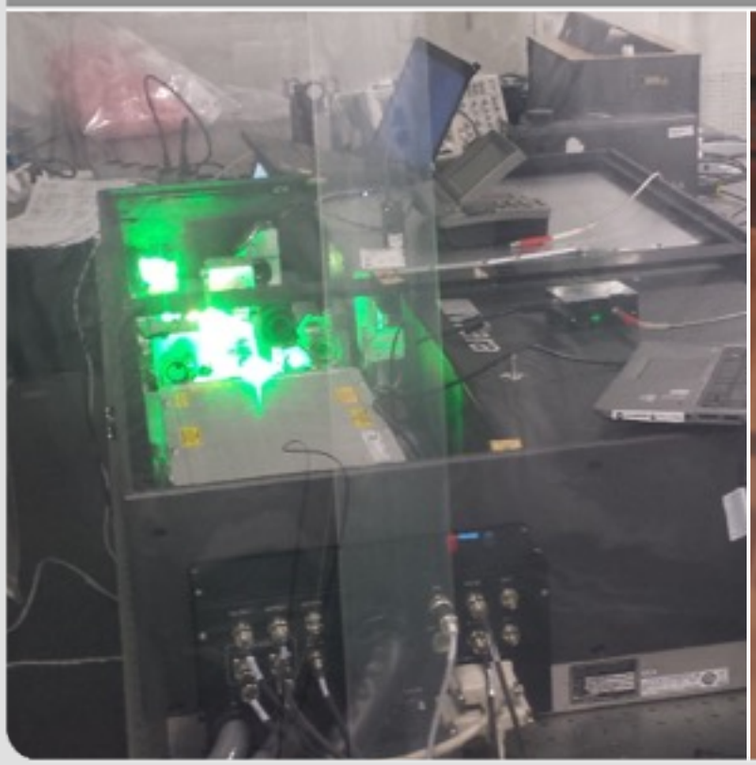
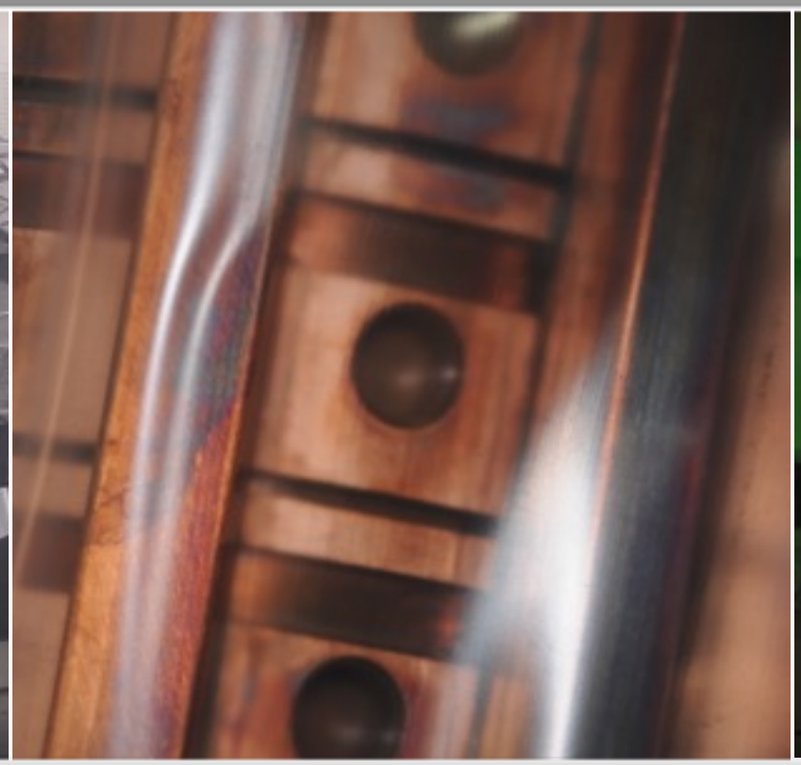
FLUTE - A Linac-Based THz Source at KIT

Bennie Smit for the FLUTE-Team

Institute for Photon Science and Synchrotron Radiation (IPS) / Laboratory for the Applications of Synchrotron Radiation (LAS)

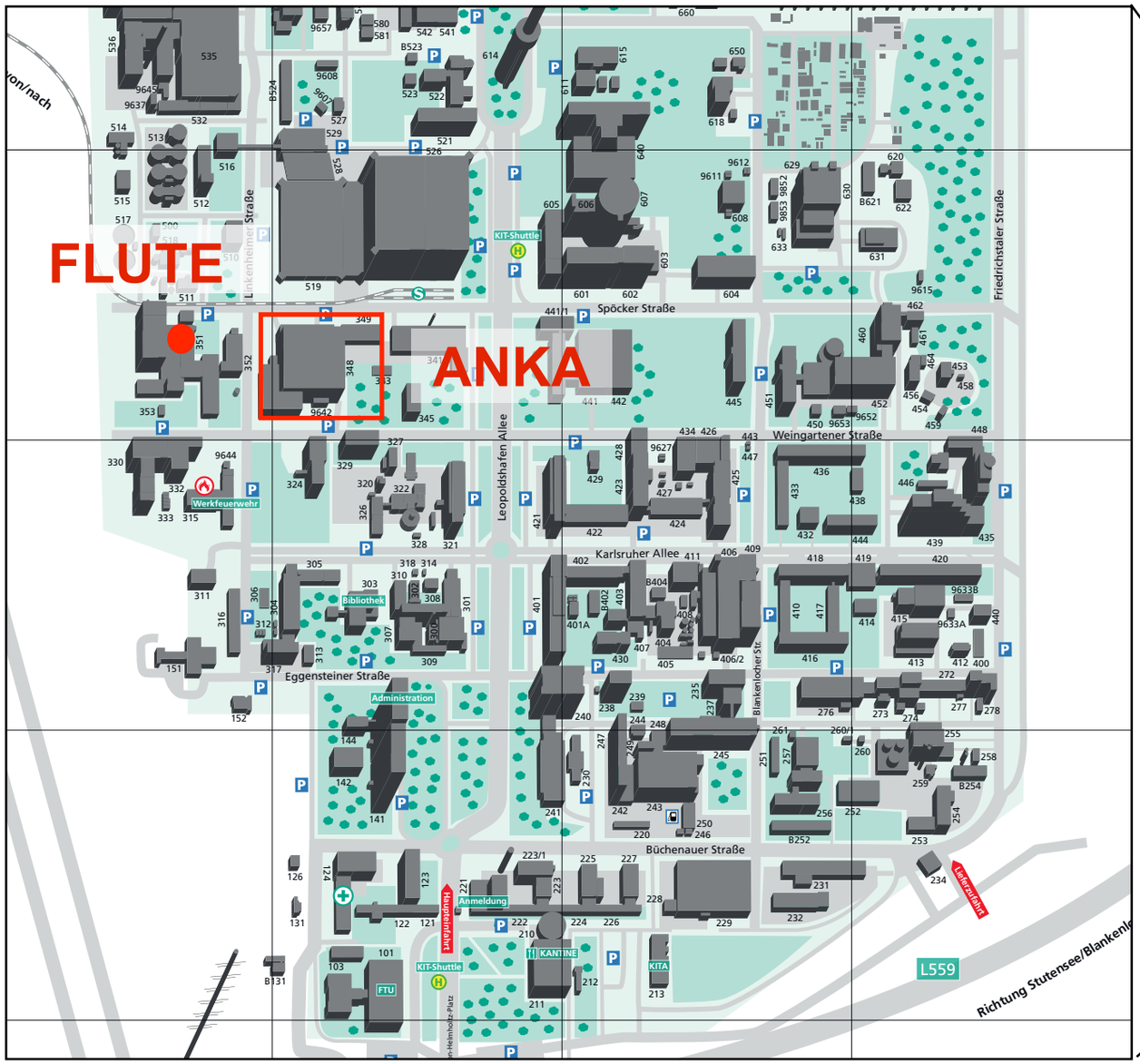




Outline

- Introduction & Motivation
- Key Components of FLUTE
- Status of FLUTE
- Outlook

