Search for Dark Matter with the CMS Experiment

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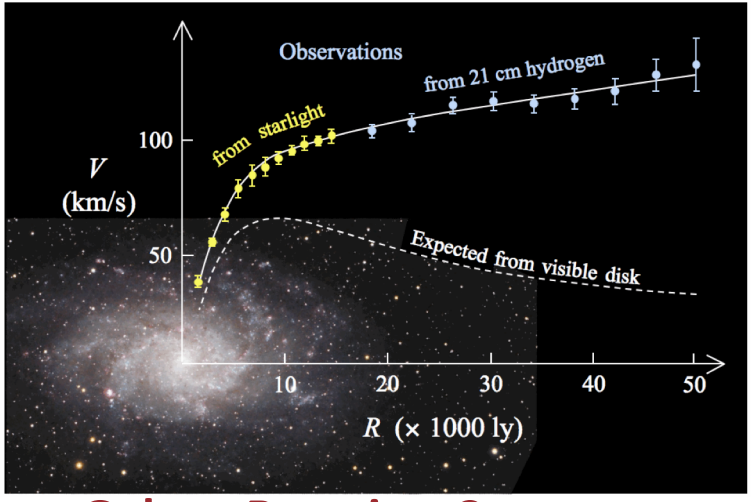
SPRACE

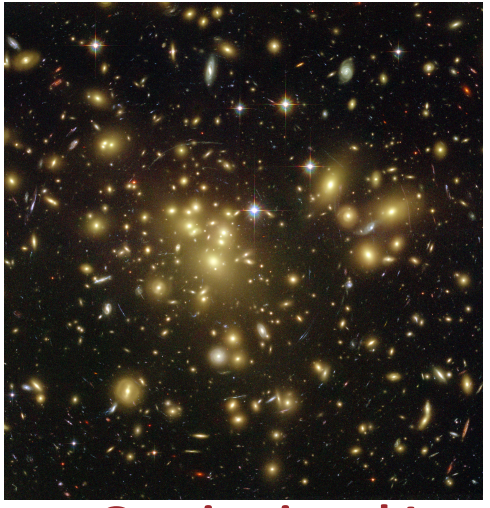
“We propose to build a general purpose detector designed to run at the highest luminosity at the LHC. The CMS (Compact Muon Solenoid) detector has been optimized for the search of the SM Higgs boson over a mass range from 90 GeV to 1 TeV, but it also allows detection of a wide range of possible signatures from alternative electro-weak symmetry breaking mechanisms.”

Abstract of the CMS Letter of Intent, submitted to the LHC Experiments Committee (LHCC) on 1 October 1992

