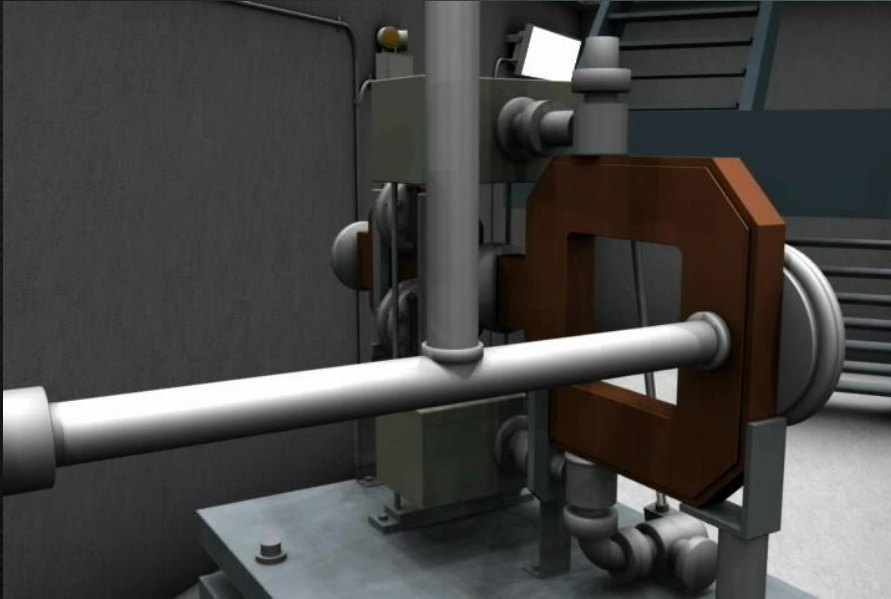


# WP3 – Gun and Injector

Massimo.Ferrario@LNF.INFN.IT



- Laser/Photocathode
- RF/DC Gun
- Solenoid
- RF Velocity Bunching

- RF Linearizer and L. Heater
- Magnetic Chicane
- Transv. RF Deflector
- Beam Diagnostics

- To design the Compact High Brightness Injector
- To design the proper matching with the X-band Linac



Funded by the European Union

Compact 

XLS-Report-2019-001  
27 June 2019

## XLS Deliverable D3.1

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

M. Ferrario<sup>1)\*</sup>, D. Alesini\*, F. Cardelli\*, G. Castorina\*,  
M. Croia\*, M. Diomedea\*, A. Gallo\*, A. Giribono\*

N. Gazis, E. Tanke and E. Trachanas, IASA

R. Hoekstra, T. Lucas, ARCNL

P. Mutsaers, TU/e

A. Paganoni\*, G. Leoni\*, G. Lodi\*, M. Bortolan\*,  
C. Blanch<sup>††</sup>, J. Fuster<sup>††</sup>, B. Gimeno<sup>††</sup>

On behalf of the CompactLight Partnership

Prepared on: 27.06.2019

\* INFN, Italy, <sup>†</sup> ST, Italy, <sup>‡</sup> CERN, Switzerland, <sup>§</sup> STFC, UK, <sup>¶</sup> IASA, Greece, <sup>||</sup> UA-IAT, Turkey,  
<sup>\*\*</sup> TU/e, Netherlands, <sup>††</sup> CNRS, France, <sup>†††</sup> CSIC, Spain

<sup>1</sup>Corresponding author: massimo.ferrario@inf.infn.it



Funded by the European Union

Compact 

XLS-Report-2019-001  
25 June 2019

## XLS Deliverable D3.2

Review report on bunch compression techniques and phase space linearization

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

On behalf of the CompactLight Partnership

Prepared on: 25.06.2019

\* Sincrotrone Trieste, Italy, <sup>†</sup> CERN, Switzerland, <sup>‡</sup> INFN-LNF, Italy, <sup>§</sup> LAL, France,  
<sup>¶</sup> ALBA-CELLS, Spain, <sup>||</sup> Sapienza, Italy, <sup>\*\*</sup> INFN-Roma, Italy

<sup>1</sup>Corresponding author: simone.dimitri@elettra.eu

# Agenda WP3

- M. Ferrario, INFN-LNF, "Introduction" 10'
- S. Di Mitri, Sincrotrone Trieste, "Review of magnetic bunch compression schemes for CompactLight, " 10'
- D. Alesini, INFN-LNF, "C-band gun design and high repetition rate challenges", 10'
- A. Latina, CERN, "Compact S+X injector scheme", 10'
- B. G. Martinez, IFIC, "X-band RF electron gun injector design", 10'
- B. Spataro, INFN-LNF, "A possible electron gun for the 35 GHz klystron", 10'
- E. Gazis, IASA-ESS, "3D design efforts for the e-gun", 10'
- Discussion (all), 20'



## Contents

<b>1</b>	<b>Work carried out &amp; Overview of the progress</b>	<b>4</b>
1.1	General Project Objectives	4
<b>2</b>	<b>Exploitation &amp; Dissemination: Update</b>	<b>17</b>
<b>3</b>	<b>Data Management Plan: Update</b>	<b>18</b>
<b>4</b>	<b>Deviations from Annex 1 &amp; Annex 2</b>	<b>19</b>
4.1	Tasks & Objectives	19
4.1.1	Workpackage 1	19
4.1.2	Workpackage 2	19
4.1.3	Workpackage 3	19
4.1.4	Workpackage 4	19
4.1.5	Workpackage 5	19
4.1.6	Workpackage 6	19
4.1.7	Workpackage 7	19
4.2	Use of resources	20
4.2.1	Partner P22, UH/HIP	20
4.2.2	Partner Pyy, Acronym	20
4.2.3	Partner Pzz, Acronym	20
4.3	Unforeseen subcontracting	20
4.3.1	Partner Pxx, Acronym	20
4.3.2	Partner Pyy, Acronym	20
4.3.3	Partner Pzz, Acronym	20
4.4	Unforeseen use of in kind contribution from third party against payment or free of charges	20
4.4.1	Partner Pxx, Acronym	20
4.4.2	Partner Pyy, Acronym	20
4.4.3	Partner Pzz, Acronym	21

