Optics Calibrations

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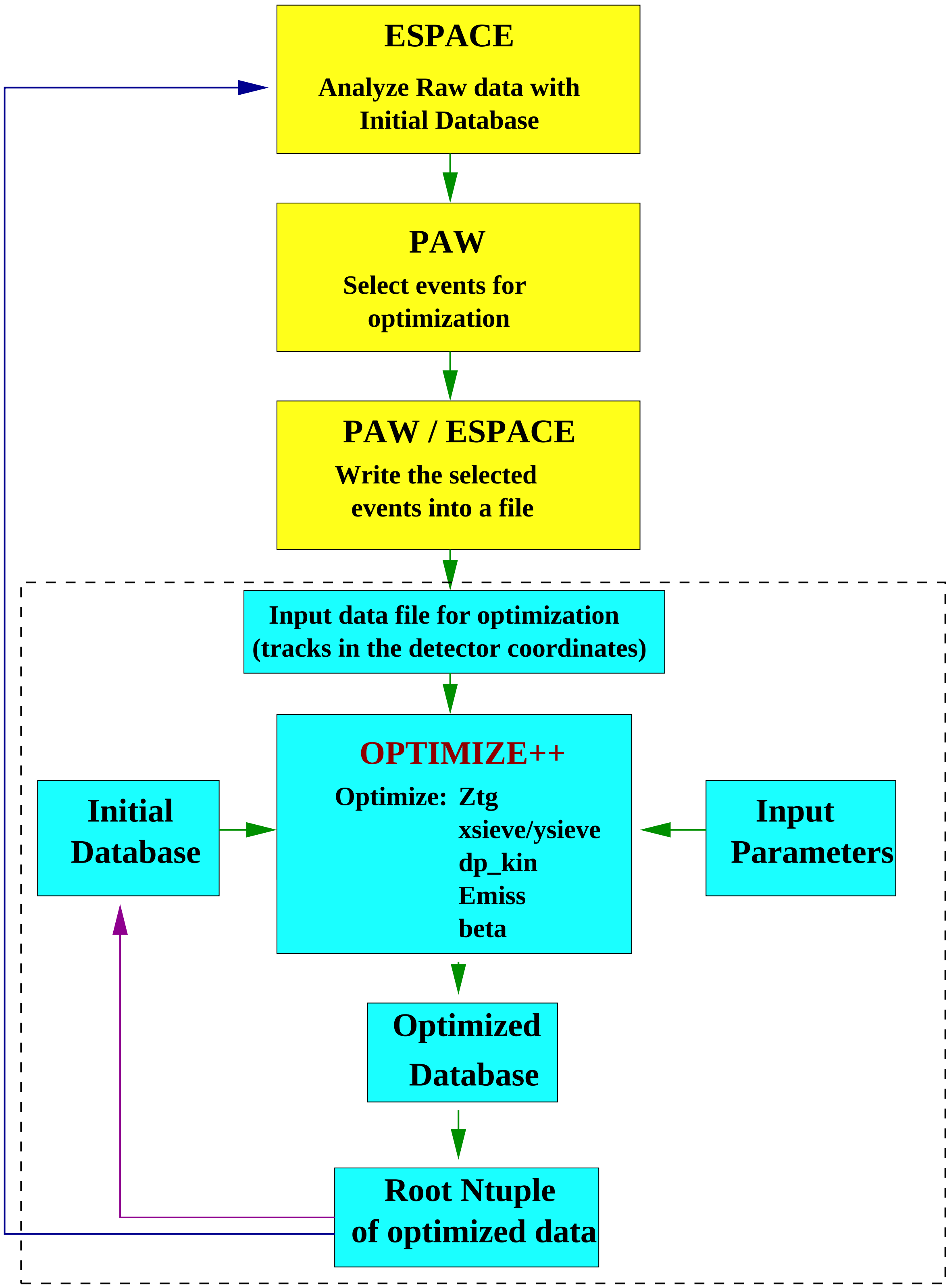
New Database optimization routine: Optimize++

Why do we need something New ?

