$Z \rightarrow \tau\tau \rightarrow l\nu\nu\, l\nu\nu$ in first data and $\gamma^* \rightarrow ll$ background estimation

mtautau working group meeting

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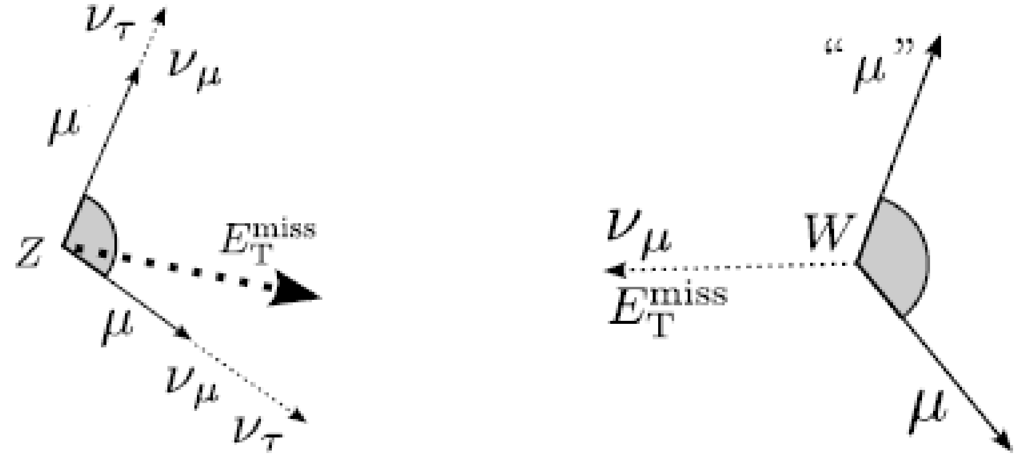
Selection strategy

- Event Cleaning (remove fake jets for E_t^{miss} calculation.)
- Trigger (ask trigger bit for 2 muons or 2 electrons with p_T>10GeV)
- Selection of good electrons and muons with p_T>10GeV

(including fiducial η cuts and quality criteria)
- Opposite sign of lepton pair
- Isolation of both leptons (ask for energy or p_T in cone around lepton)
- SumCosDeltaPhi > -0.15 (against W, Z→ll and γ*→μ)

$\cos(\Phi(lep1) - \Phi(E_T^{miss})) + \cos(\Phi(lep2) - \Phi(E_T^{miss}))$

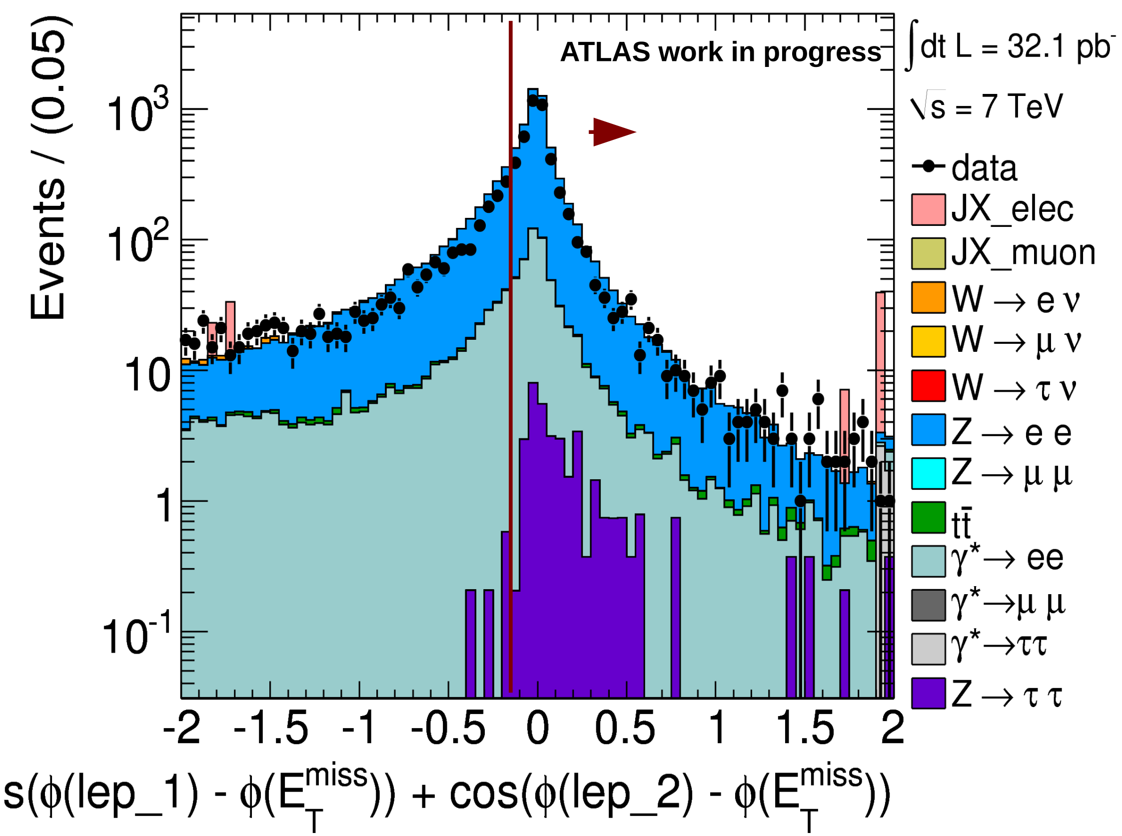


(a) $Z \to \tau\tau \to \mu\,\mu\,4\,\nu$ (b) $W \to \mu\nu$

Selection Strategy

•SumCosDeltaPhi > -0.15 (against W, Z→ll and γ*→μ)

$\cos(\Phi(lep1) - \Phi(E_T^{miss})) + \cos(\Phi(lep2) - \Phi(E_T^{miss}))$



Selection strategy

- $\sum E_T$(Jets + e + μ) + $E_t^{miss.}$ < 150 GeV (against ttbar)
- Visible LepLep Mass ϵ [30, 60] GeV (against Zee, Zμμ)

