

# ESS

## Accelerator Design Update

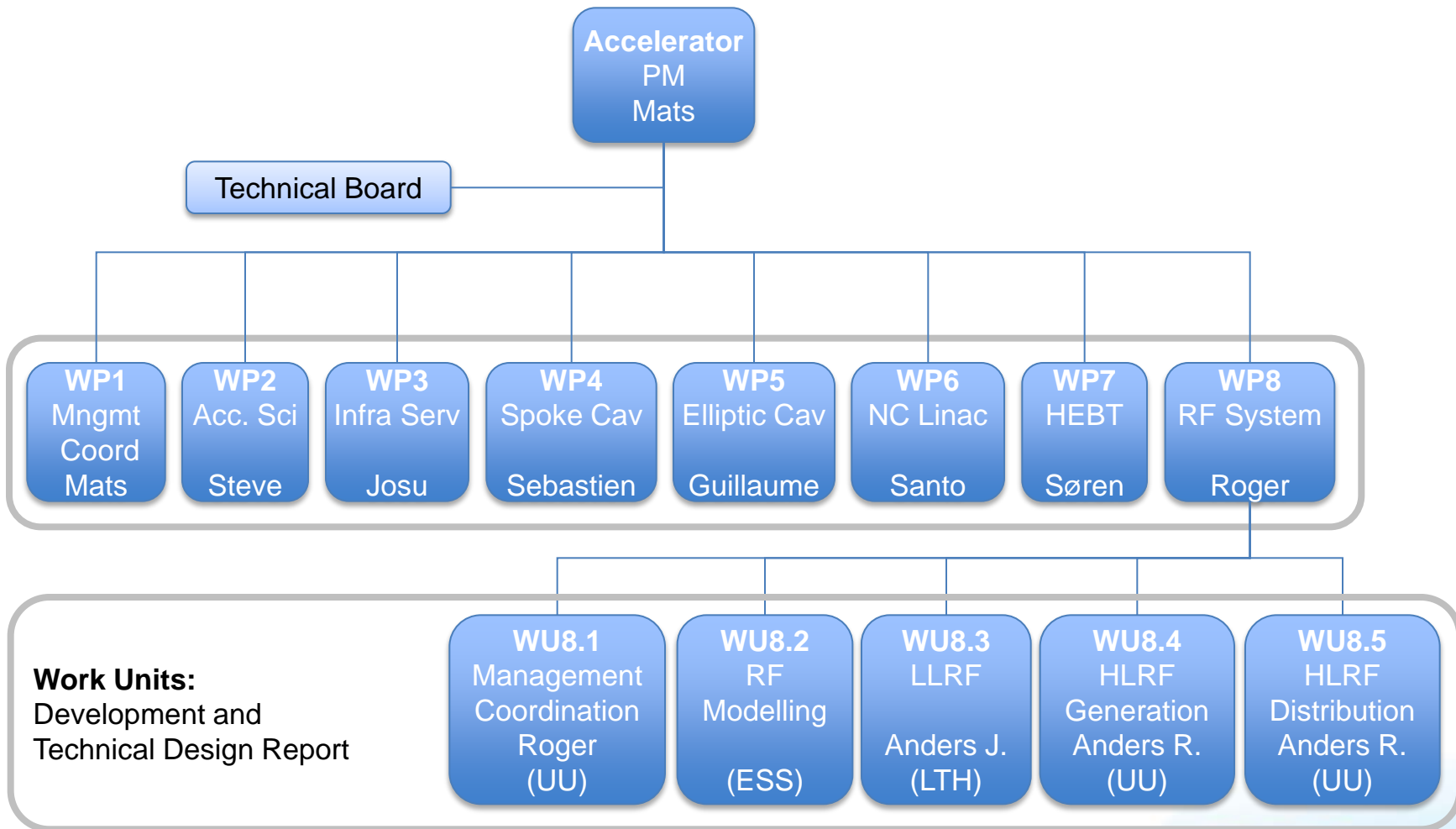
### Work Package 8

### “RF Systems”

Roger Ruber  
Uppsala University  
for the WP8 Team

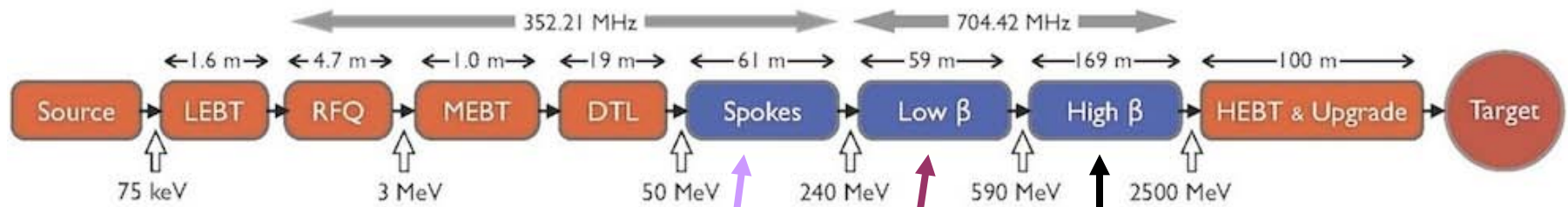
- > for the overall RF system (NC + SC linac)  
produce baseline design and present alternatives
  - **technical design report, with cost estimate (our 2012 deliverable!),**  
to start detailed engineering design and prototyping
  - RF modelling and simulation studies to enhance cavity and RF system designs
  - design LLRF system, include klystron and cavity model
  - investigate alternative RF power generation and distribution technologies
  
- > 200 accelerating structures and RF distribution points
  - minor fault might create a major risk
  - must ensure low beam loss operation
    - to prevent activation of accelerator components
  - major part of the accelerator budget
    - must be cost, energy and resource effective for construction & operation
  
- > training of future staff
  - prototyping moved to 5 years P2B (in parallel to 2 years ADU)

