MESA @ bERLinPro Joint Forces in Pursue of ERL Magnificence

Speaker: Sebastian Thomas

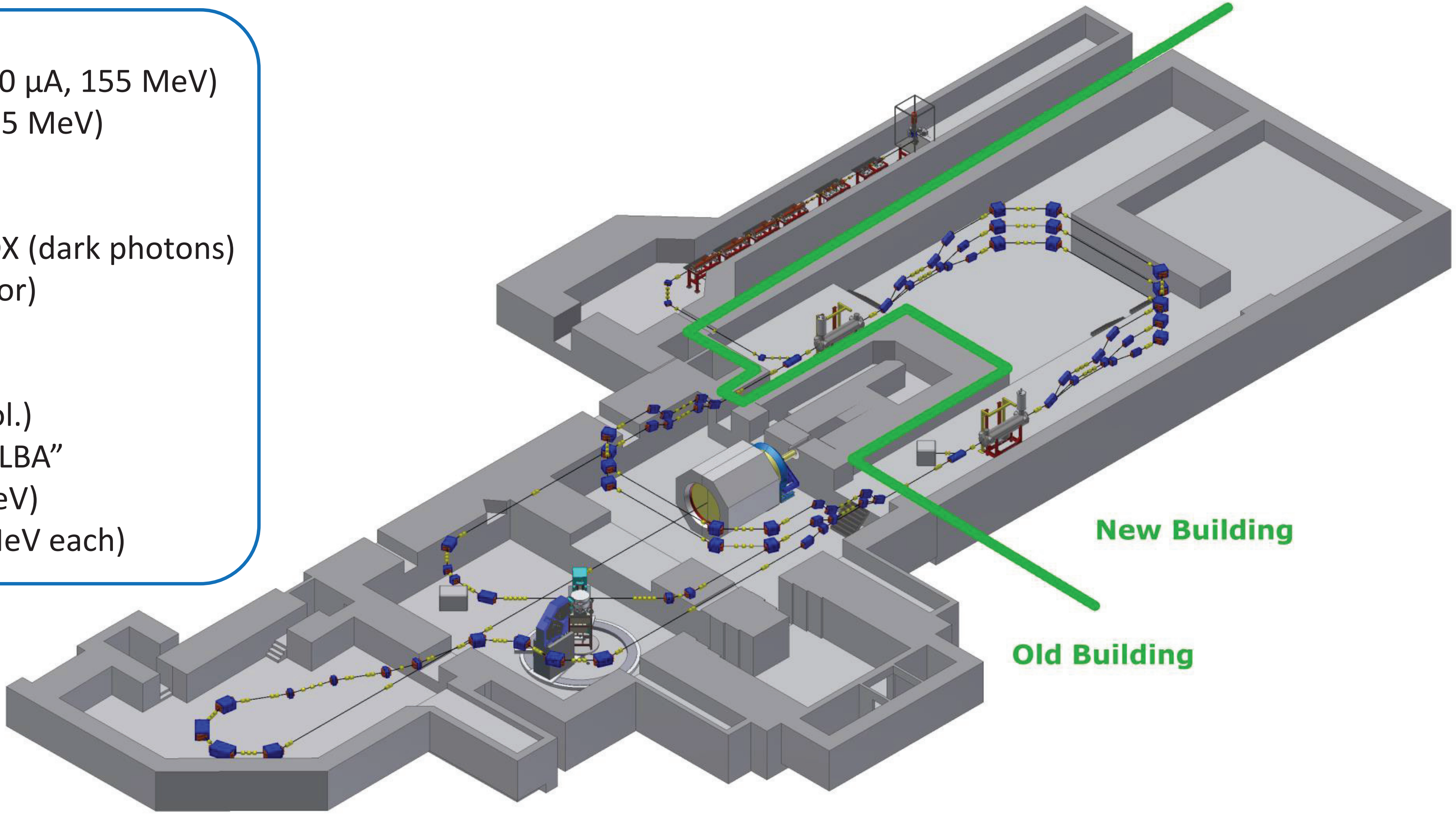
Workshop on Energy Recovery Linacs in Berlin 2019

Outline

- Introduction
  - Mainz Energy-Recovery Superconducting Accelerator MESA
  - Berlin Energy Recovery Linac Project bERLinPro
  - MESA @ bERLinPro
- The MESA Cryomodule
- Planning the Field Campaign
- Outlook

MESA

- Modes of operation:
    - External (polarized, up to 150 µA, 155 MeV)
    - ERL (unpol., up to 10 mA, 105 MeV)
- Experiments:
    - P2 (Weinberg angle Ω_W), BDX (dark photons)
    - MAGIX (Astrophysical S-Factor)
- Structures:
    - Source “Steam” (200 keV, pol.)
    - Manipulation beamline “MELBA”
    - NC Injector “MAMBO” (5 MeV)
    - Two SRF Cryomodules (25 MeV each)

