Hydrogen Møller Polarimetry for Future Parity Violation Experiments

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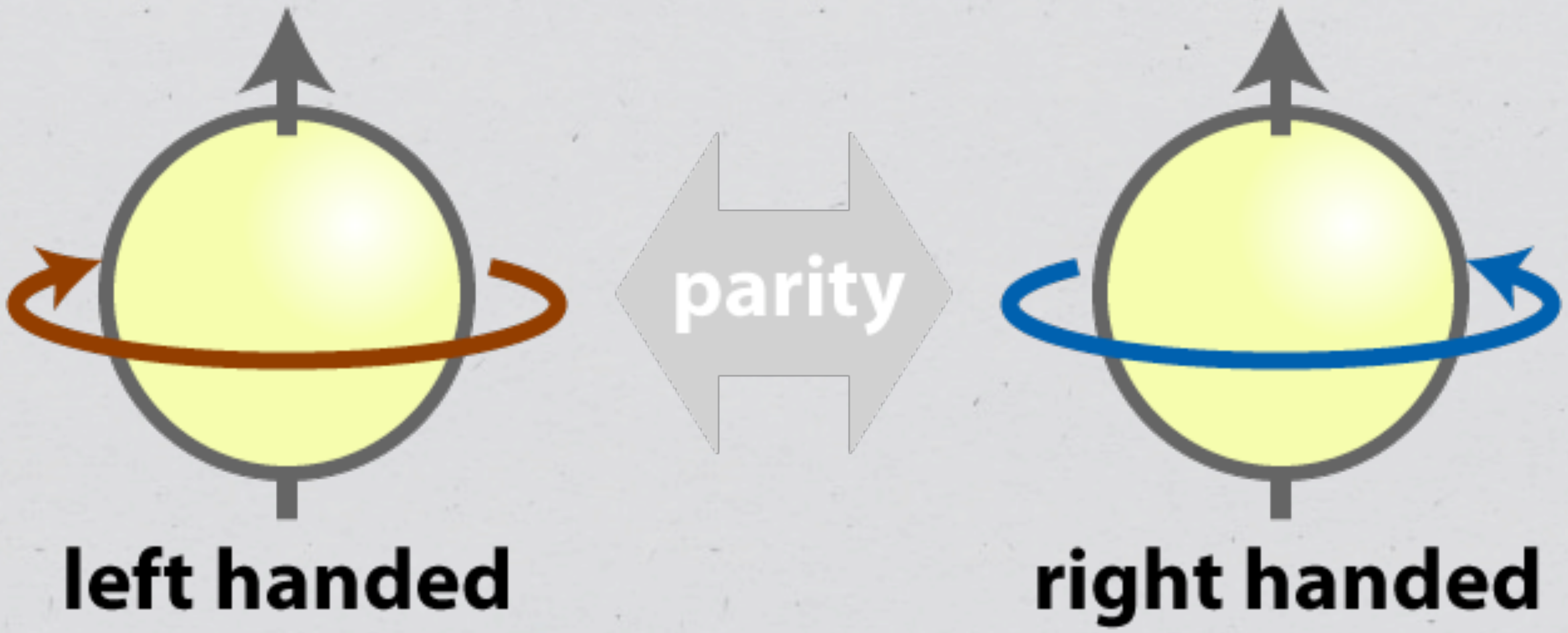
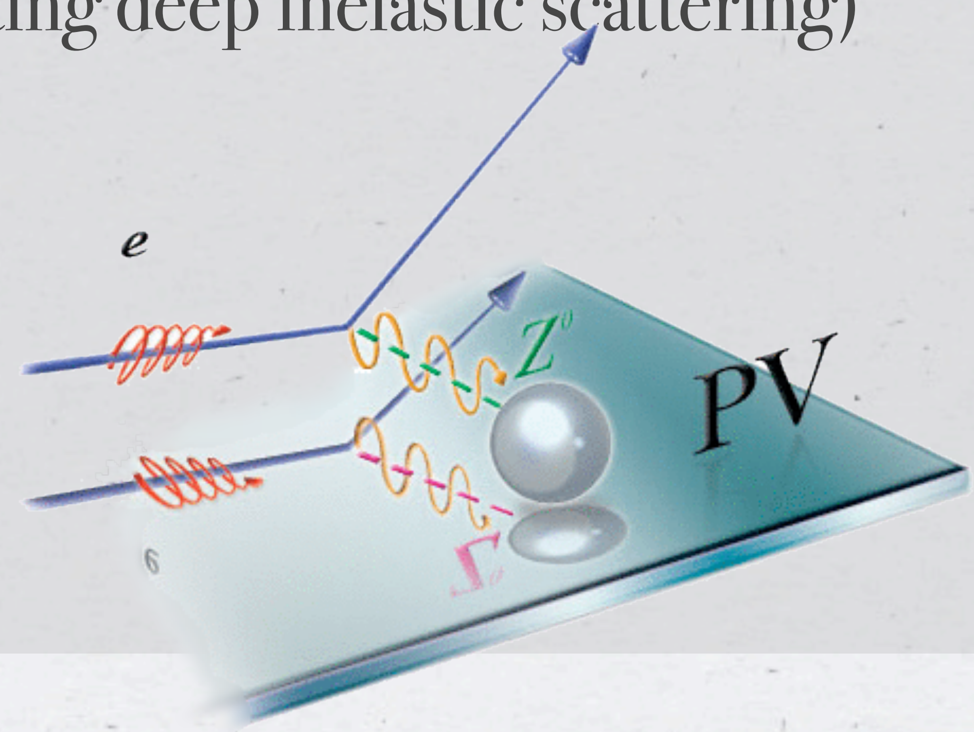
Parity Violating Electron Scattering

