Study of the 2HDMPZ2 Model for Mono Higgs(→bb)

Shin-Shan Eiko Yu
National Central University, Taiwan

Benedikt Maier
Massachusetts Institute of Technology, USA

2017/04/28 LHC Dark Matter Working Group Meeting

1

Introduction

- The 2HDMPZ2 model is detailed in arXiv:1701.07427

  - generate p p > xd xd~ h1 / z [QCD]

  - Studies are done after MADGRAPH+PYTHIA8 only, no full simulation

- Focus on only a set of parameters

  - $M(H^0)=M(H^\pm)=750$ GeV, $M(A)=500$ GeV

  - $M(DM)=1$ GeV

  - Vary $M(a)$ from 50 GeV to 600 GeV

  - Avoid $M(a)=500$ GeV and use $M(a)=490$ GeV

  - Operate in decoupling/alignment limit → light scalar boson h == SM Higgs

  - Decay widths of all Higgs bosons are set to AUTO

- We would like to see the dependence of kinematic distributions and cross sections on sinp and tanbeta

Additional Information

- MadGraph5_aMC@NLO version 2.4.2

  - Using default dynamic scale of MadGraph

  - Built-in NNPDF2.3 LO

    - cross checked: consistent results with NNPDF3.0

  NB: observed large differences between MadGraph5_aMC@NLO version 2.3.3 and 2.4.2. Most recent MG version (2.5.4) gives results consistent with 2.4.X)

Shin-Shan Eiko Yu

Higgs Naming Convention in 2HDMPZ2II

Human-readable Name	Name in Parameter Cards	
Standard-model-like Higgs		h1
	Vev Ratio $\tan\beta$	
Heavy neutral scalar H (mass set to 750 GeV)		h2
Pseudo-scalar A (mass set to 500 GeV)		h3
	Mixing: $\sin\theta$	
Charged scalar H± (mass set to 750 GeV)		hc
Pseudo-scalar a (variable mass)		h4

