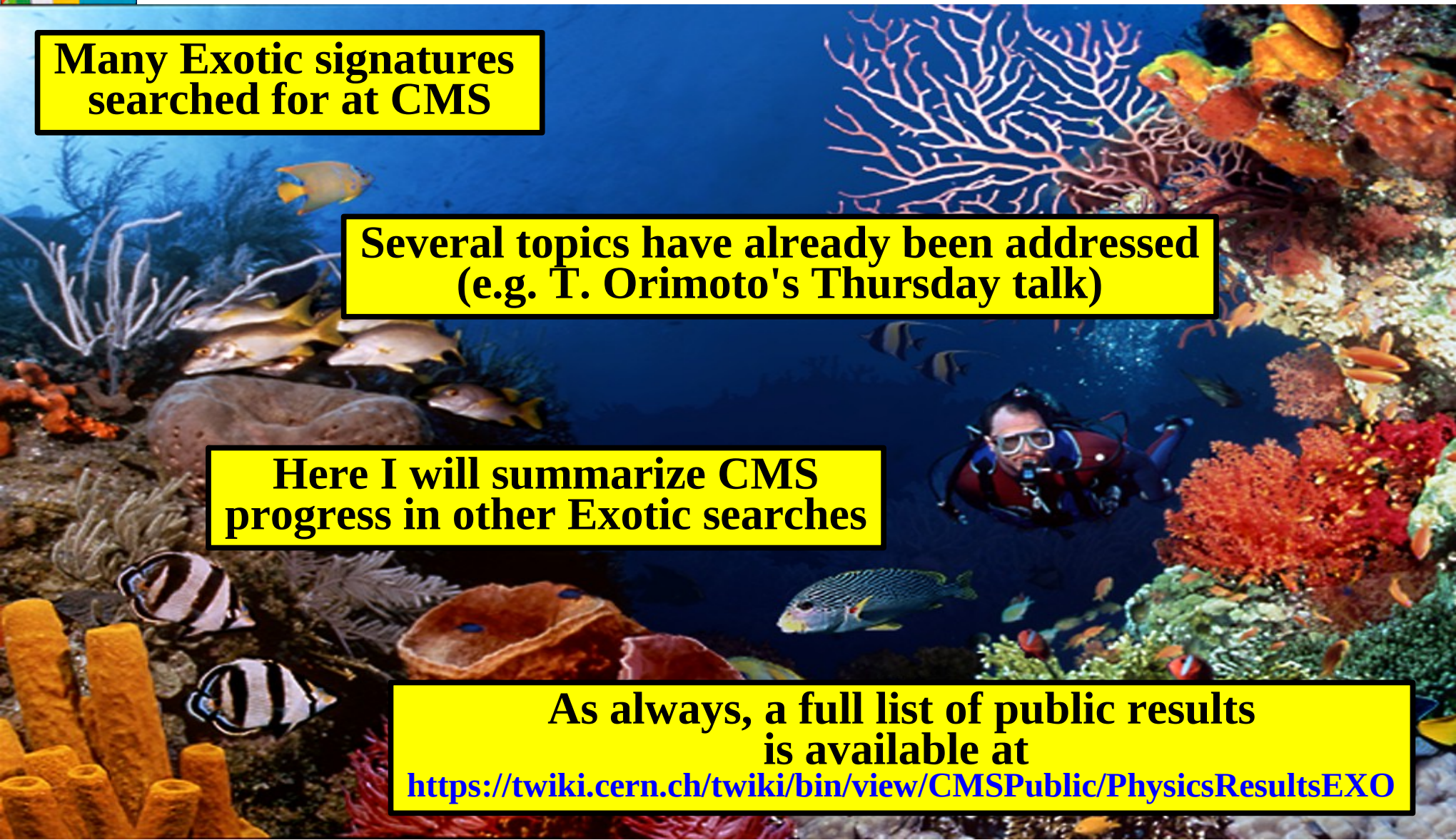
Exotica Searches at CMS

Bryan Dahmes (University of Minnesota)

On behalf of CMS

Introduction



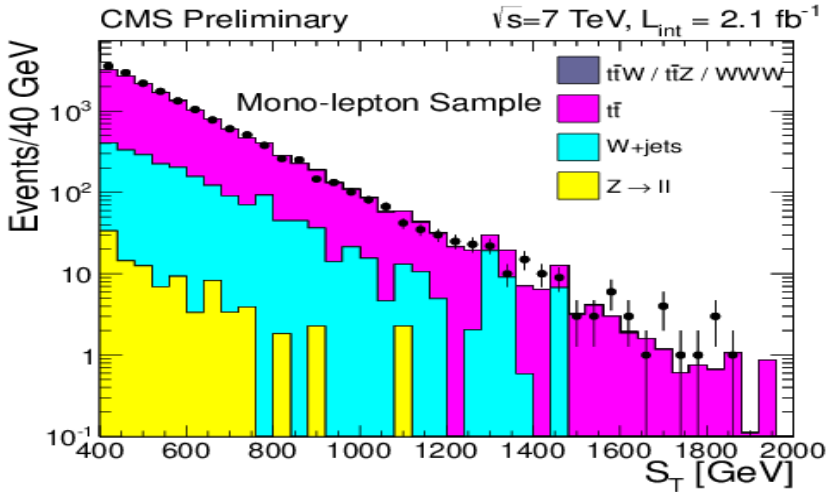
Many Exotic signatures searched for at CMS

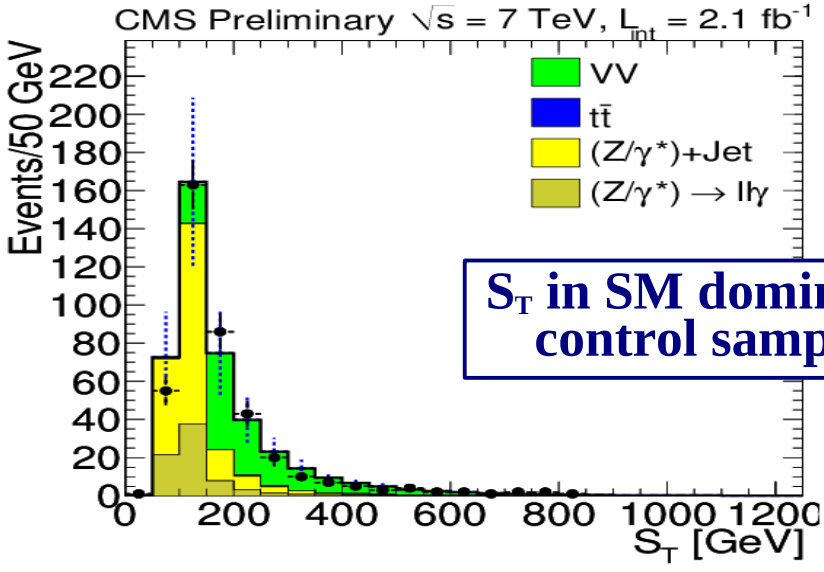
Several topics have already been addressed (e.g. T. Orimoto's Thursday talk)

Here I will summarize CMS progress in other Exotic searches

As always, a full list of public results is available at
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO

R-Parity Violation in Multilepton Events

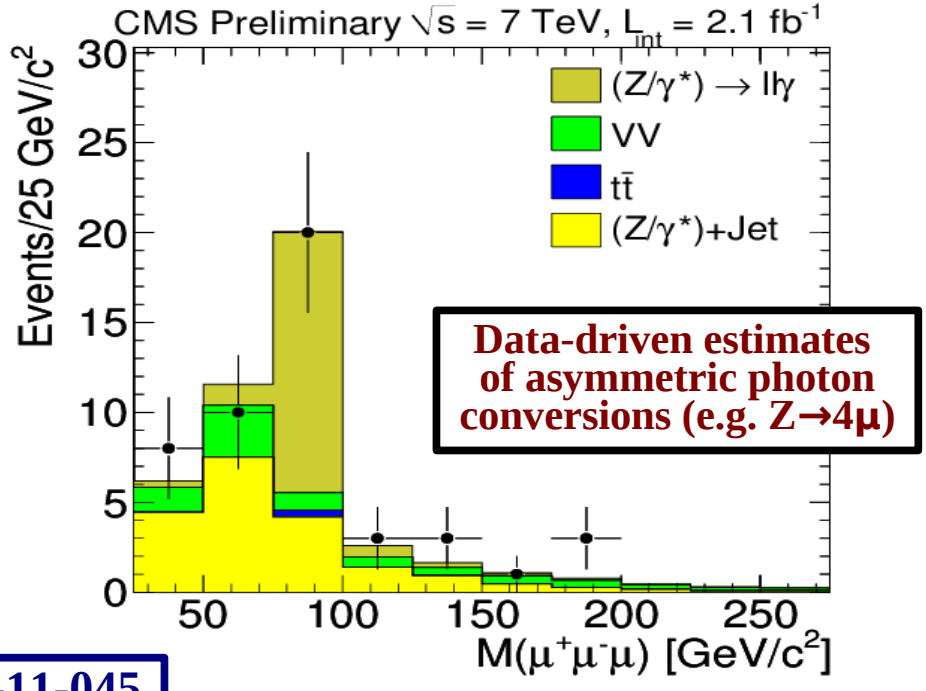




S_T in SM dominated control samples

LSP is unstable

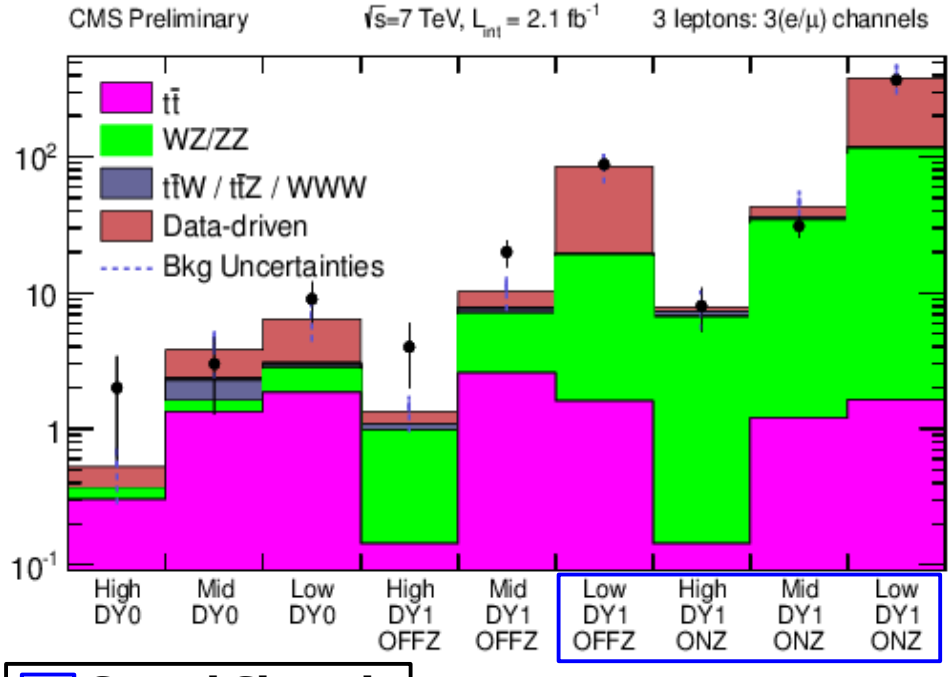
Replace missing E_T with $S_T = \Sigma p_T^{\text{jets, leptons}} + E_T^{\text{miss}}$

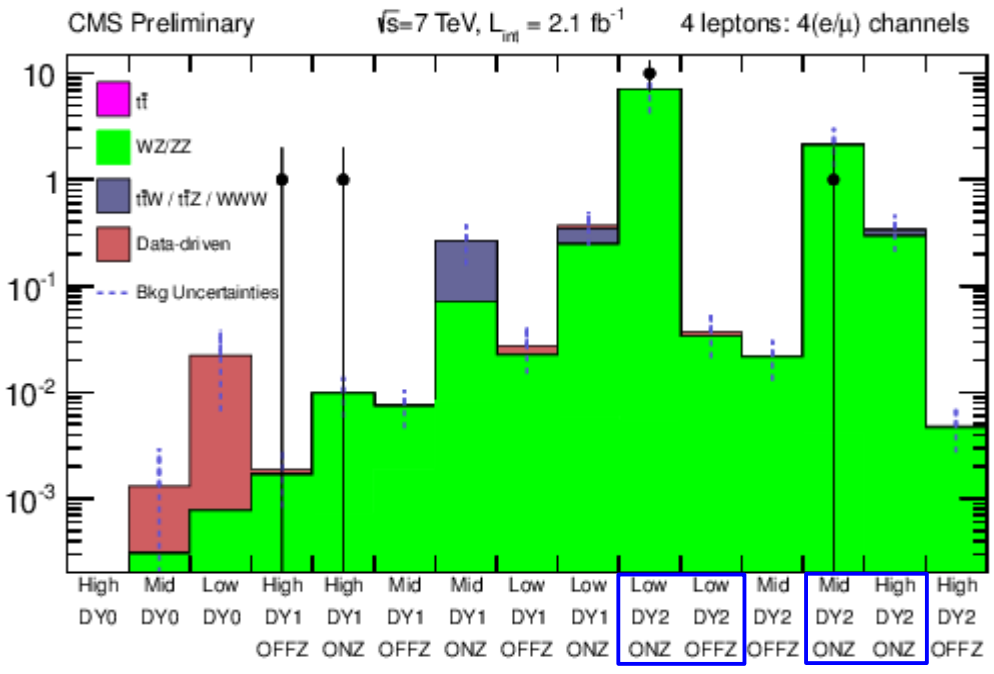


Data-driven estimates of asymmetric photon conversions (e.g. Z→4μ)

