Cosy Spin Transport Matrix in MCEEP

Added COSY spin transport to spectrometer analysis

The possibility to do spin transport through the HRS hadron spectrometer using a spin transport matrix from COSY was added to MCEEP. In the spectrometer analysis there is a new OP element to the MCEEP input deck:

```
'COS'  JLAB HALL A hadron HRS spin transport using a COSY spin matrix
```

OP='COS'

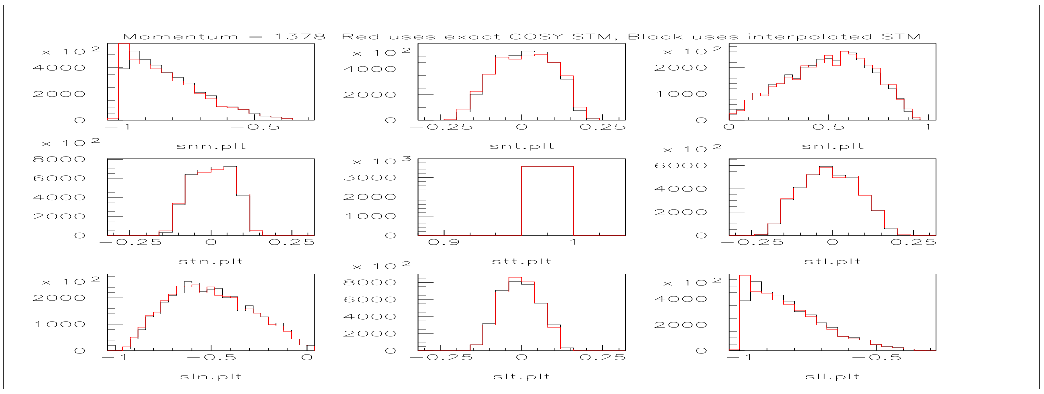
COSY_INPUT_FILE A character variable which specifies the filename of the COSY spin transport matrix file. Also one can set COSY_INPUT_FILE = internal so that MCEEP will produce a COSY spin transport matrix at the central hadron momentum by interpolating between COSY spin matrix files which are in the MCEEP DAT directory for central proton momentum between 500 to 3500 in steps of 250 MeV/c .

Spin transport matrix elements as variables in MCEEP

The variables Snn, Snt, Snl, Stn, Stt, Stl, Sln, Slt, Sll , which are the nine elements of the spin matrix were added to MCEEP as variable numbers 41 through 49. The spin matrix relates the target polarizations to the focal plane polarizations as:

$$\begin{pmatrix} P_n^{fp} \\ P_t^{fp} \\ P_l^{fp} \end{pmatrix} = \begin{pmatrix} S_{nn} \approx \cos\chi & S_{nt} \approx 0 & S_{nl} \approx \sin\chi \\ S_{tn} \approx 0 & S_{tt} \approx 1 & S_{tl} \approx 0 \\ S_{ln} \approx -\sin\chi & S_{lt} \approx 0 & S_{ll} \approx \cos\chi \end{pmatrix} \begin{pmatrix} P_n \\ P_t \\ P_l \end{pmatrix}$$

The values for the spin matrix elements assuming a simple dipole magnet are given after the $\approx$ sign and χ is the spin precesion angle . In general the spin matrix elements depend on x , theta (dx/dz), y, phi (dy/dz) and momentum and so each event with have a distinct spin matrix. In Fig. the distribution for each spin matrix element is given for protons from pion production with the proton momentum of 1378 MeV/c. The y-axis is the yield from the ^{1}H(e,ep)π° reaction. $\chi = 143^{\circ}$ for a proton at 1378 MeV/c. One can see that the distributions are centered around the expected simple dipole magnet values for the spin matrix elements. S_{nt}, S_{tn}, S_{tl} and S_{lt} are centered around zero. S_{tt} has almost no variation from one. S_{nl} is centered around 0.6 and S_{ln} around -0.6 . S_{nn} and S_{ll} should peak at -0.80, but with the crowding near -1 one should plot the distribution of arccos(S_{nn}) to see the peak.



Separate polarization into helicity dependent and independent

Another change to MCEEP was dividing up the polarization observables P_n, P_t and P_l into helicity dependent and independent parts for both the reaction frame (R frame) and the spectrometer frame (S frame). The new tags are given in Table .

