Invisible width of the Higgs and constraints on dark matter in Higgs portal models

Olmo Cerri[2] , Michele de Gruttola[1], Maurizio Pierini[1], Alessandro Podo[2], Gigi Rolandi[1,2]

1 CERN, 2 Scuola Normale Superiore Pisa

05/02/2016, FCC-ee physic workshop

Outline

- After we have repeated the Higgs->inv constraint study done for TLEP, see previous talk by Olmo

- Recompute for FCC-ee luminosity proposal
  - with the two detectors (CMS and ILD like)

- Interpret in the Higgs Portal model and compare with LHC

Motivations (1)

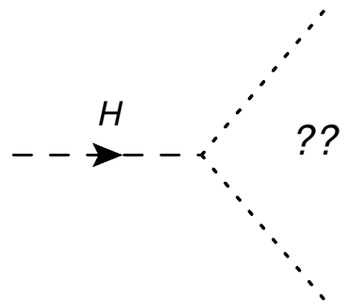
- New Physics is likely to be near the electroweak scale
  - co-responsible for generating it is a candidate to stabilize it
  - NP is likely to interact with the newly discovered h boson
    - higgs as Dark Matter (DM) Portal , where DM is supposed to carry no charges in the Standard Model gauge interactions

- Constraining H->inv down 1% is very important at FCC
  - indirect constrains from fitting the others BR
    - Total Higgs width: needed to understand possible BSM decays in a model-independent way.
  - direct constraints
    - if Higgs of shell, limits on light DM (mDM<mH/2)

Comparison with LHC

- LHC now and future

CMS-PAS-HIG-15-012 → arxiv1307.7135

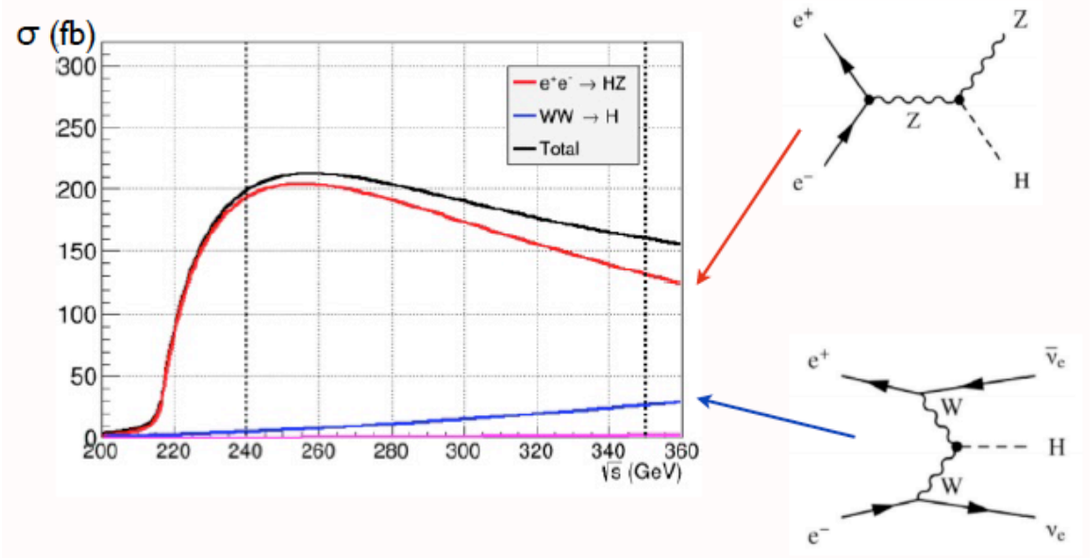


$L\,(fb^{-1})$	$\gamma\gamma$	WW	ZZ	bb	$\tau\tau$	$Z\gamma$	$\mu\mu$	inv.
300	[6, 12]	[6, 11]	[7, 11]	[11, 14]	[8, 14]	[62, 62]	[40,42]	[17, 28]
3000	[4, 8]	[4, 7]	[4, 7]	[5, 7]	[5, 8]	[20, 24]	[20,24]	[6, 17]

