Summer student 2016

SUSY Higgs → Tau Tau → e μ

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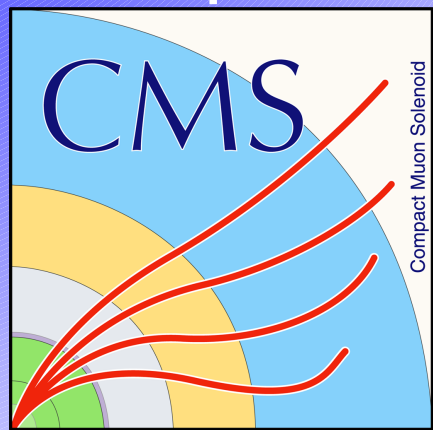
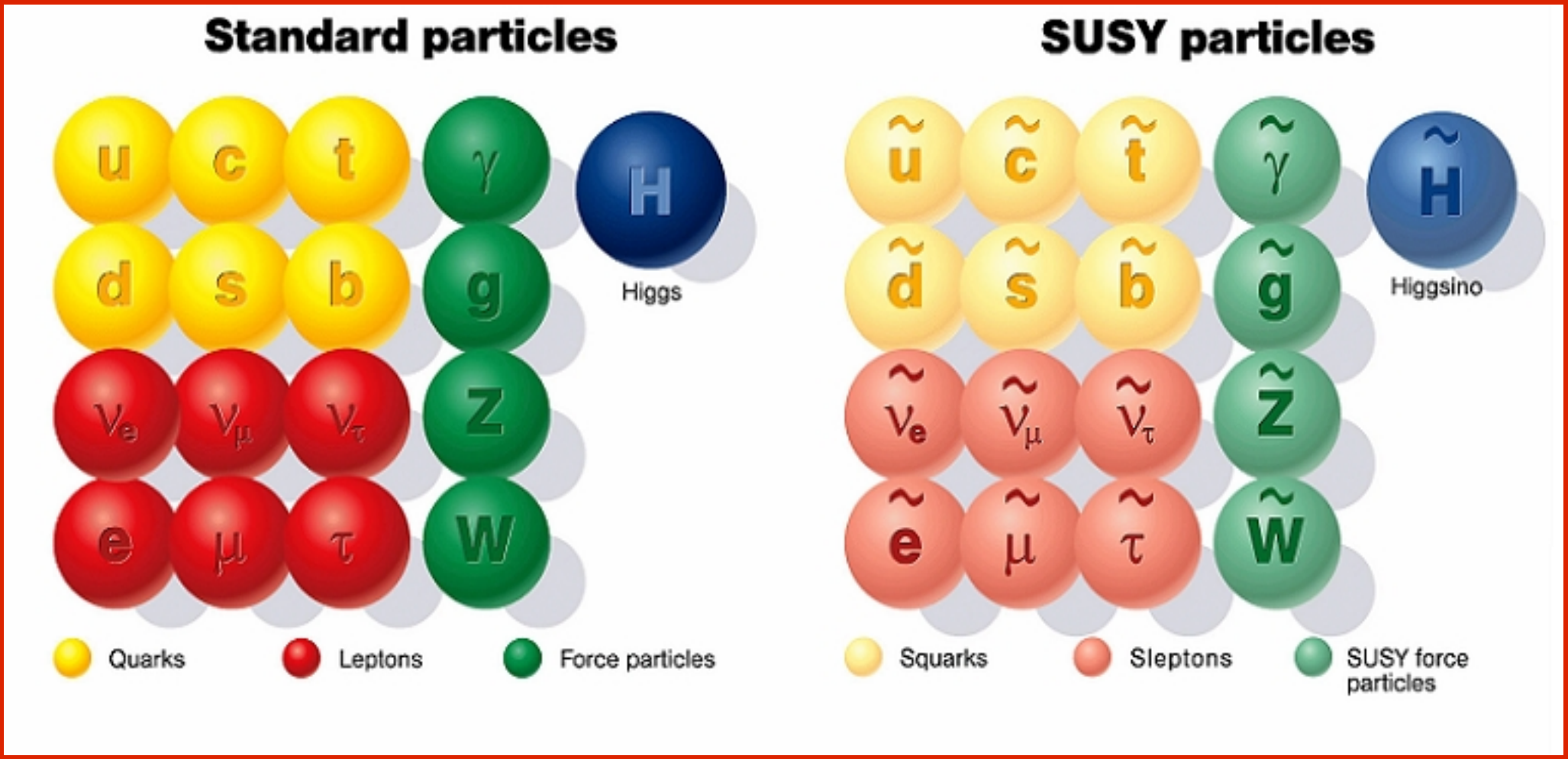
Group:



Overview

- Introduction: SUSY
- MSSM Higgs and hMSSM scenario
- Signal and background
- CMS
- Multivariate analysis: BDT
- Results
- Comments

Super Symmetry



SM particle (spin J) ⟷ *SUSY* ⟷ sparticle (spin J ± 1/2)

Higgs sector in MSSM

Two Higgs doublet model (2HDM)

$$\Phi_1 = \begin{pmatrix} \Phi_1^+ \\ \Phi_1^0 \end{pmatrix} \qquad \Phi_2 = \begin{pmatrix} \Phi_2^+ \\ \Phi_2^0 \end{pmatrix}$$

$$\langle \Phi_1 \rangle = \begin{pmatrix} 0 \\ \nu_1 \end{pmatrix} \qquad \langle \Phi_2 \rangle = \begin{pmatrix} 0 \\ \nu_2 \end{pmatrix}$$

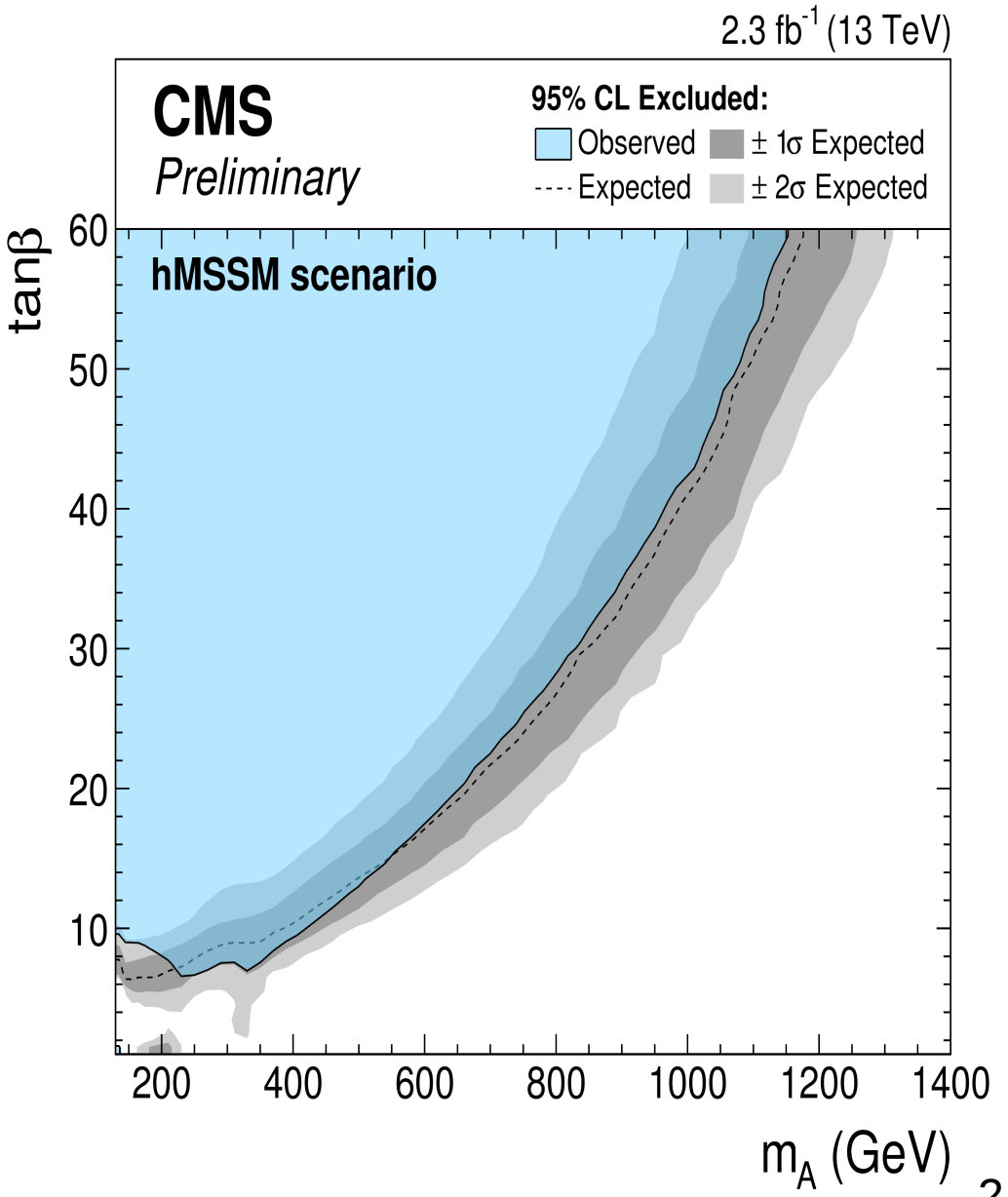
5 physical states: **h, H, A, H±**

$$\tan\beta = \nu_1/\nu_2$$

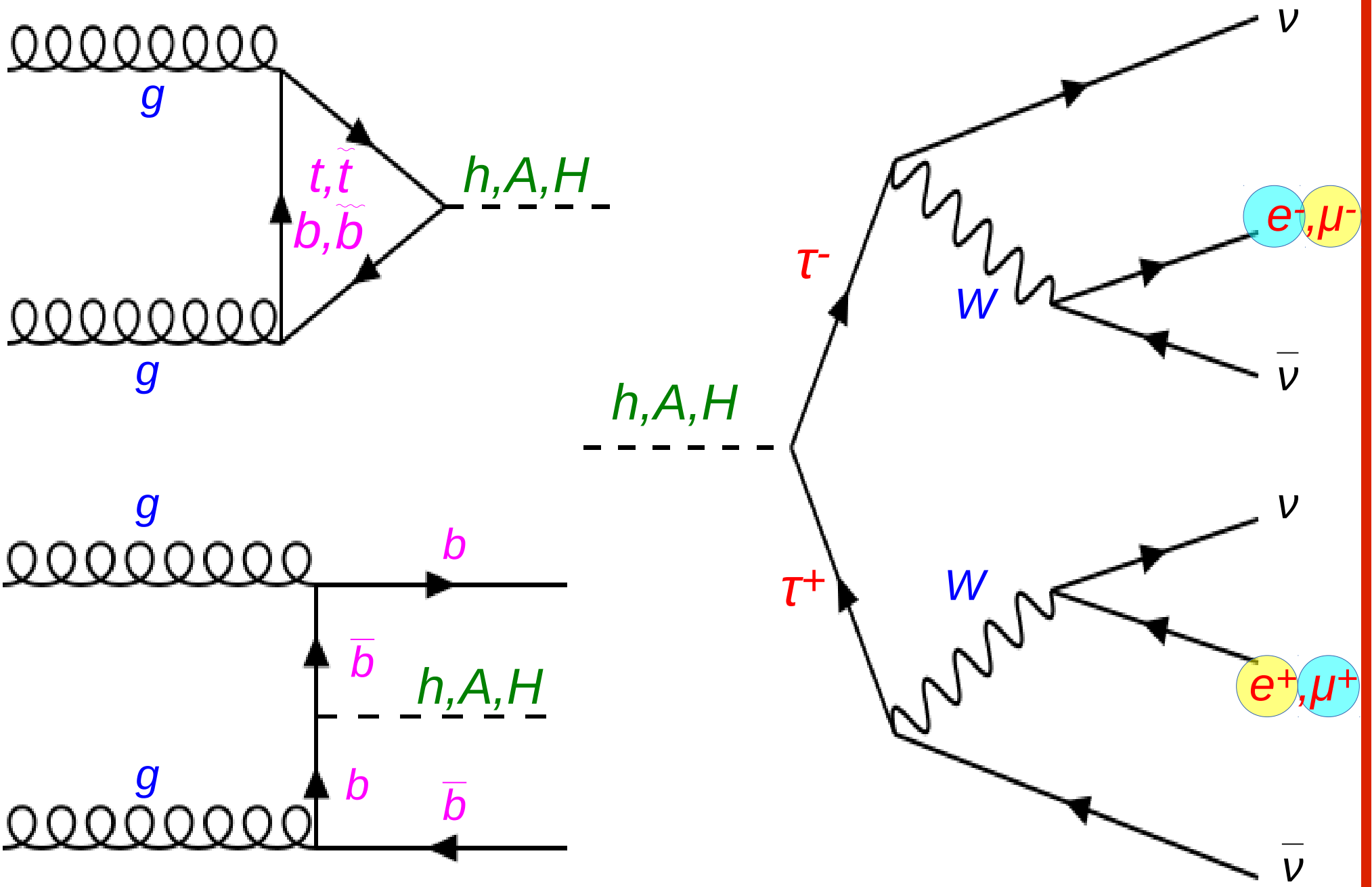
hMSSM scenario:

- h → Higgs (125 GeV)
- Two model parameters are scanned: m_A $\tan\beta$

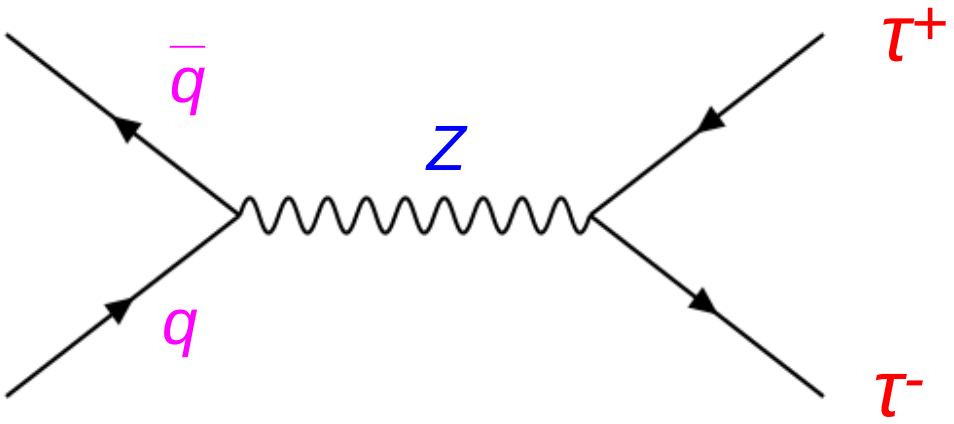
Constraints (2015 data)

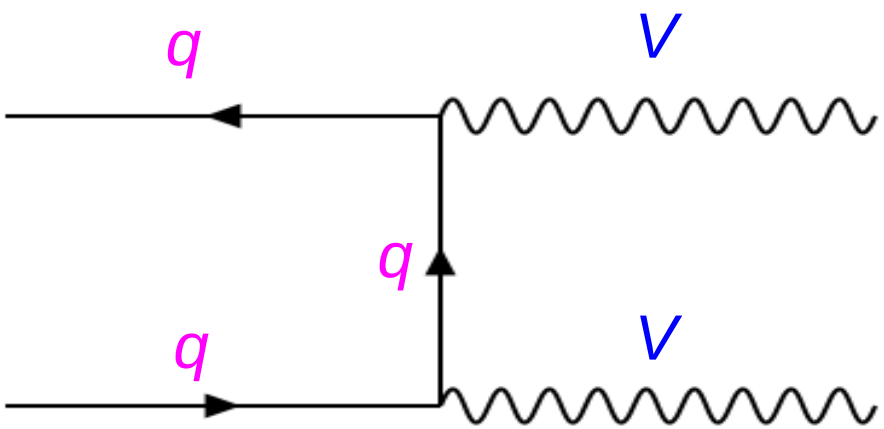


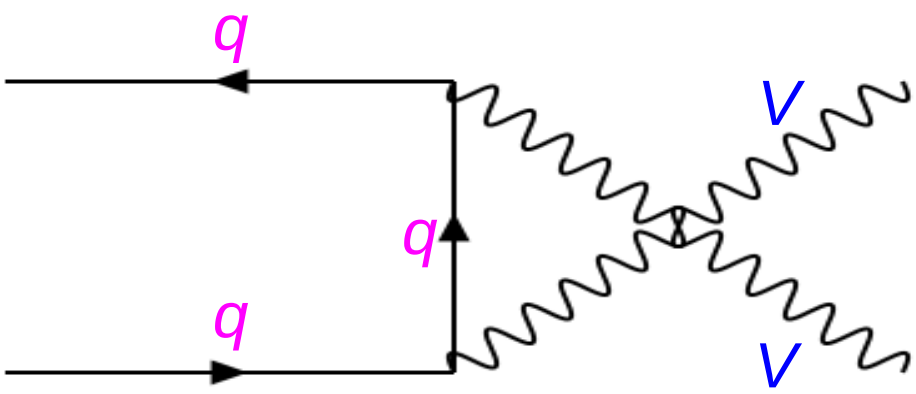
Signal: hMSSM

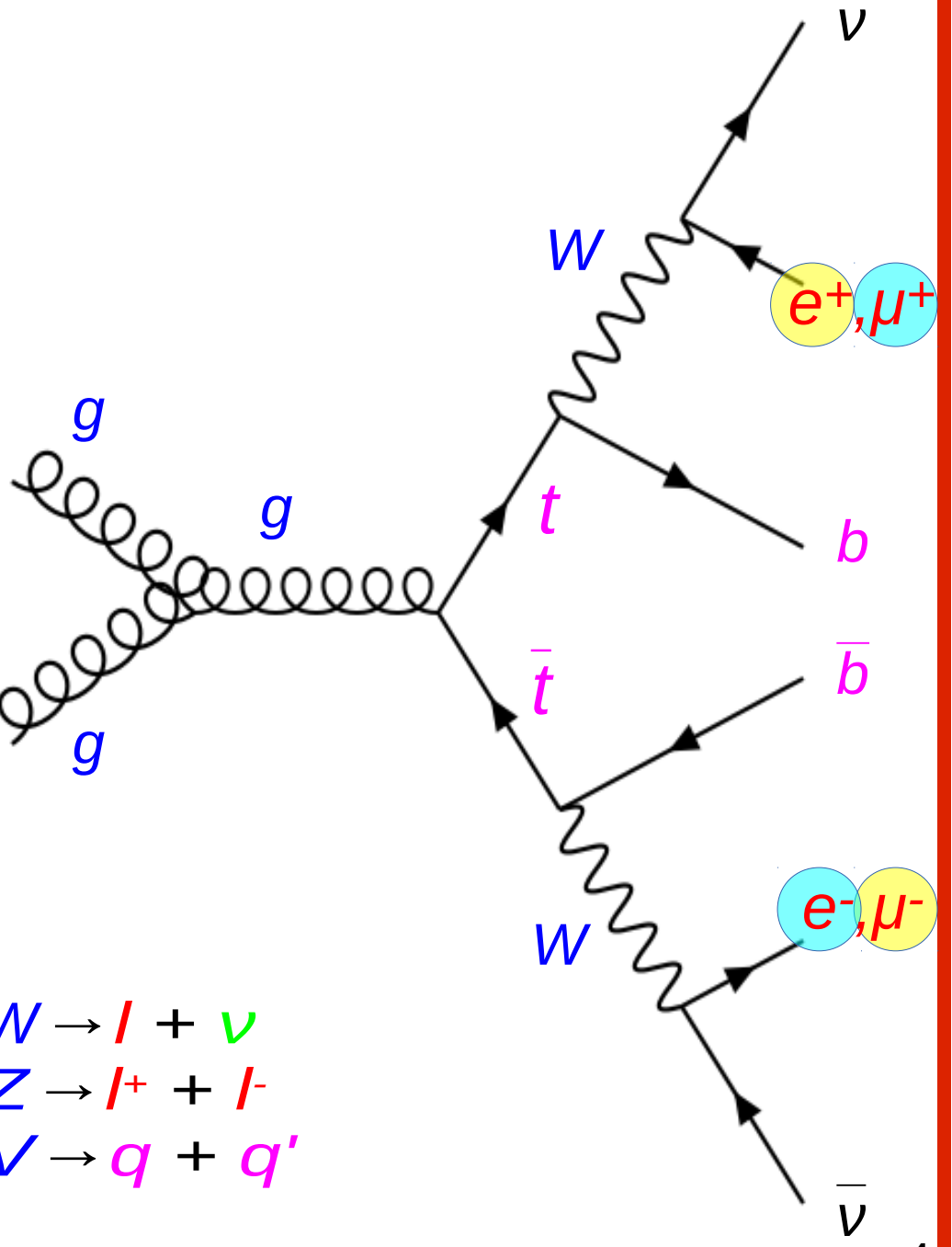


Main Backgrounds: Drell-Yan, VV, t $\bar{t}$





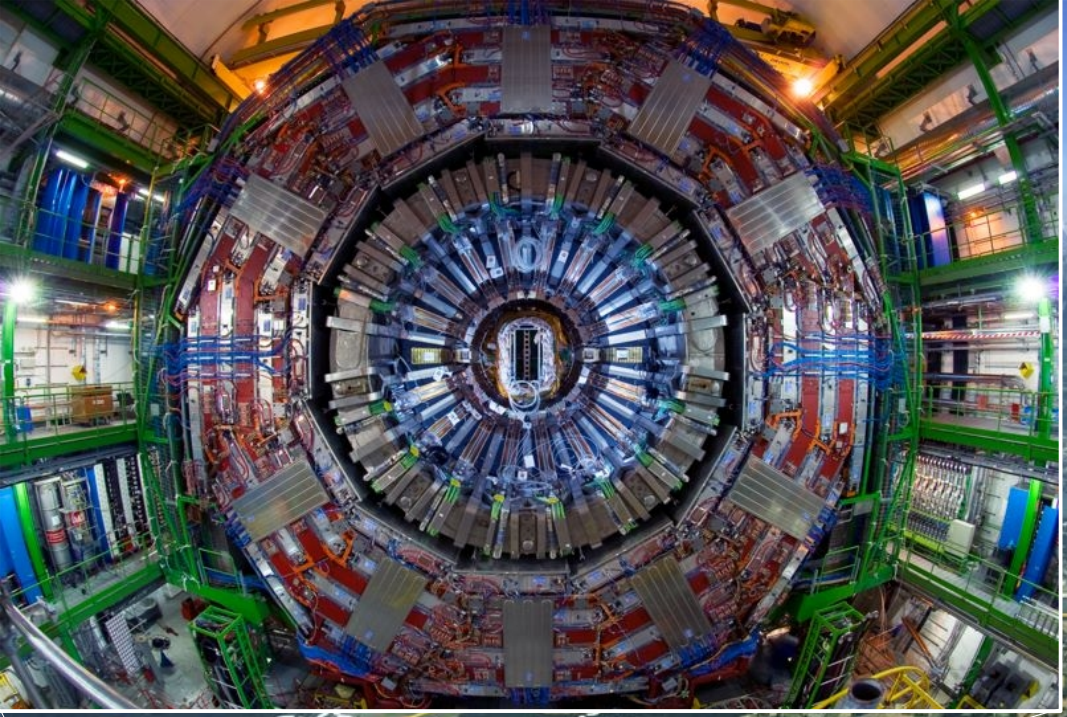




$W \rightarrow l + \nu$

$Z \rightarrow l^+ + l^-$

$V \rightarrow q + q'$



Compact Muon Solenoid (CMS)

