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The BASEL SFD Y prediction method in the DIRAC experiment

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Abstract

This note explains a new SFD Y prediction method and compares it to the ARIANE prediction method.

1 Introduction

The magnet in the DIRAC experiment divides the setup into two parts: The downstream part after the magnet and the upstream part before the magnet. The tracking starts with a track fit in the drift chambers downstream. It then extrapolates the found DC track to the upstream detectors.

The following pages explain a new extrapolation method of the DC track through the magnet to the Y plane of the upstream fiber detector. The idea behind the new method is to assume a straight line between the target and the exit point of the magnet in y direction, since this straight line is not influenced by the multiple scattering in the drift chambers. Hence the accuracy of the prediction at the level of SFD Y increases.

The predictions from our new method are then compared to the ARIANE[1] predictions by looking at the minimum distance between the prediction and the closest hit fiber as well as by comparing the acceptances of the two differing methods.

Finally the Coulomb peak resulting from Coulomb correlated pions is used as a test to see whether our new methods finds more useful events overall.

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This study is performed for the current available magnetic field description as well as for a soon to be implemented improved description.

2 Multiple scattering in the setup

The downstream track parameters are influenced by two main sources of multiple scattering besides the target:

The **first source of multiple scattering** are the upstream detectors (MSGC, SFD and IH) before the magnet. They influence the point where the track exits the magnet and also its inclination at that point as can be seen from figure 1, which models the influence of the MS in the upstream detectors as the dashed magenta lines. We see that the point where the track exits the magnet as well as its inclination is changed.

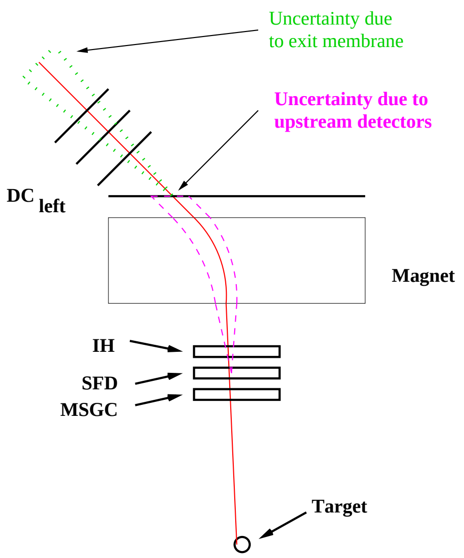

Figure 1: Multiple scattering introduced by the upstream detectors (magenta / dashed line) and the exit membrane of the big vacuum chamber of the magnet (The dotted green line).

The **second main source of multiple scattering** is the aluminium exit membrane of the big vacuum chamber of the magnet. It influences the inclination of the track in the preceding drift chambers. This influence is drawn as the dotted green lines in figure 1.

3 New SFD Y prediction concept

It is important to note that the χ^2 fit in the drift chambers will yield a wrong inclination of the track due to the multiple scattering in the aluminium exit membrane, but the point, where the fitted track crosses the membrane is not affected by the multiple scattering.

So by only using the point where the track crosses the exit membrane and obtaining the inclination by assuming a straight line to the target (see below), we get a more accurate prediction of the track at the level of SFD.

Since the magnetic field influences the track only in x direction (in first approximation), its inclination in y, $\frac{dy}{dz}$, is not altered by the magnetic field. Hence we can draw a straight line by connecting the target with the point, where the track exits the magnet, as modeled in figure 2.

