Roundtable

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DESY SM group meeting

Tuesday 3rd June, 2025

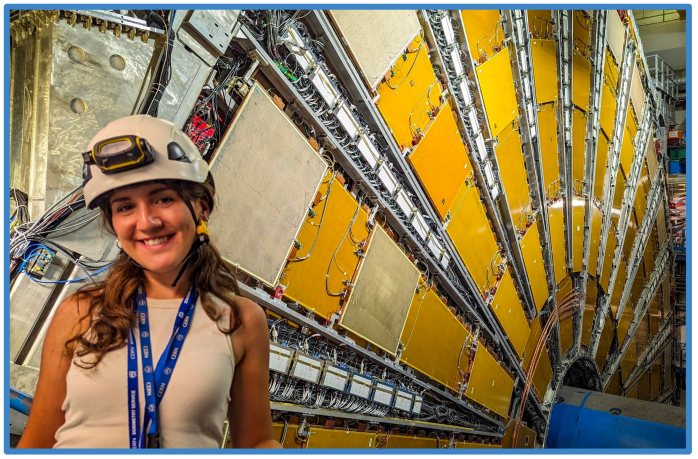
HELMHOLTZ

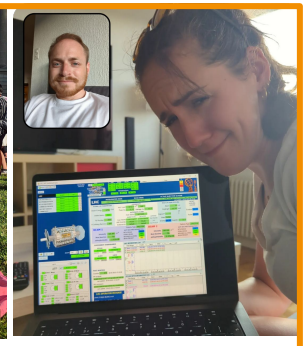
DESY.

ATLAS EXPERIMENT

What am I working on?

- **Photon-induced WW**
  - ➞ Heavily involved in observation analysis
  - ➞ Unfolded dilepton kinematic distributions in follow-up differential analysis
- **Photon-induced ττ**
  - ➞ Author of pheno study into prospects of constraining tau g-2 in LHC pp collisions
  - ➞ Analysis contact for γγ→ττ in pp analysis
  - ➞ Also involved in ATLAS heavy ion γγ→ττ analysis (mostly through supervision)
- **Forward proton CP**
  - ➞ No longer convener of AFP CP group!!
  - ➞ Involved in ALPs+AFP analysis via CP
  - ➞ Hosting upcoming ATLAS Roman Pots General Meeting at DESY
- **Soft-QCD convener**
  - ➞ Convenership started on 1st Jan 2025





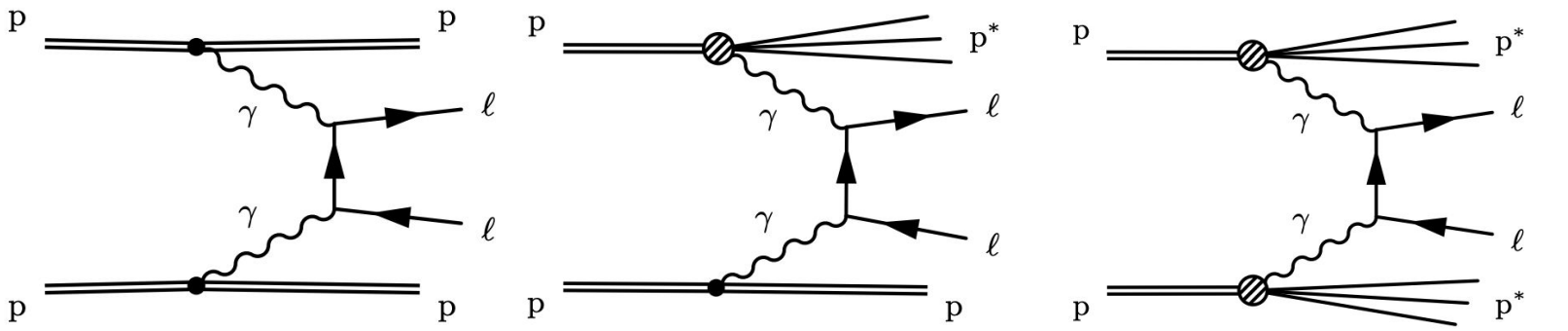
Also lots of operations at CERN as AFP on-call expert

Generating $\gamma\gamma \to ll$ with SuperChic

Intro

- Generating $\gamma\gamma \to ll$ with **SuperChic5.1 + Pythia8.310** (Ath,23.6.29)

