Petersburg Nuclear Physics Institute

Forschungszentrum Jülich

project #1861

Nuclear Polarization in Molecular Hydrogen - CELGAS -

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Outline

- Motivation
- Experimental technique
  - Experimental concept
  - Setup overview
- CELGAS commissioning
  - Superconducting solenoid
  - e^--gun and ion optics
- Coming tasks

Motivation

- Beam intensities of conventional ABS barely reach ~10^{17} at/s
  $\Rightarrow$ target density d_t~10^{14} at/cm^2 (typical T-shaped storage cell)
- Depolarization at low T of storage cell don't allow further cooling

Performance of PIT using atomic beams saturates!

- **ABS with SC magnets for Stern-Gerlach separation**
- **New storage cell materials**

Polarized molecules?

Motivation

- **Sticking time** of molecules at the surface is much **smaller** compared to atoms

  $\Rightarrow$ cell can be cooled down to much **lower T**

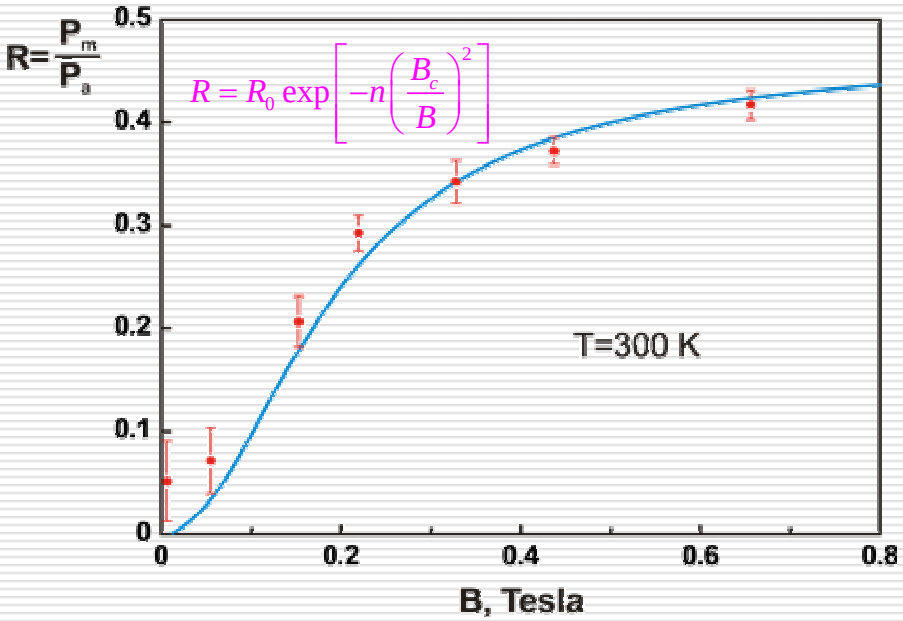
  $\Rightarrow$ **higher** target density ($d_t \sim T^{-1/2}$)

- Polarized molecules is an interesting object for **atomic physics** which has never been deeply investigated (e.g. depolarization on the surface)

- Recombination of polarized atoms in different hyperfine states is interesting to **astrophysics** (e.g. formation of molecular hydrogen in cold clouds)

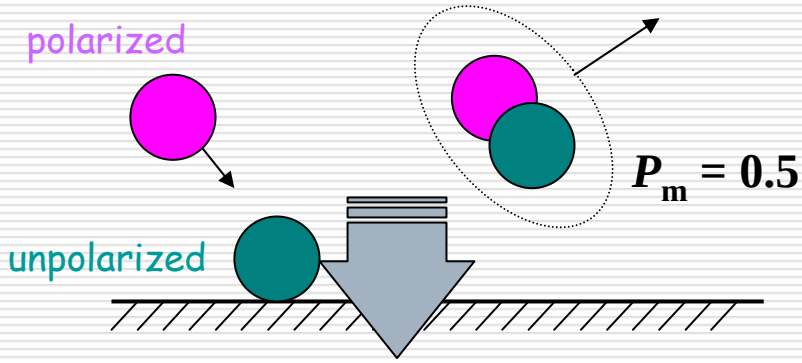
Motivation

Measurements from NIKHEF, IUCF, HERMES show that recombined molecules retain fraction of initial nuclear polarization of atoms!



Nuclear Polarization of Hydrogen Molecules from Recombination of Polarized Atoms
T.Wise et al., Phys. Rev. Lett. 87, 042701 (2001).

Naïve model



Is there a way to increase P_m (surface material, T, B etc)?