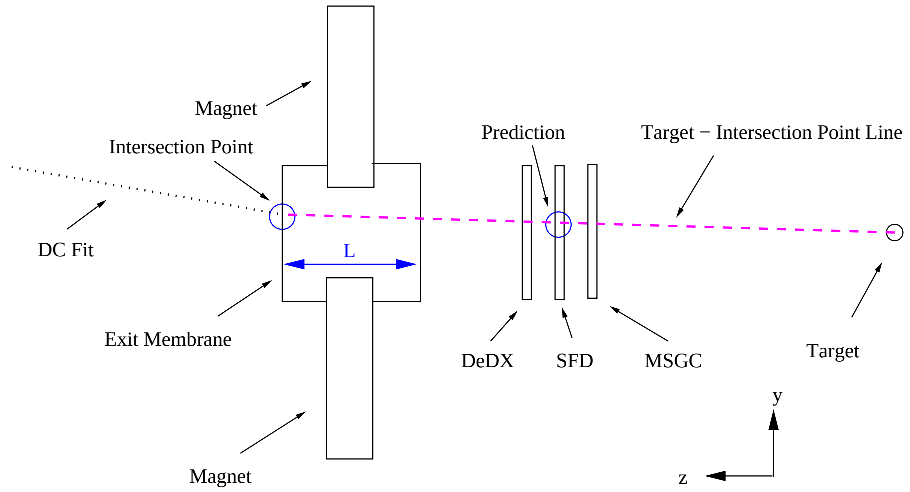

Figure 2: Experimental setup in the YZ plane. The dotted line represents the DC fit, the dashed magenta line connects the target with the intersection point of the DC track with the exit membrane of the magnet. L indicates the integral path of the particle in the magnetic field.

Our so obtained new prediction only carries the error of the multiple scattering in the upstream detectors and the error due to the approximation of no magnetic field in the y direction.

The new BASEL prediction for SFD Y can be determined in the following way:

$$y_{SFD} = (z_{SFD} - z_{Target})\, y' \tag{1}$$

where

$$y' = \frac{\Delta y}{\Delta z} = \frac{y_{intersection}}{\Delta z(intersection - target)} \tag{2}$$

with

$$\Delta z = L + \Delta z(\text{magnet begin - target}) \tag{3}$$

L is the integral path including curvature of the particle in the magnet.

This new prediction method would yield in the limit of zero thickness of the upstream detectors a prediction exactly equal to the true value.

4 Comparison of BASEL to ARIANE

4.1 Distance between the prediction and the closest hit fiber

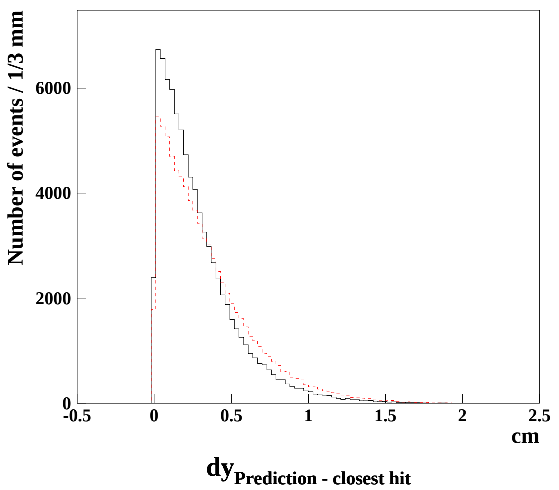

Figure 3: Absolute value of the minimum distance between the prediction and the closest hit fiber in SFD Y. The black solid line is the BASEL SFD Y prediction, the red dashed line shows the ARIANE SFD Y prediction.

Figure 3 was obtained using full trigger data from run 3733. It compares the minimum distance between the prediction and closest slab at SFD Y of the BASEL method (black solid line) with the prediction obtained using the magnetic field description included in ARIANE (the dashed red). The minimum distances from the BASEL prediction are shifted toward zero as compared to the ones using the magnetic field from ARIANE.

Prediction SFD Y	Geometrical cut and time cut SFD events	%	Additional time cut VH to SFD Y events	%
ARIANE	27811	87.7%	27811	88.2%
BASEL.or.ARIANE	31694	100.0%	31549	100.0%
BASEL.and.ARIANE	26869	84.8%	26005	82.5%
BASEL.and.not.ARIANE	3883	12.2%	3738	11.8%
ARIANE.and.not.BASEL	942	3.0%	1806	5.7%

Table 1: Events that have at least one proper prediction per track at the level of SFD Y. The events accepted by the BASEL method have to pass a geometrical cut on SFD Y as well as a time cut between the two SFD planes. The two last rows also require a time cut between VH and SFD Y.

4.2 Acceptance of good events

This study was performed with a sample of 100 thousand events taken from run 3733. The data was subject to the hardware trigger T4*T1$\pi^+\pi^-$Copl and was restricted to events with 1 track per arm.