Large Hadron Collider(LHC)

CMS detector

Total weight:	14,000 ton
Overall diameter:	15.0m
Overall lenght:	28.7m
Magnetic field:	3.8T

Steel return yoke
12,500 ton

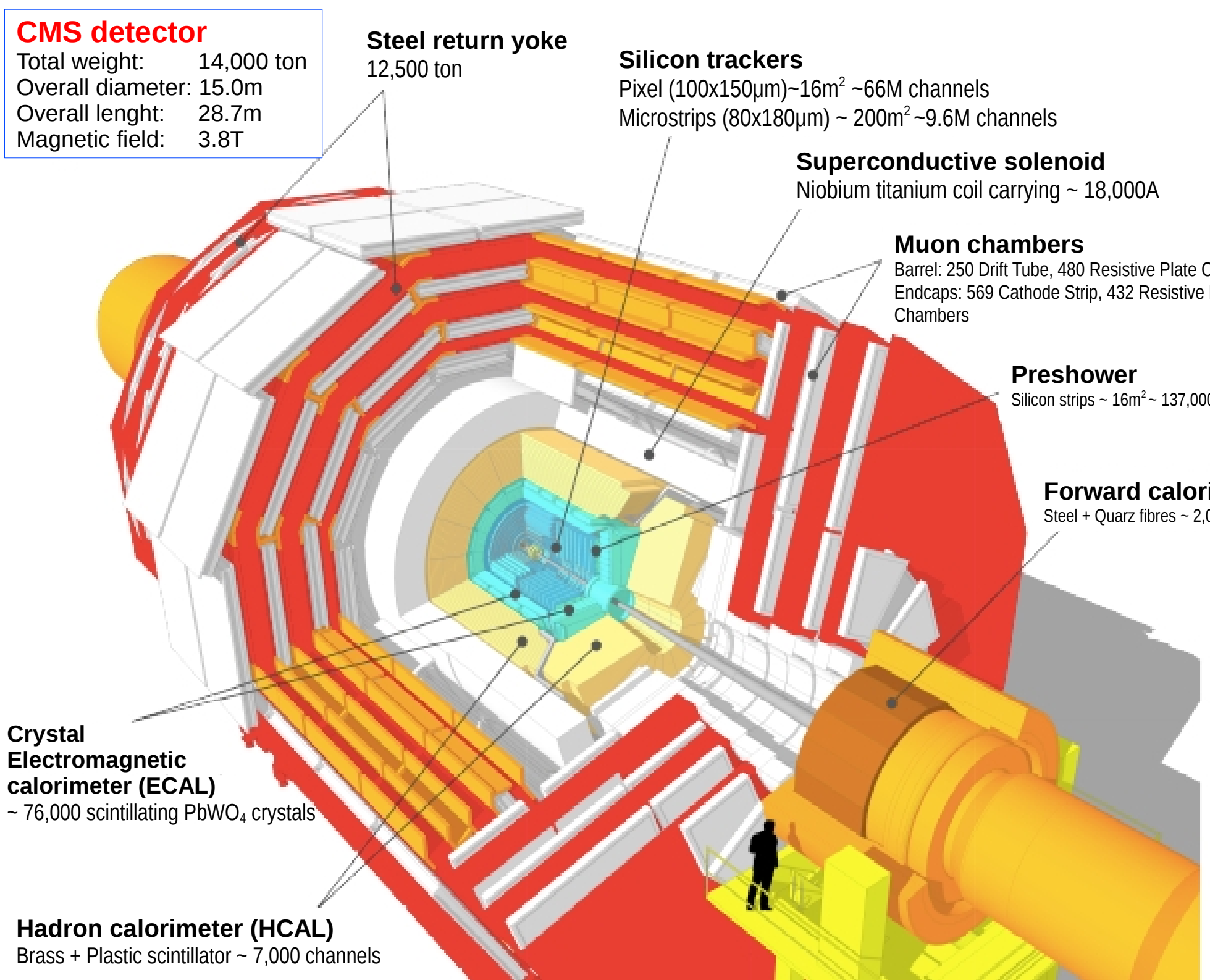
Silicon trackers
Pixel (100x150μm)~16m^2 ~66M channels
Microstrips (80x180μm) ~ 200m^2 ~9.6M channels

Superconductive solenoid
Niobium titanium coil carrying ~ 18,000A

Muon chambers
Barrel: 250 Drift Tube, 480 Resistive Plate Chambers
Endcaps: 569 Cathode Strip, 432 Resistive Plate Chambers

Preshower
Silicon strips ~ 16m^2 ~ 137,000 channels

Forward calorimeter
Steel + Quarz fibres ~ 2,000 channels



Crystal Electromagnetic calorimeter (ECAL)
~ 76,000 scintillating $PbWO_4$ crystals

