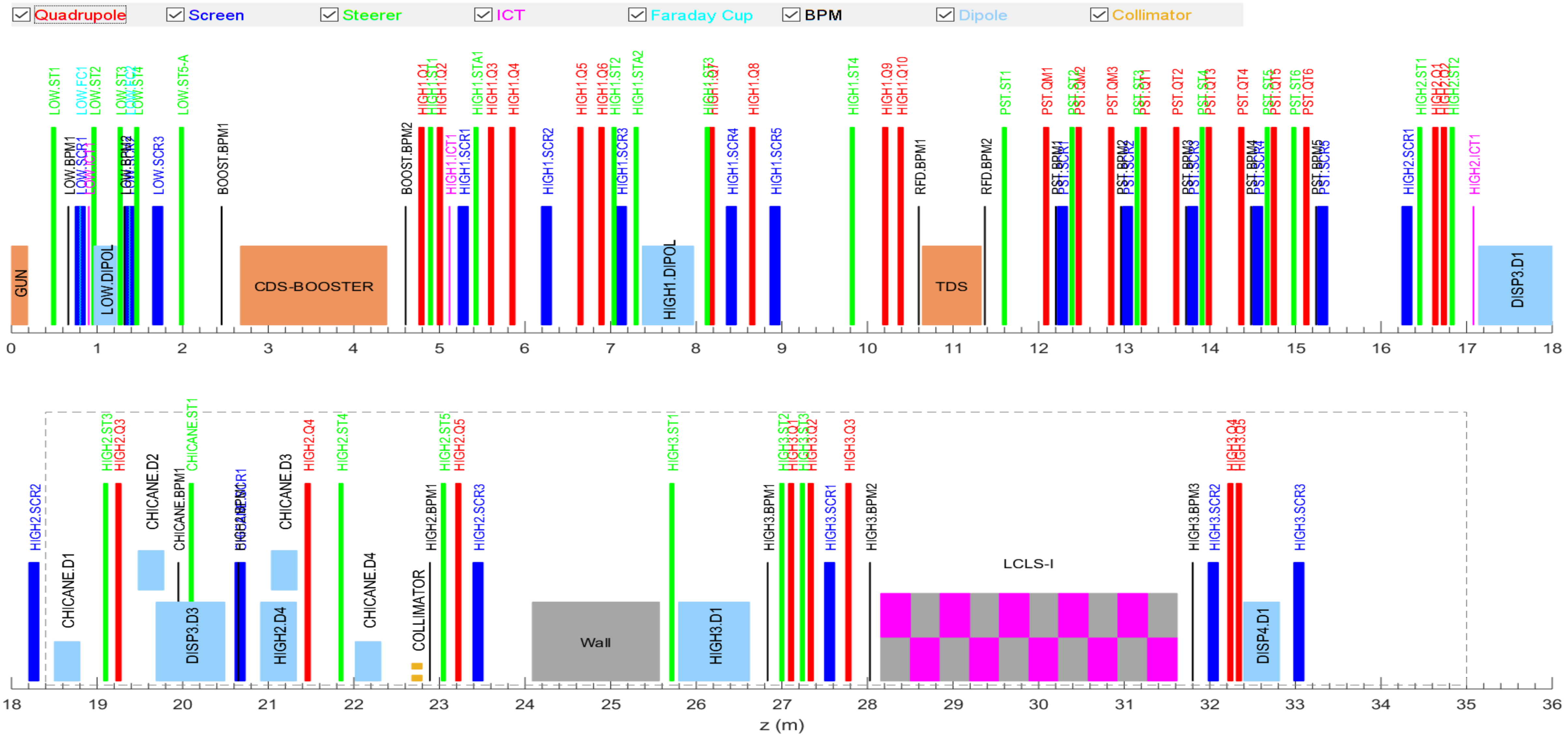
THz at PITZ Commissioning

28.07.2022 – THz @ PITZ Beamline

M. Krasilnikov for the THz@PITZ team

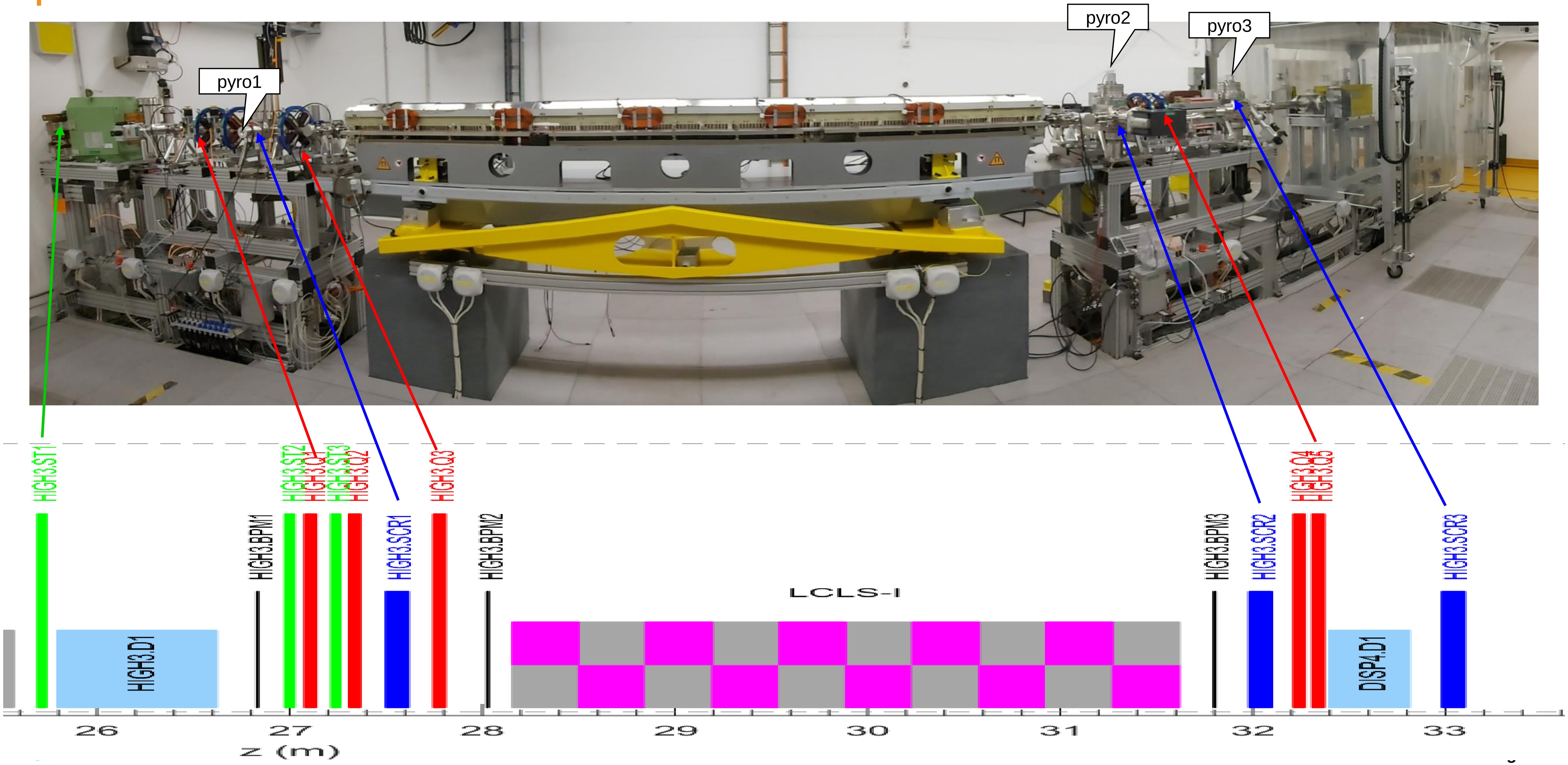
PITZ Beamline Components

Up to scale



PITZ Beamline Components

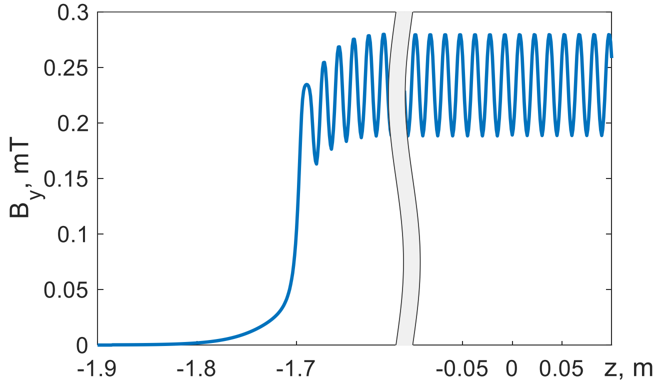
Up to scale

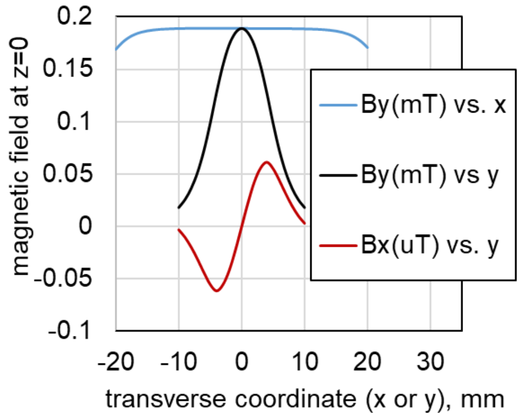


CORRECTION COIL IN UNDULATOR

To compensate the impact of the horizontal undulator field gradient

Simulated field profiles

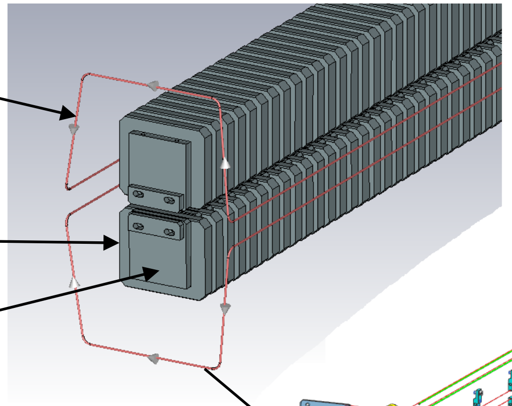


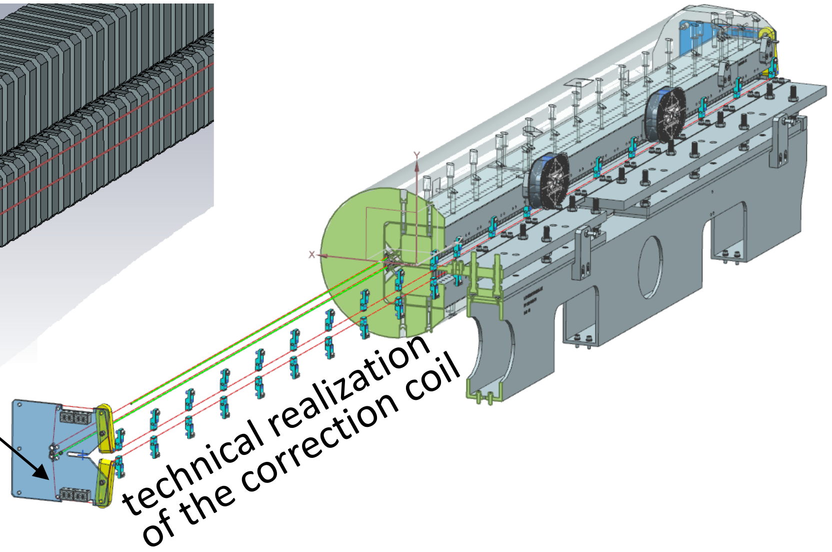


Coil design using CST EM Studio

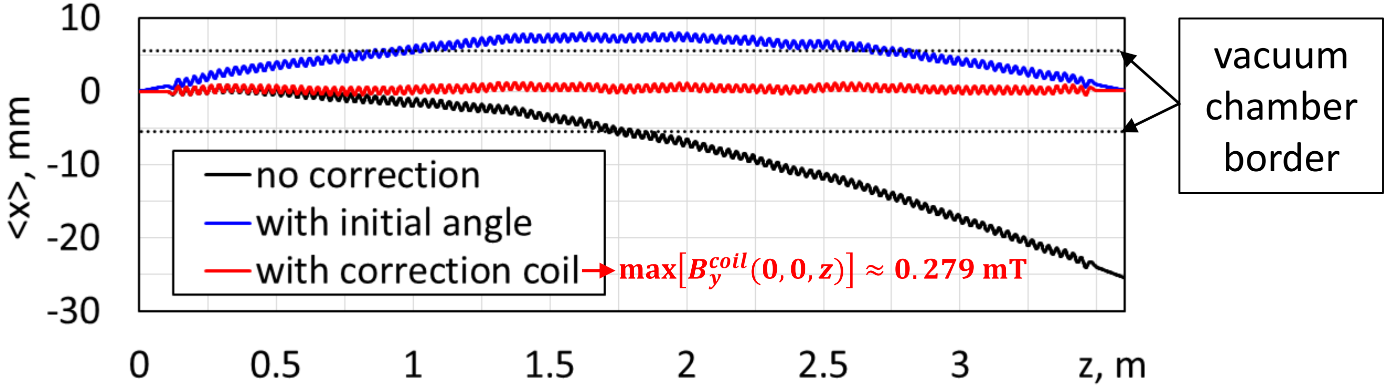
Permanent magnet, μ=1

Vacoflux, μ=1000





Reference particle trajectories in the undulator with horizontal gradient



THZ SASE FEL SIMULATIONS

ASTRA for the beam dynamics and WARP for THz SASE FEL

Electron bunch:

- $\langle P_z \rangle$=17 MeV/c
- Q_b=4 nC
- Temporal flattop ~22 ps FWHM

THZ SASE FEL

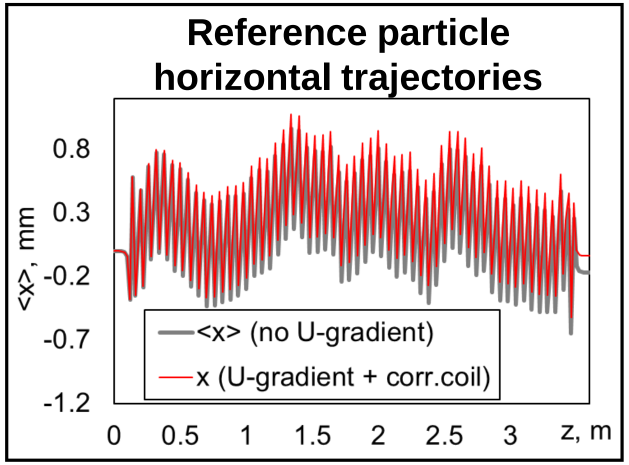
- $\langle \lambda_{rad} \rangle$=100 μm

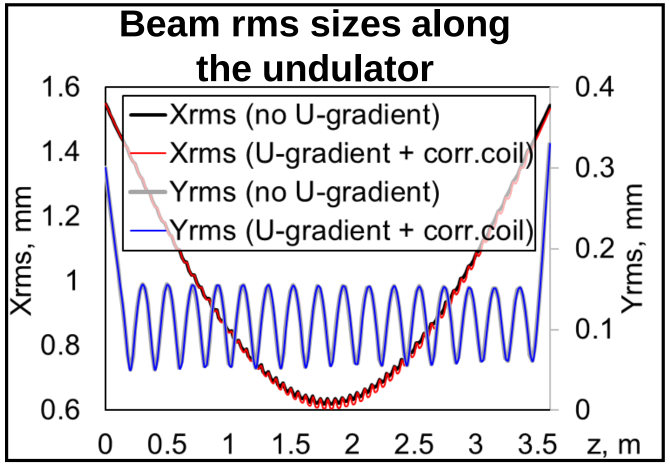
Case studies:

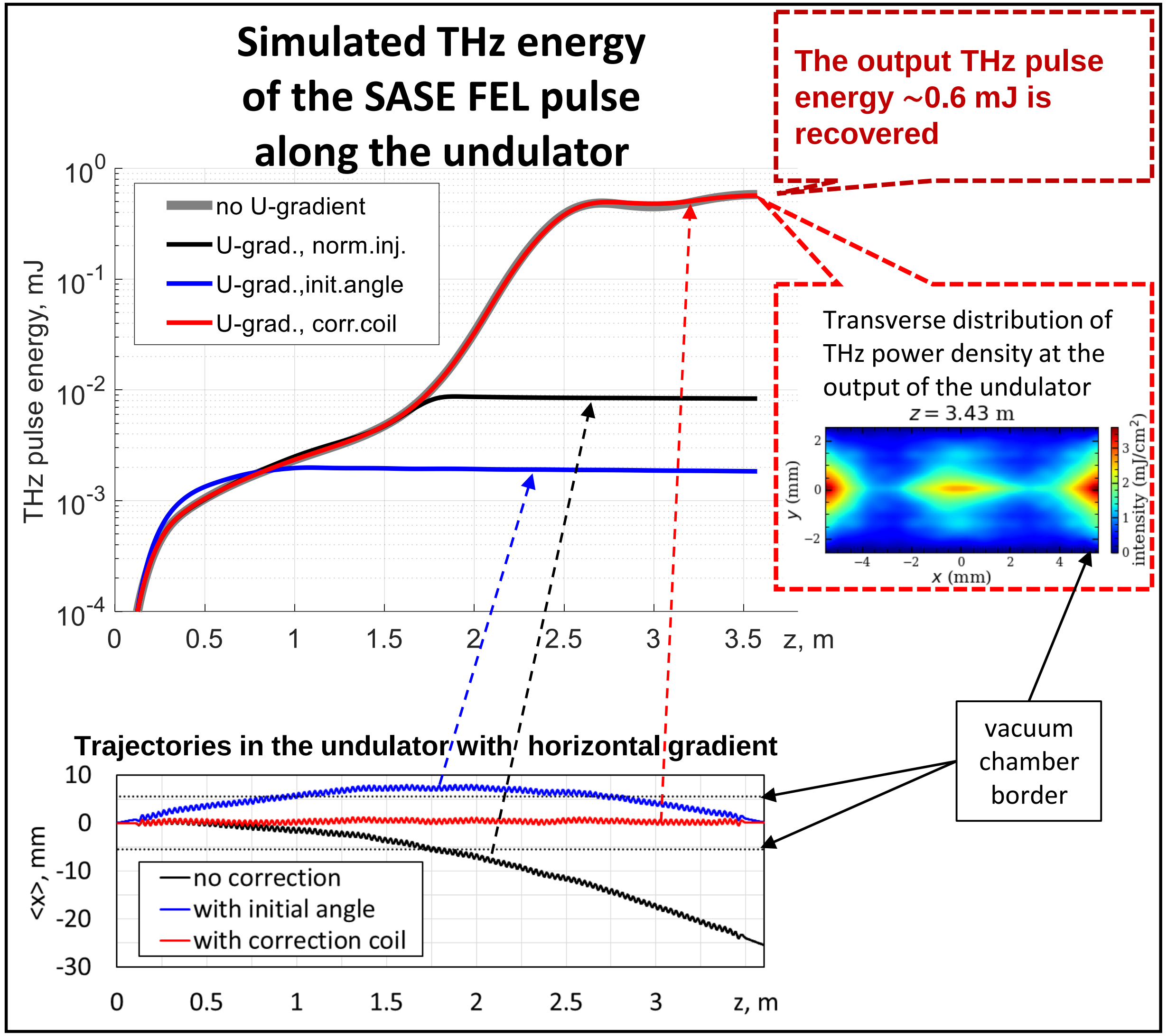
- simulation with a 3D field map with horizontal gradient and without/with compensation coil

Reference case:

- simulation with a 3D field map without a horizontal gradient

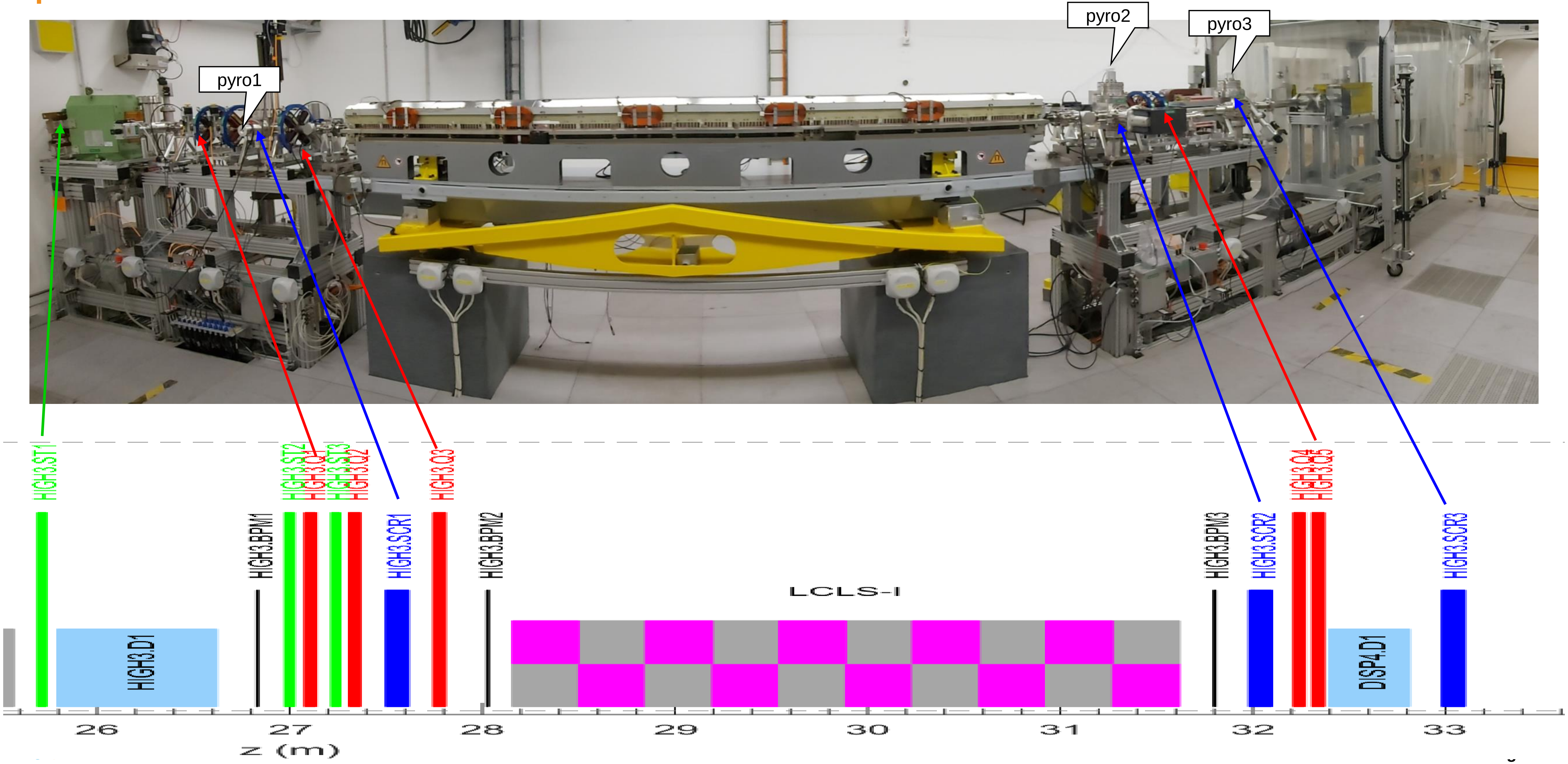






PITZ Beamline Components

Up to scale



Specification of the pyroelectric detector

THZ 10
THZ 20
THZ 30

Pyroelectric Detectors for THz-Radiation

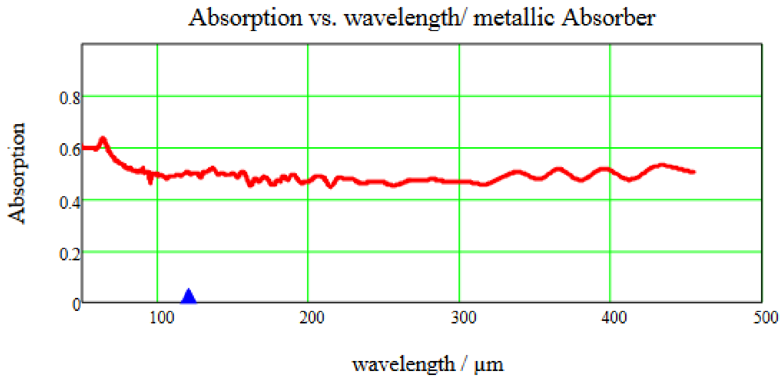
S e n s o r - u n d L a s e r t e c h n i k

Manual

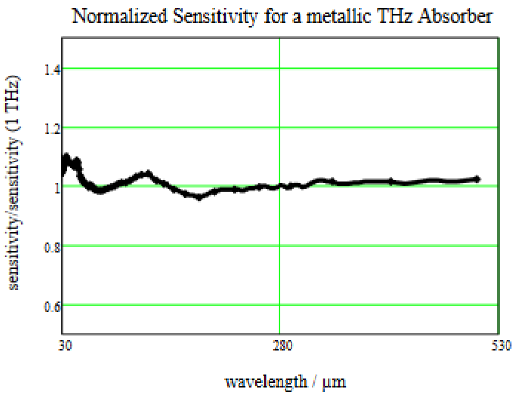
July 2016

SLT Sensor- und Lasertechnik GmbH • Freiheitstr. 124-126 • 15745 Wildau • Germany
Tel.: +49 3375-5257201 • Fax: +49 3375-5257203
www.pyrosensor.de • e-mail: service@pyrosensor.de

Absorption behaviour



The blue triangle marks the calibration wavelength (PTB Berlin)



Normalized sensitivity vs. wavelength (reference sensitivity at 300 µm)

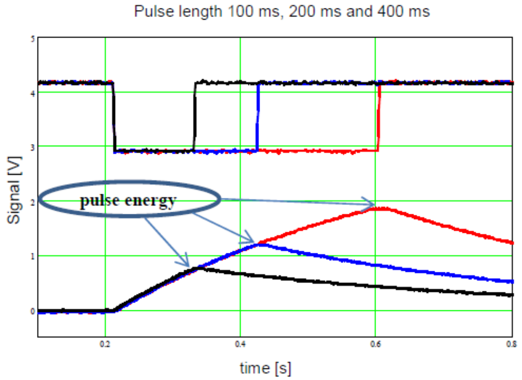
THz - Detector as Joulemeters

in combination with voltage preamplifier VST

For many application the pyroelectric sensors can be used directly in combination with an oscilloscope (R_i= 1 MΩ).

