

Z' PHYSICS AT HL-LHC/HE-LHC

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Based, in part, on Bogdan A. Dobrescu, FY [1306.2629], FY [1308.1077]

HL-LHC/HE-LHC Workshop
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Motivation

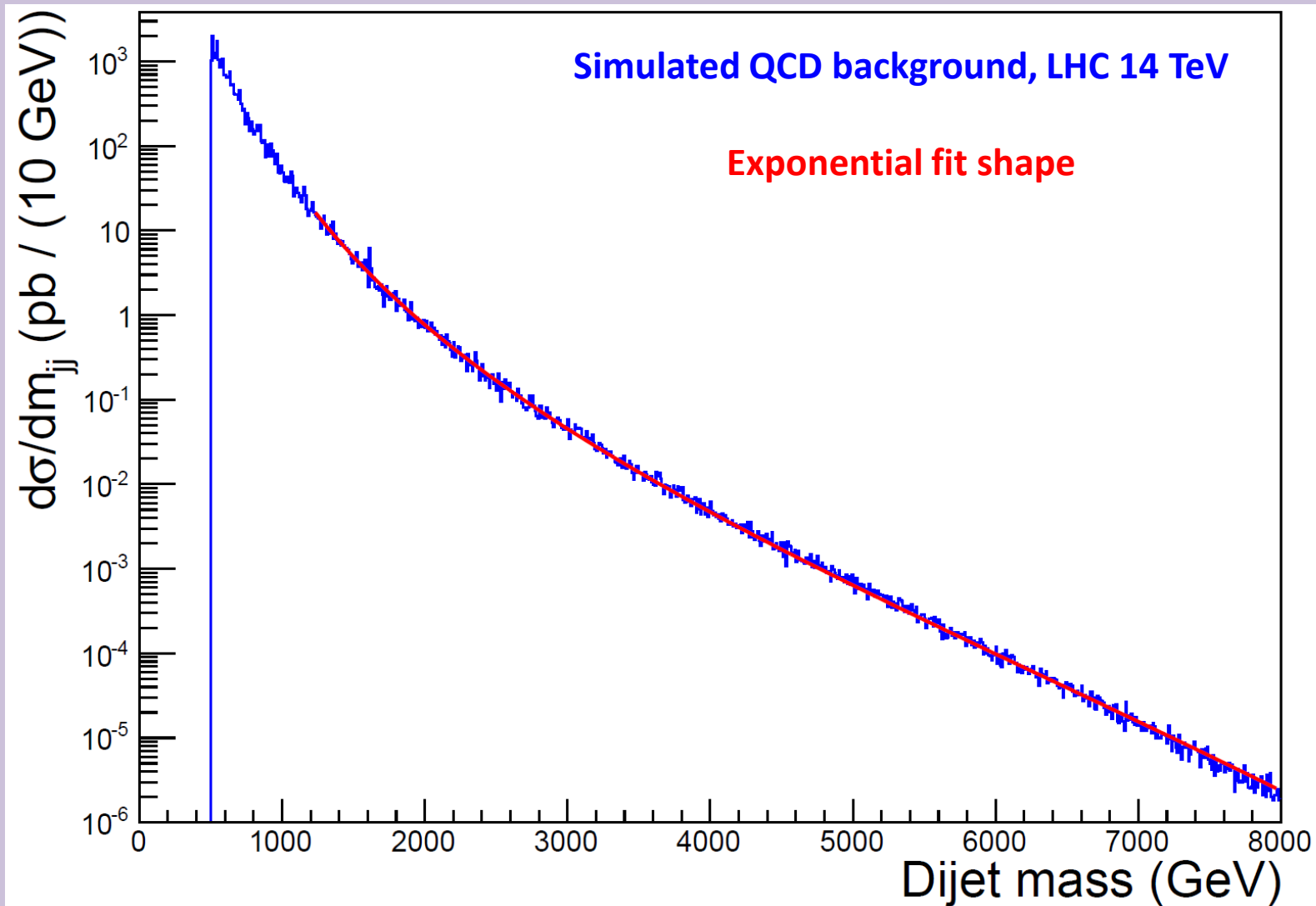
- Z' bosons are a generic prediction of many BSM models
 - New/extended gauge symmetries provide new particle interactions and force carriers
 - Some hints from low energy probes point to Z' solutions
- Richness of simplicity at colliders
 - Resonances in two-body final states: $\ell^+\ell^-$, jj , $b\bar{b}$, $t\bar{t}$, VV
 - Connections to DM production
 - Kinetic mixing with SM Z

