4 leptons* + X

Veronica Sanz (YorkU)

* lepton=muon, electron

Outline

- Why 4 leptons
- Standard Model BGs
- Models to Topologies
- Trigger and selection
- Topology reconstruction
- Samples
- Questions

Why 4 leptons

Early LHC

can be produced at pb rate

high efficiency reconstruction

low backgrounds

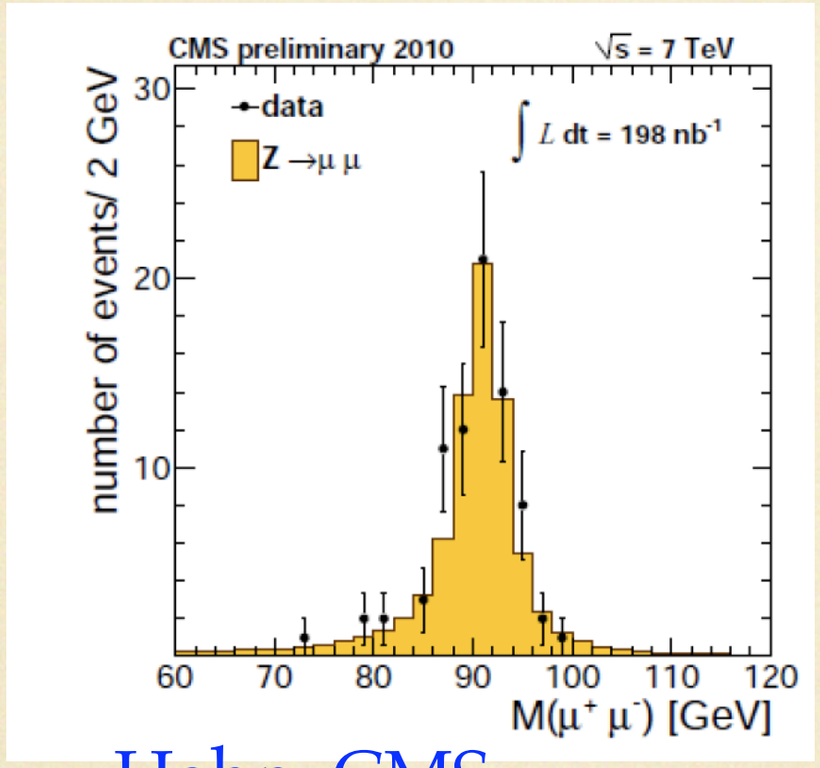
Model building

easy to obtain

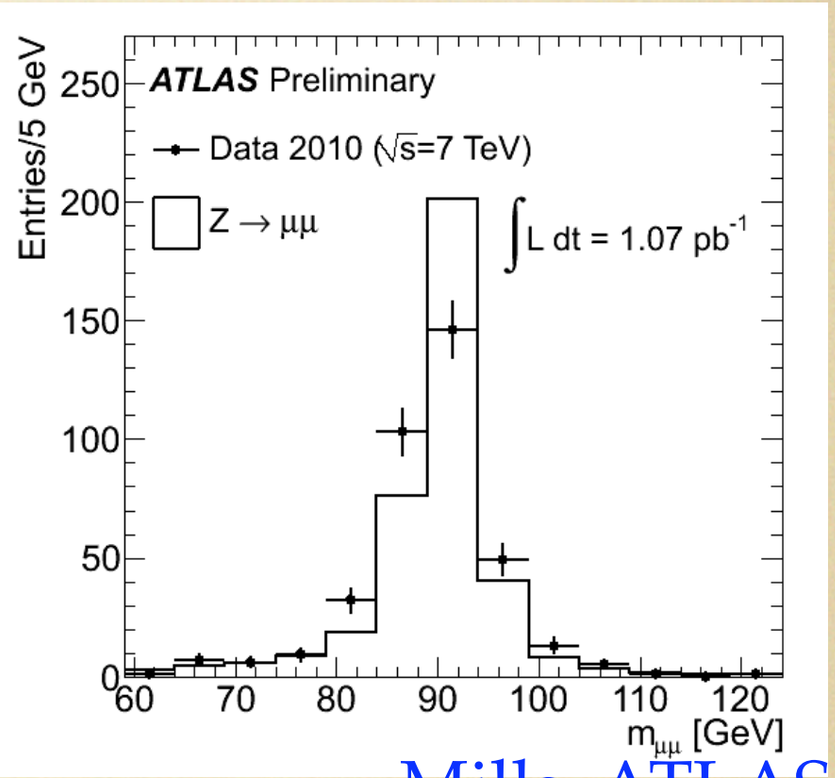
Muons

Isolated muons w / pT> 20 GeV

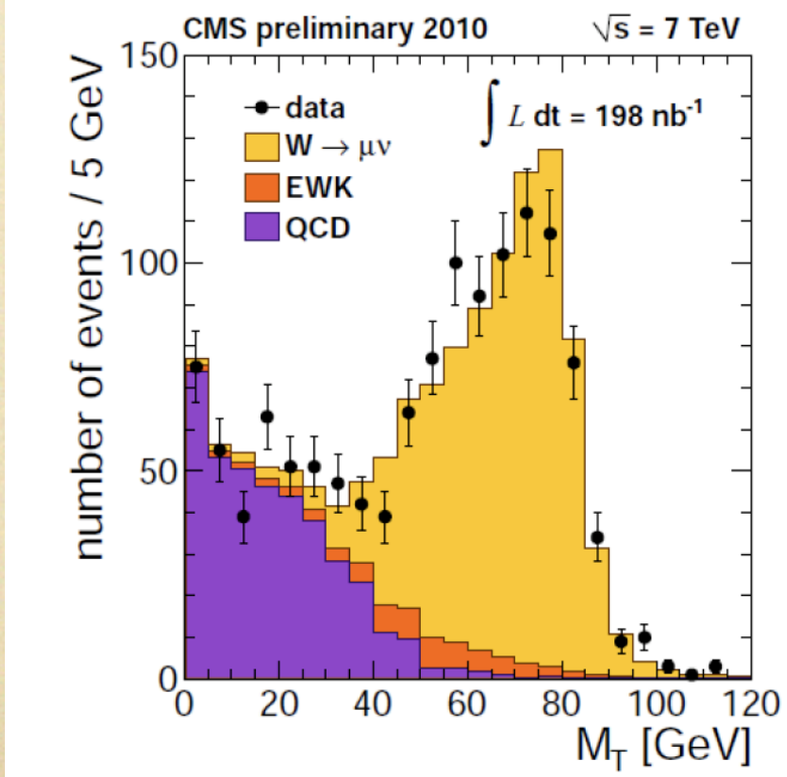
HCP August 2010

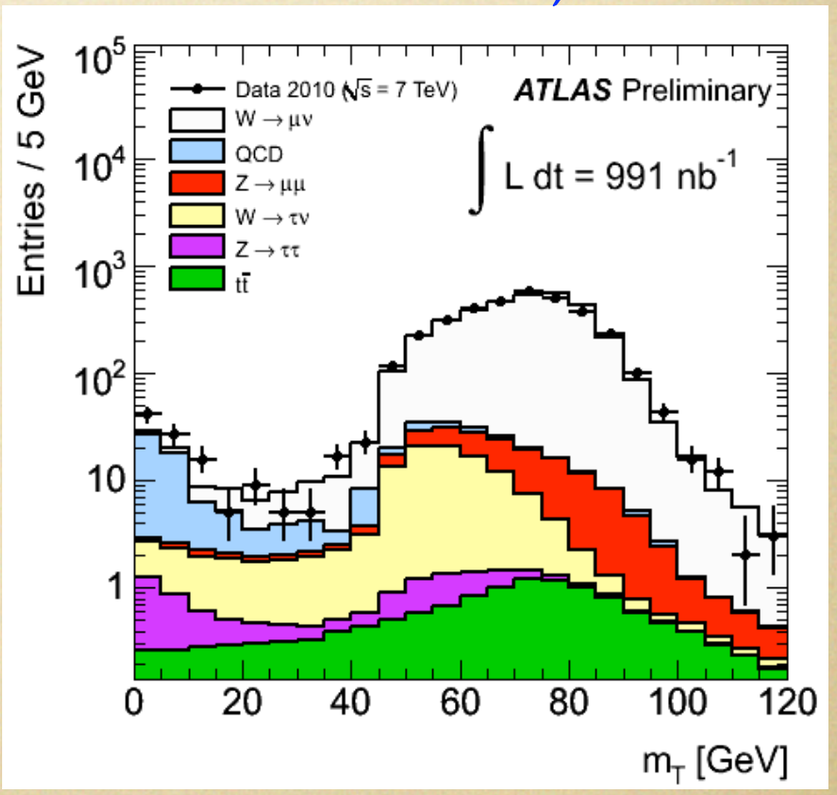


Hahn, CMS



Mills, ATLAS

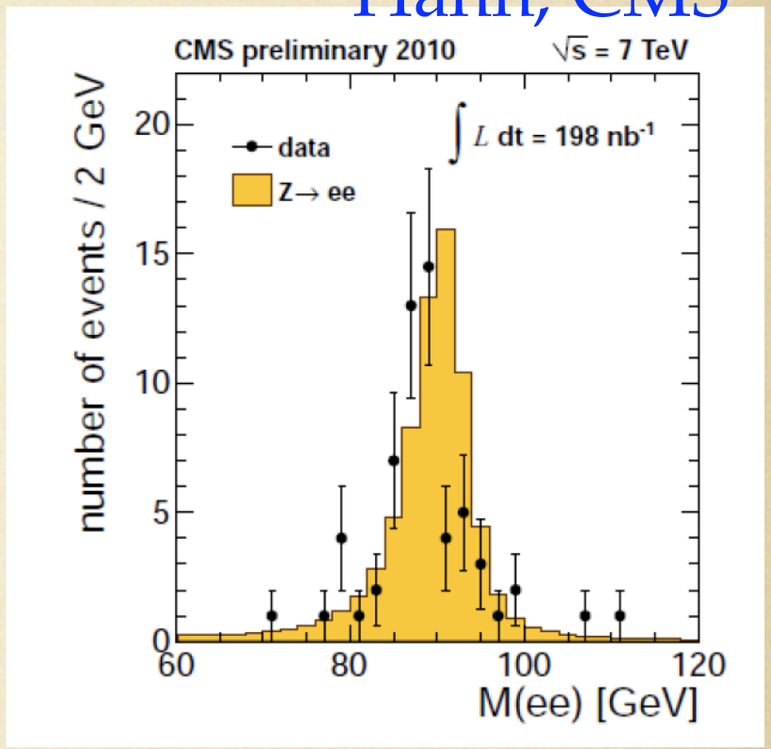


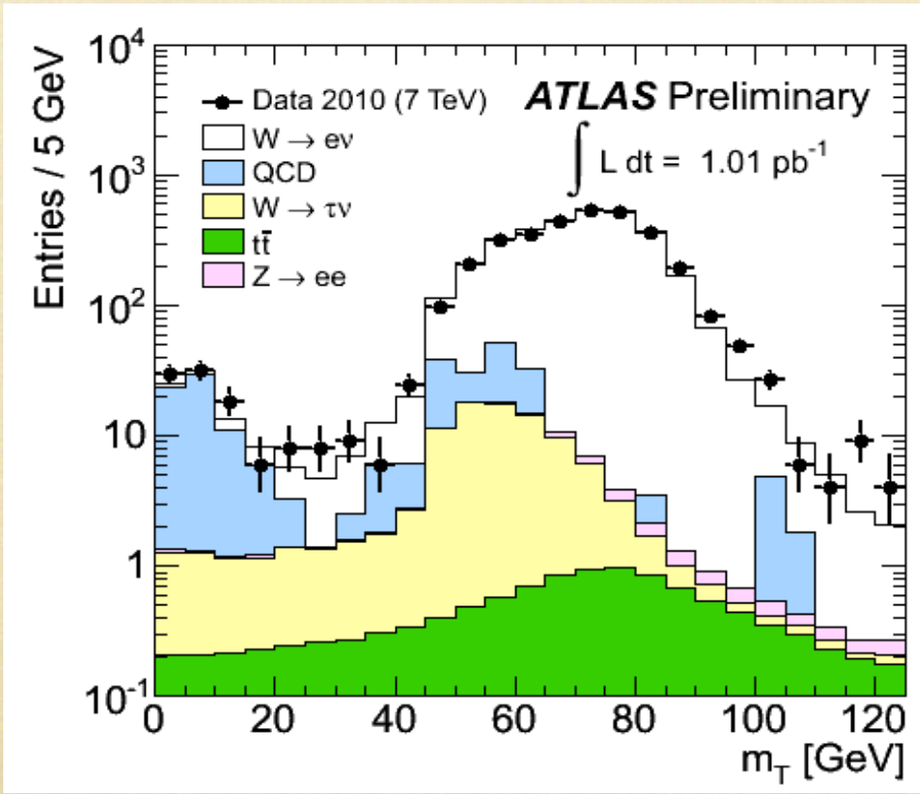


