Funded by the
European Union

DC electron gun as an injector for an X-band FEL

Thomas Lucas

on behalf of ARCNL and TU/e

Overview

1. Introduction
2. Set-up
3. X-band Accelerating Structure Design
4. GPT Simulations
5. Next Steps
   I. Simulations
   II. Test Setup
6. Conclusion

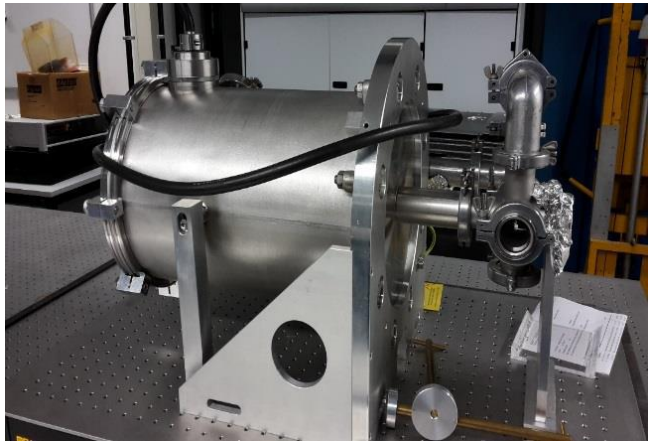
Introduction

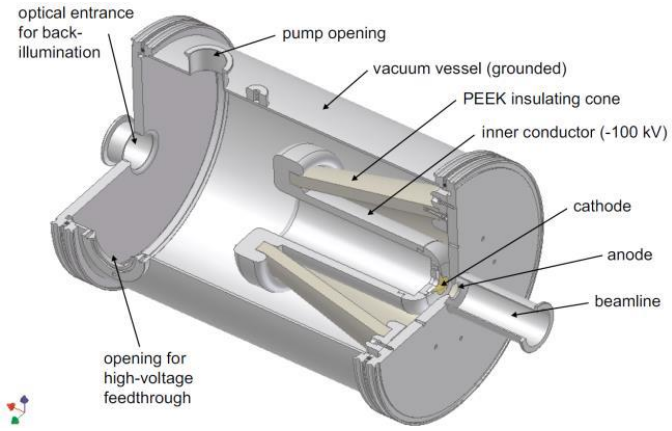
A DC photo-gun has previously been developed by the Coherence and Quantum Technology (CQT) group at Eindhoven.

This investigation looks at the possibility of using one of these photo-guns as an injector for an X-band FEL.

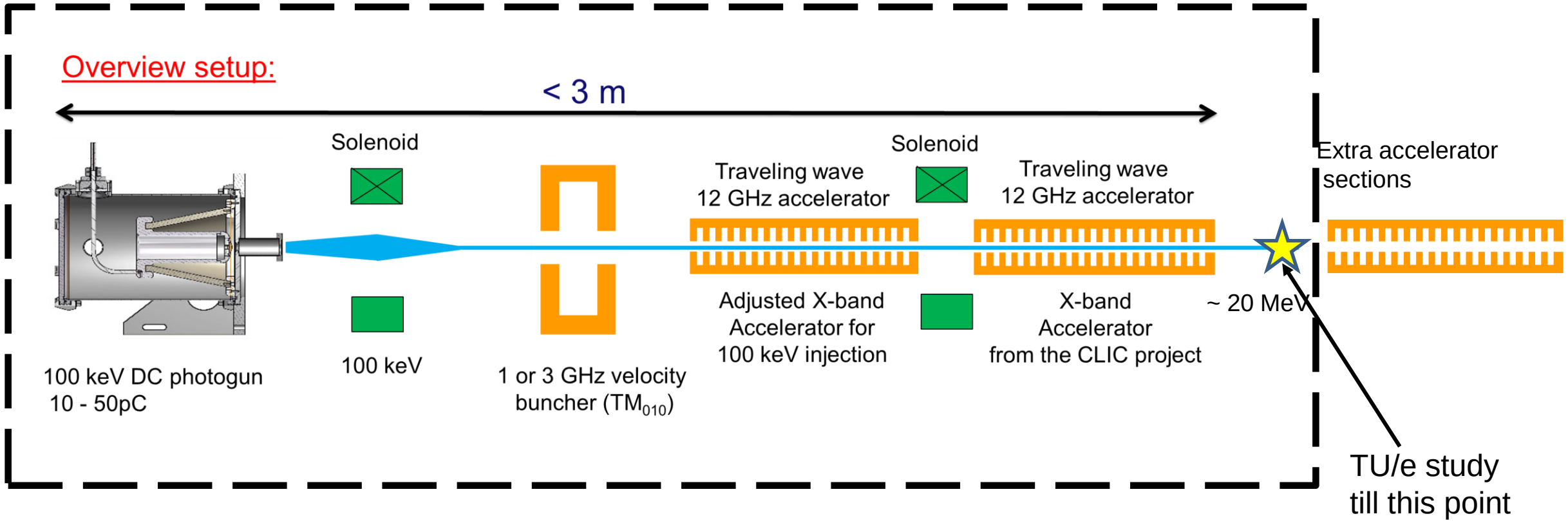
Benefits of the DC photogun:

- Cost effective injection and bunch method.
  - Low energy bunching significantly simpler!
- High reliability and robustness.

