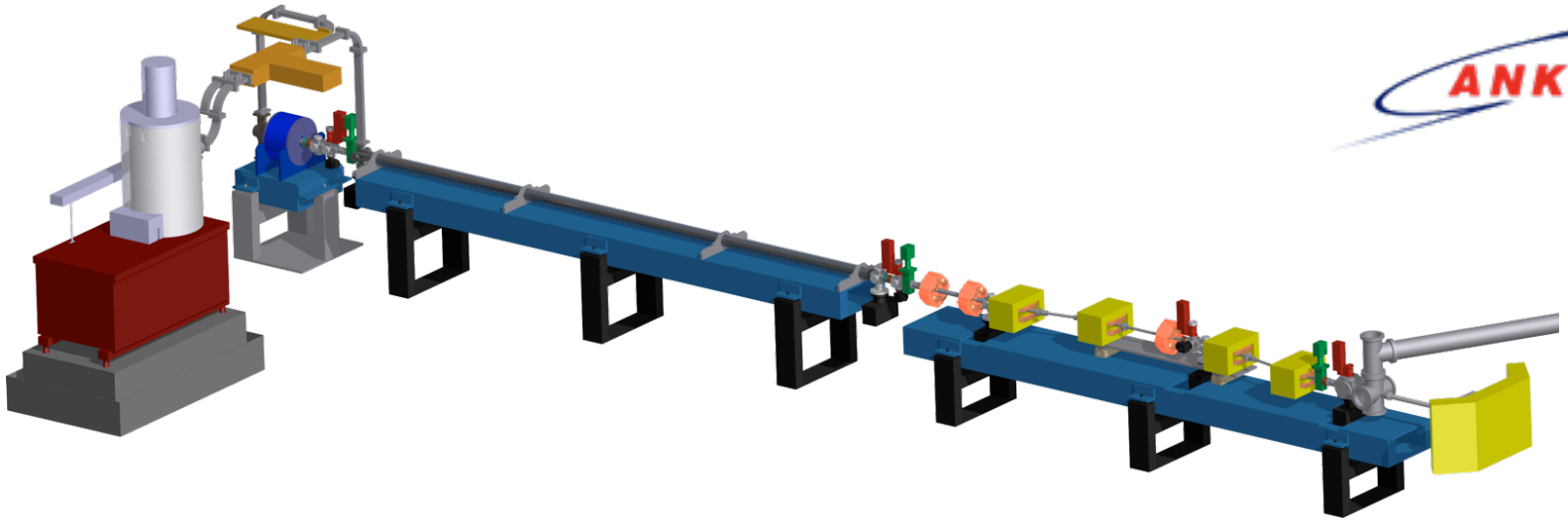
Karlsruhe Institute of Technology

FLUTE

FLUTE: A Versatile Linac-based Source of Ultra-short THz Pulses

Marcel Schuh for the FLUTE team

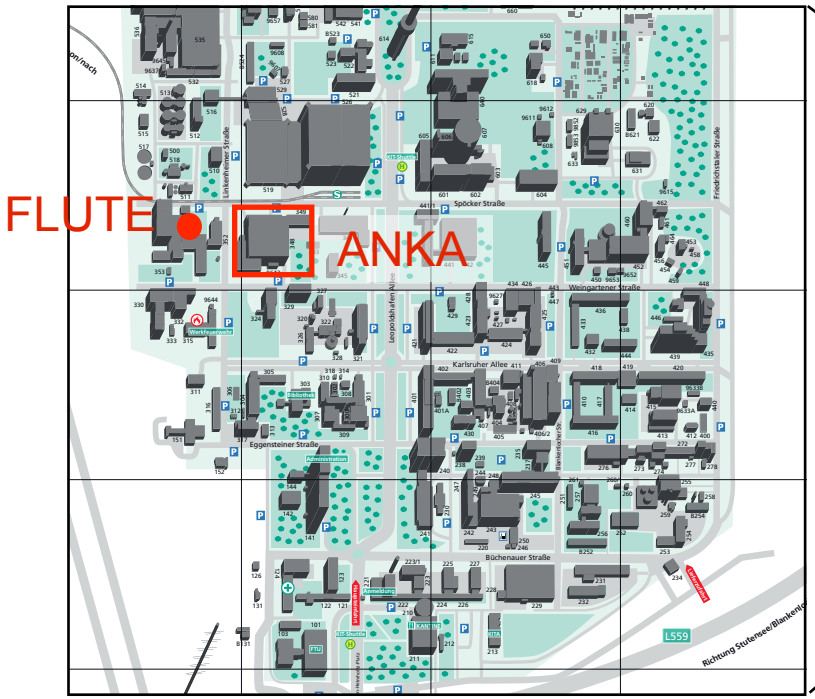
ANKA Synchrotron Radiation Facility

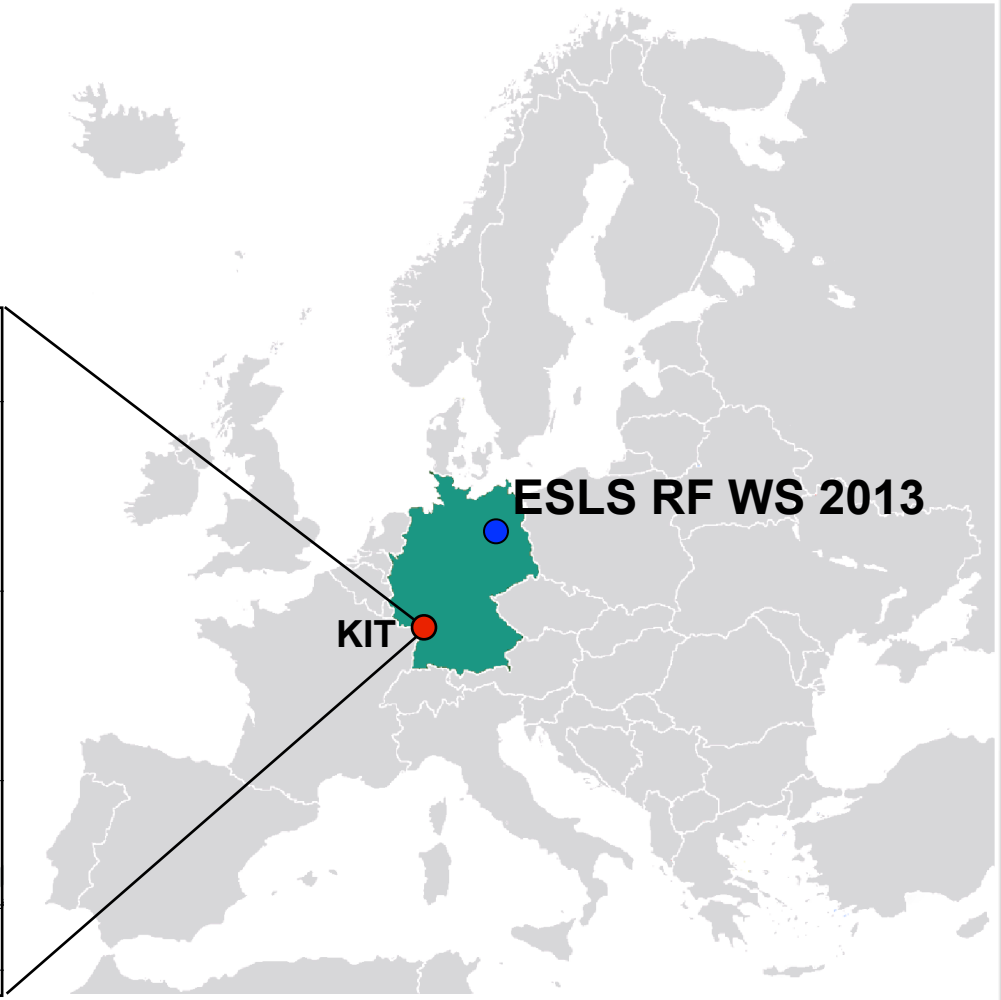


ANKA

Outline

- Project goals
- Machine layout
- Hardware
- Velocity bunching option





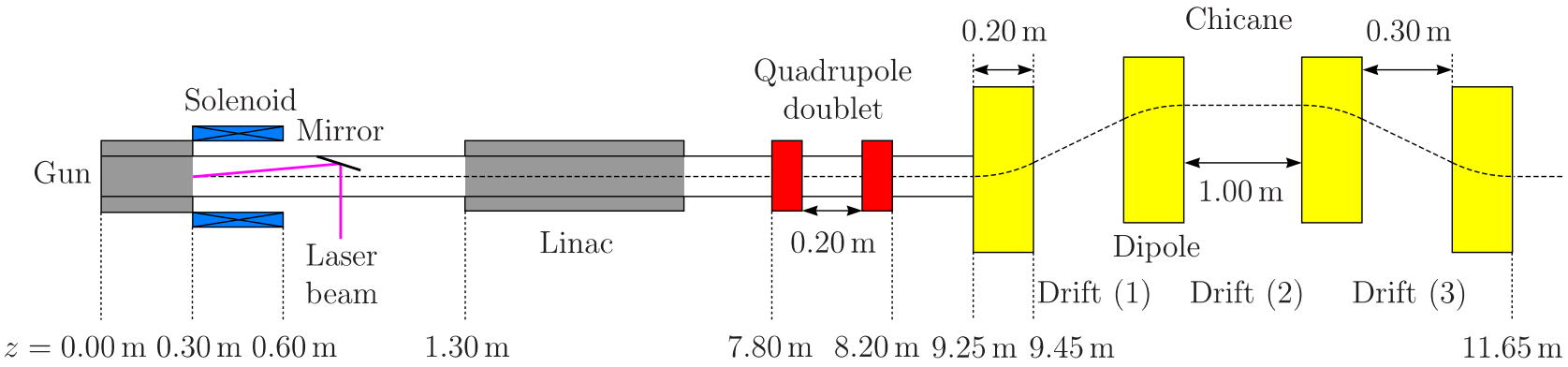
marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

Project goals

- Compare different coherent radiation generation schemes in simulation and experiment:
  - Coherent Synchrotron Radiation (CSR)
  - Coherent Transition Radiation (CTR)
  - Coherent Edge Radiation (CER)
- Systematic bunch compression studies:
  - Different compression schemes
  - Wide charge range from 1 pC up to several nC per bunch
- Serve as a test bench for new beam diagnostics methods and tools
- Test facility for accelerator studies within the Helmholtz “ARD“ initiative

