

PIT for Spin Filtering Studies at COSY and AD

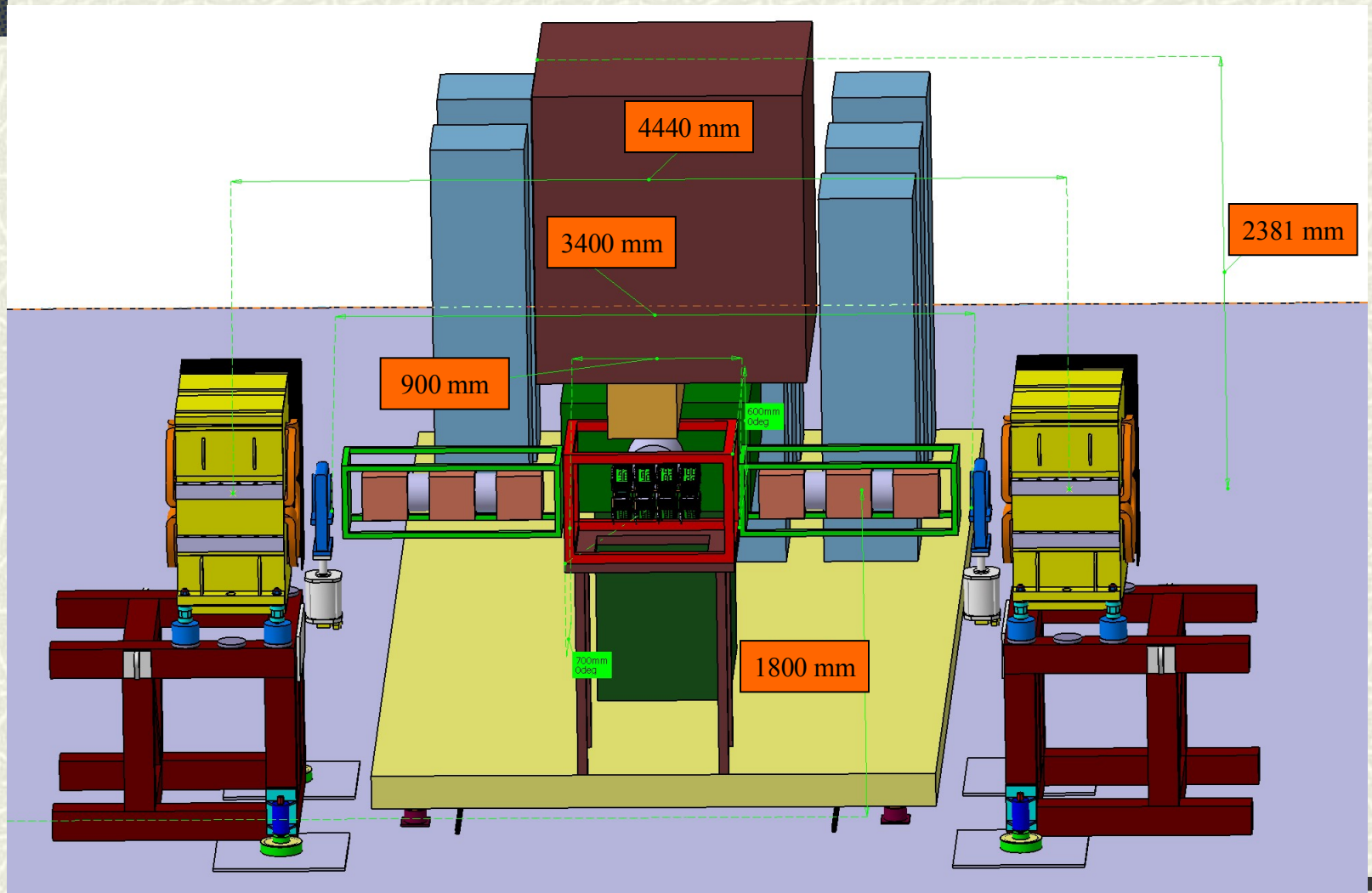
