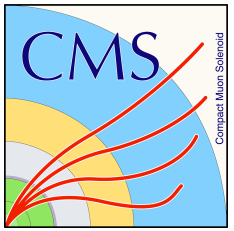
Looking for Leptoquarks and Supersymmetry



Gagan Mohanty

DHEP Annual Meeting
May 8-9, 2018

Physics thrust areas

- Standard Model measurements

Extraction of parton distribution functions

Precision top quark physics

Look for exotic charmonium-like states in B decay

- Search for signature of new physics in variety of models

Search for light charged Higgs boson

Supersymmetry in fully hadronic final state

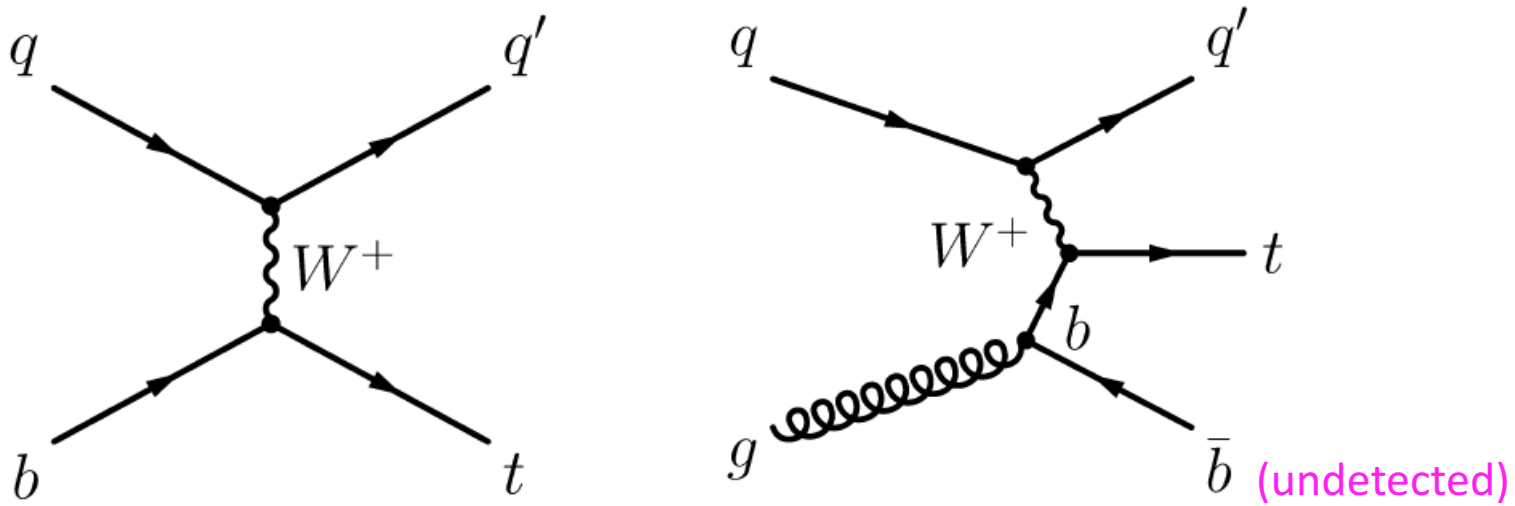
First generation scalar leptoquark

➢ Shall focus on a subset of recent studies that are either close to be published or actively being pursued

Single top production at LHC

- A unique testing ground for EW interaction, especially for the tWb vertex as well as to extract the CKM matrix element V_{tb}

- At LHC, the t-channel is the most dominant single top production process ($\sim 70\%$ at 13 TeV)

