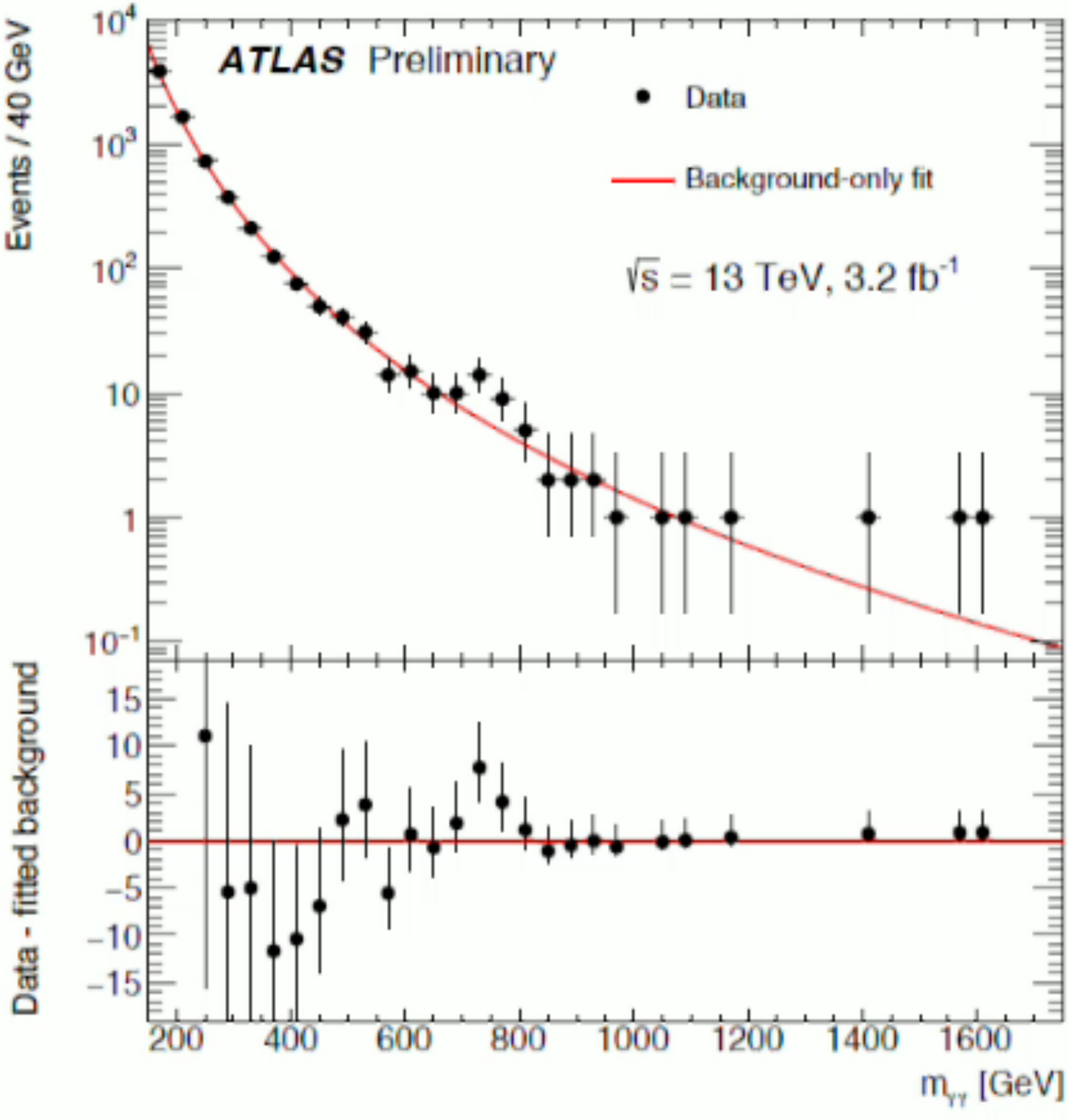
Glue to light signal of a new particle

KIAS-NCTS workshop at High1
Jan 31, 2016

Hyung Do Kim
(Seoul National University)
with Dongjin Chway, Radovan Dermisek, Tae Hyun Jung

arXiv:1512.08221


ATLAS Preliminary
Data
Background-only fit
√s = 13 TeV, 3.2 fb-1
Events / 40 GeV
Data - fitted background
mγγ [GeV]

19.7 fb^{-1} (8 TeV)

CMS

All classes combined

Γ_X= 0.1 GeV; spin-0

Observed

Expected ± 1σ

Expected ± 2σ

$\sigma B(X \to \gamma\gamma)_{95\%CL}$ (pb)

10^{-1}

10^{-2}

10^{-3}

10^{-4}

200 300 400 500 600 700 800

m_X [GeV]

Pros and Cons : Signal of New Physics?

Pro

: Diphoton channel is very clean
: Repetition of Higgs discovery
: Both in ATLAS and CMS

