The Lineage of Nuclear Polarization Instrumentation Often Leads Through Madison

Sourcery, Targetry, and Polarimetry

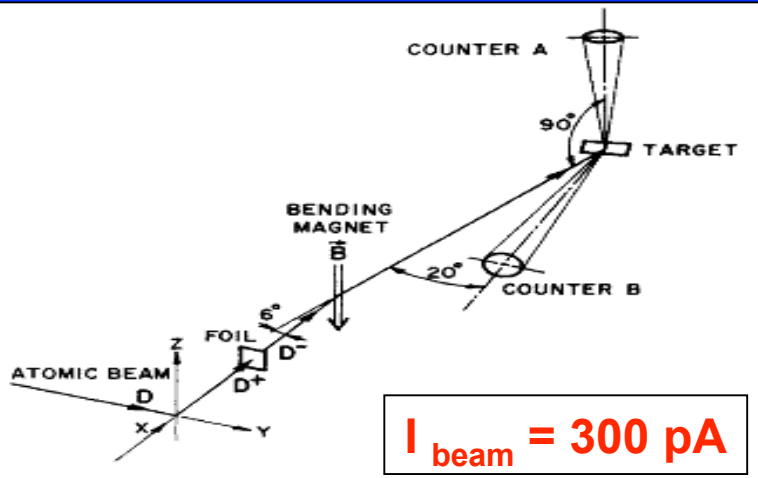
Thomas B. Clegg
University of North Carolina at Chapel Hill
and
Triangle Universities Nuclear Laboratory

Sourcery - 1964

First production of polarized H or D negative ions

PRODUCTION OF A BEAM OF POLARIZED NEGATIVE HYDROGEN IONS*

W. Gruebler, W. Haeberli, and P. Schwandt
University of Wisconsin, Madison, Wisconsin
(Received 27 April 1964)



I_{beam} = 300 pA

FIG. 1. Experimental arrangement which was used to measure the nuclear polarization of negative deuterium ions. The negative ions were produced by charge exchange of a beam of polarized deuterons in a thin foil.

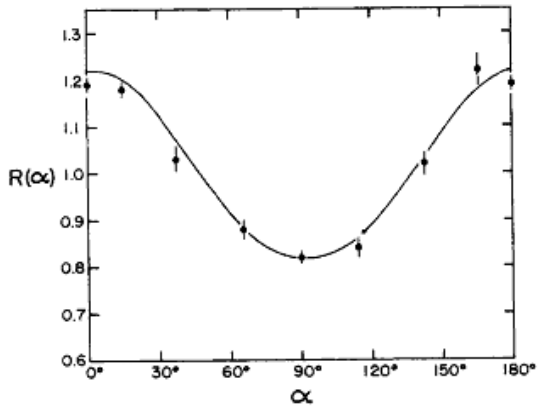


FIG. 2. The ratio R of counting rates in counter B and counter A, as a function of the angle α which the magnetic field in the ionization region makes with the x axis. The ratio R is normalized such that for an unpolarized beam $R = 1$. The errors are statistical only and do not include the uncertainty in the normalization factor.

Sourcery - 1965

First acceleration of polarized ions in tandem accelerator

VOLUME 15, NUMBER 6 PHYSICAL REVIEW LETTERS 9 AUGUST 1965

ACCELERATION OF POLARIZED PROTONS AND DEUTERONS IN A TANDEM ACCELERATOR*

W. Haeberli, W. Gruebler,† P. Extermann, and P. Schwandt

University of Wisconsin, Madison, Wisconsin

(Received 12 July 1965)

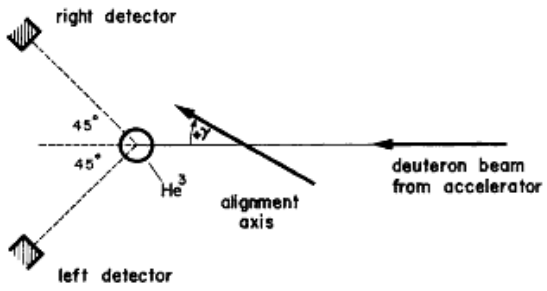


FIG. 1. Schematic diagram showing the target and the detectors. The alignment axis of the deuteron beam is in the reaction plane and makes an angle γ with the beam direction.

Polarization preserved with foil stripper

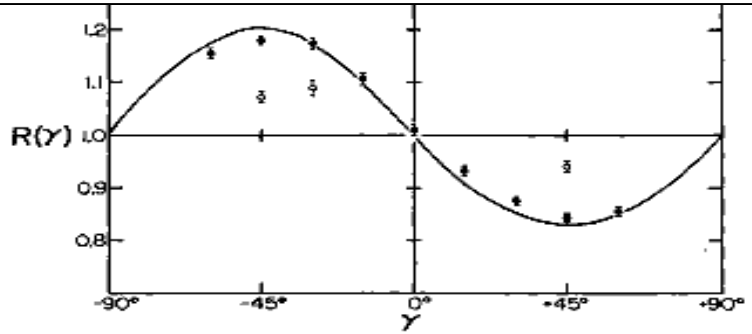


FIG. 2. The left–right ratio of counting rates as a function of the angle γ (see Fig. 1). The curve is calculated on the assumption that no depolarization takes place in the tandem accelerator. The open circles were measured with a gas stripper, the solid dots with a carbon foil stripper.

$I_{beam} \approx 10\text{-}20$ pA

$P_{beam} \approx 0.45$

Sourcery – 1967/8

First Lamb-shift polarized source installed on an accelerator
First purely vector- and tensor-polarized deuteron beams

DESCRIPTION OF A LAMB-SHIFT POLARIZED ION SOURCE INSTALLED ON A TANDEM ACCELERATOR*

T. B. CLEGG, G. R. PLATTNER, L. G. KELLER and W. HAEBERLI

University of Wisconsin, Madison, Wisconsin, U.S.A.

Received 8 September 1967

A source of polarized negative ions which uses the hydrogen metastable $2S_{\frac{1}{2}}$ state was constructed and installed on a tandem accelerator. Performance figures for proton and deuteron beams are given.

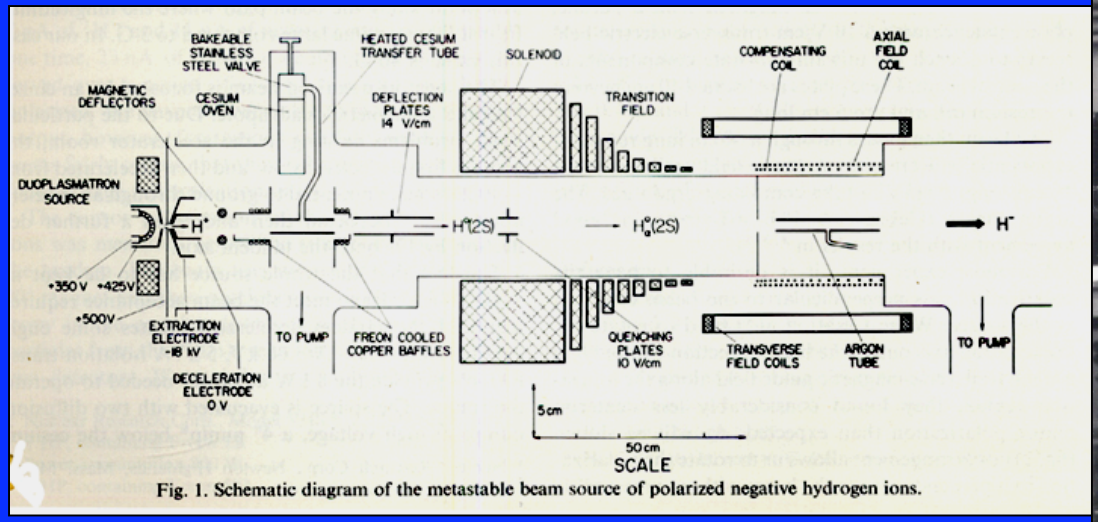
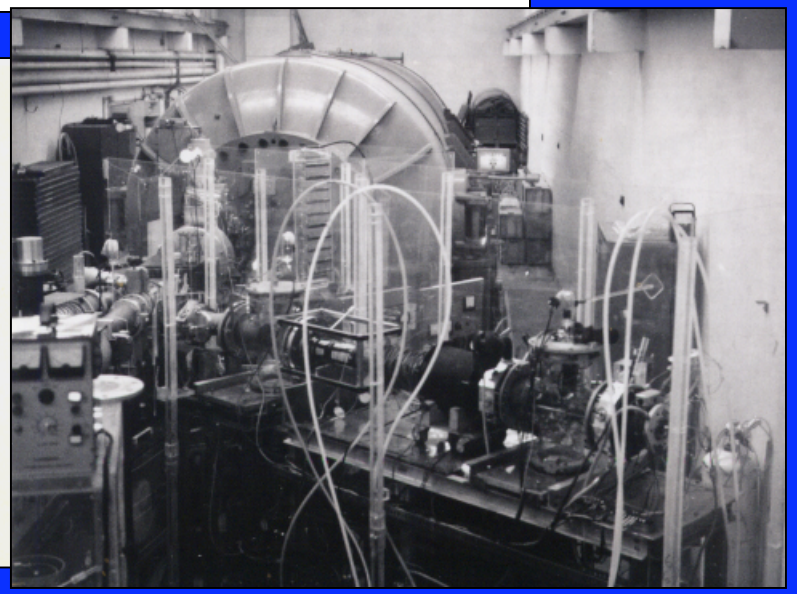


