Bundesministerium
für Bildung
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RWTH AACHEN UNIVERSITY

Search for neutral MSSM Higgs bosons decaying into two muons with CMS

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on behalf of the
CMS Collaboration

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Higgs Hunting

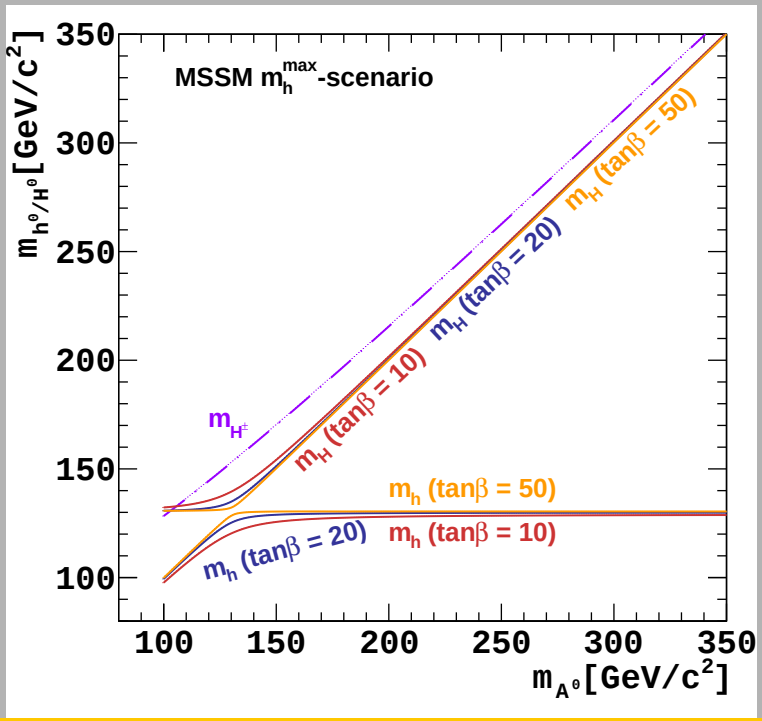
Orsay 2012

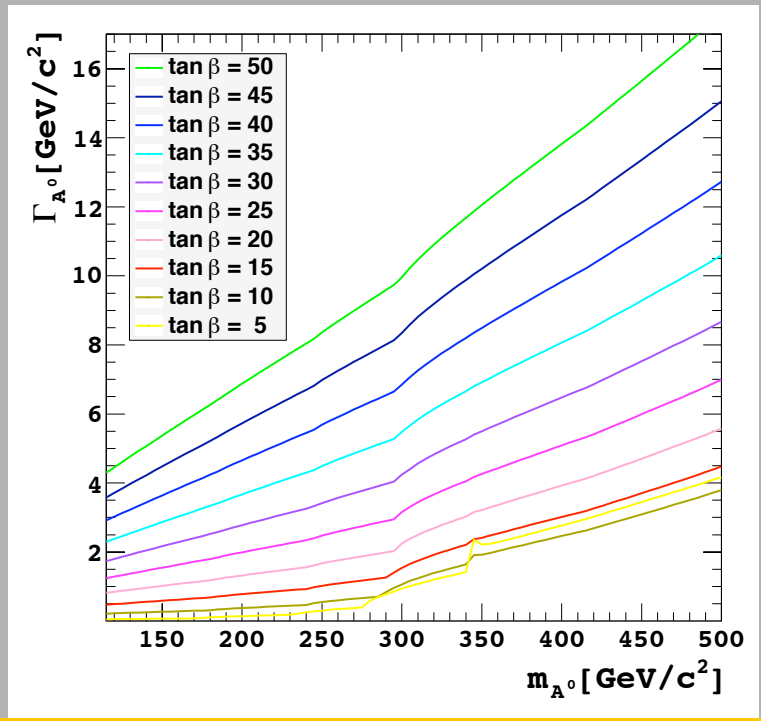
motivation

Why muons?

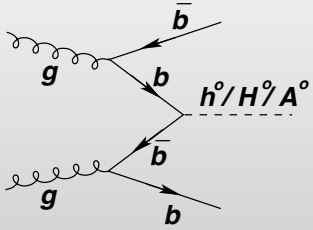
- $\varphi \rightarrow b\bar{b} \approx 90\%$ dominant for small m_A but hard to reconstruct due to the 4 b-jets in the final state
- $\varphi \rightarrow \tau^+\tau- \approx 9\%$ but the recontruction of m_A and Γ_A is very difficult
- $\varphi \rightarrow \mu^+\mu^- \approx 0.03\%$ is small, but it gives a clean signature in the detector and gives the opportunity to reconstruct m_A and Γ_A and through that $\tan\beta$