Hadron calorimeter (HCAL)
Brass + Plastic scintillator ~ 7,000 channels

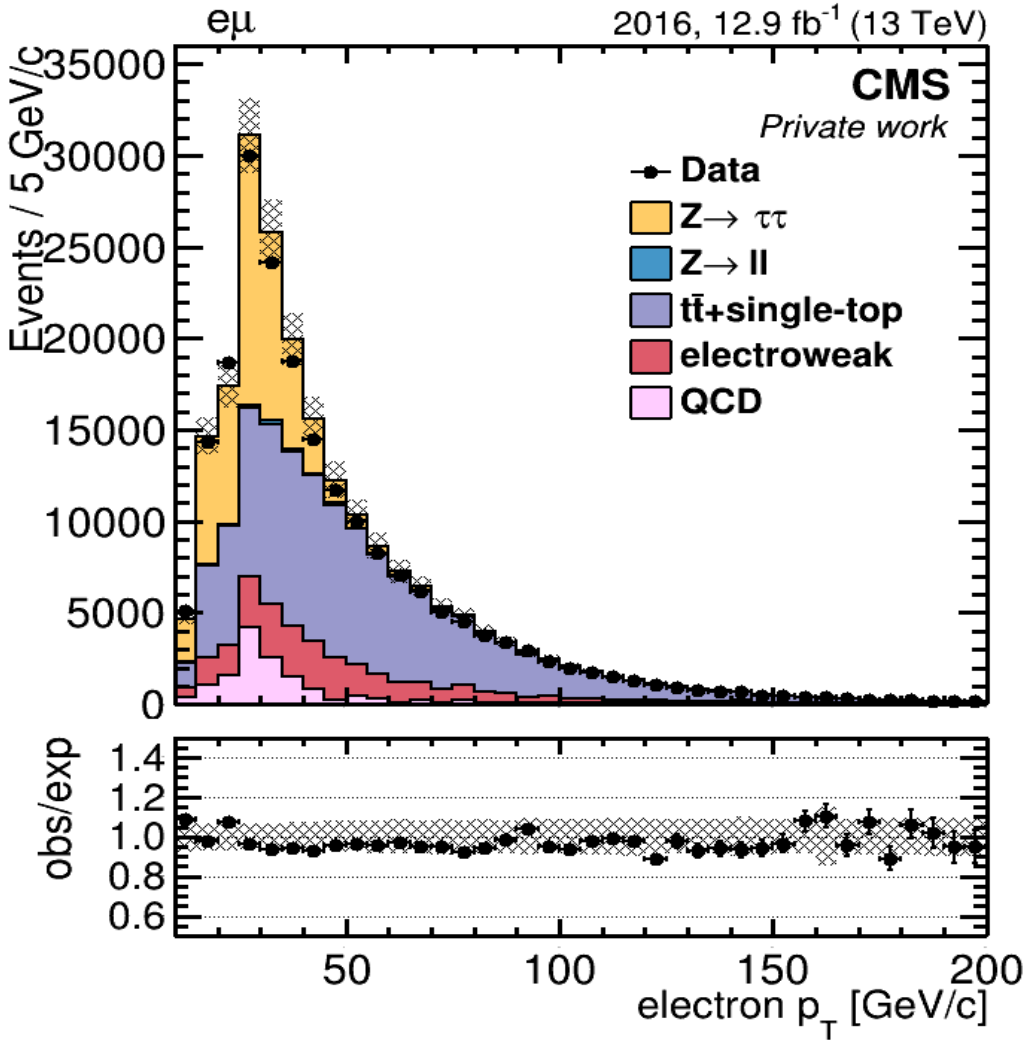
Channel: e-μ with opposite sign

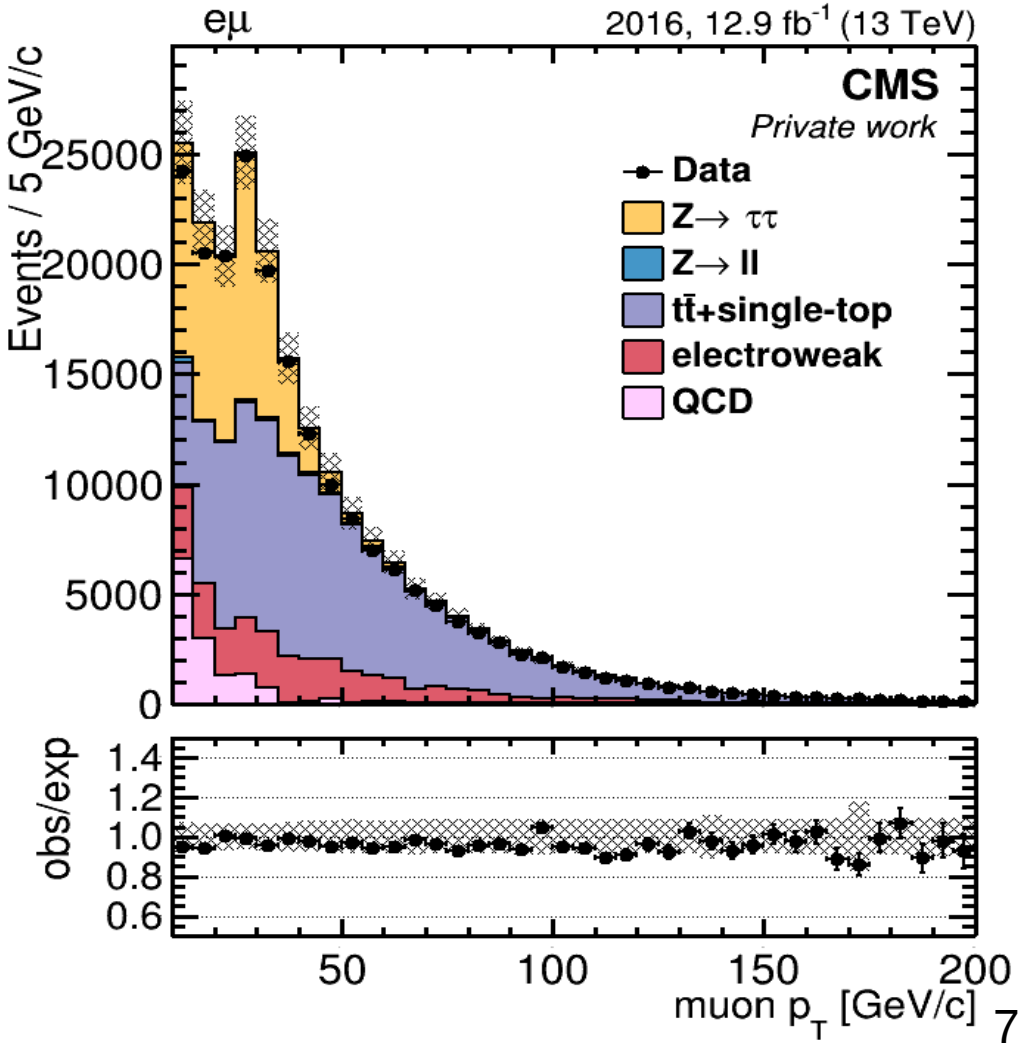
2016 Data

Luminosity: 12.9 fb^{-1}

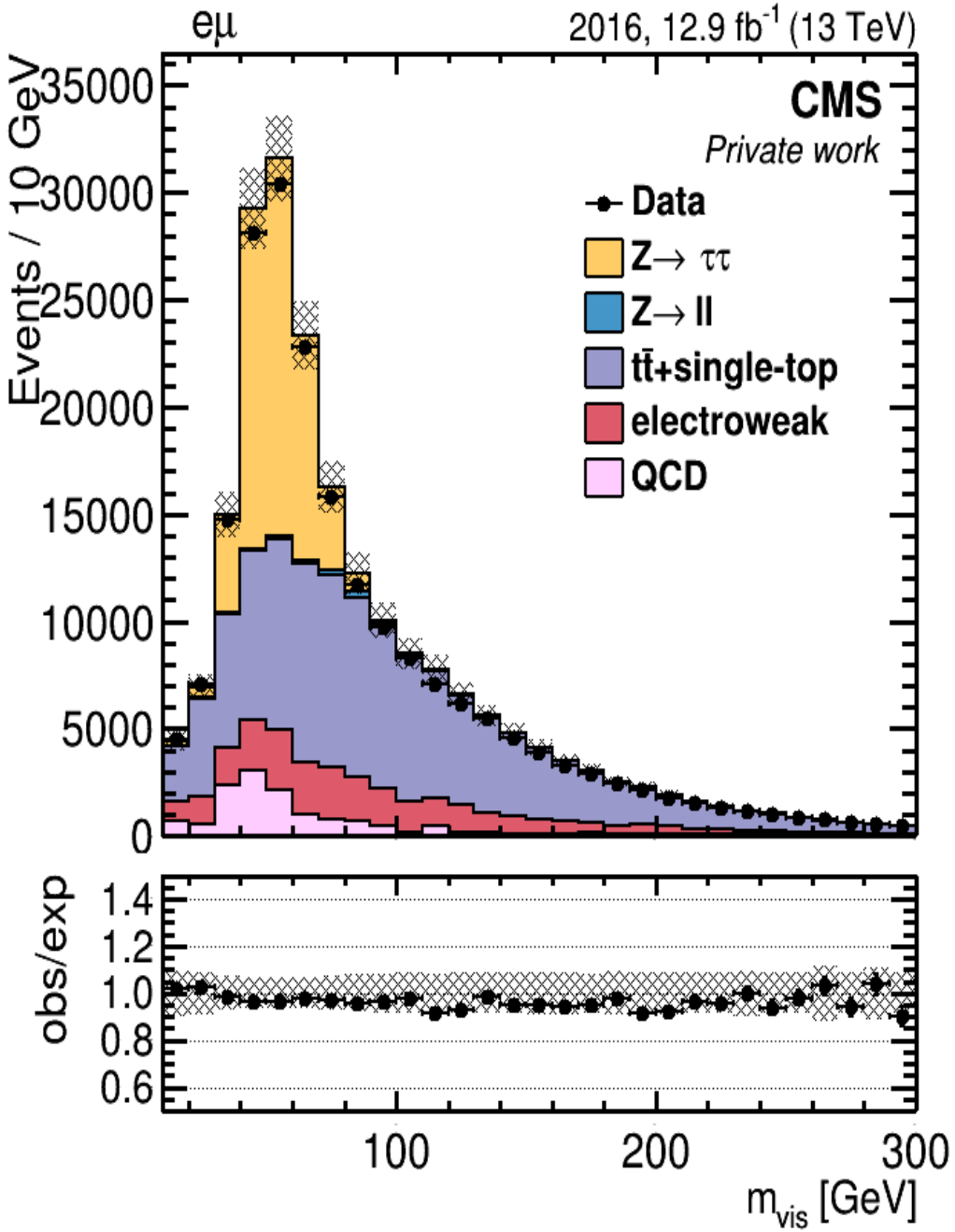
Triggers: Mu23_Ele12 OR Mu8_Ele23

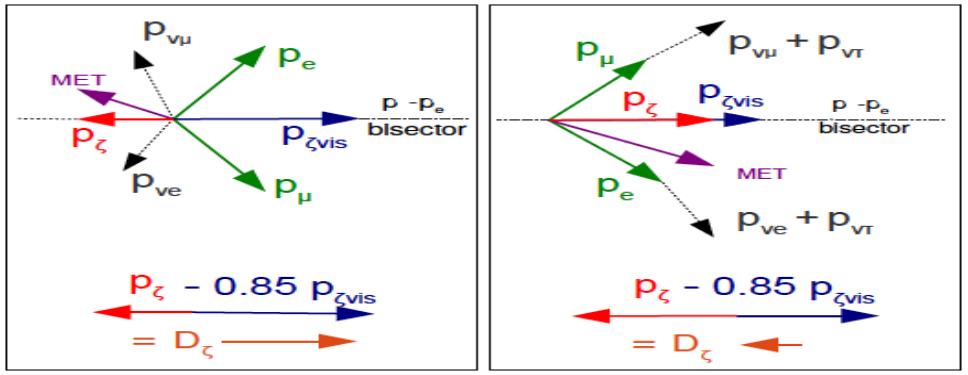
Cuts:	Pt		|η|	ΔR
e	24 GeV	13 GeV	< 2.4	> 0.3
μ	8 GeV	24 GeV	< 2.5	





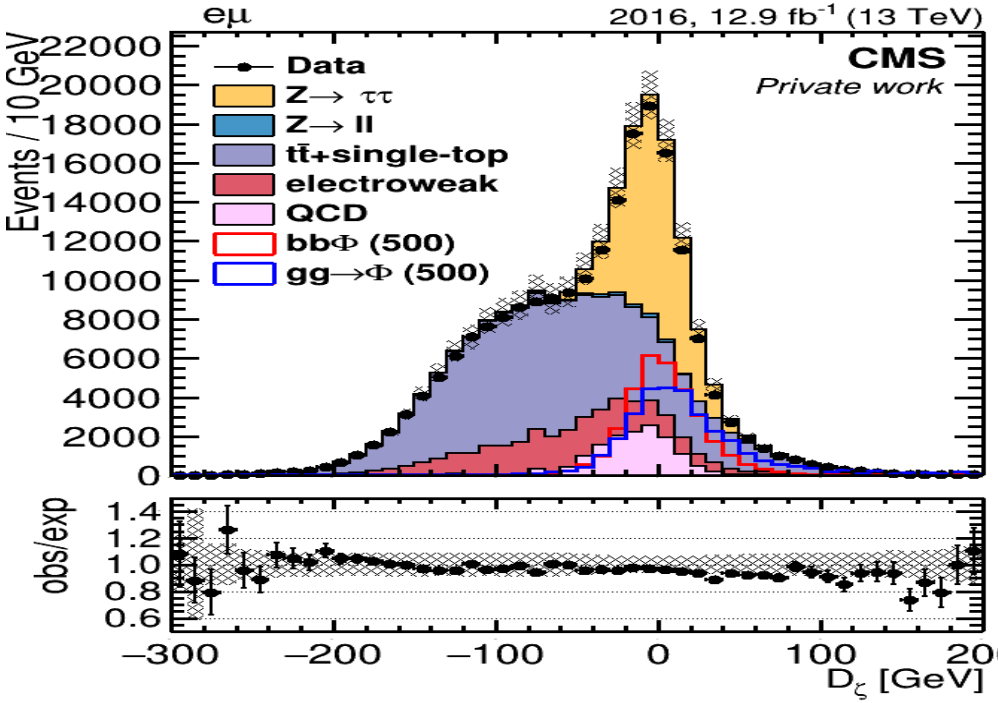
Visible mass and Dζ cut





To further reduce t-t̄ background a cut in Dζ is introduced

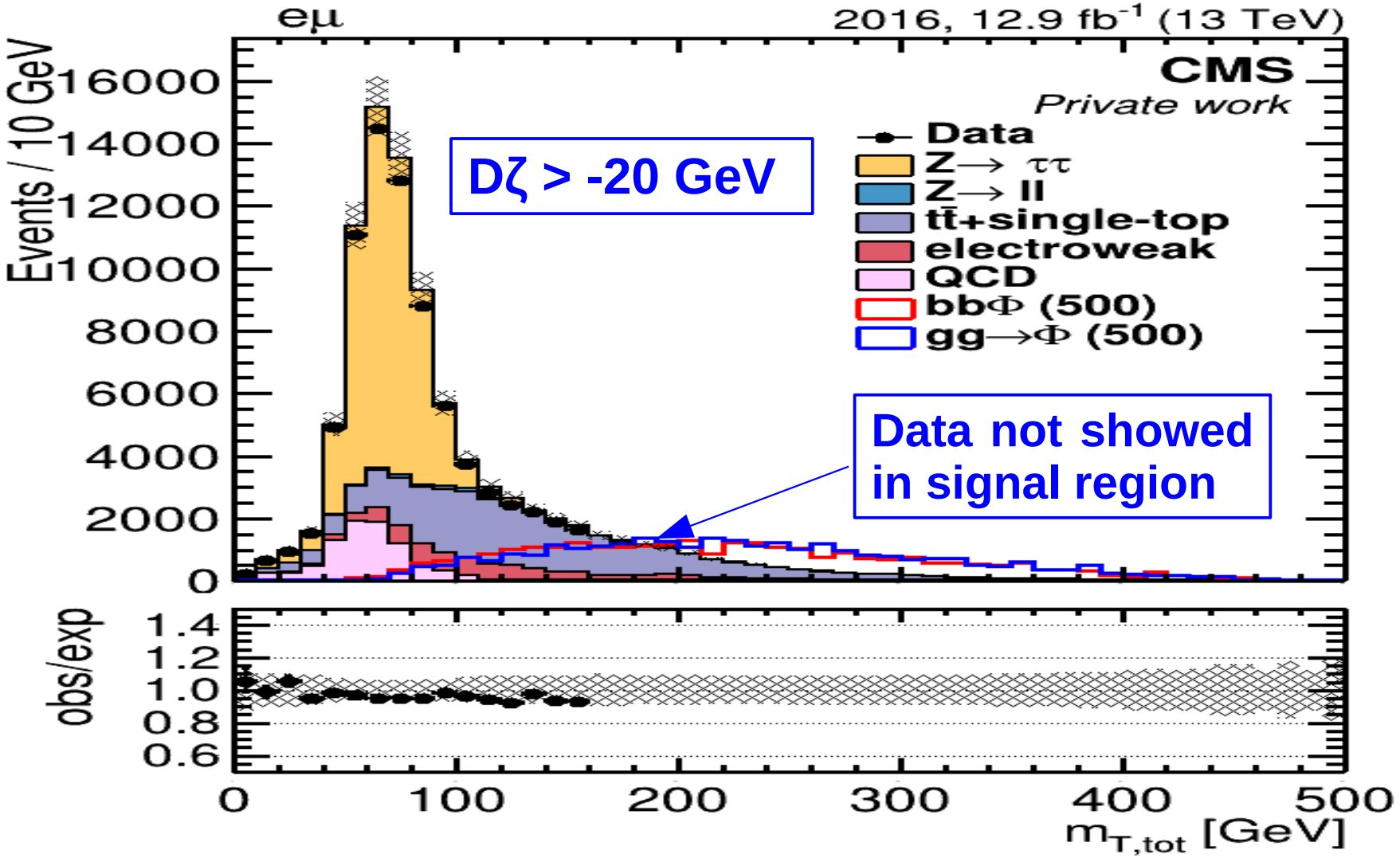
$$D_\zeta = p_\zeta - \alpha \cdot p_{\zeta\text{vis}} = \vec{\not{E}}_T \cdot \hat{\zeta} - \alpha \left(\overrightarrow{p_{T_e}} + \overrightarrow{p_{T_\mu}}\right) \cdot \hat{\zeta}$$



