The Little Higgs boson at a photon coll

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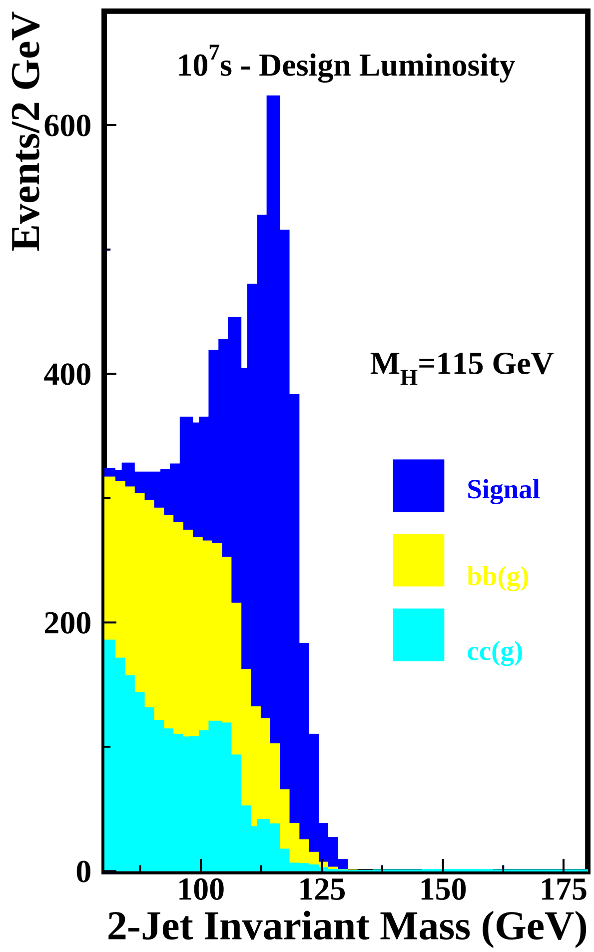
The Higgs boson is produced at a photon collider vi[a]
induced $\gamma\gamma H$ coupling.



[$\gamma\gamma \to H \to b\bar{b}$ signal
Asner et al, hep-ex/011105

Expected precisions:

M_H	$b\bar{b}$	WW^*	ZZ
115 GeV	2%	5%	11

$\gamma\gamma \to H$ in the Standard Model and beyond

$\gamma\gamma \to H$ comes from the gauge-invariant dim-6 operat

$$\mathcal{L} = \frac{C}{\Lambda^2} H^\dagger H F_{\mu\nu} F^{\mu\nu}$$

induced by W boson and top quark loops in the SM.

Taking $C = e^2/16\pi^2$ (electromagnetic, loop-induce
$\Lambda_{SM} = 165$ GeV. Right scale for W and t loops.

How high a Λ_{new} can be probed with a 2% measu
$\gamma\gamma \to H$?

If $C_{new} = C_{SM}$ (weakly coupled new physics):
$\Lambda_{new} = 1.2$ (0.74) TeV at 95% CL (5σ).

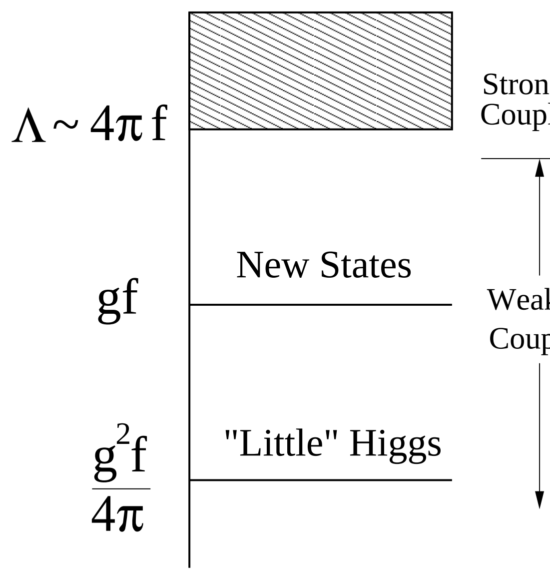
If $C_{new} = 1$ (strongly coupled new physics):
$\Lambda_{new} = 48$ (31) TeV at 95% CL (5σ).

