中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

2022年9-12月研究生考核报告

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Content

Resonant $HH \rightarrow WW\gamma\gamma$

Motivation

GEN level study

object selection and event selection

Data/MC comparison

DNN training

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Gantry A3200 & Labview 2021 update

Gantry code update

Gantry calibration

Plans

Resonant HH $\rightarrow$ WW$\gamma\gamma$

Motivation

X→ HH → WW$\gamma\gamma$

Many BSM theories have predicted resonant Higgs-pair production

the warped extra dimension model predict the spin-0 radion and spin-2 graviton resona

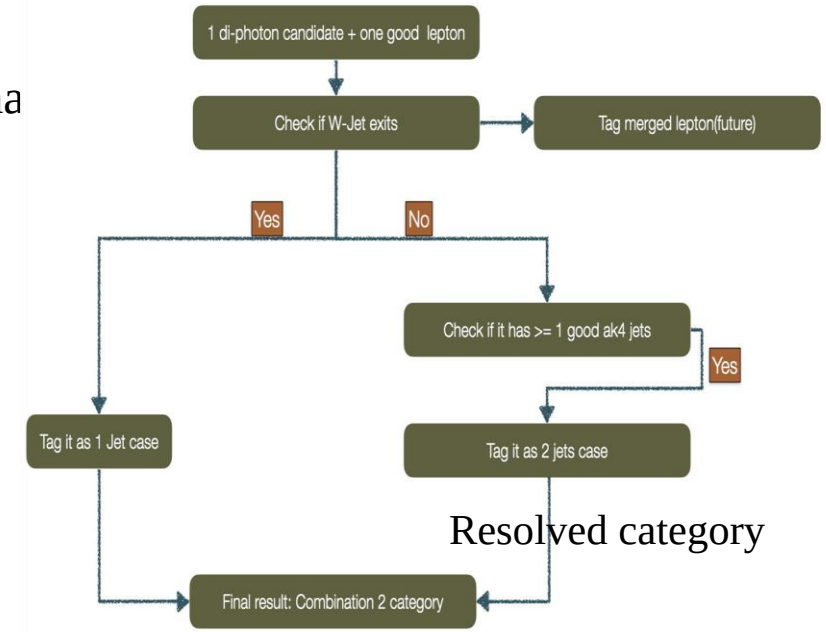
two higgs doublet model predict a spin0 heavy higgs boson which decay to dihiggs

First study of having the direct coupling with *WW$\gamma\gamma$* final state in CMS

Why *WW$\gamma\gamma$* Final state ?

the WW has second large BR in Higgs decay

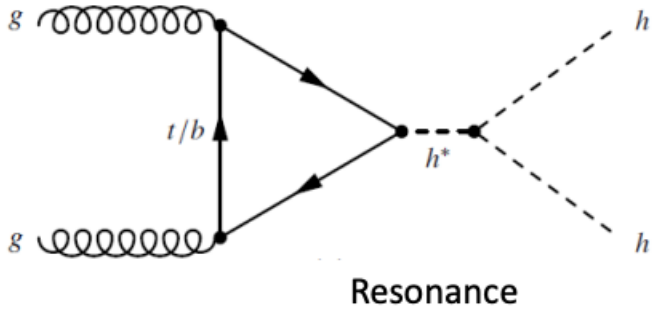
$\gamma\gamma$ has good mass resolution, easy to trigger and have high efficiency