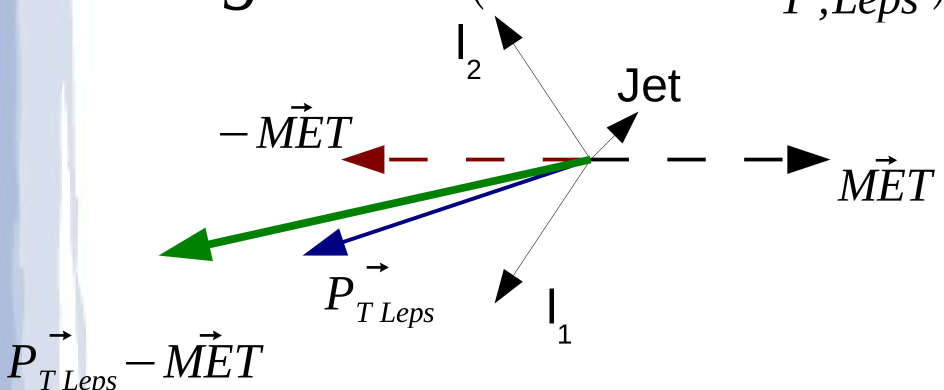
- After this selection same flavour channels (ee, μμ) are dominated by low mass γ*background

γ*→μμ and γ*→ee

In ATLAS the low mass γ*→ll sample is generated separately to the high mass region:
$m_{vis,ll}$ < 60 mainly γ*→ll
$m_{vis,ll}$ > 60 mainly Z →ll

- Diagonal cut on:

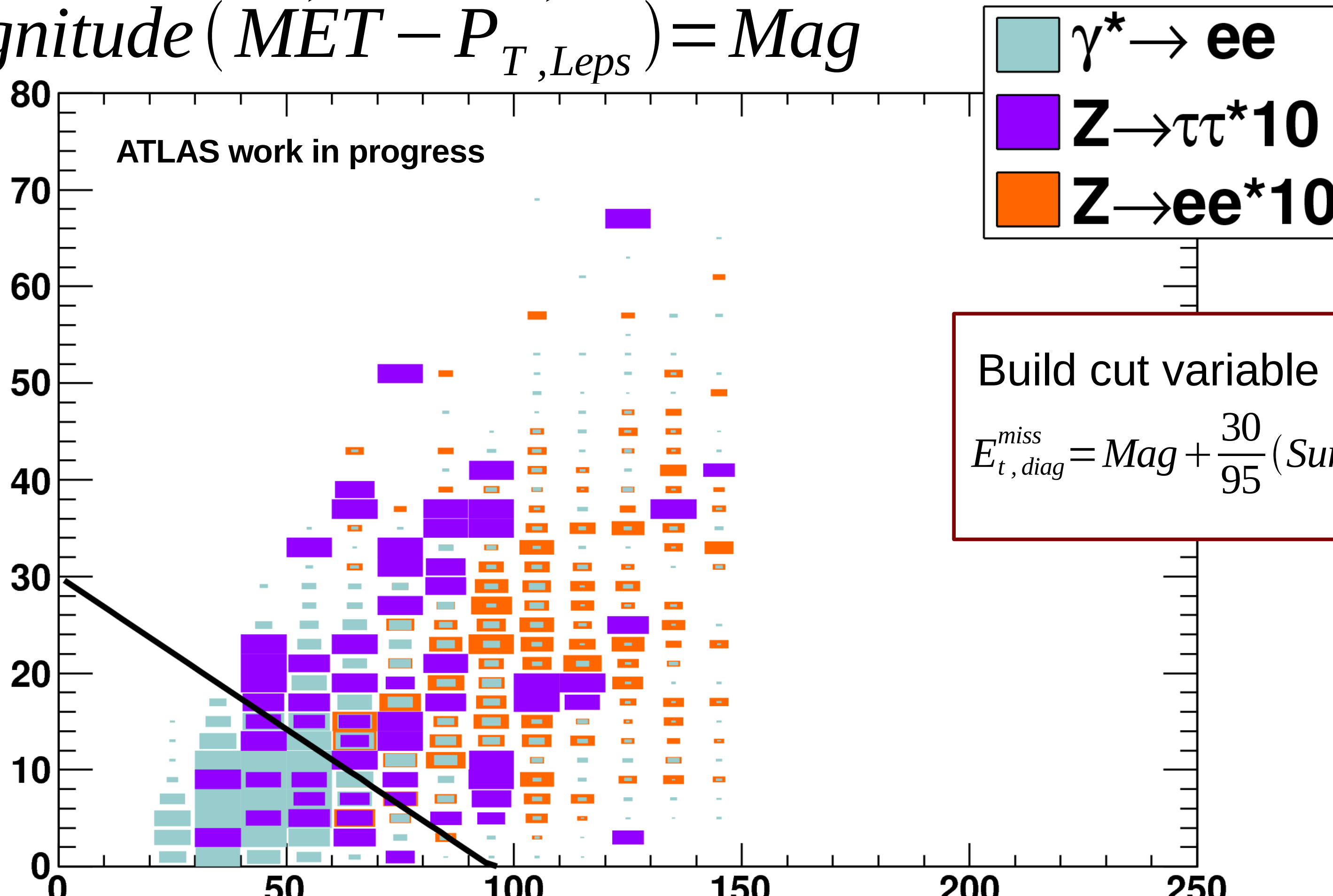
$$Magnitude(\vec{MET} - \vec{P}_{T,Leps}) \quad \text{vs.} \quad \sum E_T(Jets + e + \mu) + E_t^{miss}$$



