POLARIZATION AND RECOMBINATION MEASUREMENTS

18.12.2023 I RALF ENGELS

FZ JÜLICH / GSI DARMSTADT

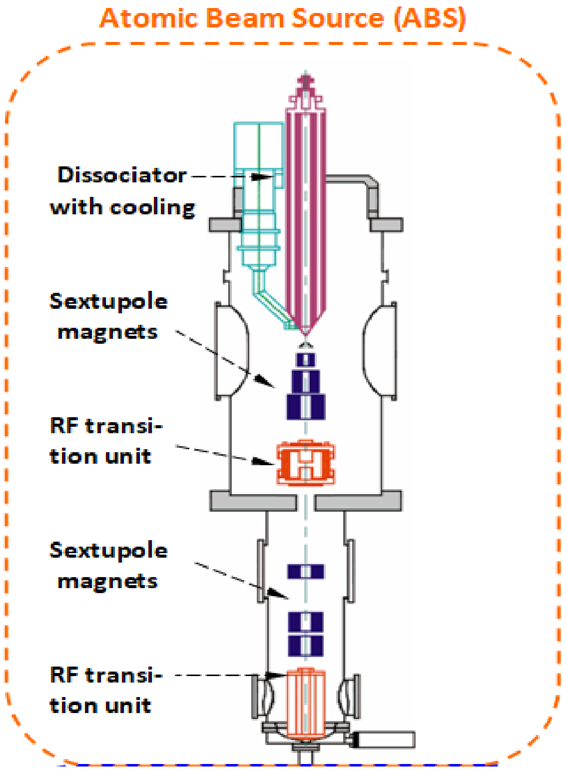
THE EXPERIMENTAL SETUP

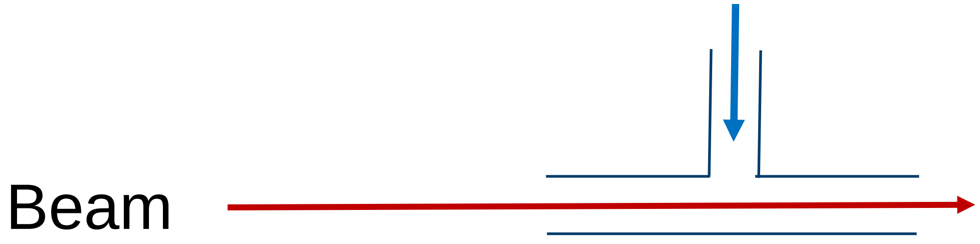
Problem:

Hydrogen Atoms are Radicals

→ chem. reactions normally destroy the polarization

Main reaction: **Recombination**





Target Density: increased by a factor ~100 : 10^{14} atoms/cm^2

STORAGE CELL COATING

Which surface coatings are working ?

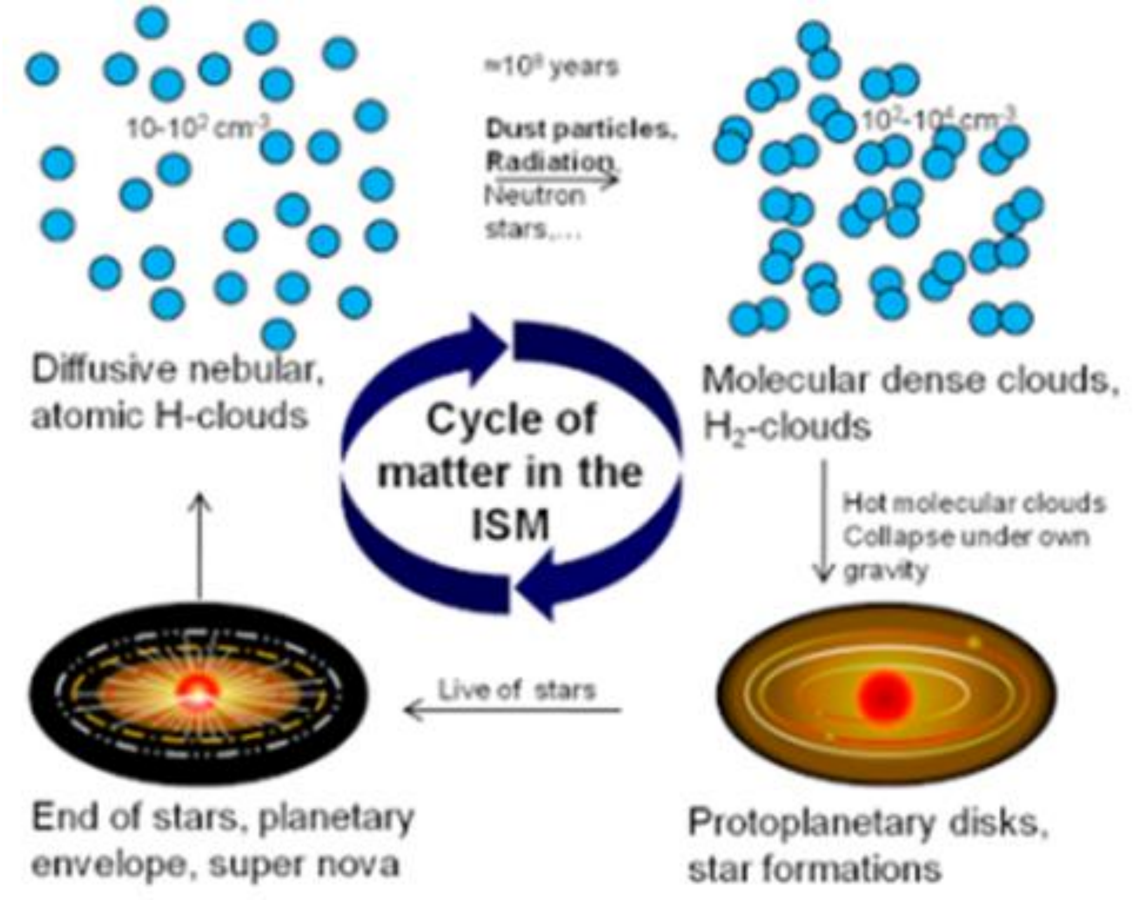
1.) Aluminium cells -> Bad secondary-electron yield -> Beam disturbance