The Littlest Higgs model

The Littlest Higgs model is a new approach to stabiliz scale against radiative corrections, thereby solving th ness problem of a light Higgs boson.

New particles at the TeV scale cancel off the SM qu vergence of the Higgs mass from top (T), gauge (Z_H and Higgs ($\Phi^{0,+,++}$) loops.

- Higgs is a pseudo-Goldstone boson from global symmetry breaking at scale $\Lambda \sim 4\pi f \sim 10 - 30$ TeV;
- Quadratic divergences cancelled at one-loop level by new states $M \sim gf \sim 1 - 3$ TeV;
- Higgs acquires a mass radiatively at the EW scale $v \sim g^2 f/4\pi \sim 100 - 300$ GeV.

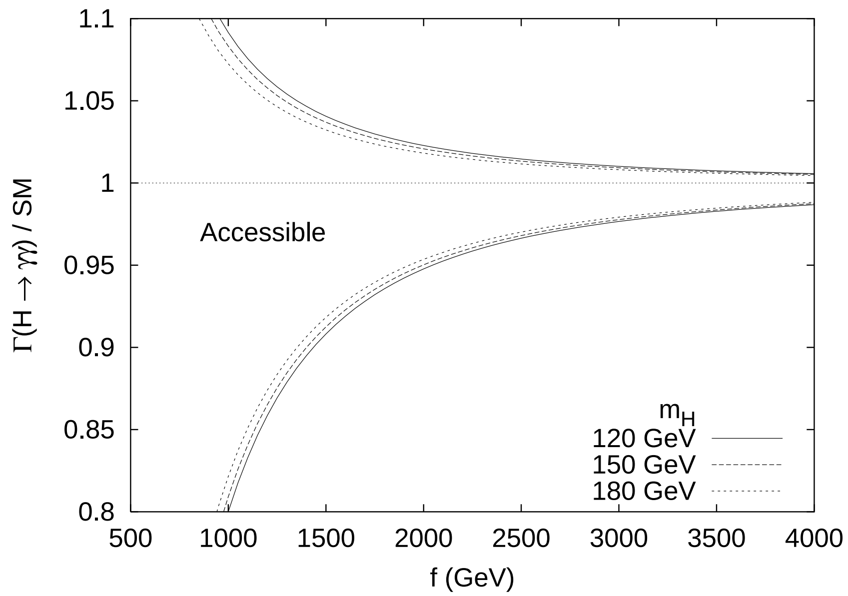


Corrections to $\gamma\gamma \to H$ in the Littlest Higgs mo

$\gamma\gamma \to H$ is loop induced: TeV-scale charged particles V
$\Phi^{\pm\pm}$ can run in the loops

Higgs couplings to SM particles modified due to mixin
SM and TeV-scale particles and corrections to SM pa

