Laser setup for quality assurance of BM@N silicon tracking modules

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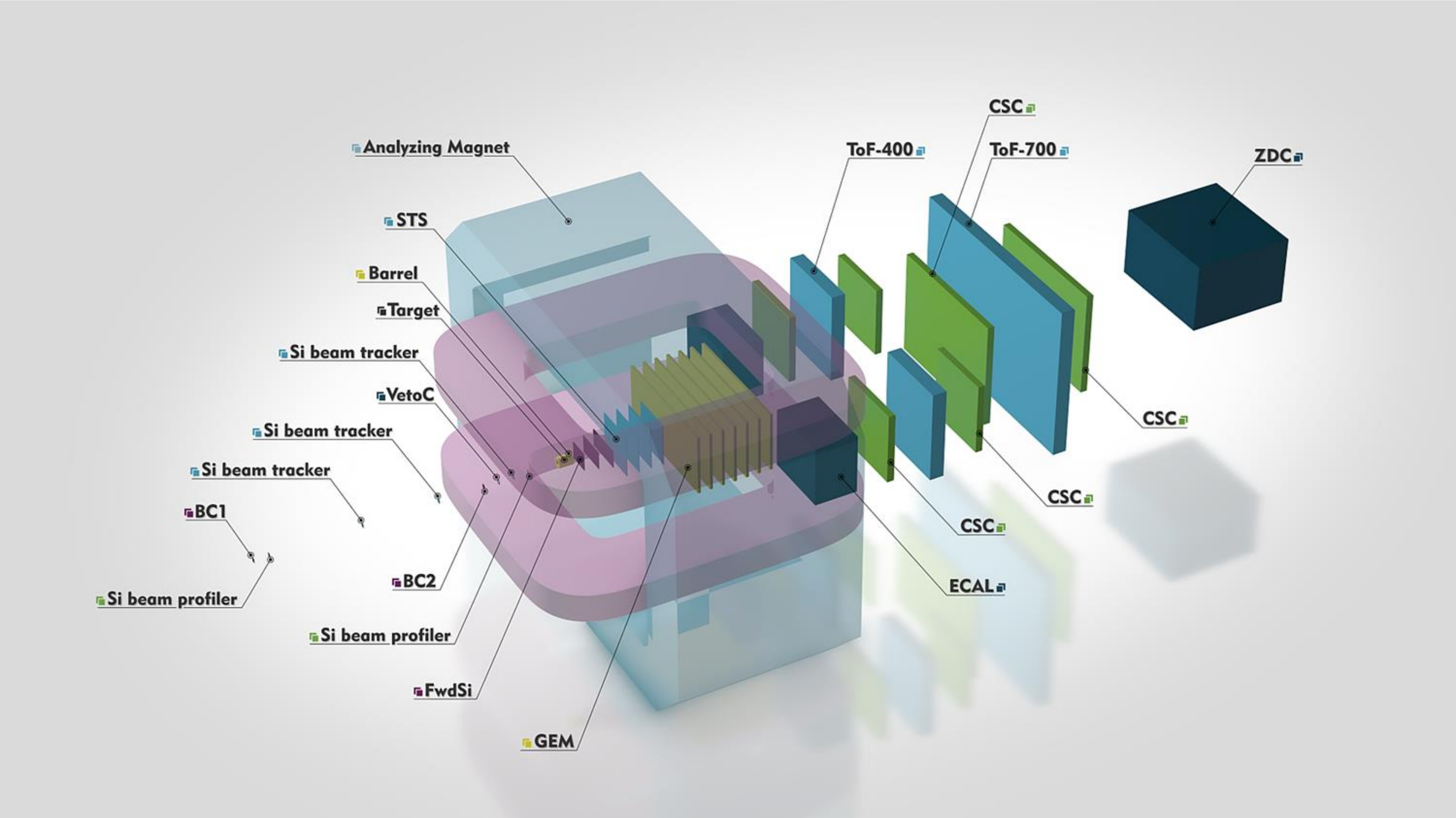
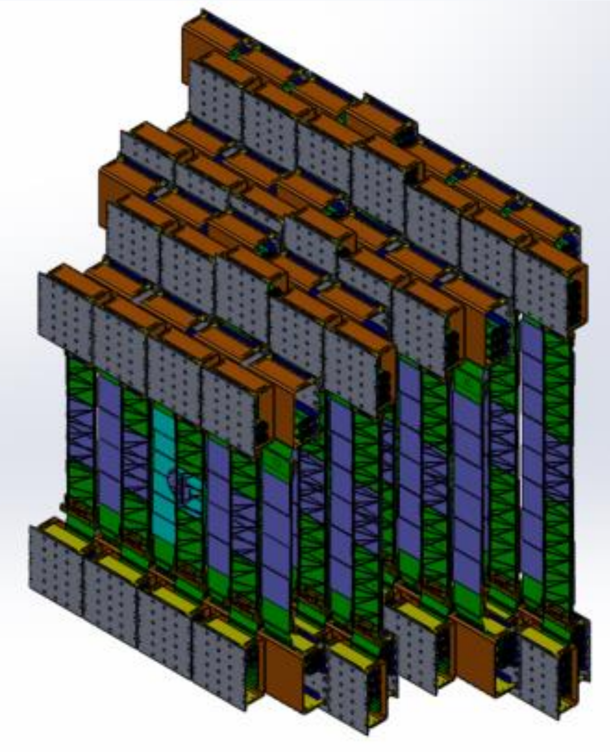
BM@N upgrade

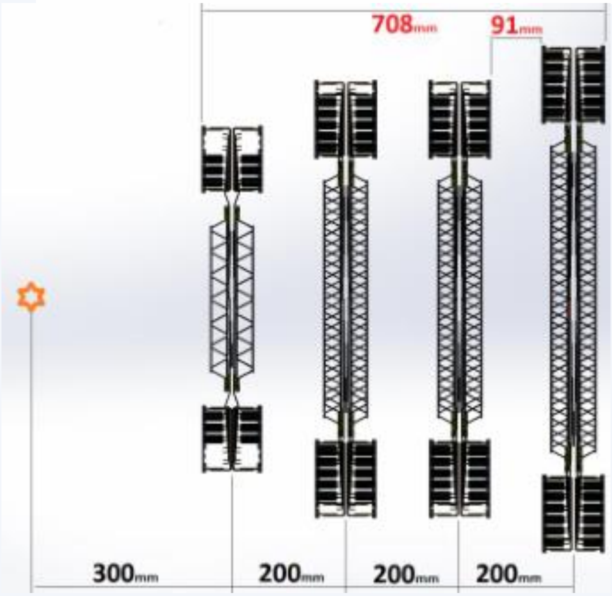


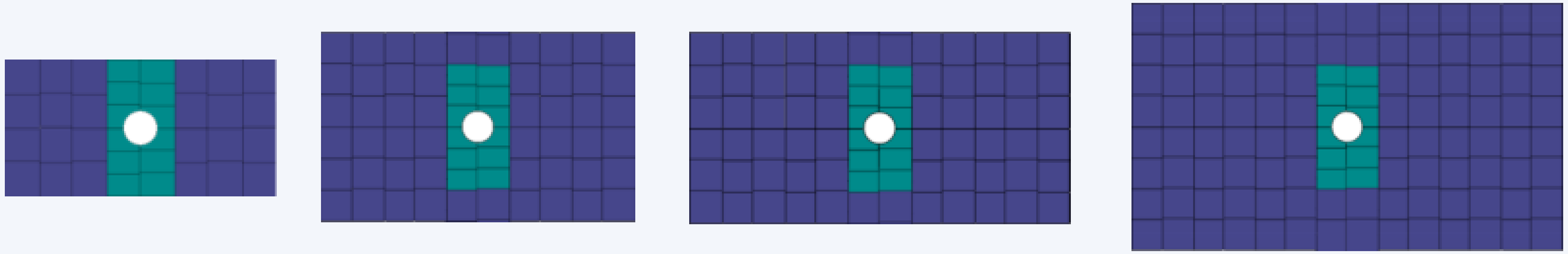
Analyzing Magnet
STS
Barrel
Target
Si beam tracker
VetoC
Si beam tracker
Si beam tracker
BC1
Si beam profiler
BC2
Si beam profiler
FwdSi
GEM
ToF-400
CSC
ToF-700
ZDC
CSC
CSC
CSC
ECAL