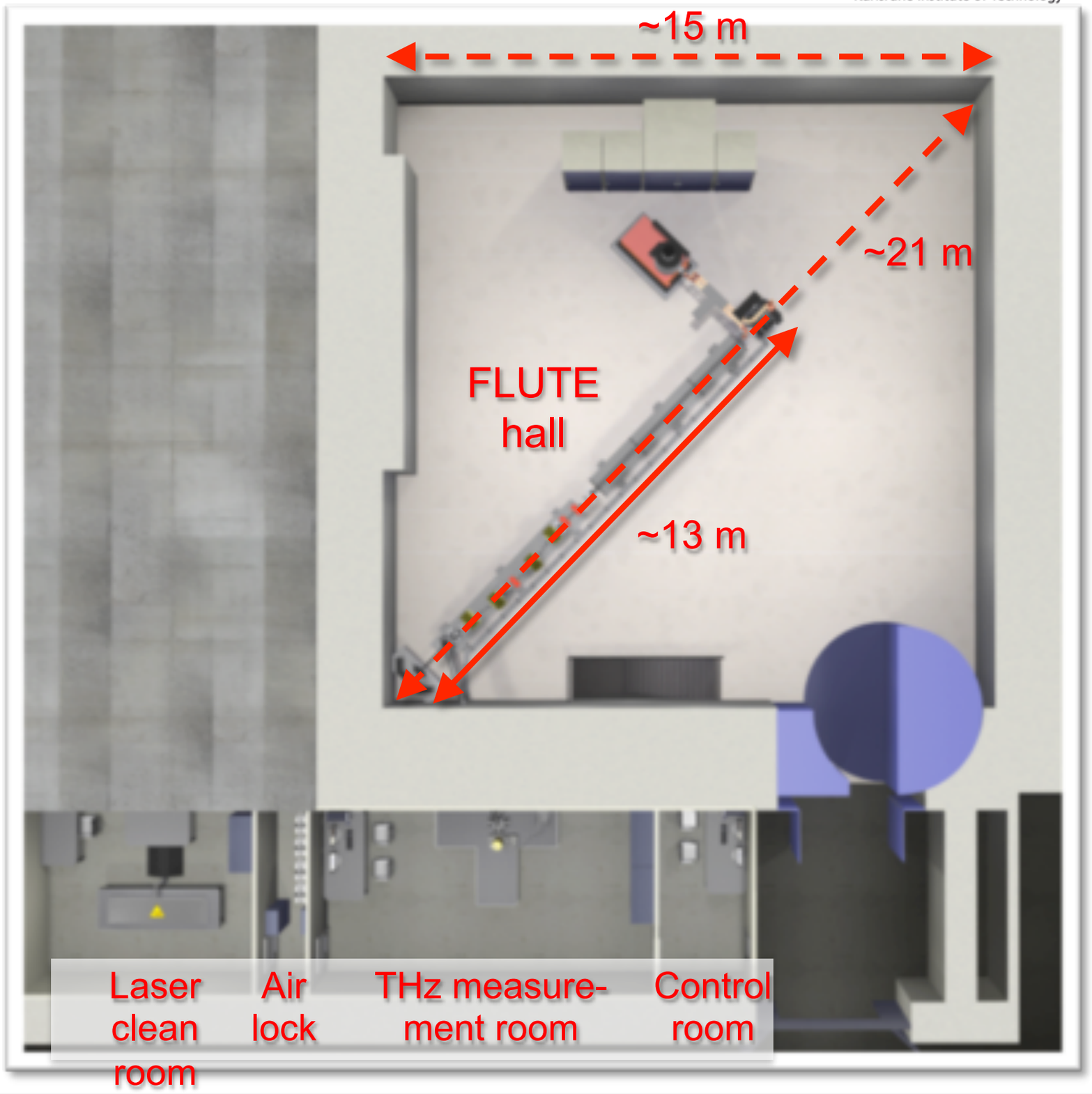
Where we are…


FLUTE
ANKA
Spöcker Straße
Weingartener Straße
Karlsruher Allee
Eggensteiner Straße
Büchenauer Straße
Leopoldshafen Allee
Friedrichstaler Straße
Linkenheimer Straße
Blankenlocher Str.
KIT-Shuttle
Bibliothek
Administration
Werkfeuerwehr
Anmeldung
KANTINE
FTU
KITA
L559
Richtung Stutensee/Blankenl


KIT

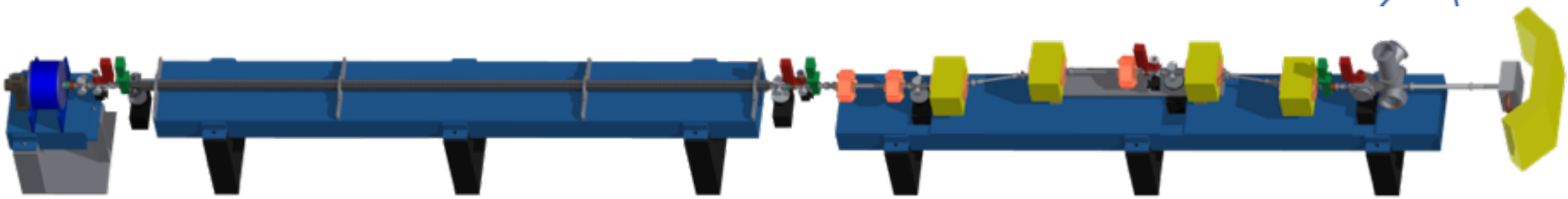
Where we are…

- Former cyclotron bunker
- Large basement underneath FLUTE hall and measurement room



Introduction: FLUTE

- FLUTE (Ferninfrarot Linac- Und Test-Experiment)
  - Test facility for **accelerator physics within ARD**
  - **Experiments** with THz radiation

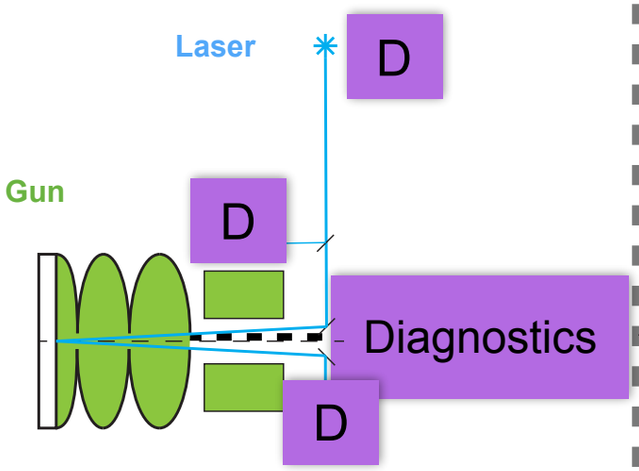


- Serve as a test bench for new beam diagnostic methods and tools
- Develop single shot fs diagnostics
- Systematic bunch compression studies
- Generate intense THz radiation
- Compare different coherent THz radiation generation schemes in simulation and experiment

Final electron energy	~ 41	MeV
Electron bunch charge	1 - 3000	pC
Electron bunch length	~1 - 300	fs
Pulse repetition rate	10	Hz
THz E-Field strength	up to 1.2	GV/m

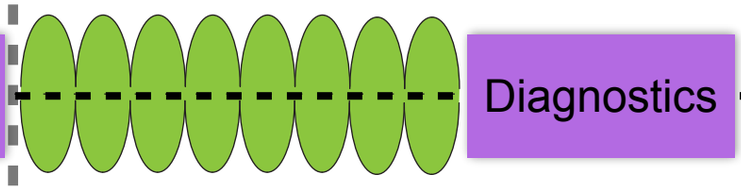
FLUTE Main Parameters

Phase 1



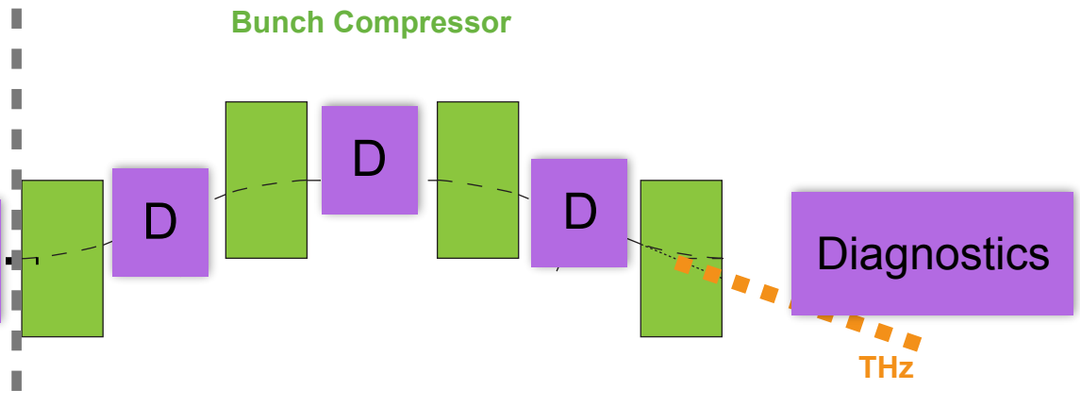
Energy	7 MeV
Bunch Charge	**1 pC** - 3 nC
Beam Size	0.4 - 4.5 mm
Bunch Length	**500 fs** - 2.5 ps
Energy spread	0.14 - 0.8 %
λ	266 nm
Spot Size	0.5 - 2.5 mm
Pulse length	500 fs - 2 ps