2.) Teflon cells -> Isolator -> Beam disturbance

3.) Water ice -> Vacuum problems !!!

⟶ **What about a carbon coating ???**

RECOMBINATION ON CARBON IN THE ISM



- Direct recombination is not probable due to energy and momentum conservation
- 3-particle interactions are very rare at these densities
- Recombination on a carbon surface as catalyser?

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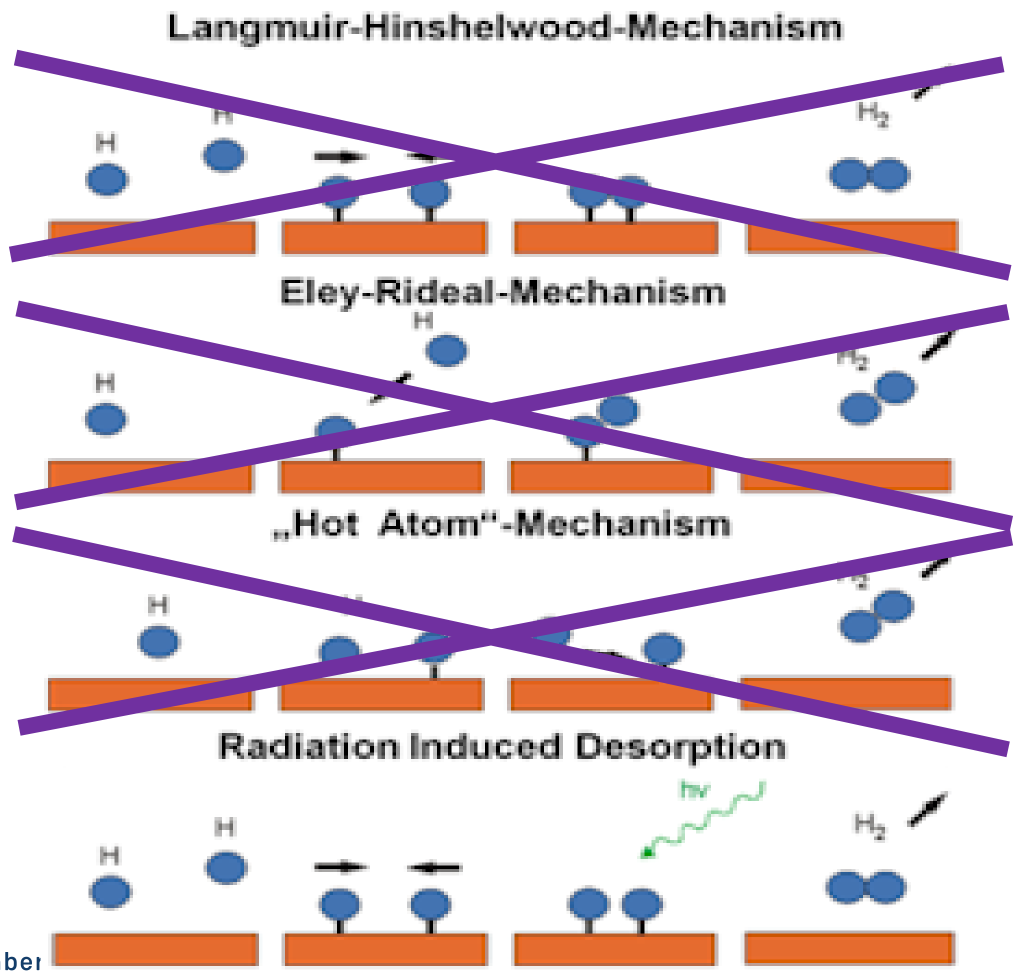
RECOMBINATION ON CARBON IN THE ISM