c.f. talk by Altmannshofer

Theory background

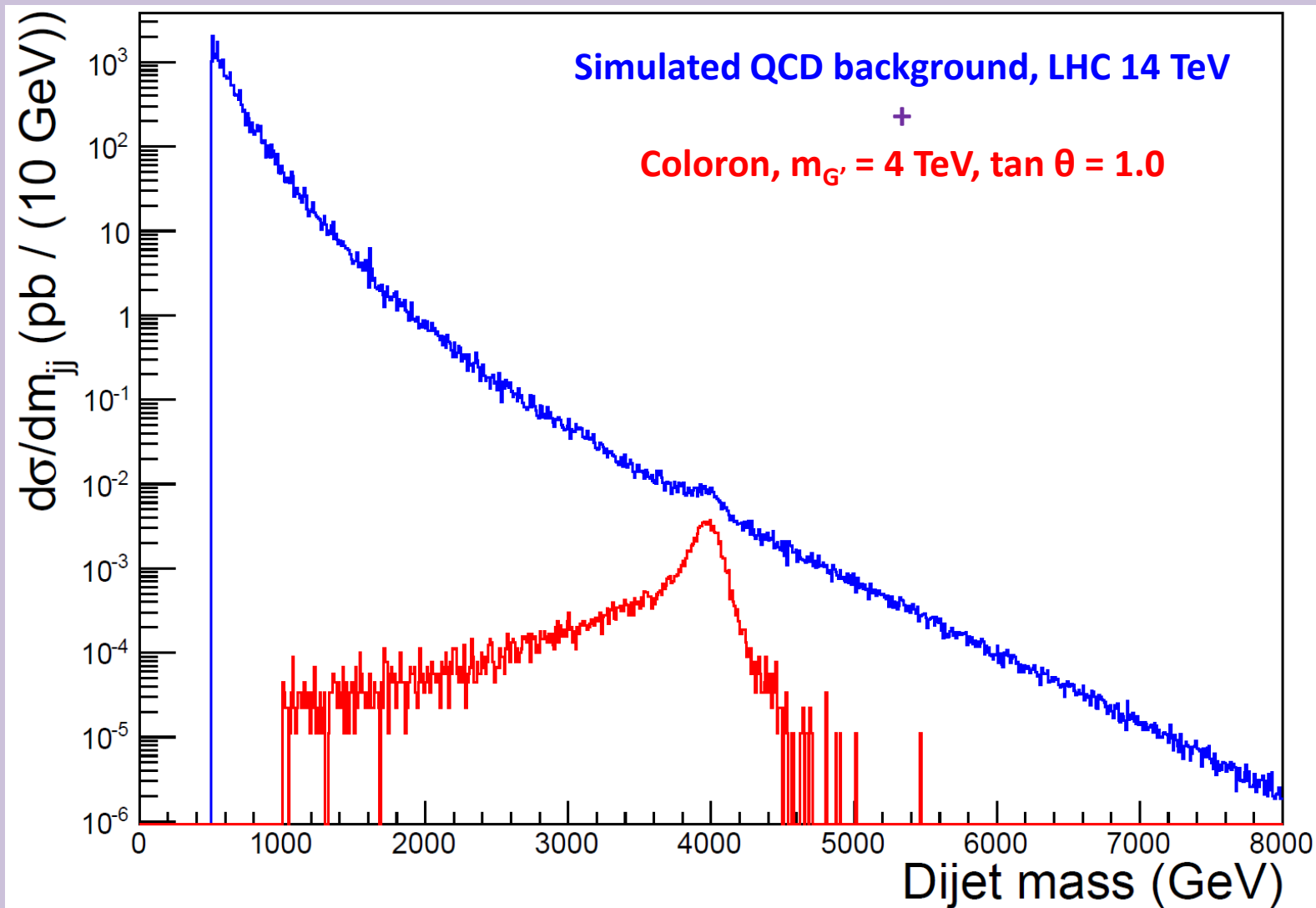
- New $U(1)'$ gauge symmetry
 - *Generally* flavor-safe if gauging a subgroup of the global SM flavor group
$$G \subset U(1)_B \times U(1)_e \times U(1)_\mu \times U(1)_\tau$$
 - Arbitrary choices (except, *e.g.*, B-L or $L_\mu - L_\tau$) violate $SU(2)^2 \times U(1)'$ and $U(1)_Y^2 \times U(1)'$ anomalies c.f. talk by Ismail
- Extended gauge groups (Pati-Salam) – also introduce new charged W' bosons