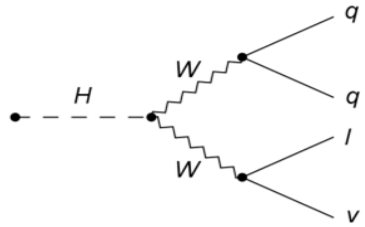
Boosted category

Resolved category

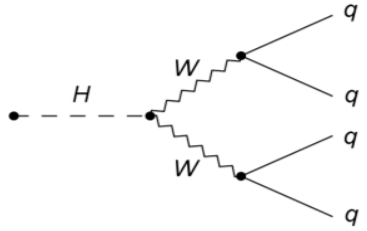
Semi-leptonic channel strategy



Resonance



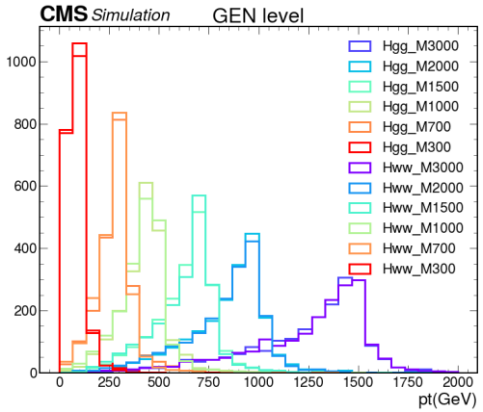
(a) Semi-Leptonic

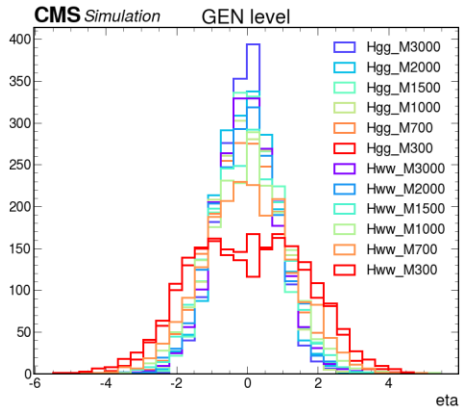


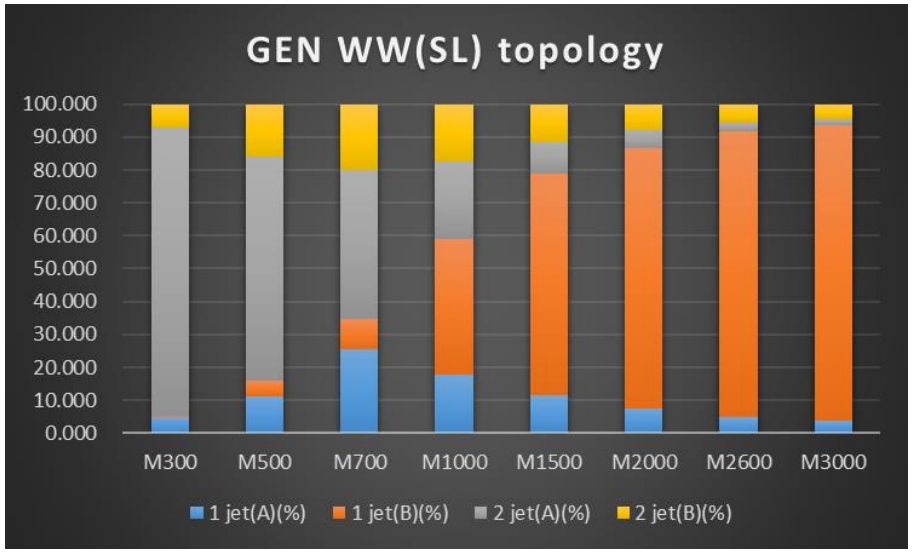
(b) Fully-Hadronic

GEN level study

Add Semi-leptonic Gen Level Study code in HiggsDNA framework
based on numba

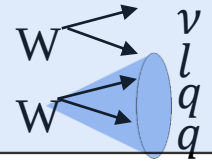
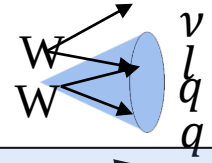
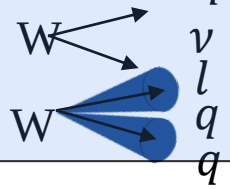
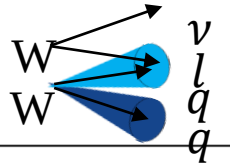






High mass region： boosted jet dominant
Low mass region： resolved jets dominant

Semi-leptonic WW toplogy:

category	dR(q1,q2) dR(q1,l),dR(q2,l)
1jet(A) 	dR(q1,q2)<0.8 dR(l,q1)>0.8
1jets(B) 	dR(q1,q2)<0.8 & dR(l,q1)<0.8 &dR(l,q2)<0.8
2jets(A) 	dR(q1,q2)>0.4 dR(l,q1)>0.4 dR(l,q2)>0.4
2jets(B) 	dR(q1,q2)>0.4 & (dR(l,q1)<0/4 | dR(l,q2)<0.4)

Object & Event Selection (SL channel)

Write Semi-leptonic channel tagger in HiggsDNA framework

Add cut flow efficiency code for each selection

Photon

Variable	Selection
p_T	>10GeV
$\|\eta\|$	[0,1.4442] [1.566,2.5]
Electron conversion veto	
R9	> 0.8
Hoe	< 0.08
HLT cut	

DiPhoton

Variable	Selection
$p_T^{\gamma_{lead}}$[GeV]	>= 35
$\frac{p_T^{\gamma_{lead}}}{m_{\gamma\gamma}}$	>= 0.33
$\frac{p_T^{\gamma_{sublead}}}{m_{\gamma\gamma}}$	>= 0.25
$p_{T\ \gamma\gamma}$	>= 100 for resonance mass >= 400
$m_{\gamma\gamma}$	[100GeV , 180GeV]

Electron

Variable	Selection
p_T[GeV]	> 10
$\|\eta\|$	[0,1.4442] [1.566,2.4]
dxy	< 0.045 cm
dz	< 0.2 cm
WPL(Loose) id	
$\triangle R(e,\gamma)$	>0.4
$\triangle R(e,jet)$	>0.4

