AEgIS collaboration

Trento Institute for
Fundamental Physics
and Applications

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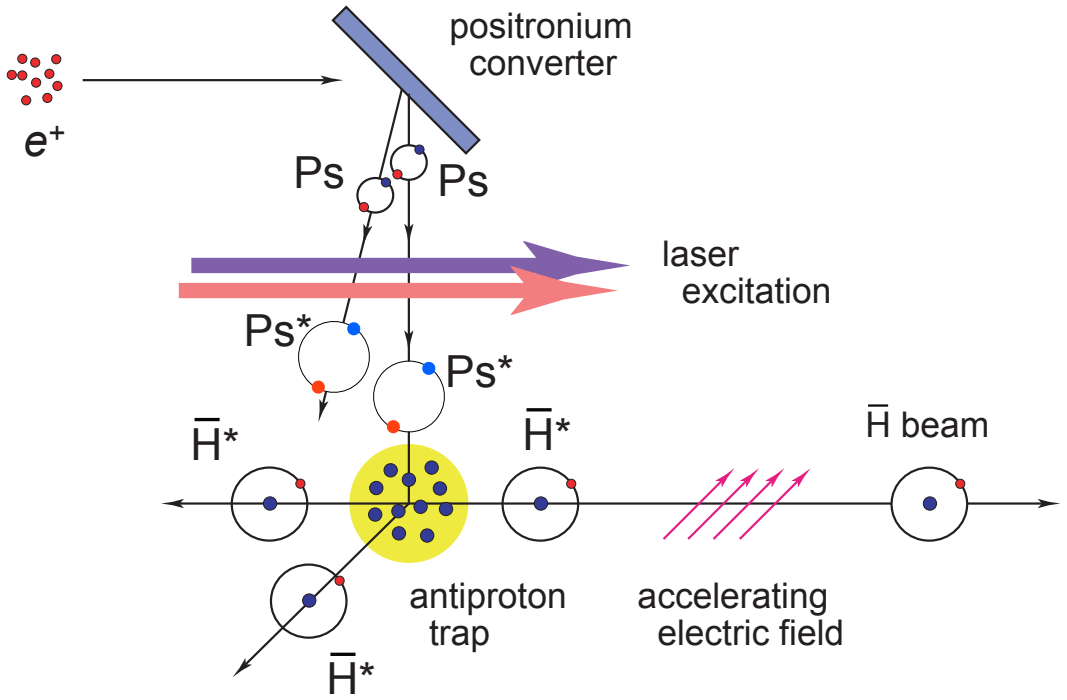
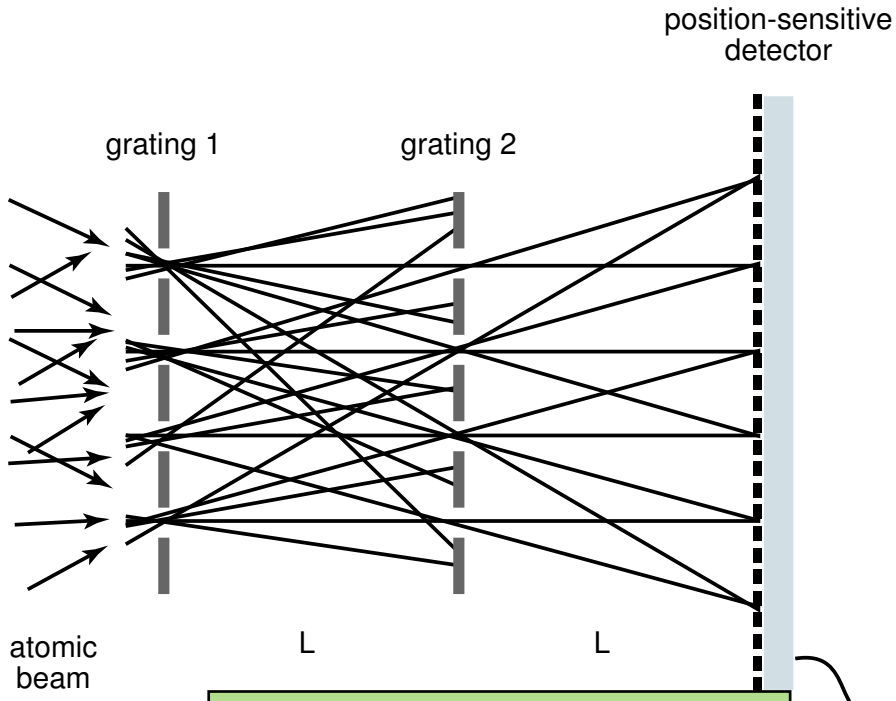
IN TORUŃ

Overview of experimental approach:

Schematic overview

$Ps^* + \bar{p} \rightarrow \bar{H} + e^-$





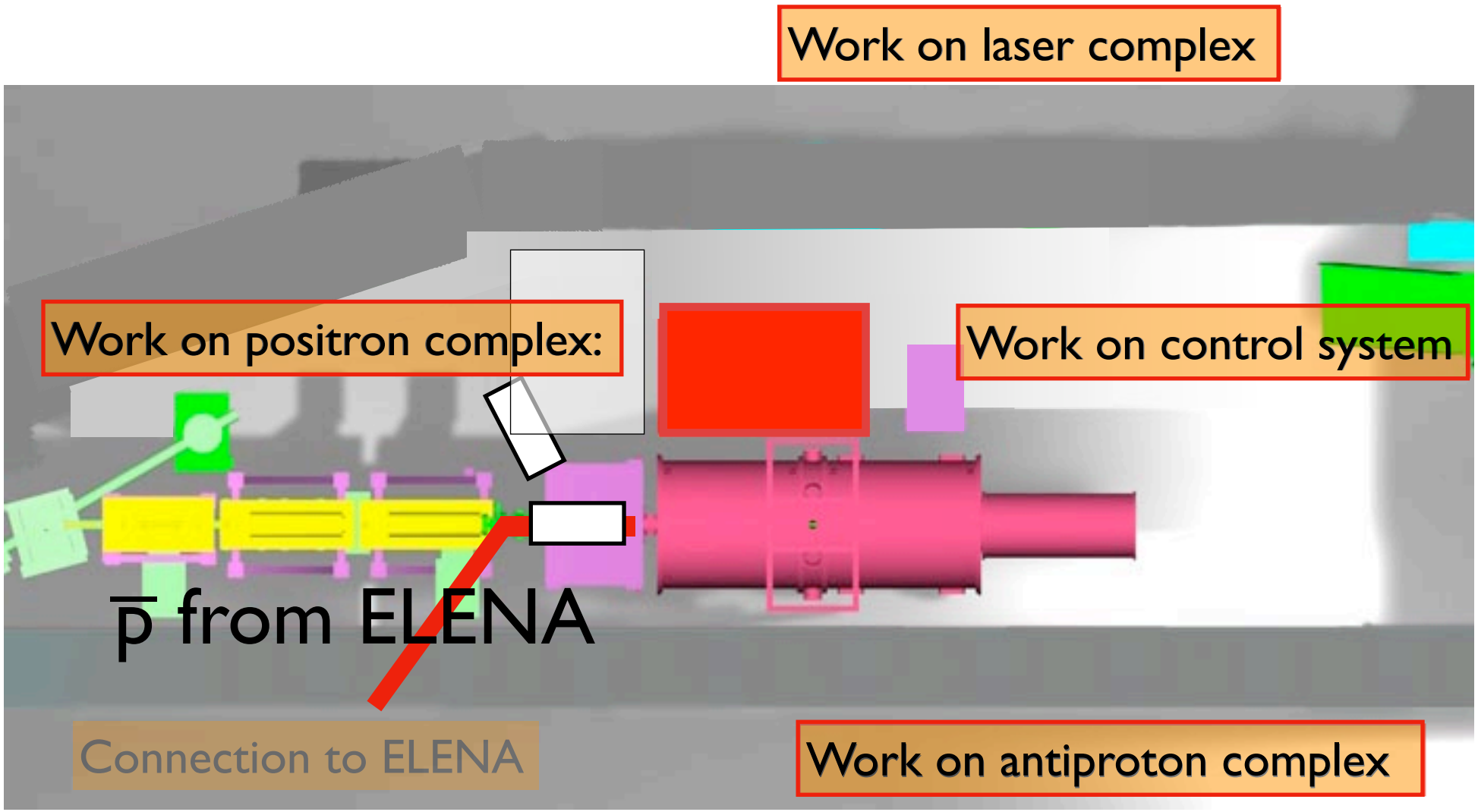
pulsed production

beam formation

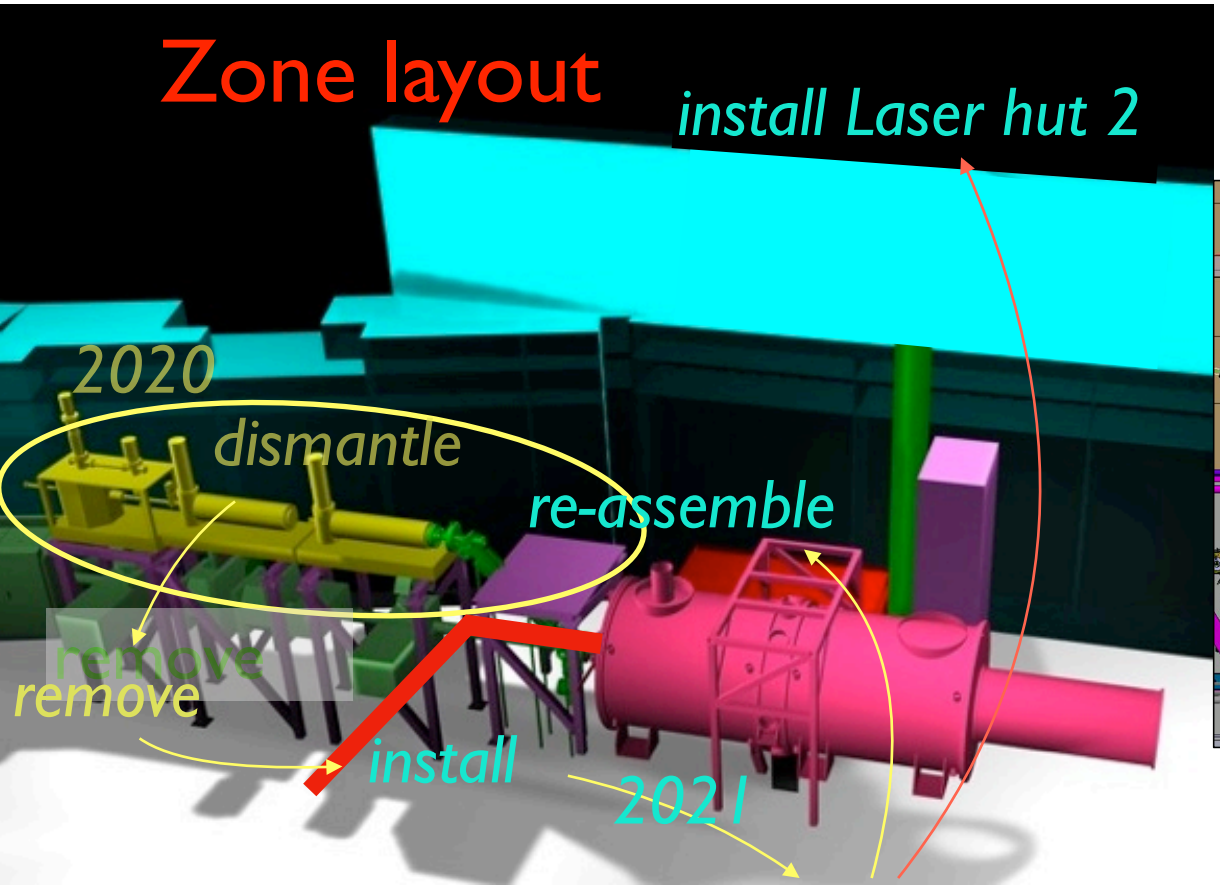
gravity measurement

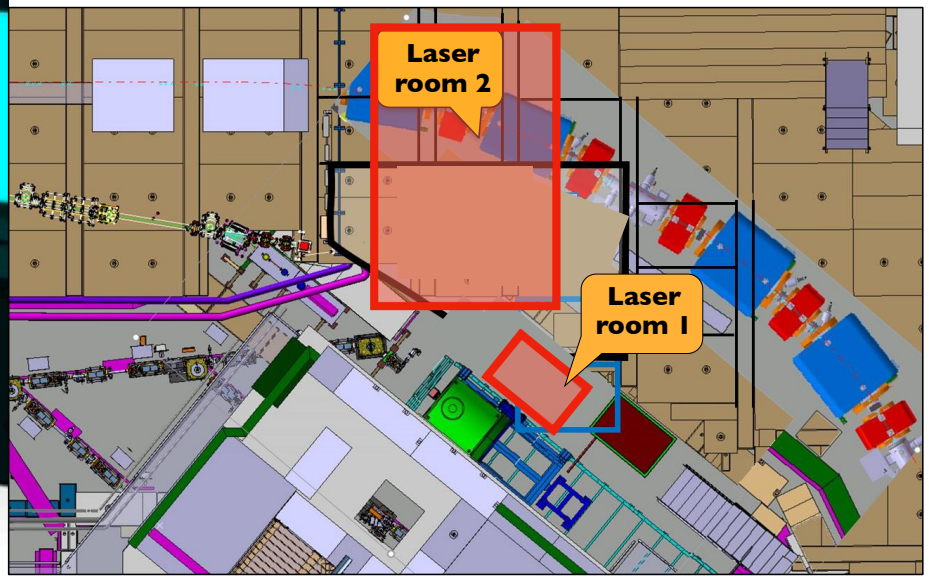
Technical steps: cold $\bar{p}$; pulsed Ps and Ps* formation ; pulsed production of $\bar{H}$; beam formation ; deflectometer

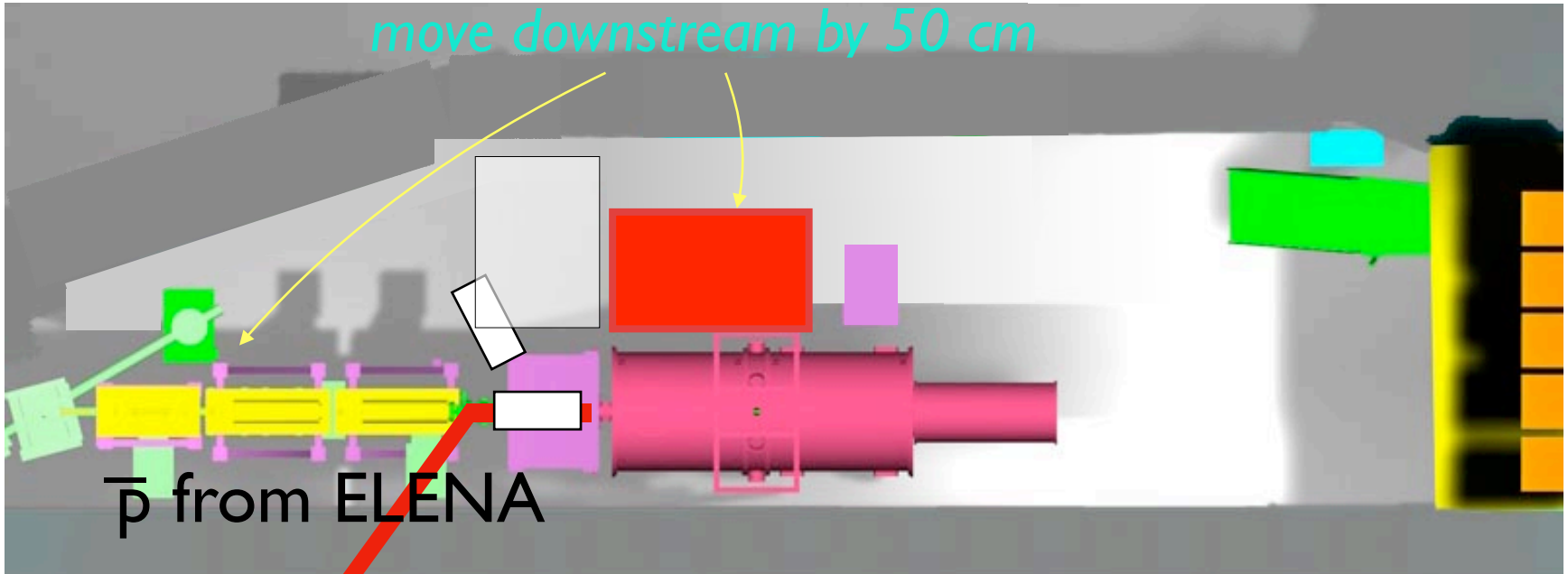
2021: many modifications / construction sites in order to provide the technical basis for achieving the physics goals



Zone layout


install Laser hut 2
2020
dismantle
re-assemble
remove
remove
install
2021


Laser room 2
Laser room 1

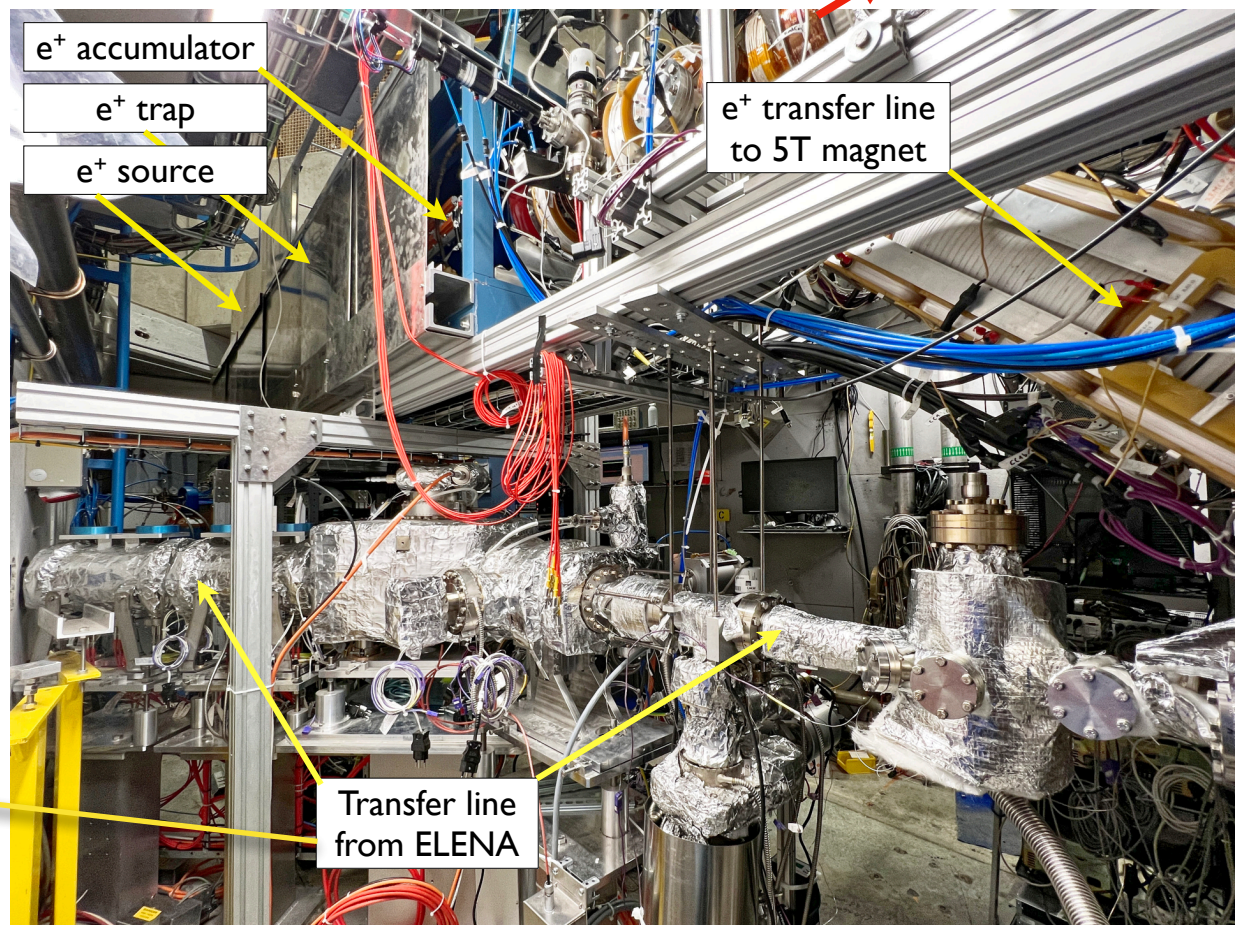

move downstream by 50 cm
$\bar{p}$ from ELENA

Work on positron complex (accumulator, test set-up):

