Diamond-II RF System

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On behalf of Diamond RF Team

Diamond-II: challenges and novel solutions for upgrading the national synchrotron light facility

Rutherford Appleton Laboratory

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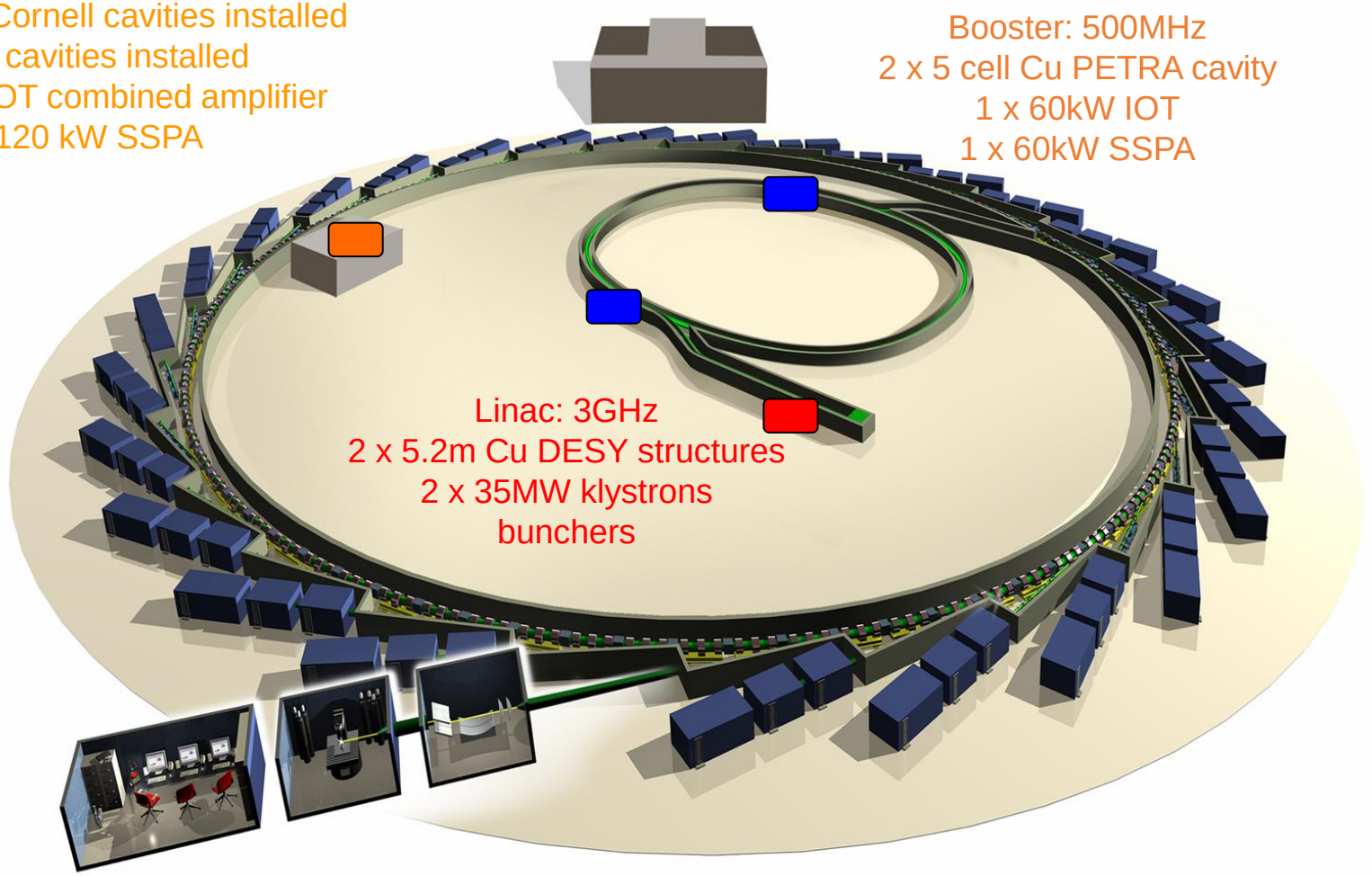
Outline

- Diamond RF System Overview
- Linac RF System
- Booster RF System
- Diamond-II Storage Ring RF Systems
  - Storage Ring Fundamental Cavities
  - Storage Ring RF Amplifiers
  - Digital LLRF
  - Higher Harmonic Cavity
- Summary

Diamond RF System Overview

Storage ring: 500MHz
2 x 1 cell Nb Cornell cavities installed
3 x NC cavities installed
3 x 300kW IOT combined amplifier
1 x 120 kW SSPA