Now concentrate on ee channel only.
μμ channel gives similar results

Diagonal cut in $Z \rightarrow \tau\tau \rightarrow ee$ channel

$$Magnitude(\vec{MET} - \vec{P}_{T,Leps}) = Mag$$



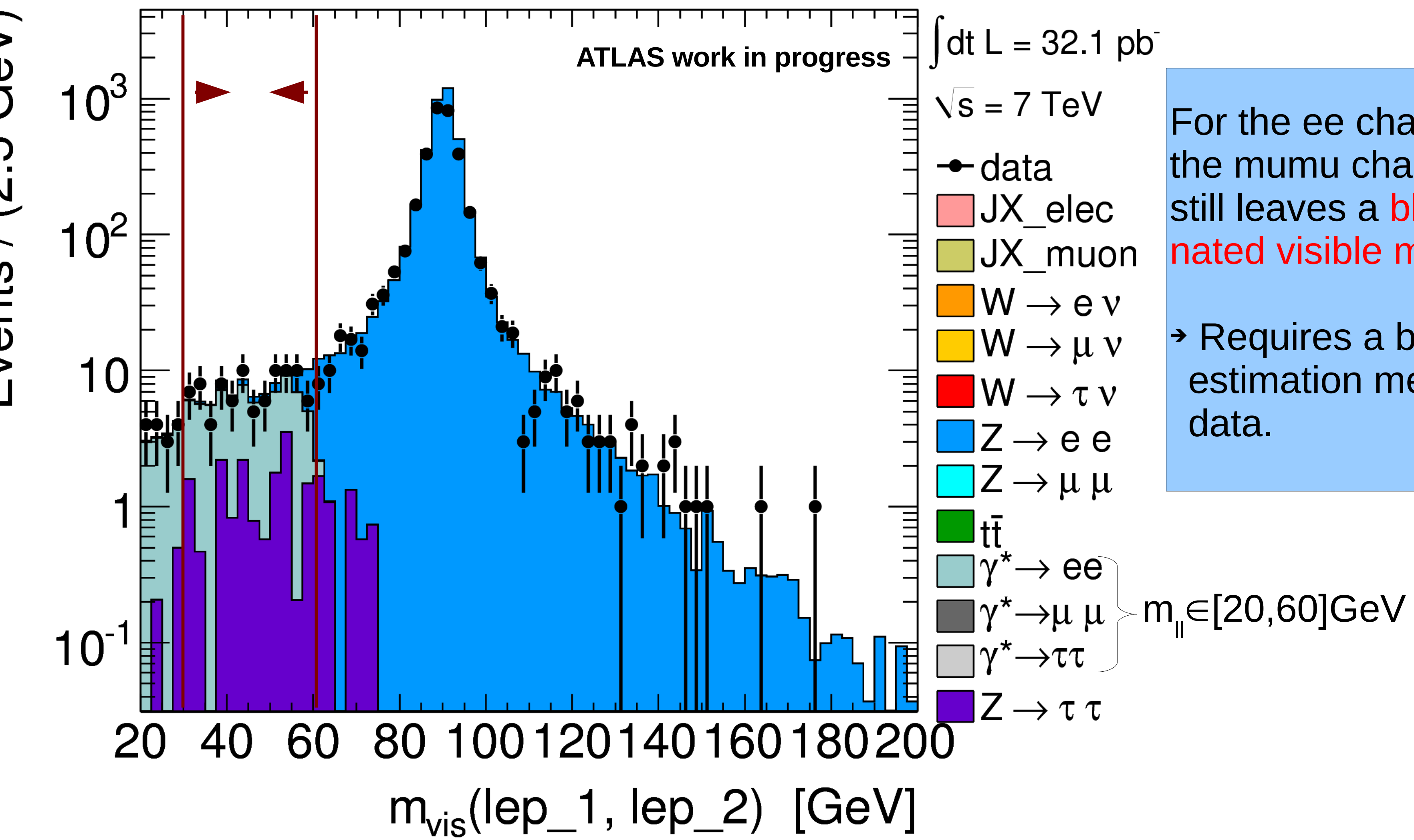
$m_{ll} \in [20,60]$GeV

Build cut variable

$$E^{miss}_{t,diag} = Mag + \frac{30}{95}(SumET + E^{miss}_{t}) > 30\,GeV$$

$$\sum E_T(Jets + e + \mu) + E^{miss}_{t} = SumET + E^{miss}_{t}$$

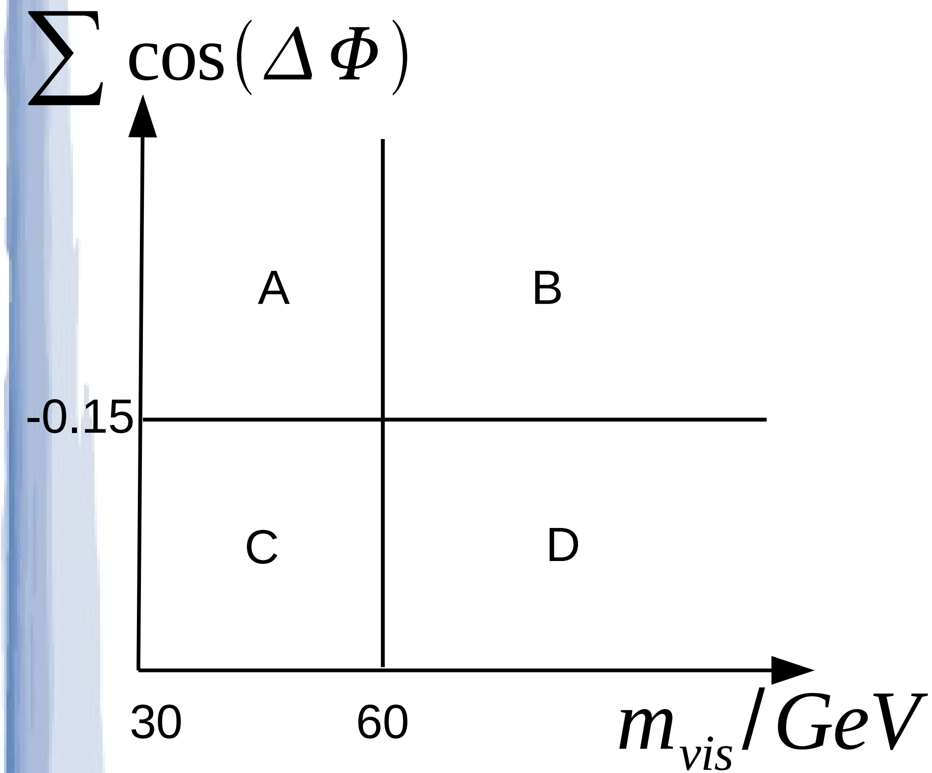
After diagonal cut, without vis leplep mass cut