complete disassembly, refurbishment, re-assembly, commissioning and upgrades

January 2021

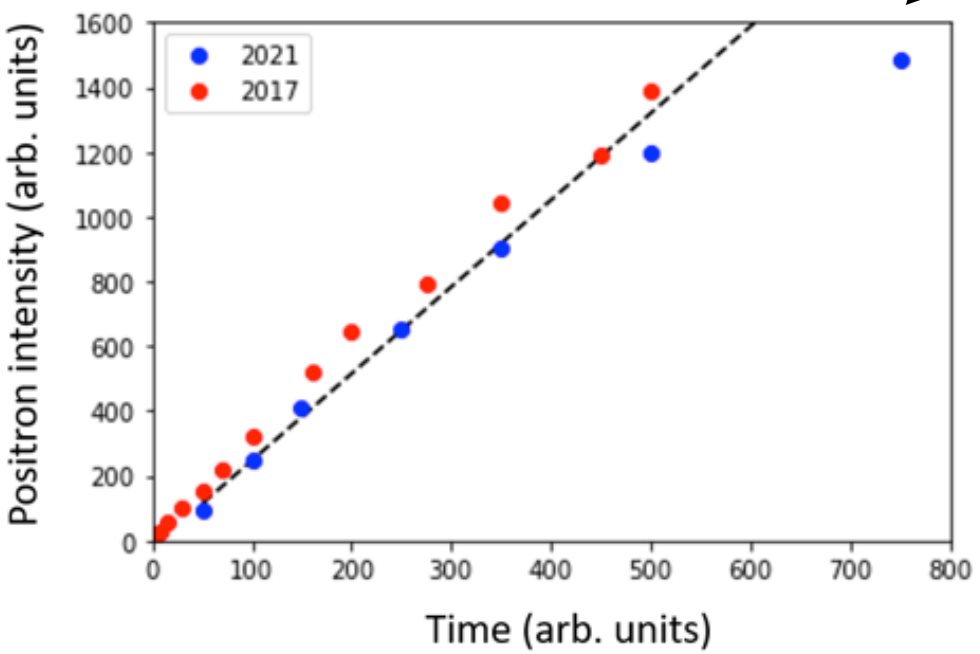
January 2022



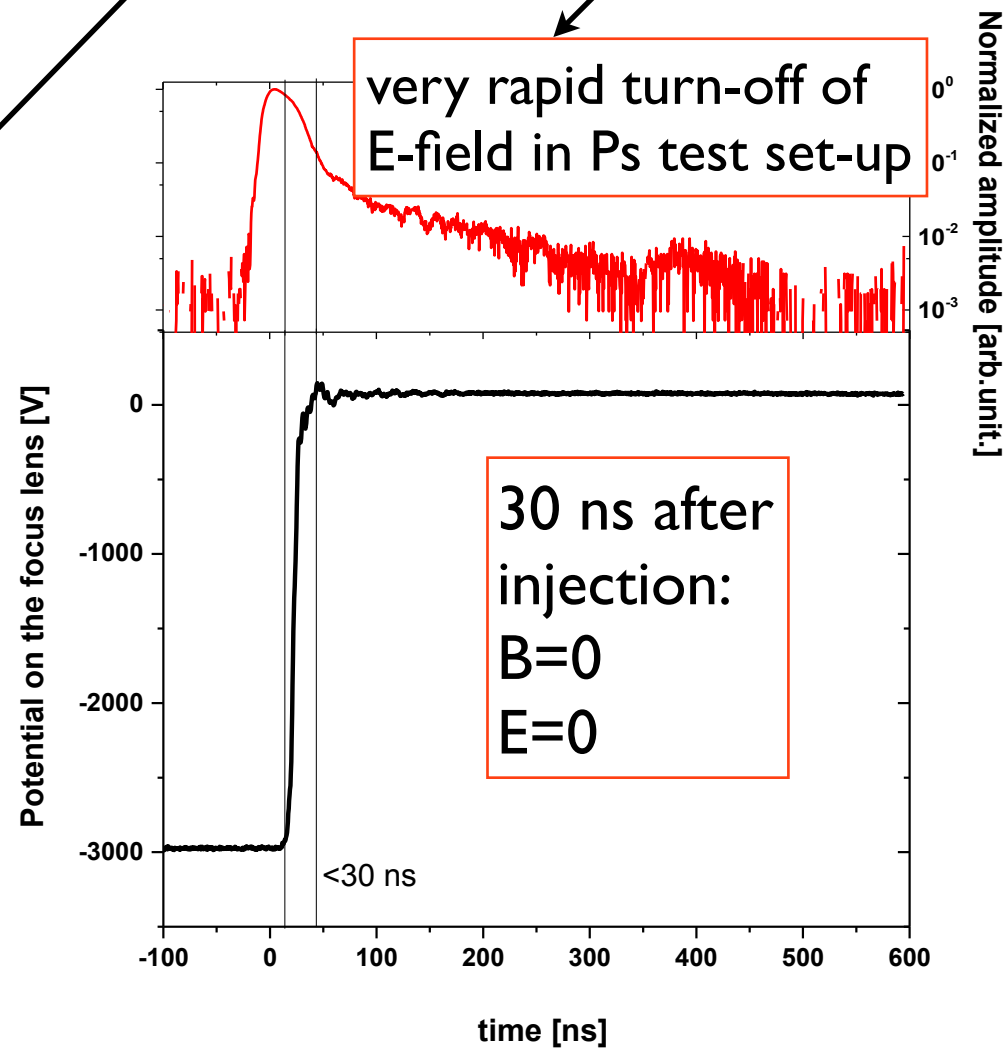
Work on positron complex (accumulator, test set-up):

complete disassembly, refurbishment, re-assembly, commissioning and upgrades

e^+ accumulation rate



very rapid turn-off of E-field in Ps test set-up

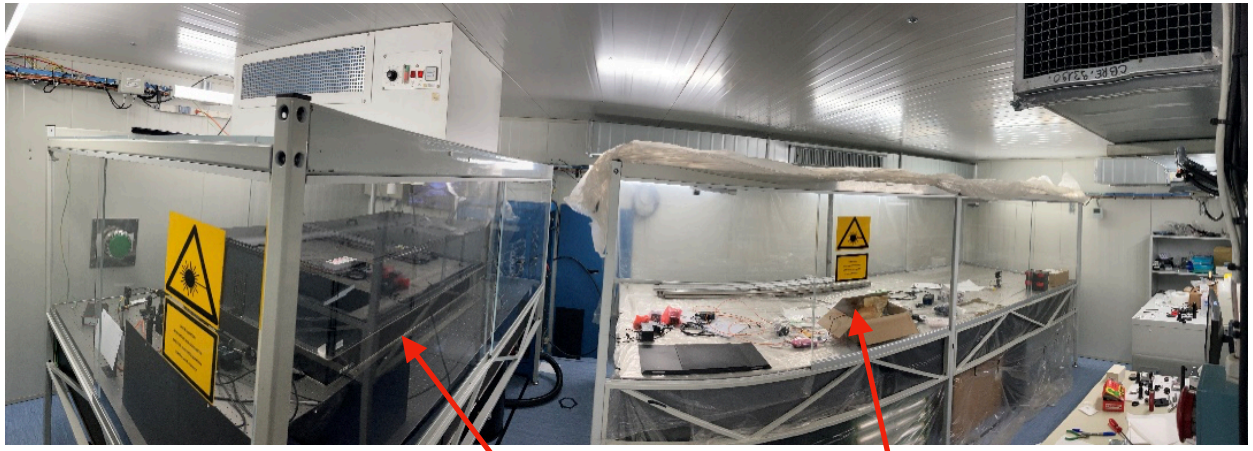


Many small improvements to e+ source
→ same accumulation rate as in 2017!

Ps evolves freely: a number of experiments on Ps become feasible

Work on laser complex:

expanding need for lasers, consolidation → additional laser hut, transfer line

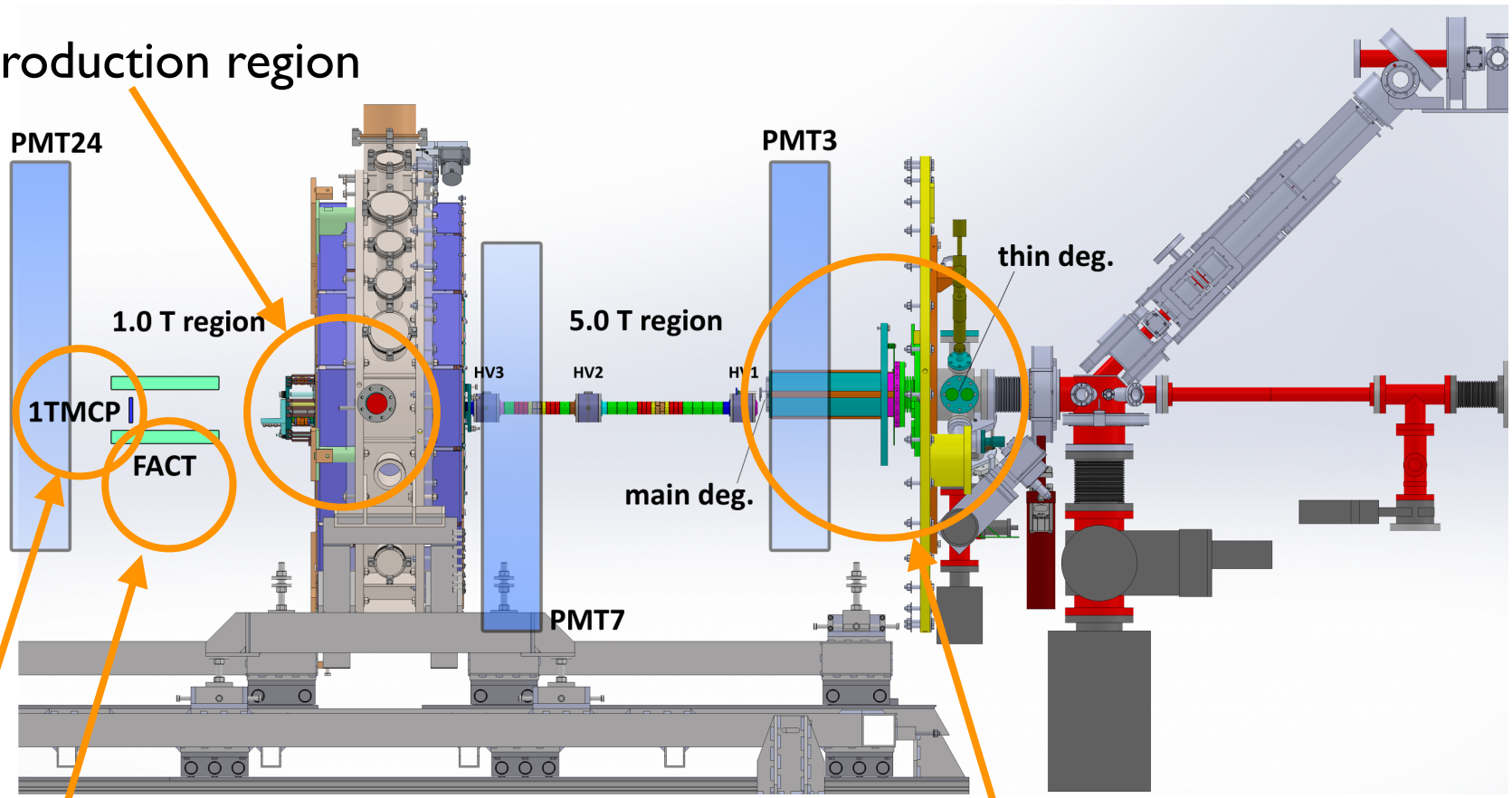


currently houses new 243 nm laser system;
space for foreseen additional laser systems

transport of UV light in
vacuum to minimize losses

Work on antiproton complex:

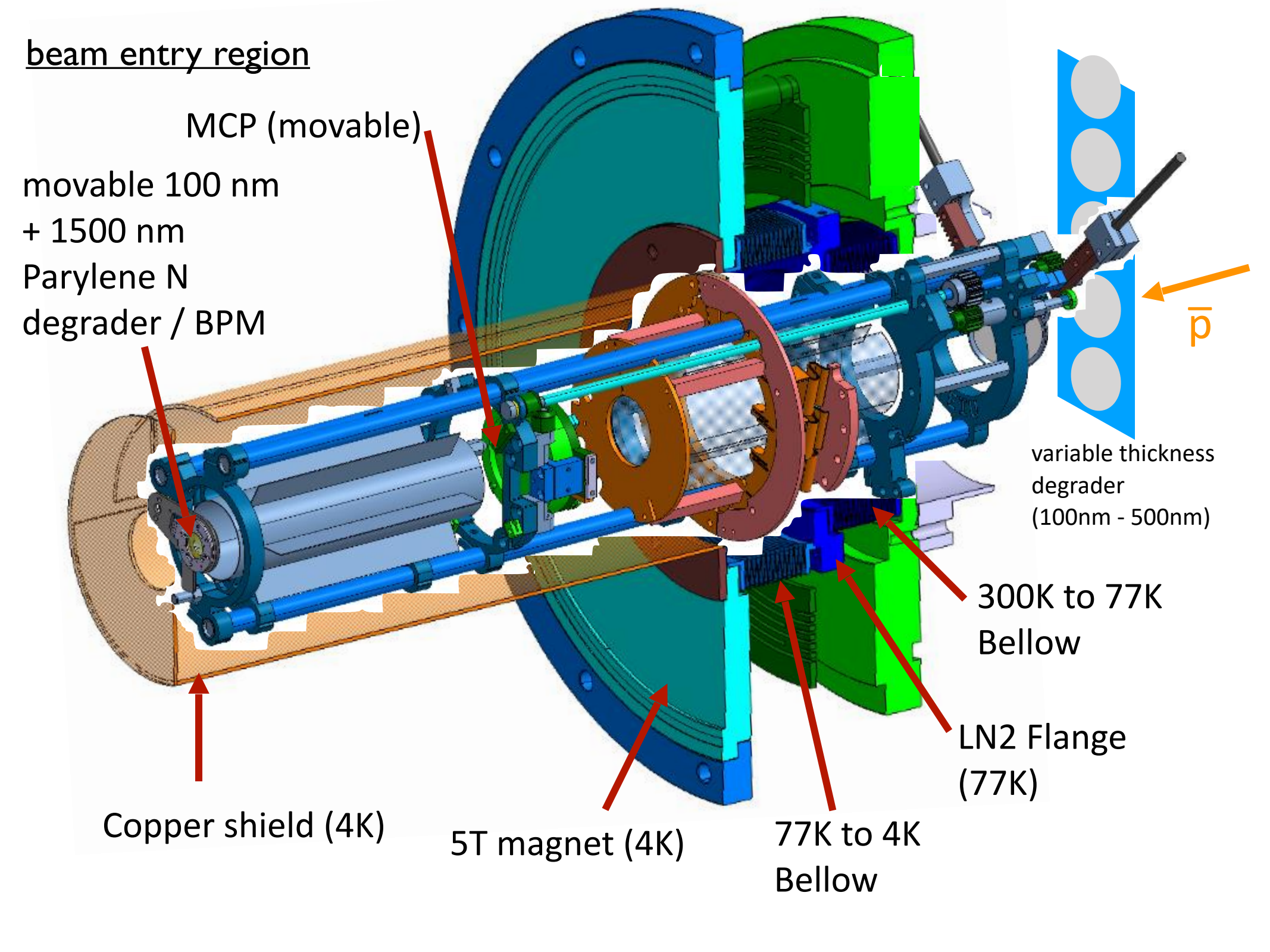
complete refurbishment / upgrade of all internal elements



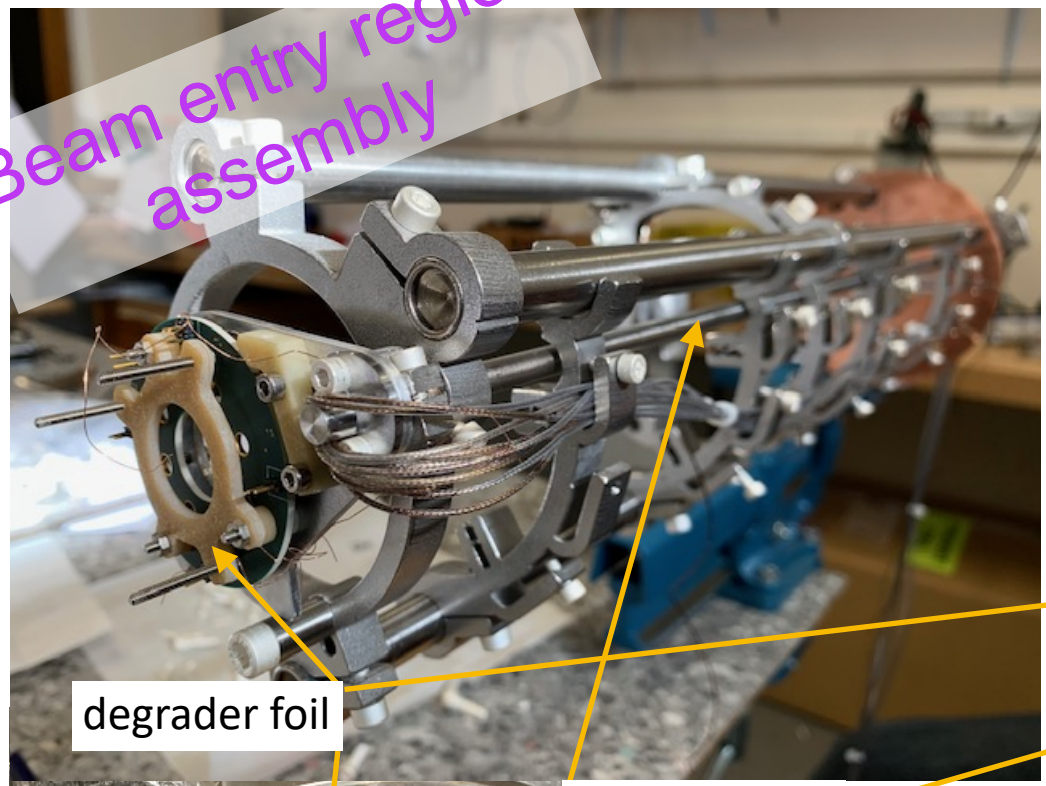
downstream MCP for imaging

anticryostat for scintillation fiber tracker (FACT)

beam entry region (degraders, BPM, detectors, mechanics, thermal shielding)

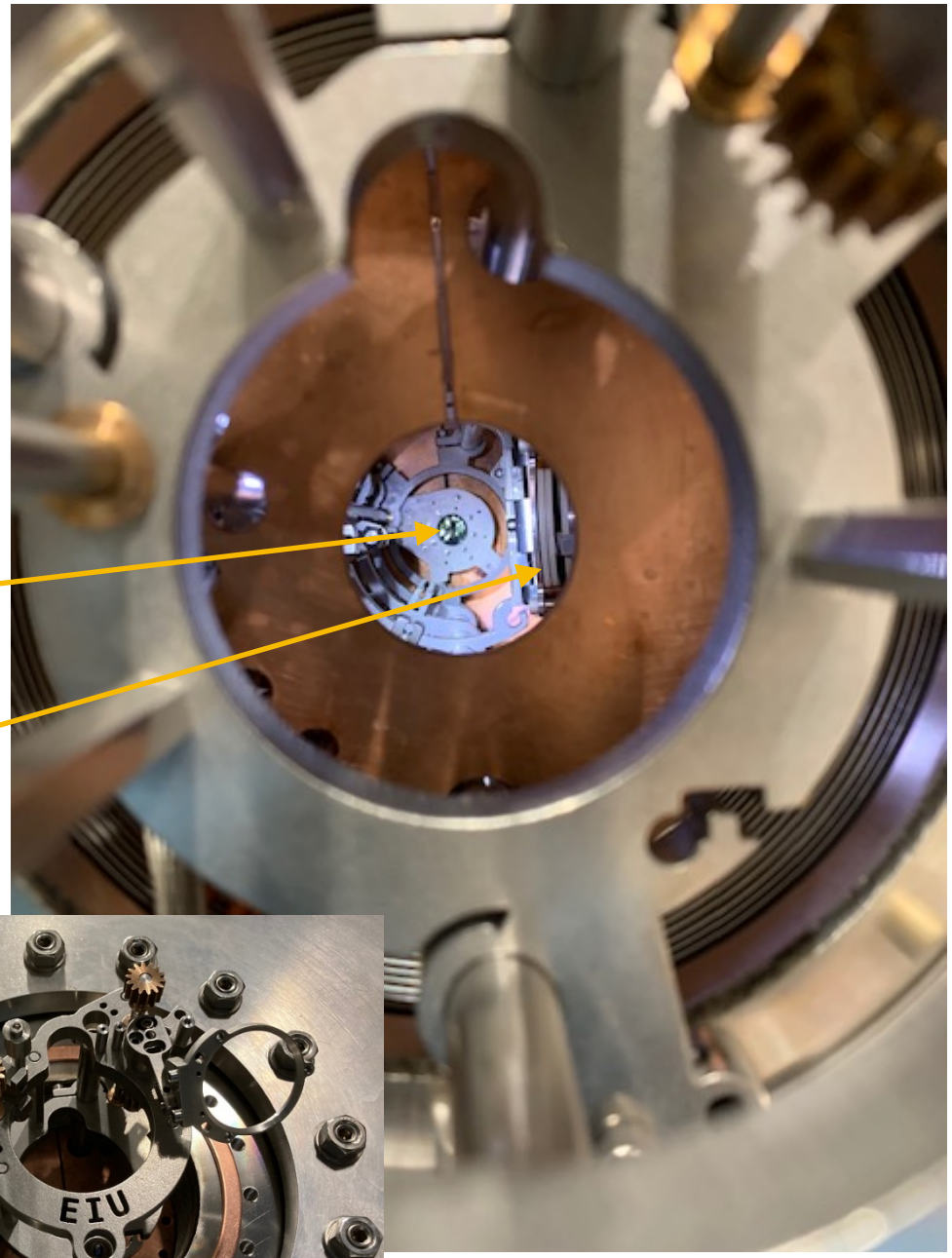

beam entry region
MCP (movable)
movable 100 nm
+ 1500 nm
Parylene N
degrader / BPM
$\bar{p}$
variable thickness
degrader
(100nm - 500nm)
300K to 77K
Bellow
LN2 Flange
(77K)
77K to 4K
Bellow
5T magnet (4K)
Copper shield (4K)

