New aspects of storage cell developments for the polarized internal target at LHCb

19.10.2021

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in collaboration with the LHCSpin group

LHCSpin project

Aim

- installing polarized gas target in front of the LHCb spectrometer
- for the first time, bringing polarized physics to the LHC
- allowing to probe polarized quark and gluon parton distributions in nuclei, especially at **high x** and **intermediate Q^2**

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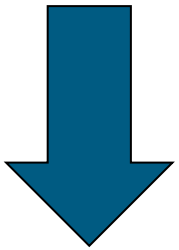
More detailed information



[42] Polarized target experiments at LHC
by Luciano Pappalardo

LHCSpin project

Storage cell

- critical component, where the beam interacts with the gas
- due to the LHC beam effects the cell should be carbon coated on the inside
- carbon coated storage cells have never been used in such an experiment

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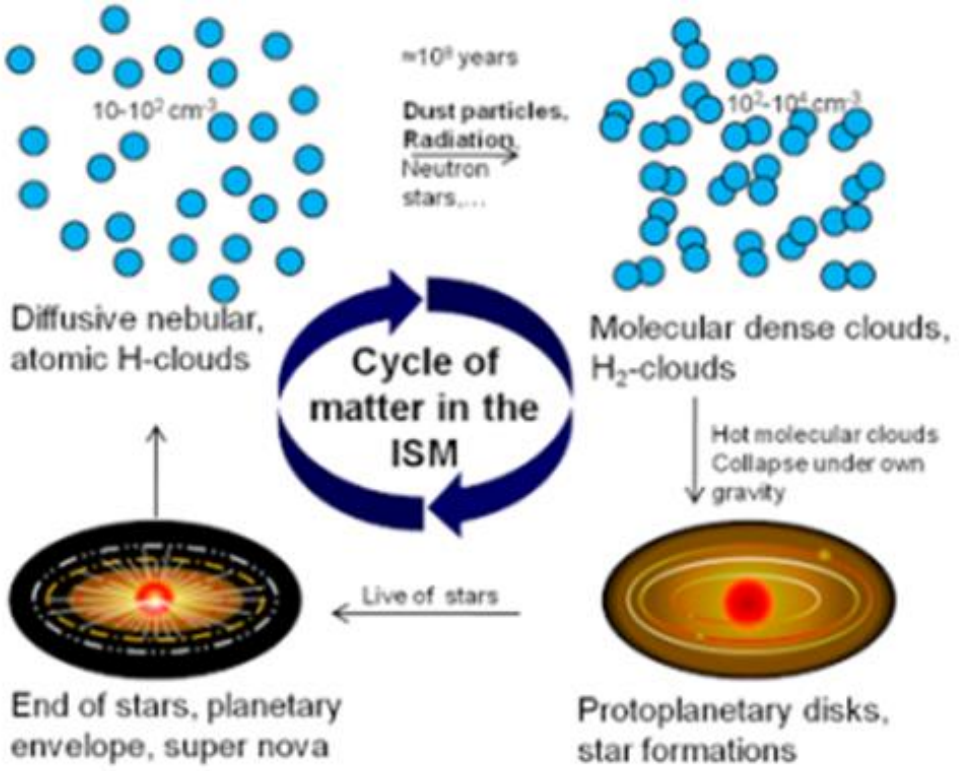
Investigation of storage cell in Jülich

1. polarization preservation inside the storage cell
2. formation of hydrogen molecules on carbon surface

Hydrogen recombination in the ISM?



- direct recombination not possible
- recombination on carbon dust grains possible, but not efficient enough

