Search for extra-dimensions at CMS

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on behalf of the CMS collaboration

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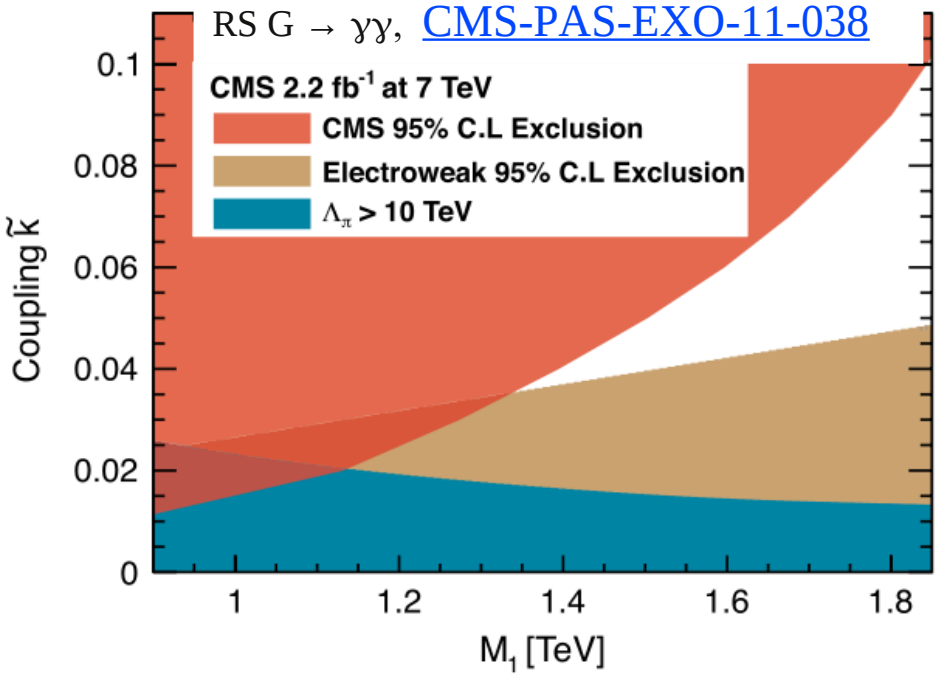
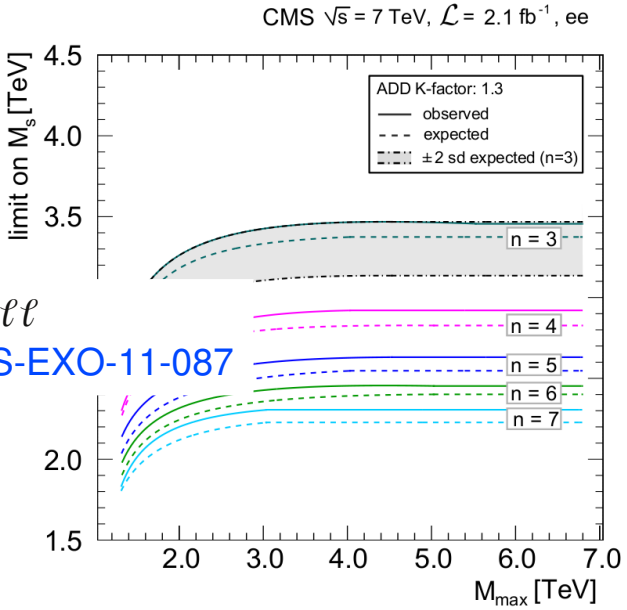
Introduction

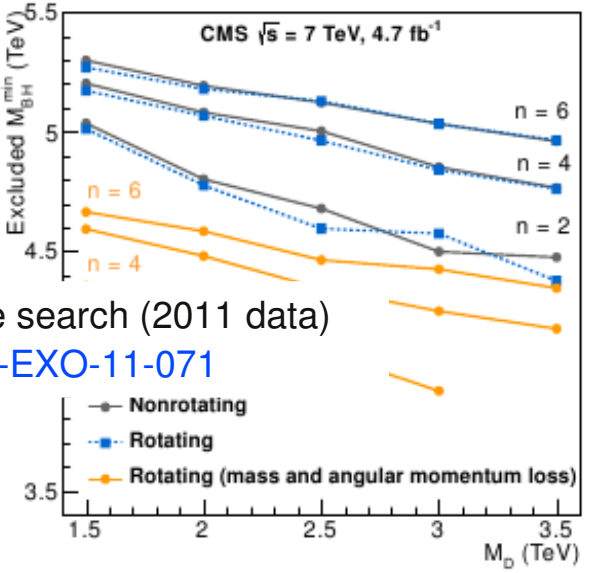
- Searches for ED at CMS so far focused on diphotons and dileptons, main decay modes for ADD and RS1
  - resonant $\ell\ell$ search with 8 TeV data in C. Wulz's report
- Main updates presented in this talk:
  - new results in VV channel (full 2011 dataset)
  - update of ADD search in ee (full 2011 dataset)
  - limits on ADD from monojet analysis (full 2011 dataset)
  - update of black hole search with 3.7 fb^{-1} at 8 TeV



ADD G→$\ell\ell$
CMS-PAS-EXO-11-087



Black Hole search (2011 data)
CMS-PAS-EXO-11-071



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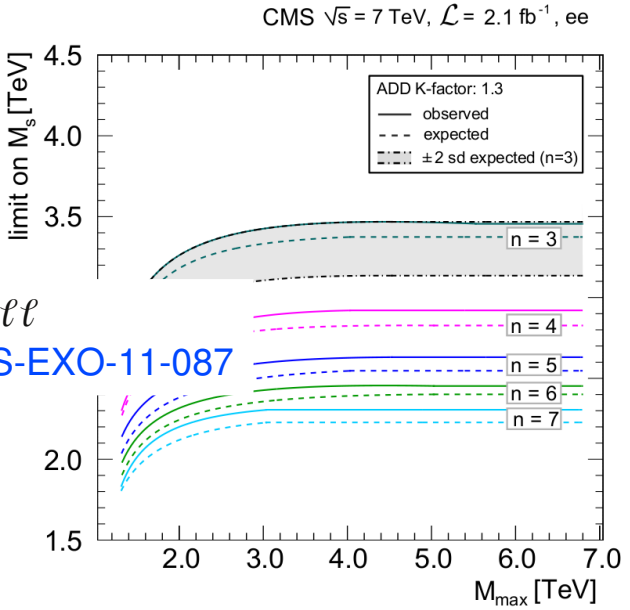