Possible Recombination Mechanisms:



WWU Münster; Phys. Institute, Prof. H. Zacharias

Strong C-H Bond (~ 4.3 eV) prevents recombination

Radiation induced Desorption

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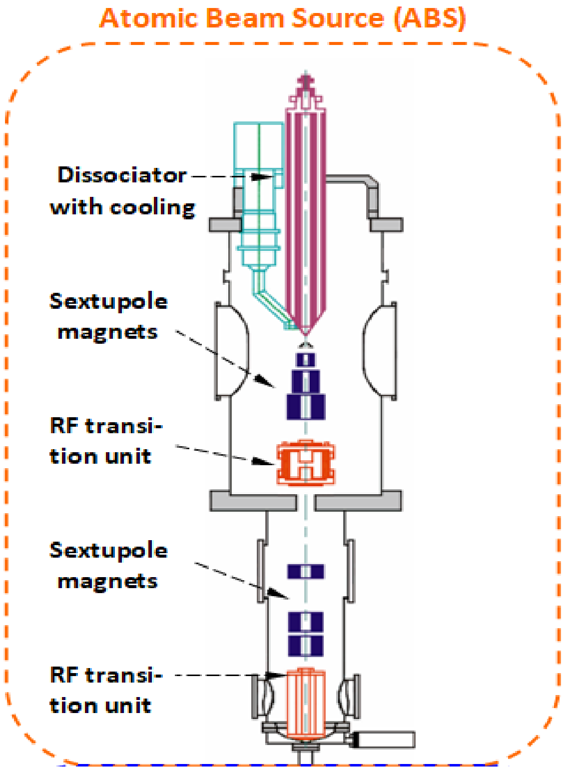
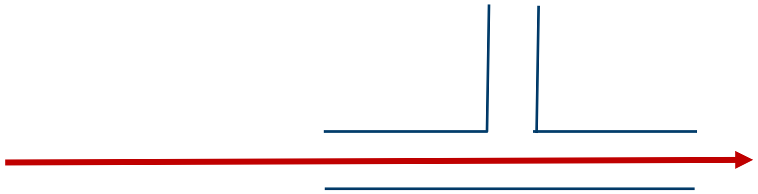


Beam



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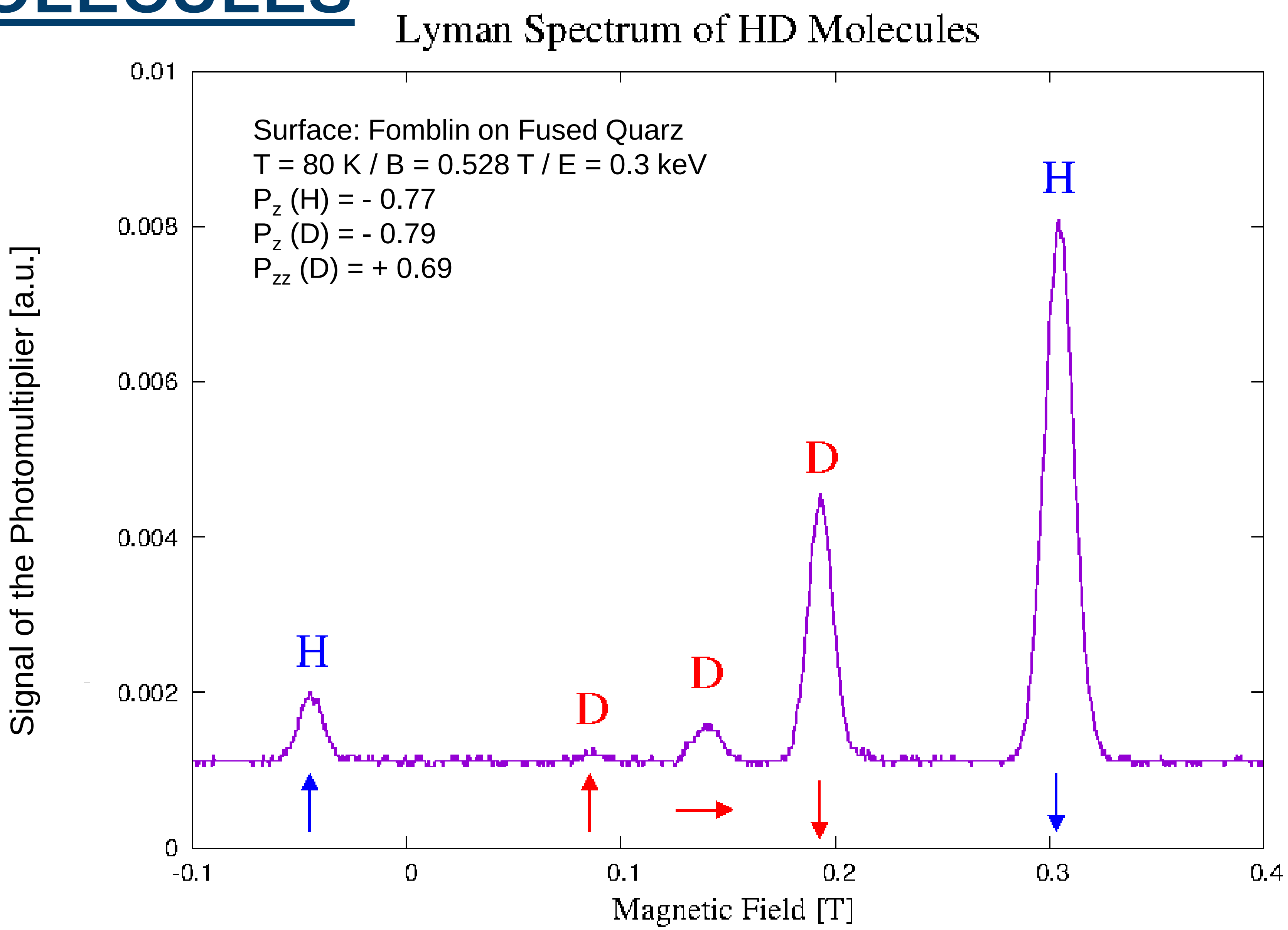
HD MOLECULES



