Search for dark matter production with top quarks at CMS

Jónatan Piedra
IFCA (CSIC - Universidad de Cantabria)

Madrid, 8 de mayo de 2017

Expertise at IFCA

Strong participation in analyses with two opposite-sign leptons in the final state: HWW measurement, WW cross section, tt cross section and WZ cross section (three leptons)

These efforts correlate with **several coordination roles**, Alicia Calderón with muons, Luca Scodellaro with b-quarks, Pablo Martínez with SUSY and myself with HWW

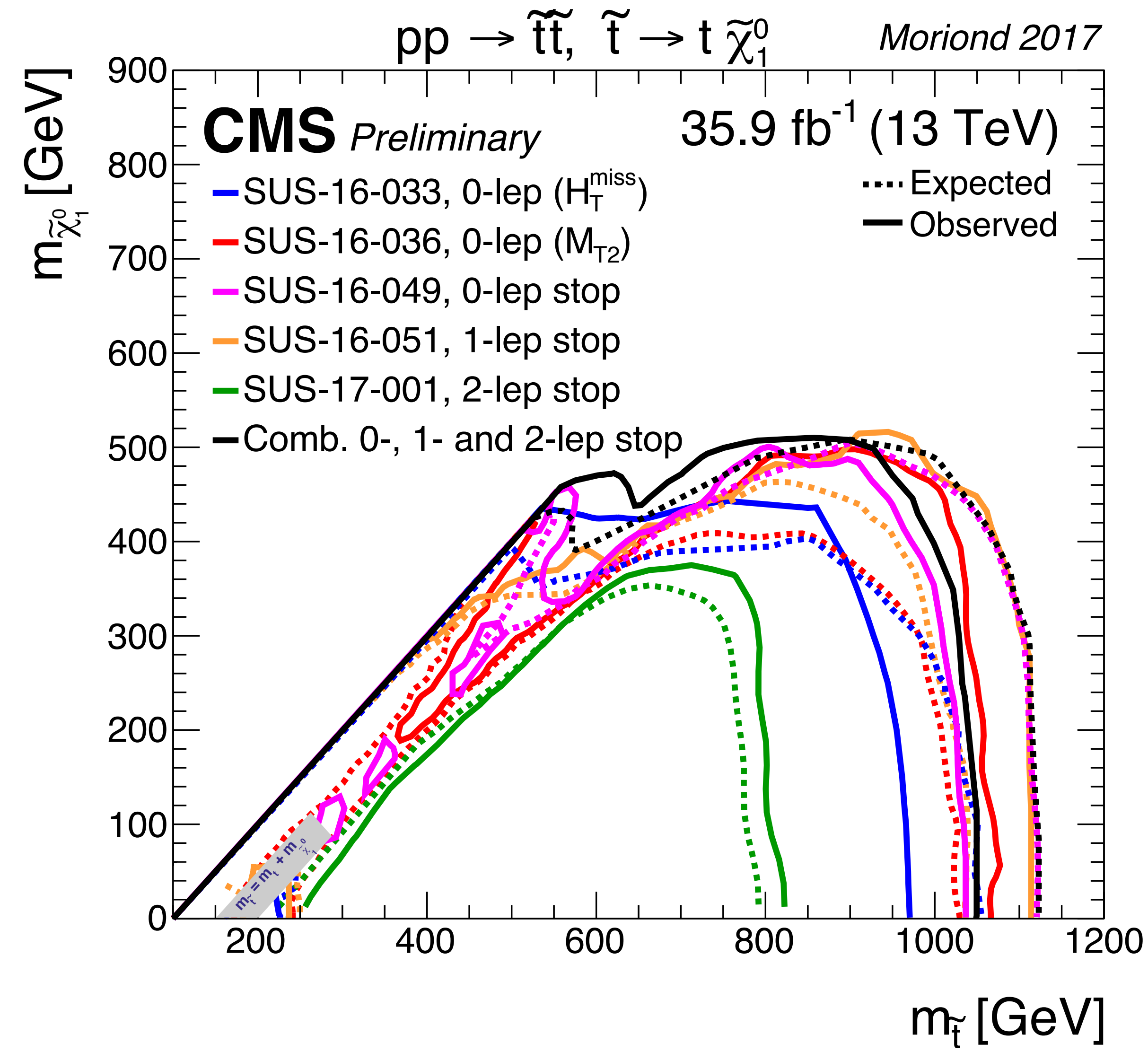
It is a natural step to extend such Standard Model analyses to different **searches: mono-Higgs (see tomorrow's talk by Nicolò) together with stop and tt + DM**