- Espace optimization routines were written for low energy Mainz experiments: for ^{12}C(ee) data.
- We need something that works at higher energies. Low cross sections exclude ^{12}C(ee).
- Difficult to use: tedious work and time consuming: $\sim$ 1-2 months for a full optimization
- Hysteresis problem forced us to re-do all the optimization.
- New projects ahead: Beyond 4 GeV, Septum, MAD ....

The new code

- Stand alone code.
- Use standard library functions for optimization.
- $\Longrightarrow$ Easy to manage and handle.
- Written in C++
- Will work with new C++ event analyzer.
- Optimizes:
  - $y_t g$
  - Z_{tg} instead of y_{tg}
  - x_{sieve}/y_{sieve} instead of θ_{tg}/ϕ_{tg}.
  - Kimenatically corrected momentum at low momenta.
  - Emiss at high momenta
  - Scintillator offsets (for β and coincidence TOF)
  - Other detector optimizations coming soon.
- Easy to use
- A full optimization in 1-2 weeks.


ESPACE
Analyze Raw data with
Initial Database
PAW
Select events for
optimization
PAW / ESPACE
Write the selected
events into a file
Input data file for optimization
(tracks in the detector coordinates)
OPTIMIZE++
Optimize: Ztg
xsieve/ysieve
dp_kin
Emiss
beta
Initial
Database
Input
Parameters
Optimized
Database
Root Ntuple
of optimized data

Present state of available databases:

- HRS-L
  - 0.4-1.0 GeV
  - 1-4 MeV
- HRS-R
  - 1-3 GeV

Spectrometer Performance Summary

For a thin target, at $E' = 0.85$ GeV

- Angle determination accuracy (relative)
  - Transverse 0.2 mr
  - Dispersive 0.5 mr
- Angle determination accuracy (absolute)
  - Transverse 0.7 mr
  - Dispersive 0.7 mr
- Angular resolution (FWHM)
  - Transverse 2.0 mr
  - Dispersive 6.5 mr
- Momentum resolution (FWHM)

