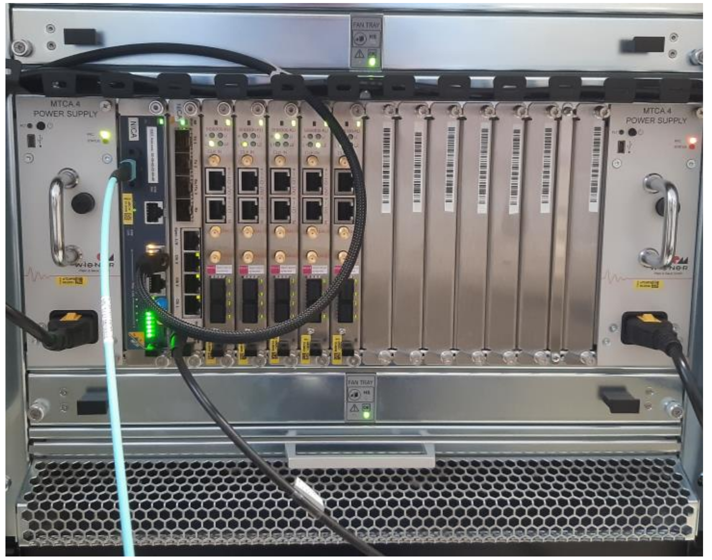
A MTCA based LLRF for the LILAC injector of the NICA project

1. December 2020

Christian Trageser, BEVATECH GmbH



BEVATECH

MICROTCA TECHNOLOGY LAB

A HELMHOLTZ INNOVATION LAB

DESY.

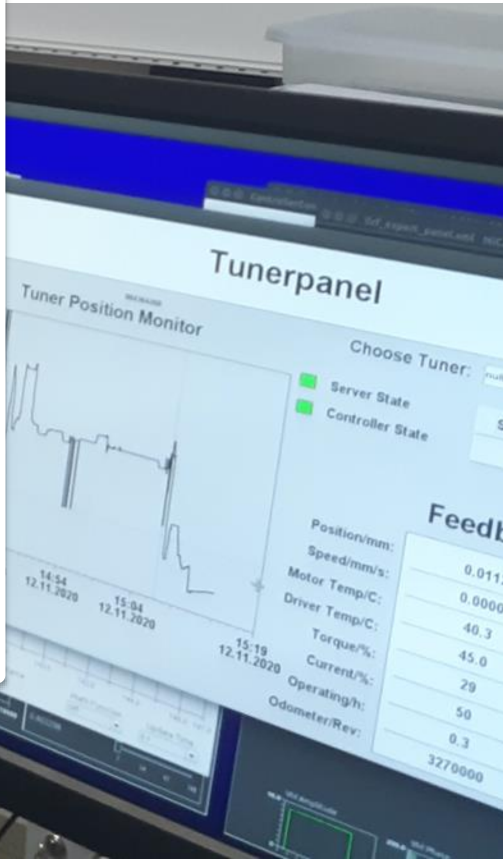
A MTCA based LLRF for the LILAC injector of the NICA project

1. December 2020

Christian Trageser, BEVATECH GmbH

Outline

1. LLRF for LILAC Injector
2. MTCA based LLRF
3. Tuner Controls for LLRF
4. Test Bench
5. Summary



BEVATECH
TECHNOLOGY LAB
A HELMHOLTZ INNOVATION LAB
DESY.

BEVATECH GmbH

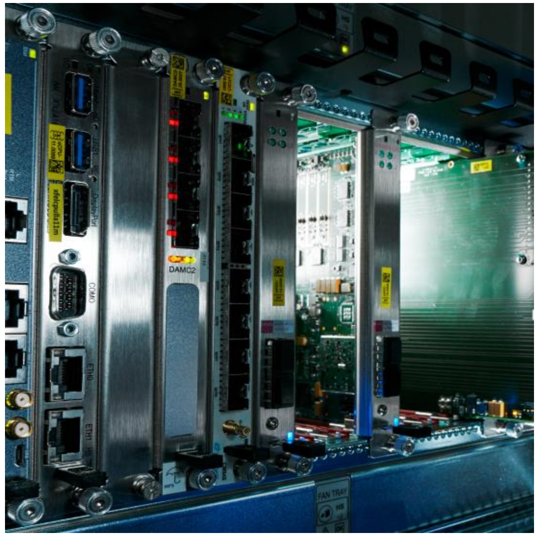
ACCELERATORS & VACUUM

- Complete LINAC Systems
- RF Cavities
- Beam Diagnostic
- Vacuum Technology
- Tumor Therapy

ENGINEERING & CONSULTING

- Beam Lines
- Vacuum
- Design Studies
- RF Research
- Outsourcing
- Project Management

ELECTRONICS & IT



- Micro TCA
- Automation
- Instrumentation & Controls
- Project Management

BEVATECH

1. LLRF for LILAC Injector

Nuclotron-based **I**on **C**ollider f**A**cility @ JINR

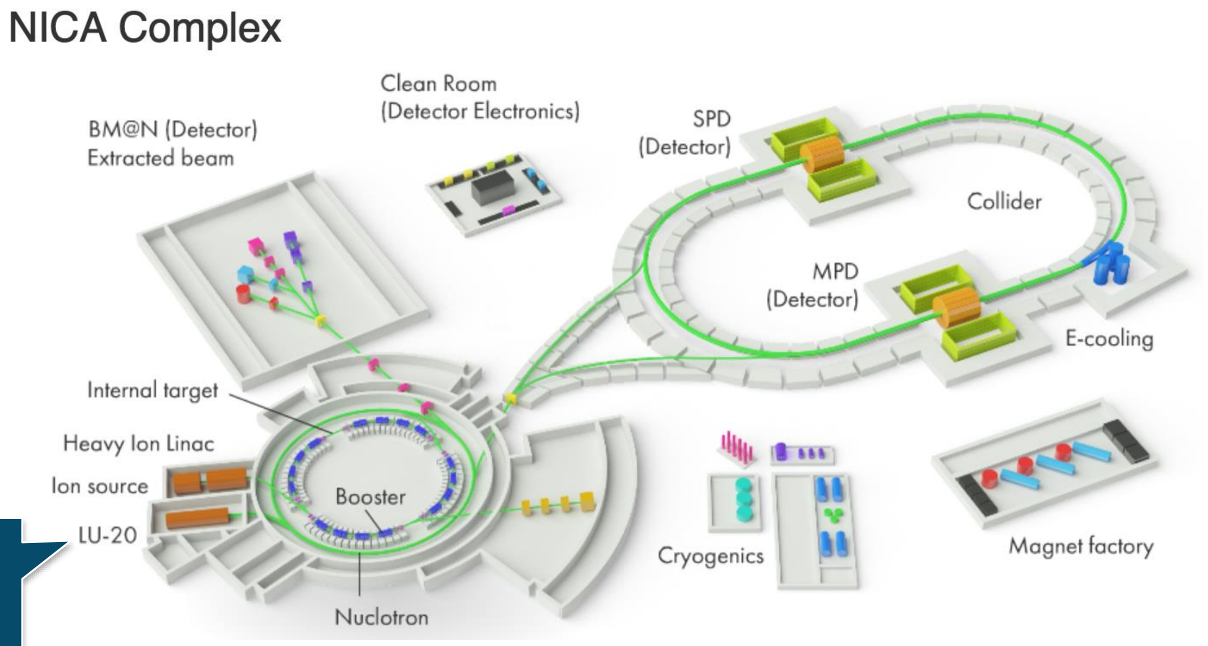
- Accelerator and Experimental Complex

Main Goal:

- Provide ion beams for hot and dense strongly interacting baryonic matter and spin physics

Facility parts:

- <u>**L**ight **I**on **L**in**AC** (LILac)</u>
- **H**eavy **I**on **L**in**AC** (HILac)
- NUCLOTRON SC Synchrotron
- BOOSTER SC Synchrotron
- Colider Ring
- Experiments



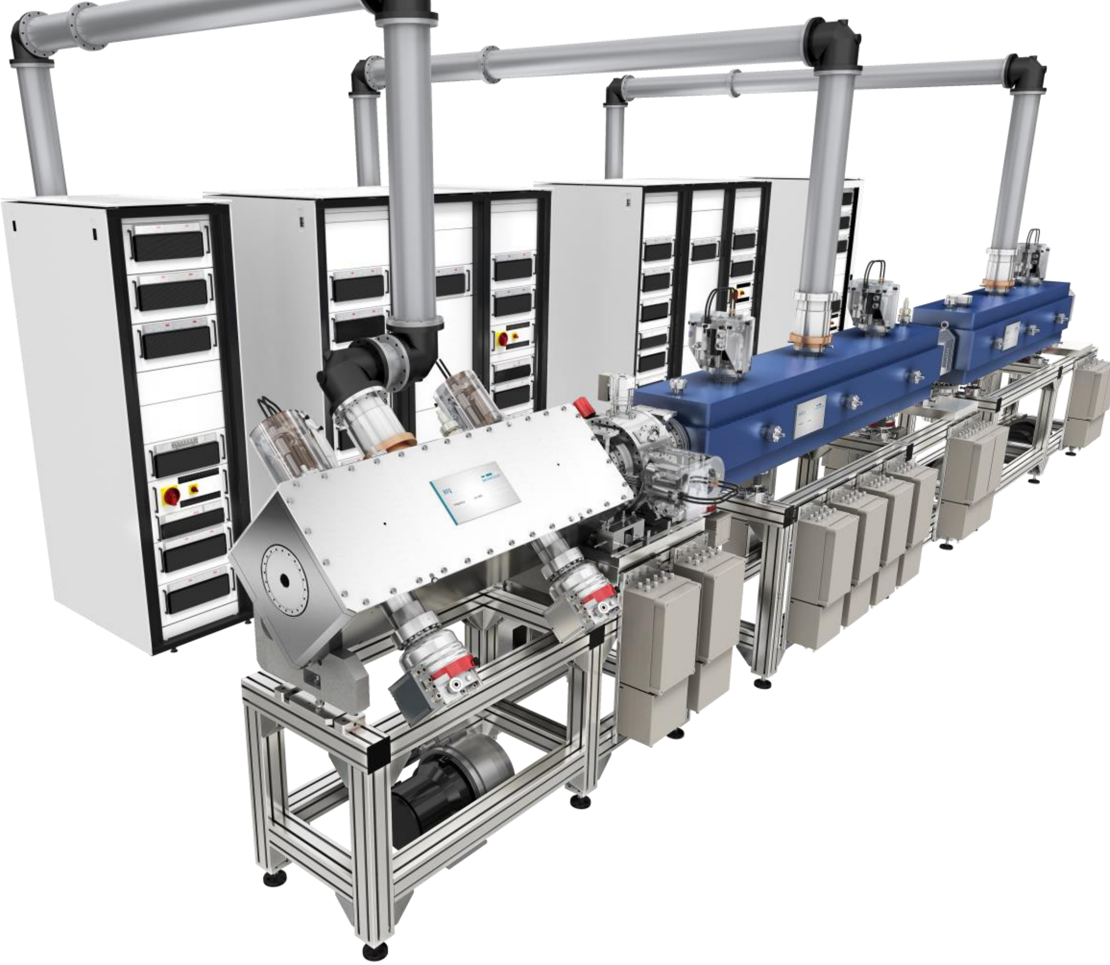
LILac will replace LU-20

Image from https://nica.jinr.ru/complex.php

BEVATECH

LILAC Injector

Parameter	Protons	C^{4+}
Min/max A/q:	1	3
Injection Energy/keV:	30	60
Exit Energiy/MeV:	7	21
Beam Current/mA	5	15
Frequency/MHz:	162.5	
Repetition Rate/Hz	5	
Current Pulse Length/us	30	
RF Pulse Length/us	200	
Puls Power/MW	1.8	
Transmission	> 80 %	
Full Length LINAC/m	< 12.5	



LILac - Light Ion LinAC

LEBT | RFQ | REBUNCHER | IH1 | IH2 | IH3 | DEBUNCHER | NUCLOTRON

6 cavities

BEVATECH

What is a Low Level RF (LLRF)?

LLRF

Low
Level
Radio
Frequency

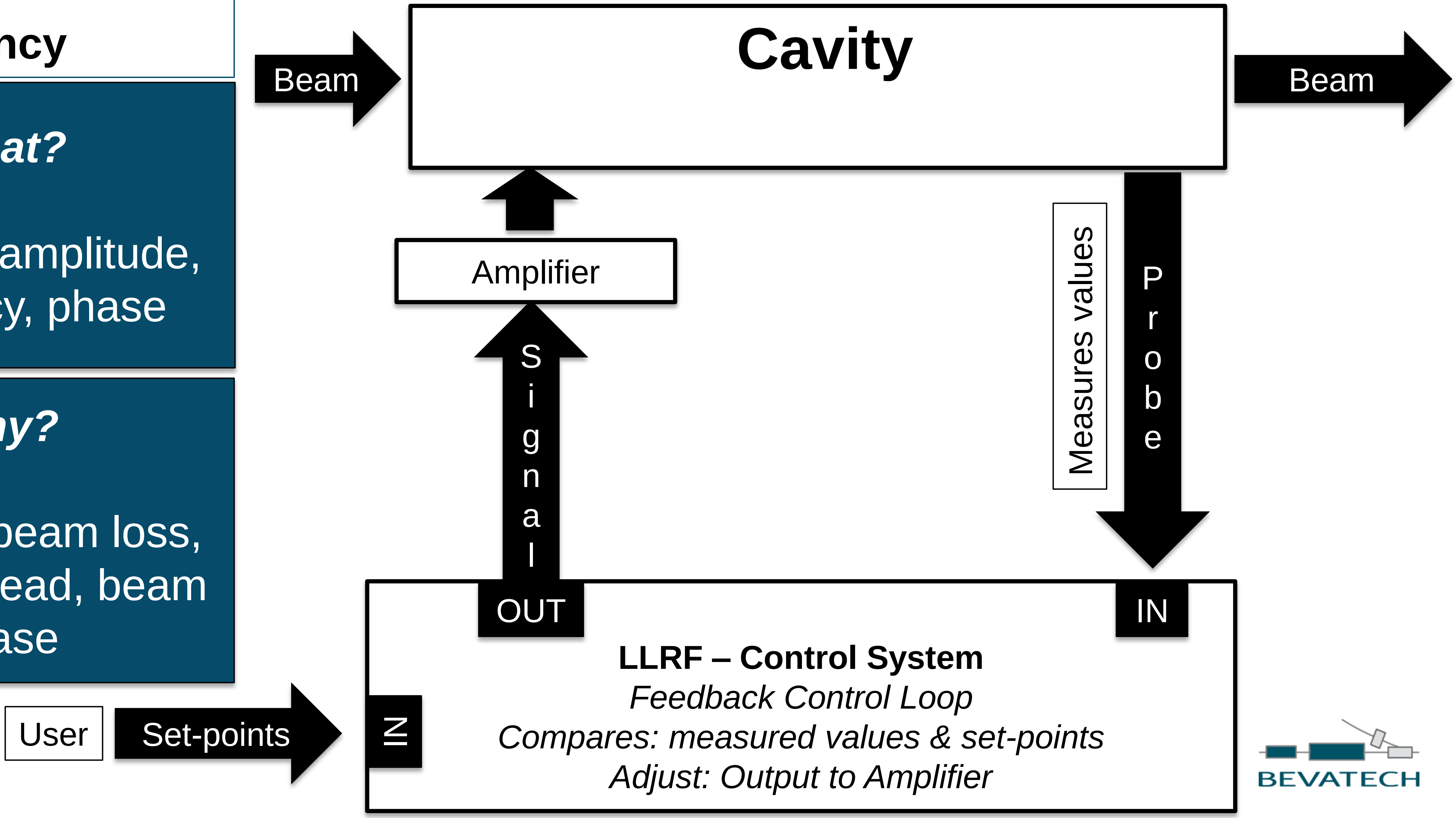
What?