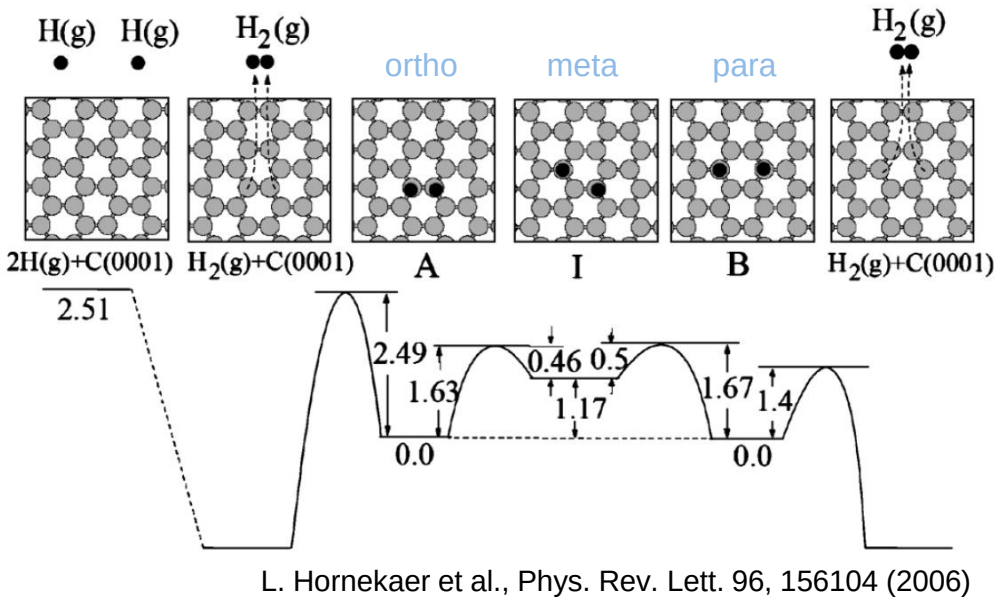
H_2 formation on graphite

Physisorption

- only for low temperature
- polarization ?

Chemisorption

- first atom: 200 meV barrier
- second atom barrier free
- para state: 1,4 eV desorption barrier
- chemisorpted hydrogen should lose its polarization



L. Hornekaer et al., Phys. Rev. Lett. 96, 156104 (2006)

H_2 formation on graphite

Physisorption

There should be no recombination of hydrogen molecules inside the storage cell!

- chemisorpted hydrogen should lose its polarization

H_2 formation on graphite

However: excitation of carbon surface with short fs 400 nm laser pulses induces desorption of hydrogen molecules

R. Frigge et al., Phy. Rev Lett, 104, 256102 (2010)

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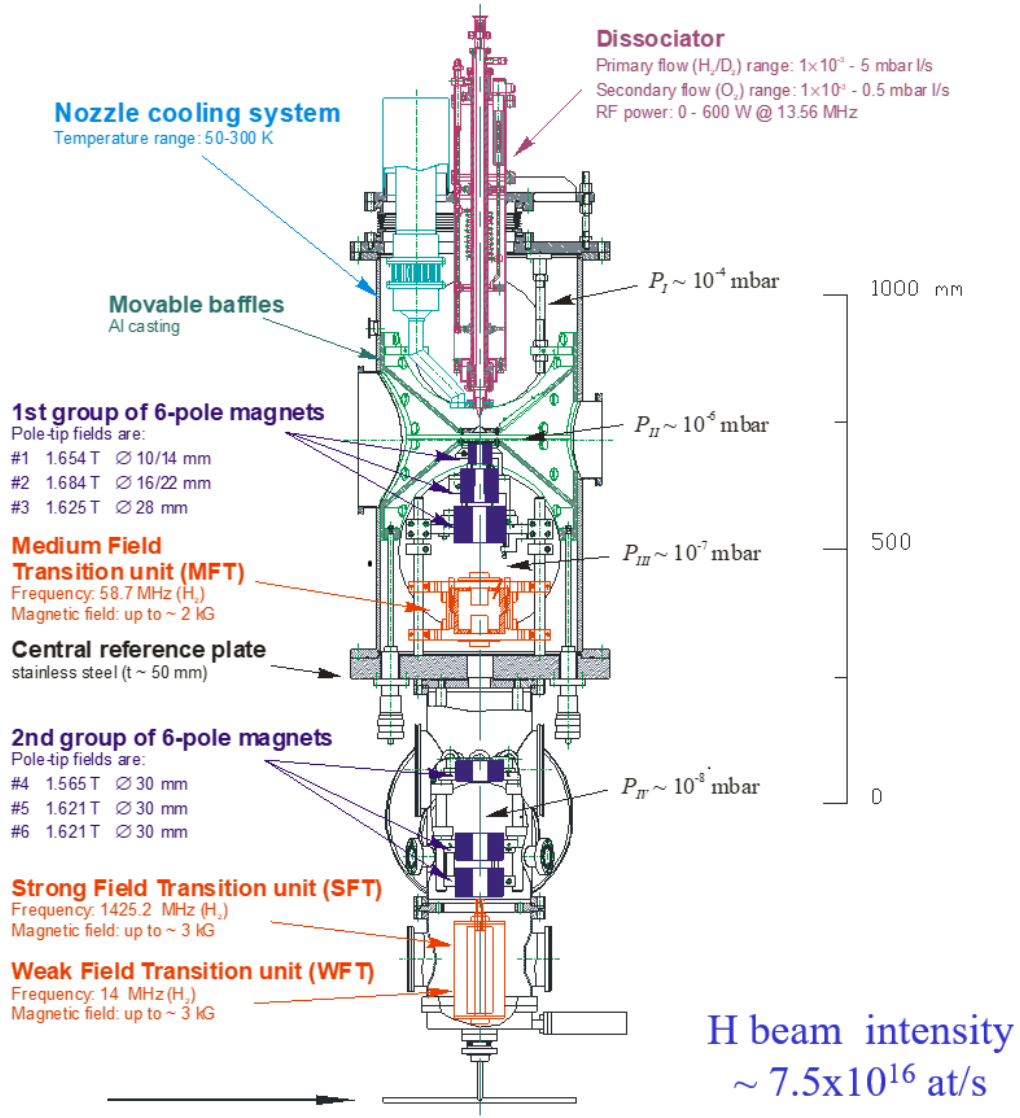
How do we get large amounts of photons into the storage cell?