### Work carried out:

- Coordinated by WP Leaders for their WF
- Review by WP partners and PCO

This work was partially supported by the European Union’s Horizon 2020 Research and Innovation programme under grant agreement No 777431 (XLS).

### Objectives & Impact:

Draft by LP  
Review by PCO

### Deviations in WPs:

- Coordinated by WP Leaders for their WP
- Review by WP partners and PCO

### Exploitation Plan:

- Draft by Regina
- Review by WP7 partners and PCO

### Other deviations:

- Concerned partners
- Review by PCO

### Data Management:

- Draft by Andrea
- Review by Communication Group and PCO





## Each Partner

- Partner Activity Reports:
  - send to WP Leaders
  - review relevant WPs
  - Integrate continuous report tables (if needed)

Deadline **15 July 2019**

- Describe and explain any deviations (subsections 4.2 - 4.4):
  - use of resources
  - unforeseen subcontracting
  - unforeseen use of resources from 3<sup>rd</sup> parties
  - Overleaf link: ask Regina

Deadline **15 July 2019**

- Partner's financial report:
  - prepare and submit
  - check PFSIGN

Deadline: **09 August 2019**

## Work Package Leaders

- Activity Report for WPs (subsections of 1.2):
  - collect contributions from WP partners (if needed)
  - prepare WP report in Overleaf

Deadline **20 July 2019**

- Deviation in the WPs (subsections of 4.1):
  - describe and explain, including contingency measures (if needed)
  - insert in Overleaf

Deadline **20 July 2019**

- General Review:
  - review and agree all parts of report

Deadline: **09 August 2019**

## PC, DPC, and AC

- Prepare General Parts:
  - drafts for structured tables
  - sections 1.1 (objectives) and 1.3 (impacts)
  - update of exploitation plan (section 2)
  - update of DMP (section 3)

Deadline: **25 July 2019**

- Send Report for Review:
  - Agree report with PCO
  - Agree report with partners

Deadline: **09 August 2019**

- Financial Reporting:
  - review partner reports
  - prepare summary financial statement

Deadline: **09 August 2019**

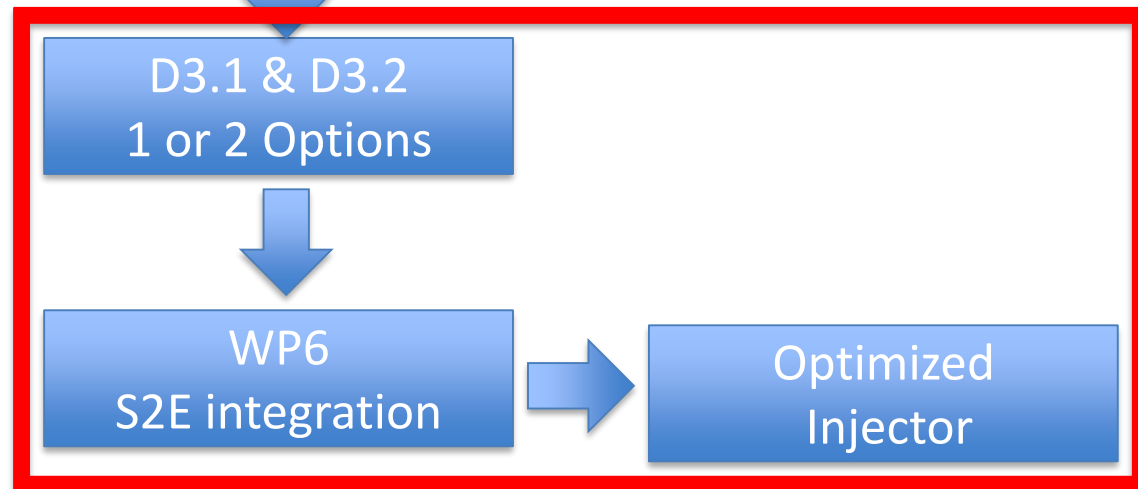
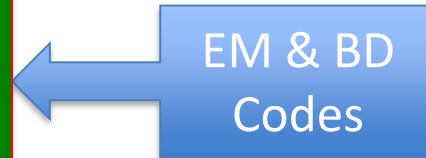
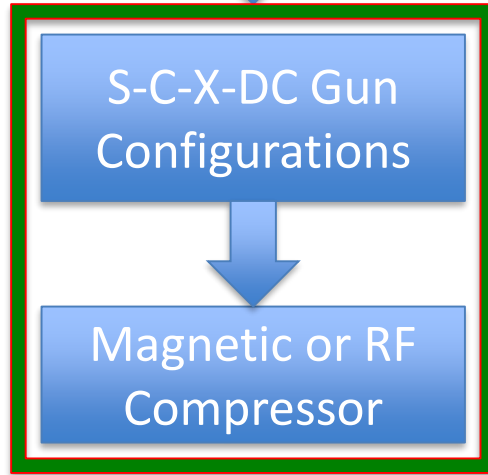
Report Submission:

**16 August 2019**

# Next Deliverables

- **D3.1** - Preliminary assessments and evaluations of the optimum e-gun and injector solution for the CompactLight design, (**=>M18**).
- **D3.2** – A review report on the bunch compression techniques and phase space linearization, (**=>M18**).
- **D3.3** – Design of the injector diagnostics/beam manipulations based on a X-band cavities, (**=>M36**).
- **D3.4** - Design of the CompactLight e-gun and injector, with phase space linearizer (**=>M36**).