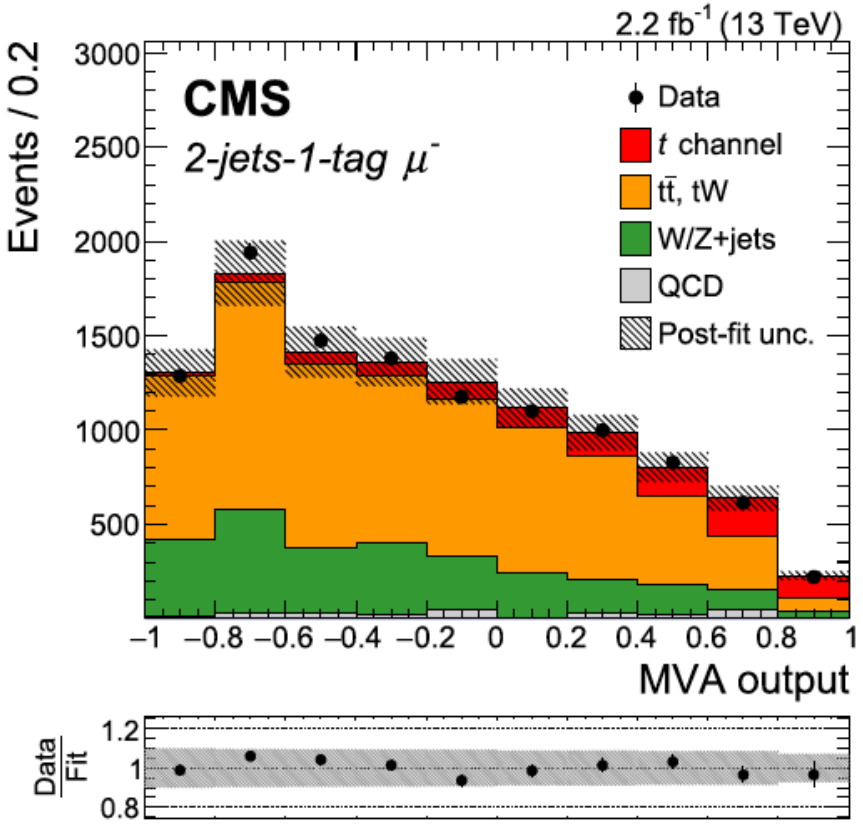


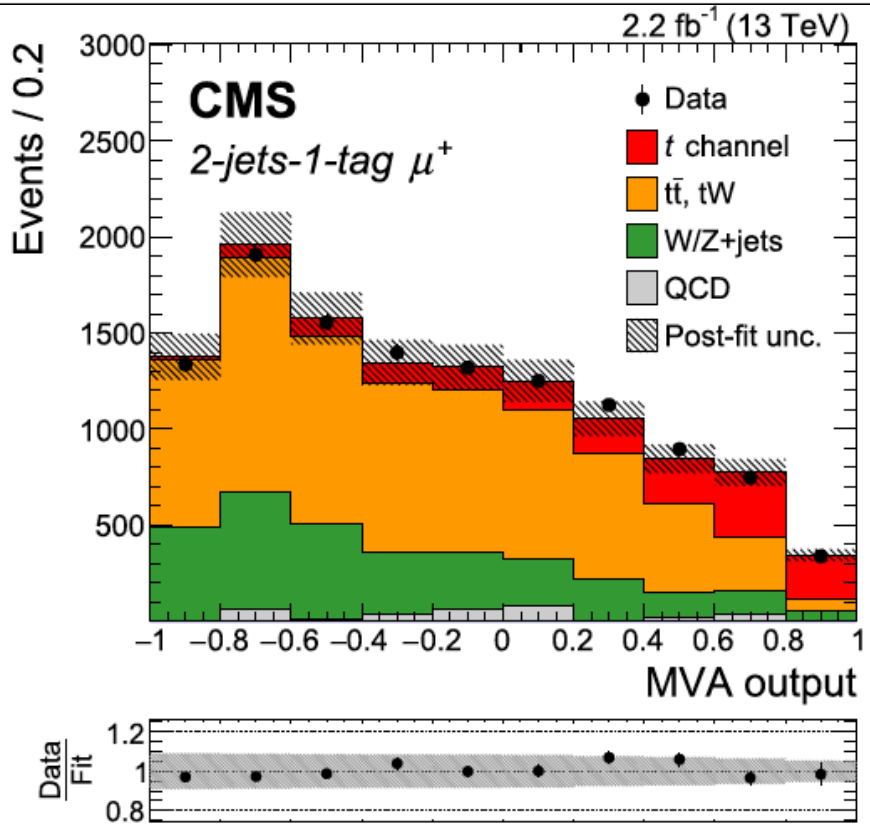
- Most distinguishing feature is the presence of a light flavor jet recoiling against the top quark

