UV photon detection simulation with Garfield++ for Lyman α measurement

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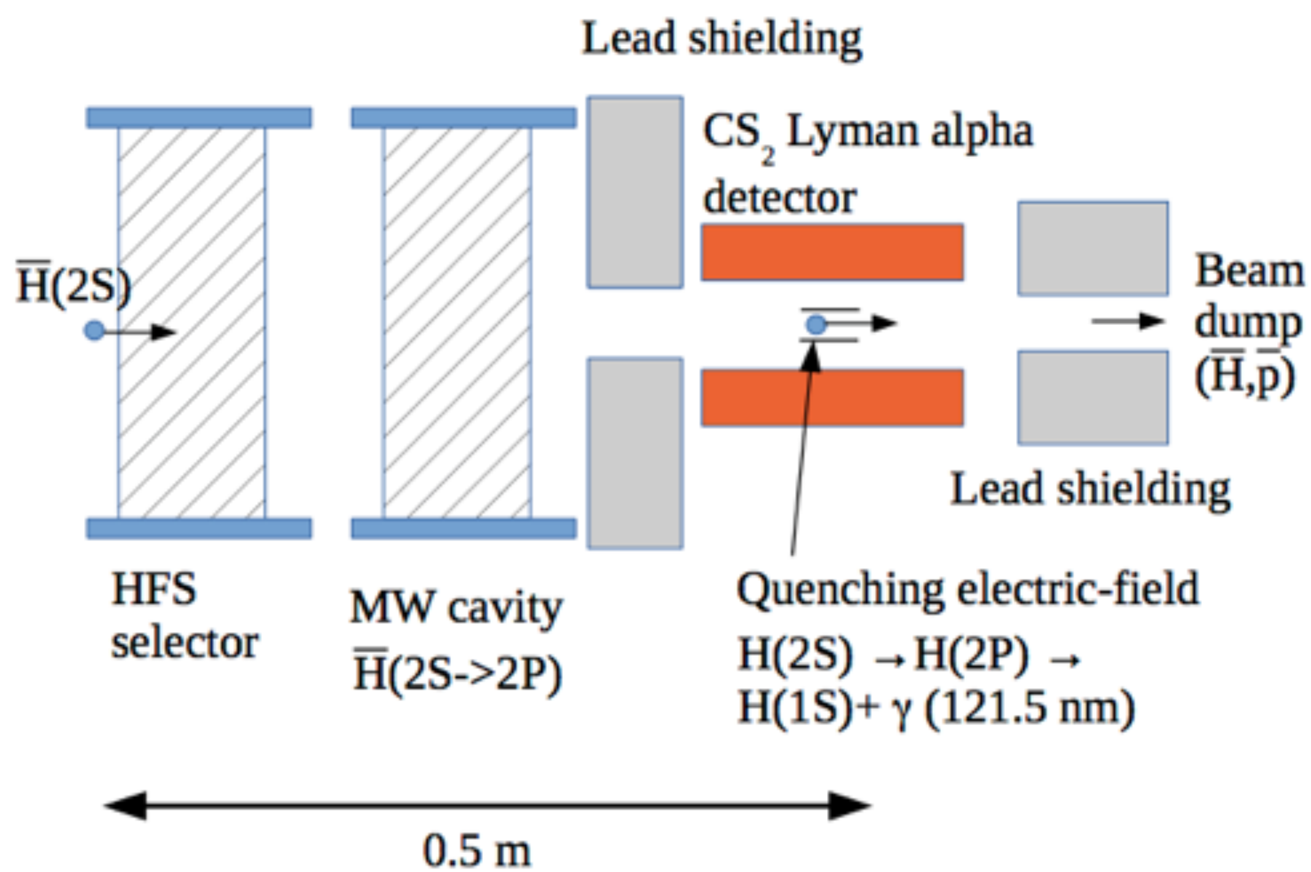
- The **anti-proton charge radius** measurement proposal by P. Crivelli et al.: http://arxiv.org/abs/1606.05977

- First determination of the antiproton charge radius: complementary CPT test in the framework of the GBar experiment: Measurement of the 2S->2P transition frequency (Lamb shift) is sensitive to the antiproton charge radius (W. Aron and J. Zuchelli Phys. Rev. 105 (1956) 1681).