EXO-11-045

R-Parity Violation in Multilepton Events





Control Channels

Results summarized in 52 exclusive channels

Number of Drell-Yan pairs
Inside/Outside Z window
S_T range (0-300, 300-600, 600+ GeV)
3/4 leptons: e/μ with 0/1/2 tau

EXO-11-045

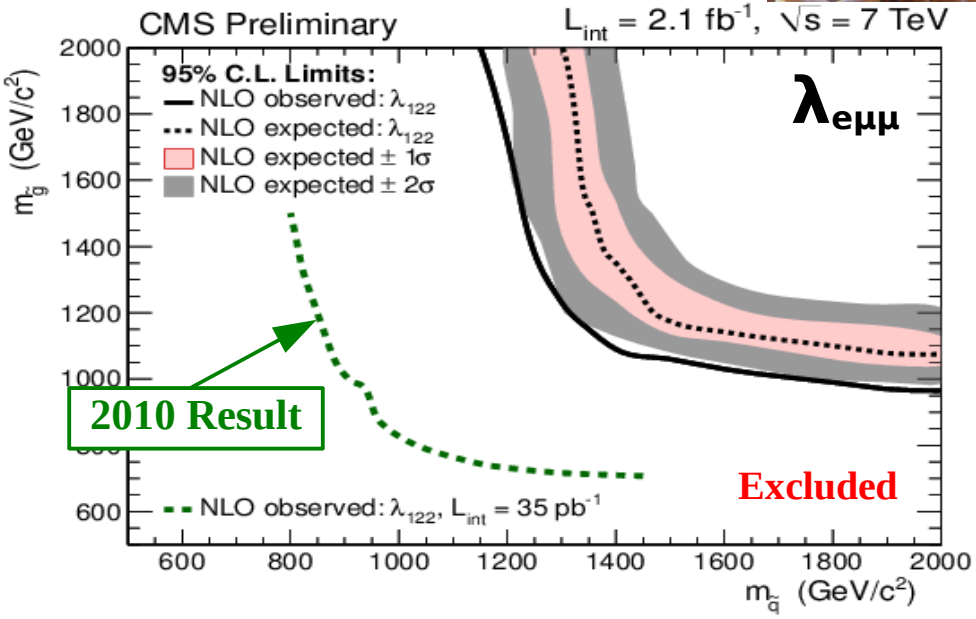
Good overall agreement with Standard Model

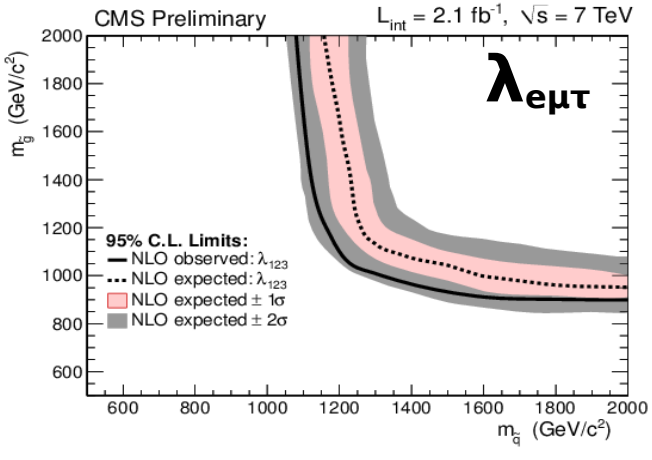
A few events seen in channels with low SM background expectations

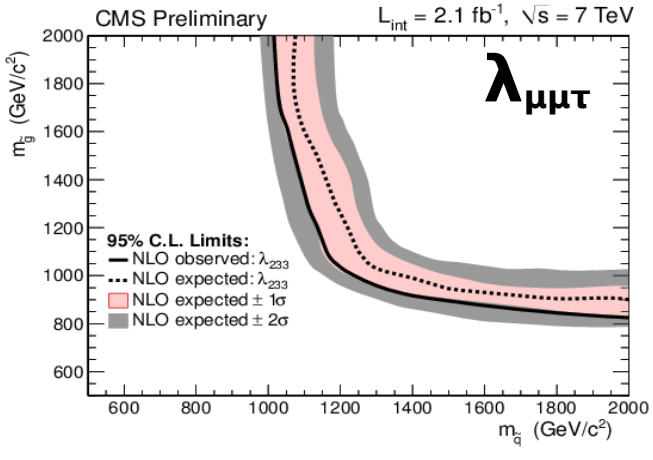
R-Parity Violation in Multilepton Events

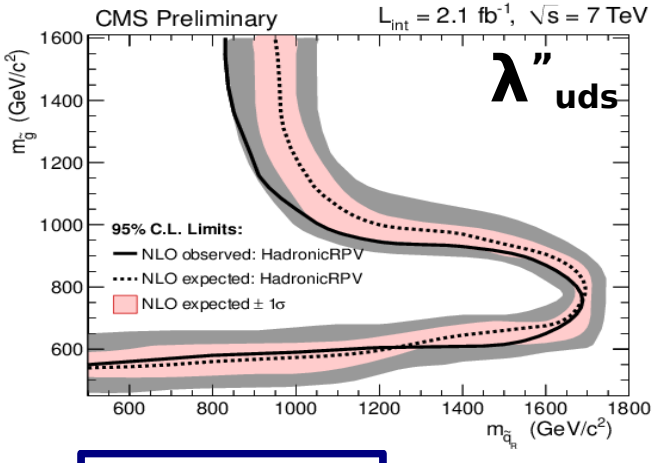
Exclusion contours for coupling strengths

Plotted in M(squark) vs. M(gluino)



