Subject: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by David Pohl on Wed, 10 Feb 2010 18:21:56 GMT
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Hi everybody,

at the moment I try to investigate the MVD particle identification capabilities. Therefore I study the Lhe track reconstruction efficiency and
the reconstructed momentum resolution for low momentum particles (p < 1 GeV/c). I found out that the reconstruction efficiency is much worse
than it was in the old BaBar framework (p. 47, Physics Performance Report). In order to compare the results I did a simulation with the
same parameters, which are:

- fixed theta = 60
- phi = 0..360
- transverse momentum pt = 0..1 GeV/c
- Lhe ideal track finder and Lhe Kalman track fitting
- 1 primary pions per event with box generator

- standard macros in the tutorials/lhetrack/ folder for STT
- PandaRoot: revision 7731 and external packages: January 2010

The criterion for a successful track reconstruction is that the MC pt value is within the 3 sigma region of the reconstructed pt value.
The following plots show the ratio between successfully reconstructed tracks divided by the total number of tracks as a function of the MC pt:

Physics Performance Report (first); Panda Root (second)

The reconstruction efficiency, especially for low momentum particles, is much worse (200MeV/c: 40% instead of 90%).

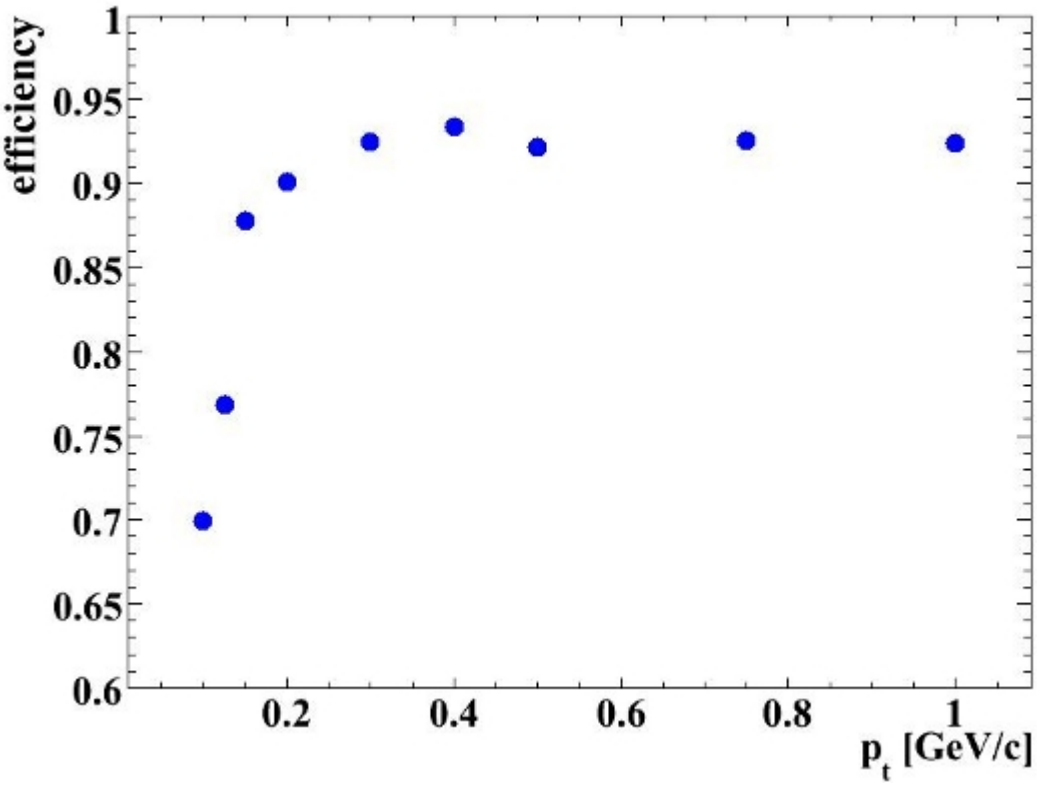
For the momentum error of the reconstructed track in comparison to the MC values I did a simulation with Pions@250 MeV/c:

One can easily see that only under 60% of the entries are in the 3 sigma region of the Gauß Fit. Or the other way round that
the intended momentum resolution of a few percent can only be achieved for 60% of the events. I'm really lost at the moment
due to the fact that so many events cannot be used and the momentum resolution is that bad...
Has anybody any idea?