h3 ←→ h4 can be interchanged
b loops are Yukawa suppressed

Shin-Shan Eiko Yu
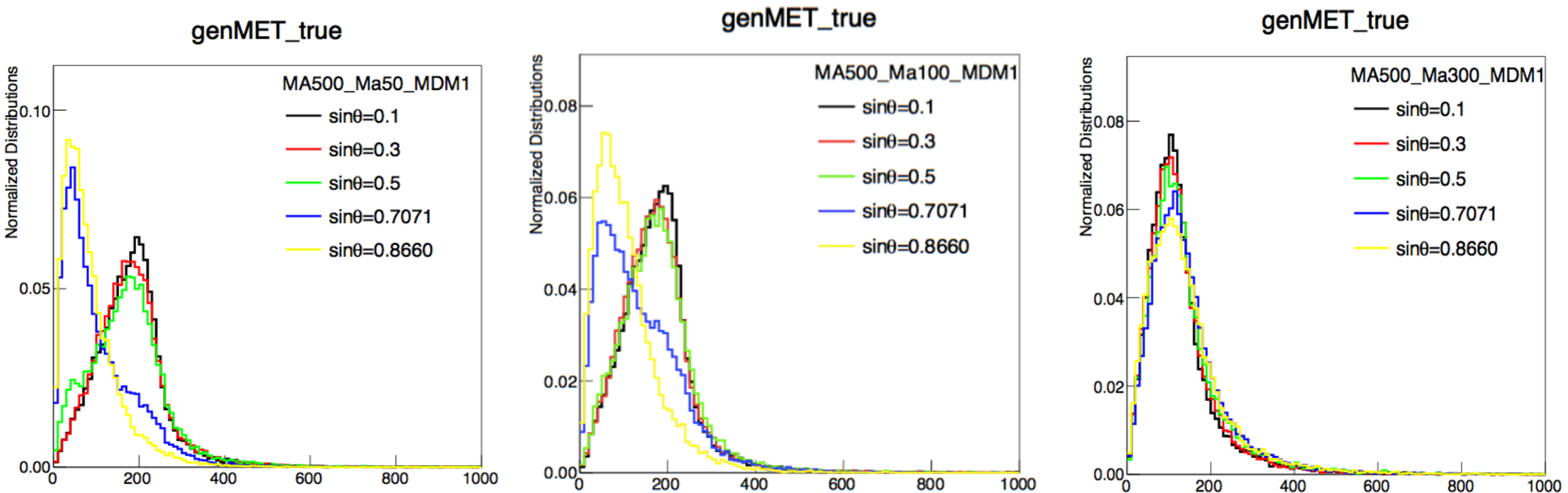
4
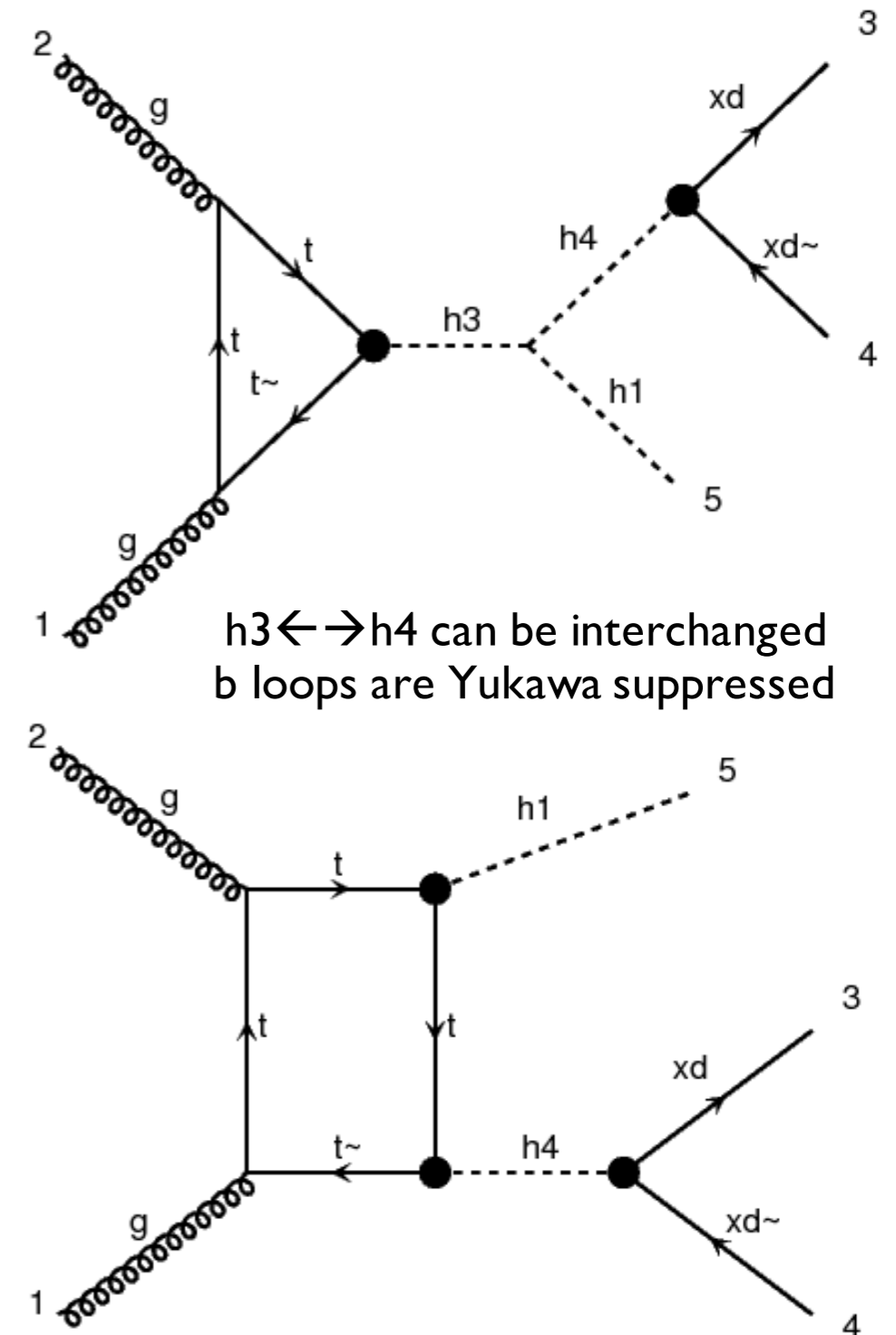
Vary sinp (sine of mixing angle between A and a) and vary M(a)

