Study of the top quark mass dependency on the K_T inclusive algorithm

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Outline

- **Introduction**
- **Top mass dependency on the K_T algorithm**
- **A more sensitive variable: the hadronic W mass**
- **Conclusions and Outlook**

Introduction

A top mass reconstruction attempt in the semileptonic channel has been performed

Framework:

- **"NIKHEF" AOD 4100 T1 sample**
- ATHENA **releases** 10.0.4/11.0.2/11.0.42

Selection criterias:

- **at least 1 lepton: Pt>20 GeV, $|\eta|< 2.5$,**
- **isolation criteria with respect to the jets: no jets within $\Delta R<0.4$, ($\Delta R^2 = \Delta\eta^2 + \Delta\phi^2$)**
- **4 jets: Pt > 40 GeV, $|\eta|< 2.5$,**
- **ETMiss > 20 GeV.**

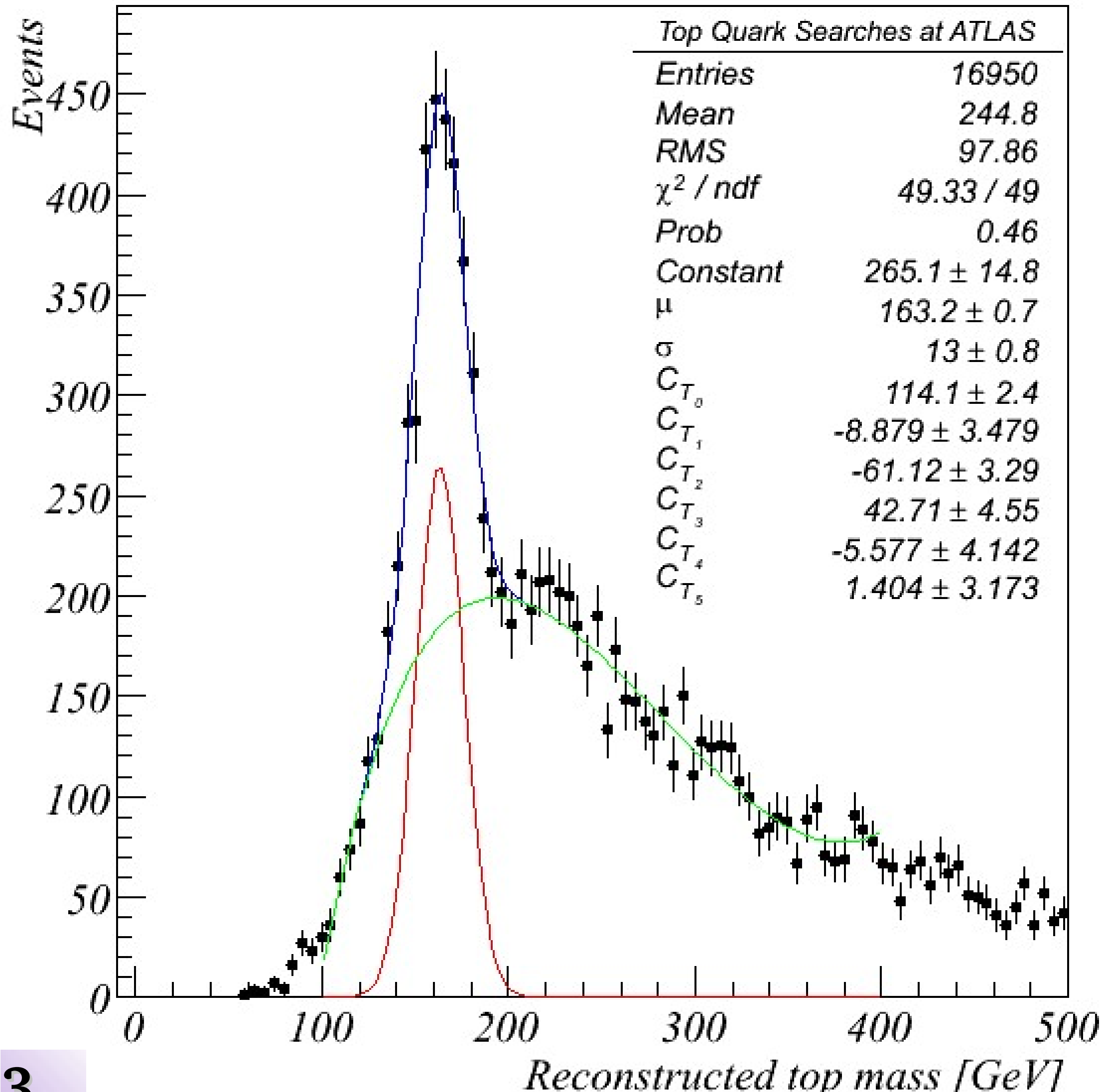
Top Mass reconstruction using the W which decays hadronically:

- **loop on all the jets,**
- **get the three jets which maximize the total Pt,**
- **find the right combination for the top mass,**
- **find the right combination for the W mass.**

Top mass dependency on Jet- algorithm

Analysis is repeated for the different Jet containers available at the AOD level. Below for $\Delta R = 0.4$.

No W mass constraint



Cone4ParticleJets

Jets are reconstructed using the Cone algorithm (see later)

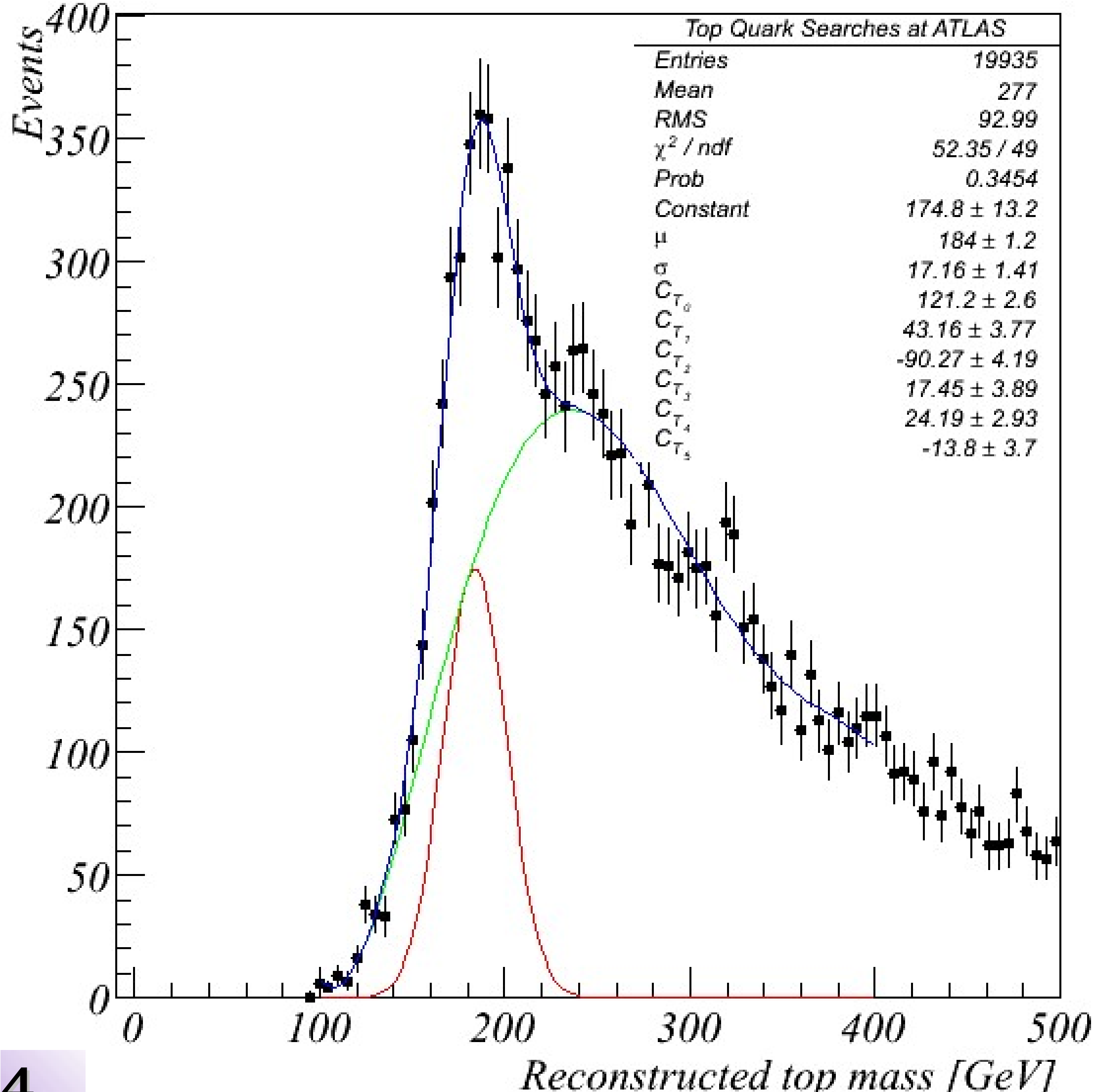
The three jet invariant mass distribution is parametrised with a Gaussian + a Chebychev polynomial

Reconstructed mass in "reasonable" agreement with the generated one:

MTop = 163.2 GeV

Top mass dependency on Jet- algorithm

Analysis is repeated with the Cone algorithm for ΔR =0.7.