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



# Reference Parameter List

**New:** 2 bunches challenge

Injector capability 100 – 1000 KHz

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





# Laser Comb technique: generation of a train of short bunches

(Parmela code)

Charge vs. Time

Energy vs. Time

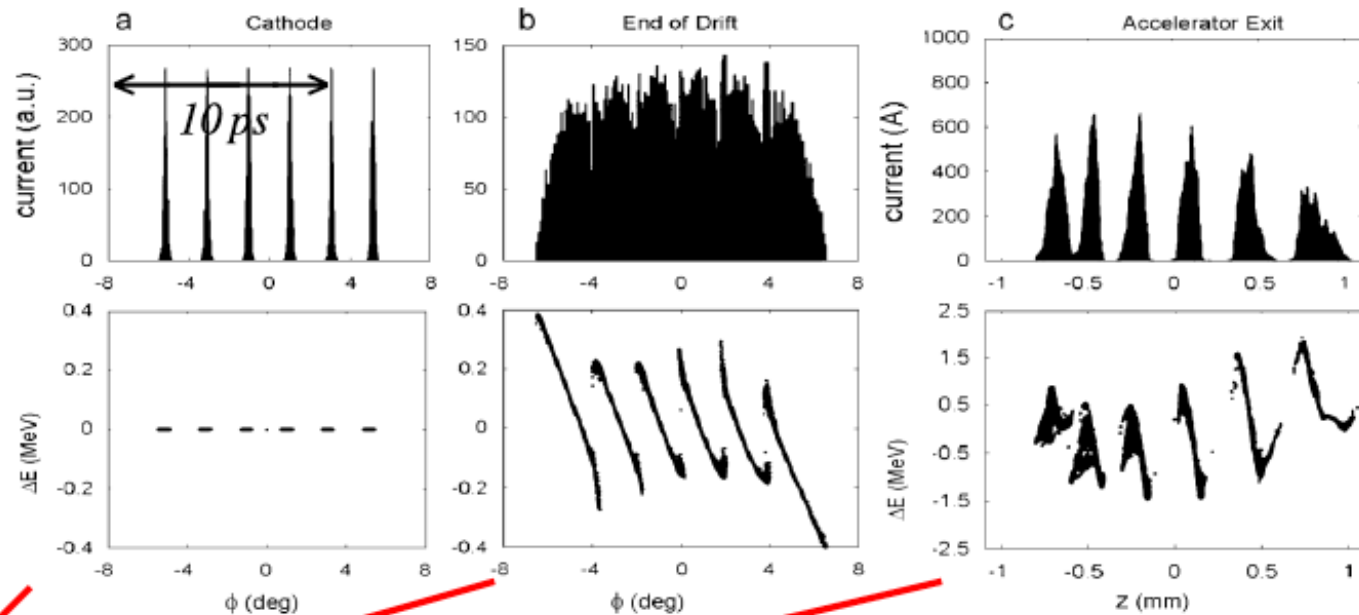
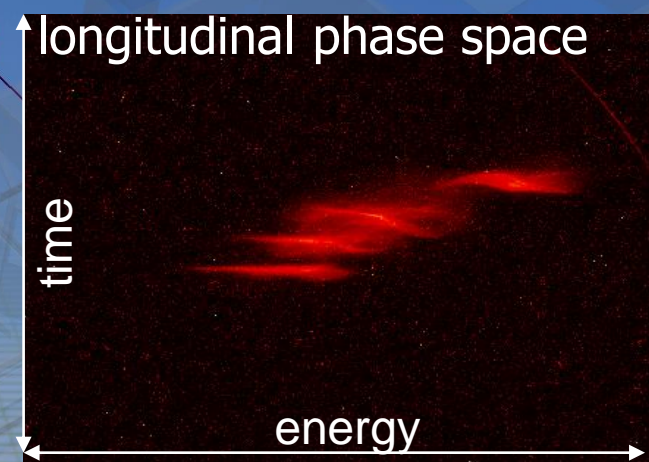
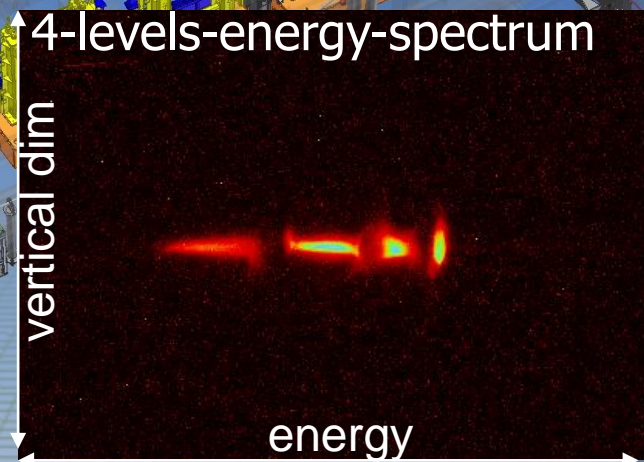