For these conditions the parameters (min. detectable energy and the max. rep. rate) are limited. In combination with a preamplifier these parameters can be extended.

Some typical parameters for detectors without preamplifier are summarized in the following list:



	Sensitivity /V/J	Min. detect. energy /µJ	Max. rep. rate
THz 10	>500	0.5	30
THz 20	>200	1	25
THz 30	>20	2	20

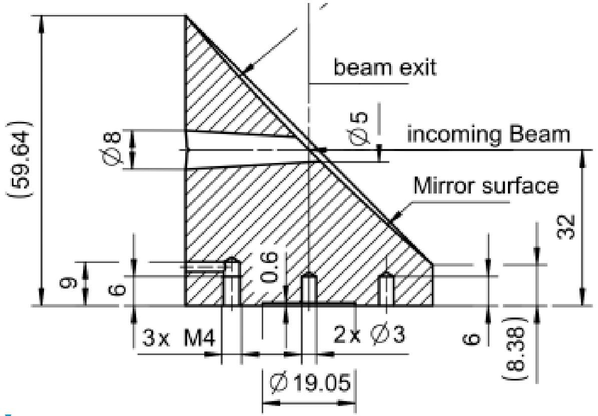
Currently: amplifier=1000

Pyroelectric Detectors at THz@PITZ

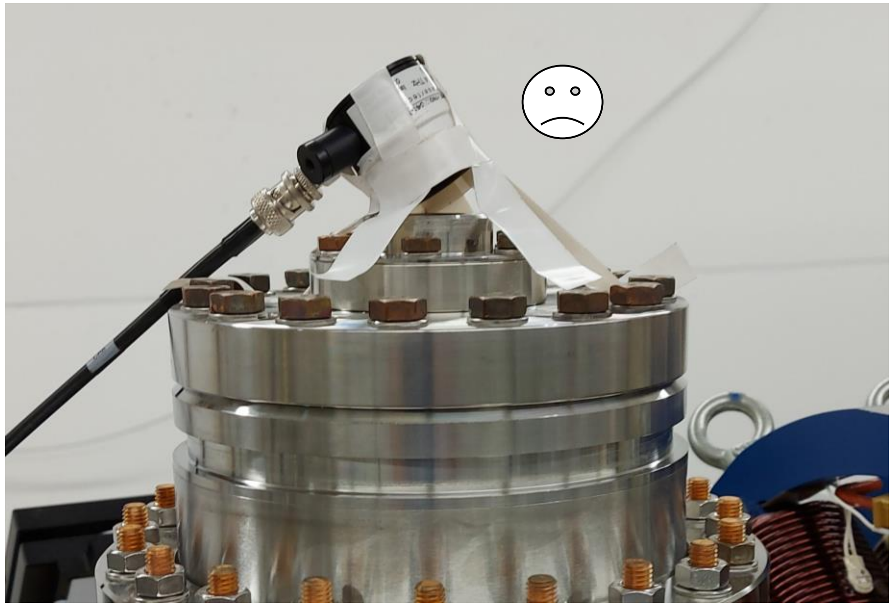
Evolution

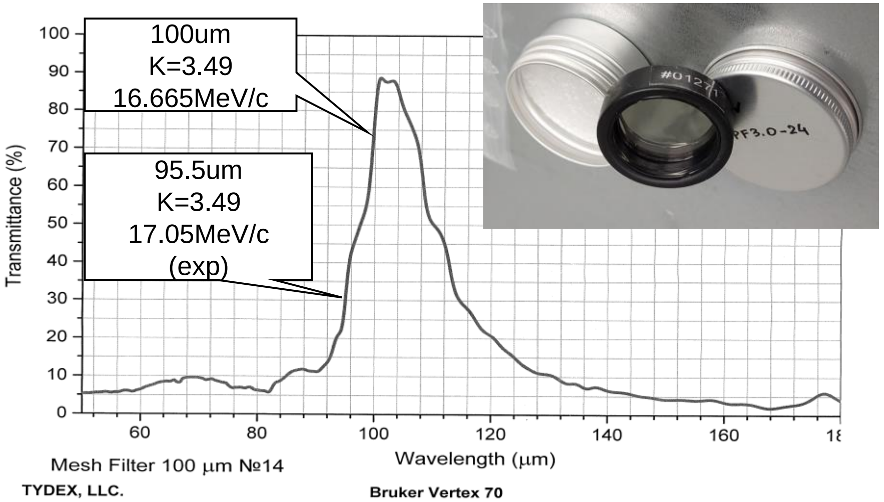
23.07.2022

23.07.2022 01:03 P. Boonpornprasert, C. Richard, M. Krasilnikov **THz pyroelectric detector installed with tape**