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

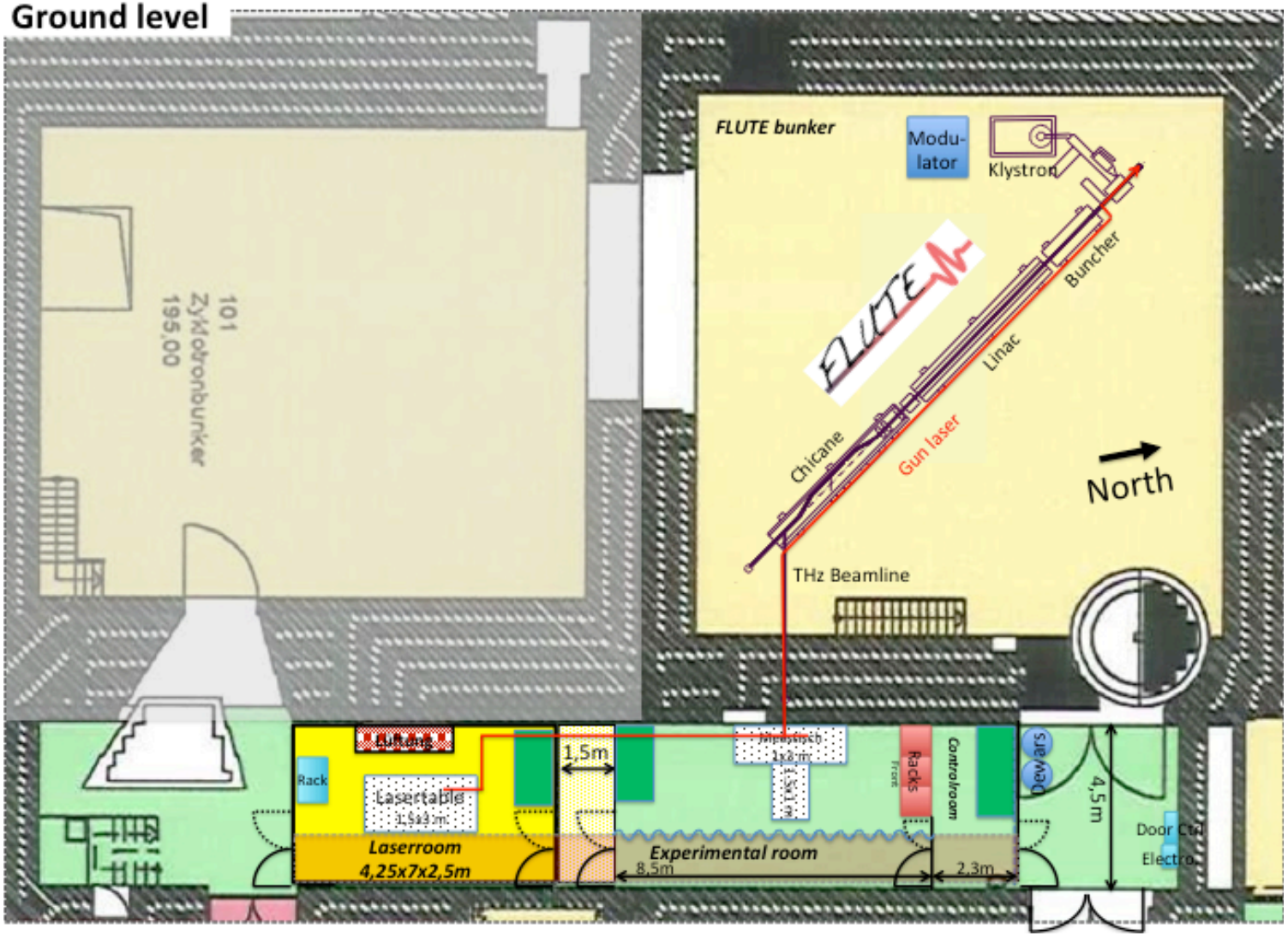
Overview baseline machine layout



Charge [nC]	Laser spot (rms) [mm]	Laser pulse (rms) [ps]	Average energy [MeV]	L_{rms} before linac [ps]	L_b [m]	D [m]	r_{bend} [m]	α [deg]	B [T]	L_{rms} after chicane [fs]
3	2.25	4	40.79	2.43	0.2	0.3	1.006	11.47	0.135	270
2	1.50	4	40.76	2.45	0.2	0.3	1.058	10.89	0.128	224
1	1.50	3	40.72	1.81	0.2	0.3	1.032	11.17	0.132	146
0.1	0.50	2	40.68	1.20	0.2	0.3	1.108	10.40	0.124	67
0.001	0.5	1	40.66	0.57	0.2	0.3	1.135	10.15	0.119	13