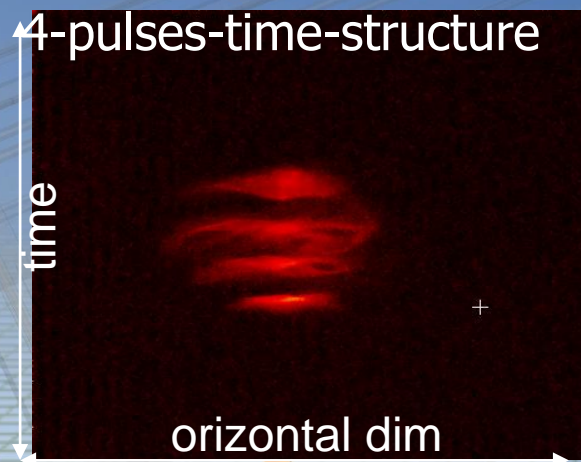
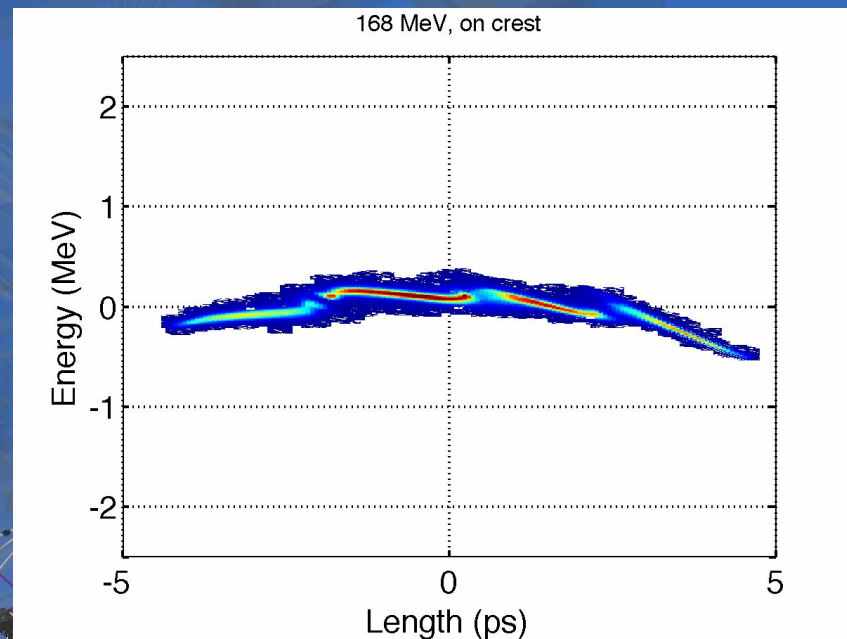
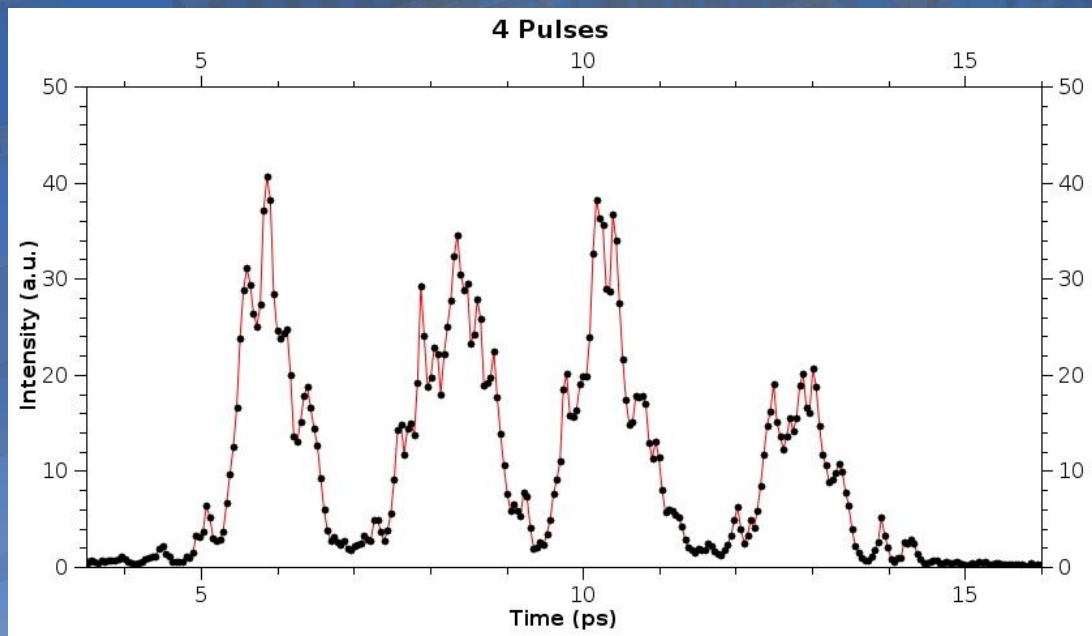


Fig. 1. Evolution of a six bunches electron beam train: the columns from left refer, respectively, to (a) the cathode, (b) the end of the drift at 150 cm and (c) the end of linac at 12 m far from cathode. The rows from top refer, respectively, to longitudinal profile and to energy modulation  $\Delta E$  (MeV).