Booster: 500MHz
2 x 5 cell Cu PETRA cavity
1 x 60kW IOT
1 x 60kW SSPA

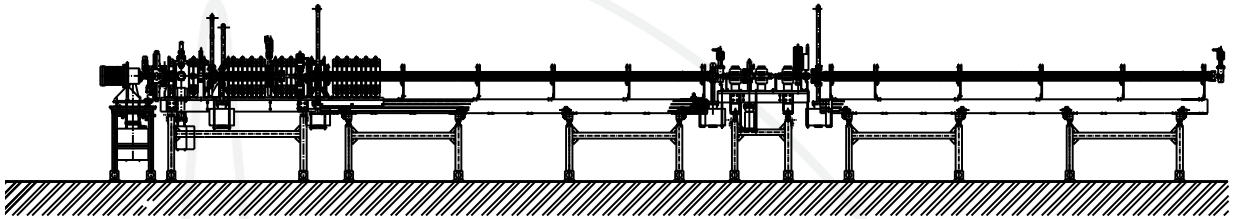


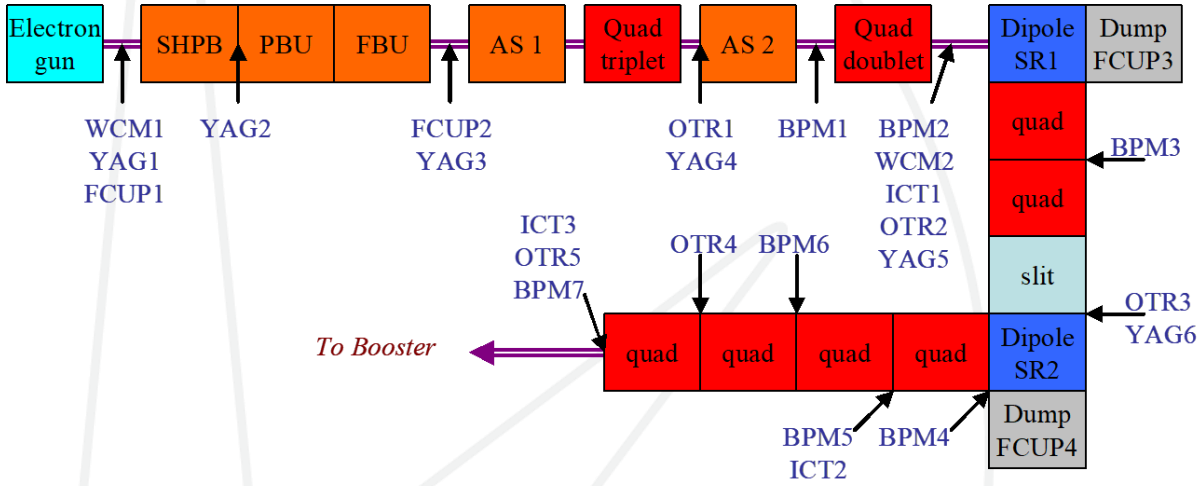
Diamond RF is concentrated in one area

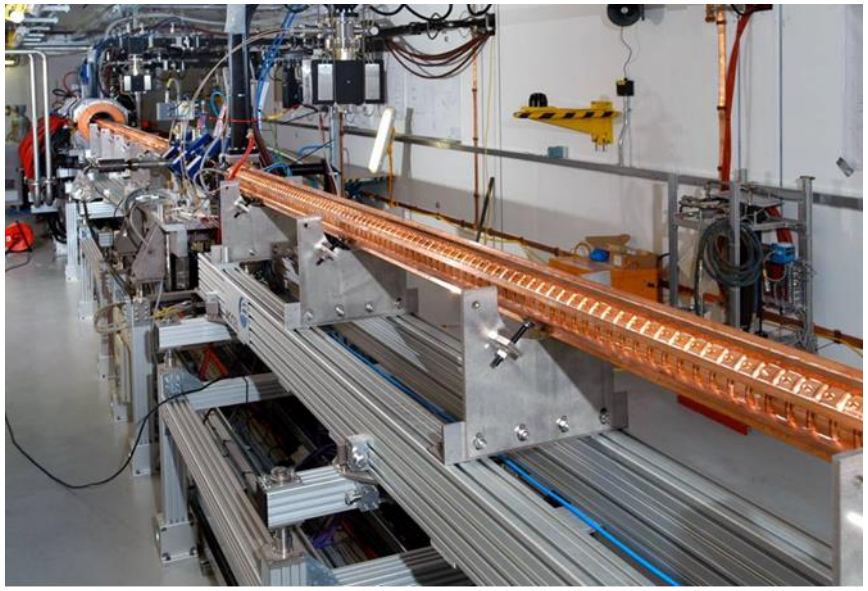
- Amplifiers in RF hall
- Cavities in single RF straight

- 3 GeV 300 mA third generation light source
- Operating for users since 2007
- NC linac and full energy booster, SC storage ring RF

