LED Graviton and Unparticle Processes in Pythia 8

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Common LED G / Unparticle Processes

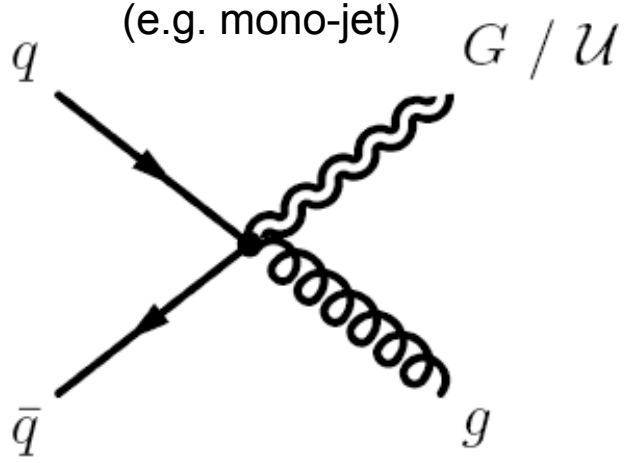
From a phenom. point of view the large extra dimension (ADD) scenario have many processes with analogous unparticle (U) versions, where the graviton (G) is replaced by an U (spin 0, 1 or 2).

Common implementation, based on unparticle formulae, where the G process is obtained (when possible) from spin-2 unparticle matrix elements.

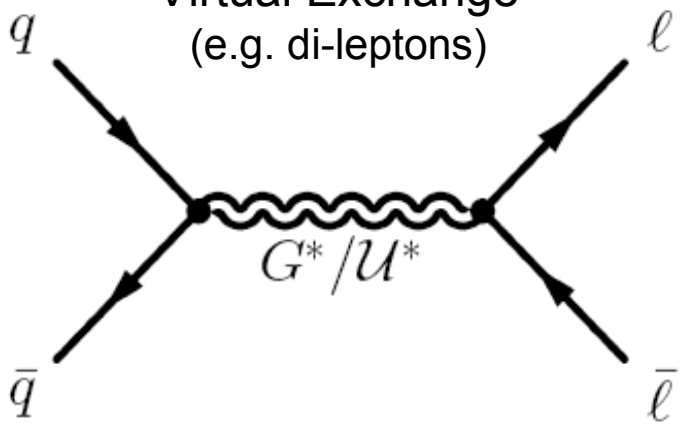
These common implementations simplifies for comparisons between the similar processes.

- Mono - photon / Z (Real Emission)
- Mono - jet (Real Emission)
- Di - photons (Virtual Exchange)
- Di - leptons (Virtual Exchange)

Real Emission
(e.g. mono-jet)



Virtual Exchange
(e.g. di-leptons)



U to G Parameter Translation

Unparticle (U) model parameters in Pythia8

K.Cheung, W.Y.Keung & T.C.Yuan, PRD 76 (2007) 055003

d_U = scale dimension parameter.
Λ_U = unparticle renormalization scale.
λ = universal coupling between U and SM operators.

Graviton (G) process obtained from spin-2 U formulae

G.F. Giudice, R. Rattazzi & J.D. Wells, NPB 544 (1999) 3

n = integer nr of large extra dimensions
M_D = scale of gravity in D = 4 + n dimensions
Λ_T = cut-off scale for virtual G exchange

G cross sections reproduced by changing only a few constant factors

U to G Emission

$$d_U = \frac{n}{2} + 1$$

$A(d_U) \leftrightarrow S(n)$ (phase space factors)

$$\Lambda_U = M_D$$

$$\lambda_1 = \lambda_2 = 1$$

U to G Exchange

$$d_U = 2$$

$$\Lambda_U = \Lambda_T$$

$$\lambda^2 \cdot \chi = 4\pi$$

χ (factor from U propagator)

Treatment of the UV Region

Several options are available related to the treatment of the UV region of the effective theory. Including a form factor for the gravitational coupling.

J. L. Hewett, T. G. Rizzo, JHEP 0712 009 (2007)

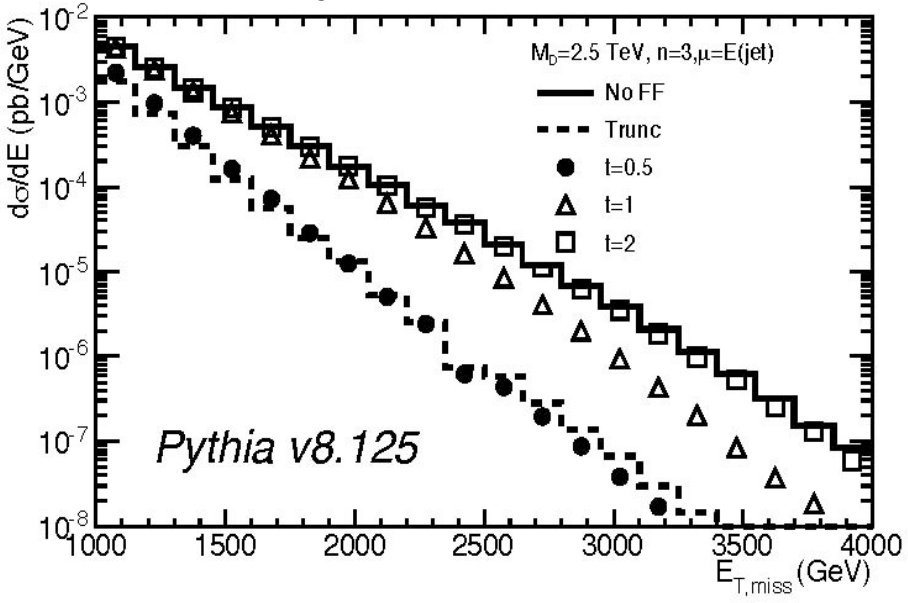
$$F(t, M_D) = \left[1 + \left(\frac{\mu^2}{t^2 M_D^2}\right)^{1+\frac{n}{2}}\right]^{-1}$$

The choice of renormalization scale (μ) follows the general Pythia parameter, *SigmaProcess:renormScale2*

t is a O(1) "free" parameter. Should be < 2 to preserve unitarity for G scattering.