# WP8 Organization

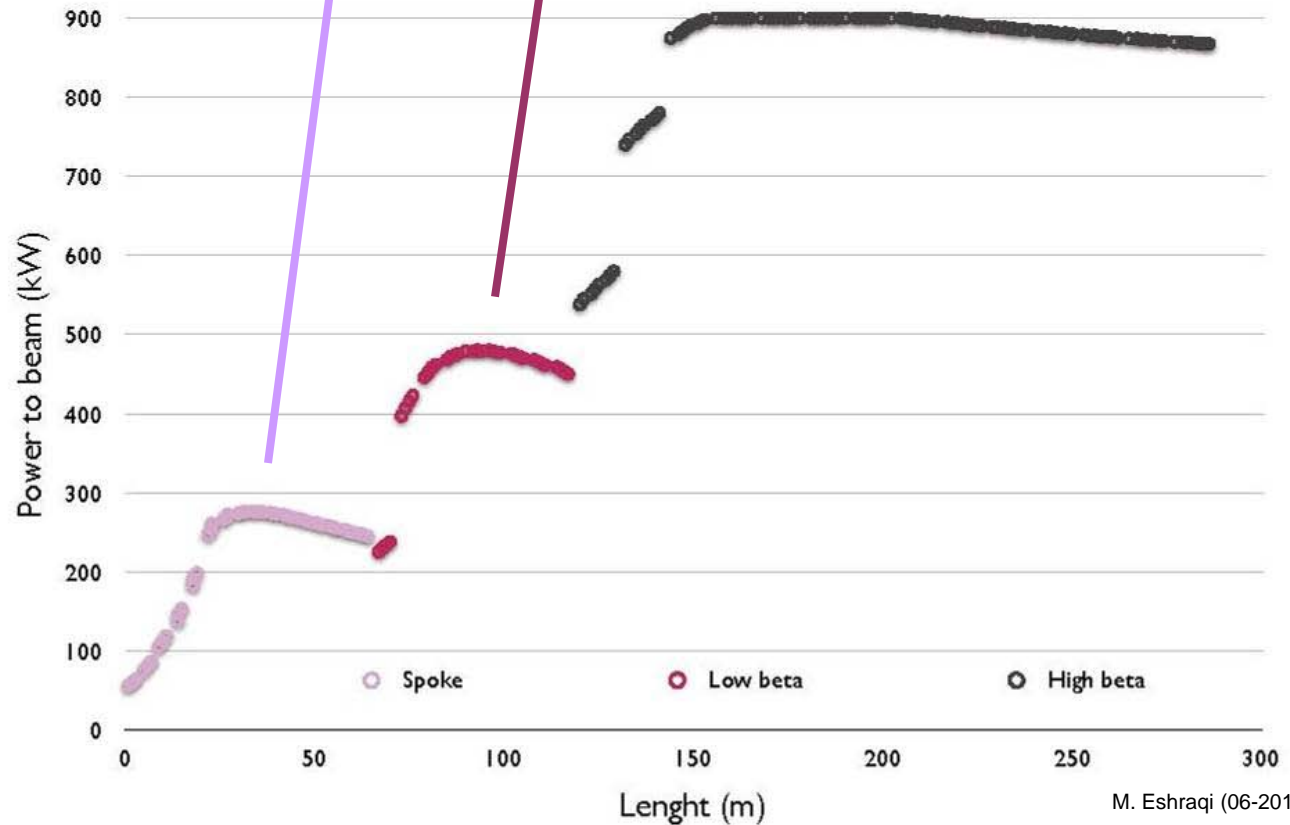


**Note:** Prototyping and test facilities moved to P2B project.

# WP8 Scientific Challenges: RF Power to Beam



- > 5 MW beam requires 20 MW RF power
- > Max. 900 kW in couplers elliptical cavities