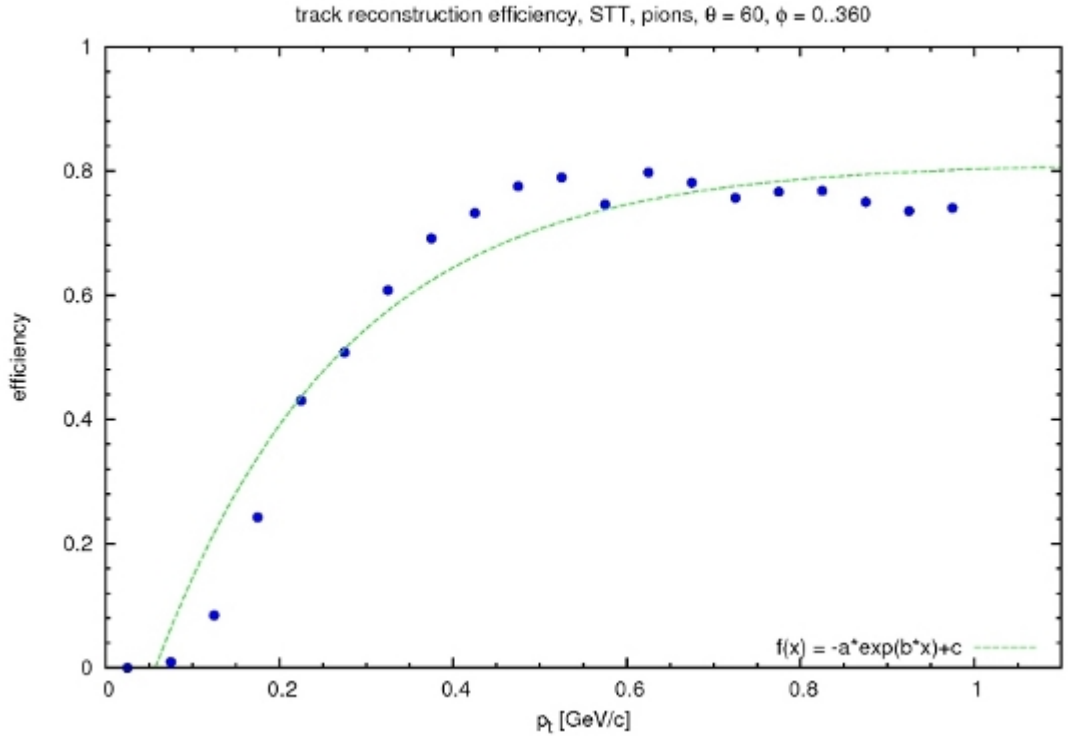
greetings,
David

File Attachments

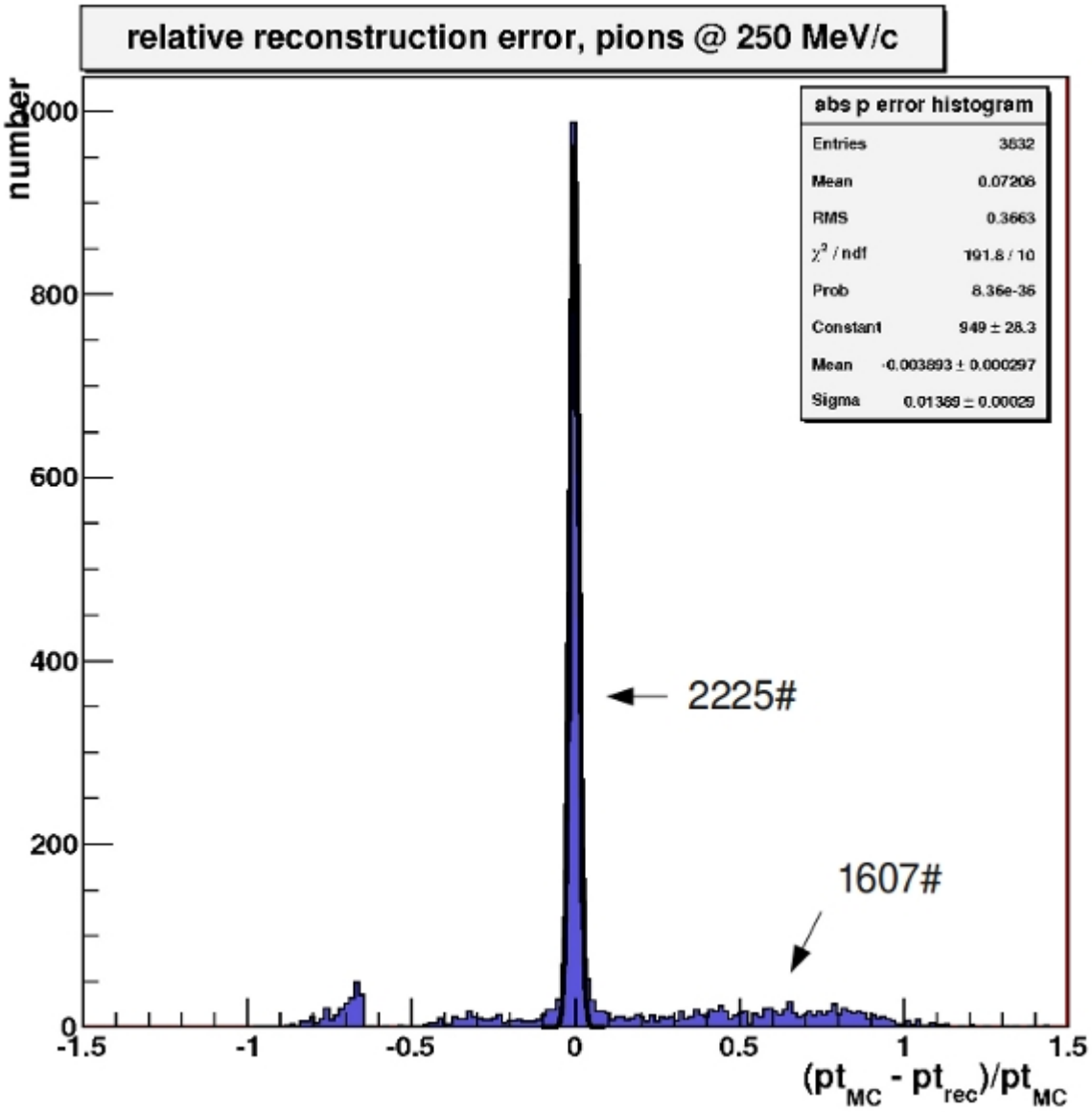
1) report.jpeg, downloaded 2083 times



2) trackefficiency.jpg, downloaded 1977 times



3) 250MeV2.jpg, downloaded 2090 times



Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by StefanoSpataro on Wed, 10 Feb 2010 20:05:29 GMT
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Hello,
this is a feature of the lhe tracking for straw tubes.
The algorythm is mainly designed for 3D points, and for STT one has to do some tricks in order to have a "decent" reconstruction. This results in a lower efficiency, as reported more than one year ago, the same plot that you are showing now. Lhe tracking reaches good performances tpc, while with stt it has this effiency loss, in particular for low momentum tracks.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Gianluigi Boca on Wed, 10 Feb 2010 22:18:20 GMT
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Stefano Spataro wrote on Wed, 10 February 2010 21:05Hello,
this is a feature of the lhe tracking for straw tubes.
The algorythm is mainly designed for 3D points, and for STT one has to do some tricks in order to have a "decent" reconstruction. This results in a lower efficiency, as reported more than one year ago, the same plot that you are showing now. Lhe tracking reaches good performances tpc, while with stt it has this effiency loss, in particular for low momentum tracks.

Naturally this doesn't mean that the STT system is unable to reconstruck tracks.

In a comparison between montecarlo momenta and momenta as obtained by a real Pattern Recognition alone (therefore without all the bonuses of a Kalman filter etc.) I am getting very incouraging results after all the improvements recently added to the code.
I will speak about this in 2 weeks as promised today.

Gianluigi

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Johan Messchendorp on Wed, 10 Feb 2010 22:49:39 GMT
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Hi all,

