

Plans for delivery and commission the RF system

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For the MICE RF team

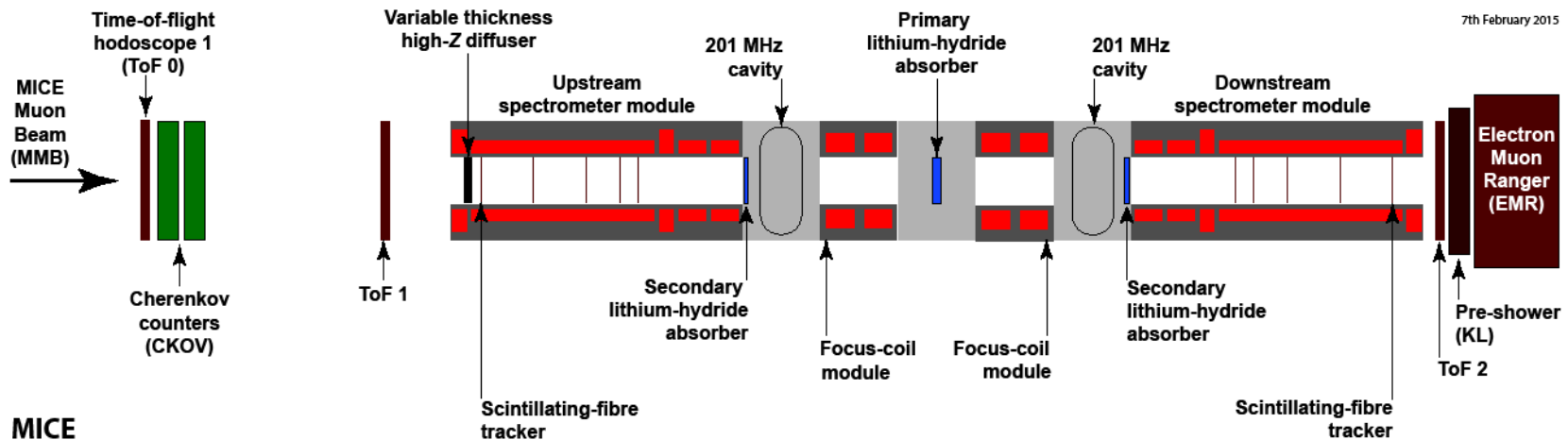


Content

- The RF System has several Key subsystems to be addressed in different talks
 - **RF Cavities and Cavity Modules**
 - Progress on the tests at the MTA discussed in the first paper
 - Cavity modules to be addressed in penultimate paper
 - **Muon-RF phase determination**
 - Discussed in preceding talk
 - **RF drive and distribution system**
 - Plans for test, delivery and installation of amplifiers will be addressed here
 - Encompasses development of remote control (2nd talk) and LLRF control (final talk)
 - **Cavity tests at RAL**
 - Opportunity for a full system test
 - Commission all major components before assembly in beam line

MICE High Power RF systems

- MICE HPRF system requirements have changed
 - Fewer cavities, no coupling coil
 - Required operational date on the beamline is Summer 2017
 - Requires early commissioning of the hardware: Starting Aug 2016
 - Enables demonstration of ionisation cooling with re-acceleration
 - First results complete before end US fiscal year 2017
- It is relevant to review the timeframe and resources required to deliver this system



MICE

MICE High Power RF drive systems: Commissioning



- **2MW peak output from RF drive amplifiers, are unchanged**
 - First triode amplifier proven and installed at RAL
 - First tetrode amplifier also proven with pulsed power modulators
 - These are now back at Daresbury
- **Commissioning System No. 2**
 - Recommissioning of tetrode amplifier no. 1 underway at DL
 - This will be used to commission triode No. 2 with first modulators
 - Tetrode No. 1 will be replaced by tetrode no 2 by end of year
 - Remote control system no. 1 will be implemented in control rack by end of year
 - 2nd Triode and Tetrode amplifiers operating with 1st control rack and modulators by end 2015
 - 2nd Triode and Tetrode Amplifiers operating with 2nd modulators and control rack by end Summer 2016
- **Effort requirement**
 - 6-8 months of RF test (two people),
 - 1.5 Months defining controls philosophy (two people)
 - PLUS electrical engineering effort drawn from the 6.6 FTE allocated 2015-2017

