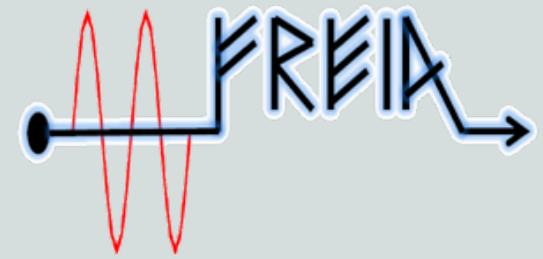




UPPSALA  
UNIVERSITET



# FREIA

## Facility for Research Instrumentation and Accelerator Development

Roger Ruber  
for the FREIA team

17 June 2013, Uppsala  
TIARA Workshop on RF Power Generation for Accelerators

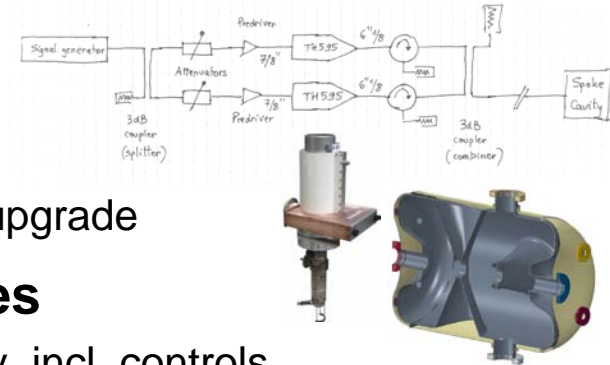
## Concentrating on microwave power (RF) and instrumentation ...

- Cyclotron (since 1948)
- CELSIUS storage & accelerator 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
  - FLASH Optical Replica Synthesizer,
  - XFEL Laser Heater
  - Stockholm-Uppsala FEL Centrum
- European Spallation Source development
  - microwave power systems
  - accelerating cavity & cryostat prototyping
  - cryomodule series acceptance testing



## 1) Contribution to the technical design & construction effort

- design concept spoke accelerating cavity power source
- design concept radio-frequency (RF) power distribution
- survey test stand infrastructure and requirements
- study of upgrade scenarios RF systems for ESS power upgrade



## 2) Development power station for spoke cavities

- soak test with water cooled load, then accelerating cavity, incl. controls
- collaboration with industry to develop vacuum tube and solid-state based prototypes

## 3) System test, power station with spoke cavity and cryostat-module

- fully dressed prototype cavity (in test cryostat)
- complete prototype module (2 spoke cavities)

## 4) Acceptance test cryostat-modules (proposal submitted)

- for all final modules before installation

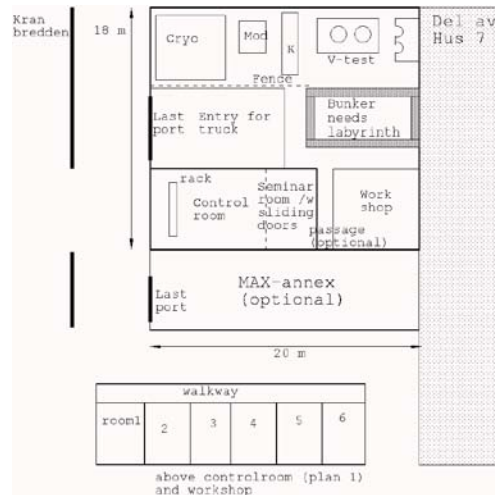
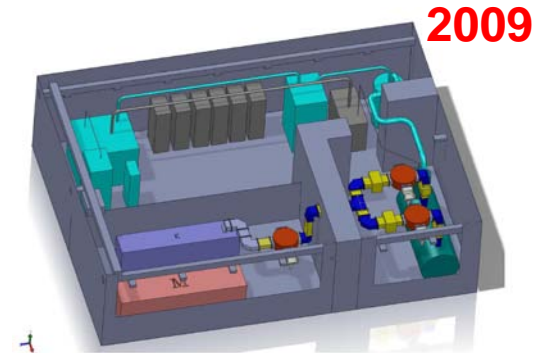
Test Stand Matrix	f [MHz]	P [kW]	prototype				series			
			low power where	high power when	low power where	high power when	low power where	high power when		
<b>P0 Cavities</b>										
ion source	--	--	LNS		LNS				on site	
LEBT buncher	352	10	LNS ?		LNS ?				on site	
RFQ	352	1000	CEA		CEA				on site	
MEBT	--	--	ESS-B ?		ESS-B ?				on site	
DTL	352	2100	LNL		CEA (10004)				on site	
double spoke	352	240	IPNO		UU	2014/5			--	
medium beta	704	500	CEA		CEA		DESY ?		--	
high beta	704	900	CEA		CEA		DESY ?		--	
<b>P1 Couplers</b>										
double spoke	352	800	IPNO		CEA		??		??	
medium beta	704	650	CEA ?		CEA		??		??	
high beta	704	1200	CEA		CEA		??		??	
<b>P2 RF System</b>										
modulator	--	5600	--	--	ESS		--		ESS	
NC linac	352	2800	--	--	ESS		--		ESS	
double spoke	352	300	--	--	UU	2014			ESS	
medium beta	704	600	--	--	ESS		--		ESS	
high beta		1200	--	--	ESS		--		ESS	
<b>P3 Cryomodule</b>										
double spoke	352	2x 300	IPNO		UU	2015/6			UU	
medium beta	704	4x650	CEA	--	CEA	--	IPNO	CEA/ESS	ESS	
high beta	704	4x1200	--	--	--	--	CEA/ESS	CEA/ESS	ESS	