* Measuring parity violating quantities through the use of electron scattering (Qweak, MOLLER, SoLID)



Parity Violating Electron Scattering

* Measuring parity violating quantities through the use of electron scattering (Qweak, MOLLER, SoLID)
* Qweak just finished running - in analysis - looking for weak charge of proton - you hear about Qweak in the next talks
* Coming soon - MOLLER (looking for weak charge of electron) and SoLID (Parity violating deep inelastic scattering)



Parity Violating Electron Scattering

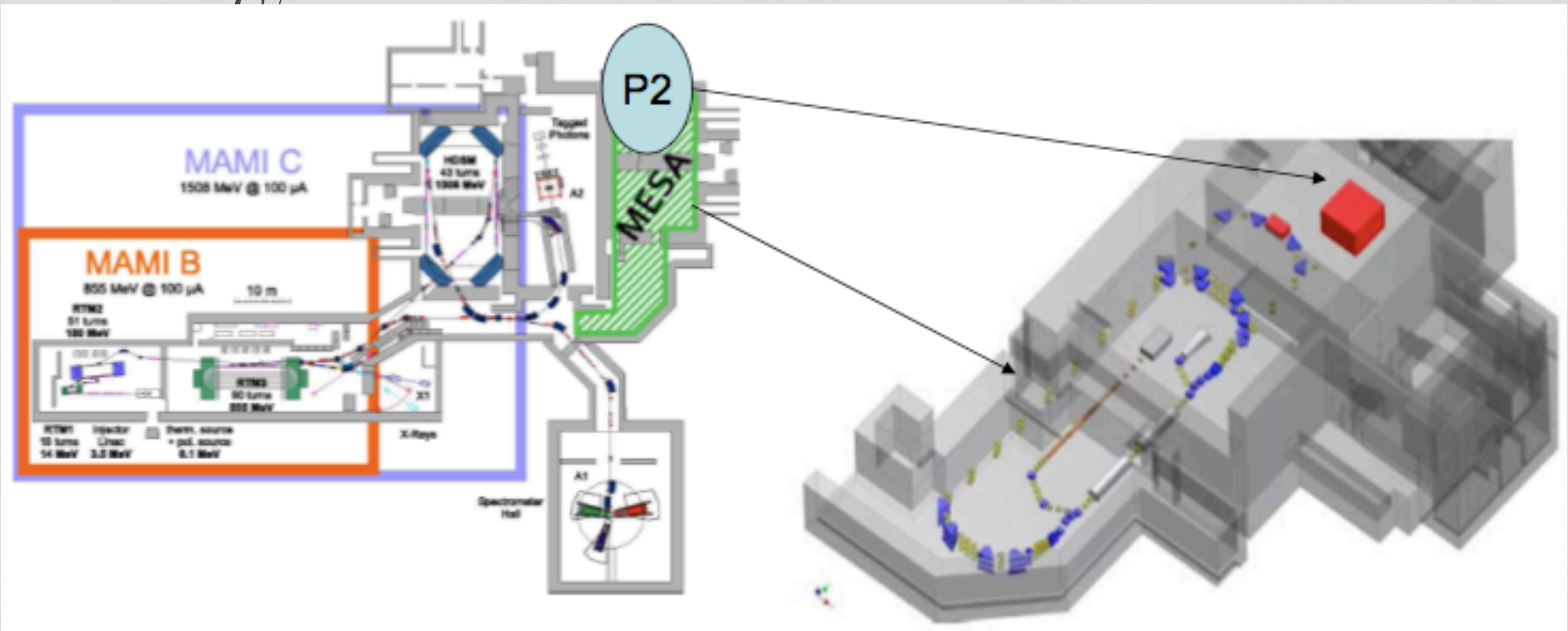
- Measuring parity violating quantities through the use of electron scattering (Qweak, MOLLER, SoLID)
- Qweak just finished running - in analysis - looking for weak charge of proton
- Coming soon - MOLLER (looking for weak charge of electron), PVDIS (Parity violating deep inelastic scattering), and P2
- In past experiments the polarization of the beam is one of the largest source of experimental systematic uncertainty
- Want to increase precision of the measurement of beam polarization