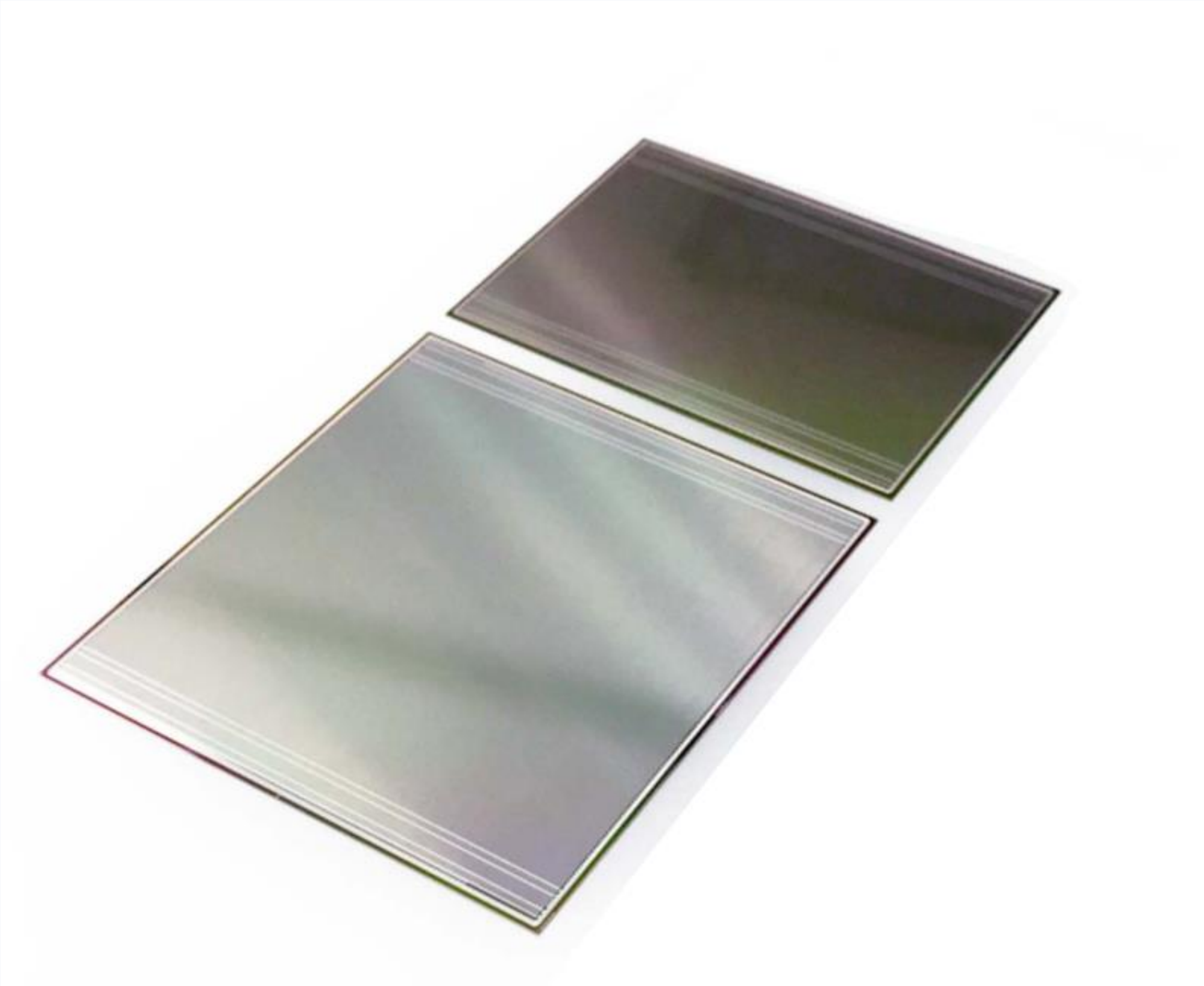
Layout of BM@N STS

- Four stations are based on CBM-type modules with double-sided microstrip silicon sensors
- Number of modules: 292
- Number of channels: ~600k
- Power consumption: ~15 kW



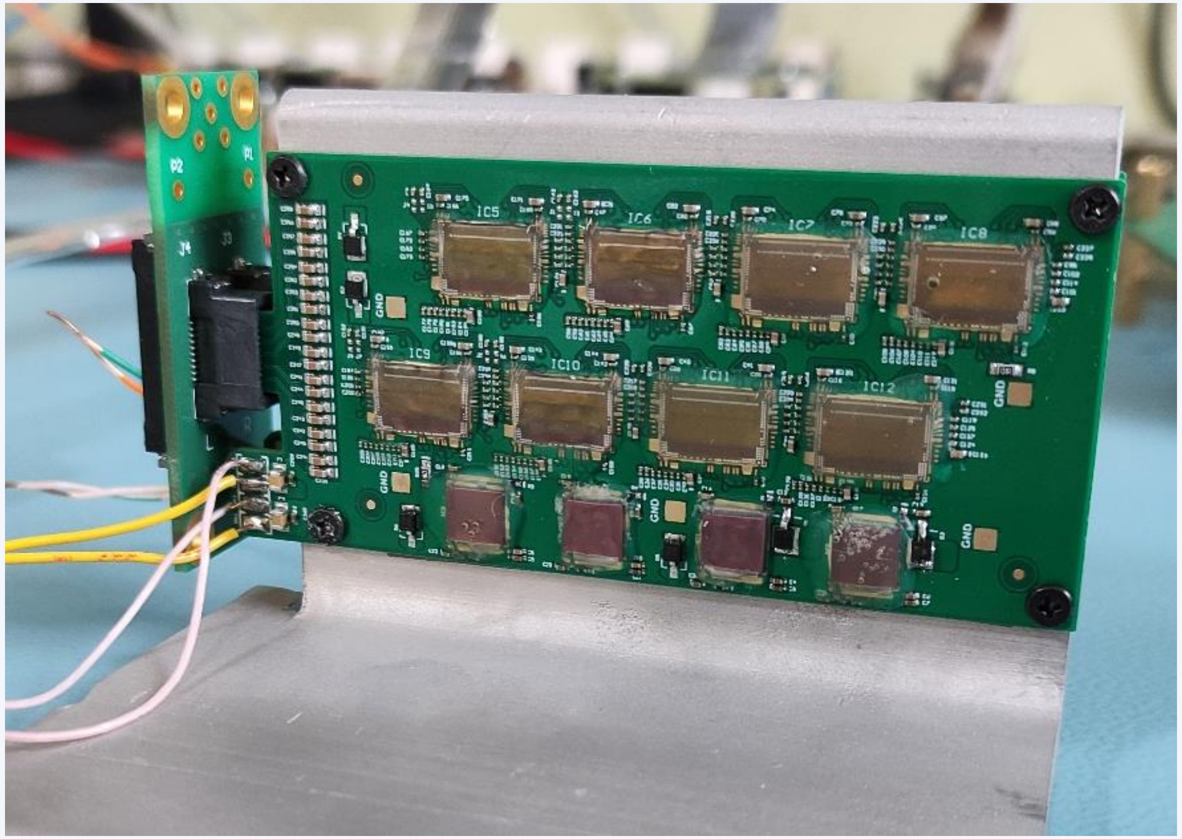


Sensors



- double-sided
- Thickness is 300 µm
- 1024 strips of 58 µm pitch
- Stereo angle 7.5°
- final prototypes realized with two vendors:
  - – CiS, Germany
  - – Hamamatsu, Japan
- Sizes:
- 6.2 x 6.2 cm
- 4.2 x 6.2 cm
- 4.2 x 6.2 cm with cut

