Compact

# WP5 Summary & Plans

*Glasgow "Virtual" Meeting – June 18th 2020*

*F. Nguyen, A. Bernhard, T. Schmidt on behalf of the WP5*

ENEA
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

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# Quarantine WP5 activities



## April 2020

08 Apr 15th WP5 Meeting

→ Undulator(s) main parameters

## March 2020

26 Mar Afterburner based on PMs Meeting

17 Mar IV-CPMU Discussion

10 Mar 14th WP5 Meeting

There are 13 events in the past. Show

Fixed (e.g. SCU with circular) polarization

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

# 1st meeting with 3D CAD modelers

## Meeting on the 3D CAD model of the XLS undulator section

Tuesday 9 Jun 2020, 15:00 → 17:00 Europe/Zurich

**Videoconference Rooms** XLS-WP5_video_room Join

**Federico Nguyen** federico.nguyen@enea.it

**15:00** → 16:00 **Input requests from CAD modelers** 1h

**Speakers:** Dr Nick Gazis (European Spallation Source - ESS ERIC), Emmanouil Trachanas (European Spallation Source), Eugene Tanke (National Technical Univ. of Athens (GR)), Andrea Bignami (European Spallation Source)

IASA-ESS_3D-XLS_... IASA-ESS_3D-XLS_...

**16:00** → 17:00 **Discussion** 1h

**Interaction with the 3D CAD modelers just started: many thanks for their availability!**
**It will be considered in the next WP5 activities!**

**The whole CAD crew is going to be added to the WP5 e-group mailing-list, if they agree!**

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# Useful considerations from N. Thompson

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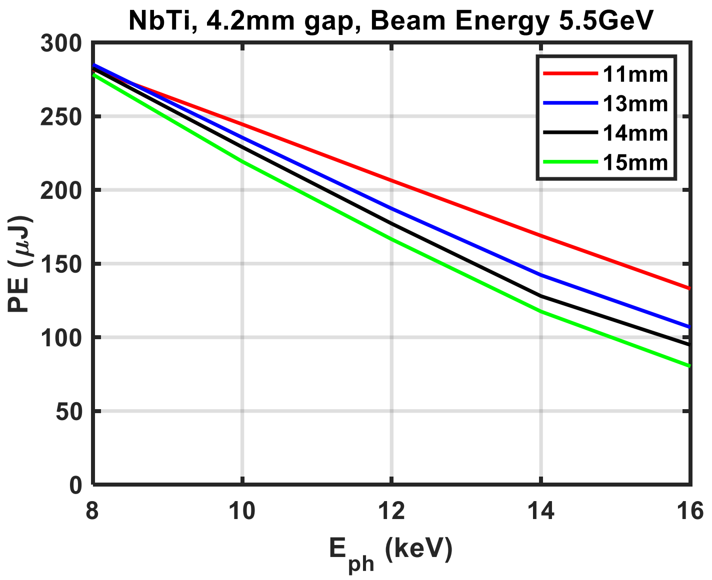
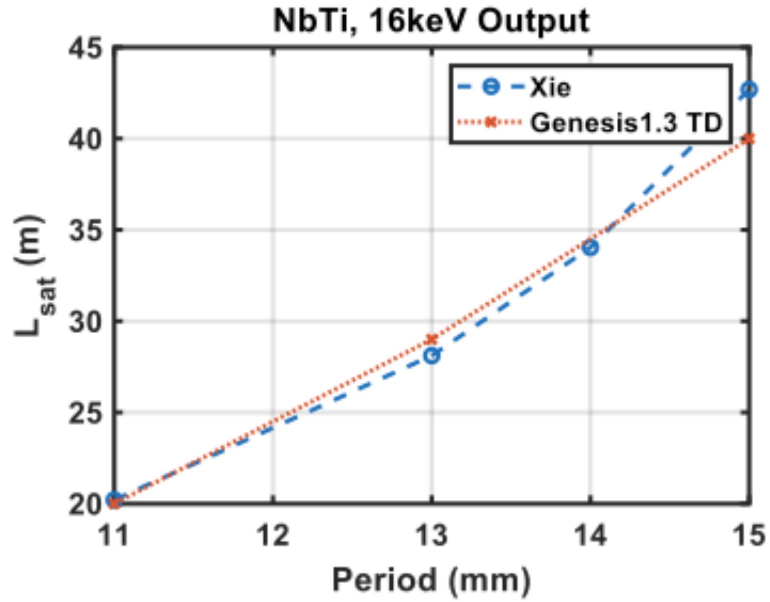
## Courtesy of N. Thompson (please, check his Yesterday's talk!)




