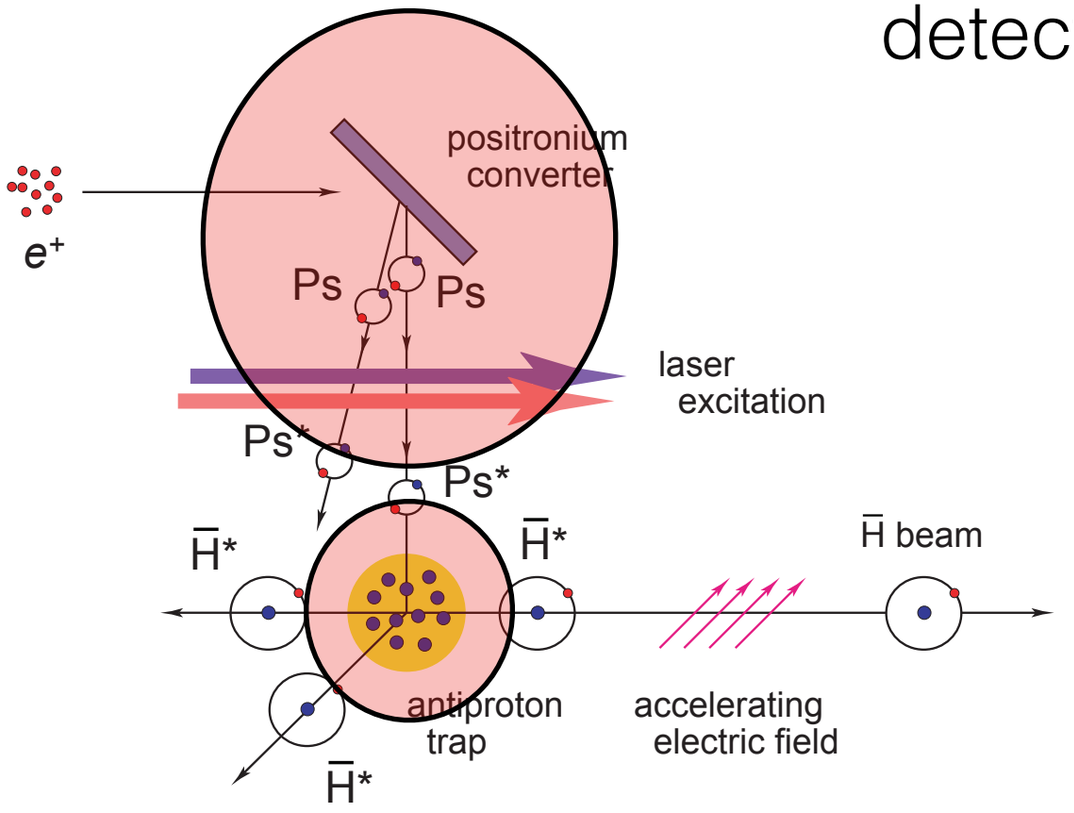
CERN project #2

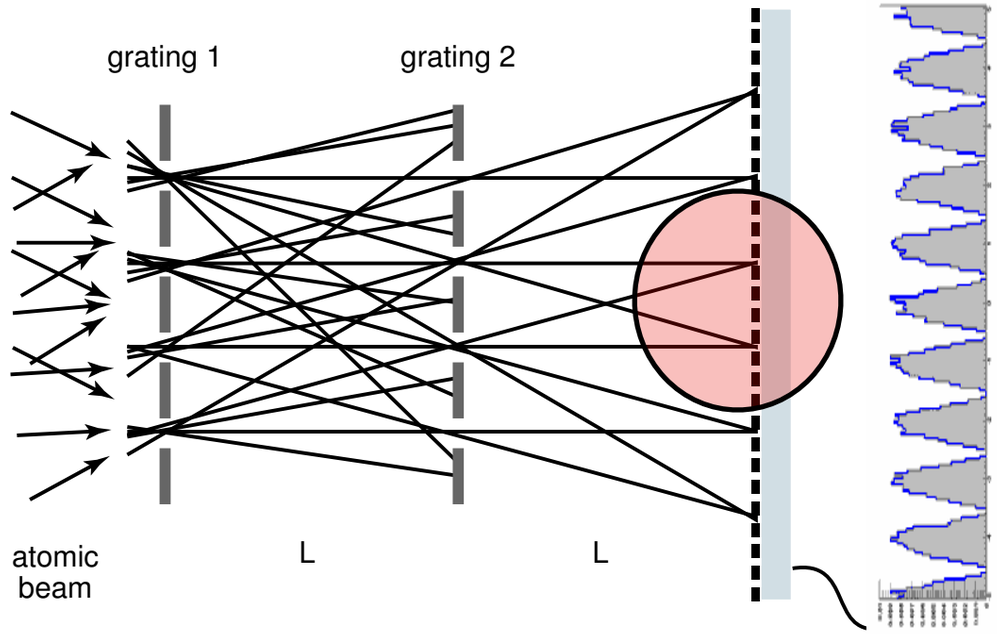
AEgIS experiment

Physics goals: measurement of the gravitational interaction between matter and antimatter, $\bar{H}$ spectroscopy, ...

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

Atomic physics experiment: integrates many sub-fields: lasers, charged plasmas, cryogenics, interferometry, positron physics, material science, physical chemistry, detectors, control systems, DAQ, ...





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Original concept: provide a general purpose facility to produce very low energy antiprotons (~keV) for detector tests, physics studies, applications