Muon

Variable	Selection
p_T[GeV]	> 10
$\|\eta\|$	[0, 2.5]
ID	Medium
pfRelIso03_all	< 0.3
dz	<0.045 cm
dxy	< 0.2 cm
$\triangle R(\mu,\gamma)$	>0.4
$\triangle R(\mu,jet)$	>0.4
Global muon	

Jet

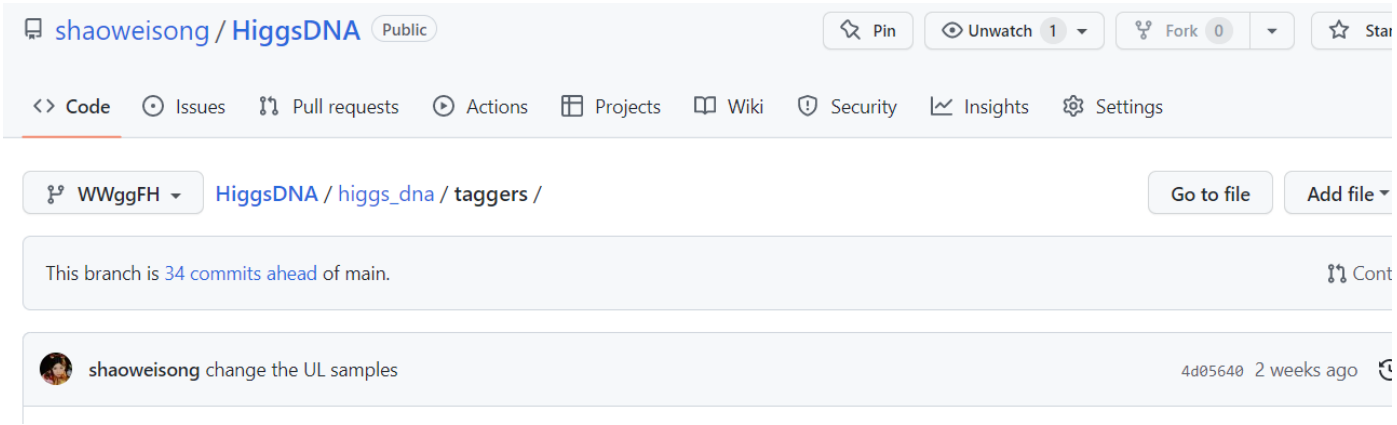
Variable	Selection
p_T[GeV]	> 25
$\|\eta\|$	< 2.5
$\triangle R(jet,\gamma)$	>0.4
$\triangle R(jet,e)$	>0.4
$\triangle R(jet,\mu)$	>0.4
puID	>=4
ID	>=3

FatJet

Variable	Selection
p_T[GeV]	>= 200
$\|\eta\|$	< 2.4
$\triangle R(jet,\gamma)$	>0.8
$\triangle R(jet,e)$	< 0.8
$\triangle R(jet,\mu)$	< 0.8

Event Selection

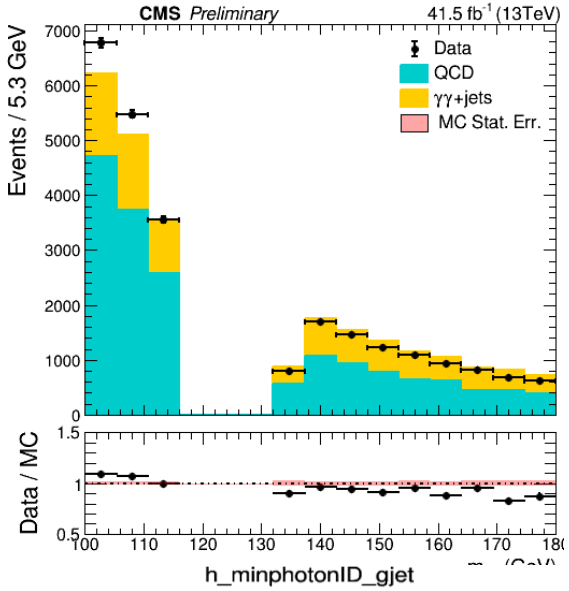
- Start with diphoton taggers
- Go through WW Tagger
- At least one good diphoton pair
- At least one lepton
- At least two jets / At least one fatjet