MICE High Power RF drive systems: Installation and Test



• Amplifier System No. 1

- First triode remains installed at RAL
- Reinstall Tetrode No.1 with Modulators No.1 and control racks No. 1 Spring- Aug '16
 - Build on previous installation for TIARA tests
 - Note there may be some conflict with key people required for installation at RAL and commissioning at DL
 - Will require mechanical modification to the Mezzanine
- Prove with 1 Month of test operation into resistive loads

• Amplifier System No. 2

- Completion of Daresbury proving trials in Aug' 2016
- Installation can commence from July '16 to Jan '17 (preliminaries need not await July '16)
 - Build on experience from installation of system No. 1
 - Will require new wiring 'loom' installation, additional cooling water panel and mechanical modification to the Mezzanine
- Prove with 1 Month of test operation into resistive loads

• Effort requirement

- 6 months of RF installation (one RF engineer), 2 months RF testing (2 staff), ~8-12 Months technicians (split between electrical and mechanical)
- 2 Months Hall manager (Service Engineering Support), 1 Month Drawing Office
- PLUS electrical engineering effort drawn from the 6.6 FTE allocated 2015-2017



Cavities: Pre-Installation

- **Cavity Module No. 1: Arrival and Installation**

- Assumed to arrive under purge and fully assembled May '16
 - Assume cavity has been baked prior to arrival
- In advance auxiliary systems will be prepared in MICE hall
 - Clean room: Essential in case any intervention is required
 - Independent cooling loop for each cavity with tight thermal regulation
- LLRF tests to verify safe transport and arrival
- Install cavity next to shield wall opposite U/S SS
- Install vacuum pumps and pump cavity ready for operation late Jun 2016 (1-2 months)

- **Cavity Module No. 2: Arrival and Installation**

- Assumed to follow same pattern as Cavity module No. 1 with object of completion at Oct 2016

- **Effort requirement**

- Primarily a mechanical and vacuum engineering problem, so should be defined by others
- Rough estimates,
 - 2 man months on clean room?
 - 2-3 man months on cavity cooling system?
 - 3 man months on vacuum system installation per cavity?



Cavities: Pre-Commissioning

- **Pre-requisites**
 - As described above RF system No.1 with full remote controls is expected to be available in July 2016
 - Cavity No 1 expected available by June 2016
 - LLRF tuner control and RF closed loop control system expected by Summer 2016
 - Installation of RF power feeds to the test point (shield wall opp. U/S SS)
- **HPRF Tests of Cavity No. 1**
 - Initial tests on a single cavity, using drive system No. 1
 - Aug '16- Oct '16, est 2 months for complete tests
- **HPRF Tests of Cavity No. 2**
 - Oct '16- Dec '16 using drive system No. 1
 - Leave in situ until last possible moment
 - Opportunistically test with drive system no. 2 if timing is good
- **Effort requirement**
 - Rough estimates,
 - 1 man months to build and install pre-comissioning distribution system
 - 6 (minimum) man months RF staff on cavity tests



Cavities: Installation

• Pre-requisites

- Completion of tests as defined in previous page on two cavities with RF amplifier No. 1
 - Ideally also pre-commissioning tests with Amplifier No. 2 and Cavity No. 2
- After tests cavities left either under vacuum or purge N_2 gas
- Removal of the STEP IV yoke and completion of the absorber, spool vacuum pieces
- Build of floor plates, mechanical integration components
- Installation of final RF distribution network (planned for Aug '16- Feb '17)

• Procedure

- Cavities should be left under purge until the last possible moment.
- Absorber and spool sections 'beam line vessel' should be pumped separately and left under purge
- When final installation is imminent, the 'beam line vessel' cavity gap be opened and the apertures blocked with thin plates
- When ready, the end plates of the cavity modules should be removed, replaced with thin plates for installation
 - Cavities immediately installed in the beam line vessel
 - Immediately 'rough pumped', then HV pumped
- Shown as starting early Feb and could complete early March 2017, validate with LLRF measurements