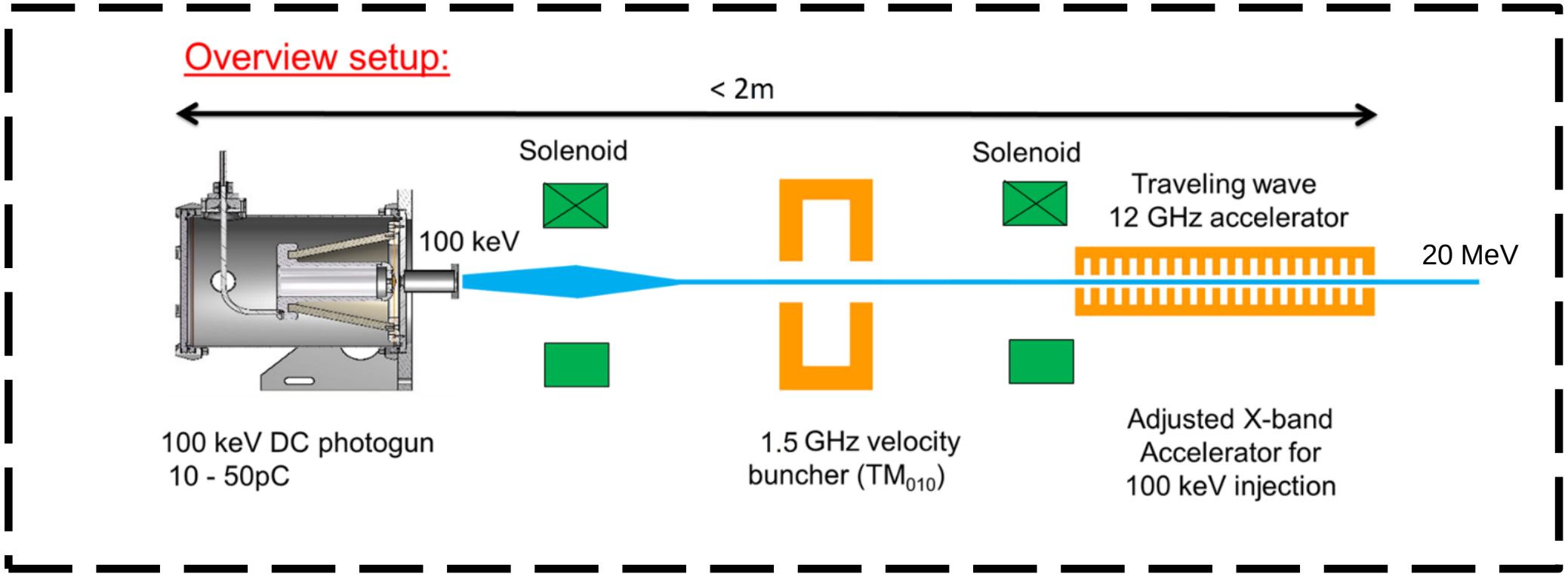


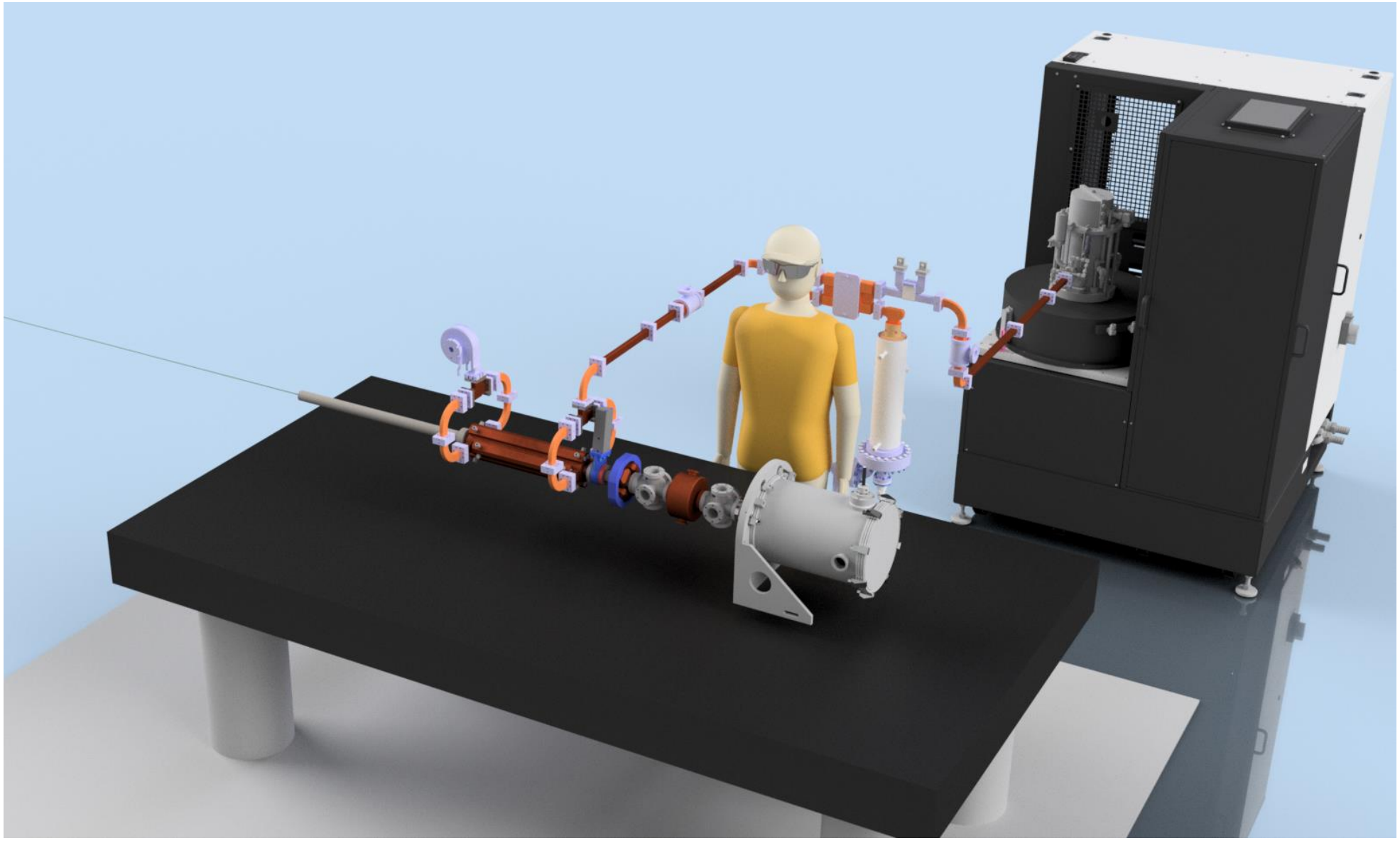


Original idea for CompactLight @ Eindhoven University of technology

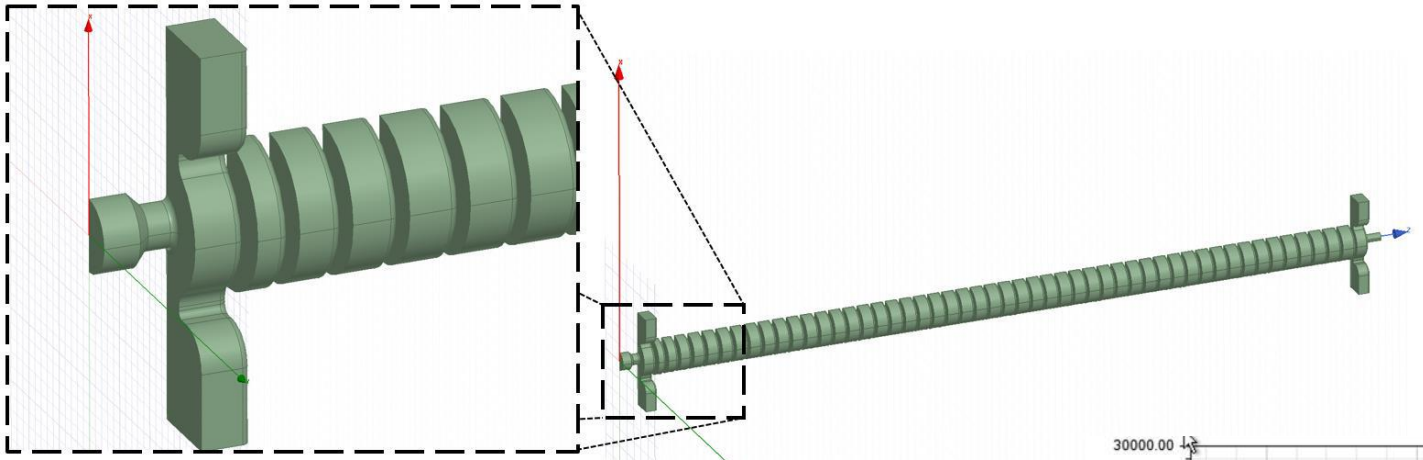