MSSM Higgs bosons masses and decay width

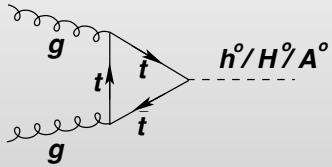




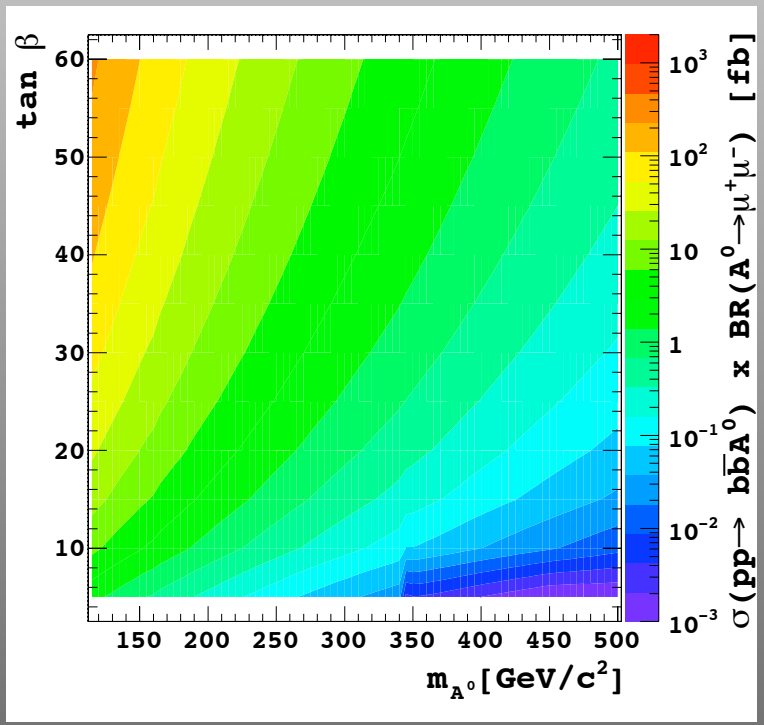
production LHC

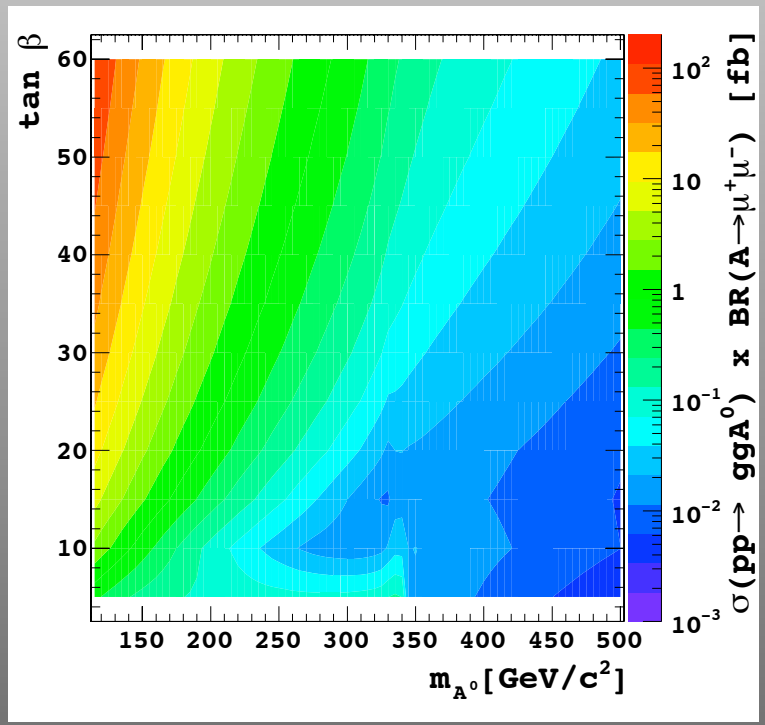


associated production
(dominant for high $tan\beta$)



gluon fusion

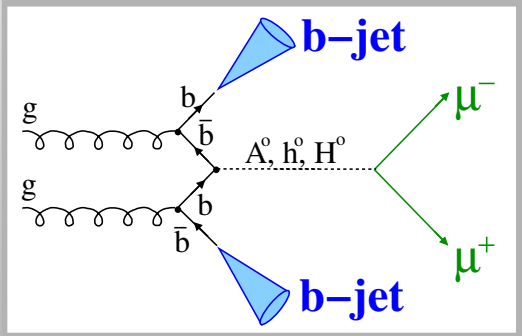




branching ratio drops for low tan β when decay into $t\bar{t}$ becomes available

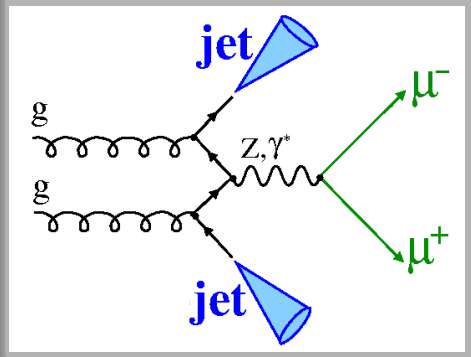
signal & backgrounds

signal



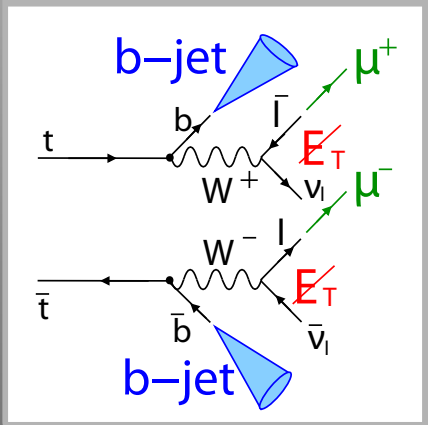
- two isolated muons with high p_T
- two b-jets with relativly low p_T
- low missing transverse energy $\not{E}_T$

Drell-Yan $Z/\gamma^* \rightarrow \mu\mu$



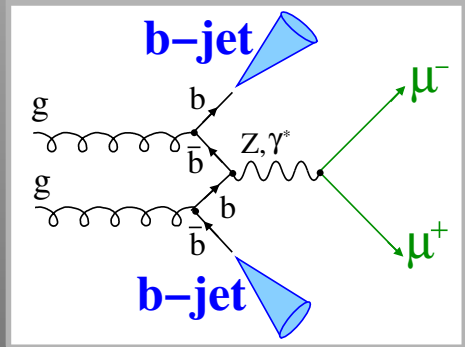
- no b-jets
- low $\not{E}_T$

top quark pairs



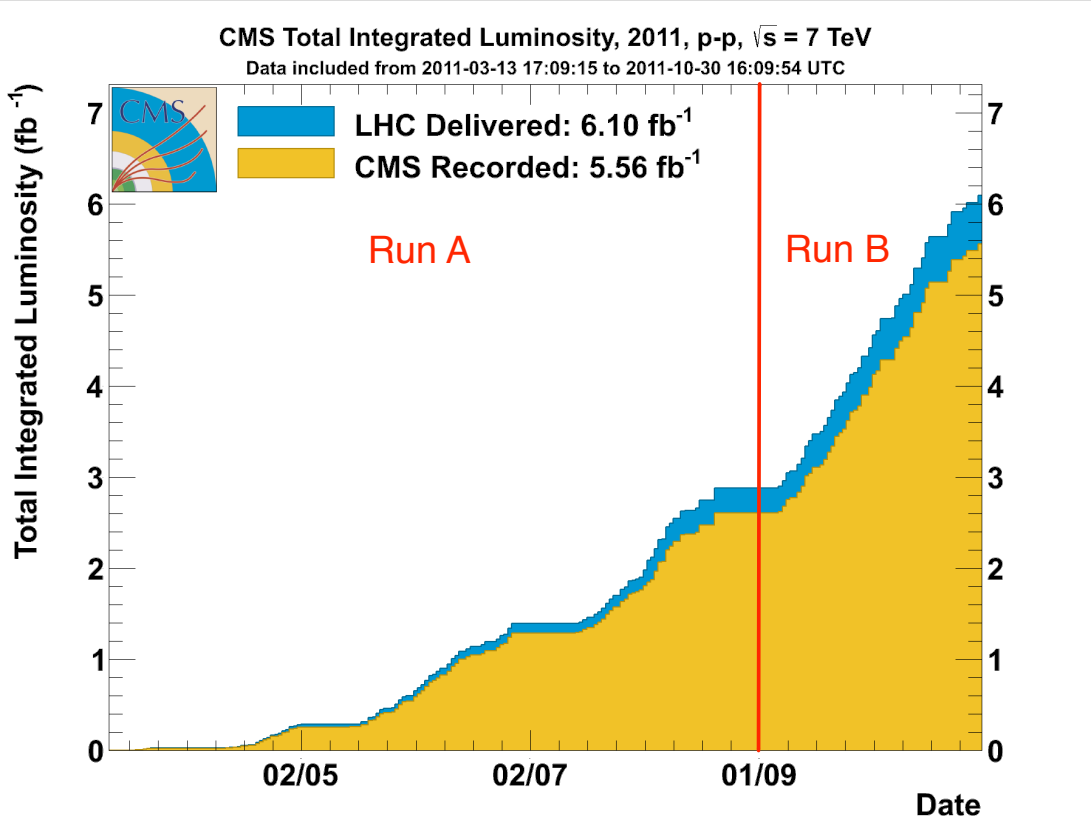
- non-isolated muons with low p_T
- high $\not{E}_T$ due to the neutrinos from the $W^{\pm}$-decay

