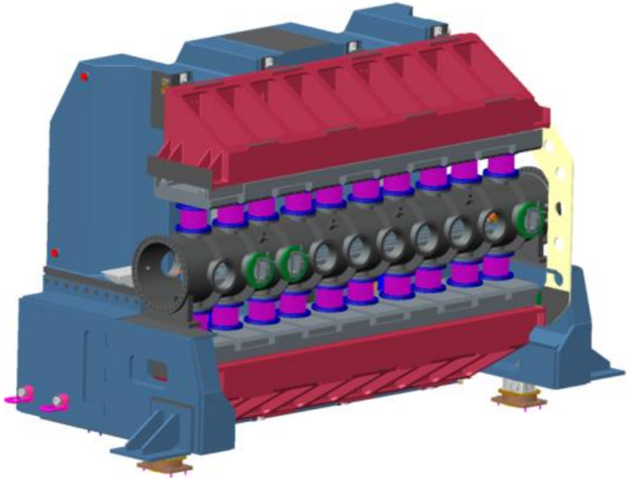


FP: Full Polarisation control

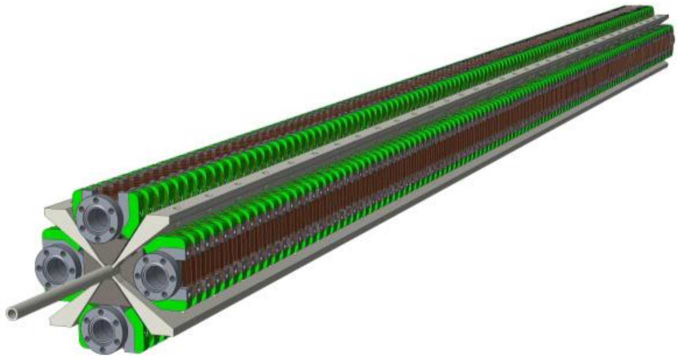
C: Circular Polarisation

Is cryo-APPLE-X really the undulator we want for Porthos

- **Cryo Apple X**
  - Full polarisation control, linear-α and elliptical
  - Cryogenics: LN2 (77K)
  - Controls: gap and shift drive system
  - Synergies with SOLEIL & HZB (LEAPS-INNOV)

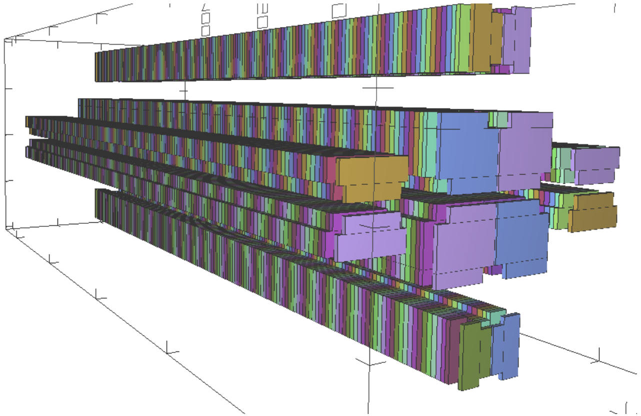


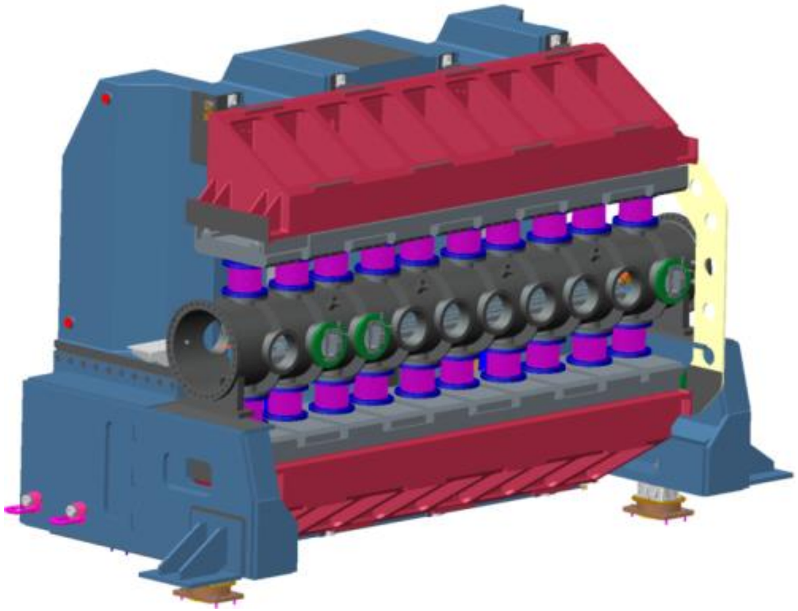
- **SCAPE**
  - Polarisation control: LV, LH and elliptical
  - Cryogenics: LHe (4.2K)
  - Controls: power supply
  - Synergies with Argonne & EuXFEL



