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Warm Linac

ESS Commissioning Plans

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On behalf of the Beam Physics Section

58th ICFA Advanced Beam Dynamics Workshop on High-Intensity and High-Brightness Hadron Beams

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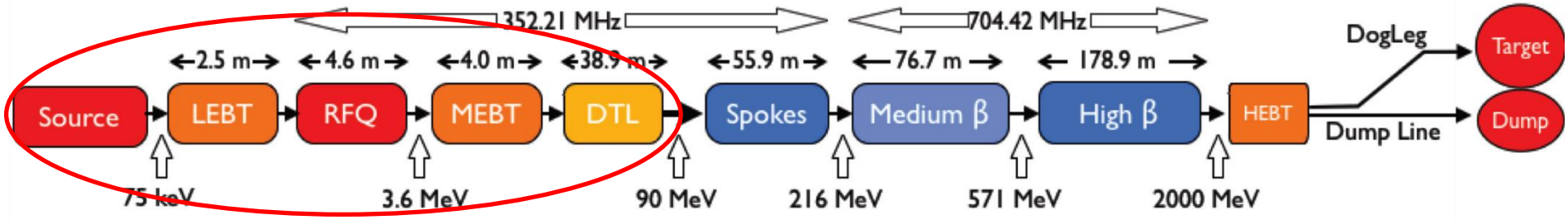
Summary

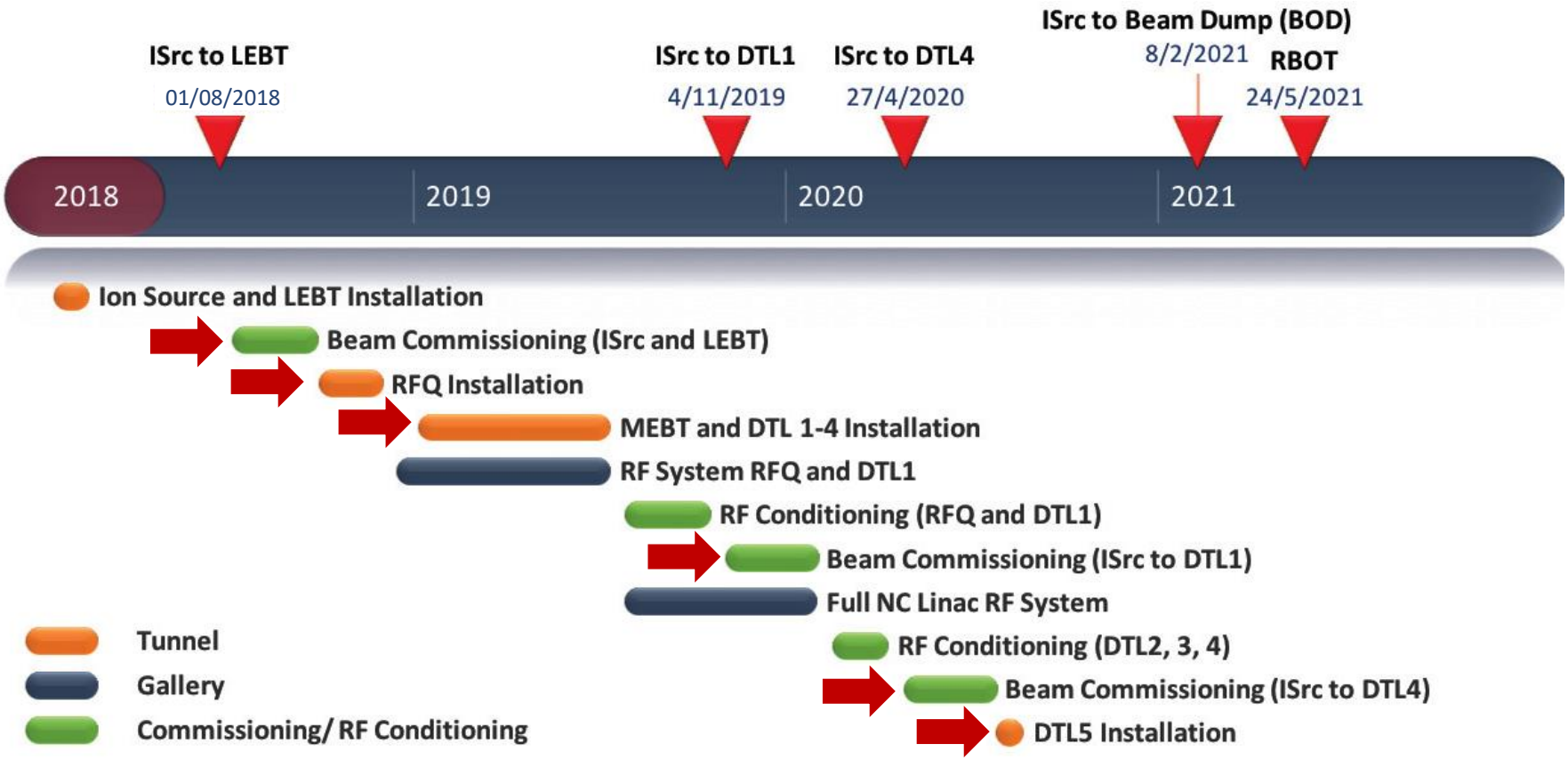
- Introduction
- Installation Schedule
- Warm Linac:
  - IS and LEBT
  - RFQ
  - MEBT and
  - DTL
- Beam Commissioning Strategy
- High Level Physics Applications
- Closing remarks
- Acknowledgements