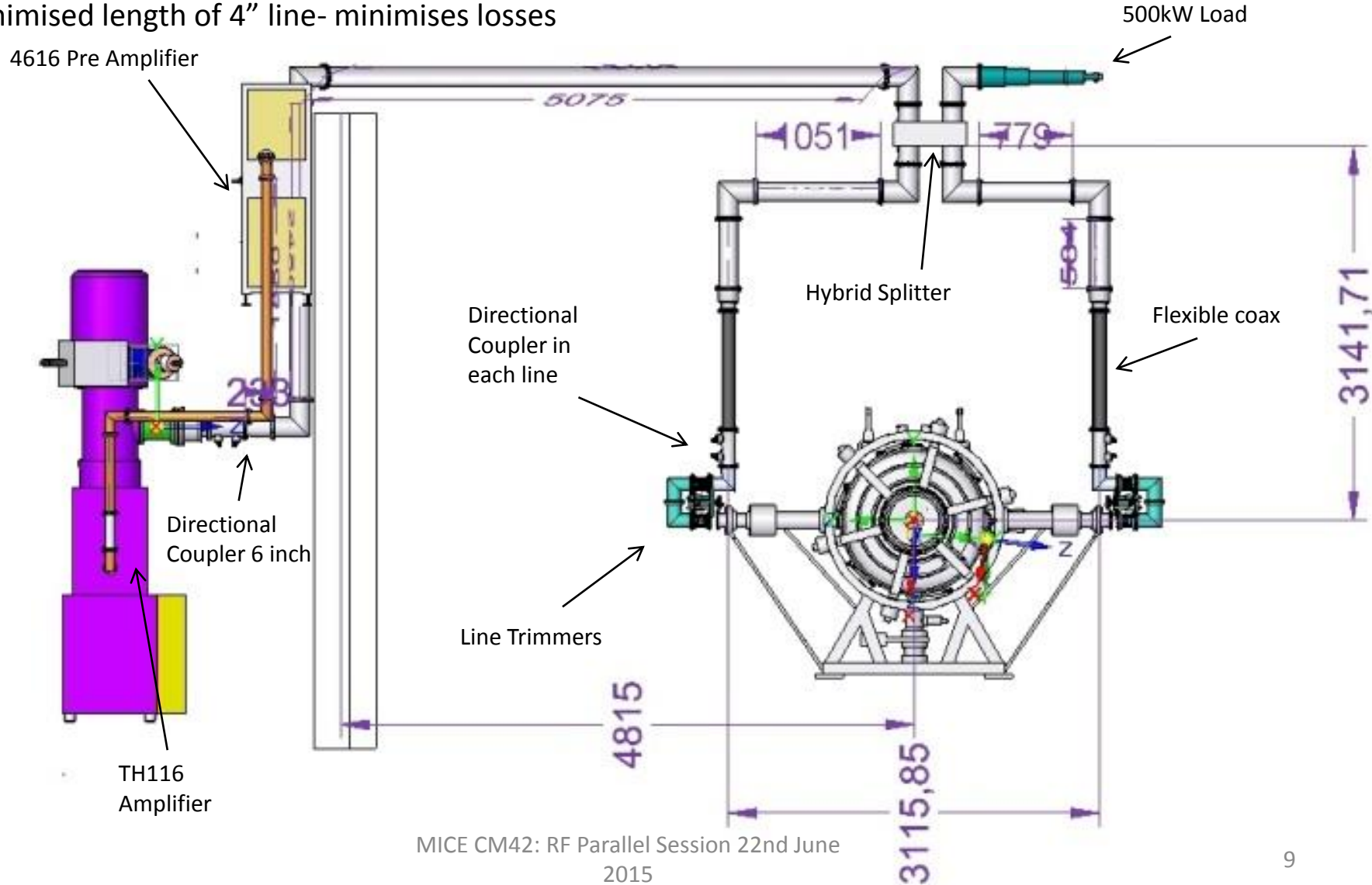
• Effort requirement

- Primarily a mechanical and vacuum engineering problem, so should be defined by others
- 2 man months to build and install distribution system