$bbZ/\gamma^* \rightarrow \mu\mu$



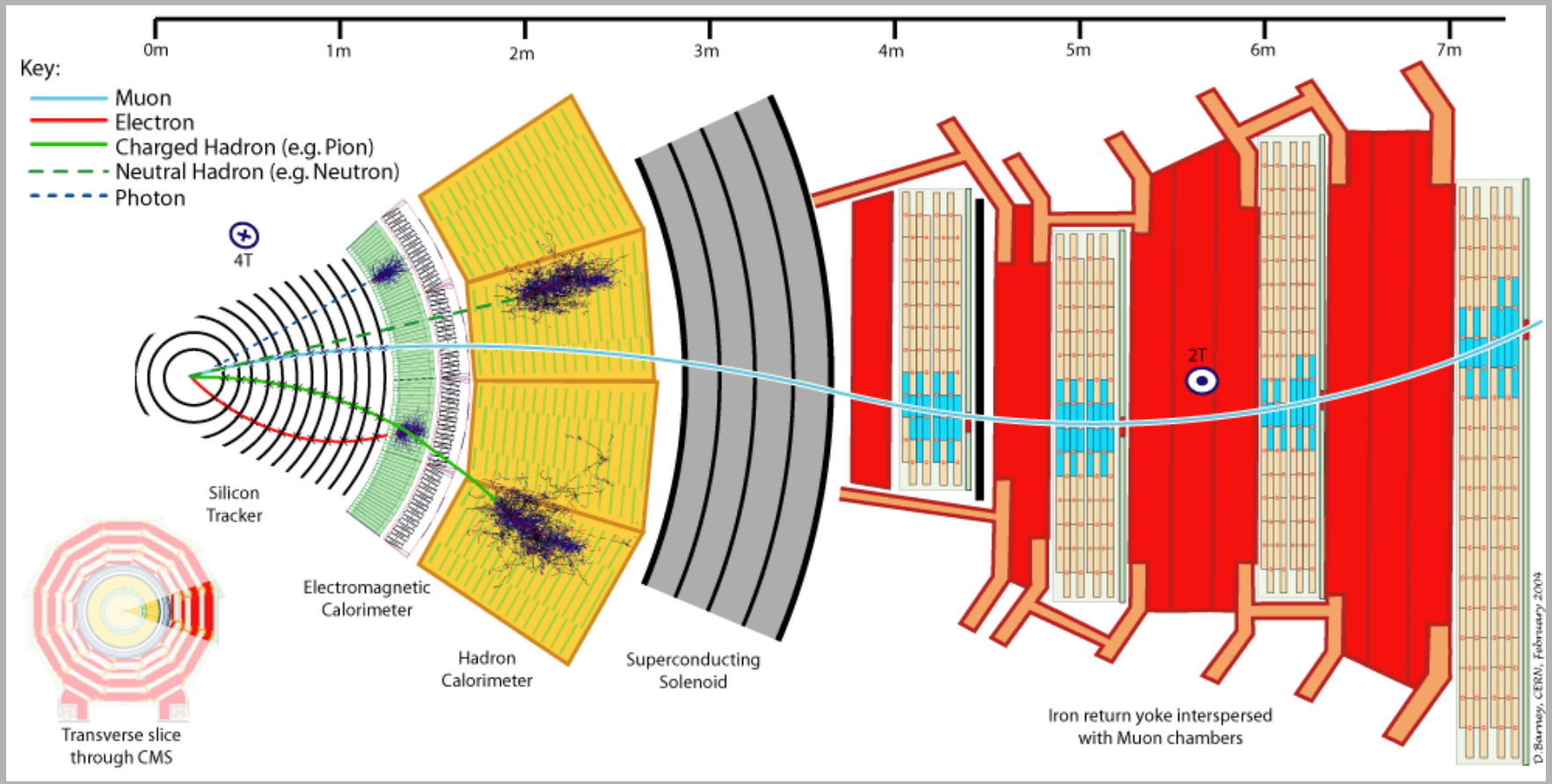
- same event topology as the signal
- two isolated muons
- two b-jets
- low $\not{E}_T$

LHC Run 2011 A & B



- 5.56 fb^{-1} recorded through 2011
- 4.96 fb^{-1} certified and used for this analysis
- data is splitted into two runs (A & B) with different pile-up scenario
- corrections on MC concerning the pile-up are applied

Compact Muon Solenoid



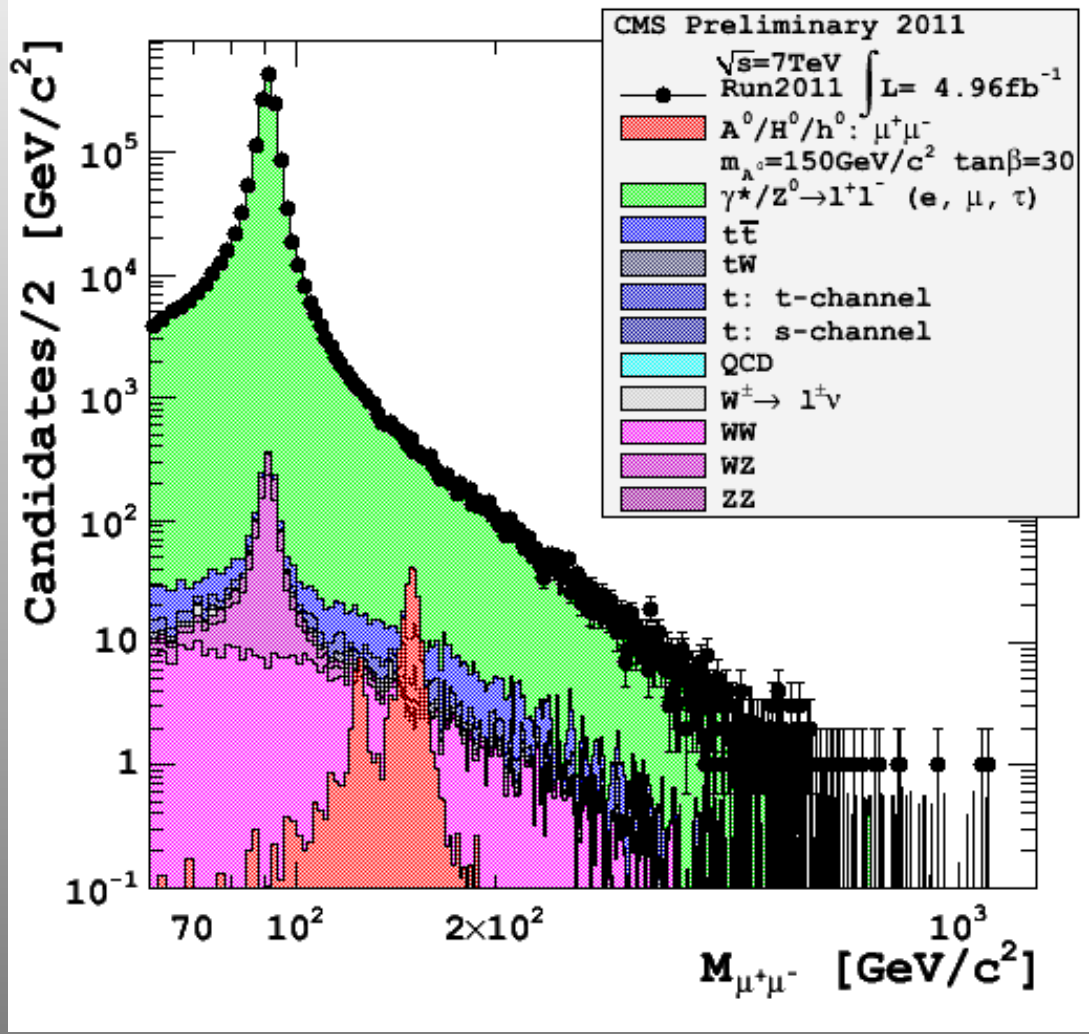
event selection

pre-selection:

- basic muon selection
  - $p_{T\mu 1} > 30\ GeV$ & $p_{T\mu 2} > 20\ GeV$
    (asymmetric due to trigger thresholds)
  - $|\eta_\mu| < 2.1$
  - isolation
- $\not{E}_T < 30\ GeV$

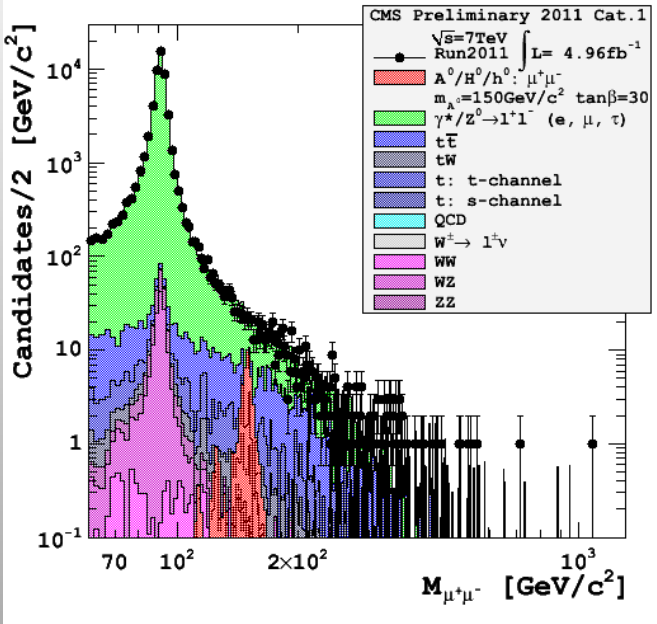
event categories:

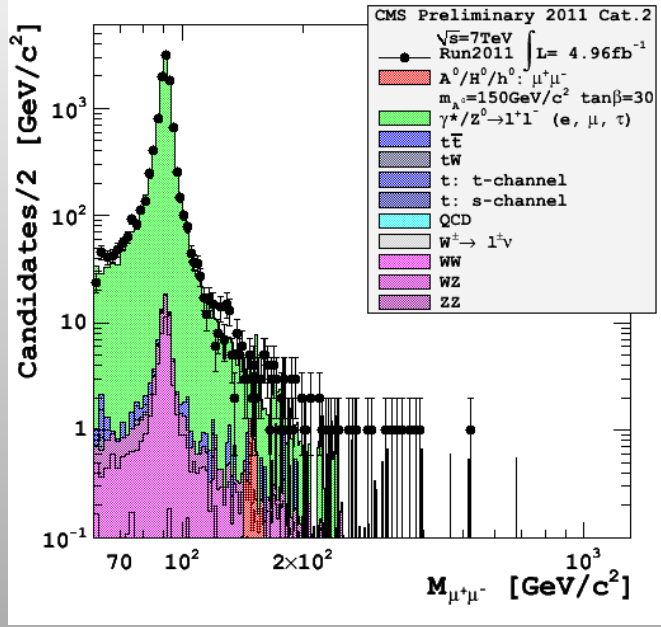
- 1 tagged b-jet
  - $p_T^{Jet} > 20\ GeV$
  - $|\eta_{Jet}| < 2.4$
  - loose b-tag ID
- 1 additional muon
  - $p_T^{\mu} > 3\ GeV$
  - $|\eta_{Jet}| < 2.4$
  - separation to other muons
- everything else