Han, Logan, McElrath, Wang '03

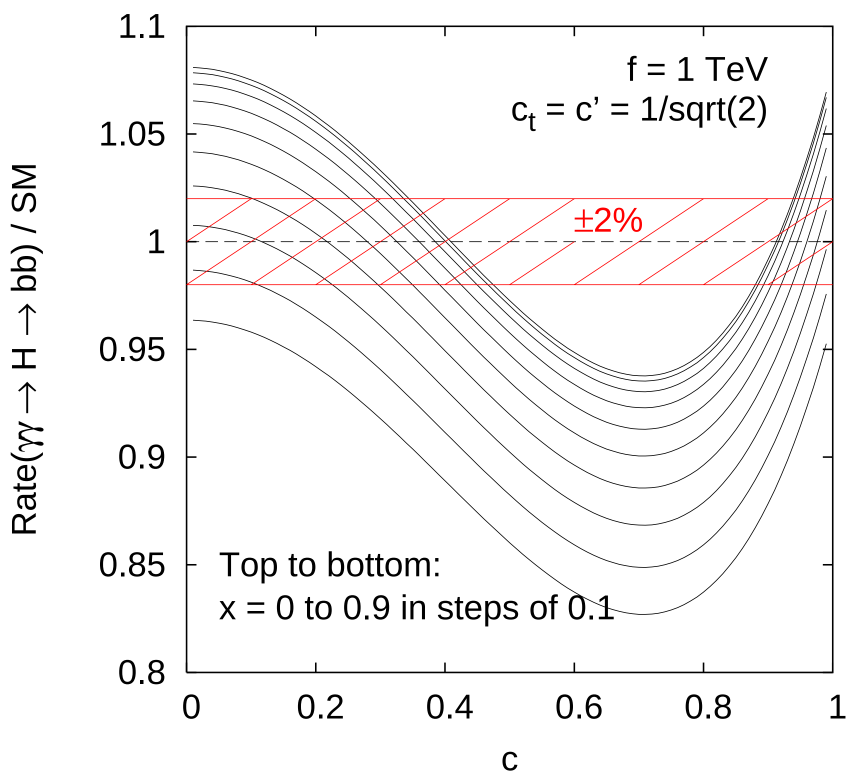


Accessible range foun
ning over model para
Corrections are of or

Higgs decays in the Littlest Higgs model

Corrections to Higgs decays [from mixing between SM
scale particles and corrections to couplings]: also $\mathcal{O}(v$

- Corrections about the same size in each channel.
- Best channel from experimental side: $H \to b\bar{b}$.



Model parameters

f – new physics sc

c – $\mathrm{SU}(2)_{1,2}$ ga
mixing angle $[Z_H,$

c_t – top sector par

x – Higgs sector
(controls triplet Φ

c' – $\mathrm{U}(1)_{1,2}$ ga
mixing angle [EW
favors only one U
$1/\sqrt{2}$, no A_H part

Using $\gamma\gamma \to H \to b\bar{b}$ to probe the Littlest Higg

What can be done with the $\gamma\gamma \to H \to b\bar{b}$ rate measur

- Test the model: probe $\Lambda_{new} \sim 1 - 3$ TeV.

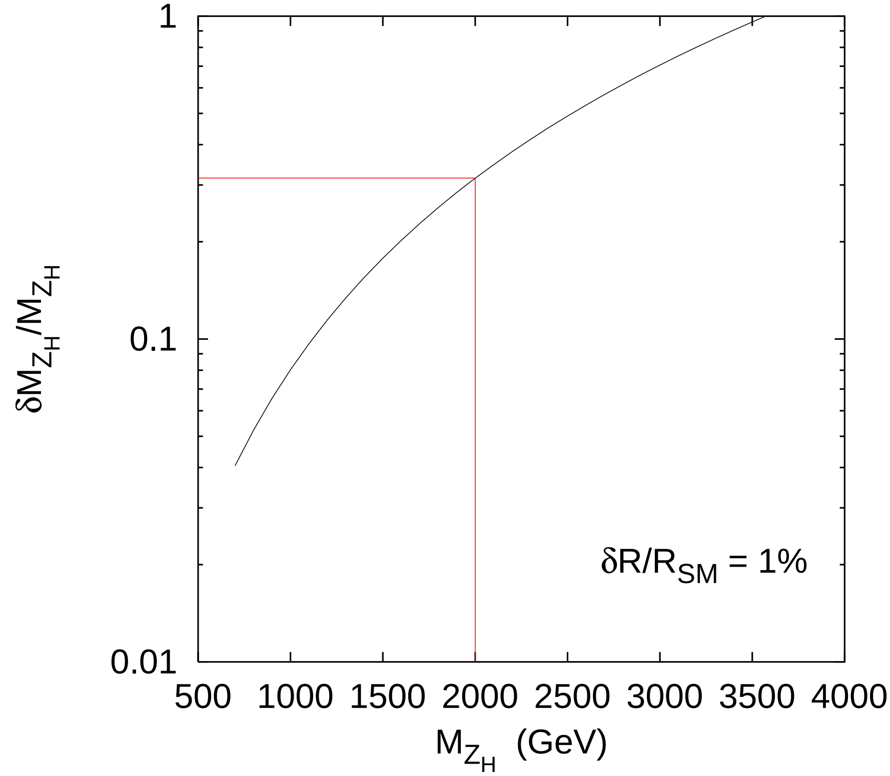
- Search for strongly-coupled UV completion:
probe $\Lambda_{new} \sim$ few$\times$10 TeV.

Must be able to predict the rate for $\gamma\gamma \to H \to b\bar{b}$, $R =$
with a precision comparable to the photon collider ex
uncertainty of 2%.