Atomic beam source

- Atomic beam source of the ANKE experiment
- 6-pol magnets separate according to Stern-Gerlach principle
- HF transition units induce transitions between different HFS

	HFS
WFT MFT SFT	$\|1\rangle + \|2\rangle$
WFT MFT SFT	$\|3\rangle$
WFT MFT SFT	$\|2\rangle + \|3\rangle$
WFT MFT SFT	$\|1\rangle$



H beam intensity
~ 7.5×10^{16} at/s

M.Mikirtychyants et.al., NIM A 721 (2013) 83-98

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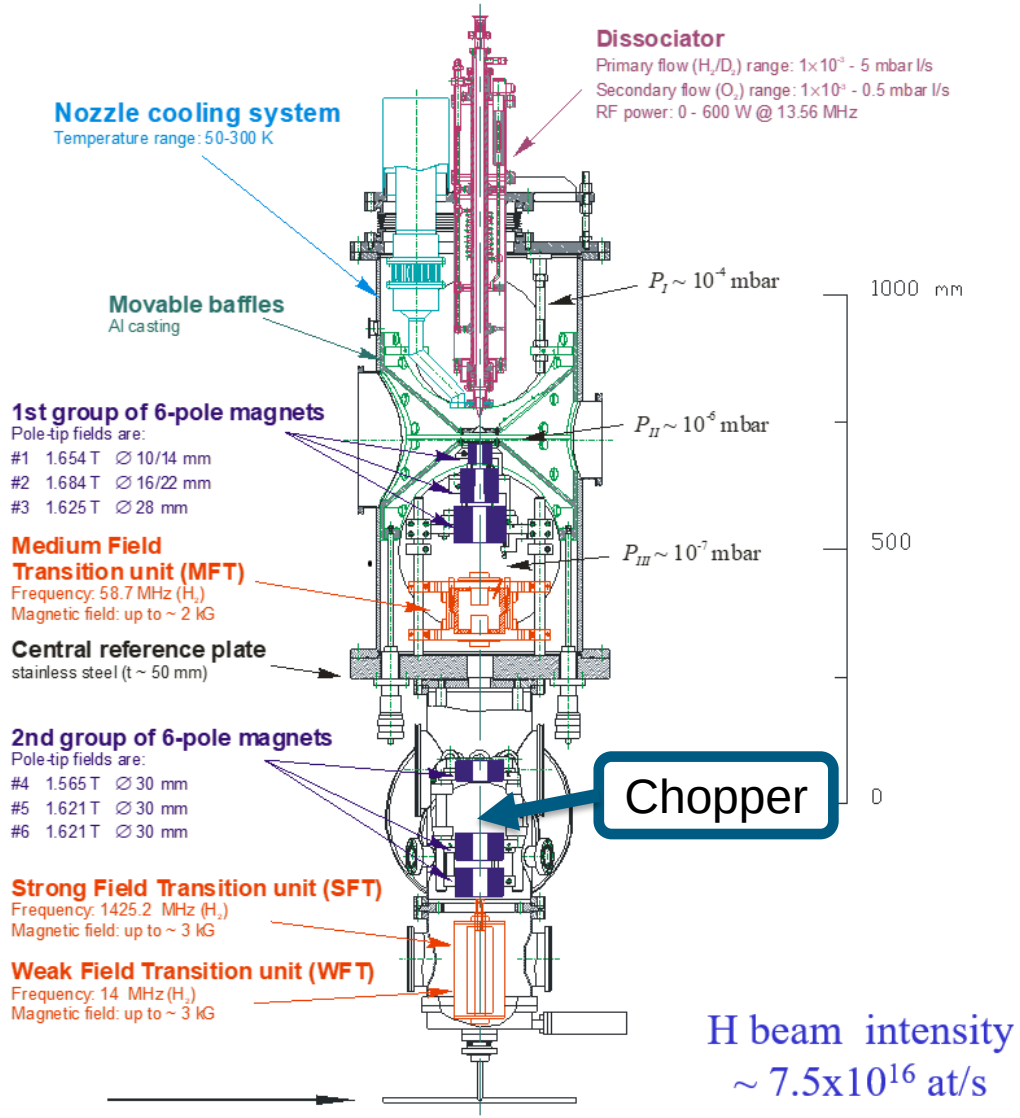

