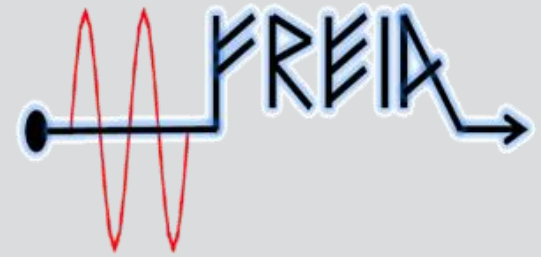




UPPSALA  
UNIVERSITET

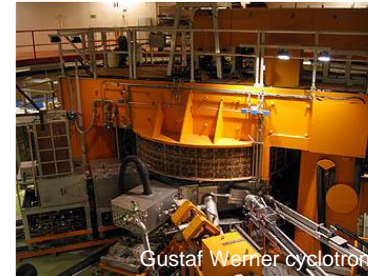


# Uppsala Plans and Activities Towards Future FELs

Roger Ruber, Volker Ziemann and Tord Ekelöf  
for the Uppsala Accelerator Group & FREIA

20 September 2013, CERN  
Workshop on Use of CLIC Technology for FELs

- Old university (1477) with 40'000 students
- Gustaf Werner Inst./The Svedberg Lab.
  - Cyclotron (since 1948)
  - proton therapy (since 1950s) → Skandion clinic
  - CELSIUS cooler ring (1984 – 2006)
- Electron-positron linear collider development
  - CERN projects CTF3/CLIC & NorduCLIC
  - Two-beam Test Stand & RF breakdown issues
  - EU FP6-EuroTeV, FP7-EuCARD, FP7-TIARA
- Free electron laser development
  - DESY FLASH Optical Replica Synthesizer,
  - European XFEL Laser Heater
  - Stockholm-Uppsala FEL Centrum
- European Spallation Source development
  - microwave power systems
  - accelerating cavity & cryostat prototyping
  - cryomodule series acceptance testing



