Update in the SFD detector response simulation
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1 Introduction

The SFD detector is a fundamental piece in the DIRAC experimental set-up: for the event timing and for the spacial information passed to the tracking, all the details are found in [1] and [2].

2 Efficiency and multiplicity simulation

Several points in the analysis of experimental and MC data have been modified since the last presented work in [3], this work is an update of the work presented there. We present here the factors that mostly modify and improve the hit multiplicity in the simulation of the SFD detector:

- Parameter of the Background Intensity: ParBeamIntBack
- Cluster generation in the SFD detector

The SFD detector response is part of the off-line analysis code Ariane, where the "true" hits from the GEANT based MC are corrected for efficiency, hits are added as electronic noise, and the cross talk between adjacent fibres or adjacent photomultiplier cells are added.

For every year we have evaluated the plane efficiency, that is introduced as a parameter to Ariane via the FFreadInput, i.e. for the years 2008 the efficiencies are $SFDX_{eff} = 98.5\%$, $SFDY_{eff} = 98.5\%$, $SFDW_{effX} = 98\%$, the summary for these parameters for the years from 2007 to 2012 is shown in Table 1. For every "true" hit we generate a random number between 0 and 1, and only if this random number is lower than the SFD_{eff} the hit is kept. Then a cluster is generated around this "survived" hit, for example for the year 2008, 1 hit is added to the original with a probability of 20%, 2 hits are added with a probability of 5%, 3 and 4 hits with a probability of 2.5%, the summary for these parameters for the years from 2007 to 2012 is shown in Table 2.

In order to take into account the noise produced in the photomultipliers we add with a probability of 3.5% an extra hit at a distance of $\Delta n = \pm 4$, where Δn is the distance in column number of the added hit from the original hit, and only in this eventuality we add with a probability of 2.25% an extra hit at a distance of $\Delta n = \pm 5$ from the original, the summary for these parameters for the years from 2007 to 2012 is shown in Table 2.

Some backgroun tracks have been added in the upstream detectors (MDC-SFD-IH), these tracks because of their trajectory do not pass the collimator and magnet system, they could be generated from the beam-pipe underneath the detectors line, or from a scattering of a particle in the

year	$SFDX_{eff}$	$SFDY_{eff}$	$SFDW_{eff}$
2007		98.5%	99.0%
2008	98.5%	98.5%	98.0%
2009	98.5%	98.5%	99.0%
2010	98.5%	98.0%	96.5%
2012	98.5%	99.0%	94.5%

Table 1: Hit efficiencies for the SFD planes X, Y and W.

year	$\Delta n = \pm 4$	$\Delta n = \pm 5$	Prob +1 hit	Prob + 2 hit	Prob + 3 hit	Prob +4 hit
2007	0%	0%	0%	0%	0%	0%
2008	3.5%	2.25%	20%	5%	2.5%	2.5%
2009	1.5%	1%	12%	3%	1.5%	1.5%
2010	1.5%	1%	8%	2%	1%	1%
2012	1%	1%	20%	5%	2.5%	2.5%

Table 2: Probability of the noise produced in the photomultipliers, and probabilities of cluster generated in the X plane.

shielding around the detector, the intensity of this background is parametrised with the values of ParBeamIntBack shown in Table 3 from Oleg Gorchakov's work.

year	ParBeamIntBack
2007	4.0
2008	4.0
2009	3.0
2010	3.0
2012	3.0

Table 3: Parameters that describe the intensity of background tracks in the upstream detectors.

Some extra noise has been added as a single hit with a percentage between 5% and 0.5% at a distance between 1 and 10 columns from the "true" hit.

After this procedure to every hits is associated a TDC and an ADC value, and the full amont of information from each of the SFD planes is sent to the PSC algorithm. The details about the algorithm are found in [4] where is explained how this electronic piece has been introduced in order to suppress the noise and the ambiguity when two or more SFD columns are hit.

The same procedure has been performed on the "true" MC hit from the Y and W plane, the percentages used for the Y and W plane are in Table 4 and 5.