25.07.2022

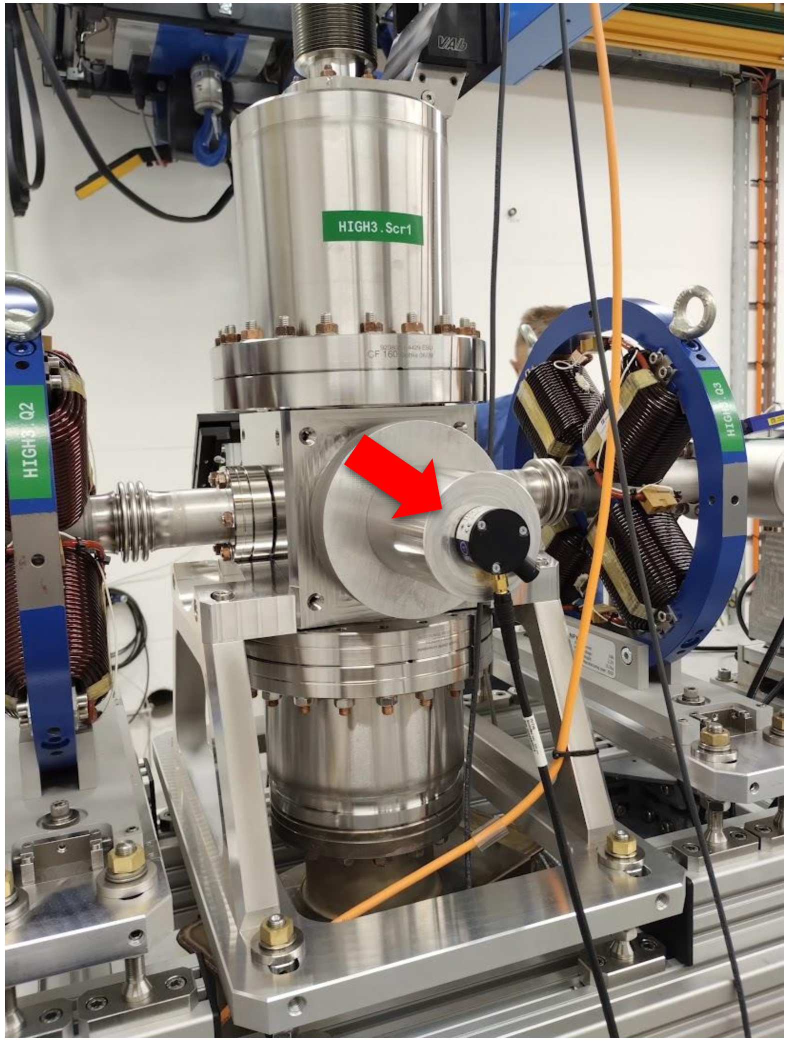


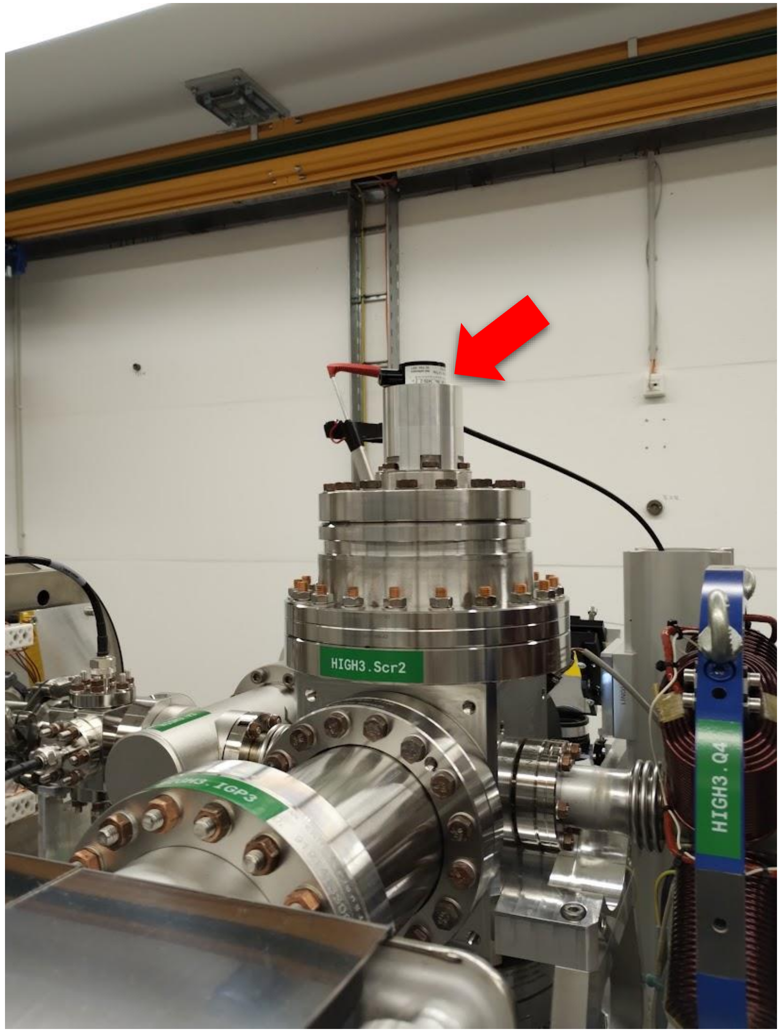


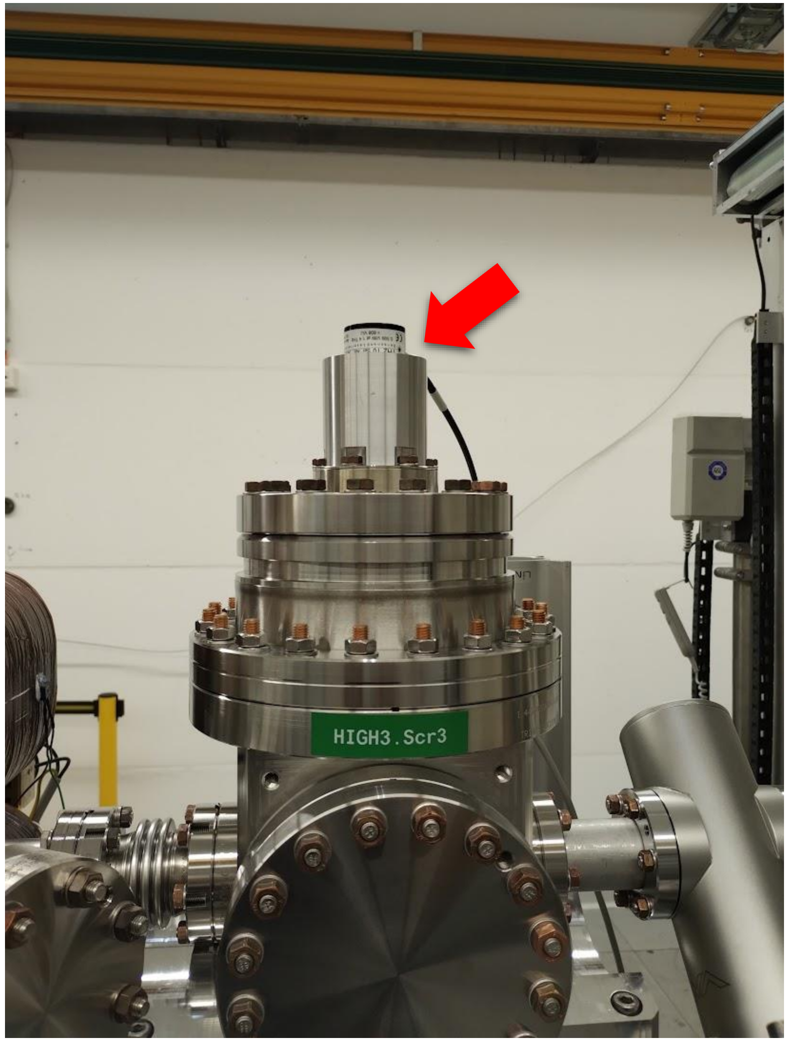
26.07.2022+

- No BPF
- BNC→SMA cable

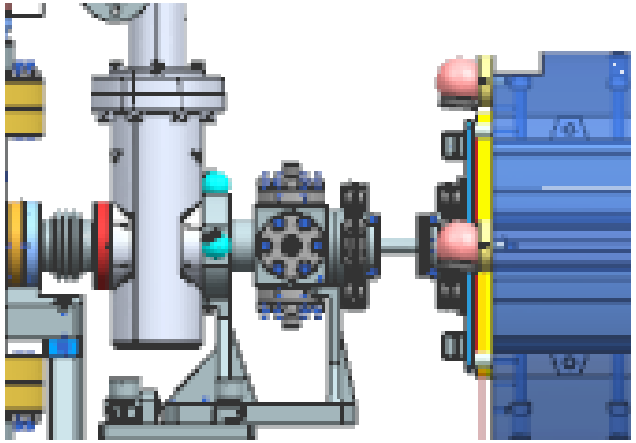
Installation of pyroelectric detectors

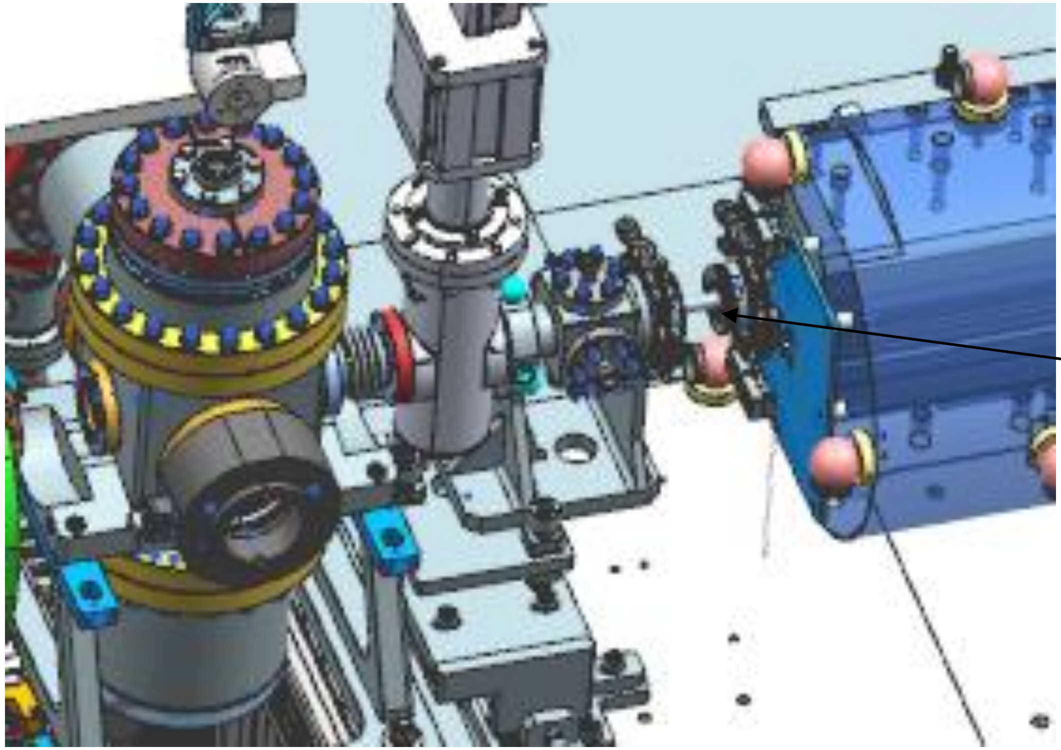






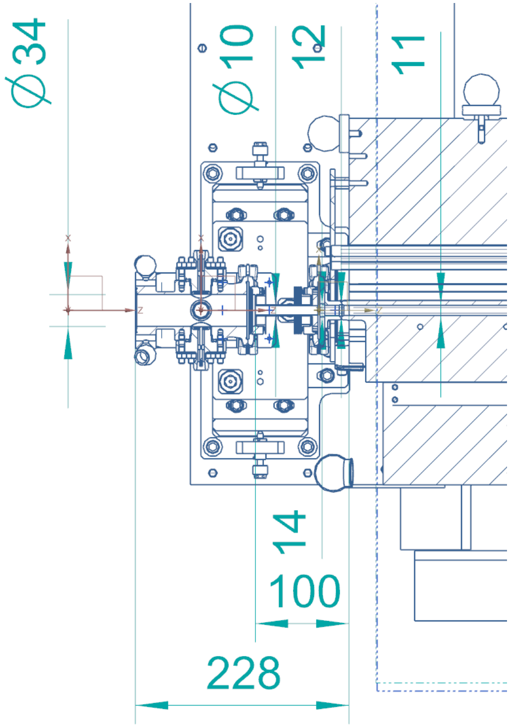
Undulator to HIGH3.Scr2 transition

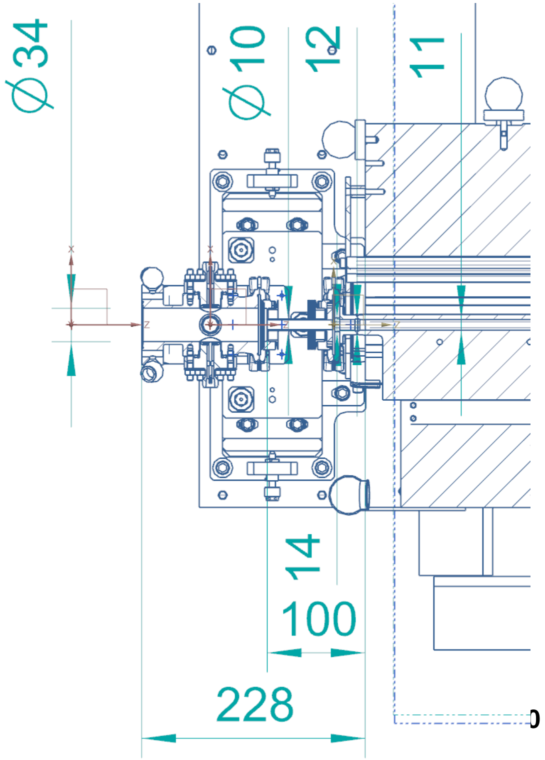




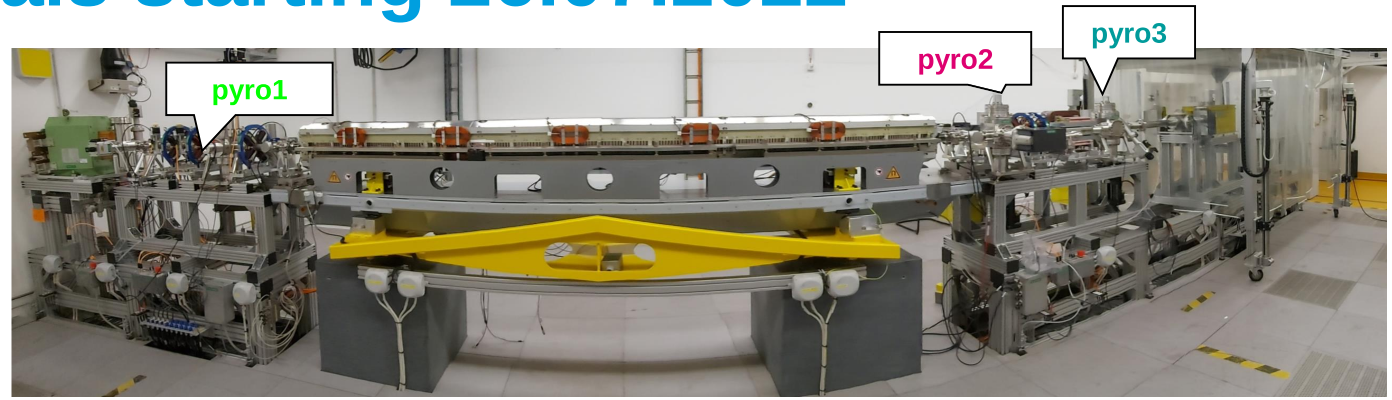
Undulator vacuum chamber

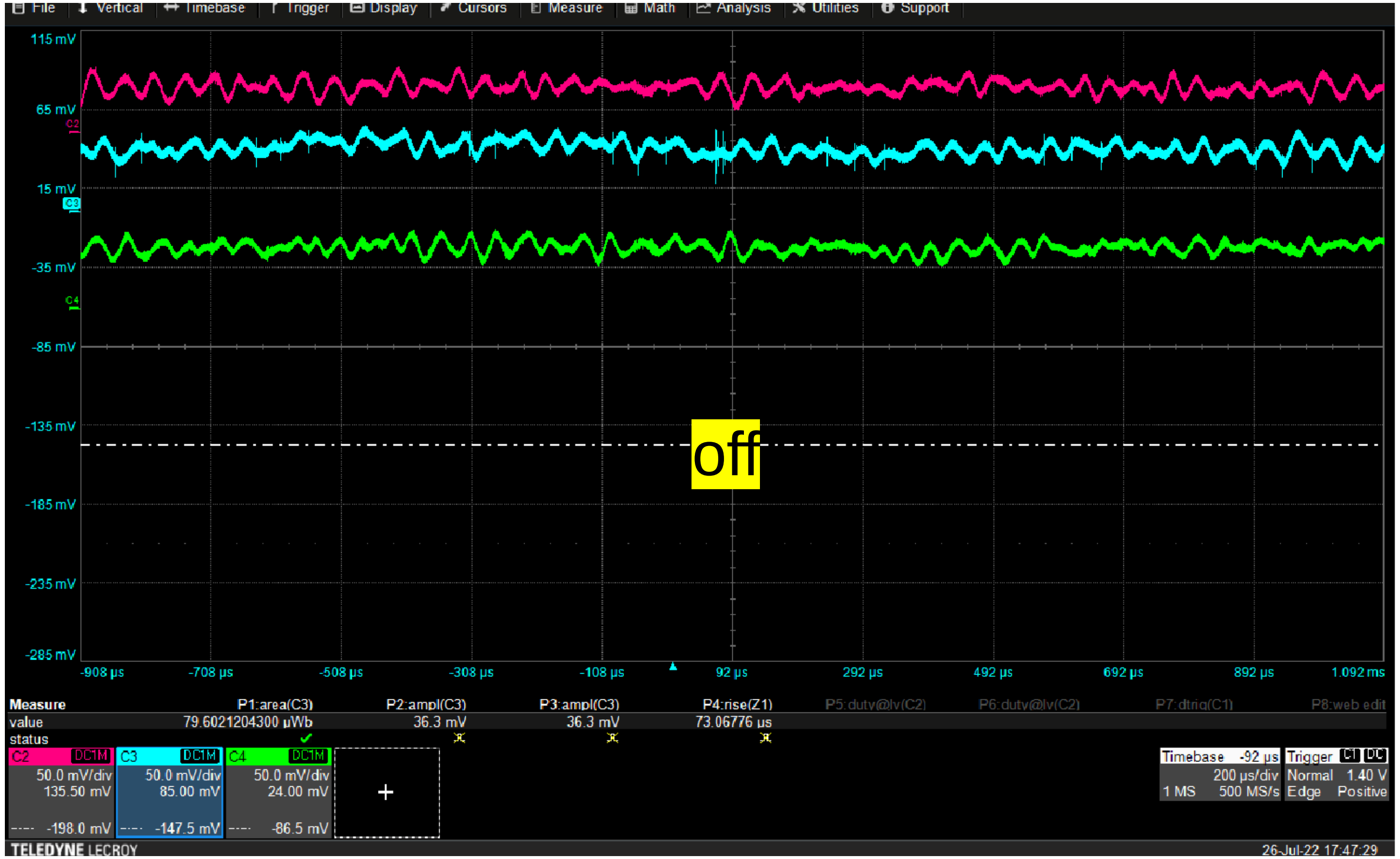
11mm x 5 mm





Pyro-signals starting 26.07.2022



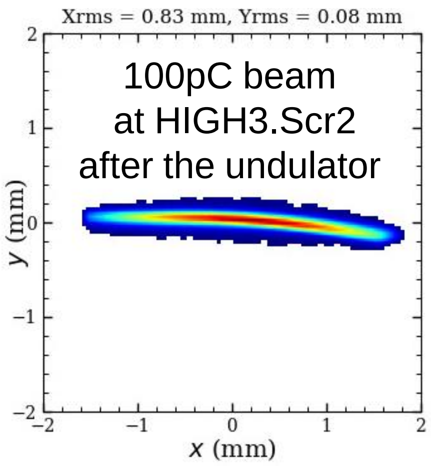


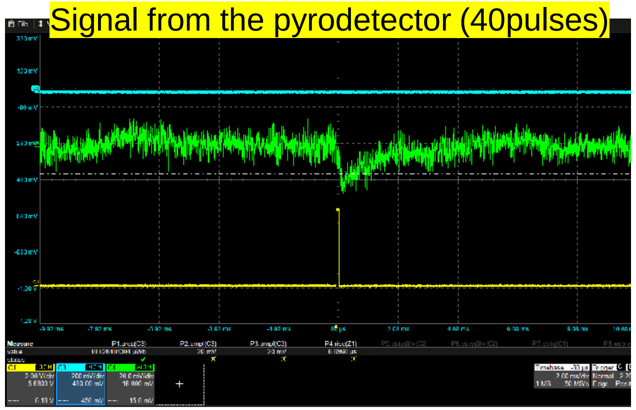
THz @ PITZ BL commissioning

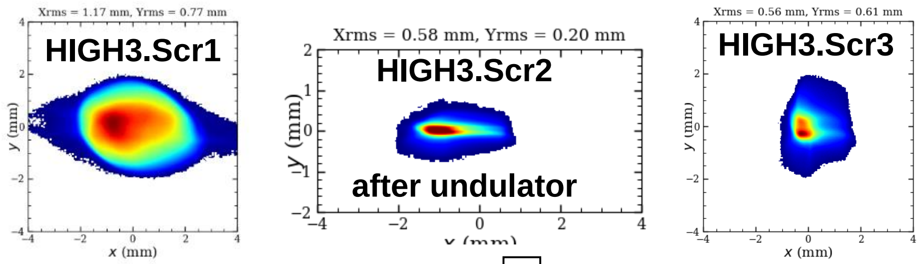
Status 25.07.2022N

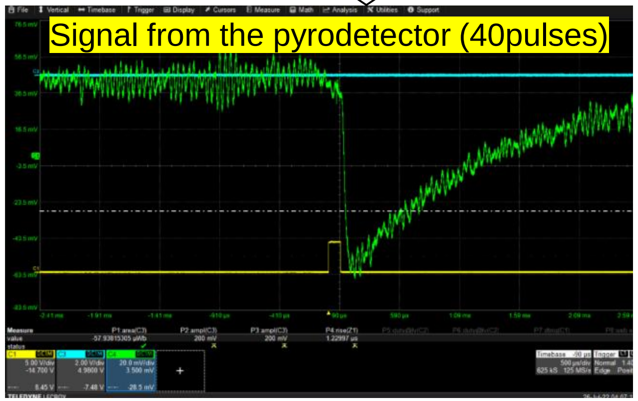
Operation/THz beamline commissioning:

- **100pC**, 17MeV/c beam transport:
  - through the undulator on 21.07.2022N! →
  - THz pyroelectric detector (THz10-3451-2 with bandpass filter BPF3.0-24) installed on top of HIGH3.Scr2 (using in-vacuum mirror with a hole)
  - First pyrodetector signal from the undulator detected on Saturday, 23.07.2022N with 100pC (M4-M5)
- **500pC** beam transport (M6):
  - through the undulator and the mirror hole at HIGH3.Scr2 till HIGH3.Scr3 on 24.07.2022M! →
  - Signal from the pyrodetector detected
- Discussions with HH-FEL-experts are ongoing
- Next steps:
  - Pyrodetector → designed mounting, remove the filter + other stations
  - **Operation: 1nC** (M7, ongoing)**, 2nC** transport **+ THz radiation**





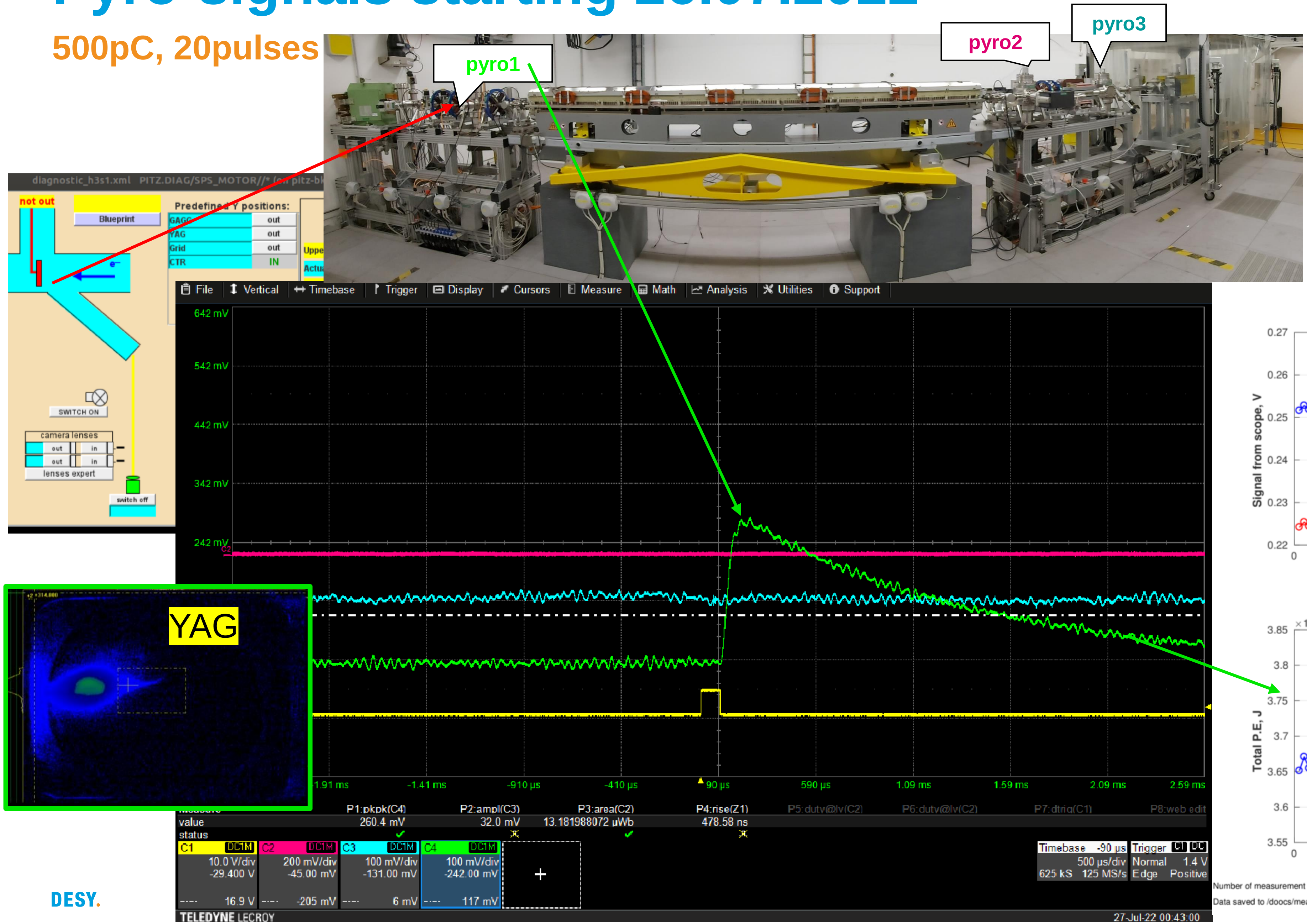




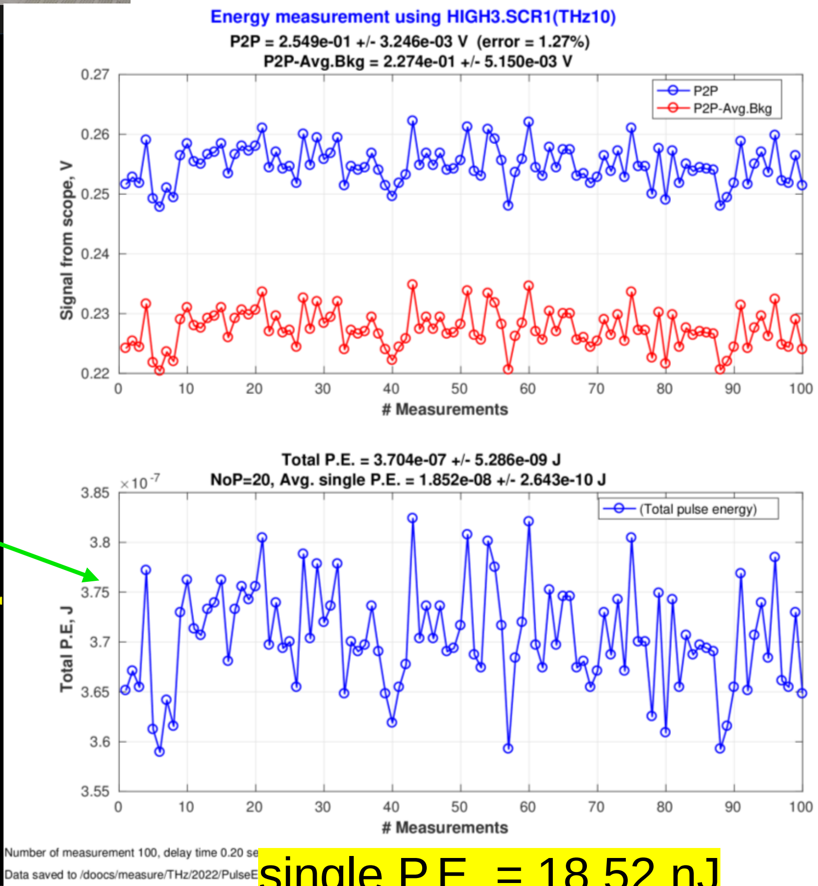
Pyro-signal<0 due to the capacitance effect (dielectric frame of the BPF)?