Readout electronics STS-XYTER



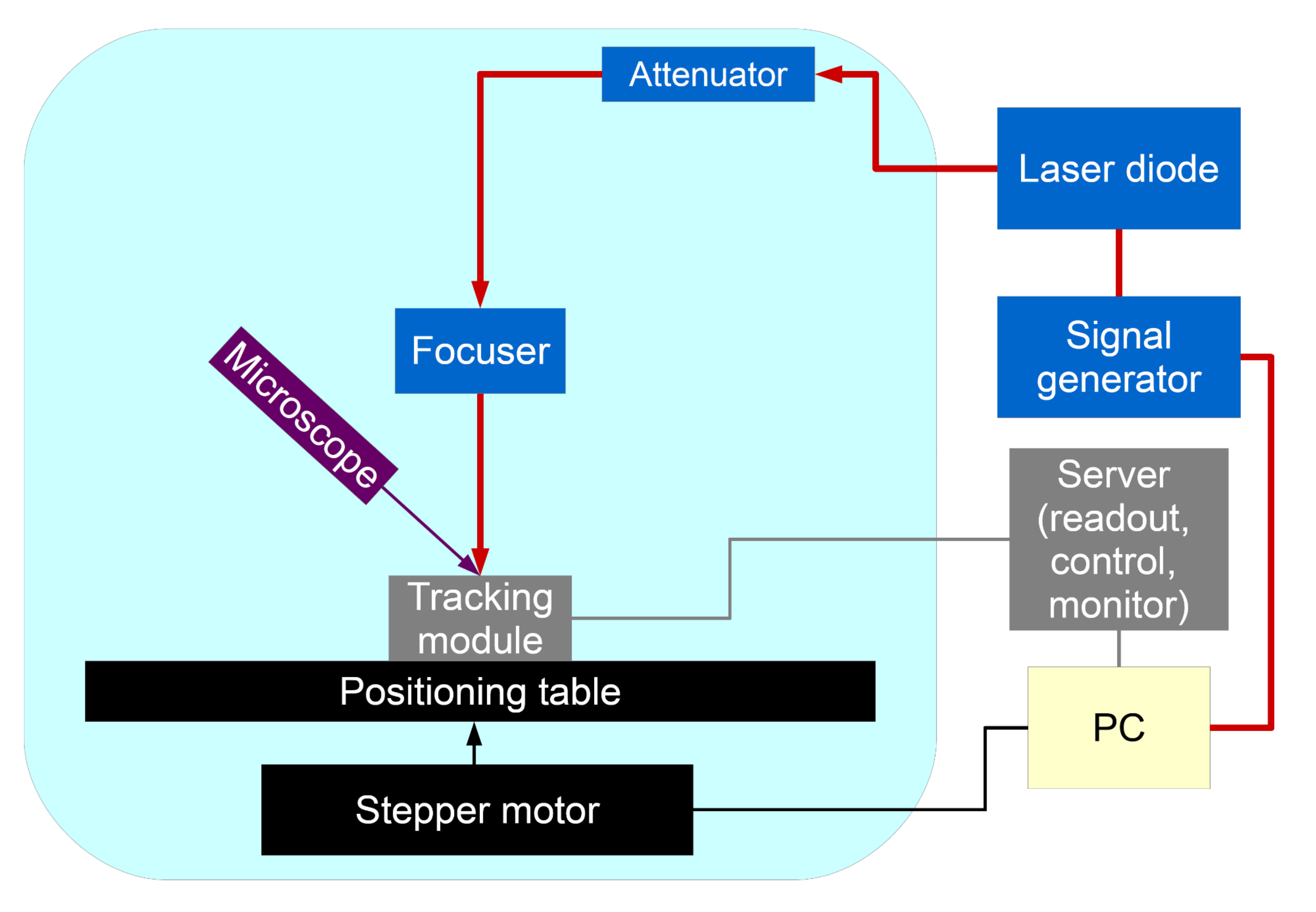
JINR_FEB8 v.2.0 with 8 STS-XYTERs

- Front-end electronics is based on STS/MUCH XYTER ASIC
- 128 channels (+ 2 test channels)
- Self-triggered readout
- 5 bit ADC, time resolution < 8 ns
- Shaping time 40-60 ns (Fast Shaper for t/s) and 80-120 ns (Slow Shaper for Amp.)
- Noise performance: <1500 ENC at 30 pF input load
- Switchable dynamic range (up to 120 fQ) and gain (Can be used for GEM detectors)

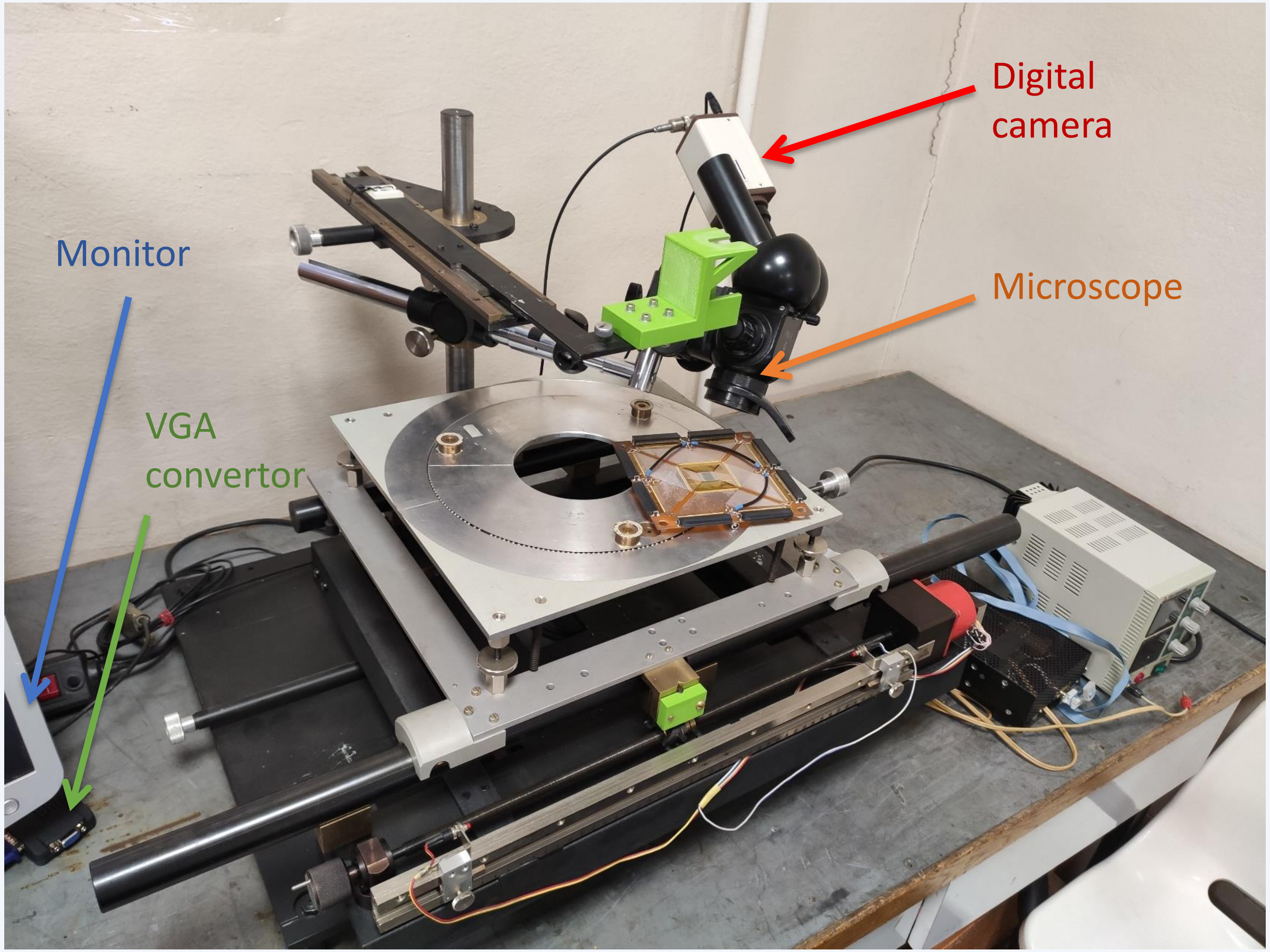
Structure of the laser setup

- Auxiliary system
  - Microscope with digital camera connected to external monitor
- Positioning system
  - Positioning table with stepper motor
- Readout, control, and monitoring
  - Through server
- Optical system
  - Laser diode powered by signal generator, optical attenuator, and focuser

