Monte Carlo for Forward & Diffractive Physics

ATLAS QCD meeting
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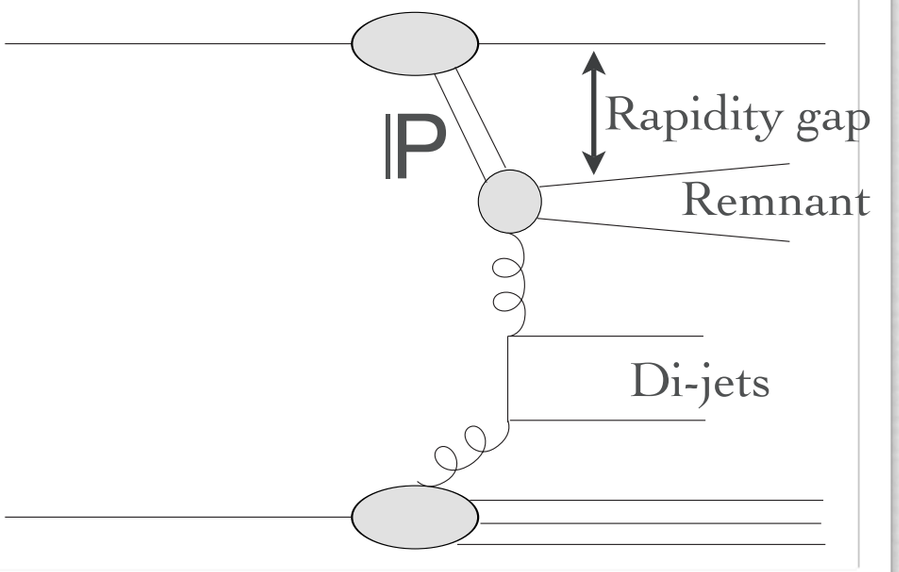
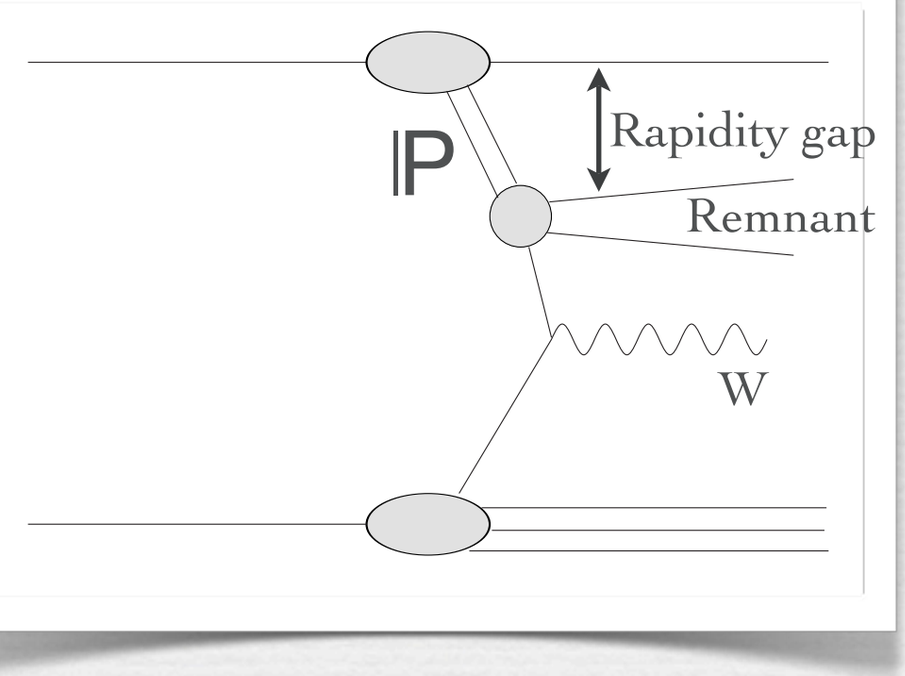
Overview

- Single & double diffraction
- Central exclusive production
- Gaps between forward jets
- QCD jet evolution

