Diffractive $W^{\pm}$ production in SCI models

D. Werder, G. Ingelman, R. Pasechnik, J. Rathsman
Uppsala University, Lund University
EPS-HEP 2013 Stockholm

Introduction

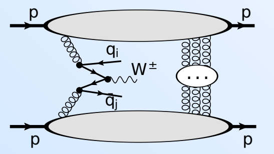
Particle collisions with tagged leading final state protons are very useful for the investigation of diffractive physics at the LHC. While the hard subprocess with a large scale defines the backbone of an interaction well, the soft part of the interaction, which is responsible for diffractive signatures like leading beam protons or large rapidity gaps, is so far not well understood due to the breakdown of perturbation theory at the low scales of the soft interactions. SCI models attempt to capture the essential physics of these processes with only a minimum of new parameters and do not use special diffractive parton density functions.
We investigate the process $pp \rightarrow p[W^{\pm}X]p$ within this model and address the claim of a possible W-charge related asymmetry. Based on [1].

SCI model

Soft color interaction (SCI) models [2] are based on the idea of color exchanges on a momentum scale below the conventional cut for perturbation theory of about 1 GeV, but above the hadronization scale Λ_{QCD}. These exchanges do not alter the momenta of the perturbative partons significantly, but do change the color topology of the event which leads to observable effects like e.g. rapidity gaps after hadronization.
Different types of SCI models have been considered. The original SCI model introduces a fixed probability for random exchanges within the event, whereas the GAL [3] model favors exchanges which minimize the color string areas.

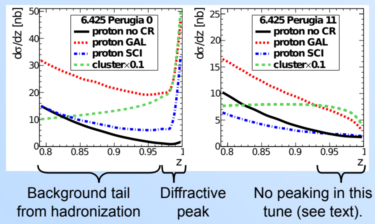
Process: $pp \rightarrow p[W^{\pm}X]p$

We investigate $W^{\pm}$ production at LHC $\sqrt{s}$ = 14 TeV. Requiring leading forward protons favors the resolution of low-x gluons in the proton. The hard subprocess consists of $q\bar{q} \rightarrow W^{\pm}$. Additional soft exchanges are depicted to the right.



Monte Carlo method

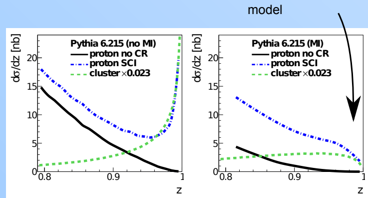
Event generation using Pythia 6.425 [4] as baseline. Generation until hadronization is standard. Partons are allowed to exchange color with momenta below Λ_{QCD}, changing the color topology of the event. Parton level event is then hadronized by the method and tune of choice. Result can contain leading beam protons, depending on kinematics, which would otherwise not hadronize into a single particle.



Parton showering and the parameters used in hadronization e.g. string hadronization [5] can have a strong influence on the final result; example shown to the right uses the Perugia 11 tune [6] which allows remnant partons to radiate in forward direction, smearing the momentum fractions to lower values already for the remnant partons.
The assumed quark masses constrain the phase space for hadronization into forward protons.

Comparison with Pythia 6.2 shows a strong dependence on the multiple interactions model (MI). Without MI we see the peaking of forward remnant partons, and the corresponding peak of forward protons.
In contrast, the non-interleaved MI in Pythia 6.2 prevent already the forward peak on parton level, which correspondingly results in no peak for the forward protons.

Peak lost due to MI model

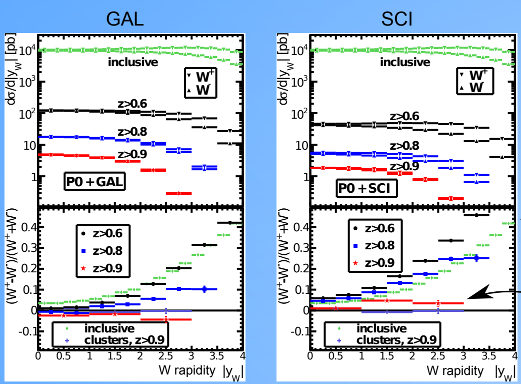


Results

SCI models together with the multi-purpose event generator Pythia reproduce essential features of diffractive physics with a minimal number of new parameters, and using only standard PDFs for the proton.

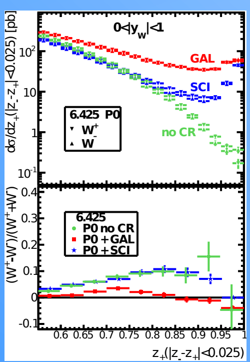
Both SCI and GAL yield similar results. The asymmetry w.r.t. the $W^{\pm}$ charge decreases with stronger cut on the forward momentum fraction z of the final state forward protons. By imposing stronger cuts on z the event sample becomes more purely diffractive.

SCI models describe both the diffractive and the inclusive component of the process in a unified way. The notion of a diffractive event sample depends on the imposed cut on the forward momentum z of the final state protons. Important when comparing with a purely Pomeron based model.



Inclusive i.e. no cut on forward protons. Asymmetry due to proton charge.

Vanishing asymmetries for strong cuts on the forward proton momentum.



Differences between the results from SCI and GAL models for this observable include:

- More forward protons in GAL at lower momentum fractions
- Steeper diffractive peak in SCI
- Less asymmetry in GAL over the whole z range
- Asymmetry in SCI follows the inclusive one below peak region

References

[1] G. Ingelman, R. Pasechnik, J. Rathsman, D. Werder, Phys. Rev. D 87, 094017, (2013).

[2] A. Edin, G. Ingelman and J. Rathsman, Phys. Lett. B 366, 371 (1996); Z.Phys. C75, 57 (1997)

[3] J. Rathsman, Phys. Lett. B 452 (1999) 364

[4] T. Sjöstrand, S. Mrenna and P. Z. Skands, JHEP 0605, 026 (2006)

[5] B. Andersson, G. Gustafson, G. Ingelman and T. Sjöstrand, Phys. Rept. 97, 31 (1983)

[6] P. Z. Skands, Phys. Rev. D 82, 074018 (2010)

Double Pomeron exchange model

In the language of Regge theory, the diffractive component of this process is described using a double Pomeron exchange by the same hard subprocess which resolves a Pomeron in both beam protons. Since the Pomeron carries vacuum quantum numbers, the beam protons stay intact by construction of the model, which describes the diffractive component of the process only.
Diffractive parton density functions (DPDF), used to model this process, are fitted to diffractive data, as is an additional $\sqrt{s}$-dependent soft gap survival factor.
Important to remember when comparing DPE with SCI, that DPE describes by definition only the diffractive component, whereas SCI provides a smooth transition between diffractive and inclusive.