Z' bump hunting



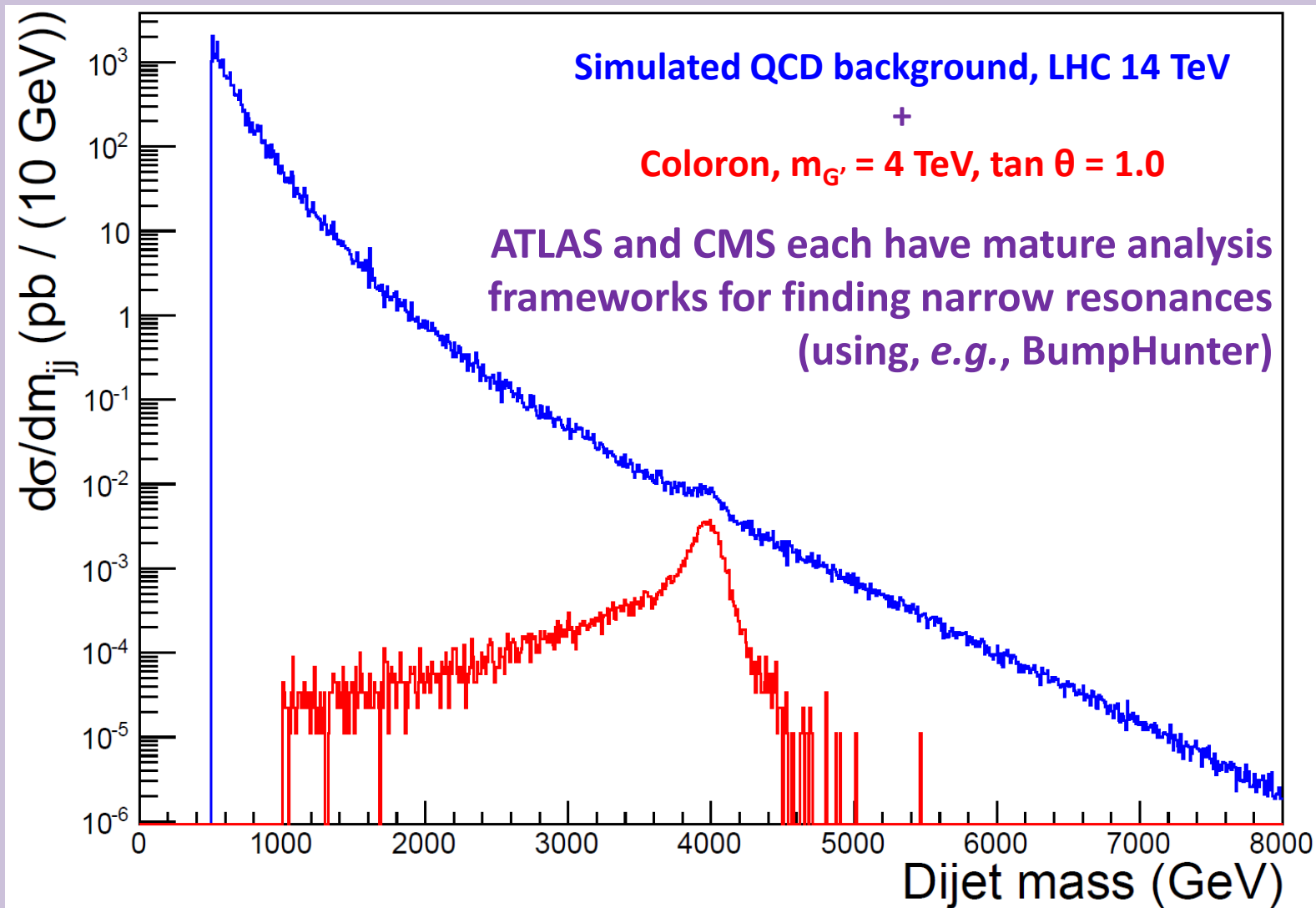
FY [1308.1077]

Z' bump hunting



FY [1308.1077]

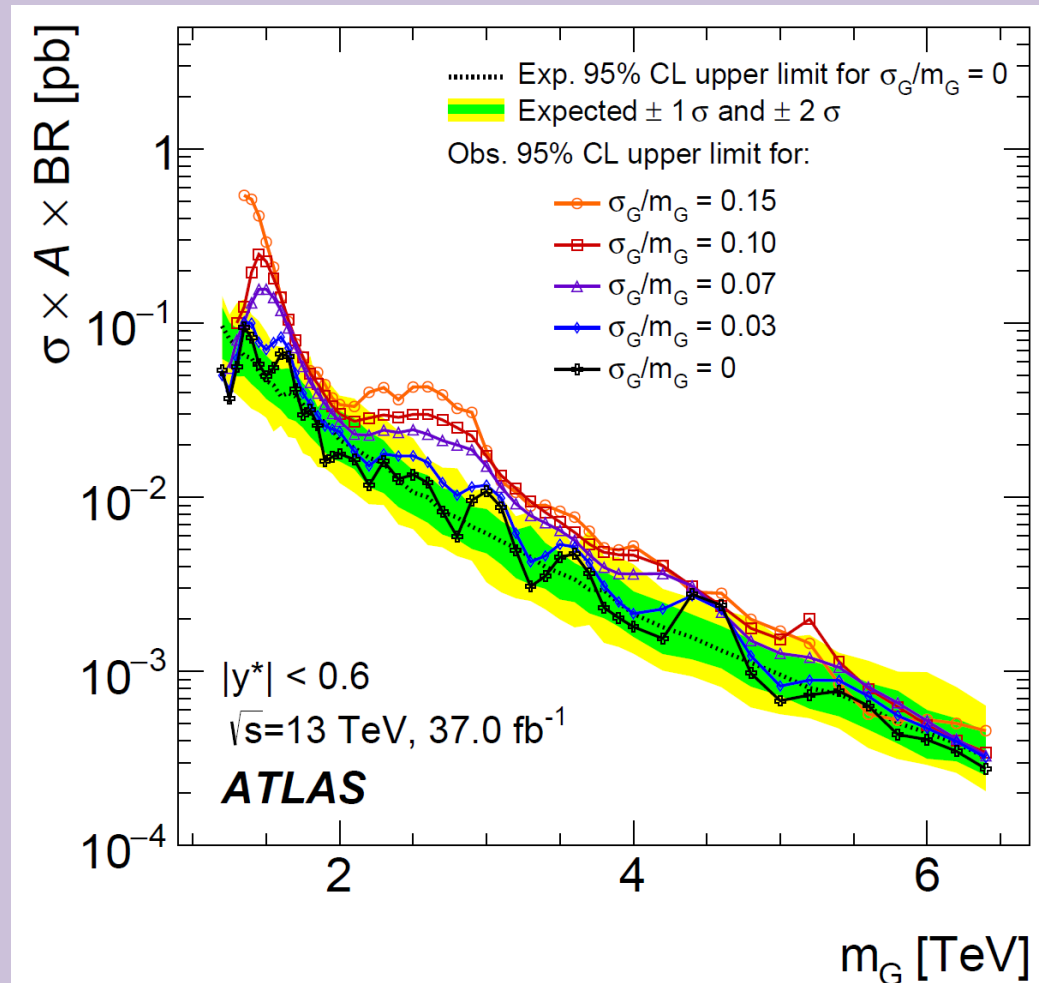
Z' bump hunting



FY [1308.1077]