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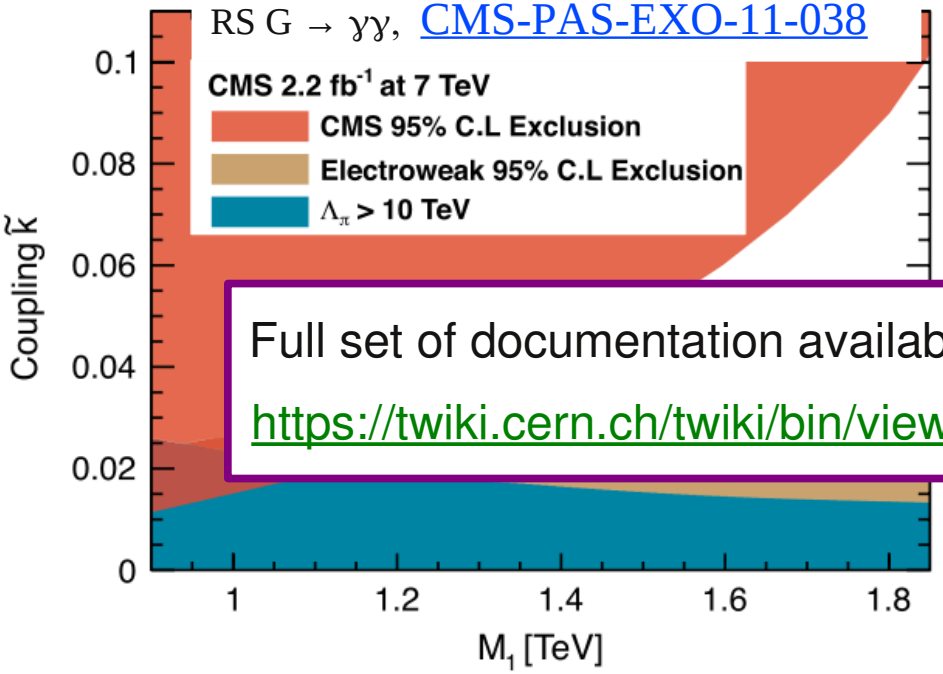
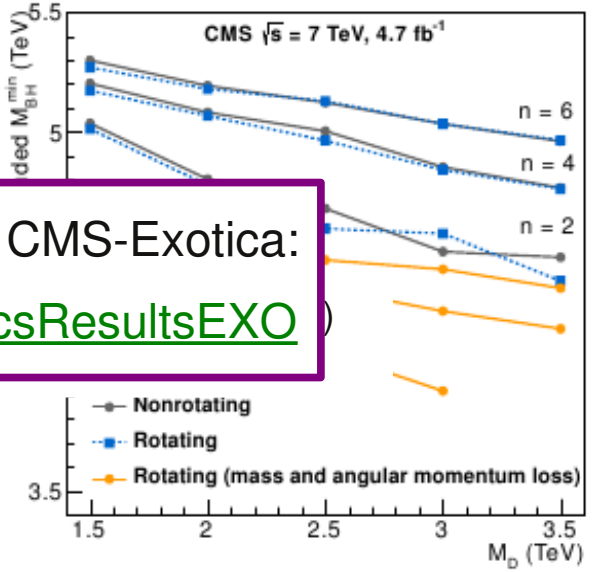
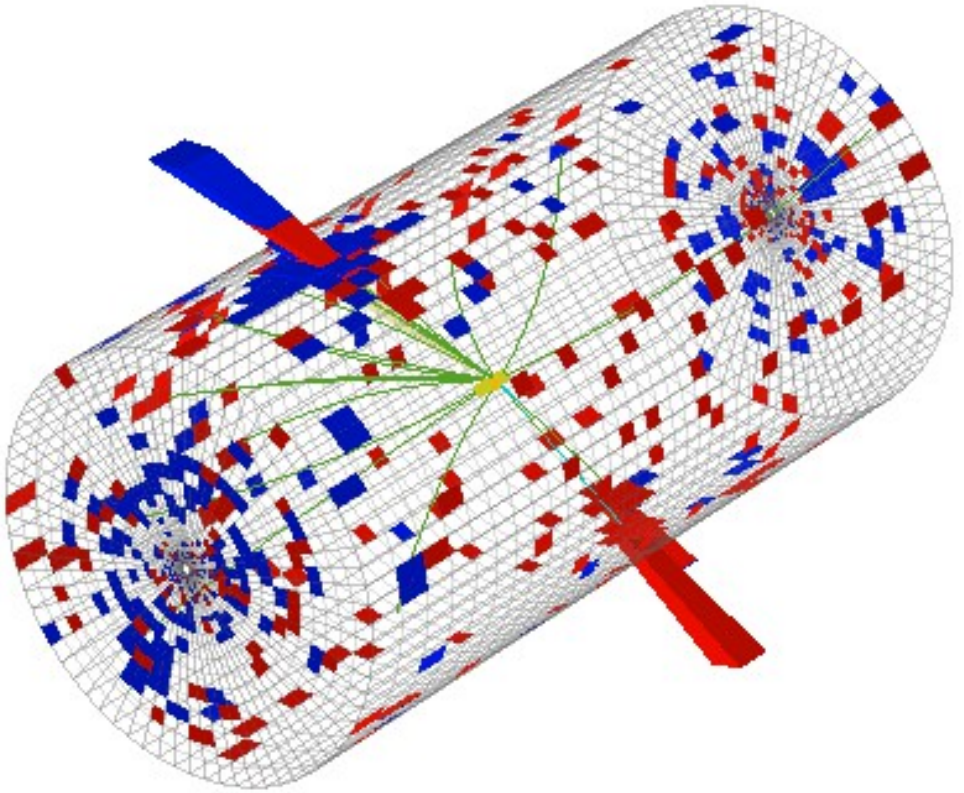




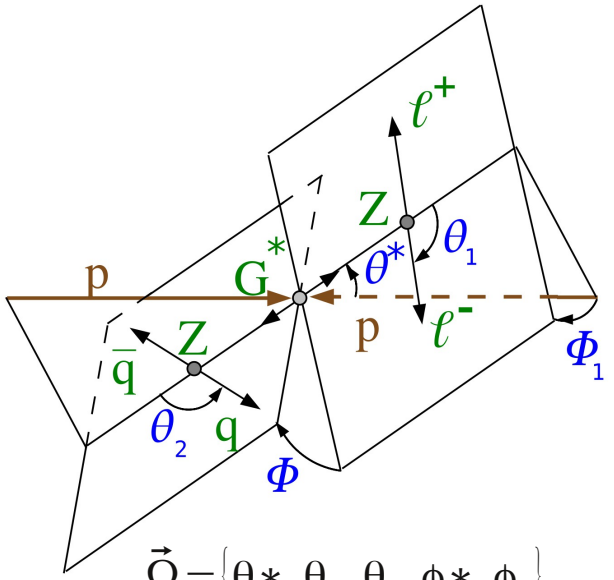
Full set of documentation available at public twiki of CMS-Exotica:
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO



Searches for resonant states

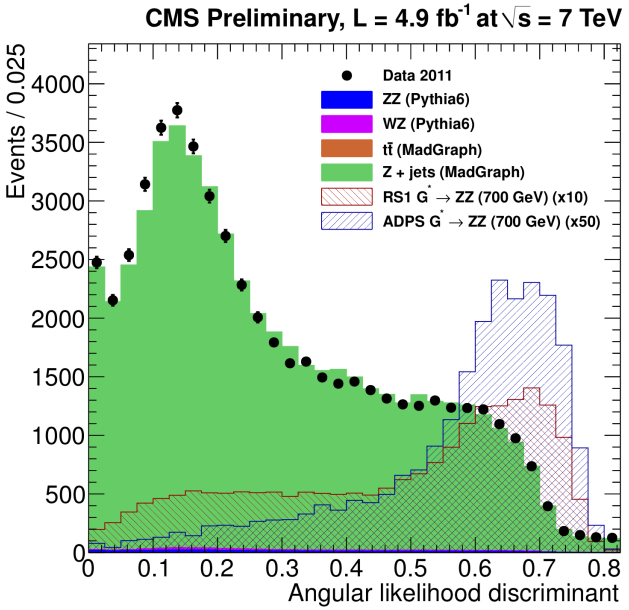
$G \to ZZ \to 2\ell 2j$ (ℓ=e,μ)

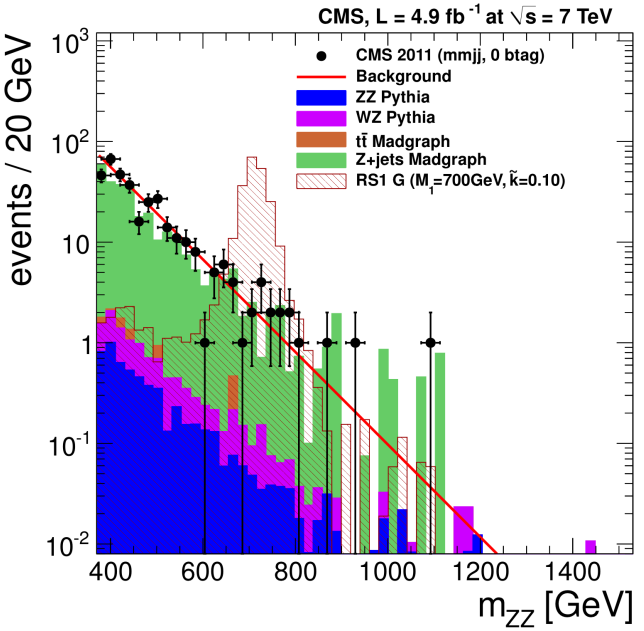
- Search for G in ZZ final state (4.9 fb^{-1} at 7 TeV) CMS-PAS-EXO-11-102
  - 2l2j final state combines high BR and good purity
- Likelihood Discriminant built from 5 helicity angles, used to select signal-like events
- Data-driven background estimation from sidebands in M_{ZZ}
- Limits on RS1 and ADPS model [Ref], analysis competitive at small k/M_{PL}



$$\vec{\Omega} = \{\theta*, \theta_1, \theta_2, \phi*, \phi_1\}$$

$$LD = \left[1 + \frac{P_{bkg}(\vec{\Omega} \| M_{ZZ})}{P_{sig}(\vec{\Omega} \| M_{ZZ})}\right]^{-1}$$





