# Multiparton scatterings and cutting rules

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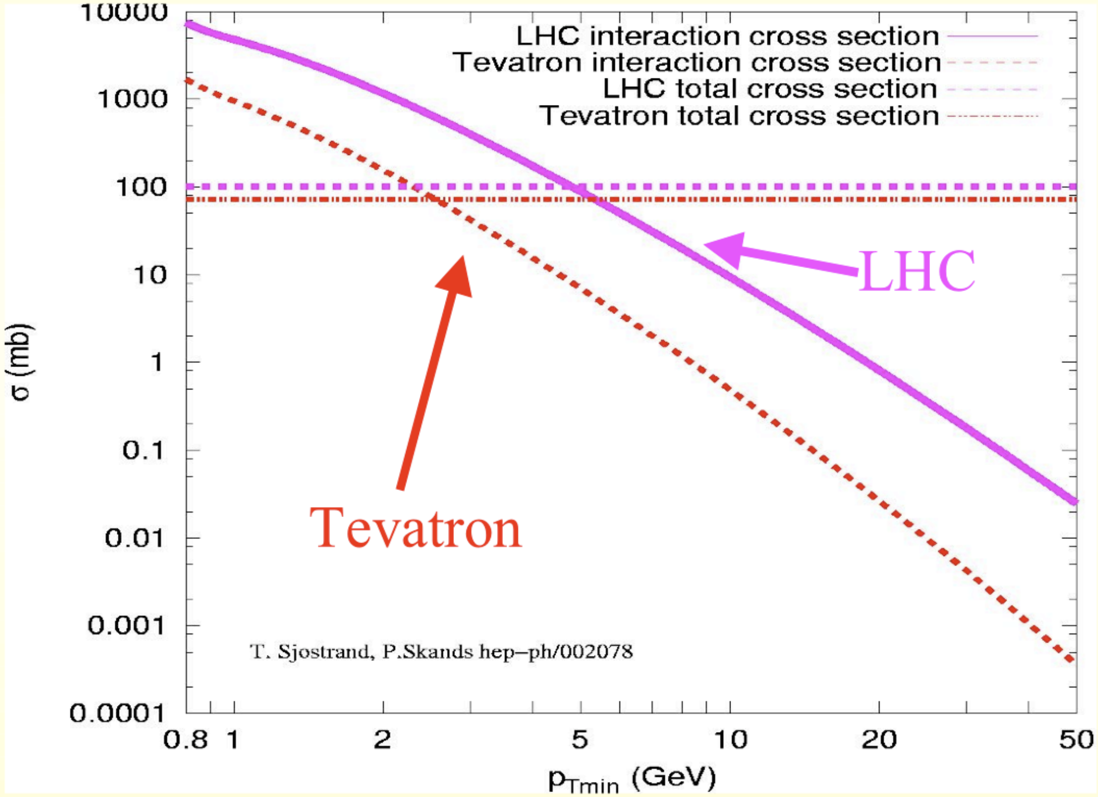
# The Physics of Multiple Interactions and Underlying Event

**Basic partonic cross section**

- **diverges faster than $(1/p_{Tmin})^4$ as $p_{Tmin} \to 0$**
- **exceeds total inelastic cross section**