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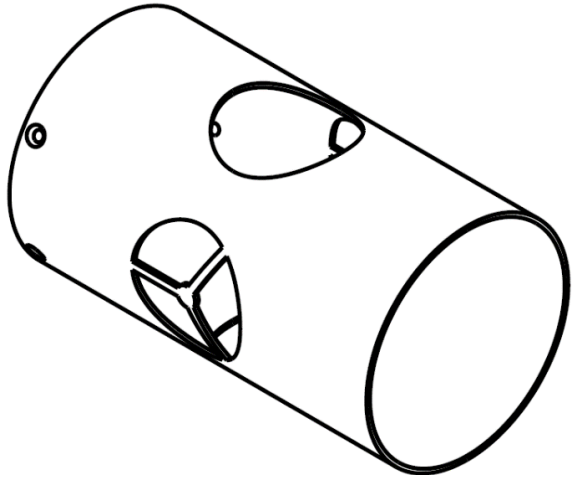
New beam chopper

old chopper

new chopper



old design full beam comes trough

new design middle part of the beam is blocked

Advantages

1. blocking unpolarized atoms in the center of the beamline → + 3% polarization - 20 % ABS flux

2. blocking photons comming from the dissociator → ? → change in the recombination rate?

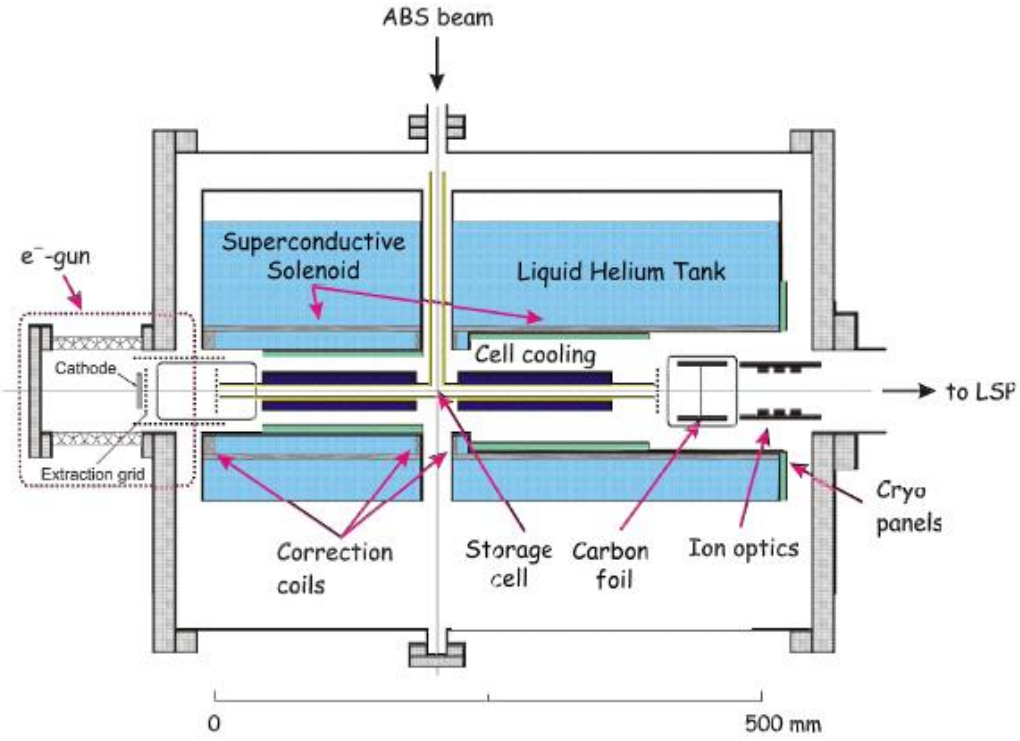
ISTC chamber

top entrance of polarized gas

center storage cell + superconducting solenoid (up to 1 Tesla)

left e-gun, creating an electron beam for ionization of the gas

right exit in direction of the lamb shift polarimeter