Fig. 1. Schematic diagram of the metastable beam source of polarized negative hydrogen ions.



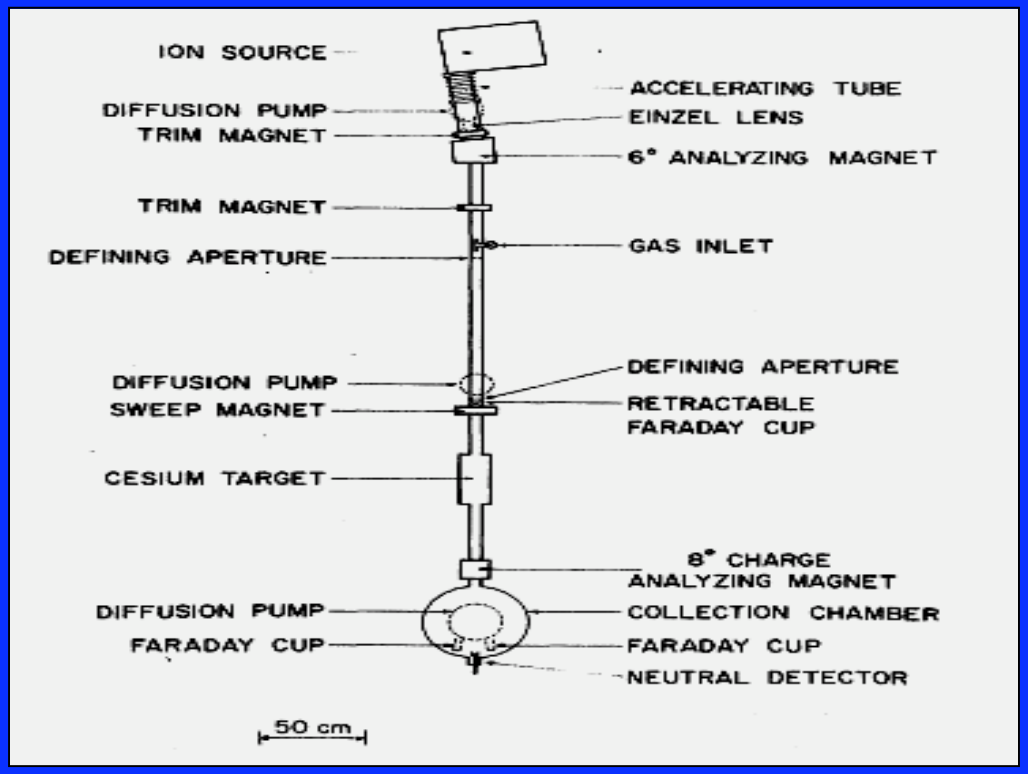
Sourcery - 1968

Begins long association with Wilmer Anderson *et al.*

PHYSICAL REVIEW VOLUME 177, NUMBER 1 5 JANUARY 1969

Charge-Exchange Collisions Between Hydrogen Ions and Cesium Vapor in the Energy Range 0.5-20 keV*

A. S. Schlachter, P. J. Bjorkholm, D. H. Loyd, L. W. Anderson, and W. Haeberli
University of Wisconsin, Madison, Wisconsin
(Received 1 July 1968)



Targetry - 1968

First spin correlation measurement with polarized beam & target

MEASUREMENT OF SPIN-CORRELATION EFFECTS IN p-^{3}He ELASTIC SCATTERING AT 8.8 MeV

D. H. McSHERRY and S. D. BAKER
Rice University, Houston, Texas
and
G. R. PLATTNER and T. B. CLEGG †
University of Wisconsin, Madison, Wisconsin ††

Received 25 November 1968

$P_{target} \approx 0.1$

$I_{beam} \approx 0.5$ nA

Two points in 48 hours!

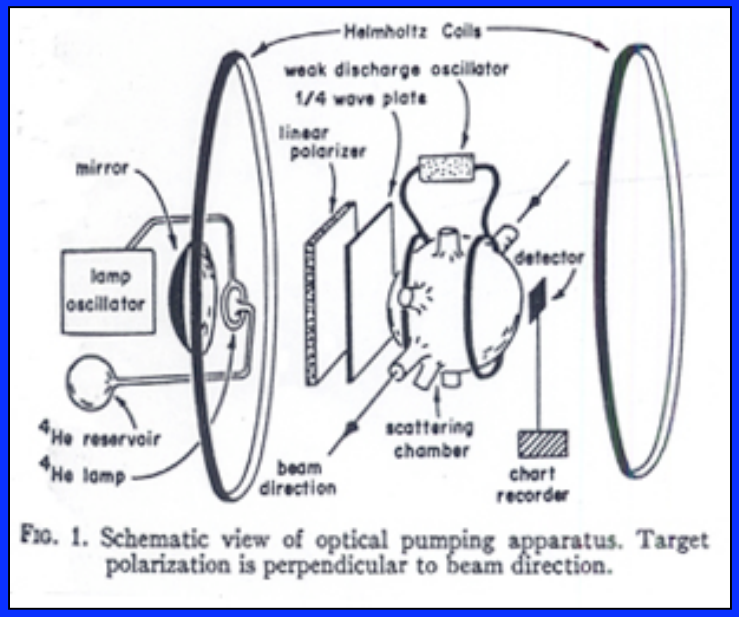
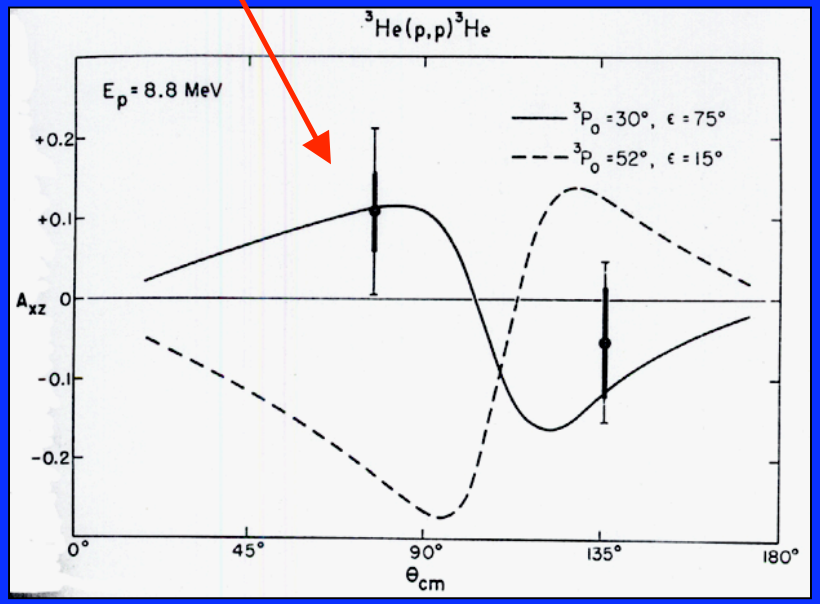


FIG. 1. Schematic view of optical pumping apparatus. Target polarization is perpendicular to beam direction.