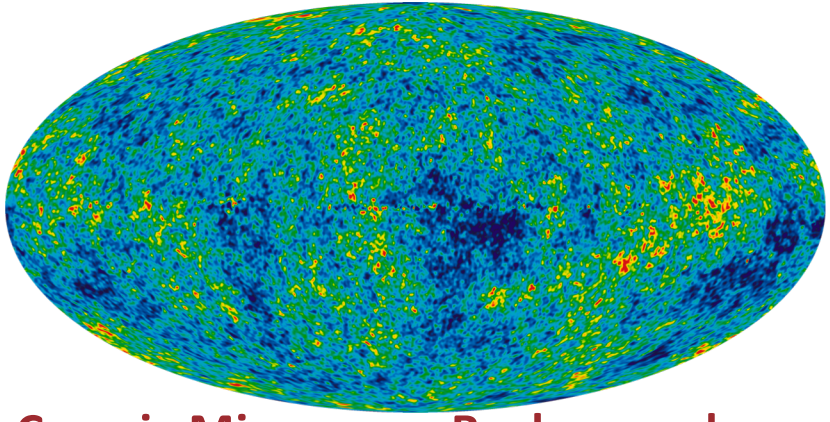
Dark Matter



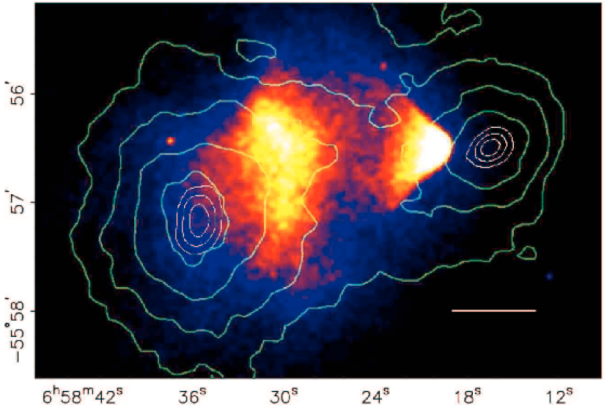
Galaxy Rotation Curves



Strong Gravitational Lensing

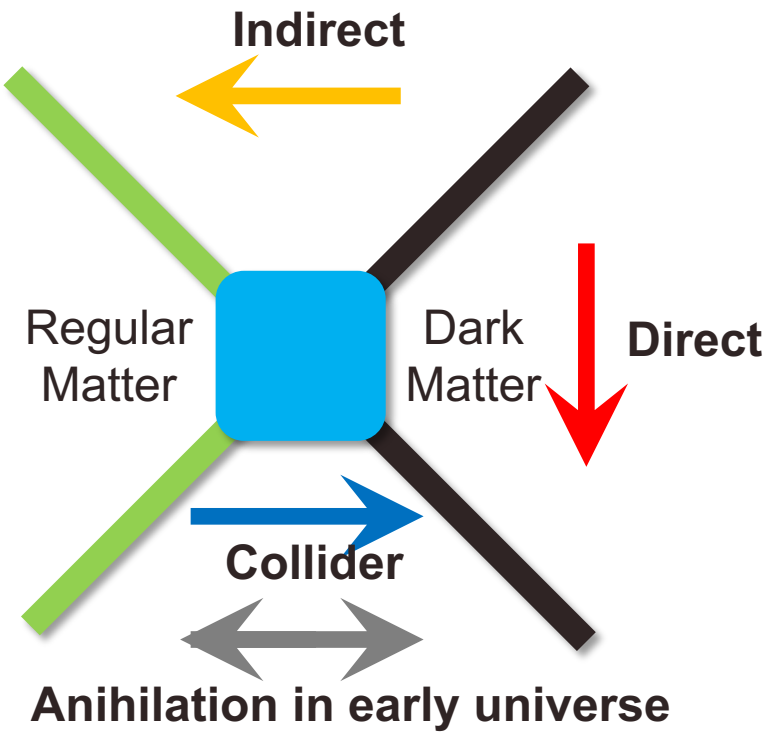


Cosmic Microwave Background



Bullet Cluster

Strategies to Search for Dark Matter



Direct detection

- ❑ DM-nucleus scattering

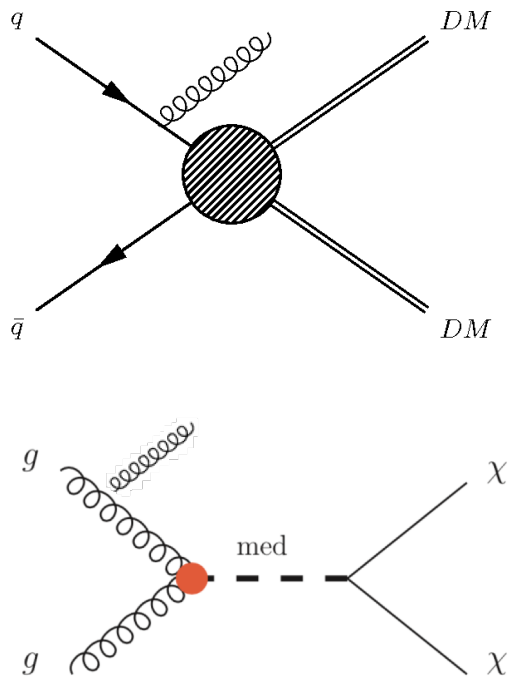
Indirect detection

- ❑ DM Annihilation products

Collider production

- ❑ Production of DM at the lab (e.g. LHC)
  - Clear strategy for WIMP
  - Sensitive to a large DM mass range

Modeling Dark Matter Production at the LHC



Model-independent search

- Contact Interaction
  - Limited at LHC energies
- Simplified Models
  - DM: pair-produced Dirac fermion
  - Mediator: (vector or scalar), NWA
  - Minimal flavor violation
  - Parameters:
    - Coupling structure, M_{med}, M_{DM}, g_{sm}, g_{DM}

Benchmark model search

- SUSY
- Inert Two-Higgs Doublets Model

Sprace Dark Matter Activities

SPRACE Collaborations (SPRINT)

- Southampton
  - Phenomenology interplay
  - i2HDM phenomenology paper
- Texas Tech
  - Experimental analysis
  - Collaboration with monojet group
  - Collaboration with Fermilab (LPC)

Search in monojet channel

- Most promising channel Very competitive

Run II Data

- Monojet Analysis
  - Journal of High Energy Physics 07, 014 (2017)
  - Phys. Rev. D 97, 092005 (2018)

