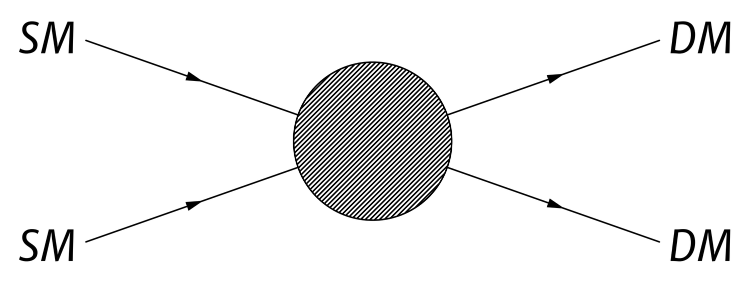
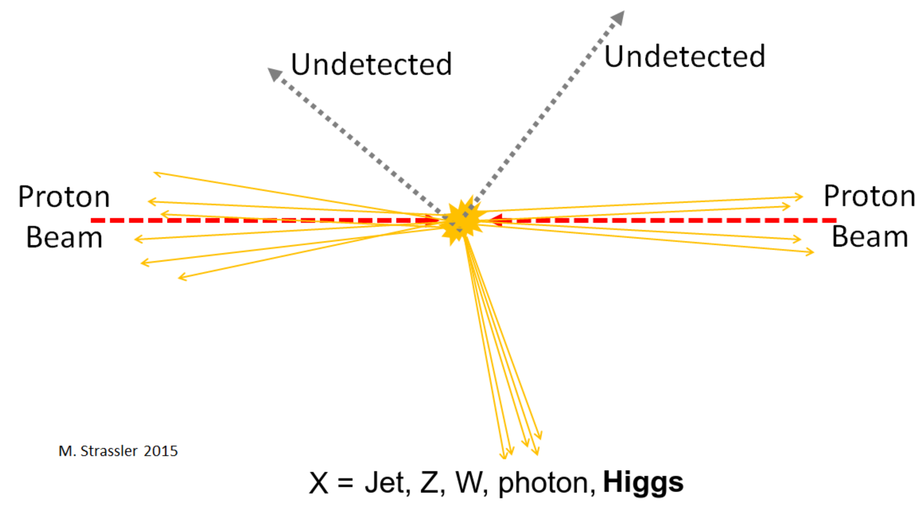
Search for Mono-Higgs at LHC with the CMS detector

Poster 277: Jónatan Piedra Gómez for **Nicolò Trevisani** (IFCA – CSIC – UC) on behalf of the CMS collaboration

Searching Dark Matter at LHC

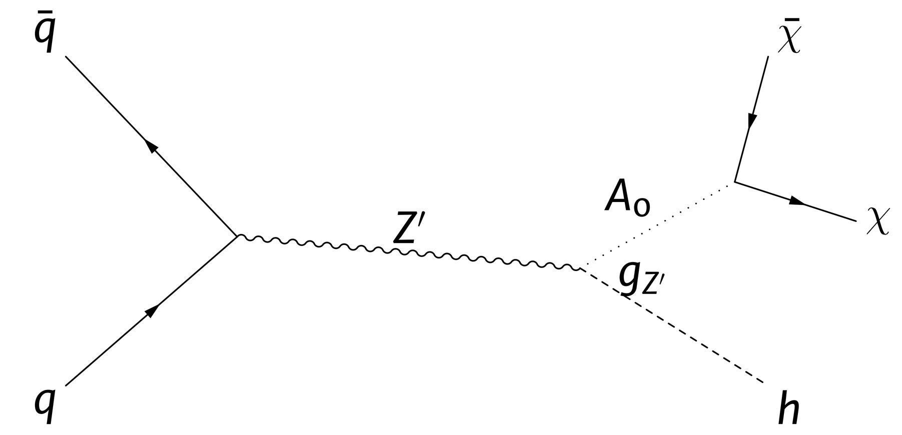
- Dark Matter particle nature is unknown and cannot be explained within Standard Model
- At a hadron collider have to assume interaction between Standard Model and Dark Matter candidate particles
- Main candidate: **Weakly Interacting Massive Particle**
- Final state with two Dark Matter particles and SM particle(s)
  - Missing Transverse Momentum (**p_T^{miss}**) + **X** signatures
  - In this case **X is a Higgs boson**