Stabilizes amplitude, frequency, phase

Why?

Improves beam loss, energy spread, beam phase

Requirements for LILAC LLRF
Amplitude stability < 0.2 %
Phase stability < 0.1 °



BEVATECH

What is a Low Level RF (LLRF)?

LLRF

Low
Level
Radio
Frequency

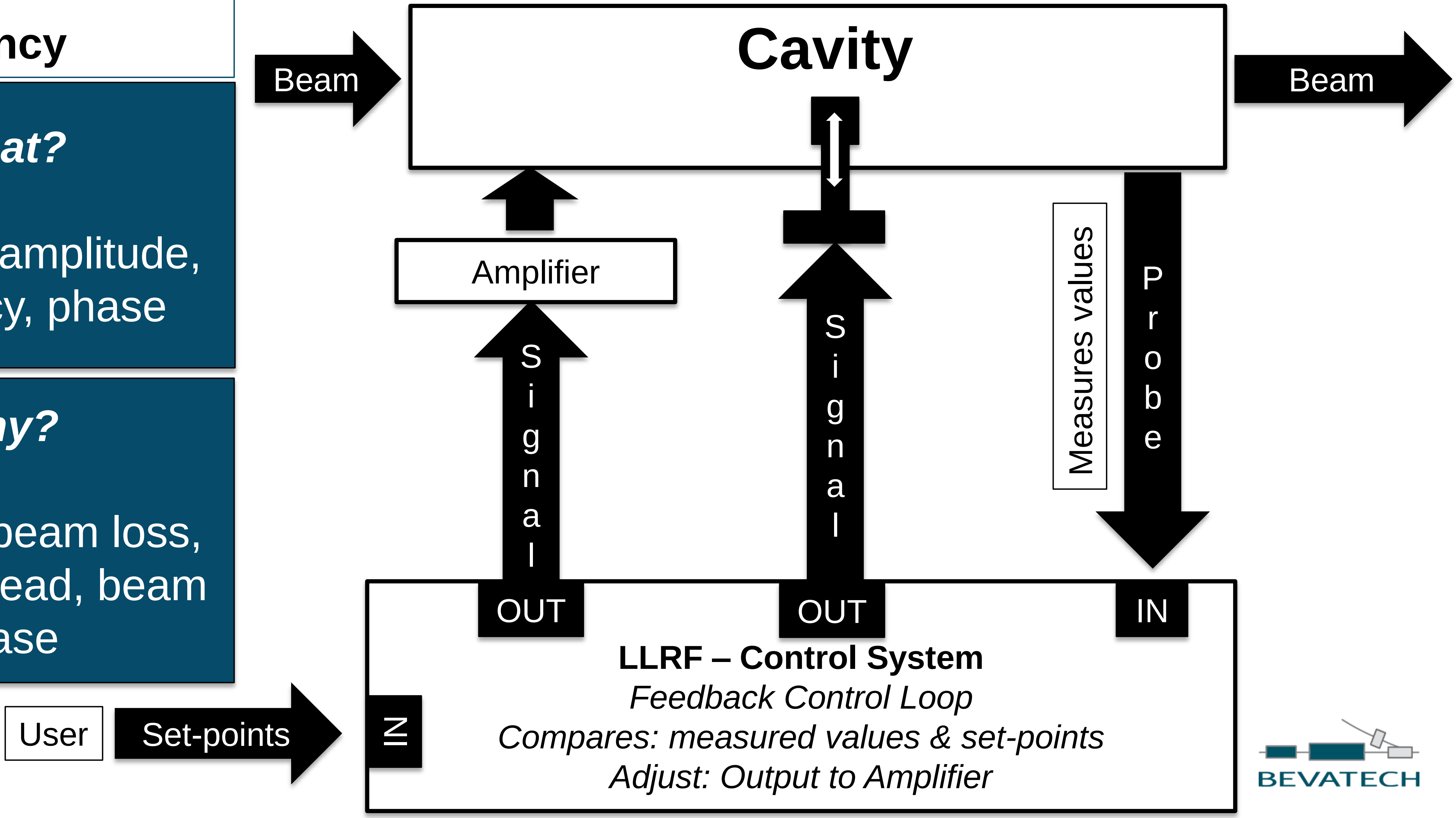
Requirements for LILAC LLRF
Amplitude stability < 0.2 %
Phase stability < 0.1 °

What?

Stabilizes amplitude, frequency, phase

Why?

Improves beam loss, energy spread, beam phase



BEVATECH

Cooperation

BEVATECH
MicroTCA TECHNOLOGY LAB
A HELMHOLTZ INNOVATION LAB
DESY.

- **2017** Discussion to derive XFEL LLRF for Hadron Linacs
- **2018** Suggested TDR to JINR
- **2019** Developing and Testing LLRF
- **2020** Awaiting Commissioning with first cavity