Cone7ParticleJets

Jets are reconstructed using the Cone algorithm (see later)

The three jet invariant mass distribution is parametrised with a Gaussian +a Chebychev polynomial

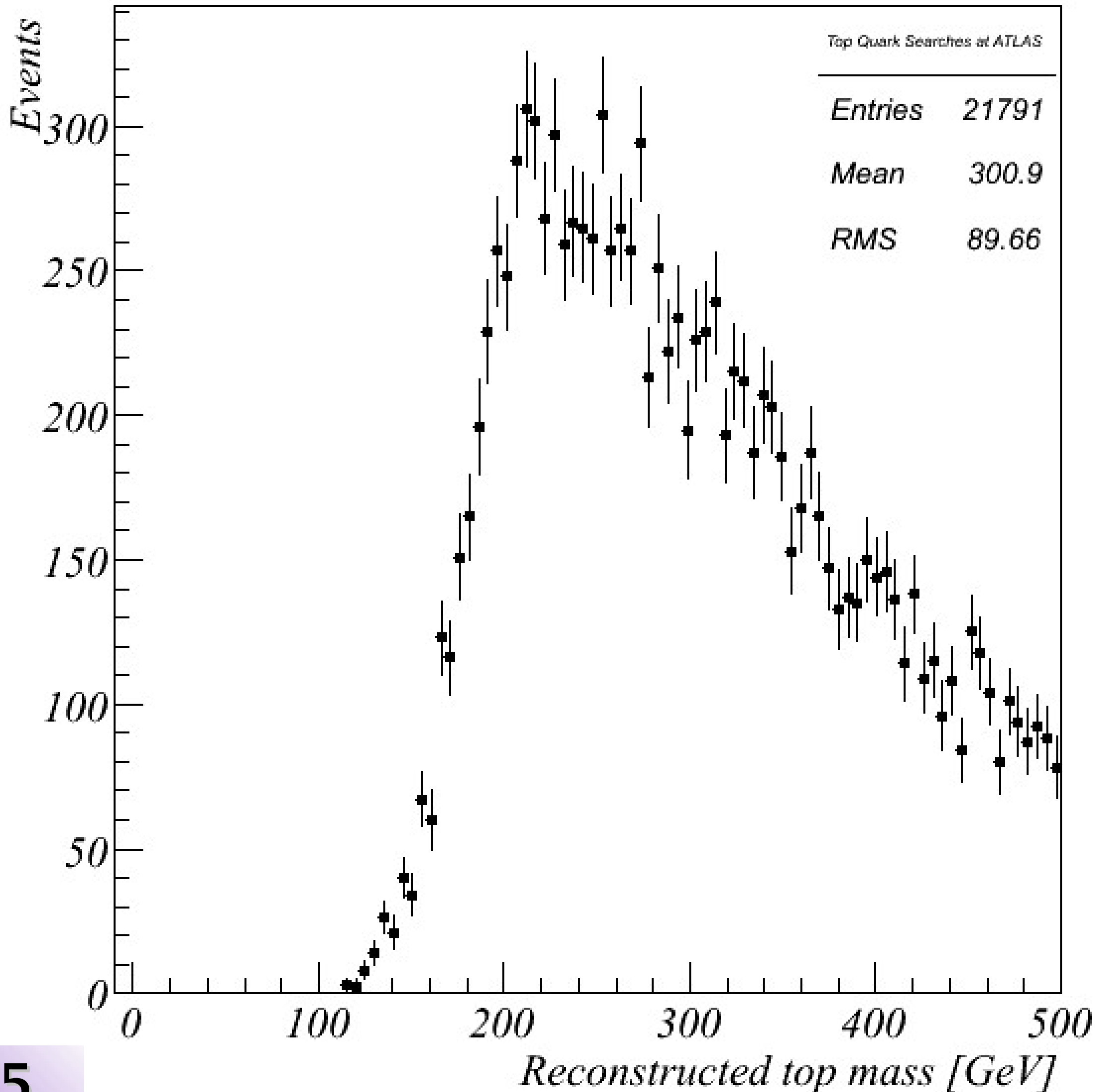
Reconstructed mass in "reasonable" agreement with the generated one:

MTop = 184.0 GeV

Top mass dependency on Jet- algorithm

On the other hand, with the K_T algorithm, ...

(using the default `KtTowerJet_jobOptions.py`**)**



KtTowerParticleJets

Jets are reconstructed using the K_T algorithm (see later)

We miss the top mass peak!

Moreover the distribution is shifted to higher mass values.

So what's wrong with the K_T ?

Features of the different Jet algorithms (simplified)

CONE ALGORITHMS

(see e.g. hep-ph/0005012)

Cone4TowerJet_jobOptions.py

-Initial seeds are objects with

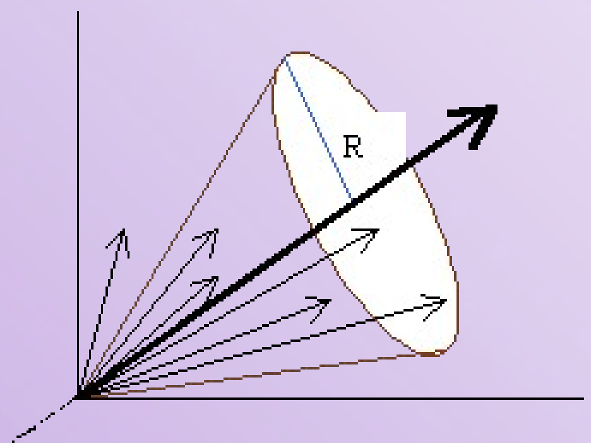
$E_T > 2$ GeV.

- Merge all the objects with

$\Delta R < 0.4$ or $\Delta R < 0.7$ w.r.t. the seed.

$$\Delta R^2 = \Delta\eta^2 + \Delta\phi^2$$

Iterate (+ split / merge) until a stable cone axis is found



K_T ALGORITHM (inclusive)

Ellis & Soper, PRD48, 3160, (1993)

KtTowerJet_jobOptions.py

Start from a set of objects:

$\{p_1, p_2, \ldots, p_i, p_j, \ldots, p_n\}$

For each object pair ij:

define d_i and d_{ij} in the ΔR scheme:

$$d_i = (p_{Ti})^2$$

$$d_{ij} = \mathrm{Min}((p_{Ti})^2, (p_{Tj})^2) * \Delta R^2 / D^2$$

if $d_{ij} < d_i$, merge objects i and j:

by several recombination schemes

(E, p_t, p_t^2, E_t or E_t^2).

For instance, the E scheme:

$$p_{ij} = p_i + p_j$$

if $d_i < d_{ij}$, object i is a jet

Analysis Framework

Our main concern is to know whether/how we can tune the inclusive K_T parameters. Namely:

- **which recombination scheme:** E, p_t, p_t^2**, etc...**
- **what scaling factor** D **values**

give the closest reconstructed top mass to the generated one?

The analysis framework at the generator level:

- **hard process event generation with** MCATNLO **program**

- **Output (**ASCII **file) is fed into the** ATHENA **machinery for Hadronization (**JIMMY/HERWIG**) and K_T based algorithm jet reconstruction .**

Analysis Framework

We considered the following phase space for the D parameter:

D **in** [0.1, 1.4] **with a step of** 0.1

We studied three different recombination schemes of the ΔR K_T scheme, namely:

E: $p_{ij} = p_i + p_j$

p_t: $p_{t\ ij} = p_{t\ i} + p_{t\ j}$

$\eta_{ij} = (\eta_i\, p_{t\ i} + \eta_j\, p_{t\ j}) / p_{t\ ij}$

$\phi_{ij} = (\phi_i\, p_{t\ i} + \phi_j\, p_{t\ j}) / p_{t\ ij}$

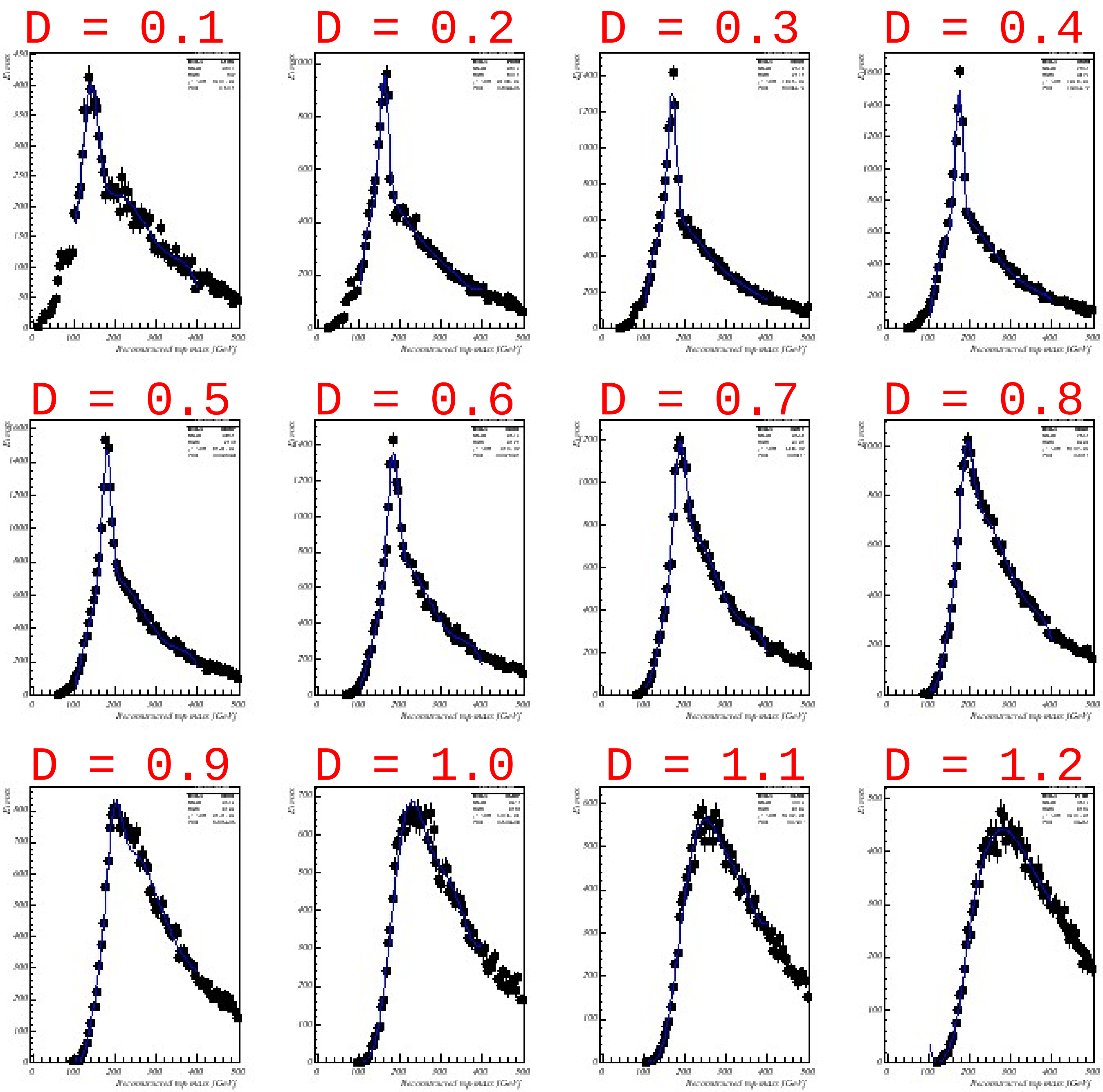
p_t^2: $p_{t\ ij} = p_{t\ i} + p_{t\ j}$