A_{xz}

—cm

Polarimetry – 1968-71

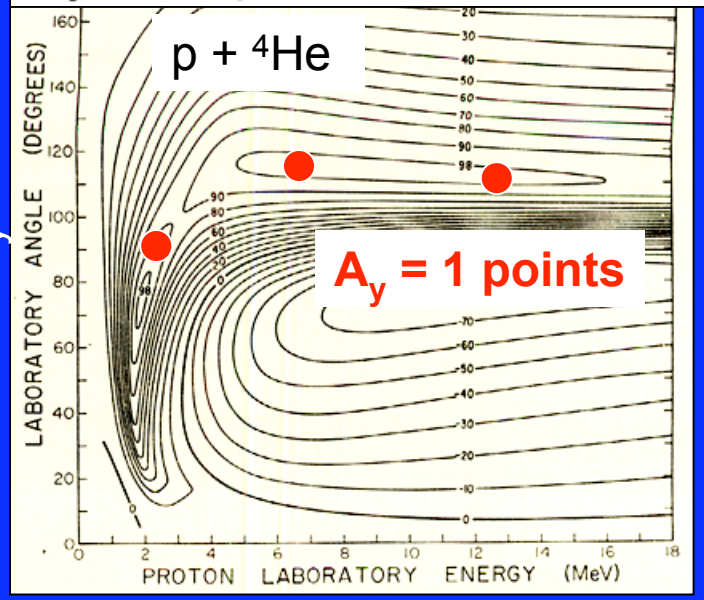
First absolute calibration method for spin-1/2 particle polarization

ABSOLUTE CALIBRATION OF SPIN-½ POLARIZATION

G. R. PLATTNER
Physics Department, University of Basel, Basel, Switzerland
and
A. D. BACHER ‡
Lawrence Radiation Laboratory, Berkeley 94704, *USA*

Received 16 July 1971

It is shown that the polarization $P(\theta,E)$ of spin-½ particles scattered from particles without spin must reach the value $|P| = 1$ at some point (θ_1, E_1), if the scattering amplitudes fullfill certain conditions at two other energies $E_0 < E_1$ and $E_2 > E_1$. As examples, nucleon-^{4}He and ^{3}He-^{4}He elastic scattering are investigated in this respect.



A_y

Proton Lab Energy

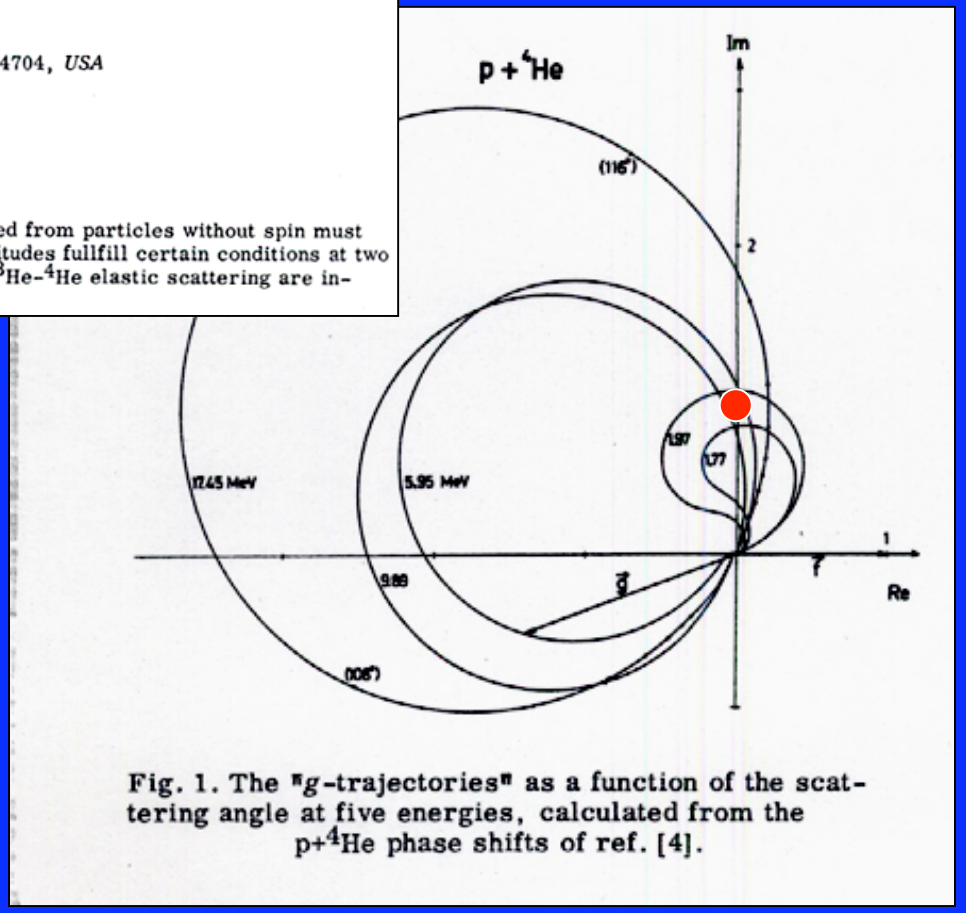


Fig. 1. The "g-trajectories" as a function of the scattering angle at five energies, calculated from the p+^{4}He phase shifts of ref. [4].

Sourcery - 1978

First ionization of polarized atoms with a cesium beam

VOLUME 40, NUMBER 19 PHYSICAL REVIEW LETTERS 8 MAY 1978

Production of Polarized H^- or D^- Ions by a Colliding-Beam Method

D. Hennies, R. S. Raymond, L. W. Anderson, and W. Haeberli
Department of Physics, University of Wisconsin, Madison, Wisconsin 53706

and

H. F. Glavish
ANAC Incorporated, Santa Clara, California 95050

(Received 16 February 1978)

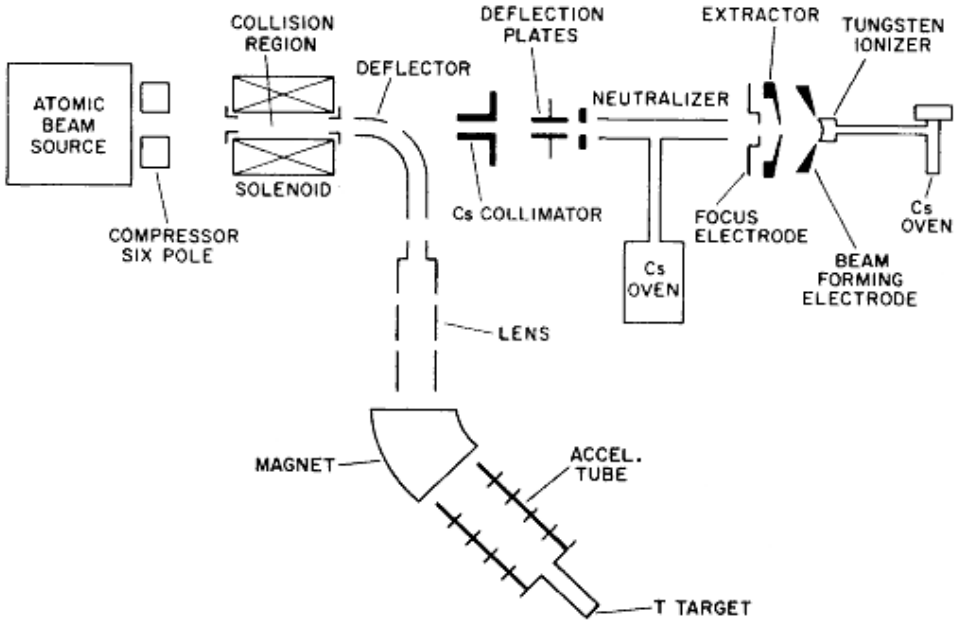


FIG. 1. Schematic diagram of the experimental arrangement.

