MTCA.4 based LLRF for the European Spallation Source

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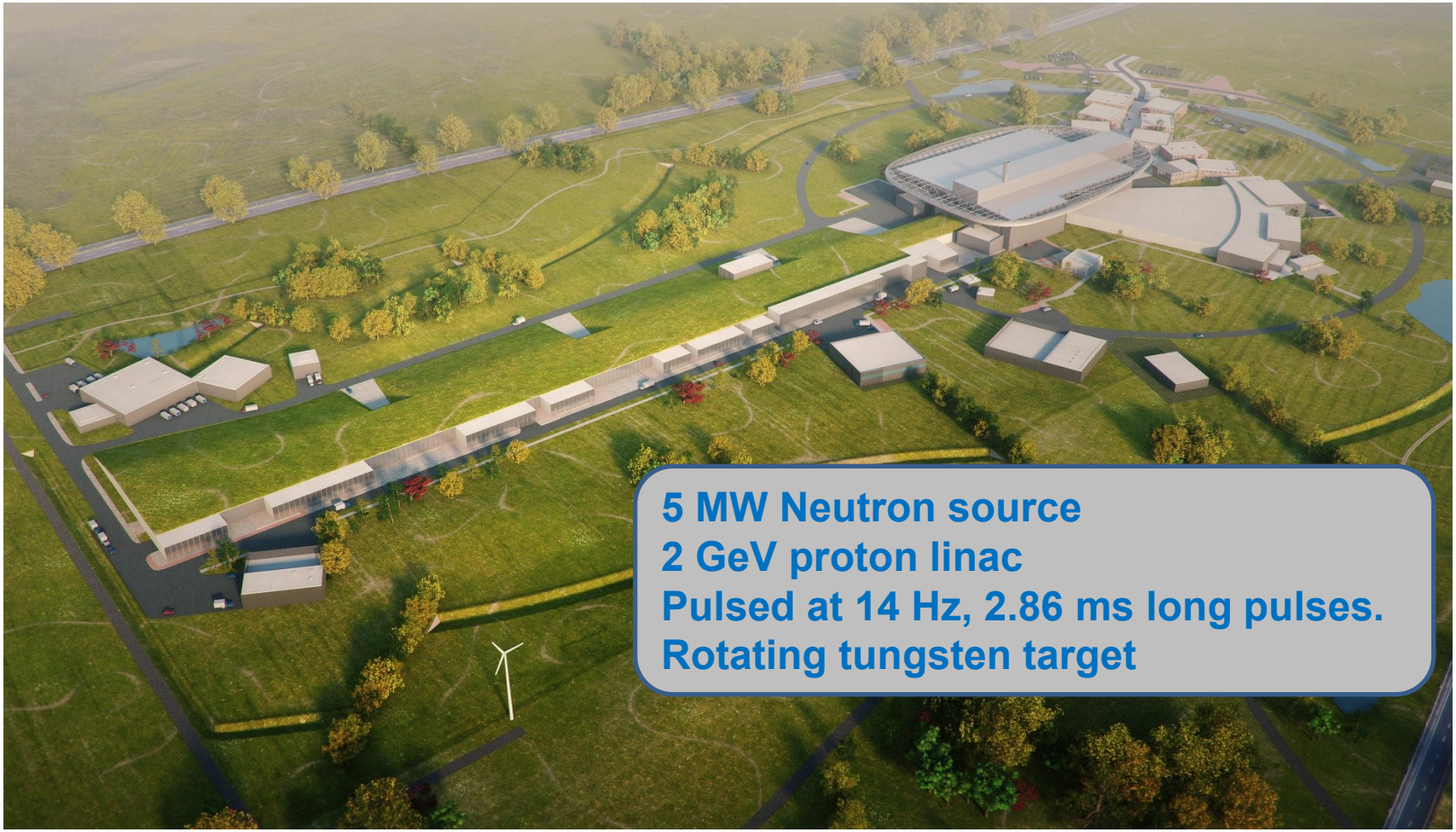
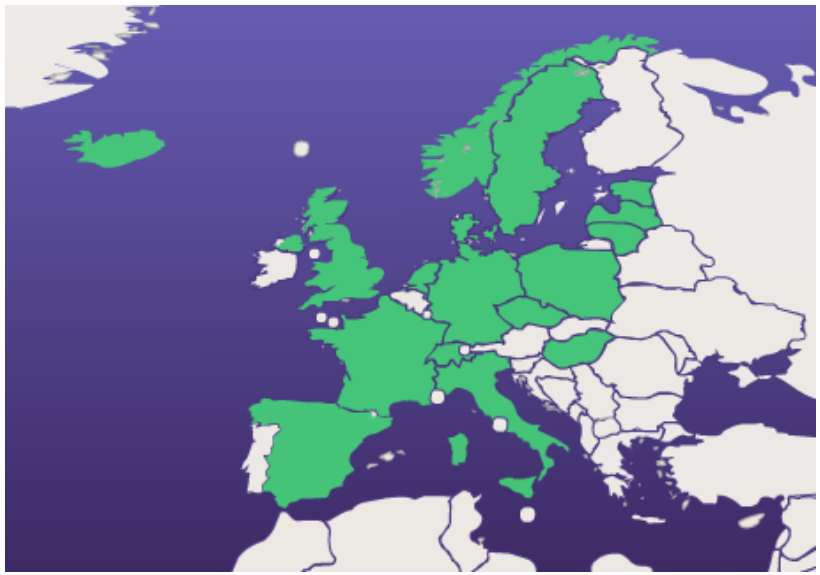
European Spallation Source