Mono-Higgs Physics Model

- The search exploits 2.3 fb^{-1} Data collected during 2015 by the CMS detector
- The benchmark model inspected and its parameters have been chosen following **LHC DM Working Group** recommendations **[http://cern.ch/go/8MQC]**
  - **Z'-2HDM**: A vector boson mediator Z' decays into a Higgs boson and a pseudoscalar A_0
  - The A_0 then decays into two dark matter particles
- Two **Higgs decay channels** investigated **[arXiv:1703.05236]**
  - $h \to bb$: higher branching ratio, lower m_h resolution
  - $h \to \gamma\gamma$: lower branching ratio, higher m_h resolution



h→ bb Analysis Strategy

Two categories to enhance the sensitivity of the analysis

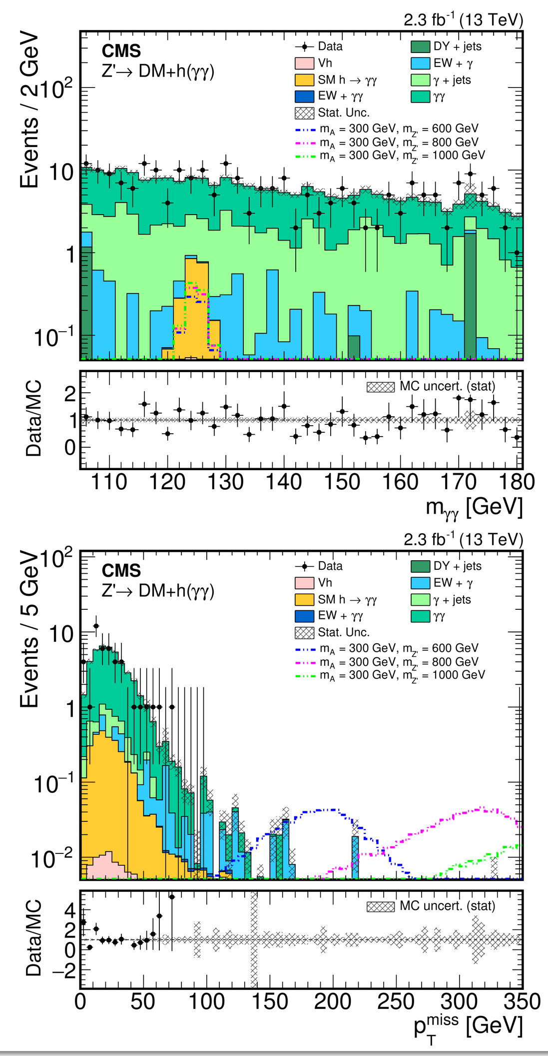
Resolved (low Higgs boost)	Merged (high Higgs boost)
Two b-tagged AK4 jets with p_T > 30 GeV	One AK8 jet with p_T > 200 GeV with two b-tagged sub-jets
E_T^{miss} > 170 GeV	E_T^{miss} > 200 GeV

- **Multi-jet** rejection
  - $\Delta\phi(AK4_{jet}, \vec{p}_T^{miss}) > 0.4$
  - $\Delta\phi(\vec{p}_T^{miss}, \vec{p}_{T,trk}^{miss}) < 0.7$
- **Semi-leptonic top** and **W + jet** rejection
  - Lepton (e, μ, τ) veto
  - No additional b-jets
  - No more than 1 additional AK4 jets

Main backgrounds ($Z \to \nu\nu$ + jets, Top, W + jets) normalized in **control regions**

h→ γγ Analysis Strategy

- Reduce **jets faking photons** contribution
  - Low $\frac{E_{HCAL}}{E_{ECAL}}$
  - Isolation requirements applied
- Avoid **$m_{\gamma\gamma}$ spectrum distortion**
  - $\frac{p_T^{\gamma 1}}{m_{\gamma\gamma}} > 0.5$ and $\frac{p_T^{\gamma 2}}{m_{\gamma\gamma}} > 0.25$
- Reject **Mis-measured p_T^{miss}** events
  - $|\Delta\phi(\gamma\gamma, \vec{p}_T^{miss})| > 2.1$
  - $|\Delta\phi(jet, \vec{p}_T^{miss})| > 0.5$ for every jet with p_T > 50 GeV
- Reduce **EW background**
  - Veto events with muons or more than 1 electron
- Select events with a Higgs boson **recoling against $\vec{p}_T^{miss}$**
  - p_T^{miss} > 105 GeV
  - $p_T^{\gamma\gamma}$ > 90 GeV