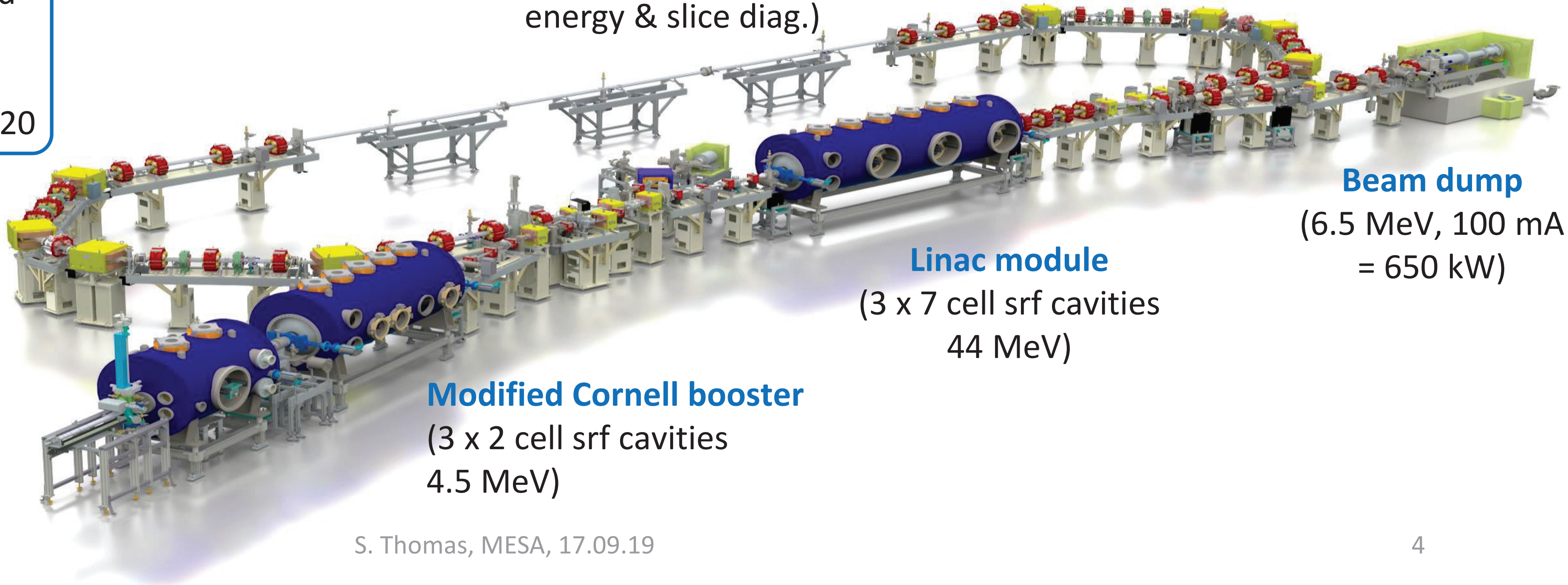


bERLinPro

	Basic Parameter
max. beam energy	50 MeV
max. current	100 mA (77 pC/bunch)
normalized emittance	1 μm (0.5 μm)
bunch length (straight)	2 ps or smaller (100 fs)
rep. rate	1.3 GHz
losses	< 10^{-5}

- Project started 2011, fully funded
- Building ready 2017
- First electrons 2018
- Recirculation beam line 2019/2020

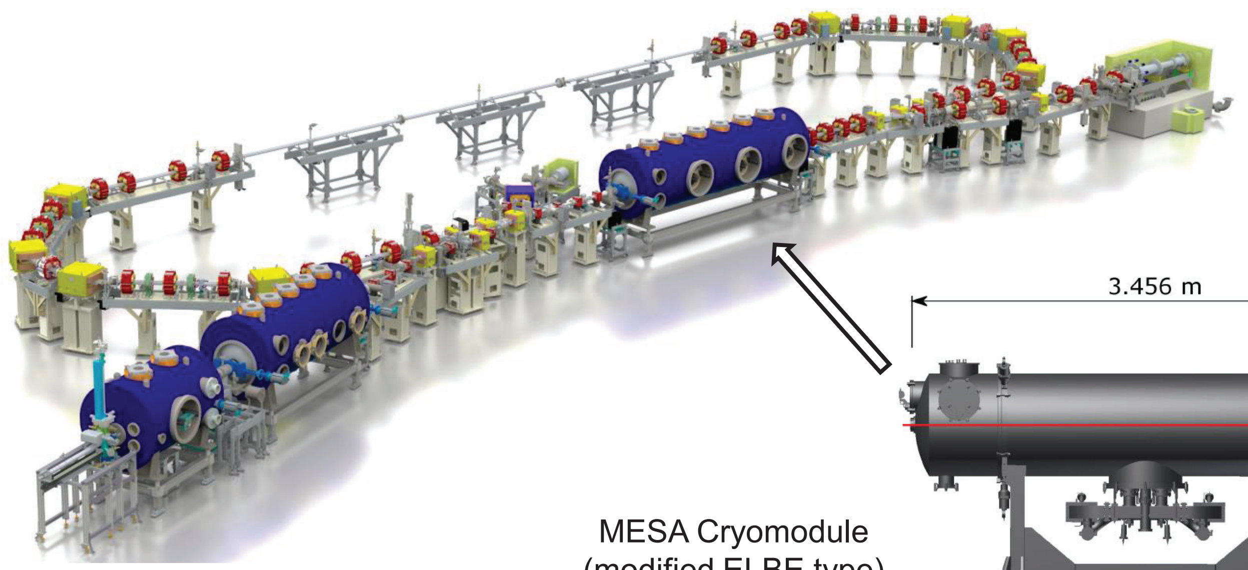
bERLinPro
Helmholtz-Zentrum Berlin

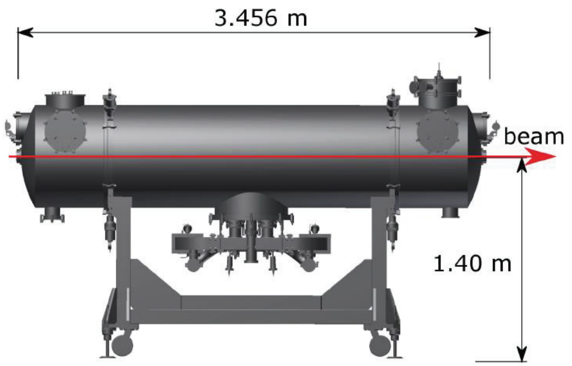


MESA @ bERLinPro

bERLinPro: existing hall, injector and recirculation beam line
but no linac cryomodule

