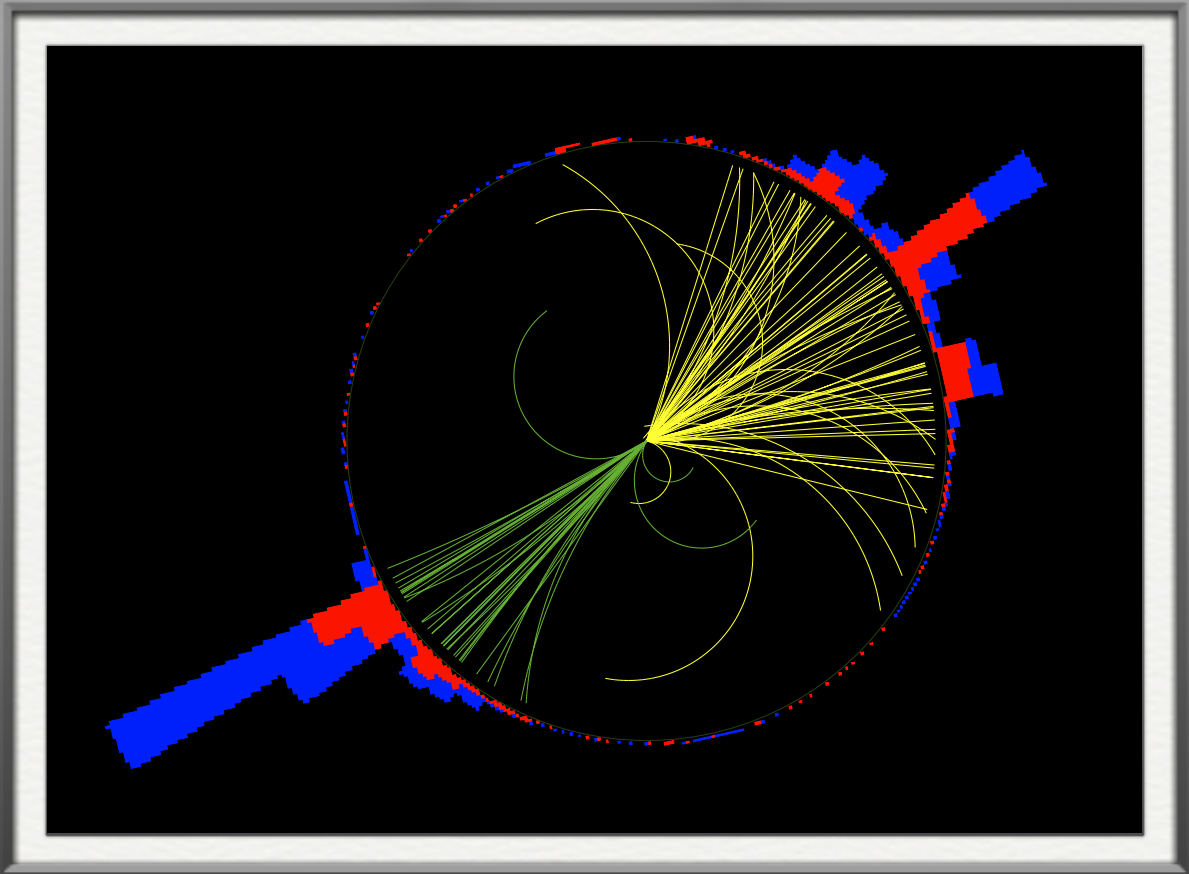
CMS : Searches for SUSY & New Physics using Heavy Flavour

Fermilab
UIC University of Illinois at Chicago



Richard Cavanaugh, Fermilab / UIC

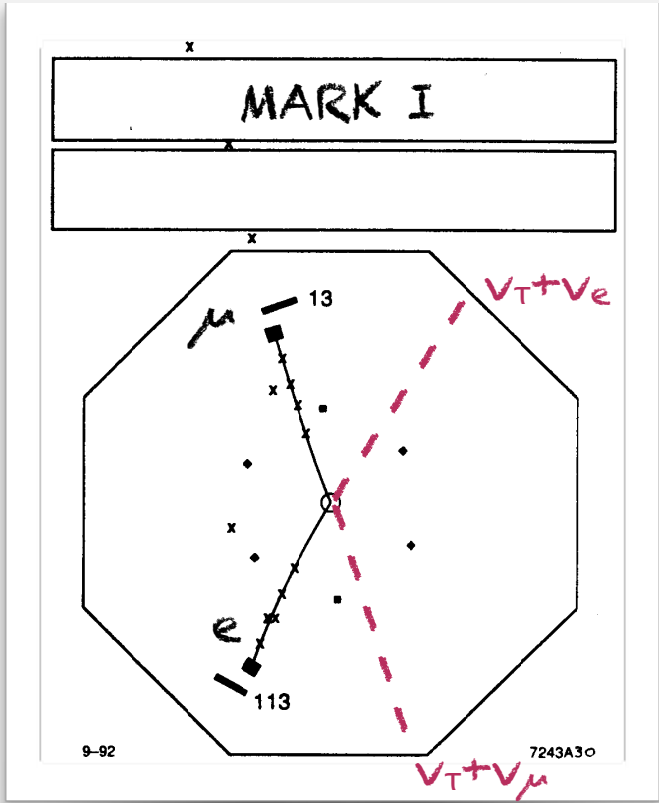
Chicago 2012 Workshop
02 May, 2012

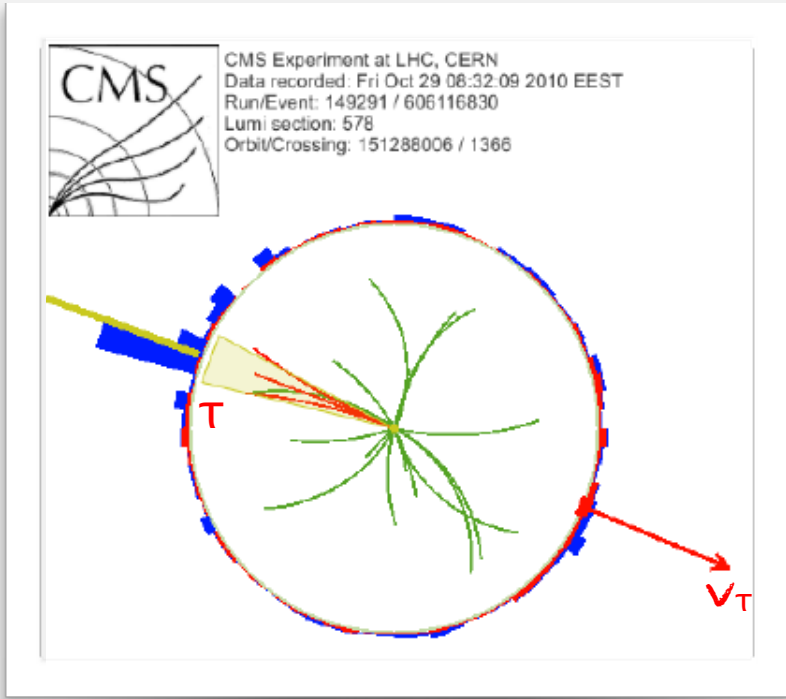
LPC LHC Physics Center

New Physics & Heavy Flavour

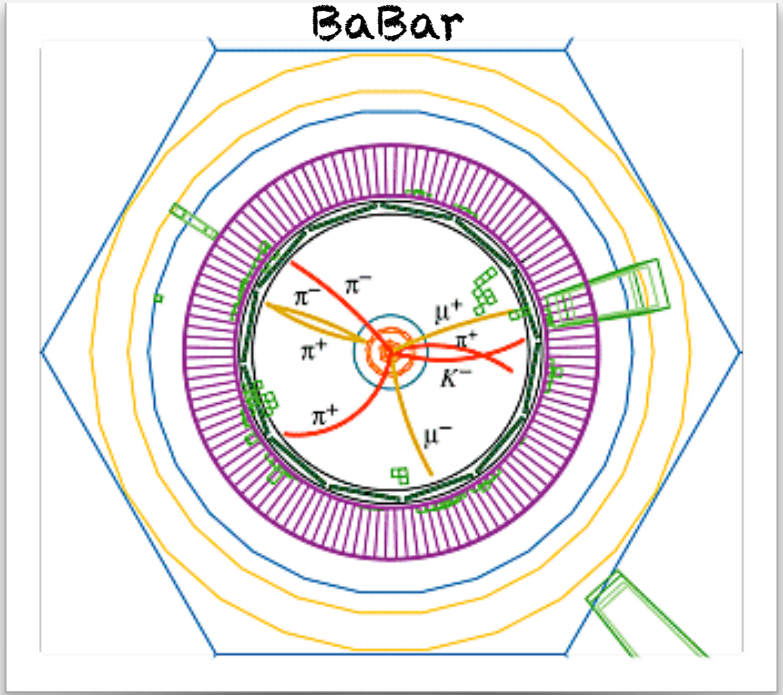
- We do not understand Flavour in the Standard Model!
  - Perhaps most perplexing conundrum of all
  - It's why we built all of the b-factories!
- Flavour intimately tied with EWSB through Yukawas
  - defines a special role for heavy flavour!
- Supersymmetry and EWSB seem to be related
  - at least via the hierarchy problem
    - limits Heavy Flavour sparticle masses
  - perhaps also through RGEs
- Other Reasons to search for New Physics with Heavy Flavour
  - Number of generations? Is there a Heavy 4th?
- Lot of interest in Searches for New Physics using Heavy Flavour

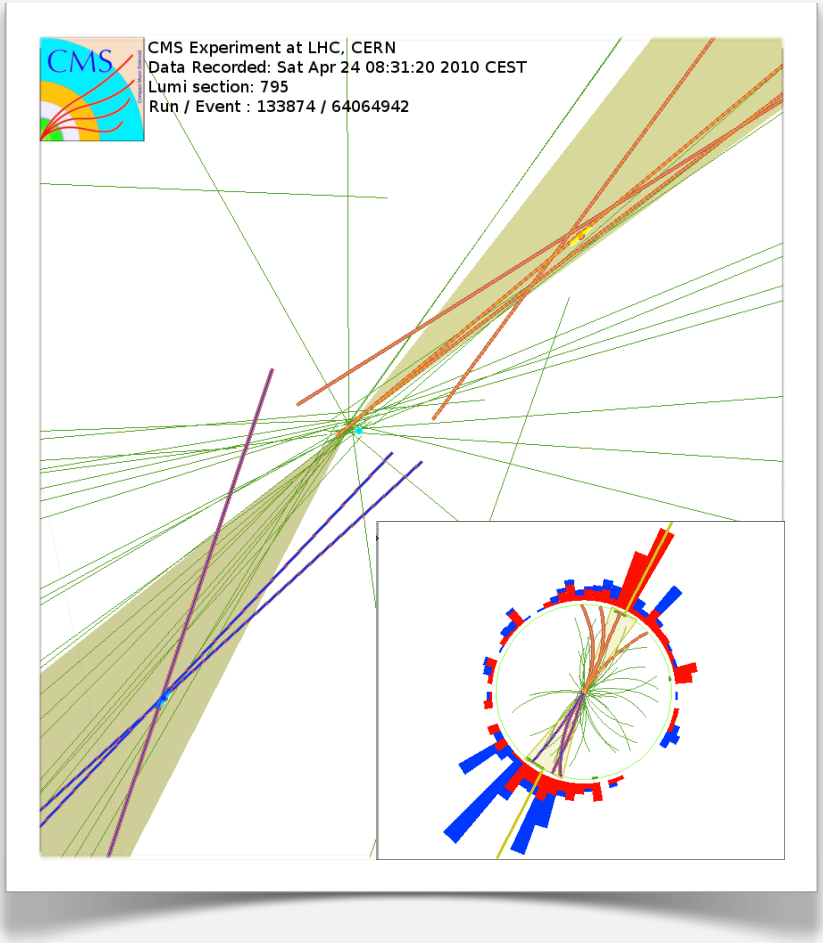
From tau's to tau-jets



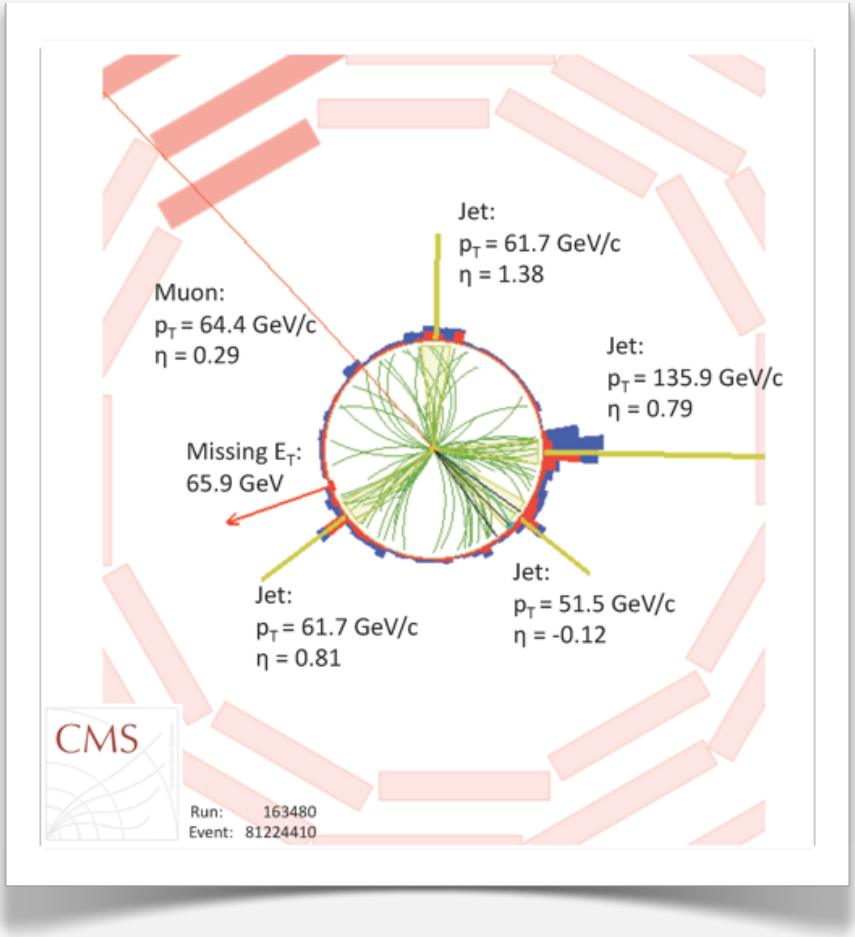


From b's to b-jets





From tops to…


Jet:
p_T = 61.7 GeV/c
η = 1.38
Muon:
p_T = 64.4 GeV/c
η = 0.29
Jet:
p_T = 135.9 GeV/c
η = 0.79
Missing E_T:
65.9 GeV
Jet:
p_T = 61.7 GeV/c
η = 0.81
Jet:
p_T = 51.5 GeV/c
η = -0.12
CMS
Run: 163480
Event: 81224410

...to top-jets

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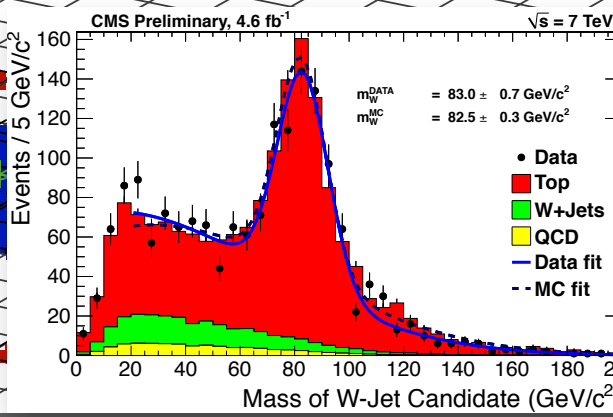
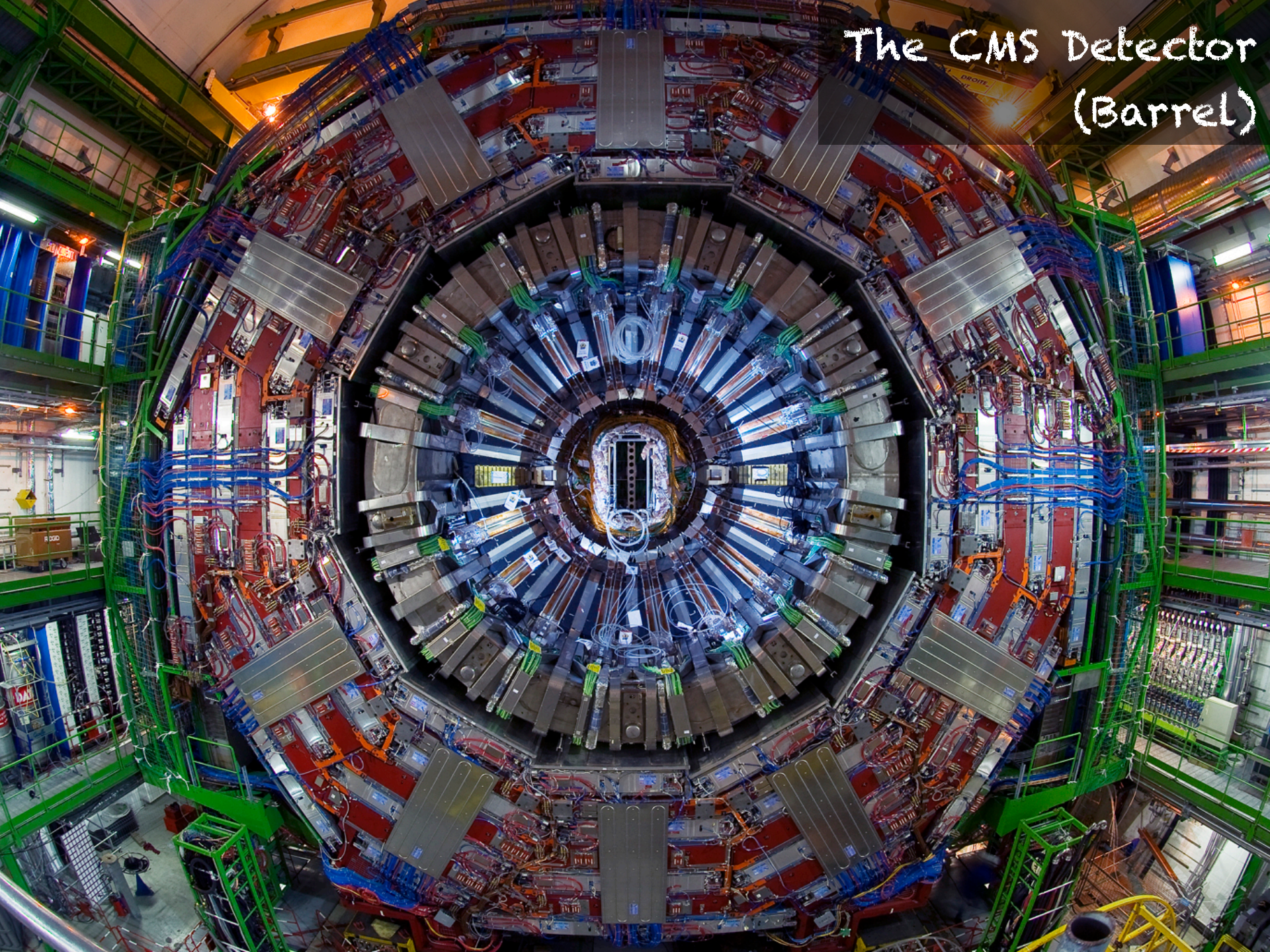
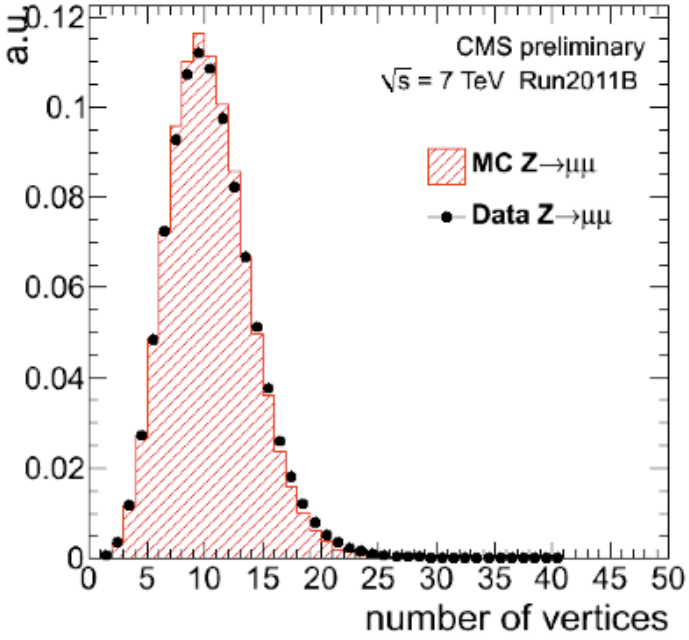
EXO-11-006

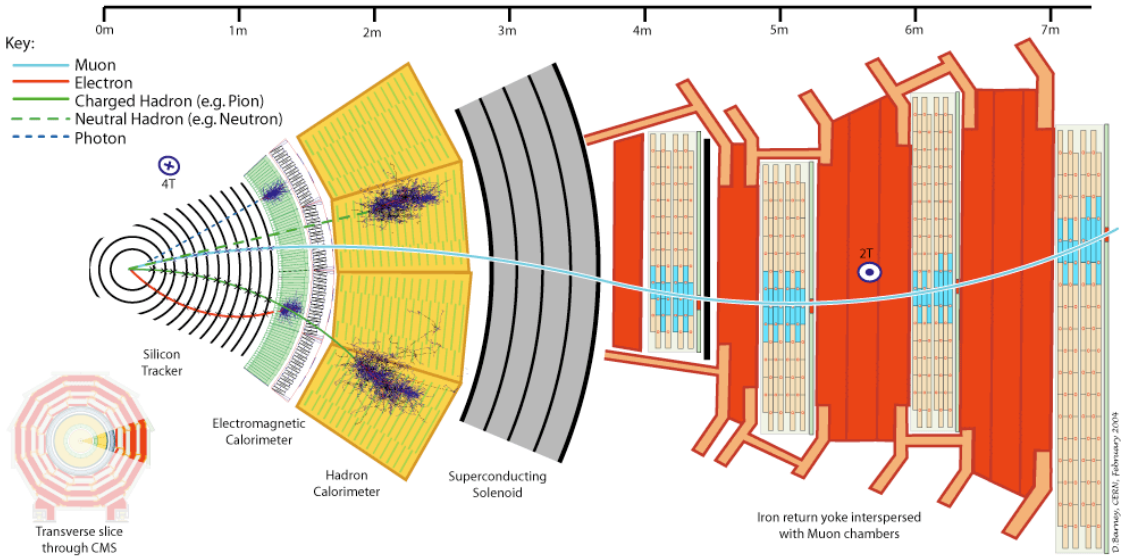


See Sal Rappacio's talk!


The CMS Detector
(Barrel)

Datasets and Reconstruction

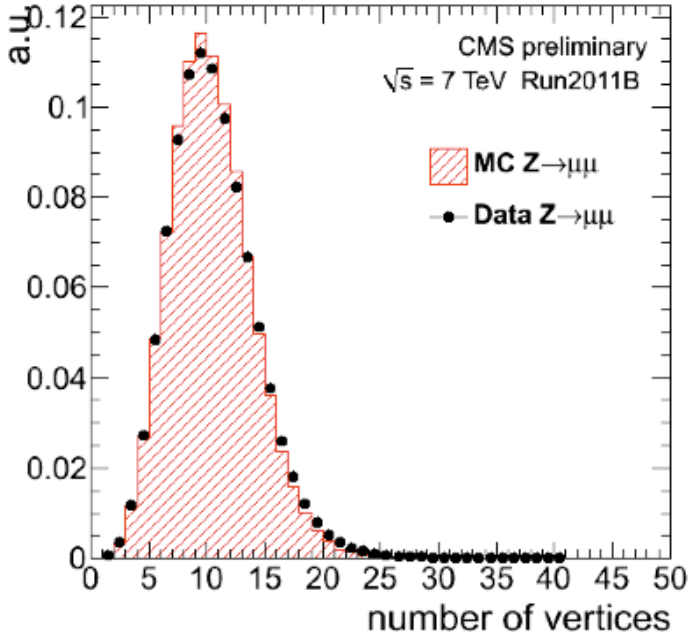


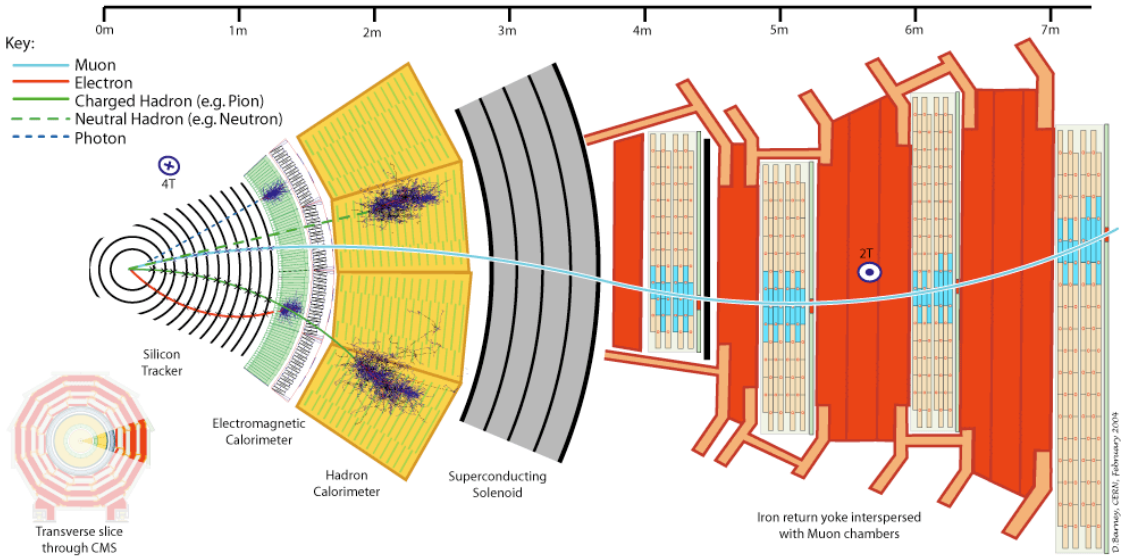


Datasets and Reconstruction

Excellent Performance

- More than 5 fb^{-1} data collected @ 7 TeV
- Peak lumi 3.5×10^{33} $cm^{-2}s^{-1}$
- Data taking efficiency: 90%
- Data certified for analysis: 90%
- Mean pileup: 10





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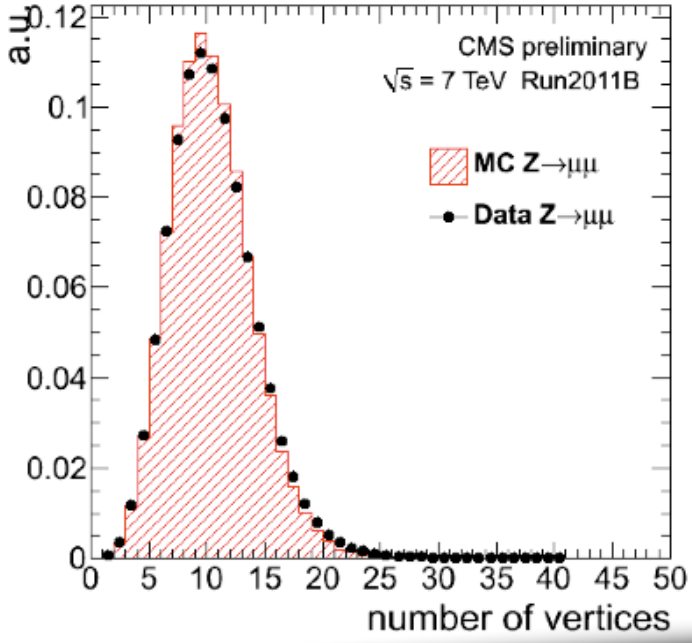
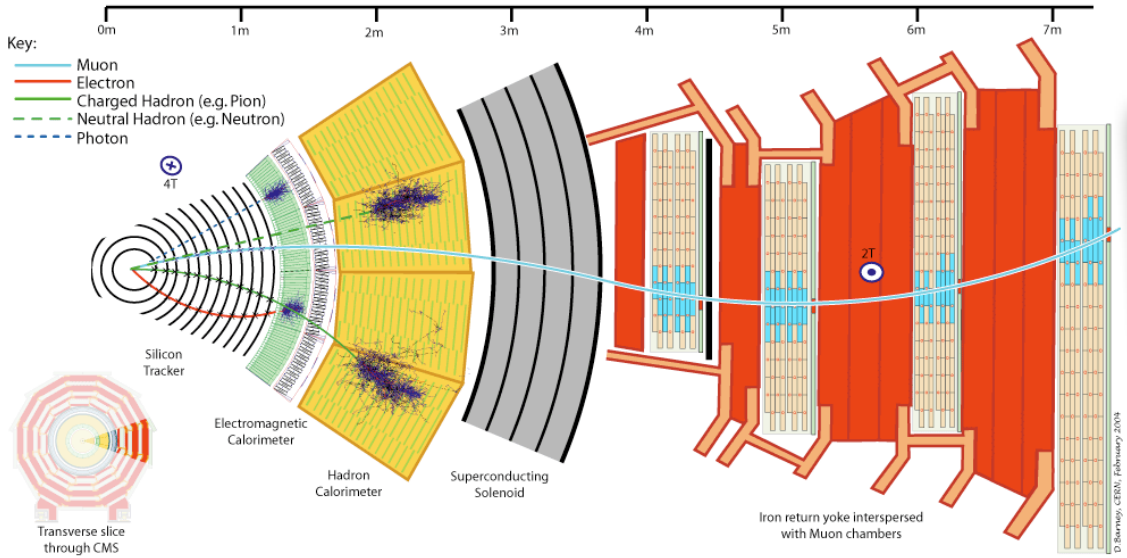




Particle Flow in CMS

- Aim to reco. EVERY particle in event
- Exploit detector redundancy, whilst avoiding double counting
- Provides global event description
  - via list of individual particles
- Huge improvements to τ, jets, & MET
- Improvements to isolation, PU subt.

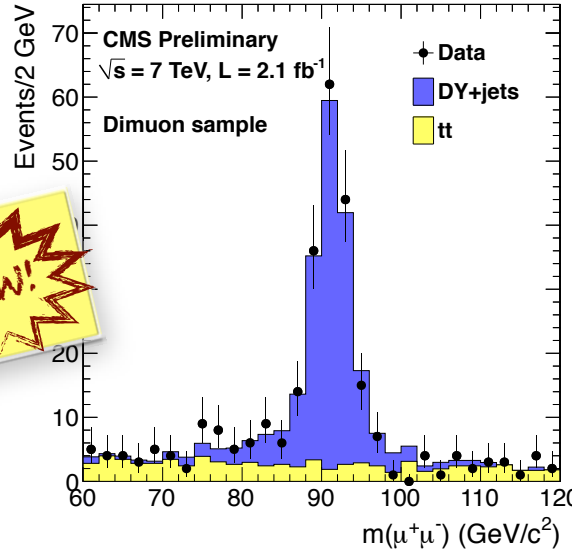
Ex: b-tag performance with Z's

SMP-12-003

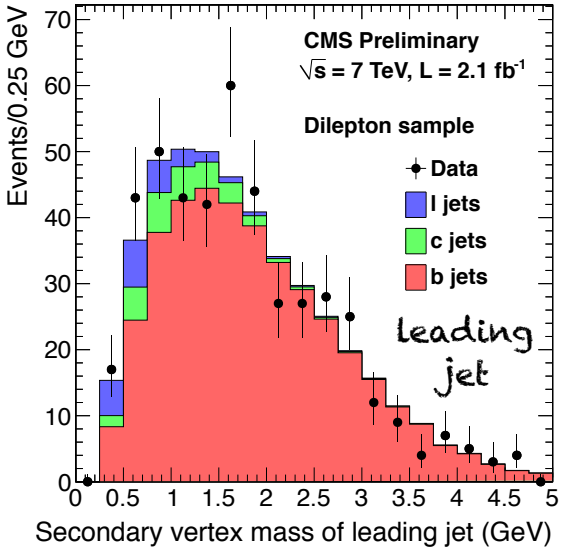
Z+bb

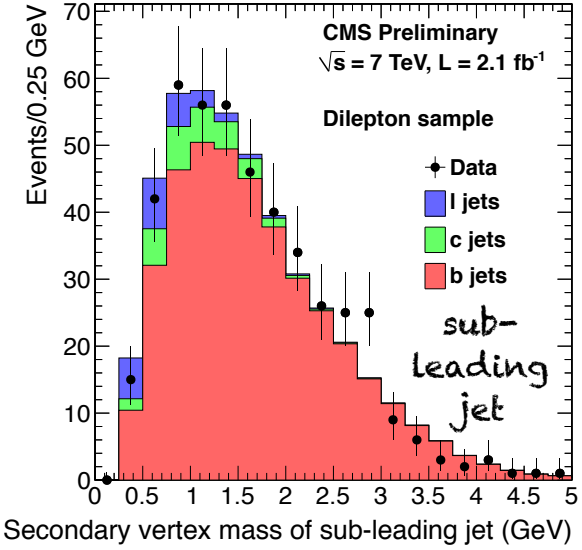
- Important QCD Measurement
- Benchmark channel (& bkg) for Higgs search
- Simulation: ME+PS using MadGraph+Pythia
- Data unfolded to hadron-level

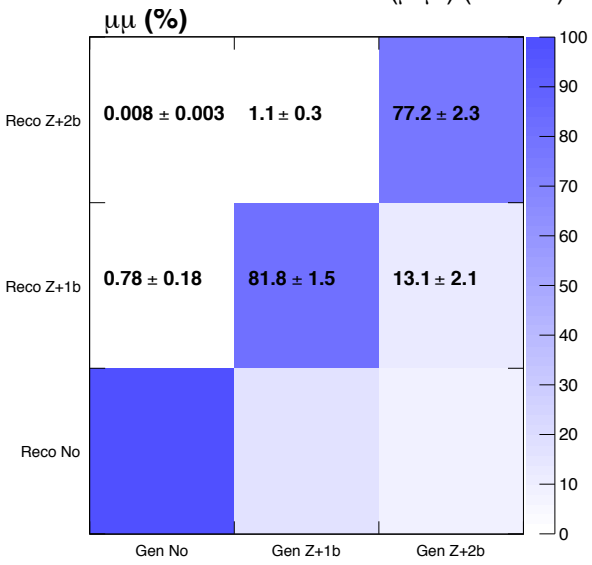
NEW!



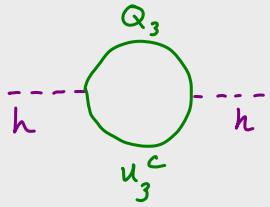
Multiplicity bin	ee	$\mu\mu$
σ_{hadron}(Z+1b,Z→ $\ell\ell$)(pb)	$3.25 \pm 0.08 \pm 0.29 \pm 0.06$	$3.47 \pm 0.06 \pm 0.27 \pm 0.11$
σ_{hadron}(Z+2b,Z→ $\ell\ell$)(pb)	$0.39 \pm 0.04 \pm 0.07 \pm 0.02$	$0.36 \pm 0.03 \pm 0.07 \pm 0.03$
σ_{hadron}(Z+b,Z→ $\ell\ell$)(pb)	$3.64 \pm 0.09 \pm 0.35 \pm 0.08$	$3.83 \pm 0.07 \pm 0.31 \pm 0.14$







Hierarchy Problem



$$\delta m_h^2 \sim \frac{3\lambda_t^2}{8\pi^2} \Lambda_{UV}^2 \sim (.3\Lambda_{UV})^2$$

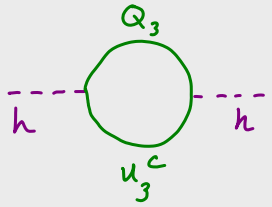
N_c

→ For $m_h \sim 120$ GeV, need new colored "top partners" beneath ~ 400 GeV.

Nima Arkni-Hamid
Implications of LHC Workshop
31 October, CERN

Also R. Barbieri, A. Weiler, etc, etc

Hierarchy Problem



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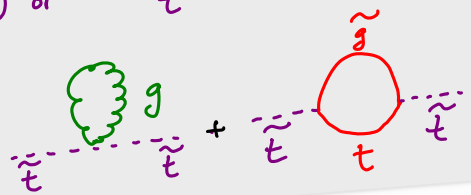
Also need Gluino

For $m_{\tilde{t}} \lesssim 400$ GeV to be natural:



$M_{\tilde{g}} \lesssim 1.5$ TeV

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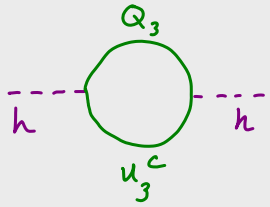

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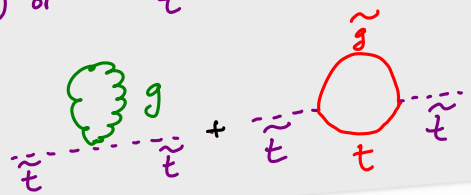

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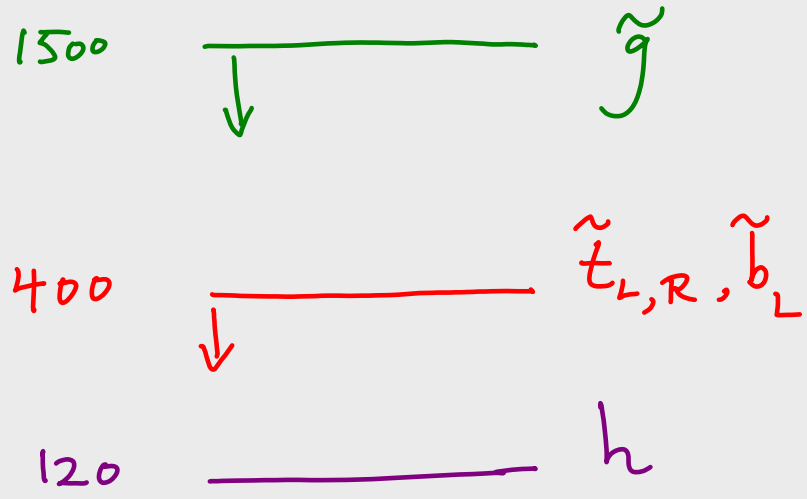
Cumpulsory Natural SUSY



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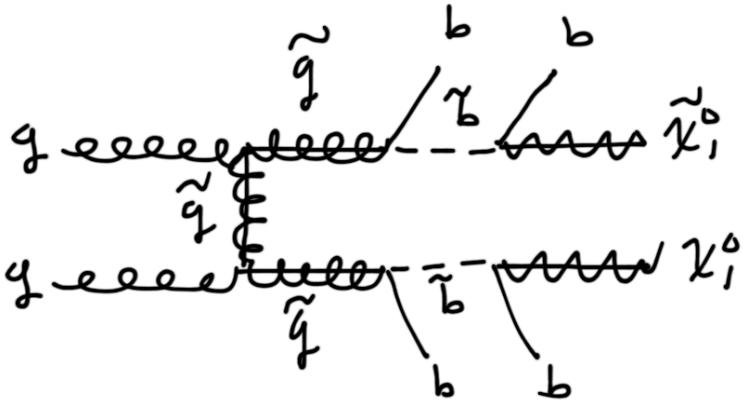
MET and b-jets



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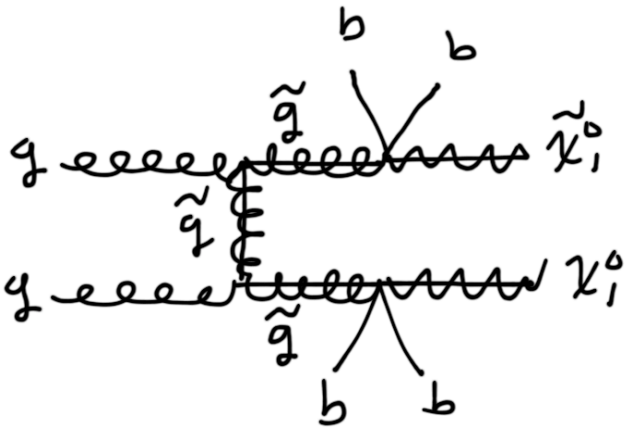

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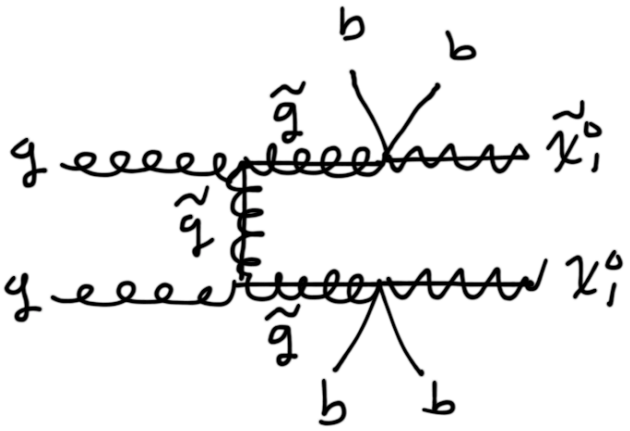

Strategy

- Cut-and-count
- Four Signal Regions defined for ≥ N(b-tags), Loose vs tight in HT & MET
  - Loose: HT > 350 GeV, MET > 200 GeV
    - ≥ 1, ≥ 2 b-tags
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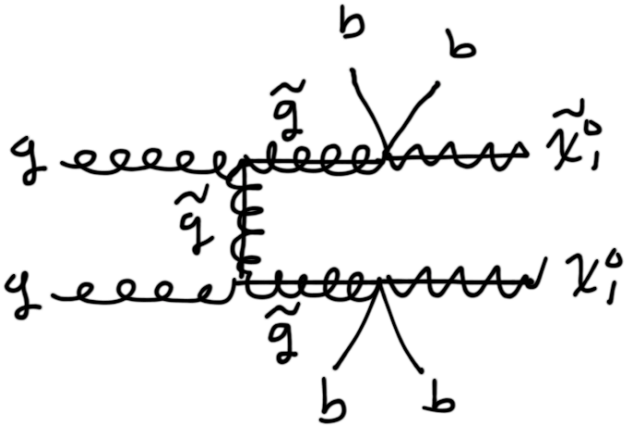
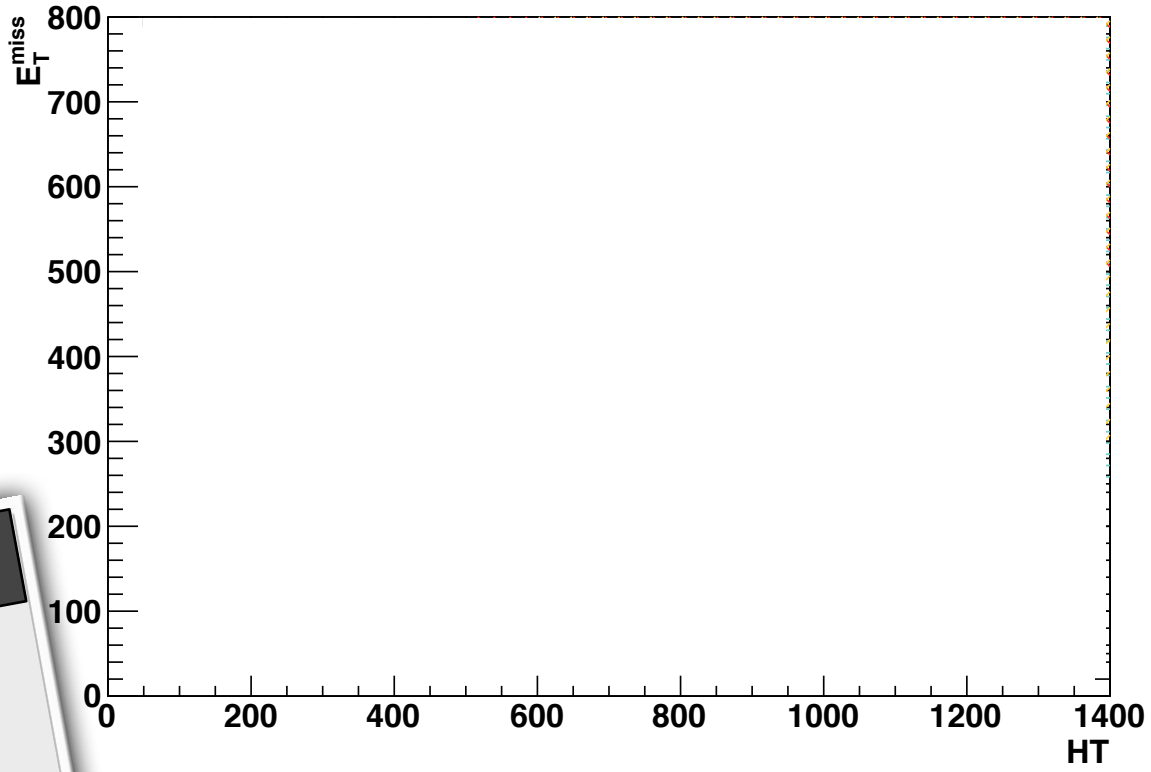
MET and b-jets





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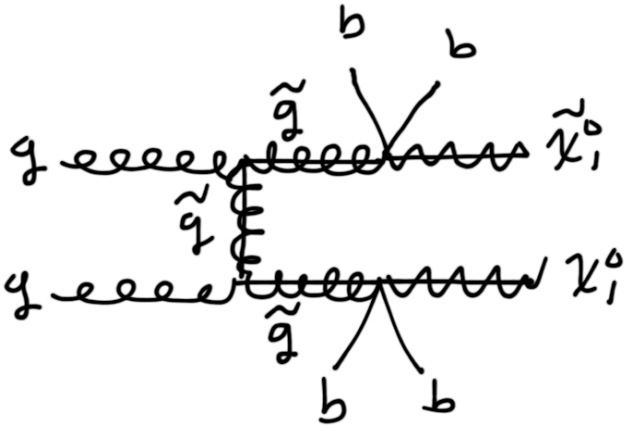

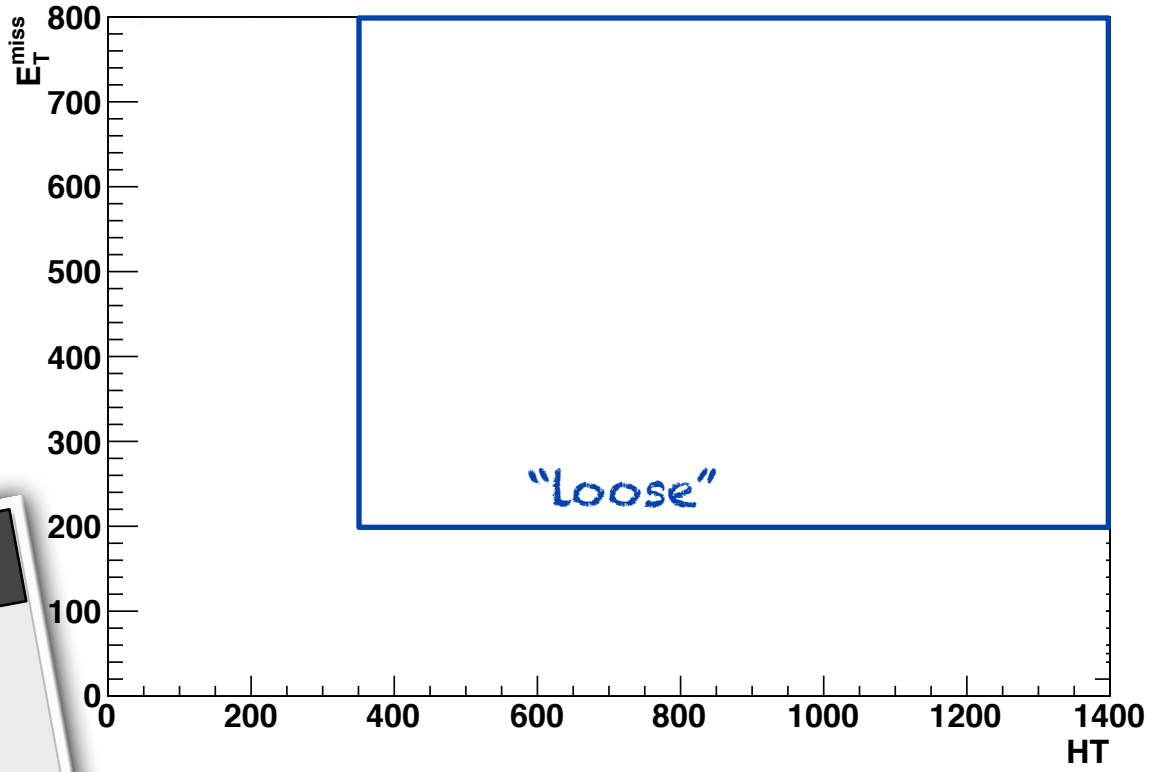

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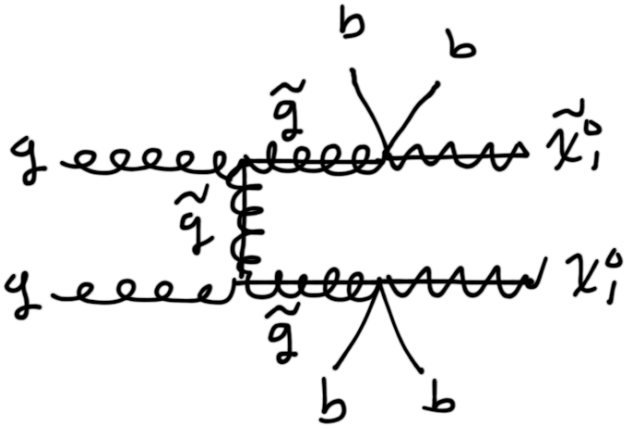

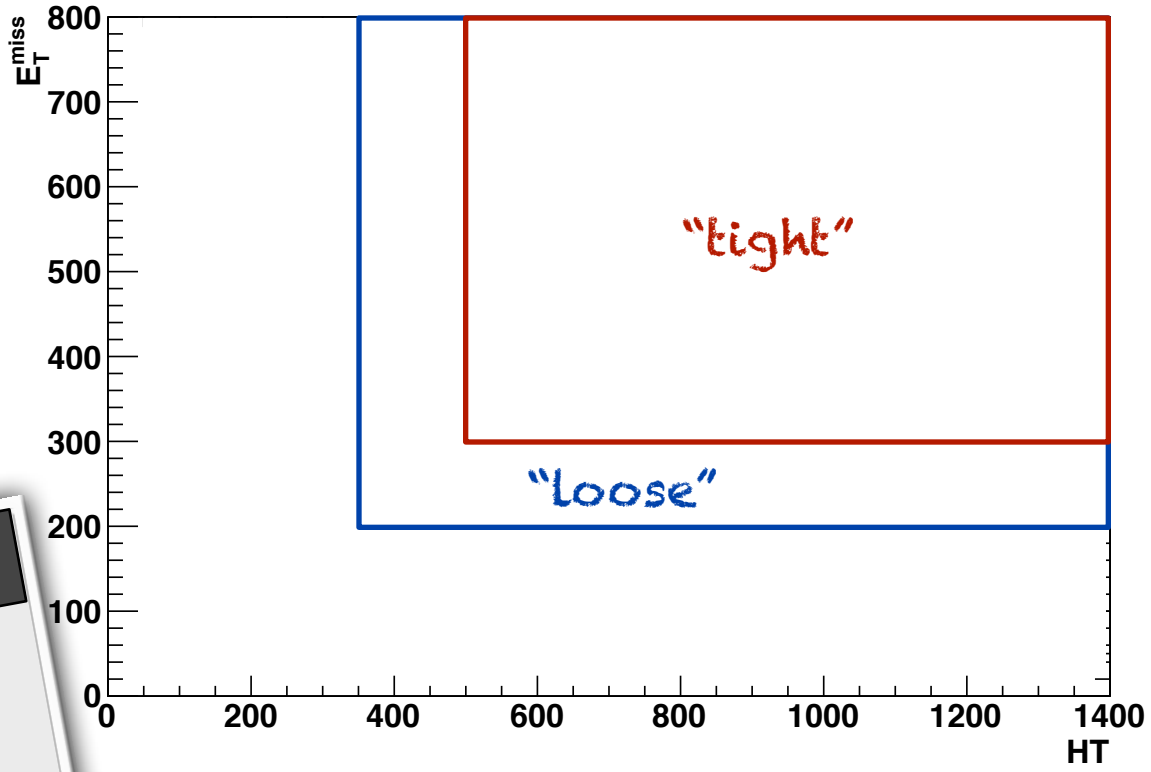

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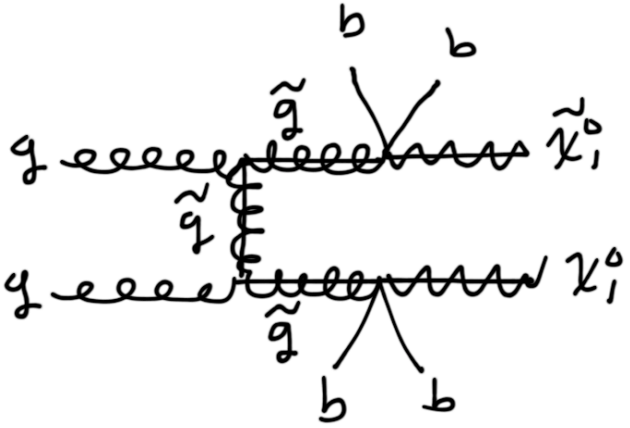

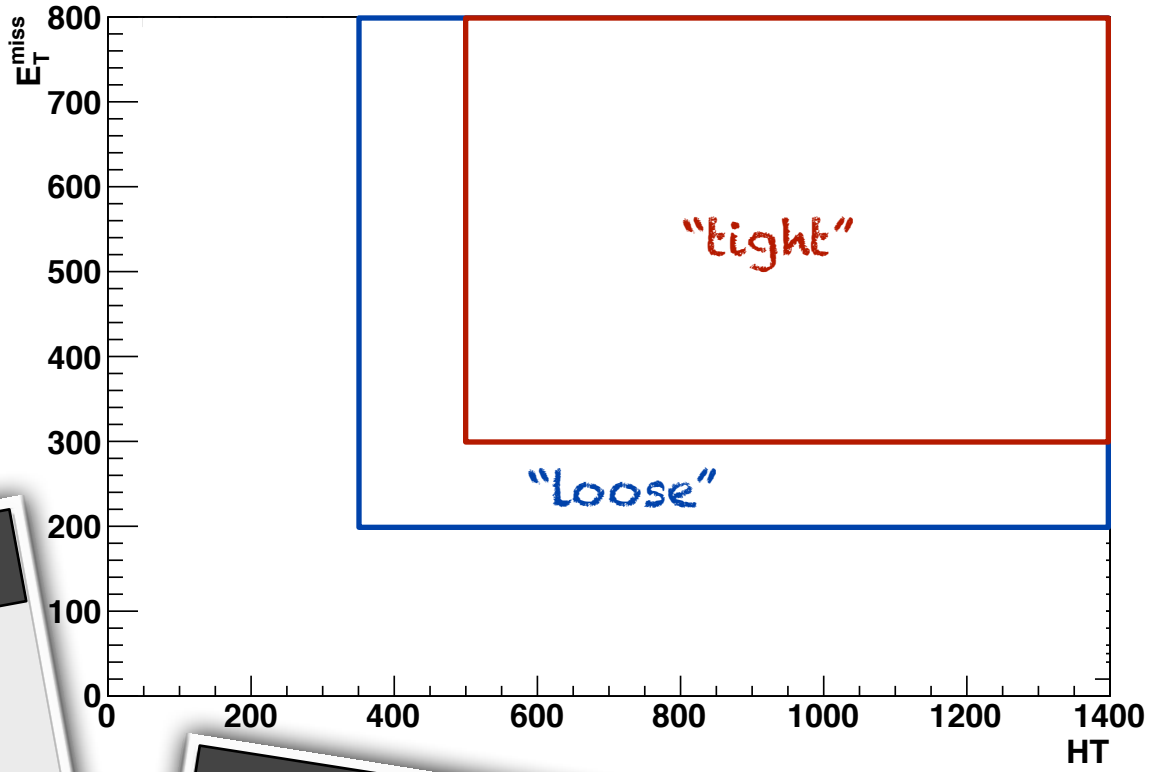

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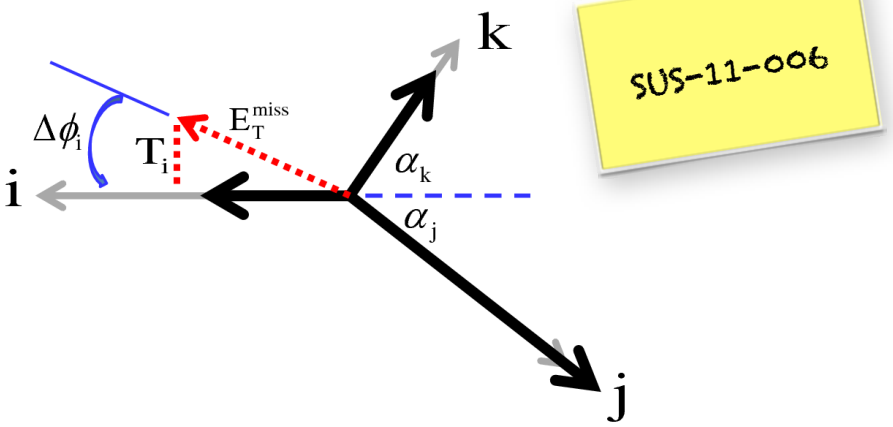
Strategy

- Data Driven
- Define Control Regions
- Apply "ABCD" Method
  - Need variable uncorrelated with MET

MET and b-jets



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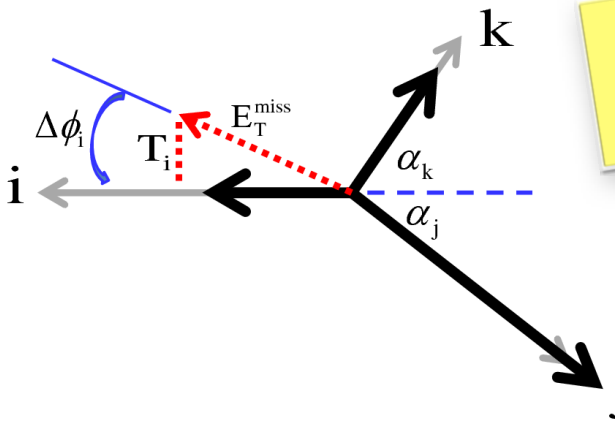

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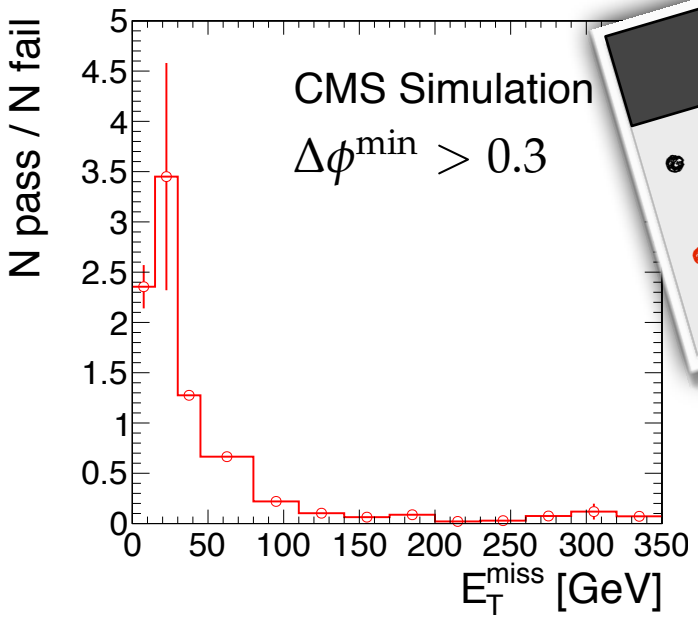
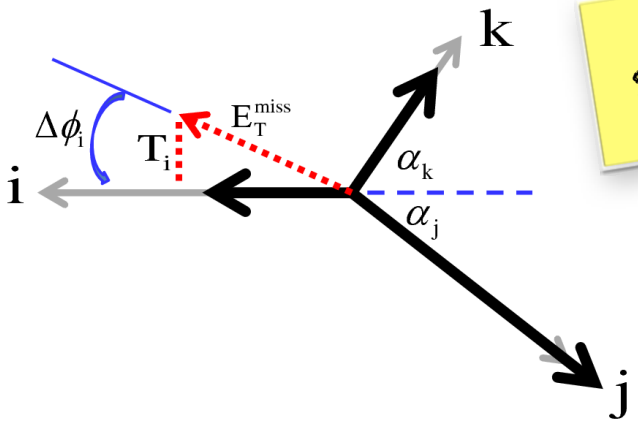


$\Delta\varphi_{min}$ variable

- Often used to identify fake MET due to instrumental sources
- Highly correlated with MET
- Not suitable for ABCD method!