Analysis methodology

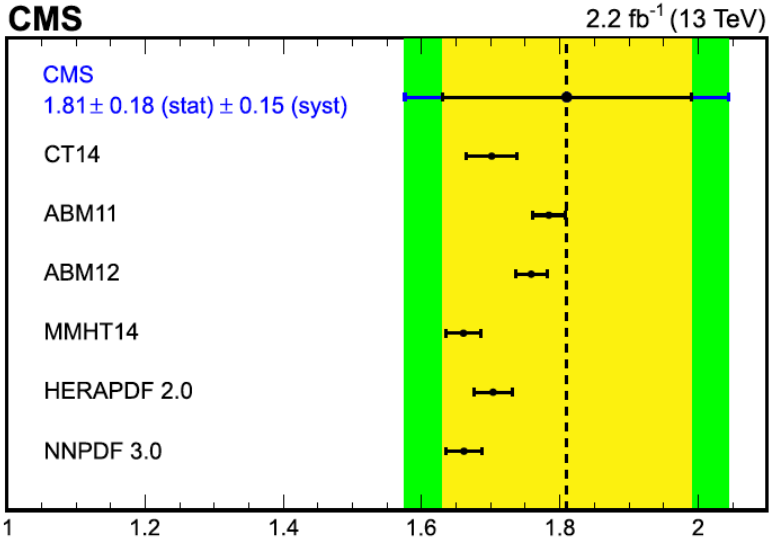
- Use an MVA method that combines 11 variables

Variable	Description
Light quark $\lvert\eta\rvert$	Absolute value of the pseudorapidity of the light-quark jet
Top quark mass	Invariant mass of the top quark reconstructed from muon, neutrino, and b-tagged jet
Dijet mass	Invariant mass of the two selected jets
Transverse W boson mass	Transverse mass of the W boson
Jet p_T sum	Scalar sum of the transverse momenta of the two jets
$\cos\theta^*$	Cosine of the angle between the muon and the light-quark jet in the rest frame of the top quark
Hardest jet mass	Invariant mass of the jet with the largest transverse momentum
ΔR (light quark, b quark)	ΔR between the momentum vectors of the light-quark jet and the b-tagged jet.
Light quark p_T	Transverse momentum of the light-quark jet
Light quark mass	Invariant mass of the light-quark jet
W boson $\lvert\eta\rvert$	Absolute value of the pseudorapidity of the reconstructed W boson





Results and discussion



- Most precise cross section result at 13 TeV (based on just 2.2 fb^{-1} data)

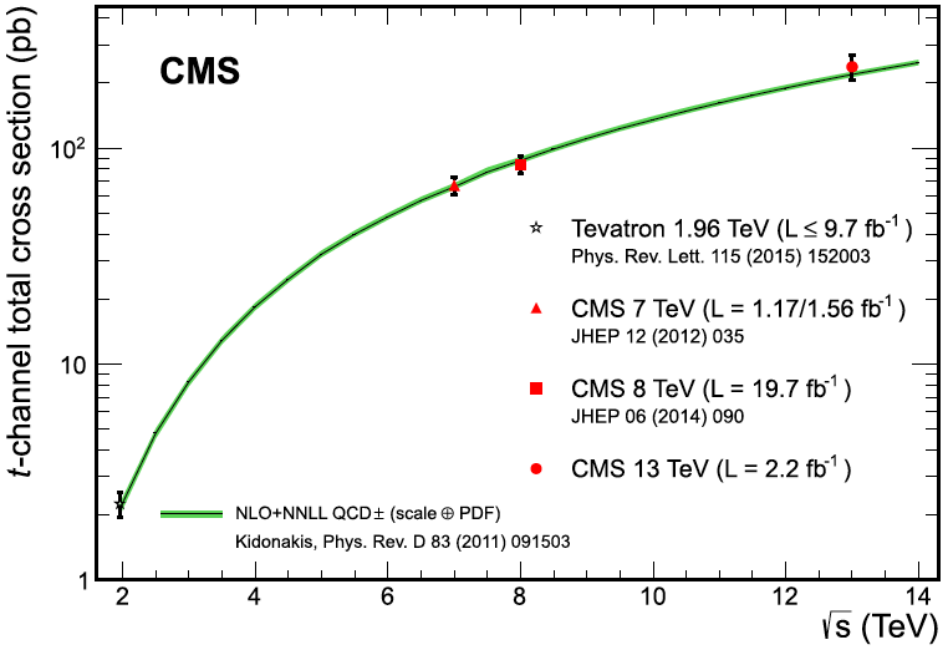
PLB 772, 752 (2017)

$$\sigma_{t\text{-ch.,t}} = 154 \pm 8\,(\text{stat}) \pm 9\,(\text{exp}) \pm 19\,(\text{theo}) \pm 4\,(\text{lumi})\,\text{pb}$$

$$R_{t\text{-ch.}} = 1.81 \pm 0.18\,(\text{stat}) \pm 0.15\,(\text{syst})$$

$$|f_{LV}V_{tb}| = 1.05 \pm 0.07\,(\text{exp}) \pm 0.02\,(\text{theo})$$

- All results are in agreement with recent SM predictions



Exotic chamonium-like states

- Charged charmonium-like Z states are exotic and potential candidates for tetraquarks with a quark content of

