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CompactLight progress and status

2nd Midterm Review Meeting
Helsinki 1-4 July 2019

Agenda

Monday, 01 July 2019				
13.30	14.45	75'	Lunch	
14.45	15.30	45'	Registration	
15.30	15.45	15'	Welcome	Katri Huitu (UH/HIP Director)
WP1 Activity Report and Discussion				
15.45	16.50	20'	CompactLight Status	Gerardo D'Auria (ST)
		15'	Project Communication	Andrea Latina CERN)
		15'	Periodic Report Status	Regina Rochow (ST)
		15'	Overleaf & Mendeley Tutorial	M. Aicheler (UH/HIP)
Coffee Break				
WP7 Activity Report and Discussion				
17.10	18.15	5'	Introd. on Status of WP7 Activities	Regina Rochow (ST)
		15'	Project Breakdown Structure	Carlo Rossi (CERN)
		20'	Cost Analyses & Technology Transfer	Evangelos Gazis (IASA)
		10'	Action Plan' for Use of XLS Technology	Regina Rochow (ST)
		15'	EDMS Data & Document Storage	Markus Aicheler (UH/HIP)
18.15	18.30	15'	Discussion	All

Tuesday, 02 July 2019 - Morning Session				
WP2 Activity Report and Discussion				
09:00	10:15	25'	CompactLight layout and next steps for WP2	Jim Clarke (STFC)
		15'	Schemes for the simultaneous operat. of soft and hard x-ray FEL beamlines	Simone DiMitri (ST)
		15'	Consideration of the photon beamline design for CompactLight	Vitaliy Goryashko/Peter Salen (UU)
		15'	XARA - a potential application of CompactLight technology	Neil Thompson/Louise Cowie (STFC)
10:10	10:30	20'	Discussion	All
Coffee Break & Meeting Photo				
WP3 Activity Report and Discussion				
11:00	12:15	10'	Introduction On Status of WP3 and D3.1	Massimo Ferrario (INFN)
		10'	D3.2: Review of magnetic bunch compression schemes for CompactLight	Simone Di Mitri (ST)
		10'	C-band gun design and high repetition rate challenges	David Alesini (INFN)
		10'	Compact S+X injector scheme	Andrea Latina (CERN)
		10'	X-band RF electron gun injector design	Daniel Gonzalez-Iglesias (CSIC)
		10'	A possible electron gun for the 35 GHz klystron	Bruno Spataro (INFN)
		10'	3D design efforts for the e-gun	Eugene Tanke (IASA)
12:15	12:30	15'	Discussion	All

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Agenda

Compact

Tuesday, 02 July 2019 - Afternoon Session				
WP4 Activity Report and Discussion				
14:00	15:15	15'	Introduction on Status of WP4 Activities	Walter Wuensch (CERN)
		15'	Review of the baseline rf module design (and development of high repetition rate capability)	David Alesini (INFN)
		15'	Linac layout	Markus Aicheler (UH/HIP)
		15'	Progress towards the 36 GHz, 3 MW, 2 µs and 1 kHz gyroklystron plus 48 GHz gyroklystron	Laurence Nix (USTR)
		15'	Plans for & progress on Industrialisation	Miranda Van den Berg (VDL-ETG)
15:15	15:30	15'	Discussion	All
Coffee Break				
WP5 Activity Report and Discussion				
16:00	17:15	3'	Introduction on Status of WP5 Activities	Federico Nguyen (ENEA)
		12'	Overview on Permanent Magnet Undulators	Jordi Marcos (ALBA-CELLS)
		12'	Overview on Superconducting Undulators	Axel Bernhard (KIT)
		12'	Overview on Exotic Undulators	Adrian Cross (USTR)
		12'	Alternative FEL schemes and undulators for a Compact device	Guiseppe Dattoli (ENEA)
		12'	Quantitative analysis of undulator technologies for CompactLight FEL	Neil Thompson (STFC)
		12'	Variable polarisation & Two-Colour Schemes	Hector M. C. Cortes (STFC)
17:15	17:30	15'	Discussion	All
19:00 - 21:30 Dinner on Boat Bus will leave from hotel at 18:00 - Bus back to hotel at 22:00				

Wednesday, 03 July 2019 - Morning Session				
WP6 Activity Report and Discussion				
09.00	10.15	10'	Introduction on Status of WP6 Activities	Avni Aksoy (UA-IAT)
		12'	Hard X-Ray FEL study Case for fist deliverable	Hector M. Castaneda Cortes
		12'	Status of S-band Injector Based Compact Light design	Edu Marin
		12'	Recent Improvement of RF-Track	Andrea Latina
		12'	1D optimisation for the full X-band solution	Xingguang Liu
		12'	DC electron gun as an injector for an X-band FEL	Thomas Geoffrey Lucas
10.15	10.30	15'	Discussion	All
Coffee Break				
Presentations from Industries				
11.00	13.00	20'	Presentation CPI	C. Van Daele
		20'	Presentation Canon	F. Satoshi
		20'	Presentation Thales Group	A. Buenas
		20'	Presentation ScandiNova Systems	M. Lindholm
		20'	Presentation Jema Energy	B. Eikelboom
		20'	Discussion	All
Lunch				

To discuss the current status of Modulator & Klystron technology and expected developments in the next 3-5 years

Agenda

Wednesday, 03 July 2019 - Afternoon Session				
SAC Session				
14:15	15:00	45'	XLS-SAC Joint Session	All
Joint WP Session				
15:00	15:45	45'	Discussion on PBS and EDMS	All
Coffee Break				
WP or Working Group Meetings				
16:15	17:45	90'	1st Periodic Report Working Group	WP Leaders
		90'	Overleaf & Mendeley Support	Markus Aicheler with interested Partners
		90'	Brainstorming on future Dissemination and Technology Transfer Activities	Andrea Latina & Evangelos Gazis with interested Partners
		90'	Other Working Groups, if requested	interested Partners

Thursday, 04 July 2019				
General Discussion				
09:00	10:30	90'	- Six months ahead activity plans - Deliverables - Next meeting ...	All
Coffee Break				
11:00	12:30	90'	Collaboration Board Meeting	CB Members
Lunch				
14:00			Organised Visit	All interested partners & guests

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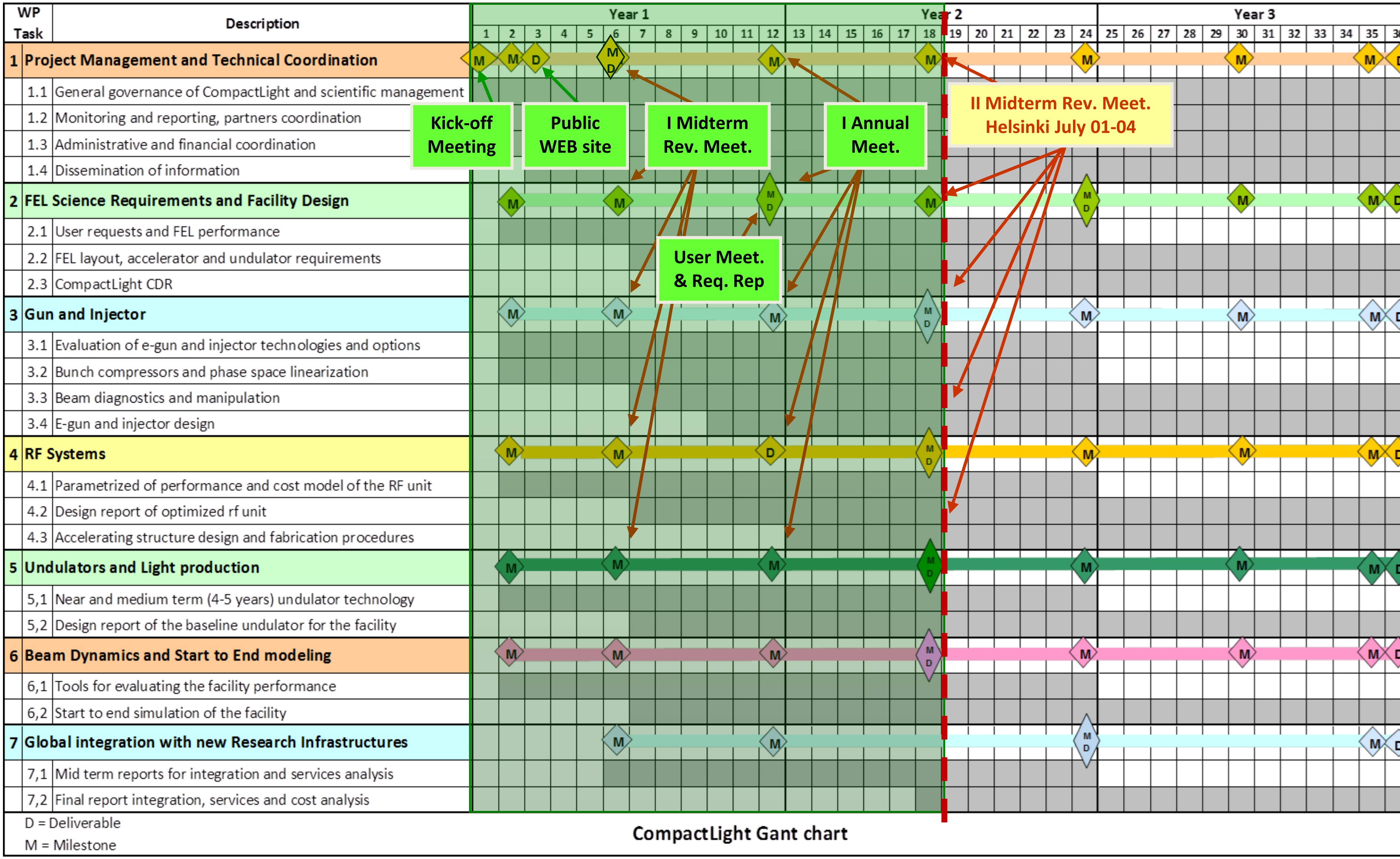
Time plan, Milestones and Deliverables