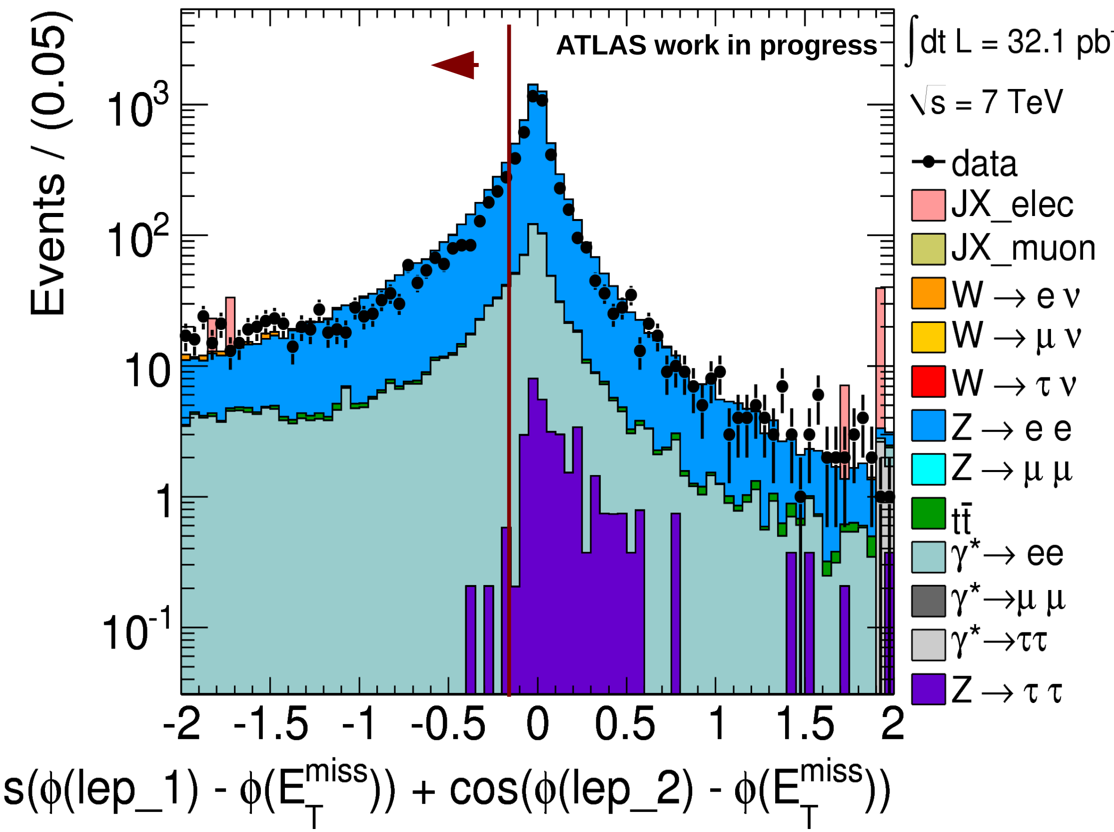
For the ee channel and the mumu channel this still leaves a bkg dominated visible mass region

➔ Requires a background estimation method from data.

The method

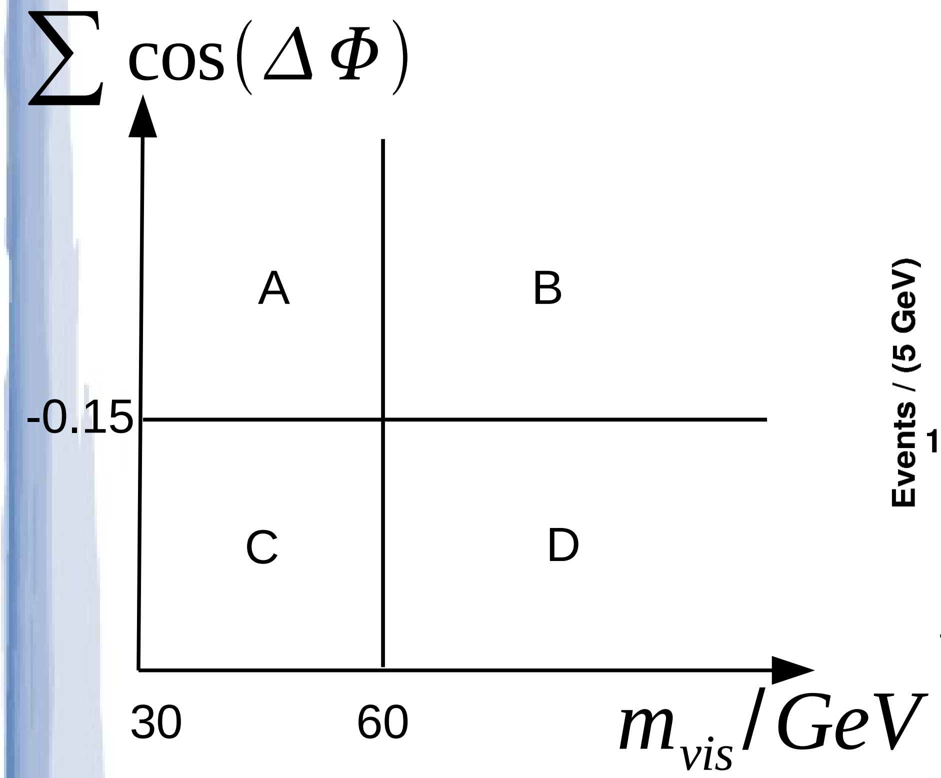


Invert the cut on ∑cos(ΔΦ) to get a signal clean control region.