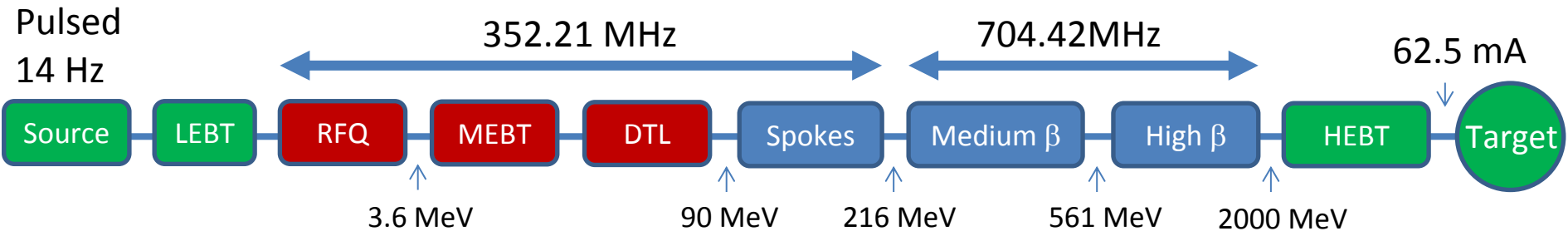
Building status

European Spallation Source



- 17 Member states
- ESS ERIC – European Research Infrastructure Consortium

ESS Accelerator



- 1 RFQ
- 3 Pillbox buncher cavities in MEBT.
- 5 Drift Tube Linac sections.
- 26 Superconducting spoke cavities.
- 36 Superconducting medium-β cavities.
- 84 Superconducting high-β cavities.