Compact



CompactLight Gant chart

Milestones

Milestone Number	Milestone title	Due date (in months)
MS1	Kick-off Meeting.	**1**
MS2	Official bodies	**1**
MS3	Installation of governance bodies.	**1**
MS4-MS8	First meetings of WP2-WP6.	**6**
MS9	First Meeting of WP7	**6**
MS10	1st WP2-WP6 Joint Meeting – Hardware assessments.	**6**
MS11	1st Mid-term Project Review.	**6**
MS12	1st Annual Meeting and Project Review Joint Session.	**12**
MS13	2nd WP2-WP6 Joint Meeting – Hardware specification.	**18**
MS14	2nd Mid-term Project Review.	**18**
MS15	2nd Annual Meeting and Project Review Joint Session.	**24**
MS16	3rd WP2-WP6 Joint Meeting – Hardware Design.	**30**
MS17	3rd Mid-term Project Review.	**30**
MS18	Final Annual Meeting and Project Review Joint Session.	**35**

Deliverables submitted on Friday June 28th

XLS Deliverable D3.1

Preliminary assessments and evaluations of the optimum e-gun and injector solution for the CompactLight design

M. Ferrario[1)*], D. Alesini[*], F. Cardelli[*], G. Castorina[*], M. Croia[*], M. Diomede[*], A. Gallo[*], A. Giribono[*], J. Scifo[*], B. Spataro[*], C. Vaccarezza[*], A. Vannozzi[*], S. Di Mitri[†], R. Rochow[†], A. Latina[‡], M. D. Kelisani[‡], S. Doebert[‡], D. Angal-Kalinin[§], J. Clarke[§], E. Gazis[¶], A. Aksoy[‖], J. Luiten[**], A. Rajabi[**], X. Stragier[**], A. Faus-Golfe[††], Y. Han[††], D. Esperante[‡‡], M. Boronat[‡‡], C. Blanch[‡‡], J. Fuster[‡‡], B. Gimeno[‡‡]

On behalf of the CompactLight Partnership

XLS Deliverable D3.2

Review report on bunch compression techniques and phase space linearization

J.M. Arnesano[‖], M. Croia[‡], S,. Di Mitri[1)*], L. Ficcadenti[**], A. Faus-Golfe[§], A. Giribono[‡], Y. Han[§], A. Latina[†], X. Liu[†], E. Marin Lacoma[¶], R. Muñoz Horta[¶], A. Mostacci[‖], L. Palumbo[‖], B. Spataro[‡], C. Vaccarezza[‡]

On behalf of the CompactLight Partnership

XLS Deliverable D4.1

Report on the computer code and simulation tools which will be used for RF power unit design and cost optimization

W. Wuensch[1)*], M. Diomede[†], A. Gallo[†], D. Alesini[†], C. Rossi[*], A. Cross[‡], L. Zhang[‡], L. Nix[‡], X. Wu[*]

On behalf of the CompactLight Partnership

XLS Deliverable D5.1

Technologies for the CompactLight undulator

F. Nguyen[1)*], A. Aksoy[†], A. Bernhard[‡], M. Calvi[§], J. A. Clarke[¶], H. M. Castañeda Cortés[¶], A. W. Cross[‖], G. Dattoli[*], D. Dunning[¶], R. Geometrante[**], J. Gethmann[‡], S. Hellmann[§], M. Kokole[†††], J. Marcos[††], Z. Nergiz[*], F. Perez[††], A. Petralia[*], S. C. Richter[‡,‡‡], T. Schmidt[§], D. Schoerling[‡‡], N. Thompson[¶], K. Zhang[§], L. Zhang[‖], D. Zhu[***]

On behalf of the CompactLight Partnership

XLS Deliverable D6.1

Computer codes for the facility design

Avni Aksoy[1)*], Anna Giribono[†], Andrea Latina[‡], Héctor Mauricio Castañeda Cortés[§], Neil Thompson[§], Federico Nguyen[†]

On behalf of the CompactLight Partnership

DRAFT

777431 (XLS) RIA

HORIZON 2020

Call: H2020-INFRADEV-2016-2017

Topic: INFRADEV-01-2017 Unit: RTD/G/03

Summary for publication | Deliverables Ethics, DMP, Other Reports | Milestones | Critical Risks | Publications | Disseminat... | Patents (IPR) | Open Data | Gender | ABS Regulation

Deliverables, Ethics, DMP, Other Reports

For each Deliverable, a single file (max 52MB) can be uploaded

Hide Filters Clear Filters

Title | Lead Beneficiary

Description | Status: Approved

Deliverables

WP No	Del Rel.	Del No	Title	Description	Lead Be	Nature	Dissemin	Est. Del. Date (ar	Receipt Date	Approval Date	Status
WP1	D1.1	D1	CompactLight public Webs	Creation of the CompactLight public Website...	ST	Websites, patents filling, etc.	Public	31 Mar 2018	31 Mar 2018	28 Jun 2019	Approved
WP1	D1.2	D2	Data Management Plan	Outline and implement a Data Management Plan (D...	ST	ORDP: Open Research Data Pilot	Public	30 Jun 2018	30 Jun 2018	28 Jun 2019	Approved
WP2	D2.1	D3	Users requirements and FE	Report providing users requirements and FEL per...	STFC	Report	Public	31 Dec 2018	20 Dec 2018	28 Jun 2019	Approved

Description | Status: Submitted

Deliverables

WP No	Del Rel.	Del No	Title	Description	Lead I	Nature	Dissemin	Est. Del. Da	Receipt Dat	Approval Date	Status
WP3	D3.1	D4	Optimum e-gun and inject	Evaluation report of the optimum e-gun and inje...	INFN	Report	Public	30 Jun 20	28 Jun 20		Submitted
WP3	D3.2	D5	Bunch compression and ph	Review report on the bunch compression techniqu...	INFN	Report	Public	30 Jun 20	28 Jun 20		Submitted
WP4	D4.1	D6	RF unit design	Computer code report for RF power unit design a...	CERN	Report	Public	30 Jun 20	28 Jun 20		Submitted
WP5	D5.1	D7	Technologies for the Comp	Review report comparing the different technolog...	ENEA	Report	Public	30 Jun 20	28 Jun 20		Submitted
WP6	D6.1	D8	Computer codes for the fa	Review report on the most advanced computer cod...	UA-IA	Report	Public	30 Jun 20	28 Jun 20		Submitted