### In Neil's words

- ***In my opinion***, 13mm looks the best choice, assuming
  - *4.2mm gap*
  - *Field obtained is a match to the parameterisation*
  - *NbTi SCU*
- 15mm gives too long saturation length at 16keV and only better performance in SXR from 0.25 – 0.8keV
- 11mm gives marginally better performance 8 – 16keV
- But 13mm gives nearly double the pulse energy in the SXR compared to 11mm with only a small compromise in pulse energy and saturation length

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# Afterburner considerations



## In Neil's words

- If we take 13mm as undulator period, we have to choose the afterburner parameters to cover the same tuning range, i.e. 650eV to 2keV @ 2.36GeV

- Assume APPLE-X, with parameters from D5.1

**Courtesy of N. Thompson**

| Min Gap | 3 mm | 4mm |
|---|---|---|
| Period | 18mm | 19mm |
| $a_w$ @ 650 eV | 1.96 | 1.75 |
| $a_w$ @ 2 keV | 0.68 | 0.62 |

**Period 19 mm is the best match between SASE and Apple-X lines, in the SX.
Best performance is not guaranteed on both SX & HX with the same configuration.
H. M. C. Cortes is studying the FEL performance reaching 150-200 μJ/pulse, in the SX**

**After Athens, it came up that SX only will need the afterburner, HX polarisation realised by optically manipulating the output beam: I believe this has to be thoroughly discussed and validated within a dedicated joint WP2-WP5 meeting!**

# XLS-CompactLight Afterburner



## From T. Schmidt

Afterburner concept: (cryogenic) in-vac APPLE X

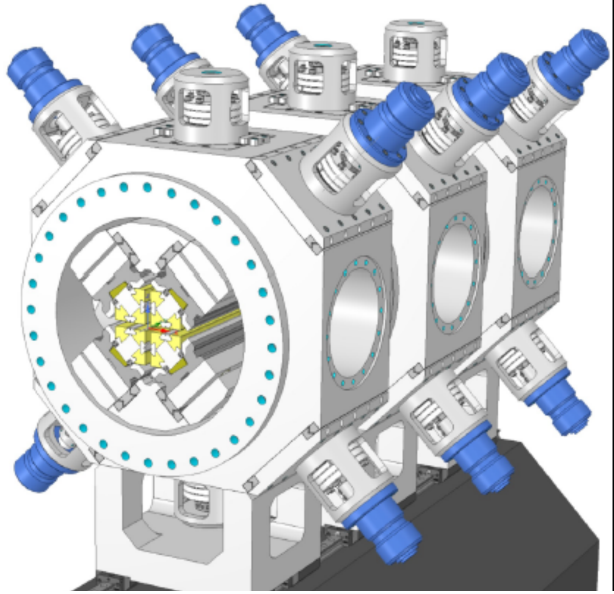
$B_r$ = 1.37T @ RT, 1.7T @ 77K
round gap with 5mm diameter
period length 16 – 18 (19) mm

State of the art: 1 in-vac APPLE (BESSY II)
APPLE in FELs: FERMI and PSI (with 0.2mm wall thickness)

All new **compact** design concept:

- modular machined vacuum chamber on a girder
- no external support structure
- distributed drive unit at any link rod
- new hydraulic drives combine strength with sub-µm precision
- 8 magnets / period for higher K @ RT

compact would also mean cost effective:
dimensions comparable with scu FEL undulator
reduced infrastructure in cranes, floor preparation for air cushions



# Afterburner (Apple X)

Courtesy of T. Milharcic

- Out of vacuum / in-vacuum
- Room temperature / cryo-cooled
- Individual magnets / magnet soldering
- Traditional mag. structure / magnetic compensation
- Traditional VC / segmented VC as support structure

Opt 1

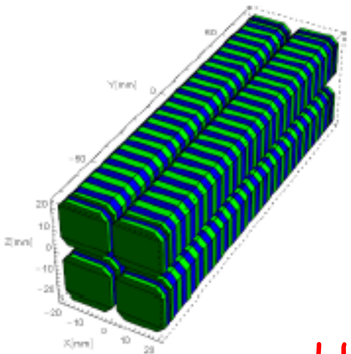
Opt 2

- Easier installation and alignment.
- Lighter structure, more compact solution.

