W+D Charm Jet Fragmentation

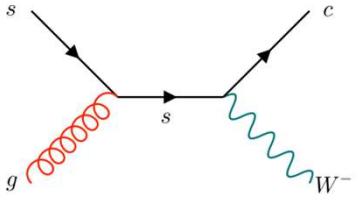
FERMILAB-POSTER-24-0147-V

Alec Lynch, Marjorie Shapiro, Miha Muskinja, University of California Berkeley, Lawerence Berkeley National Laboratory

Continuing work carried on while a member of the Fermilab Mu2e experiment tracker team, Summer 2024

Abstract

Using ATLAS Run 2 data, proton-proton collisions at 13 TeV center of mass energy are analyzed to measure the properties of Charmed particle fragmentation. The process $pp \to W \pm c$, where the c-quark fragments to a D^+ hadron is used. Since quarks are not directly seen from the collision, a jet of particles containing the charmed hadron is used. This is accomplished by comparing the distribution of z_T , the ratio of the transverse momentum of the D^+ to that of the track jet containing the hadron, to several Monte Carlo generators.

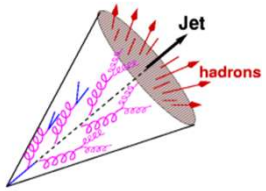


In Leading Order (LO) W+c production, W bosons and charm quarks always have opposite-sign electric charges.

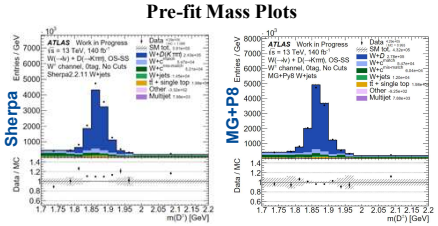
References: arXiv.2302.00336

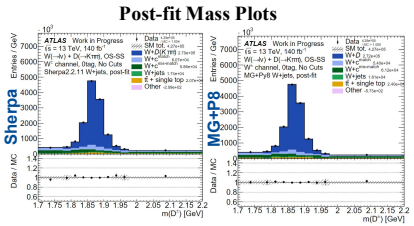
To "find" the charmed quarks after the pp collision we use charmed "Jets" that contain the energy indicative of charmed quarks.

Reference: Professor Marjorie Shapiro. Physics 129 Fall 2022



D Meson Mass Fit





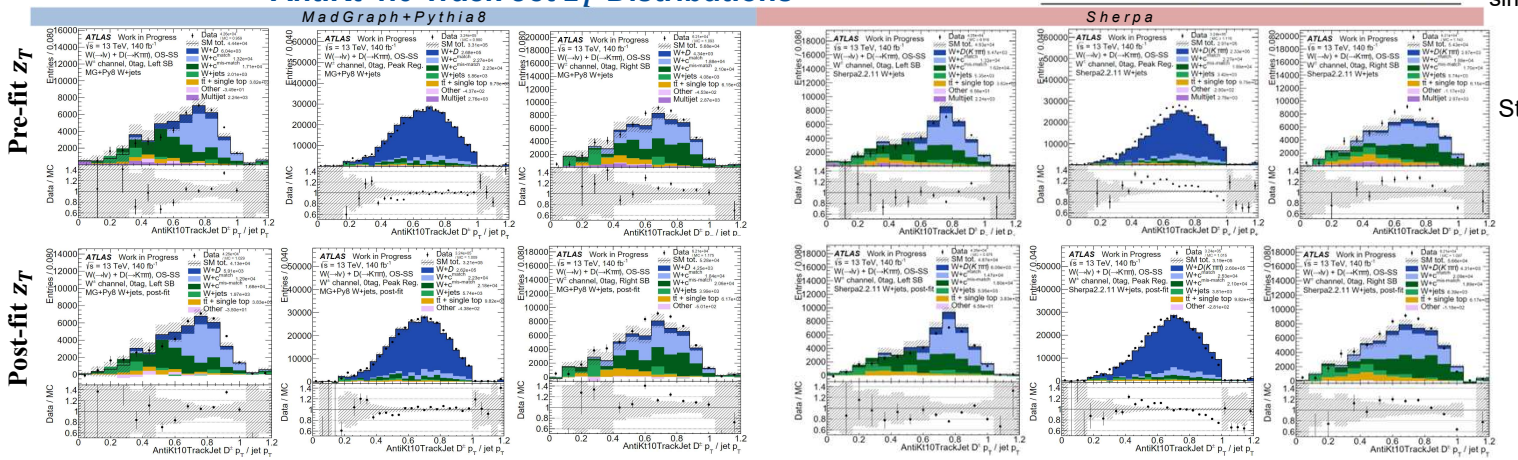
- Exploit charge correlations between W and D: Via Opposite Sign (OS) – Same Sign (SS) subtraction
- First sign of *Sherpa* not agreeing with the data as well as *MadGraph+Pythia8*

Data and Monte Carlo

Category	Normalization	$m(D^{(*)})$ shape
$W+D^{(*)}$ (D^+ channel)	Sherpa 2.2.11	Sherpa 2.2.11
$W+D^{(*)}$ (D^* channel)	Sherpa 2.2.11	aMC@NLO+Py8 (NLO)
$W+c^{\text{match}}$ (D^+ channel)	MG+Py8 (CKKW-L)	MG+Py8 (CKKW-L)
$W+c^{\text{match}}$ (D^* channel)	Sherpa 2.2.11	Sherpa 2.2.11
$W+c^{\text{mis-match}}$	Sherpa 2.2.11	LIS Sherpa 2.2.11
$W+$jets (D^+ channel)	Sherpa 2.2.11	LIS Sherpa 2.2.11
$W+$jets (D^* channel)	MG+Py8 (CKKW-L)	LIS MG+Py8 (CKKW-L)

Via Monte Carlo simulations seen above, simulated data is created to compare to real proton-proton collision events from ATLAS. From these comparisons the Monte Carlo code may be adjusted to more accurately simulate these events.

AntiKt 1.0 Track Jet z_T Distributions



D^+ Selection and Mass Cuts

Study $D^\pm \to K^\pm\pi^\pm\pi^\pm$ with $p_T^{D>8Ge}$ and $|\eta^{D<2}, 2|$

Mass Cuts

- Left Sideband: $1.7 \leq m[GeV] \leq 1.8$
- Peak Region: $1.8 \leq m[GeV] \leq 1.95$
- Right Sideband: $1.95 \leq m[GeV] \leq 2.2$

These selections cuts in the mass region are used to show how well the two different Monte Carlo simulations model the variables of interest for the background and how much of it is removed.

Results found that comparing reco level distribution of $z_T \equiv p_T^D / p_T^{jet}$ of data to predictions of *Pythia8* and of *Sherpa:*

- There is good agreement between *MadGraph*+Pythia8 and data.
- Sherpa predicts too hard a fragmentation function.

The next steps would be to implement statistical and systematic uncertainties into the samples.©

Fermi National Accelerator Laboratory

This document was prepared by ATLAS using the resources of the Fermi National Accelerator Laboratory (Fermilab), a U.S. Department of Energy, Office of Science, Office of High Energy Physics HEP User Facility. Fermilab is managed by Fermi Research Alliance, LLC (FRA), acting under Contract No. DE-AC02-07CH11359.