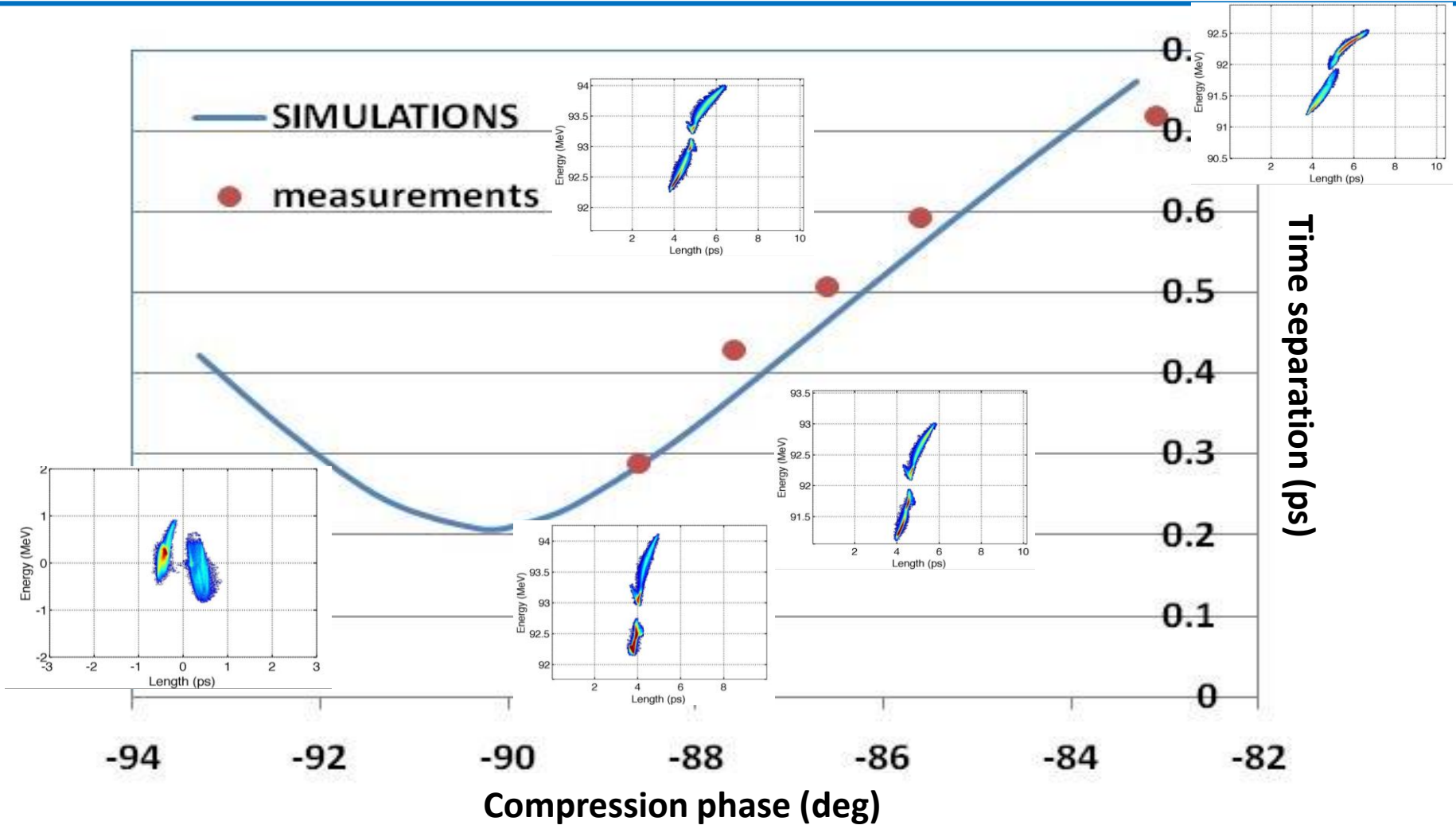
- P.O.Shea et al., Proc. of 2001 IEEE PAC, Chicago, USA (2001) p.704.
- M. Ferrario, M. Boscolo et al., Int. J. of Mod. Phys. B, 2006

# Laser COMB: experimental results



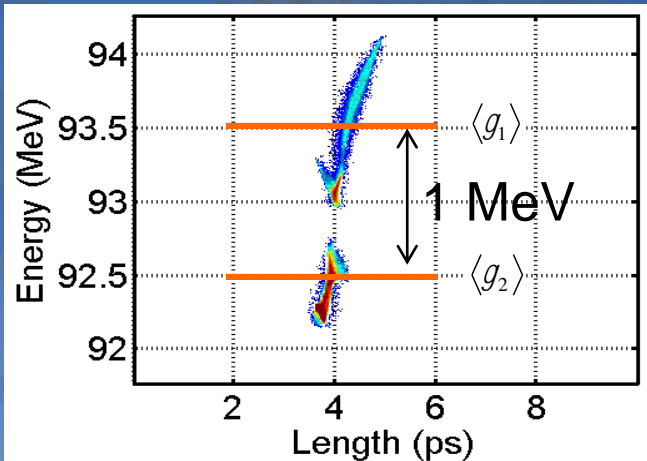
- M. Ferrario et al., Nucl. Inst. and Meth, A 637 (2011)
- A. Mostacci et al., Proc. of IPAC 2011, Spain

# Longitudinal Dynamics: Compression Curve





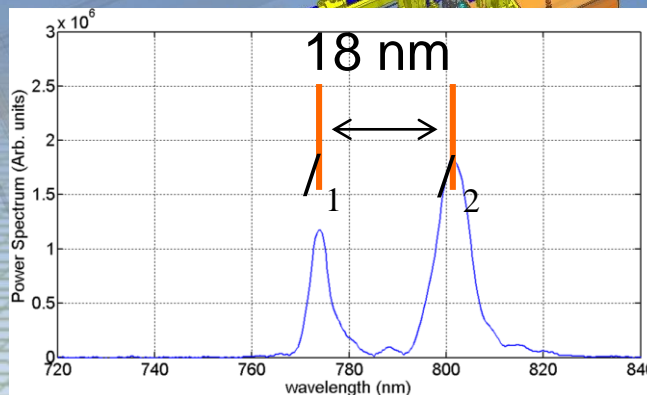
# TWO COLORS SASE FEL



two bunches with a two-level energy distribution and time overlap (Laser COMB tech.)