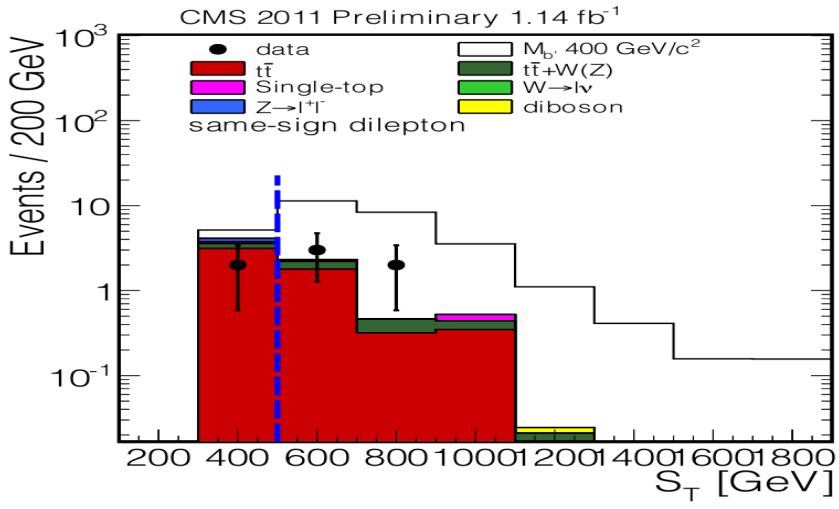


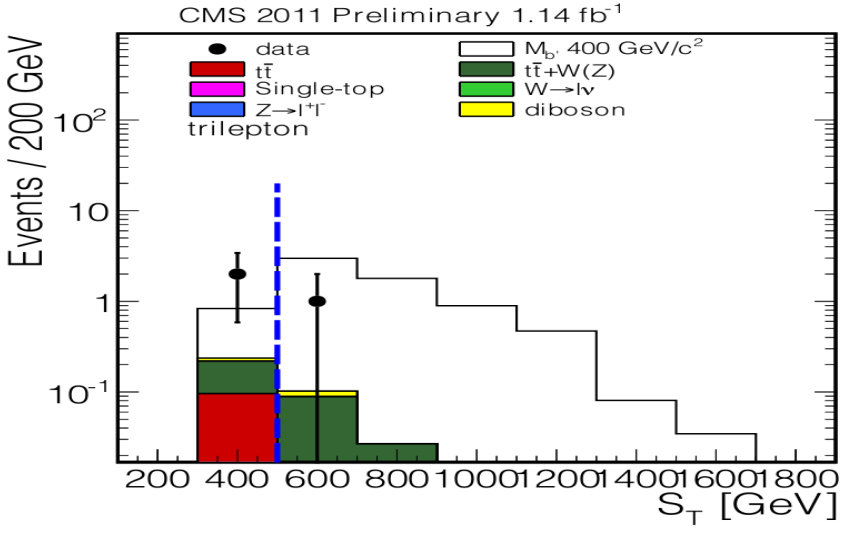




EXO-11-045

4th Generation Quarks

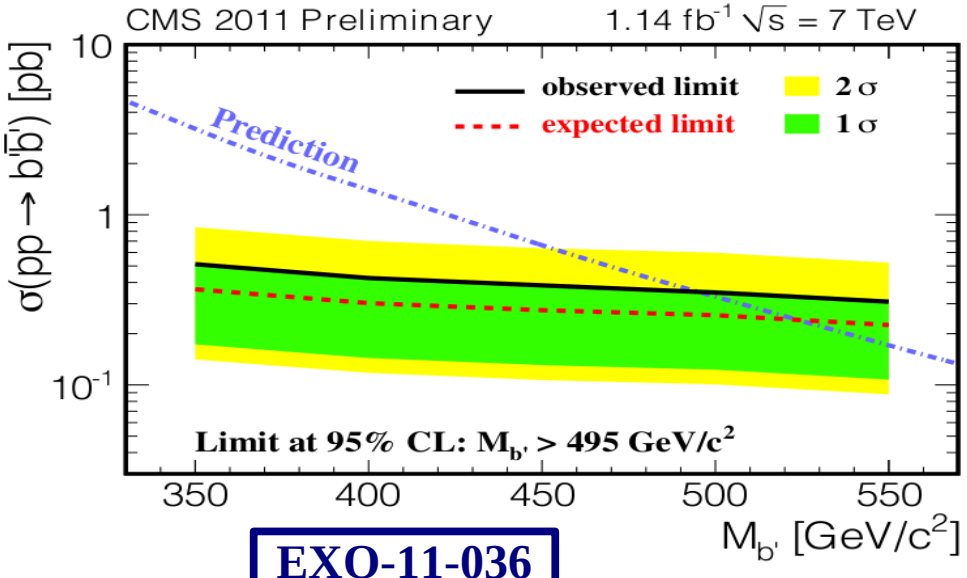




Searches for b' with final-state leptons

b'b'→tWtW→2b+4W

Examine S_T for events with three leptons or same-sign dileptons



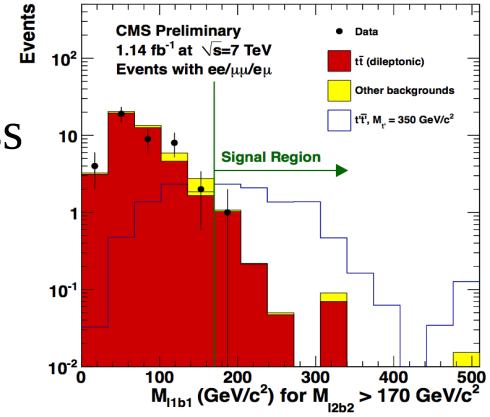
EXO-11-036

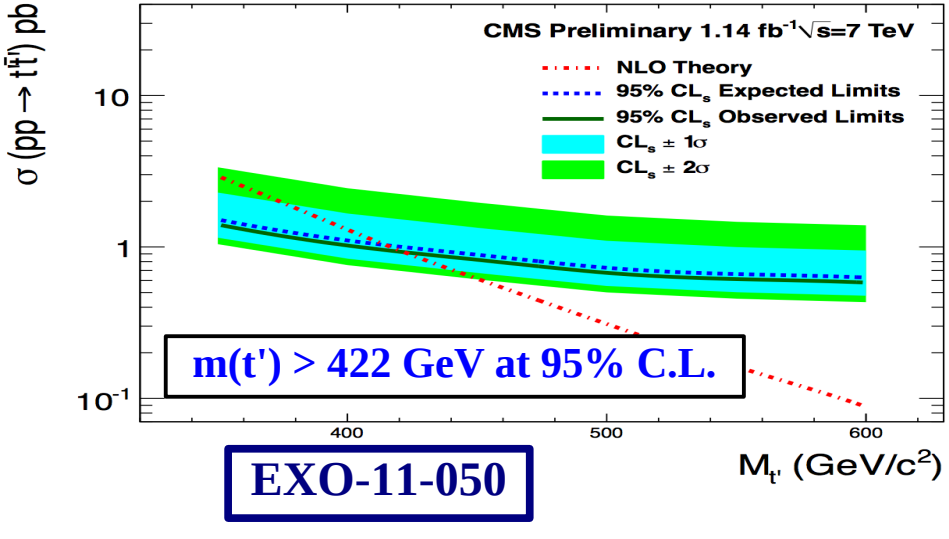
4th Generation Quarks

Searches for t' with final-state leptons

$t't' \to bWbW \to 2b+2\ell+E_T^{miss}$

Signal region: Mass of each ℓb combination above 170 GeV



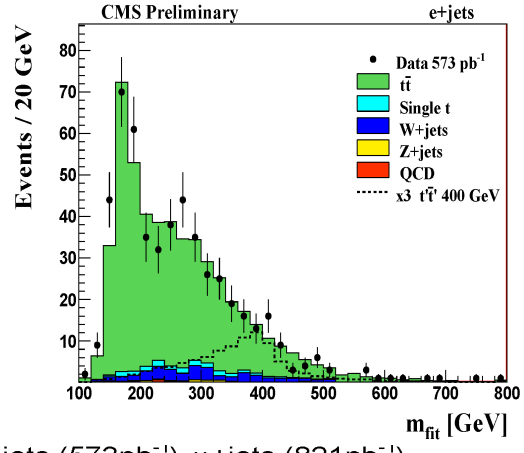


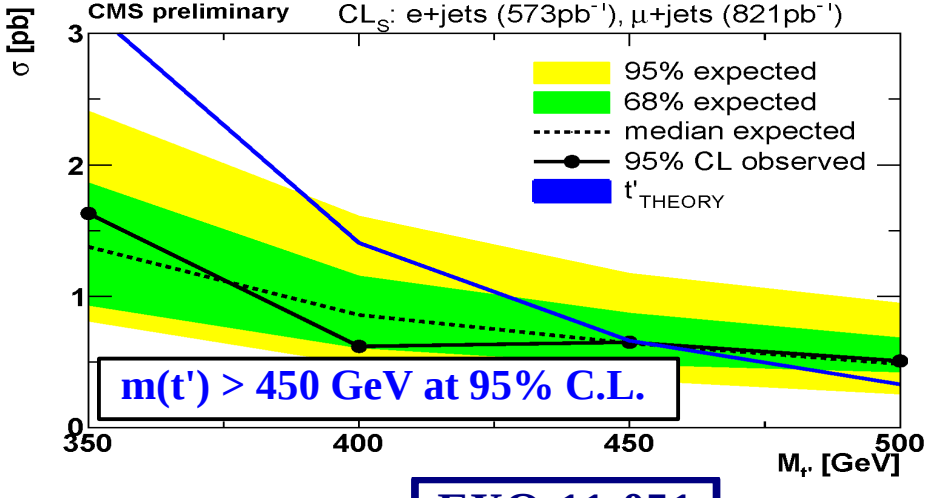
m(t') > 422 GeV at 95% C.L.

EXO-11-050

$t't' \to bWbW \to \ell+jets+E_T^{miss}$

Constrain $m(b\ell\nu) = m(bjj)$
Examine fitted t' mass, H_T





m(t') > 450 GeV at 95% C.L.

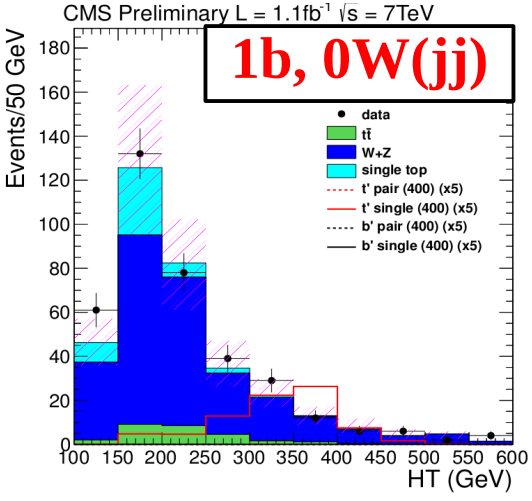
EXO-11-051

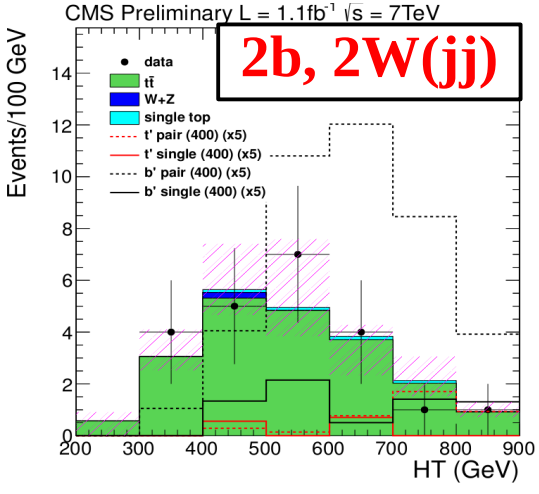
4th Generation Quarks

Search for new t' or b' quarks produced singly or in pairs

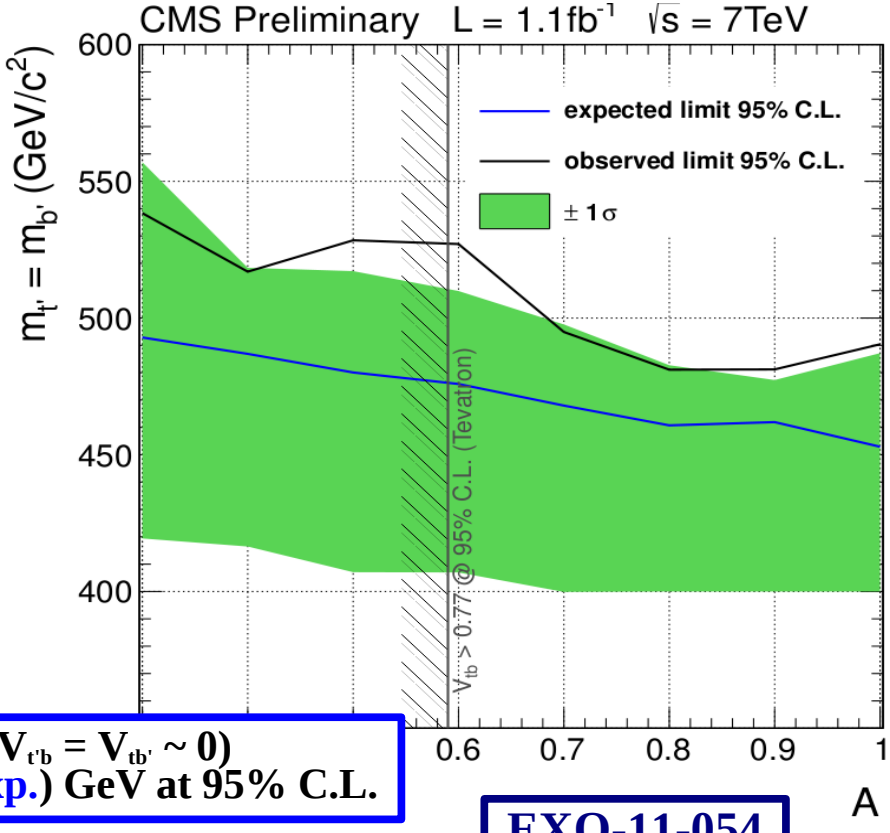
b't→tWbW→bWWbW
b'b'→tWtW→bWWbWW
t'b→bWb
t't→bWbW

$$\text{CKM4} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} & V_{ub'} \\ V_{cd} & V_{cs} & V_{cb} & V_{cb'} \\ V_{td} & V_{ts} & V_{tb} & V_{tb'} \\ V_{t'd} & V_{t's} & V_{t'b} & V_{t'b'} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \sqrt{A} & \sqrt{1-A} \\ 0 & 0 & \sqrt{1-A} & \sqrt{A} \end{pmatrix}$$





Examine channels with b jets, W→jj



At $V_{tb} \sim 1$ ($V_{t'b} = V_{tb'} \sim 0$)
m(q') > 490 (453 exp.) GeV at 95% C.L.

EXO-11-054

T/t'→tZ

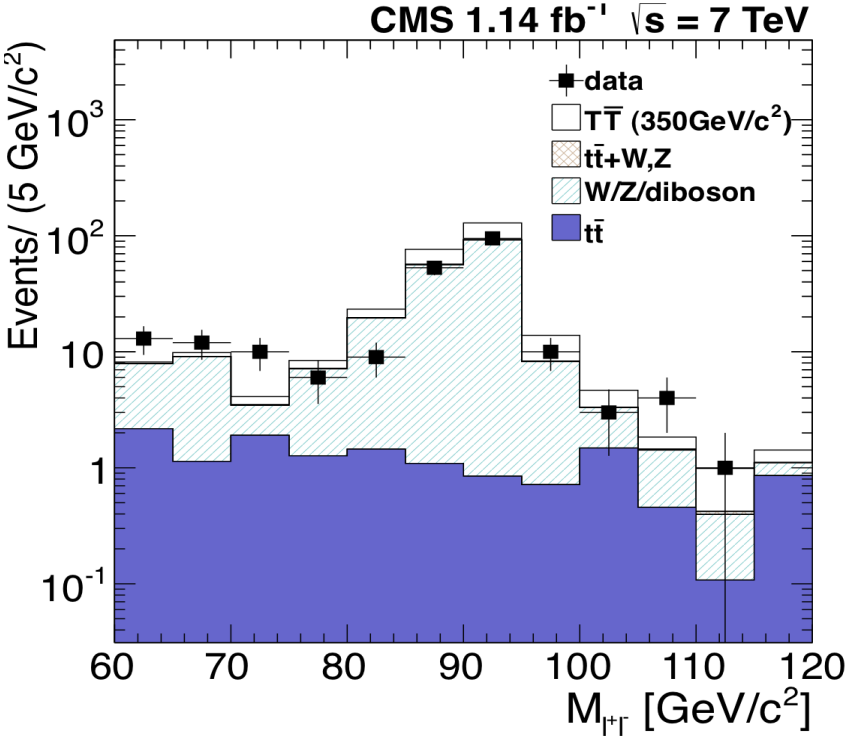
Search for pp→TT→tZtZ→bbWWZZ

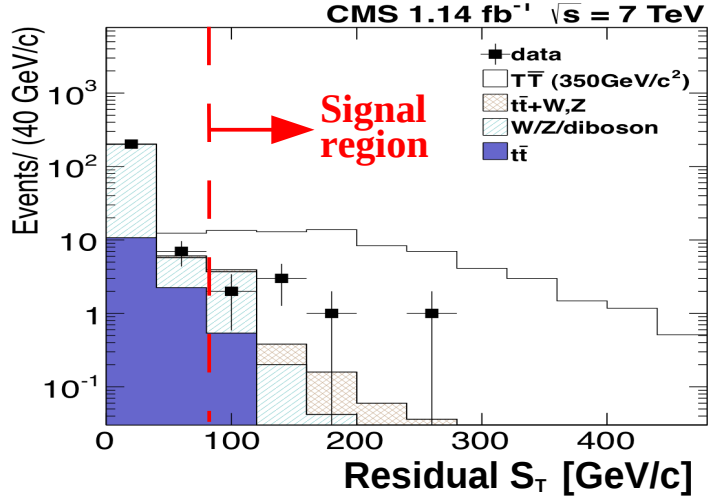
Require at least 3 leptons, 2 jets

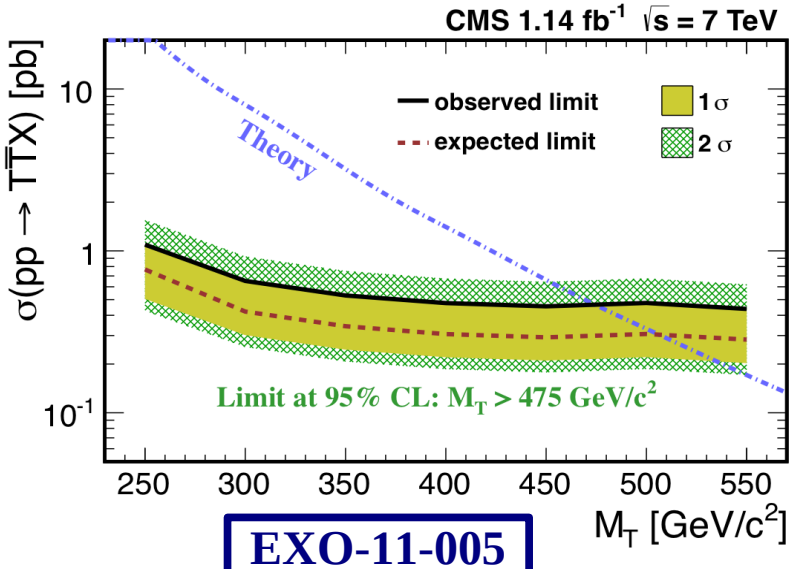
At least one reconstructed $Z \rightarrow \ell\ell$