# Why FREIA?

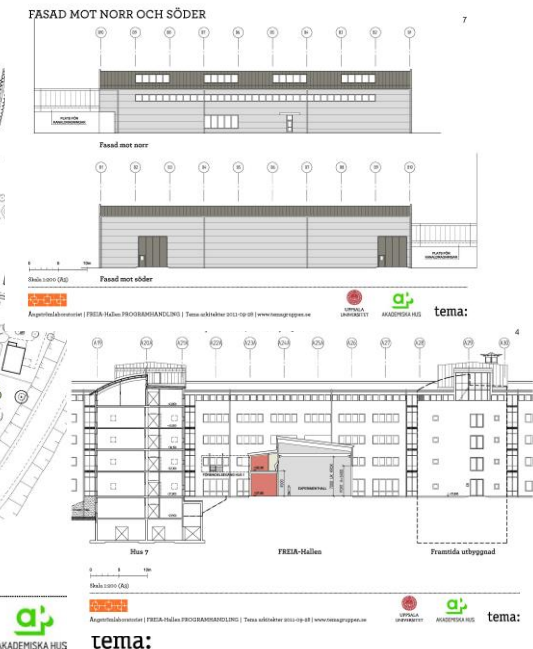
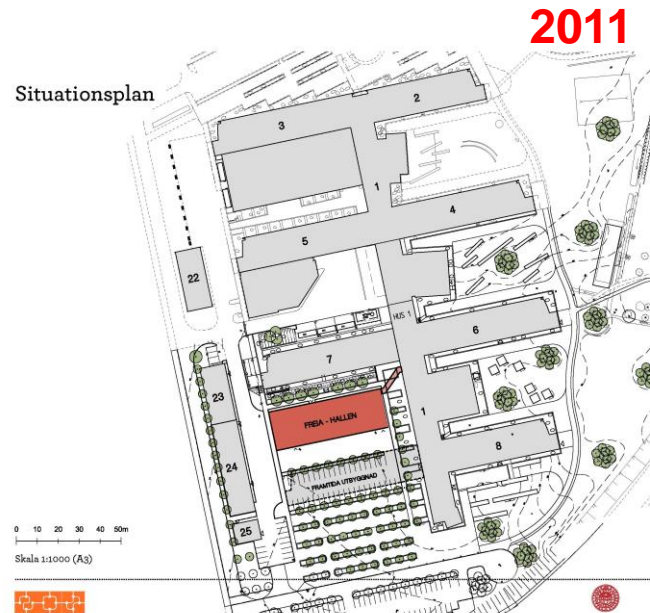
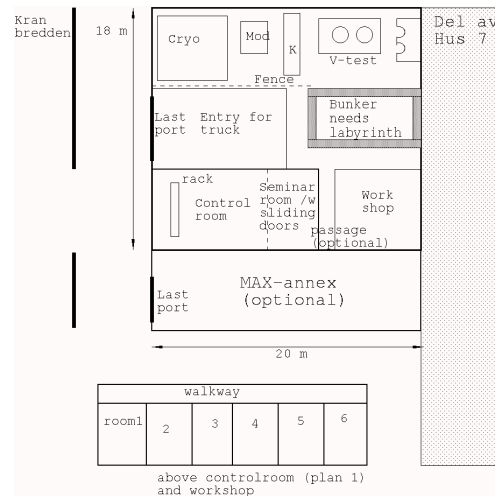
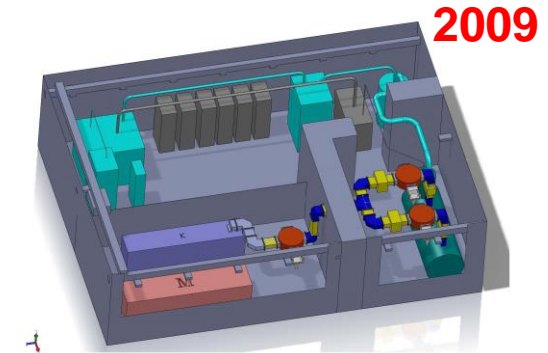


## Several circumstances

- ESS test stand requires space and bunker
- CELSIUS accelerator hall already re-assigned

