CMS dileptonic “edge” search

TH BSM Forum -- CERN -- 17.Oct.2014

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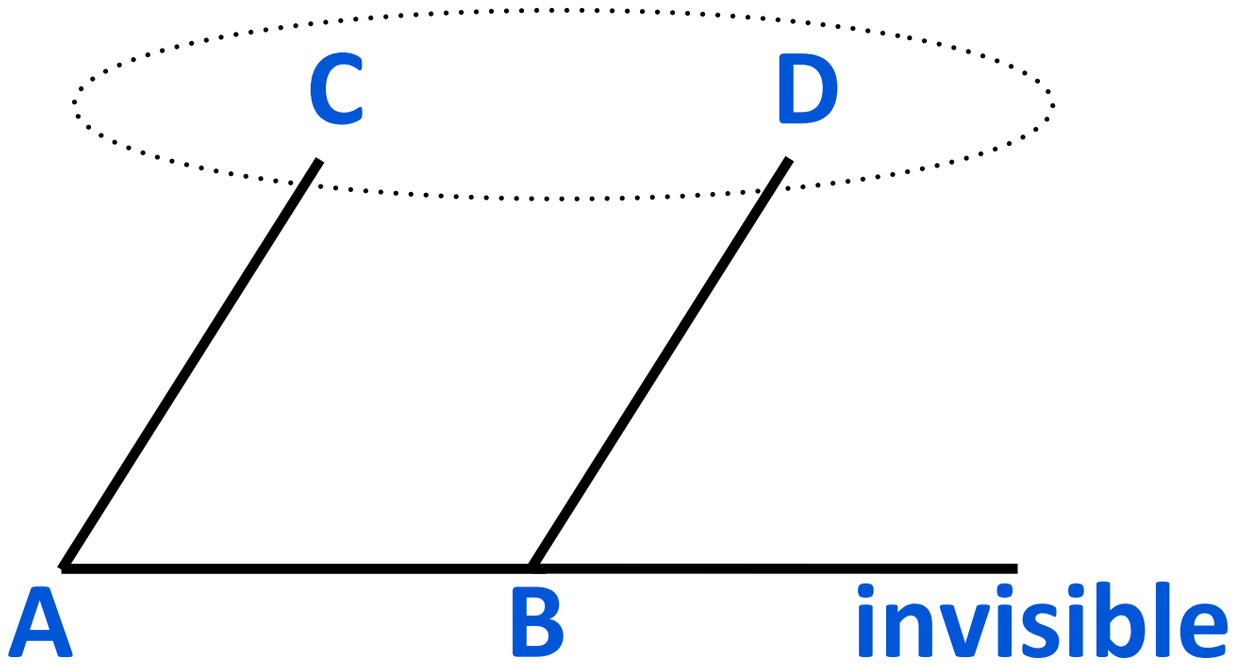
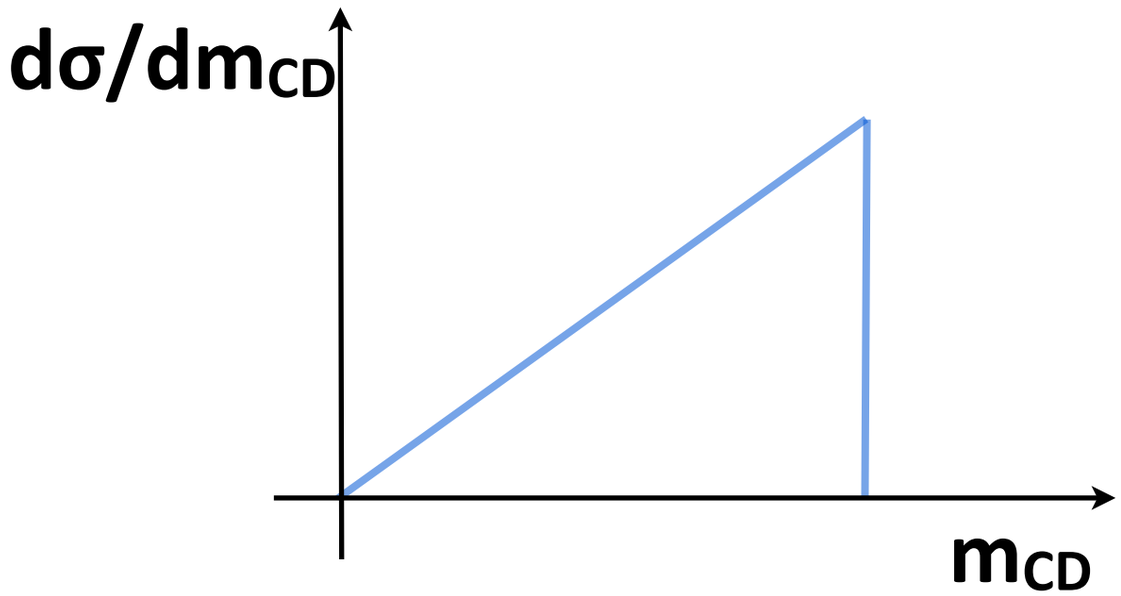
(on behalf of the CMS Collaboration)

ref: CMS PAS SUS-12-019

Kinematic endpoints

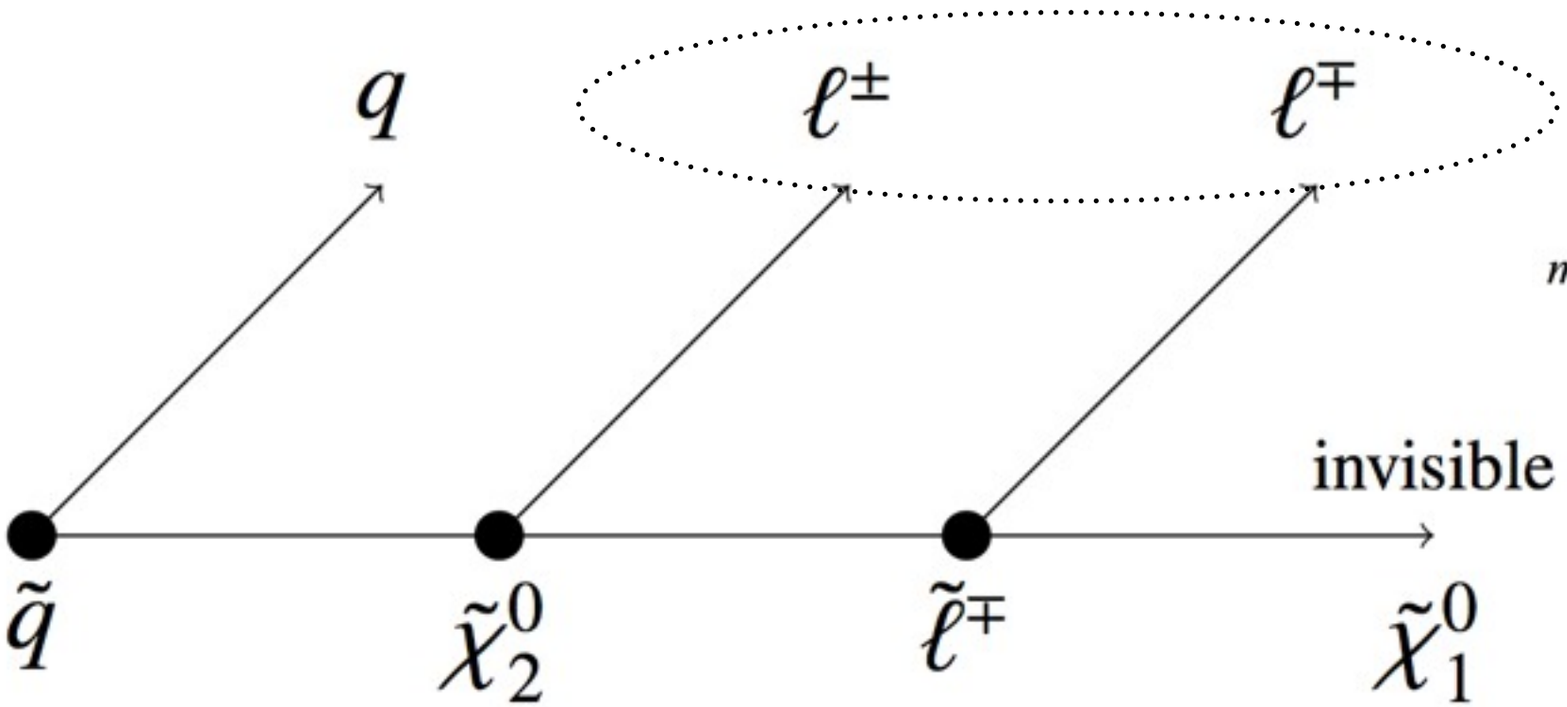




Invariant mass distribution $\mathbf{m_{CD}}$ exhibits a threshold effect

- Sequential 2-body decays give an endpoint in m_{CD}
- 3-body decay of **A→ C D inv** gives also an edge
- Location of the edge gives info about $\mathbf{m_A, m_B, m_{inv}}$
- If **A** is neutral **C,D** could be an OSSF (l^+l^-) dilepton

Neutralino decays



$$m_{\ell\ell}^{max} = m_{\tilde{\chi}_2^0}\sqrt{\left(1-\left(\frac{m_{\tilde{\ell}}}{m_{\tilde{\chi}_2^0}}\right)^2\right)\left(1-\left(\frac{m_{\tilde{\chi}_1^0}}{m_{\tilde{\ell}}}\right)^2\right)}$$

- In SUSY, the topology is exemplified in neutralino decays; higher mass neutralinos can also contribute; direct 3-body decays via offshell Z boson are also possible but give a different endpoint = $\Delta m(\chi 2 - \chi 1)$

Triggers & Acceptance

Electrons

- $p_T > 20$ GeV
- $|\eta| < 2.4$

MET (particle flow)

