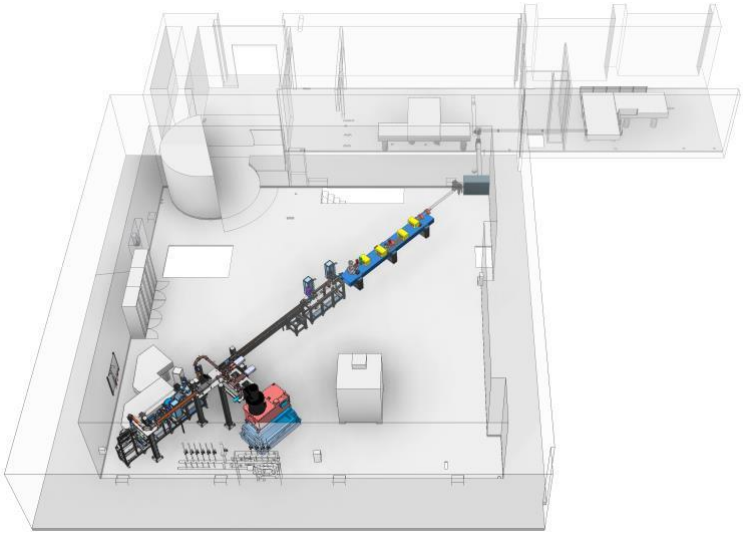
Karlsruhe Institute of Technology

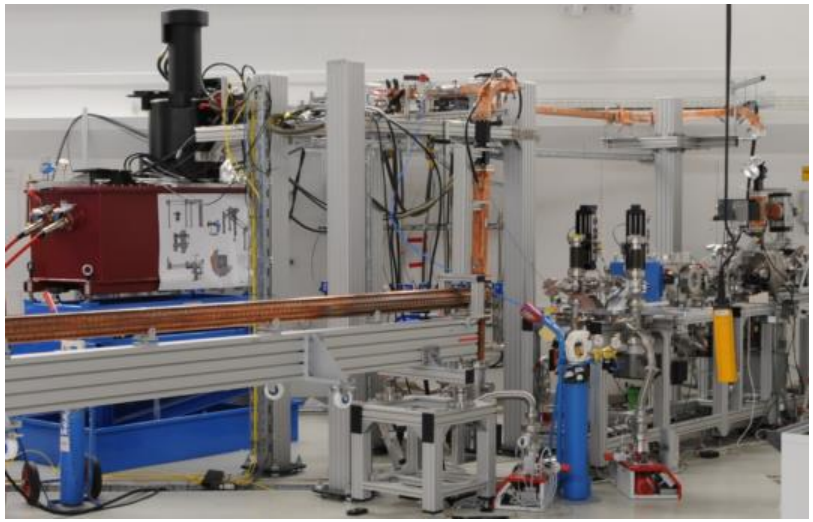
FLUTE

Present status of FLUTE RF system and future upgrades

Dr. Anton Malygin on behalf of FLUTE team

Institute for Beam Physics and Technology (IBPT)