Pyro-signals starting 26.07.2022

500pC, 20pulses



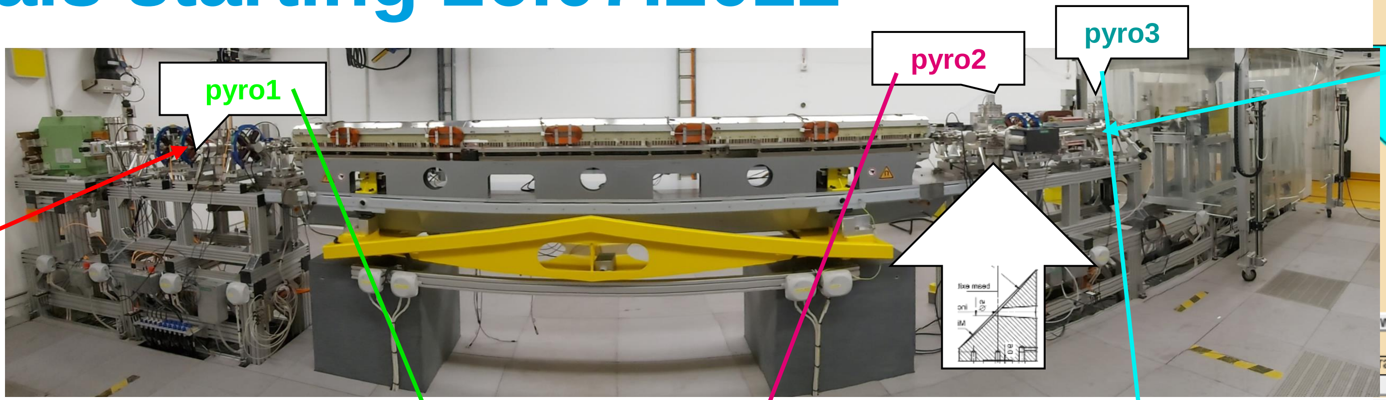
No signals from other pyrodetectors

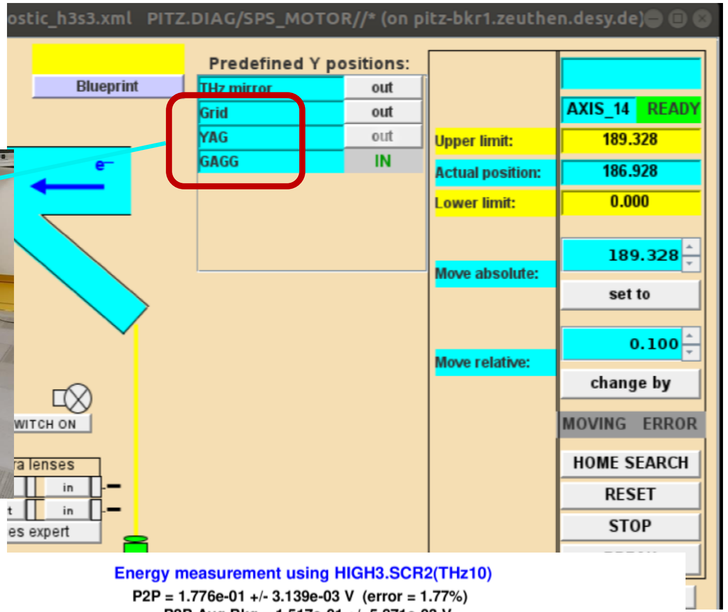


single P.E. = 18.52 nJ

Pyro-signals starting 26.07.2022

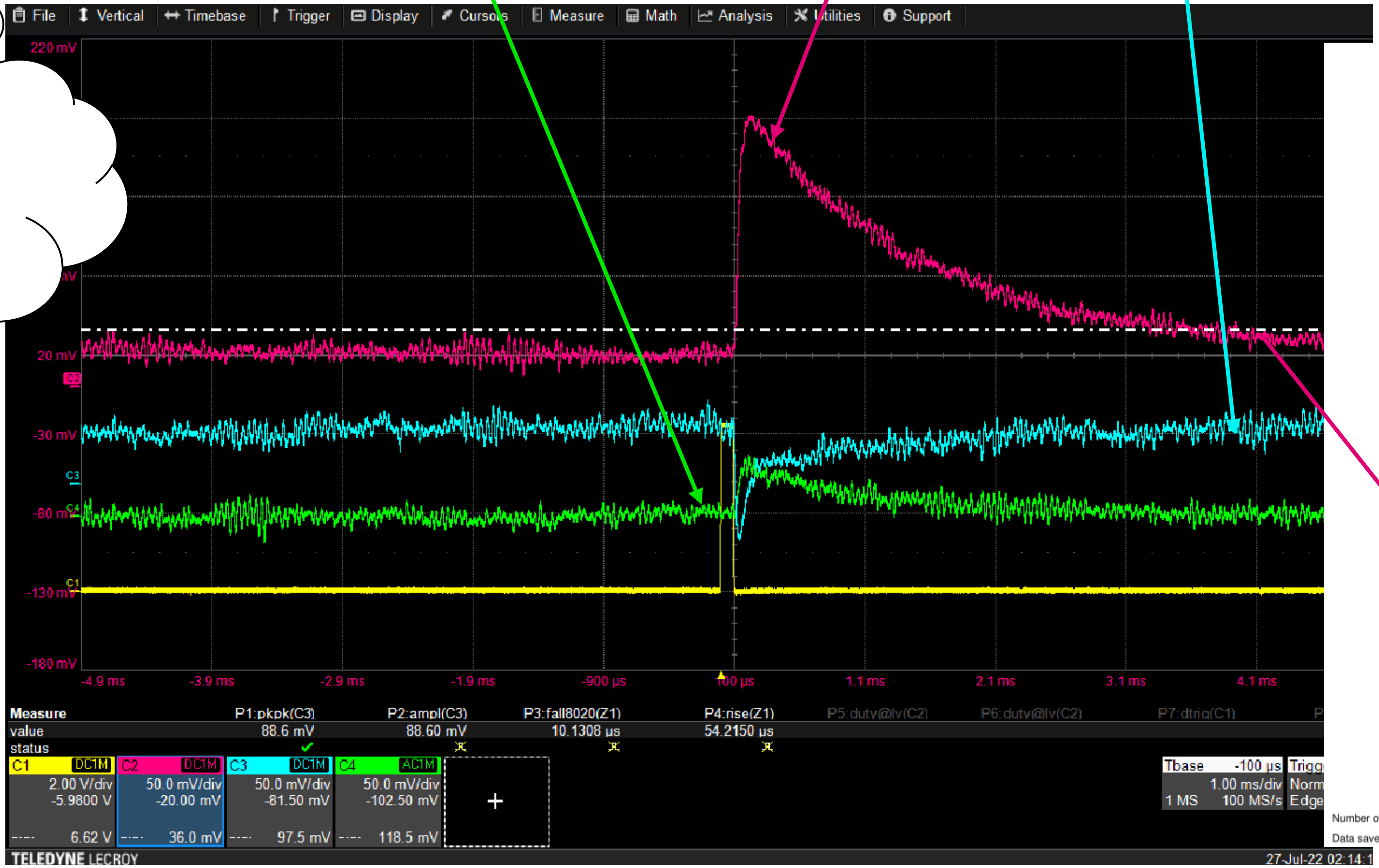
500pC, 20pulses

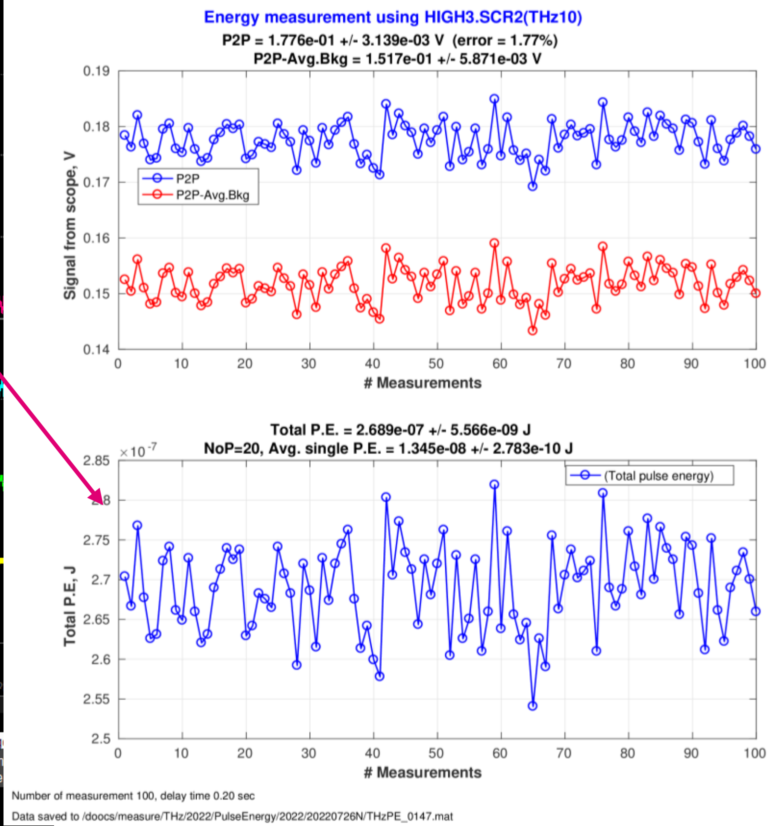




out

Weak positive pyro1 due to the positive image charge from the beam?

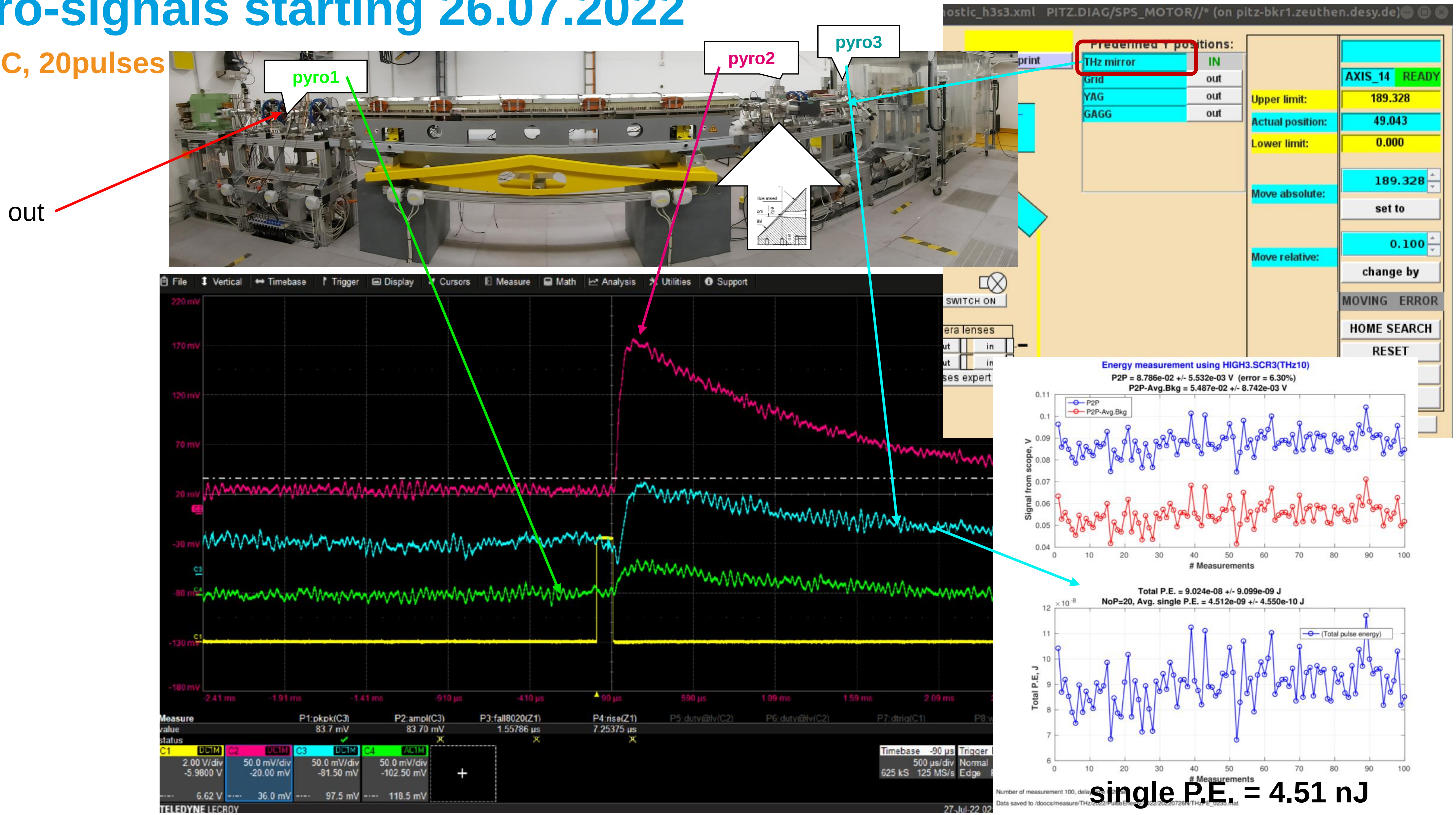




DESY.

