Studies of isolation optimization with Fake background by using fake factor method

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Introduction

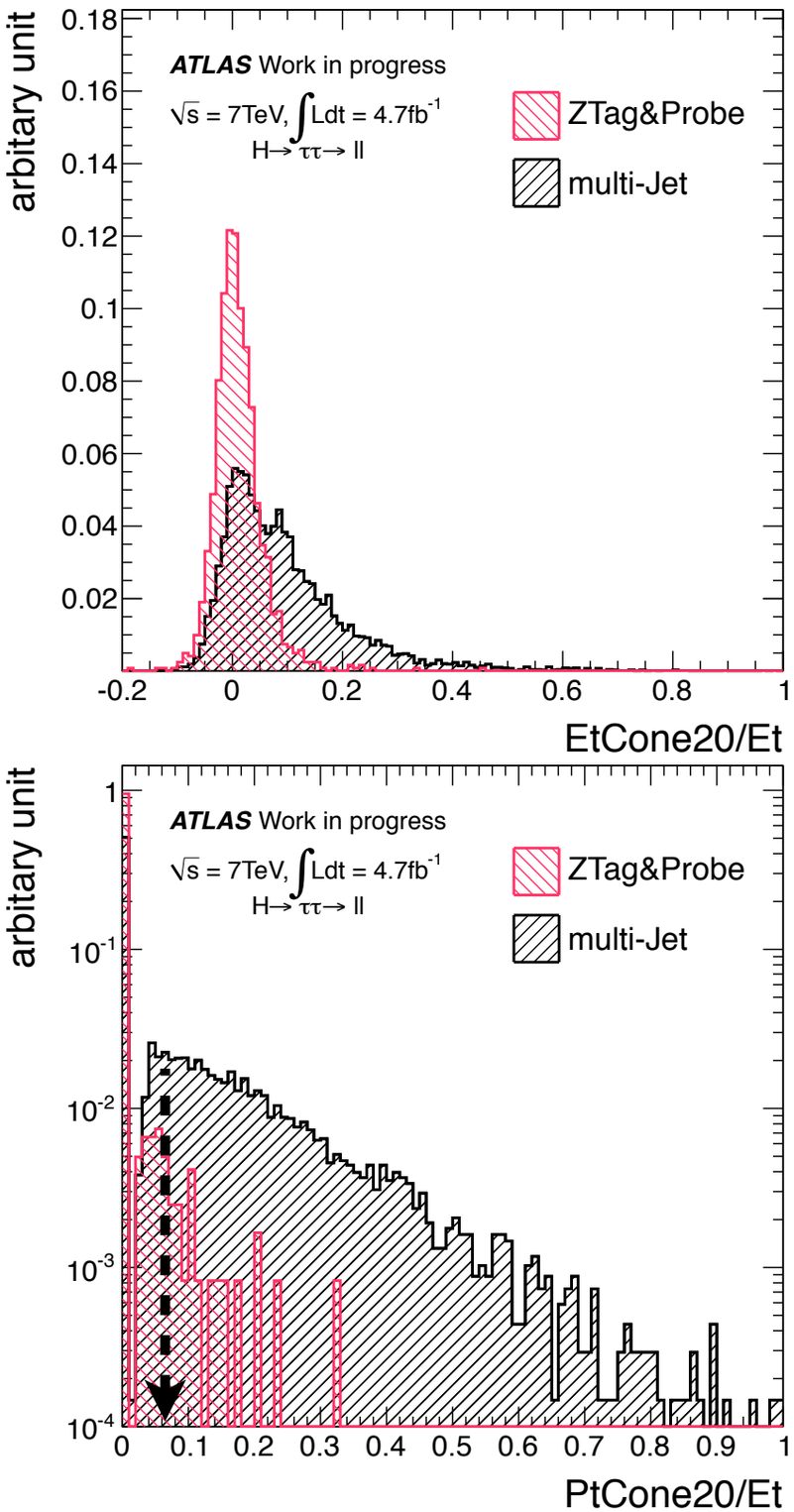
- Now HSG4-leplep believe that the fake events is under the control of us.
- Xin has shown us a more looser isolation analysis in 2011 data.
- But the looser isolation cut has a huge risk of enhance the fake events from W+Jets.
  - W+Jets shape is similar to a signal shape.
  - Because of this, systematics uncertainty might be increased.
- We need to optimize the isolation against the fake lepton.
- I have performed a simple S/√B scan by using the fake factor method for only electron fakes.