Phase 2



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 %

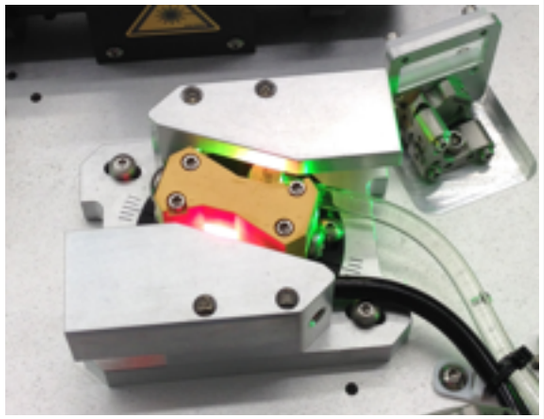
Phase 3



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 %

Gun Laser Status

- Commercial frequency tripled, amplified Ti:Sa laser (800 nm) to generate UV (267 nm) pulses for photo injector
- Laser commissioned
- Laser safety system set-up
- Laser transport and diagnostics planned and laid out



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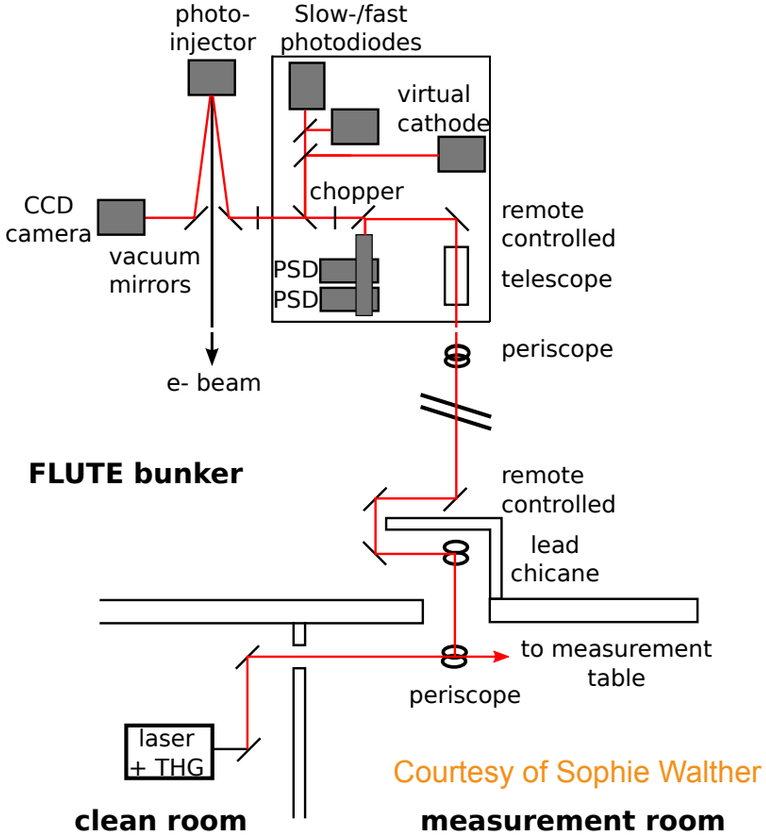
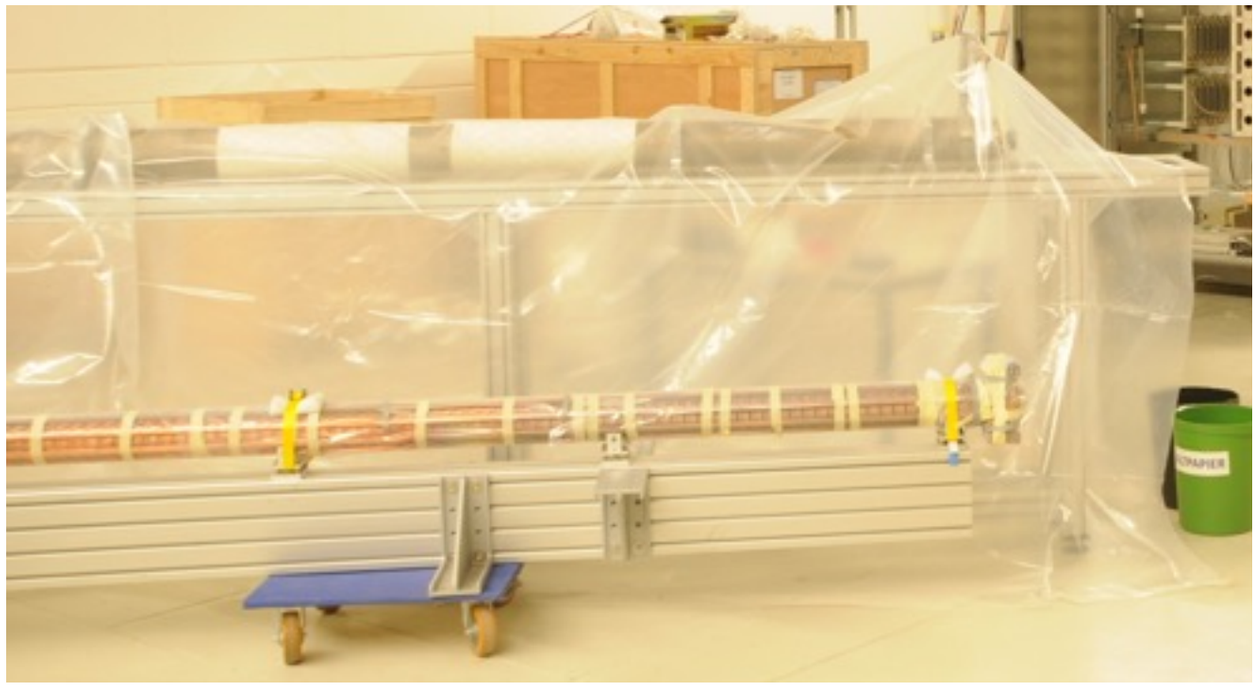
λ	266 nm
Spot Size	0.5 - 2.5
Pulse length	500 fs - 2
Repetition rate (Laser)	1 kHz
Repetition rate (Gun)	10 Hz

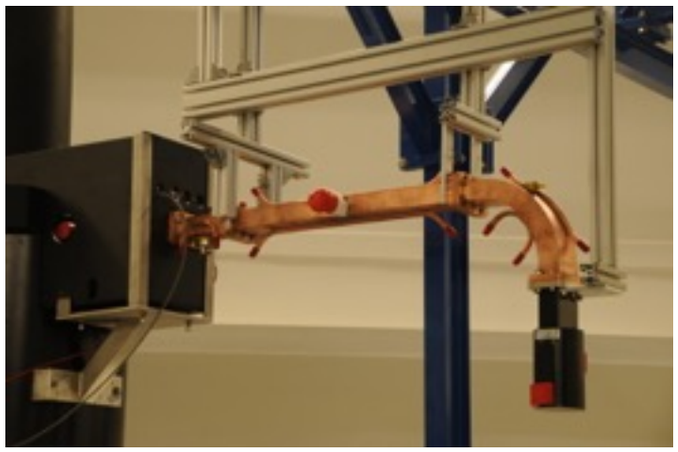


Courtesy of Sophie Walther

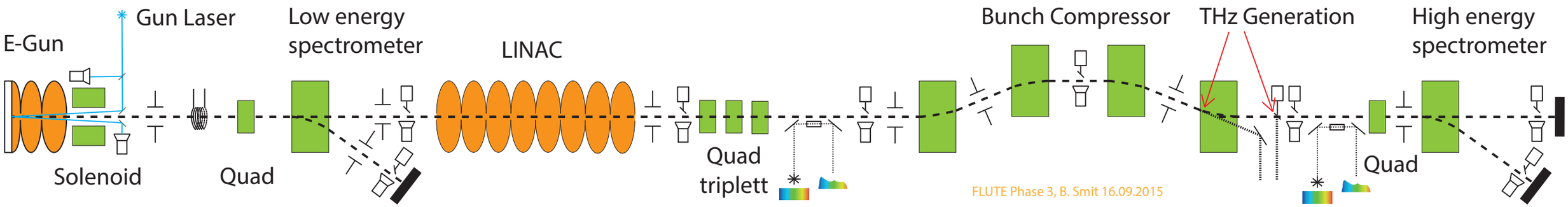
RF Status

- Modulator interlock tests are currently underway
- LLRF from DESY arrived
- Klystron installed and prepared for commissioning





