UPPSALA UNIVERSITET

Uppsala Commitment to ESS and FREIA Planning

Roger Ruber

for the FREIA team

Dept. of Physics and Astronomy

Uppsala University

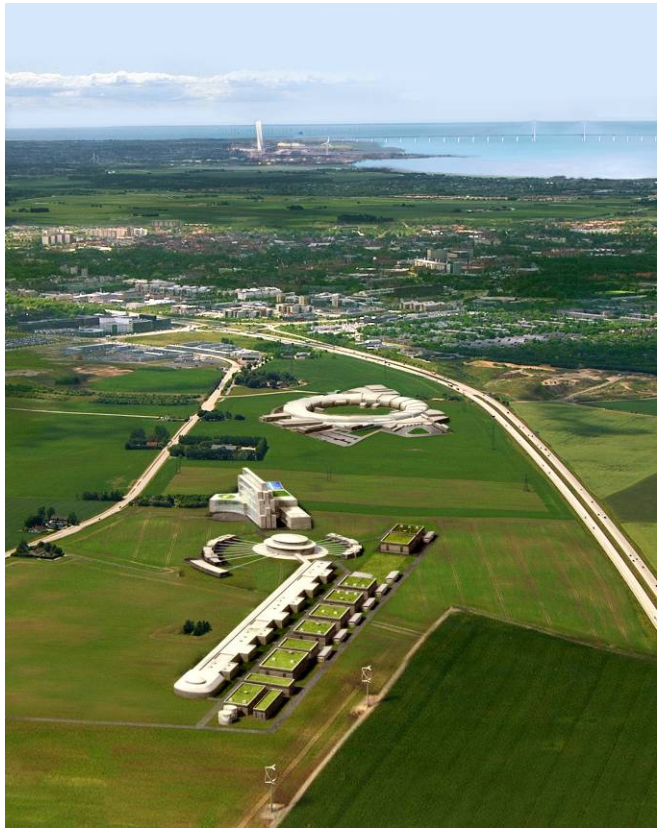
Accelerator Physics at Uppsala University

Concentrating on RF and instrumentation …

- Cyclotron (since 1948)
- CELSIUS ring (1984 – 2006)
- CTF3 / CLIC
  - Two-beam Test Stand & RF breakdown issues
  - FP6-EuroTeV, FP7-EuCARD
  - NorduCLIC
- FEL
  - FLASH Optical Replica Synthesizer,
  - XFEL Laser Heater
  - Stockholm-Uppsala FEL Centrum
- ESS
  - RF systems

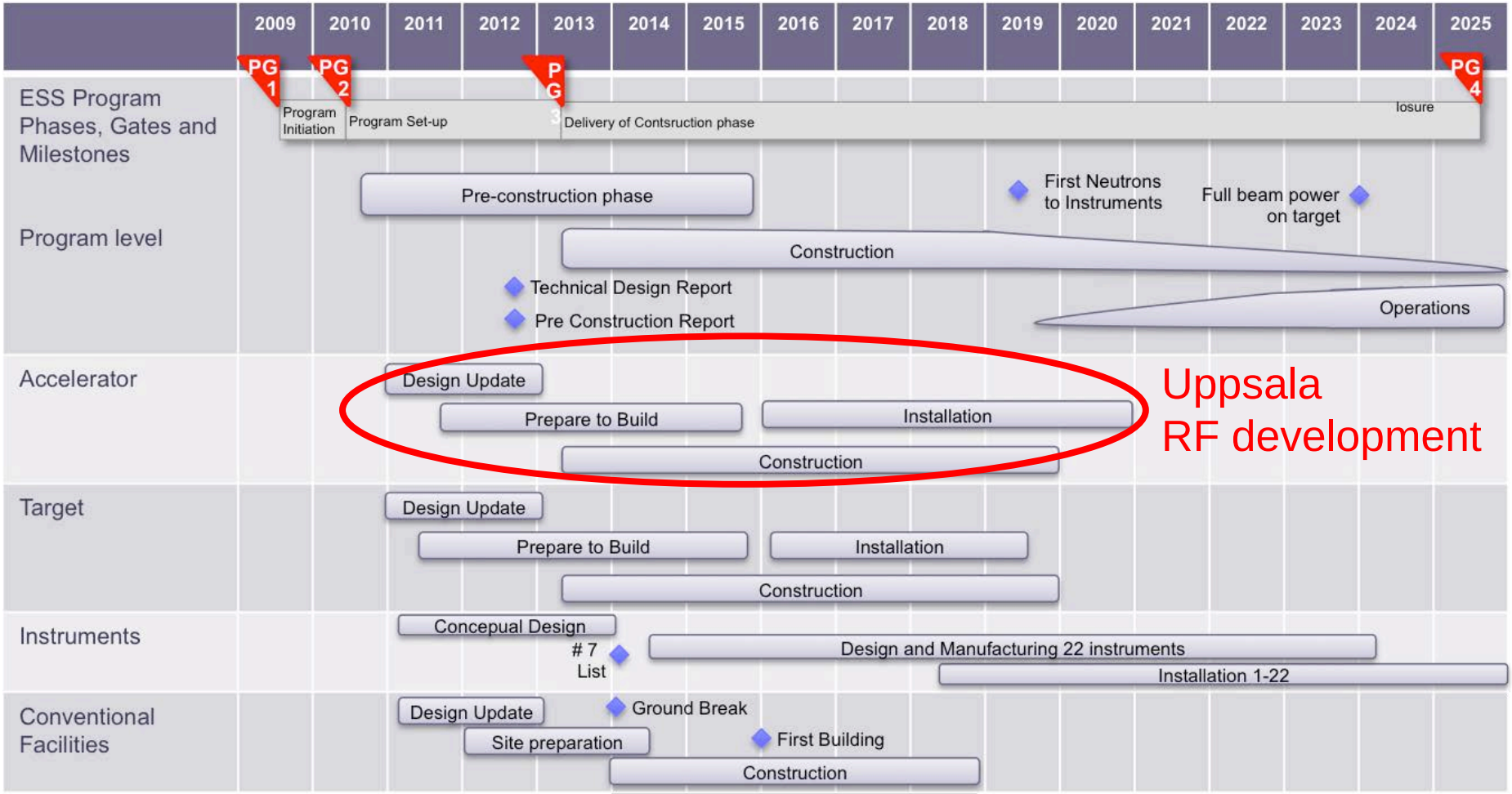
The European Spallation Source (ESS)