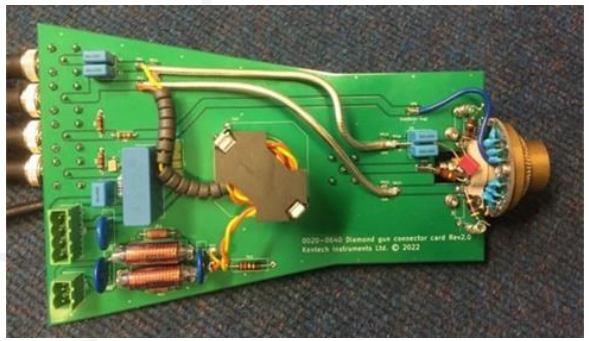
LINAC

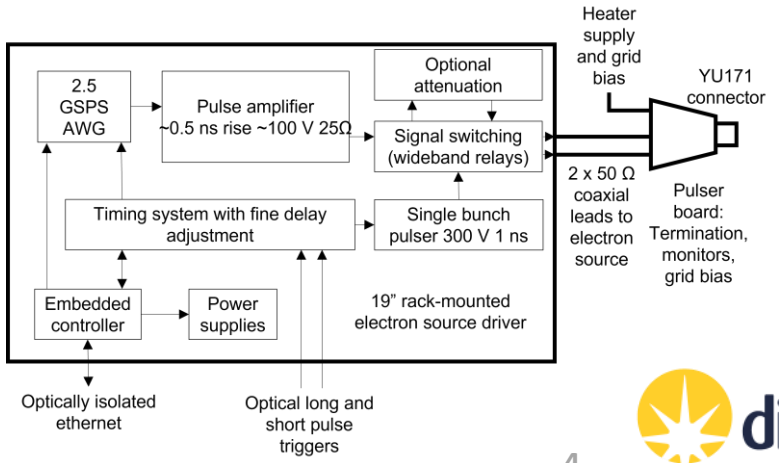






100 MeV SLS-style NC linac

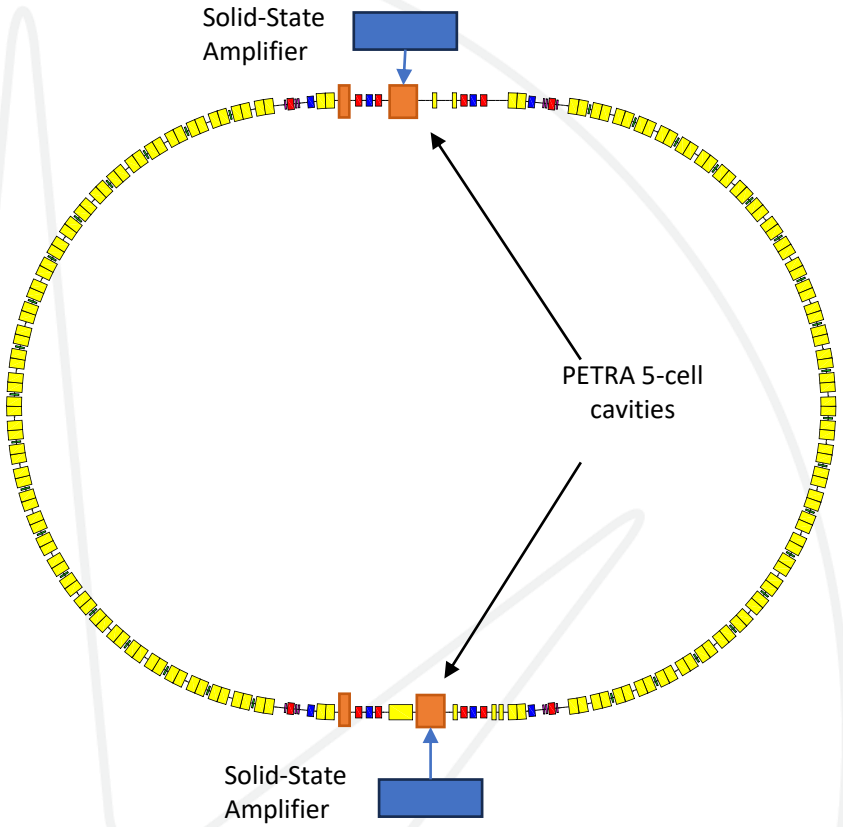


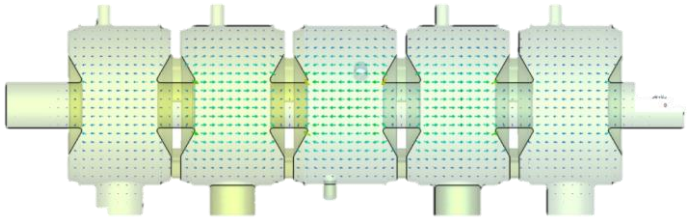


LINAC RF System

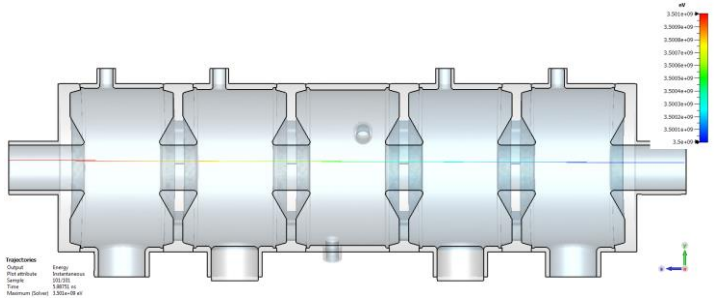
- 2 Thales TH2100 Klystron tubes operating at 12-15 MW (37MW)
- LINAC RF frequency is 3GHz
- 2 PPT modulators with PFN network
- Klystron sits in Stangenes tank

Booster RF System





Electric field uniformity