Diagnostics Status

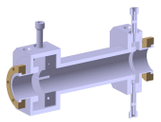


Laser Diagnostics

- Virtual Cathode
- Cathode Imaging
- Auto-Correlator / Grennouille

Charge / Position / Size

- Integrating Current Transformer
- Faraday Cup
- 7-8 Cavity BPMs
- 6 Movable Screens



Energy

- 2 Spectrometers (7 & 41 MeV)

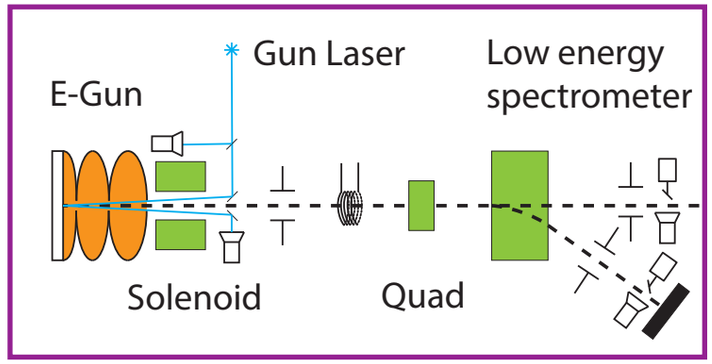
Bunch Length

- 2 Electro-Optical Monitors
- THz deflector

THz Diagnostics

- Fast THz-Detectors
  (e.g. HEB, Schottky Diodes)
- Martin-Puplett Interferometer
- Michelson Interferometer
- Electro-Optical Methods
  (far-field)

Status FLUTE phase 1

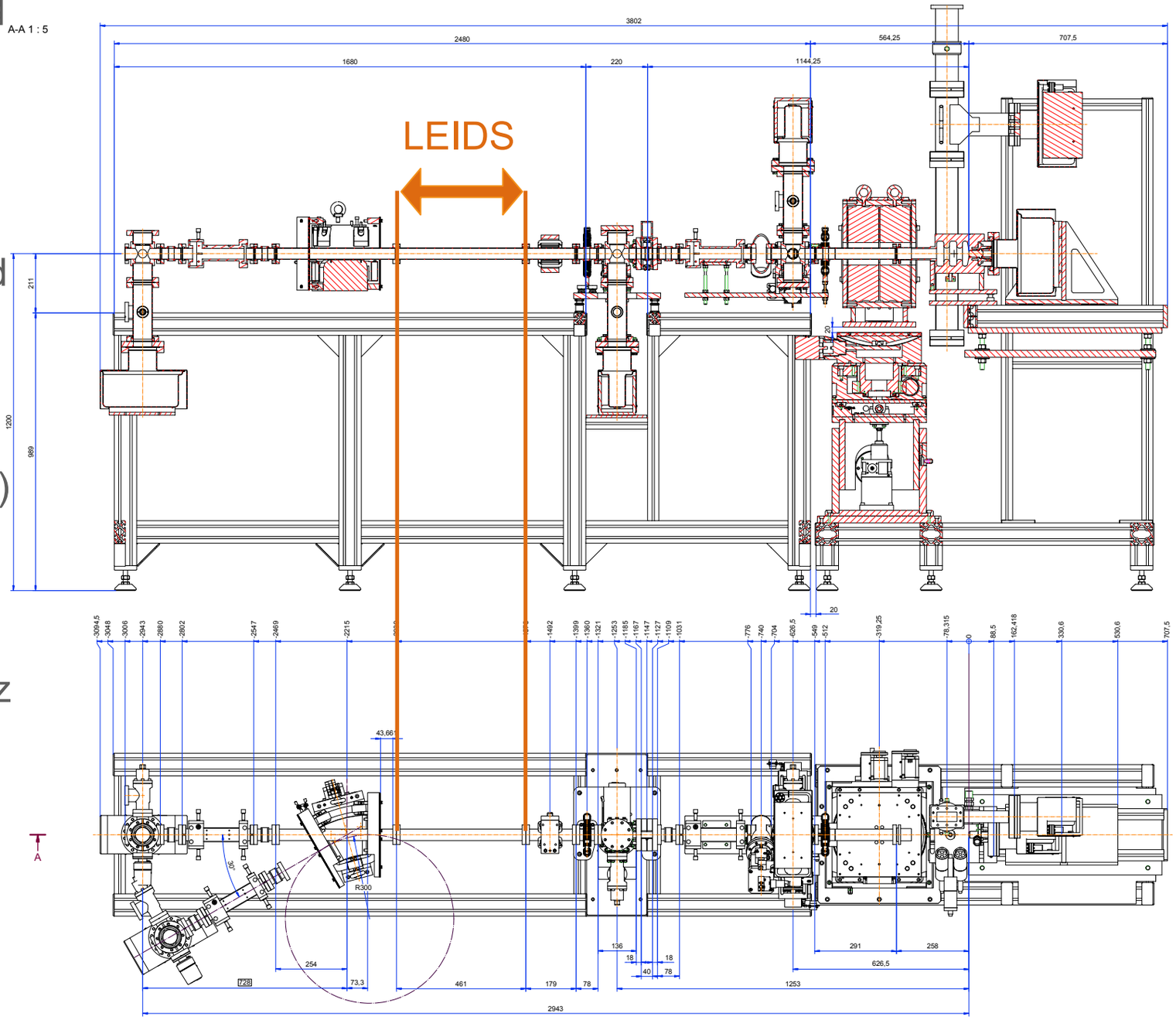


Magnets

- All magnetic components ordered
- Integration in the control system starting early 2016

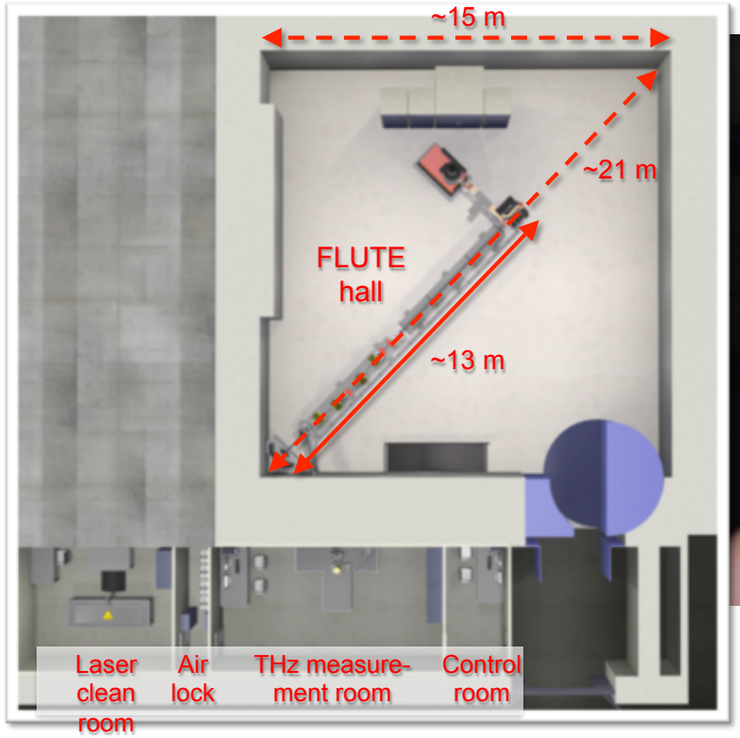
Diagnostics

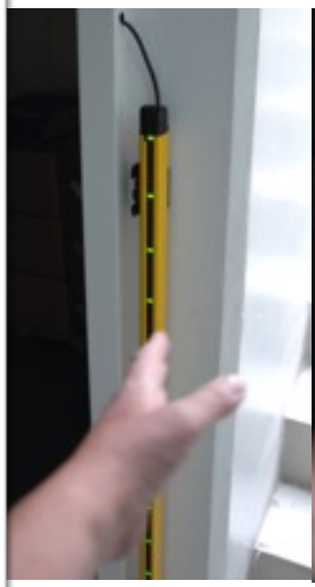
- All diagnostic components arrived
- 2 Screen monitors foreseen
- Integrating Current Transformer (ICT)
- 3 Beam Position Monitors (BPMs)
- Integration in the control system starting early 2016
- LEIDS: Reserved space for additional diagnostics/RF, i.e. THz streaking or Buncher cavity