Residual $S'_T = \Sigma p_T^{\text{jets, leptons}} > 80$ GeV

(*) Exclude two highest p_T leptons, jets



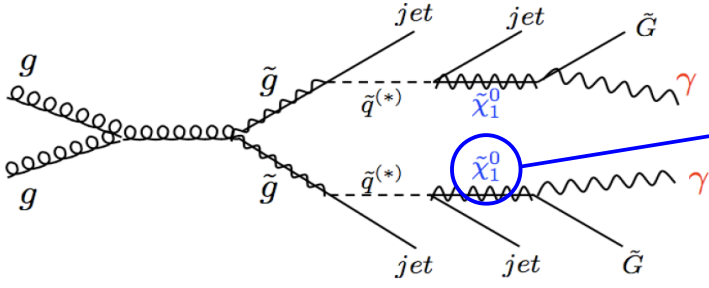


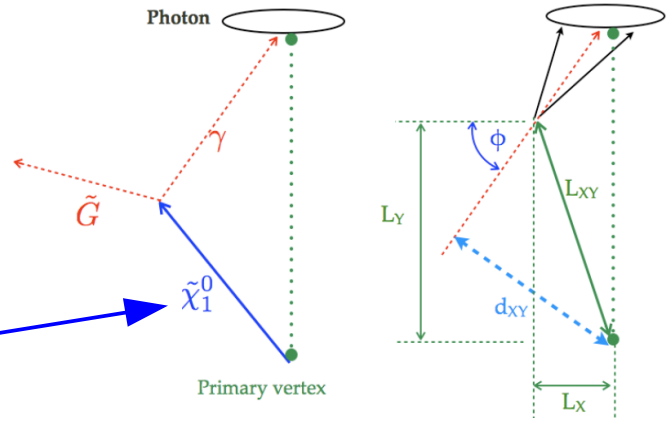


EXO-11-005
arXiv:1109.4985

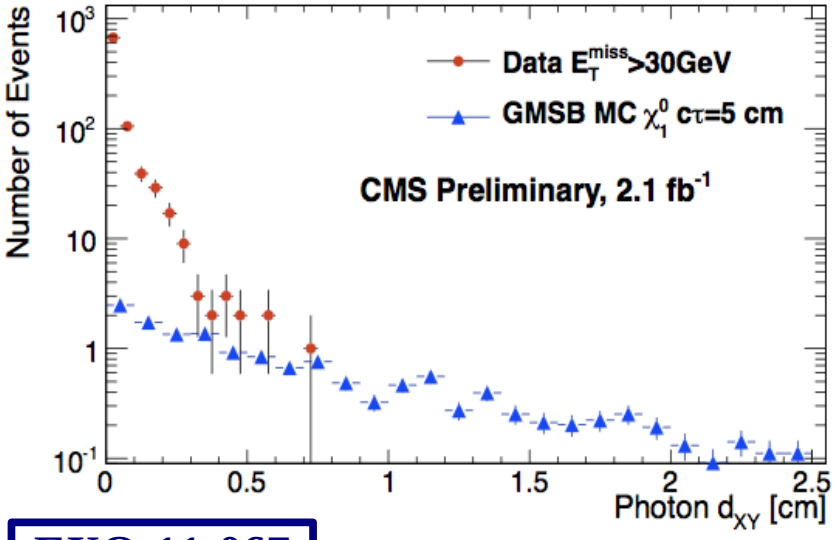
Long-Lived Particles, γ + Missing E_T

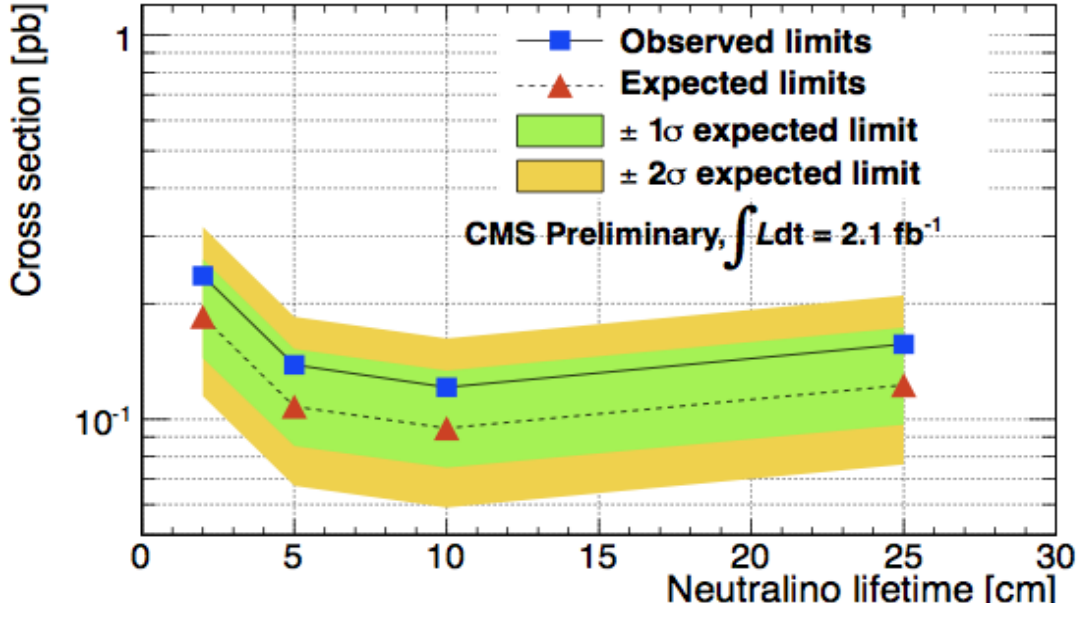
Example: Neutralino with non-zero lifetime





Converted photons will point away from collision vertex



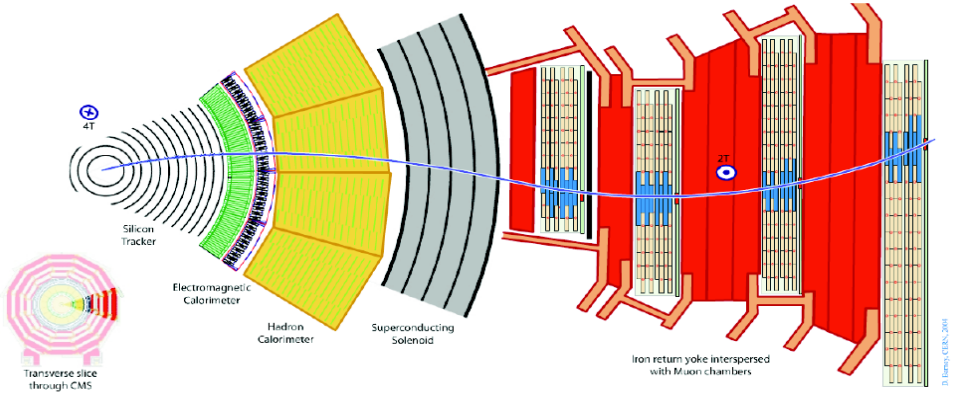


$c\tau$ [cm]	2	5	10	25
σ [pb] 95% C.L	0.24	0.14	0.12	0.16

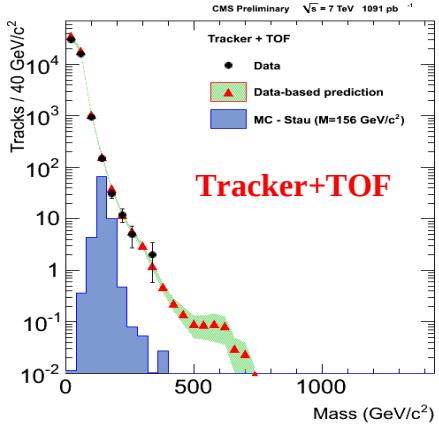
EXO-11-067

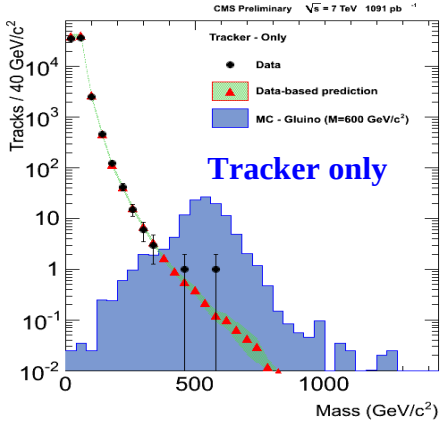
Heavy Stable Charged Particles

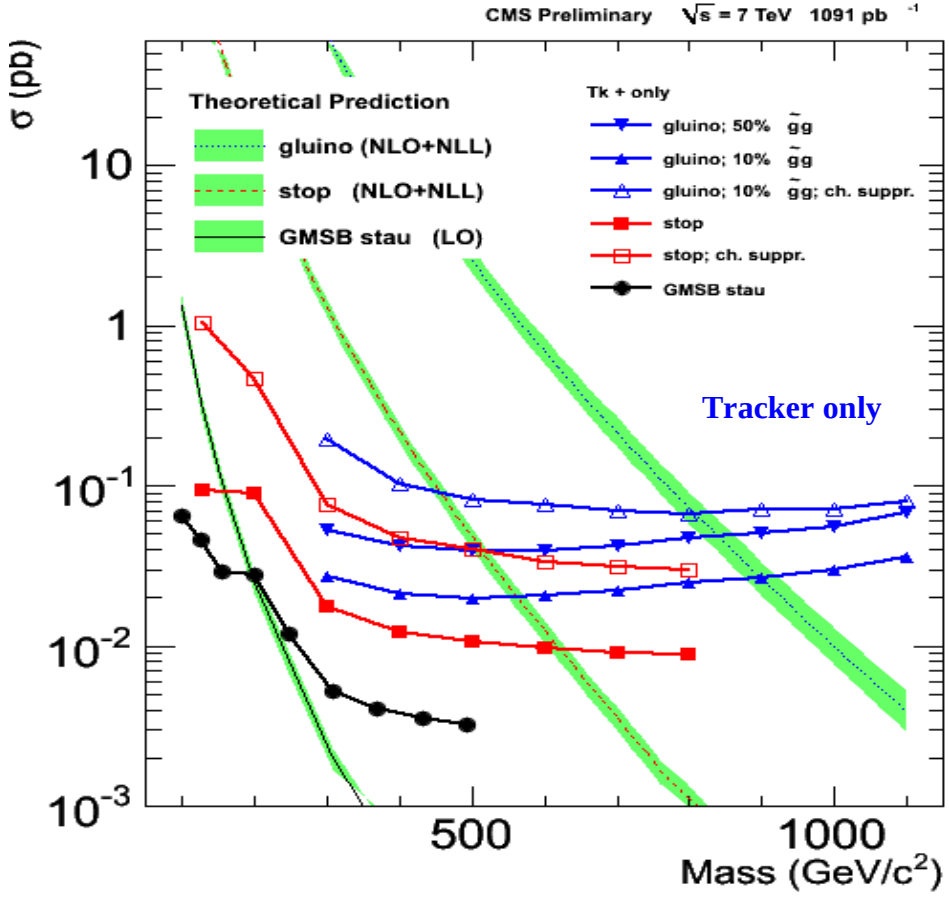
Tracker + TOF (Muon): Search for long-lived charged particle as it travels through CMS



Tracker only: Sensitive to particles that become neutral or stop in CMS

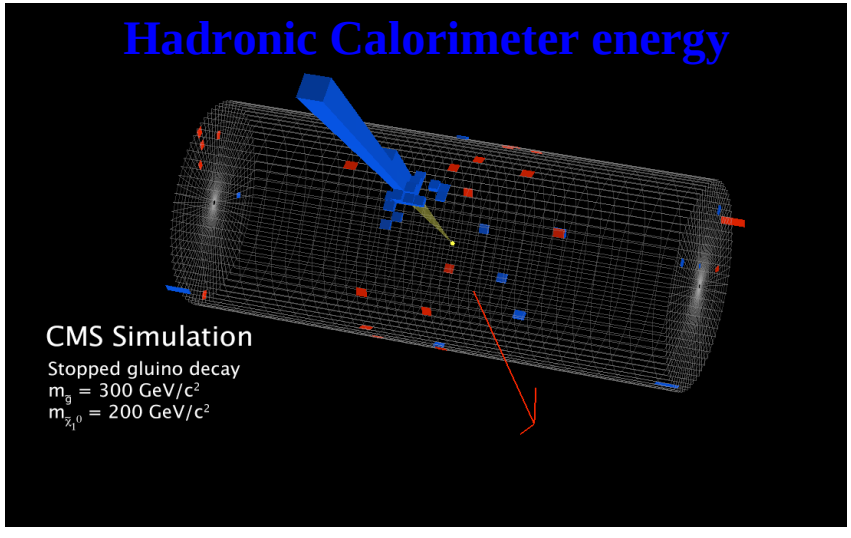




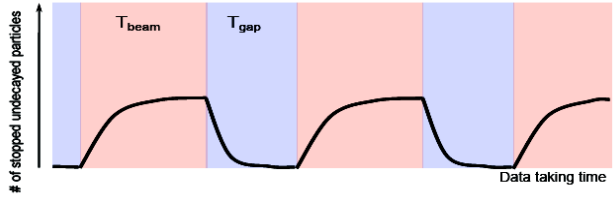


EXO-11-022

Stopped Particles

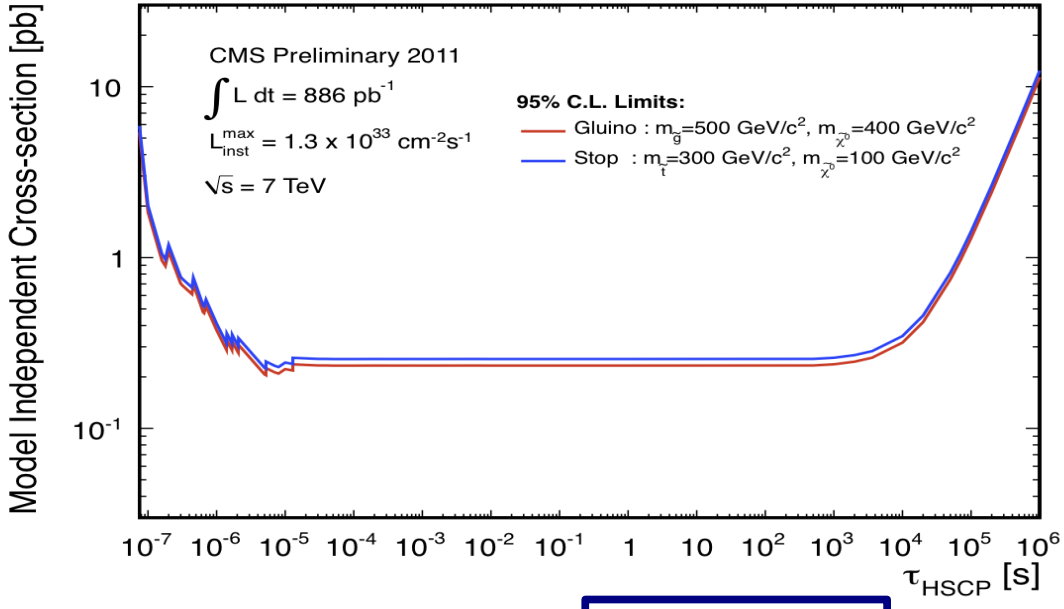


Heavy, stable charged particles that stop in CMS and decay "out of time" with respect to pp collisions