- no cut at pre-selection

Dilepton triggers

- SF = ee/μμ (i.e. logical .OR.)
- OF = eμ

Muons

- $p_T > 20$ GeV
- $|\eta| < 2.4$

Jets (AK0.5)

- $p_T > 40$ GeV
- $|\eta| < 3.0$

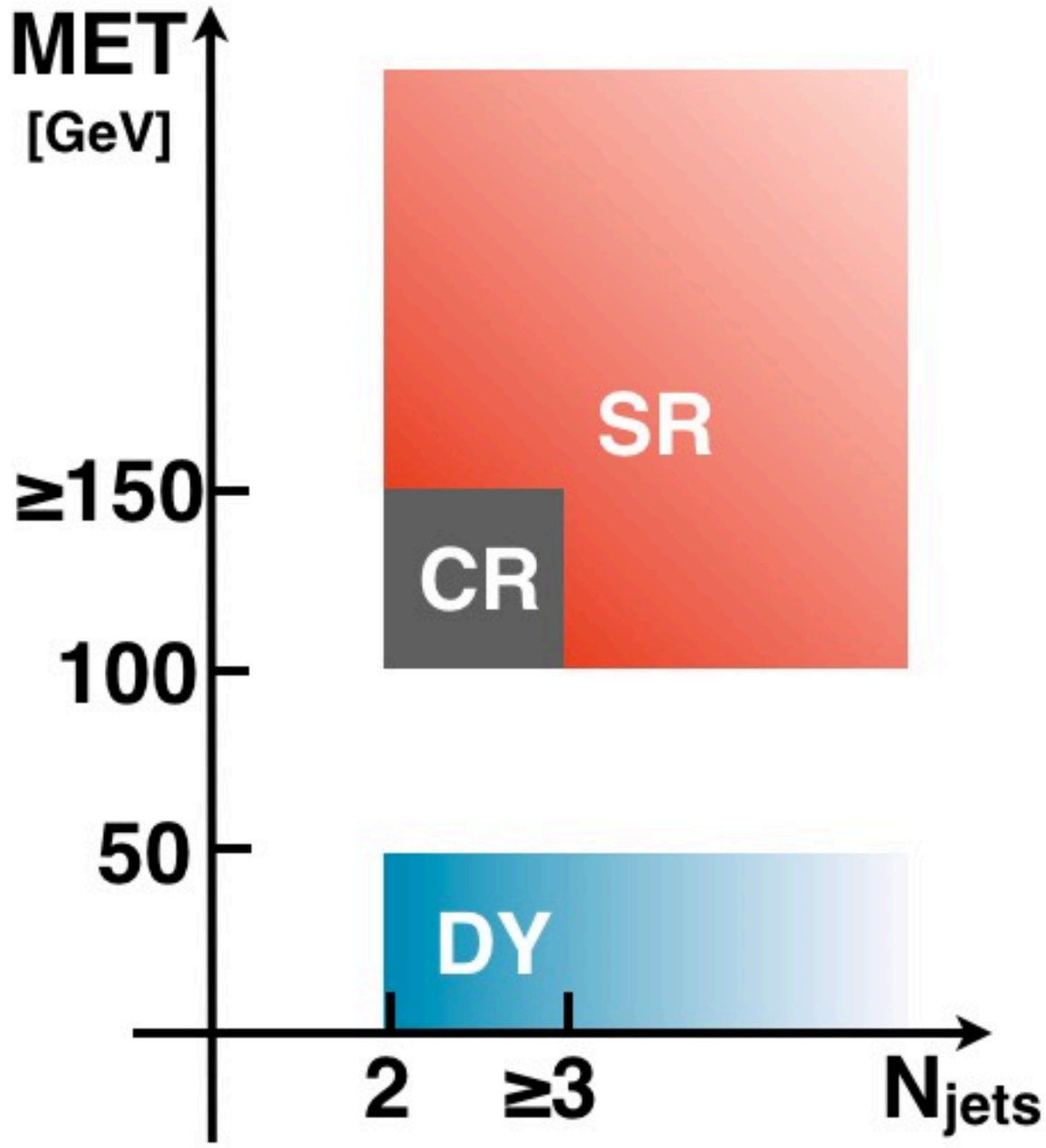
Signal & control samples

$N_{lep} \geq 2$ (reject $1.4 < |\eta| < 1.6$)

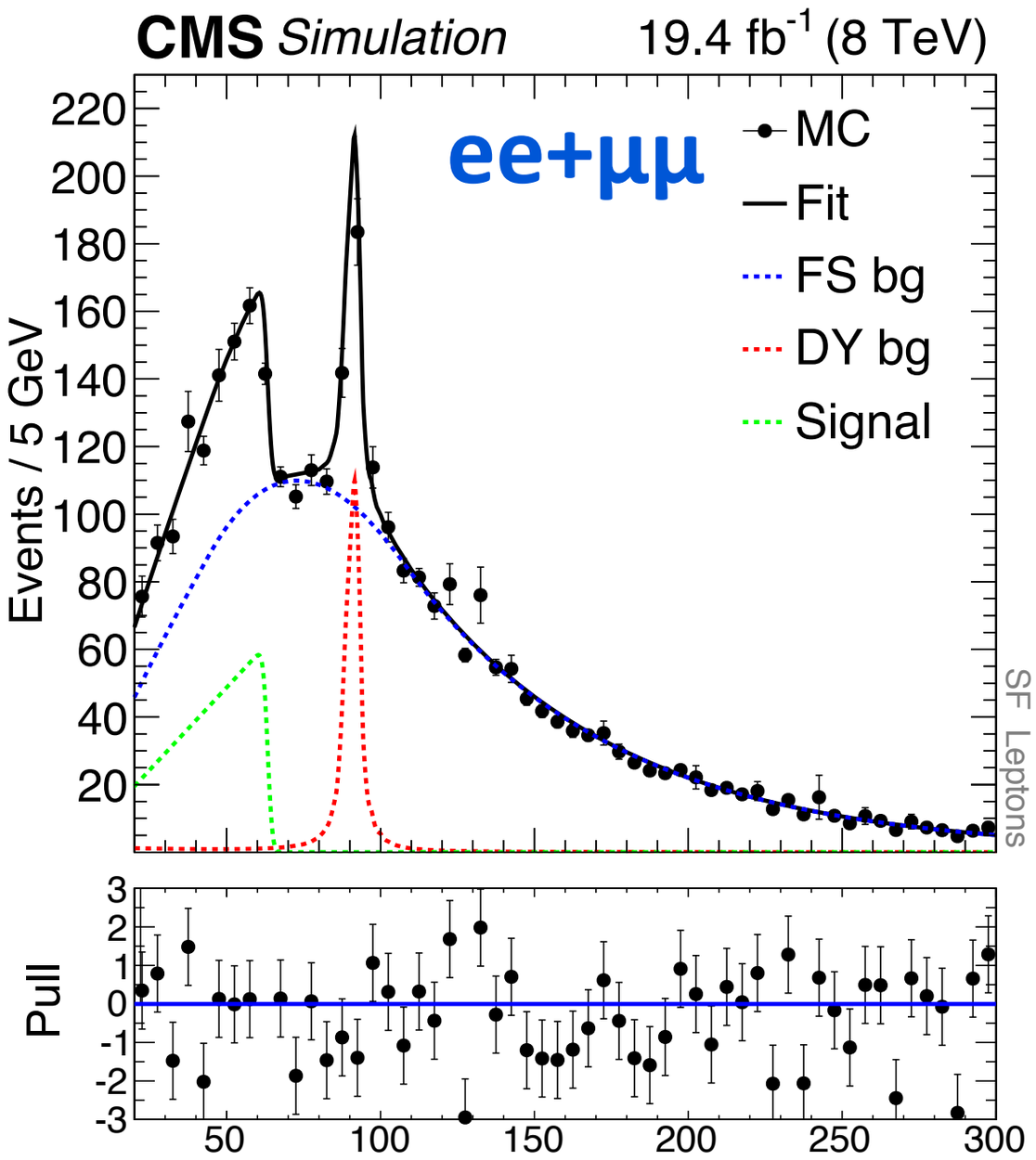
- **"central"** = both with $|\eta| < 1.4$
- **"forward"** = NOT **"central"**