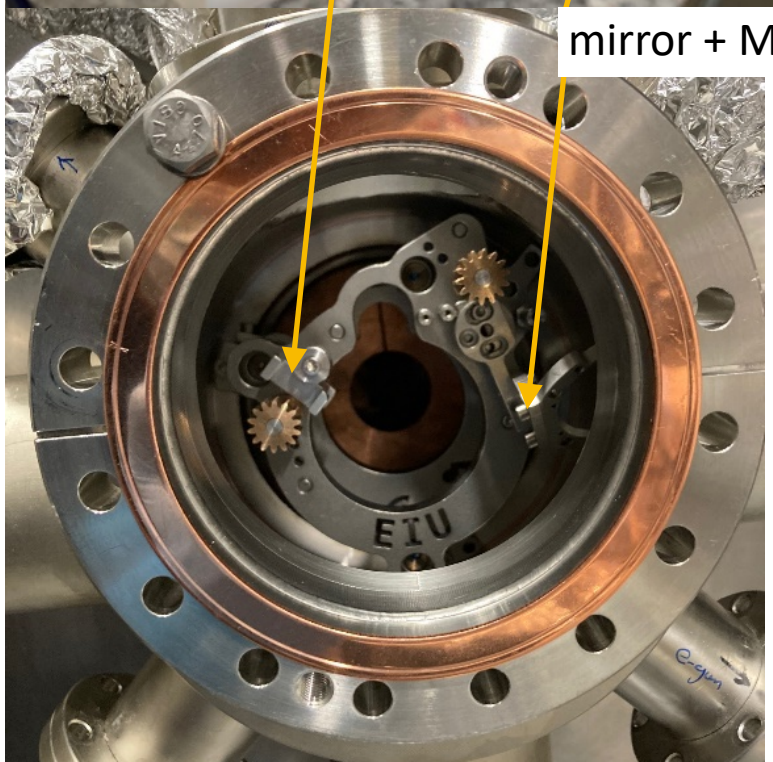
Beam entry region assembly

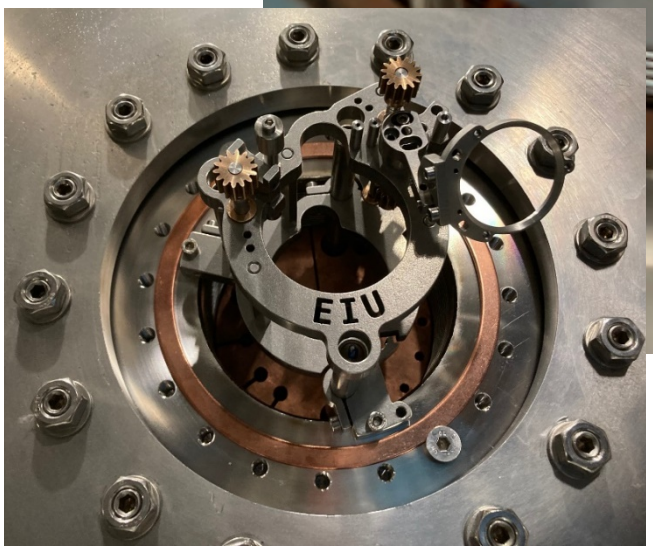


degrader foil

mirror + MCP





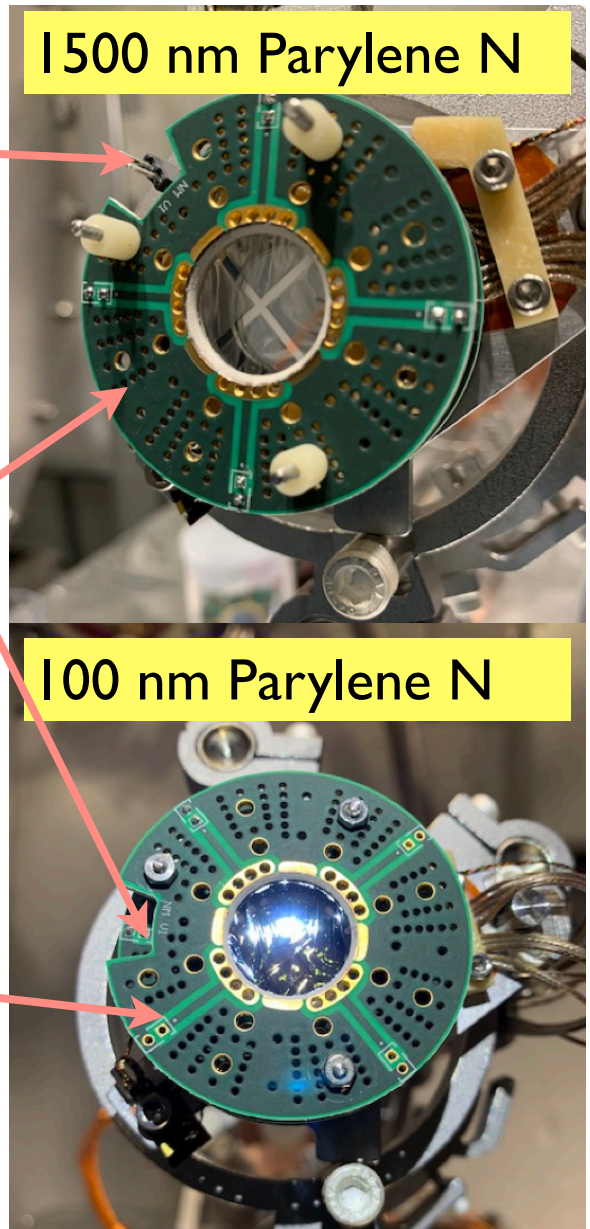


Beam entry region
degrader stack

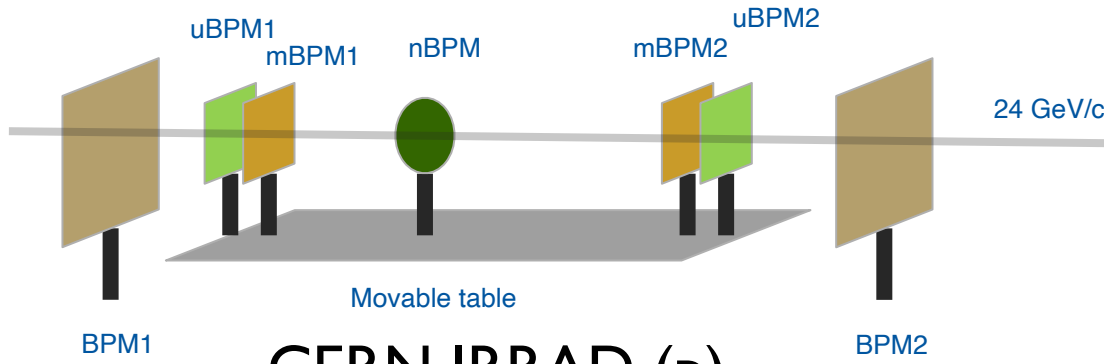
read-out
PCB

segmented
foil holder

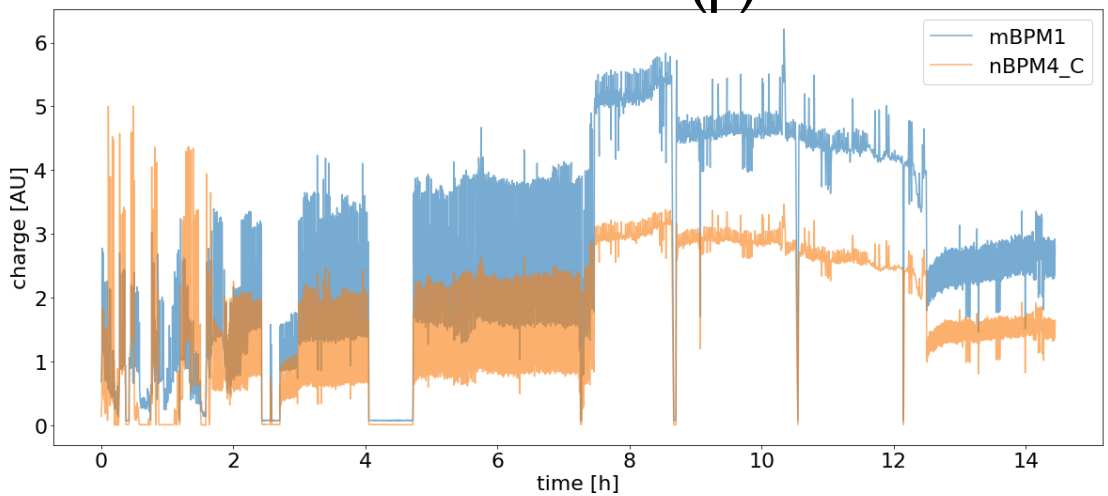
holder
PCB for
100 nm
foil



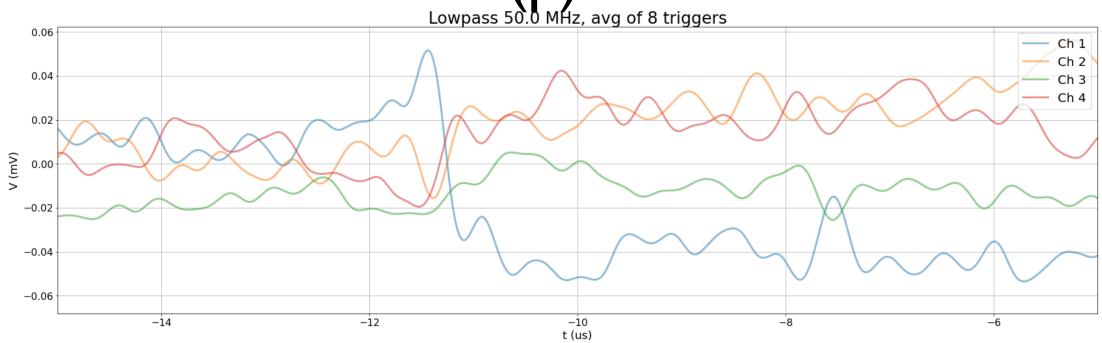
beam entry region: degrader / BPM tests



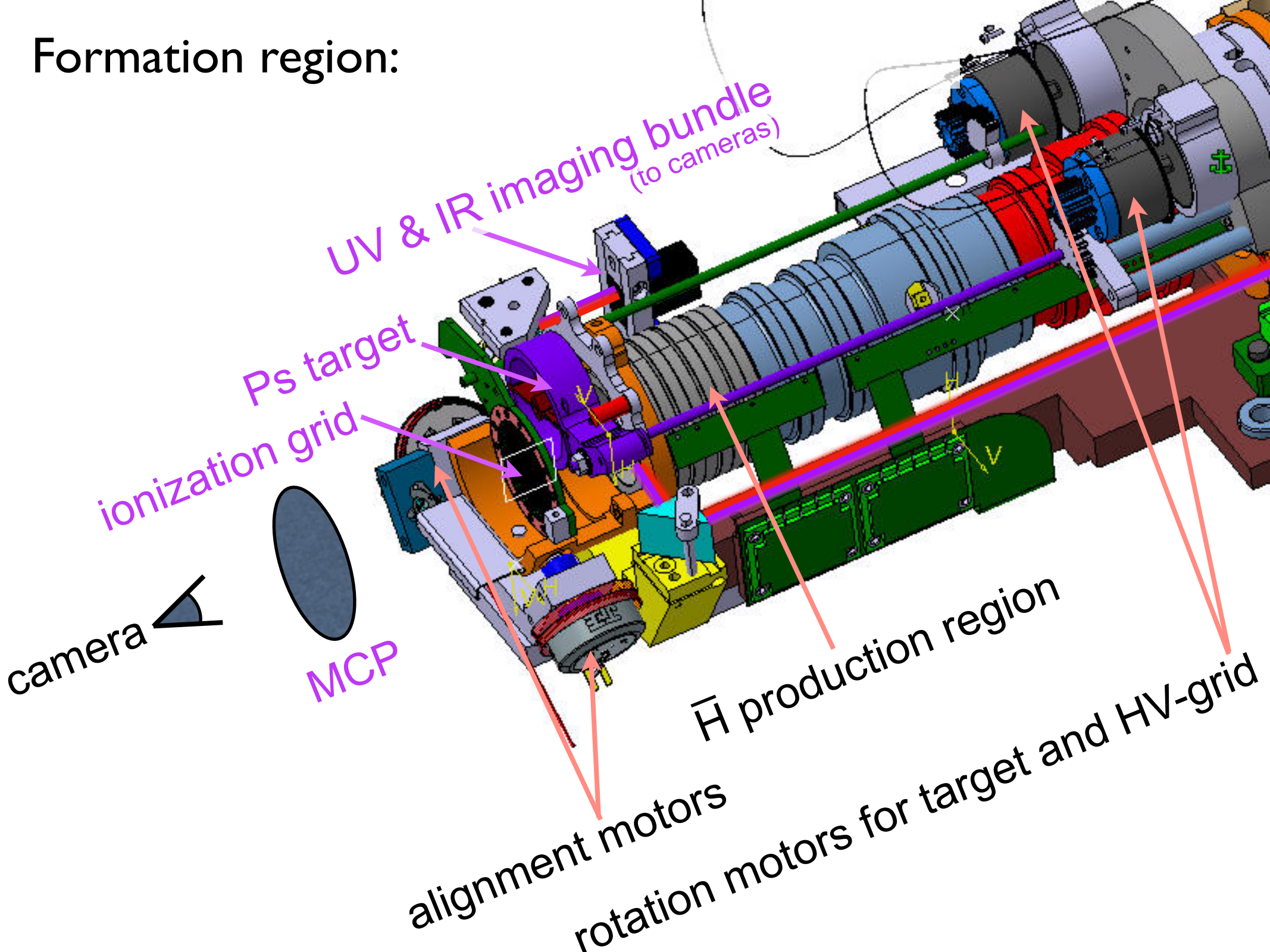
CERN IRRAD (p)