Description | Status: Pending

Deliverables

WP No	Del Rel.	Del No	Title	Description	Lead Be	Nature	Dissemin	Est. Del. Date (ar	Receipt Date	Approval Date	Status
WP1	D1.3	D11	Short monograph summari:	Production of a short monograph summarizing the...	ST	Report	Public	31 Dec 2020			Pending
WP2	D2.2	D9	FEL design with accelerato	Report providing a global analysis of the most ...	STFC	Report	Public	31 Dec 2019			Pending
WP2	D2.3	D12	Hard X-ray FEL Conceptual	The conceptual design report for a Hard X-ray F...	STFC	Report	Public	31 Dec 2020			Pending
WP3	D3.3	D13	Injector diagnostics and be	Design report of the injector diagnostics and b...	INFN	Report	Public	31 Dec 2020			Pending
WP3	D3.4	D14	E-gun and injector Design	E-gun and injector Design Report with diagnosti...	INFN	Report	Public	31 Dec 2020			Pending
WP4	D4.2	D15	RF power unit	Design report of the optimized RF unit.	CERN	Report	Public	31 Dec 2020			Pending
WP4	D4.3	D16	RF unit design and fabricat	Report on RF unit design and fabrication proced...	CERN	Report	Public	31 Dec 2020			Pending
WP5	D5.2	D17	Conceptual Design Report	Design Report of the undulator to be included i...	ENEA	Report	Public	31 Dec 2020			Pending
WP6	D6.2	D18	Start to end facility simula	Final report of the accelerator lattice, FEL de...	UA-IAT	Report	Public	31 Dec 2020			Pending
WP7	D7.1	D10	CompactLight global integ	Mid-term report with CompactLight global integr...	ST	Report	Public	31 Dec 2019			Pending
WP7	D7.2	D19	CompactLight global integ	Final report giving an overview of the Facility...	ST	Report	Public	31 Dec 2020			Pending

List of Deliverables

Deliv.	Deliverable name	WP Lead part.	Type Del. date	
D1.1	CompactLight Public Website.	WP1-ST	DEC-PU-M3	2018
D1.2	Data Management Plan	WP1-ST	ORDP-PU-M6	
D2.1	Report providing users requirements and FEL performance specification.	WP2-STFC	R-PU-M12	
D3.1	Evaluation report of the optimum e-gun and injector solution for the XLS CDR.	WP3-INFN	R-PU-M18	2019
D3.2	A review report on the bunch compression techniques and phase space linearization	WP3-INFN	R-PU-M18	
D4.1	Computer code report for RF power unit design and cost optimization.	WP4-CERN	R-PU-M18	
D5.1	A review report comparing the different technologies for the CompactLight undulator.	WP5-ENEA	R-PU-M18	
D6.1	Review report on the most advanced computer codes for the facility design	WP6-UAIAT	R-PU-M18	
D2.2	Report summarizing the FEL design with accelerator and undulator requirements.	WP2-STFC	R-PU-M24	
D7.1	Mid-term report with CompactLight global integration and cost analysis	WP7-ST	R-PU-M24	
D3.3	Design report of the injector diagnostics/beam manipulations based on a X-band cavities	WP3-INFN	R-PU-M36	2020
D3.4	E-gun and injector Design Report with diagnostics and phase space linearizer	WP3-INFN	R-PU-M36	
D4.2	Design report of the optimized RF unit	WP4-CERN	R-PU-M36	
D4.3	Report on RF unit design and fabrication procedure	WP4-CERN	R-PU-M36	
D5.2	Conceptual Design Report of the undulator	WP5-ENEA	R-PU-M36	
D6.2	Final report with start to end facility simulations	WP6-UAIAT	R-PU-M36	
D7.2	Final report with CompactLight global integration analysis, services and cost.	WP7-ST	R-PU-M36	
D2.3	Hard X-ray FEL Conceptual Design Report.	WP2-STFC	R-PU-M36	
D1.2	Production of a short monograph summarizing the Conceptual Design Report.	WP1-ST	R-PU-M36	

31 Dec. 2019 { D2.2, D7.1 }

- Towards An Ultra-Compact X-Ray Free-Electron Laser, 22-25 January 2019, UCLA-LA, USA.
- 12th Meeting of the TIARA Collaboration Council, 20 February 2019, CERN, Geneva, CH.
- CLIC Project Meeting 2019, 07 May 2019, Geneva, CH.
- 12th Int. WS on Breakdown Science and High Grad. Techn. HG2019 , 11 – 14 June 2019, Chamonix, FR.
- First year's symposium, University of Groningen, June 24, 2019, NL.
- XIII Iberian Meeting on Comput. Electrom. EIEC 2019, 15th-18th October 2019, Potes Cantabria, ES.
- 39th Free Electron Laser Conference FEL 2019, 26th-30th August 2019, Hamburg, DE
- EUV Sources for Lithography, 4th-6th November 2019, Amsterdam, NL.

An article about CompactLight will appear at the end of July on "**Platinum**", an international magazine on European Entrepreneurship, Research & Innovation, Industry.

research&innovation

Small and powerful lasers

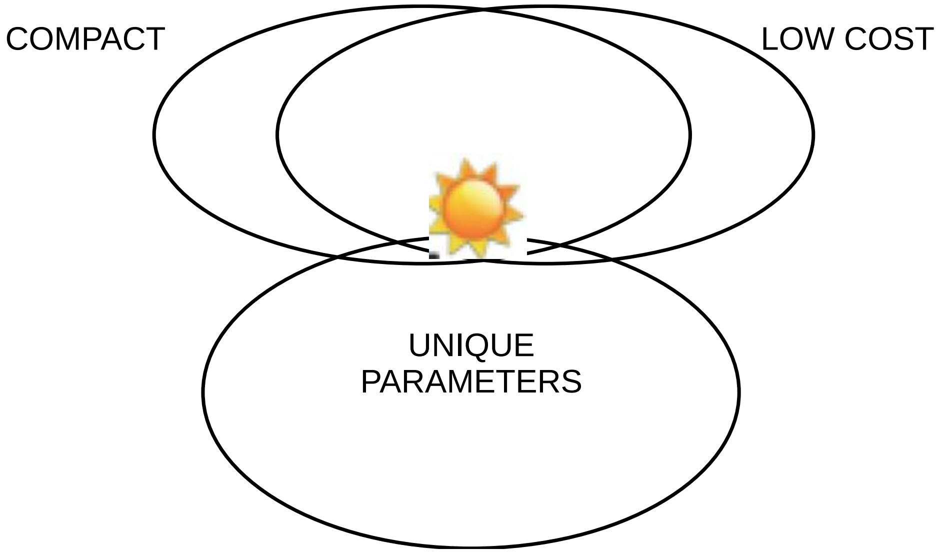
They are key elements of a project aiming at industrialising plasma accelerators

Accelerators producing high energy particle beams are exceptional devices, though having remarkable dimensions and being extremely expensive. For this reason, an H2020 project named "EuPRAXIA" aims at studying the feasibility of an infrastructure able to "compact" accelerators through a technological leap, thanks to a new plasma technology whose purpose is that of using very high power lasers, generating a "pre-industrial" product that will then be industrialised by future projects. Within the European consortium EuPRAXIA - led by the DESY laboratory in Hamburg - The National Institute of Opitcs of CNR in Pisa, for years at the forefront in the research with high power lasers and plasmas, coordinates the design of the EuPRAXIA laser system in collaboration with research centres and industrial partners in the sectors of lasers and high technology. "In fact, laser is considered as the innovative element supplying energy to the system we are currently designing - explains Leonida Gizzi of CNR -: for this reason we need to build a compact and powerful laser system. Our aim is that of creating, for the first time, a machine that could work based on this principle: plasma technology is currently studied in the main laboratories in the world, CERN included and in Italy also at the INFN Laboratories in Frascati, a leading partner in the project. Our aim is to make such technology industrially accessible, creating a prototype meant for the future users". The technology employed by CNR for the new laser is called CPA (from the English Chirped Pulse Amplification): and was developed by Gérard Mourou and Donna Strickland, winners of the Nobel Prize for Physics 2018. "This technology allows to build very powerful lasers that, - unlike the huge lasers existing in the US and France - present compact dimensions as they exploit the short duration of the emission and the repetition of the process". In practice, an extreme peak power and high average power system that can be contained in a room: a true revolution for future industrial, environmental and biomedical applications of particle accelerators. For further information concerning the project visit www.eupraxia-project.eu, and CNR of Pisa www.ilil.ino.it. ■

THE LASER SYSTEM AT THE NATIONAL OPTICS INSTITUTE AT CNR OF PISA

110 PLATINUM - November 2018

Facility Design



Users requirements

ESSENTIALS:

- Photon energy range at the fundamental: 0.25 – 16.0 keV
- Variable, selectable polarization
- Repetition rate 100 Hz (higher, very welcome!)
- 2-colours operation with timing separation +/- 100fs and colour separation 20% in SXR and 10% in HXR
- Wavelength tuning primarily by undulator scanning with several discrete beam energies
- Pulse duration 1- 50 fs
- Even pulse spacing and <10 fs synchronisation between FEL pulse and external laser
- Competitive pulse energy

DESIDERABLES:

- Stability
- Seeding at all wavelengths
- Repetition rate 1kHz
- Simultaneous HXR/SXR operation
- Peak brightness 10^{33} ph/s/mm mrad^2/0.1%bw at 16keV

Preliminary FEL Parameters based on user's requirements

Parameter	Unit	Soft x-ray FEL	Hard x-ray FEL
Photon energy	KeV	0.25 - 2.0	2.0 - 16.0
Wavelength	nm	5.0 - 0.6	0.6 - 0.08
Repetition rate	Hz	100 to 1000*	100
Pulse duration	fs	0.1 - 50	
Pulse energy	mJ	< 0.3	
Polarization		Variable - Selectable	
Two-pulse delay	fs	± 100	
Two-colour separation	%	20	10
Synchronization	fs	< 10	

*A repetition rate of 1000 Hz would be a unique and desirable feature of our design! We recognise that this is a very challenging target that we may have to reduce during the study.