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

Site layout

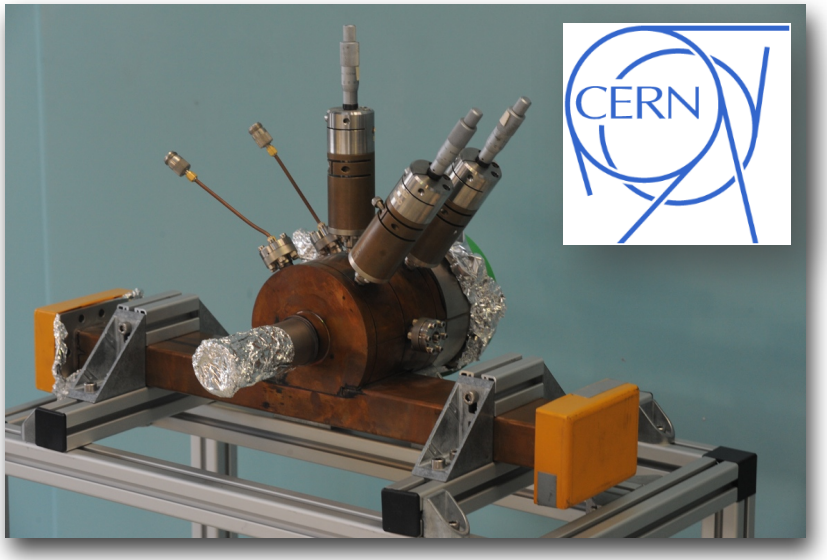


marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

RF photo injector

- CERN CTF (CLIC Test Facility) gun
- Designed for high current
- Status:
  - Successful power test in Bonn in July 2013
  - Preparing installation in bunker

Property	Unit	Value
Frequency	GHz	2.998
Cells		2.5
Peak E-Field	MV/m	~120
Peak power	MW	~20
Output energy	MeV	7



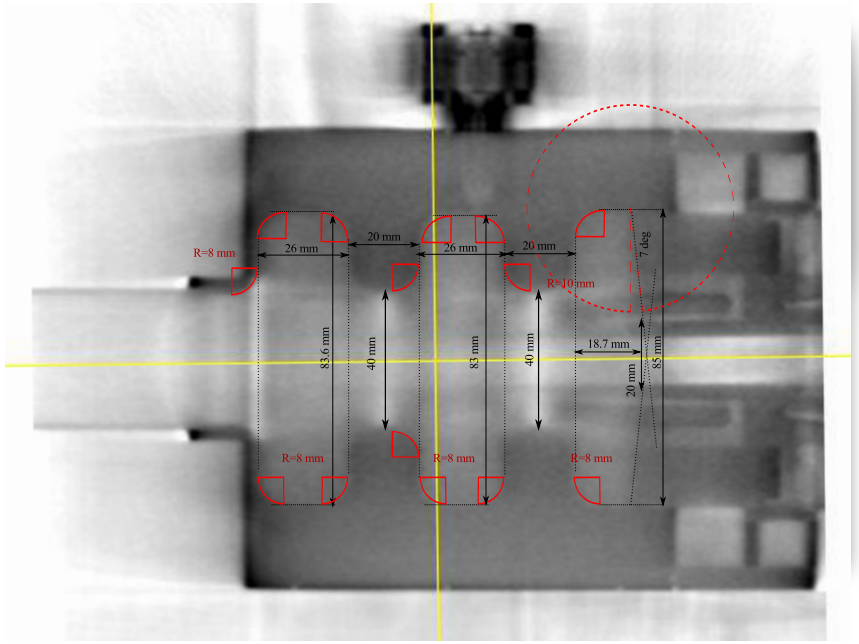
- Cathodes:
  - Cu: start phase
  - Cs_2Te: for high current

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

RF photo injector

- CERN CTF (CLIC Test Facility) gun
- Designed for high current
- Status:
  - Successful power test in Bonn in July 2013
  - Preparing installation in bunker

Property	Unit	Value
Frequency	GHz	2.998
Cells		2.5
Peak E-Field	MV/m	~120
Peak power	MW	~20
Output energy	MeV	7