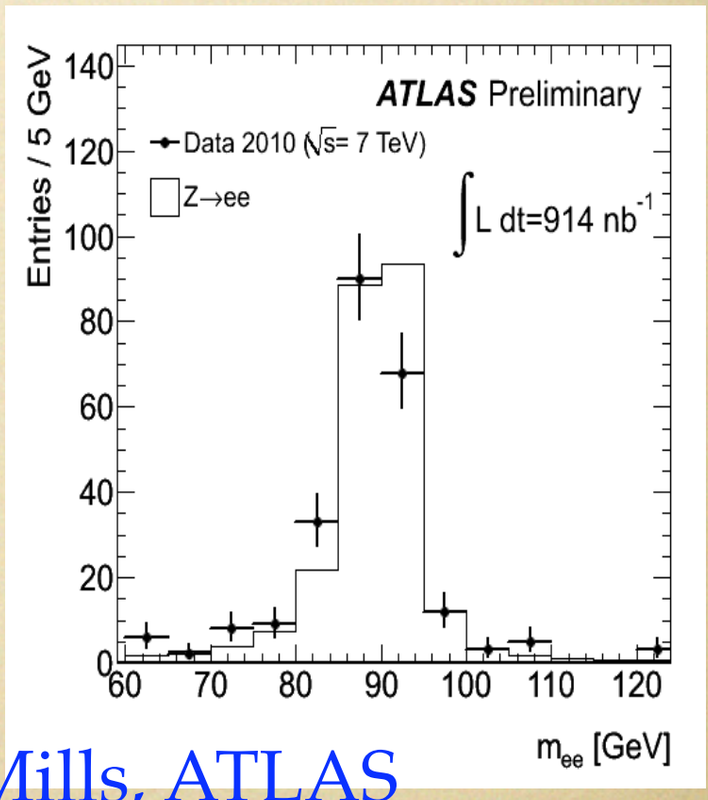
Electrons

Isolated electrons w/ pT> 20 GeV

Hahn, CMS







Mills, ATLAS

HCP August 2010

Backgrounds to 4ℓ+X

$t\bar{t}+\text{jets}$

$W+\text{jets}$

QCD jets

$W\,Z+\text{jets}$

$Z\,Z+\,jets$

$Z+\,jets$

$b\,\bar{b}\,Z/\gamma$

Low, but need to quantify

After imposing

$$n_\ell \geqslant 4$$

$$p_{\ell,T} \geqslant 20\ \text{GeV}$$

$$\Delta R_{\ell,object} > 0.4$$

$$\eta_\ell < 2.5$$

Any BG near the fb level?

Backgrounds to 4ℓ+X

Efficiencies for fakes

jet faking electron 10^{-4}

jet faking muon? we used 10^{-4}

(punch-through rate?)

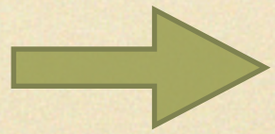
b decay producing isolated lepton $5\,10^{-3}$