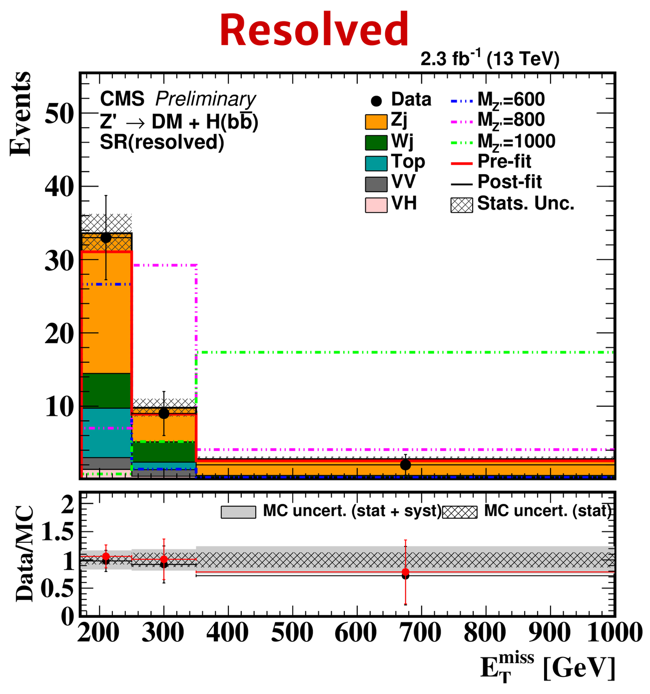


h→ bb Signal Extraction

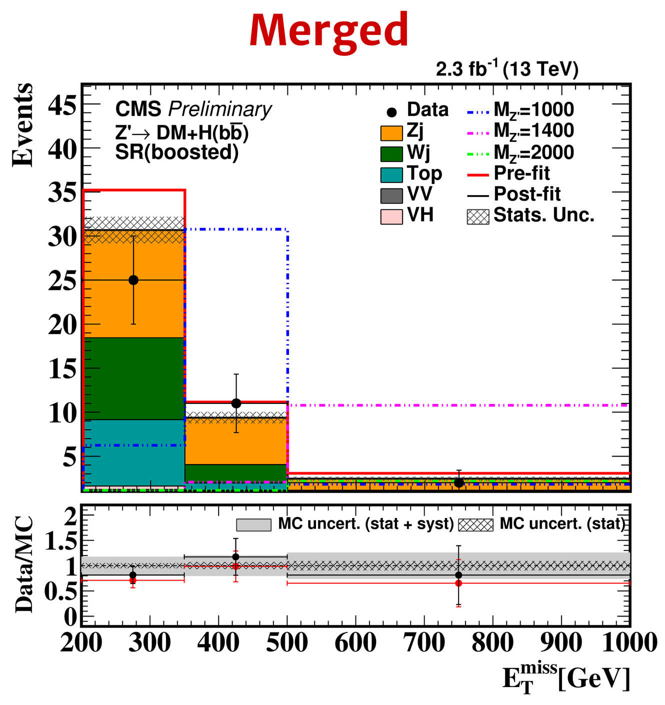
The signal is extracted with a **simultaneous fit of the signal region and the control regions**