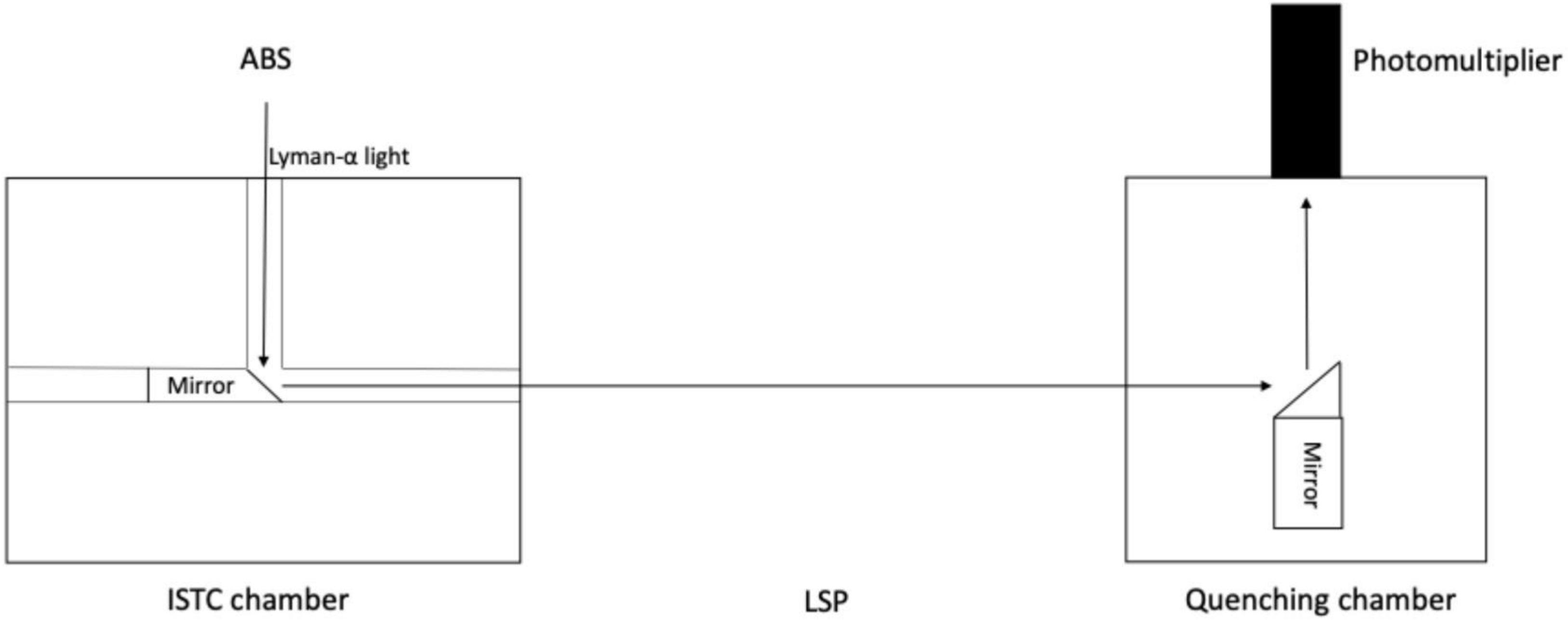
R. Engels et al., Phys. Rev. Lett. **124** 113003 (2020)

RADIATION TEST FOR LYMAN-ALPHA

Possible Light Source: Dissociator of the ABS

Bright Balmer light visible -> are there even Lyman photons ?