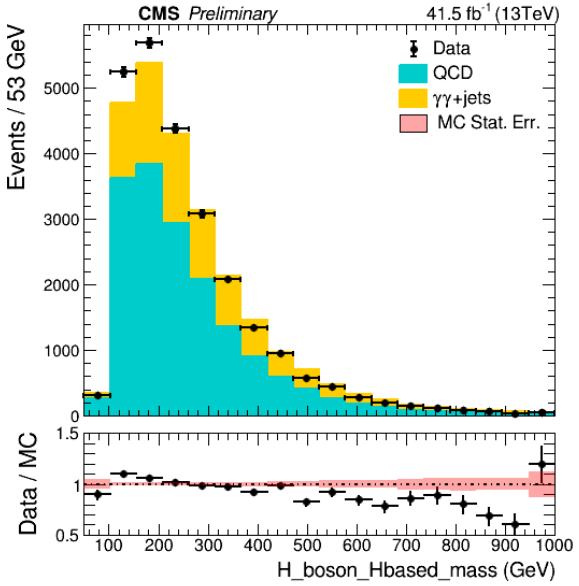


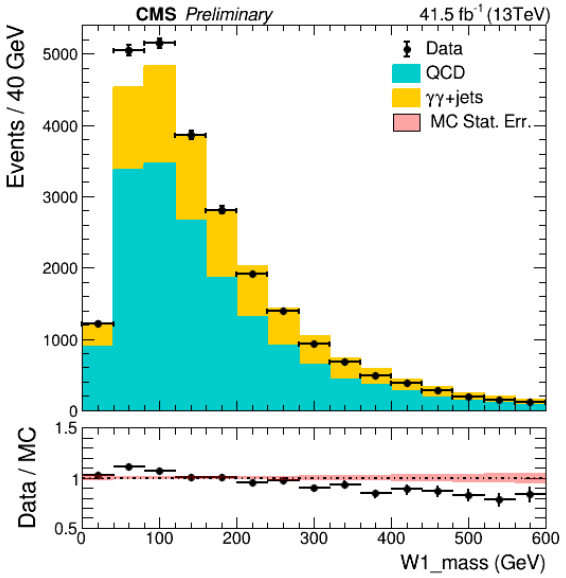
Data/MC comparison plots without DNN cut

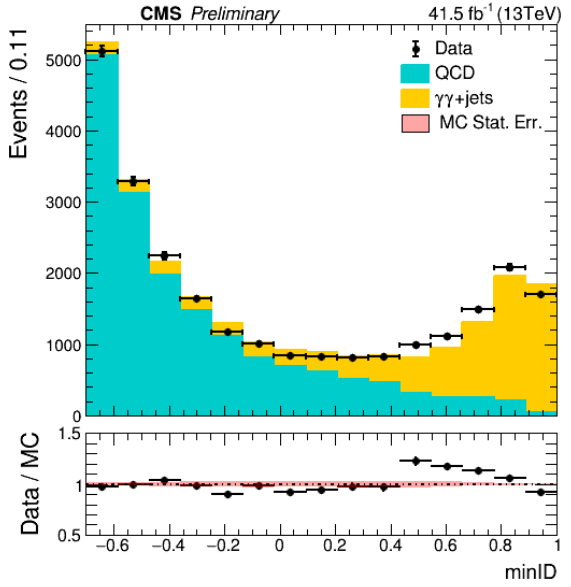
Fully Hadronic channel

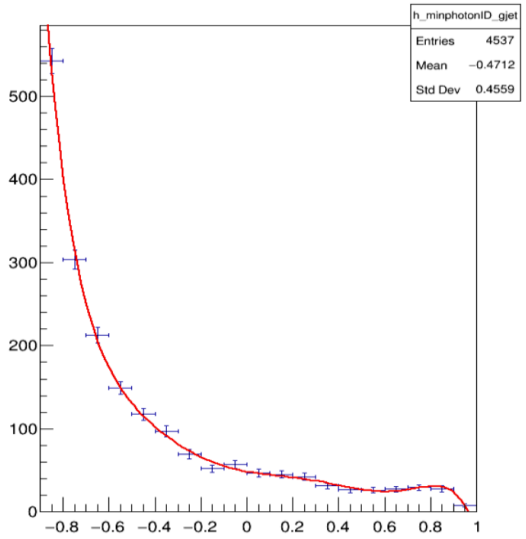
Data-Driven QCD (similar strategy as [HIG-19-013])



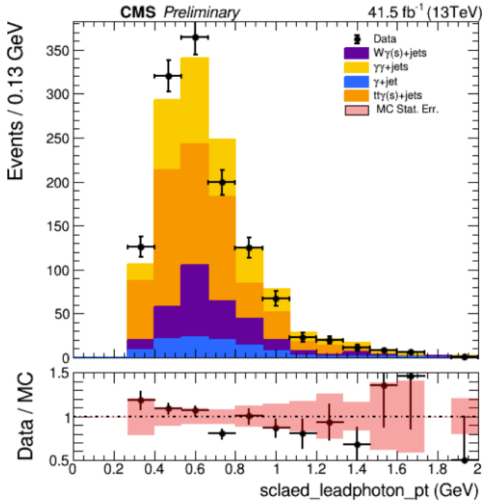








Semi-leptonic channel



Good agreement between Data and MC

Each SL & FH channel DNN input variable Data/MC comparison plot can be found on this web:
https://shaoweisong.web.cern.ch/