What is the state-of-the art worldwide for this technology?

- **Cryo Apple X**… nobody is working on this very specific configuration at the moment
- On going efforts on a very similar version - **Apple II/III**
  - –Asymmetry between LH & LV: LH > C > LV

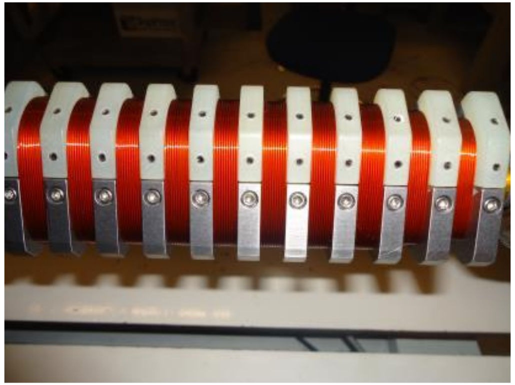


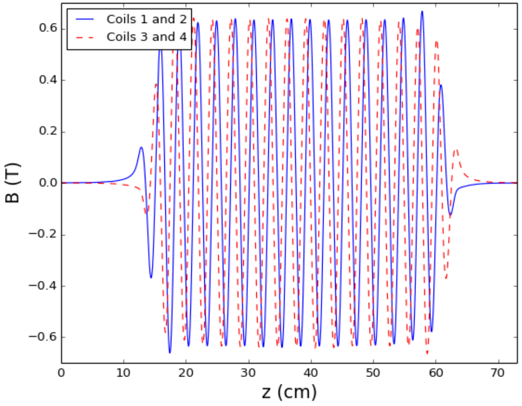


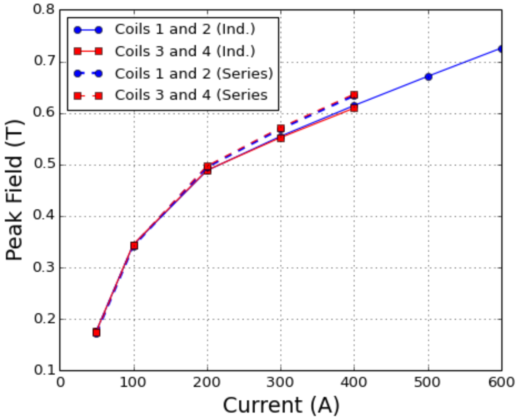
What is the state-of-the art worldwide for this technology?

SCAPE 0.5m long prototype magnet was built and tested in LHe at Argonne:

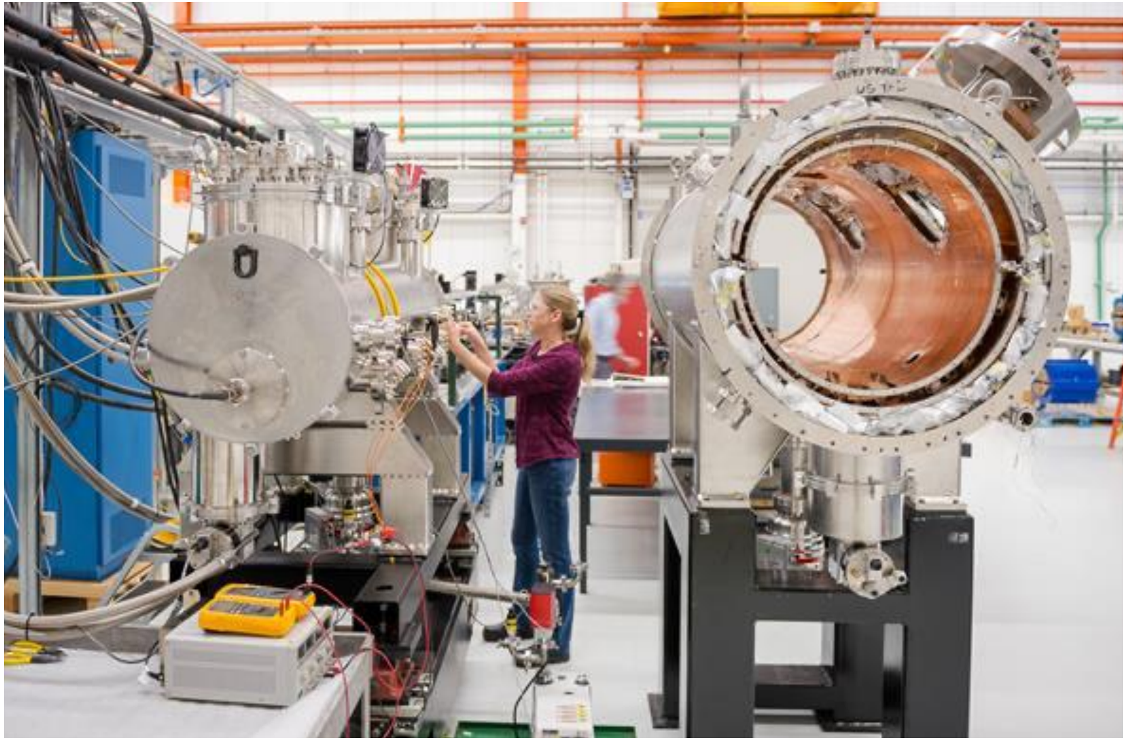
- Period length 30mm
- Magnetic gap 10mm
- On-axis field 0.7T