## Decision on new construction at Ångström (2010)

- funding support from KAWS, government and university





# The New FREIA Laboratory



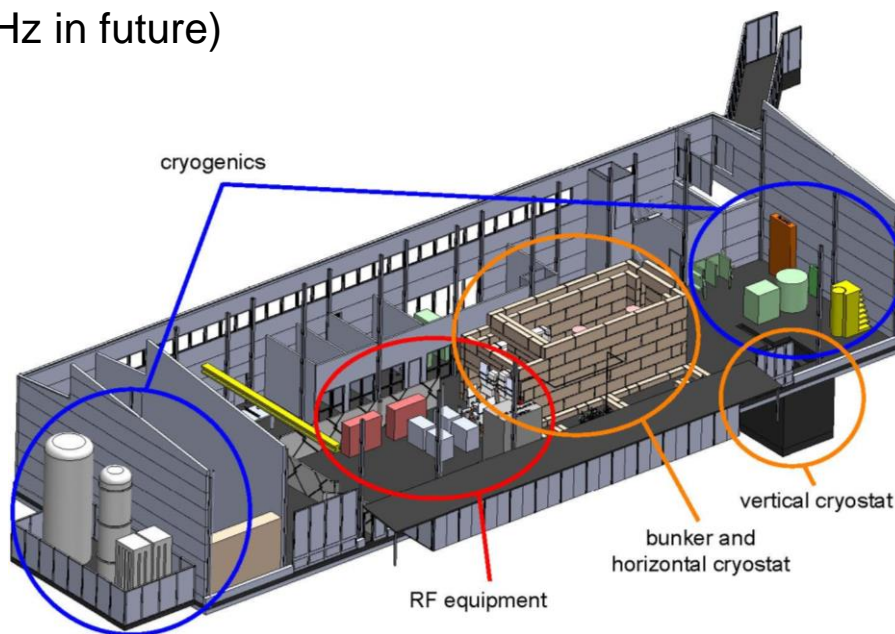
**Inaugurated  
18 June 2013**





## Facility for Research Instrumentation and Accelerator Development

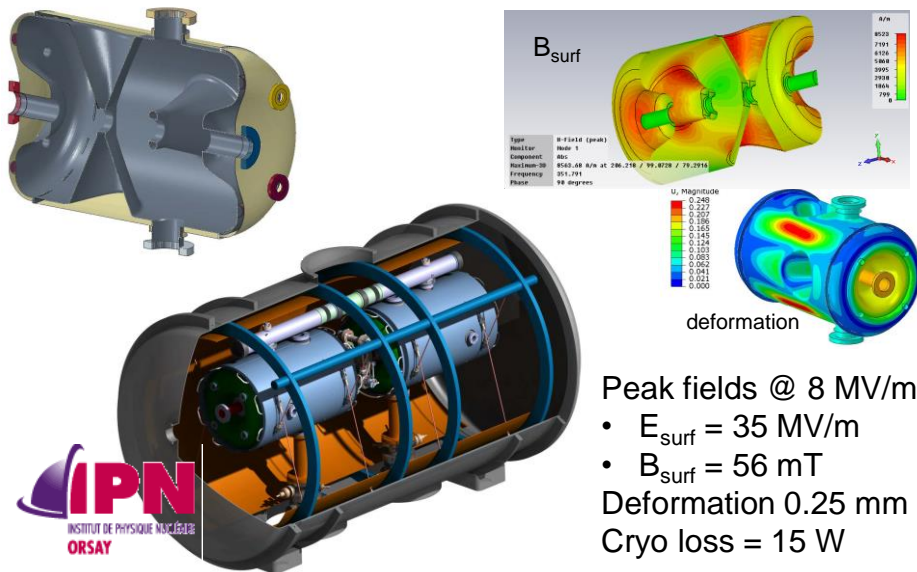
- General Infrastructure
  - liquid helium, nitrogen production & distribution
  - specialized workshop, control room
  - concrete bunkers
- Accelerator & General Test Stands
  - horizontal test cryostat (vertical in future)
  - power sources: 352 MHz (704 MHz, 12 GHz in future)
- Neutron Generator
  - neutron tomography, detector tests
  - student exercises and projects



## ESS Accelerator

### High power system test of source, spoke cavity and cryostat-module

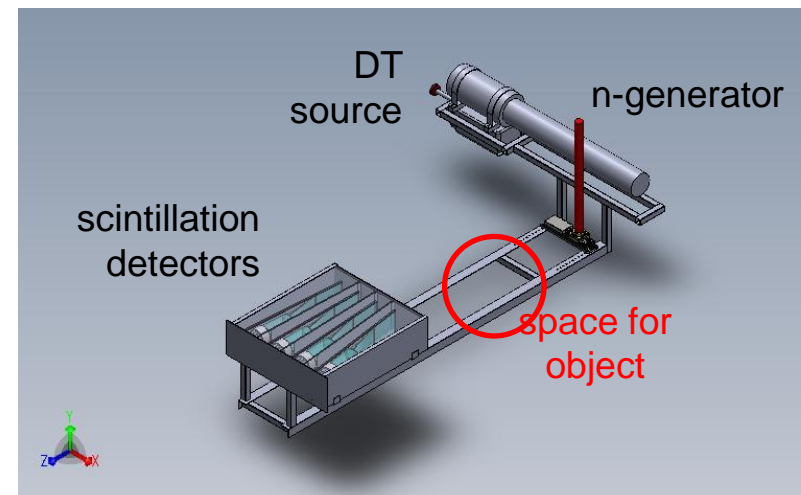
- high power soak testing of power source, controls, amplitude and phase stability with accelerating cavity
- test cavity tuning system, dynamic load, electron emission and multipactoring



