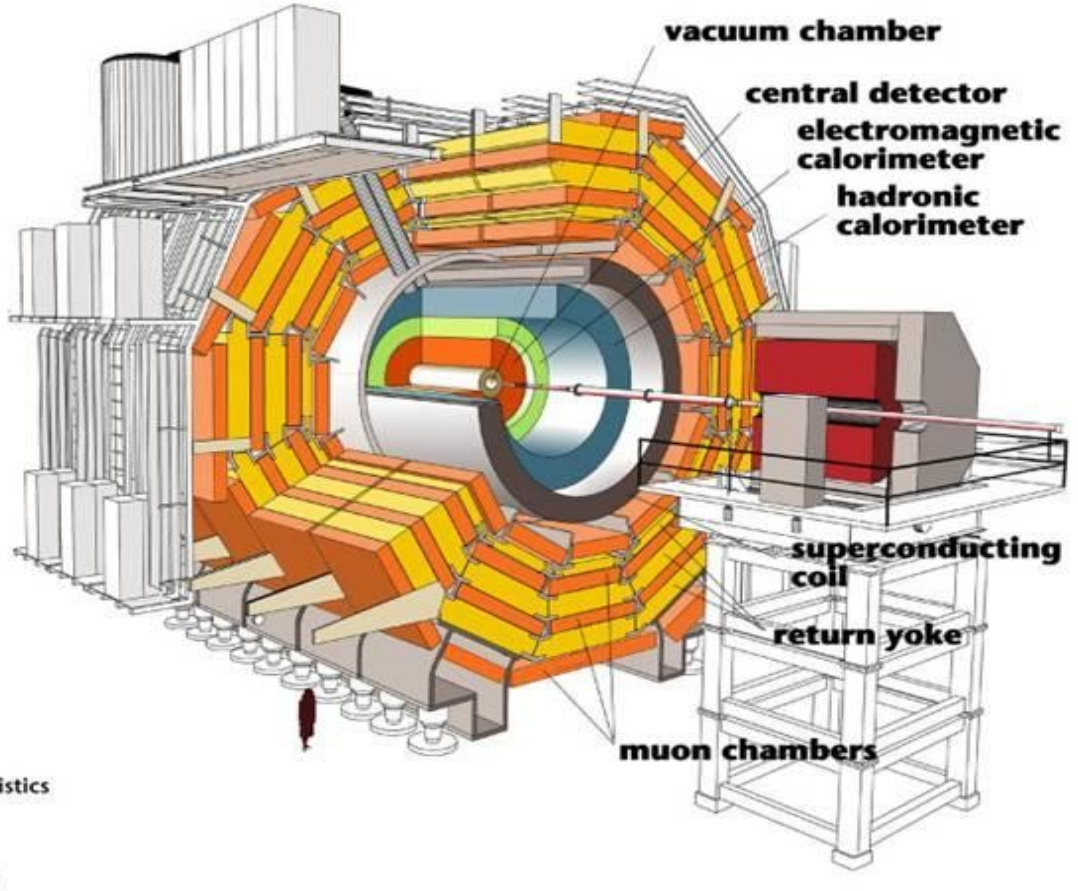
Top Project 2009 Outline

- Work with the Top Quark group of the Hamburg University co. CMS at CERN
- The CMS detector @ LHC
- What is the Top? & Why Top?
- Production & decay of the Top
- Study of the kinematic variables for differential X section
- Estimating the detector effects
- Fighting the bias of the reconstruction

The Compact Muon Solenoid detector



- 4π detector ; PbWO4 scintillating E.cal. & full silicon Tracker
- H.cal. in the superconducting solenoid, hence the compactness
- 4 Tesla magnetic field in solenoid and 2 T in the Yoke -> detection of energetic muons

Why Top?

Discovered 1994, the heaviest quark of SM 17 events observed & 10^3 until now

Within the SM

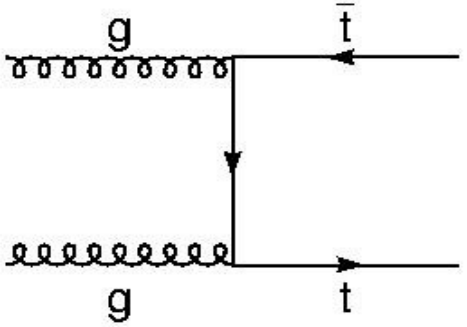
- Mass: (171.2±2.1) GeV/c^2
- Charge probably: 2/3
- lifetime: 5*10^{-25}s is 20 times shorter than hadronisation scale
- Study of a “bare” quark
- CKM Matrix elements