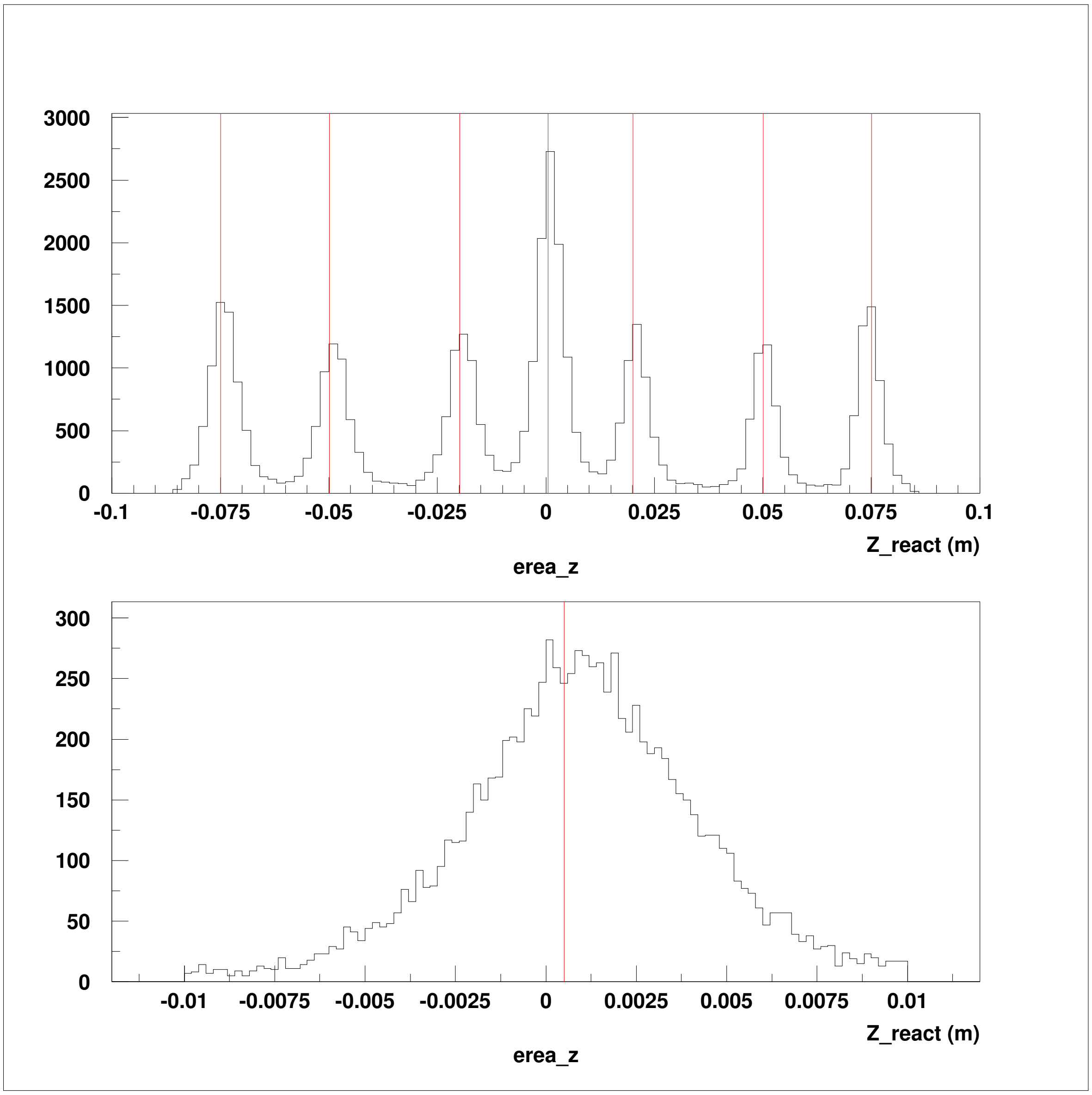
  For $y_{tg} = 0$ 3×10^{-4}

  Overall 4.0×10^{-4}
- Transverse position determination (relative)