- Scheme: Metastable 2S anti-hydrogen beam is produced by charge exchange between antiprotons and dense positronium. After a state selector a MW field induce 2S->2P transitions and an electric field quenches the remaining 2S states to the unstable 2P state. The resulting 2P states decay to GS emitting a UV photon (Lyman alpha, 121.5 nm).

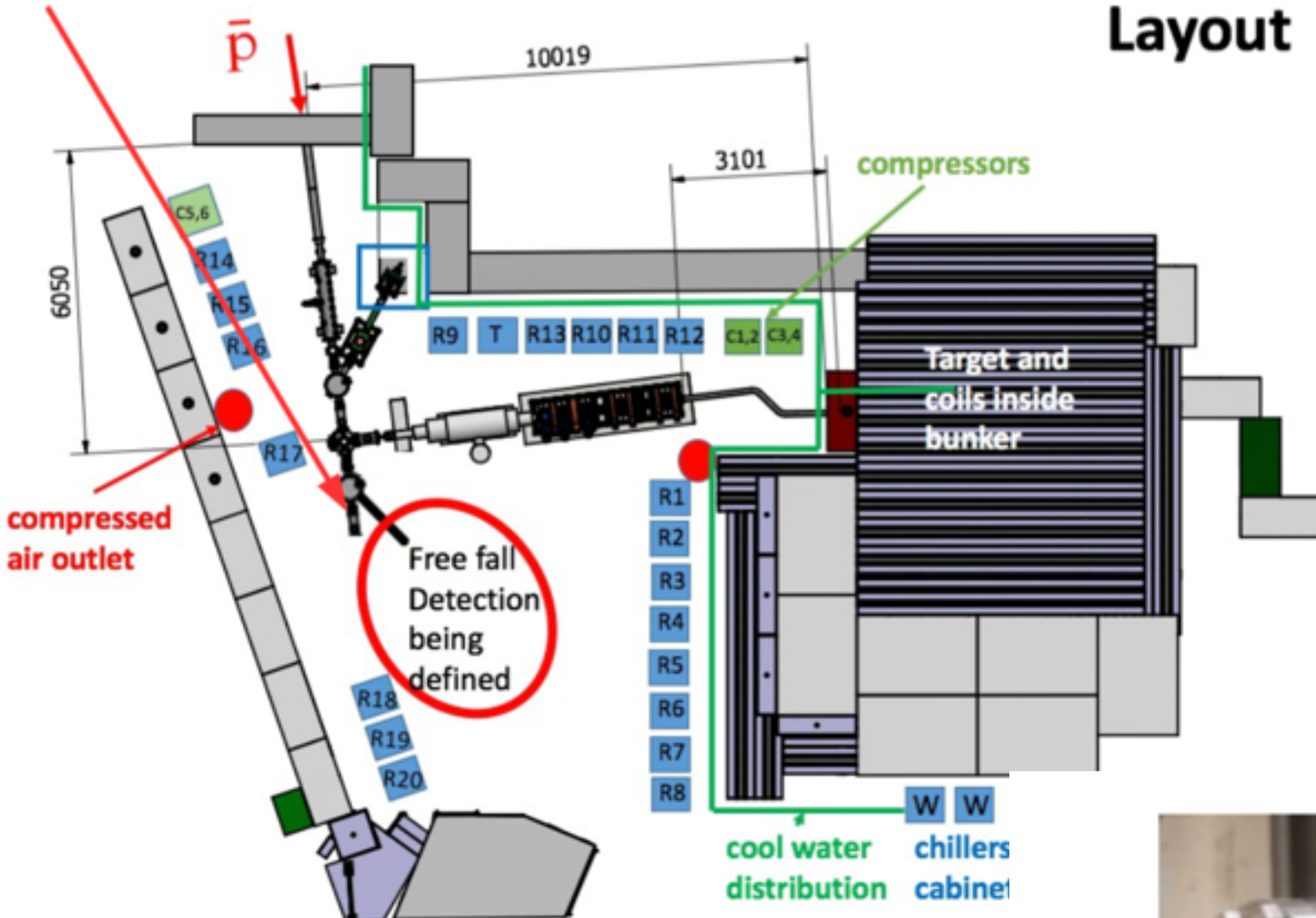
- Measuring the quenched fraction of atoms as a function of the MW frequency allows to determine the Lamb-shift, and extract the antiproton charge radius.