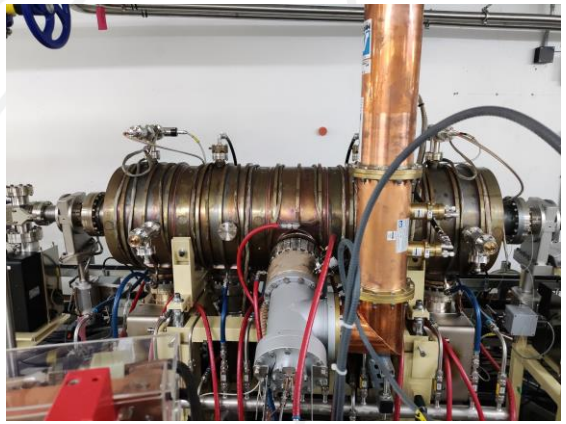


Off-axis trajectory

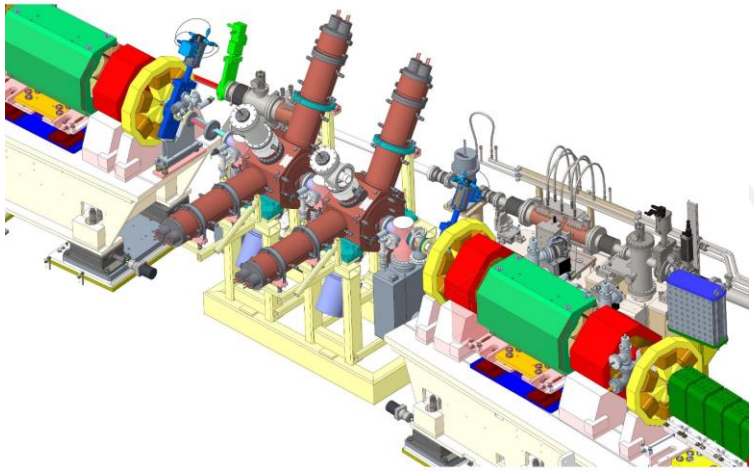
- Booster ring uses both currently installed PETRA 5-cell cavities
  - Can use existing Solid-State Amplifiers to power cavities up to 1 MV each
  - Space for two EU HOM-damped cavities as back-up
- Extracted beam passes off-axis through cavity
  - Inner cavity bore can accommodate off-axis extracted beam
  - CST calculation shows uniform field across axis

