



ESS Linac WP8 Radio Frequency Systems and Test Facilities

ESS/SPL Collaboration Meeting

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**UPPSALA
UNIVERSITET**

ESS Linac WP8: RF Systems Outline



- **Work package description**
 - objectives
 - organization
 - work breakdown structure
- **Development challenges**
 - design baseline
 - critical design requirements
 - development steps
- **Strategy for test facilities**
- **Scientific collaboration**

WP8: Work Package Description

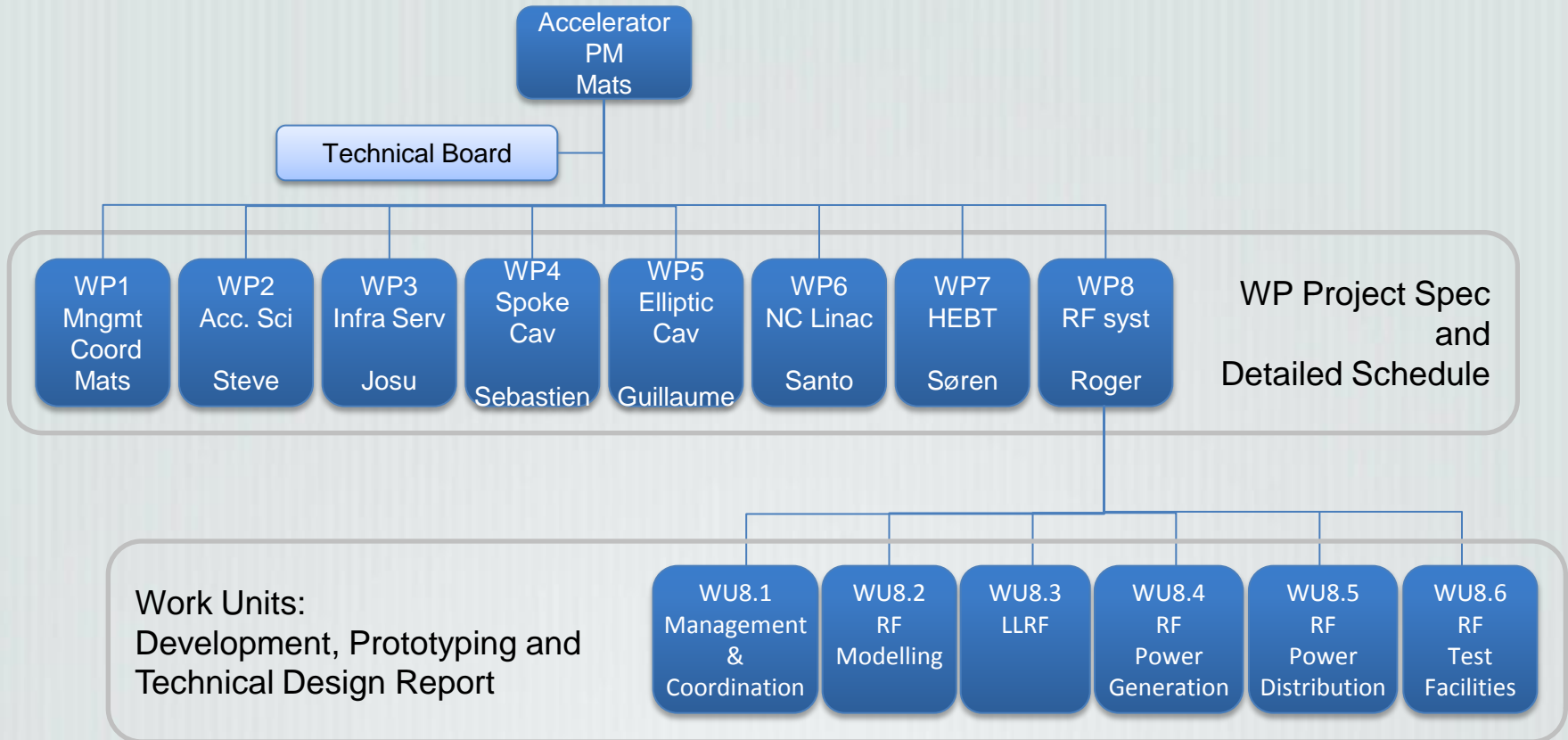
Work Package Objectives



- **Baseline**
 - design all 352 + 704 MHz RF systems
 - one power source per cavity
- **Issues to be addressed**
 - RF system is a major part of the budget
 - must be cost effective
 - 200 cavities/distribution points
 - minor fault might create a major risk
- **R&D focus**
 - Overall energy & resource efficiency
 - R&D power generation efficiency, life-time, reliability
 - RF power for 704 MHz SC elliptical cavities
 - investigate two-cavities-per-klystron concept