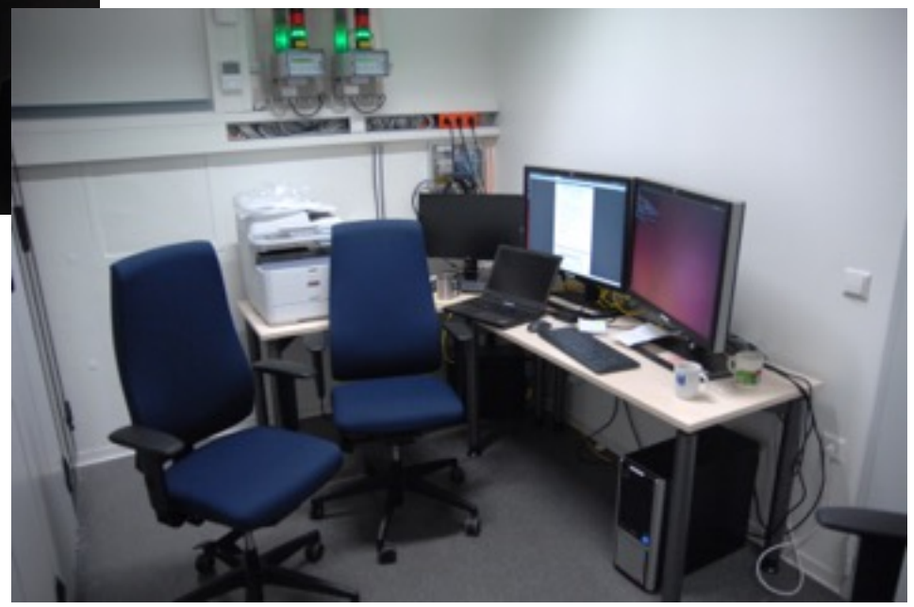


Status FLUTE phase 1

- Infrastructure
- Personnel Safety system
- Control system and archiver running







Acknowledgements

We would like to thank…

… all of our collaboration partners at PSI & DESY for the great support!

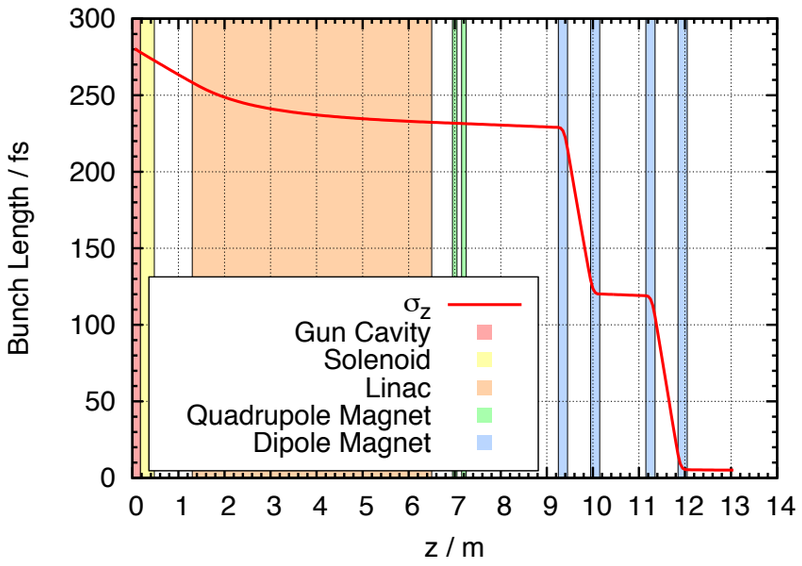
… our colleagues at KIT (inside and outside of the FLUTE-Team) who are giving us great support be it technical or scientific!

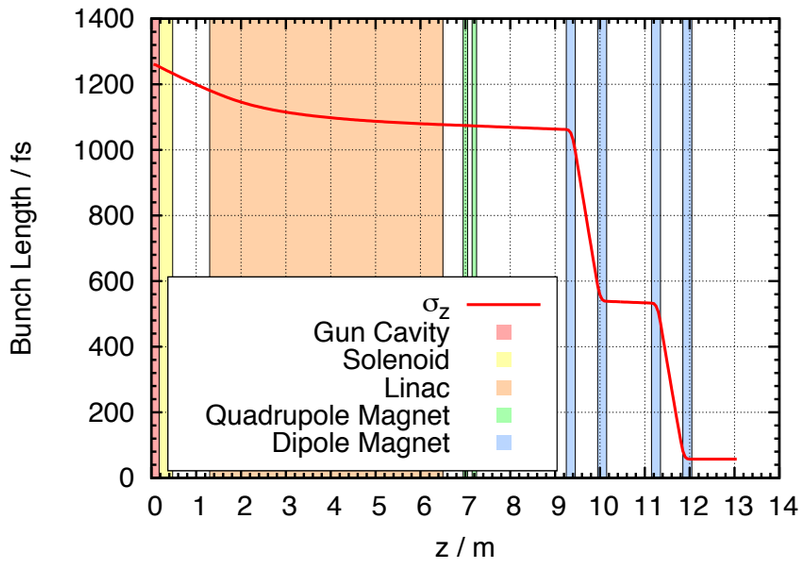
… all the people from other facilities who have given us lots of feedback and tips and explained to us how they had solved certain issues.