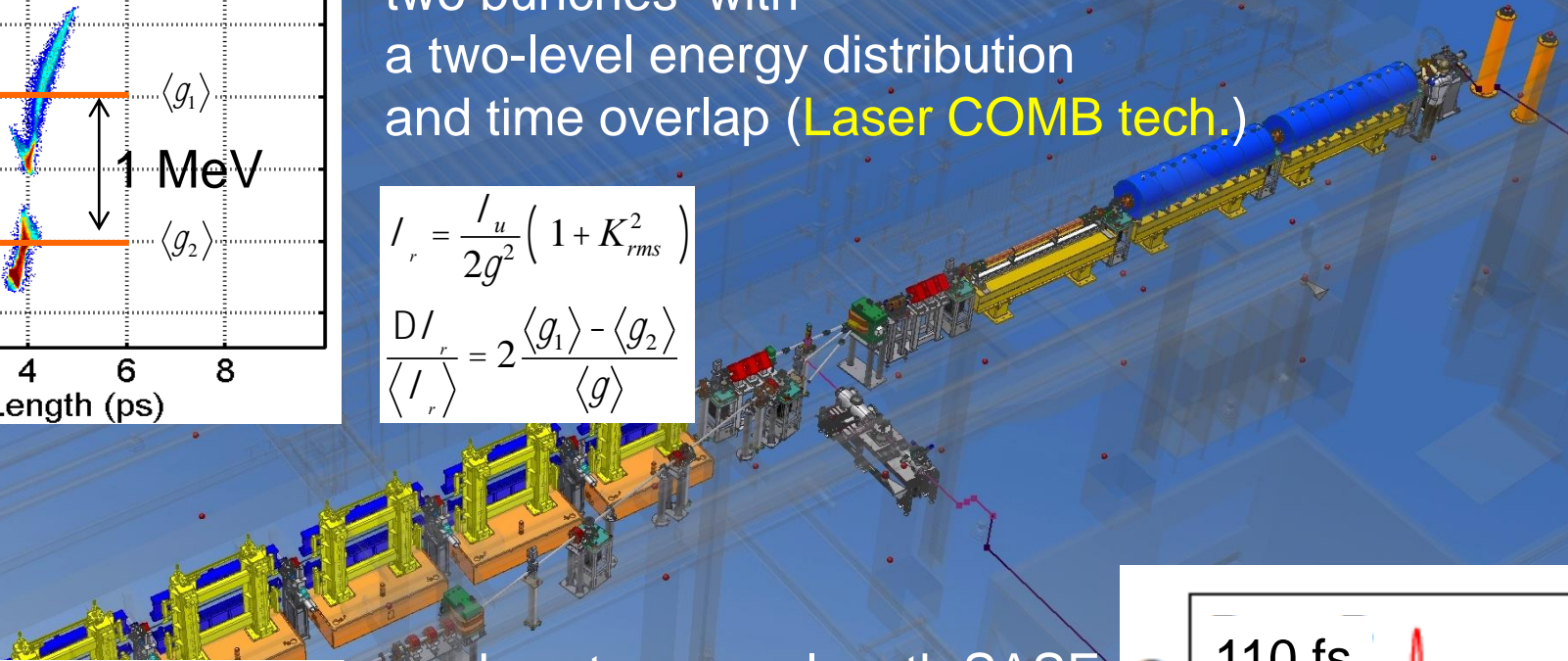
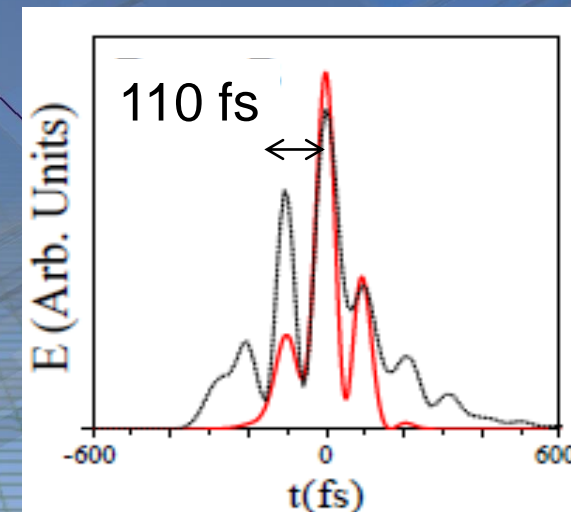
$$I_r = \frac{I_u}{2g^2} (1 + K_{rms}^2)$$

$$\frac{D/I_r}{\langle I_r \rangle} = 2 \frac{\langle g_1 \rangle - \langle g_2 \rangle}{\langle g \rangle}$$



produce two wavelength SASE-FEL radiation with time modulation

$$Dt = \frac{I_u (1 + K_{rms}^2)}{4c \langle g \rangle \langle g_1 \rangle - \langle g_2 \rangle}$$



