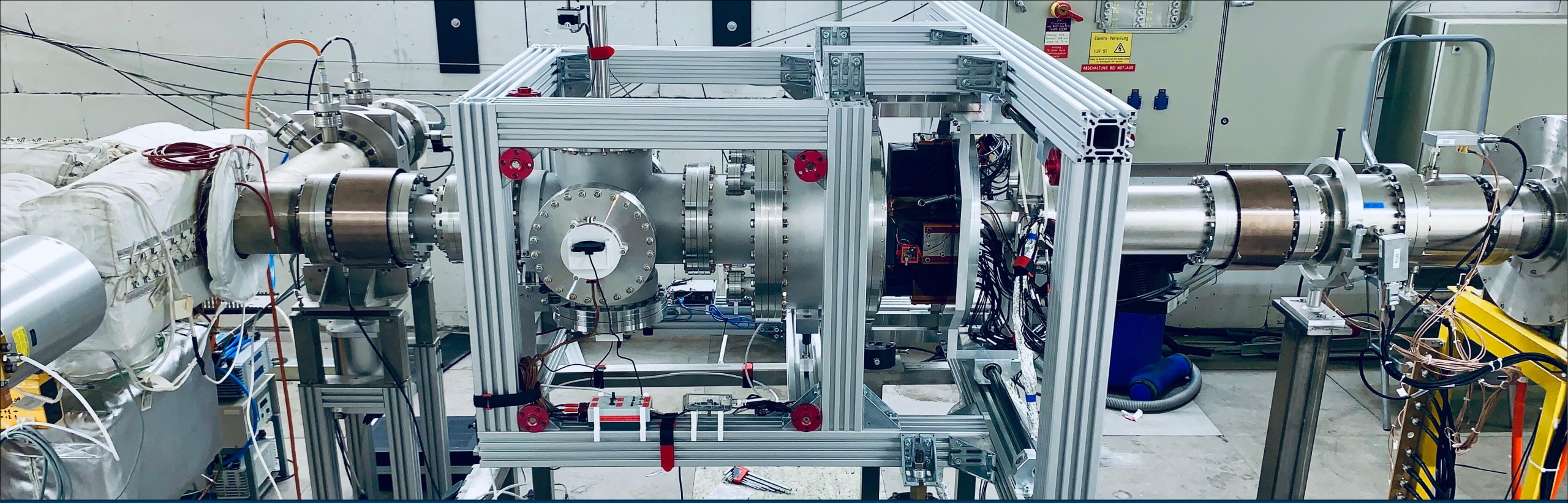


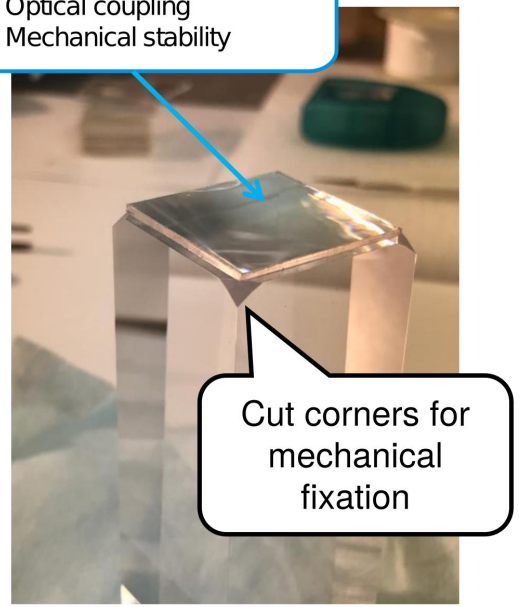
Contributions to the SMART|EDM_Lab

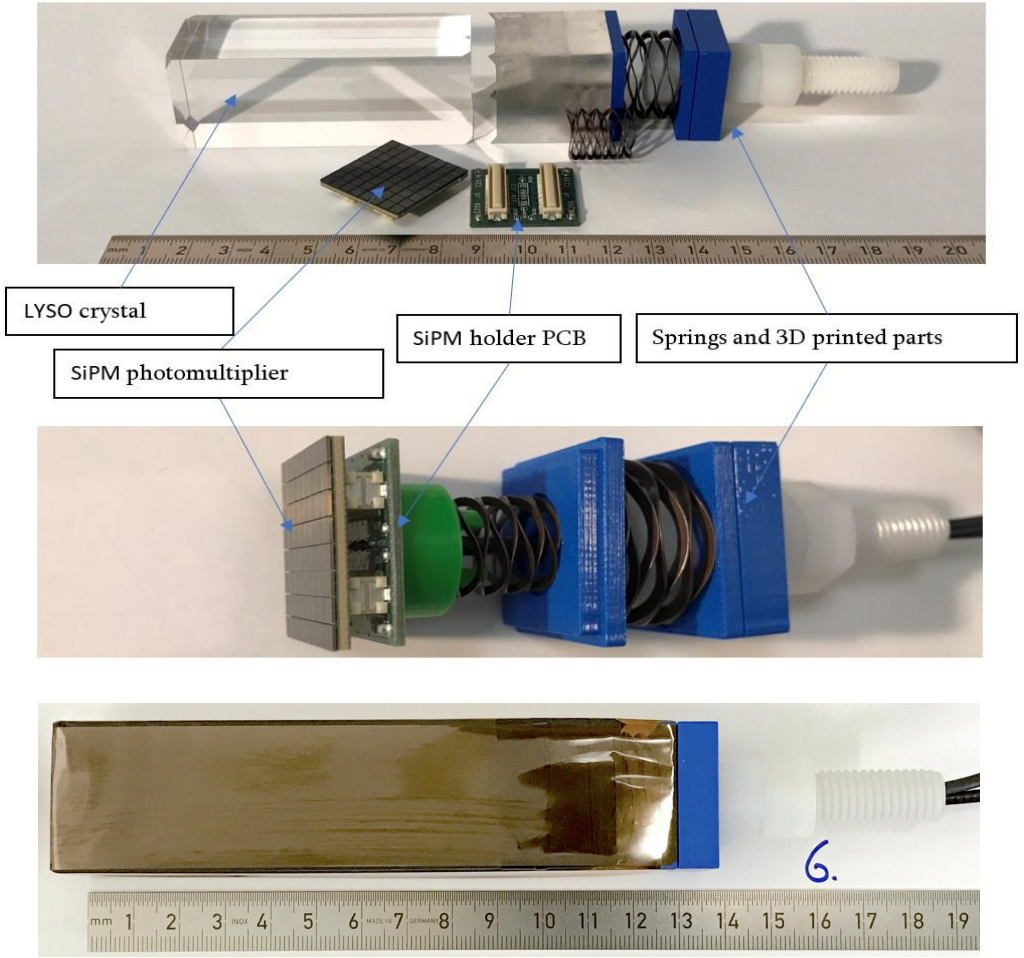
GGSB (Georgian-German Sciense Bridge) 2022

15.09.2022 OTARI JAVAKHISHVILI

Detector modules

- 52 independent LYSO modules
- Each module is tested and calibrated separately

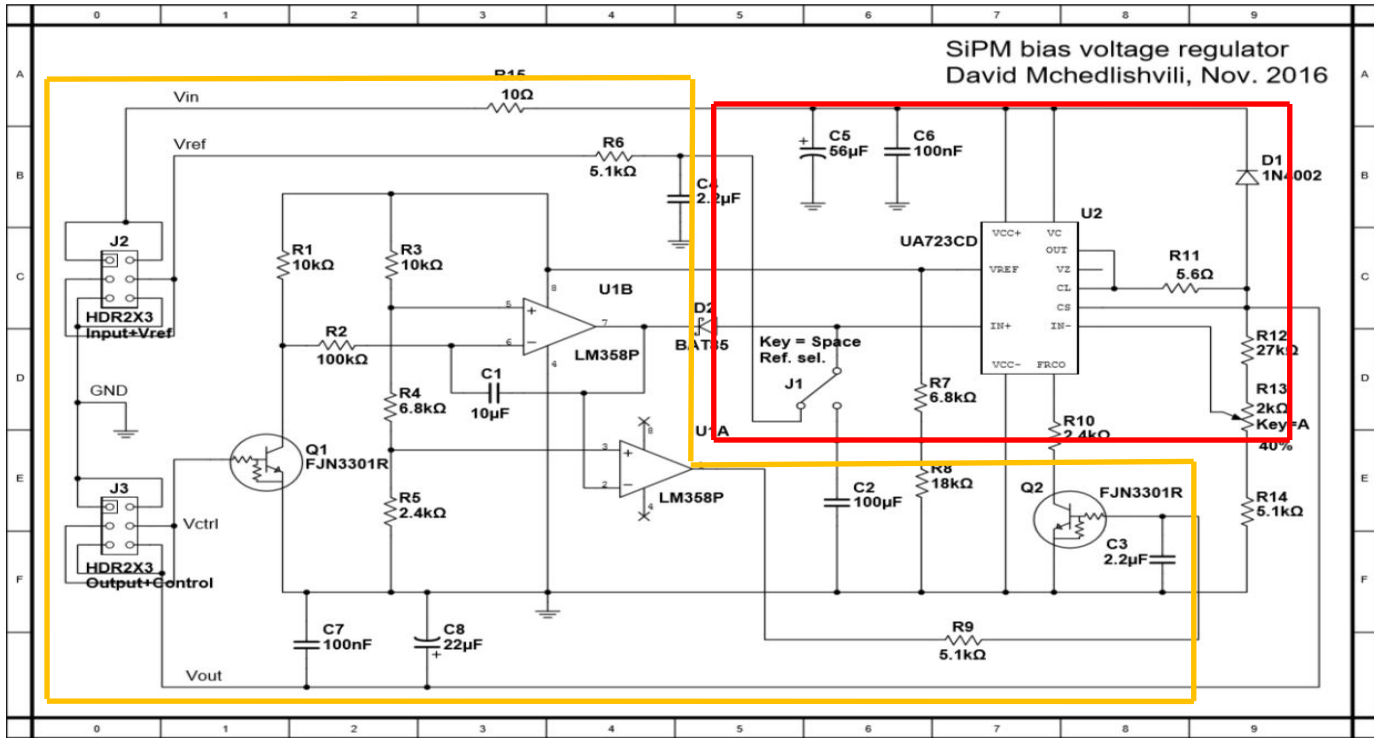




Development of a new voltage source

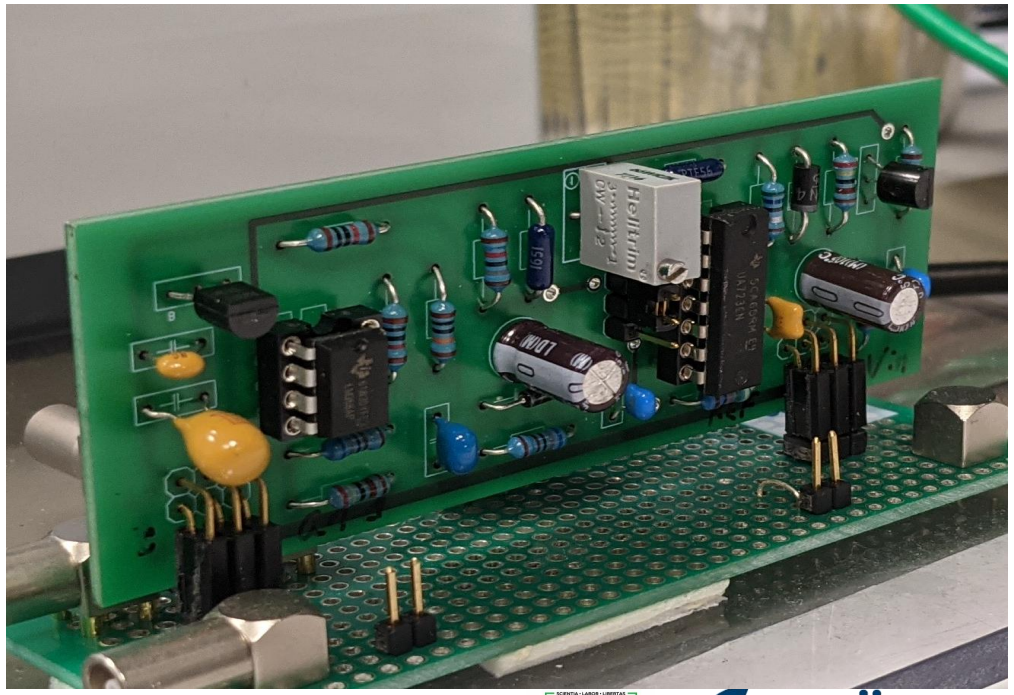
Basic requirements:

- Modular design
- High output stability *(temperature, long/short term, low noise)*
- Remote on/off capability *(currently organized using Raspberry Pi)*
- Voltage adjustment *(currently only manual)*

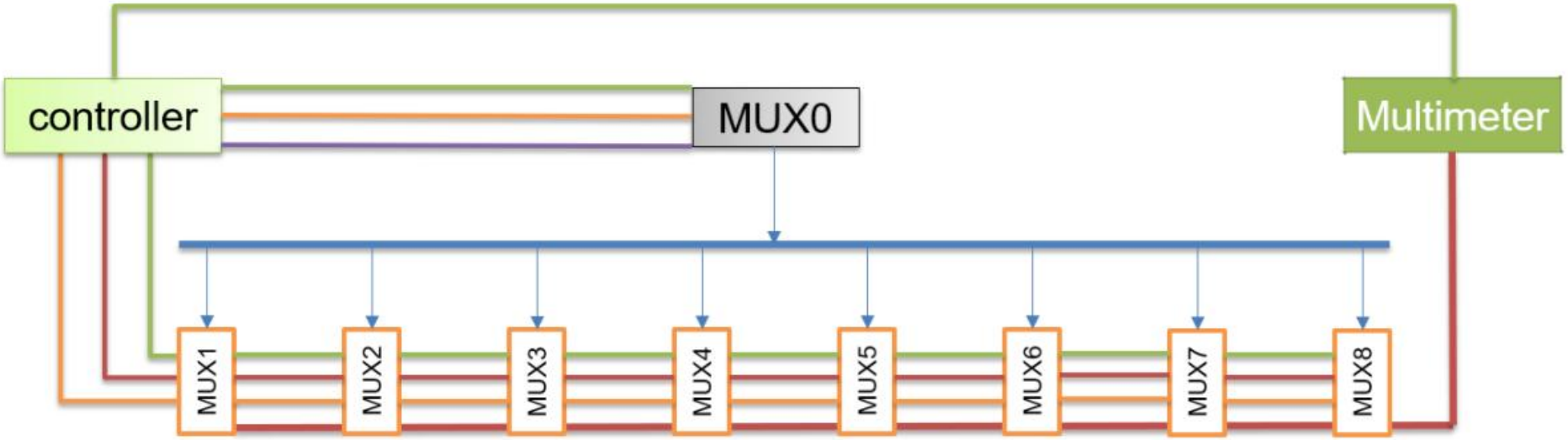


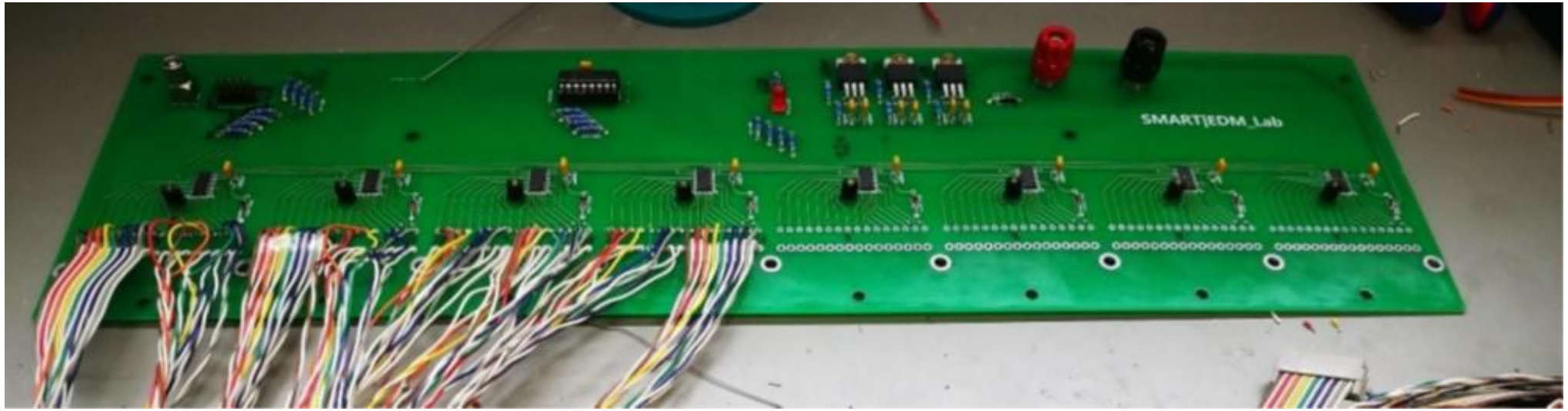
* Linear voltage regulator part

* Ramp generator and on/off part

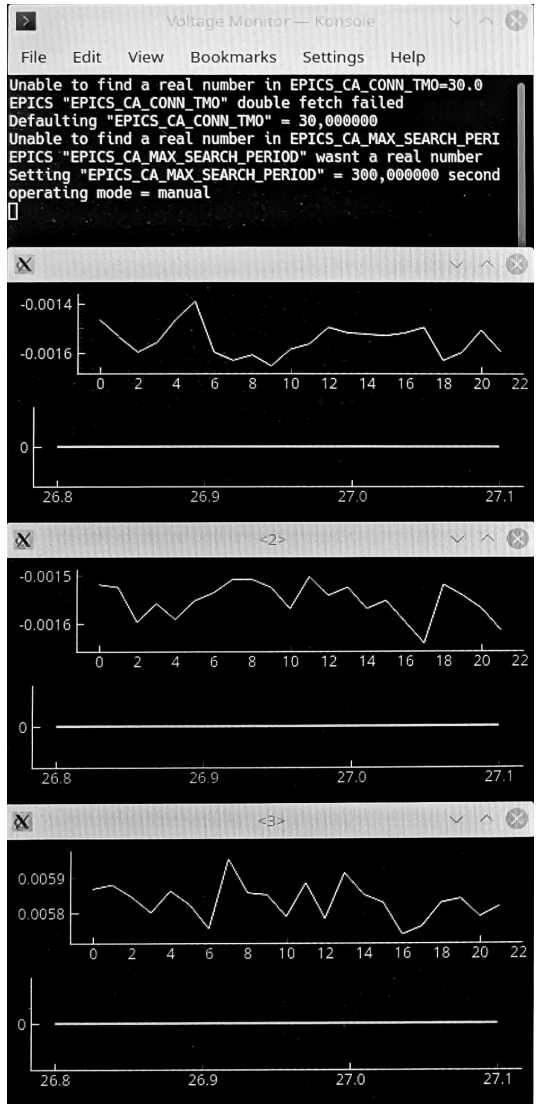


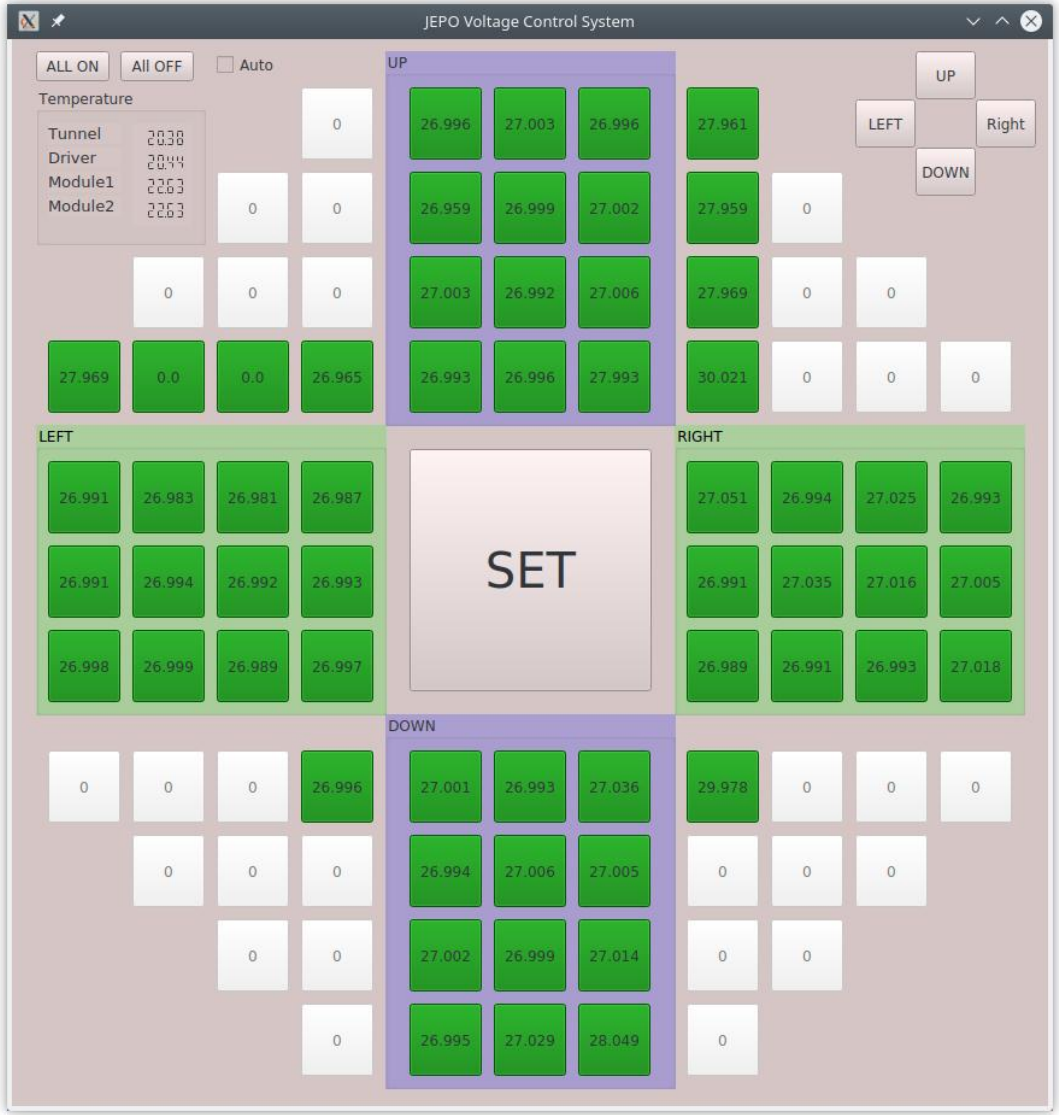
Voltage monitoring system



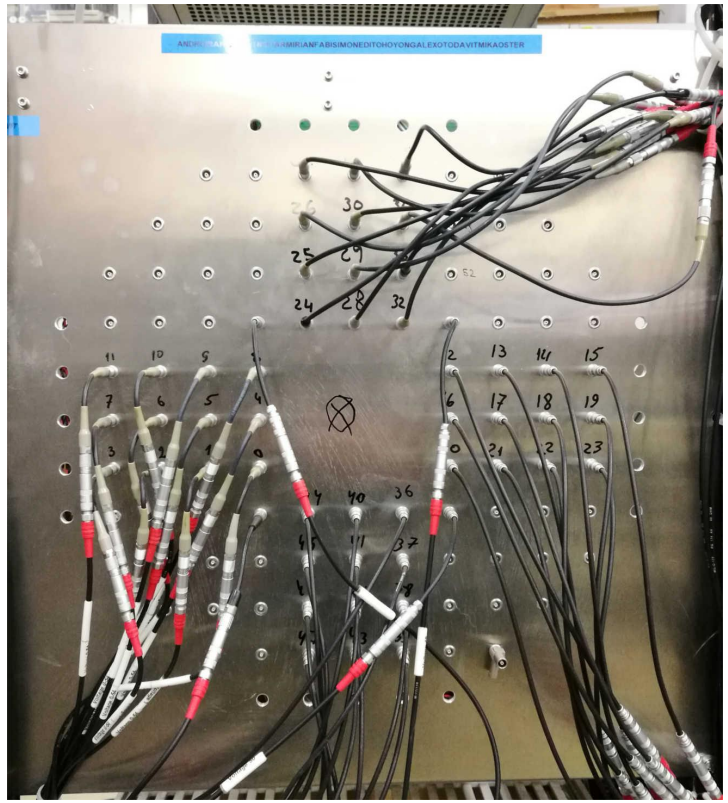


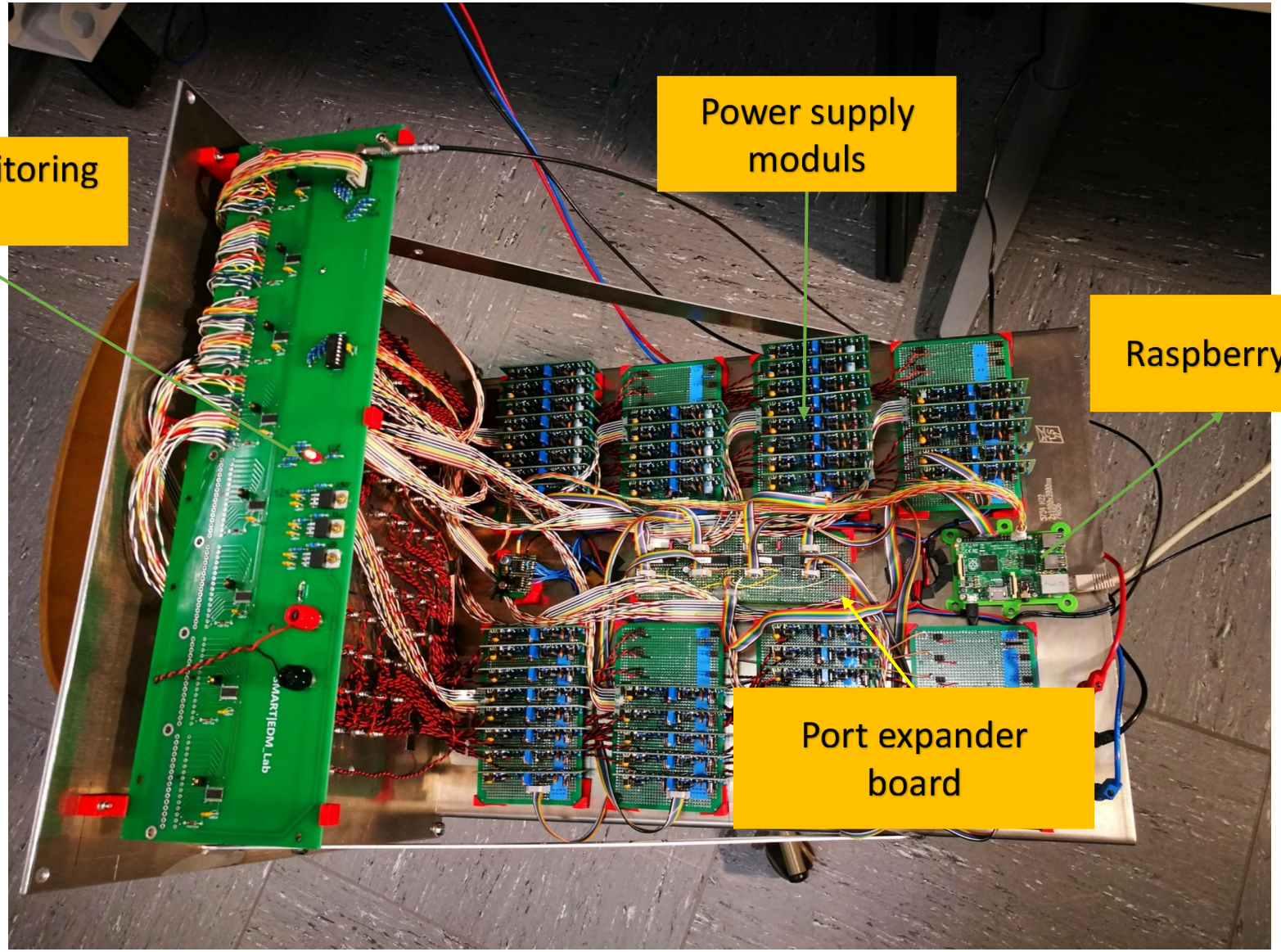
Power supply control software