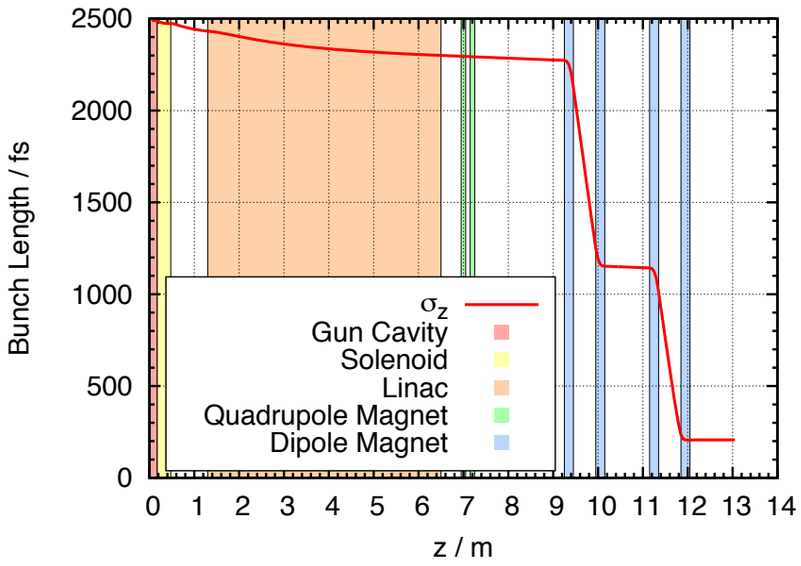
FLUTE gun laser

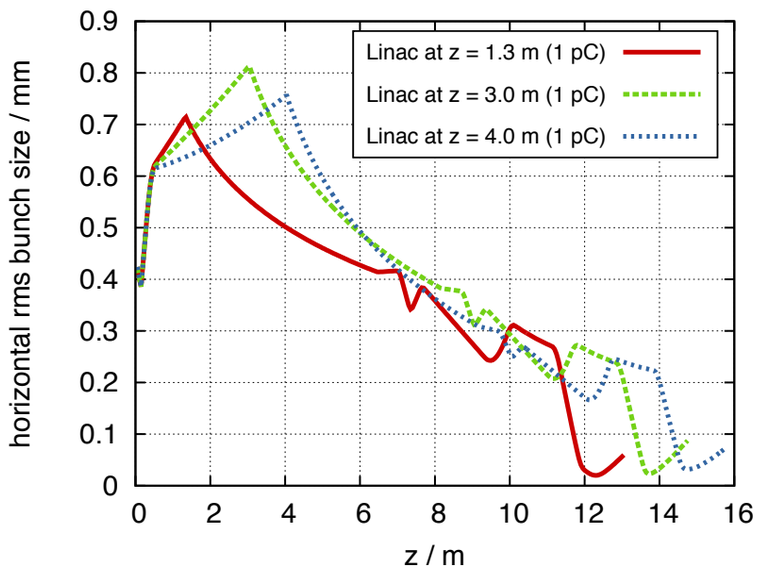
Backup Slides

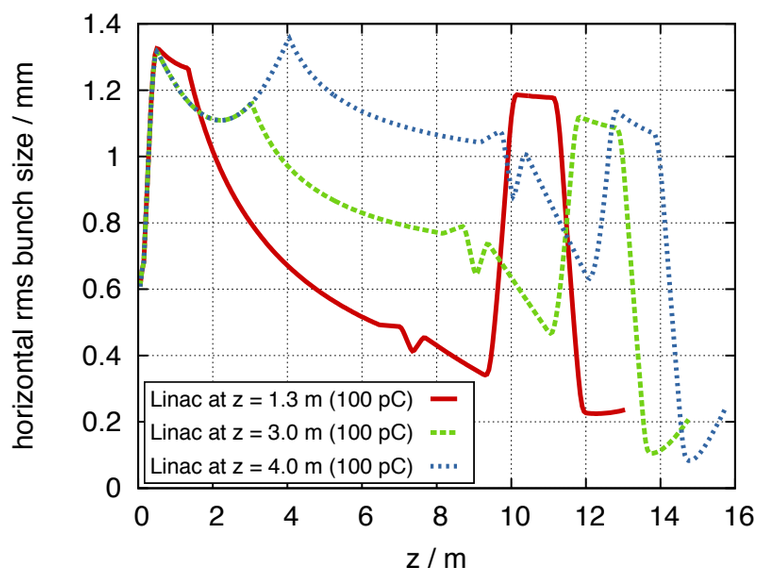
Beam Size and Bunch Length

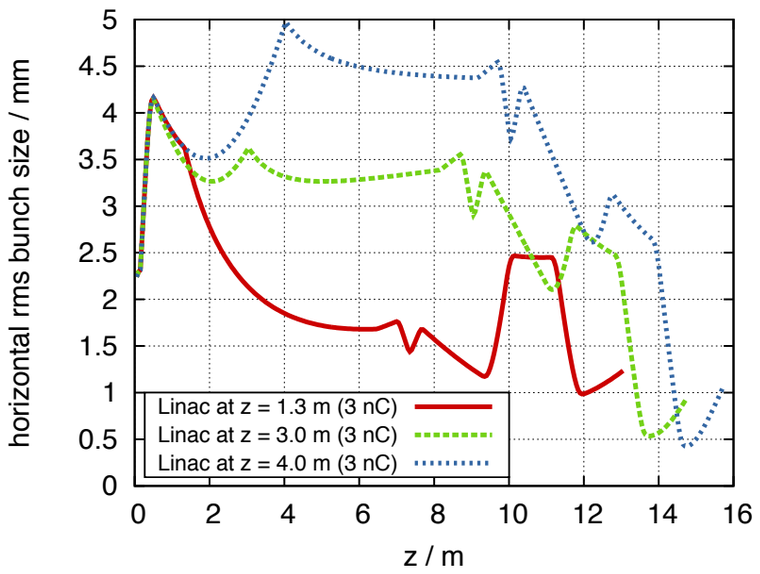




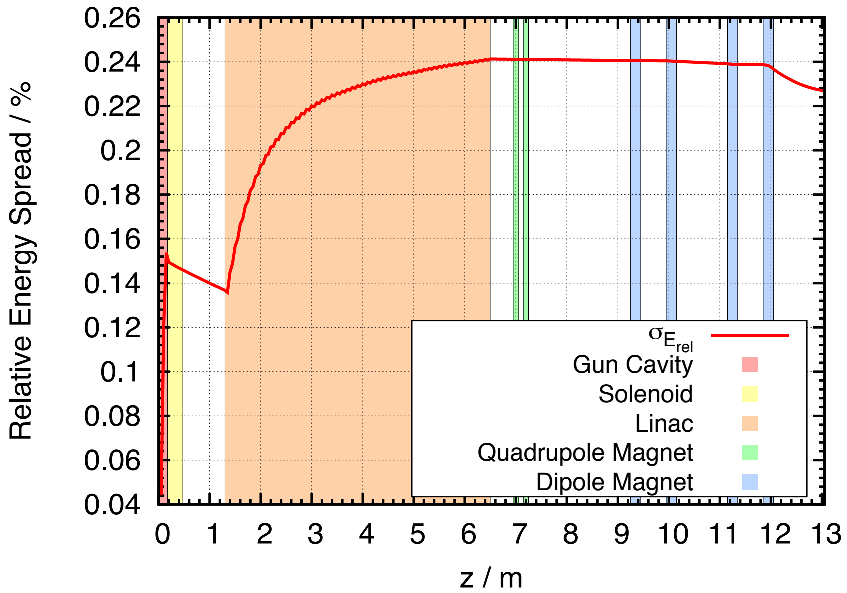


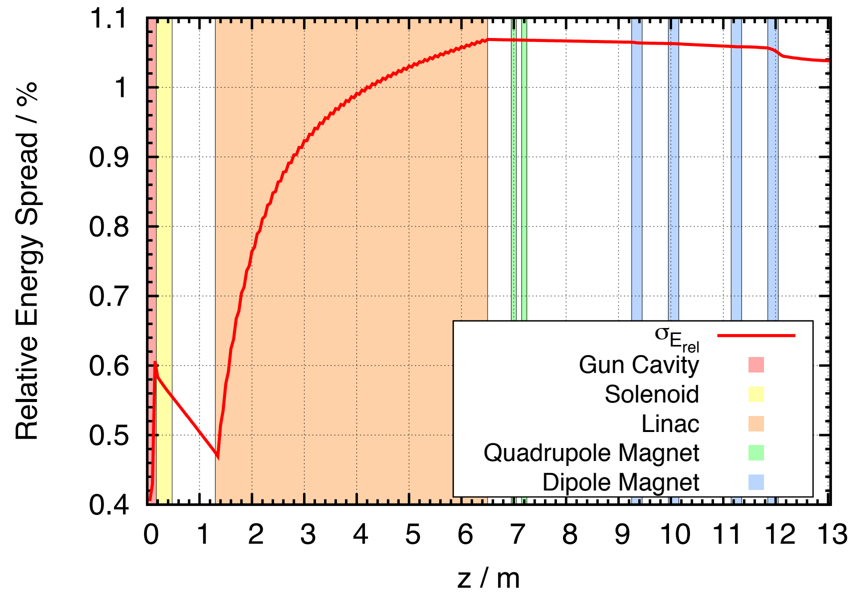


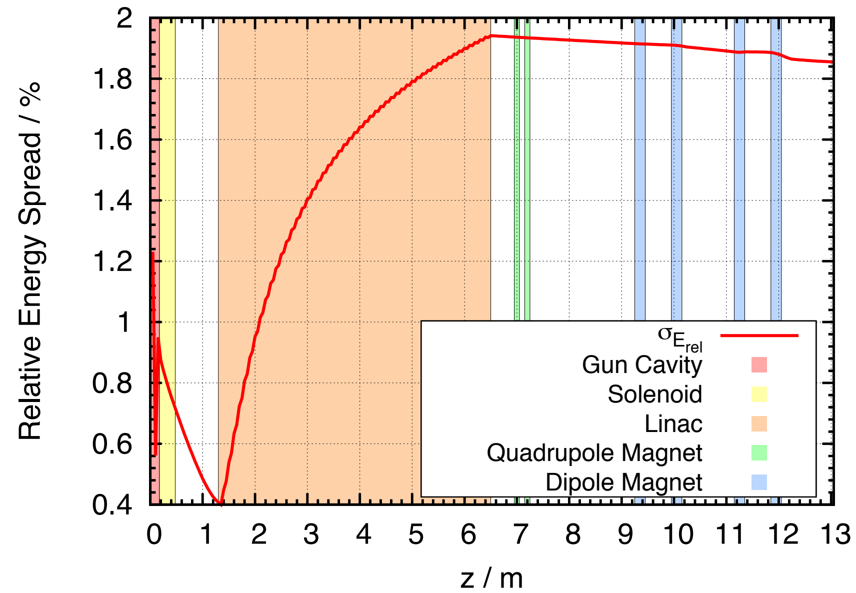


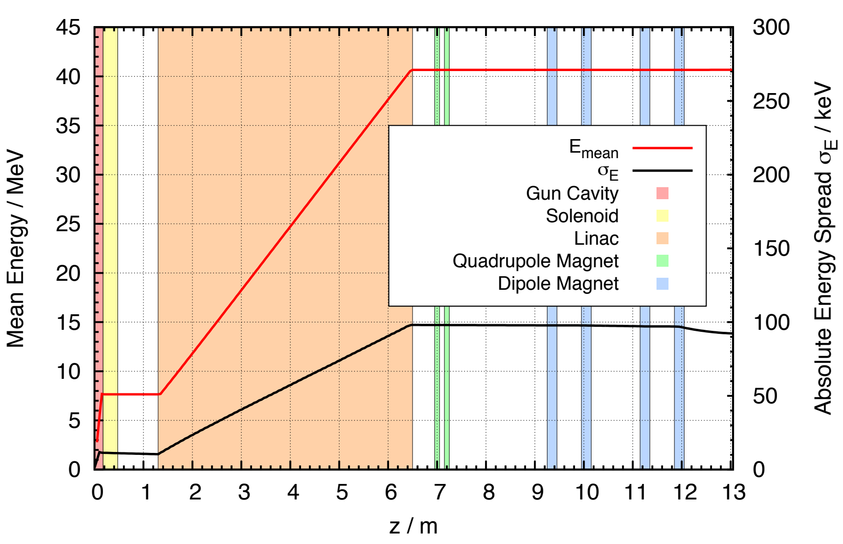


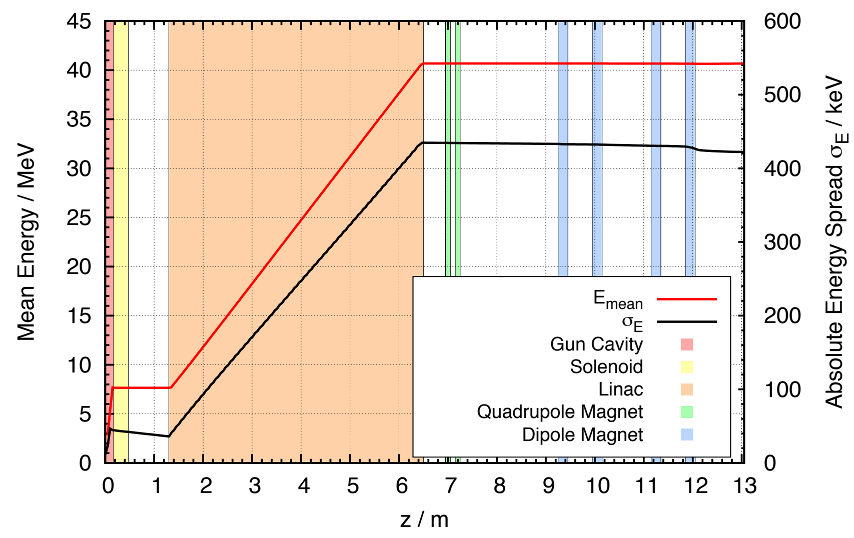
Energy Spread (absolute & relative)