ALPGENv213

with MLM matching

PYTHIAv6.4

PGS (Pretty Good Simulator)v4



Estimated

no BG near fb

Topologies for 4ℓ+X

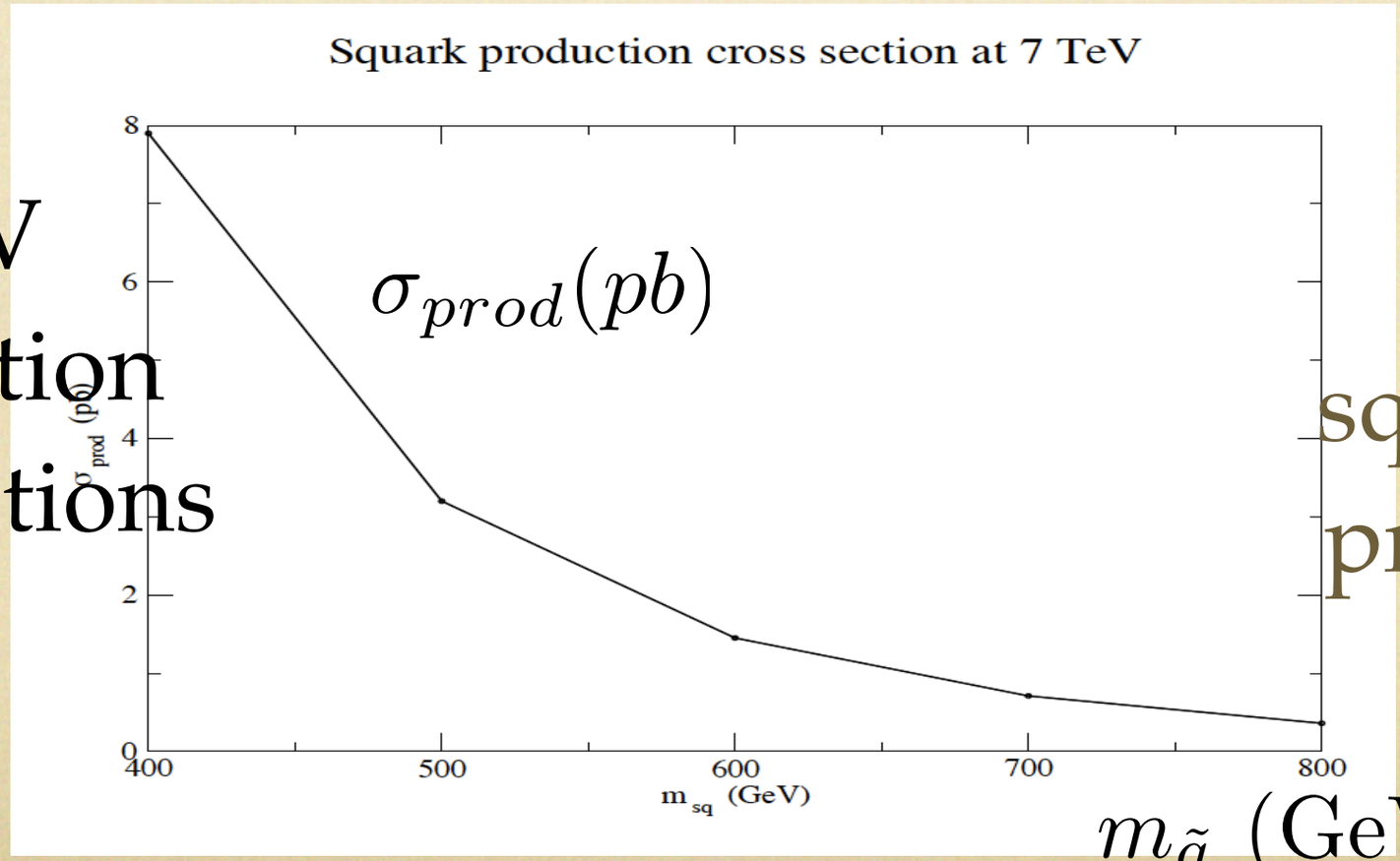
In theory space, many options

Early LHC

Production mechanism

pair colored particles

7 TeV production cross sections



squark pair production

$m_{\tilde{q}}$ (GeV)

