The Polarized Internal gas Target at ANKE / COSY

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Polarized Internal Gas Target

PIT main components:

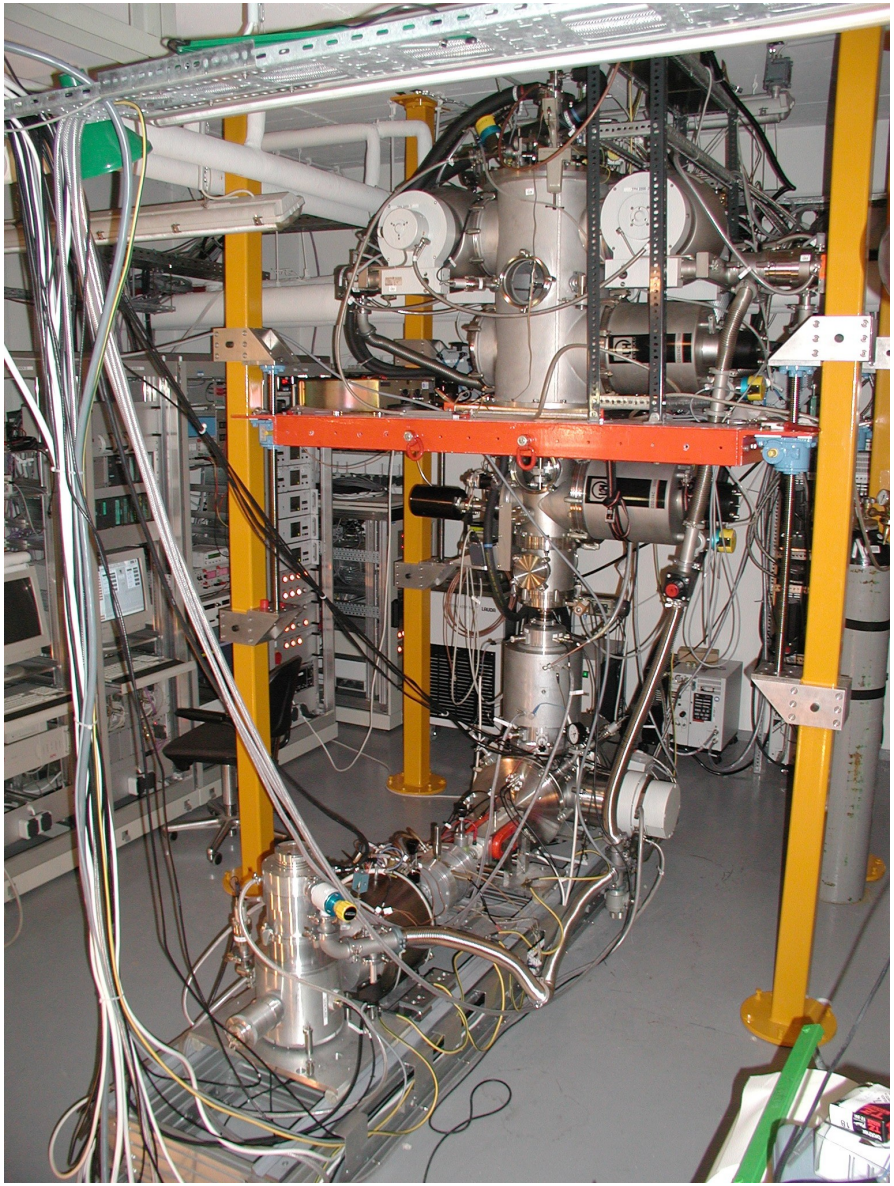
- Atomic Beam Source (ABS)
  - **H** or **D**
  - H beam intensity (2 HFS)

    $7.6 \cdot 10^{16}$ atoms/s
  - Beam size at the IP

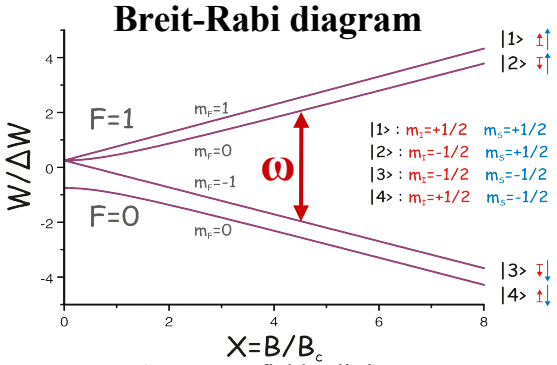
    $\sigma = 2.85 \pm 0.42$ mm
  - Polarization for hydrogen

    $P_z = 0.89 \pm 0.01$

    $P_z = -0.96 \pm 0.01$
- Lamb-Shift Polarimeter (LSP)
- Target chamber with Storage Cell

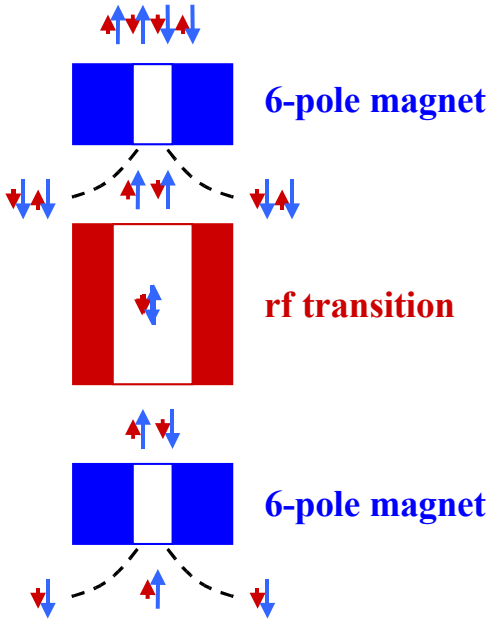


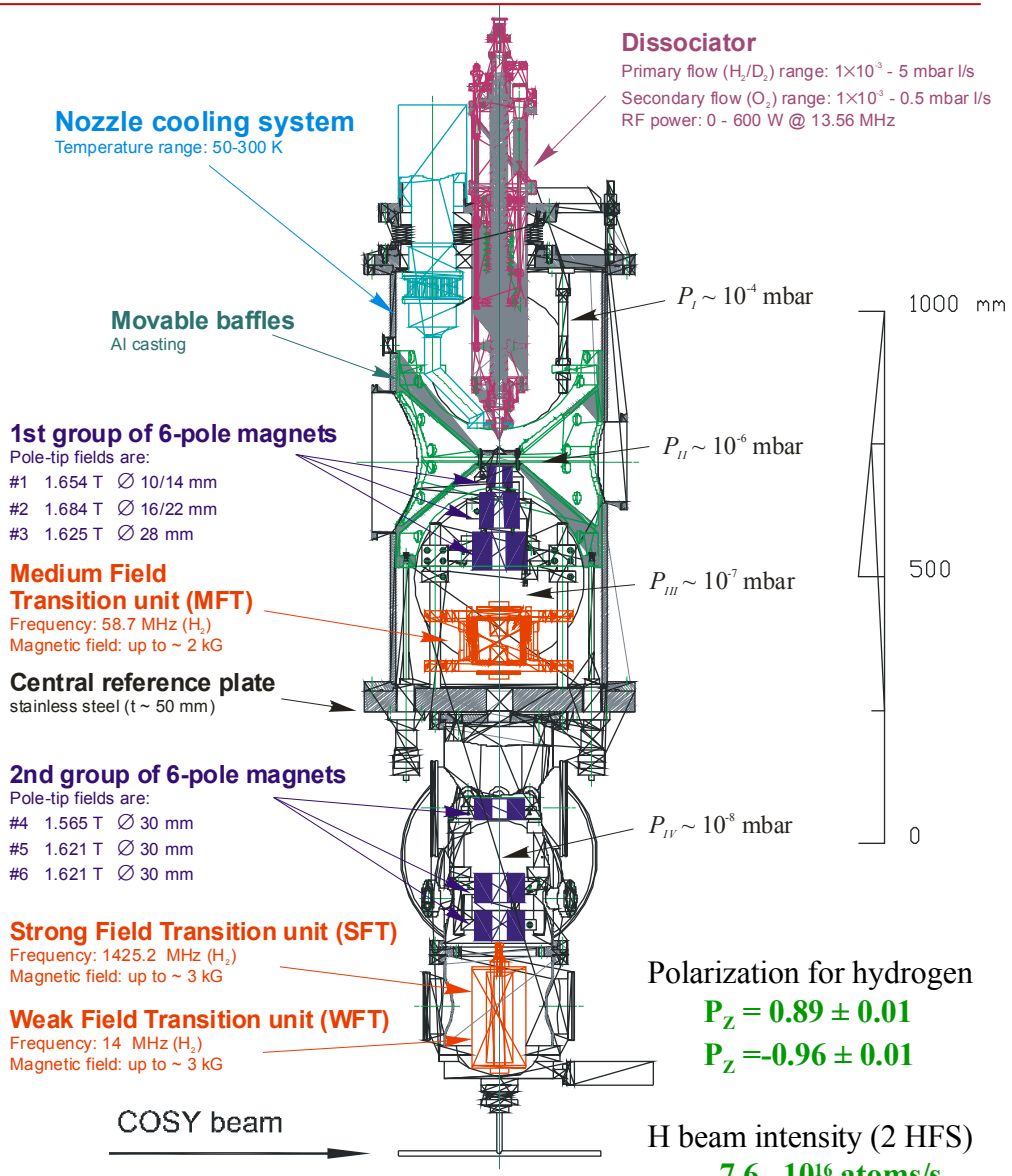
Atomic Beam Source



ΔW – zero-field splitting

B_c – critical field (507 G for H)