Flow chart of the setup



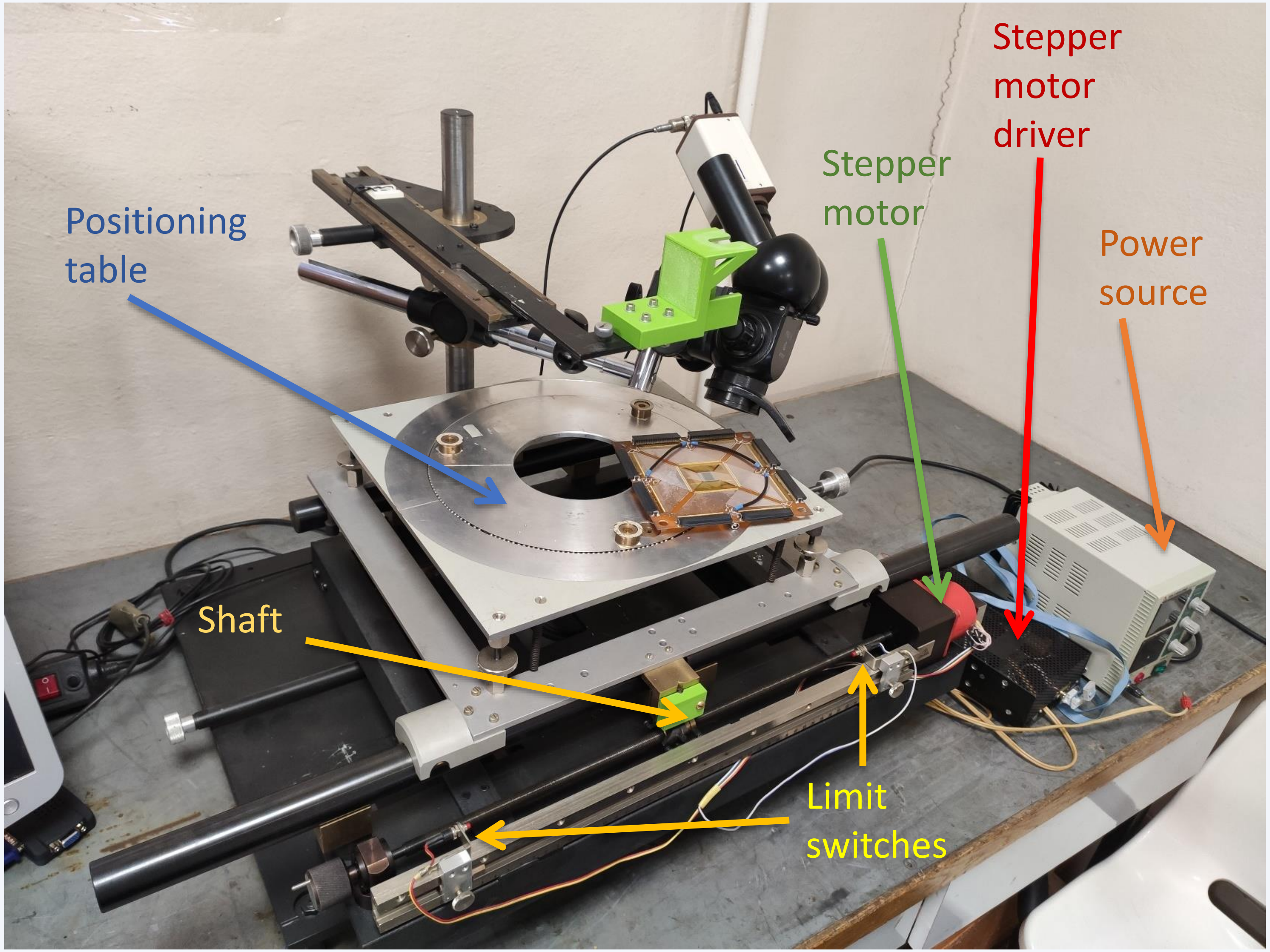
Auxiliary system



Partially assembled setup

- Microscope with digital camera (given by SINP MSU) connected to an external monitor though RCA-VGA convertor
- Used only for supplemental adjustments of other systems
- Is not to operate during tests