WP8: Work Package Description

Work Package Organization



WP8: Work Package Description

Work Breakdown Structure

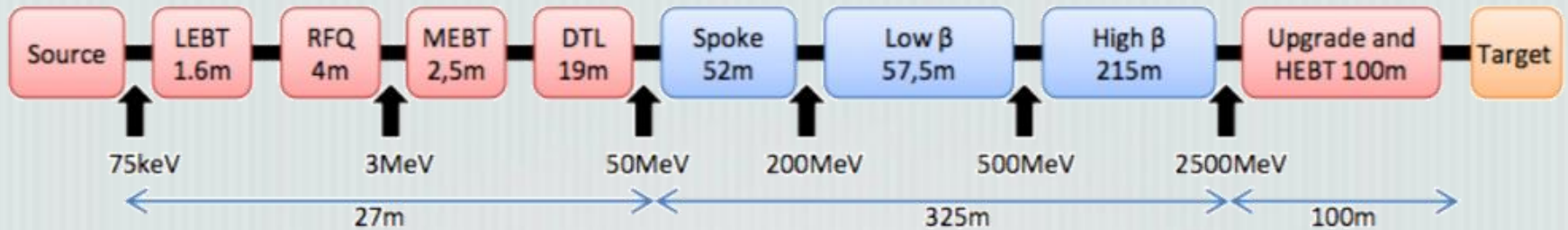


- Preparing detailed WBS/PBS

WP8 RF SYSTEMS			
WUB.1 Management			
WUB.1.1	Meetings, planning and monitoring	WUB.1.1.1	Web site
		WUB.1.1.2	Topical workshop on LLRF
		WUB.1.1.3	Topical workshop on HPRF and test stands
WUB.1.2	TDR	WUB.1.2.1	Conceptual design
		WUB.1.2.2	Contribution to TDR
WUB.1.3	Technical specifications for tendering	WUB.1.3.1	Specifications for LLRF systems
		WUB.1.3.2	Specifications for RF power generation systems
		WUB.1.3.3	Specifications for RF power distribution systems
		WUB.1.3.4	Specifications for auxiliary equipment and instrumentation
WUB.2 RF Modelling			
WUB.2.1	RF parameter list		
WUB.2.2	Mathematical model	WUB.2.2.1	Requirements analysis
		WUB.2.2.2	Conceptual design
		WUB.2.2.3	Mathematical model for LEBT buncher
		WUB.2.2.4	Mathematical model for RFQ
		WUB.2.2.5	Mathematical model for DTL
		WUB.2.2.6	Mathematical model for spoke cavities
		WUB.2.2.7	Mathematical model for elliptical cavities
		WUB.2.2.8	Mathematical model for two cavities per klystron concept
WUB.2.3	RF simulations	WUB.2.3.1	Requirements analysis
		WUB.2.3.2	Conceptual design
		WUB.2.3.3	Simulation model for LEBT buncher
		WUB.2.3.4	Simulation model for RFQ
		WUB.2.3.5	Simulation model for DTL
		WUB.2.3.6	Simulation model for spoke cavities
		WUB.2.3.7	Simulation model for elliptical cavities
		WUB.2.3.8	Simulation model for two cavities per klystron concept
		WUB.2.3.9	Simulation model for full cryomodule
WUB.2.4	HOM Studies	WUB.2.4.1	Spoke HOM calculations in frequency domain report
		WUB.2.4.2	EM simulation of the whole spoke cryomodule report
		WUB.2.4.3	Spoke HOM sensitivity with single particle (Qext specs)
		WUB.2.4.4	Damping schemes for spoke cavities report
		WUB.2.4.5	Med. b. HOM calculations in frequency domain report
		WUB.2.4.6	EM simulation of the whole med. b. cryomodule report
		WUB.2.4.7	Med. b. HOM sensitivity with single particle report
		WUB.2.4.8	High b. HOM calculations in frequency domain report
		WUB.2.4.9	EM simulation of the whole high b. cryomodule report
		WUB.2.4.10	High b. HOM sensitivity with single particle report
		WUB.2.4.11	Conceptual design for HOM damping for elliptical cavities report
WUB.2.5	Multipactor Studies	WUB.2.5.1	Multipactor study in spoke cavity report
		WUB.2.5.2	Multipactor study in spoke power coupler report
		WUB.2.5.3	Multipactor study in spoke HOM couplers report
		WUB.2.5.4	Multipactor study in medium beta cavity report
		WUB.2.5.5	Multipactor study in med. b. HOM couplers report
		WUB.2.5.6	Multipactor study in high beta cavity report
		WUB.2.5.7	Multipactor study in high b. HOM couplers report
		WUB.2.5.8	Multipactor study in elliptical cavity couplers report
WUB.3 LLRF			
WUB.3.1	Architectures	WUB.3.1.1	Requirements analysis
		WUB.3.1.2	LEBT buncher, RFQ, DTL, spoke and elliptical
WUB.3.2	Prototype 352 MHz For IPN Orsay	WUB.3.2.1	State of art analysis and new alternatives, conceptual designs
		WUB.3.2.2	Specifications and call for tenders
		WUB.3.2.3	Fabrication follow-up
WUB.3.3	Prototype 704 MHz	WUB.3.3.1	Acceptance tests
			Specifications and call for tenders

