How do we search in ATLAS?

From the MC-event generation to the event-selection

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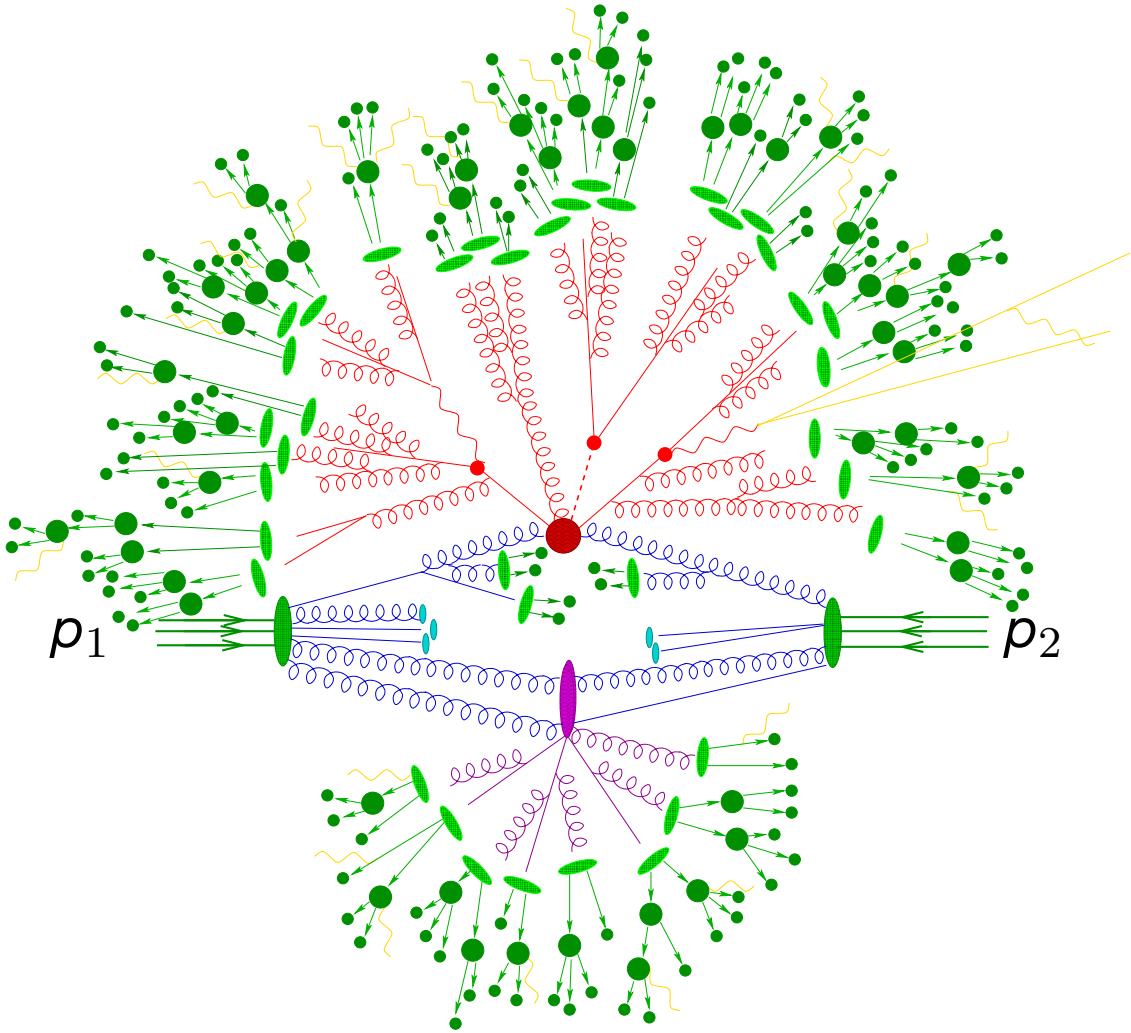
Thursday 23rd February, 2017

MAX-PLANCK-GESELLSCHAFT

Describing a *pp* - collision



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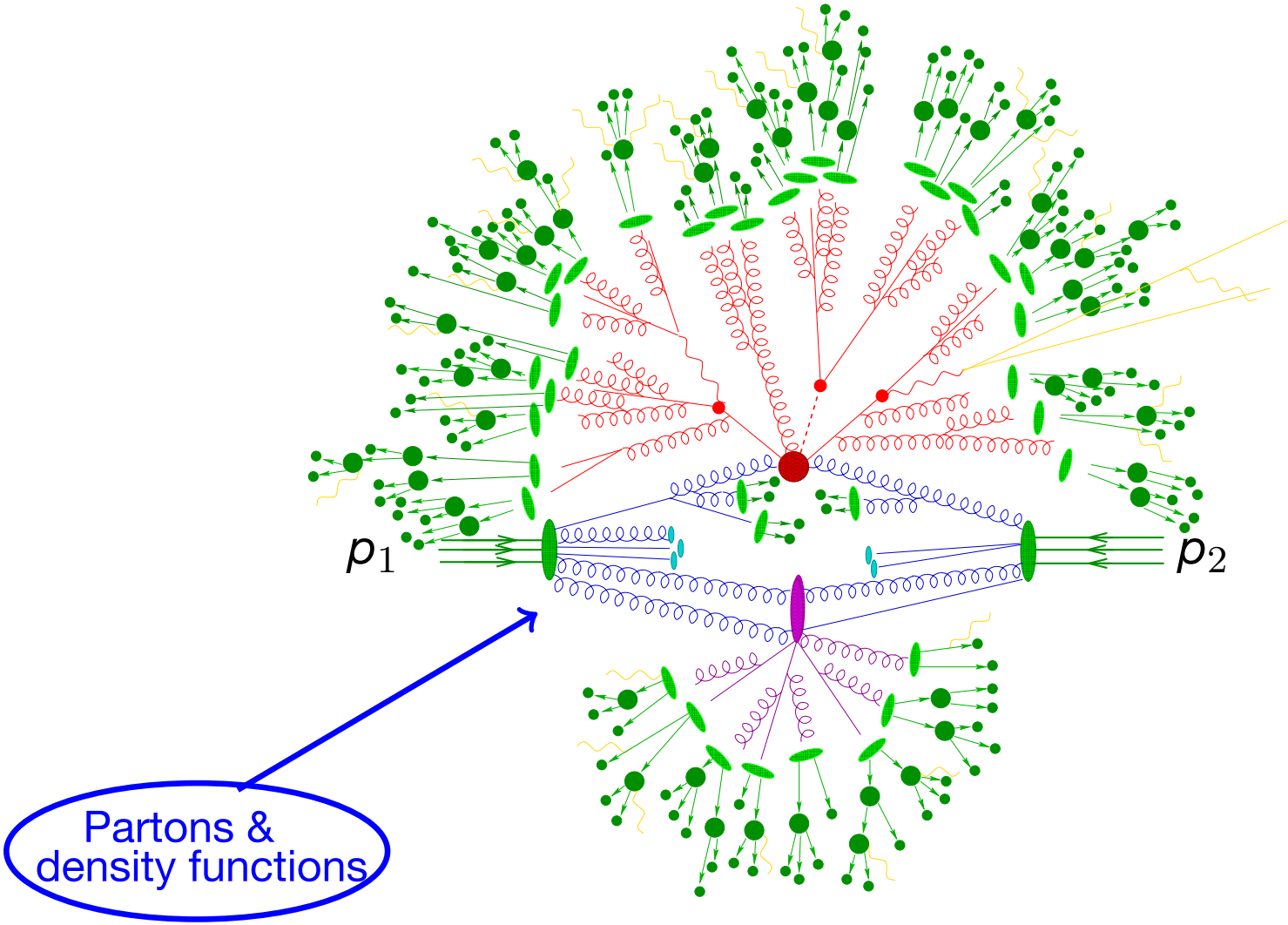

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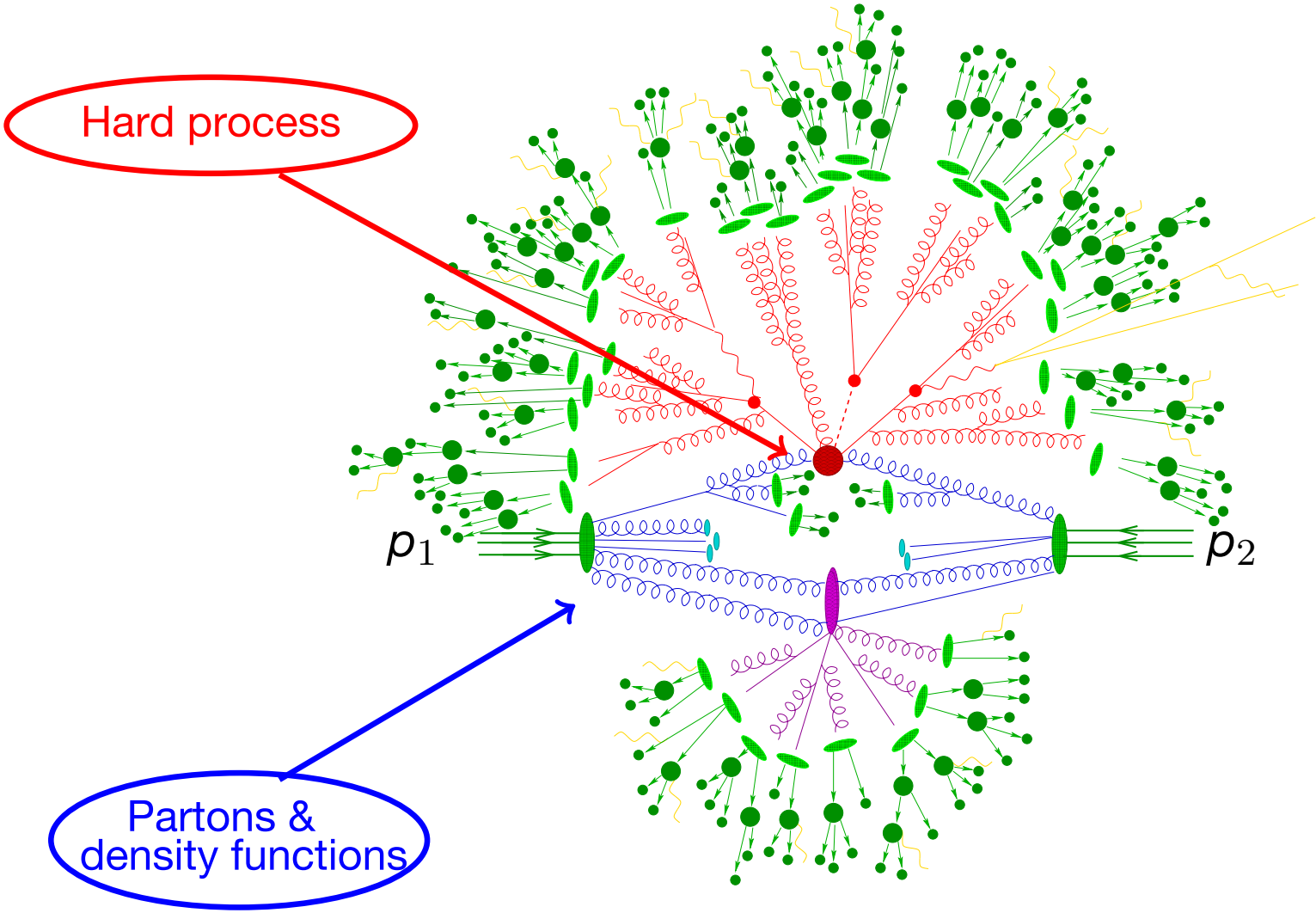