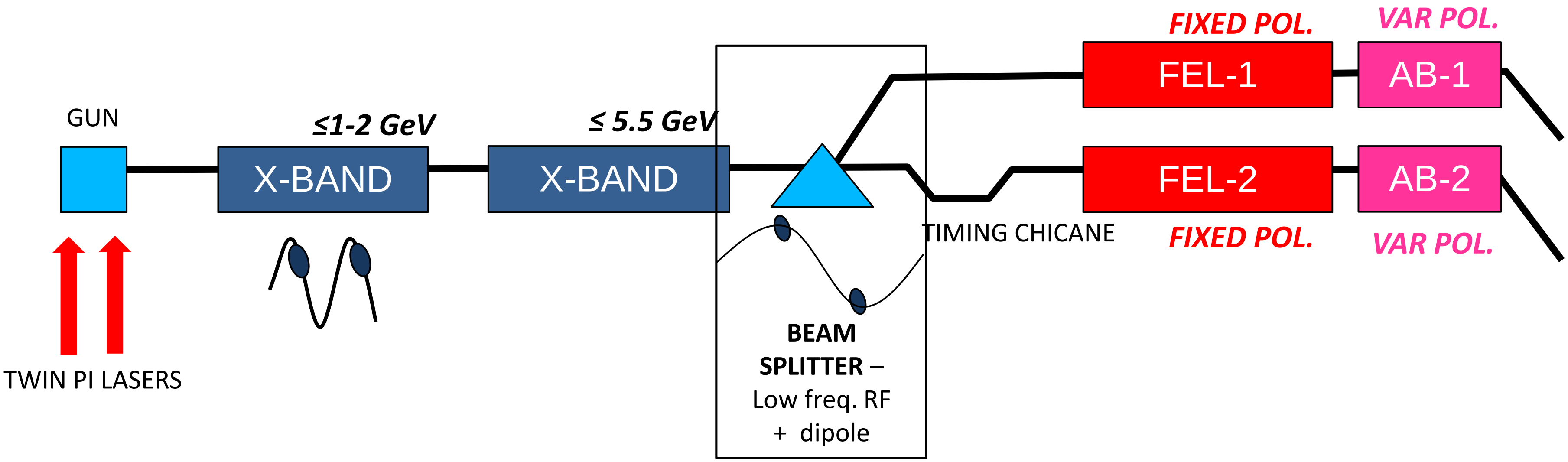
Ingredients to meet the

Requirements

- Use of a strong field undulator with short period and small gap to minimise the beam energy is required.
- Choose an appropriate set of the undulator period in order to give a factor of two wavelength tuning at each beam energy (i.e. D. Dunning proposal: 6 discrete beam energy working points to cover the whole range 0.25 –16 keV).
- The variable polarisation could be provided by using an “Afterburner” for the last gain lengths.
- Use two photo-injectors to have a double electron bunch with each bunch on separate RF cycle, independent charge, separated in energy and a controlled delay between them, to have pulses separated in time and wavelength.

D. Dunning , N. Thompson

Core machine schematic layout

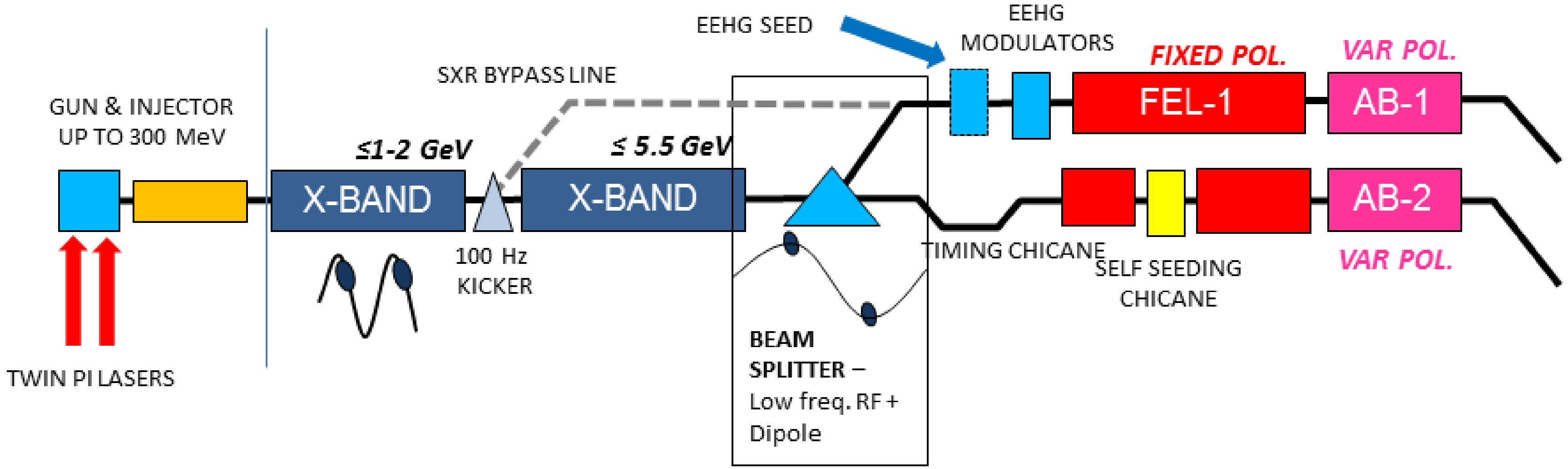


OPERATING MODES

1. FEL-1/FEL-2 independent double pulses to one experiment HXR 100Hz
2. FEL-1/FEL-2 independent single pulses to two experiments HXR 100Hz
3. FEL-1/FEL-2 independent double pulses to one experiment SXR 1kHz
4. FEL-1/FEL-2 independent single pulses to two experiments SXR 1kHz

D. Dunning , N. Thompson

Upgraded layout



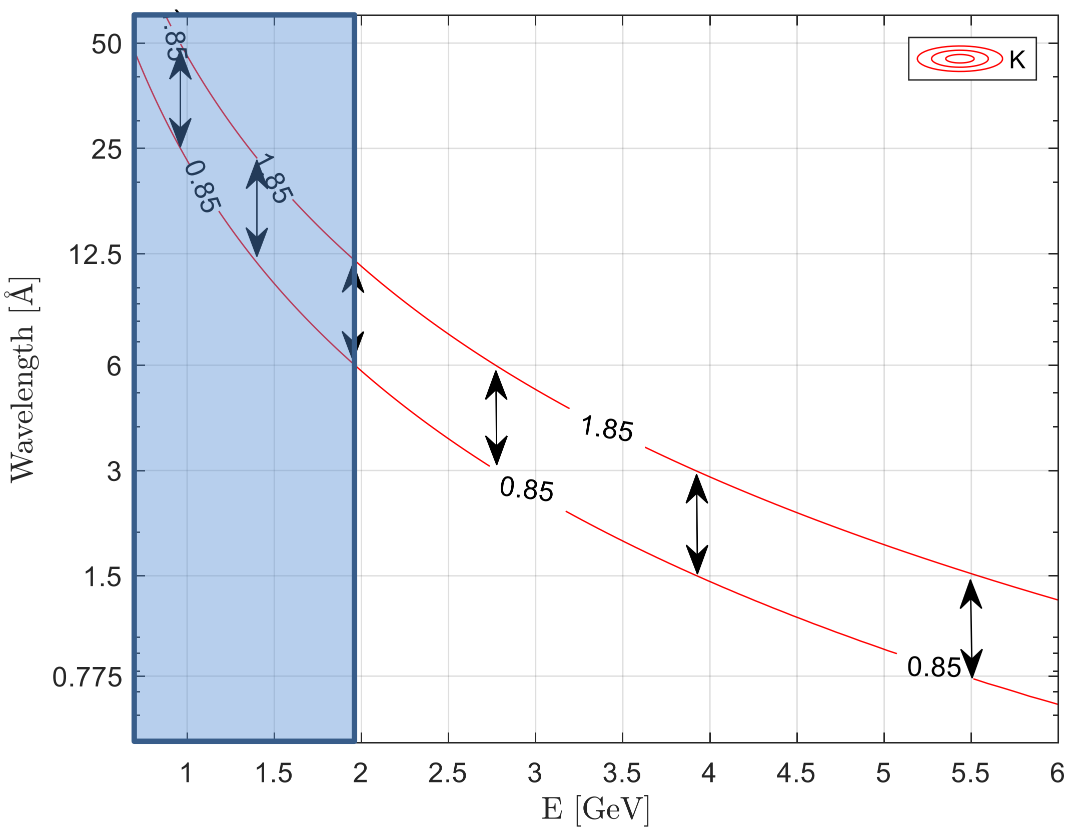
Operating modes:

1. FEL-1/FEL-2 independent double pulses to one experiment HXR 100Hz
2. FEL-1/FEL-2 independent single pulses to two experiments HXR 100Hz
3. FEL-1/FEL-2 independent double pulses to one experiment SXR 1kHz
4. FEL-1/FEL-2 independent single pulses to two experiments SXR 1kHz
5. FEL-1 SASE/SEEDED SXR 100Hz + FEL-2 SASE/SELF SEEDED HXR 100Hz

D. Dunning , N. Thompson

Undulator parameters

Soft X-ray Hard X-ray



Both undulator lines have identical parameters, so K is tuneable to provide a factor of 2 wavelength tuning for both Soft X-ray and Hard X-ray

$\lambda_u \approx 13mm$
$K_u \approx 0.85\text{-}1.85$

- **Soft X-ray**
  $E_{beam} \approx 1.0/1.4/1.95GeV$
  (~3 discrete working points @increased rep.rate, TBC)

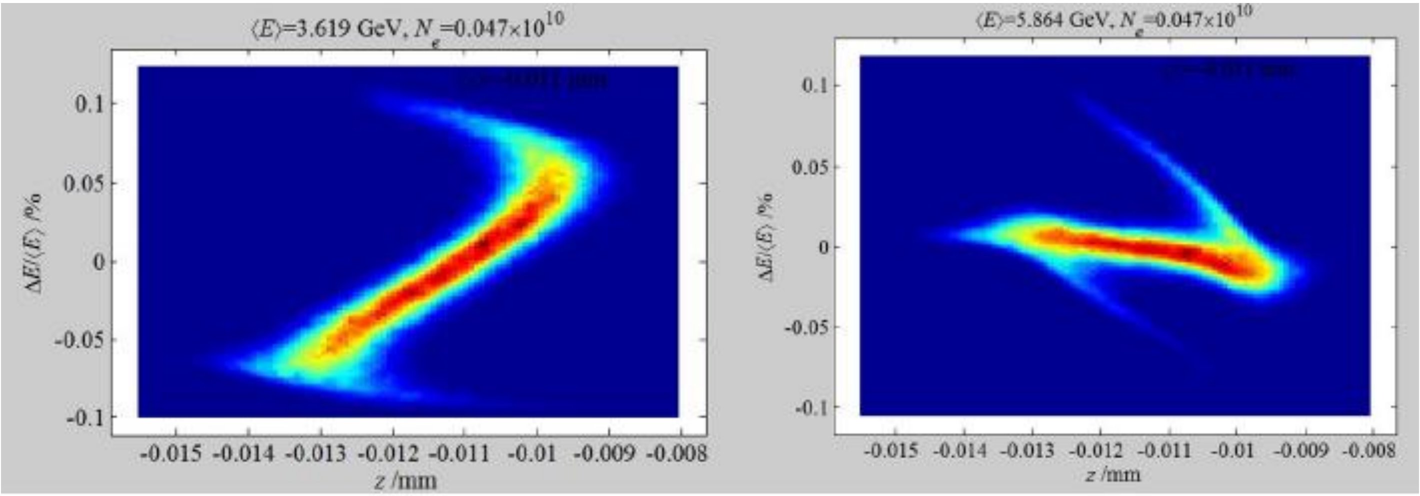
- **Hard X-ray**
  $E_{beam} \approx 2.75/3.9/5.5GeV$
  (~3 discrete working points @100Hz)

D. Dunning

Beam parameters

Parameter	Value
Max energy	5.5 GeV @100 Hz
Peak current	5 kA
Normalised emittance	0.2 mm.mrad
Bunch charge	$<$ 100 pC
RMS slice energy spread	10^{-4}
Max photon energy	16 keV
FEL tuning range at fixed energy	$\times 2$
Peak spectral brightness @16 keV	10^{33} ph/s/mm^2/mrad^2/0.1%bw

Main Electron Beam Parameters



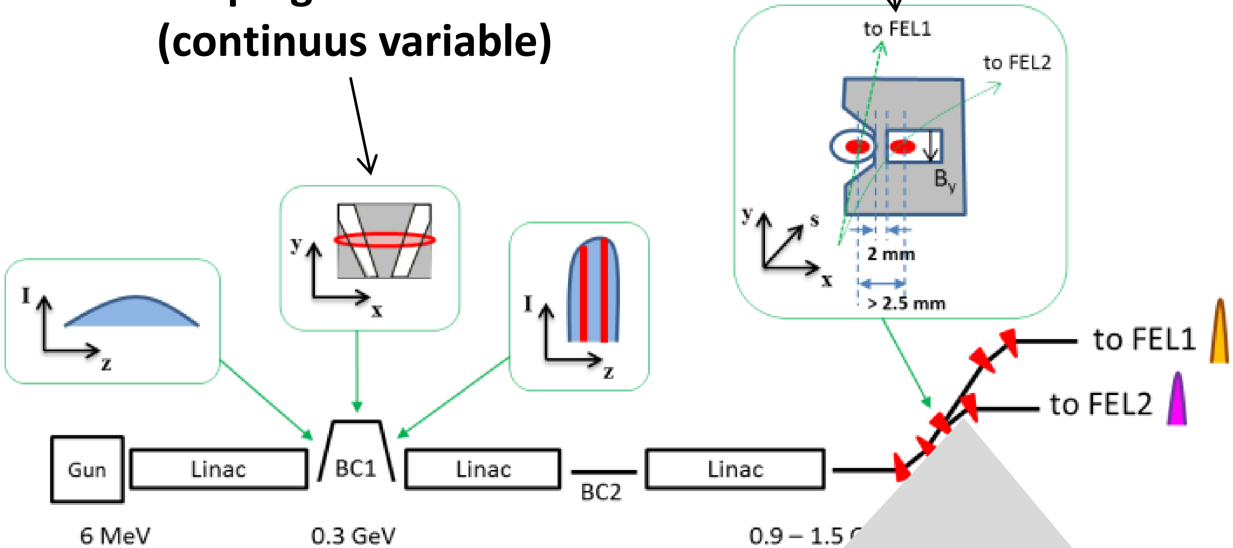
Longitudinal phase space from 1-D tracking at the exit of the linac for SXR FEL (left) and at the exit of the linac for HXR FEL (right)