ESS Linac Overview



Parameter	Value	Unit
Average Power	5	MW
Energy	2	GeV
Peak Current	**62.5**	mA
Pulse Length	**2.86**	ms
Repetition Rate	**14**	Hz
Duty Cycle	4	%

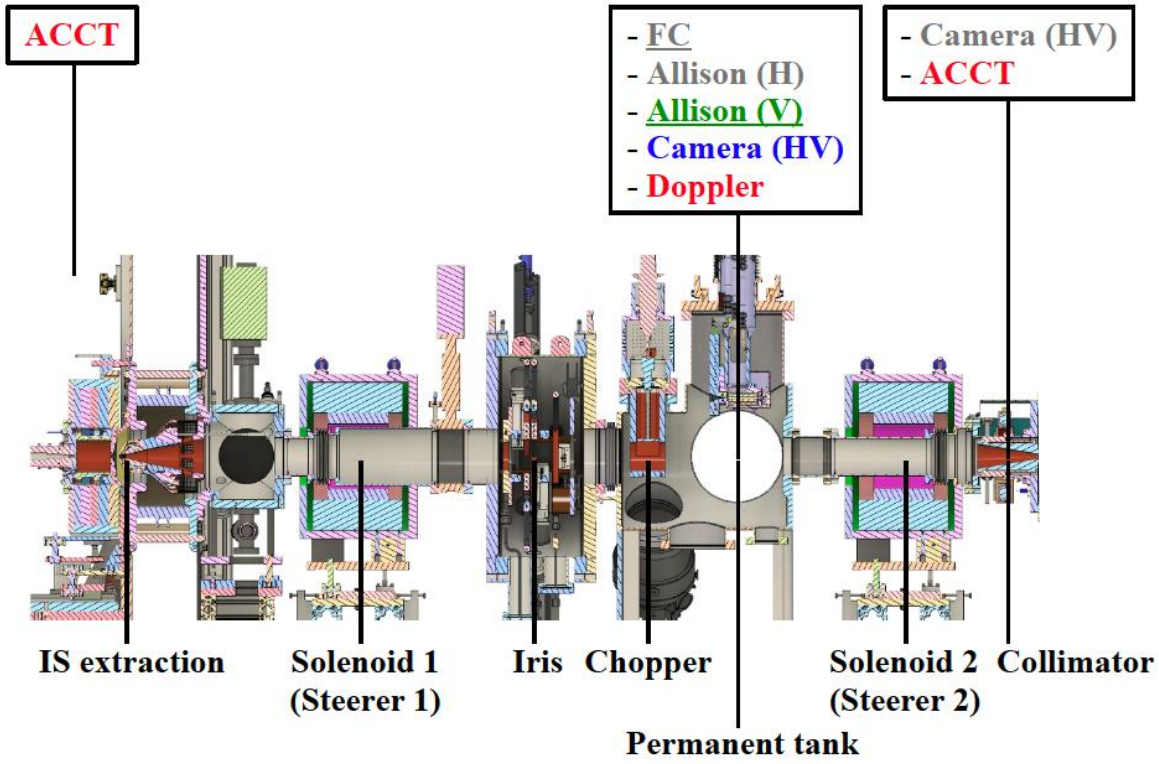
Installation Schedule



Installation Schedule: upcoming commissioning IS+LEBT

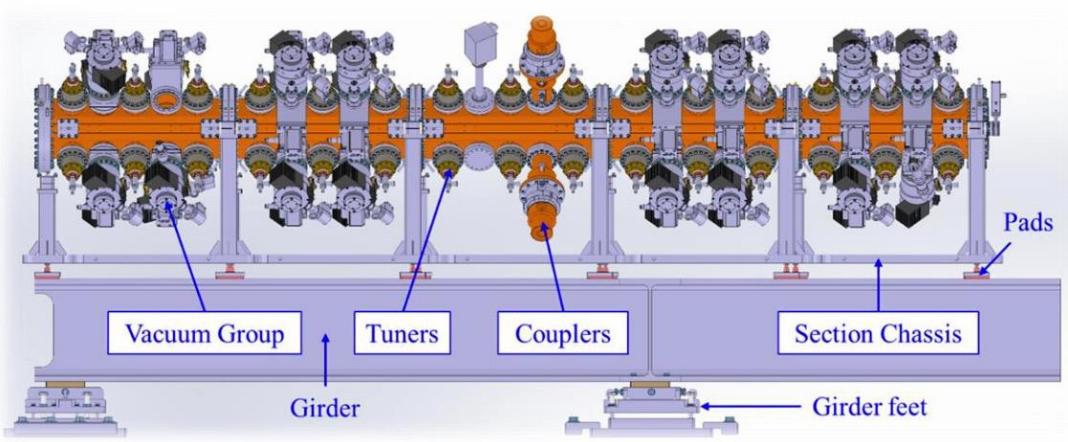
- Installation of the water skid started mid-June.
- Front-end building power ready early July.
- Safety Readiness Review (SRR) scheduled to happen on July 17-18th:
  - Mainly focused on safety.
  - ~+2 week to implement recommendations.
- Commissioning starts August 2018 and runs for approximately 3 months.
- RFQ ready for installation in ~December 2018.

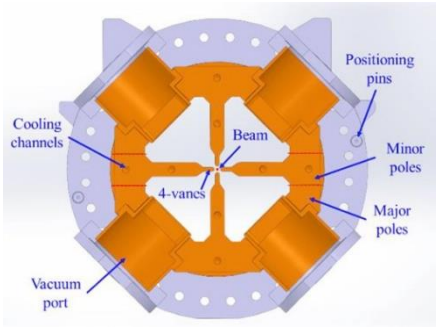
Warm Linac: IS and LEBT



- In-kind contribution from LNS-INFN.
- Focusing/Transporting channel with 2 solenoids, 2 steeres, iris and chopper.
- The LEBT is 2.5 m long.