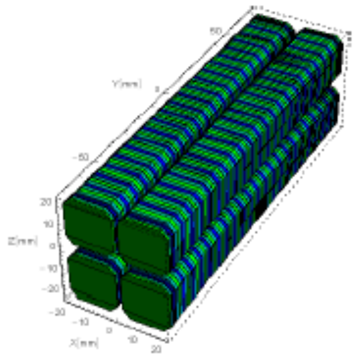
Courtesy of M. Kokole

- RADIA model including errors for Br and magnetization angles
- Two models
  - (1) Standard EPU with 4 magnets per period
  - (2) EPU with 8 magnets per period
  - Flat and Normal distribution of errors for Br and magnetization angles
  - 500 random assemblies are calculated.

Standard EPU magnetic assembly with 4 magnets per period



Proposed EPU with 8 magnets per period



Have to check against parameters hinted by Neil

# Next steps in the Afterburner



**From T. Schmidt**

Next steps:

define total length (number of modules) with 2m to 4(5)m length each
use of APPLE X transverse gradients could allow special operation modes

CDR -> TDR for risk analysis and better cost estimations

FEM analysis of mode dependent deformations
gap measurement with distributed drive system
interface to electron beam, foils or slotted pipe
flexible taper
integration of cooling incl. shielding
integrated measurement system

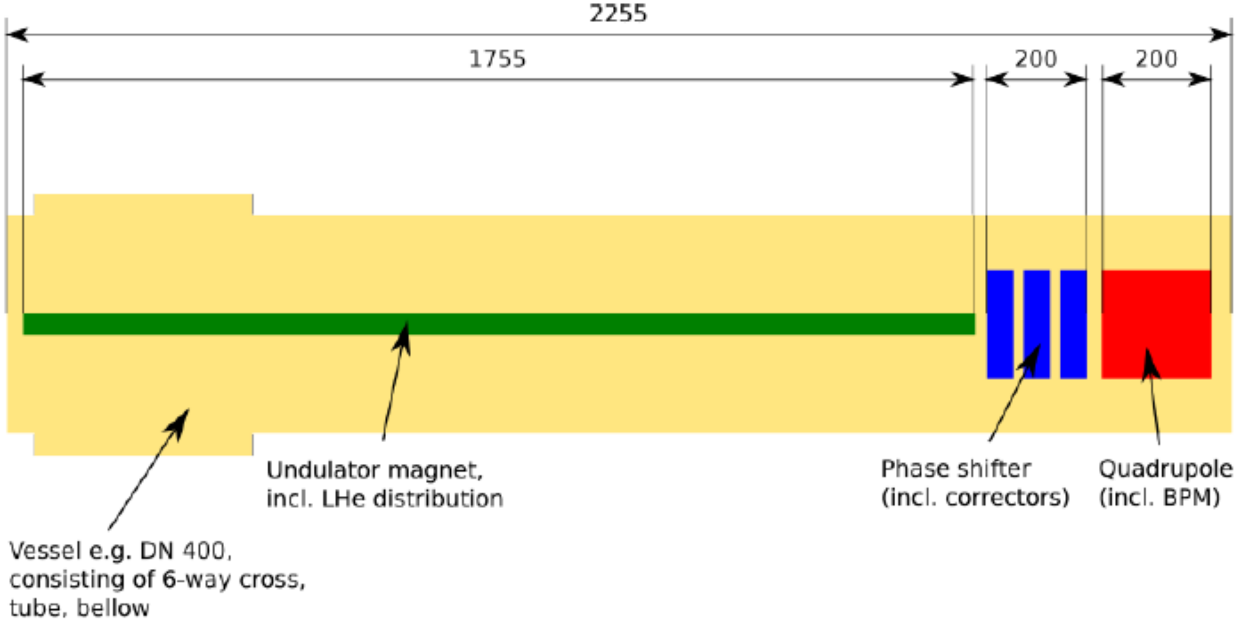
Synergies:

modular compact design as option for SLS 2.0 upgrade
cryogenic APPLE also topic in LEAPS

**Both room temperature and cryogenic structures will be written in the XLS CDR**

# Helical SCU Conceptual Design






**FEL 1&2 basic layout:**

- 16 Cryomodules
- Incorporating SCU, phase shifter, quad and diagnostics

**From A. Bernhard**

## Conceptual Design Status&Progress

- SCU: extended performance studies (Neil) confirm $\lambda_u$=13 mm, g = 4.2 mm
- Phase shifter: 2 conceptual design options elaborated and under discussion (SC and PM)
- To be done (soon): quadrupole, diagnostics & cryogenics conceptual design
- Conceptual design and cost analysis will benefit from new XLS partner Bilfinger Noell (see M. Gehring's talk)