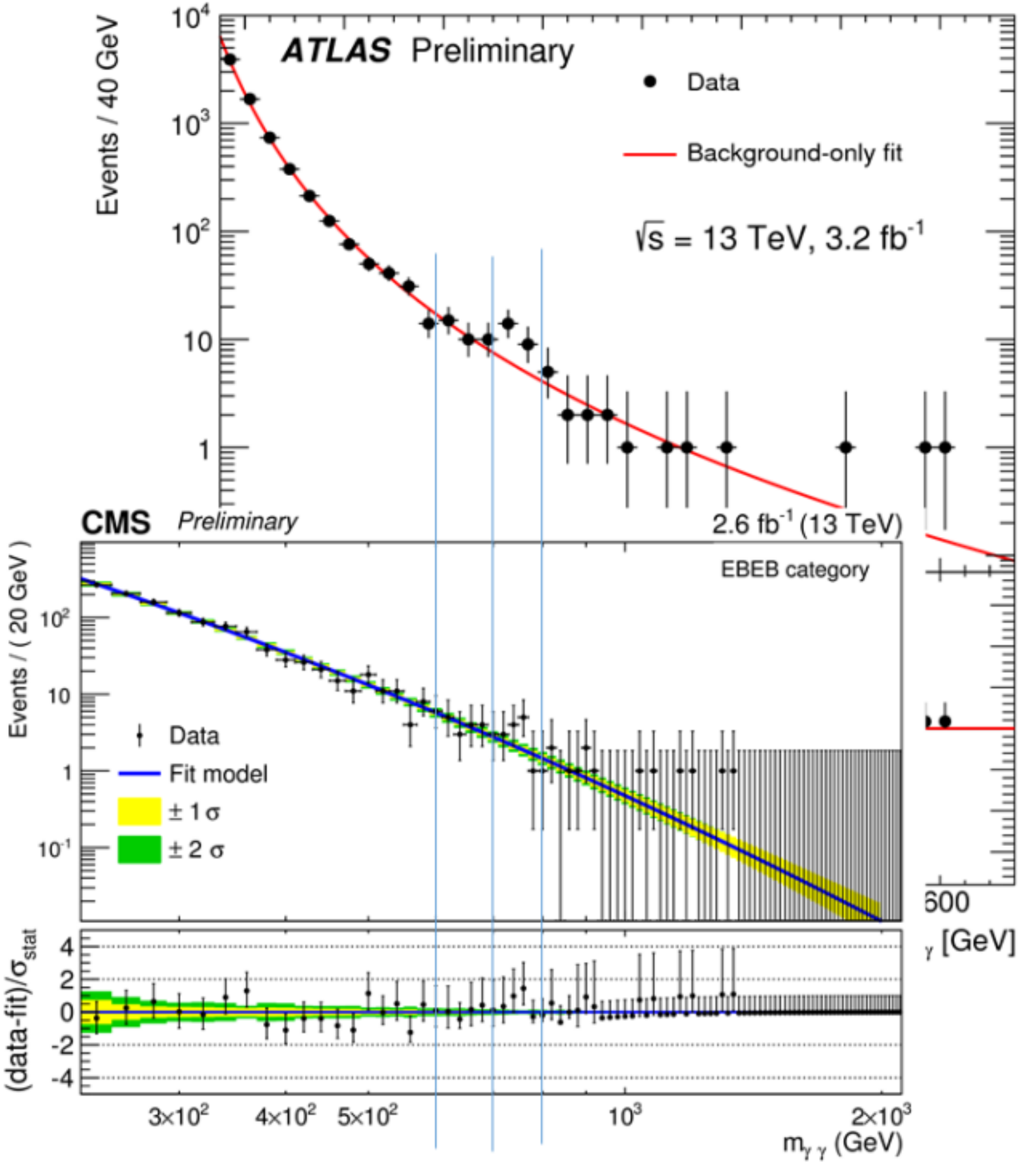
Con

: Excess is close to the event tail
: Not in ttbar, jj, ll
: So many 2 sigma bumps in CMS
: Strong coupling is necessary
(cross section*Br is too big)
: No motivated BSM can explain it
: Not seen at Run I

We have to wait for six months (2016 summer) or a year

Independently of the result, it would be a great opportunity for postdocs and students

It can also stimulate some ideas



Excess of events
from 700 ~ 800 GeV
(a few 10s events)

750 GeV peak
with 45 GeV width
fits the best
(narrow width is consistent)

ATLAS : 3.6 sigma
CMS : 2.6 sigma

from 1601.03153

Background function	Free width	NWA
$y = (1-x^{1/3})^b x^{a_0}$	3.9σ	3.6σ
$y = (1-x^{1/3})^b x^{a_0+a_1 \log x}$	2.9σ	2.6σ
$y = (1-x^{1/3})^b (x^{c_0} + x^{a_0+a_1 \log x})$	2.0σ	2.0σ

omitted zero event bins

from 1601.07330

Background function	NWA	Free-width
Fixed normalisation		
$k = 0$	4.2σ	4.9σ
$k = 1$	3.4σ	3.7σ
$k = 2$	3.4σ	3.7σ
Free normalisation		
$k = 0^\dagger$	3.4σ	3.6σ
$k = 1$	3.5σ	3.8σ
$k = 2$	3.4σ	3.6σ
ATLAS reported	3.6σ	3.9σ

Physics of ambulance chasing

One success in 2012 Dec.
: precursor of Higgs discovery

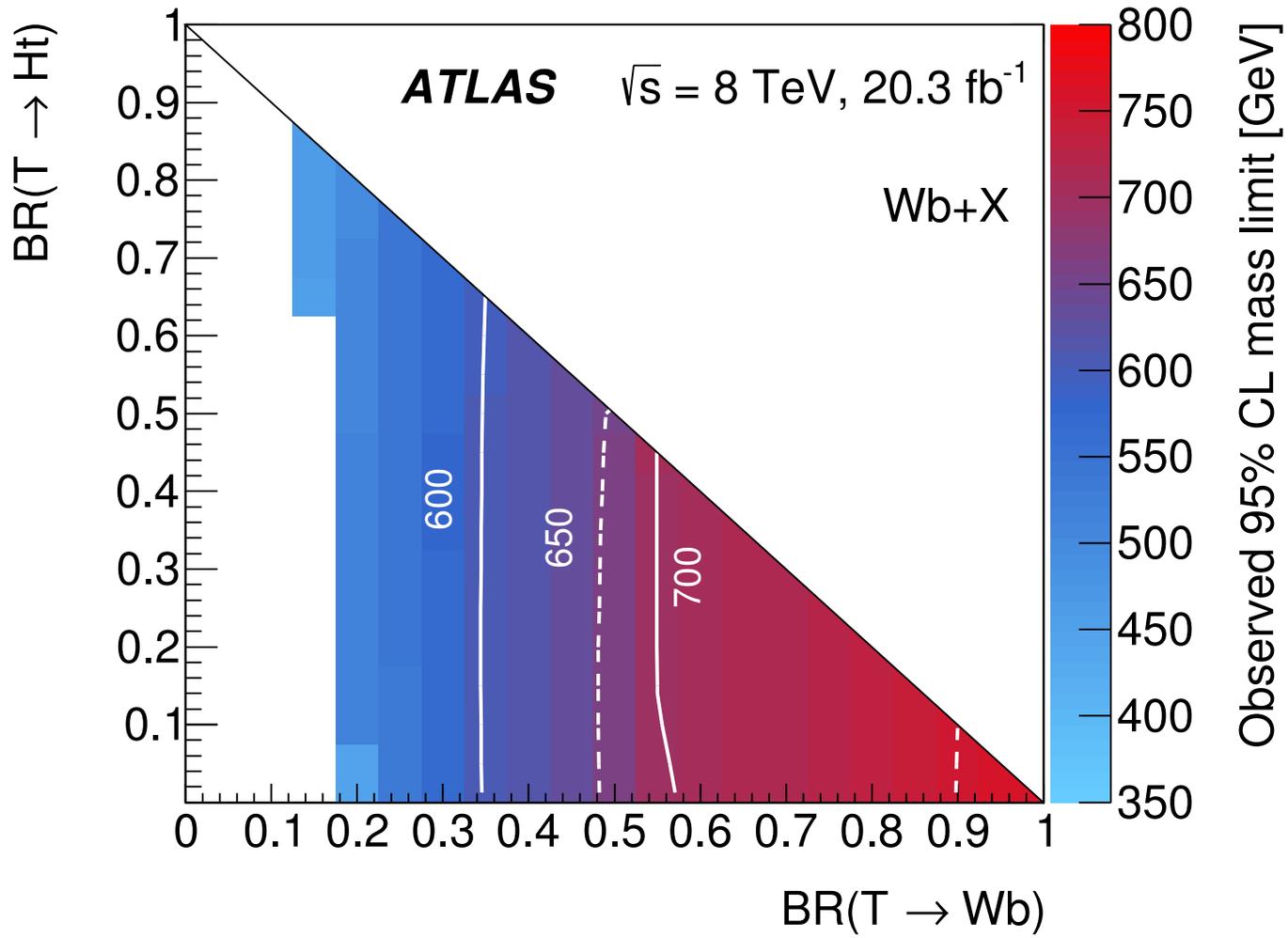
Many other failures
: Many B physics anomalies
Tevatron W+dijet,
dimuon charge asymmetry,
top A_FB,
DAMA/LIBRA,
CoGeNT,
PAMELA,
140 GeV Higgs (WW*)
BICEP2