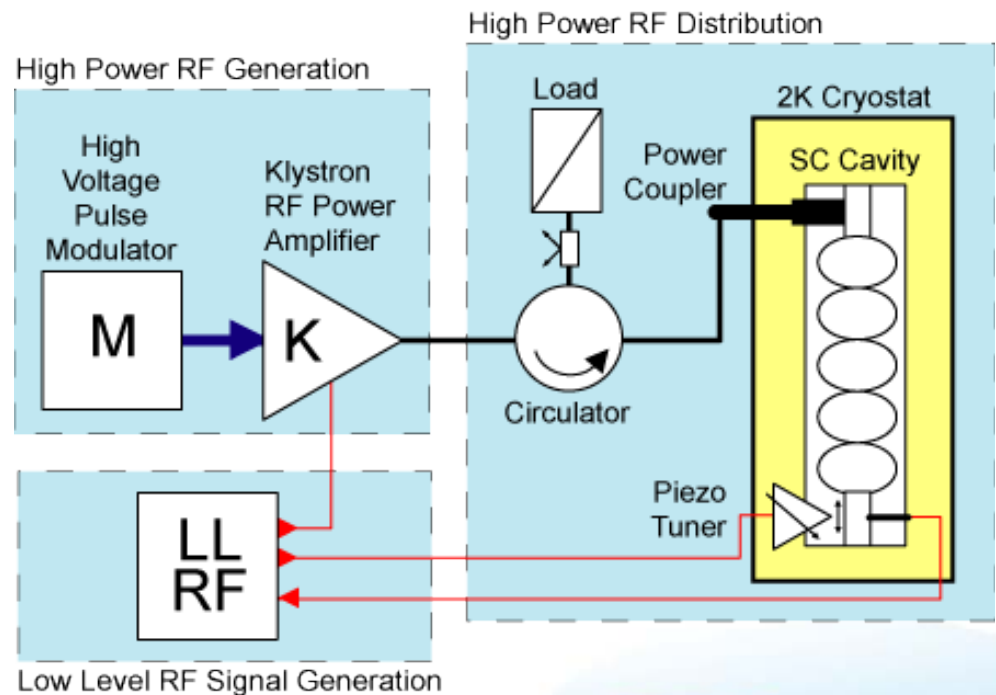
M. Eshraqi (06-2010)

## > Baseline with conservative off-the-shelf technology

- one power source per structure, peak power up to 1.2 MW
- 352 MHz: 1 RFQ, 2 buncher cavities, 3 DTL tanks, 45 spoke cavities
- 704 MHz: 152 elliptical cavities

