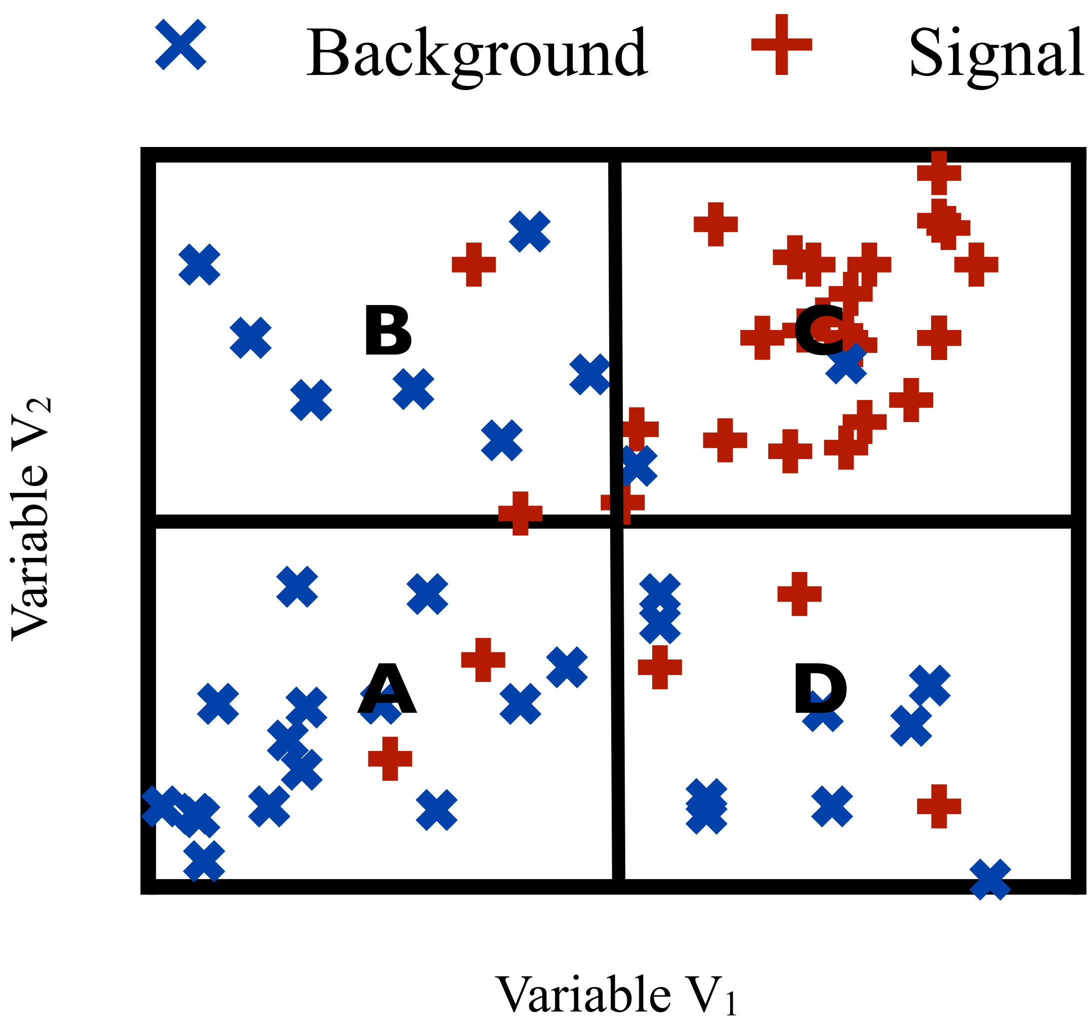
QCD background studies with the ABCD method for the Inclusive N-Jet SUSY Search (RA2)

- The method derived from the famous "ABCD"
- Treatment of systematic uncertainties
- Integration into the common framework for integration of all backgrounds



Classical equation for the ABCD method:

$$N_C = N_D \cdot \frac{N_B}{N_A}$$

… this holds if the ratio N_B/N_A is independent from V_1!

If variables with a constant ratio are not available
⇒make an assumption for the shape of the ratio

Extended ABCD method:
ratio r(x) is evaluated in the control regions **A**,**B**
and applied to the control region **D**

$$N_C = \sum_D r(x)$$

Sum over all events in region D

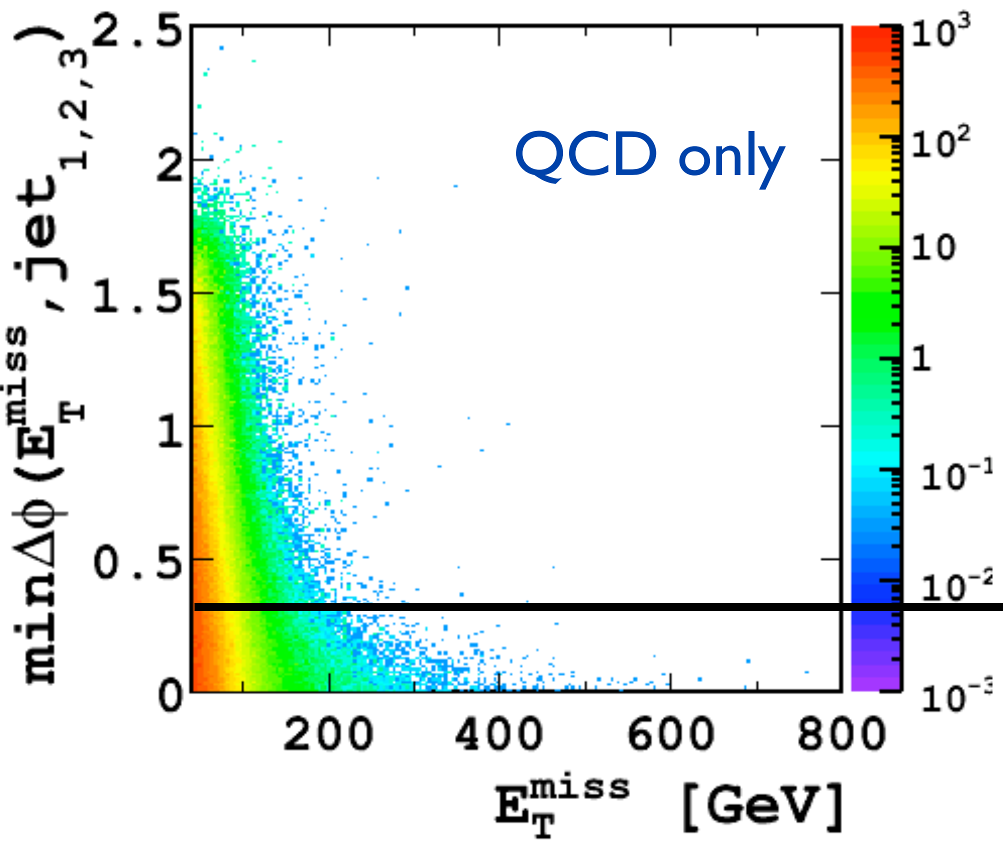
ABCD Method applied to RA2

Variables and cuts in the RA2 default selection:

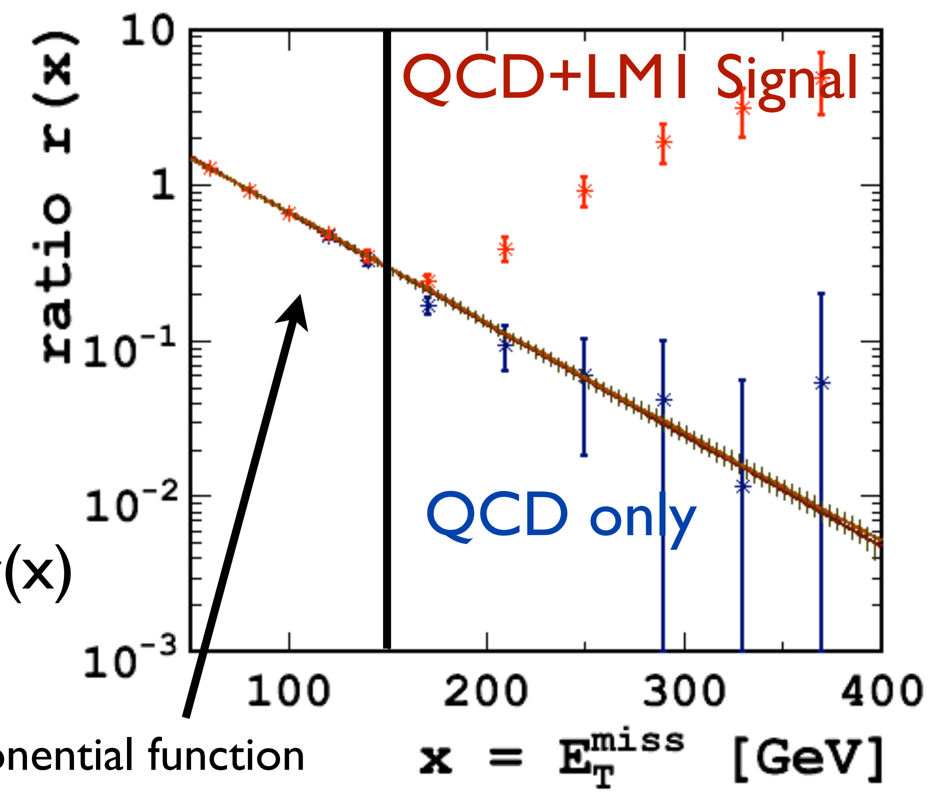
1st jet: pT > 180 GeV, $|\eta|$ < 2.5, 0.05 < EM fraction < 0.95
2nd jet: pT > 150 GeV, $|\eta|$ < 2.5, 0.05 < EM fraction < 0.95
3rd jet: pT > 50 GeV, $|\eta|$ < 2.5, 0.05 < EM fraction < 0.95
Veto on muons and electrons
MET > 150 GeV
min $\Delta\varphi$ (jet 1-3, MET) > 0.3

→ have best QCD separation power

https://twiki.cern.ch/twiki/bin/view/CMS/SusyRA2InclusiveNJetProjectTable



$$\frac{\#(\min \Delta\varphi > 0.3)}{\#(\min \Delta\varphi < 0.3)} = r(x)$$



fit with exponential function in control region

Uncertainties

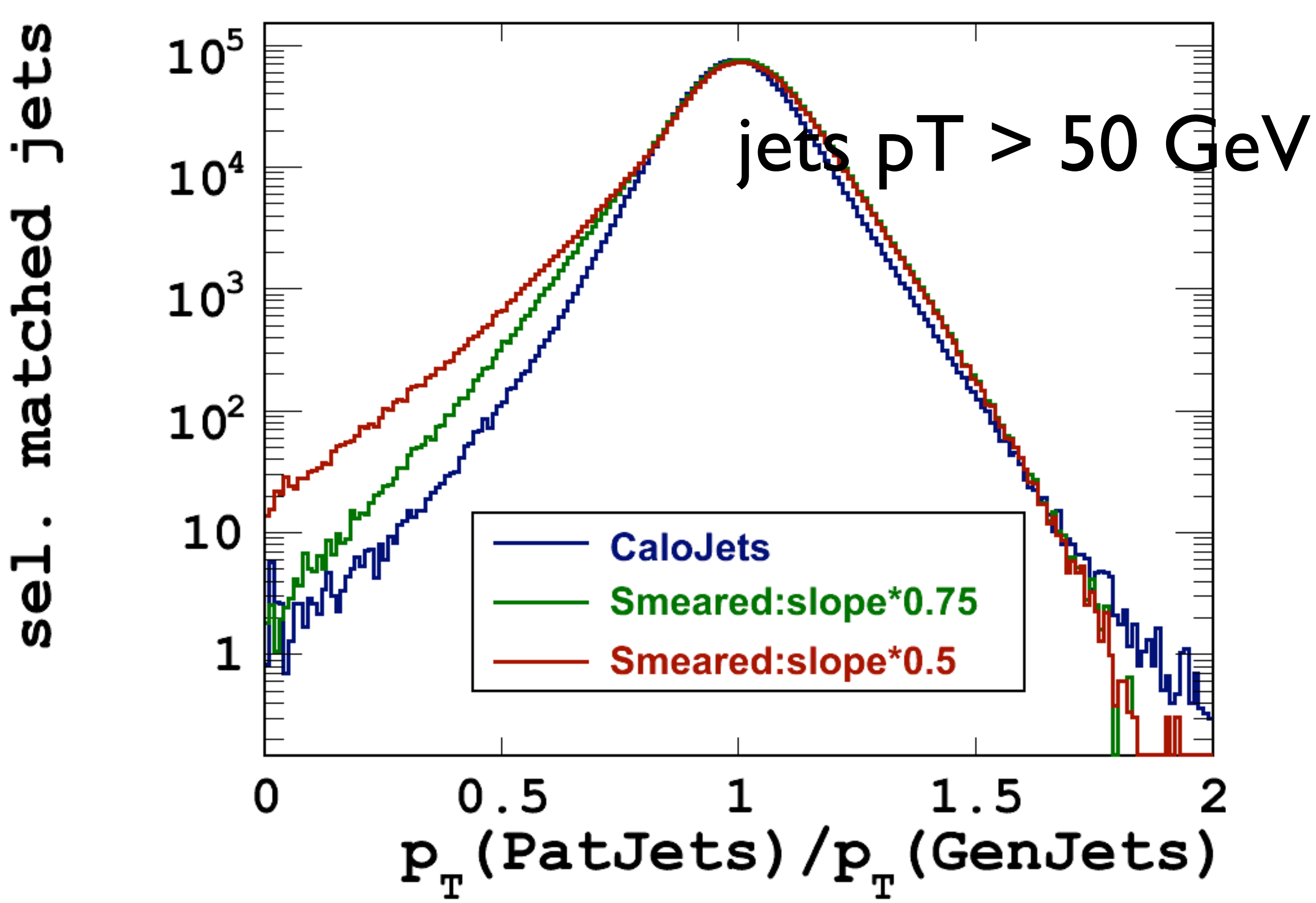
- Statistical uncertainties:
  - Errors on the fit parameters
    ⇒ Small in the case of low MET control region and exponential fit to min $\Delta\varphi$ ratio
  - Limited Statistics in control region **D**
    ⇒ would be much worse for variables with less QCD separation power than min $\Delta\varphi$