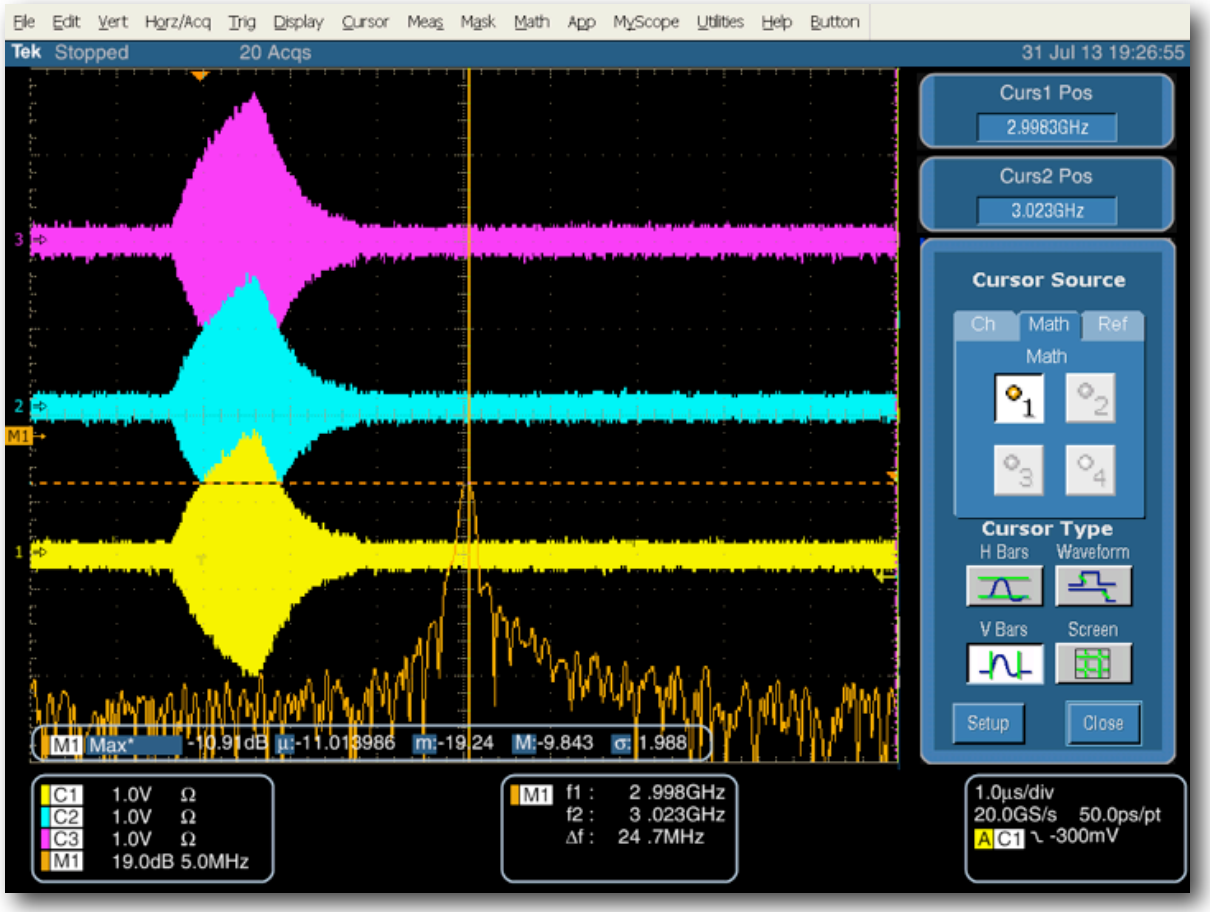


- Cathodes:
  - Cu: start phase
  - Cs_2Te: for high current

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

Power tests at ELSE

- First successful power test at ELSA in Bonn using equipment from MAX-LAB and RI in July 2013
  - RF pickup signal of all cells
  - FFT of cell 1
  - 1MW, 1µs
  - Vacuum limited (conditioning in progress)