MET and b-jets



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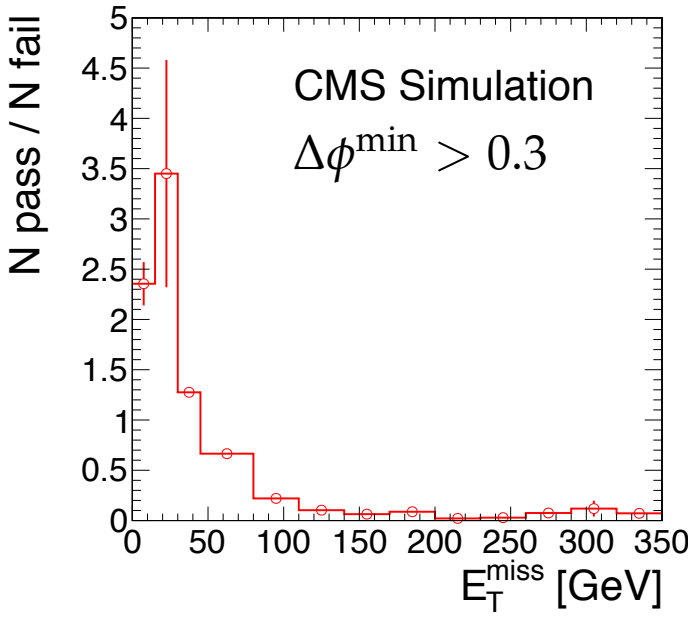
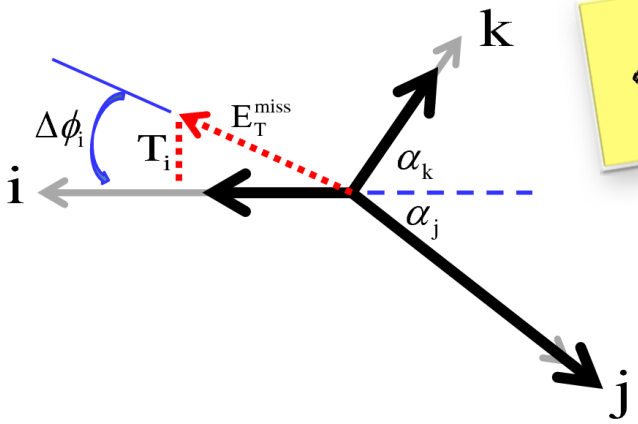


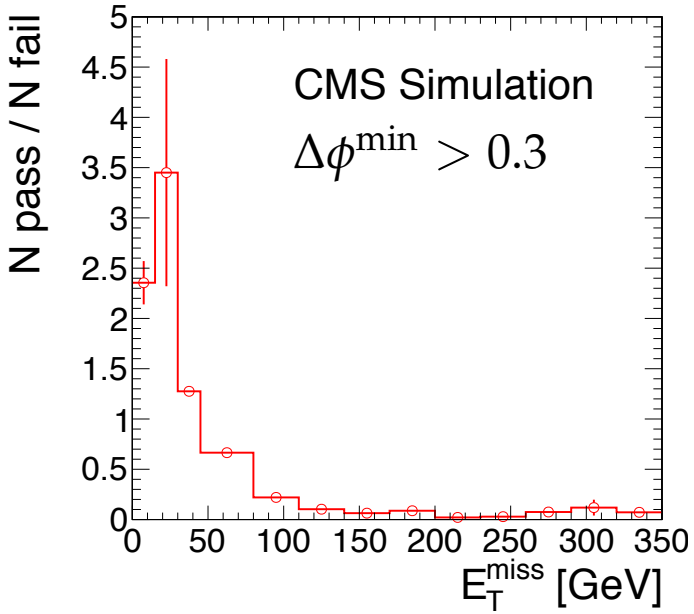
MET and b

SUS-11-006

$\Delta\varphi_N^{min}$ variable

- Normalise $\Delta\varphi$ by its resolution





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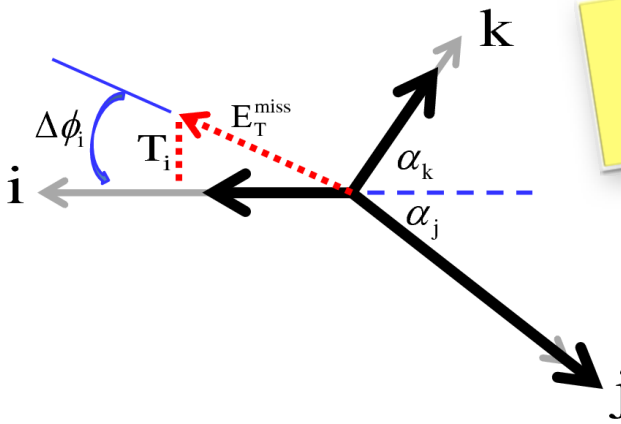

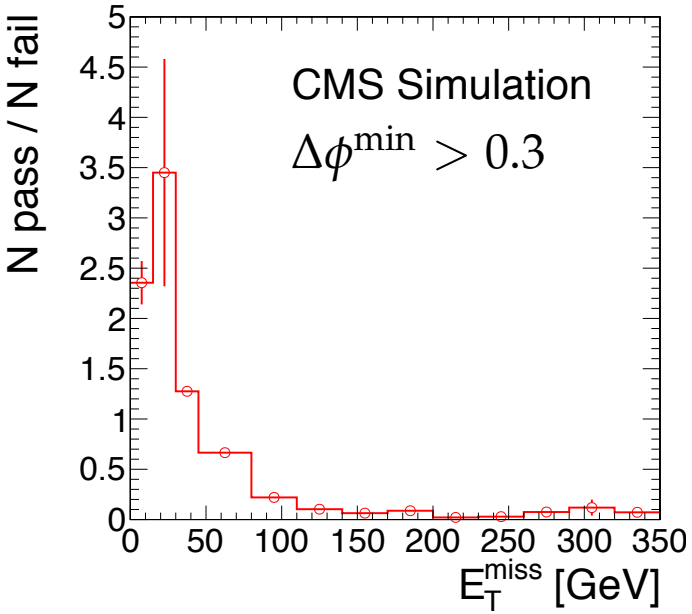

Consider $\sigma^2(E_\perp^j) = \sum_i^{i<n_{\text{jets}}} \left[\sigma(p_T^i)\sin(\Delta\phi_{ij})\right]^2$

MET and b

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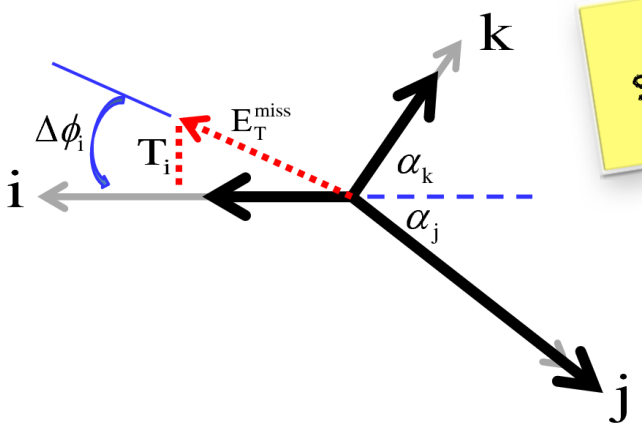

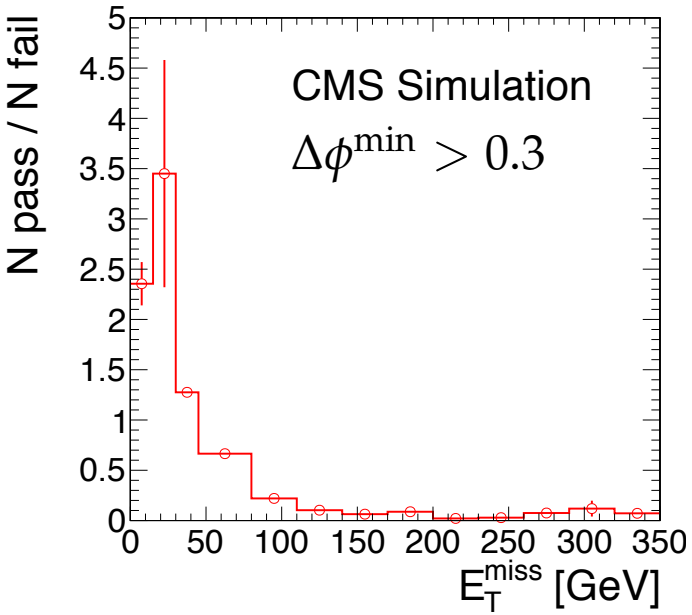

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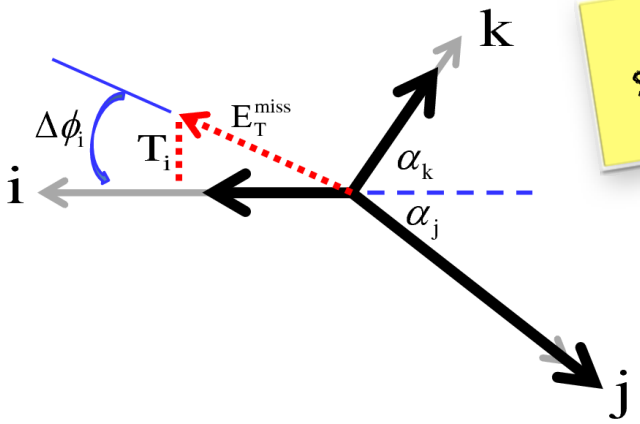
MET and b

SUS-11-006

$\Delta\varphi_N^{min}$ variable

- Normalise $\Delta\varphi$ by its resolution



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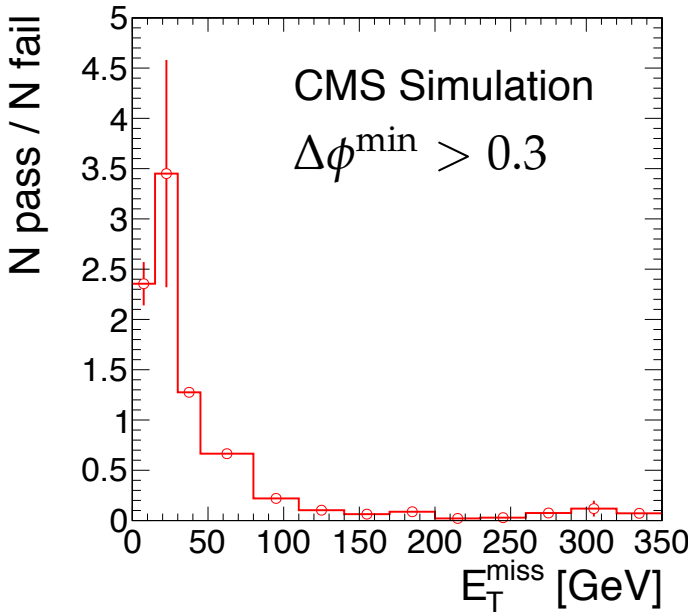

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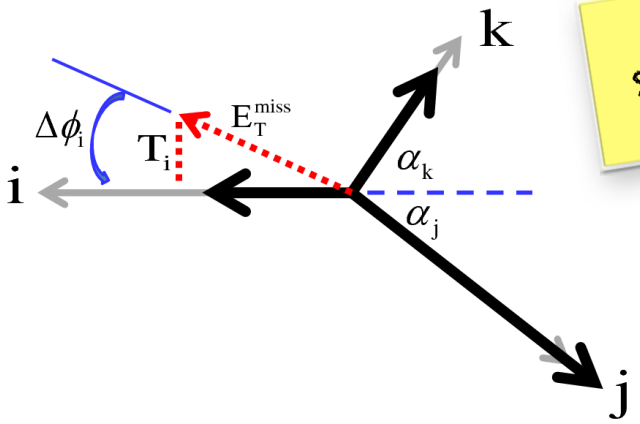

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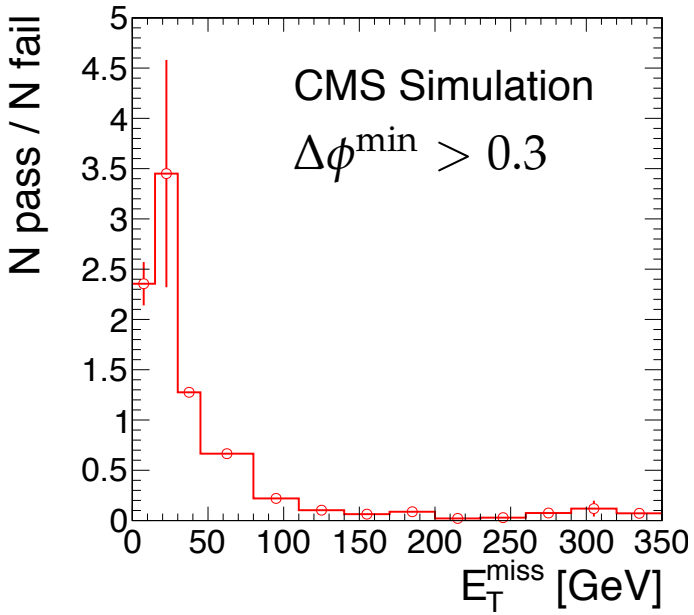

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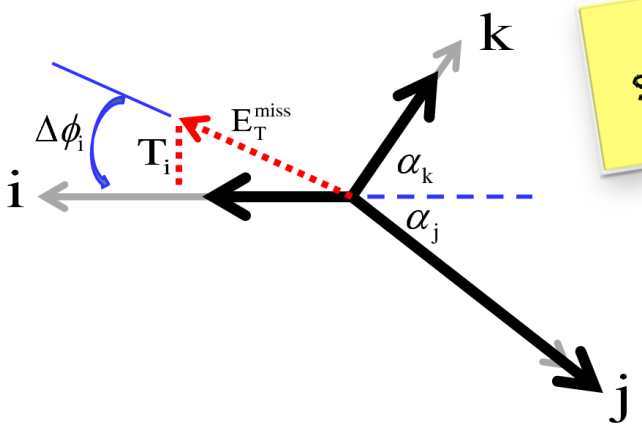

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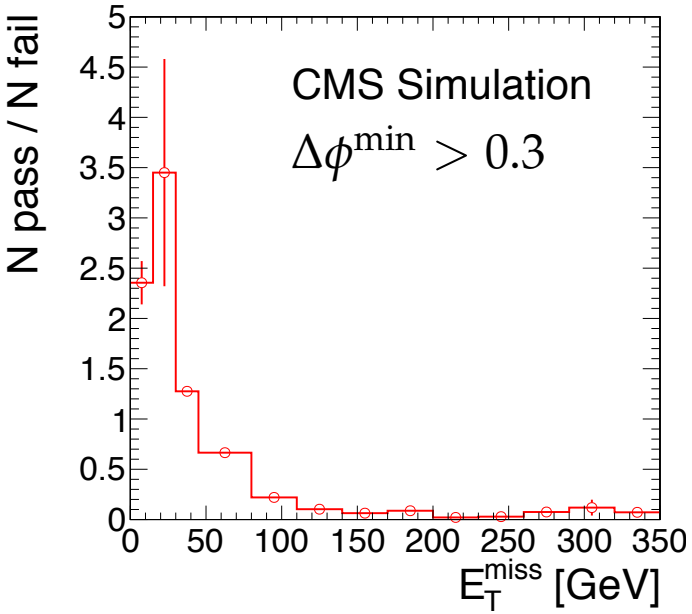

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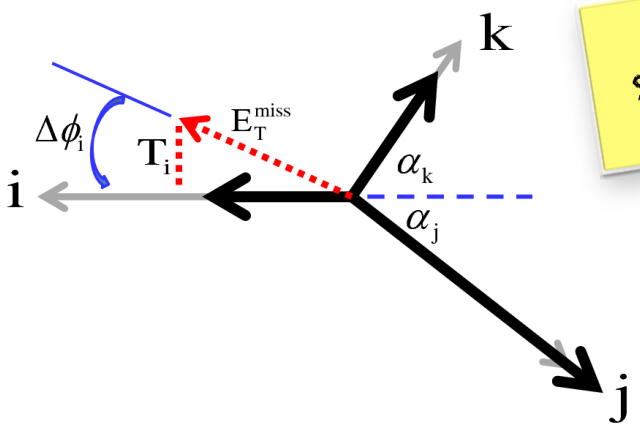

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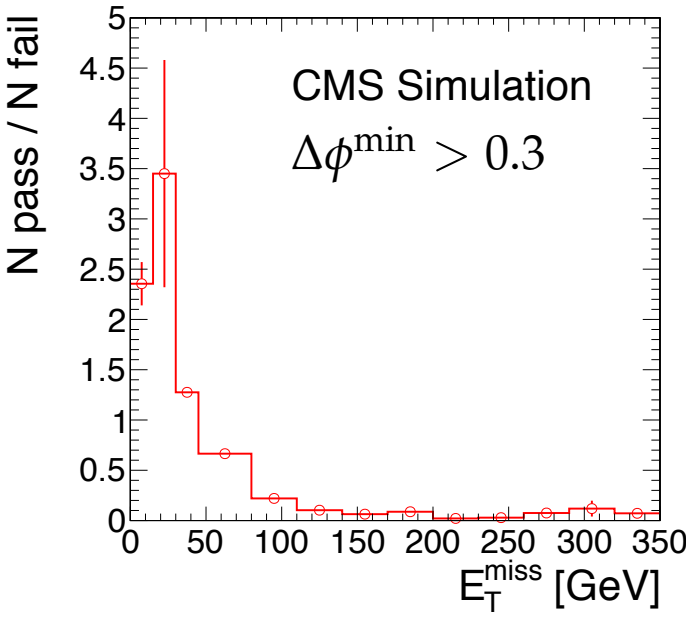

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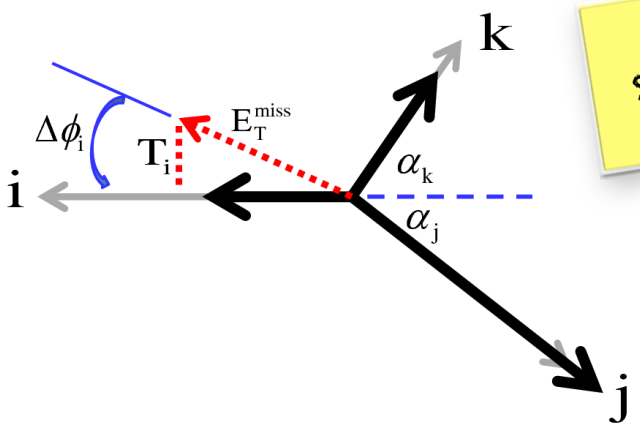

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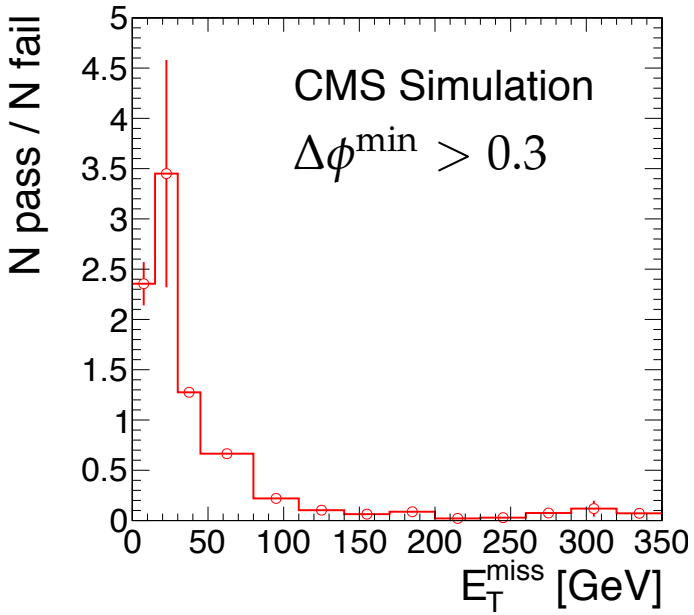

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MET and b

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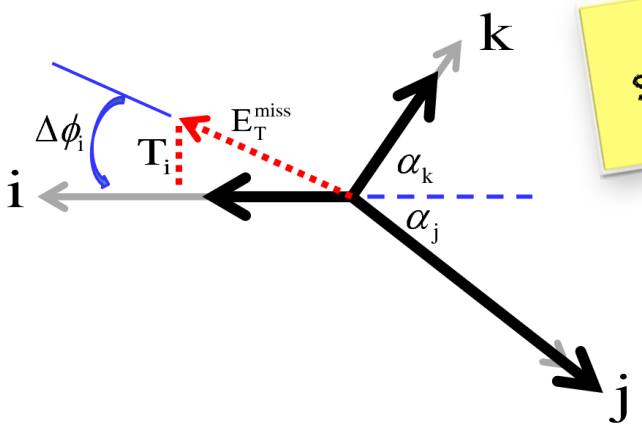

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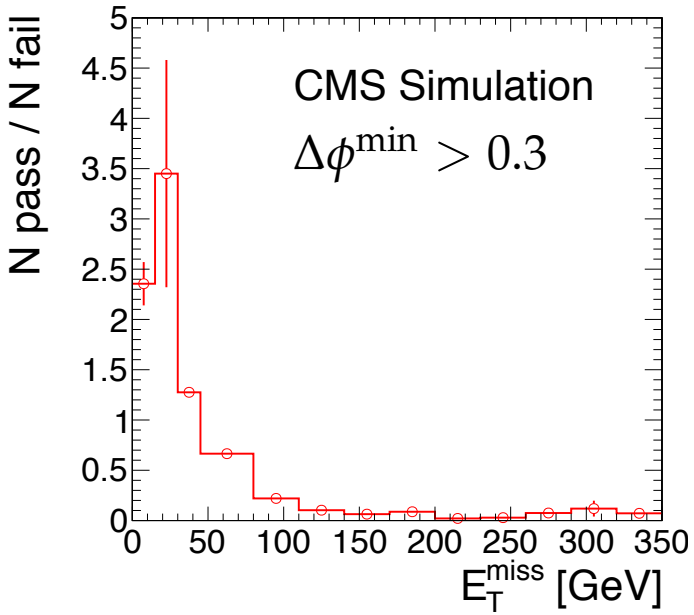

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MET and b

SUS-11-006

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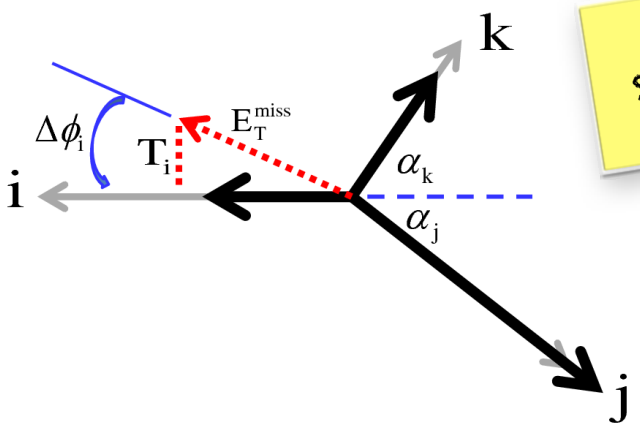

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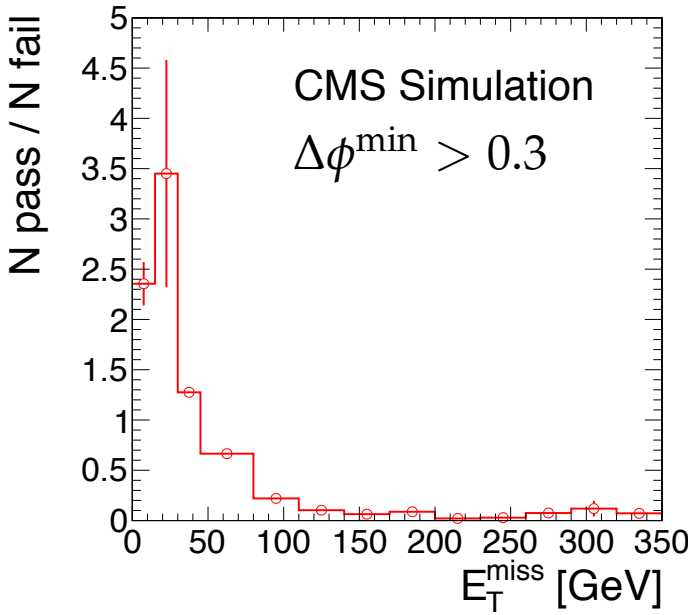

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MET and b

SUS-11-006

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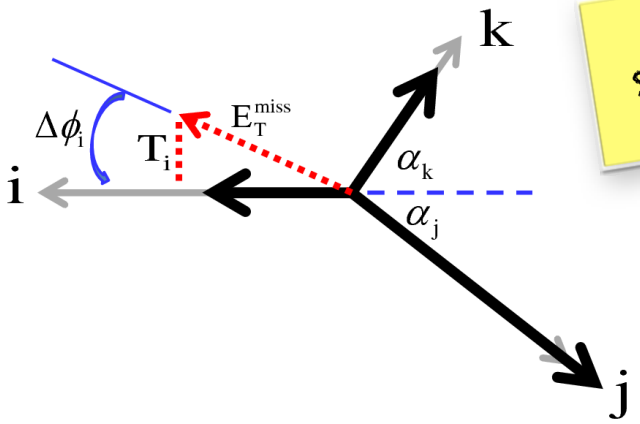

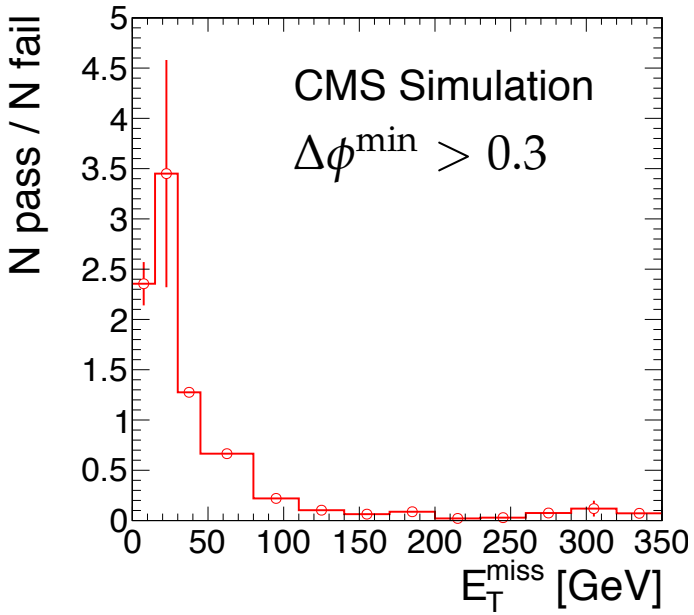

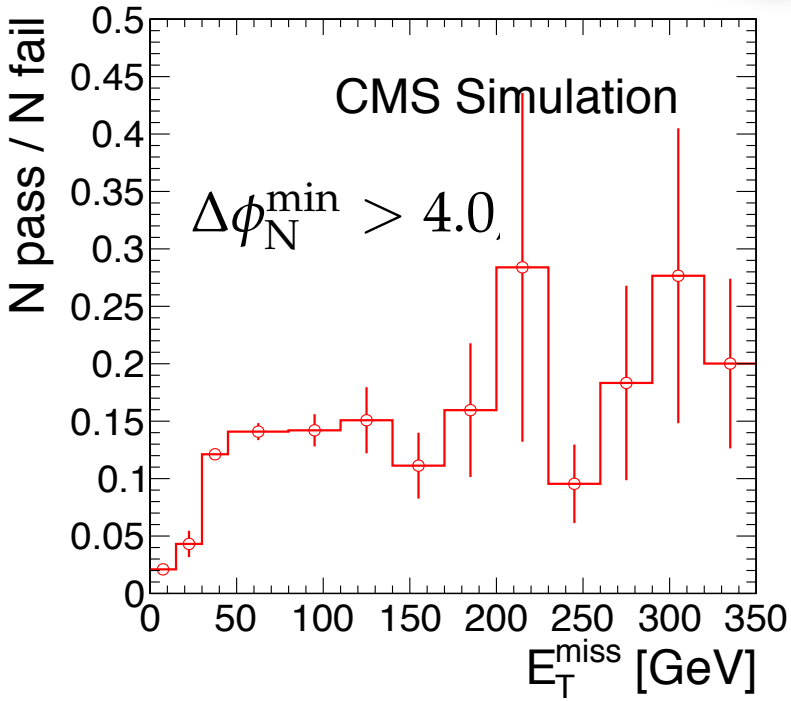

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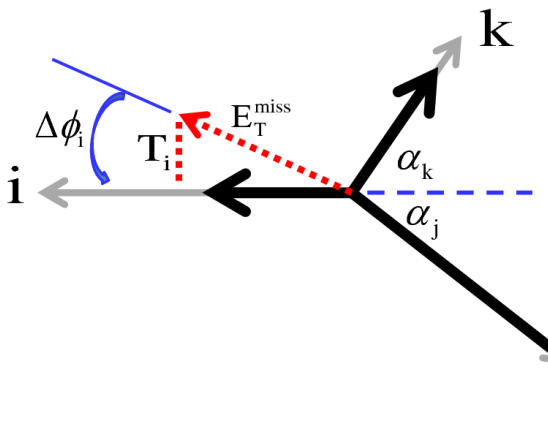

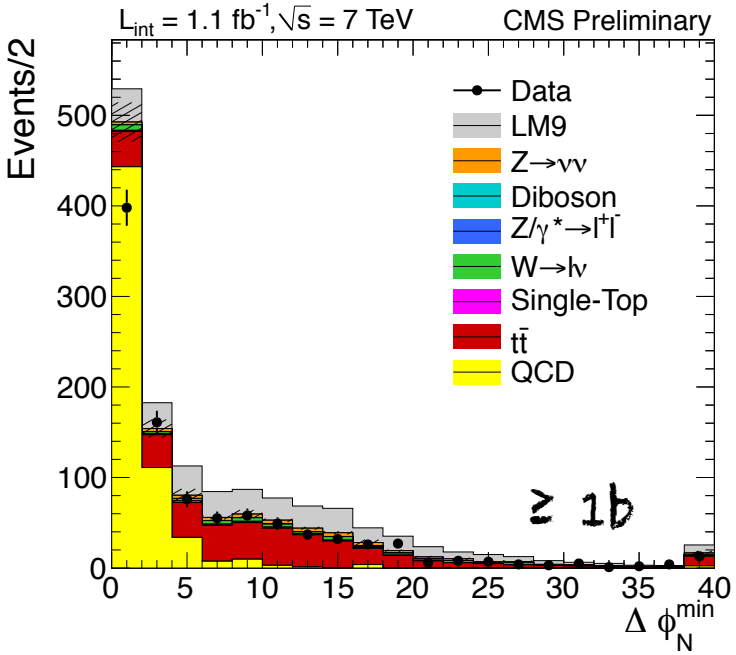

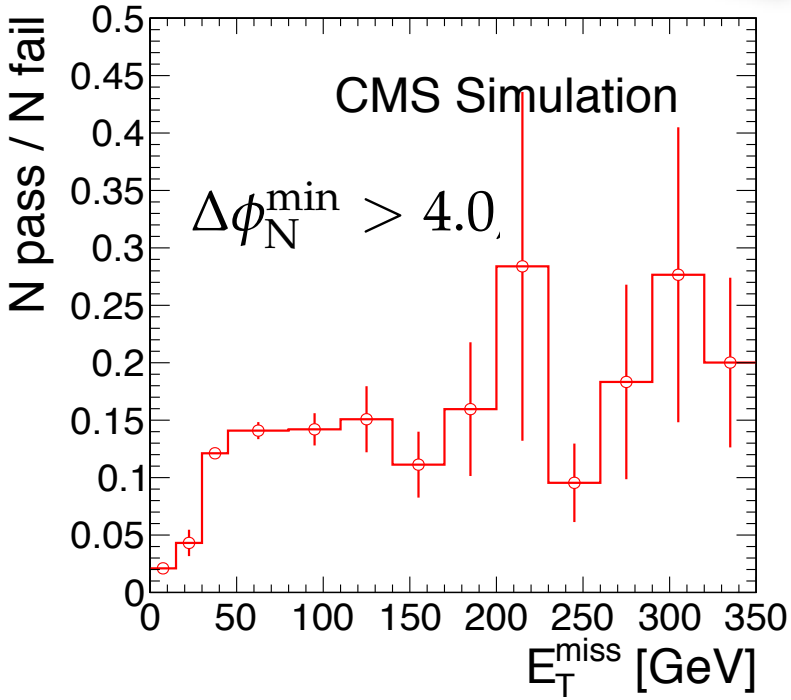

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MET and b

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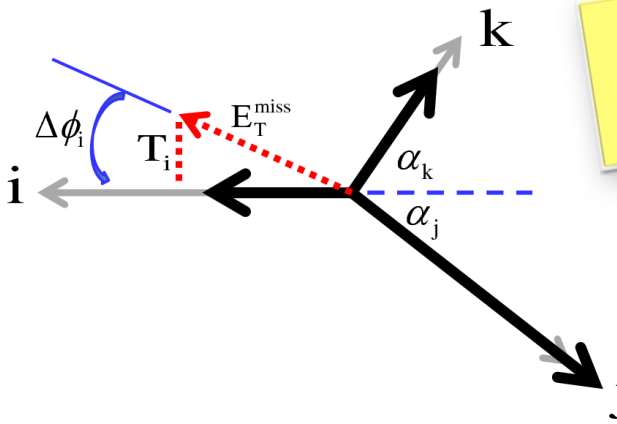

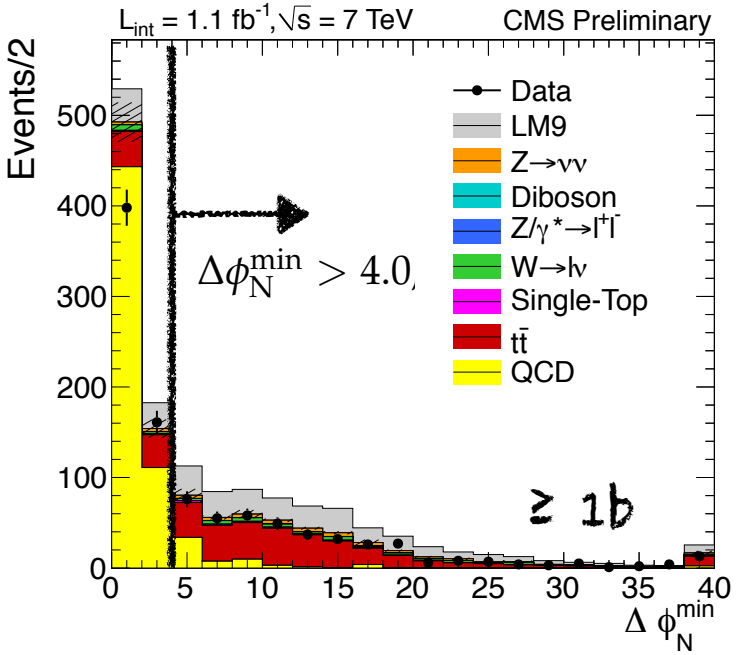

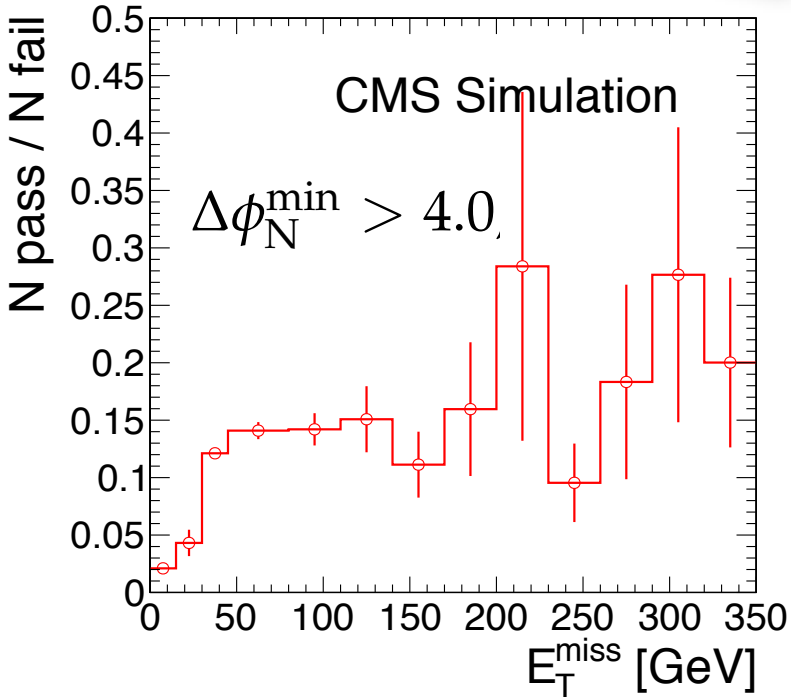

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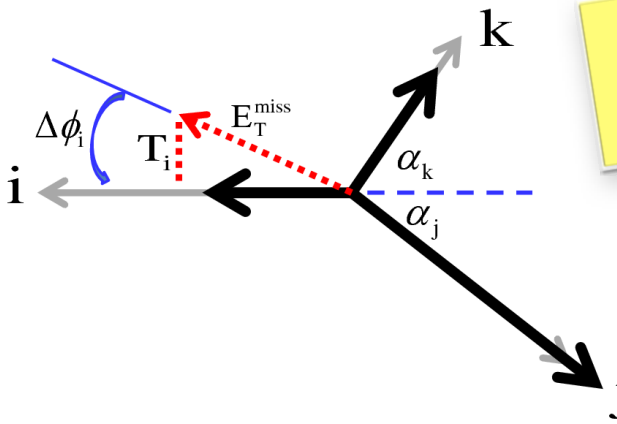

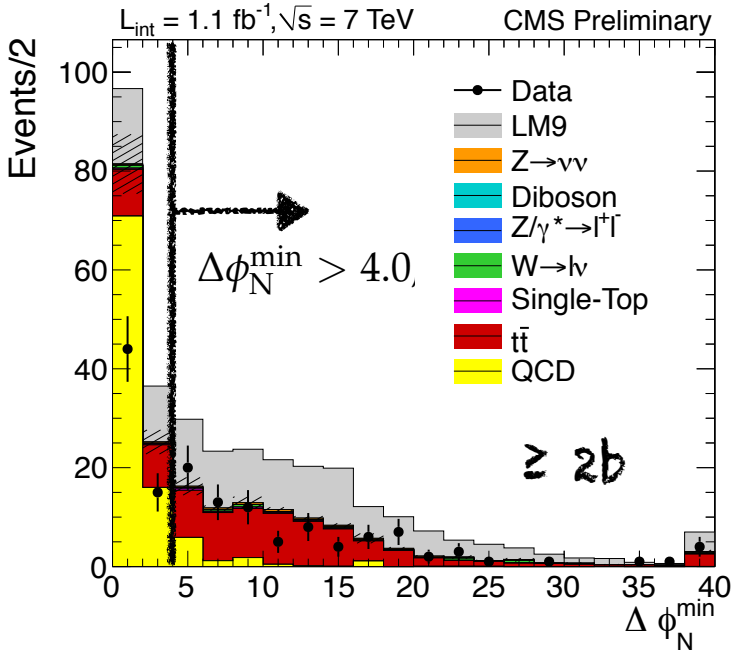

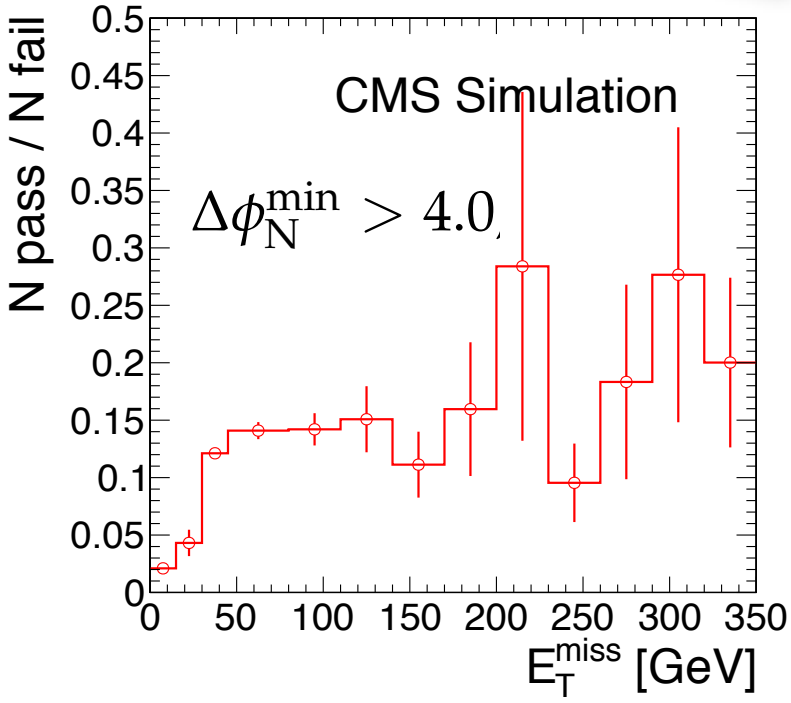

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LPC LHC Physics Center

MET and b-jets

Background Strategy

- Define signal window: $\Delta\varphi^{min}$ vs MET
  - $\Delta\varphi^{min} > 4.0$
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SUS-11-006

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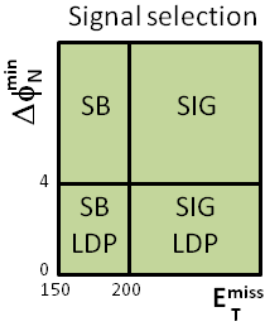

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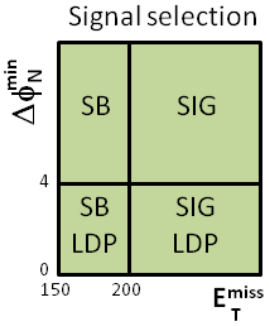

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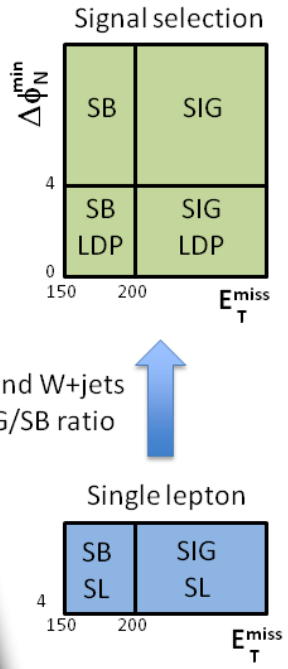

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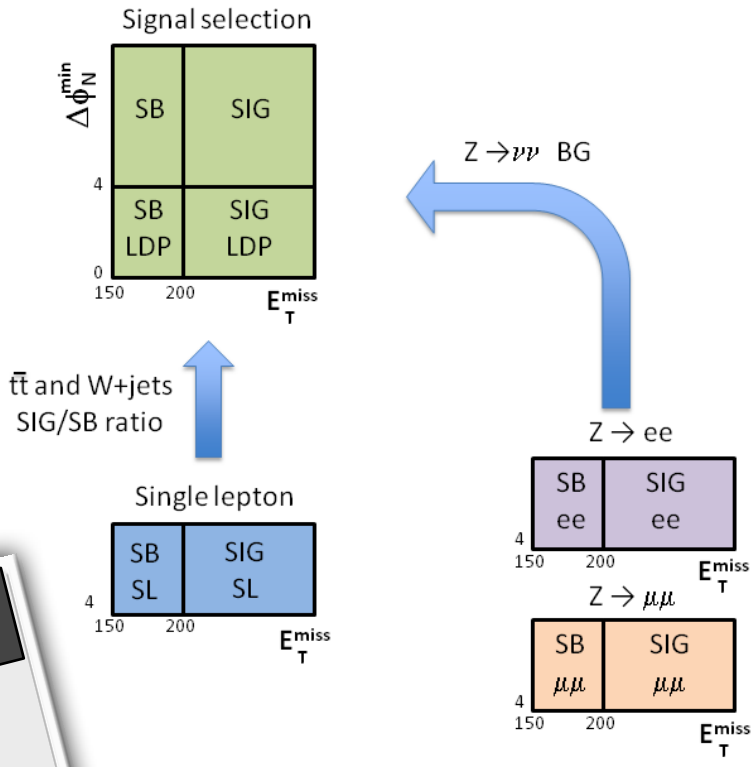

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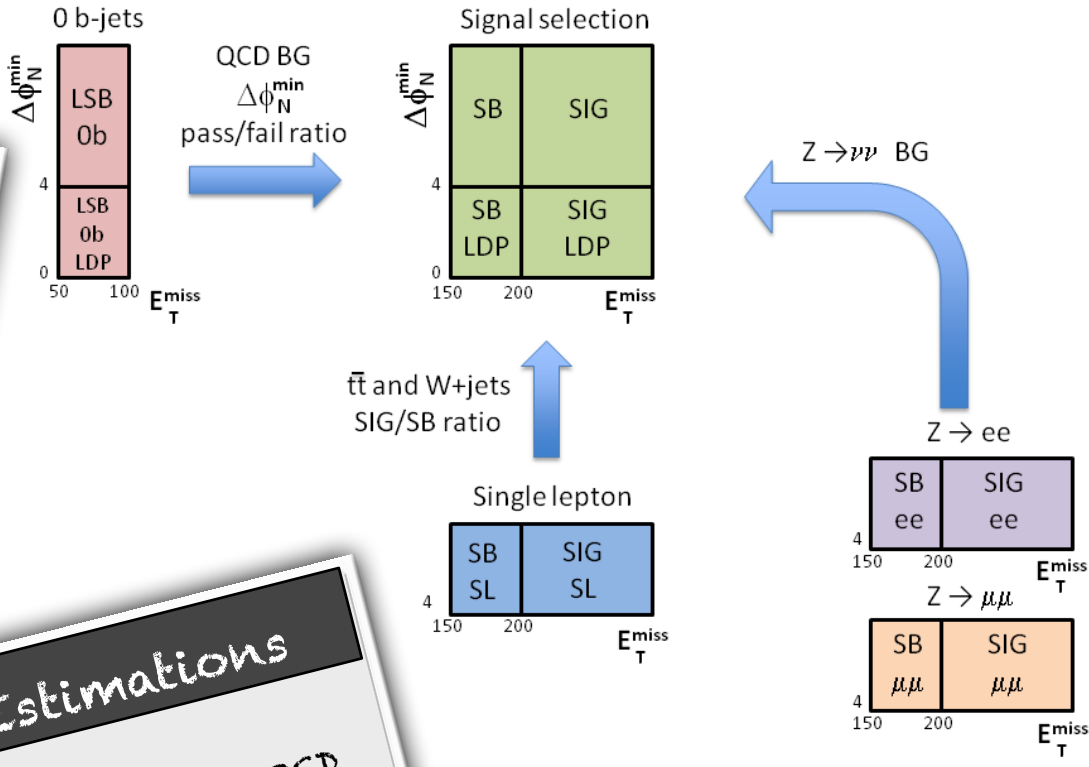

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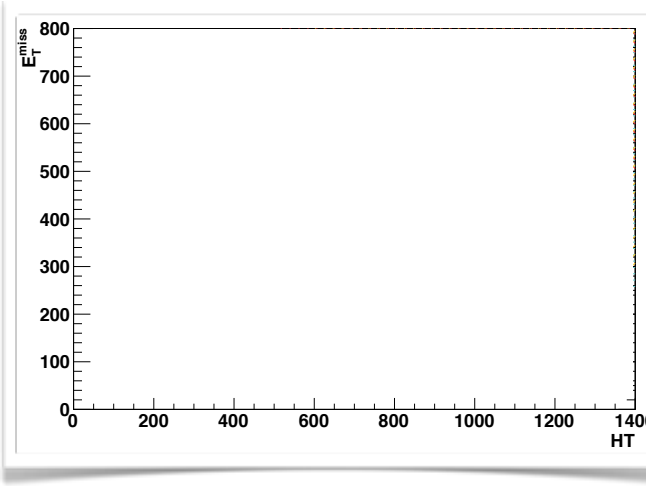

