BSM Working Group
Status Report Part I

Les Houches 2009

Prologue

Wiki pages (program & BSM page) have extensive information and references. Keep them updated!

Apologies for all errors, typos, omissions, dropped/added names, etc.

Proceedings are coming... get ready!

Extra Dimensions

Radion Production and Decay

Eduard Boos

Viacheslav Bunichev

Margarete Muehlleitner

Michael Spira (the violent one)

Radion production and decay including the proper mixing with the Higgs andthe NLO corrections. This extends previous LO analyses or approximate NLO studies.

Particular emphasis is put on the couplings to gluons and photons.

Radion production and decay at NLO

E. Boos, V. Bunichev, M. Mühlleitner, M. Spira

- radion coupling to gluons: QCD beta function $[N_F = 6]$:

$$\mathcal{L}_{eff} = \frac{\alpha_s}{\pi} G^a_{\mu\nu} G^a_{\mu\nu} \; \frac{\phi}{\Lambda_\phi} \; \frac{7}{8} \left[1 + \frac{13}{14} \frac{\alpha_s}{\pi} \right]$$

- limit of heavy top quarks: integrate out $\Rightarrow N_F = 5$

$$\mathcal{L}_{eff} = \frac{\alpha_s}{\pi} G^a_{\mu\nu} G^a_{\mu\nu} \; \left\{ \frac{\phi}{\Lambda_\phi} \frac{23}{24} \left[1 + \frac{25}{23} \frac{\alpha_s}{\pi} \right] + \frac{H}{v} \frac{1}{12} \left[1 + \frac{11}{4} \frac{\alpha_s}{\pi} \right] \right\}$$
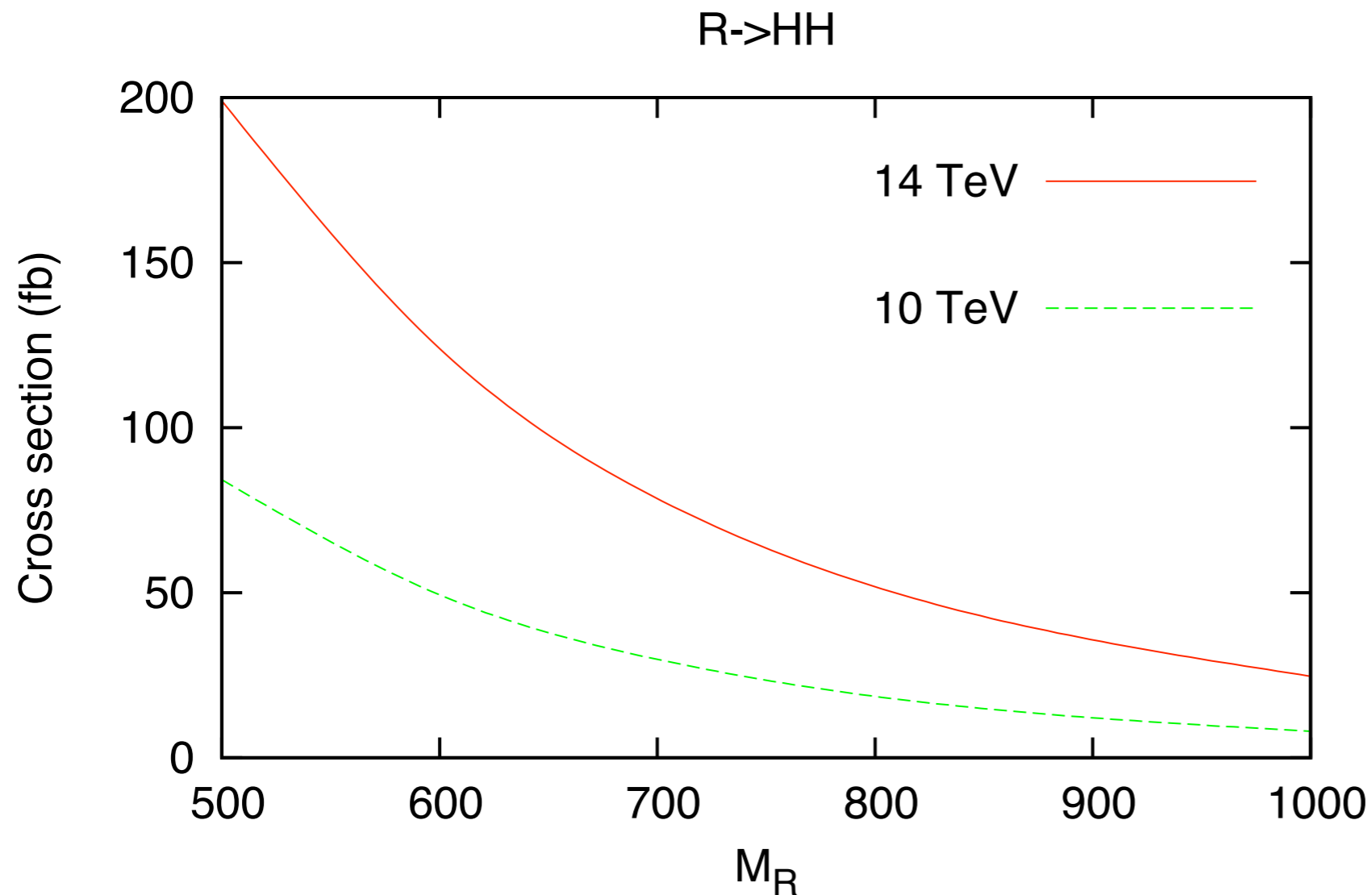
$\Rightarrow$ mismatch of radion and Higgs couplings

- mixing: ϕ, H current eigenstates, ϕ', H' mass eigenstates

$$\begin{aligned} \phi &= a_1 \phi' + a_2 H' \\ H &= a_3 \phi' + a_4 H' \end{aligned}$$

Radion to 2 Higgs

Christophe Grojean
Rogerio Rosenfeld
Muge Unel
Seung Lee
Shri Gopalakrishna
Kaustubh Agashe

R->HH

CalcHep calculation
of pp->R->HH for both
10 and 14 TeV

Single KK fermion (custodian) Production in RS with SU(2)$_L$xSU(2)$_R$ & bulk matter

K.Agashe, S.Gopalakrishna, G.Moreau, R.K.Singh

Cross sections for 2 sets of profiles along the 5th dimension (reproducing m$_t$ & m$_b$)

<div>

m$_{b'}$ = 325 GeV

σ (pp -> b'b') = 13800 fb

(pp -> b'Z$_L$) = 200 fb
(pp -> b'h^0) = 62 fb
(pp -> tb') = 165 fb

(pp -> bb'Z$_L$) = 506 fb
(pp -> bb'h^0) = 861 fb
(pp -> qbb') = 1730 fb
(pp -> tb'W$_L$) = 3370 fb
(pp -> qtb') = 2630 fb

