Suez
and the
Event Display

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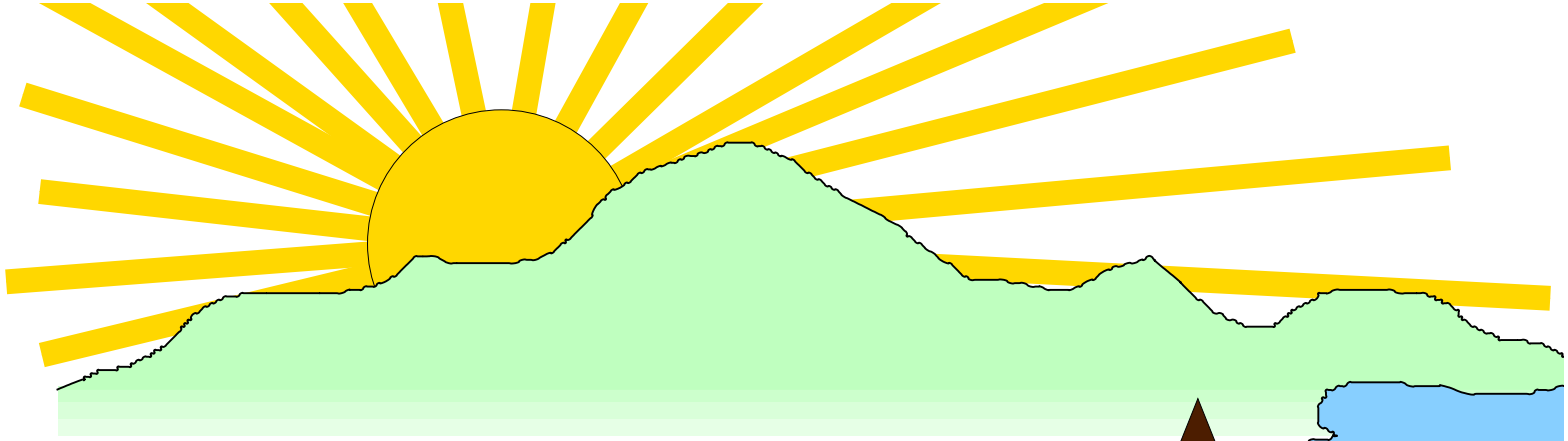
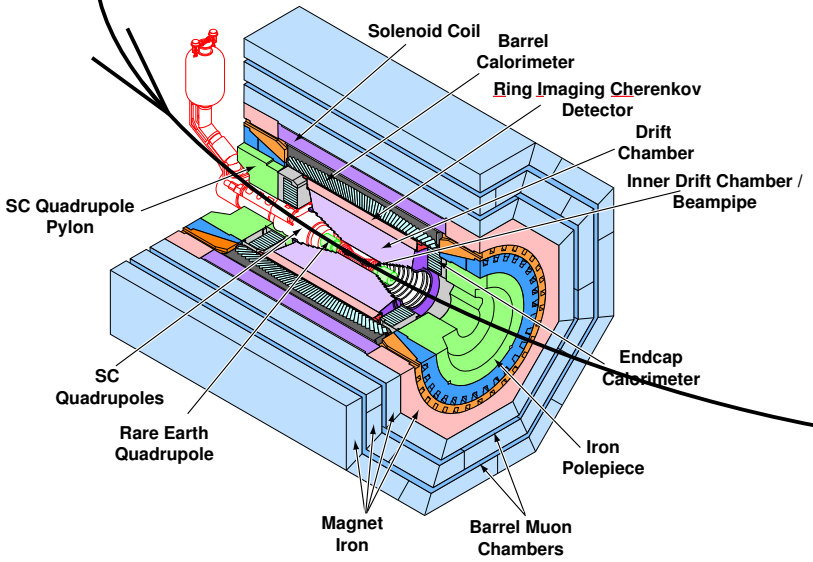


Electrons (negative curvature) go EAST
(negative cos(theta), negative Z)