Polarization for hydrogen

$P_Z = 0.89 \pm 0.01$

$P_Z = -0.96 \pm 0.01$

H beam intensity (2 HFS)

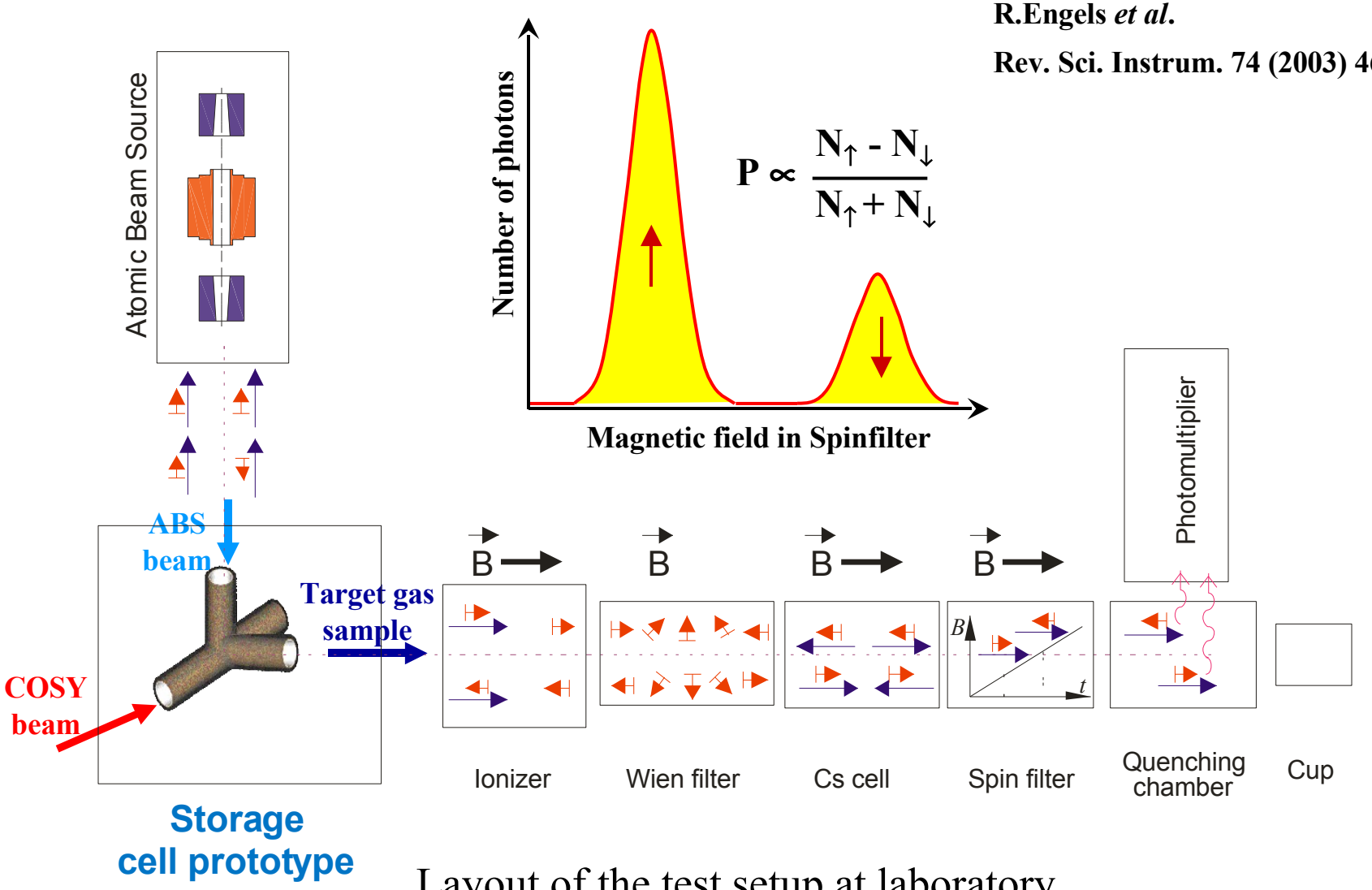
$7.6 \cdot 10^{16}$ atoms/s

More details in talk by Alexander Nass

Lamb-Shift Polarimeter

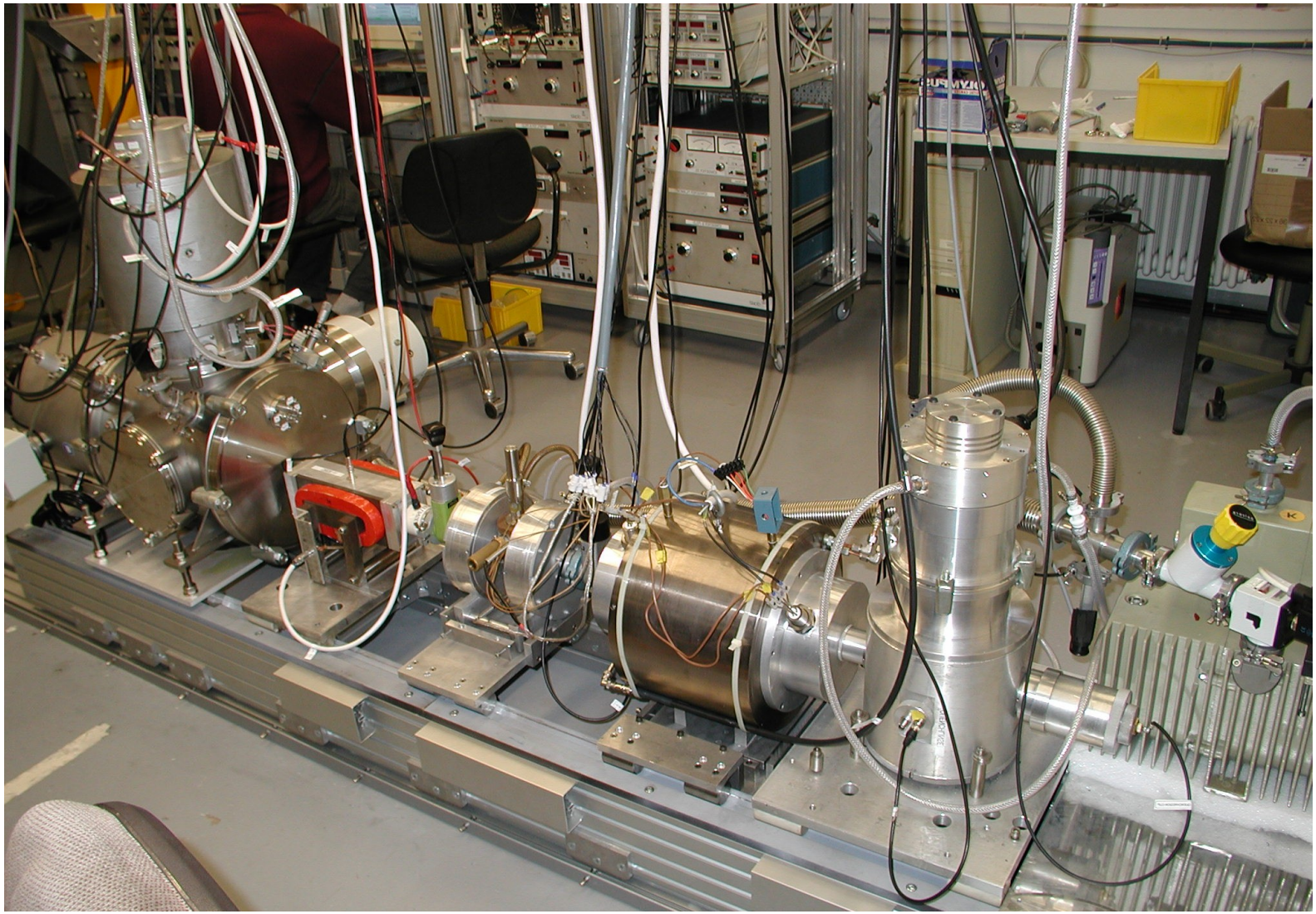
R.Engels *et al.*

Rev. Sci. Instrum. 74 (2003) 4607



Layout of the test setup at laboratory

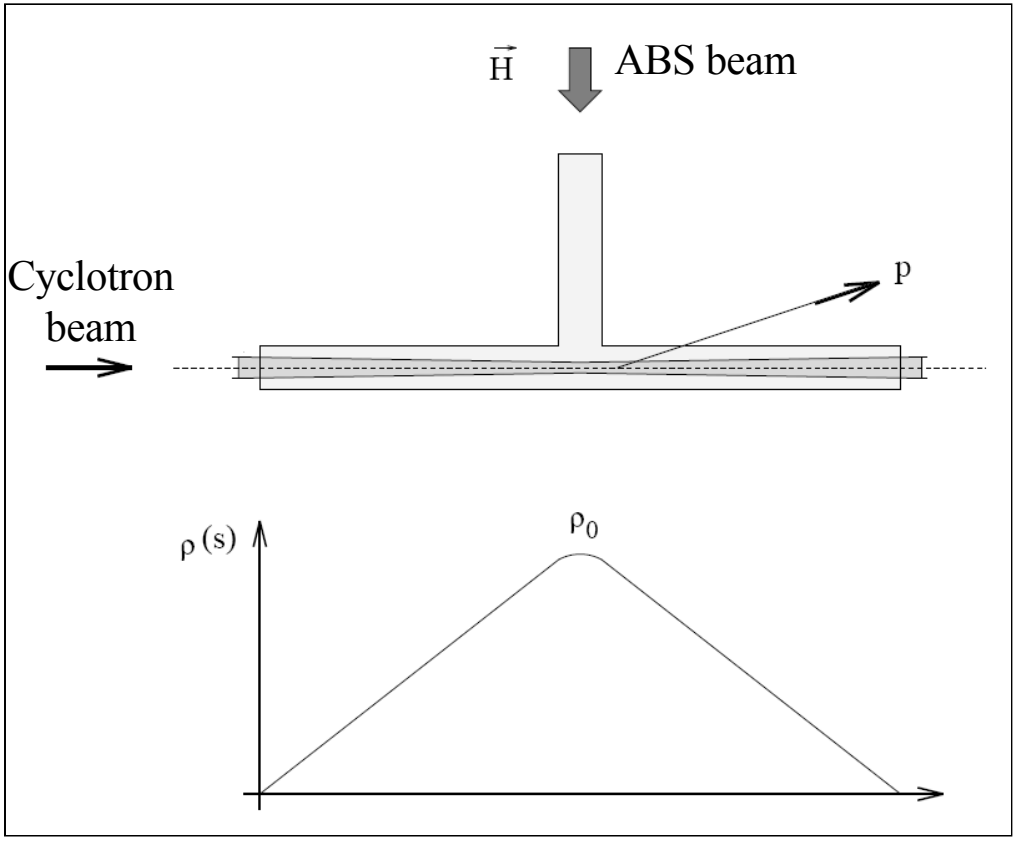
Lamb-Shift Polarimeter



Lamb-Shift Polarimeter at the laboratory

Storage cell

Proposed by W. Haeberli
2nd International Symposium On Polarization Phenomena, Basel, 1966