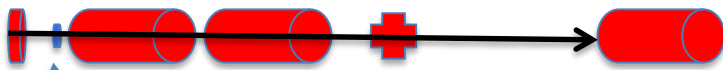
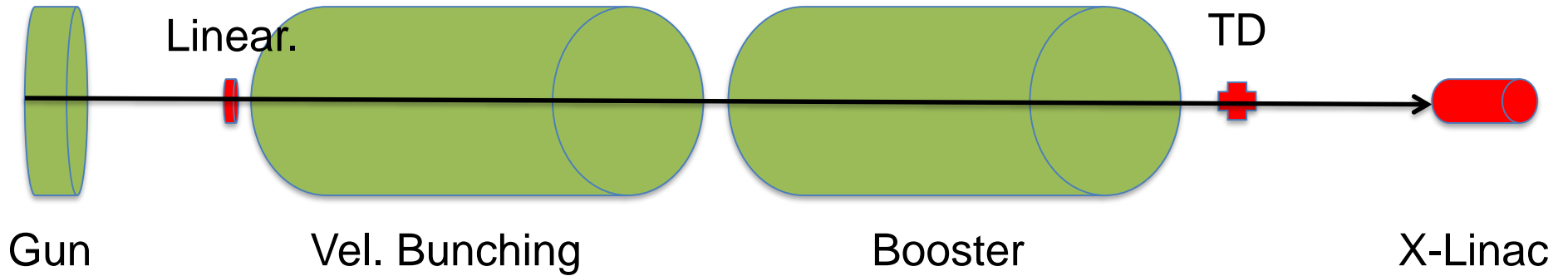
# Tasks and sub-Tasks

(task leaders institutes in **bold**)

- **Task 3.1 - Gun Design (RF, Solenoid, Cathode, Laser, Diagnostics) => D3.1 M18 => D3.4 M36**
  - a) S-Band Gun RF Design (**CNRS** + IASA+UAIAT-INFN+ALBA )
  - b) C-Band Gun RF Design (**INFN** +IASA+Sapienza)
  - c) X-Band Gun RF Design (**CSIC-IFIC** + UAIAT+ Sapienza)
  - d) DC Gun Design (**TU/e** )
  - e) Laser/Photocathode (**IASA**+CNRS+INFN )
- **Task 3.2 - Compressor Design (Velocity Bunching, Magnetic Chicane) ) => D3.2 M18 => D3.4 M36**
  - a) S-Band Velocity Bunching (**TU/e** + IASA+ALBA)
  - b) C-Band Velocity Bunching (**INFN** +IASA+TU/e )
  - c) X-Band Velocity Bunching ( **Sapienza**+CERN+IASA+INFN )
  - d) Magnetic Compressor (**ST** + CERN+INFN+CNRS)
- **Task 3.3 – X-Band Transverse RF Deflector (Sapienza+ IASA+ ) => D3.3 M36**
- **Task 3.4 - : RF Linearizer Design => D3.2 M18 => D3.3 M36**
  - a) X-Band RF Linearizer Design (**Sapienza** )
  - b) K-Band RF Linearizer Design (**ULANC** +Sapienza )
  - c) Passive linearizer (**CNRS** )

# Configurations with Velocity Bunching

S-band , C-band , X-band , K-band

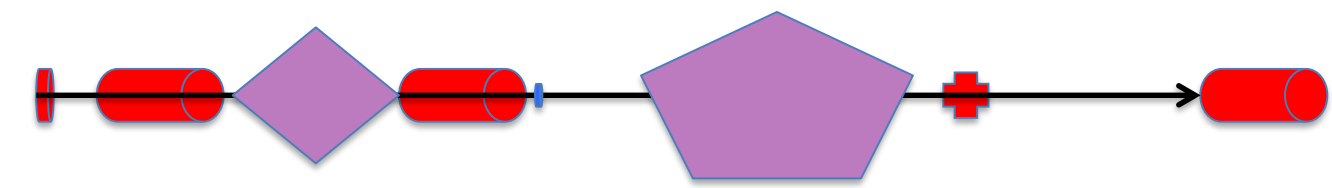
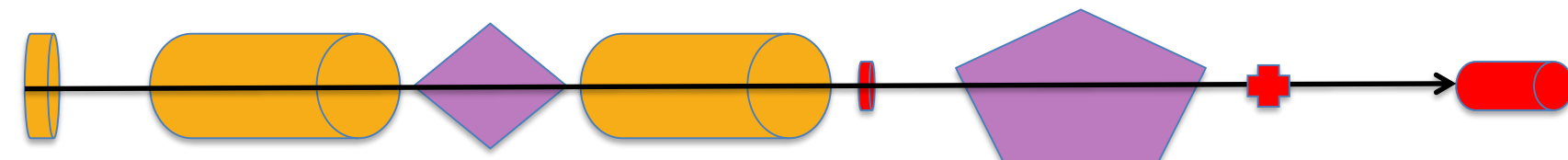
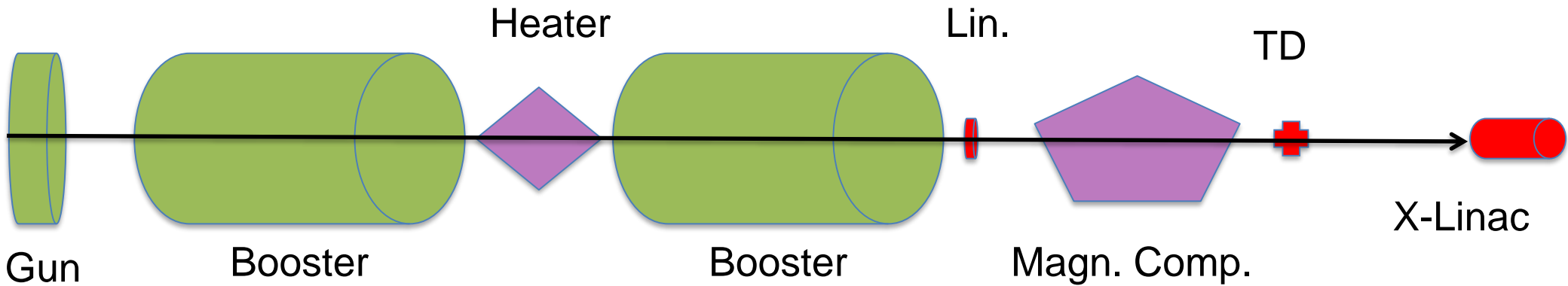