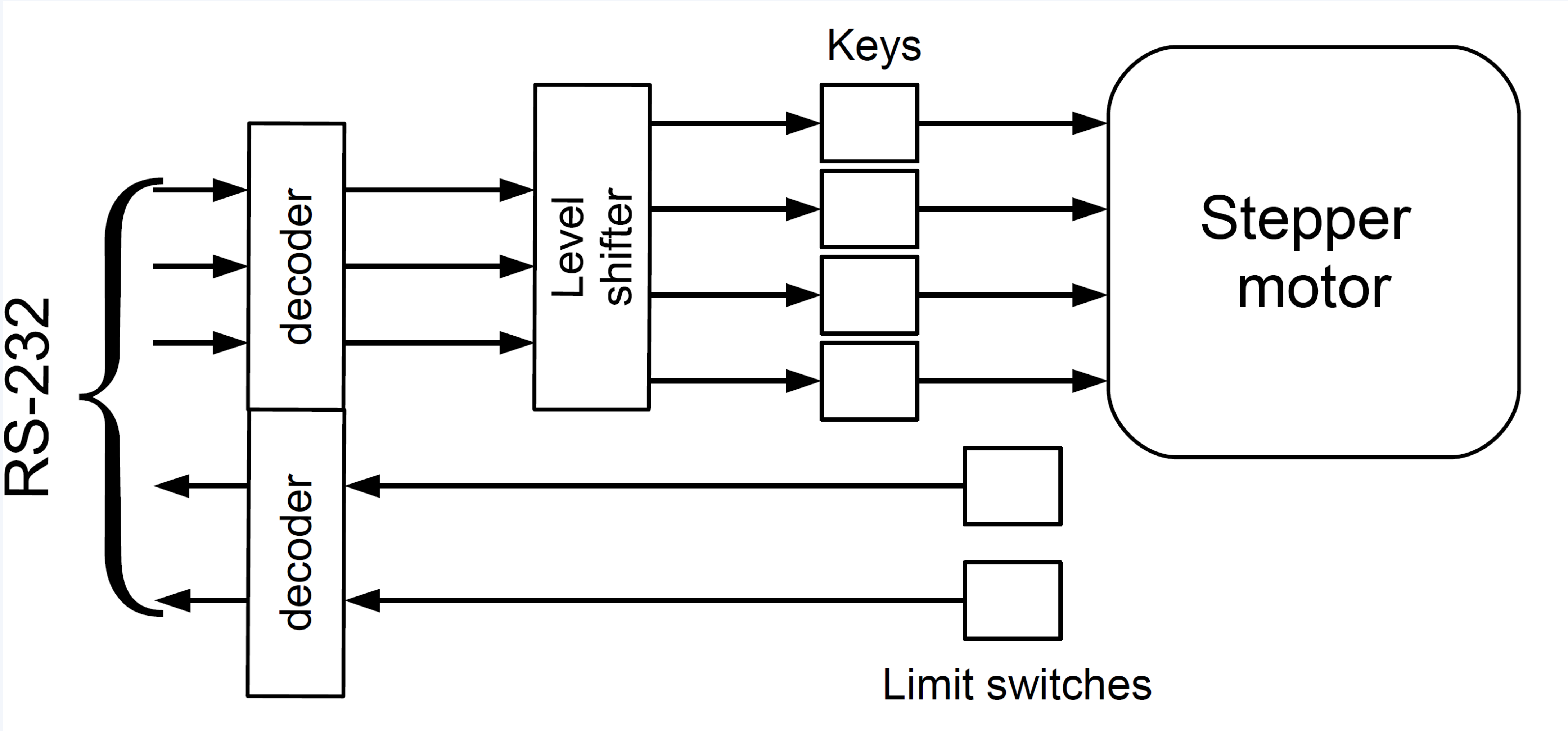
Positioning system



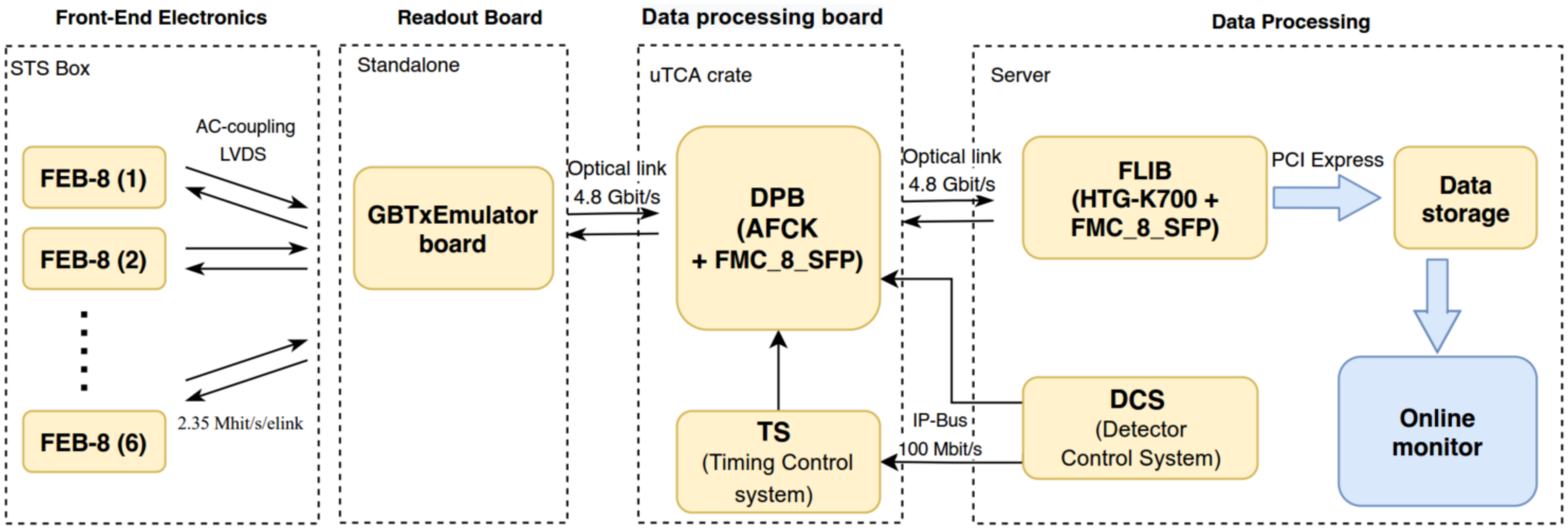
Partially assembled setup

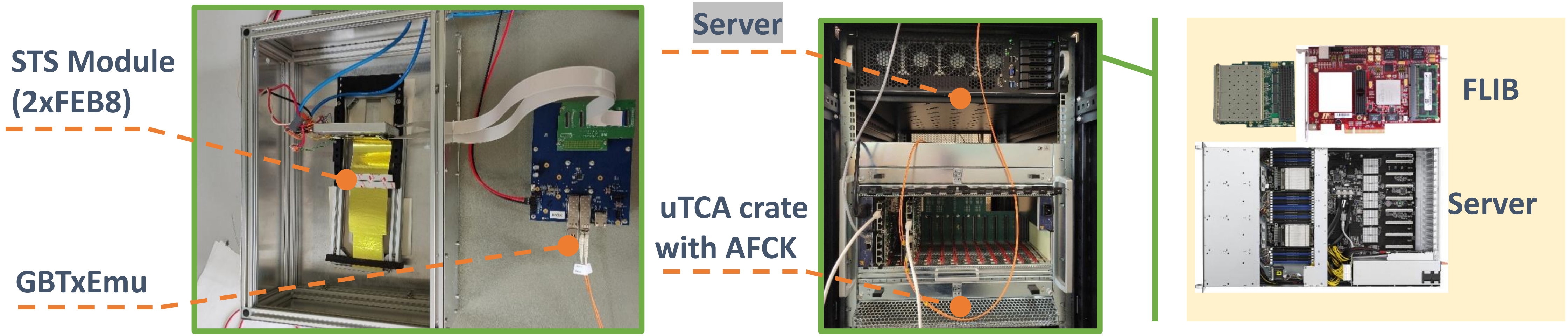
- The positioning table connected to the shaft
- Actuated by the stepper motor DShI-200-2
- Controlled by the driver
- The driver is connected to a PC through a serial port
- The driver is operated through a software written in Python with pyserial library

Flow chart of stepper motor driver



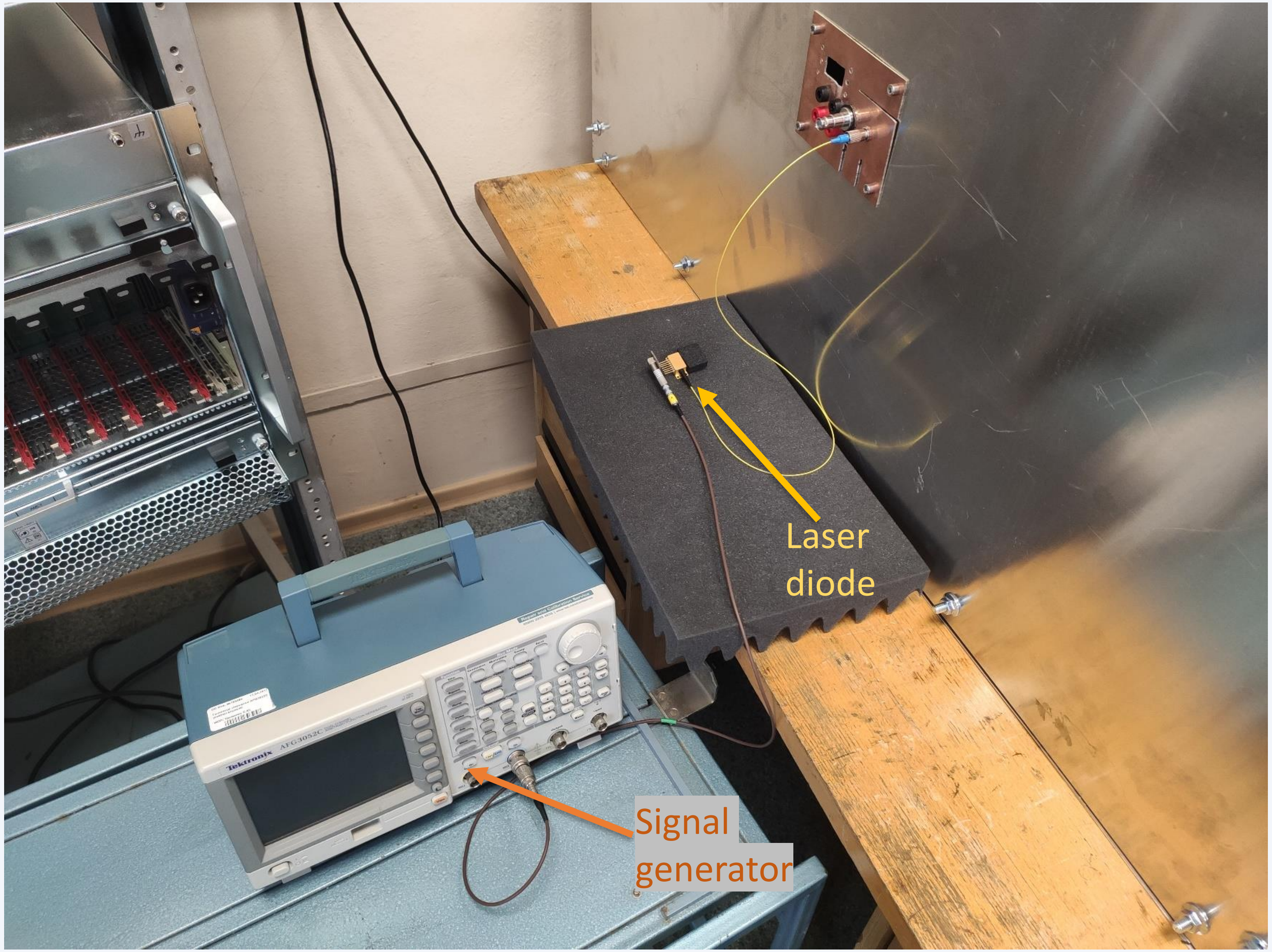
Current Readout system





Slide by Dmitrii Dementev from "RFBR grants for NICA", Oct. 2020

Optical system (outside casing)