More than 150 papers attempting to explain the excess
considers a 750 GeV singlet scalar resonance.

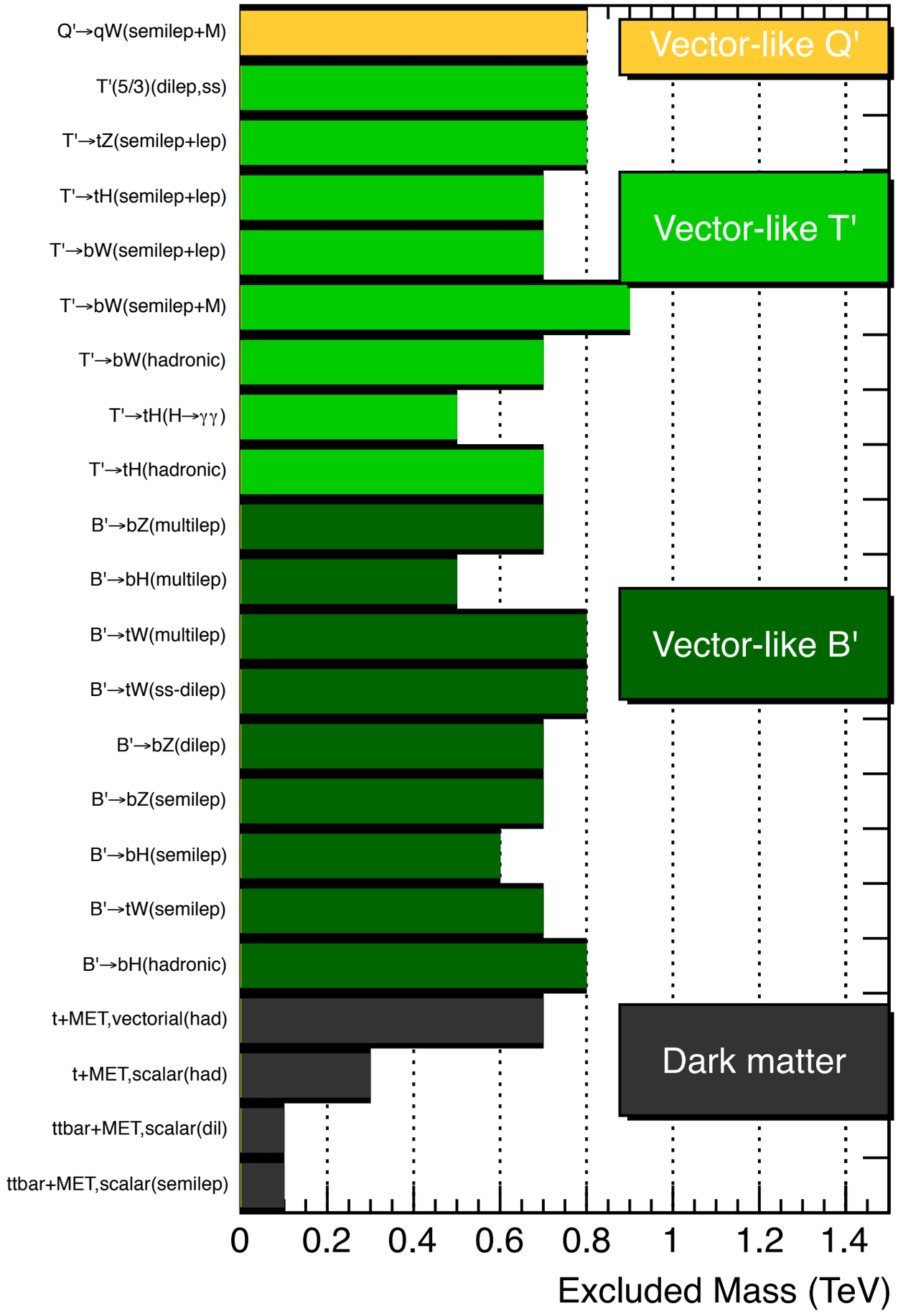
The motivation of the paper 1512.08221 is to suggest a model independent search strategy for colored and charged (new) particle in diphoton channel at LHC.