The parameters vary a bit between the years, and have been taken into account when simulating the atoms, Coulomb correlated and non-correlated signals for $\pi\pi$, $k\pi$ and for the Λ and $\bar{\Lambda}$ analysis for the different years of data taking. To be noted that during the year 2007 the X plane of the SFD was not read-out.

year	$\Delta n = \pm 4$	$\Delta n = \pm 5$	Prob +1 hit	Prob + 2 hit
2007	0%	0.4%	9.6%	0%
2008	2%	1.2%	8%	2%
2009	2%	2%	16%	1.2%
2010	1.6%	1.6%	16%	16%
2012	1.2%	0.8%	16%	2%

Table 4: Probability of the noise produced in the photomultipliers, and probabilities of cluster generated in the Y plane.

year	$\Delta n = \pm 4$	$\Delta n = \pm 5$	Prob +1 hit	Prob +2 hit	Prob + 3 hit	Prob +4 hit
2007	2%	0%	40%	2.5%	2.5%	2.5%
2008	2%	0%	29%	2.5%	2.5%	2.5%
2009	2%	0%	52%	27%	2.5%	2.5%
2010	2%	0%	42%	18%	2.5%	2.5%
2012	2%	0%	37%	20%	6%	6%

Table 5: Probability of the noise produced in the photomultipliers, and probabilities of cluster generated in the W plane.

3 Event selection

The events selected for this analysis are $\pi^+\pi^-$ data and MC simulated data, the cuts applied on them are listed below:

- $|\Delta(t)_{VH}| < 0.5ns$
- 1 track per arm (DC)
- $|Q_L| > 10MeV$
- No electrons, cut applied on the N_2 Cherenkov amplitudes are $Ampl_{N_2^-} < 62$ $Ampl_{N_2^+} < 75$.
- No muons, cut applied $AND(Muonflag, 3) \neq 0$, this means that there is no hit in muon detector which corresponds to the reconstructed track.
- For the MonteCarlo events, the simulation of the background has been added and the events have been weighted in order to reproduce the momentum $(P_{\pi^+} + P_{\pi^+})$ distribution shape in experimental data.

4 Comparison of Experimental and MC Data

The resulting SFD multiplicity in the three planes is shown in Table 6 for the experimental data and in Table 7 for the MC events, the hit multiplicity is expressed like the mean value (M.V.) of the distribution and the associated error is the width of the distribution. The agreement is very good.

year	SFDx	SFDy	SFDw
	M.V. $\pm$ width	M.V. $\pm$ width	M.V. $\pm$ width
2007		3.4 ± 0.7	3.0 ± 0.7
2008	3.6 ± 0.8	4.1 ± 1.0	3.6 ± 0.8
2009	3.3 ± 0.8	3.7 ± 0.9	3.2 ± 0.8
2010	2.9 ± 0.8	3.3 ± 1.0	3.0 ± 0.8
2012	2.9 ± 0.8	3.5 ± 1.0	3.0 ± 0.8

Table 6: SFD Hit Multiplicity Experimental data (3pl tracking).

year	SFDx	SFDy	SFDw
	M.V. $\pm$ width	M.V. $\pm$ width	M.V. $\pm$ width
2007		3.5 ± 0.6	3.4 ± 0.6
2008	3.8 ± 0.6	4.0 ± 0.6	3.7 ± 0.6
2009	3.3 ± 0.6	3.6 ± 0.6	3.3 ± 0.6
2010	3.1 ± 0.8	3.4 ± 1.0	3.0 ± 0.8
2012	2.8 ± 0.9	3.4 ± 1.0	2.9 ± 0.9

Table 7: SFD Hit Multiplicity MC data (3pl tracking).

In order to study the SFD response we concentrate here on the distributions of the SFD hits used by the tracking in the reconstruction of $\pi^+$and π^-, and defining the distance between these hits as Δn.

To compare fully the experimental data and MC we have selected events that present

- very close tracks ($\Delta n_X < 3$) in one projection (X) and studied the distribution of Δn in Y
- close tracks but with a wider range in X ($\Delta n_X < 6$),
- well separated tracks in X, events which have ($\Delta n_X > 6$)
- the totality of events.