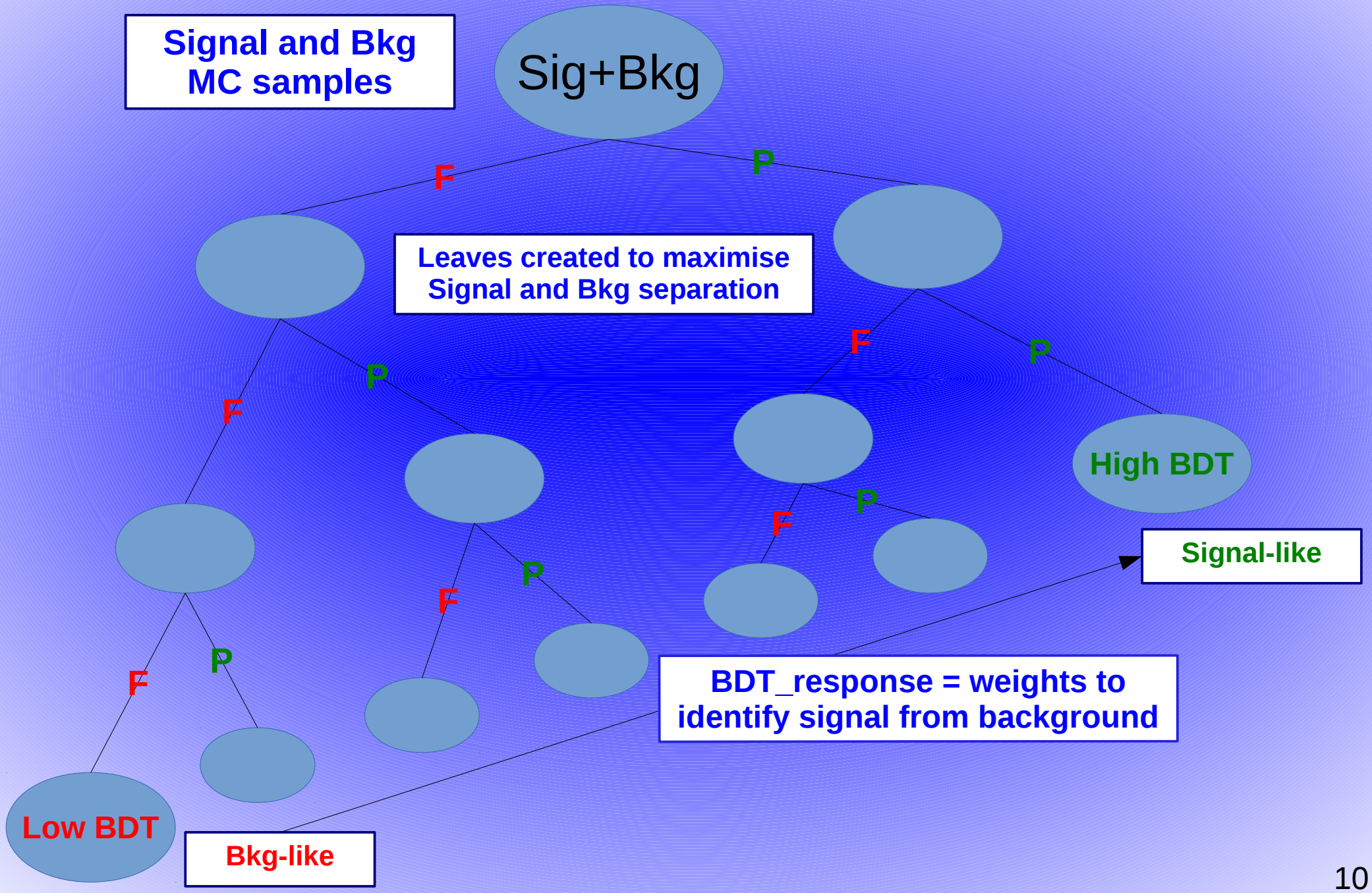
$m_{T,tot}$: signal extraction

$$m_{T,tot} = \sqrt{m_T^2(e, p_T^{mis}) + m_T^2(\mu, p_T^{mis}) + m_T^2(e, \mu)}$$

Where: $m_T(L_1, L_2) = \sqrt{2\, P_T^1\, P_T^2\, (1 - \cos\theta_{1,2})}$



Boosted Decision Tree (BDT)



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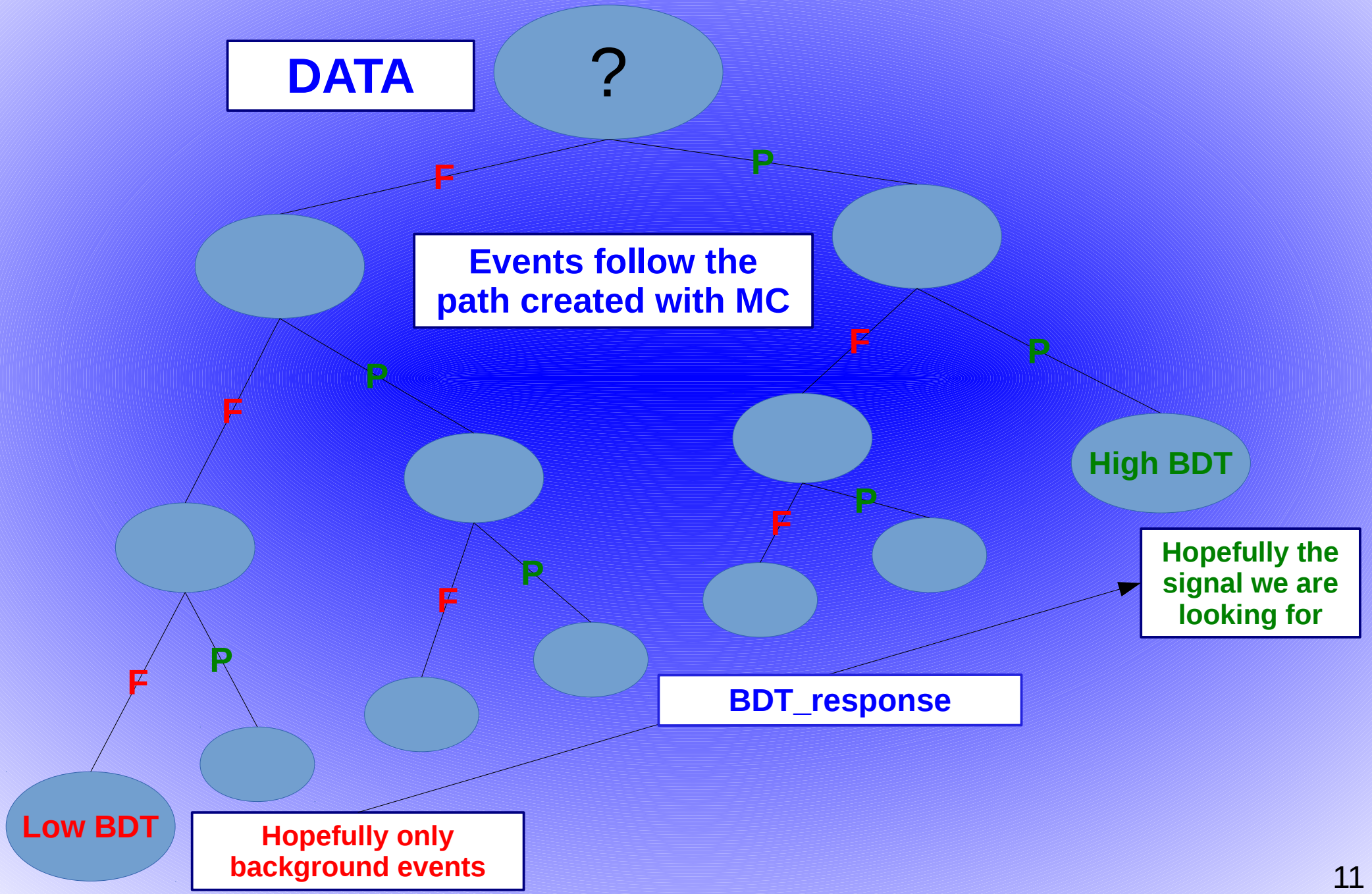