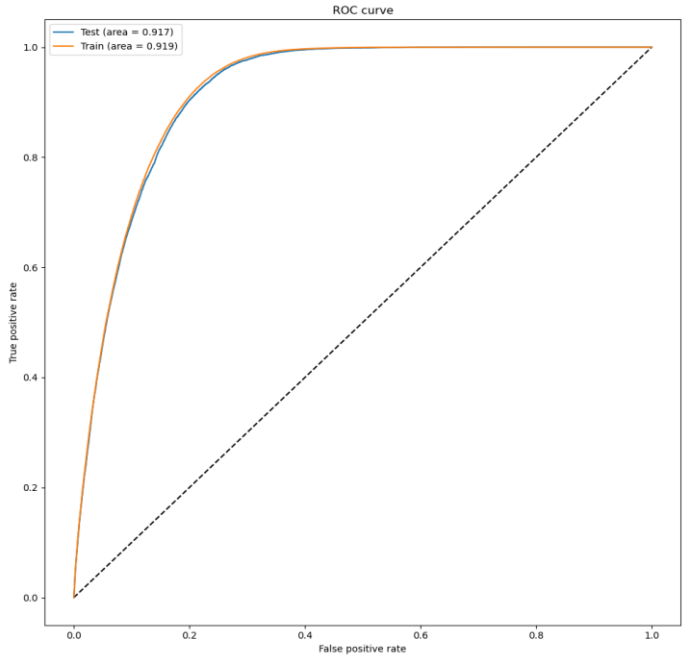
DNN Training

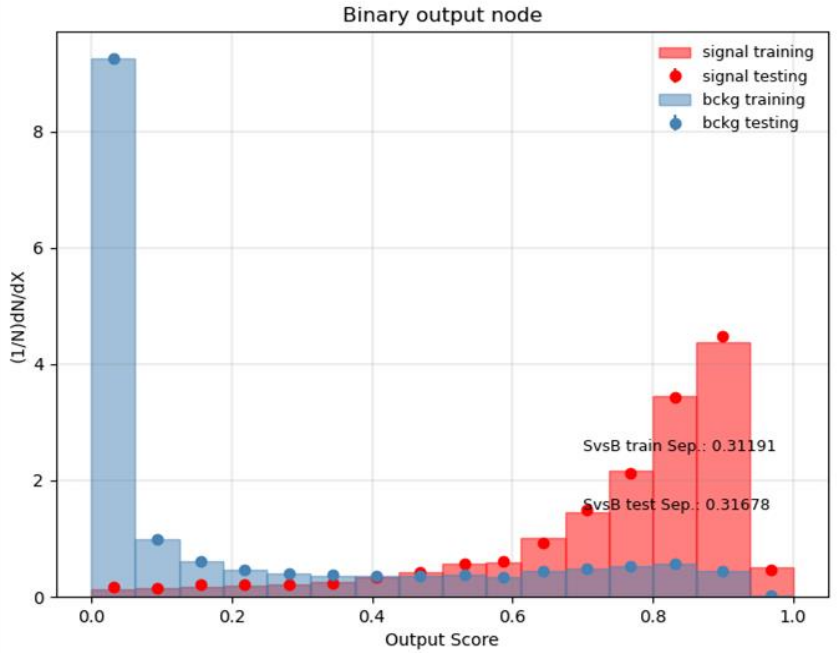
Low good jet efficiency in FH channel

Goals: Improve match efficiency

Using Mass Point 300GeV Signal

Loss function and ROC curve are fine





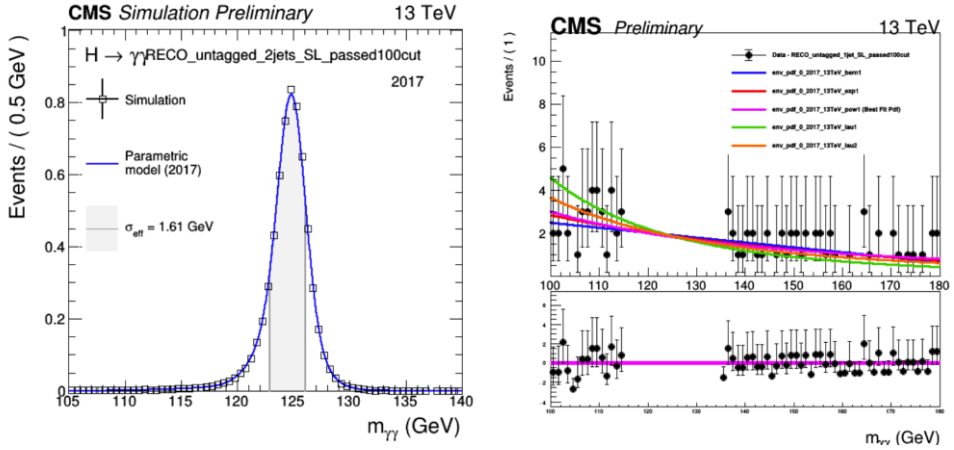
Improve the match efficiency from 16.8% to 43.7%

