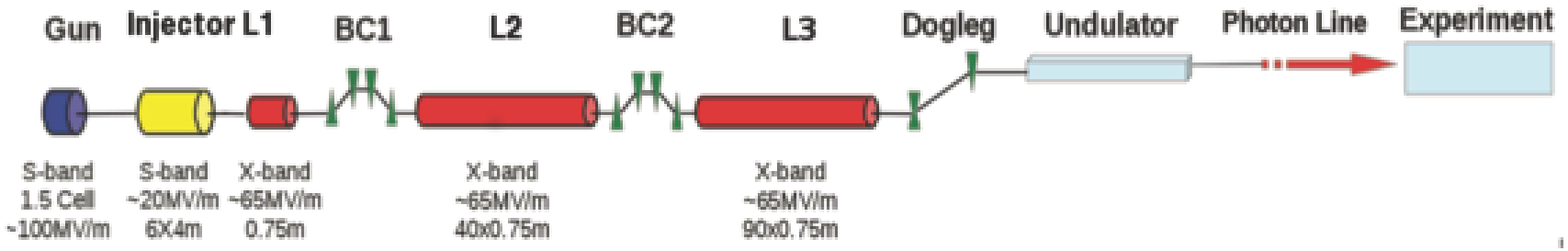
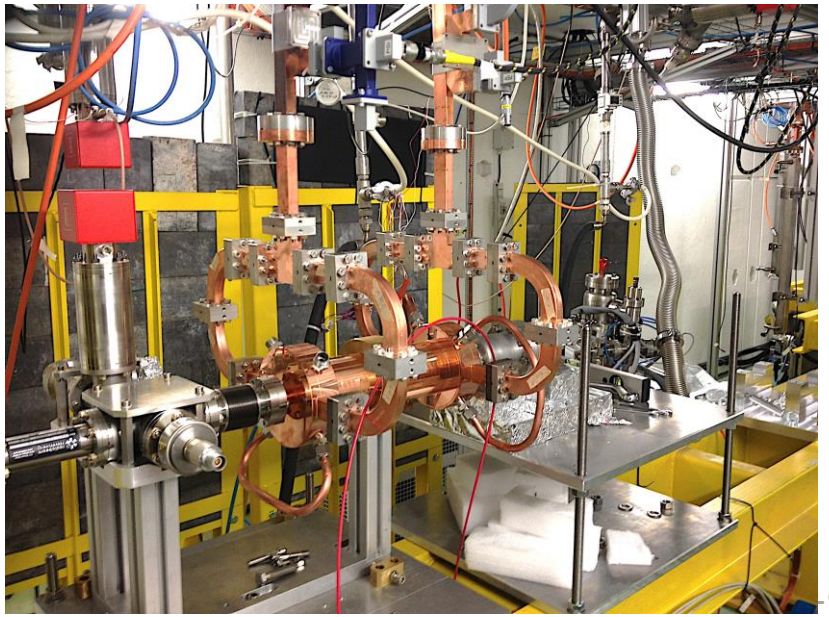
WP4 – rf system