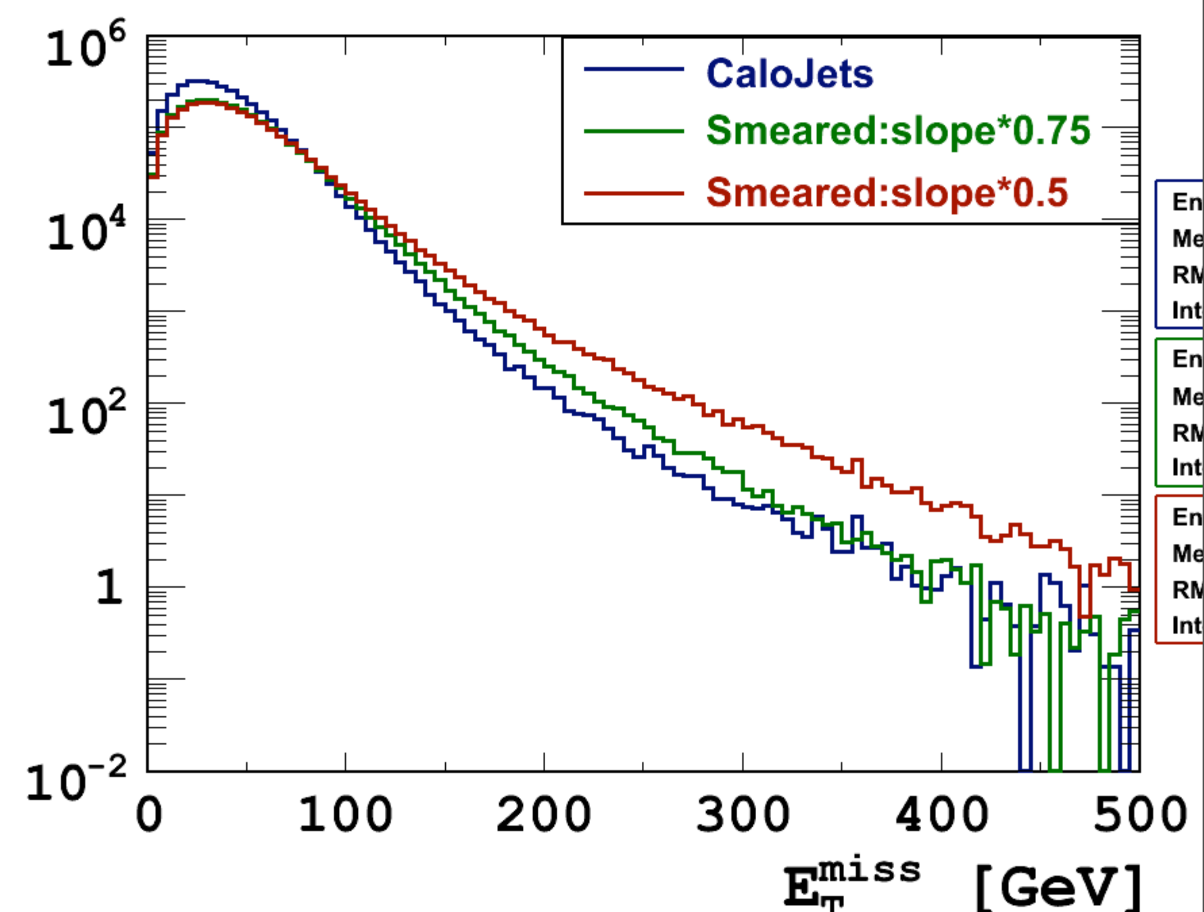
- Systematic uncertainties:
  - Effects of the selection cuts and control region definition on the extrapolation
    ⇒ for jet and MET cuts this is tested with a variation of the jet energy scale
  - Deviation of the assumed functional form of the ratio from the truth
    ⇒ to test: need a data-derived QCD sample (provided from the Smearing Method)
    ⇒ to evaluate the uncertainty: change the jet undermeasured tail in the input smearing function(dominant effect)
  - Contamination from signal and other backgrounds

⇒ Other backgrounds: in MC ≈ 10% effect. Use corrections from other background predictions?

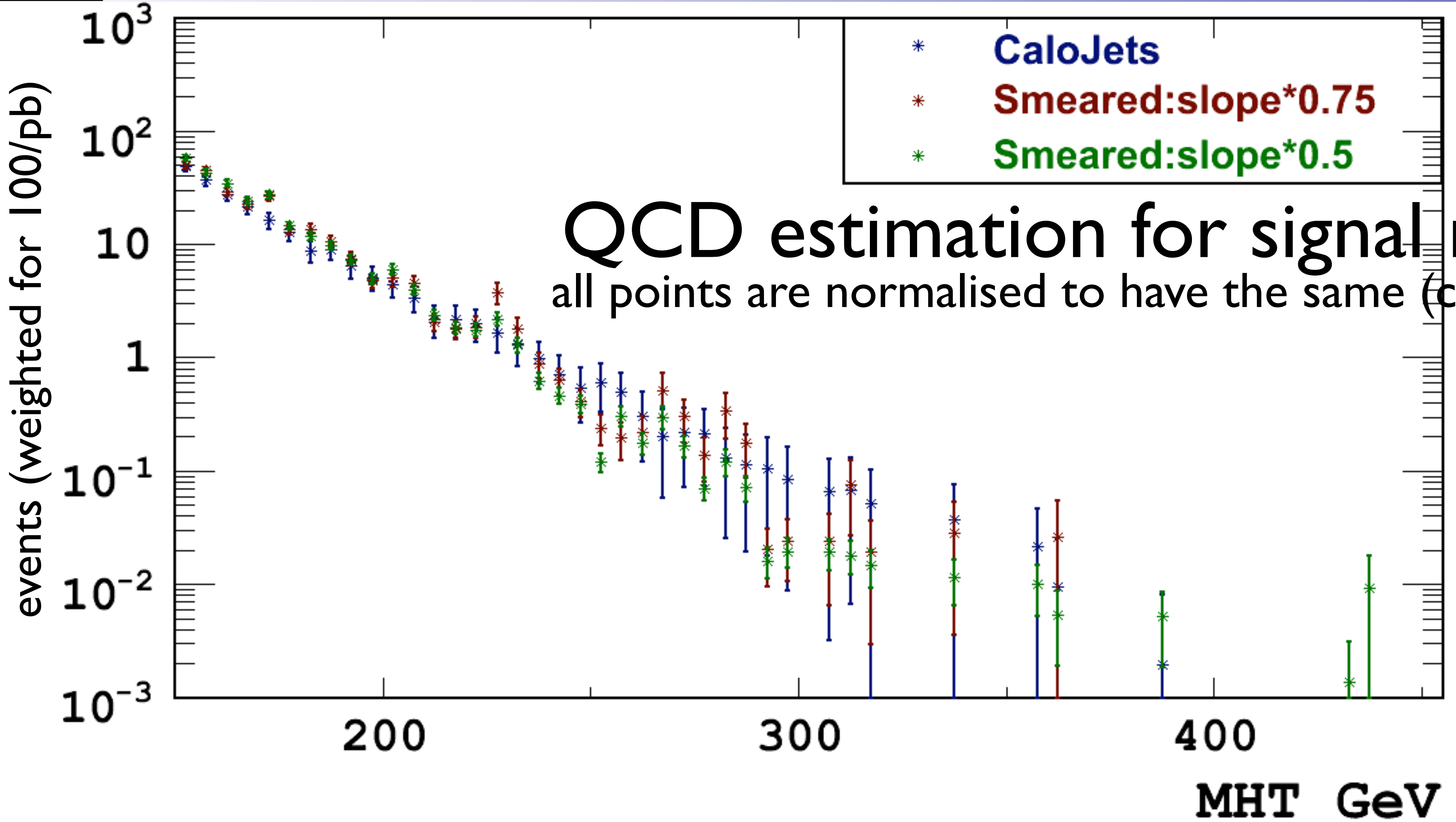
MC based uncertainty

- Investigating the uncertainty of the method in MC
  - Idea: Change the jet resolution by smearing GenJets
  - dominant contribution: lower tail in the jet response (non-Gaussian part)
  - Smearing function for the GenJets: derived from CaloJet response for different pT bins and modified for two scenarios
    - increase tail moderate by reducing the slope by a factor 0.75
    - increase the tail strongly by reducing the slope by a factor of 0.5