Booster RF System

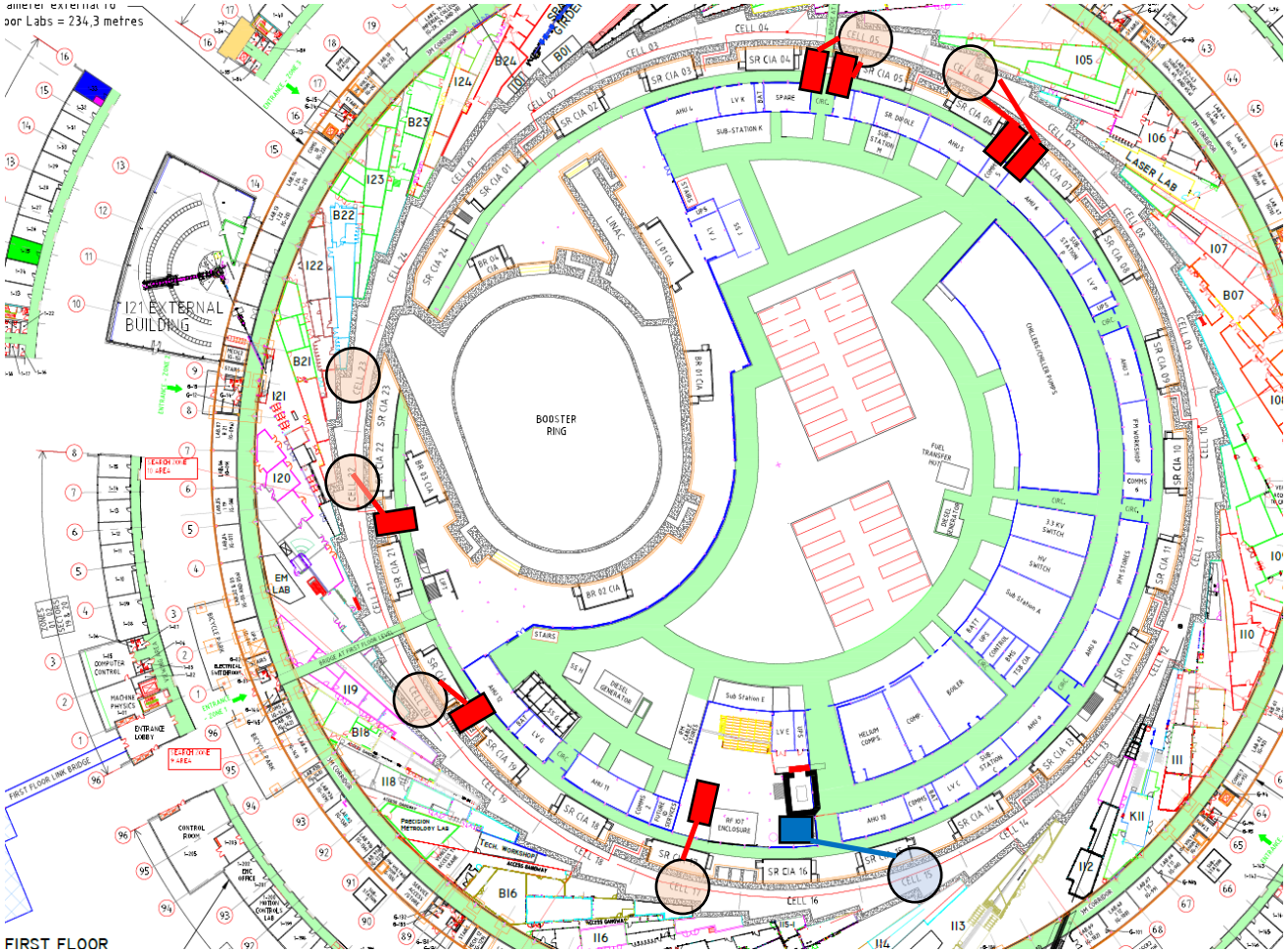
- Frequency for the Booster RF system is 500MHz
- Each cavity is powered by a 60kW Solid-State Power Amplifier (SSPA)
- 3.5 GeV Booster
- 158 m circumference
- Extraction at 3.5 GeV
- Top up operation (5Hz)
- 2 RF cavities ~1MV each
- Two digital LLRF