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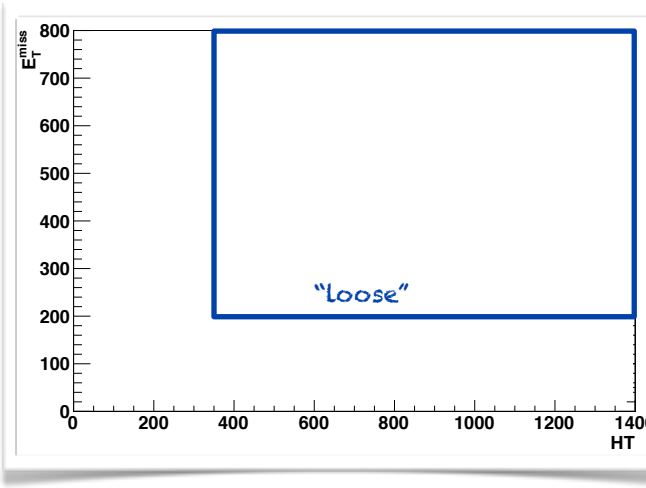

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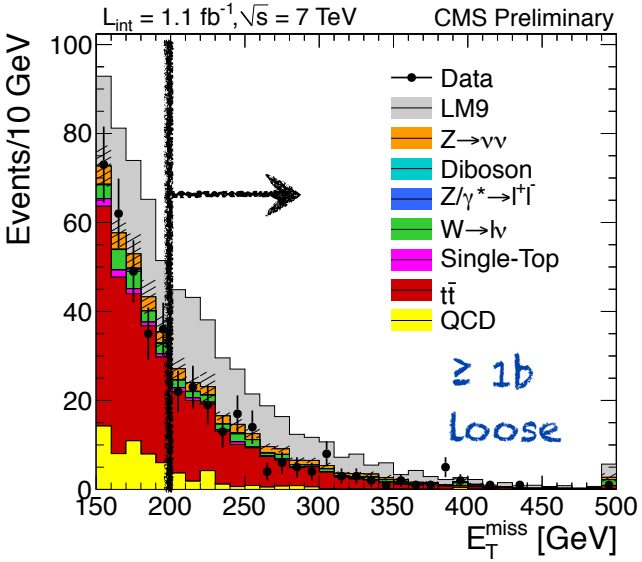

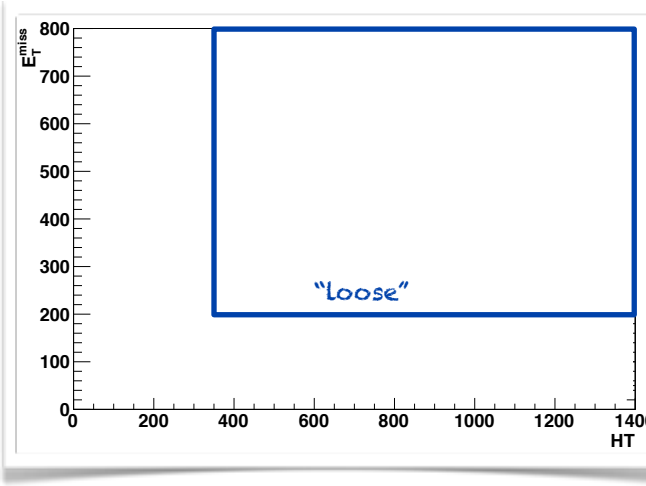

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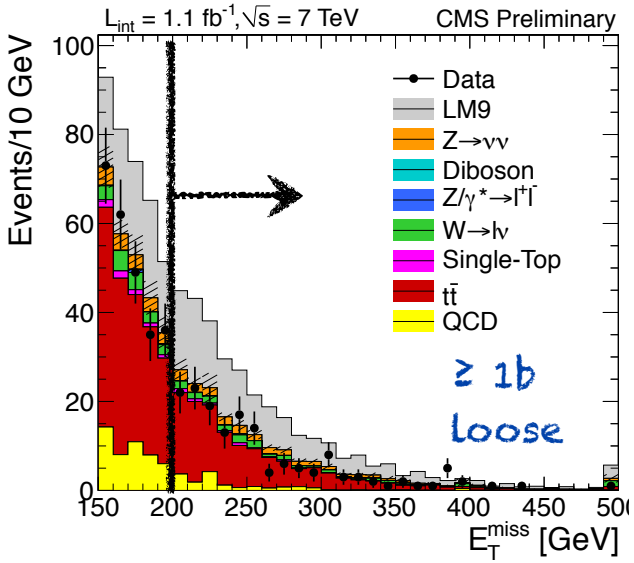

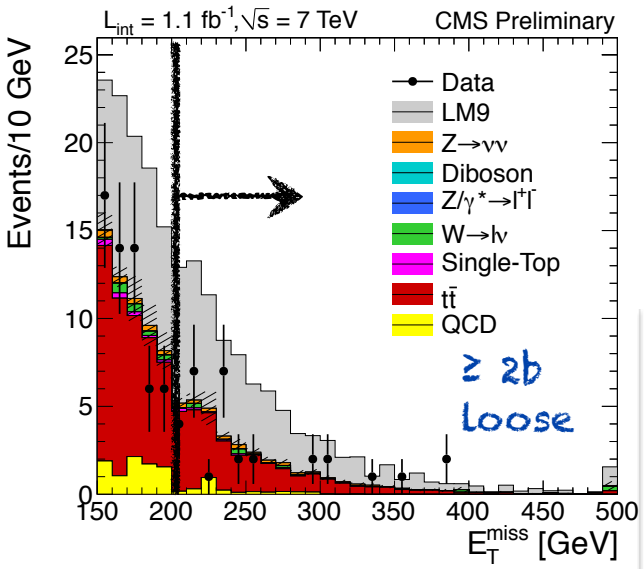

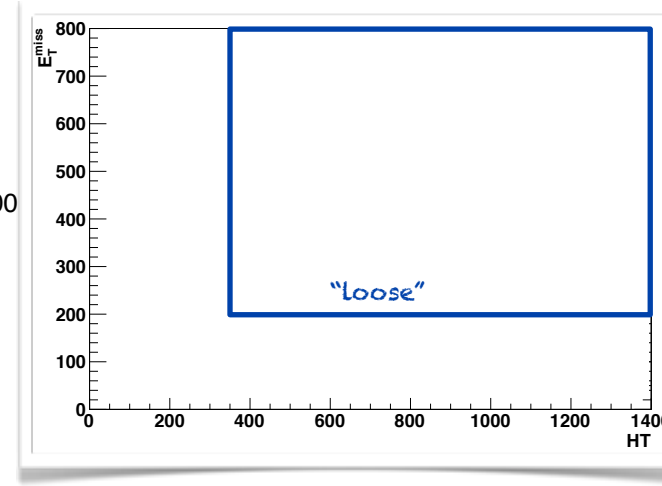

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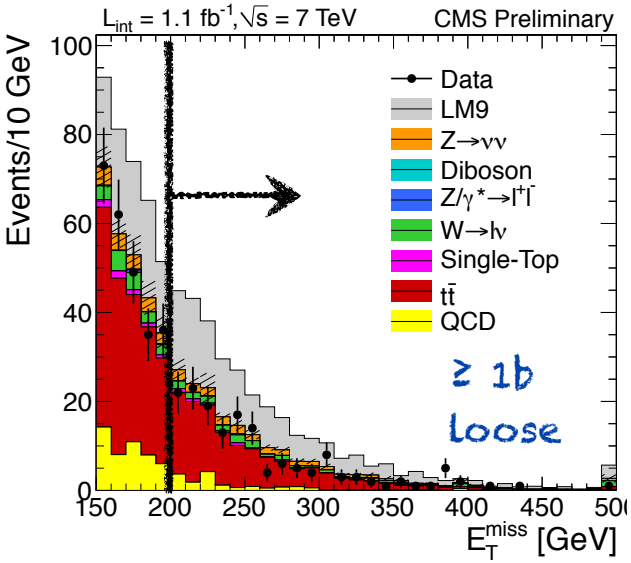
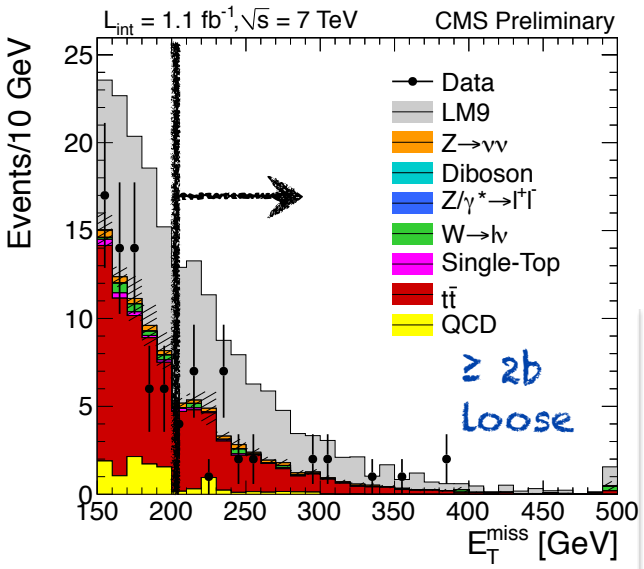
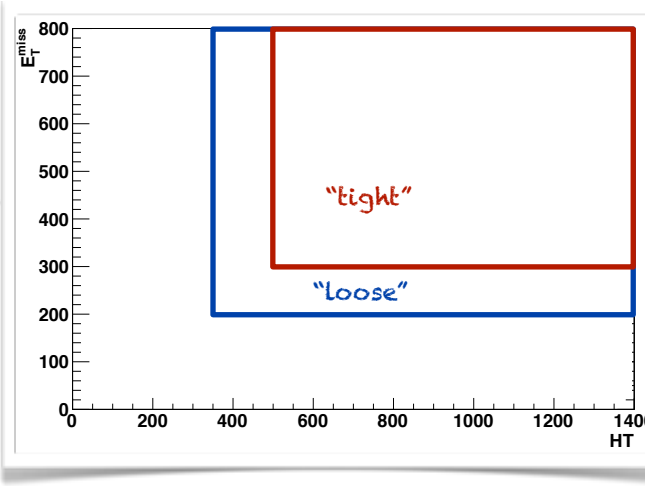
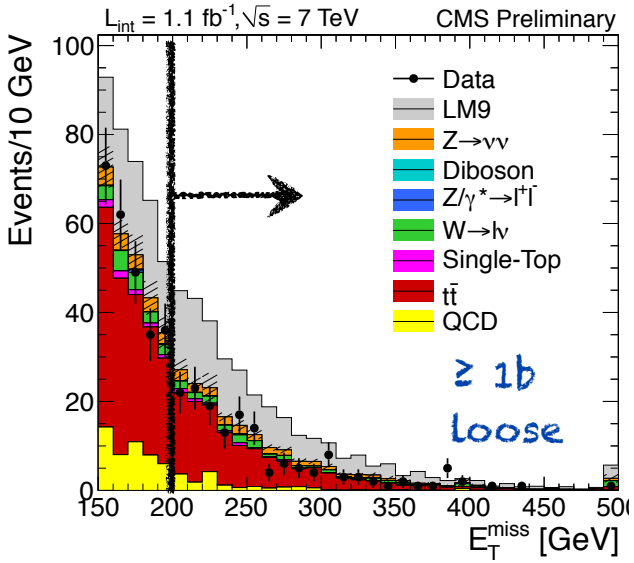


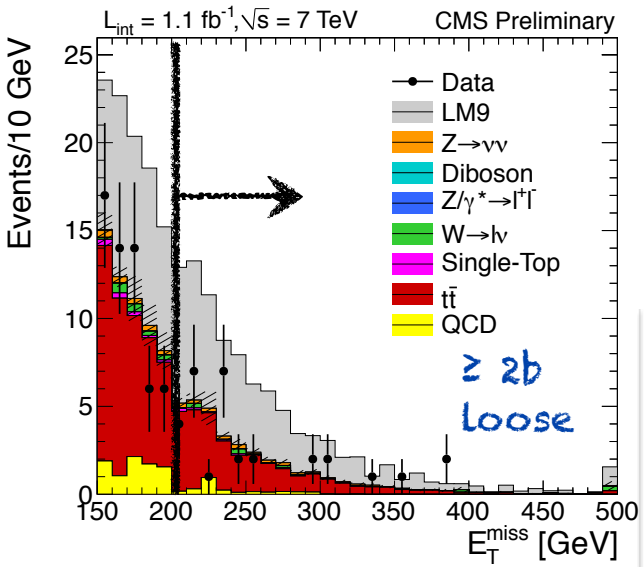


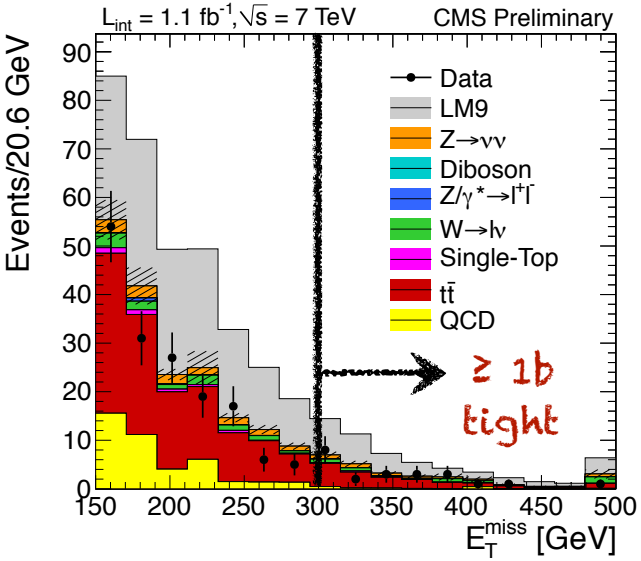


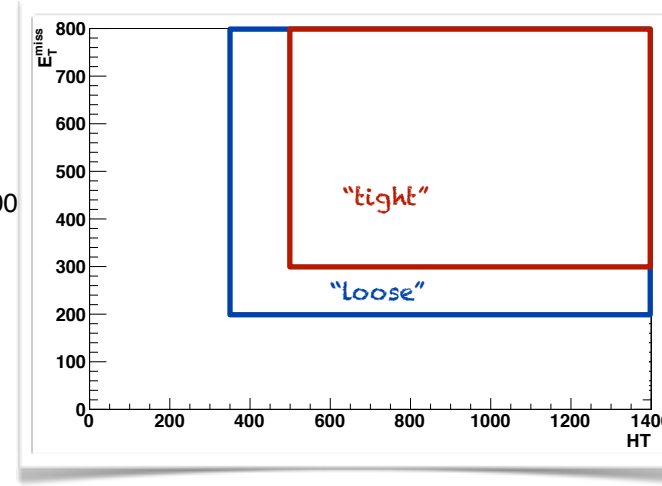
SUS-11-006

MET and b-jets



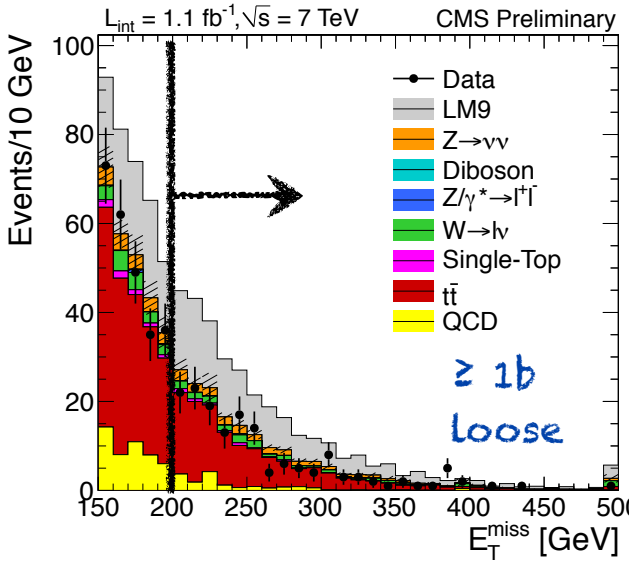


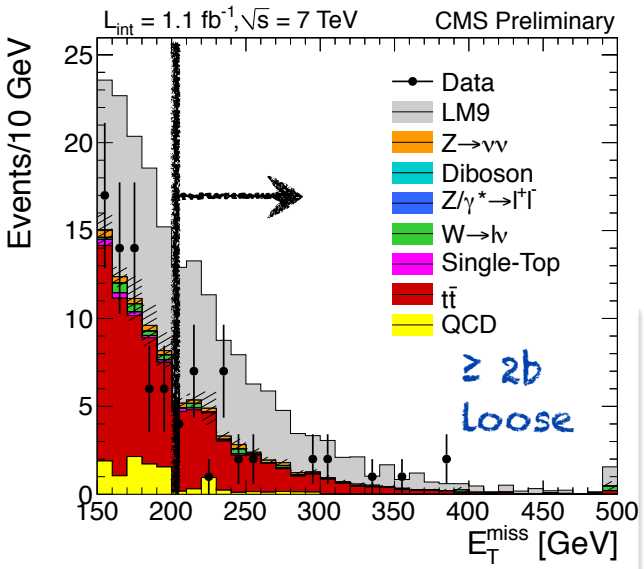


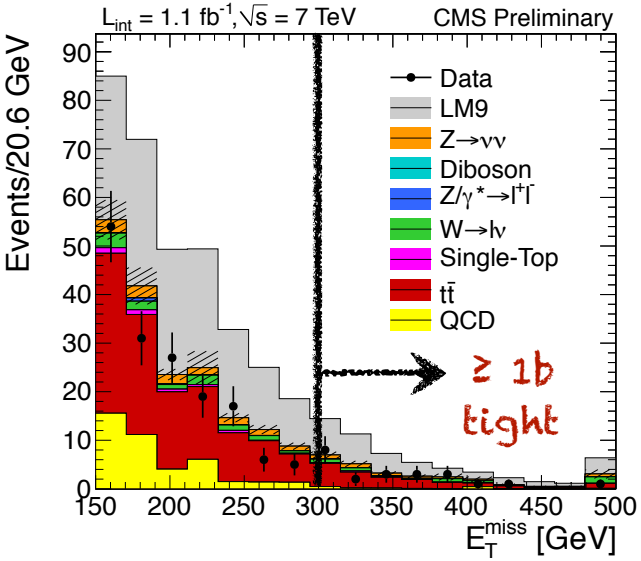


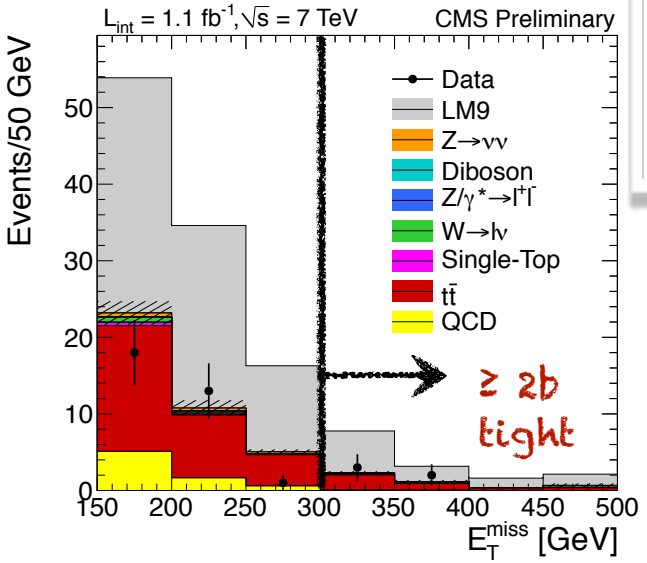
SUS-11-006

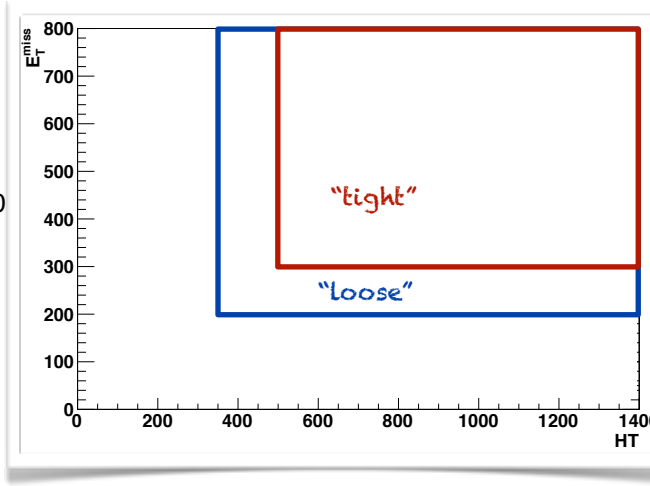
MET and b-jets





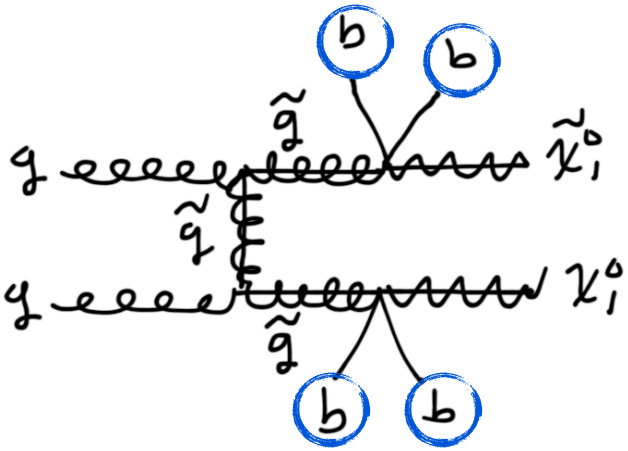






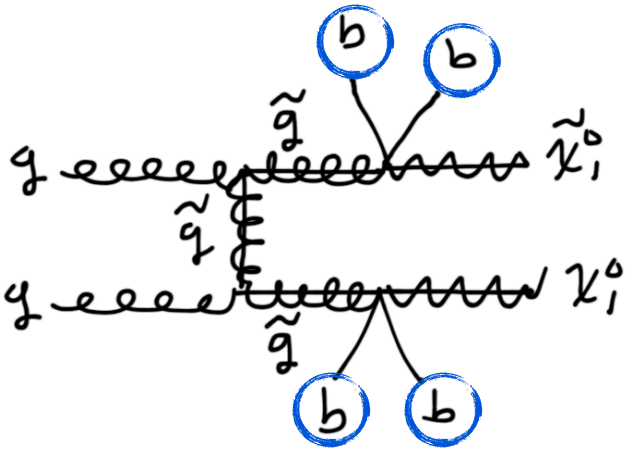
SUS-11-006

MET and b-jets

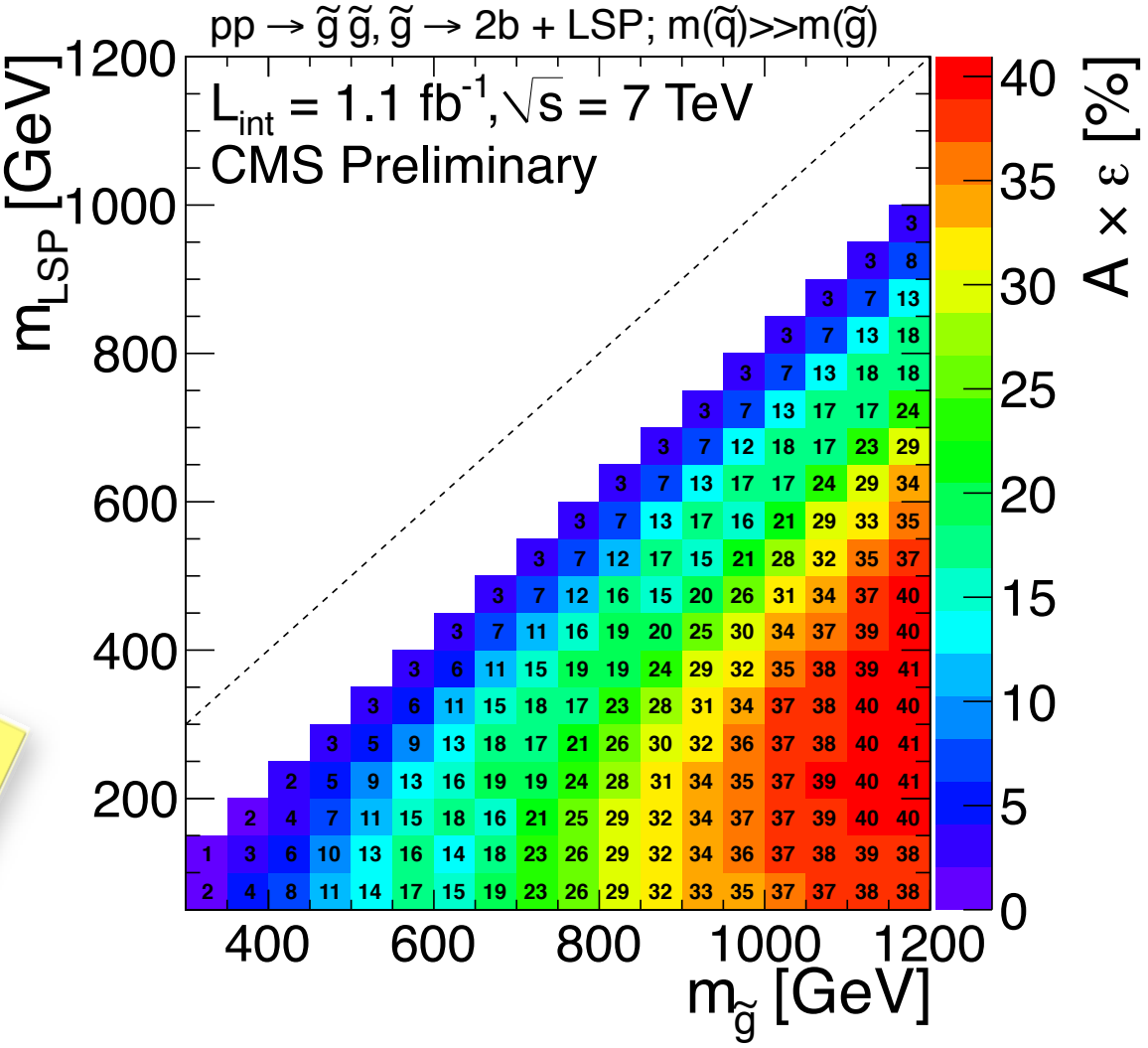


SUS-11-006

MET and b-jets



SUS-11-006



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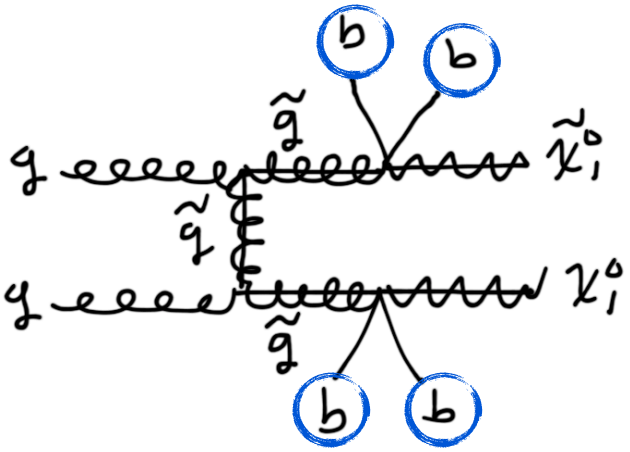
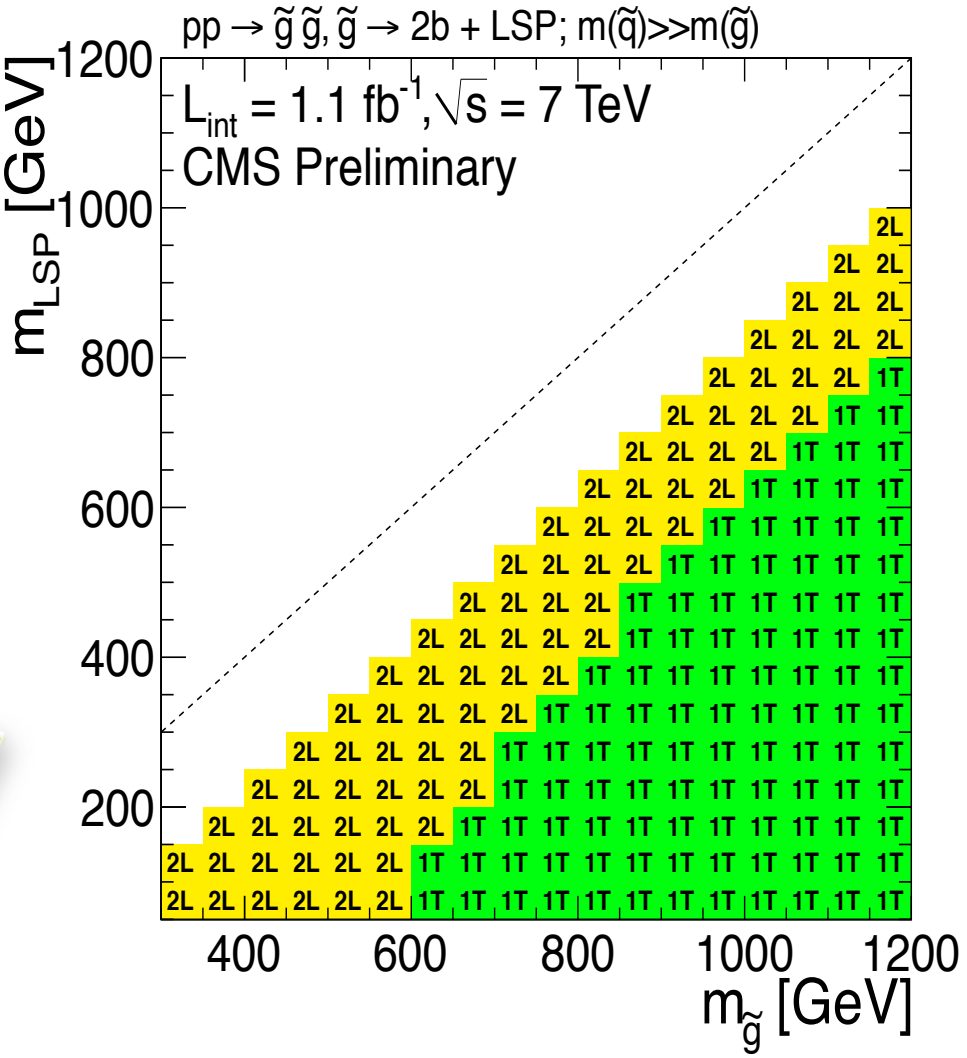


SUS-11-006



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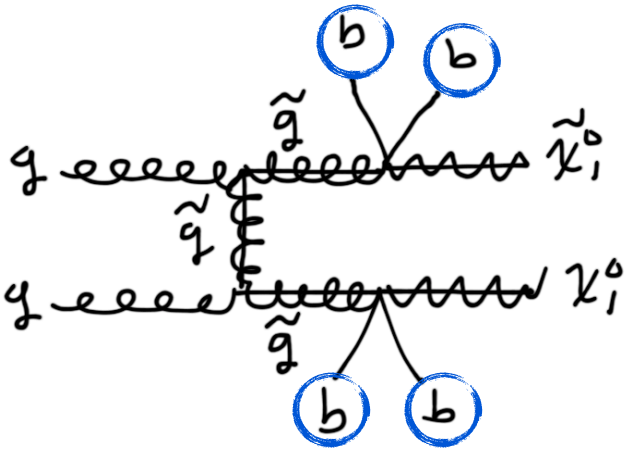
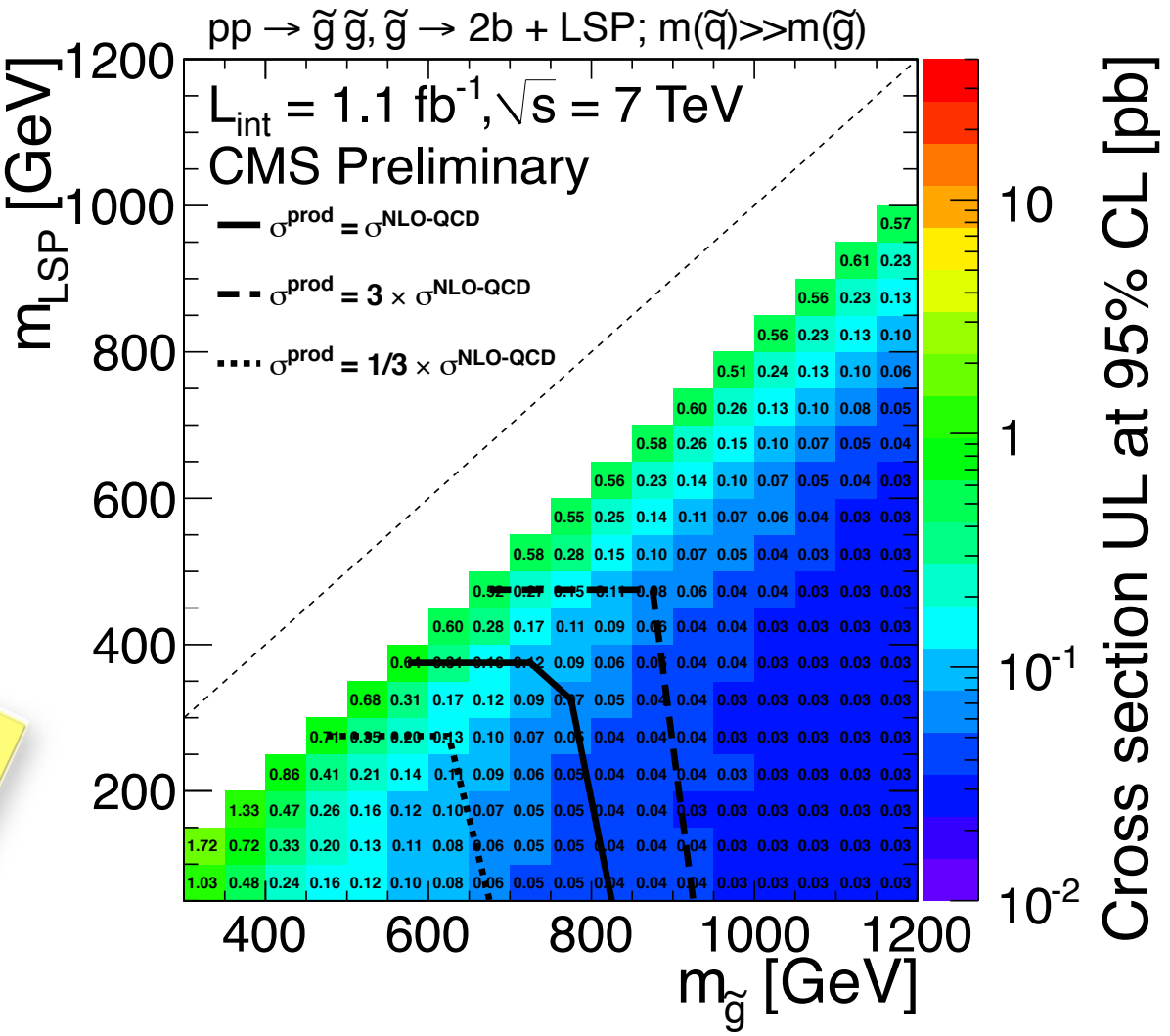


SUS-11-006



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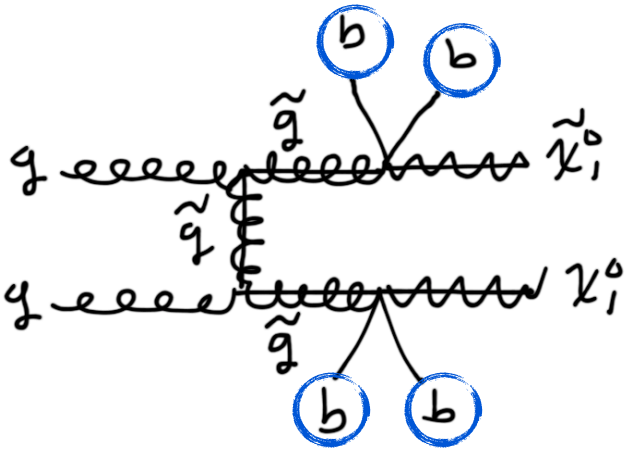
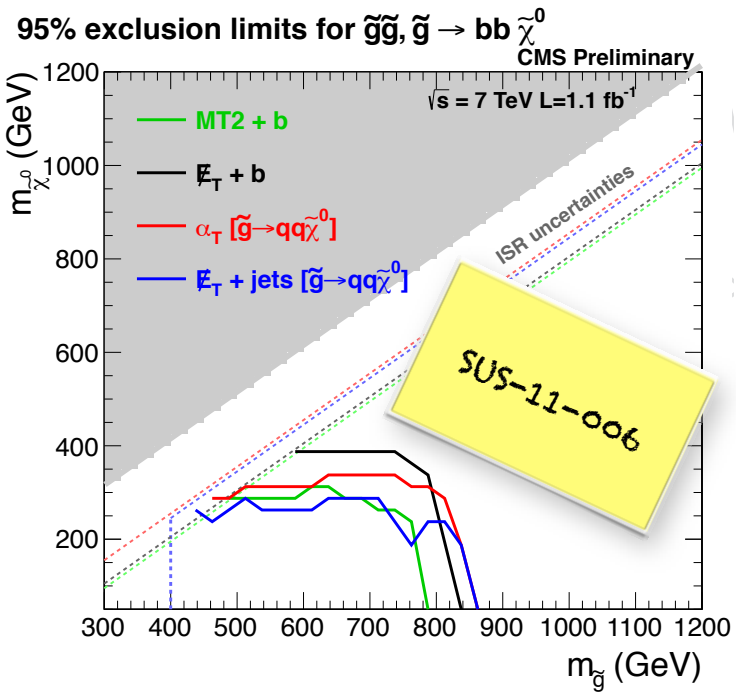
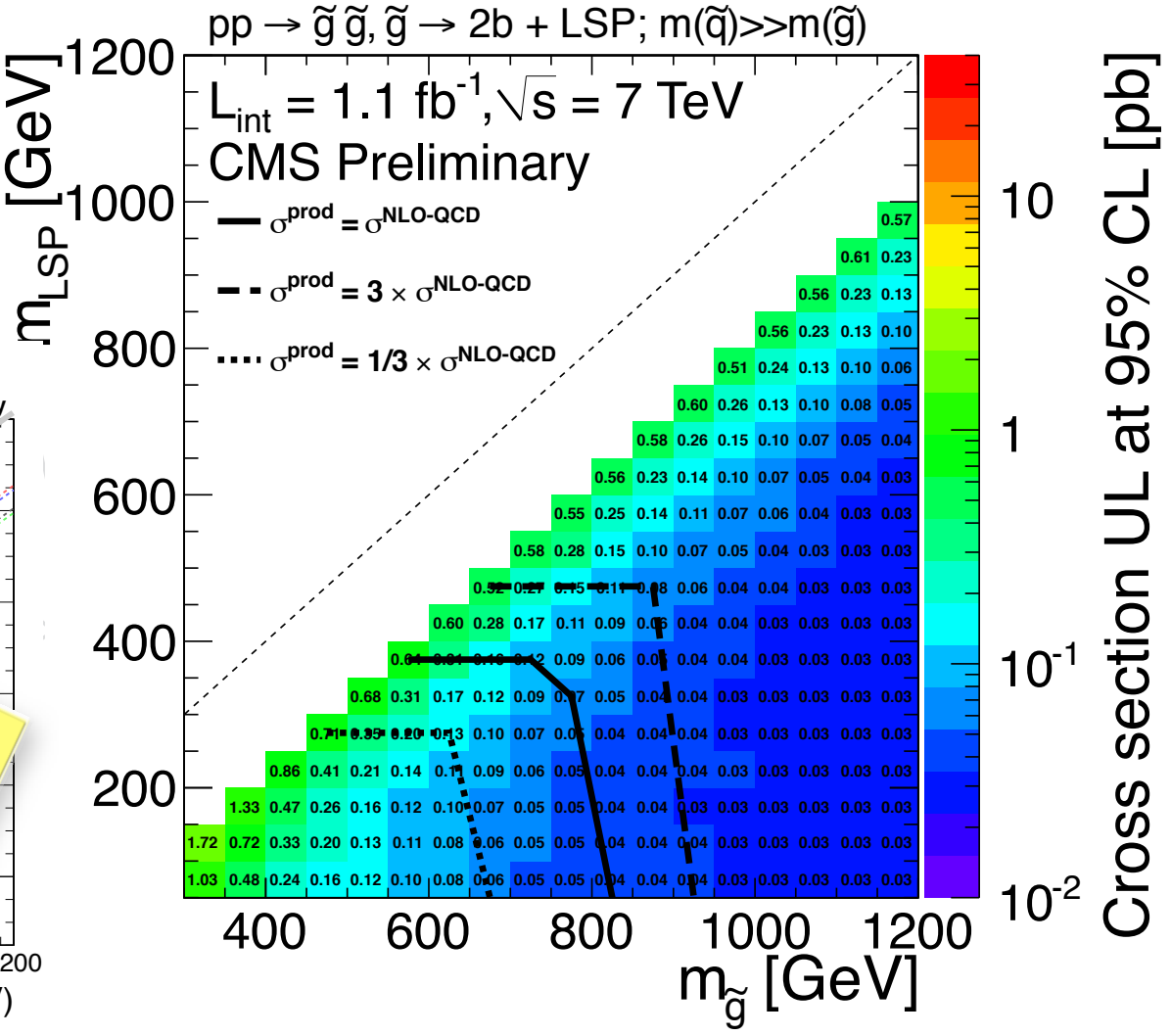
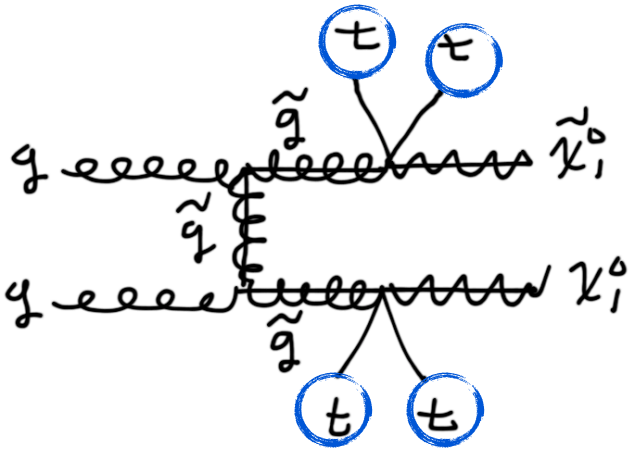




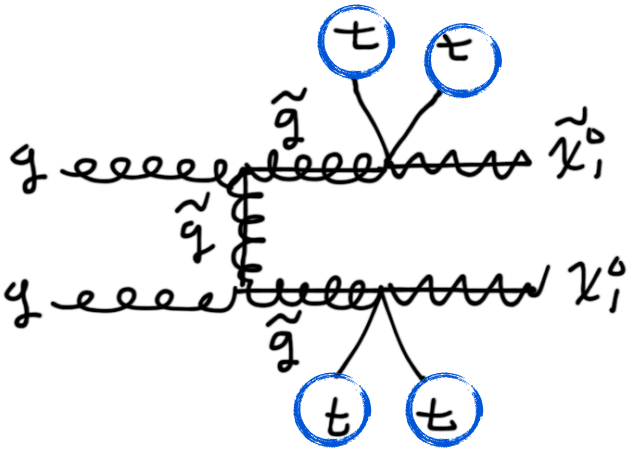


MET and b-jets

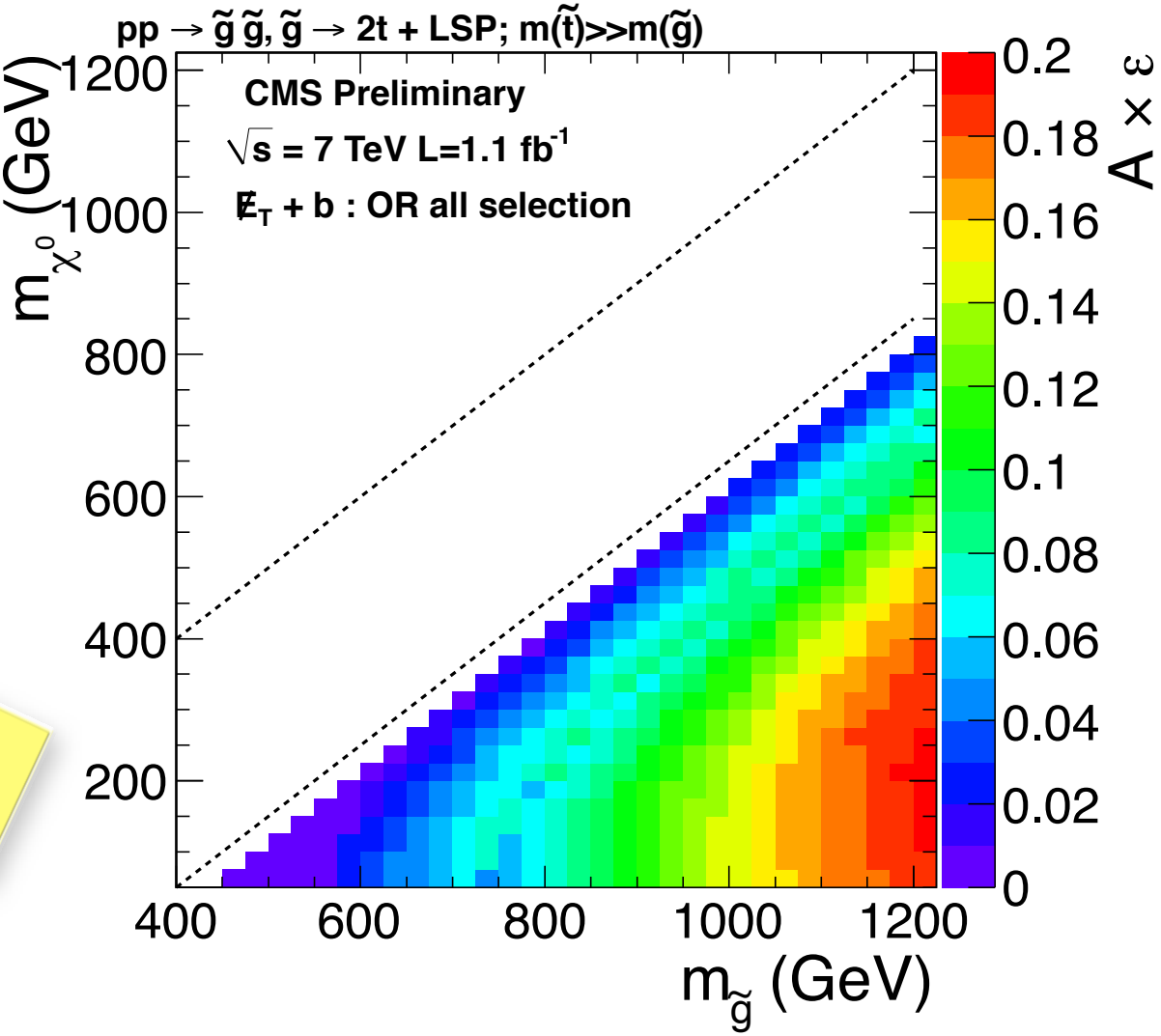


SUS-11-006

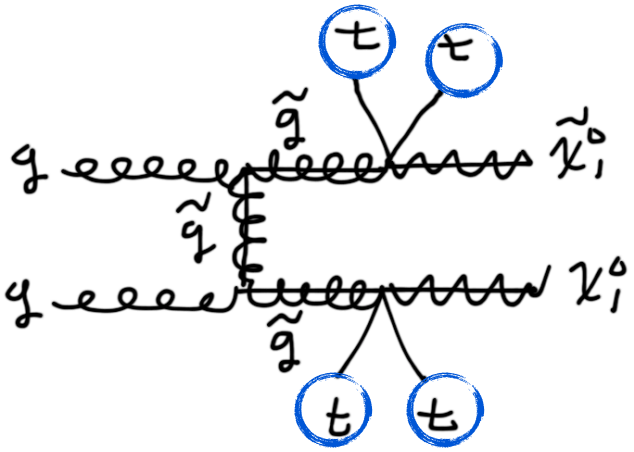
MET and b-jets

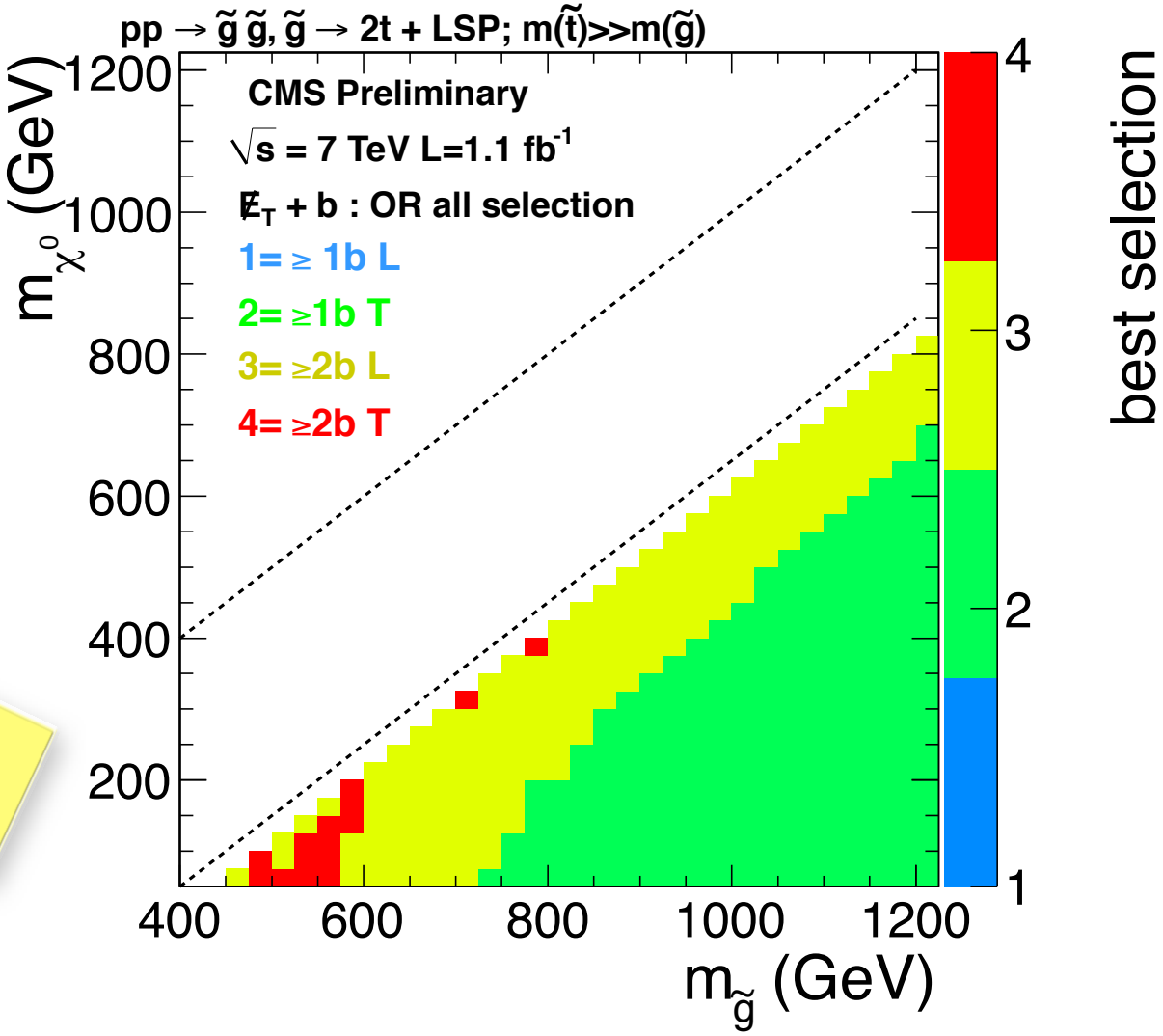


SUS-11-006



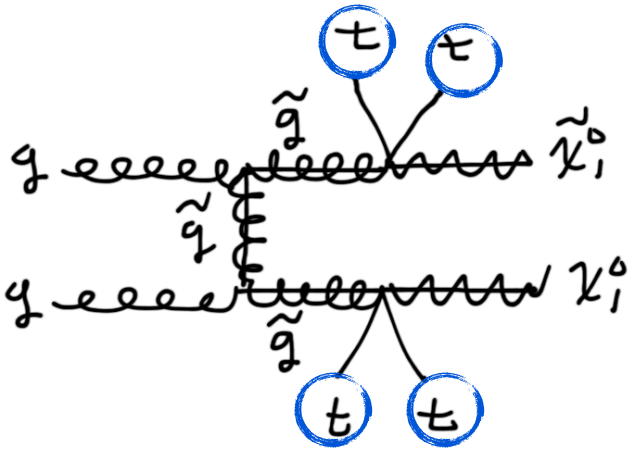
MET and b-jets





SUS-11-006

MET and b-jets



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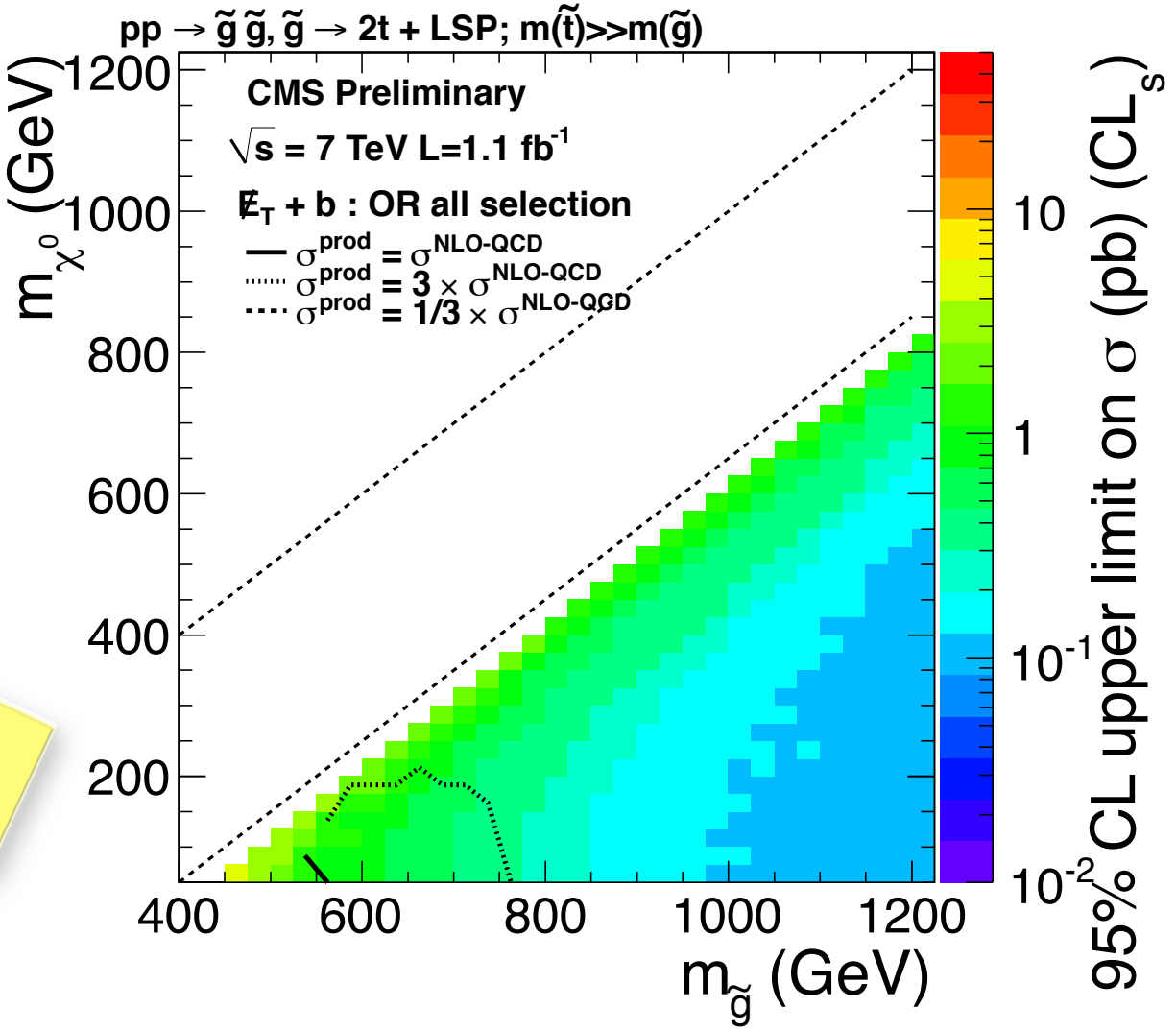
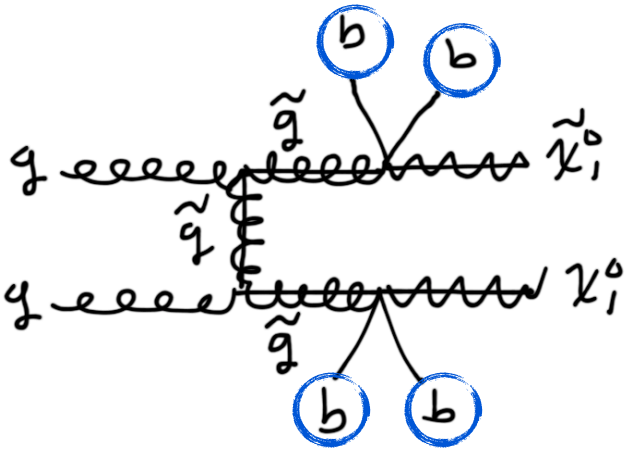