2. MTCA Based LLRF

MTCA Crate

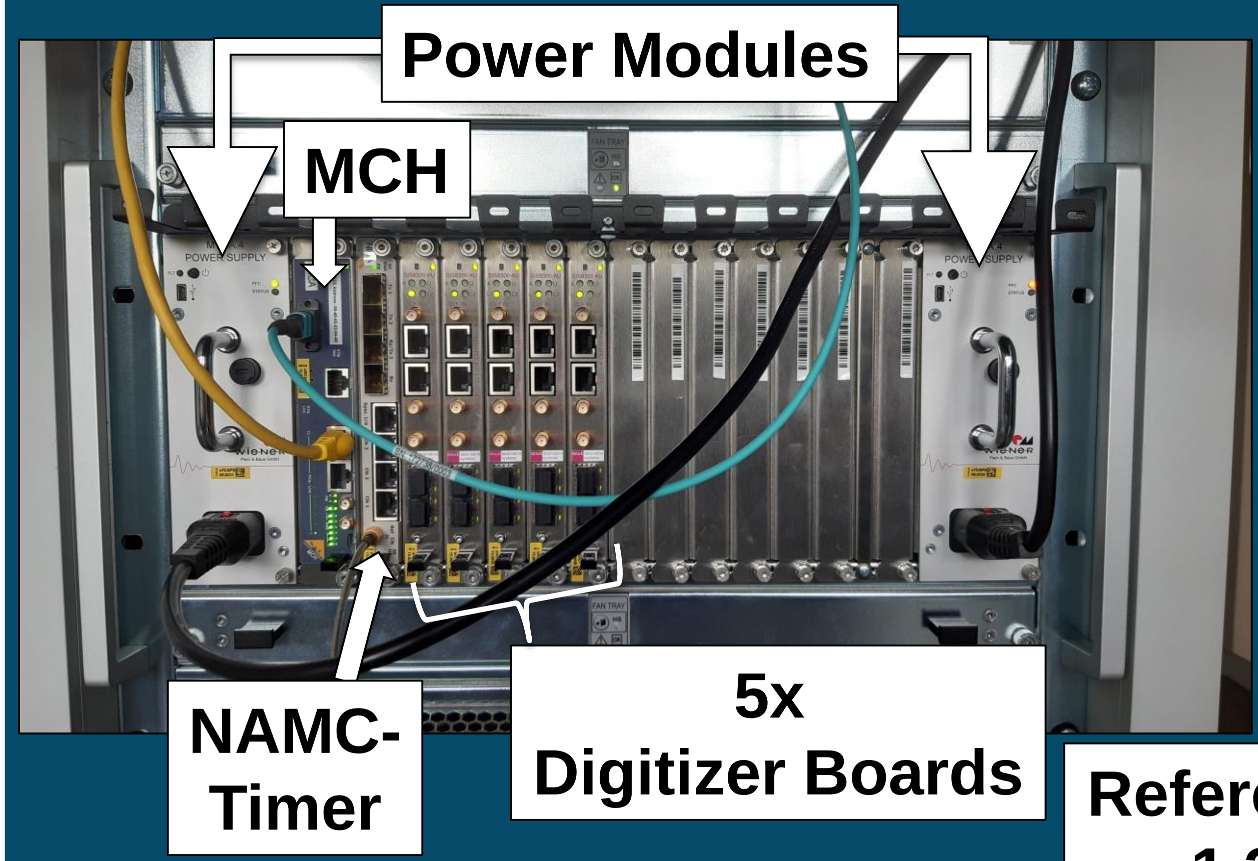
Vector Signal Generator

External CPU

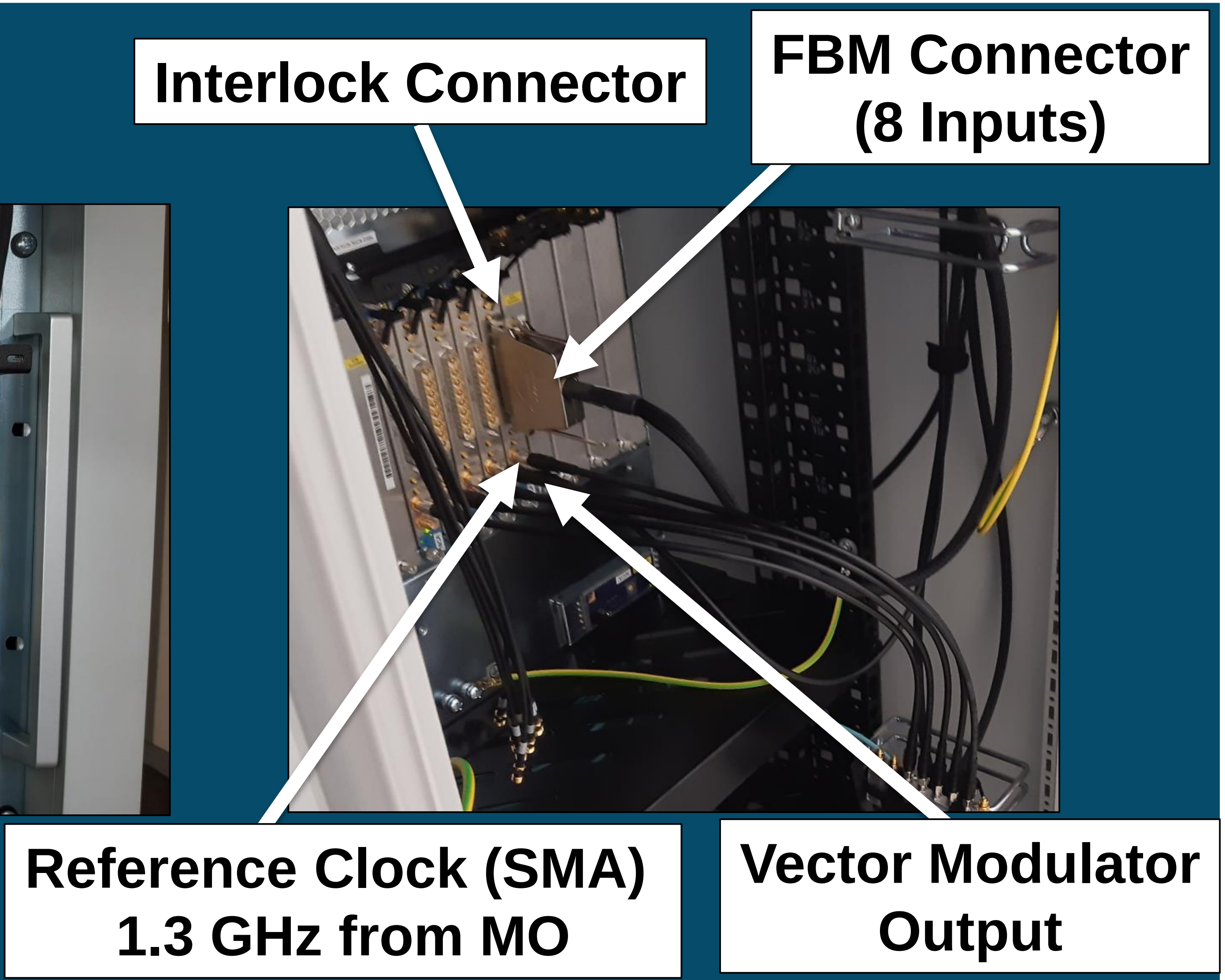
Signal Processing, Control System Algorithm

Providing Clocks 162.5 MHz & 1.3 GHz

Running Software



MTCA – Crate (front)



MTCA – Crate (rear)