</div>

<div>

m$_{b'}$ = 800 GeV

σ (pp -> b'b') = 107 fb

(pp -> b'Z$_L$) = 4,3 fb
(pp -> b'h^0) = 5,8 fb
(pp -> tb') = 1,7 fb

(pp -> bb'Z$_L$) = 14 fb
(pp -> bb'h^0) = 186 fb
(pp -> qbb') = 282 fb
(pp -> tb'W$_L$) = 5 fb
(pp -> qtb') = 39 fb

</div>

Several single production processes compete with pair production at LHC especially for large m$_{b'}$

Virtual Effects of KK Gluons

Manoranjan Guchait
Nazila Mahmoudi
K. Sridhar

We are proposing to study the virtual effects of KK gluons at hadron colliders by including the interference with the SM. The aim is to study the detection channels of the high-momentum tops that will be produced in the decay of the KK gluons, and study the impact of the virtual effects of the KK gluon at both the LHC and the Tevatron. During this workshop, we have already implemented the matrix elements for the process in a code with which we plan to simulate the top final states.

Flavor Observables w/ SuperIso

Kaustubh Agashe
Nazila Mahmoudi

Calculation of flavor observables
in other-than-SUSY new physics models such as Universal extra dimension and/or Littlest Higgs with T-parity using the SuperIso program. The idea here is to start with the Wilson coefficients at TeV scale calculated in these models and use SuperIso to evolve them down to hadronic scales, compute BR and compare to experiment etc. This later part is in principle independent of new physics scenario.

UED in Pythia

Helenka Przysiezniak

Work towards implementing UED in Pythia,
comparing the UED implementations in Herwig and Pythia

(see also MC group)

Overlapping Resonances

Giacomo Cacciapaglia

Aldo Deandrea

Jeremie Llodra-Perez

Hidden Valleys

Hidden Valleys

Paddy Fox

Yuri Gershtein

Graham Kribs

Adam Martin

Tuhin Roy

Matt Strassler

Claire Shepard

Ian Tomalin

Conor Henderson

David Morrissey

Renaud Bruneliere

Peter Richardson

Frank Krauss

Steffan Schumann

Working on choosing and simulating Hidden Valley Benchmarks for the purpose of challenging trigger, reconstruction and data storage at CMS and ATLAS. Includes Hidden Valley benchmarks for analysis, which are a different class; dark matter and Higgs experts are helping.

Hidden Valleys: Trigger/RECO Challenge

H -> XX (Fox)

SUSY w/ hidded U(1) (Morrissey)

broken SU(N)   (IAS group + SHERPA/HERWIG)

confining Nf > 1 (Strassler,Wacker + SHERPA/HERWIG)

Nf=1 (Wacker)

Nf=0 quirky models:

      glueballs (Strassler);

      ultrasoft (Kribs, Henderson; Davis group, Mrenna)

long-lived / highly boosted / clustered / ultra-soft / weird tracking ...

(discussed by Claire)

HidSec benchmark points

Hidden Sector Benchmarks

[References need to be added]

The group investigating hidden sector benchmarks focused on hidden valley models in general (with considerable discussion of dark-matter motivated models with light particles [$<$ few GeV] that have a large branching fraction to muons and/or electrons, often leading to lepton-jets) and on quirks in certain regimes (including dark-matter-motivated examples.)

There were two types of benchmarks that were discussed actively.

1) Benchmarks to challenge the trigger and reconstruction systems at the LHC experiments.

The key challenges of which we are aware involve one or more of the following:

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a) Long-lived particles decaying in flight (which pose many different
types of challenges)
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b) Highly boosted light particles
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c) Unusual clustering of particles
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d) Ultra-soft signatures (involving many standard model particles
below a few GeV).
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e) Tracking challenges (which we did not discuss actively).
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M. Strassler has been coordinating with F. Moortgat and R. Brunliere, among others, to generate various data sets and ensure they will run through ATLAS and CMS software. These data sets involve problematic regimes of many of the models listed below, as well as others. (The software used is not fully validated as far as total cross-sections and branching fractions as a function of model parameters, and is not appropriate for analysis-level studies, but should be sufficient for stressing the systems.) A web page with the data sets will be established, along with an explanation of the models and their phenomenology. The specific models will be adjusted, replaced or expanded as issues emerge, or do not emerge, with triggering, reconstruction, and data storage.

2) Benchmarks to serve as springboards for experimental analysis during the early running (a few hundred inverse pb of data.)

The signatures from hidden sectors for which models seem especially appropriate for early running are

Hidden Valley Parton Showers

Frank Krauss
Peter Richardson
Steffen Schumann
Matt Strassler
Jay Wacker

(see also MC group)

Quirky Signals & Ecal Ht trigger

Conor Henderson

Graham Kribs

+ Strassler + Davis Group + Mrenna

Feasibility study for an ECAL-only H_T trigger for CMS. The idea here is to be able to trigger on potential 'quirk' or 'hidden valley' scenarios which de-excite through emission of a cloud of soft photons, without any hard particles capable of firing existing triggers.
I think it likely that we can do this with a threshold of 100 - 200 GeV, but quantitative estimates of the background rates from the underlying event need to be done.