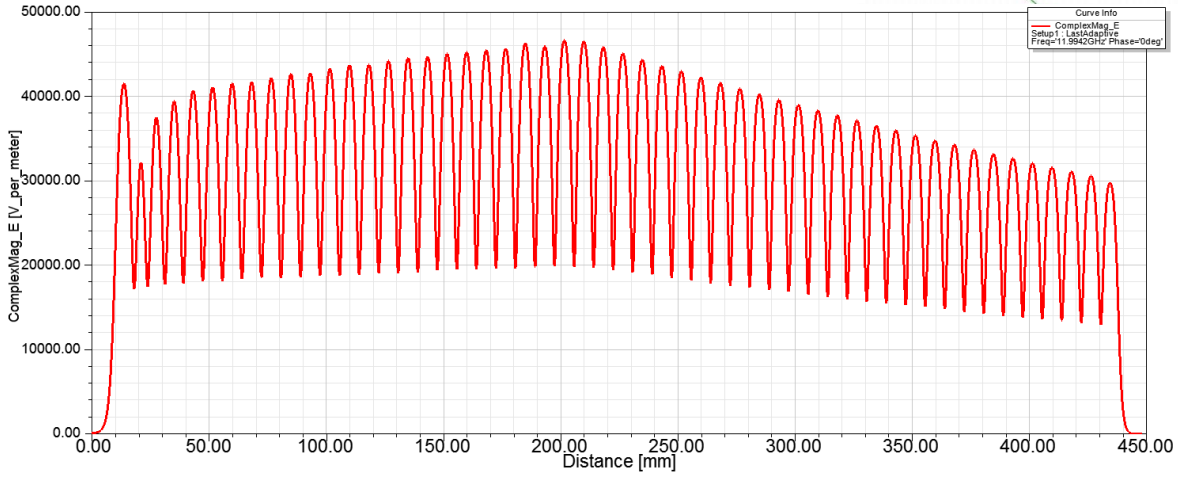
DC Electron Gun Injector

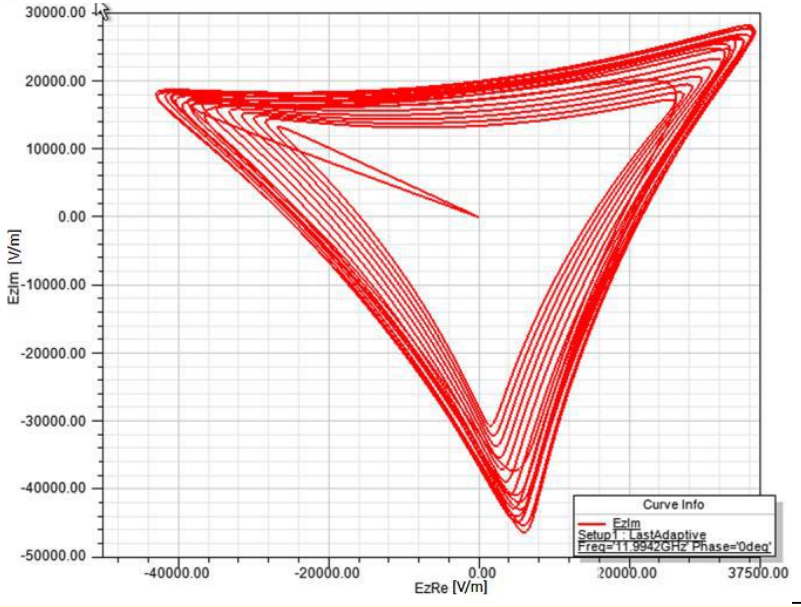




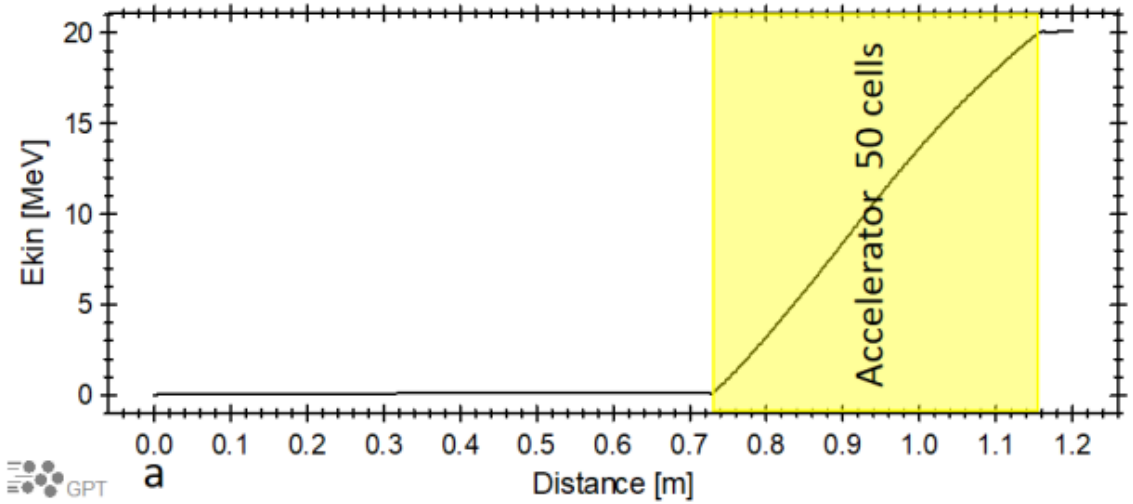
X-band Accelerator for Injector