EVATECH

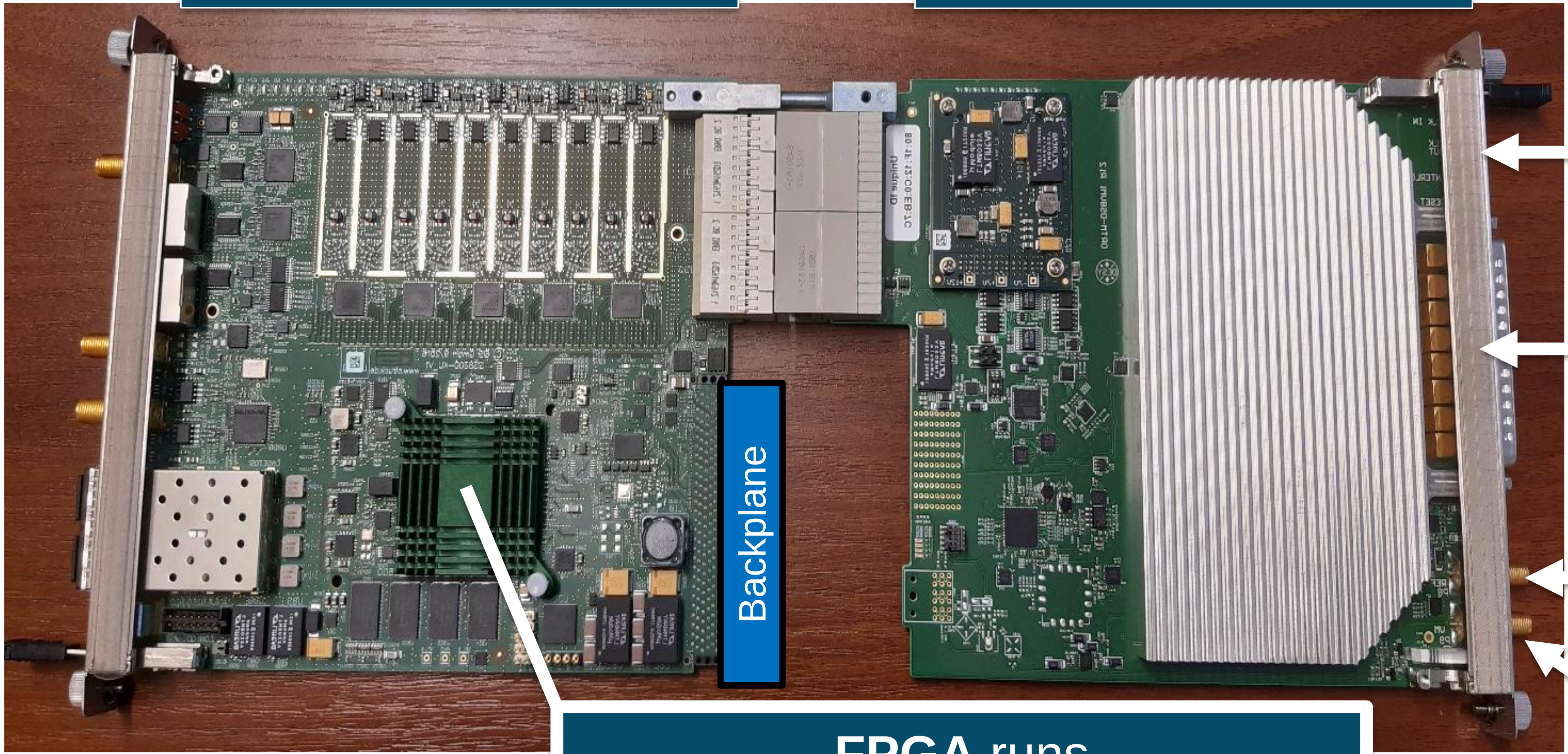
AMC/RTM for each cavity

Front

AMC: SIS8300KU

Rear

RTM: DS8VM1



Interlock

Probe, Forwarded, Reflected Signals

Ref. Clock (162.5 MHz)

Vector Modulator (Output)

FPGA runs
control algorithm for
Amplitude/Phase Control System

struck innovative systeme

DESY.

BEVATECH

LLRF Software

DOOCS

The Distributed Object-Oriented Control System Framework

JAVA
DOOCS
DATA
DISPLAY

Firmware (on FPGA)

Control Algorithm

DOOCS Server (on external CPU)

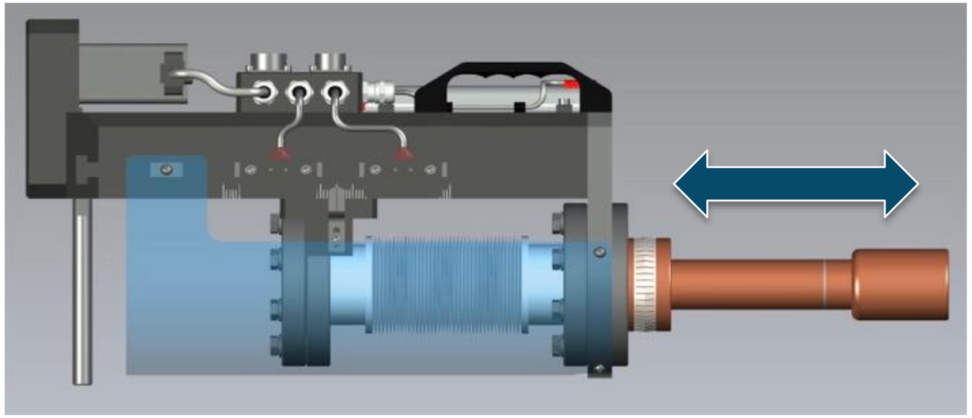
Configuring, Controlling, Monitoring, Connecting Digitizer Boards

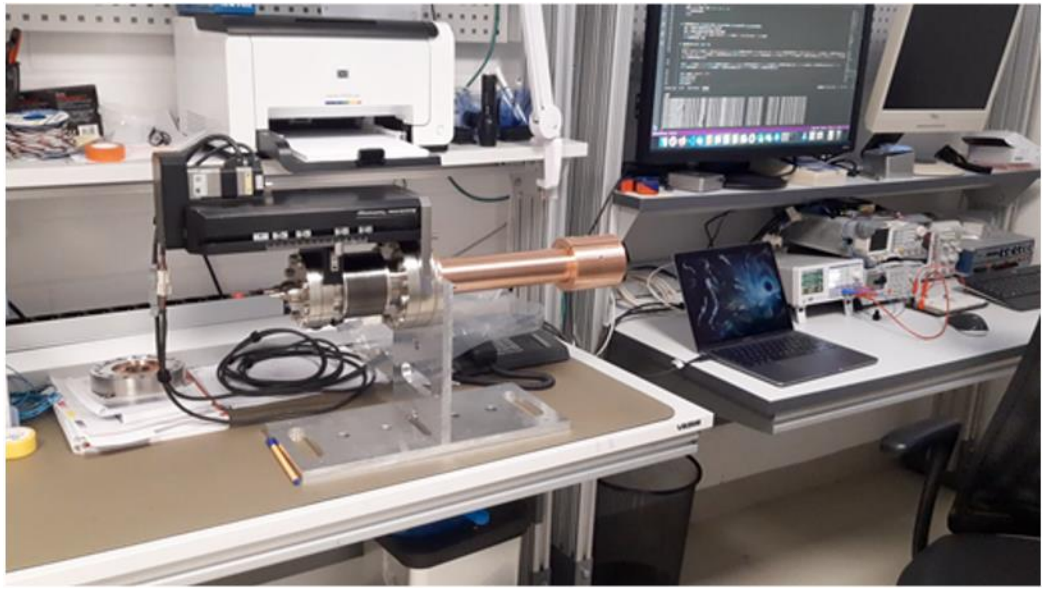
GUI (remote)