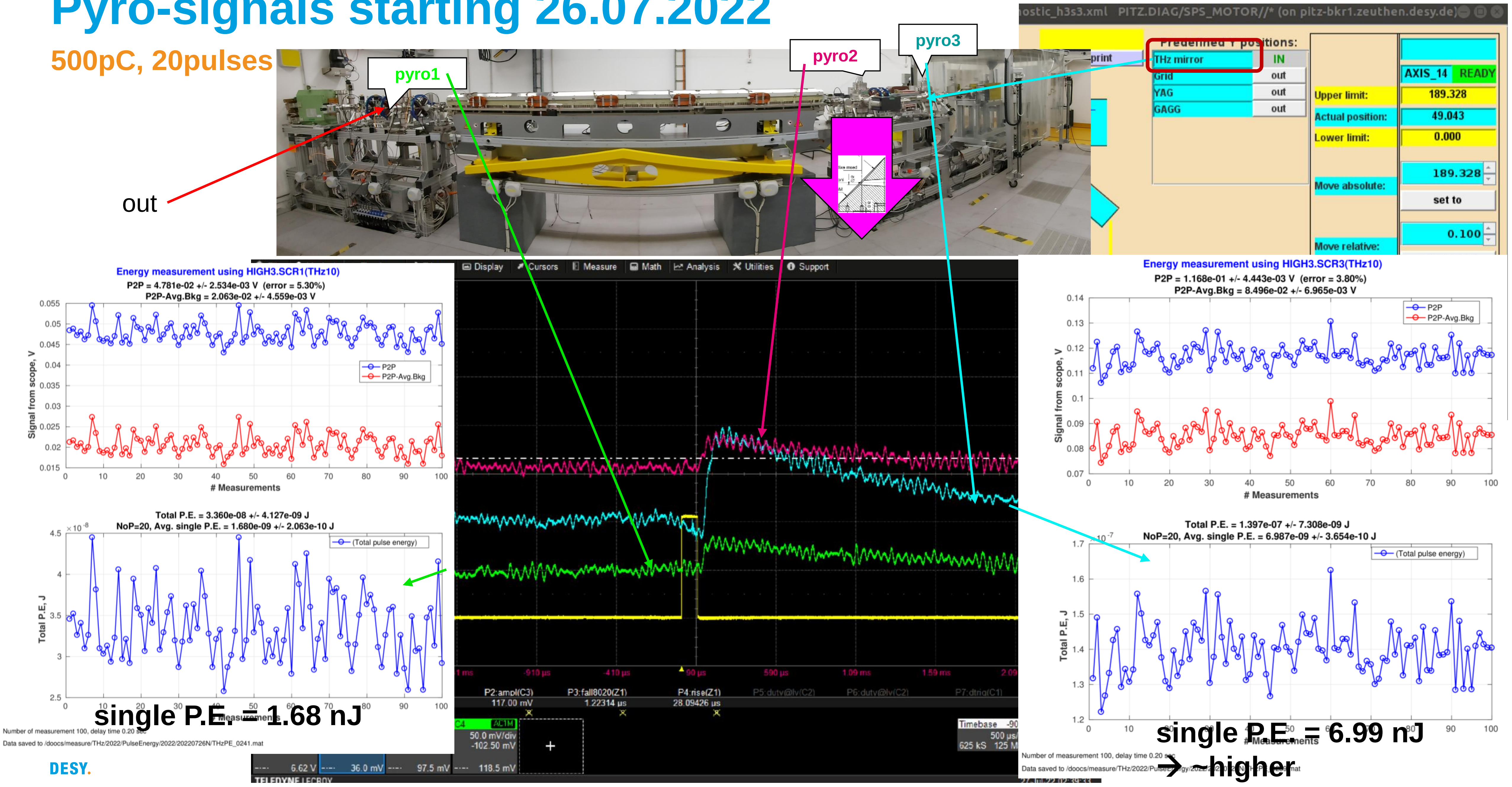
Pyro-signals starting 26.07.2022

500pC, 20pulses



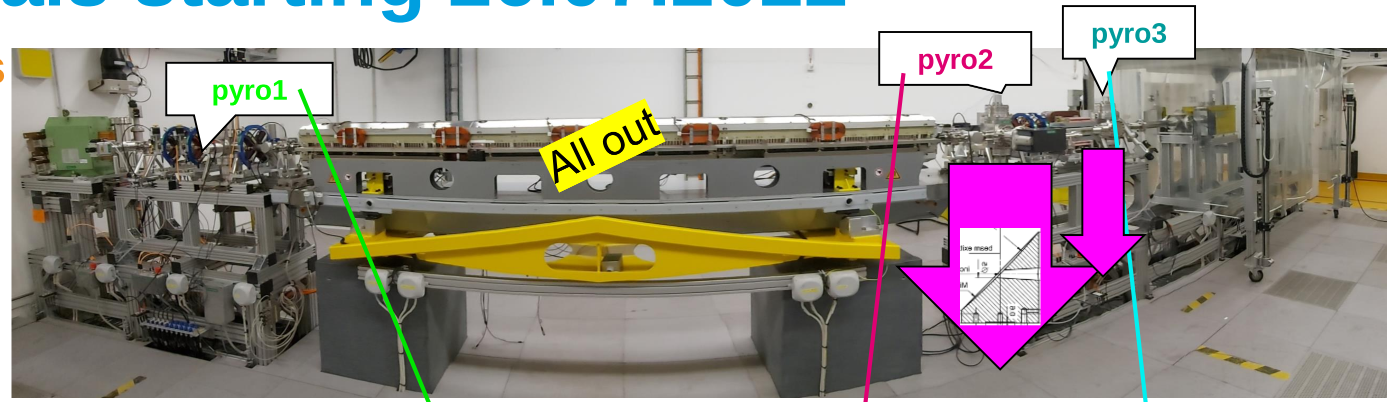
Pyro-signals starting 26.07.2022

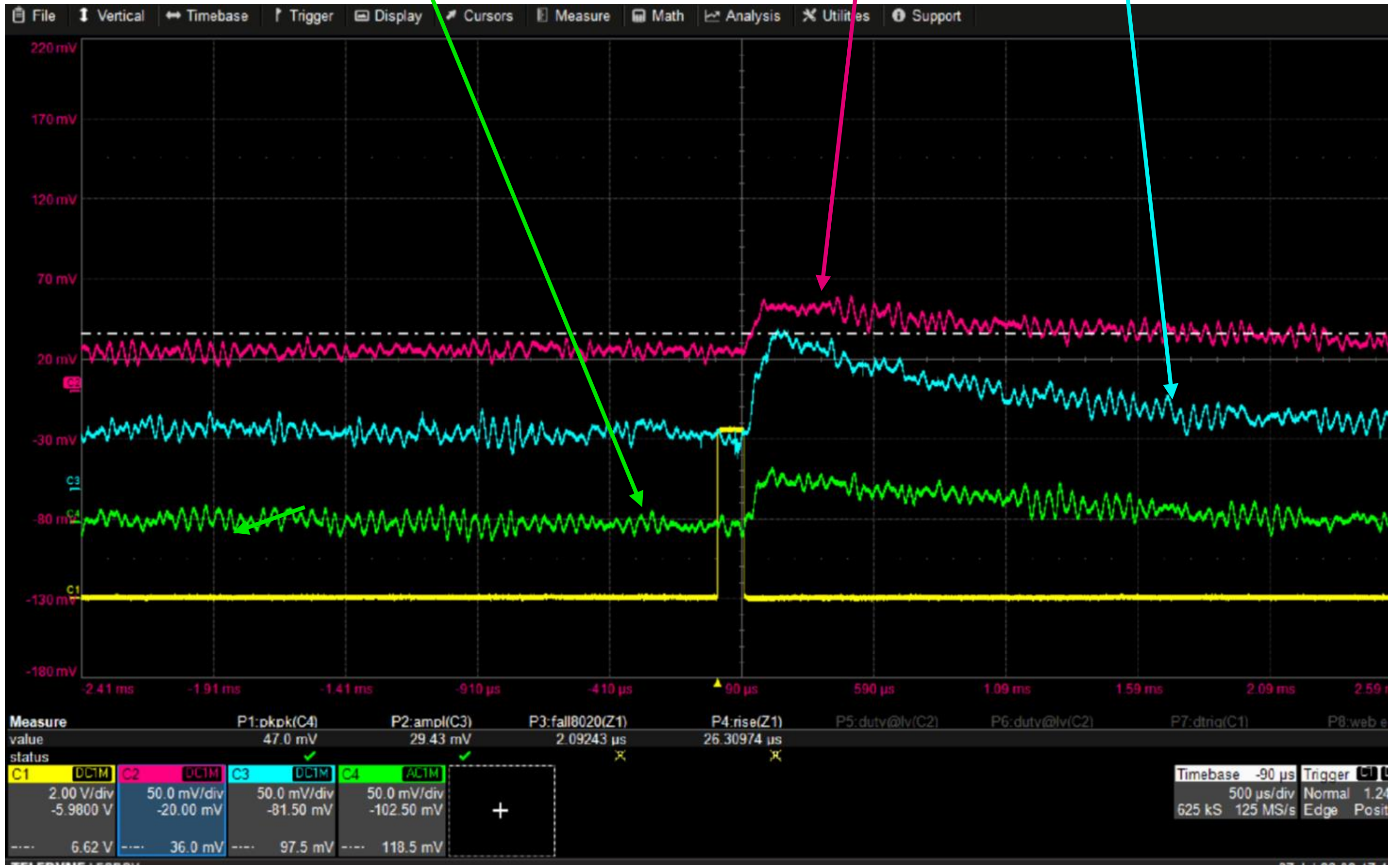
500pC, 20pulses



Pyro-signals starting 26.07.2022

500pC, 20pulses

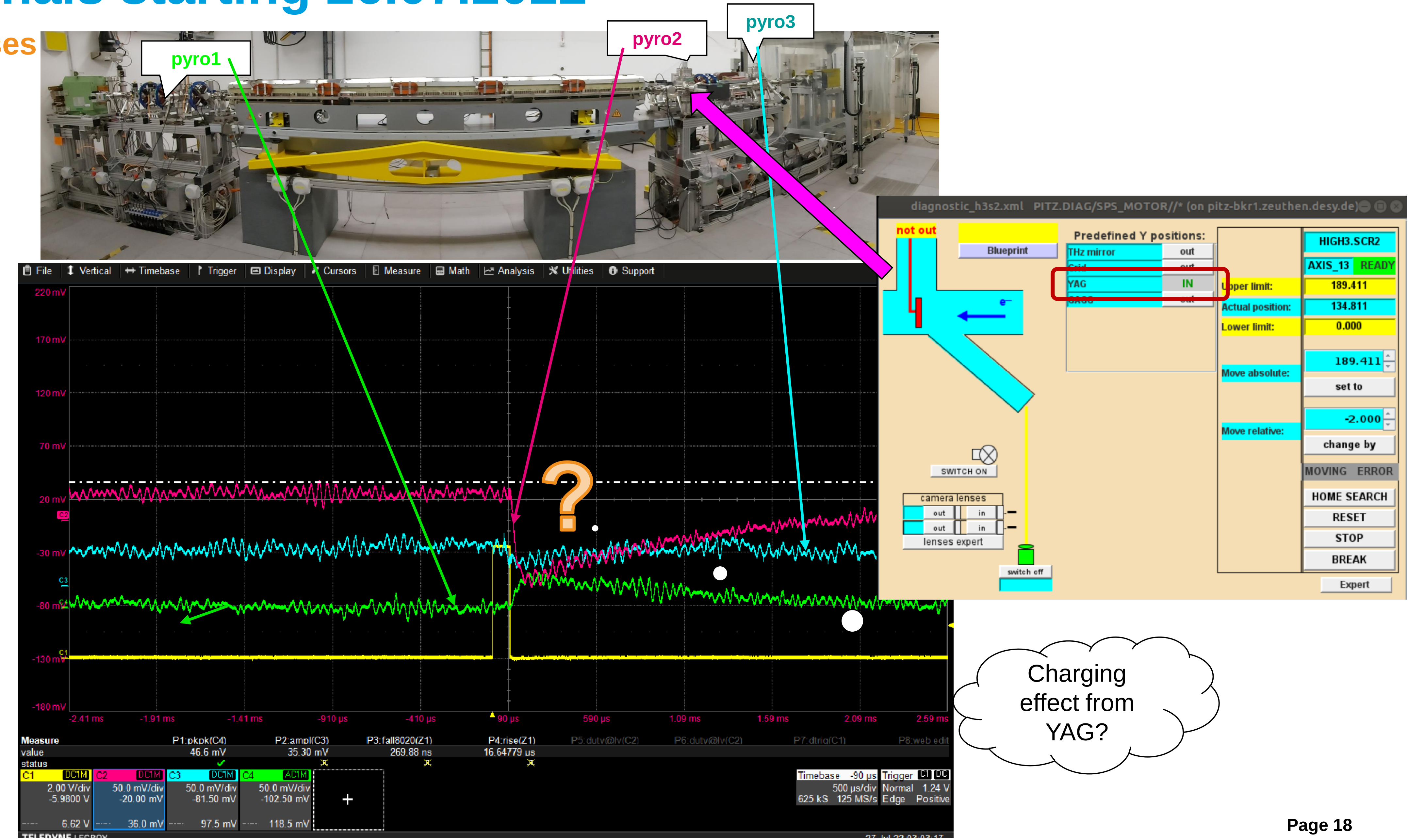




Only signal from pyro3 got smaller. Signals from pyro1 and 2 were similar to that when High3.Scr3 mirror was inside.