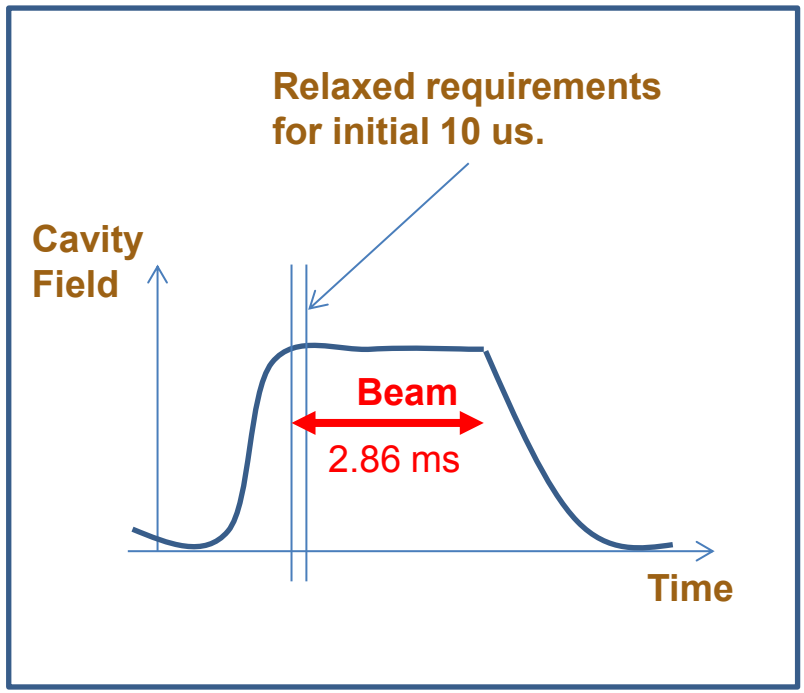
ESS RF power amplifiers

- One power amplifier per accelerating cavity
  - 2.8 MW Klystron for RFQ
  - 30 kW Solid State for Buncher
  - 2.8 MW Klystron for DTL
  - 2x200kW Tetrode combined for Spoke
  - 1.5 MW Klystron for Medium- Beta Elliptical
  - 1.2 MW IOT for High Beta Elliptical

Field Stability

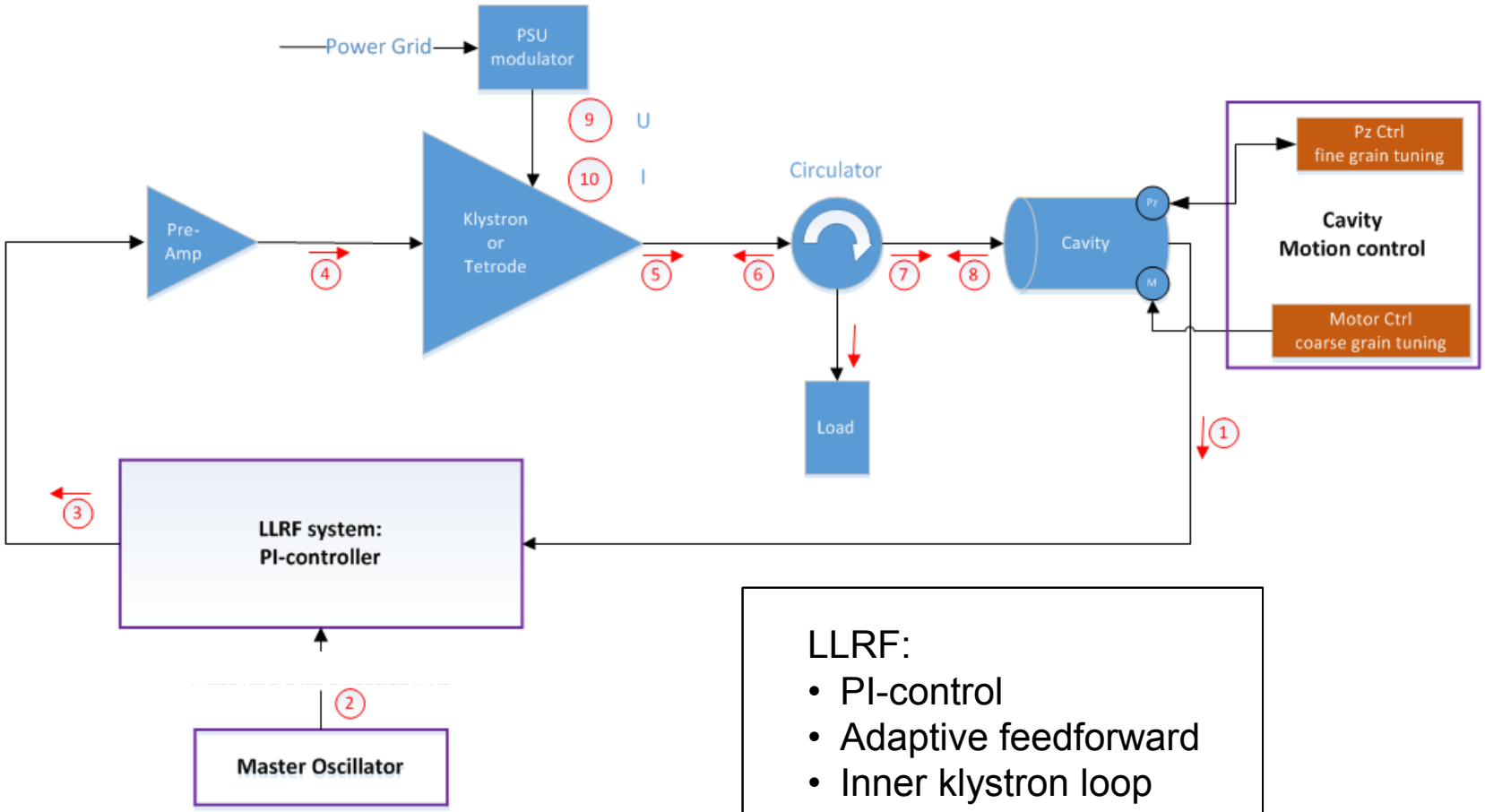
Typical requirements for regulation accuracy of the cavity field.