Dark Matter Inspiration

Dark Matter Inspiration

Graham Kribs
Seung Lee
David Morrissey
Tuhin Roy
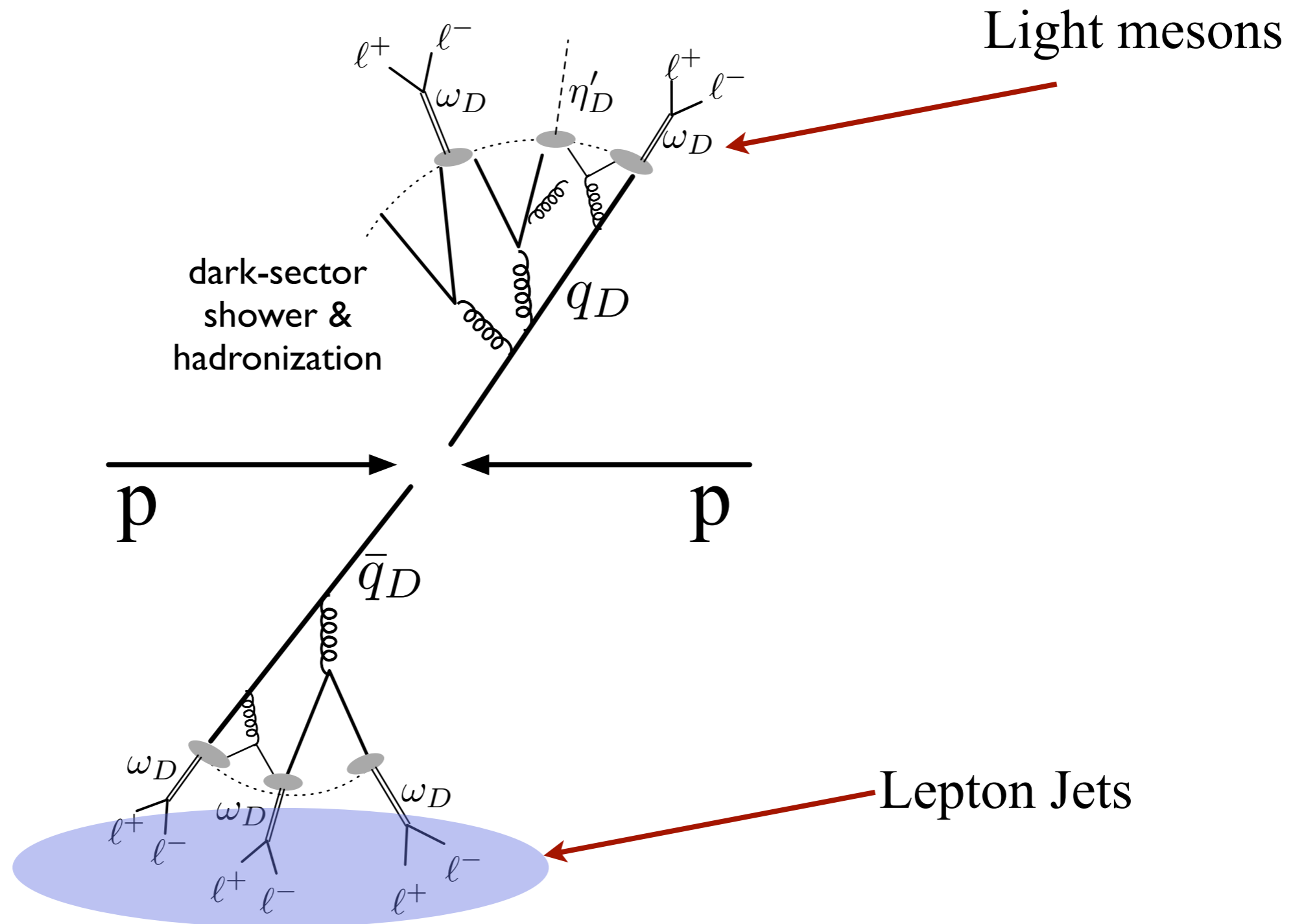Jay Wacker
Kaustubh Agashe
Geraldine Servant

Genevieve Belanger
Sylvain Fichet
Giacomo Cacciapaglia
Jeremie Llordra-Perez

- Abelian Hidden Sector models, Sommerfeld (Morrissey)
- composite dark matter, DAMA, lepton "jets" (Wacker)
- Z3 versus Z2 phenomenology (Agashe, Servant)
- RH-neutrino as DM (Belanger)
- 6D Model of Dark Matter & LHC (Cacciapaglia)

Collider Signals

- Many models and many possibilities!

- Not Uncommon Features:

    – missing energy

    – displaced tracks

    – collimated "jets" of leptons

- Sample Spectra #1-2 can exhibit all of these features.

Morrissey

Collider Signatures

Light mesons

ℓ^+ ℓ^-

ω_D

η'_D

ℓ^+ ℓ^-

ω_D

dark-sector
shower &
hadronization

q_D

p

p

$\bar{q}_D$

ω_D

ω_D

ω_D

ℓ^+ ℓ^-

ℓ^+ ℓ^-

ℓ^+ ℓ^-

Lepton Jets

Wacker

- Many other possibilities:

  - longer $U(1)_x$-sector cascades

  - events initiated by heavy states with SM and $U(1)_x$ charges

  - more complicated light $U(1)_x$ sectors

  - $U(1)_x$ mixing with non-Abelian hidden gauge groups
    $\rightarrow$ hidden parton shower

Morrissey

Dirac SUSY

Dirac Gauginos & R symmetric

Kaustubh Agashe
Paddy Fox
Graham Kribs
Adam Martin
Tuhin Roy

David Morrissey
Conor Henderson
Genevieve Belanger
Filip Moortgat
Siba Prasad Das

Renaud Bruneliere
Claude Duhr
Benjamin Fuks
Fawzi Boudjema

Dirac Gauginos Les Houches projects

☝ **Monte Carlo:**

Check the existing Monte Carlo implentations

FeynRules implementation: both pseudo-Dirac and R-symmetric cases, choice controlled by user

(Belanger, Duhr, Fox, Fuks, Kribs, Martin, Roy)

✌ **Dirac gaugino benchmark:**

At least one point with low mass, similar rates to SPSXX, maximum difference between Dirac and Majorana (MSSM) case

(Belanger, Fox, Martin, Renaud)

other benchmark points?

Dirac Gauginos Les Houches projects

Chargino NLSP, Gravitino LSP:

occurs generically for fully Dirac gauginos (R-symmetric models), implies all SUSY events contain:

$$W^+ W^- + \not{E}_T + X$$

study lepton multiplicities, correlation between

$$\text{jets} + \not{E}_T, \quad \text{jets} + \text{leptons} + \not{E}_T$$

(Henderson, Martin, Roy)

Technicolor

LOW-SCALE TECHNICOLOR at the LHC

K. Black, T. Bose, S. Harper, C. Henderson

K. Lane, Y. Maravin, A. Martin

1. $\rho_T^\pm, a_T^\pm \to W^\pm Z^0 \to \ell^\pm \ell^+ \ell^- \not{E}_T$ (TB & YM).