## Several circumstances

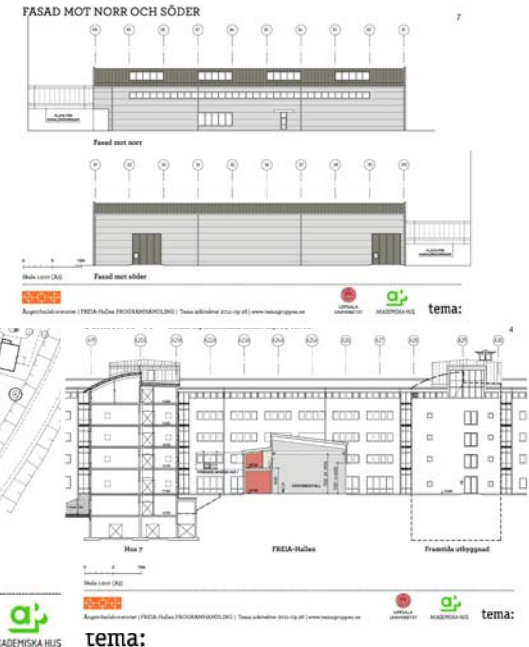
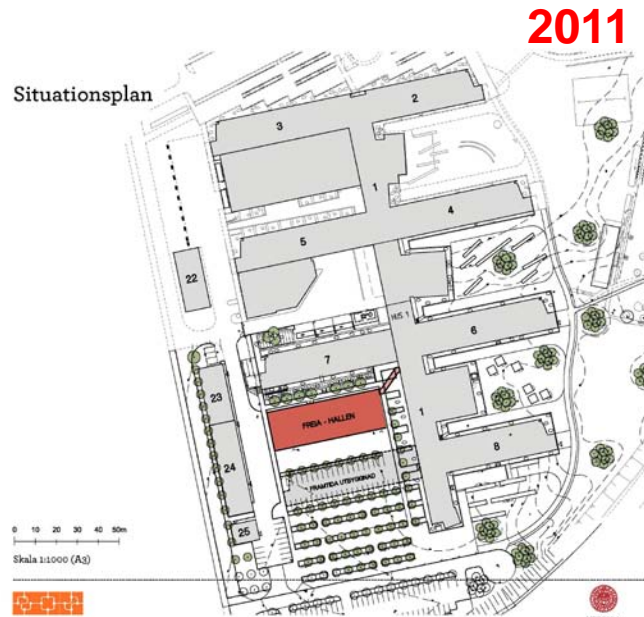
- test stand needs large experiment space and bunker
- university's helium liquefier in need of replacement