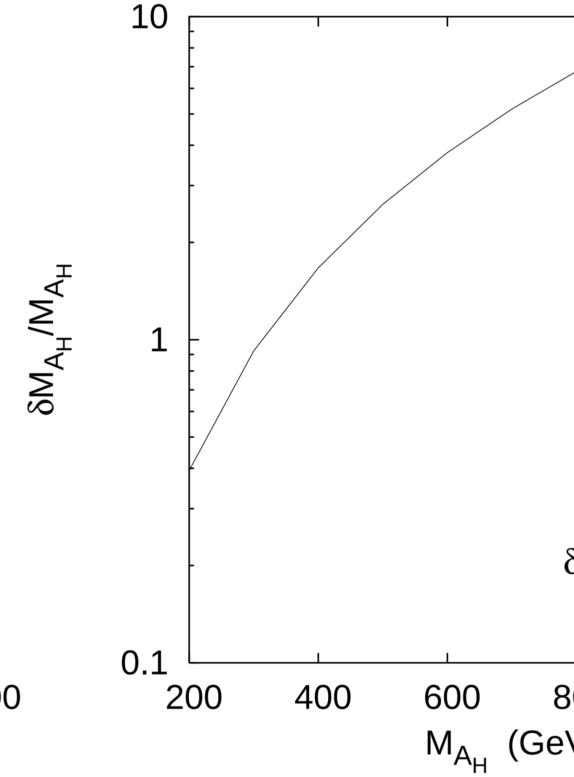
We therefore compute how well each model paramet
measured (at the LHC) in order to contribute no mor
uncertainty to R (i.e., $|\delta R/R_{SM}| \leq 1\%$).

Input precisions: M_{Z_H} and M_{A_H}

EW precision data:
$M_{Z_H} \gtrsim 2$ TeV.



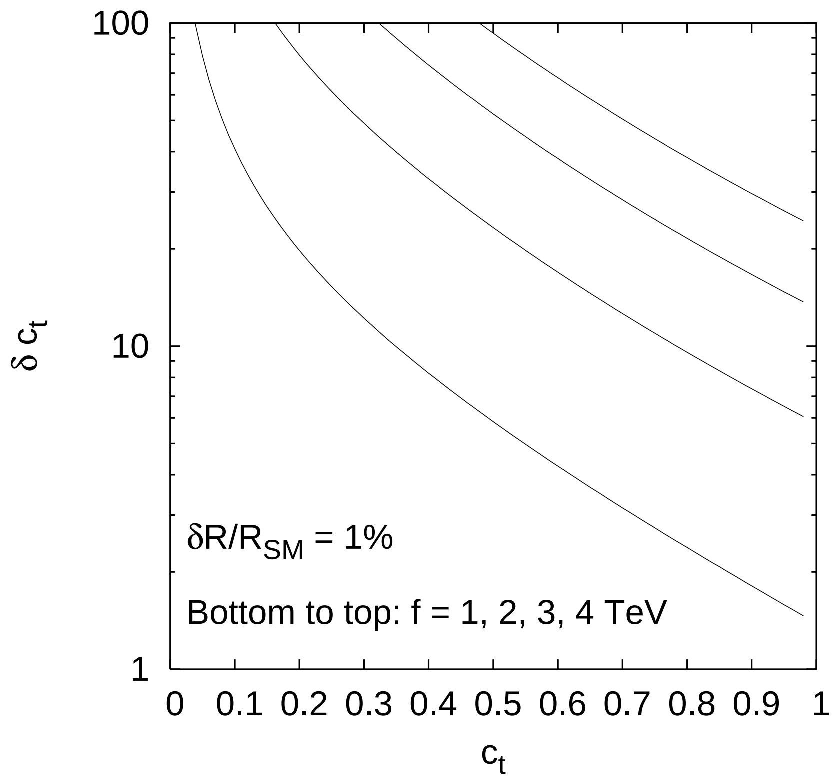
If model contains
(Disfavored by EV



Measure Z_H $(A_H) \to$ dileptons.

Dilepton invariant mass resolution typically a few per
$\to$ no problem.

Input precisions: c_t



The $\gamma\gamma \to H \to b\bar{b}$ sensitive to c_t at a level.