- 100 GeV < m_h < 150 GeV
- Fit is performed on a three-bin p_T^{miss} histogram

Resolved



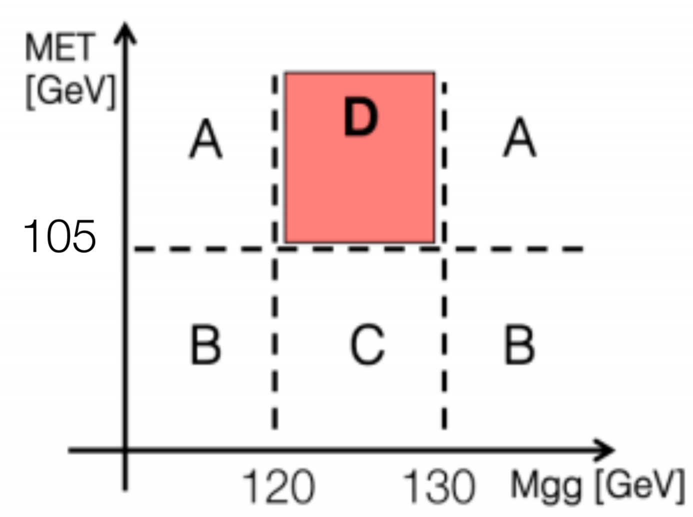
Merged

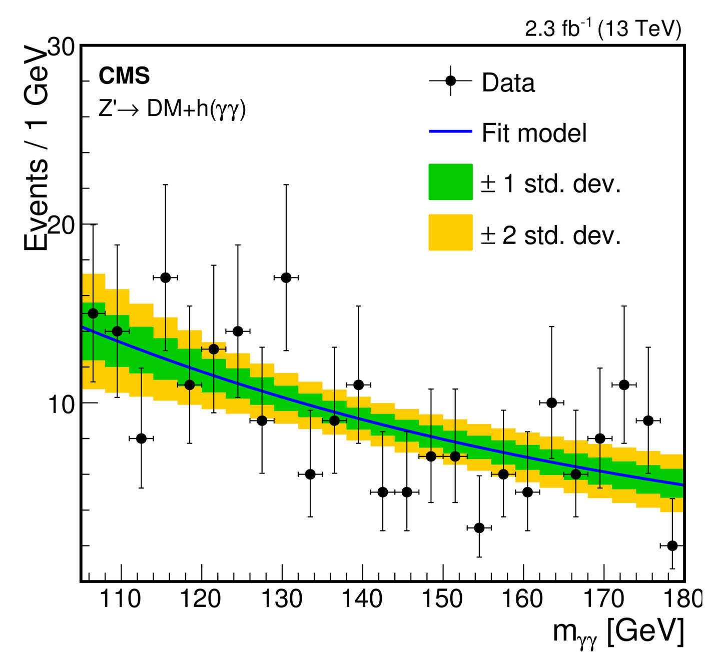


h→ γγ Signal Extraction

The signal is extracted by **counting the events in the Singal Region**

- **SM Higgs** contamination is taken from simulations
- **Non-resonant background** contribution in SR is estimated from Data
  - Transfer factor $\alpha = N_C / N_B = N_D / N_A$ is **extracted in low p_T^{miss}** region
  - And then **applied in high p_T^{miss}** region: $N_D = \alpha \cdot N_A$





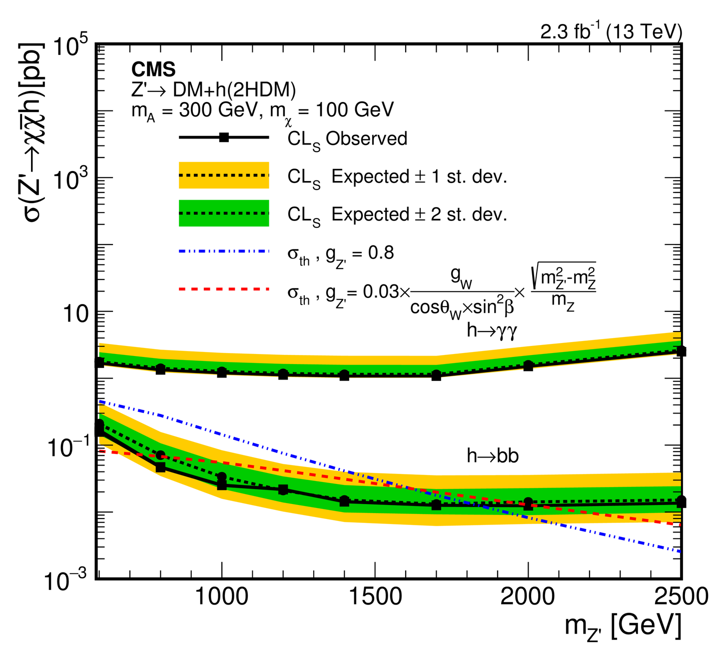
Systematic Uncertainties

- The main uncertainties affecting the **$h \to bb$ fit**
  - Jet energy scale
  - b-tagging (6%)
  - $Z \to \nu\nu$ + jets and W + jets simulated samples statistics
- The background contamination estimation of the **$h \to \gamma\gamma$** signal region is mainly **statistical dominated (70%)**
  - Transfer factor estimation (20%)
  - Signal region side-bands population
  - Another important source of uncertainty is the imperfect knowledge of the background $m_{\gamma\gamma}$ shape (20%)
- In the **combination** of the two analyses all **signal** and **p_T^{miss}**-related uncertainties as well as the **luminosity** uncertainty are assumed to be fully correlated

Combination

- Result intepreted in terms of **upper limits on the DM production** cross section via **Z'-2HDM** model since no excess wrt SM predictions observed
- Mass scan: $m_{Z'}$ = (600 GeV - 2500 GeV), m_{A0} = (300 GeV - 800 GeV)
- Two Z'-A_0-h coupling constant $g_{Z'}$ values studied

h→bb and h→ γγ for m_{A0} = 300 GeV



Full Combination Results