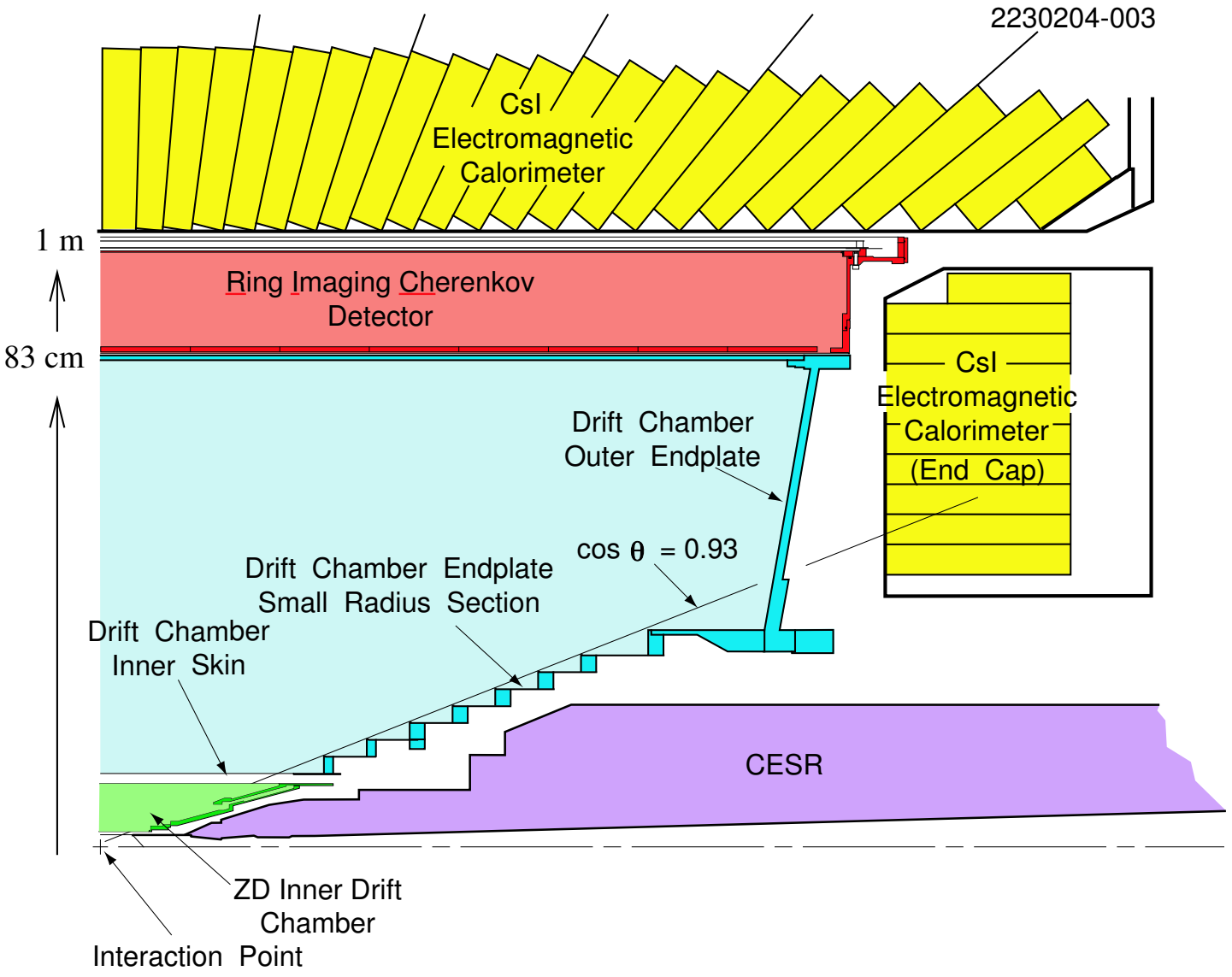
+y (up)

+z (along beamline)

+x (out of the ring)

Positrons (positive curvature) go WEST
(positive cos(theta), positive Z)

Your plaything:



(beamspot is about 3 cm wide in Z, tiny in XY)

What is Suez?