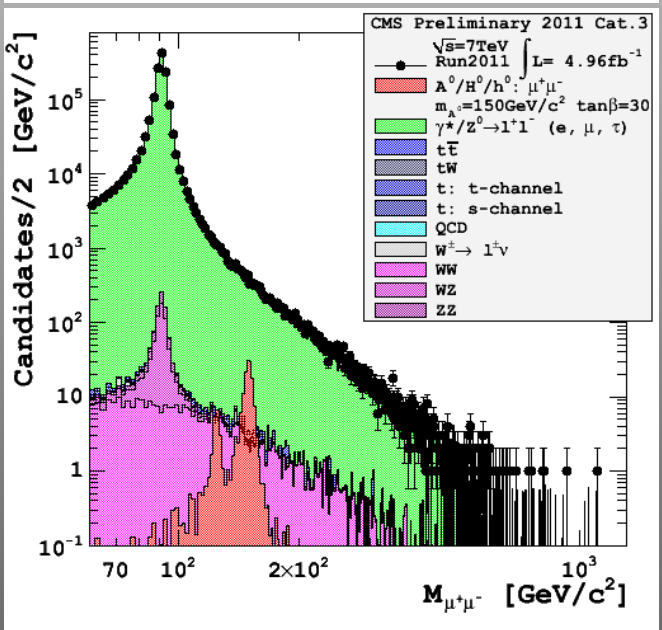


invariant di-muon mass
after pre-selection

categories

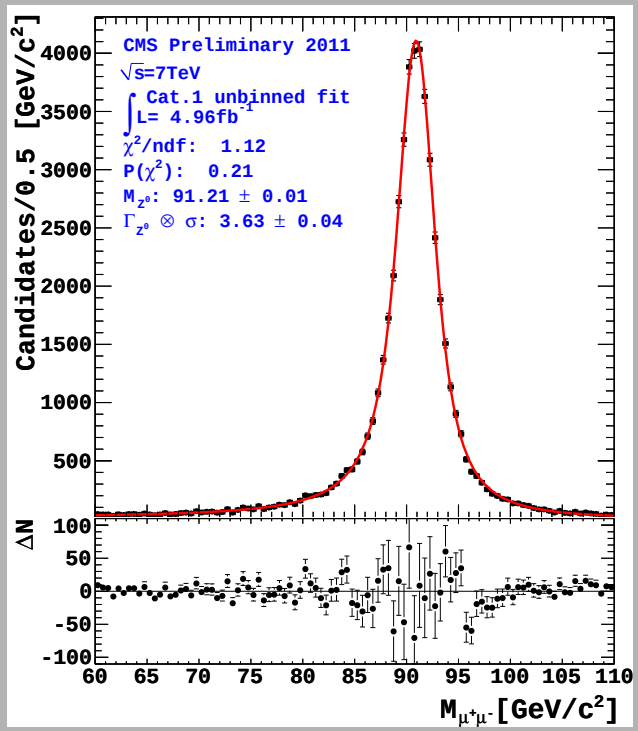


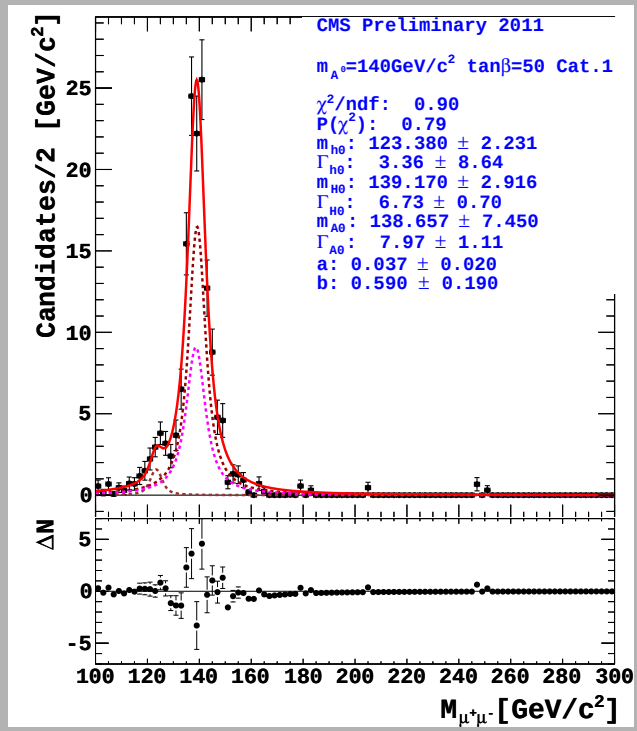




- category 1 has best signal to background ratio
- category 3 has highest statistics
- category 1 and 3 have highest sensitivity
- category 2 has low sensitivity, but serves as verification if a signal appears in category 1 or 3

background estimation from data

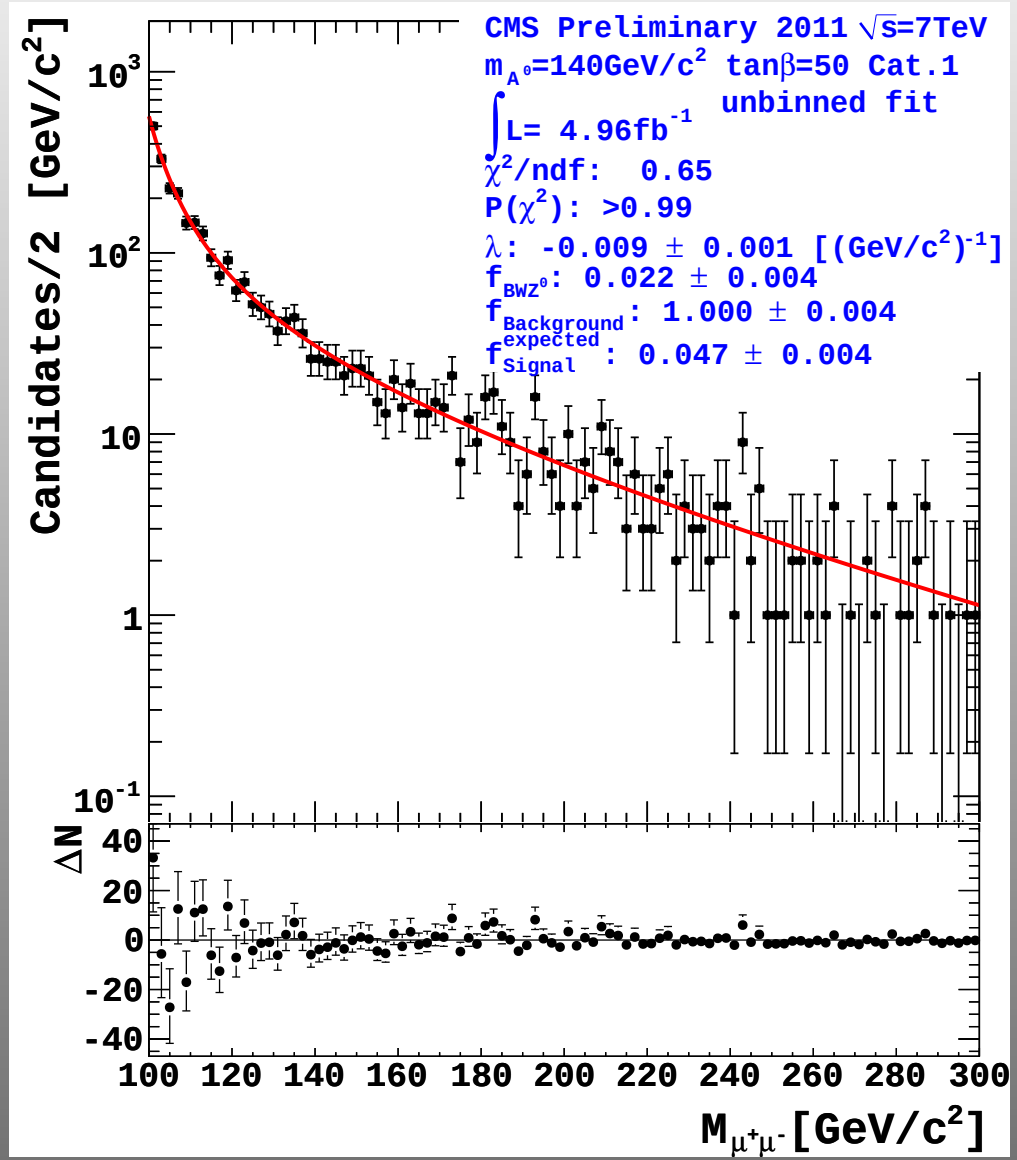




- background model: linear combination of
  - Breit-Wigner at the Z peak
  - photon propagator contribution
  - both multiplied with a falling exponential for the pdf contribution
  - Z parameters fixed from fit to data with crystal ball (outside of signal region)
- signal model:
  - linear combination of three Breit-Wigner peaks, convoluted with a common detector resolution
  - signal parameters fixed by a fit to simulation