MC based uncertainty



QCD estimation for signal region

all points are normalised to have the same (caloJets) truth value

	truth	estimation	chi^2 / ndof	rel. estimation
CaloJets	199	216 ± 13	10.0 / 18	+ 8.5 %
Smeared 1	499	618 ± 27	14.1 / 18	+ 23.8%
Smeared 2	876	1110 ± 42	38.9 / 18	+26.7%

Plans for uncertainty estimation from data

- Jet response can be fitted in data with a Gaussian + a step function for the tail
  - see Matthias' talk today
- Applying the fitted smearing functions to data produces an QCD sample to test the method
  - see Sue Ann's talk today
- The ABCD estimation is sensitive to variations of the tail
  - a conservative error on the fitted step function can be used to derive the systematic uncertainty for the ABCD method

ABCD method implementation

Scheme to combine the RA2 background predictions, presented by Christian Auterman:

http://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=73510

http://cmssw.cvs.cern.ch/cgi-bin/cmssw.cgi/UserCode/auterman/RA2/

Here, specialized to ABCD prediction:

1. step: Evaluation of ratio function in control regions **A**,**B**
2. step: Application to control region **D**, see next slide

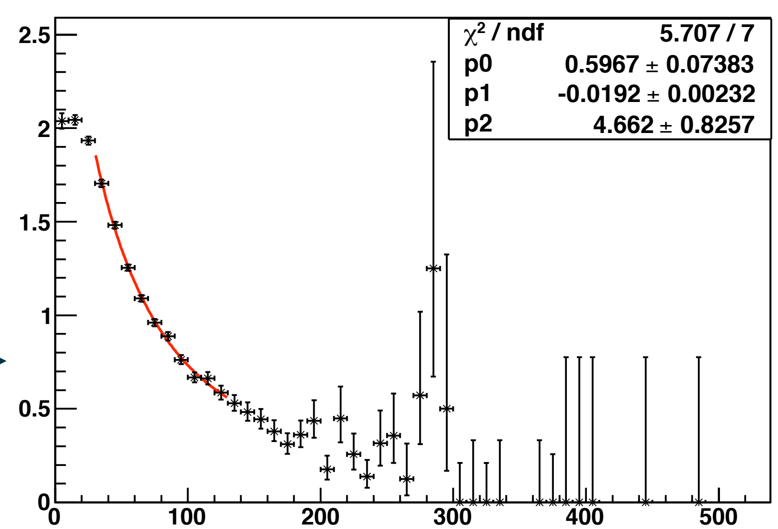
PAT

Filter:
SUSY RA2 Selection
(without MET and min $\Delta\varphi$ cut)

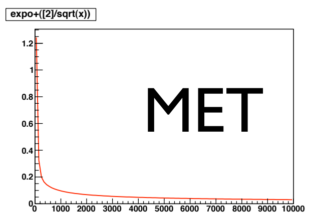
add RA2 variables to output

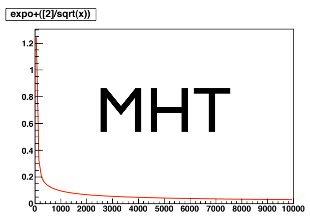
Producer:
QCDSmearProd
JES

for systematic uncertainties



ABCDFunctions.root





etc.

ABCD method implementation

PAT or PAT: JES±5% or PAT: Smeared jets

Filter: SUSY RA2 Selection (without MET and min Δφ cut)