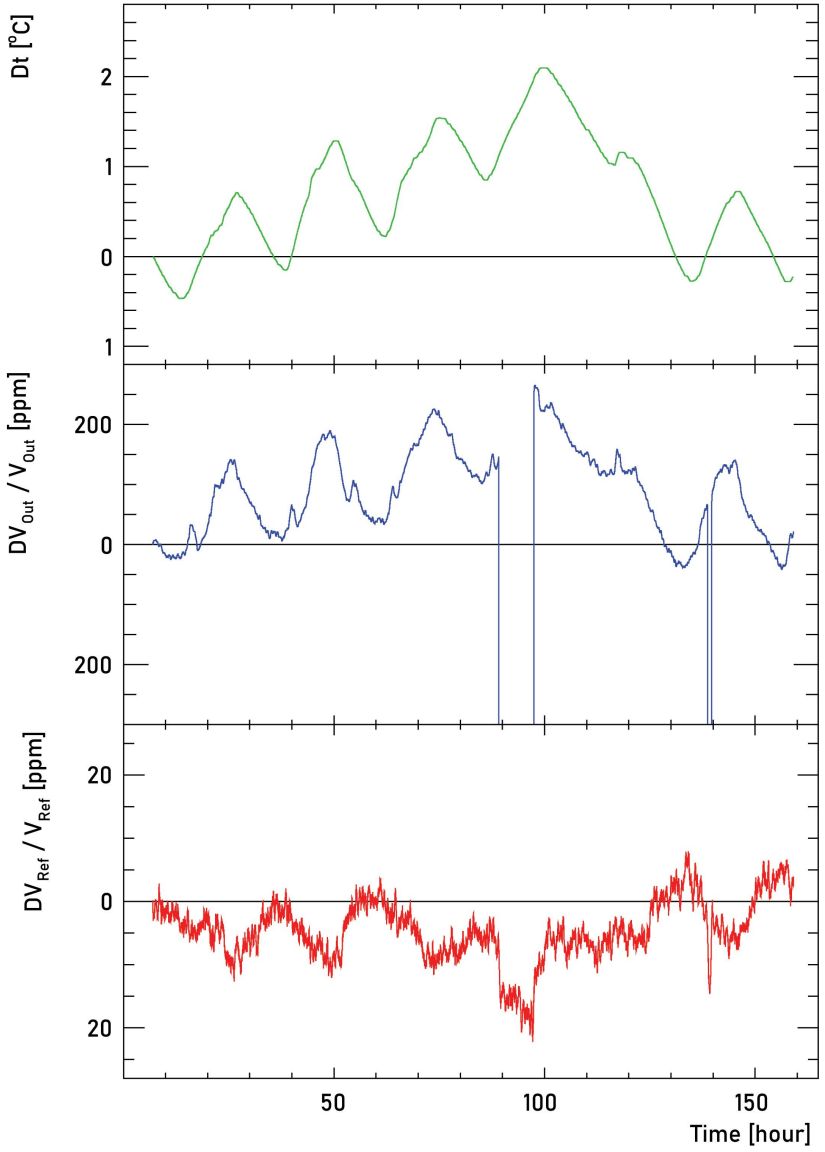
Power Supply

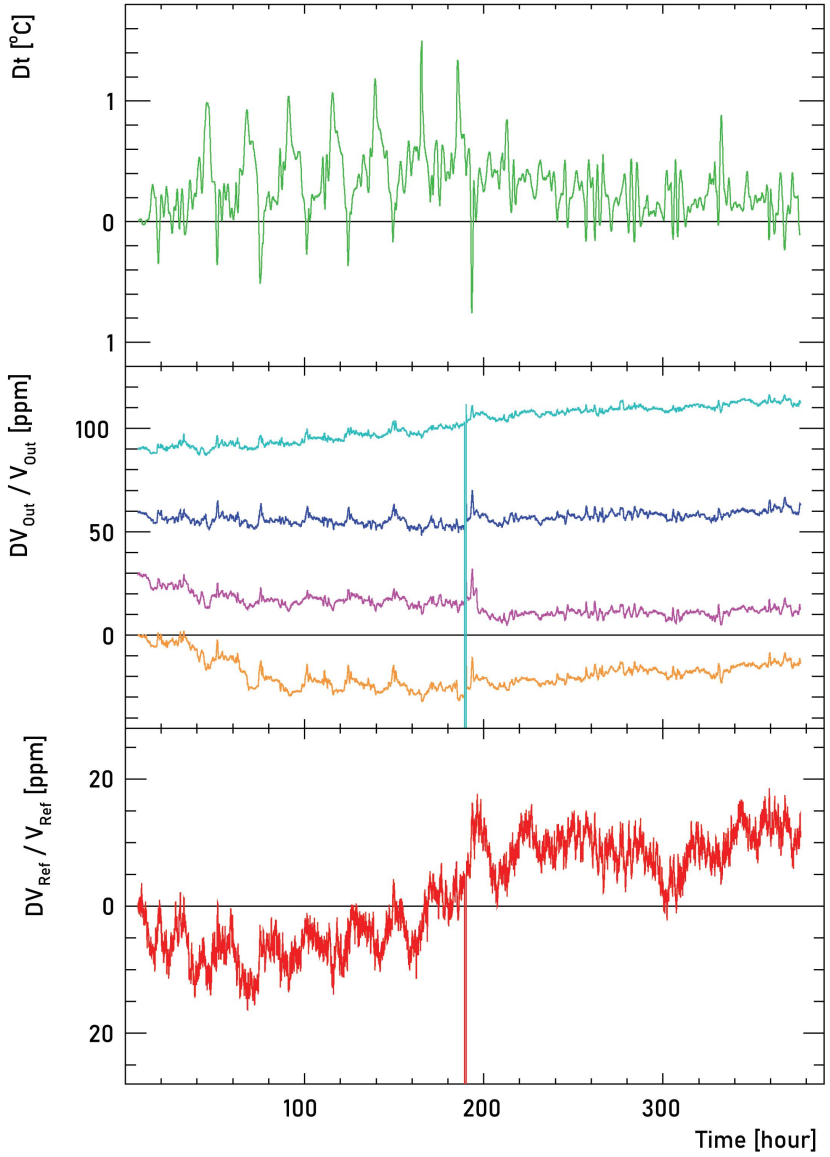




Temperature stability

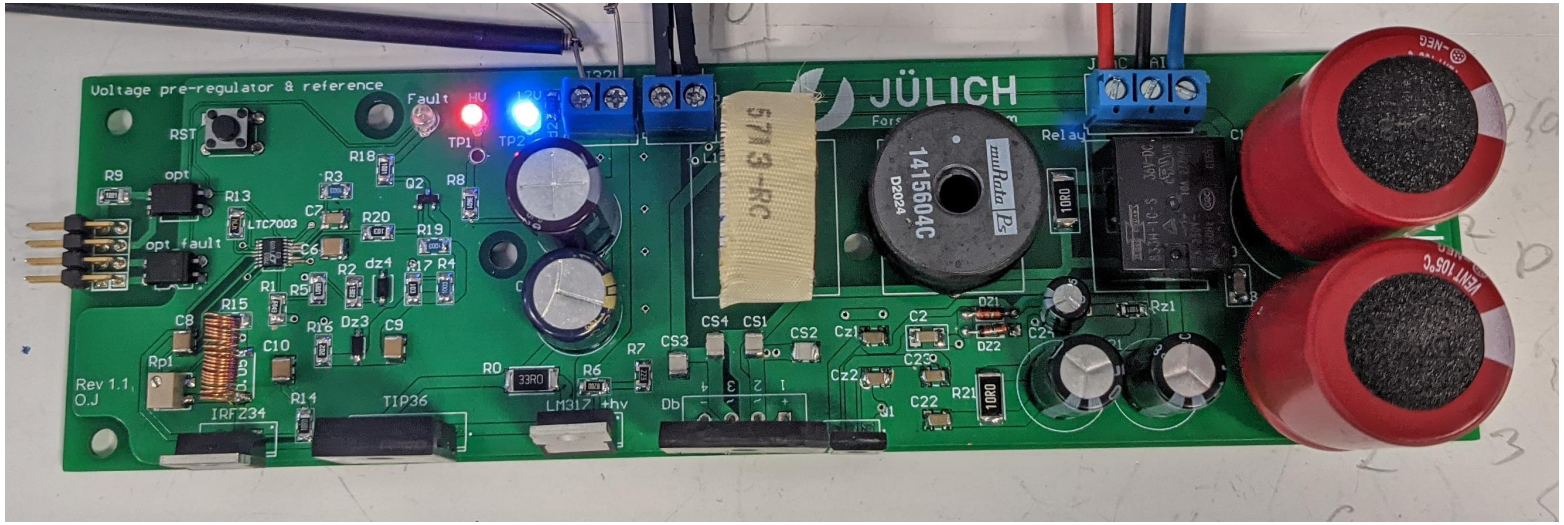
- Temperature chamber has been made to test power supply parts. temperature range is 15-35℃ at room temperature of 23℃
- The voltage reference temperature coefficient has been measured to be 4µV/K ≈ 0.8ppm at 5V
- The temperature coefficient of power supply modules has been determined to be 3.4mV/K ≈ +120ppm/K at 28V
- After improvement the coefficient has been decreased to -0.25mV/K ≈ -9ppm/K

