Multi-Dimenstiona Cross Section and BSA Analysis

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July 17, 2017

OVERVIEW

Here I outline the basic steps that I follow to go from raw data to final cross sections and beam spin asymmetries (BSA) for the NPS1a experiment. The overall procedure is the similar for exclusive pi0, DVCS, pi0-Delta, and SIDIS channels. I focus on pi0 analysis here: for DVCS the biggest differences are more complicated phi* dependence, the pi0 background, and the need for better photon energy resolution.

Step 1: Full Replay

Do full replay of all runs. Pass 0 done. Come back to this step when calibrations, wave=rform analysis code are ready.

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Step 2: Run List

Make Run List. I use text-based format, one line per run, suitable to read into analysis code. Entries based on Report Files, EPICS data, wiki page information on beam energy and polarization, and logbook entries. Include everything needed to obtain kinematics and cross sections.

My list has both static info (beam energy, …) and dynamic info (good/bad/fixable), which “super-run”…)

Step 3: Calibrations

Calibrate all HMS detectors and beam line elements (BCMs, BPMs), and HMS optics.

Calibrate NPS photon energies in time intervals with good stability (I find about 40 needed for my preliminary calibrations).

For pass0, determined that they are all “good enough” for 5% systematic errors.

Step 4: Skim files

Make "skim" files for each run. I make one set of files for pi0 candidates, and another for DVCS candidates. Skim files keep only events with good HMS electron ID, and process the NPS data with small refinements to the gains and timing, and make refinements to the on-line cluster finding routines. I apply a relatively narrow time window as well to reduce the file size. I keep the HMS focal plane tracking information and raster position so that changes to the recon matrix elements can be applied later for HMS momenta above 5.3 GeV.

Step 5: Luminosity Studies

Study runs with different triggers and beam currents to determine corrections to the nominal luminosity after application of target boiling corrections, BCM calibrations, etc., using HMS e-pi0 accidental-subtracted coincidence rate. For pass0, find “small” corrections.

Step 6: Combining runs

Form "super runs" of all runs taken under identical conditions. Eliminate runs that have a poor chi2/d.f. for agreement of total e-pi0 rates with the other runs in the group. By identical conditions, I include beam energy, HMS angle and momentum, NPS angle, NPS distance from target, trigger configuration and trigger thresholds, target fan/pressure, and stable performance of NPS crystals within a fiducial region. At present, found 56 super runs with bulk of statistics, and about 100 more with alternate triggers, etc.

Step 7: Binning

For each super run, accumulate pi0 (gamma,gamma) accidental-subtracted invariant mass spectra in bins of (x, nu, Mx, Pt**2, phi*, helicity, Cu), where nu is E-Eprime, Mx is the e-pi0 missing mass (equivalent to z for SIDIS), Pt**2 is the transverse momentum squared (same as t-tmin for exclusive reactions), “Cut” is variety of cuts on fiducial region, minimum photon energy, energy

Step 8: Background

For each bin, subtract smooth background under pi0 mass peak. Also subtract the scaled Dummy counts from the LH2 and LD2 counts. For SIDIS, subtract pair-symmetric background (negligible for other cases).

Step 9: LH2 model

Determine LH2 density profile and contamination. In the He scenario, this amounts to finding out a) what percentage of the cell is filled with He gas bubbles as a function of y-target, and b) what is the effective density of He (thought to be about 5% that of LH2 under our conditions). Cross check primary determination from DIS with e-p elastic, p-e elastic runs. Also check agreement over time when fan/pressure unchanged (ie long periods except at the end of the run).

Step 9: Ratios to SIMC

Generate SIMC distribution of weights in the same 5-dinemaional binning as for the given "super run", applying the same HMS and NPS cuts as in the real data for a given Cut. Obtain cross section in a given bin by multiplying data/SIMC by the model cross section in the nominal bin center, after accounting for computer live time, electronic dead time, and HMS electron detection efficiency. Complication: tricky to match SIMC to the VTE one-photon and 2-photon trigger, when used. Need model of LH2 density profile for each super-run.

Step 10: combine all super-run

Combine all "super runs" for a given target together to obtain cross section in five dimensions (exclusive pi0, DVCS) or six dimensions (SIDIS). Fit final results as a function of phi* to obtain (Sigma_T + epsilon *Sigma_L), BSA (sin(phi)) and cos(phi) and cos(2phi) terms. Fit versus epsilon to obtain five cross section components in three dimensions (x,nu,Pt2) for exclusive reactions and four dimensions (add Mx or z) for inelastic pi0.

Step 11: Models

Iterate on the models used in SIMC until reasonable agreement is found. For exclusive pi0, need only that model. For DVCS, need DVCS/BH model as well as exclusive pi0 model. For SIDIS, need pi0 exclusive, pi0-Delta, and SIDIS models. I have codes to fit world data that I can share with others who want to get a jump on this.