25 input features

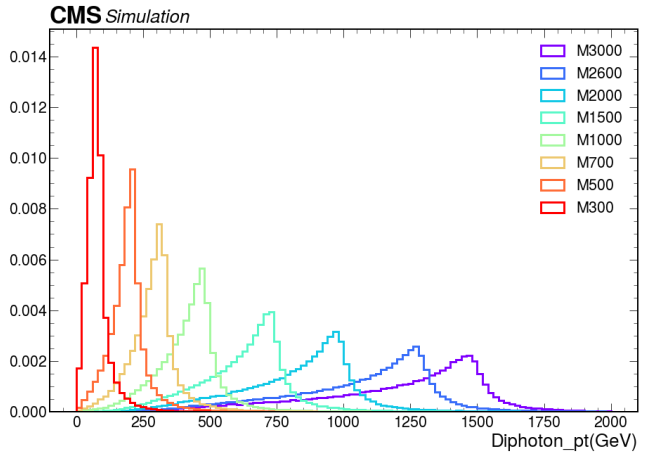
- 4 jets 4D momentum information, and
- two dR with photon for each jet
- One sphericity which is defined in terms of the eigenvalues of the transverse-momentum tensor. It is widely used for discriminating symmetric multi-jet topologies.

$$M_{xy} = \sum_i \begin{pmatrix} p_{xi}^2 & p_{xi}p_{yi} \\ p_{xi}p_{yi} & p_{yi}^2 \end{pmatrix}, \qquad S_{\perp,g}^{pheri} \equiv \frac{2\lambda_2}{\lambda_1 + \lambda_2}.$$

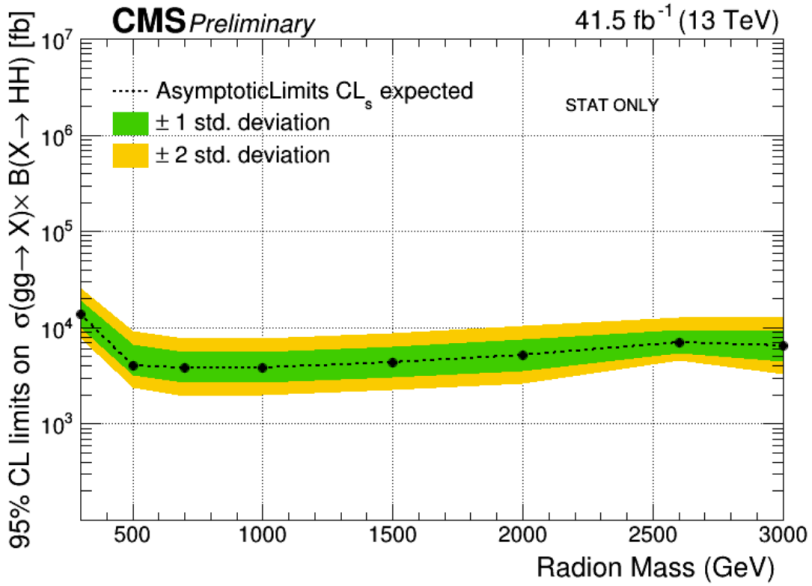
SL channel Signal and Background Modeling & Limit



Used multi-gaussians to construct the signal model
Discrete profiling method for the background modeling

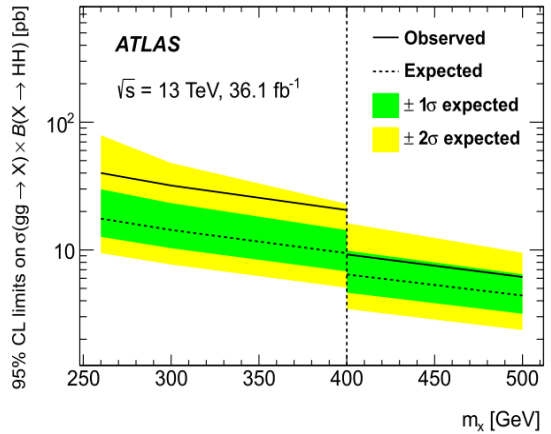


X Mass >300 GeV, almost all background can be rejected by $p_{T\,\gamma\gamma}$ >100 GeV cut



Mass point	Limit (pb^{-1})	Limit (pb^{-1})
300	14.8437	13.7109
500	8.8672	**4.0000**
700	7.4609	3.7970
1000	7.3633	3.8437
1500	8.8672	4.3828
2000	10.3906	5.1328
2600	12.1875	6.9433
3000	14.0234	6.4219

Better limit result!