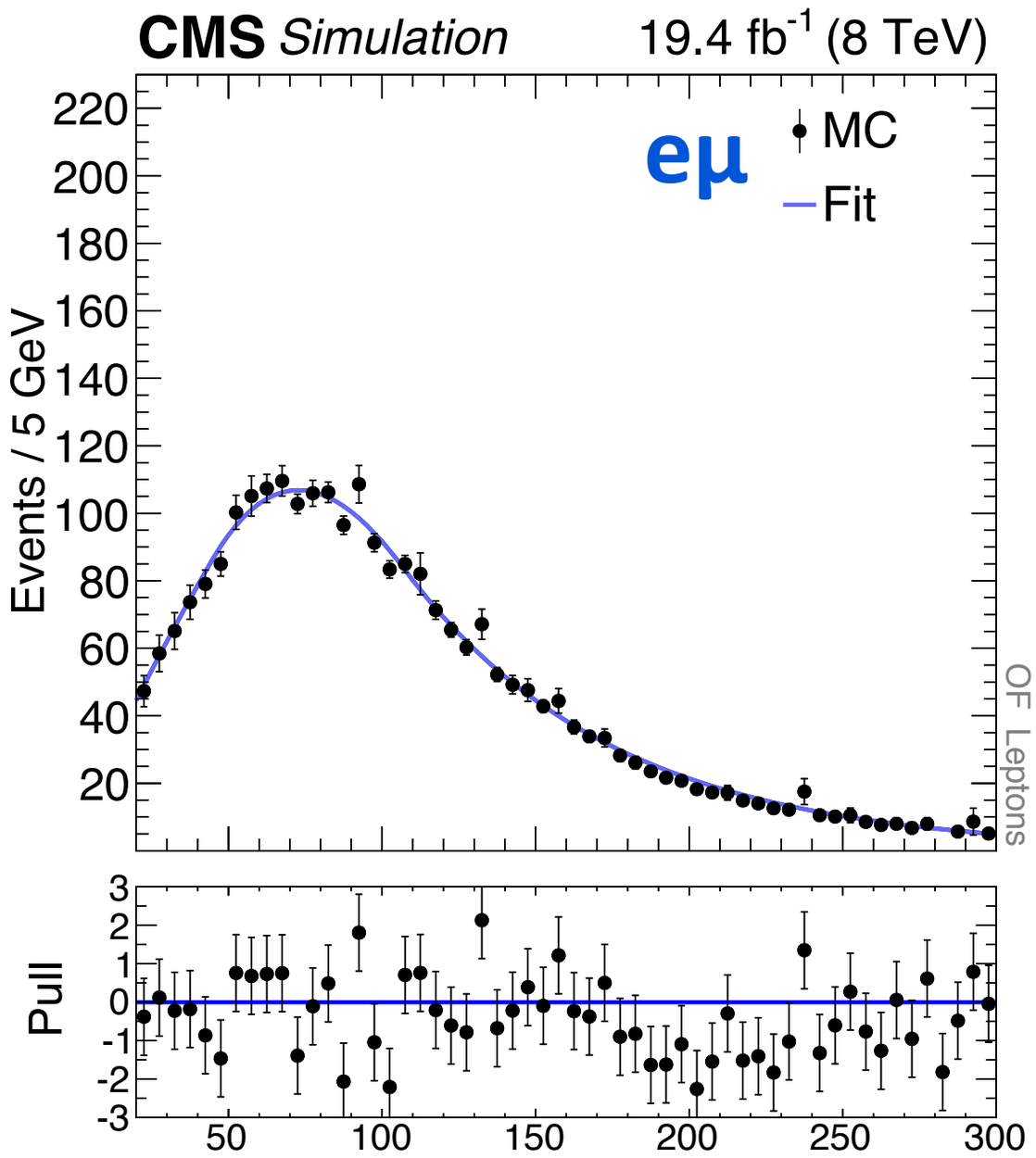
JetMET selection:

- **DY: get R(SF/OF) & DY shape**
- **CR: get R(SF/OF)**
- **SR: signal region**
  - kinematic fit in mll [20,300] GeV
  - cut'n'count in mll [20,70] GeV



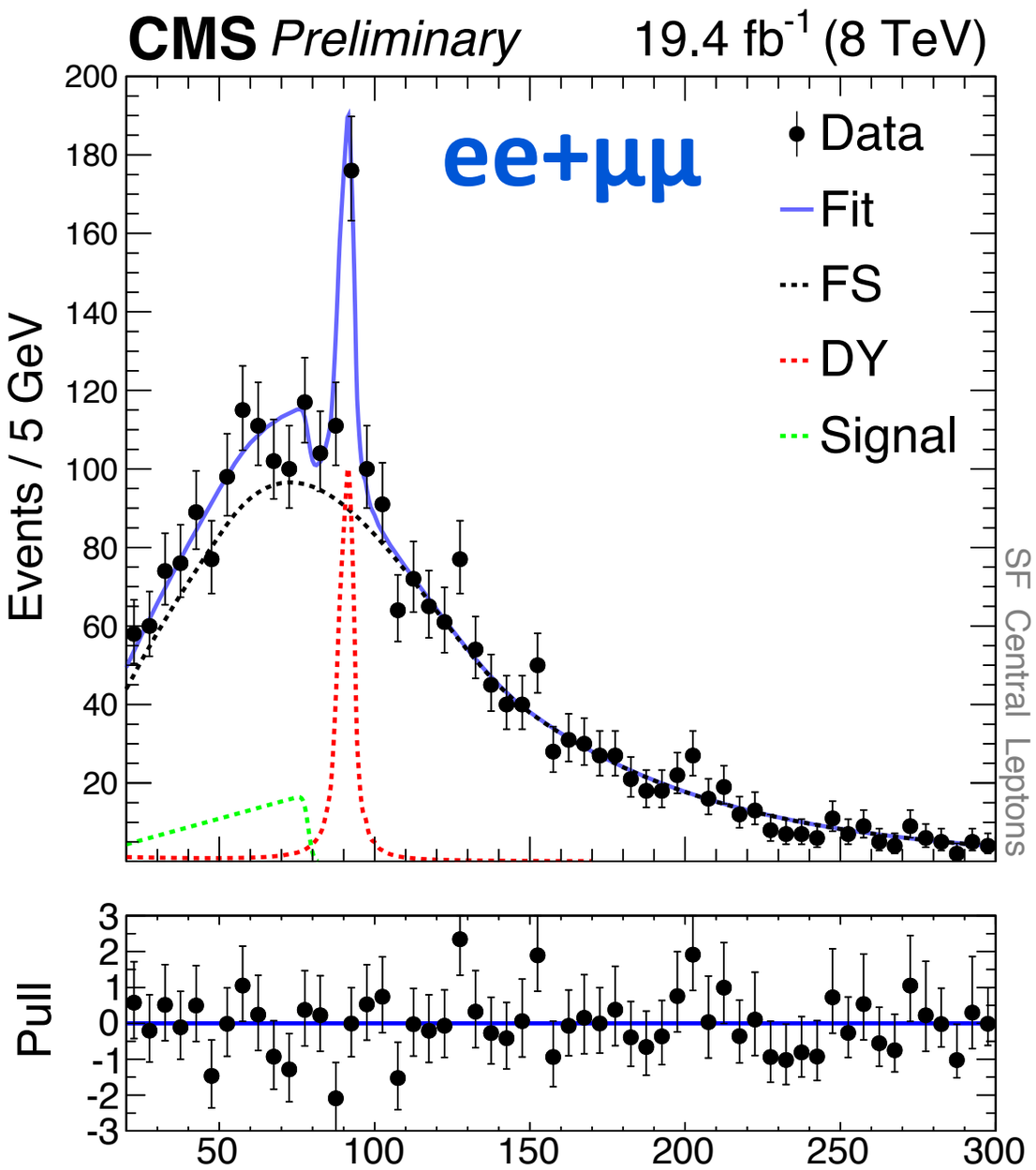
Cut at jets & MET and plot m(ll)

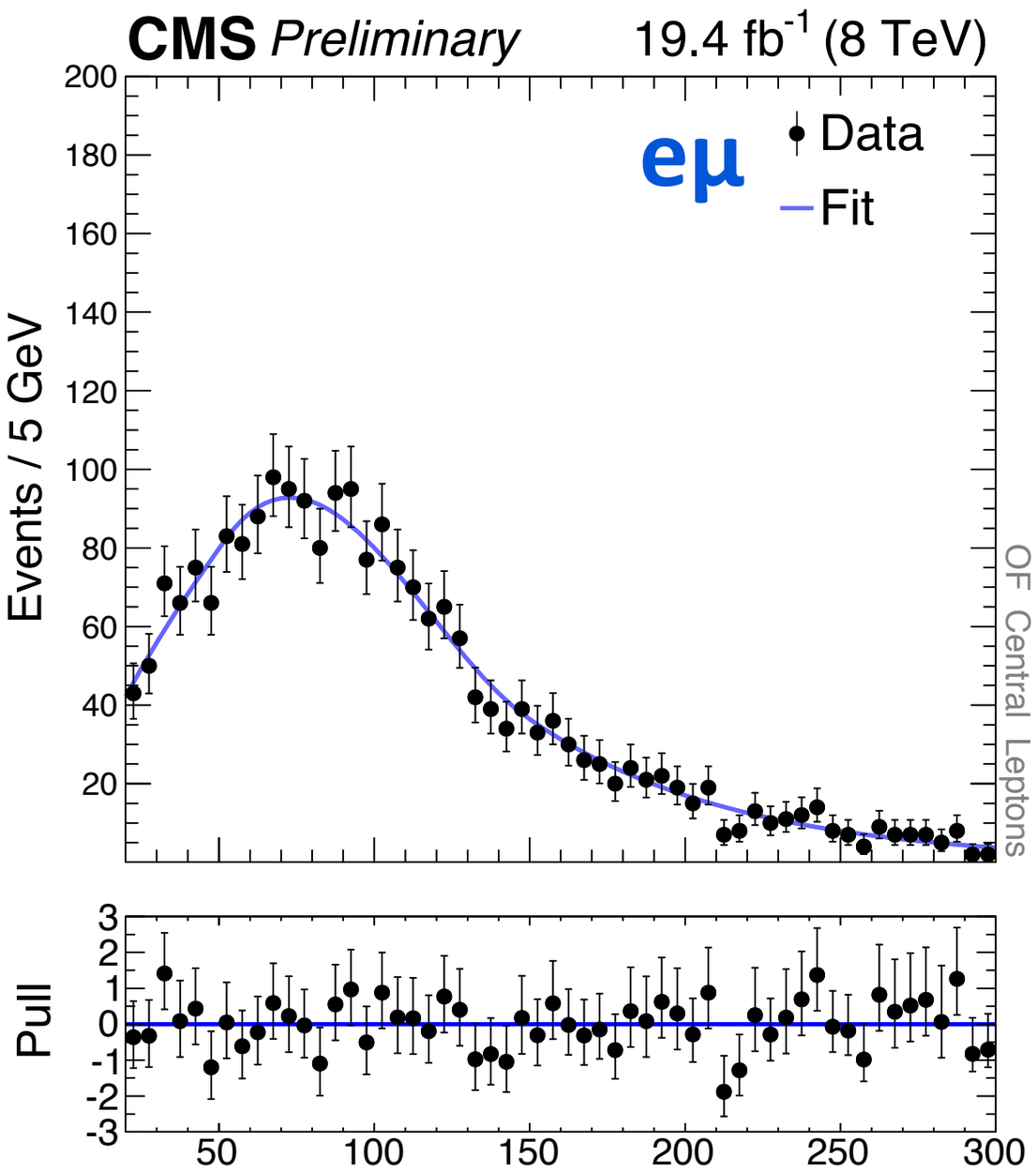




- That's only **simulation** with signal injection (the signal used is a SUSY benchmark)