Storage cell

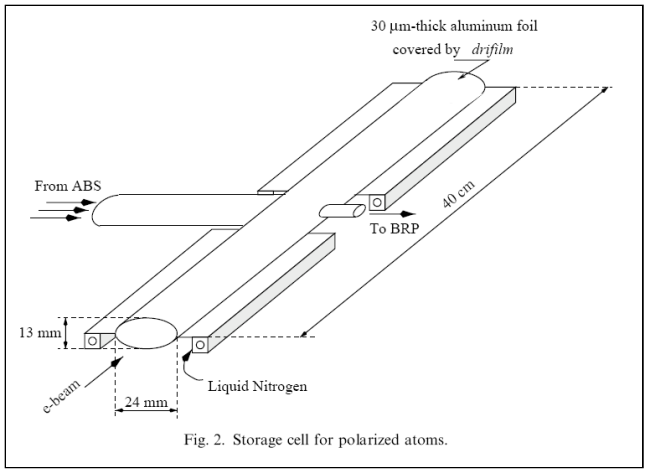
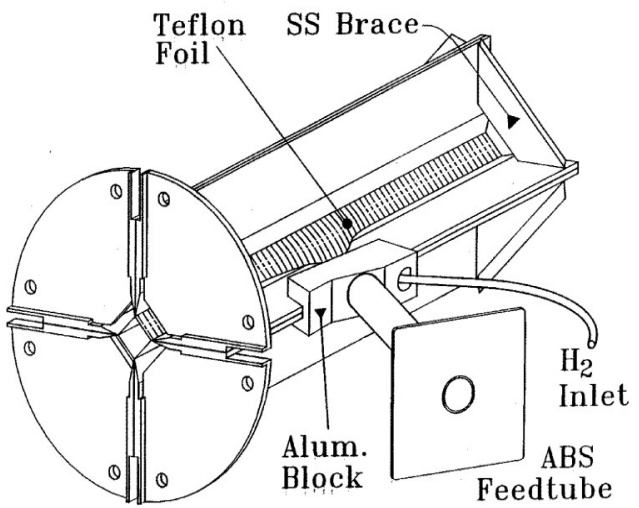
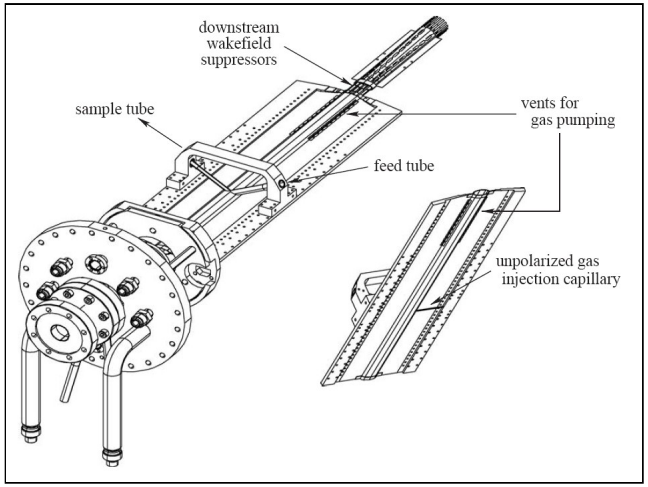


Fig. 2. Storage cell for polarized atoms.

The first cell. Deuteron, VEPP-3





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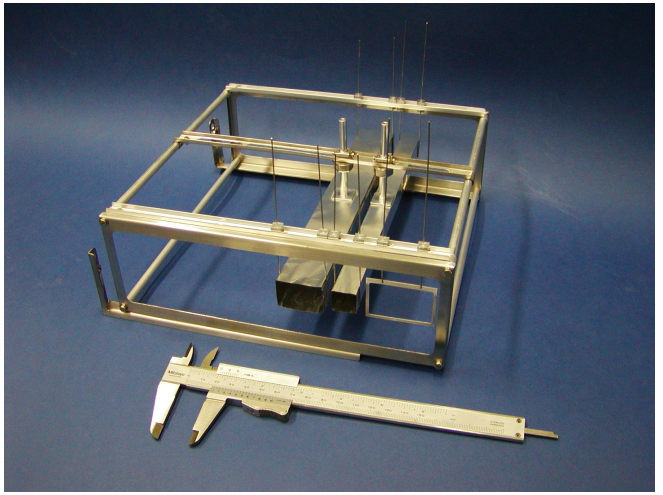


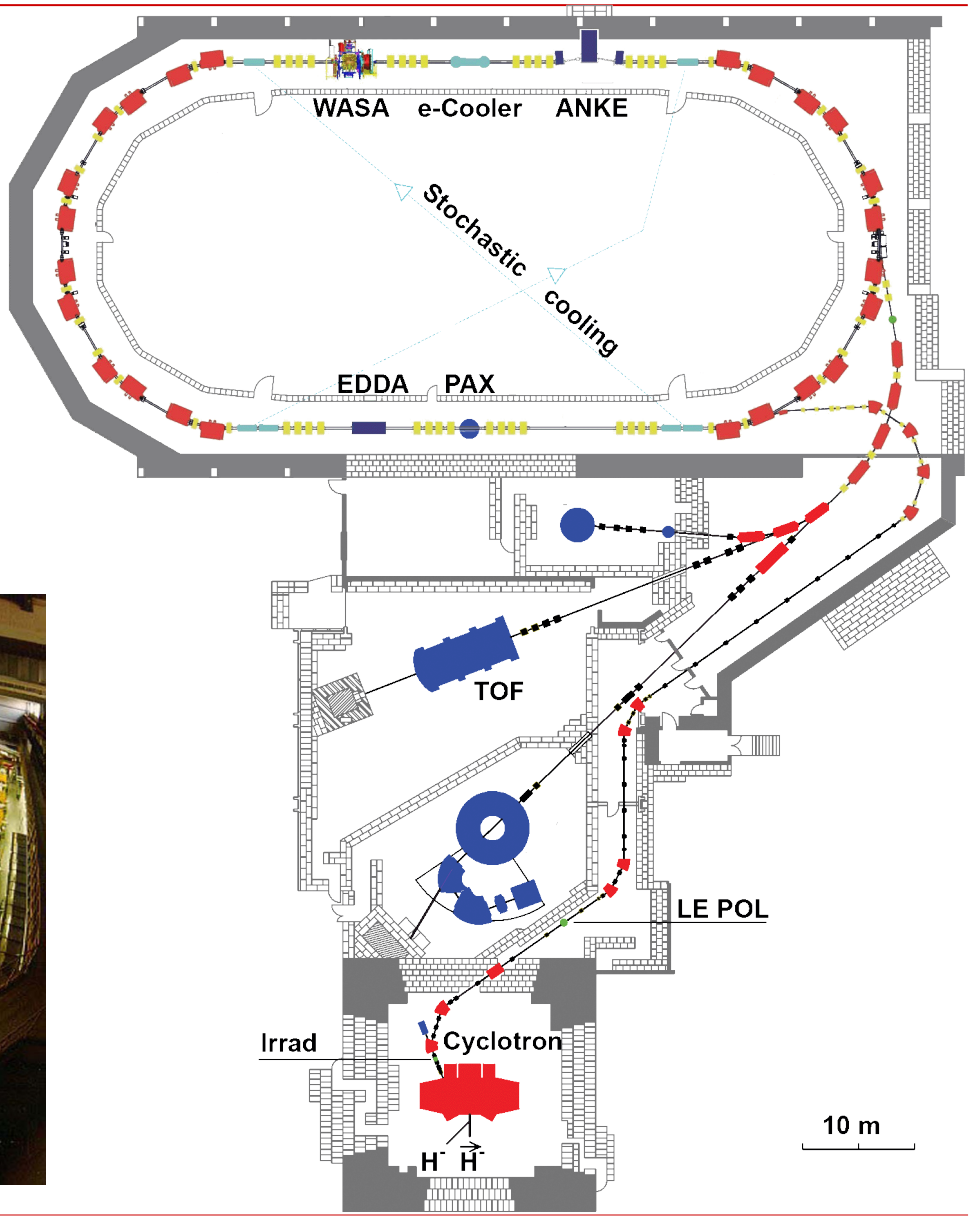
ANKE, COSY

COSY – COoler SYnchrotron

$p, \vec{p}, d, \vec{d}$

with momenta up to 3.7 GeV/c

- **internal experiments** – with the circulating beam
- **external experiments** – with the extracted beam