MOLLER Experiment

- Run after the 12 GeV upgrade at JLAB
- Looking for the weak charge of the electron
  - like QWEAK could signify physics beyond the standard model

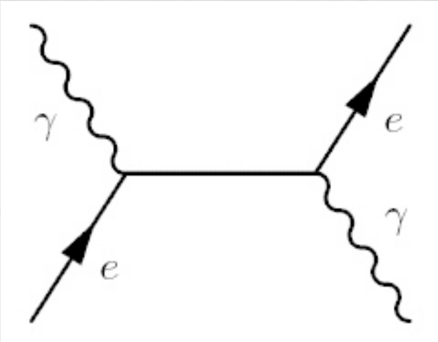
P2 Experiment in Mainz

- P2 like QWEAK but with improved statistics and systematics
- Low beam energy which will give a low γ - Z box graph contribution
- Lower energy transfer which means low form factor contribution



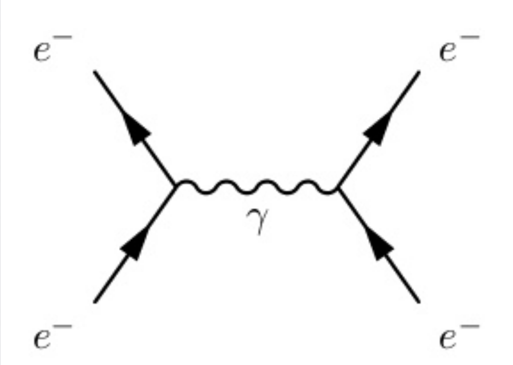
Measuring the Electron Beam Polarization

* Compton
  * Advantage: non-invasive, continuous



* Møller
  * Advantage: asymmetry well understood
  * Disadvantage: low current only, invasive, non-continuous, Levchuk effect, depolarization of Fe foil

* New technique: use Møller scattering from electrons of hydrogen atoms
  * Instead of using a ferromagnetic materials for Møller scattering use hydrogen gas