Elastic (EL) **Single-dissociative (SD)** **Double-dissociative (DD)**

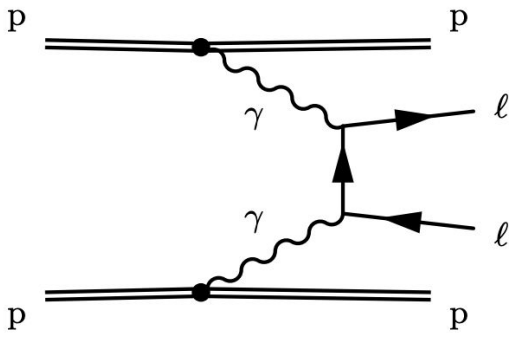


ATLAS SuperChic interface: gitlab.cern.ch/atlas/athena/-/tree/main/Generators/Superchic_i

Interfacing to parton showers

- Parton showers generally don't know how to handle photon-induced processes

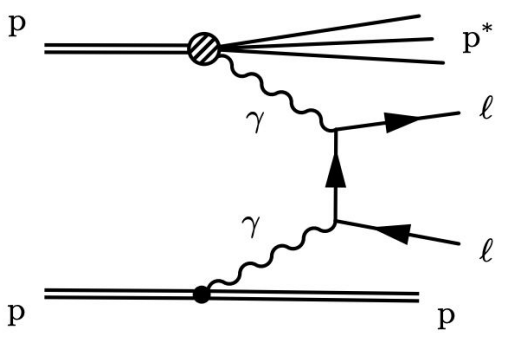
Elastic (EL)



Pythia wants to shower the protons, have to turn off multi-parton interactions and enforce a dipole shower scheme (no colour flow)

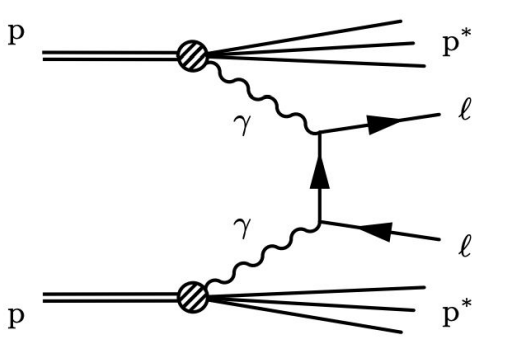
```
PartonLevel:MPI=off
SpaceShower:dipoleRecoil=on
```

Single-dissociative (SD)



This is the most difficult to get right. Pythia doesn't know how to handle one proton that doesn't shower and one that does. Lots of fiddling around with shower parameters in the config.

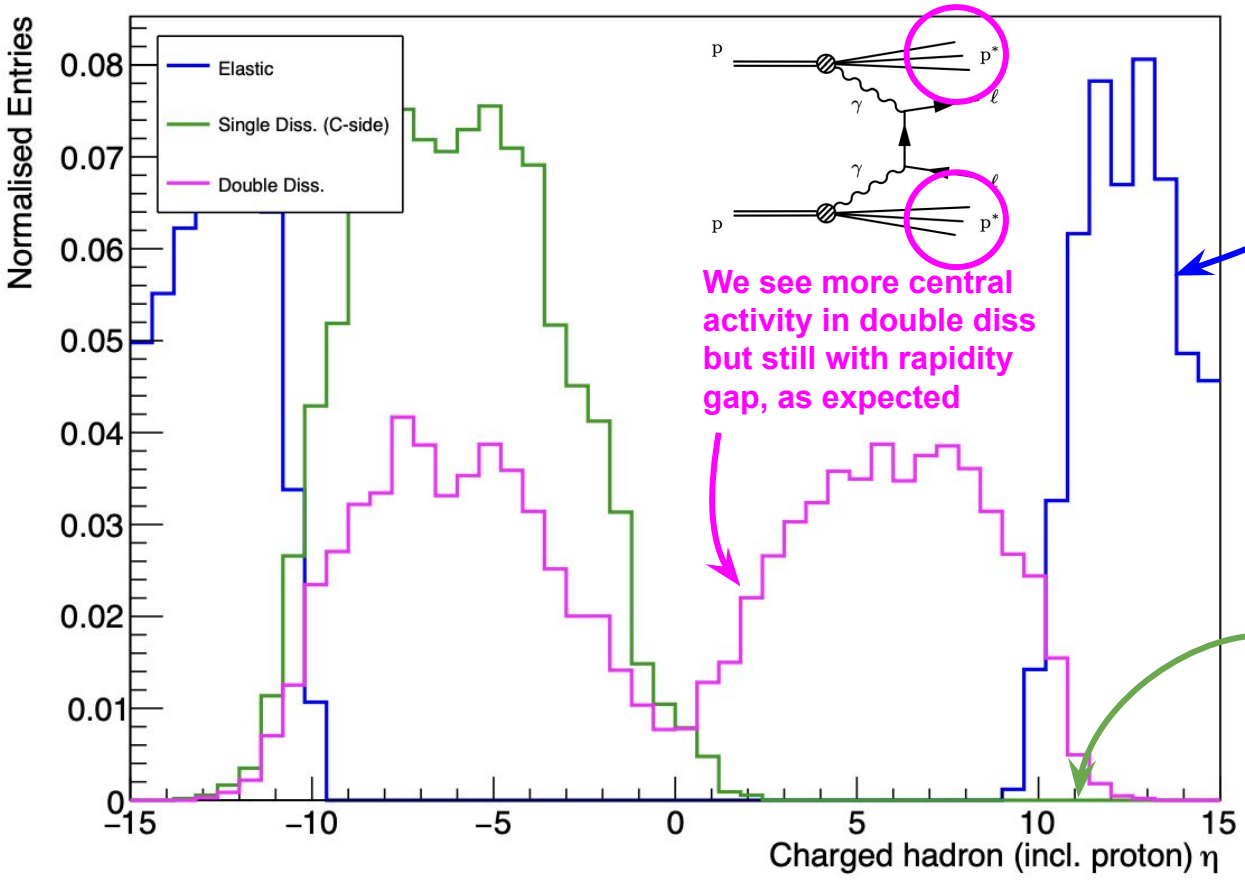
Double-dissociative (DD)