## Decision on new construction at Ångström (2010)

- funding support from KAWS, government and university



2010







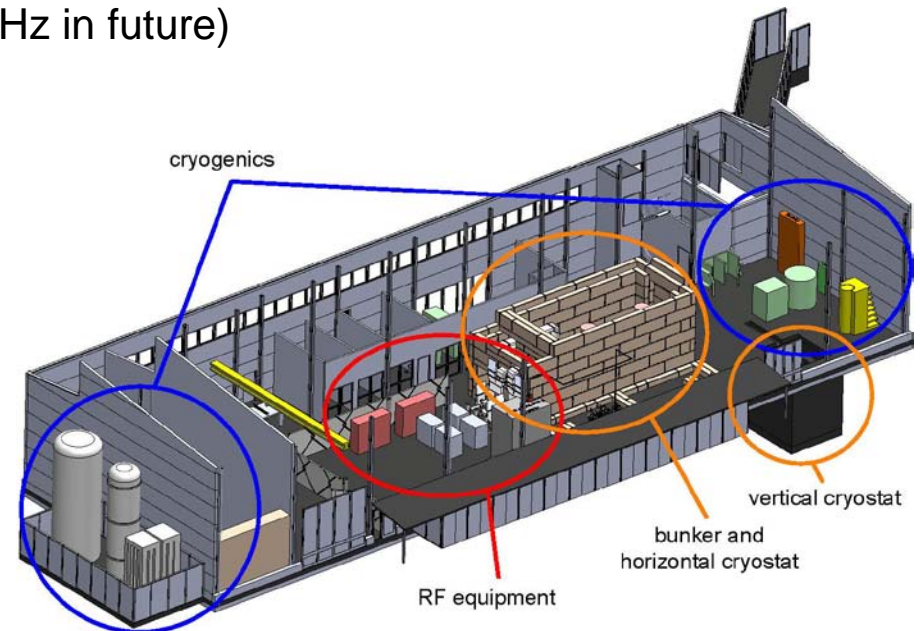
## Inauguration Tomorrow





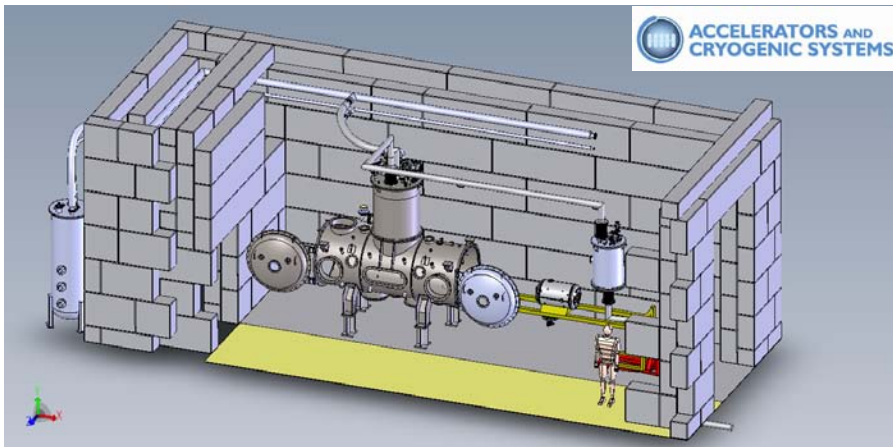
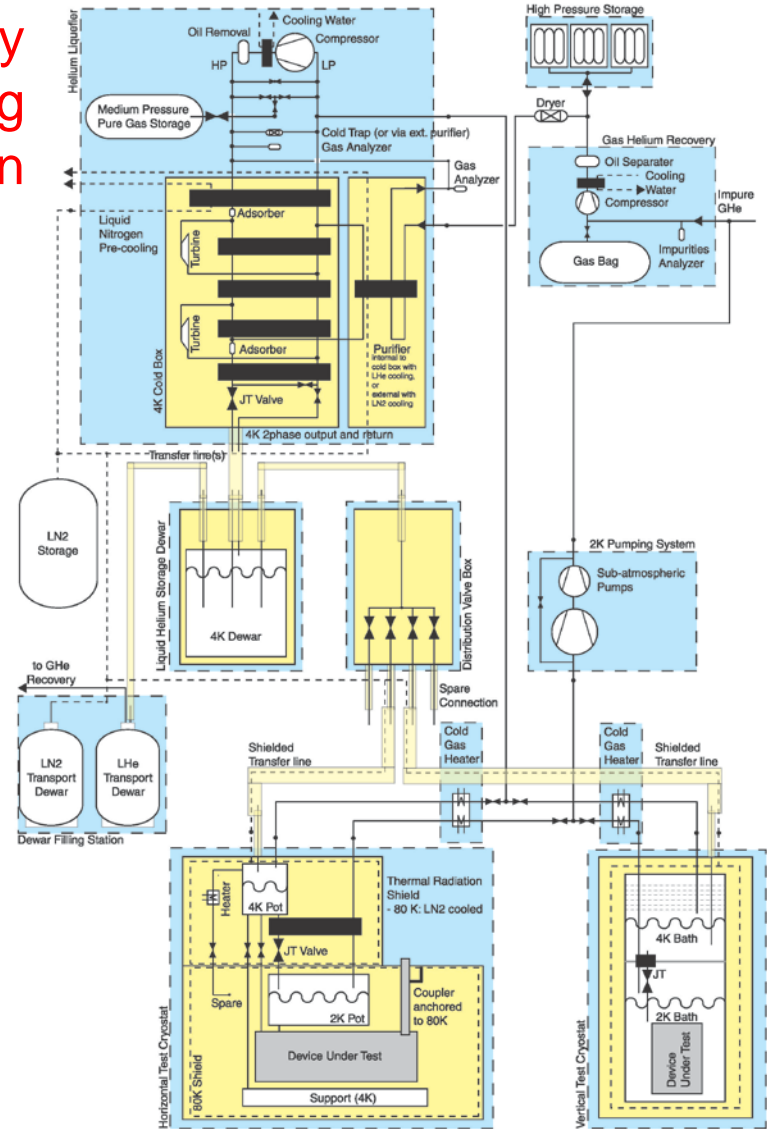
## Facility for Research Instrumentation and Accelerator Development