## Neutron Generator

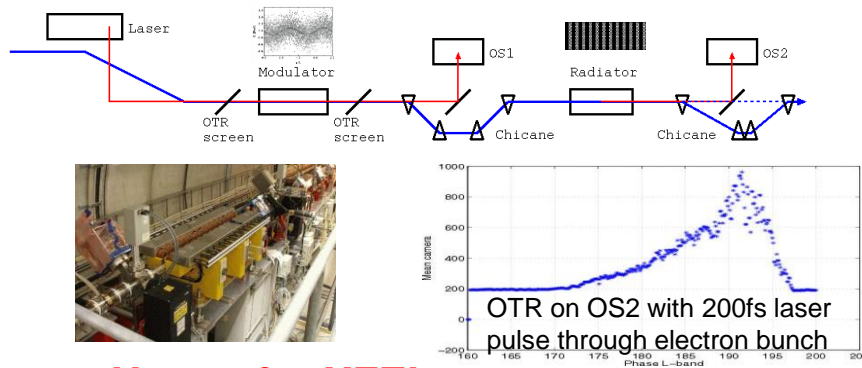
### Access to neutrons

- neutron tomography and detector tests
- student exercises and projects
- physics experiments in combination with solid-state based gamma-detector
  - nuclear fission
  - activation analysis



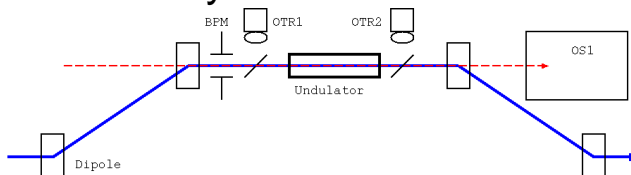
## Optical Replica Synthesizer

- measure ultra-short bunches (fs range)
- too fast for electronics, but can be done with optics (FROG)



## Laser Heater for XFEL

- electrons are born very cold (3keV) → susceptible to plasma oscillation instabilities
- add Landau damping (decoherence) in a well controlled way