I guess what is important to discuss here is to what level we can compare the pandaroot outcome to the results presented in the physics performance book. As far as I understood, the track efficiency in the physics performance book were obtained from a very idealized Monte Carlo pattern recognition which is significantly different than what is used in pandaroot. Although, I don't understand anymore what "Lhe ideal track finder" now really means?! Maybe Stefano can explain this in more detail. Well, the final aim is to get as close as possible to the idealized results presented in the physics performance report, but we are not there yet since reality is not that simple and requires some time-consuming investigations. Gianluigi is one of the key persons working on that and he achieved already promising improvements on this front. A few questions to David which would interest me:

could you compare the efficiencies before and after the Kalman fitting?
...and do a similar analysis with the TPC as replacement for the STT?

Best wishes and thanks in advance,

Johan.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by StefanoSpataro on Wed, 10 Feb 2010 23:21:11 GMT
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Hi,
LHE ideal track finder is an ideal track finder (no conformal mapping) inside lhe package

However, the SttHelixHit are coming from the (realistic) STT helix fit. This means that, if for some reason the stt helix fit failed, lhe will have no hits (or maybe wrong hits), and the track will be simply lost. This effect is more pronounced at low momenta, were for some unknown reason the Z coordinate had systematic deviations.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Johan Messchendorp on Wed, 10 Feb 2010 23:30:36 GMT
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Stefano Spataro wrote on Thu, 11 February 2010 00:21Hi,
LHE ideal track finder is an ideal track finder (no conformal mapping) inside lhe package
However, the SttHelixHit are coming from the (realistic) STT helix fit. This means that, if for some reason the stt helix fit failed, lhe will have no hits (or maybe wrong hits), and the track will be simply lost. This effect is more pronounced at low momenta, were for some unknown reason the Z coordinate had systematic deviations.