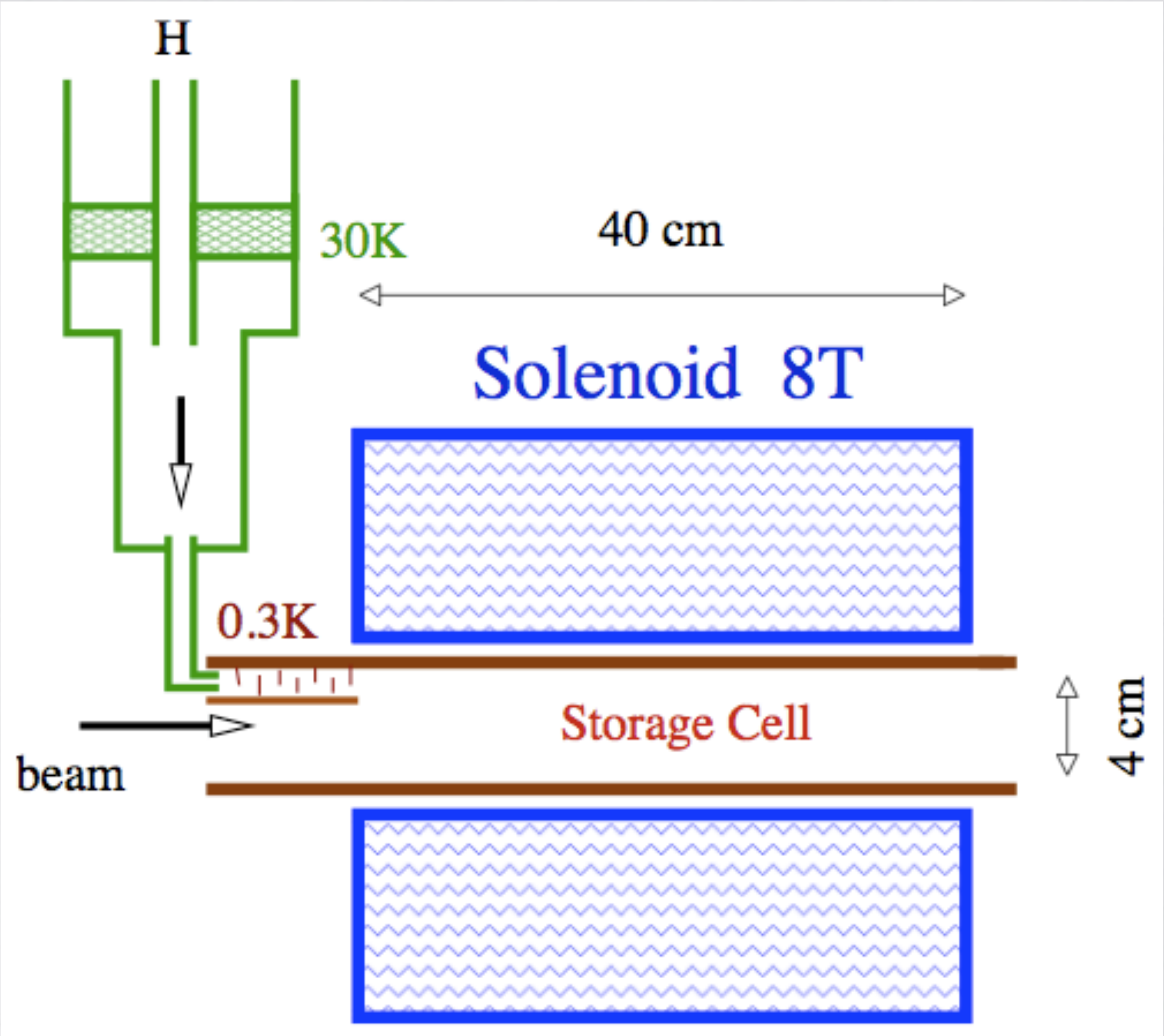
Møller Measurement Systematic Errors

Variable	Hall C Møller	Hydrogen Møller
Target Polarization	0.25%	0.01%
Analyzing Power	0.24%	0.10%
Levchuk Effect	0.30%	0.00%
Target Temperature	0.05%	0.00%
Others	0.10%	0.33%
Total	0.47%	~0.35 %

- Disclaimer: These are projected uncertainties from proposals

How does Hydrogen Møller Polarimetry work

- Low density cold hydrogen gas is put into the beam line
- Solenoid placed around the beam line, which will polarize the hydrogen atoms
- Beam comes into the H Møller target and interacts with the polarized electrons via Møller scattering