- 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



- Multiple users
  - external users (dewars)
  - horizontal test cryostat
  - vertical test cryostat (future extension)
- Liquid nitrogen
  - 20 m3 tank
- Helium liquefier & recovery system
  - 140 l/h peak at 4 K, 2000 l storage
  - 80 m3/h recovery, 100 m3 gas balloon
  - ~8 g/s, 80 W peak load at 2 K

supported by  
Wallenberg  
foundation

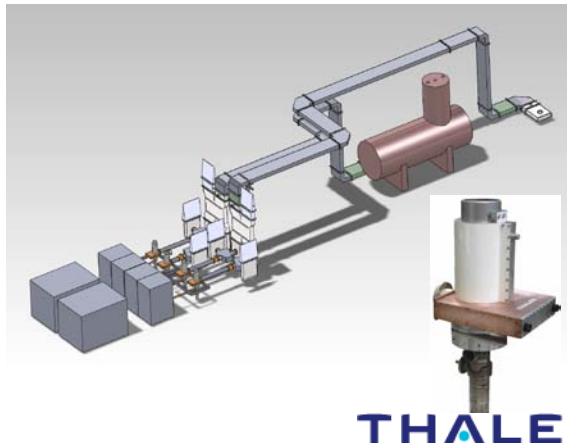


## ESS pre-series #1

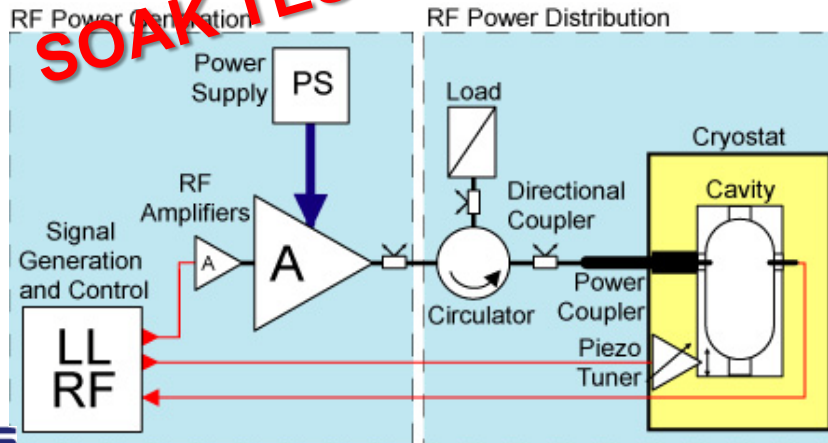
- 352 MHz, 400 kW pulsed
  - FREIA 2pc
  - ESS linac 28pc
- FREIA design based on TH595
  - tender >350 kW (2012 design)
  - allowed alternative solutions
  - 12 offers: tetrode, IOT, solid-state
  - TH595 solution most competitive