Direct search (vector-like fermions > 600 ~ 900 GeV, sfermions > 600 GeV)
highly depends on the decay channels
but there is a loop diagram independently of the decay channels.

from 1505.04306

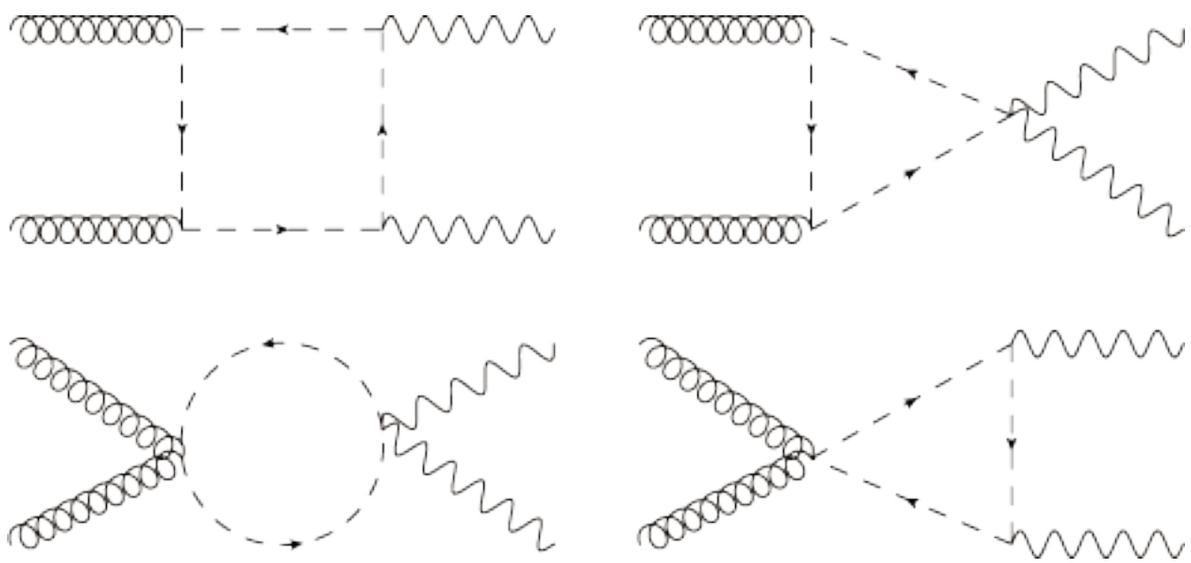


CMS 8 TeV 20 fb-1

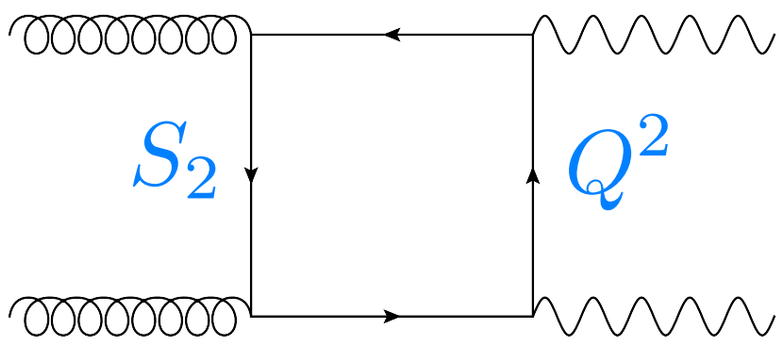


$gg \to \gamma\gamma$

Scalar



Fermion



$$C = N S_2 Q^2$$

Any new colored/charged particle will contribute to the loop of $gg \to \gamma\gamma$

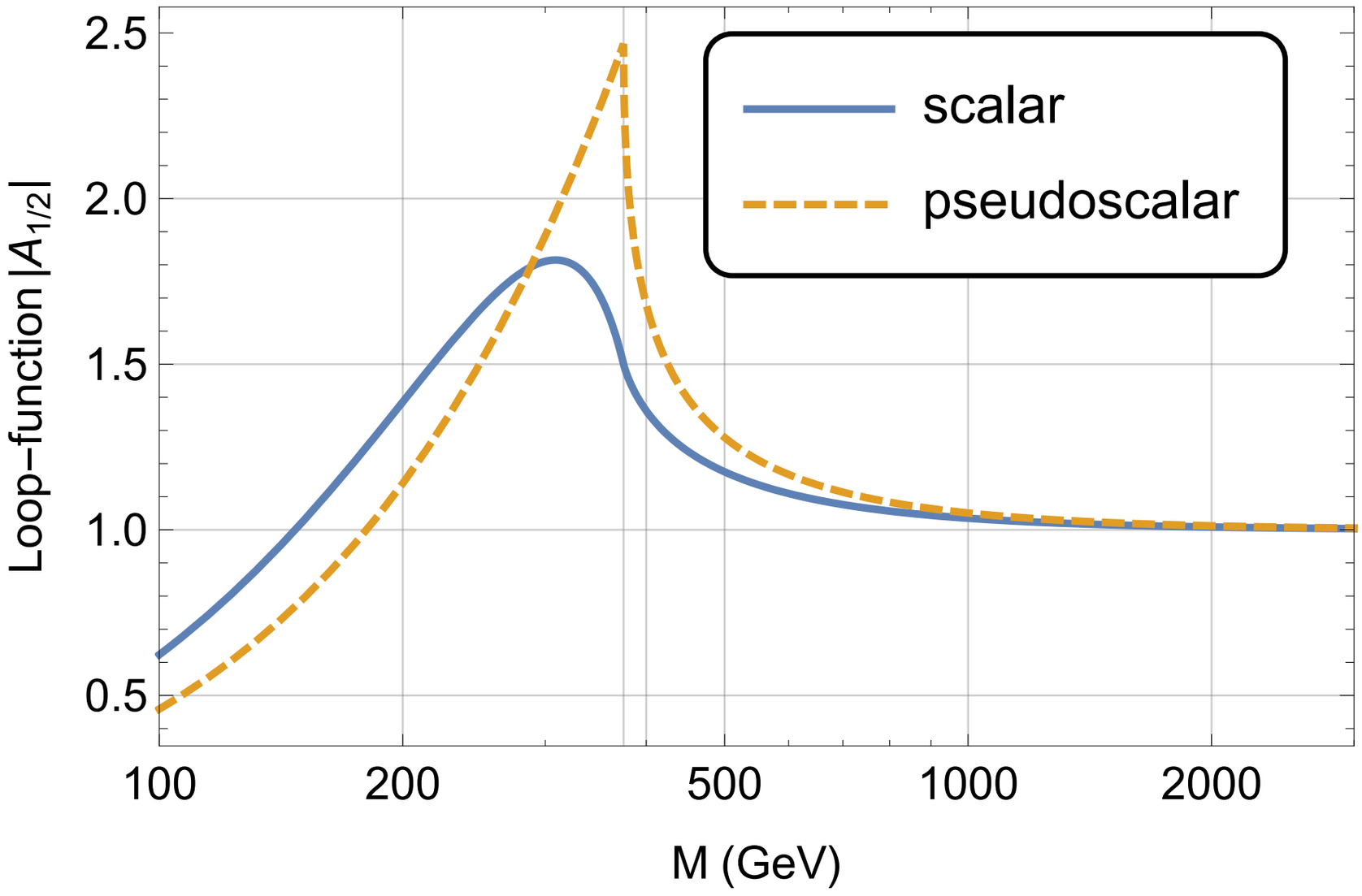
When the invariant mass is twice of the loop particle mass,
on-shell enhancement is visible in the loop amplitude.