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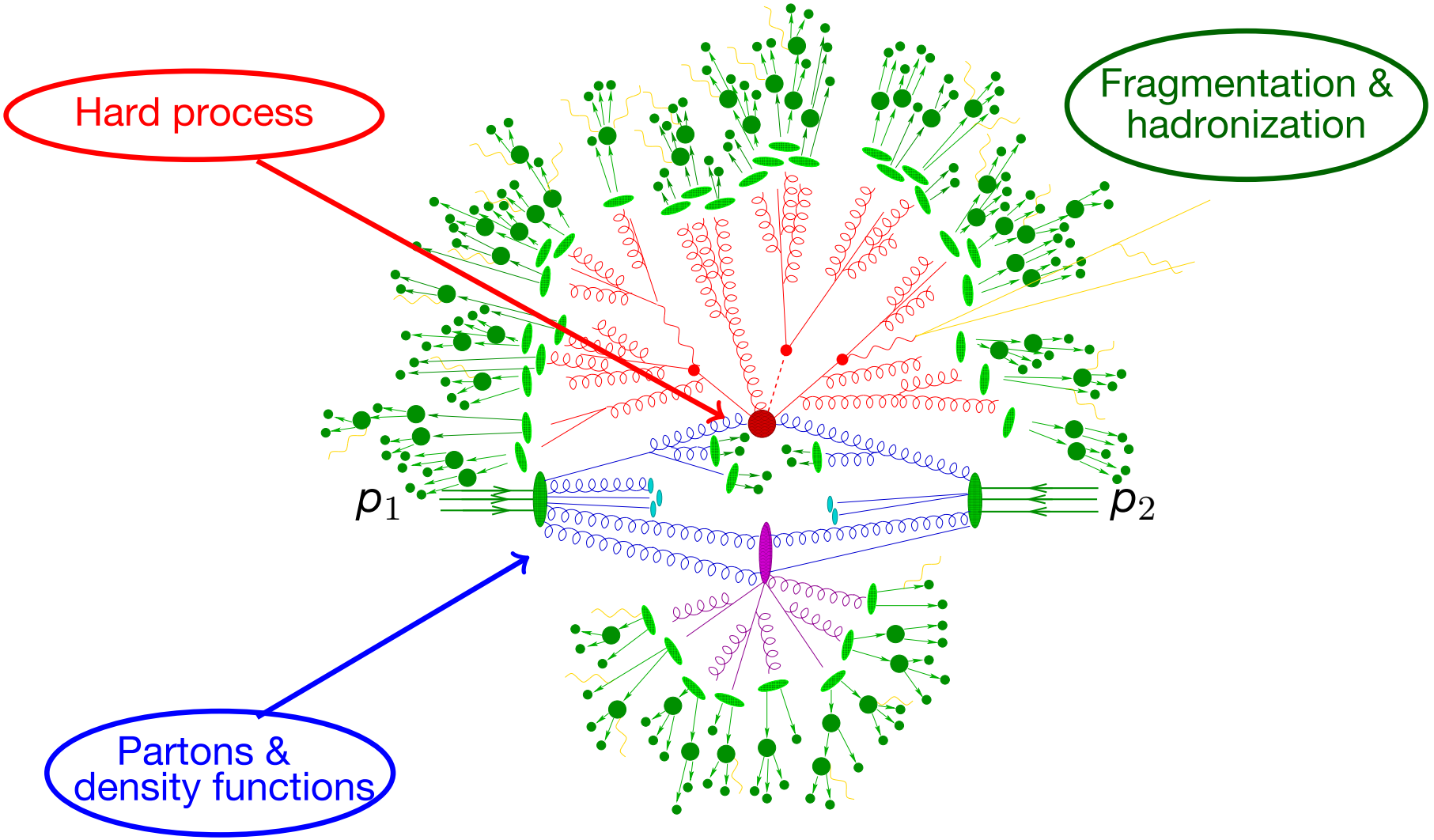

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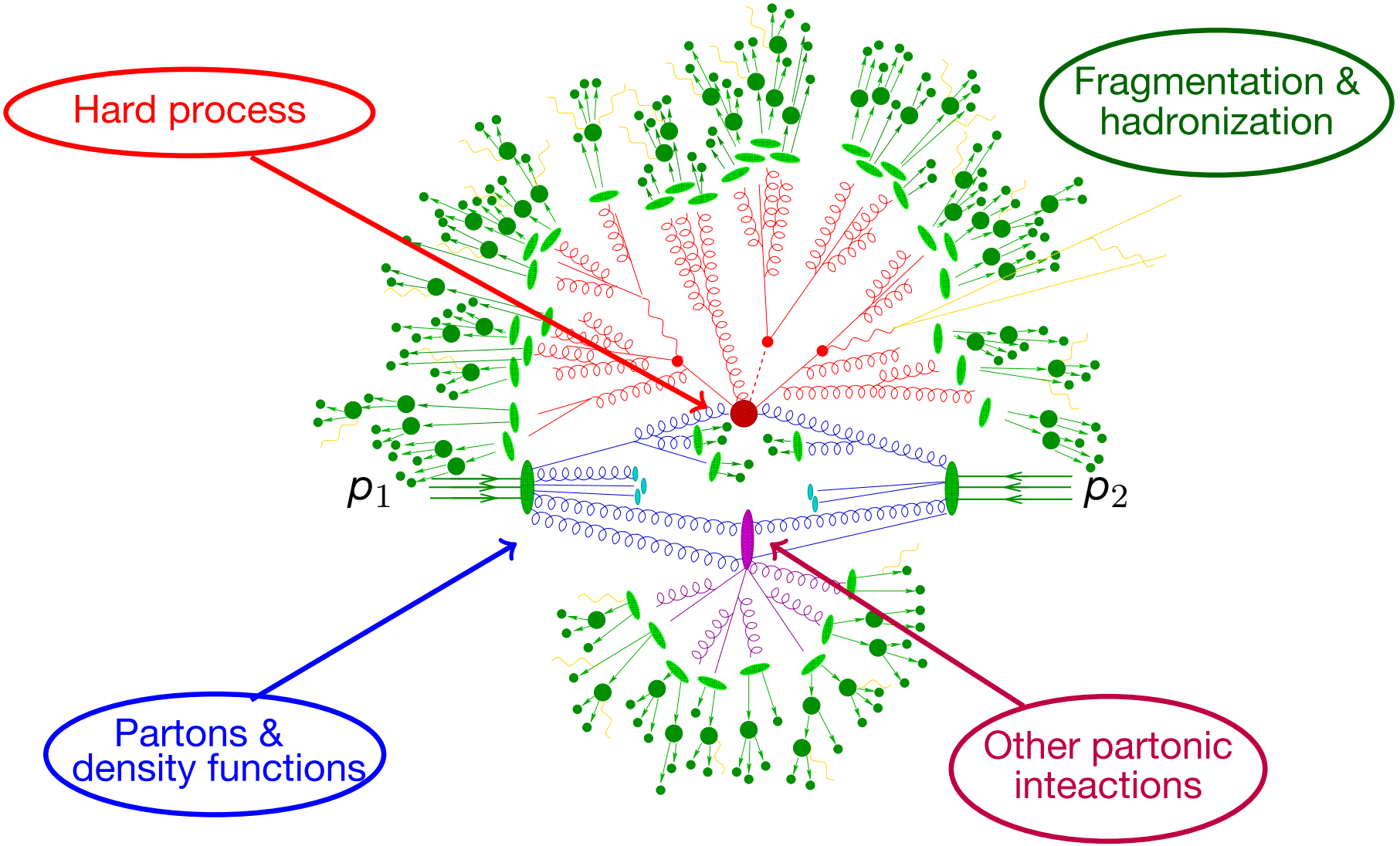