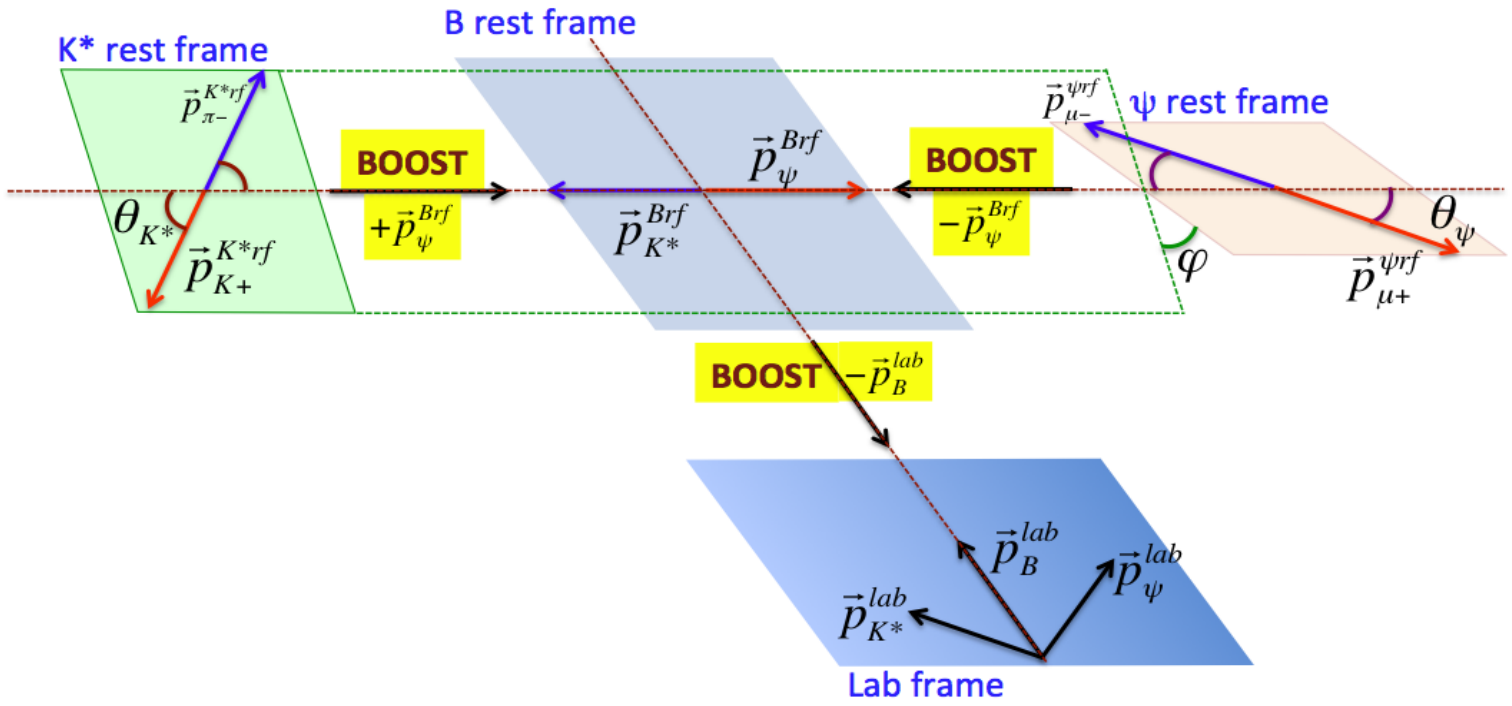
- Searching for $Z(4200)^-$ and $Z(4430)^-$ states in the $B^0 \to (J/\psi\pi^-)K^+$ decay in pp collision data recorded at 8 TeV

- Found by Belle a while ago but without any results from other expts including LHCb