Single Diffraction

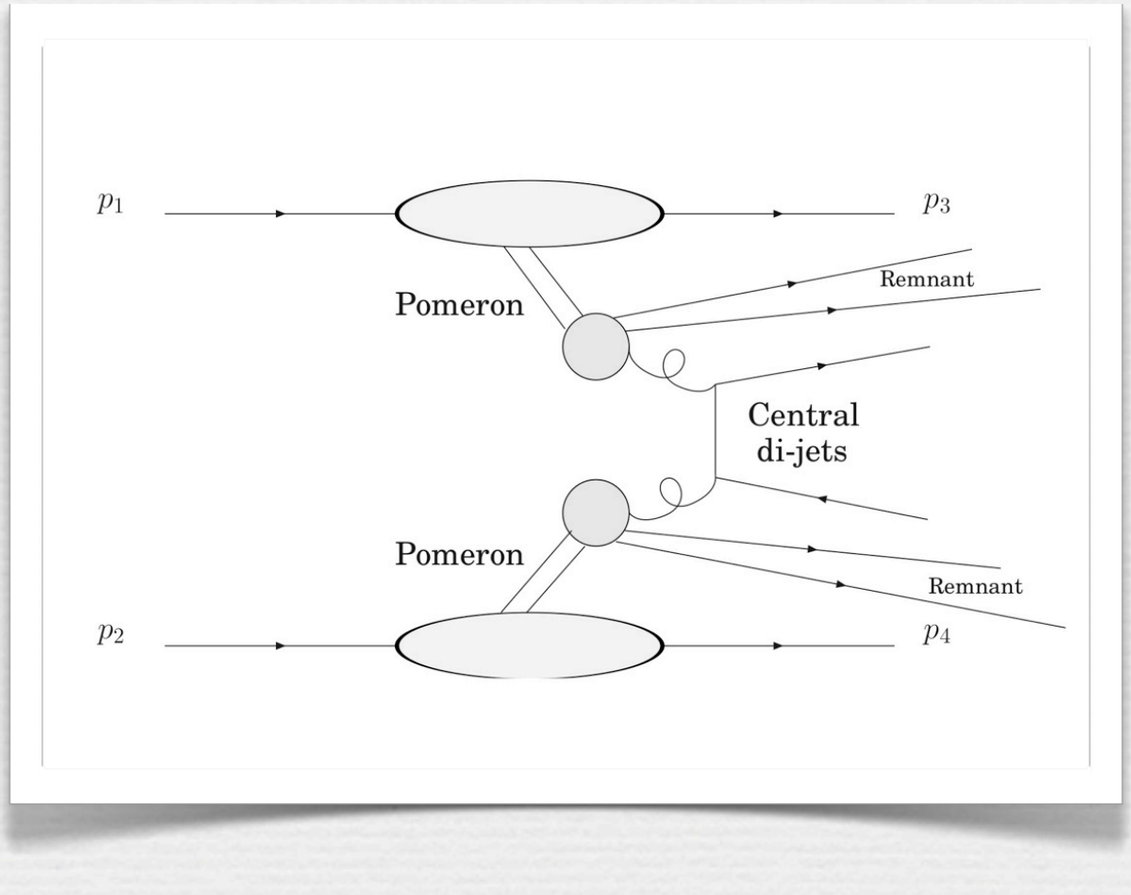




- Pomeron (colour singlet) emitted from proton.
- No QCD radiation (rapidity gap) between pomeron remnant and proton.
- Parton from pomeron via structure function

Double diffraction

- Pomeron emitted from both protons.
- Rapidity gap on both sides of event
- Soft survival unknown but necessary for diffractive predictions.
- Soft survival accounts for additional soft interactions between protons that may ruin the gap