S. Di Mitri

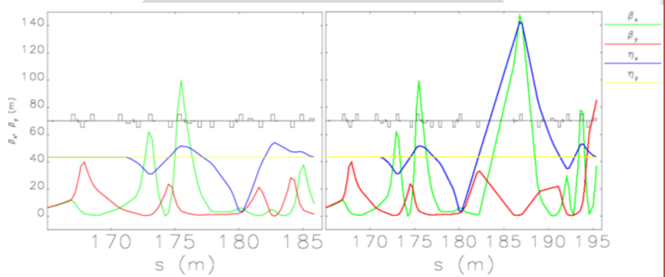
FEL Doubler

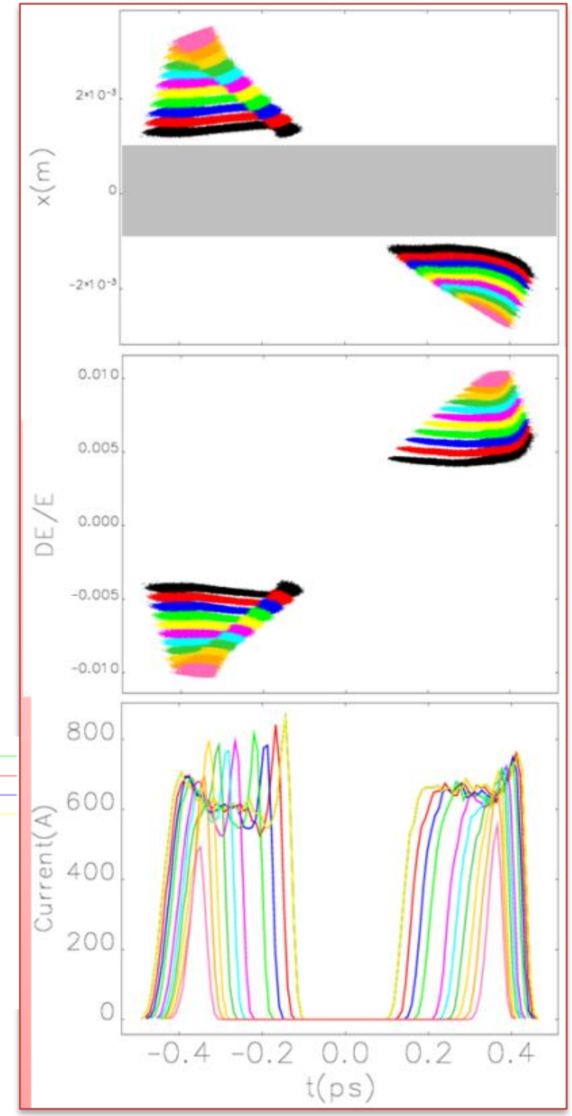
Beam scraping with a double slits (continuus variable)

Septum



Quantity	@ BC1	@ UND	Units
Charge	0.7	~0.2	nC
Mean energy	0.27	1.25	GeV
Relative energy spread, rms	2.0	< 0.03	%
Duration, fwhm	10.8	0.3	ps
Peak current (core)	650	650	A
Horizontal normalized emittance, projected rms	0.6	0.7	µm
Vertical normalized emittance, projected rms	0.6	0.6	µm
Mask slit width	1		mm
Mask apertures width	3		mm





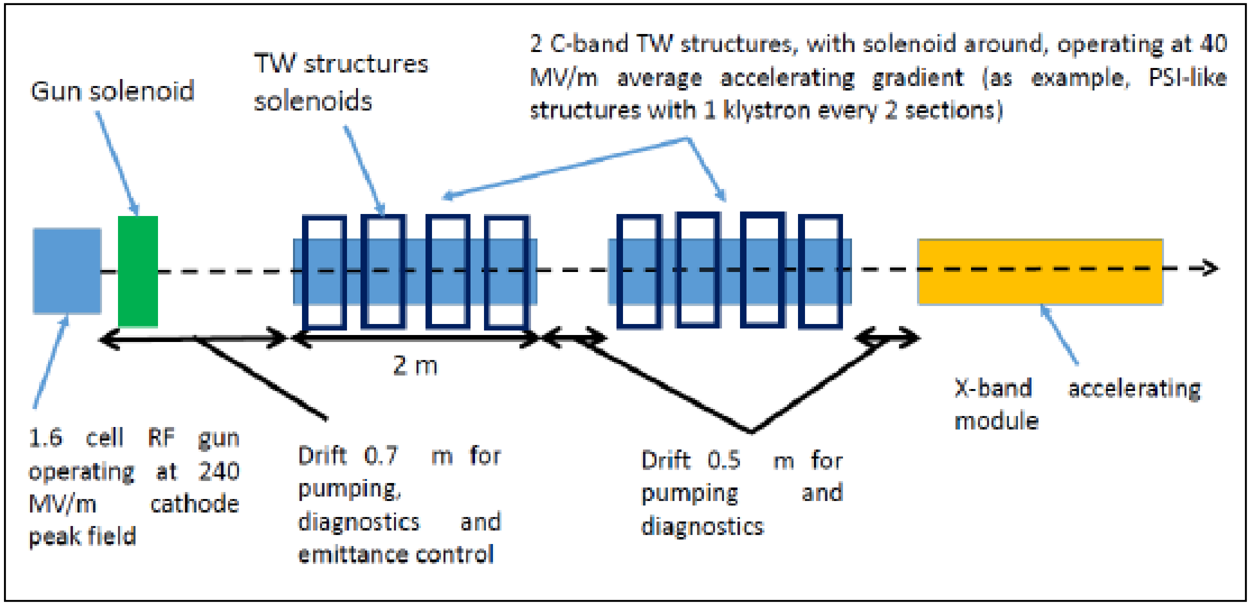
Beam brightness after scraping is almost preserved!

S. Di Mitri

C-band Injector

Parameters	Units	After VB and / or BC1
Charge (Q)	pC	75
Beam energy	MeV	300
rms bunch length (σ_t)	fs	350
Peak current ($Q/\sqrt{12}\sigma_t$)	A	60
rms Energy spread	%	0.5
Projected rms norm. emittance	μm	0.2
Repetition rate	Hz	100-1000

Expected bunch parameters at the injector exit



Schematic layout of the C-band injector

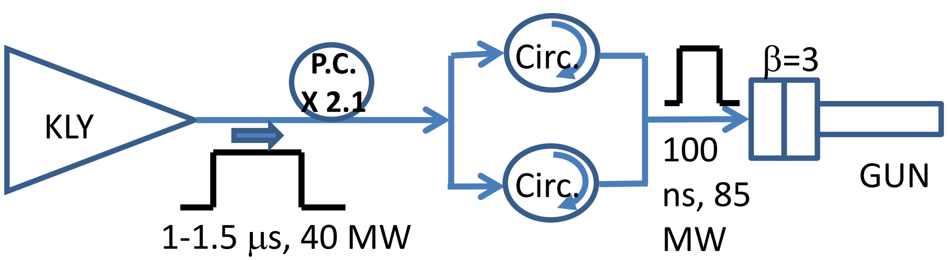
D. Alesini

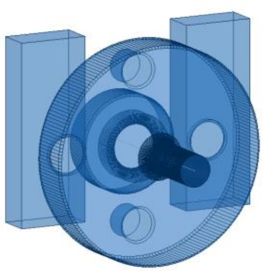
C-Band Ultra-Fast GUN Design (prel.)

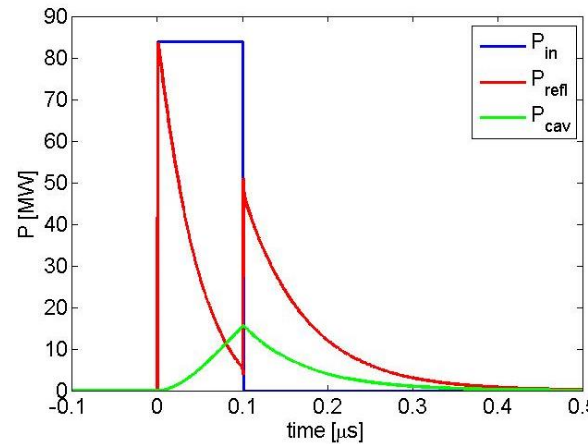
- ⇒ The **C-band injector is based on an ultra-high gradient C-band gun (1.6 cells)** operating at **240 MV/m** cathode peak field
- ⇒ We proposed to adopt an **ultra-fast gun (rf pulses <150 ns)** keeping under control all quantities that drive the breakdown phenomena (Modified Poynting vector, surface electric field, etc.)
- ⇒ The design of the overall system is based on commercially available components (klystrons, circulators, pulse compressors, ect…)
- ⇒ We have optimized the 2D profile of the cells and the input coupler exploring different solutions. An input coupler working on the TM020 mode on the full cell seems to be the best solution

Main parameters of the C-band gun (preliminary)

Parameters	Value
Resonant frequency [GHz]	5.712
$E_{cath}/\sqrt{P_{diss}}$ [MV/(mMW$^{0.5}$)]	65 (55)
RF input power [MW]	40 (70)
Cathode peak field [MV/m]	120
Repetition rate [Hz]	100
Quality factor	11000 (14000)
Filling time [ns]	150
Coupling coefficient	3
RF pulse length [ns]	180
Mode separation 0 -π [MHz]	
Pulsed heating [$^{\circ}$C]	<40
Average did. Power[W]	200