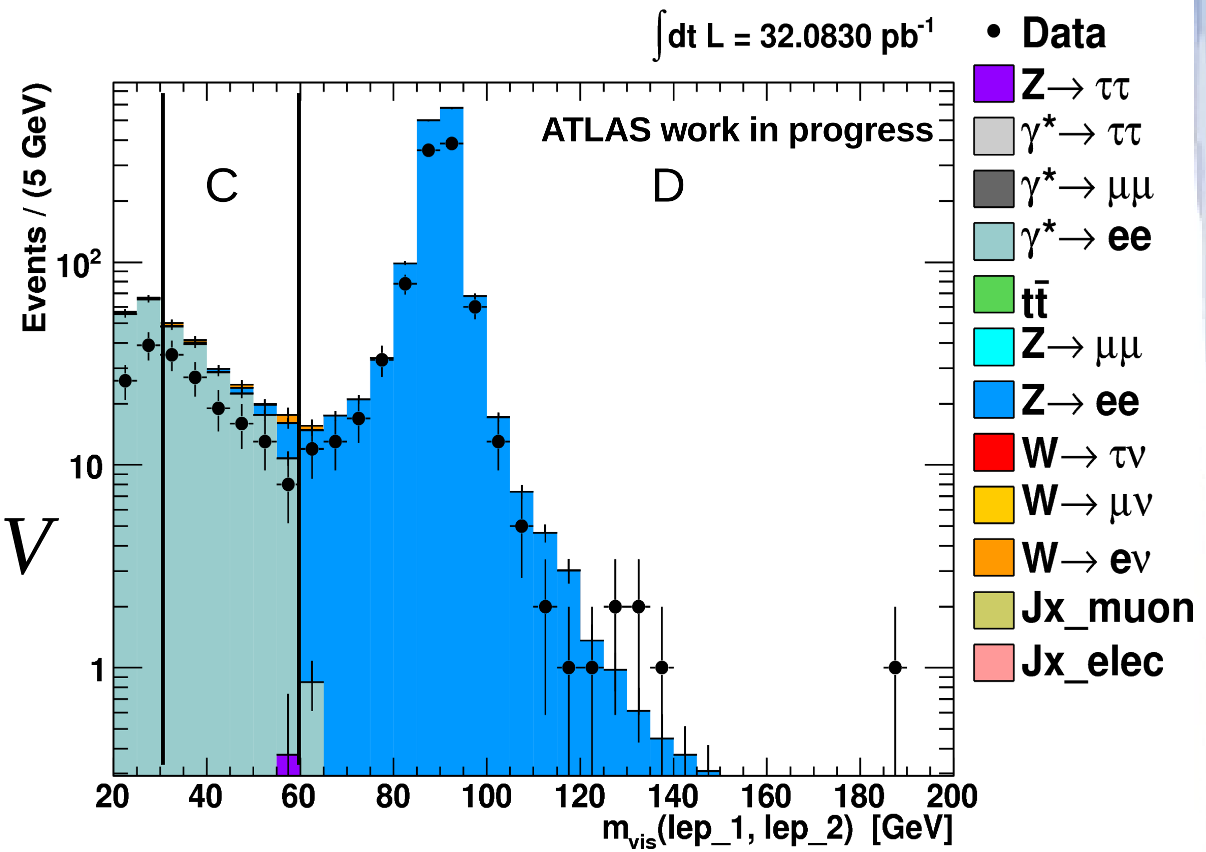


The cut changes the ratio γ*→ll/Z→ll, which makes a pure ABCD method based on event yields impossible.

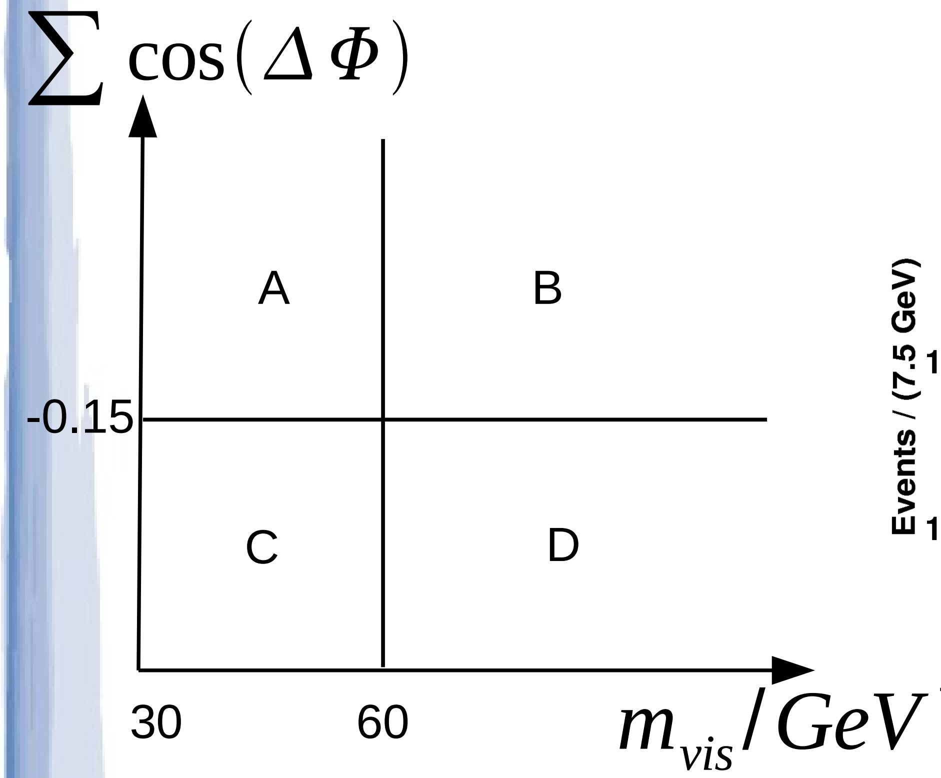
The method



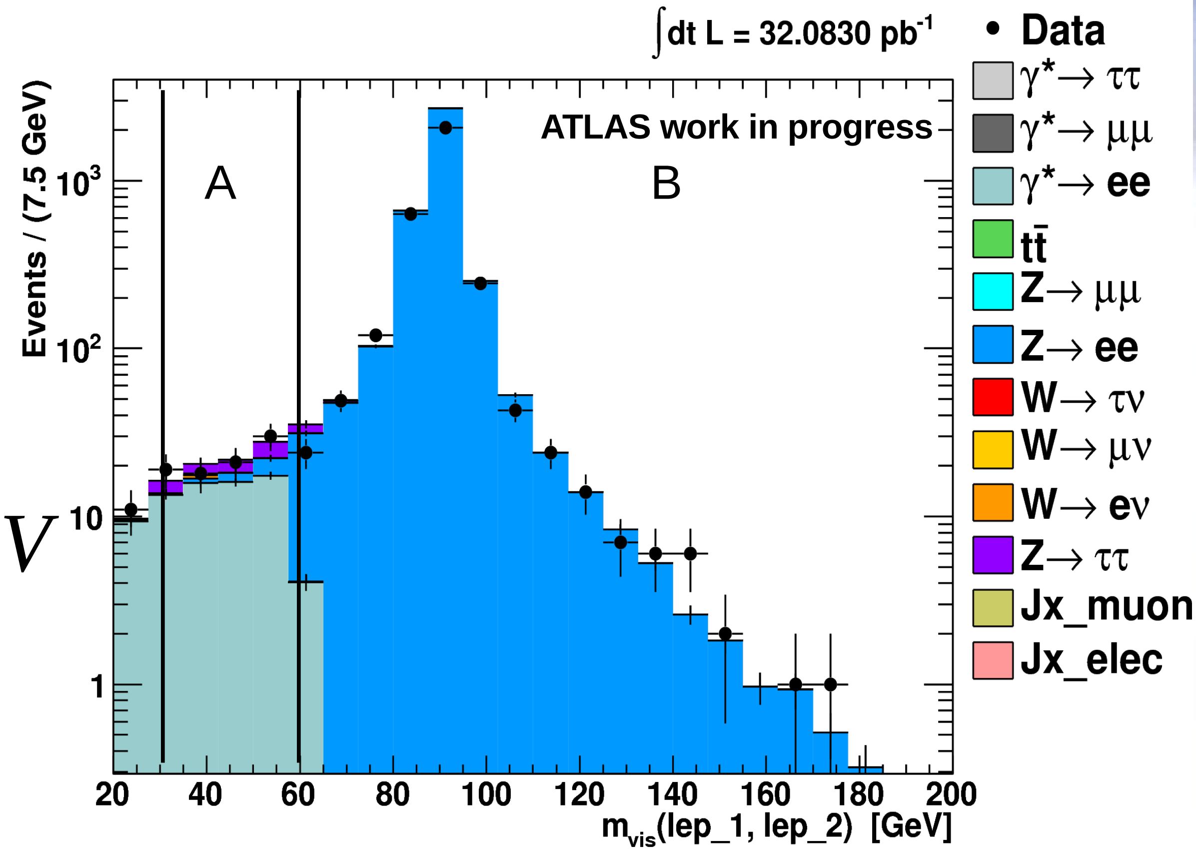
Vis leplep mass in Control region.
(Purity for γ*/Z→ll is 96.7%.)



