

Exclusive processes as a channel to search for invisible particles

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Introduction

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Definition:

Invisible particles = particles that could be produced at LHC, but be overlooked by standard methods

- Decaying to neutrinos
- Slow and long-lived
- Trapped (magnetic monopoles, monopolium)
- Behaviour not foreseen in triggering schemes

Idea:

Using energy-momentum conservation, look for missing invariant mass in the event.

Central exclusive production

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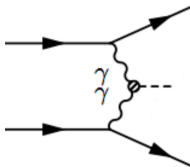
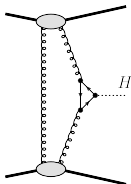
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- Simple final state

$$pp \rightarrow pXp$$

- Possible mechanisms:

- QCD two-gluon exchange
- two-photon process



- Measurement of forward protons \rightarrow determination of M_X

$$M_X = \sqrt{s\xi_1\xi_2}, \quad \xi_i = \frac{\Delta E_i}{E_0}$$

- Dedicated detectors for measurement of forward protons at LHC: ATLAS-AFP and CMS-TOTEM PPS
- Goal of the present study: estimate sensitivity of the method, define optimal scenario for data taking

Signal model

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- Assuming photon/pomeron flux:

$$\Phi_{\gamma/IP}(\xi_1) \sim \xi^\alpha$$

- Assuming production of a single particle (resonance):

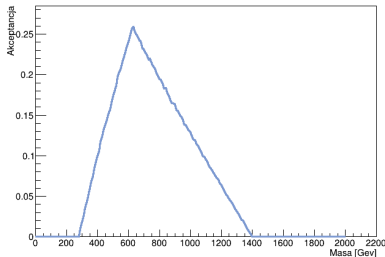
$$d\sigma \sim \Phi(\xi_1)\Phi(\xi_2)\delta(\xi_1\xi_2 - M_X^2/s)$$

- Then, both ξ_1 and ξ_2 distributed as $1/\xi$
- Signal generation:
 - ξ_1 drawn randomly from $1/\xi$ distribution (limits!)
 - for a given M_X value: $\xi_2 = M_X^2/s\xi_1$
 - ξ_2 also has $1/\xi$ distribution

Forward proton detectors cannot register all protons



Signal generator allows calculation of mass acceptance:

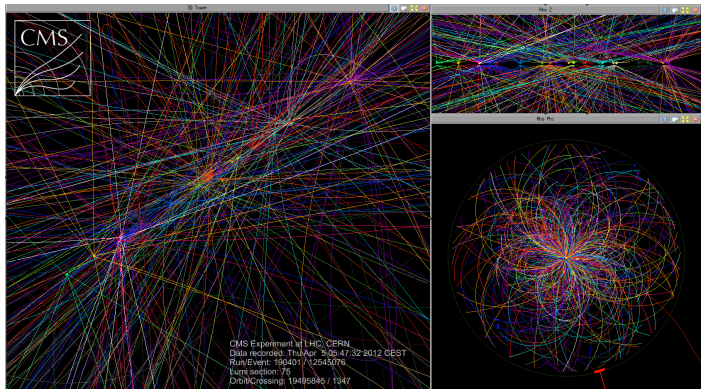


Background

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- Signal signature: two protons
- Two background sources:
 - two protons originate from a single pp interaction
 - two protons originate from independent interactions

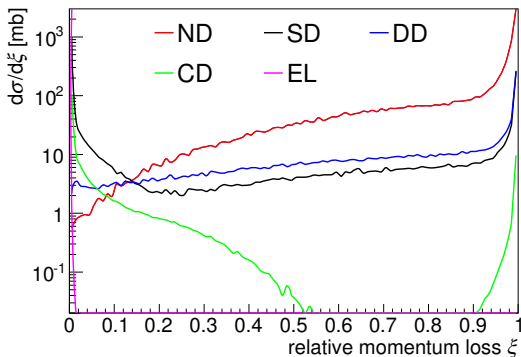
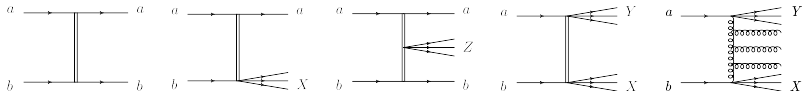
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Background processes

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Predictions from PYTHIA event generator.