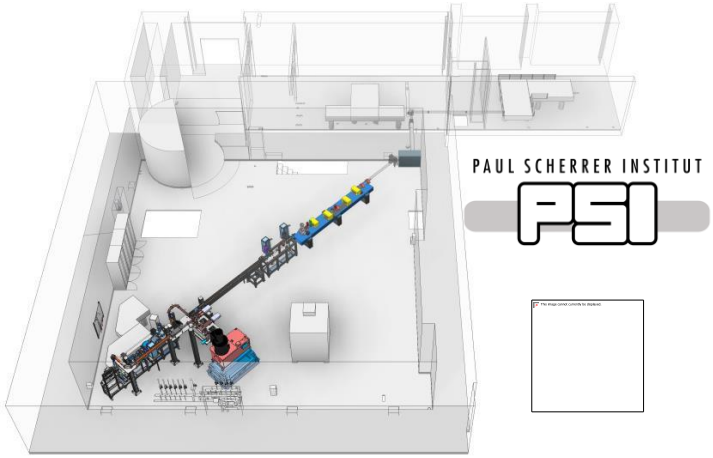




FLUTE: Ferninfrarot Linac- Und Test-Experiment

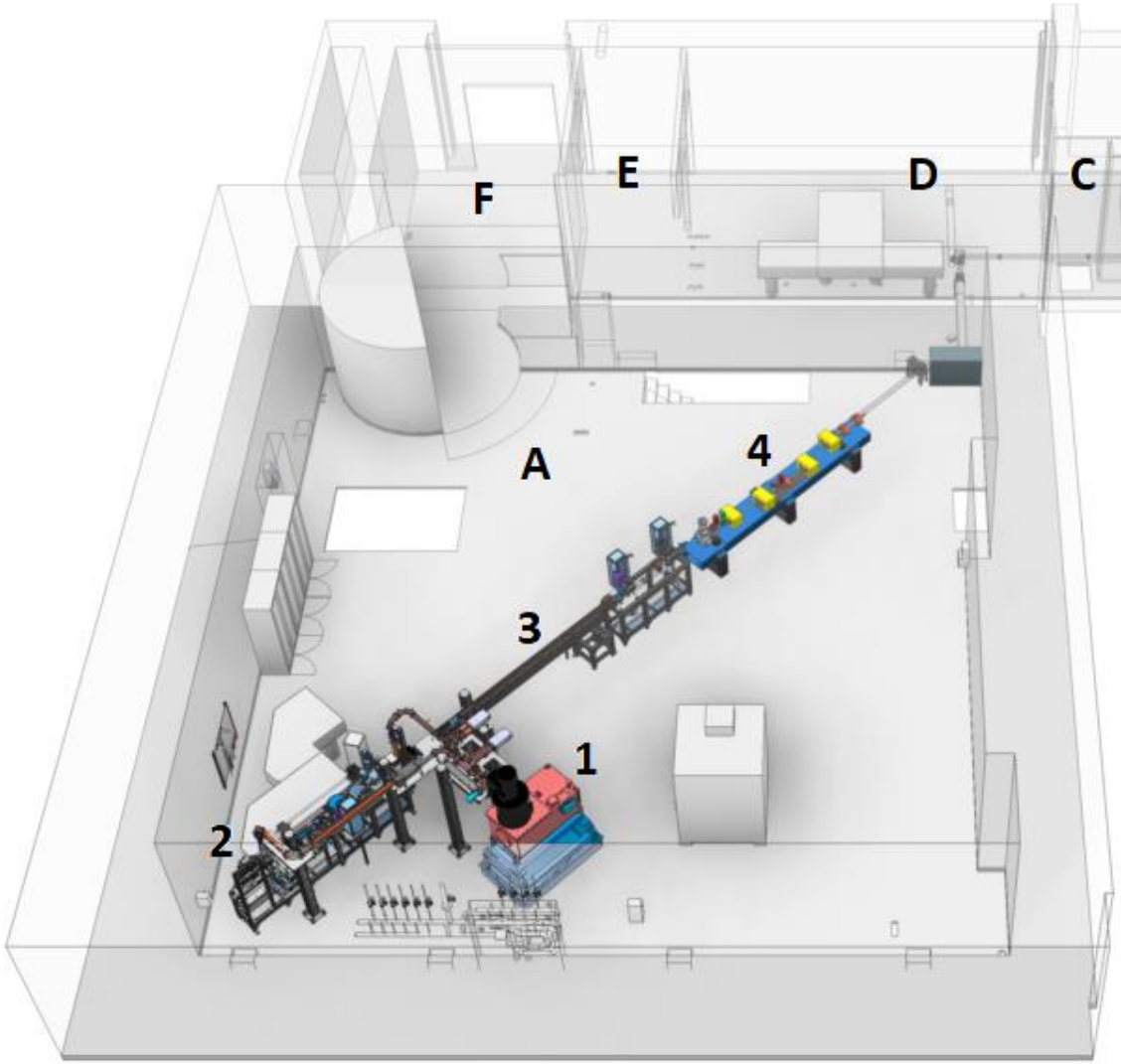
- **Main goals for FLUTE**
  - Test facility for accelerator physics
  - Experiments with THz radiation

- **R&D topics**
  - Test bench for new beam diagnostics
  - Systematic bunch compression and THz generation studies
  - Development of single-shot fs diagnostics
  - Synchronization on a femtosecond level



Final electron energy	~ 41 MeV
Electron bunch charge	1 pC - 3 nC
Electron bunch length	1 - 300 fs
Pulse repetition rate	10 Hz
THz E-Field strength	up to 1.2 GV/m

FLUTE: Layout



A – Experimental hall:

- **1** – Klystron with auxiliaries
- **2** – RF photo-injector gun
- **3** – Linac
- **4** – Bunch compressor