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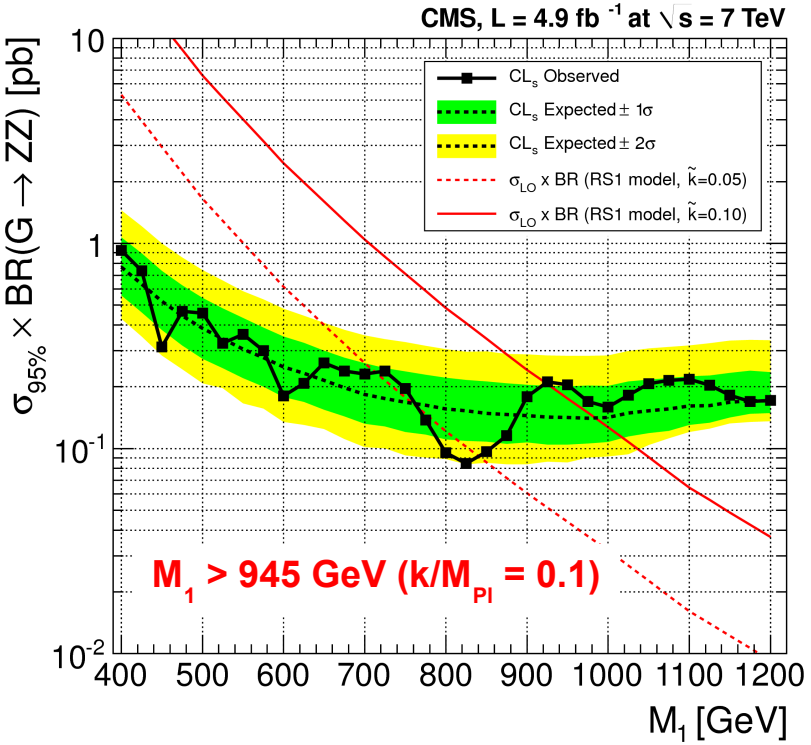
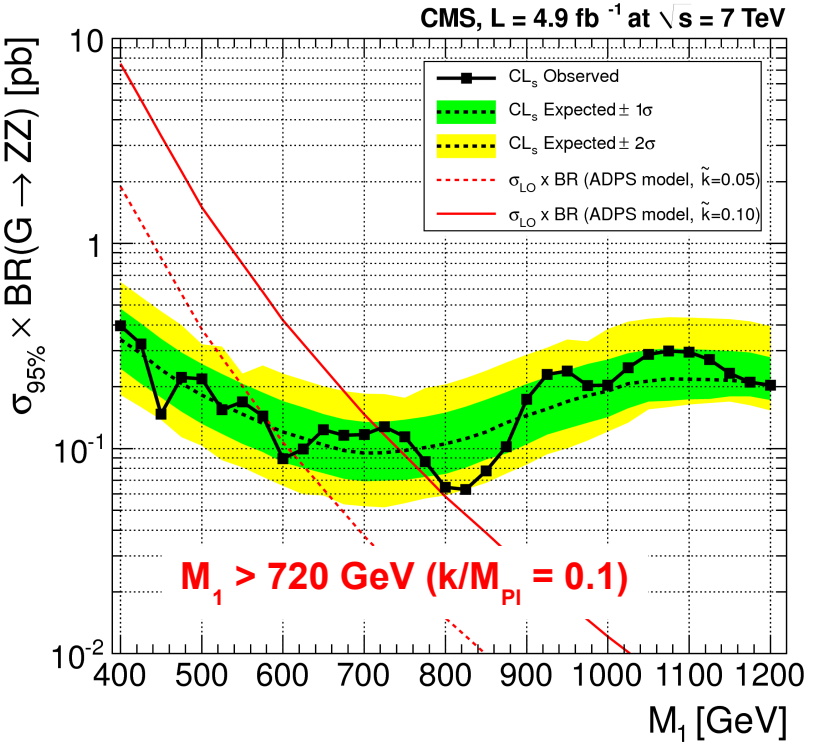
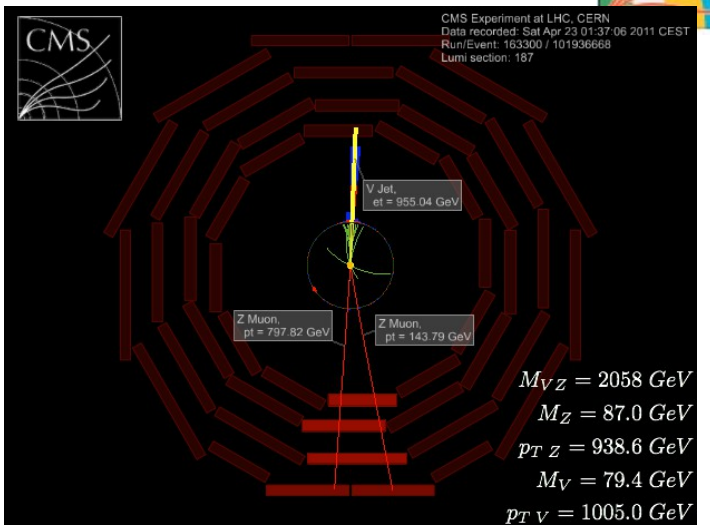