R.W. Engels et al., Rev. Sci. Instr., 85, (2014)

Storage cell

- T-shaped quartz glass tube
- similar size as the future cells for LHCSpin
- for carbon surface a pre coating with metal is needed
- after ‘Corona delay’, carbon coating is performed by CERN workshop in the moment

Lamb shift polarimeter

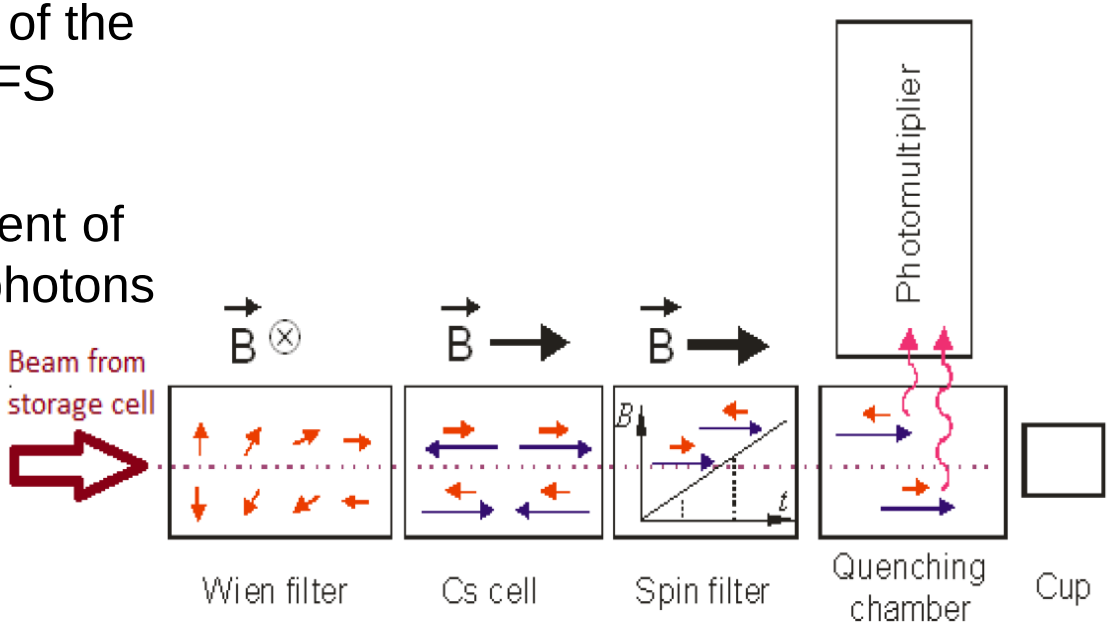
Wien filter mass separation

cesium cell creation of meta stable states

$$H^+ + Cs \rightarrow H_{2S_{1/2}} + Cs^+$$

spin filter separation of the different HFS

quench chamber measurement of Lyman-α-photons



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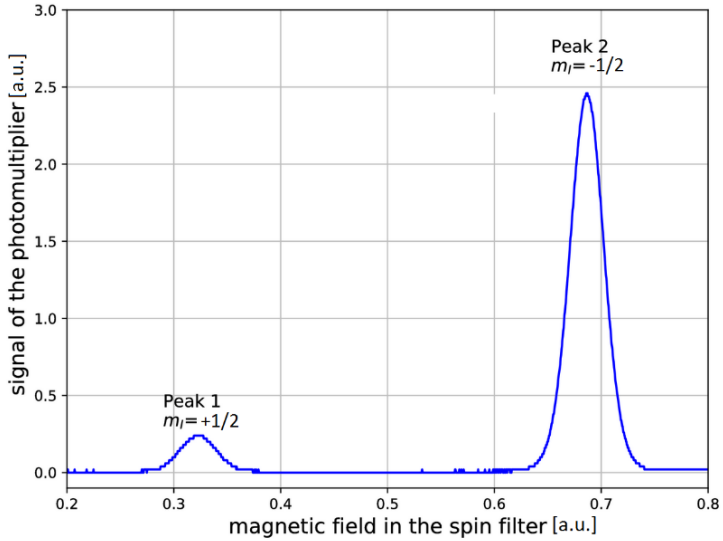