Idea: use second (mostly unused) beam line in the AEgIS experimental zone at CERN's AD; degrade the beam to < 100 keV; Einzel lenses & electrostatic deflection to select out very low energy fraction (expected flux: ~10^-6 of AD flux).

In the mean time: device has been designed (by undergrad, doctoral student & postdoc), built, commissioned, used for detector tests. Further optimization is possible (higher voltage, better beam optics, magnets)

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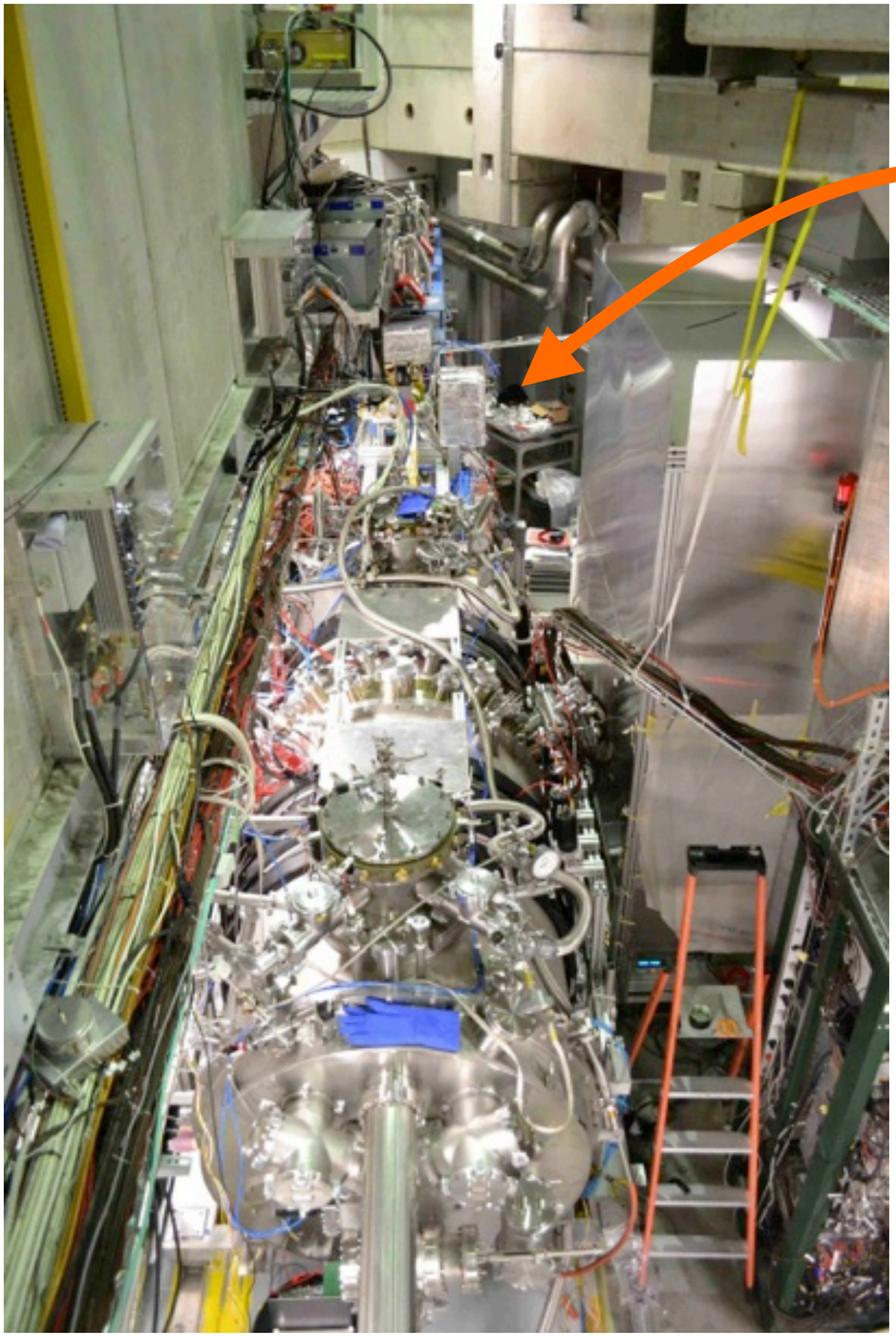