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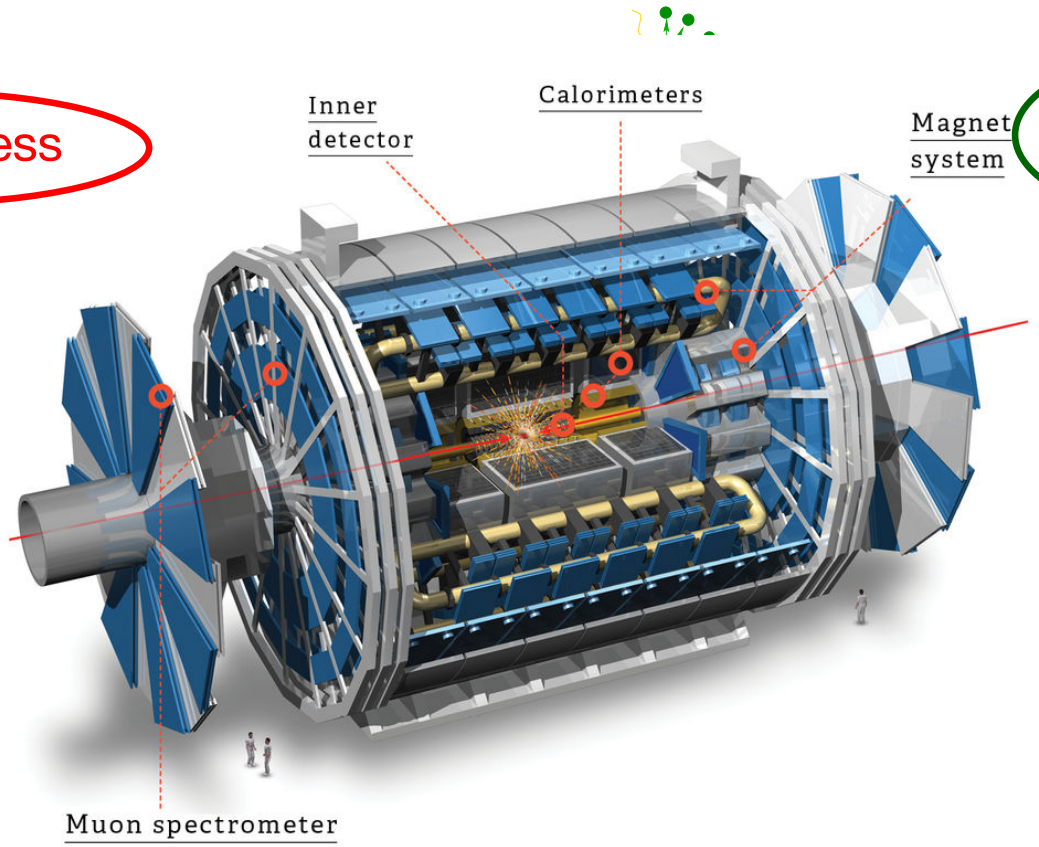

Fragmentation & hadronization

p_2

Partons & density functions

Other partonic inteactions

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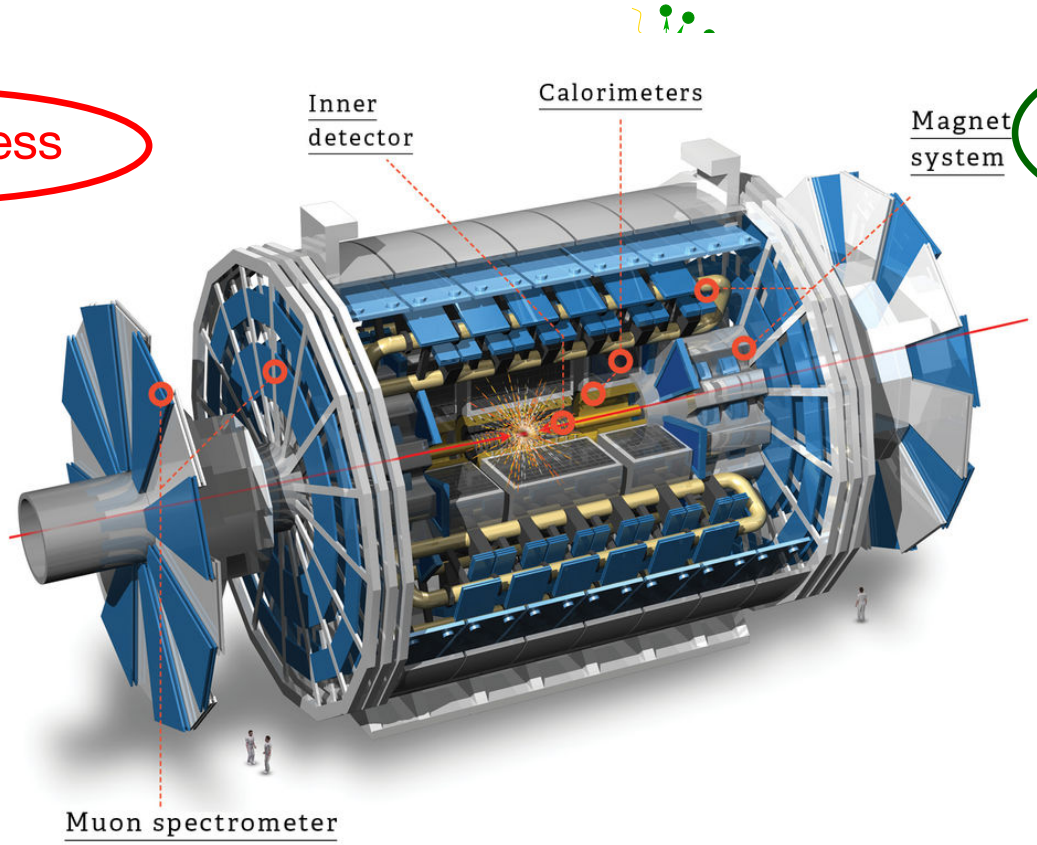

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The begin of a journey

ATLAS simulation

- How good is our ability to record the event of interest?
- Build ATLAS inside the PC in ~ 4.1M different blocks
  - Active detector material
  - Supporting structure & cabling

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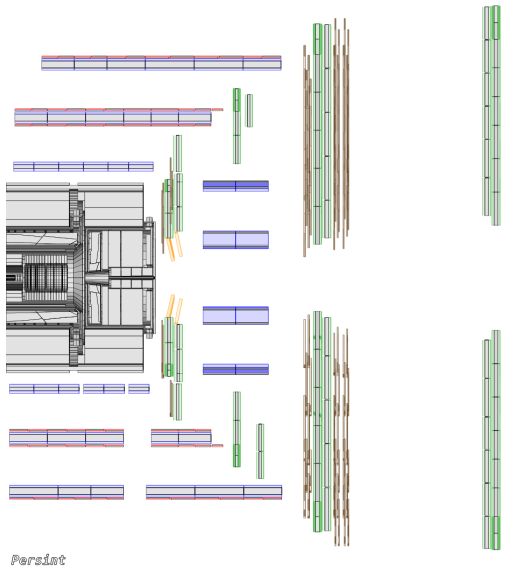

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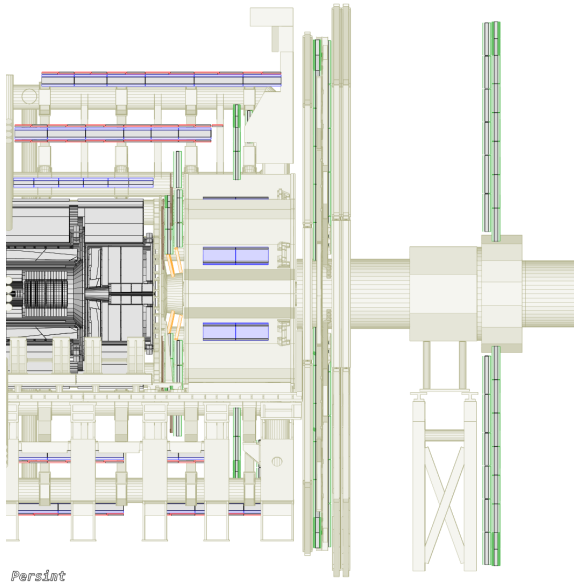

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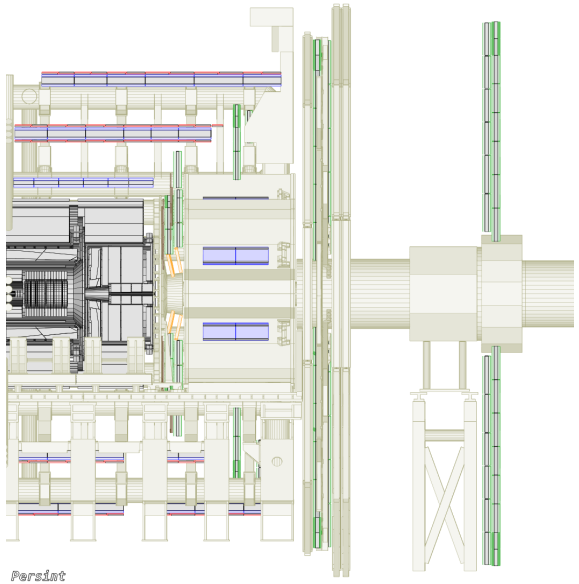
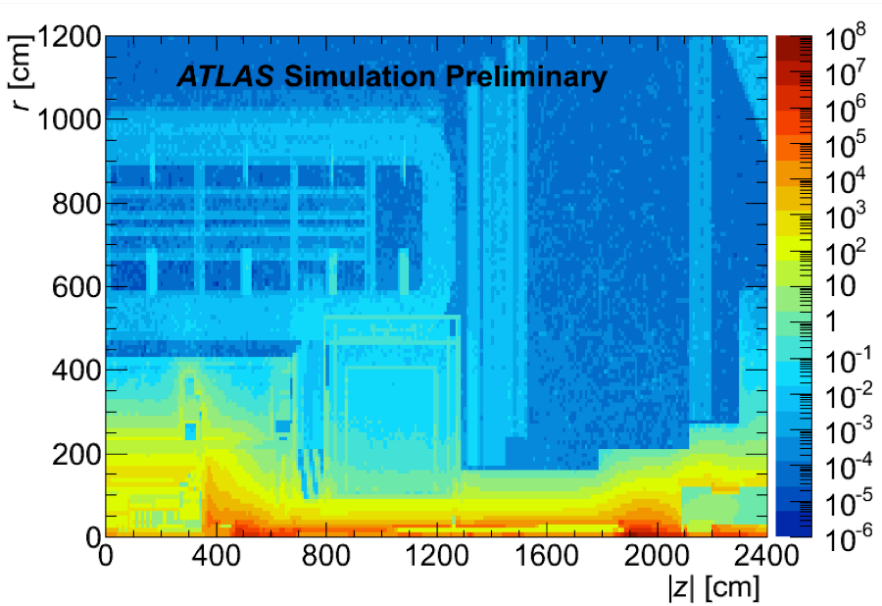
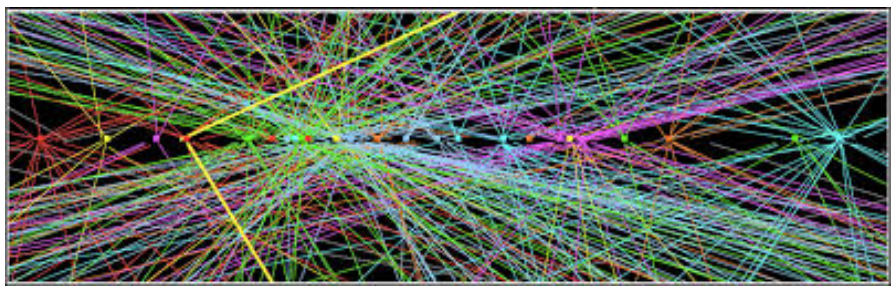