Beyond the SM

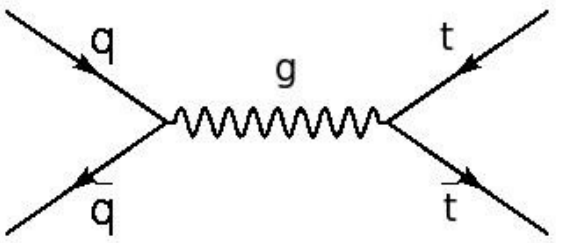
- KK- Theory -> excited bosons decay favoured into tops
- Higgs couples to mass in all models -> top loop and H production
- SUSY & MSUGRA scenarios with decays into tops

Top Production

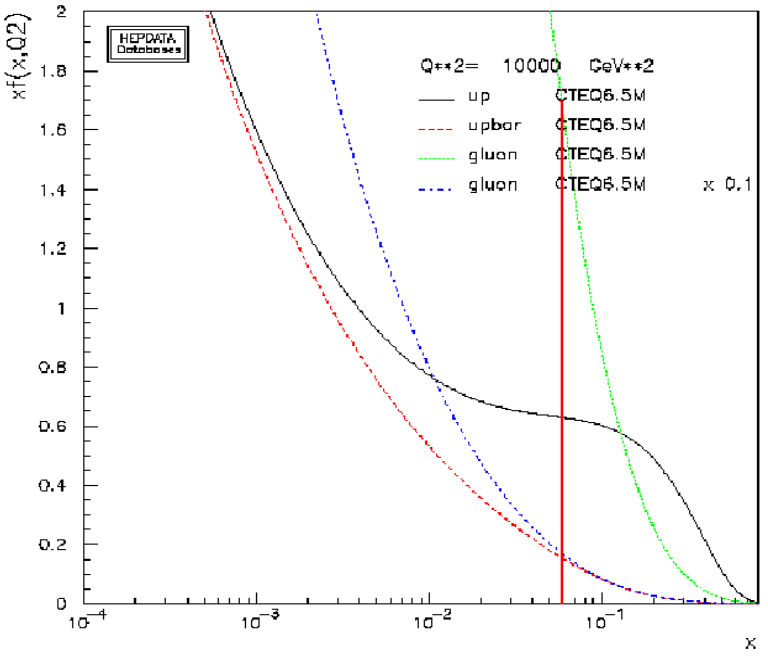
- Gluon gluon



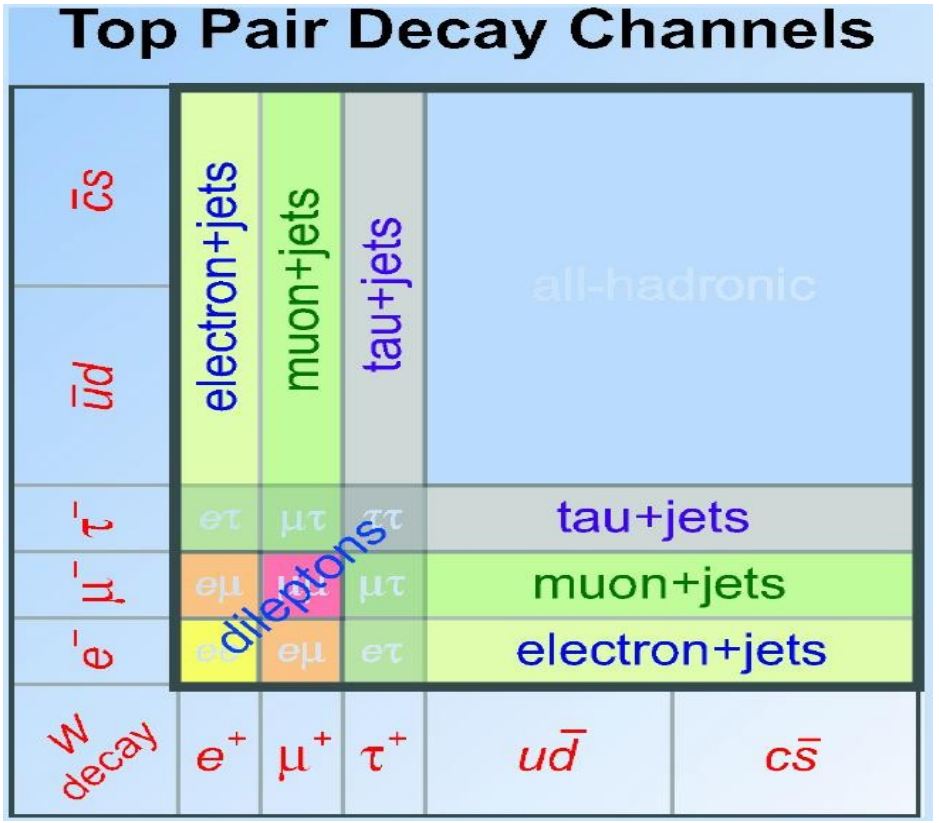
- Quark antiquark

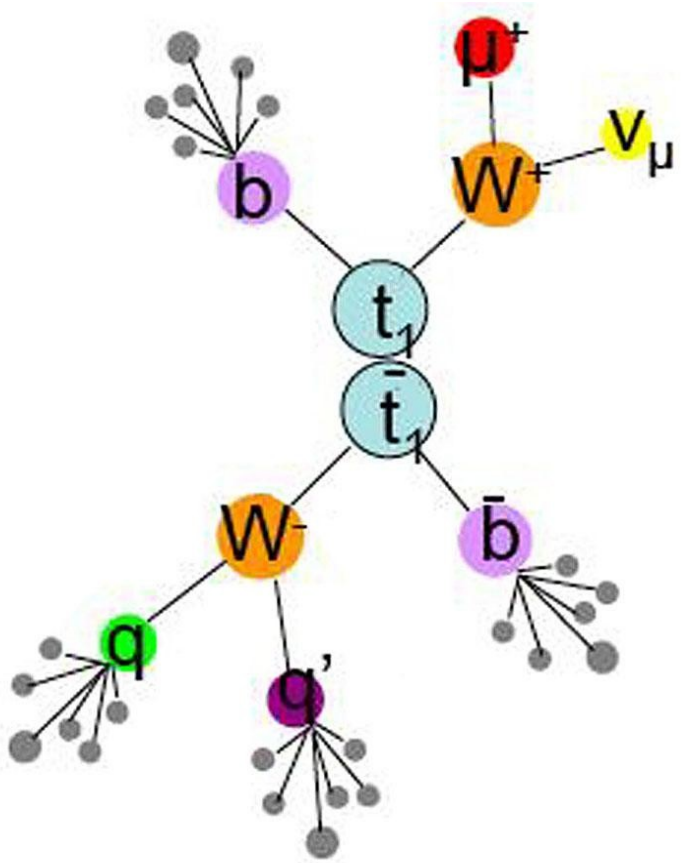


- Less than x=1/20 sufficient for t t-bar production
- Gluon fusion dominates @ LHC