$\eta_{ij} = (\eta_i\, p_{t\ i}^2 + \eta_j\, p_{t\ j}^2) / (p_{t\ i}^2 + p_{t\ j}^2)$

$\phi_{ij} = (\phi_i\, p_{t\ i}^2 + \phi_j\, p_{t\ j}^2) / (p_{t\ i}^2 + p_{t\ j}^2)$

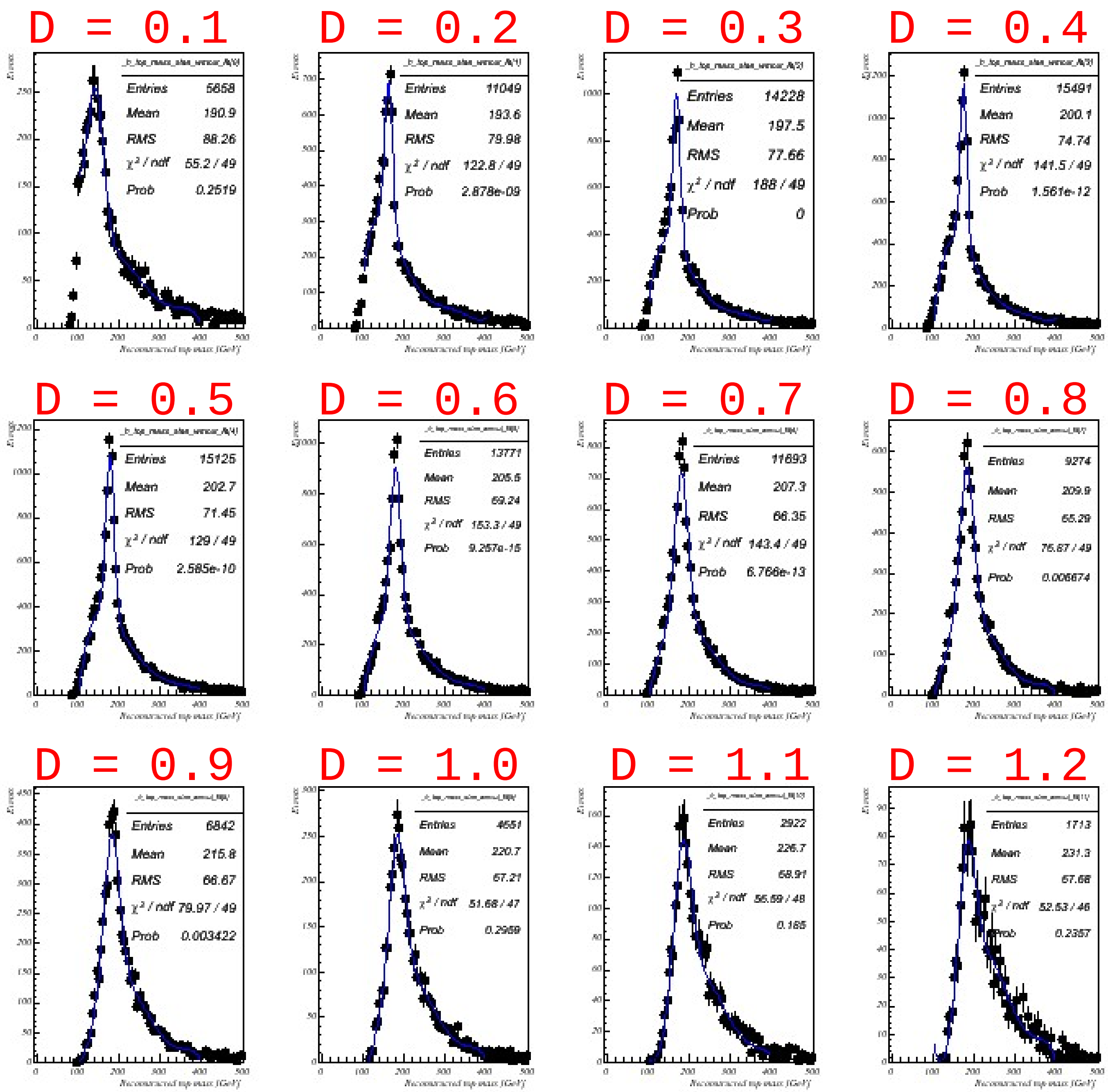
Which D gives the closest reconstructed top mass to the generated one (175 GeV) ?

Top mass reconstruction: E scheme



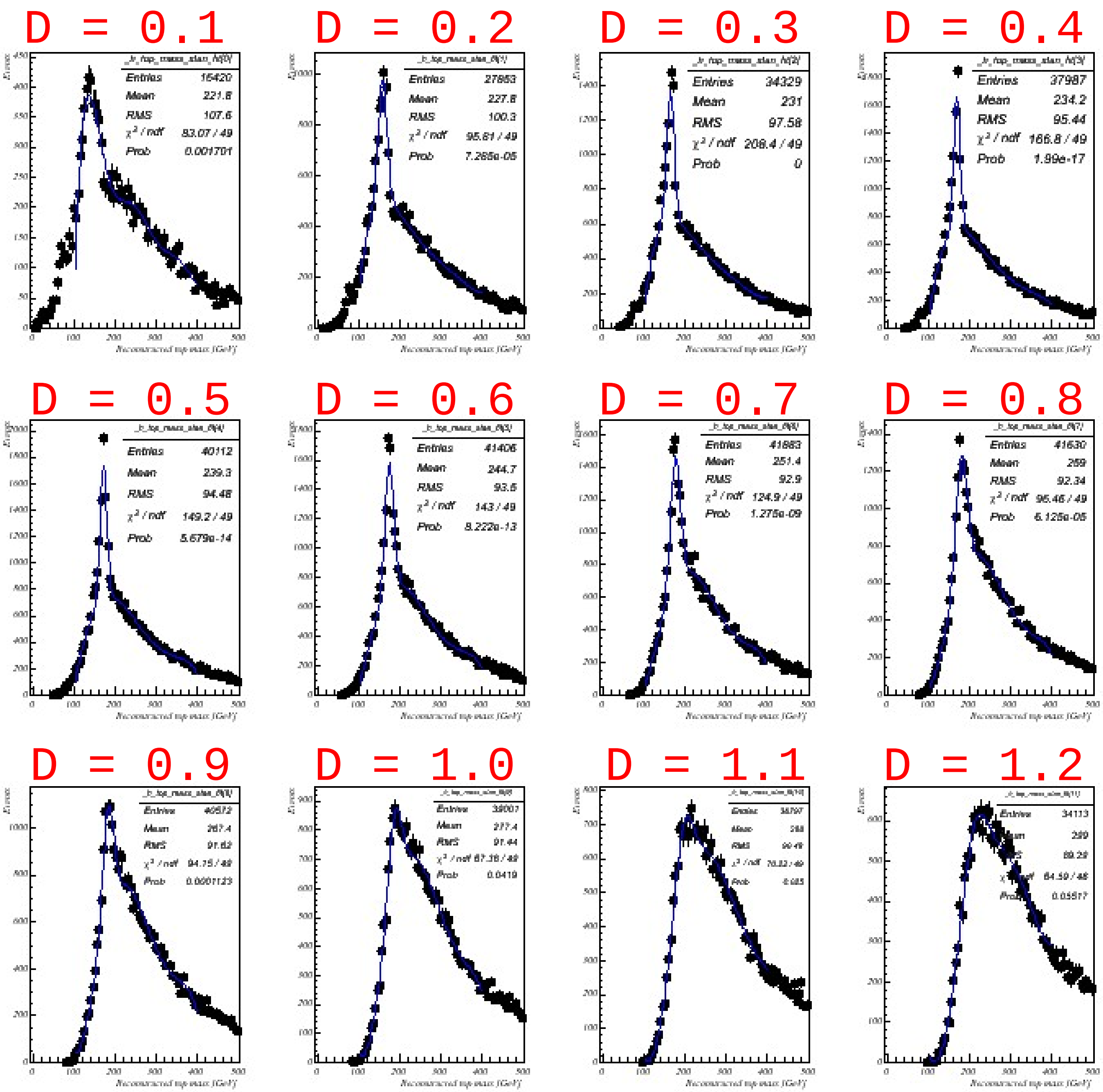
three jets of the four which maximize the total Pt