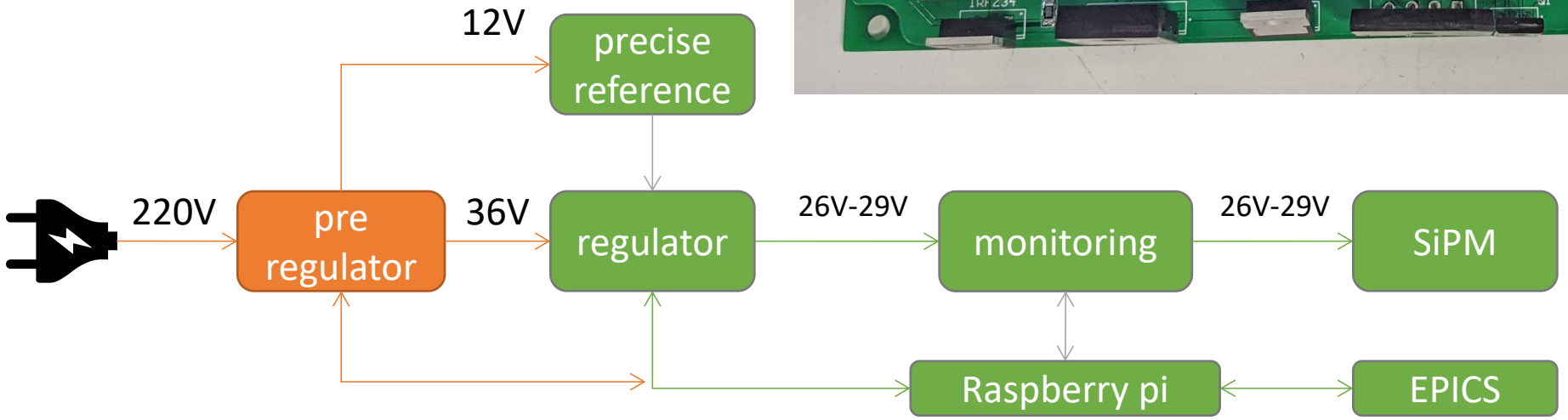




Power supply update

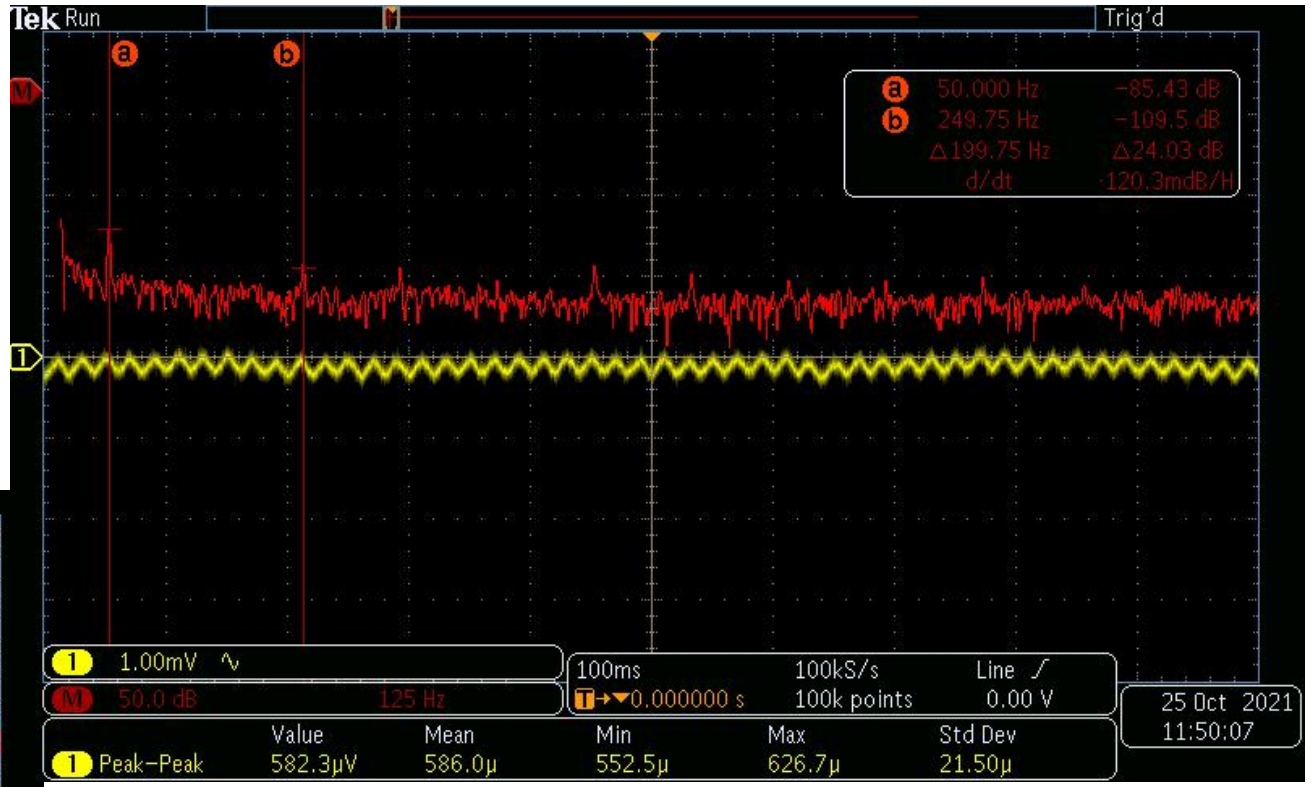
1. Low noise level, high stability
2. 36v and 12v output voltage
3. Overvoltage, overcurrent, undervoltage, short circuit protections
4. Power supply status and online monitoring

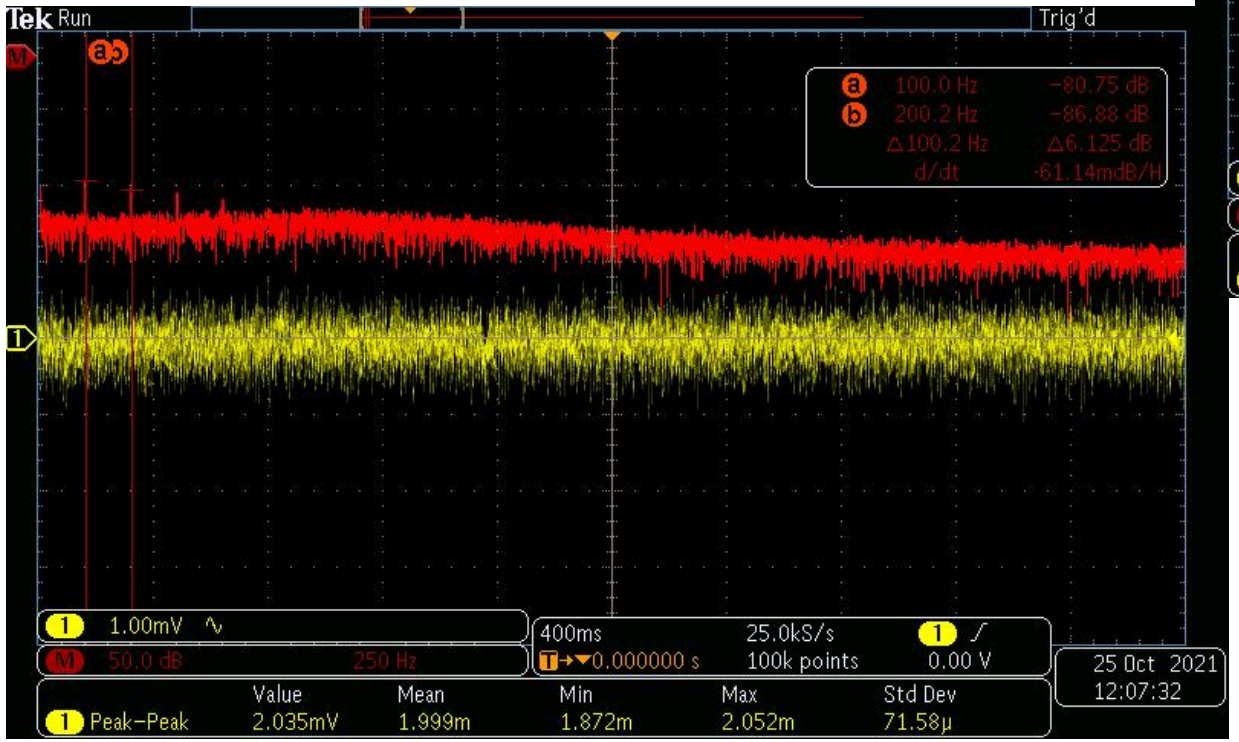




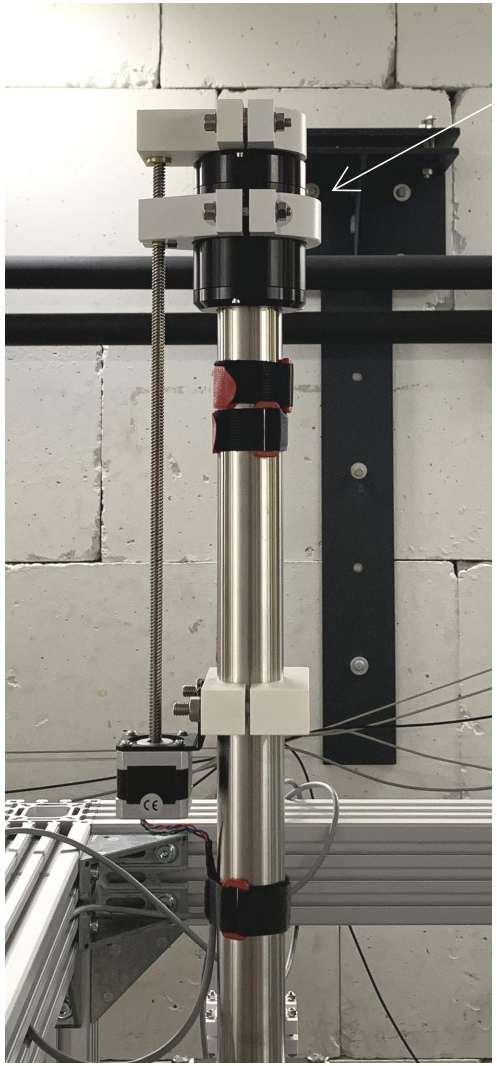
Power supply update

Pre-regulator noise level ≈ $2mV_{p\text{-}p}$
Regulator output noise level ≈ $580\mu V_{p\text{-}p}$