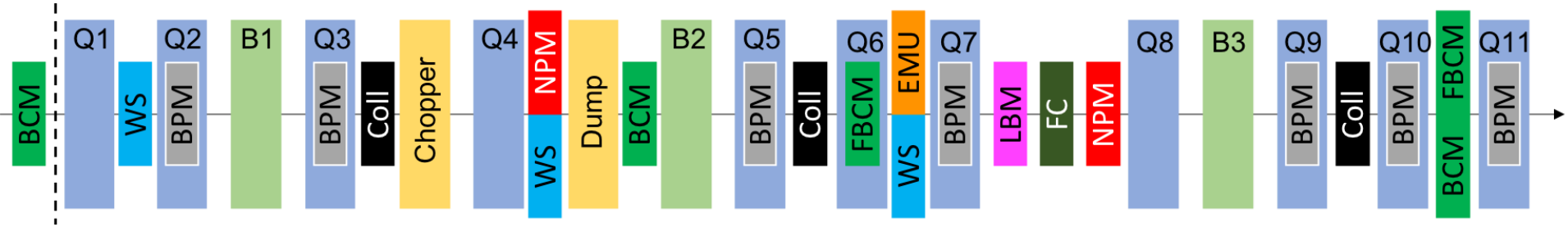
Warm Linac: RFQ





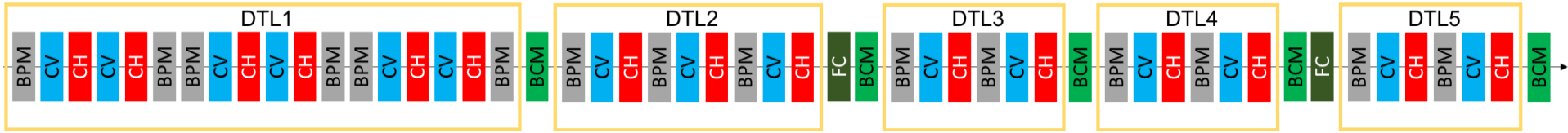
- In-kind contribution from CEA-Irfu.
- Expected to arrive in Lund during the 4th quarter of 2018.
- 4-vanes structure, 4.6 m long and accelerates the beam from 75 keV up to 3.6 MeV.
- It was design and optimized for high transmission (>97%).

Warm Linac: MEBT



- In-kind contribution from ESS-Bilbao.
- Includes 3 buncher cavities and is 4 m long.
- Contains a series of diagnostics in order for us to be able to characterize the beam coming from the RFQ and be able to match it to the DTL section.
- Capable to measure transverse (EMU, wire scanners and NPMs) and longitudinal profiles (LBM).
- Fast chopper to clean the edges of the pulse (~ 20 µs from the front and back).