Top mass reconstruction: E scheme



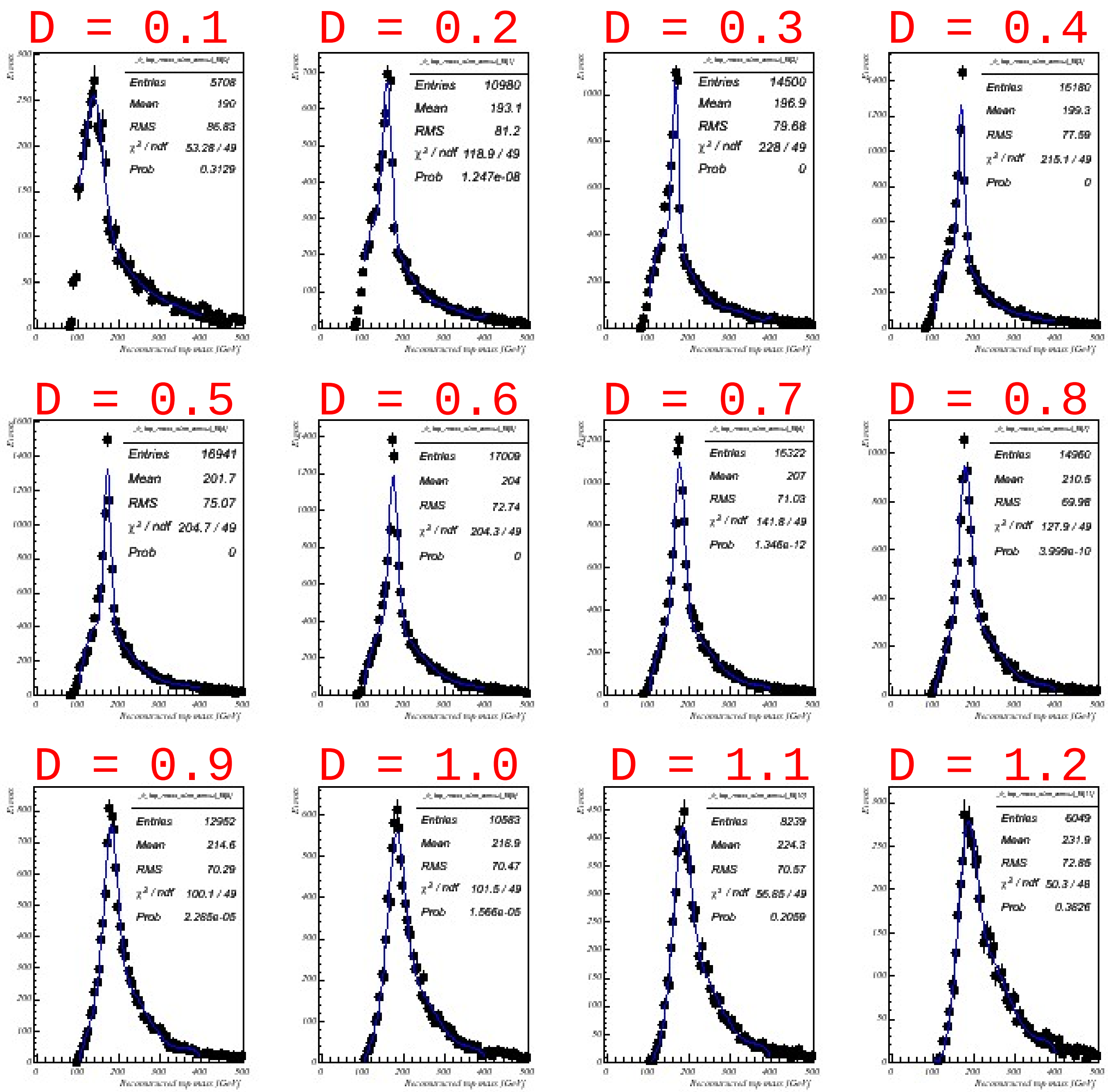
Adding the W mass constraint

Top mass reconstruction: P_t scheme



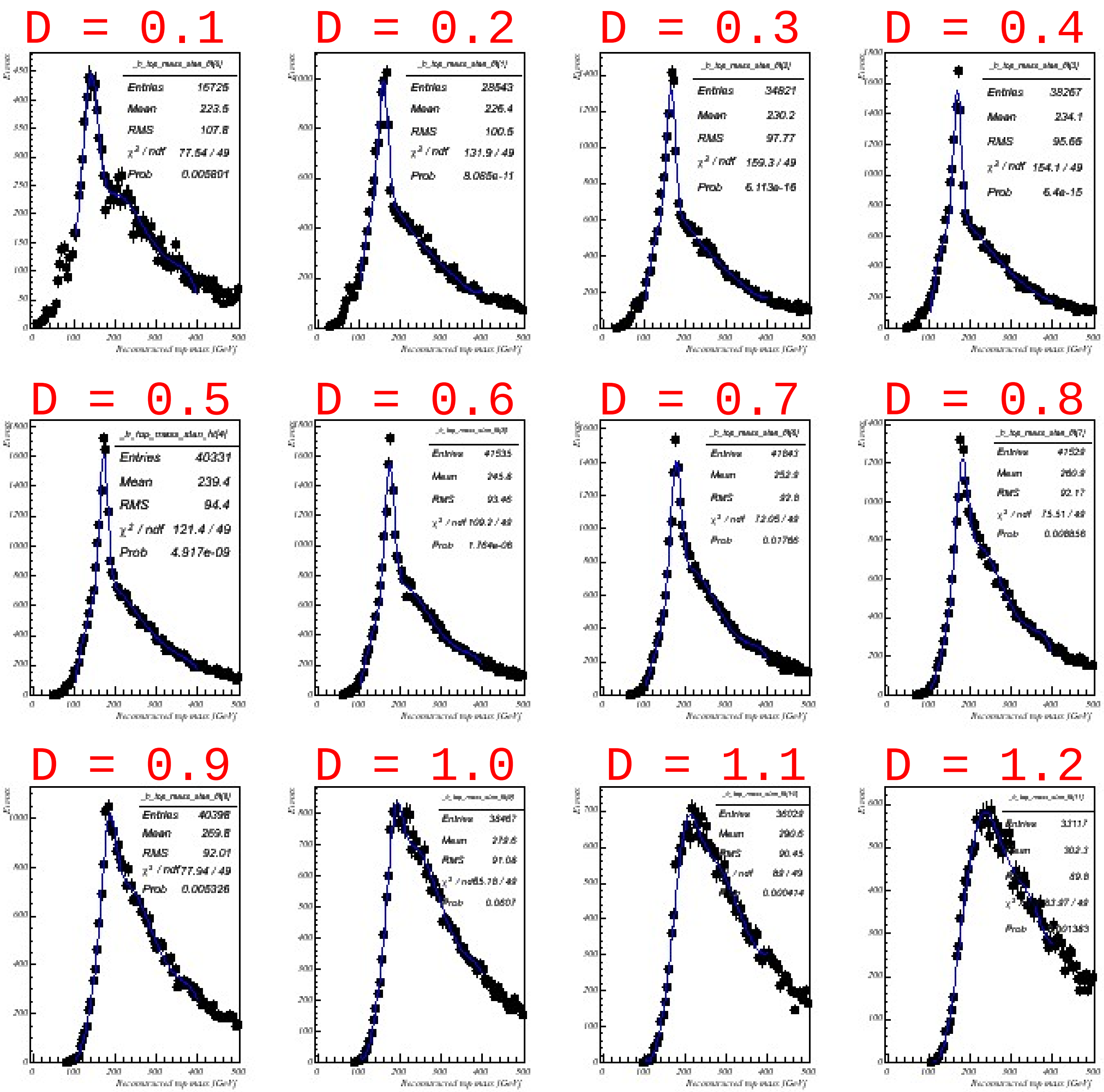
three jets of the four which maximize the total Pt