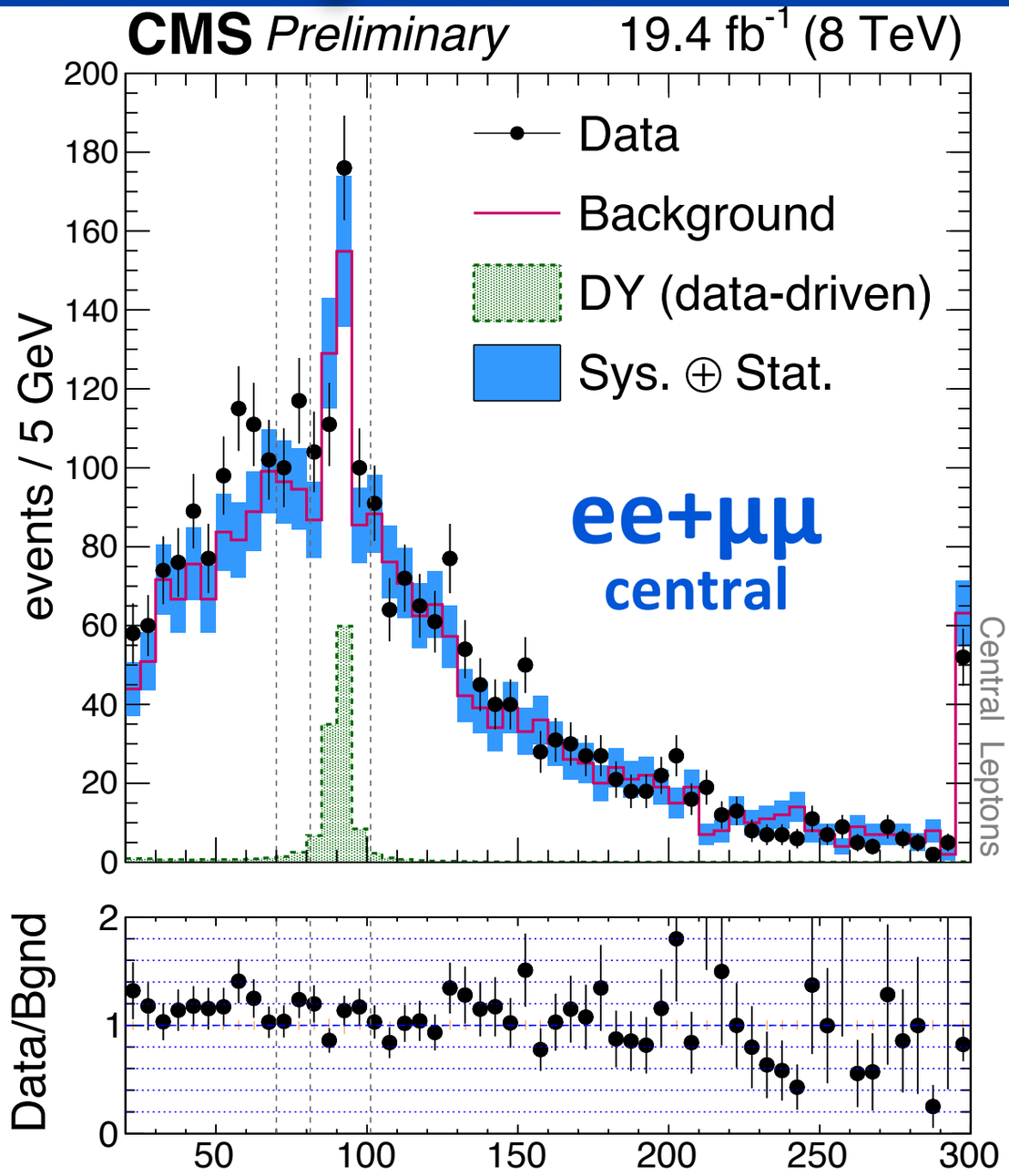
Cut at jets & MET and plot m(ll)

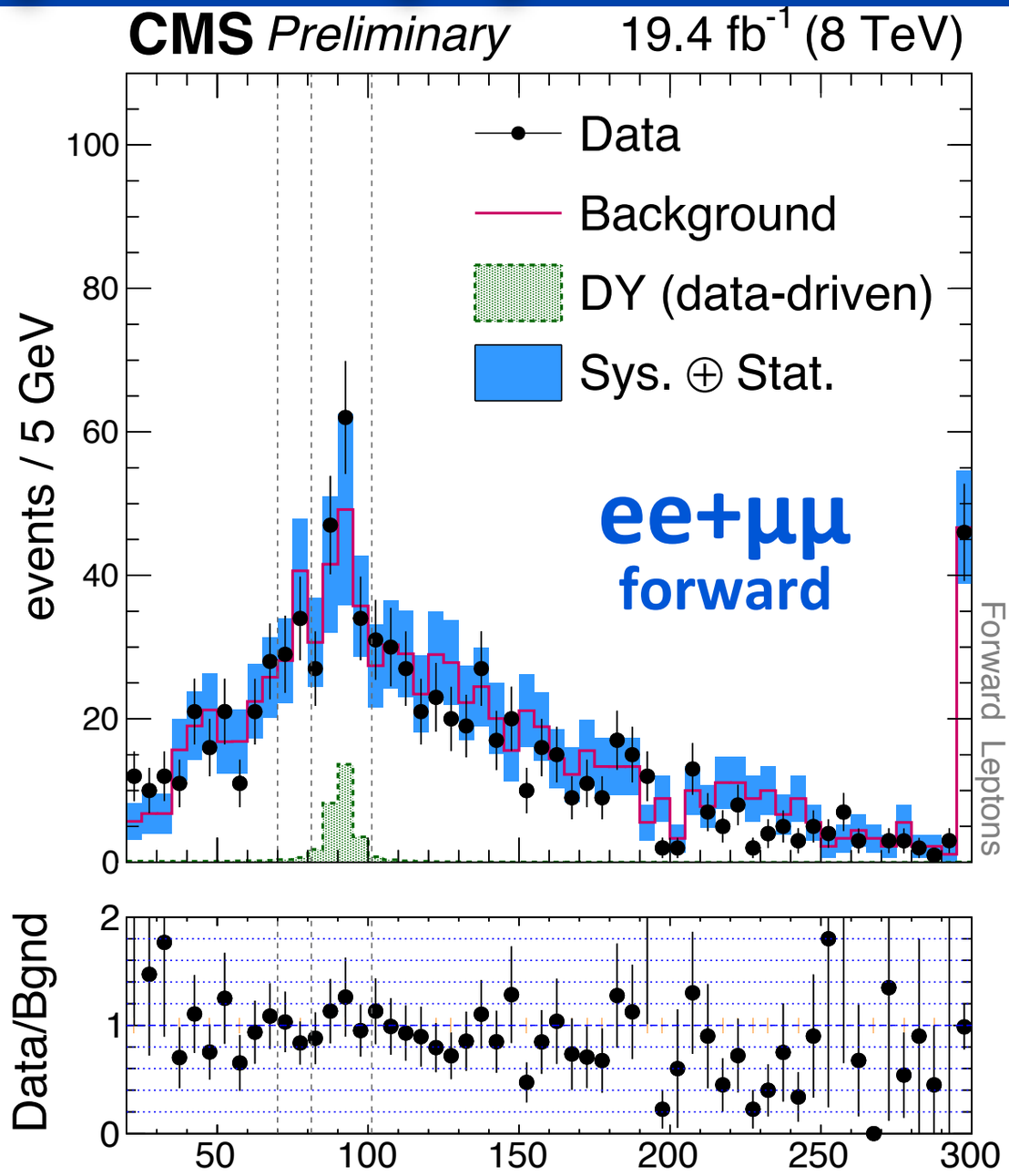




- Data with central leptons ($|\eta| < 1.4$)