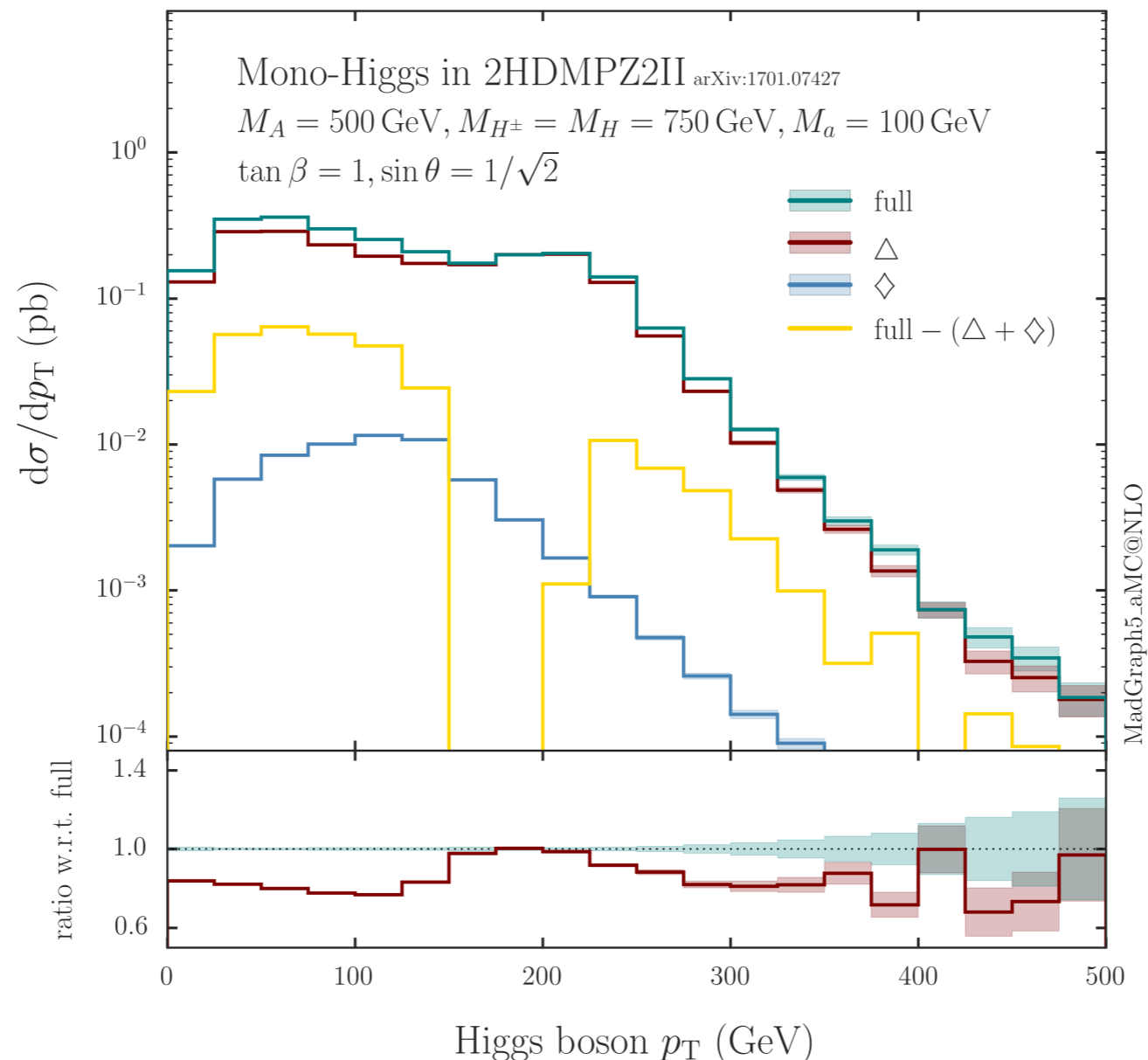# Generator-level Missing Et

- keep tanβ=1

- Strong dependence of kinematics on sinp

- Additional peak appearing if A can be resonanlty produced, i.e. if M(a)+M(h1)<<M(A)