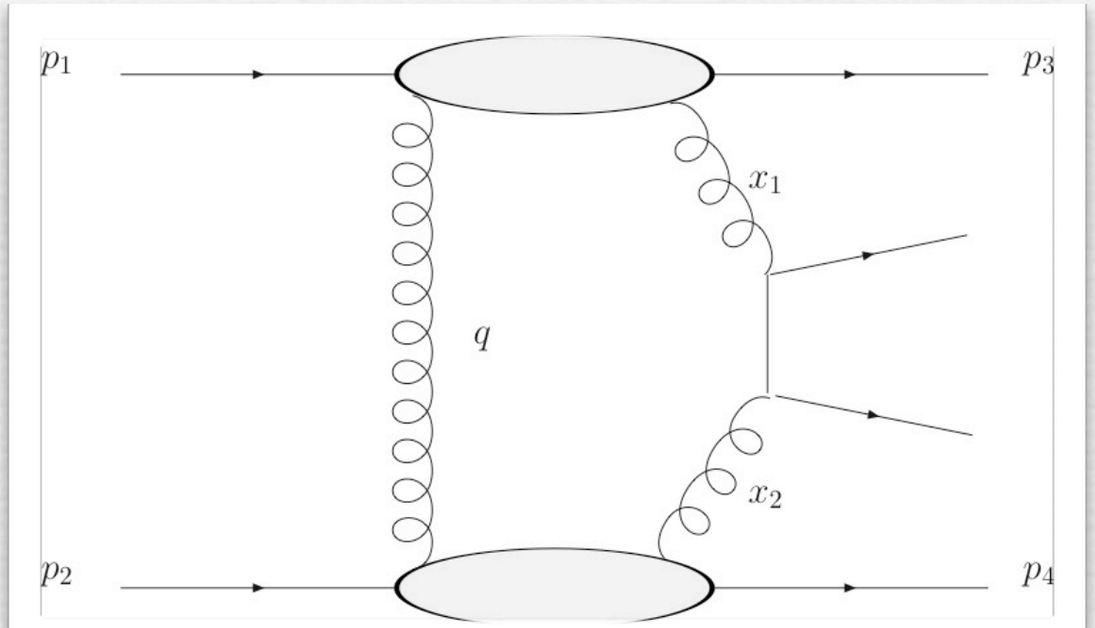


Pomwig

- Pomwig runs Herwig in electron-proton collisions (single diffraction) or electron-electron collisions (double diffraction)
- Replaces the photon flux from the electron by a pomeron flux.
- Photon structure function replaced by pomeron structure.
- An Athena interface for Pomwig exists in /offline/Generators/Pomwig_i.
- Pomwig_i only works with Herwig_i versions in release 14.4.0 or later (Herwig_i-00-03-06).
- Pomwig_i should be validated against both the stand-alone version of Pomwig at truth level and some data from HERA and possibly the Tevatron.
- Need to add Evgen job transform infrastructure (job options, random numbers etc.)
- Nevertheless, can privately generate single and double pomeron exchange right now
- Would eventually like official samples for single and double diffractive di-jets and $W^{(*)}$

Central Exclusive production

- No colour exchange between proton and central system. Outgoing protons not observed.
- See two jets in central detector and nothing else
- Same issue with soft survival as single and double diffraction (but different value?)