Step 13: Systematic Errors

Study things such: sensitivity to Cuts, stability of rates and peak positions, agreement of phi* moments at different energies after correcting for kinematic factors, as well as basic sanity checks such as using waveform or on-line cluster routines, etc. In other words, is there anything that makes a difference to the final answers that shouldn’t?

Repeat as needed

Go back and repeat steps as needed, noting that the Steps are not necessarily chronological, and some steps may be considered complete before others

In particular, the BSA in pi0 production is relatively insensitive to acceptance cuts, SIMC models, target thickness, etc. Ideal if want to graduate soon.

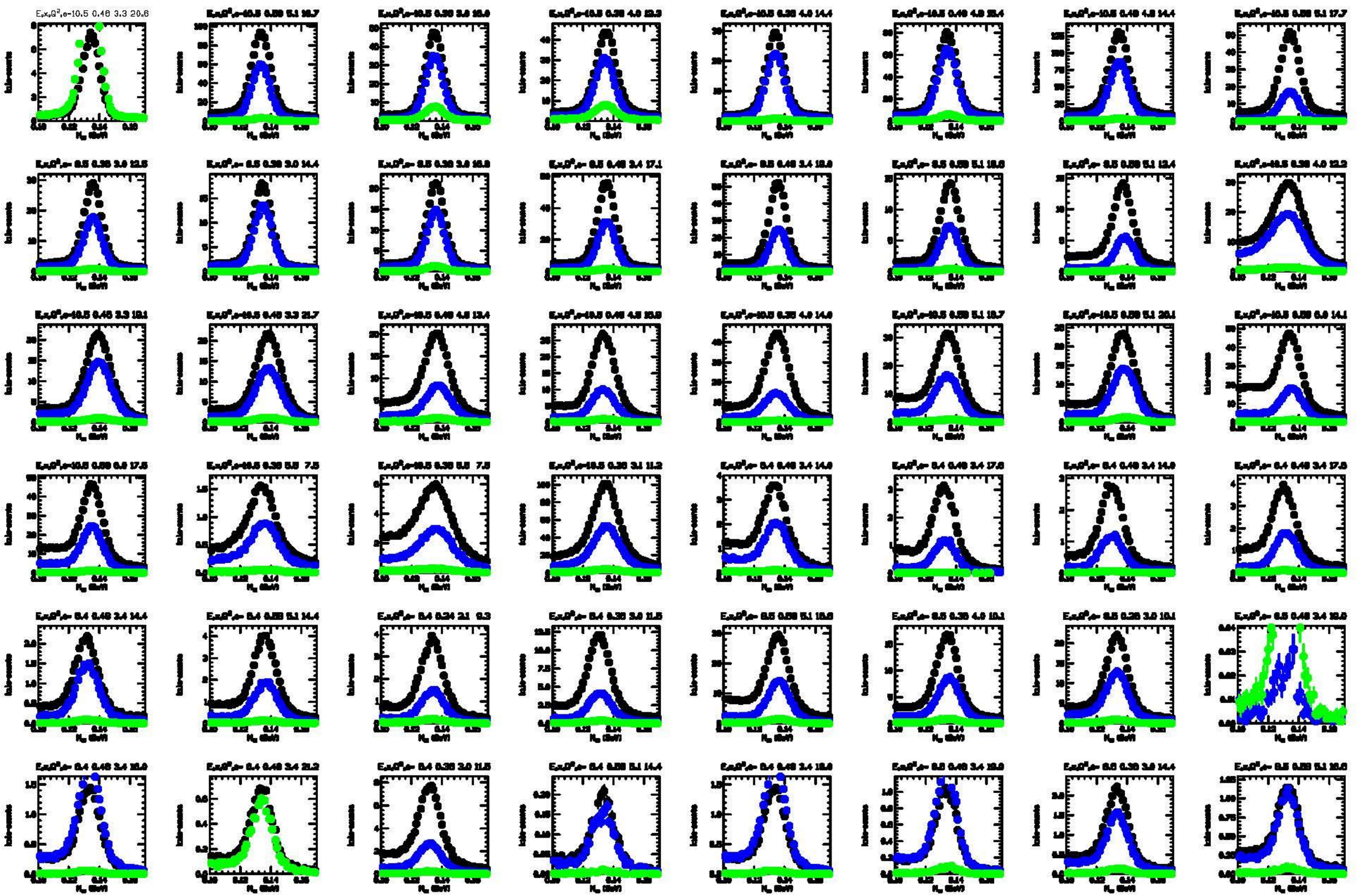
Status of my pi0 analysis

Made “skim” files all production runs
made run list with everything I need in it
Formed 56 (for now) primary Super-runs (SR)
Did rough NPS calibrations each SR
weeded out “bad” runs (don’t agree other in a SR)
Checked pi0 mass and epi0 missing mass peaks
worked on models for SIMC
wrote code to generate SIMC input files
Studied LH2 problem using SIDIS ratio p/d

What’s a talk without a plot?