B – Laser clean room

C – Airlock

D – THz measurement room

E – Control room

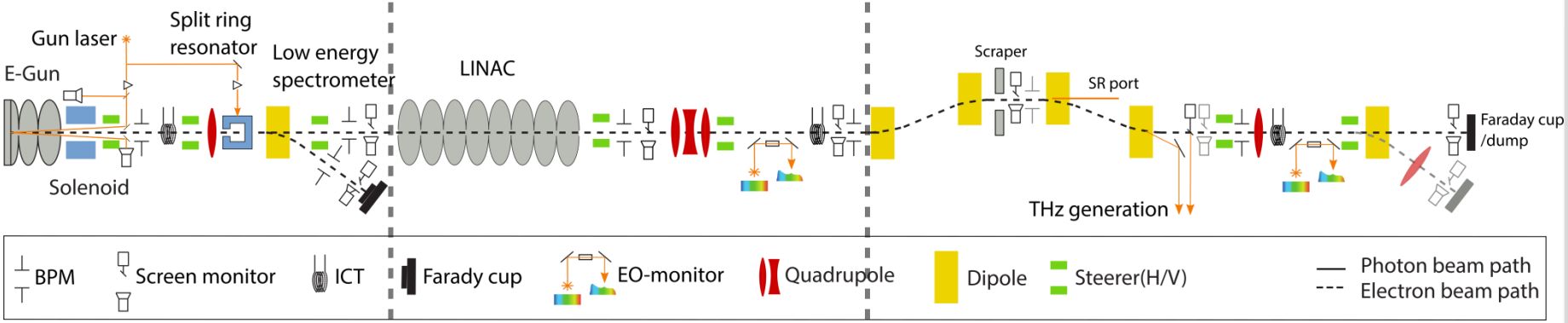
F – Entrance area

FLUTE: Layout & implementation

5 – 7 MeV section

41 MeV section

Buncher and THz section

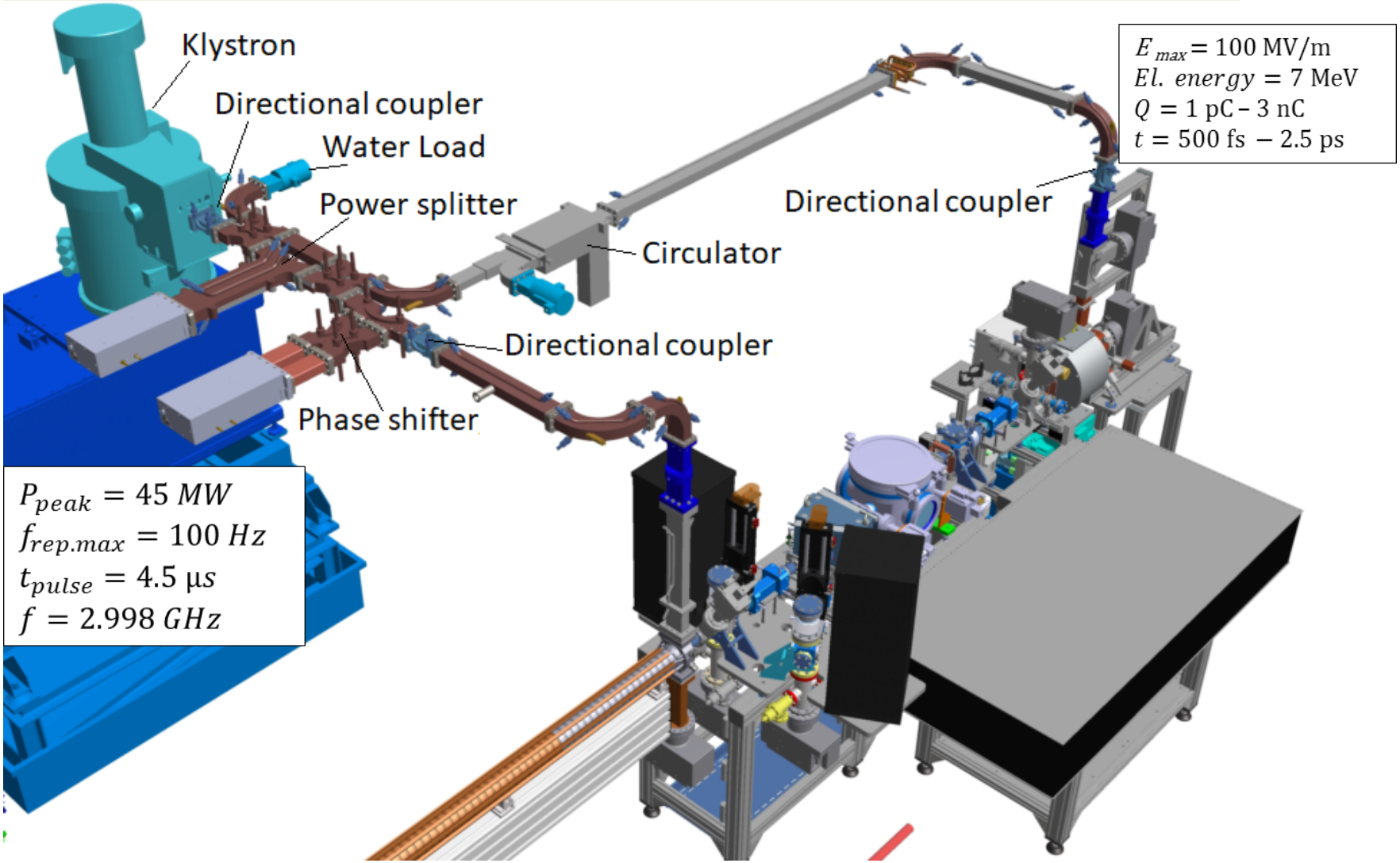


Energy	5 – 7 MeV
Bunch charge	**1 pC**-3 nC
Beam size	0.4-4.5 mm
Bunch length	**500 fs**-2.5 ps
Energy spread	0.14-0.8 %
λ (laser)	266 nm
Spot size	0.5 - 2.5 mm
Pulse length	500 fs - 2 ps