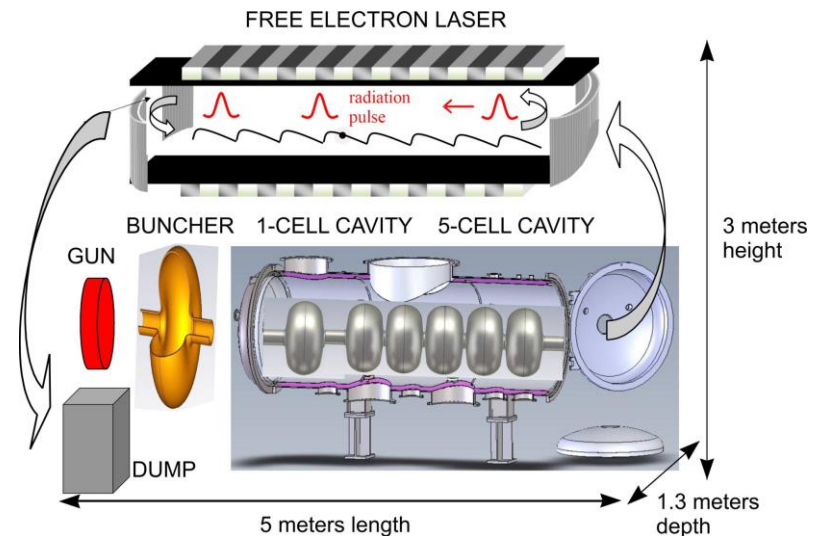


## THz FEL

- THz radiation non-ionizing, strongly absorbed by water

## Biology and Material Science

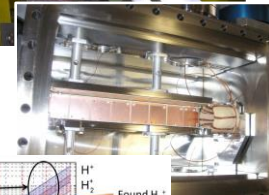
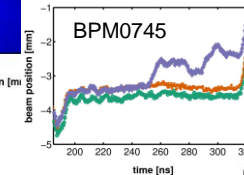
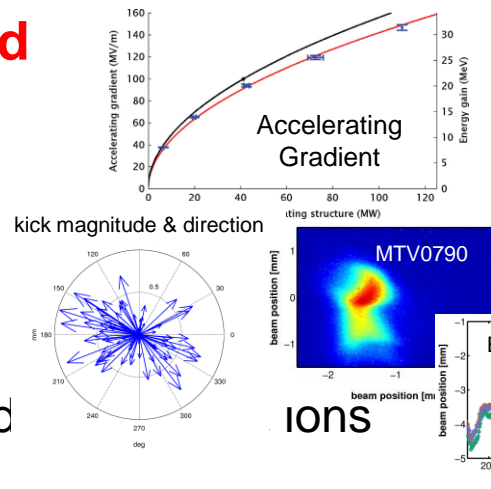
- imaging & spectroscopy for biological tissues, proteins, molecular and material science
- extends existing efforts by the Microwave group





## CTF3 Two-beam Test Stand

- two-beam acceleration
  - up to 140 MV/m
- effects of RF breakdown
  - possible beam kick
- Flashbox for studies of ejected
  - found  $H_2^+$  ions

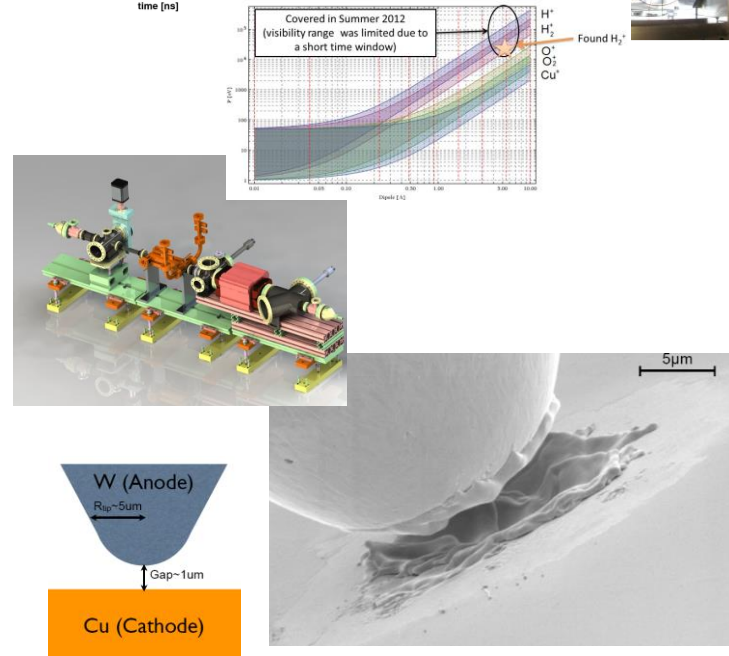


## CTF3 Xbox / 12 GHz Test Stand

- study of ejected electrons & ions
- preparing pepperpot with spectrometer

## Discharges in SEM

- focused ion beam (FIB) for surface shaping
- electrical and structural analysis of field emission and discharges

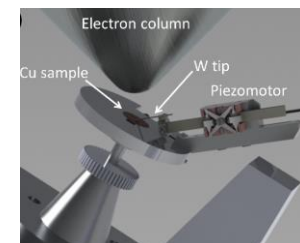
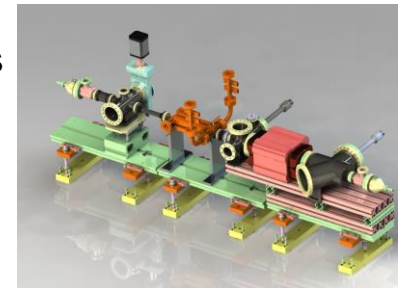
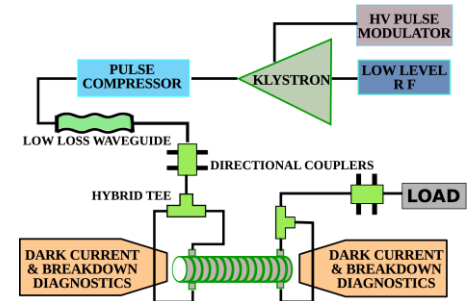