The number of reconstructed good events[1] using the standard ARIANE package or the BASEL method are shown in table 1. The table is divided into events that pass for the BASEL method a geometrical cut and a time cut between the two SFD planes, and into events that pass an additional time cut between VH and SFD Y.

It can be seen from the table that using BASEL and ARIANE together in an .or. mode would increase the present statistics by about 12% . It shows further that by applying a second time cut between VH and SFD Y, the BASEL method rejects a few events more that ARIANE finds, while the number of excess events found by the BASEL method over the ARIANE method is roughly stable.

4.3 Acceptance of Coulomb correlated events

Current version of the magnetic field description A further test is to compare the acceptance of Coulomb correlated events for the two methods. The following study was performed with the current magnetic field description available using approximately 25 million real data full trigger events from the runs 3733 to 3785. The BASEL method was run with the additional time cut between VH and SFD Y (see above).

[1]defined as: The tracking was able to fully reconstruct the event.

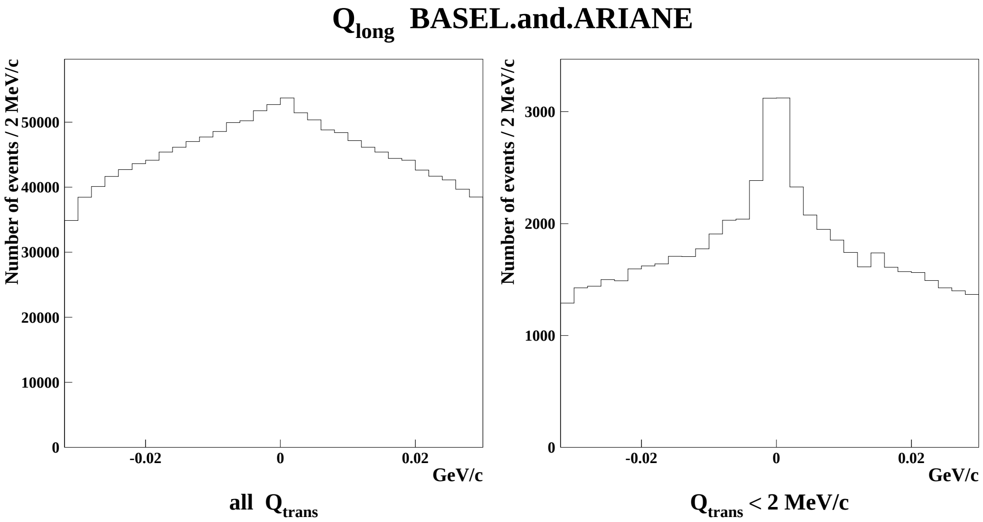

Figure 4: Qlong for time-correlated prompt events without (left plot) and with (right plot) a cut applied to the transverse relative momentum $Q_{trans} < 2$ MeV/c. The events had corresponding SFD Y prediction from the BASEL and the ARIANE tracking.

Figure 4 shows the Q_{long} distributions for prompt events with (right plot) and without (left plot) a cut on transverse Q of $Q_{trans} < 2$ MeV/c.

All events in figure 4 were required to have a valid SFD Y prediction using the BASEL and the ARIANE prediction methods (BASEL.and.ARIANE). Clearly visible is the Coulomb peak around Q_{long} equal zero.

Figure 5 shows the same two Q_{long} distributions for events that have only a valid prediction using the BASEL prediction method and no prediction using the ARIANE code (BASEL.and.not.ARIANE). These are the events that ARIANE doesn't recognize. From the right plot one can see that there is a slight Coulomb enhancement. We can therefore conclude that the current ARIANE prediction loses some events.

Figure 6 finally shows again the same plots for the ARIANE prediction method for events that were not recognized by the BASEL approach (ARIANE.and.not.BASEL). The distributions in this case look rather different from the previous one. Also there is no Coulomb peak visible. To reject those events, one could require for each event found by ARIANE to have a corresponding BASEL prediction.

For the current magnetic field description the best overall method would be to include the BASEL method in ARIANE and use it for the SFD Y prediction.