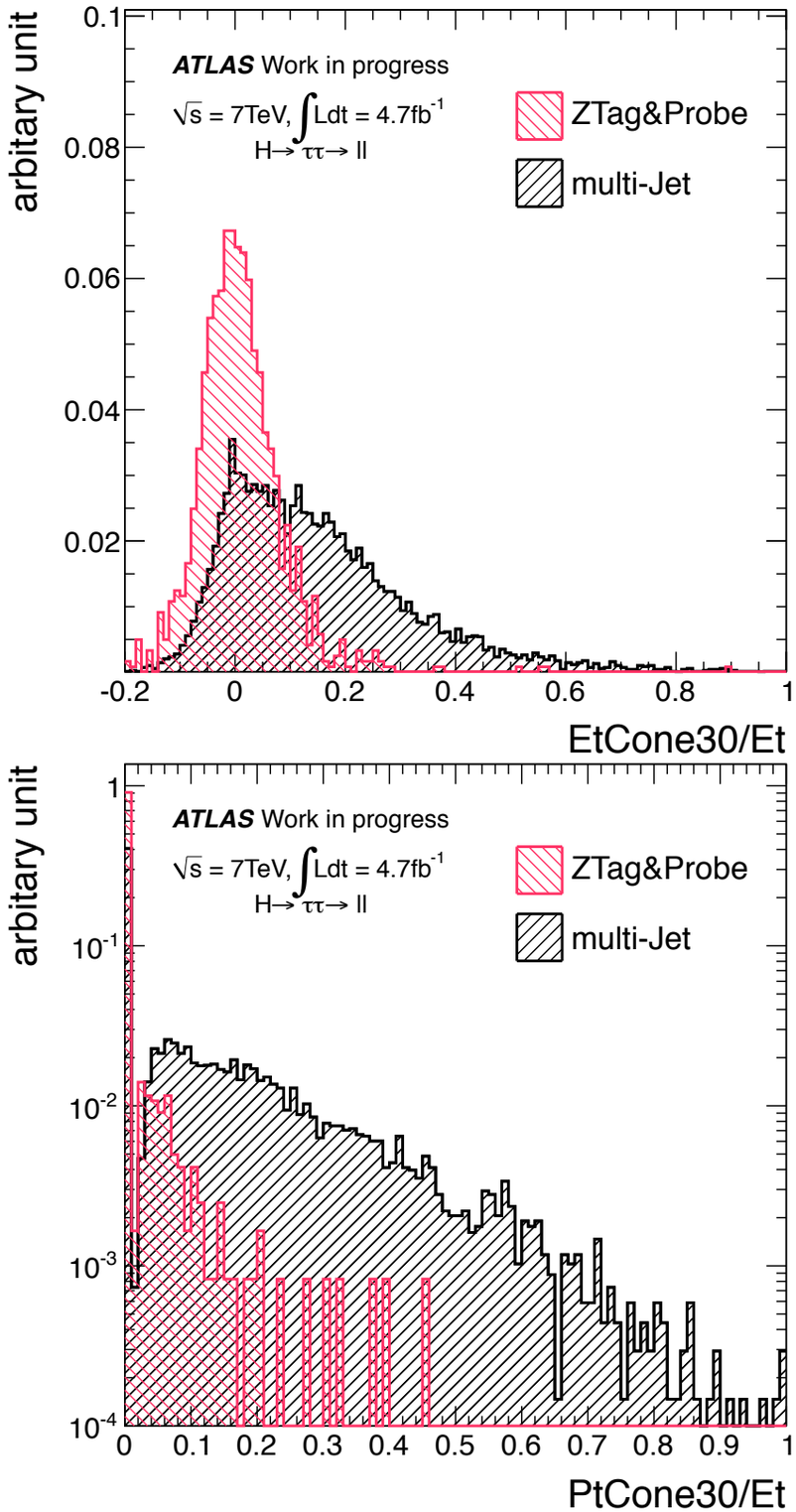
Z Tag & Probe

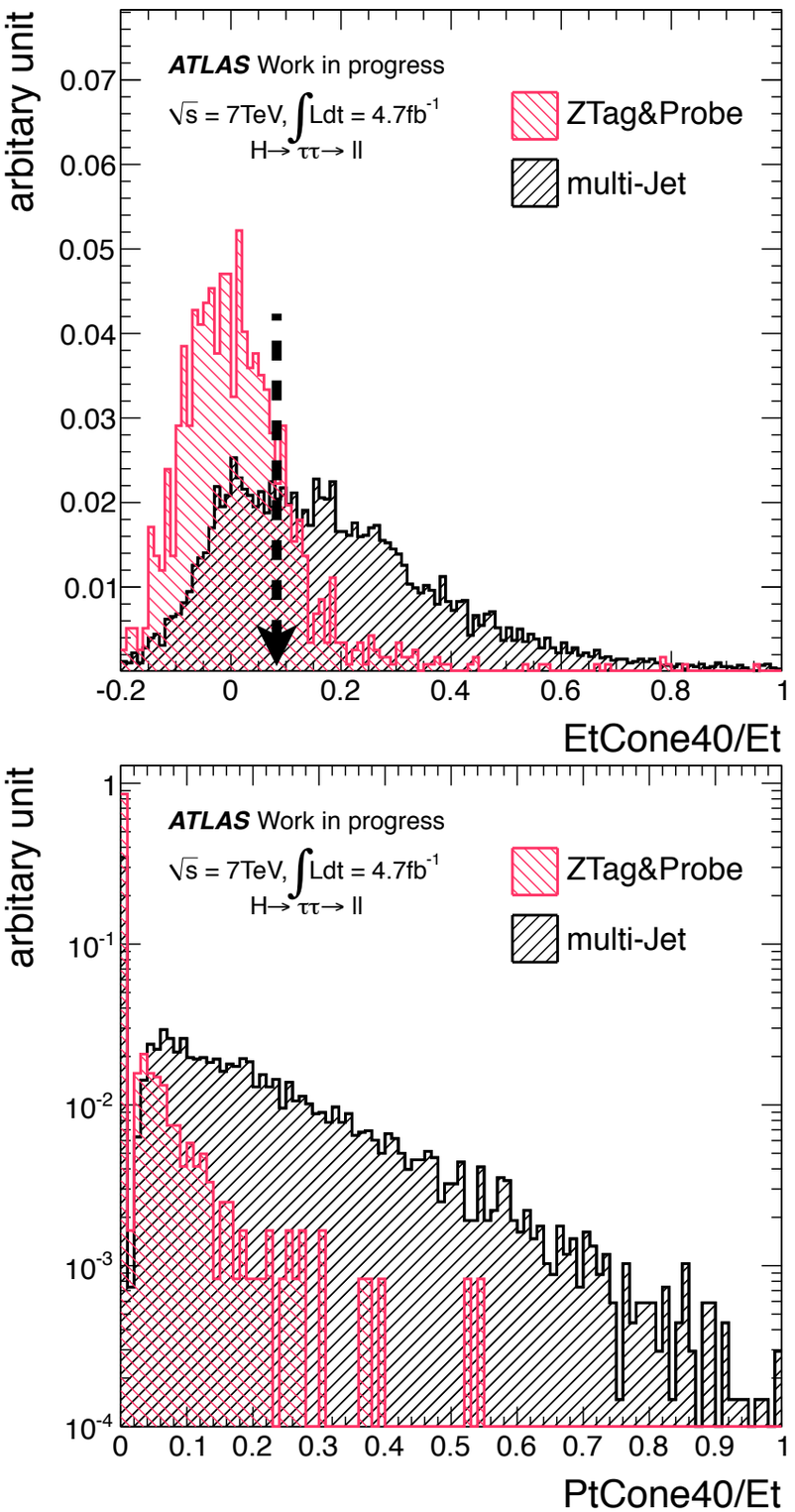
- I used “Z Tag & Probe” method for real leptons.
  - Tag: HSG4 leplep lepton definition.
  - Probe: HSG4 leplep lepton definition without any isolation cut.
  - mass window: $|m_{LL} - m_Z| < 15GeV$, minimum lepton pair.

