Search for Dark Matter in a Coannihilation Codex Model With CMS Detector

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Introduction

Properties of Dark matter:

Cold

Non-Baryonic

Electrically Neutral

Relic Density Ωh^2 = 0.1198 ± 0.0026

Coannihilation Codex
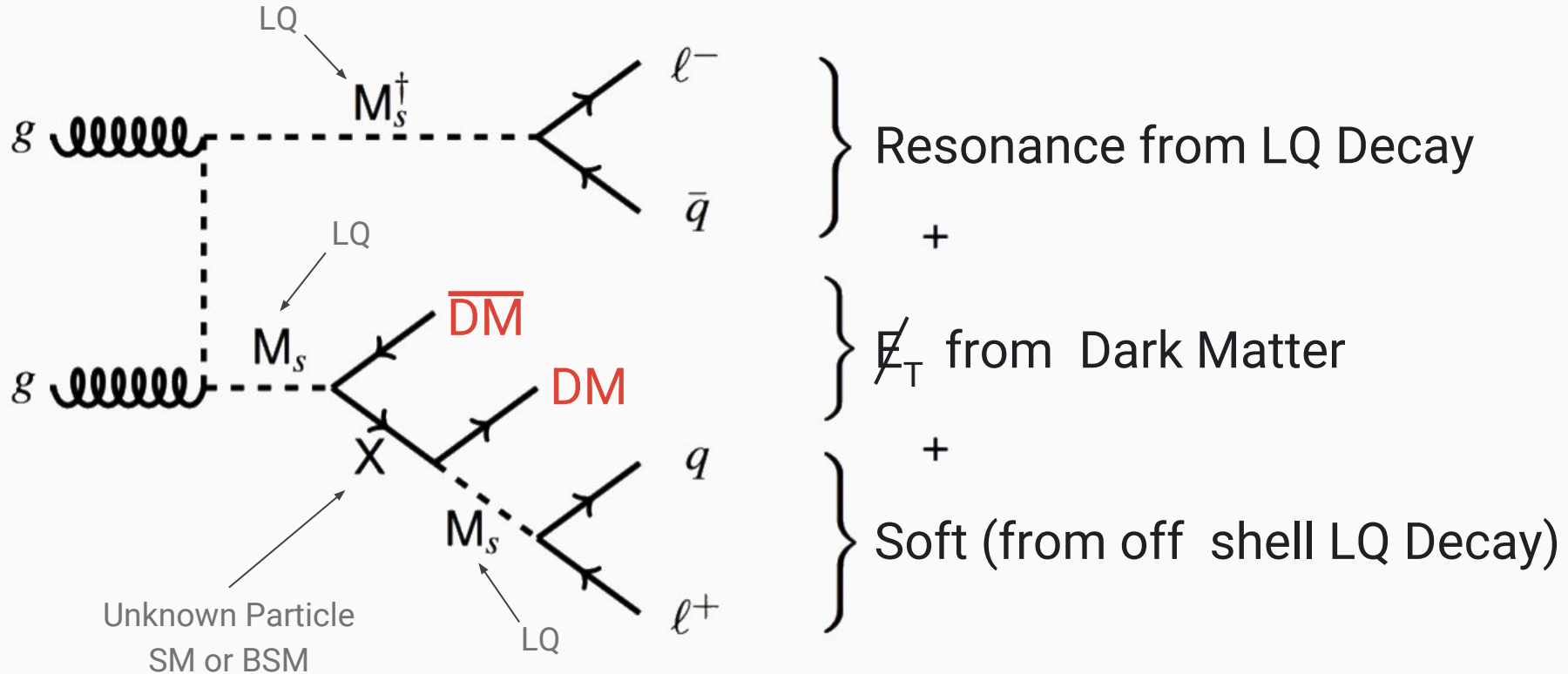
General Classification of simplified Models

Dark Matter (DM) & Coannihilation partner X

Forms a pair of standard model particles

$$DM + X \xrightarrow{M} SM_1 + SM_2$$

Mediating Particle M

LQ

$M_s^\dagger$

g

ℓ^-

$\bar{q}$

} Resonance from LQ Decay

+

LQ

M_s

g

$\overline{\text{DM}}$

DM

X

} $\not{E}_T$ from Dark Matter

+

q

M_s

ℓ^+

Unknown Particle
SM or BSM

LQ

} Soft (from off shell LQ Decay)