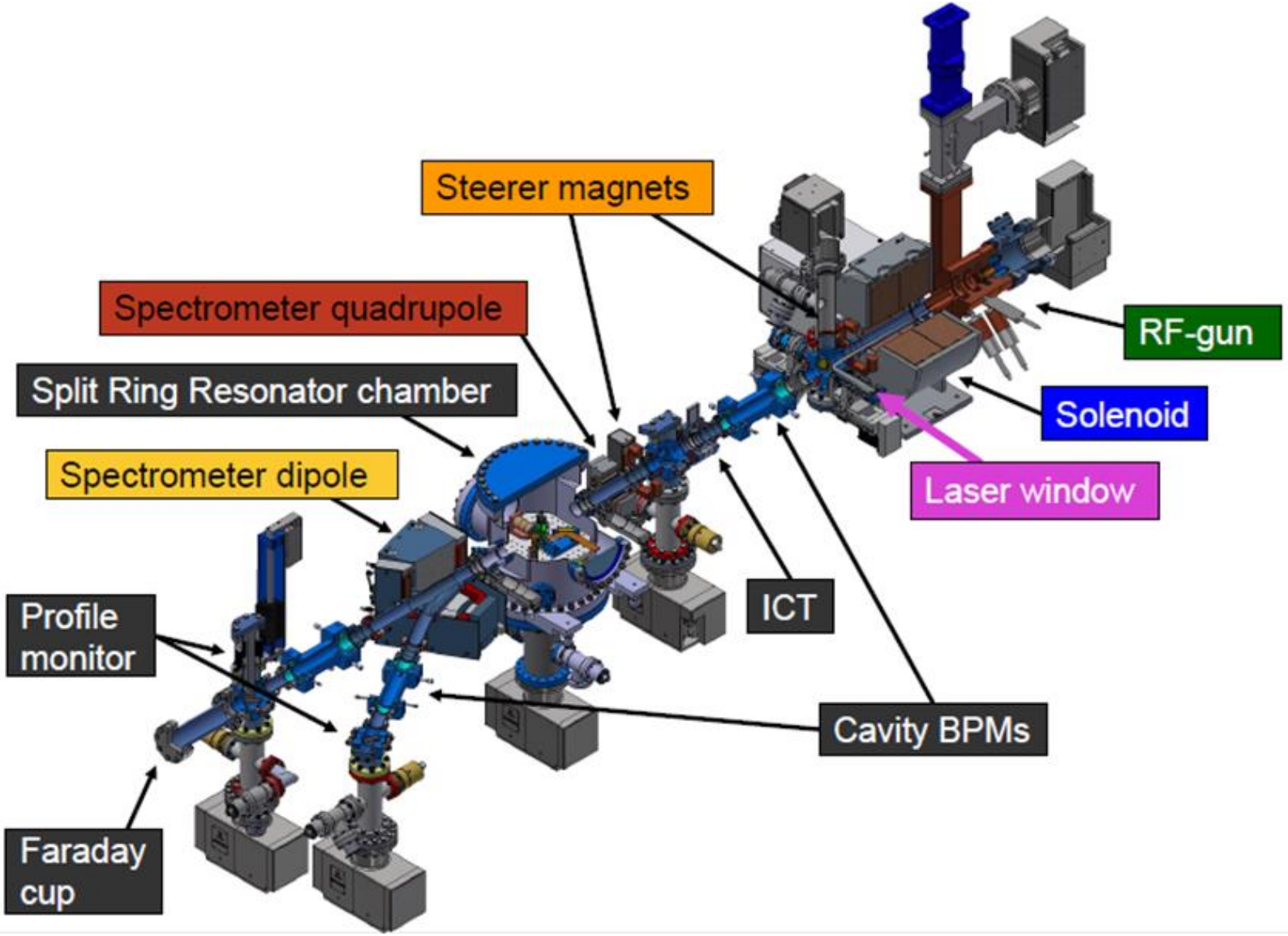
Energy	**41 MeV**
Bunch charge	**1 pC** - 3 nC
Beam size	0.4 - 4.5 mm
Bunch length	500 fs - 2.5 ps
Energy spread	0.24 - 1.8 %

Energy	41 MeV
Bunch charge	**1 pC** - 3 nC
Beam size	40µm - 3 mm
Bunch length	**few fs** - 500 fs
Energy spread	0.24 - 1.8 %

RF system configuration



Beam diagnostics



Update on the Split Ring Resonator experiment

- Optics for photo-injector & SRR experiment set up and working
- High THz generation efficiency reached (up to ~0.03%)
- Laser diagnostics needs to be aligned and commissioned
- Temporal and spatial overlap needs to be established