- I used multi-jet enriched sample for fake leptons.
  - Require passing HSG4 leplep lepton definition.
  - Trigger matching with EF_g20_etcut trigger object.
  - Z veto: $|m_{LL} - m_Z| > 15GeV$,
  - W veto: $mT < 40GeV$, Missing $E_T < 25GeV$

Isolation distributions







- All calo isolations are corrected by egammaUtils tool.

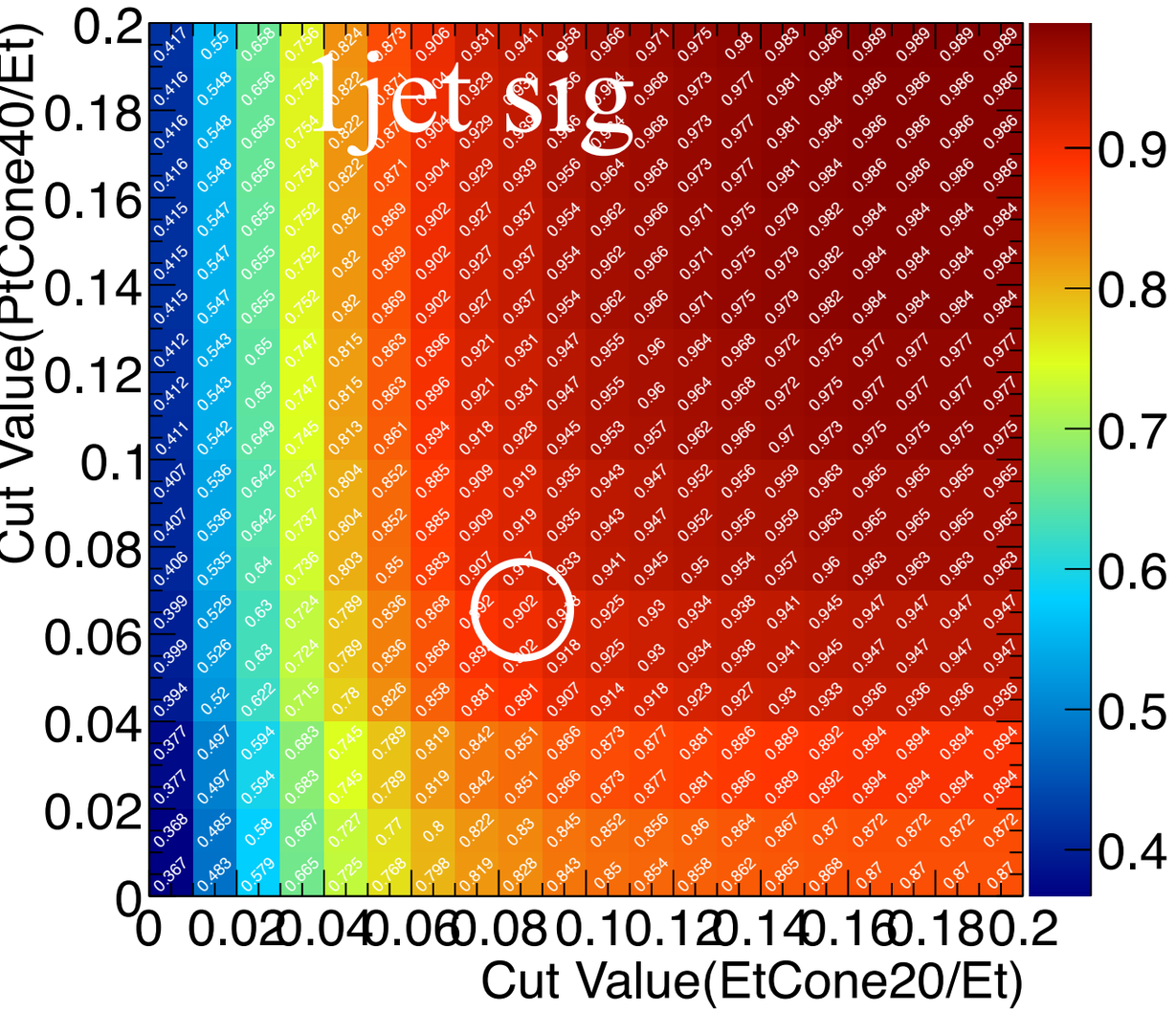
Sensitivity Calculation

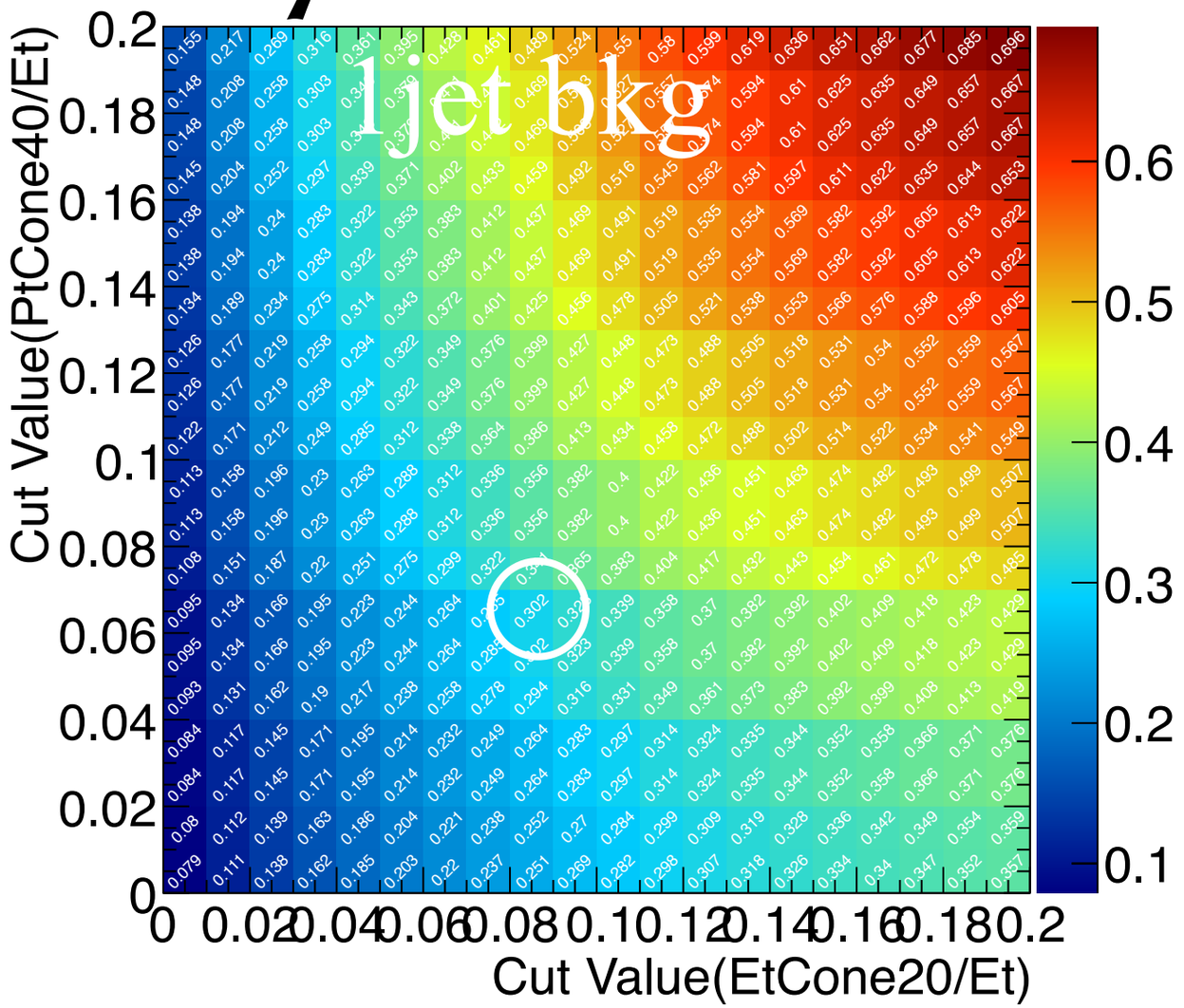
$$\frac{S}{\sqrt{N_{bkg}+\sigma^2_{W+\mathrm{Jets}}}} = \frac{r_s^2 \times N_{sig}}{\sqrt{r_s^2 \times N_{bkg}^{\mathrm{real}} + r_s r_f N_{bkg}^{\mathrm{fake}} + \left(\frac{\sigma_f}{f} r_s r_f N_{bkg}^{\mathrm{fake}}\right)^2}}$$

- $r_{s,f}$ is efficiency ratio of signal,fake lepton.
- σ_f/f is W+Jets relative systematics. (= 0.6)

- The significance is defined above equality.
  - This significance take into account only electron fake.
  - Sensitivity scan has been performed this formula.
- The efficiency ratio is approximated by the product of 1D×1D(Calo×Track) isolation efficiency.
- In correctly we should calculate a 2D(Calo-Track) isolation efficiency due to a correlation between Calo and Track isolation.