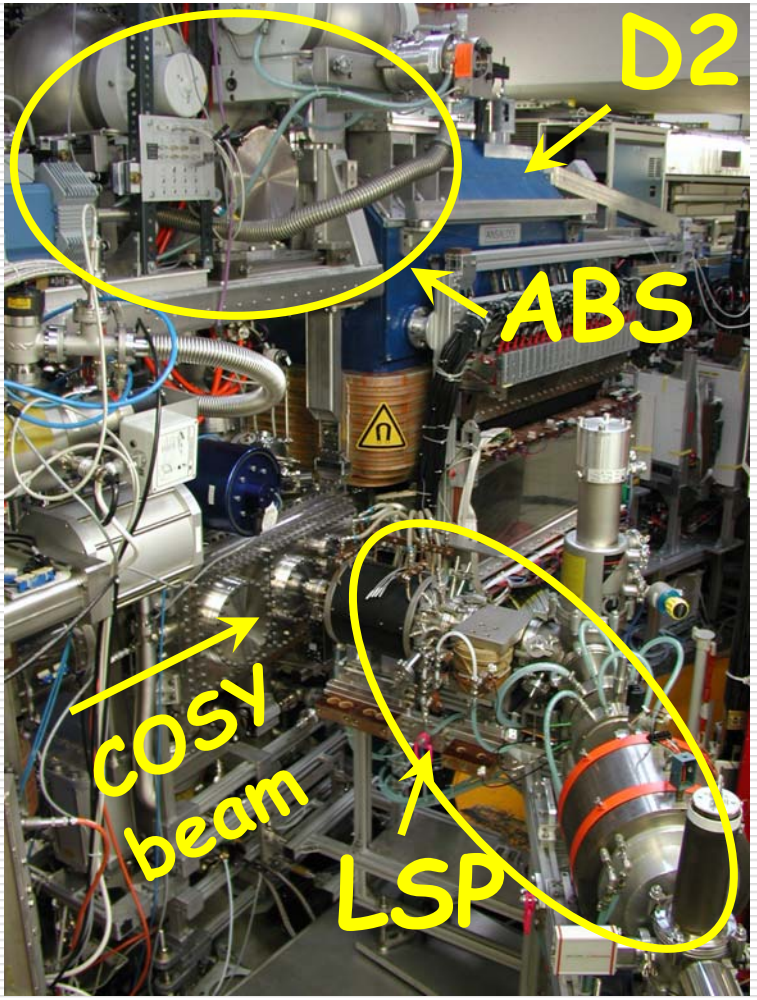
$$\lim_{B\to\infty} R = 0.5$$

Experimental technique

What do we need to study nuclear polarization in molecules?

- Polarized atomic beam
- Polarimetry
- ☑ available from ANKE PIT

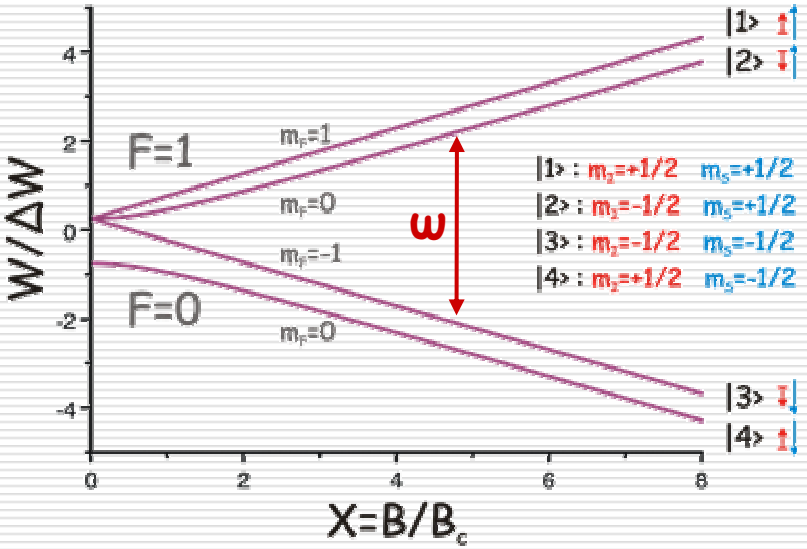
  (6 month per year)
- Recombiner – the heart of CELGAS
  - Exchangeable cells with different coatings
  - Magnetic field up to ~ 1 T