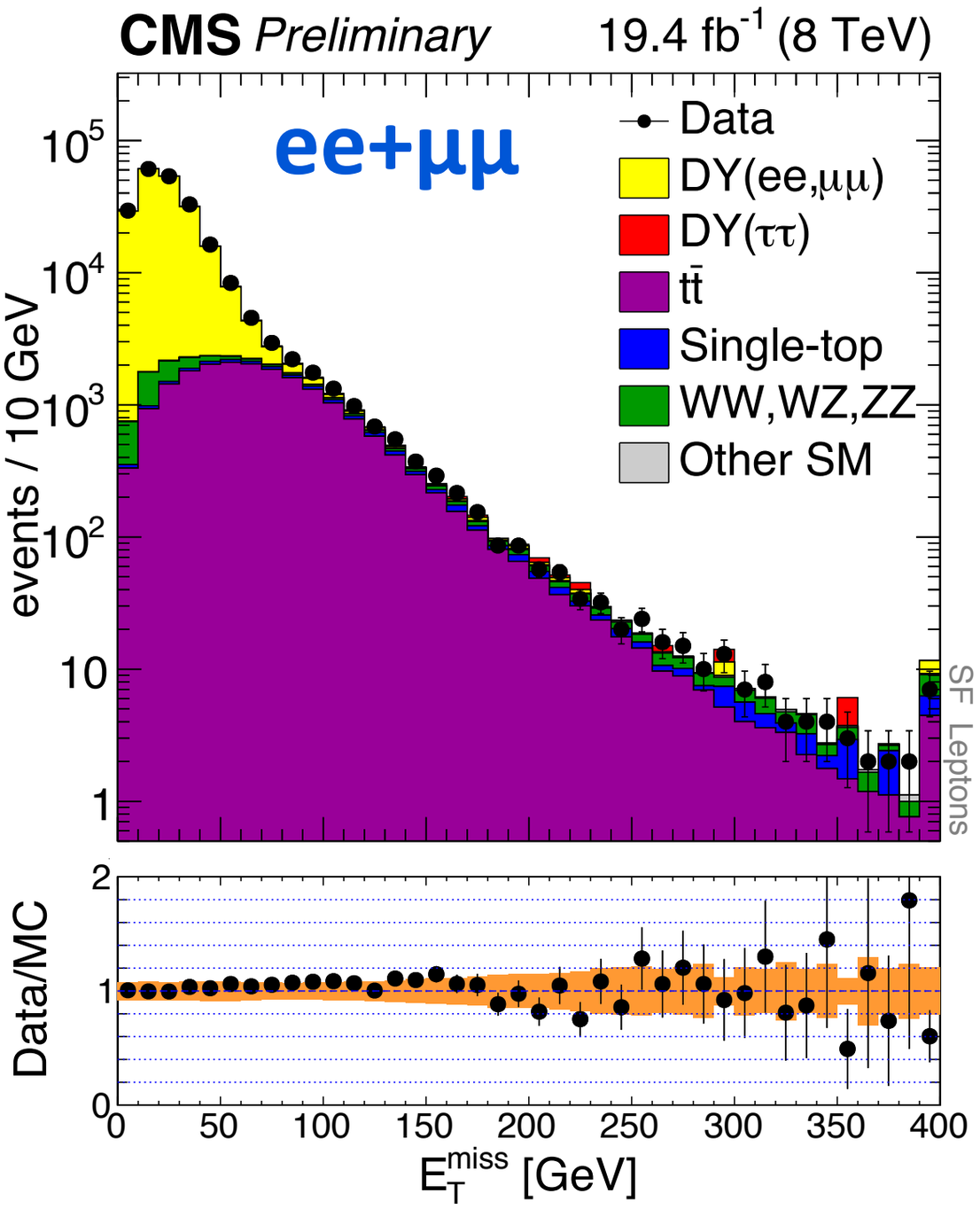
Cut at jets & MET and plot m(ll)

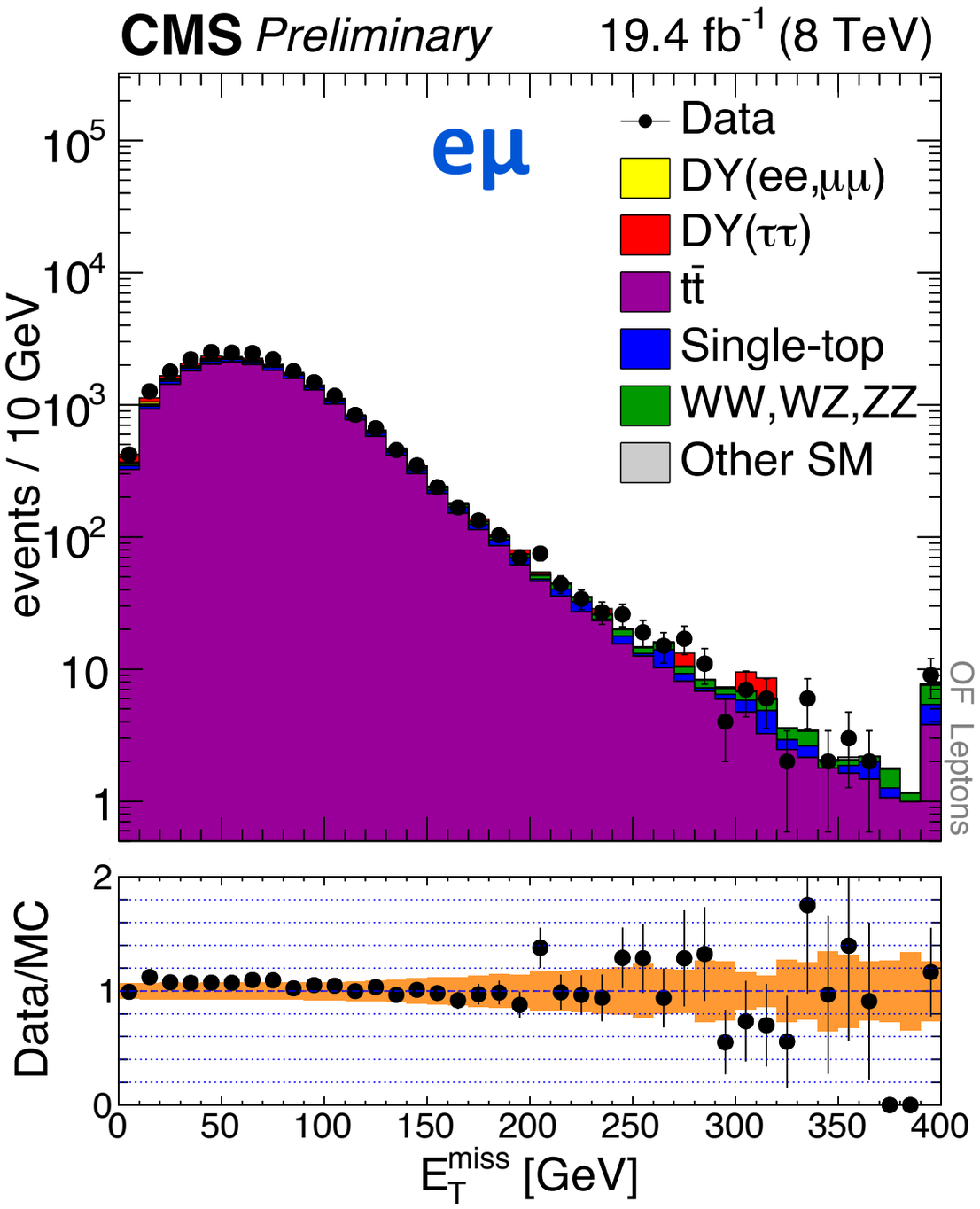




- Data with binned background estimation
- **We achieved 5% (10%)** experimental uncert. in central (forward)

