Detector Optimization and Performance

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The copy of this talk one can find at the http://www.desy.de/˜morgunov

Introduction

Actually there are two well separate tasks here.

Detector parameter optimization (should be done by the end of January).

and Detector performance:

The list of the physical processes will be used as it was proposed by physics benchmark working group.

Full events should be used , that means with luminosity curve, ISR and background for the final (optimized) detector geometry to extract the detector performance as whole.

February we should spend to calculate a detector performance.

This will be our last step.

So, we have a bit more than two month including Christmas to do a detector optimization.

Parameters of an optimization

The optimization can be done without luminosity curve and ISR for the simplest events such as:

$$e^+e^- \rightarrow \quad q\bar{q}(u,d,s); \;\; q\bar{q}(c,b); \;\; t\bar{t}\;(6\;jets); \;\; W^+W^-\;(cos < 0.9) \;\; \text{and} \;\; Zh(120\;GeV)\,.$$

Optimization independent parameters include:

B field dependency;

TPC size dependency;

TPC material budget dependency in terms of X_0 and λ_0 before a calorimeter;

Calorimeter size dependency;

Calorimeter sell size dependency;

Calorimeter material dependency.

Overall material budget in terms of X_0 and λ_0 subdetector by subdetector.

Everyone might think about the additional independent parameters for the optimization.

All proposals are welcome.

By the end of January we should present of a few tens of curves / plots.

What is the object of an optimization ?

The event selection plays a crucial role to get good and interesting physics results in the usual event analysis during almost any high energy physics experiment.

The powerful selection criteria is usually based on the mass, momentum or angular distributions of an individual particle or group of particles (jets), either on the particle identification or on the finding of the particular decay chains (so called b, c tagging).

The analysis of the selected events includes almost the same characteristics to be measured.

But the number of events of these two categories are pretty different. The usual selections include almost all event statistics the same time the interesting physical processes are rear. So, the detector should be optimized to make good job for such a kind of tasks in addition to the perfect measurements of the parameters of the selected events.

Calorimeters are able to measure an energy and particle ID due to the splited measurement in the ECAL and HCAL. Tracker can measure a momentum and particle ID by the energy lost distribution along the track. The vertex detectors should measure mainly particle decay processes at the short distances.

Particle flow attends to measure four momentum of each particle in event for that which are visible in principle, combining of the tracker and calorimeter measurements together as well as the finding of the decays and interactions at the TPC volume, that was included particle identification as default as well as the decay channel finding.

What are the distributions of function of event four momenta we are going to optimize ?

Functions of $\hat{P}_i$ of events to optimize

It was shown recently then for the comparison with the true information better use the true functions calculated with taking into account the actually visible energy / particles in an event.

1. Di–jet mass difference between reconstructed and true, if it exists.
2. Jet mass difference between reconstructed and true, if it exists.
3. Whole mass of event = $\sum_{i=1}^{n} \hat{P}(i)_{rec}$ difference between reconstructed and true

   (the mass includes the angular uncertainties as well)
4. Whole event energy = $\sum_{i=1}^{n} E(i)_{rec}$ difference between reconstructed and true
5. Particle momentum uncertainties as function of momentum module, angles and particle ID.

   (it means the vector difference between true momentum vector and reconstructed one for the same true particle).
6. Comparison of number of reconstructed V_s^0 and kinks as a function of momentum and particle ID with true one.
7. Leakage and lost particles as a function of momentum, angles and particle ID.

Any other proposals are welcome.

The program to calculate all of these is under development.

The comparison of the quality of different reconstruction programs is under discussion as well as an influence of the reconstruction quality on the optimization robustanse / stability.

On the other hand this list of functions will show us the detector performance as whole and in details.

How to proceed ? Simulation

First of all we should tune and fix–up the existing tools.

Simulations: we have Mokka and BRAHMS for the cross–check.

1. All geometries which will be used should be checked carefully as by eyes as by tree different geometry testers that exist in GEANT 4 and DAWN.

First check overlaps, then actual sizes of geometry if / when differ, and realize what kind of subdetectors are in LDC00Sc model, replace if need.

All overlaps should be fixed (obligatory).

2. Physics lists in Mokka should be traced – does it work or not ?

3. Put CED into Mokka – to check the tracking and physics lists.

4. Put new features: Mokka should have a possibility to change:

a) Calorimeter materials.

b) Calorimeter length independently on the TPC radius and length.

c) Calorimeter sampling thickness as for absorber as for scintillator.

d) Number of layers in calorimeter.

Without this features we could not path through the significant part of the detector optimization.

To do this we have a time up to Christmas.

How to proceed ? Reconstruction

An ambition plan.

1. Check and improve Track-Wise and Wolf.
2. Check Mark Tompson reconstruction.
3. Check Japanese reconstruction.
4. And apply all of them to optimization.