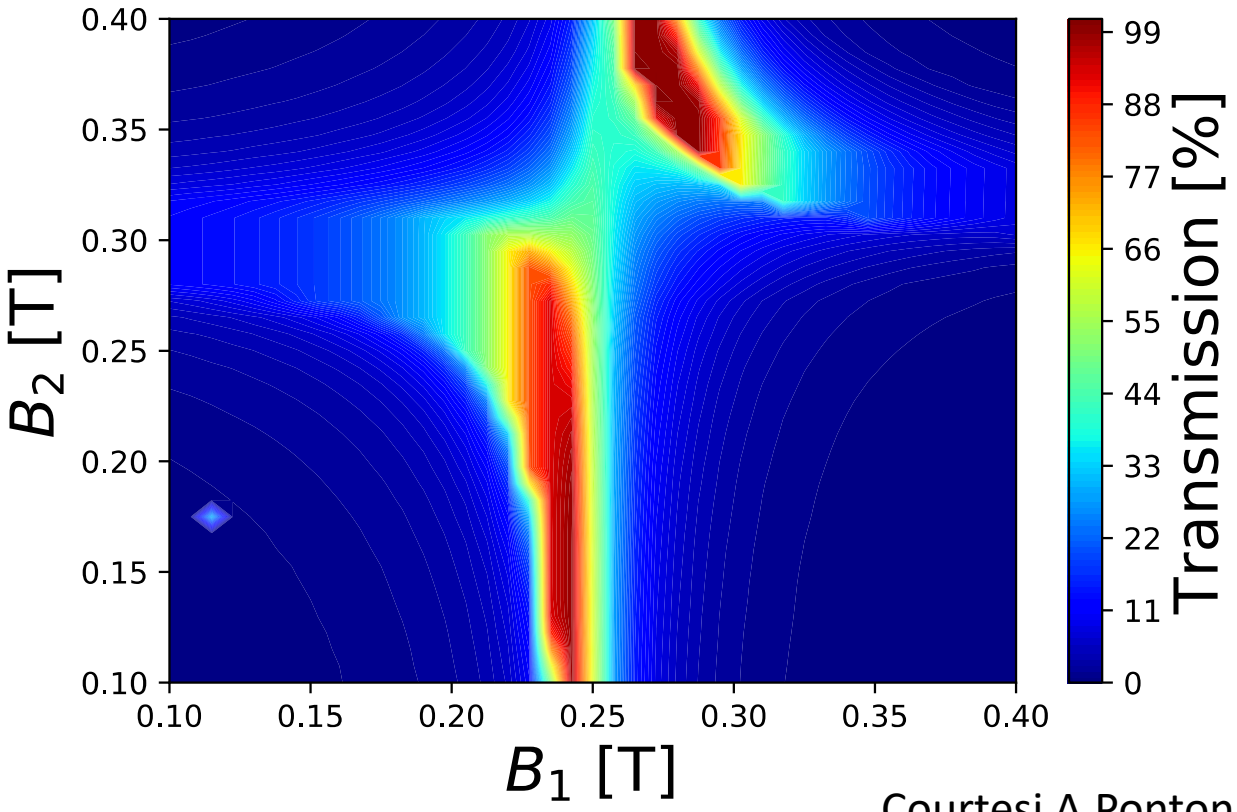
Warm Linac: DTL



- In-kind contribution from INFN-LNL.
- 38.8 m long structure divided in 5 tanks.
- Lattice is a FODO and composed of permanent quadrupole magnets.
- Accelerates the beam further from 3.6 MeV to 90 MeV and into the super-conducting sections.
- Diagnostics is basic and there are only BPMs and BCMs.
- For beam trajectory corrections there are H/V steerers.

Beam Commissioning Strategy: IS and LEBT

Parameter	Value	Unit
Energy		
Peak currer		
Peak currer		
Proton frac		
Pulse lengtl		
Pulse repet		
Duty cycle		