Search for stop production in a compressed region

Analysis similar, yet different, to the tt+DM search. **Work being performed in close collaboration with Oviedo**

Focus on the stop - neutralino intermediate mass region, complementing other CMS stop searches

$$m_W + m_b < \Delta m(\tilde{t}_1, \tilde{\chi}_1^0) < m_t$$



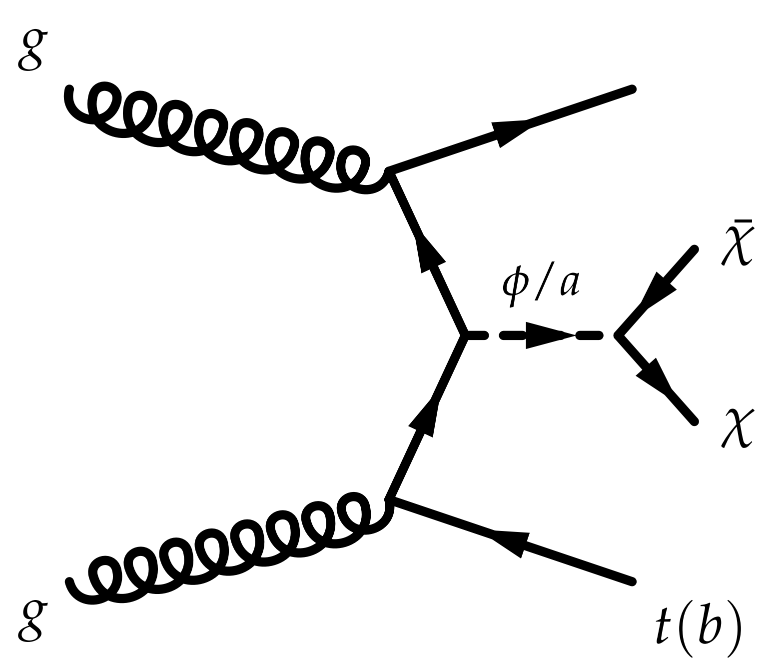
Define signal regions based on the number of b-tags, M_{T2} and MET

$$M_{T2}^2(ll) = \min_{\mathbf{p}_{T1}^{miss} + \mathbf{p}_{T2}^{miss} = \mathbf{p}_T^{miss}} \left(\max \left[M_T^2(\mathbf{p}_T^{\ell 1}, \mathbf{p}_{T1}^{miss}), M_T^2(\mathbf{p}_T^{\ell 2}, \mathbf{p}_{T2}^{miss}) \right] \right)$$