$I_{beam} \approx 3\_A$

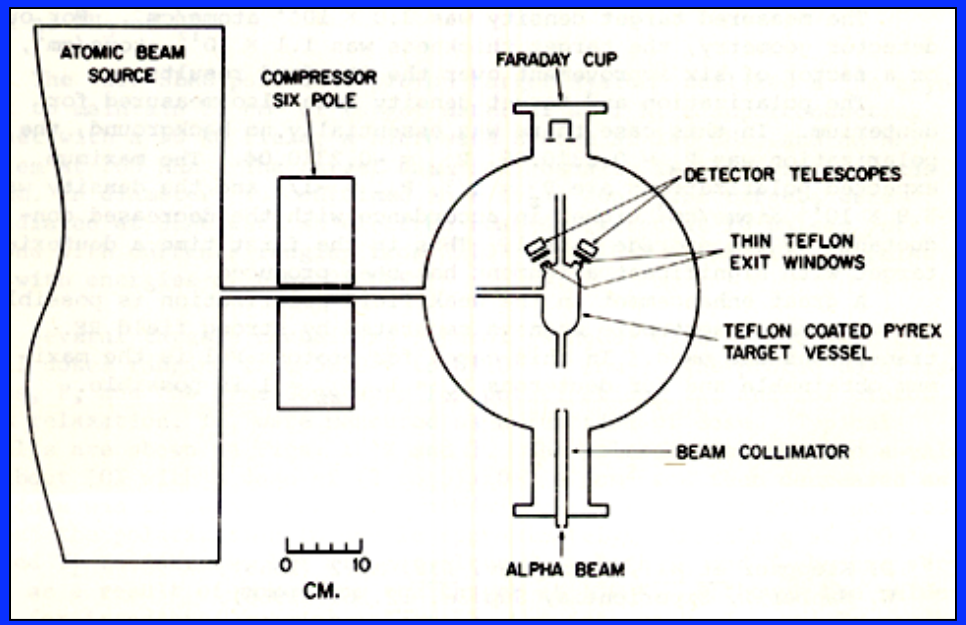
$P_{beam} \approx 0.89$!!

Targetry - 1980

First test of teflon-coated target cell for stored polarized atoms

A TARGET OF POLARIZED HYDROGEN
BY STORAGE OF ATOMS IN
A COATED PYREX VESSEL

M.D. Barker, G. Caskey, C.A. Gossett, W. Haeberli
D.G. Mavis, P.A. Quin, S. Riedhauser, J. Sowinski
and J. Ulbricht
University of Wisconsin, Madison, WI. 53706†



Some target atom polarization was maintained after ~900 wall collisions

Targetry - 1992

Proved that storage cell target was compatible with the IUCF Cooler Ring and that p + p scattering measurements are possible with such a target.

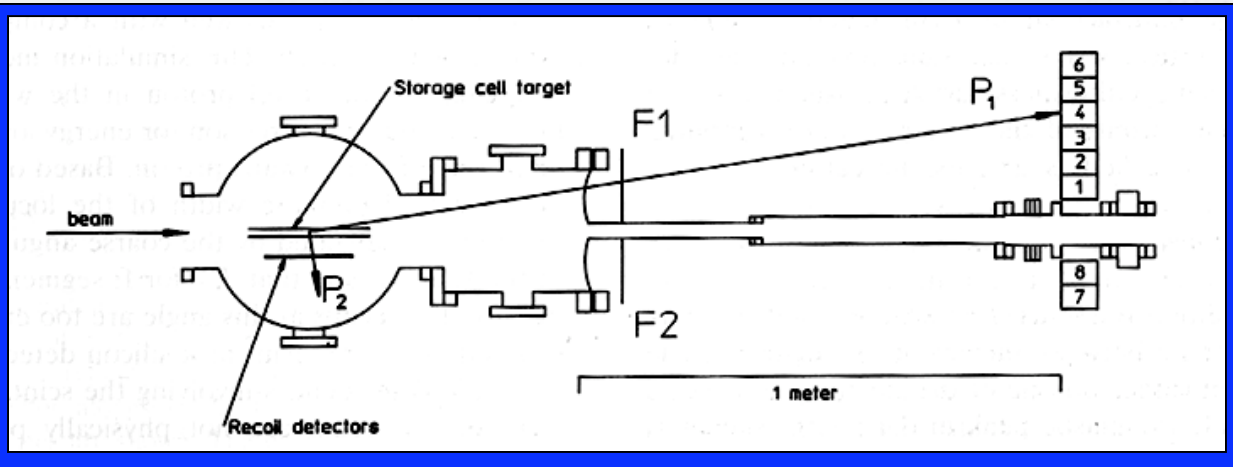
Test of a windowless storage cell target in a proton storage ring

M.A. Ross, W.K. Pitts [1], and W. Haeberli
Department of Physics, University of Wisconsin, Madison WI 53706, USA

H.O. Meyer, S.F. Pate [2], R.E. Pollock, B. von Przewoski, T. Rinckel, J. Sowinski and F. Sperisen
Indiana University and Indiana University Cyclotron Facility, Bloomington, IN 47405, USA

P.V. Pancella
Western Michigan University, Kalamazoo, MI 49008, USA

Received 30 June 1992 and in revised form 19 October 1992



Targetry - 1992

First measurement of polarization of ions extracted from a target

Polarization measurement for polarized gas targets *

J.S. Price and W. Haeberli

University of Wisconsin, Madison, WI 53706, USA

Received 8 September 1992

Recently proposed experiments with polarized gas targets in storage rings require methods
an accuracy of a few percent or better. The task is made more difficult because the target a
target cell to increase the target thickness available from atomic beam sources or optically
extract ions formed in the cell by the charged particle beam, and to measure their polarizati
advantage of this method is that the average target polarization is determined independent
polarization. The proposed method was applied to a deuterium gas target, whose tensor polar
^{3}H(d, n)^{4}He reaction. We show that uniform ion extraction can be achieved for a cell with a l
that the deuterons in molecules formed by recombination of polarized deuterium atoms are
target polarization measurements must include measurements on molecules as well as atoms.
to measure the polarization of H and D targets, as well as atomic methods to measure the p

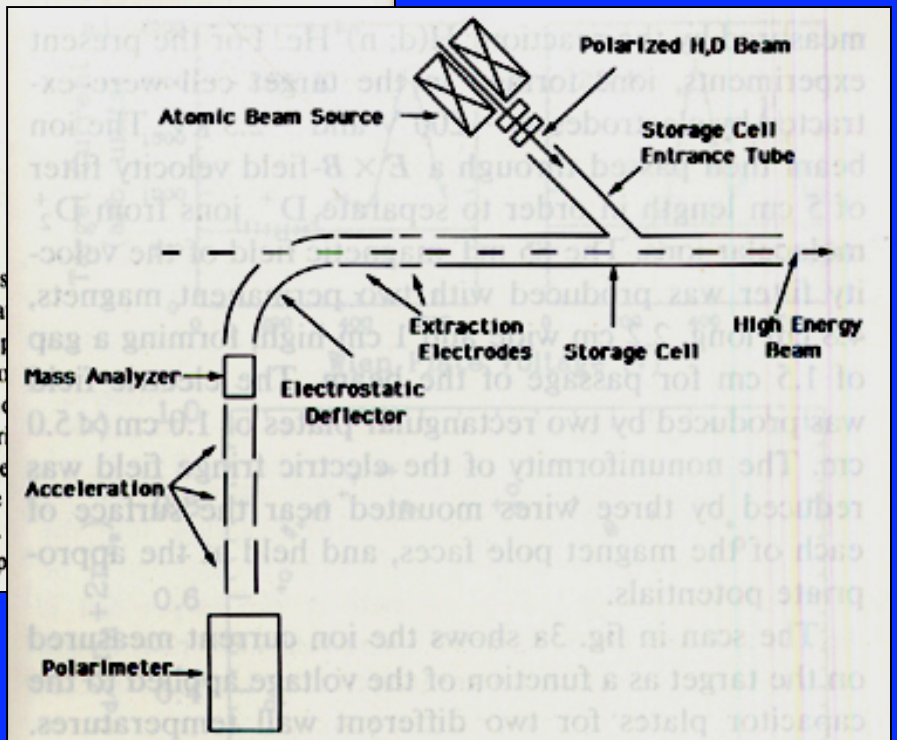


Fig. 1. Schematic diagram of polarimeter. Polarized gas target atoms are ionized in the target cell by a charged particle beam passing through the target, and are extracted using cylindrical electrodes. Ions are brought out of the beam line and pass through a mass analyzer to separate atomic and molecular ions. The selected ions are accelerated before entry into the polarimeter.