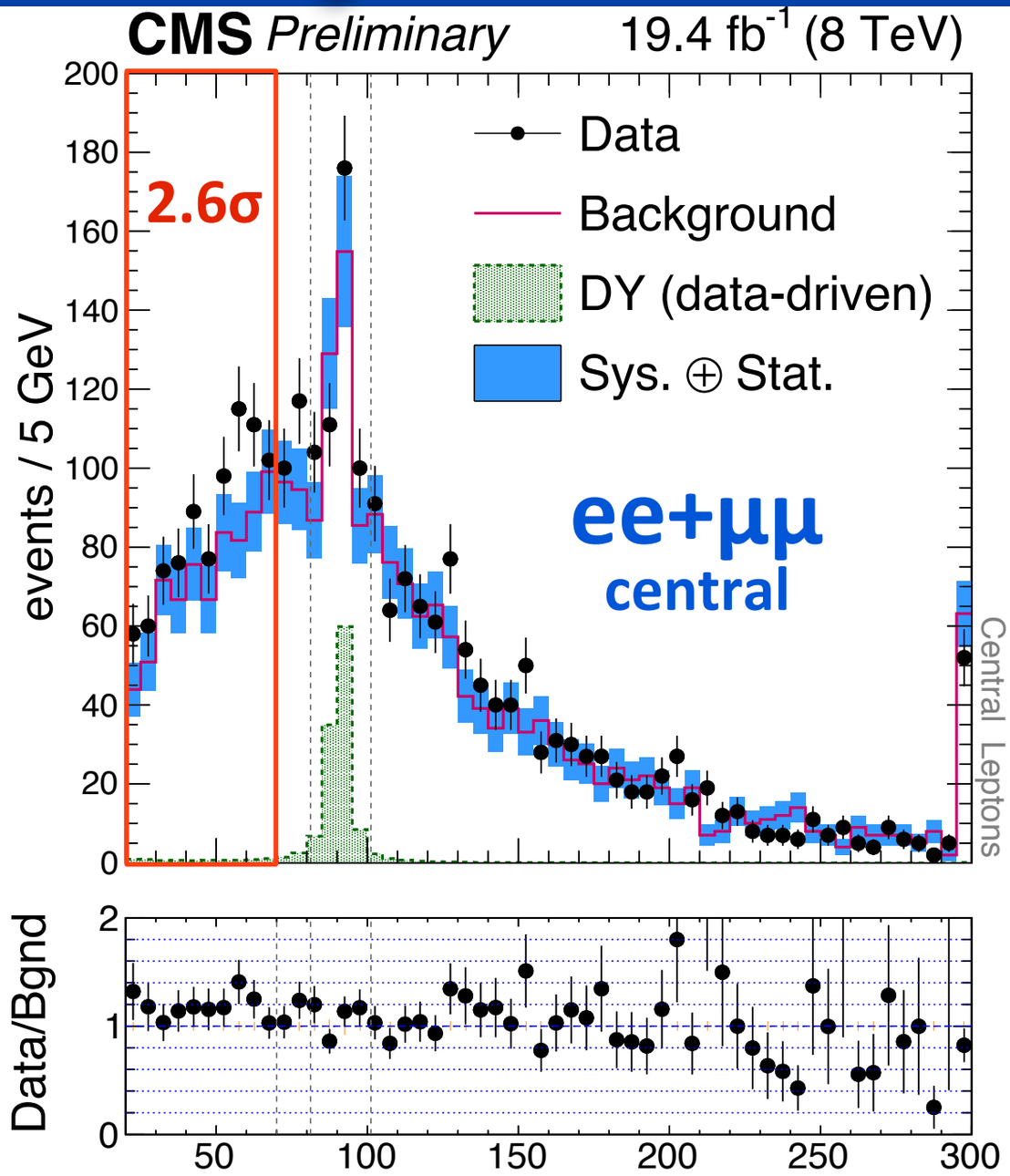
Background estimations

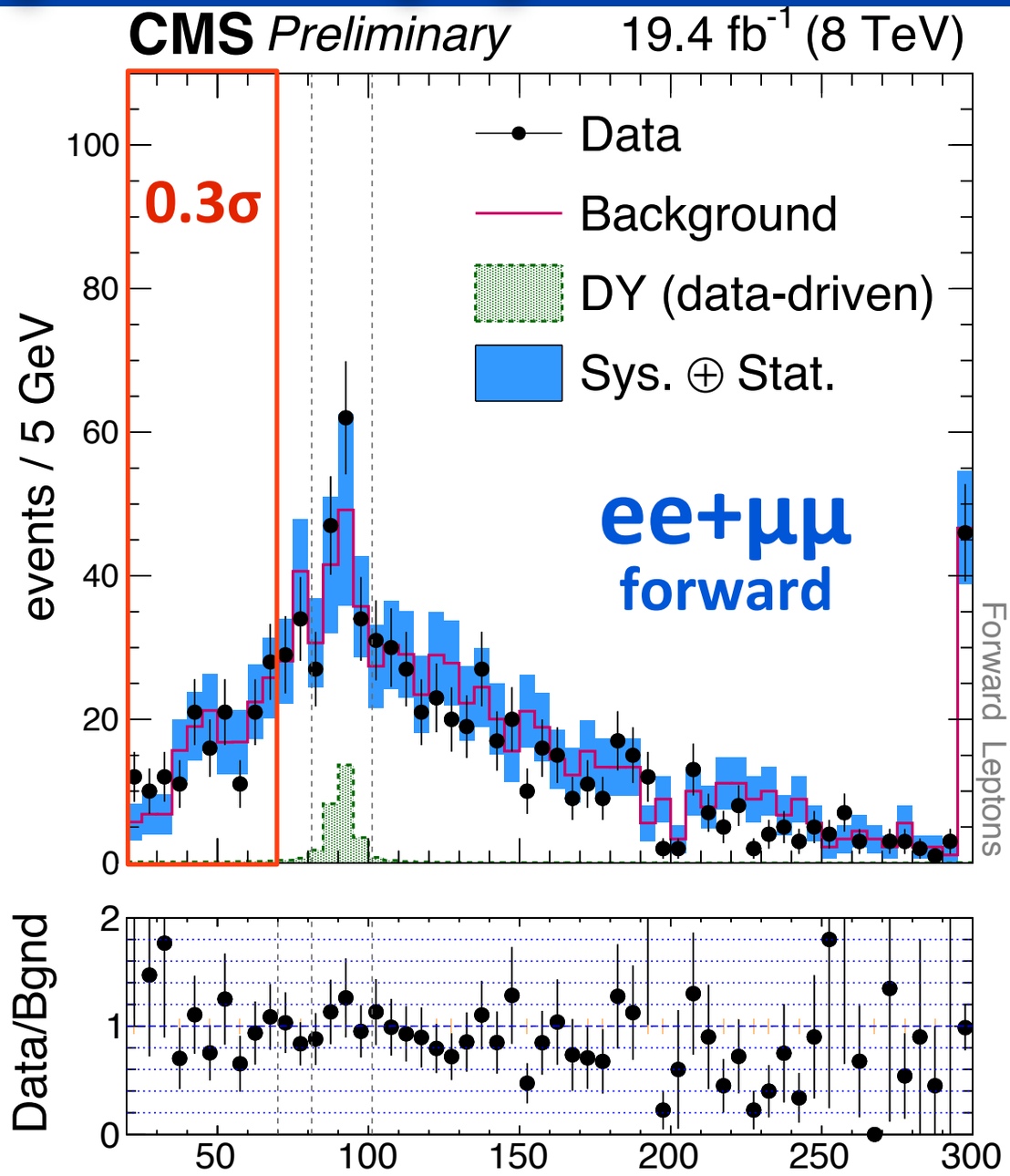




- Efficiency corrected **eμ** data are used to model the bgnd in **ee+μμ [SUS-12-019]**
- DY is modeled using Jet-Z-Balance & MET templates data **[PLB 716, 260-284 2012]**

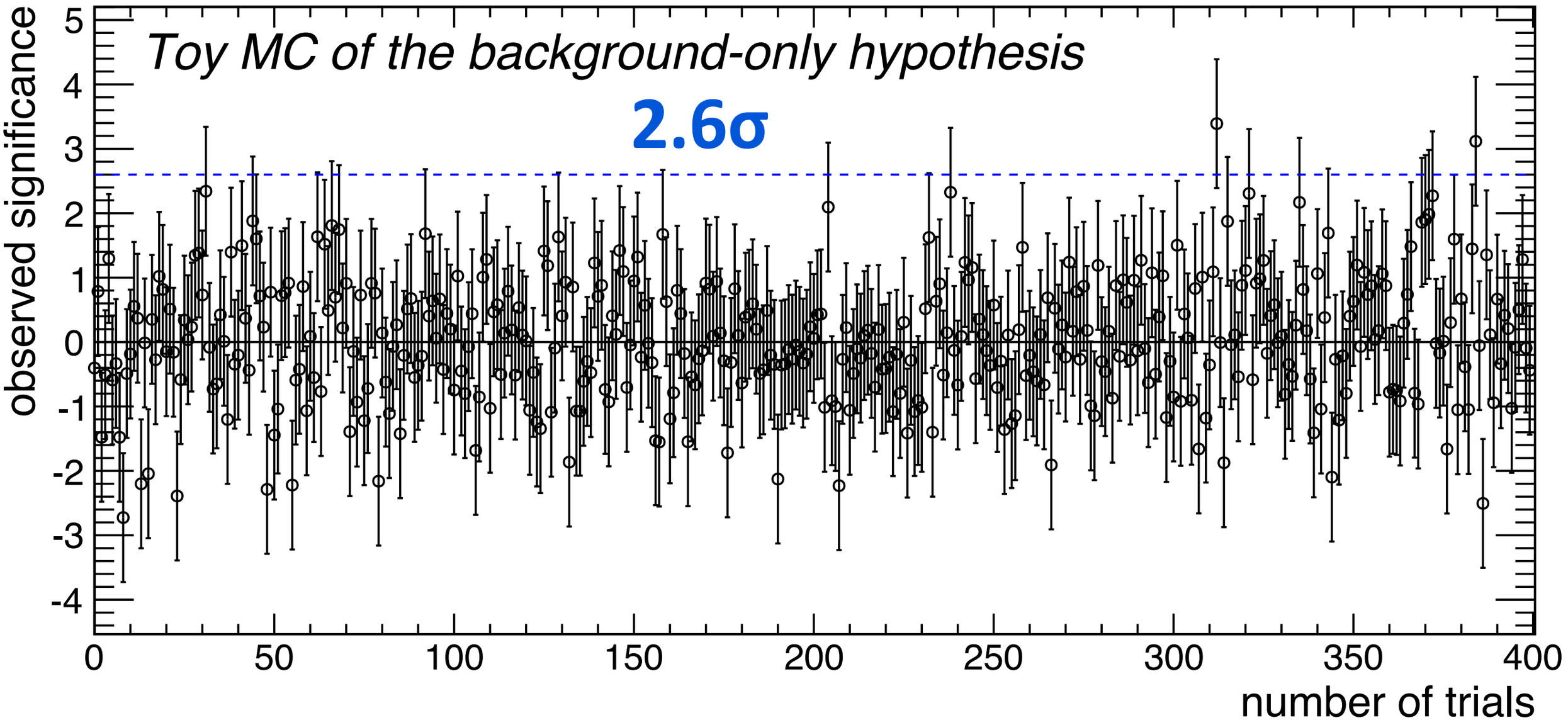
Cut at jets & MET and plot m(ll)





- Counting experiment in 20 < m(ll) < 70 [GeV]
- Local significances: 2.6σ (0.3σ) in central (forward)