More realistic: make the first only; but without this we will do nothing.

5. We need a well working GEAR to be sure then we will have a correct geometry description at the reconstruction stage.

To do this we have a time up to Christmas.

Time schedule and Details

Everything should go in parallel.

Week # one:

CED into Mokka...... (who?)

Mokka find overlaps...... (who?)

Mokka debug for differ geometries...... (who?)

Mokka Physics Lists debug and fixing...... (who?)

Mokka new drivers for calorimeter – development...... (who?)

GEAR additional development...... (who?)

Reconstruction debug for mistakes...... (who?)

Reconstruction analysis development...... (who?)

Add if I forgot something....

Week # two:

GEAR test...... (who?)

Mokka geometry overlap fixing...... (who?)

Mokka new drivers for calorimeter – development...... (who?)

Reconstruction analysis – development...... (who?)

Reconstruction mistakes fixing...... (who?)

Add if I forgot something....

Time schedule and Details

Week # tree:

Start GRID new 1000 events differ geometries only..... (who?).

Reconstruction analysis – development...... (who?)

Reconstruction mistakes fixing...... (who?)

Add if I forgot something....

Week # four:

Check everything again to cross–check a geometries...... (who?)

Check reconstruction and new analysis program...... (who?)

Add if I forgot something....

Week # five, six, seven, eight – Christmas:

GRID for all events and parameters...... (who?)

GRID all event reconstruction...... (who?)

Developing how final pictures will look like...... (who?)

Add if I forgot something....

Time schedule and Details

January:

Make everything again...... (who?)

Fix everything that was not done before, but in the reconstruction only...... (who?)

Choose the optional geometry...... (who?)

Start event generation for the detector performance...... (who?)

Start GRID calculations for the detector performance...... (who?)

Add if I forgot something....

February:

Start analysis for the detector performance...... (who?)

Extract the final results of the detector optimization and performance...... (who?)

Add if I forgot something....

Speech

Please, add all I miss.

Remarks

1. for TPC: I would propose for everybody to think about the physics from which one can extract the limit for the TPC track momentum resolution (it should not be one and unique physical reaction with attobarn crossection).

2. Specially check the PFA properties for the particles at the small angles up to the half of the endcap radius. Can be done by the special procedures. (select p with cos $<$ 0.7 or so and look at the PFO existence if it exists to compare with true one)

3. Remove all debug printing for TPC Brahms–like reconstruction.

4. Do not forget each time to make cross–check of the simulated geometries and parameters of the reconstruction. If it is possible to include GEAR information into LCIO file for each Mokka run; and read it into reconstruction once at the beginning of the run.

5. CED should have possibility to change sizes "automatically" when it was asked in the steering file. (create class, then fill it inside drivers, then refill CED geometry with this class information and start CED, the same time may be it is possible to fill GEAR ?)

6. The number of tracks in the calorimeter will be order of 10^5 – is CED memory enough if all hits on screen?

7. Physics list – printing which is really started (changes in the local GEANT 4 copy/library and keep a track on the physics processes if/when it run. Temporary to understand than all works well.)

Remarks

8. Write special analysis to find a difference between reconstructed PFO and HEP record including V^0 and kink finding; i.e. two step procedure. With this program put the big difference on screen – first; then analyze what kind of PFO has the biggest difference with HEP record; is it tracks or neutrals; what is the critical energy/momentum to get a big disagreement or is it the critical angle exist? or critical P_T ? Find all of them and make histogram with its properties and look which of them will bring the biggest error into the optimized functions and how bit it is. and at which level of the reconstruction the mistake occurred?

9. We should make an analysis of the main terms in the physical part of event. What kind of particles or its parameters should be measured better to reduce width of M_{jj} or some other performance (optimization itself).

10. During the PFO–HEP comparison keep a special attention on the quality of the main tracker and investigate of the near by beam tube axis zone specially for the W^+W^- events.

11. Also special investigation should be done for the low momentum tracks. Carefully look at the influence of the low momentum tracks on M_{jj} width and on the other parameters.

12. W^+W^- events can be used also to better understand forward region singularity by cheating of the FTD and comparison with HEP record. Plot N of hits V.S. P_T or angle.

13. These events also can help to find the cut–offs for the reasonable selection of W events to get a good W mass resolution and see how many and what accuracy do we need for the M_W reconstruction and what will be the restrictions?

Remarks

14. PFA reconstruction quality might be as an integral as we also need some differential characteristics, something like double–differential cross–section for the PFA uncertainties.

15. How to include the background into TPC taking into account the radial and Z dependence of it ?

16. How to calculate background at the $M_W - M_Z$ plot? And how to extract quantitatively that 30% of sqrt of E ?