Z' bump hunting – dijets

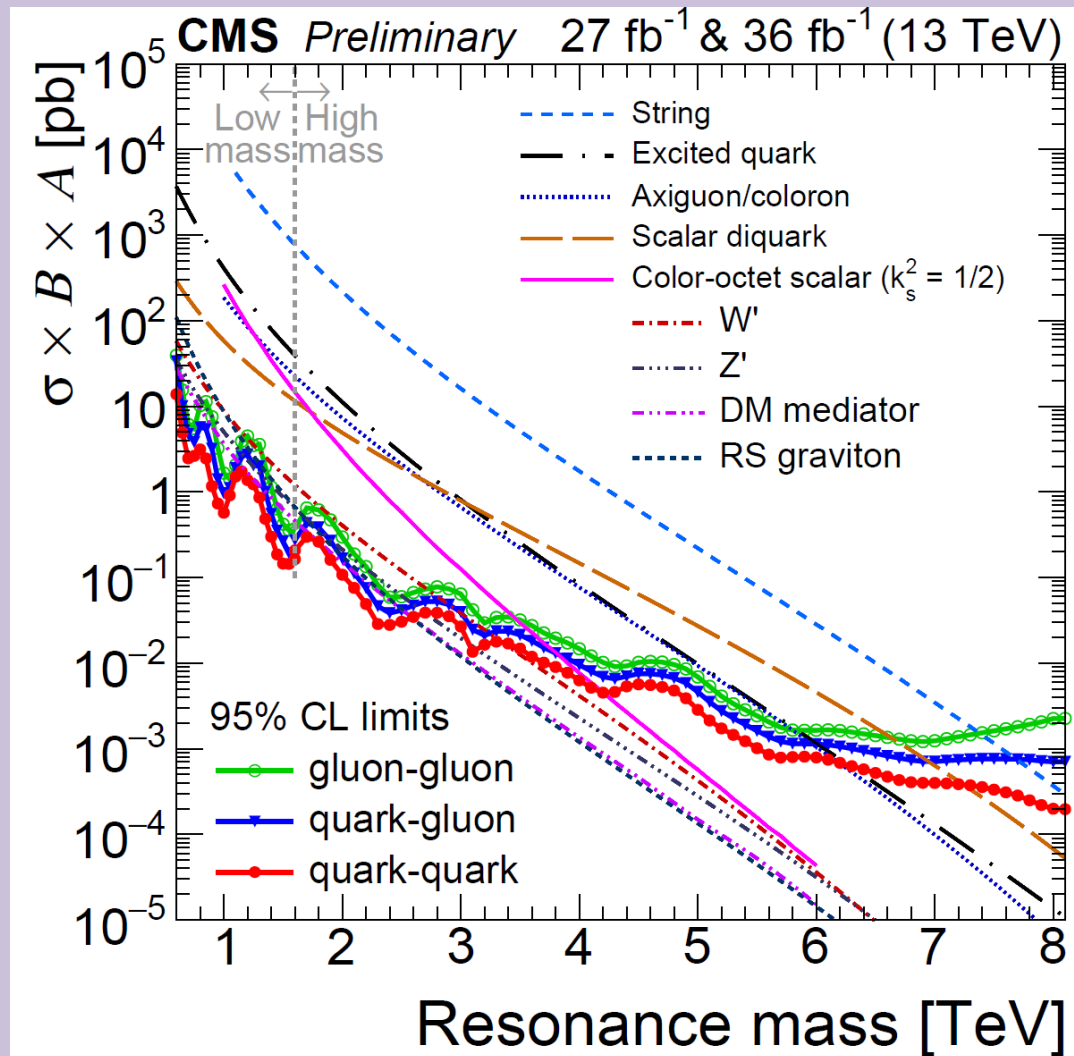
- Beyond narrow resonances, ongoing activity in wide dijet resonances



ATLAS [1703.09127]