## > Limitations

- 5 MW beam → 20 MW RF, (losses and LLRF overhead)
- power coupler max. 900 kW, limits gradient (high beam loading)
- klystron in linear range for LLRF, 30% below saturation (also lower efficiency)
- klystron has limited life time

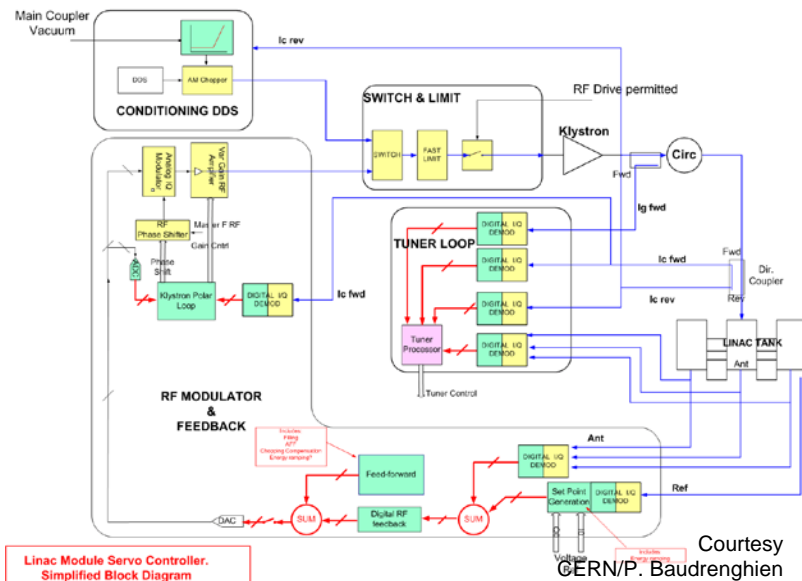
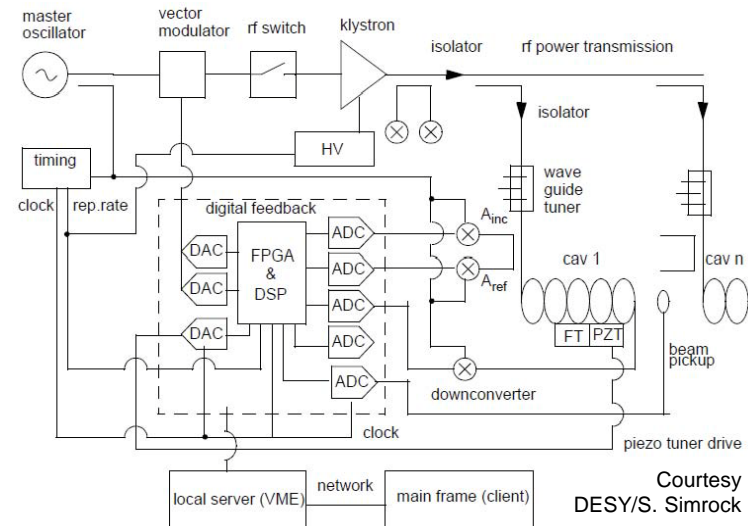


## > RF modelling

- prepare and maintain list of nominal RF parameters
  - development RF system is tightly interlinked to RF structure developments, RF parameters have to be decided on together
- mathematical model
  - RF-to-beam interaction, include behavioural data from real elements
  - use to determine boundary conditions
- RF simulations
  - RF-to-beam interaction, HOM generation and damping schemes,
  - inter-cavity transitions,
  - design update/enhancements to cavity & couplers, (in coordination with WP4, WP5, WP6)
  - minimize beam loss, (in coordination with WP2)
  - decrease power usage (in coordination with WP3 and WP7)
- multipactor studies
  - effect on beam acceleration,
  - design update/enhancements to cavity & couplers (in coordination with WP4, WP5, WP6)

## > LLRF

- investigate alternative architectures
  - developments at other institutes,
  - commercial alternatives
- adopt baseline design
  - for all systems: NC linac, spoke, elliptical
  - two-cavities-per-klystron concept
- investigate energy efficiency
  - klystron and cavity model, inside hardware it could be used for commissioning w/o beam & power
  - investigate feasibility of klystron linearization, to run at higher efficiency
  - define global phase reference, to master phase noise and jitter