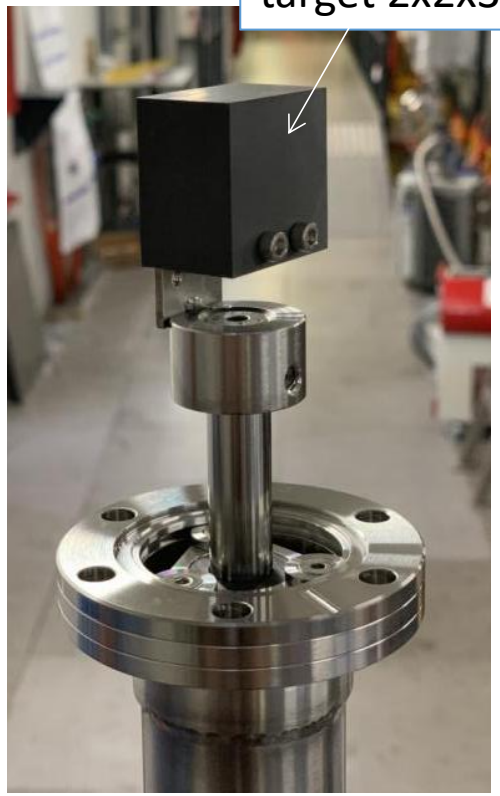




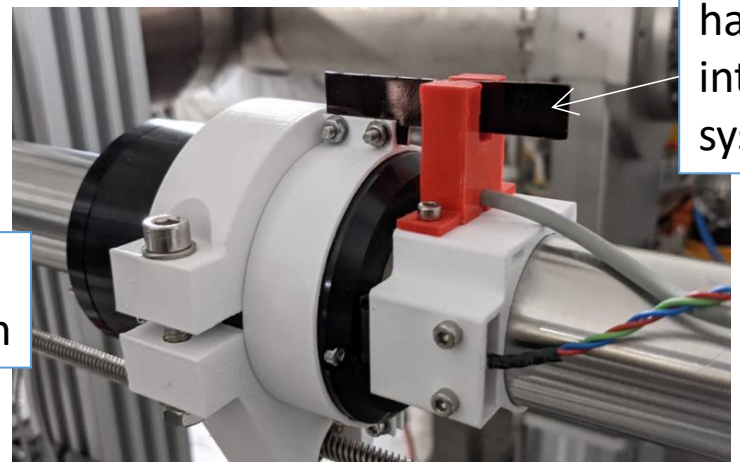
Carbon block target used in JePo



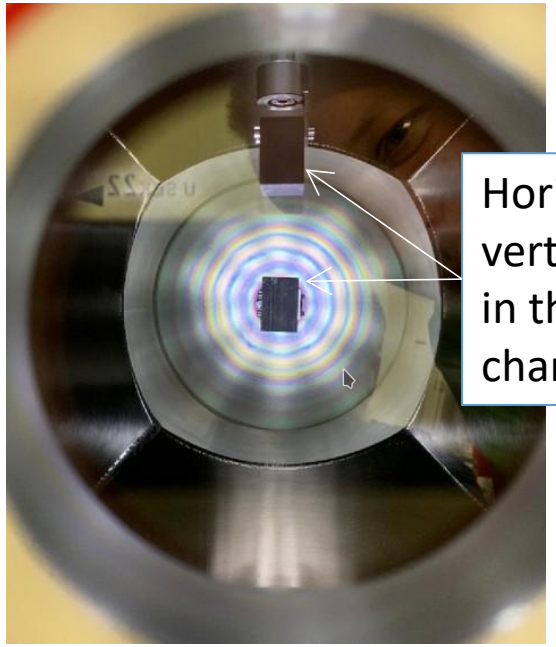
target driver system



carbon block target 2x2x3cm



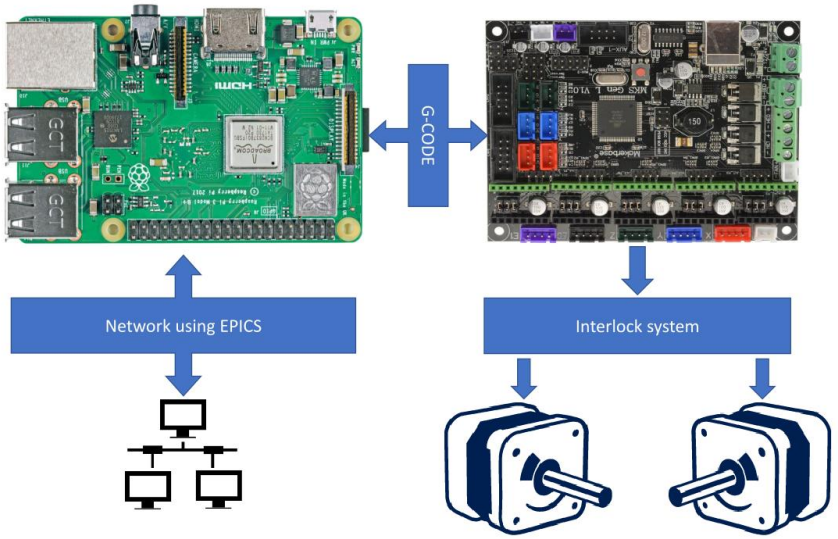
hardware interlock system

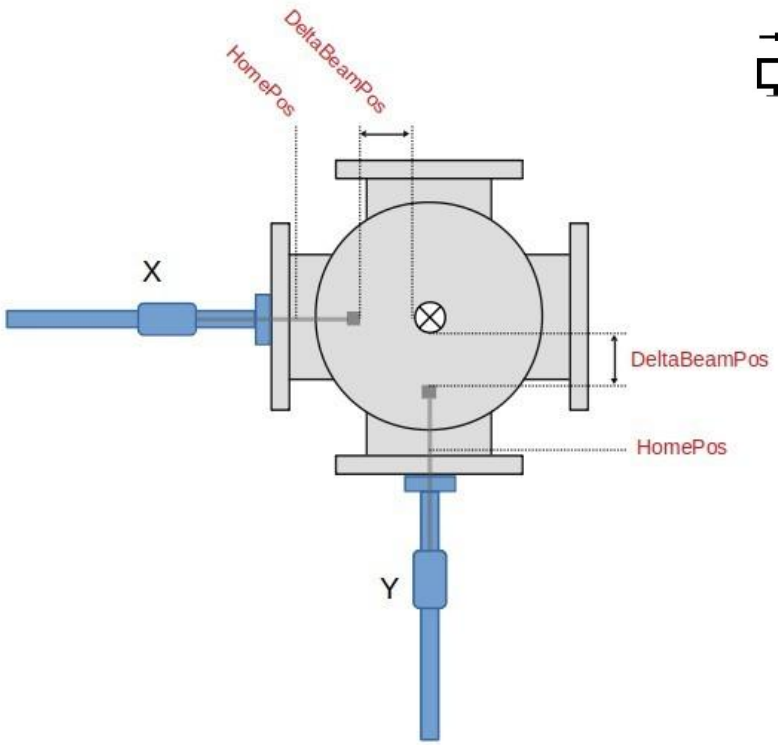


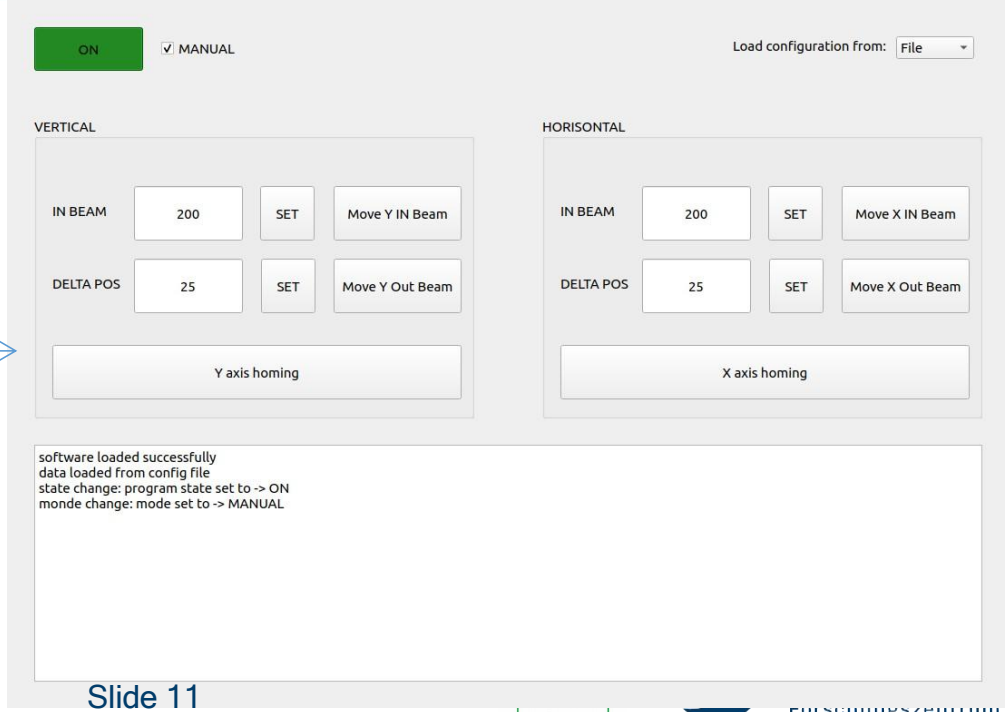
Horizontal and vertical targets in the target chamber

Carbon block target (working principle)

1. Industry standart G-code interface
2. EPICS based network controll
3. Several level safety systems
4. Automatic position search
5. Automatic controll mode

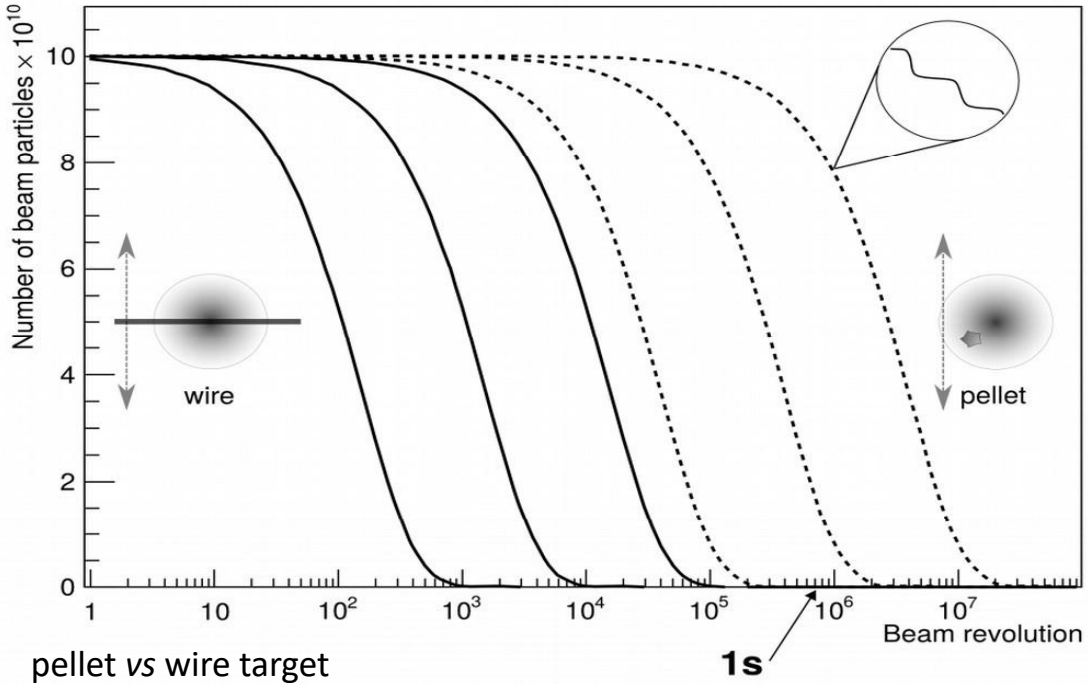




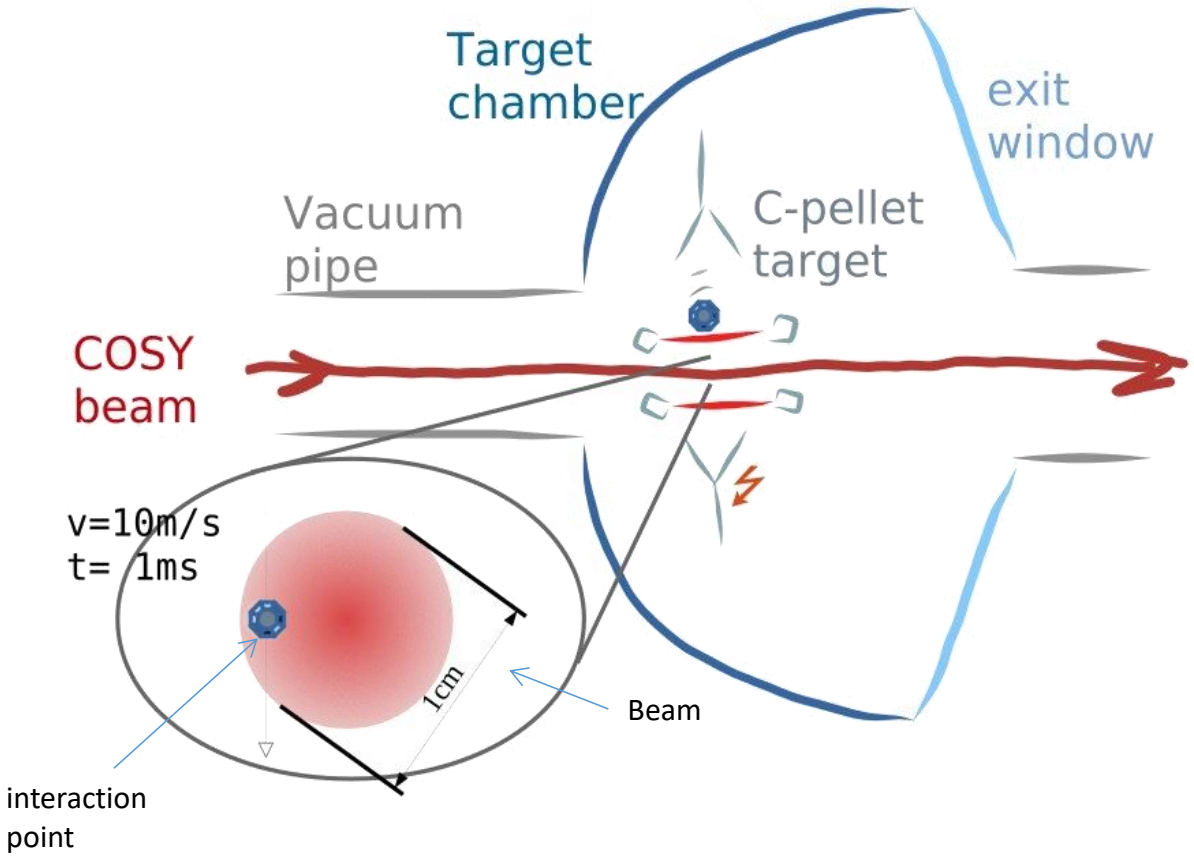


JUDIT - Juelich Ballistic Diamond Pellet Target

- Target capable to measure 2D/3D polarization profile
- Huge dynamic range in effective target thickness
- ”quasi” Non-invasive, no rest gas
- small size 10-100 μm diamond pellets

