

# **Working Group 1: Simplified models / Monte Carlo / reinterpretation and RECAST-ing**

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**Main goal:** ensure LHC LLP searches are optimally useful in the future, cover all relevant signatures, and final states

**Specific tasks:**

- 1) Presentation of LLP experimental results
- 2) Strengthen RECAST for long-lived particle searches
- 3) Define a few benchmark simplified models
- 4) Identify gaps in LHC sensitivity

# Presentation of Results

## Theorists

Want enough  
information for reliable  
theorist recasting

i.e., efficiency maps  
for physics objects

## Experimentalists

Want to provide  
simplified model  
interpretations

i.e., a {few} mass vs  
lifetime exclusions

# Presentation of Results

## MORE IS BETTER

Recasting valuable — cut flow tables for a few points, detailed description of signal (MC best), digitized data, plots of observables, detailed description of trigger, efficiency maps

- 1) Efficiency maps for LLPs ( $\epsilon(m, \beta, \theta, L)$ , a la CMS HSCP)
- 2) Simplified models,  $m$  vs  $c\tau$  efficiencies
- 3) Compromise?  $\epsilon(L, \beta)$  for a few  $m / \Delta m$

Special thanks to Eric Conte, Jong Soo Kim, and Michele Selvaggi

# RECAST

Another complementary path is RECAST

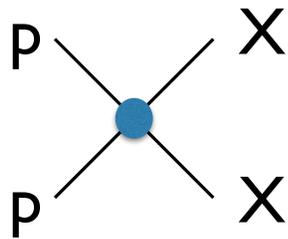
Framework is now heavily developed

Currently no LLP searches implemented,  
but we should change that

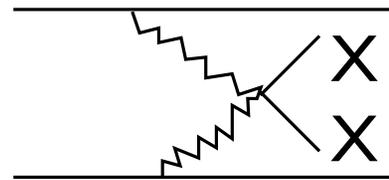
Experimentalists should have a comprehensive  
reinterpretation strategy independent of theorists  
aided by the RECAST framework

# Simplified Models

## LLP production modes

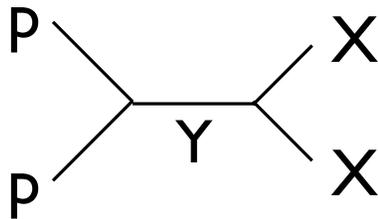


Pair  
Production

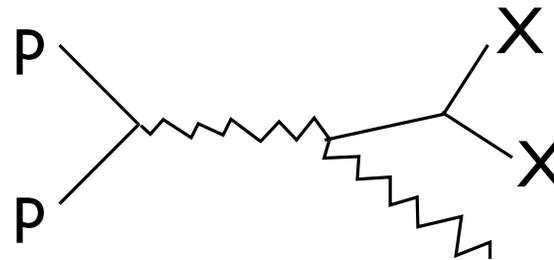


VBF

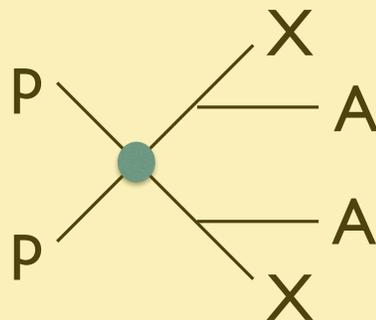
lovely image by DC



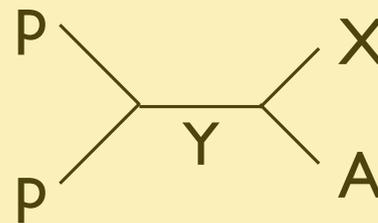
Resonance



Associated  
Production



Heavy  
Parent



Single  
Production

A = invis, j, top, W, Z, L, h (oof...) ... maybe even  $\gamma$ ?

# Simplified Models

LLP decay modes

|                       |                |          |           |              |
|-----------------------|----------------|----------|-----------|--------------|
| $e + \text{inv}$      | $ee$           |          |           |              |
| $\mu + \text{inv}$    | $\mu\mu$       | $ej$     | $\mu e$   | $e\gamma$    |
| $\tau + \text{inv}$   | $\tau\tau$     | $\mu j$  | $\mu\tau$ | $\mu\gamma$  |
| $j + \text{inv}$      | $jj$           | $\tau j$ | $\tau e$  | $\tau\gamma$ |
| $\gamma + \text{inv}$ | $\gamma\gamma$ |          |           | $j\gamma$    |

Also,  $xy + \text{inv}$  with or without  $xy$  resonance

# Simplified Models: Option 1

production  $\otimes$  decay spans  
most LLP simplified models\*

Prescription generates simplified models!

Reserve of Production MC  $\otimes$  Decay MC?

Very sensible for LLP!

All production  $\otimes$  Decay relevant for your search

\* not dark showers

# Simplified Models: Option 1

production  $\otimes$  decay spans  
most LLP simplified models\*

Prescription generates simplified models!

## ON THE OTHER HAND...

~ few hundred (mostly redundant) cases

Lacks theory guidance

**Encroaches on complete coverage**

... but very unwieldy

\* not dark showers

# Simplified Models: Option 2

Consider a few good models

“Gauge”/  
“Yukawa”

“Stau”

“Slepton”

“Bino”

ee

$\tau + \text{inv}$

e + inv

$\gamma + \text{inv}$

$\mu\mu$

$\mu + \text{inv}$

$\tau\tau$

jj

High theory motivation

Span a lot of un(der)charted territory

Very manageable

# Simplified Models: Option 2

Consider a few good models

“Gauge”/  
“Yukawa”

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$\tau + \text{inv}$

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$\mu + \text{inv}$

$\tau\tau$

jj

**ON THE OTHER HAND...**

Definitely not comprehensive!!!

Less generic

# Simplified Models: Option 3

Combine options 1 & 2?

Reserve of Production MC  $\otimes$  Decay MC

Tie into motivated theory scenarios

Maybe the best of both worlds?

# Simplified Models: Option 3

Combine options 1 & 2?

Reserve of Production MC  $\otimes$  Decay MC

Tie into motivated theory scenarios

**ON THE OTHER HAND...**

The most work

# Simplified Models

Regardless of option, augment searches once designed with simplified models that probe the **limitations** of the search

Many models can produce the displaced dilepton signature ( $\mu^+\mu^-$ )

Where can this search lose sensitivity?

1. Low cross-section / long or short lifetime

Almost any benchmark will do! Pick the “most motivated” one!

2. Low LLP mass

Complementarity with lepton-jets?

3. High LLP boost (i.e. collimated decay products)

Scalar resonance to two pseudoscalars  $pp \rightarrow S \rightarrow aa, a \rightarrow \mu^+\mu^-$   
for fixed xsec and lifetime (or  $\gamma c\tau$ ), (1)  $m_a$  vs  $\epsilon$ , (2)  $m_S$  vs  $\epsilon$

4. Soft decay products

SUSY higgsino + singlino,  $\tilde{\chi}^0 \rightarrow \tilde{S}(Z^* \rightarrow \ell^+\ell^-)$ , fixed  $m_{\tilde{\chi}}$ ,  $\Delta m$  vs  $\epsilon$

# Moving Forward

- 1) Decide what to do about simplified models
- 2) Acceptable solution for presentations of results
- 3) Examine prompt sensitivity to LLPs via RECAST
- 4) Implement LLP searches in RECAST
- 5) Use simplified models to expand LLP program

## Discussion?