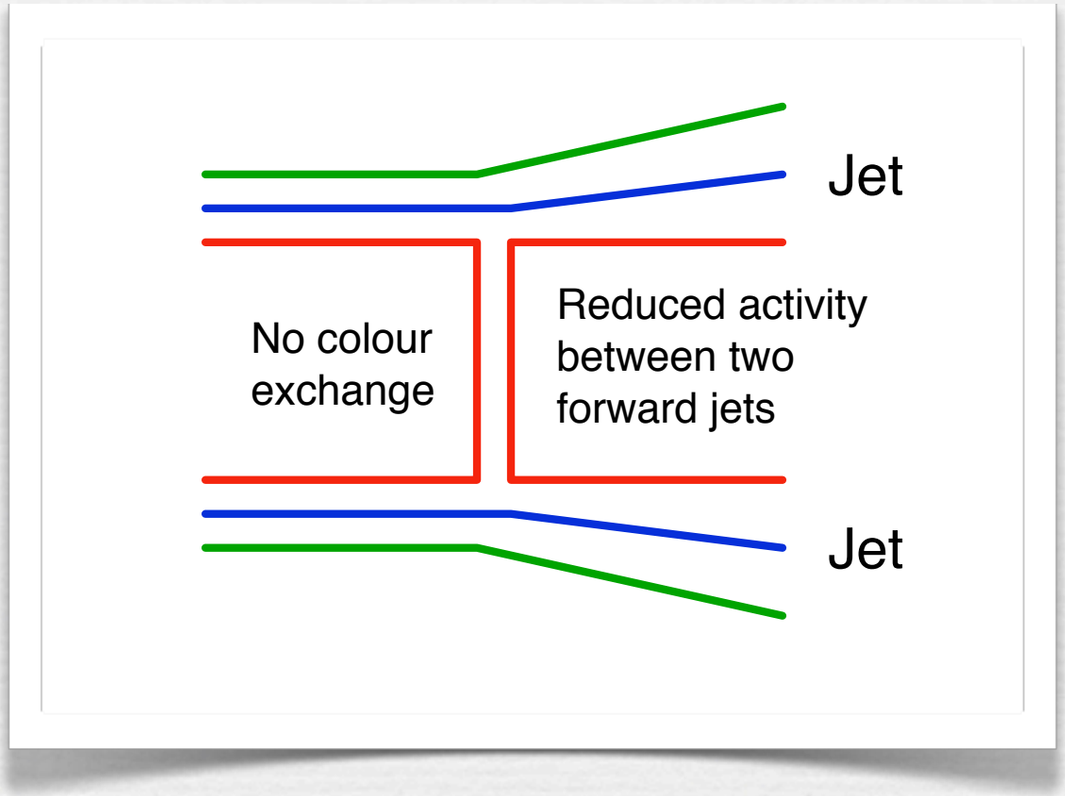


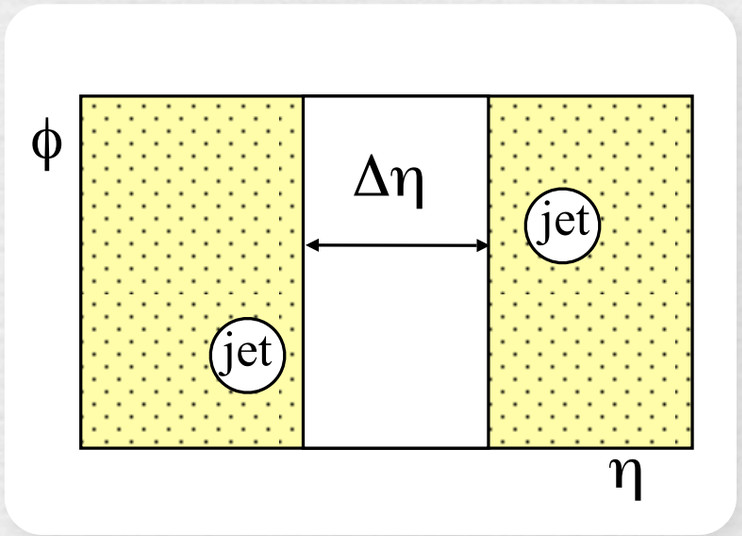
ExHuME

- Implements a perturbative calculation of central exclusive production by Khoze et. al. (ref)
- Pythia for parton shower and hadronisation.
- Interface to Athena available as /offline/Generators/Exhume_i
- No official production (yet)
- Single result from the Tevatron against which it could be tested
- Double diffractive di-jet production (Pomwig) is expected to be the biggest background. Standard QCD dijets a smaller background.
- Would like official central exclusive di-jet samples for early running.

Gaps between jets

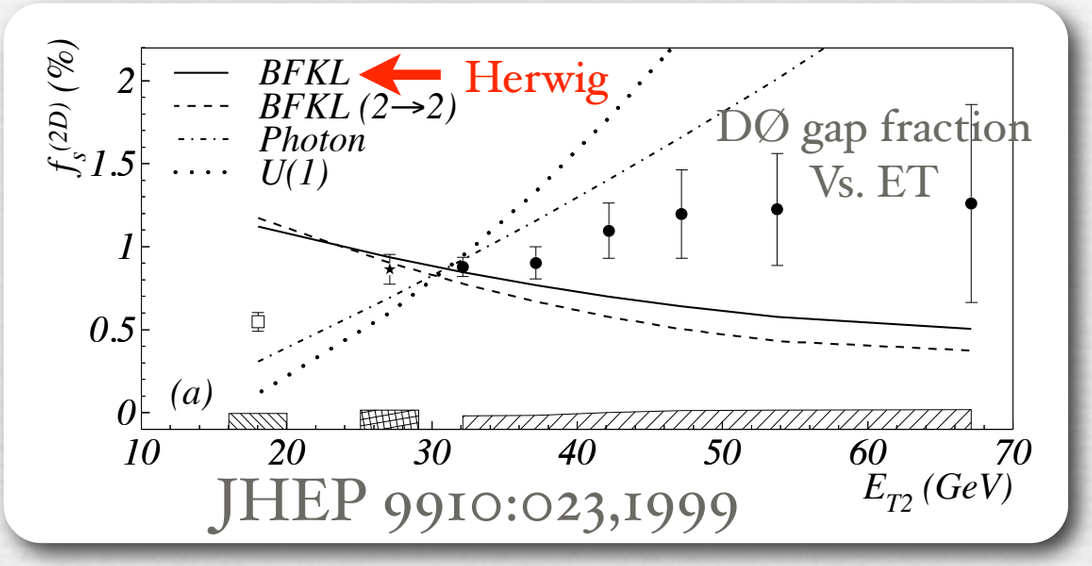
- Colour singlet exchanged between protons.
- No radiation in central region (a “gap”)
- Two forward jets from proton remnants.