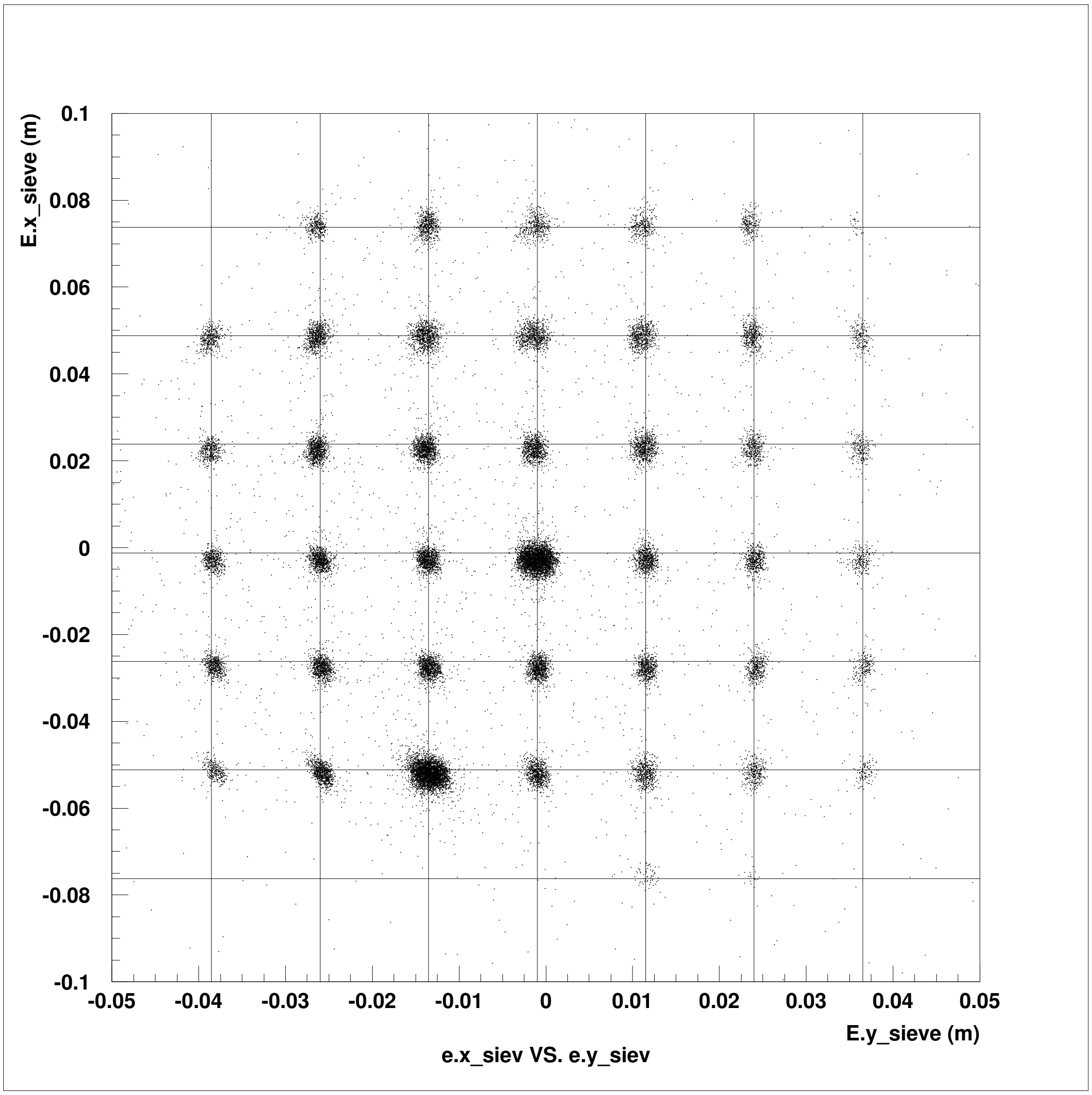
  $\pm$ 0.2 mm
- Transverse position determination (absolute)