MT2 and b-jets



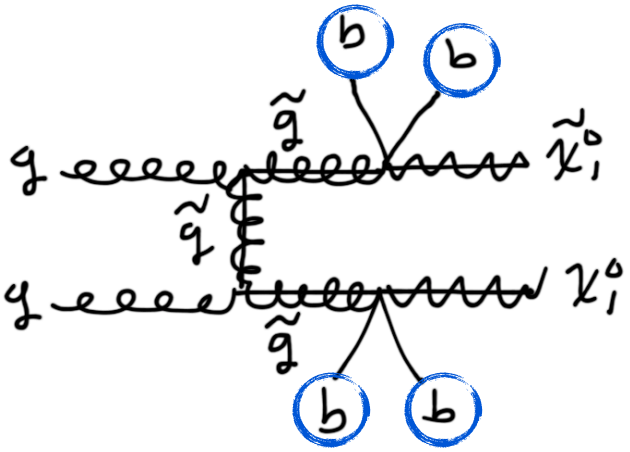
SUS-11-016
SUS-12-002

$$(M_{T2})^2 = 2\ p_T^{vis(1)} p_T^{vis(2)} (1 + \cos\phi_{12})$$

Strategy

- stransverse mass as discriminator
  - Endpoint at parent mass
  - Force event in hemispheres; assume M(LSP)=0
- Require
  - ≥ 1 b-tagged jet
  - ≥ 4 jets (150, 40, 40, 40)
  - MT2 > 125
  - HT > 750, HT > 950

MT2 and b-jets



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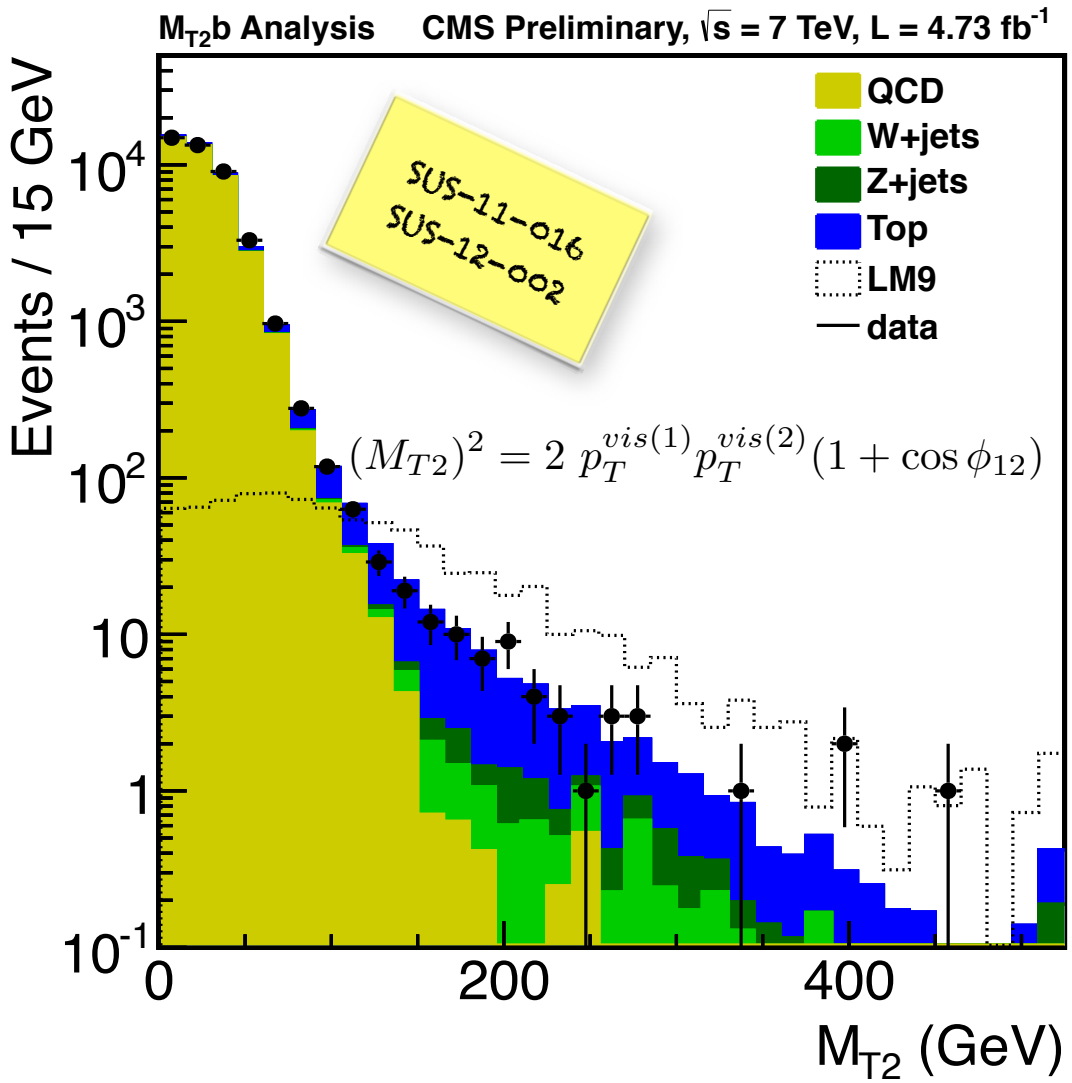
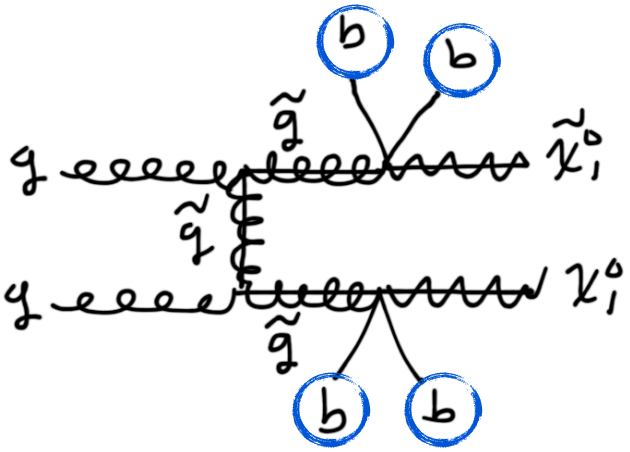


MT2 and b-jets



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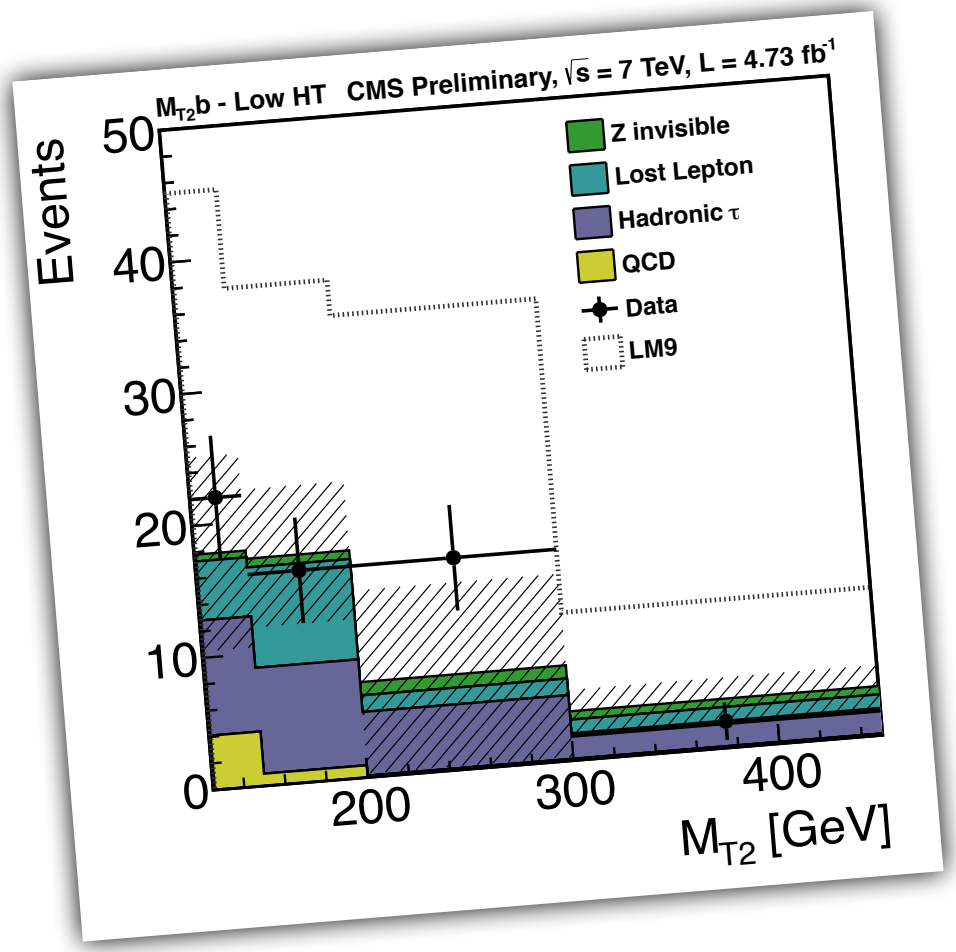
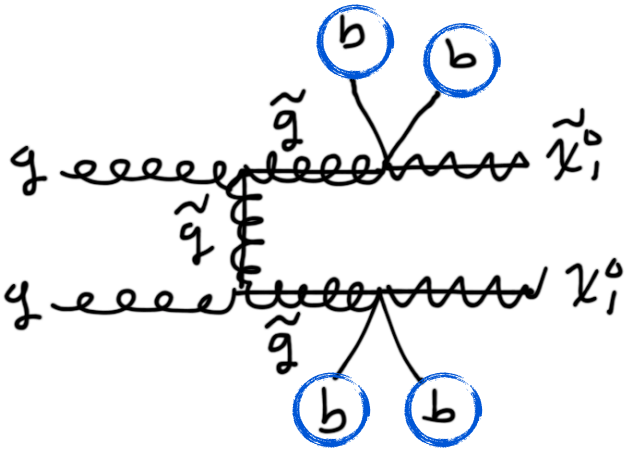


SUS-11-016
SUS-12-002

MT2 and b-jets



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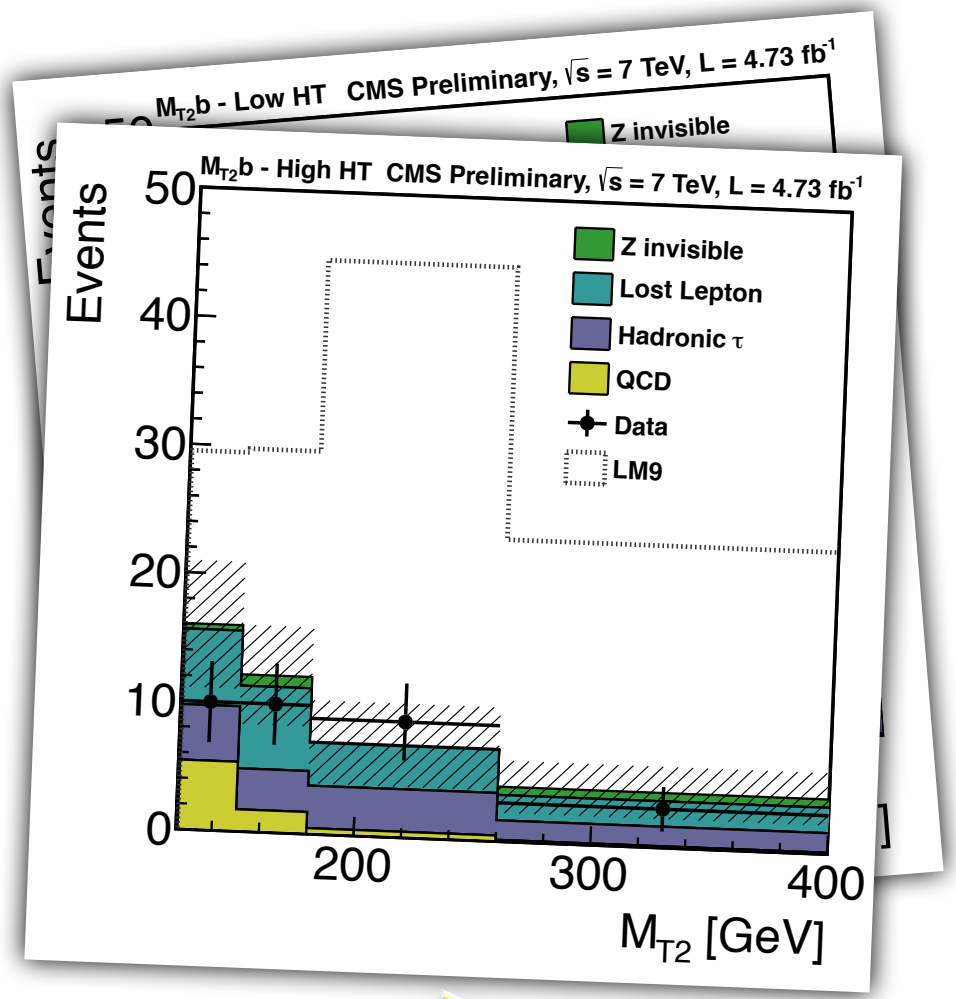
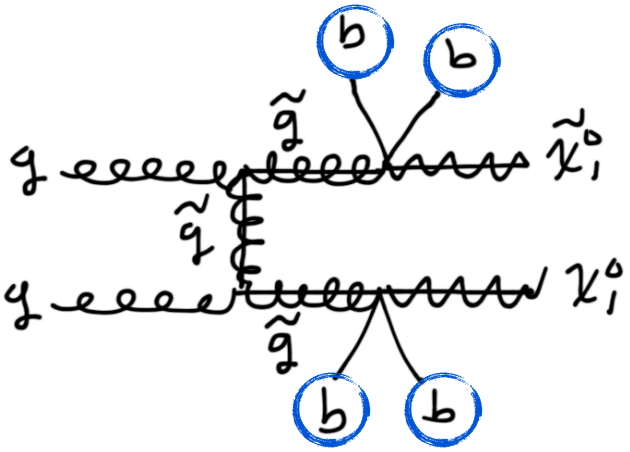


SUS-11-016
SUS-12-002

MT2 and b-jets



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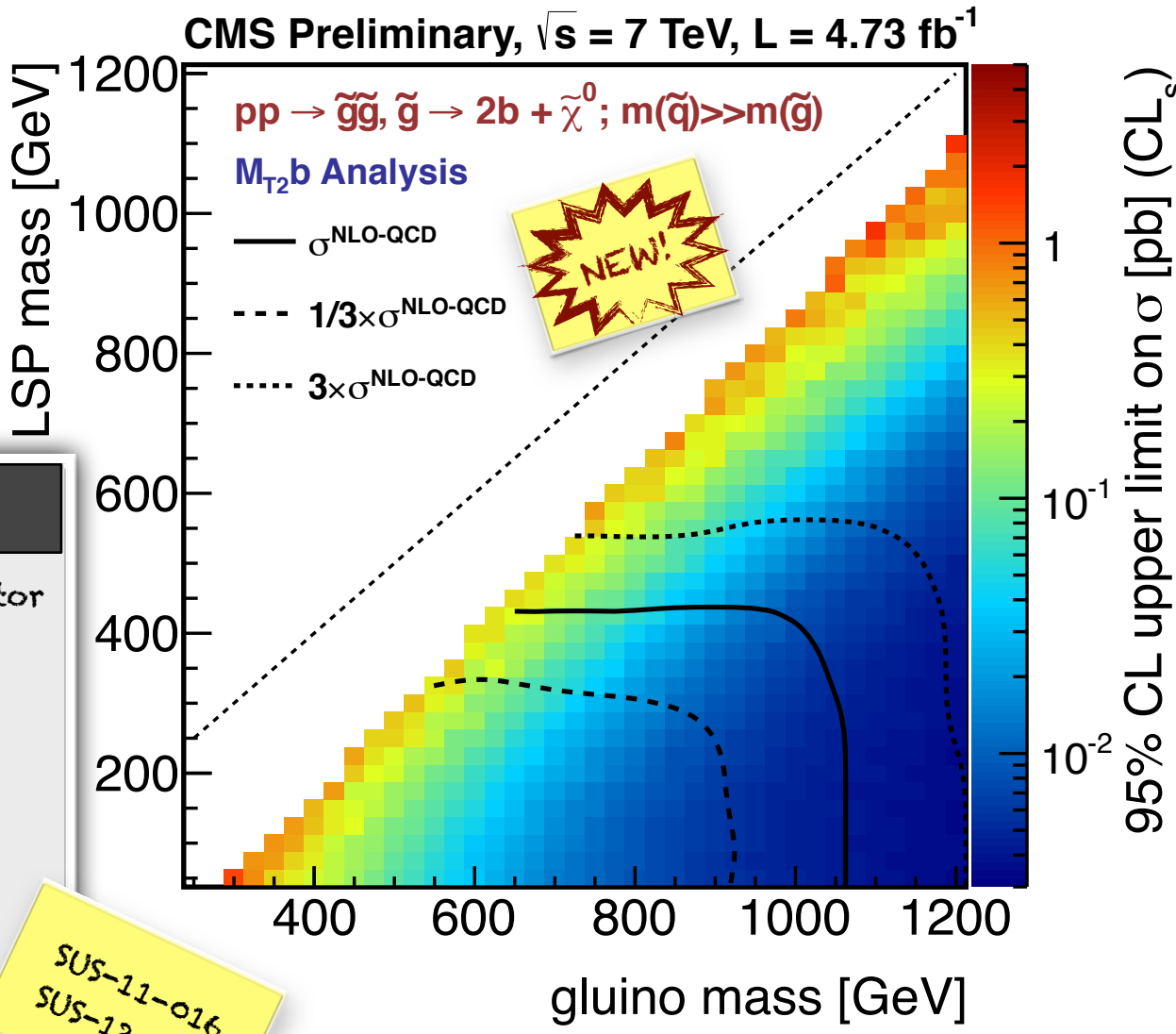
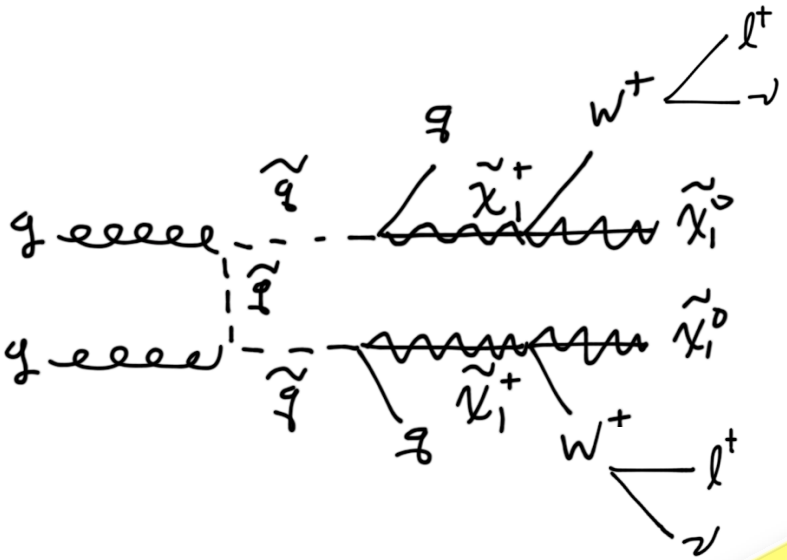


SUS-11-016
SUS-12-002

SS dileptons

Strategy

- SM backgrounds highly suppressed.

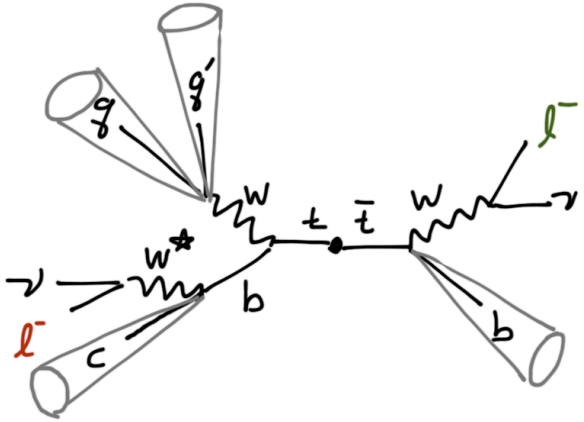


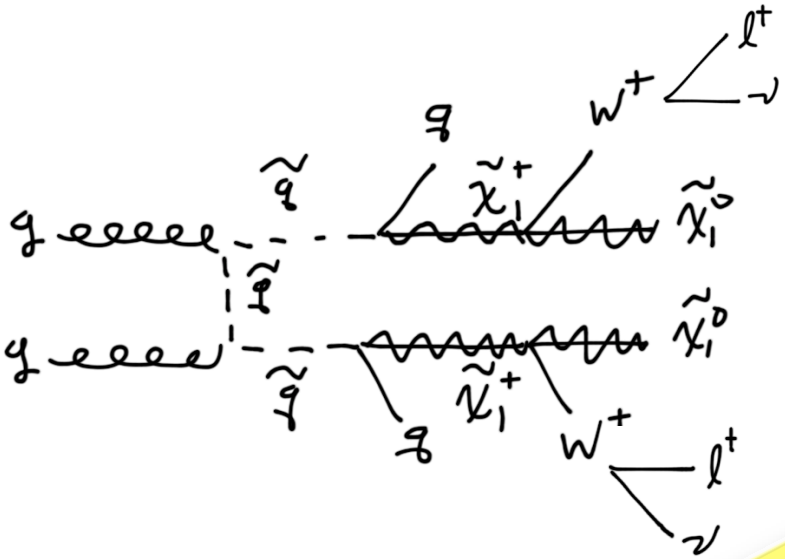
SUS-11-010

SS dileptons

Strategy

- SM backgrounds highly suppressed.
  Challenge is to measure fake leptons!



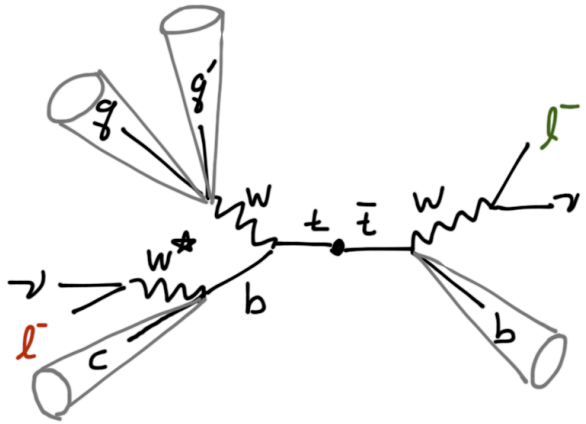


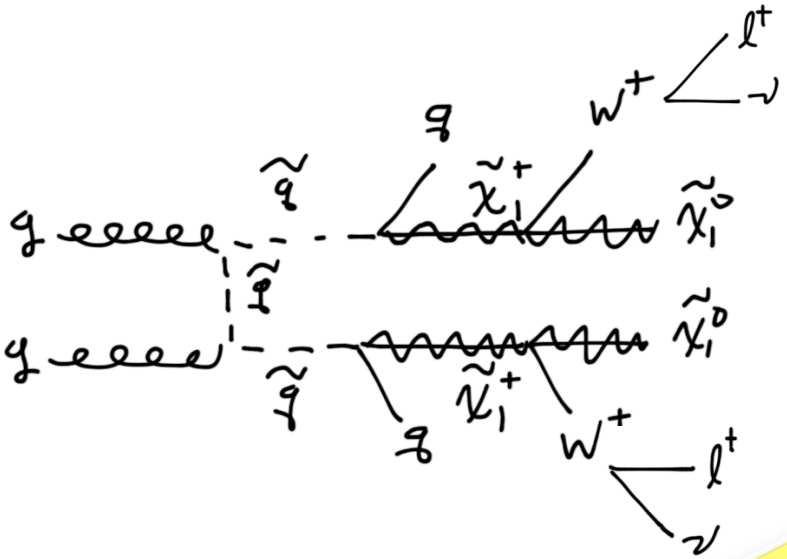
SUS-11-010

SS dileptons

Strategy

- SM backgrounds highly suppressed. Challenge is to measure fake leptons!
- Two data-driven methods
  - B tag-and-probe method
  - "Tight-Loose" method





$$\text{TL ratio: } R_{TL} = \frac{\text{leptons passing analysis selection}}{\text{leptons passing loose selection}}$$

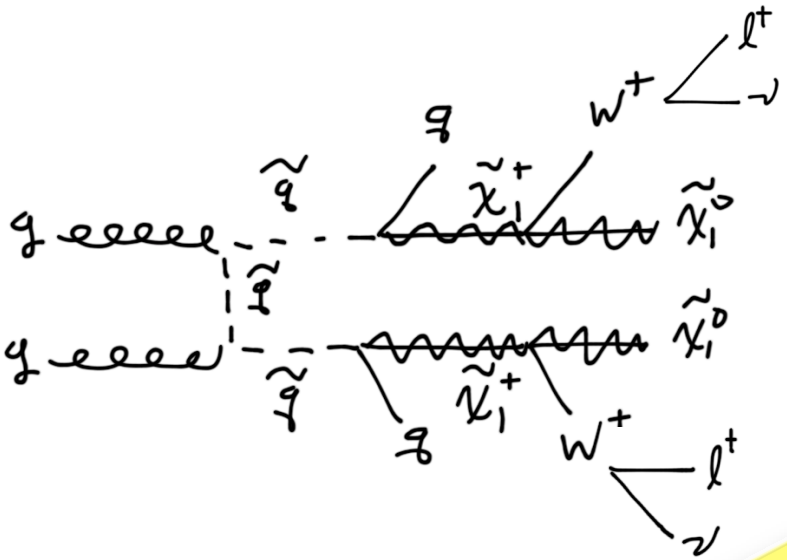
Measure R_{TL} in independent QCD dominated Control Sample

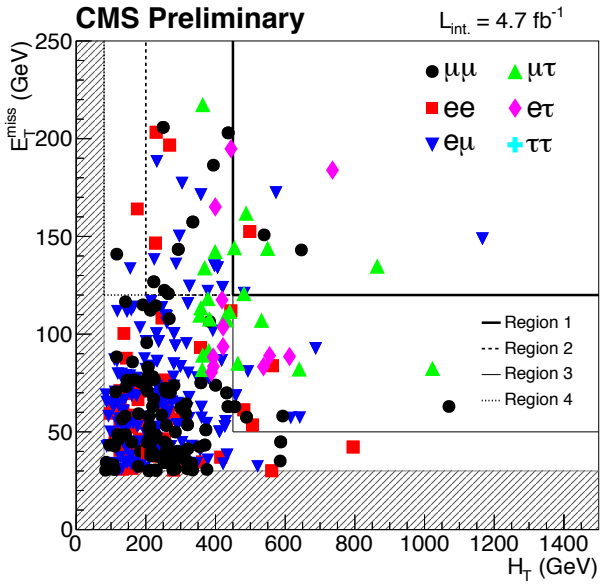
SUS-11-010

SS dileptons

Strategy

- SM backgrounds highly suppressed. Challenge is to measure fake leptons!
- Two data-driven methods
  - B tag-and-probe method
  - "Tight-Loose" method
- Define Signal Regions in MET & HT





SUS-11-010

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  - B tag-and-probe method
  - "Tight-Loose" method
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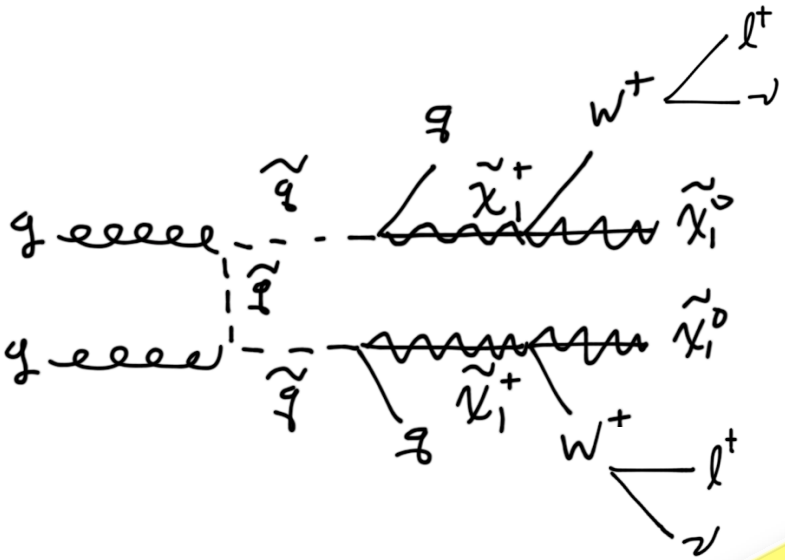
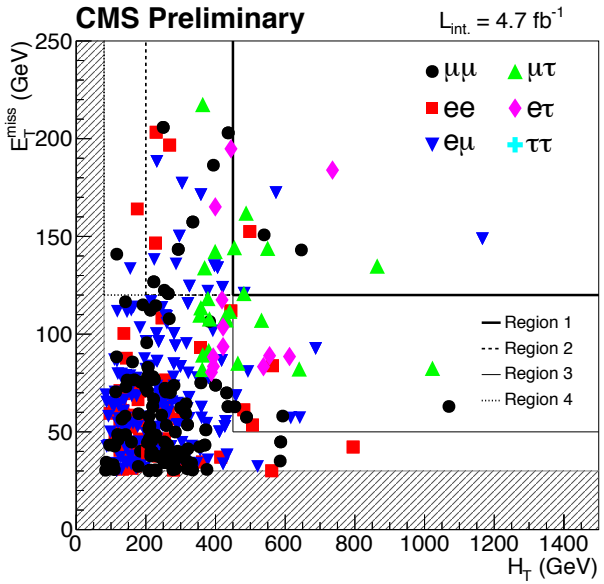
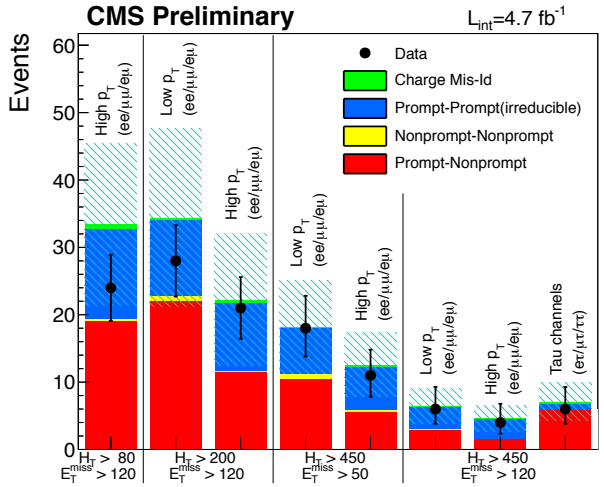
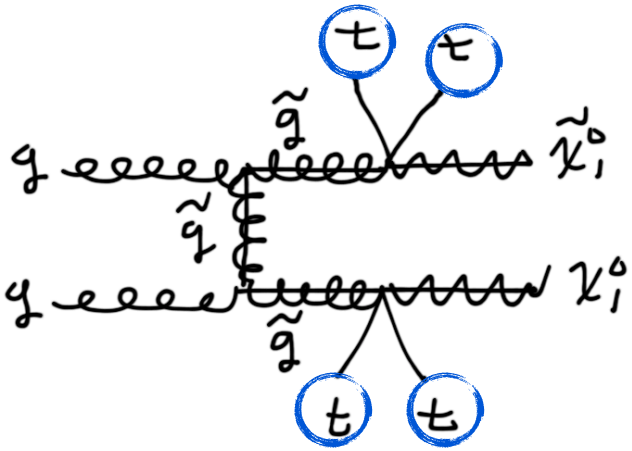






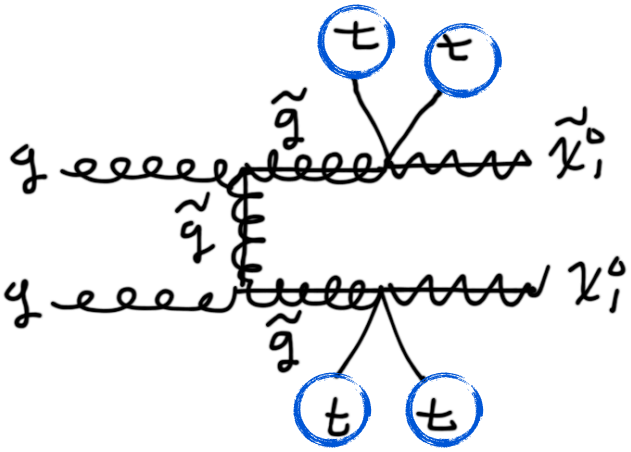
SUS-11-010

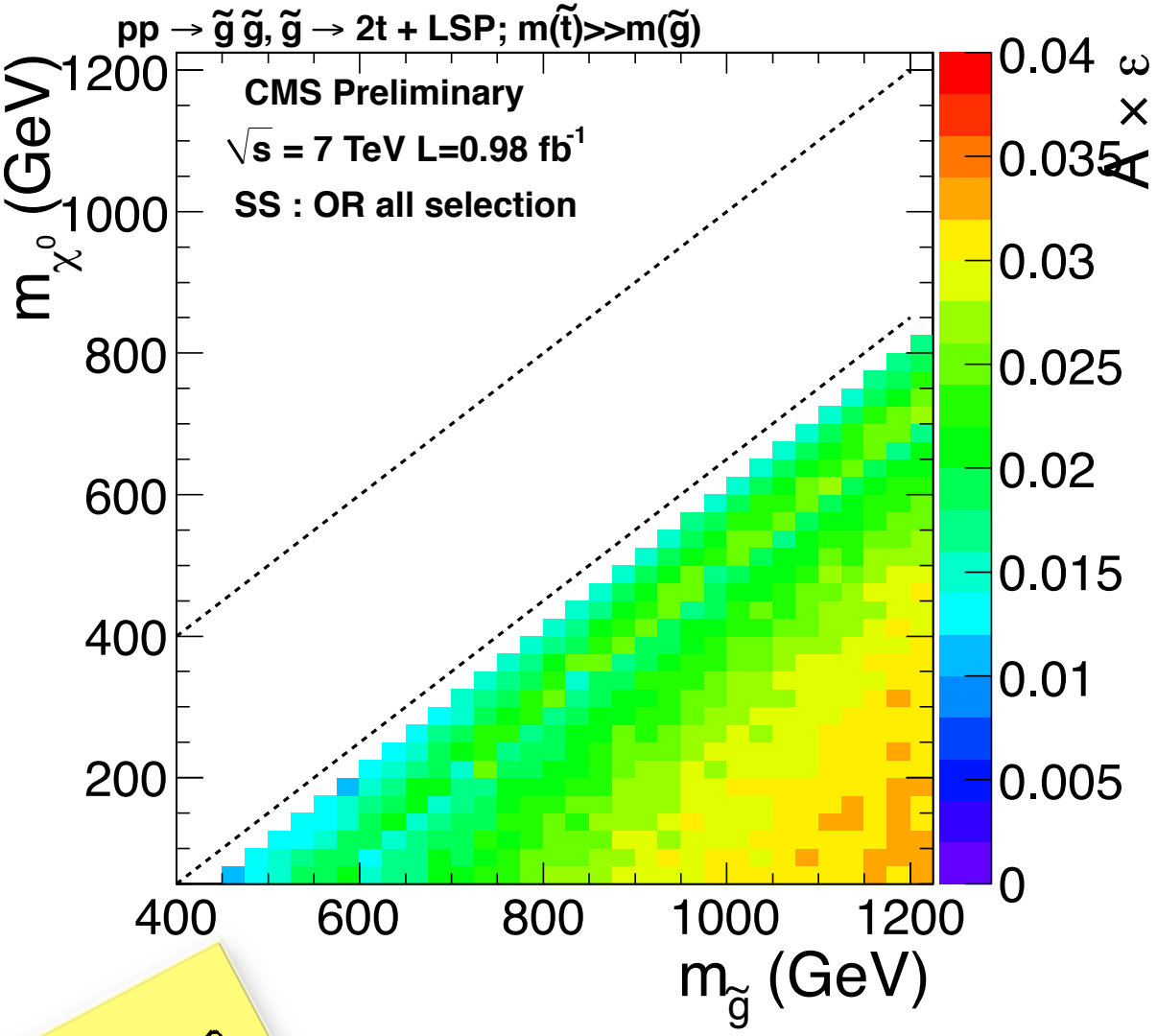
SS dileptons



SUS-11-010

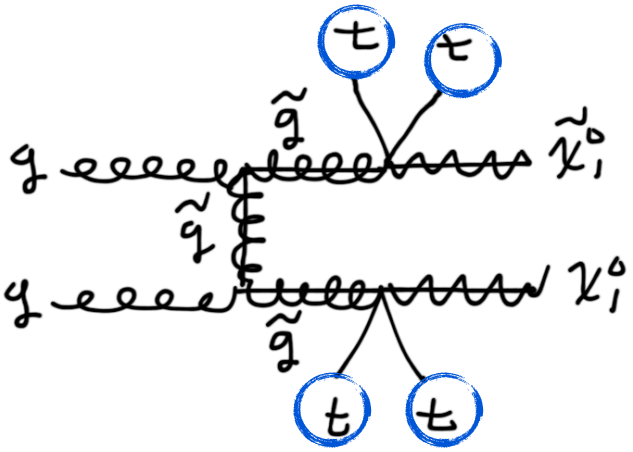
SS dileptons

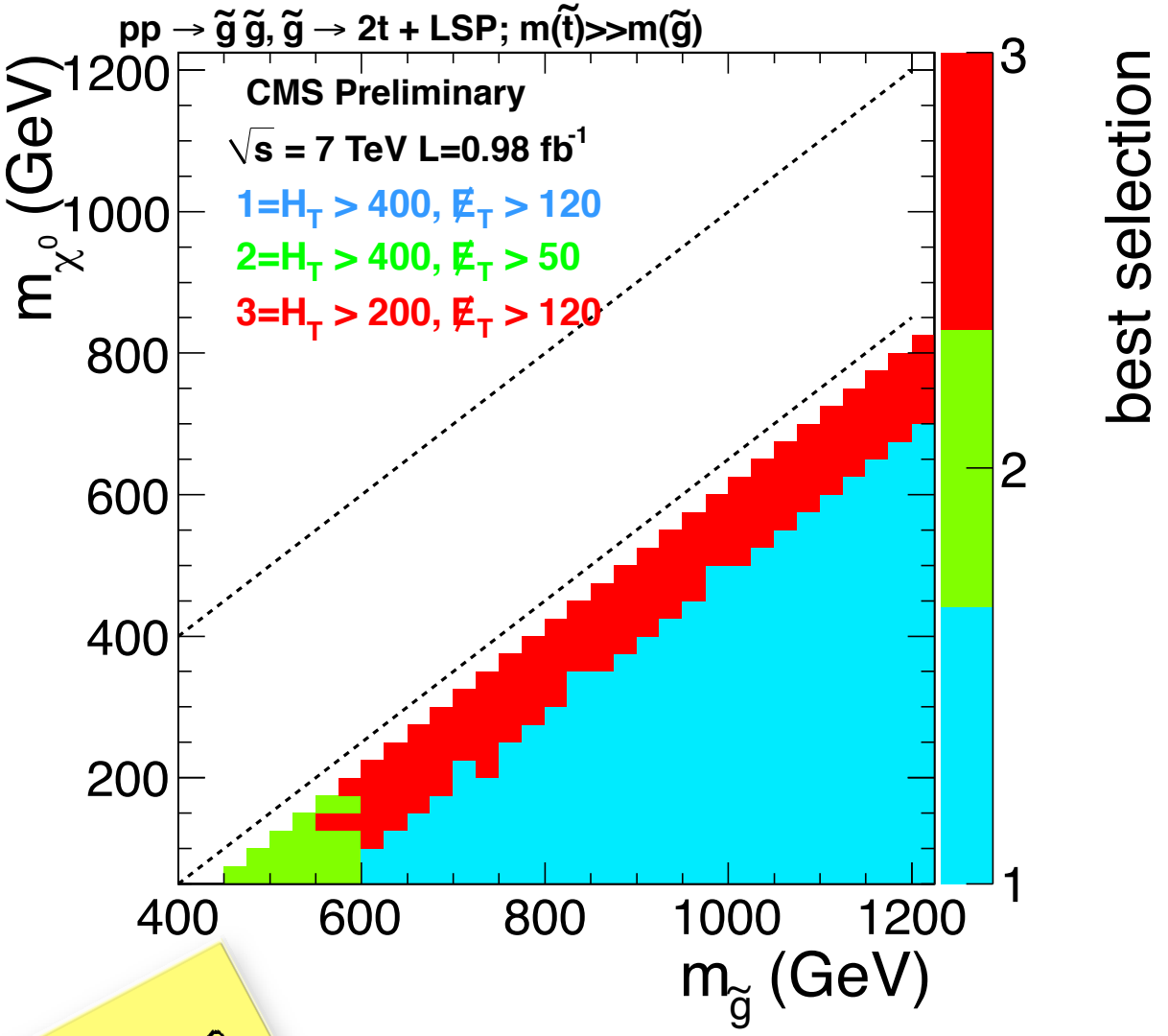




SUS-11-010

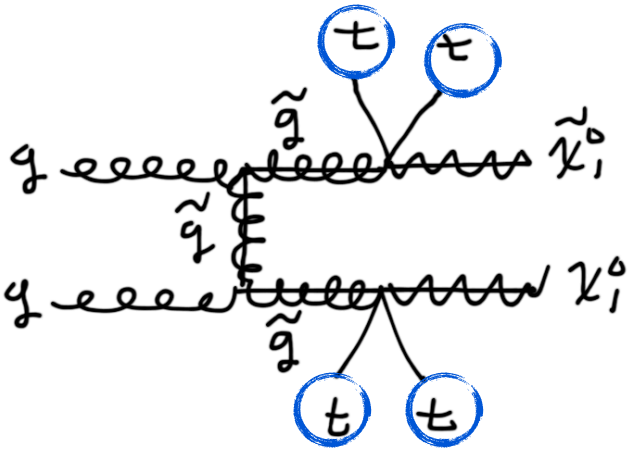
SS dileptons

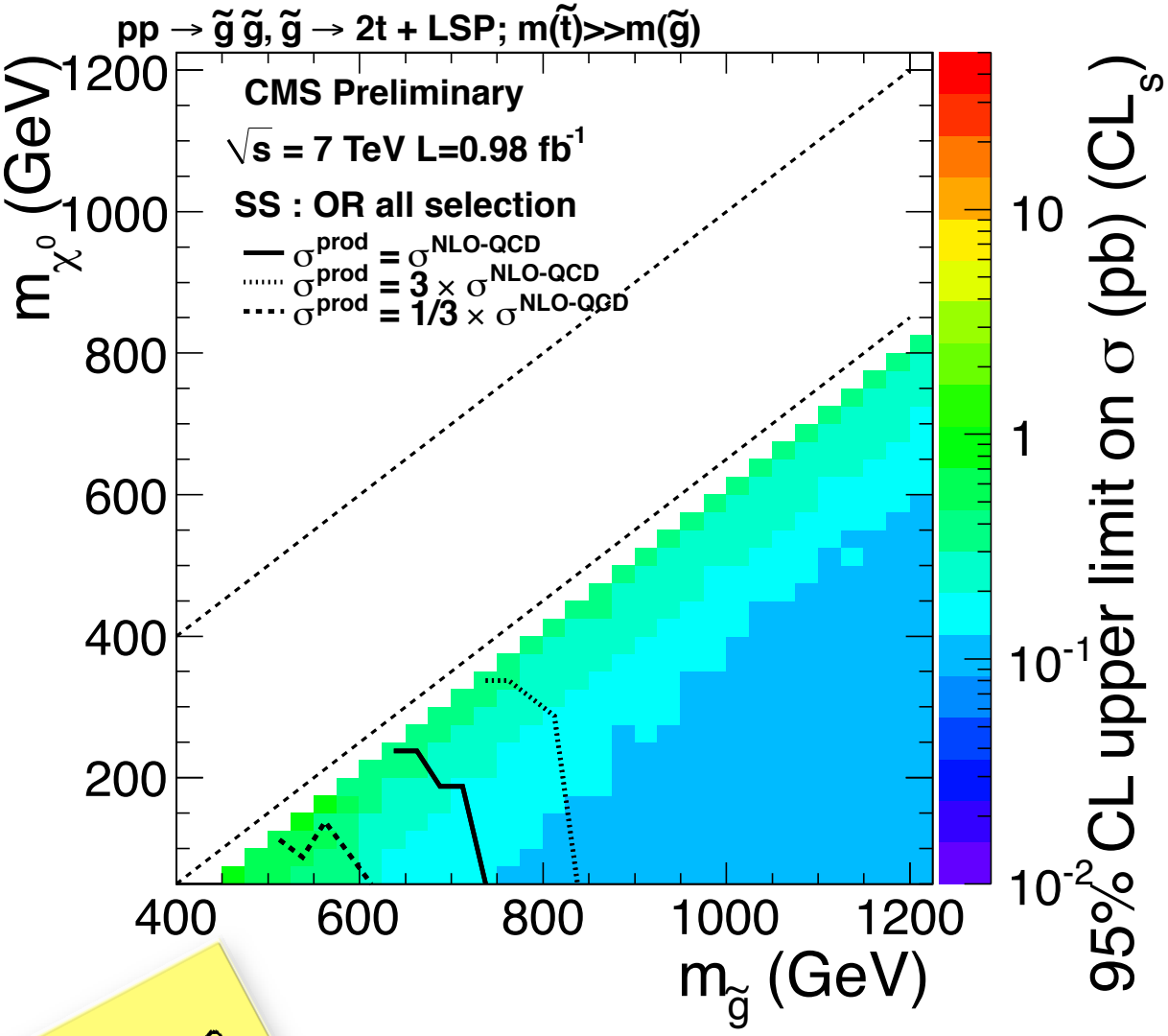




SUS-11-010

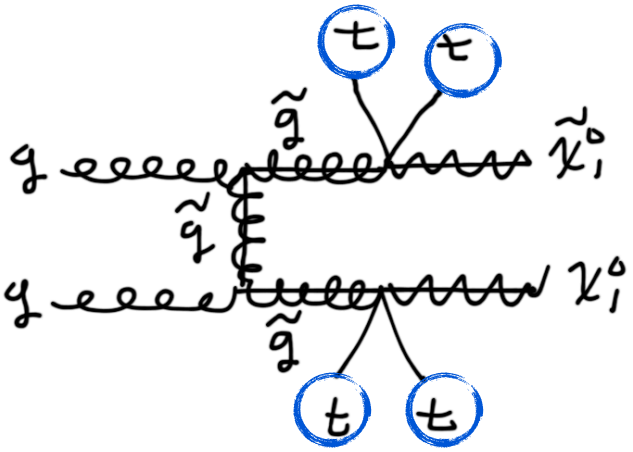
SS dileptons

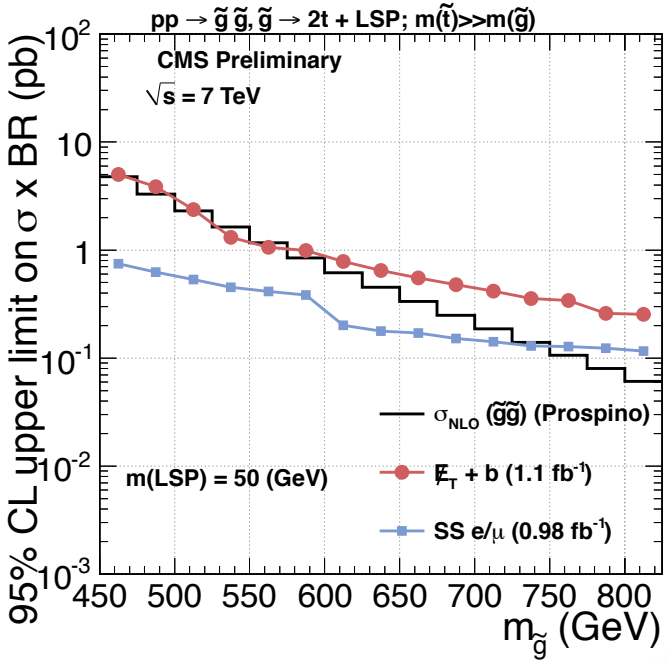


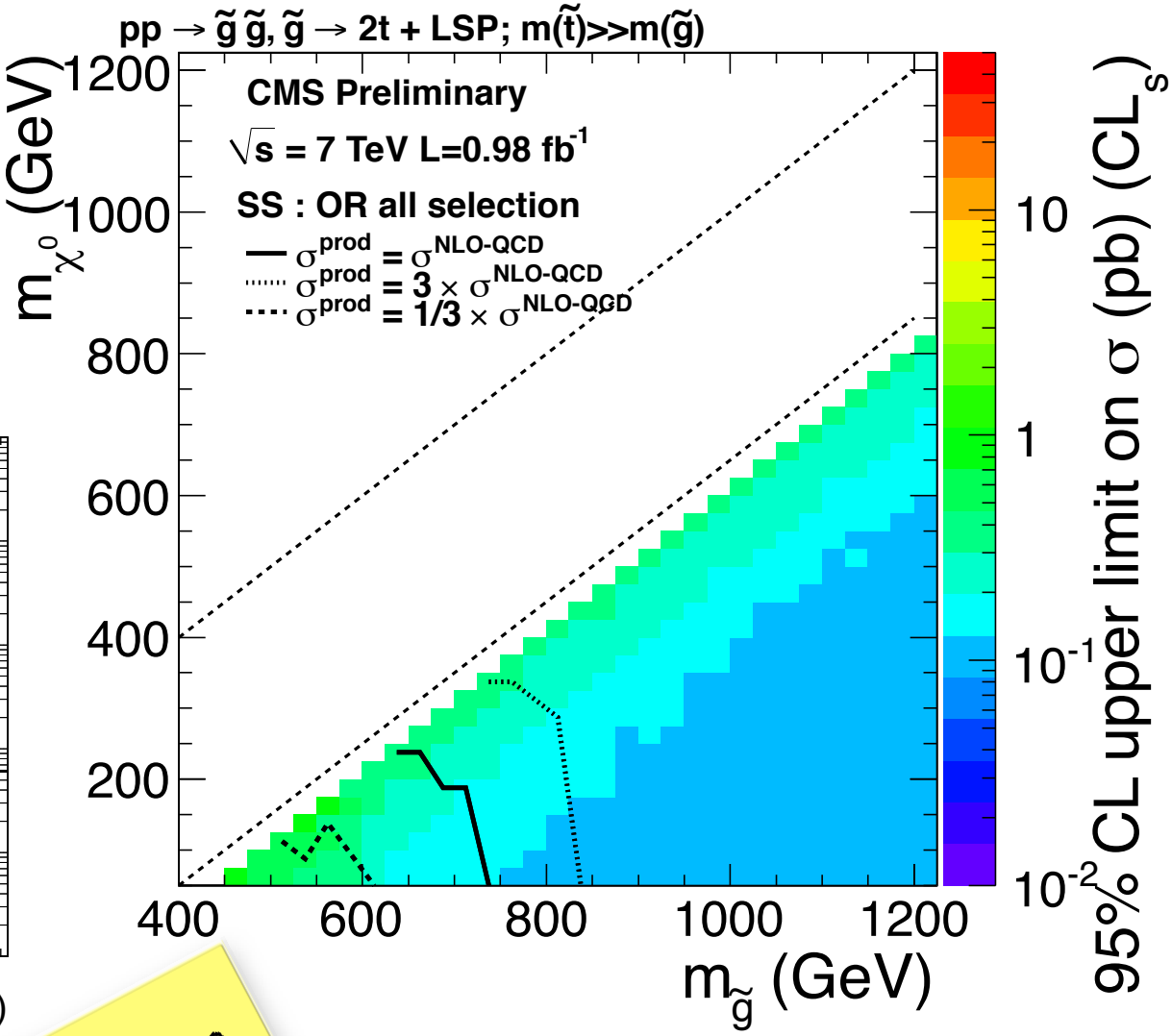


SUS-11-010

SS dileptons







SUS-11-010

SS dileptons and b-jets

SS Dileptons + 2b-jets

- Similar to SS dilepton analysis: just add 2 b-tagged jets
- Fake lepton background from b's dramatically smaller!
- top contribution expected to decrease by factor of 2!
- More exclusive search
  - Same-sign top production
  - SUSY 4 top final states
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  - SUSY 4b4W final states

SUS-11-020

SS dileptons and b-jets

SS Dileptons + 2b-jets

- Similar to SS dilepton analysis: just add 2 b-tagged jets
- Fake lepton background from b's dramatically smaller!
- top contribution expected to decrease by factor of 2!
- More e
  - Same
  - SUSY
  - SUSY
  - SUSY

SUS-11-020

NEW!