$BR_{H\to invisible} < 34\%$ (LHC)

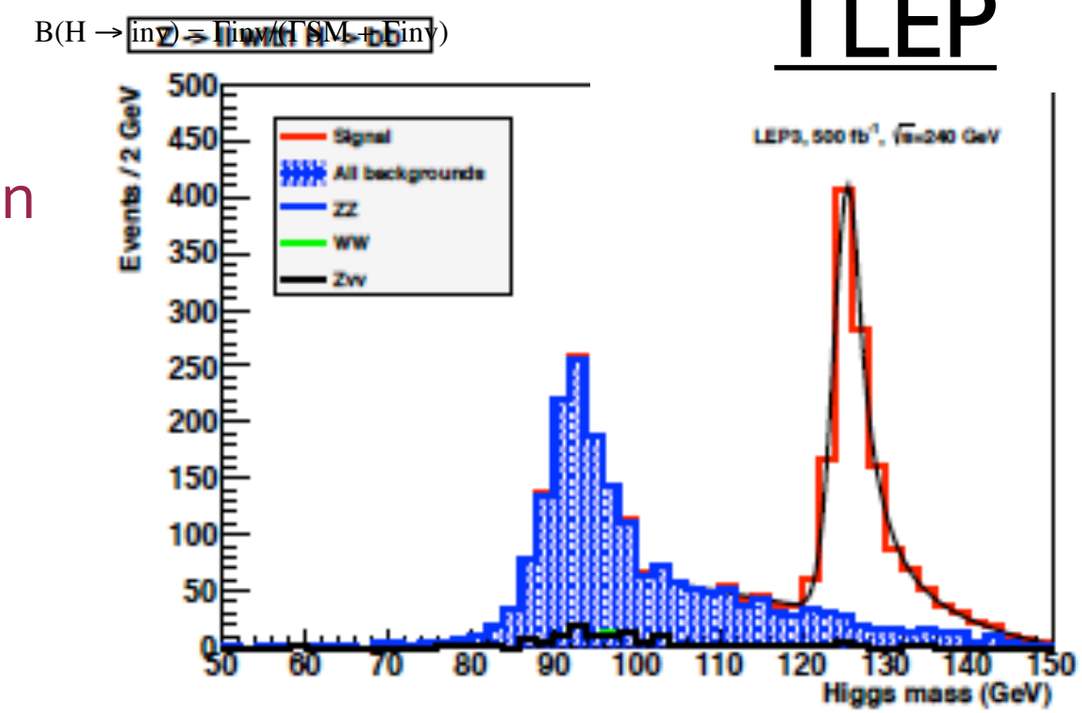
FCC-ee at 240 GeV

- FCC-ee at 240 GeV is very suitable for that!
  - FCC-ee 3rd run:
    - √s = 240GeV
    - L = 3.5ab−1/yr
    - 7.0·105 HZevents/yr
  - Reconstructed peak at mmiss = mH independent of H decay mode!
  - inclusive measurement of Zh production
    - tagging events under the peak allows determination of individual BRs
  - Missing mass distribution may also be used to search for invisible decays: missing invariant mass