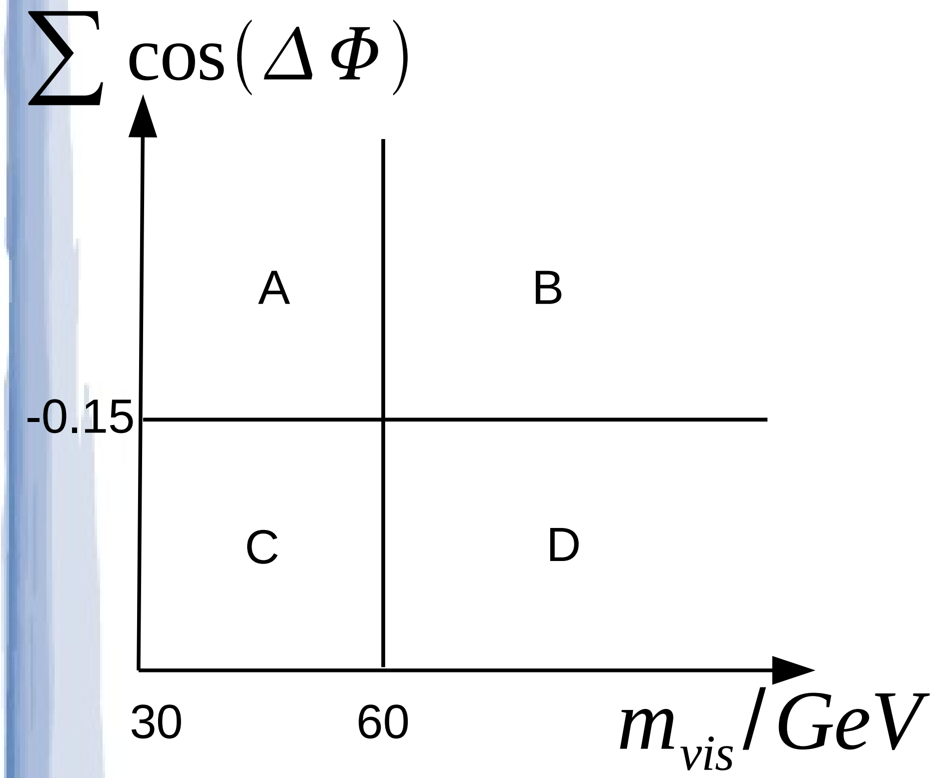
The method



Vis leplep mass in Signal region,
after subsequent cut on 2 dimensional variable.



The method



Use the ABCD method with event yield ratios, instead of event yields.

Define signal (SR) and control regions (CR)
A – SR, contains mainly $Z \to \tau\tau$, $\gamma^* \to ll$
B – SR, contains mainly $Z \to ll$
C – CR, contains mainly $\gamma^* \to ll$
D – CR, contains mainly $Z \to ll$

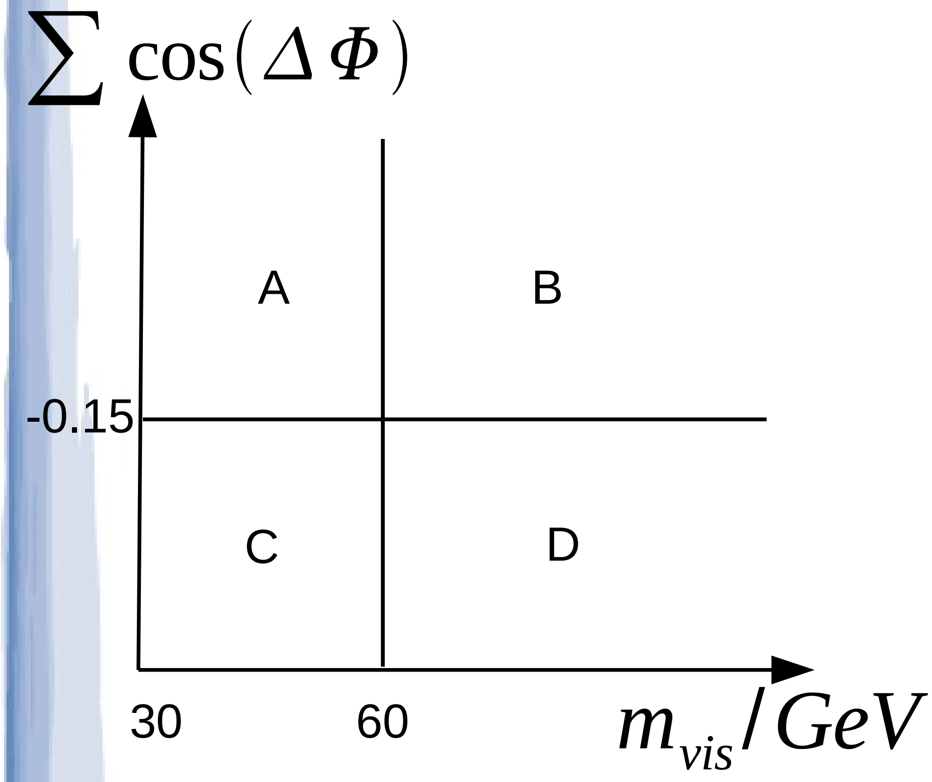
How much changes Data/MC from C to D?

$$\frac{D_{Data}}{D_{MC}} = F \cdot \frac{C_{Data}}{C_{MC}}$$

With $\frac{D_{Data}}{D_{MC}} = \tilde{D} \to \tilde{D} = F \cdot \tilde{C}$

The method

$$\tilde{X} = \frac{X_{Data}}{X_{MC}}$$
$$X = A, B, C, D$$



Central assumption is that F does not change From the control region (C – D) to the signal region(A – B).

$$\tilde{D} = F \cdot \tilde{C}$$
$$\tilde{B} = F \cdot \tilde{A}$$

Here $\tilde{A}$ consists only of BKG events.
Now estimate amount of BKG in region A.

$$\tilde{A} = \frac{\tilde{B}}{F} = \tilde{B} \cdot \frac{\tilde{C}}{\tilde{D}}$$

$$A_{Data\,BKG} = A_{MC\,BKG} \cdot \tilde{B} \cdot \frac{\tilde{C}}{\tilde{D}}$$

Results

Method was applied to ee and μμ channel.