<u>Second beam line</u>:

Originally used for biological studies with antiprotons of 500 MeV/c momentum, but also 100 MeV/c available:
~150 μm range in Al;
100 keV ~ 1 μm;
10 keV ~ few nm

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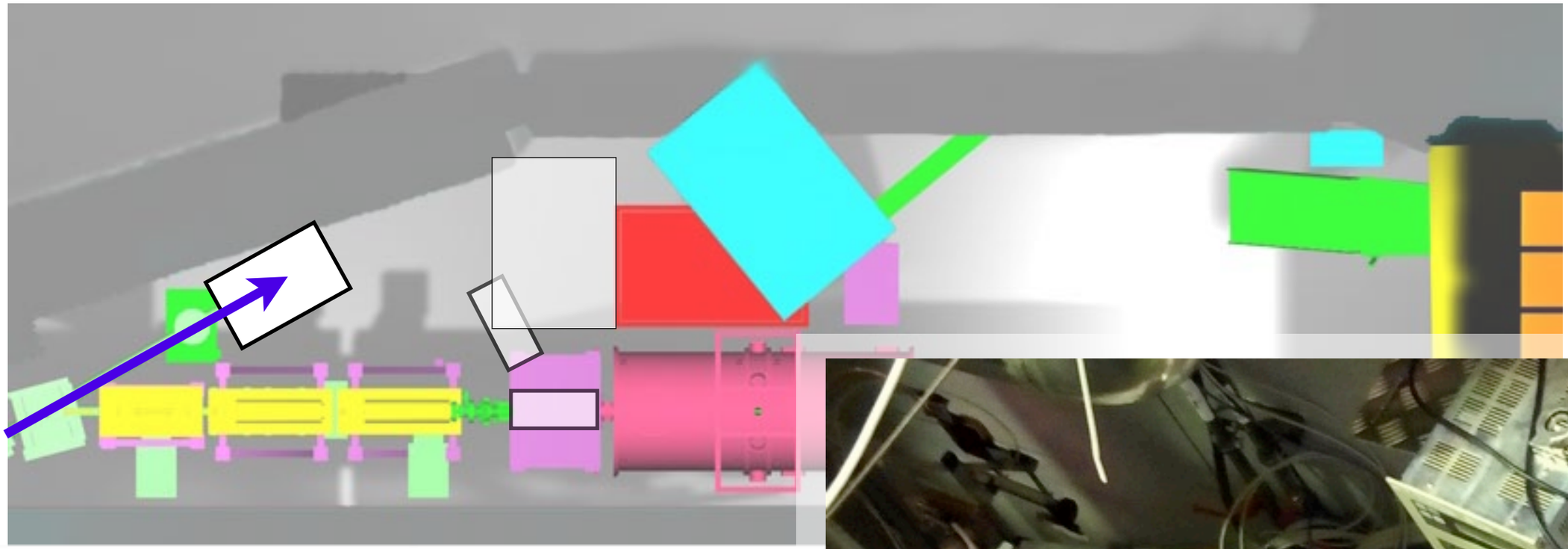