$$M_{\text{miss}} = \sqrt{(\sqrt{s} - E_Z)^2 - |\vec{p}_Z|^2}$$

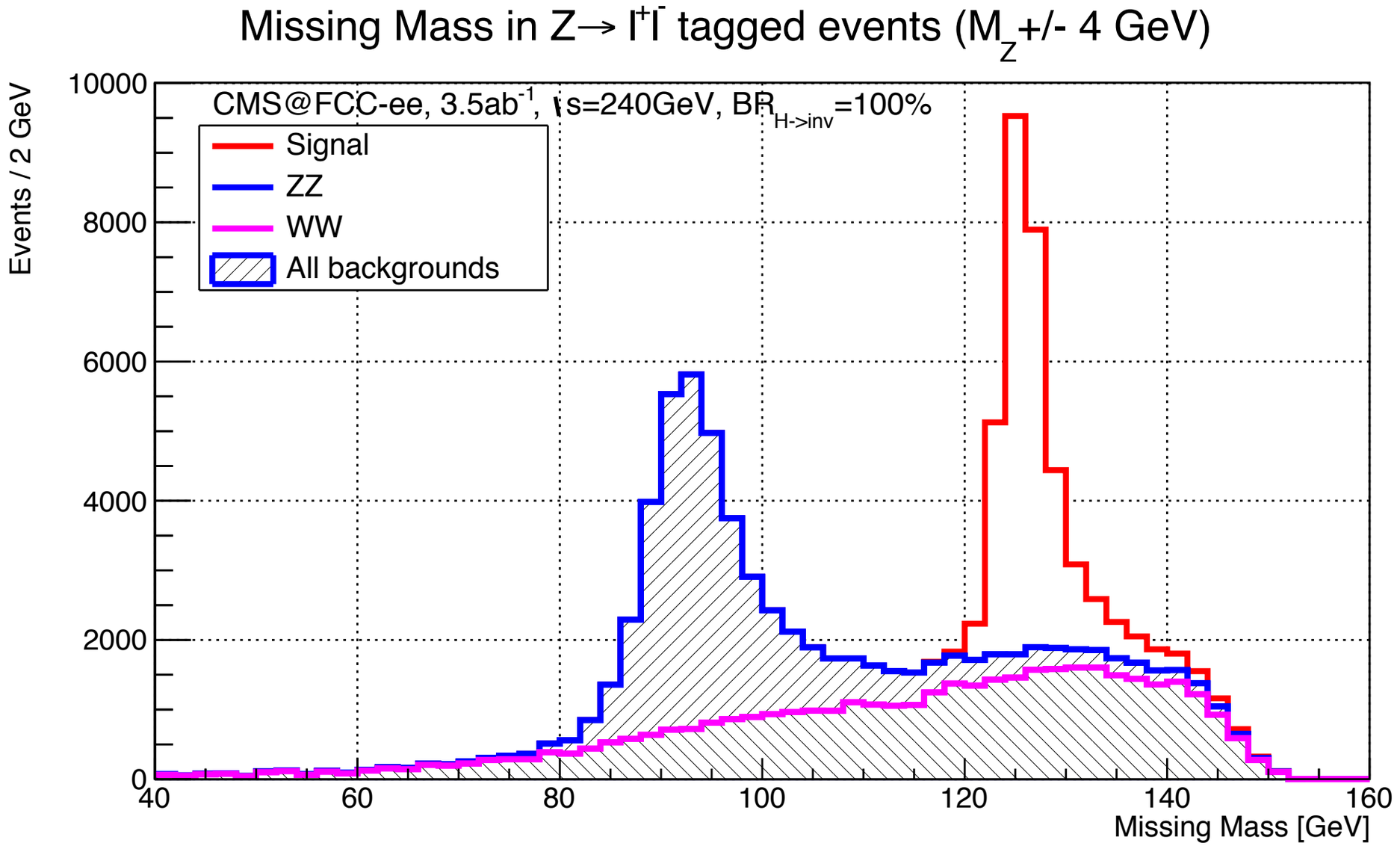
TLEP



$$B(H \to \text{inv}) = \Gamma\text{inv}/(\Gamma\text{SM} + \Gamma\text{inv})$$

Results for CMS-like detector, 1y of FCC