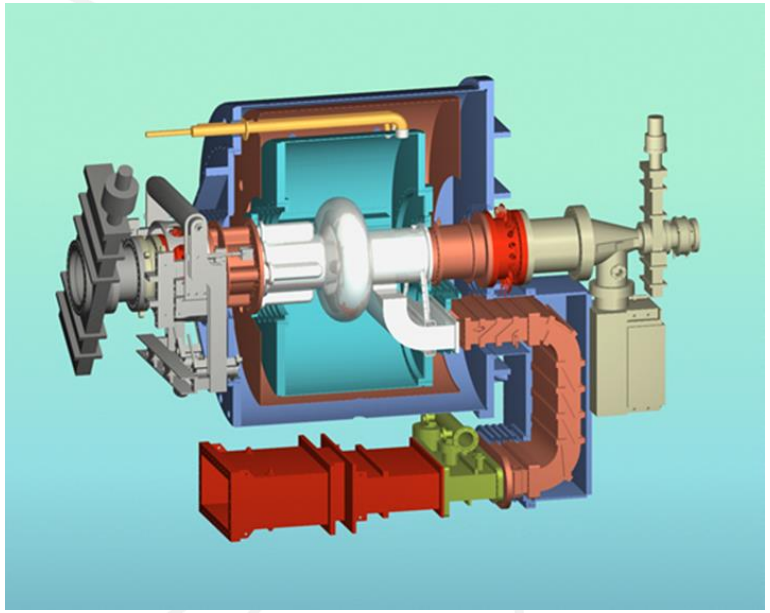
Storage Ring RF System

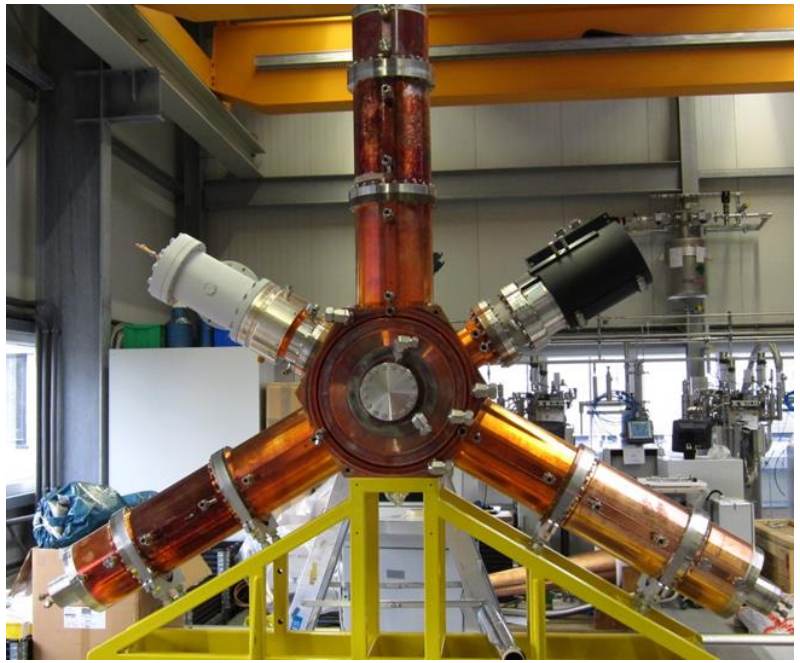


- A total of 7 normal conducting cavities will be installed in the Storage Ring plus a super conducting 3rd harmonic cavity
- Each fundamental cavity will be powered by one Solid-State Power Amplifier (SSPA)
- A new insertion device for a new flagship beamline will be installed in what is now the Diamond RF straight
- All cavities must move to mid-section straights
  - Platforms must be provided for amplifiers
  - Easier to fit multiple smaller amplifiers than smaller number of large amplifiers
  - Harmonic cavity is subject to the same constraints