- Propagation of particles through $\overrightarrow{B}$ & interactions with the detector
- Inclusion of external effects e.g. cavern radiation

Pile-up & trigger

- Up to now only the *pp*-interaction of interest simulated
- LHC collides proton bunches



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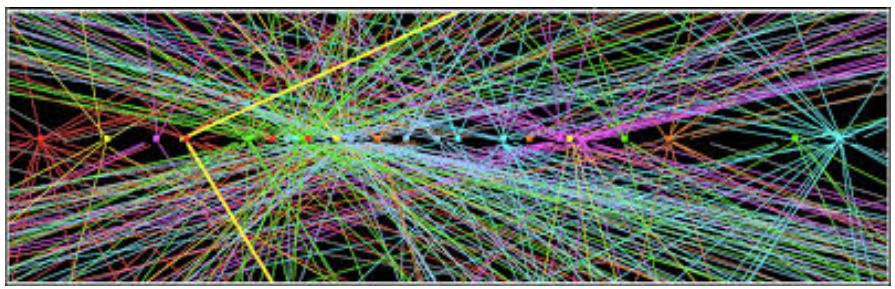
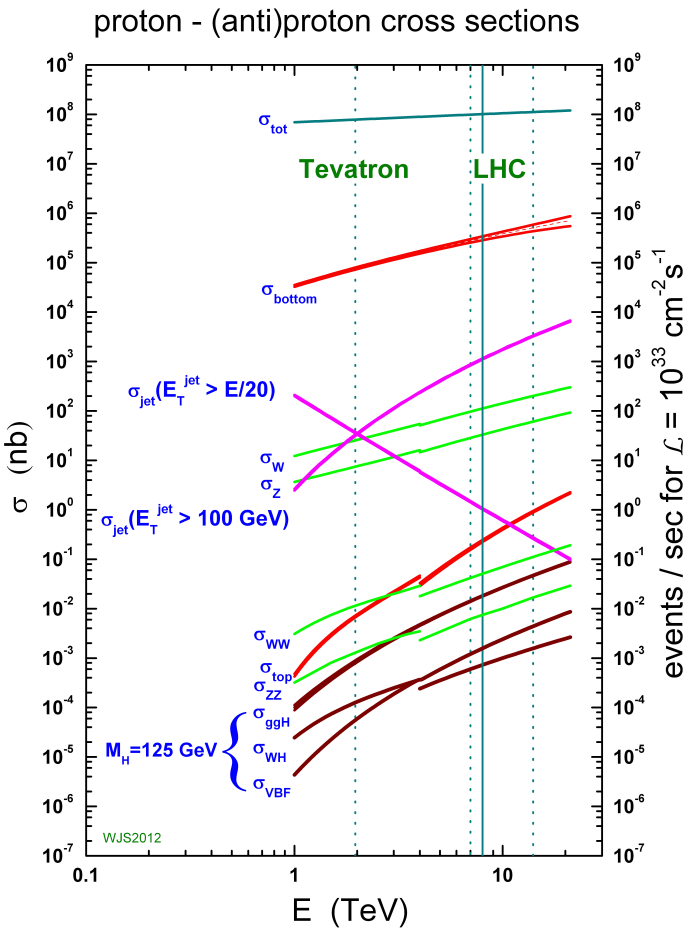


→ Additional soft *pp* interactions added to the event

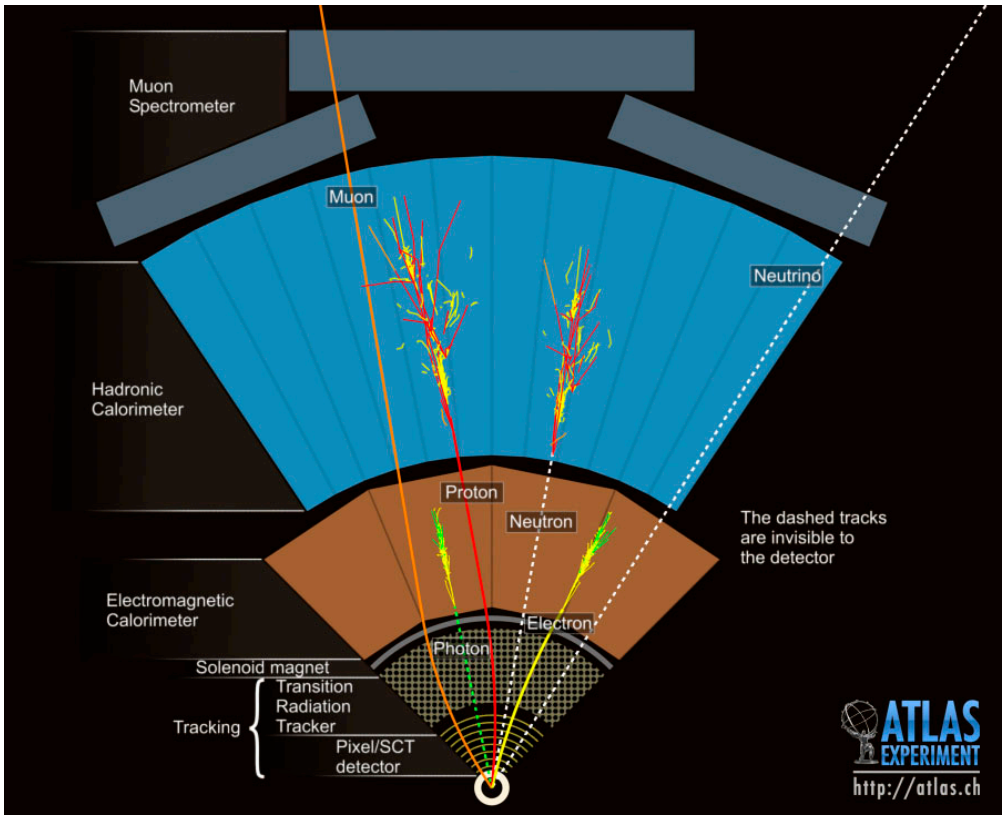
- Huge rate of uninteresting QCD-interactions
- Highly selective trigger system

$$f_{\text{event}} \approx 40 \text{ MHz} \rightarrow f_{\text{data}} \approx 1 \text{ kHz}$$

- Possible impacts on *signal* efficiency studied using simulation



Convert the signals into physical objects



- Physical object reconstruction using information from the ATLAS-subsystems:
  - Electrons

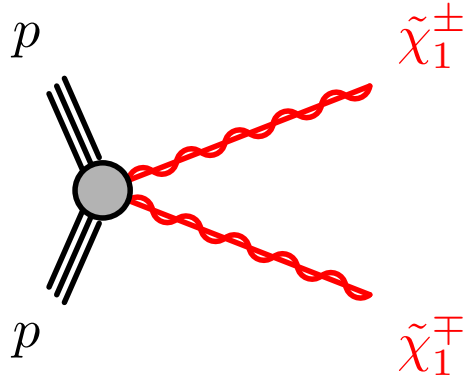
    Tracker + Calorimeters
  - Muons

    Tracker + Muon system
  - Hadrons (Jets)

    Clustering of energy deposits

- Followed by callibration & detector-performance measurements
  - Let's talk about the details next time

Considering new physics scenarios



- Need hints to new theories beyond the Standard Model
- Favoured example: **Supersymmetry**
  - Lot's of new particles & free parameters

- Number of free parameters reduced by the approach of a simplified model
  - Pair production of new heavy particles (e.g. $\tilde{\chi}_1^{\pm}$)
  - One cascade into other SUSY & SM particles

    Other new particles decoupled to high masses
  - 'Special' scenario: subsequent $\tilde{\chi}_1^0$ decay

- Main important parameters: $m_{\tilde{\chi}_1^{\pm}}$ & $m_{\tilde{\chi}_1^0}$

$\Rightarrow$ Hints for new physics may be found in multi-lepton events

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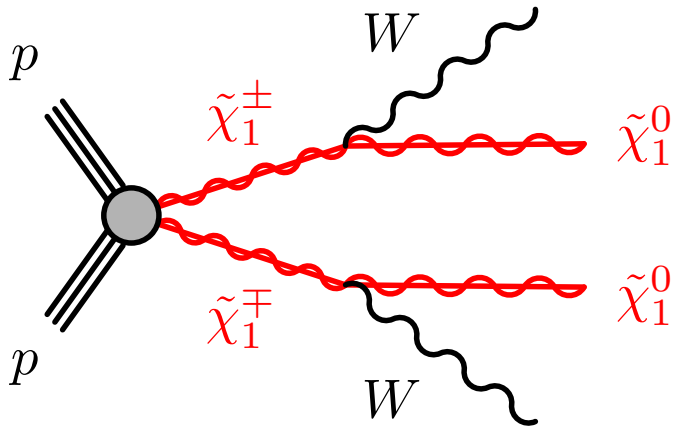