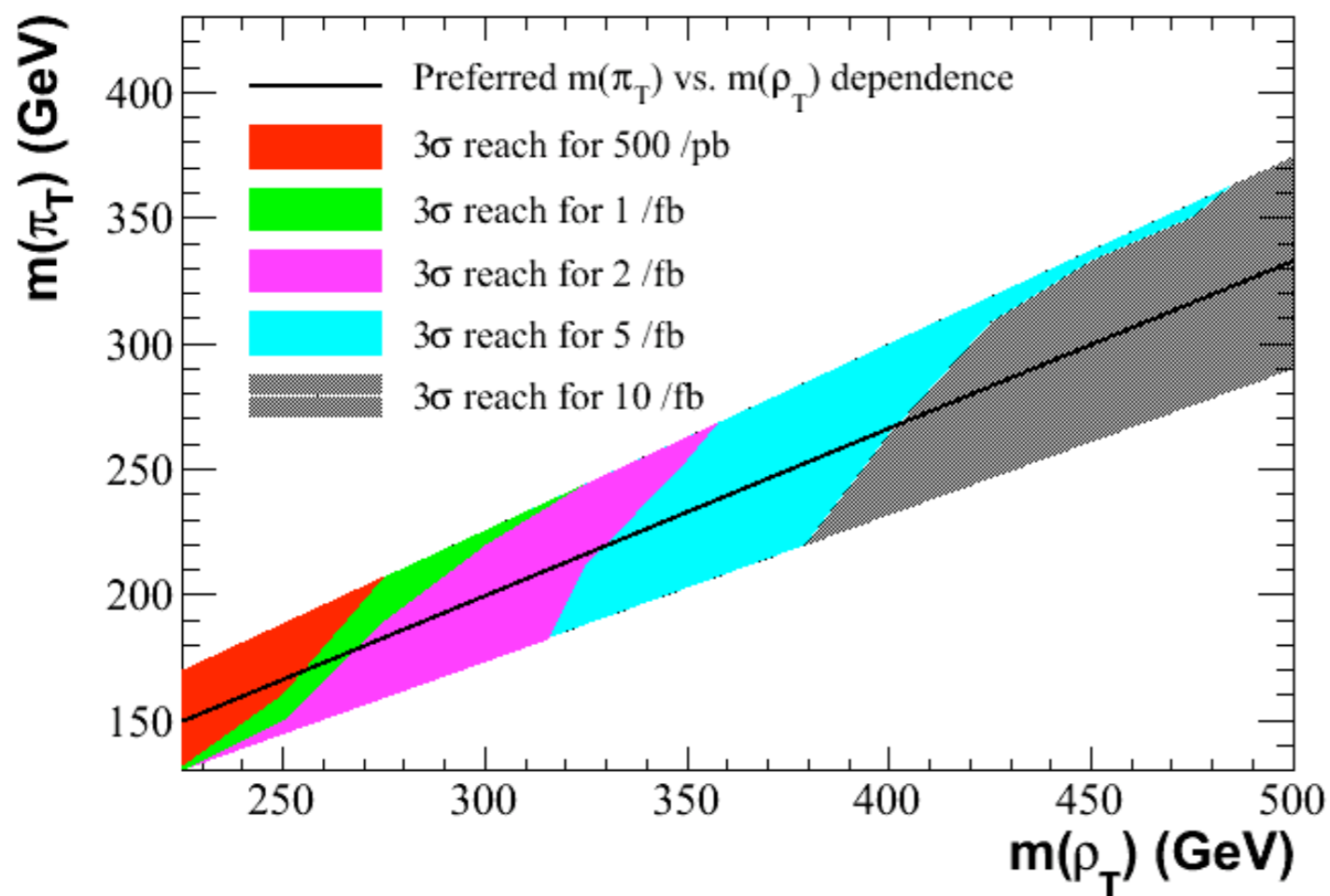2. $a_T^\pm, \rho_T^\pm \to \gamma W^\pm \to \gamma \ell^\pm \not{E}_T$ (YM).

3. $\omega_T \to \gamma Z^0 \to \gamma \ell^+ \ell^-$ (KB).
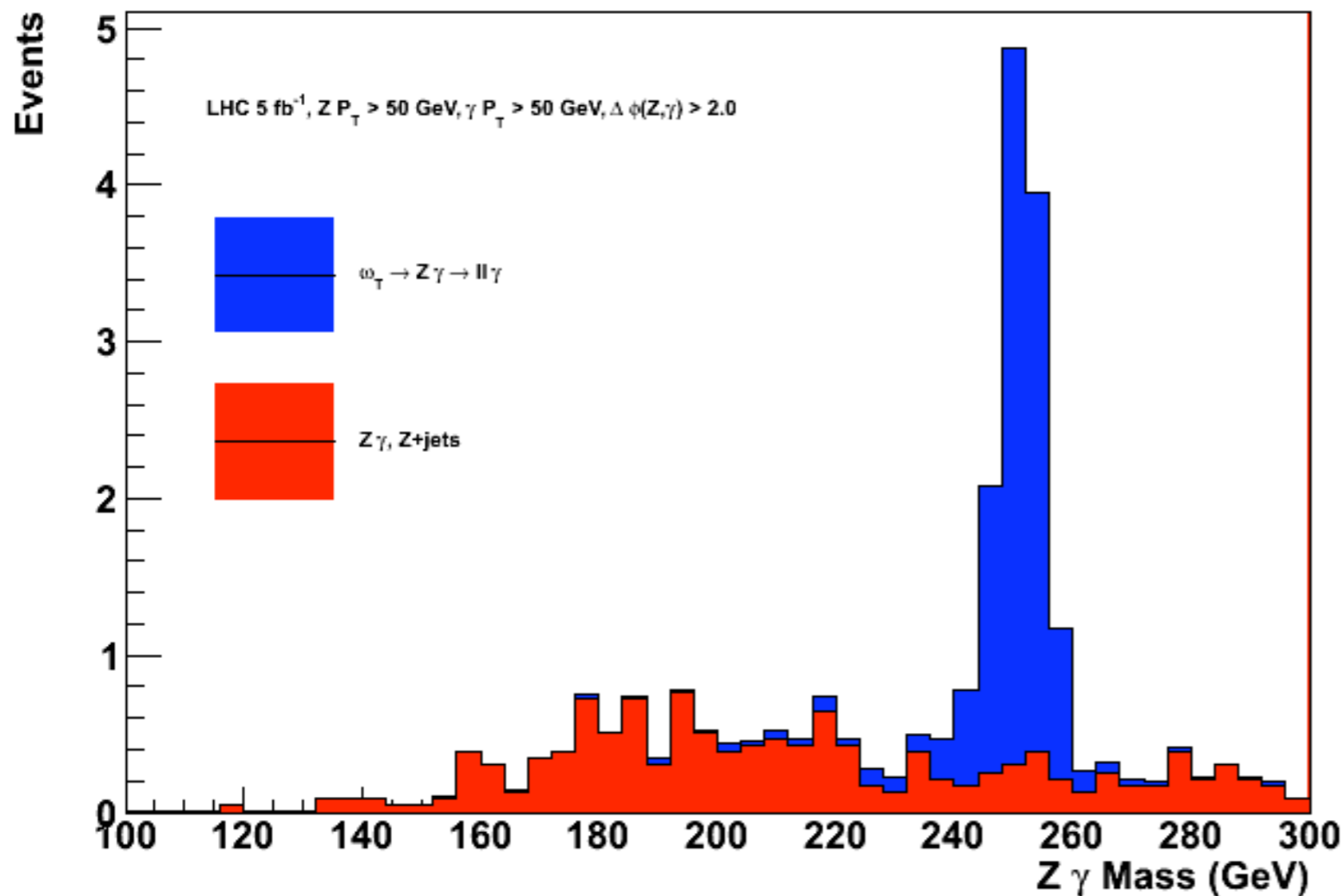
4. $\omega_T, \rho_T^0, a_T^0 \to e^+ e^-$ (SH).