Gamma-Gamma mass for primary super-runs
Black: ND2
Blue: LH2
Green: Dummy

Peaks all centered at 0.135 GeV
Width fairly constant over 8 months
Background varies with setting. Worse for larger NPS distance from target



Another plot: SIDIS z distributions

Kilo counts vrs SIDIS z for primary super-runs

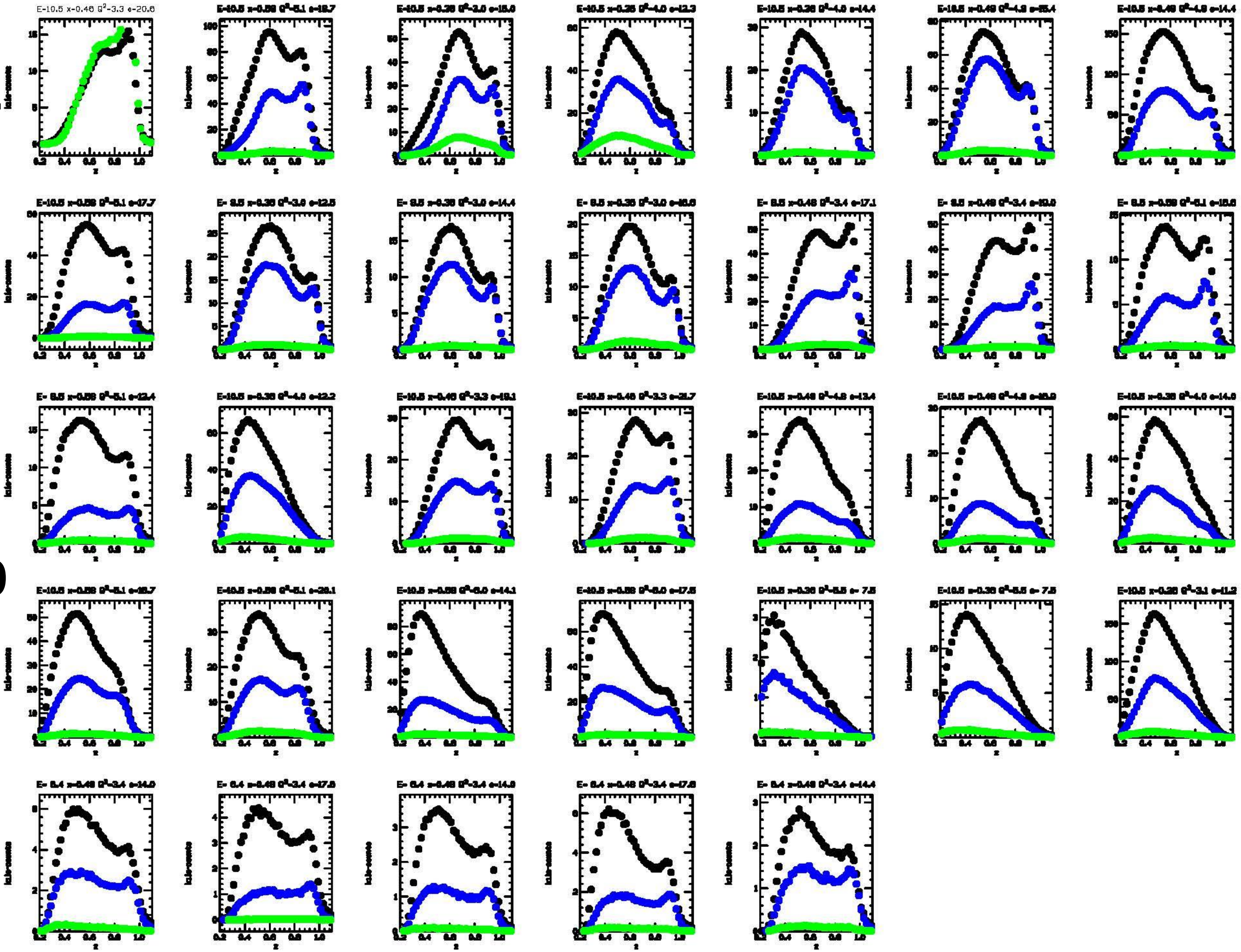
Black: ND2

Blue: LH2

Green: Dummy

Peaks near z=1 as expected for exclusive pi0 reaction

Exclusive peak relatively big at hig x, small at low x

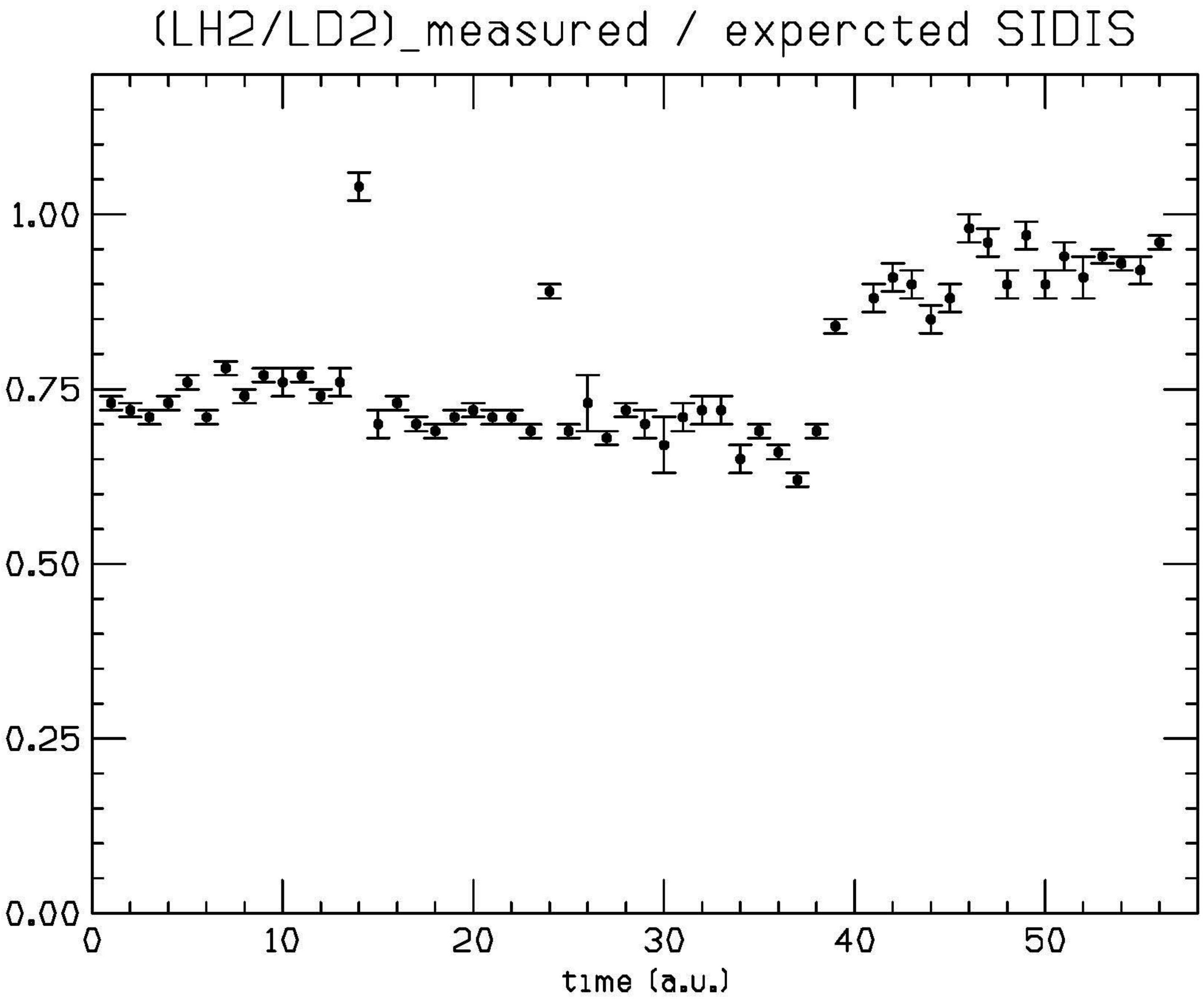


Study of LH2 depletion using SIDIS

VERY preliminary

Assumes SIDIS multiplicity same for proton and neutron. No radiative corrections. Very rough endcap subtractions. Other corrections needed...

BUT, does support other observations that depletion was much less at the end of the run.



Study of background under pi0 mass peak

Harut Avakian shared LUND/PEPSI Monte Carlo outputs for 10.6 GeV electrons on both proton and neutron.

I used these files to generate expected rates for the SIDIS proposal.

Files can also be used to generate shape of background under pi0 mass peak, arising from photons from two different pi0s in the same event (so in time with each other).

I can help anybody who's interested in learning how to use PEPSI output files (it's a bit tricky).

that may not be on master list yet

Non-linearity correction to NPS photon energies
Luminosity dependance of photon energies
Optimal treatment of nearby clusters in NPS
Matching VTP threshold to true energies
Study of ep elastic and p-e elastic cross sections
Study of ep elastic and p-e super elastic regions
Gather world data together and start on fitting routines
Use BSA versus run to check IN/OUT half-wave plate
Compare BCM1, 2, 4a (I've been using BCM1, maybe bad)