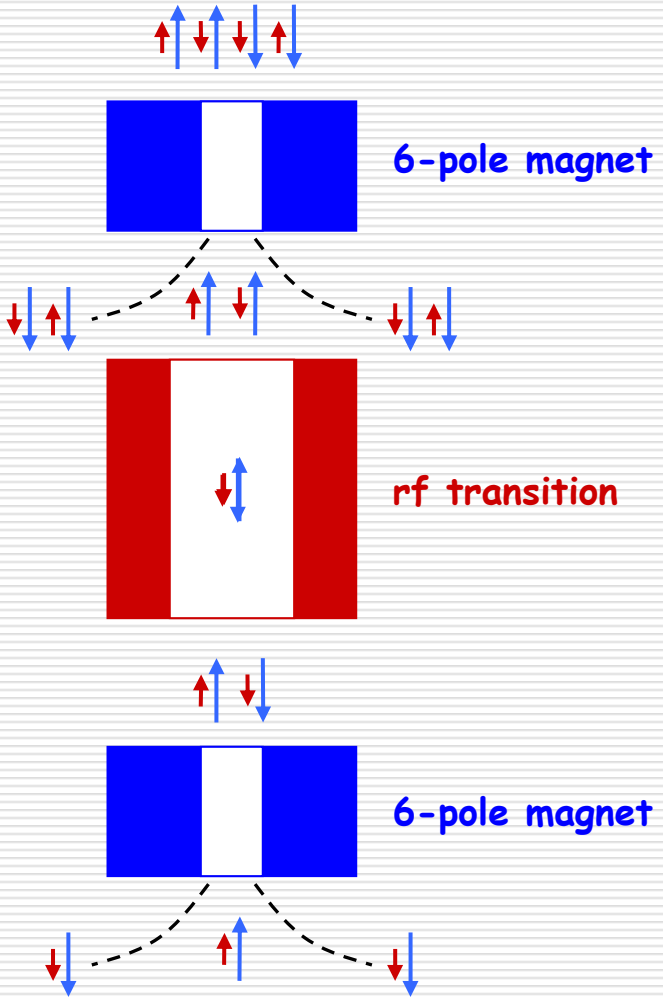
Experimental technique

Atomic Beam Source (ABS)

Breit-Rabi diagram



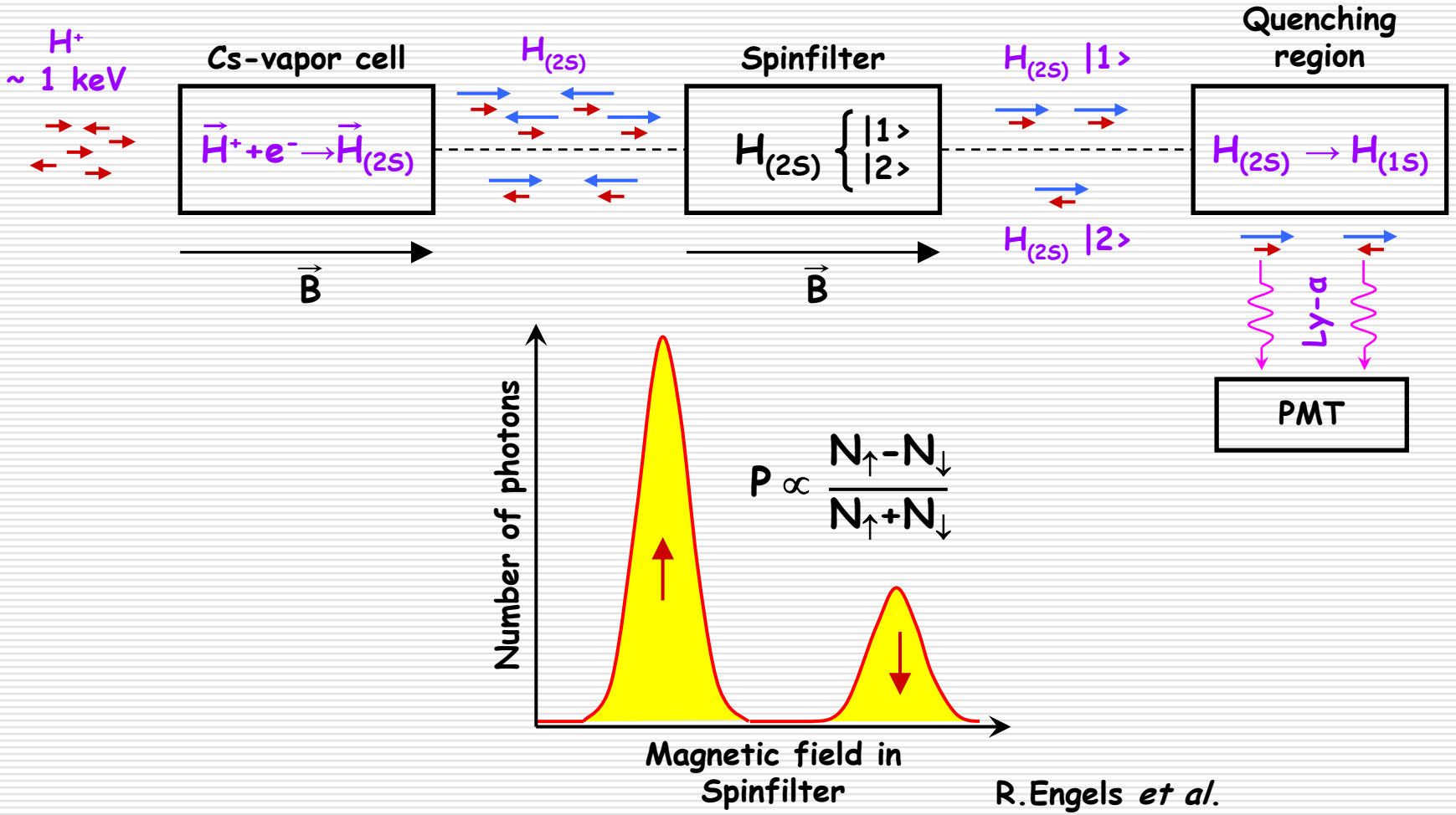
ΔW – zero-field splitting
B_c – critical field (507 G for H)