Topologies for 4ℓ+X

In theory space, many options

Early LHC

Production mechanism

pair colored particles

Topologies: leptons coming from

A. 2 -body

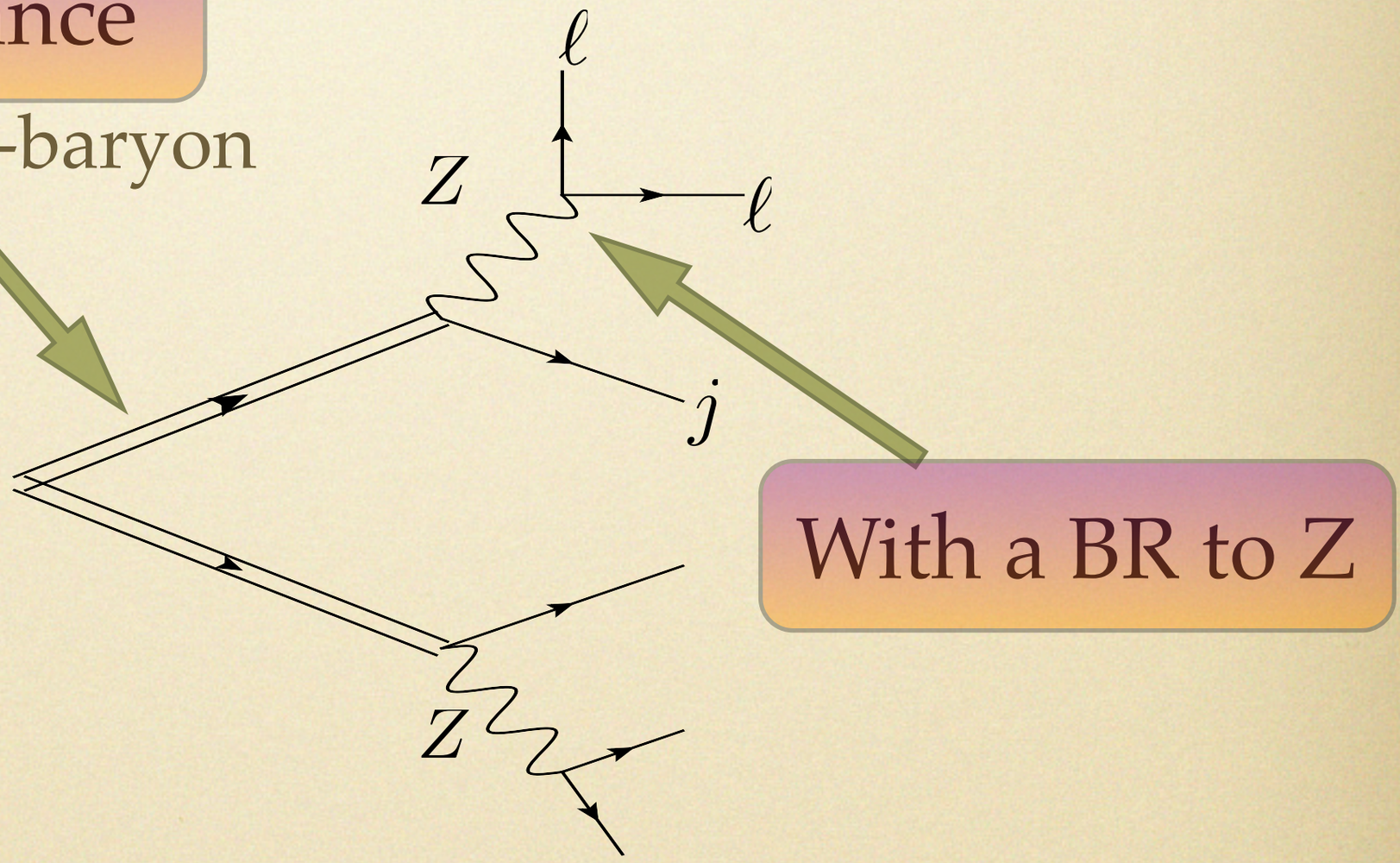
B. 3-body DECAYS

C. cascade

A. 2-body decays

Colored resonance

ex. KK-quark, techni-baryon

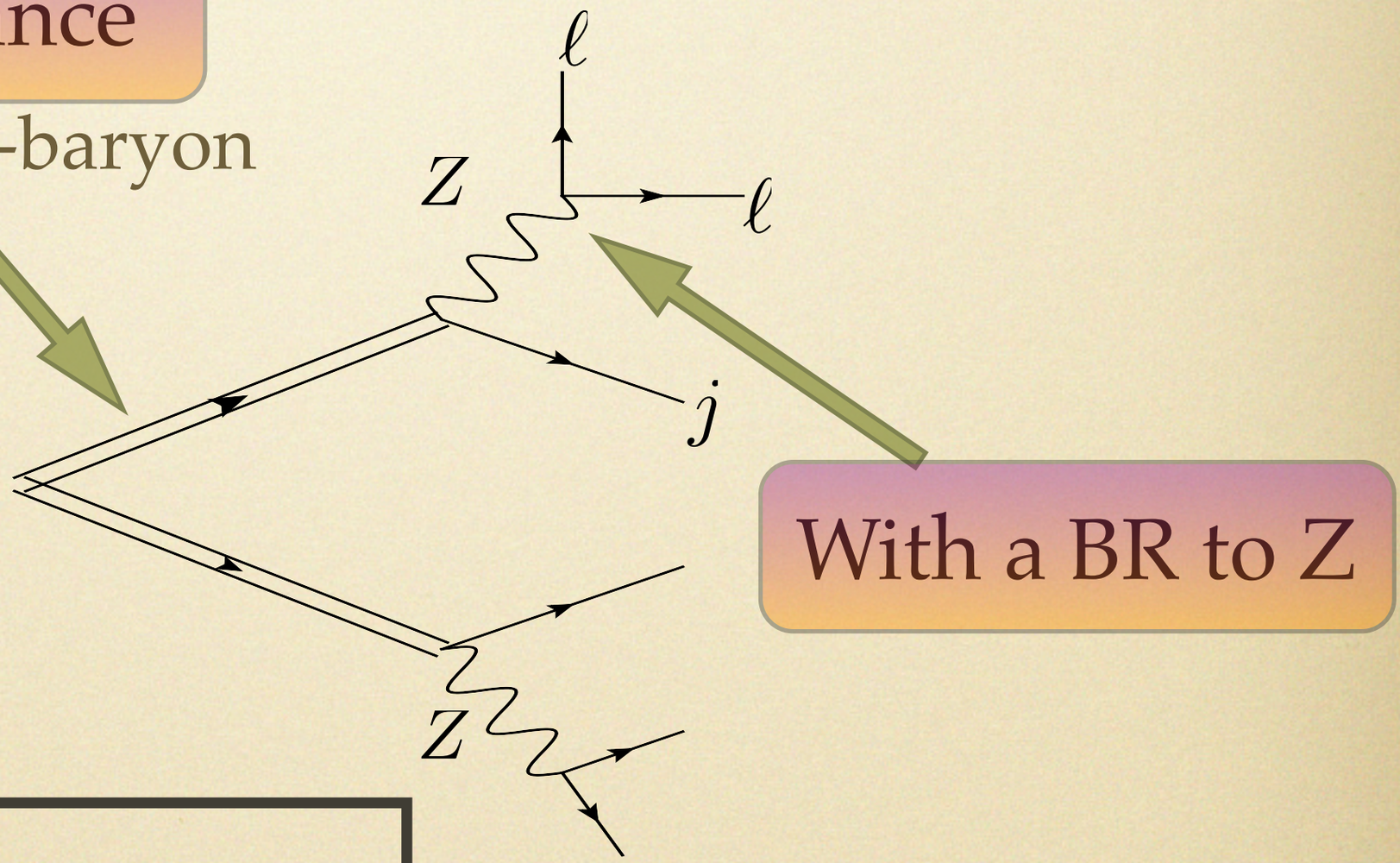


With a BR to Z

A. 2-body decays

Colored resonance

ex. KK-quark, techni-baryon



With a BR to Z

Ryuichiro's talk on natural SUSY

Examples: cured Higgsless, Technicolor, MSSM

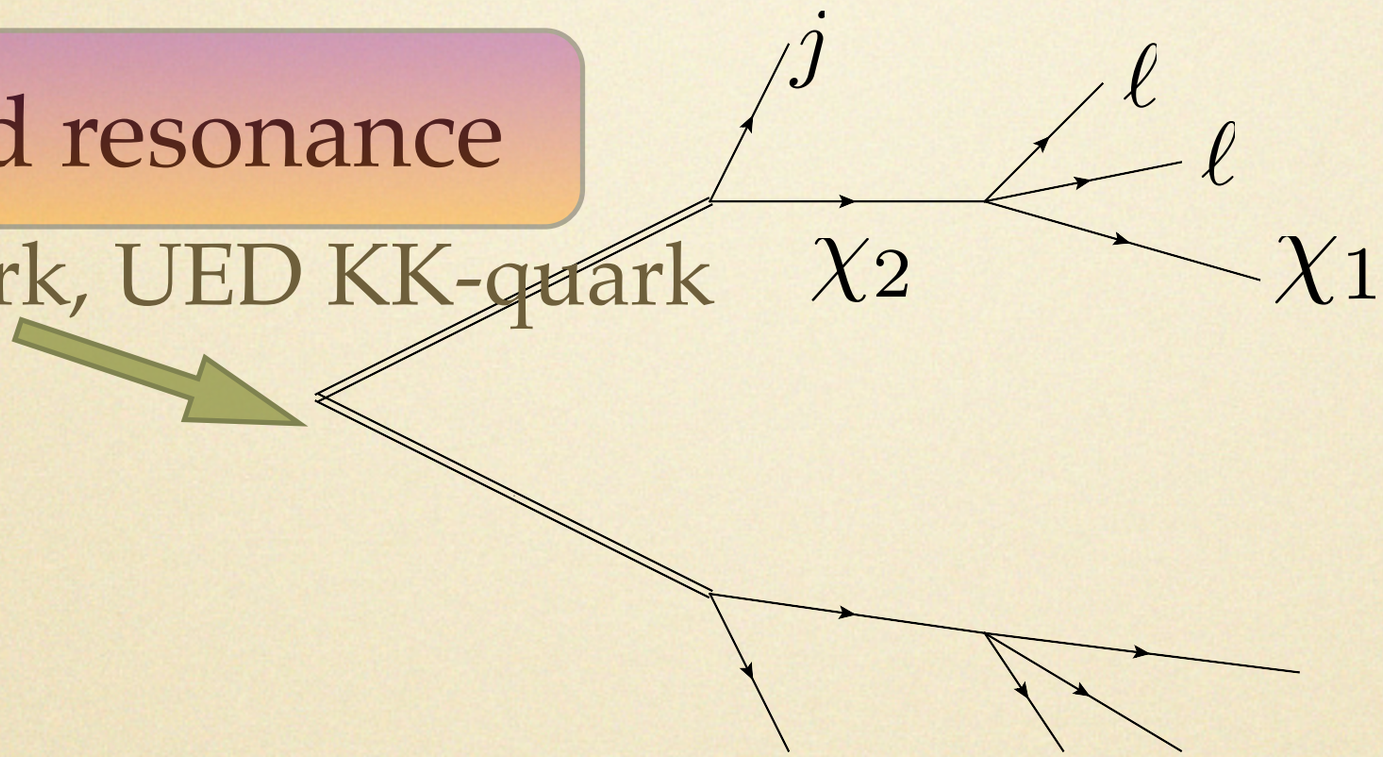
ex: Martin, V. S., **JHEP 2010:1-28,2010**