Looks more like what Pythia is used to but still need to prevent colour flow between the beam remnants with dipole shower scheme

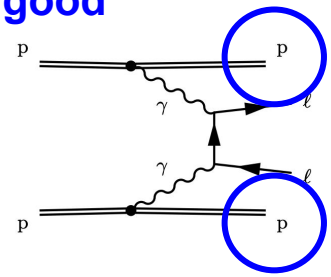
Reminder

- Last time I showed validation plots for charged hadron eta distributions
  - → Missing forward protons in single-dissociative simulation

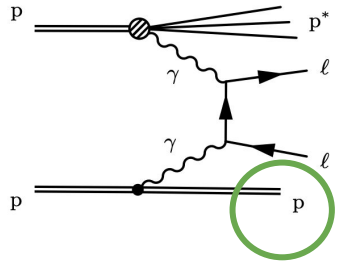


We see more central activity in double diss but still with rapidity gap, as expected

Elastic protons look good

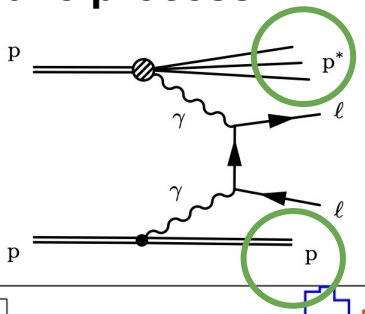


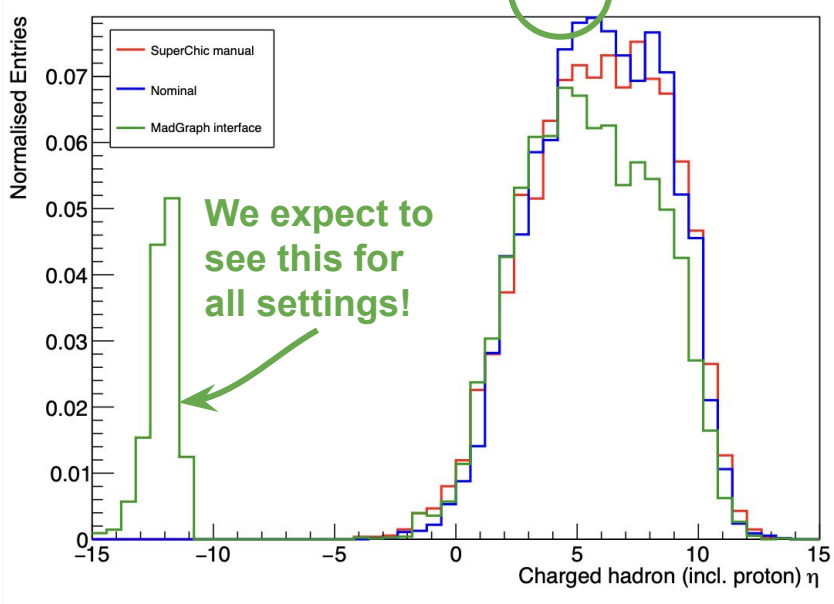
But where is our elastic proton in single diss events? :(