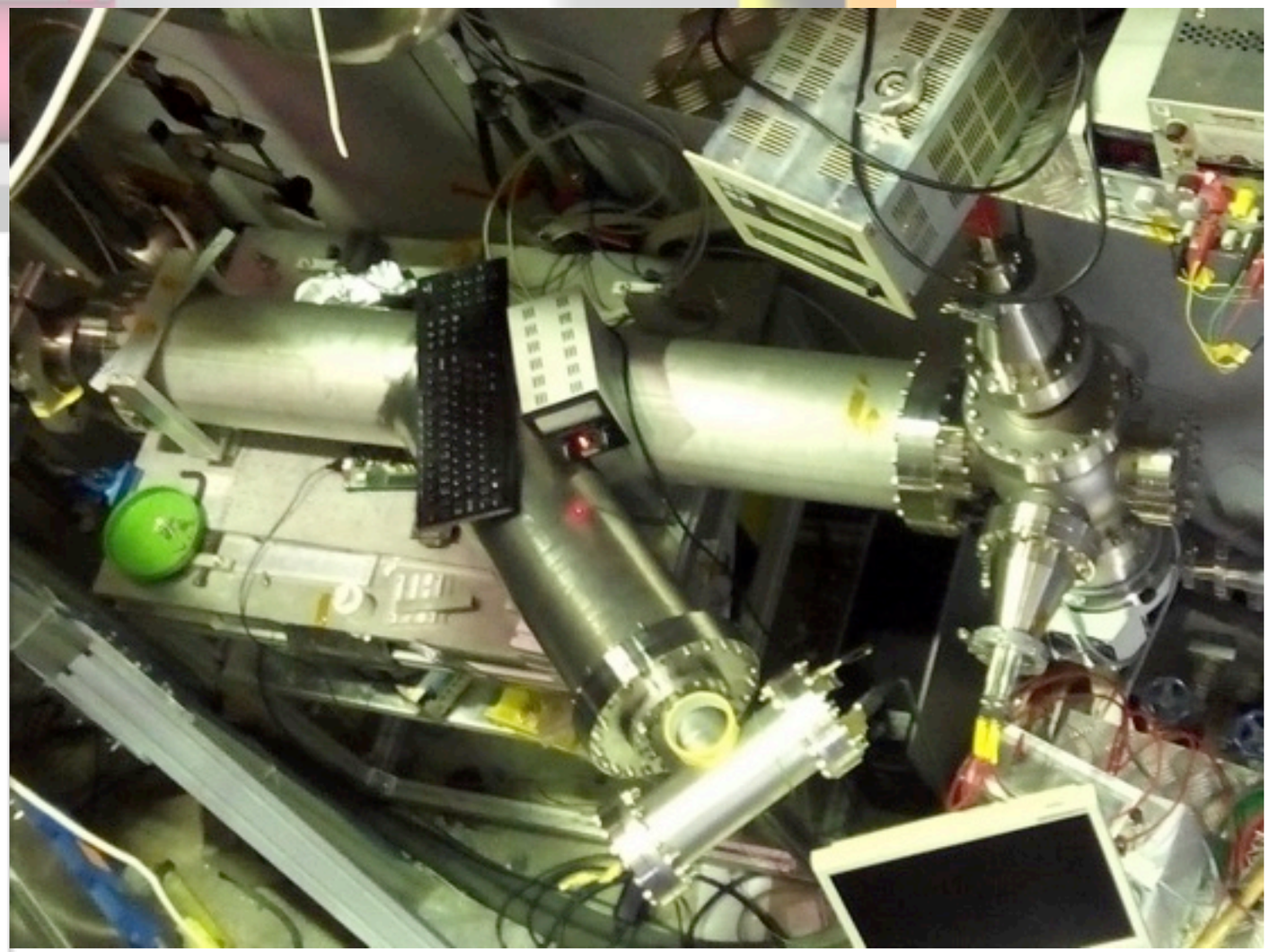

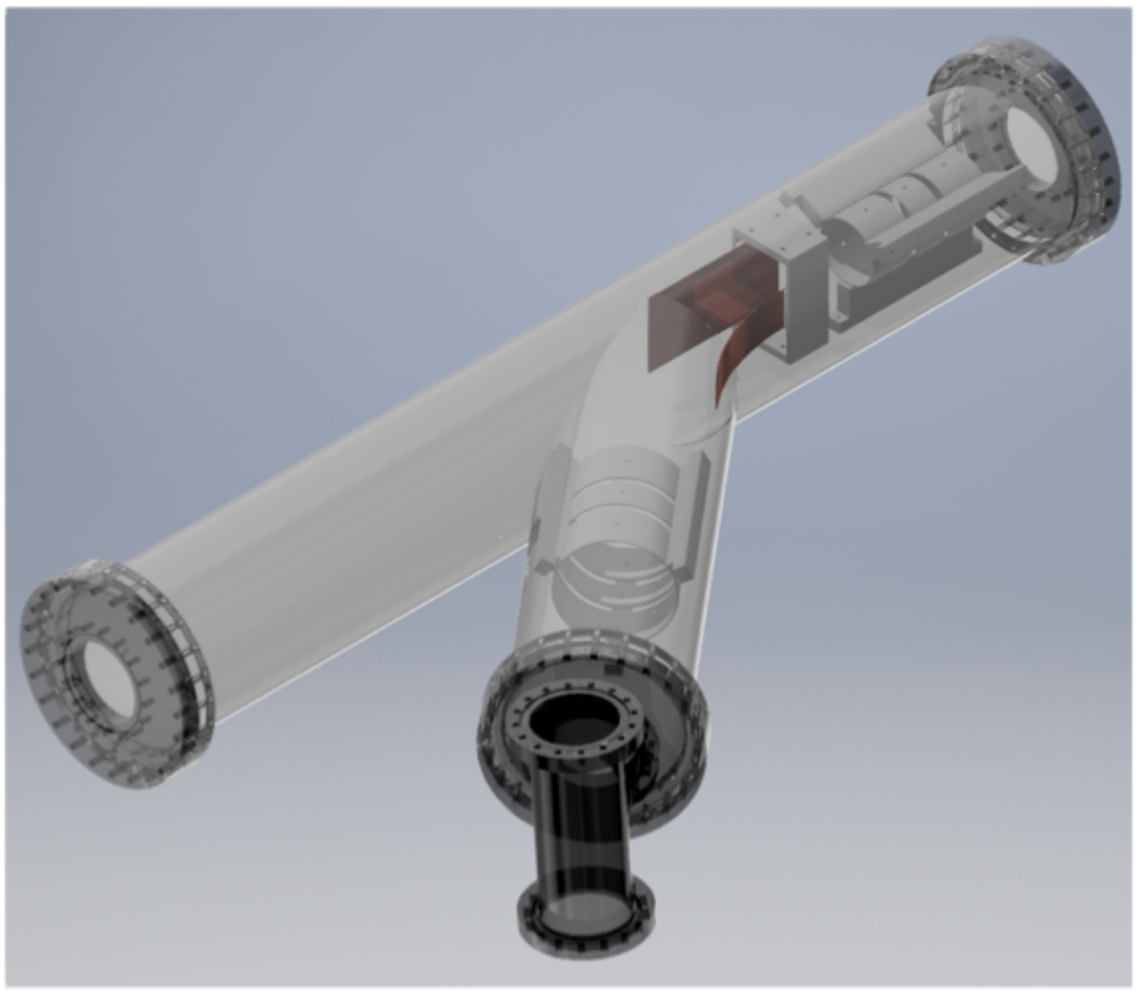