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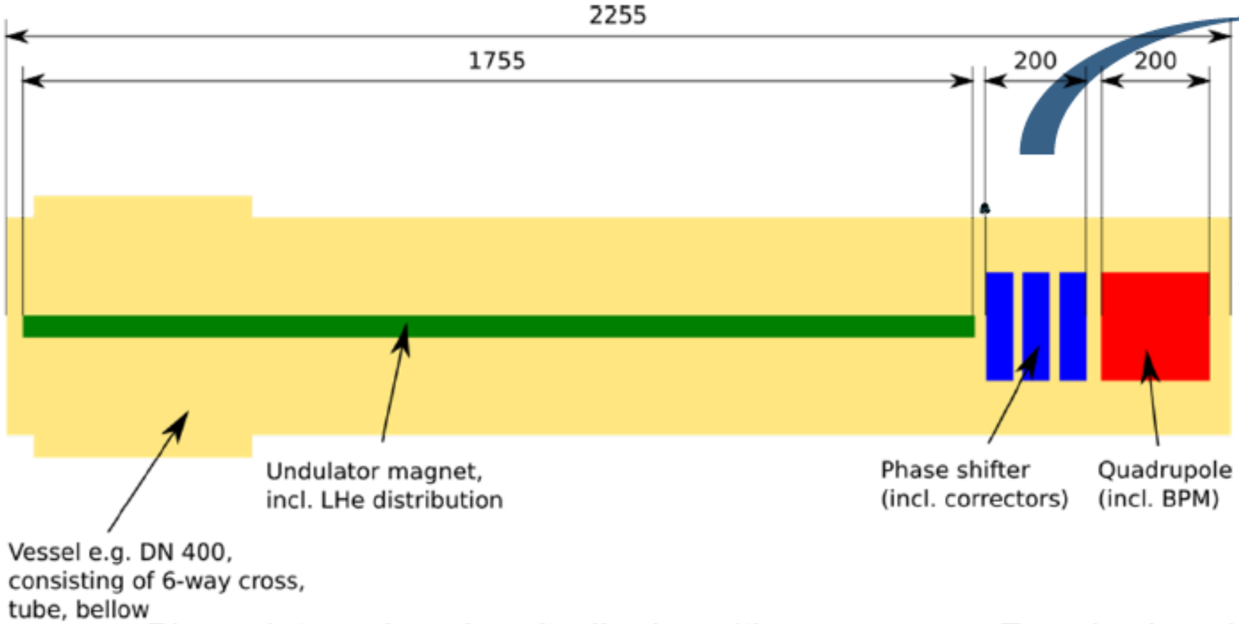
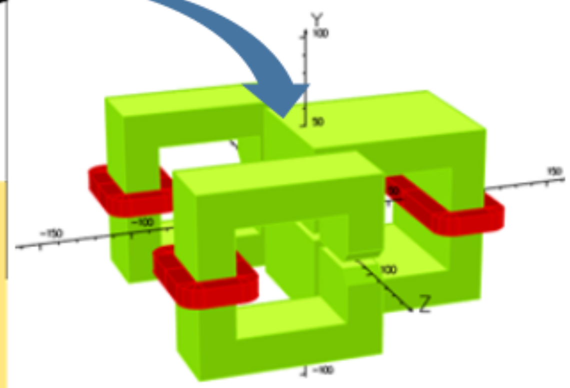
# Helical SCU Conceptual Design