Producer: QCDabcdProd.cc ← ABCDFunctions.root

Filter: SUSY RA2 Final Selection

produces weights for control region

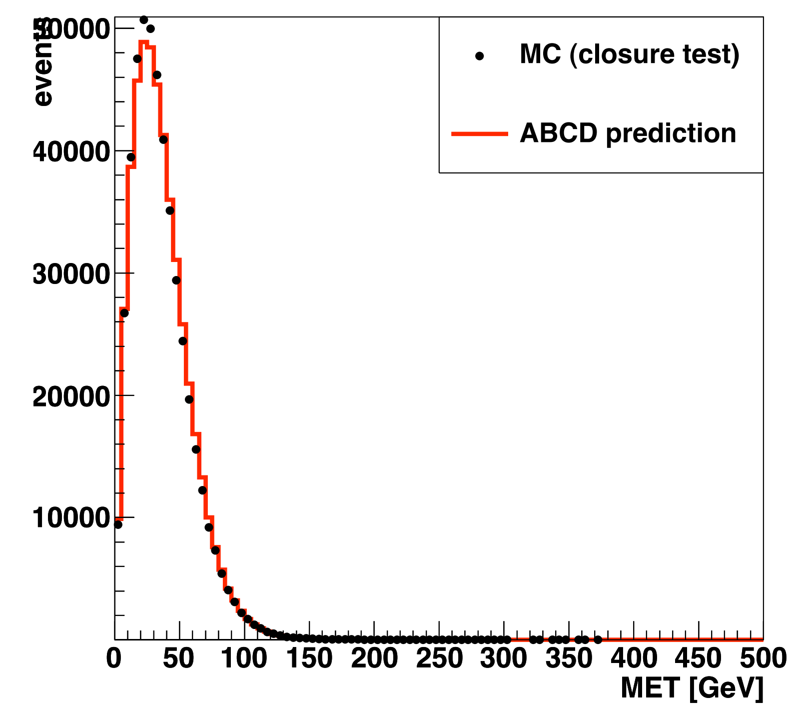
Analyzer: FinalPlots.cc

fill plots for signal region

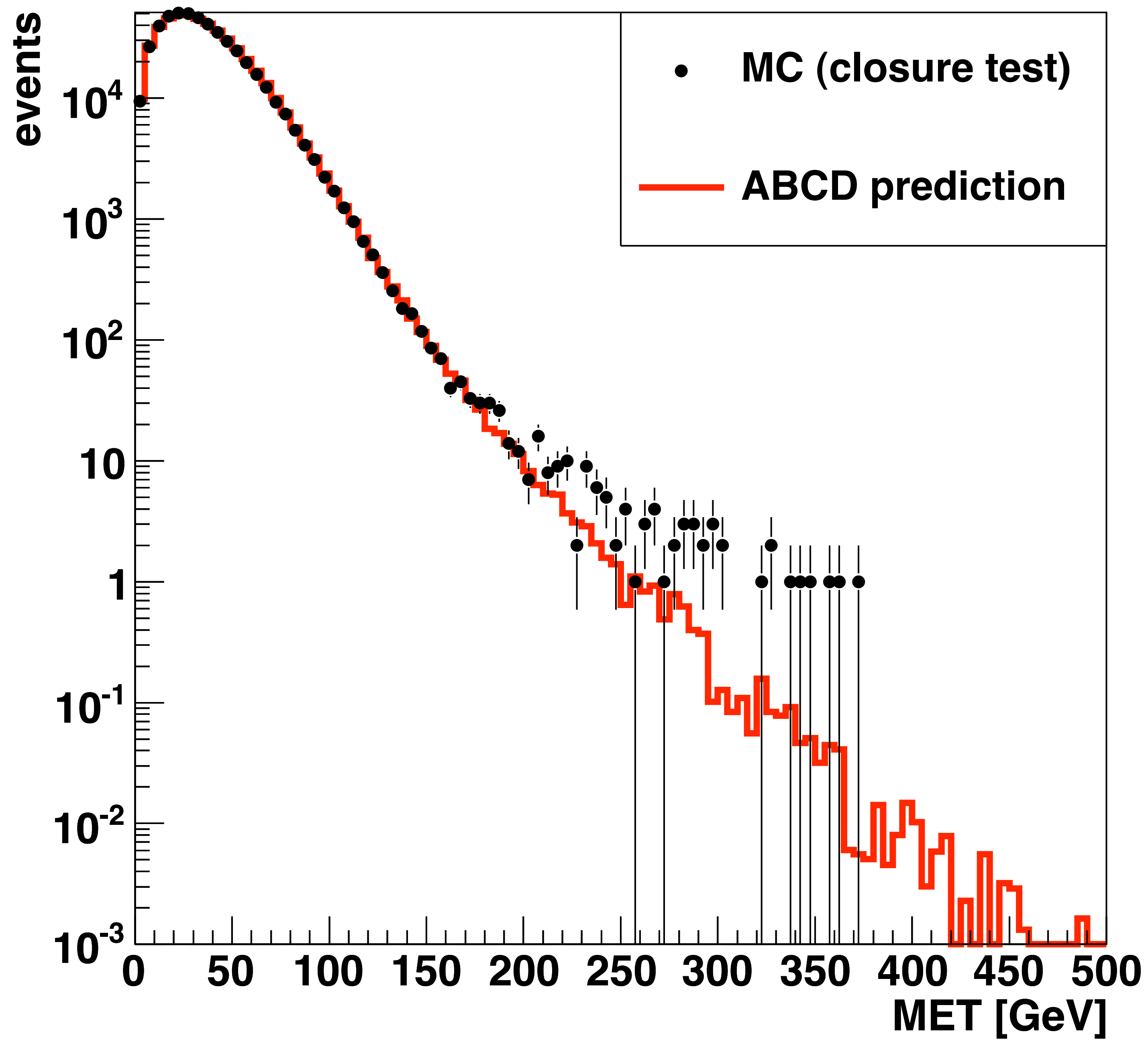