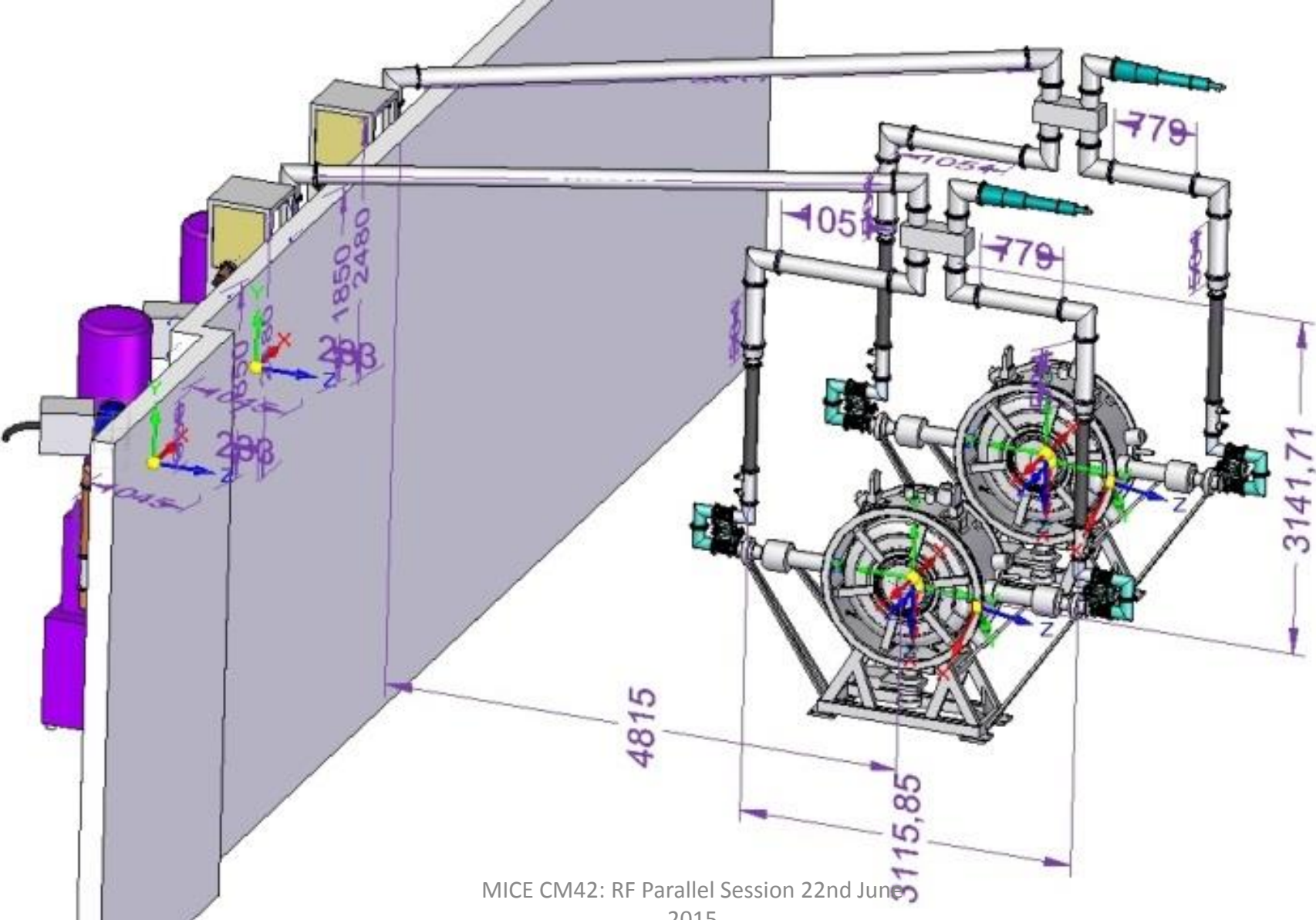
RF network



- Simplified distribution network- feasible to route overhead
- Off-centre mounting of hybrid takes up phase shift
- Orientation of load arbitrary- align with the 6" distribution line and share mountings
- Minimised length of 4" line- minimises losses



