Update on background study of semi-leptonic WW$\gamma\gamma$=

Yu Zhang

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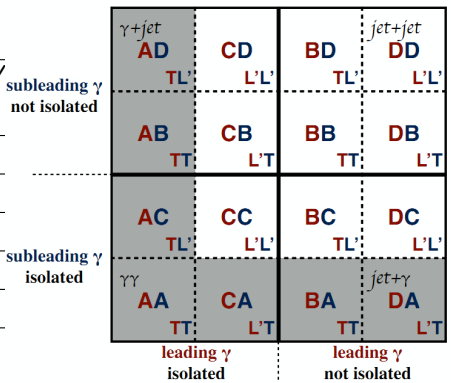
Diphoton purity

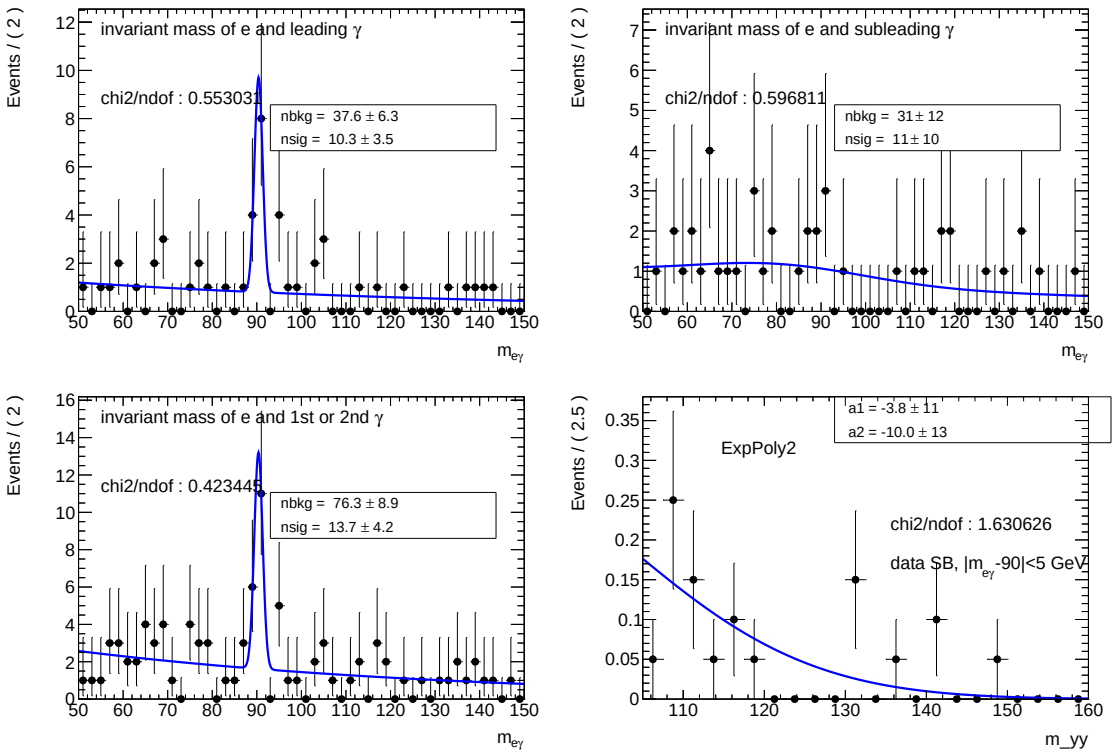
- 2x2DSB method is used to measure the fraction of $\gamma\gamma, \gamma - jet, jet - jet$
- CR definition : define A Tight-Iso(TI), B Tight-noIso(TnI), C loose-not-Tight-Iso(nTI), D loose-not-Tight-noIso(nTnI) for single photon.
- Totally 16 regions, AA, AB.....DD

