To:          Polarimeter Group          Date:       19 February 2002
From:       Bill Franklin
Subj:       Pre-run job list for Compton polarimeter

*** = MUST be done – essential – highest priority
** = should be done – useful – medium priority
*  = might be done – convenient or cosmetic – low priority
✓  = HAS been done – but may require final checking

EB = Ed Booth
DD = Dipaangar Dutta
MF = Manouchehr Farkhondeh
BF = Bill Franklin
KH = Ken Hatch
XG = Xiaosong Geng
EI = Ernie Ihloff
JM = June Matthews
JQ = John Quattrochi
TS = Tim Smith
UM = Michigan Spin Physics Group
CV = Chris Vidal
TZ = Townsend Zwart

Mechanical

*** (CV) Build new chopper wheels with different duty cycles
*** (EB) Devise method for insertion of lead absorbers in gamma line
** (EI) Design and build hood for laser table
*** (JQ) Redo radiation safety system in North Beam Dump
** (EI) Build remote actuator for mirror in vacuum
*** (EI,CV) Optimize Ring vacuum in Interaction Region (IR)
✓ (CV) Install Remote Gas Analyzer (RGA) in IR
✓ (CV) Install fiber-optic cable and computer for RGA
*** (BF,CV) Investigate effect of laser on vacuum in IR
** (EB) Build absorption magnet and stand allowing it to be inserted remotely
*** (EB,TZ) Check status of halo scrapers
** (?) Improve stability of camera mounts for use with framegrabber
Laser

✓ (BF) Check performance of laser
*** (BF) Clean all optics and improve shielding from dust
*** (BF) Clean out chiller and refill
*** (BF) Check performance of all mirrors, especially inside vacuum
*** (DD) Measure laser polarization at end of line
*** (BF) Order spare polarizer and mirror
✓ (BF) Order high current HV supplies for Pockels cell
*** (DD) Check new pockels switch and HV supplies
** (BF) Obtain backup switch for pockels cell
** (KH) Install new rack under laser table for PC switch and HV
*** (DD,BF) Investigate effect of Pockels cell voltage on laser transmission, circular polarization
* (DD) Move pockels cell to rail above dipole
*** (DD,BF) Measure spin-dependence of laser position at IR exit using quad diode
*** (BF) Order piezoelectric mirror mount and controller for feedback and helicity correction
** (DD) EPICS control for piezo mount (add DAC to VME crate)
*** (DD) Make switch to allow helicity-correlated voltage delivered to piezo
** (DD) Develop feedback algorithm for piezo voltage
*** (TZ,DD) Implement framegrabber for documentation of laser spot
** (TZ,GT,DD) Test response of CCD camera for speed, suitability of use in feedback system

Calorimeter

*** (EB) Check 3” PMT with UV transmitting window for CsI
*** (EB) Obtain backup PMT and base for CsI
✓ (EB) Construct set of 4 segmented scintillators for beam alignment
*** (KH) Run additional HV cables to D-tunnel for scintillators
*** (BF) Set up high voltage channels for new scintillators
*** (BF) Set up new scalers for segmented scintillators
*** (EB) Verify alignment of calorimeter and collimators and improve documentation
*** (EB) Align segmented scintillators and calorimeter on gamma line
** (EB) Check CsI response as function of incoming position using source
* (? ) Revisit CsI base design
* (? ) Locate additional CsI
** (? ) GUI script for Compton Polarimeter HV control
Data Acquisition and Electronics

✓ (BF) Get existing DAQ system running with MVME167
** (KH) Install patch panel in Compton data rack
*** (BF,DD) Reestablish timing and logic
*** (BF,DD) Clean up Compton electronics and improve documentation
*** (TZ,BF) Develop method for gating and clocking new digitizer
*** (XG) Write driver to read out new digitizer
** (TZ) Build faster integrator in case problems arise with pulse sampling
*** (XG) Throughput test of digitizer readout speed
*** (TZ,BF) Develop method for logging status bits for chopper wheel, pockels cell, polarized source on event-by-event basis
*** (BF,XG,?) Software for building spin-sorted histograms in CPU from ADC data in MVME167
** (TZ,XG,?) Get DAQ to run with PowerPC or other faster processor
** (?) Develop pile-up rejection software
*** (TZ,BF) Develop plan for synchronizing scaler read with digitizer read
*** (TZ,BF) Determine scheme for sorting scalers by spin state
*** (BF,XG,?) Interface new DAQ with existing analysis package
*** (BF,EB) Check out new acquisition system with source tests
*** (TZ,BF) Crosstalk check for digitizer
*** (?) Integrate polarimeter data with BLAST event stream

Analysis Software

*** (BF,?) Improve software for background subtraction, fitting spectra
*** (BF,?) Improve software for polarization extraction
*** (?) Improve simulation to include all beamline components, finite resolution, and if possible pile-up
*** (BF) Software to analyze data from new scintillators
** (?) Set up to use EPICS variables for beam current, pressure to calculate expected brems rate