	SR1	SR2	SR3	SR4	SR5	SR6	SR7
No. of jets	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 3
No. of btags	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 3
Lepton charges	$++/--$	$++$	$++/--$	$++/--$	$++/--$	$++/--$	$++/--$
$\not\!\!E_T$	≥ 30 GeV	≥ 30 GeV	≥ 120 GeV	≥ 50 GeV	≥ 50 GeV	≥ 120 GeV	≥ 50 GeV
H_T	≥ 80 GeV	≥ 80 GeV	≥ 200 GeV	≥ 200 GeV	≥ 320 GeV	≥ 320 GeV	≥ 200 GeV
q-flip BG	1.1 ± 0.2	0.5 ± 0.1	0.05 ± 0.01	0.3 ± 0.1	0.12 ± 0.03	0.026 ± 0.009	0.008 ± 0.004
Fake BG	3.4 ± 2.0	1.8 ± 1.2	0.32 ± 0.50	1.5 ± 1.1	0.81 ± 0.78	0.15 ± 0.45	0.15 ± 0.45
Rare SM BG	3.2 ± 1.6	2.1 ± 1.1	0.56 ± 0.28	2.0 ± 1.0	1.04 ± 0.52	0.39 ± 0.20	0.11 ± 0.06
Total BG	7.7 ± 2.6	4.4 ± 1.6	0.9 ± 0.6	3.7 ± 1.5	2.0 ± 0.9	0.6 ± 0.5	0.3 ± 0.5
Event yield	7	5	2	5	2	0	0
N_{UL} (12% unc.)	7.4	6.9	5.2	7.3	4.7	2.8	2.8
N_{UL} (20% unc.)	7.7	7.2	5.4	7.6	4.8	2.8	2.8
N_{UL} (30% unc.)	8.1	7.6	5.8	8.2	5.1	2.8	2.8

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SUS-11-020

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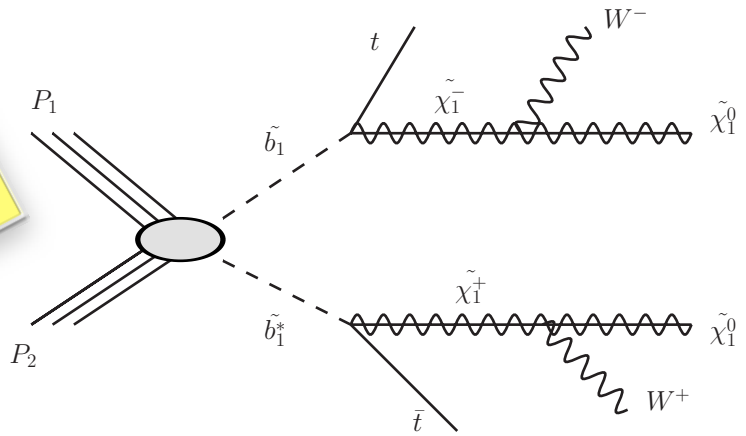
SUS-11-020



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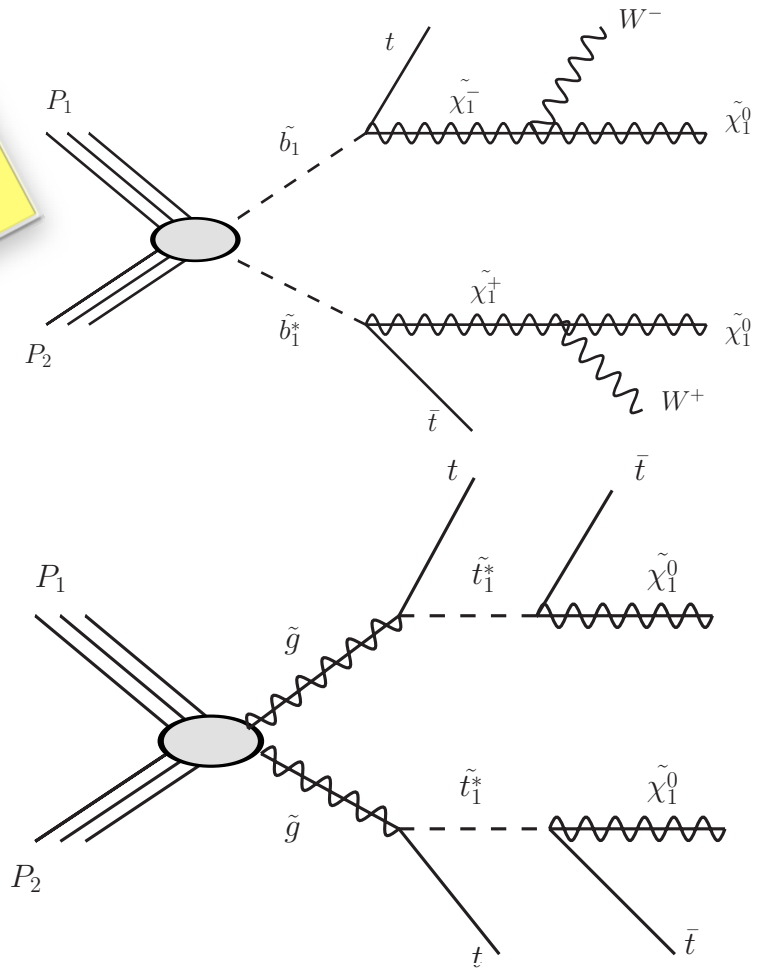

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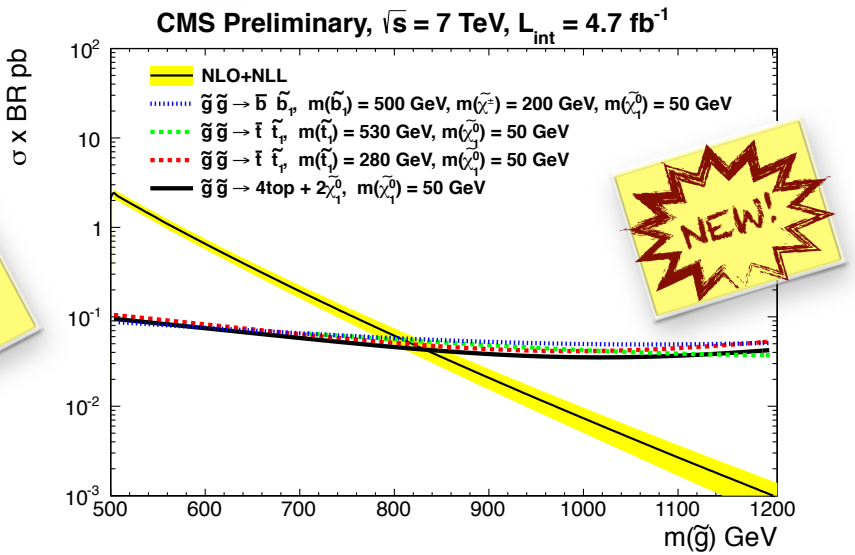

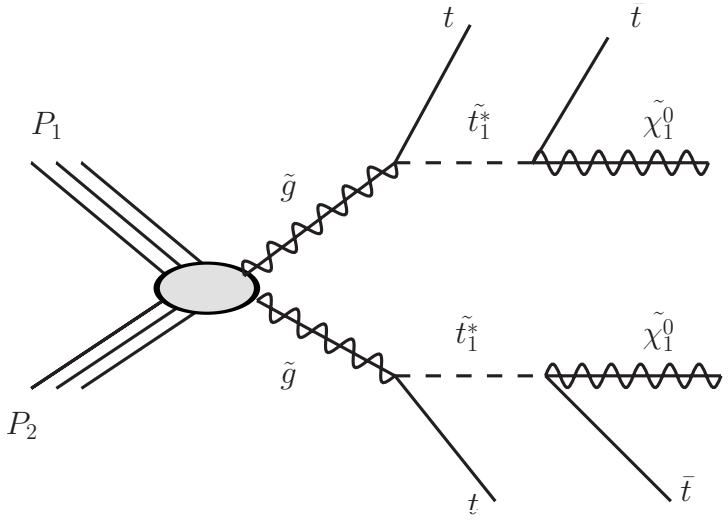

LPC LHC Physics Center

SS dileptons and b-jets

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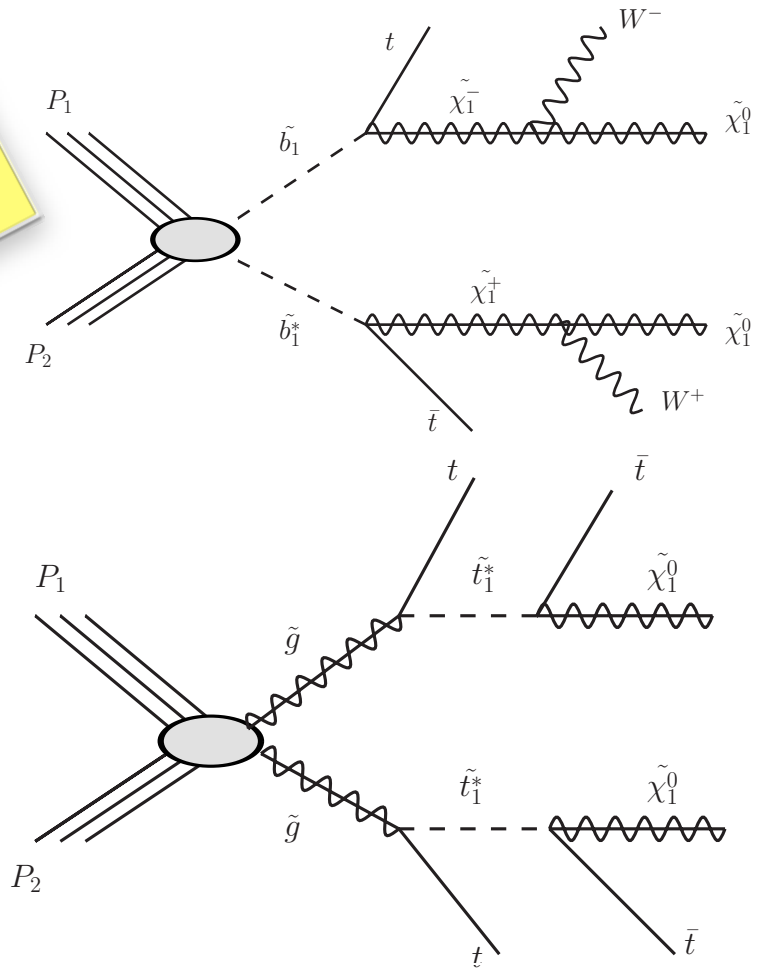
SUS-11-020



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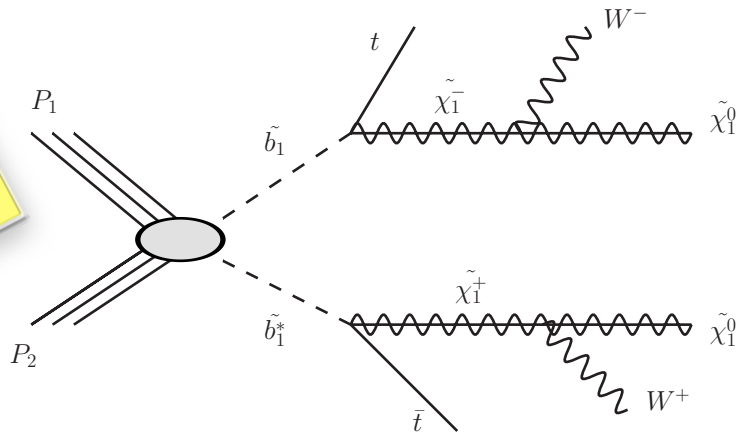

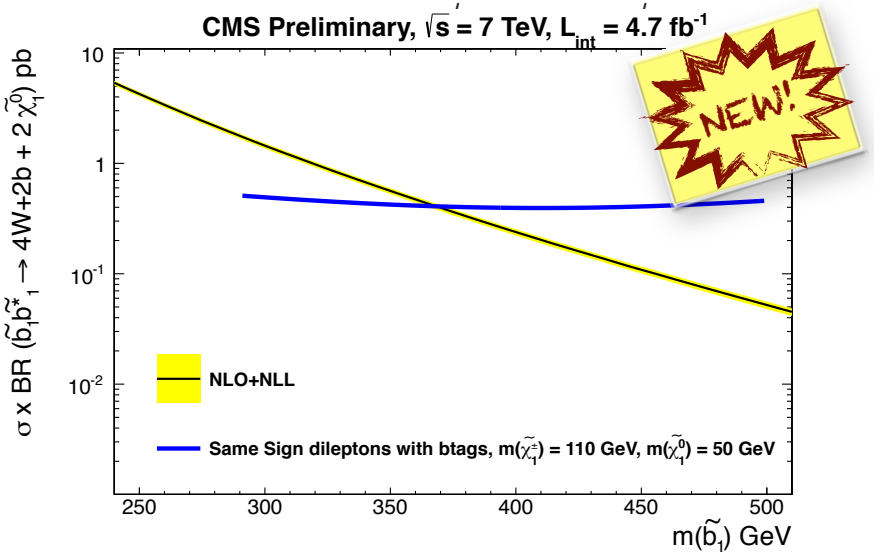

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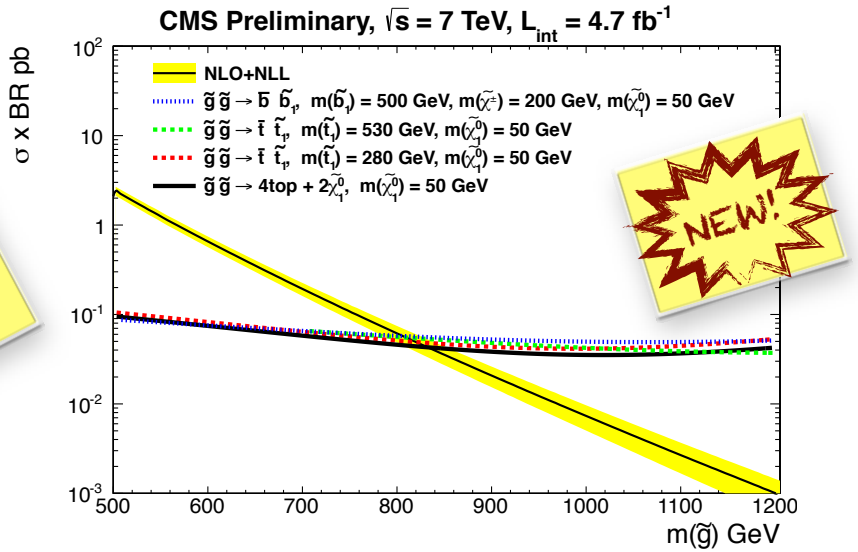
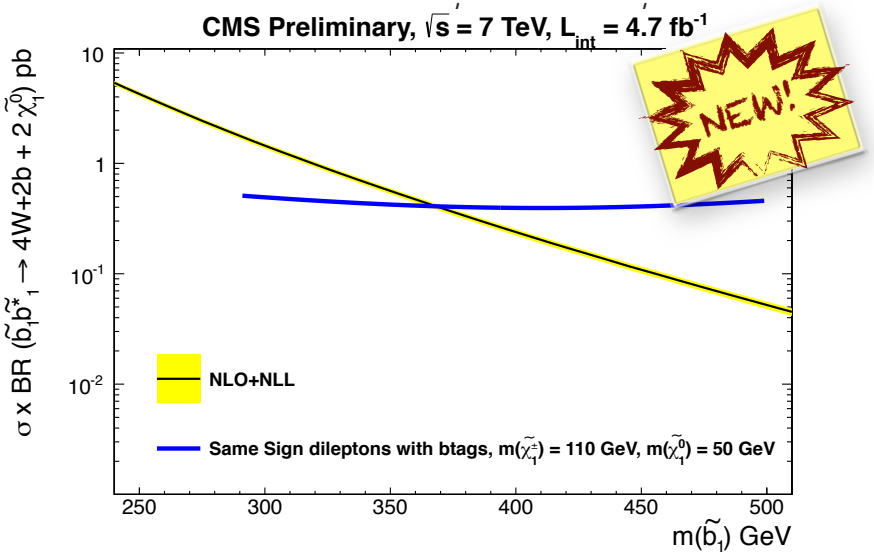
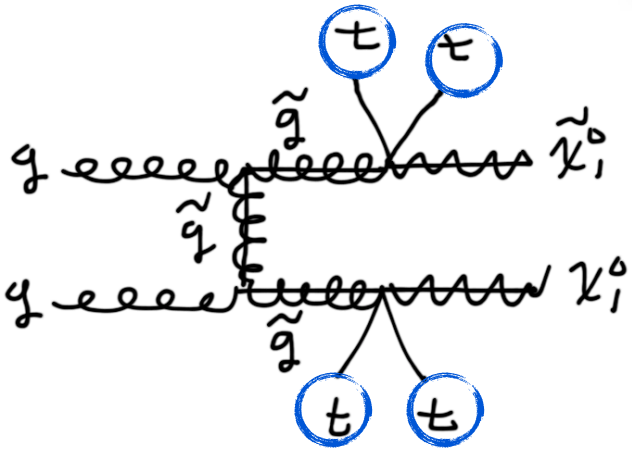




SS dileptons and b-jets



SUS-11-020

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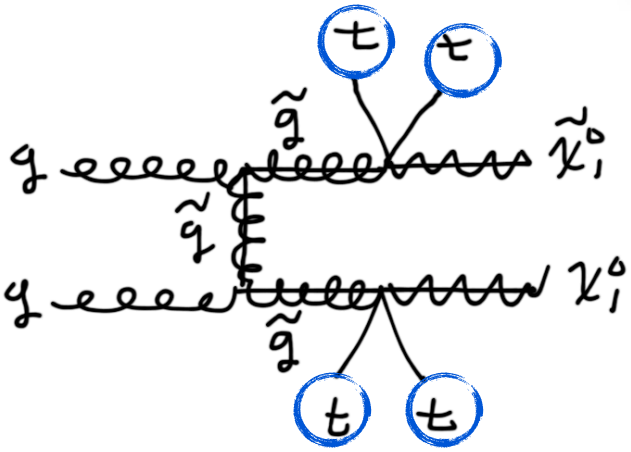

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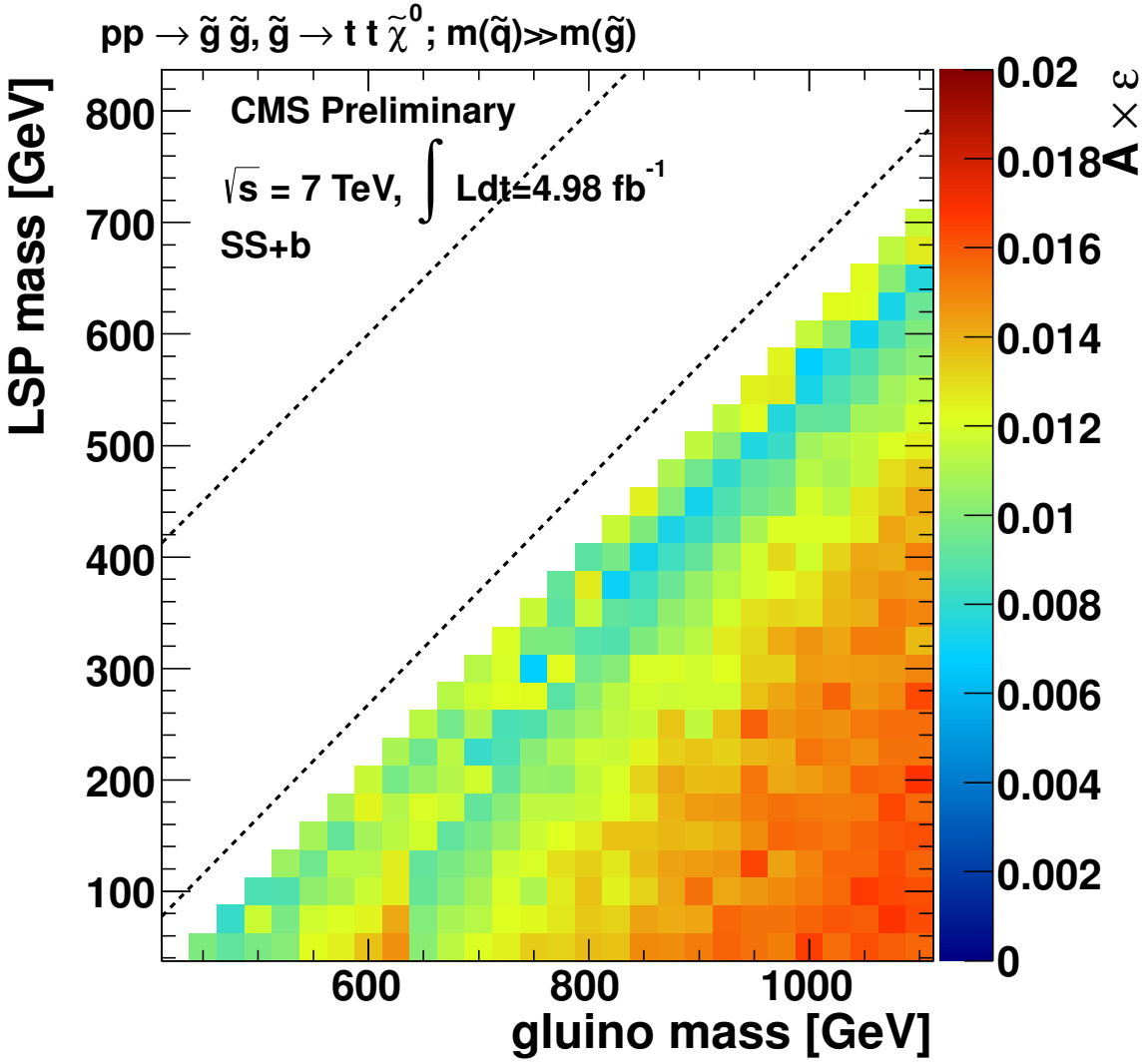

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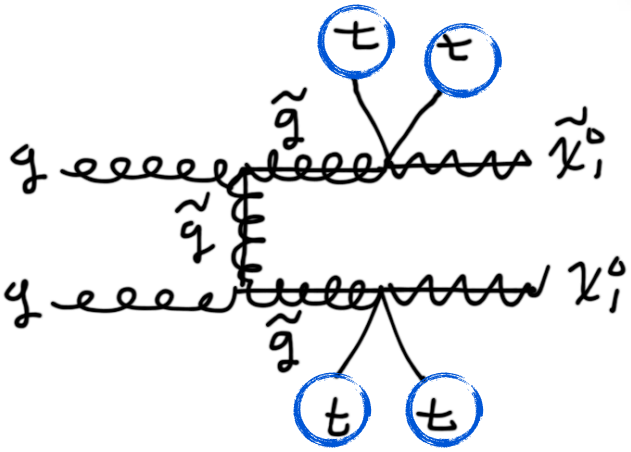

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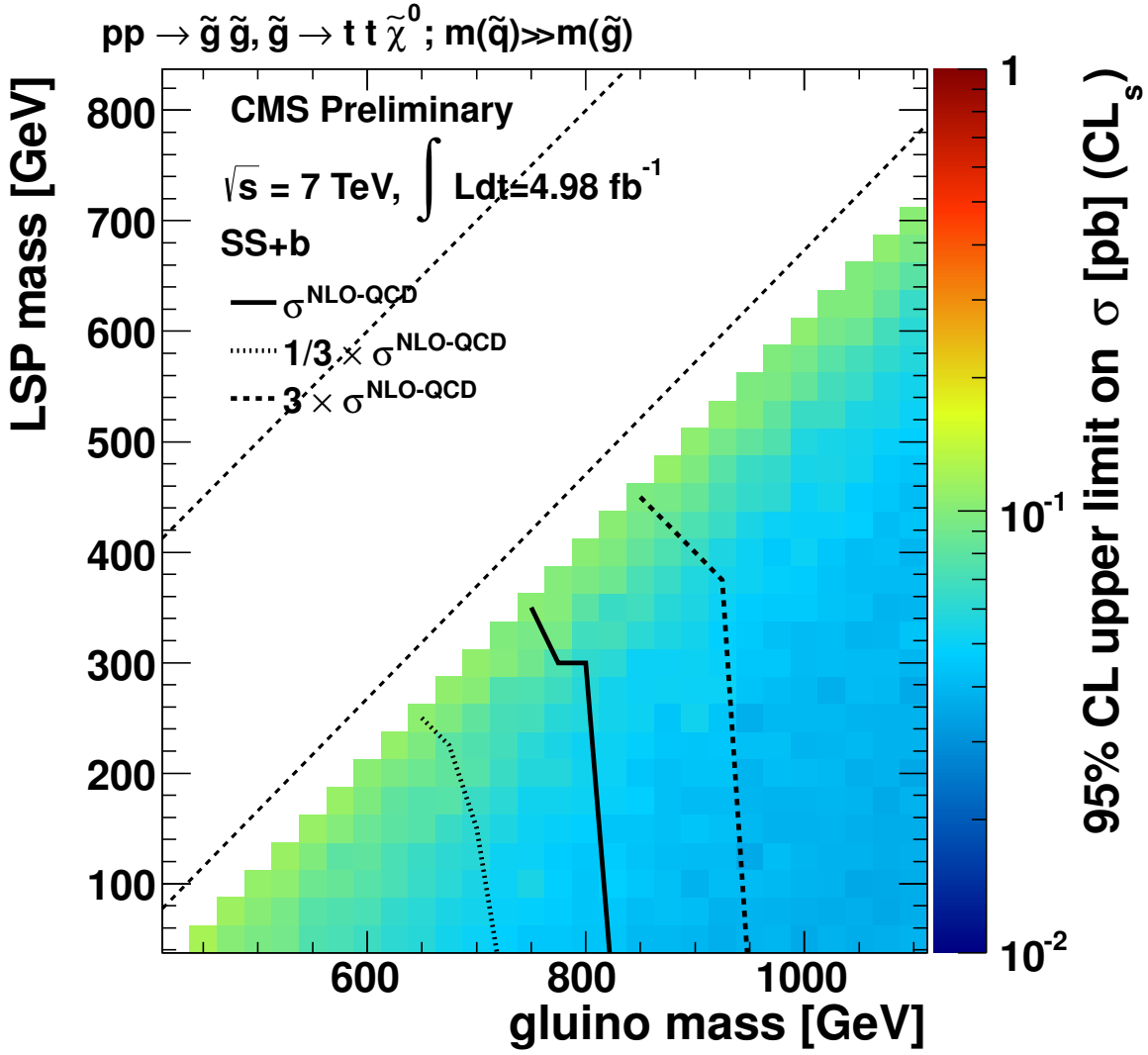
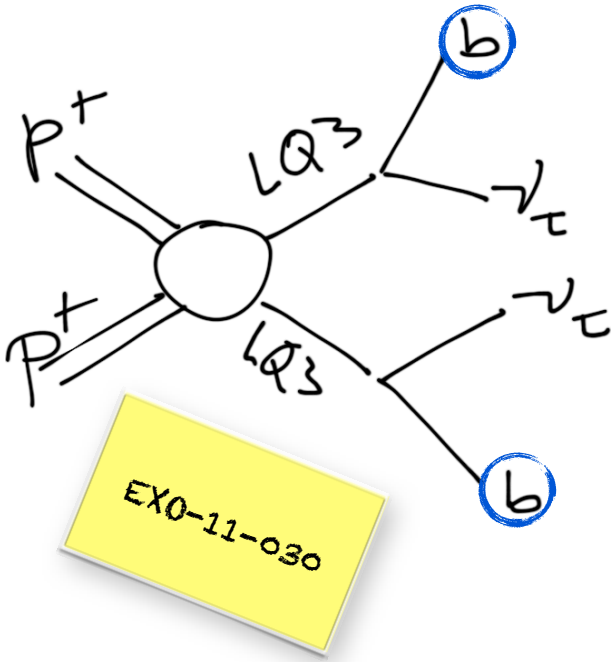


3G Lepto-quarks



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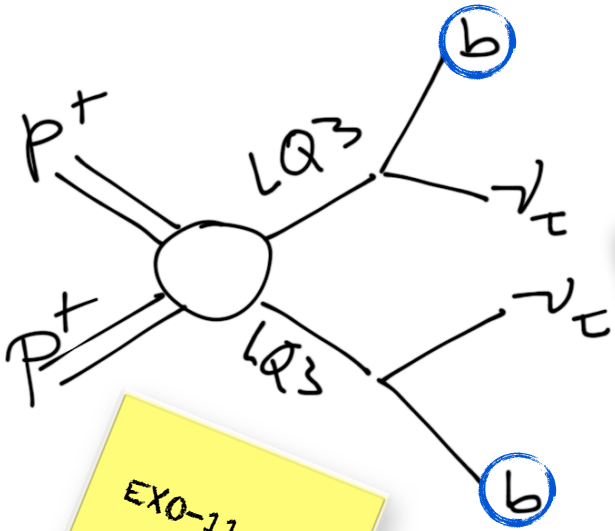

Strategy

- pair of b-jets, large MET, no isolated leptons
- Form two mega-jets
  - less sensitive to ISR/FSR
- Use clever Kinematic Vars.
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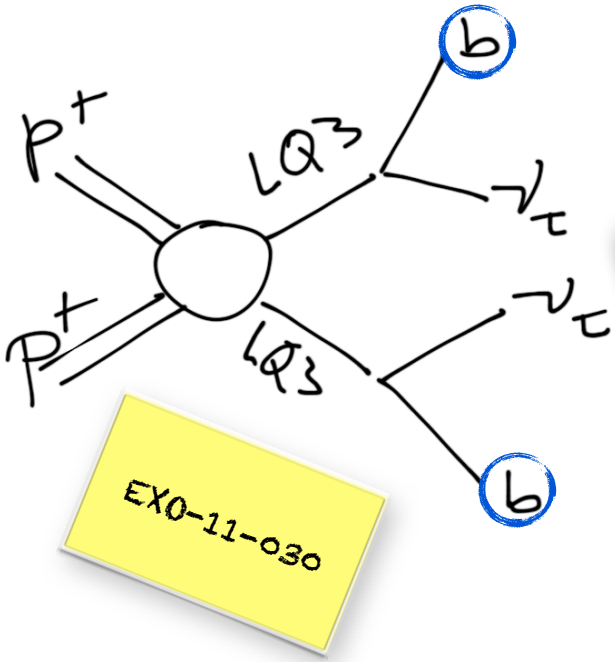

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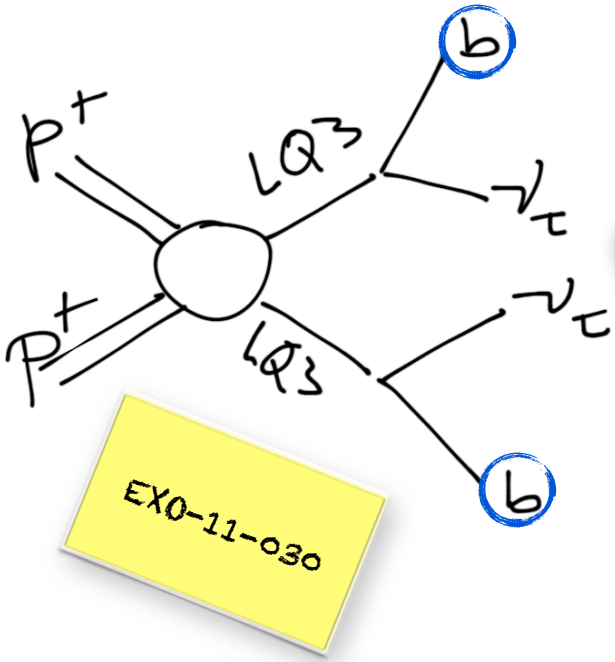

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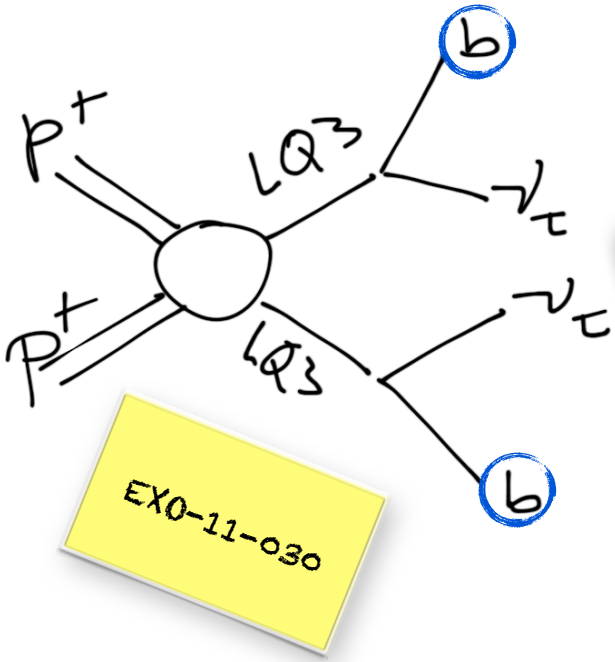

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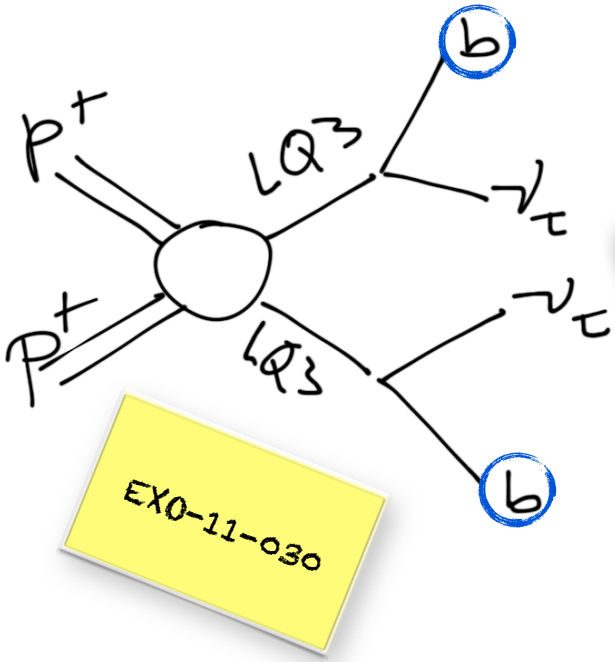

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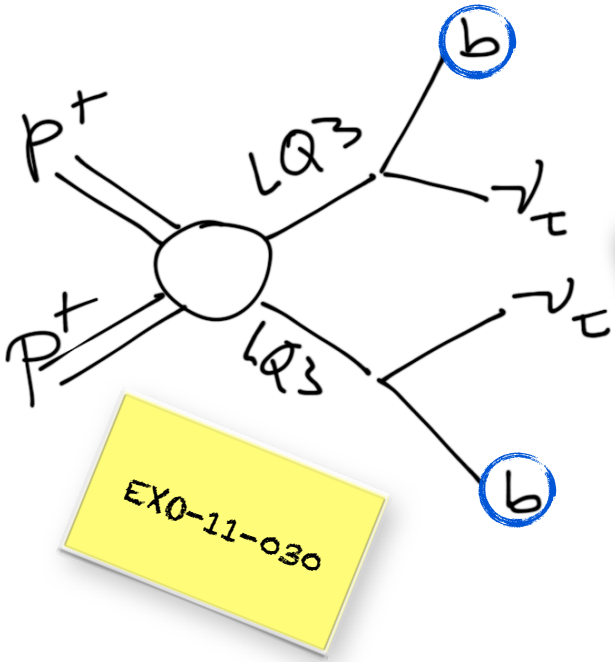

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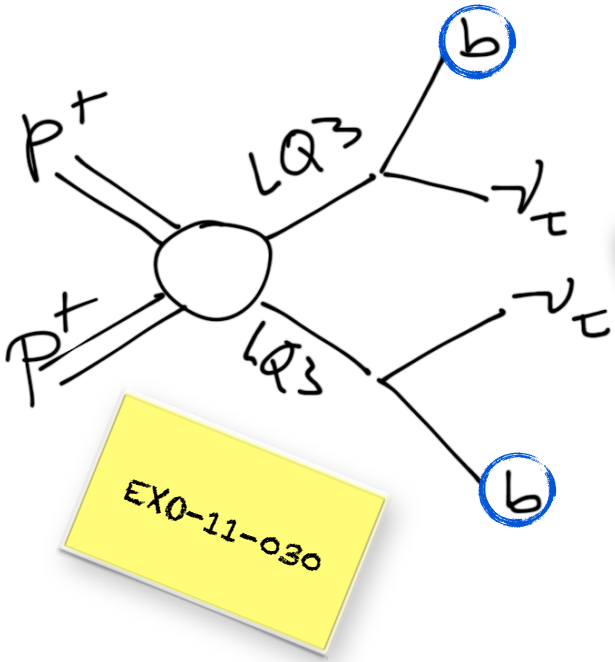

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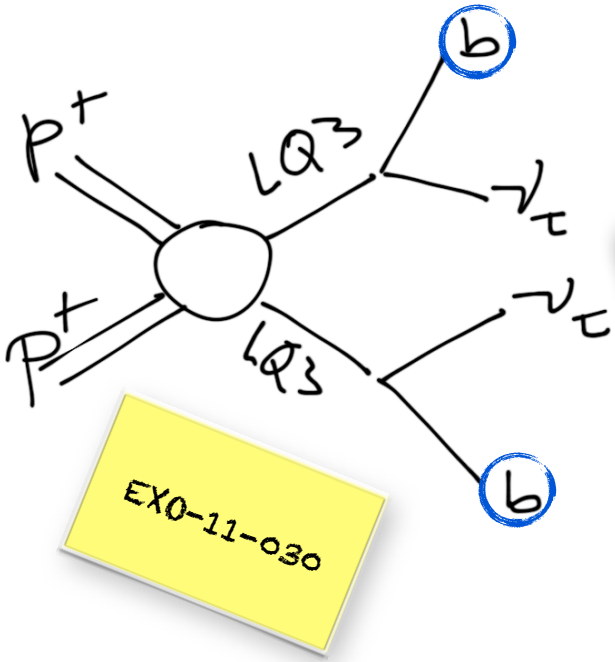

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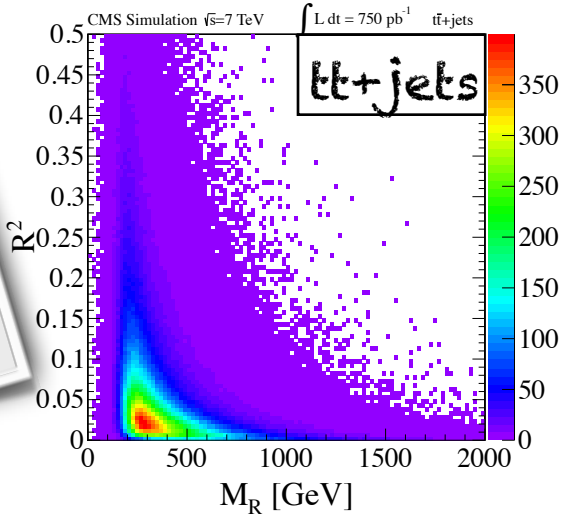

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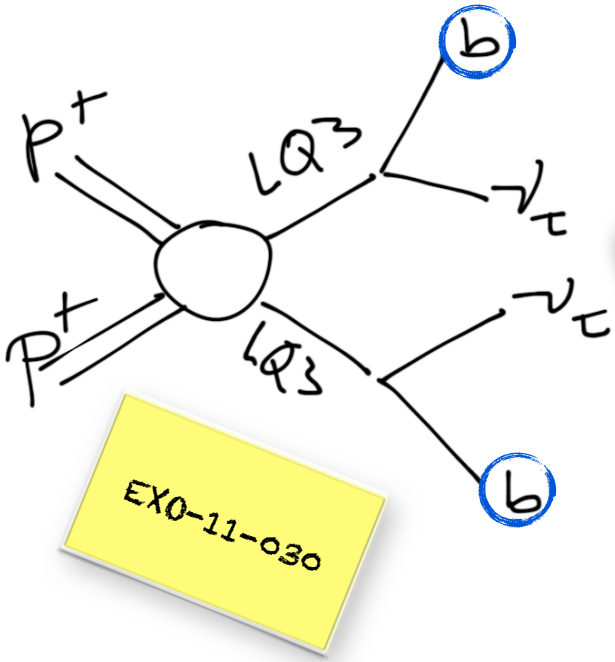

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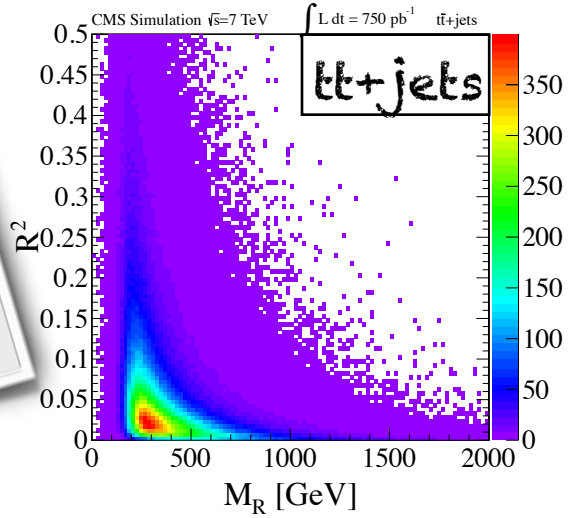

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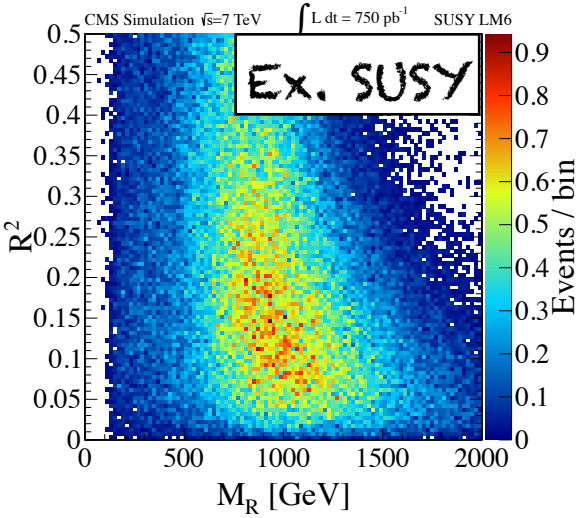

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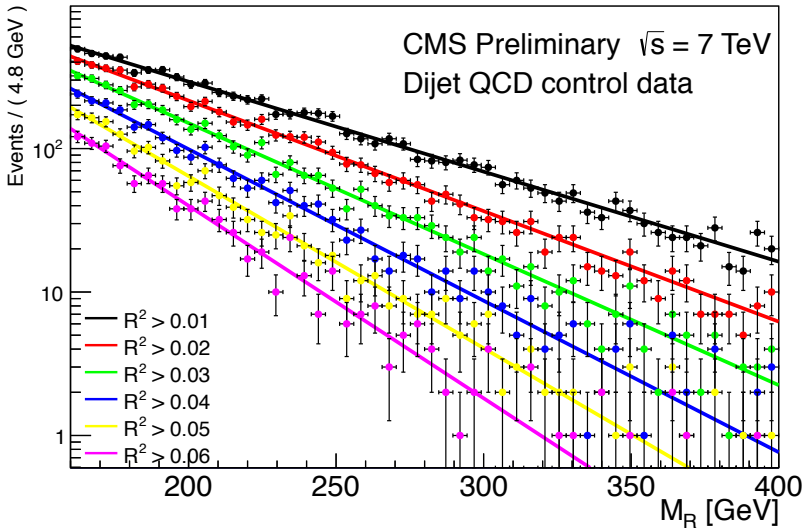
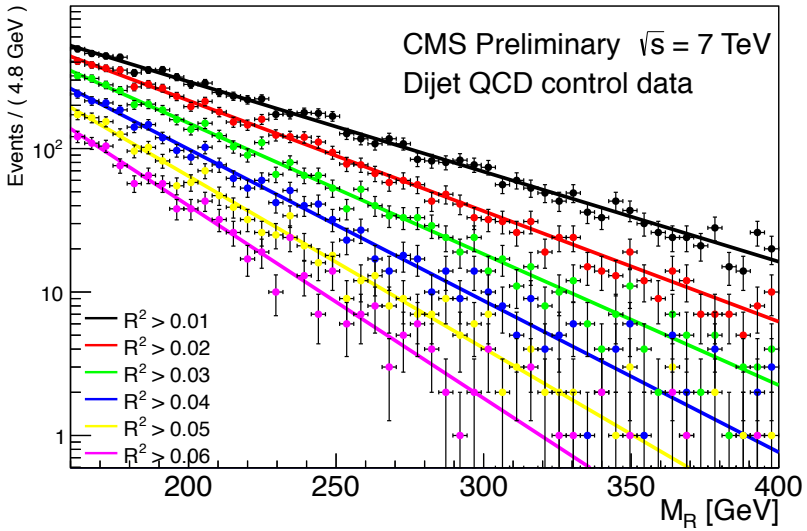


EXO-11-030

Search Strategy

- M_R observed to fall exponentially
- Background strategy
  - fit exponential to data in Control Regions
  - extrapolate into Signal Regions

3G Lepto-quarks



Basic Idea:

EXO-11-030

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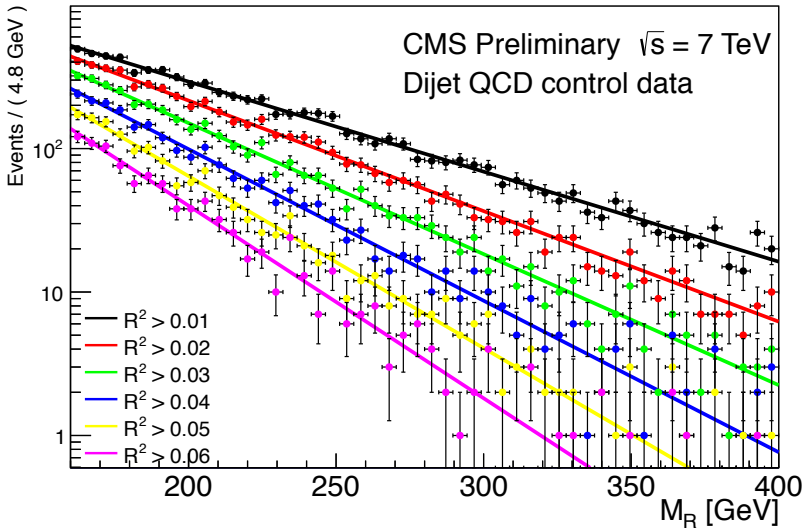
3G Lepto-quarks



Basic Idea:

$$f(M_R) \propto \exp[-SM_R]$$

EXO-11-030

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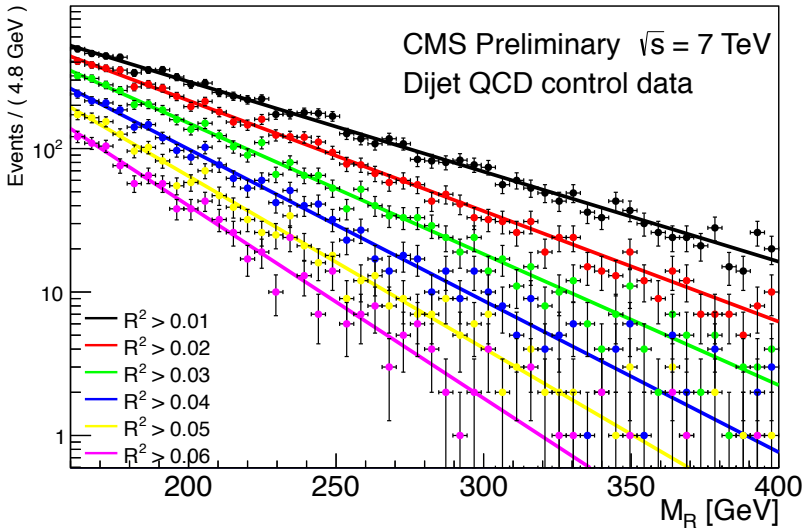
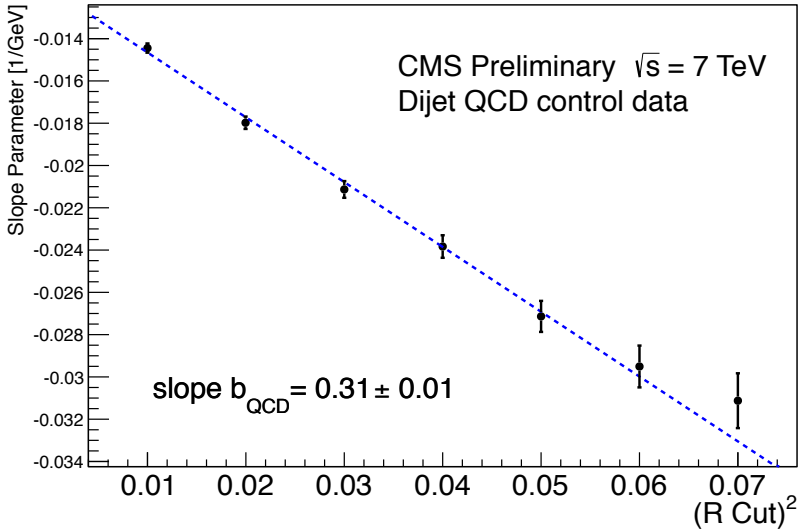
3G Lepto-quarks





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$$f(M_R) \propto \exp[-SM_R]$$

EXO-11-030

Search Strategy

- M_R observed to fall exponentially
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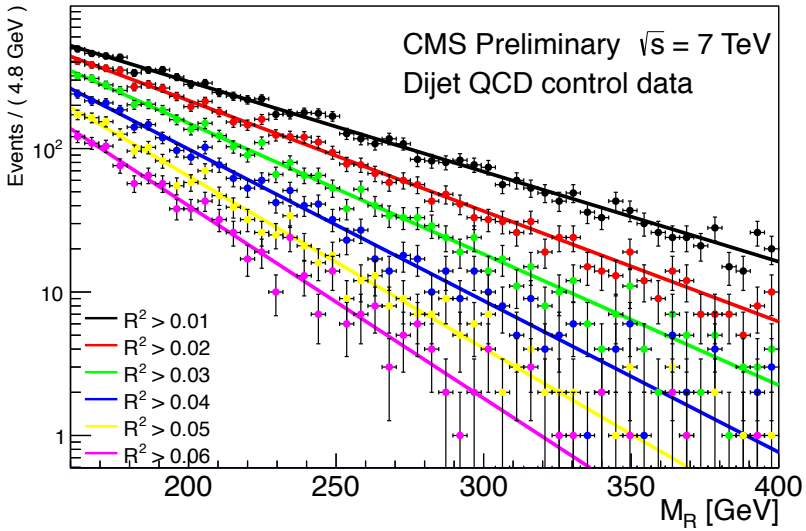
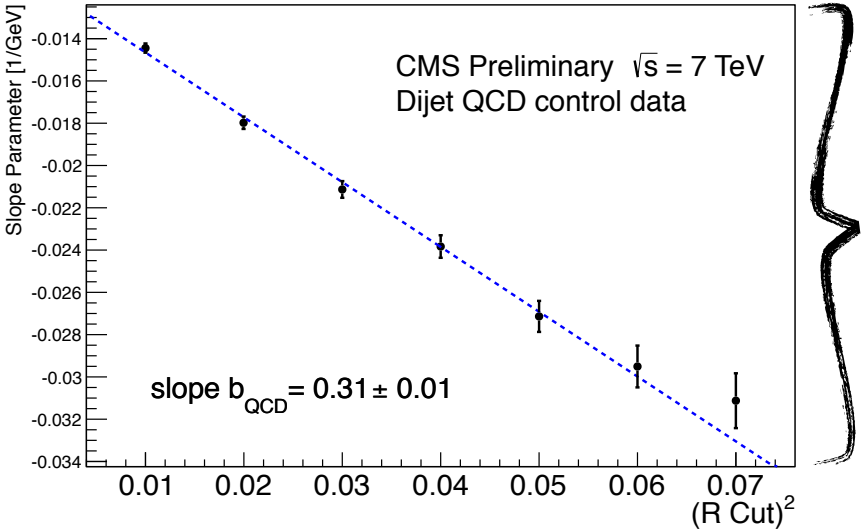
  - extrapolate into Signal Regions

3G Lepto-quarks





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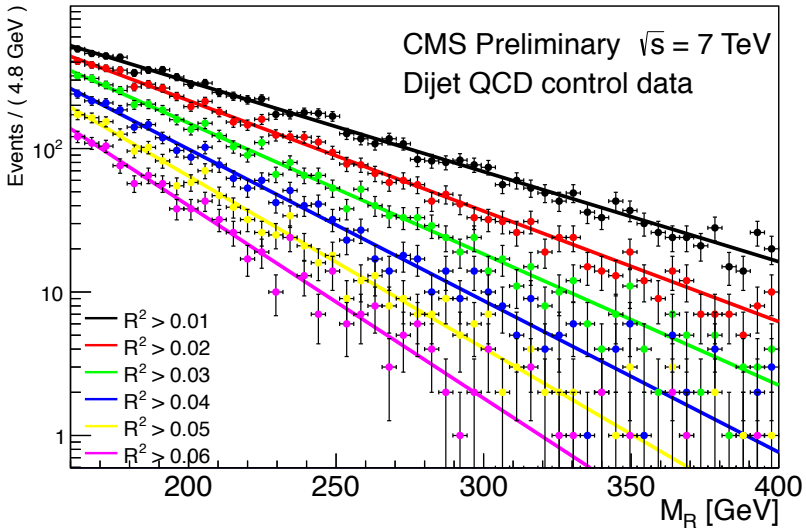