- Lund, Sweden, next to MAX-IV
  - 17 member states
- 5 MW pulsed neutron source
  - 14 Hz rep. rate, 4% duty factor
  - >95% reliability for user time
- Cost estimates (2008 prices)
  - 1,5 G€ / 10 years
  - 50% by Sweden, Denmark, Norway
- Time frame:
  - 2019 first neutrons
  - 2019 – 2025 consolidation and operation
  - 2025 – 2040 operation

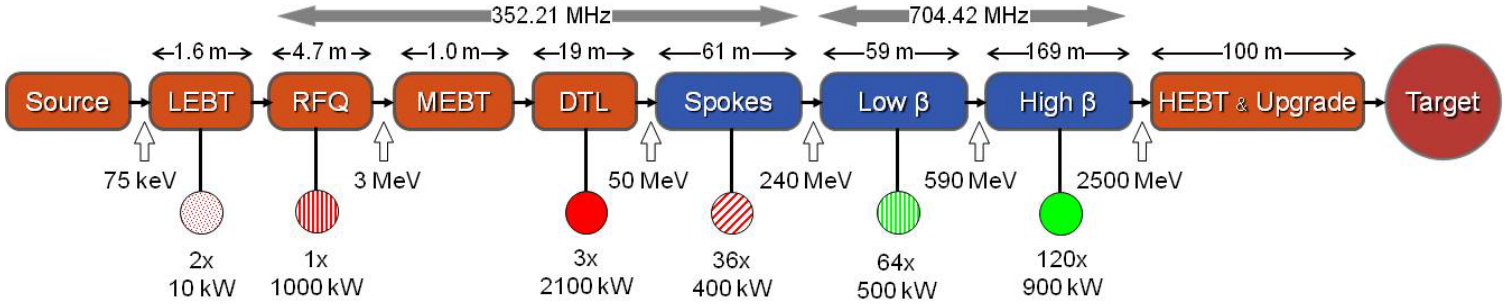


- High intensity allows studies of
  - complex materials, weak signals, time dependent phenomena