Showed that deuterons
in extracted
molecular ions are almost
completely unpolarized.

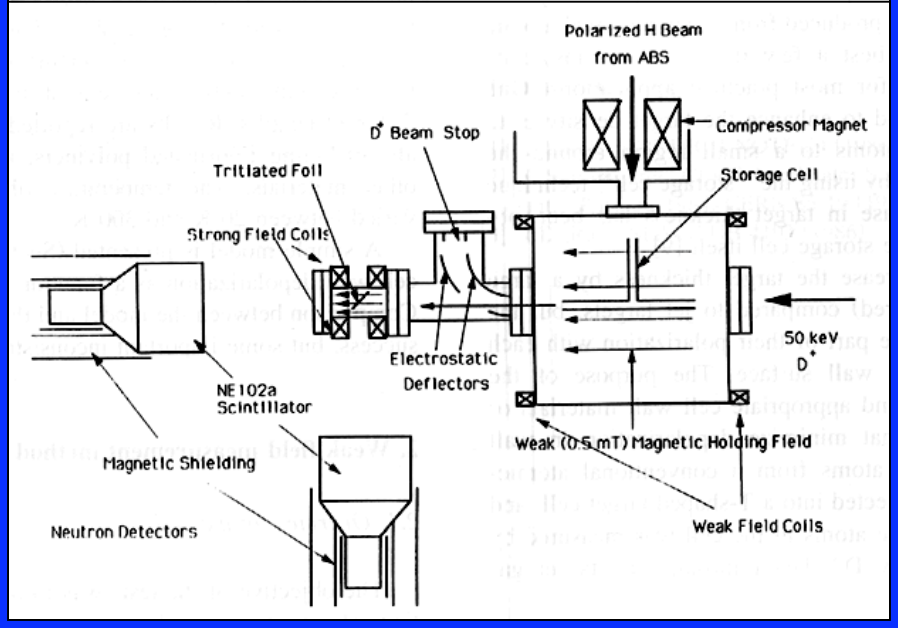
Targetry – 1993-4

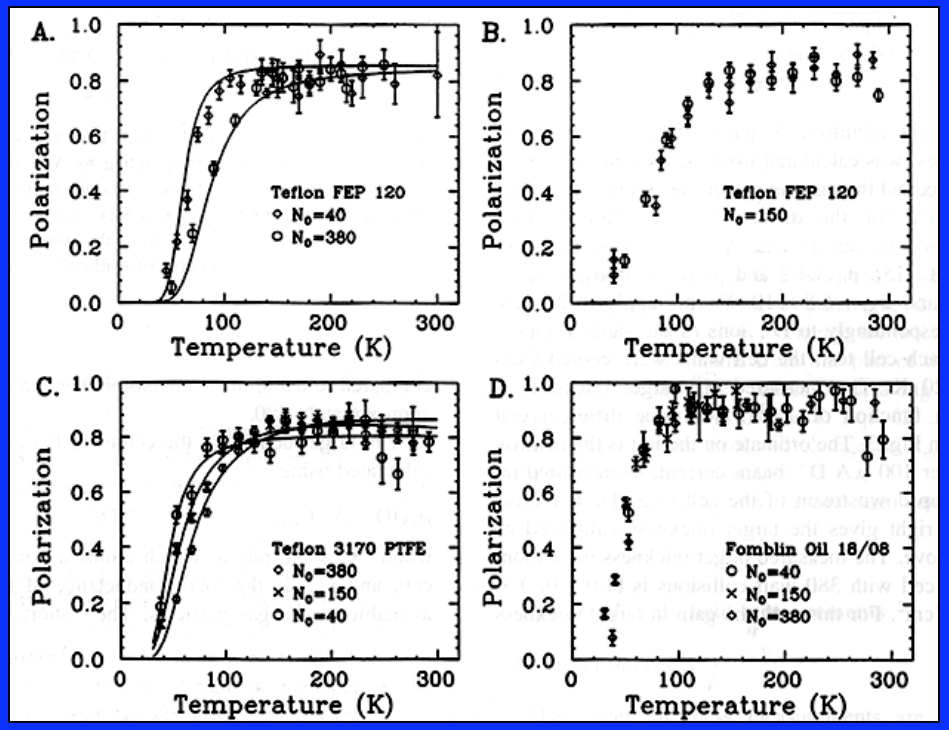
First detailed studies of depolarization of stored atoms on various wall surfaces over a range of temperatures

Measurement of cell wall depolarization of polarized hydrogen gas targets in a weak magnetic field ☆

J.S. Price *,[1], W. Haeberli
University of Wisconsin, Madison, WI 53706, USA

Received 24 May 1994





Targetry – 1993

First test of polarization of atoms in a prototype of the Indiana Cyclotron Facility Cooler Ring polarized target

Polarization Measurements of a Storage Cell Target

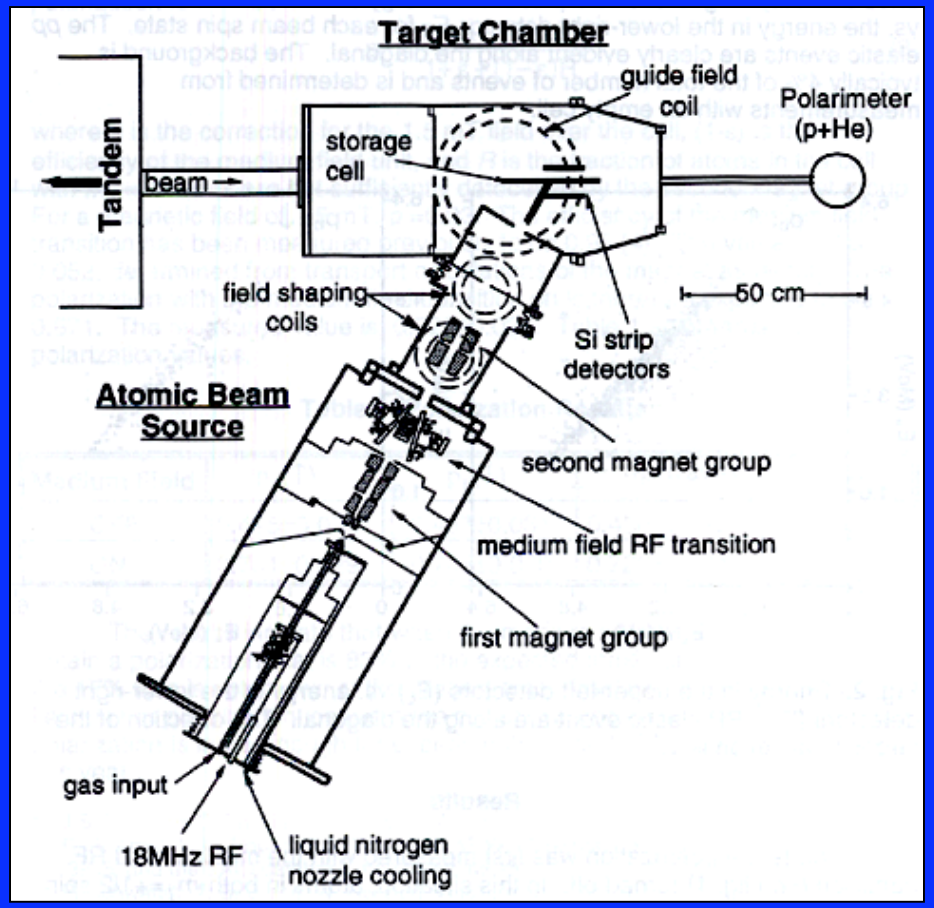
M. A. Ross, A. D. Roberts, T. Wise, W. Haeberli
University of Wisconsin
W. A. DeZarn, J. Doskow, H. O. Meyer, R. E. Pollock, B. v. Przewoski, T. Rinckel, F. Sperisen
Indiana University Cyclotron Facility
P. V. Pancella
Western Michigan University

Abstract

A storage cell has been constructed for use as an internal target at the IUCF electron-cooled storage ring (Cooler). We report on nuclear polarization measurements of hydrogen, produced by an atomic beam source (ABS), in this storage cell. The results indicate a target polarization in excess of 0.70 for atoms in a single spin state.