Top mass reconstruction: P_t scheme



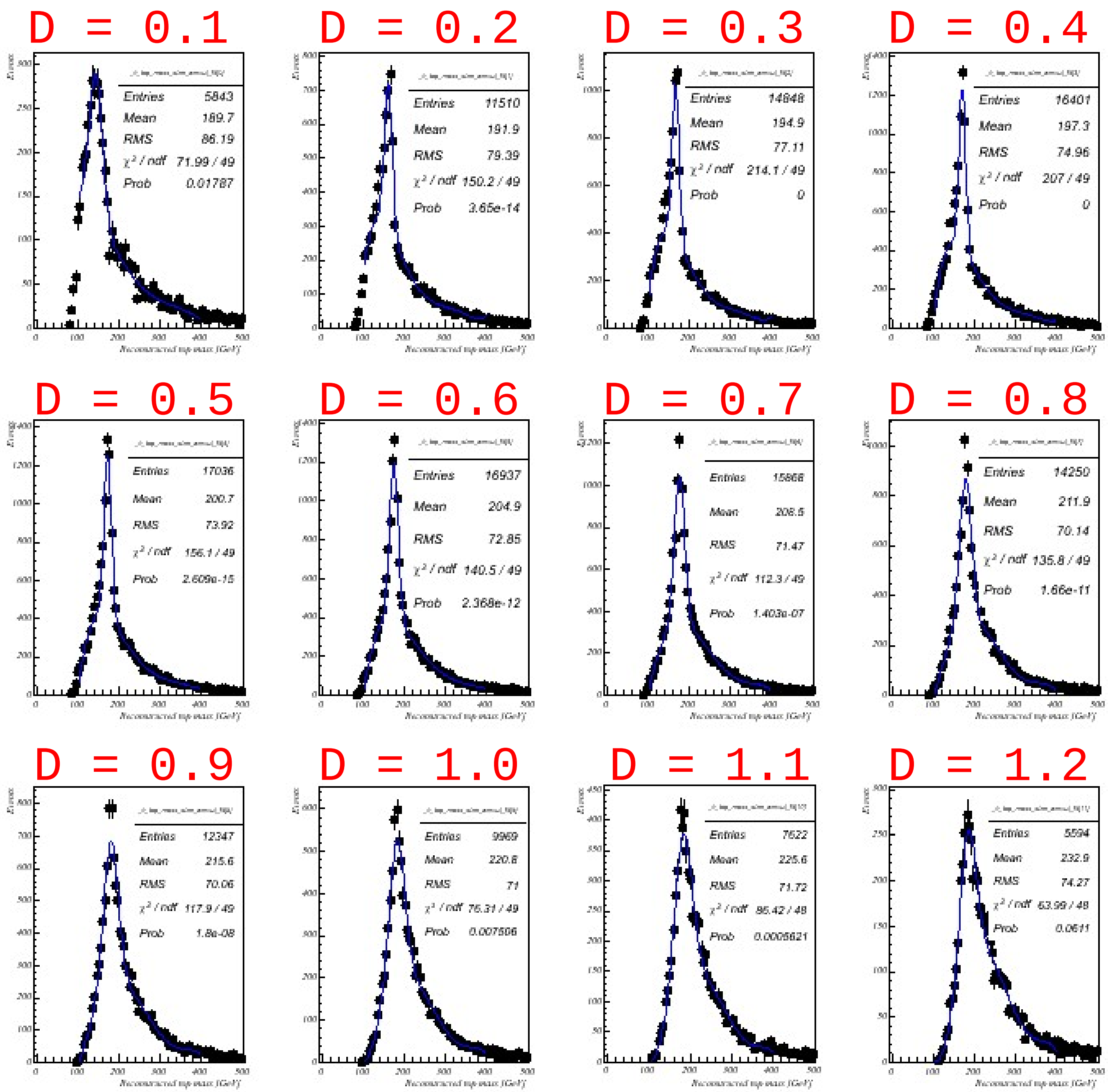
Adding the W mass constraint

Top mass reconstruction: $P_t{}^2$ scheme



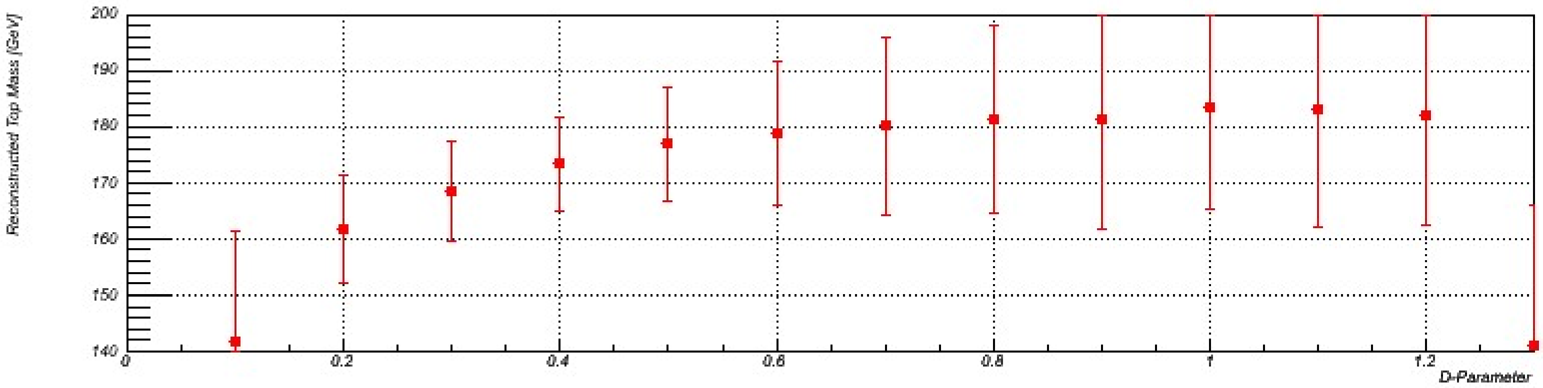
three jets of the four which maximize the total Pt

Top mass reconstruction: $P_t^{\,2}$ scheme

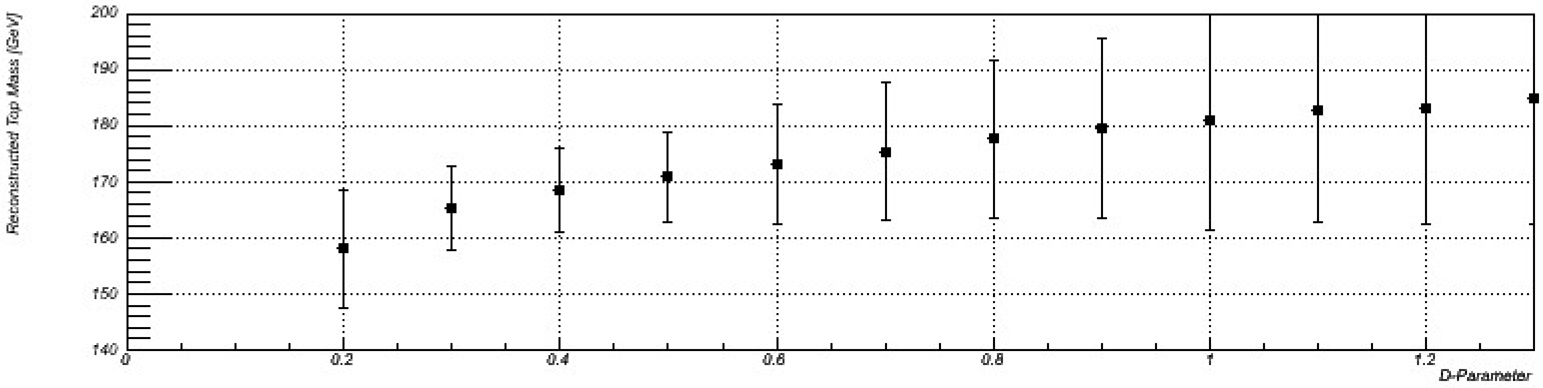


Adding the W mass constraint

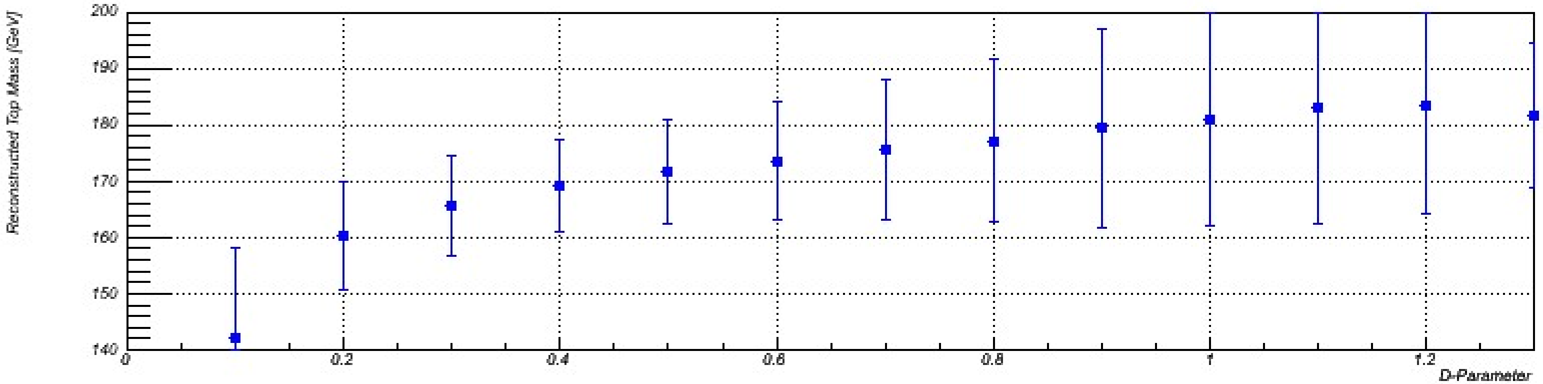
Top mass reconstruction:



E- scheme

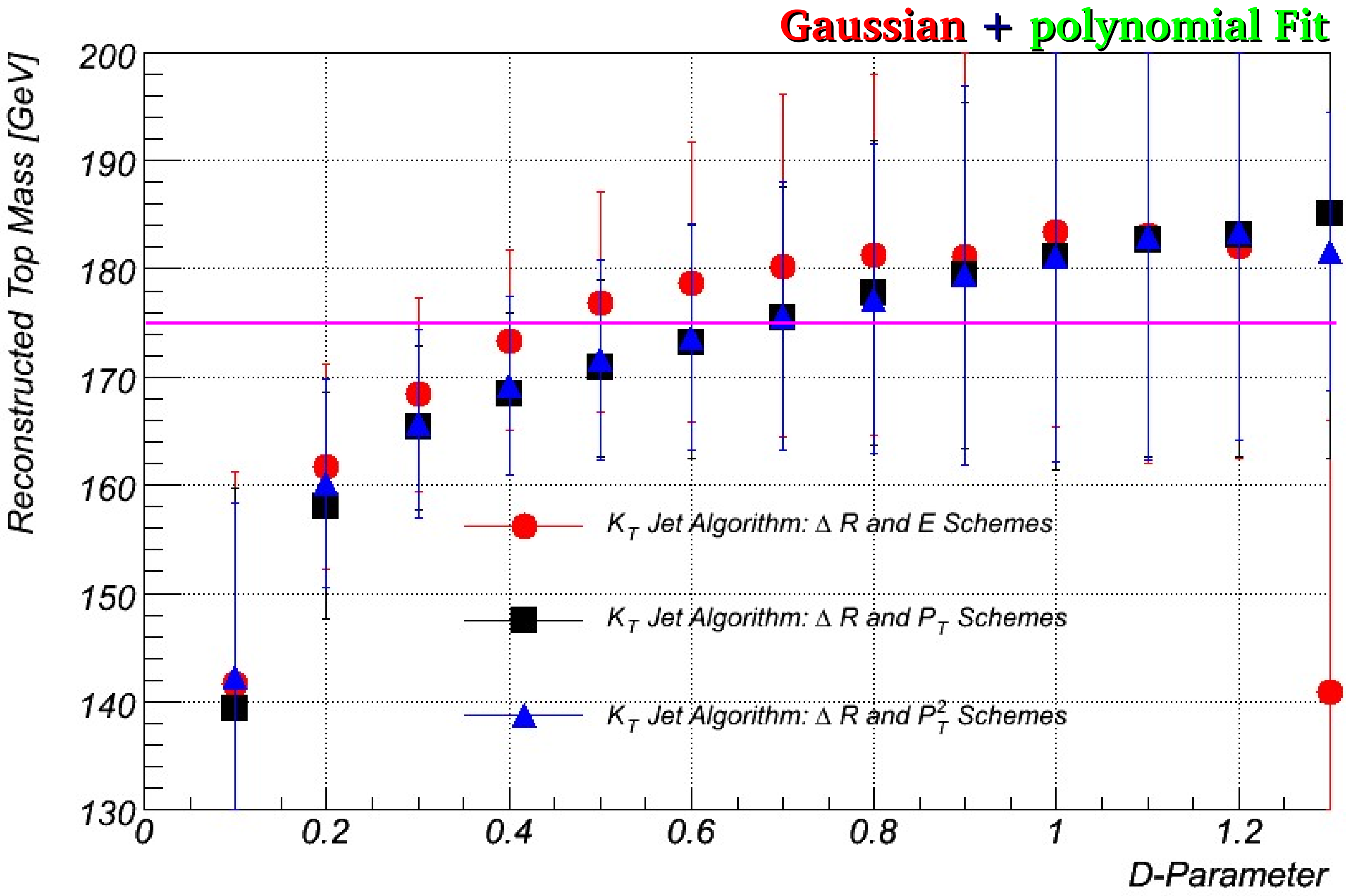


P_t- scheme



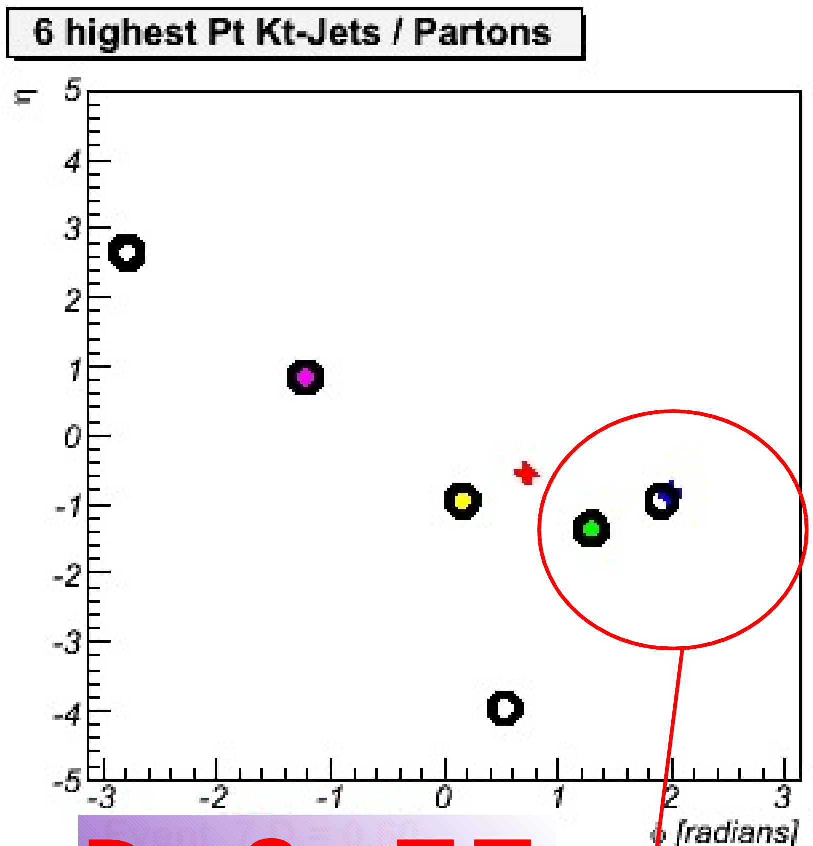
P_t^2 - scheme

Top mass reconstruction:

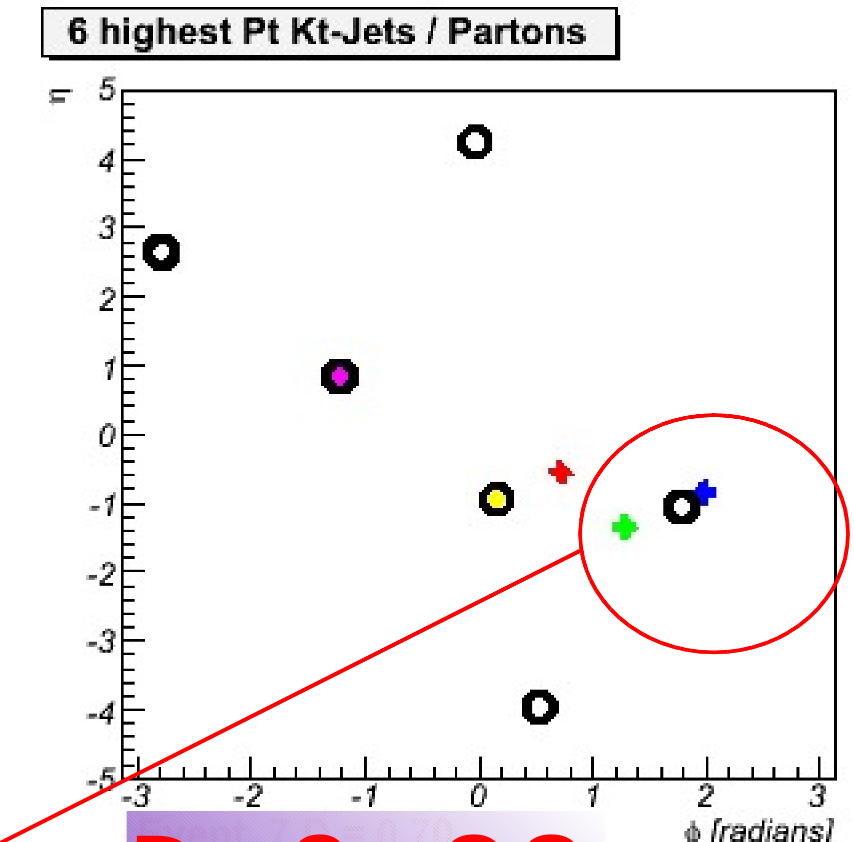


- The reconstructed top mass depends on the K_T algorithm,
- Higher values for D correspond to a higher reconstructed mass,
- The P_T scheme seems to be better than the E scheme