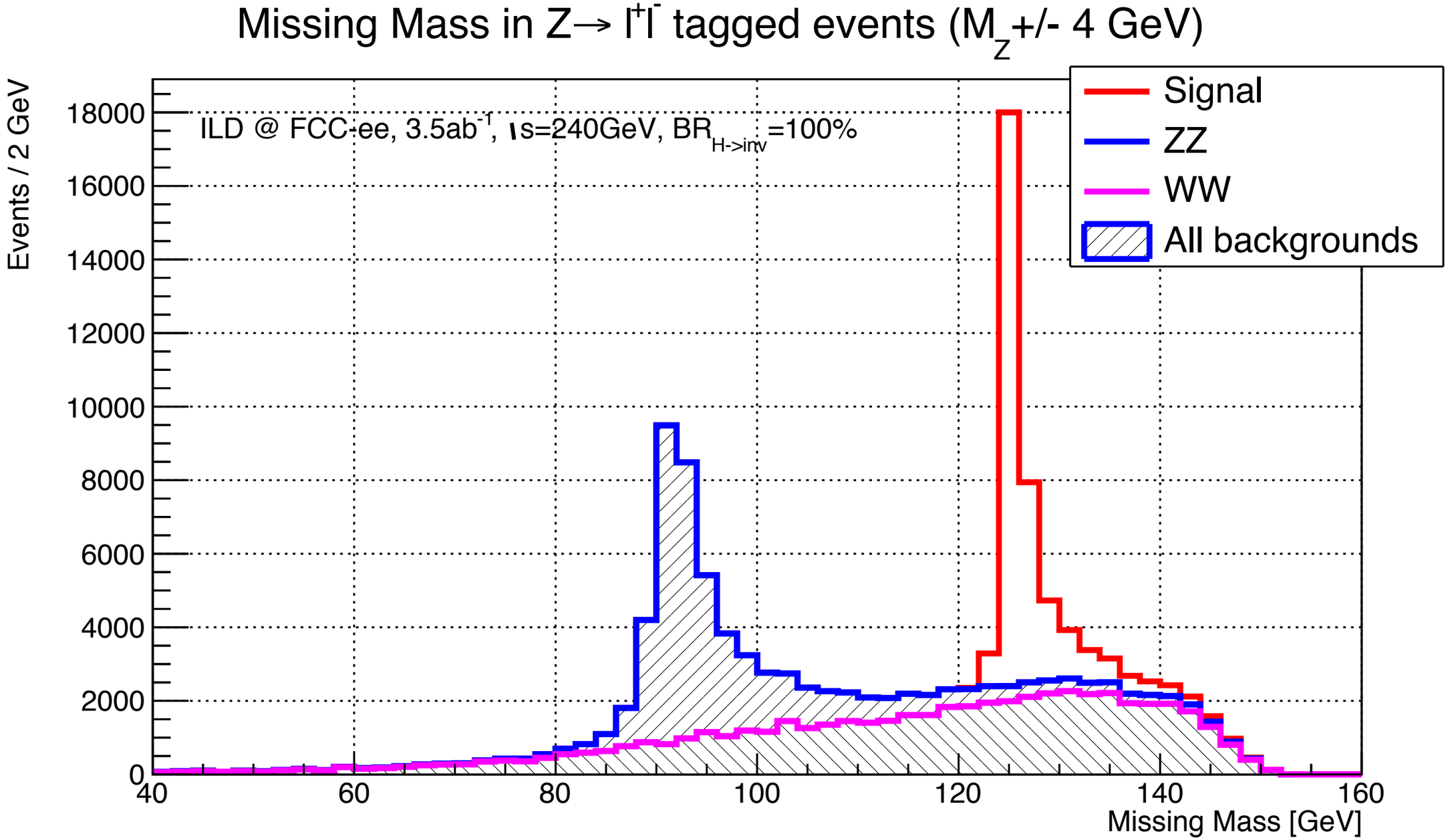
- Tagging Z->ll, from the missing mass we get for 1 y of FCC



$$BR_{lim95\%} = \underline{0.92 \pm (0.30)_{stat} \pm (0.02)_{sys}\%} \text{ , } 68\% \; CL$$