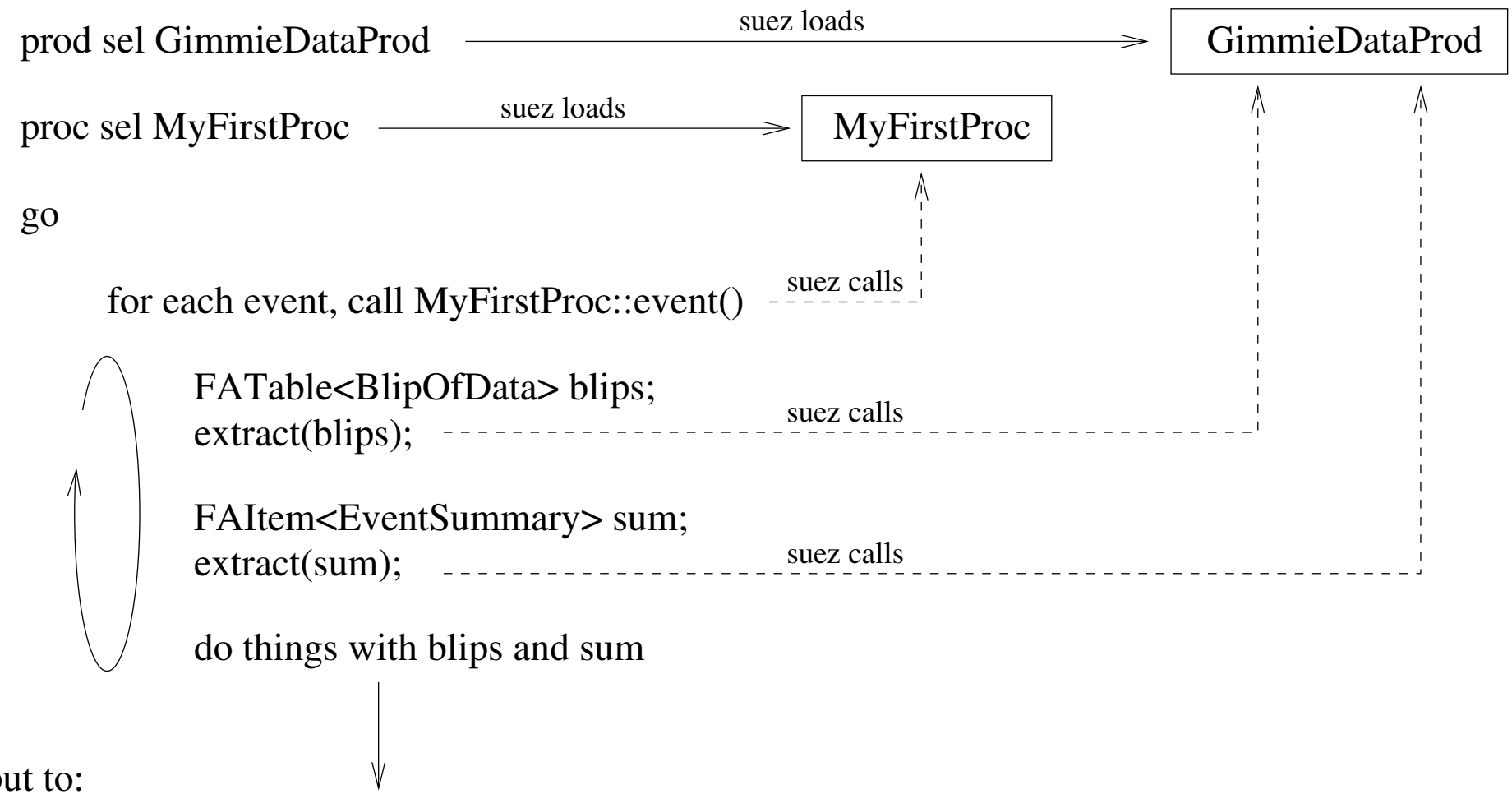
A commandline-driven program that unifies all CLEO code. All CLEO data is accessible inside Suez, and all algorithms can be accessed by dynamically loading modules ("producers").

We will always run Suez as a batch process: we will put all of our commands into a `.tcl` file and run it by

```
suez -f whatever.tcl
```

You will write a "processor" (`e.g. MyFirstProc`) which is C++ code that is executed on every event. In your processor, you will get data with an `extract` command, which executes code in the producers that you dynamically loaded (or crash, if you forgot to do that). The producers might just read the data off the disk and give it to you, or they might do some processing first.

suez −f whatever.tcl



output to:

- logfile, which you can parse with perl or something (slow and lazy)
- HBOOK files (simple and old−fashioned)
- ROOT trees
- private data subset, or list of event numbers

What is the Event Display?

An event-by-event viewer written as a collection of Suez processors (accessible by a single command).

Because everything is dynamically-loadable, you can run your processor AND look at the same events in the Event Display.

It will be most useful to you as a diagnostic: when you can't figure out what's wrong with your plots but you can define selection criteria ("cuts") to pick out the problem events, to see what they look like. It is constantly running during data-taking.

What is HistogramViewerProc?

