

*A Kinematic Fitter for GlueX
and others...*

$$\pi^0 \rightarrow \gamma\gamma$$

GlueX PID Meeting

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Carnegie Mellon University

July 26th, 2007

OUTLINE

- 1 WHAT IS KINEMATIC FITTING?
- 2 HOW DOES IT WORK?
- 3 STATISTICAL MEASURES OF FIT
- 4 THIS VERSION OF THE FITTER

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 - Masses of final state particles?
 - Missing tracks?
 - Intermediate states?
 - Gives you a statistical measure, *confidence level*, for the **entire event** which can be used for making event selection.
- References:
 - *Statistics for nuclear and particle physicists*, Lyons
 - *CLAS NOTE 03-017, GlueX doc 818-v1*, Williams and Meyer

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 - $(E_{\pi^+} + E_{\pi^-})^2 - (\vec{p}_{\pi^+} + \vec{p}_{\pi^-})^2 = M_{K^0}^2$
 - 2 equations of constraint (2C fit)

MECHANICS OF KINEMATIC FITTER

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 - Note that these are in terms of 4-momenta of the tracks.

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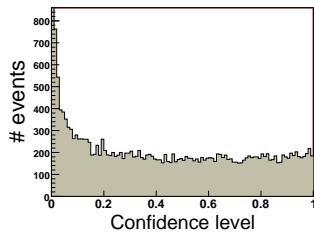
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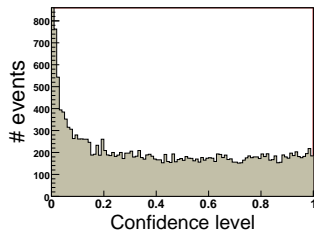
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- It does this with 10 iterations of matrix multiplications.
 - Deterministic process.

CONFIDENCE LEVEL

- Confidence level

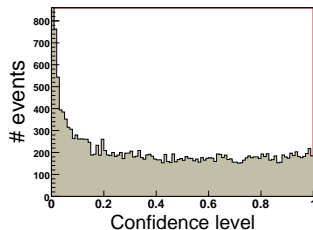


CONFIDENCE LEVEL



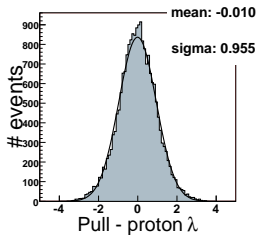
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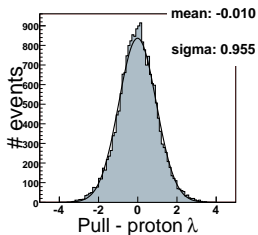
- Confidence level
- Function of χ^2 and number of degrees of freedom.
- This is a small set of CLAS data from the 4C fit ($\gamma p \rightarrow p\pi^+\pi^-$)
- Spike at lower end is indicative of events which do not fit very well to the event hypothesis.
- Can cut on this quantity, usually around 10%.

PULLS



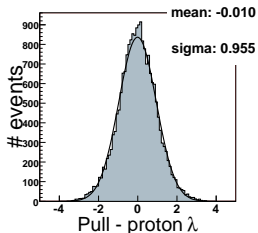
- For a 4C fit, it is also worth looking at the pulls.

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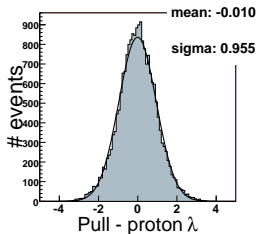
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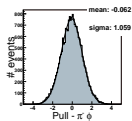
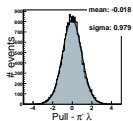
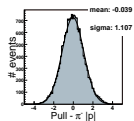
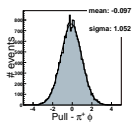
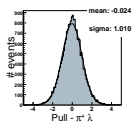
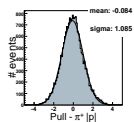
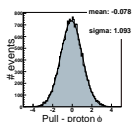
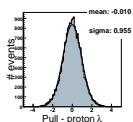
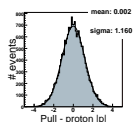
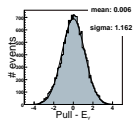
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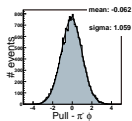
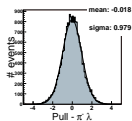
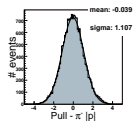
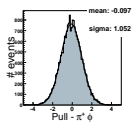
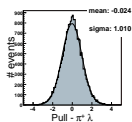
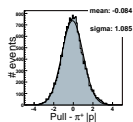
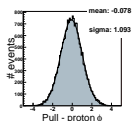
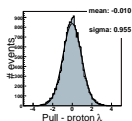
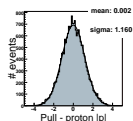
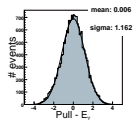
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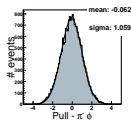
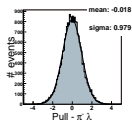
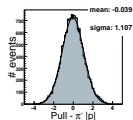
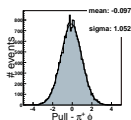
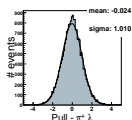
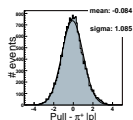
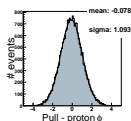
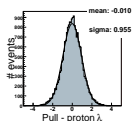
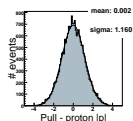
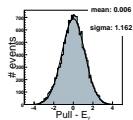
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- Momentum corrections and corrections to the covariance matrix had to be developed.