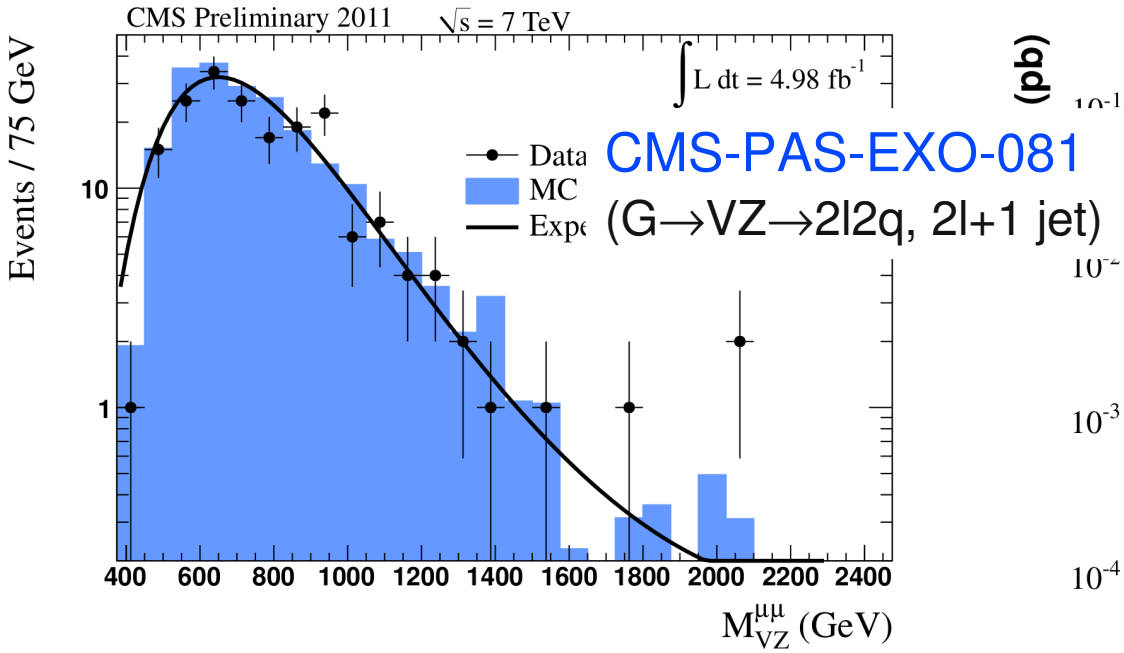


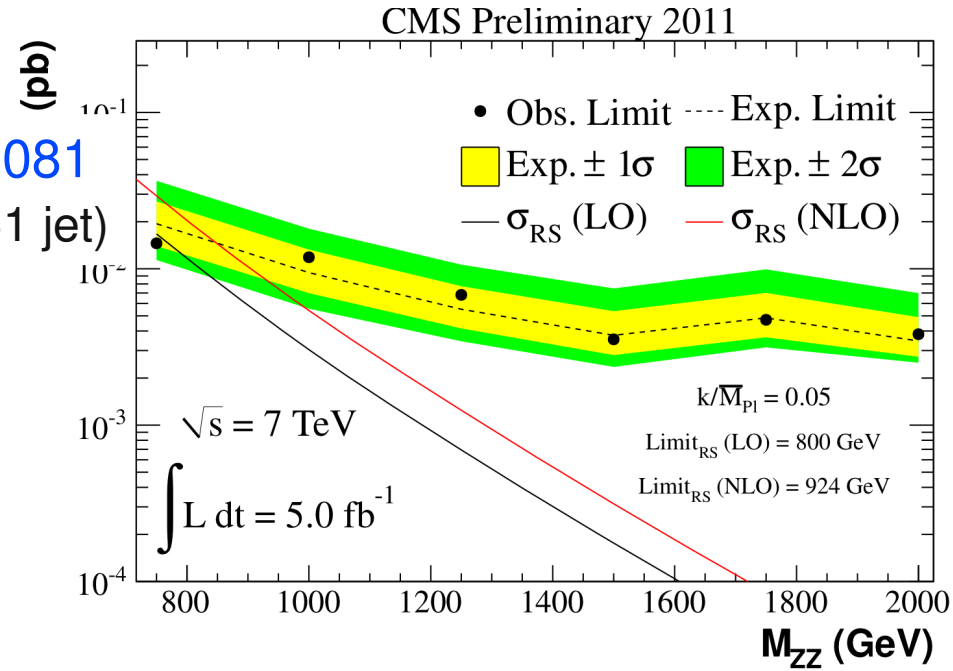
G → VV in the boosted regime

For heavier G, high boost of the V (V=W, Z) → merged jets

- identify V from mass of highest p_T jet: $60<M_J<100$ GeV
- M_J efficiency determined in $t\bar{t}$ control sample
- Background estimation from M_J sideband
- Limits set on RS1 G and W'