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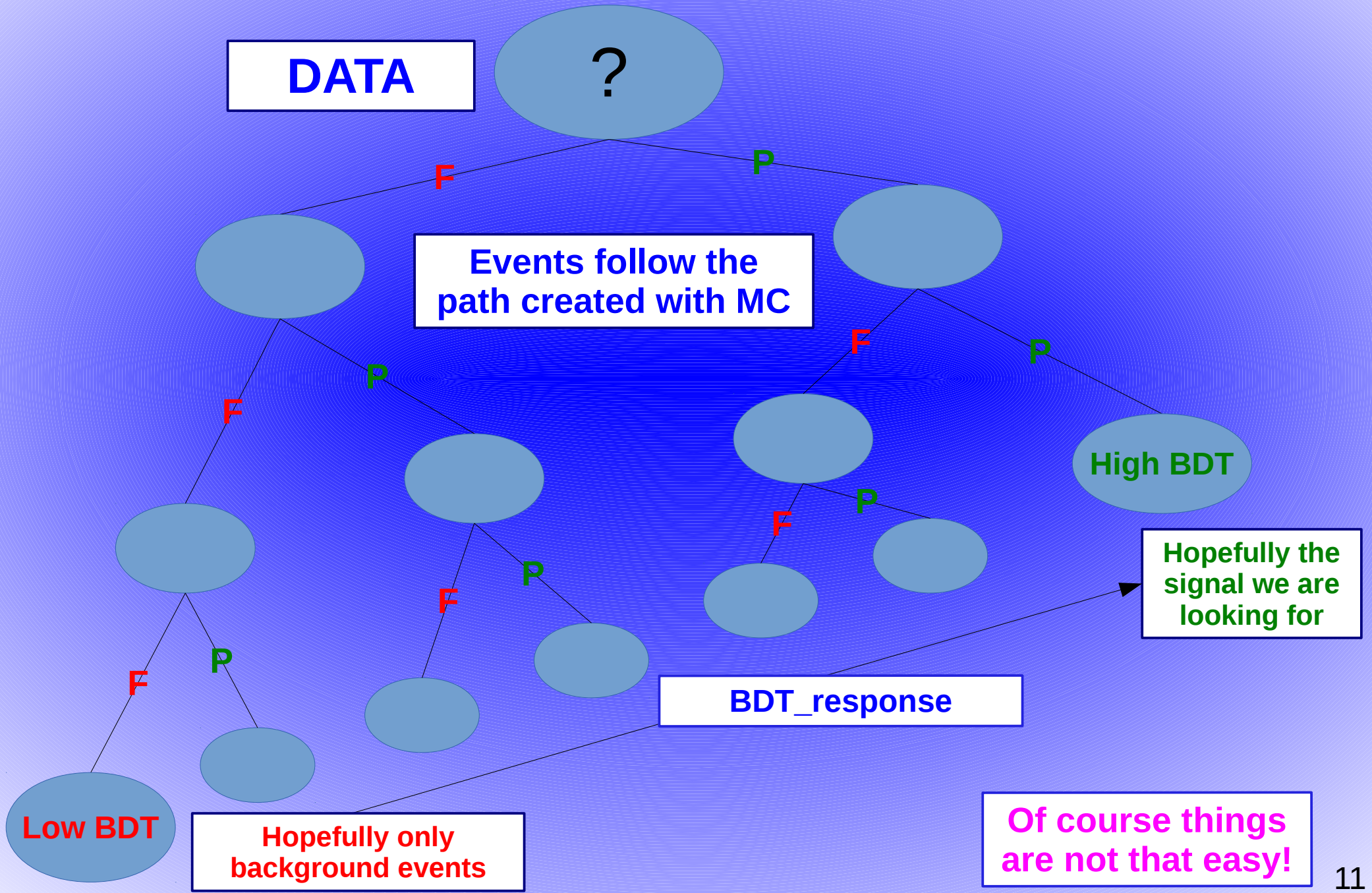
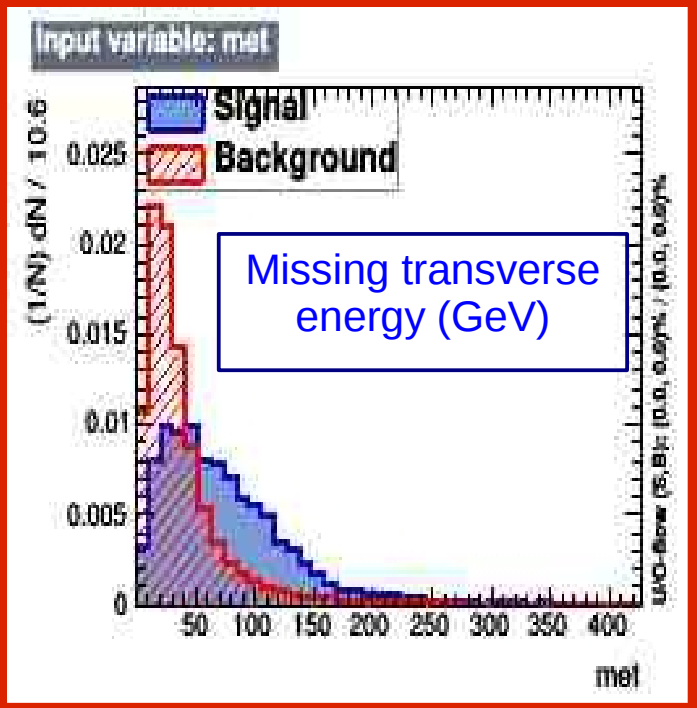
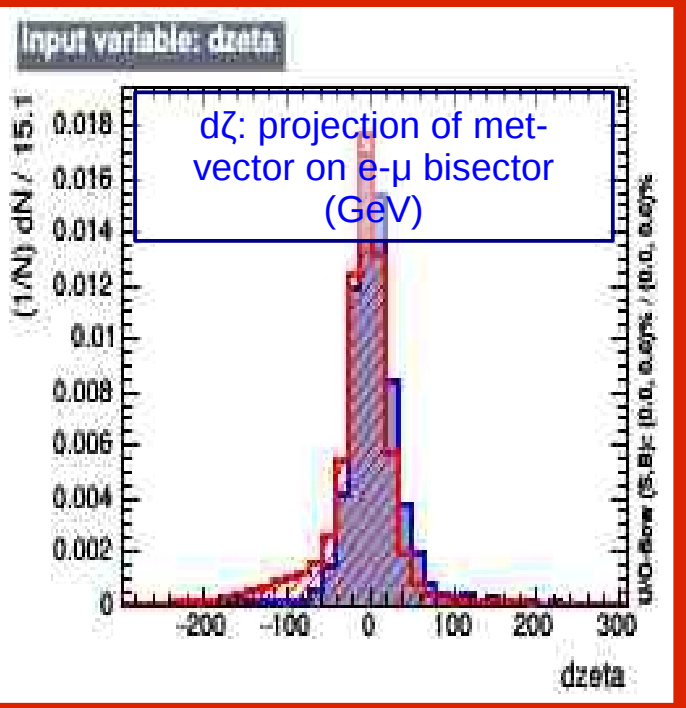
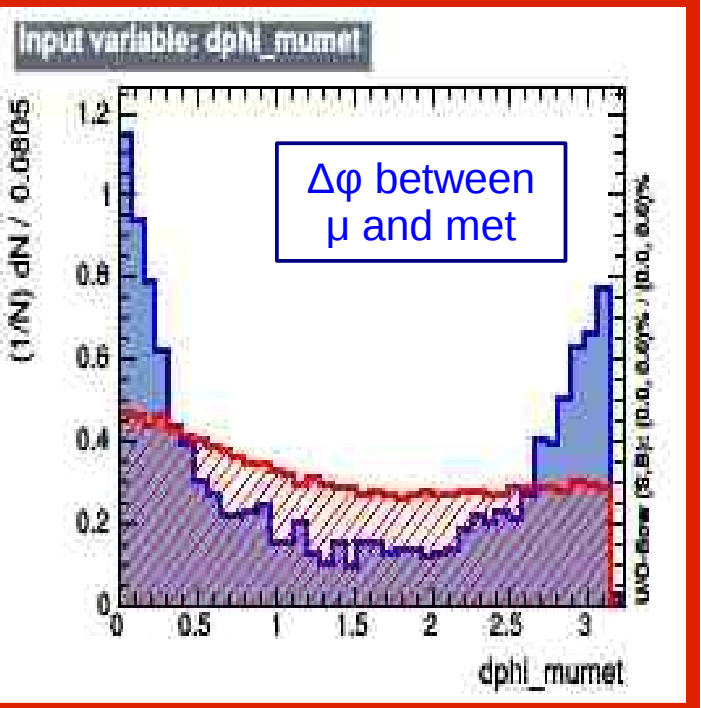


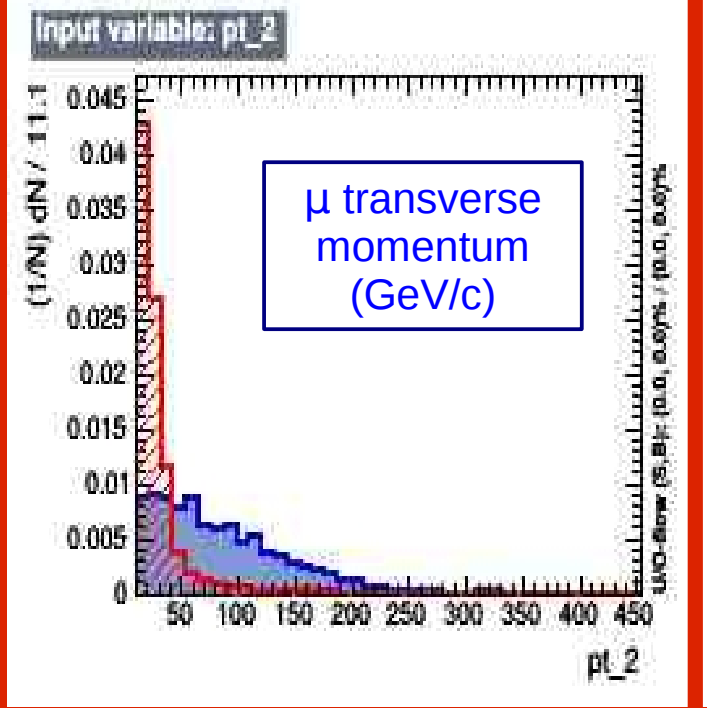

BDT: A more accurate picture
There are quite
a lot of trees!
(Vallombrosa woods,
Florence, Tuscany)

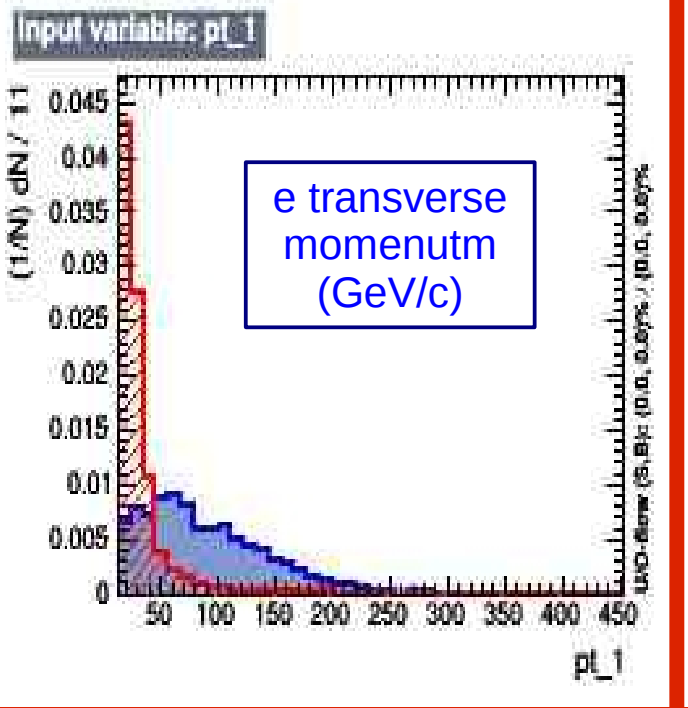
Variables: gg → Φ(500 GeV)