- RFQ
  - +/- 0.2 % RMS amplitude
  - +/- 0.2 º RMS*
- Normal Conducting
  - +/- 0.2 % RMS amplitude
  - +/- 0.2 º RMS
- Super Conducting
  - +/- 0.1 % RMS amplitude
  - +/- 0.1 º RMS



*Relative the phase reference line. All other phase requirements relative the beam.

RF Cell

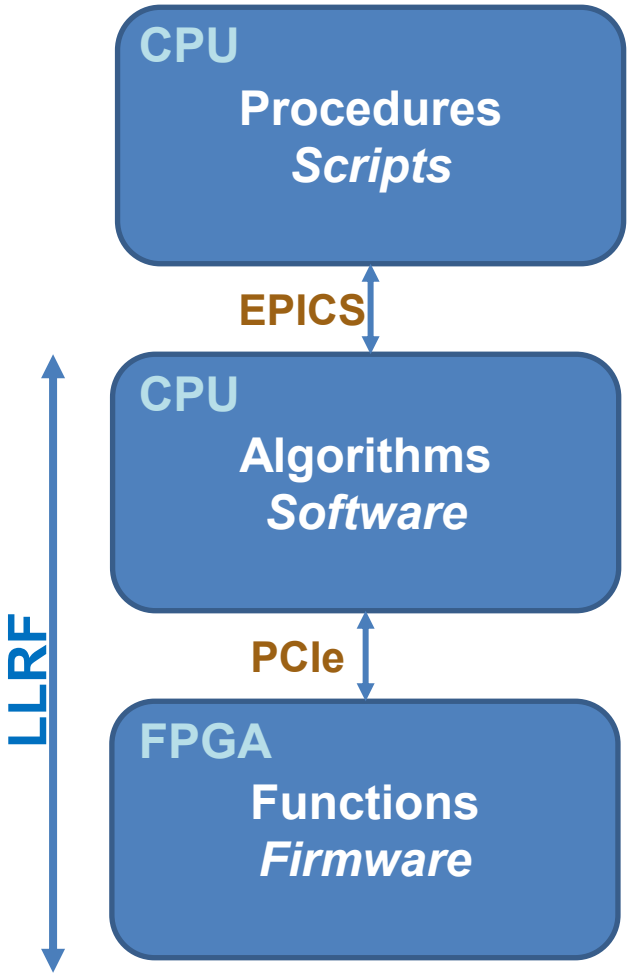


LLRF:

- PI-control
- Adaptive feedforward
- Inner klystron loop
- Beam current variation compensation