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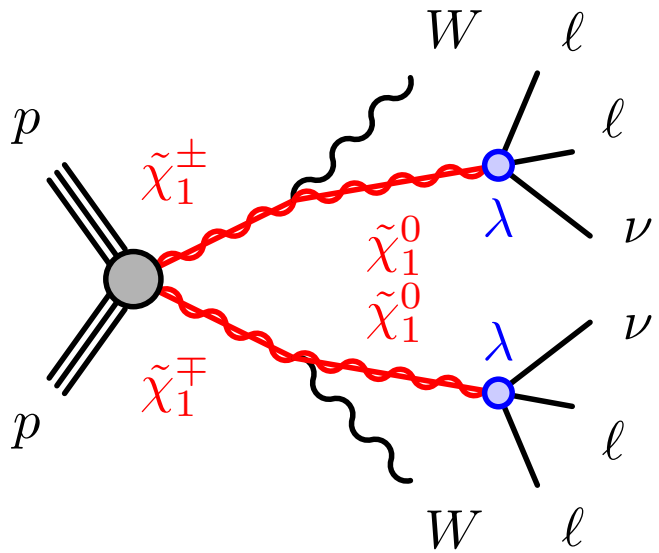

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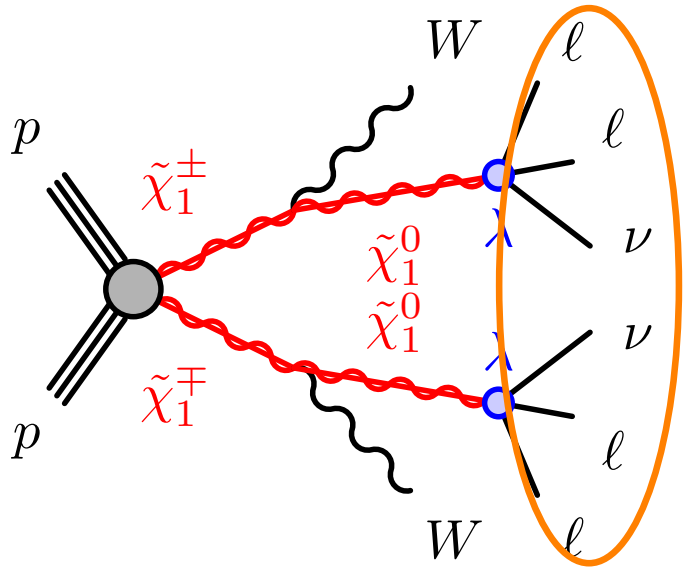

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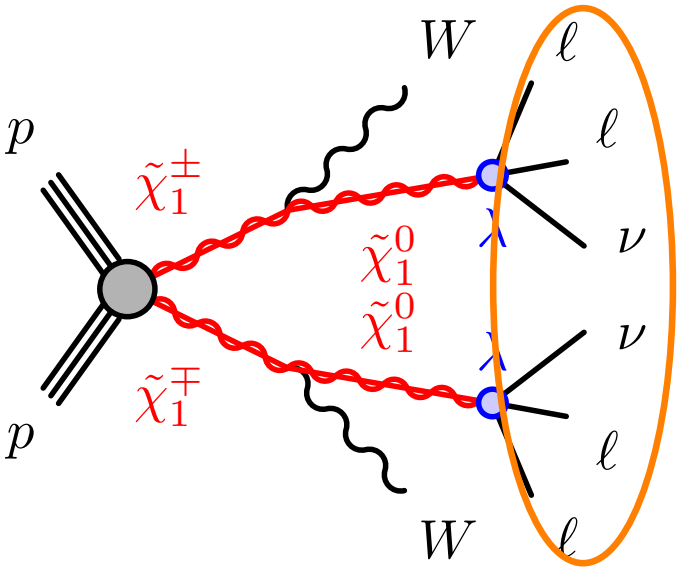

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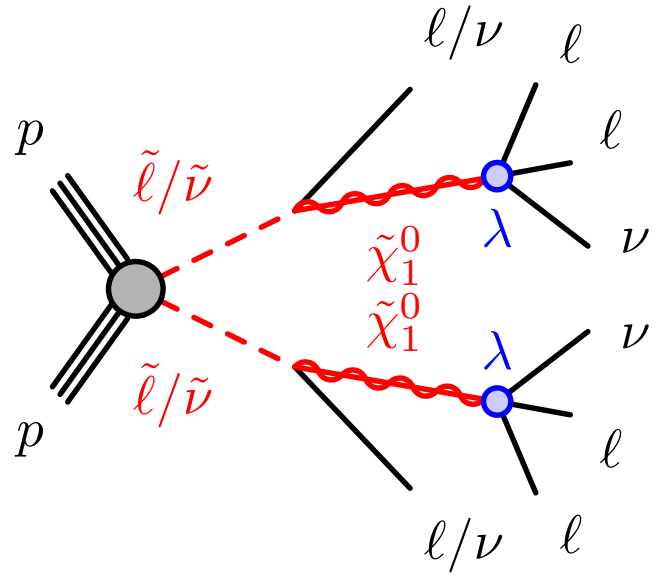

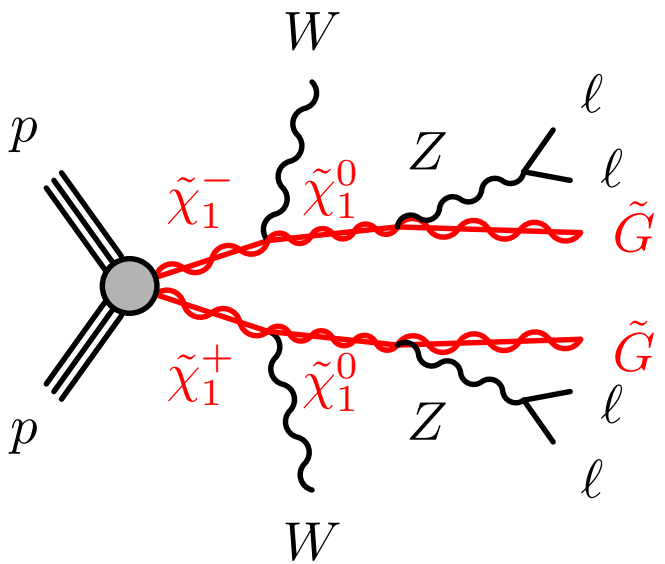

⇒ Hints for new physics may be found in n

How to get multi-lepton events in the SM?

- Estimate background processes in the SM giving multi-lepton events
- Backgrounds split into two kinds:
  1. Irreducible
     - All emerging ℓ from primary vertex
     - Estimated by Monte Carlo predictions
  2. Reducible
     - Some selected ℓ from secondary q-decays
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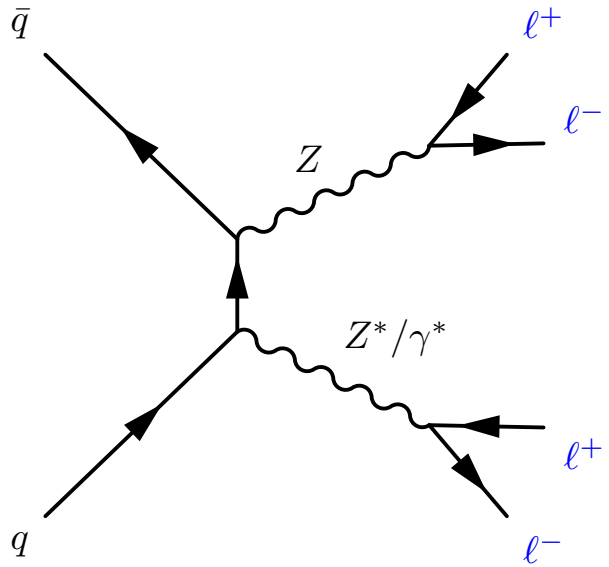

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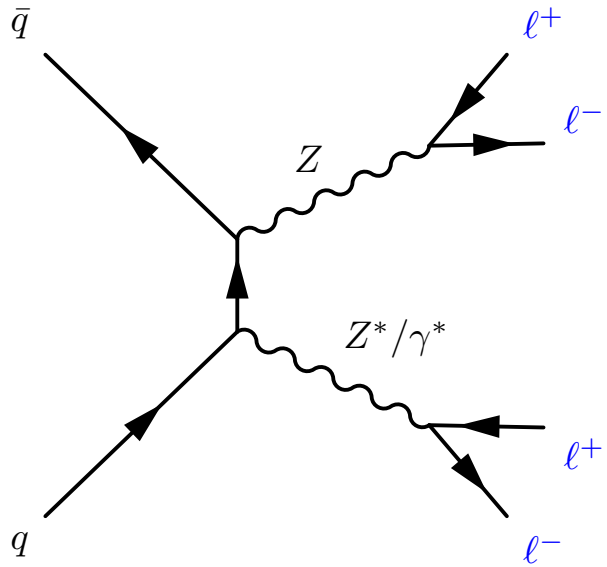