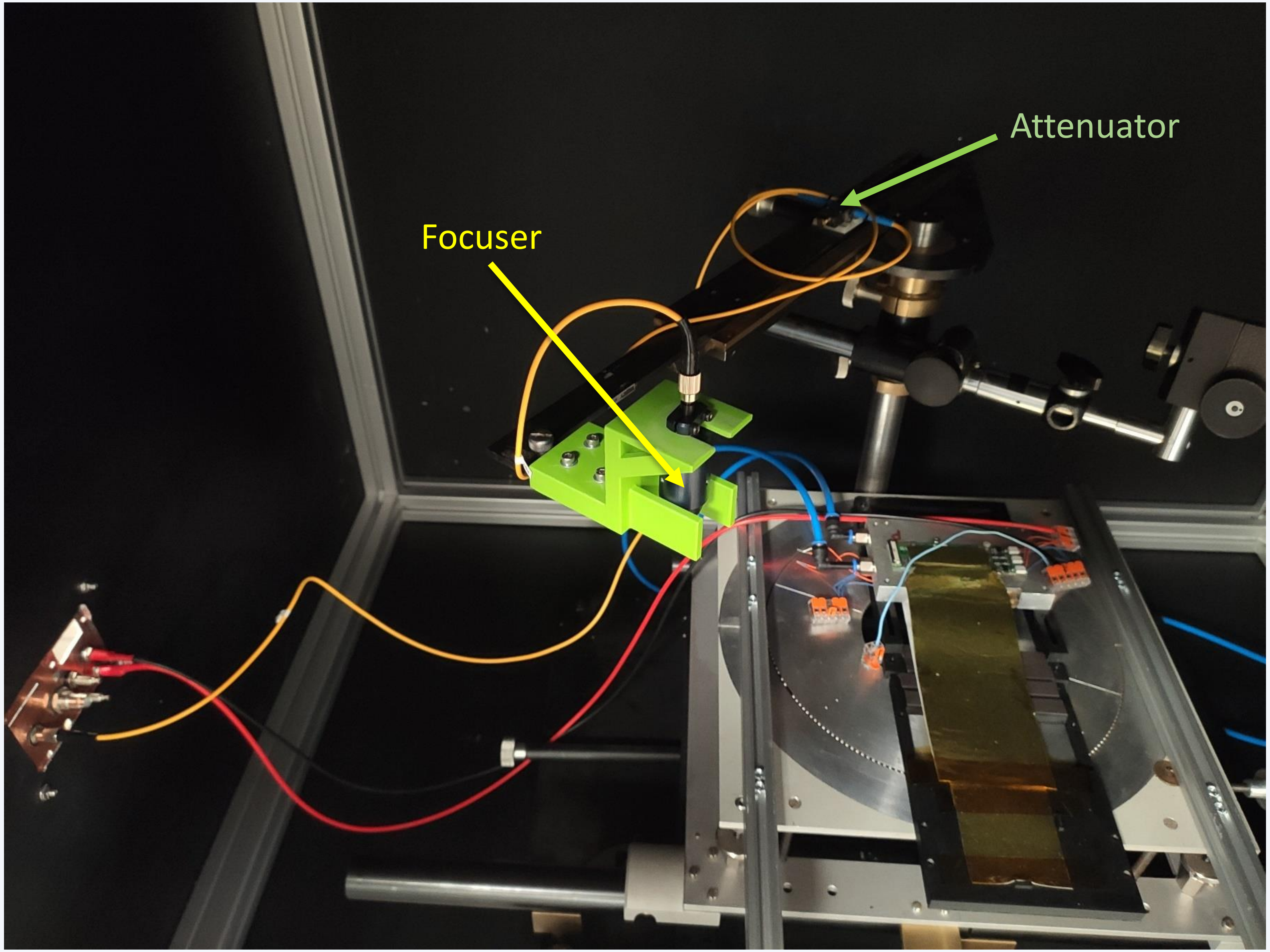


- The 1mW laser diode is powered by the signal generator
- Tektronix AFG3052C can generate rectangular pulses with length 12 ns and period 1.2 ms
- Length of such a pulse is ~ charge collection time

$$1mW \times 12ns = 1.2 \cdot 10^{-11} J \gg E_{MIP} \sim 10^{-15}$$

- Laser diodes: FPL-635-14BF-1 or FPL-1064-14BF-1 from “Nolatex”

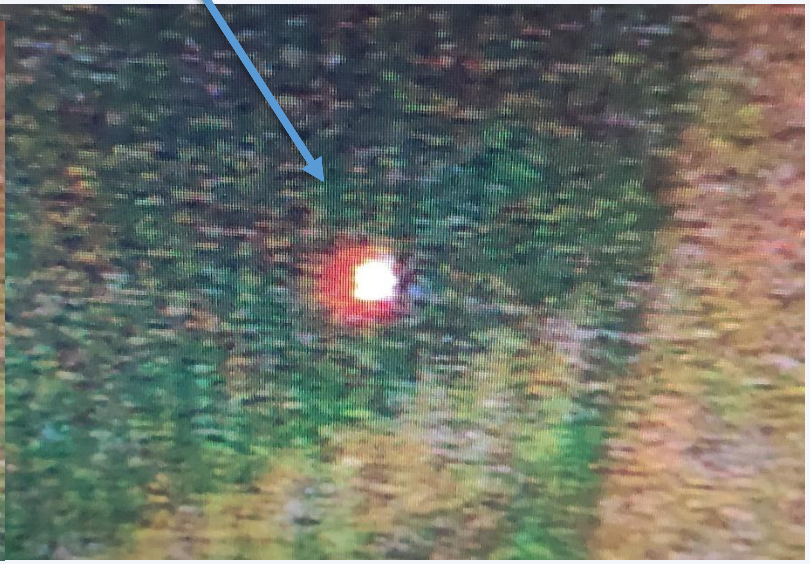
Optical system (inside casing)



- The laser diode connects to optical variable attenuator VOA630-FC or VOA1064-FC from “Thorlabs”
- Attenuation up to 50 dB
- Connected to the condenser PS-2 from “SolarLS”
- The condenser is used as focuser with focal length 4 cm
- It is possible to focus laser beam into spot 50 µm in diameter

Examples of focusing

- Tested on Hamamatsu baby sensor
- Strip pitch 58 μm
- Two strips are alight
- Focused in between strips
- One strip is alight



Why laser diodes 635 and 1064 nm?

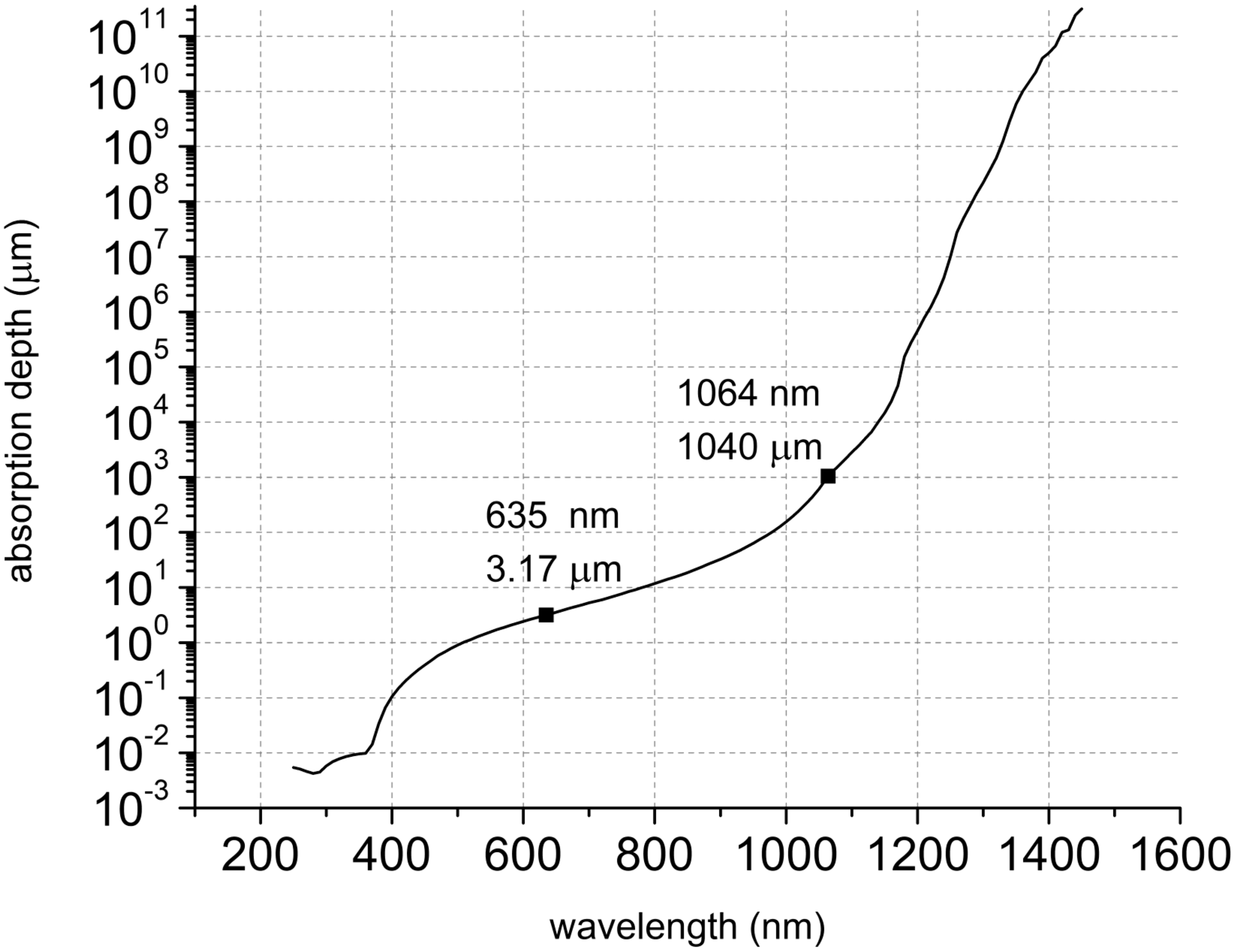
- Corresponding photon energies are 1.95 and 1.17 eV. (Band gap of Si is 1.12 eV)
- Full energies of MIP-like laser pulses are equal:

$$E_{635} = 1.95 eV \times 22500 = 43.875 keV = 7.0 * 10^{-15} J,$$

$$E_{1064} = 1.17 eV \times 22500 = 26.325 keV = 4.2 * 10^{-15} J.$$

- Penetration depths for wavelength 635 nm is 3.17 µm, for 1064 nm it is equal to 1040 µm in silicon.
- Only about 25% of initial infrared laser pulse is absorbed by 300 µm of silicon.
- Red laser diode is easier to operate and adjust; infrared is better for testing of double-sided sensors.

Absorption depth



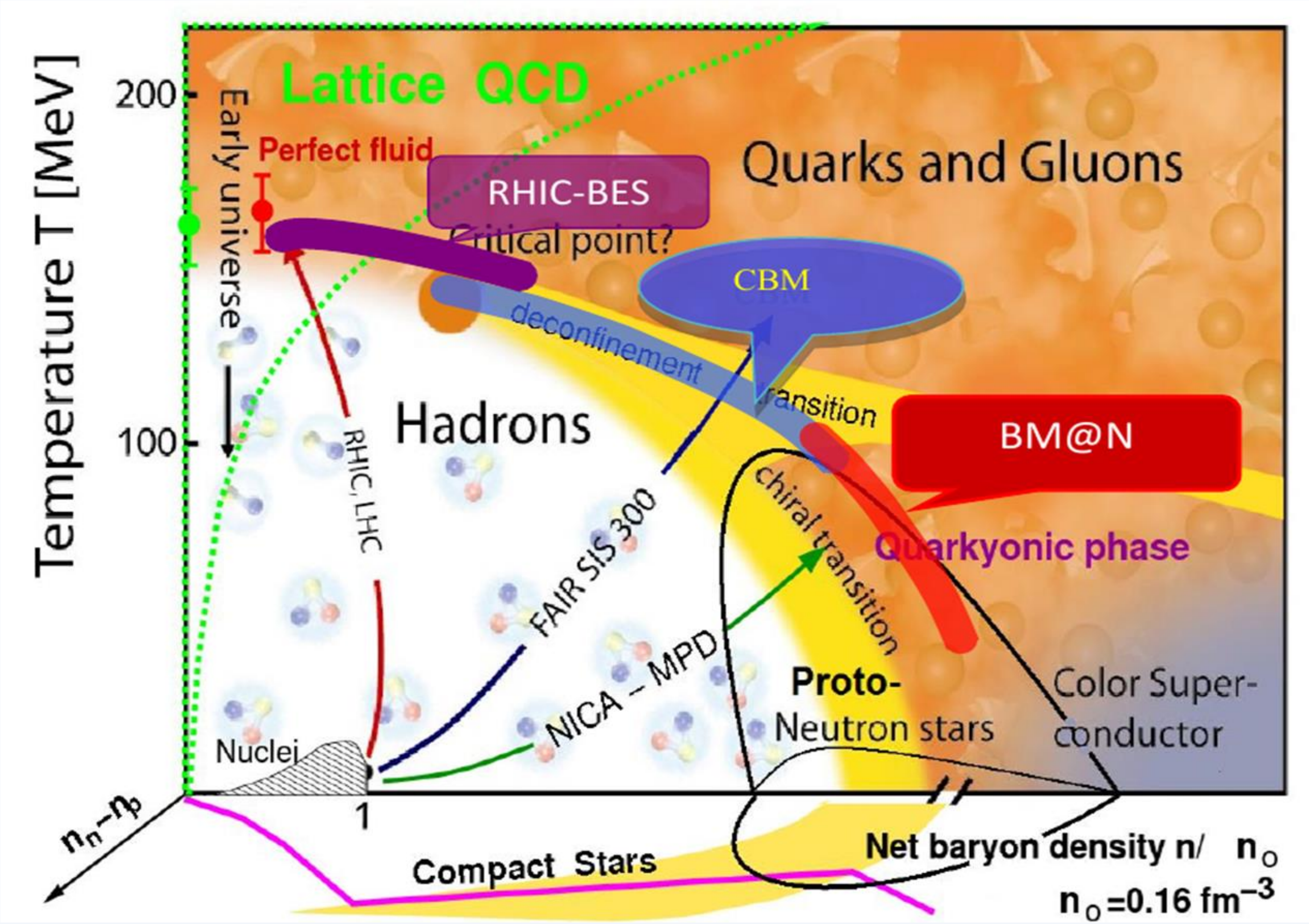
Conclusions

- All components have been tested.
- Software for positioning system and laser diode power supply control has been developed.
- Calibration of positioning system has been done; the most stable mode of operation for stepper motor driver has been chosen.
- Shielding casing with mat black coating is assembled.
- Operation of the laser setup is under testing.