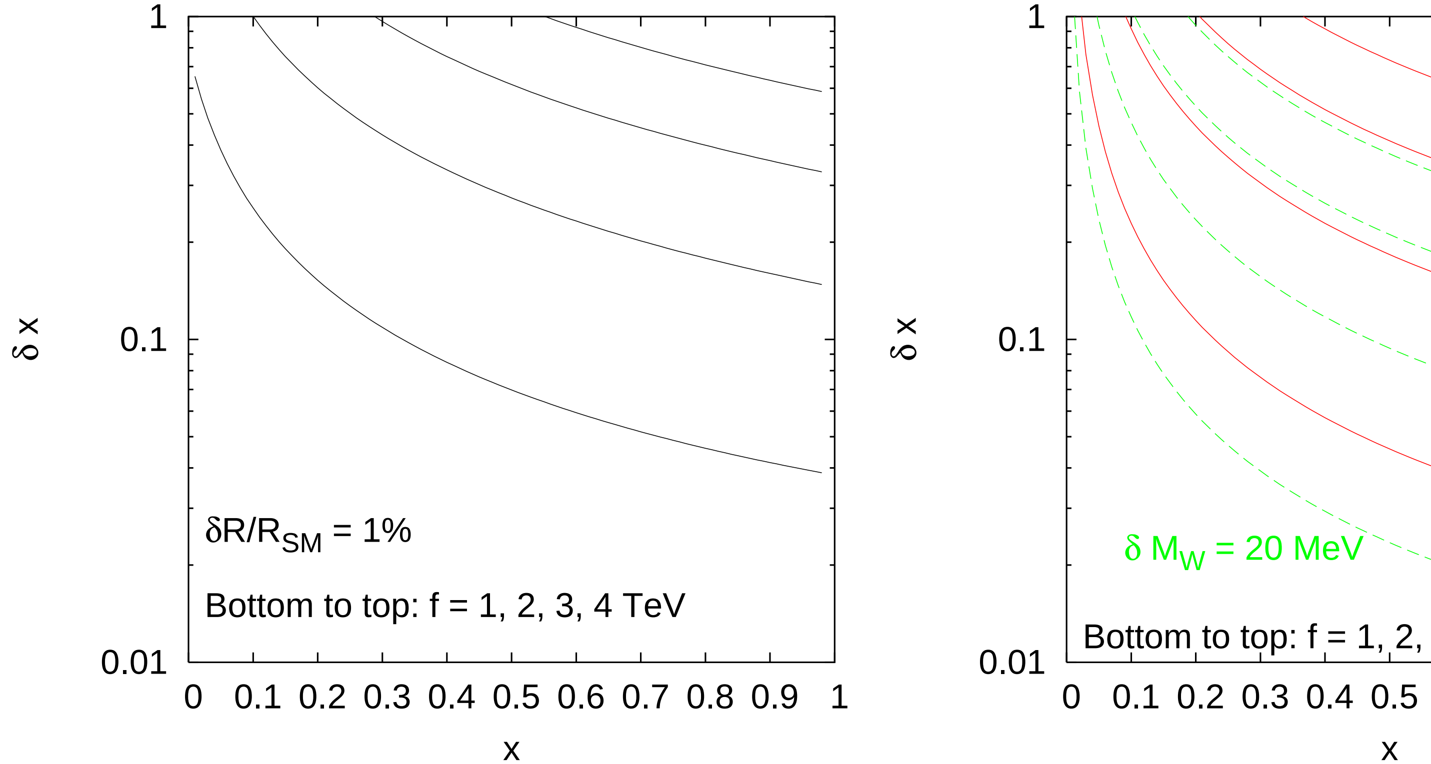
$\to$ Don't need a meas this parameter.