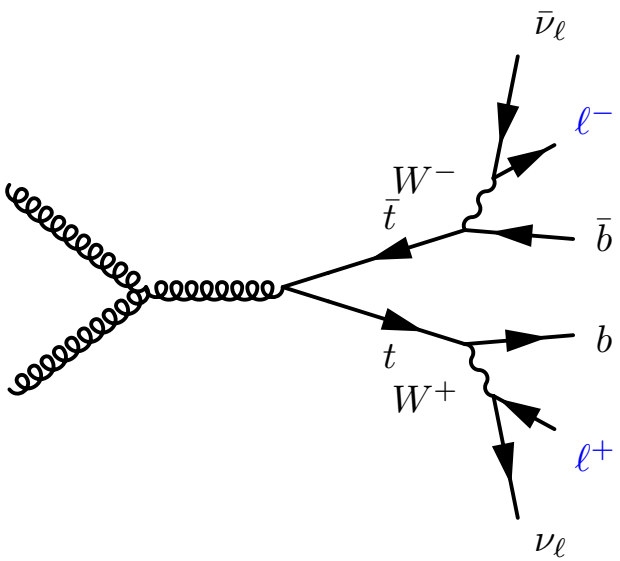

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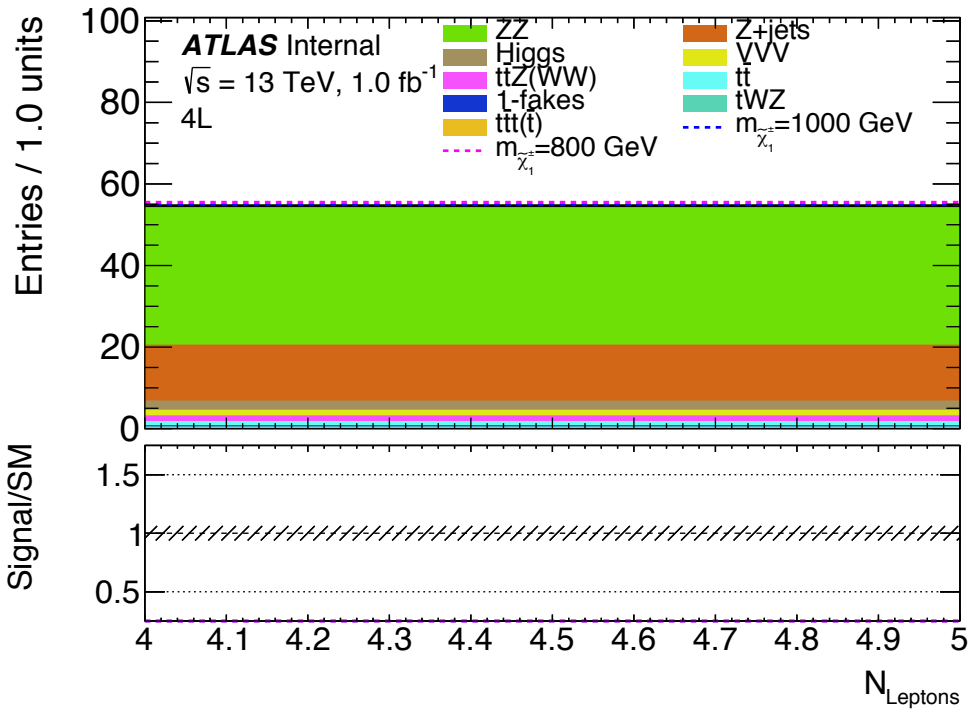

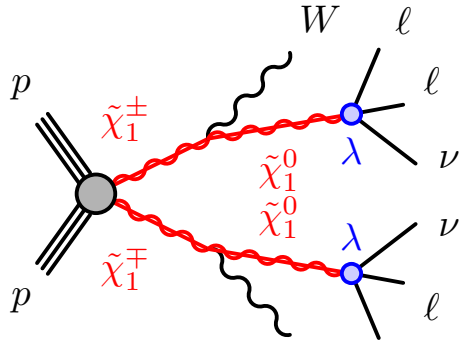

- **Aim:** Find event properties sorting out the SM
- Very basic requirement: $N_{e/\mu} \geq 4$
- Reject event with $m_{ee/\mu\mu} \approx m_Z$
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- Let's start with $m_{\text{eff}} \geq 600$ GeV

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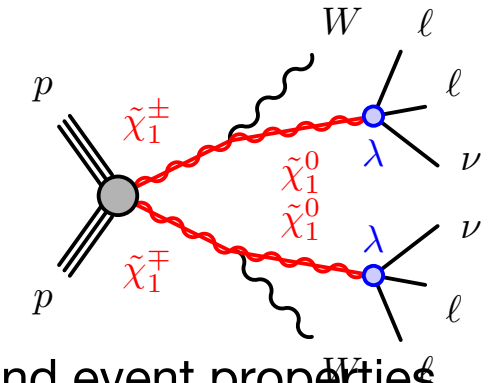

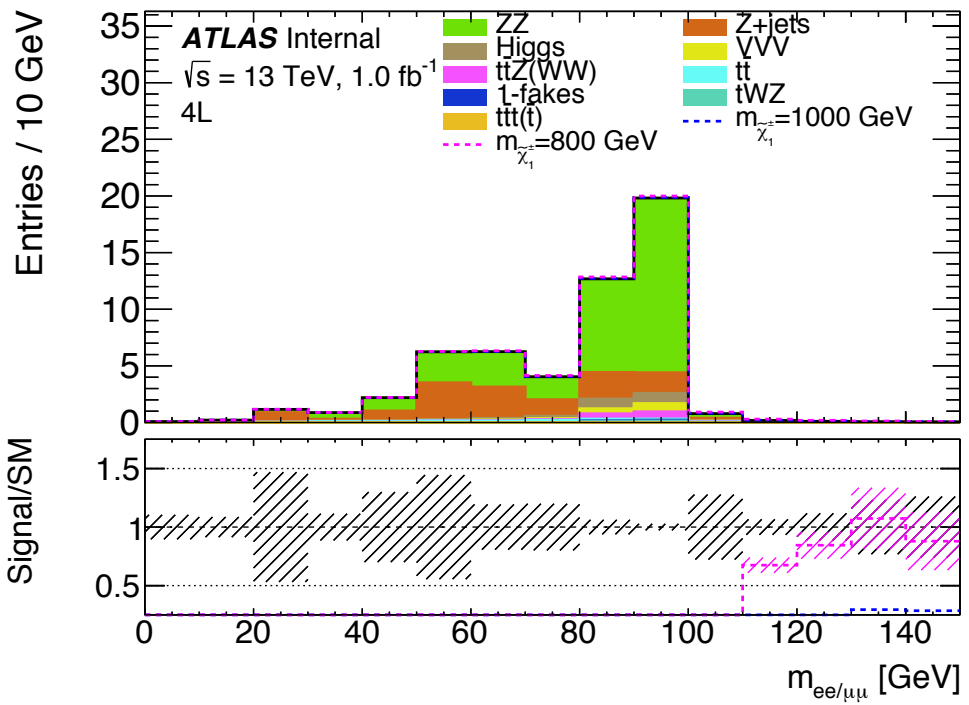

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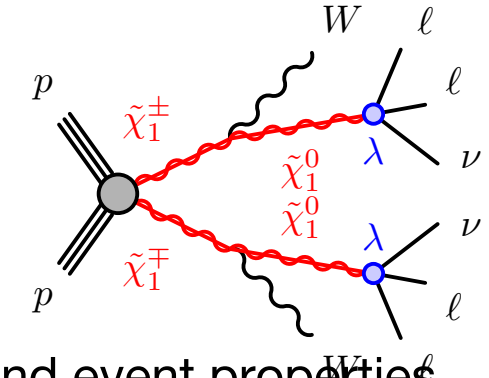

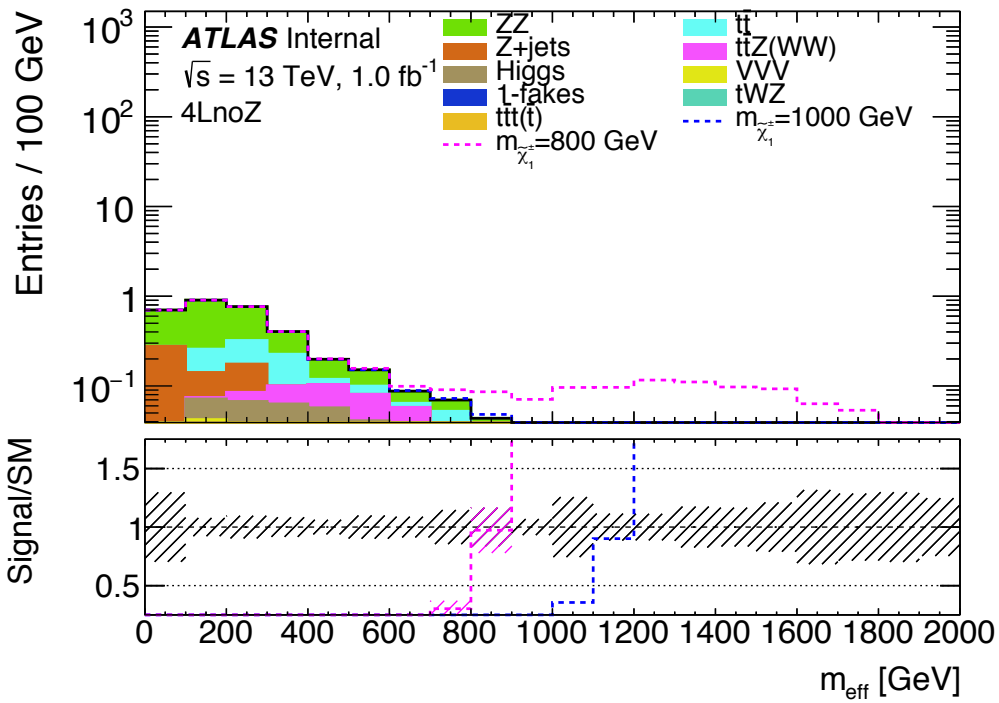

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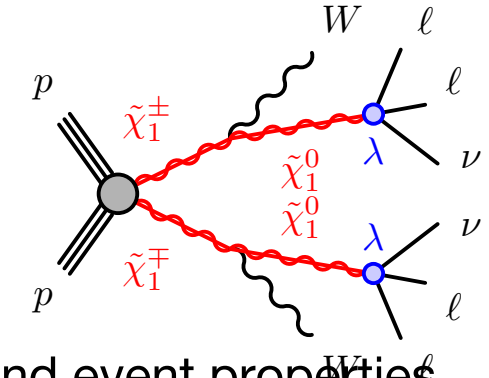