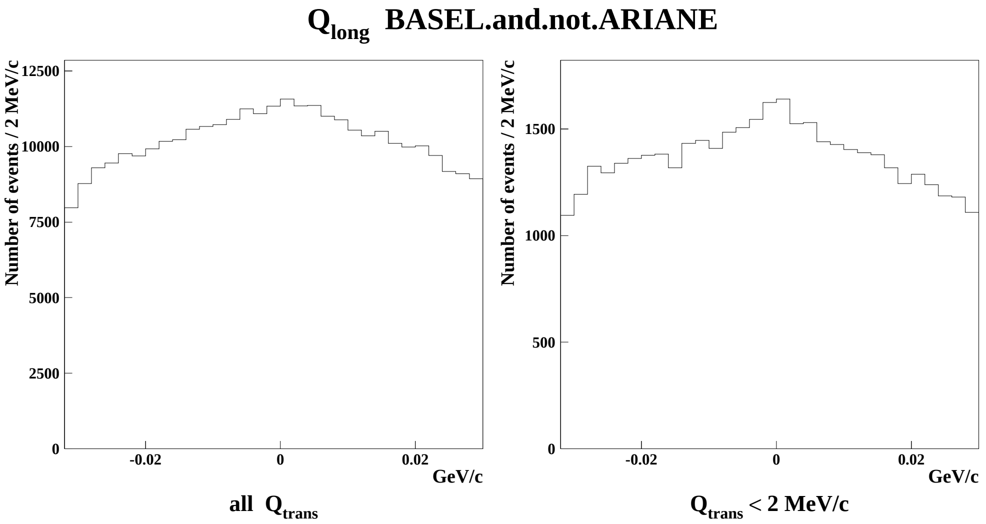

Figure 5: Qlong for time-correlated prompt events without (left plot) and with (right plot) a cut applied to the transverse relative momentum $Q_{trans} < 2$ MeV/c. The events have only a correct prediction with the BASEL method and not with ARIANE.

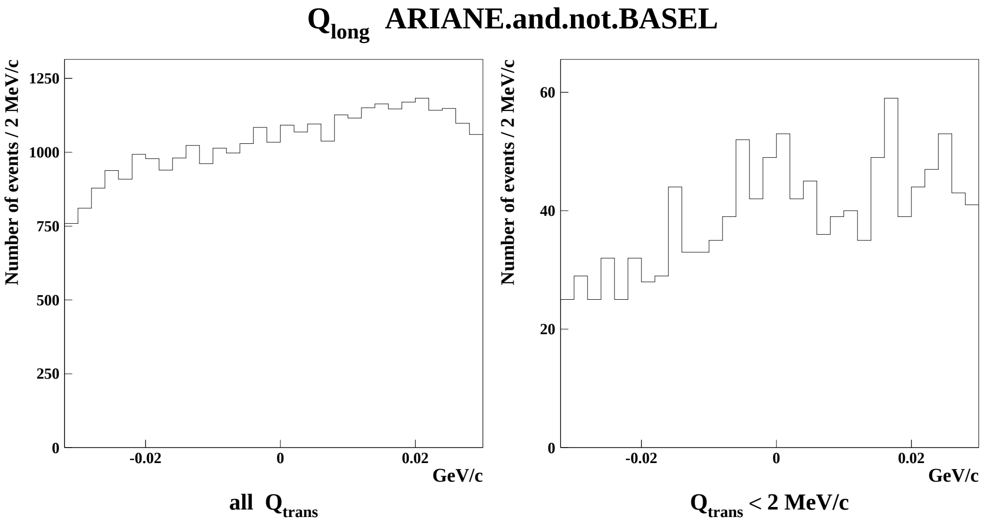

Figure 6: Qlong for time-correlated prompt events without (left plot) and with (right plot) a cut applied to the transverse relative momentum $Q_{trans} < 2$ MeV/c. The events have only a correct prediction with the ARIANE method and not with the BASEL method.

Future version of the magnetic field description O. Gortchakov and V. Yazkov are currently testing some improvements of the current magnetic field description. V. Yazkov performed the following study using these improvements for full trigger events taken from the runs 3733 to 3750.