Collaboration: KIT, PSI, University Bern

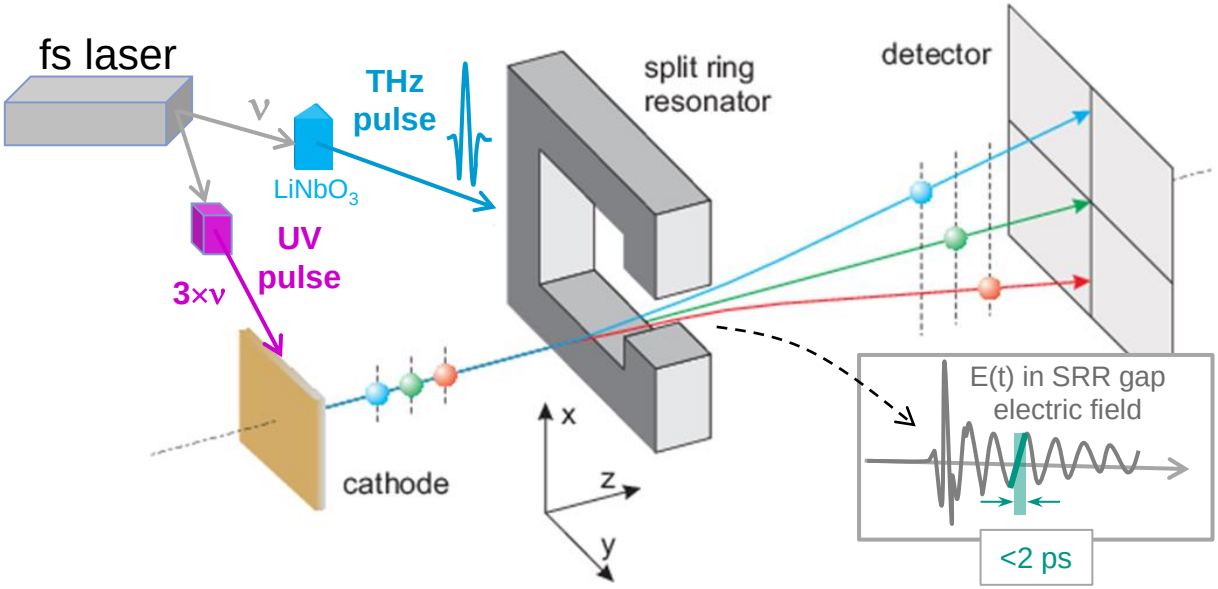
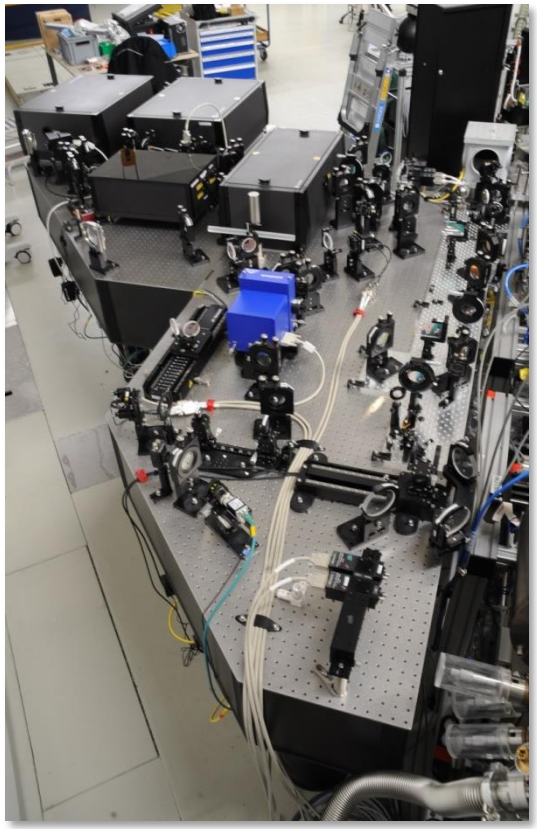
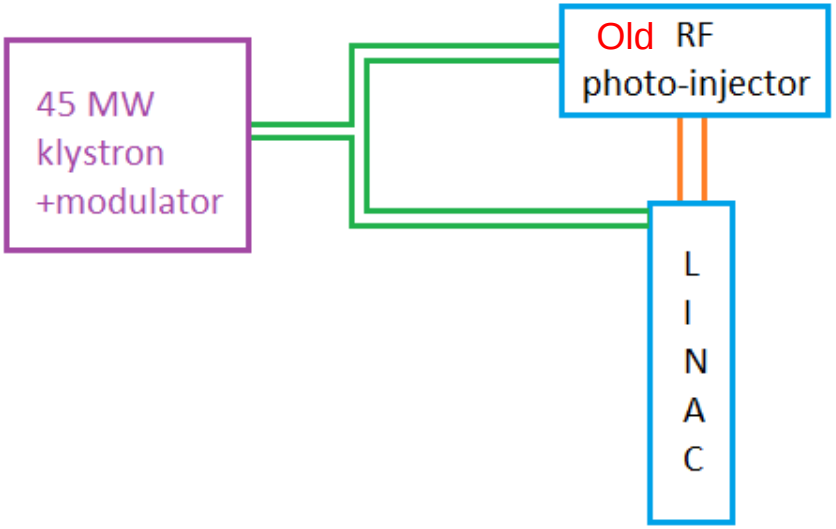


Image adapted from: J. Fabiańska, G. Kassier, T. Feurer. Sci. Rep. 4, 5645 (2014)