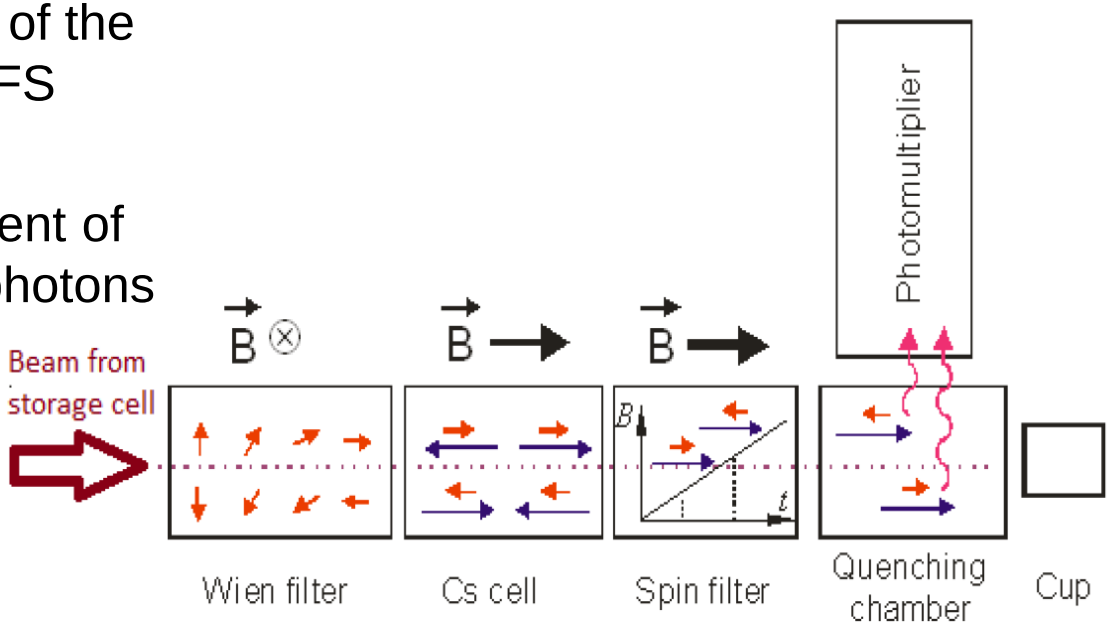

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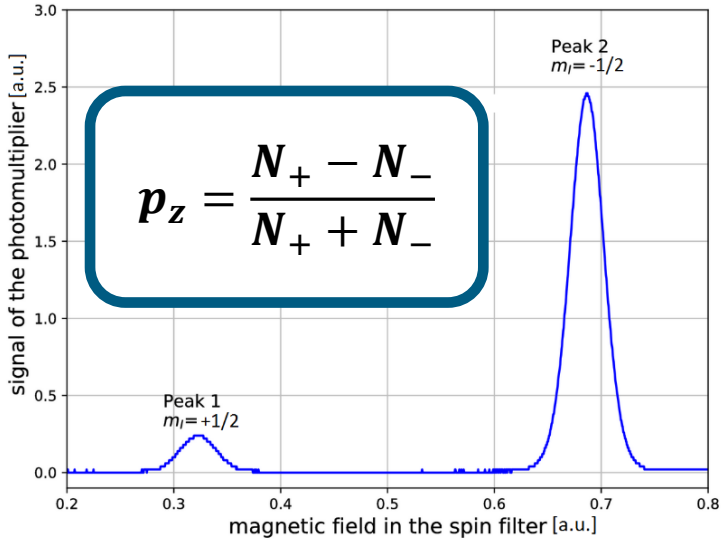
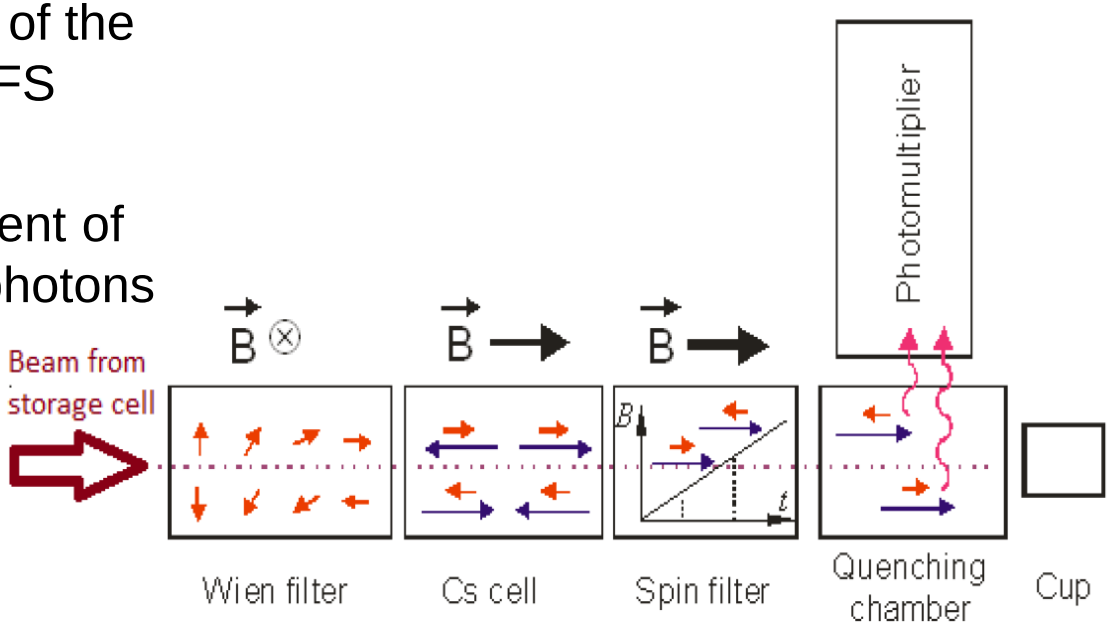
$$p_z = \frac{N_+ - N_-}{N_+ + N_-}$$





Foreseen measurements

1. intensity and polarization of the molecular hydrogen beam

2. polarization of atomic hydrogen, e.g. $P_{a,HFS3}$, as function of magnetic field