ANKE at COSY

Magnets

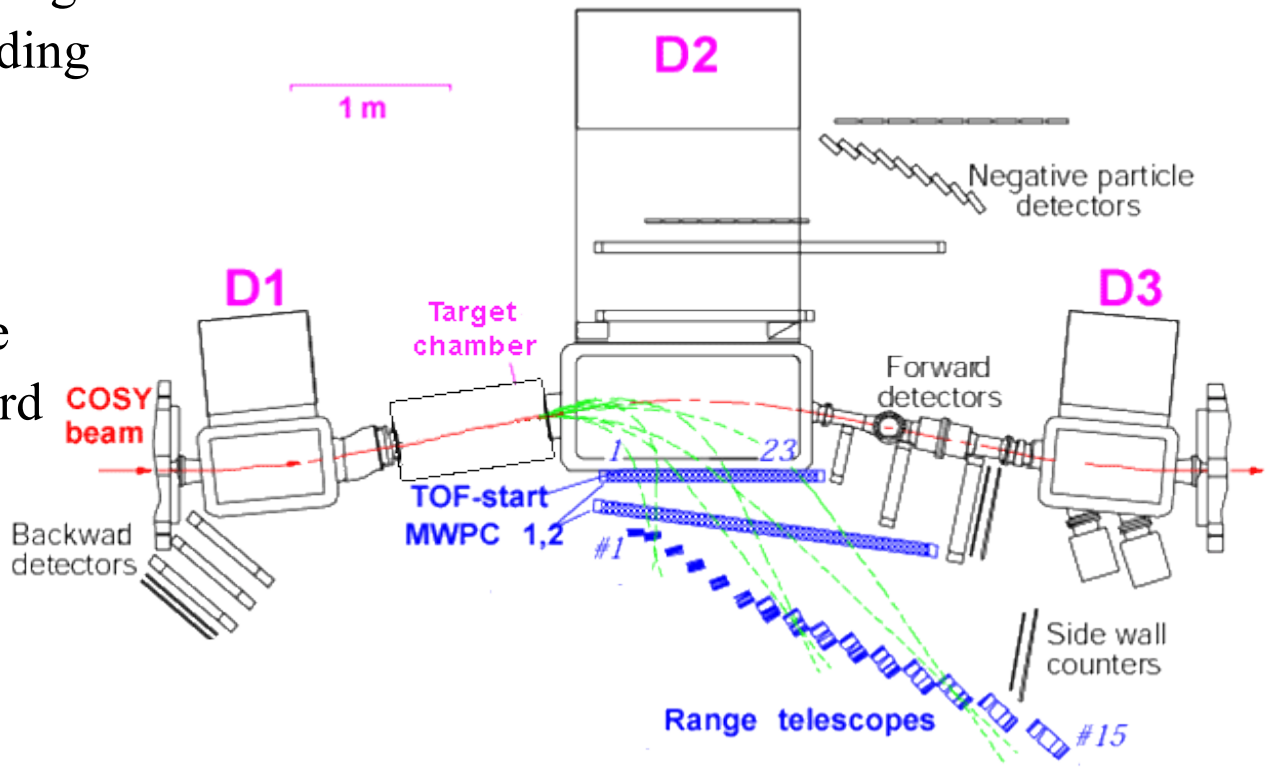
- D2 – spectrometer magnet
- D1, D3 – beam bending magnets

Detector systems

- Positive & Negative
- Forward & Backward
- Spectator Detectors

Targets

- Solid strip
- Cluster jet
- Polarized gas cell (polarized gas jet)



Spectrometer ANKE

ABS and LSP in the COSY hall

December 2004 – transfer to COSY hall (outside of the COSY tunnel)

May 2005 – tests after reassembling

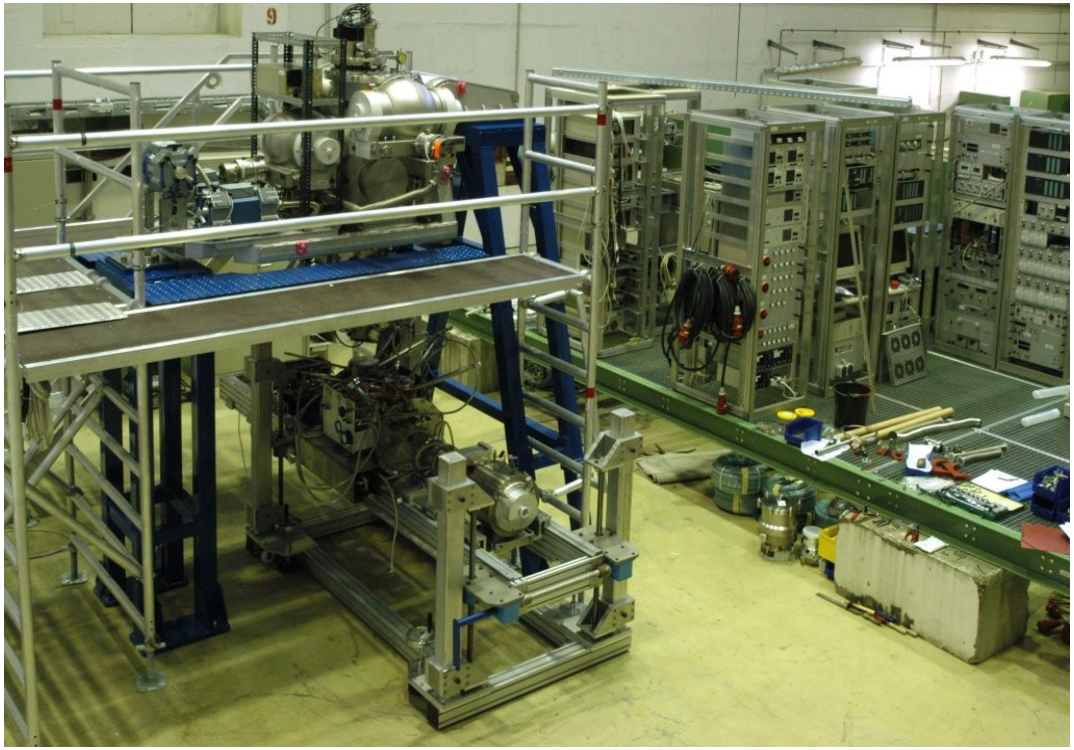
☹ Platform for all electronic and supply components