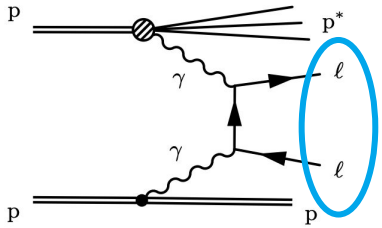


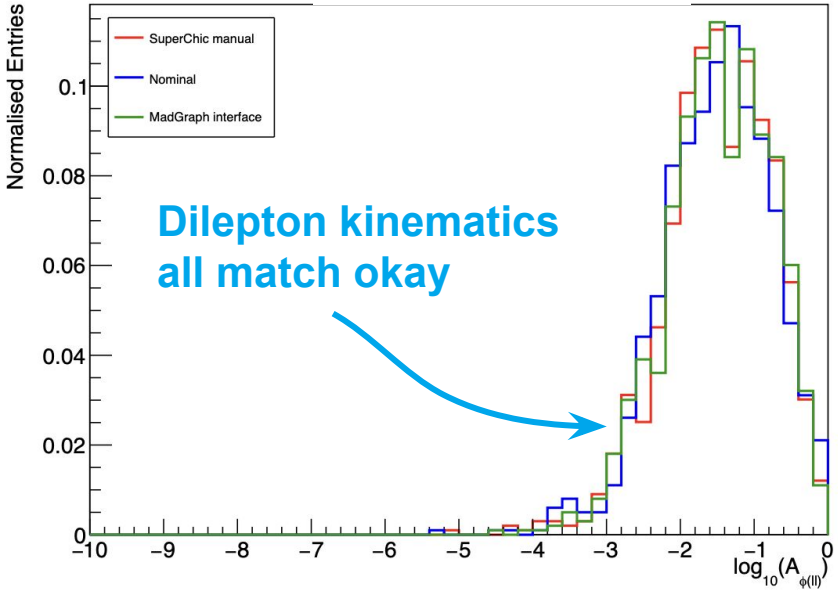
Testing alternative shower settings

- I tried comparing **different parton shower settings** for the same **single dissociative process:**