- CMS with its excellent tracking and muon identification system is well suited for the study of final states containing charmonia that decay into a di-muon pair, albeit without charged hadron identification capability

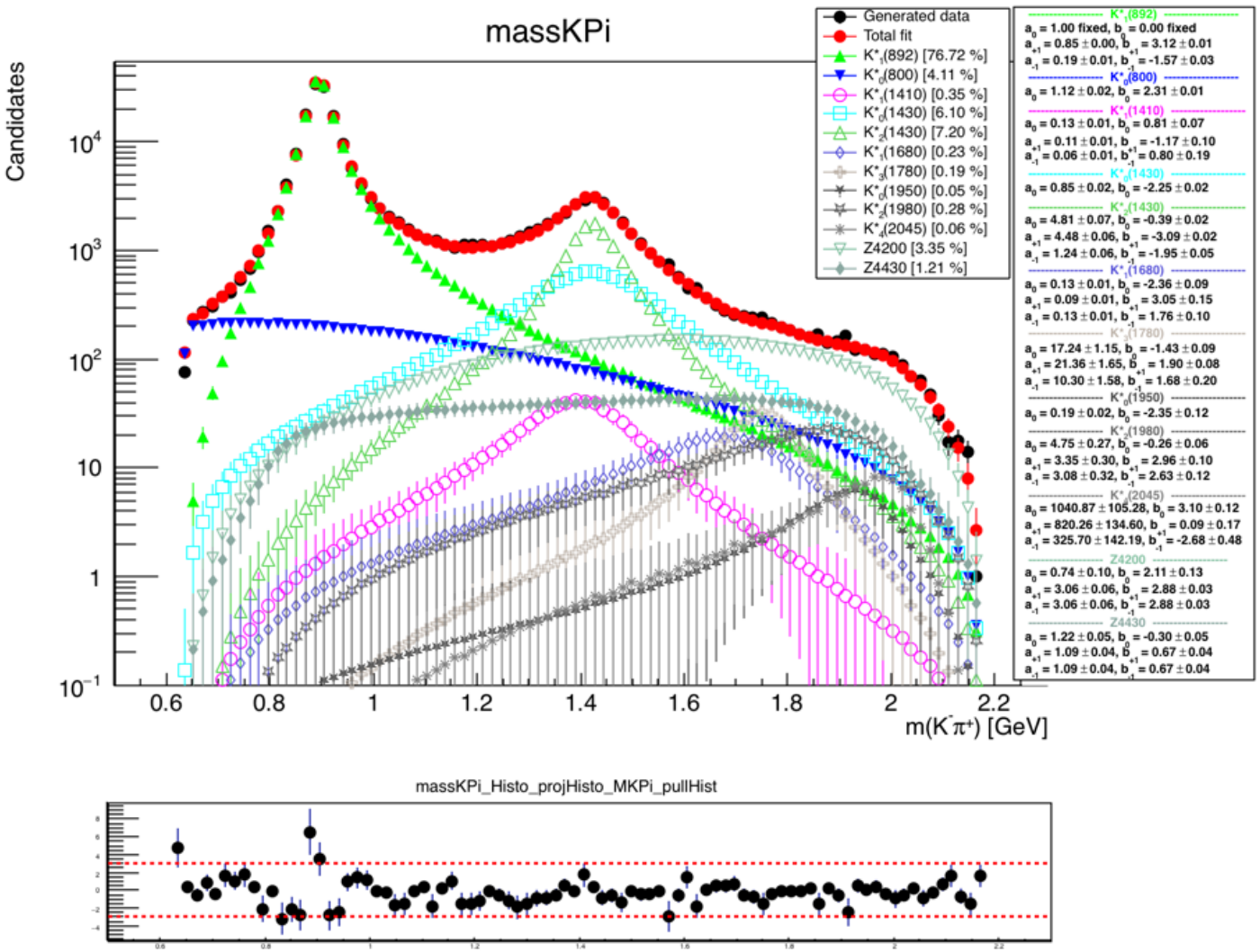
Angular analysis strategy

- Decay kinematics can be completely described by four variables: $\Phi \equiv (M^2_{K\pi}, M^2_{J/\psi}, \theta_{J/\psi}, \phi)$



- Developed a robust angular analysis framework, where the most critical aspect was on how to model Z states in terms of the same set of variables