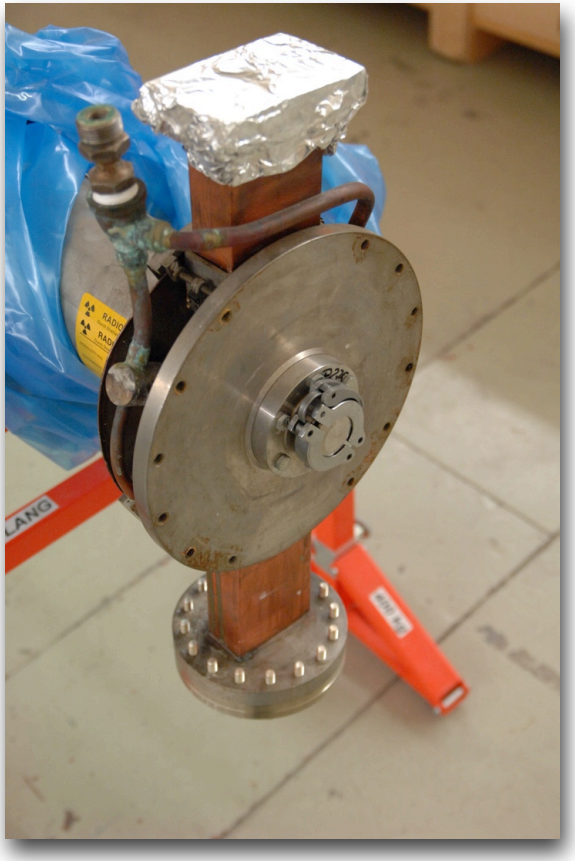


marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

Traveling wave linac

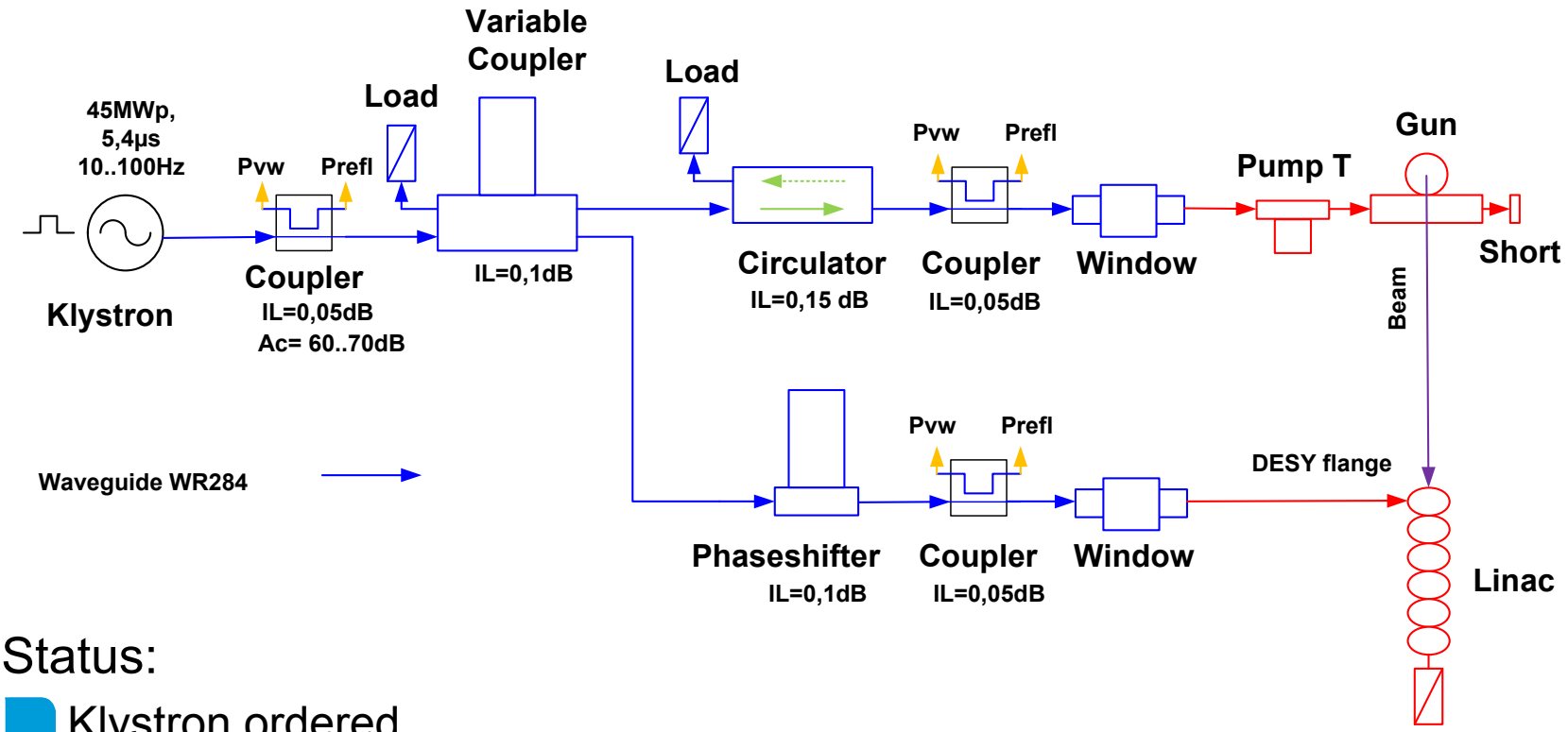
- DESY Linac II structure
- 2/3π structure
- Last operated at PSI
- Status:
  - At KIT
  - Girder in planning

Property	Unit	Value
Frequency	GHz	2.998
Number of cells		156
Iris diameter	mm	29.7 to 22.1
Length	m	5.2
Acc. gradient	MV/m	~10
Peak power for 10 MV/m	MW	16



marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

RF Distribution

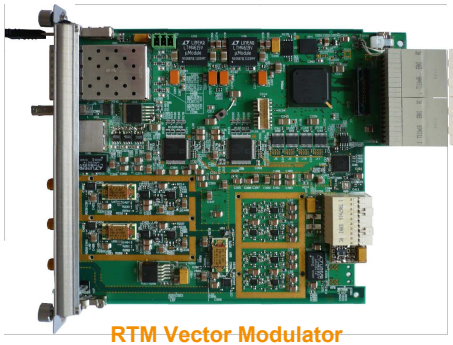


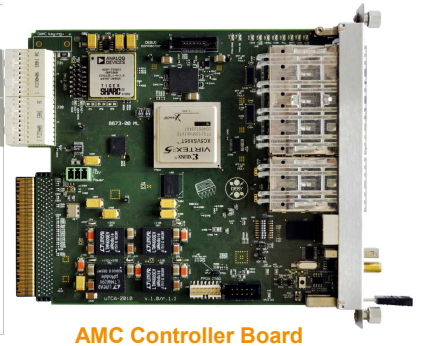
- Status:
  - Klystron ordered
  - Wave guides ordered
  - Modulator modification in progress

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

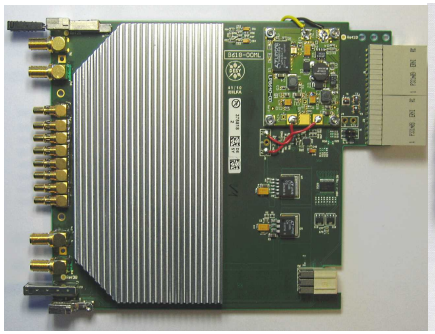
Low level RF system

- µTCA system developed at DESY
  - New version
  - Timing board
  - Advanced mezzanine card with a rear transition module
- Collaboration between DESY and KIT
- Use FLUTE as test bench
- EPICS (Experimental Physics and Industrial Control System) integration at KIT