Reflections on aluminum surface for Lyman photons ~ 100%



Bachelor Thesis of Onur Bilen (HHU)

STORAGE CELL COATING

Which surface coatings are working ?

1.) Aluminium cells -> reflects Lyman-α photons

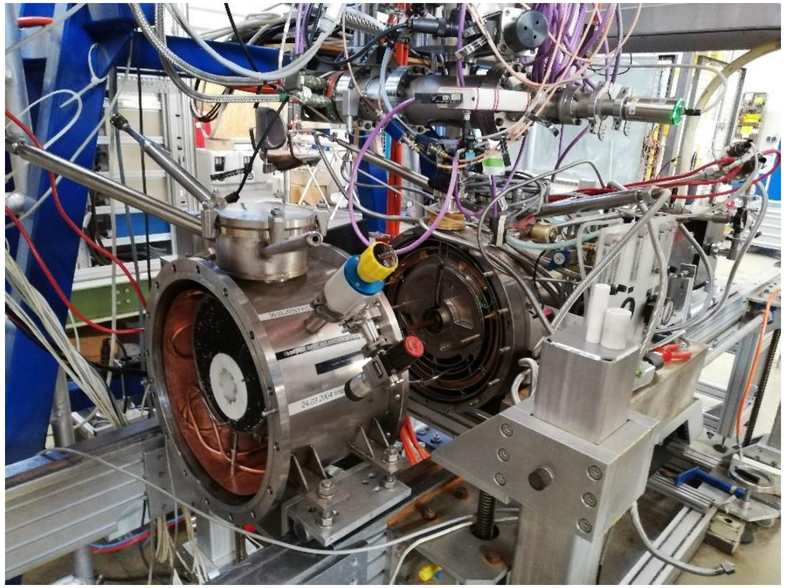
2.) Teflon cells -> transmission through the surface ?

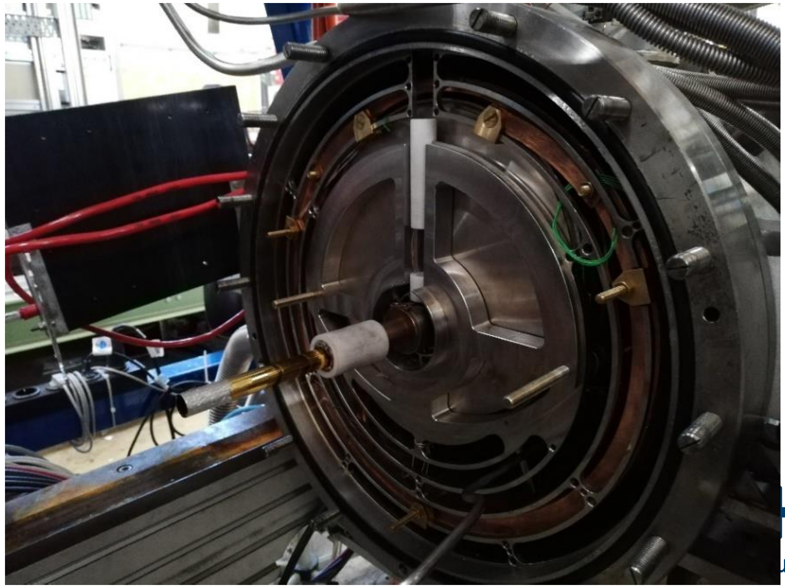
3.) Water ice -> reflects Lyman-α photons / transmission through the surface ? (O-H: ~ 4.8 eV)

Expectation for Carbon: -> Large Recombination in Combination with Lyman-α radiation !