Monojet Search – 2016 data

Phys. Rev. D 97, 092005 (2018)

Main backgrounds

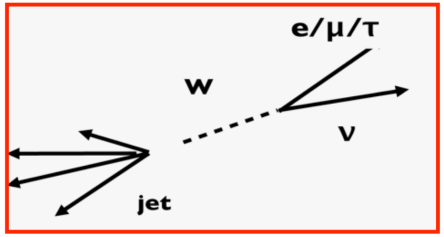
- W → $\ell\nu$ + jets (missing lepton)
- Z → $\nu\nu$ + jets

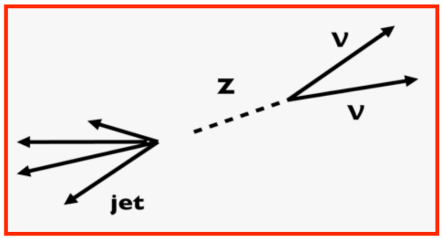
Subdominant backgrounds

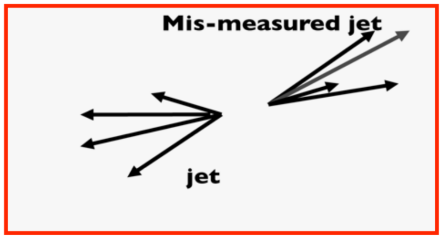
- QCD multijets
- Top quark, SM dibosons

Estimation

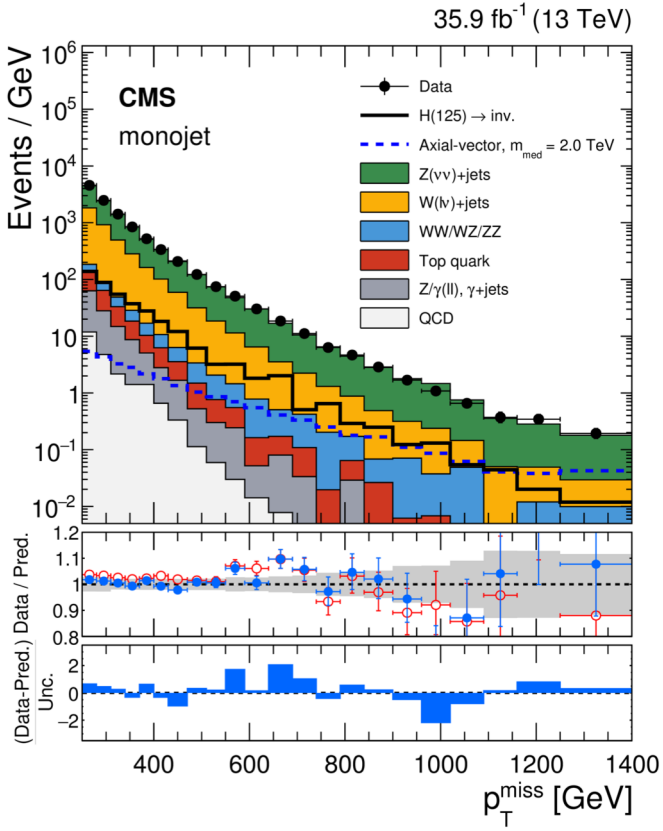
- Bosons: control regions + transfer factors
  - W / Z / gamma symmetry from SM
  - Binned likelihood simultaneous fit
- Multijet: $\Delta\phi$ extrapolation method
- Top, SM dibosons: simulation