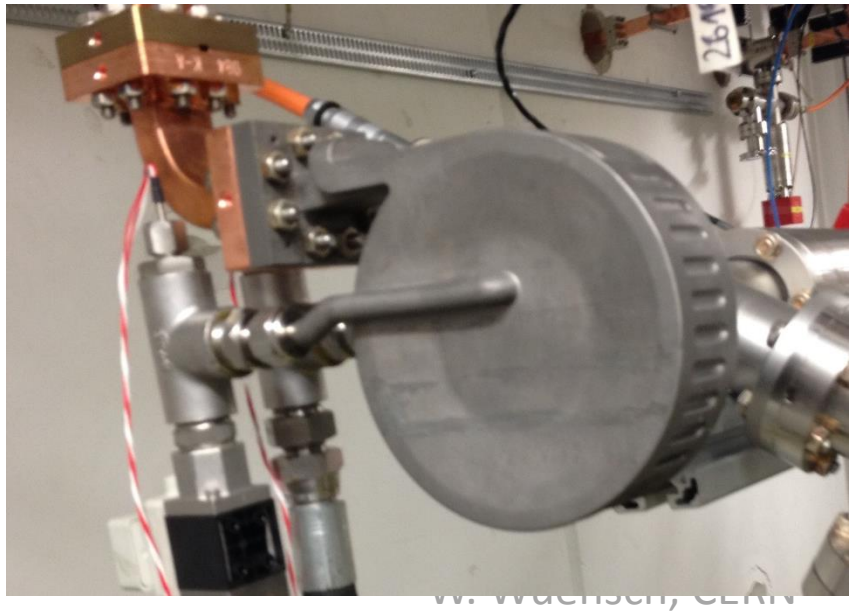
Introduction

- One of the driving motivations for CompactLight is to implement recent advances in high-gradient and X-band technology in an XFEL design.
- We expect a significant decrease in cost from decreased accelerator length (gradient), lowered pulse energy (frequency), etc.
- This is a continuation of the story of increasing frequency exemplified by SACLA, SwissFEL and SXFEL. S to C and now X-band, an octave each time.
- WP4 is responsible for the integrating the high-gradient and X-band technology and optimizing and defining the linac.

WP4 objective: Detailed parameters, design and cost of linac rf system optimized in overall facility.







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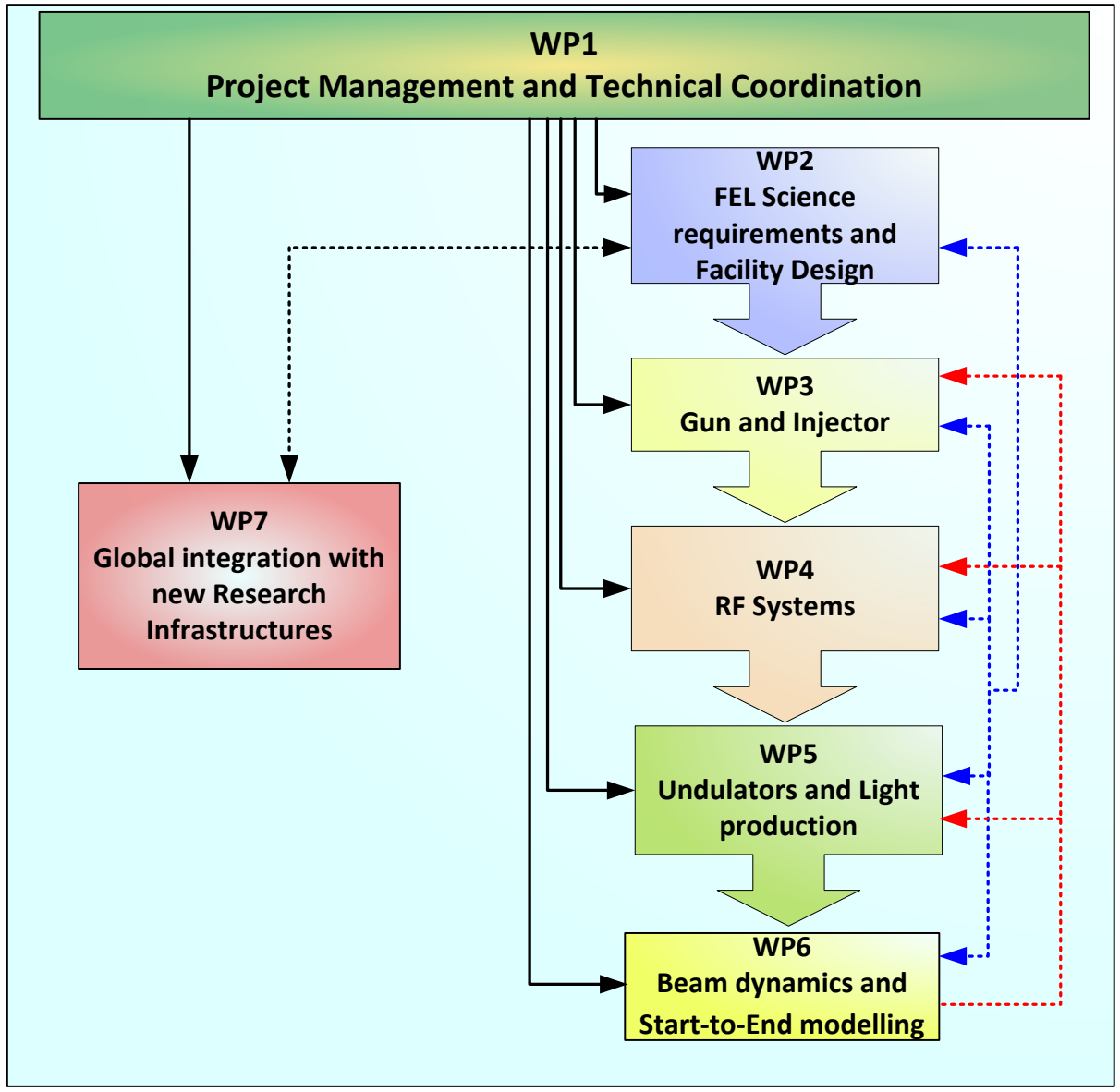

