CompactLight

H2020 Design Study Proposal

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on behalf of the CompactLight Collaboration

TIARA Collaboration Council
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Outline

- **Context**
  - Previous bid and EU feedbacks
- **CompactLight**
  - Aims
  - Participants
- **Work Package Breakdown**
  - Top level summary
  - WP details
- **Timeline and Resources**
- **Acknowledgement**

Previous bid and EU feedback

The XbFEL Design Study was submitted Sept 2014 (INFRADEV-1-2014-1) with the intend **to validate the use of the X-band technology for the construction of future FEL based photon sources** and to promote the construction of a new generation of FELs based on a technological solution more efficient (cost, space, power consumption).

Our aim was to demonstrate the maturity of the concept through a dedicated design study.

- Duration 3 years
- 12 paricipants, lead Institute: ELETTRA - Sincrotrone Trieste

Feedback from EU:

- **Very positive/very highly scored, but……**
  - ***Too much emphasis on demonstration of (X-band) brilliant technology instead of designing a fully fledged user facility***
  - ***More clarity needed on how XbFEL fits into ESFRI landscape***

CompactLight Objectives

Our aim is to facilitate the widespread development of X-ray FEL facilities across Europe and beyond, by making them more affordable to construct and operate through an optimum combination of emerging and innovative accelerator technologies.

(Clear focus on conceptual design of a Facility rather than demonstration of the technical maturity of the X-band technology)

We will design a Hard X-ray FEL facility using the very latest concepts for:

- **bright electron photoinjectors**
- **very high gradient accelerating structures**
- **novel short period undulators**

The resulting facility will benefit from:

- a **lower electron beam energy** than current facilities, due to the enhanced undulator performance
- will be **significantly more compact** due to lower energy and high gradient structures
- will have a **much lower electrical power demand** than current facilities
- will have **much lower construction cost and running cost**

Making X-ray FELs affordable

Participants

1 (Coordinator)	Elettra – Sincrotrone Trieste S.C.p.A.	Italy
2	CERN – European Organization for Nuclear Research	International
3	STFC – Daresbury Laboratory	UK
4	SINAP, Chinese Academy of Sciences	China
5	Institute of Accelerating Systems and Applications	Greece
6	Uppsala Universitet	Sweden
7	The University of Melbourne	Australia
8	Australian Nuclear Science and Tecnology Organisation	Australia
9	Ankara University Institute of Accelerator Technologies	Turkey
10	Lancaster University	UK
11	VDL Enabling Technology Group Eindhoven BV	Netherlands
12	Technische Universiteit Eindhoven	Netherlands
13	Istituto Nazionale di Fisica Nucleare	Italy
14	Kyma S.r.l.	Italy
15	University of Rome "La Sapienza"	Italy
16	Italian National agency for new technologies, Energy and sustainable economic development, ENEA	Italy
17	Consorcio para la Construccion Equipamiento y Explotacion del Laboratorio de Luz Sincrotron	Spain
18	Centre National de la Recherche Scientifique, CNRS	France
19	Karlsruher Institut für Technologie	Germany
20	Paul Scherrer Institut PSI	Switzerland
21	Agencia Estatal Consejo Superior de Investigaciones Científicas	Spain
22	University of Helsinki – Helsinki Institute of Physics	Finland
23	Pulsar Physics	Netherlands
24	VU University Amsterdam	Netherlands
Third Parties	**Third party's organisation name**	**Country**
	Universitetet i Oslo – University of Oslo	Norway
	Advanced Research Center for Nanolithography (JRU of VU)	Netherlands

Italy	5
Neth.	4+1
UK	2
Spain	2
Austr.	2
China	1
Greece	1
Sweden	1
Turkey	1
France	1
Germany	1
Switz.	1
Finland	1
Norway	0+1
Internat.	1

Institutes I

- ***Elettra Sincrotrone Trieste (Italy)***
  - *X-band diagnostics and beam manipulation*
  - *X-band testing*
  - *FERMI upgrade*
- ***CERN (EU)***
  - *X-band testing & prototyping*
  - *Beam dynamics modeling*
  - *Facility design integration and optimisation*
- ***STFC, Lancaster (UK)***
  - *Undulator R&D*
  - *X-band diagnostics R&D*
  - *UK-FEL: hard X-Ray FEL*
- ***INFN (Italy)***
  - *Injector guns*
  - *SPARC upgrade*
  - *Basic science (photon-photon scattering)*