Z' bump hunting – dijets

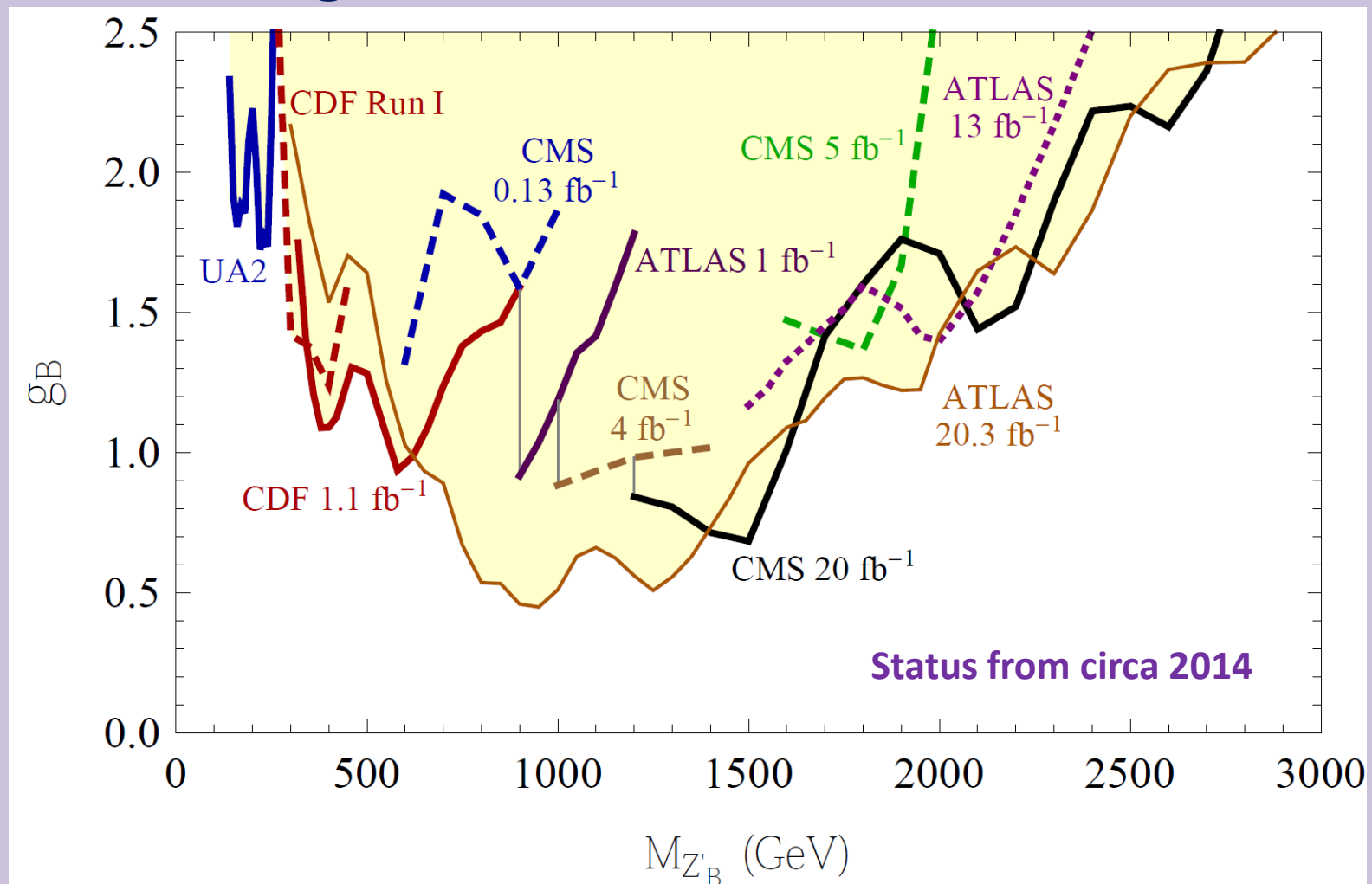
- Also, ongoing activity in differentiating production modes