☹ Heat exchanger with closed cooling-water circuit

☹ New support bridge

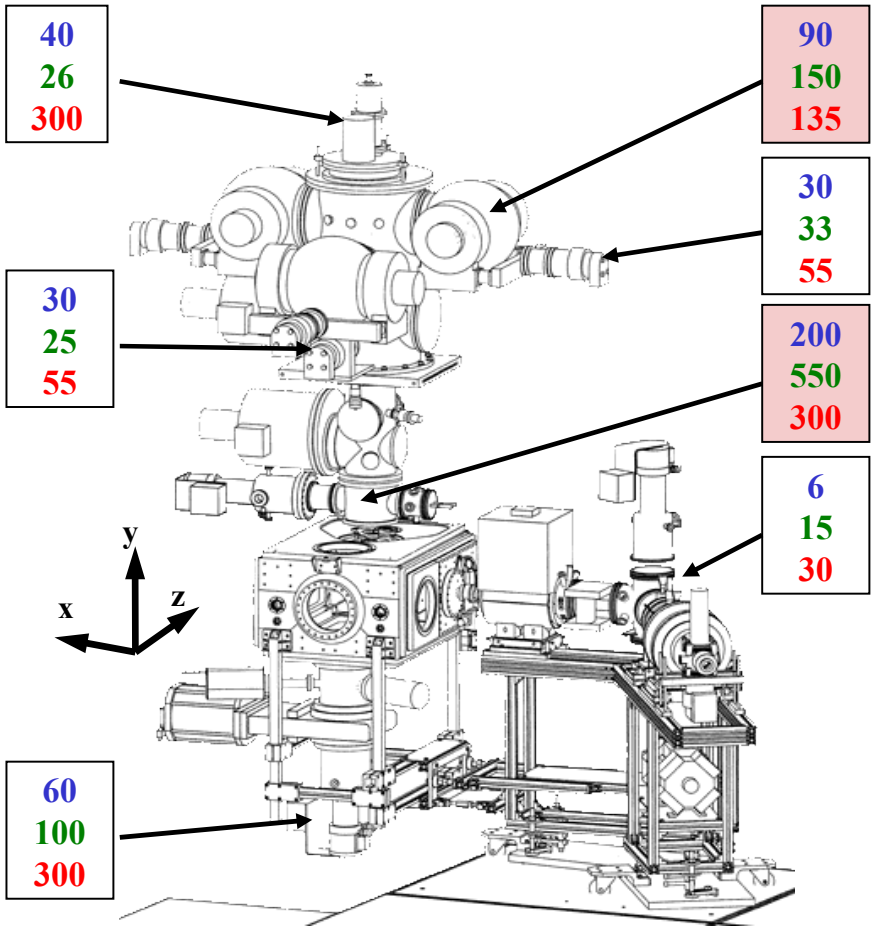
☹ Supports representing D1 and D2

June 2005 – setup ready for installation at ANKE

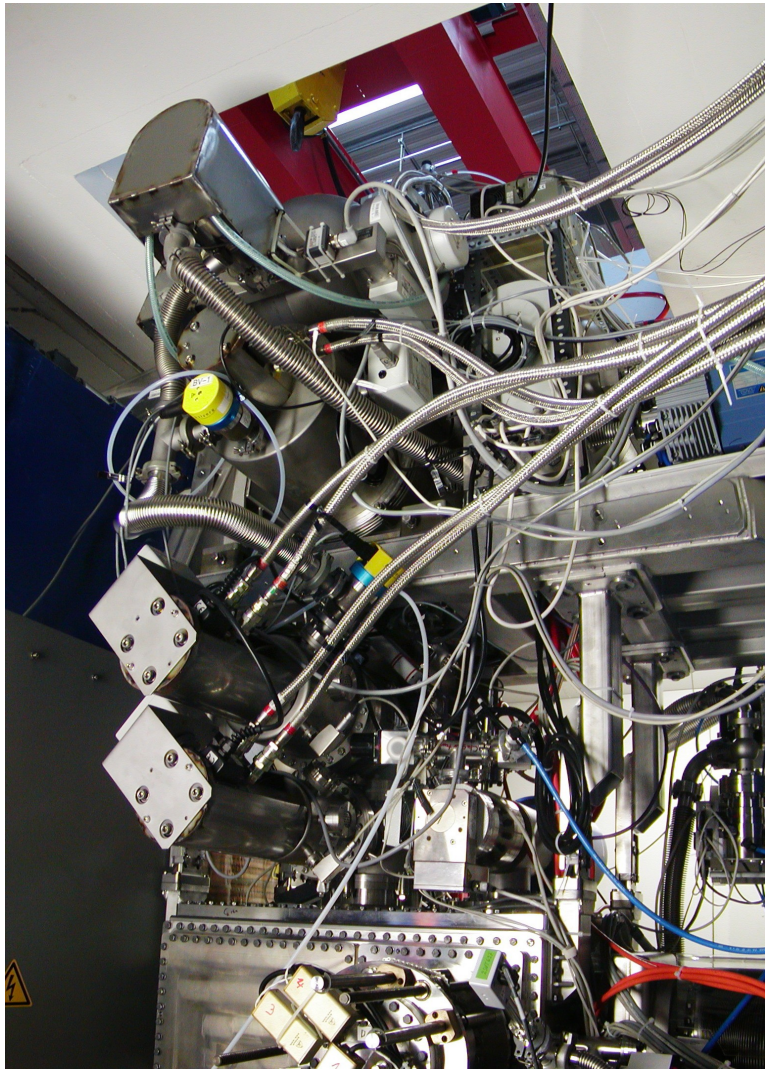


Setup in the COSY hall

Magnetic stray field of D2

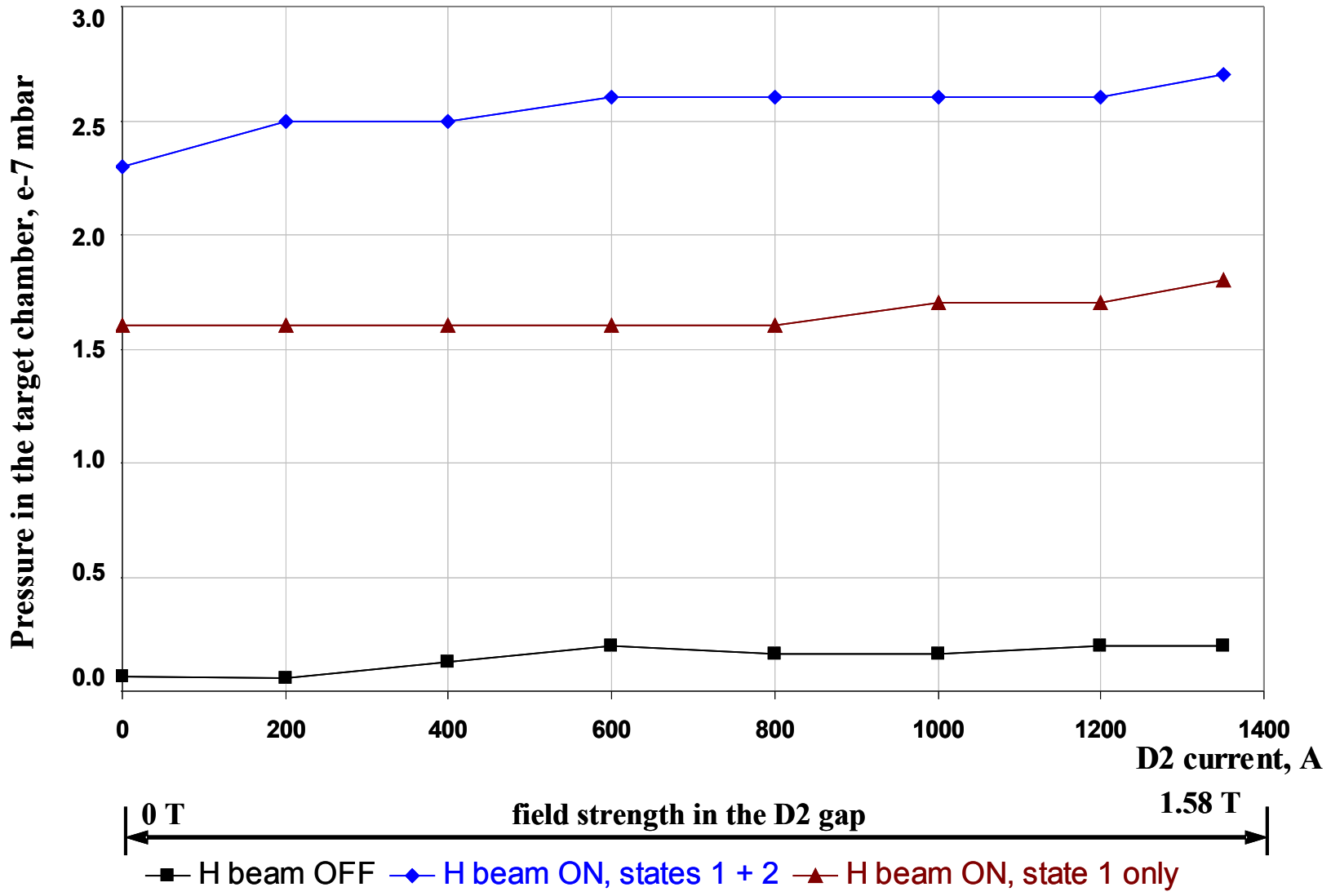


calculated field strength (G)
measured field strength (G)
permissible field strength for the device given by the producer (G)



PIT setup with shielded components at ANKE

Test of the Medium-field RF-Transition Unit



Do we have zero field crossings along the ABS axis?

Magnetic field scan with ANKE at 5.3º using a 3D Hallprobe (Gatchina):

Magnetic field along ABS axis

- I_{D2} = 563 A
- I_{D1D3}= 1294.84 A

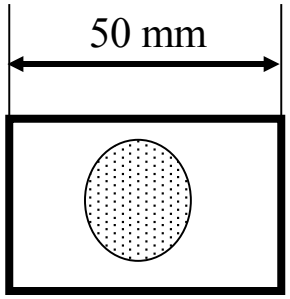
1. Determine the local Larmor precession frequency ω_L
2. The angular velocity of the magnetic field ω_B.

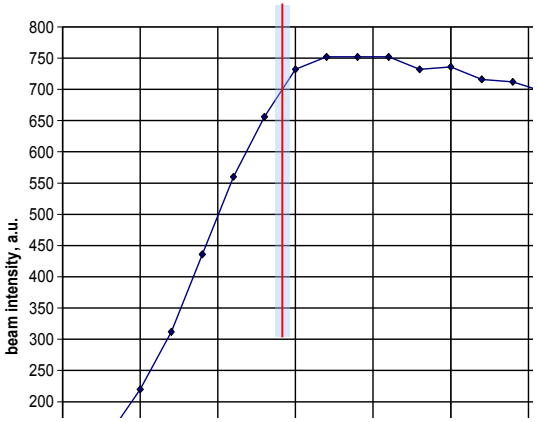
As long as the ratio $R=\omega_L/\omega_B$ is large, the spin of the atom follows the field direction.

