

2HDM+a mono-h \rightarrow bb: mass scans with different m_H & $\sin(\theta)$

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On the behalf of the mono-h \rightarrow bb analysis group

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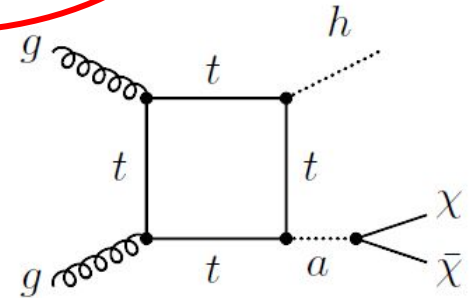
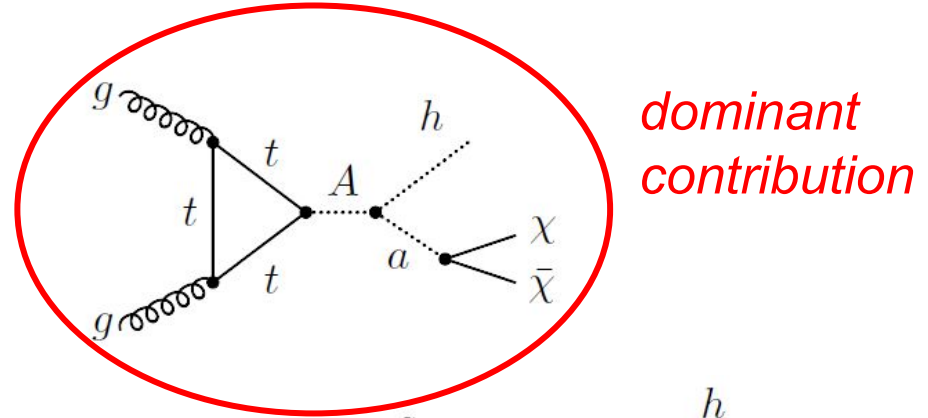
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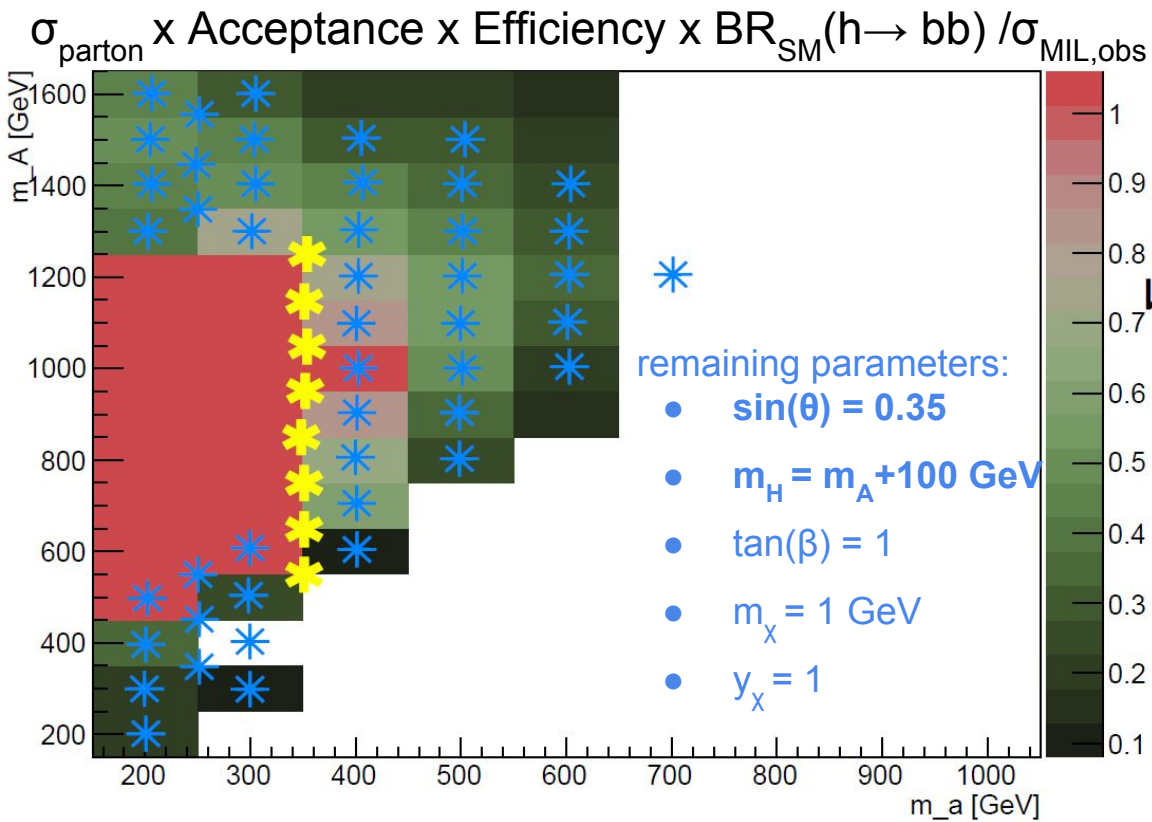
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The Model and its Parameters