The figures 1, 2, 3 are the results found for the 2009 data, and they shows respectively the study of Δn_X for different selection of Δn_Y in figure 1, the study of Δn_Y for different selection of Δn_X in figure 2, and the study of Δn_W for different selection of Δn_X and Δn_Y simultaneusly in figure 3. A pair of close tracks in the W plane is defined as $|\Delta n_X| <= 5$ and $|\Delta n_Y| <= 5$. The figures 4, 5, 6 are the results found for the 2008.

5 Conclusion

The multiplicities of the SFD planes is well reproduced in the MC data, this is important because in the tracking procedure the hit multiplicity is strongly connected with the number of track candidates and this influence the tracking efficiency. The final shape of the distributions of hit is very well reproduced for data outside the "one-hit region" with the MC data. This partcular "one-hit region" is then taken care in the final analysis with the tuning of the IH (DeDx measurement in the Ionisation

Hodoscope) : tracks that share the same SFD hit have to have a double ionisation amplitude, and again these threshold values are evaluated year by year. The SFD performance is in general very well reproduced in the MC data.

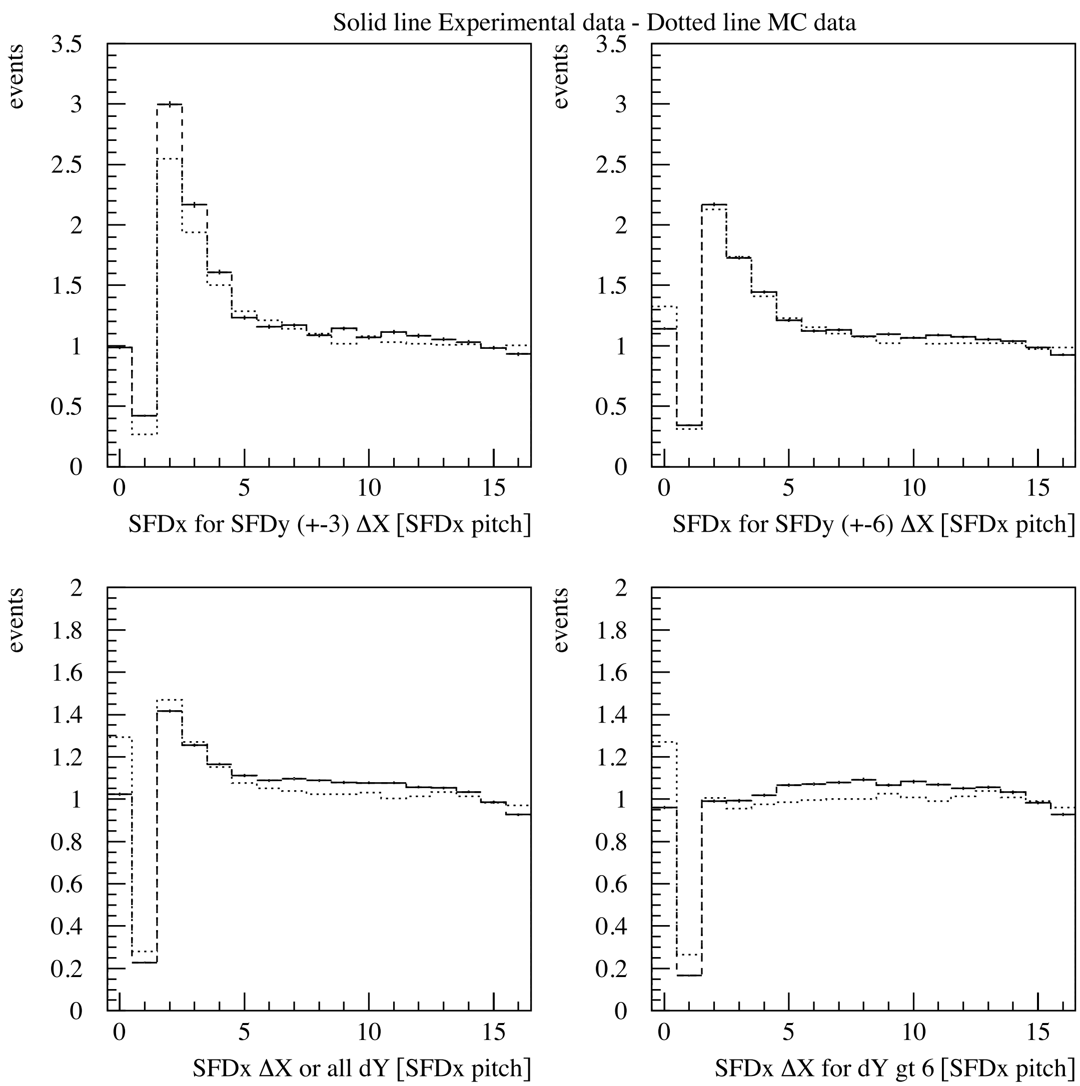

Figure 1: SFD X 2009

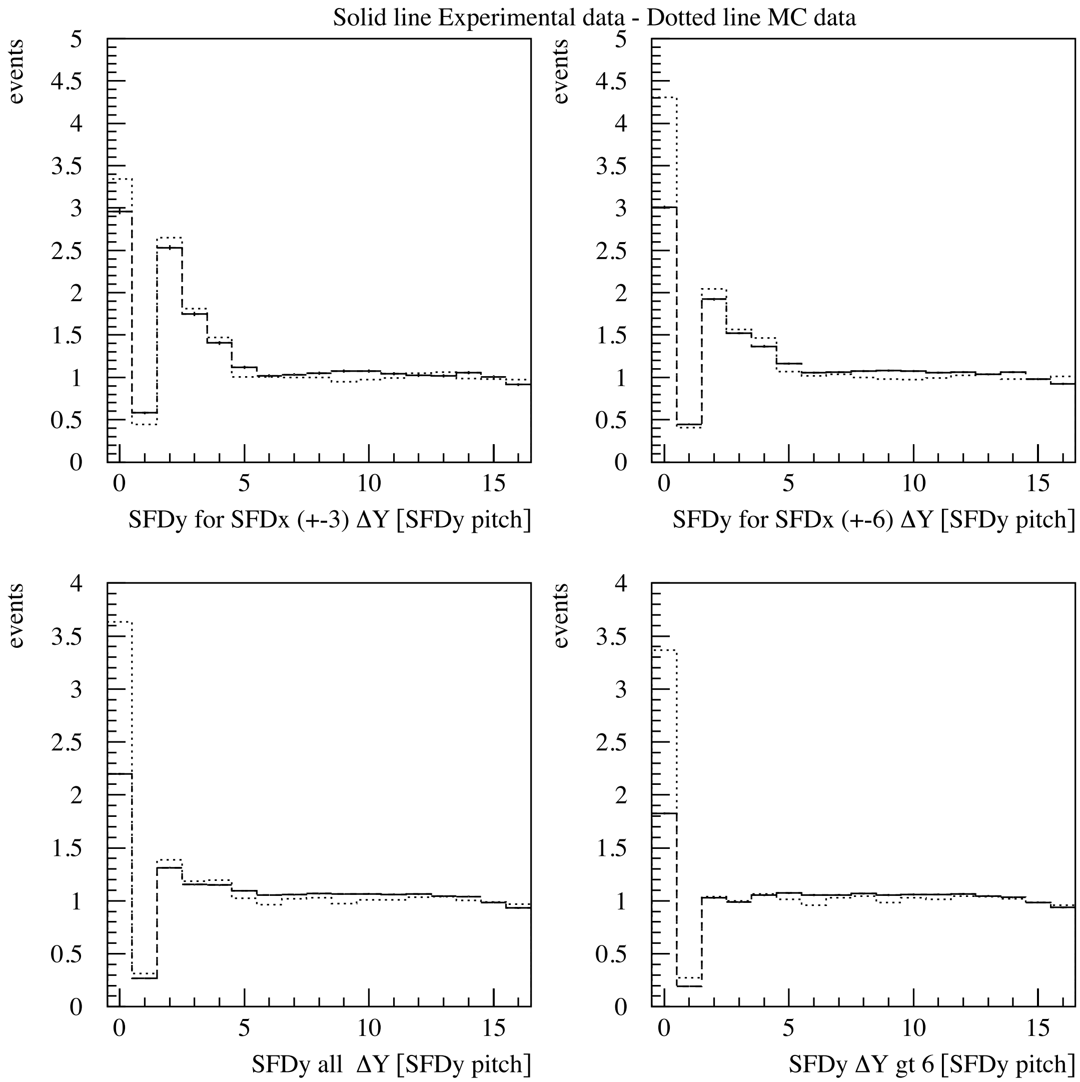

Figure 2: SFD Y 2009

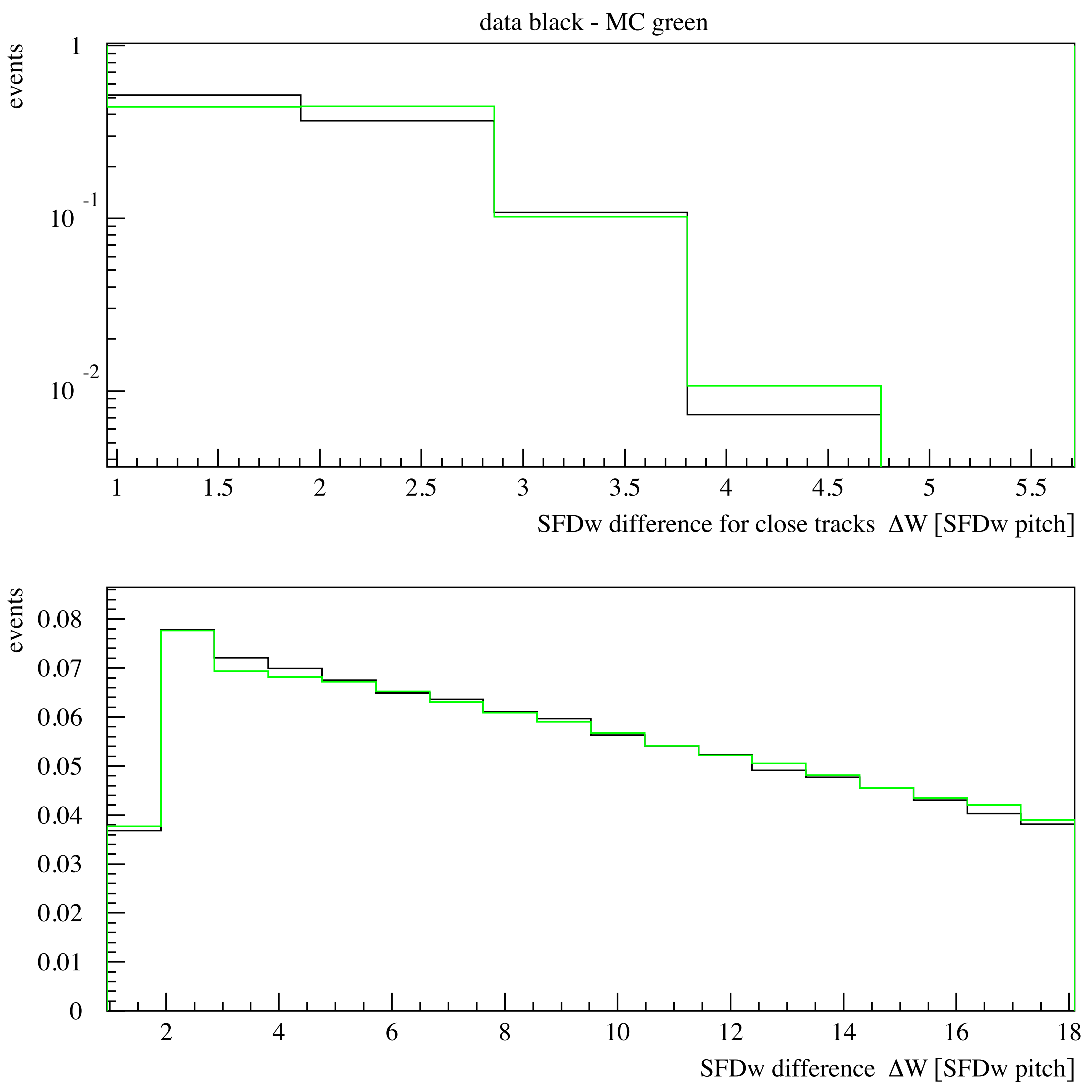

Figure 3: SFD W 2009

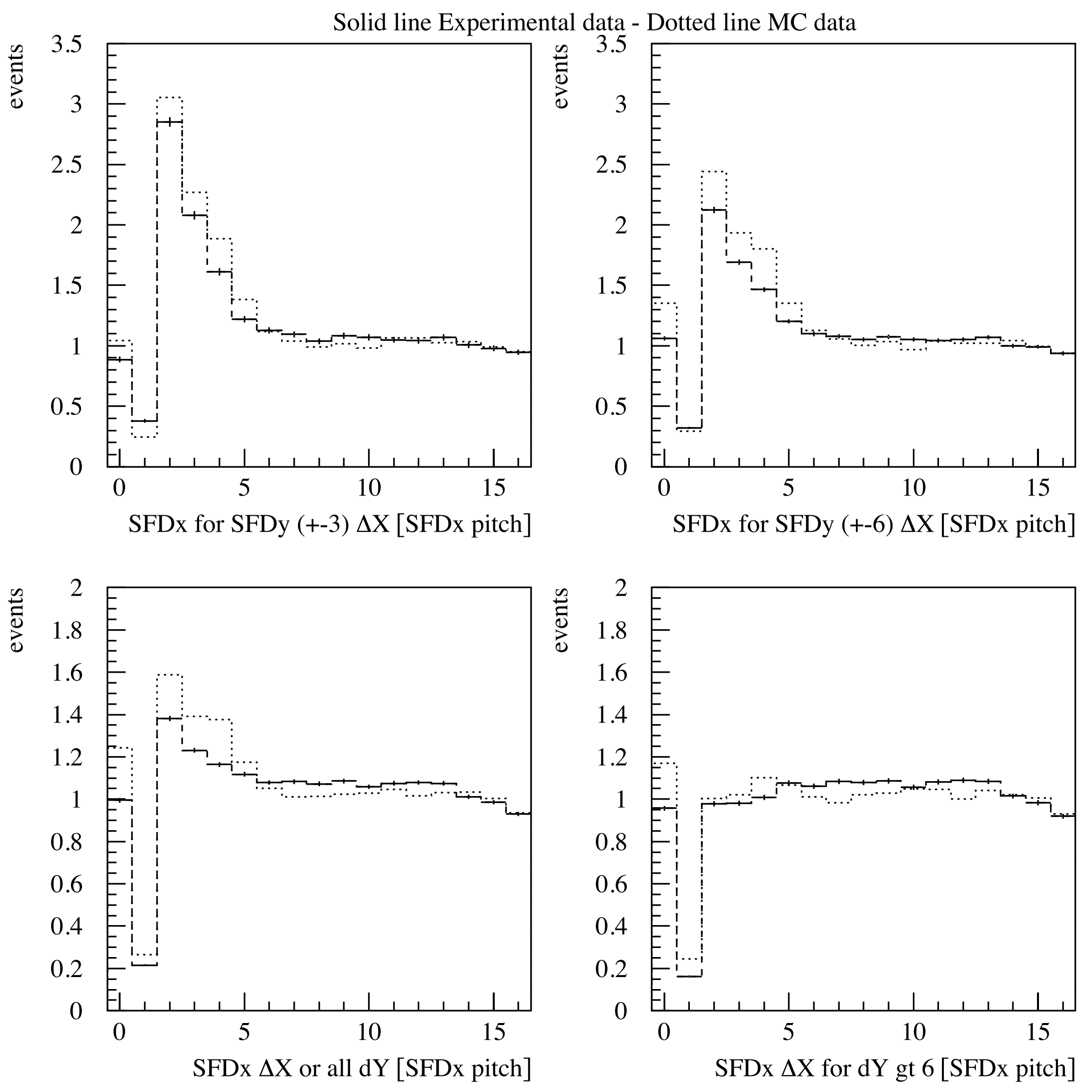

Figure 4: SFD X 2008

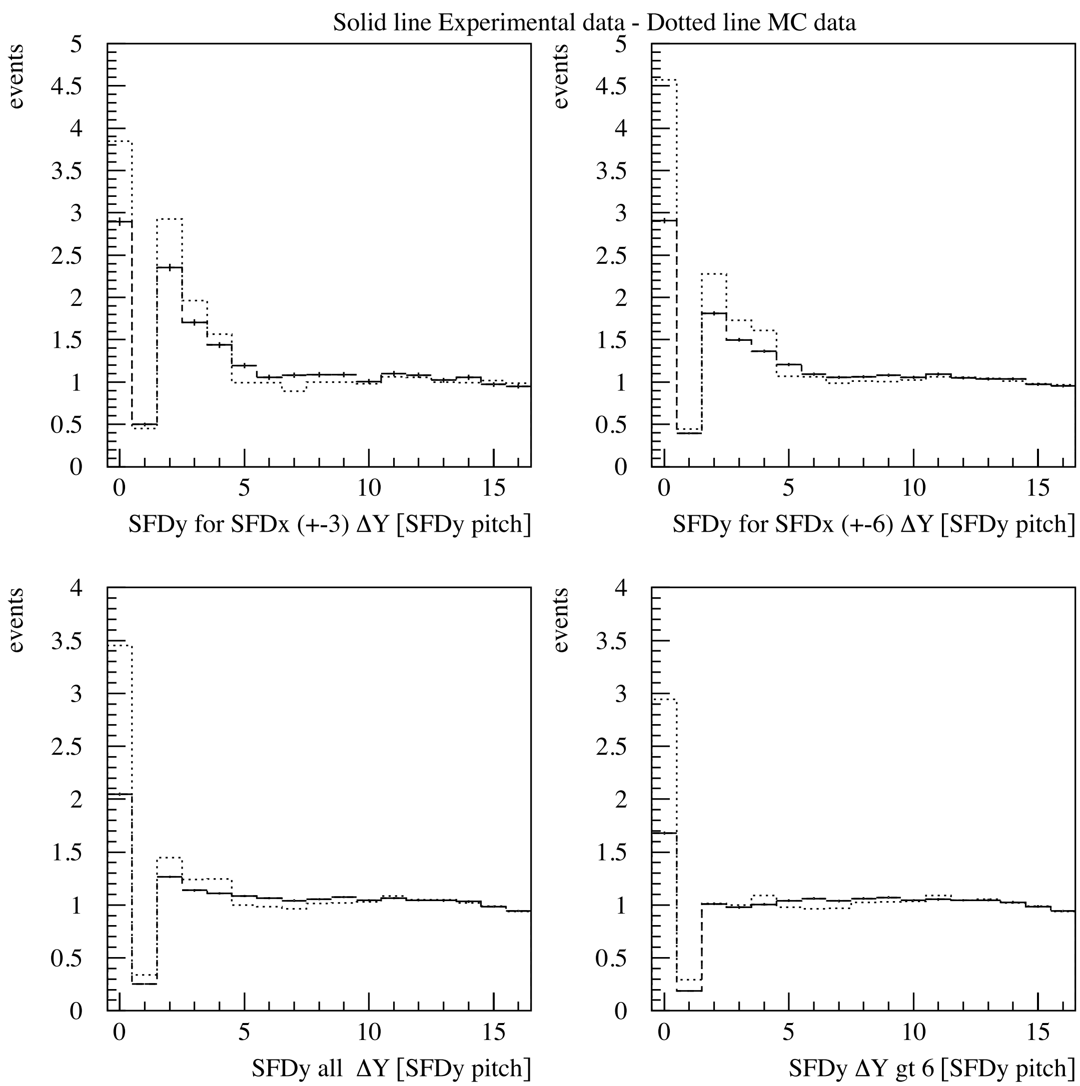