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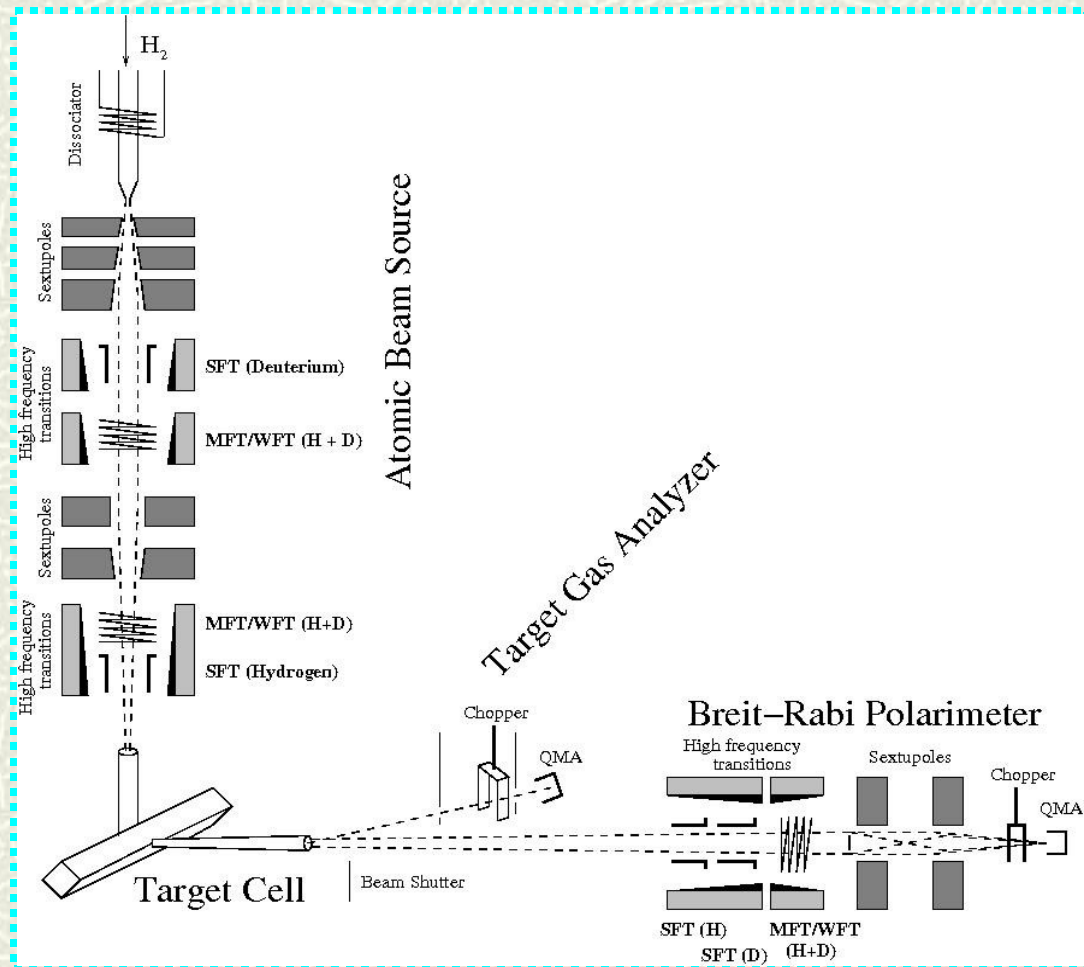
Overview over the Target Section