$$BR_{5\sigma} = 2.5 \pm (0.2)_{stat} \pm (0.1)_{sys}\% \text{ , } 68\% \; CL$$

Results for ILD-like detector, 1y of FCC



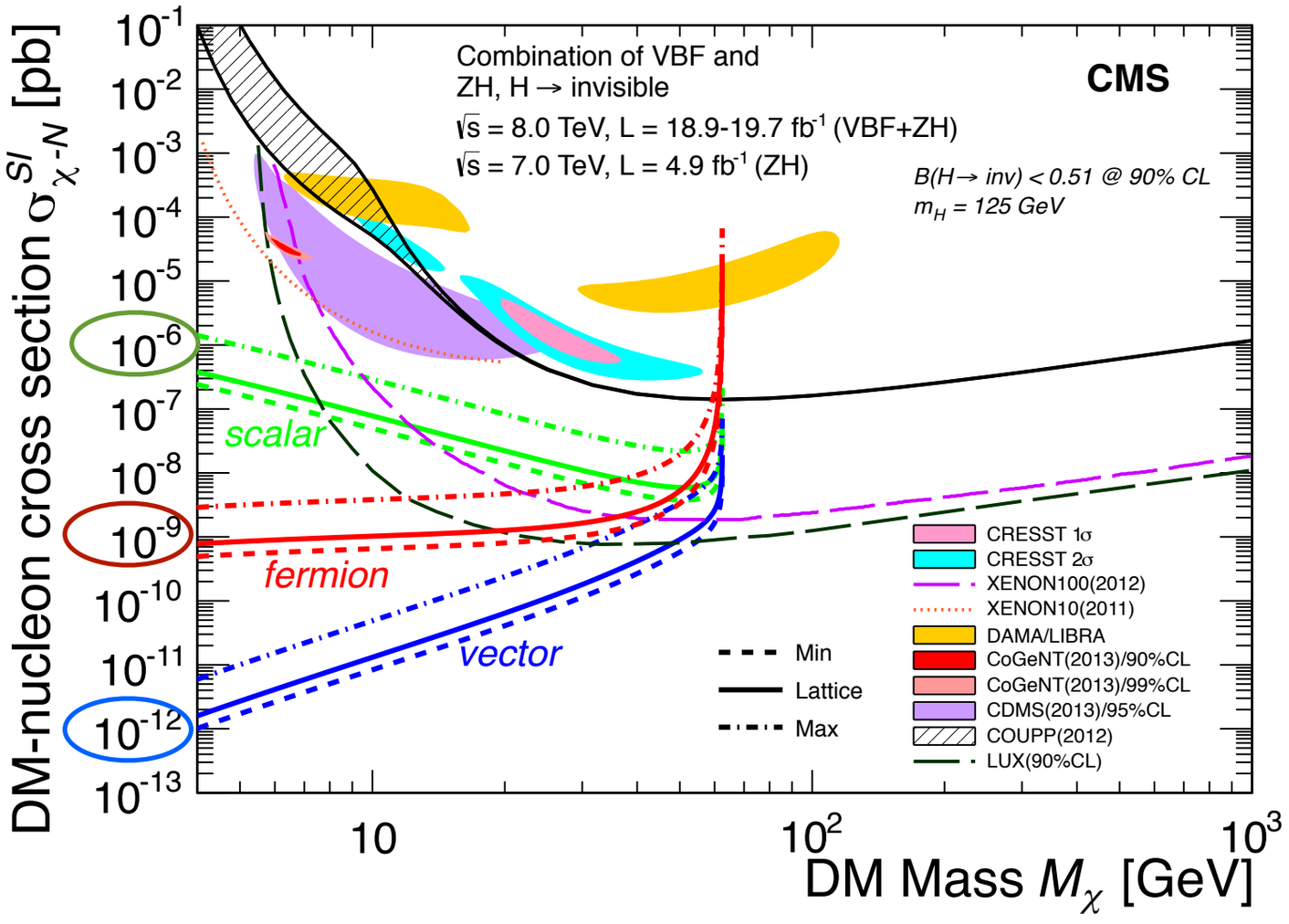
$BR_{lim95\%} = 0.63 \pm (0.20)_{stat} \pm (0.02)_{sys}\%$, 68% CL