Spin Flipper

*** (EI) Build ceramic beam pipe to fit inside rf dipole aperture
*** (CV) Install rf dipole
*** (BF,UM) Determine run plan and schedule for commissioning of spin flipper
*** (UM) Bring amplifier for spin-flipper operation
*** (?) Implement logic to denote status of spin flipper
Miscellaneous

*** (BF) Update commissioning plan for polarimeter
*** (BF) Update web documentation for operation procedures
*** (BF, MF, TS) Implement electronic logbook for Compton
*** (BF, JM) List projects suitable for URQP student
*** (?) Determine whether to use B-Line Möller Polarimeter
Laser Feedback Motivation

- Fast feedback to correct for small movements of laser correlated with helicity (20 Hz)
- Slow feedback to correct for long-term drifts in laser or in trajectory of electron beam
- Increase resolution of laser transport system to improve backscatter rate
- Eliminate need for repeated manual scans during long-term operation
Backscatter Rate as function of HPC Voltage

- Scan laser angle horizontally in Interaction Region to find highest backscatter rate
- Compare rates for 2 different voltages applied to Helicity Pockels Cell
- Observed shift in centroid of 0.8 steps, corresponding to 0.016 mrad for run with left-handed vs. run with right-handed circular polarization
Possible evidence for helicity-correlated laser steering

16 microrad shift in centroid for S vs. P polarization

Centroids consistent for P polarization
Kinematics of Compton scattering are defined almost exclusively by properties of electron beam (very little dependence on laser crossing angle).

For nearly head on collisions, small change in laser trajectory can result in large change in effective interaction point (0.3 m shift in z for 16 microrad shift).

Change in interaction point affects luminosity.

Tight collimation of backscattered photons can produce additional false asymmetry, particularly at low energies.
Asymmetry Spectra with Unpolarized Beam and Collimators In

1” hole collimator

0.5” hole collimator

0.5” hole collimator, half-wave plate in
Dependence of gamma angle on energy very gentle for low beam energy.
Role of the Spin Flipper

Suppose we have a spin-flipper with 100% efficiency, allowing reversal of the electron spin once per minute.

In this case, we can make the following approximations for the spin-dependent yields:

\[ Y_{+L} \approx Y_{-R} \]
\[ Y_{-L} \approx Y_{+R} \]

This leads naturally to the cross-ratio method for calculating the average asymmetry:

\[ A = \frac{r - 1}{r + 1} \quad r = \frac{Y_{+L}Y_{-R}}{Y_{-L}Y_{+R}} \]

**Crucial advantage:** Factors associated purely with the spin-state of the laser or with the spin state of the beam, but not with both, will cancel exactly (e.g. luminosity difference due to PITA).

**Questions to Address**

- What efficiency is required for flipper?
- What is the maximum false asymmetry we can tolerate?
Necessity of Helicity-Correlated Laser Feedback

**PRO**

- Laser scan data are consistent with a shift in laser position which is correlated with laser polarization
- False asymmetry observed at low photon energies with tight collimation

**CON**

- Laser scan data also consistent with movement of electron beam or irreproducibility of stepper motors
- Helicity correlation not observed during vertical laser scan
- For wide collimators, false asymmetry appeared to be less than 0.003 for unpolarized electron beam and independent of backscattered photon energy
- Initial bench tests did not show large helicity-correlated laser steering
Proposed basis of laser feedback system

Polytec PI S-330 Piezoelectric Tilt Platform

- Easily fast enough for 20 Hz helicity flip
- Angular resolution spec of 0.1 microrad (compare to 20 for steppers)
- Closed-loop device, eliminates long-term instability from piezo creep
- Programmable to handle fast helicity-correlated as well as slow feedback
Drawbacks and Issues for Laser Feedback System

- Cost: $14K. Cheaper systems available, but not which meet all needs for fast feedback system
- Implementation: Needs experienced person, best use of limited resources?
- Feedback mechanism must be determined. Candidates include the following:
  - Quad diode to monitor laser position at exit window
  - Framegrabber to monitor laser position in multiple locations
  - Beam itself. Average over polarization states.
  - Quad scintillators in front of calorimeter
Options

- Proceed with feedback system identified. Produce working system for summer 2002.
- Search for cheaper system to do slow feedback only. Aim for long-term stabilization and improved resolution, but ignore helicity-correlated feedback for now.
- Concentrate manpower on other items until summer. Conduct more tests with beam. Defer implementation until FY03 if necessary.
Transit survey located beam height at collimator using wall target. Plumb bob located beam line at floor target. Quad height used for beam height at sweep magnet. Beam line at sweep lined up visually between floor target and wall target. Sighting from sweep cross hair to wall target lined up cross hairs at collimator. Sighting from cross hairs on sweep to cross hairs on collimator lined up dummy CsI.

From survey find beam comes out near center of pipe thru quad and goes close to center of collimator.

Propose: leave moveable slits in place until run, using them to check beam position and as diagnostic for brem from beam pipe. After that, move one of them to area labelled "1/2" absorber". Install 4 scintillator beam position monitor and veto.

Townsend polarization magnet to be installed close to floor target. Remote positioning mechanism has not been found. Could hand install on pedestal carrying absorber or on jack table over floor target.