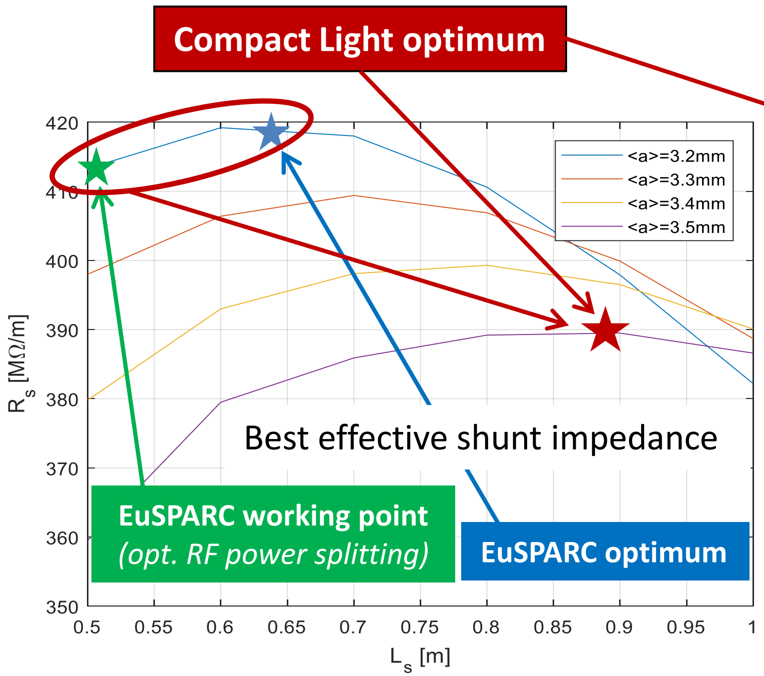


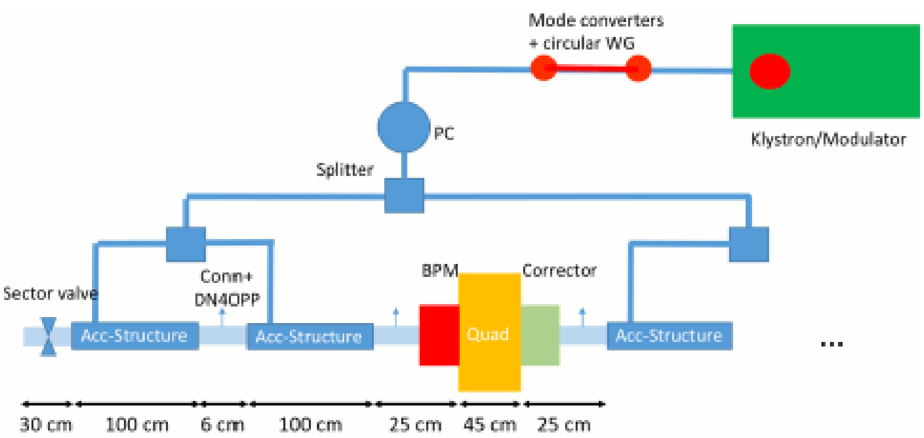




M. Croia

RF structure parameters





M. Aicheler

Freq. of 2π/3 mode [GHz]	**11.9942**
Average iris radius <a> [mm]	3.5
Total length of the TW structure L_s [m]	0.9
RF pulse [µs]	1.5
Average gradient <G> [MV/m]	**65**
Linac Energy gain E_{gain} [GeV]	5.5
Linac active length L_{act} [m]	84.7
Unloaded SLED Q-factor Q_0	180.000
External SLED Q-factor Q_E	21400
Iris radius a [mm]	4.3-2.7
Group velocity v_g [%]	4.5-1.0
Effective shunt Imp. R_s [MΩ/m]	**389**
Filling time t_f [ns]	140
Input power per structure P_{k_s} [MW]	9.8
Structures per module N_m (input power per module P_{k_m} [MW])	**4 (39)**
Total number of structures N_{tot}	**100**
Total number of klystrons N_k	**25**

A. Gallo

Towards higher rep rate operation

Different scenarios under investigations:

1st scenario (1 klystron x LINAC Module): **RF pulse shortening**

50 MW, 1.5 μs, 100 Hz $\langle E_{acc} \rangle$ = 65 MV/m	→	50 MW, 140 ns, 220 Hz $\langle E_{acc} \rangle$ = 30 MV/m

- Linac energy downgraded to ≈ 45% of the max value @ 220 Hz rep rate;
- Not flexible: as soon as the SLED is removed the gradient is reduced by a factor ≈2.2;
- Max rep rate very much dependent on modulator dead time τ_{trans}

2nd scenario (1 klystron x LINAC Module): **klystron peak power reduced**

50 MW, 1.5 μs, 100 Hz	→	**1.5 μs, 10 MW, 200 Hz** **1.5 μs, 5 MW, 250 Hz**	→	**$\langle E_{acc} \rangle$ = 29 MV/m @ 200 Hz** **$\langle E_{acc} \rangle$ = 20.5 MV/m @ 250 Hz**

- Linac energy downgraded to ≈ 30% of the max value @ 250 Hz rep rate;
- Flexible: different compromises between rep rate and RF peak power explorable;
- Klystron operated in a wide range of working points (realistic?)

3rd scenario (2 klystrons x LINAC Module): **- high rep rate/reduced peak power klystrons**
- low rep rate/HP klystron

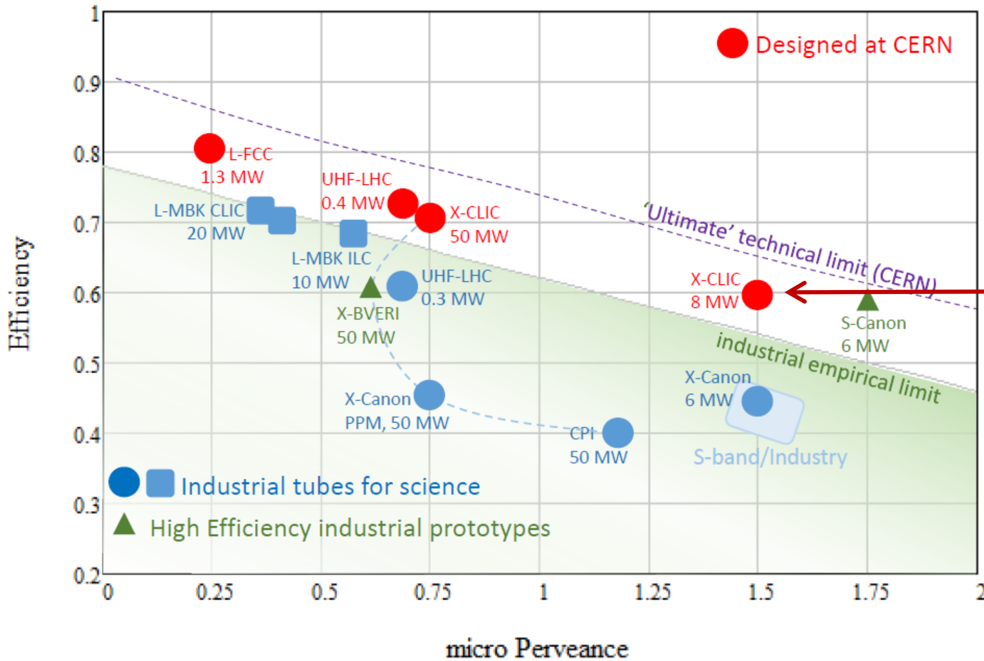
CANON E37113 klystron, 6 MW 1.5 μs, 1 KHz + CPI VKX 8311A	→	$\langle E_{acc} \rangle$ = 65 MV/m @ 100 Hz $\langle E_{acc} \rangle$ = 23 MV/m @ 1 kHz

- …………?????