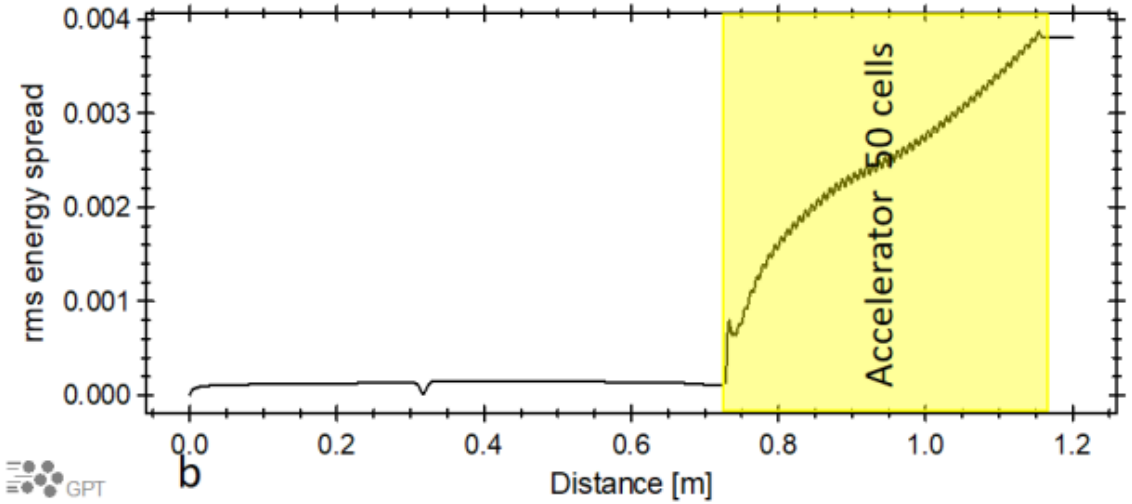


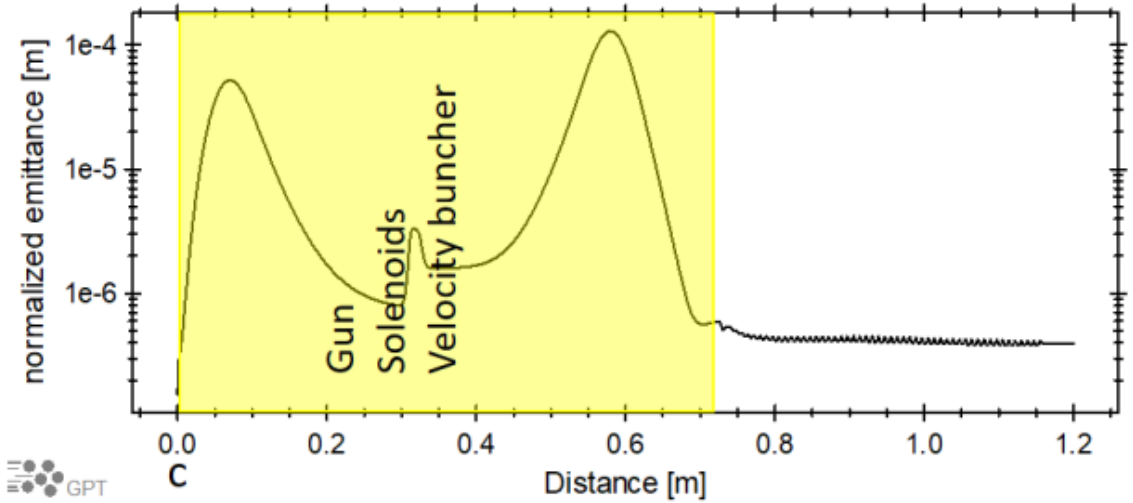


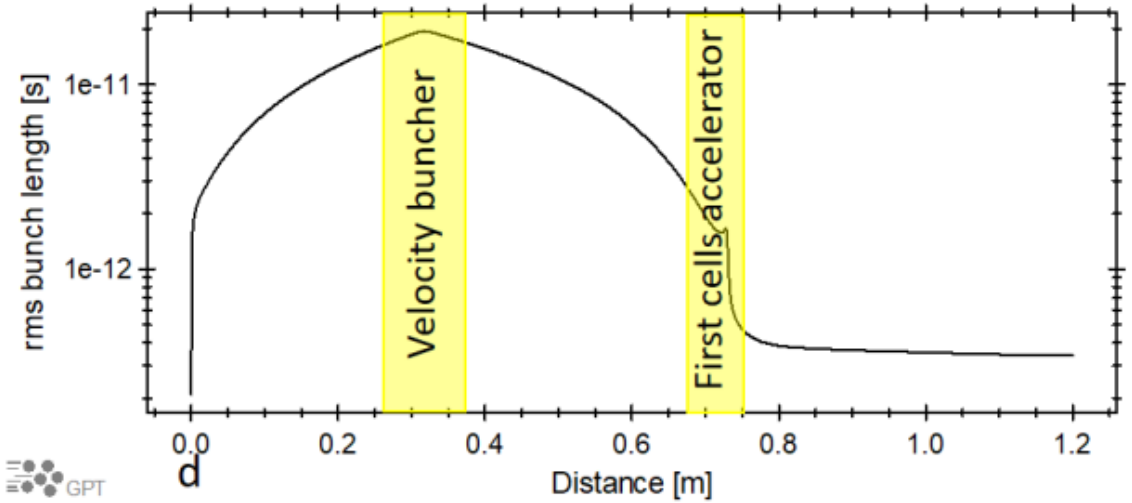


Full Beamline Simulations in GPT