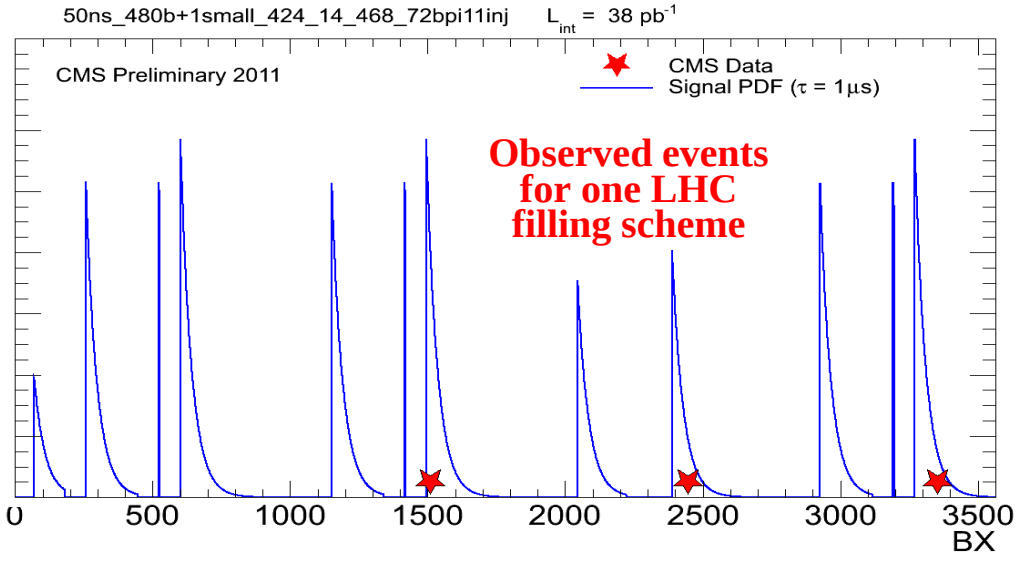
No excess seen over expected background

Set 95% C.L. Exclusion limits over **13 orders of magnitude** in HSCP lifetime

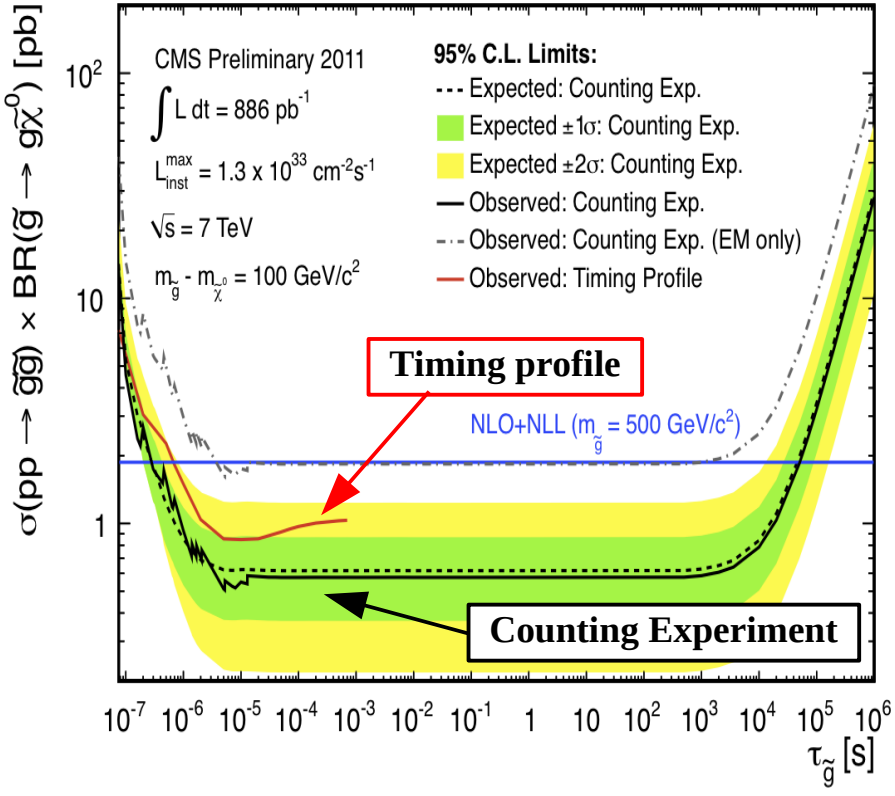


EXO-11-020

Stopped Particles



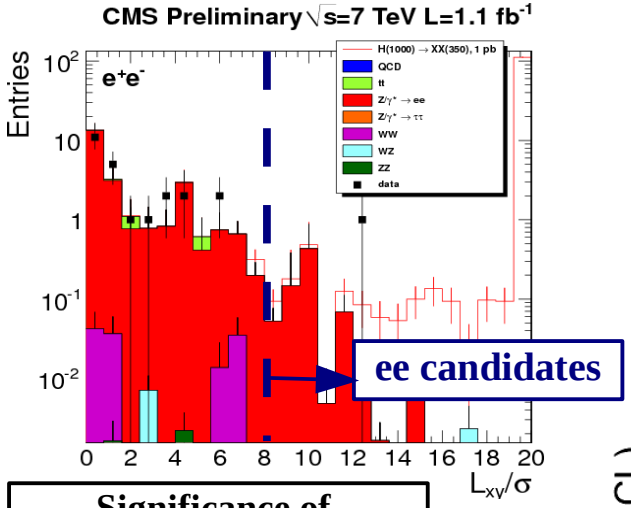
Exploit bunch structure for LHC fills and account for different time profiles for signal and background



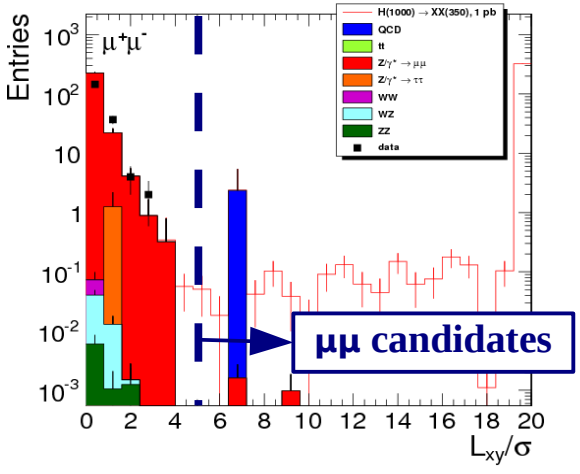
EXO-11-020

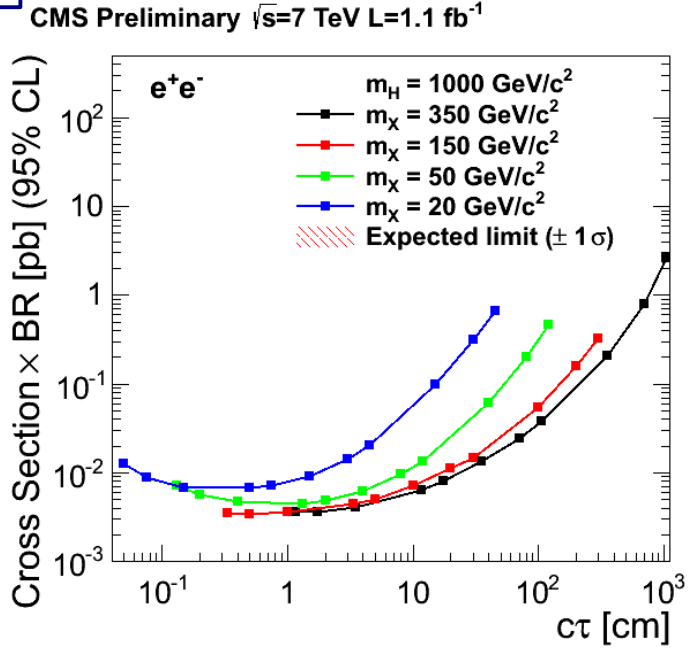
Displaced Leptons

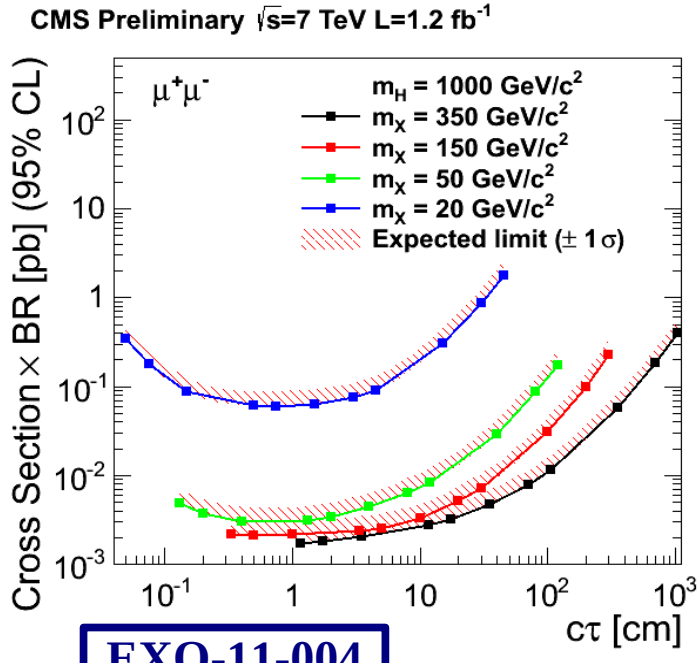
Search for massive neutral particles that travel before decaying to leptons
(e.g. $pp \rightarrow H \rightarrow 2X$, $X \rightarrow \ell^+\ell^-$)
Pairs of charged tracks with common displaced vertex