Requirements for Spin Filtering

- # High polarization of the target
 - # Density up to 10^{15} atoms/cm²
 - # Variability of the direction of the spin axis
 - # Openable storage cell for AD
 - # Ability to produce electron and nuclear polarization separately
 - # Polarization measurement independent of the beam
 - # Ability to produce polarized H and D in short sequence with the same setup for filtering with D and measuring with H (no A_y for pd known)
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Setup of the Polarized Target



- ▣ Production of a polarized atomic beam by an atomic beam source (ABS)
- ▣ Increase of the target density by means of an openable storage cell
- ▣ Analysis of target polarization by a so-called Breit-Rabi polarimeter (BRP) and a target gas analyzer (TGA)

Polarization of the Target Gas

Hydrogen states are defined as ($|a\rangle = |m_S, m_I\rangle$):

$$|1\rangle = |1/2, 1/2\rangle$$

$$|2\rangle = \cos \theta |1/2, -1/2\rangle + \sin \theta | -1/2, 1/2\rangle$$

$$|3\rangle = | -1/2, -1/2\rangle$$

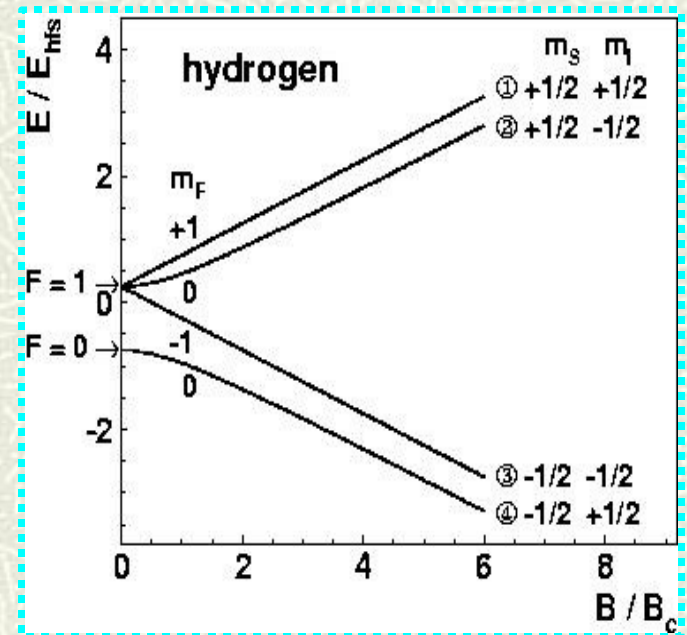
$$|4\rangle = -\sin \theta |1/2, -1/2\rangle + \cos \theta | -1/2, 1/2\rangle$$

with $\theta = \frac{1}{2} \arctan(B_c/B)$

Polarization:

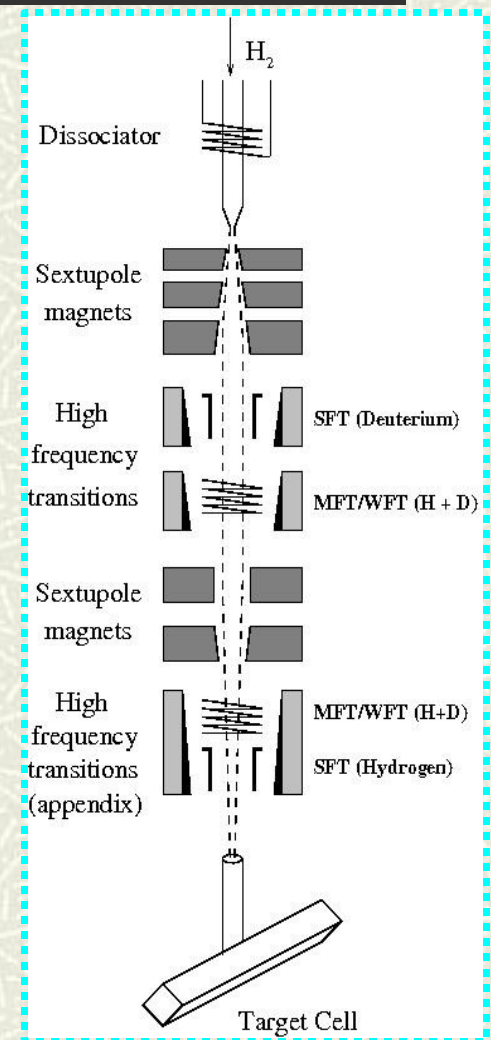
$$P_e = n_1 - n_3 + (n_2 - n_4) \cos 2\theta$$

$$P_z = n_1 - n_3 - (n_2 - n_4) \cos 2\theta$$



The Atomic Beam Source

- ❏ ABS vacuum consists of 7 turbo molecular pumps with total pumping speed of ~ 10000 l/s
- ❏ Atomic beam is produced when the dissociated gas expands through a cooled nozzle into the vacuum
- ❏ Sextupole magnets produce electron polarization by focussing atoms in hyperfine states $|1\rangle$ and $|2\rangle$ and defocussing $|3\rangle$ and $|4\rangle$
- ❏ High frequency transitions (HFT's) exchange populations of hyperfine states and are used to produce nuclear polarization
- ❏ HFT's will be tuned for **H** and **D** for filtering with D and beam polarization measurement with H