Tag	Weight
±12	(e,e$'$X) for helicity independent N-type polarization (R frame)
±13	(e,e$'$X) for helicity independent T-type polarization (R frame)
±14	(e,e$'$X) for helicity independent L-type polarization (R frame)
±15	(e,e$'$X) for helicity independent N-type polarization (S frame)
±16	(e,e$'$X) for helicity independent T-type polarization (S frame)
±17	(e,e$'$X) for helicity independent L-type polarization (S frame)
±22	(e,e$'$X) for helicity dependent N-type polarization (R frame)
±23	(e,e$'$X) for helicity dependent T-type polarization (R frame)
±24	(e,e$'$X) for helicity dependent L-type polarization (R frame)
±25	(e,e$'$X) for helicity dependent N-type polarization (S frame)
±26	(e,e$'$X) for helicity dependent T-type polarization (S frame)
±27	(e,e$'$X) for helicity dependent L-type polarization (S frame)

Modifying MCEEP version 3.1

One get the file changes_mceep.tar.gz from http://www.jlab.org/~jones/e91011 . The tar file will have directories *cmn*,*dat*,*sources*,*gross*.

Files in the *sources* directory.

compute_cosy_spin.f	hyd_elastic.f	physics.f
compute_transp_to_cosy.f	input.f	pwia_vo.f
deut_elastic.f	mceep.f	read_cosy_input_file.f
he3_elastic.f	mceep_misc.f	spectrometer.f

Files in the *cmn* directory.

spectrometer.cmn	spin.cmn	var_dat.cmn

Files in the *dat* directory.

cosy_pc0703.spin	stm_pc0500.spin	stm_pc1750.spin	stm_pc3000.spin
cosy_pc0818.spin	stm_pc0750.spin	stm_pc2000.spin	stm_pc3250.spin
cosy_pc1065.spin	stm_pc1000.spin	stm_pc2250.spin	stm_pc3500.spin
cosy_pc1289.spin	stm_pc1250.spin	stm_pc2500.spin	
cosy_pc1378.spin	stm_pc1500.spin	stm_pc2750.spin	

File in the *gross* directory is deep.f . The files in these directories should be moved to the appropriate MCEEP directory. There is a makefile in the tar file. It is probably best to do a *diff* with your present makefile for MCEEP and edit the changes into that makefile. For those interested in pion production there is a new version of epiprod_monte.f for epiprod v4.0 which has the helicity independent and dependent polarizations components returned to MCEEP instead of the sum. This should be used to create a new epiprod library. If you aren't interested in pion production then you should edit physics.f and comment out the calls to subroutines init_mceep_mode and epiprod_xsec .

Creating COSY spin matrix files

If one wants to create a new spin matrix file for a specific momentum then you need to run COSY. The manual and code are available at http://bt.nscl.msu.edu/cosy/index.htm . If you have access to JLAB Sun machine then you should copy the files COSY.bin, SYSCA.DAT, cosy, hrs_general.fox, hrs_mceep.fox from the directory /work/halla/e93027/replay/gep/Cosy into your own directory and make cosy and COSY.bin executable. hrs_general.fox and hrs_mceep.fox are script files for the Hall A Hadron spectrometer which are from an original script created by Mohammad Khayat and modified by Gilles Quéméner. The hrs_mceep.fox should be used to create spin matrix files for MCEEP and the hrs_general.fox for spin matrix files for the code gepni_cosy. First type "cosy" and you will get the the following response:

```
                      ************************************
                      *                                  *
                      *    C O S Y    I N F I N I T Y    *
                      *                                  *
                      *       FOXY LANGUAGE SYSTEM       *
                      *                                  *
                      *           VERSION  8.0           *
                      *                                  *
                      *           (C) MSU 1997           *
                      *                                  *
                      ************************************
 GIVE SOURCE FILE NAME WITHOUT EXTENSION .FOX
```

Respond with "hrs_mceep" or "hrs_general" . Then the program types:

```
 --- BEGINNING COMPILATION
 --- BIN FILE READ: COSY
 --- BEGINNING EXECUTION
Order for maps (1-7):
```

Respond with 5 . Past experience has found no difference in results between 5th and 6th order. Then the program types:

```
Enter the central momentum in GeV/c:
```

Respond with the desired momentum. Then the program runs for 10-30 minutes and produces a file called cosy.spin which is the spin matrix file.

One note is the in hrs_general.fox the quadrupoles are scaled by a momentum which is 1.007 times higher than the momentum for the dipole. This is because, until January 2000, the Hall A magnets were set so that actual central momentum in the dipole was 1.007 times lower than what one thought the dipole was set for. So when running COSY you need to use the central momentum that the Hall A spectrometer was actual at, while the quads are scaled to the set value. After January 2000 the dipole should be set to a value closer to the actual value (at the 1.0007 level) and one can use the hrs_mceep.fox which doesn't change the momentum used to scale to quads.