More details in talk by Alexander Nass on Thursday, September 7

Experimental technique

Lamb-shift polarimeter (LSP)

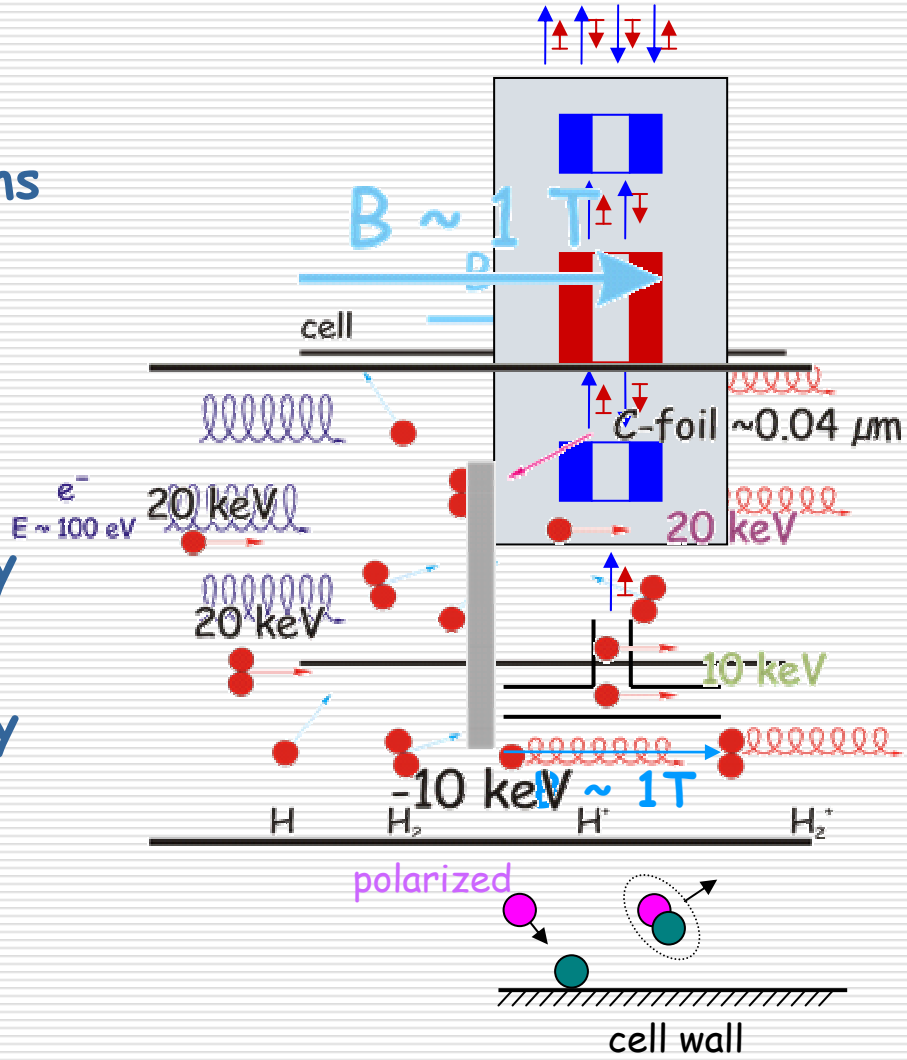


R.Engels *et al.*
Rev. Sci. Instrum. 74 (2003) 4607

Experimental technique

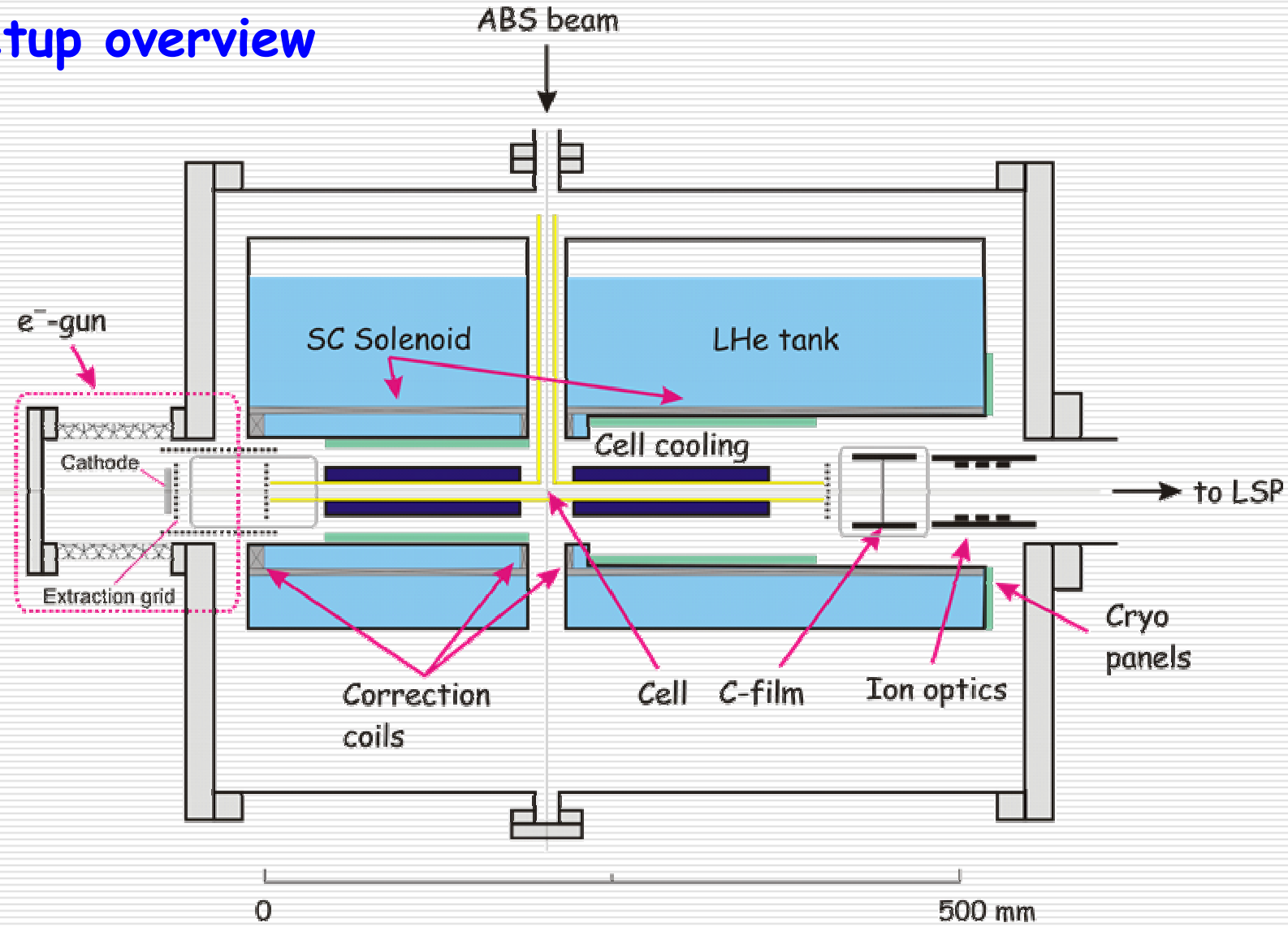
Recombiner

- Recombination of polarized atoms into molecules
- Conversion of polarized atoms and molecules into ions
- Conversion of H_2^+ and H^+ ions into protons with different energy (suggested by W.Haeberli)
- Separation of protons by energy
- Measurement of proton polarization in LSP