It's a processor that we'll use to look at histograms while still running over data. Usually, you'll output all of your data in some interactive format (HBOOK, ROOT...) and make your histograms outside of Suez.

"Useful facts" (first page of the exam)

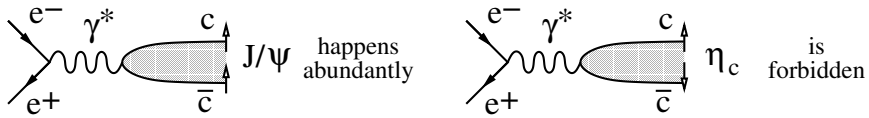
Jackson p. 582 (the useful page):

$$p_T = 3.00 \times 10^{-4}\,(\mathrm{MeV}/c/\mathrm{gauss/cm})\; B \times R$$
$$p_T = 0.3\,(\mathrm{GeV}/c/\mathrm{m}) \times R$$

where $R = 1/2/\mathrm{curvature}$ and $B_{\mathrm{CLEO}} \approx 9.94$ kgauss.

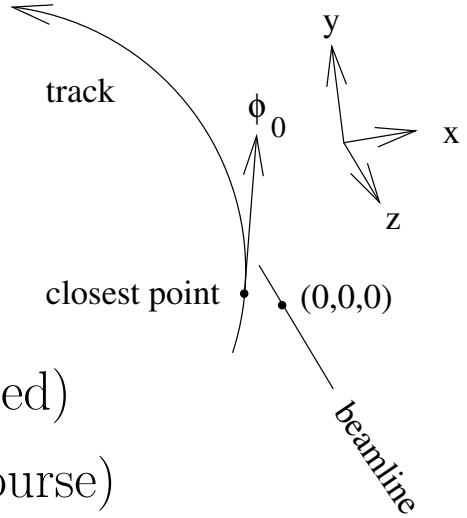
Isotropic (radially-symmetric) decays are uniform in $\cos\theta$.

If no particles are lost or double-counted,

- Total energy is $2 \times$ beam energy
- Total momentum is almost (0, 0, 0) (there's a *small* crossing angle)
- Total charge is zero
- Total angular momentum is $J = 1$: 

Momentum from `trackItr->pionFit()->`

- `momentum()`: a `HepVector3D` ("+" and "∗" do linear algebra)
- `momentum().x()`, `momentum().y()`, `momentum().z()`
- `momentum().mag()`: $|\vec{p}|$
- `momentum().perp()`: p_T (magnitude of projection onto XY)



Track parameters (from `trackItr->pionHelix()->`)

- `curvature()` in m^{-1}: remember the factor of 2!
- `d0()`: distance of closest approach to (0,0,0) in XY plane (signed)
- `z0()`: distance of closest approach to (0,0,0) in Z (signed, of course)
- `phi0()`: angle in XY closest to (0,0,0) (ranges from 0 to 2π)
- `cotTheta()`: $\cot\theta = \dfrac{\cos\theta}{1-\cos^2\theta}$ and $\cos\theta = \dfrac{\cot\theta}{1+\cot^2\theta}$

`http://www.lns.cornell.edu/restricted/webtools/doxygen/Offline/html/classTDTrack.html`
`http://www.lns.cornell.edu/restricted/webtools/doxygen/Offline/html/classNavTrack.html`
`http://www.lns.cornell.edu/restricted/webtools/cleo3/source/other_sources/CLHEP/CLHEP/Vector/ThreeVector.h`
(don't worry about difference between `Hep3Vector`, `HepVector3D`, `HepPoint3D`...)

Stuff from `showerItr->attributes().` (note the dot, rather than arrow)

- `energy()` in GeV
- `phi()` (0 to 2π) and `theta()`: assume shower came from the origin
- `momentum()`: energy in direction ϕ, θ (`Hep3Vector`)
- `hot()`: this crystal is always on, and therefore not to be trusted

Stuff from `showerItr->`

- `noSimpleMatch()`: (boolean) no track came near this shower
- `simpleMatch()`: nearest `FAItem<NavTrack>` to this shower
- `angSimpleMatch()`: angle between shower and track, if there is one

Be careful! Accessing `simpleMatch()` when `noSimpleMatch()` is true will cause a segmentation fault. A `FAItem<NavTrack>` can be used like a `trackItr`:

`showerItr->simpleMatch()->pionHelix()->d0()`, etc.