CMS EXO-16-056

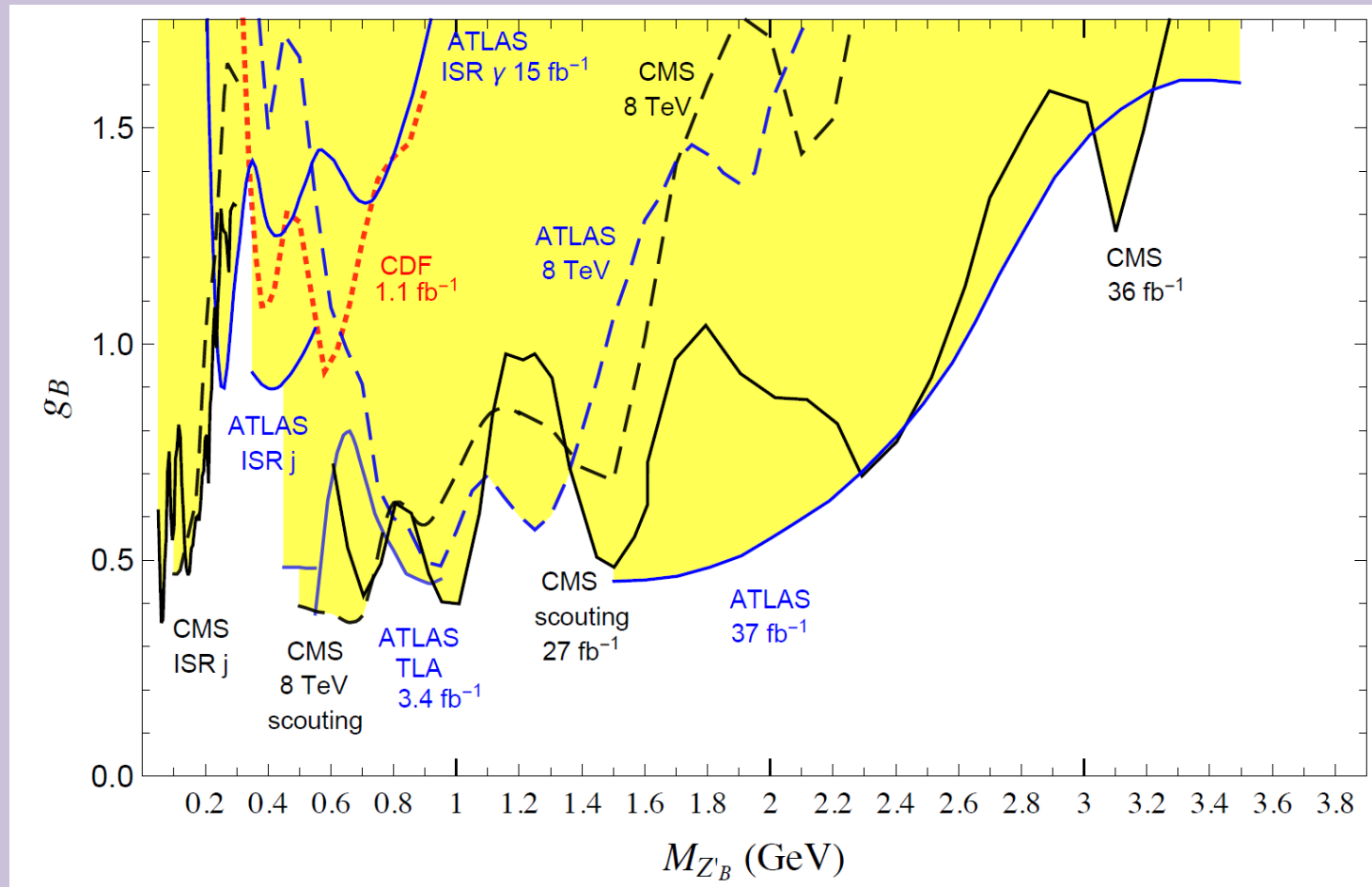
Z' bump hunting – dijets

- Recent resurgence to focus on low-mass resonances



Z' bump hunting – dijets

- Recent resurgence to focus on low-mass resonances



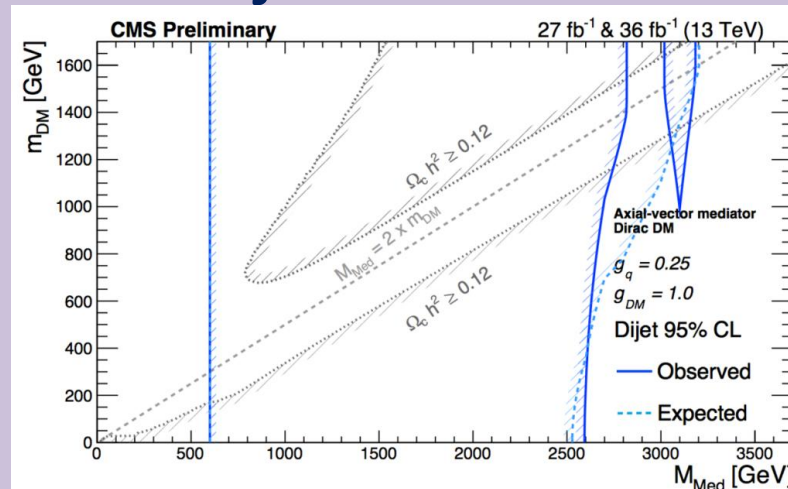
B.A. Dobrescu, FY [in progress]

See also ATLAS [1801.08769]

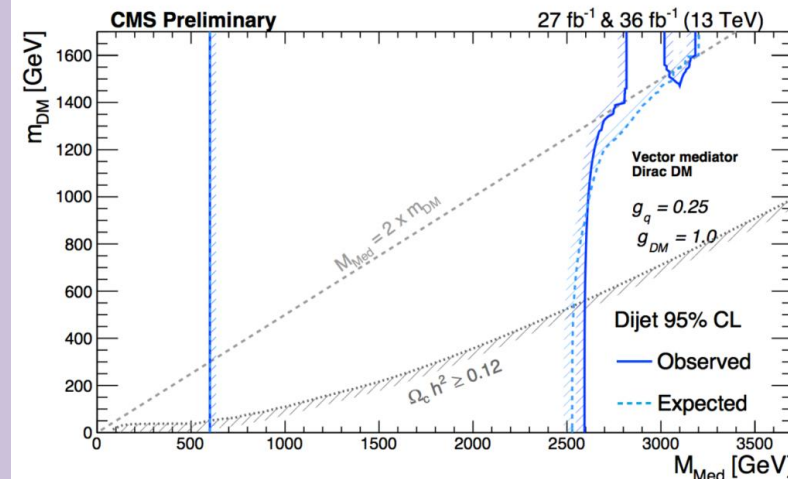
Z' bump hunting – dijets vs. invisible

- Z' simplified models for DM predict complementary sensitivity in mono-jet vs. resonant dijet searches