Interaction User

BEVATECH

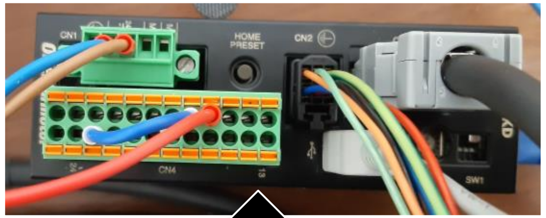
3. Tuner Controls





Communication

Orientalmotor

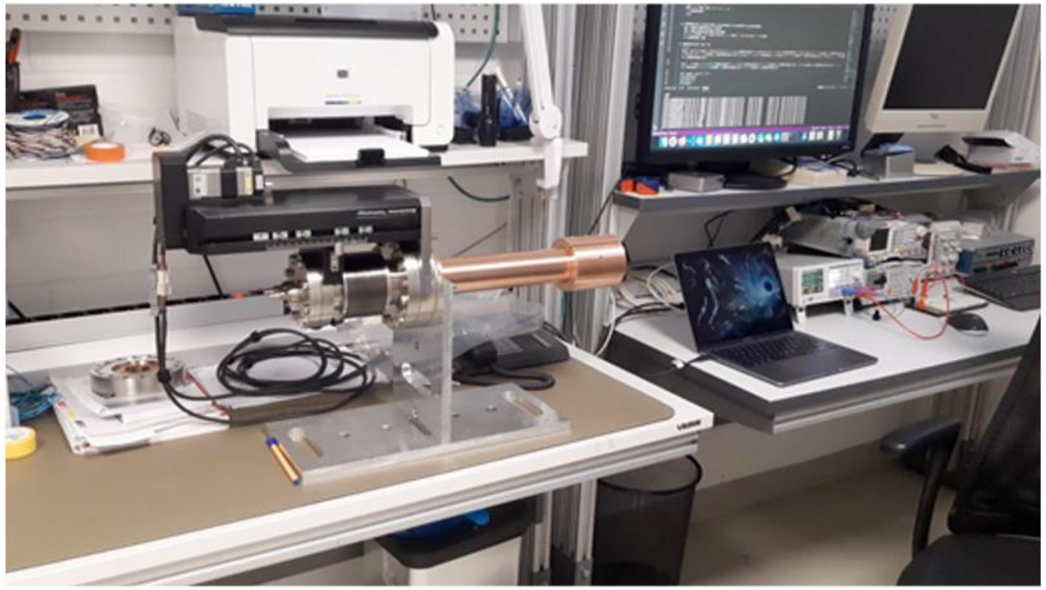


Modbus

TCP

gridconnect

Cable



LLRF

MicroTCA
TECHNOLOGY LAB
A HELMHOLTZ INNOVATION LAB

BEVATECH

Tuner Software written ChimeraTK

Write in ChimeraTK

Compile/link to

EPICS	OPC UA	DOOCS	TANGO

not yet available

Switch between

LLRF so far DOOCS

NICA uses TANGO

Control system and
Hardware
Interface with
Mapped and
Extensible
Register-based device
Abstraction
-
Tool
Kit

ChimeraTK

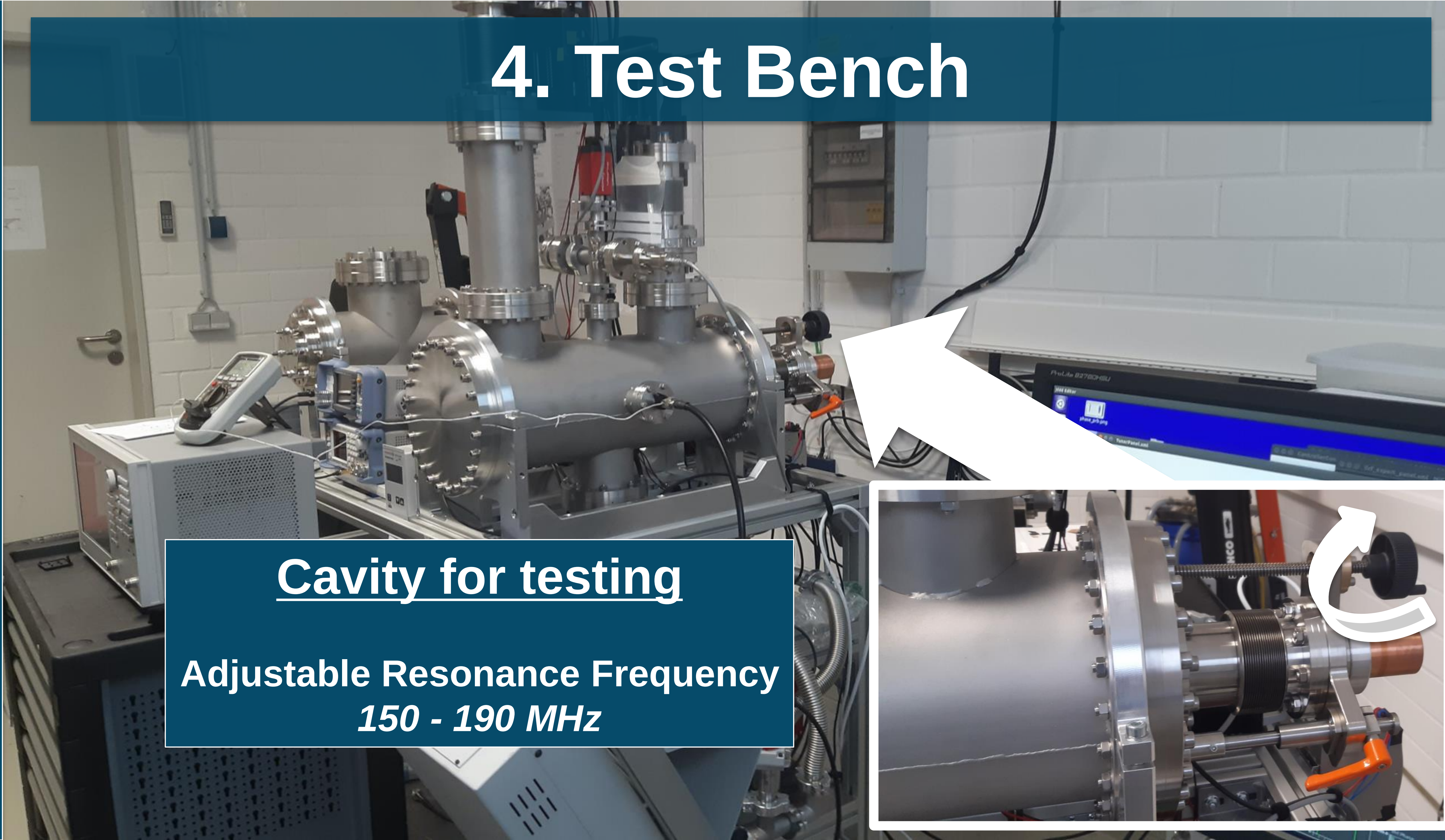
Open Source

`https://github.com/ChimeraTK`

DESY.

