WP5 – Overview & Activity Report

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On behalf of the WP5 Crew

First Midterm Review Meeting – Trieste, June 19th 2018

WP5 – Tasks declared in the Grant Agreement

Task 5.1 - Review the technology trends for undulators R&D worldwide, and compare the potential for innovation and performance. In particular: superconducting undulators enabling field amplitude adjustment along the undulator, enhanced-bandwidth FEL radiation or super-radiant light sources at short wavelengths.

Task 5.2 - Select a few outstanding options to be considered for CompactLight.

Task 5.3 - For the options selected in T5.2, perform a systematic optimization of the electron beam parameters at the linac-to-undulator interface to maximise the photon production, in close contact with WP2 and WP6.

Task 5.4 - Report the conceptual design of the selected options as resulting from T5.3.

WP5 – Deliverables

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D5.1	Technologies for the CompactLight undulator	16 - ENEA	Report	Public	18
D5.2	Conceptual Design Report of the undulator	16 - ENEA	Report	Public	36

- The 1st WP5 deliverable is the undulator technology survey (see also EuPRAXIA), ~ 1 year from now, for several reasons (getting to know each other & team building) we decided to meet and exchange information soon and often

- We believe that an added value to both deliverables is the possibility to indicate which undulators could better match sophisticated FEL schemes, provided that these could be realized with the CompactLight *e*-beams

WP5 – Tasks definition: guidelines

- Each undulator technology (superconducting, permanent magnet, exotic configurations such as microwave or plasma undulators) should pursue an ideal R&D to maximize its performance. We need to assess quantitatively the limits of each technology in terms of field/period/gap ➔ 3 tasks associated to the different technologies

- Relevant practical considerations on diagnostic tools of magnetic performance measurements and on cost effectiveness (how far are the most performant and the cheapest?) ➔ 1 task dedicated to these arguments

$$\text{FEL schemes for users (WP2)} \rightarrow \text{WP5} \rightleftharpoons \text{Beam Dynamics S2E (WP6)}$$

- 1 task interfacing WP5 with WP2: potential FEL users' needs should drive undulator characteristics + 1 task interfacing WP5 with WP6: for a desired FEL radiation, the undulator performance constrains the *e*-beam phase space, and conversely the set of *e*-beam schemes allows a certain FEL performance