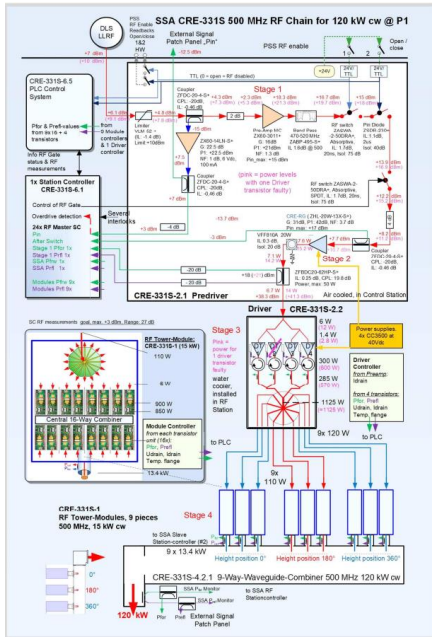
Storage Ring RF Cavities

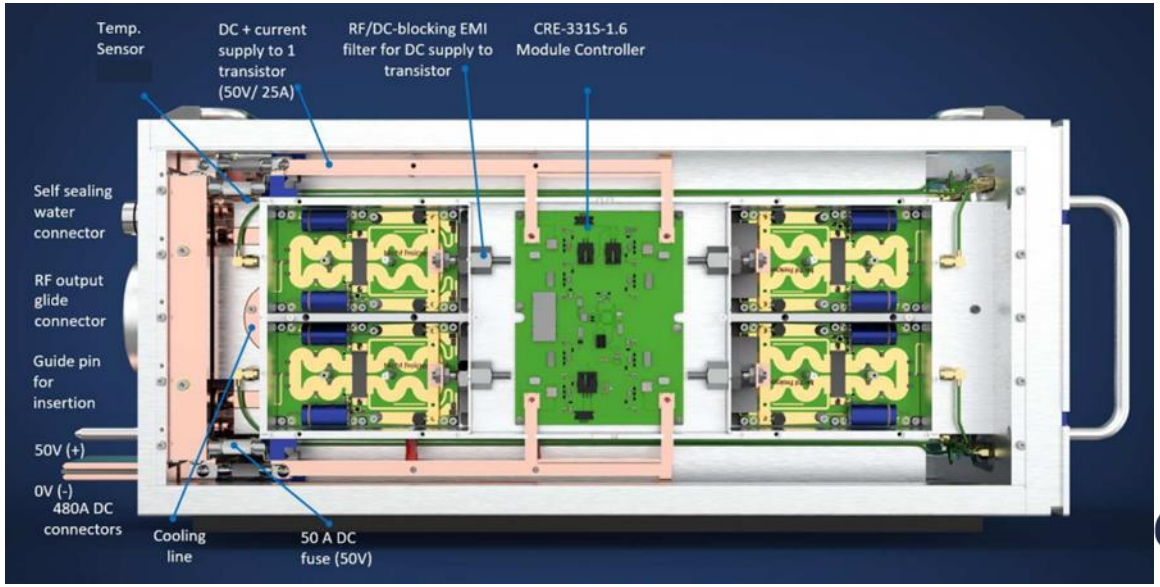




Storage Ring SSPAs

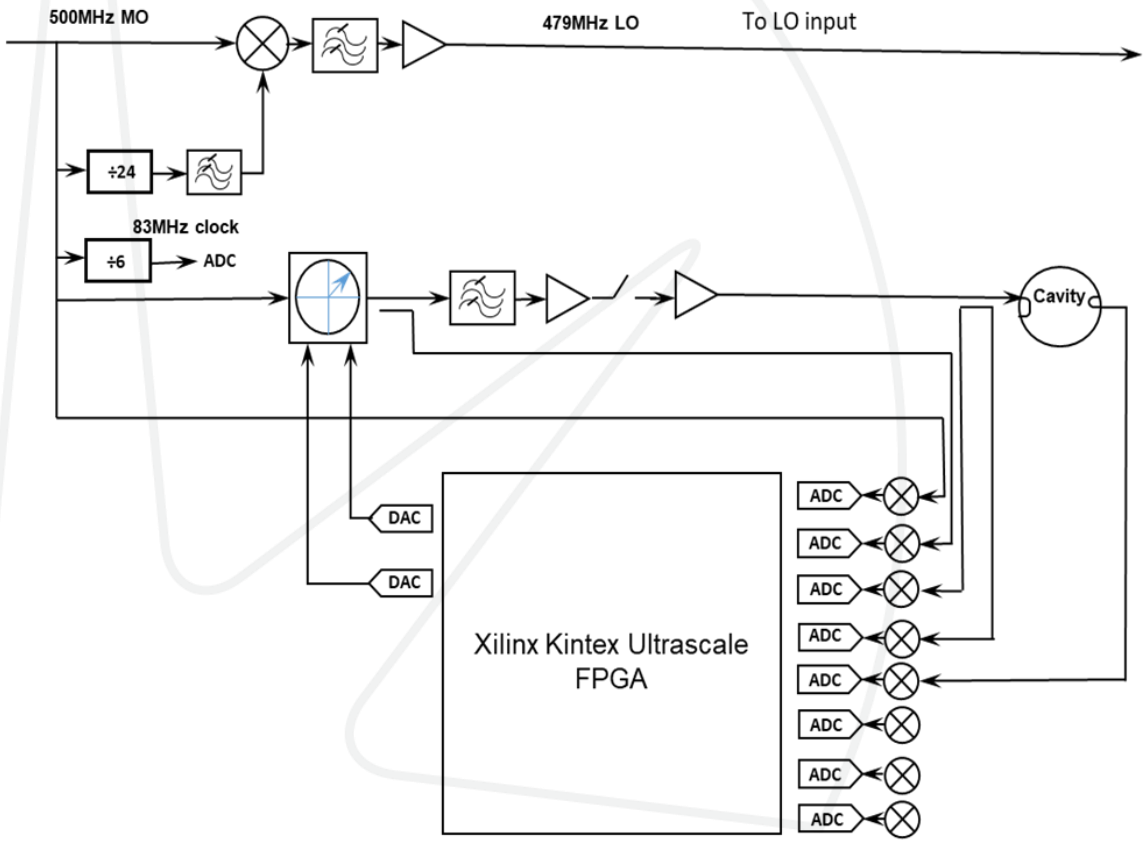
- Seven 120kW Solid-State Power Amplifiers will be used for the Storage Ring
- One SSPA for each cavity
- Frequency 500 MHz
- Efficiency 60%