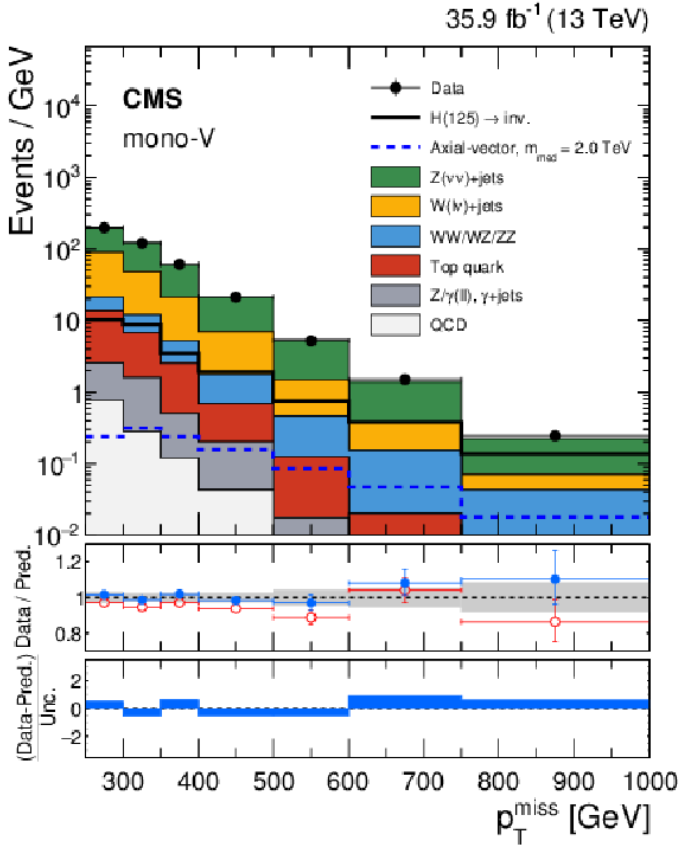






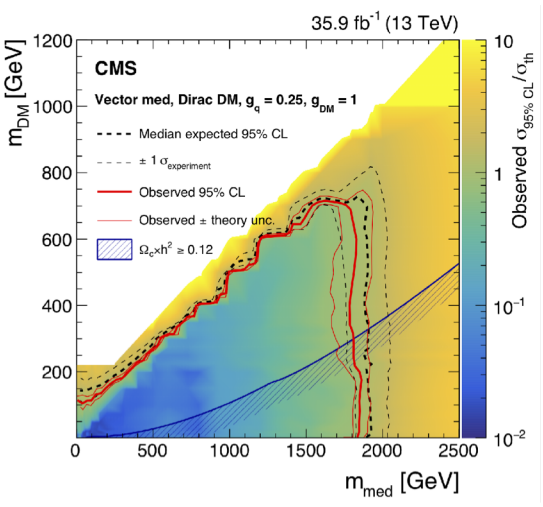
DM Search in CMS – Data/Background

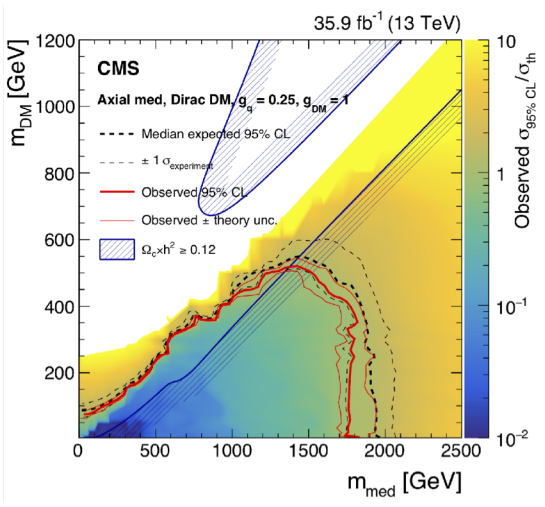


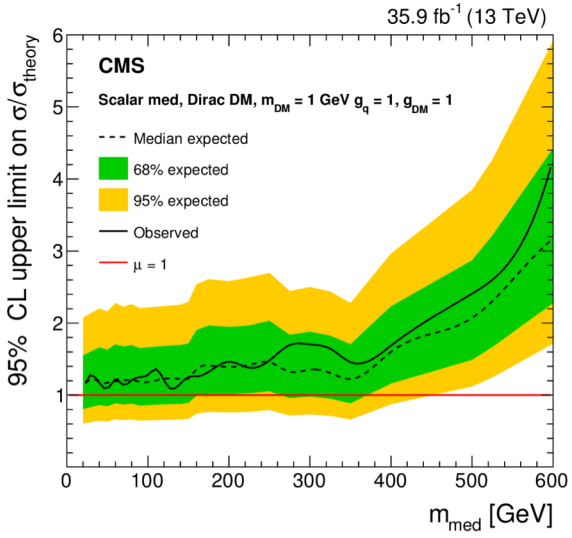


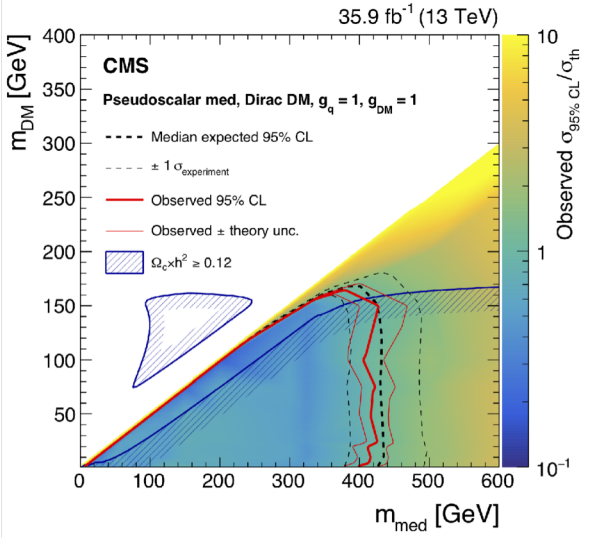
Simplified Model

Results for vector, axial, scalar and pseudo scalar mediator



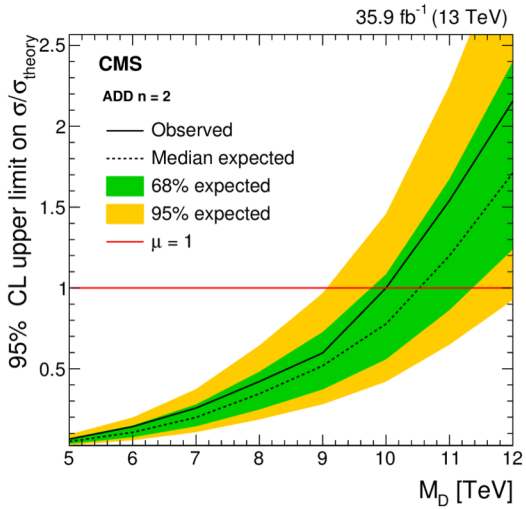


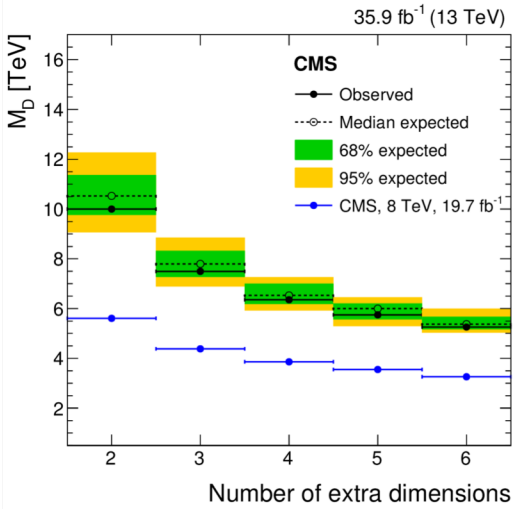