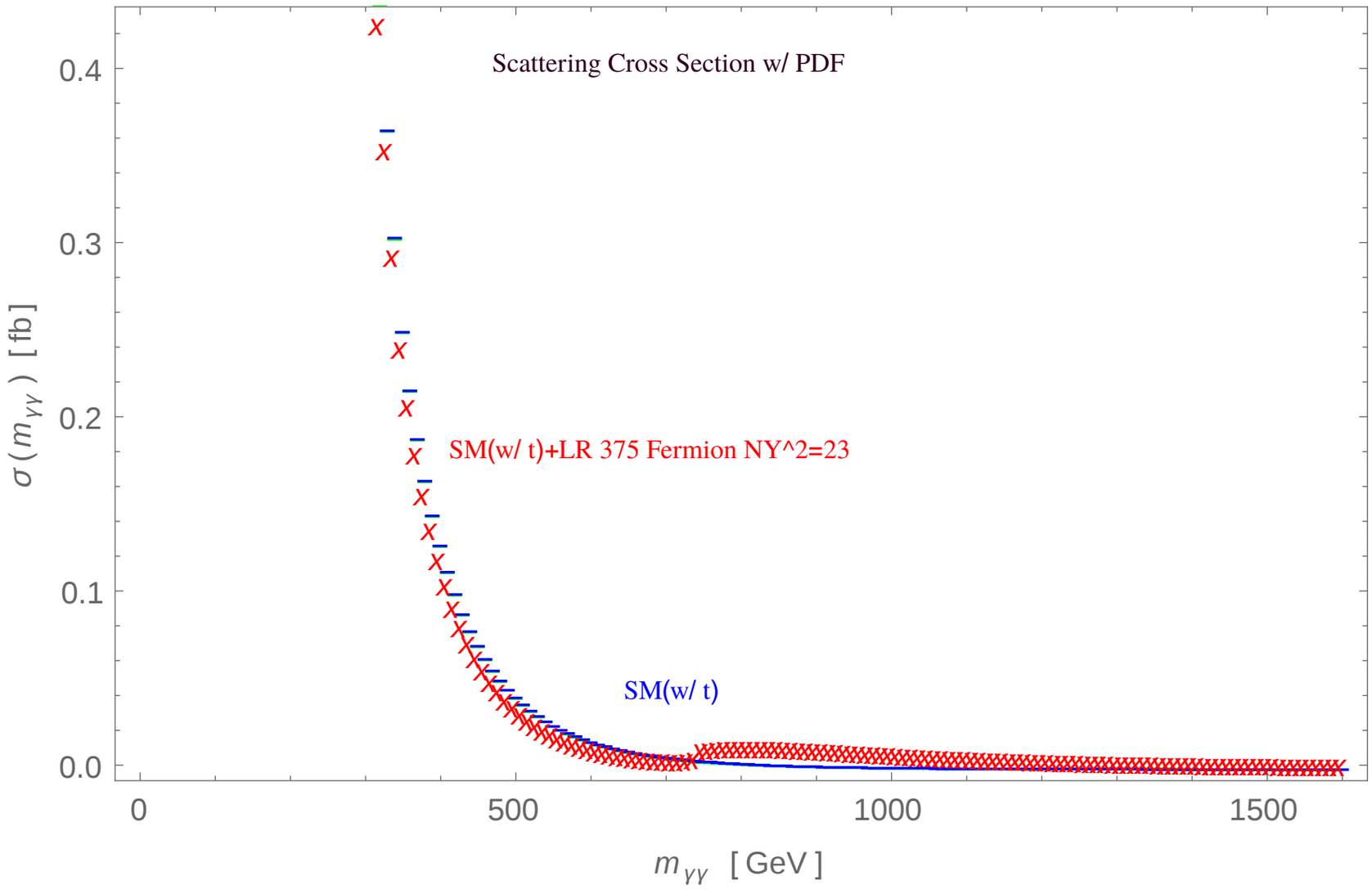
It is a consequence of rapid rising of imaginary part
and related change of the real part amplitude.

Loop amplitude has tensor indices
and physics is clear after the polarization sum