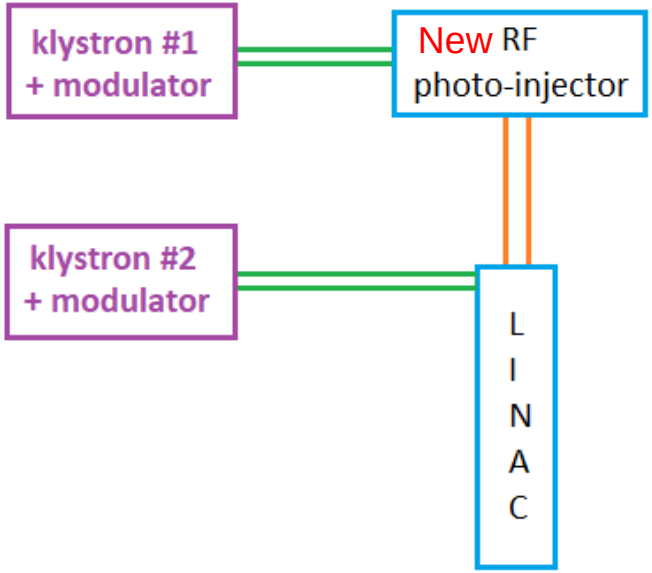


RF system upgrade plans

Current configuration



New (planned) configuration

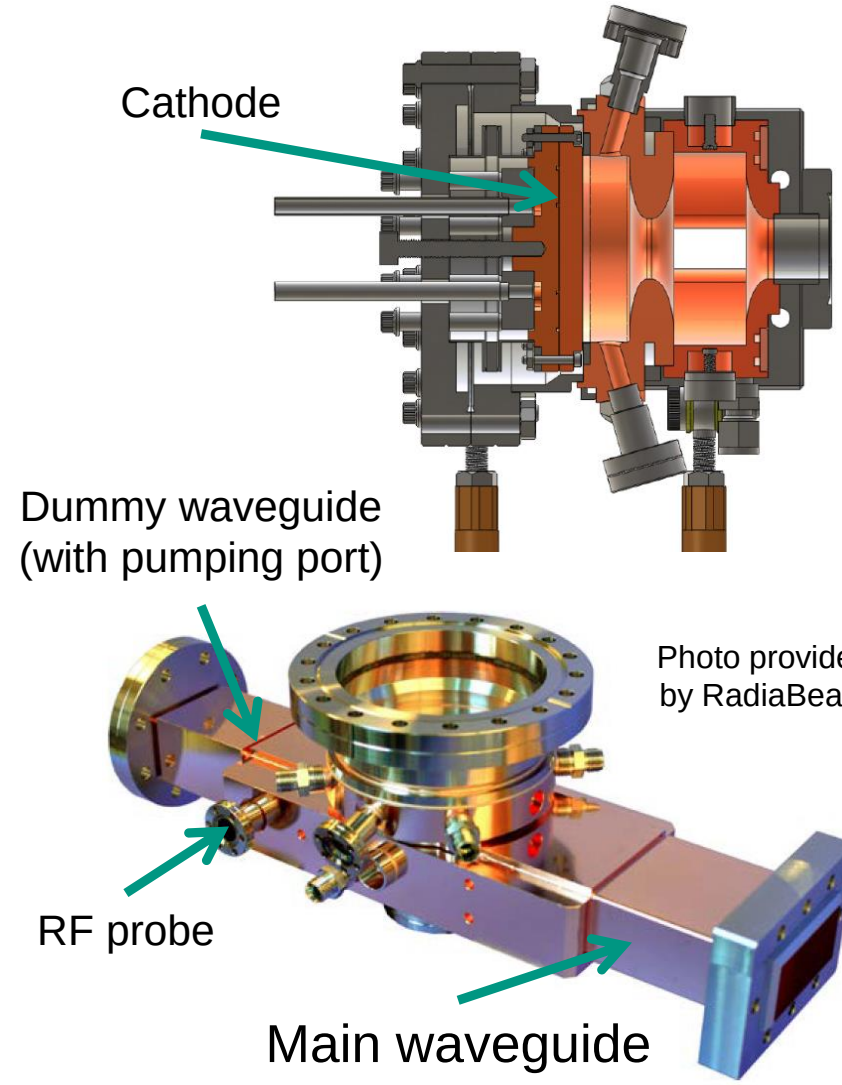


Advantages of new RF system configuration:

- New klystrons + state-of-the-art solid state modulators with high repetition rate
- Better and easier RF power stabilization (with LLRF) using two separate sources
- RF photo-injector optimized for bunch charge range from 10 pC to 1 nC (with low dark current) and high rep. rate (up to 50 Hz)

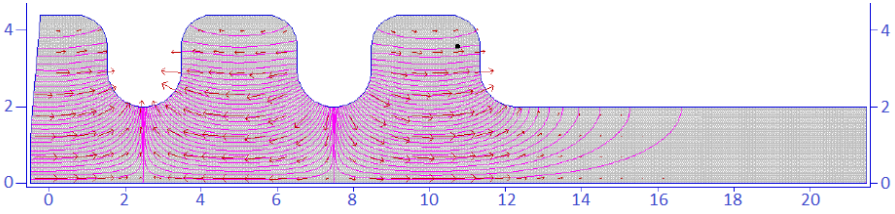
New RF photo-injector (from RadiaBeam)

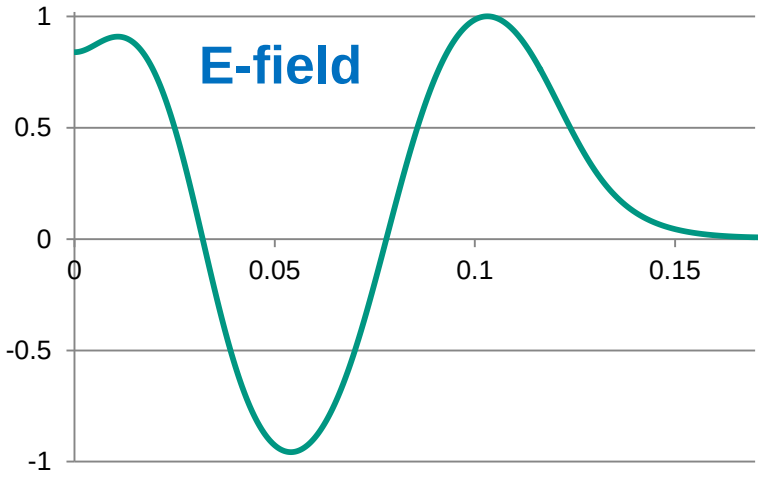
Parameter	Value
Maximum Input power	9.5 MW
Output Energy at 9.5 MW	5.5 MeV
Operating Frequency	2.998 GHz
Maximum repetition rate	50 Hz
Peak surface field	102 MV/m
Peak cathode field	120 MV/m
Maximum bunch charge	Up to 1 nC
Cathode	Rempovable
Number of RF feeds	1
Laser injection	Off-axis or on-axis
Quantum efficiency	3×10^{-5}