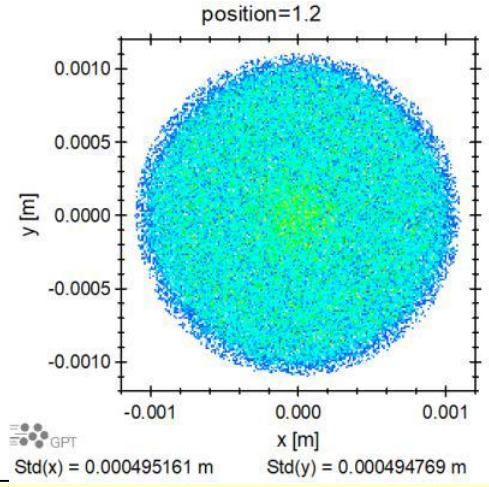


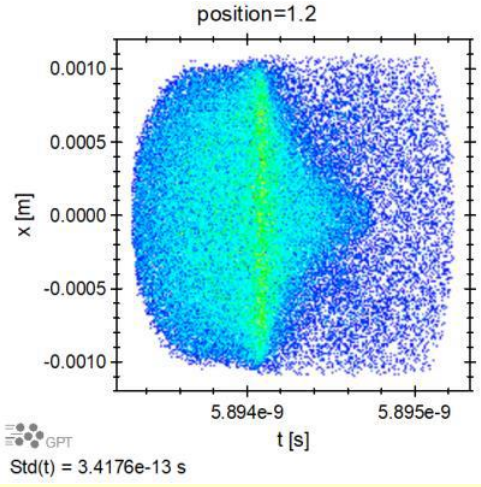


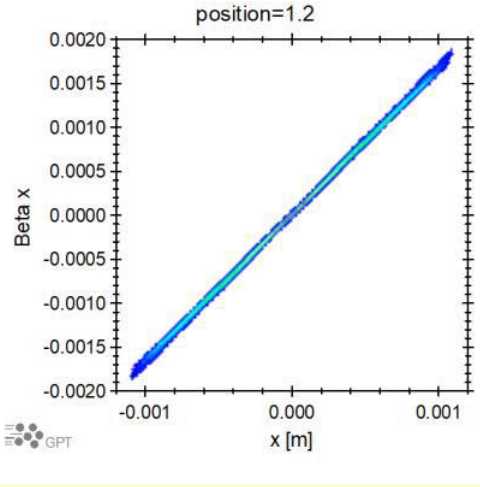


Main Parameters

Bunch Property	Exit of DC Photogun	Exit of Adjusted X-band Accelerating Structure
Charge [pC]	10	10
Kinetic Energy [MeV]	0,1	20
RMS Energy Spread [%]	0,01	0,38
RMS Bunch Length [ps]	2	0,35
Normalised Emittance [μm]	0,1	0,4