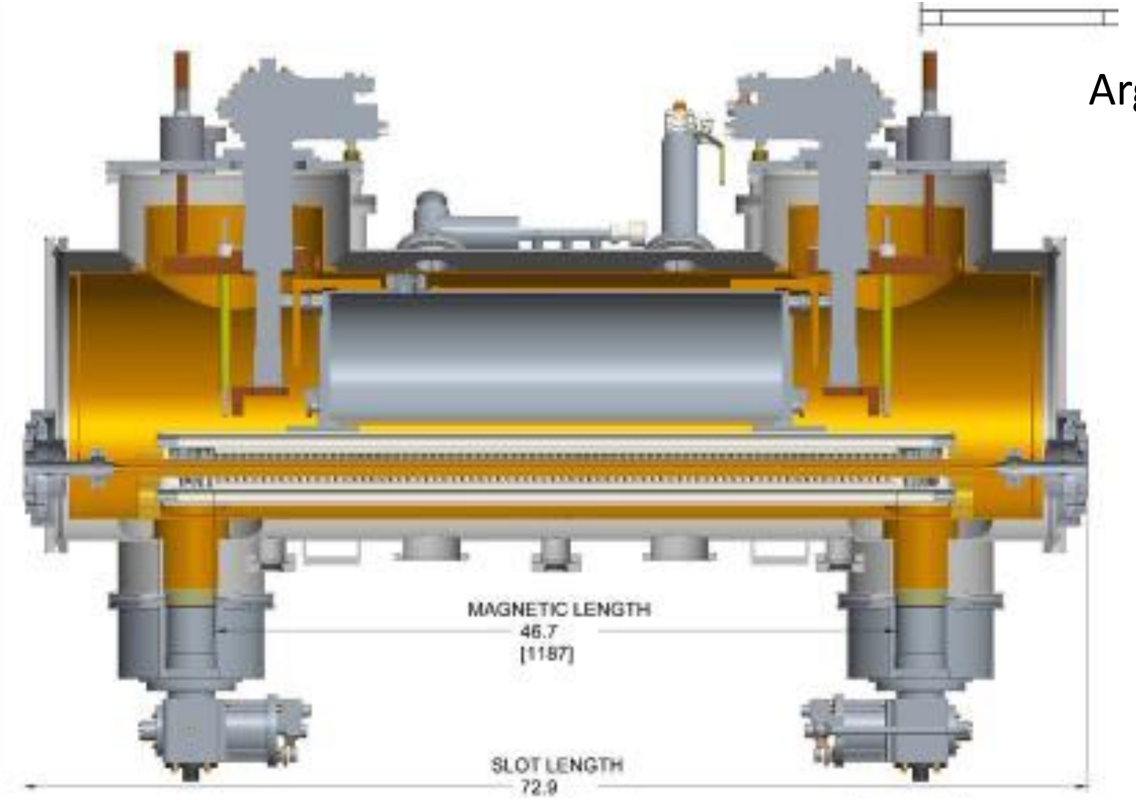


Cryostat with LHe using thermosyphon effect



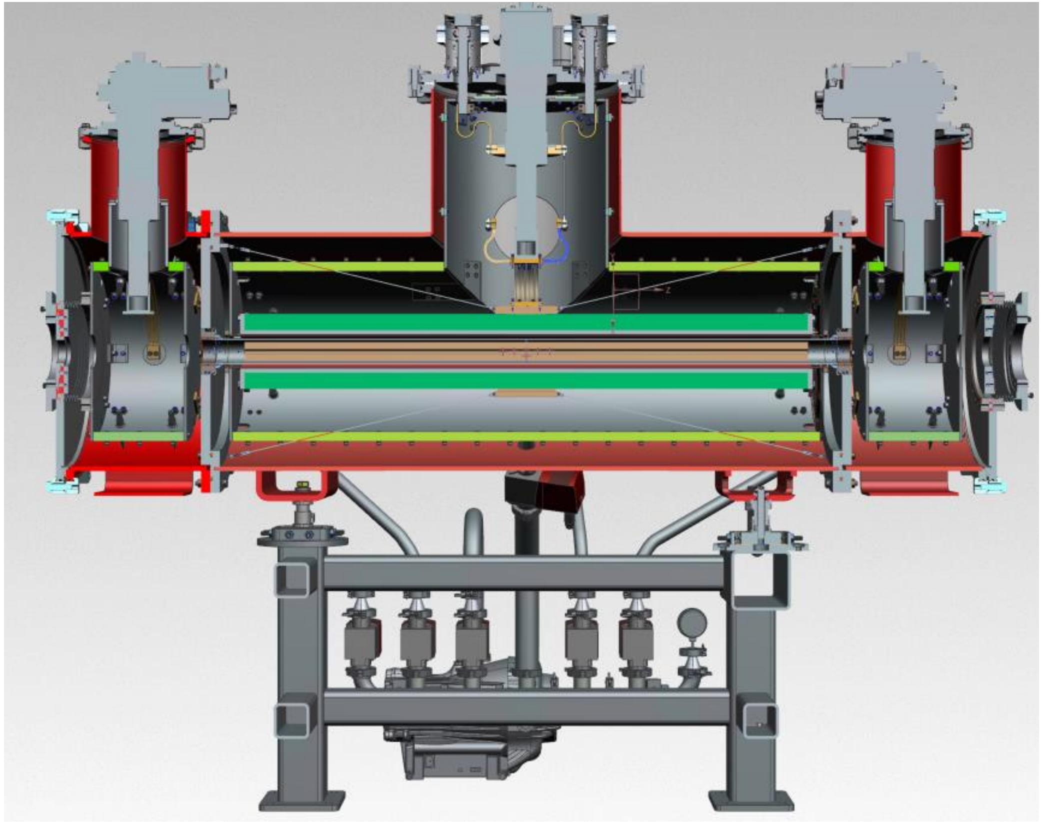
Argonne

Cryostat with LHe using thermosyphon effect



Argonne

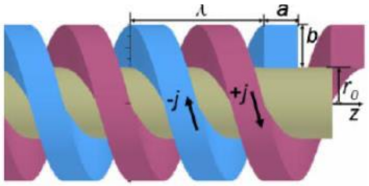
Conduction cooling cryostat

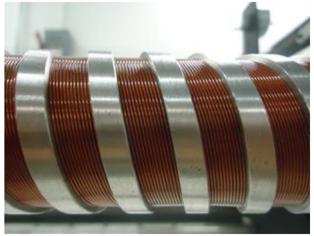


Fermilab/PSI

Sc Helical undulator