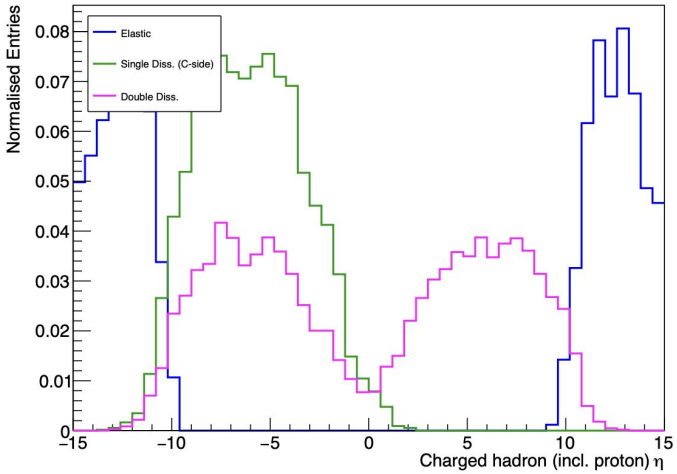




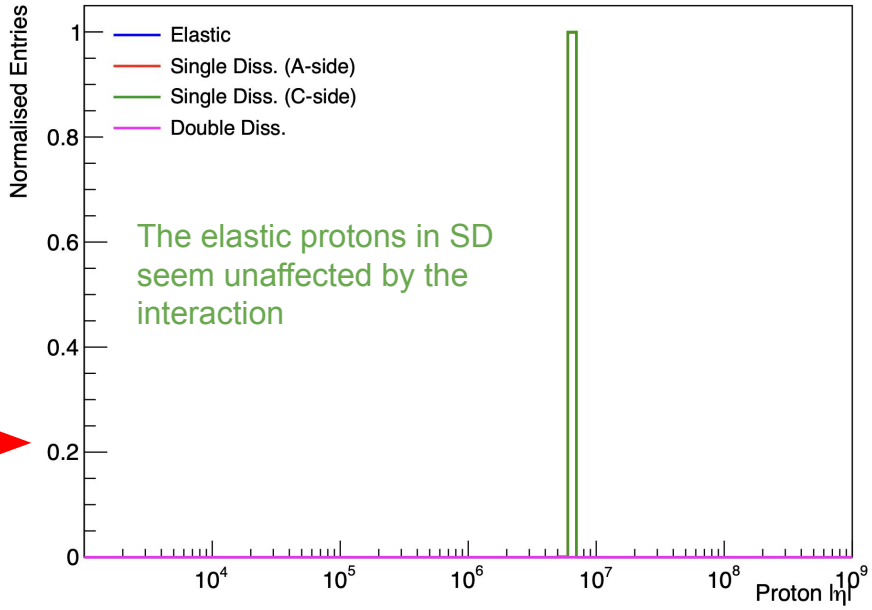
- Only the MadGraph settings show the elastic proton in single-diss

The hunt for missing protons

- I started to compare the differences between the MG and SC shower settings
  - ➞ I noticed that MadGraph does not use the dipole recoil scheme
  - ➞ I started to wonder… maybe my protons weren't missing after all…
  - ➞ Maybe I just wasn't looking for them in the right place

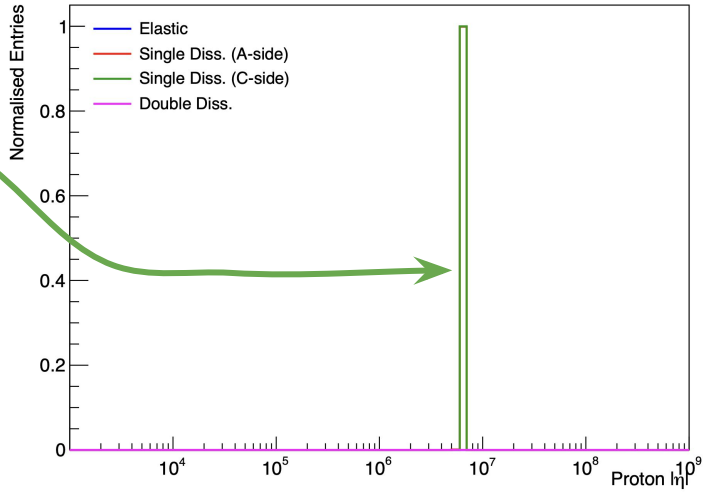


Look forward by several orders of magnitude…



The hunt for missing protons

- From Pythia 8.310, there is the option to sample photon momentum from an external photon flux (using the **`PDF:Proton2gammaSet`** option)
  - ➞ Motivated by the fact that MadGraph only provides collinear photons (kT = 0) so sampling is necessary to have a realistic central system kinematics
  - ➞ However, this **overwrites the photon momentum assigned by SuperChic**
- Can prevent this by setting **`Photon:sampleQ2=off`**
  - ➞ However, the kT values of the photons from SuperChic do not propagate into the Pythia remnant treatment and therefore **elastic protons have zero transverse momentum** (and there will be slight violation of momentum conservation in the event)
  - ➞ Can suppress the related warnings and errors from Pythia by increasing the allowed tolerance with settings **`Check:epTolErr=1.e-3`** **`Check:epTolWarn=1.e-3`**



TLDR: as we will not measure forward protons and the dilepton kinematics are not affected, **this is not a problem for our analysis**

Testing alternative shower settings

Can we blindly apply one set of parton shower settings to all ME generator outputs?

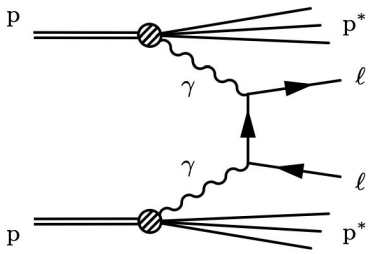
- In principle yes, the PS takes the LHE output which is a consistent format
- BUT what the ME generators feed to Pythia might not be the same, e.g. SuperChic reassigns the dissociating proton as an up-quark in SD events
- From discussion with Marek Taševsky:
  - → *"In general, Py8.3 settings for SC and MG5 may be different - because MEs and underlying physics process may communicate differently with Pythia. BUT: I can imagine that the same Py8.3 setting works equally well for SC and MG5 for a specific process and some part of phase-space."*