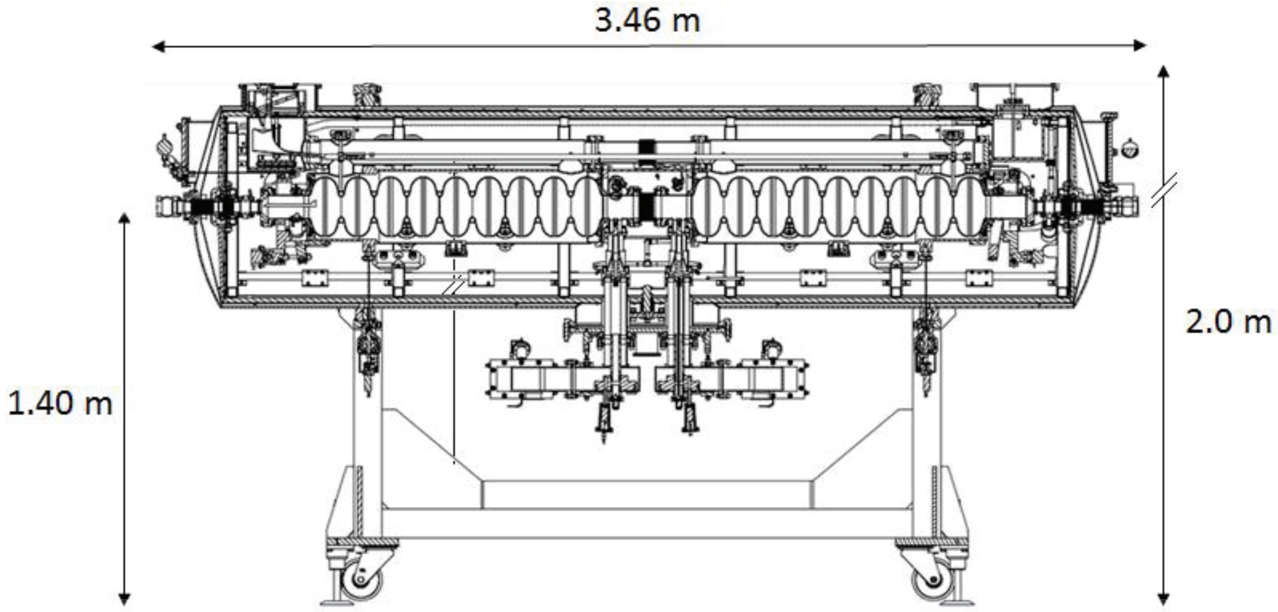
MESA: existing cryomodule
but no hall, recirculation, …



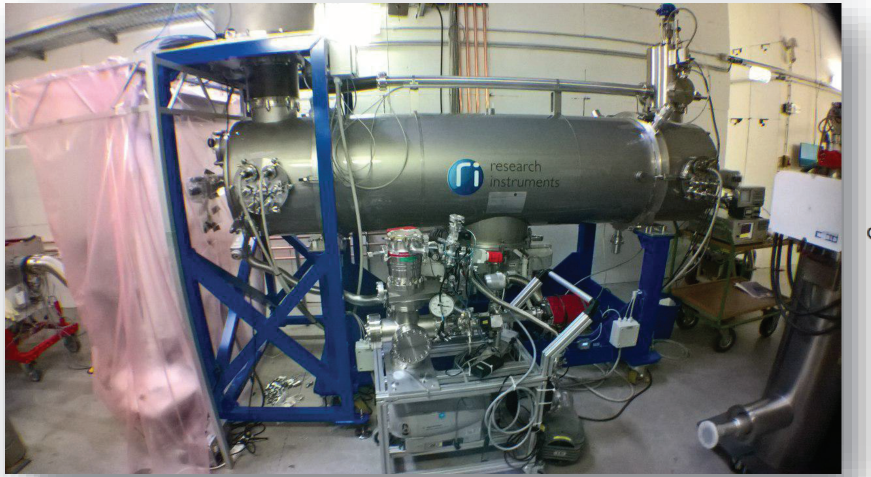


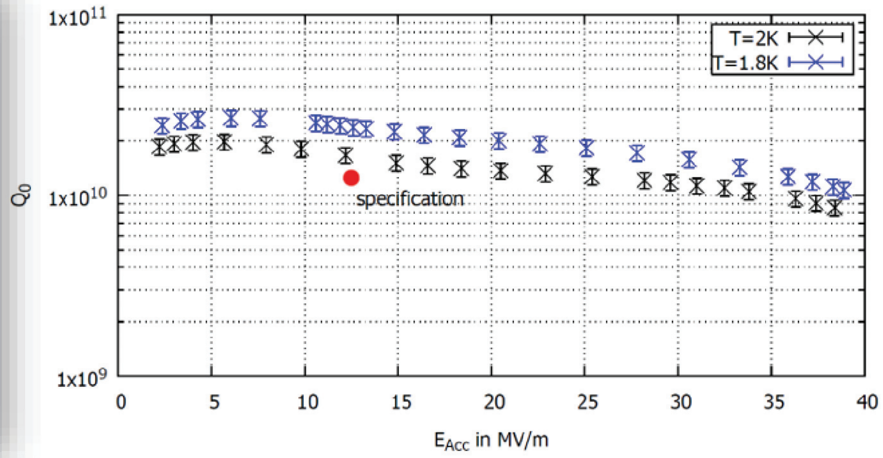
MESA Cryomodule
(modified ELBE type)

MESA Cryomodule



- ELBE Type Cryomodules with modifications:
  - Added XFEL piezo tuners
  - Modified HOM dampers and feedthrough
- 9-cell TESLA Nb Cavities, 1.3 GHz, $Q = 1.25 * 10^{10}$ @ 12.5 MV/m
- Cavities tested at DESY vertical test stand
- Modules are currently tested at Mainz
- First module passed SAT