Coannihilation Codex: arXiv:1510.03434 [hep-ph]
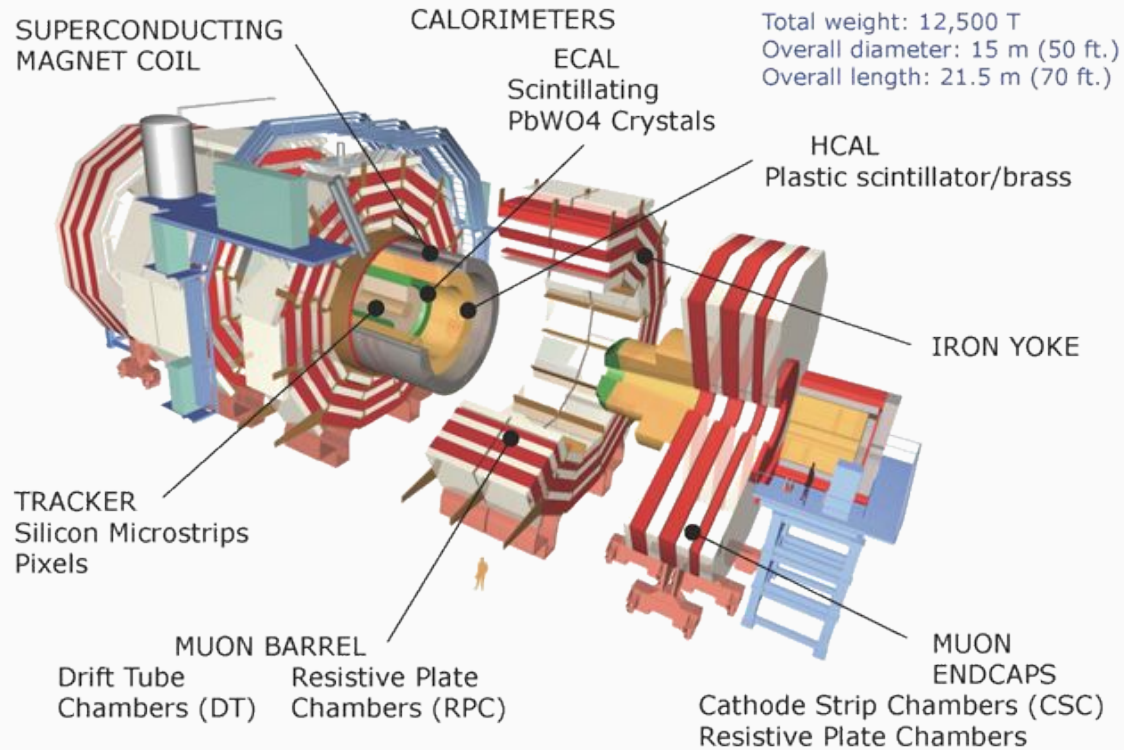
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Coannihilation Condition

Relative mass splitting small

$$\Delta = \frac{m_X - m_{DM}}{m_{DM}} < 0.2$$

Soft decay product

Pair production of 1st generation LQ

CMS Detector

Analysis Signature

Final Signature:

    High Pt Electron

    High Pt Jet

    High MET

$LQ \longrightarrow e^- + u$

$LQ \longrightarrow DM + X$

From CMS 2016 Data:

$\sqrt{S} = 13$ TeV

$L_{int} = 35.9^{-1} fb$

Dataset

Background (CMS Simulation):

    TT (Powheg)

    Single Top (Powheg)

    ZTT (Madgraph)

    W (Madgraph)

    QCD

Signal (CMS Simulation):

Privately produced using Madgraph

Dataset:

2016 singleElectron Dataset

Preselection Cuts

Electron: P_T > 60 GeV & |η| < 2.5
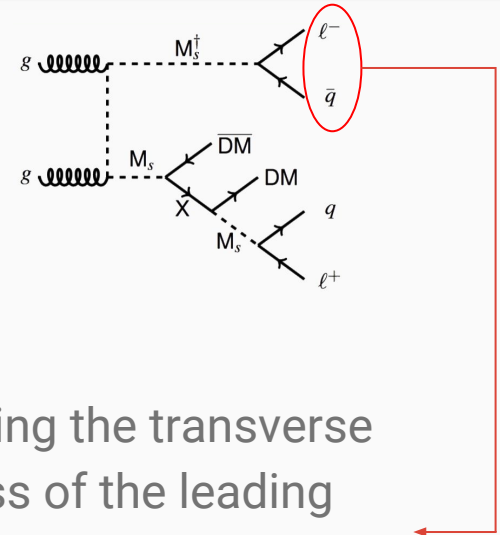
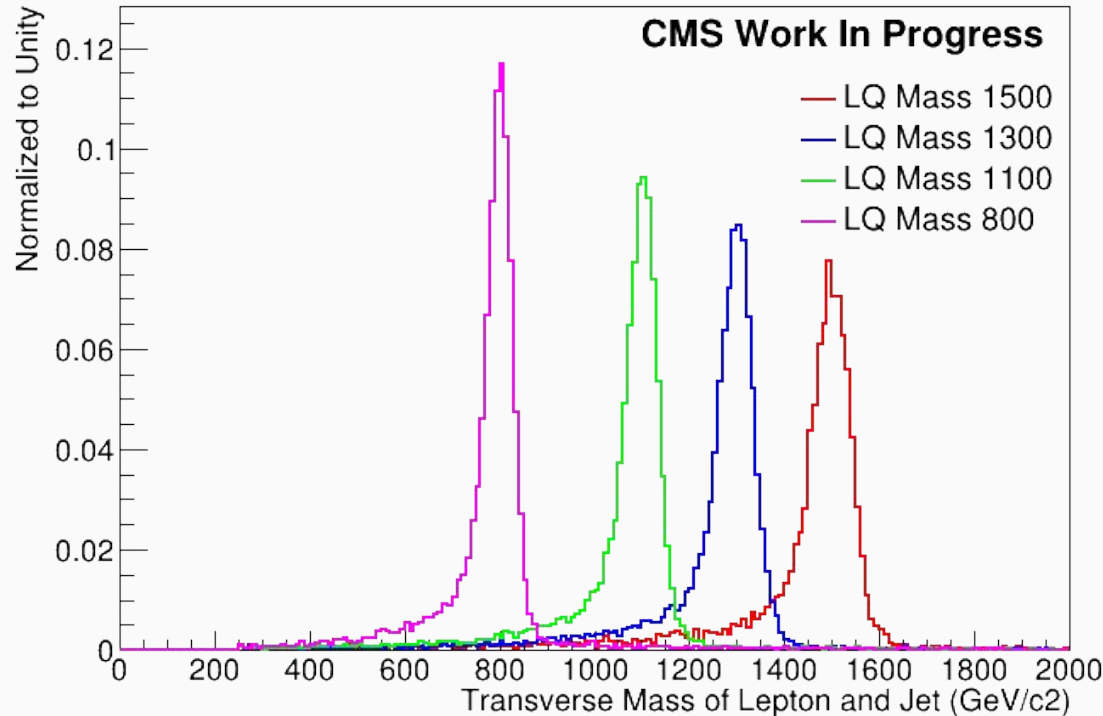Jet: P_T > 100 GeV & |η| < 2.5 & LooseJetID

MET: P_T > 50 GeV & all MET filters

Tau veto: P_T > 20 GeV & |η| < 2.3 & LooseMVAID

Bjet veto: P_T > 20 GeV & |η| < 2.3 & Tight CSV Discriminant

Leptoquark Transverse Mass

Dark Matter Signal Samples:

CMS Work In Progress

LQ Mass 1500
LQ Mass 1300
LQ Mass 1100
LQ Mass 800

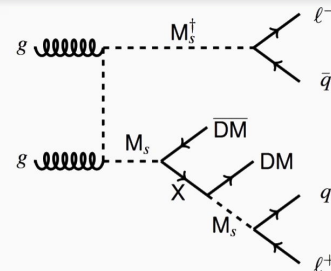Taking the transverse mass of the leading lepton and leading jet gives us the leptoquark mass