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- Derived classes:
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- **It is the responsibility of the DKinematicData object author to return the 4-momentum and error matrix in Cartesian coordinates regardless of the local tracking coordinates used.**
- This allows us to keep the kinematic fitter clean and general.

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- So far DKinFit has only been tested with photons reconstructed from FCAL and BCAL.
- Not as general as final version...but good enough for now.
- Let's take a look at how the functions are called by the user...
- If you're not into this type of detail, feel free to zone out for the next few minutes.

RUNNING Fit

- MyProcessor::evt

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    DKinFit *kfit = new DKinFit();
    kfit->SetVerbose(VERBOSE);
}
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- MyProcessor::evnt

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    DKinFit *kfit = new DKinFit();
    kfit->SetVerbose(VERBOSE);

    if(eventLoop->Get(photons))
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    if(eventLoop->Get(photons))
    {
        for(int i=0;i<(int)photons.size();i++)
        {
            kindata.clear();
            kindata.push_back((DKinematicData*)photons[i]);
        }
    }
}
```

RUNNING Fit

- To setup and run the fit.

```
kfit->SetFinal(kindata);  
kfit->FitTwoGammas(0.13498);
```

- `SetFinal` - This sets the photons as the only particles in the final state.
- `FitTwoGammas` - Wiggles the three-momenta of the photons such that the initial state is the sum of their 4-momenta and has an invariant mass of 0.13498.

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- Get the pulls for one of the wiggled quantities.

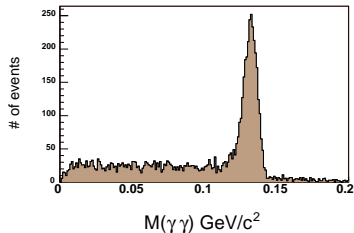
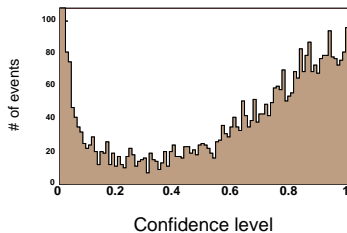
```
kfit->GetPull(i)
```

- *Coming soon!* Map strings for ease of use.