High level LLRF architecture

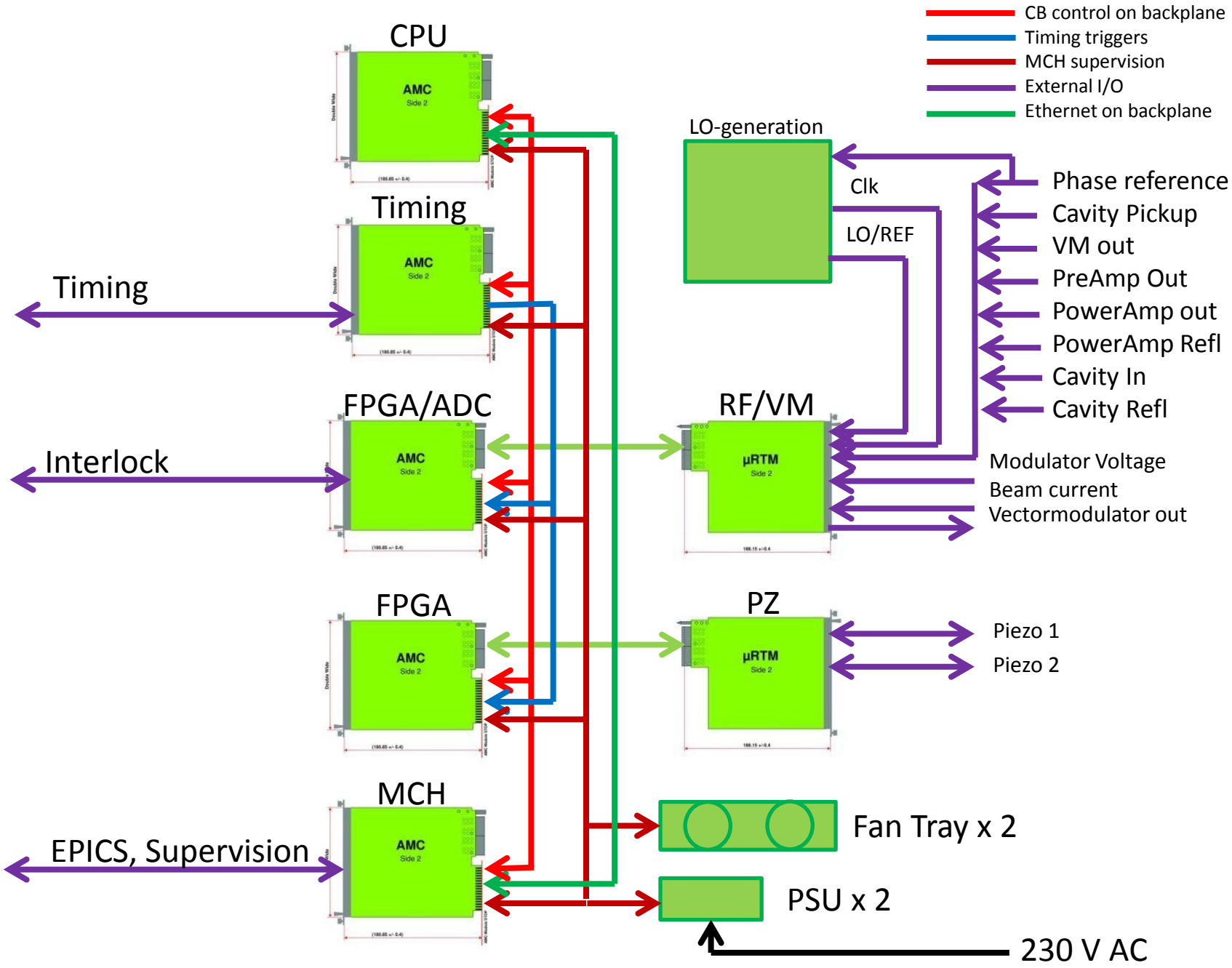
- Procedures
  - Schemes that involve longer times and multiple pulses.
- Algorithms
  - Updates that take place between pulses (68 ms).
- Functions
  - Real-time control within a pulse (3.5 ms).