X= 2 high-pT jets

B.3-body decays

Colored resonance

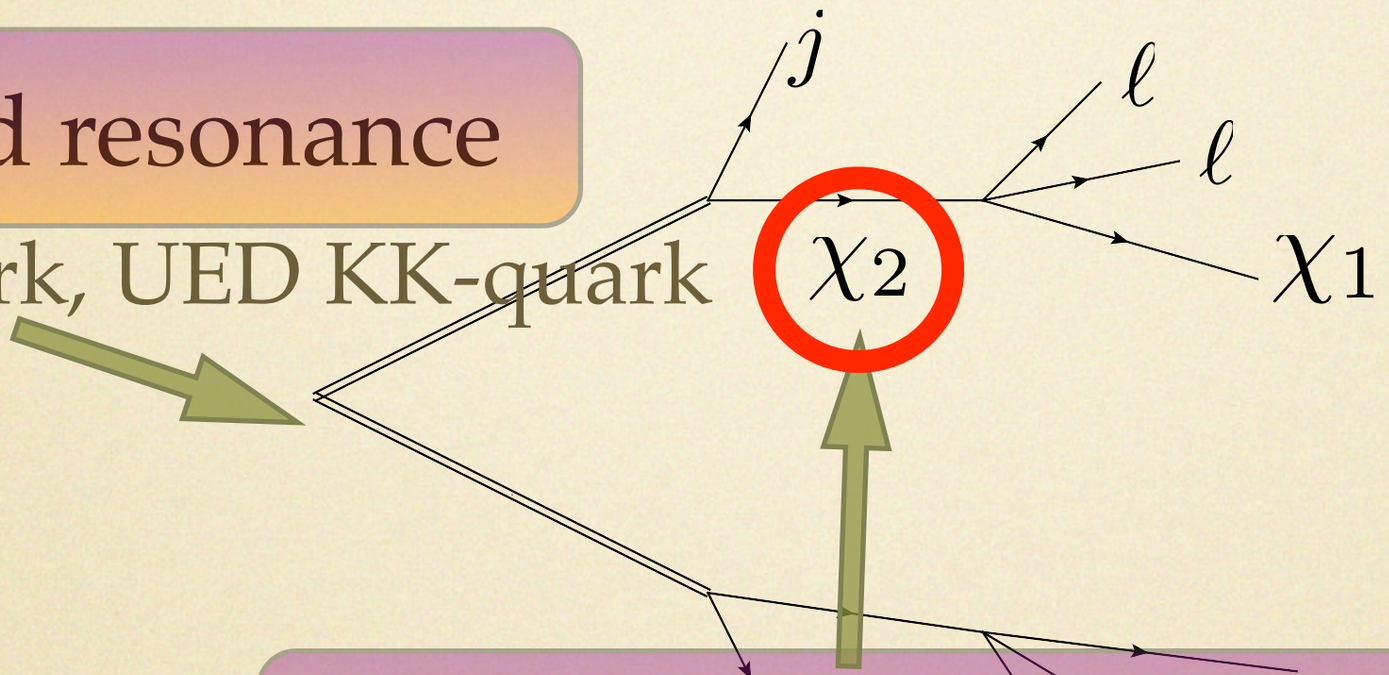
ex. squark, UED KK-quark



B.3-body decays

Colored resonance

ex. squark, UED KK-quark

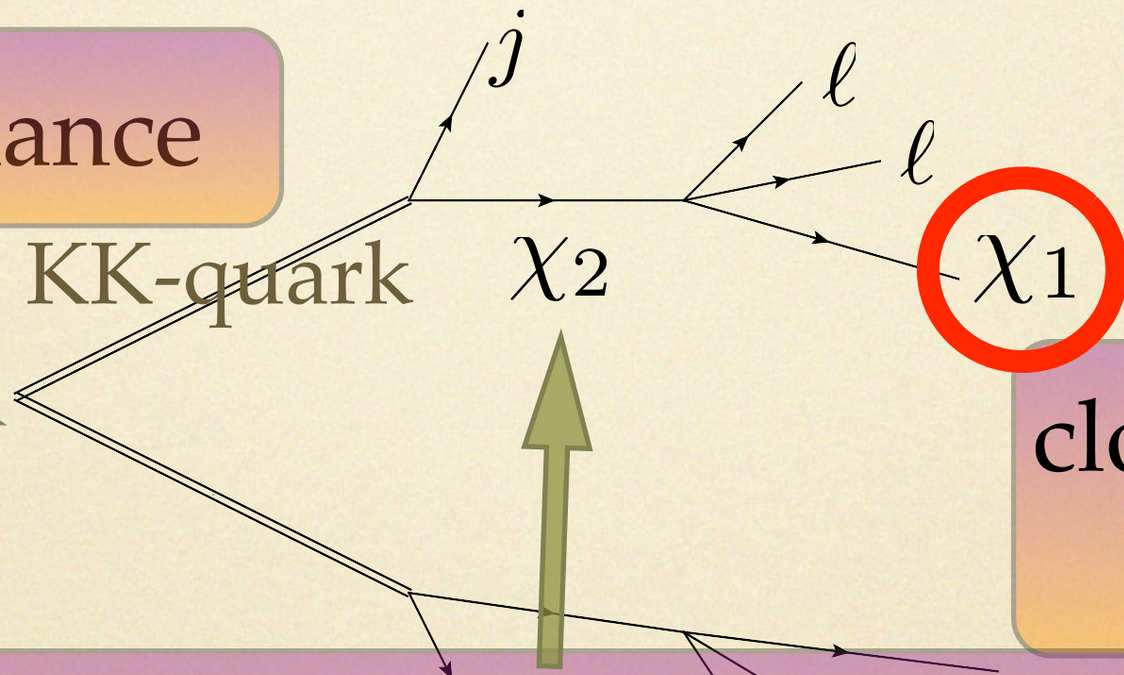


decays to a new neutral fermion or scalar

B.3-body decays

Colored resonance

ex. squark, UED KK-quark

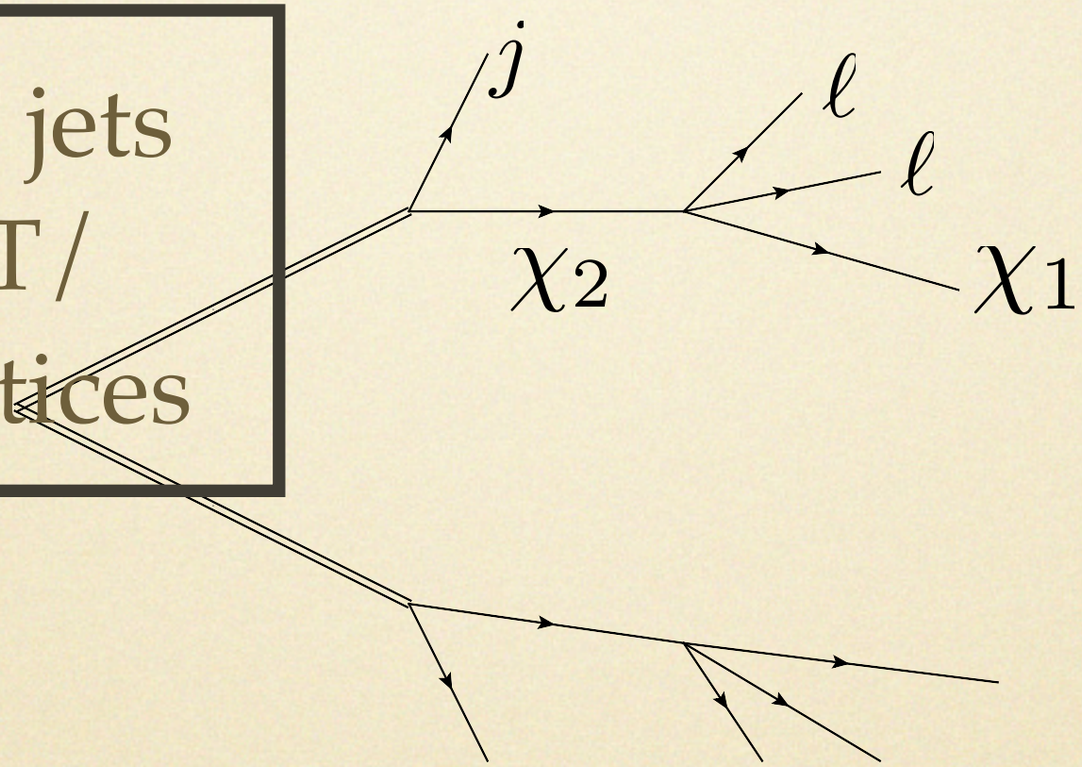


close in mass to stable DM

decays to a new neutral fermion or scalar

B.3-body decays

X= 2 high-pT jets
+missing ET/
displaced vertices



Examples:

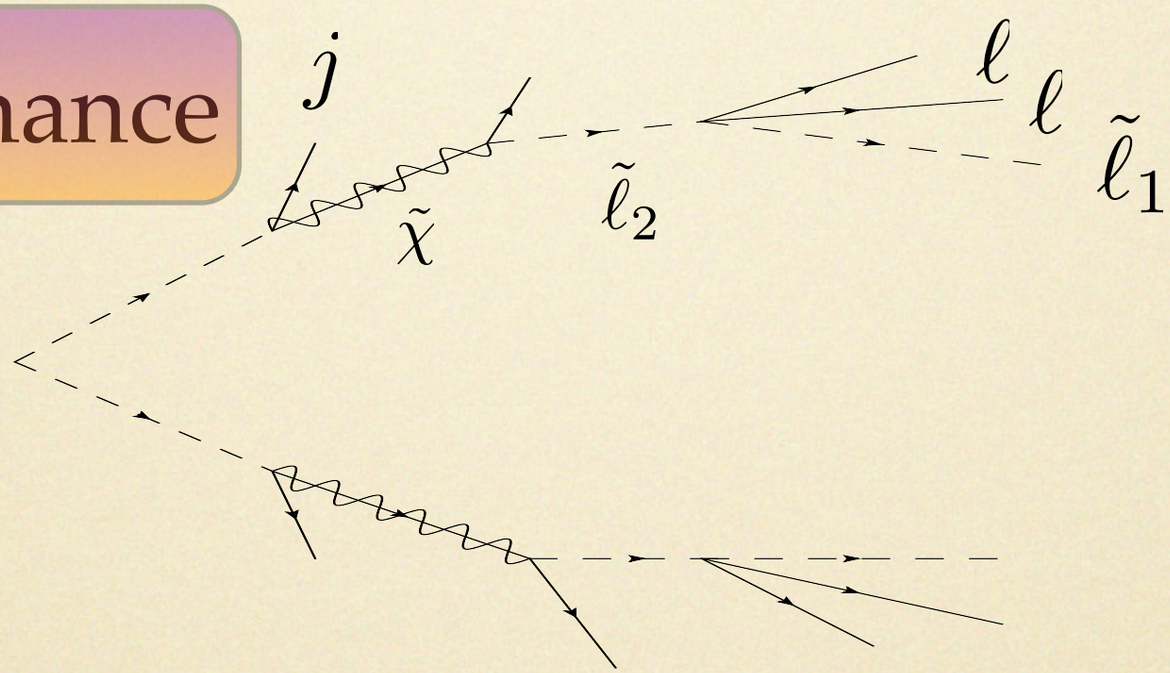
MSSSM, pseudo-Dirac Dark Matter

De Simone, V.S., Sato**, Phys. Rev. Lett. 105 (2010)**

C. cascade decays

Colored resonance

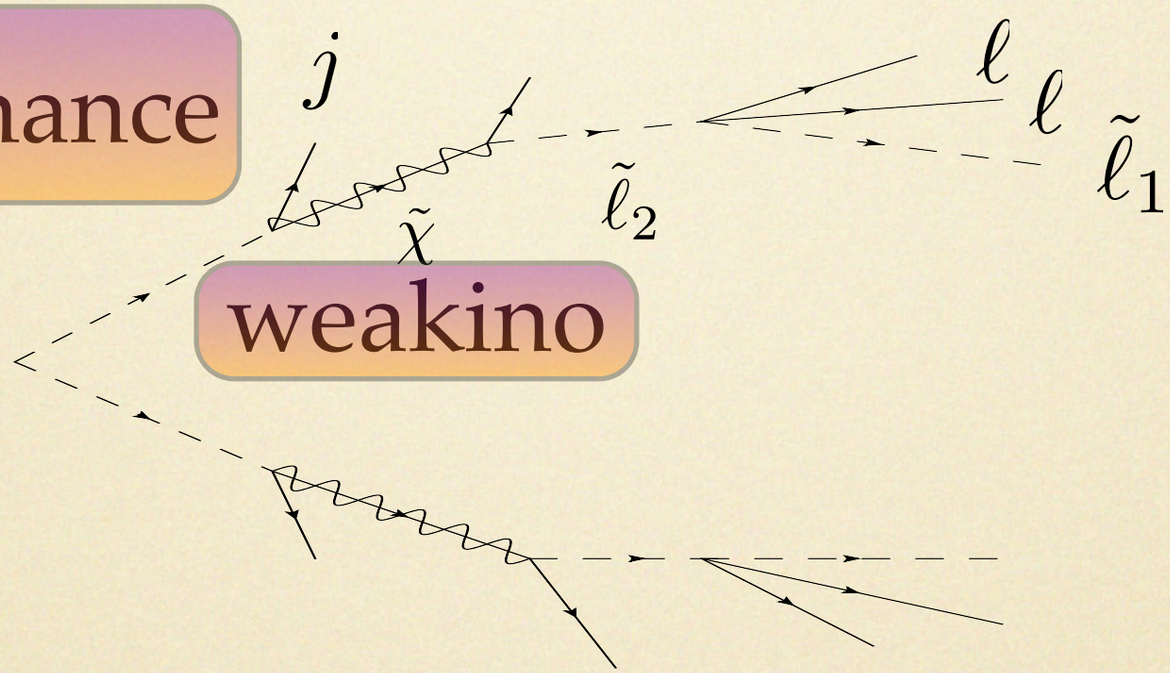
ex. squark



C. cascade decays

Colored resonance

ex. squark



weakino

C. cascade decays

Colored resonance

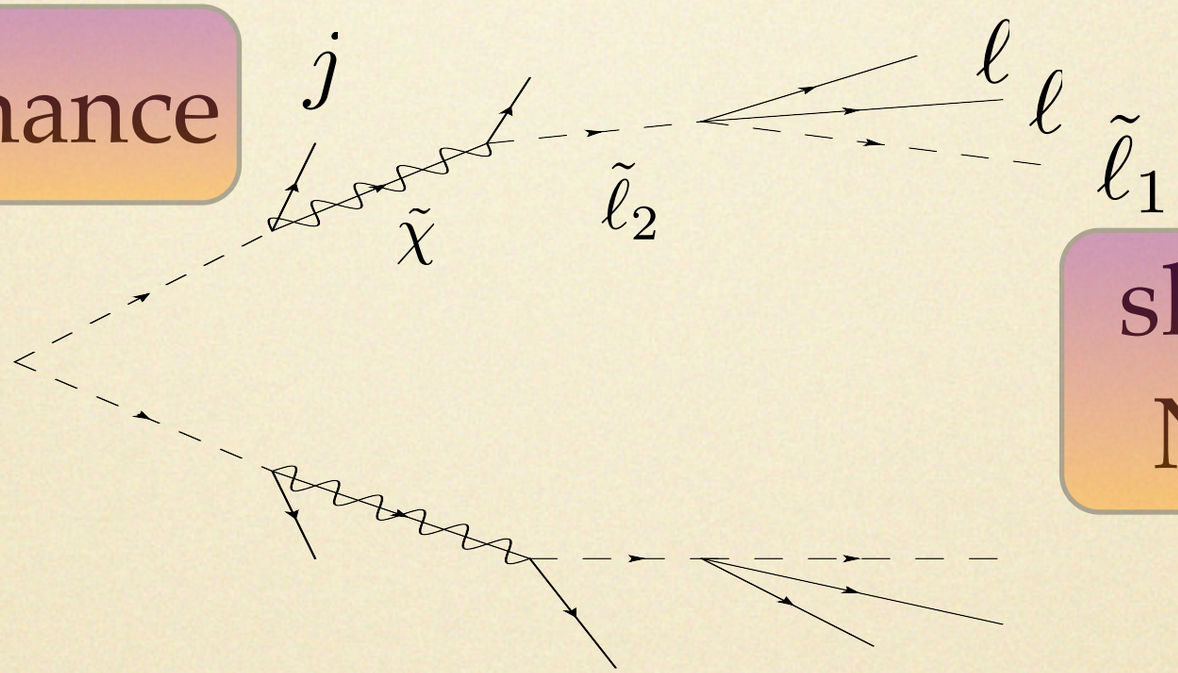
ex. squark

slepton

C. cascade decays

Colored resonance

ex. squark

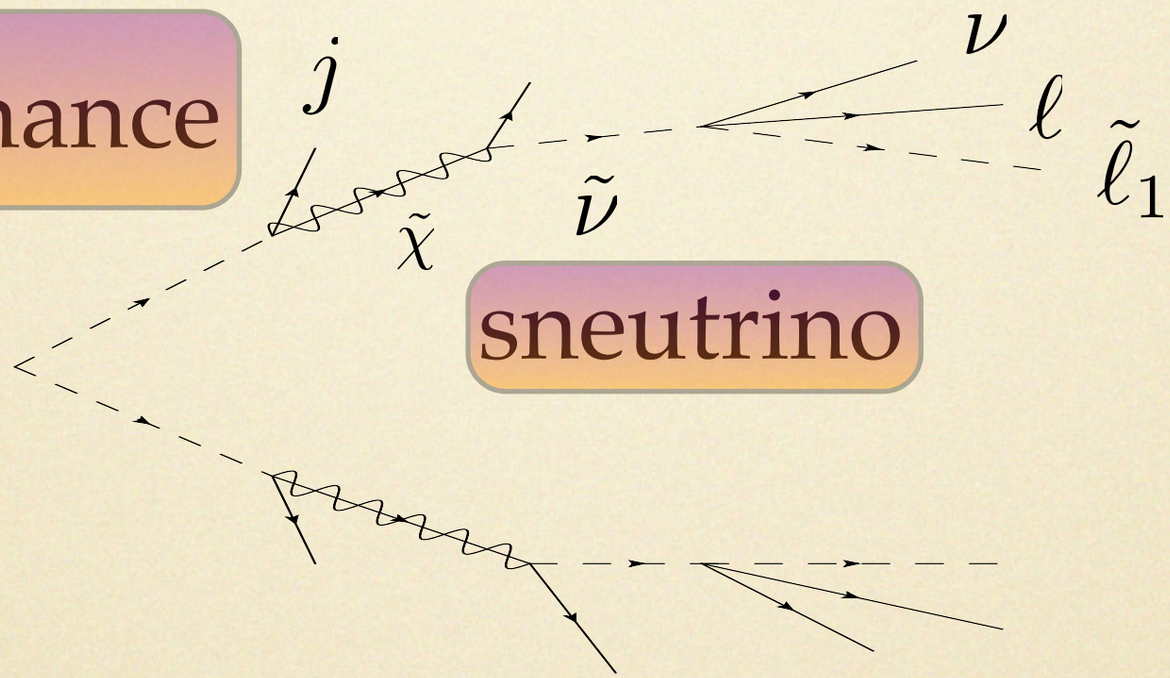


slepton NLSP

C. cascade decays

Colored resonance

ex. squark