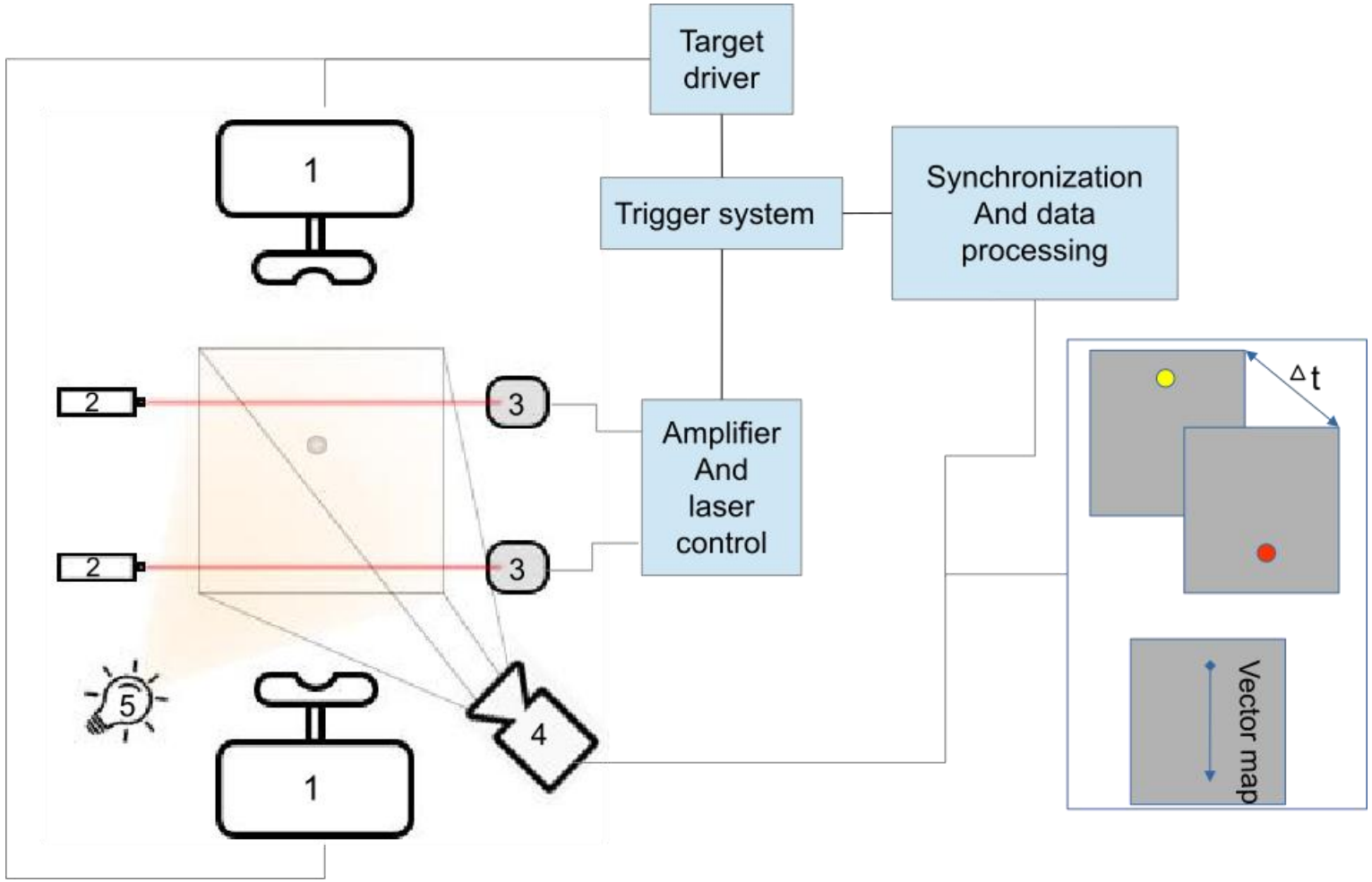


pellet *vs* wire target

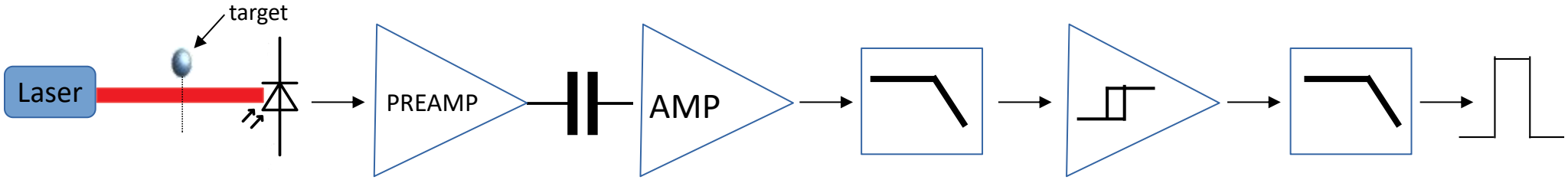


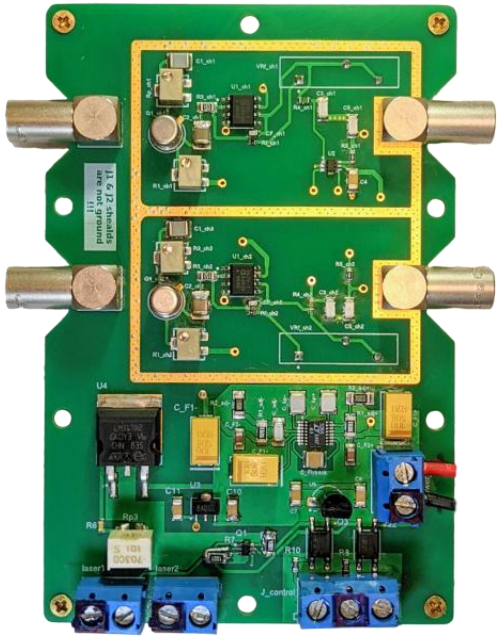
❖ Tracking the Pellet and measuring precise scattering time allows scanning 2D **polarization profile of the beam**.

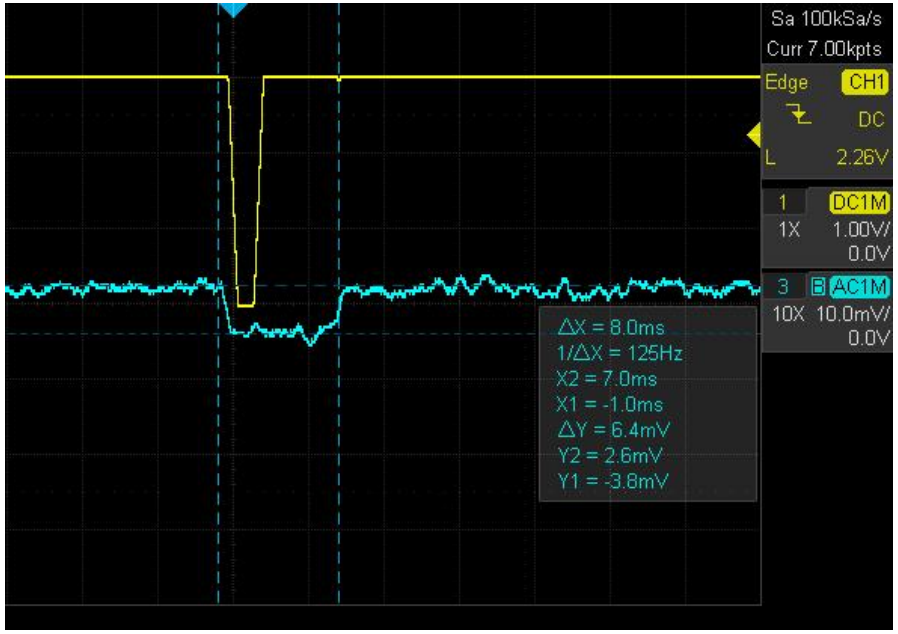
Pellet target system (realisation)

