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Mono-Higgs: A new 100 TeV collider probe of dark matter

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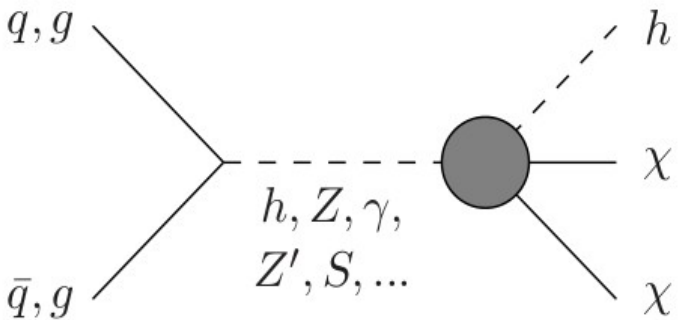
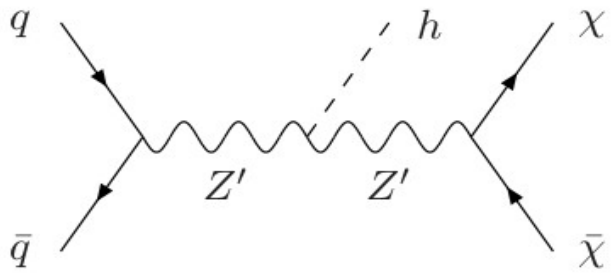
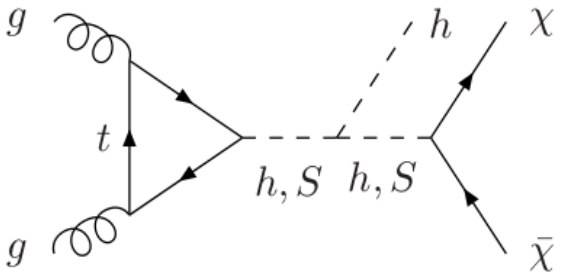
Mono-Higgs DM Models

- Other mono-X channels have DM pair recoiling against X via ISR of X from quark/gluon. ISR suppressed in mono-H, so H and DM emitted from same vertex. This probes the DM-H coupling directly, which is expected if DM acquires mass via H-like mechanism



- Hxx vertex depends on model [1]. Two classes of models (x scalar or fermion, gauge singlet under SM group):
  - EFT: DM couples directly to h via n-dimensional operator, valid at energies below cutoff scale Λ. Simplest case is scalar 4-dim λHHxx (erase grey blob in graph above)
  - Simplified: New massive particle mediates DM-H interaction, ex: Z' vector boson, S scalar coupling only to Higgs field