Analyzer: FinalPlots.cc

fill plots with weights from control region

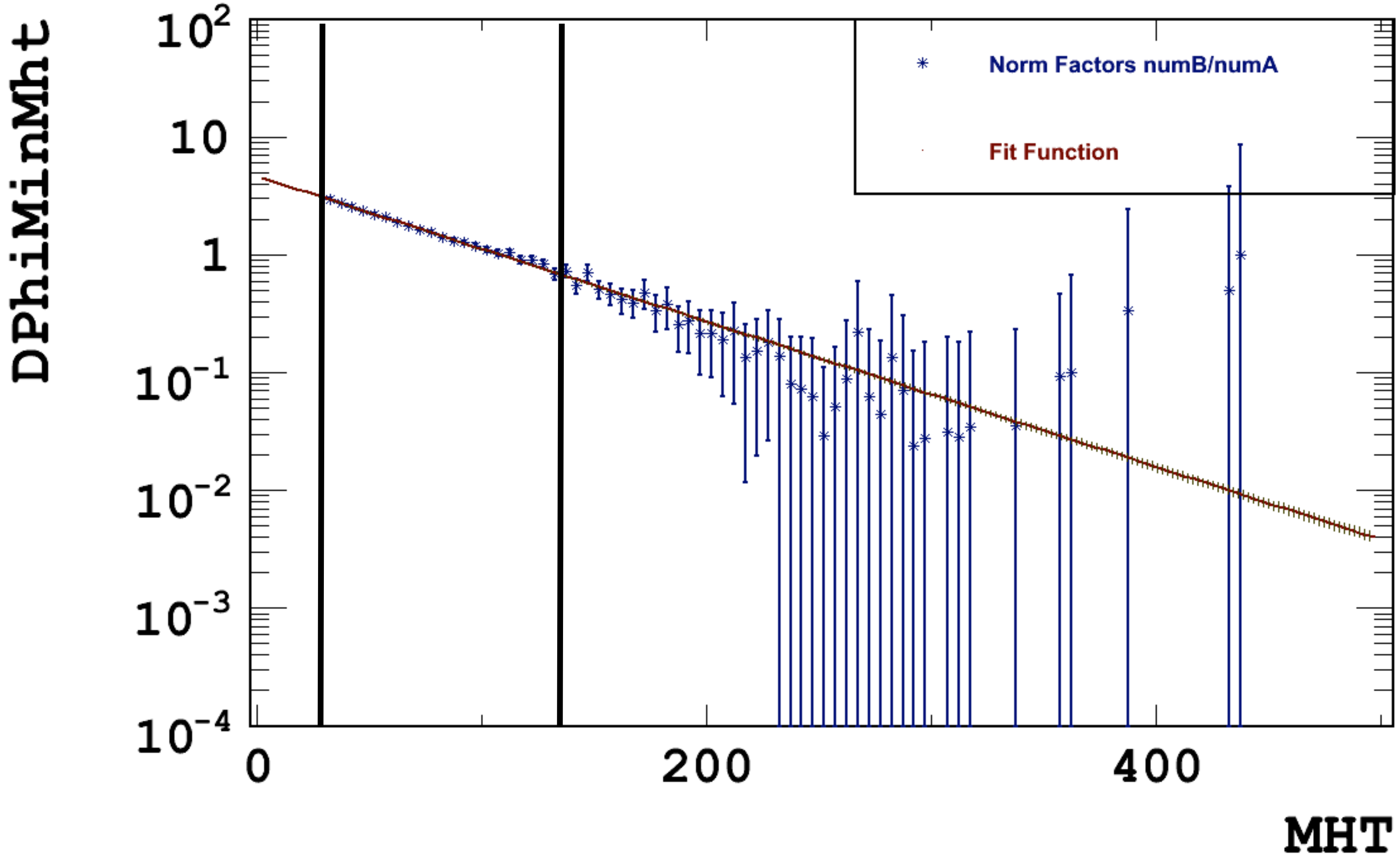
finalplots.root →

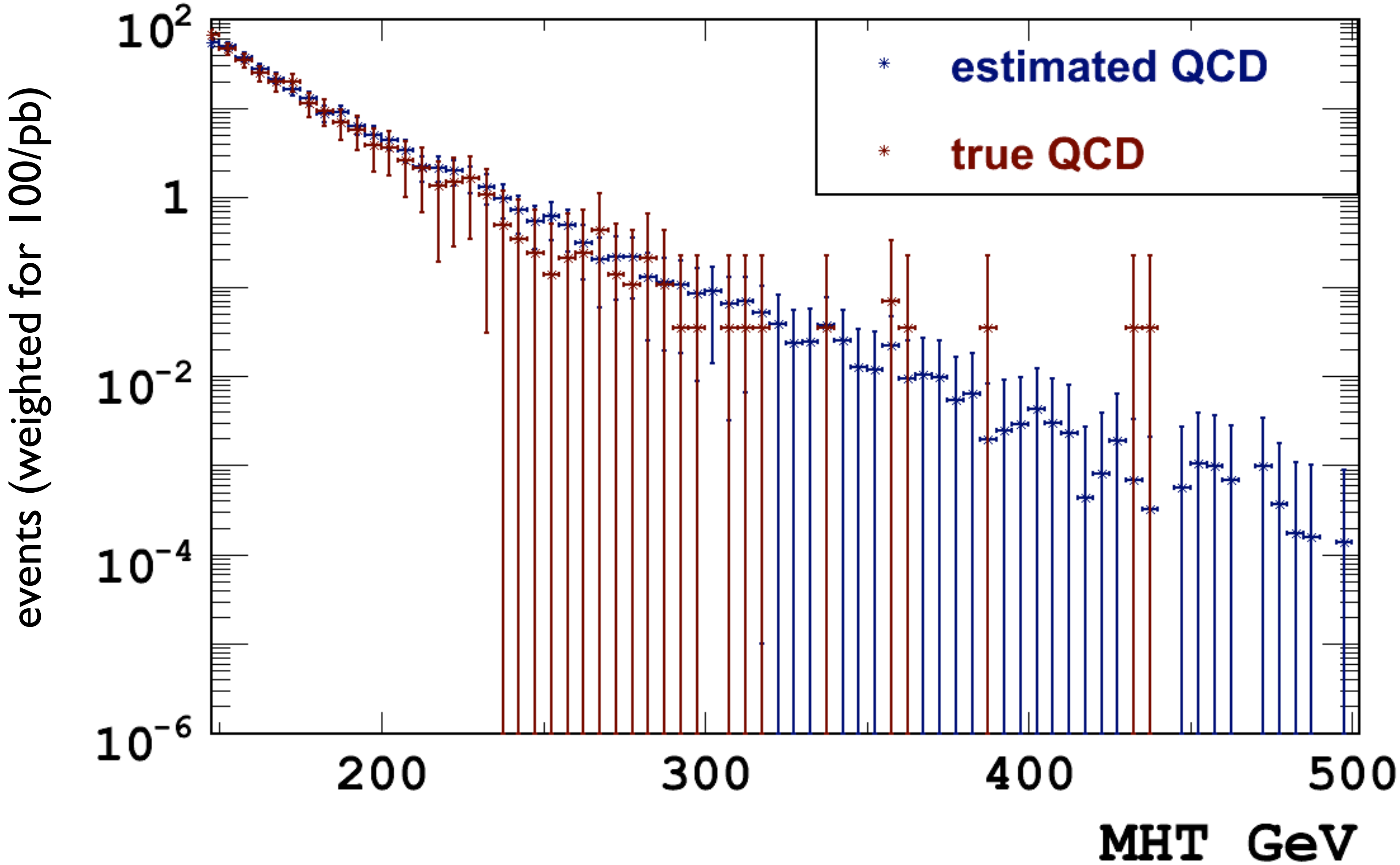


Closure-Test with RA2 framework

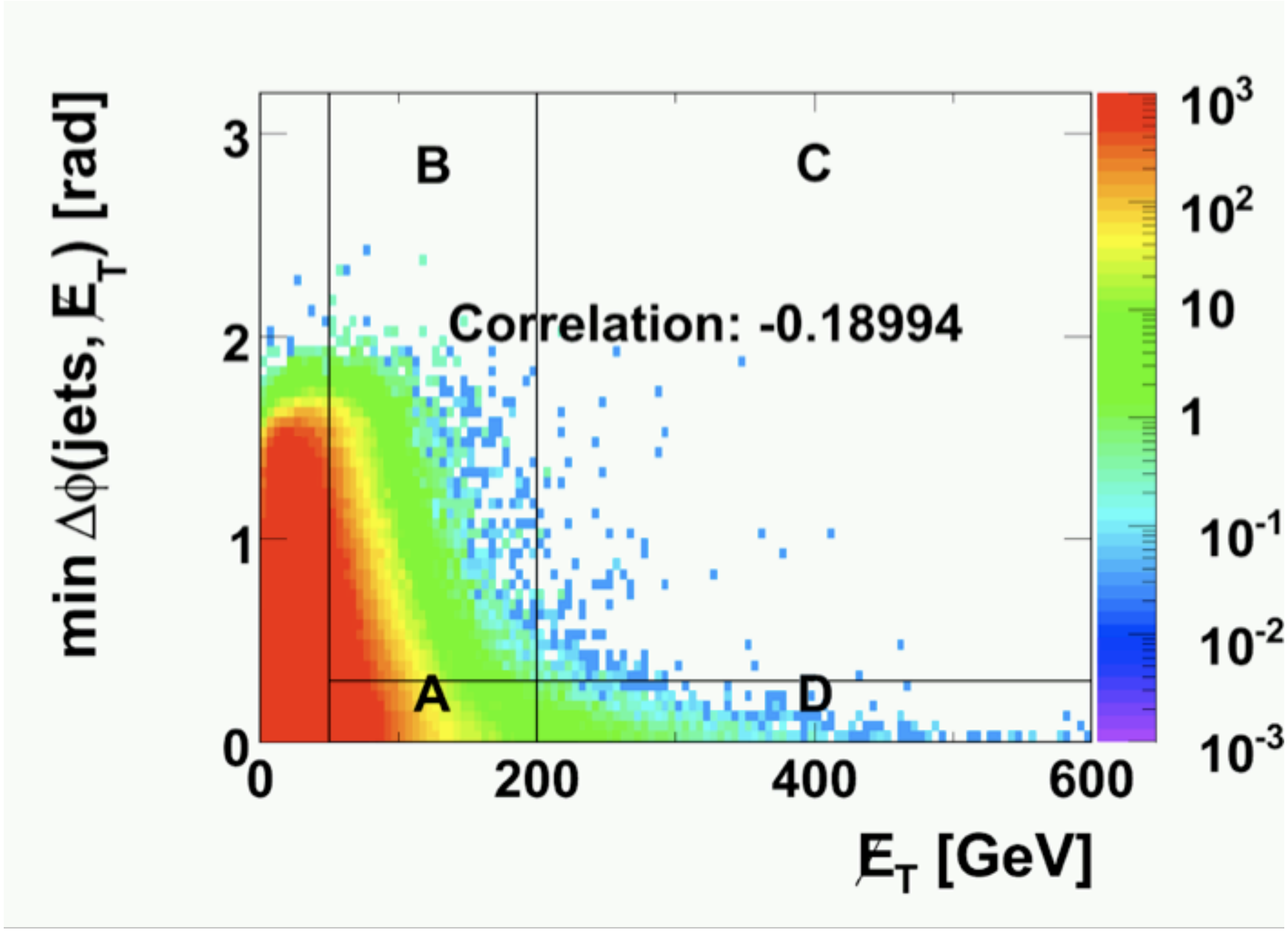


Conclusions & Outlook