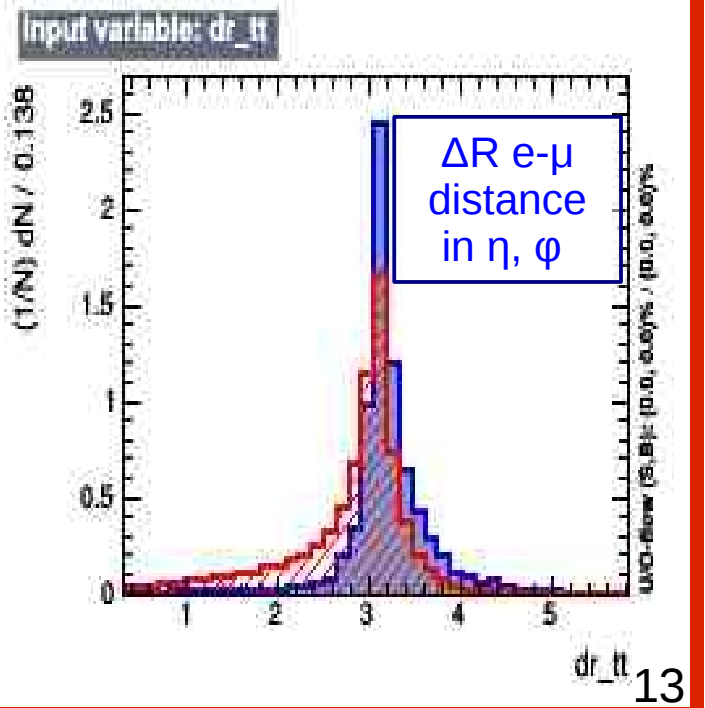




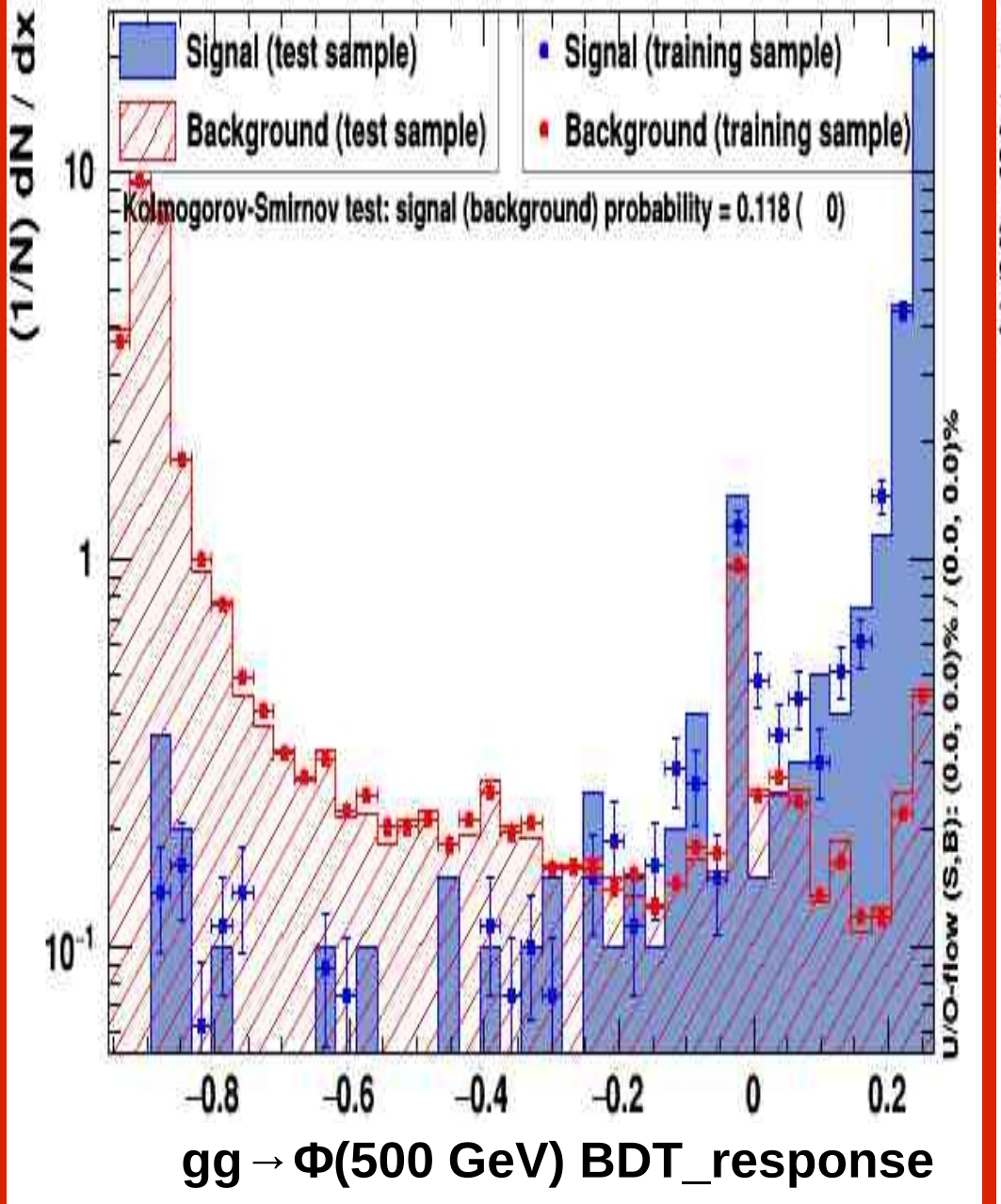




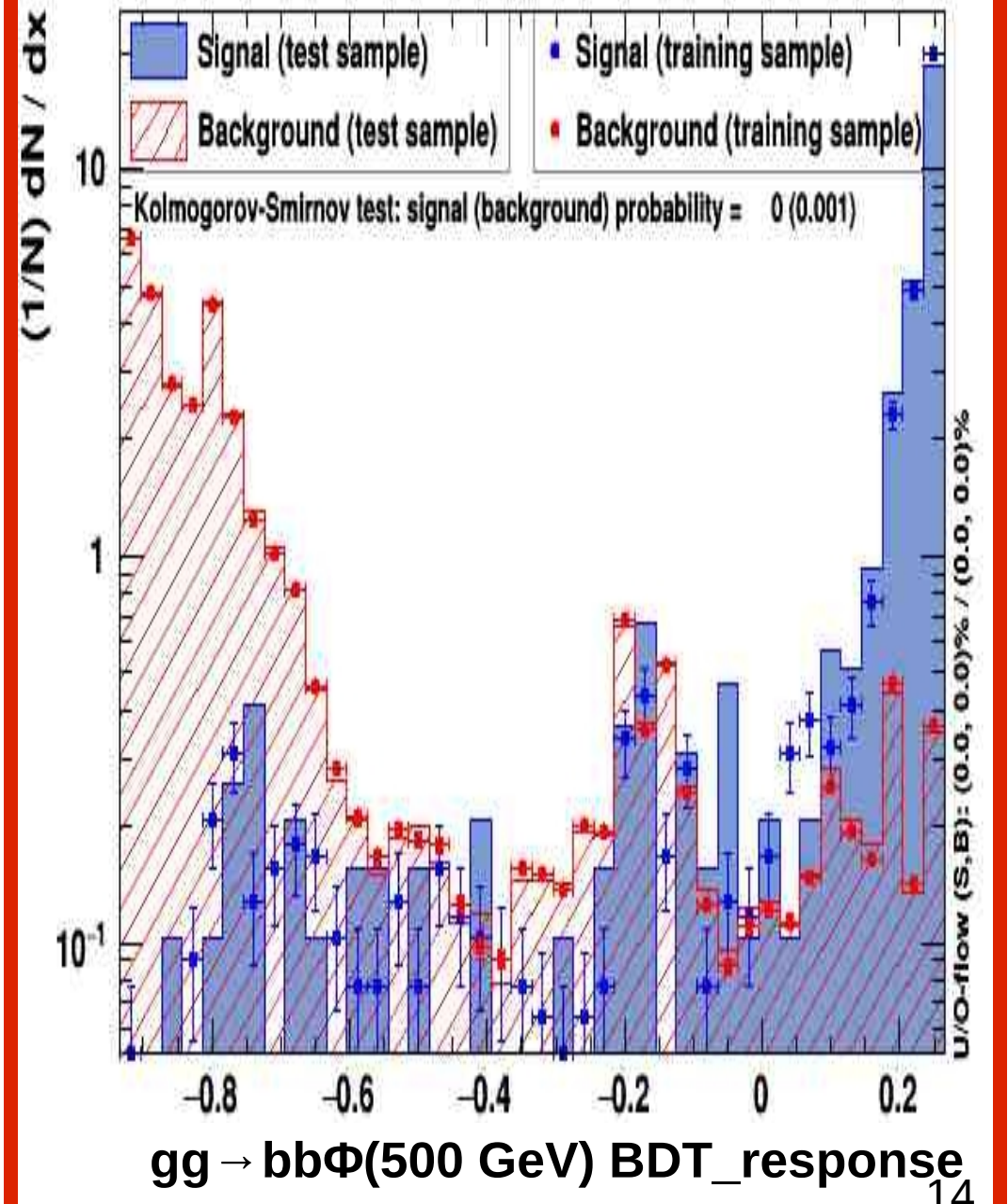




BDT response

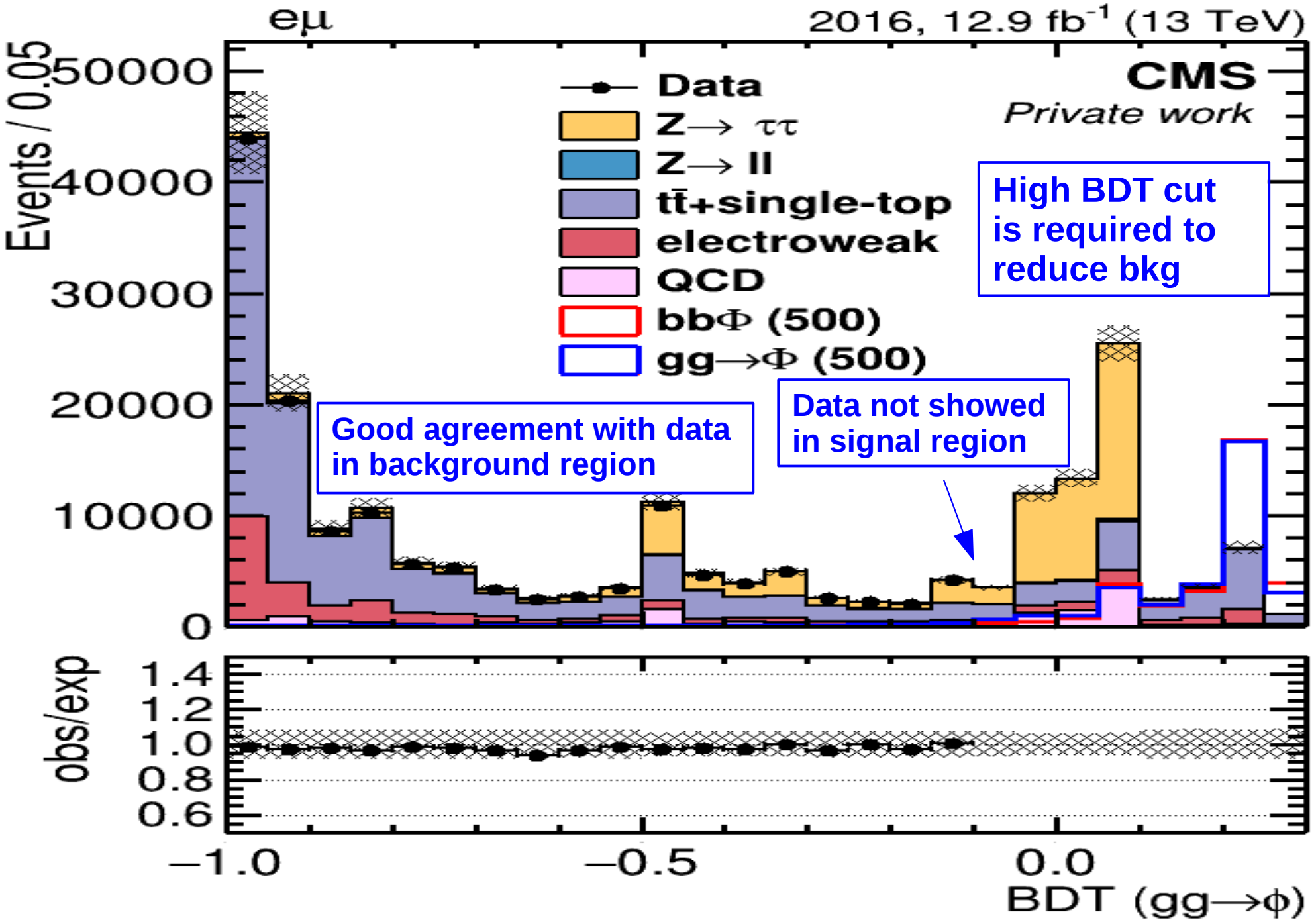


gg → Φ(500 GeV) BDT_response

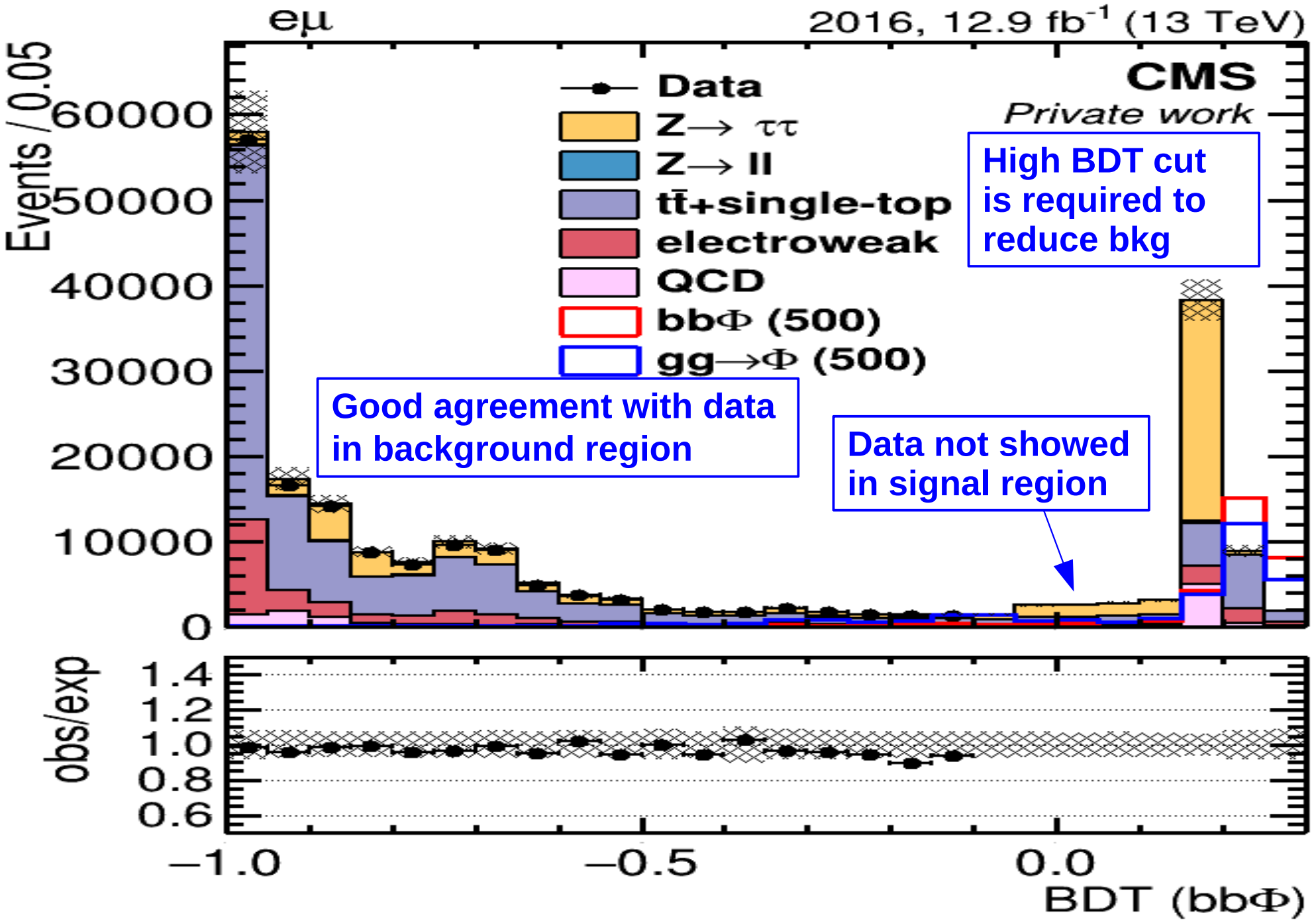


gg → bbΦ(500 GeV) BDT_response

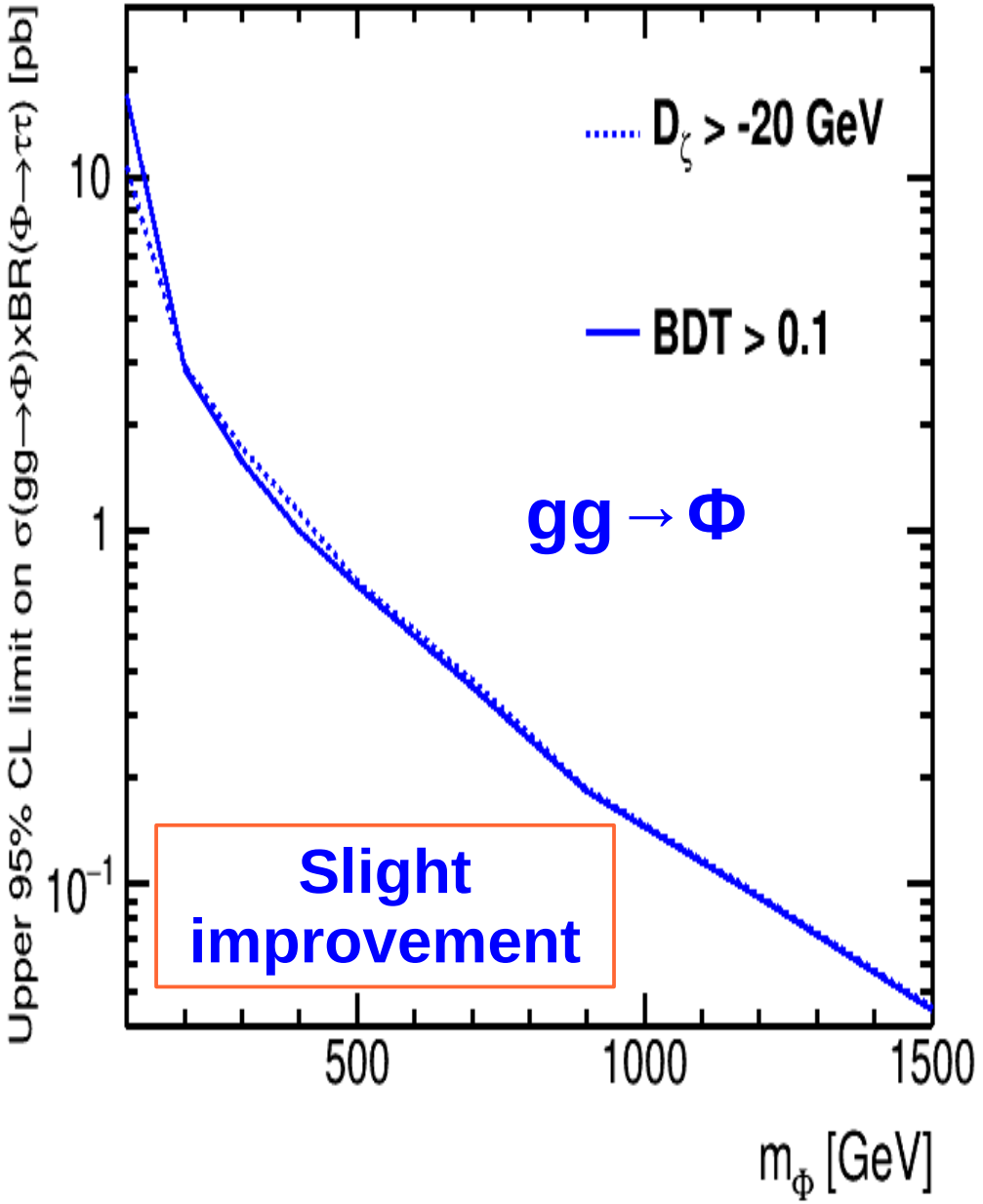
BDT evaluation(gg → Φ)

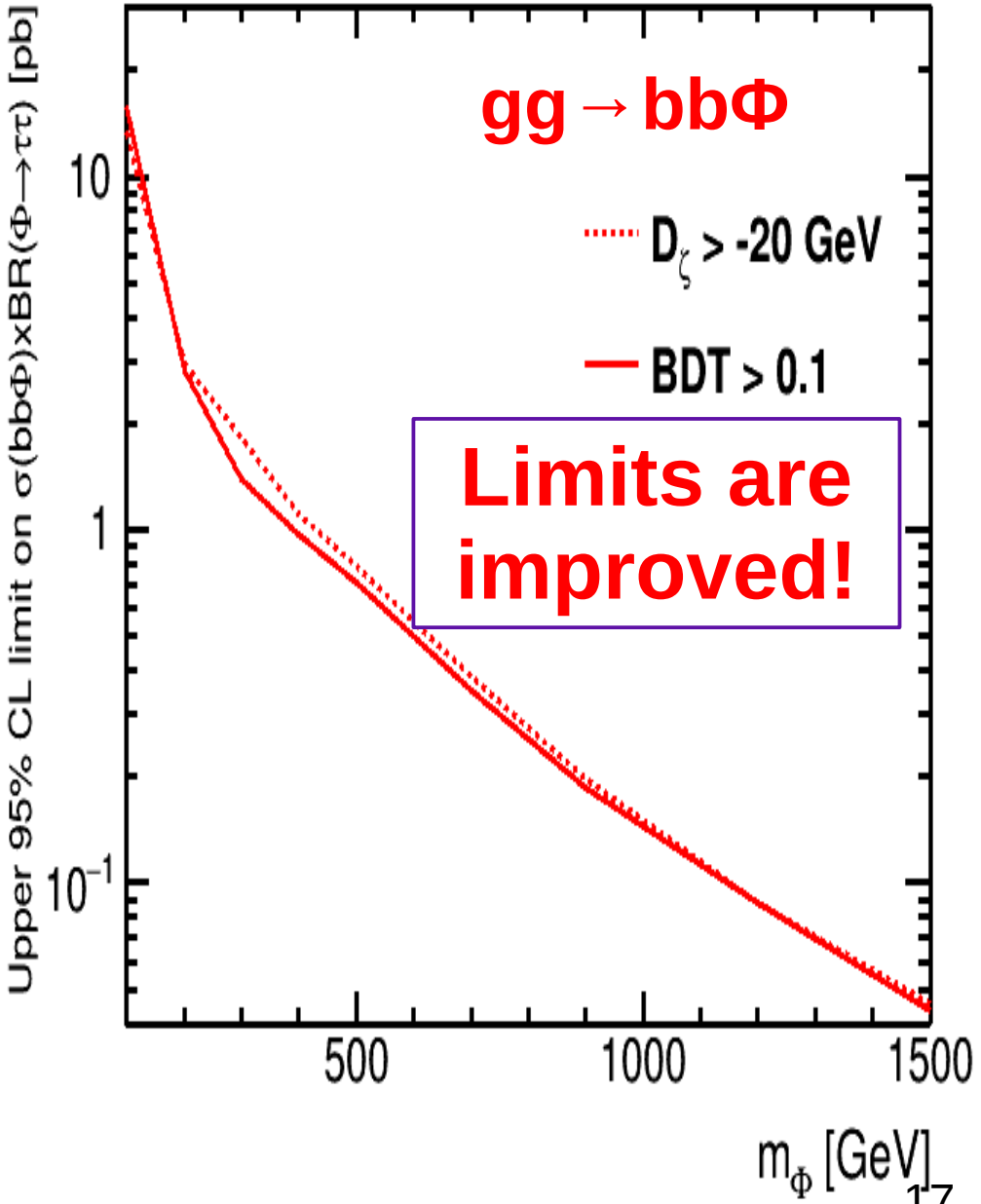


BDT evaluation($gg \rightarrow bb\Phi$)



Expected limits





Summary

- First BDT analysis in Higgs → Tau Tau → e μ channel
- Higher sensitivity achieved compared with $D\zeta > -20$ GeV cut for masses above 200 GeV
- We intend to apply this technique in the official CMS SUSY Higgs → Tau Tau → e μ analysis

Thanks for the attention

SUSY2215

SUSY: THE NEW HOPE

- QUANTUM MECHANICS AND QFT STILL HOLD
- THE ORBITAL COLLIDER STILL SEES NOTHING

THREE CENTURIES OF TRIUMPH FOR SUSY AND STRINGS!

The seasonal trends

Extremely-weeny constrained SUSY

NSFWMSSM

FF3C10ACBA9-MSSM

MSSM retrograde

Anthropic landscaping and trimming it down

The problem of condensed matter: They still don't get it

Strings - The Perpetual Revolution

Number of free parameters: P or NP complete?

Invited seminar

How to ensure your model remains predictability-free

Forum

Is choice moral?

"Every time you choose a path of action, a multiverse is killed"

Special topic

If the universe is not supersymmetric is it necessarily existing?

The perpetual conference

5 Jan - 5 Mar: Chamonix
15 Mar - 30 June: Hainan Island
1 July - 15 Sep: Wailea, Maui
15 Sep - 20 Nov: Jumeirah 1
21 Nov - 24 Dec: Hainan Island

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