Also, you'd need `#include "Navigation/NavTkShMatch.h"` in your `.cc` and `TrackShowerMatching` in your `Makefile`'s `CLEO3_LIBS` to use track-shower matching.

`http://www.lns.cornell.edu/restricted/webtools/doxygen/Offline/html/classNavShower.html`
`http://www.lns.cornell.edu/restricted/webtools/doxygen/Offline/html/classCcShowerAttributes.html`

```
#include "CleoDB/DBEventHeader.h"
#include "BeamEnergy/BeamEnergy.h"
#include "BeamSpot/BeamSpot.h"
#include "MagField/MagneticField.h"
```

```
FAItem<DBEventHeader> eventHeader;
extract(iFrame.record(Stream::kEvent), eventHeader);
```
use `evenHeader->run()` and `evenHeader->number()` for run and event numbers.

```
FAItem<BeamSpot> beamSpot;
extract(iFrame.record(Stream::kBeginRun), beamSpot);
```
use `beamSpot->center()` (a HepPoint3D)

```
FAItem<MagneticField> magneticField;
extract(iFrame.record(Stream::kStartRun), magneticField);
```
use `magneticField->BField()`

```
FAItem<BeamEnergy> beamEnergy;
extract(iFrame.record(Stream::kStartRun), beamEnergy);
```
use `beamEnergy->value()`

These require `CleoDB`, `BeamEnergy`, `BeamSpot`, and `MagField` in your `Makefile`.

Very important webpages/places to look for things:

Finding out what member functions are available:

`http://www.lns.cornell.edu/restricted/webtools/doxygen/Offline/html/hierarchy.html`

Looking at the code:

`http://www.lns.cornell.edu/restricted/webtools/cleo3/`

`ls $C3_CVSSRC/` (DON'T TAB-TAB!)

`ls $C3_OTHER/`

Finding out what producer you need to add to your `.tcl`:

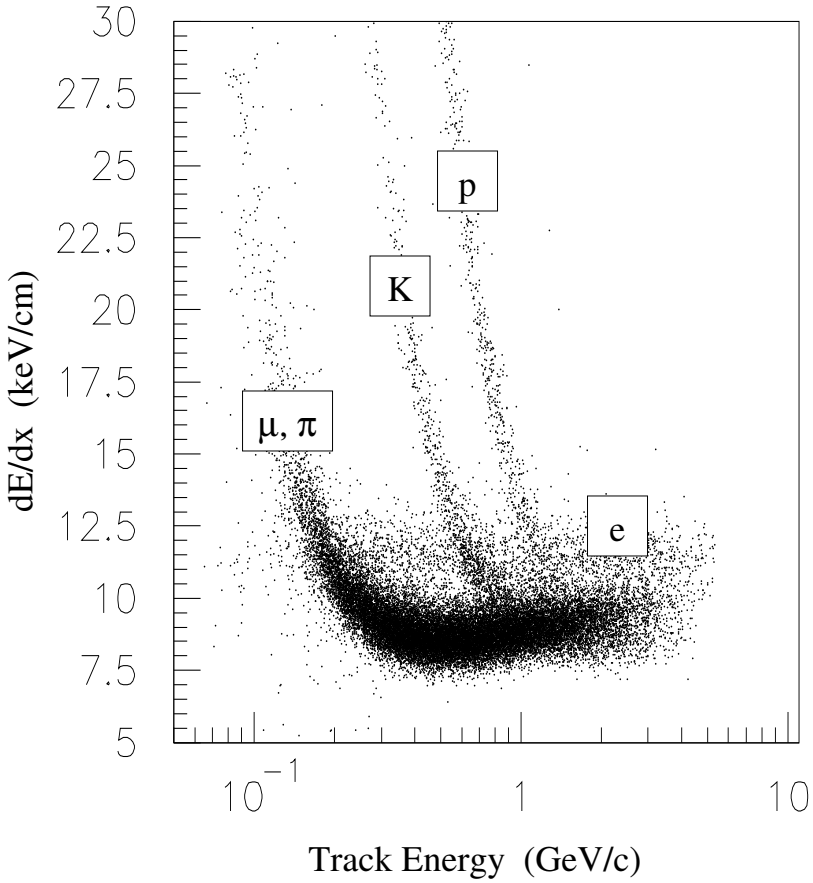
`http://www.lns.cornell.edu/~cleo3/current/data/proxiesOfProducers.txt`

Finding out what cuts have already been applied to your data:

`http://www.lns.cornell.edu/restricted/CLEO/CLEO3/soft/hints/`

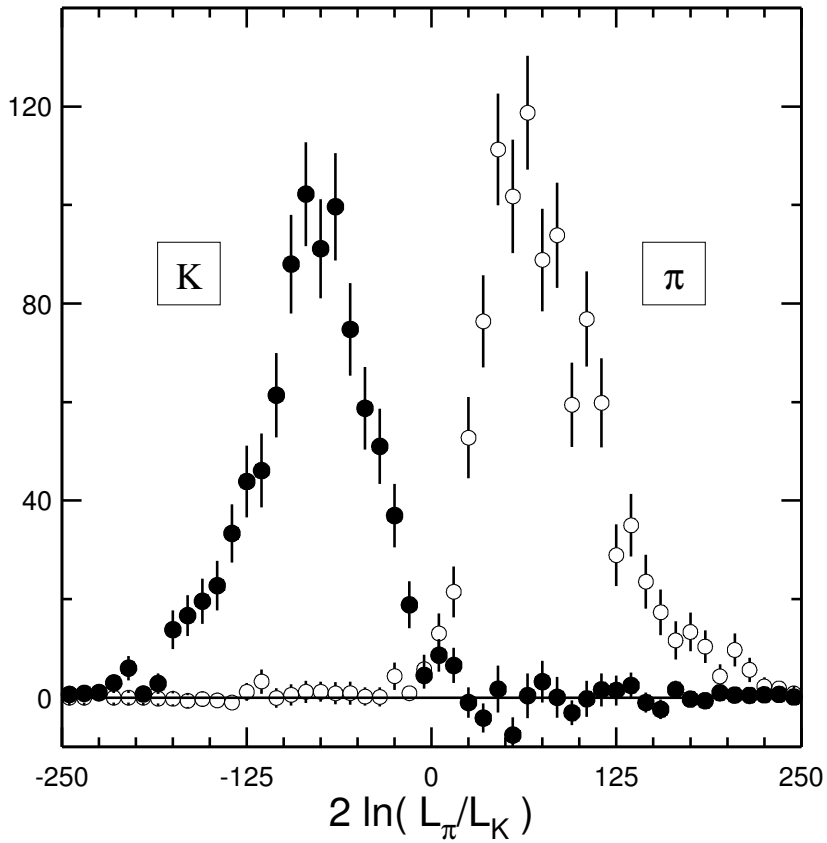
`CLEOIIIEventClassificationDescription.html`

Energy loss in the drift chamber



`trackItr->dedxInfo()`

Ring-Imaging Čerenkov Detector



`trackItr->richInfo()`

Homework (that you do here, not at home)

1. Run the Event Display on hits and everything, and
   a. under View, select Create Info View and see what happens when you select hits and tracks;
   b. select all SeedTracks in the Hierarchy View and make them invisible (under Action menu);
   c. with Set 2D Representation, turn all CCShowerAttributes (showers) into momentum vectors at the origin and KinePionFits (fitted tracks) into momentum vectors originating at their "position," then step through a few events. When a shower clearly belongs to a pair of tracks that made them, why do the arrows sometimes not line up?
   d. Again with Set 2D Representation, turn the CalibratedDRHits into lines from endPoint1 to endPoint2 and look at them in the front and side views. Which ones are the stereo hits? From Select→Select by Data, select CalibratedDRHits with layer number ≥ 17 (stereo).

Homework continued (slightly more difficult, but you should do at least one)

2. Show me an event display of $e^+e^- \to e^+e^-\gamma$, a really dramatic one, with $E_\gamma \sim E_{e^\pm}$. These are rare, so you'll have to make a filtering processor to find them.

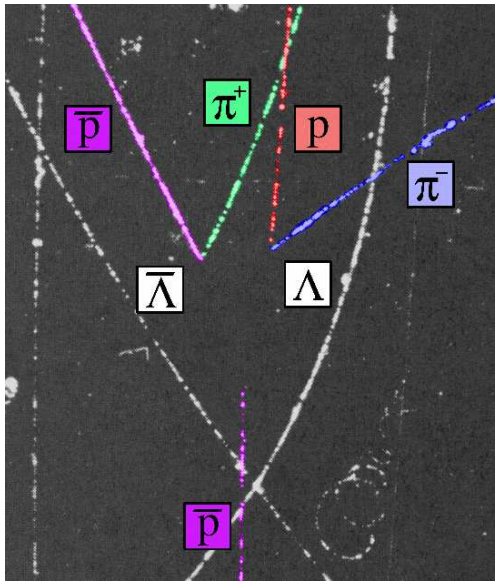
3. Plot $\cos\theta$ of $e^+e^- \to \gamma\gamma$ (and compare Peskin and Schroeder p. 169—I have a copy).