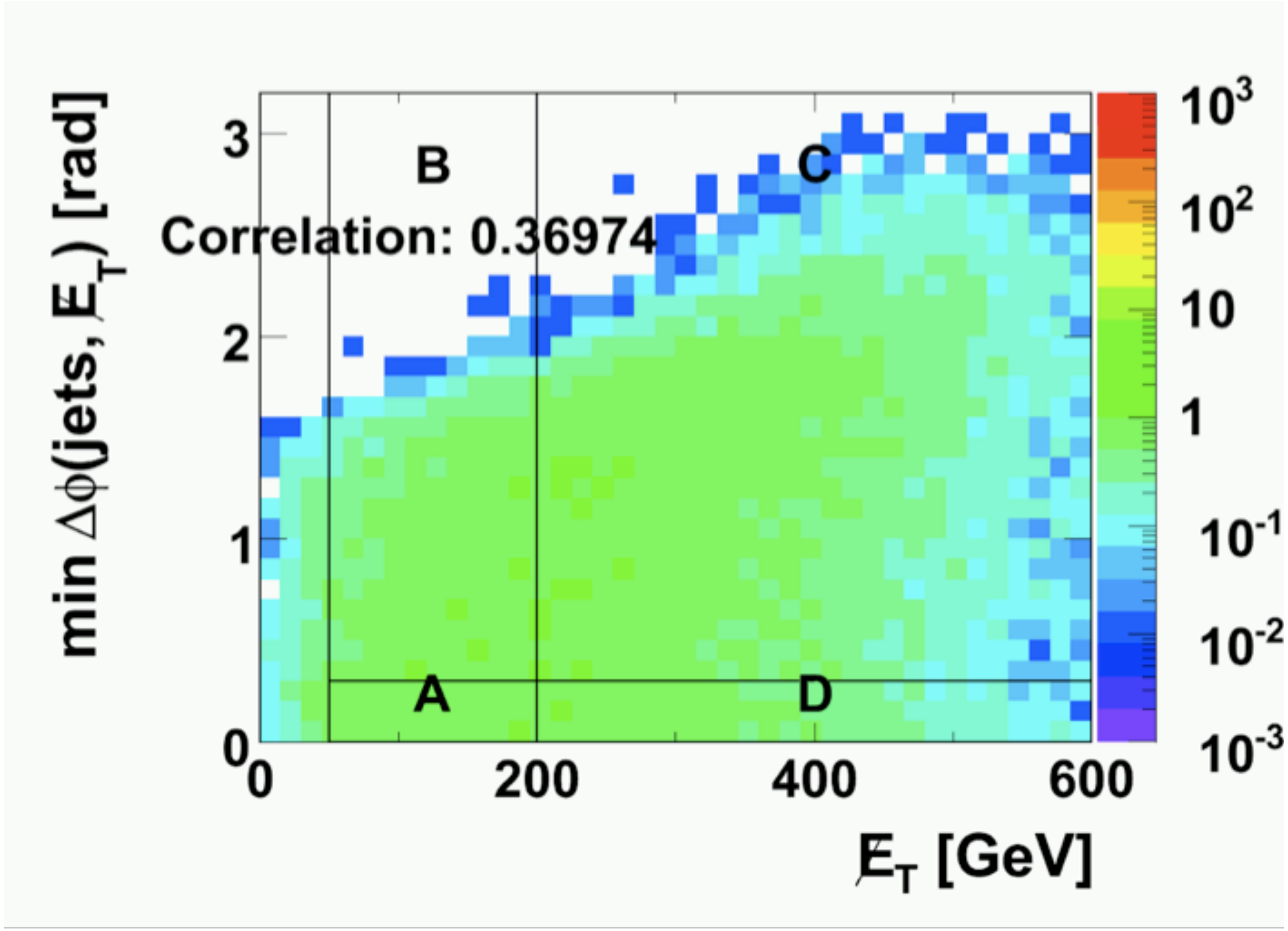

DPhiMinMht
MHT
Norm Factors numB/numA
Fit Function
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
200
400



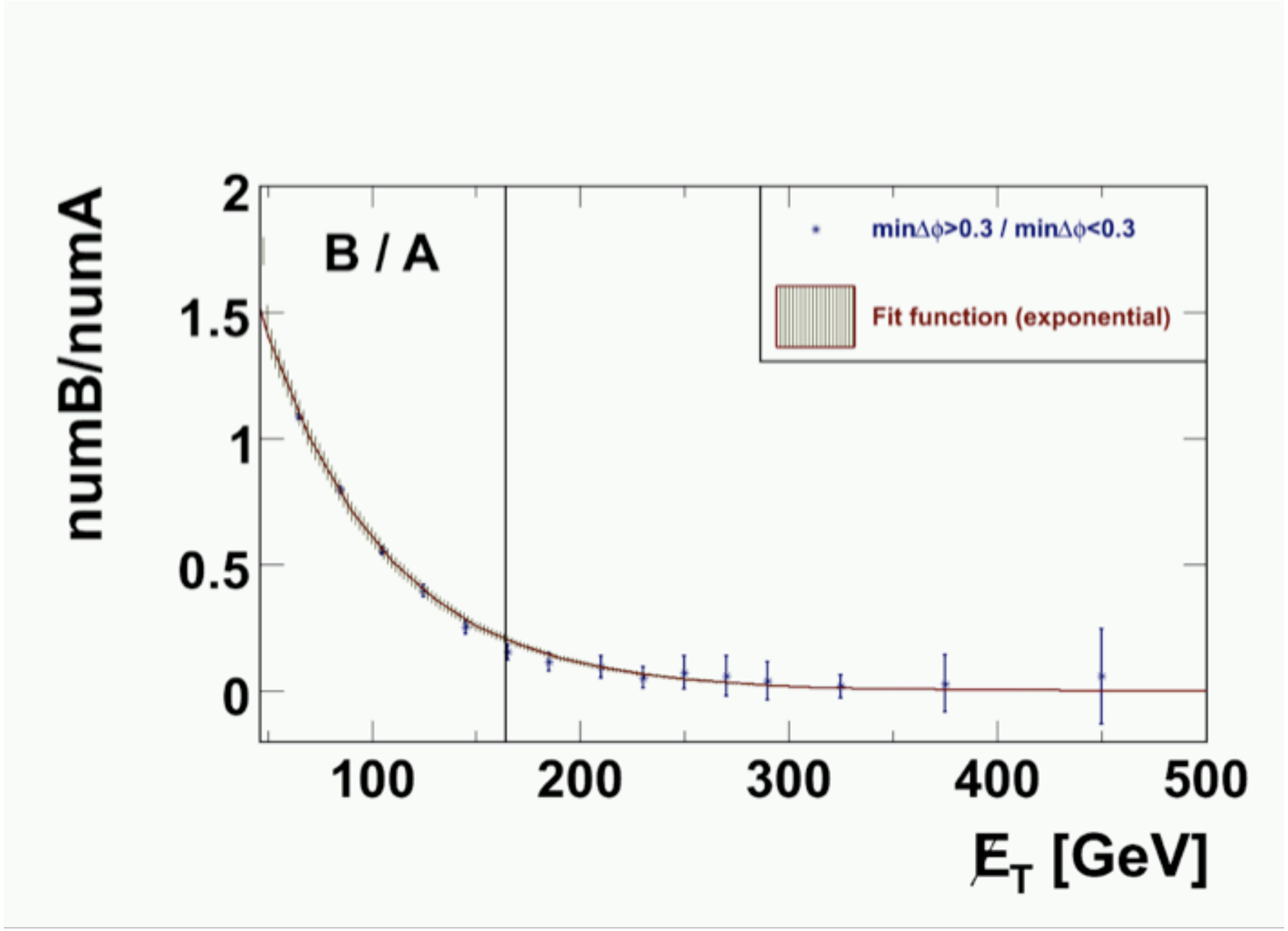
- Signal region MHT > 150 GeV, min $\Delta\varphi$ > 0.3