$$P_{a,HFS3}(B) = A * P_{a,0} + \frac{M * P_{m,0}}{1 + \frac{\overline{n}}{\ln(2)} * \left(\frac{B_{c,m}}{B}\right)^2}$$

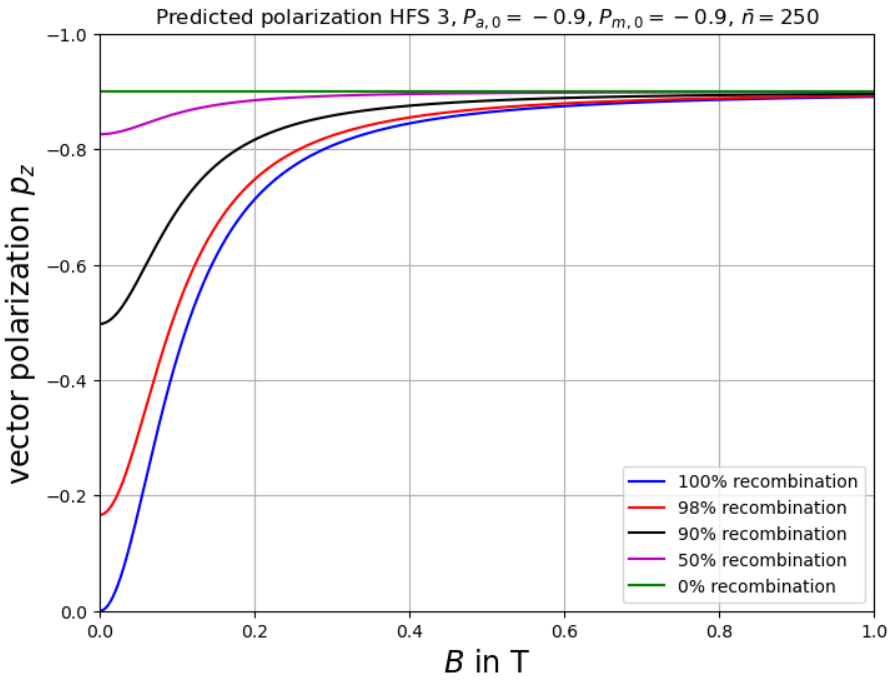
A = atomic fraction
M = molecular fraction
$\overline{n}$ = average number of wall collisions
$B_{c,m}$ = critical magnetic field of hydrogen (5.4 mT)
$P_{i,0}$ = initial polarization