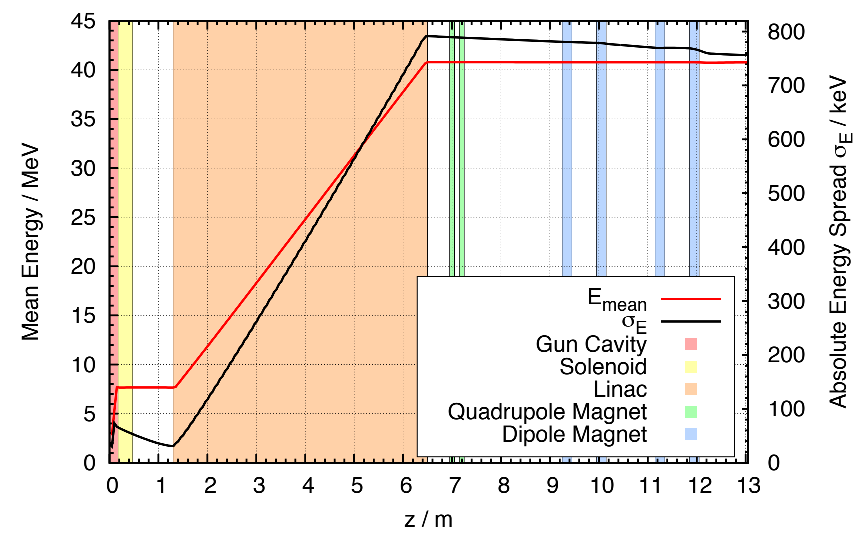












Gun Laser System

- **Commercial frequency tripled, amplified Ti:Sa laser (800 nm) to generate UV (267 nm) pulses for photo injector**
- **Oscillator: Vitara T-HP**
  - Average power > 930 mW
  - Pulse length < 20 fs
  - Repetition rate ~83 MHz
  - Completely sealed off

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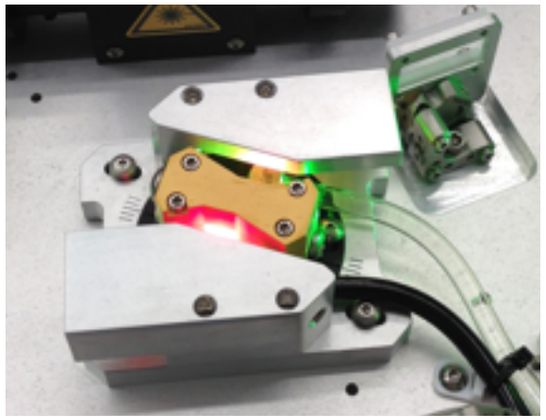
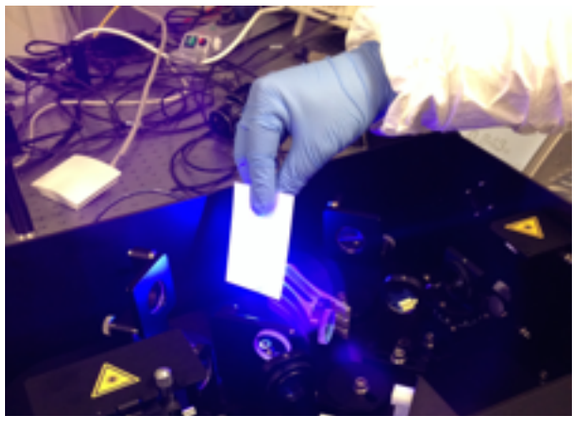
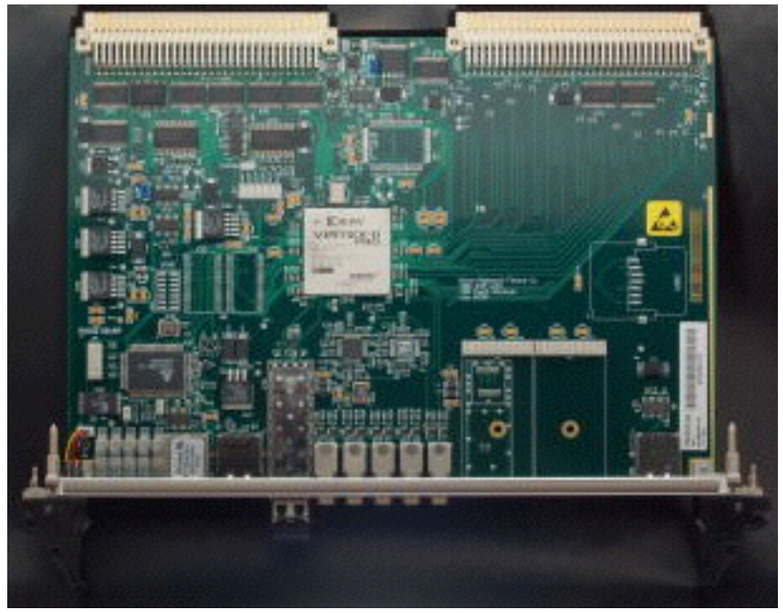