BEVATECH

4. Test Bench

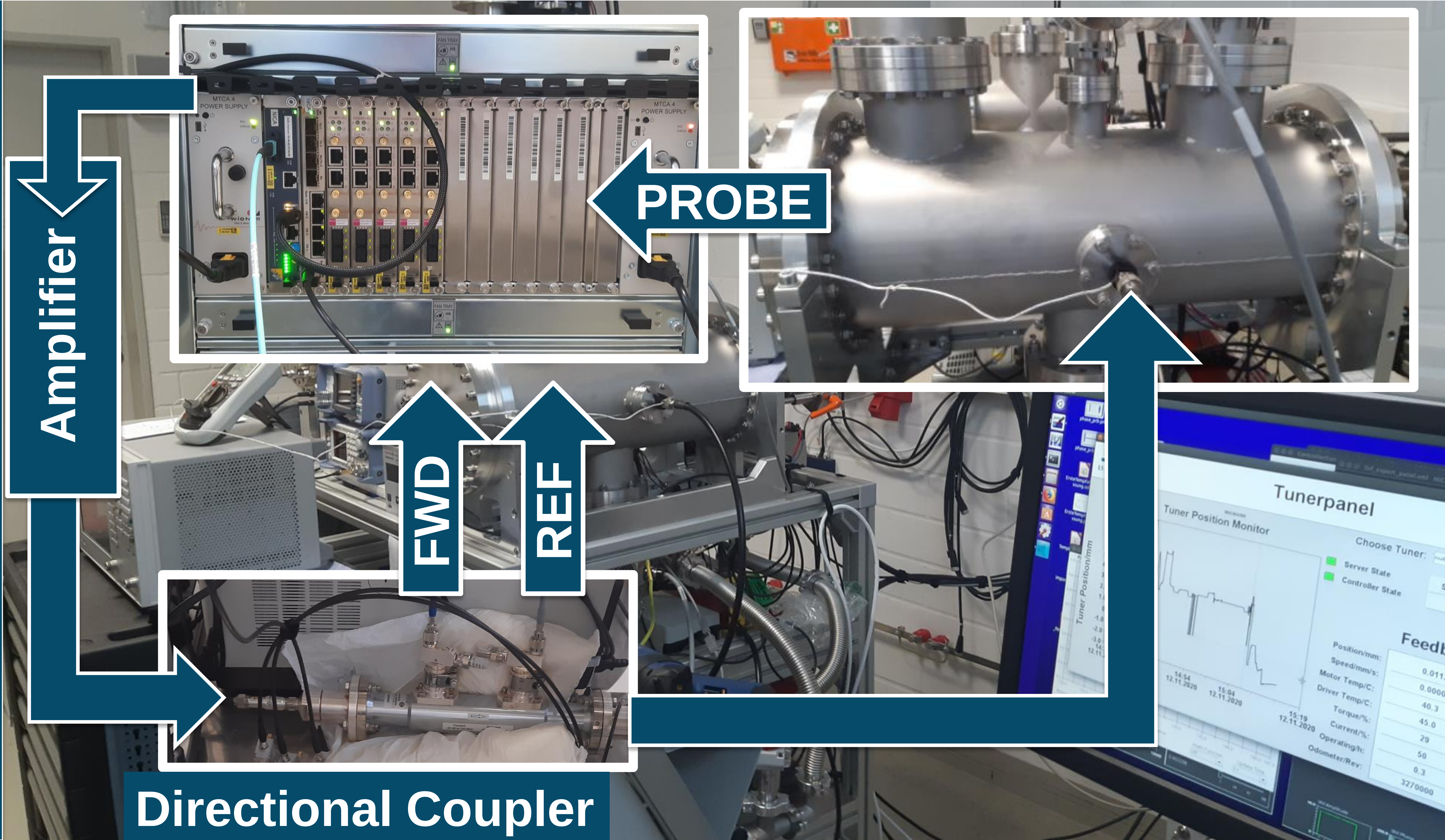


Cavity for testing

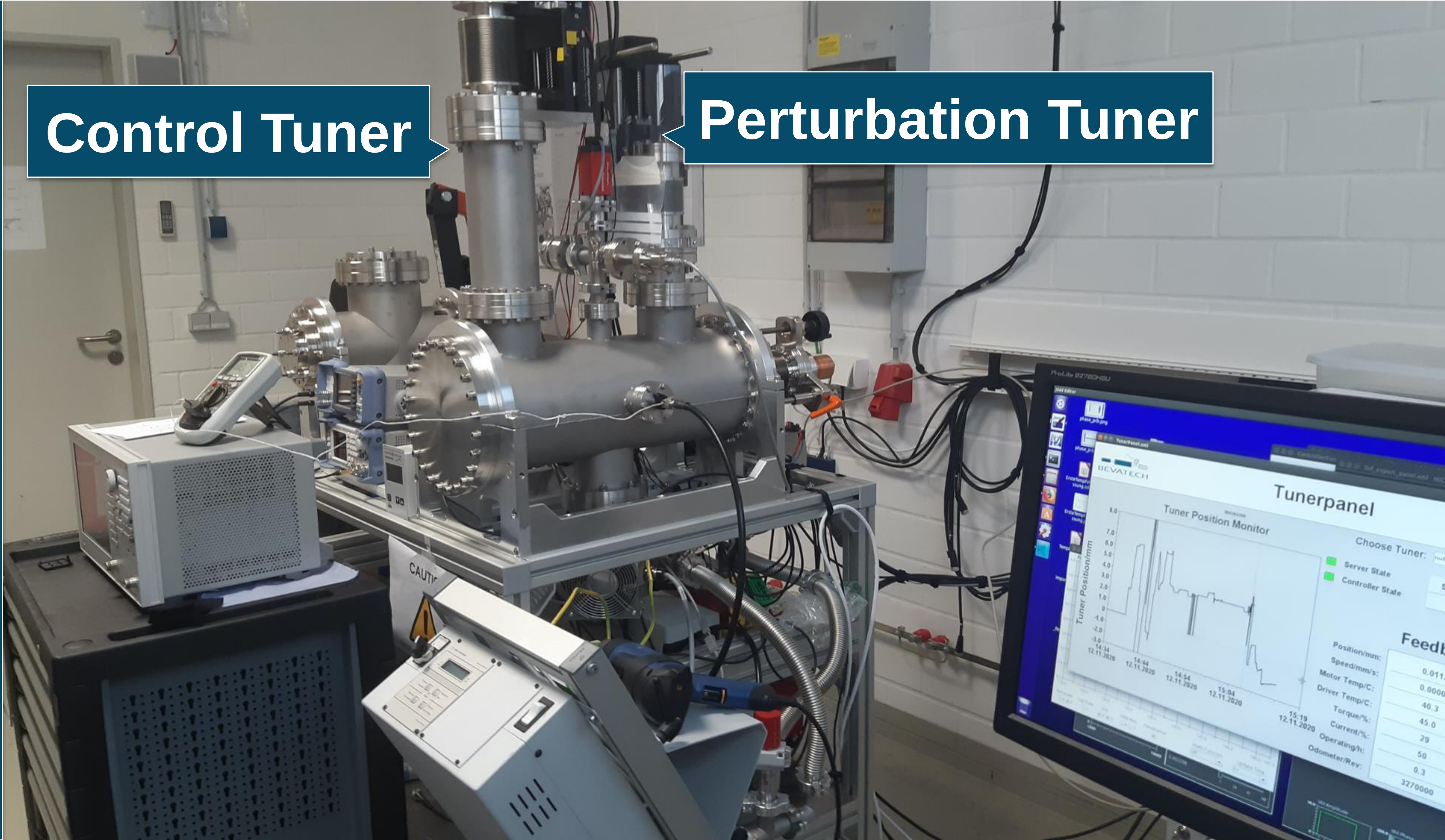
Adjustable Resonance Frequency

150 - 190 MHz

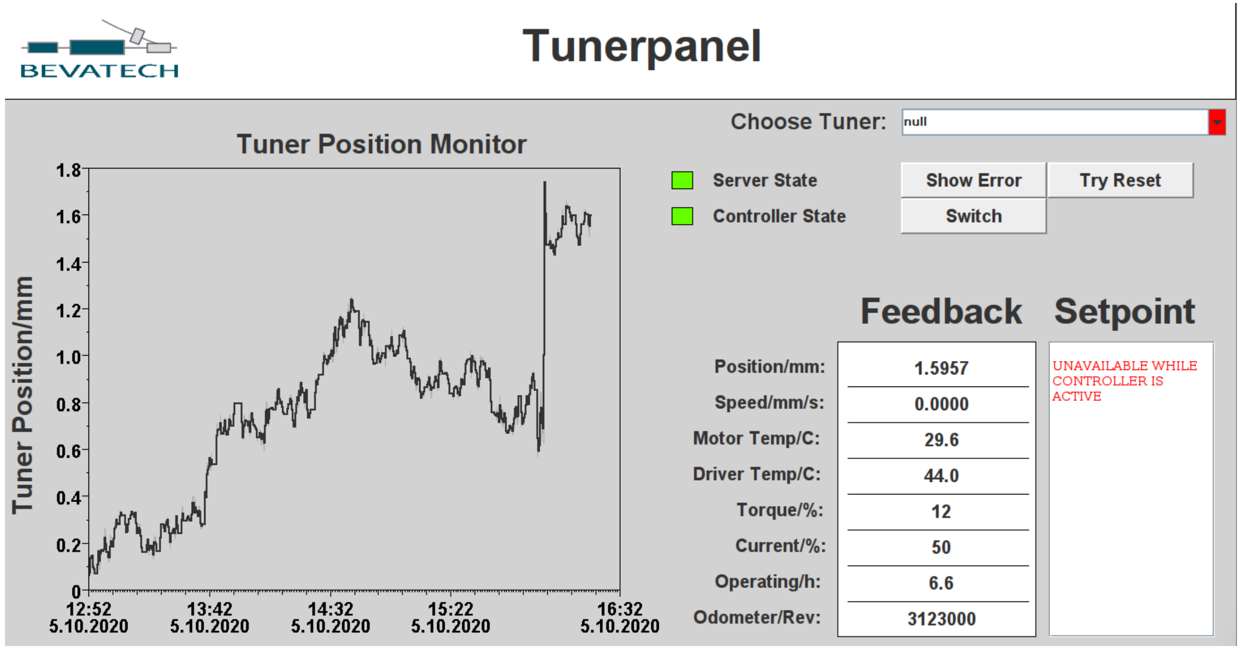
Test Bench – Connection to LLRF

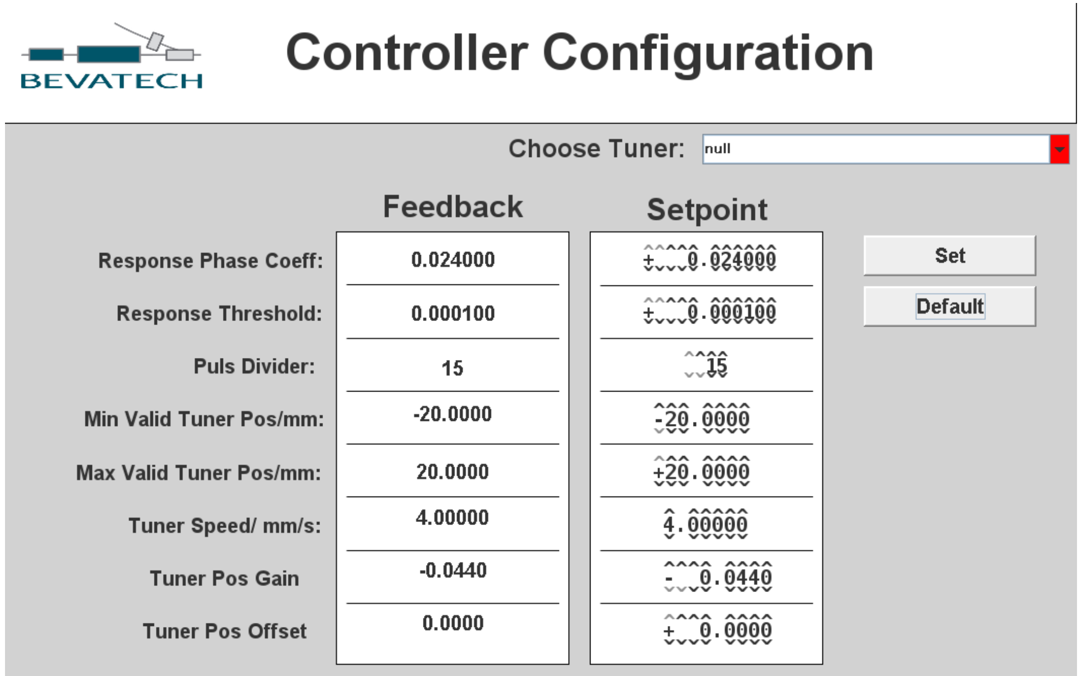


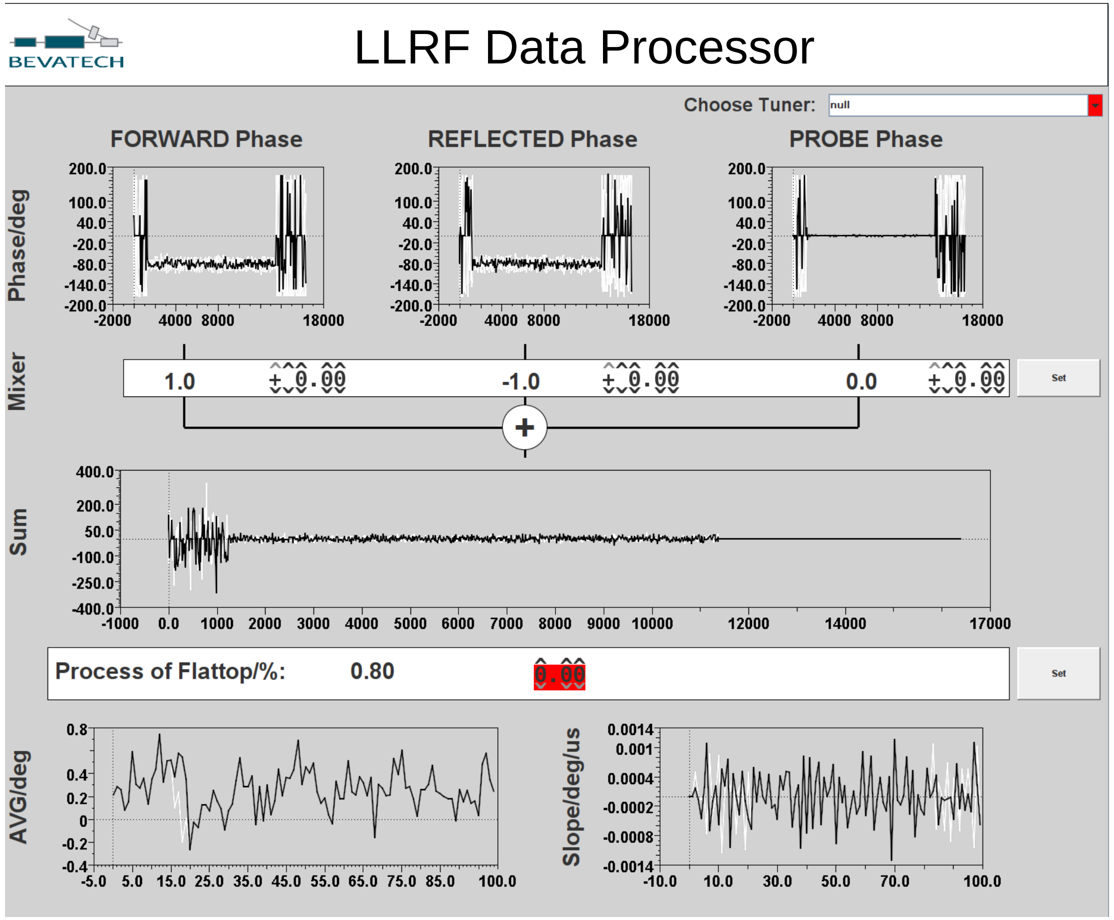
Test Bench - Tuner



Tuner Software GUI







Lab GUI

5. Summary

- **System under testing @ BEVATECH**
- **Tuner Control System is under development**
- **Testing with cavities is ongoing**

- **MTCA based LLRF highly customizable and flexible**
- **ChimeraTK allows for early use of the system and later easy adaption to NICA control system environment**
- **JDDD allows to create simple GUIs quickly**
- **Excellent Cooperation with MTCA Techlab**