Component data	SR no $pT_{\gamma\gamma}$ cut 165	CR no $pT_{\gamma\gamma}$ cut 54762	SR $pT_{\gamma\gamma} > 100GeV$ 39	CR $pT_{\gamma\gamma} > 100GeV$ 8415
$\gamma\gamma$	146±15	46855±876	35.4±6.4	7829±120
$\gamma - jet$	6.25±5.08	4139±218	2.78±1.85	501±54
$jet - \gamma$	7.37±5.30	2971±129	1.00±1.00	449±42
jet-jet	5.65±2.72	780±43	0.22±0.25	46.6±9.5
purity	0.884±0.063	0.856±0.006	0.898±0.074	0.881±0.010



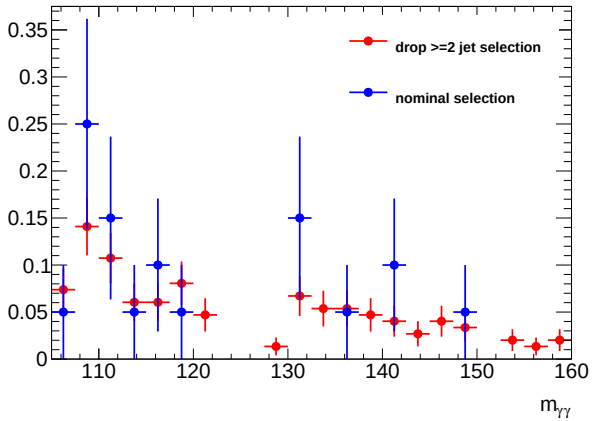
Fake photon from $Z\gamma$ events

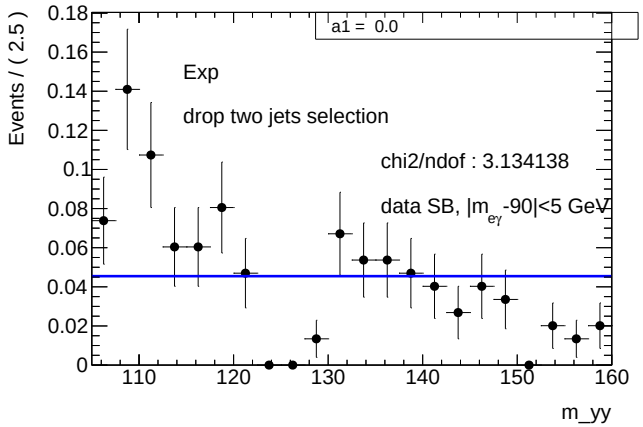
- In Z($\rightarrow$ee)γ events, one electron could be mis-identified as a photon. Requiring $m_{e\gamma}$ off Z peak could reduce this kind of background.
- Upper two plots are the $m_{e\gamma 1}$ and $m_{e\gamma 2}$. Bottom left is the sum of upper two plots and bottom right is ExpPoly2 fit.
- The fitted yield from bottom left plot is 13.7, 10.4% of 132 events after the full selection.

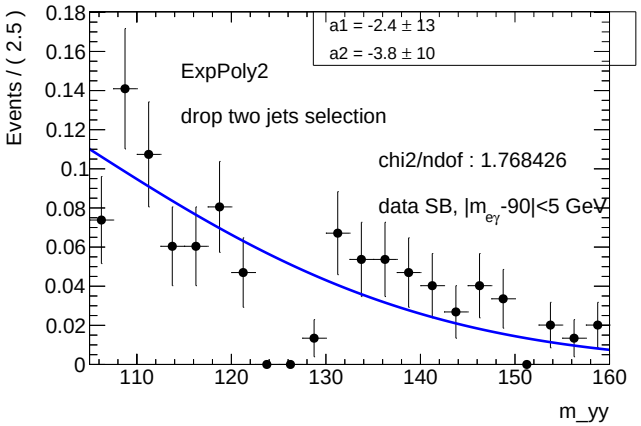


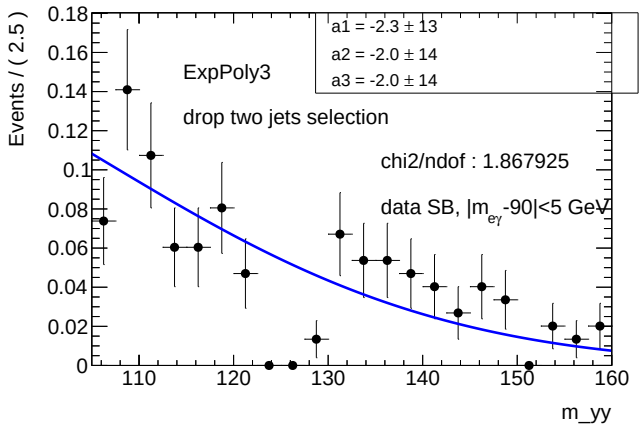
Loose the selection to improve the statistic and shape — drop 2 jet selection