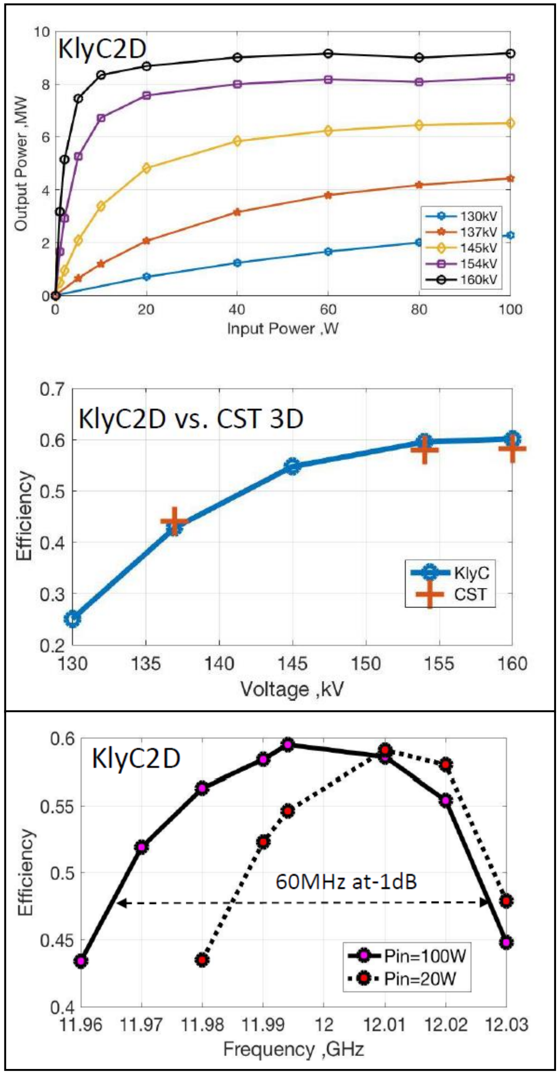
More detailed studies needed!

A. Gallo

Klystron efficiency/perveance map



8-9 MW X-band klystron from industry



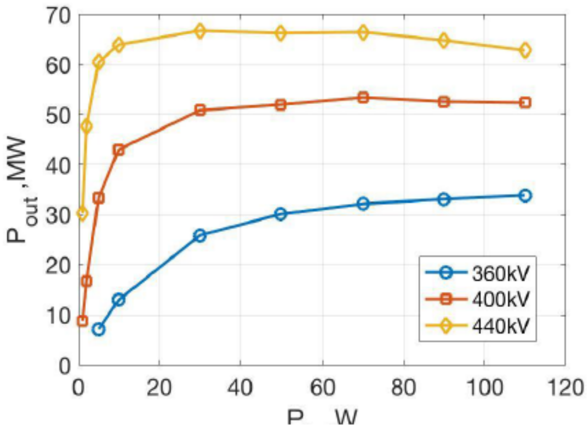
- **The HE retrofit design shall provide up to 10 MW (170 kV) peak RF power**.
- The existing gun is re-used, thus in DC mode the limits on avarage power will be similar. **With 2.5 µsec pulses** (typical in Xbox3 with pulse comporessor), **the rep rate could be doubled (800 Hz)** with out any modifications.
- **With intellegent operation (rep. rate shall be reduce when switcjing from RF to DC mode**), the 1.5 kHz will accesible without modificationson of the klystron design.
- **Special care shall be given to the window design that shall to be adopted to the high avarage power.**

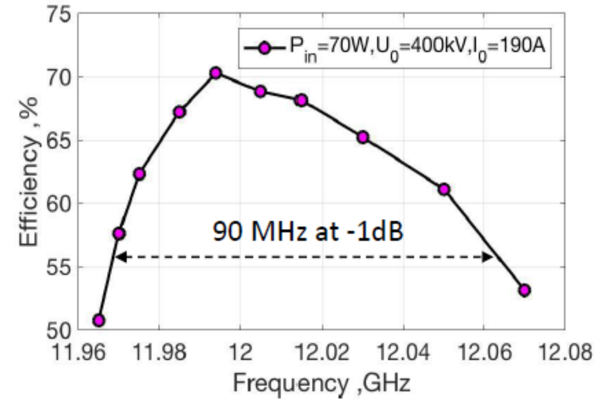
I. Syratchev, J. Cai

High efficiency klystrons

The 50 MW HEX klystron progress summary

Parameter	Target value	KlyC/2D
Frequency, GHz	11.994	11.994
Voltage, kV	400	400
Current, A	190	190
Perveance, $\mu AV^{-3/2}$	0.75	0.75
Efficiency, %	~70	**70.2**
Power, MW	53	**53.4**
Surface E field, MV/m	≤ 100	**<100**
Pulse length, ns	2000	2000
Power gain, dB	> 55	**58.8**
Cathode loading, A/cm^2	< 5	**4.74**





The final design is communicated to industry (CPI) for the final evaluation.

The HE design has lower (almost a factor 2) beam power for the same peak RF output power. The rep. Rate can be double (200Hz) in straightforward way without any modifications of collector and/or cooling system

I. Syratchev, J. Cai

Conclusions

- ✓ Thanks to all the Partners, the project is running well and all the WPs are progressing according to the time schedule.
- ✓ Advanced and challenging FEL schemes have been proposed and are under investigation.
- ✓ A big effort to check the possibility to operate the SXR facility at high repetition rate needs to be addressed asap.
- ✓ Our main objective for the coming months is to finalize the CompactLight Design, therefore a strong effort will be required. We are facing a very intense and stimulating period…….!

Thanks to all of YOU!

Funded by the European Union

Compact

Thank you!

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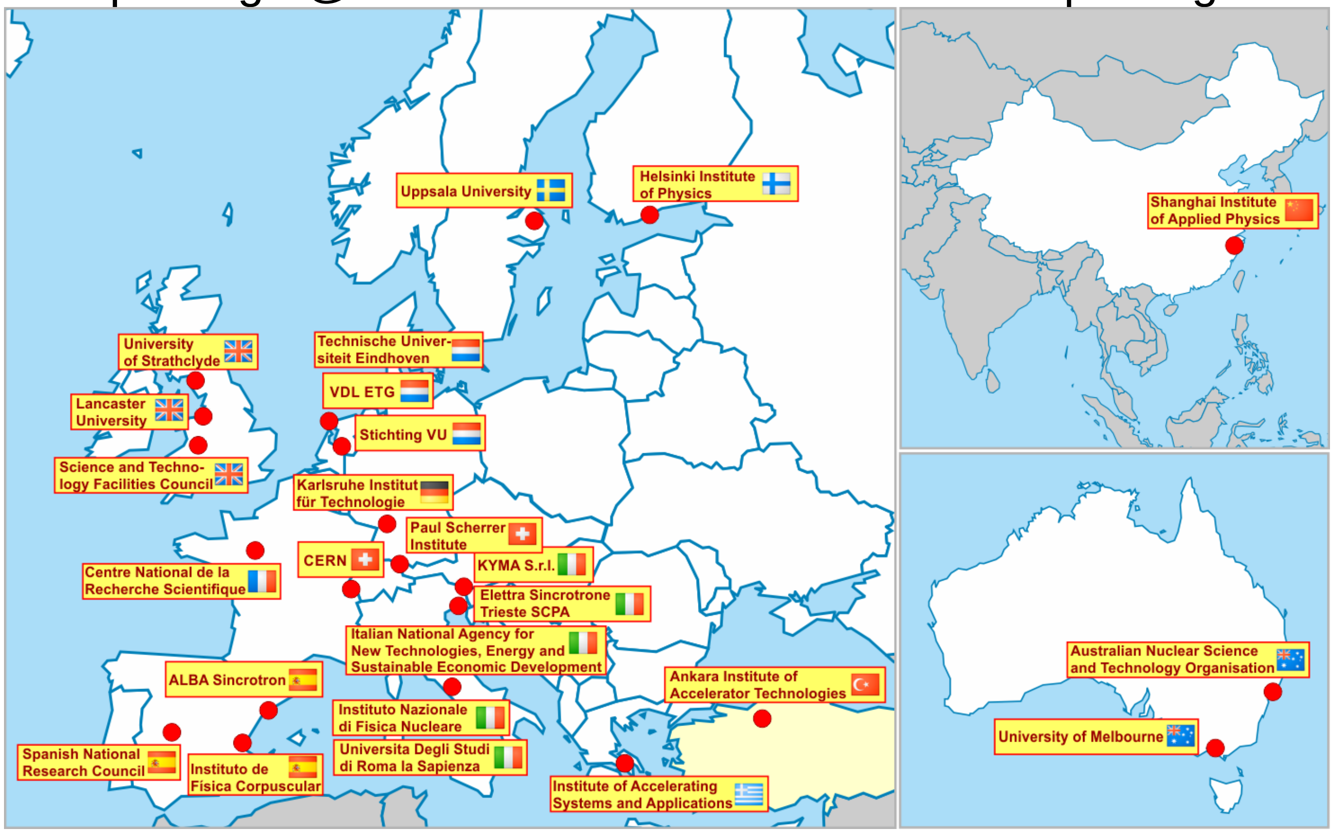

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