Cryogenics

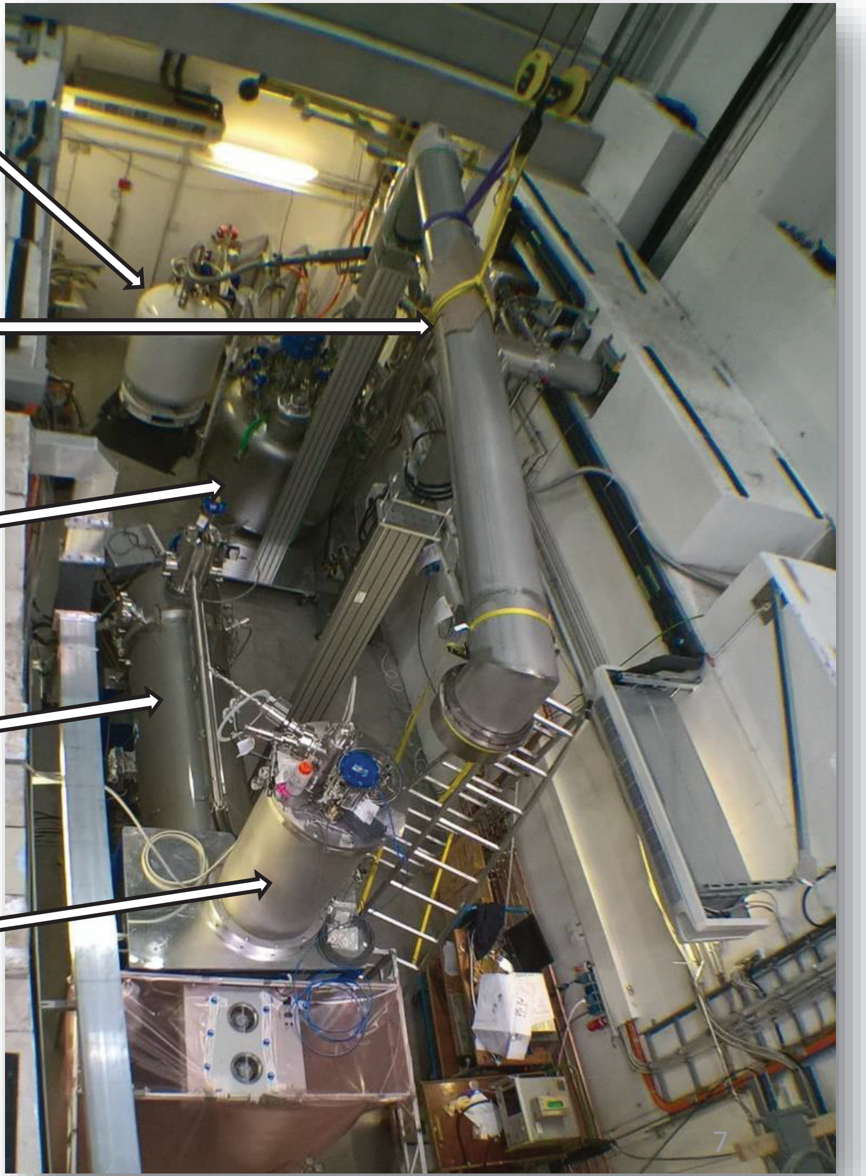
Dewar
(phase separation, Lhe storage)

MCTL
(LHe, GHe, LN2)

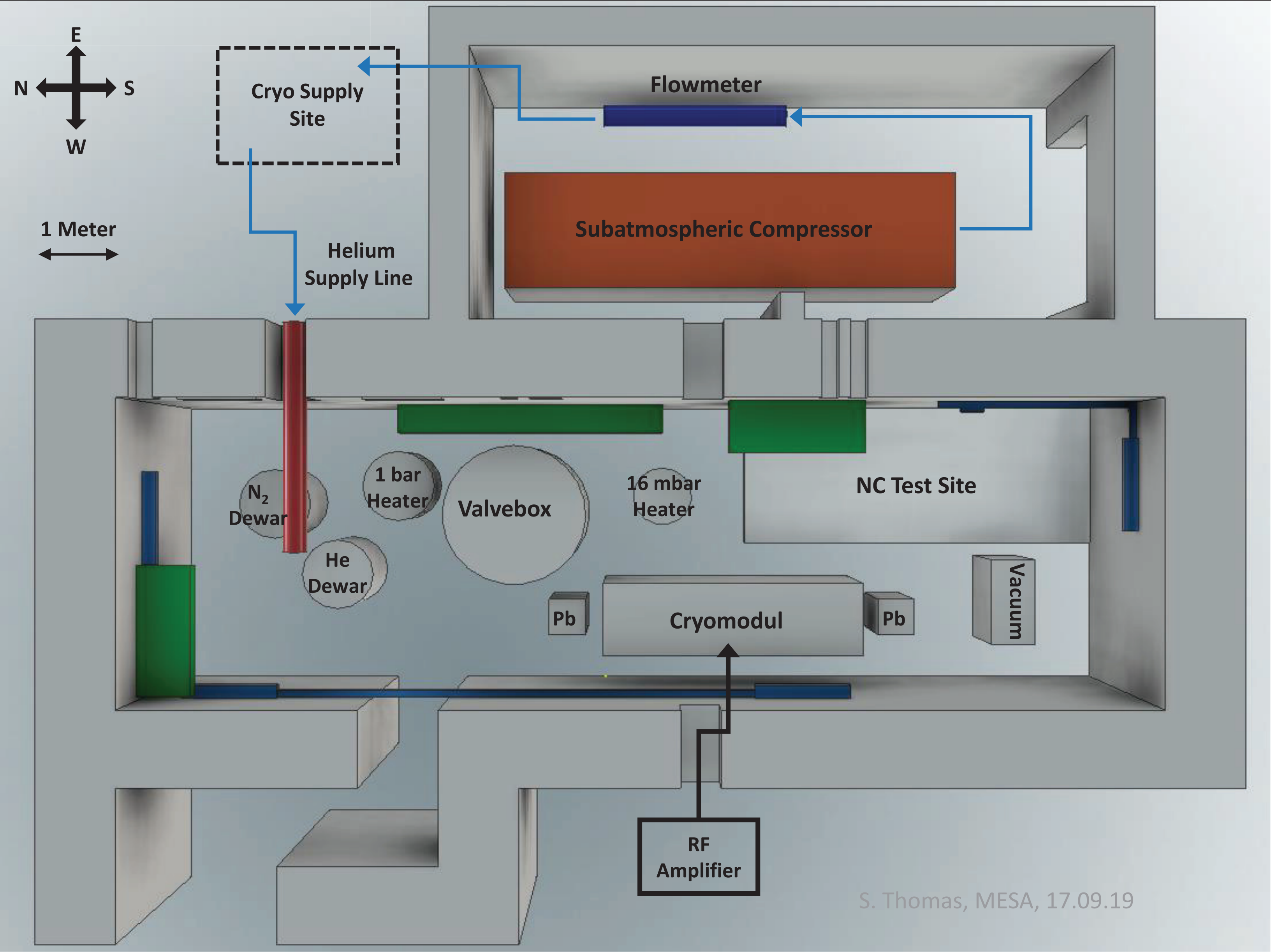
Valve Box
(level, pressure regulation)