  $\pm$ 0.7 mm
- Transverse position resolution

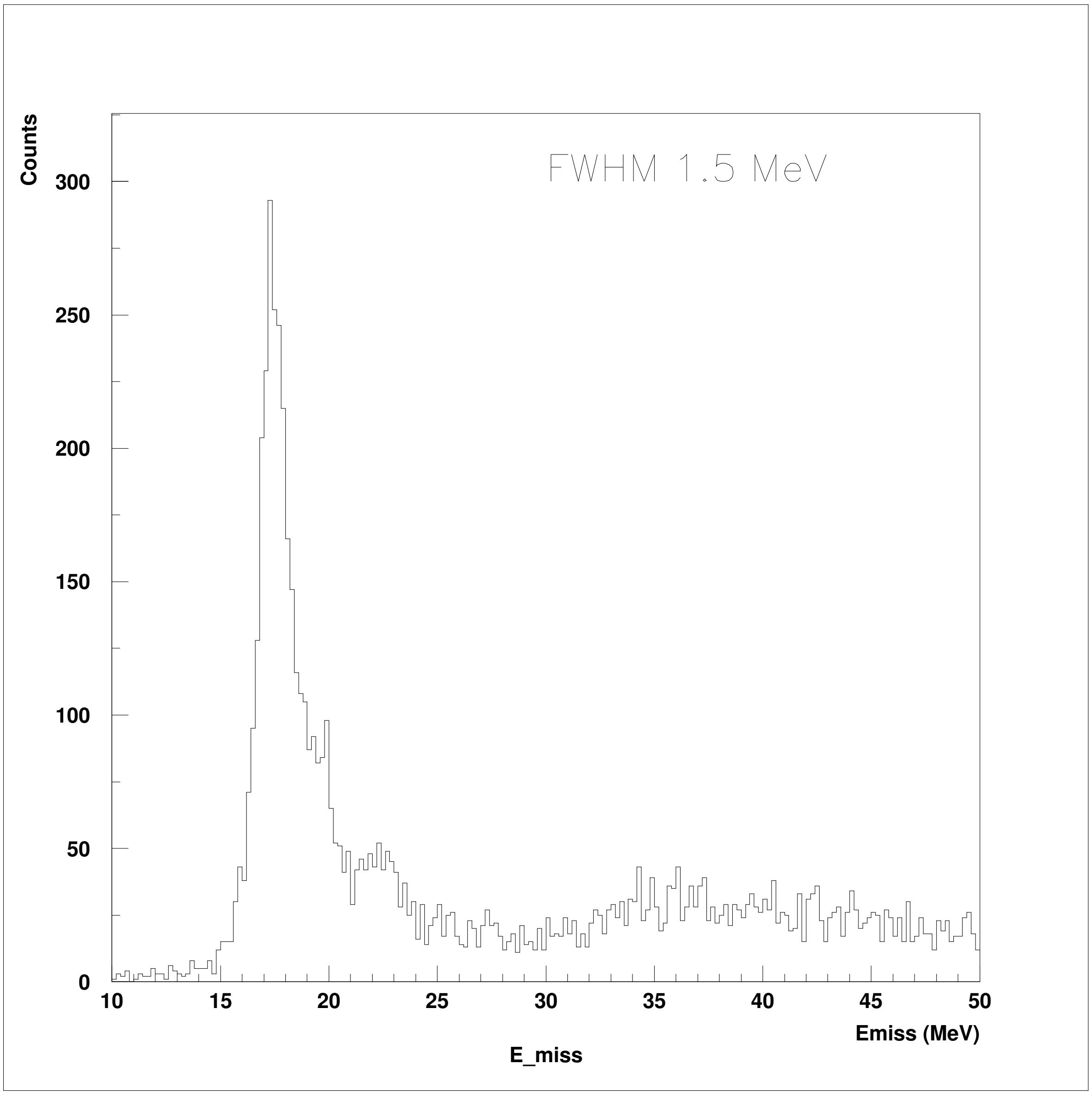
  3.7 mm



HRSE foils target data with $E' = 3.6 GeV$



HRSE sieve image with the H_2 target $E' = 3.6 GeV$


FWHM 1.5 MeV
Counts
0
50
100
150
200
250
300
10
15
20
25
30
35
40
45
50
Emiss (MeV)
E_miss

HRS spectrometer constants

Γ relates the central momentum ($\mathrm{P_0}$) to central magnetic field ($\mathrm{B_0}$).

$$P_0 = \Gamma B_0$$

- Use precise beam energy measurements to calculate spectrometer constants.
- Use ^{12}C(e,e) and ^{12}C(e,e'p) reactions:
  - Not sensitive to angle measurements
  - Negligible energy loss corrections
- Monitored the constants over the full momentum ranges over 15 months.
- Stable well within accuracy ($\sim 5 \times 10^{-4}$)

Spectrometer constants

Date	P (GeV)	Γ_{HRS-L} (MeV/kG)	Method
09/22/99	1.26	270.1 $\pm$ 0.1	^{12}C(e,e) direct
12/06/99	0.84	270.2 $\pm$ 0.1	^{12}C(e,e) direct
10/01/00	0.83	270.2 $\pm$ 0.1	^{12}C(e,e) direct

Table 1: Γ_{HRS-L}.