Ok, now I understand. As a proof of principle, would it be possible to have the option to take the MC-matched PndSttHits, which are - I guess - before the helix fit? I am trying to see whether we would could provide easily a more efficient track efficiency, albeit less realistic.

Johan.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by StefanoSpataro on Thu, 11 Feb 2010 06:47:08 GMT
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As I as writing before, lhe is based in 3D points -> XYZ.
In the case of SttHit this information is not available, and the helix fit transforms straw hits into point of closest approach to the central wire, used by lhe for the finding.
Maybe one could write an "ideal" stt helix hit producer, which does not take the reconstructed PCA but the MC point -> points for the finder, hits for the fitter.
But I am not so sure if this is want we want/need.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Johan Messchendorp on Thu, 11 Feb 2010 08:47:42 GMT
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Stefano Spataro wrote on Thu, 11 February 2010 07:47As I as writing before, lhe is based in 3D points -> XYZ.
In the case of SttHit this information is not available, and the helix fit transforms straw hits into point of closest approach to the central wire, used by lhe for the finding.
Maybe one could write an "ideal" stt helix hit producer, which does not take the reconstructed PCA but the MC point -> points for the finder, hits for the fitter.
But I am not so sure if this is want we want/need.

I see. In any case we need to understand what the origin is of the loss in efficiency. I understand that most probable it is related to the (x,y,z) reconstruction for the STT that

troubles the helix fit. It would, nevertheless, be nice to confirm it in some way or the other. What about comparing directly with the track finding code of Gianluigi? That is available now and should be easy to do, right?

Greetings,

Johan.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by StefanoSpataro on Thu, 11 Feb 2010 09:05:48 GMT
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Lhe tracking does not substitute stt pattern recognition, but it runs after. It requires an already existing stt stand-alone tracking.
After stt pattern recognition, once you have a stt helix, then you use lhe to merge helixhit together with mvd and gem. This means that you are running two patern recognition algorythm, and two fits. Of course, if each algorythm has an efficiency of 0.9, the combined efficiency will be 0.9*0.9 -> 0.8. And you have to add the Z problem of the helix hit producer, which decreases the efficiency again.
For tpc one has only one pattern recognition, therefore the efficiency is higher. And there is no pre-pre-fit.

In this sense, the comparison cannot be straightly done, and one has to invent something different.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by David Pohl on Thu, 11 Feb 2010 09:43:23 GMT
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Wow, you're answering fast. Ok, of course I did the same analyses with the TPC. The track reconstruction
efficiency is better like you said. It goes up to 90%, but expecially in the low momentum range you can see
the same behavior.