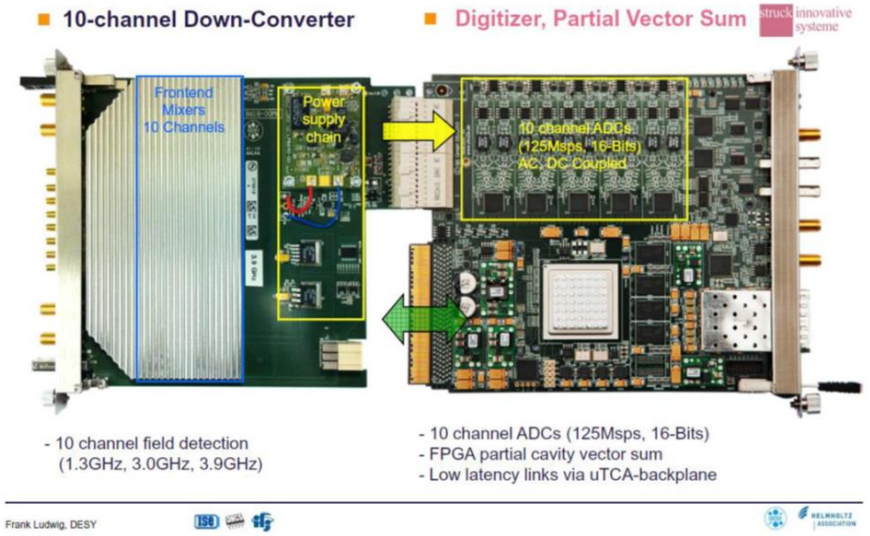




Digital LLRF

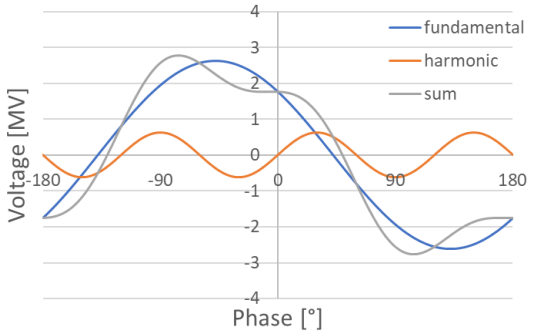
All the Analogue LLRFs will be replaced by Digital LLRF

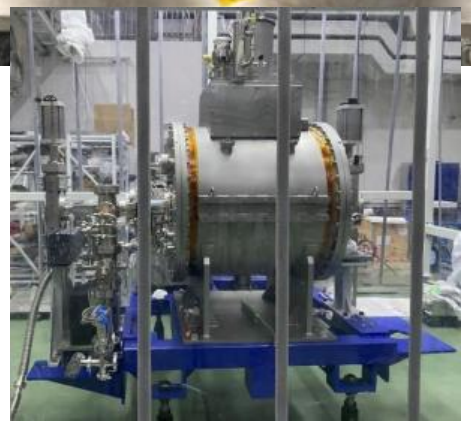




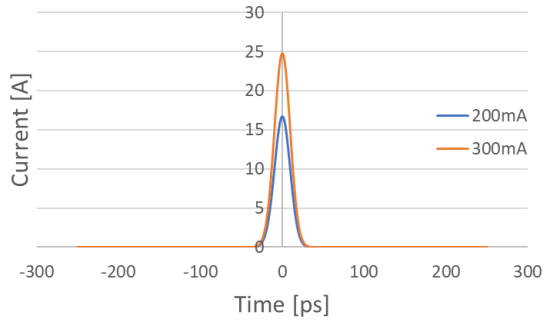
High Harmonic RF Cavity

- Higher harmonic cavity is needed to
  - ✓ Minimise RF heating
  - ✓ Alleviate collective instabilities
  - ✓ Maximise beam lifetime

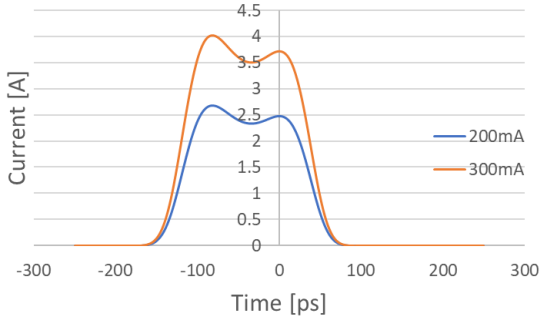


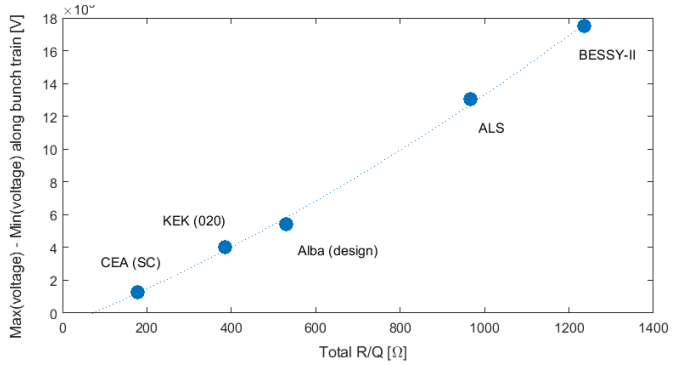


HHC fully detuned



HHC: 57kHz@300mA 38kHz@200mA





Summary

- Design has been finished
  - 500MHz RF frequency
  - 7 normal conducting cavities
  - 7 solid-state amplifiers, 120kW each
  - Digital LLRF in microTCA format
  - Superconducting third harmonic cavity

- D-II improvements
  - More reliability
  - Better availability
  - Modular RF system
  - Better performance

- Diamond RF Group
  - Arash Kaftoosian, Pengda Gu, Shivaji Pande, David Child, Peter Marten, Adam Rankin, Anton Tropp, Marco Marziani