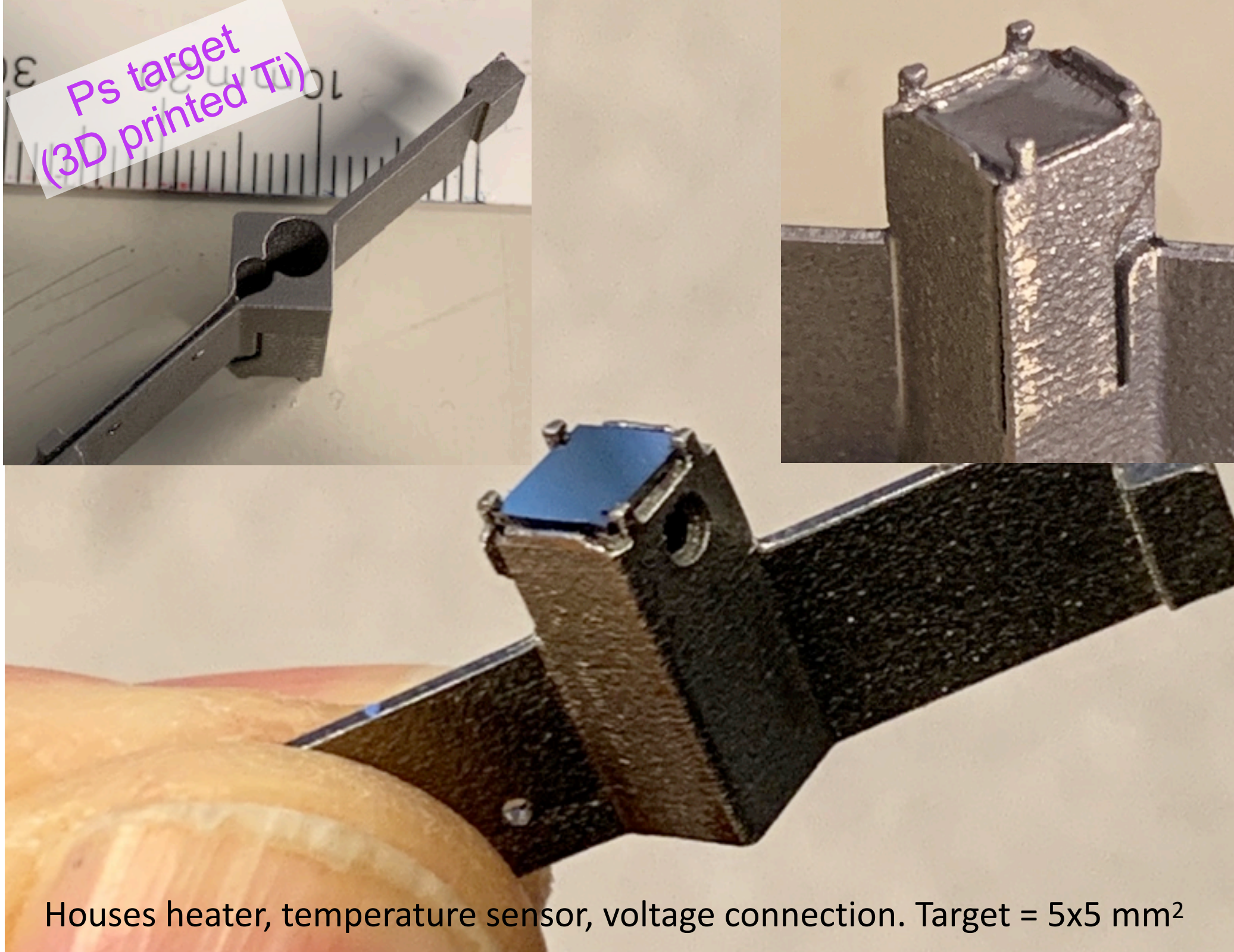


ELENA ($\bar{p}$)

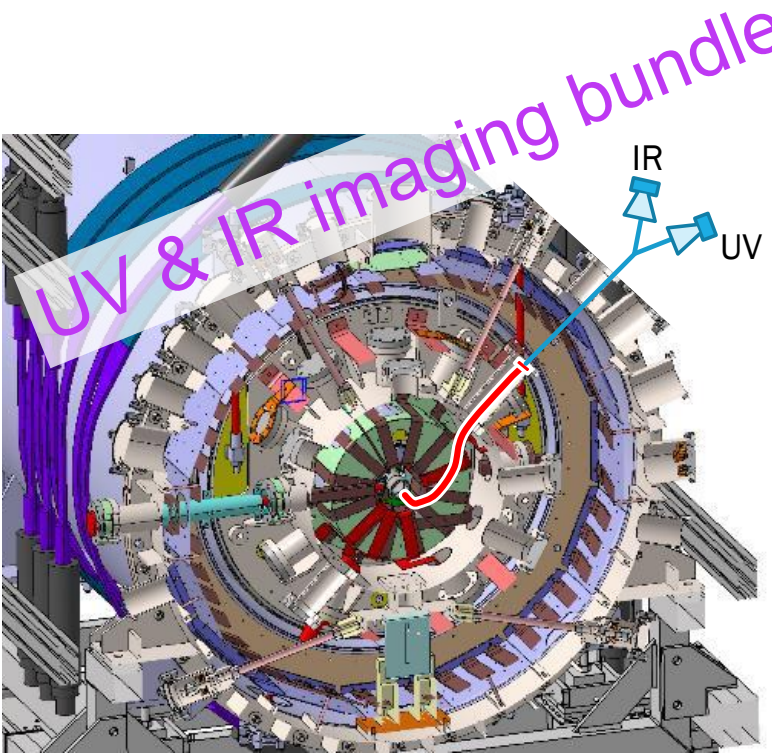


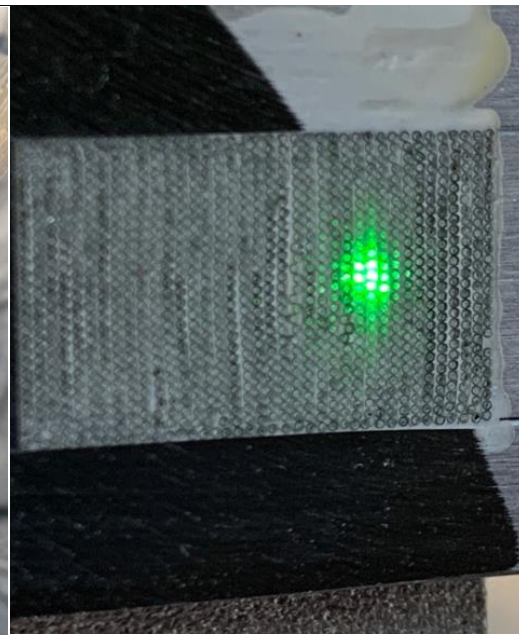
Formation region:





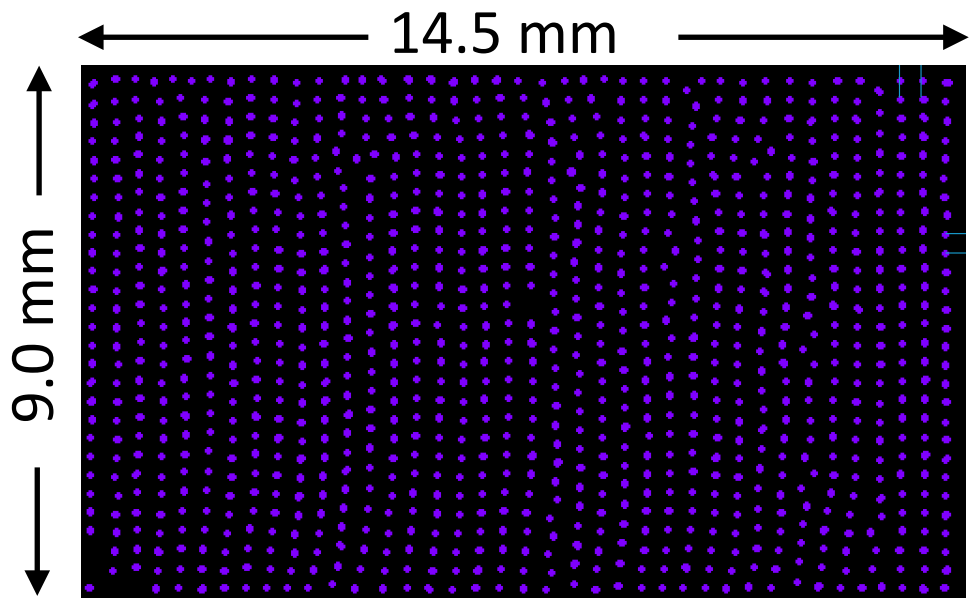
Houses heater, temperature sensor, voltage connection. Target = 5x5 mm^2