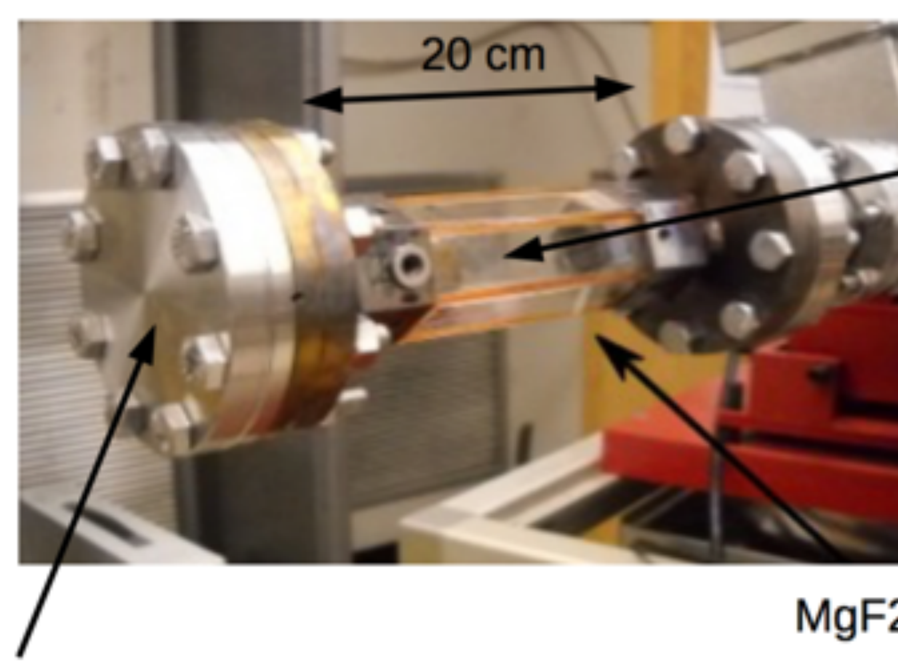


- Similar gas based UV photoionisation detectors were employed, see e.g.: A. K. Stober, R. Scolnik, and J. P. Hennes, Appl. Optics 7, 735 (1963).

Lyman-alpha detector

Position somewhere but not more than 1 meter from Ps target
Otherwise HBAR beam will blow up (if less than 1 meter even better)