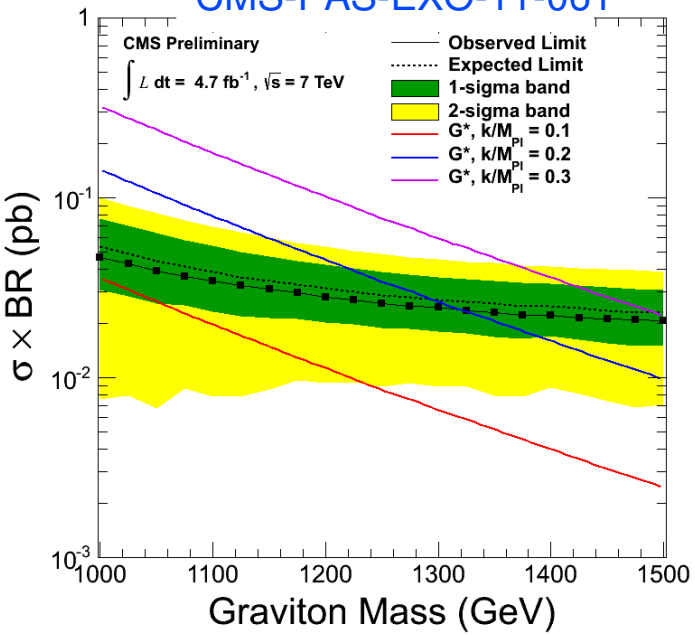




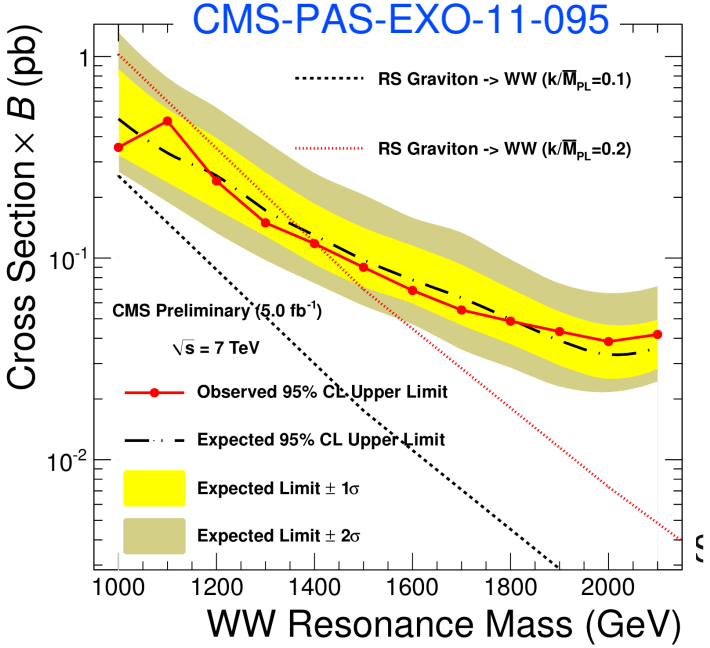


Searches in VV final state

CMS-PAS-EXO-11-061

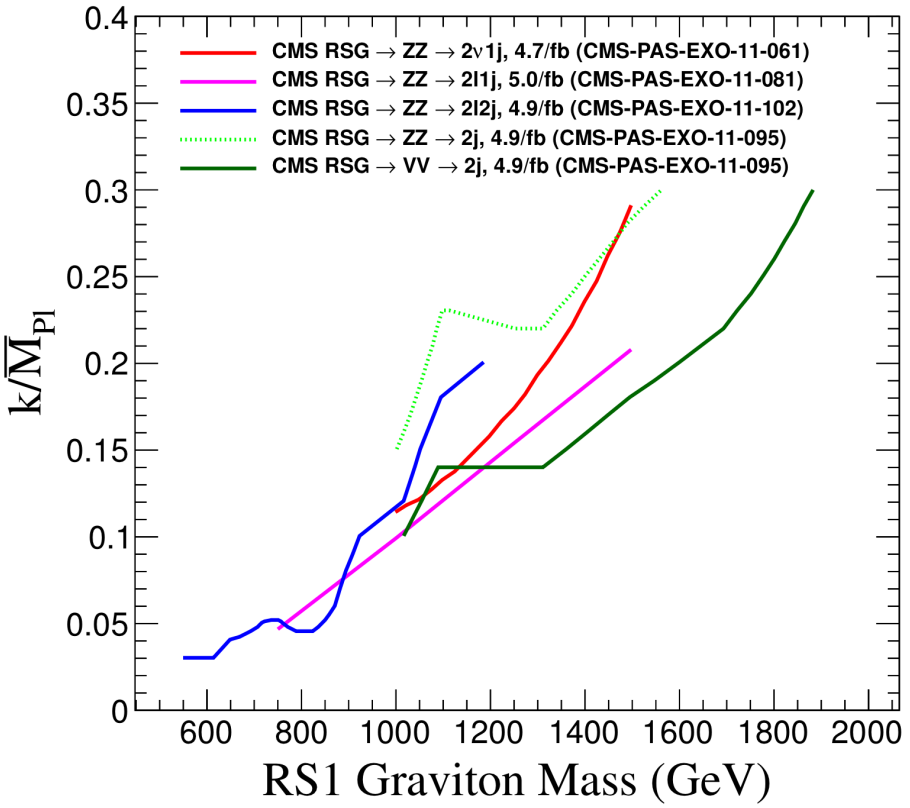


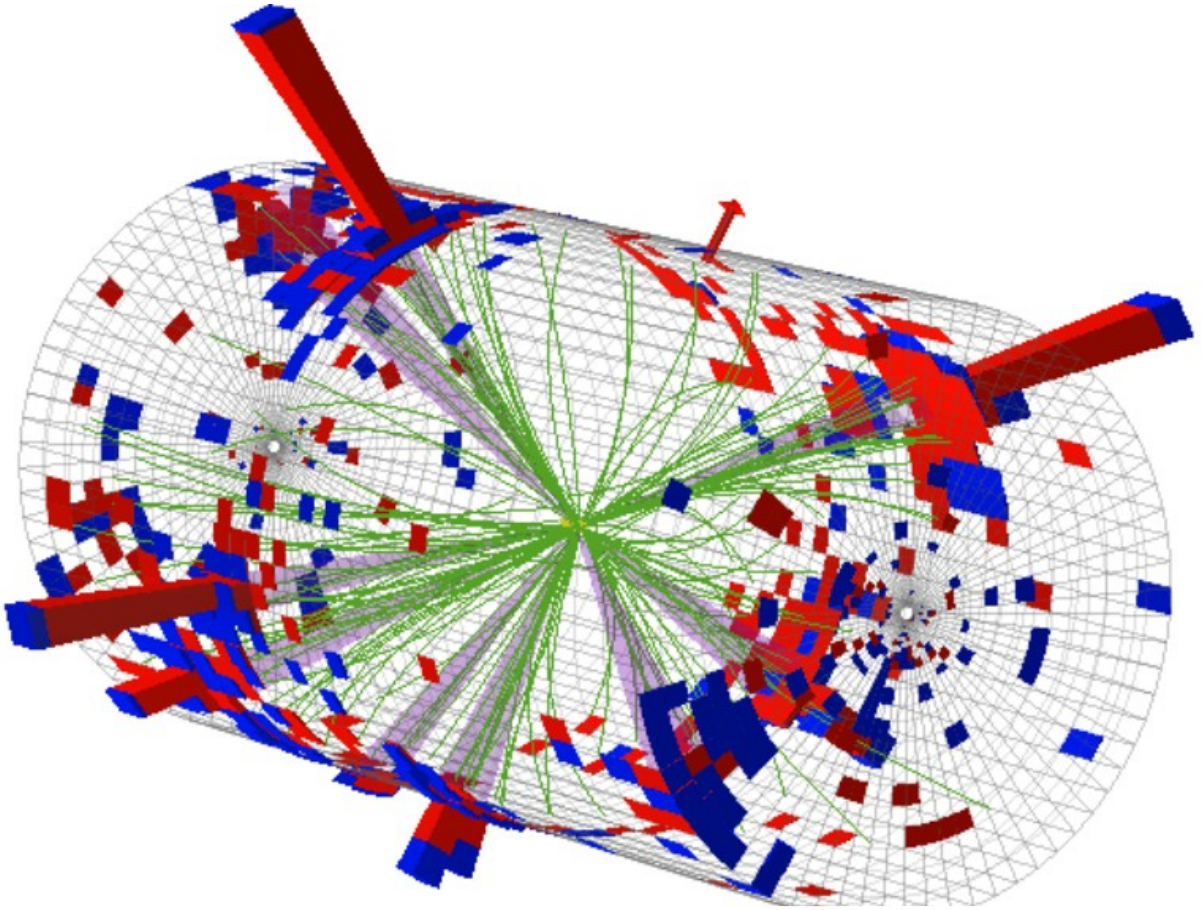
CMS-PAS-EXO-11-095



More analyses probing the VV final state (V=W or Z), focus on RS1 model and boosted V (i.e., merged jets):

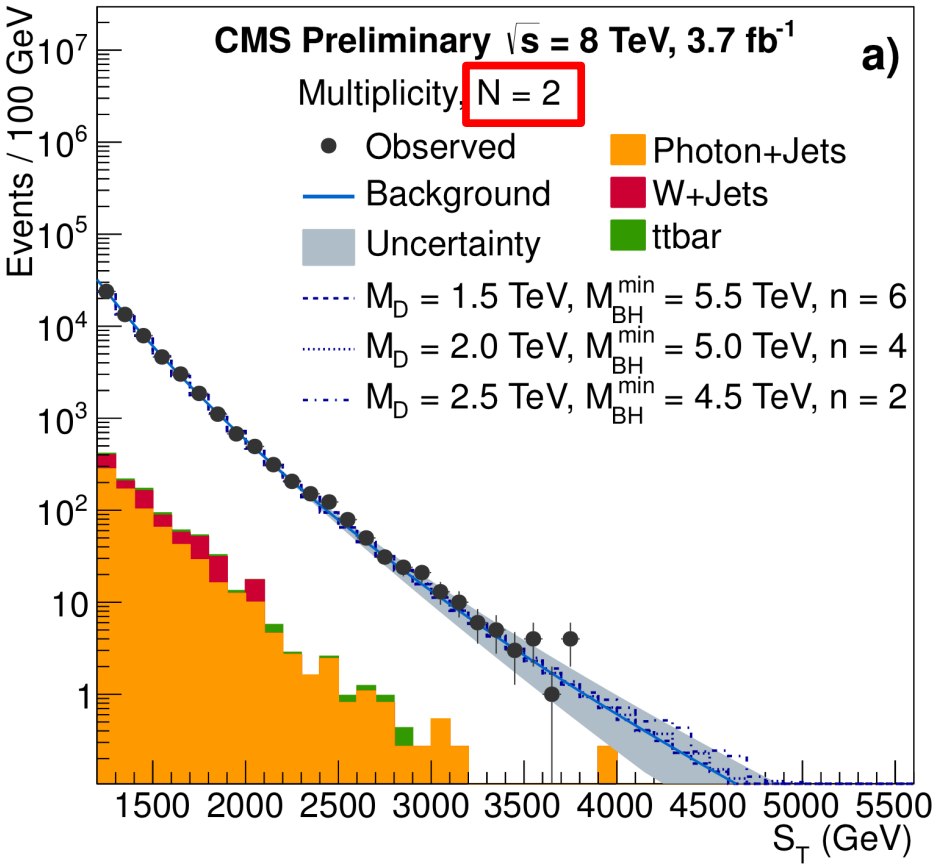
- CMS-PAS-EXO-11-061: VZ→ 2q2ν (1j+MET obs. final state)
- CMS-PAS-EXO-11-095: VV→ 4q (2j obs. final state), jet substructure on top of jet mass (see talk by A. Hinzmann)





Searches for non-resonant states

Searches for Black Holes



JHEP04(2012)061 (4.7 fb^{-1} at 7 TeV data)

CMS-PAS-EXO-12-009 **(3.7 fb^{-1} at 8 TeV data)**

Search for tiny innocuous microscopic BH, **updated with 8 TeV data !**

- BH evaporates in many high pT objects
- Main background from QCD, estimate in a fully data-driven way

$$S_T = \sum_{j,e,\mu,\gamma,MET}^{N} p_T$$

Only phys obj with $p_T > 50$ GeV

- Shape of S_T independent on multiplicity
- Background shape from fit to in S_T signal-free region (N==2)
- Background normalization determined for each multiplicity bin separately in range 1800-2200 GeV
- Main systematic uncertainties from fit and (only for signal acceptance) JEC

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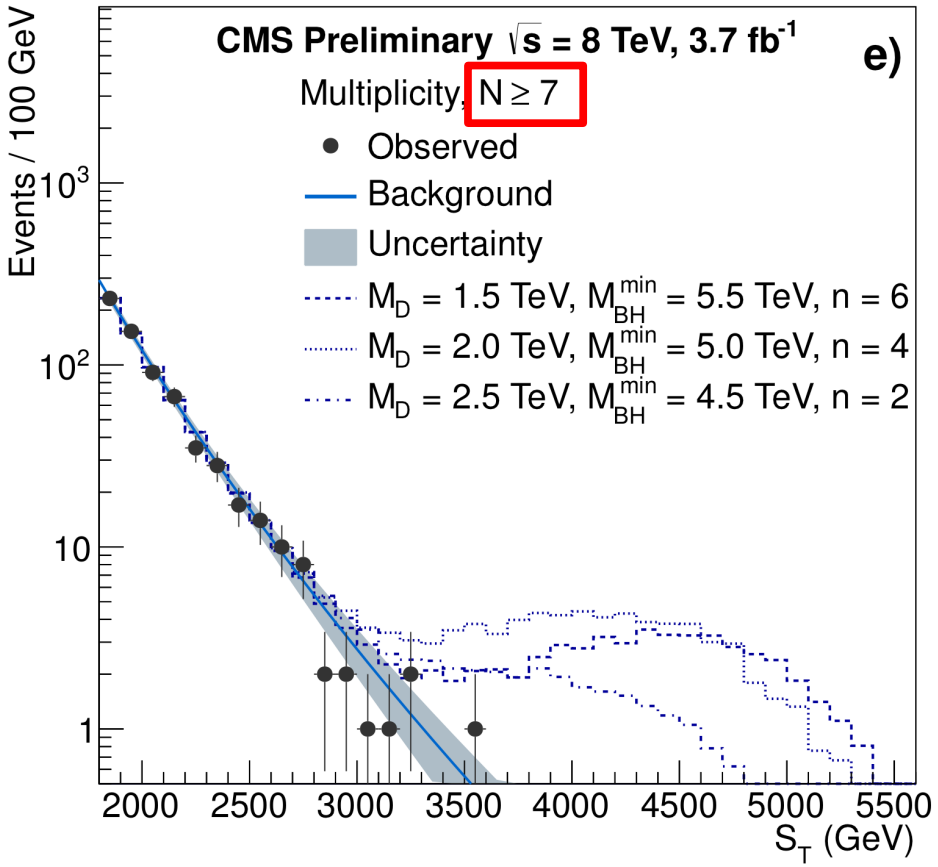