Apparatus design from University of Michigan

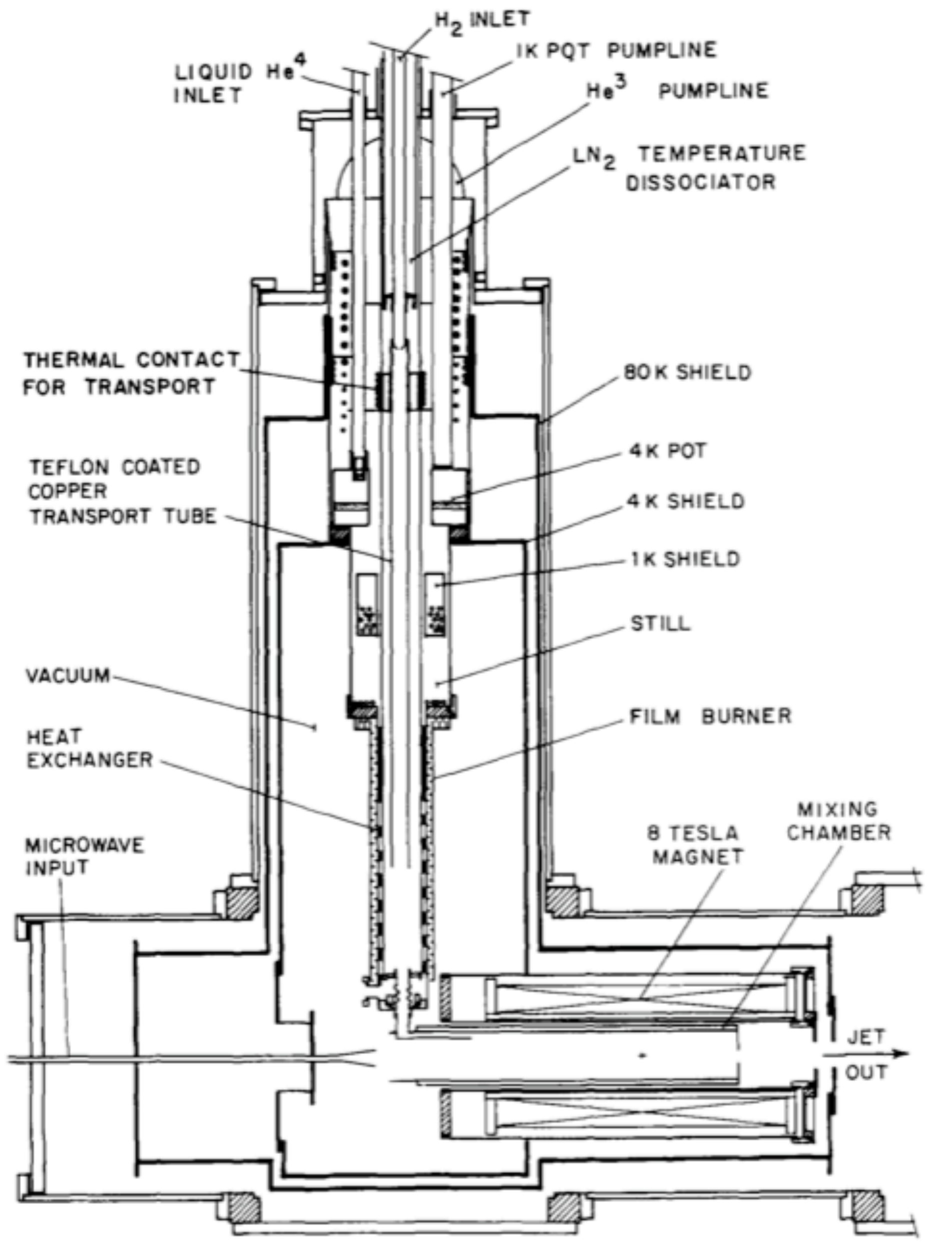