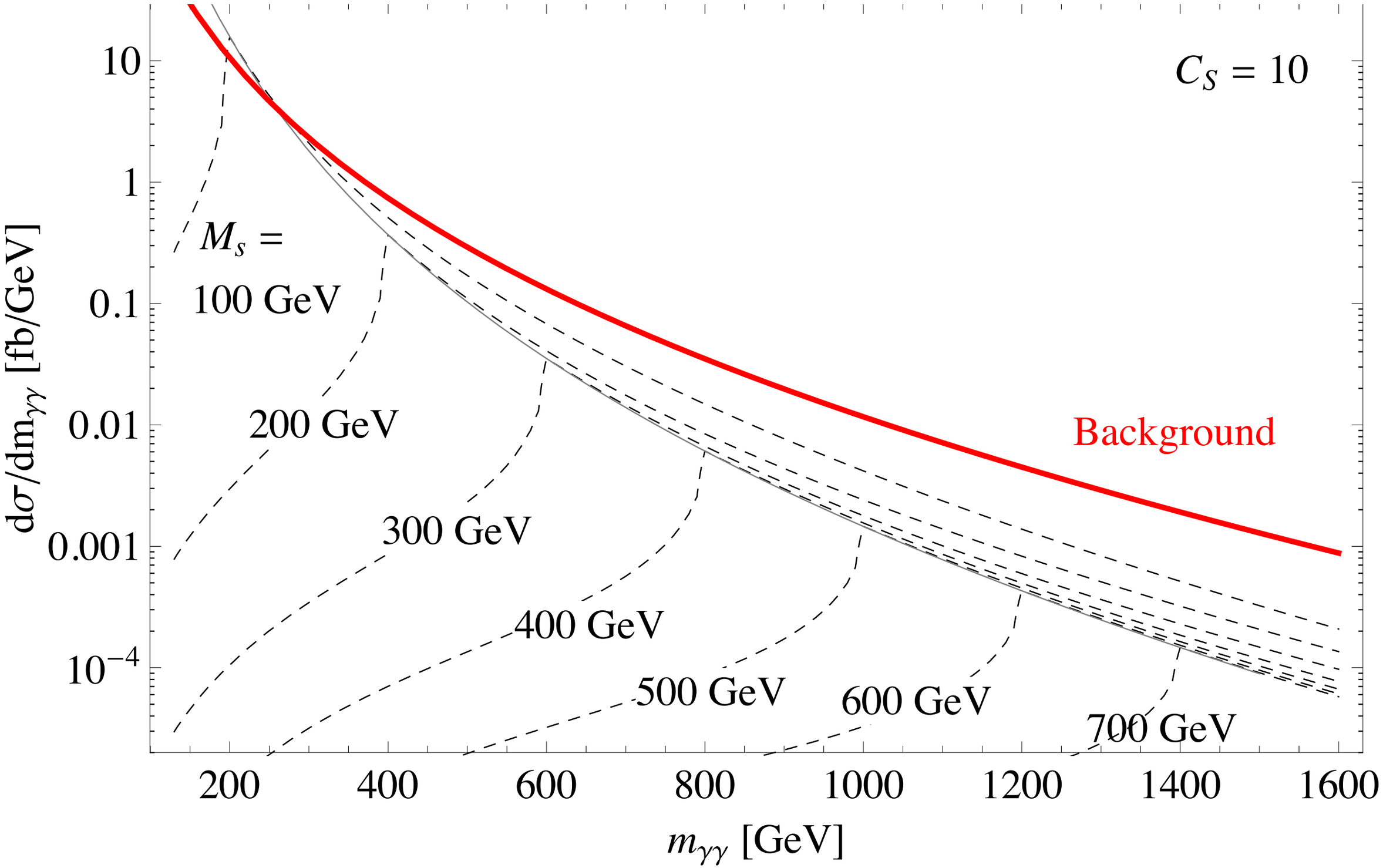
Instead scalar example would be illustrative

diboson to scalar amplitude from 1512.07624

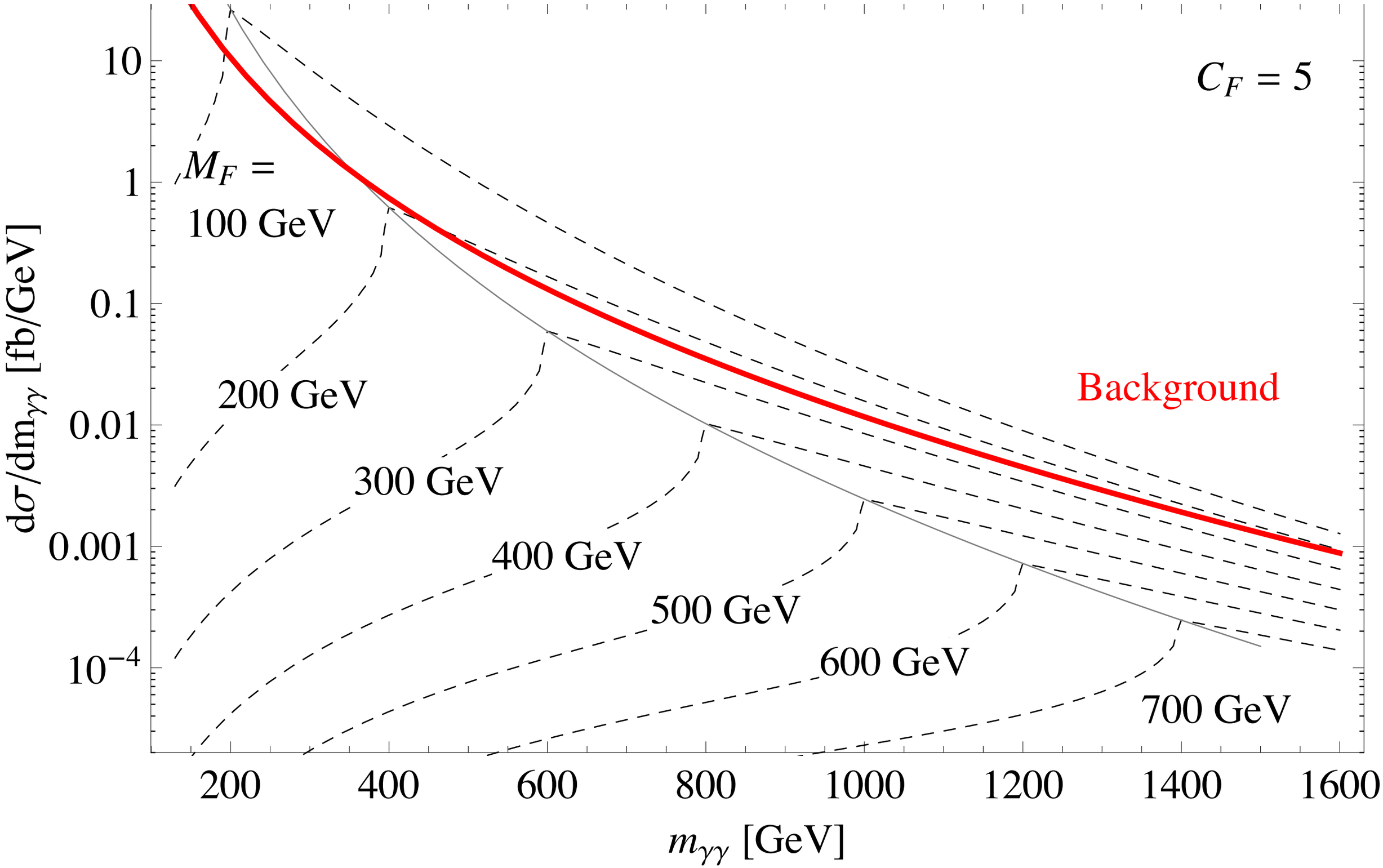



Scattering Cross Section w/ PDF
SM(w/ t)+LR 375 Fermion NY^2=23
SM(w/ t)
0.4
0.3
0.2
0.1
0.0
0
500
1000
1500
$\sigma(m_{\gamma\gamma})$ [fb]
$m_{\gamma\gamma}$ [GeV]