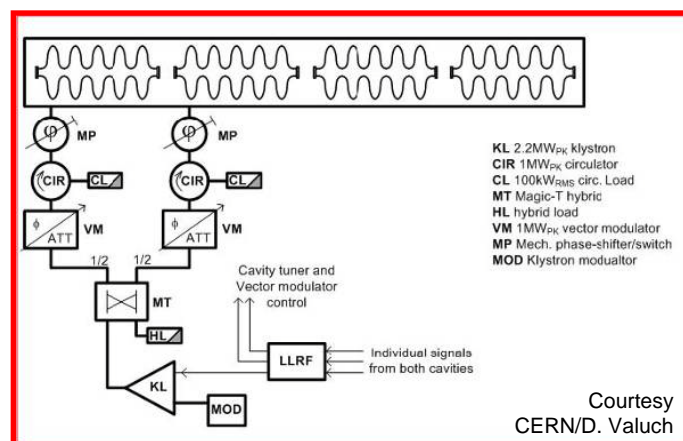
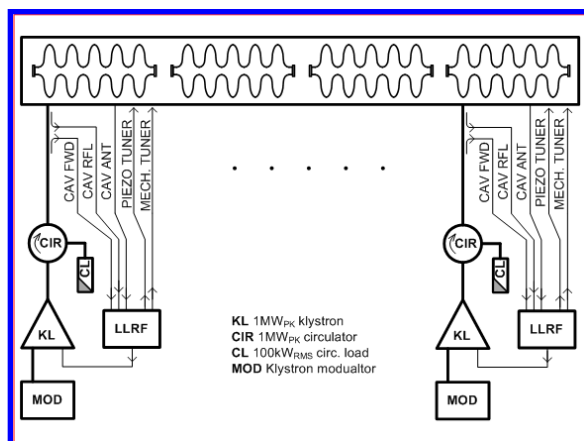


## > RF power generation and distribution

- investigate alternatives
  - standard off-the-shelf solutions (for baseline)
  - solid state technology
  - phase locking magnetrons (ideas A. Dexter/Lancaster)
- investigate energy/resource efficiency and recovery
  - two-cavities-per-klystron concept (fast vector modulator)
  - low-loss components (vector modulator)
  - higher efficiency klystrons
  - RF-to-DC recovery in loads (ideas F. Caspers/CERN)
  - heat recovery from high temperature cooling water (power sources, loads)



704.4 MHz Klystron (CPI)



Courtesy  
CERN/D. Valuch

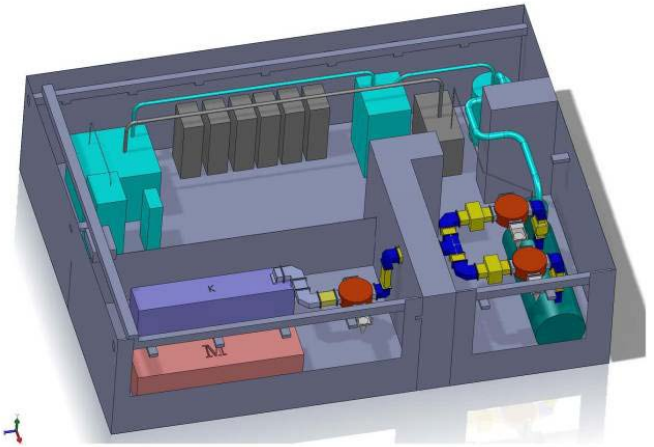


## > RF Test Facility at Uppsala University

- prototyping of LLRF and HLRF solutions
- energy efficiency studies
- training of students and staff

## > 4 Years development phase

- 2011 – 2012: design, tendering
- 2013 – 2014: commissioning, R&D two-cavities-per-klystron concept
- 2015 and beyond: energy efficiency, component testing



## > Hardware:

- HV pulse modulator
- 704 MHz klystron (1.5 MW)
- RF distribution system
- LLRF system
- 2 SRF elliptical cavities
- helium liquefier