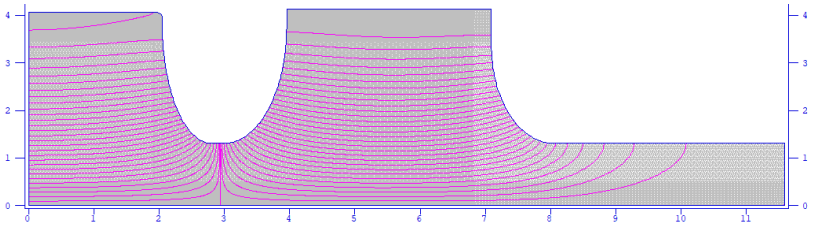
RF photo-injectors simulations

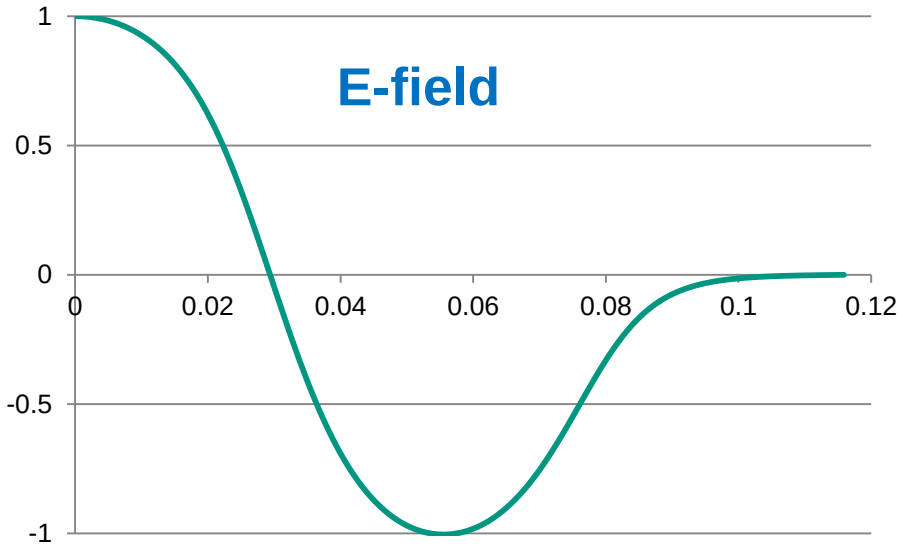
Old FLUTE RF photo-injector





New RF photo-injector

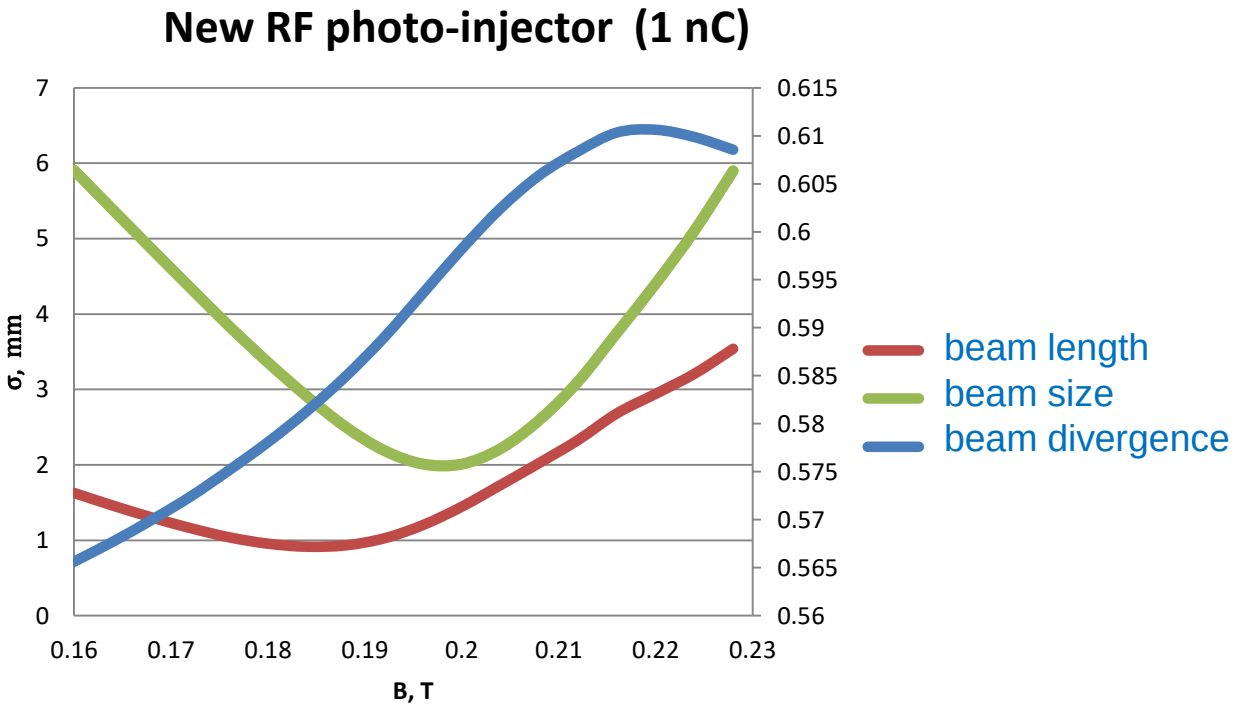




Summary for 1 nC beam simulation (ASTRA code)