Significance of transverse decay length

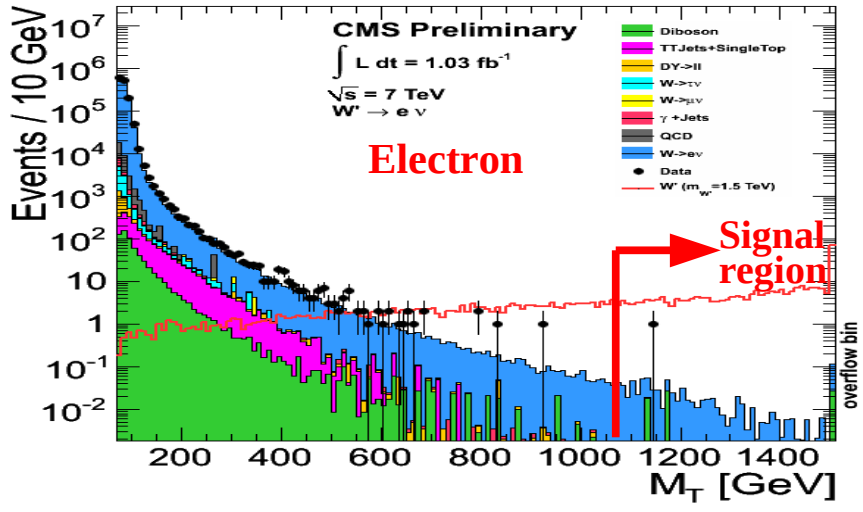


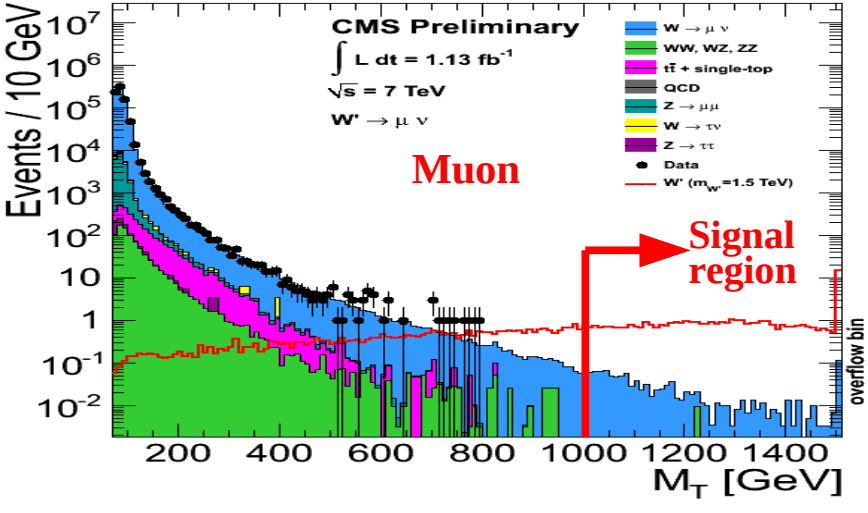




EXO-11-004

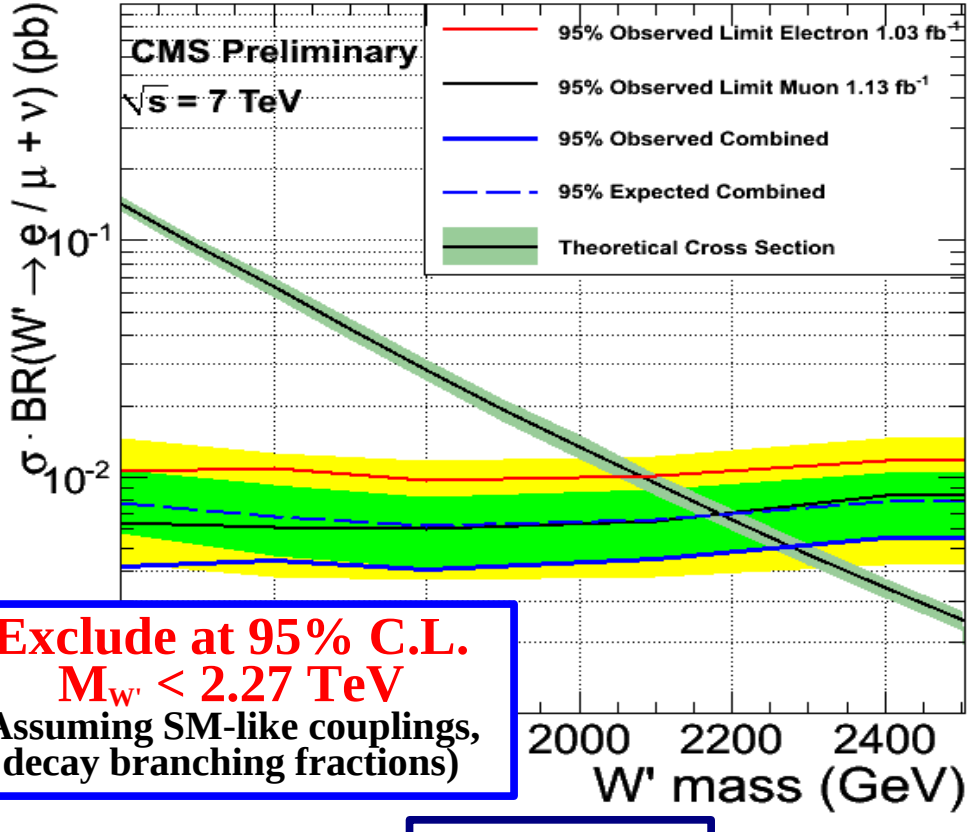
W' Searches





W'→ℓν:
High energy lepton and "nothing else"

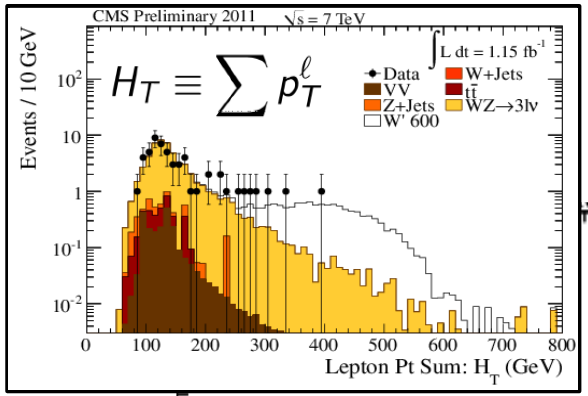
$$M_T = \sqrt{2 p_T E_T^{\text{miss}} (1 - \cos \Delta\phi_{\ell,\nu})}$$



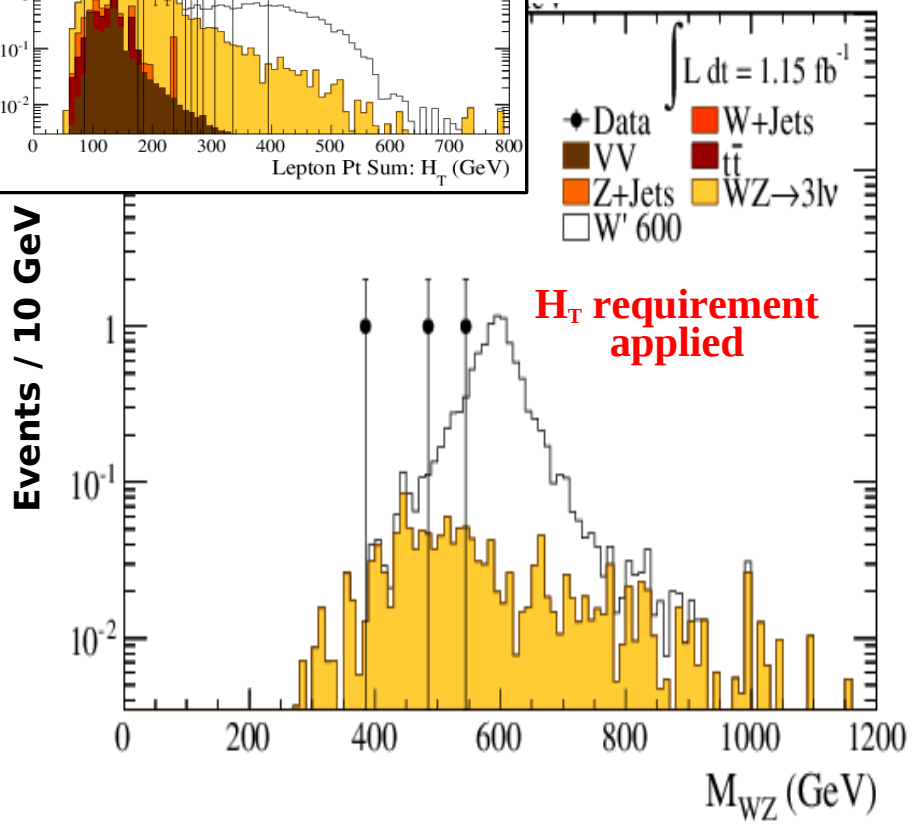
Exclude at 95% C.L.
$M_{W'} < 2.27$ TeV
(Assuming SM-like couplings, decay branching fractions)

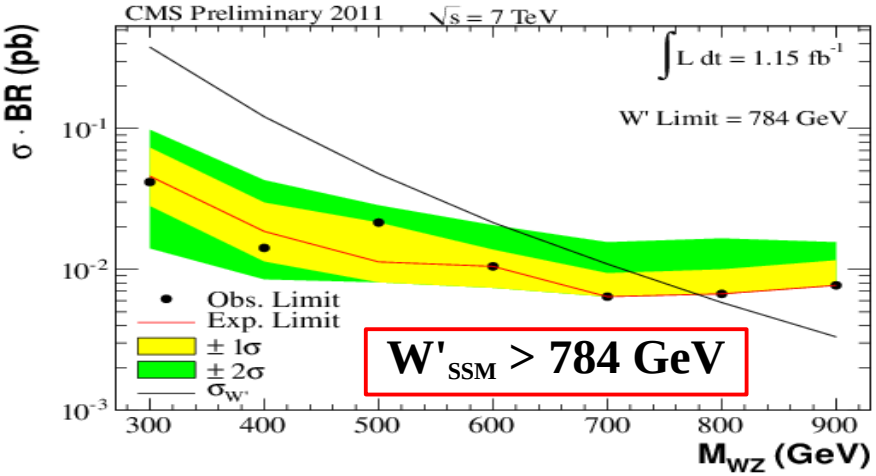
EXO-11-024

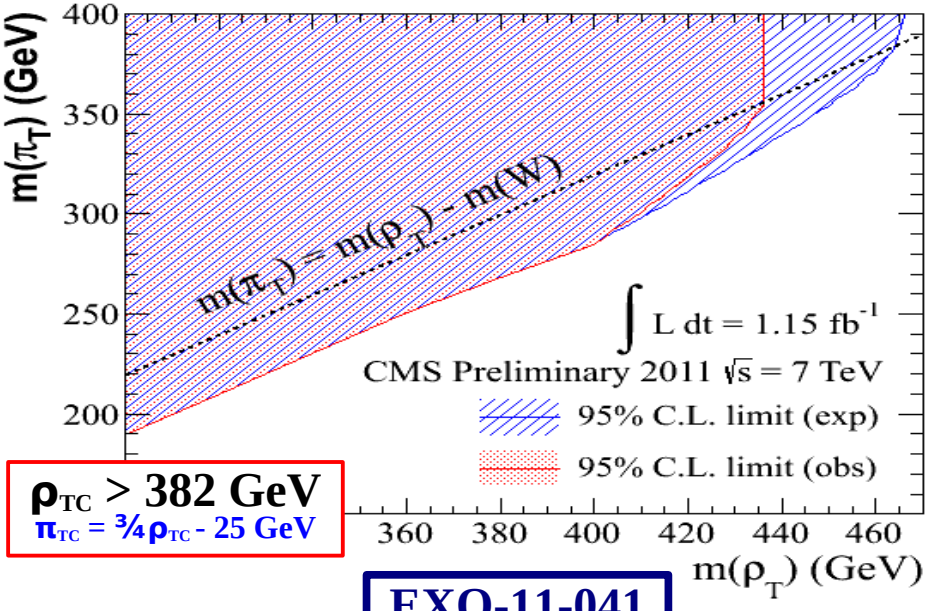
WZ Resonances



Search for W' or narrow ρ_{TC} decaying to WZ



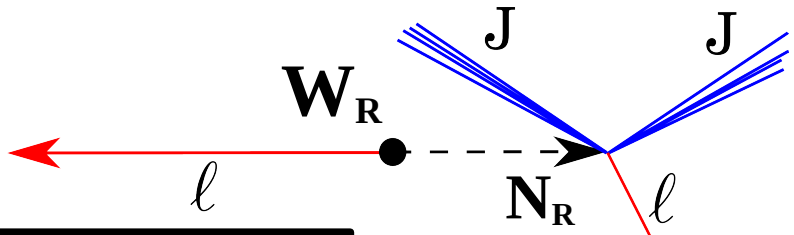




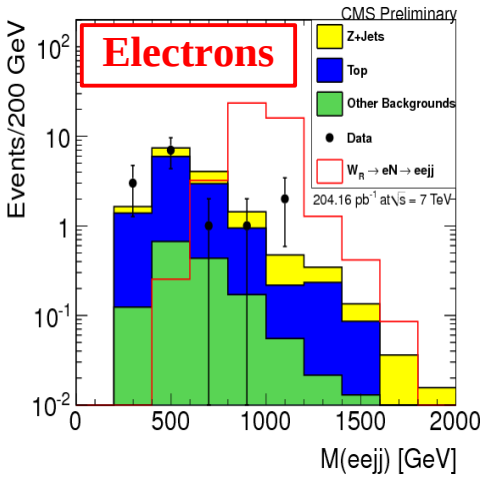
ρ_{TC} > 382 GeV
$\pi_{TC} = \frac{3}{4}\rho_{TC} - 25$ GeV