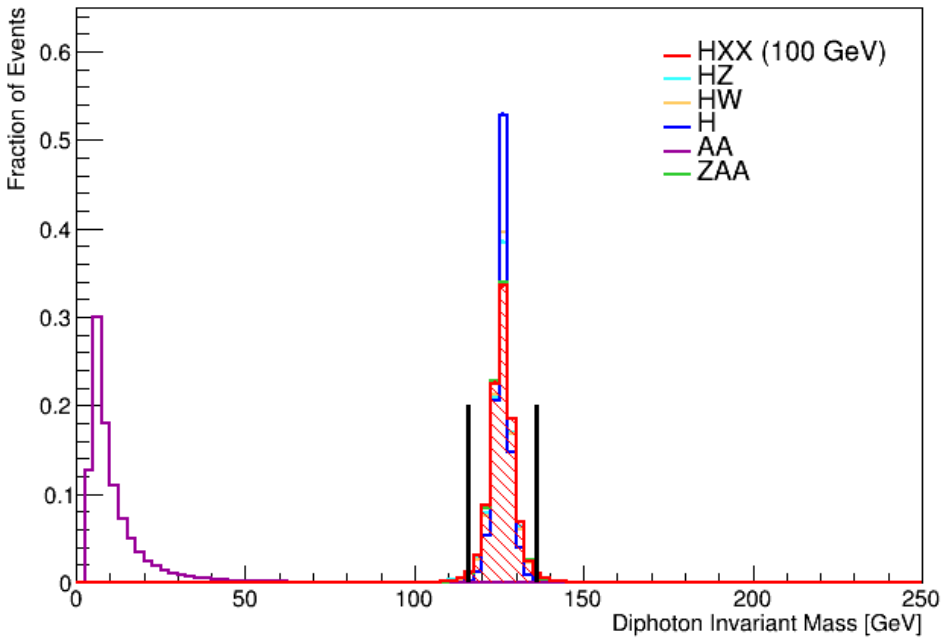


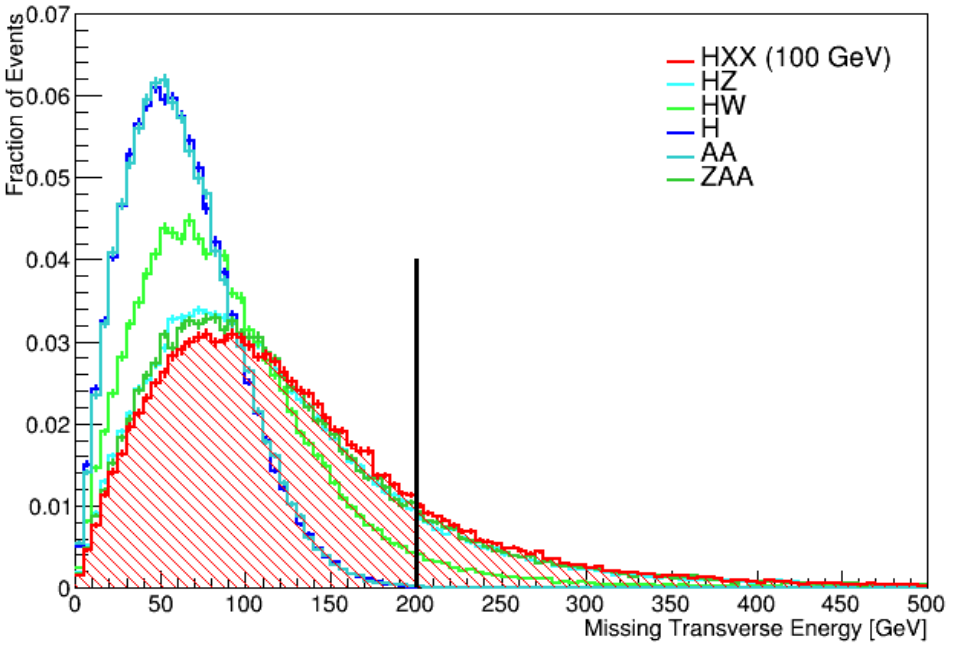
Analysis Plan

- My adviser Prof. Mulhearn and others did 8 and 14 TeV sensitivity study [1]
  - H > gamma gamma and H > ZZ > 4l channels have the most sensitivity, so we'll focus on these for 100 TeV study
- I've adapted analysis code framework to 100 TeV for H > gamma gamma, which I'll present preliminary results for today
  - I plan on expanding framework to include H > ZZ > 4l
- MC generated with Madgraph->Pythia->Delphes sequence for one benchmark DM model (dim-5 EFT, fermion DM, vev/Λ = 0.05, m_x = 1,10, 100,500,1000GeV)
  - Pileup at 100 TeV accounted for manually by scaling MET by ad hoc Gaus(0,50) random factor
  - I need to modify Delphes card to account for pileup to make this more rigorous (tutorial at https://indico.cern.ch/event/315979/)
- MC generated for backgrounds that are expected to be dominant
- Cut and count method with HiggsAnalysis/CombinedLimit tool used to set expected cross section limits

Kinematic Variables and Event Selection

- Below I plot the main variables used in the selection cuts
  - The event must have 2 photons in the final state
  - The histograms are all normalized to one
  - Vertical black lines bound the selected regions
  - Signal benchmark model for m_x = 100 GeV, σ_x = 1 fb