Figure 5: SFD Y 2008

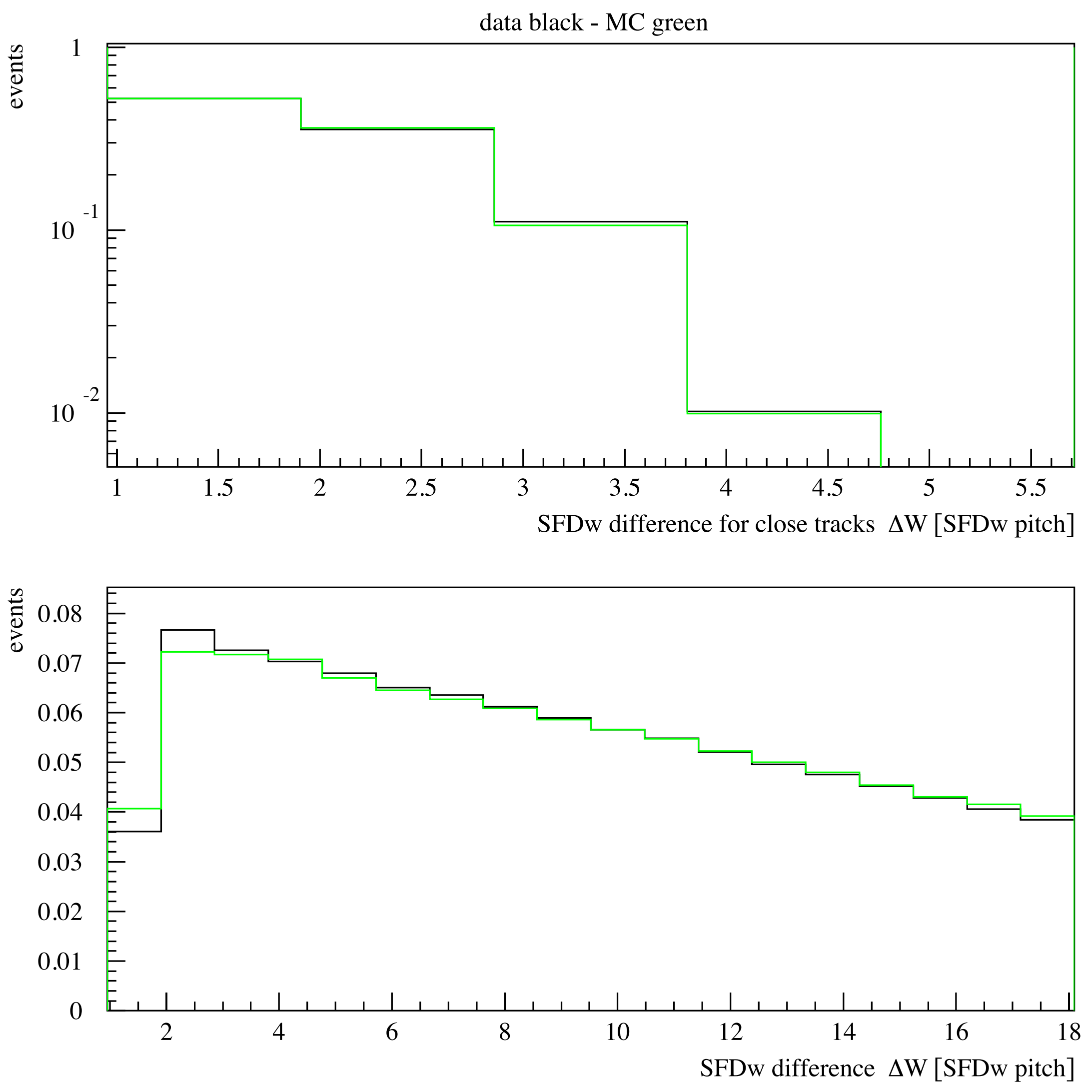

Figure 6: SFD W 2008

References

[1] New detector paper;

[2] Detection of atoms with the DIRAC spectrometer at CERN, J. Phys. G: Nucl. Part. Phys. 30 (2004) 1929-1946.

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