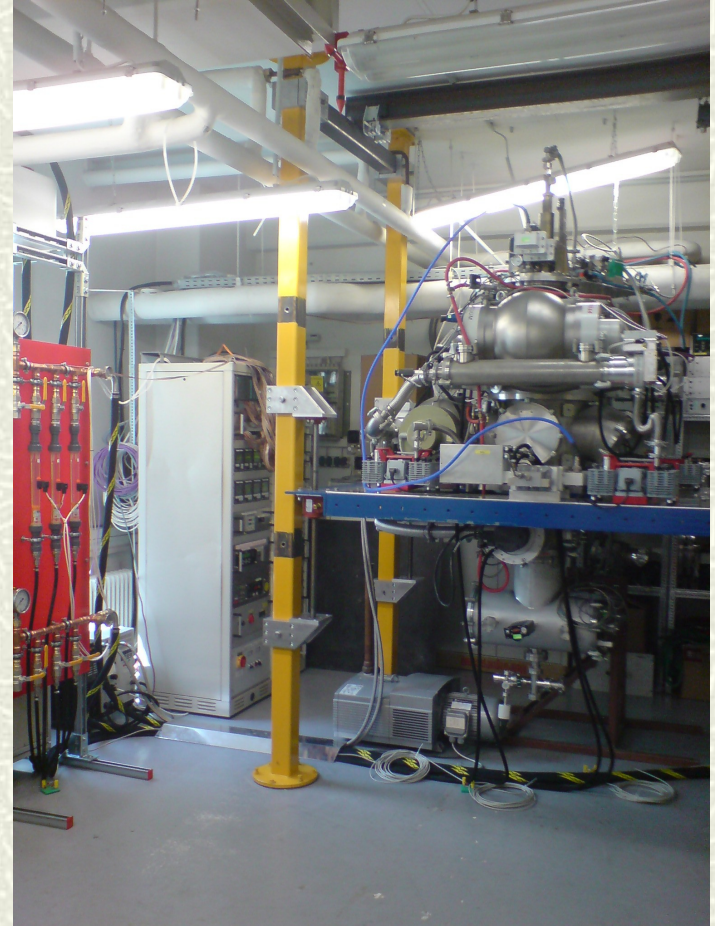


Running modes at COSY and AD

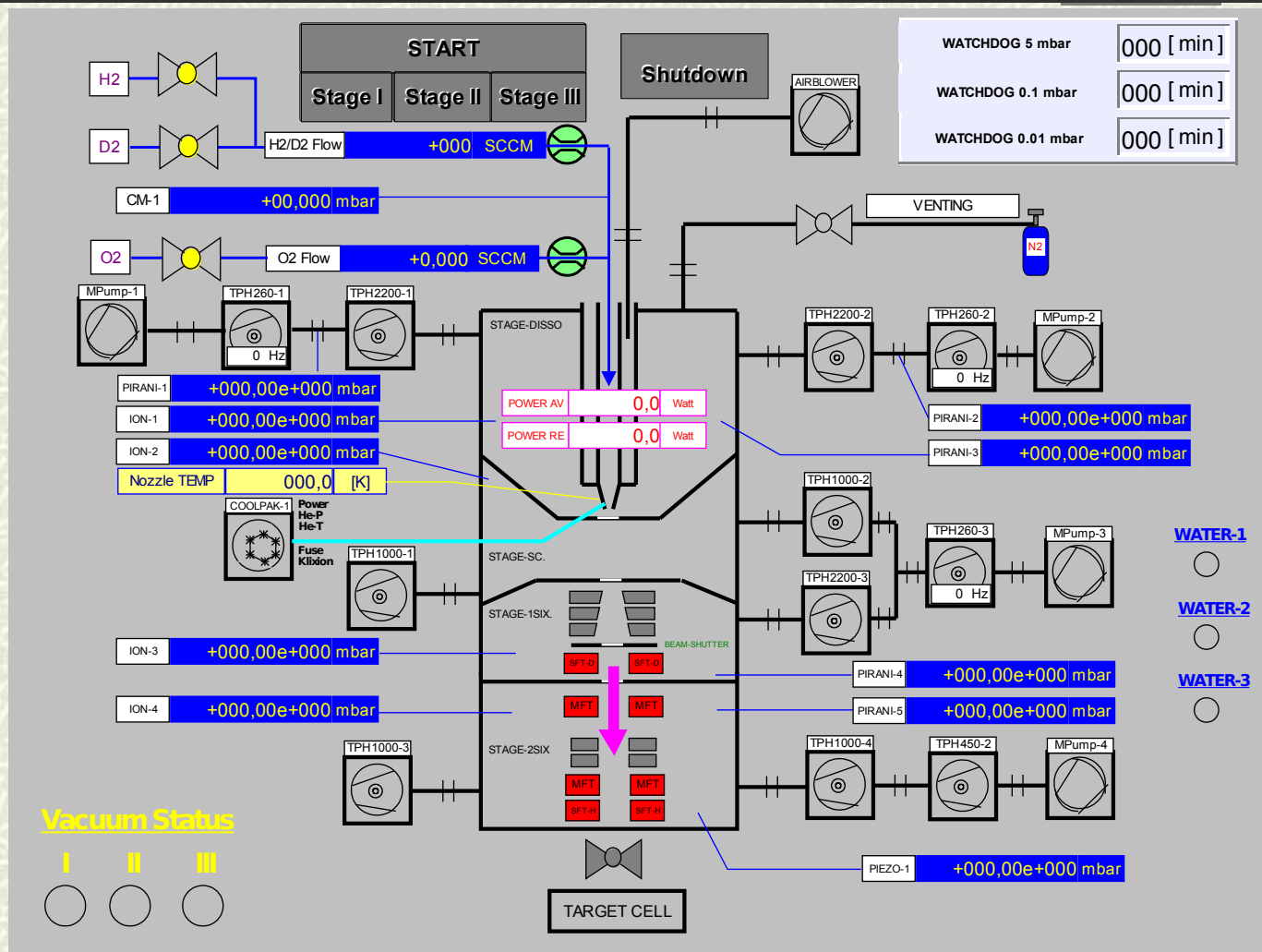
Gas	States after					Polarization in weak B		Polarization in strong B	
	Dissociator	1st 6-poles	SFT (D), MFT/WFT	2nd 6-poles	MFT/WFT, SFT (H)	P_e	P_z	P_e	P_z
H	$ 1\rangle 2\rangle 3\rangle 4\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 3\rangle$	$ 1\rangle$	$ 1\rangle$	+1	+1	+1	+1
H	$ 1\rangle 2\rangle 3\rangle 4\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 2\rangle$	$+1/2$	$+1/2$	+1	0
H	$ 1\rangle 2\rangle 3\rangle 4\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 4\rangle$	$+1/2$	$+1/2$	0	+1
H	$ 1\rangle 2\rangle 3\rangle 4\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 2\rangle$	$ 1\rangle 2\rangle$	$ 2\rangle 3\rangle$	$-1/2$	$-1/2$	0	-1
D	$ 1\rangle 2\rangle 3\rangle 4\rangle 5\rangle 6\rangle$	$ 1\rangle 2\rangle 3\rangle$	$ 1\rangle 4\rangle 6\rangle$	$ 1\rangle$	$ 1\rangle$	+1	+1	+1	+1

Status of the Source

- ❏ Former HERMES ABS rebuilt with modified vacuum system (cryo pumps replaced by turbo-molecular pumps) on a new support
- ❏ New cabling and interlock system
- ❏ Vacuum system with the MW-dissociator is running
- ❏ Construction of a new analysis chamber with QMS and compression tube
- ❏ First intensity measurements to be done soon