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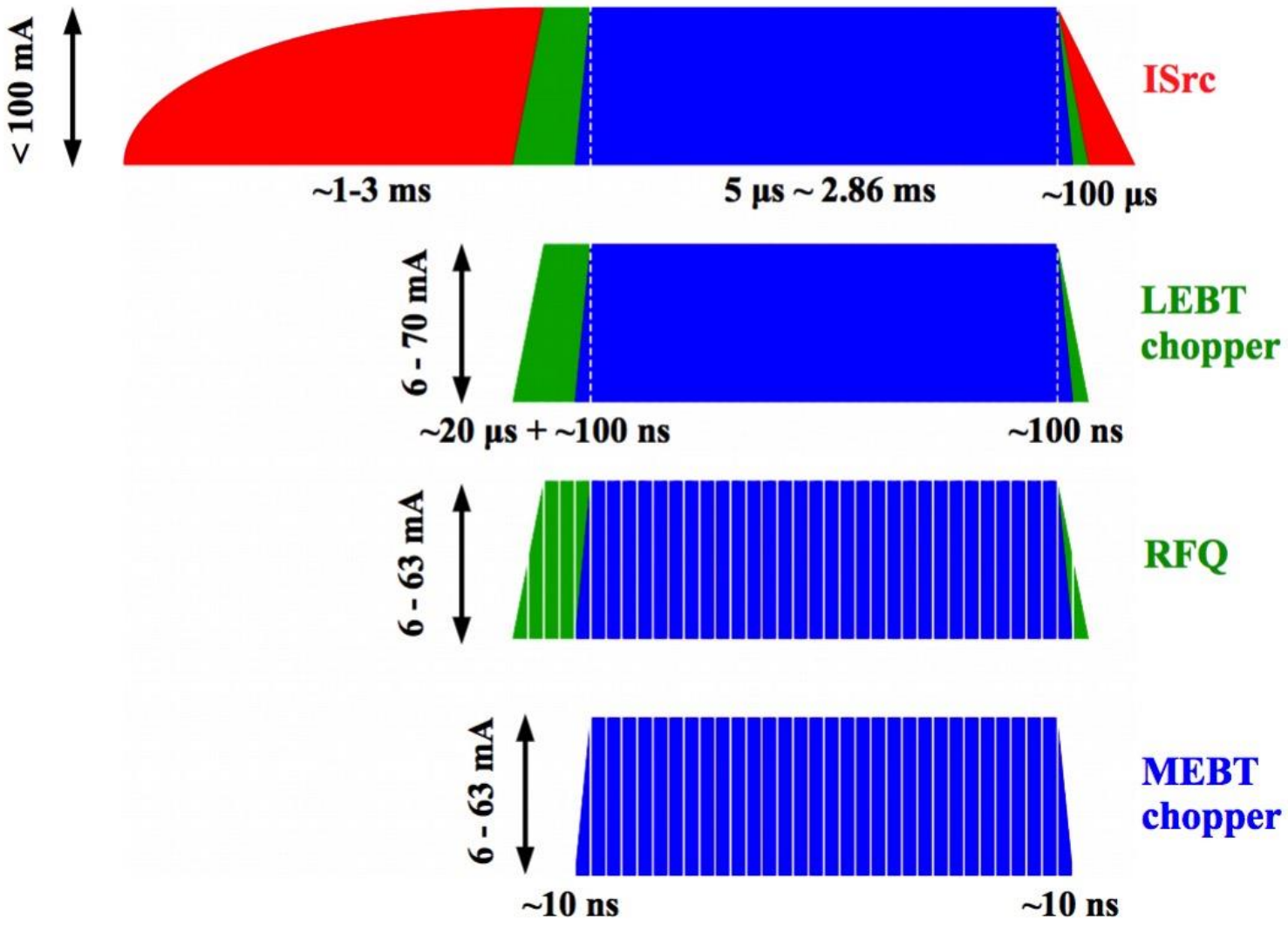
- – Optimization and long-term stability test
  - Identify (candidates of) the optimum IS setting and gas injection for beam transmission in the RFQ.

Beam Commissioning Strategy: Pulse structure evolution



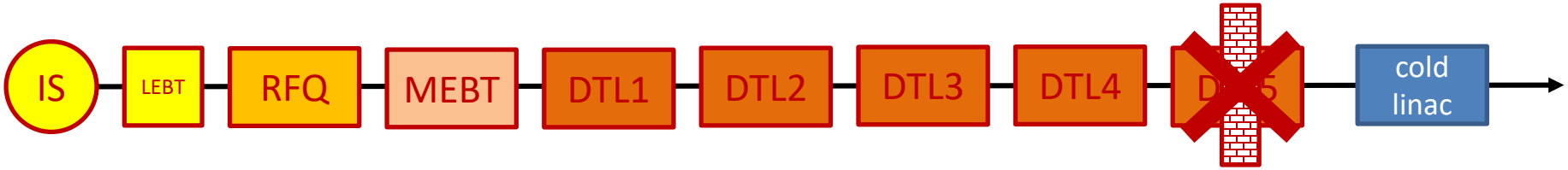
Beam Commissioning Strategy: Beam Modes for Warm linac tuning

Type	Destination	Main Usage	Peak Current [mA]	Pulse Length [µs]	Repetition rate [Hz]
Probe	Any beam stop	Initial system check Beam threading	6	≤ 5	≤ 1
Fast tuning	Any beam stop*	RF check	6-62.5	≤ 5	≤ 14
Slow tuning	Any beam stop*	Invasive measurement LLRF setting	6-62.5	≤ 50	≤ 1

* Subjected to maximum dose limit for the DTL FCs.