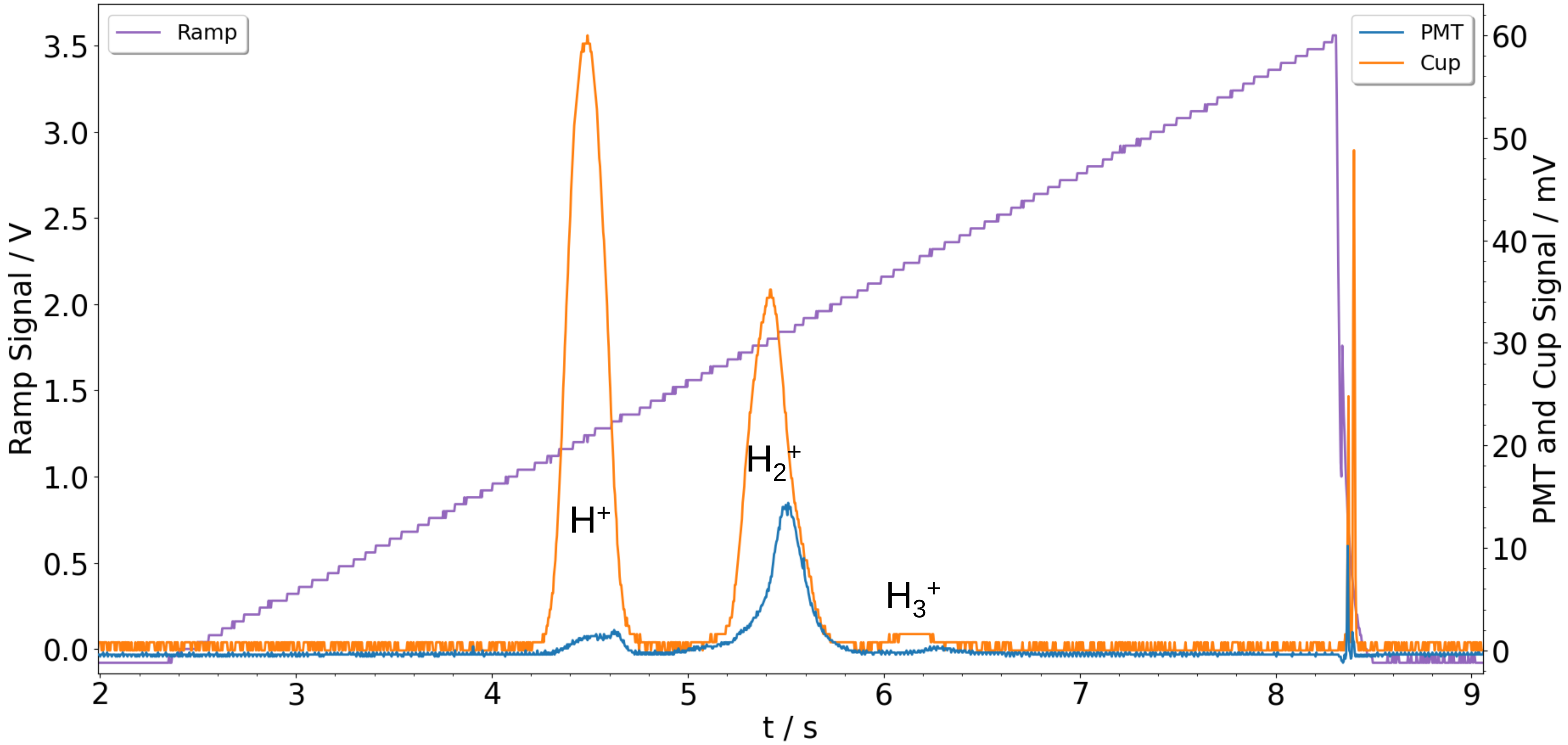
PREPARATION OF NEW STORAGE CELL

- A 200 nm amorphous carbon-coated storage cell was provided by Pedro Costa Pinto from CERN
- Requirements:
  - High polarization preservation
  - No recombination
- 4 gold plated tungsten wires run along the inside of the storage cell
- Installation into the interaction chamber