5. $\omega_T \to \gamma \pi_T^0 \to \gamma \gamma \gamma$ (CH) — a long shot!

6. The effective Lagrangian for LSTC (validity of the W_L/Z_L approximation, angular distributions, etc.) (KL & AM).

Preferred $m(\pi_T)$ vs. $m(\rho_T)$ dependence
3σ reach for 500 /pb
3σ reach for 1 /fb
3σ reach for 2 /fb
3σ reach for 5 /fb
3σ reach for 10 /fb

3-sigma observation for
rho_T, a_T -> WZ -> lll nu
for sqrt{s} = 10 TeV;
M_{a_T} = 1.1 M_{rho_T}
(prepared by Yurii Maravin and Tulika Bose)

LHC 5 fb^{-1}, Z P$_T$ > 50 GeV, γ P$_T$ > 50 GeV, $\Delta \phi(Z,\gamma)$ > 2.0

$\omega_T \to Z\gamma \to ll\gamma$

$Z\gamma$, Z+jets

signal and background
for a 250 GeV
omega_T -> gamma Z -> gamma l+l-
for 5/fb with cuts:
2 isolated leptons with p_T > 20 GeV
Z-mass within +- 15 GeV of 90, and
photon p_T > 50 GeV

BSM on top

Top Decay

Eduard Boos

Viacheslav Bunichev

Maxim Kiryushin

Ritesh Singh

We intend to calculate the full quadratic contribution of the anomalous tbW couplings to various kinematic distribution in the top-decay. We further want to assess the effects of these couplings on single top-production process and various distributions therein.

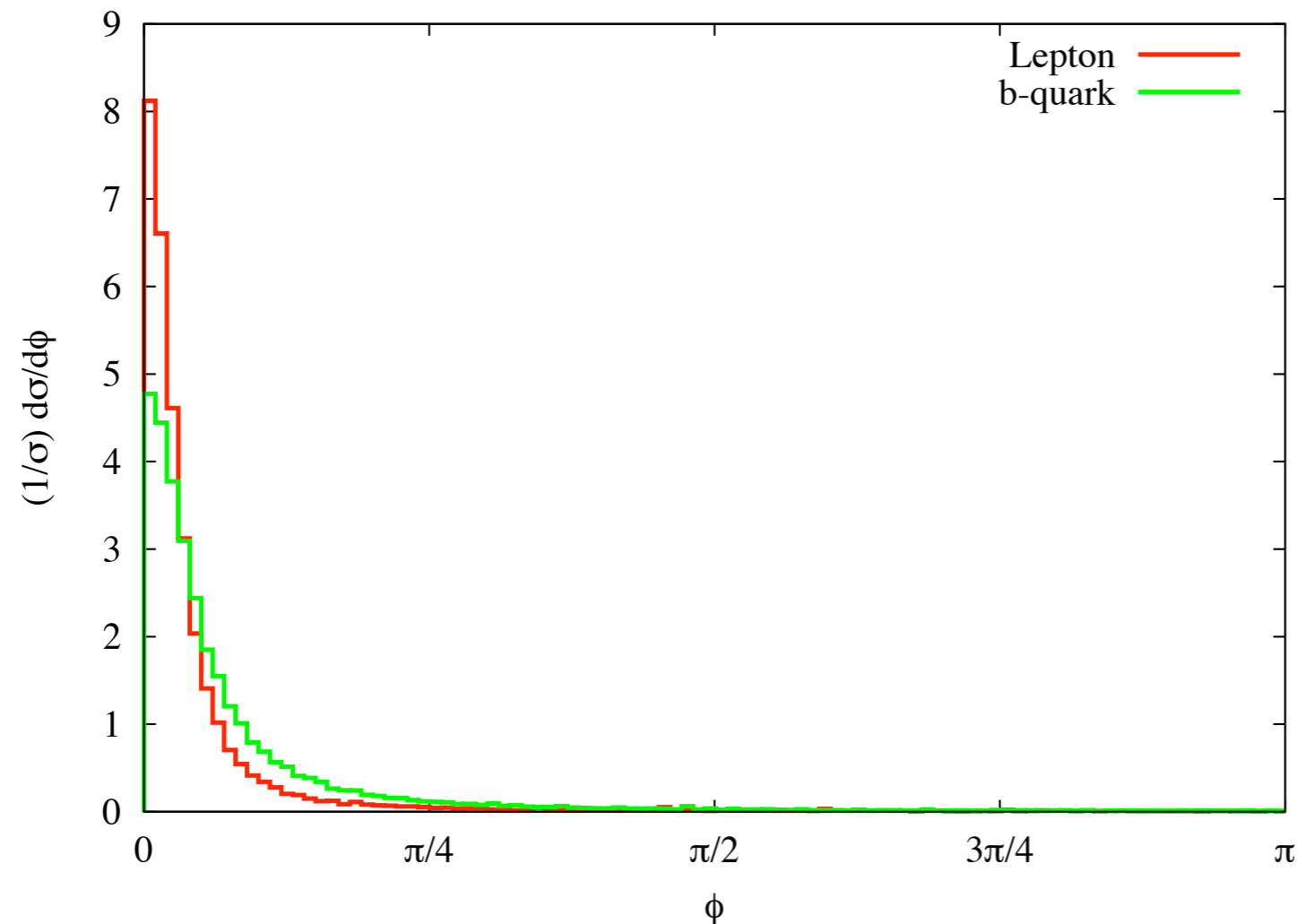# Angular Distributions in t Decay & Top Polarization

Fawzi Boudjema

Werner Porod

Ritesh Singh

We have recently constructed an observable sensitive to the top polarization based on the azimuthal distribution of the visible leptons and b-quarks. We inted to study the futher use of this observable to get some information about the top spin.