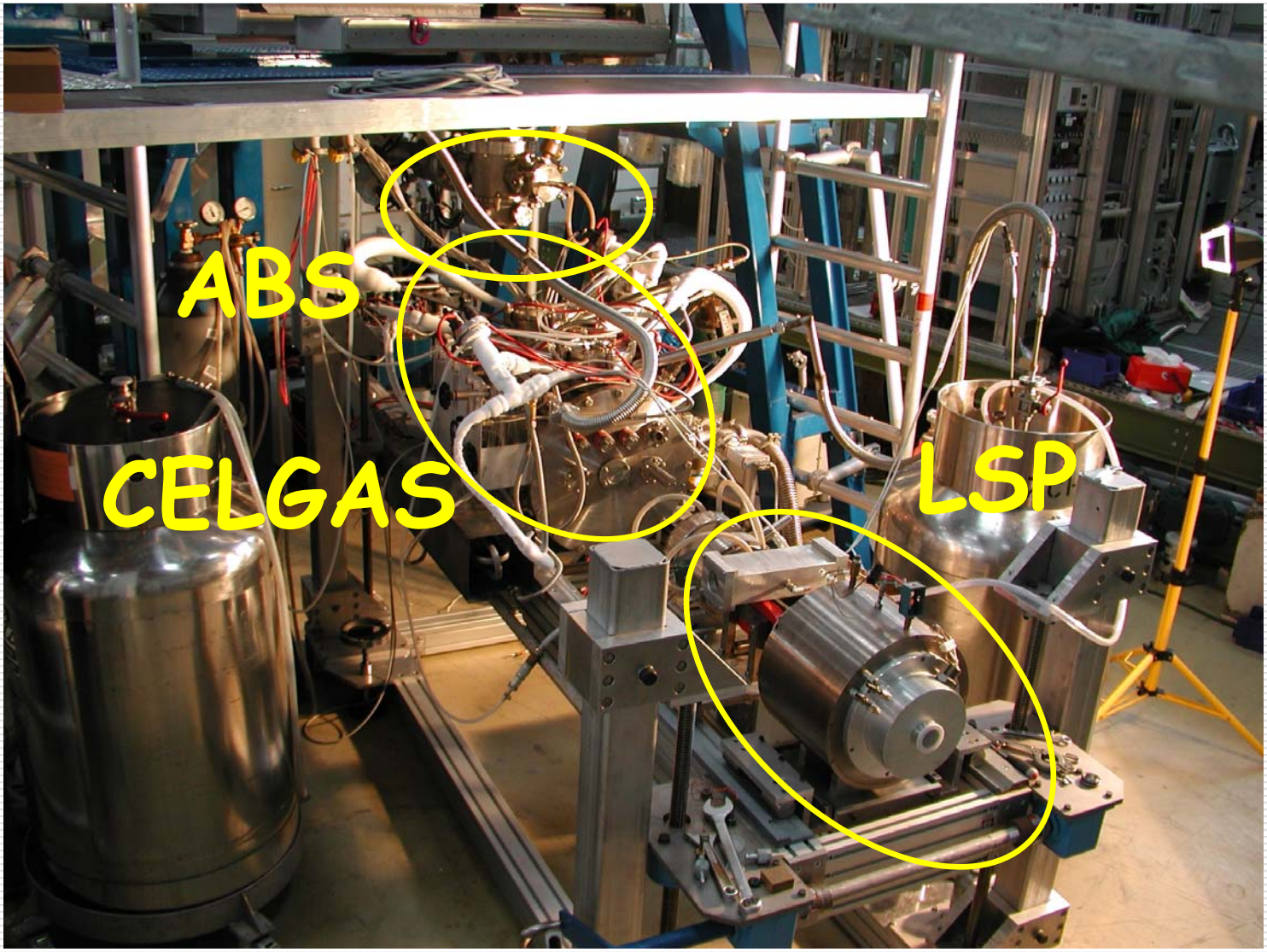


Experimental technique

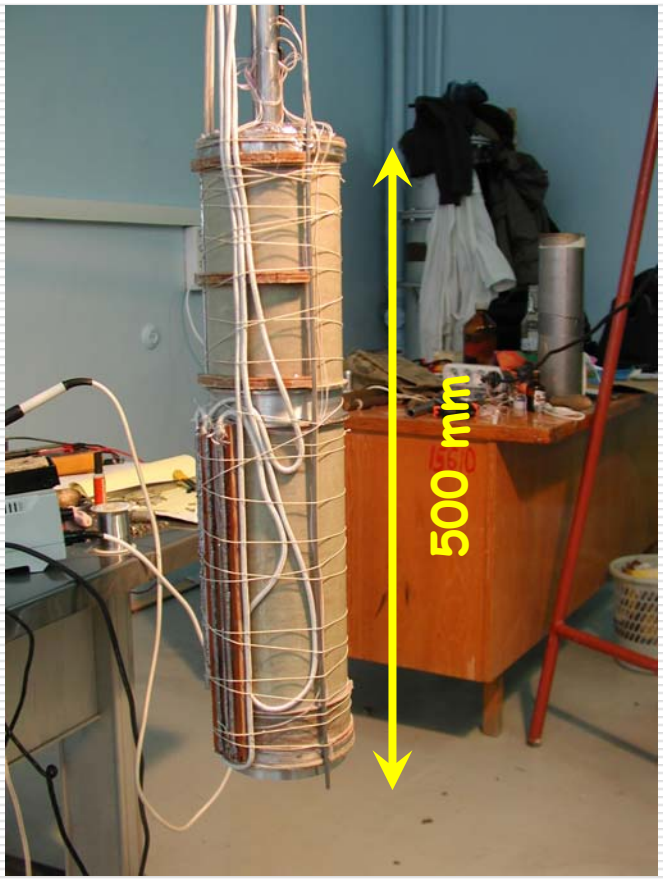
Setup overview



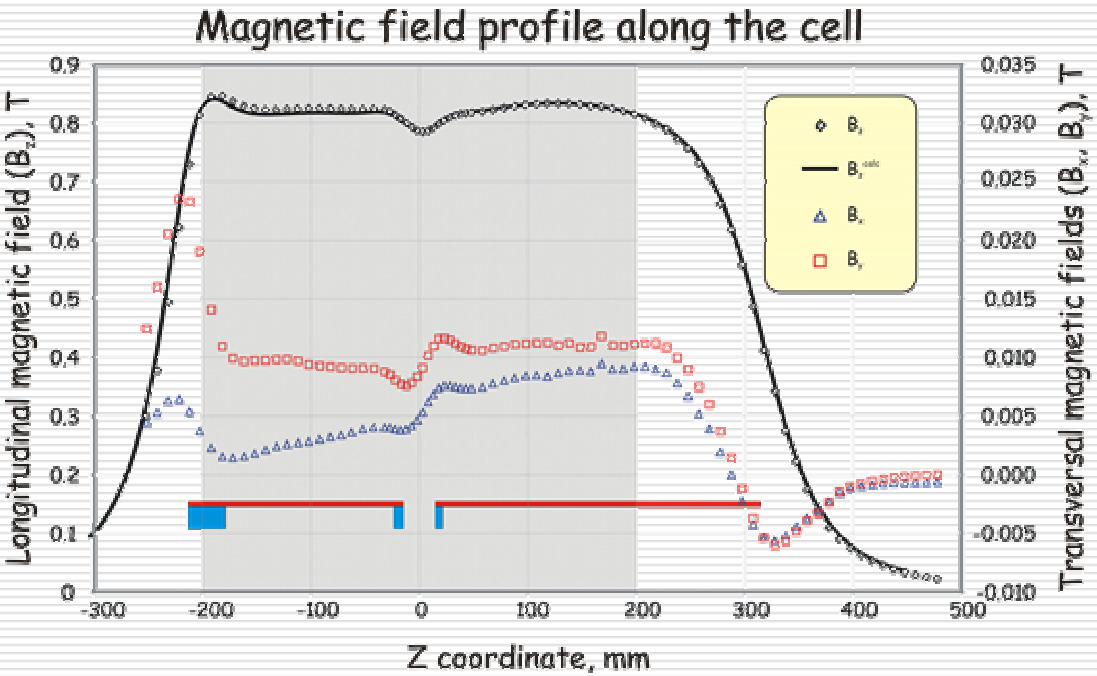
Experimental technique



Superconducting Solenoid

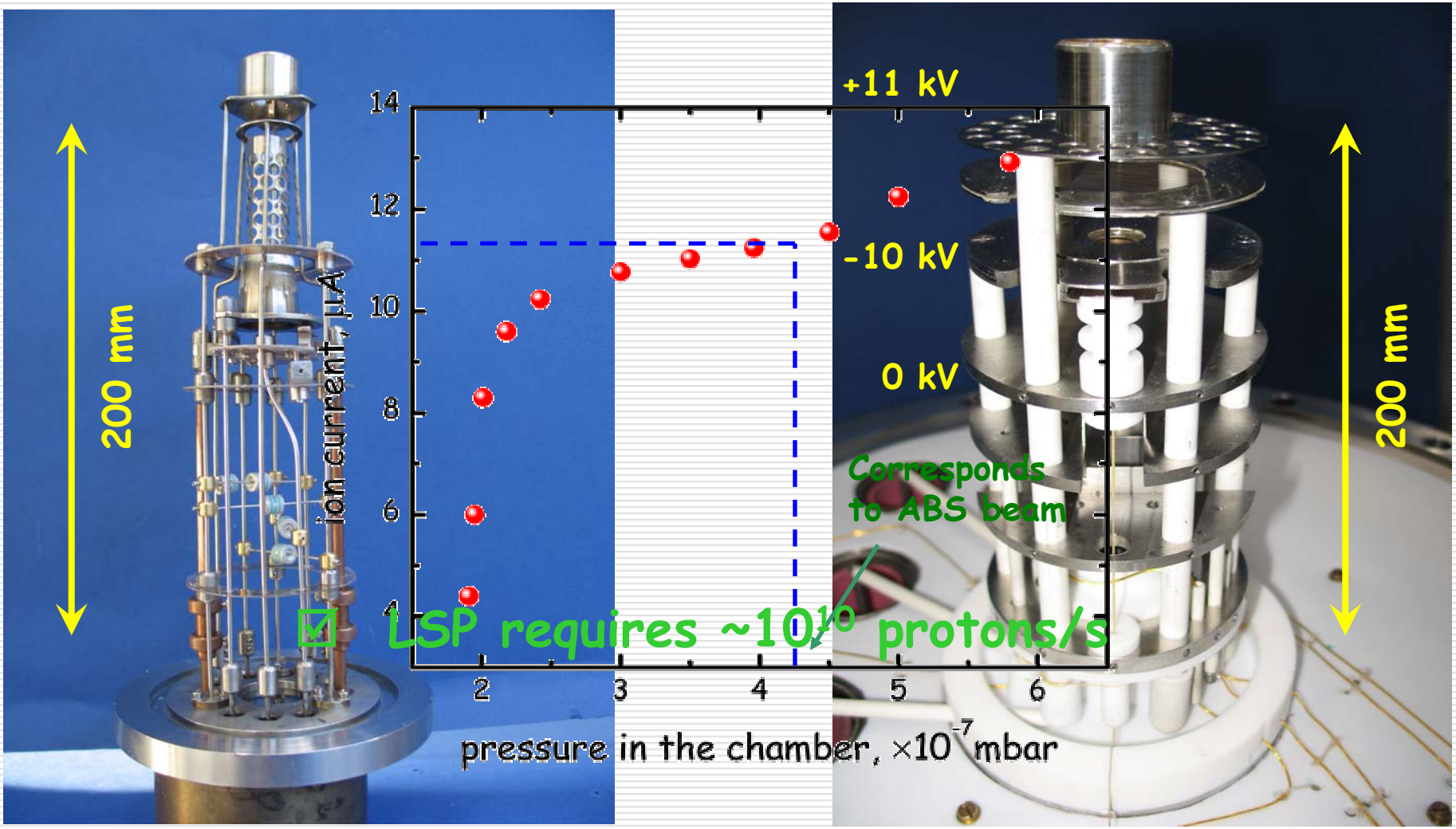


- SC wire NiTi+Cu (Ø 0.5 mm)
- Nominal current 50A ⇒ B ~ 1 T
- Degradat ion of frozen field ≤ 0.1% per 5 hrs
- LHe consumption ~ 8 l/h



CELGAS commissioning

e^--gun and ion optics



First results

Measurements take place right now in Jülich

Coming tasks

- Studies of **depolarization** of atoms on Au-coated cell under **various conditions** (T, B_z, atomic beam intensity, HFS etc.)

- **Polarization** measurement of **molecular beam** under various conditions (T, B_z, atomic beam intensity, HFS, cell coating material etc.)

Acknowledgments

We would like to express our gratitude to

for the strong support of this project!

More information can be found at

http://lkst.pnpi.nw.ru/celgas/