- 2HDM+a with pseudoscalar DM-mediators a, A
- <https://arxiv.org/abs/1701.07427>
- **14** parameters in total
 - 7 fixed by symmetry, EW-precision measurements, observed higgs properties,...
- **7** free parameters:
 - **4** affect MET shape:
 - m_a
 - m_A
 - m_H
 - $\sin(\theta)$
 - **3** only affect total cross-section:
 - $\tan(\beta)$
 - m_χ
 - y_χ



Reminder: previous grid proposal



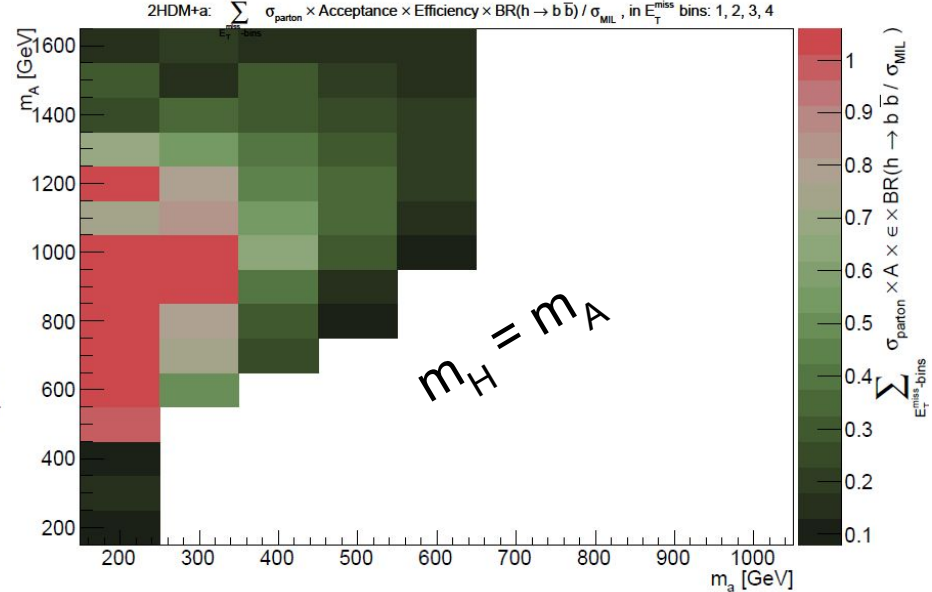
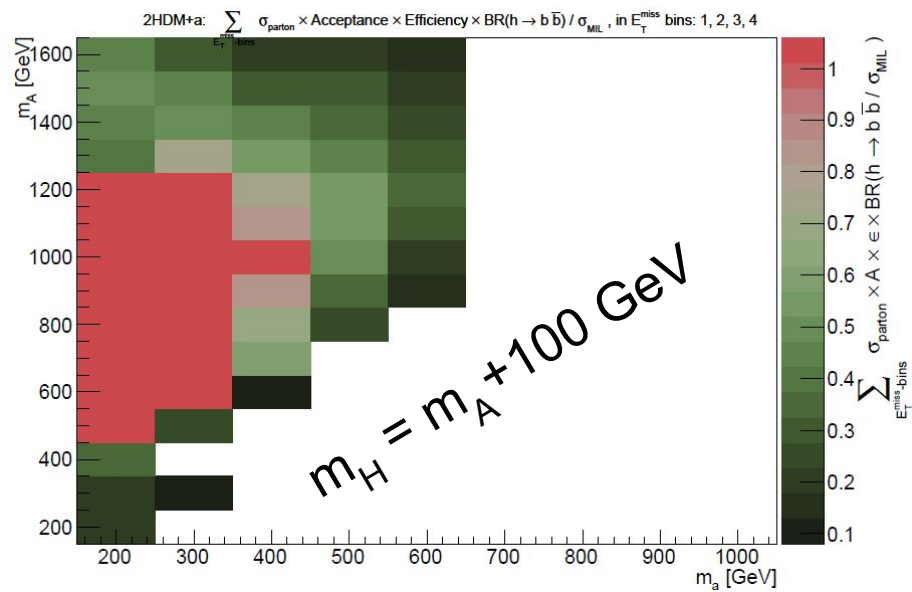
- remaining parameters:
- $\sin(\theta) = 0.35$
 - $m_H = m_A + 100 \text{ GeV}$
 - $\tan(\beta) = 1$
 - $m_\chi = 1 \text{ GeV}$
 - $y_\chi = 1$