RF network





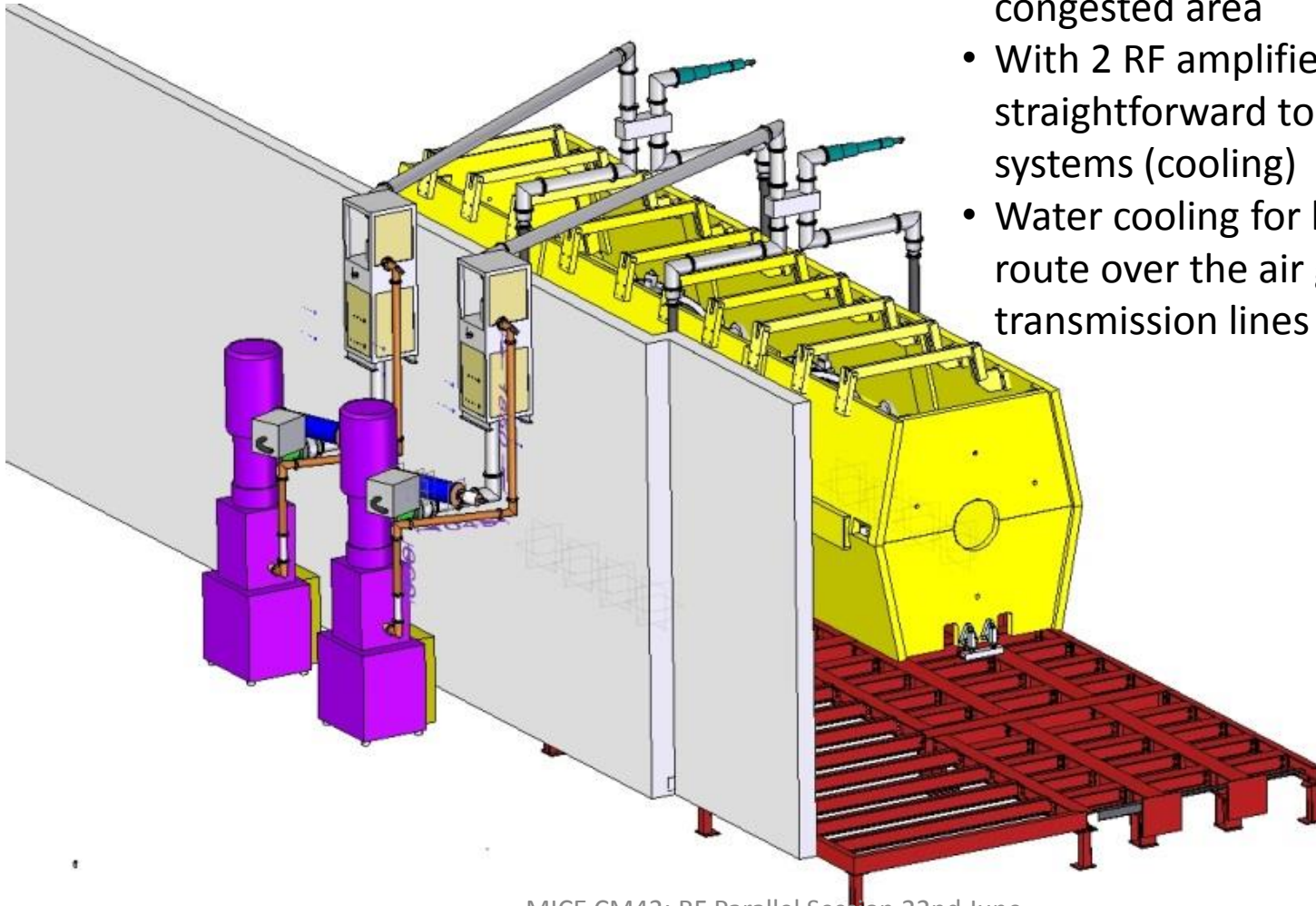
Cavities: Commissioning

- **Commissioning without B field**
 - Cavities should be HPRF tested on beam line before yoke is complete
 - In case any intervention is required
 - Estimate <1 month operation of both cavities together, so completion by April 2017
- **Commissioning with B field**
 - Requires completion of Yoke and recommissioning of all magnets
 - Note ONE magnet only will be added to the STEP IV set
 - Yoke plate final installation est ~ 1 wk
 - Commissioning of magnets will benefit from the STEP IV plan- presently assumed to be the same process, planned for April 2017
 - Tests of the cavities with magnetic field and all systems April 2017, say 2wks- 1mnth
 - In parallel with magnet commissioning if possible
- **Effort requirement**
 - Requires effort to integrate magnets- will be similar to STEP IV
 - 2 months of RF effort (2 people)

RF network

- Load on each splitter to absorb unbalanced reflections
- Retracted crane hook clears coax over the wall.
- Support from present 'shield wall' and yoke

- 2nd amplifier moved to 3rd position behind wall to ease installation in congested area
- With 2 RF amplifiers now relatively straightforward to place auxiliary systems (cooling)
- Water cooling for load will need to route over the air gap on the transmission lines



Summary



- **Drive Commissioning Timetable**
 - Amplifier No. 1 with automation installed and operational by Aug 2016
 - Amplifier No. 2 with automation installed and operational by Feb 2017
 - LLRF and cavity control systems operational by Aug 2016
- **Cavities**
 - Arrival May 2016
 - Cavity no. 1 ready for standalone tests by end June 2016 : Complete by Oct 2016
 - Cavity No. 2 ready for standalone test by Oct 2016 : Complete by Dec 2016
 - Cavity installation to beamline Mar '17
 - Installation of distribution network by Feb '17
 - Tests of the cavities without B-field late march /early April
 - Tests of Cavities with B-field, May 2017
- **Timetable to be integrated into Gantt Chart**