→ no depolarization due to zero crossings

Principle of the aperture test

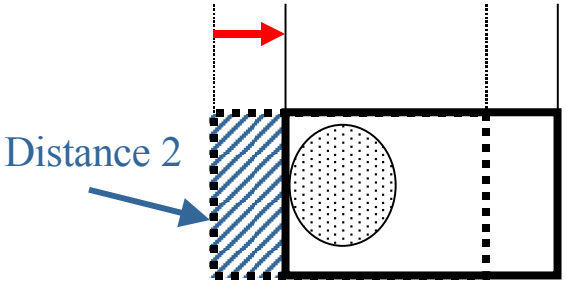
1. Beam in the center of the aperture

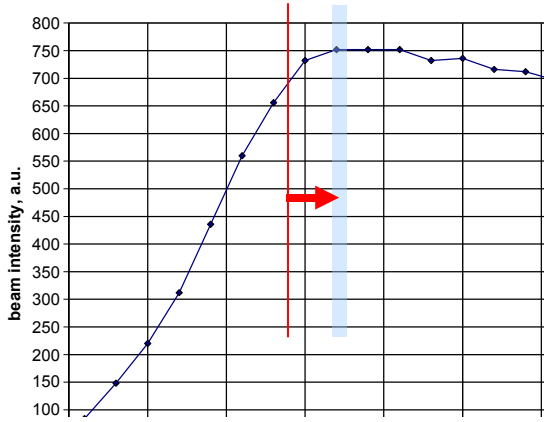




Beam intensity is maximum

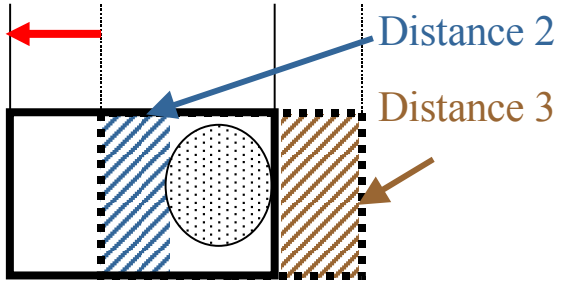
2. Aperture moves to the right until intensity drops +5 mm

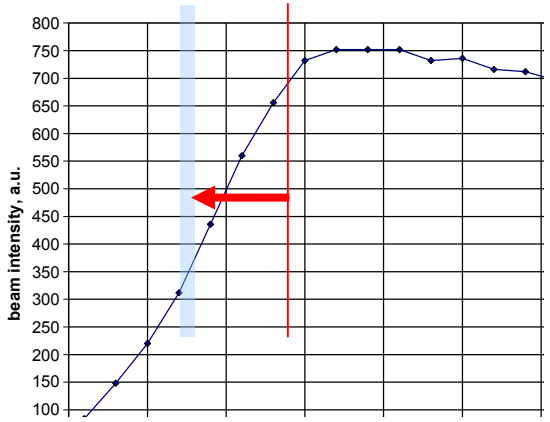




Beam intensity starts to decrease

3. Aperture moves to the left until intensity drops 11 mm



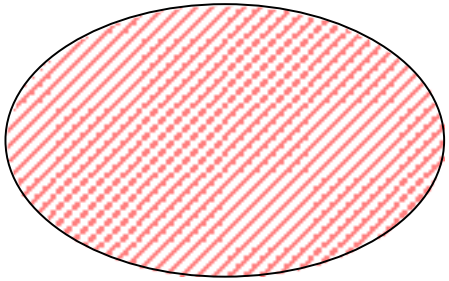


Beam intensity starts to decrease

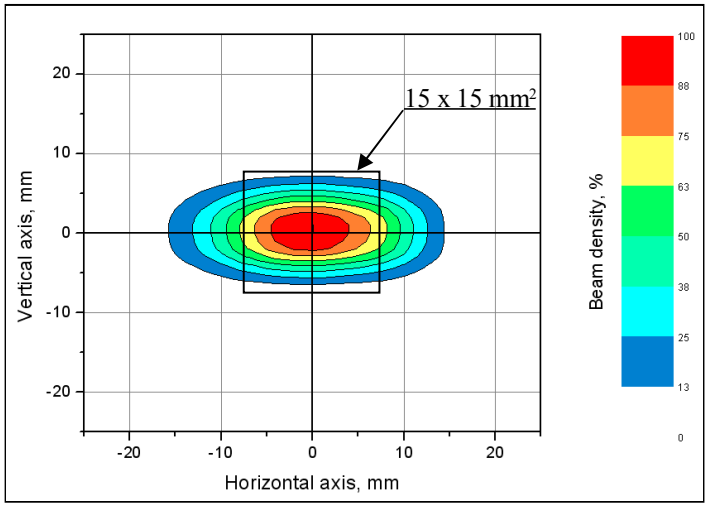
Beam diameter = Aperture inner width - (Distance 2 + Distance 3)

Estimated COSY-beam profile

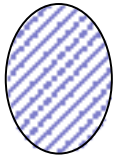
at injection



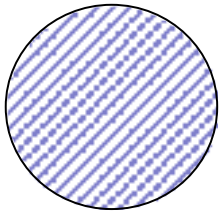
36x16 mm



with an accelerated beam



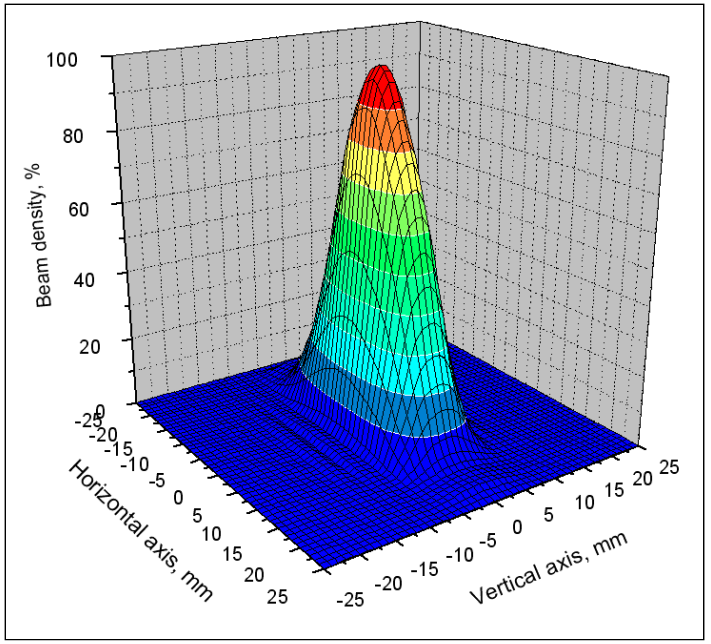
9x12 mm



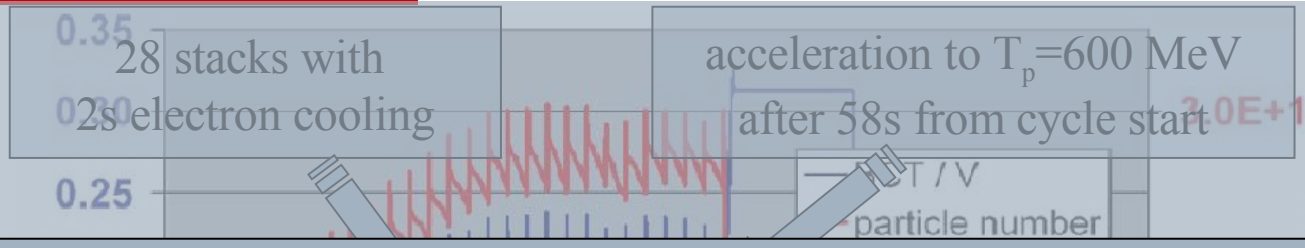
16x15 mm

no target

with cluster target
(density ~ 10^{14} at/cm^2)