Cryomodule
(2 XFEL Cavities @ 12.5 MV/m)

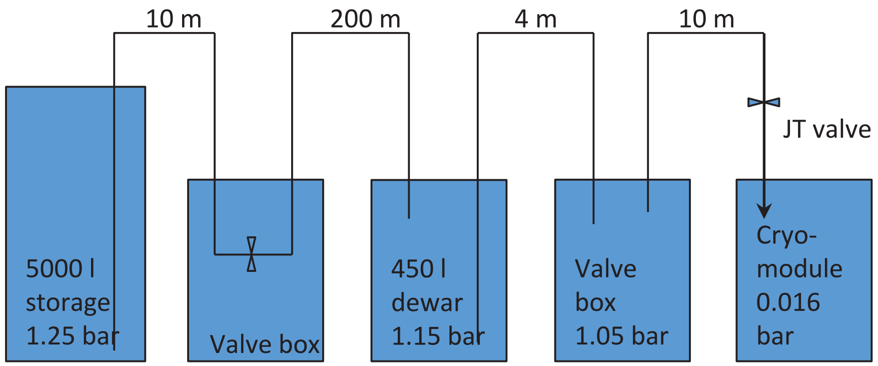
LHe/LN2 supply box
(JT valve & heat exchanger)



Cryomodule Test Site



- Measured heat load of the module 1 at 2 K
  - $P_{static} = 9.0$ W
  - $P_{dyn,12.5\ MV/m} \leq 15.7$ W
- Integration into the bERLinPro Cryosystem needs replacing of the Helium supply box on top of the module
- Helium pressure in bERLinPro higher than MESA, safety valves need to be redesigned



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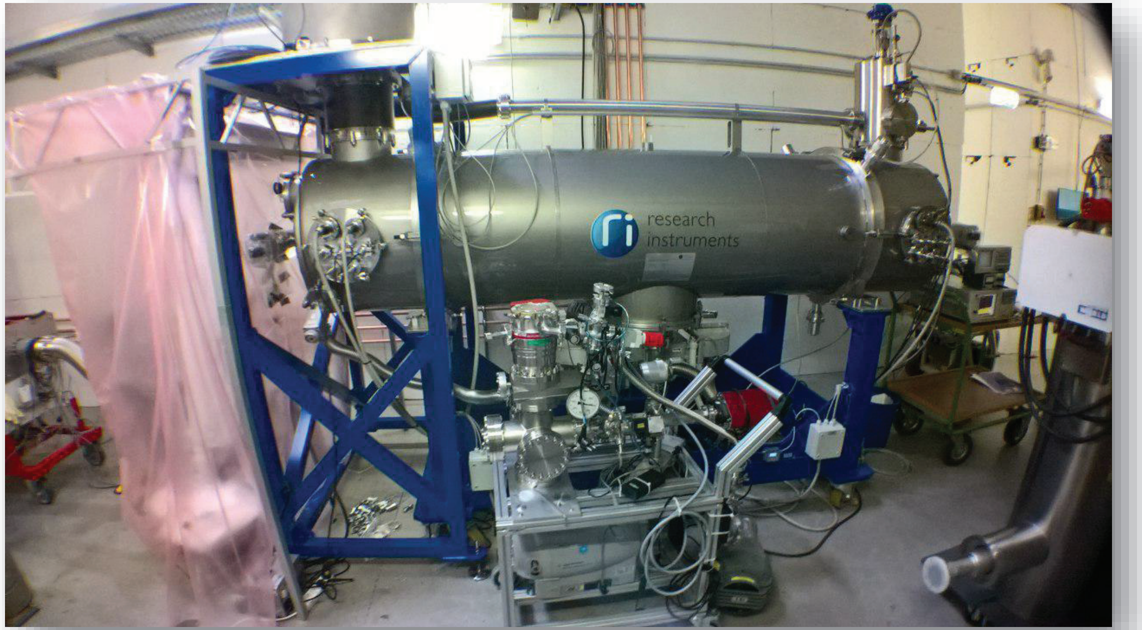
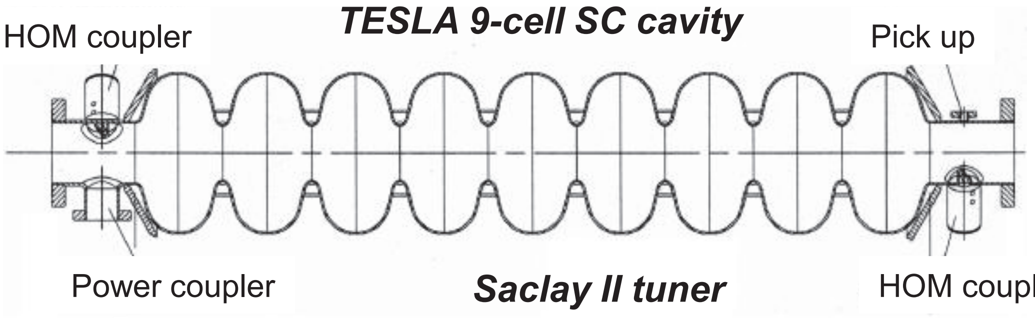
Vacuum