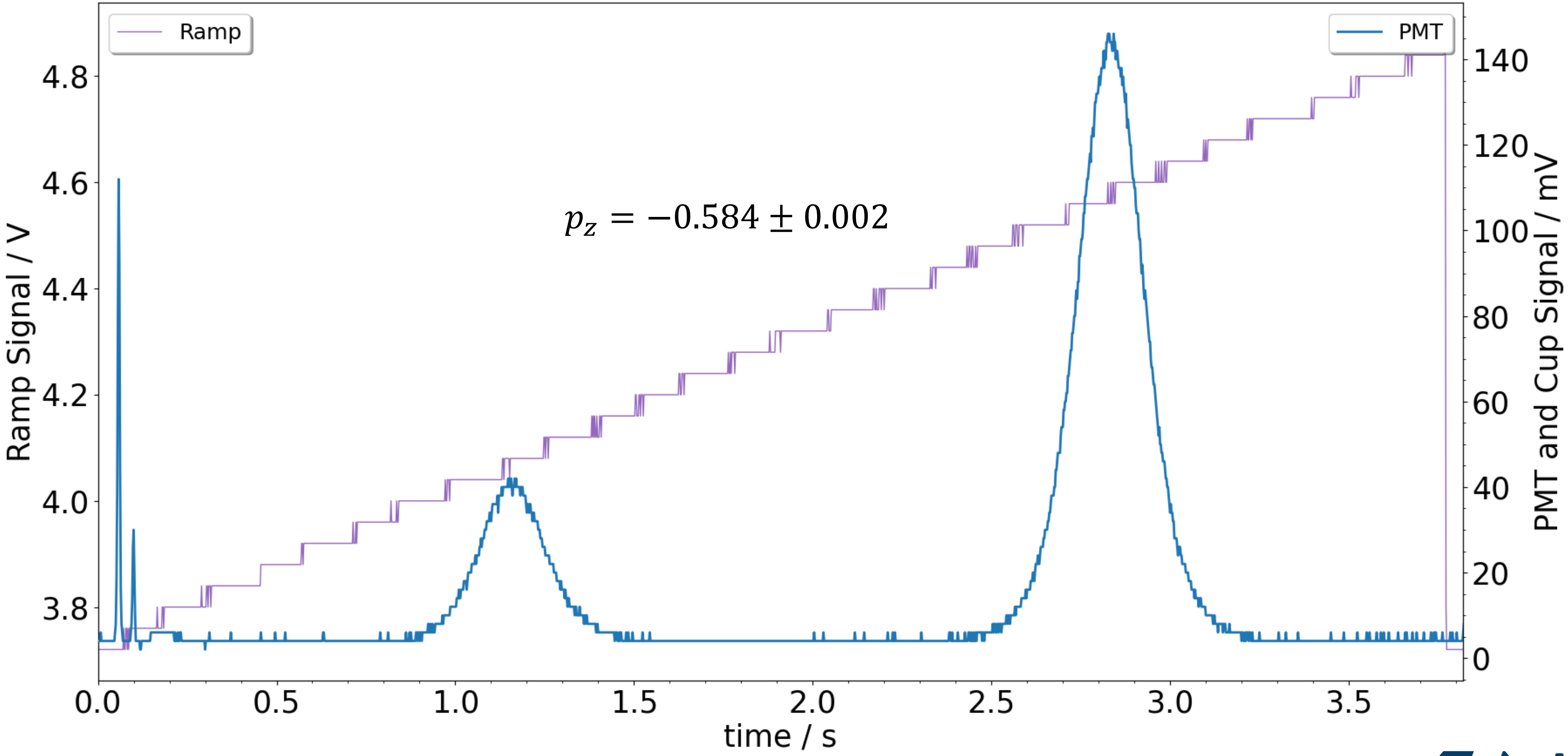


MASS SPECTROSCOPY



LYMAN SPECTRA FOR H

Polarization spectrum of the Weak Field Transition Unit for H



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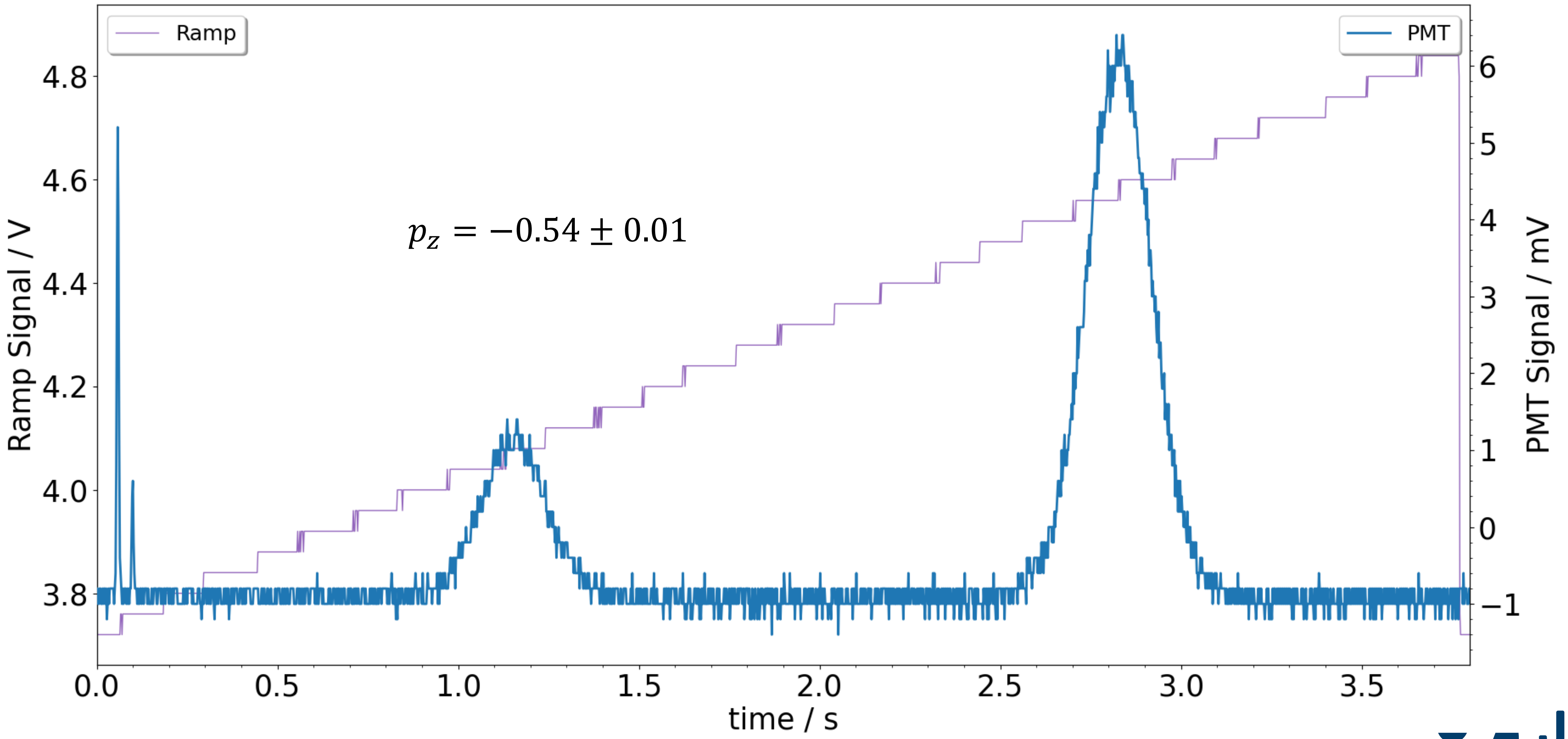
LYMAN SPECTRA FOR H_2