A typical ttbar event showing the hadronic W issue



D~0.77



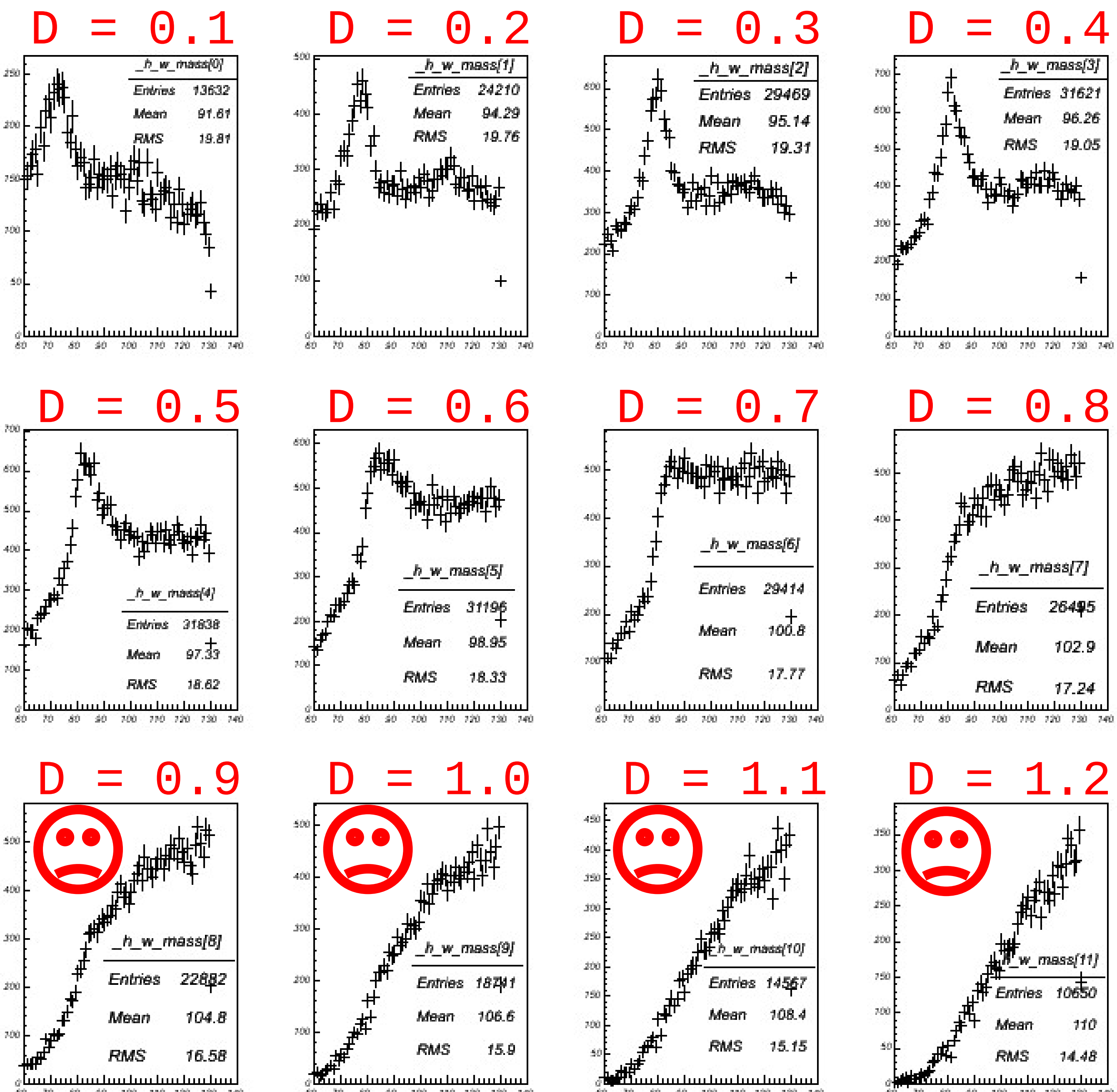
D~0.83

A typical scenario...

there is a non-negligible chance that K_T merges the two jets from the W into one single jet object !

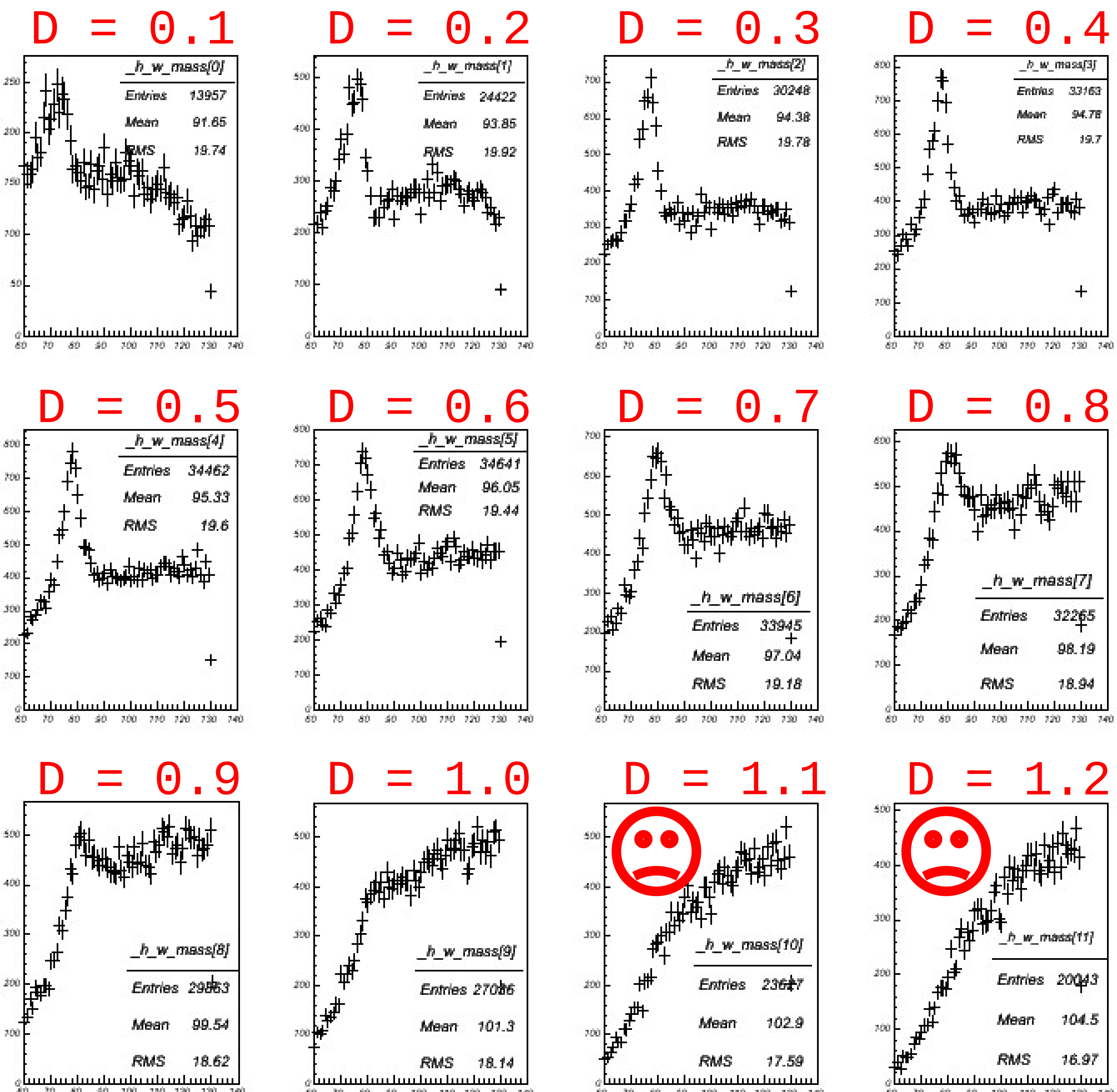
The W-mass peak reconstruction is a clear Figure Of Merit for the Kt-Algorithm

W mass reconstruction: E scheme



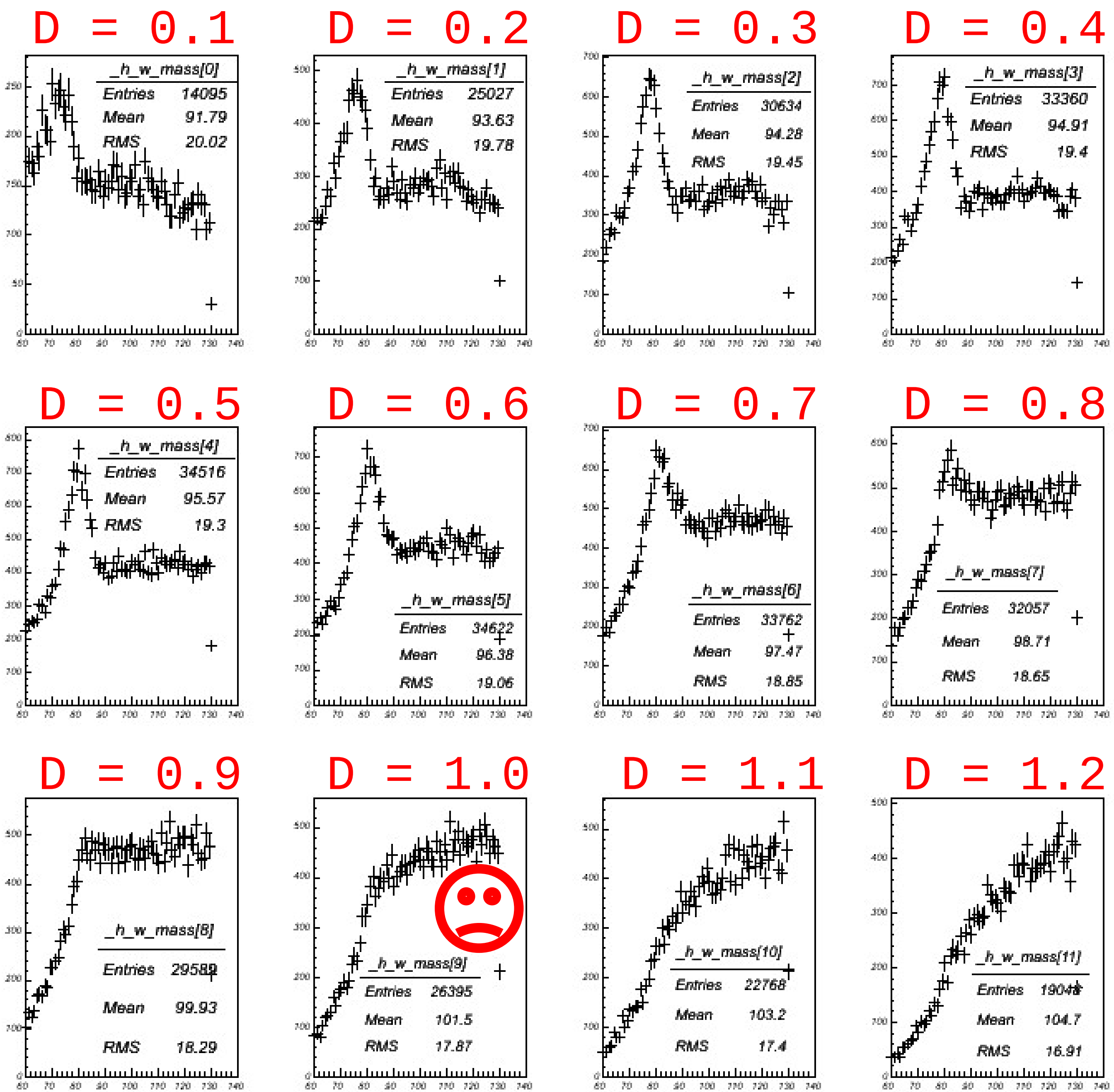
Increasing D, the reconstructed W shifts to larger mass values, but D should not be too large...