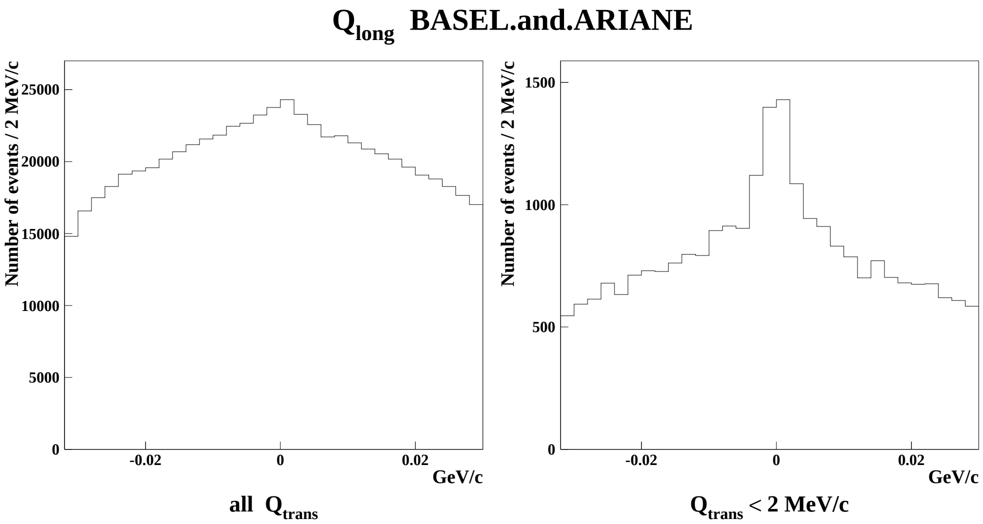

Figure 7: Qlong for time-correlated prompt events without (left plot) and with (right plot) a cut applied to the transverse relative momentum $Q_{trans} < 2$ MeV/c. The events had corresponding SFD Y prediction from the BASEL and the ARIANE tracking.

Figure 7 shows the Q_{long} distributions for prompt events with (right plot) and without (left plot) a cut on transverse Q of $Q_{trans} < 2$ MeV/c for the situation BASEL.and.ARIANE. Clearly visible is the Coulomb peak around Q_{long} equal zero as before in figure 4.

Figure 8 shows the same two Q_{long} distributions for the case BASEL.and.not. ARIANE. These are events that ARIANE misses with the future magnetic field description. From the right plot one can see that there is no Coulomb enhancement.

Comparing the right plot in figure 8 to the right plot in figure 5 shows that the new magnetic field description allows ARIANE to find also those events that with the current magnetic field description only the BASEL method found.

Figure 9 finally shows again the same plots for ARIANE.and.not.BASEL. The distributions look different and there is no Coulomb enhancement visible.

The best overall setup for the new magnetic field description is therefore to combine both methods and only accept events that have a SFD Y prediction

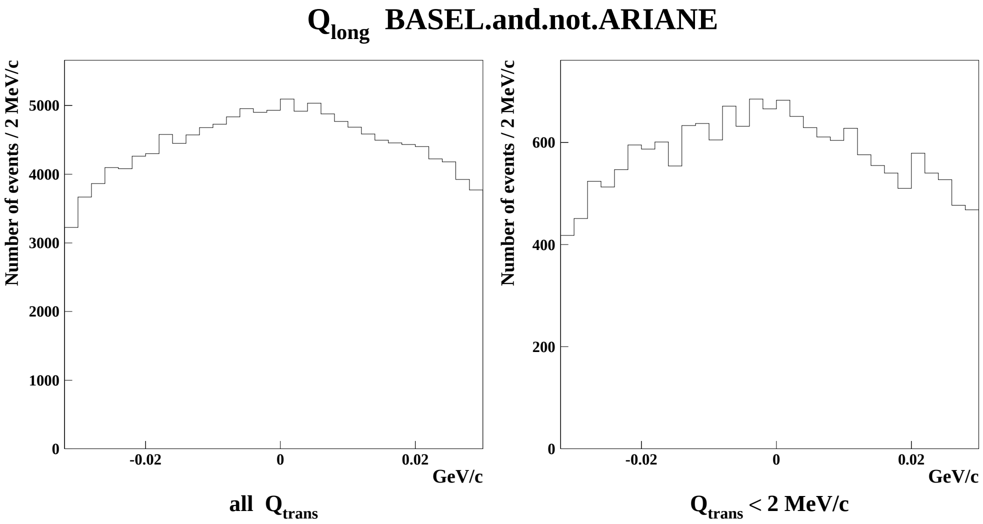

Figure 8: Qlong for time-correlated prompt events without (left plot) and with (right plot) a cut applied to the transverse relative momentum $Q_{trans} < 2$ MeV/c. The events have only a correct prediction with the BASEL method and not with ARIANE.