Proof of the principle



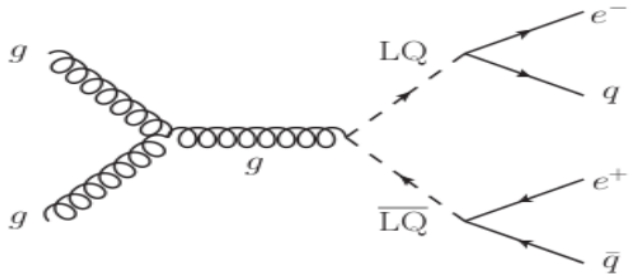
- At the end, the framework is developed and well tested with MC simulated data; now we are ready to look at collision data

Searching for leptoquarks

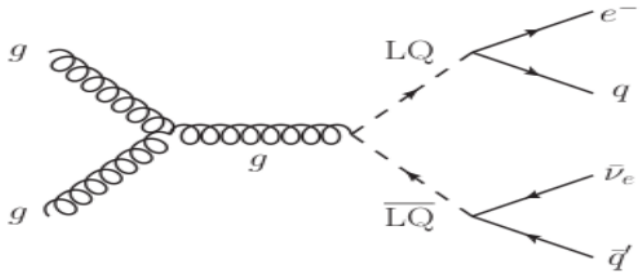
- Leptoquarks arise in many theories beyond the standard model such as Pati-Salam, GUTs, technicolor etc.

- They appear as spin-0 or spin-1 bosons carrying both baryon and lepton numbers as well as fractional electric charge

- We are looking for pair production of 1st generation scalar LQs, produced mainly via gluon-gluon fusion at the LHC