Control System



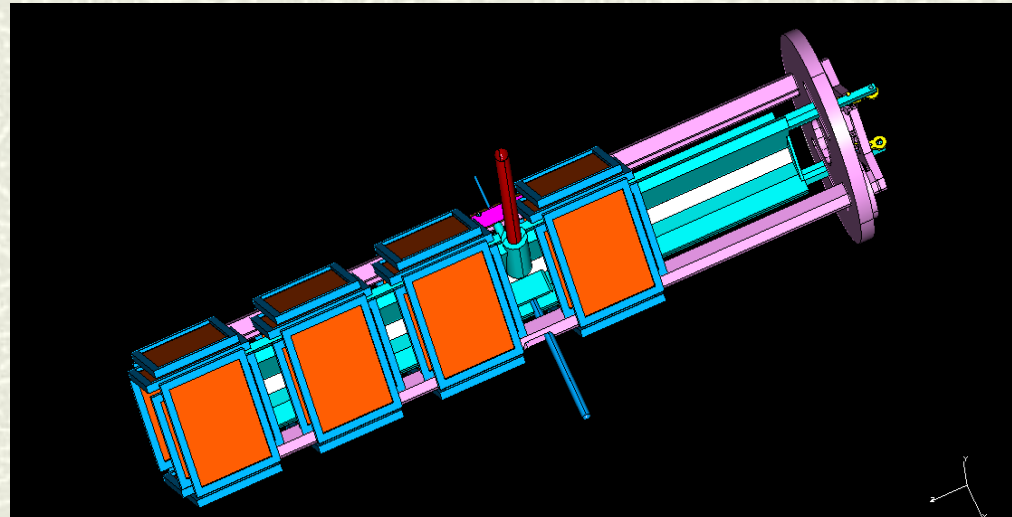
Performance of the new Vacuum System

	PIR 1 (mbar)	PIR 2 (mbar)	IG 1 (mbar)	IG 2 (mbar)	IG 3 (mbar)	IG 4 (mbar)	IG _{CT} (mbar)
base pressure	5×10^{-4}	1×10^{-3}	1.8×10^{-7}	3.9×10^{-8}	2.6×10^{-7}	4.5×10^{-7}	1.9×10^{-6}
H ₂ part. pressure with gas inlet (90 sccm H ₂)	2×10^{-2}	3×10^{-2}	3.6×10^{-4}	4.0×10^{-5}	1.9×10^{-6}	7.2×10^{-7}	9.6×10^{-6}
MW-dissociator running (H ₂ partial pressure)	2×10^{-2}	3×10^{-2}	4×10^{-4}	9.5×10^{-5}	2.7×10^{-6}	1.5×10^{-6}	1.2×10^{-4}

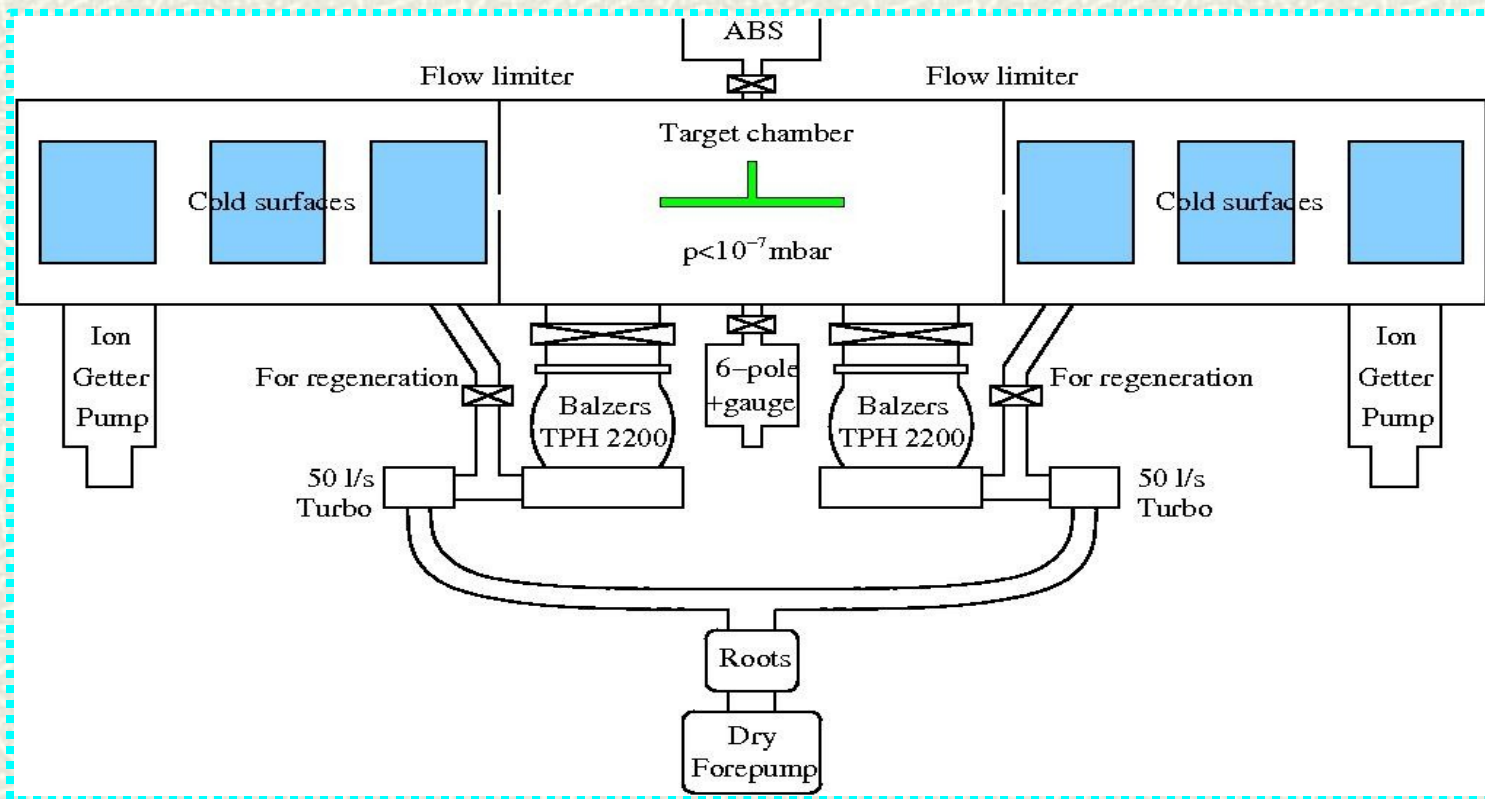
Sufficient pumping speed of new forevacuum system