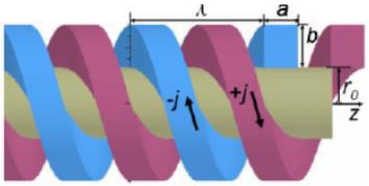
Argonne

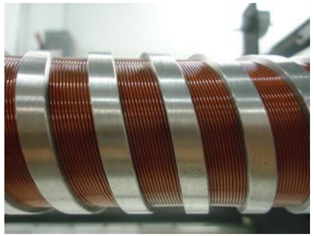


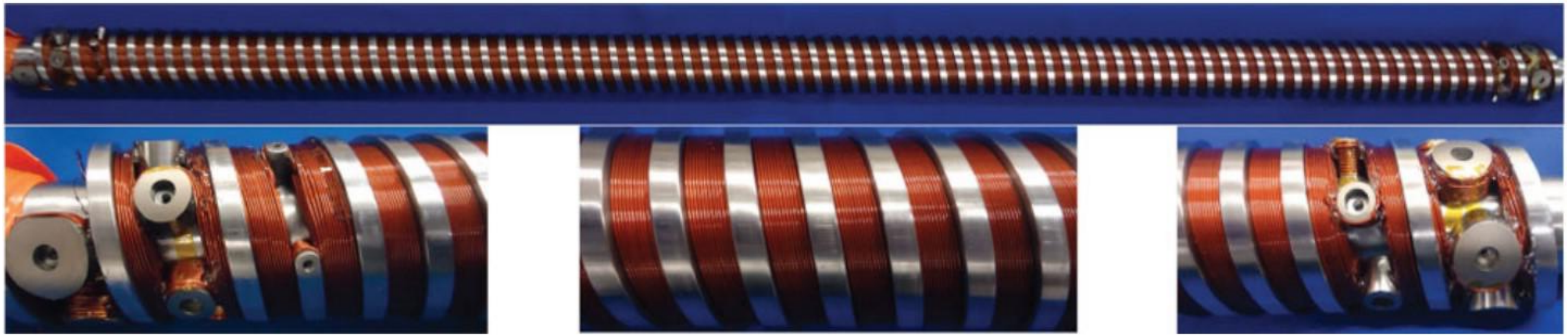


Sc Helical undulator

Argonne







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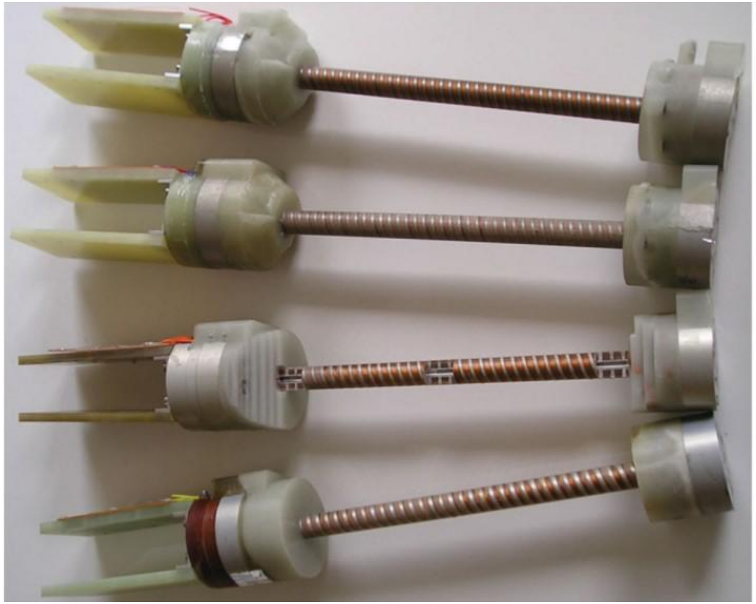
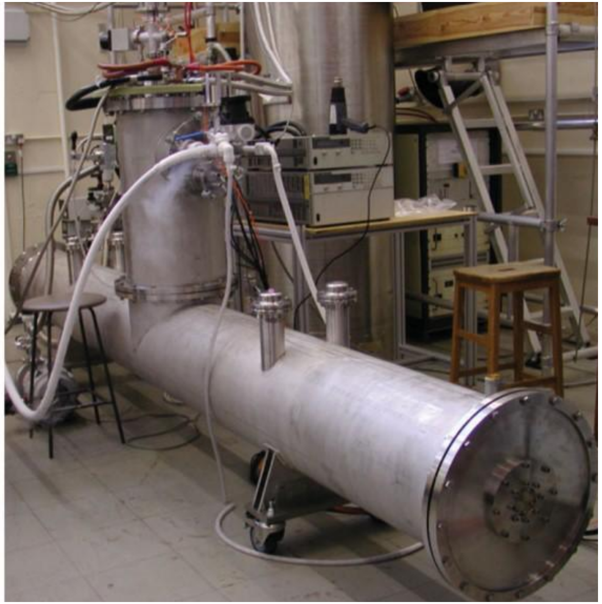
Sc Helical undulator