Setup

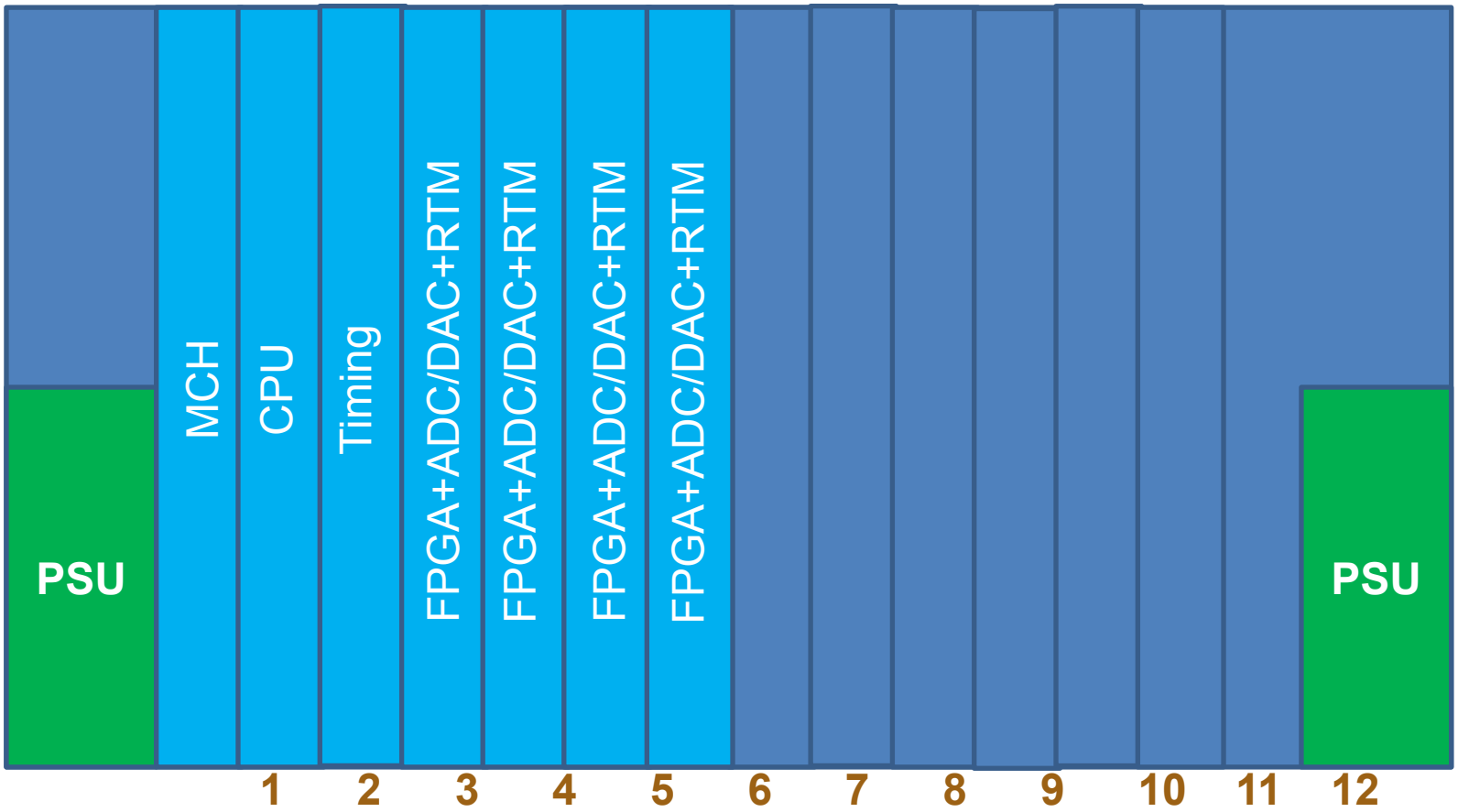
- 1 LLRF system per crate
  - Availability of accelerator
  - Redundance of parts
- Crate placed with other RF cell instrumentation
- 155 Crates in total, distributed over 400 m.

704.42 MHz MTCA.4 LLRF Medium-Beta



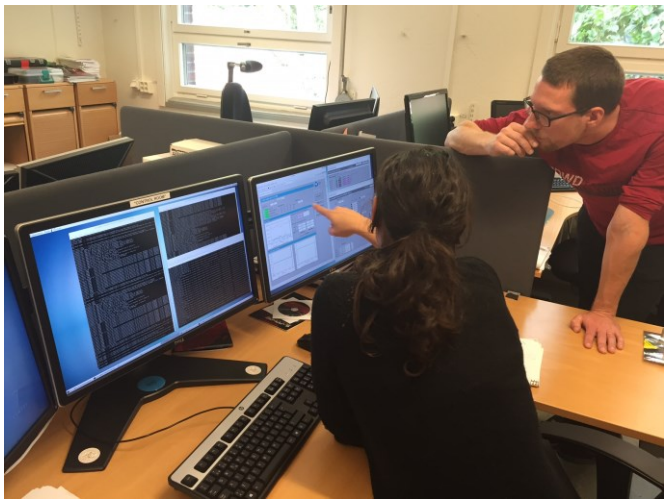
MTCA cards in crate for RFQ

- RFQ has 22 sensors, uses multiple acquisition cards.