- Loose the selection to enlarge the statistic and obtain better shape. Fit with Exp, ExpPoly2, ExpPoly3, Bern3, Bern4 and Bern5.





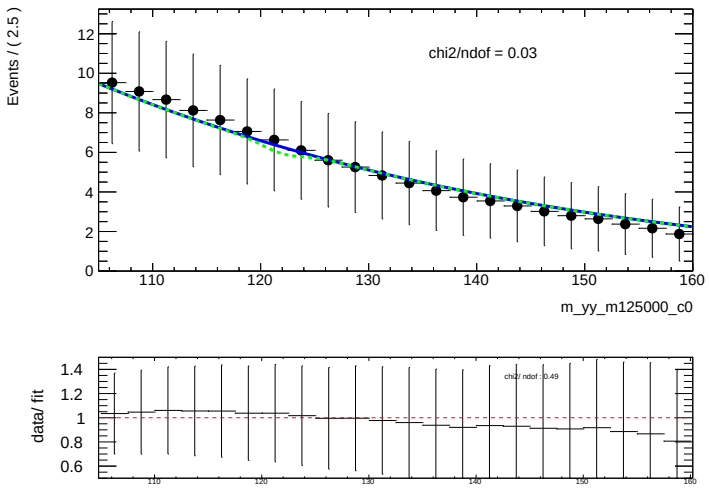


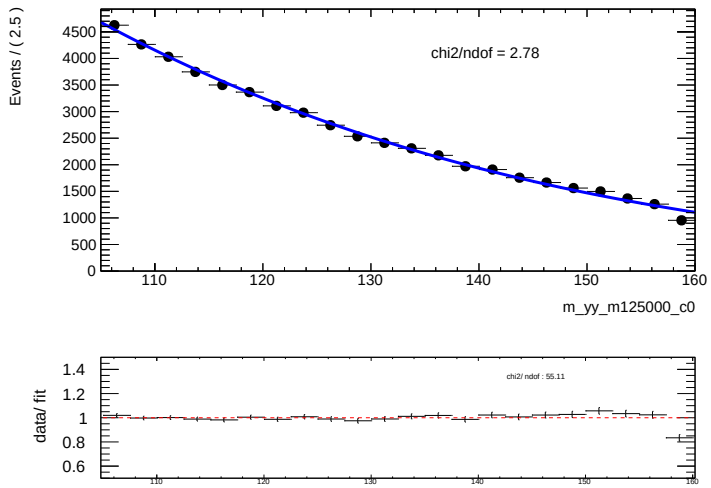


Spurious Signal

- Add $Z\gamma$ component to the mimic background to low mass test. Suppose the shape is ExpPoly3 and yield is obtained from Exponential+Gauss fit. Many functions of $Z\gamma$ shape are tested and ExpPoly3 gives the best N_{ss}.
- S+B fit is shown at $m_h = 122 GeV$.

Mass	Max(N_{ss})	Max($N_{ss}/\Delta S$)	Max(N_{ss}/S_{ref})
$m_H = 260 GeV$	0.845858	0.194842	1.6359
$m_H = 300 GeV$	0.826406	0.189248	1.45292
$m_H = 400 GeV$	-0.398046	-0.169399	-0.516232
$m_H = 500 GeV$	-0.395486	-0.172747	-0.460771
non-resonant	-0.402366	-0.174128	-0.497784