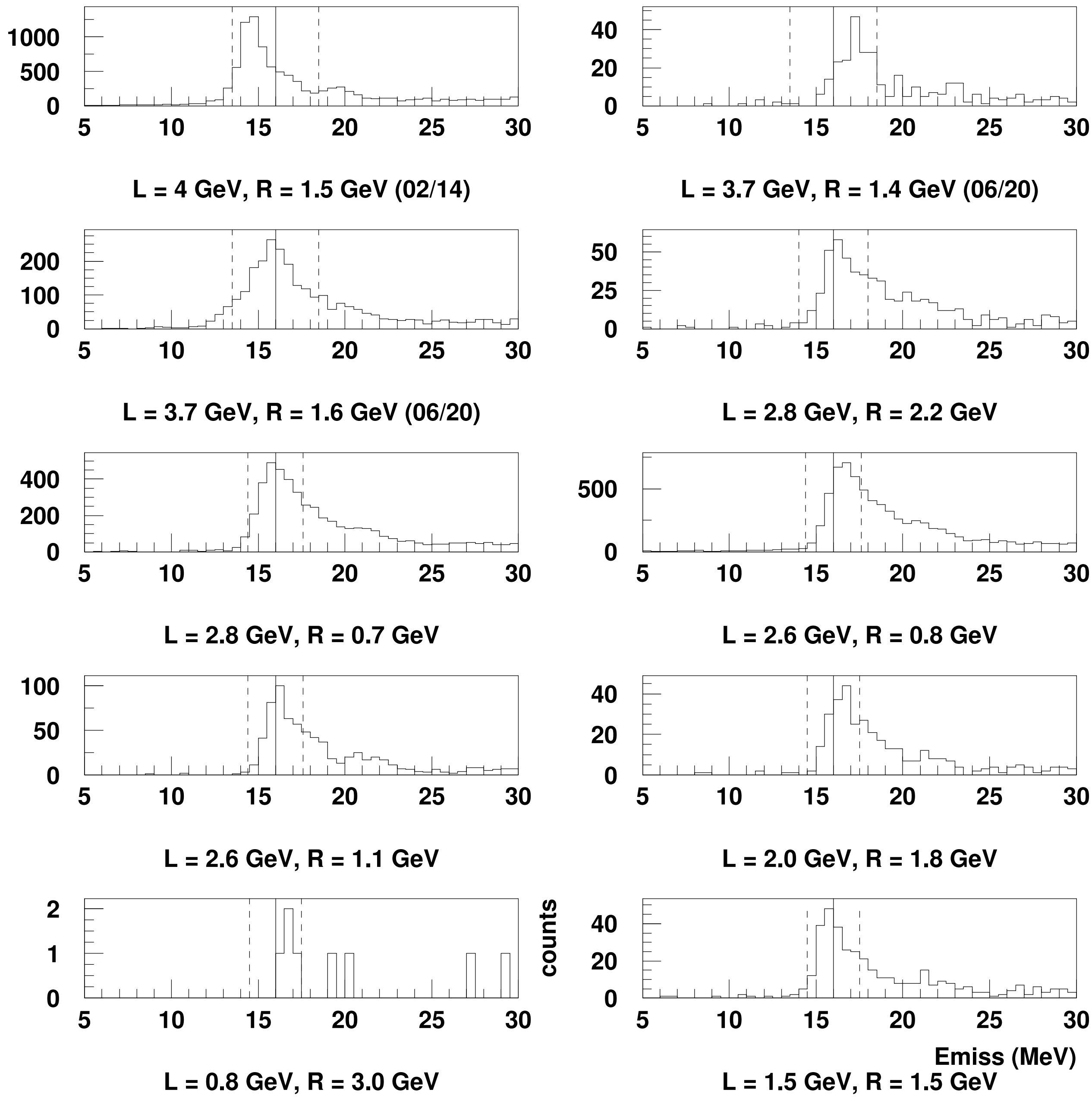
Date	P (GeV)	Γ_{HRS-R} (MeV/kG)	Method
08/12/99	0.86	269.8 $\pm$ 0.2	^{12}C(e,e) indirect
12/06/99	0.84	269.8 $\pm$ 0.1	^{12}C(e,e) direct
10/01/00	0.83	269.9 $\pm$ 0.1	^{12}C(e,e) direct