WP5 – Institution breakdown in tasks

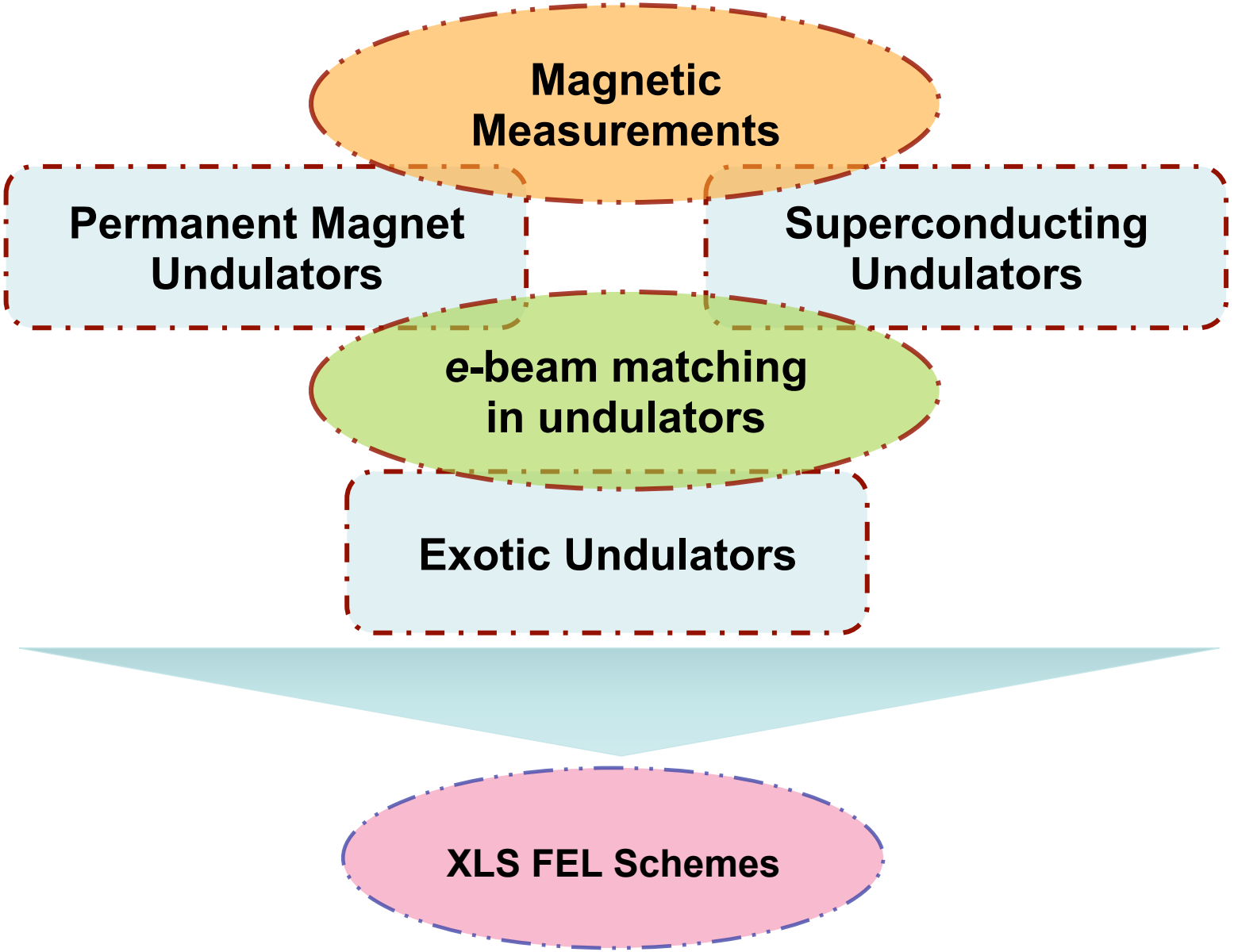
XLS WP5 data

Participant	Normal conducting Undulators	Superconducting Undulators	Beam dynamics (optics & matching in undulators)	Magnetic measurements facilities	Exotic undulators (microwave, laser, plasma)	FEL properties & schemes (coherence, harmonics)
KYMA	R. Geometrante					
CERN						
Strath						
STFC						H. M. C. Cortes
KIT		A. Bernhard				
PSI				T. Schmidt		
ANSTO					D. Zhu	
AU-IAT			Z. Nergiz			
ALBA						
ENEA						

Some warnings on the Exotic Undulators task

- μ-wave undulators now not as mature as PMUs or SCUs, but given the strong RF interests and expertise within this project ➔ it's worth the challenge!
- If there is strong interest, plasma and laser wave undulators could be addressed

WP5 – Task interactions



WP5 Tasks and parameters

To be driven by FEL users (WP2)

Table 1.1: Preliminary Parameters of CompactLight hard X-ray FEL facility.

Parameter	Value	Unit
Minimum Wavelength	0.1	nm
Photons per pulse	$>10^{12}$	
Pulse bandwidth	<<0.1	%
Repetition rate	100 to 1000	Hz
Pulse duration	<1 to 50	fs
Undulator Period	10	mm
K value	1.13	
Electron Energy	4.6	GeV
Bunch Charge	<250	pC
Normalised Emittance	<0.5	μrad

WP5 core business

To be negotiated with the other WP's

Undulator technologies to be addressed
- helical & planar Nb-Ti superconducting
- planar High Temp. superconducting tape
- bulk High Temp. superconducting enhanced permanent magnet

Also exotic undulator configurations such as
- beam driven RF standing wave undulators

Different undulator solutions are subject to the following investigations:

① shortest possible wavelength for a given beam energy?

② highest possible FEL performance (shortest gain length, highest saturation power) for a given target wavelength?

③ highest possible undulator performance (shortest longitudinal space per undulator module, shortest undulator gap width) for a given focusing scheme?

④ Most efficient lattice (FODO, average beta) matching scheme for a given set of undulator period and K?

WP5 – Workflow

Phase 1

Each undulator solution, provides quantitative answers to the previous figures of merit

Phase 2

Phase 1 results, also presented in D5.1, are compared against input/output from other WPs

Phase 3

Optimised final layout → advanced FEL schemes made possible by the XLS choice of beam & undulator parameters, weighted by Cost + Risk models

WP5 – Meetings held so far

XLS - WP5 - Undulators and light production

May 2018

30 May 5th WP5 Meeting

April 2018

18 Apr 4th WP5 Meeting

March 2018

14 Mar 3rd WP5 Meeting

February 2018

14 Feb 2nd WP5 Meeting - Workflow Discussion

December 2017

18 Dec 1st WP5 Organizational Meeting

If you are interested or wish to contribute, please join!

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WP5 – Outlook

- In good shape towards the 1st deliverable document: we are going to hear each undulator technology deploying its potential
- Joint WP5+WP2 meetings to discuss and identify potential XLS light users ➔ FEL schemes ➔ undulator solutions
- Also joint WP5+WP6 meetings should be put in view, to understand soon which e-beam parameters to drive the XLS FEL

11:50	WP5 reports	F. Nguyen	ENEA	10'	WP5 overview and activity report
		A. Bernhard	KIT	10'	Superconducting undulators
		R. Geometrante	Kyma	10'	Permanent magnet undulators
		A. Cross	USTR	10'	Exotic undulators
12:30	Lunch Break				
14:00	WP5 reports	T. Schmidt	PSI	10'	Magnetic set-ups & cost effectiveness
14:10	External Contribution	J. Rosenzweig	UCLA	20'	Compact X-ray FEL Based on Micro-Undulators and High Field RF Acceleration