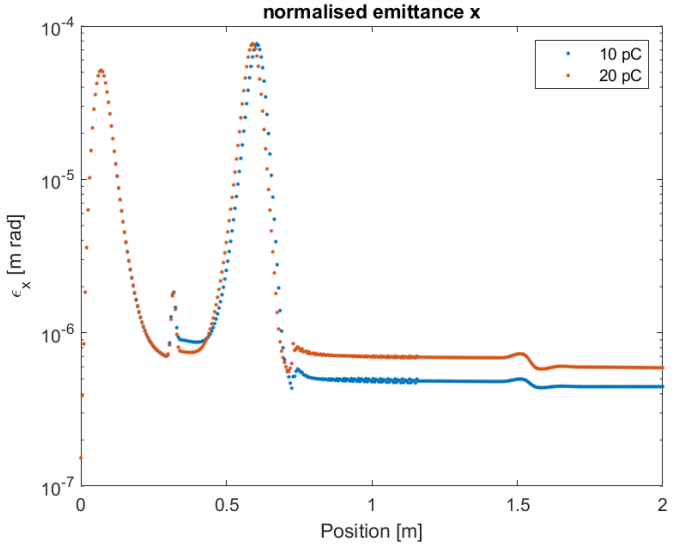


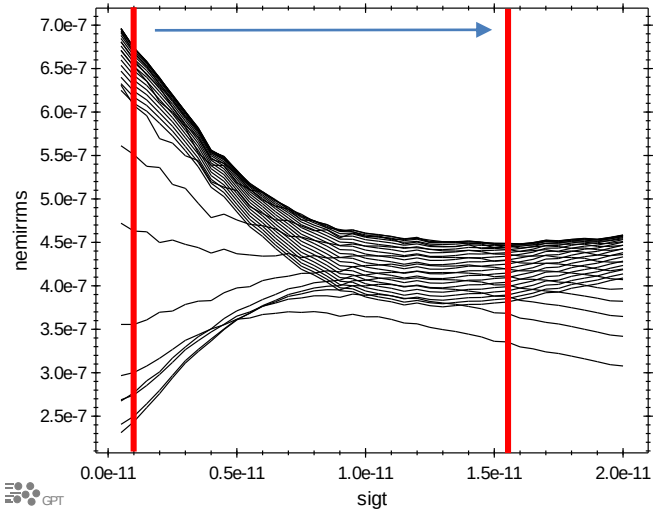
Reducing Emittance

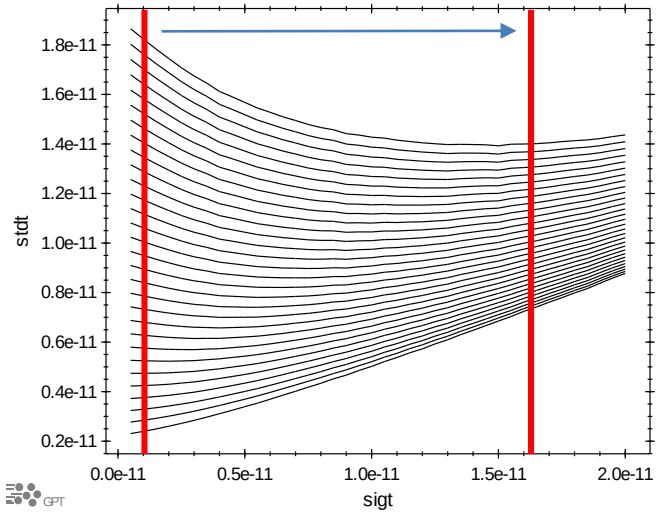
Simulations have been performed with larger bunch charges.

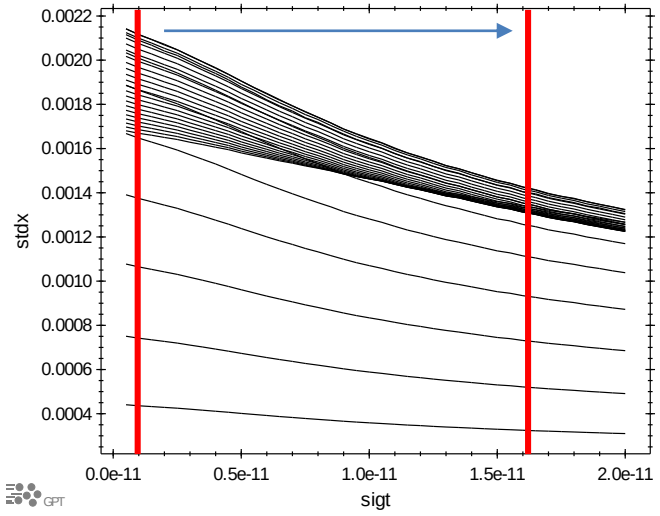
- Up to 30pC possible but emittance increases by factor ~2.

Investigating injection with longer bunch lengths (~16 ps) to mitigate emittance blow-up. Maybe beyond 30pC?