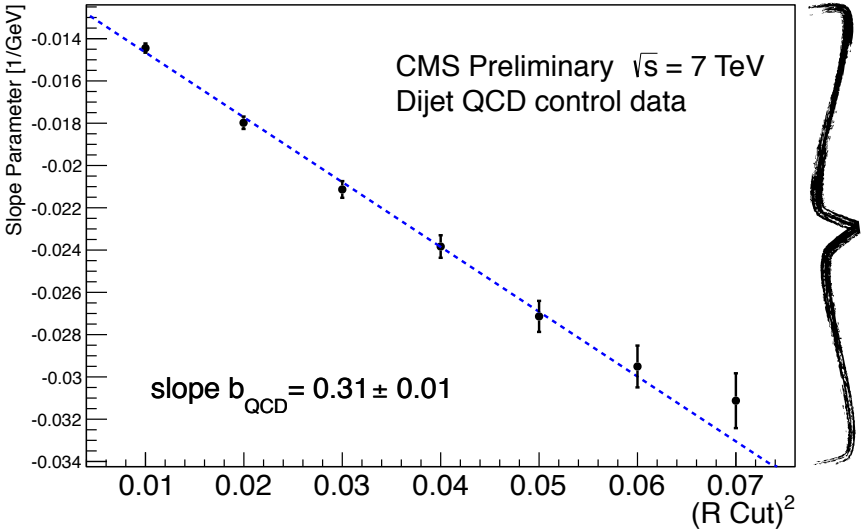

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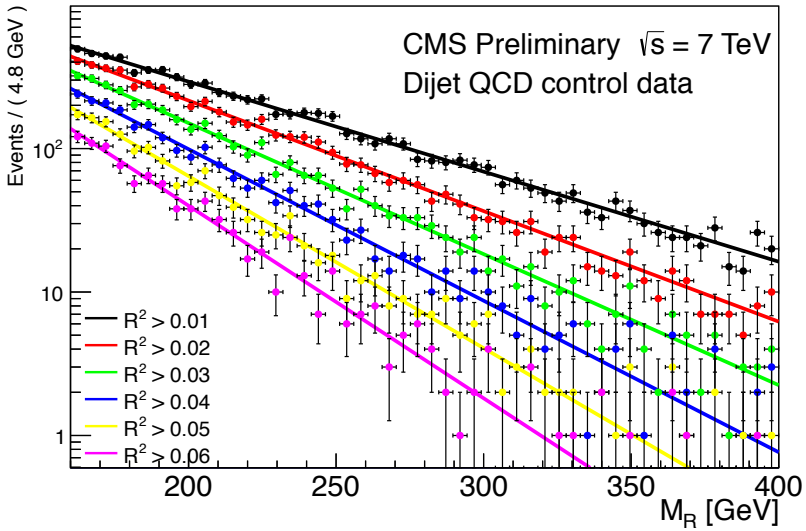

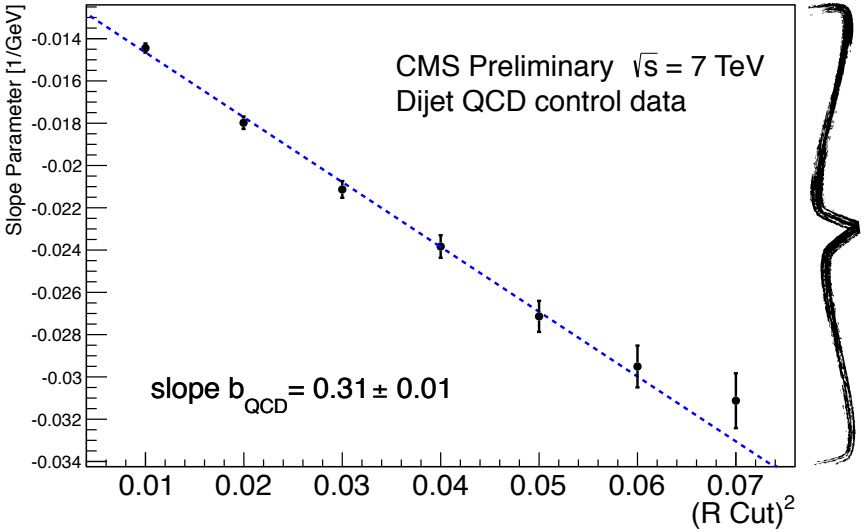

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$$S = a + bR^2_{\text{cut}}$$

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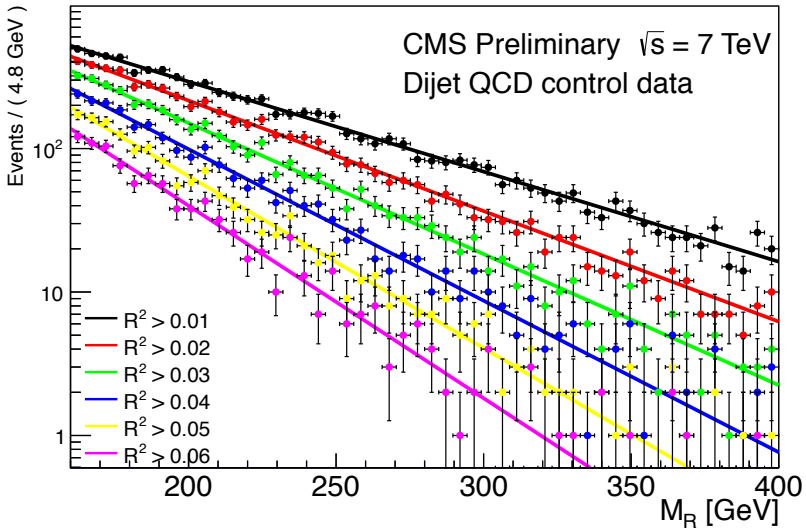

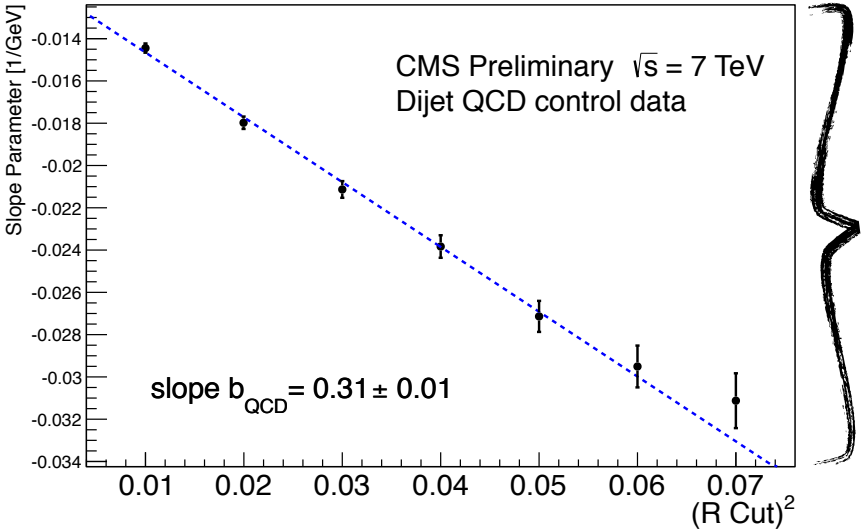

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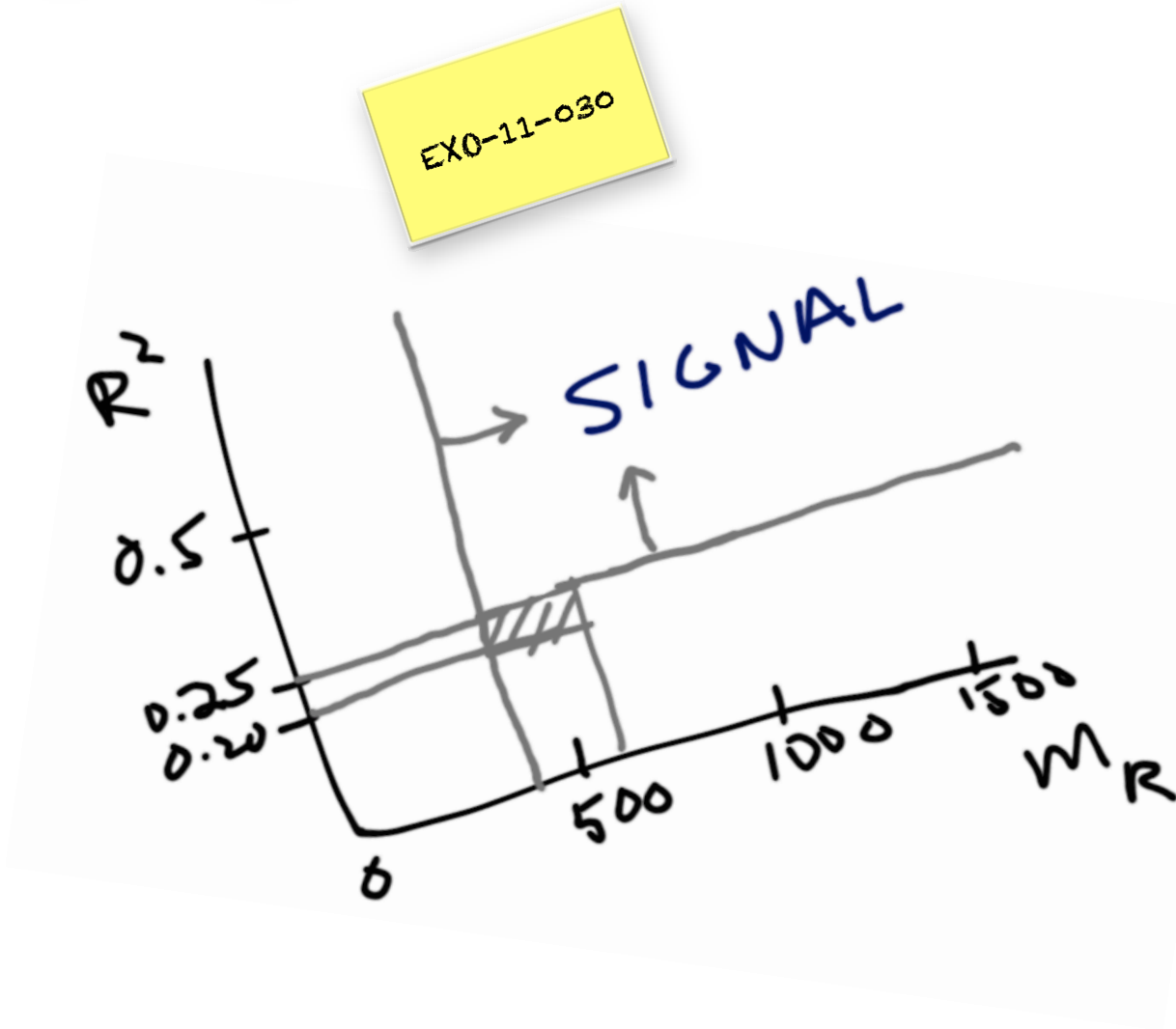
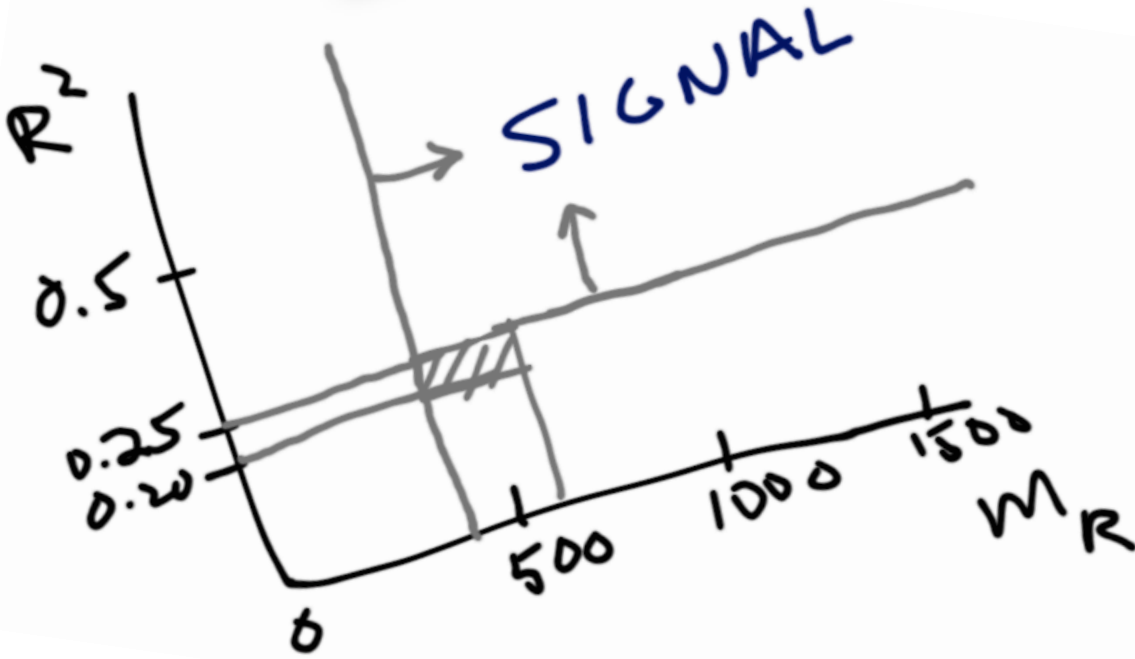


3G Lepto-quarks

Control Sidebands

- Lepton Sidebands (treat l as ν):
  - Electron Box: remove e veto
  - Muon Box: remove μ veto
- =1 b-tag Sidebands

EXO-11-030



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Backgrounds

- W/Z + b-jets
  - Shape: MC
  - Norm: SB in Hadron box; =1 b-tag SB
- ttbar + jets
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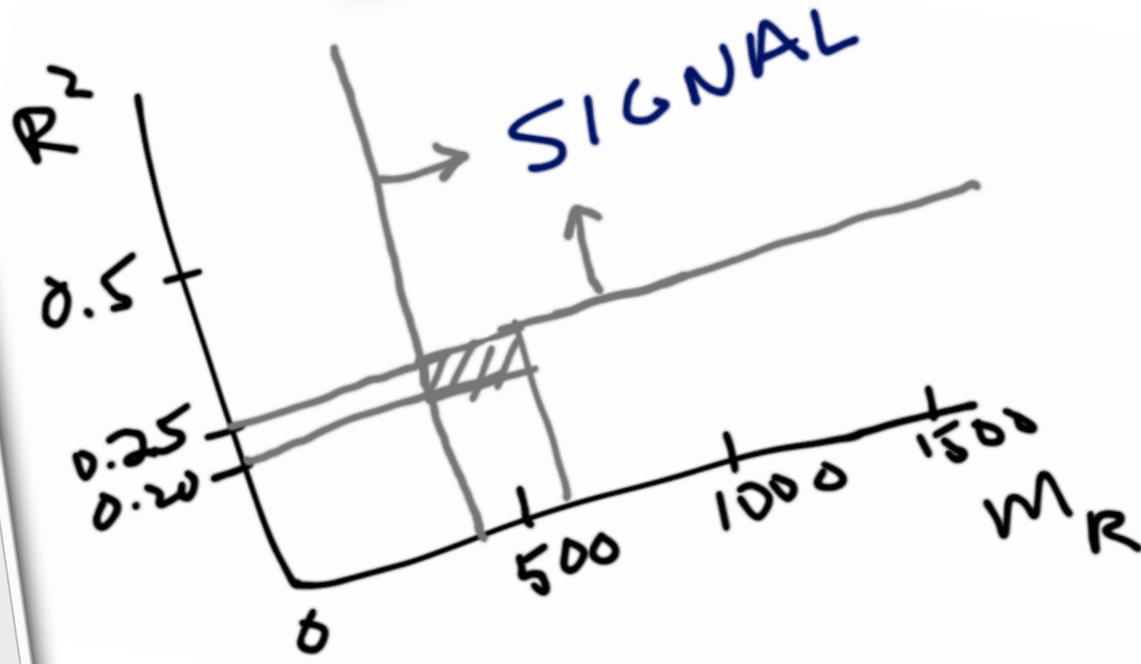
EXO-11-030



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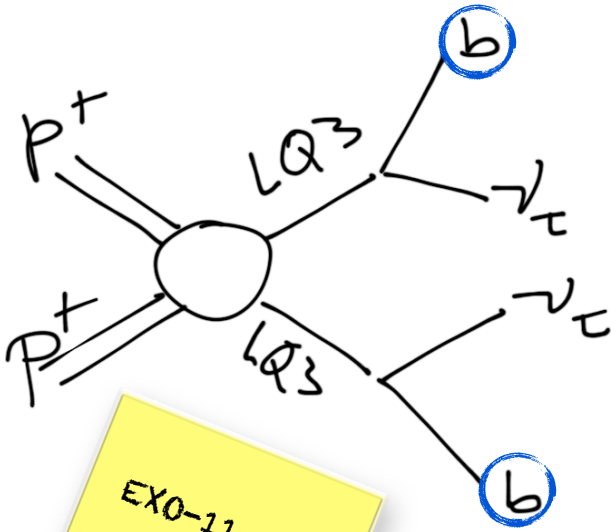

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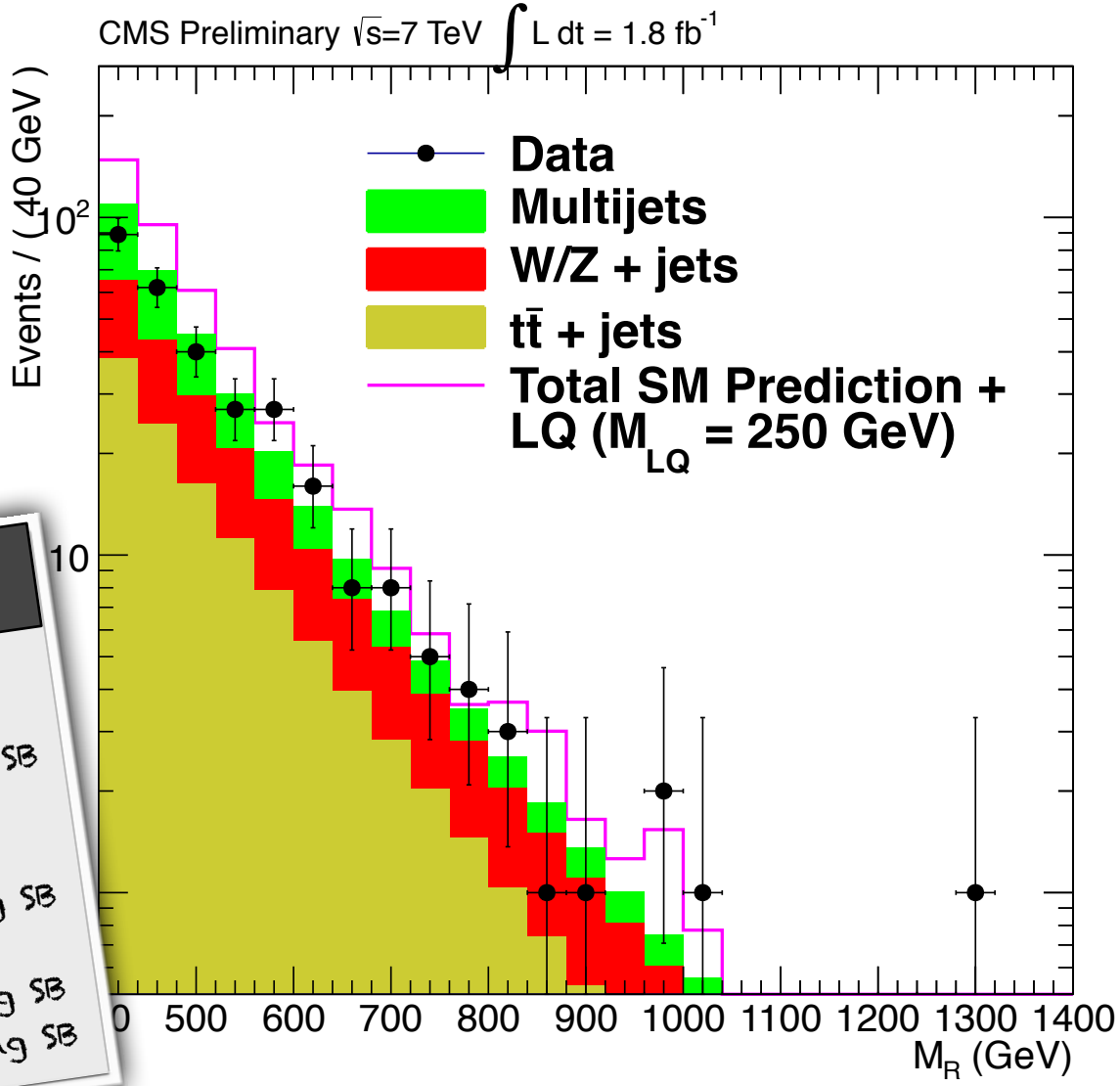

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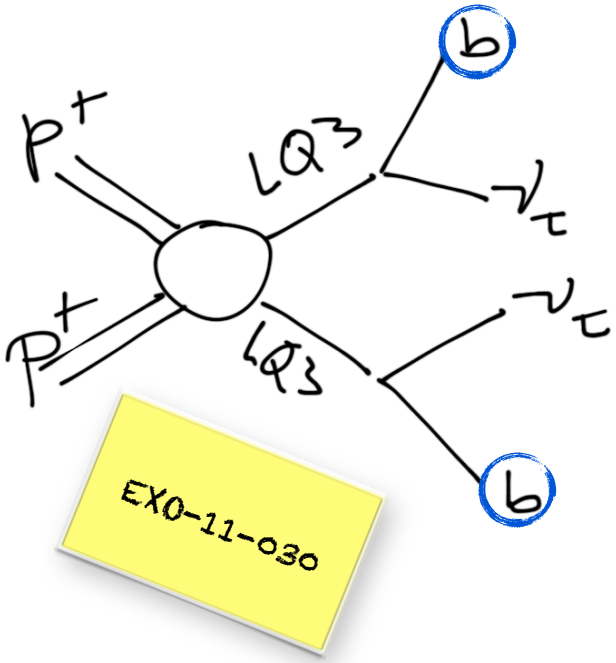

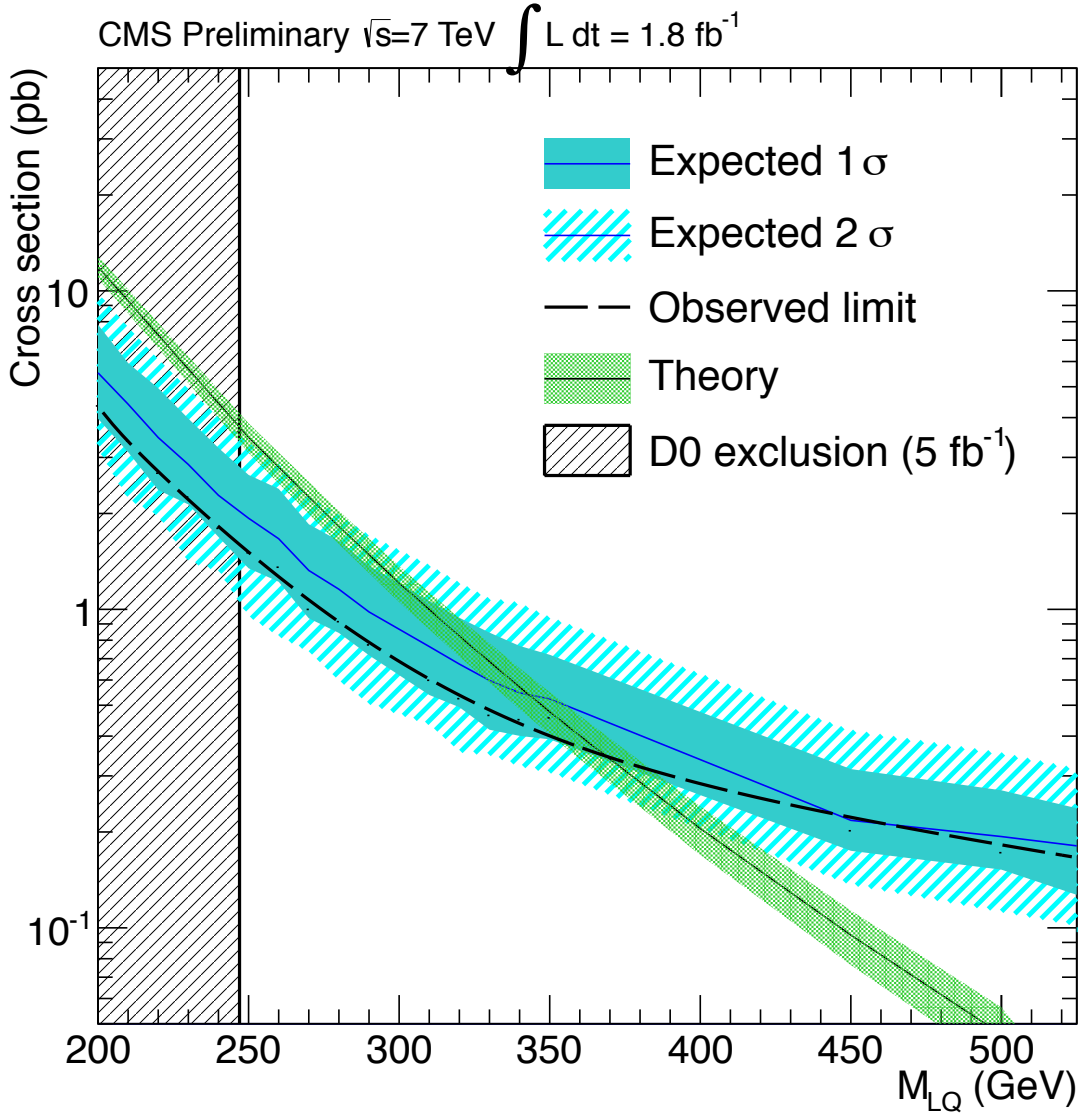

EXO-11-030 pas

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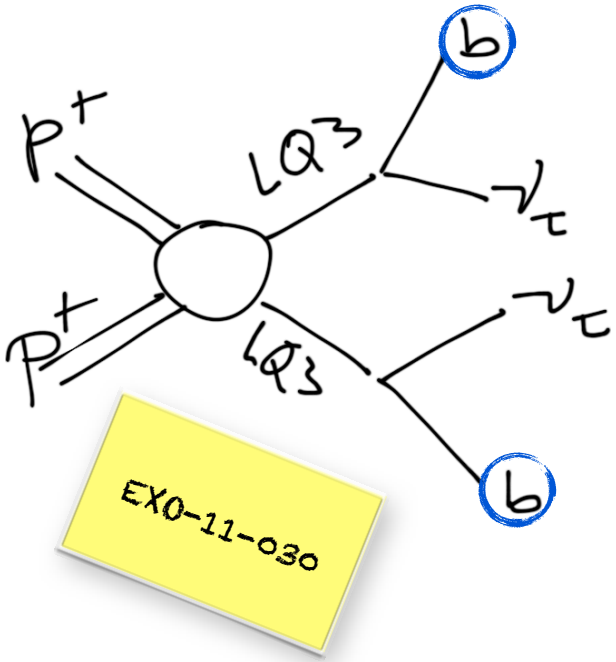
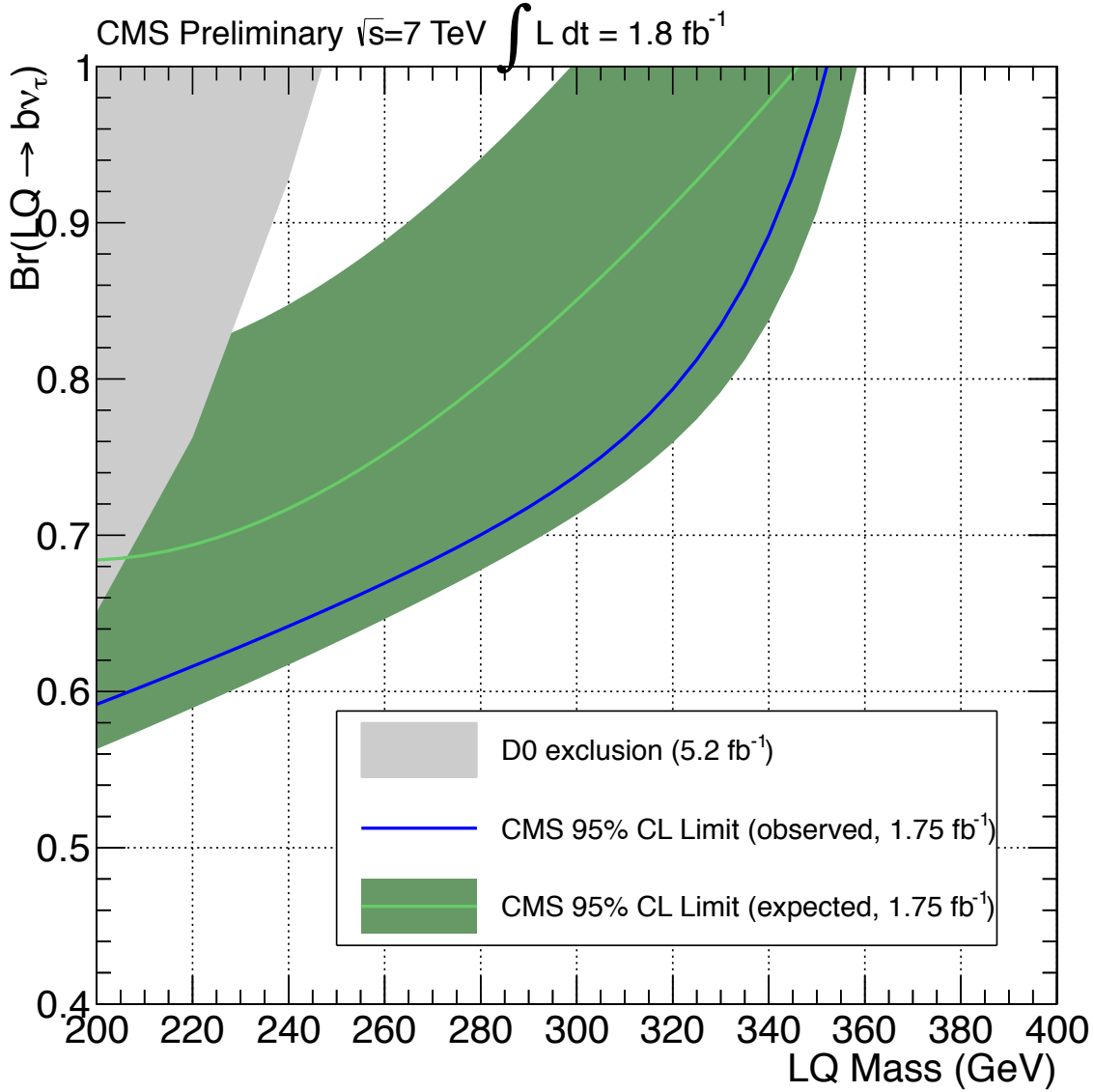
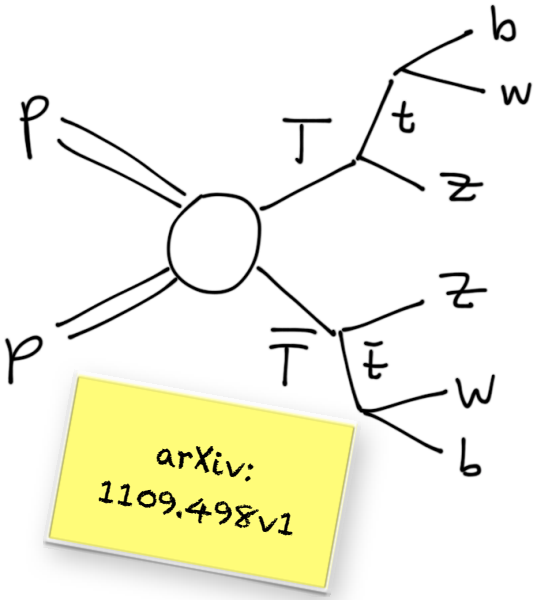




EXO-11-030 pas

Vector-like T



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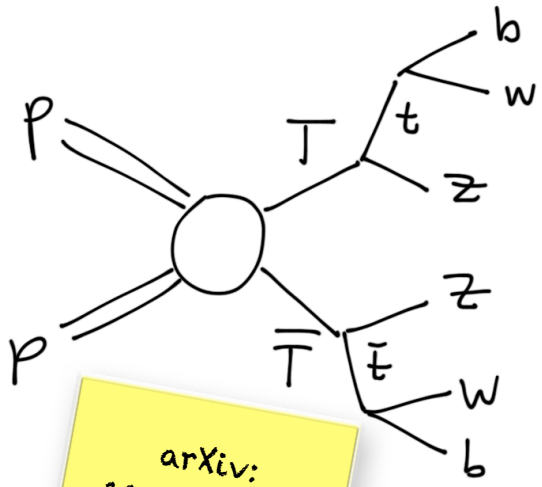

arXiv: 1109.4985v1

Strategy

- Search for FCNC decay T -> tZ -> tll:
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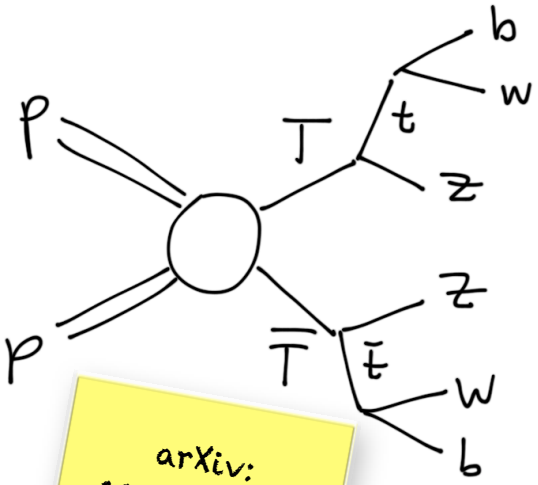

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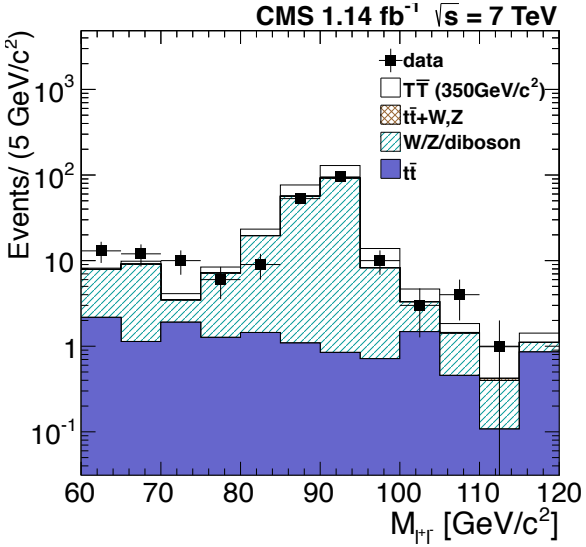

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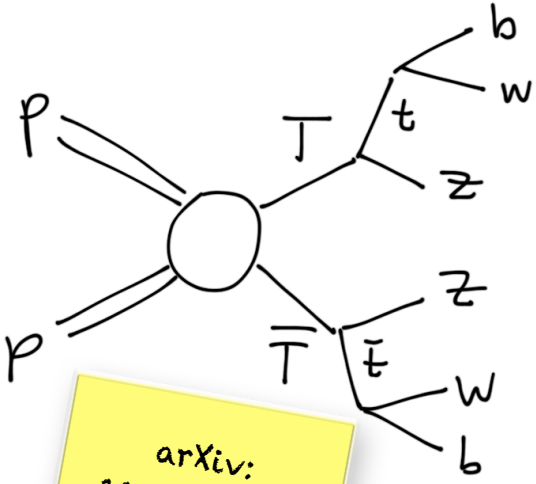

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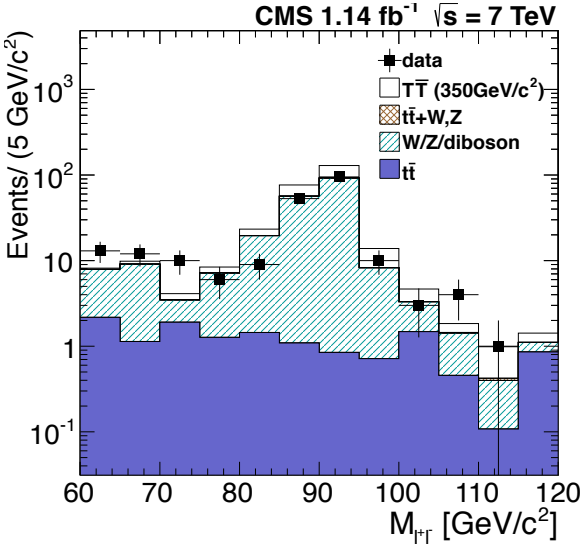

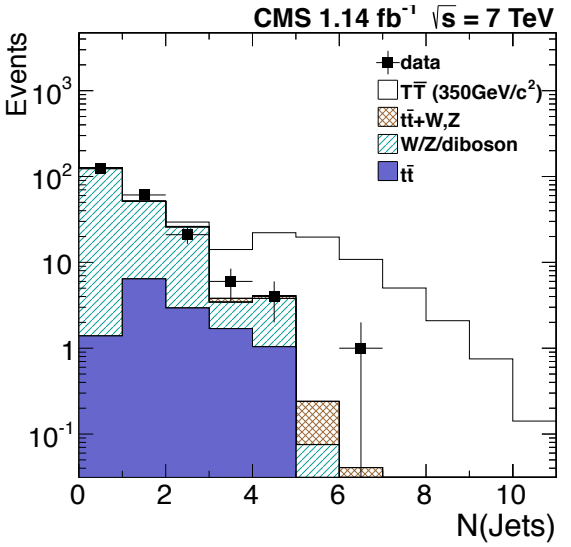

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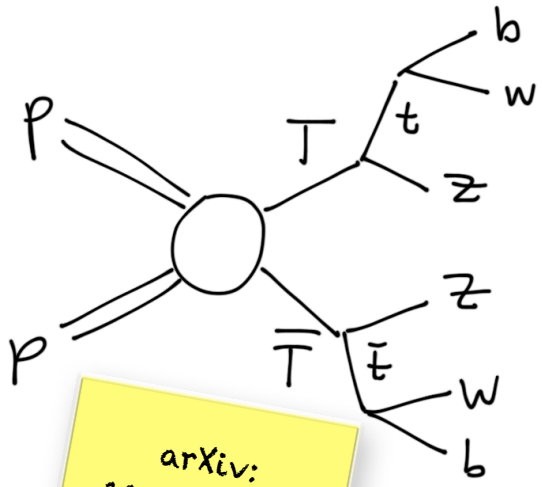

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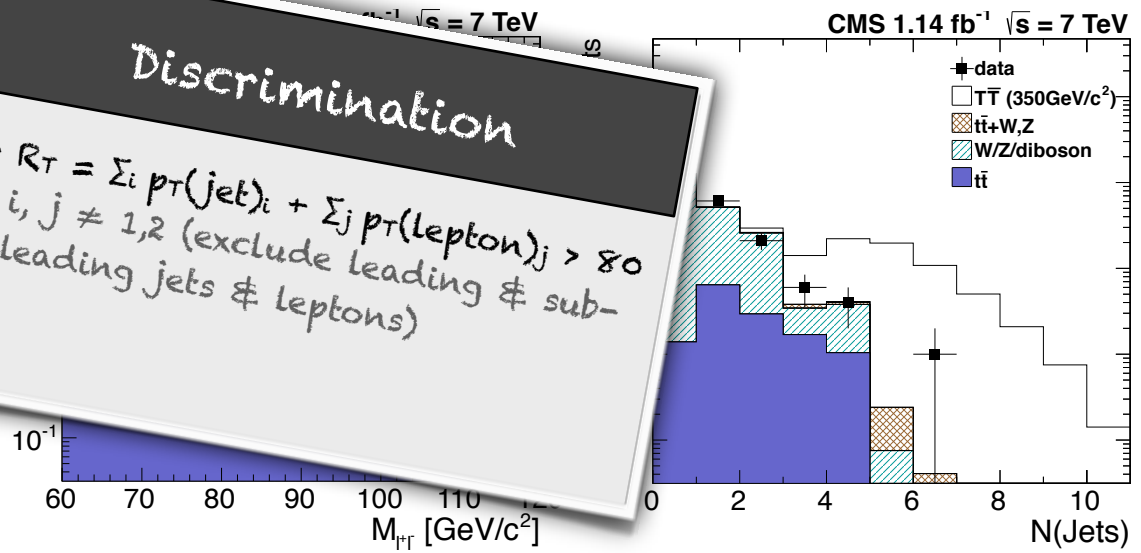
- $R_T = \Sigma_i p_T(\text{jet})_i + \Sigma_j p_T(\text{lepton})_j > 80$ $i, j \neq 1,2$ (exclude leading & sub-leading jets & leptons)



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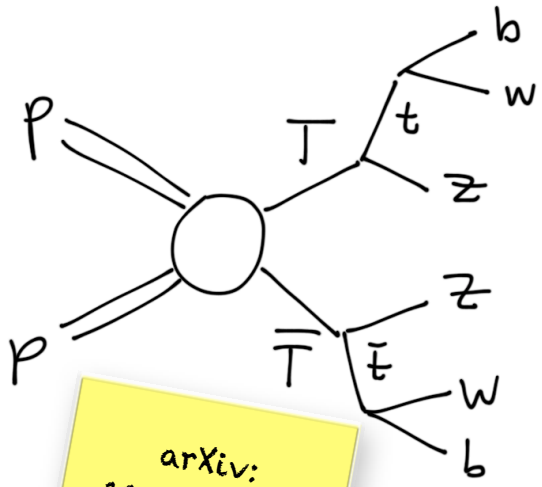

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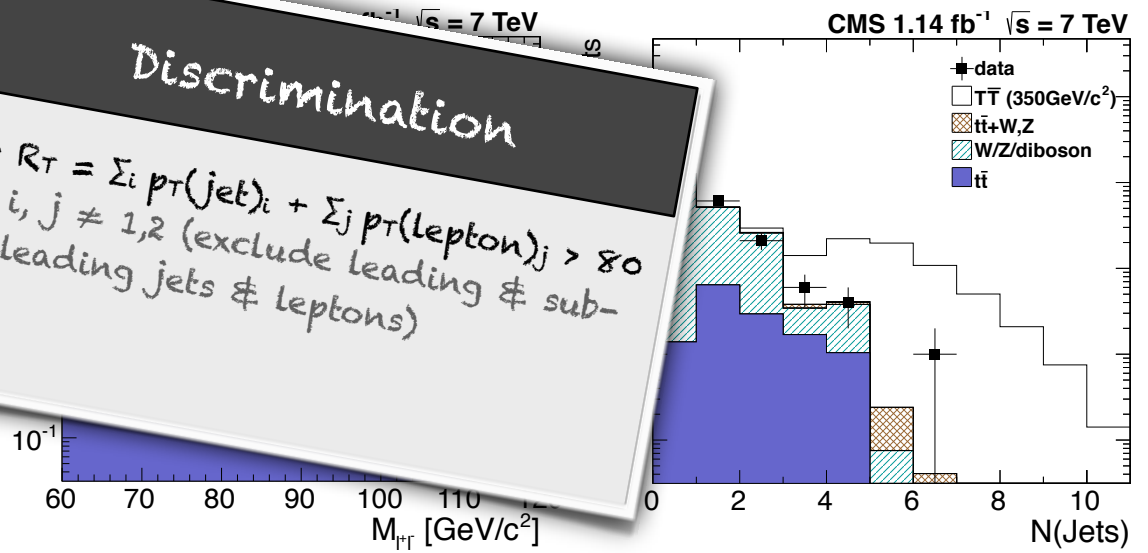

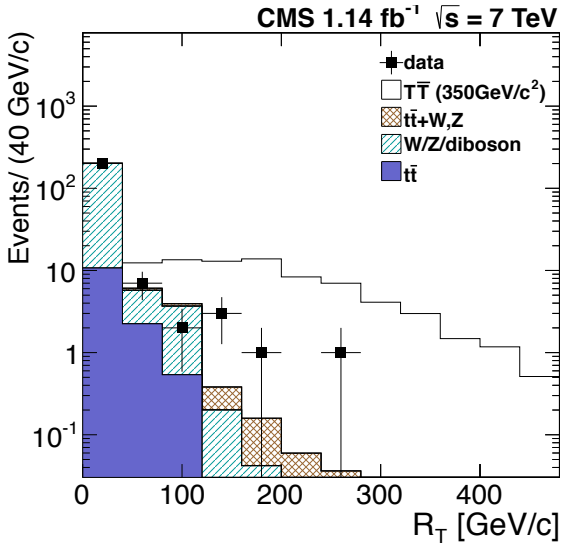

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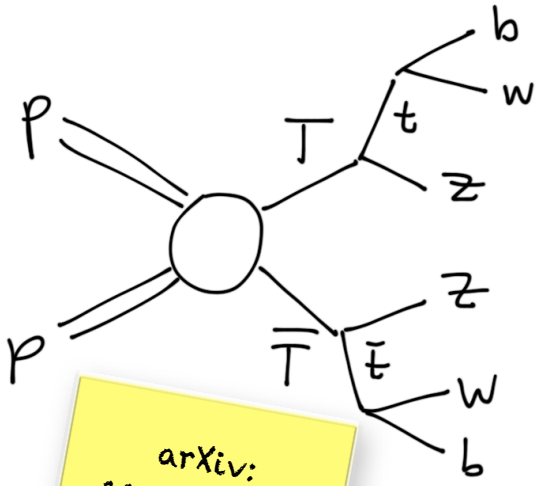

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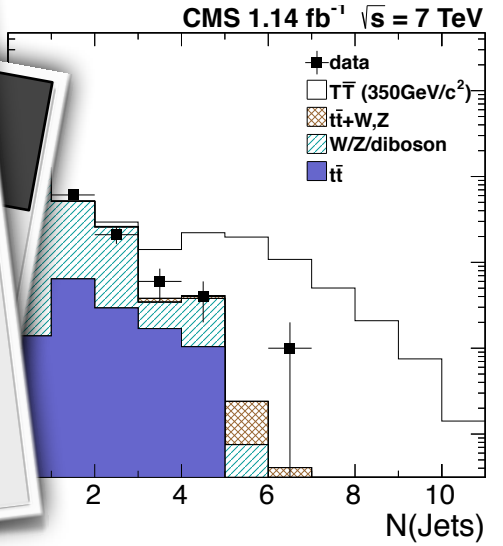

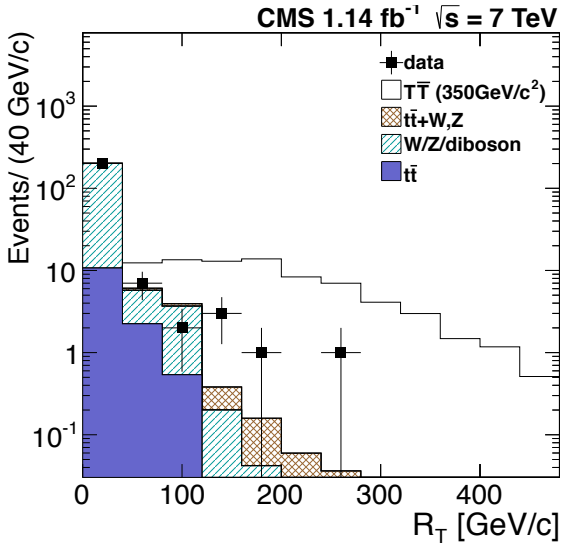

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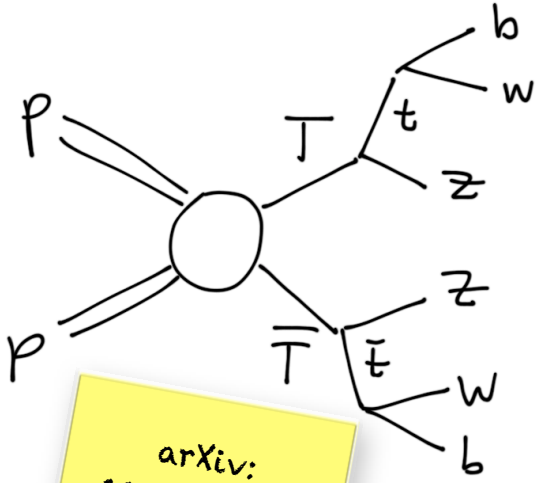

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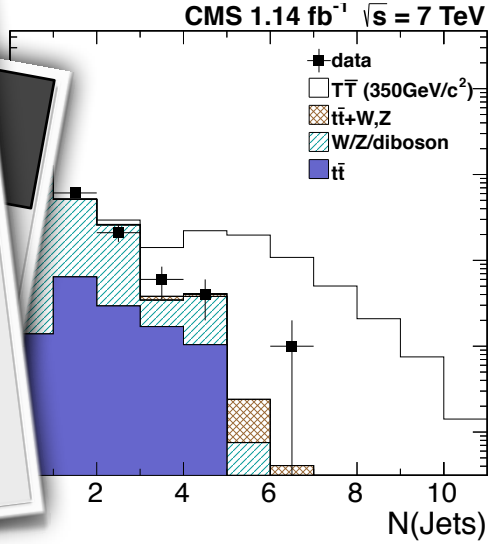

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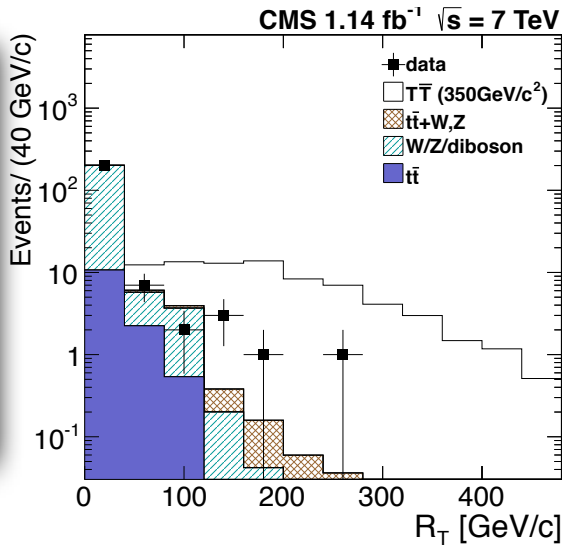
Results

Channel	eee	eeμ	$\mu\mu$e	$\mu\mu\mu$	Total
$B_{2\ell}$	$0.2^{+0.3}_{-0.2}$	0.8 ± 0.5	0.9 ± 0.4	1.1 ± 0.5	3.0 ± 0.8
$B_{3\ell}$	0.3 ± 0.1	0.3 ± 0.1	0.5 ± 0.2	0.5 ± 0.2	1.6 ± 0.5
B_{total}	0.5 ± 0.3	1.1 ± 0.5	1.4 ± 0.5	1.7 ± 0.6	4.6 ± 1.0
Data	0	2	2	3	7



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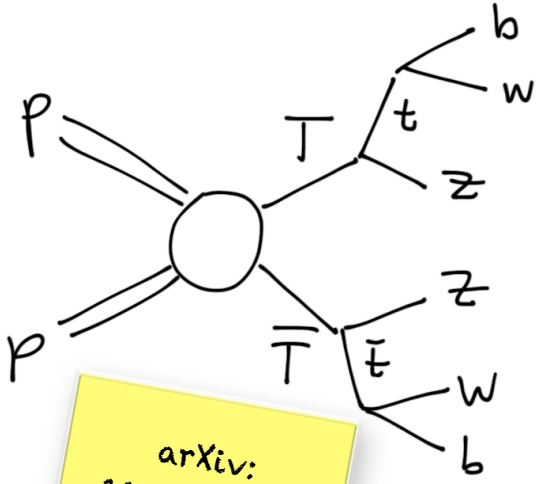

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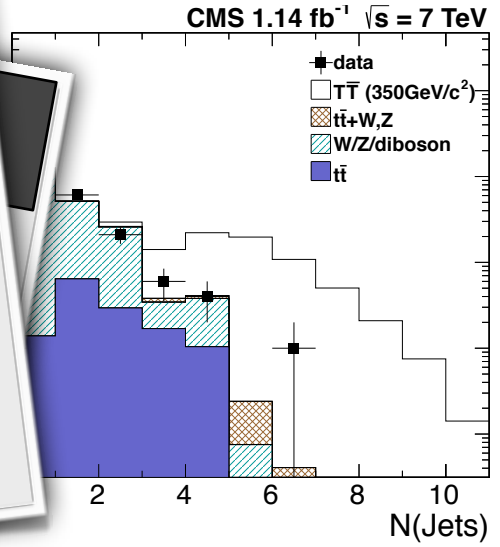

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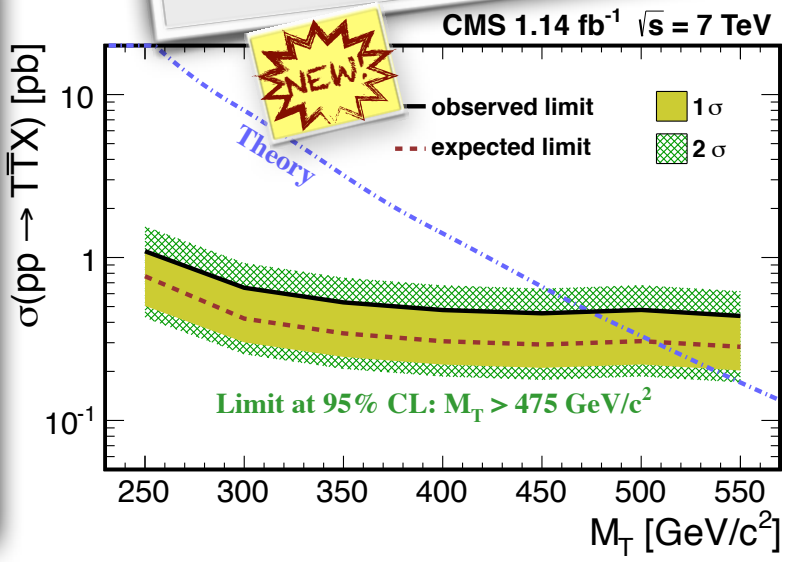
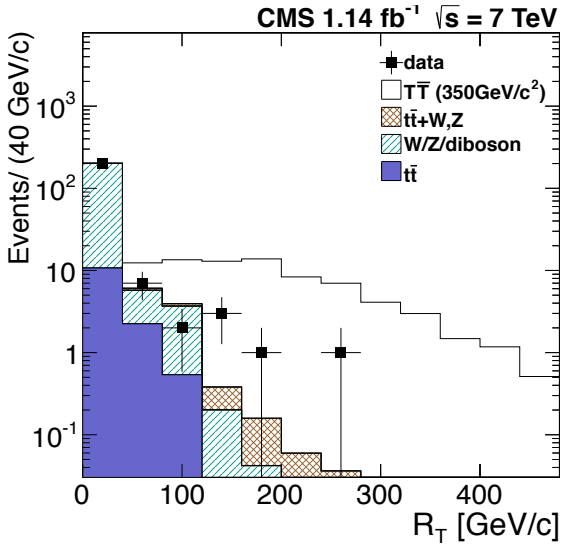
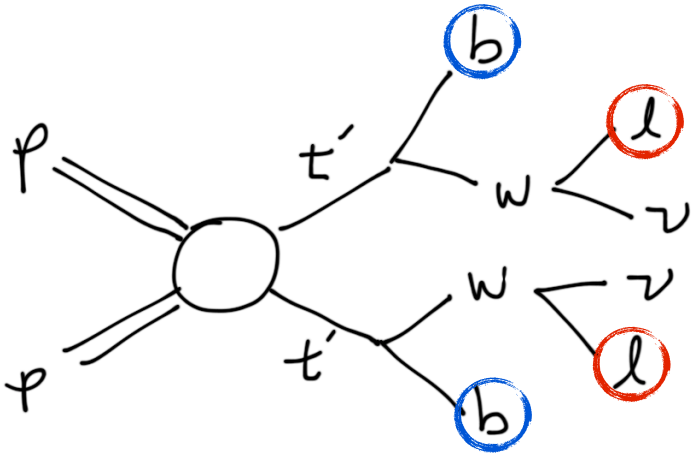