WP8: Development Challenges

Design Baseline

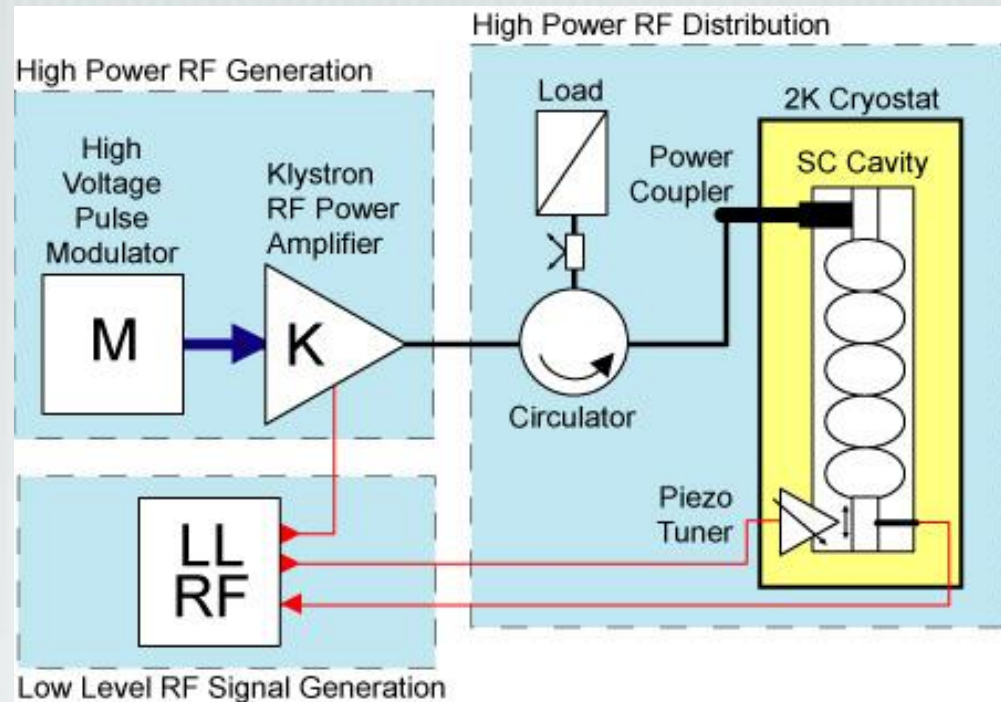


- **ESS proton linac: high reliability above 95%**
 - 2.5 GeV, 2.3 ms pulses at 20 Hz
 - 50 mA, **average 5.0 MW** (beam loss <1 W/m)
 - Future upgrade to 75 mA, 7.5 MW
- **Power provided by RF system**
 - 352 MHz: 1 RFQ, 3 DTL, 56 SC spoke cavities; buncher cavities
 - 704 MHz: 136 SC elliptical cavities
 - one power source per cavity; peak power up to 1.2 MW

WP8: Development Challenges

Design Baseline 704 MHz

- **High Power RF:**
 - klystron amplifier
 - power distribution (A, Φ)
 - power coupler, HOM coupler
- **Low Level RF:**
 - RF source, regulate (A, Φ)
 - monitor cavity RF (A, Φ)
 - cavity tuning



WP8: Development Challenges

Critical Design Requirements



- Baseline with conservative off-the-shelf technology
- RF system is a major part of the budget
 - construction, operation & maintenance
 - must be cost & resource effective
 - design shall assure efficient heat recovery
 - 200 cavities/distribution points
 - minor fault might create a major risk
 - use reliable technology
 - try to be efficient with spare parts

WP8: Development Challenges

Development Steps



- Investigate LLRF controls
 - piggy back on existing systems & developments
 - enhancements to decrease power usage? (ideas K. Rathsmann)
- Investigate alternative power sources
 - solid state technology?
 - phase locking magnetrons? (ideas A. Dexter/Lancaster)
 - improve klystron efficiency? (ideas E. Jensen/CERN)
- Investigate alternative power distribution schemes
 - two-cavities-per-klystron concept