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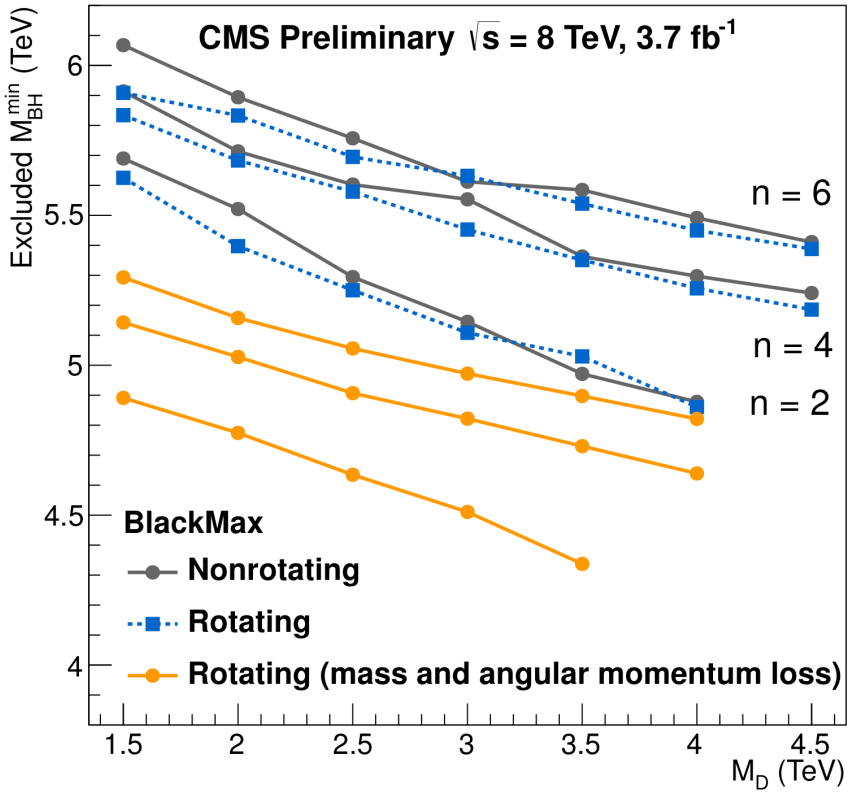
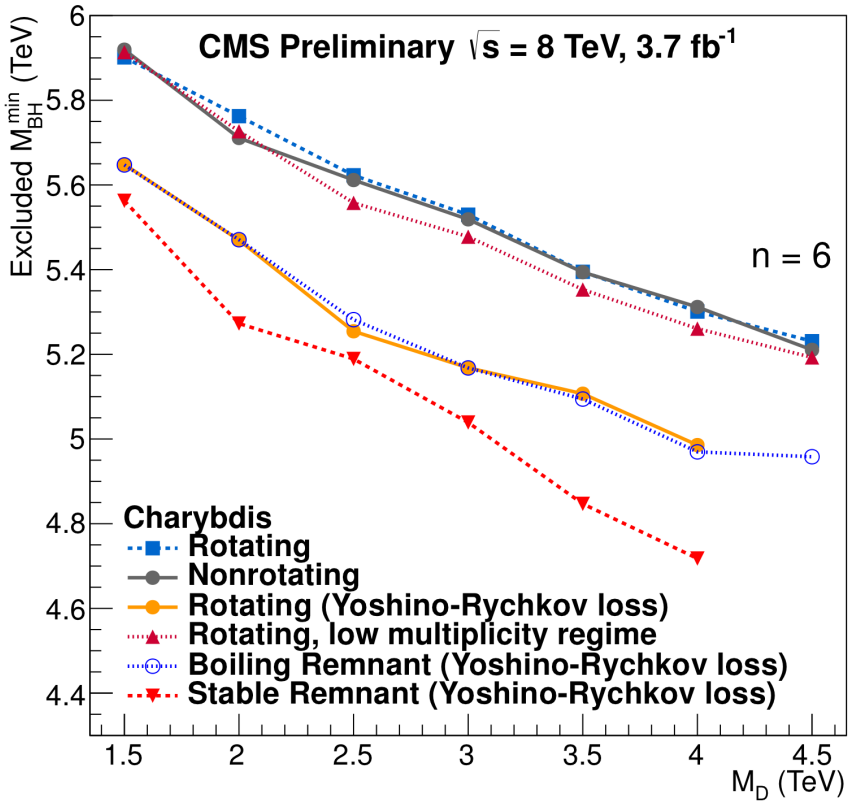
Model-dependent interpretation

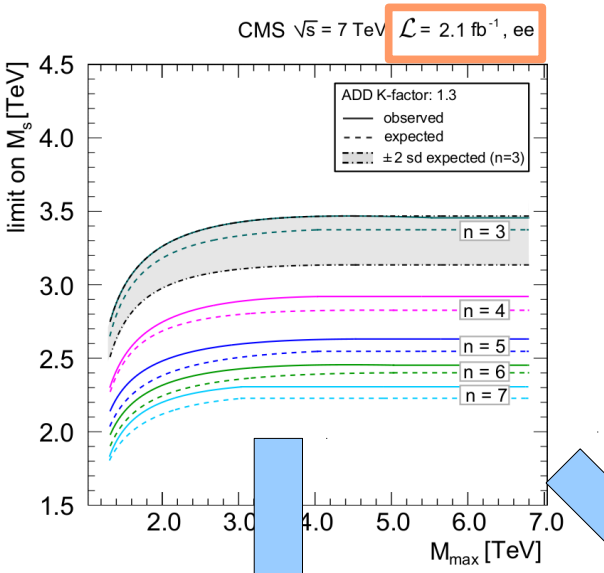




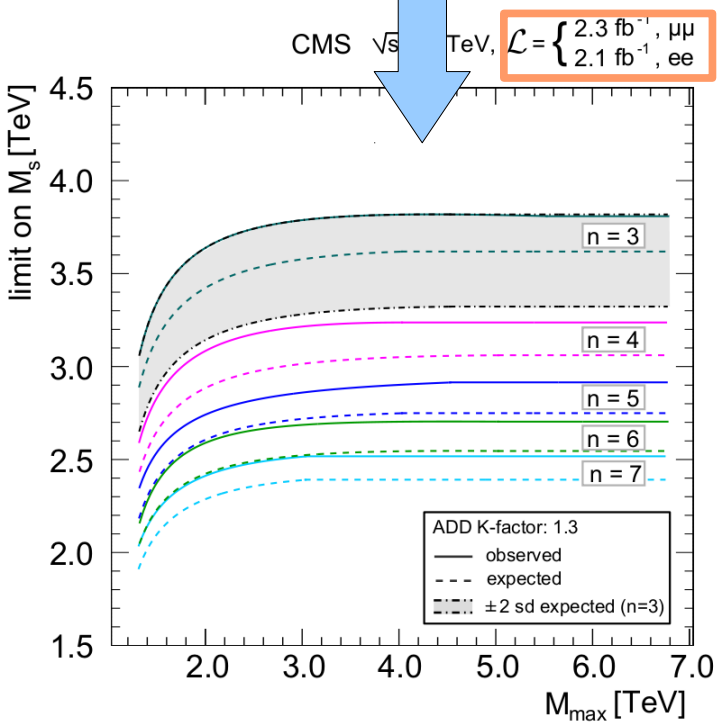
Use the same results for setting limits on ADD assuming specific BH models:

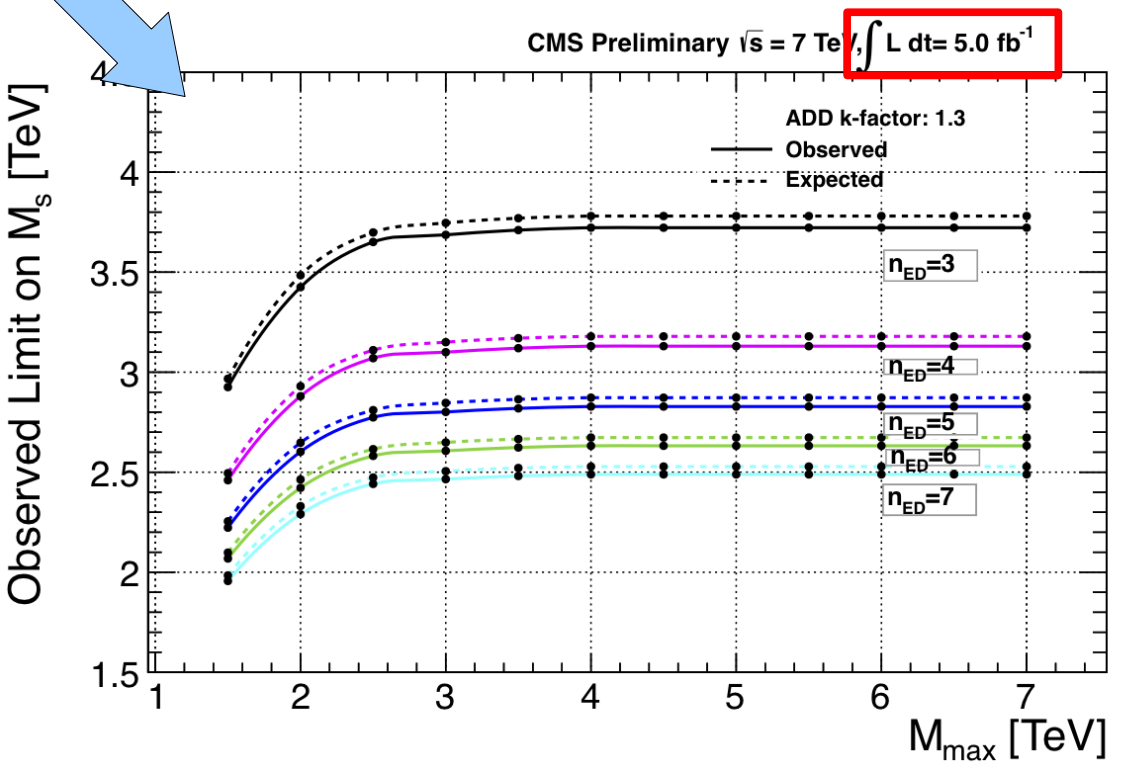
- for $n_D = 2$, $M_{BH} > \sim 4.8 – 5.8$ TeV
- for $n_D = 6$, $M_{BH} > \sim 5.3 – 6.1$ TeV
- **large improvement (~10-20%) with respect to 2011 analysis** (~25% less lumi !)

$G \to \ell\ell$



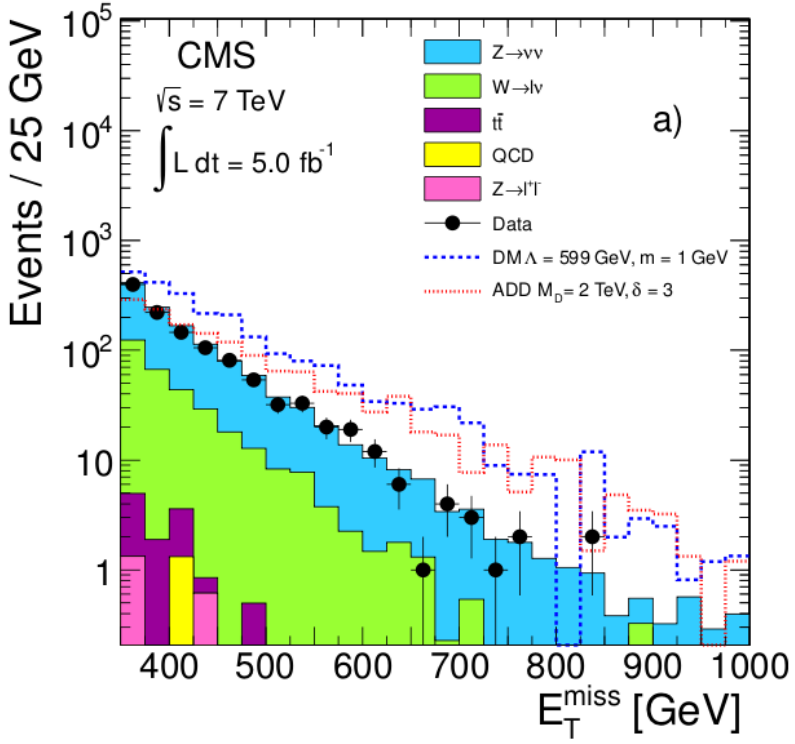
- PLB 711, 15-34 (2012) : Combination of ADD searches at 7 TeV $G \to \mu\mu$ (2.3 fb^{-1}) and $G \to ee$ (2.1 fb^{-1})
  - $M_S > 3.8$ TeV (2.5 TeV) for $n_D=3$ ($n_D=7$)
- CMS-PAS-EXO-12-013: Update of ee analysis with full 2011 luminosity (5.0 fb^{-1})

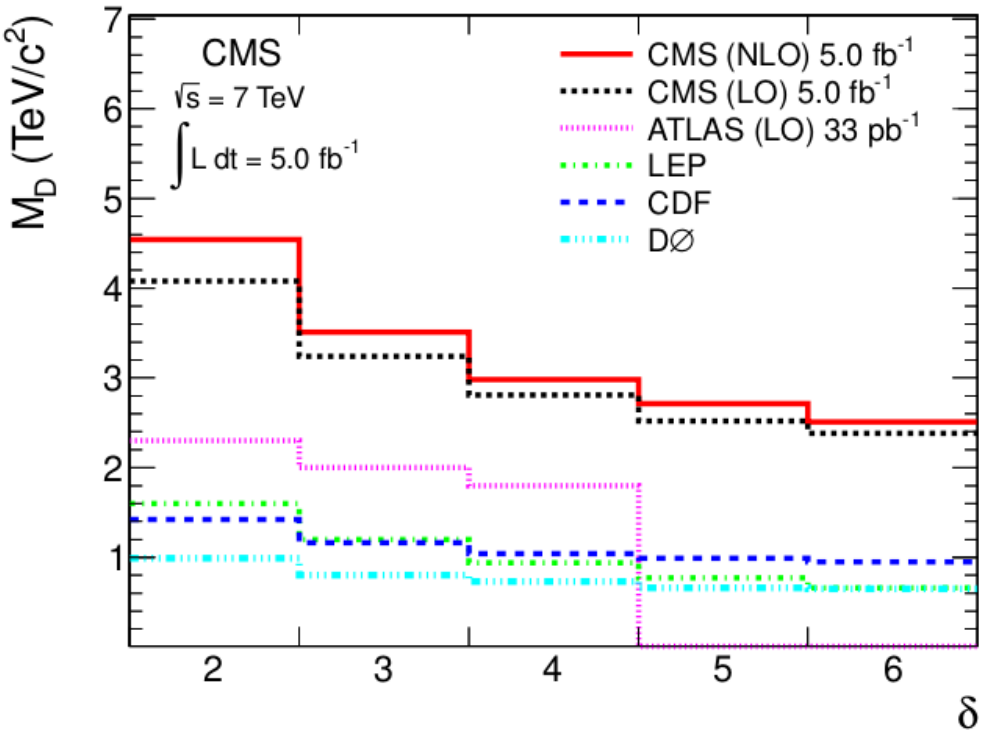




ADD search in mono-jet analysis

- CMS-PAS-EXO-11-059 (sub. to JHEP): analysis constrains dark matter searches
  - extensively described in S. Malik's talk
- MET > 350 GeV, p_T of leading-p_T jet >110 GeV ; control regions in data for V+jets
- Stringent limits in ADD model: fundamental Planck scale above 2.5 – 4 TeV





Conclusions

- Extensive searches for ED at CMS in many different final states, no significant excess found so far. Stringent upper limits on several models
  - new results on searches in VV (V=W,Z), both boosted and non-boosted regime
  - update with full stats at 7 TeV of search of ADD to ee
  - search in 1 jet + MET interpreted in ADD model
- Update with 2012 data at 8 TeV (~3.7 fb^{-1}) of search for black holes
  - profiting from enlarged phase space, new limits much more constraining
- More reloads of 2011 analyses with 2012 data due to come
- All results and documentation linked on the public CMS-Exo Twiki: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO

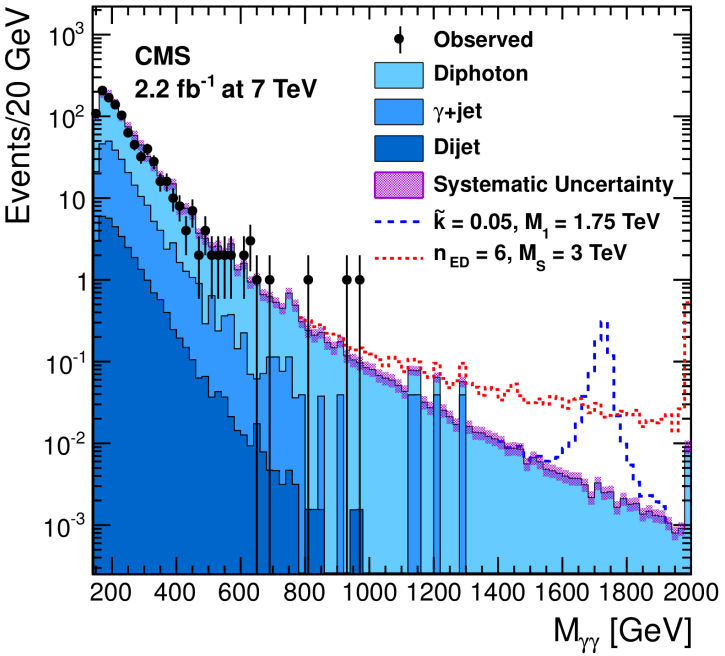
Additional material

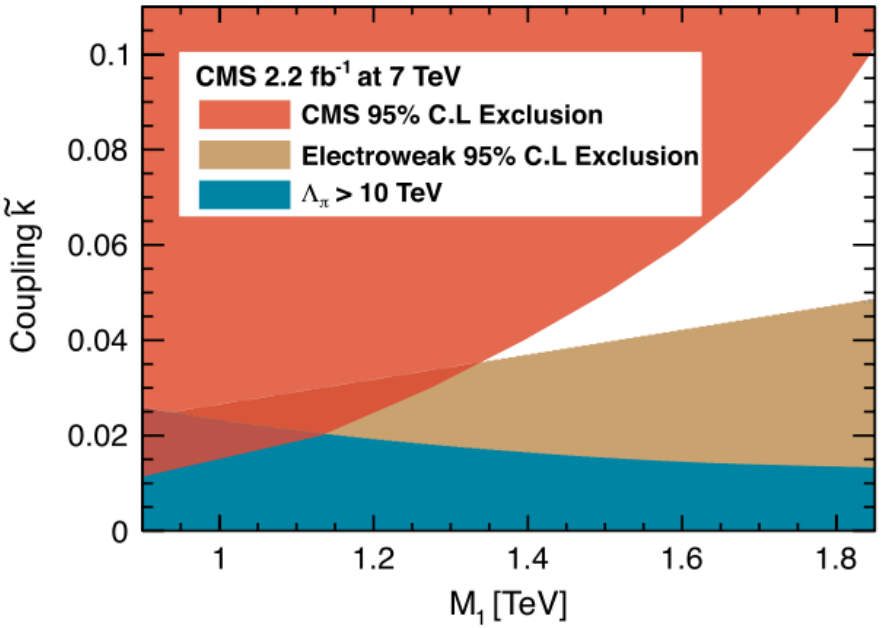
G → γγ

PRL 108, 11801 (2012)

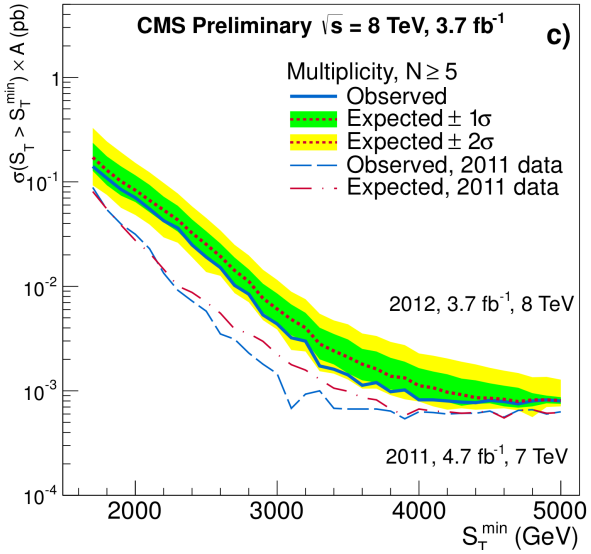
Search for ADD and RS G in diphoton (2.2 fb^{-1} at 7 TeV):

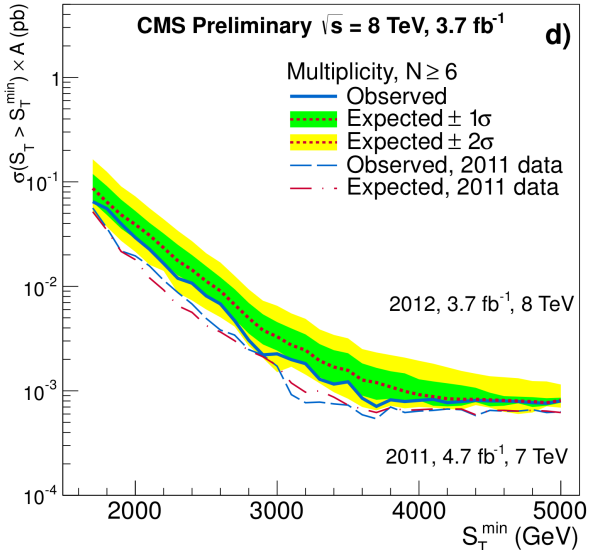
- Two isolated γ with p_T >70 GeV and $M_{\gamma\gamma}$>140 GeV
- Main backgrounds: SM diphoton and fakes from QCD (both multijet and γ+jets)
  - SM diphoton from Pythia* NLO K-factor (DIPHOX+GAMMA2MC), 15% syst unc. on K-factor
- Very stringent limits on both ADD and RS1 G
  - ADD (deviation of tail from SM): M_S > 2.3 – 3.8 TeV
  - RS1 (bump search): M_G > 0.86 – 1.84 TeV

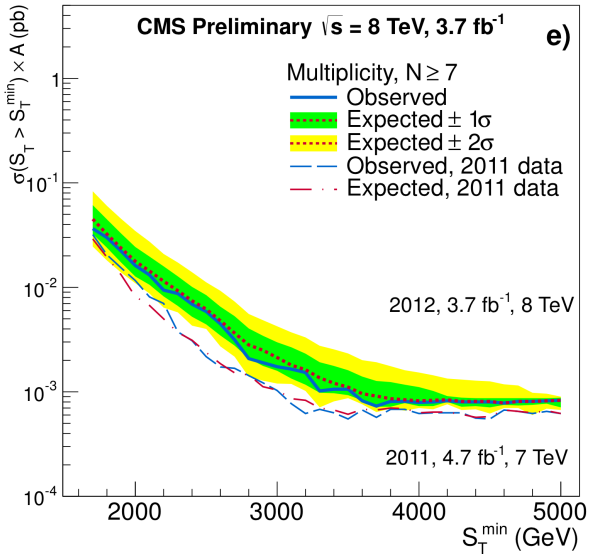


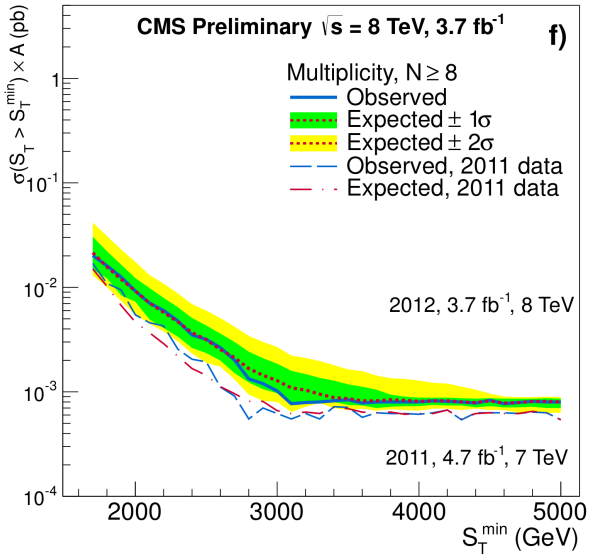


Search for black holes: model-independent interpretation









- Model-independent approach set limits on cross section of new physics producing large S_T
- Slightly less stringent than those at 7 TeV because of higher QCD background (depends on parton luminosity, higher at 8 TeV) and less lumi analyzed.
- BH cross section production increases dramatically thanks to enlarged phase space
  → **most stringent limits on specific BH models**