Input precisions: x

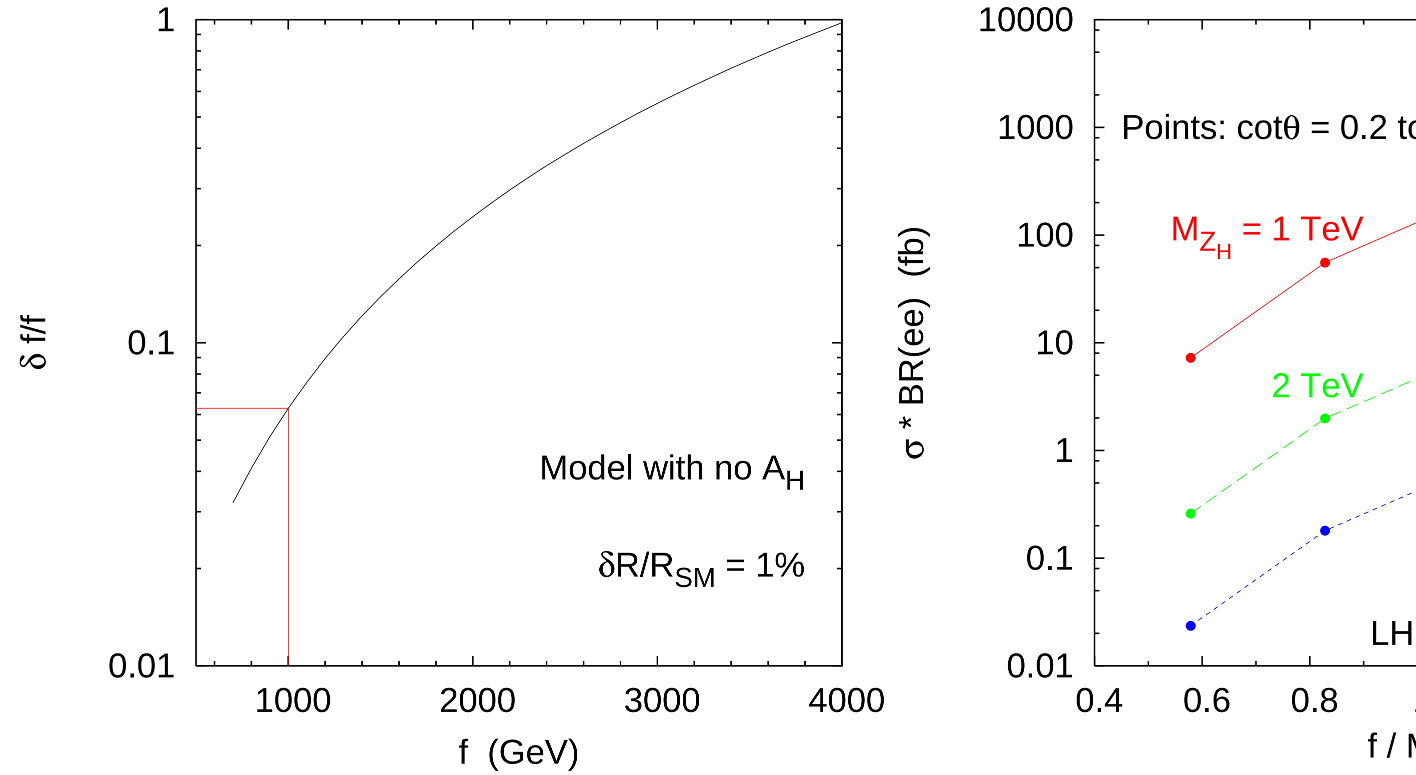
If f, c and c' are known, then x can be extracted from
the current $\delta M_W = 39$ MeV gives good enough pre
(except for $x \lesssim 0.1$, $f = 1$ TeV).
[Tevatron Run II (2 fb^{-1}) goal: $\delta M_W = 20$ MeV.]

Precision wanted on x:

Precision on x fro
surement:



Input precisions: f



EW precision constraints: $f \gtrsim 1$ TeV $\rightarrow$ want $\gtrsim 6\%$ p

Extract f from $M_{Z_H} = gf/2sc$ and cross section $\propto c^2/$

Uncertainty on cross section from statistics: $\delta\sigma/\sigma =$

Summary

Photon collider can measure Rate($\gamma\gamma \to H \to b\bar{b}$)
$m_H = 115$ GeV.

Rate($\gamma\gamma \to H \to b\bar{b}$) in the Littlest Higgs model can
calculated from LHC data on model parameters in a
of the parameter space.

Probe the UV completion at ~ 10 TeV!

- A strongly coupled UV completion contributes at
  order as the TeV-scale particles:
  $\sim$ several percent for $f \sim 1 - 3$ TeV.

- A weakly coupled UV completion should not affe
  at an observable level:
  $\to$ Measurement is a test of model consistency.