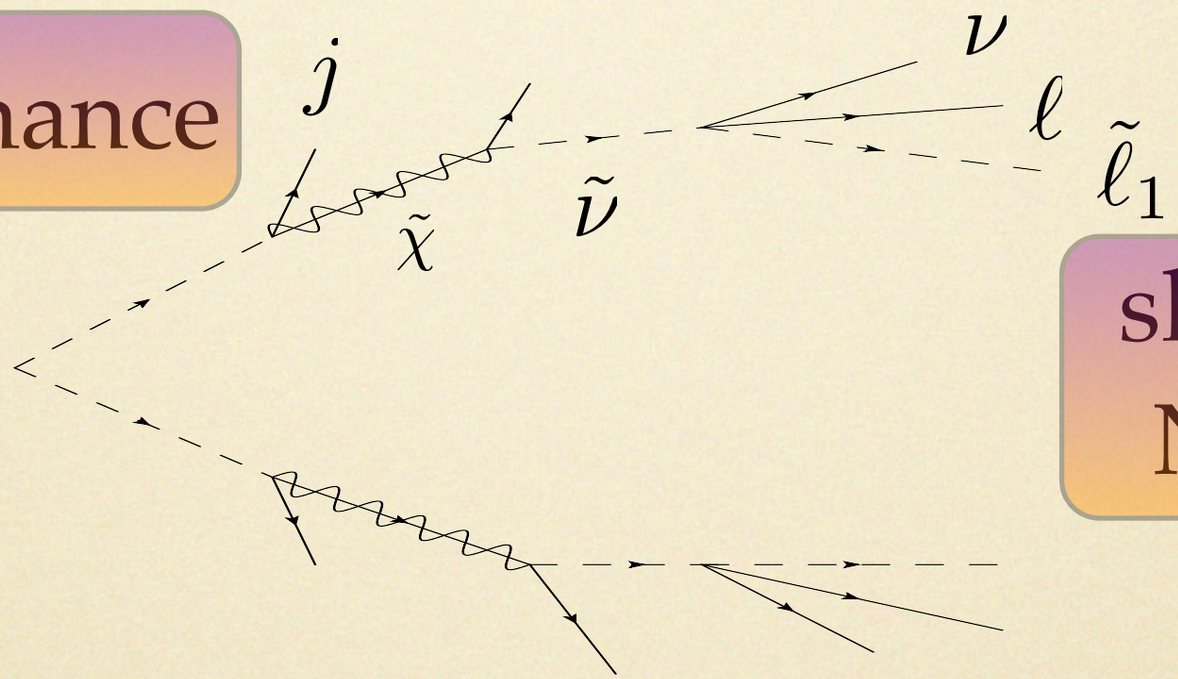


sneutrino

C. cascade decays

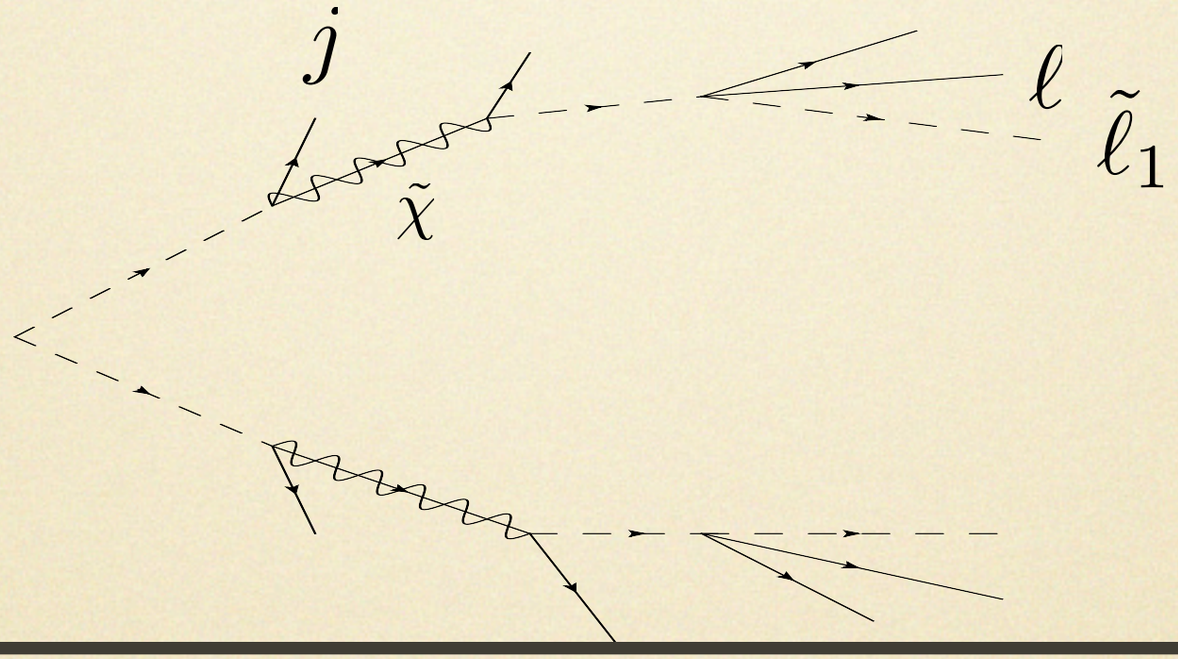
Colored resonance

ex. squark



slepton NLSP

C. cascade decays



X= 2 high-pT jets+CHAMPS/leptons/missing ET

Examples: MSSM, Lepto-SUSY

De Simone, Fan,V.S., Skiba**, Phys. Rev. D80(2009)**

Trigger and selection

My pick

$$n_\ell \geqslant 4$$

$$p_{\ell,T} \geqslant 20 \text{ GeV}$$

$$\Delta R_{\ell,object} > 0.4$$

$$\eta_\ell < 2.5$$

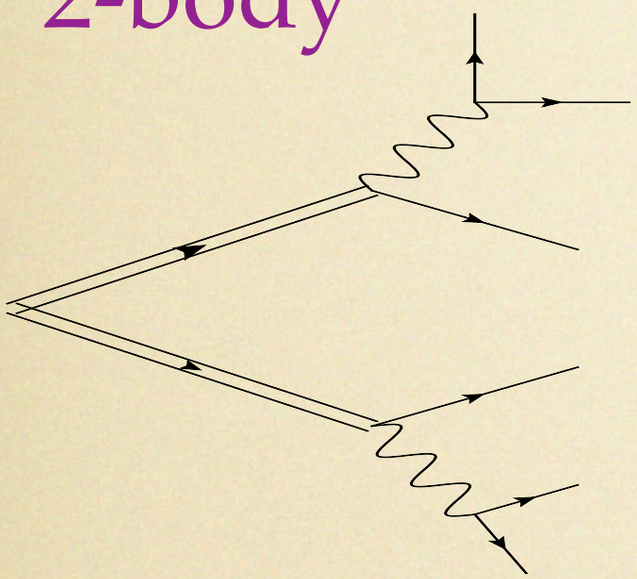
Colored particle pair production
TeVatron bounds about 400 GeV