ATLAS result: 4.4 pb^{-1} at 500 GeV Mass point for SL limit

HGCAL Work

Gantry system & code update & Gantry Calibration

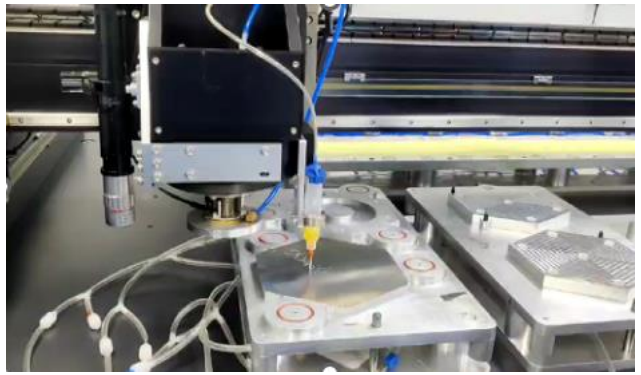
Create LD V3 New Glue Pattern

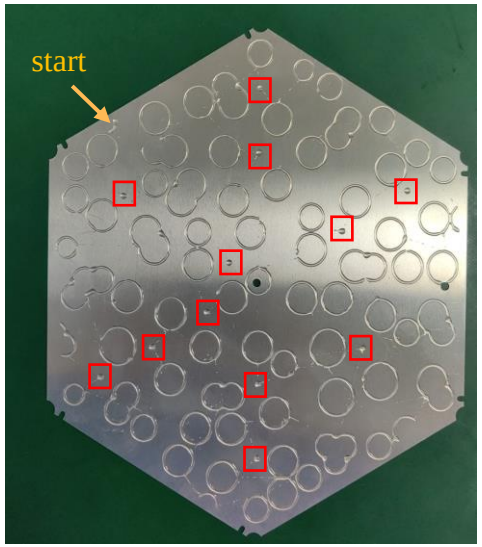
Dispense on sensor

3 patterns: point, arc, full circle

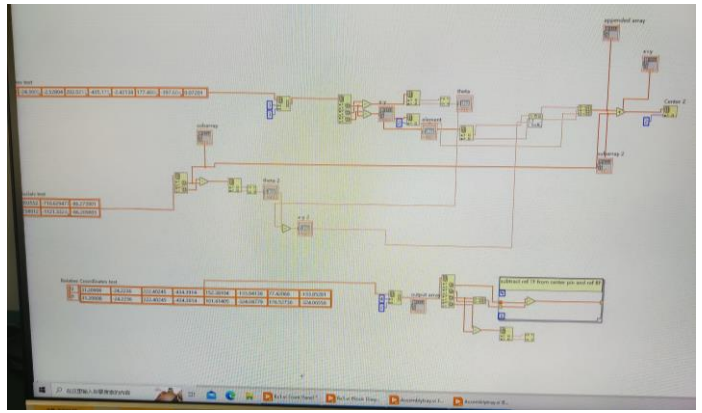
Dispense pressure: 6

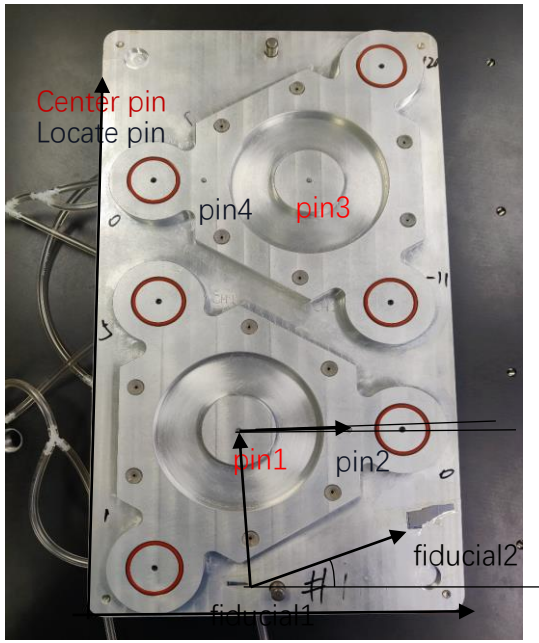
Dispense time: ~ 5 min



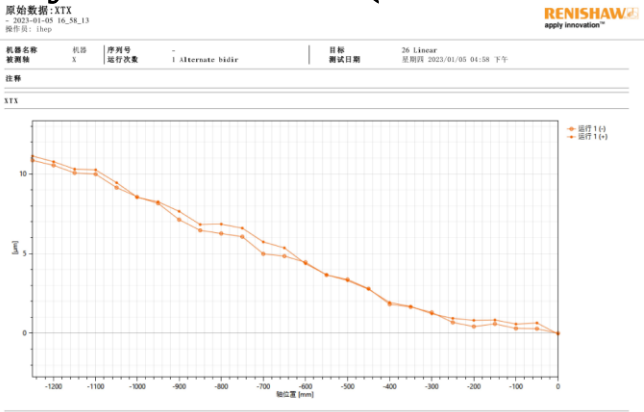


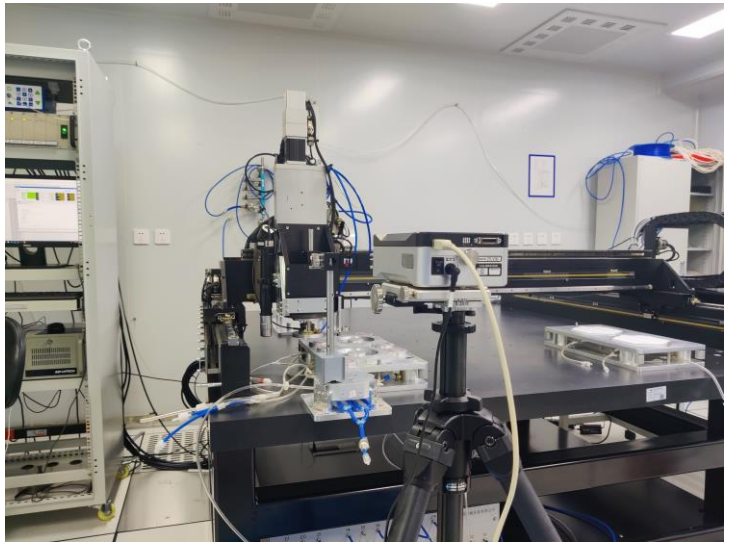
CMU New Position code (using fiducials and pins)





Gantry Calibration (Laser interferometer)