That's us!

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What we wrote in the proposal

Description of work (where appropriate, broken down into tasks), lead partner and role of participants

WP4 will define the RF system for the main linac of the FEL facility in the main and sub-design variants. A key goal will be to define a standardized RF unit which can be used in all main and sub-design variants. Making a standardized design available can simplify the preparation of future construction projects, stimulate the industrialization process and cost savings by future facilities.
WP4 is led by CERN and will be divided in three tasks:

Task 4.1 - Development of the design and costing tools needed to provide input for the global optimization done in WP2. This will be done in collaboration with the experts from existing facilities as well as the ongoing effort to optimize the CLIC klystron-based initial 380 GeV energy stage. CERN will lead this task.
Task 4.2 – Hardware development and prototype testing. This includes active contact and coordination with ongoing projects including CLIC, the CLEAR facility and X-band systems under development for deflectors in existing XFEL facilities to incorporate the latest developments there. CERN will take the leading role for this task. The work will be supported by all WP4 partners.
Task 4.3 - Industrialized and cost reduction. Industrialization will cover the high-power RF system, klystrons, modulators, pulse compressor and waveguide network, as well as the tight-tolerance, high-gradient accelerating structures. The task will be led by CERN and carried out with the support of VDL ETG.

What we wrote in the proposal

Deliverables (brief description and month of delivery)

D4.1 - A parameterized performance and cost model of the RF unit to be used by WP2 for the facility optimization. The model will be established in computer code and described in a report, (R, PU, M18).

D4.2 - A design report of the optimized RF unit. Based on the parameters emerging from the facility optimization, the design of the RF unit will be established at the component level and described in a report, (R, PU, M36).

D4.3 - A report on the design and fabrication procedure, optimized for series industrial production, of the accelerating structure which is an important cost driver for the facility, (R, PU, M36).

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- Our task is to design and optimize the complete rf system and define a standard rf unit or minimum number of versions.
- Work with WP6, Beam Dynamics and Modeling must be close and will require numerous iterations.
- There will be numerous technical system overlaps with WP3.
- Our deliverables are inputs to WP2, Facility Design.
- A WP4 kick-off meeting was held 30 November last year https://indico.cern.ch/event/682656/