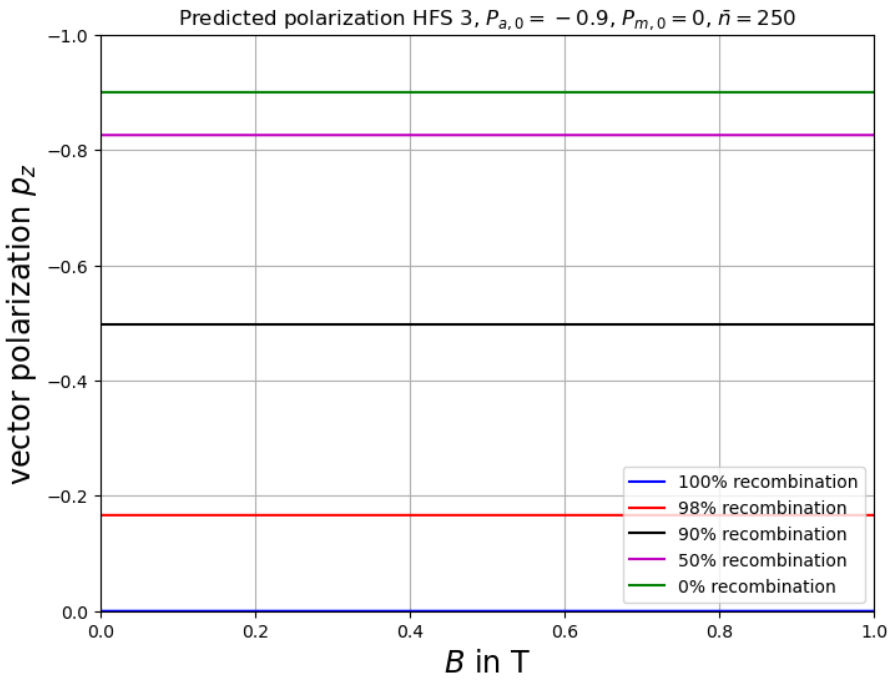
3. recombination rate C

$$C = \frac{2*M}{2*M + k*A} \qquad k \approx 0.18$$

k = correction factor, due to different ionization probability

Foreseen measurements





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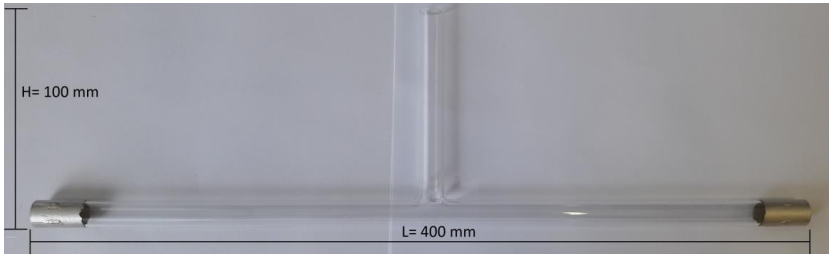
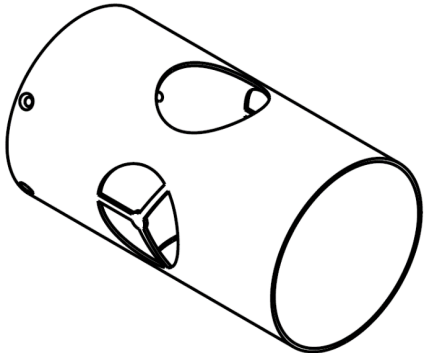
Summery

- experimental setup is similar to the setup of LHCSpin experiment



- polarization properties of carbon coated storage cells will be investigated



- measurement of the polarization of atoms and molecules and calculation of the recombination rate
- influence of photons on the recombination process can be investigated

possible new hints for understanding the formation of hydrogen molecules in the ISM