Polarization measured by p + p scattering at 7.6 MeV.

P_{target} > 70% of P_{max}



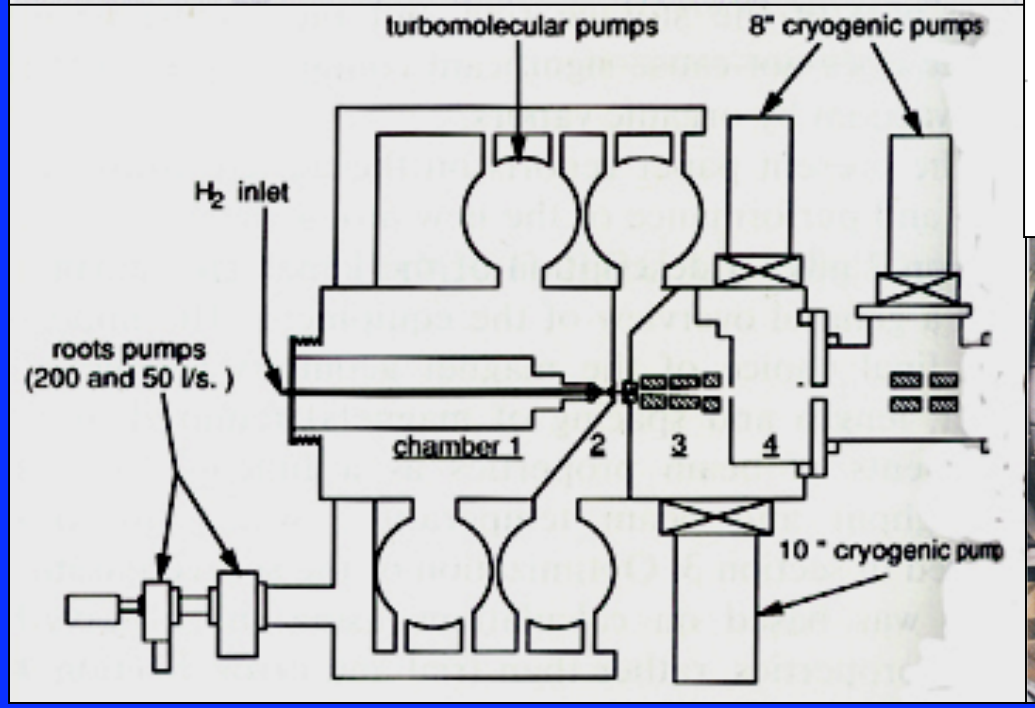
Sourcery ~ 1991-93

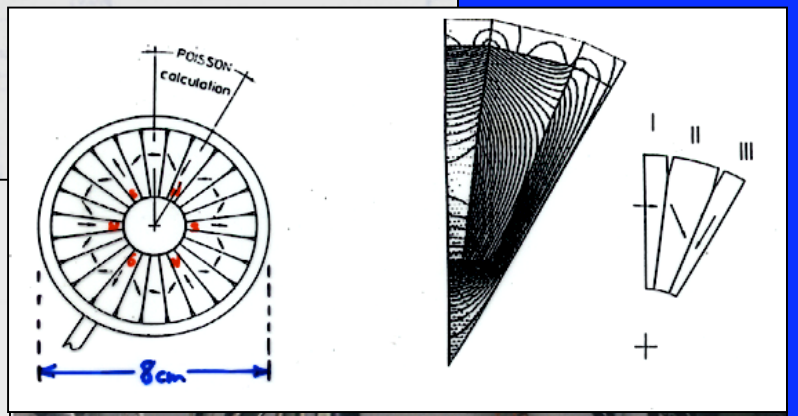
Developed an optimized atomic beam source with permanent magnet sextupole systems

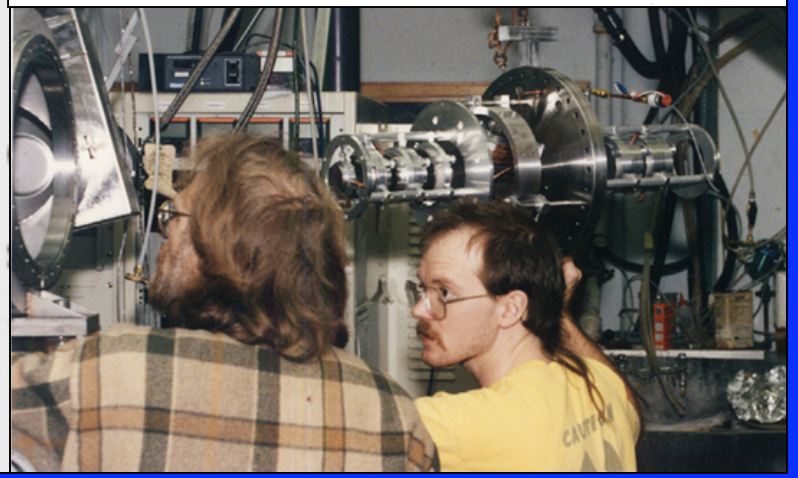
A high-brightness source for polarized atomic hydrogen and deuterium

T. Wise, A.D. Roberts and W. Haeberli
University of Wisconsin, Madison WI 53706, USA

Received 28 June 1993







Targetry ~ 1989-95

Scattering from stored polarized atoms in a storage ring

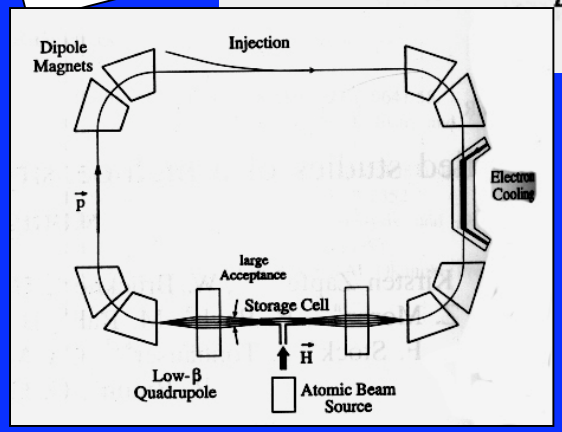
Detailed studies of a high-density polarized hydrogen gas target for storage rings

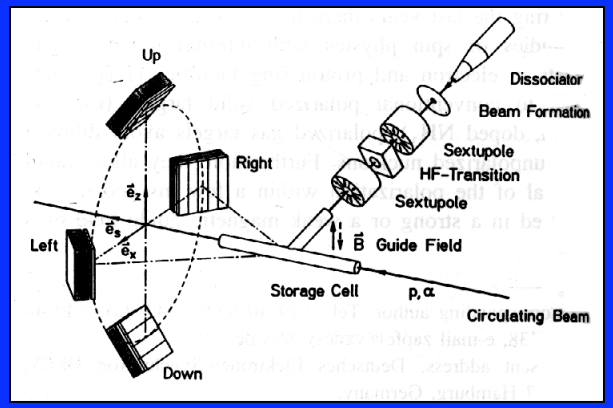
Kirsten Zapfe[a,*,1], W. Brückner[a], H.-G. Gaul[a,2], M. Grieser[a], M.T. Lin[a,3], [a,4], B. Povh[a], M. Rall[a], B. Stechert[a], E. Steffens[a,5], J. Stenger[a,5], k[a], J. Tonhäuser[a,2], Ch. Montag[b,1], F. Rathmann[b,6], D. Fick[b], B. Braun[c], G. Graw[c], W. Haeberli[d]