Cooler Stacking with the Storage Cell



Stored particles in the ring = $6.4 \cdot 10^9$ protons

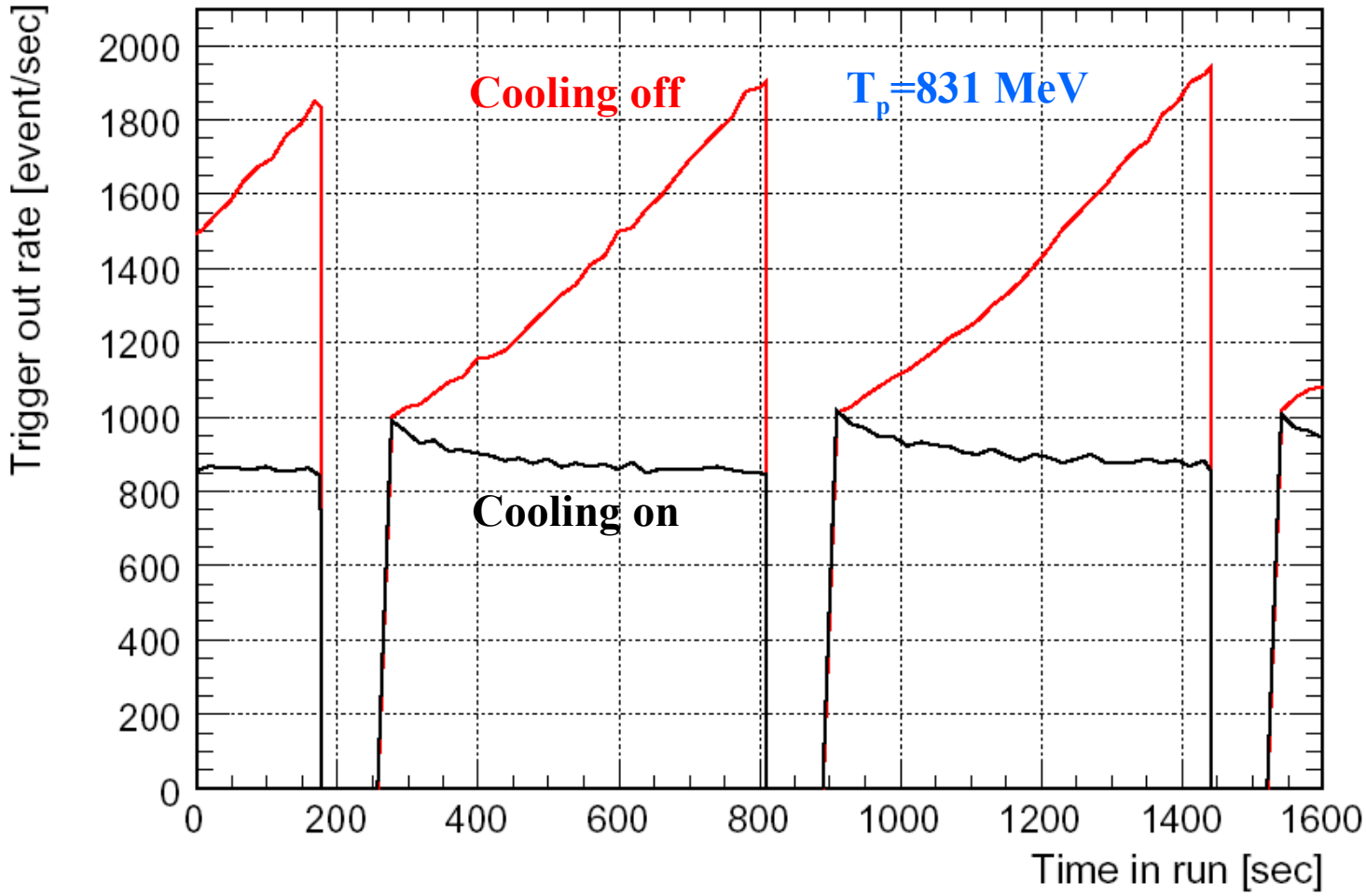
&

H target thickness = $2 \cdot 10^{13}$ atoms/cm^2

Average luminosity > 10^{29} cm^{-2}s^{-1}

Θ				ll
0°	electron cooling	1.4×10^{10}	3.5×10^9	
	Stacking + electron cooling	2.6×10^{10}	2.0×10^{10}	
9.2°			6.0×10^9	6.4×10^9

Stochastic cooling



- Length of the cycle = 10 min
- Minimum energy for stochastic cooling is 831MeV

Measurements at COSY

- First PIT commissioning

  (ANKE at 9.2º, COSY beam – 600 MeV protons)

  - Storage cell (Al foil coated with PTFE)
  - ABS jet with cryo-catcher
  - Polarized ABS-jet measurements

- Second PIT commissioning

  (ANKE at 5.3º, COSY beam – 831 MeV protons)

  - Storage cell (pure Al foil)
  - Background investigations

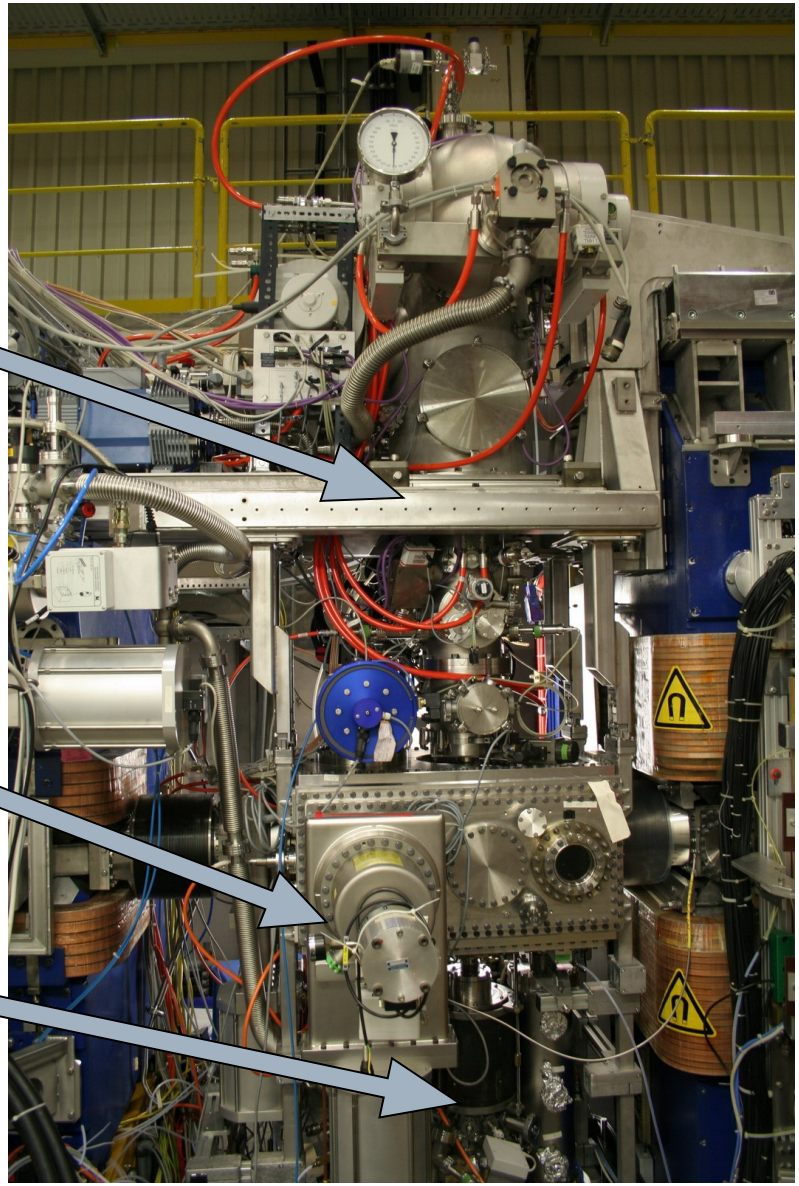
- **First double polarized experiment** $\vec{d}\vec{p} \rightarrow ppn$

  (ANKE at 5.5º, COSY beam – 1.2 GeV polarized deuterons)

  - Storage cell (Al foil coated with PTFE)
  - LSP measurements

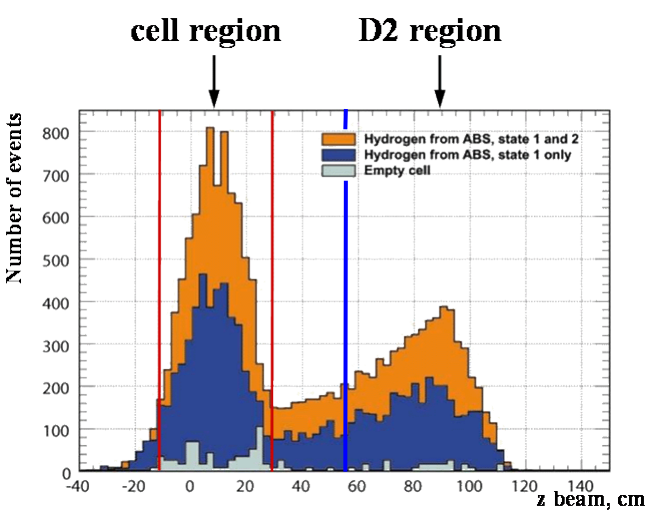
PIT at ANKE

- Supporting bridge between D1 and D2
- Additional shielding from the D2 stray fields
- Cryopump at the target chamber
- Polarimeter ionizer under the target chamber



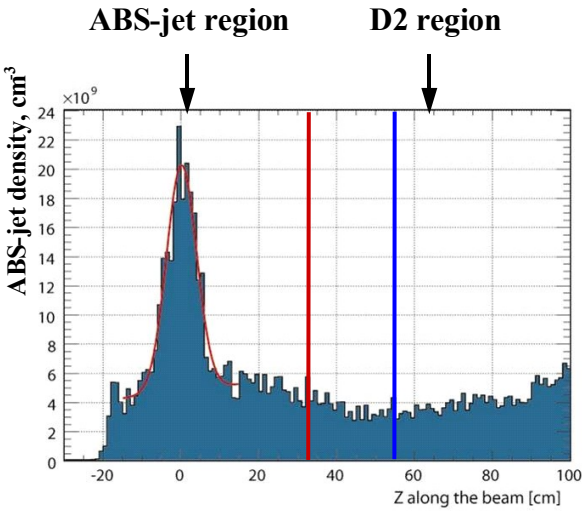
Commissioning results

Target – **storage cell**
with (un)polarized ABS beam



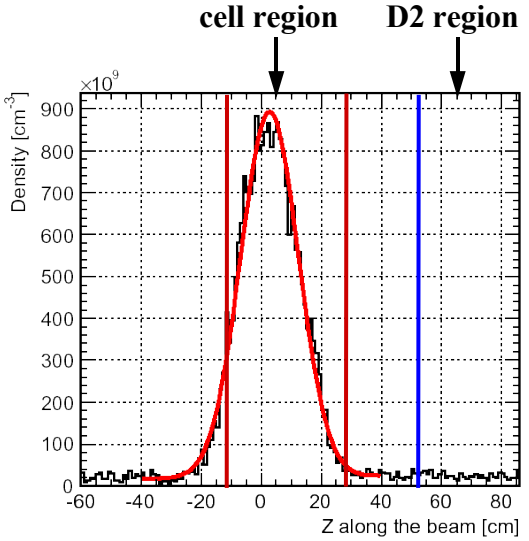
target thickness ~ 10^{13} cm^{-2}
Hydrogen in HFS 1 only