Daresbury lab
Rutherford lab
Argonne

future TeV-scale positron-electron linear collider (ILC) positron sources





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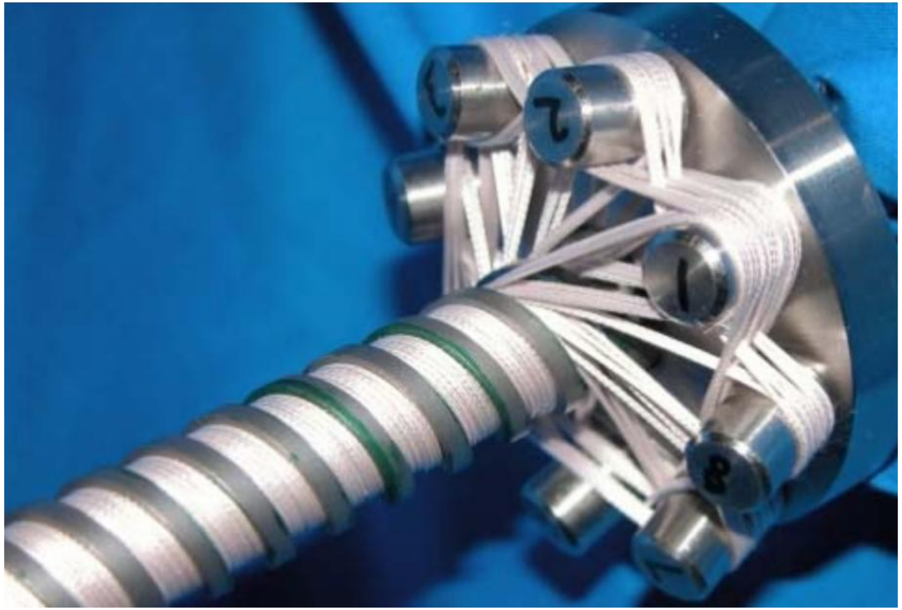
Sc Helical undulator

End design



UK

USA

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In the table here on the right a summary of the last 40 years effort in superconducting IDs worldwide,

You can find it on indico within the review paper we recently prepared under the request of the SUST journal

