Steps for a simulation of the spin-filtering experiment

Main issues to be adressed by the simulation are

- to estimate rates for different polarized physics reactions (pp, $\overline{p}p$, $p\alpha$, pd)
  - study signal/background ratio
  - make predictions for the expected signal and achievable statistical precision vs running time
- to define number and spacial position of the telescopes
  - maximize acceptance
- to define the pitch, thickness and number of active layers in each telescope
  - optimize tracking and energy measurement in the energy range of interest
  - anticipate performances of the detector (energy resolution, background rejection and related systematic uncertainty)

Main goals

A) *[As soon as possible]* a first guess of the above points should be available possibly before Tbilisi to drive the discussion and to provide a starting point for more detailed simulations.

B) *[before October]* a simulation for the $p\alpha$ case should be ready before the submission of the proposal in October for the $p\,^4$He depolarization study at ANKE. This could be done best with the existing codes of the ANKE experiment.

C) *[before end of the year]* a full simulation of pp and $\overline{p}p$ cases, which requires a generator of physics processes, a GEANT simulation of the detector response, a code for track-reconstruction. An analysis code should be available before the beginning of next year, when we would join the FP7 call, and submit the TDR for polarization filtering experiments at COSY and AD.

Goal A: first guess

A first guess could be based on

- the PAX Note n.1 of M. Tabidze et al. which indicates the optimum polar angle for the detector from simple considerations about cross-section and analyzing powers for a point-like target;
- the characteristics of the existing silicon telescopes of the ANKE Spectator, i.e. see Ralf Schleichert talk at the X PAX meeting, and the example provided by the HERMES Recoil Silicon detector. A preliminary sketch is available in the PAX Note n.3.

Form the PAX Note n.1 one may argue that the best scattering angles valid for almost all the energies correspond to about $\theta_{\rm lab} \approx 20^\circ$ for the forward scattered and to about $\theta_{\rm lab} \approx 70^\circ$ for the recoil particle.

Considering the detector layout in the PAX Note n.3, the miminum distance between interaction point and first active layer would be of the order of 2.5 cm, which corresponds to a path length of 7 cm (1 cm) along the beam direction (z) for the forward (recoil) particle before being detected. The origin of the coordinate system is at the center of the storage cell. Looking along the beam direction (z), the x-axis points to the left, the y-axis points up.

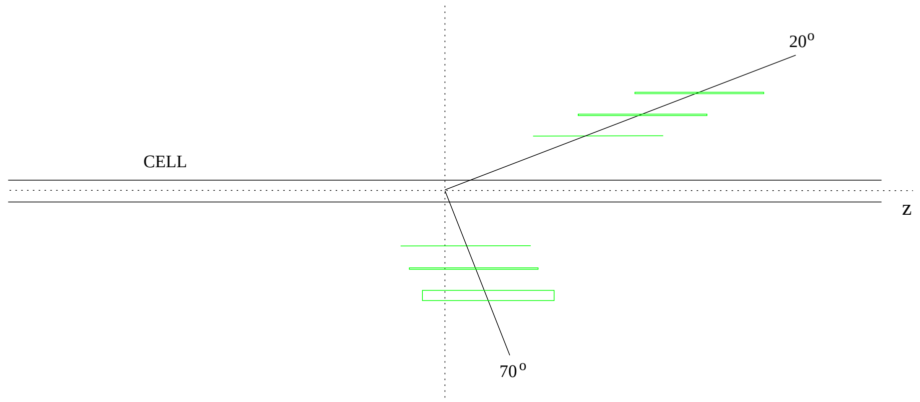

Figure 1: First guess for the polarimeter layout.

By centering the telescopes at +1 cm (recoil) and +7 cm (forward) in z, with respect the center of the cell, one would cover the region of maximum target density. In the compact design where silicon layers are parallel to the beam line, the layers of the telescopes can be staggered to best match the 20° and 70° inclination of the detected tracks, see Fig. 1. Alternatively the forward telescopes can be tilted to be perpendicular to the incoming track, with the price of a more complex geometry of the scattering chamber. Simulations will tell us the best choice.

The recoil and forward telescopes can have a different composition of active layers since there is a clear distinction between the recoil and forward cones in the accepted events. For a beam energy ranging from 20 to 200 MeV, the recoil energy (at 70°) varies approximately from 4 to 40 MeV. Hence a design similar to the ANKE Spectator is envisaged for the recoil telescope. The forward energy (at 20°) varies from 30 to 170 MeV and a telescope composite of standard 300 μm silicon layers can be considered.

Goal B: simulation code for depolarization studies at ANKE

Dieter Oellers, David Iamanidze and Misha Nekipelov should contribute to this goal. This task could be adressed with the existing code for the ANKE Spectator device. A prototype of the event generator described in the next section would be required.