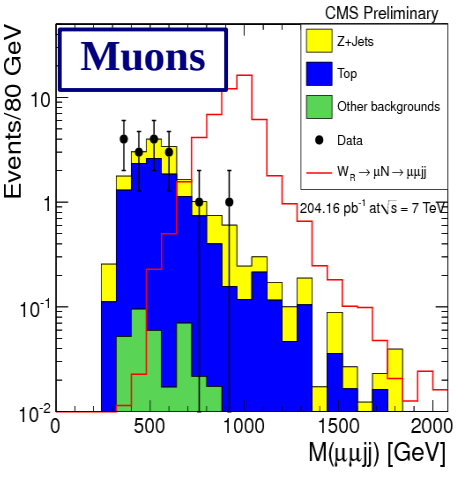
EXO-11-041

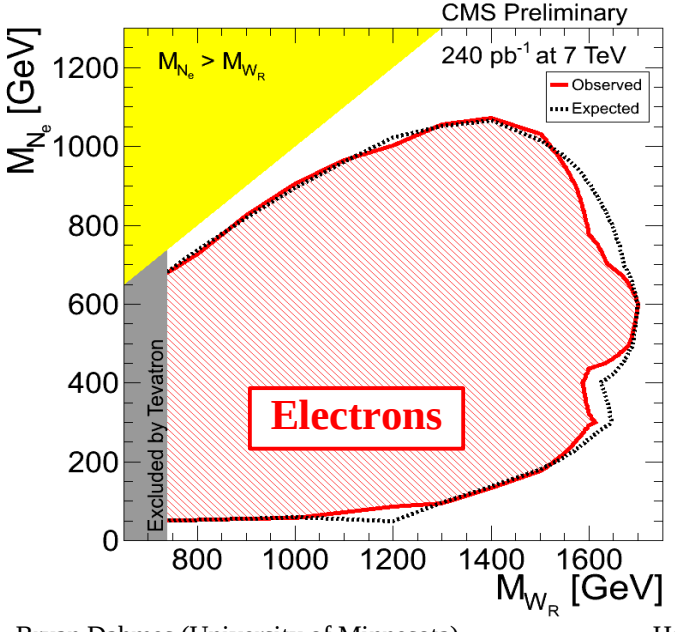
$W_R \to \ell N \to \ell\ell jj$

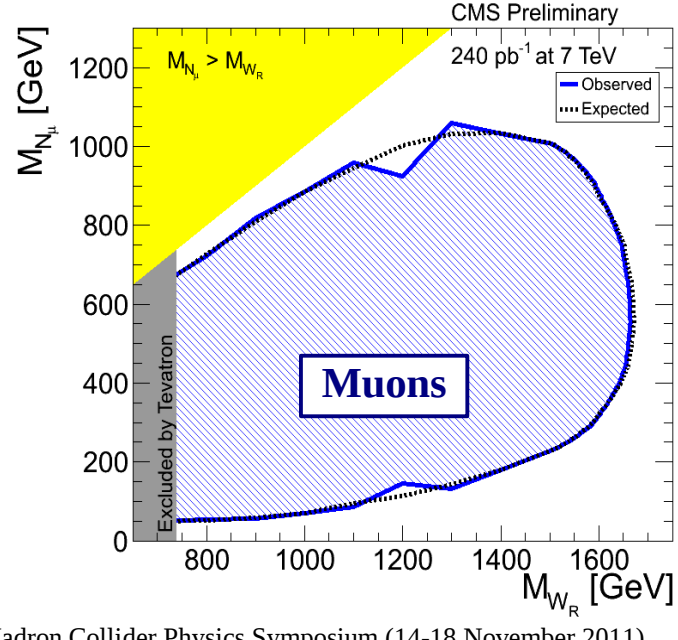


W_R, N_R from Left-Right Symmetric SM Extension









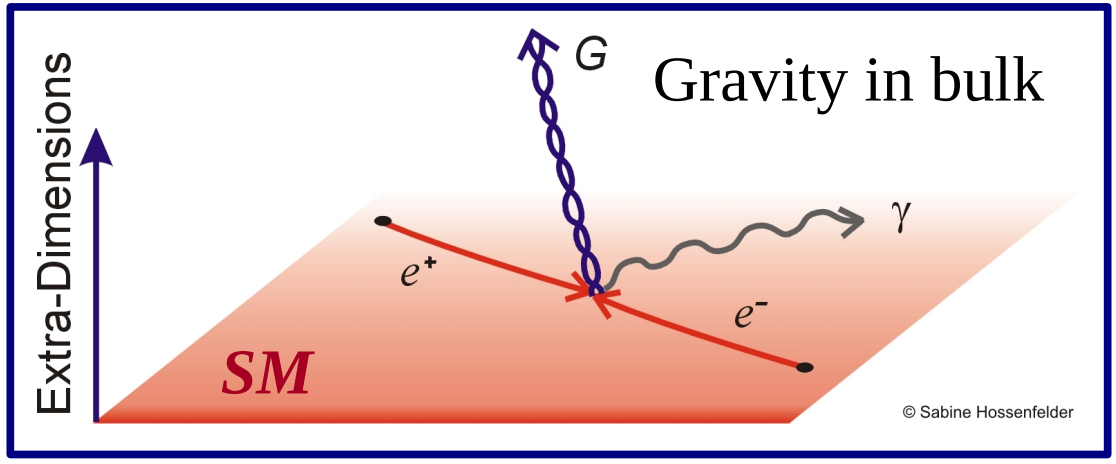
95% C.L. Exclusion extends to M_{W_R} = 1.7 TeV

EXO-11-002

Extra Dimensions

Extra spatial dimensions proposed as a solution to the hierarchy problem

$$M_{Pl} >> M_{EWK}$$



Effective Planck scale M_D

ADD: Additional compatified Extra Dimensions
$M_D^{n+2} \sim M_{Pl}^2/r^n$

RS: Warped compatified Extra Dimensions
$M_D \sim M_{Pl}/e^{kr_c\pi}$

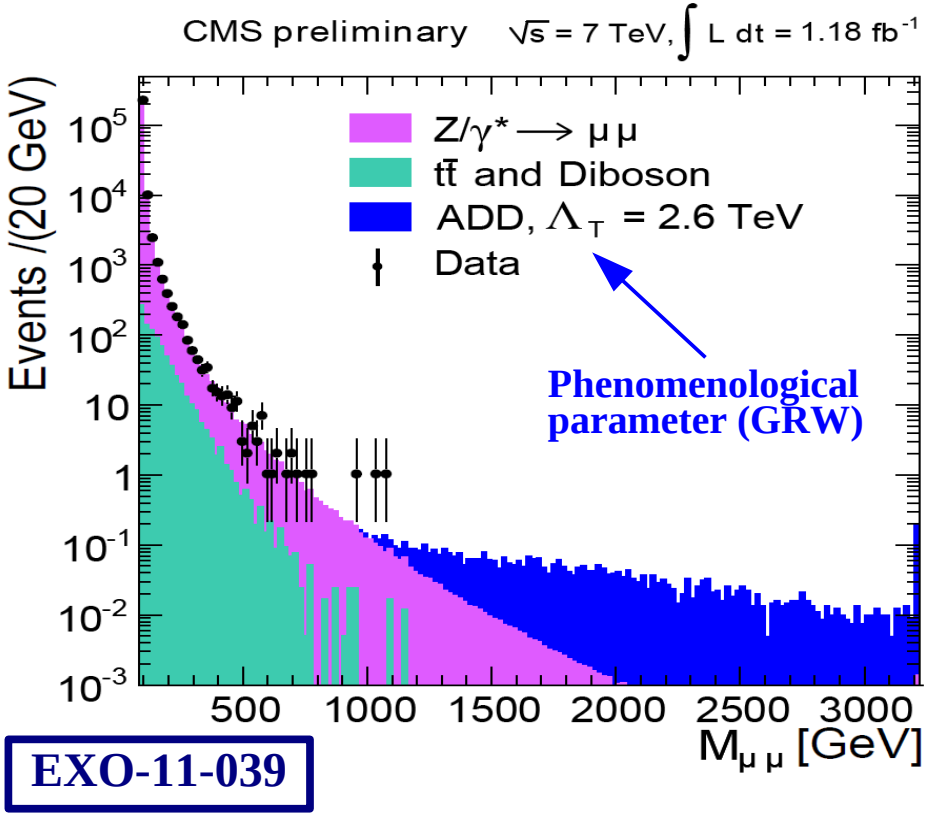
Search for enhanced dilepton, diphoton(*) production via (virtual) Graviton

Search for Graviton production in association with jet, photon

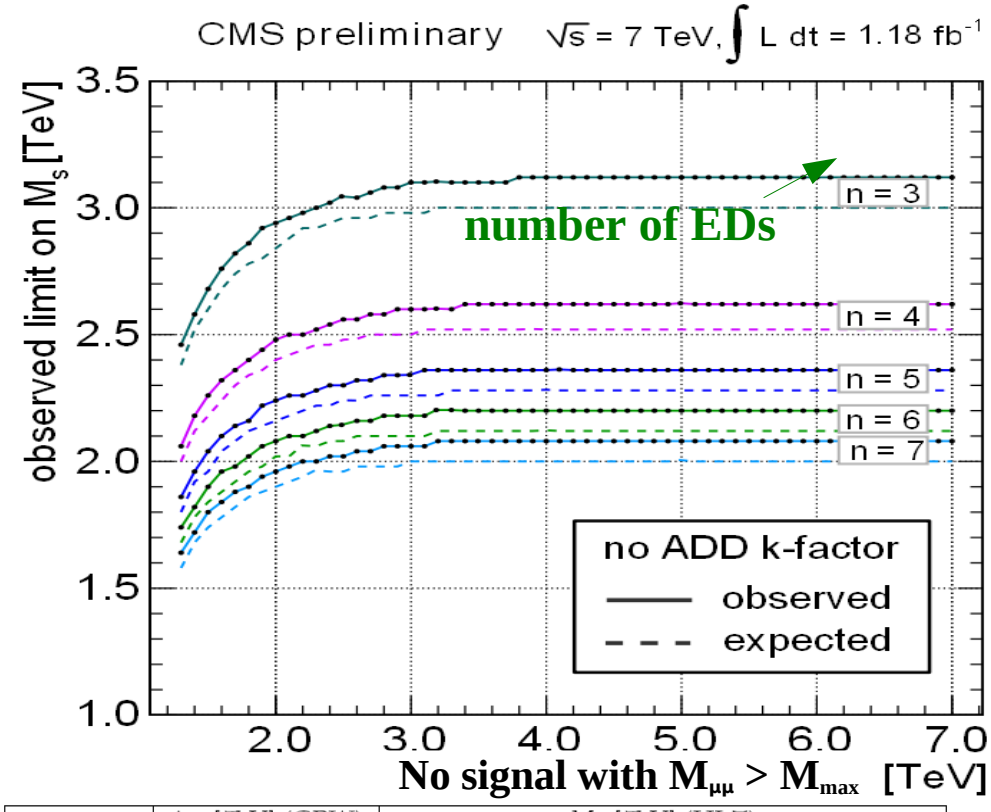
(*) See T. Orimoto's talk

Dimuon Production

(ADD) Virtual graviton exchange leads to enhanced non-resonant dimuon production

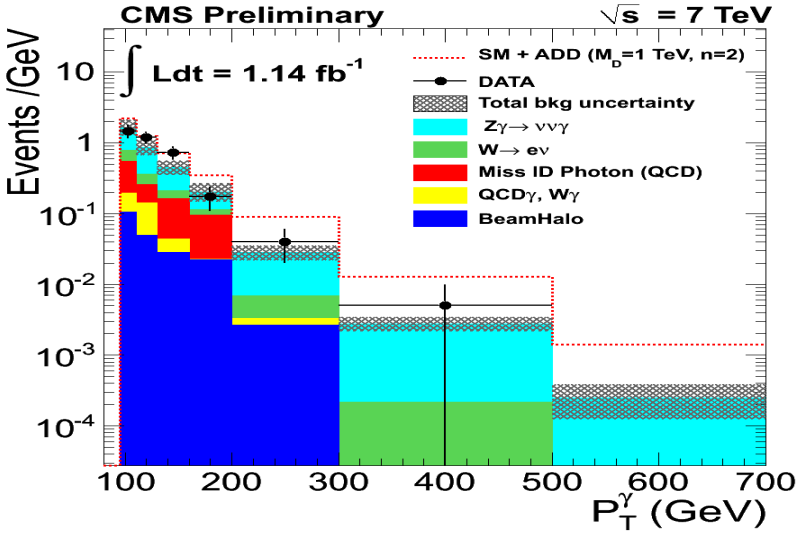


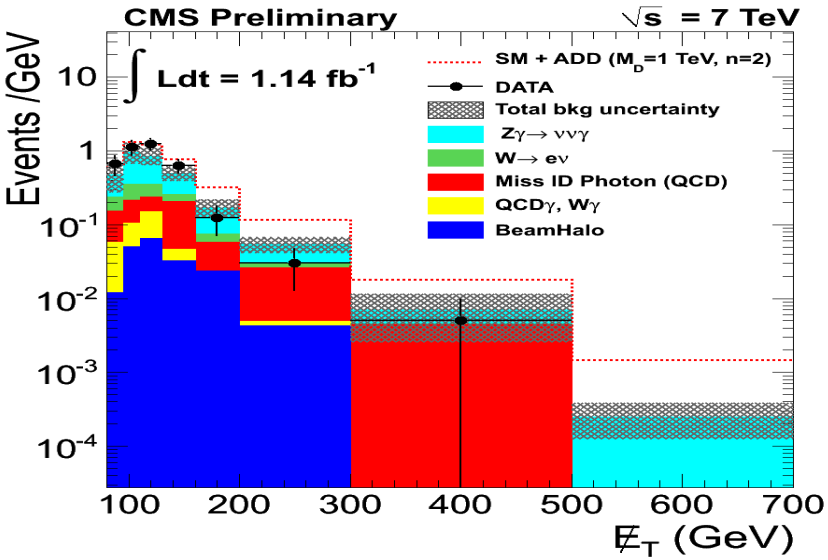
EXO-11-039



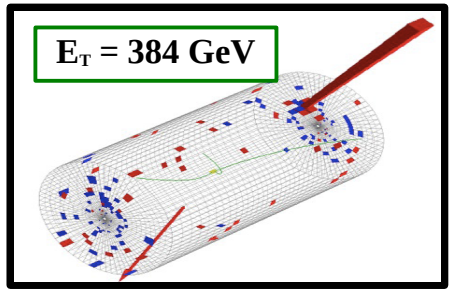
	Λ_T [TeV] (GRW)	M_s [TeV] (HLZ)					
		$n=2$	$n=3$	$n=4$	$n=5$	$n=6$	$n=7$
ADD k-factor: 1.0							
Full	2.62	2.58	3.12	2.62	2.36	2.20	2.08
Truncated	2.56	2.58	3.10	2.56	2.27	2.09	1.95
ADD k-factor: 1.3							
Full	2.70	2.72	3.22	2.70	2.44	2.28	2.16
Truncated	2.66	2.72	3.20	2.66	2.37	2.17	2.02