Institutes II

- ***National Technical University of Athens (Greece)***
  - *Soft X-Ray FEL*
  - *Diagnostics R&D*
- ***Uppsala (Sweden)***
  - *X-band testing and impedance qualification*
  - *Sub-picosecond photo injector*
  - *Undulator R&D (Single-cycle light pulses carrying orbital angular momentum)*
- ***Ankara University (Turkey)***
  - *FEL of Turkey*
  - *Undulator R&D*
- ***Technische Universiteit Eindhoven + VU University Amsterdam (Netherlands)***
  - *X-band design*
  - *Hi-rep Soft X-Ray FEL*
- ***La Sapienza University Rome (Italy)***
  - *X-band diagnostics and beam manipulation*
- ***ENEA (Italy)***
  - *Undulator theory and modeling*
  - *Compact FEL facility*

Institutes III

- ***ALBA + IFIC (Spain)***
  - *X-band LLRF R&D*
  - *RF high power R&D*
  - *Beam dynamics & modeling*
  - *Industry development and manufacturing*
- ***University of Helsinki (Finland)***
  - *X-band breakdown R&D*
  - *Thermo-mechanical modeling*
  - *Innovative cooling techniques for beam instrumentation*
- ***LAL, CNRS (France)***
  - *Compact Compton source R&D*
  - *High-gradient RF injector gun R&D*
  - *Industry development for manufacturing of HG-RF structures*
- ***KIT, Karlsruhe (Germany)***
  - *Superconductive Undulator R&D*
  - *Ultra-precise beam diagnostics R&D*
- ***PSI (Switzerland)***
  - *Facility upgrade*
  - *Undulator R&D*
  - *X-band R&D*

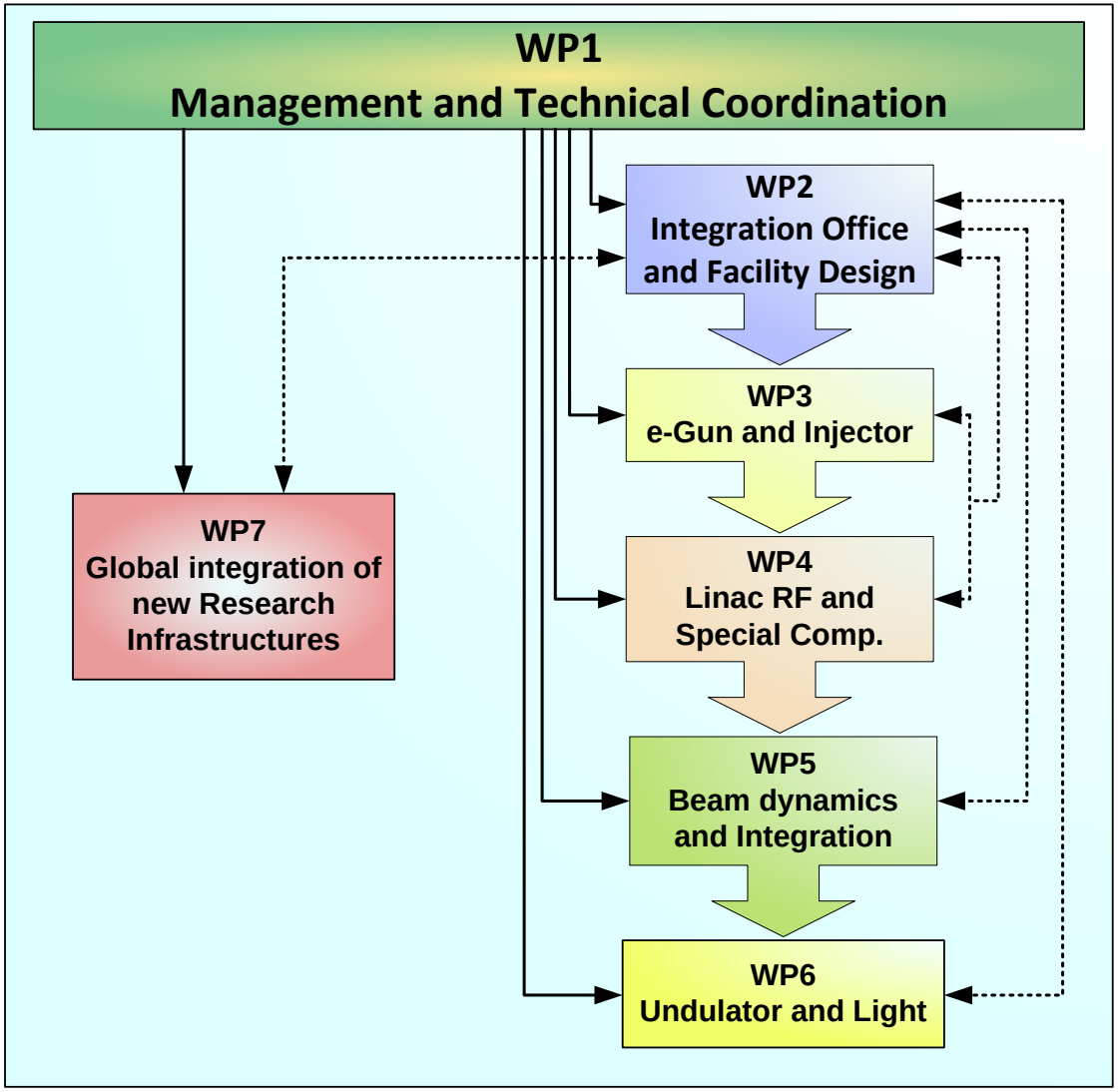
Institutes (International & Third Parties)