LPC LHC Physics Center

t' to dileptons



arXiv:
1203.5410v1

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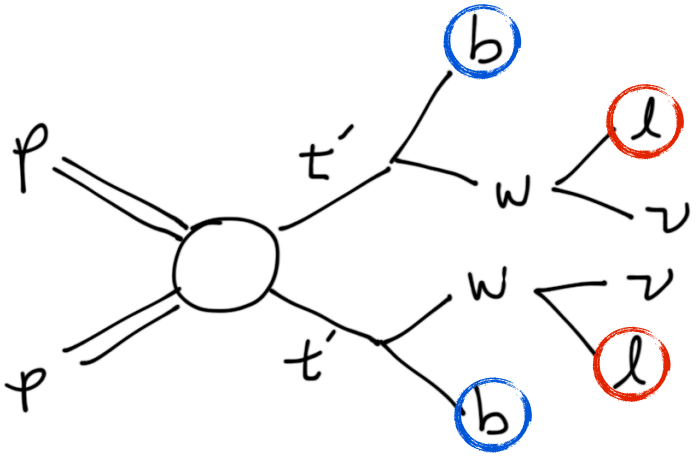

Strategy

- EWK precision constraints: $M_{t'} < M_{b'} + M_W$
- Require
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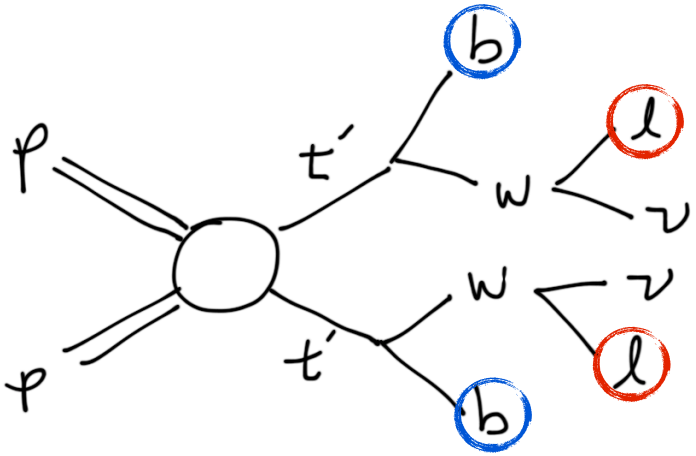
- Main discriminator:
  - minimum of four M_{lb} combinations

arXiv: 1203.5410v1

t' to dileptons



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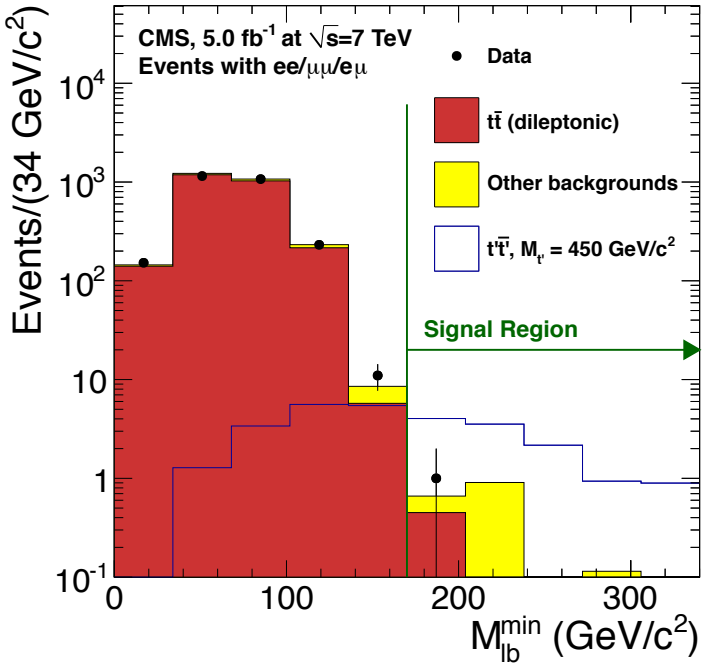

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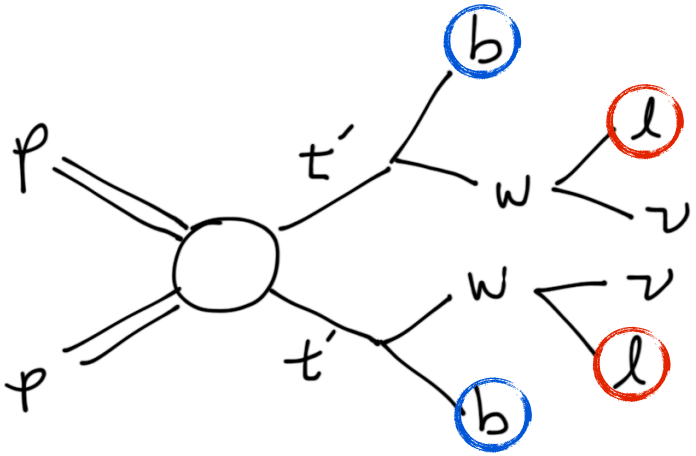
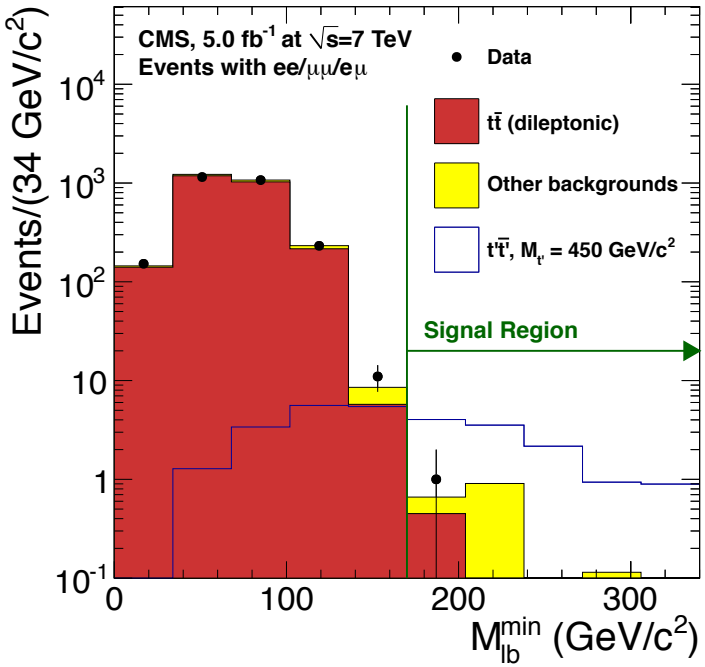




Strategy

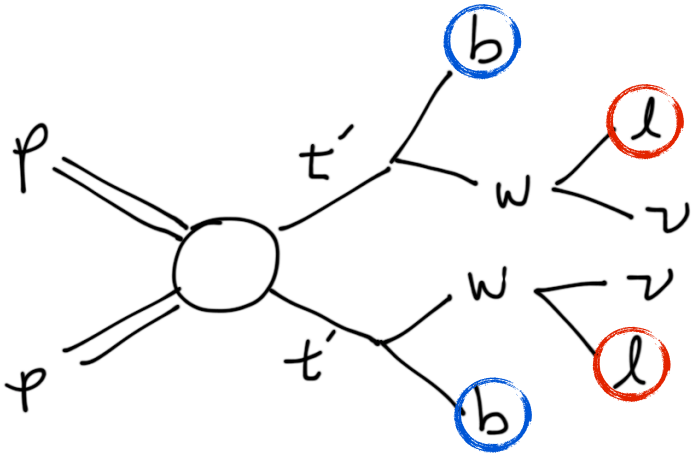
- EWK precision constraints: $M_{t'} < M_{b'} + M_W$
- Require
  - 2 OS leptons
  - 2 b-tagged jets
- Main discriminator:
  - minimum of four M_{lb} combinations

arXiv: 1203.5410v1

Backgrounds

- Category I: 2 prompt leptons, ≥1 mis-tag b-jet(s)
- Category II: ≥1 fake leptons, 2 real b-jets
- Category III: 2 prompt leptons, 2 real b-jets
- Category IV: ≥1 fake leptons, ≥1 mis-tag b-jet(s)
  - negligible

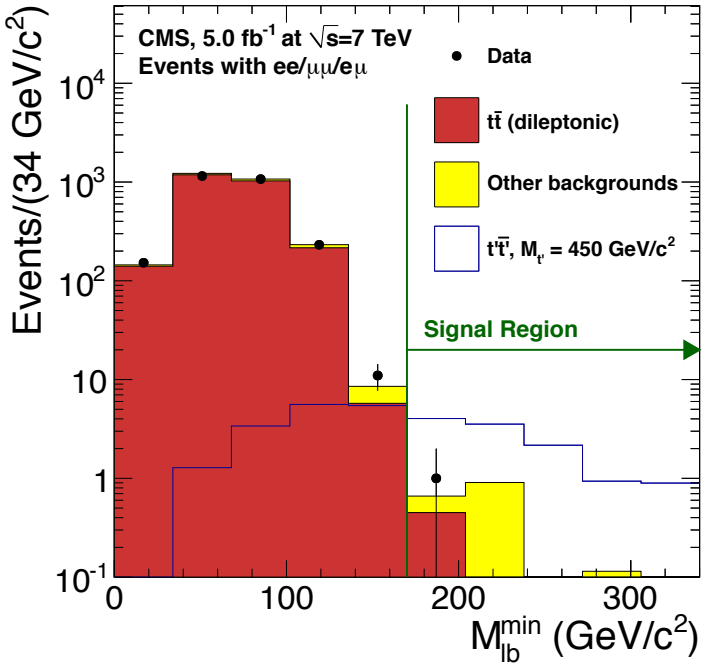
t' to dileptons



Results

Sample	Yield
Category I (from data)	0.7 ± 0.8
Category II (from data)	$0.0^{+0.4}_{-0.0}$
Category III (simulated)	1.0 ± 0.7
Total prediction	1.8 ± 1.1
Data	1

arXiv: 1203.5410v1



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- Category I: 2 prompt leptons, ≥1 mis-tag b-jet(s)
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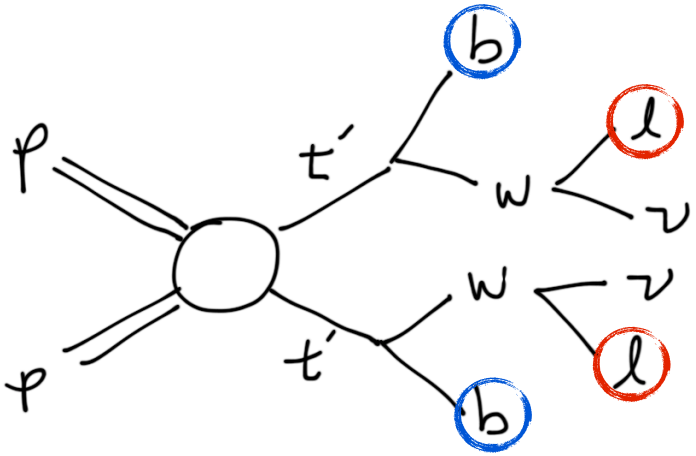
t' to dileptons



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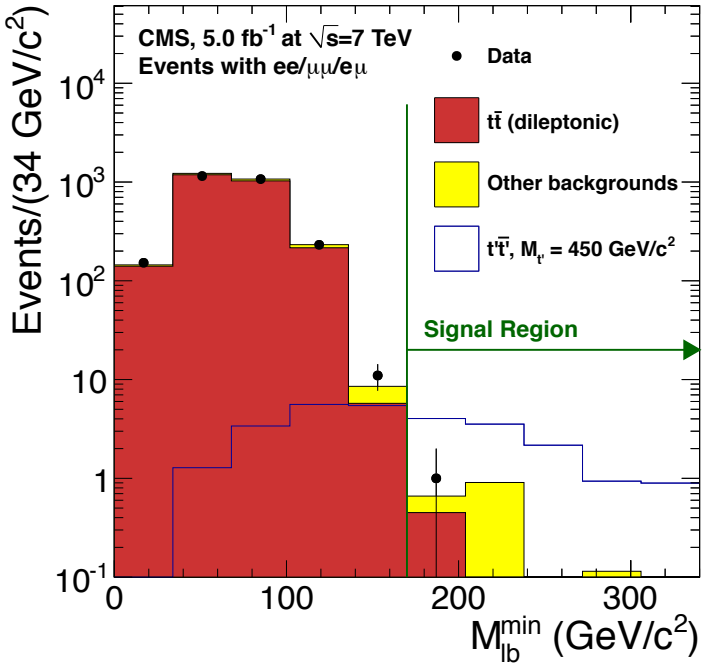
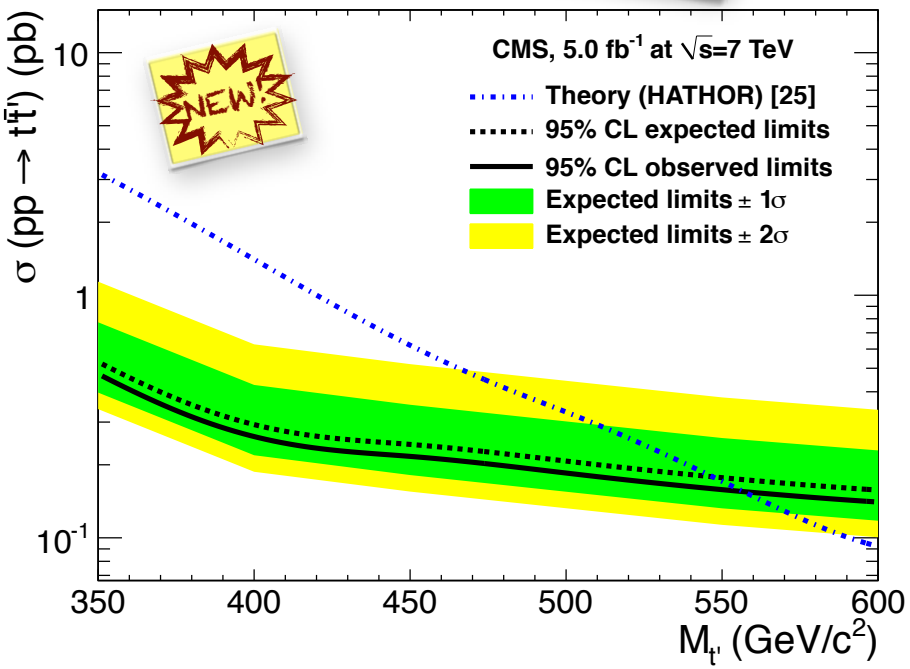
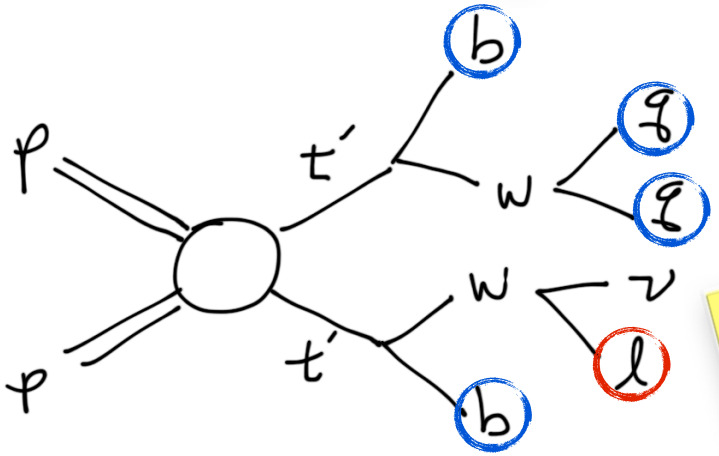




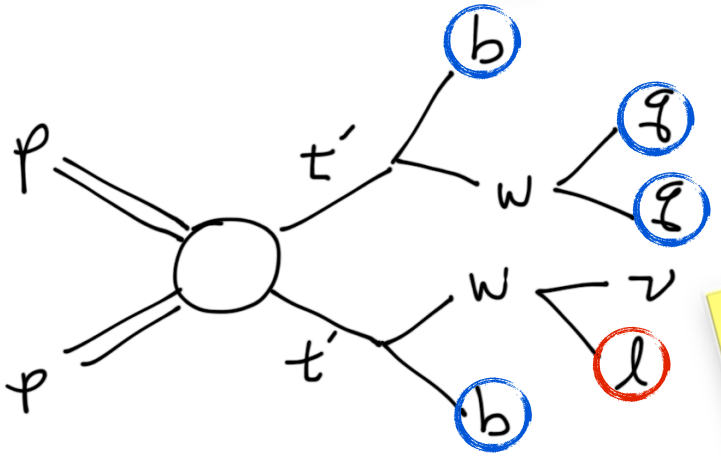
LPC LHC Physics Center

t' to lepton+jets



EXO-11-099

t' to lepton+jets

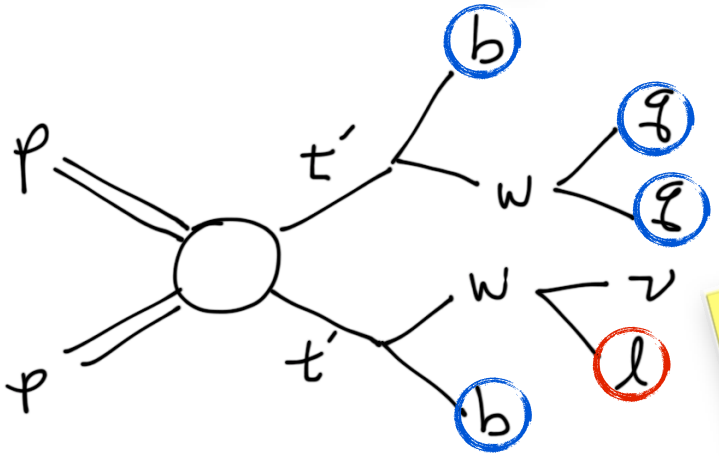


EXO-11-099

Strategy

- EWK precision constraints: $M_{t'} < M_{b'} + M_W$
- Require
  - = 1 isolated lepton
  - ≥ 4 jets (pT > 120, 90, 50, 35)
  - ≥ 1 b-tagged jet (from the above 4)
- Main discriminators:
  - constrained kinematic fit:
    m(lν) = M_W; m(qq) = M_W; m(lν) = m(qq) = M_{fit}
  - HT

t' to lepton+jets



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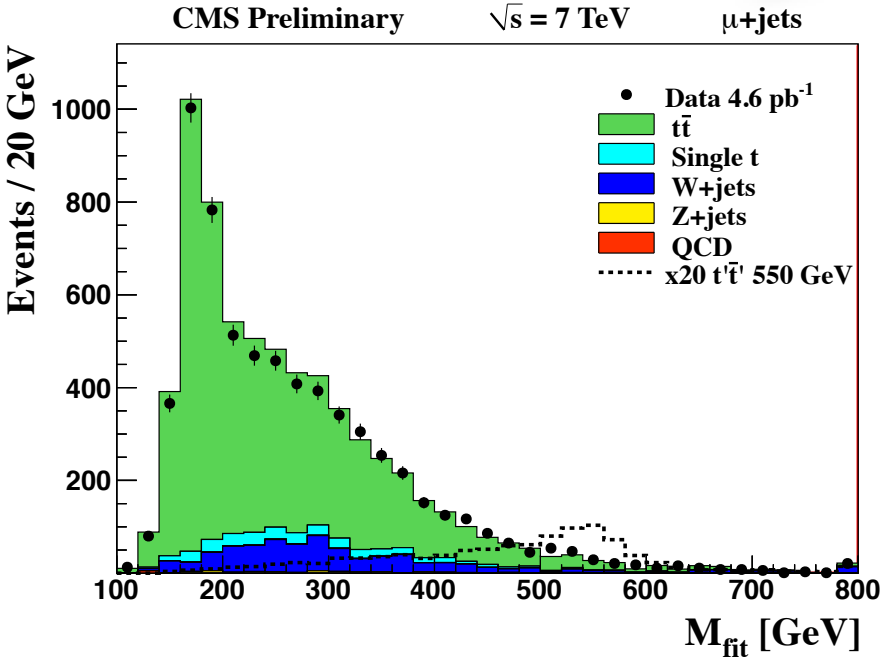
EXO-11-099



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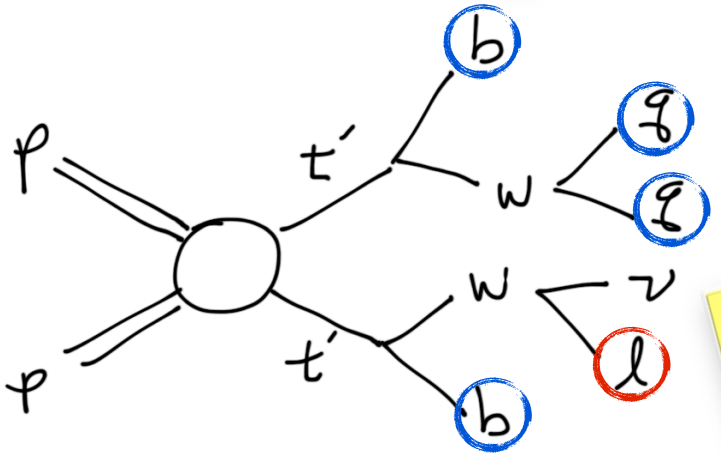
t' to lepton+jets



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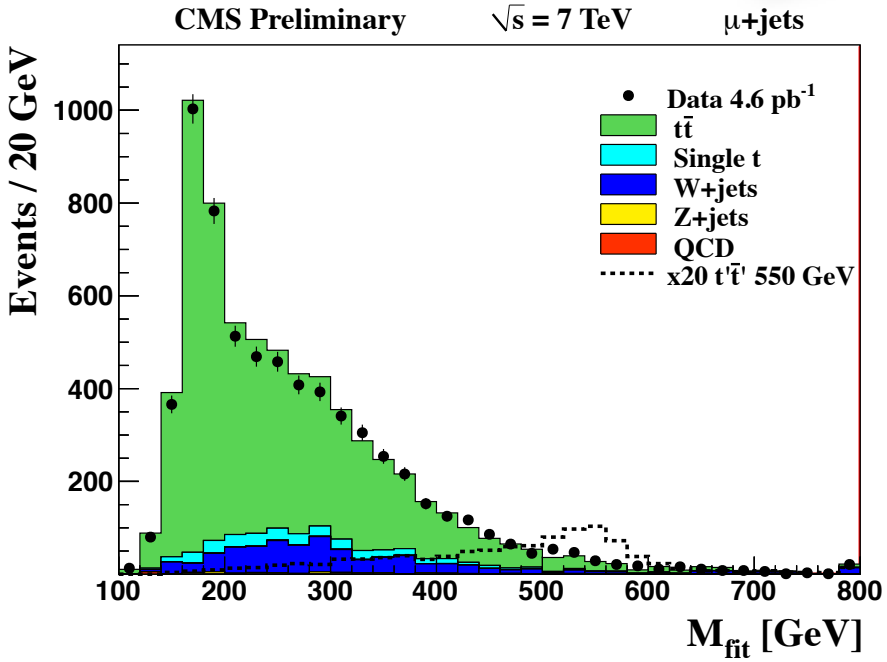
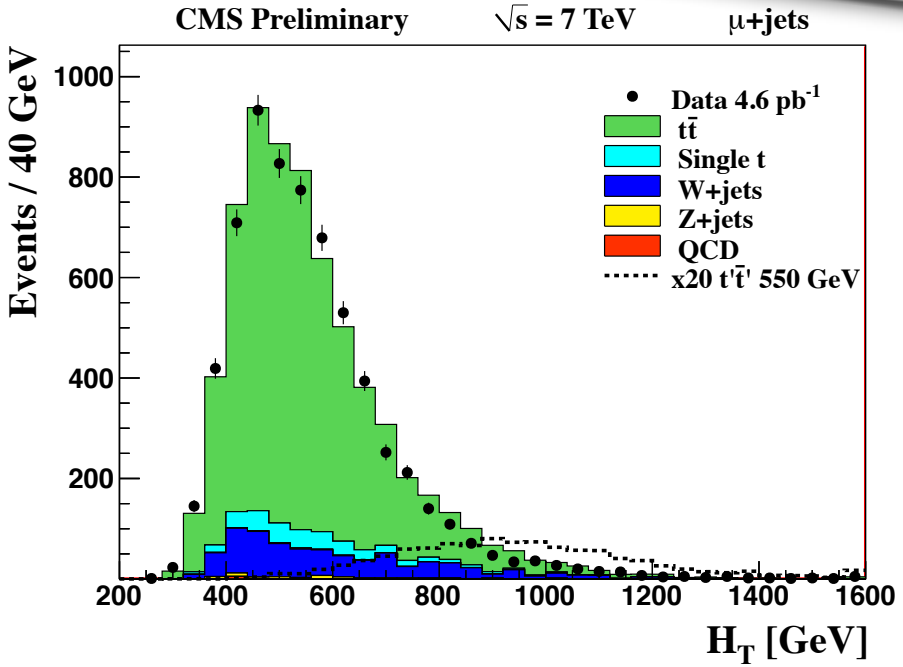
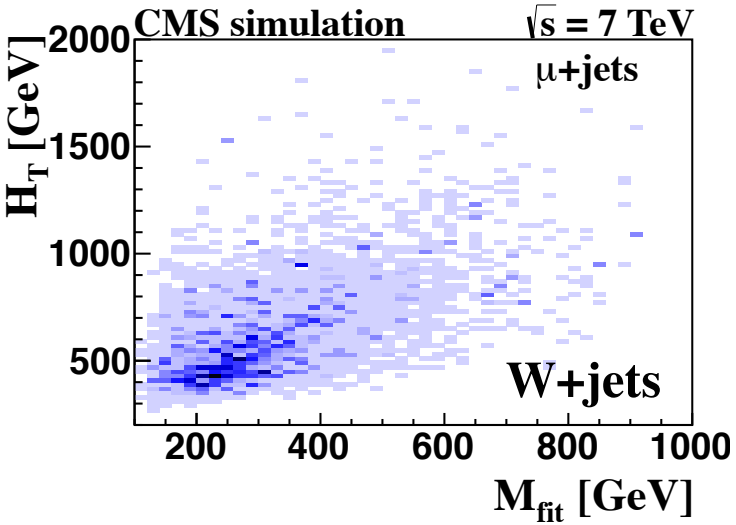
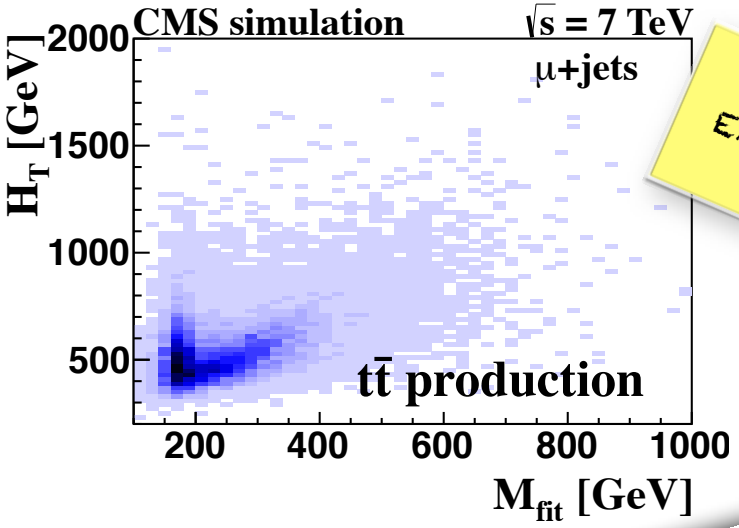




LPC LHC Physics Center

t' to lepton+jets



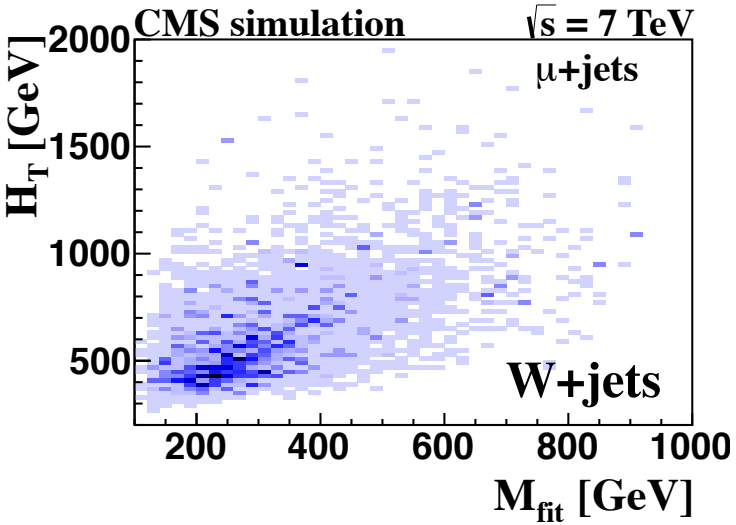


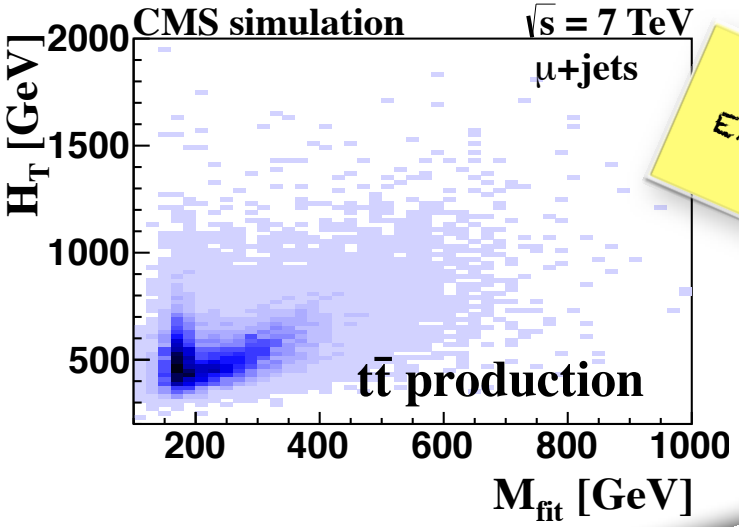
EXO-11-099

Main Backgrounds

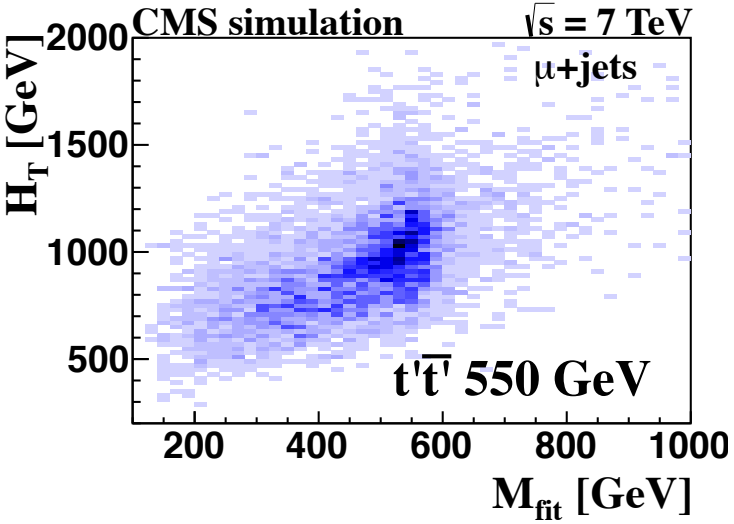
- Largest: ttbar
  - MC normalised to CMS meas. x-section
- moderate: W+jets
  - MC normalised to MCFM (50% syst. err)
- Small: Z+jets, single top, dibosons
  - MC normalised to MCFM (50% syst. err)

t' to lepton+jets





EXO-11-099



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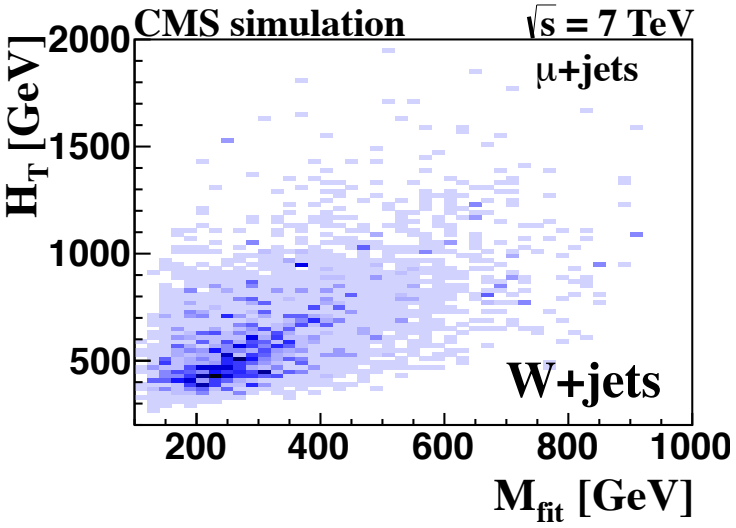
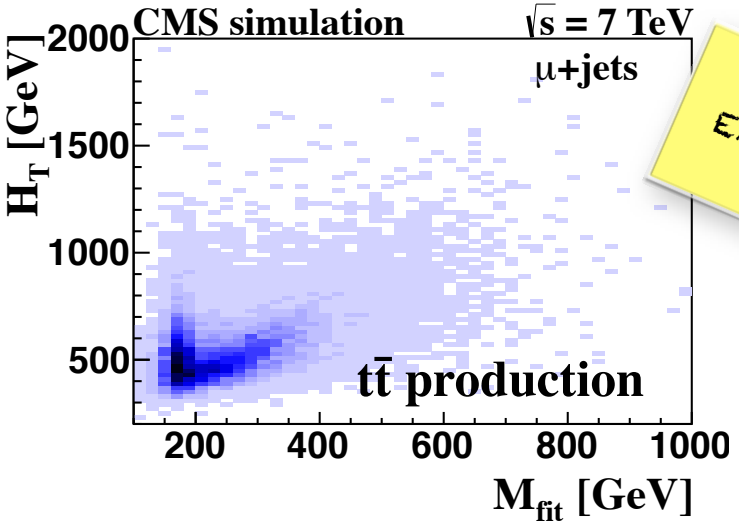
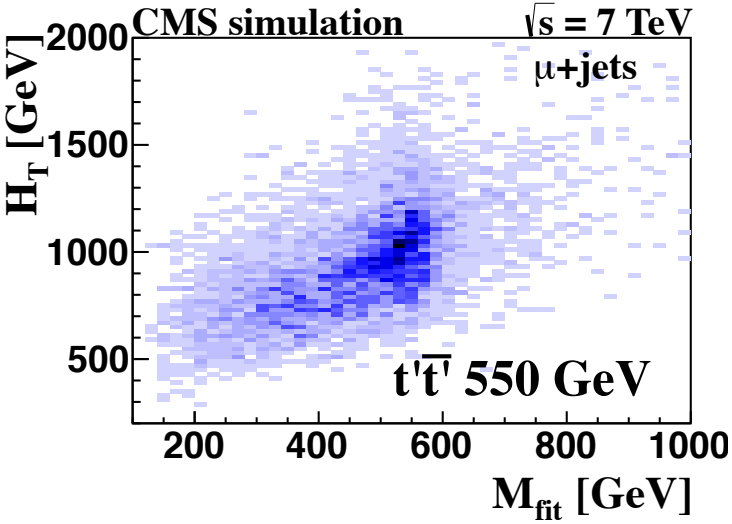
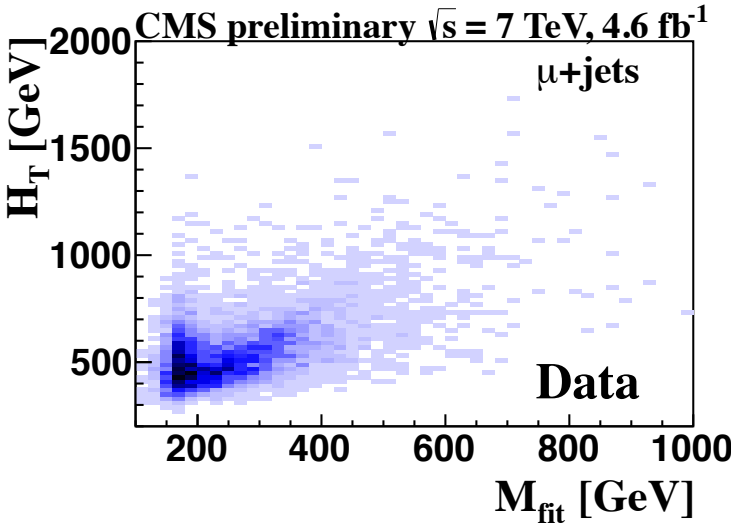


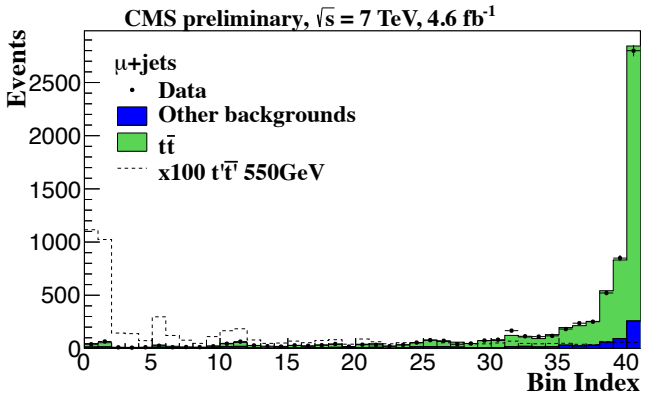


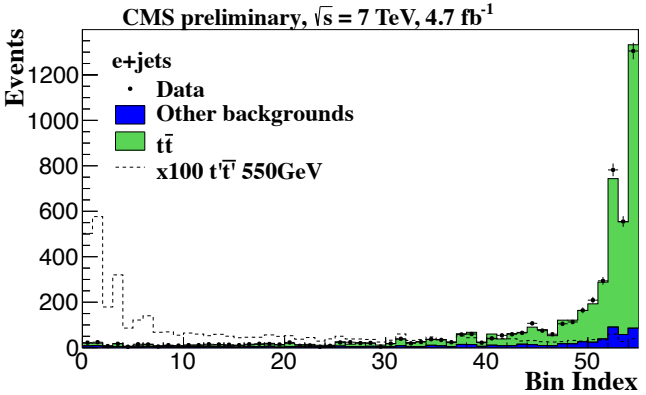
EXO-11-099





t’ to lepton+jets

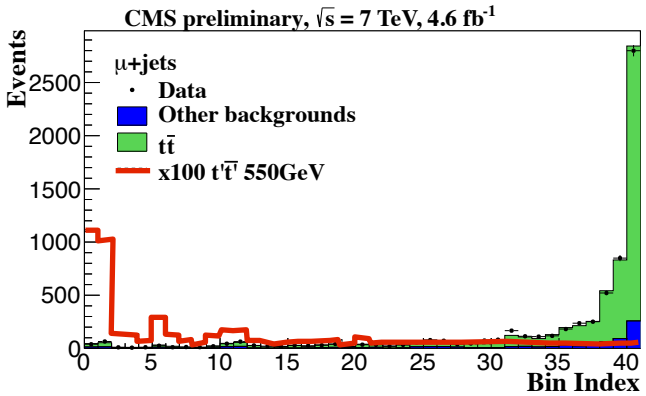


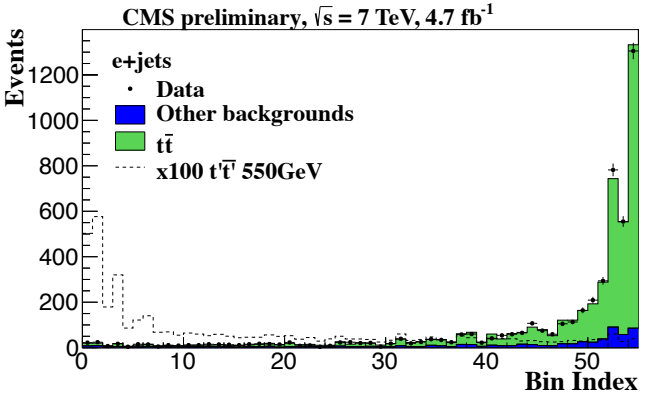


σ(pb)

EXO-11-099

t' to lepton+jets

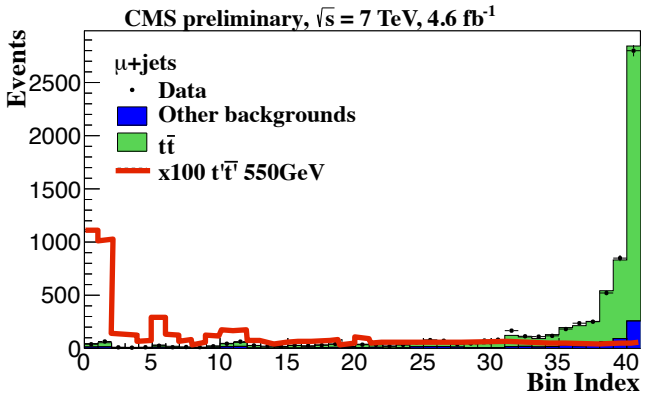


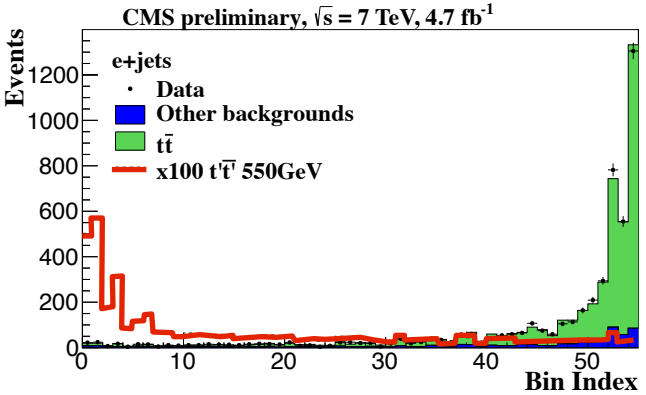


σ(pb)

EXO-11-099

t’ to lepton+jets





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EXO-11-099

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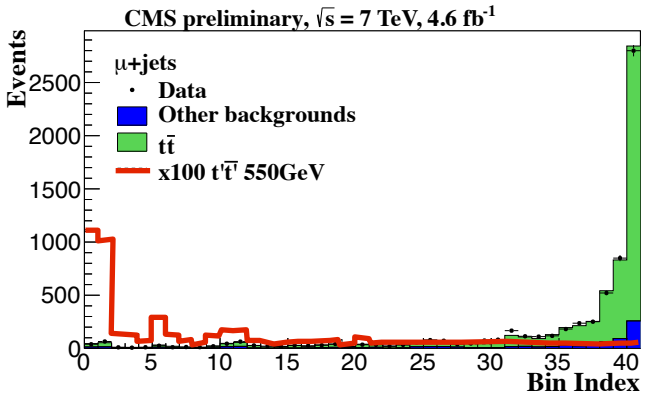
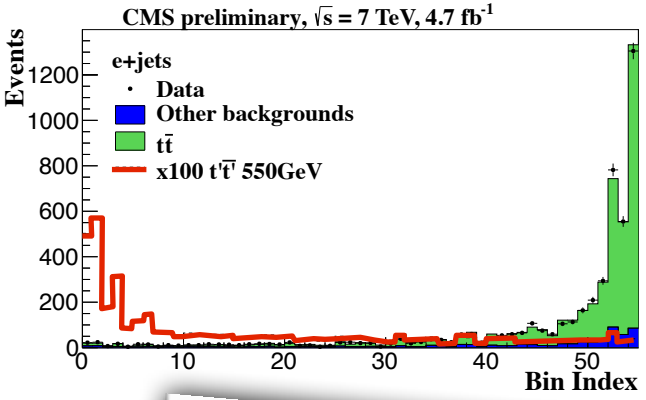




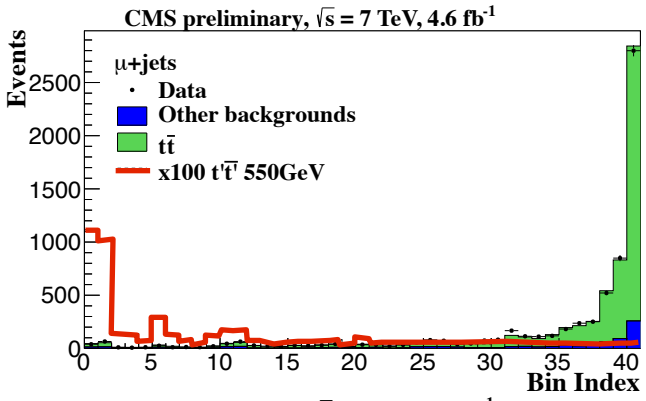
σ(pb)

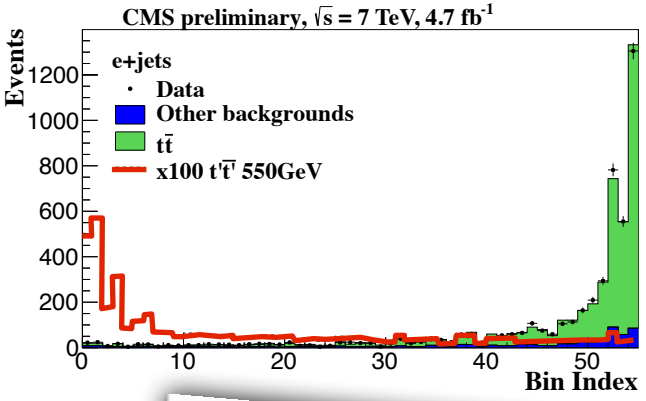
Shape Analysis

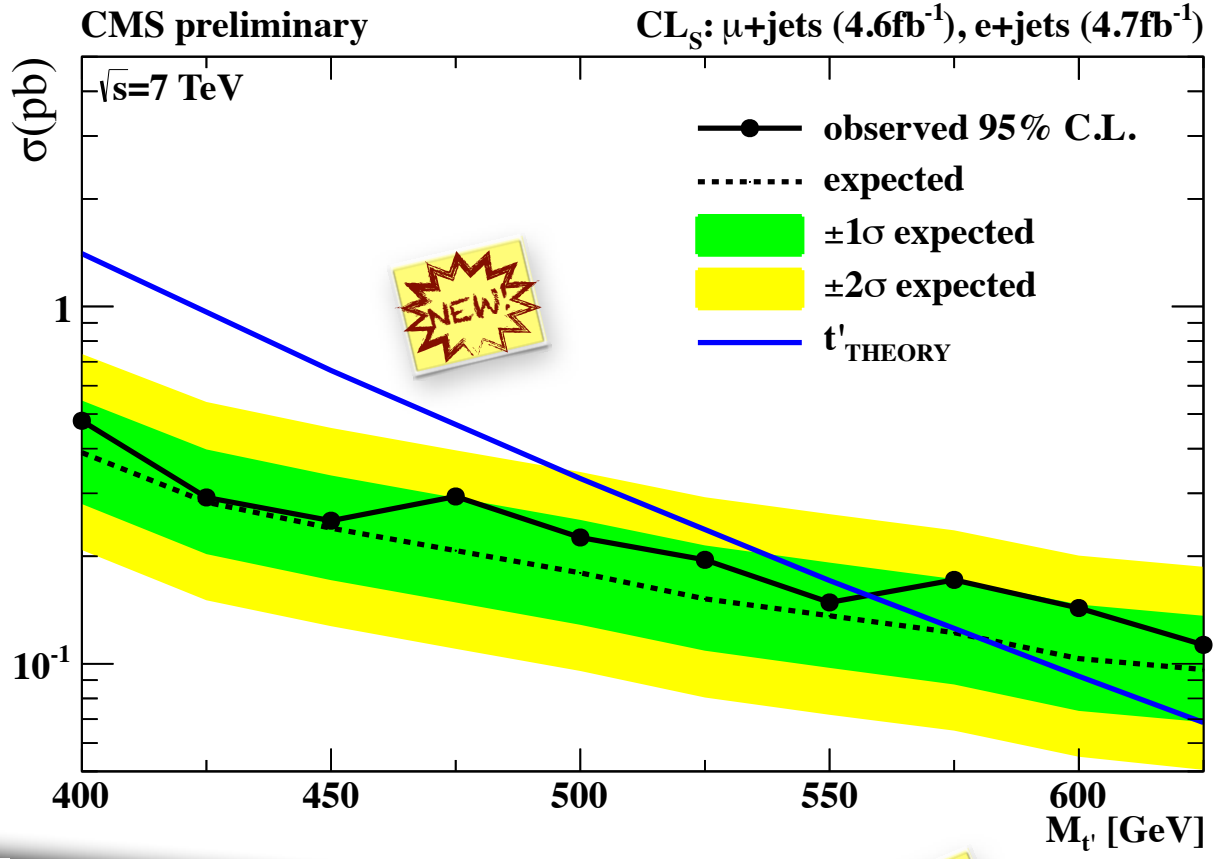
- Use MC templates for each background component
- Test each bin for B vs S+B hypothesis

EXO-11-099

t' to lepton+jets







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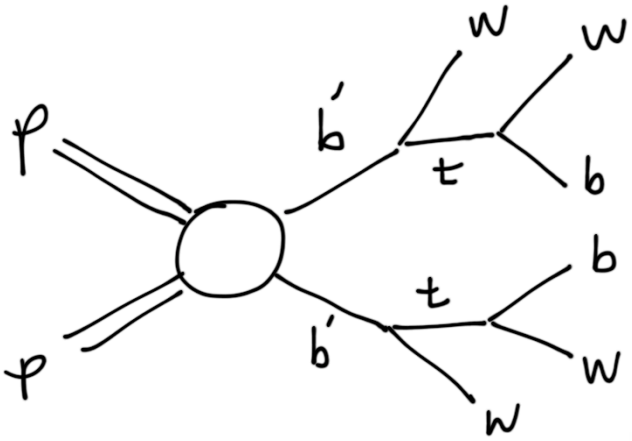
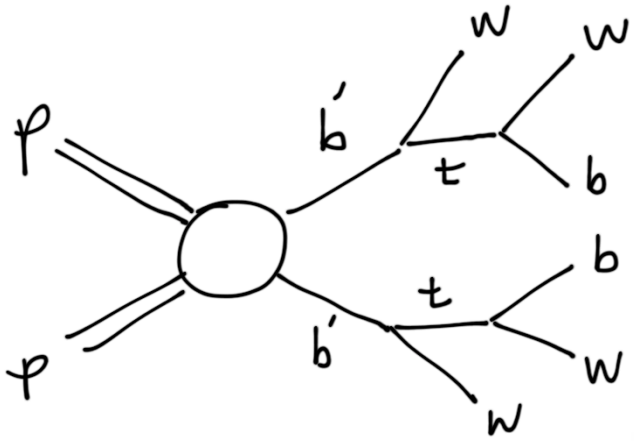
EXO-11-099

b’



arXiv:
1204.1088v1

b’

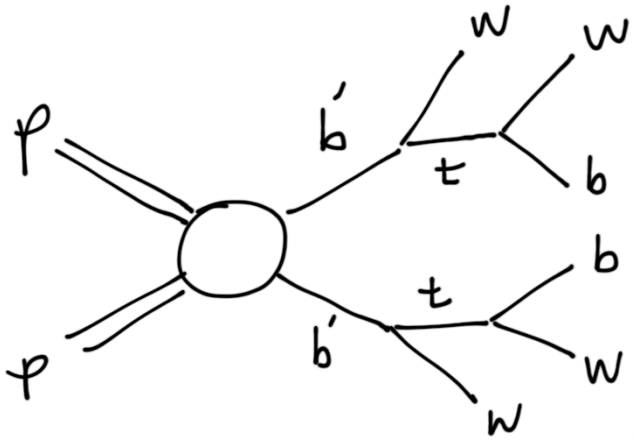


arXiv: 1204.1088v1

Strategy

- EWK precision constraints:
  $M_{t'} < M_{b'} + M_W$
- Require:
  - ≥ 1 b-jet
  - 2 SS leptons
    - ≥ 4 jets
  - 3 leptons (2 OS; veto if M_Z)
    - ≥ 2 jets
  - S_T > 500 GeV

b'



$S_T = \sum |\vec{p}_T(\text{jets})| + \sum |\vec{p}_T(\text{leptons})| + \not{E}_T$

arXiv: 1204.1088v1

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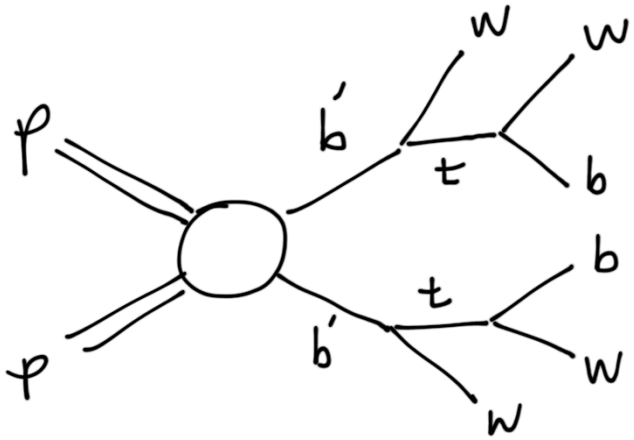