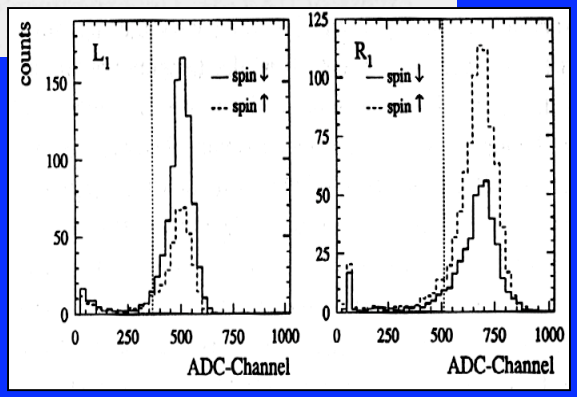
[a]*Max-Planck-Institut für Kernphysik, D-69117 Heidelberg, Germany*
[b]*Fachbereich Physik der Philipps-Universität, D-35032 Marburg, Germany*
[c]*Sektion Physik der Universität München, D-85748 Garching, Germany*
[d]*Department of Physics, University of Wisconsin, Madison, WI 53706, USA*

Received 24 May 1995

FILTEX Source at Heidelberg

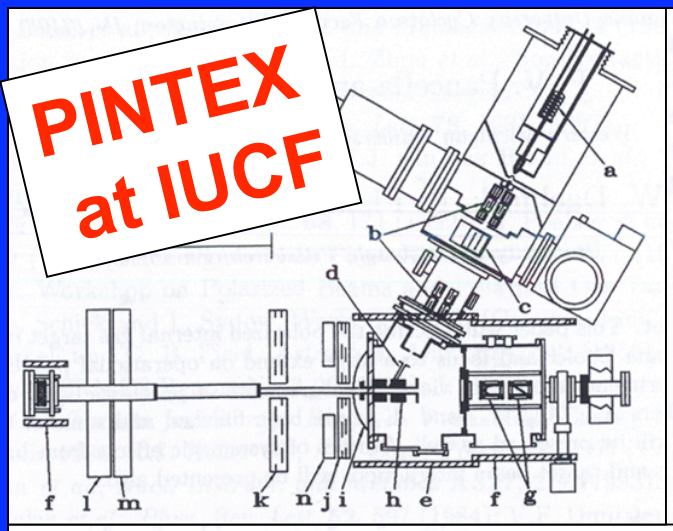






Targetry ~ 1992-98

PINTEX at IUCF



The Wisconsin-IUCF Polarized Gas Target

Frank Rathmann[1], W. Haeberli, B. Lorentz, P. Quin, B. Schwartz, and T. Wise

University of Wisconsin-Madison, Madison, WI 53706, USA

H. O. Meyer, R. E. Pollock, J. Doskow, M. Dzemdzic, J. H. Hardie, B. v. Przewoski, T. Rinckel, F. Sperisen, and M. Wolanski

Indiana University Cyclotron Facility, Bloomington, IN 47408, USA

nd P .B. Ugorowski

ity, Kalamazoo, MI 49008, USA

mmang, and D. Tedeschi

, Pittsburgh, PA 15260, USA

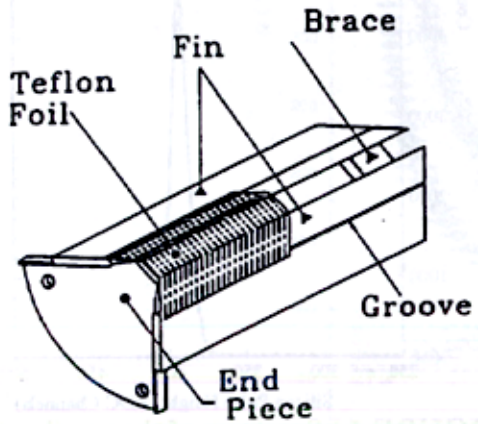


FIGURE 2. One quadrant of the storage cell target. Thin teflon foil is stretched over fins and held in place by a wire pressing into a groove.

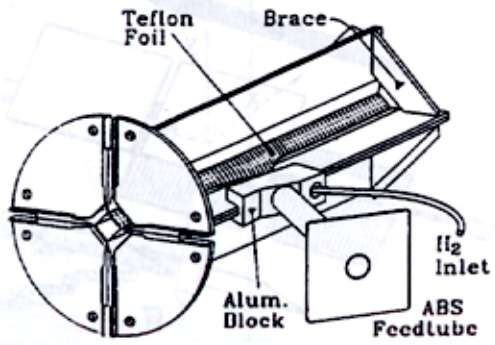


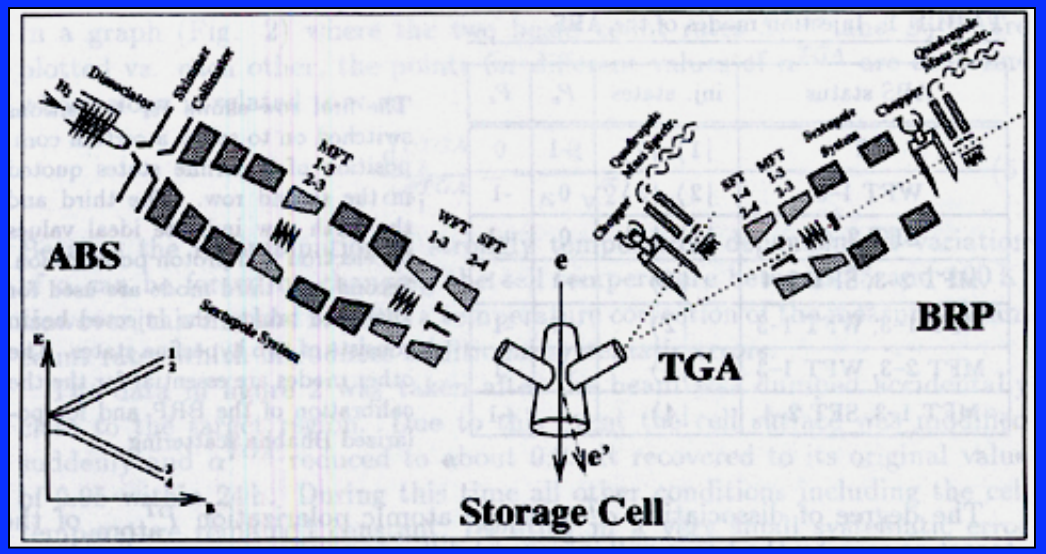
FIGURE 3. Fully assembled storage cell with feed tube for the atomic beam and unpolarized inlet for H_2 or other gases.

he polarized internal gas target installed in
rge extend on operational properties from
easurements of *pp* elastic spin correlation
have been finished and some of the recent
dies of systematic effects from background
s will be presented also.

Targetry ~ 1993-2005

Internal storage cell target enabled first measurements of nucleon's internal spin structure

HERMES Collaboration at DESY



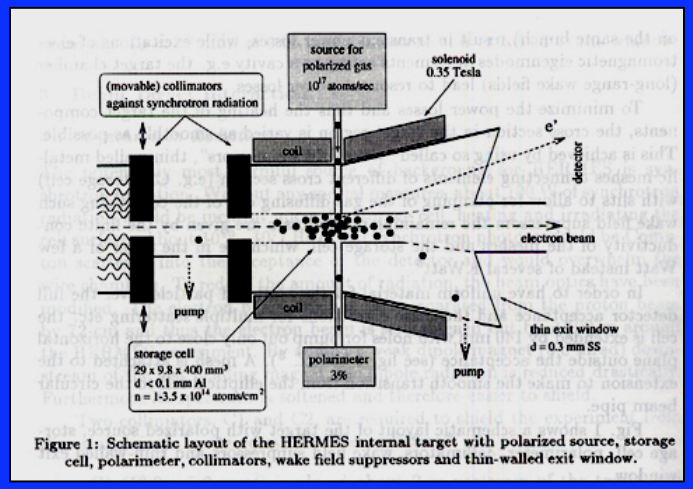
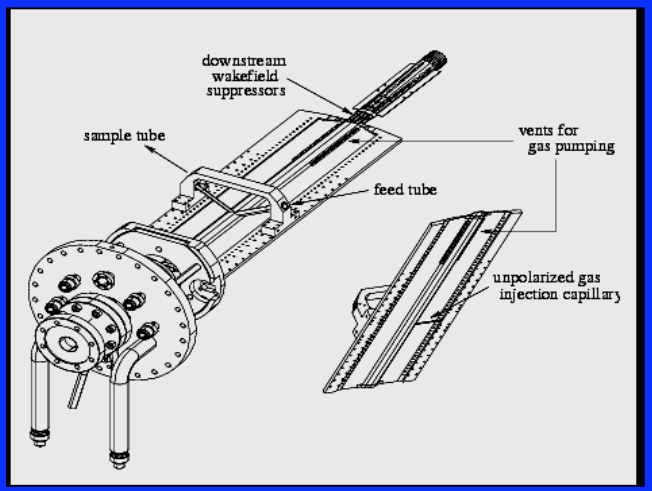


Figure 1: Schematic layout of the HERMES internal target with polarized source, storage cell, polarimeter, collimators, wake field suppressors and thin-walled exit window.