- ***SINAP (China)***
  - *Compact Compton Source*
  - *Soft / hard X-Ray FEL*
  - *Undulator R&D*
  - *X-band R&D*
- ***Australian Light Source + Melbourne University (Australia)***
  - *Facility upgrade*
  - *Soft / hard X-Ray FEL*
- **Third Parties:**
  - *Oslo University (Norway)*
  - *Advanced Research Center for Nanolithography (Netherlands)*

WPs top level summary

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	
	Management and Technical Coordination	Integration Office and Facility Design	e-Gun and Injector	Linac RF and Special Components	Beam Dynamics and Integration	Undulator and Light Production	Global Integration of new Research Infrastructures	Key deliverable
Hard X-ray FEL	X	X	X	X	X	X	X	CDR UK compatible (Main deliverable)
Soft X-ray FEL	X	X	X	X	X	X	X	CDR (sub deriv.)
Upgrading of existing machine	X	X	X	X	X	X	X	CDR (sub deriv.)
Deliverables, Activities, Comments	Administration, Reporting, Management Dissemination, Applications, User-Commun. Political issues/relations	Facility design Project Office, CDR authors, parameters, drawings, cost and power Industry relations and involvement	State of art e-Gun Development of new e-Guns Prototyping and tests	Accel. Struct. Design XBOX and beam tests at TWA in AERES LLRF systems, RF deflectors, linearizers, klystrons	Modelling S2E simulations. Delivery consistent tools Parameters for all machines	State of art Undulators and future development Comparative studies of "ambitious" undulators on the time scale of 4-5 years, matched to averall design	Global integration for new Research Infrastructures. Research services to be provided at International level Preliminary estimation of constr/operat costs.'	

WPs Structure



WP1: Project management and coordination

WP1 carries the overall management of the XLS Design Study to ensure timely achievement of project results through technical and administrative management. It will be lead by the Project Coordinator and be focused on the effective management and coordination of all the WPs and deliverables, the budget and the project implementation plans.

WP1 will have responsibility for:

- ***Coordination of all the partners and conflict resolution.***
- ***Organisation of periodic meetings and workshops.***
- ***Contacts with the Advisory and Executive boards.***
- ***Preparation and supervision of annual cost claims, audit certificates submitted by all project beneficiaries and EC reporting.***
- ***Preparation of documents for all beneficiaries.***
- ***Issuing and filling of financial records.***
- ***Identify risks and foresee contingencies at WP level, inform the Project Coordination Office in a timely manner, and propose corrective actions.***

WP2: FEL science requirements and facility design

The objective of WP2 is to provide the overall design of the FEL. It will determine performance specification for the Facility based on user-driven scientific requirements. It will identify and chose the most appropriate technical solutions considering cost, technical risk and performance.

WP2 will coordinate and have responsibility for:

- ***The Project Office.***
- ***The Design Study***
- ***The XLS Design Report***
- ***Machine parameters, costs and implementation plans.***
- ***Industry relations and involvement.***

The deliverables of WP2 are:

- WP2.1: A document summarising the requests from the users and defining the performance specifications for the FEL.
- WP2.2: The conceptual design report.

WP3: Gun and injector

The objective of WP3 is the comparative assessment of advanced gun and injector designs. Options considered:

- A full-X-band solution, inclusive of higher-harmonic linearization in K band. This aims to utilize the recent achievements in the design of X-band guns and reduce limitations of machine repletion rate currently given by the injector.
- High-gradient injectors at existing gun frequencies, S and C bands (towards lower emittance guns).

Phase-space linearizers, compact magnetic chicanes to achieve longitudinal bunch compression, will be also compared for the different variants and detailed designs produced for the final design choice.

The deliverables of this WP are:

- WP3.1: A design of a full X-band injector gun, an explorative study of a K-band linearizer and a magnetic chicane;
- WP3.2: A design of a high-gradient C-band injector, inclusive of X-band linearizer and a magnetic chicane;
- WP3.3: A design of a high-gradient S-band injector, inclusive of X-band linearizer and a magnetic chicane;
- WP3.4: An assessment of the suitability of these three designs hard X-ray FEL, soft X-ray FEL and Compton source.