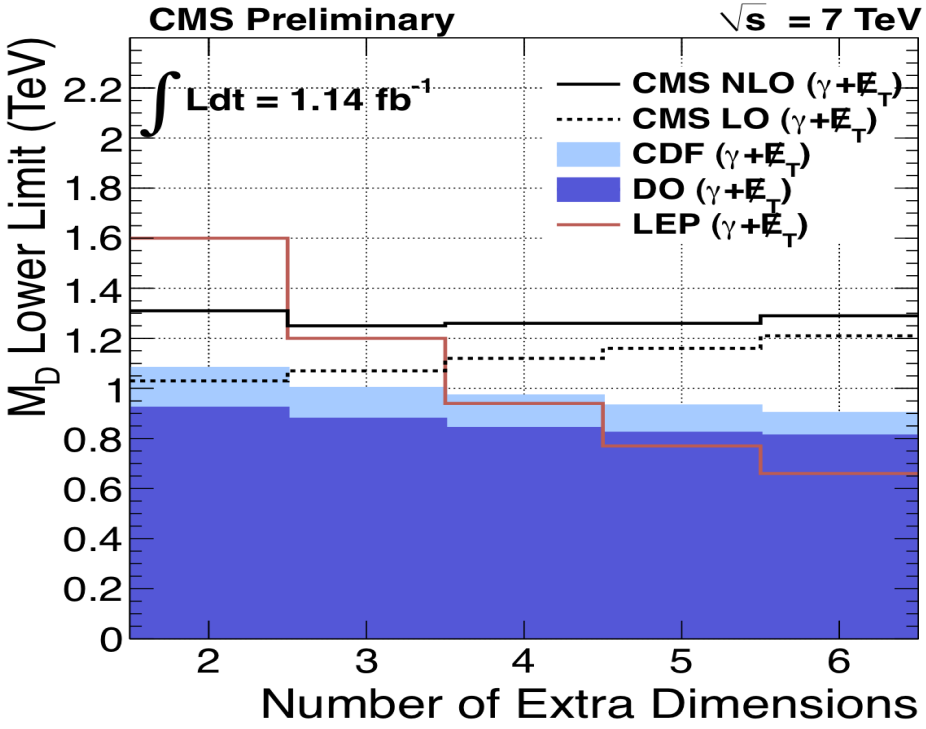
Monophoton Production





Search for ADD EDs:
Photon+MET final state

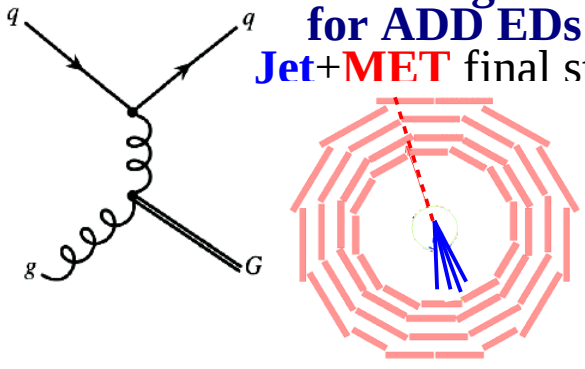




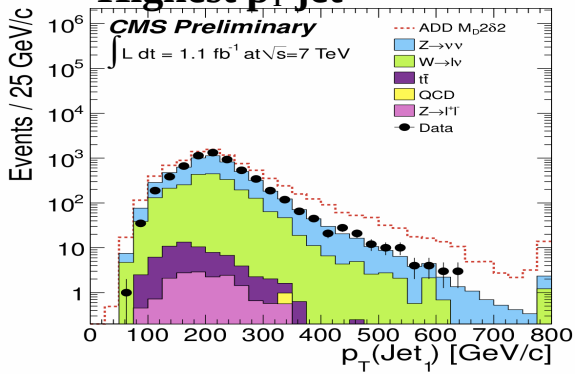
EXO-11-058

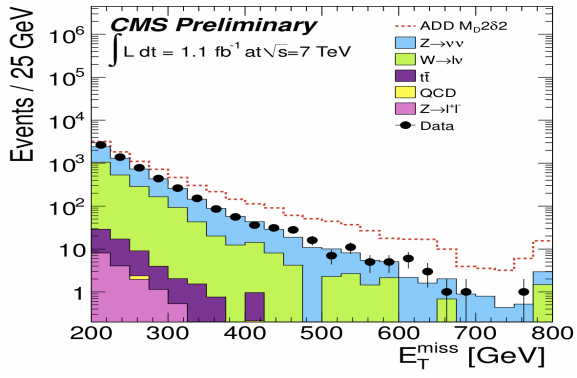
Monojet Production

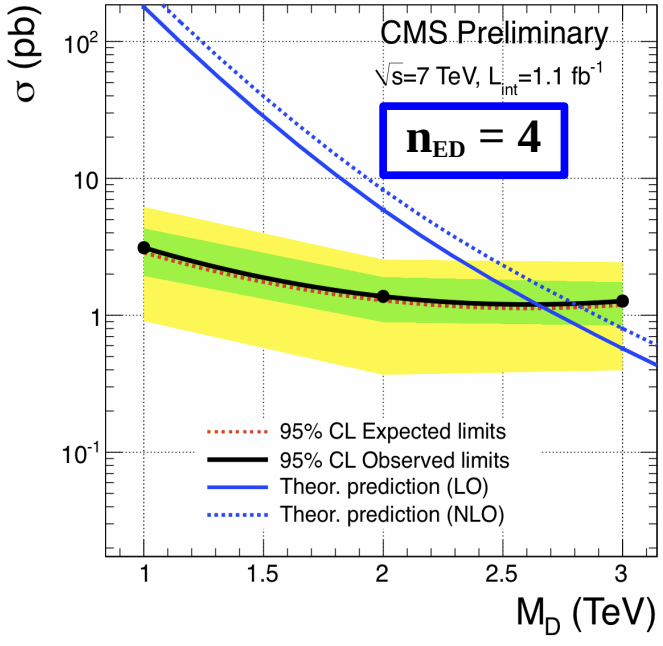
Possible signature for ADD EDs:
Jet+MET final state



Highest p_T jet





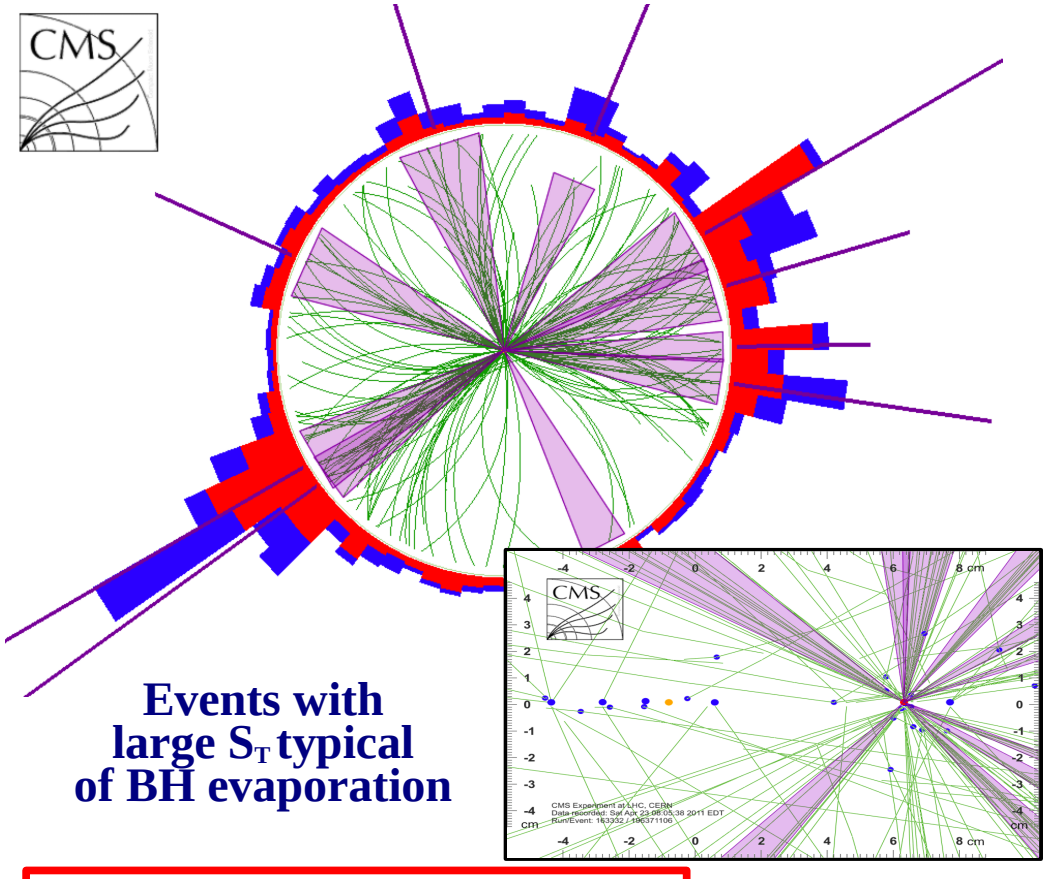


Expected and observed limits, E_T^{miss} > 350 GeV

n_{ED}	Expected Limit	Observed Limit
2	4.10	4.03
3	3.25	3.21
4	2.83	2.80
5	2.57	2.55
6	2.39	2.36

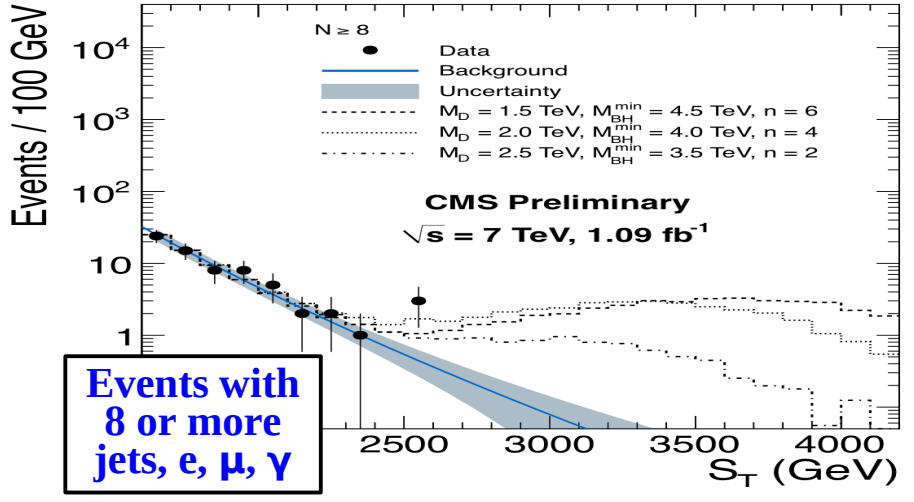
EXO-11-059

Black Holes

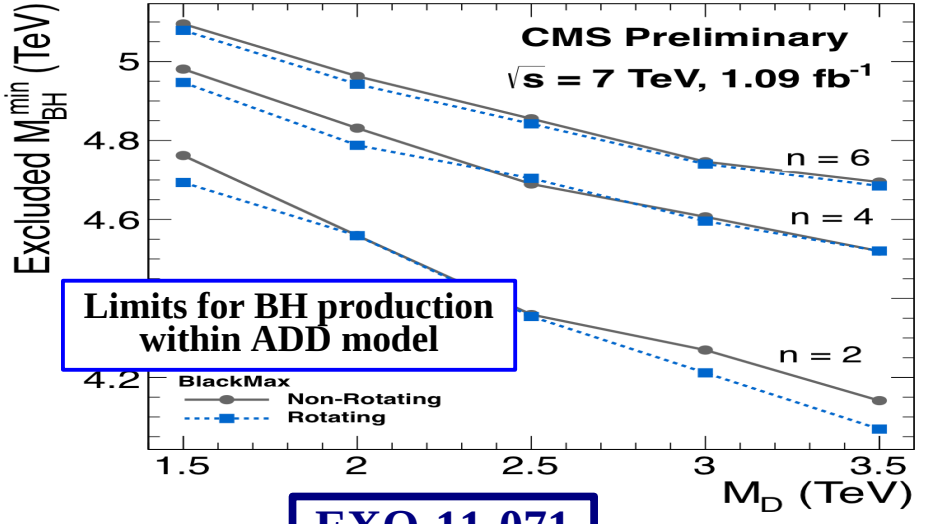


Events with large S_T typical of BH evaporation

10-jet event, S_T = 1.1 TeV
All jets from the same pp collision



Events with 8 or more jets, e, μ, γ



Limits for BH production within ADD model

EXO-11-071

Conclusion

Expansive search program at CMS
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO

Results in good agreement with Standard Model expectations

Exclusion limits set using up to 2 fb^{-1} of data collected in 2011

Additional data will continue to improve our sensitivity