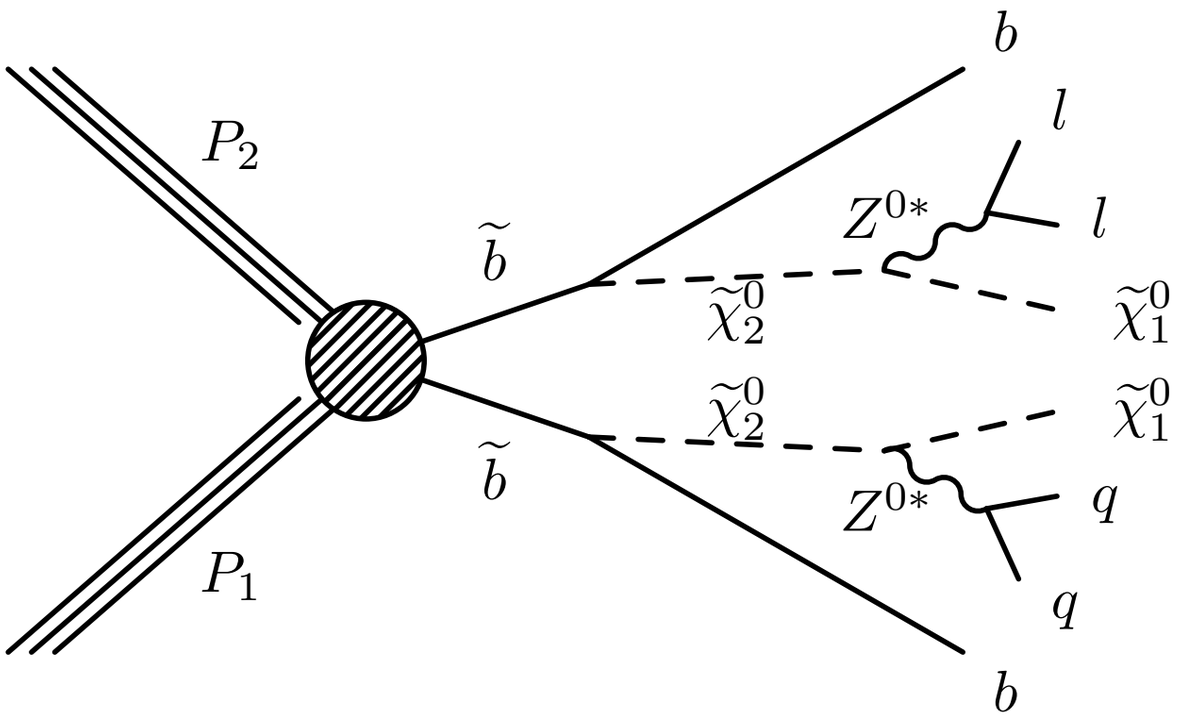
SM background fluctuations



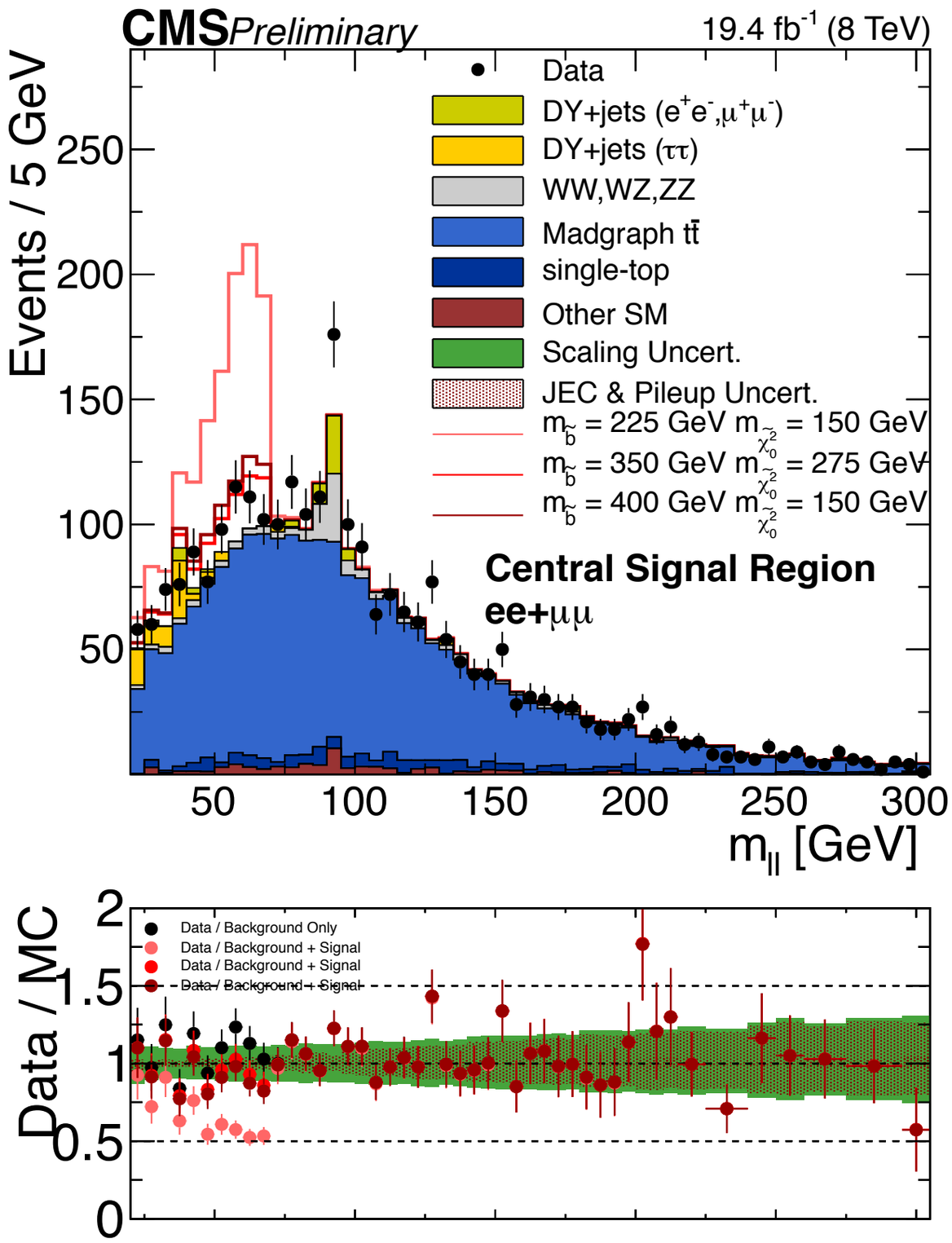
- We can't reject the bknd-only hypothesis; a 2.6σ effect should happen often when you try a lot (it only proves that we work too much)
- We expect 1 such observation every 200 trials

Data/MC

MC background estimations **are not used in the analysis**, they are shown here, together with some benchmark signals for reference



Simplified Model for the signal; with fixed $\Delta\chi$ = 70 GeV



Few words about the excess

It is not easy to corroborate the excess in other final states (trigger & background uncertainty is an issue)

- Very low MET, analysis starts at 100 GeV
- Very low HT, analysis starts at 80 GeV

