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MEMORANDUM

From : E. Chudakov and R. Michaels

To : K. de Jager

Subject : Upgrade of Hall A Møller Polarimetry for Lead-Parity Experiment

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1 Introduction

The present Møller beam polarimeter in Hall A can not provide the adequate ($\sim$1% at 50 μA) accuracy for the planned parity experiment on lead. The limitations are:

- the beam current is limited to 0.2-0.5 μA by the event rate;
- the beam current is limited to 2-4 μA by the target heating;
- the target polarization accuracy is about 3%.

We see at the moment two ways to upgrade the polarimeter:

a) Try to build a polarimeter target based on polarized atomic hydrogen trap. This, if worked out, would provide an accuracy better than 1% and, potentially, can provide an accuracy better than 0.5%, at 50 μA or more.

b) Use a modified Hall C polarimeter target scheme, suggested by I.Sick at the Precision Polarimetry Workshop on June 9, 2003, including the 4 T magnet and a rotating 1 μm foil. With installing additional collimators between the target and the first quadrupole magnet one can hope to be able to run at about 20 μA, providing a systematic error of about 1%, scaled from the published accuracy of the Hall C polarimeter. The 1 μm rotating iron foil may turn out to be unstable, in this case we will have to use a thicker foil (a 4 μm static foil works in Hall C) with the proportional decrease in the allowed beam current.

Both ways would need a helium supply at the area 17 m upstream of the pivot. P.Brindza estimated the cost of such a supply, with an intermediate tank to feed the low pressure cryostat of the Hall C spare magnet and the existing hydrogen trap prototype, as about \$50-70k. The alternative would be to purchase liquid helium in tanks. The cost may be about \$5-10k per month for running a Hall C magnet, or several times more to run the hydrogen target. For the further estimate, we assume that we build a supply line.

2 Atomic Hydrogen Trap

The suggested scheme contains two stages:

Stage 1) Build a test module on the base of the Michigan's group prototype, in order to prove the principle, and, if it works, use it in the lead parity experiment. As much as possible of the equipment needed should be borrowed in the Lab for the tests and the experiment running. We estimate this stage takes 2.5 to 3 years.

Stage 2) Build the completed polarimeter as a fully equipped and permanent facility. Progressing to this stage is contingent upon successful experience with the test module and a continued need for high accuracy polarimetry.

It is expected to receive support from the JLab cryo-target group, in terms of the expertise, infrastructure for the tests, sharing certain tools and using a small amount of material, like wire, pipes, soldering equipment etc.

In Table 1 we display the estimated costs for equipment and material needed by the project. Manpower costs are not included. The "1st stage" costs are those that must be paid to accomplish the goals of the first stage. We assume that a number of expensive items can be borrowed for the first stage, e.g. the ^{3}He sealed pump sets can be borrowed from UVa. However, for some items it is at present uncertain with about 50% probability whether we can borrow it. The column labeled "recovery" indicates the fraction of the equipment cost that can be recovered by using that equipment elsewhere in the lab, in the event that the second stage of the project does not proceed. For example, computers and much of the instrumentation can be used elsewhere, while the helium supply line could be used for the alternative way to upgrade the Møller polarimeter (Hall C scheme).

At the moment we have only a very crude scheme for the liquid ^{4}He cooling supply. The Michigan prototype consumed about 15 ℓ/h, equivalent to 0.52 g/s. This is less than 2% of the HRS magnets consumption in Hall A ($\sim$30 g/s). On the other hand, it is too much to run for months on helium purchased in dewars from an external supplier ($\sim$\$3.5 /ℓ). It is better to invest in a cryo-line. We hope that we will be able to install a cryo-line in Test Lab, to run the tests, and after that transfer it to Hall A. Such a line could be also used for the Hall C target clone. This scheme is assumed in Table 1, but it needs elaboration. Another possibility would be to fill dewars at JLab, and return the warm gas into the system. So far, such operations have not been done at JLab.

We conclude that to accomplish the first stage will cost \$208k of which \$110k is recoverable as items usable elsewhere if stage 2 is not pursued.

If stage 1 is successful it will cost about \$150k more to equip the polarimeter. At that level other improvements may become attractive, therefore we are not discussing here the cost of stage 2 or the way to finance it.

The needed manpower and other resources are summarized in Table 2. The time table for the 1-st stage is shown on Table 3.

item	price, k$ (full)	1-st stage estimated expenses	recovery after stage 1
Michigan Equipment			
Prototype: dilution refrigerator, 8 T magnet	50	100%	0%
Dilution Refrigerator			
^{3}He $\sim$ 100 liters	12	100%	50%
^{3}He sealed pumps set	100	0%	0%
^{4}He evaporator pumps set	25	0%	0%
^{3}He manifold rack with a LN_2 trap	2	100%	0%
Needle valves remote control system	2	100%	50%
Superconducting solenoid 8 T			
Power supply	5	100%	75%
Vacuum Tank			
Insulating vacuum turbo pump	15	50%	50%
Backing mechanical pump	5	0%	0%
Two automatic gate vacuum valves	6	100%	50%
Dissociator			
RF Generator, RF Amplifier, RF Power peak reading Watt-meter	15	50%	50%
^{4}He Film System			
Piezoelectric Valve	1	100%	50%
Current pulse generator	5	100%	50%
Hydrogen Density Monitor			
Capacitance meter	10	100%	50%
Instrumentation			
AC temperature bridge	8	100%	75%
Power supplies	5	50%	75%
Computer	2	100%	100%
Miscellaneous			
^{4}He and LN_2 level meters, Vacuum gauges, valves, flow meters, Materials	10	50%	50%
Liquid He supply			
^{4}He, liquid, purchased in dewars	5	100%	0%
^{4}He permanent supply line	70	100%	100%
Total, k$	353	208	110

Table 1: The estimated costs for the equipment and material needed for the atomic hydrogen project. The "1st stage" spending indicates what part of the cost has to be paid at the first stage of the project. The column "recovery" indicates the equipment purchased for the first stage that can find a use at Jlab if the second stage is not pursued. See text for more details.

Personnel	occupancy	duration
Physicist	100%	3 years
Technician	50%	2 years
Designer	100%	3 months
Machine shop	-	400 hours
Visitor*	100%	6 months
Graduate student*	100%	3 years

Table 2: The estimated manpower and machine shop resources, needed to accomplish the first stage of the hydrogen project, additional to the resources normally spent for Møller polarimetry in Hall A. Items with an asterisk (∗) would be helpful but not necessary.

Resource	value	1-st year	2-nd year	3-rd year
Equipment and material	$208k	70%	30%	0%
Technician	occupancy	50%	50%	10%
Designer	3 months	80%	20%	0%
Machine shop	400 h	70%	30%	0%
Standalone tests		0%	80%	20%
Beam tests		0%	0%	100%

Table 3: The time table for the 1-st stage of the hydrogen project.