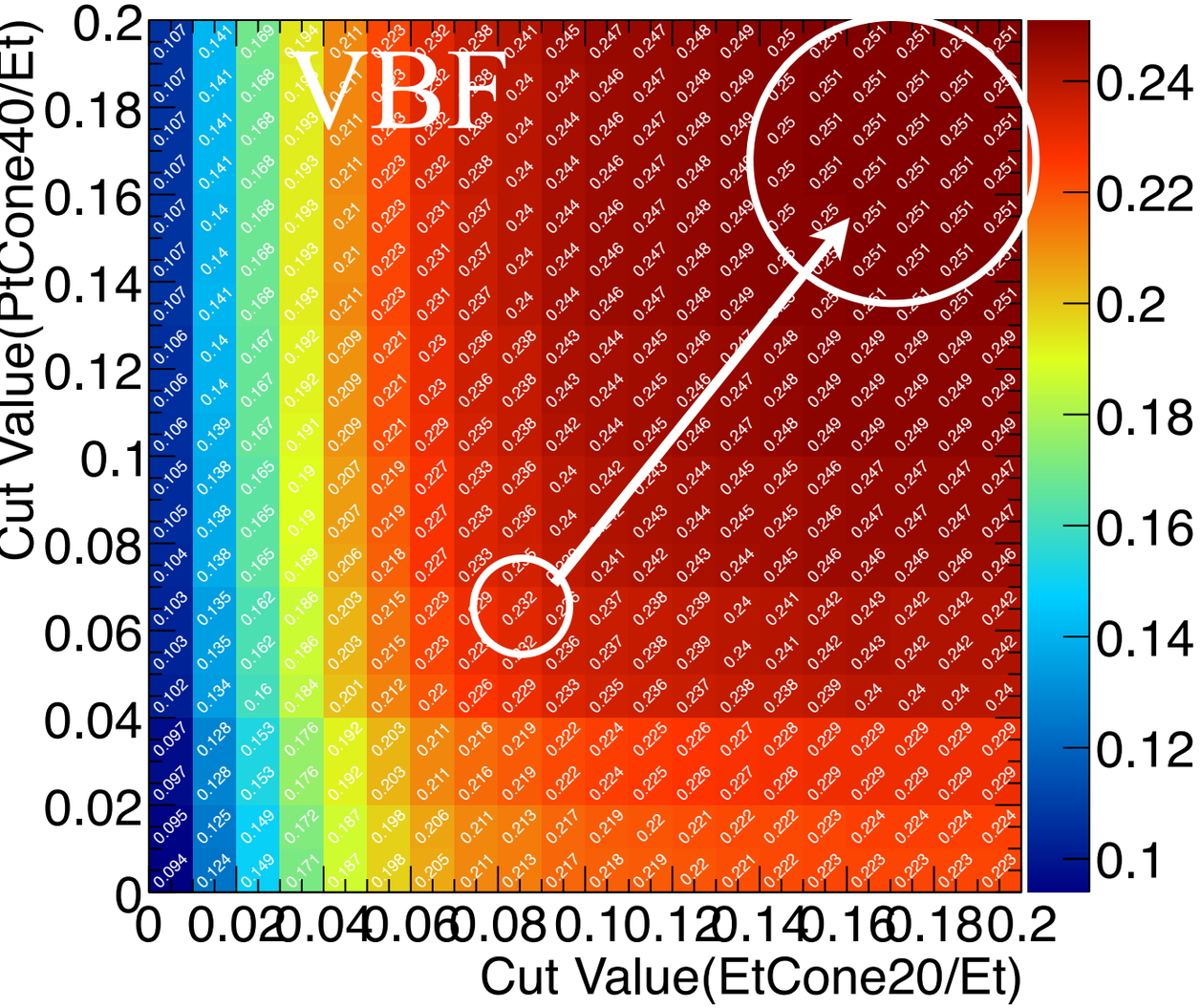
2D Efficiency Scan

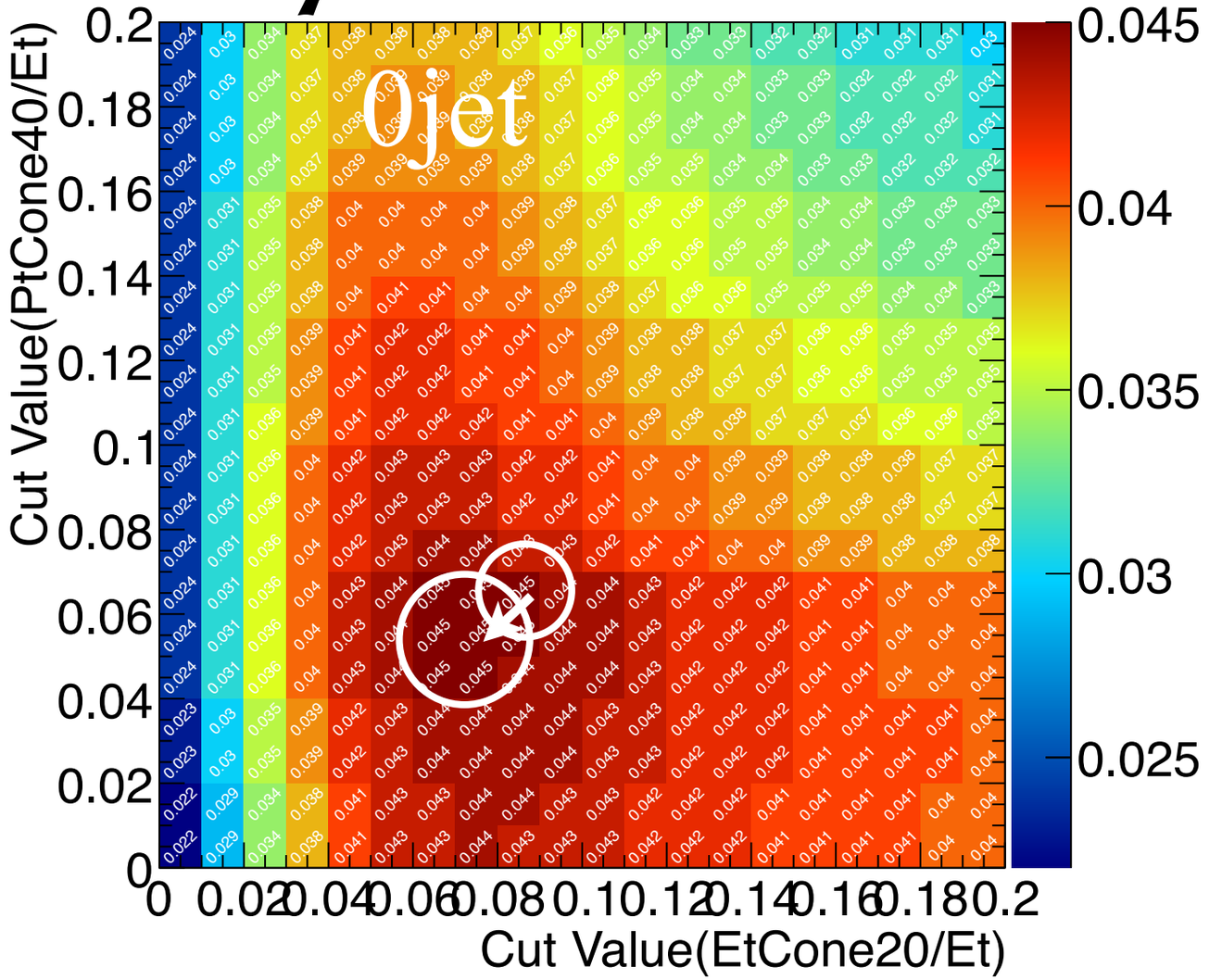




- This efficiency is calculated by a simple product of 1D efficiency of $E_T$cone40 and E_T*p_T cone/E_T.
- In 1jet, signal efficiency is 90%, bkg efficiency is 30% at 2011 optimal point.