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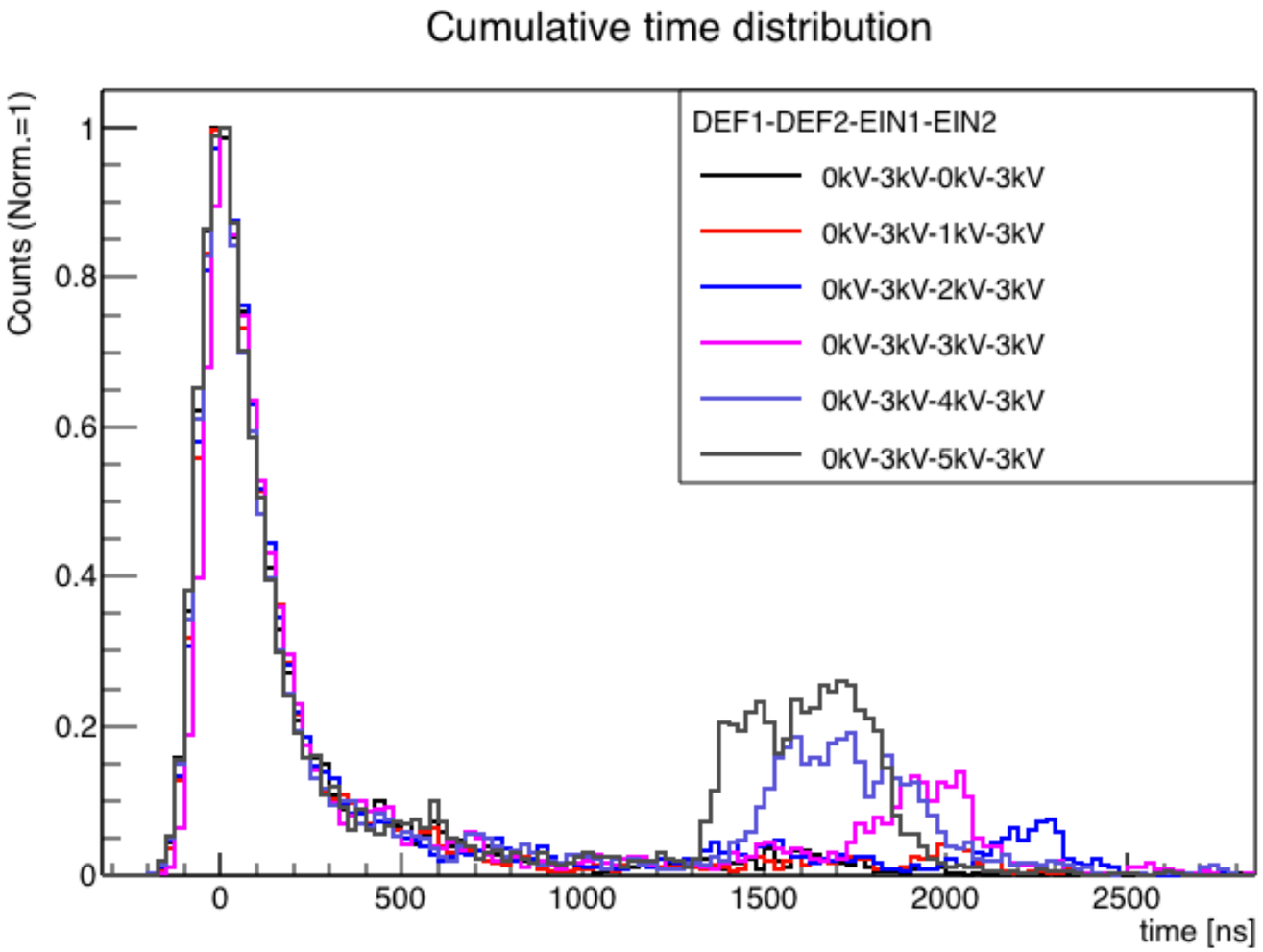