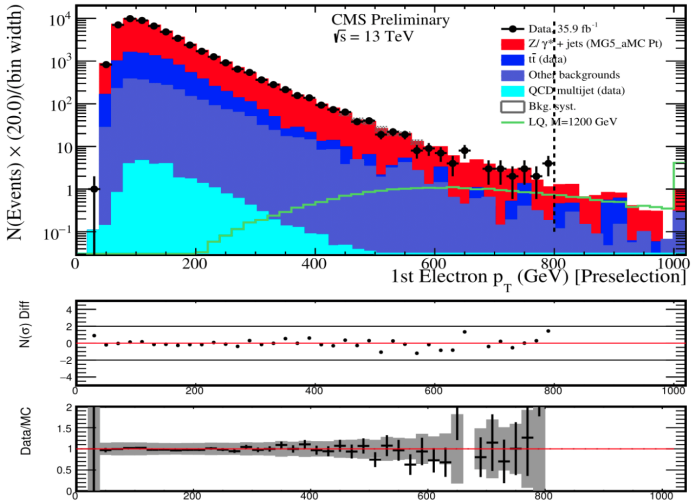
(1) $eejj$ channel

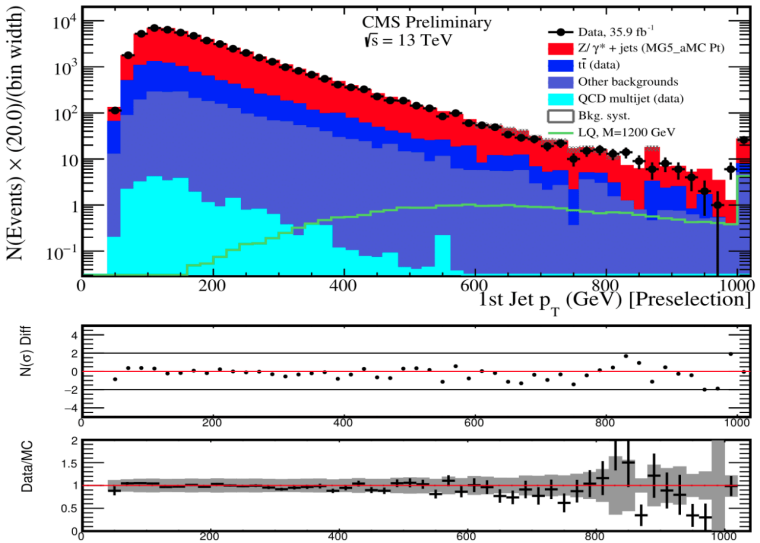


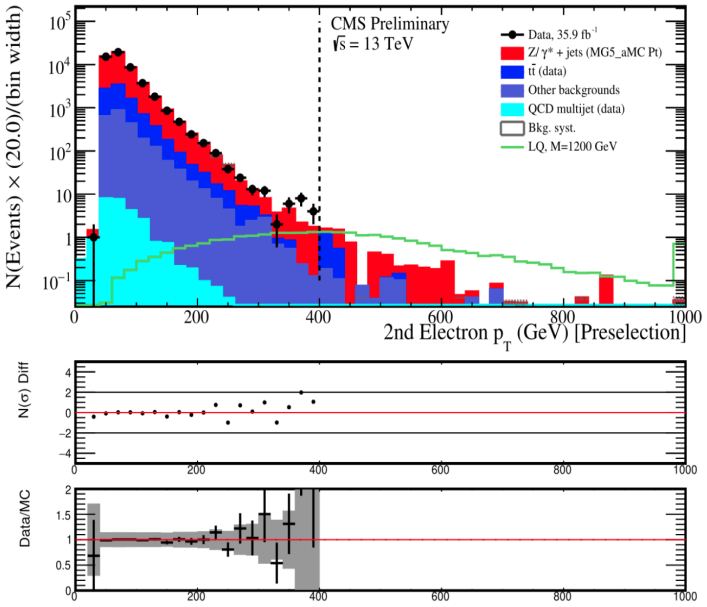
(2) $e\nu jj$ channel

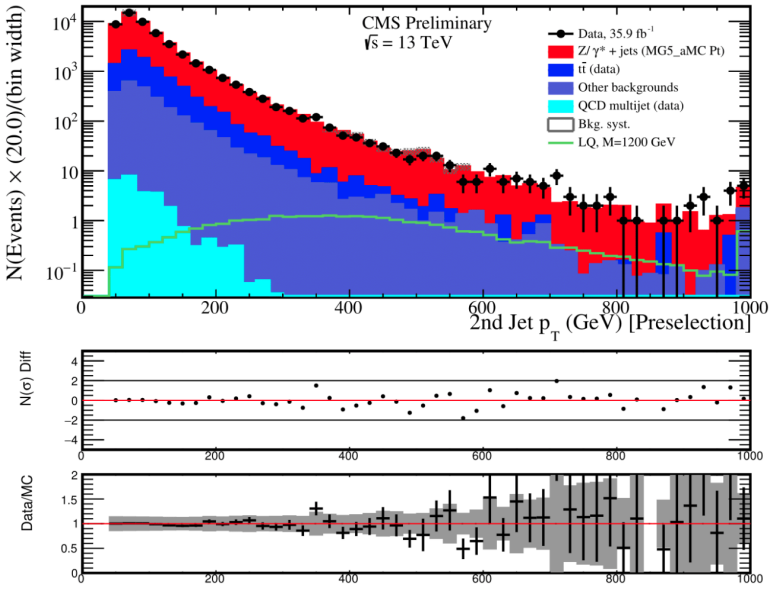
➢ Final state: two isolated leptons, two jets or one lepton, two jets and MET