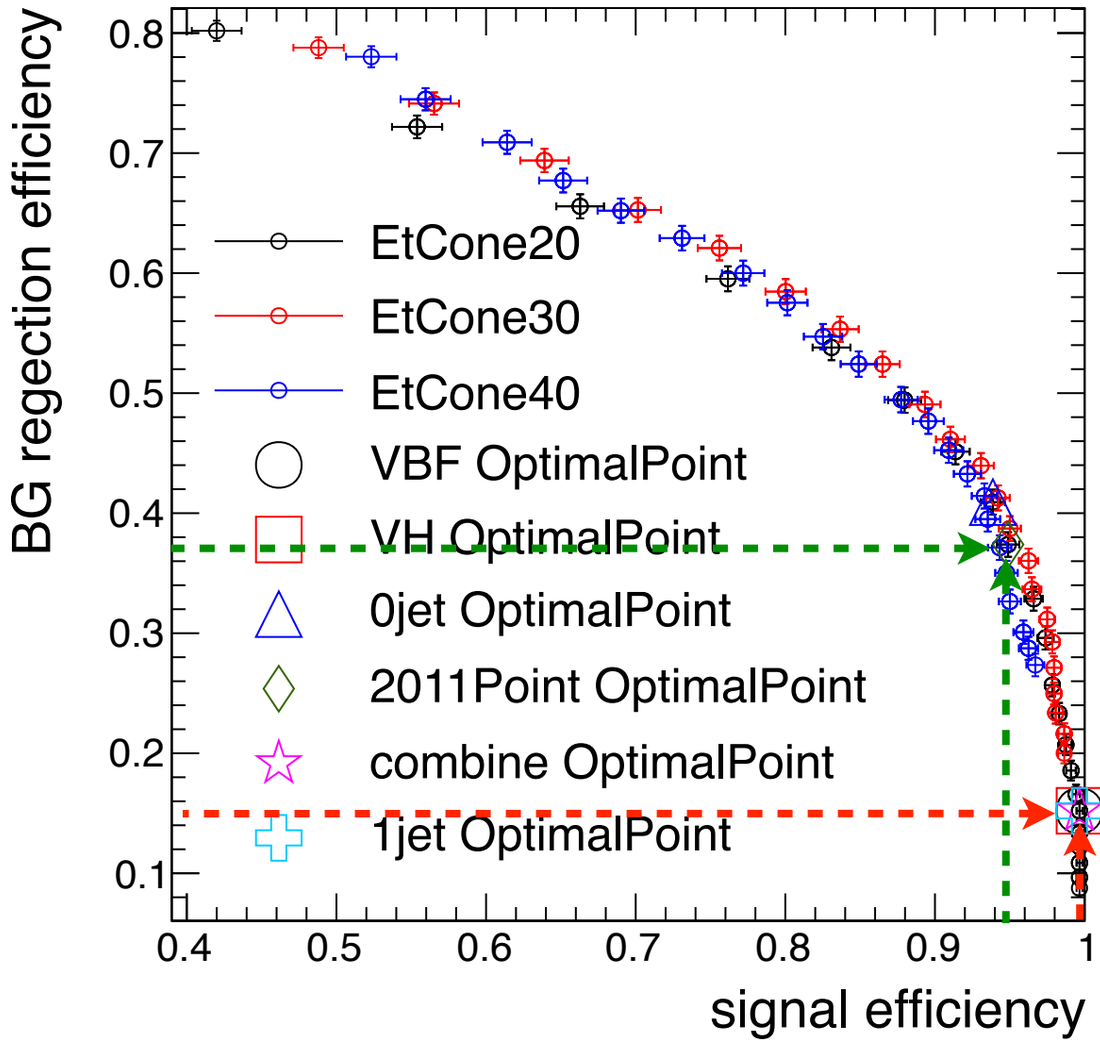
2D Sensitivity Scan

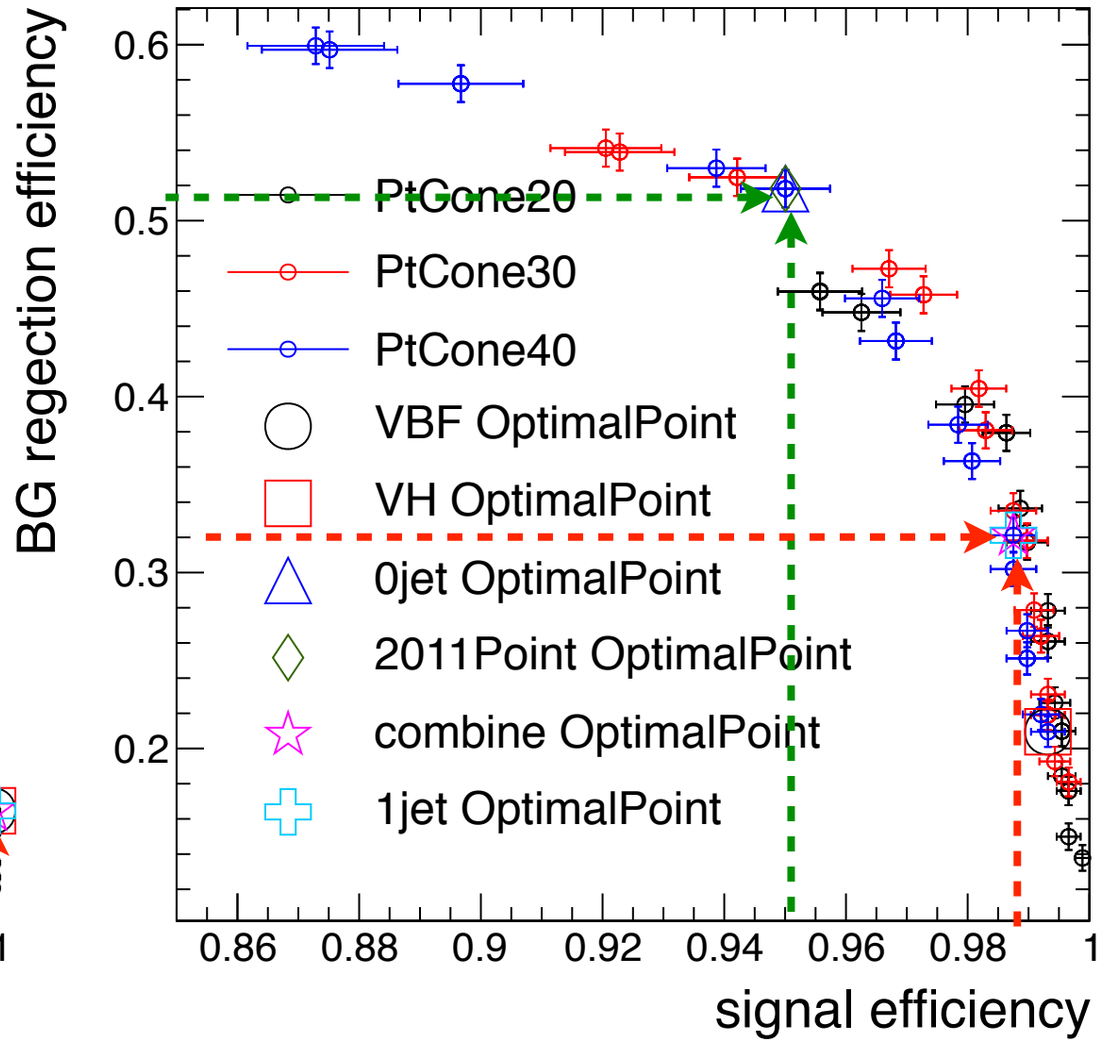




- VBF optimal point is more looser than 2011 operating point.
- But 0jet optimal point is tighter than 2011 operating point.
  - This reason is that 0jet has a big fake events compared with other channels.

ROC curve & Optimize Point





- We can move to a loosen isolation for both cut value.
  - But sensitivity gain is small, for example VBF's gain is about 4%.
  - For 0jet, we need to move more tight cut!!
- Can we divide an isolation cut value between 0jet and others?

Optimization Results

sensitivity			
ch	2011	New	improve
VBF	0.232	0.251	8.2%
VH	0.121	0.131	8.3%
1jet	0.198	0.210	6.0%
0jet	0.045	0.036	-30%
combine	0.331	0.354	7.0%