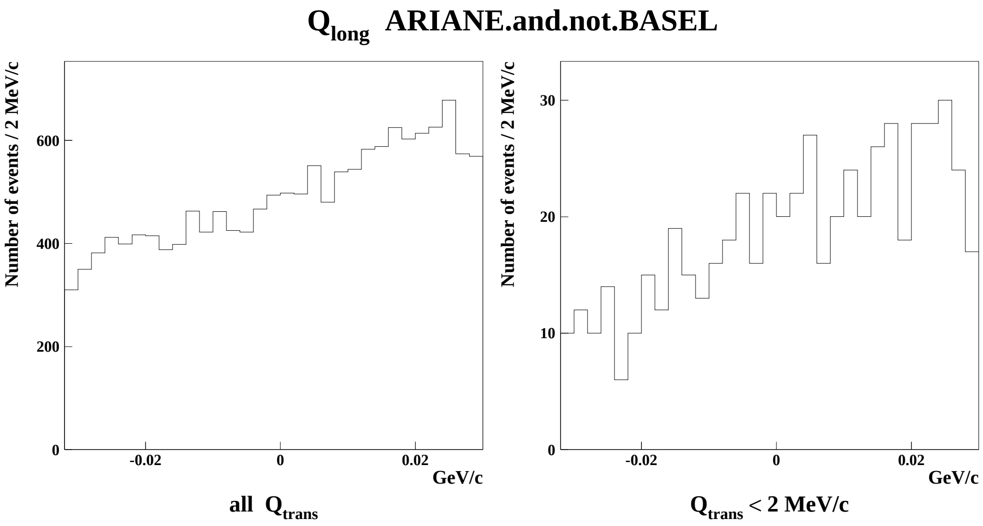

Figure 9: Qlong for time-correlated prompt events without (left plot) and with (right plot) a cut applied to the transverse relative momentum $Q_{trans} < 2$ MeV/c. The events have only a correct prediction with the ARIANE method and not with the BASEL method.

from both. This will clean our data sample from background by about 3% .

5 Conclusion

We developed a new approach to obtain a prediction in SFD Y. The main enhancement of the BASEL method is that it avoids one source of multiple scattering that influences the prediction. Hence the resulting uncertainty due to MS decreases.

As a result the distribution of the average distances between the prediction in SFD Y and the closest hit fiber in SFD Y shifts toward smaller dy values.

Using the new BASEL method in combination with the ARIANE method yields about 12% more reconstructed events at the level of SFD Y.

The acceptance of specific Coulomb correlated events for both methods with the current magnetic field description is slightly higher for the BASEL method than for the ARIANE prediction.

Using the new magnetic field description, which is to be implemented in the next major release of ARIANE also enables ARIANE to find those events it didn't find for the current magnetic field description.

The best overall combination of the two methods with the new magnetic field description is to accept only events that have a proper prediction in SFD Y from the BASEL and the ARIANE method. This will clean our data sample from background by about 3% .

A User Control

The user has the possibility to control the new tracking package by redefining parameters (FF cards) in the file FFreadInput. The following FF cards can be changed:

- **ARIANESFDY** can be set to true (T) or false (F). It defines whether the algorithm uses the ARIANE SFD Y determination or not.
- **BASELSFDY** can be set to true (T) or false (F). It defines whether the algorithm uses the BASEL SFD Y determination or not.
- **VHSFDYCut** can be set to either true (T) or false (F). It defines whether the program makes an additional time cut between VH and SFD Y or not.

ARIANESFDY and BASELSFDY can be set both to true. If done so, both SFD Y prediction if available are entered into the Kalman filter. At least one of them has to be set to true for the program to work.

References

[1] ARIANE version 304-12.