In the following analysis, selection efficiency is assumed to be 100%

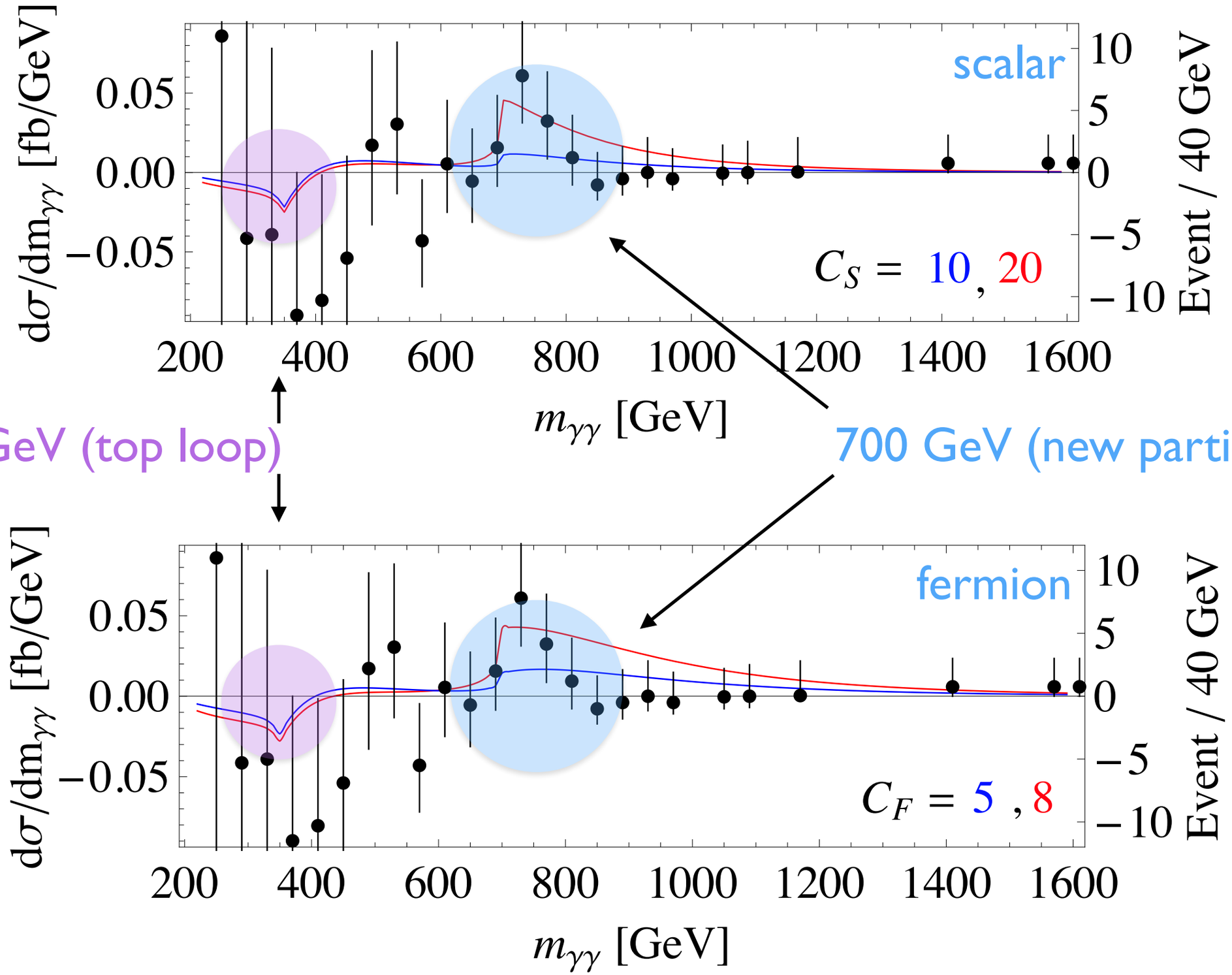


Signal cross section as a function of the loop particle (scalar) mass



Signal cross section as a function of the loop particle (fermion) mass

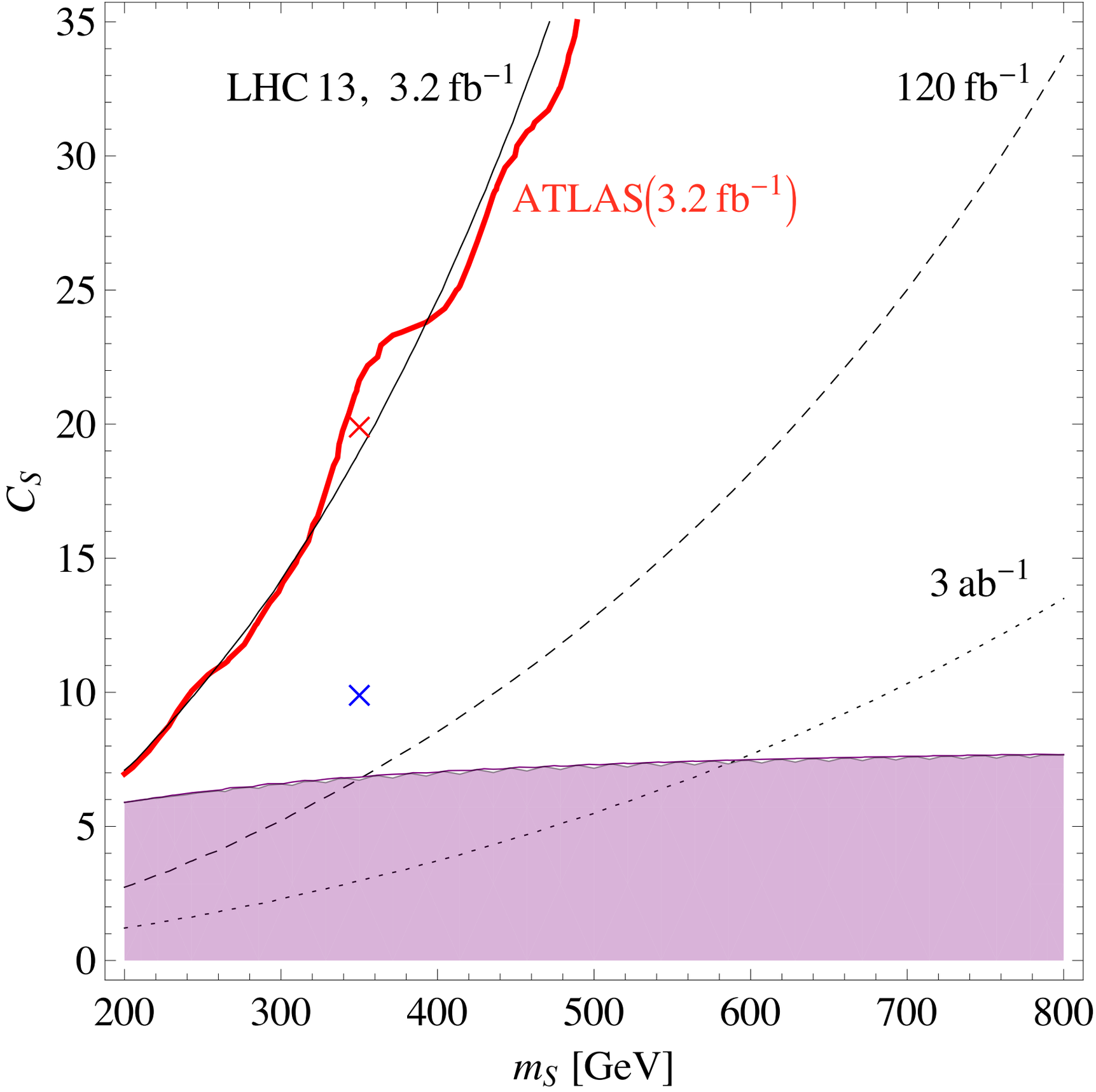
*Background is subtracted with the usual fitting function