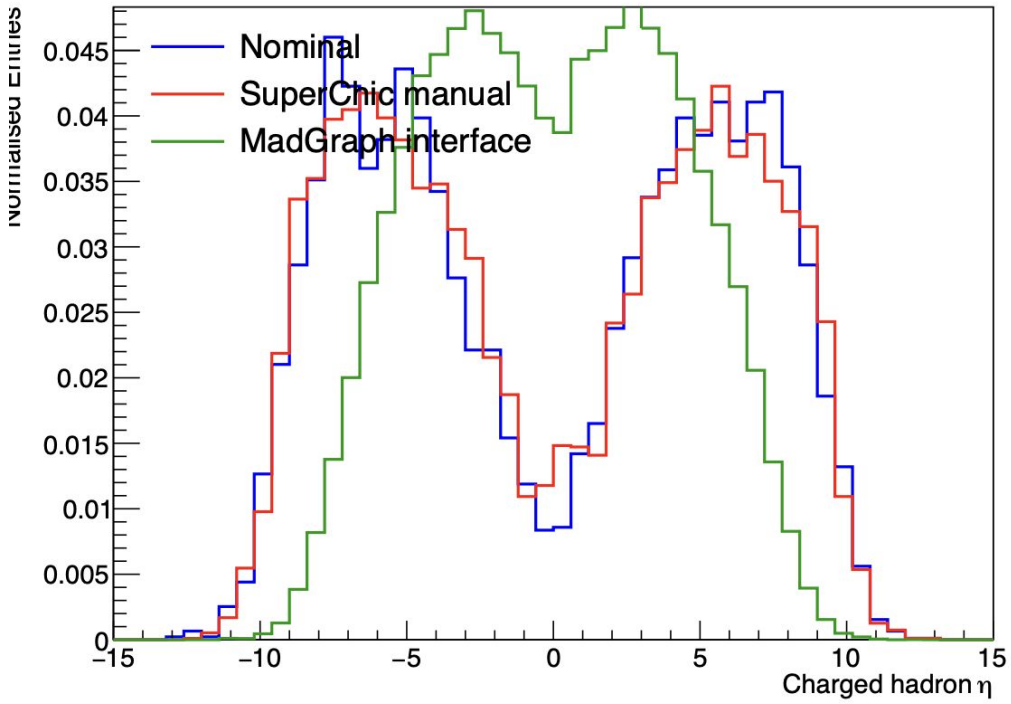
⚠️ **Caution needed!**

Testing alternative shower settings

Why don't you just use the MadGraph parton shower settings then..?

- Because we also know they are not fully appropriate for all processes/distributions
  - ➞ Take the double-dissociative process:





Summary

- I am set up to generate SuperChic $\gamma\gamma \to ll$ processes for all elastic and dissociative modes
  - → Should be easily extendable to $\gamma\gamma \to WW$ but requires a little more config
- Getting the parton shower right for photon-induced processes (especially single-dissociation) is not trivial
  - → Lots of work going into finding appropriate settings
  - → Theory uncertainties will likely come from variations in shower settings
- **NEW:** ATLAS SuperChic interface updated to properly generate the $\gamma\gamma \to \tau\tau$ process with new BSM modifications in SC v5.4
- We plan to put an MC request in ASAP
  - → **AthGeneration,23.6.48** (SuperChic v5.4.1 and Pythia v8.314)
  - → Using the parton shower settings recommended by the SuperChic authors

Backup

Explanation of sensible Pythia settings

- **PartonLevel:MPI=off** otherwise you are effectively double counting the survival factor. To have this on also does not account for specific impact parameter dependence of EL, SD and DD, giving uniformly S^2~10% and no kinematic dependence.
- **SpaceShower:dipoleRecoil=on** is specifically designed for cases where there is no colour flow between the two initiating protons
- **SpaceShower:pTmaxMatch=2** in order to fill the whole phase space with the parton shower
- **SpaceShower:pTdampMatch=1** to damp emission when it is above the scale SCALUP in the LHE, which we set to the maximum of the two photon q^2; in practice, this latter option is found to have little effect on the results.
- **BeamRemnants:primordialKT=off** as we wish to keep the initiating quark (proxy for initiating proton in pythia) completely collinear to fully match the kinematics from the structure function calculation
- **SpaceShower:QEDshowerByQ=off** (only relevant for SD production due to one elastic and one inelastic emission in the event) such that there is no back evolution from the photon, consistent with this being an elastic emission. Treating the initiating photon as on–shell in the event kinematics is an approximation to the true result, but for most purposes is a very good one.