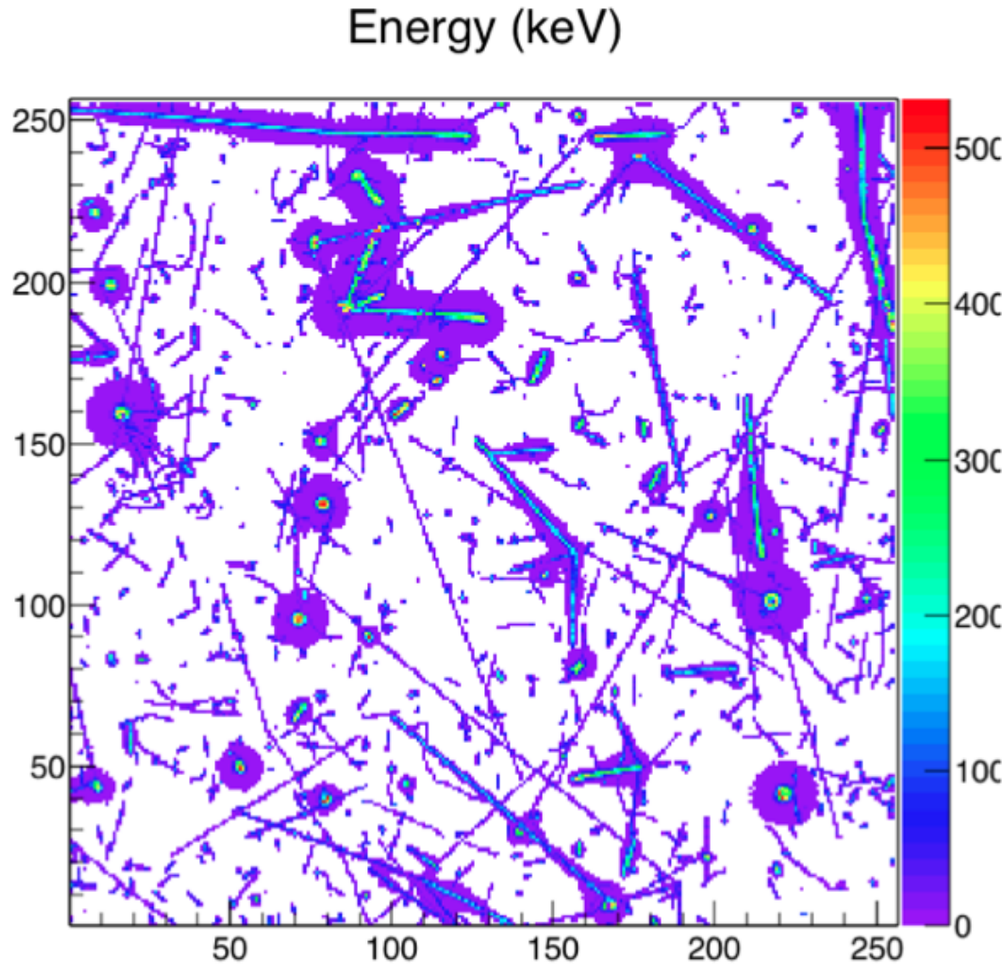
Energy distribution (1500 ns ~ 5 keV)