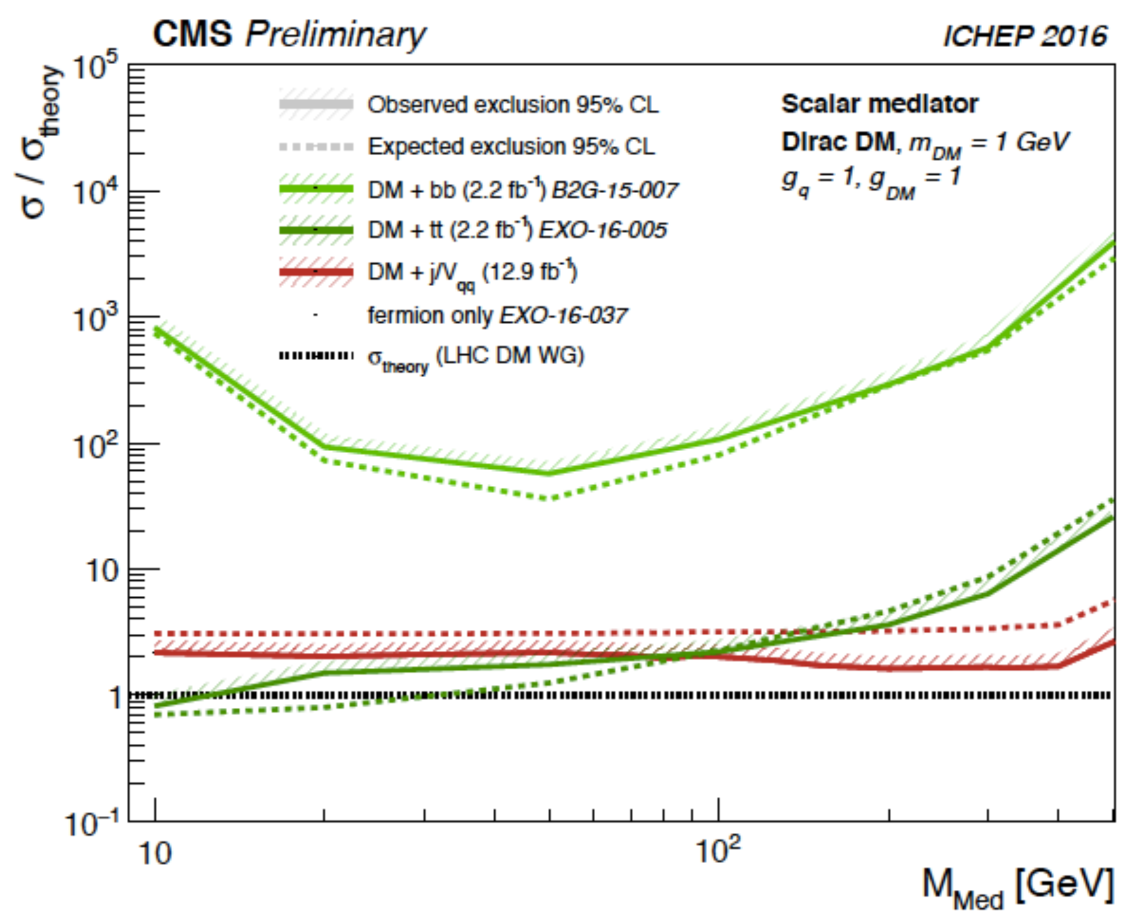
Why search for dark matter with top quarks?

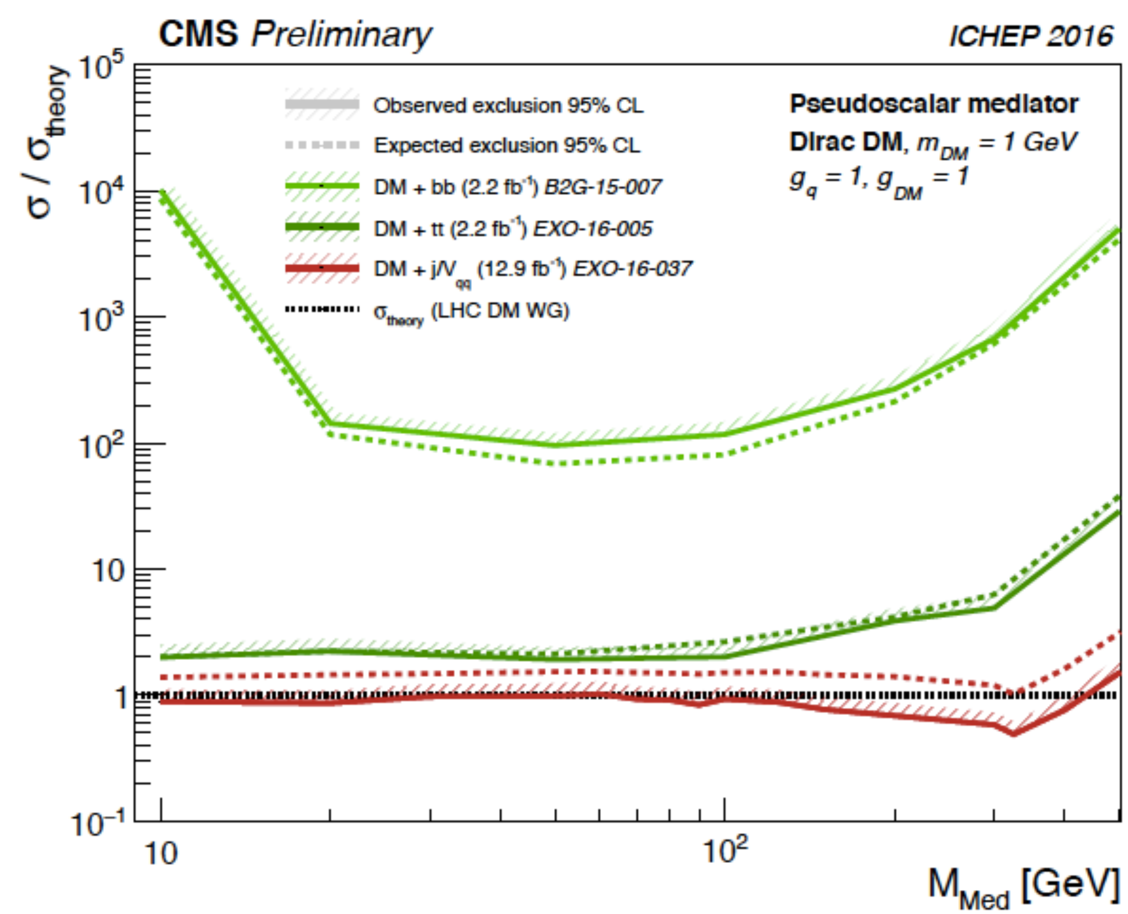
Assume that the collider production of DM particles proceeds via a mediator with couplings to the SM