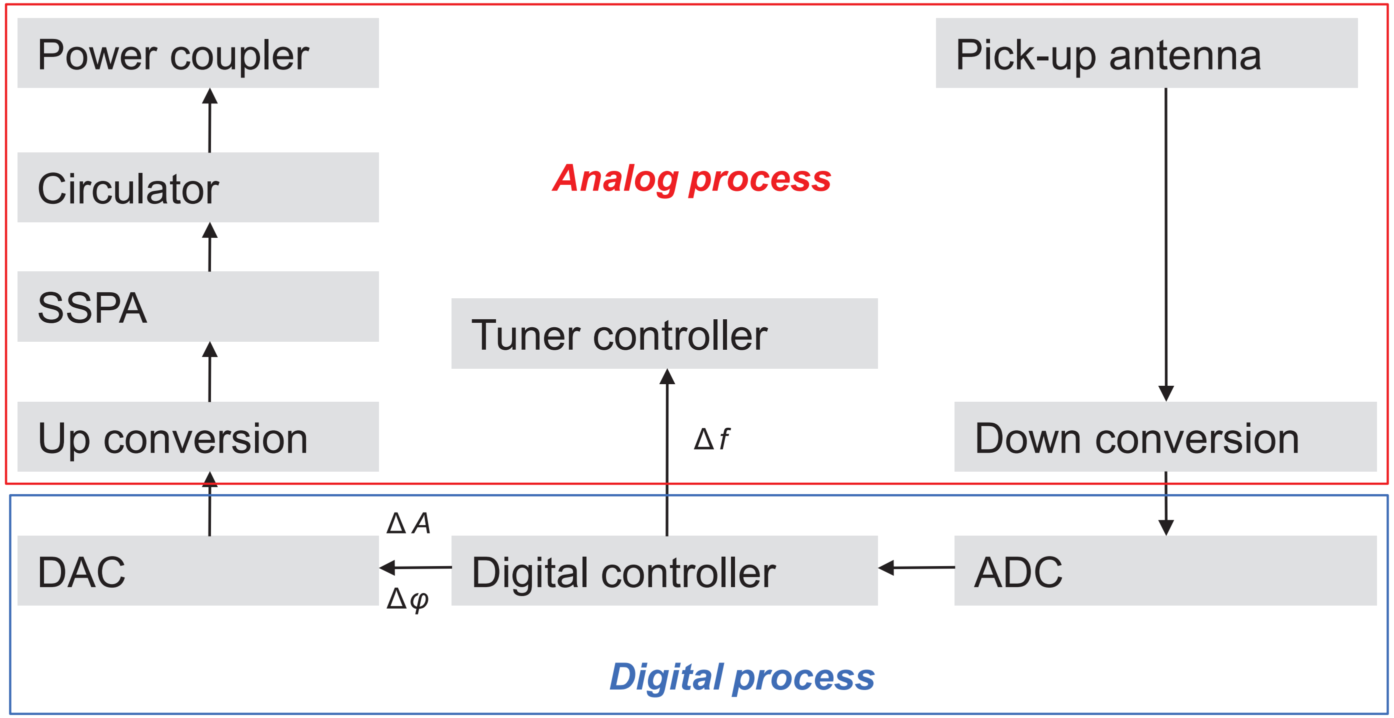
- The module will be delivered to Berlin evacuated and being constantly pumped
- First, the module will be tested still connected to the MESA vacuum system
- Then, the connection to the bERLinPro system will be established
  - An adapter unit (DN100 to DN40) is being designed by a bachelor student
  - Assembly will happen under clean room conditions