Storage Cell and Holding field

- # Filtering requires 10^{15} atoms/cm² therefore use of storage cell
- # Use of Teflon foil to detect recoils and suppress depolarization and recombination
- # Openable cell to allow injected uncooled AD beam to pass
- # Weak holding field coils included in cell design to define spin axis
- # Pair of superconducting Helmholtz coils to provide a strong longitudinal holding field for separate determination of nuclear and electron effects during spin-filtering



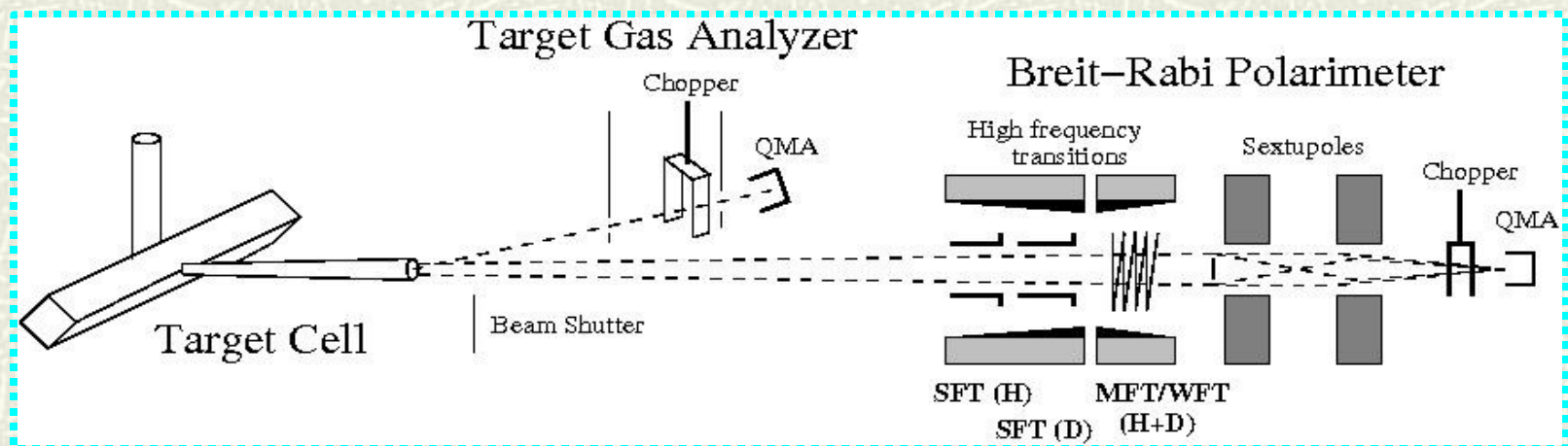
Beam Line Vacuum at the Target



- # Flow limiters to reduce gas flow into the adjacent sections
- # Pump with cold surfaces of the superconducting quadrupoles