$$H_T > 800 \text{ GeV}$$

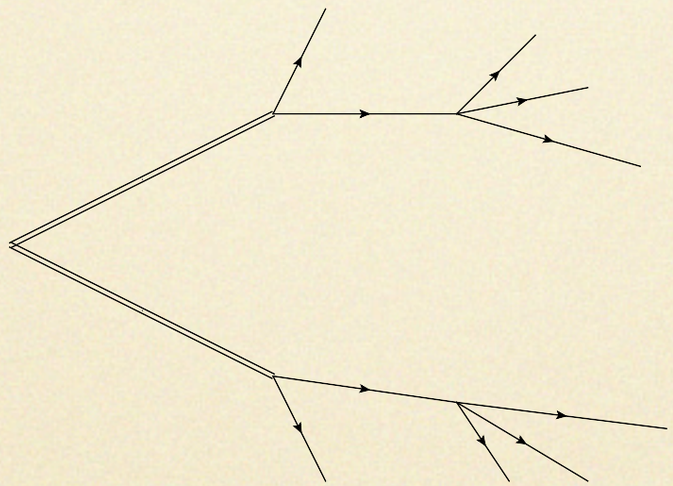
including leptons

Topology reconstruction

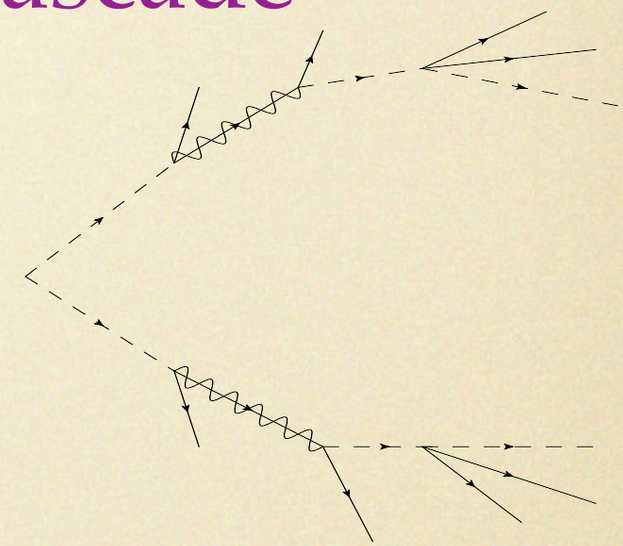
2-body



3-body



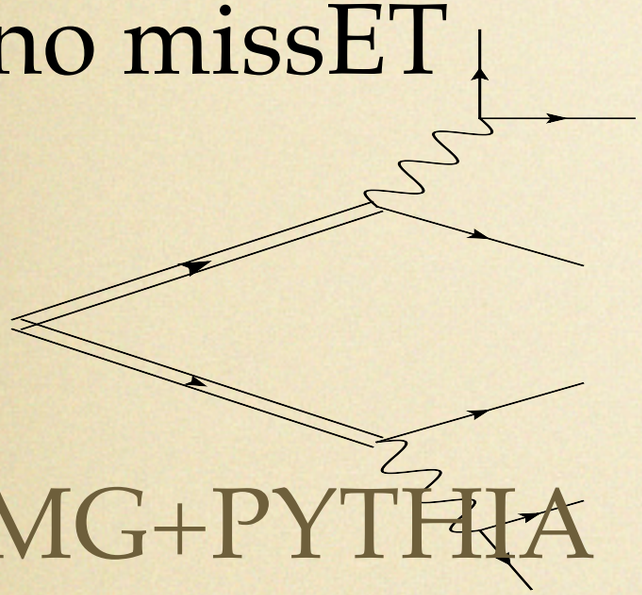
cascade



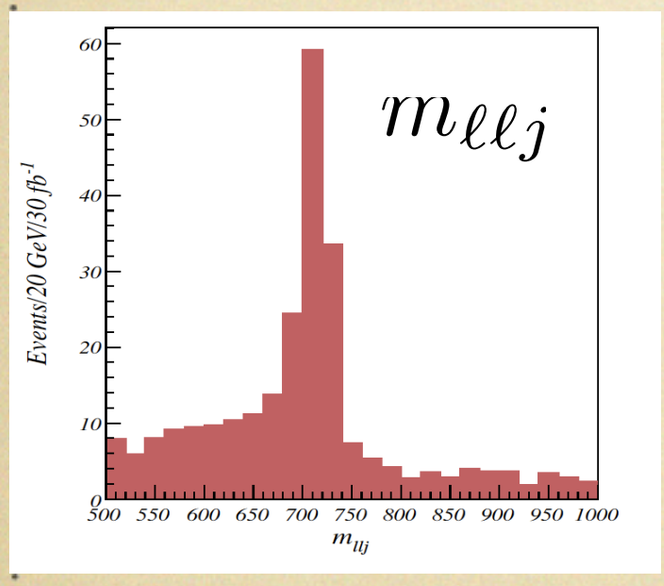
Can we beat combinatorics?

Topology reconstruction

no missET



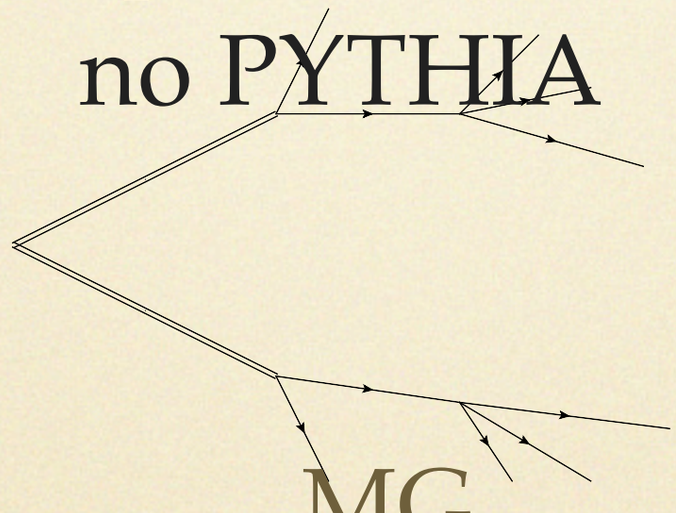
MG+PYTHIA +PGS



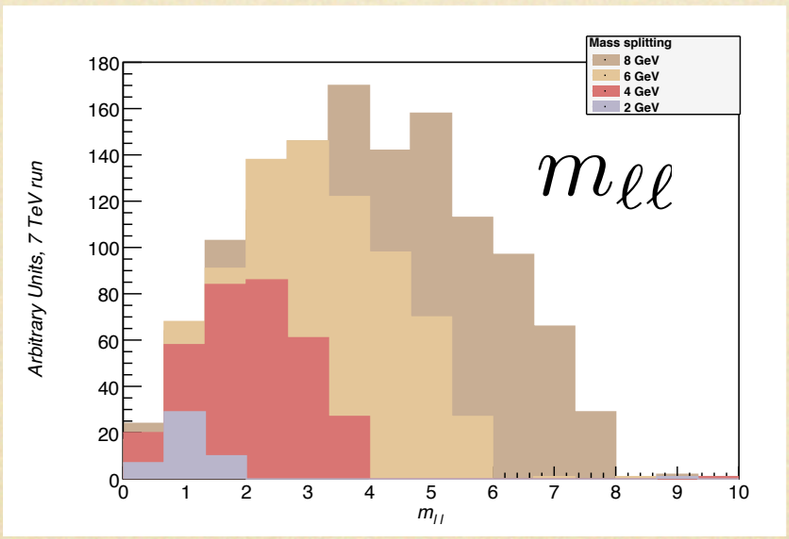
Higgsless / Technicolor

Martin, V. S.,
JHEP 2010:1-28 (2010)

displaced vertex
no PYTHIA



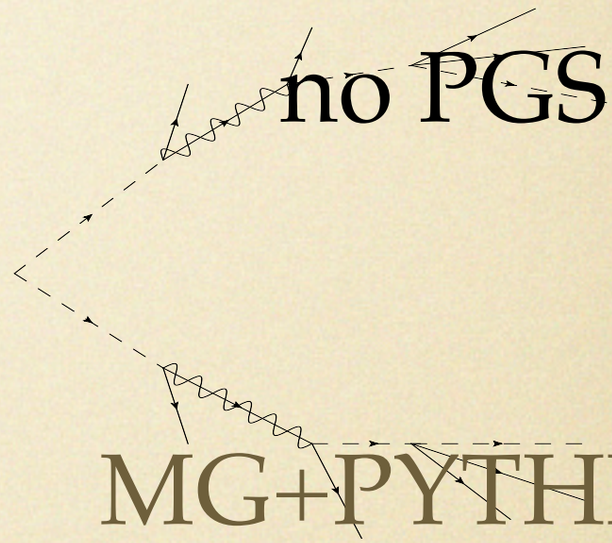
MG



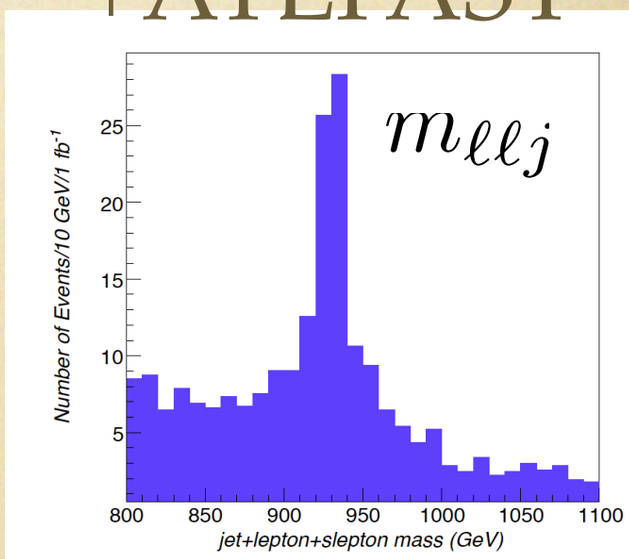
pDirac dark matter

De Simone, V.S., Sato,
Phys. Rev. Lett. 105 (2010)

CHAMP
no PGS



MG+PYTHIA +ATLFAST



Lepto-SUSY

De Simone, Fan,V.S., Skiba,
Phys. Rev. D80(2009)

Samples

MadGraph/MadEvent:
Model and parameter cards
BRIDGE decay matrix
PYTHIA card (CHAMPS)

Samples based on
2-body: cured Higgsless
3-body: MSSM with nearby binos
cascade decays: SUSYHIT to Lepto-SUSY

Questions

To experimentalists

Multi-lepton trigger: loosen pT cuts?

Rates from data for BG determination:
lepton charge misID, light jet to lepton,
b-jet to lepton, punch-through
as a function of lepton-pT, for isolated lepton

PYTHIA: displaced vertex, HV searches

To theorists

your model multi-leptonic? does it fit in one of these topologies?
long cascade decays: new MG or Bridge?
long-lived sleptons: PGS?