LHC: $pp \to t\bar{t} \to be^+\nu_e \, \bar{b}e^-\bar{\nu}_e$

$$\Delta = \left| \frac{d\sigma}{d\phi_l} - \frac{d\sigma}{d\phi_b} \right|$$

$\Delta = 0$ for $\eta_3 = 0$

Depends upon:
- Top polarization η_3
- p_t^T distribution

$\sigma = 41.5$ fb
$\eta_3 = +0.819$

Model: SM+$g^{(1)}$
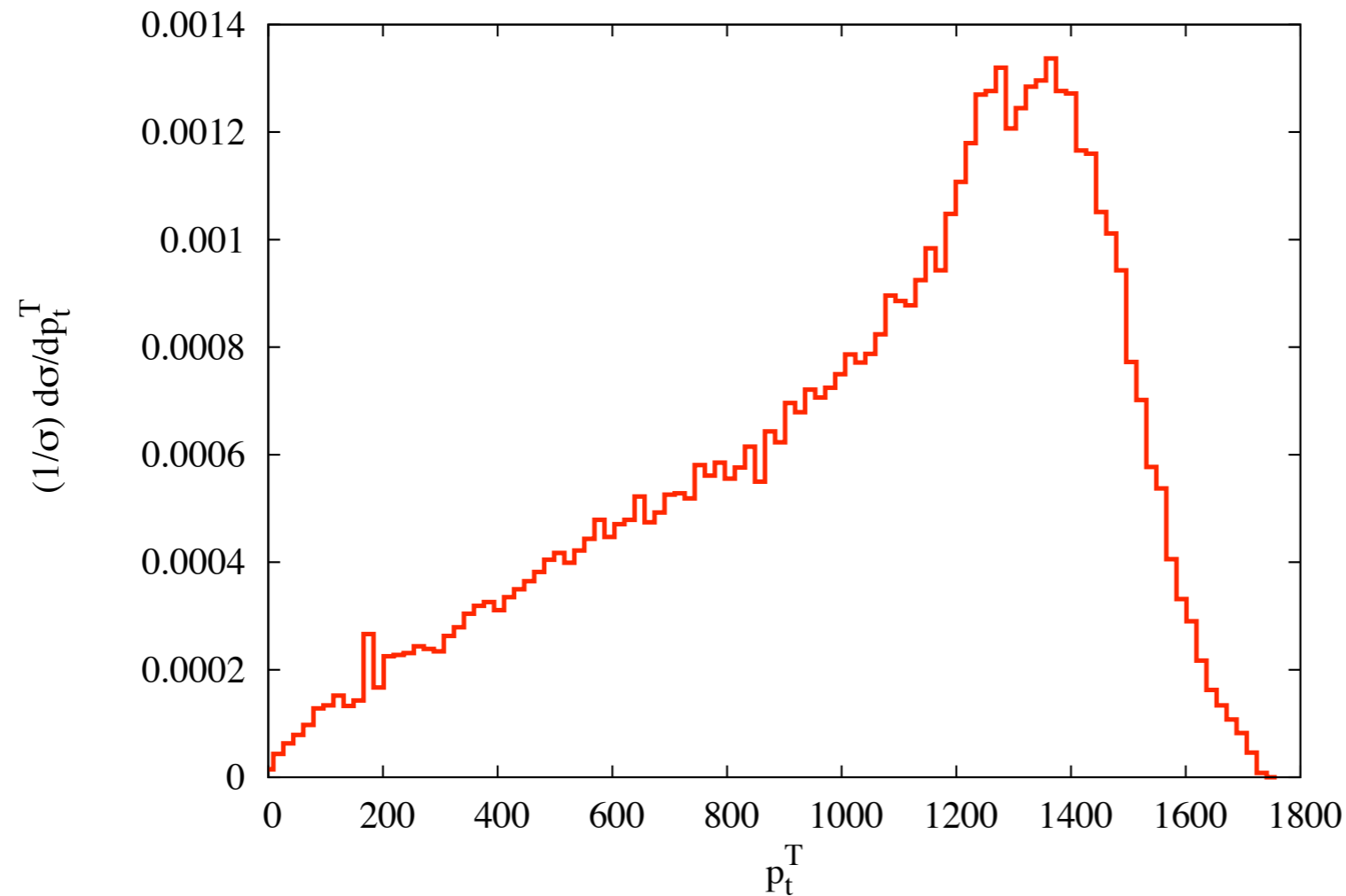
$M_g = 3000$ GeV, $\Gamma_g = 500$ GeV

$C_L^t = 1.118, C_R^t = 5.201$

Cuts: $m_{t\bar{t}} := [2500, 3500]$ GeV

ϕ **is the angle between transverse directions of** t **and the decay products in lab.**

Needs to recontruct p_t^T direction in the lab.

Singh

LHC: $pp \rightarrow t\bar{t} \rightarrow be^+\nu_e\,\bar{b}e^-\bar{\nu}_e$

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Needs to recontruct p_t^T direction in the lab.

Singh

Boosted tops

Gustaaf Brooijmans

J-R Lessard

Marcel Vos

Working on how to treat the transition zone between classical ttbar to ttbar with high invariant mass that lead to boosted tops. The ultimate goal would be to be able to accurately reconstruct the full dMtt/Dsigma spectrum. The plan is to see roughly what that transition zone is and then include analyses efficiency and so on.

BSM, Higgs, & SUSY

Flavor-violating Higgs couplings
(Agashe, Das, Guchait, Lari, Vos)

- Single Higgs doublet with higher-dimensional operators: model-independent analysis (Agashe, Contino)

- Warped/composite SM (Agashe, Contino; Azatov, Toharia, Zhu):

  $\text{BR}\,(t \to cH) \sim 10^{-4},\, \text{BR}\,(H \to tc) \sim 5 \times 10^{-3}$ (also radion)

- LHC sensitivity (Aguilar-Saavedra, Branco):
  $\text{BR}\,(t \to cH) \sim 5 \times 10^{-5}$ (with $H \to b\bar{b}$, $M_H \stackrel{<}{\sim} 130$ GeV)

- Can we improve?

- Study $H \to WW$ for 130 GeV $\stackrel{<}{\sim} M_H \stackrel{<}{\sim}$ 160 GeV

- For $M_H \stackrel{>}{\sim} m_t$, study Higgs decay or production
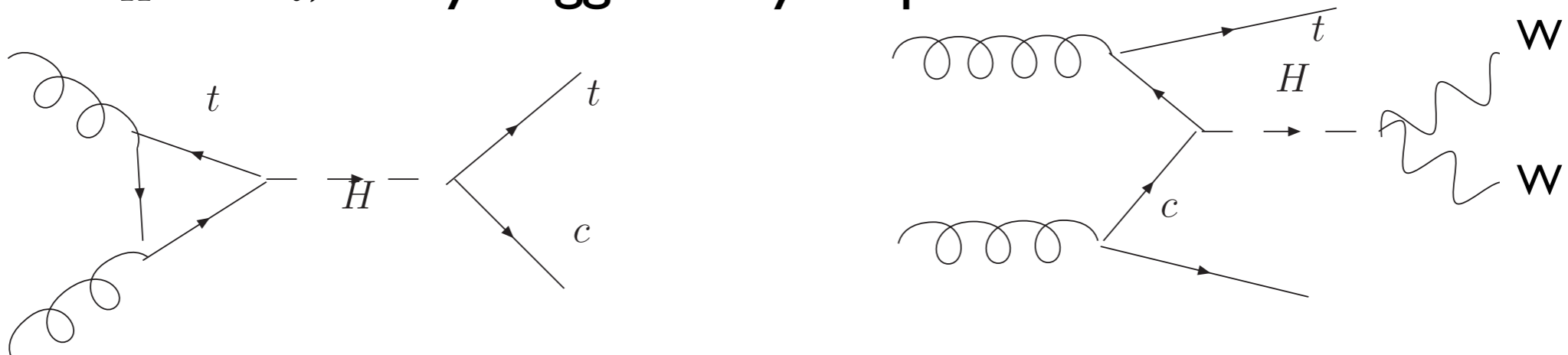
RPV Decays of Light Gluino @ Tevatron

Gavin Salam
Are Raklev
Jay Wacker

It is a neat little investigation of light gluinos at the Tevatron using jet-substructure. The gluino resonances, although having a huge pair-production cross section of hundreds, if not thousands, of picobarn, would be mostly invisible if decaying through RPV UDD operator to multiple soft jets.