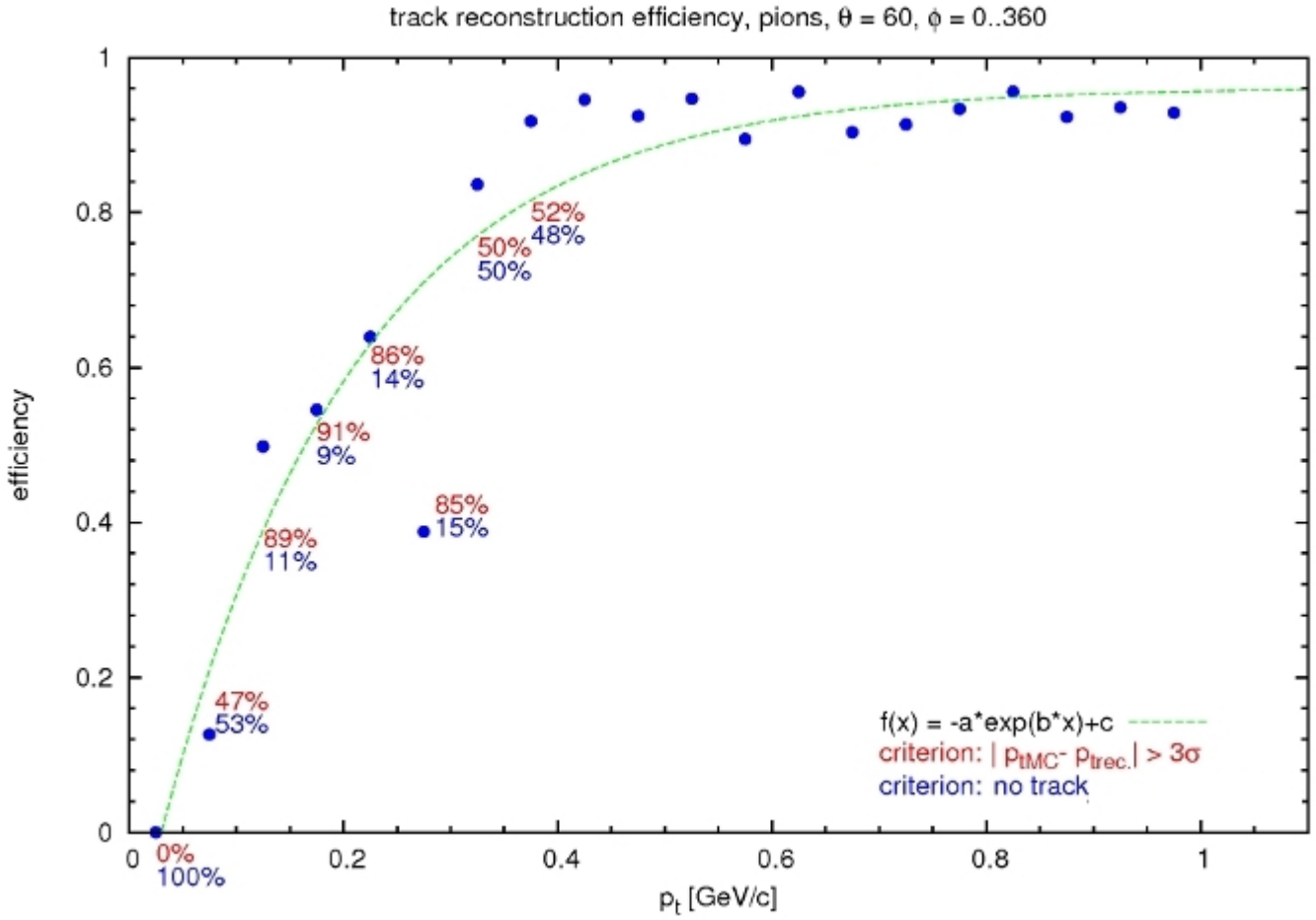
MVD+TPC+GEM, standard macros in tutorial folder

The blue criterion means that no track is produced. Very low momentum pions decay before a detector
is reached and as a result to less points (<3 MVD+TPC hits) are created for tracking. So this is should be
just a physical reason.

greetings,
David

File Attachments

1) trackefficiency2.jpg, downloaded 1618 times



Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by StefanoSpataro on Thu, 11 Feb 2010 10:05:47 GMT
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Once you go to lower momenta, energy loss plays a more important role and the track is not anymore a helix. Lhe is based on "helix" tracks, then you lose efficiency.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by David Pohl on Thu, 11 Feb 2010 10:15:50 GMT
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So and as a result LHE cannot be used for low momenta?

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by StefanoSpataro on Thu, 11 Feb 2010 10:20:02 GMT
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As result, lhe has a lower efficiency for lower momenta, but it can be used (with tpc). Below

200 MeV you can forget to have nice results.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by StefanoSpataro on Thu, 11 Feb 2010 11:49:22 GMT
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Hi,
I have added a new option in the LheHitsMaker.
If you set SttMode(4) instead of 3, then you will use stt helix hit but BUT with position taken from MC points (and not from the helix fit). In this case you will be independent from a "wrong" helix fit in stt tracking.
Finally, the kalman will use the stt helix hit with the realistic signal (not mc points).

Could you please update lhetrack from svn, use Stt mode 4, recheck the numbers and see if the efficiency goes up?

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by David Pohl on Thu, 11 Feb 2010 13:22:31 GMT
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hi Stefano,

I did the simulation again with your changes. In the region between 150-350 MeV/c the reconstruction
efficiency is much better:

STT reco efficiency with and without helix fit

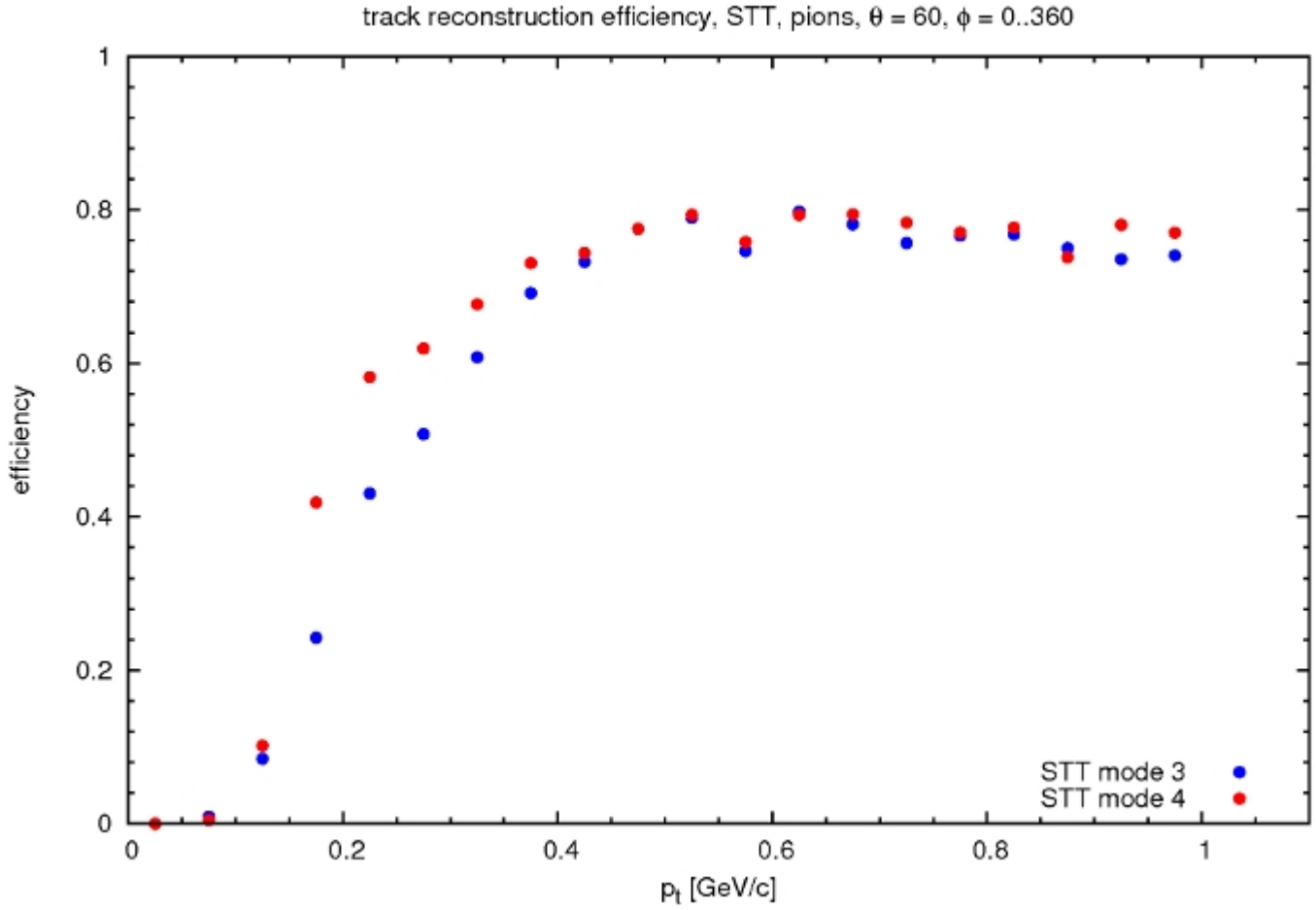
Ok, if you say that the reconstruction efficiency is that bad due to the higher energy loss in the low momentum
region I can understand this. The helix should look more like a spiral and this leads Lhe to fail, right?
But the other thing is how to identify if a track fit is good. When you look at the third picture in my first post,
you can see that I have a lot of background (error > 3 sigma, 40% events). These events cannot be used for PID.
I thought that the Chi square of a PndTrack should be a good indication for the goodness of the momentum
resolution but sadly the values are not correlated:

Chi Square, p is transverse momentum

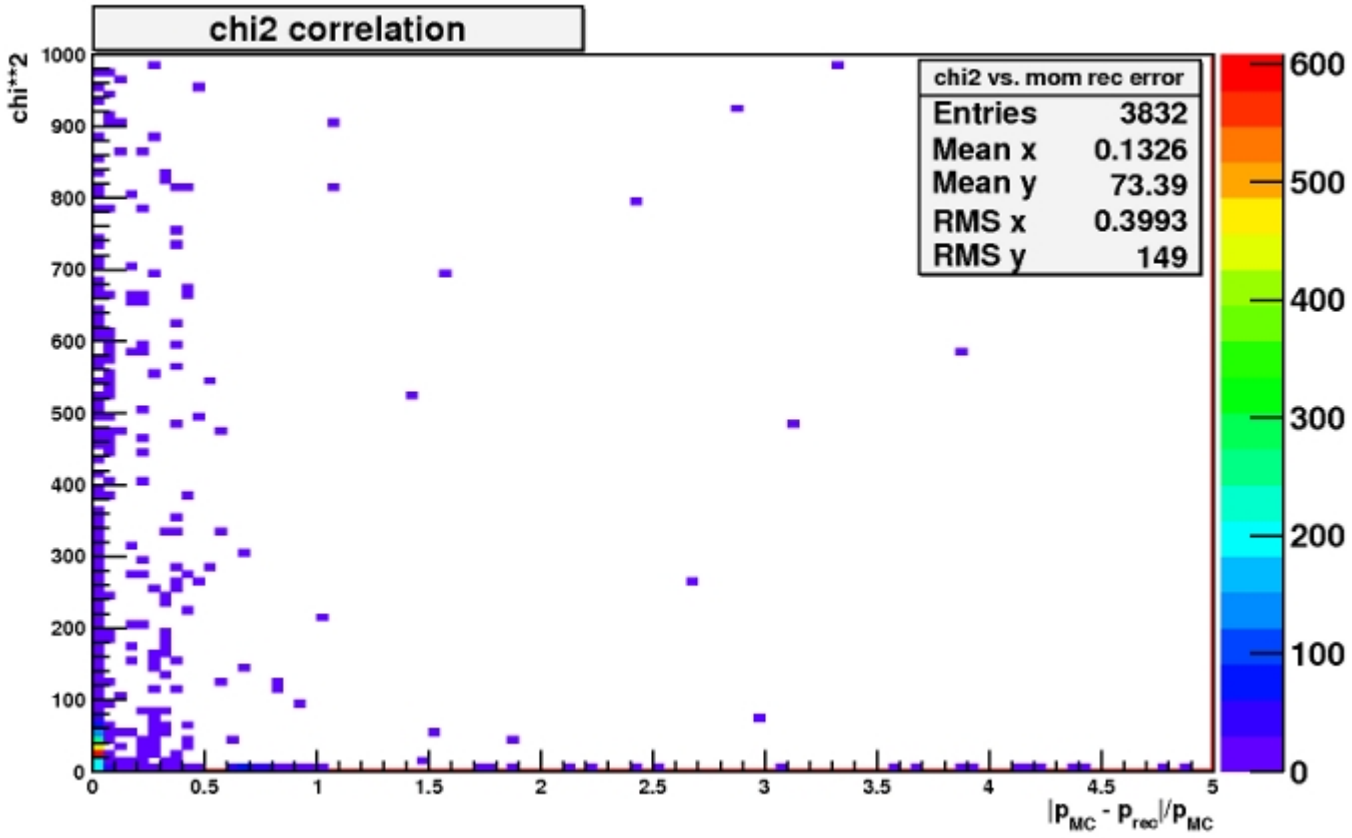
greetings,
David

File Attachments

1) EfficiencyComparison.jpg, downloaded 1594 times



2) chi2.jpg, downloaded 1623 times



Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by asanchez on Thu, 11 Feb 2010 13:34:17 GMT
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Hi everybody,
to my understanding
tracking of low momentum particle(e.g pions P < 100 MeV/c)
are not considered by geane.(See GeaneTrackRep.cxx)

```
139    // protect against low momentum:
140    if(fabs(fState[0][0])>10){
141      GFException exc("GeaneTrackRep: PROTECT AGAINST LOW
MOMENTA",__LINE__,__FILE__);
142      exc.setFatal();
143      throw exc;
144    }
```

I have checked to move this cut to lower momentum values(P ~60 MeV/c,
it works but there are still instabilities(crashes after 5000 events)

Nevertheless even if the particle is losing energy
geane should be able to take care of that? or am i wrong?
So far i know instead of a helix, geane considers then a parabola(x,y,dx/dz,dy/dz).

cheers

Alicia.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by asanchez on Thu, 11 Feb 2010 13:49:06 GMT
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hi again,
maybe one can make use of the information
of the de/dx in the low momentum region, namely by parameterizing the momentum
dependence on the mean value of de/dx via a polynomial
and replace the momentum of the track candidate
by the corresponding value obtained via de/dx(p) = Polyn(p).

cheers ALicia.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Lia Lavezzi on Thu, 11 Feb 2010 14:19:29 GMT
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Hi Alicia,
the cut for low momentum particles was put there because of some instabilities of GEANE for low momenta, but in principle GEANE can propagate also low momentum particles.
I will make some tests removing the cut to see what happens and to fix the crashes if/when they happen. Unfortunately I am working on several other things at the moment and I have to postpone a little this investigation (sorry!).
Quote:Nevertheless even if the particle is losing energy
geane should be able to take care of that? or am i wrong?
So far i know instead of a helix, geane considers then a parabola(x,y,dx/dz,dy/dz).
Yes, GEANE follows the particle while it loses energy. The trajectory of the particle is made by pieces of helix (in each step GEANE tracks with an helix, but the different helices can have different radius of curvature, for example, to take care of the energy loss).
With GEANE you don' t have the track as a whole helix with fixed radius of curvature.

Concerning the "parabola", it is just a track representation (the parameters used to describe the track are the ones you wrote). You always can convert it to the helix parameters, but the important thing is that you have the description of the track in one point and the parameters don' t stay constant along the helix (while if you use the helix fit you have that the momentum, and so the radius, is constant along the track).