Australian Synchrotron – ANSTO

- *Greg LeBlanc, Head of Accelerator Science and Operations*
- **Rohan Dowd, Senior Accelerator Physicist**
- Eugene Tan, Senior Accelerator Physicist
- David Zhu, Accelerator Physicist
- **Karl Zingre, Principal RF Engineer**
- **Peter Corlett, Senior RF Engineer**
- **Mark Atkins, Instrumentation Scientist**

synchrotron.org.au

Australian Synchrotron

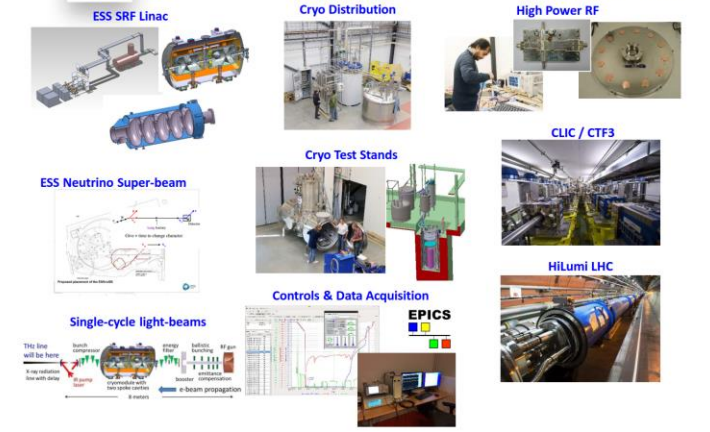
VDL ETG

Strength through cooperation

Our added value to CompactLight

VDL

FREIA Laboratory Activities



CERN

Getting to know each other

ABP Group, Department of Physics

G. Adam, D. Barclay, Adrian Cross, C.R. Donaldson, B. Eliasson, Wenlong He, T. Heelis, P. MacInnes, Laurence Nix, A. Phelps, C. Robertson, K. Ronald, D. Speirs, C. Whyte, D. Woodward, H. Yin, A. Young, L Zhang

Atoms, Beams & Plasmas (ABP) Research Group, Department of Physics, SUPA, University of Strathclyde, Glasgow, G4 0NG, Scotland, UK

- ABP Group of ~ 18 ➡ staff + postgrad students
- 30 years experience in RF, high power microwave and mm-wave research
- 200MHz to 1THz
- GWs to 100Ws
- Pulse lengths from 300ps to CW
- Amplifiers and oscillators
- Novel high power measurement techniques
- Extensive modelling and simulation capability
- PhD and masters teaching

INFN-LNF contribution to WP4 activities

30/11/17

Expertise:

RF structure/linac design (electromagnetic/mechanical), realization and test.

Areas of contribution:

⇒**design/optimization of linac accelerating structures** (structure length, effective shunt impedance, cell, couplers,...) using the same approach we are following for the EuSPARC X-band linac;

⇒**optimization of accelerating structures and RF components fabrication techniques**. We will also investigate, in the next months/years, this topic in the framework of the EuSPARC linac design and realization, including fabrication and test of prototypes of accelerating structures.

Resources:

LNF personnel/experts and PhD students.

CompactLight kick-off meeting, 29-1-2

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LAL-CNRS participation in WP4

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Areas of expertise:

- **Longstanding electron linac design effort**
  - RF simulation and design
    - High-Gradient Accelerating structures
  - Optimization integrated with beam dynamics
  - Cost estimation, Prototyping

Participation in WP4:

- **Industrialization processing**
  - High-Gradient RF structures
  - Depacc RF part time engineering (M. El Khaldi)

Examples CLIC-module

CLIC CDR baseline design from 2013 test-mockup

- Running thermal tests combined with numerical simulations in order to predict individual deformations and compensate for
- Testing individual components for installation and alignment methods
- Powering and cooling of individual components for establishing heat dissipation to air and cooling optimisation

Helsinki Institute of Physics

Ankara University Instiute of Accelerator Tech.