	ee	μμ	both
MC background prediction	99.6 ± 1.9	126.7 ± 2.3	226.3 ± 3.0
background estimation	79.7 ± 2.0 ± 7.9	117.1 ± 2.6 ± 8.5	196.8 ± 3.3 ± 11.6

Errors on estimation: value ± error_MC ± error_Data

Application to ee channel:

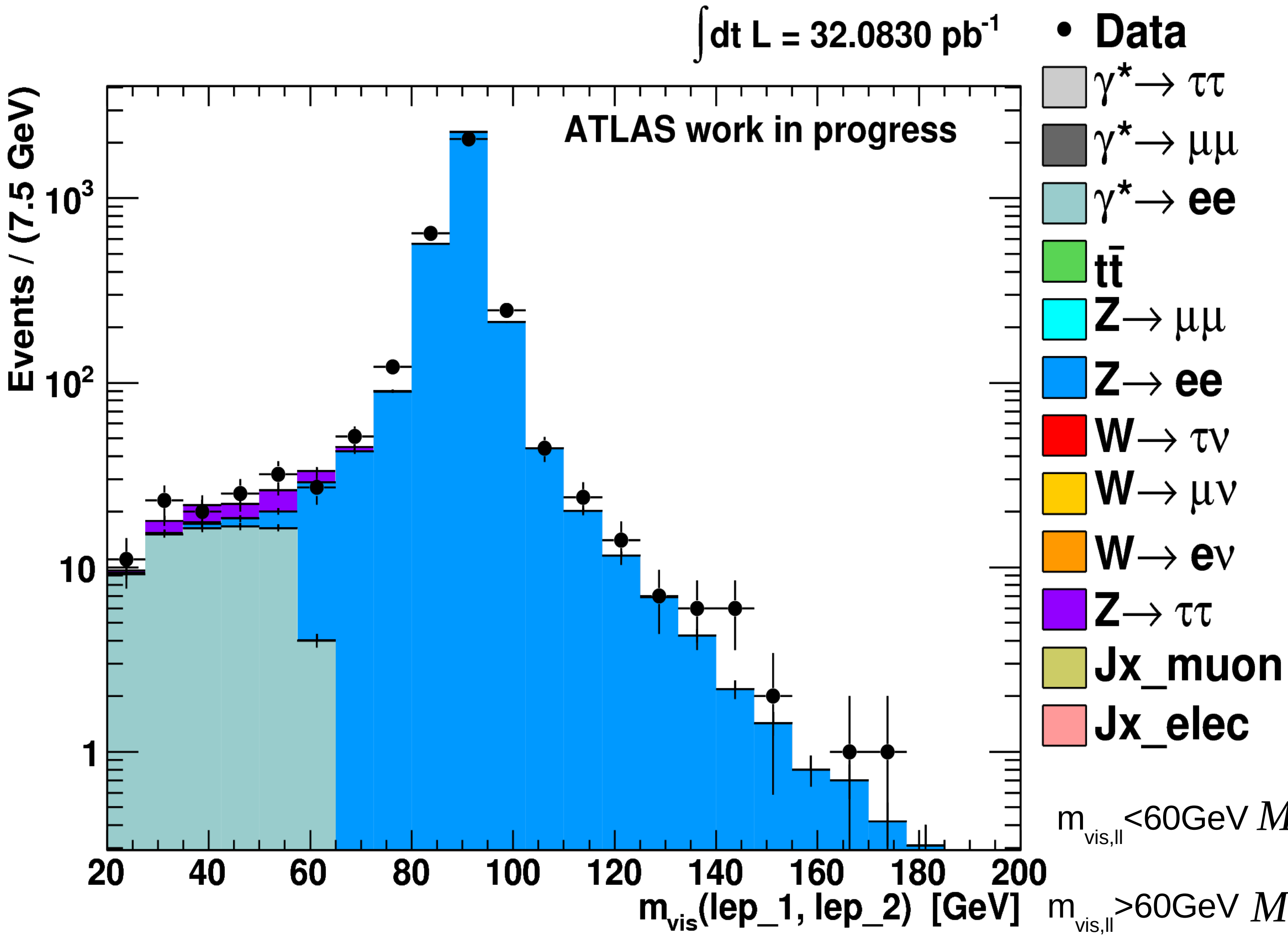
For the following pages all MC background prediction is scaled:

- $M_{vis,ll} < 60$: $MC_{plot} = MC \cdot \tilde{A} = MC \cdot 0.88$

- $M_{vis,ll} > 60$: $MC_{plot} = MC \cdot \tilde{B} = MC \cdot 0.84$

Results for ee channel

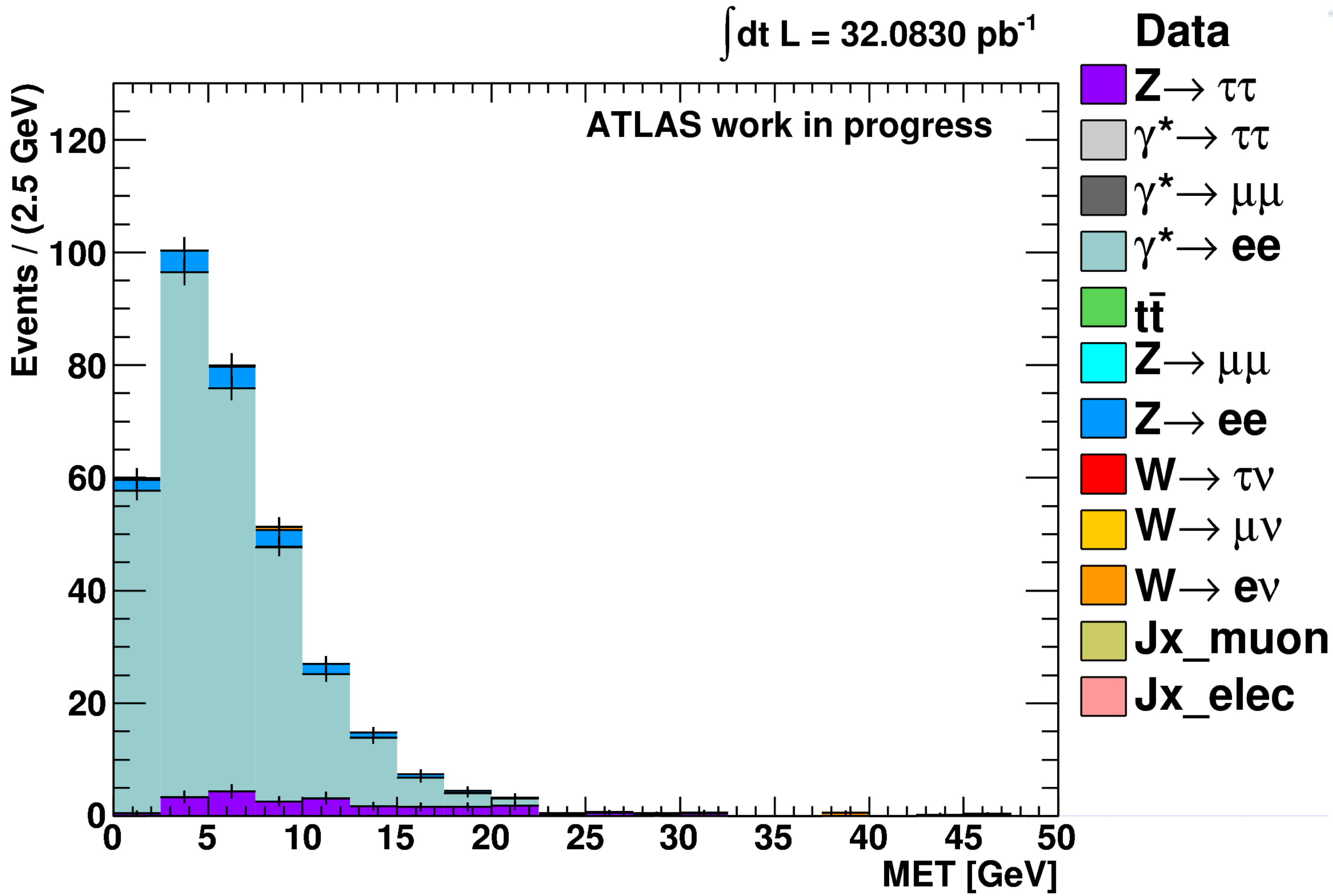
After diagonal E_t^{miss} Cut w/o vis mass cut