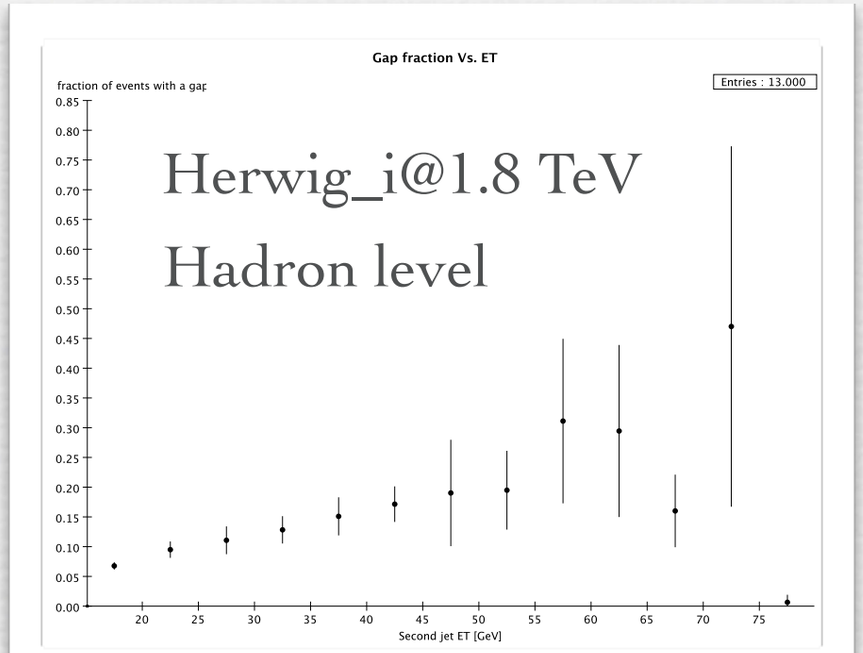




Herwig for Gaps between jets

- Herwig IPROC 2400 is colour singlet exchange.
- Did not describe the low ET DØ data well. Data show a rise in the fraction of "gap" events Vs. ET, Herwig did not.
- Suggestion was to use a non-running α_s at the pomeron-proton vertex
- Made this change for the latest Herwig_i





Herwig for Gaps between jets

- Can use Jimmy underlying event as an estimate for the soft survival. It has not been tuned for this purpose!
- Often prefer to leave the underlying event off since otherwise most events fail the cuts.
- Generated some private full sim samples with no underlying event.
- Truth level filter on jet ET and gap size (borrowed from vector boson fusion)
- Would like some official samples of the same
- Again, job transforms need sorting out.