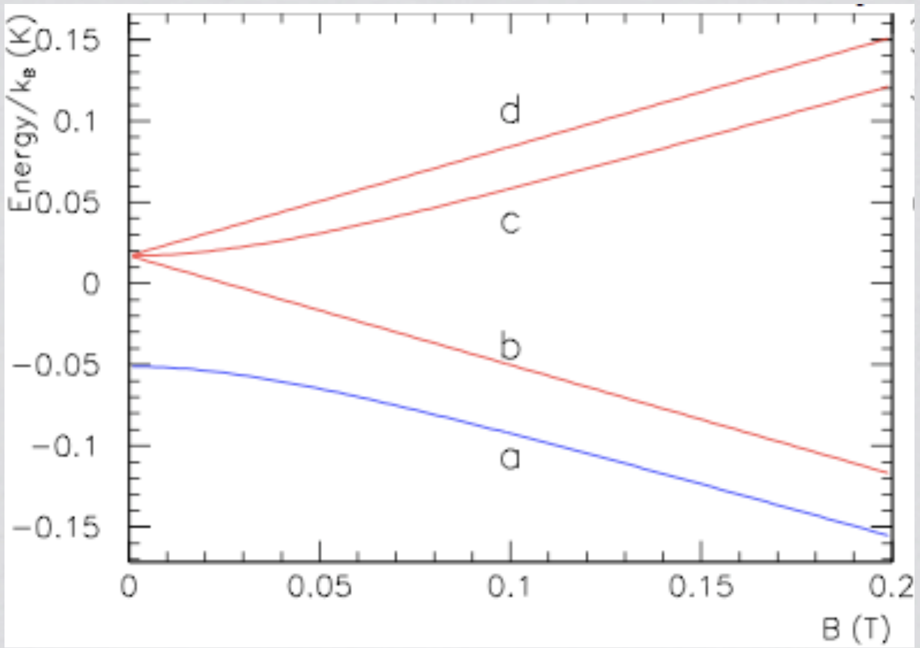
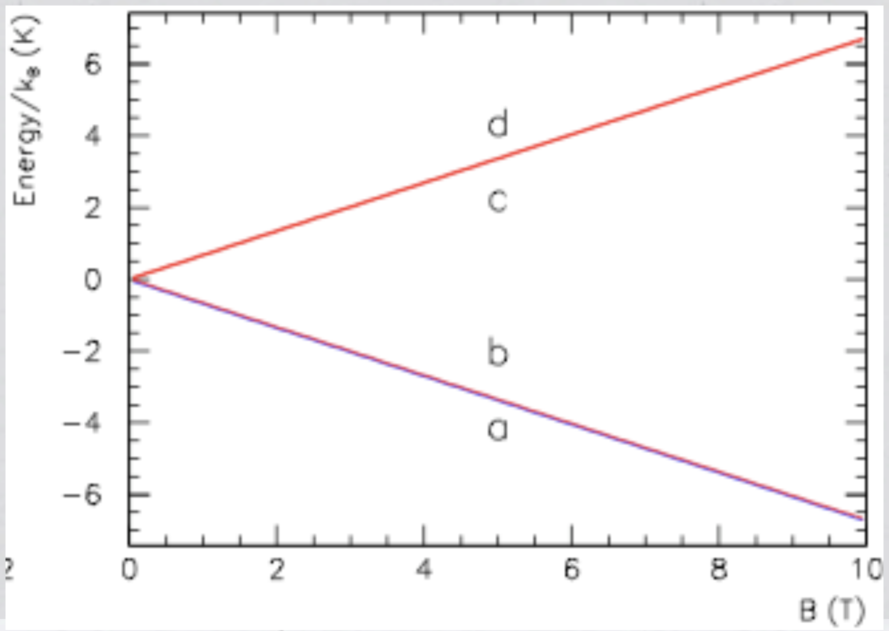