Pyro-signals starting 26.07.2022

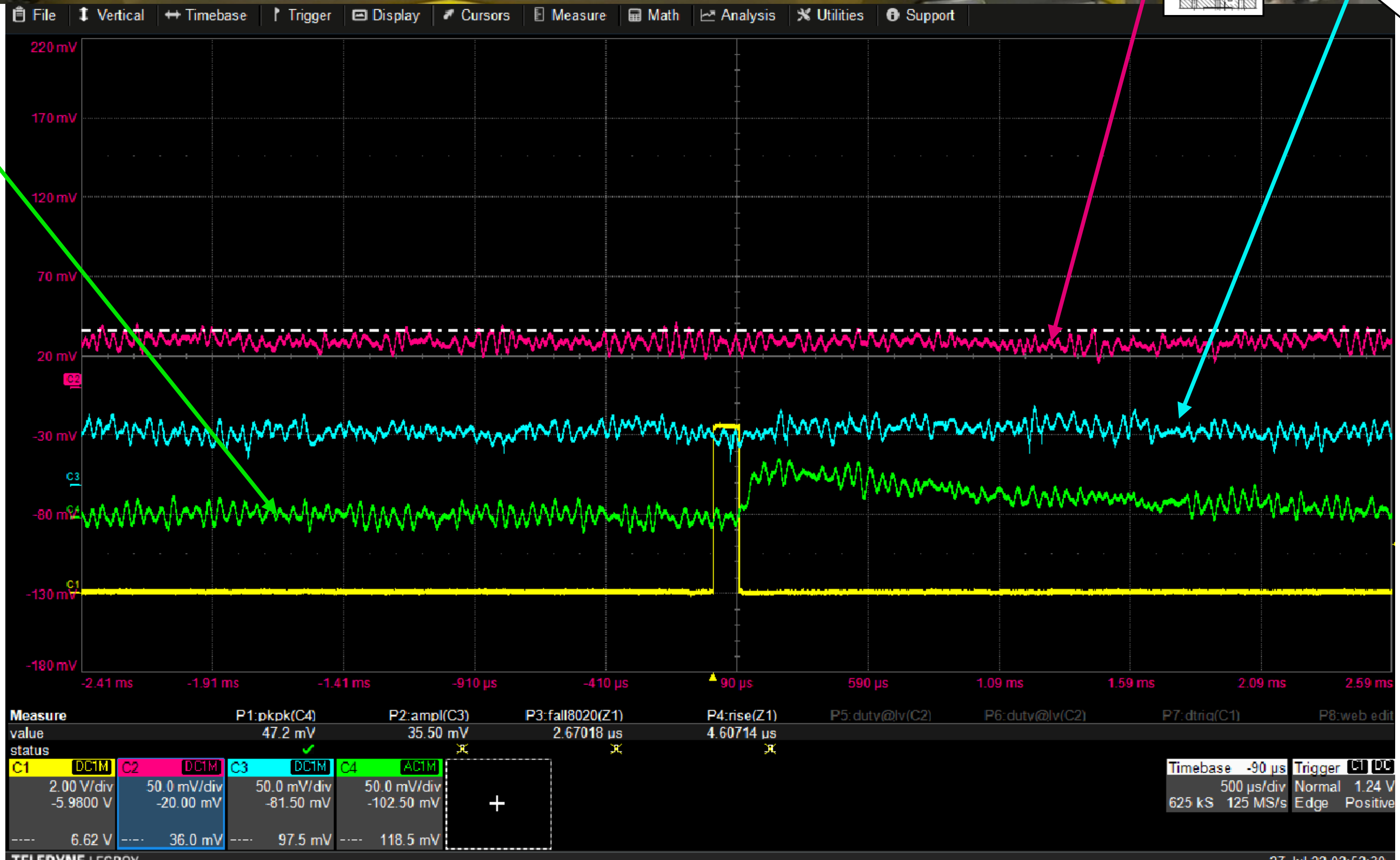
500pC, 20pulses



Charging effect from YAG?

Pyro-signals starting 26.07.2022

500pC, 20pulses



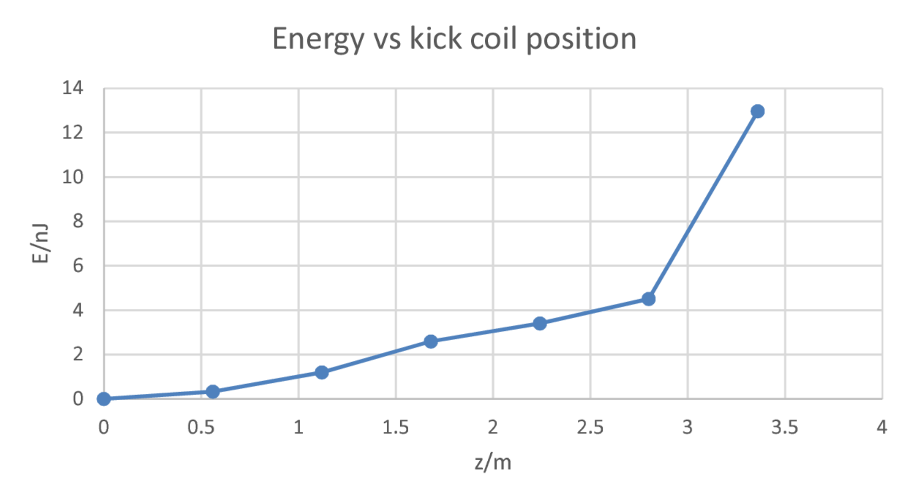
Kicked the beam towards the vacuum chamber with SCC1

No beam detected here

Pyro-signals starting 26.07.2022

500pC, 20pulses, pyro2 vs. SCCoil# kick

#	z/m	E/J	E/nJ
0	0	0	0
1	0.56	3.336E-10	0.3336
2	1.12	1.198E-09	1.198
3	1.68	2.59E-09	2.59
4	2.24	3.397E-09	3.397
5	2.8	4.502E-09	4.502
6	3.36	1.296E-08	12.96



Summary of 27.07.2022N

X.-K. Li, M. Liebel

The waveforms were taken and saved on scope desktop: ending with 000x.csv

1. Scope output signs:

-High3.Scr1, positive signals with long tail for both YAG (0002) and CTR (0001), measured more with CTR;
-High3.Scr2, positive signal with long tail for mirror (0003) and negative with long tail for YAG (0004), measured more with mirror;
-High3.Scr3, positive signal with long tail for mirror (0006) and negative with short tail for YAG (0005), measured more with mirror and even more when High3.Scr2 was empty.

2. Measured the most radiation energy at High3.Scr1, with CTR inserted.

3. For High3.Scr2, the scope output was maximized when the beam passed through the hole, contrary to findings of prev. night shift; when moving the mirror (even by 10 mm, beam completely gone at High3.Scr3), the signals became weaker but didn't vanish, which was also unlike prev. night shift. See 02:47.

Could it be that now with the cone, the collection efficiency is higher? Moving the mirror means the focusing from the mirror is not perfect, but with the help of the collector, radiation could still be measurable?

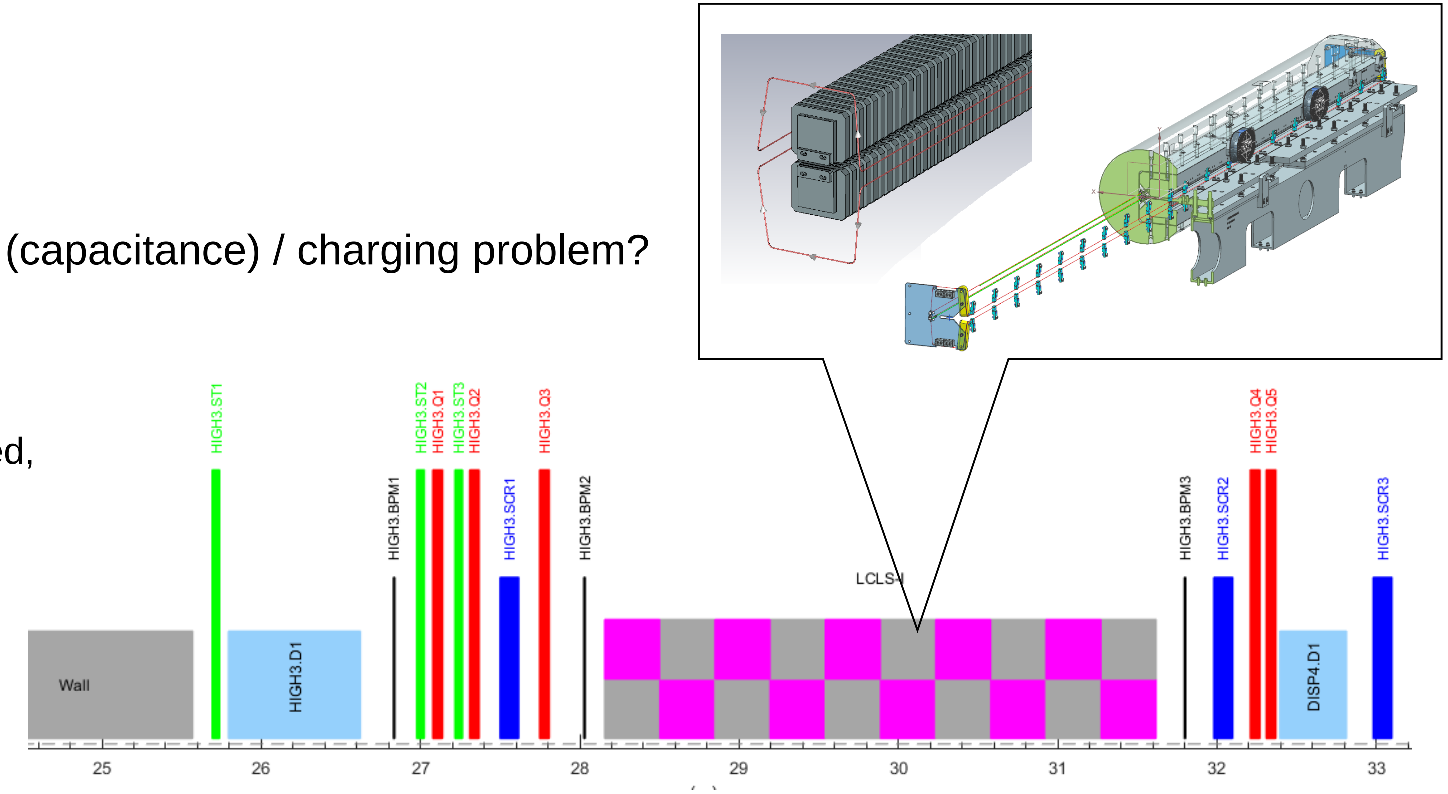
4. When the mirror was inserted at High3.Scr3, the detector measured more radiation energy if High3.Scr2 was empty.

5. When all three screen stations were empty (electrons went to the dump), still measured something from all three detectors.

Discussion

Next steps

- Pyro detector signals interpretation? Grounding (capacitance) / charging problem?
- Tools for trajectory / matching optimization:
  - HIGH1.Scr1,2,3 → Full functionality
  - BPM → Limited functionality (not precisely calibrated, the signals are OK)
  - New magnets → Limited functionality:
    - All → Tine (not DOOCS) protocol only
    - Rotational stages→ very preliminary GUI
  - BLMs→ Not available
- Next:
  - 1nC (ongoing)
  - 2nC
  - 4nC?
  - Gain curve(s)
  - 20-22MeV



- High3.St1-X,Y
- High3.St2-X,Y
- High3.St3-X,Y

- Long Corr. Coils LCC1,2 -X
- Short corr. Coils SCC1,2,3,4,5-X

Elaborate the transport matrix model for the undulator section?

- Very new update (27.07.2022A) → MBI photocathode laser problems (booster) → low and unstable pulse energy… → Pharos 250pC max (BSA=1.5mm)