hypothetical loss of sensitivity in a less precise analysis

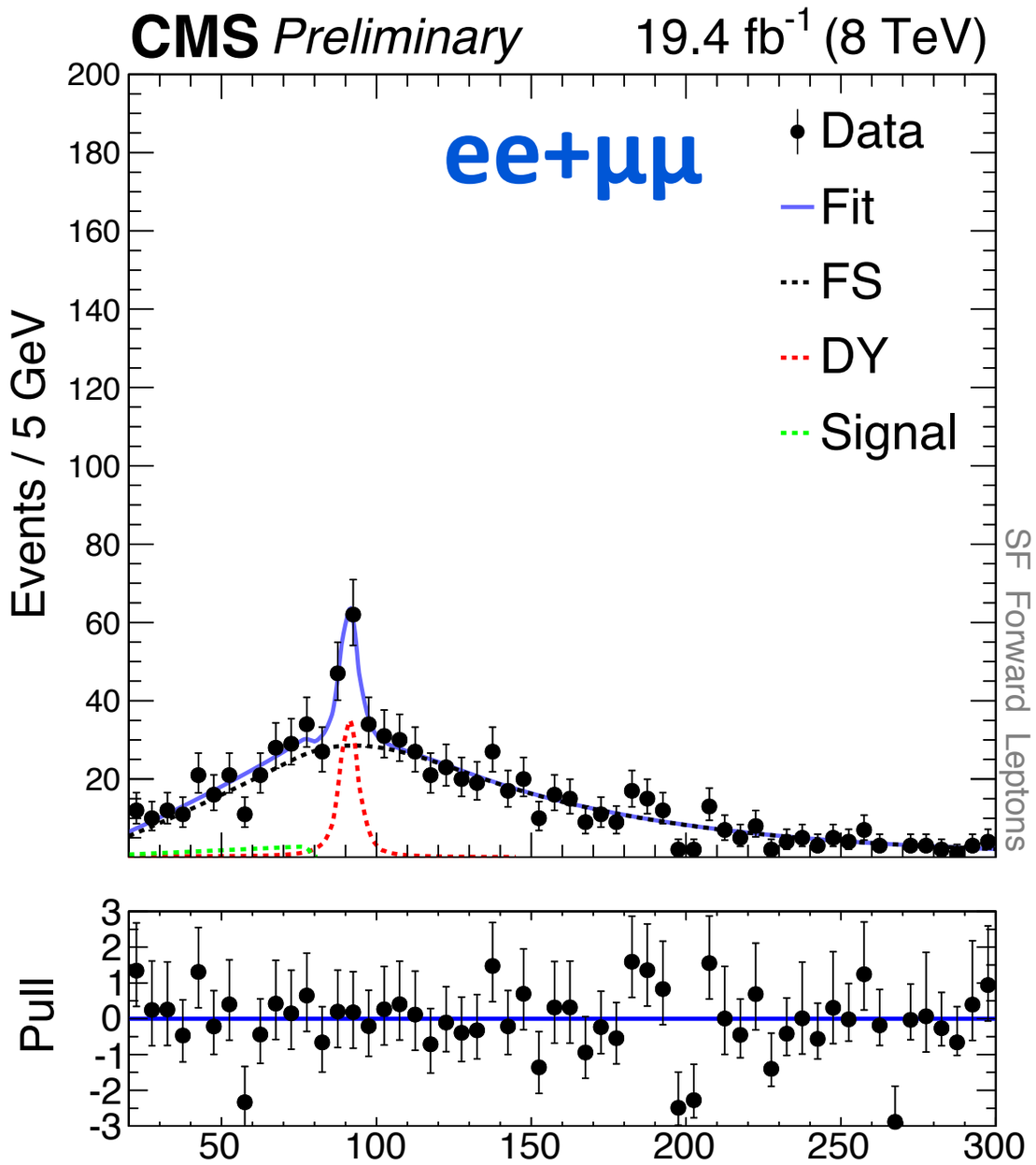
δB/B	20%	5%
significance	0.9σ	2.6σ

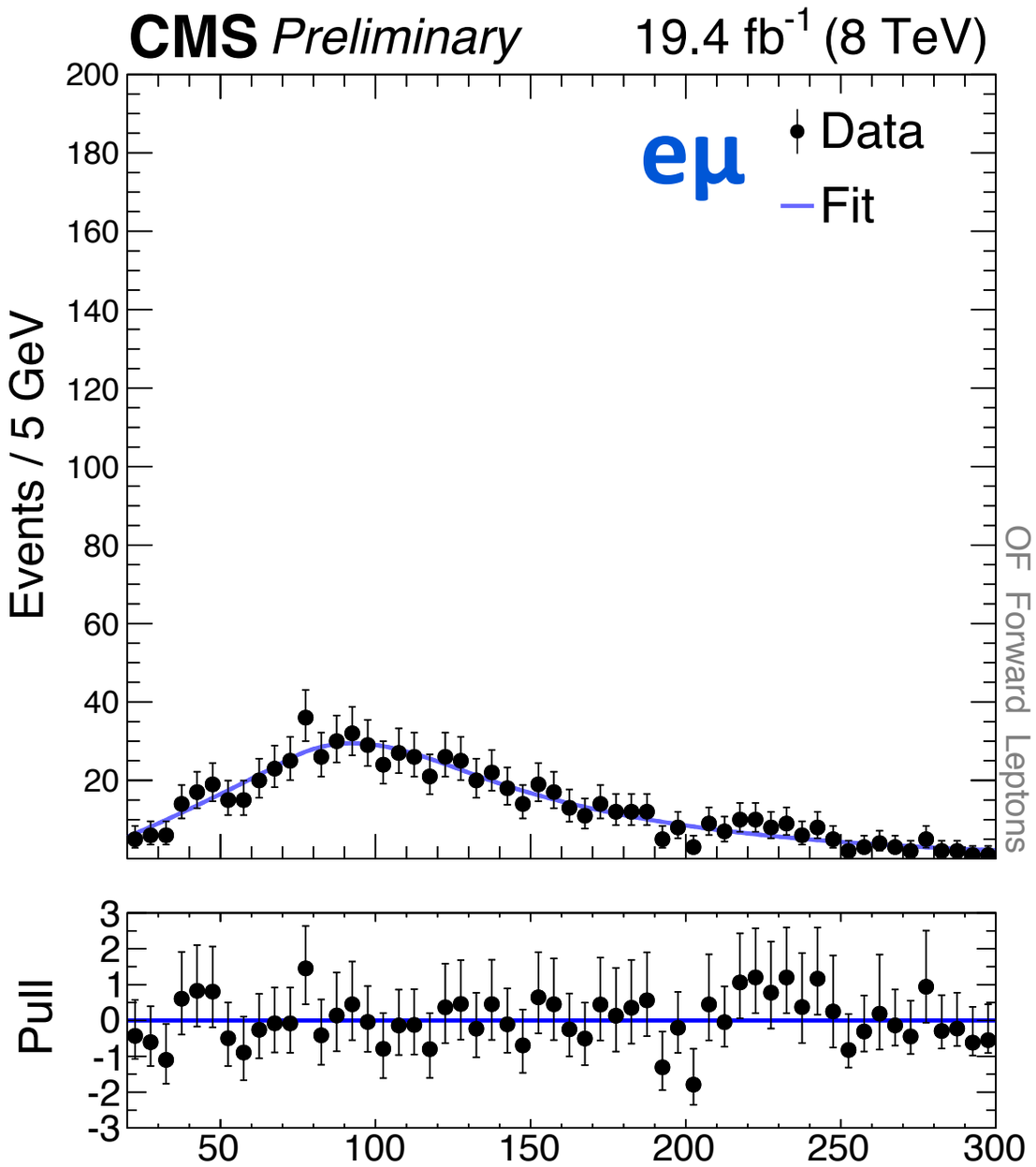
Concluding remarks

- We invested a lot of efforts in reducing δB/B -- and thus being sensitive to the smallest background fluctuation; *most probably this is what we see in the central region*
- Optimizing a search for exclusion is a different game (B→0, δB/B ~anything)
- Corroborated evidence won't come for free
- Guidance from theory for possible interpretations is vital in order to be ready for all conceivable scenarios, including possible signs of the same model in different final states

BACKUP

Cut at jets & MET and plot m(ll)

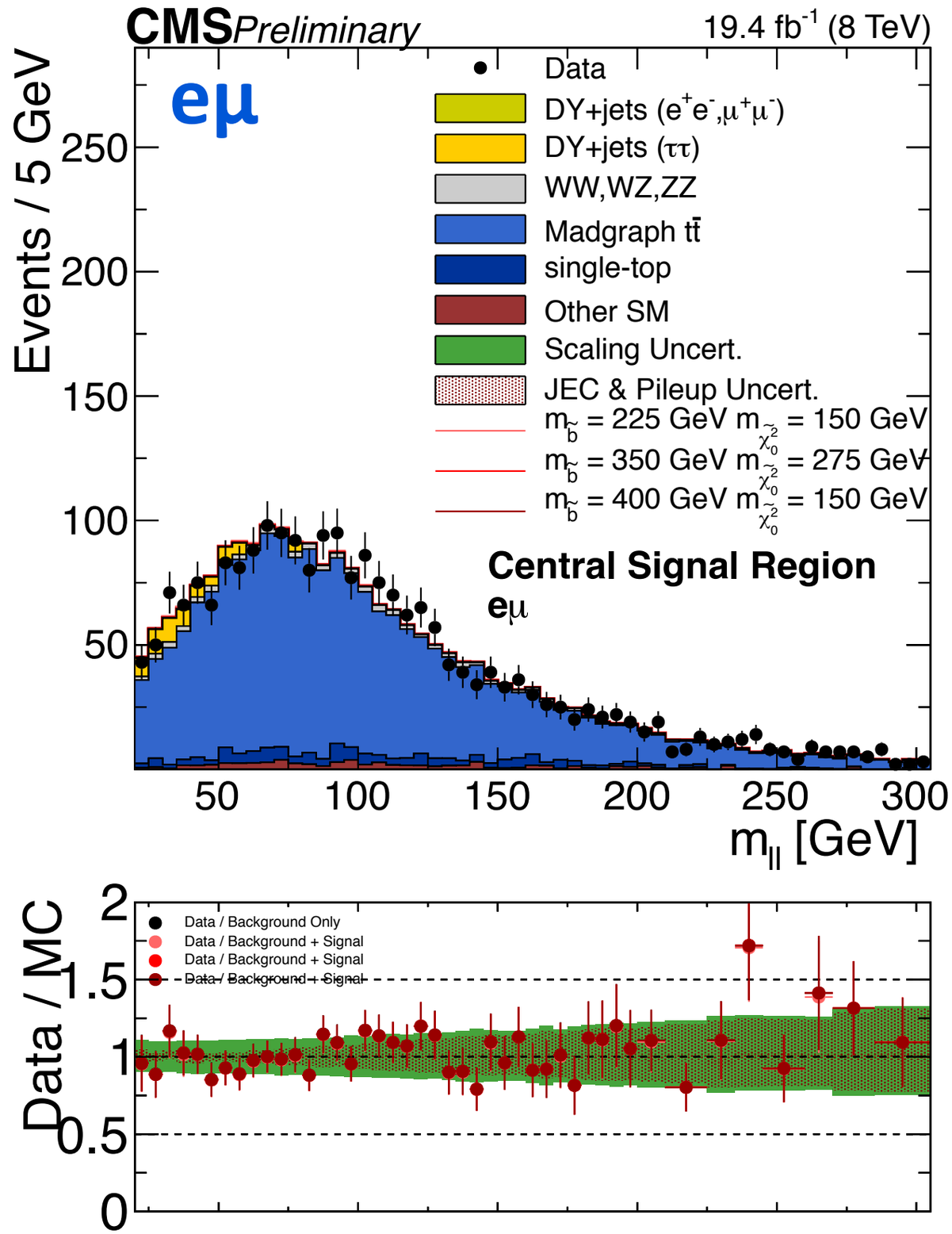




- Data with forward leptons (at least one $|\eta| > 1.6$)

Central signal region (Data/MC)

MC background estimations **are not used in the analysis**, they are just shown here for reference



Tables

	Central	Forward
Drell–Yan	158 ± 23	71 ± 15
Flav. Sym. [OF]	2270 ± 44	745 ± 25
$R_{\mathrm{SF/OF}}$	1.03	1.02
Signal events	126 ± 41	22 ± 20
$m_{\ell\ell}^{\mathrm{edge}}$ [GeV]	78.7 ± 1.4	

	Central	Forward
Observed [SF]	860	163
Flav. Sym. [OF]	$722 \pm 27 \pm 29$	$155 \pm 13 \pm 10$
Drell–Yan	8.2 ± 2.6	1.7 ± 1.4
Total estimates	730 ± 40	157 ± 16
Observed – Estimated	130^{+48}_{-49}	6^{+20}_{-21}
Significance [σ]	2.6	0.3

	central	forward
Factorized method		
$R_{\mathrm{SF/OF}}$	$1.03 \pm 0.01 \pm 0.06$	$1.11 \pm 0.04 \pm 0.08$
$R_{\mathrm{ee/OF}}$	$0.47 \pm 0.01 \pm 0.061$	$0.46 \pm 0.02 \pm 0.102$
$R_{\mu\mu/\mathrm{OF}}$	$0.56 \pm 0.01 \pm 0.07$	$0.65 \pm 0.03 \pm 0.14$
$r_{\mu\mathrm{e}}$	$1.09 \pm 0.00 \pm 0.11$	$1.18 \pm 0.00 \pm 0.24$
R_{T}	$1.03 \pm 0.01 \pm 0.062$	$1.10 \pm 0.04 \pm 0.07$
Control region method		
$R_{\mathrm{SF/OF}}$	$0.99 \pm 0.05 \pm 0.02$	$1.11 \pm 0.11 \pm 0.03$
$R_{\mathrm{ee/OF}}$	$0.44 \pm 0.03 \pm 0.01$	$0.49 \pm 0.06 \pm 0.02$
$R_{\mu\mu/\mathrm{OF}}$	$0.55 \pm 0.03 \pm 0.01$	$0.62 \pm 0.07 \pm 0.02$
$r_{\mu\mathrm{e}}$	1.12 ± 0.04 (stat.)	1.12 ± 0.08 (stat.)
R_{T}	0.98 ± 0.05 (stat.)	1.11 ± 0.11 (stat.)
Combined		
$R_{\mathrm{SF/OF}}$	1.00 ± 0.04	1.11 ± 0.07
$R_{\mathrm{ee/OF}}$	0.45 ± 0.03	0.48 ± 0.05
$R_{\mu\mu/\mathrm{OF}}$	0.55 ± 0.03	0.63 ± 0.07