## Solid-state R&D station

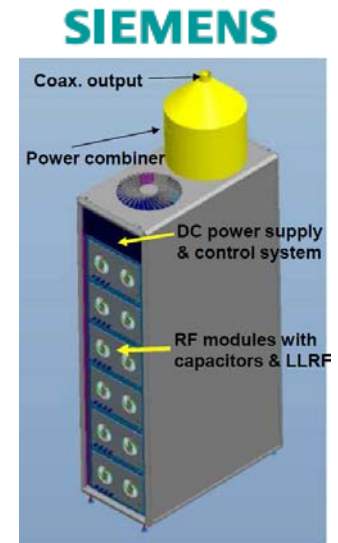
- 352 MHz, 400 kW pulsed
  - FREIA 1pc
- Commercial design
  - 1 kW transistors
  - 8 kW modules
  - coaxial combiner



THALES



**SOAK TESTING**

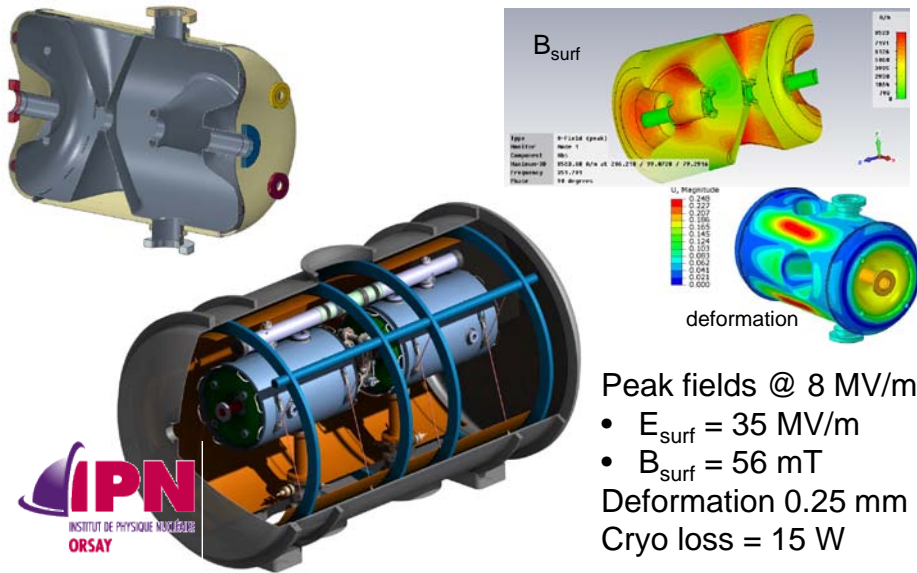




## ESS Accelerator

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

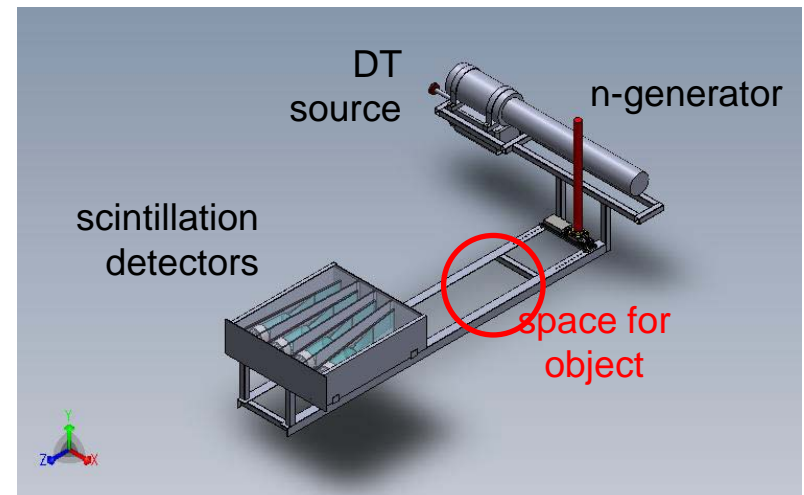
- high power soak testing of power source, controls, amplitude and phase stability with accelerating cavity
- test cavity tuning system, dynamic load, electron emission and multipactoring