Axial-vector coupling



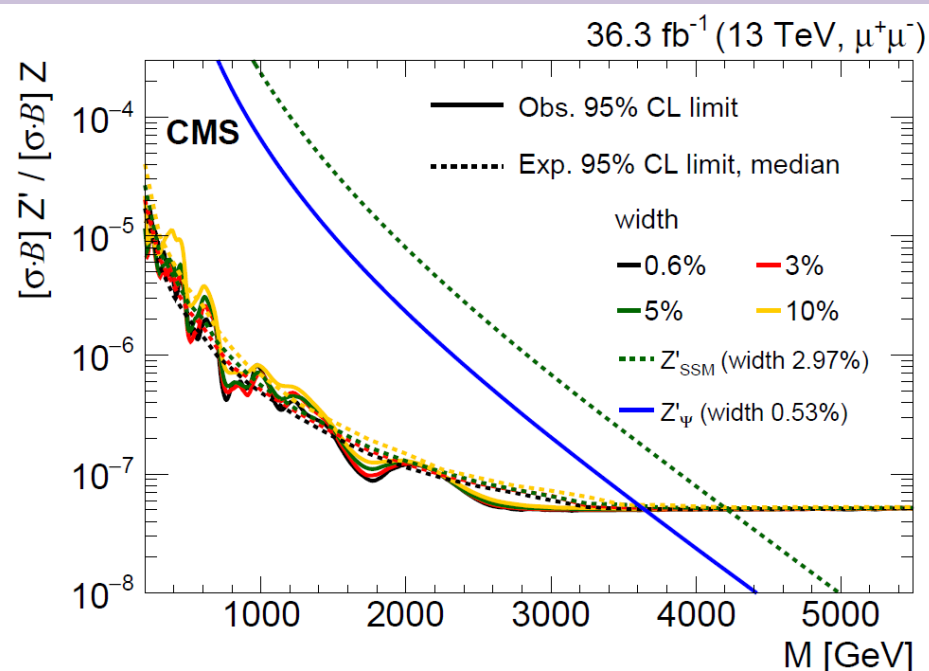
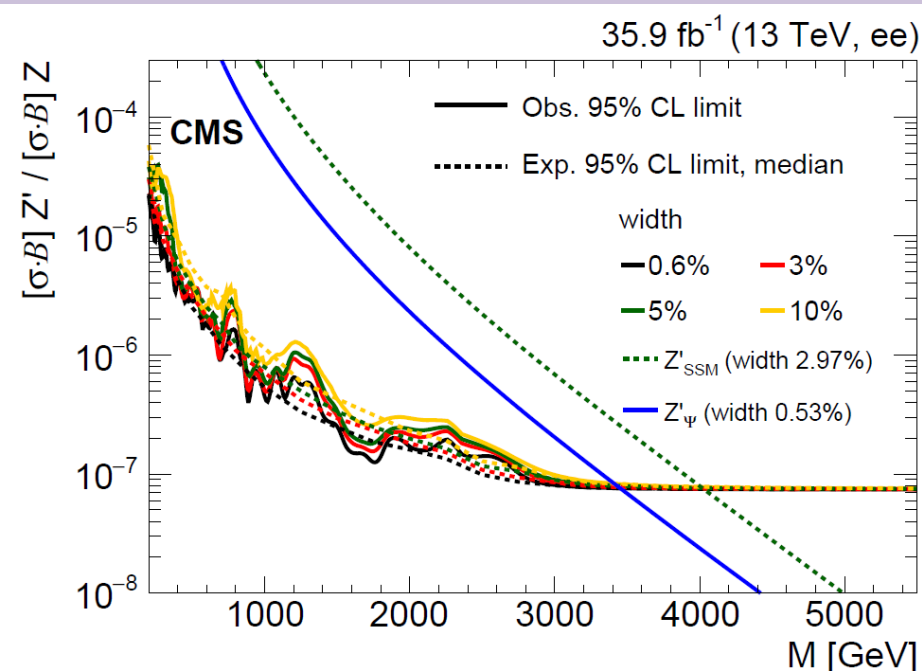
Vector coupling



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Z' bump hunting – dileptons

- Strongest Z' limits from dilepton final states
 - Include interference at high tails from Drell-Yan
 - Necessary for kinetic mixing sensitivity