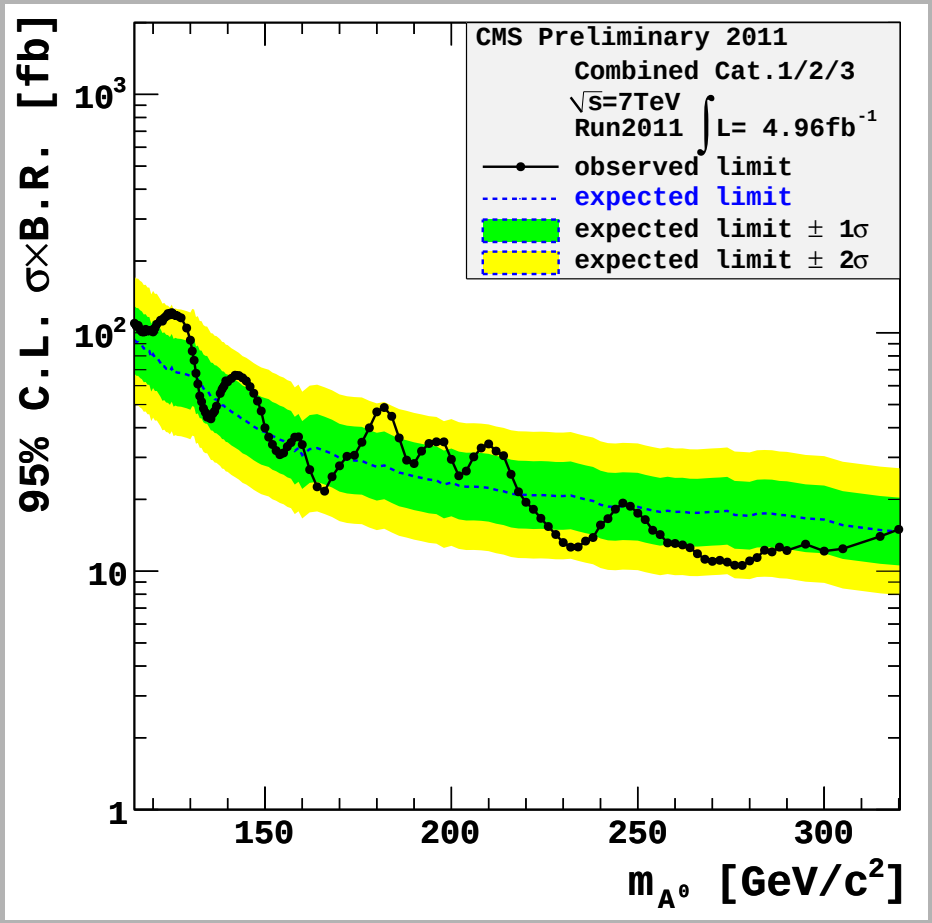
background estimation from data

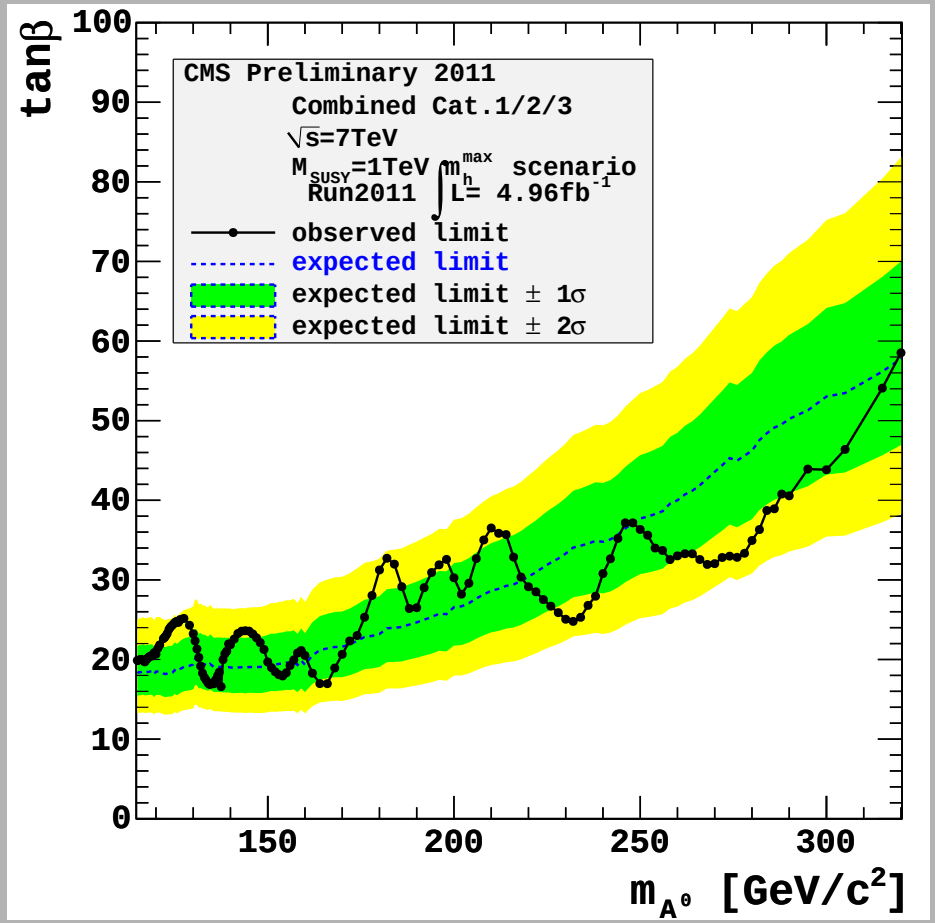
- fit of $s + b$ hypothesis to data
- signal strength as free parameter
- signal and background shapes used in limit calculation:
  - signal shape from fit to simulation
  - background shape from fit to data
- confidence level scanned in $m_A - \tan\beta$ plane
- limits calculated with signal samples closest to 95% C.L. in the scan



limit calculation

Combination





biggest contribution to the combination from categories 1 & 3

conclusions & outlook

conclusions

- $m_A = 110 - 180\ GeV$ excluded at $\tan\beta = 30$
- single mass points with $\tan\beta = 15$ can be excluded
- overall good agreement with expectations
- no significant excess ($> 2\ \sigma$) observed
- expectations for 60 fb^{-1} @ 14 TeV from TDR exceeded with only 5 fb^{-1} @ 7 TeV