$BR_{5\sigma} = 1.7 \pm (0.1)_{stat} \pm (0.01)_{sys}\%$, 68% CL

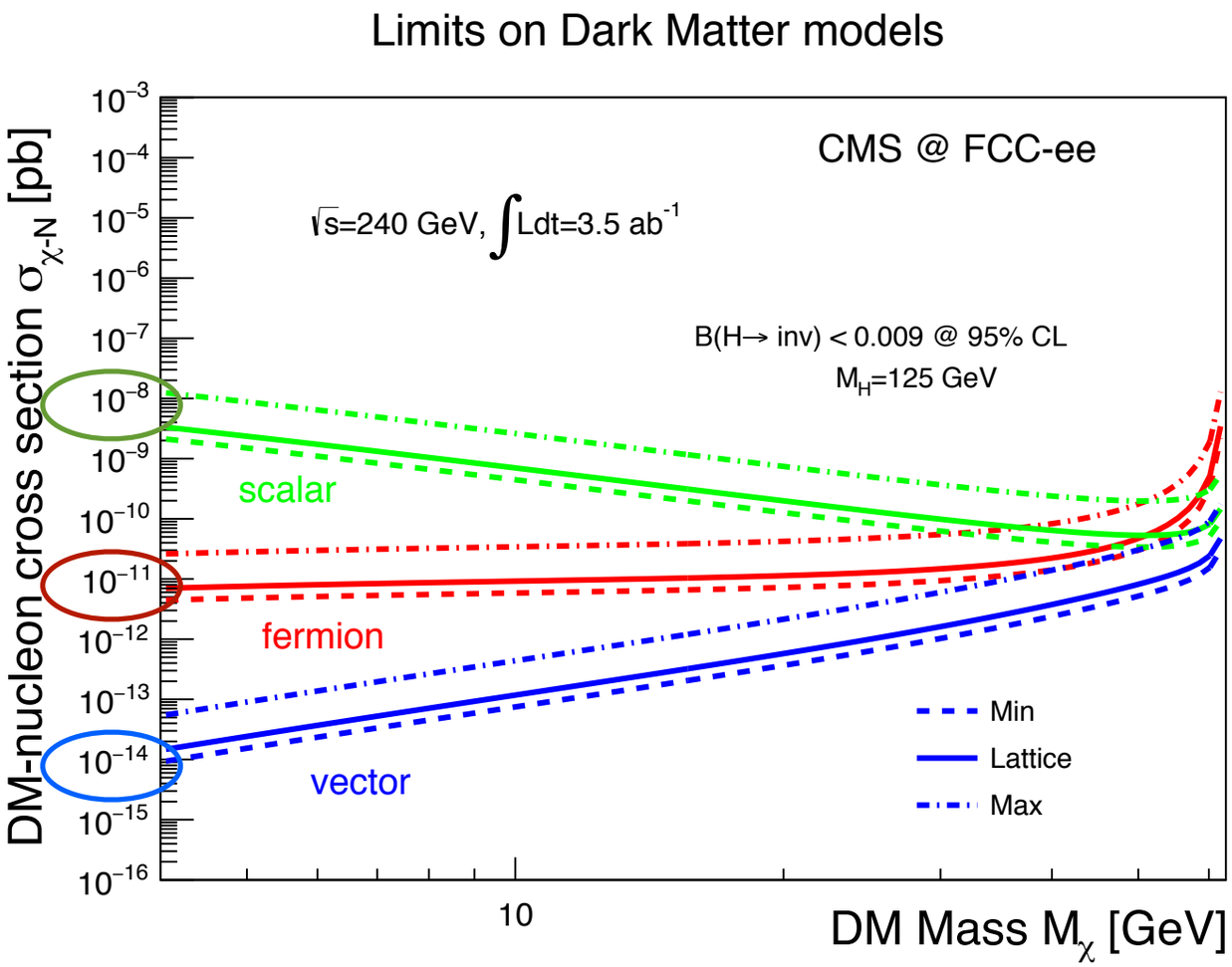
Interpretation in Hidden sector

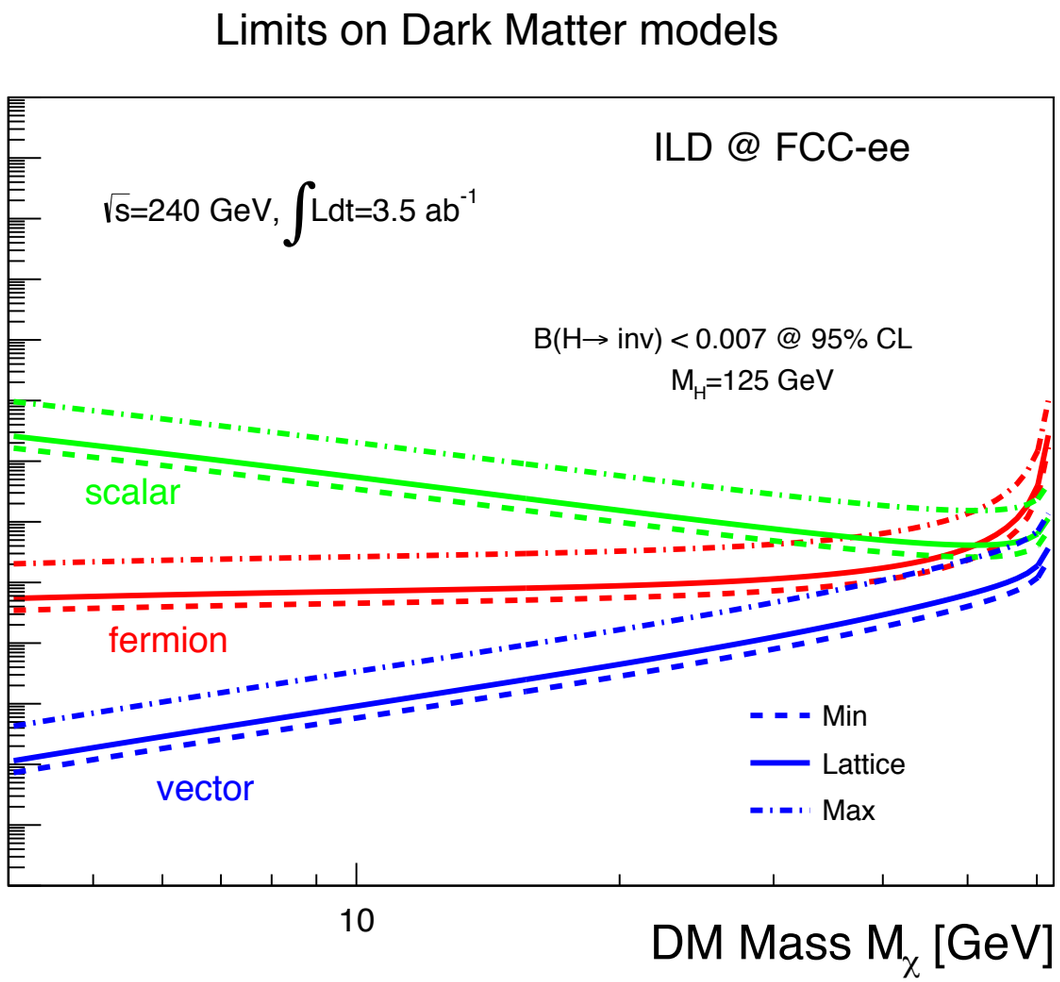
- If the DM candidate has a mass below mH/2, the invisible Higgs boson decay width, Γinv, can be directly translated to the spin-independent DM-nucleon elastic cross section, as follows for scalar (S), vector (V), and fermionic (f) DM
  - . In direct detection experiments, the elastic interaction between DM and nuclei exchanged through the Higgs boson results in nuclear recoil which can be reinterpreted in terms of DM mass, Mχ, and DM-nucleon cross section.

$$B(H \rightarrow inv) = \Gamma inv/(\Gamma SM + \Gamma inv)$$



FCC-ee@3.5ab^{-1}





- We can exclude wrt to current CMS more ~2 order of magnitude lower DM-nucleon cross section

Conclusions

- FCC-ee very well suited for costraining the H->inv width
  - both in indirect than direct way

- With FCC-ee, 1 y of data taking we can reach precision of .5% with just one detector

- This would improve 2! order of magnitude current constraint on the DM-nucleon cross section in the Higgs portal model

BACKUP