- Capability to produce the beam modes has to be verified during the IS and LEBT commissioning.
- Linac power ramp-up: current determines the total power (pulse length and repetition rate are fixed).

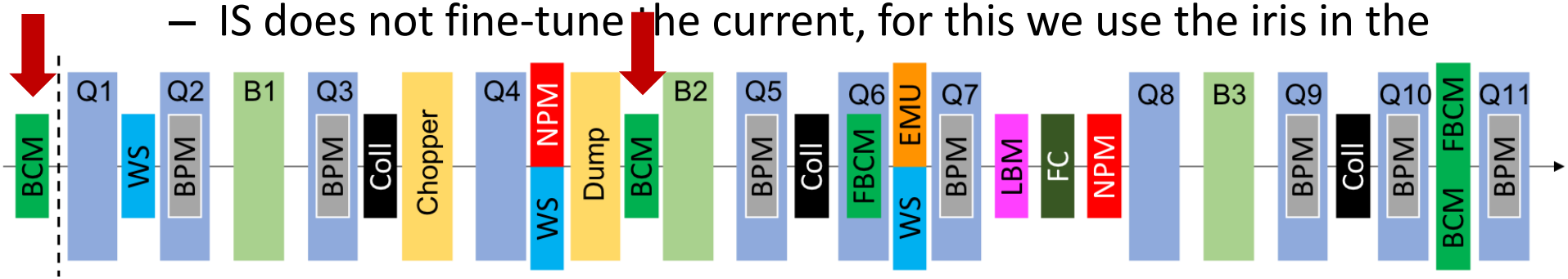
Beam Commissioning Strategy: Commissioning order



- Since the RFQ, MEBT and DTL tank 1 will be installed together we will use the MEBT diagnostics to characterize the beam coming from the RFQ.
- DTL tank 5 will not be installed at first and on its place a wall will be built. This setup will allow commissioning up to DTL tank 4 in parallel with the superconducting linac installations