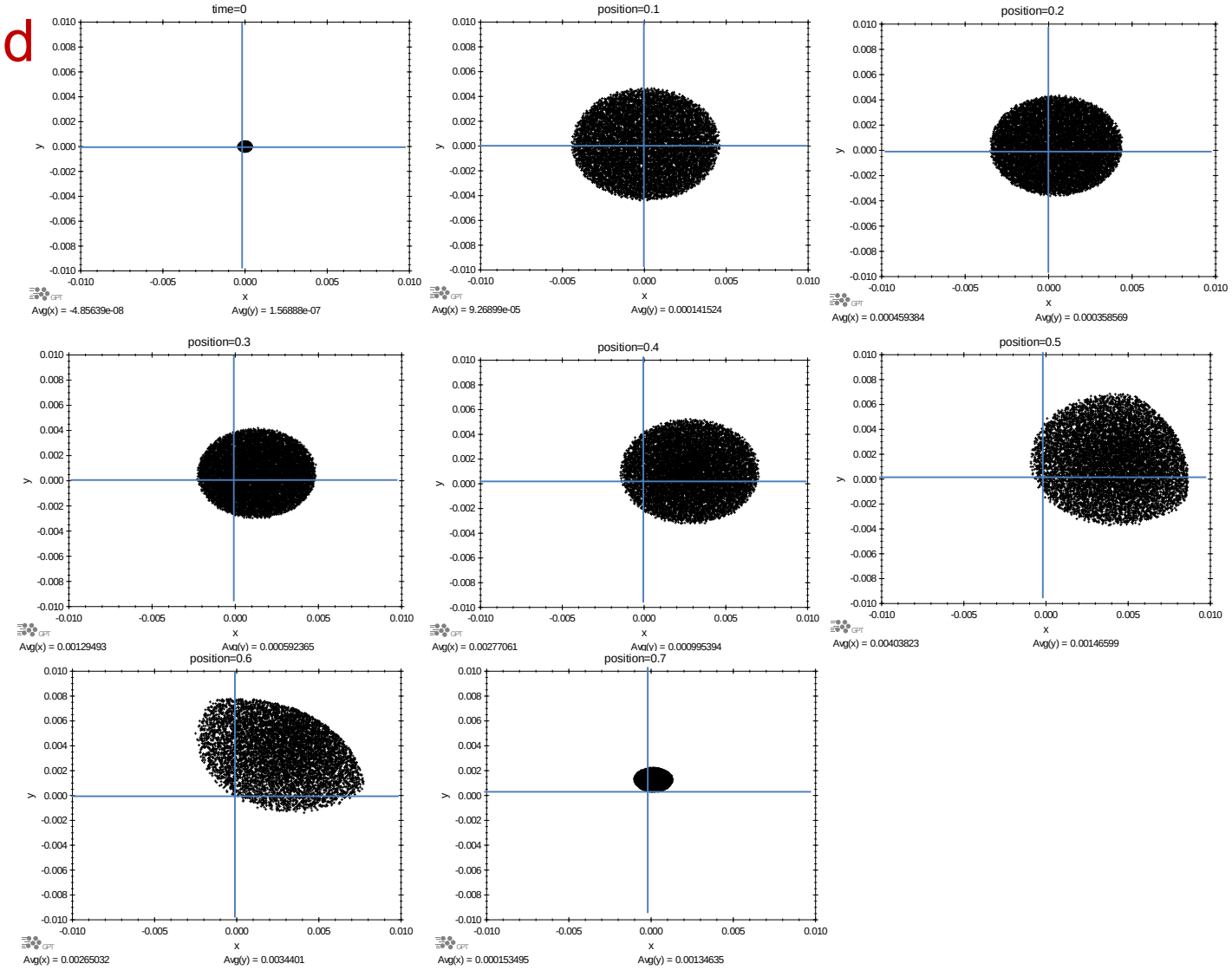
Effects of Earth's magnetic field

Earth's magnetic field assumed to be vertical at 50uT.

Beam centroid displaced by the earth's magnetic field.

Coupling between horizontal and vertical displacement resulting from the solenoids.

Offset at the input of the structure 1.3 mm in the vertical axis and 150 um in the horizontal.

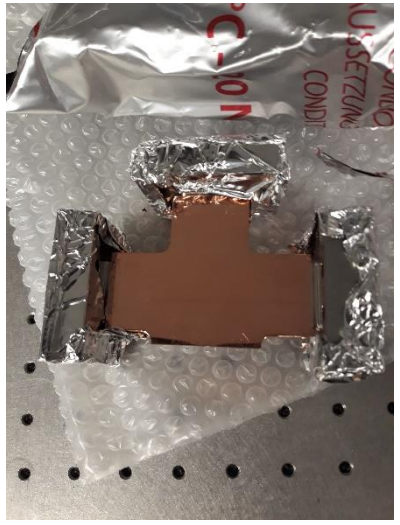


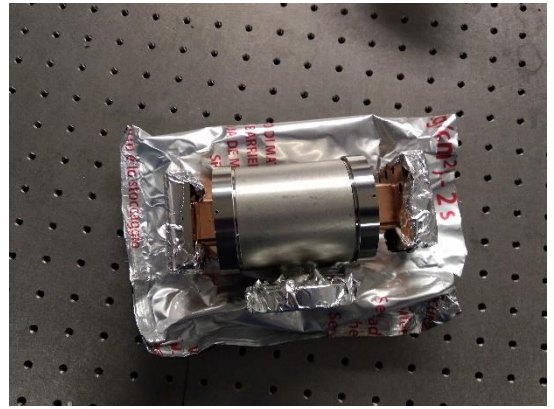
Test Setup

Test setup to be built.

Begin conditioning of high X-band structure start of 2020!

Part	Status	Delivery Date
Gun	Vacuum Testing	Arrived
Accelerator	Design finished, disk are ordered	September/ October 2019
Pulse compressor	In production	1st August 2019
Klystron/modulator	Ordered	September/October 2019
Velocity buncher	Under design	September 2019
High Power RF Components	Under Fabrication/Arrived	September/October 2019





Up to 750 Hz (quoted).
Maybe 1 kHz!

Conclusion

- GPT simulations establish that it is possible to generate 20MeV, 10pC bunches whose bunch length is 350 fs and normalized emittance is 0.4um.
- A repetition rate of 750 Hz is achievable.
- Future reductions in the emittance are could be possible with longer bunch injection.
- Complete test setup to be built by mid 2020.

I’d like to acknowledge:

ARCNL
- Ronnie Hoekstra (University of Groningen)

TU/e
- Jom Luiten
- Peter Mutsaer
- Xavier Stragier
- Ali Rajabi

CERN
- Walter Wuensch
- Alexej Grudiev
- Nuria Catalan-Lasheras

Funded by the
European Union

Compact

Thank you!

CompactLight@elettra.eu www.CompactLight.eu

CompactLight is funded by the European Union's Horizon2020 research and innovation programme under Grant Agreement No. 777431.