$m_{vis,ll}$<60GeV $MC_{plot} = MC \cdot \tilde{A} = MC \cdot 0.88$

$m_{vis,ll}$>60GeV $MC_{plot} = MC \cdot \tilde{B} = MC \cdot 0.84$

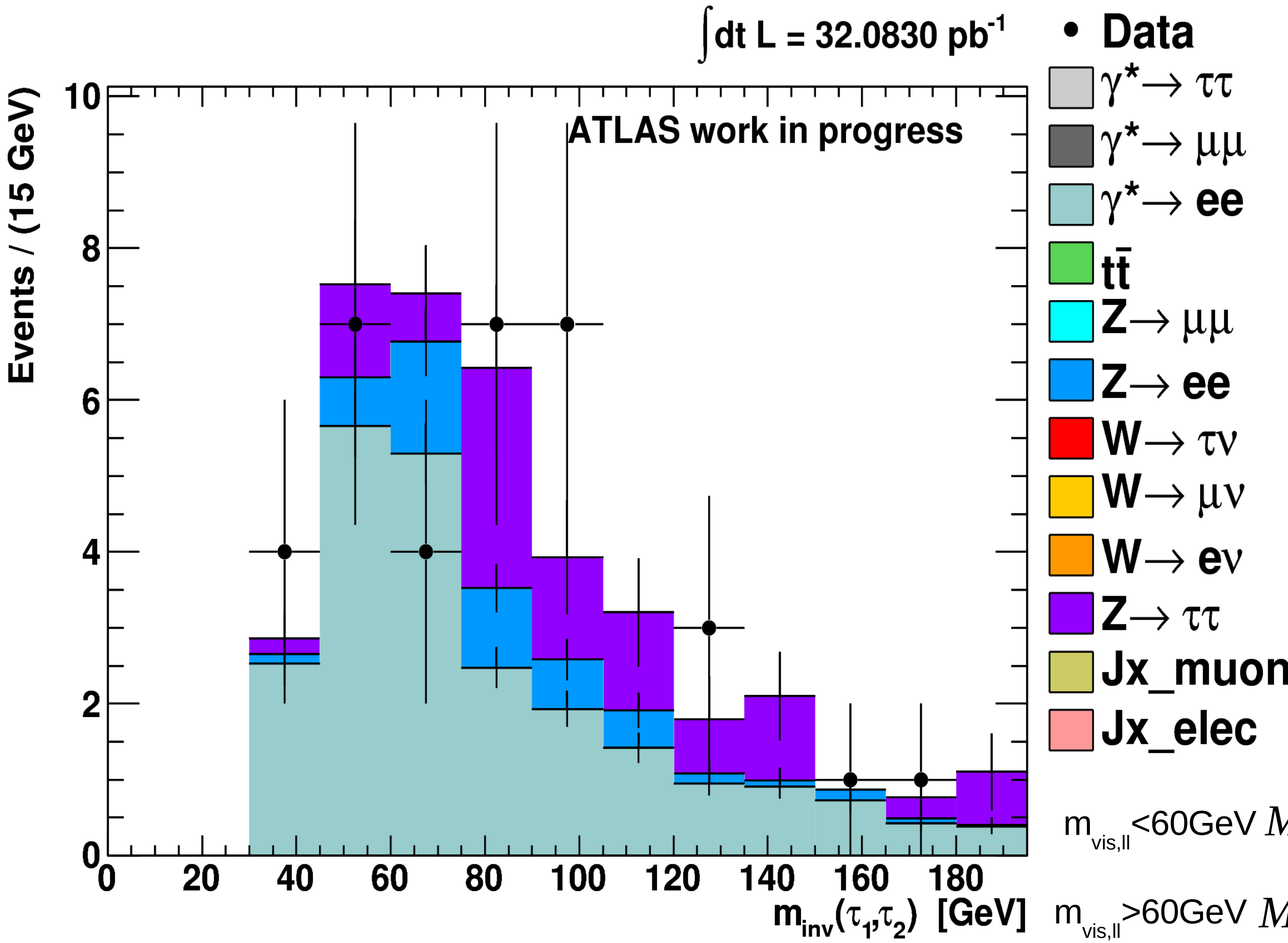
BACKUP



- E_t^{miss} distribution after all cuts except diagonal cut.
- E_t^{miss} not suitable to separate signal from $\gamma^* \rightarrow ll$ after vis mass cut

Results for ee channel

After diagonal E_t^{miss} Cut and vis mass cut



InvMass with restriction

$$x_1 \cdot x_2 > 0$$

$m_{vis,ll}$<60GeV $MC_{plot} = MC \cdot \tilde{A} = MC \cdot 0.88$

$m_{vis,ll}$>60GeV $MC_{plot} = MC \cdot \tilde{B} = MC \cdot 0.84$