LLRF

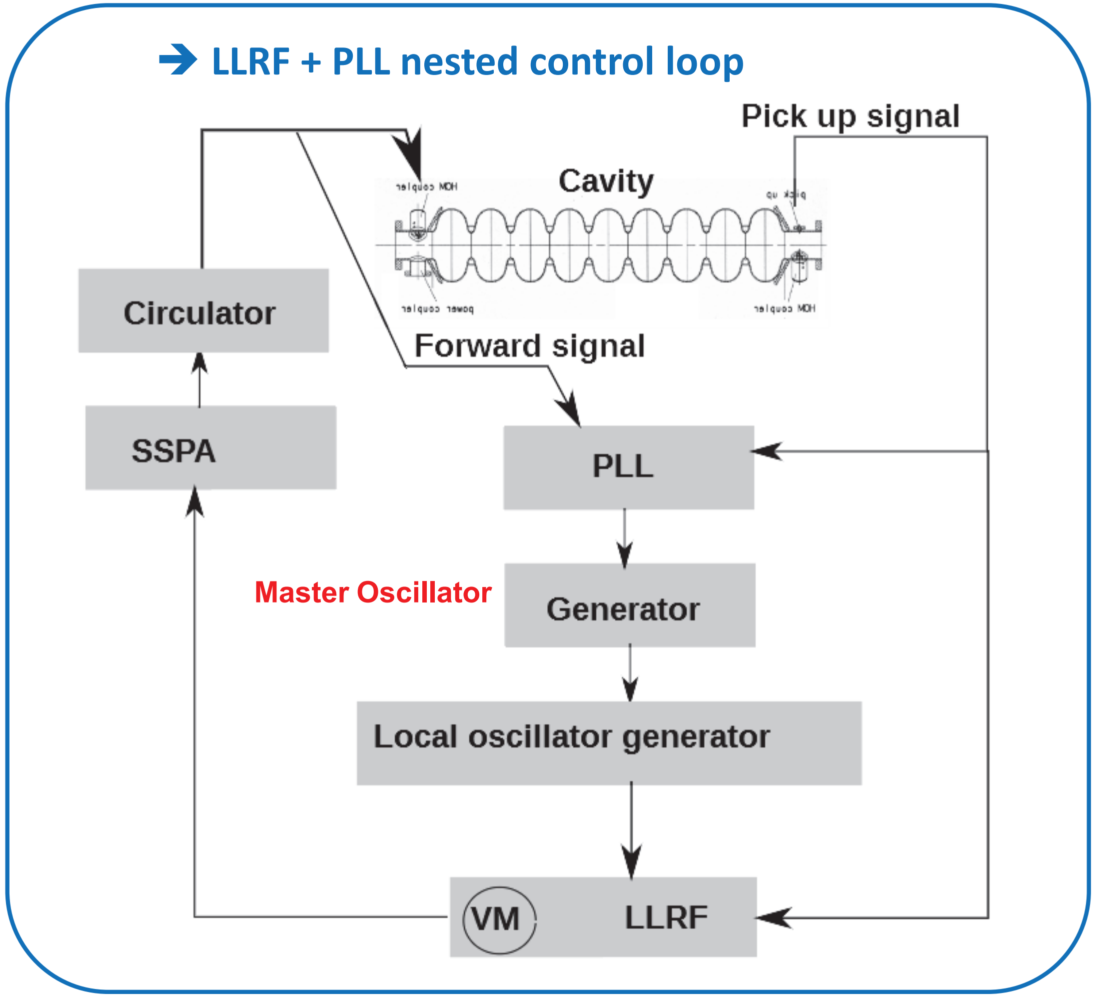
- Low energy spread demands
  - High amplitude stability $< 0.01\ \%$
  - High phase stability $< 0.01\ \%$
- PLL used for SAT, µTCA based LLRF will take over operation in accelerator
- LLRF system is tested parasitically in module test at Mainz