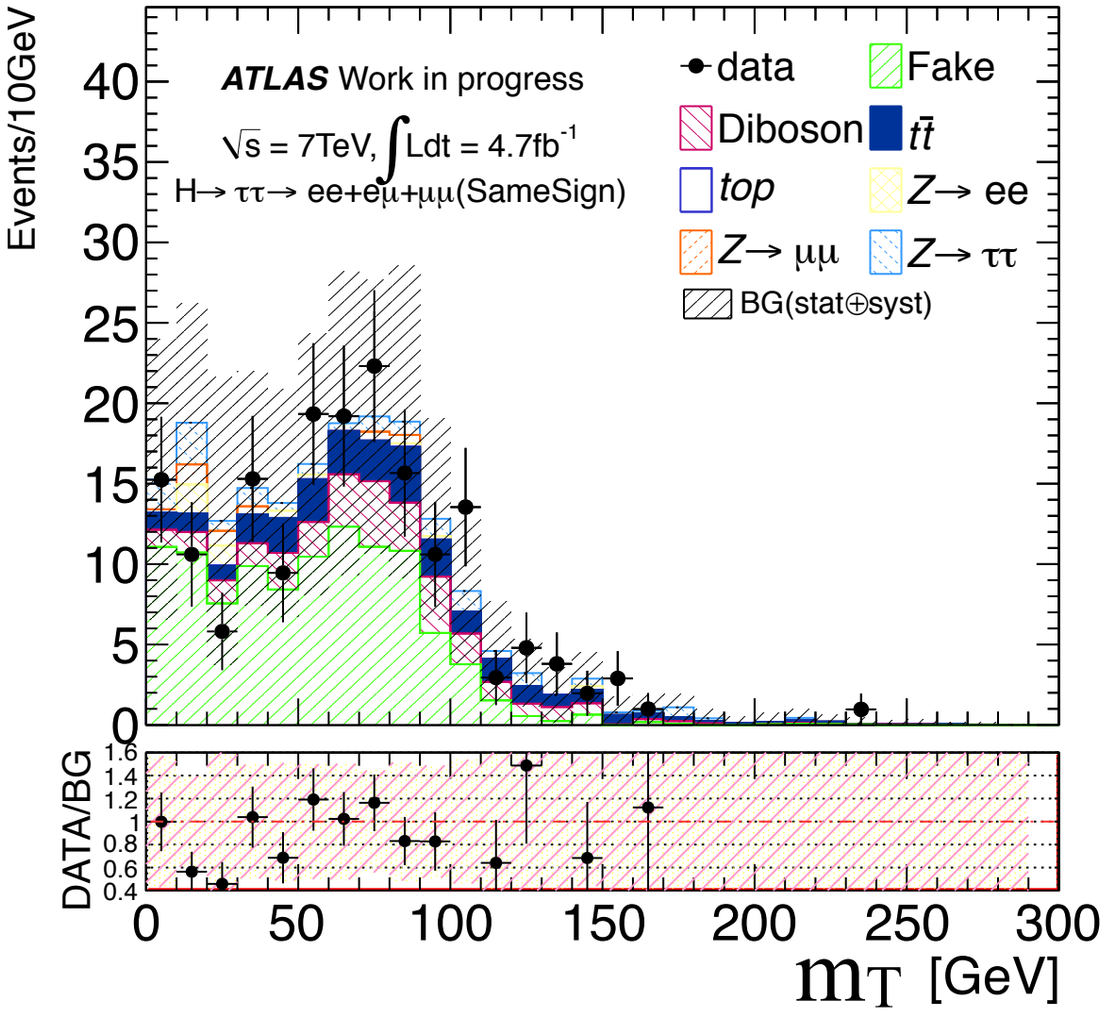
- The optimal point is
  - $E_T$cone40/E_T < 0.16, $p_T$cone20/E_T < 0.13 (all channel)
  - $E_T$cone40/E_T < 0.16, $p_T$cone20/E_T < 0.13 (w/o 0jet)
  - $E_T$cone40/E_T < 0.07, $p_T$cone20/E_T < 0.05 (0jet only)
- We can get 7.0% gain by all channels combined.
  - But 0jet was decrease its sensitivity.
  - We need to check different isolation cut value between 0jet and other channels.

Conclusion

- We have preformed the optimization of both isolation for 2011 analysis.
  - We have got ~2.5% sensitivity gain by using loosen isolation cut.
  - But 0jet's sensitivity was decrease.
  - We can use different cut values between 0jet and other channels.
  - In this case we can get about 3% sensitivity gain.
- As a ToDo
  - I should check more carefully the number of fake events in each ee/eμ/μe/μμ channel.
  - Optimization in 2012 data soon!!

Back Up!

The fake events



- Left plot is 1st lepton transverse mass distribution in same sign CR.
- Cut level is after missing E_T cut.

Fake events Result		
	Official(Template)	Fake Factor
VBF	$1.3 \pm 0.8 \pm 0.6$	$2.00 \pm 0.26 \pm 0.83$
VH	$13 \pm 2 \pm 5$	$15 \pm 0.7 \pm 7$
1jet	$30 \pm 4 \pm 12$	$30 \pm 0.9 \pm 15$
0jet	$1183 \pm 12 \pm 473$	$3713 \pm 9 \pm 2858$

The fake events

# of Events			
ch	signal	non-fake bkg	fake bkg
VBF	1.42	37.1	2.0
VH	1.96	260	6.0
1jet	5.0	624.5	13.0
0jet	22.54	10125	1071

# of Fake Events					
ch	ee	$e\mu$	μe	$\mu\mu$	Total
VBF	0.0	1.0	0.0	1.0	2.0
VH	0.0	4.0	0.0	1.0	6.0
1jet	0.0	10.0	1.0	2.0	13.0
0jet	$\times$	994	77	$\times$	1071

# of Fakable for 1j,2j (Egamma/Muons)			
ch	1st lepton	2nd lepton	ratio
ee	104	157	(40%,60%)
$e\mu$	300/278	702/4	(45%,55%)
μe	147/1	235/515	(17%,84%)
$\mu\mu$	94	312	(23%,77%)

# of Fakable for 0j (Egamma/Muons)			
ch	1st lepton	2nd lepton	ratio
$e\mu$	6077/3241	13582/18	(47%,59%)
μe	2196/37	3537/10940	(13%,87%)