Learn and write Labview codes for gantry

Ready For Production!

Plans

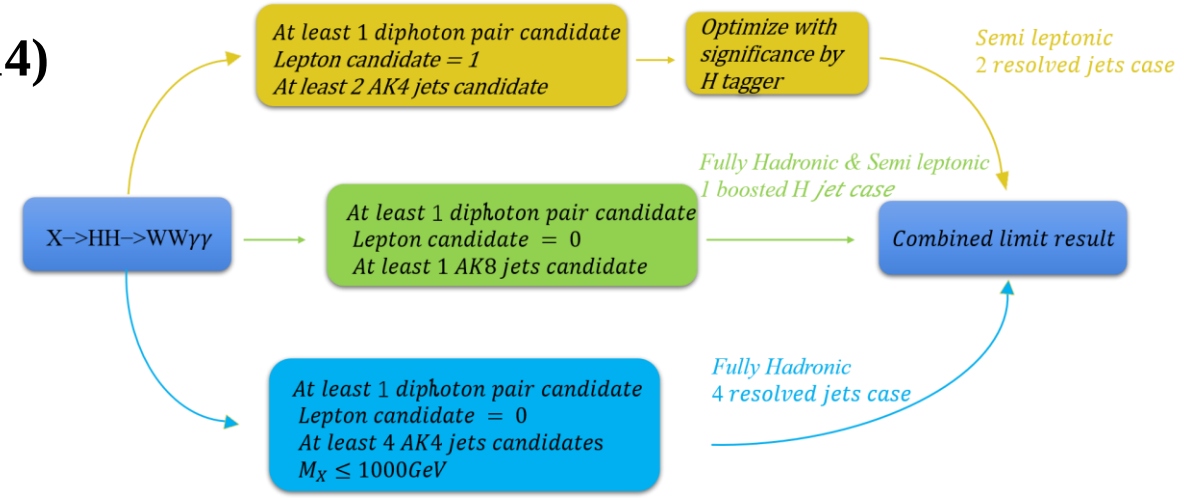
Resonant HH→WW$\gamma\gamma$:

A dedicated framework for the combination with FH & SL has been developed, tested and studied very detailed.

Using this new framework to get the combined limit result.

Combine paper with resonant $bb\gamma\gamma$ and $\tau\tau\gamma\gamma$

Combine the result with non-resonant WW$\gamma\gamma$(HIG-21-014)



New framework analysis strategy

HGCAL Work:

HGCAL modules production

Develop visual tracking algorithm for gantry