If the new physics associated with DM satisfies minimal flavour violation (the interaction between the mediator and quarks has the Yukawa structure) **the most relevant DM production mechanism at the LHC involves couplings between spin-0 mediators and top quarks**



Current status (EXO-16-005)





DM + tt (hadronic + semileptonic) more sensitive for DM mass below 100 GeV

DM + j/V$_{qq}$ more sensitive for mediator mass above 100 GeV

Current status (EXO-16-028)

CMS published DM + tt (dileptonic) with 2.2 fb^{-1} of (2015) data

Signal extraction performed using the MET shape after sequential cuts

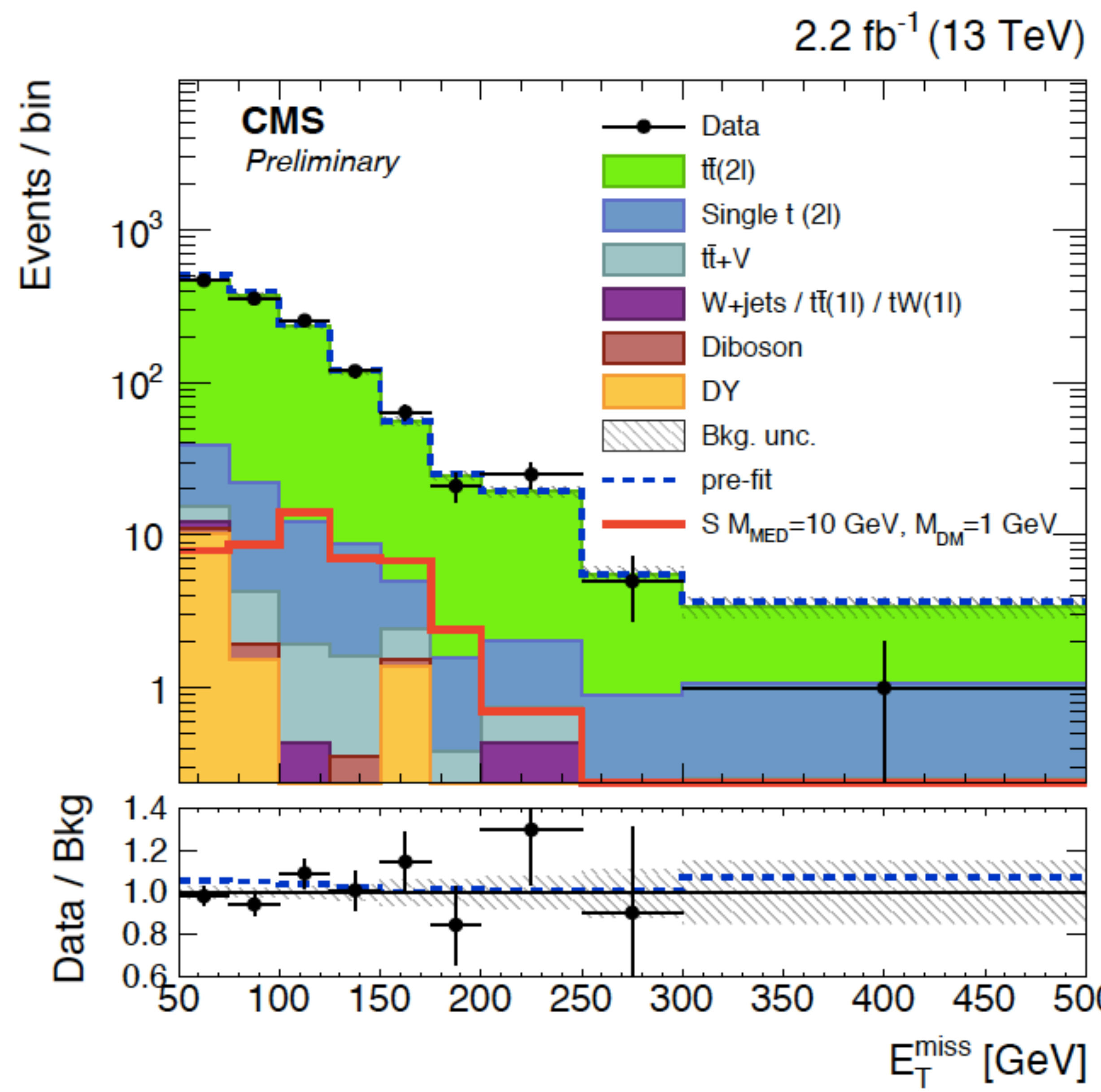
Compared with hadronic and semileptonic, **the dileptonic channel (ee, eμ and μμ) has competitive limits for scalar mediator mass below 20 GeV**

It also improves the exclusion limit from 33 to 42 GeV on the scalar mediator mass ($g_q = g_{DM} = 1$ and $m_{DM} = 1$ GeV)

In addition, there is a 5% improvement on the hadronic+semileptonic results by **further constraining the uncertainties on jet energy scale and QCD renormalisation and factorisation scales for the (dominant) tt background**

How do the backgrounds look like?

Process	ee
$t\bar{t}(2\ell)$	1221.5 ± 108.3
Single t (2ℓ)	64.4 ± 13.2
$t\bar{t}$+V	10.1 ± 1.6
$W+\text{jets}/t\bar{t}(1\ell)/tW(1\ell)$	1.8 ± 3.1
Diboson	2.13 ± 0.55
DY	8.4 ± 12.1
S $M_{\text{MED}} = 10$ GeV, $M_{\text{DM}} = 1$ GeV (pre-fit)	47.7 ± 10.0
SM expected (pre-fit)	1372.1 ± 9.5
SM expected (post-fit)	1308.2 ± 109.8
Data	1312



Current work

The analysis requires two tight (good quality and from the PV) leptons, both with *pt* above 20 GeV (or more if needed by trigger constraints)

To enhance the tt flavor of the sample, we require **at least two 30 GeV jets, with one of them b-tagged**. As usual, the Z peak is removed and events with MET < 80 GeV are discarded

We are using the full 2016 luminosity. This means 36 fb^{-1} in the control regions and a subset (1 every 15 events) in the signal regions

How to improve things?

We should extract as much information as possible from the event kinematics. Being tt the dominant background, we perform top reconstruction

The top reconstruction should work well for events with b-quarks, jets and neutrinos, and perform worse when there are DM particles in the event

We combine the top reconstruction with discriminating variables such as M_{T2}, MET and Δϕ(MET,leptons), to **build a Multi Variate Analysis (MVA) for the different mediator (scalar, pseudoscalar) and DM masses**

In addition, we are also working on improving the background description / control regions