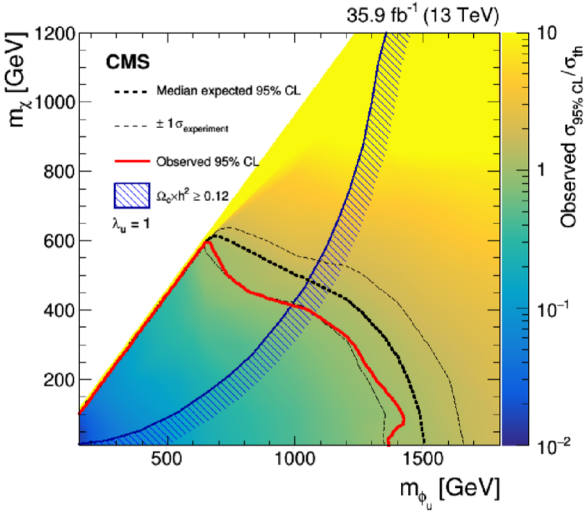


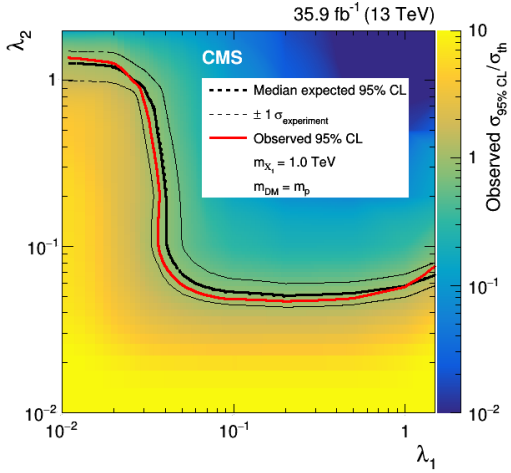
Alternative Models

Results for LED, Fermion Portal and non-thermal DM









Summary and Perspective

SPRACE group has large experience on searching for Beyond Standard model physics

Focus on search for Dark Matter

Contribution with Texas Tech/LPC Fermilab

Monojet channel

- Reach channel to look for Missing E_T signature
- Monojet
  - Include different types of jet