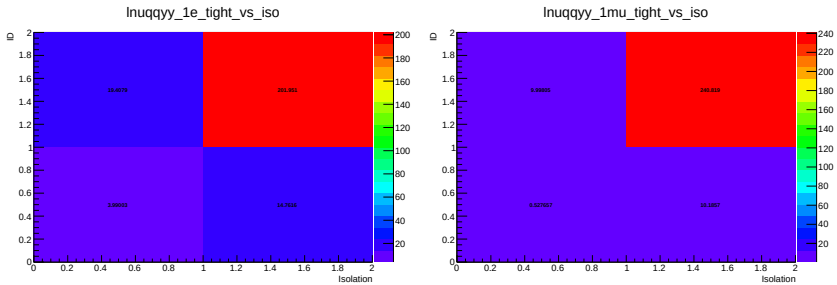
Fake lepton

- Current lepton requirement is Medium ID and Loose(GradientLoose) for electron(muon).
- Estimate jet fakes from ABCD method.
- CR definition : T tight ID, nT medium-not-tight, I FixedCutTight,nI loose-not-FixedCutTight
- Isolation criteria from twiki page :
  FxedCutTight : for electron(muon), topoetcone20/pt<0.06, ptvarcone20(ptvarcone30)/pt<0.06. Since muon ptvarcone30 is not saved in ntuple, ptvarcone20 is used to hint but not in any official working point. Events are splitted into 4 regions in electron and muon category.
- Suppose ID and Isolation are not correlated.
- construct the χ^2 : $\chi^2 = \sum_i \frac{(N_i - N_{i,pred})^2}{N_i}$, i=TI, TnI, nTI, nTnI

Fake lepton

- The correlation factor of ID and Isolation is 9e-3 *in* 1mu channel and 0.11 *in* 1e channel from MC.
- Obtain the ID and Iso efficiency from $l\nu jj\gamma\gamma$ sample

efficiency	data	MC
electron tight ID	0.75	0.922
electron tight ISO	0.76	0.902
muon tight ID	0.92	0.960
muon tight ISO	0.74	0.960



$$
\begin{aligned}
N_{TI,pred} &= W1 * \epsilon_{ID} * \epsilon_{ISO} + W2 * f_{ID} * f_{ISO};\\
N_{TnI,pred} &= W1 * \epsilon_{ID} * (1-\epsilon_{ISO}) + W2 * f_{ID} * (1-f_{ISO});\\
N_{nTI,pred} &= W1 * (1-\epsilon_{ID}) * \epsilon_{ISO} + W2 * (1-f_{ID}) * f_{ISO};\\
N_{nTnI,pred} &= W1 * (1-\epsilon_{ID}) * (1-\epsilon_{ISO}) + W2 * (1-f_{ID}) * (1-f_{ISO});
\end{aligned} \tag{1}
$$

$W1$: *real lepton yields*; $W2$: *fake leptonyields*;

ϵ_{ID}, ϵ_{ISO} : *efficiency of ID and ISO, obtained from MC*;

f_{ID}, f_{ISO} : *fake rate of ID and ISO selection*;

Fake estimation of electron

- fit result and estimated yield in ABCD region.

Parameter	fit
W1	43.0507±11.2414
W2	23.9493±10.2914
f_{ISO}	0.475728±0.173654
f_{ID}	0.469924±0.166589

fit (real + fake)	FixedCutTight	loose-not-FixedCutTight
tight	35.646±5.35402	3.09965±5.90034
medium-not-tight	3.96067±6.03934	0.344406±6.65559

data	FixedCutTight	loose-not-FixedCutTight
Tight	41	9
medium-not-tight	10	7

Fake estimation of muon

- fit result and estimated yield in ABCD region.

Parameter	fit
W1	28.1647±14.0766
W2	38.5004±14.6546
f_{ISO}	0.495349±0.172062
f_{ID}	0.8±0.0419173

fit (real + fake)	FixedCutTight	loose-not-FixedCutTight
tight	25.9566+15.2569	1.08152+15.5434
medium-not-tight	1.08152+3.81423	0.0450635+3.88585