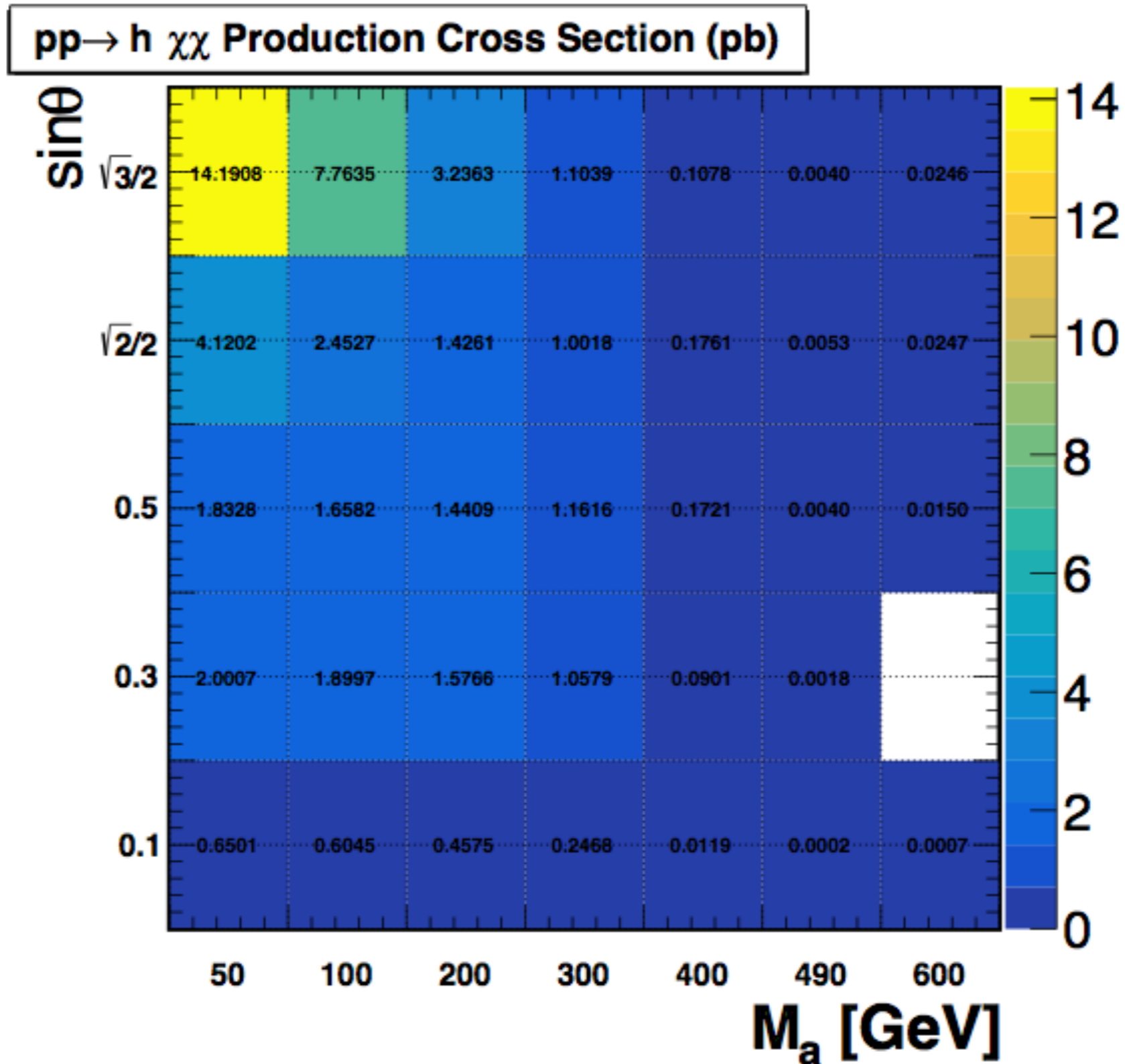genMET_true — MA500_Ma50_MDM1, MA500_Ma100_MDM1, MA500_Ma300_MDM1 (sinθ=0.1, 0.3, 0.5, 0.7071, 0.8660)
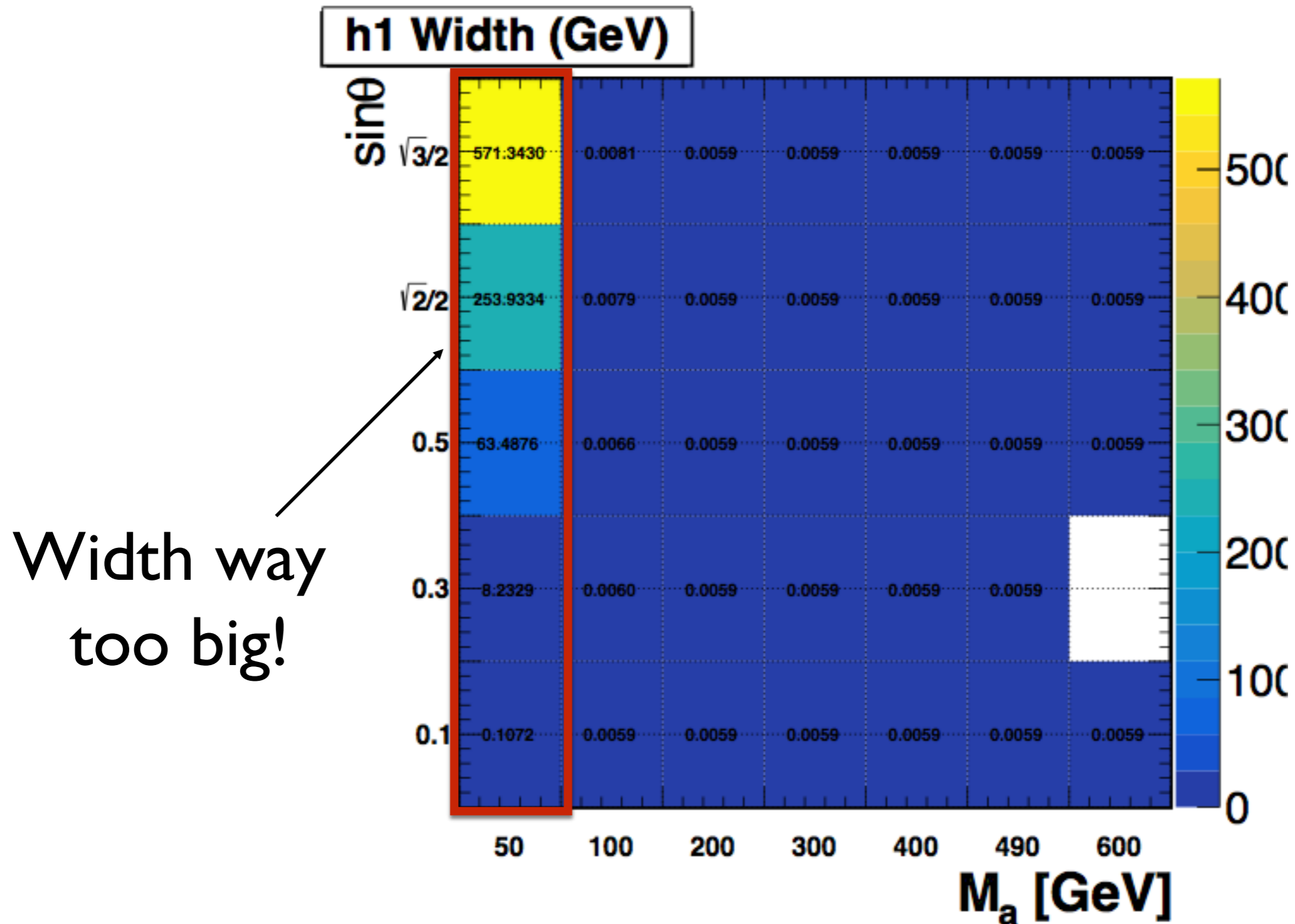
A closer look into mixing A/a