4. The two incident beams don't collide exactly head on, but at a slight angle. Measure this momentum offset (hint: it will be ∼10 MeV). What is the direction of this offset?

5. Plot $\Sigma\, p_z$ for events in which one incident beam hits a gas atom ("beam-gas"). What cuts would identify an event that comes from the beam but not the beam collision point?

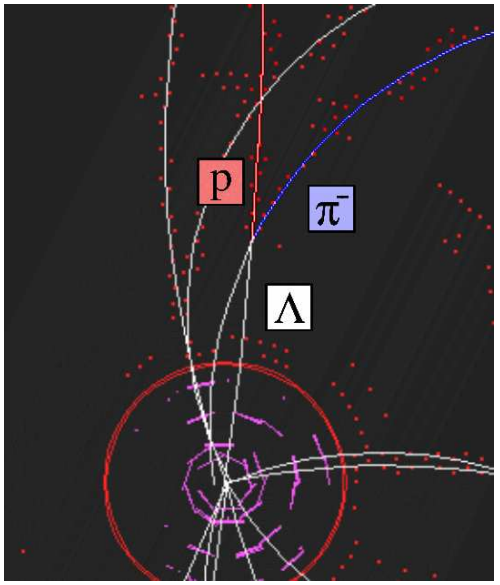
Advanced homework: hunt for strange particles! ($\Lambda \to p\pi^-$ or $K^0_S \to \pi^+\pi^-$)

Hydrogen Bubble Chamber

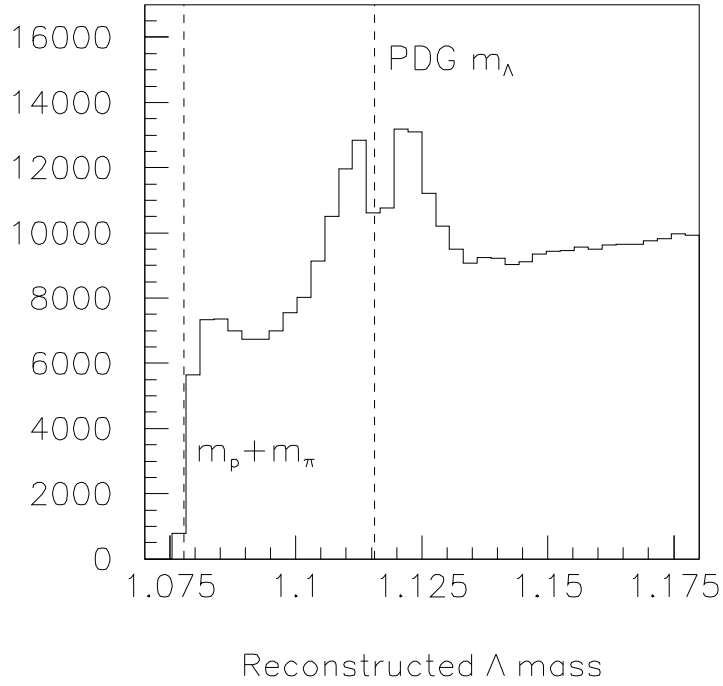


$p\bar{p} \longrightarrow \Lambda\bar{\Lambda}$
$\hookrightarrow \bar{p}\pi^+$
$\hookrightarrow p\pi^-$

CLEO III



$e^+e^- \longrightarrow q\bar{q} \longrightarrow \Lambda$ (+ stuff)
$\hookrightarrow p\pi^-$



1. Find track intersections far from the origin (hint: simplify the tracks as straight lines in XY or something)
2. Reconstruct Λ mass from the two observed tracks (for K^0_S, replace m_p with m_π)

$$m_\Lambda{}^2 = E_\Lambda{}^2 - \vec{p}_\Lambda{}^2 = \left(\sqrt{|\vec{p}_p|^2 + m_p{}^2} + \sqrt{|\vec{p}_\pi|^2 + m_\pi{}^2}\right)^2 - |\,\vec{p}_p + \vec{p}_\pi\,|^2$$

3. What did I do wrong in my plot? Why the double-peak?