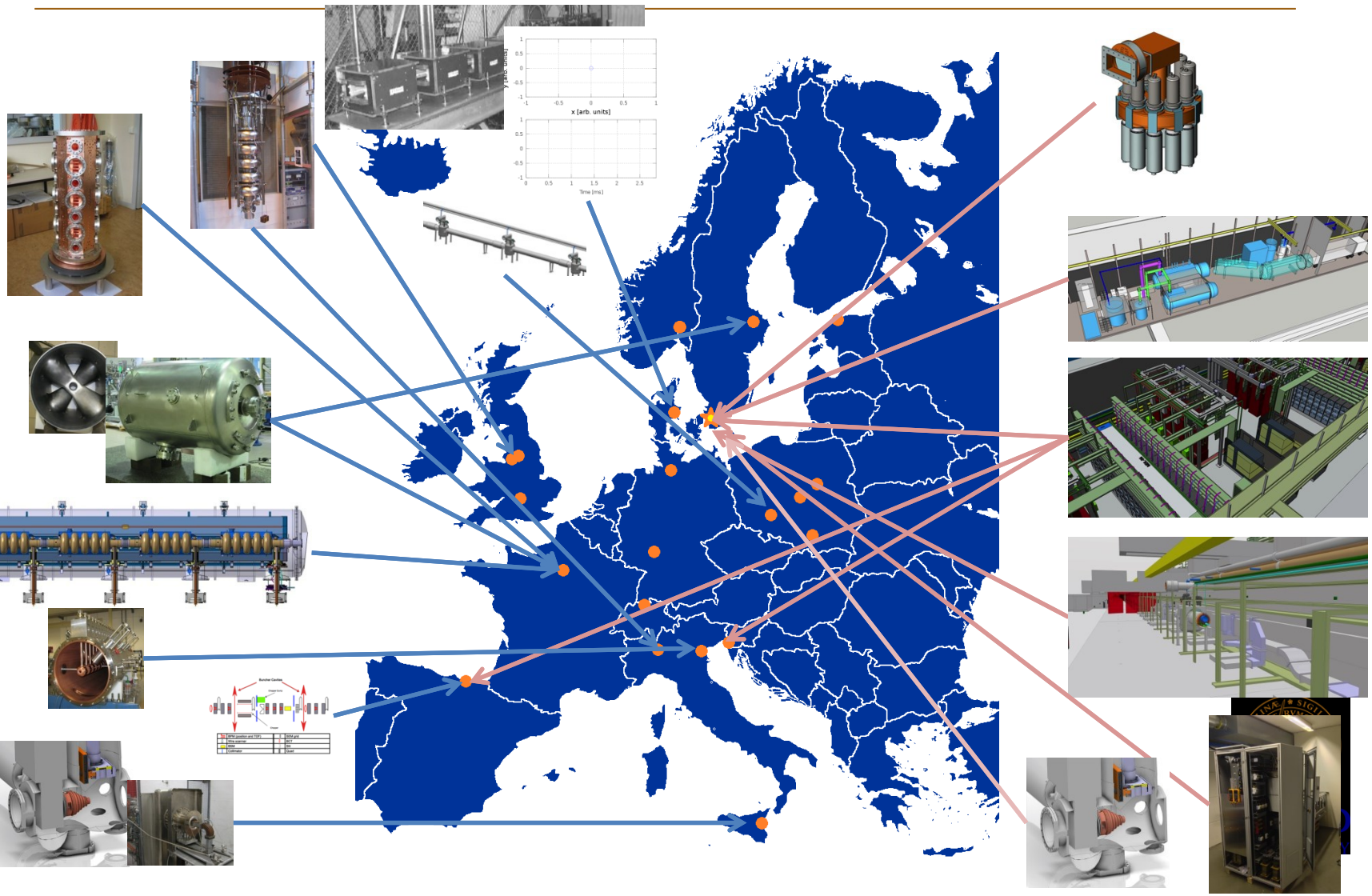
Status

- Two test benches up and running at Lund University
  - 352.21 MHz
  - 704.42 MHz
- Test benches controlled from a central ”control room” computer and screens.
- One prototype running at Freia test hall at Uppsala University.



352.21 MHz downconverter RTM card

Selected accelerator technologies



ESS LLRF Collaboration

- The LLRF system is designed by Lund University, Sweden.
- The LLRF hardware for 352.21 MHz part is planned to be delivered from ESS Bilbao, Spain.
- The LLRF hardware for 704.42 MHz is planned to be delivered from Polish Electronics Group, Poland.
- One RTM card designed by SLAC under contract.
- In addition, all collaborators are doing additional design work on separate components of the complete system.

MTCA experience

- Good, but…

- Would benefit from even better care taken of:
  - Standard Interfaces
    - » FMC, Zone 3,…
  - Interoperability
    - » Between crates, MCHs, AMCs, RTMs, etc.
  - Second source possibilities
    - » Longevity of supply for user facilities

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