1. simulate parton-level x-sec
2. bin into 4 MET bins
3. fold (bin-by-bin) with Acceptance x Efficiency
4. multiply with SM $h \rightarrow \text{bb}$ branching ratio
5. divide (bin-by-bin) by observed upper limit on $\sigma(h \rightarrow \text{bb}) + \text{MET}$
6. sum over 4 MET bins

Range in $E_T^{\text{miss}} / \text{GeV}$	$\sigma_{\text{vis},h+\text{DM}}^{\text{obs}}$ [fb]	$\sigma_{\text{vis},h+\text{DM}}^{\text{exp}}$ [fb]	$\mathcal{A} \times \varepsilon$ %
[150, 200)	19.1	$18.3^{+7.2}_{-5.1}$	15
[200, 350)	13.1	$10.5^{+4.1}_{-2.9}$	35
[350, 500)	2.4	$1.7^{+0.7}_{-0.5}$	40
[500, ∞)	1.7	$1.8^{+0.7}_{-0.5}$	55

$$m_H = m_A + 100 \text{ GeV vs. } m_H = m_A$$

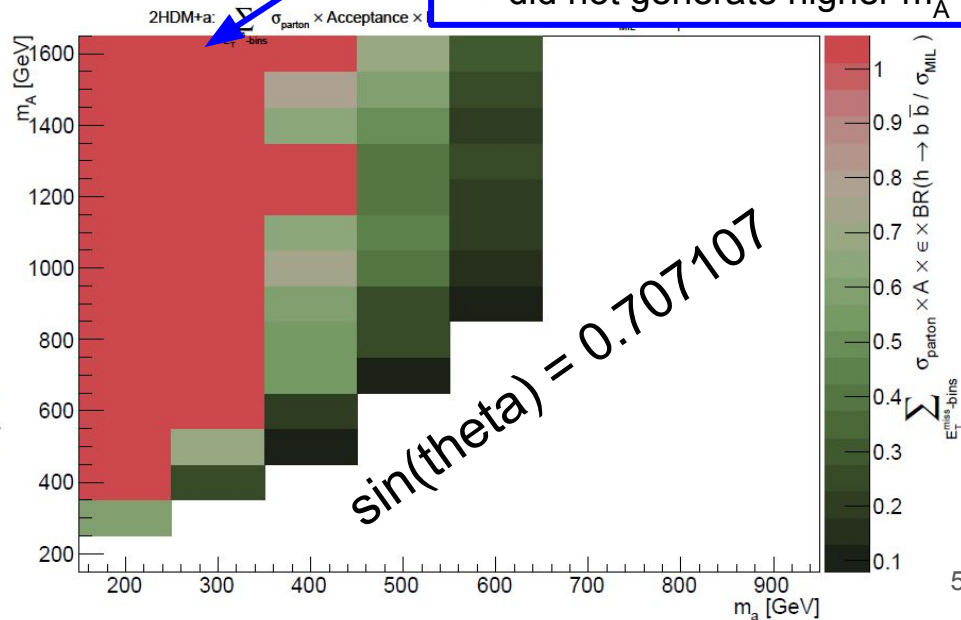
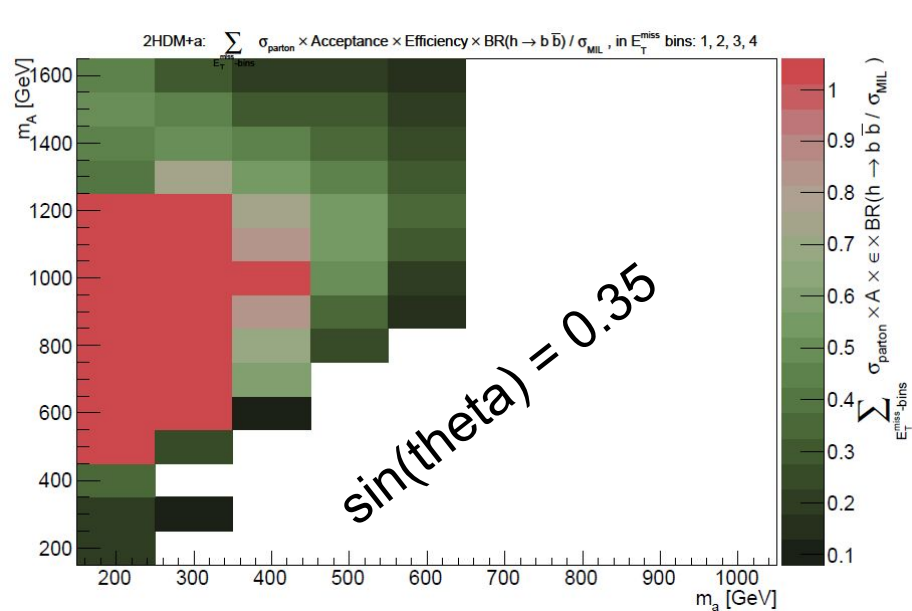
- **less sensitive to $m_H = m_A$** scenario (reduced cross-section)
- would mono-Z benefit much from $m_H = m_A$?
 - \Rightarrow if not, stick to $m_H = m_A + 100 \text{ GeV}$