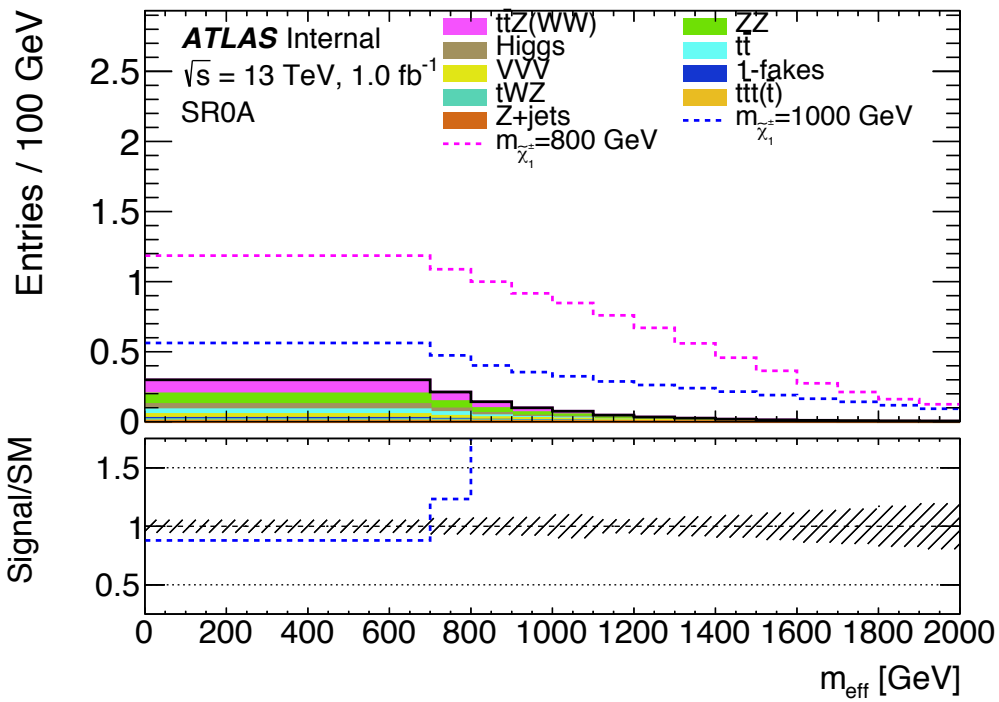

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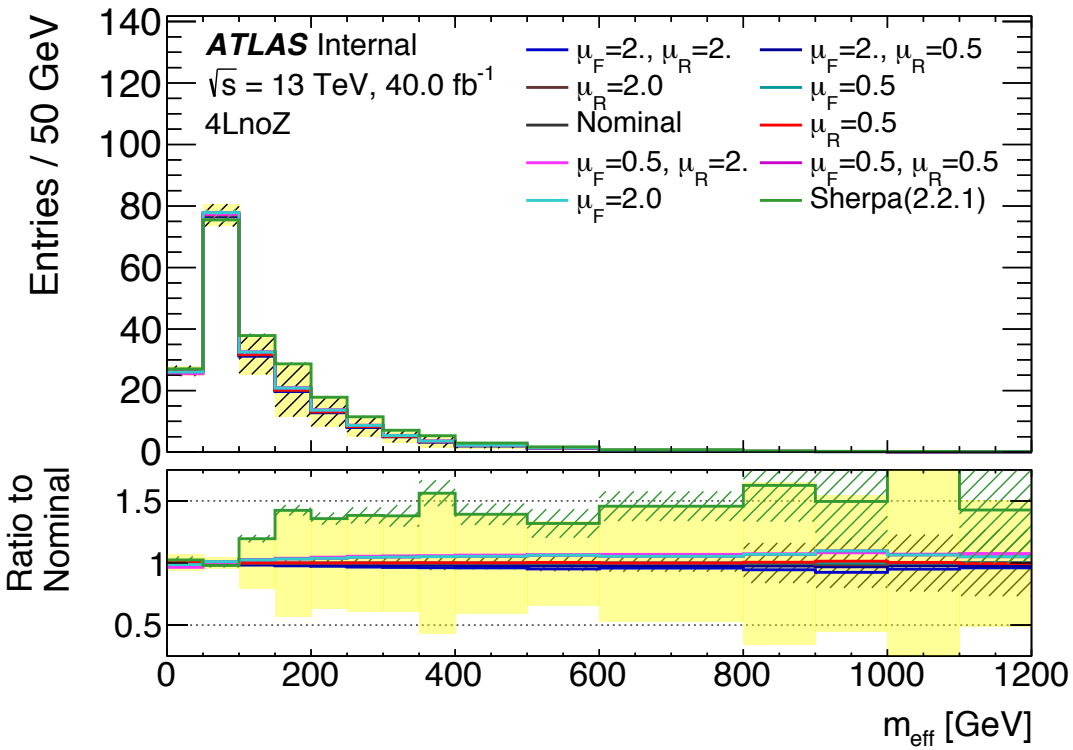

- Obtaining predictions ✔

  Uncertainties?

- Stat uncert. $\rightarrow$ easy ✔

- Systematics $\rightarrow$ challenge

1. Experimental:
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   - Performance measurements
2. Theoretical:
   - Shape of distributions
   - Total σ_{process}

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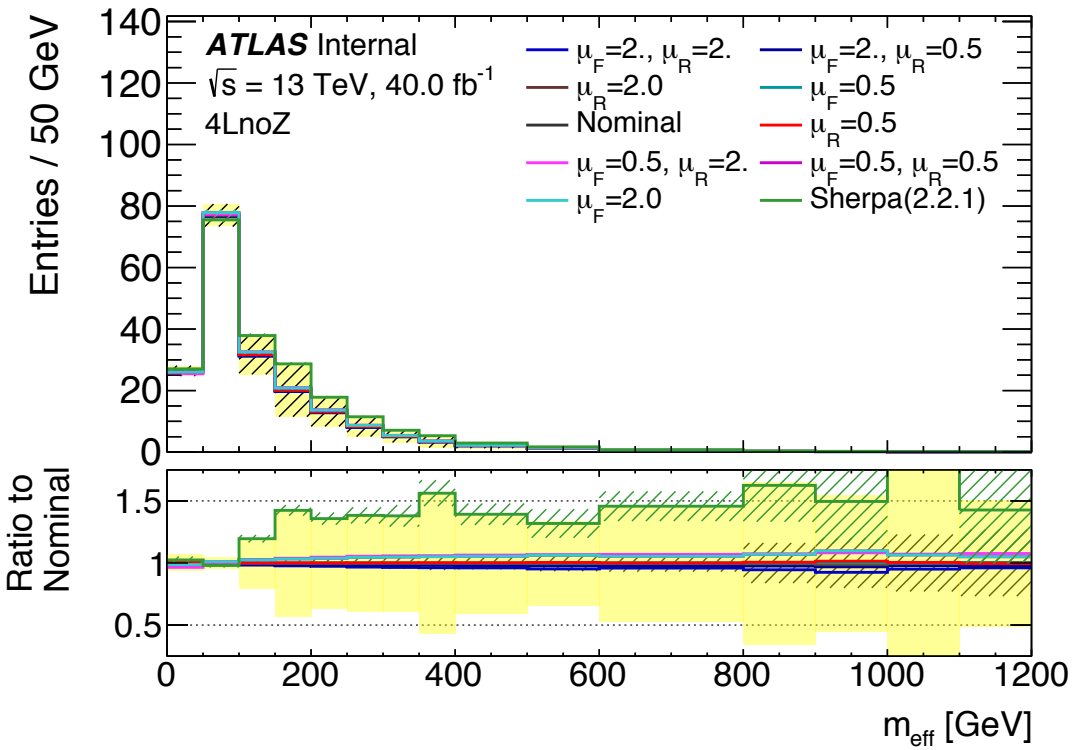

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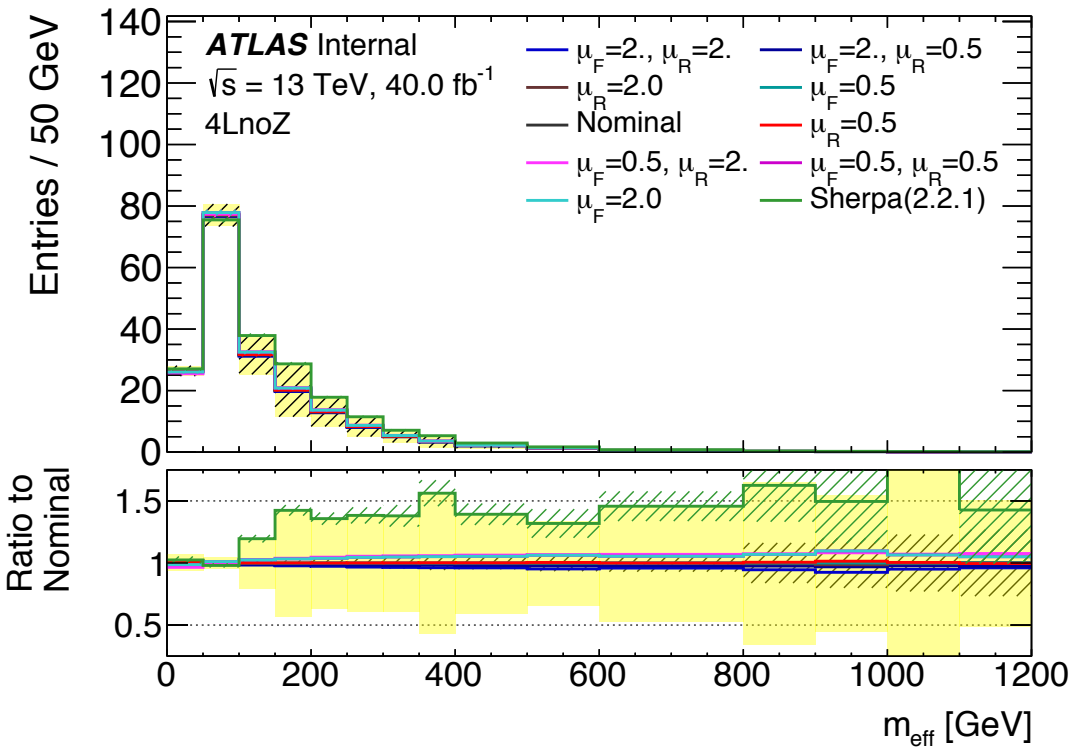