- Splitting up generation into triangle and box diagrams

- Done for Ma=100 GeV

- Around second peak, A produced resonantly in triangle diagrams (s-channel)

  - → Also dominant contribution on inclusive level; box diagrams subdominant; interference sometimes up to 30%


Mono-Higgs in 2HDMPZ2II arXiv:1701.07427
$M_A = 500\,\text{GeV}, M_{H^\pm} = M_H = 750\,\text{GeV}, M_a = 100\,\text{GeV}$
$\tan\beta = 1, \sin\theta = 1/\sqrt{2}$

full
$\triangle$
$\diamond$
full $- (\triangle + \diamond)$

MadGraph5_aMC@NLO

Shin-Shan Eiko Yu

Inclusive Production Cross-section

pp→ h χχ Production Cross Section (pb)
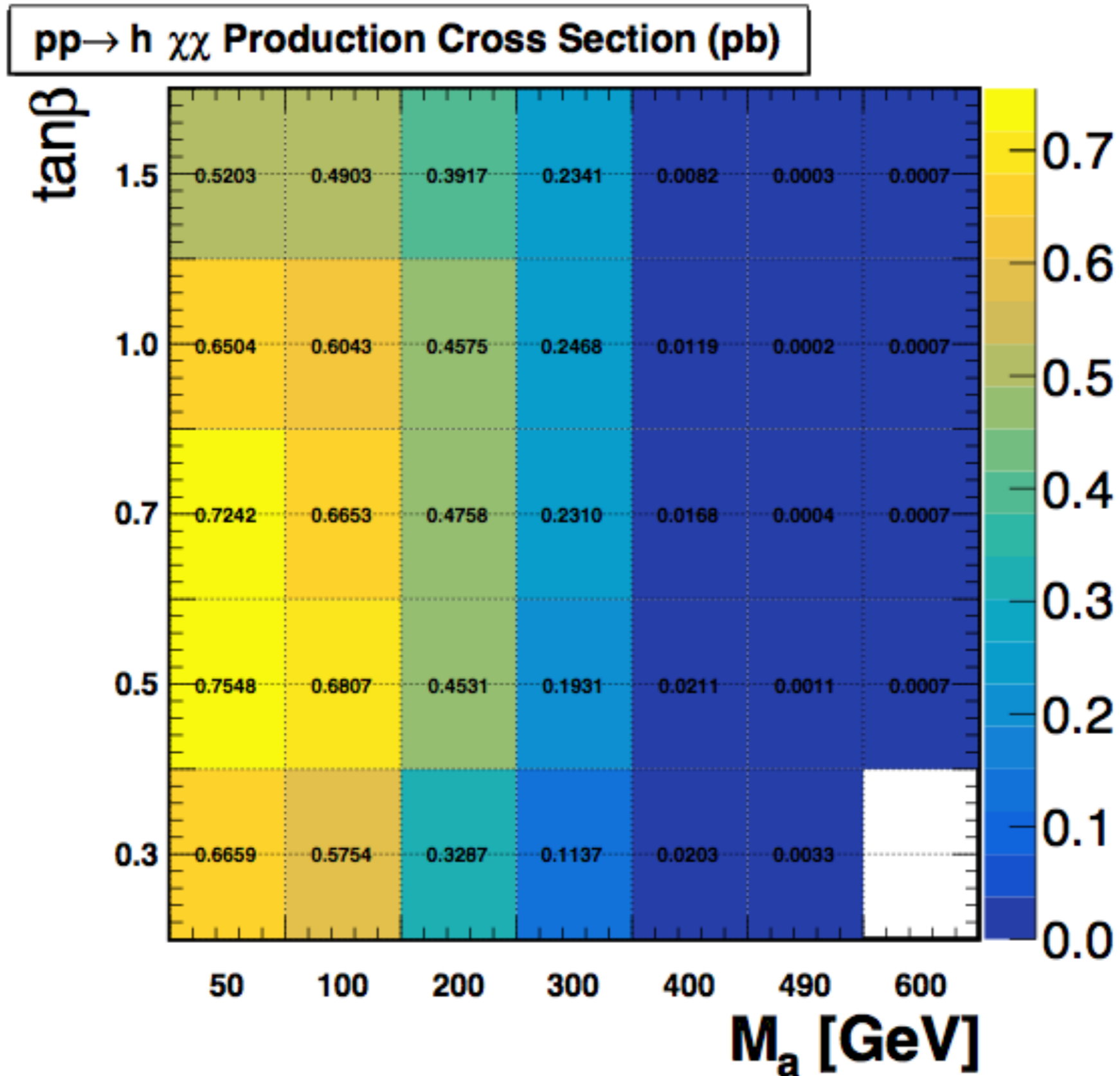
Width of standard-model-like Higgs h1