data	FixedCutTight	loose-not-FixedCutTight
Tight	41	16
medium-not-tight	5	0

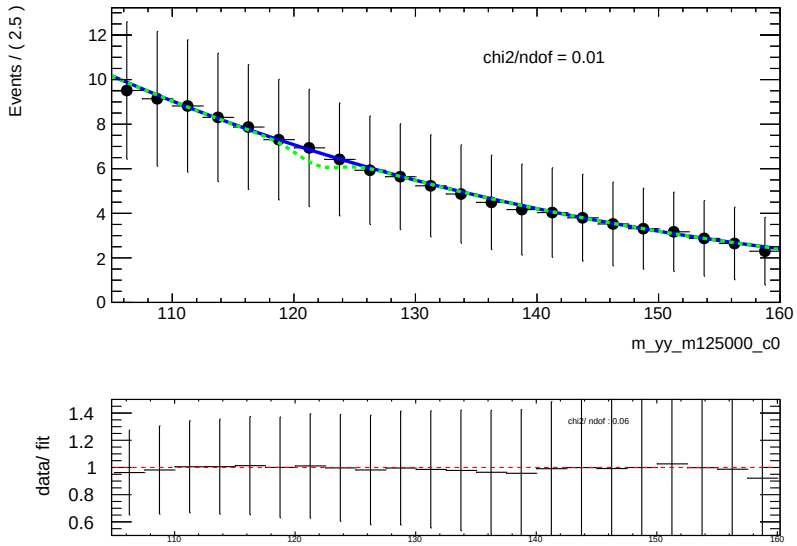
Summary

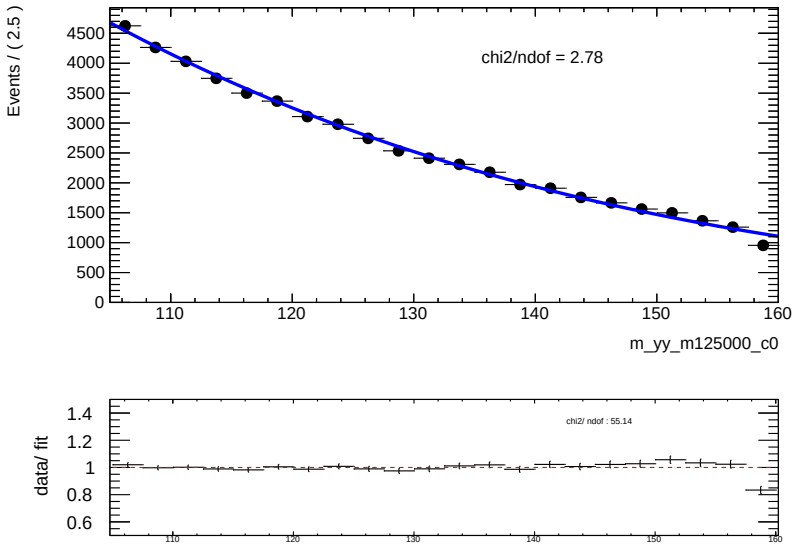
- Spurious Signal
  - Estimate the $Z\gamma$ background shape and yield from data sideband
  - Add $Z\gamma$ to the mimic background, normalize $\gamma\gamma$ $\gamma - jet$ according to the purity and redo the spurious signal test.
  - Update the spurious signal : ExpPoly2 pass the cirteria in each mass point.
- Fake lepton
  - Estimate the fake from ABCD region defined by Tight ID and Tight Isolation vs medium ID and loose Isolation.
  - The fake background is considerable from the fit, but this estimation is rough and has large stat error without systematic, especially muon channel. Thinking about computing limit after tight ID and Isolation.
- Discussion
  - In VH($\rightarrow \gamma\gamma$) analysis, $|m_{e\gamma} - 89| > 5GeV$ is used. Shall we follow it or keep the strategy of $Z\gamma$ estimation in this talk?
  - Should we tighten the isolation? A technique issue is that ptvarcone30 for muon is not saved.

Back up

Spurious signal

- If we use ExpPoly2 to describe $Z\gamma$ shape
- By eye, the consistency is better, but the spurious signal is larger.





Mass	Max(N_{SS})	Max($N_{SS}/\Delta S$)	Max(N_{SS}/S_{ref})
$m_H = 260 GeV$	-1.31293	-0.289227	-2.53921

$Z\gamma$ events with $pT_{\gamma\gamma}$ cut

- No Z peak after $pT_{\gamma\gamma}$ cut.