350 GeV (top loop)

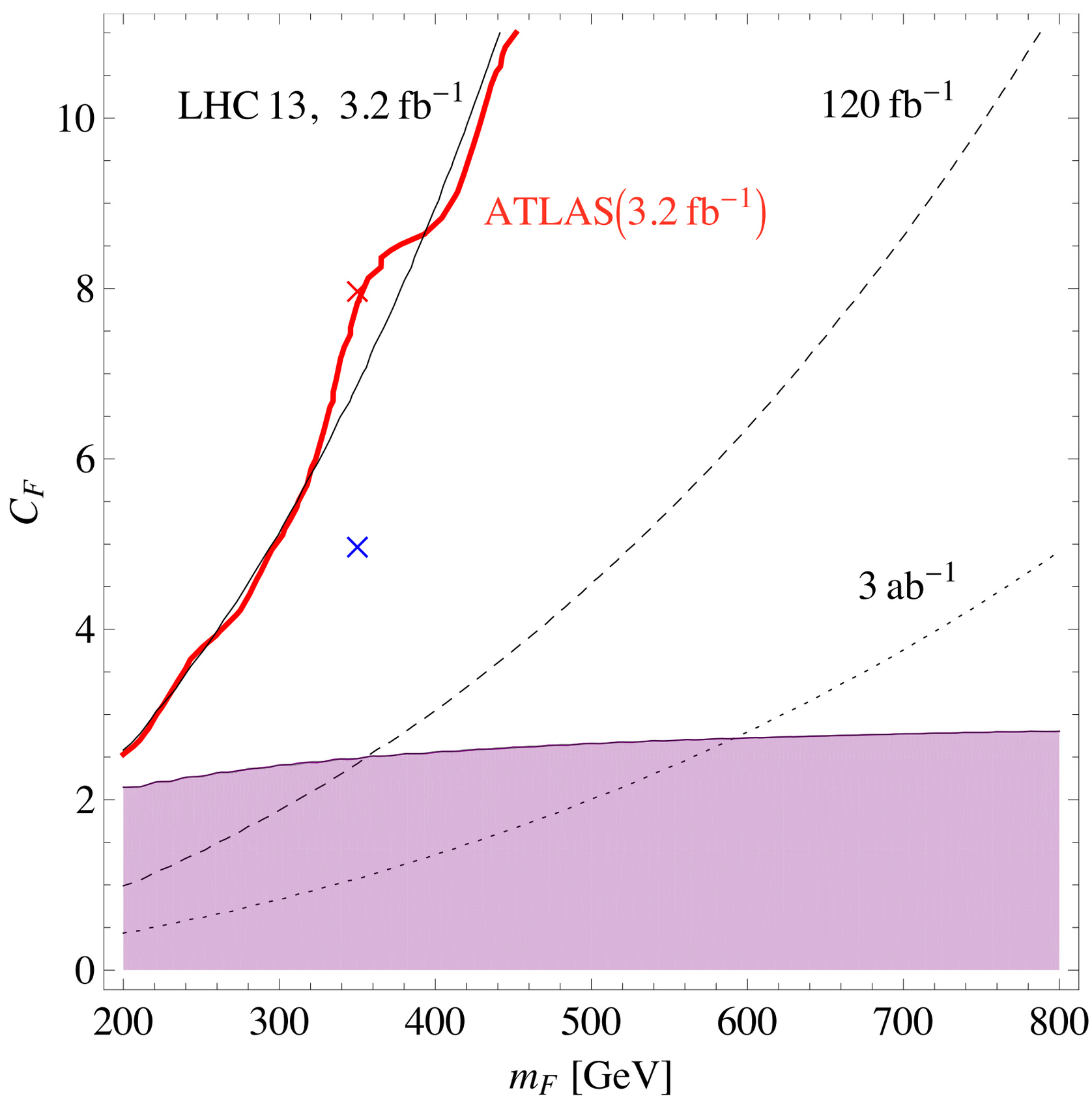
700 GeV (new particle)

Best fit (red) and small color/charge (blue)



Interference is important

Upper limit on C (scalar) and expected upper limit



Interference is important

Upper limit on C (fermion) and expected upper limit

Model independent upper bounds on colored and charged particles are obtained from diphoton channel at LHC.

It can compete with the monojet search bounds.

Working in progress 1

Observation of ttbar threshold from diphoton spectrum (in collaboration with KCMS group in SNU)

Working in progress 2

Bound state can give comparable effects
if the constituent particle lives long enough.

Interesting interference effect is expected
from loop diagram and bound state.

Double counting issue should be correctly addressed
to interpolate different regions of parameter space.