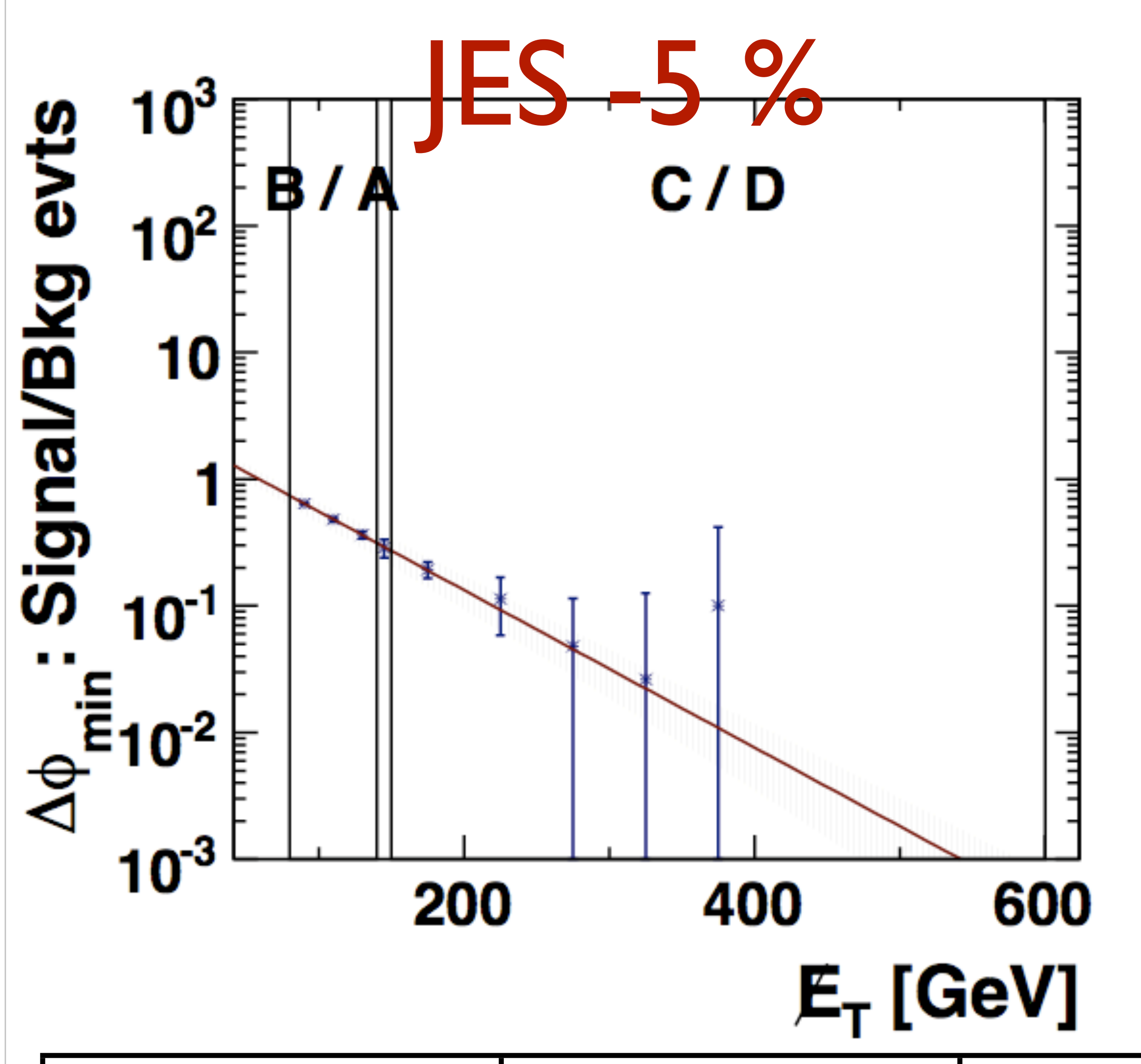
min Δφ(jets, $\not{E}_T$) [rad]
3
2
1
0
0
200
400
600
$\not{E}_T$ [GeV]
B
C
A
D
Correlation: -0.18994
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}

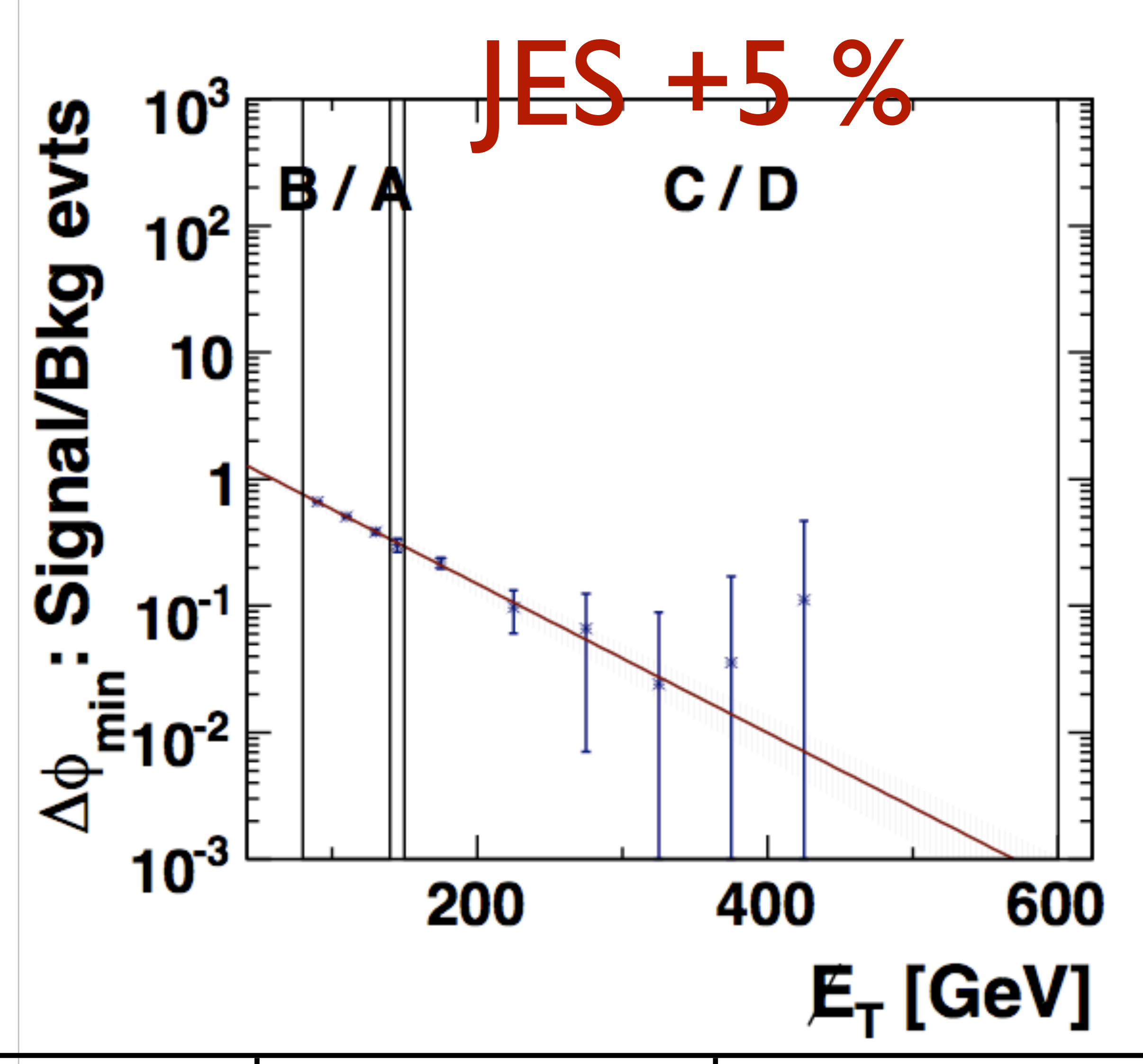


min Δφ(jets, $\not{E}_T$) [rad]
3
2
1
0
B
C
Correlation: 0.36974
A
D
0
200
400
600
$\not{E}_T$ [GeV]
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}


numB/numA
2
1.5
1
0.5
0
B / A
minΔφ>0.3 / minΔφ<0.3
Fit function (exponential)
100
200
300
400
500
$\not{E}_T$ [GeV]

Shifting the Jet Energy Scale





	true QCD	estimation	stat. error	true/est
Default	91	92	± 21	1%
JES -5%	62	68	±18	10%
JES +5%	130	142	± 27	9%