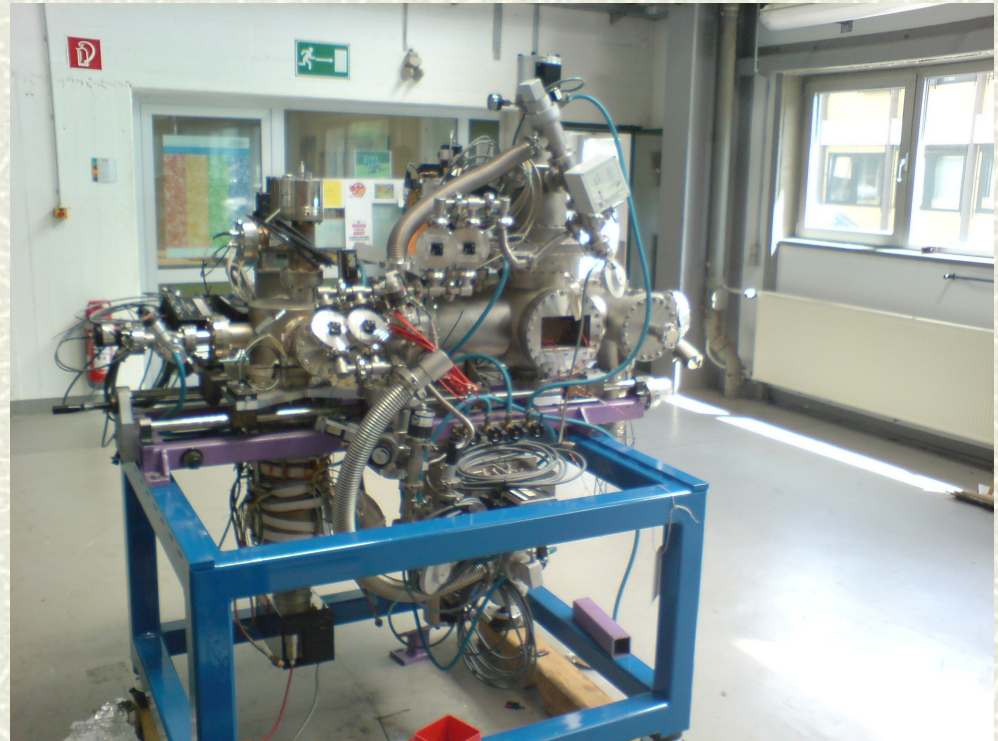
Polarization Analysis

- ❏ TGA is used to determine atomic fraction of the target gas
- ❏ BRP measures the polarization of the target gas atoms using combinations of high frequency transitions in ABS and BRP
- ❏ Calibration for **H and D** to measure both in a short time interval
- ❏ **Cross check** of the BRP measurement using **pp** ($p\bar{p}$) scattering with unpolarized **COSY** (AD) beam



Status of the Polarimeter

- ❏ Former HERMES BRP rebuilt on a new support with modifications due to new configuration with the ABS
- ❏ Tracking calculations lead to modified sextupole magnet configuration for 300 K effusive hydrogen / deuterium beam
- ❏ Next Step: New cabling and interlock system



Outlook

- # Measurements of the intensity and the degree of dissociation with the ABS this summer
 - # Testing of different dissociator setups if time allows
 - # Setup of the BRP with cabling and interlock
 - # Move of the setup to **COSY** hall January 2008
 - # Measurements with ABS, BRP and the storage cell in the analysis chamber in 2008
 - # Start of design and construction of the target chamber hopefully soon
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Summary

- # Polarized gas target meets the requirements for the filtering tests
 - # Ability to provide highly polarized **H and D** in short sequence
 - # Storage cell will increase density to the values needed but thin teflon wall will allow to detect recoils
 - # Change of spin direction can be achieved by switching the weak target holding field from vertical to longitudinal
 - # BRP will be able to measure the target polarization with required accuracy (calibration using pp ($\bar{p}p$) scattering)
 - # Target setup will be completed end of 2007, measurements starting in summer **2009** at **COSY** and **2010/11** at AD
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