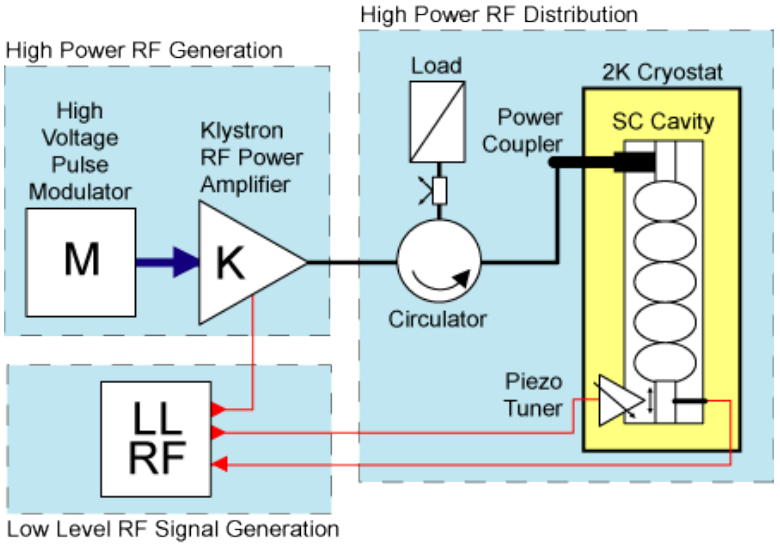
ESS Time Line for Construction



ESS RF Systems



- single pass linear proton accelerator
  - 5 MW p^+: 50 mA, 2.5 GeV, 14 Hz, 2.86 ms
  - < 1 W/m losses
  - 95% user beam time reliability
- ~200 RF systems (352 + 704 MHz)
  - NC or SC accelerating cavity
  - RF source, amplifiers, distribution, controls
- auxillary systems
  - cryogenics, water and air cooling



Why RF Development and Testing?

- **Validation technical design and performance**
  - validation under close-to-realistic conditions
  - ensure reliability & contingency
  - ease of installation & maintenance

- **Optimization technical design**
  - improve cost, energy and resource effectiveness for construction & operation

- **Acceptance testing of series components**
  - RF system: power source, amplifiers, distribution and controls
  - complete cryomodules with multiple cavities & components

- **Training of staff**
  - participate in testing to prepare for operation

ESS-UU Collaboration

- **2009**
  - ESS has need for R&D and test stand,
    - but small staff, no buildings, existing test stands occupied
  - start discussion with UU on 704 MHz RF development
  - proposal for ESS dedicated test facility at UU
- **2011**
  - Spring:
    - ESS-UU contract on 704 MHz RF R&D
    - ESS changes to 14 Hz rep rate, 2.89 ms beam pulse
  - Fall:
    - ESS changes pulse modulator strategy ’ delays UU test stand
- **2012**
  - UU starts work on 352 MHz RF for spoke resonators
    - spoke resonators require new power source development
    - spoke resonators have never been used in an accelerator
  - maintain compatibility with 704 MHz development

UU Responsibility for ESS Accelerator

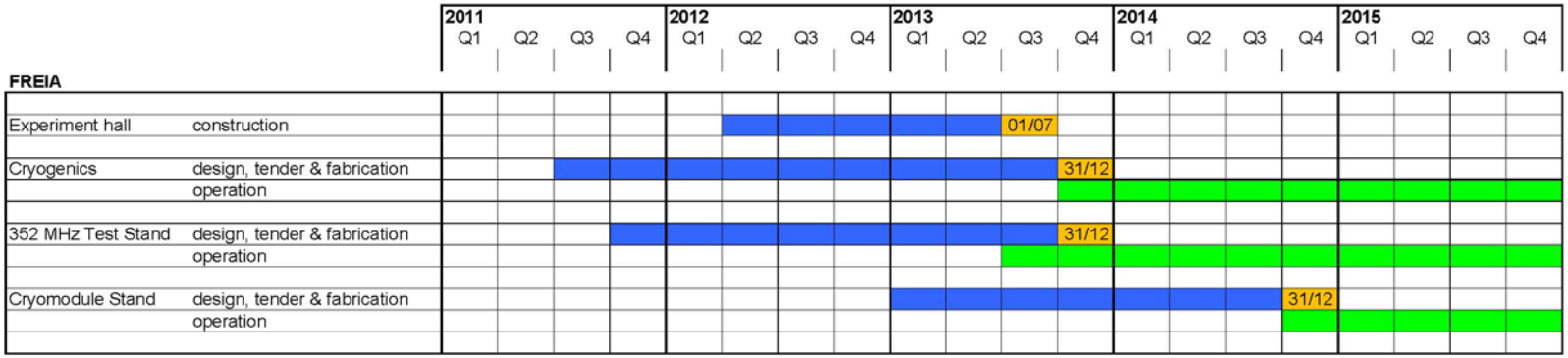
1) **Contribution to the Technical Design Report (WP8)**
   - design concept 352 MHz spoke source
   - design concept RF distribution
2) **Contribution to the construction planning effort (WP19)**
   - survey test stand infrastructure and requirements
   - study of upgrade scenarios RF systems for ESS power upgrade
3) **Development 352 MHz RF power amplifier for spokes (WP19)**
   - 1st prototype, soak test with water load and SRF spoke resonator, incl. LLRF
4) **RF system test prototype spoke cryomodule (WP19)**
   - high power test with 2nd RF power amplifier and LLRF
5) **Acceptance testing spoke cryomodules (under discussion)**
   - for all final cryomodules before installation
6) **Development klystron pulse modulator (under discussion)**
   - full soak test incl. klystron and RF system, if available with SRF cavity