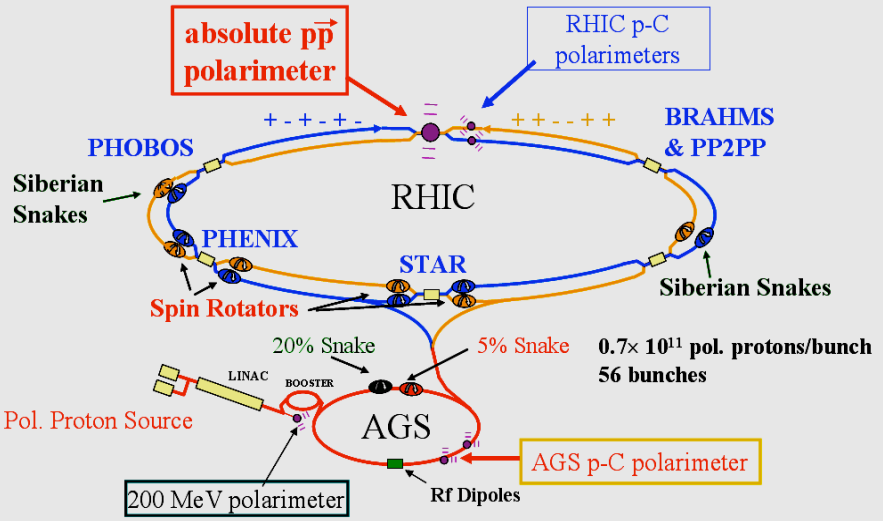
Polarimetry/Targetry ~ 2001-05

Developed polarized jet target to measure the RHIC beam polarization after acceleration by using p + p scattering

H-Jet at RHIC

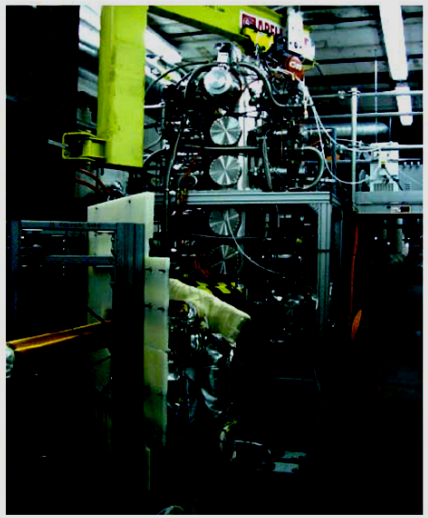
The RHIC Complex $50 < \sqrt{s} < 500$ GeV

present performance: $L=4\text{x}10^{30}\text{s}^{-1}\text{cm}^{-2}$, $P_{beam} \sim 40\%$



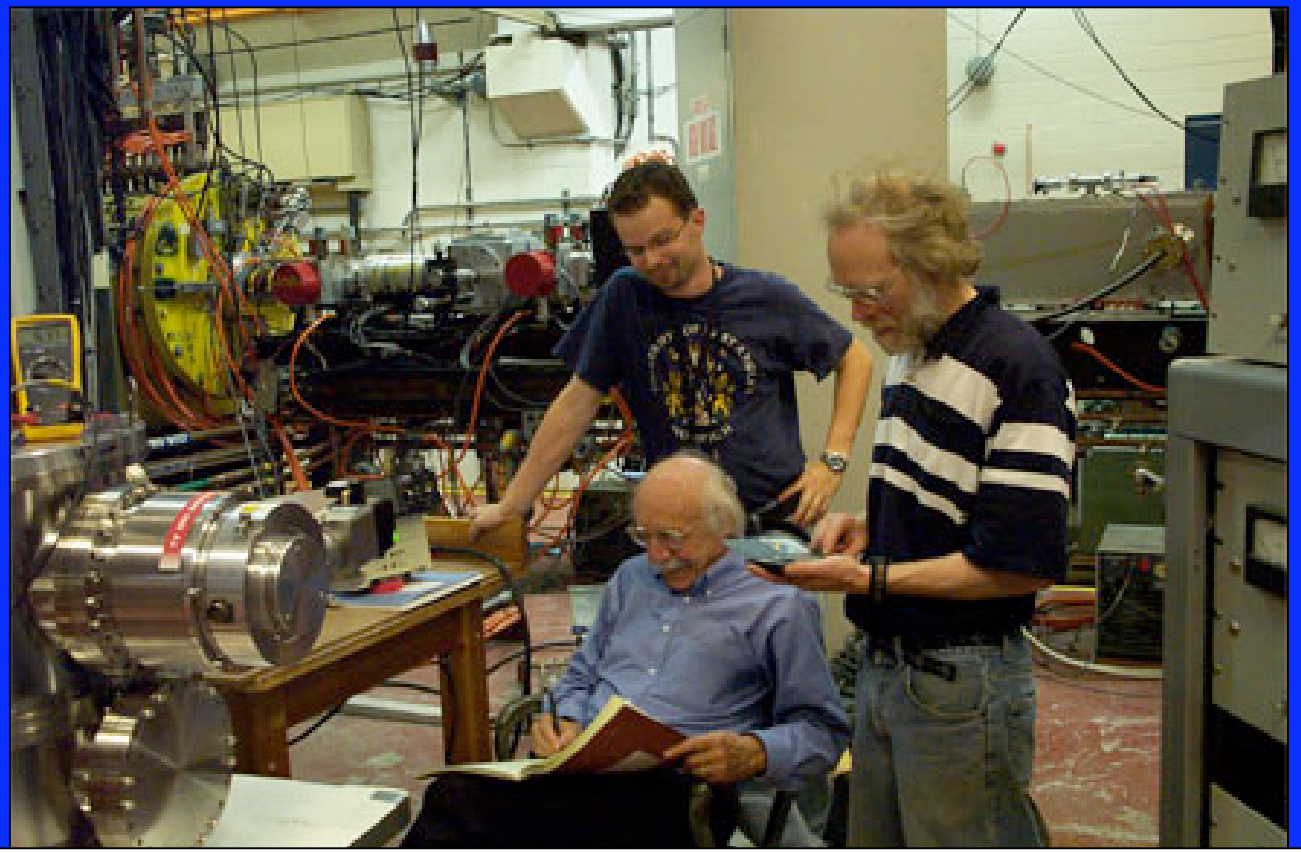
H-Jet collaborators:

Wisconsin:, T. Wise, M. Chapman, W.H.
BNL: A. Bravar, G. Bunce, R. Gill, Z. Li,
A. Khodinov, A. Kponou, Y. Makdisi,
W. Meng, A. Nass, S. Rescia, A. Zelen
Kyoto: H. Okada, N. Saito
ITEP-Moscow: I. Alekseev, D. Svirida
IUCF: E. Stephenson
RIKEN-BNL: O. Jinnouchi,
Rikkyo U: K. Kurita
ANL: H. Spinka



THE UNIVERSITY of WISCONSIN MADISON

BROOKHAVEN NATIONAL LABORATORY



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Sourcery, Targetry, and Polarimetry

SPIN NIdS SPIN SPIN SPIN NIdS SPIN SPIN