CMS Simulation
Preselection applied
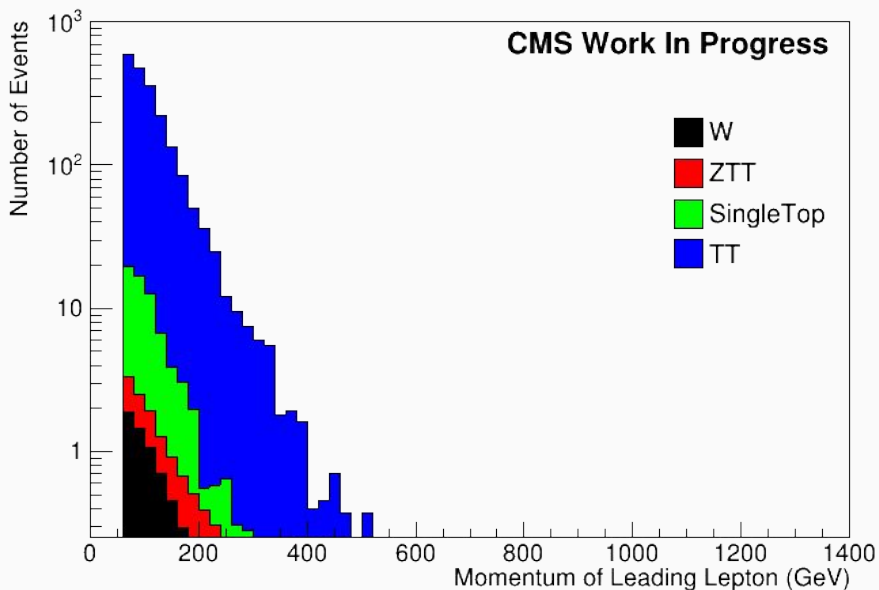
Kinematics: Momentum of Lepton
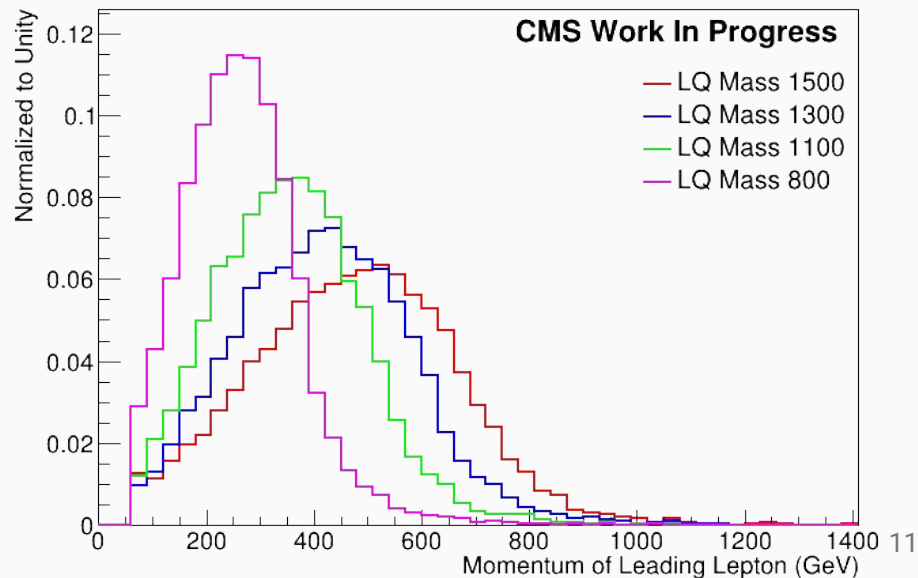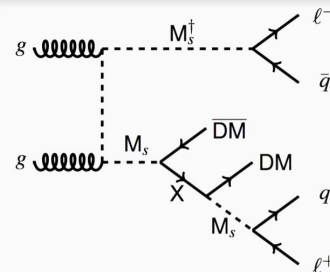
CMS Simulation
Arbitrary normalization applied
Preselection applied

Standard Model Background Samples:

CMS Work In Progress

W
ZTT
SingleTop
TT

Number of Events

Momentum of Leading Lepton (GeV)

Dark Matter Signal Samples:

CMS Work In Progress

— LQ Mass 1500
— LQ Mass 1300
— LQ Mass 1100
— LQ Mass 800

Normalized to Unity

Momentum of Leading Lepton (GeV)