commissioned

SCU type	Conductor	Year	Laboratory	No. of periods	Period length (mm)	Magnetic bore/gap (mm)	vacuum bore/gap (mm)	Peak on-axis field (T)	Type
Helical	NbTi wire	1973	Stanford U. [9]	160	32.3	9.8	8	V(H)=1.30	Device
		1974	Stanford U. [9]	160	32.3	12.5	10.2	-	Device
		1992	BINP [14]	8	24	20	18	V(H)=0.47	Device
		2002	Cornell U. [15]	64	2.4	1.5	0.9	V(H)=0.34	Prototype
		2005	Kurchatov Inst. [11]	6	28	11	-	V(H)=1.06	model
		2005-07	STFC [18]	20	14	6	-	V(H)=0.9	model
		2005-07	STFC [18]	25	12	6	-	V(H)=0.53	model
		2005-07	STFC [18]	25	12	6	-	V(H)=0.96	model
		2005-07	STFC [18]	42	11.5	6.35	-	V(H)=0.82	model
		2008	STFC [18]	150	11.5	6.35	5.23	V(H)=1.13	prototype
		2018	ANL [18]	38.5	31.5	31	8	V(H)=0.41	Device
	Nb_3Sn wire	2007	ANL [18]	17	14	7.94	-	V(H)=0.9	model
		2012	Ohio State U. [23]	17	14	8	-	V(H)=0.8	model
	MgB_2 wire	2009	Ohio State U. [24]	17	14	8	-	V(H)=0.25	model
Planar	NbTi wire	1980	PARIS XI [27]	23	40	22	12	V=0.45	Device
		1990	BNL [50]	3	8.8	4.4	-	V=0.5	model
		1996	BNL [51]	23	8.8	4.4	3.8	V=0.51	prototype
		1998	KIT [29]	100	3.8	1	1	V=0.56	Device
		2003	KIT/ACCEL [32]	10	14	5	-	V=1.33	model
		2006	KIT/ACCEL [33]	100	14	8	7.4	V=0.38	Device
		2008	NSRRC [60]	20	15	5.6	-	V=1.45	model
		2011	NSRRC [61]	65	15	5.6	-	V=1.36	model
		2013	ANL [53]	20.5	16	9.5	7.2	V=0.8	Device
		2015	KIT/Noell [39]	11.5	20	8	-	V=1.2	model
		2015	ANL [55]	59.5	18	9.5	7.2	V=0.98	Device
		2016	SINAP [62]	5	16	8	-	V=0.93	model
		2016	KIT/Noell [35]	100.5	15	8	7	V=0.73	Device
		2016	BINP [86]	15	15.6	8	-	V=1.2	model
		2018	BINP [87]	40	15.6	8	-	V=1.2	model
		2018	ANL [57]	70	21	8	-	V=1.67	model
		2019	KIT/Noell [41]	74.5	20	8	7	V=1.18	Device
		2019	KIT [42]	24 or 12	17 or 34	6	-	V=1.3 or 2.3	model
		2019	STFC [47]	19	15.5	7.4	5.4	V= > 0.8	Device
		2021	BINP [88]	119	15.6	8	-	V=1.2	model
		2021	SINAP [64]	50	16	10	7.5	V=0.62	Device
		2021	IHEP [65]	30	15	7	-	V=1.01	model
	Nb_3Sn wire	2018	LBNL [47]	73	19	8	-	V=1.83	model
		2021	ANL [76]	28.5	18	9.5	-	V=1.2	model
	ReBCO tape	2012	KIT/Noell [78]	--	--	--	--	--	model
		2014	LANL [79]	3	14	3.2	-	V=0.77	model
		2017	ANL [82]	5	16	9.5	-	V= > 0.2	model
	ReBCO bulk	2013	Kyoto U. [104]	5	10	4	-	V=0.85	model
		2019	PSI [109]	5	10	6	-	V=0.85	model
		2021	PSI [3]	10	10	4	-	V=1.54	model
Variable	NbTi wire	2010	NSRRC [120]	4.5	24	6.8	-	V(H)=0.61	model
		2019	ANL [126]	15	30	-	6	V(H)=0.6	model
		2020	BINP [121]	14	22	8	-	V=1.0, H=0.7	model

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Which crucial properties do we need to verify with the prototype?

- K as a function of the polarisation
- Phase error (warm-cold)
- Polarisation quality (no surprise expected)
- ....

Cost/feasibility of a prototype (location, cryogenics etc.)

- Costs:
  - Full scale prototype >2m, 3MCHF
  - Short prototype <0.5m, 1MCHF
- Feasibility:
  - **Cryo Apple X**: there is no design available, starting from Athos…!?!
  - Cryo Appple II/III: collaboration with HZB and/or SOLEIL (Rial/Valleau)
  - SCAPE: collaboration contract with Argonne or EuXFEL (Kesgin/Casalbuoni)
  - Sc Helical: collaboration with Daresbury/Rutherford Lab (Shepherd)
- Location/Cryogenics: new cryo laboratory at PSI (Magnet& ID group)

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R&D in the R&D

- SCAPE can be upscaled to Full polarisation control