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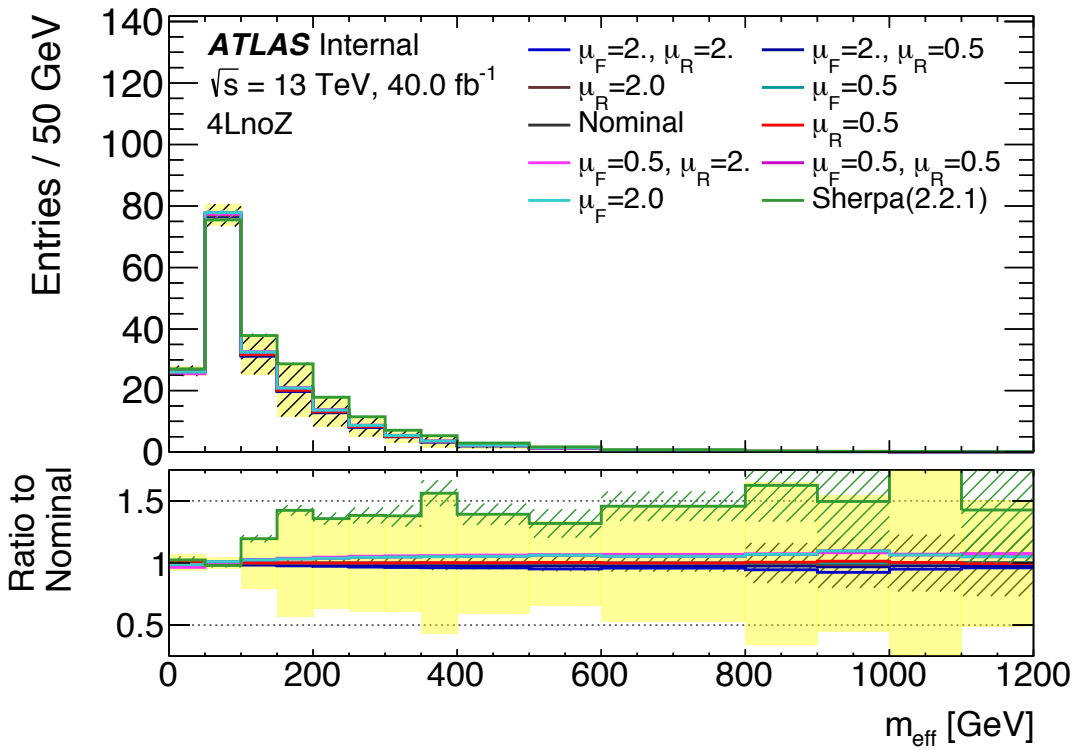

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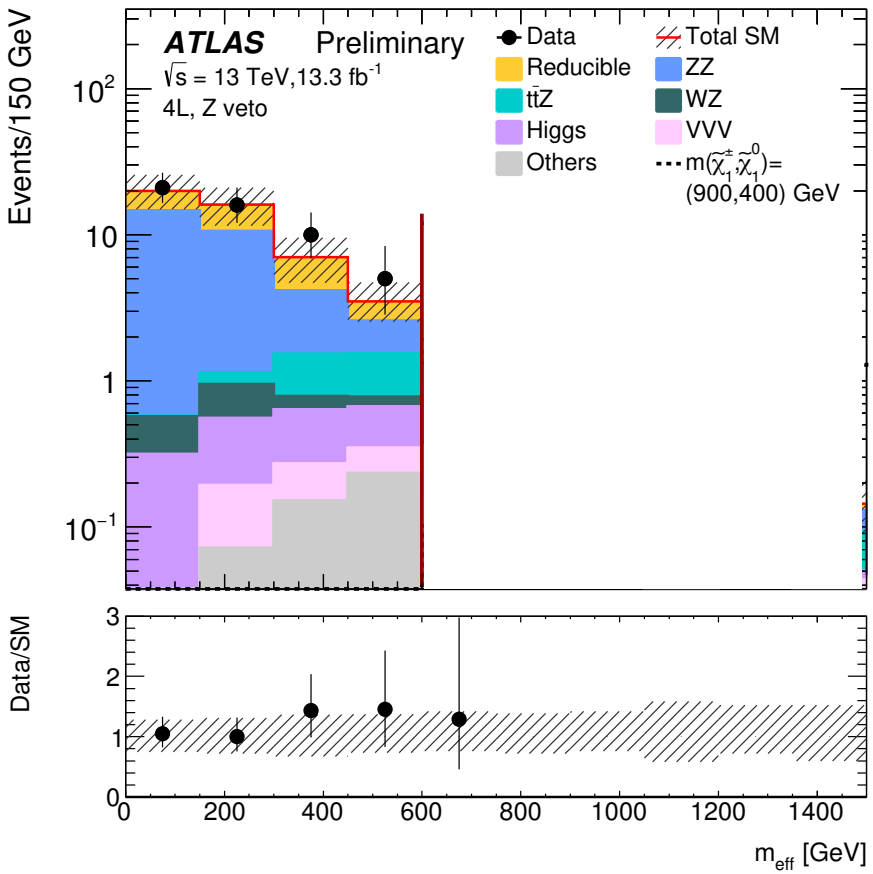
To access 2:

- Produce Monte-Carlo of the same process with different programs

Test of the modeling in data

- Use control data to test your background prediction
- Good Data/MC agreement observed

→ Open the box



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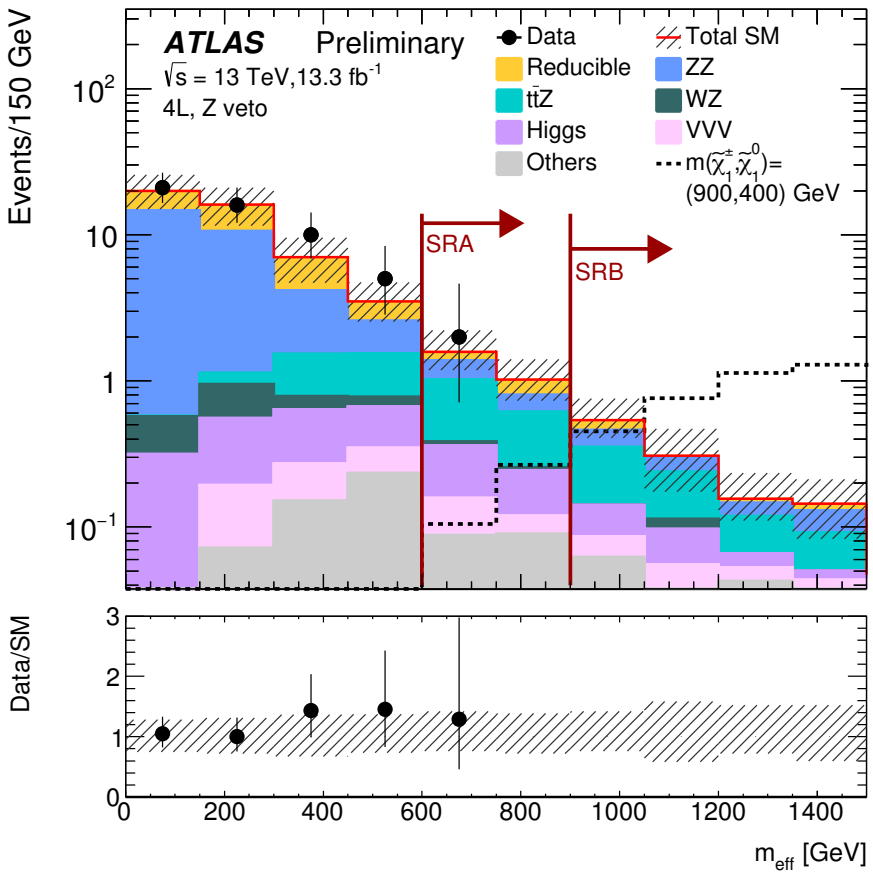
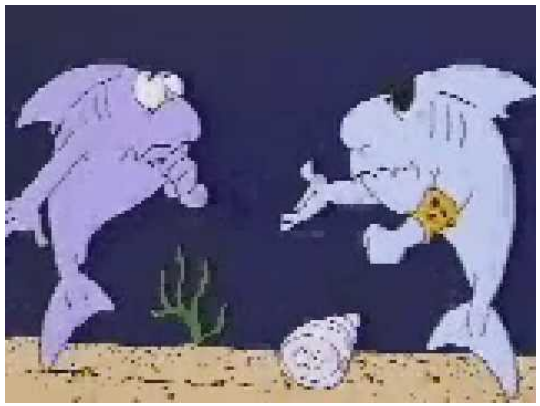


Summary

- Simulations are the basic tool in data analysis
- To perform a good job we need:
  1. Precise predictions of the SM in *pp*-scattering
  2. Good modeling of ATLAS



- Many theories beyond SM currently tested at the LHC

→ Looking for excesses in data-signatures motivated by theory

Challenges:

1. Find best variables to seperate background from signal
2. Know the errors on your background prediction

- Philipp'll tell you how the journey continues

→ Stay tuned for his talk