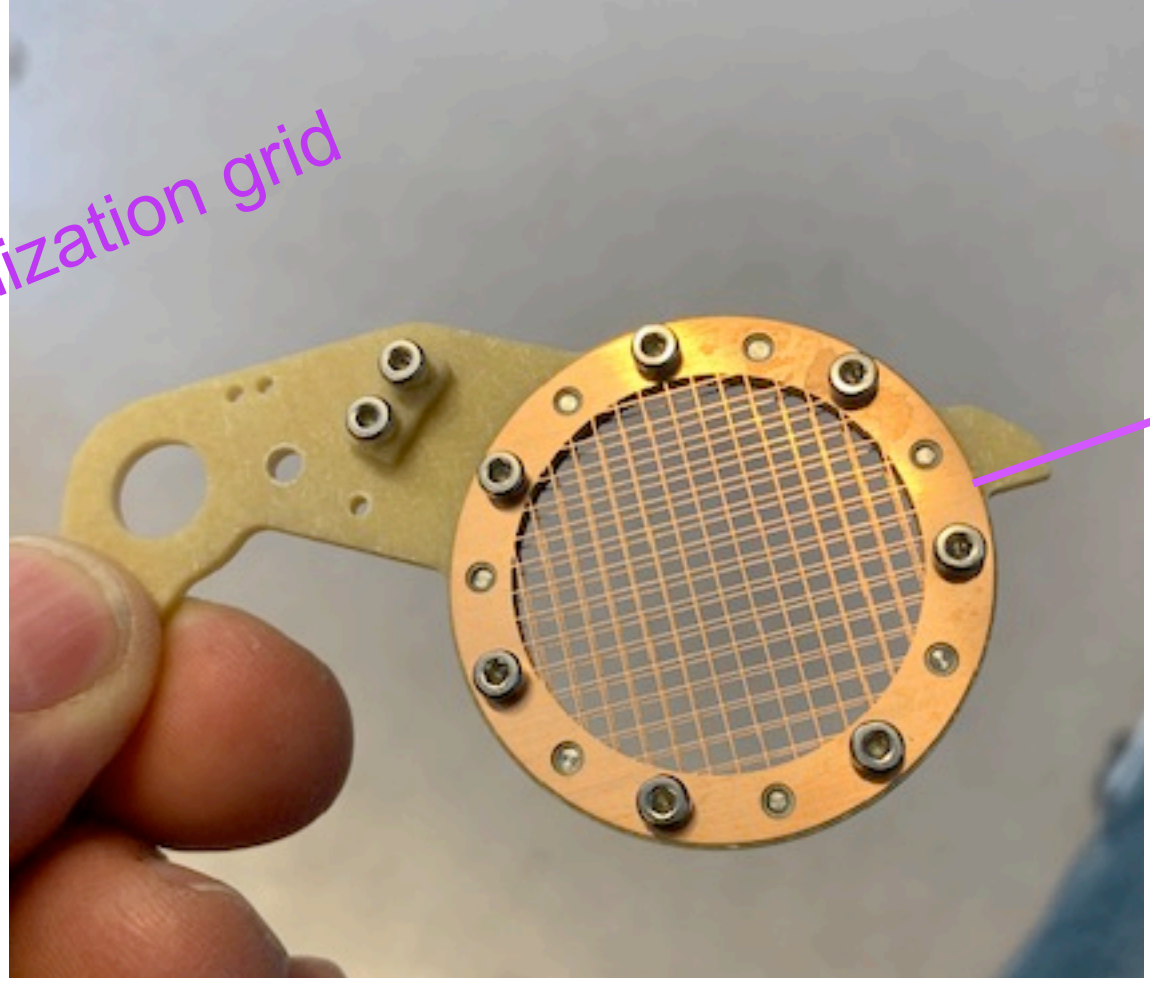


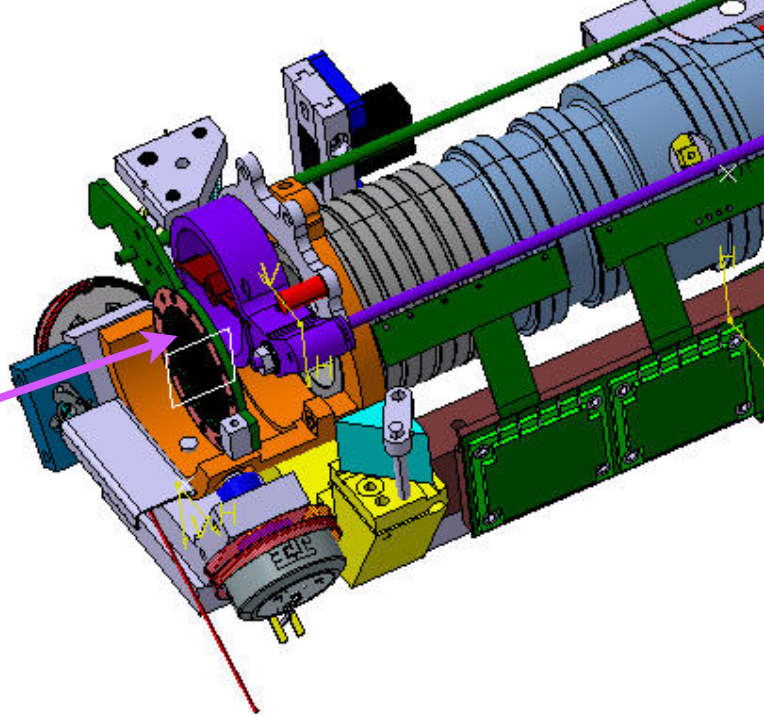


Real-time monitoring of Ps excitation lasers: array (37x28) of transparent 0.35 mm ⌀ fibers transparent for XUV and IR readout by dedicated UV, IR cameras

Calibration: fibers within 0.2 mm of nominal positions, can follow shifts of lasers at 0.1 mm level







Field ionization of downstream-moving Rydberg atoms → n-state population

Dual-plane etched Cu-Be structure for planarity, stiffness, homogeneity
Tested for ΔV of 5 kV

Work on control system:

Address: 24/7 x 7 month beam times with very small (local) crew;
Address: custom-built electronics, major HW modifications

replace control SW of full experiment control (was custom built LabView code)
→ ARTIQ ecosystem of open source SW + LabView +Python

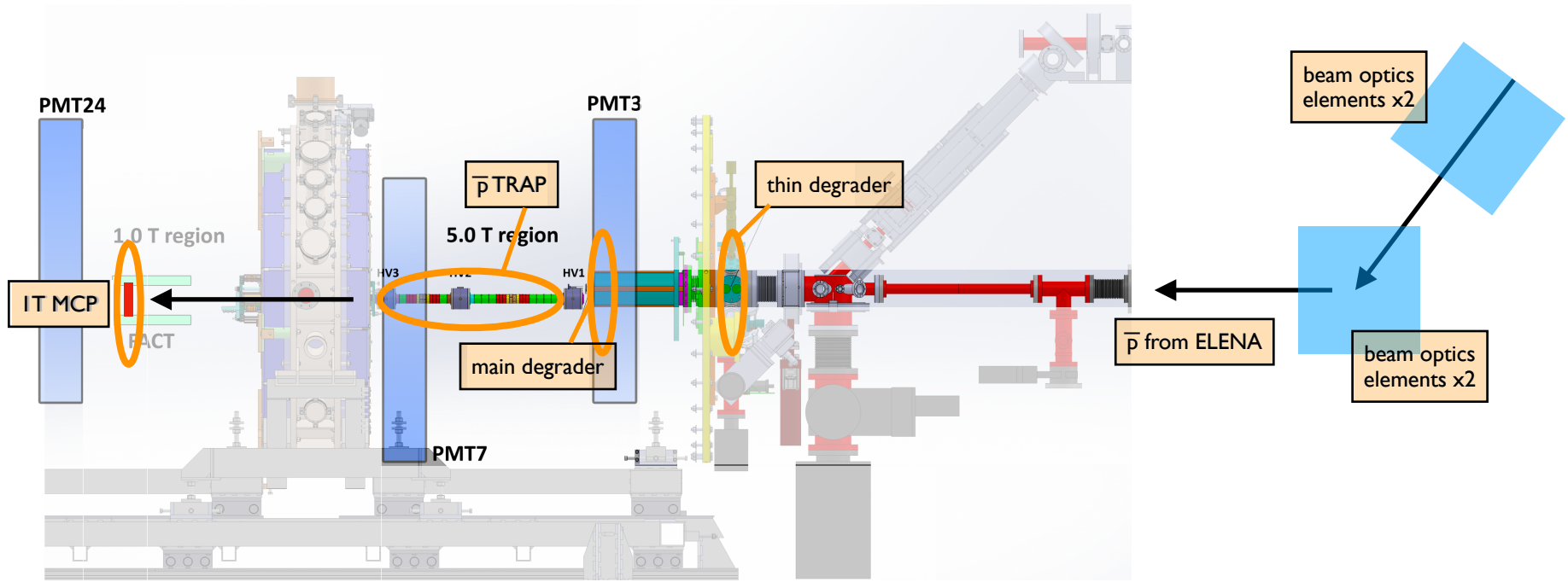
replace electronics of full experiment control (DAC, controller, ns-timing, DIO)
→ Sinara family of HW

→ synchronized, compact, easy-to-use, automated, extendable, stable, maintainable

Antiproton run 2021:

Goals of beam time:

- beam steering
- test control system
- test degrading
- test trapping
- test entrance region modifications
- test downstream region modifications

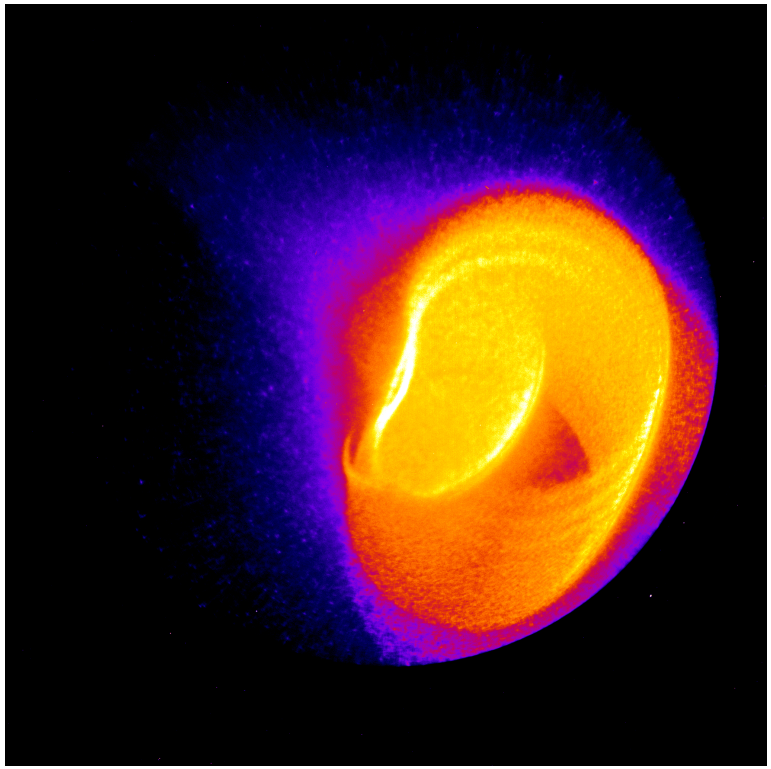


IT MCP as beam steering diagnostic:

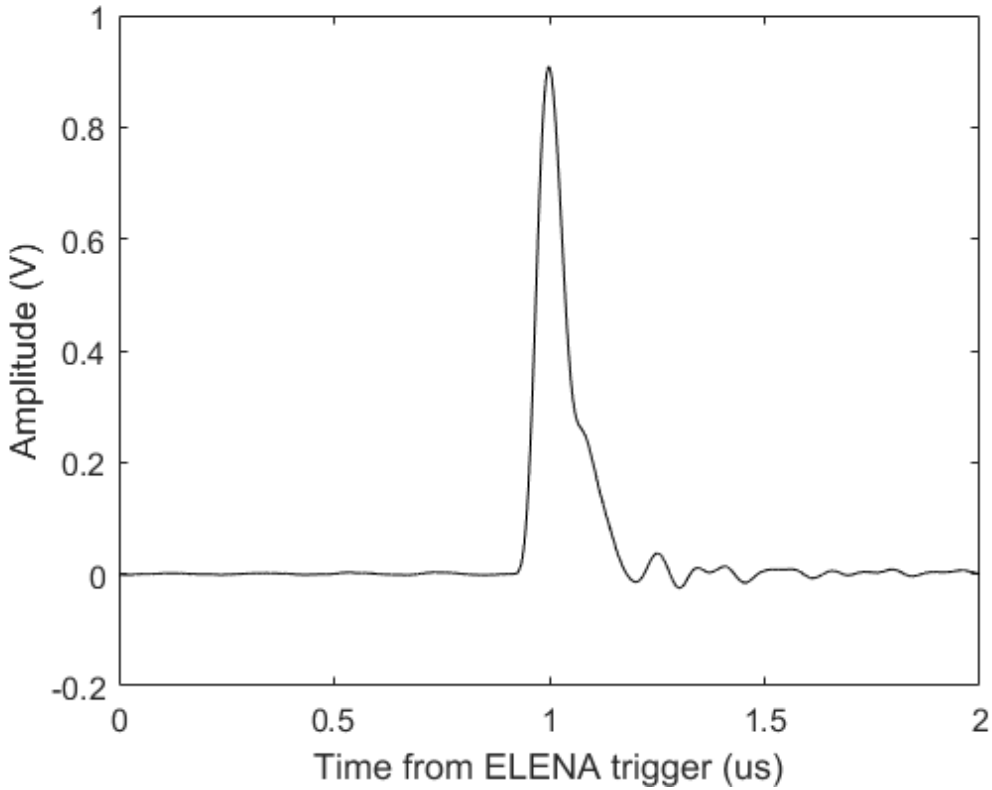
Goals of beam time:

- beam steering
- test control system
- test degrading
- test trapping
- test entrance region modifications
- test downstream region modifications

time-integrated 2D image of impact points of antiprotons at end of IT magnet



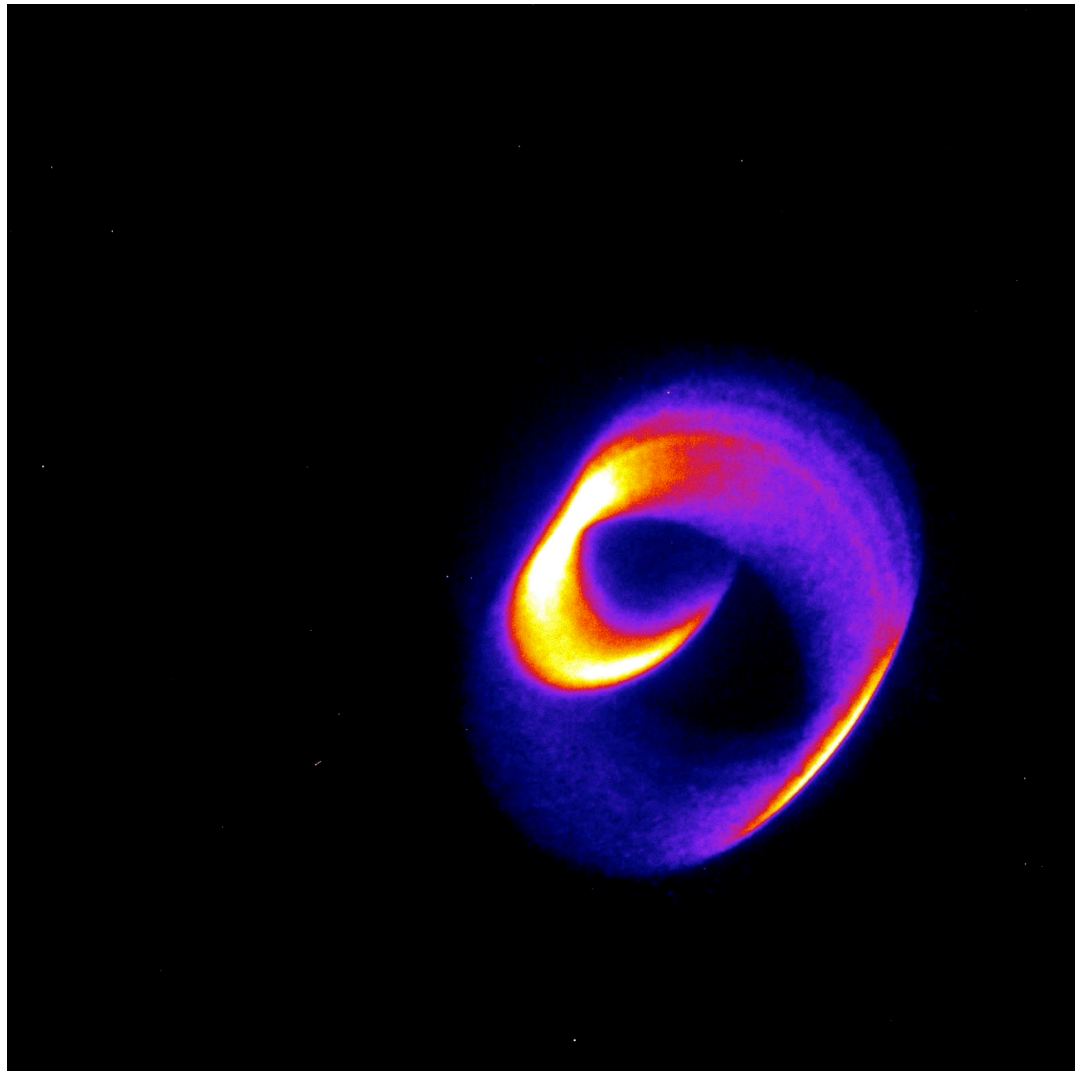
current on phosphor screen of MCP = arrival time of antiprotons at end of IT magnet



Goals of beam time:

- beam steering
- test control system
- test degrading
- test trapping
- test entrance region modifications
- test downstream region modifications

Automated beam scan of ELENA beam line LN02 (x, y, dx, dy)

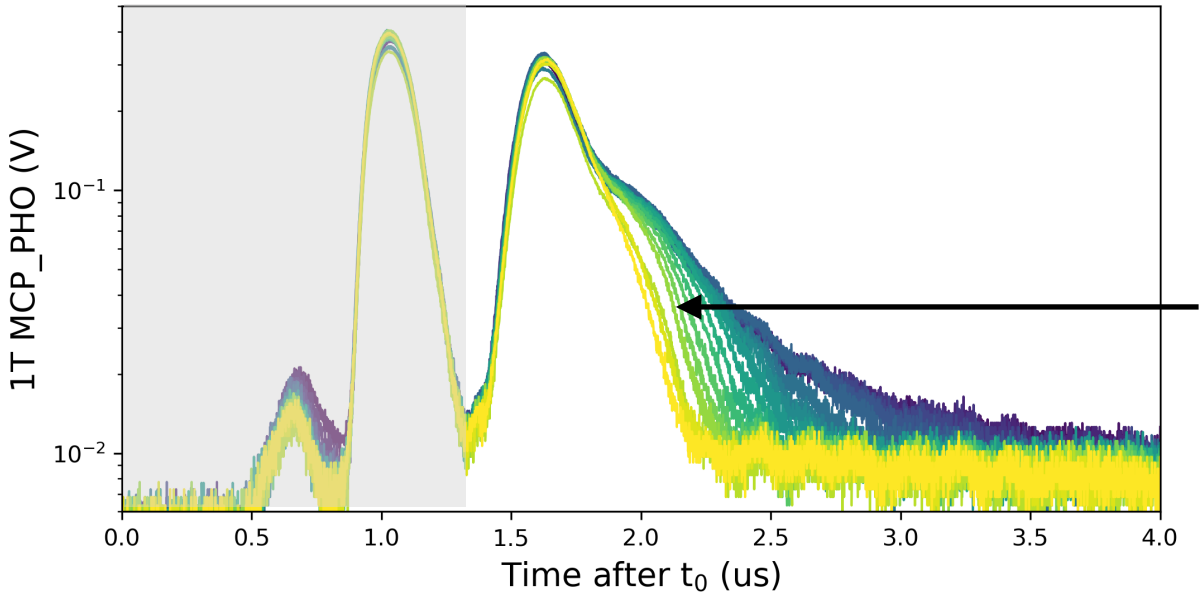


Outcome of the 4D scan on ELENA parameters (offset H/V, angle H/V) [473 images at 15 fps]

Goals of beam time:

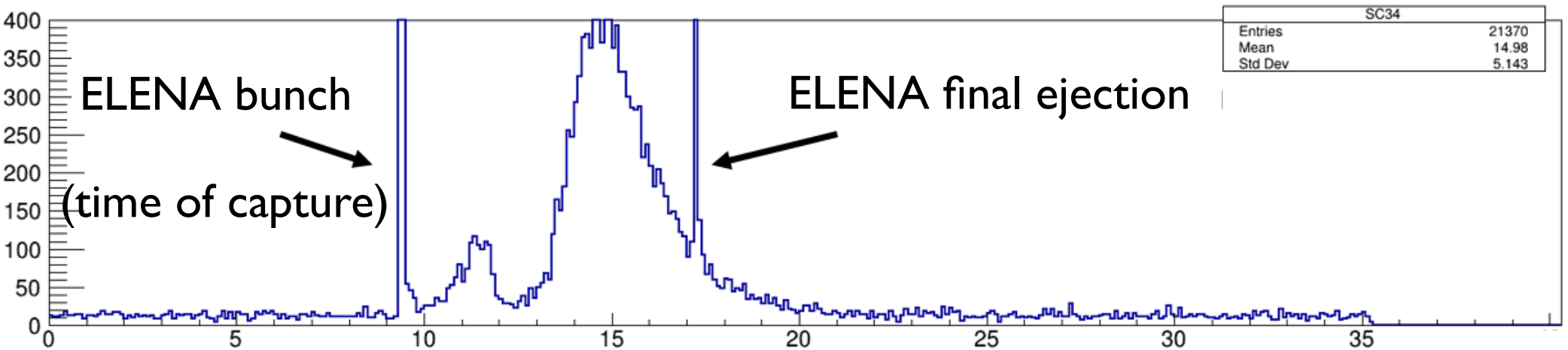
- beam steering
- test control system
- test degrading
- test trapping
- test entrance region modifications
- test downstream region modifications

$\bar{p}$ time-of-flight for different decelerating HV's



$\bar{p}$ after 1500 nm Parylene N

controlled release of trapped $\bar{p}$ a few s after trapping: annihilation rate



Summary and outlook

Covid-19 continued to have a major impact on our program in 2021, resulting in delays on several fronts, which we have attempted to mitigate

2021 $\bar{p}$ run: Many major modifications completed and tested; automated control system commissioned; recovery of pre-LS2 performance of e^+ system demonstrated, antiproton degrading and trapping validated.
Many thanks to ELENA team for excellent beam performance !

In parallel, work on Ps formation and manipulation is ongoing;

$\bar{H}$ formation region hardware developed and greatly improved, will be installed in the coming months, will be ready for 2022 $\bar{p}$ run time;

Goal for 2022 $\bar{p}$ run time: major increase of $\bar{H}$ production through strong increase in # of trappable $\bar{p}$, on-axis Ps* formation; work towards reducing Ps momentum spread in non-$\bar{p}$ beam time with new Alexandrite laser system; prepare ion injection HW

End of slides