Target – **ABS jet**
with unpolarized Hydrogen



target thickness ~ $1.5 \cdot 10^{11}$ cm^{-2}

Target – **storage cell**
with unpolarized ABS beam



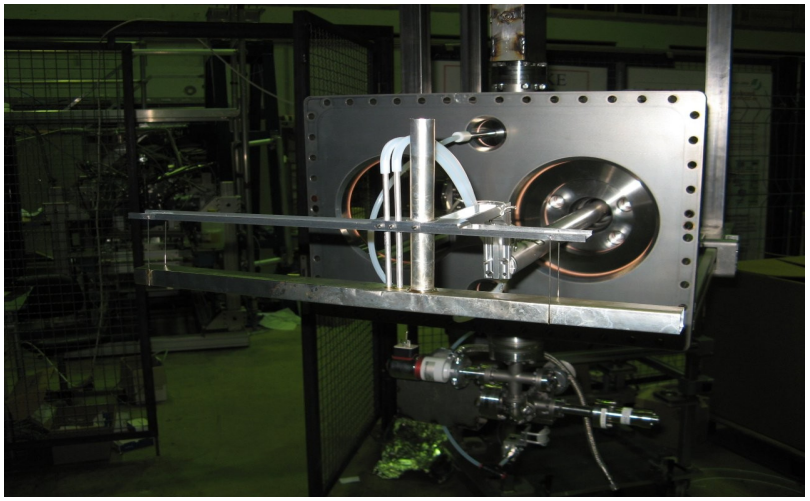
target thickness ~ $2.1 \cdot 10^{13}$ cm^{-2}
luminosity ~ 10^{29} cm^{-2}s^{-1}

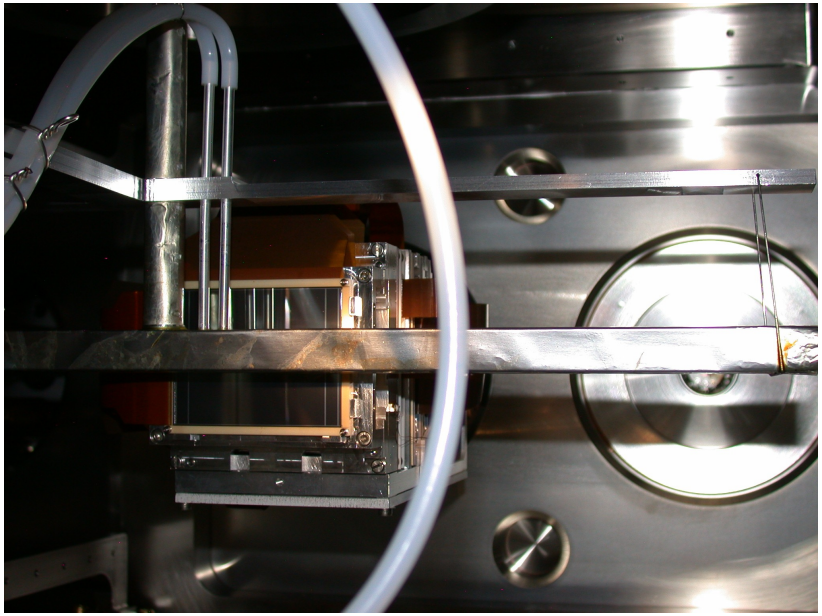
Measured polarization → **P = 0.44±0.03**

Theoretically expected → **P = 0.56 (0.51)**

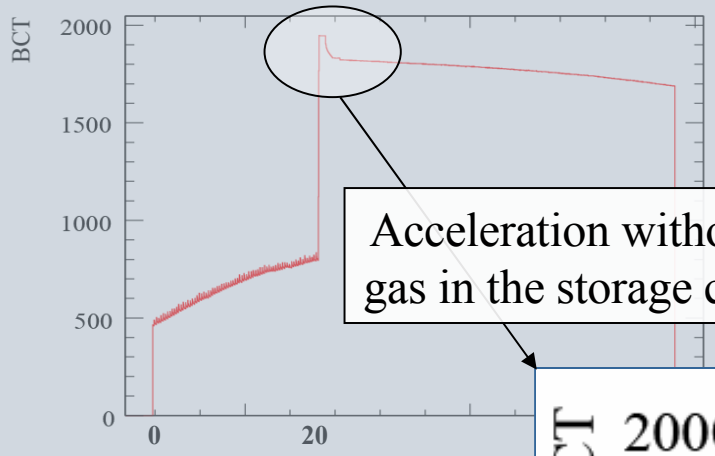
Preparation for the experiment

- Tools for the experiment
  - New storage cell & support
    - > high target density
    - > unpolarized gas feeding system
  - LSP below the target chamber
    - > online measurement of the ABS beam polarization
  - Silicon tracking telescope (STT)
    - > measurement of spectator protons nearby the storage cell center



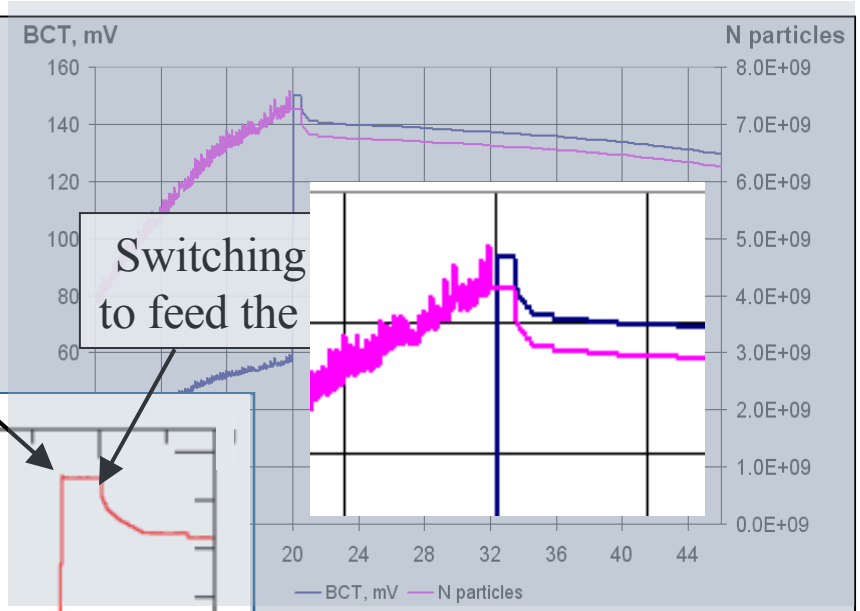


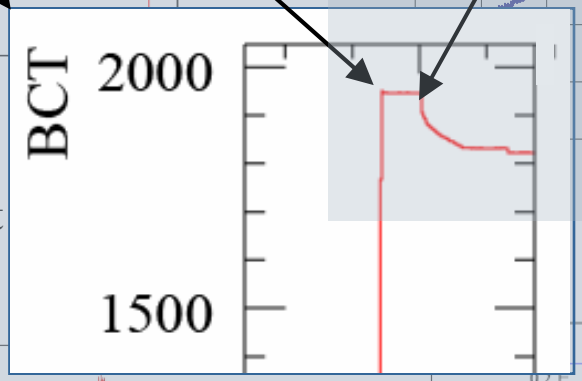
Double polarized experiment results



Acceleration without gas in the storage cell

Switching to feed the

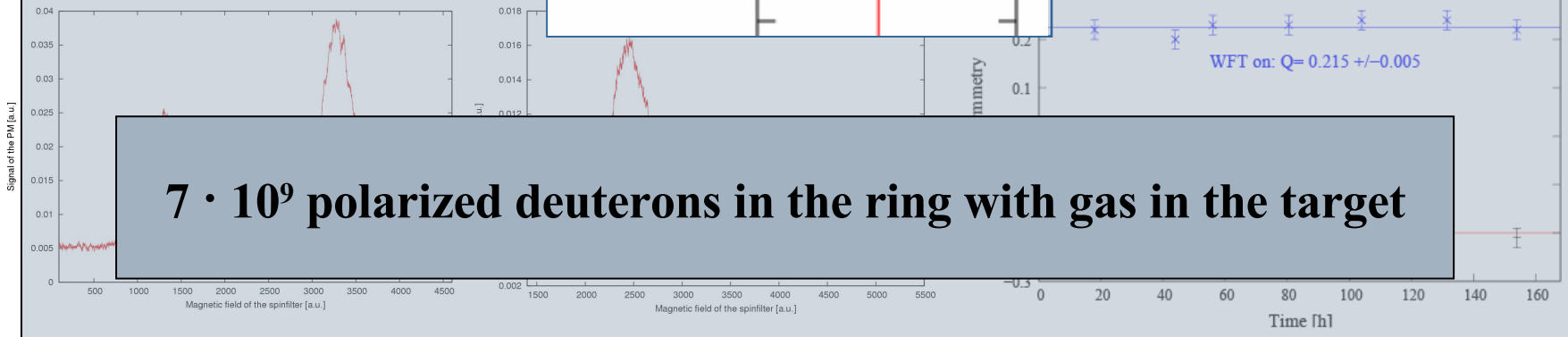




Stacking → 120 injection with 10

Flat top → 30 min, to have about

WFT on



$7 \cdot 10^9$ polarized deuterons in the ring with gas in the target

Ly-α peaks measured with LSP

Measured asymmetry with LSP

Results and future plans

Results

- Stable polarization, measured with LSP every 24h
- High density of the polarized gas target **$1.34 \cdot 10^{13}$ at/cm^2**
- High luminosity with polarized deuteron COSY beam **$\sim 1 \cdot 10^{29}$ s^{-1}cm^{-2}**
- Hydrogen target polarization from nuclear reaction **0.75 ± 0.06**

Talk by A. Kacharava

Plans

- 4 weeks double-polarized experiment in the beginning of 2008 accepted by PAC
- ABS transition units calibration for deuterium beam for the future experiments with polarized deuteron target