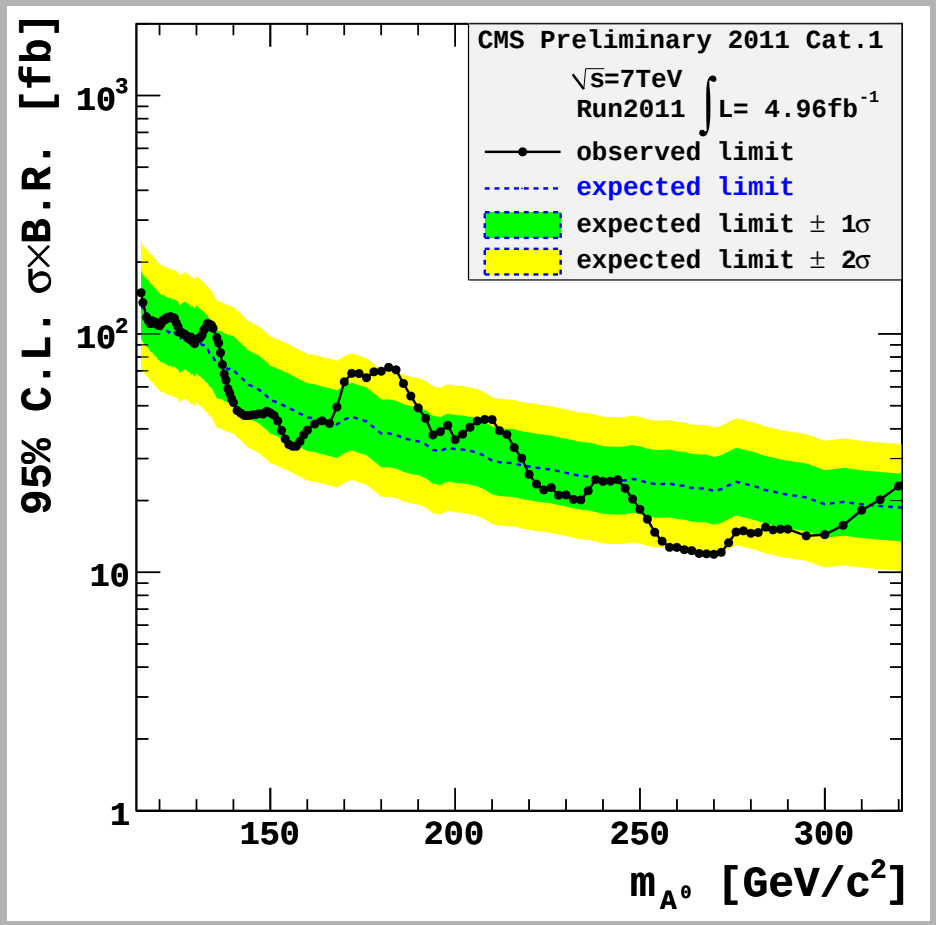
outlook

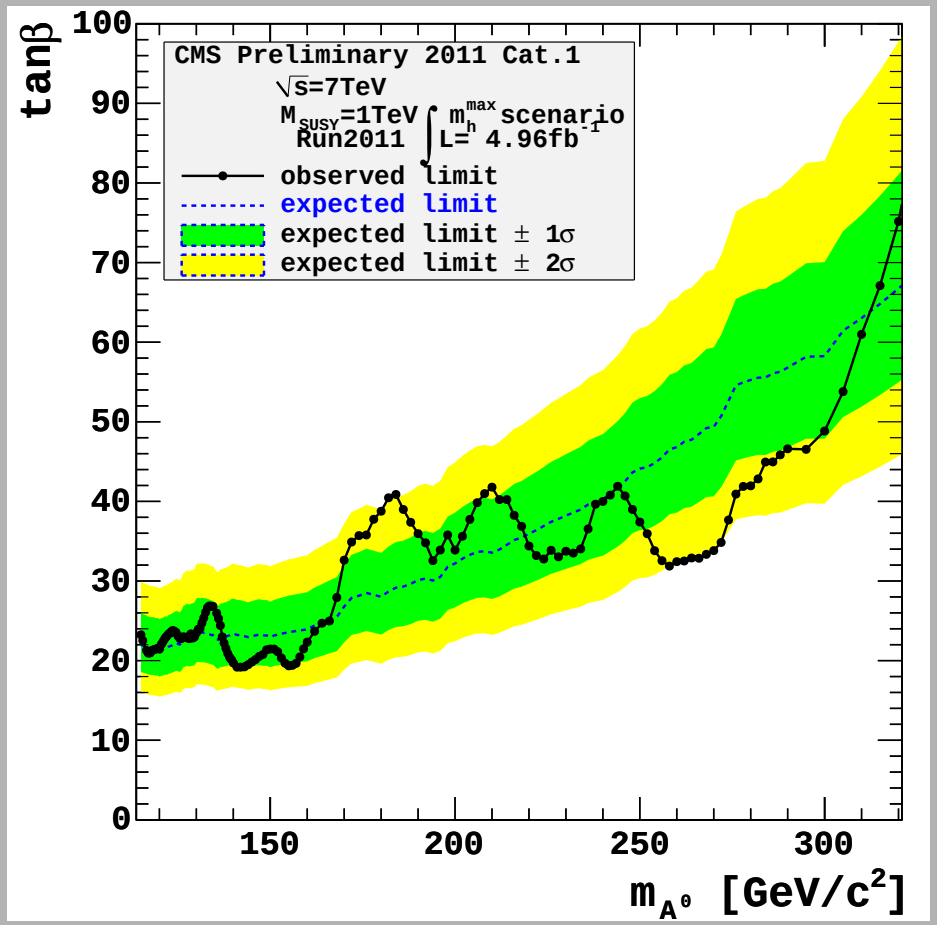
- update to $\sqrt{s} = 8\ TeV$
- contribution to the final limit combination for CMS

Backup

limit calculation

Category 1 (b-tagged jet)