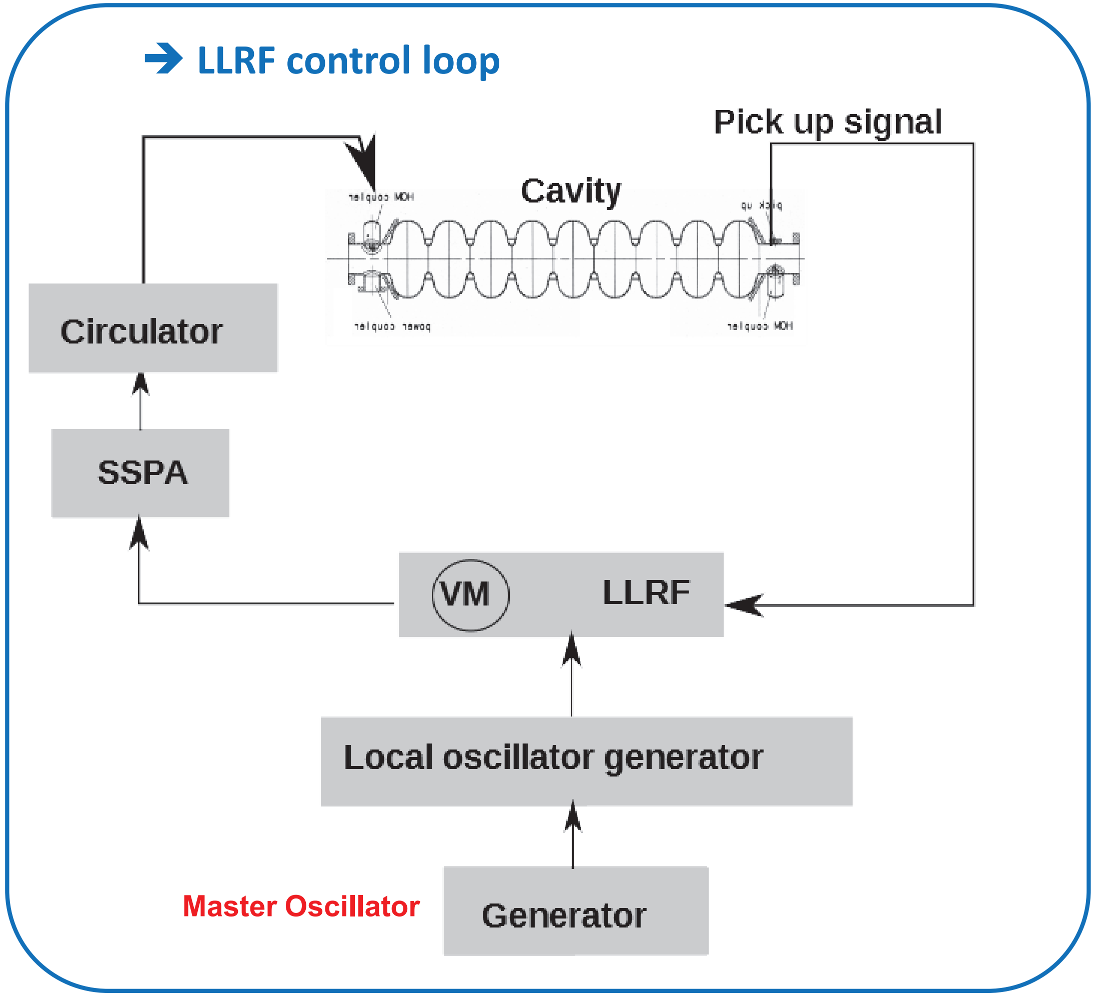




By Jiaoni Bai

LLRF





PLL: Frequency modulation

→ Resonance frequency control loop

LLRF: Amplitude modulation

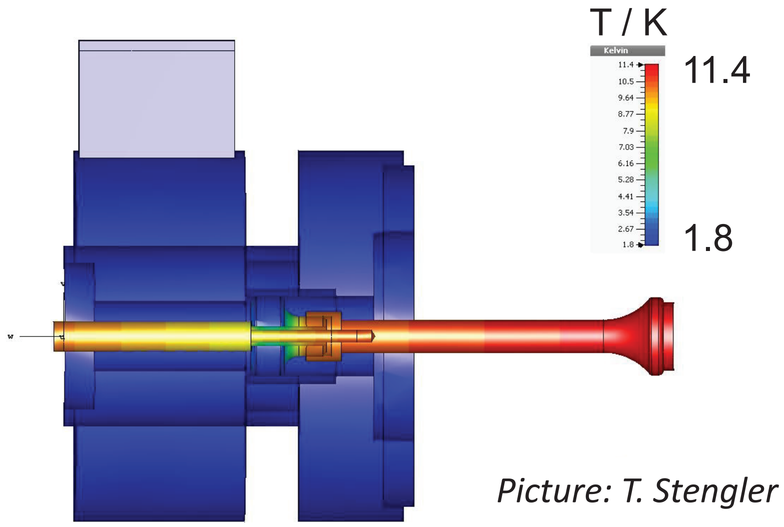
→ Amplitude & Phase control loop

By Jiaoni Bai

Planning a Field Campaign

After all connections are established, the module will be cooled down and the first measurements will be taken:

- Spectra of Microphonics and HOMs at the new location
- First beam operations:
    - One pass acceleration
    - Cavity behavior in transient beam loading
    - Differently pulsed beams will be used
    - Control accuracy of the LLRF will be tested



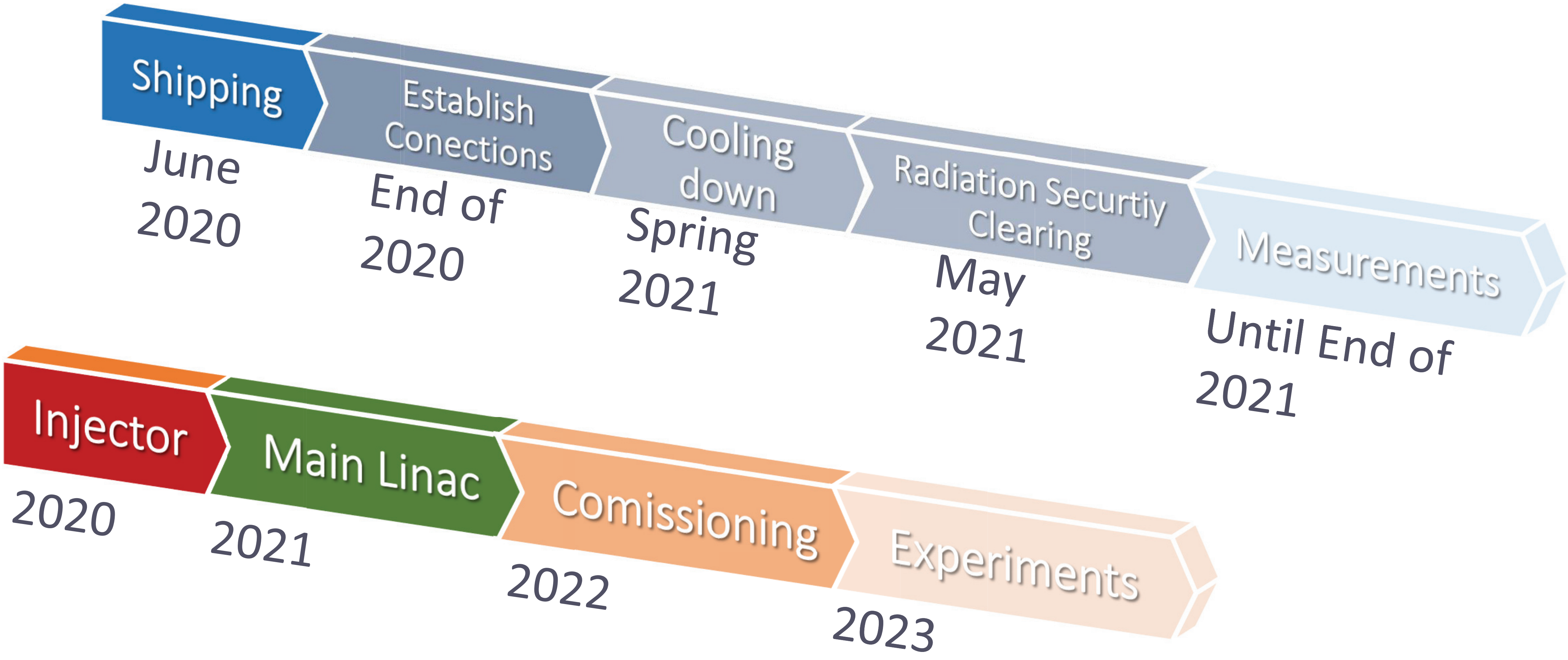
Picture: T. Stengler

After that was successfully completed, we will start with ERL operations:

- The excitation and damping of HOMs will be measured
- Heating of the HOM feedthroughs will be investigated
- BBU limits will be probed

Further, beam diagnostics will be integrated into the LLRF system of HZB to establish optimal timing for effective ERL operations.

Outlook


Shipping
June 2020
Establish Conections
End of 2020
Cooling down
Spring 2021
Radiation Securtiy Clearing
May 2021
Measurements
Until End of 2021
Injector
2020
Main Linac
2021
Comissioning
2022
Experiments
2023

Thank you!