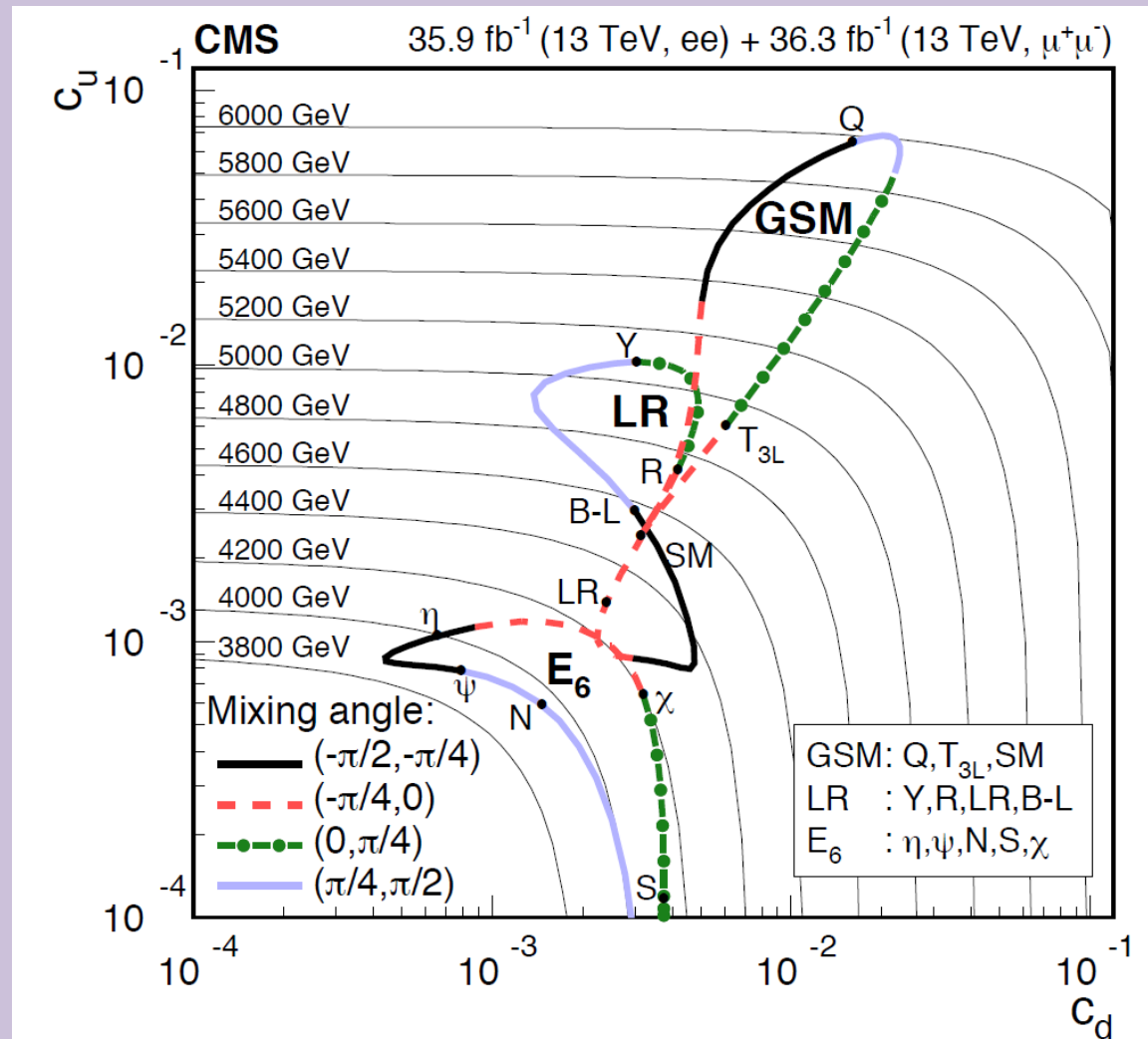


CMS [1803.06292]

Z' bump hunting – dileptons

- Also disentangle production modes

CMS [1803.06292];
See Carena, Daleo, Dobrescu, Tait
[hep-ph/0408098]



Z' Outlook

- Other final states (and experimental projections) – talks by Hoepfner ($t\bar{t}$, $\tau\tau$), and remainder in this session
- Theory work – distortions at high invariant mass from EW Sudakovs
- Experimental issues – lepton kinematics at high p_T saturate capabilities of current design
- More channels to consider
 - Flavor-violating
 - $\nu\nu$ “Invisible” decay
 - Relation to W' and other resonances

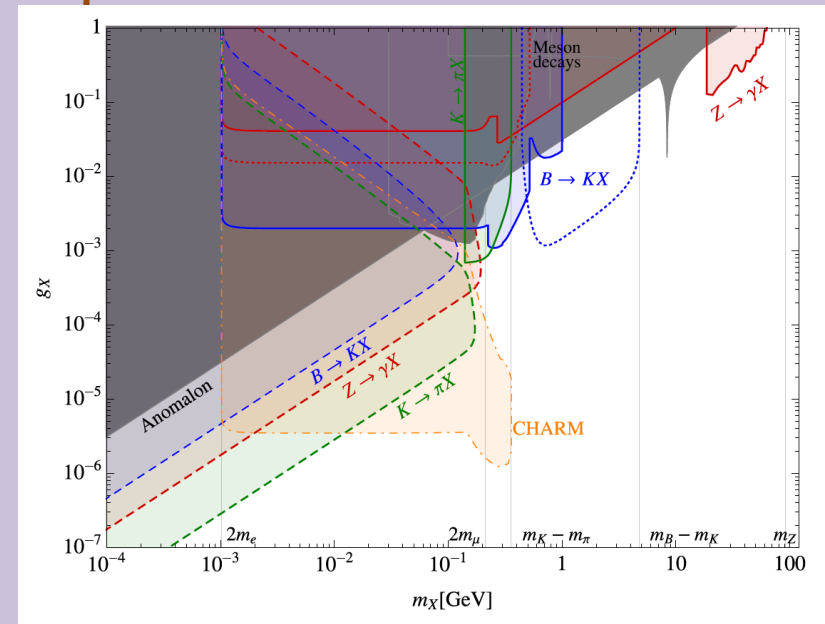
cf. talk by Altmannshofer

Z' post-discovery roadmap – HL to HE-LHC

- Observation of a new bump generally difficult to dismiss as experimental/theoretical systematics
- Z' characterization follows analogously as Higgs program
 - Establish patterns of production and decay modes
 - Spin determination/Flavor universal vs. non-universal/Mixing with SM Z /New Higgs boson?
 - Direct observation of total width (unlike Higgs) can overconstrain particle properties
 - UV completions to be tested with full HL-LHC or HE-LHC data

Z' bump hunting – looking ahead

- Goal: enhance sensitivity across entire coupling and mass range accessible
 - Simultaneous search for NP mass scale as well as NP coupling strength
 - Natural complementary overlap with accelerator-based probes



Summary

- Z' physics is bread and butter for HL/HE-LHC
- Simple and rich signatures to study covers a wide range of possible UV models and inspires a broad range of experimental analyses

EW Sudakov and dijets

- EW virtual and tree corrections alter leading and subleading jet p_T

Mishra, et. al. [1308.1430]

- Expect reduced effect if include real EW emission in shower

$$\sigma^{\text{NLO}} = \sigma_{\text{QCD}}^0 \times (1 + \delta_{\text{EW}}^{\text{tree}}) \times (1 + \delta_{\text{weak}}^{\text{1-loop}})$$
$$\simeq \sigma_{\text{QCD}}^0 \times (1 + \delta_{\text{EW}}^{\text{tree}} + \delta_{\text{weak}}^{\text{1-loop}}).$$

Not too significant for M_{jj}