Goal C: full simulation for spin-filtering experiments at COSY and AD

G. Macharashvili agrees to work on this task. The relevant tools to be prepared for a full simulation are (starting from his preliminary list)

- Event generator for signal
  - able to work at different beam energies: at least few relevant beam energies that range from 20 to 200 MeV using the known cross sections and analyzing powers available from SAID;
  - incorporate the predictions of different models (A, D, Meyer-Horowitz, Walcher) for electromagnetic and nuclear polarization build up. It should be enough to implement a lookup table with the final expected beam polarization with different models, at few beam energies and filtering times;
  - distribute the events according to either a point-like target for specific studies or to the density distribution of a storage cell target. Being not negligible in size, the beam transverse profile should be added too. A first indication of the maximum beam radius at the IP can be found in the talk of Archil Garishvili at the X PAX meeting.
- Event generator for background
  - account for reaction outside the target fiducial volume (rest gas along the beam line, collimators and cell material). It is really a not trivial task to estimate the rates of such events without a perfect knowledge of the experimental set-up and beam halo characteristics. However the simulation could at least estimate the rejection power of our detector against such kind of events;
  - account for annihilation processes in the $\overline{p}p$ case. We should look for already existing codes since the number of final states is large and would require a big effort to be implemented. Since we want to veto such events

we do not care too much about possible polarization effects in annihilation.

- IP description
  - All the not-active materials (cell, magnet coils, shieldings...) should be described to account for energy loss and multiple scattering, affecting both the measurable energy range (minimum detectable energy) and the energy resolution. A first guess of the IP layout can be found in the PAX Note n.3.
  - The description of the magnetic field around the cell is not trivial due to the expected non-uniformity of the field generated by the target coils and because of the fringe-fields from the nearby quadrupoles of the IP lattice. However, since the fields are expected to be weak (of the order of ten Gauss) the simulation can neglect them.
- Silicon detector simulation
  - a first guess of number, type and spacial position of the silicon telescopes can be found in the PAX Note n.3.
  - to provide a reliable estimation of the energy and coordinate resolution based on the pitch and the thickness of the active layers. Relevant informations can be found in A. Mussgiller's Ph.D Thesis and Ralf Schleichert talk at the X PAX meeting.
  - a simple digitalization for the channels above threshold can be based on the estimated deposited energy and smearing. A full description of the silicon behaviour, with dead channels, pedestals and electronic noise is probabily not needed.
  - a trigger simulation would be useful to study the efficiency of the trigger at the different scattering energies.
- General framework
  - provide a datacard to choose the relevant parameters of the simulation (reaction, beam energy, target polarization....)
  - store both the generated events and the data after digitalization
  - provide an output of the simulation compatible with the reconstruction program of the experiment, i.e. ems output stream in order to process the events in RootSorter framework. Define the variables describing the status of the experiment to be used for Data Quality selection (beam and target status and polarization ....). A preliminary flow-chart of the simulation code has already been drawn by Gogi, see Fig.2.
- Reconstruction program

– a complete event reconstruction program with tracking and vertex finding algorithms. This may include already developed components from the ANKE Spectator reconstruction and analysis codes.

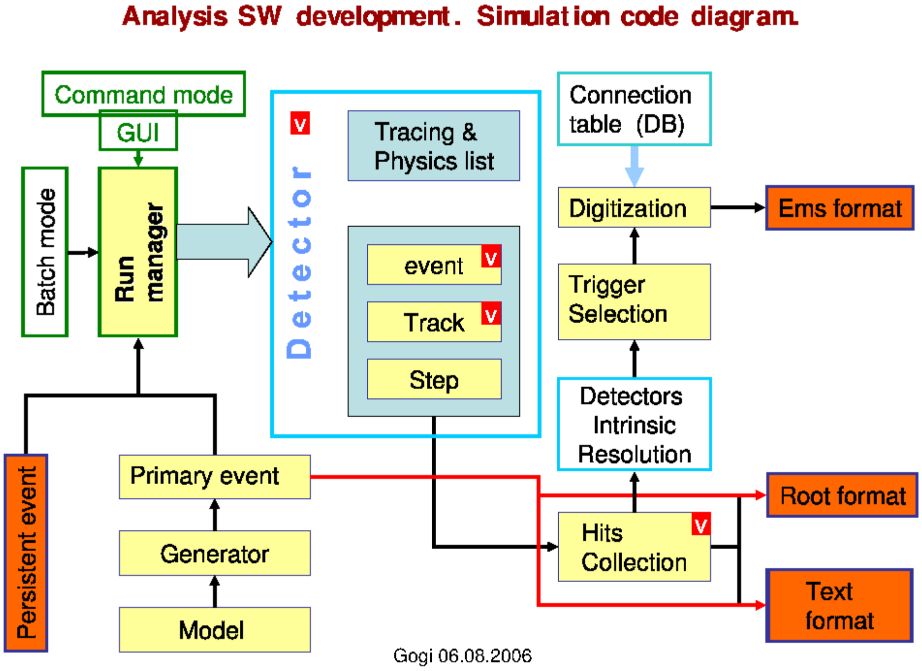

Figure 2: Preliminary flow-chart of the simulation code (by Gogi).