- **Amplifier: Astrella**
  - Average power > 6 W (> 6 mJ)
  - Repetition rate ~1 kHz
  - Pulse length < 35 fs
- **Higher harmonic generation**
  - Conversion efficiency SHG ~50%
  - Conversion efficiency THG ~19%



Timing & Synchronization

- **RF Based 3 GHz master oscillator**
  - SINTEC FLUTE Master Oscillator V2.0 (identical to the one for REGAE)
- **Timing System from Micro Research Finland**
  - Compatible with the ANKA timing system



MRF VME Event Receiver

http://www.mrf.fi/index.php/vme-products/76-vme-event-receiver-wo-rf-vme-evr-230

- **3 Laser Synchronization Units: µTCA-based (DESY design)**
  - Coherent Astrella Ti:Sa Gun laser (83 MHz)
  - 2x Yb-doped fiber lasers for EO-diagnostics (62.5 MHz)

µTCA based laser sync @ DESY

Collaboration DESY-KIT Low Level RF System

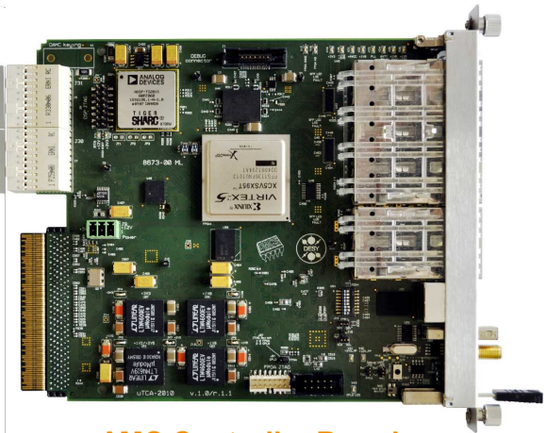
- µTCA system developed at DESY
  - New version
  - Timing board
  - Advanced mezzanine card with a rear transition module

- Collaboration between DESY and KIT

- Use FLUTE as test bench

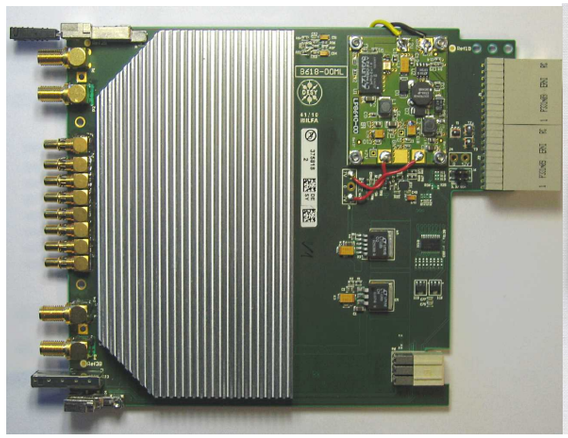
- EPICS (Experimental Physics and Industrial Control System) integration at KIT

RTM Vector Modulator

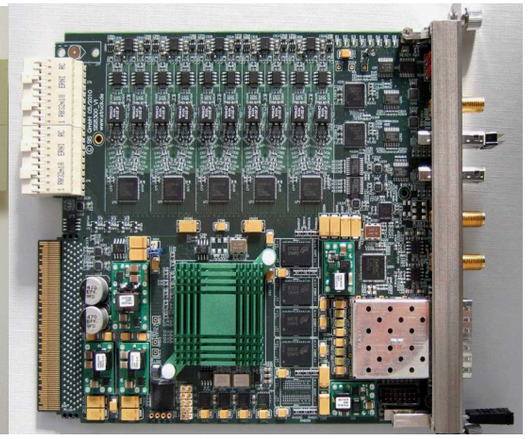


AMC Controller Board

RTM Downconverter



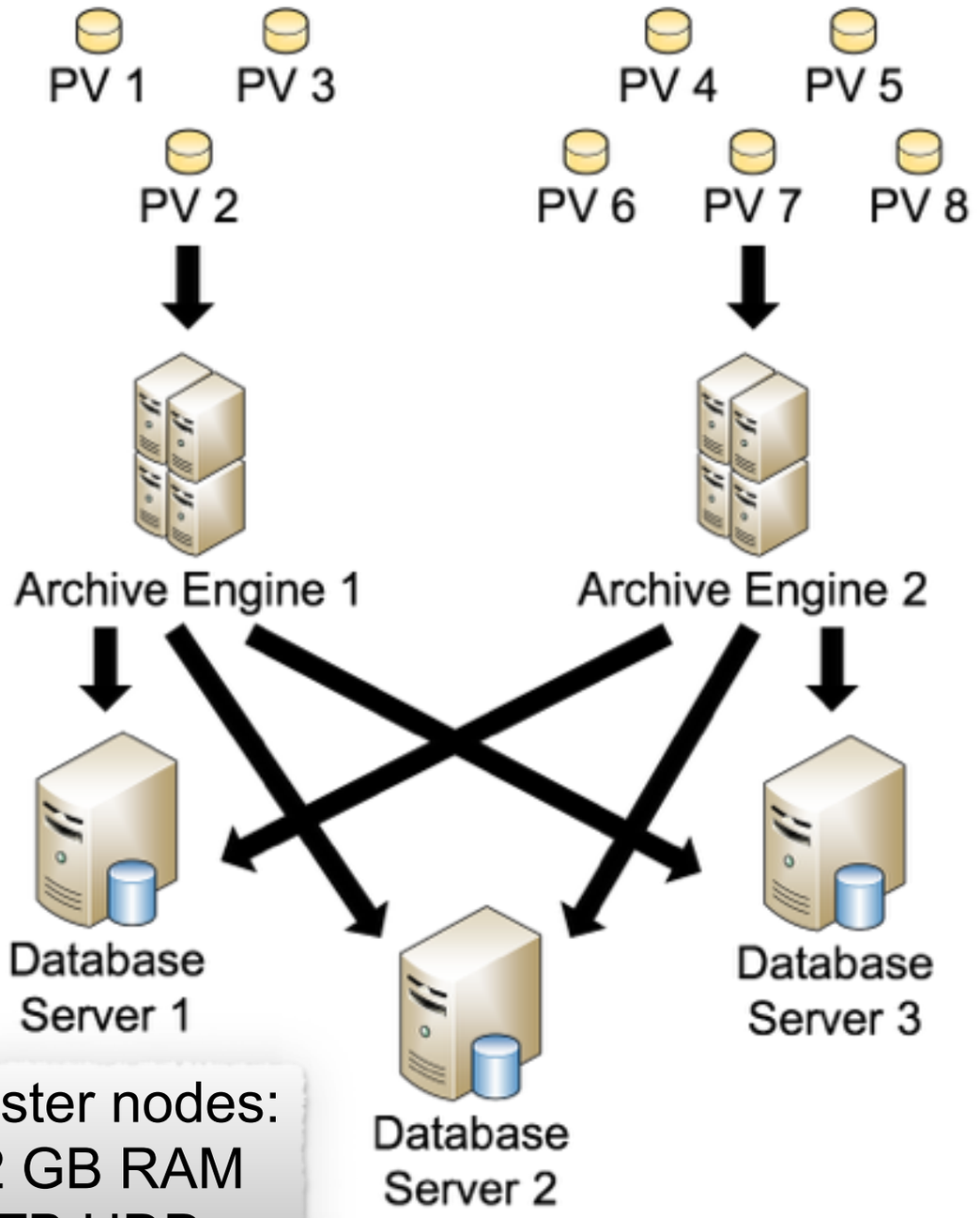
AMC ADC Board (SIS8300)



M. Hoffmann et al., DESY

Control system

- Hardware
  - PCs with x86_64 architecture
  - SIEMENS S7 PLCs
  - MicroTCA
  - TCP/IP over Ethernet
- Software
  - Linux (Ubuntu 14.04 LTS)
  - **EPICS**
  - Control System Studio
  - Apache Cassandra
- Status
  - Most hardware components arrived
  - Basic server infrastructure has been setup



36 cluster nodes:
- 1152 GB RAM
- 144 TB HDD

S. Marsching

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