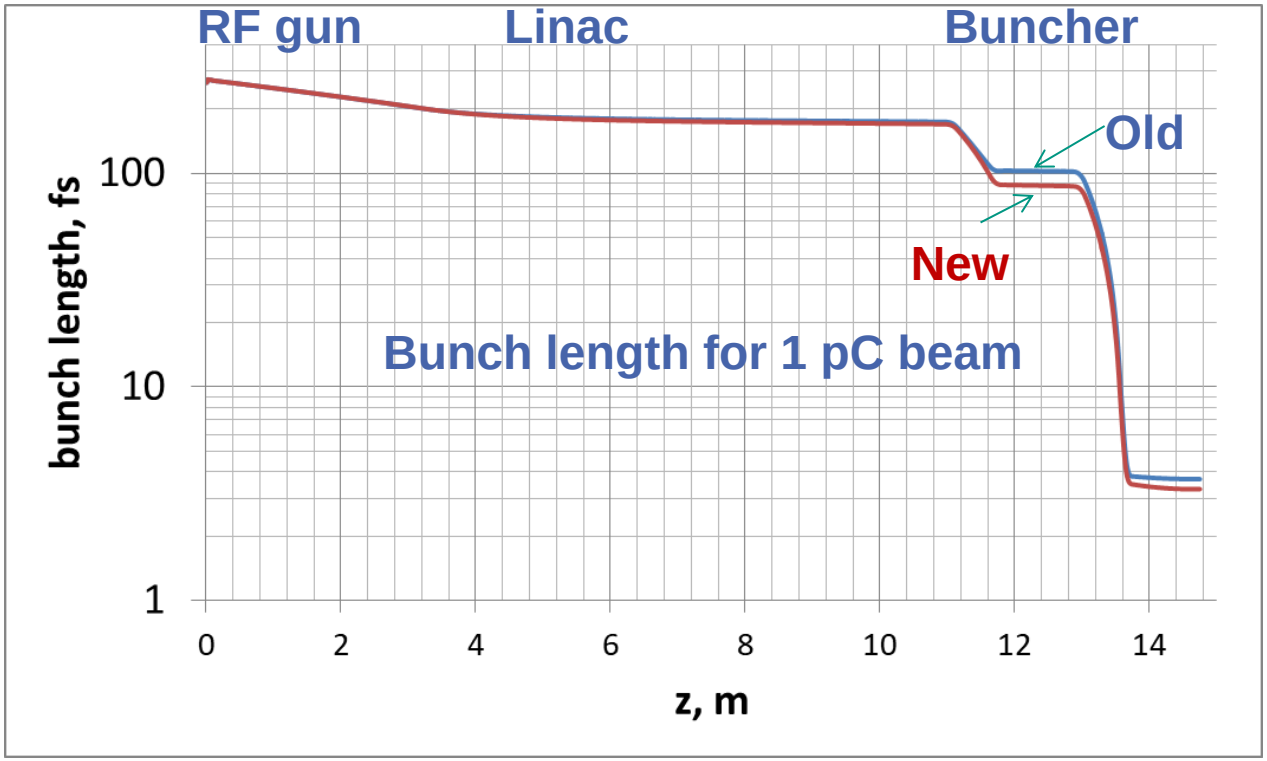
Main electron beam parameters at the entrance of the linac (2.8 m from cathode)

RF gun	Beam size	Beam divergence	Bunch length	Beam type
Old	2.19 mm	1.07 mrad	0.59 mm	Laminar
New	1.9 mm	1.06 mrad	0.57 mm	Laminar



Complete FLUTE simulations

Comparison of the old and the new RF photo-injector beam dynamics



RF gun	Beam length (1pC)	Beam length (1 nC)
Old	3.3 fs	200 fs
New	3.1 fs	180 fs

Summary

- Simulation of the new RF photo-injector (from RadiaBeam) have been performed. It showed very good results by achieving bunch length shorter than with existing FLUTE RF photo-injector. Further optimization of FLUTE configuration with wider parameters range is planned.
- New RF system with two klystrons and two modulators will allow to achieve higher electron beam energy, higher repetition rate and better RF power stabilization with LLRF feedback system.
- Design of the vacuum chamber for the chicane is in progress. Dipoles and quadrupoles were measured and accepted.
- Design of the new RF waveguide system and cooling system for new RF photo-injector is in progress.
- Optics for photo-injector & SRR experiment set up and working. High THz generation efficiency reached (up to ~0.03%). Alignment of laser diagnostic is in progress.

Thank you for your attention!