$\sin(\theta) = 0.35$ vs $\sin(\theta) = 1/\sqrt{2}$

- large significance gain for high- m_A , low- m_a region
 - low-MET, but high x-sec signal
- $\Rightarrow \sin(\theta)$.the-reweighting of interest here

Width of A $\sim m_A/3$. for $m_A \geq 1.5$ TeV
 \Rightarrow cannot rely on Auto-Calc.
 Widths
 \Rightarrow did not generate higher m_A

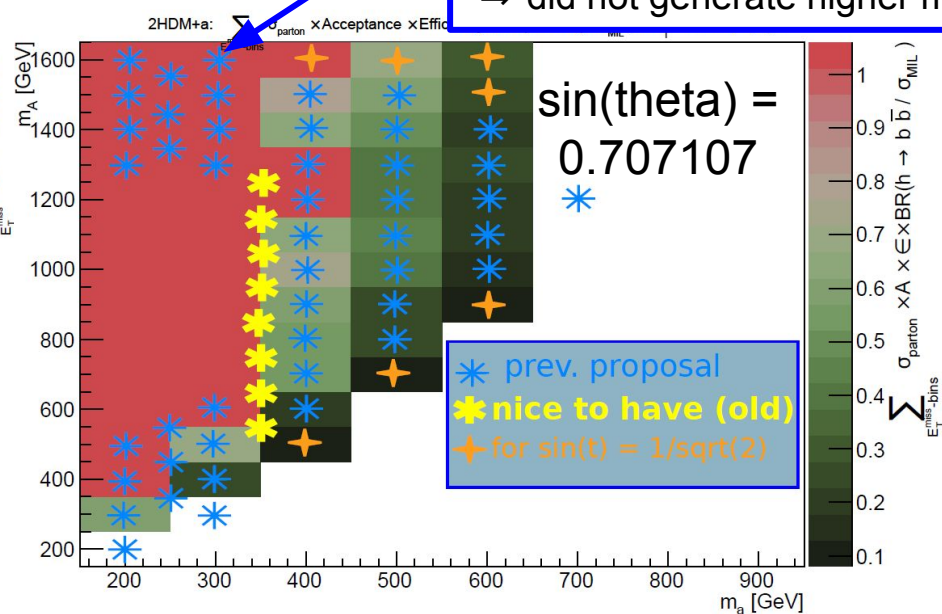
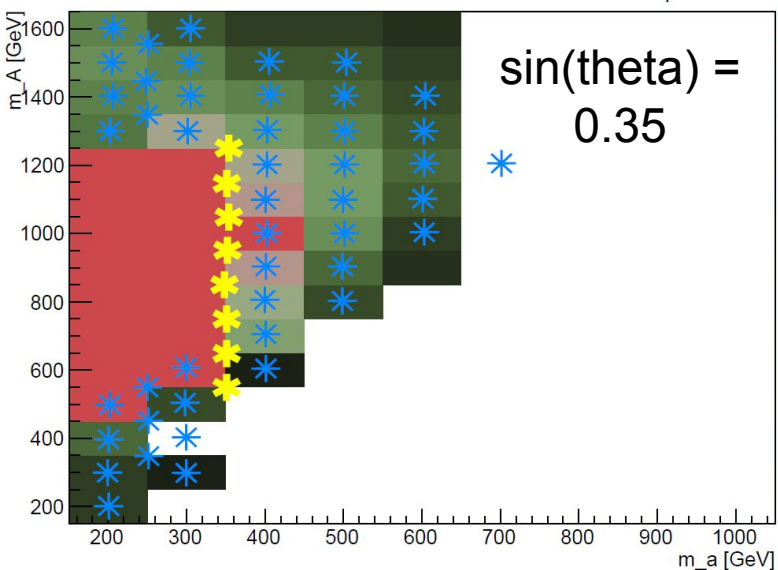