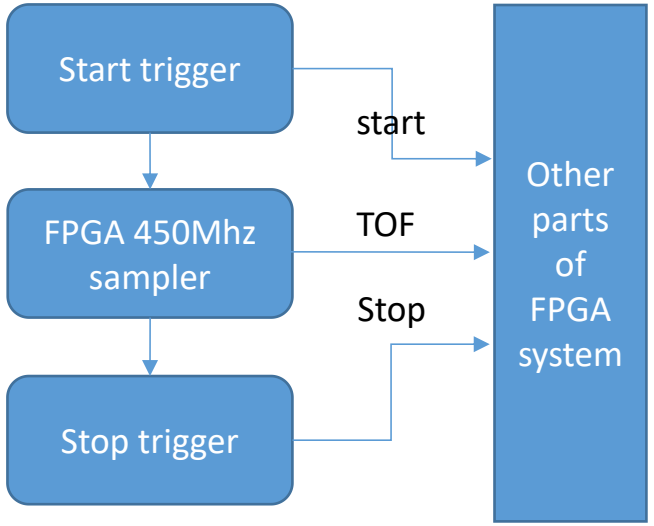


Pellet TOF (time of flight) measurement

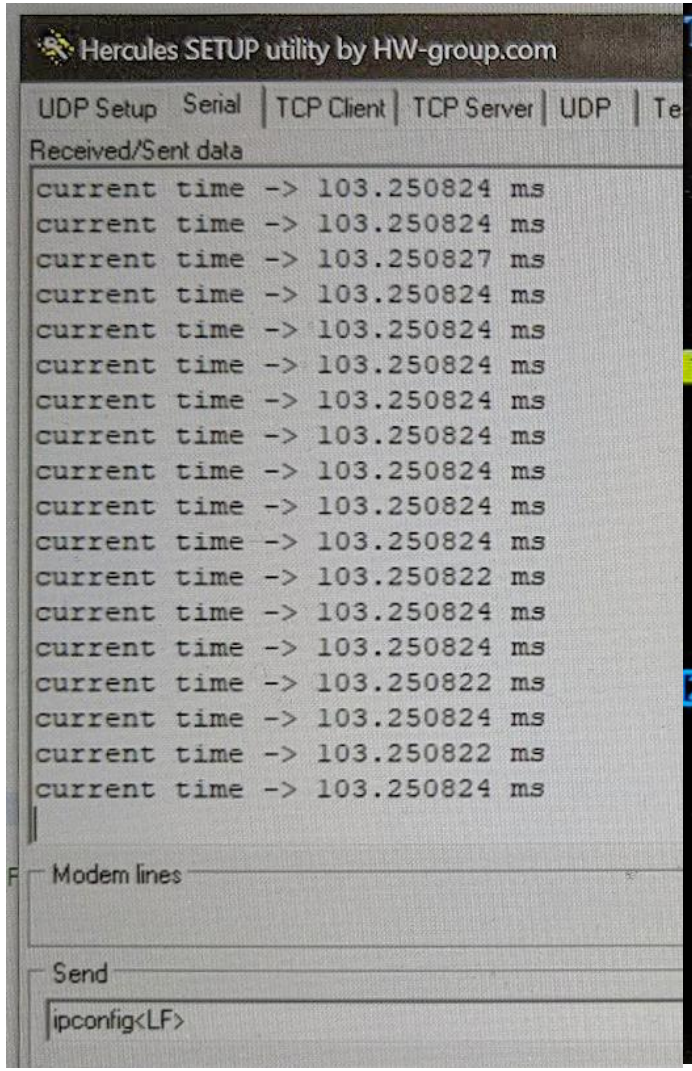








Pellet TOF tests



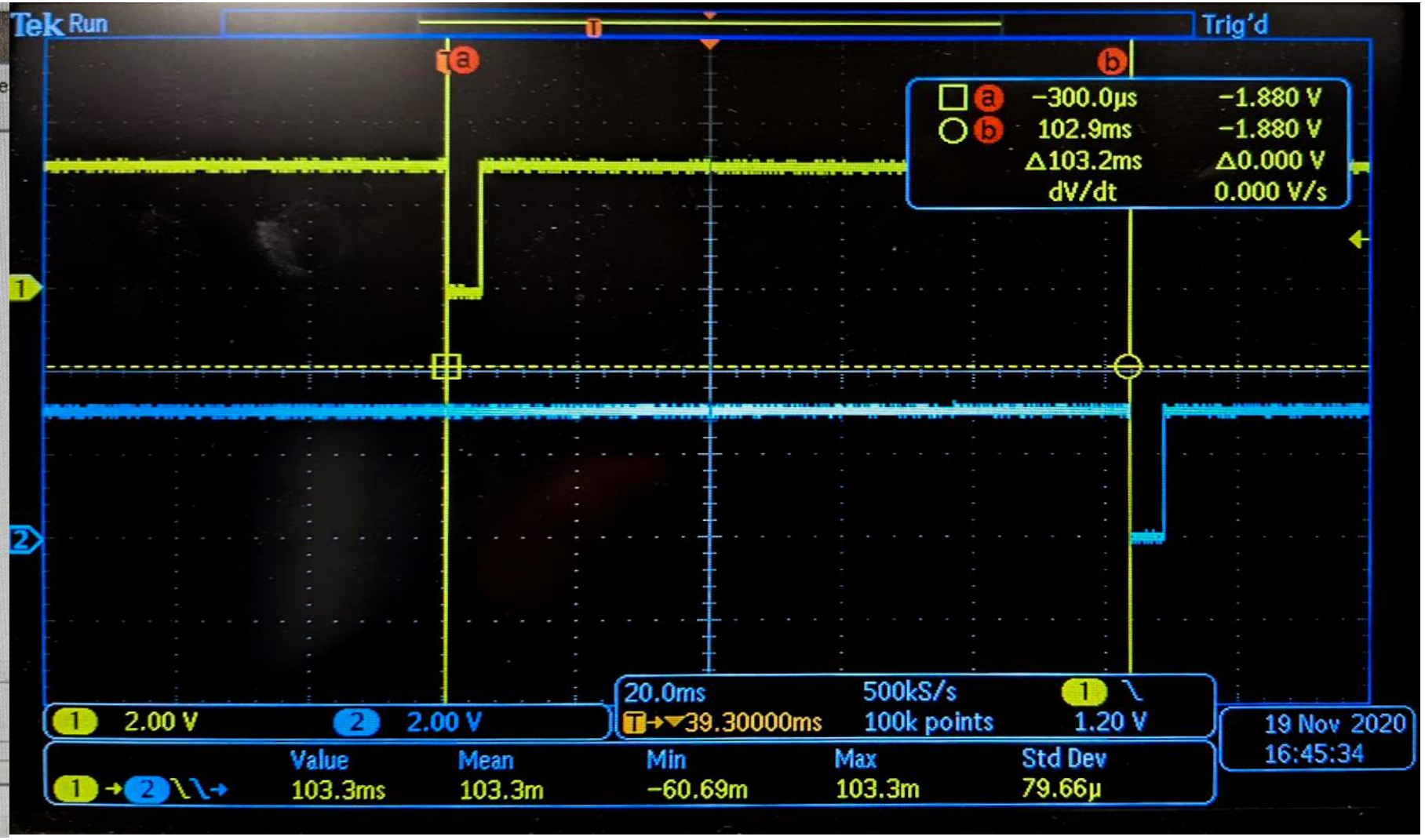


Image processing

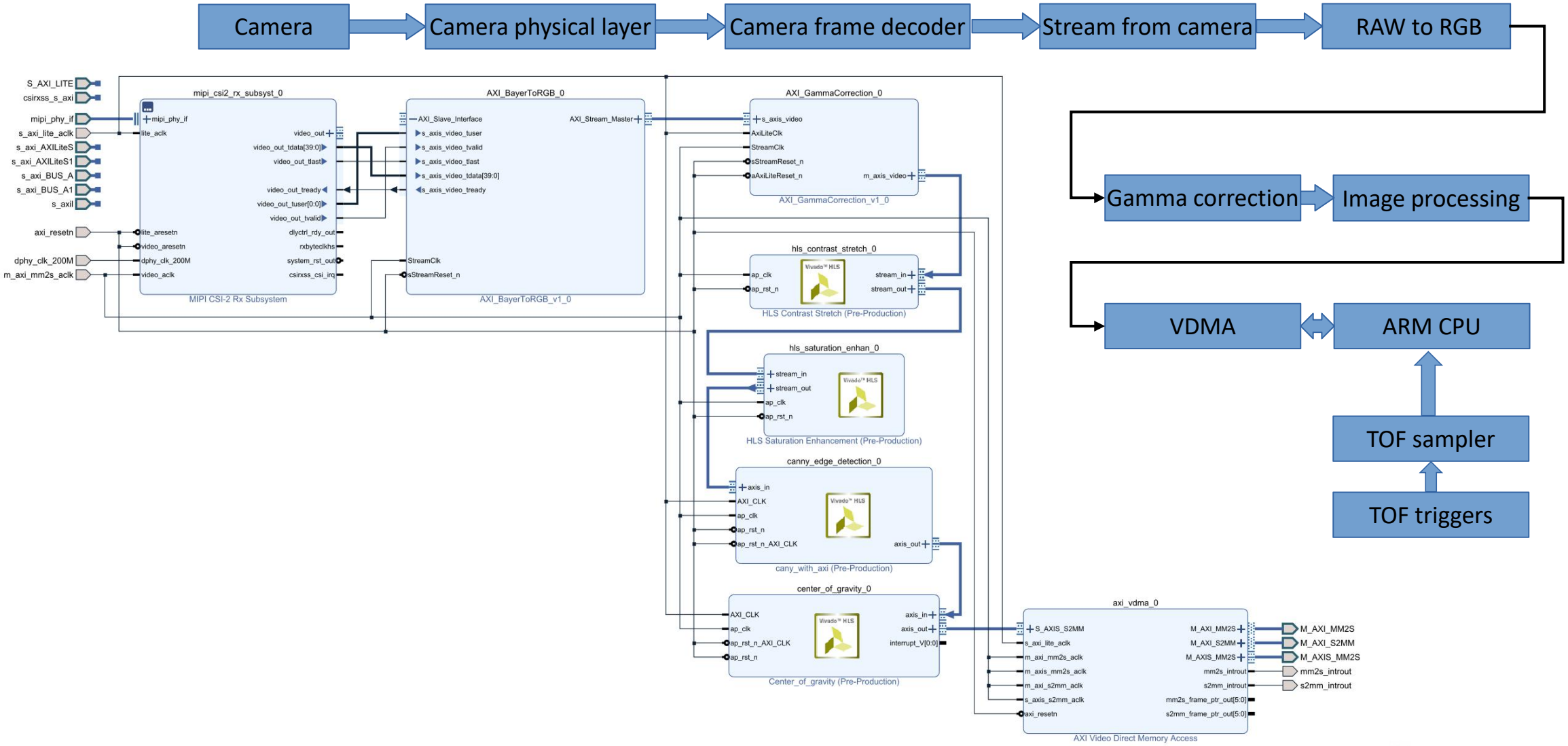
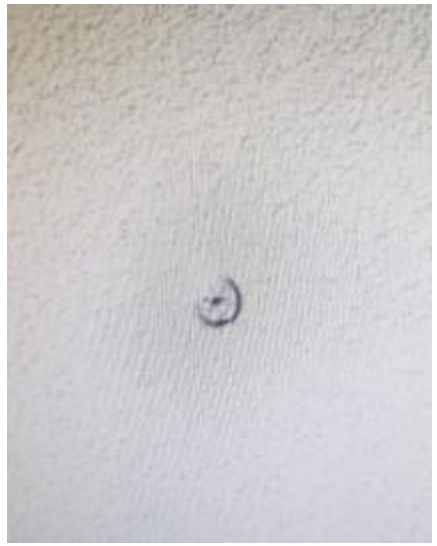


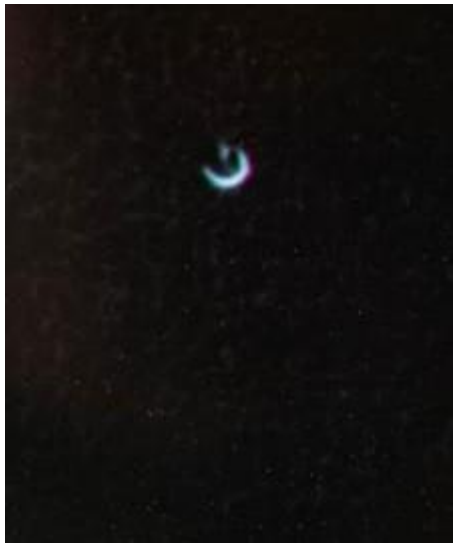
Image processing tests

Image from custom linux running on FPGA board

Test using color invert and Sobel filter



Test using Pewitt filter



Test using canny edge detect ad standalone firmware with SD card frame grabber

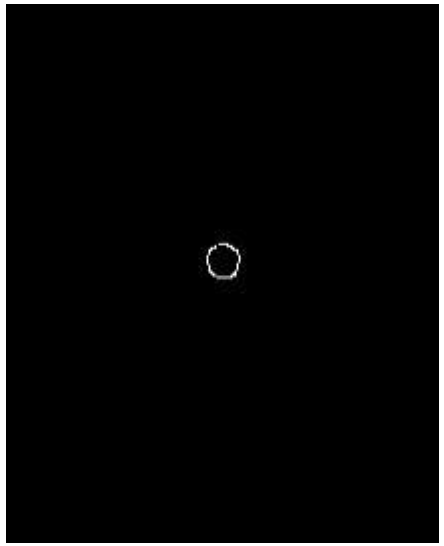
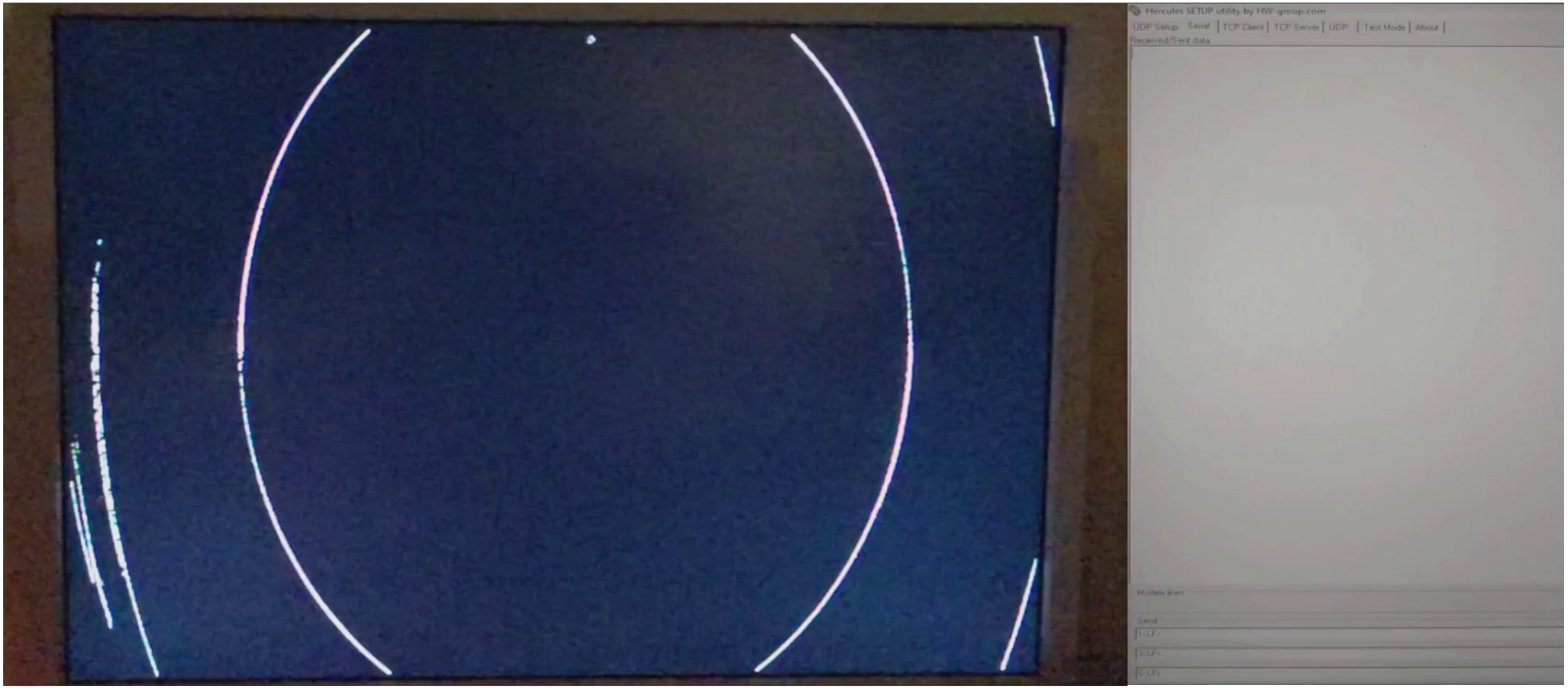