Event Selection and Yields

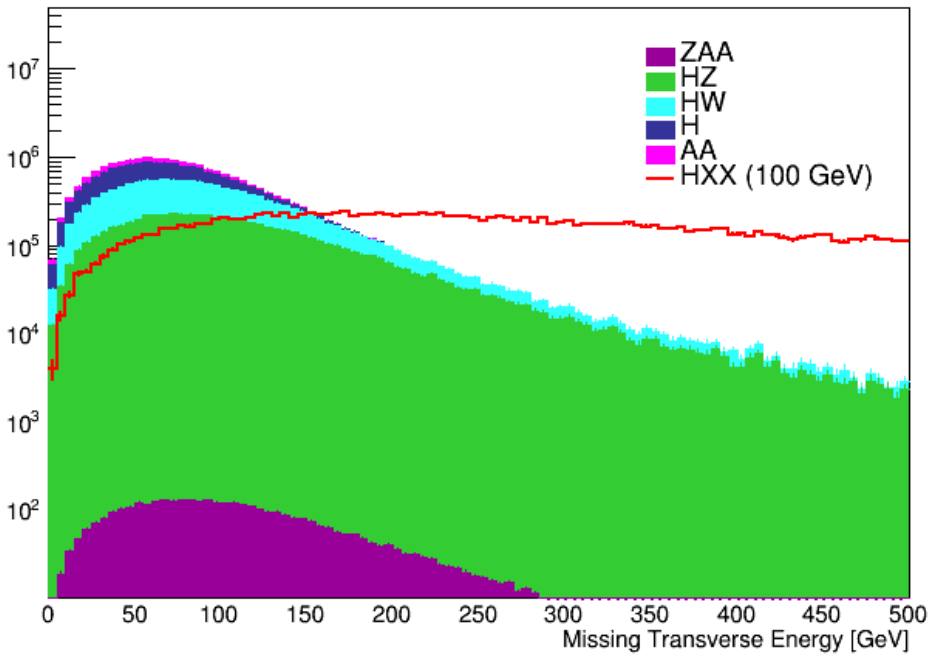
- Exactly two final state photons, each with $p_T > 20$ and $|\eta| < 2.5$
- $m_{\gamma\gamma} \in [116, 136]$ GeV
- Final state leptons have $p_T < 20$ and $|\eta| > 2.5$
- MET > 200 GeV

Channel	Yield
ZH, $Z \to \nu\bar{\nu}$	491702 ± 5763.62
WH, $W \to l\nu$	4944.96 ± 713.743
$H \to \gamma\gamma$	0
$\gamma\gamma$	0
$Z\gamma\gamma$, $Z \to \nu\bar{\nu}$	329.444 ± 4.12062
Total Background	
Total Signal	1170.57 ± 5.92597

Table 1: *Event Yields*

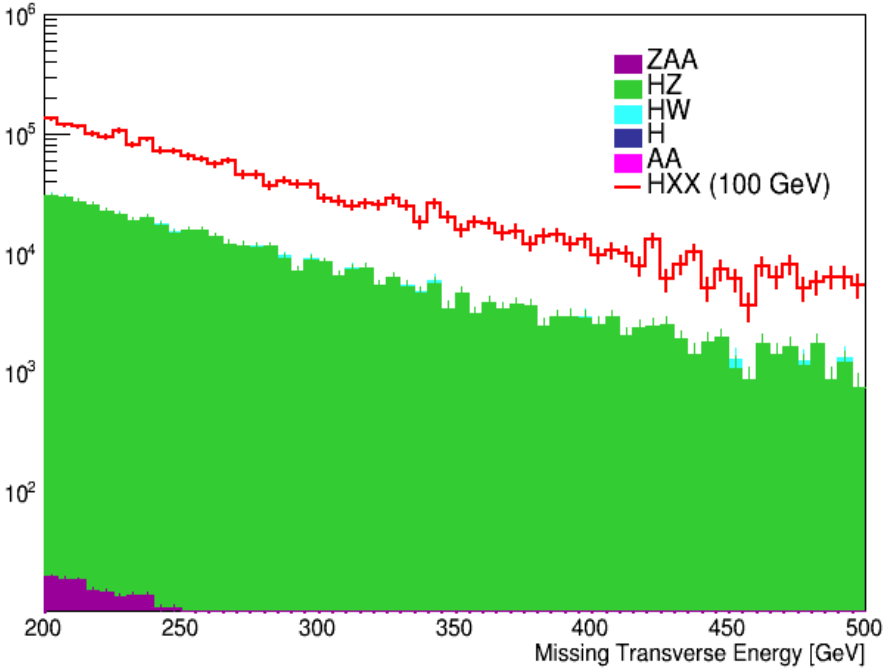
Before cuts:

3000/fb, sqrt(s) = 100 TeV



After cuts:

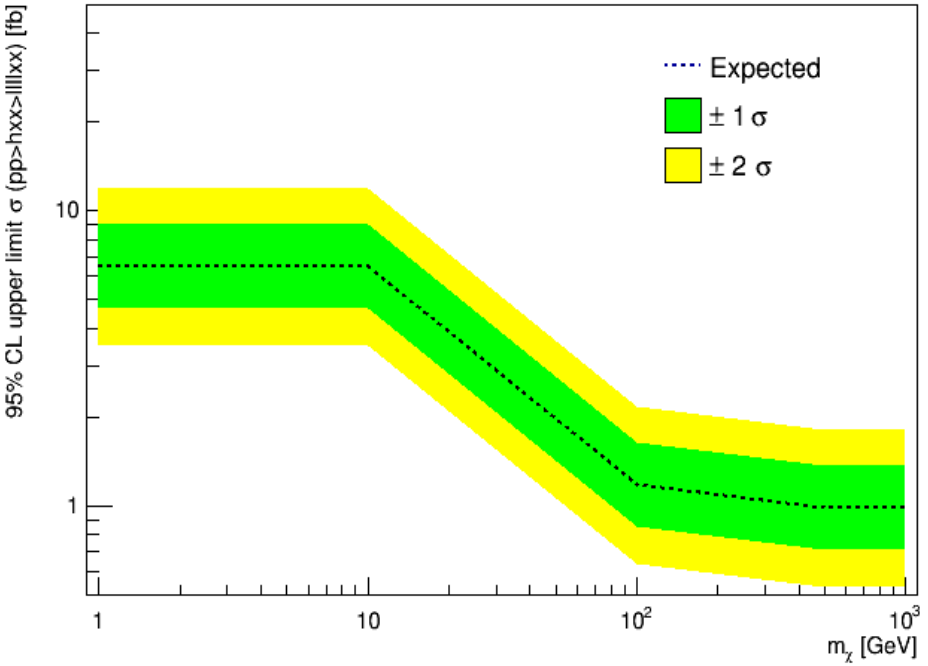
3000/fb, sqrt(s) = 100 TeV



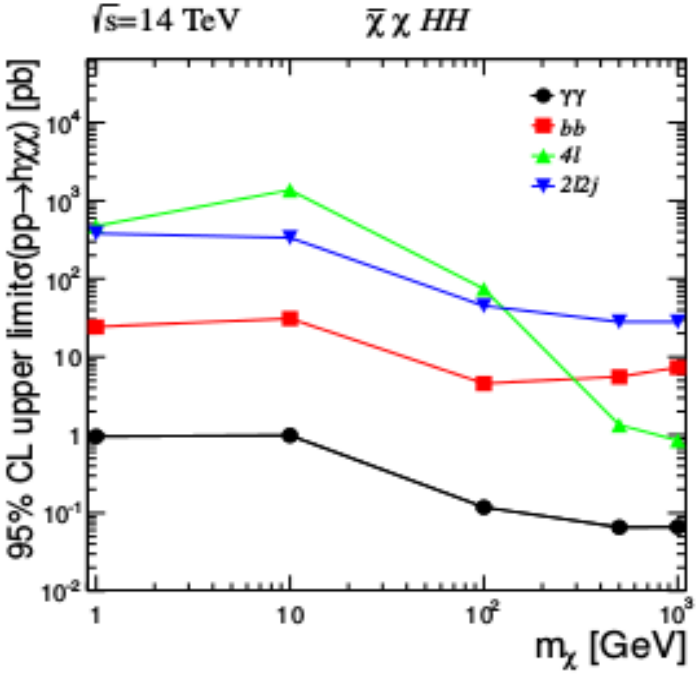
Expected Cross Section Limits

- Using HiggsAnalysis/CombinedLimit tool and event yields, I find non-shape based Bayesian 95% one-sided credible interval (upper limit) and error bands on expected cross section as a function of m_x

First pass Delphes 100 TeV:



Phenom paper 14 TeV:



Next Steps

- Configure Delphes to account for pileup at 100 TeV following tutorial at https://indico.cern.ch/event/315979/
  - Once this is done, regenerate MC for backgrounds, add in other signal benchmark models
- Generalize analysis code framework for H > ZZ > 4l channel
  - Generate MC for these backgrounds and signal models
- Writing independent CLs limit setter to cross check CMSSW tool

References

[1] http://link.aps.org/doi/10.1103/PhysRevD.89.075017