$\sin(\theta) = 0.35$ vs $\sin(\theta) = 1/\sqrt{2}$

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 \Rightarrow did not generate higher m_A

Signal significance, summed over the four E_T^{miss} bins



* prev. proposal
 * nice to have (old)
 + for $\sin(\theta) = 1/\sqrt{2}$

Summary

- repeated m_a , m_A scans with different m_H , $\sin(\theta)$
 - $m_H = m_A$ (prev.: $m_H = m_A + 100$ GeV)
 - decreased sensitivity
 - $\sin(\theta) = 0.707107$ (prev.: $\sin(\theta) = 0.35$)
 - higher sensitivity in $m_A \gg m_a$ region
- Conclusions:
 - keep $m_H = m_A + 100$ GeV
 - would mono-Z benefit from $m_H = m_A$?
 - try to get $\sin(\theta)$ reweighting to work

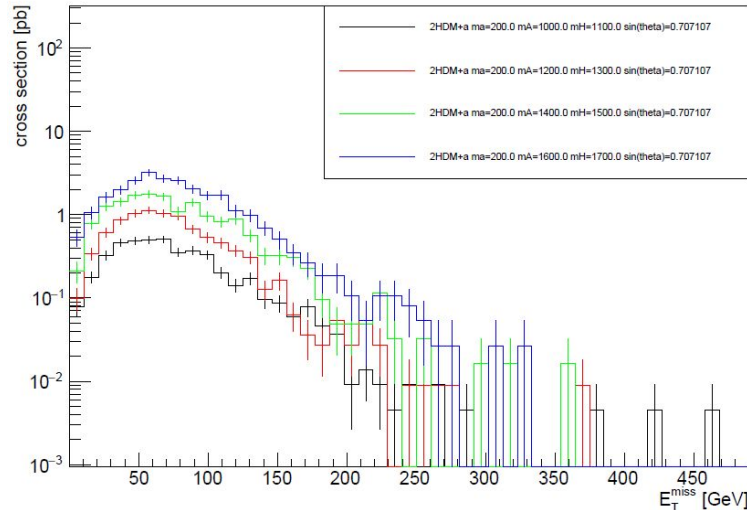
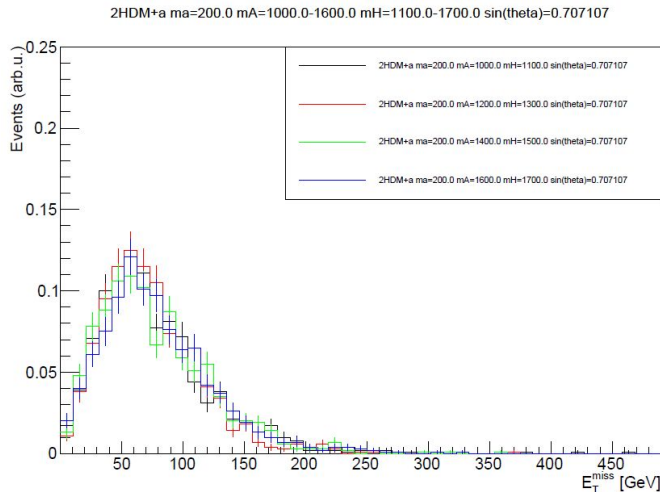
Backup