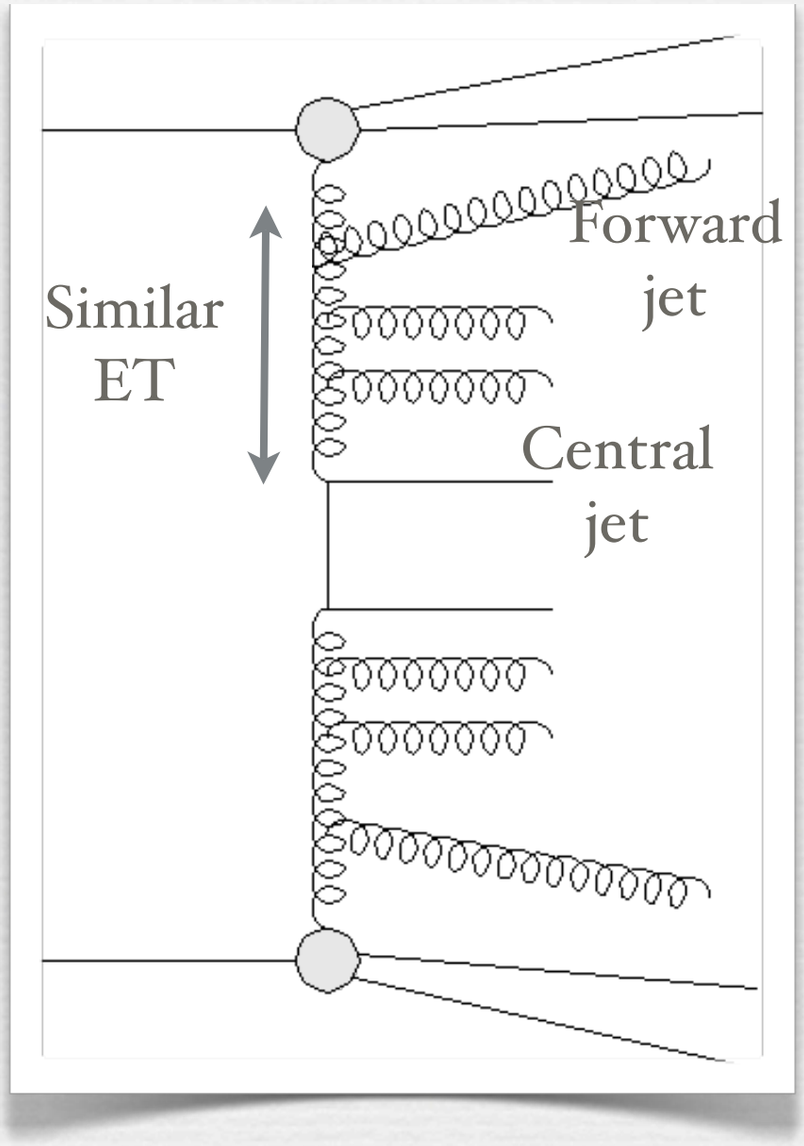
Low x jet evolution

- Conventional DGLAP parton showers re-sum large $\ln(Q^2)$ terms - KT ordering of the radiation.

- Difficult in DGLAP to have jets of similar ET widely separated in η.

- At very low x (=forward jets) there can be $\ln(1/x)$ terms larger than the $\ln(Q^2)$ terms. No ordering of the radiation in ET

- BFKL evolution instead of DGLAP



Cascade for CCFM evolution

- CCFM has features of BFKL at low x and DGLAP at large $\ln(Q^2)$.
- Angular ordering of radiation in shower
- Implemented in the Cascade parton shower Monte Carlo.
- Interface to Cascade at /offline/Generators/Cascade_i
- Should be validated by the MC working group
- Probably needs some attention to the evgen job transforms (official job options)
- Would like some official Cascade jet samples with jets covering a large rapidity span

Ariadne and Sherpa for Colour dipole parton showers

- In a colour dipole shower pairs of colour charge radiate as a dipole.
- Dipoles beget dipoles.
- Ariadne is a fortran parton shower Monte Carlo. Uses Pythia for hadronisation
- Standard hadronisation tuned assuming DGLAP evolution (shower runs down in KT). Should alter Pythia hadronisation settings for Ariadne.
- No Ariadne interface to ATLAS software at present.
- Sherpa is a matrix element Monte Carlo - it generates additional partons from the matrix element as well as the shower.
- Sherpa authors have a colour dipole shower in development. Available before first data?
- Sherpa already in use at ATLAS.

Truth filters

- Full simulation takes ~20 minutes - do not want to simulate events that will never make diffractive cuts

- To generate Herwig gaps between jets used a vector boson fusion filter to impose a gap of size 5.2 at truth level. Something similar should be used for official production.

- For Single and double pomeron there should be a gap in the forward region at truth level. This filter probably needs to be written. Same goes for Central exclusive.

- For low x evolution there should be a central and forward jet of similar ET. Wrote a filter along these lines based on TruthJet filter. Needs testing.

Summary

- Single and double diffractive di-jets (Pomwig)
- Single and double diffractive W (Pomwig)
- Central exclusive di-jet production (ExHuME)
- Forward jets with central gaps (Herwig)
- QCD evolution at low x. Compare different parton showers from Cascade (CCFM), Ariadne and Sherpa (colour dipole).

Summary

Generator	Processes	Status	Samples
Pomwig	Single and double diffractive di-jets and W	Interface exists. Needs validating and evgen job transforms writing	None (truth used for testing)
Herwig	Gaps between jets	In release. Needs official evgen production job options and official production	Some private full sim (~100k events) exist
ExHuME	Central exclusive di-jets	Interface exists. No official production. Needs evgen job options. Validation?	Some private runs
Cascade	CCFM low x jet evolution	Interface exists. No production yet	None.
Sherpa	Colour dipole parton shower	Sherpa colour dipole still in beta development.	None
Ariadne	Colour dipole parton shower	No interface exists. Completely new version of Ariadne in the future?	None