Some kinematic observables: eejj



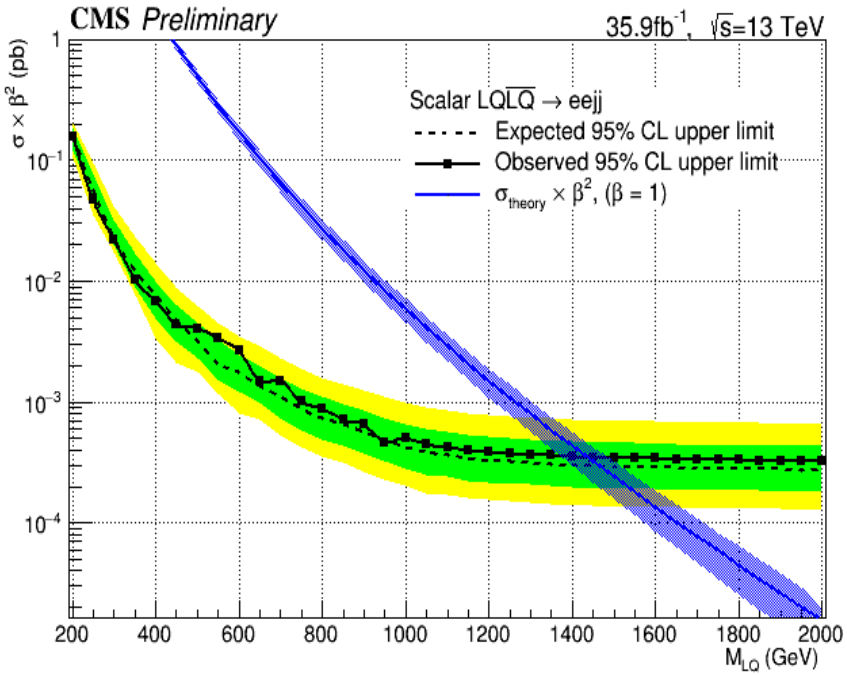






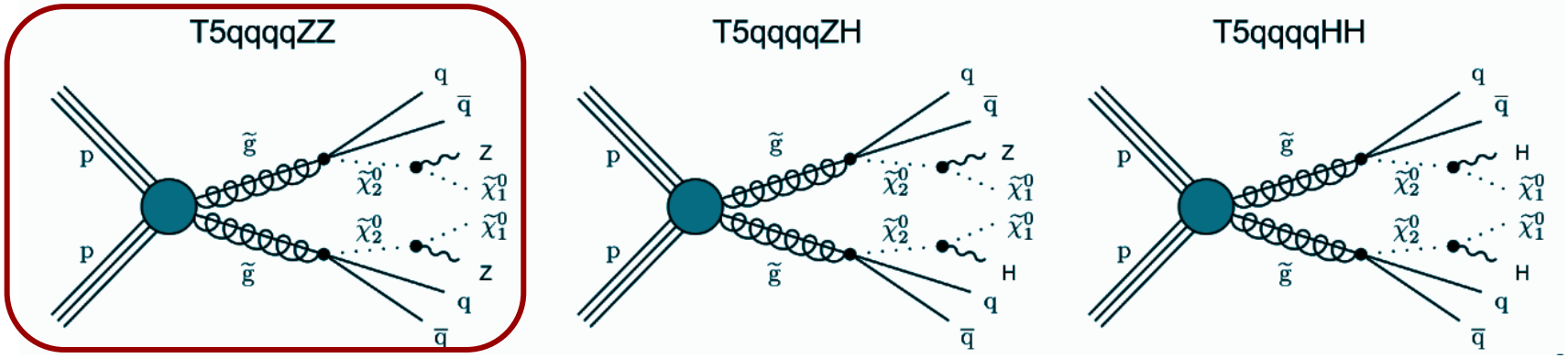
Limit on leptoquarks

- In absence of a statistically significant signal, 95% CL upper limits are set on $\sigma \times \beta^2$ and $\sigma \times 2\beta(1-\beta)$ for eejj and evjj, respectively
- Expected limit on the LQ mass: 1465 (1209) GeV for eejj (evjj) while the corresponding observed limit is less by 30 (13) GeV
- Limits in the evjj channel obtained for the first time at 13 TeV
- Significant improvements over results from 2015 data and 8 TeV

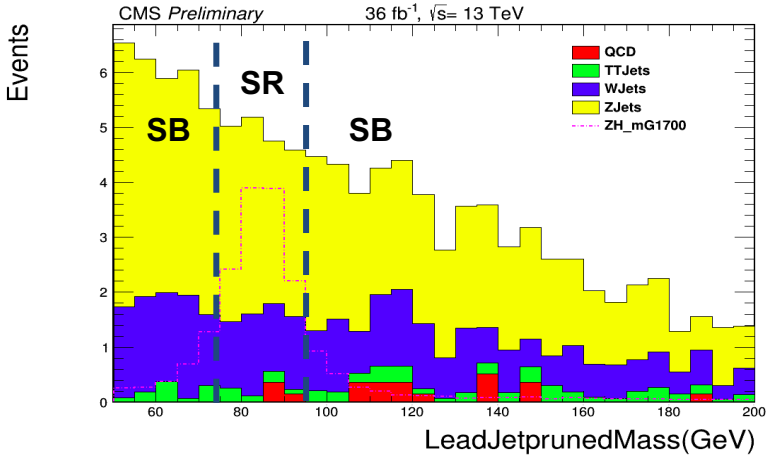


Search for Supersymmetry

- Looking for pair produced gluinos in the final state of boosted vector bosons and MET due to escaping neutralinos ☛ candidate for dark matter



- In development a classic cut-and-count analysis method with the invariant mass of the leading large-radius jet as the final variable
- Signal is expected to peak around the nominal Z mass while SM backgrounds are smoothly falling



- ➢ Fully data-driven background estimation will be employed
- ➢ Encouraging results from a preliminary look