W mass reconstruction: Pt scheme



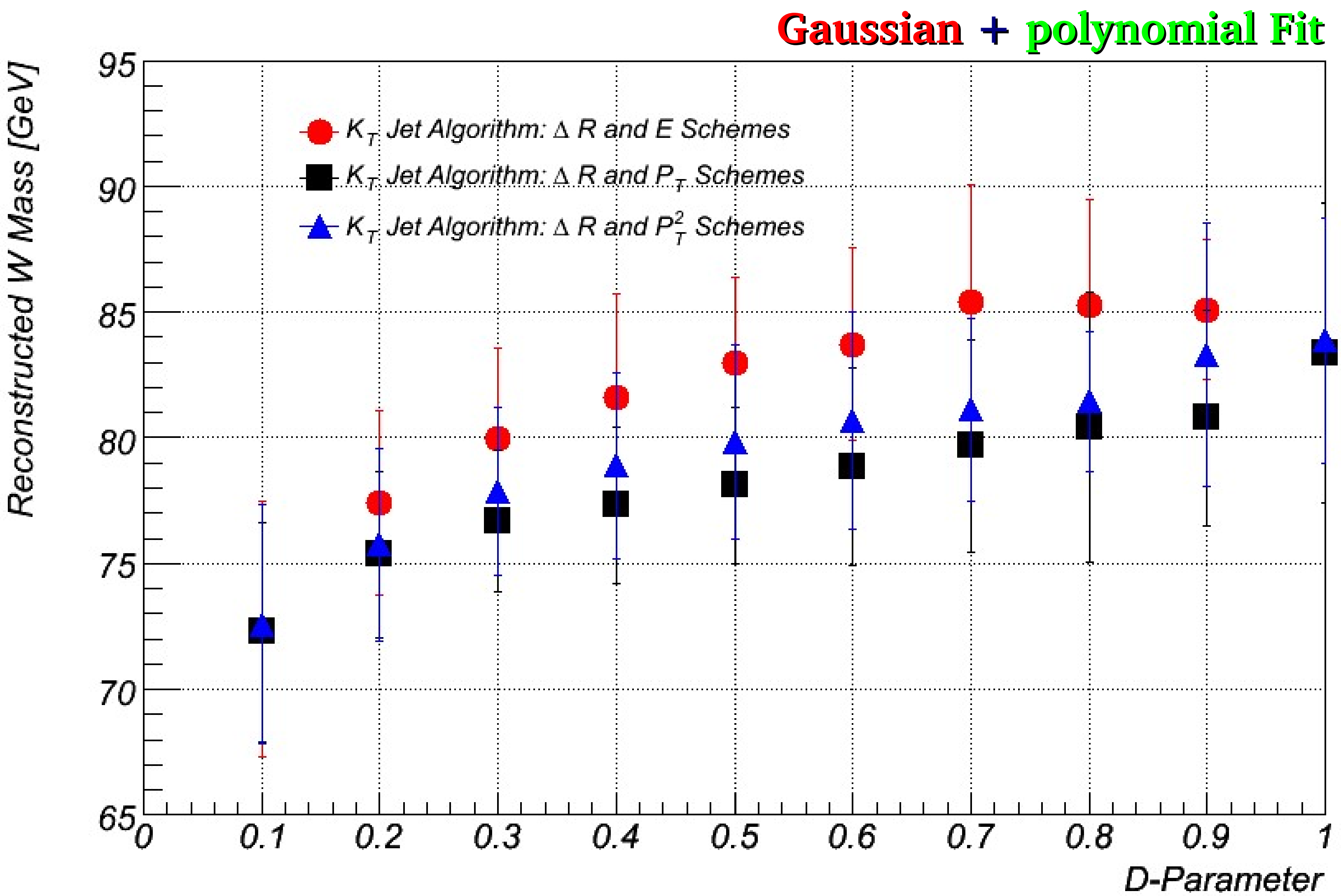
The Pt scheme seems to be a better choice than the E recombination scheme for the W-mass, but still D

W mass reconstruction: $P_t^{\ 2}$ scheme



The Pt² scheme seems to be a bit worse than Pt

W mass reconstruction:



For the P_t recombination scheme, the reconstructed W-mass is within ±7 % of the truth W-mass for D-parameter ∈ [0.2 – 0.9]

Conclusions and OutLooK

Based on a <u>generator level</u> (MCATNLO/JIMMY/HERWIG) study (no detector simulation), we have shown that:

- the D-parameter is a crucial parameter in the case of an inclusive jet reconstruction, using the Kt algorithm

- two domains for the D-parameter:
- **- too low values, we split the jets**
- **- too 'large values', we merge the two jets of the W, and miss the W mass.**

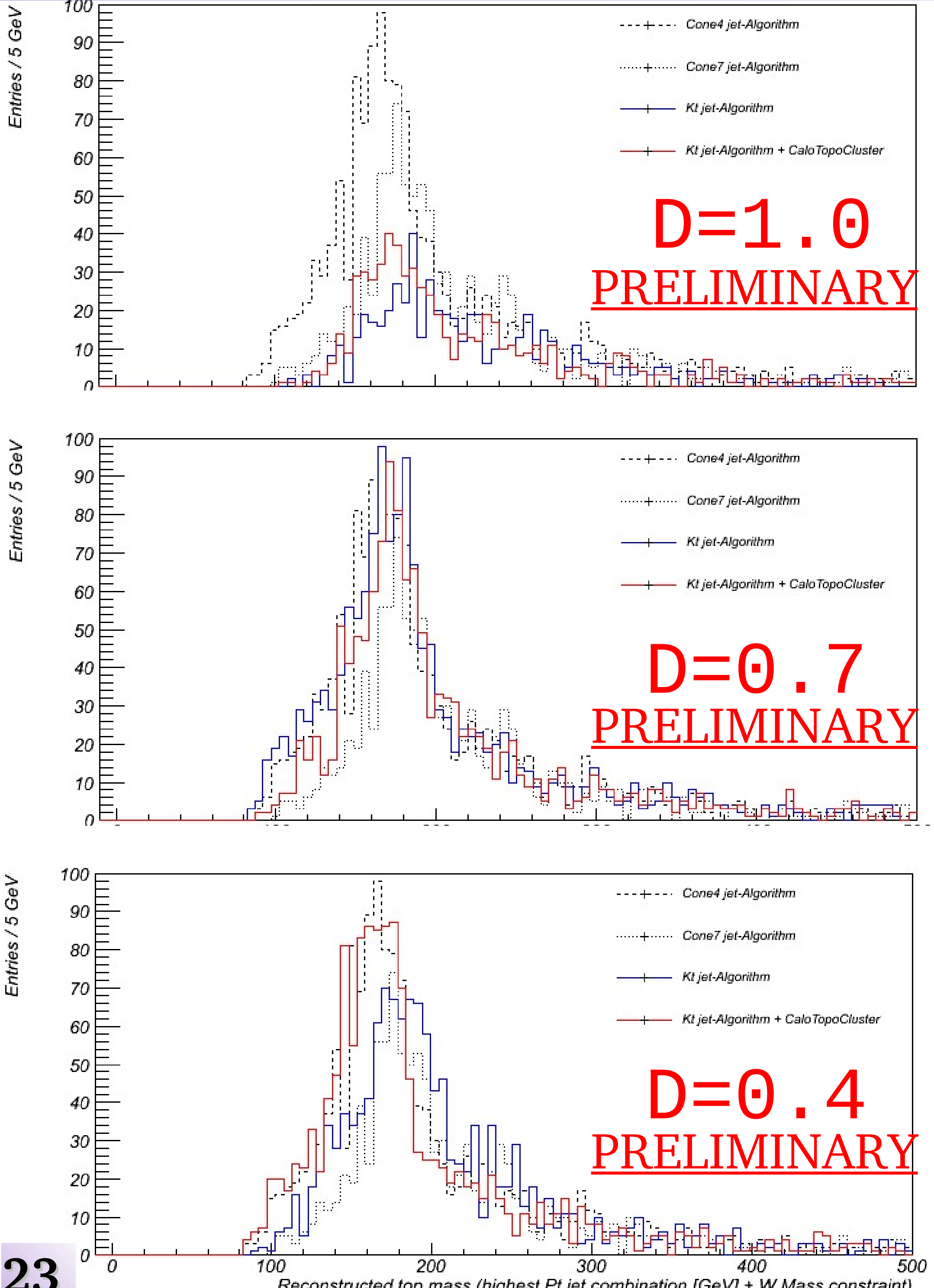
- the default settings of the K_T algorithm for jet reconstruction (using the inclusive approach, and ΔR scheme) is not the appropriate one to extract a good top mass, our goal.

- We came to the result that there are more "optimal" settings for the K_T algorithm (inclusive case!), namely:

recombination scheme: P_t

D **0.4 – 0.6 is a reasonnable choice.**

Conclusions and OutLook



T1 4100 sample-

All statistics has been processed:

ESDs with ATHENA-11.0.42 **are available on CASTOR).**

AODs with different Kt-D parameter values available.

But, still need to finalize analysis with all the T1 statistics…

+

make sure of everything <u>consistent…</u>