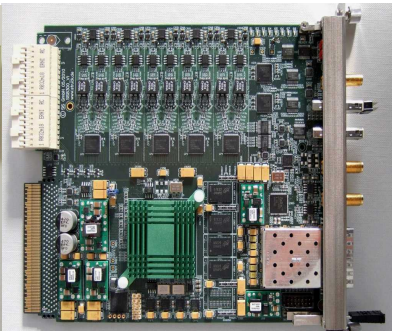

RTM Vector Modulator


AMC Controller Board

RTM Downconverter



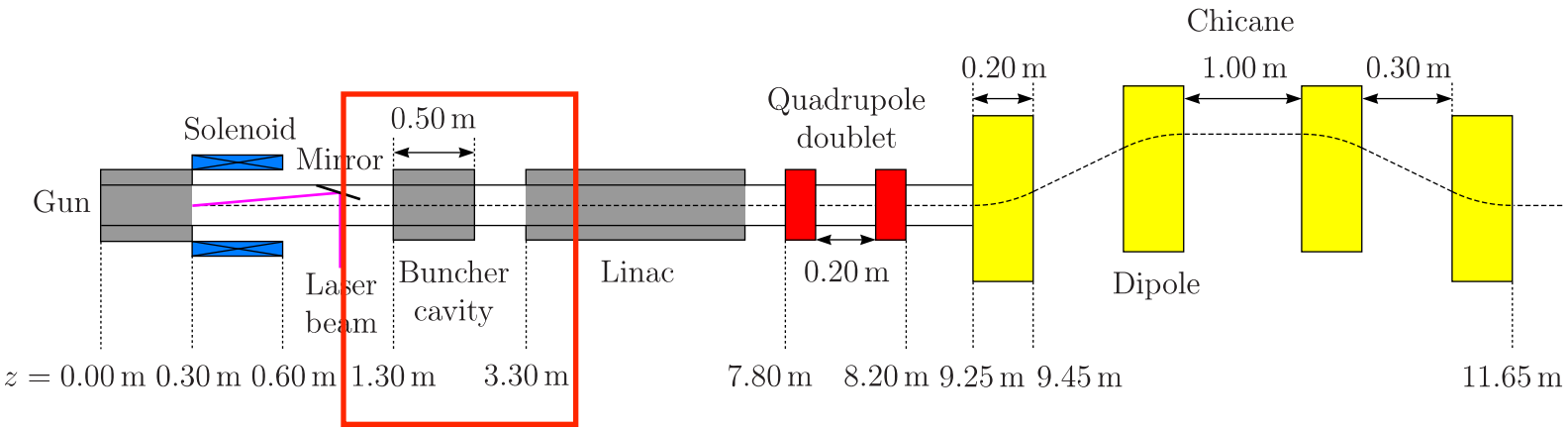
AMC ADC Board (SIS8300)