Backup:

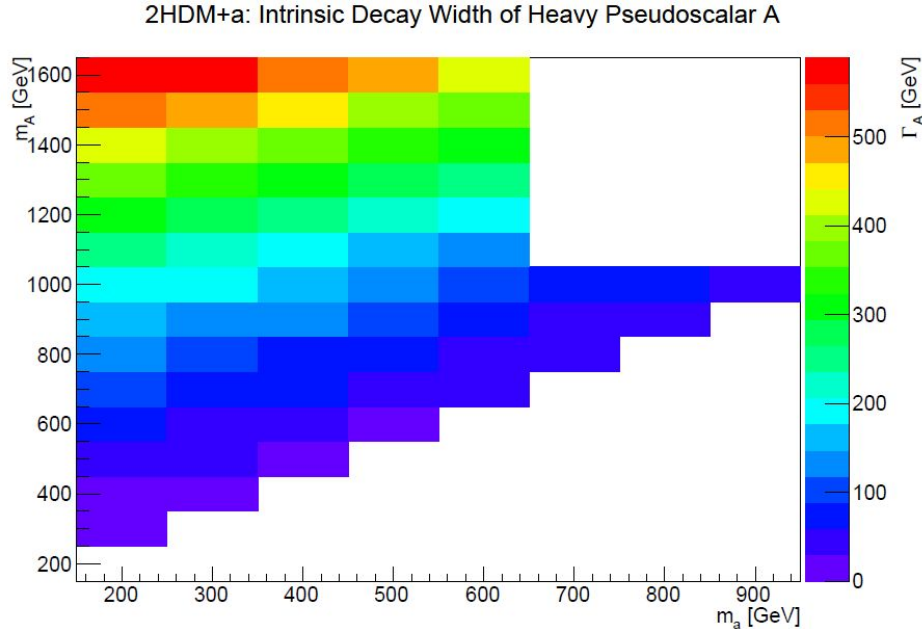
m_A signal degeneracy for $\sin(\theta) = 1/\sqrt{2}$

- only minor signal shape changes from changing m_A ($\gg m_a$) for $\sin(\theta) = 1/\sqrt{2}$
- dominant effect is cross-section increase
- \rightarrow exclusion largely independent of m_A in this region

2HDM+a $m_a=200.0$ $m_A=1000.0-1600.0$ $m_H=1100.0-1700.0$ $\sin(\theta)=0.707107$



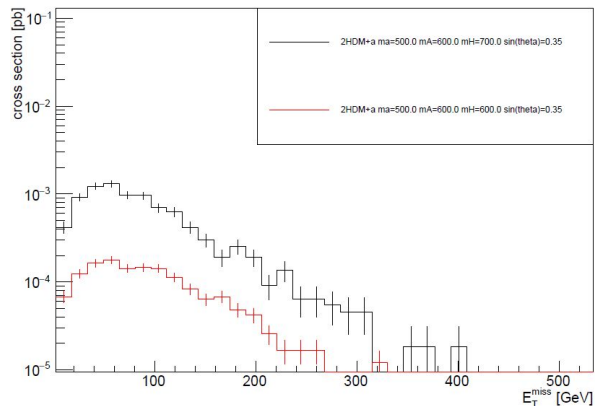
Backup: The Width of A



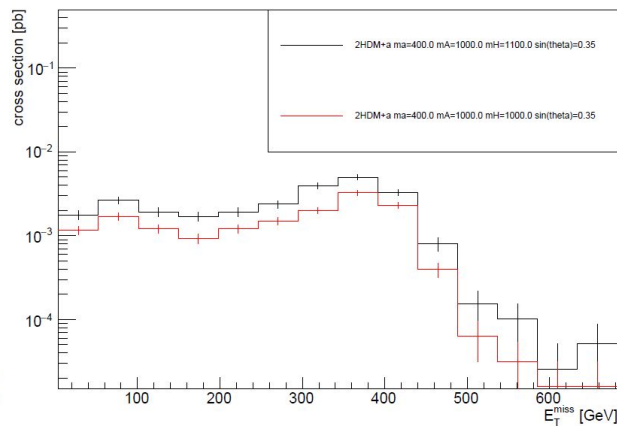
- with $\sin(\theta) = 1/\sqrt{2}$, the width of A is comparable to $m_A/3$ for $m_A \gg m_a$
 - \Rightarrow NWA breaks down
 - cannot trust MG's width calculations for width $> m/3$