Table 2: Γ_{HRS-R}.

$$P_0 = \sum_{i=0}^{2} \Gamma_i \mathrm{B}_0^{\mathrm{i}} = \Gamma_0 + \Gamma_1 B_0 + \Gamma_2 B_0^2 + \Gamma_3 B_0^3$$

B_0 in kG

	Γ_0	Γ_1	Γ_2	Γ_3
HRS-L	0.0	270.2 $\pm$ 0.15	0.0	-1.6 E-03 $\pm$ 0.7 E-03
HRS-R	0.0	269.8 $\pm$ 0.15	0.0	-1.6 E-03 $\pm$ 0.7 E-03



^{12}C(e,e'p) E_{miss} spectra

Future

- RCS will collect optics data for HRS-L at 4.1 GeV.
- Completely new calibration with Septa.
- For experiments with standard HRS configuration we have all the optics data.
- BUT
- Detector offsets can change.
- Sometimes “un-explained” changes seen in optics

Optics data needed:

To get offsets

- A five step delta scan of the ^{12}C(e,e) peak.
- Best done at one pass ($E_0 < 1$ GeV)
- Spectrometers at $< 16^o$ in - polarity.
- Sieve slit on both spectrometers.
- No raster, Fast-feed-back on.
- Requires about 1 shift.

If this is not possible

- Quasi-elastic ^{12}C(e,e$'$) data in negative polarity.

Requirements:

- Has to be done during the experiment.
- Survey of both spectrometers.
- BPM-Harp calibration to center the beam