## 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

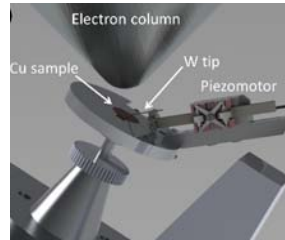
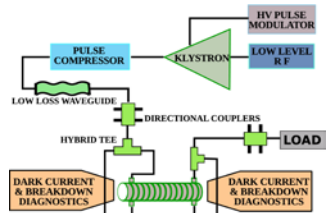
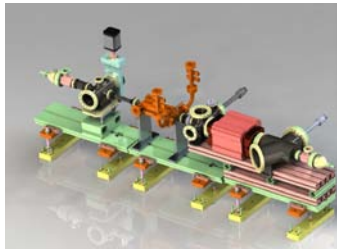


## SIGURD

Set-up and Instrumentation for GHz Research and Development

### High Gradient RF research

- compact high gradient accelerators (medical, FEL, particle collider)
- vacuum breakdown pattern, rate, relation to gradient, memory effects
- pulse heating, plasma formation, dark currents, breakdown currents
- post-mortem analysis of structures in SEM at Microstructure Lab
- link to theory developments (Helsinki University)

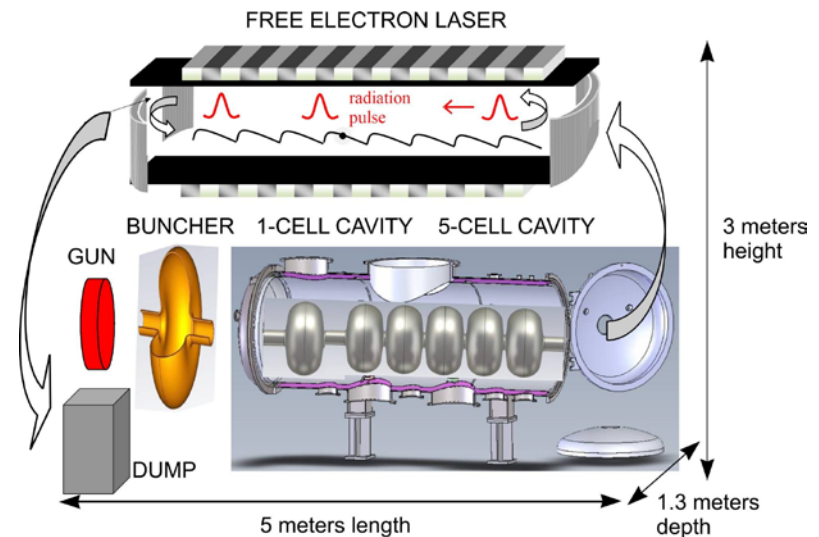


## THz FEL

- THz radiation non-ionizing, strongly absorbed by water

### Biology and Material Science

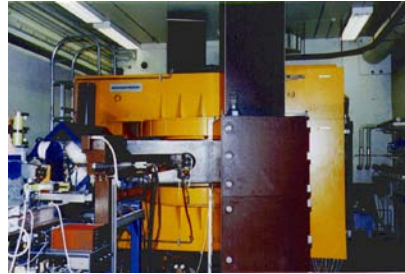
- imaging & spectroscopy for biological tissues, proteins, molecular and material science
- extends existing efforts by the Microwave group



- Scanditronix

- major supplier

- cyclotrons 1970-80's
- PETs 1980's



- GE Medical Systems  
PET and cyclotrons  
– former Scanditronix



- IBA Dosimetry

- former Scanditronix Wellhöfer



- ScandiNova

- high voltage  
pulse modulators



- Scanditronix Magnets

- magnets



- Gammadata

- physics tools  
education,  
research,  
industry



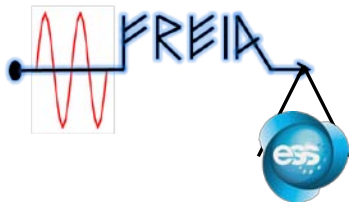




# Summary



- FREIA is building a bridge between fundamental scientific research, applied physics and industry
- FREIA laboratory enables
  - accelerator R&D for medical and research purposes,
  - construction of ESS for biology and material science,
  - enlarged Cryo Centre
  - enlarged R&D space
- FREIA opens new opportunities for unique scientific projects in Uppsala



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