WP8: Strategy for Test Facilities Overview

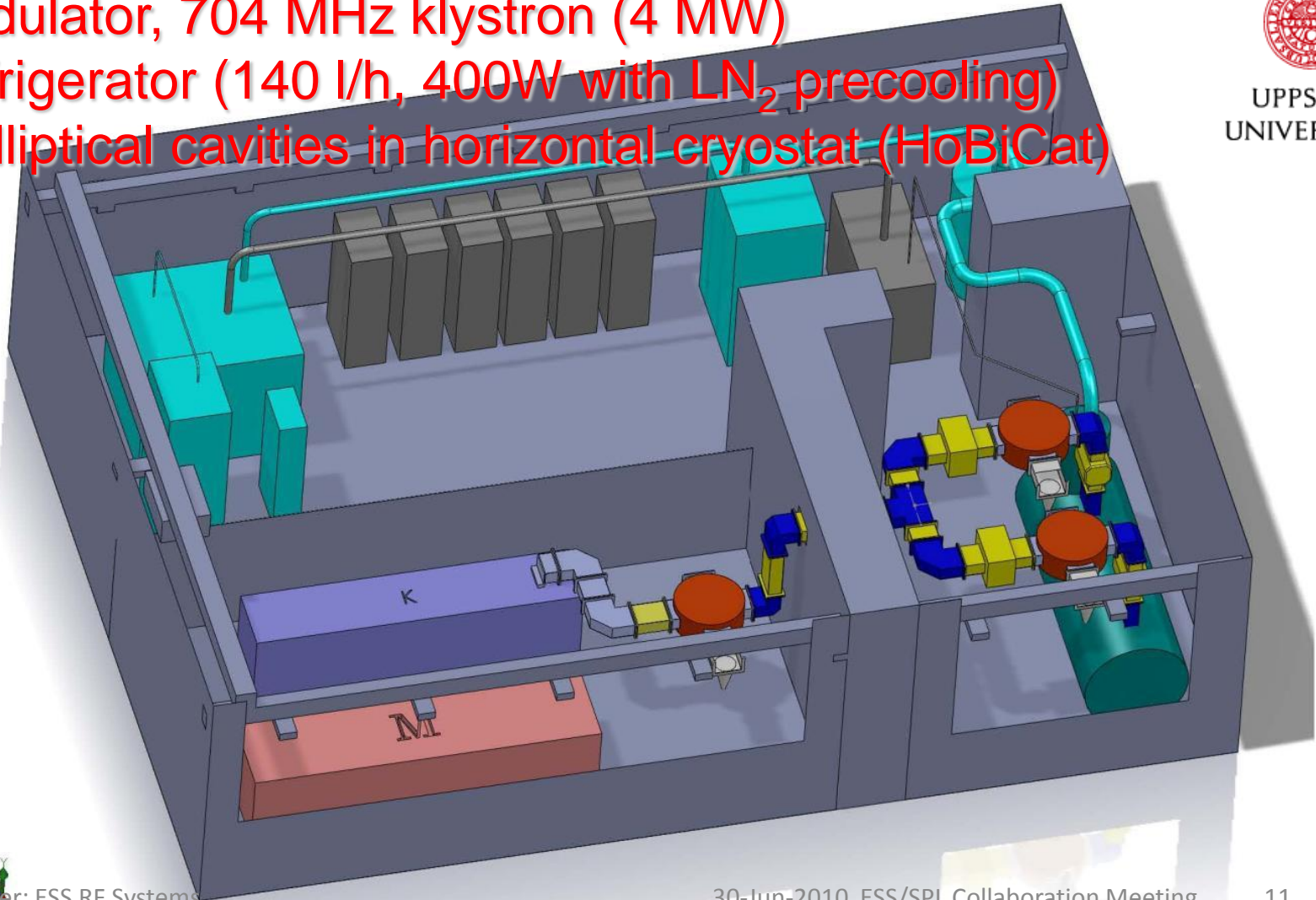


- Needed for development and construction
- Both 352/704 MHz, if possible back-up facility
 - 352 MHz normal conducting
 - piggy back on existing facilities for NC linac development
 - 352 MHz spoke cavities
 - CEA Saclay: existing
 - IPN Orsay: planned, to be completed by 2012
 - 704 MHz elliptical cavities
 - CEA Saclay: existing, upgrade required for cryomodule
 - CERN: upgrade required, to be completed by 2012 (ESS modulator)
 - DESY: upgrade required, only after completion XFEL (2015)
 - Uppsala: proposed, to be completed by 2012 (focus on RF generation/distribution)

WP8: Strategy for Test Facilities

Uppsala Test Facility (FREIA)

- Modulator, 704 MHz klystron (4 MW)
- Refrigerator (140 l/h, 400W with LN₂ precooling)
- 2 Elliptical cavities in horizontal cryostat (HoBiCat)



WP8: Scientific Collaboration Timeframe and Planning



	2010 Year 0	2011 1st Year	2012 2nd Year	2013 3rd Year	2014 4th Year	2015 5th Year
WU8.1 Coordination and Communication						
Coordination						
Technical design report						
Technical specifications						
WU8.2 RF Modelling						
RF parameter list						
Mathematical model						
RF simulations						
WU8.3 Low Level RF						
Investigation alternatives						
352 MHz prototype						
704 MHz prototype						
704 MHz prototype 2 cavities concept						
WU8.4 RF Power Generation						
Investigation alternatives						
352 MHz prototype						
704 MHz prototype						
704 MHz prototype 2 cavities concept						
WU8.5 RF Power Distribution						
Investigation alternatives						
352 MHz prototype						
704 MHz prototype						
704 MHz prototype 2 cavities concept						
WU8.6 RF Test Facility						
352 MHz test facility						
704 MHz test facility						
704 MHz test facility 2 cavities concept						
704 MHz test facility 8 cavities cryomodule						

WP8: Scientific Collaboration Partners



- Collaboration tasks based on WBS/PBS
- Discussions starting, anybody interested please contact us!