- **Responsibility**
  - WP6: Beam dynamics and start to end modelling: Defining key parameters and performance estimates of the overall facility. Start to end simulations covering cover the beam transport from the cathode to the undulator exit, including Space Charge effects, Coherent Synchrotron Radiation in magnetic compressors, Wake Field effects in the X-band linac and FEL performances.
- **Expertise:**
  - Beam Dynamics for low and high energy sections of machine, simulation on FE generation
- **Contribution to WP6**
  - WP6 is closely linked to WP2, WP3, WP4 and WP5.
  - *Optimization of accelerating structures in terms of wakefield, gradient etc.,*
  - *comperasion the results of power sources, modulators, pulse compressors, waveguide networ instrumentation and alignment system.*
- **Resources**
  - 4 PhD in the fields of Deam Dynamics, FEL generation, RF source

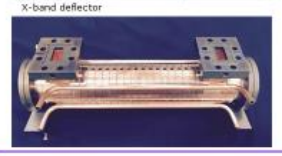
X-band and C-band RF system

1. C-band RF system for SXFEL.
2. X-band RF system for SXFEL linearizer.
3. Prototype of X-band deflector for SXFEL.

10 C-band RF systems for SXFEL main linac

X-band RF system for linearizer

X-band deflector



SINAP 中国科学院上海应用物理研究所 Shanghai Institute of Applied Physics, Chinese Academy of Sciences

CERN participation in WP4

Participation in WP4:

- WP coordination
- Design and optimization tools
- Component designs
- Testing/measurement possibilities
- X-band team available part-time
  - Nuria, Alexej, Igor, Gerry, Walter
  - Leverage presence at CERN of collaborators
  - Dedicated CompactLight postdoc

Overall strategy – transfer CLIC-developed tools to CompactLight collaborators who then carry out actual project design/optimization.

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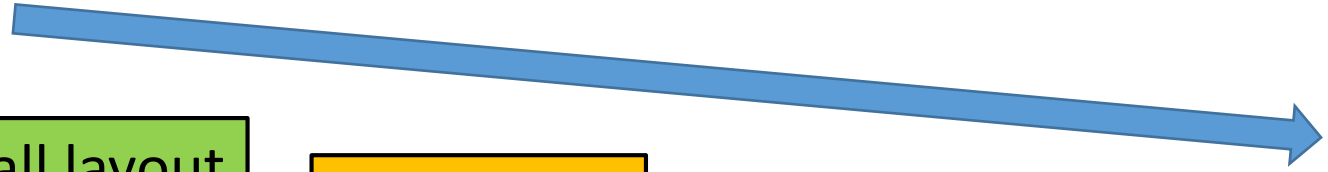
W. Wuensch, CERN

WP4 kick-off meeting, 30-11-2017

WP4 – Expertise and participation overview

	Technical area						Activity			
	Modulator	Power source	Waveguide network	Accelerating structures	Module	LLRF/control/ diagnostics	rf design/ optimization	Mechanical design	Layout/ integration	Costing/ industrialization
CERN		■	■	■	■		■	■	■	■
CNRS-LAL				■			■			
INFN Frascati			■	■			■		■	
Institute of Accelerator Technology, Ankara				■			■			
SINAP	■		■	■			■	■	■	
Sincrotrone Trieste										
University of Helsinki/HIP					■			■	■	■
University of Melbourne/ANSTO			■			■	■			
University of Strathclyde		■					■			
Uppsala University	■									■
VDL			■	■	■			■	■	■

Tasks, workflow and responsibilities



Organize
Lead: WW

Overall layout
Lead: tbd

Cost model
Lead: tbd

Phase 1

Merge
D4.1, M18
Lead: tbd

Phase 2

Parameterized component-level design
Lead: tbd

Inter-WP
output/input

Phase 3

Final layout(s)

RF unit design document, D4.2, M36

Detailed component-level design

Accelerator mass production, D4.3, M36

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Next WP4 meeting:

- Thursday, 8 February at 10:00 https://indico.cern.ch/event/697502/.
- I assume most of you will connect remotely.
- Objective is to identified Phase 1 task leaders.
- Elaborate workflow.
- Review resources, hiring plans etc.

The first face-to-face meeting (with remote available) will be at HG2018 in Shanghai in June, https://indico.cern.ch/event/675785/

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thomas.geoffrey.lucas@cern.ch

Please register with the email list https://e-groups.cern.ch/e-groups/Egroup.do?egroupName=xls-wp4&tab=3 if you are part of WP4 and have not done so already.