## SIGURD High Gradient RF research

### Set-up and Instrumentation for GHz Research and Development

- scientific aims:
  - technology development for efficient and compact accelerators
- combine RF and SEM studies on one site
  - X-band test stand at FREIA for
    - breakdown detection
      - vacuum breakdown pattern, rate, relation to gradient, memory effects
    - location of breakdown site
      - pulse heating, plasma formation, dark currents, breakdown currents
    - instrumentation for
      - electron and ion currents, X-ray,
      - light: plasma and dynamic vacuum diagnostics
  - SEM at Microstructure Laboratory for
    - post-mortem analysis of structures
      - surface analysis, feedback on construction and preparation
- link to theory developments (Helsinki University)

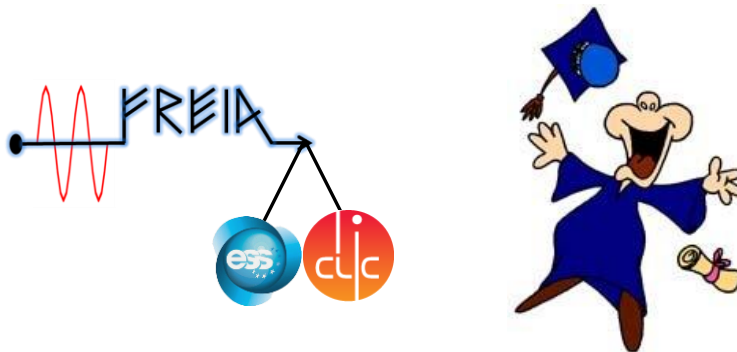
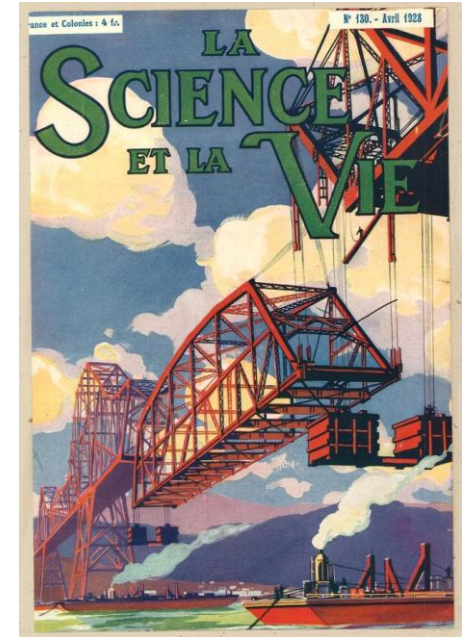


## Technology development for compact & efficient future accelerators

- particle collider: participation in CLIC/CTF3
- proton therapy: collaboration with TERA, Uppsala has a long history and presently constructing specialized Skandion clinic
- FEL: strong interest from MAXlab (Lund) and Stockholm-Uppsala FEL center
  - MAX IV:
    - S-band injector linac, to be **extended** to 5-6 GeV range
    - X-band extension option if beneficial (physics, costs, space, reliability) but no plans to replace entire linac
  - Stockholm-Uppsala centre for FEL research
    - coordinates contributions to XFEL
    - studies implementation of a local FEL



- FREIA laboratory enables
  - accelerator R&D for medical and research purposes,
  - neutrons for physics, biology and material science
- FREIA opens new opportunities for unique scientific projects in Uppsala
  - access to technology and experience for future FEL in Sweden (Lund or Stockholm-Uppsala region) either superconducting and normal conducting
- Planned FEL projects
  - SIGURD test stand for X-band structure optimization



Thanks to  
university, faculty,  
physics & astronomy department  
and the FREIA team.