WP4: RF systems

- **The primary objective of WP4 is to define the rf system for the linac of the XFEL in the main and sub-design variants.**
- **Additionally the WP will take responsibility for defining specialized rf hardware in other systems, for example for an eventual 36 GHz lineariser system in the injector and deflectors for longitudinal profile measurement systems.**
- **A key goal will be to define a standardized rf unit:**
  - **simplify the preparation of future construction projects**
  - **cost savings (industrialization of linac hardware)**

The deliverables of this WP are:

- **WP4.1: 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.**
- **WP4.2: A design report of the optimized rf unit.**
- **WP4.3: A report on the design and fabrication procedure, optimized for series industrial production, of the accelerating structure.**

WP5: Undulators and light production

➢ **The primary objective of WP5 is to determine the undulator design for XLS. It will start by investigating state of art undulators and then consider on-going developments. "Ambitious undulators" will be compared with the boundary conditions of technologies available on 4-5 years time scale. These will include:**

- **novel short period undulators**
- **superconducting undulators**

and more exotic devices like:

- **RF-microwave undulators**
- **laser electromagnetic wave undulators**

➢ **Close collaboration with WP6: transport line studies, matching the undulators section to the characteristics of the accelerated beam (preservation of the beam quality).**

➢ **WP5 will provide important input to WP2, supporting the possibilities for very compact photon sources.**

The deliverable of the WP will be:

- **WP5.1: A report comparing near and medium-term undulator technologies .**
- **WP5.2: A design report for the baseline undulator, containing all necessary information for overall facility design and optimization and specifying the undulator at the component level.**

WP6: Beam dynamics and start to end modelling

The main objective of WP6 is to provide key parameters and performance estimates of the Facility. This serves as input to WP2 to elaborate the overall facility design.

- **Estimates, based on simulations, will be the basis for technology choices for critical components and for accelerating structures, undulators, power sources, modulators, pulse compressors, waveguide network, instrumentation and alignment system. WP6 will provide an important linking role for the technical WPs 3-5 and the link to WP2.**
- **S2E simulations from the cathode to the undulator exit.**
- **Tolerance studies will be also performed.**
- **Beam-based alignment and tuning methods that can relax the tolerances.**

WP6 will develop consistent tools for modelling the machine, as the basis for the integrated performance studies.

The deliverables of WP6 are:

- **WP6.1: A set of tools need to evaluate the facility performance.**
- **WP6.2: A performance prediction of the facility including the key tolerances and mitigation strategies to deal with imperfections. This work will be summarized in a report.**

WP7: Global integration with new Research Infrastructures

WP7 will address strategic issues related to the objectives of XLS, namely the impact and benefits for the user community, in both the public and private sectors, at the scientific and technical level. The results of this work package will be a series of reports which target funding agencies and policy makers and that can be used in the decision making process for the approval of new research infrastructures or the upgrade of existing facilities. The work will be split into three activities:

- **Address the global integration of X-band technology for new accelerator-based research Infrastructures both at the European level and worldwide.**
  - The present and future requirements from the user community will be taken into account to show how the specific nature of X-band technology will address these requirements.
- **Address the services that can be provided to the community at a global level based on the exploitation of the new technology.**
- **Evaluate costs and estimated budgets required for the construction and operation of these facilities. Comparison of costs will be made with conventional technology.**

Main Deliverable

The main deliverable of CompacLight will be a Conceptual Design Report of an X-band Hard X-ray facility.

The CDR will include:

- ✓ **Executive summary**
- ✓ **Overall concepts**
- ✓ **Layout and parameters**
- ✓ **Detailed design at the sub-system level**
- ✓ **Cost evaluations**

Timeline and Resources

European Commission

Horizon2020

Work Programme 2016-2017

Research Infrastructures (RIs)

"Development and long-term sustainability of new pan-European RIs"

Research Infrastructures (RTD)	2016	2017	TOTAL	Single grant
CALL H2020-INFRADEV-2016-2017	**80**	***60***	***140***	
INFRADEV-10: Design studies		*20*	*20*	From 1 to 3 M€
INFRADEV-02: Preparatory Phase	40		40	Up to 4 M€
INFRADEV-03: Individual Support	30	*40*	*70*	From 2 to 5 M€
INFRADEV-04: Eur. Open Science Cloud	10		10	From 5 to 10 M€

+ 5 M€

Deadlines: **30 March 2016** **22 June 2016** ***29 March 2017***

Request from EU: 3.0M€ **Duration 3-4 years** **Assumed start date: Jan 2018**

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