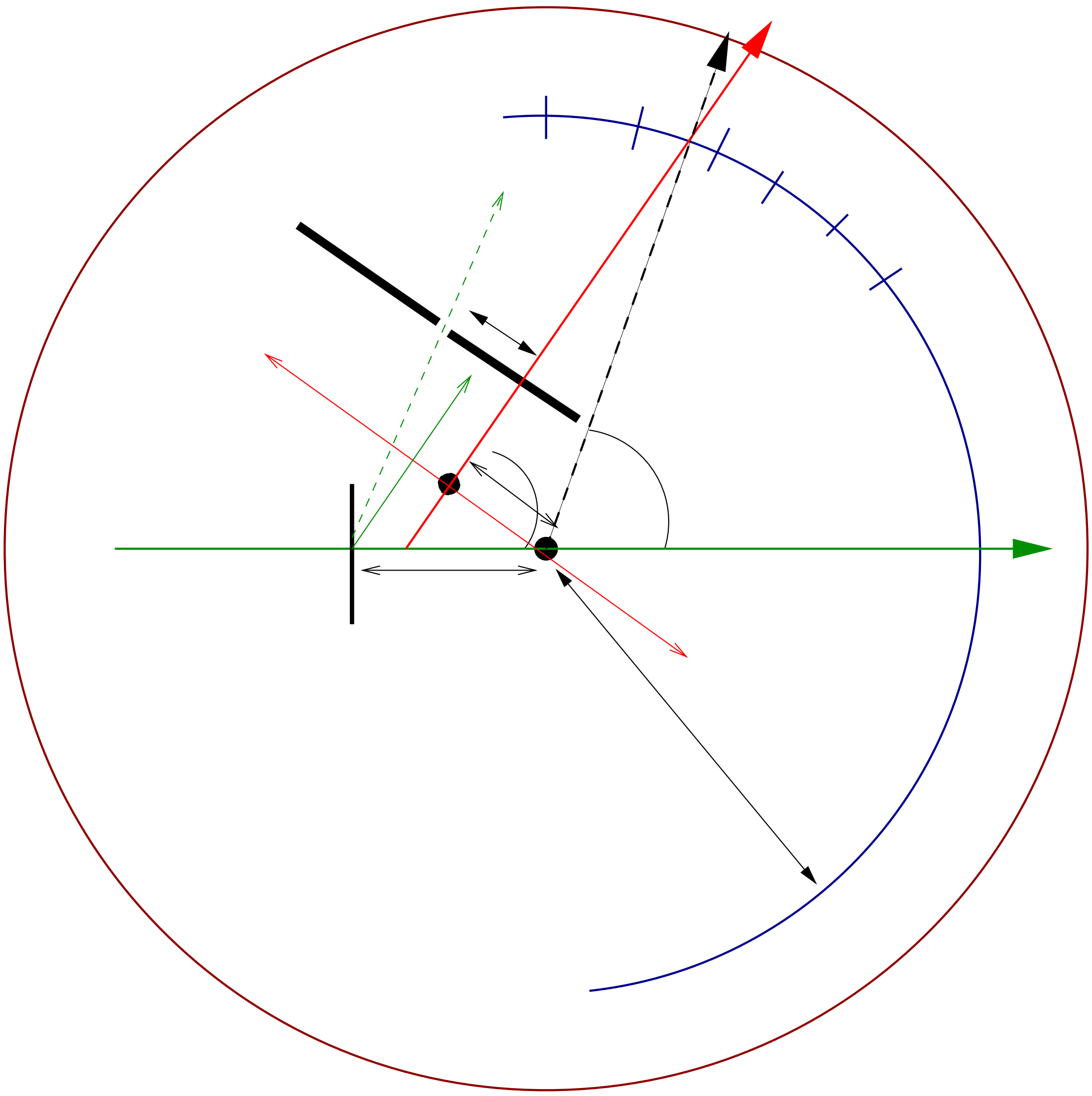
To check optics (and a lot of other things)

- At every setting of each spectrometer take 5 min. of data with the optics target.

.kumac files available for testing optics using this data

Documentation

- "Spectrometer constant determination for the Hall-A High Resolution Spectrometer pair", JLAB-TN-01-049
- "Optics optimization of the Hall-A High Resolution Spectrometer pair", to be published as a JLAB TN
  (rough draft available at
  http://www.jlab.org/ nilanga/physics/optimization.ps)



$$y_0 = \mathrm{Tg}_{off} \times Sin(\theta_e) - \mathrm{Spect}_{off}$$

$$\phi_0 = (\mathrm{Sieve}_{off} - y_0)/1.18$$

$$\theta_e = \theta_e^0 - \mathrm{Spect}_{off}/10$$

How accurate are the absolute angles we measure ?

- Mid plane symmetry violations in HRSH has indicated that the sieve slit might be off by ~ 2 mm.
- But all the surveys so far have given the same number.
- There will be a very detailed survey in August.
- If it is actually 2 mm off, the absolute angles we measure will be about 2 mr off.
- H(eep) data from October showed that $E_0(\theta_e, \theta_p)$ is about 0.7% higher than Arc and EP.
- If HRSE angle was correct, this required that HRSH angle to be off by about 1.5 mrad !!
- We did a detailed study of different H(eep) angle combinations.
- Results coming soon.

Summary

- New Database optimization routine: Optimize++
  - works well and all the other nice things
  - documentation is being developed
- For experiments with current HRS configuration: optics databases available and meet design goals.
- Spectrometer absolute momenta calculated to better than $\sim 5 \times 10^{-4}$.
- Absolute angles known to $\sim$ 0.6 mrad.
- work underway to get this down to 0.2 mrad.
- Need optics data in each experiment to
  - Check Detector offsets.
  - To check optics (and a lot of other things)
- Doug Higinbotham will take over Hall A optics