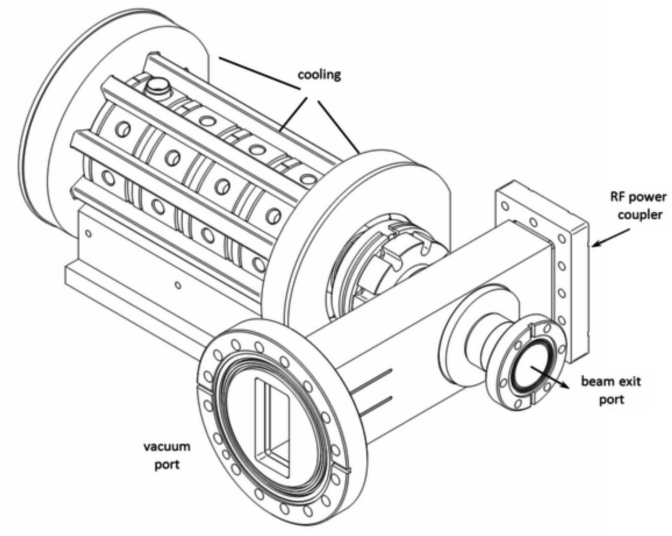
M. Hoffmann et al., DESY

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

Study of an RF buncher cavity option



- Example: REGAE buncher cavity



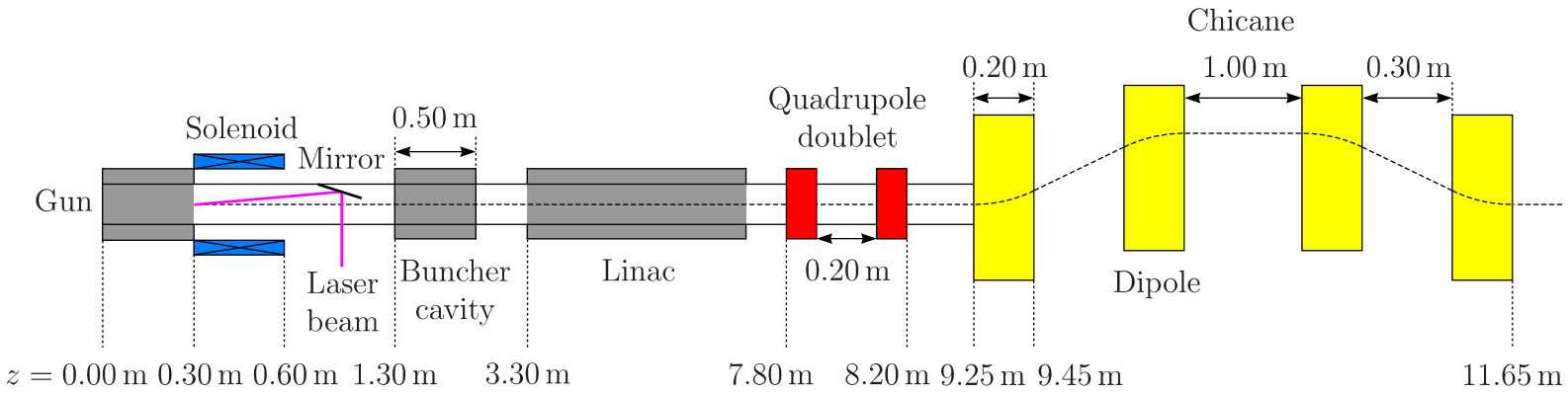
DESY

Property	Unit	Value
Frequency	GHz	2.998
Cells		4
Gradient	MV/m	25
Length	cm	46

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

First simulation results

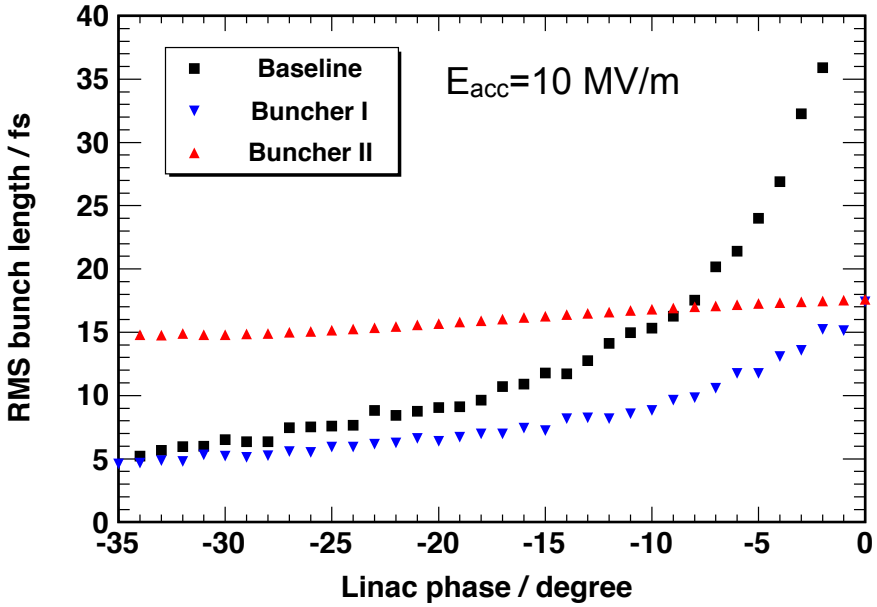
- Buncher I: place buncher cavity at 1.3 m and shift linac 2 m downstream
- Buncher II: place buncher cavity at 1.3 m and shift linac 5 m downstream (min. bunch length) and remove magnetic chicane
- Simulation code: ASTRA + analytic calculation of bunch compression in chicane (no space charge and CSR effects included in chicane)

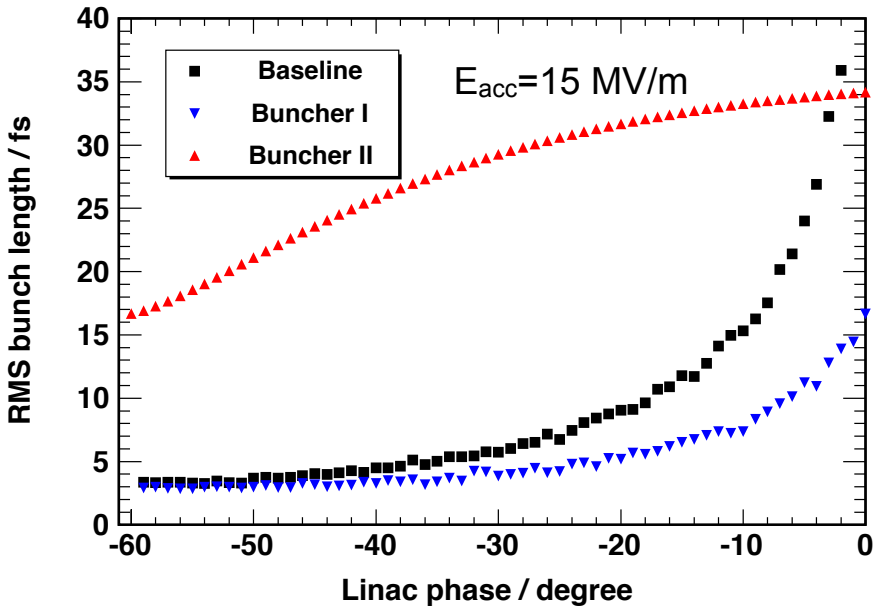


marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

First simulation results

- Buncher I: place buncher cavity at 1.3 m and shift linac 2 m downstream
- Buncher II: place buncher cavity at 1.3 m and shift linac 5 m downstream (min. bunch length) and remove magnetic chicane
- Simulation code: ASTRA + analytic calculation of bunch compression in chicane (no space charge and CSR effects included in chicane)





marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

Summary

- FLUTE is a test facility for a versatile linac-based THz source
  - Ultra short pulses & high peak fields
  - Test bench for diagnostics and instrumentation
- Construction of baseline design and hardware tests started
- Simulations ongoing for later phases

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility

Summary

- FLUTE is a test facility for a versatile linac-based THz source
  - Ultra short pulses & high peak fields
  - Test bench for diagnostics and instrumentation
- Construction of baseline design and hardware tests started
- Simulations ongoing for later phases

Thank you for the attention!

marcel.schuh@kit.edu
ANKA Synchrotron Radiation Facility