**→ more than one interaction per pp collision**
**(note: no pile-up is meant !)**

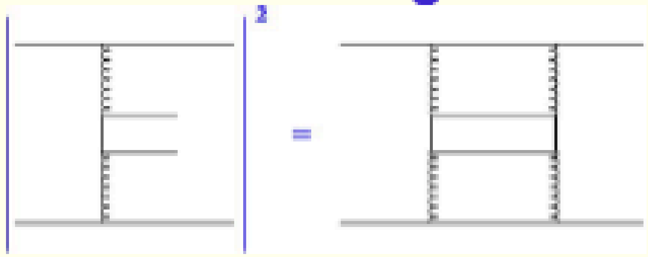
# pp Physics with CASTOR

**Multiple Interactions and Underlying Event structure are crucial for all precision measurements @ LHC**

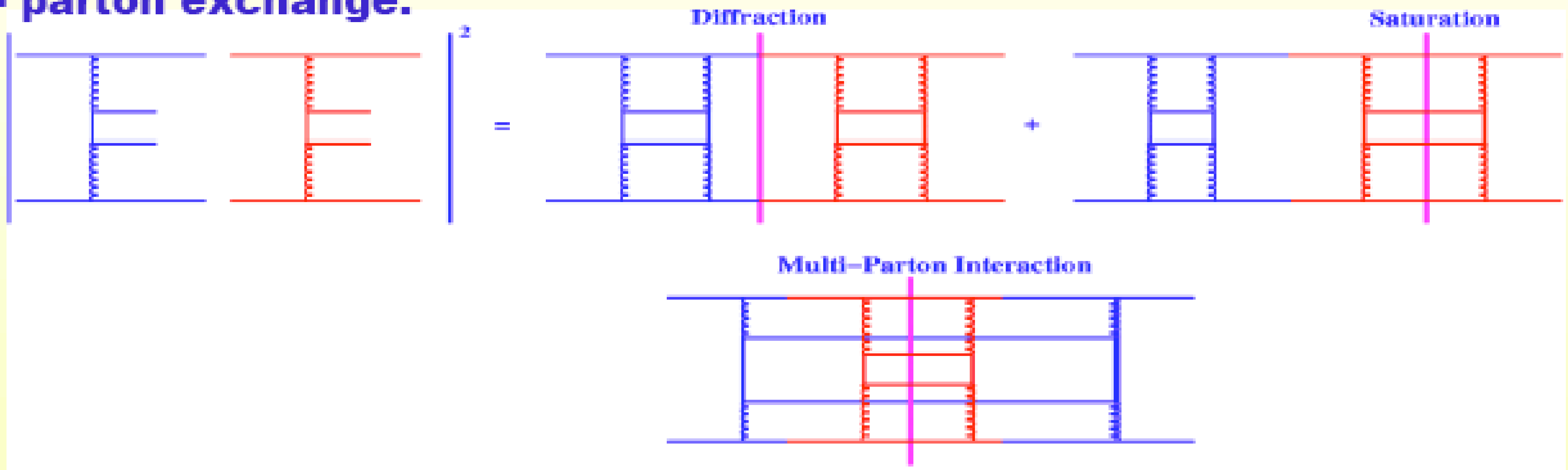
**→ need to understand both: hard and soft multiple interactions**

**Multiple Interactions and Underlying Event are closely related to Diffraction and to Saturation: AGK cutting rules**

**1 - parton exchange:**



**2 - parton exchange:**



The case of interest is that of independent Pomeron exchanges.

Two different kinds of cuts are dominant at high energy:

Cut Pomerons and cuts between Pomerons

*Cut Pomerons* contribute to the multiplicity distribution and to the inelastic cross section

*Cuts between Pomerons* contribute to the diffractive and elastic cross sections

Summing all contributions of all different cuts one obtains the total cross section.

Neglecting energy conservation all cuts are related in a simple way, basically by binomial coefficients (AGK weights)

By summing all contributions to the inelastic (non diffractive) cross sections with the corresponding multiplicity of cut Pomerons one obtains a simple result

The whole sum is equal to the contribution of the single cut Pomeron term (AGK cancellation)

Each term with n-cut Pomerons contributes with multiplicity n to the inclusive cross section. The inclusive cross section is hence given by the single cut Pomeron term.

When taking into account only independent Pomeron exchanges, there is *no unitarity correction to the inclusive cross section*

The inelastic (non diffractive) cross section is, on the contrary, unitarized by the multiple independent Pomeron exchanges.

In the multiplicity distribution of cut Pomerons, the average number is given by the single cut Pomeron term. In general the nth moment of the distribution is given by the n-cut Pomeron term

A *cut Pomeron* may be either *hard*, when there are large $p_t$ partons in the final state, or *soft*, when no large $p_t$ parton is present in the final state

Distinguishing between hard cut Pomerons and soft cut Pomerons, one has hence three different kinds of leading cuts at high energy

*Hard cut Pomerons, soft cut Pomerons* and *cuts between Pomerons*

The *elastic + diffractive cross section* is given by the sum of all *cuts between exchanged Pomerons*, including all possible uncut Pomeron exchanges

The *soft cross section* is given by the sum of all *soft cut Pomerons*, with *no hard cut Pomeron* and including all possible uncut Pomeron exchanges

The *hard cross section* is given by the sum of all *hard cut Pomerons*, including *all possible soft cut Pomeron* and all possible uncut Pomeron exchanges

The sum of the elastic+diffractive, soft and hard cross sections gives the total cross section

Comparing hard cut Pomerons, soft cut Pomerons and cuts between Pomerons one cannot hence expect any simple relation, as the distinction between hard and soft is cutoff dependent

One may however show that, looking at the *distribution in multiplicity of hard cut Pomerons* (where in addition all soft cut Pomeron and all possible uncut Pomeron exchanges are included), *all moments in the multiplicity are given by the corresponding n hard cut Pomeron term*

# Summarizing

- There is no simple link between hard cuts and diffractive+elastic cuts

- In a regime with multiple parton interactions it's interesting to measure the distribution in the number of hard interactions

- The moments in the distribution in the number of hard interactions give the inclusive multi-parton scattering cross sections

- "Saturation", namely unitarity corrections, induced by multiple hard interactions do not affect the inclusive cross sections

- On the contrary, the different contributions to the inelastic cross section, with a given number of hard parton collisions, are unitarized by higher order hard interactions and are well defined in the infrared region.