K-Linear.



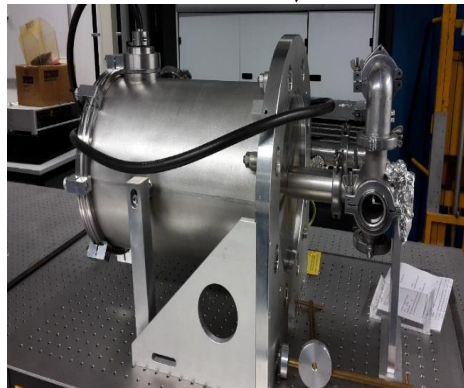
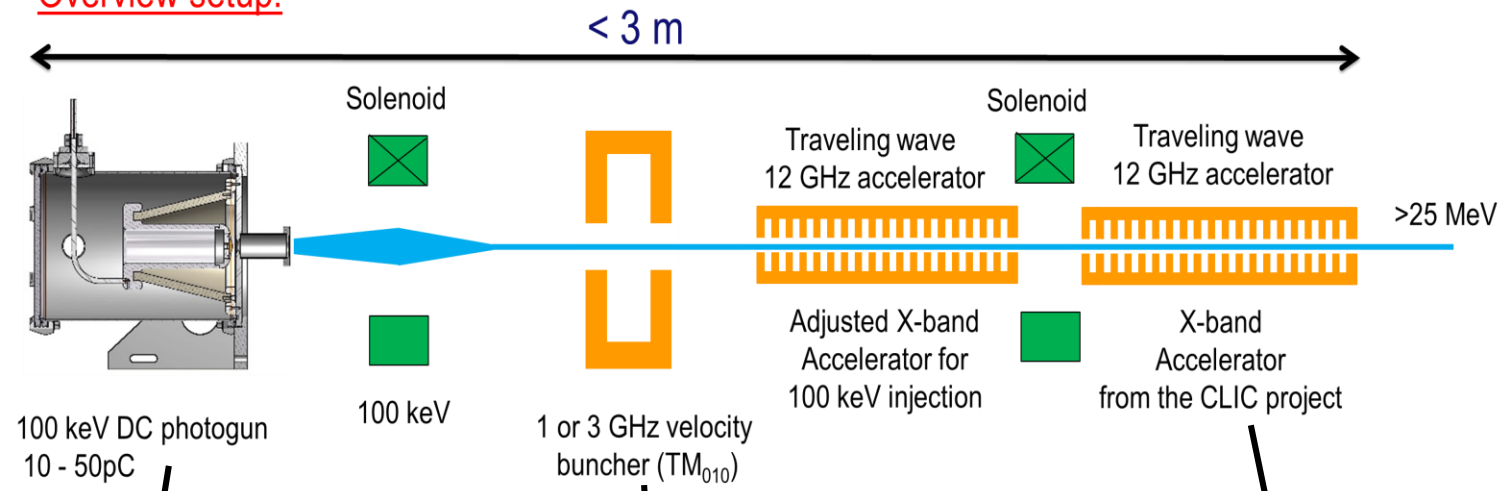
# Configurations with Magnetic Compressor

S-band , C-band , X-band , K-band

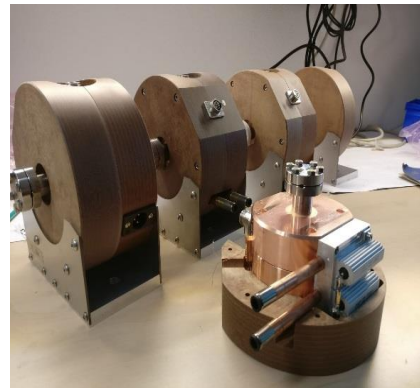


# DC gun

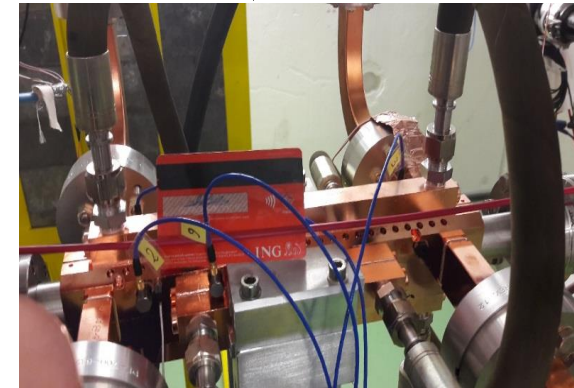
Overview setup:



Made by ACCTEC



Made by ACCTEC



CLIC accelerator

<https://conferences.pa.ucla.edu/hbb-2019/index.html>

# “High Brightness Beam Physics”

7-11 April 2019

Crete – Greece



Thanks for your collaboration

**Compact**  