HAMC = Hall A Monte Carlo

Bob Michaels
Two Previous Monte Carlos

- **SAMC** (A. Deur, V. Sulkosky)
- **genercone** (D. Lhuillier, K. Paschke, B. Moffit)

  - much was learned from these
  - were used for theses and publications
  - but ... not easy to adapt to PREX / PVDIS
HAMC – Ideas

- based on ROOT histograms, ntuples, etc.
- C++ Design
  - Extensible to other experiments
  - Description of problem provides the classes & their relationships.

  e.g. “... in an EVENT the BEAM (a type of TRACK) hits a TARGET, the KINEMATICS are generated .... TRACKS go through a SPECTROMETER which has a TRANSPORT MODEL ... ”

- **NOUNS** = the classes
- Relationships : inheritance, usage, containment
- Such design makes things easier (we hope)
HAMC Main Classes

- **Physics, Experiment, Target** (abstract)

  Experiments = singles or coincidence (only HRS)
  New experiments inherit from these, e.g. hamcTgtPREX = lead/diamond

- **Event** (procedure of 1 event)

- **Track** (→ Beam, TrackOut)

- **SpectHRS** (only HRS, concrete class)

- **Transport** (→ LeRose Transport, Matrix, other models foreseen)

- **InOut** (database, control, ROOT histograms and ntuples)
HAMC Event Procedure

- Generate the beam for this event.
- Target position uniformly generated.
- Phase space filled uniformly.
- **Cross section weighting** (option for histograms).
- Compute energy losses and multiple scattering in materials
- Compute Internal Bremsstrahlung
- Compute parity violation
- Transport to various points in HRS (and Septum).
- Apply acceptance cuts at those points.
- Event Analysis
Spectrometer Model

Uses LeRose functions (Fortran) with C++ interface

Break Points

Transport to here
Apply Acceptance Cut

beam
Target
Septum (if exists)  Q1  Q2

Dipole

Hall A  Jefferson Lab,  Dec 3, 2008  Software Workshop – p.6
Example 1 : Adding a histogram

```cpp
Int_t hamcKine::Init(hamcExpt* expt) {
    // to weight ? brk point
    // ^ care-acc ? ^
    //         ^      ^
    expt->inout->BookHisto(kTRUE, kFALSE, ITARGET,
        "th1", "Theta Generated",
        &theta, 120, 0.8*thetamin, 1.2*thetamax);

    // produces a histogram `th1` weighted by cross
    // section, with no acceptance cut. Variable is
    // plotted at the target break point.
}
```
Example 2: Adding variables to event ntuple

```c
Int_t hamcKine::Init(hamcExpt* expt) {

    expt->inout->AddToNtuple("energy", &energy);
    expt->inout->AddToNtuple("theta", &theta);
    expt->inout->AddToNtuple("qsq", &qsq);

    // produces variables 'energy', etc in ntuple
    // (filled at focal plane).
}
```
Control File

# This file:  prex.dat
# Read by hamc and parsed by hamcInout.

# Setup choices for HRS
hrs_setup coldseptum uselerose
# Beam parameters and raster
beam  E0 1.1 E0sigma 0.00011
rastered  xraster 0.0004  yraster 0.0004

# uncomment the following line if want to iterate
# iterate
# A variable to iterate (relevant class looks for this)
kick:track P0 0.003
Iterations

Obtained when specifying “iterate” in control file

Produces iterated (‘‘x’’) histograms for each histogram, for variable after iteration.

root [1] .ls

KEY: TH2F xyq3o;1 Transport X-Y at Q3 exit

KEY: TH2F xyq3ox;1 Transport X-Y at Q3 exit_ITERATION
Dispersion Study

For a \(\delta\)-fcn \(P_0\) on lead with (new) warm septum.
HAMC Status  /  To-do List

- ~ 90% written
- 5 kHz on my Dell 520 Laptop (core 2 duo T7200 2 Ghz)
- Needs more care at target

find vertex, treat the physics for that material.
understand discrepancies of diff. versions of radiation codes.

- PVDIS not written yet  (easy)
- Preliminary comparisons to real data will be shown.

→ next slides
X-Y in Focal Plane for HAPPEX

Very preliminary results, still a work in progress ...
$Q^2$ for HAPPEX

HAMC simulation

<table>
<thead>
<tr>
<th>$Q^2$ (weighted, in accept)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries: 17238</td>
</tr>
<tr>
<td>Mean: 0.09868</td>
</tr>
<tr>
<td>RMS: 0.02814</td>
</tr>
</tbody>
</table>

Real Data

<table>
<thead>
<tr>
<th>HAPPEX 2005 run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries: 100557</td>
</tr>
<tr>
<td>Mean: 0.1071</td>
</tr>
<tr>
<td>RMS: 0.02304</td>
</tr>
</tbody>
</table>

HAPPEX 2005 run

Comparing to some test data with old septum.

**Weighted X-Y at focal plane (X on X-axis)**

**HAMC Simulation**

**XY for Real Data**

$E = 1.1 \text{ GeV}, \theta = 6$

Cold Septum Magnet, ca 2005
HAMC Goals

- Understand the acceptance-averaging of asymmetry.
- Design collimator for PREX.
- Compute sensitivities to position, angle, energy.
- E & M radiative corrections to point asymmetry (HAPPEX-III).
- Simulation of PVDIS trigger.
- Develop strategies to study transverse asymmetry systematics.
- Study MFT model dependence for PREX.
- etc ...