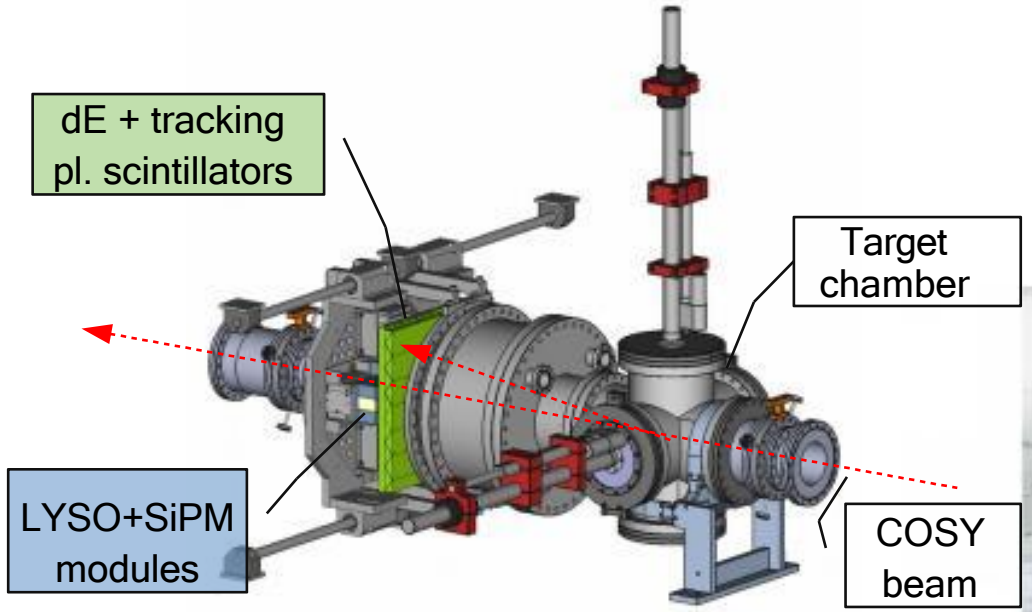
Image processing test

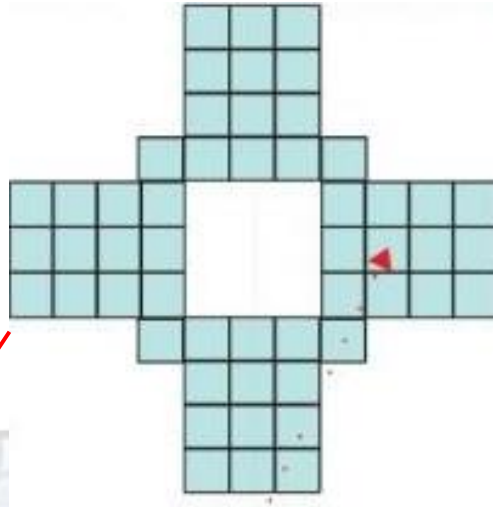


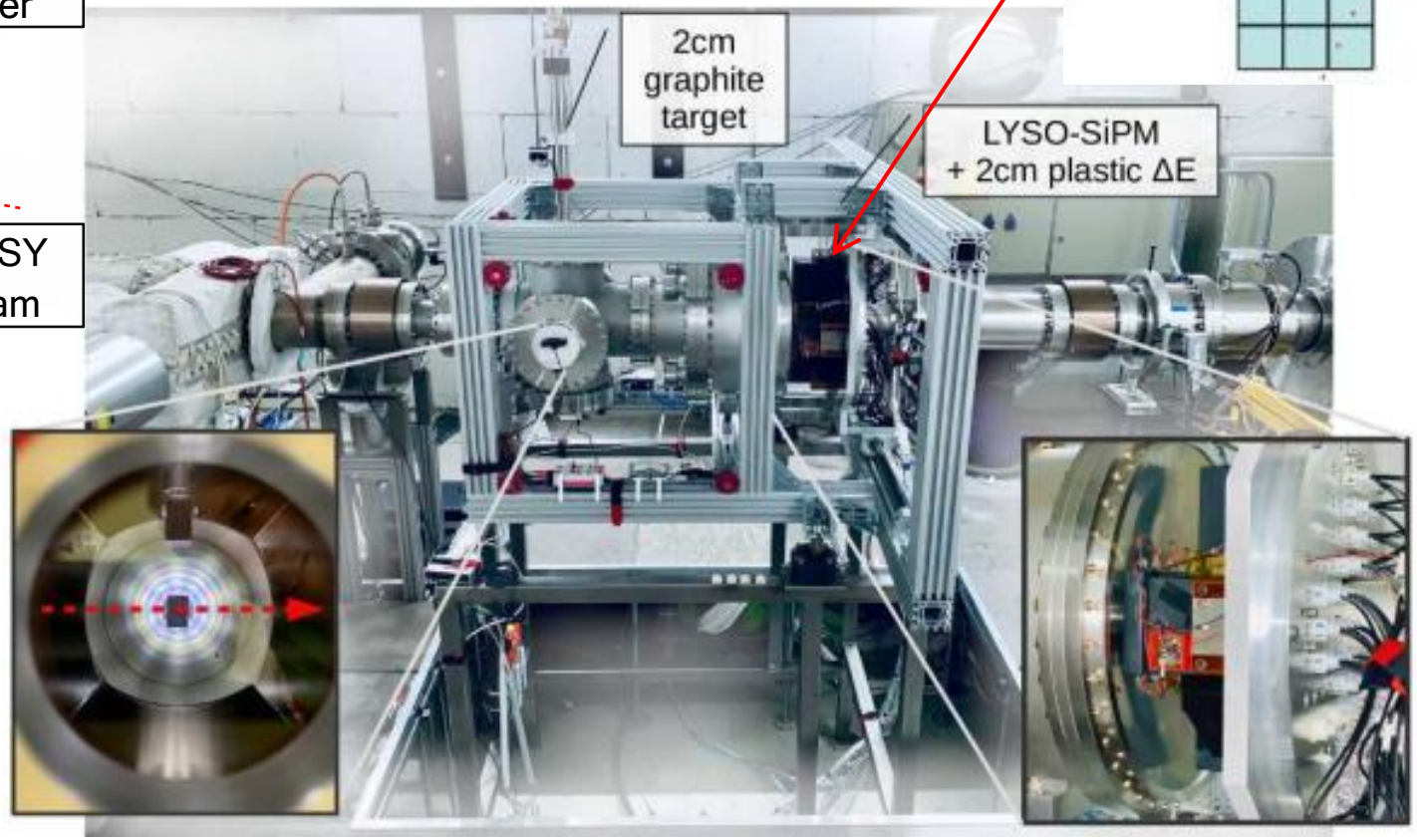
Summary

- 52 LiSo modules has been assembled and installed in JePo
- JePo has been installed at COSY ring and successfully used in several EDM experiments
- Carbon block target control, monitoring and safety systems has been developed and tested
- Pellet target (JUDIT) concept has been suggested
- TOF system is developed and tested on test bench
- Different parts for pellet target system has been developed, includeing interfacing with camera and HDMI
- The object detection and tracking IPs has been created and demonstrated with simulations

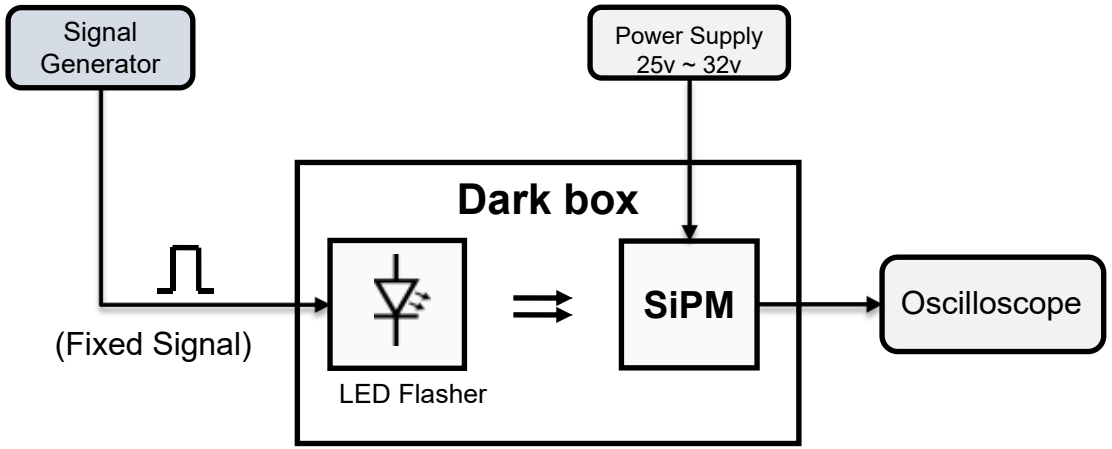
Polarimeter (JePo) setup in COSY ring







SiPM characterisation



Quantity	Value
LYSO light decay parameter	36 ns
LYSO crystal cross section	30×30 mm^2
LYSO crystal length	80 mm
Number of photons per hit (300 MeV)	$\approx 8 \times 10^6$
Number of pixels in the SiPM array	$\approx$ 900 kp
Electrical load of the SiPM array	25 Ω
Output signal parameters:	
Decay constant of the rising edge	$\approx$ 25 ns
Decay constant of the falling edge	$\approx$ 1.3 μs
SiPM bias voltage	27-31 V
Maximum overall instability of the SiPM supply voltage	$\approx$ 10 mV

Image processing hardware

667 MHz dual-core Cortex-A9 processor

High-bandwidth peripheral controllers: 1G Ethernet,

USB 2.0, SDIO 1 GB DDR3L RAM

FPGA - XC7Z020-1CLG400C Look-up Tables (LUTs) 53,200 Flip-Flops 106,400

5MP color system-on-chip image sensor

Dual lane MIPI CSI-2 image sensor interface

Supports QSXGA@15Hz, 1080p@30Hz, 720p@60Hz, VGA@90Hz and QVGA@120Hz

Output formats include RAW10, RGB565, CCIR656, YUV422/420, YCbCr422, and JPEG compression

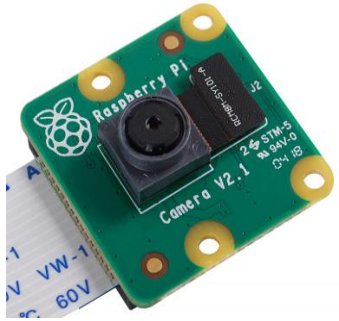
IMX219PQ 8 megapixels, resolution 3280 x 2464

Dual line MIPI CSI-2 image sensor interface

Supports 1080p@30, 720p@60 and 640x480p@90

Potencially suported 720p@120, 640x480p@200,

640x128p@682, 640x80p@1000



Camera driver settings

Parameter	Value(s)
Resolution	OV5640 (1 = 1280x720, 2 = 640x480, 3 = 320x240), IMX219 (1 = 1280x720, 2 = 640x128, 3 = 640x80)
Write to image sensor register	address and value of sensor register in hex
Read from image sensor	address of image sensor register in hex
Gamma correction values	1, 1/1.2, 1/1.5, 1/1.8, 1/2.2
Saturation	0 = 0, 1 = -0, 2 = 0.2, 3 = 0.4, 4 = 0.6, 5 = 0.8, 6 = 1.0, 7 = 1.2
Contrast	0 - 255 in hex
Operating mode	Bypass or Image processing mode
Canny edge detection thresholds	High, Low thresholds and zero padding in hex
Camera analog gain	Gain of the sensor to compensate low light in high FPS
Camera integration time	Different for every resolution, but can be overridden to change the FPS (not all values will work)

Image processing

Contrast stretch → Saturation enhancement → Canny Edge Detection → Center of Gravity

Canny Edge Detection

- ფოტოს გაგლუვება
- ინტენსივობის გრადიენტის დადგენა
- გრადიენტების დონეების დადგენით მცდარი კიდეების უგულებელყოფა
- ორმაგი ზღვრით კიდეების დადგენა
- ყველა სხვა მონაცემის ჩახშობა რომლებიც არ არიან ძლიერ კიდეებთან კავშირში

Center of Gravity

- ინტერესის რეგიონის განსაზღვრა
- X კოორდინატზე ყველა თეთრი პიქსელის ჯამი
- Y კოორდინატზე ყველა თეთრი პიქსელის ჯამი
- X და Y ის საშუალო მნიშვნელობა
- წინა კადრთან შედარება