Backup: Signal shapes for different m_H

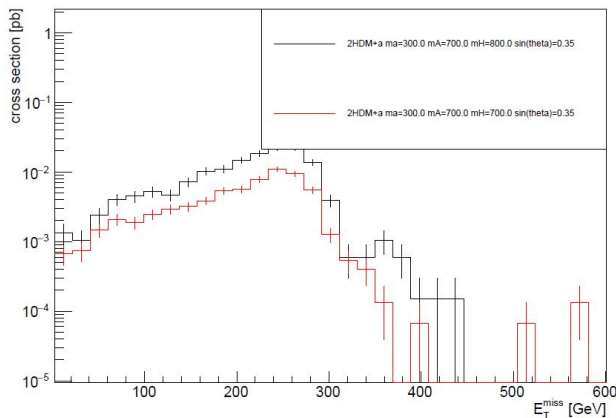
2HDM+a $m_a=500.0$ $m_A=600.0$ $m_H=600.0-700.0$ $\sin(\theta)=0.35$



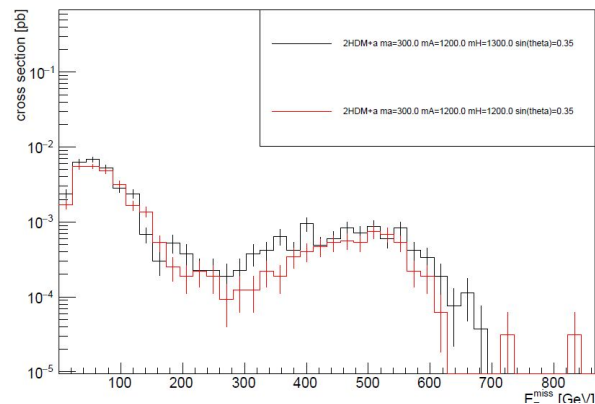
2HDM+a $m_a=400.0$ $m_A=1000.0$ $m_H=1000.0-1100.0$ $\sin(\theta)=0.35$



2HDM+a $m_a=300.0$ $m_A=700.0$ $m_H=700.0-800.0$ $\sin(\theta)=0.35$

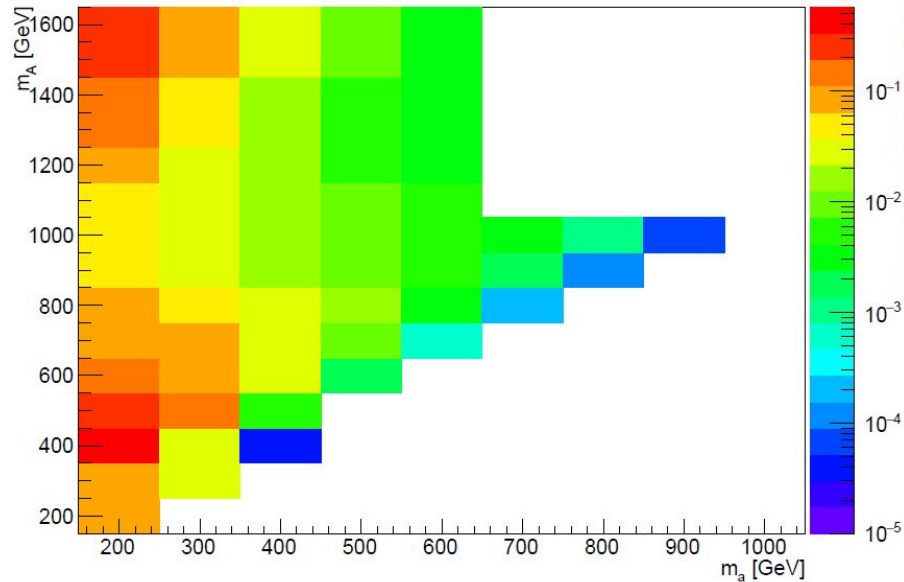


2HDM+a $m_a=300.0$ $m_A=1200.0$ $m_H=1200.0-1300.0$ $\sin(\theta)=0.35$



Backup: Parton-level x-sec for $m_H = m_A$

2HDM+a: parton level cross section



2HDM+a: parton level cross section, after a MET ≥ 150 GeV Cut