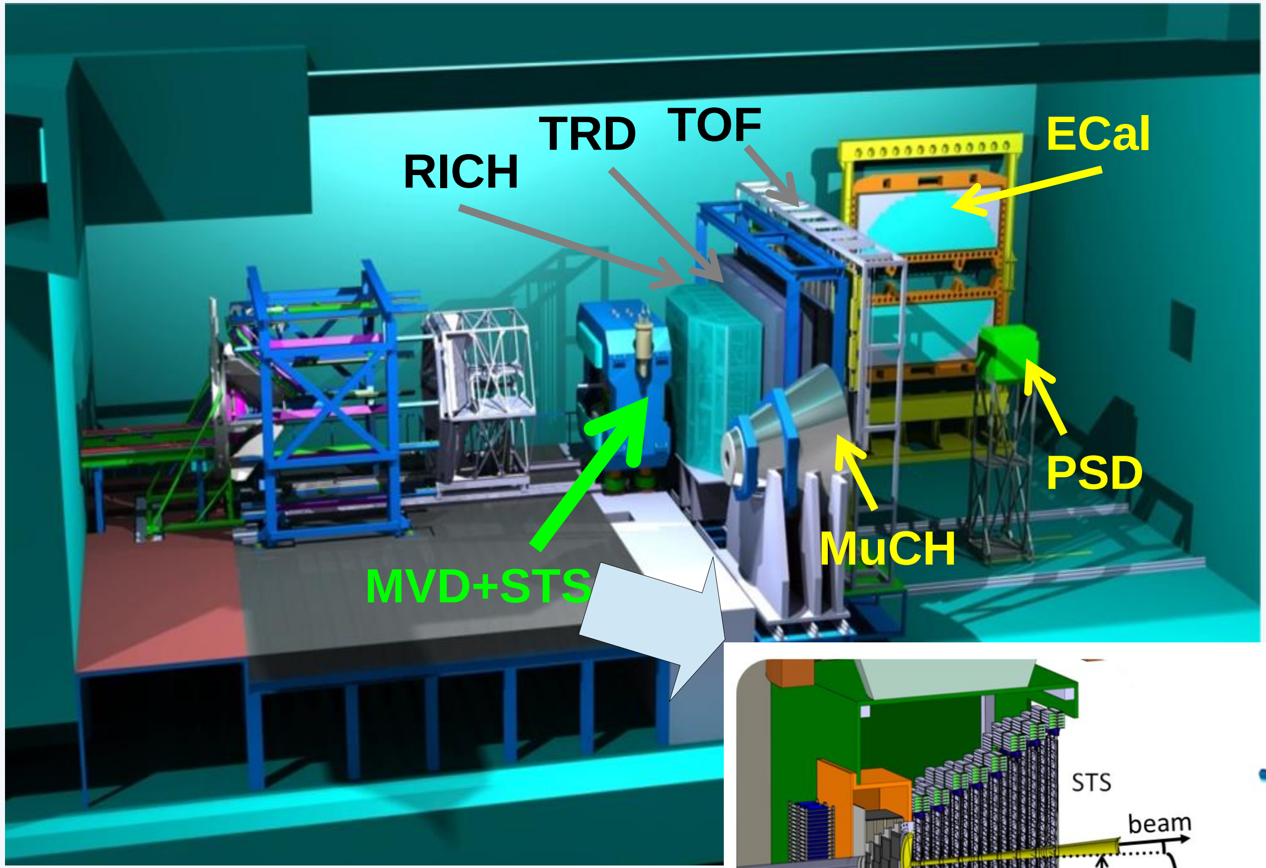
Thank you for your attention!

Backup slides

Phase diagram of QCD



CBM@FAIR detector

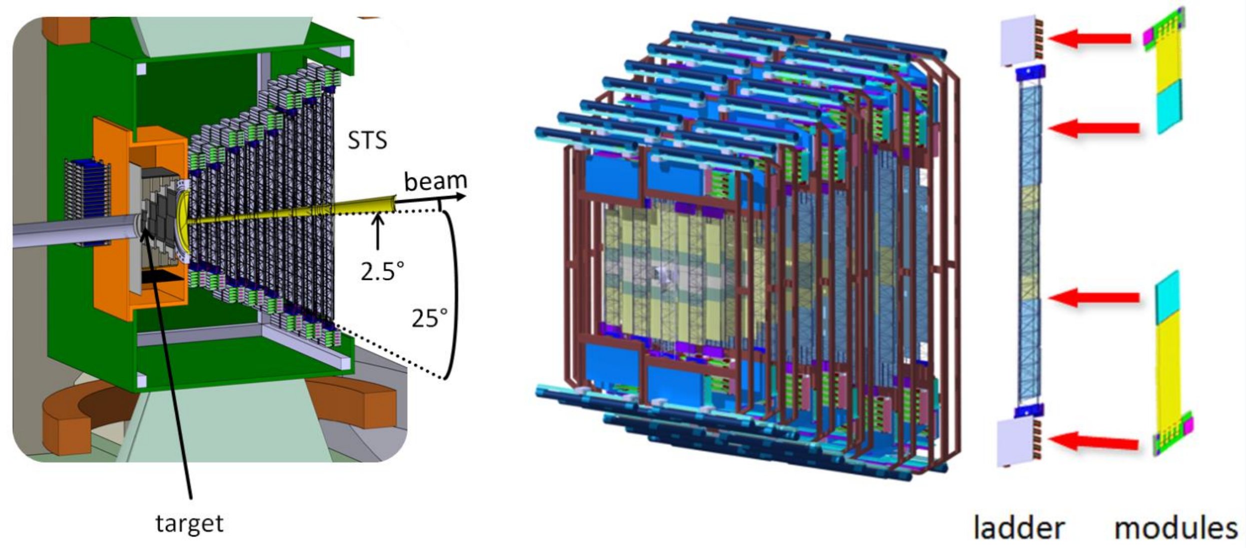


STS:

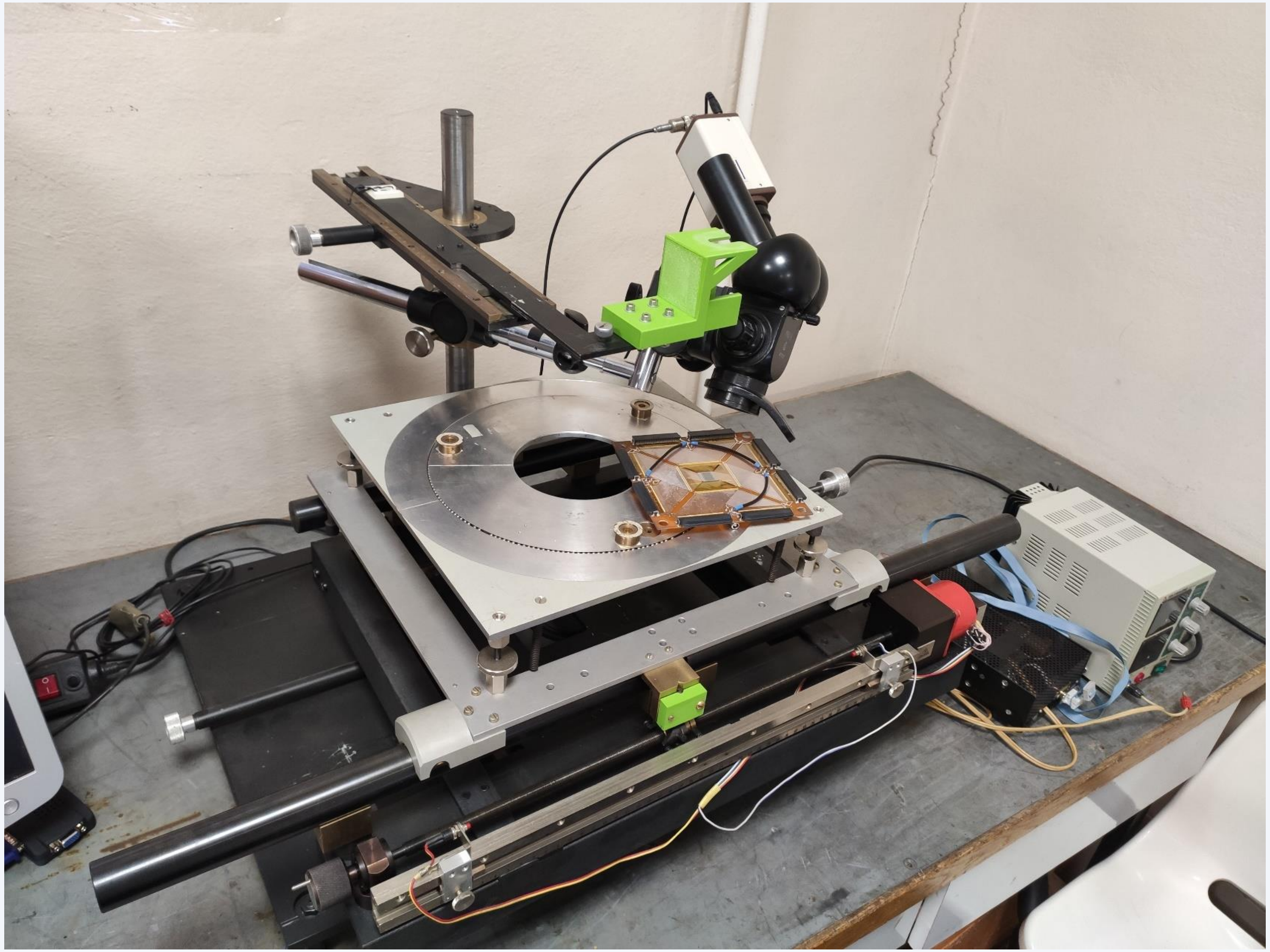
2 053k channels

16 000 Readout chips

1292 sensors



Partially assembled setup



Examples of focusing