Width way too big!

Vary tanβ (ratio of vacuum expectation values of 2HDM)

Generator-level Missing Et

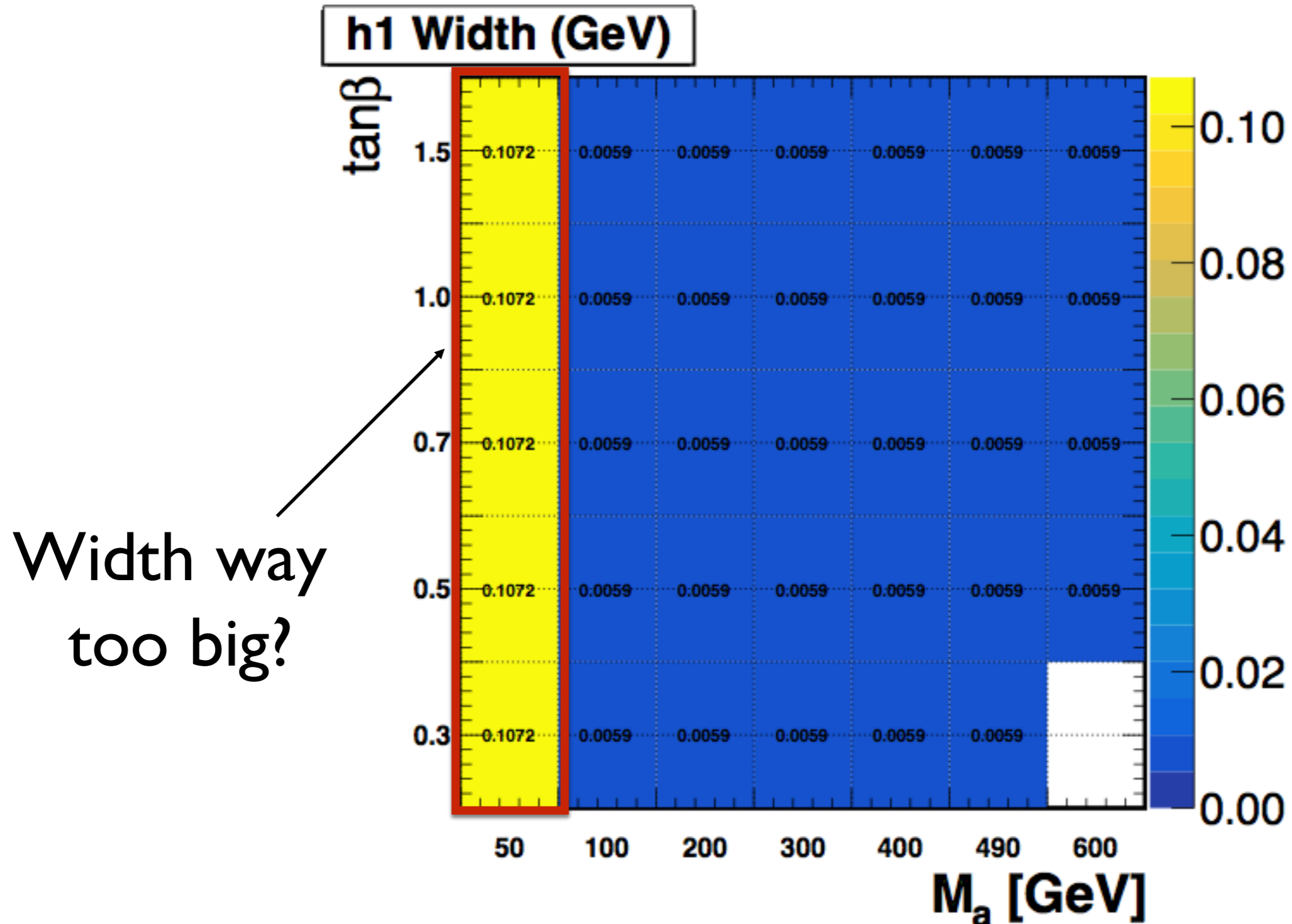- keep sinp=0.1

- Slight dependence of kinematics on $\tan\beta$

Inclusive Production Cross-section

Shin-Shan Eiko Yu
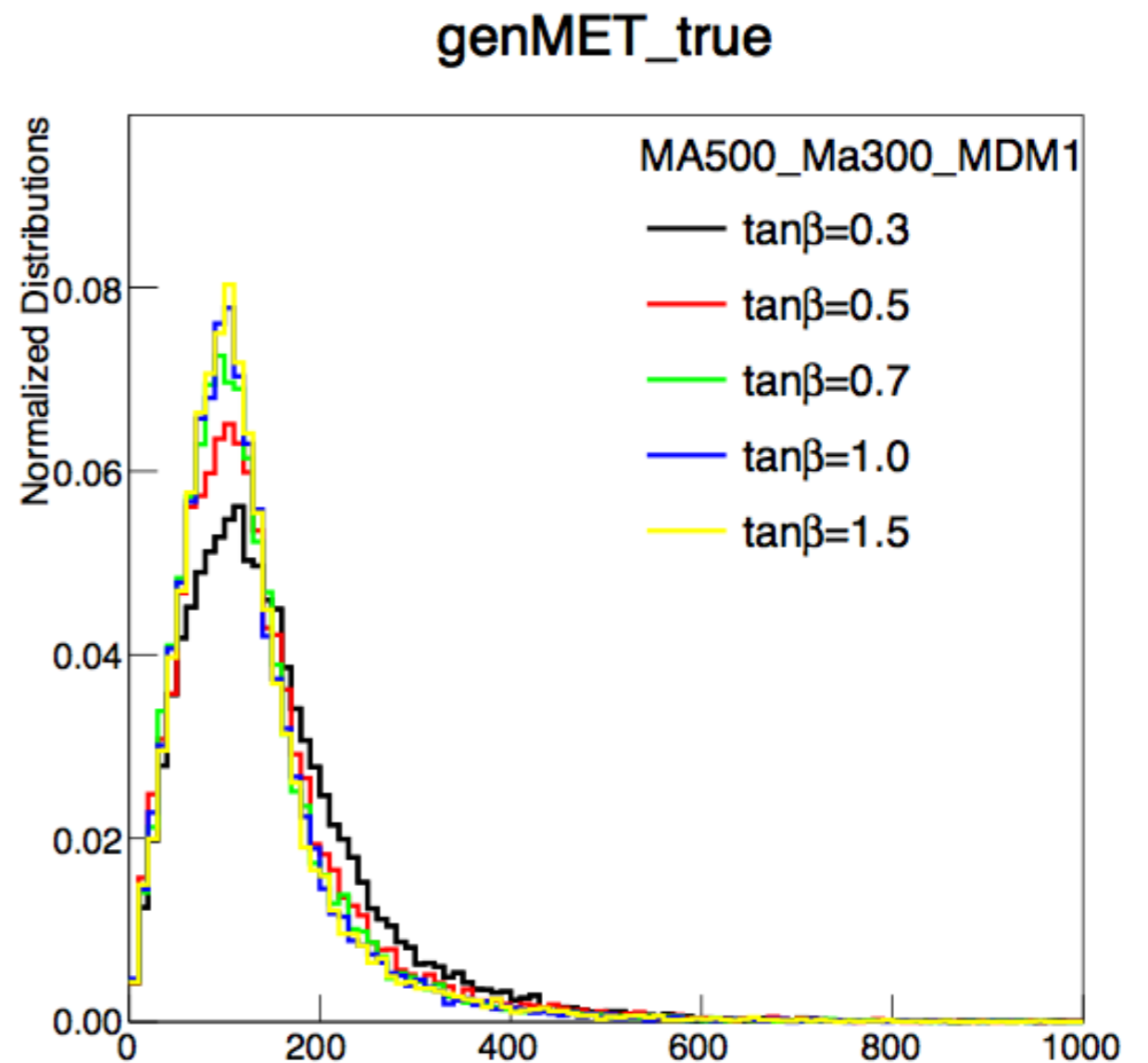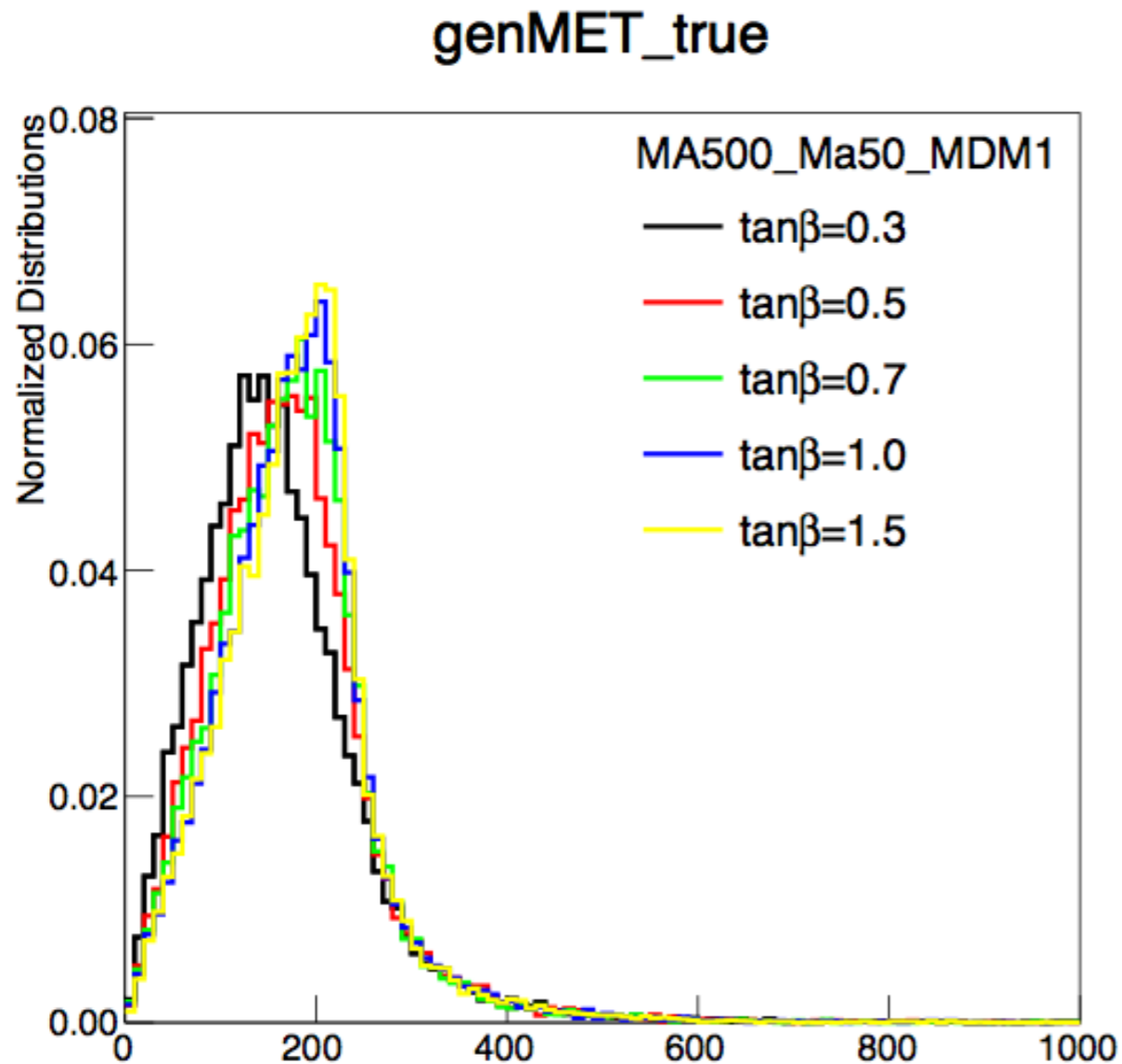
Width of standard-model-like Higgs h1

- Widths of other Higgs bosons are [here](#) and [sinp=√2/2](#)

Conclusion

- For a given set of mass points, the kinematic distributions have non-zero dependence on sinp and tanβ

- M(a)=M(A)-M(h) seems to be a transition point for kinematics because of on/off-shell A production

- It seems that we need to avoid Mh>2*Ma GeV to get sensible width for the standard-model-like Higgs boson h1

Shin-Shan Eiko Yu