We look at the small fraction of gluinos in the high pT tail of production and the substructure of their collimated jets. By using apropriate cuts on the substructure the gluinos can be seen as a bump on the jet mass distribution (red), where the background is QCD di-jets (black).

RPV gluino decays at the Tevatron

Light gluino decaying to three quarks migh have been missed at the Tevatron depite huge cross section.

$m_{\tilde{g}} = 70$ GeV

$\lambda''_{223} = 0.001$

$\tilde{g} \rightarrow qqq$
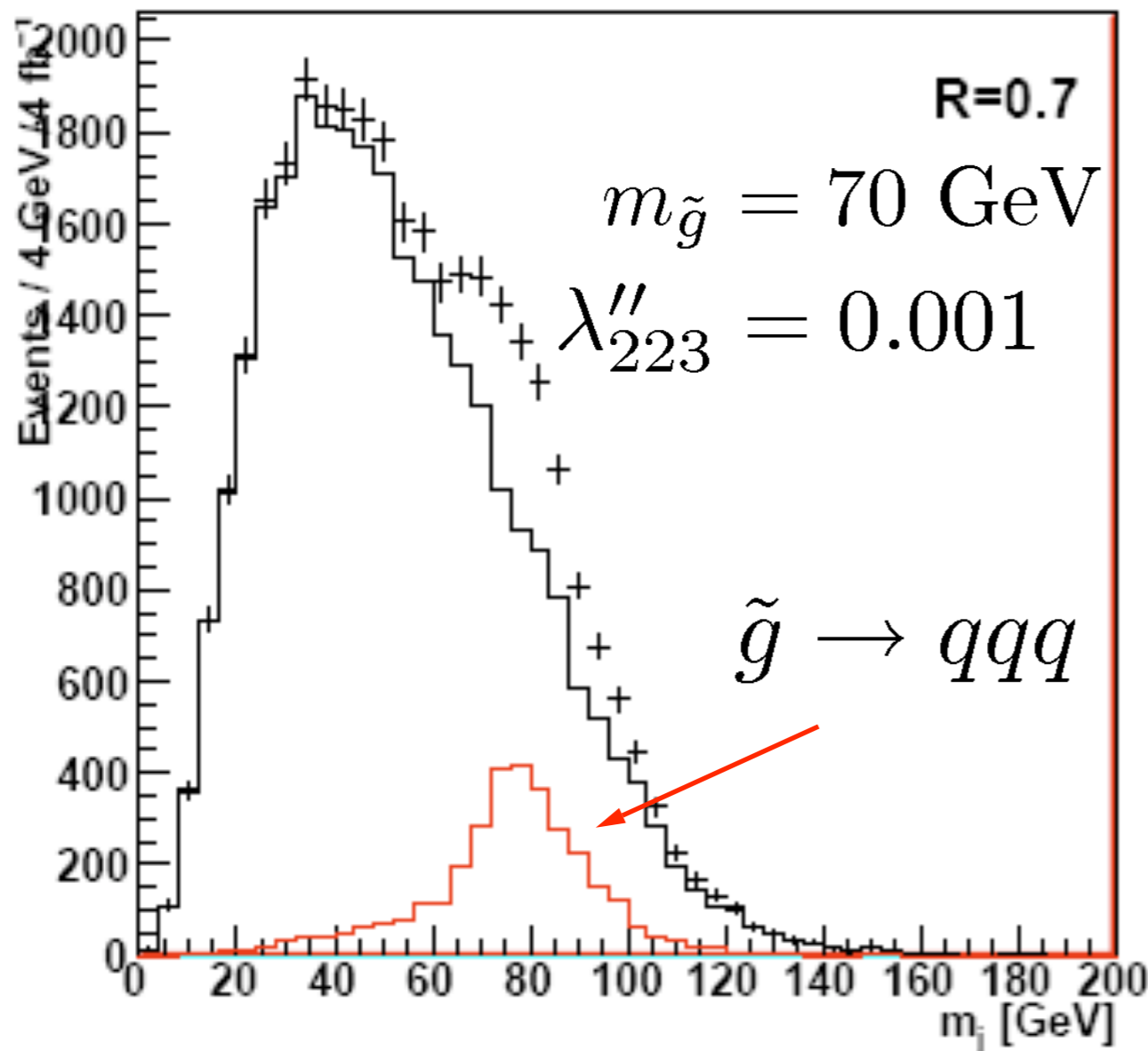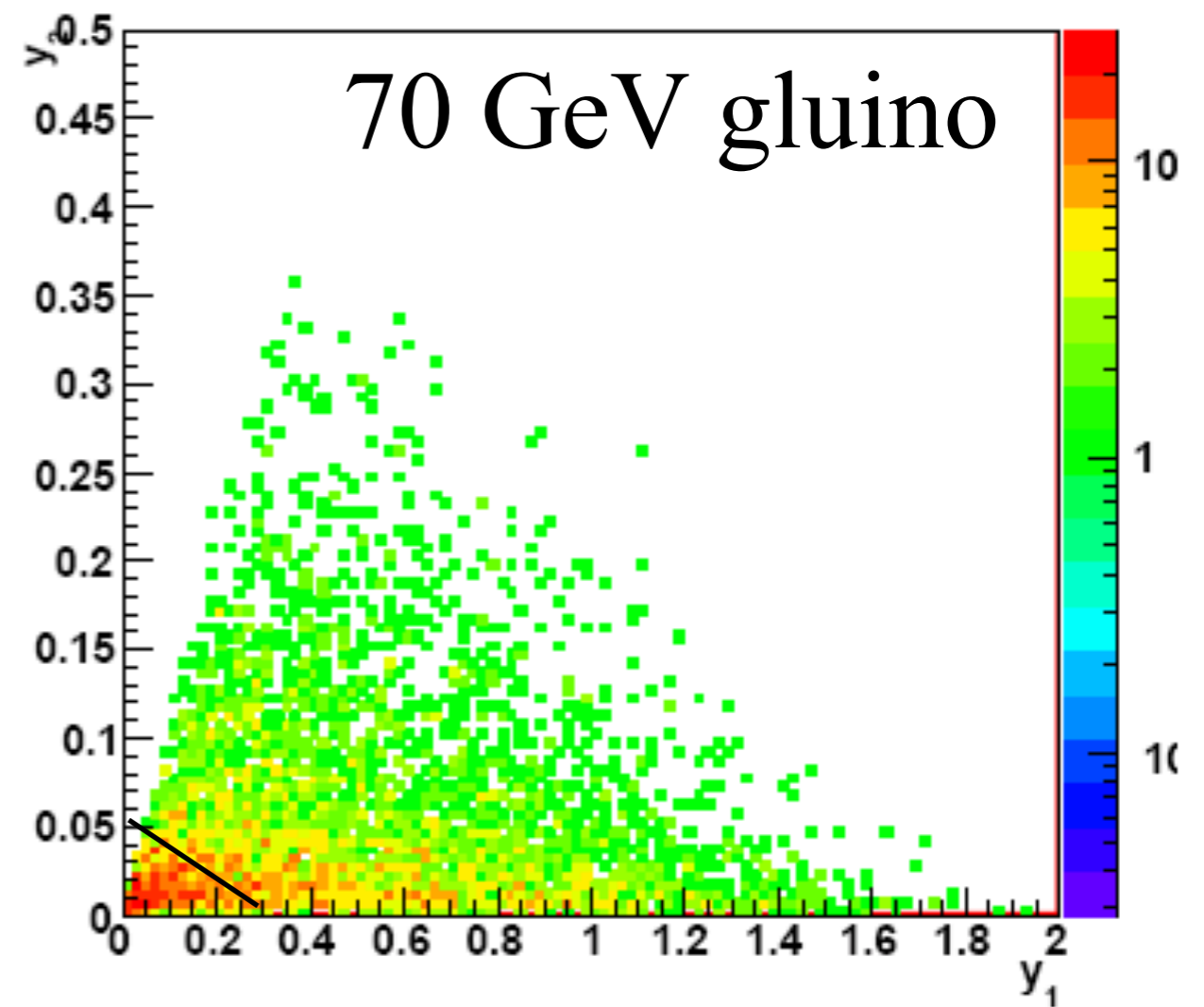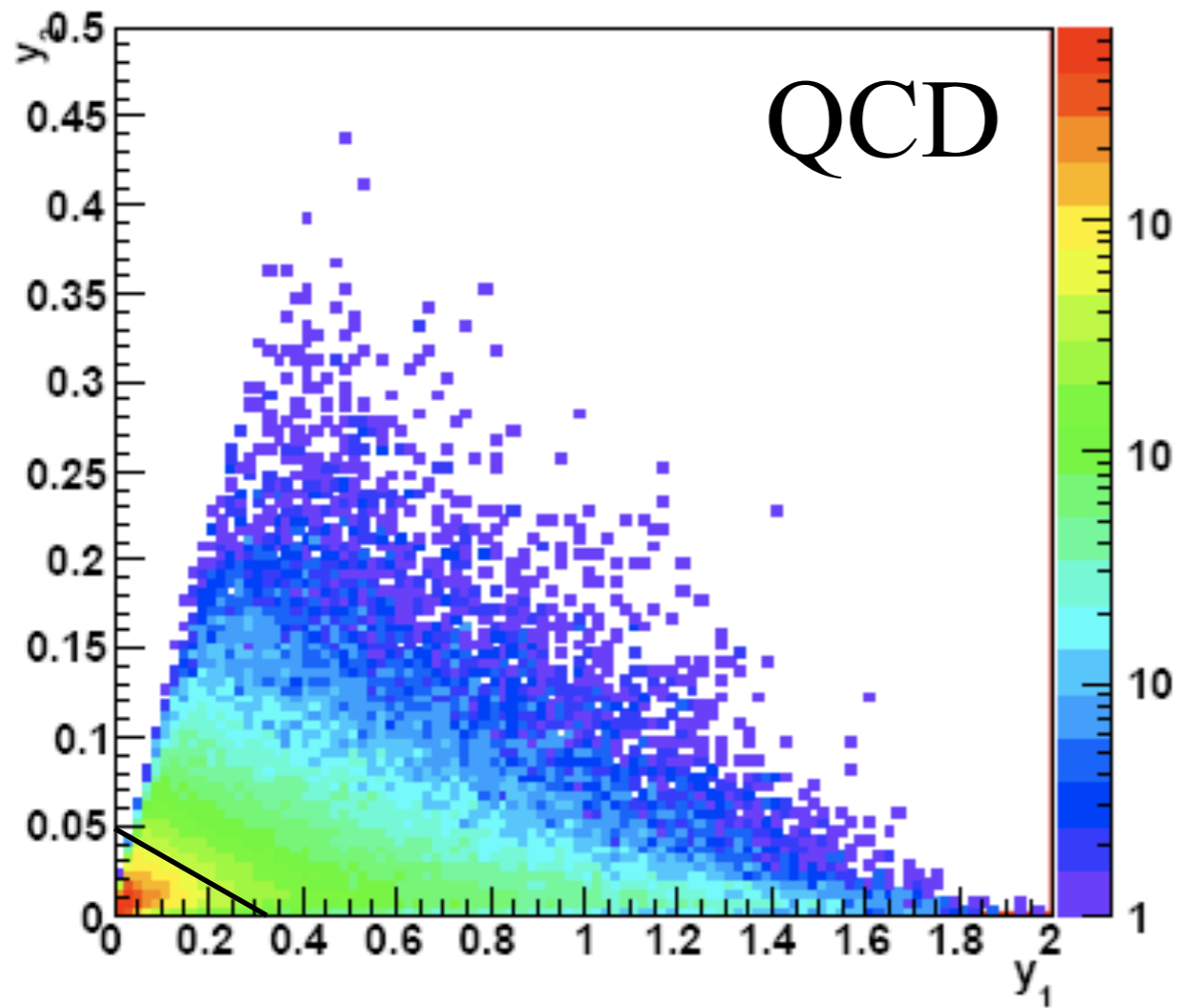
Use k_T-alg. requiring two jets $p_T > 250, 200$ GeV with cut on substructure parameter d_{kl} in first two jet mergings, where

$$d_{kl} = \frac{\min\left(p_{Tk}^2, p_{Tl}^2\right)}{m_j^2} \Delta R_{kl}^2$$

Clear signal excess when requiring $d_2 > -0.17\, d_1 + 0.05$.

HEP-Colloquium Oslo
15 May 2009   (J)et-algorithms and
New Physics at the LHC   /16

Backup

Non-standard Higgs Decays

Paddy Fox
Adam Martin
Conor Henderson

We are in discussions about features of such models at colliders and are trying to construct a few benchmark points for serious collider studies

Not a summary... informal status report

Don't forget proceedings!

(we won't let you)

Thanks for making this the best
Les Houches I have ever been to!