Fig. 4. Schematic diagram of the apparatus showing the vertical dilution refrigerator with the horizontal mixing chamber, the solenoid magnet, and the microwave and hydrogen feed.

Hydrogen States: 100% Polarization

- 4 states for splitting
  - $|a\rangle = \sin\theta|\uparrow_e\downarrow_p\rangle - \cos\theta|\downarrow_e\uparrow_p\rangle$
  - $|b\rangle = |\downarrow_e\downarrow_p\rangle$
  - $|c\rangle = \cos\theta|\uparrow_e\downarrow_p\rangle + \sin\theta|\downarrow_e\uparrow_p\rangle$
  - $|d\rangle = |\uparrow_e\uparrow_p\rangle$
  - where $\tan(2\theta) = \dfrac{0.05\mathrm{T}}{\mathrm{B}}$
- only states |a> and |b> are in strong magnetic field
- population of |c> and |d> = $e^{-\frac{2\mu_e B}{kT}} = 3\cdot 10^{-16}$



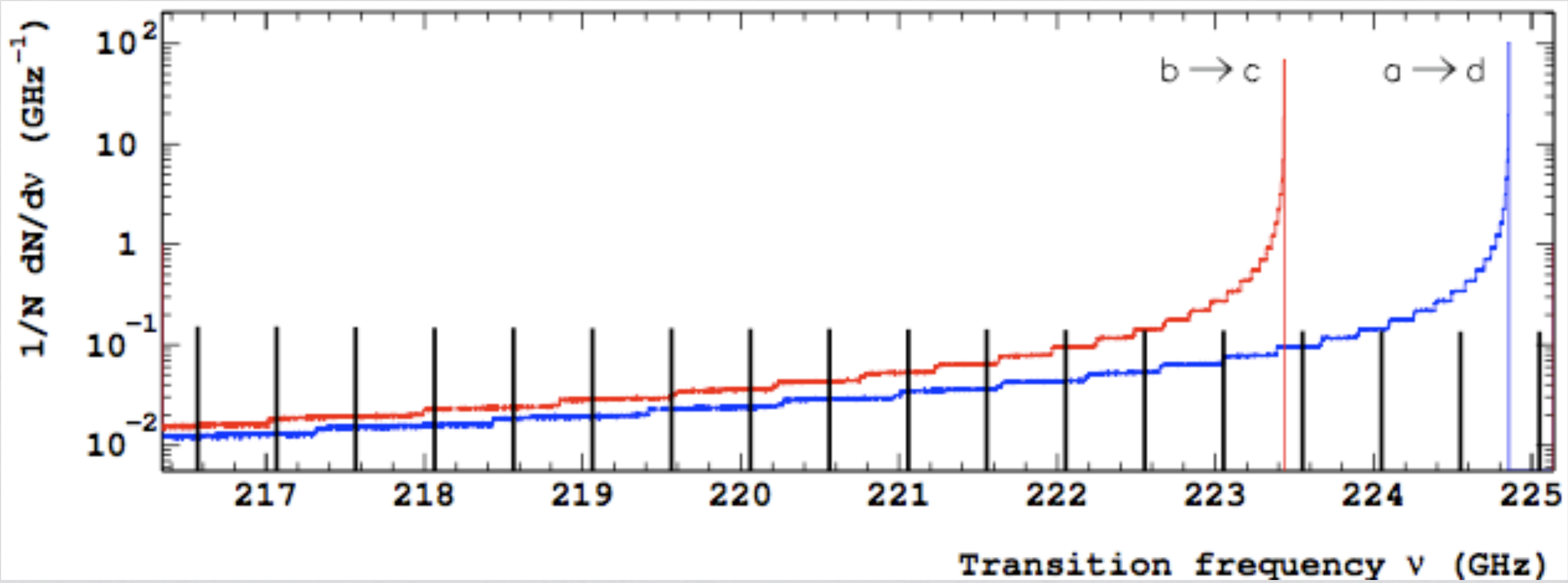


Advantages

- Non- invasive measurement of beam polarization
  - Leaving beam characteristics unchanged
- Hydrogen electron polarization is high (close to 100%)
- Decrease in dead-time -> reduction in systematic error
- No Levchuk effect

Systematic effects on the Hydrogen Gas

- Depolarization by electron beam
  - excited states (states |c> and |d>)
- Hydrogen molecules



Systematic effects on the Hydrogen Gas

- Hydrogen Ions
  - use an electric field to reduce this
- Helium and other residual gas

Work to be done

* Work on simulations
    * E and B field simulations
    * particle beam simulations
* Build and test apparatus

* Cell has been shipped from UVA to Mainz
    * plans to put it in the beam line
* Dilution refrigerator and the Magnet are at Mainz

Collaboration Team

- College of William and Mary
- Jefferson Lab
- Mainz
- University of Virginia

THE END