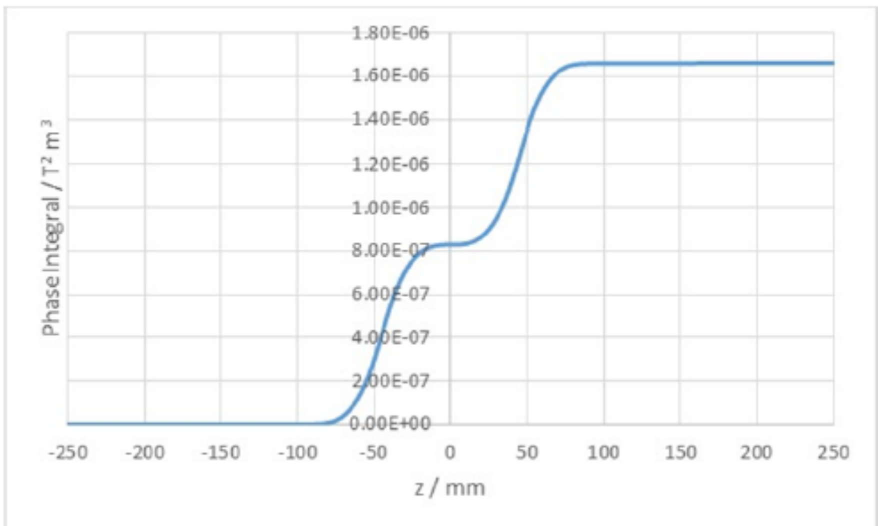




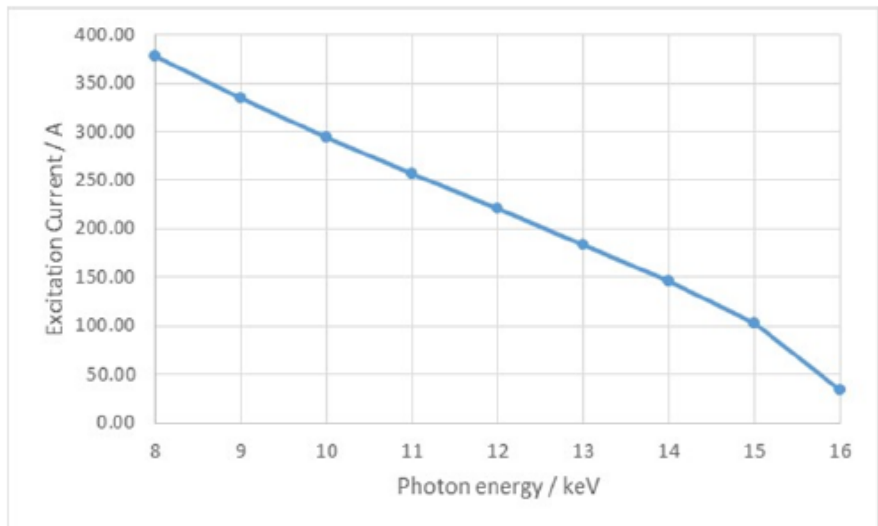



SC Phase Shifter Layout
Courtesy: **Alex Hinton, Ben Shepherd, STFC**

Phase integral vs. longitudinal position




Required excitation current vs. SCU tuning range



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# SCAPE as the Afterburner

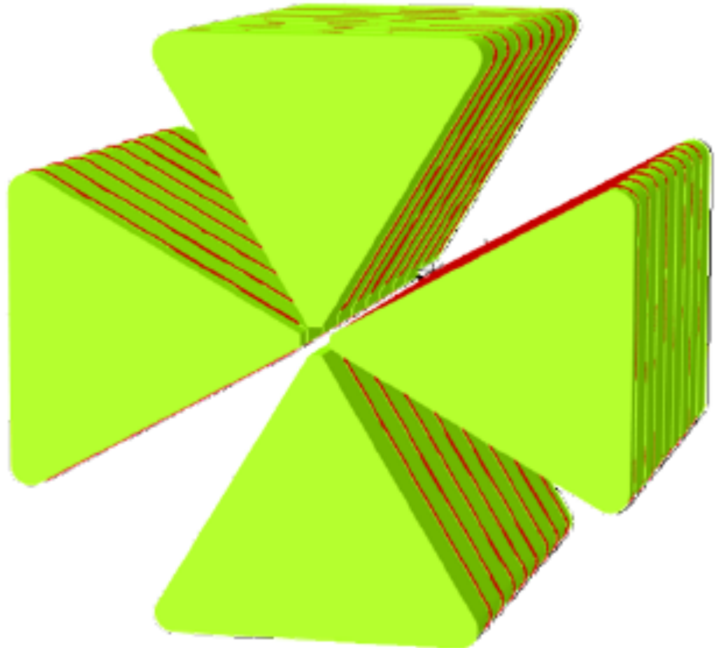


- **SuperConducting Arbitrarily Polarizing Emitter, SCAPE: two pairs of superconducting planar magnets**

Magnet modelling ongoing

- **It allows generating either planar or circular polarized photons**

- **Magnetic field and tuning depends on the coil currents and can be varied without any mechanical movement of the cores**



Courtesy: Julian Gethmann, KIT

**SCAPE will be considered as the Upgrade configuration for the CompactLight Undulator in the CDR, with the related cost/benefit/risk & TRL considerations**

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# Thank you!

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