Kinematics: Momentum of Jet

CMS Simulation
Arbitrary normalization applied
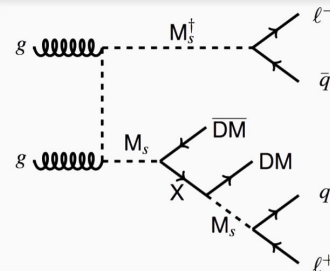Preselection applied
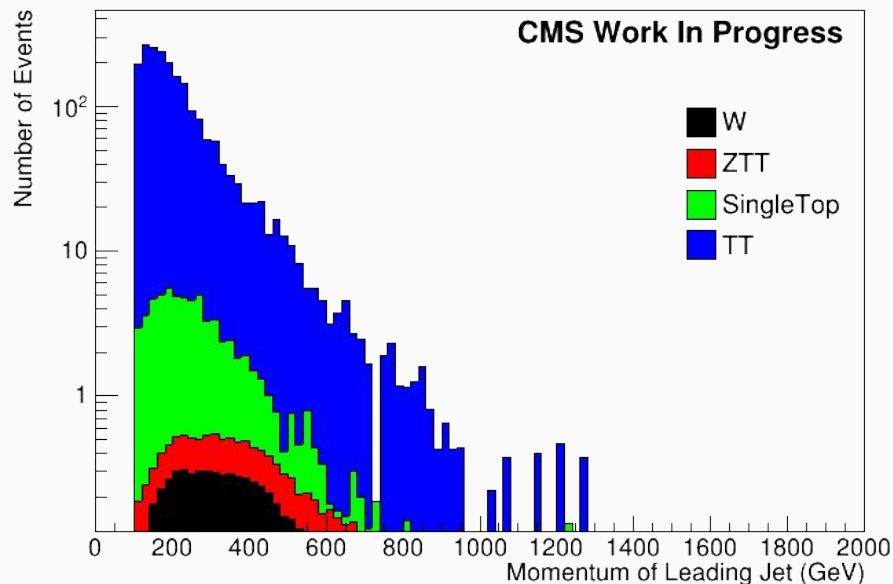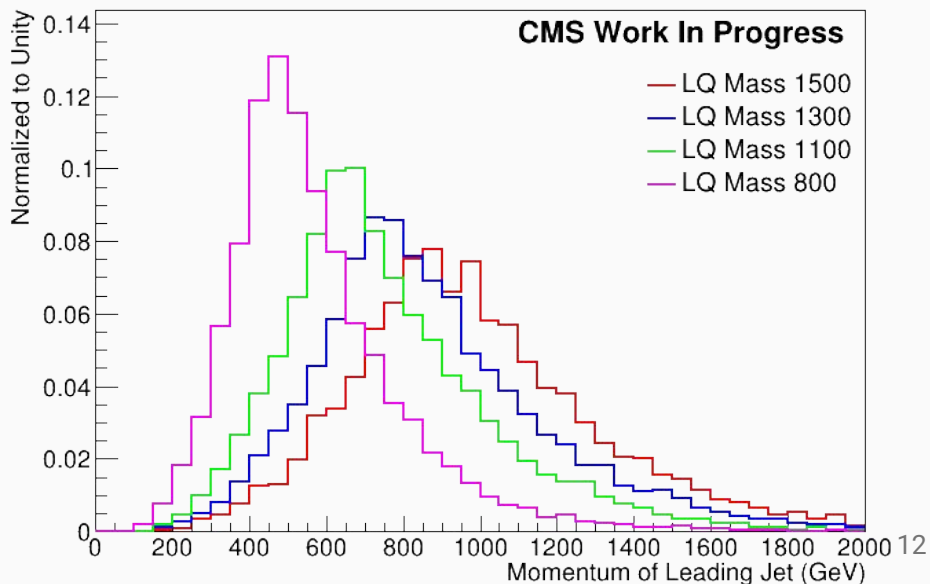
Kinematics: Missing Transverse Energy

CMS Simulation
Arbitrary normalization applied
Preselection applied

Summary

We have begun a search for interesting signature from a coannihilation codex model

Kinematic features

       High Pt Lepton & High Pt Jet

       Missing ET

Optimizing selection

Hope to find something exciting in 2016 data