5 keV antiprotons in silicon detector (Timepix3)



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Recent changes: since end of 2016: new decelerator (ELENA) producing 100 keV antiprotons.

However:

- no generic beam line (all dedicated to experiments)
- AEgIS experiment remains in current area for 2 more years; that area then becomes available in 2021 with current beam conditions

Further developments meaningful also in the long term

But: not enough for ESR, since most of the work has already been done. Instead, extend the project.

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Low energy beam:

- of antiprotons, but also of antihydrogen (involves plasma physics in addition to electrostatics)
- currently, antiprotons are trapped in Penning traps (B field = 1~5 T); would be very useful to be able to transfer into B-field free trap (Paul RF trap)
- Antiproton energies in trap are ~ eV: easy to re-accelerate, but details depend on trap
- Several technologies to be explored: low rate direct extraction of $\bar{p}$ via existing device; extraction of $\bar{p}$ from Penning-trap (into Paul trap); production of a pulsed beam of $\bar{H}$

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Training (needs) in:

- electrostatic and magnetic beam simulations
- plasma physics & GHz electronics
- data acquisition & experimental control
- cryogenic and ultra-sensitive electronics

More generally: training available in

- laser physics and technologies
- detectors (silicon, photon detection, MCP, ..)
- ultra-high vacuum
- material studies using positrons and antiprotons