For U*/G* exchange, $tM_D \rightarrow t'\Lambda_T$

G + jet emission at LHC



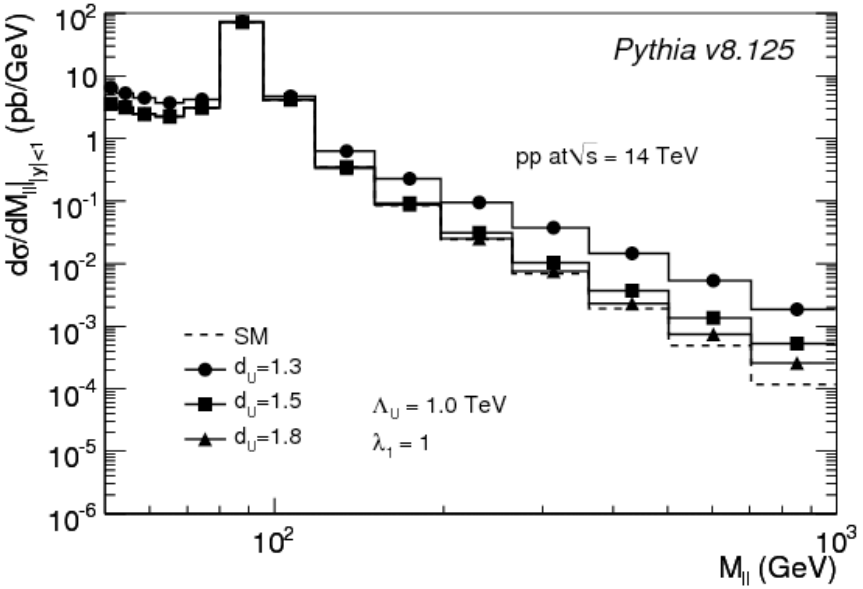
Helicity Dependent U Couplings

The di-lepton process include the possibility of helicity dependent couplings between a spin-1 U and fermions.

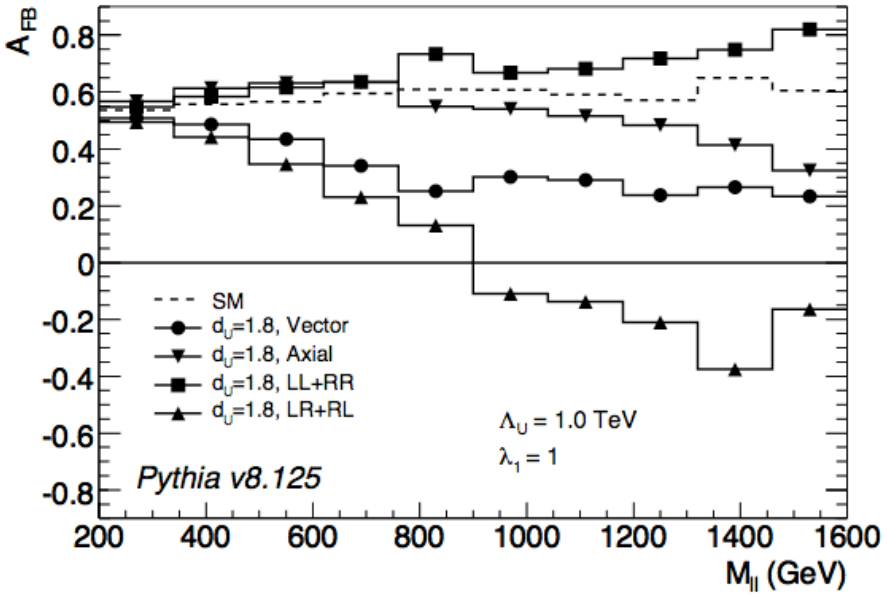
Could lead to interesting interference patterns and effects on the angular distribution of the leptons.

H. Georgi, Phys. Lett. B650 (2007) 275

Di-lepton production at the LHC



Forward-Backward Asymmetry



Documentation

The processes are documented in, arXiv:0912.4233v1 [hep-ph] which is linked from the MCnet page.

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Real Emission and Virtual Exchange of Gravitons and Unparticles in Pythia8

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Abstract

Models with large extra dimensions as well as unparticle models could give rise to new phenomena at collider experiments due to real emission or virtual exchange of gravitons or unparticles. In this paper we present the common implementation of these processes in the Monte Carlo generator PYTHIA8, using relations between the parameters of the two models. The program offers several options related to the treatment of the UV region of the effective theories, including the possibility of using a form factor for the running gravitational coupling. Characteristic results obtained with PYTHIA8 have been used to validate the implementations as well as to illustrate the key features and effects of the model parameters. The results presented in this paper are focused on mono-jet, di-photon and di-lepton final states at the LHC.

Together with the Pythia8 online manual:
http://home.thep.lu.se/~torbjorn/Pythia.html
--> Documentation: "8.135 php installation"