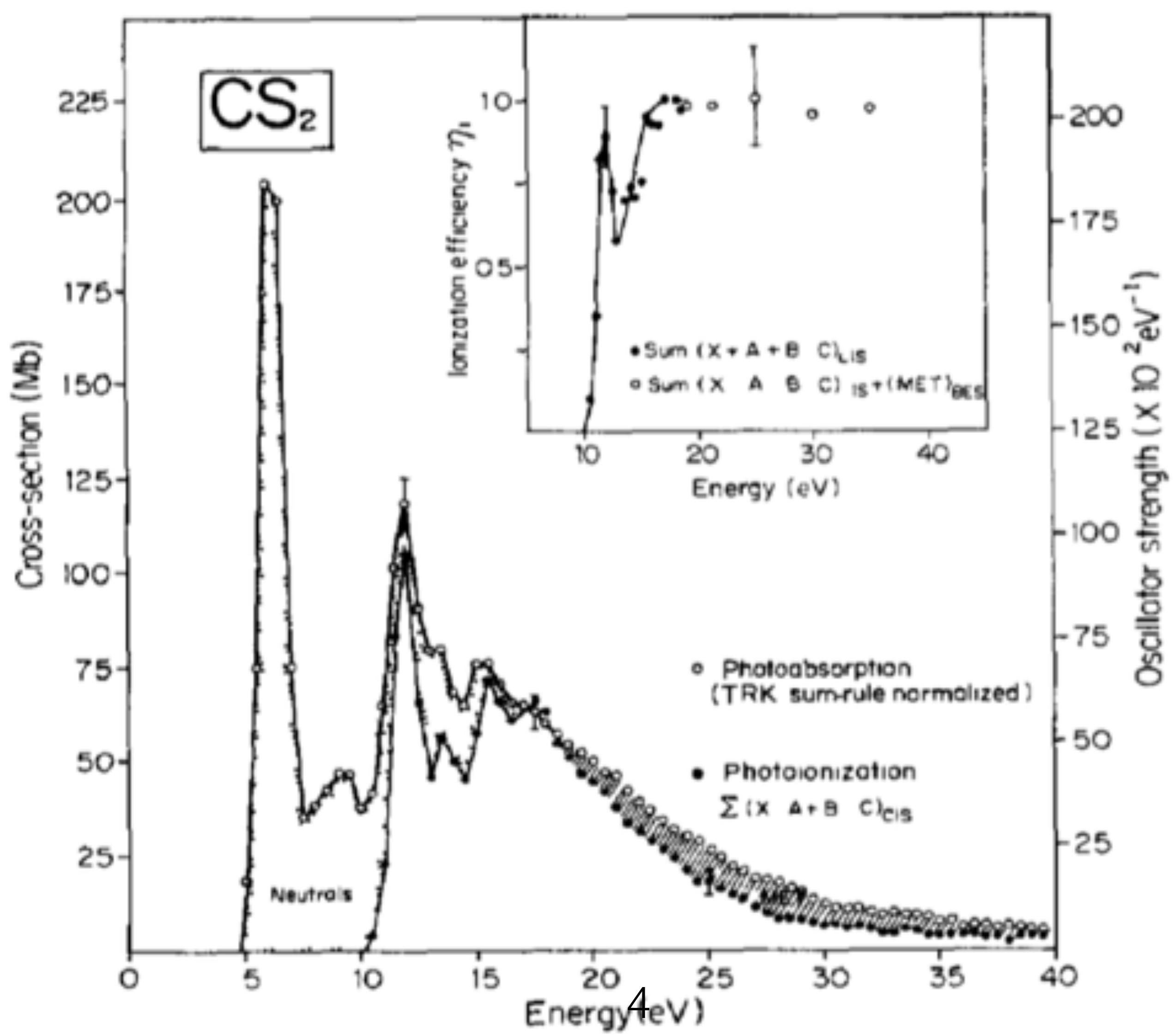


MgF2 window allows ~50% transparency for UV photons

https://indico.mitp.uni-mainz.de/event/14/contribution/10/material/slides/0.pdf

Photo-absorption/ionization cross sections of CS_2

- Literature values, e.g. see F. Carnovale et al. Journal of Electron Spec. and Rel. Phen., 24 (1981) 63
- Relatively high (10^5) photo-collision rate is expected from the ~25-50 Mbarn cross section with a ~15 Torr pressure and room temperature.



Garfield++

- Garfield++ includes CS_2 gas as option (also NO). Heed++ provides low energy photon collision cross sections which was roughly cross checked with literature values (see previous slide) and they agree reasonably. The literature measured values seem to be slightly higher but same order of magnitude.

- Upon simulation MediumMagboltz::Mixer reports "*Photon collision rates could not be calculated.*", which Rob and Heinrich confirmed is OK:

  - Magboltz low-energy molecular photo-absorption cross section data is not included for CS_2 . But Heed++ calculates the molecular photoabsorption/ionization cross sections from atomic data.

- Preliminary simulation results shows that in a simple Micromegas structure, with 3 mm drift gap

  - 100% Lyman alpha ionisation efficiency (primaries = 1)

  - I ~1-10 fC/ns signal on sensor (depending on the gain, etc.)

  - Gain of $\sim 10^4$ can be achieved

Status and Plan

- Preliminary simulation show that CS_2 gas is feasible to detect Lyman alpha UV photons with high efficiency.
- Additional backgrounds expected: cosmic rays and charged pions from annihilations (discrimination can be done by vetoing with external scintillators, or using event topology).
- Prototype detector is under construction.
- Systematic simulations are to be done to optimise for experimental conditions.