Effect of pile-up

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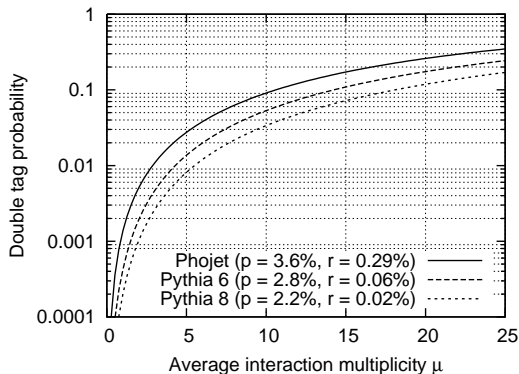
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Probability of having a double tag event for average pile-up multiplicity μ (combinatorial formula convoluted with a Poisson distribution):

$$P(\mu) = 1 - 2e^{-\mu p} + e^{-\mu(2q-r)}$$

where

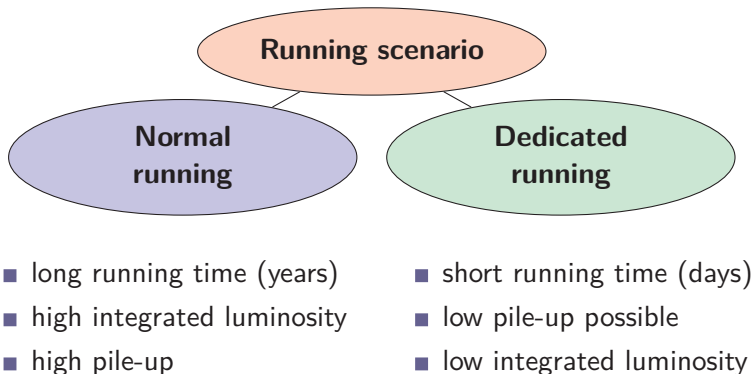
- p – single tag probability
- r – double tag probability



Experimental conditions

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Studied scenatios:

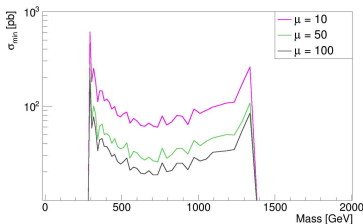
- $\mu = 10, 50, 100$
- $\mu = 0.01, 0.1, 1$
- $t = 1 \text{ year}$
- $t = 8 \text{ hours}$

Preliminary results

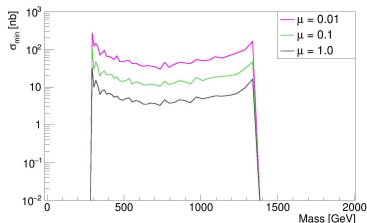
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- Neglecting systematic uncertainties of background (assuming data-driven estimates)
- Assuming that the resonance is narrower than the detector resolution ($\sim 2\% M_X$)
- Discovery: $N_S > 5\sqrt{N_B}$ in a given mass window
- Estimated sensitivity:



1 year



8 hours

Summary

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- Forward detectors allow searches for invisible particles
- Complementary method to other searches
- Exclusive processes:

$$pp \rightarrow pXp$$

- Conservation laws + measurement of protons $\rightarrow M_X$
- Pile-up \rightarrow background
- Running scenario:
 - standard runs – high luminosity, but high background
 - dedicated runs – low background, but low luminosity
- Outlook:
 - Consider veto on central detector at low pile-up