Where do we fit in …

ESS Test Stand Matrix		f	P	Pupg	cryo	prototype				series			
						low power		high power		low power		high power	
		[MHz]	[kW]	[kW]		where	when	where	when	where	when	where	when
P0	**Structures**												
	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		CERN				on site	
	spoke resonators	352	400	800	y	IPNO		UU				UU ?	
	medium beta elliptical	704	500	1000	y	CEA ?		CEA ?		DESY ?		DESY ?	
	high beta elliptical	704	900	1800	y	CEA		CEA ?		DESY ?		DESY ?	
P1	**Couplers**												
	spoke resonators	352	800	1600	--	IPNO		CEA		??		??	
	medium beta elliptical	704	650	1300	--	CEA ?		CEA ?		??		??	
	high beta elliptical	704	1200	2500	--	CEA		CEA ?		??		??	
P2	**RF System**												
	modulator 1x 3 MW klystron	--	5600		--	--	--	IPNO ?		--			
	modulator 2x 1.5 MW klystron	--	5600		--	--	--	UU ?		--			
	NC linac 1 mod. + 1 kl. + RFQ/DTL	352	2800		--	--	--			--			
	spoke 1 source (tbd) + 1 spoke	352	400		--	--	--	UU		--			
	elliptical 1 mod. + 2 kl. + 2 cavities	704	1300		--	--	--	UU ?		--			
P3	**Cryomodule**												
	spoke 2 cavities	352	2x P2		y	IPNO		IPNO/UU				UU ?	
	SPL prototype 4 cavities	704	1x 1500		y	CERN		CERN		--			
	ESS prototype 4 cavities	704	? ? ?		y	CEA ?				--		--	
	low beta elliptical 6 cavities	704	6xP2 or 1x5000		y	--	--	--	--	DESY ?		DESY ?	
	high beta elliptical 8 cavities	704	8xP2 or 2x5000		y	--	--	--	--	DESY ?		DESY ?	

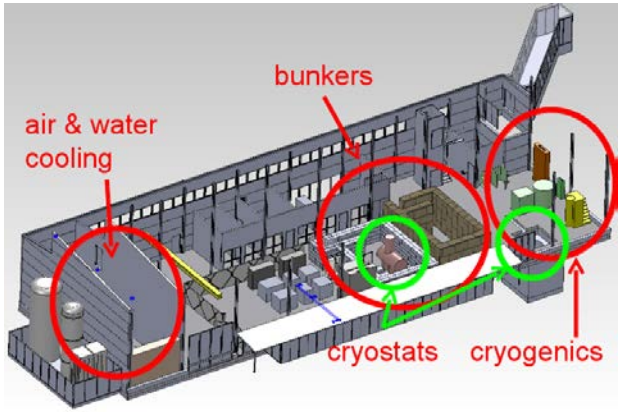
Facility for Research Instrumentation and Accelerator Development

- Cryogenic centre (kryocentrum):
  - liquid helium and liquid nitrogen production and distribution
  - horizontal test cryostat
- RF test stands (ESS RF development)
  - 352 MHz RF source prototyping for ESS spoke cavities
  - spoke cryomodule prototyping and acceptance testing at full power
- General infrastructure
  - small workshop with “clean” room (preparation vacuum chambers)
  - control room for operation cryo plants, RF systems and experiments
  - concrete bunkers for RF and neutron experiment stations



How?

1. space
   - new 1000 m^2 FREIA hall
2. electricity, air conditioning, water cooling
3. cryogenic cooling (LHe)
   - new 100 l/h liquefier
4. radiation protection shielding (neutrons, X-rays)
5. specific test equipment
   - cryostat
   - RF power
6. people
   - accelerator group
   - TSL
   - FREIA



Construction Progress

Dependencies and Deliverables

		2011				2012				2013				2014				2015			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Dependencies by ESS AB to UU																					
Spoke resonators	prototype cavity												31/12								
	prototype cryomodule																31/12				
LLRF system	prototype for single load/cavity										30/06										
	prototype for cryomodule																31/12				
Deliveries by UU to ESS AB																					
WU 8.6	report, spoke source								15/10												
WU 8.9	report, RF distribution								15/10												
WU 19.3	report, test stand survey												31/12								
WU 19.4	report, RF system upgrade														30/06						
WU 19.5	report, spoke source proto																31/12				
WU 19.6	report, spoke cryomodule																				31/12

FREIA Planning