Polarization spectrum of the Weak Field Transition Unit for H_2



POLARIZATION OF THE PROTONS

Proton fraction: a = 0.04 ± 0.15 → 95.5% < c < 100%

Wall collisions: n = 435 ± 236

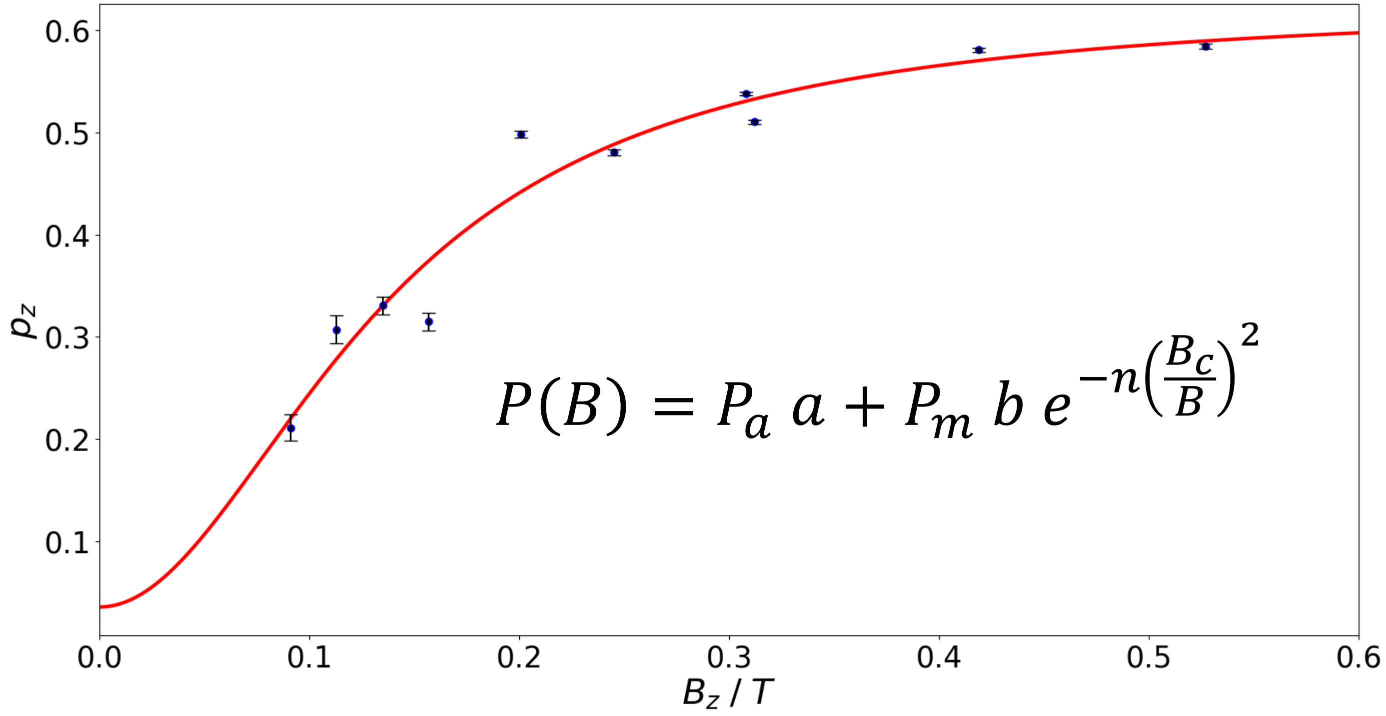
Initial molecular pol.: $P_m = 0.57 \pm 0.03$

Initial atomic pol.: $P_a \approx 0.8$

Master Thesis of

Tarek El-Kordy

(FH Aachen)



CONCLUSION

- (Exceptionally) high recombination rate: 95.5% < c < 100% driven by Lyman-α photons.

- No dominant water layer present; no buildup of water layer on amorphous carbon.

- Initial molecular polarization (fit): $P_m = 0.57 \pm 0.03$ ($P_a = 0.78$).

- Max. polarization for H_2 from direct measurements: $p_z = -0.54 \pm 0.01$.

Corresponding Paper is in Preparation by Tarek El-Kordy