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SS dilepton Backgrounds

- three categories:
  - real dilepton + misID chg elect.
    - Zee control sample
  - real lepton + 2 fake leptons
    - use tight-loose ratio method
  - real dileptons
    - ttZ, ttW, diboson
    - taken from MC; normalise to NLO

arXiv: 1204.1088v1

Strategy

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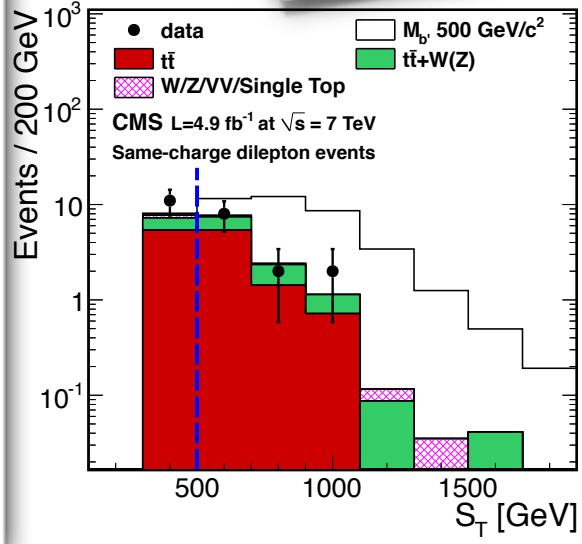
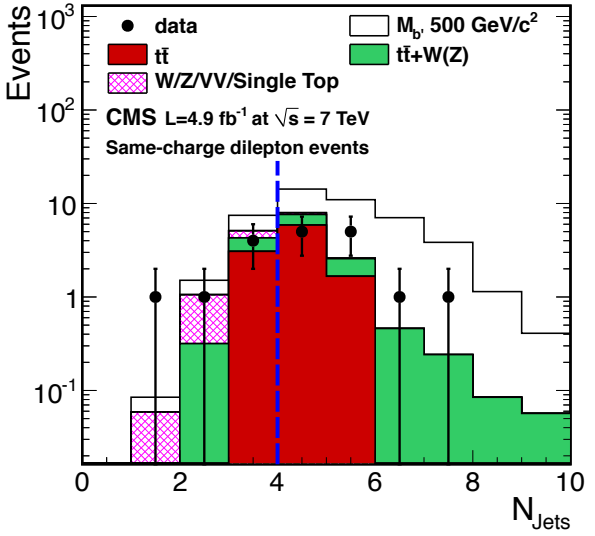
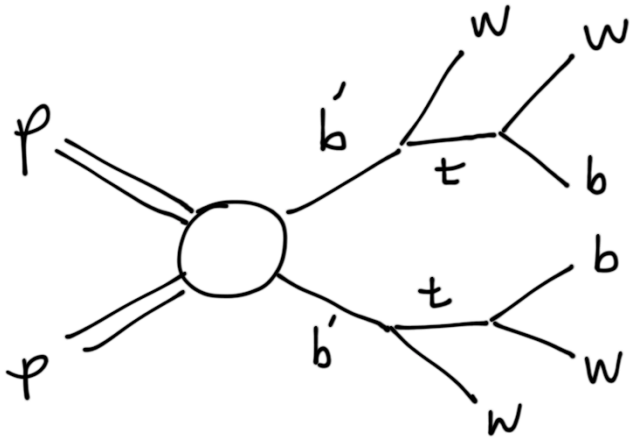




b'



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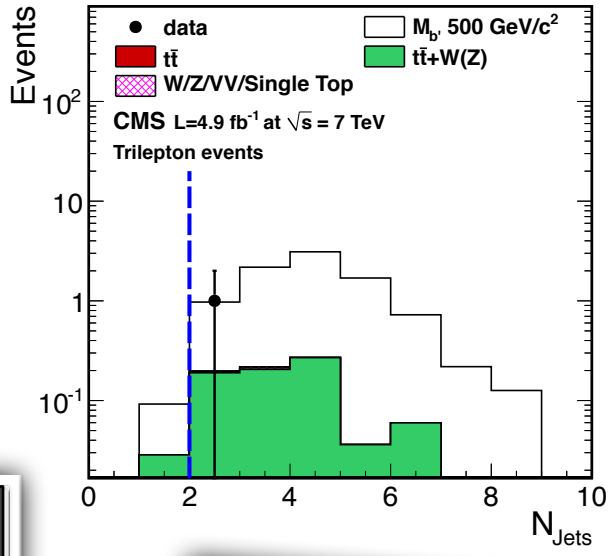

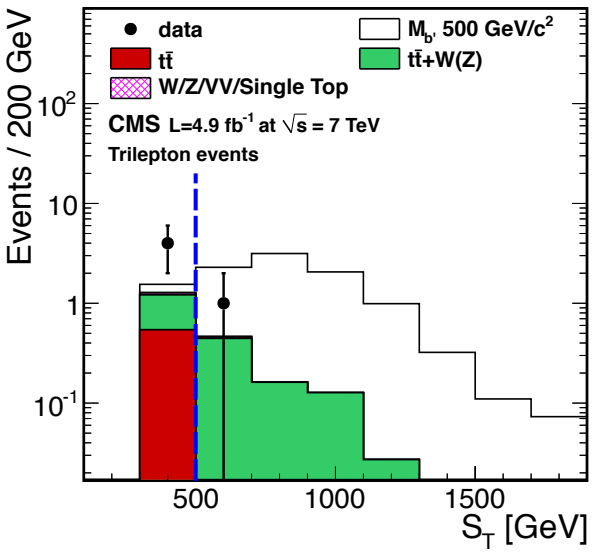

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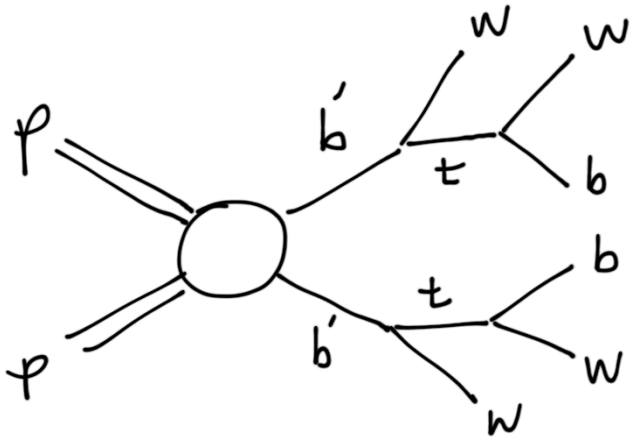
    - ≥ 2 jets
  - S_T > 500 GeV

arXiv: 1204.1088v1

Trilepton Backgrounds

- dominated by three real leptons
  - tt+W/Z: from MC; norm. to NLO
  - tt, W/Z: from MC; norm. to CMS meas.
  - single top: from MC; norm to NNLO
  - dibosons: from MC; norm to MCFM
  - $W^{\pm}W^{\pm}$: from MC; norm to NLO

b'



$$S_T = \sum |\vec{p}_T(\text{jets})| + \sum |\vec{p}_T(\text{leptons})| + \not{E}_T$$

Strategy

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    - ≥ 2 jets
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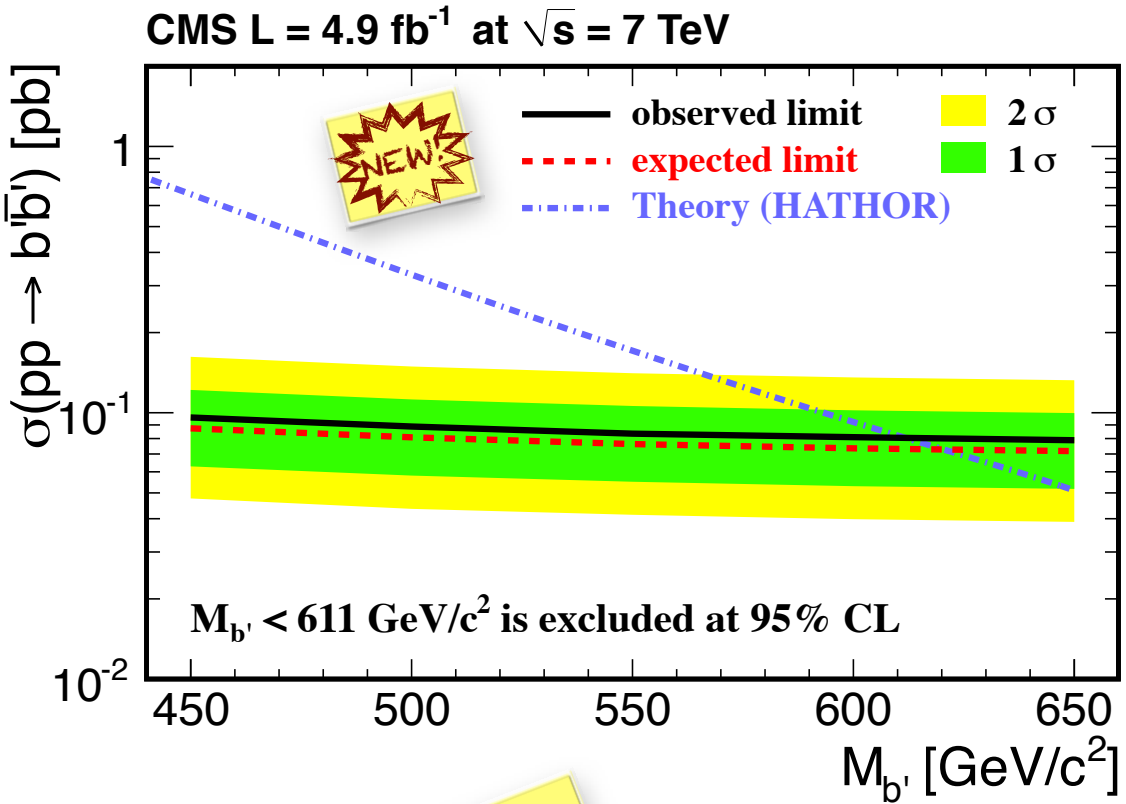


arXiv:
1204.1088v1

SUMMARY

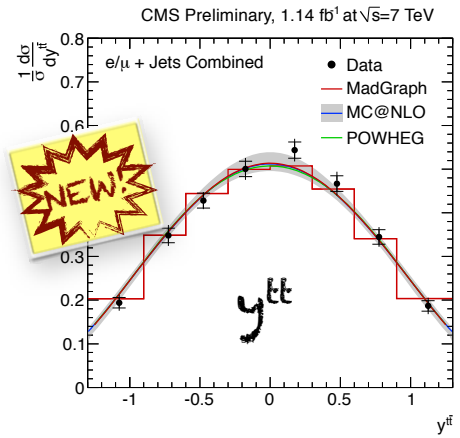
- CMS had an excellent 2011!
  - more than 40 new results sent to winter conferences:
    Standard Model, B-physics, Top, Higgs, SUSY, Exotica
- Stay tuned for more 2011 results:
  - Several 5fb-1 results are in the pipeline; will be released soon
  - Many involving SUSY with heavy flavour:
    - all hadronic + b-jets; single-lepton + b-jets, all hadronic + τ's
  - Already analysing > 1 fb-1 (gulp!) 2012 data
    - LHC and CMS performing extremely well!

ttbar well understood!

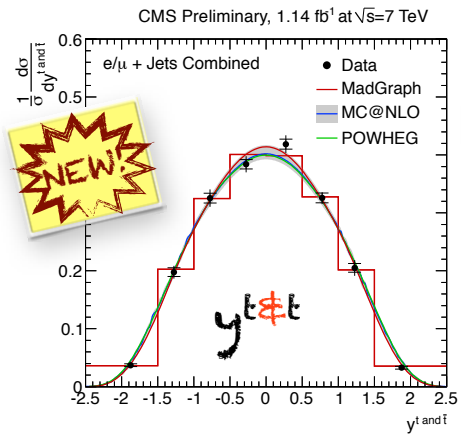
TOP-11-013

Good agreement found for all quantities studied

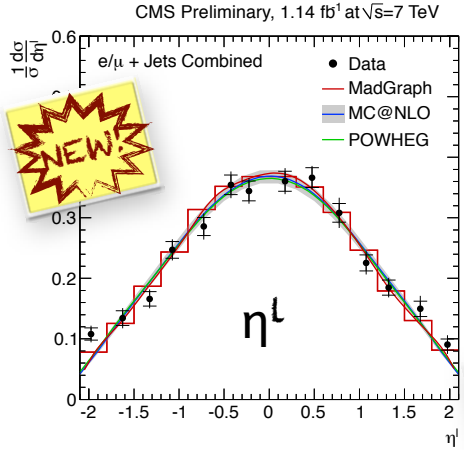
Top pairs



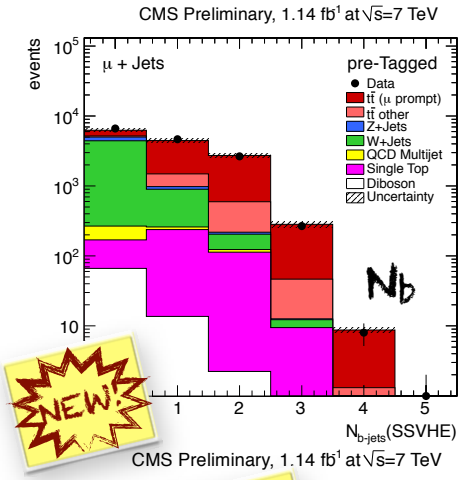
Individual tops

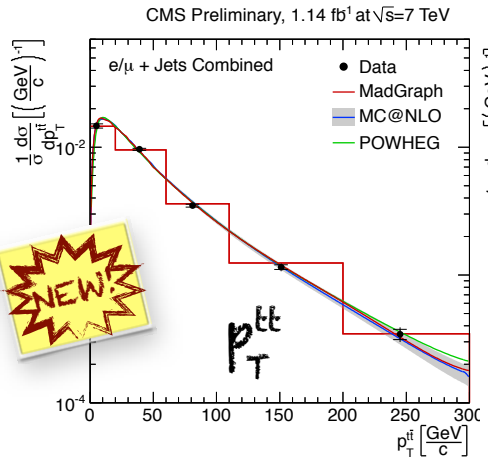


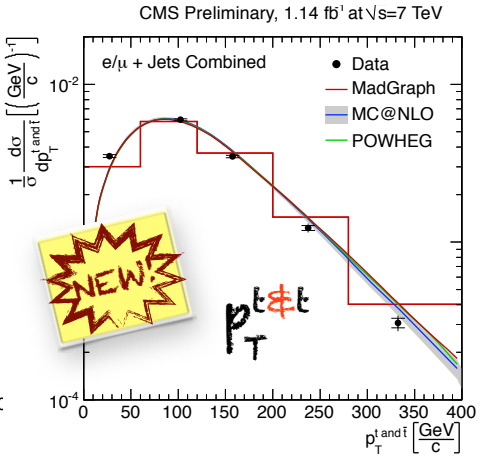
lepton

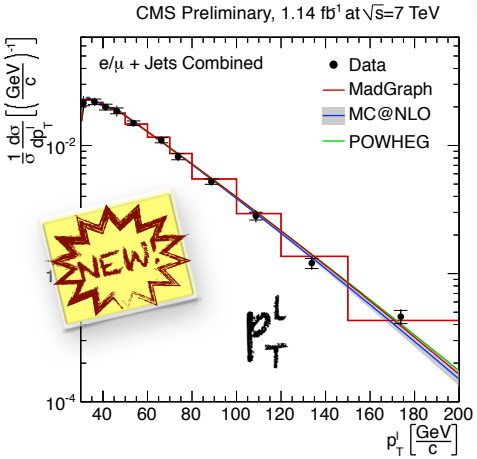


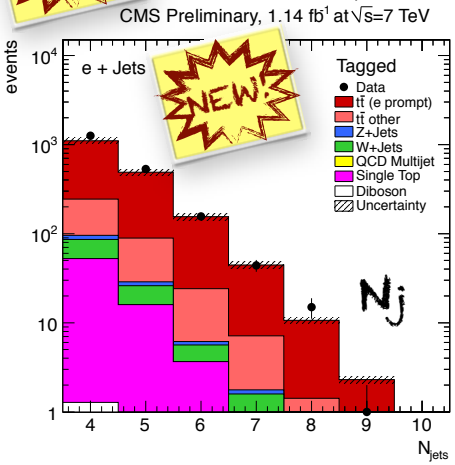
jets











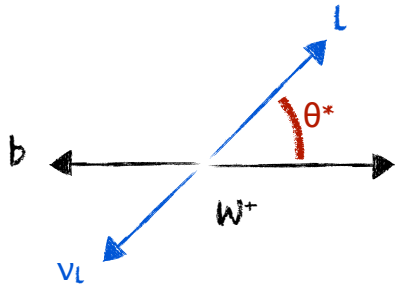
LPC LHC Physics Center

W helicity in ttbar

TOP-11-020

W helicity in ttbar

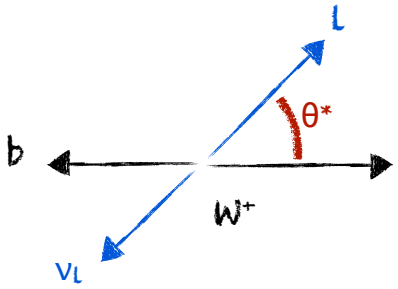
- Measure θ*, angle between lepton and b (W rest frame)

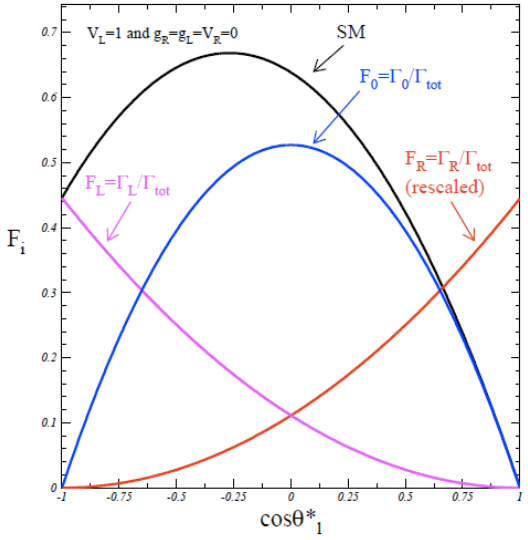


TOP-11-020

W helicity in ttbar

- Measure θ*, angle between lepton and b (W rest frame)
- Distribution reflects 3 possible W polarisations
  - $F_0 = 0.698$,
    $F_L = 0.301$,
    $F_R = 4.1 \times 10^{-4}$





TOP-11-020

Fermilab
UIC University of Illinois at Chicago

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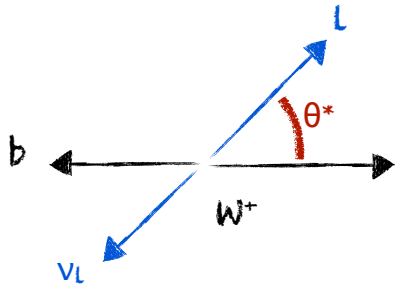
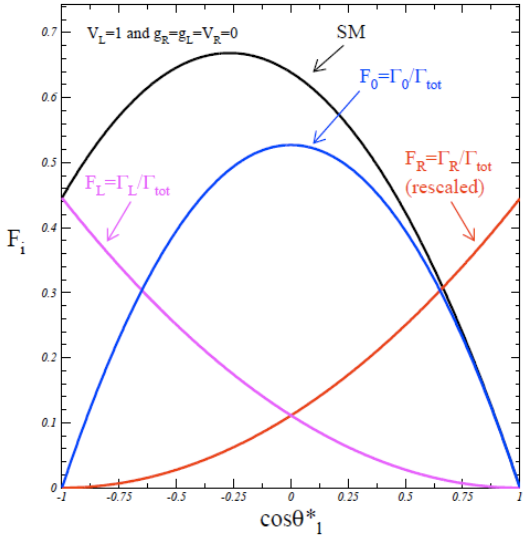
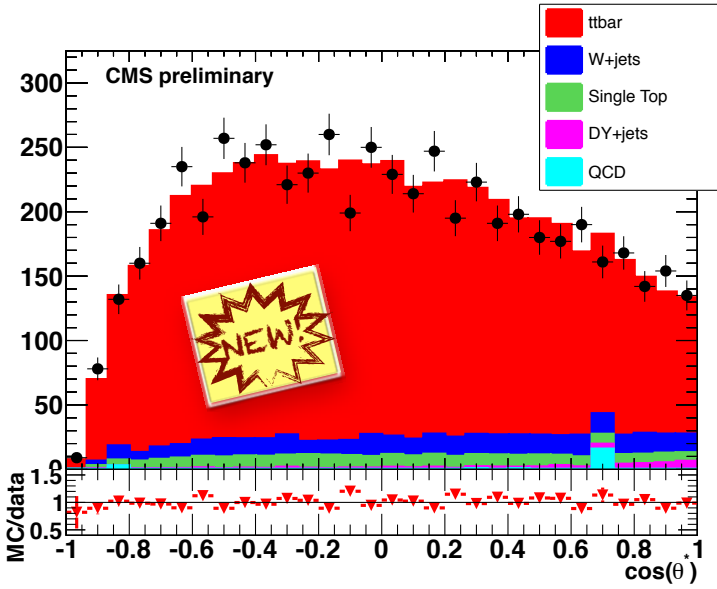




TOP-11-020



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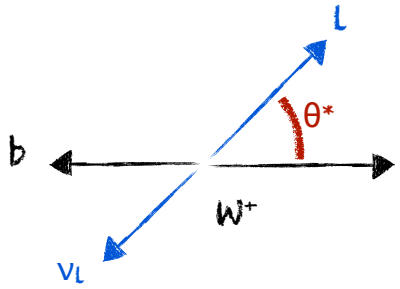
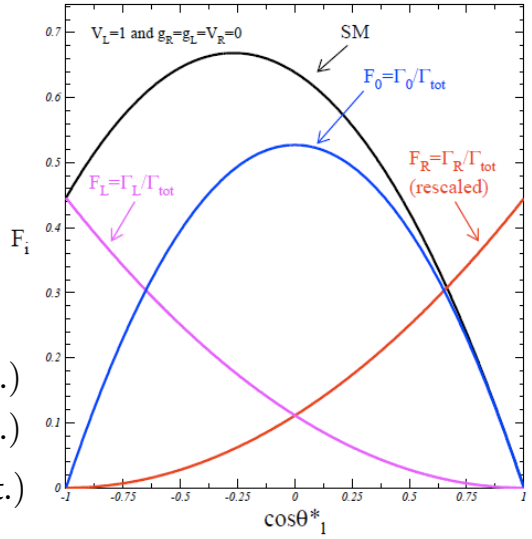
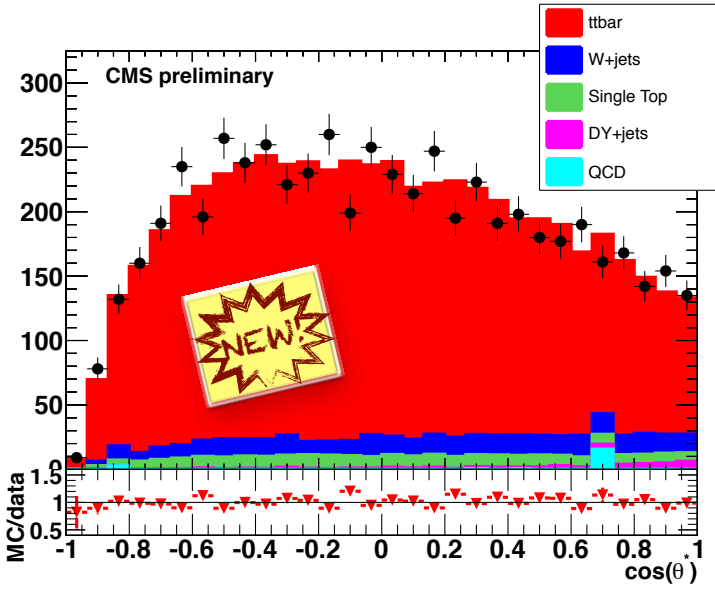




$$F_0 = 0.567 \pm 0.074(\text{stat.}) \pm 0.047(\text{syst.})$$
$$F_L = 0.393 \pm 0.045(\text{stat.}) \pm 0.029(\text{syst.})$$
$$F_R = 0.040 \pm 0.035\ (\text{stat.}) \pm 0.044(\text{syst.})$$

NEW!



TOP-11-020

W helicity in ttbar

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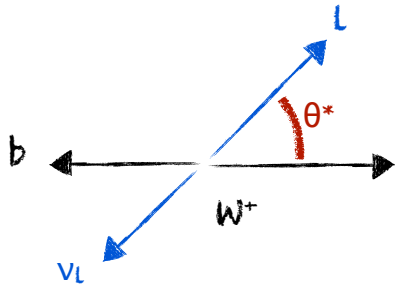
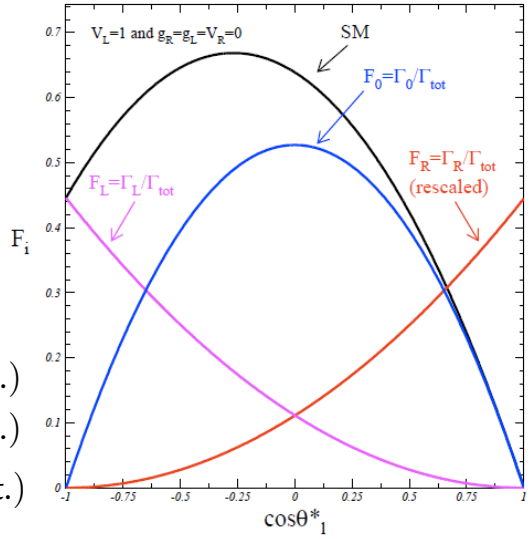
  - $F_0 = 0.698$, $F_L = 0.301$, $F_R = 4.1 \times 10^{-4}$
- Anomalous tWb couplings lead to deviations





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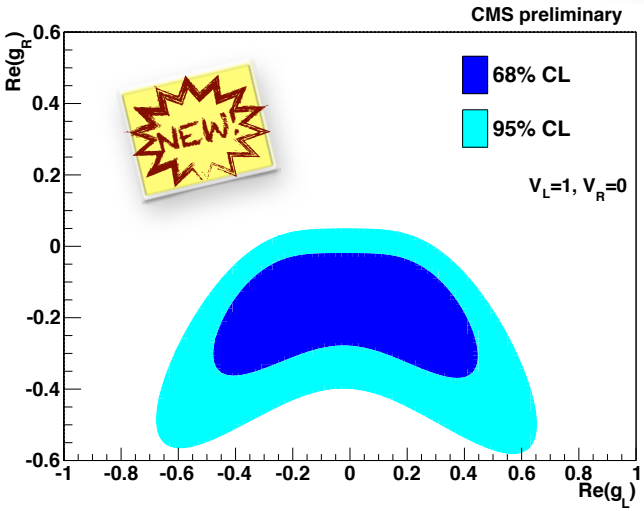
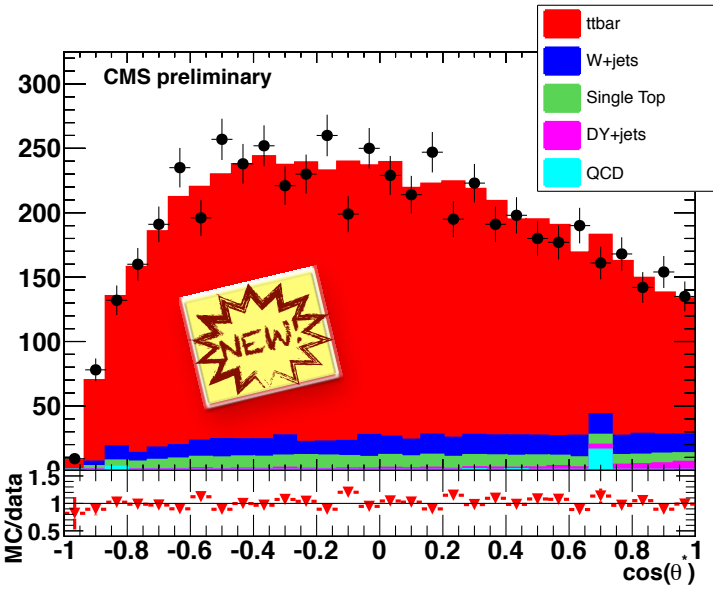
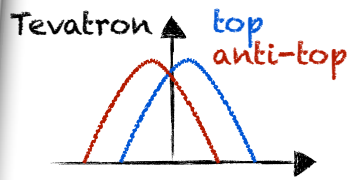




TOP-11-020

Top Charge Asymmetry

- Tevatron sees a possible differential dependency on charge asymmetry
- Asymmetry $A^C = (N^+ - N^-)/(N^+ + N^-)$



TOP-11-030

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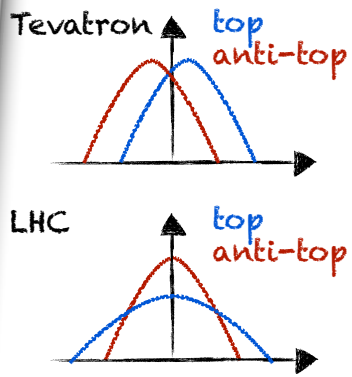
- Crucial difference at LHC: gluon collider!



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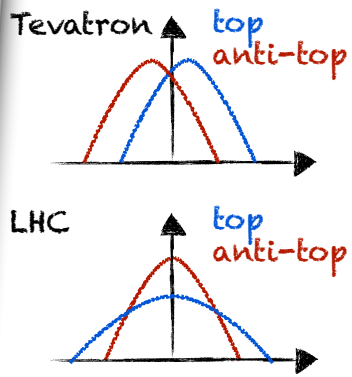

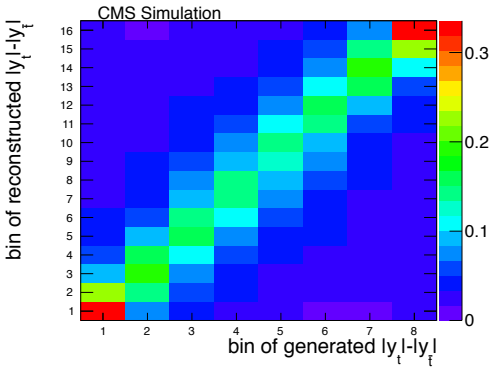

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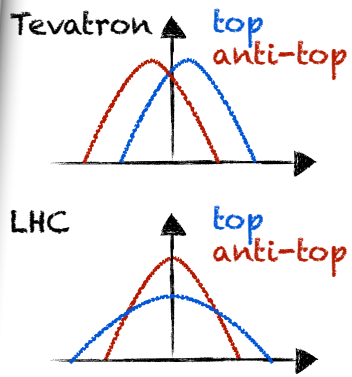

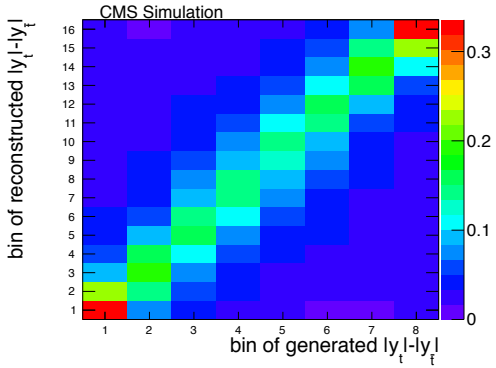

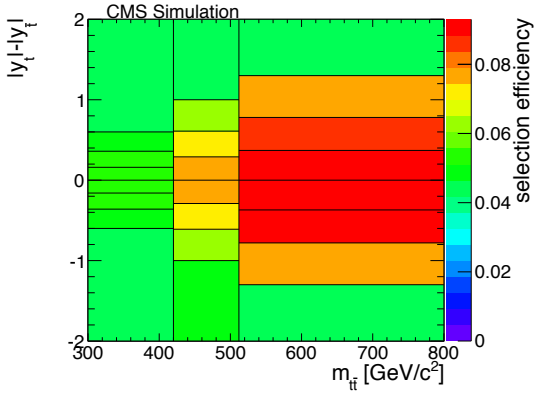

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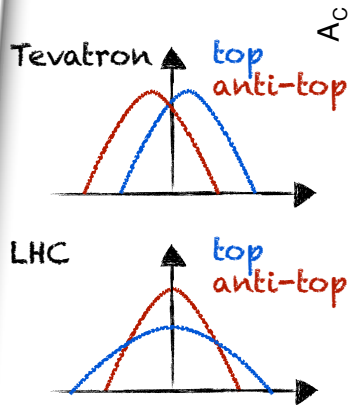

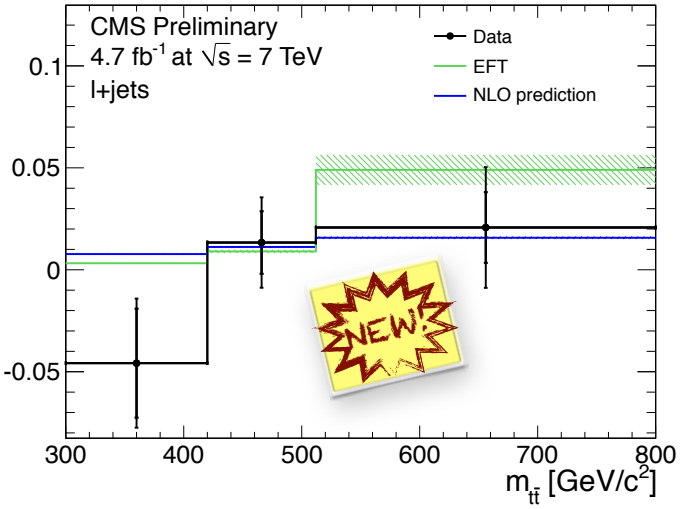

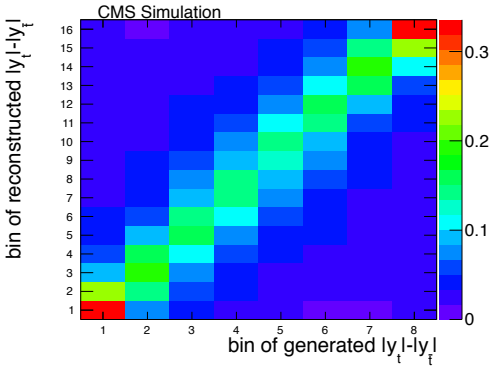

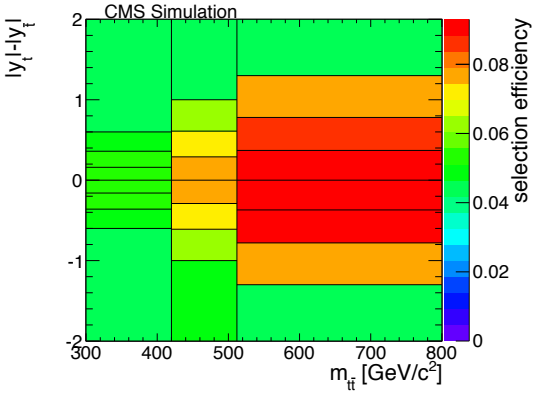

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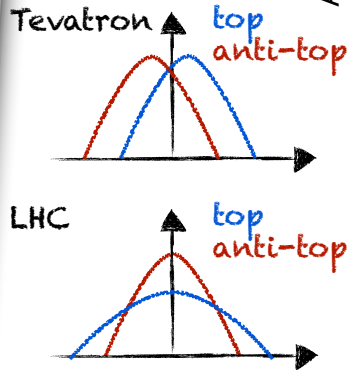

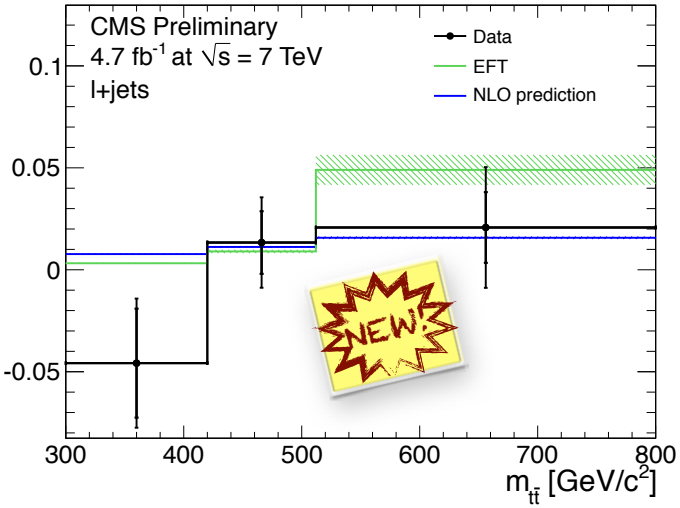

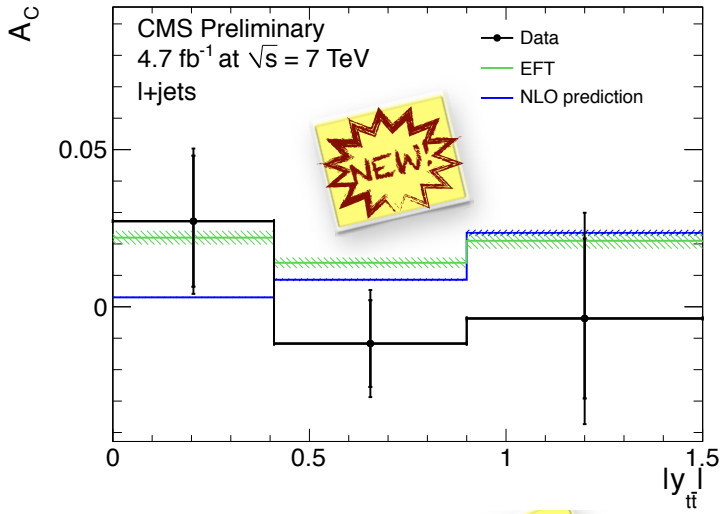

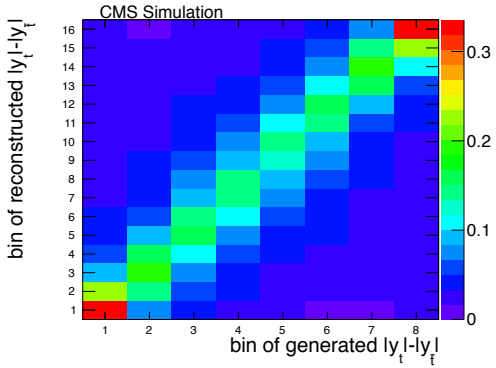

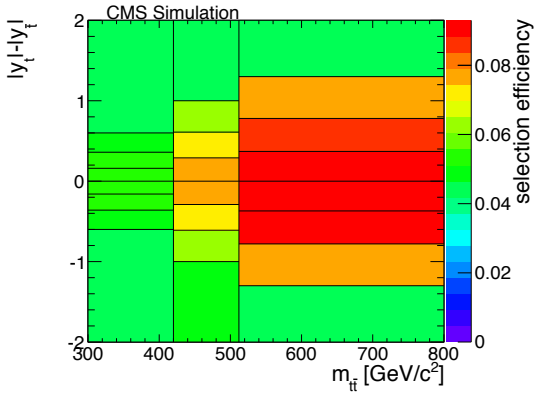

TOP-11-030

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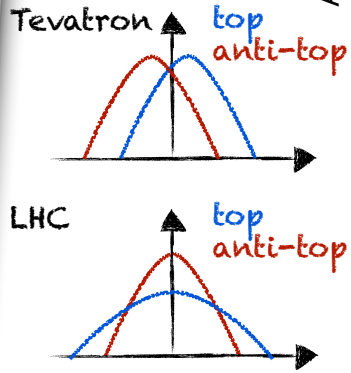

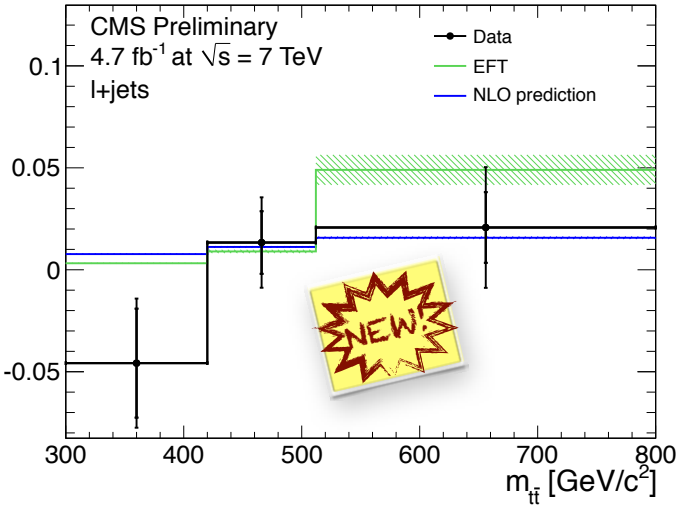

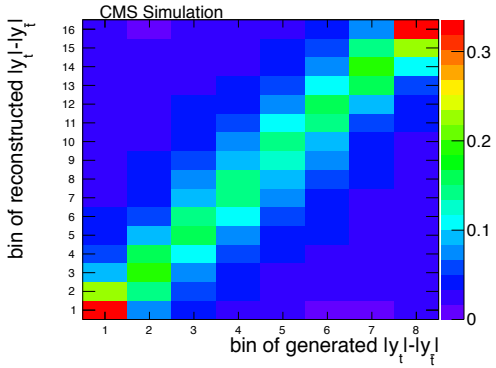

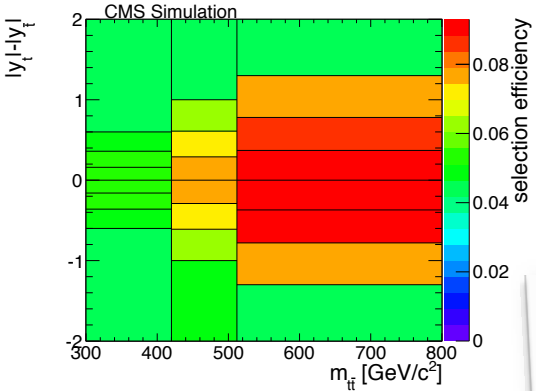

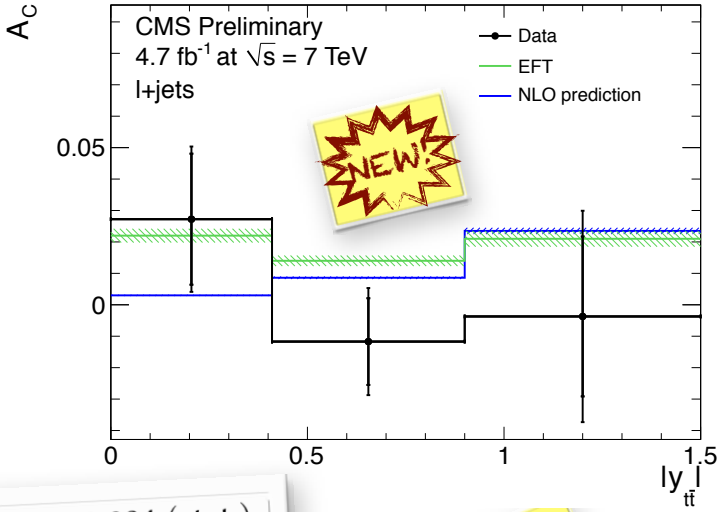

Uncorrected	0.003 ± 0.004 (stat.)
BG-subtracted	0.001 ± 0.005 (stat.)
Final corrected	0.004 ± 0.010 (stat.) ± 0.012 (syst.)
Theory prediction (SM)	0.0115 ± 0.0006

TOP-11-030

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UIC University of Illinois at Chicago

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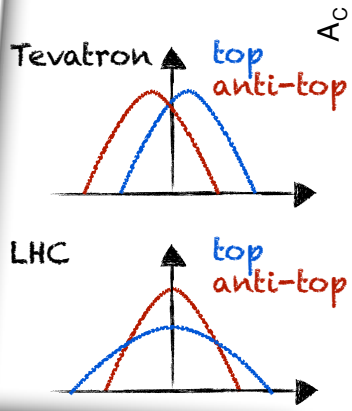
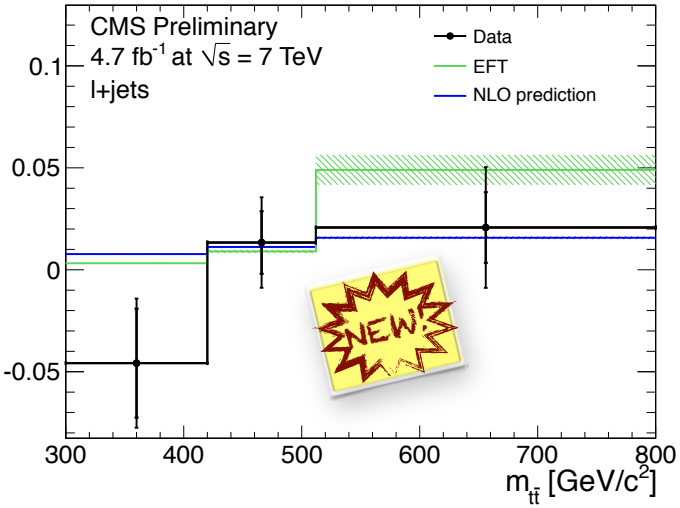
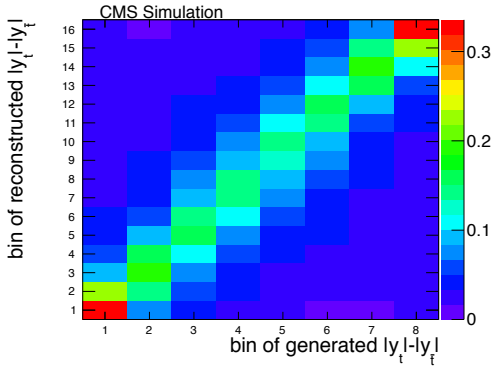
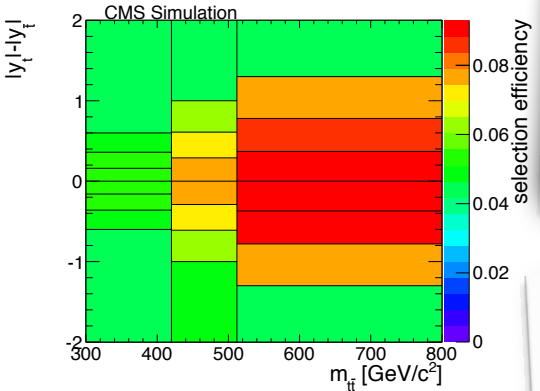
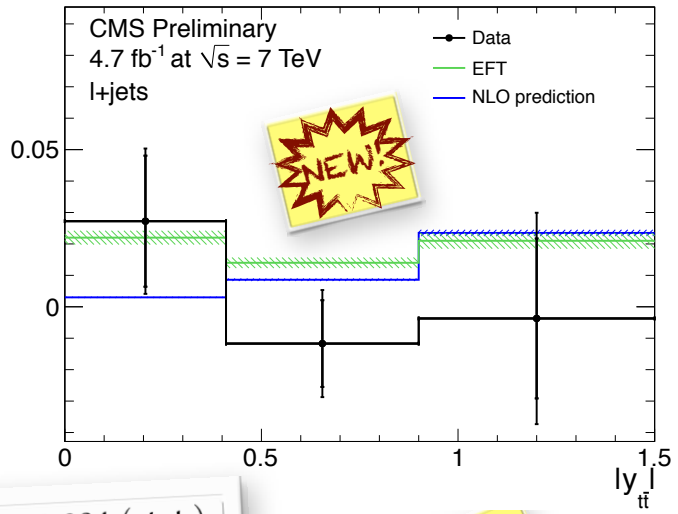








Systematic uncertainty	inclusive A_C
JES	0.002
JER	0.002
Pileup	0.001
Generator	0.001
Migration matrix	0.002
Unfolding	0.008
W+jets	0.004
Multijet	0.001
Lepton ID/sel. efficiency	0.006
Q^2 scale	0.002
Hadronization	0.001
PDF	0.002
Total	0.012



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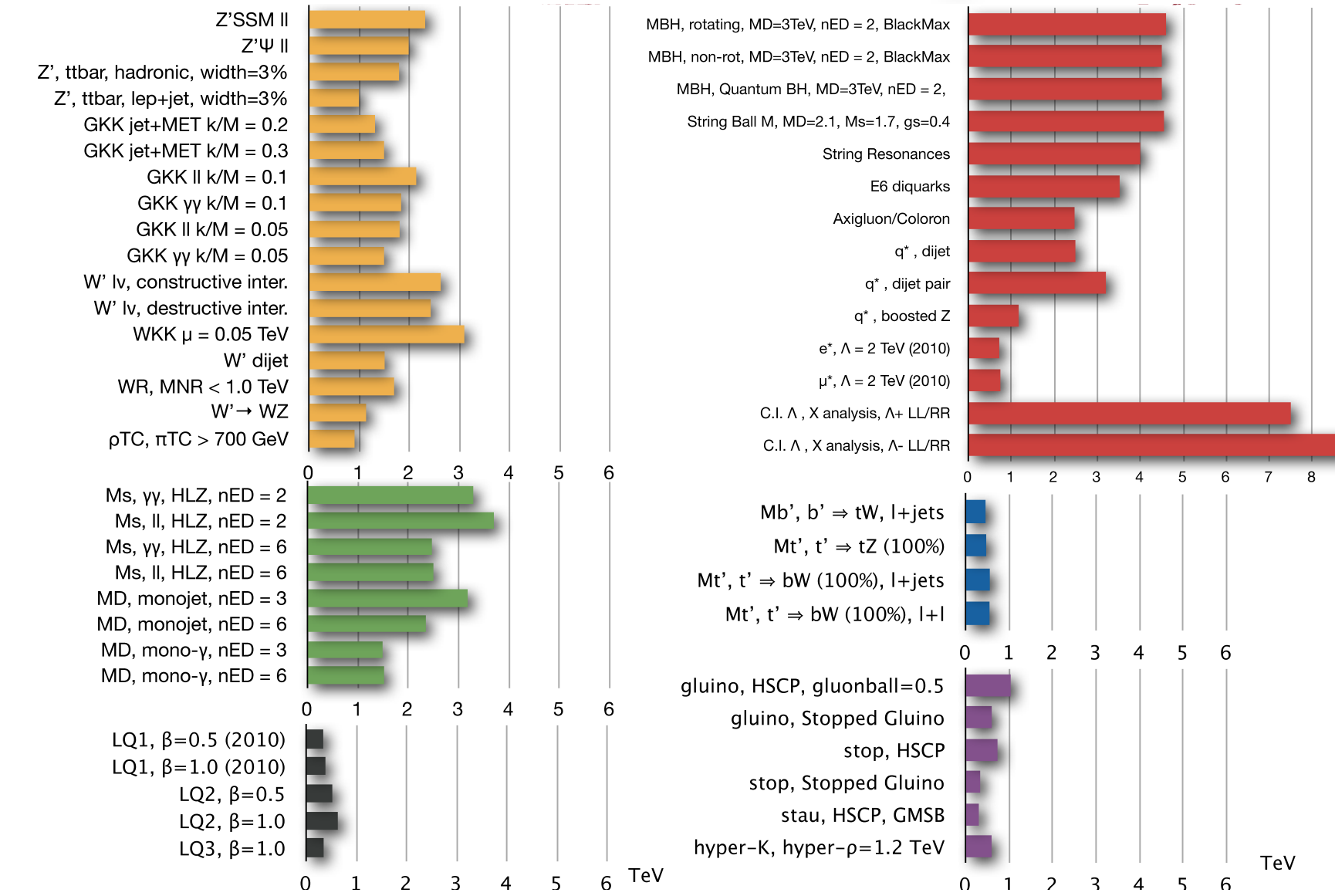
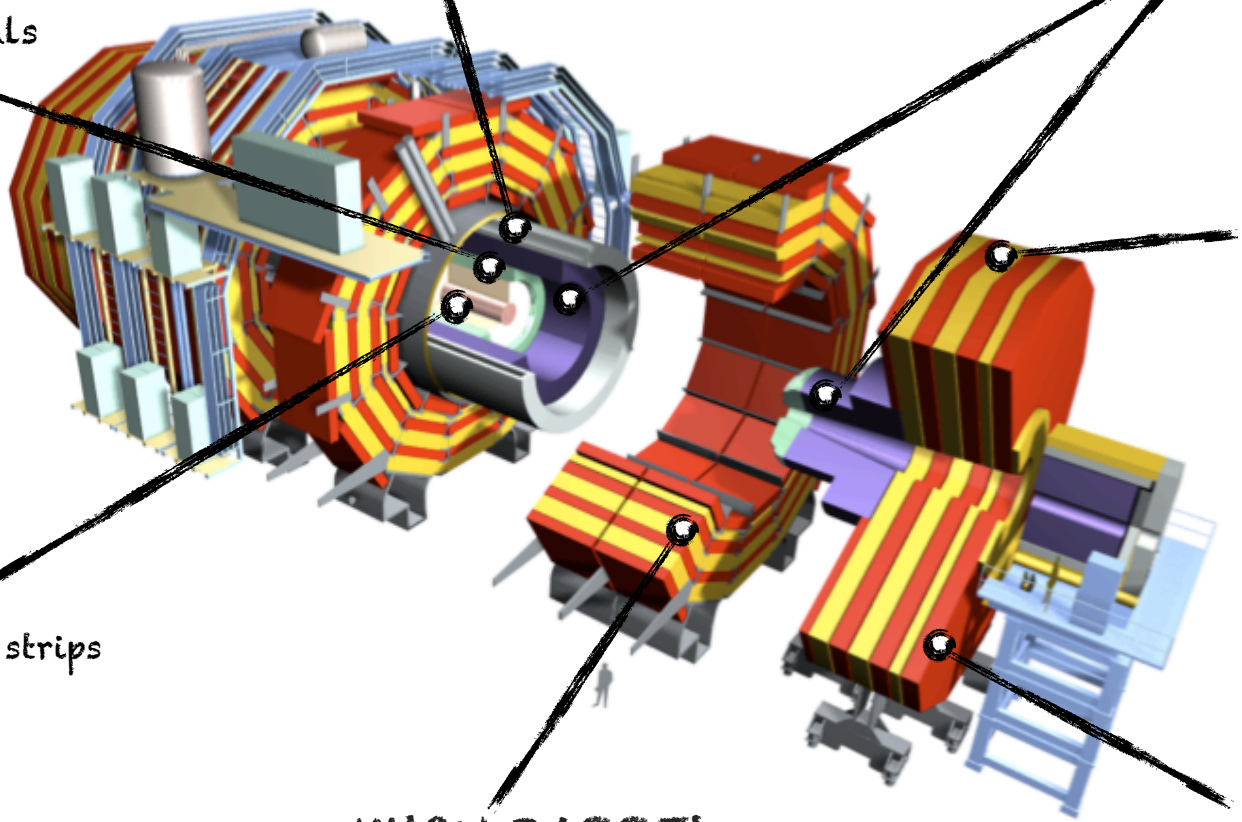
TOP-11-030

Exotica Summary





Length: 21.6 m
Diameter: 15 m
Weight: ~12,500 tons
Magnetic Field: 4 Tesla