```
kfit->FitTwoGammas("pi0")
```

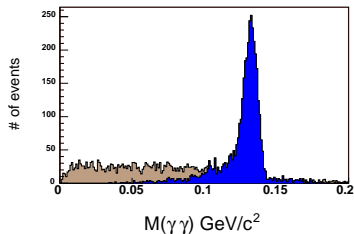
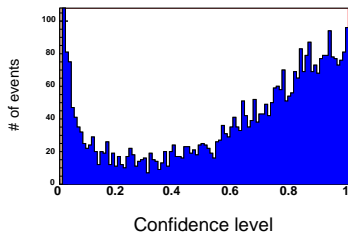

RESULTS OF THE FIT

- We can look at cuts on the CL and effects on the 2- γ mass.



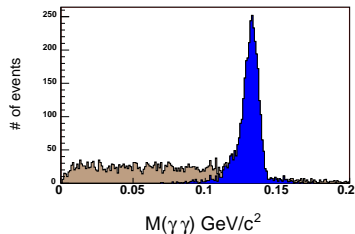
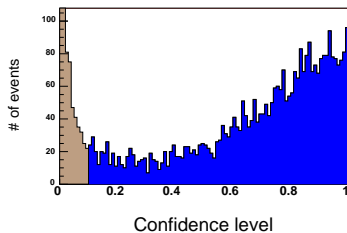
RESULTS OF THE FIT

- CL > 0.01



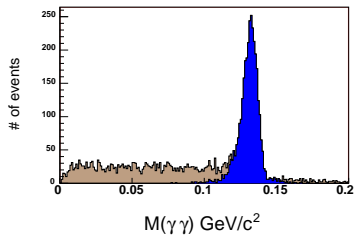
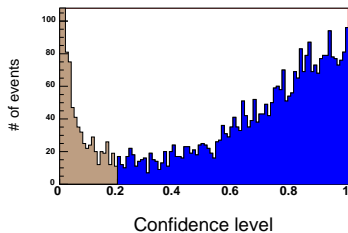
RESULTS OF THE FIT

- CL > 0.10



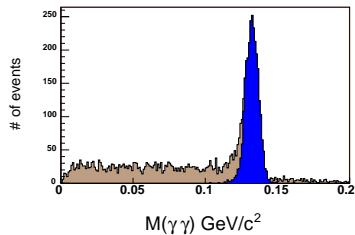
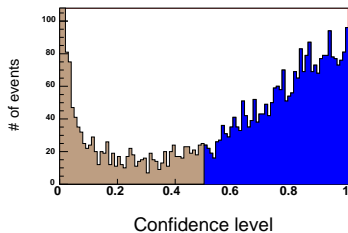
RESULTS OF THE FIT

- CL > 0.20



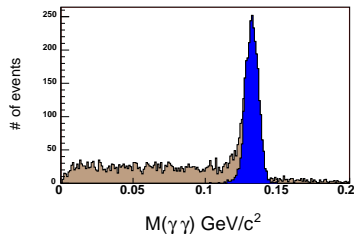
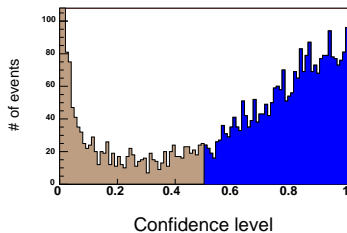
RESULTS OF THE FIT

- $CL > 0.50$



RESULTS OF THE FIT

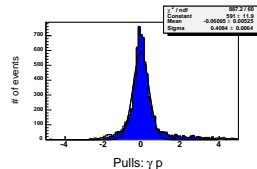
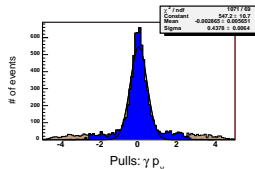
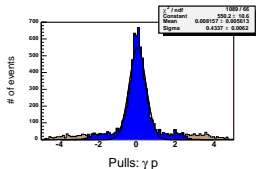
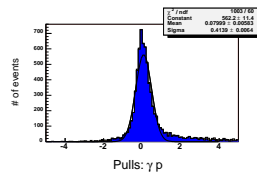
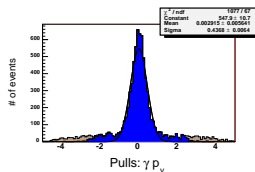
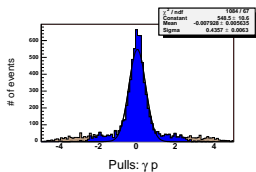
- CL > 0.50



- Note that there is still background under the signal.
- The kinematic fit will *not* remove this background.

RESULTS OF THE FIT - PULLS

- We can look at the pulls for this fit as well.
- Width is too narrow (0.5).



THIS VERSION OF THE FITTER

- Where are we?

THIS VERSION OF THE FITTER

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 - DKinFit checked into Hall-D repository.
 - While it may make sense to check this in to a 12GeV repository, for the time being, I would urge development in this more familiar setting.

THIS VERSION OF THE FITTER

- Where are we?
 - DKinFit checked into Hall-D repository.
 - While it may make sense to check this in to a 12GeV repository, for the time being, I would urge development in this more familiar setting.
 - FitTwoGammas function works!
 - Can start trying this with η 's.
 - Gimme', gimme', gimme'...I need data to push the development of DKinFit.

THIS VERSION OF THE FITTER

- Coming soon...

THIS VERSION OF THE FITTER

- Coming soon...
 - Need better error matrices for FCAL/BCAL.

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 - Charged tracks?

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 - Start checking with other reactions.
 - Check full events.

THIS VERSION OF THE FITTER

- Coming soon...
 - Need better error matrices for FCAL/BCAL.
 - Charged tracks?
 - Start checking with other reactions.
 - Check full events.
 - Coming soon:
 - `SetInitial` - set beam and target and go from there.
 - `ConstrainMasses` - Constrain any number of intermediate state masses.

THIS VERSION OF THE FITTER

- Coming not soon...but not too long...

THIS VERSION OF THE FITTER

- Coming not soon...but not too long...
 - Vertex fitting.

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 - Timing information.
 - Could combine χ^2 from kinematic fit with χ^2 from TOF system.

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 - `PID->GetProbability("proton:pi+:pi-")`
 - `PID->GetProbability("proton:K+:K-:pi0")`

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 - `PID->GetProbability("proton:K+:K-:pi0")`
 - `PID->GetBestProbability("proton:K+:K-:pi0")` - to loop over charge combinations.
 - `PID->GetBestProbability("pi0:eta")`