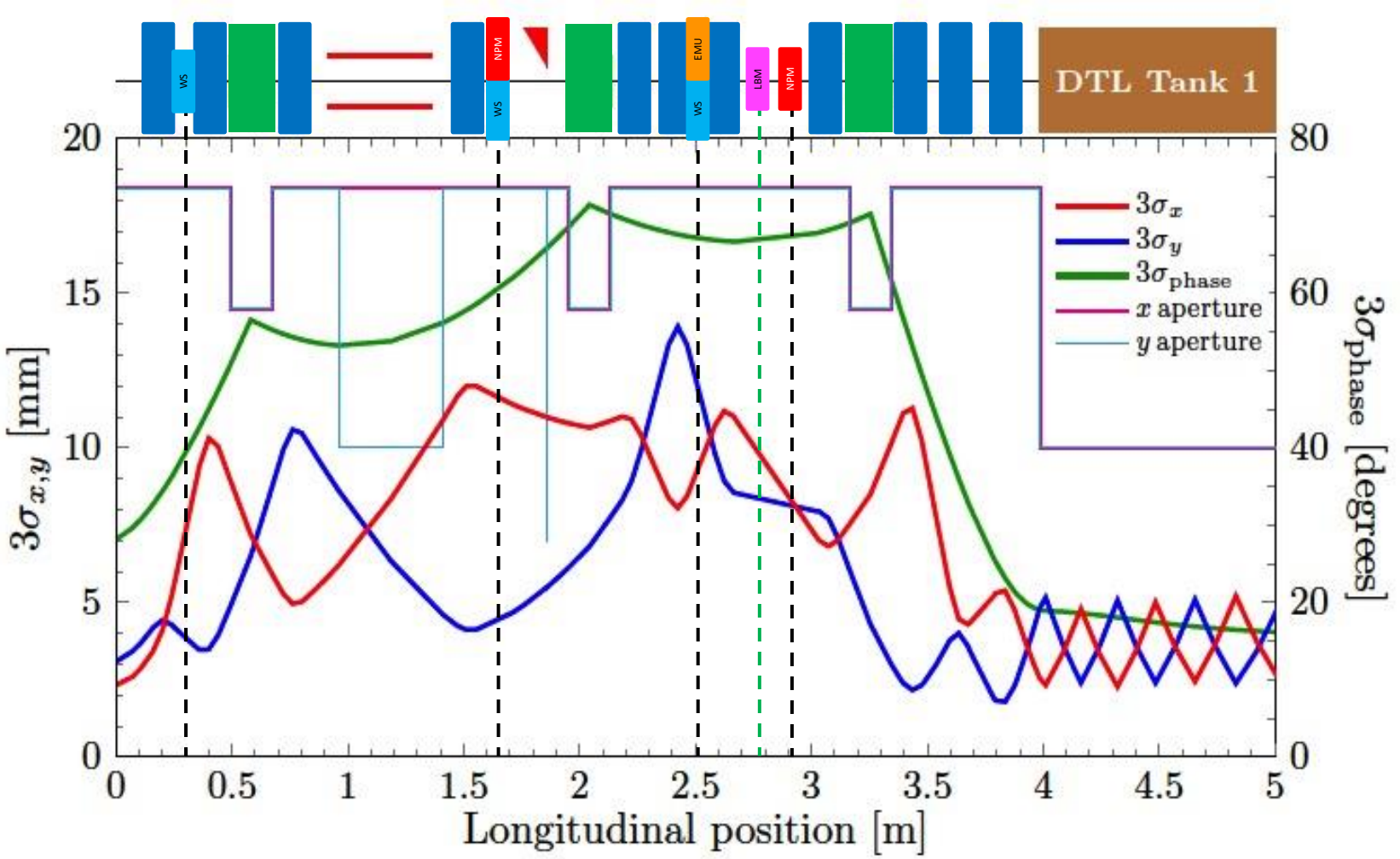
Beam Commissioning Strategy: RFQ transmission verification

- Downstream section from the RFQ cannot handle more than the nominal current of 62.5 mA.
- Steps:
  - Use of various configurations of the LEBT and IS
  - IS does not fine-tune the current, for this we use the iris in the



  - Measure Transmitted current using the BCM in the middle of the MEBT and compare to the measurement at the end of the RFQ (check for particles with the wrong energy).
- Check RFQ output energy using ToF on the MEBT BPMs.

Beam Commissioning Strategy: MEBT and DTL sections



High Level Beam Physics Applications

- Based on the OpenXAL Framework.
- A lot of site-specific development:
  - Lattice is imported from Tracewin.
  - Generic field map element (much like Tracewin).
  - RF field-map optimized element, 30% faster (1st order integrator).
  - 2D (cylindrical) and 3D fieldmap elements → LEBT Solenoids.
  - New DTL tank element.
  - Moving from the original Swing GUI interface to JavaFX → this required a major modification of the Application Class → FxApplications Class under development.
  - Integration of the ESS Logbook (e-log) into OpenXAL.

High Level Beam Physics Applications

- ers.

High Level Beam Physics Applications

- Main applications required for the Warm commissioning:
  - Phase Scan (for buncher cavities and DTLs),
  - Trajectory correction (under development with a test version ready) and
  - Transverse matching (using data from WSs and EMU).
- We are also planning an upgrade of the Virtual Accelerator → very useful for application debugging and performing system tests.
- Plans to migrate from XML to HDF5 for saved data and files in the applications.

Closing remarks

- Commissioning of IS and LEBT should start still in 2018.
- There is a solid plan for the Warm linac commissioning which should occupy us, in Beam Physics, in 2019 and 2020.
- Applications needed for commissioning are in a good track path and more sensitive/complex applications like Phase Scan, Transverse Matching and Trajectory Correction are being developed already.
- Fun and exciting times lie ahead…

Acknowledgment

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