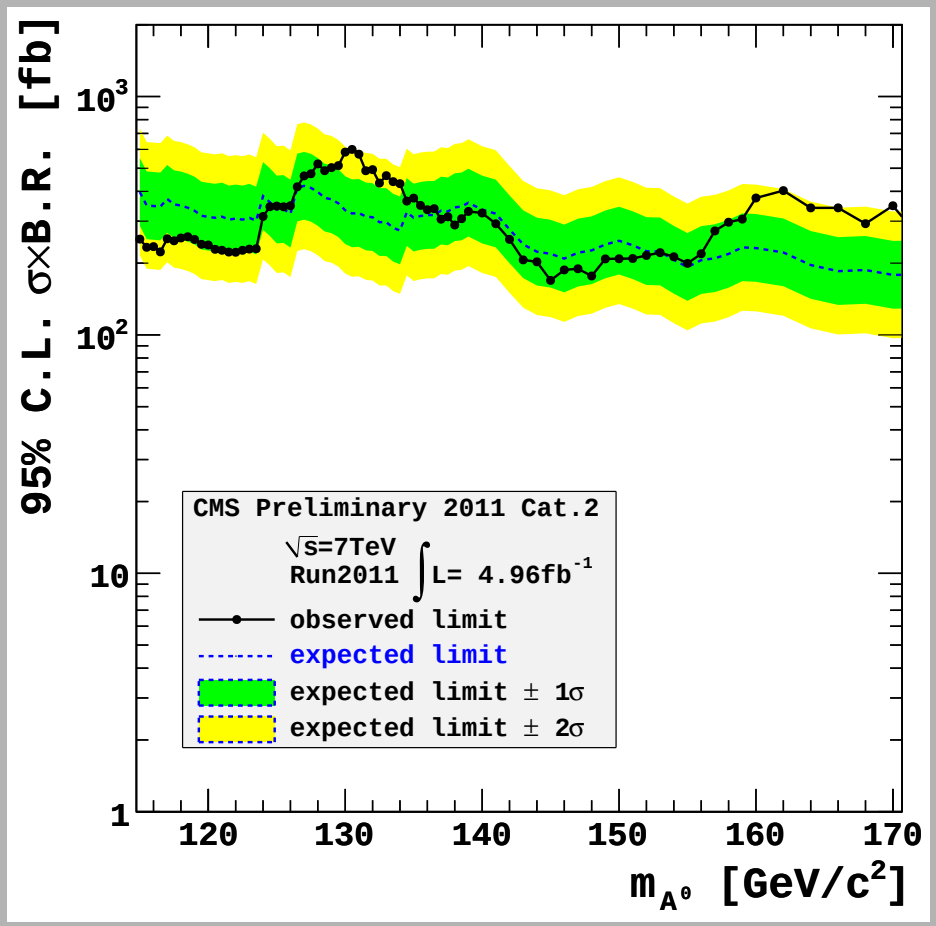


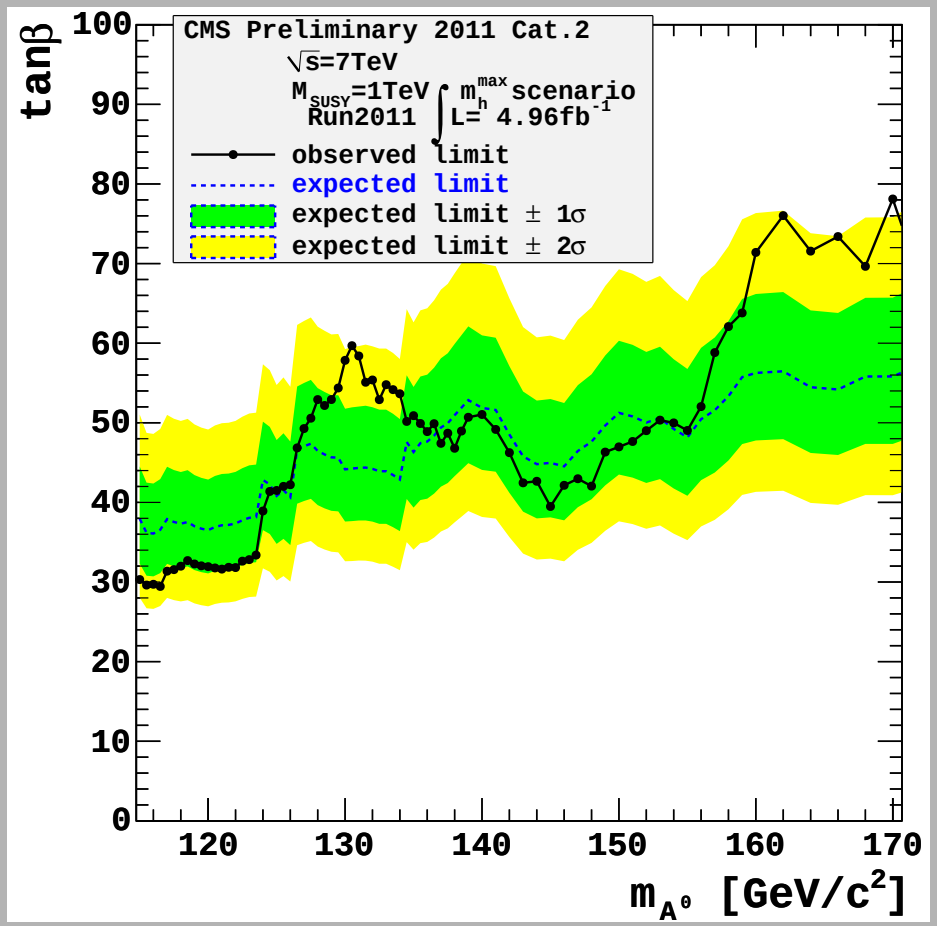


limits calculated using the asymptotic algorithm using the CLs method

limit calculation

Category 2 (additional muon)

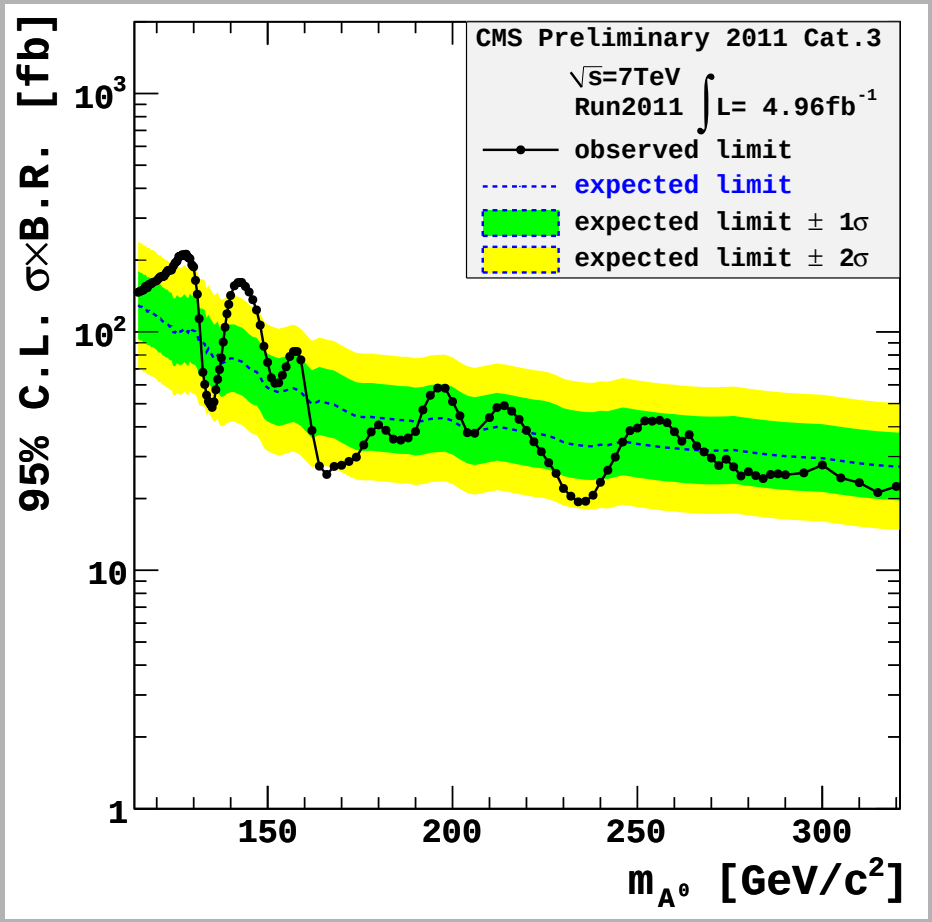


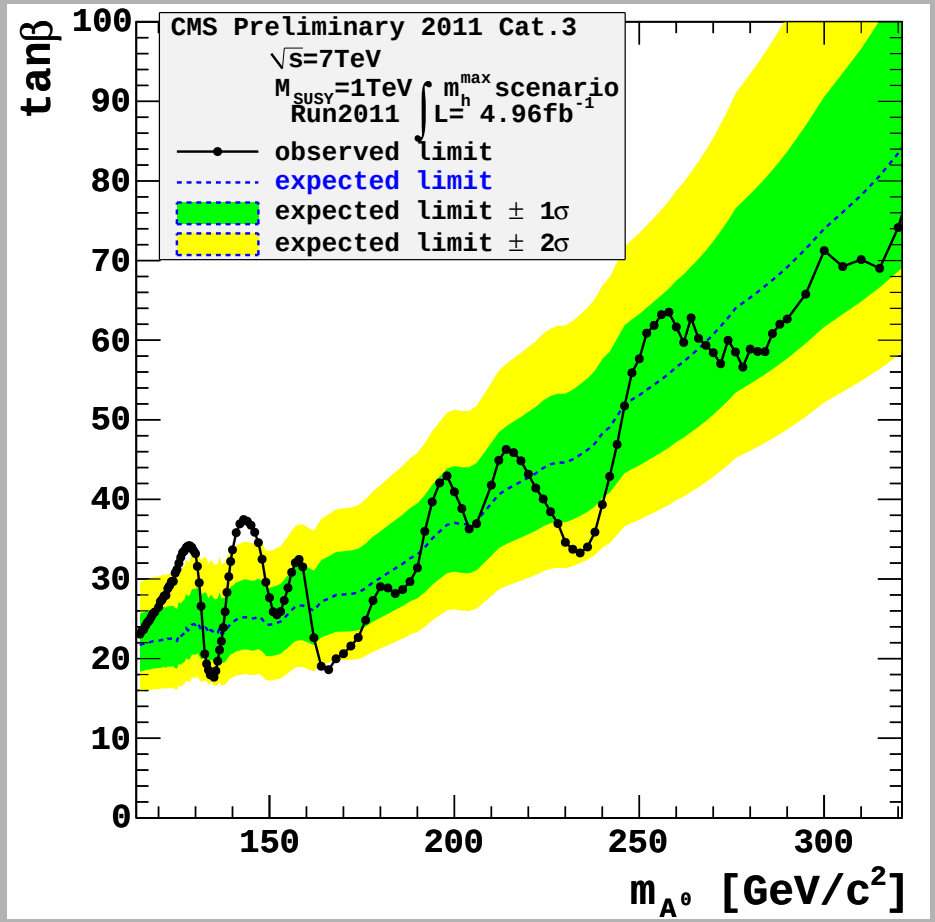


poor sensitivity due to very low statistics in this category

limit calculation

Category 3 (everything else)





good sensitivity due high statistics in this category