Ciao,
Lia.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by asanchez on Thu, 11 Feb 2010 14:35:20 GMT
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hi Lia,
thank you very much
for your explanations
and for your efforts .

best regards.
ALicia.

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Anonymous Poster on Thu, 11 Feb 2010 14:46:31 GMT
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Hi,

GEANE can follow particles to lower momenta, as Lia says. I played a lot with that for another experiment. But the models with which GEANE can propagate the errors (multiple scattering, energy loss straggling) and the state vector (energy loss) are to be studies I think at these low momenta. I am very interested in the issue, since it has a big impact on another experiment (Belle II) where we will use GENFIT with Geane or with another track follower we are working on. Also there, the questions of how to treat material effects for low momenta is not clear yet. Could the GEANE experts please maybe state their opinion on low momentum performance of the physics models inside GEANE? I would very much appreciate it!

Cheers, Christian

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Alberto Rotondi on Thu, 11 Feb 2010 17:51:24 GMT
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Hi Christian,

the physics contained in GEANE is the following:

Mean values: dE/dx is the same of GEANT3, that is valid down to 10 keV (Bethe Bloch, Tables and Bremmstrahlung). Multiple scattering has zero mean value. Magnetic field works for any energy. However, spiralization could create problems, depending on the particular geometry. This is, in my experience, the main problem, because the user has to manage missing planes, missing volumes and so on.

Errors: multiple scattering sigma should work for any energy.
At low energy the shape deviates from Gaussian, but only on the tails, and the effect should be small.
dE/dx sigma is calculated with the standard formula sigma^2=csi*Emax*(1-beta^2/2)
which works very well at low energy.

In conclusion, I think that the main problem is spiralization.
I do not exclude the existence of problems due to the
robusteness of the program in dealing with a complicated track

geometry, but this should be verified in practice.

Best regards
Alberto

Subject: Re: Momentum resolution and reconstruction efficiency of LHE tracking
Posted by Gianluigi Boca on Sat, 13 Feb 2010 22:06:57 GMT
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Sorry for the late reply.
Yes it is possible now to use the real pattern recognition for
the Straw Tube system.
As I have already said in my previous message, one example is in
$VMCWORKDIR/macro/stt/runreco.C

where one needs to substitute
PndSttTrackFinderIdeal* sttTrackFinder = new PndSttTrackFinderIdeal(iVerbose);

with

PndSttTrackFinderReal* sttTrackFinder = new PndSttTrackFinderReal(iVerbose);

This macro produces the famous Helix Hits with the statement

```
  PndSttHelixHitProducer* sttHHProducer = new PndSttHelixHitProducer();
  fRun->AddTask(sttHHProducer);
```

Notice that in this macro there is also Lia's fit to the tracks just after the
pattern recognition, with the statement

```
  // trackfitting ....
  PndSttTrackFitter* sttTrackFitter = new PndSttHelixTrackFitter(iVerbose);
  PndSttFitTracks* sttFitTracks = new PndSttFitTracks("STT Track Fitter", "FairTask",
sttTrackFitter);
  sttFitTracks->AddHitCollectionName("STTHit");
  fRun->AddTask(sttFitTracks);
```

From the study that I am going to show at the next EVO meeting, I conclude
that for muon tracks, the resolution on the Momenta component are in general better
after Lia's fit compard to the values obtained directly by the Pattern Recognition
(with the exception of the resolution on Pz at momenta < 1. GeV/c).
Therefore today I think that the best is to use the real pattern recognition and then Lia's fit.

Typically the resolution on the Transverse Momentum ranges from 1.5% for 300 Mev/c
total momentum muons, to 20% for 10 GeV/c muons.
Typically the resolution on Pz ranges from 5% for 300 MeV/c muons up to 34% for
10 GeV/c total momentum muons.

Consequently, I would expect a not so bad resolution on the J/Psi mass after real pattern recognition + Lia's fit.

One comment on the resolution obtained in the J/Psi channel using the Ideal Straw Tube pattern recogniton.
Lia-Susanna-Alberto last year obtained a good resolution with the Ideal Pattern recognition + fit with muon tracks of different total momentum.

Now David Pohl claims he obtains a quite worse result.

I think that in his study the J/Psi decays hadronically or maybe even in e+e- ??
That could make things worse.

I would suggest first of all to study the decay channel into mu+mu- and see what happens.
In that case the results would be directly comparable to those of the Pavia group.

Gianluigi

Johan Messchendorp wrote on Thu, 11 February 2010 09:47Stefano Spataro wrote on Thu, 11 February 2010 07:47As I as writing before, lhe is based in 3D points -> XYZ.
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Johan.