Top Decay





- Decay into b and W
- W decay: hadronic or leptonic

- The “Golden channel”
- 4 Jets & Isolated muon & 2 b-Jets

The Cycle

Generated by MC

Detector Simulation

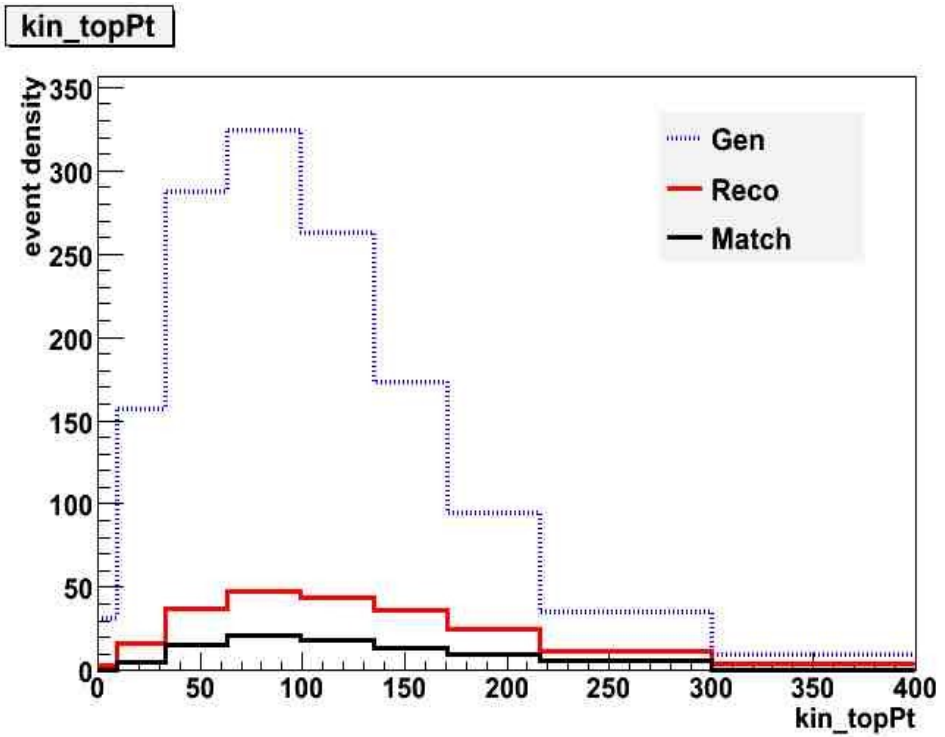
Re-construction

Filter

Rec. Selected

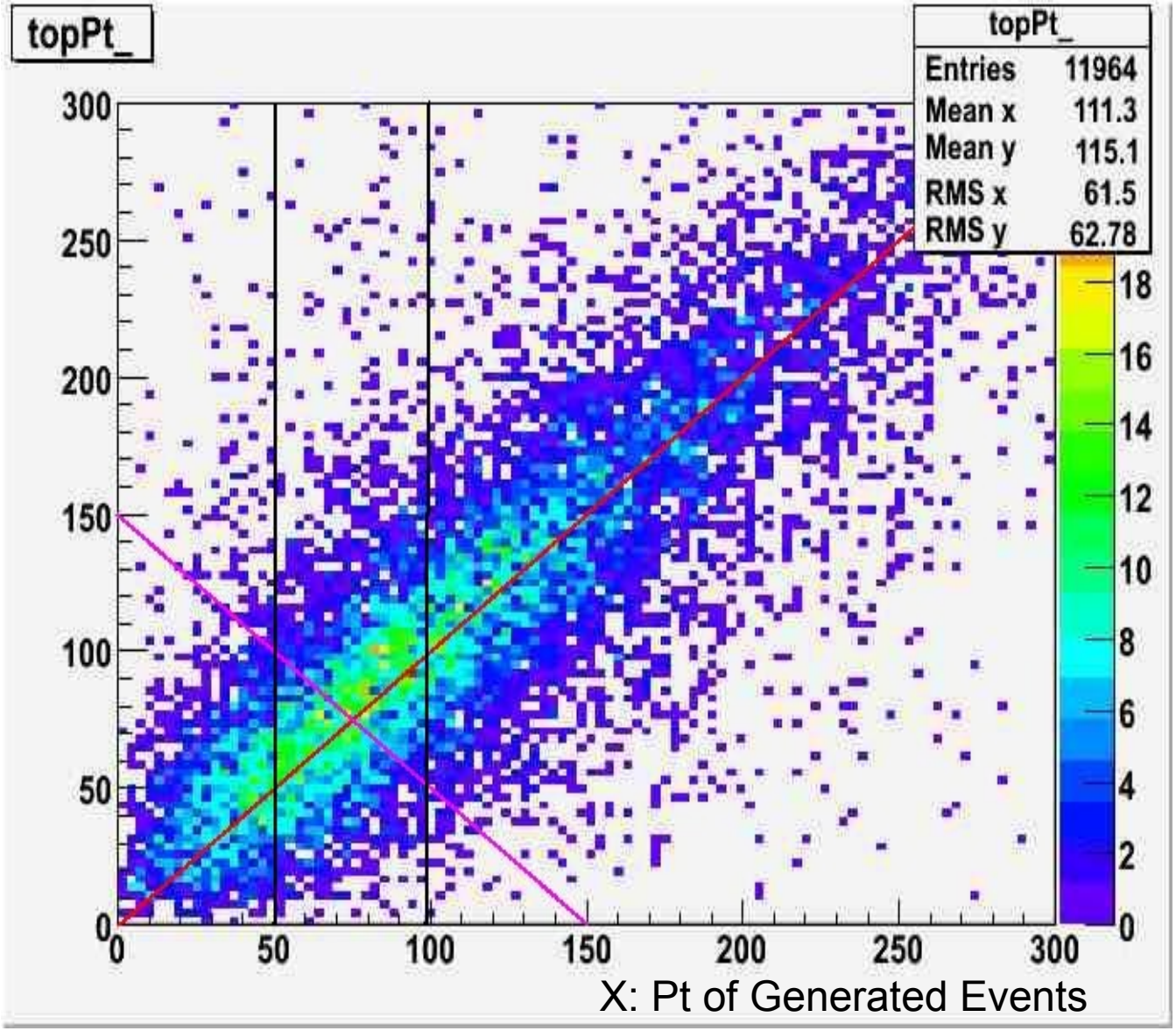
Matching

Efficiency = $\frac{\text{Rec Selected}}{\text{Gen Events}}$

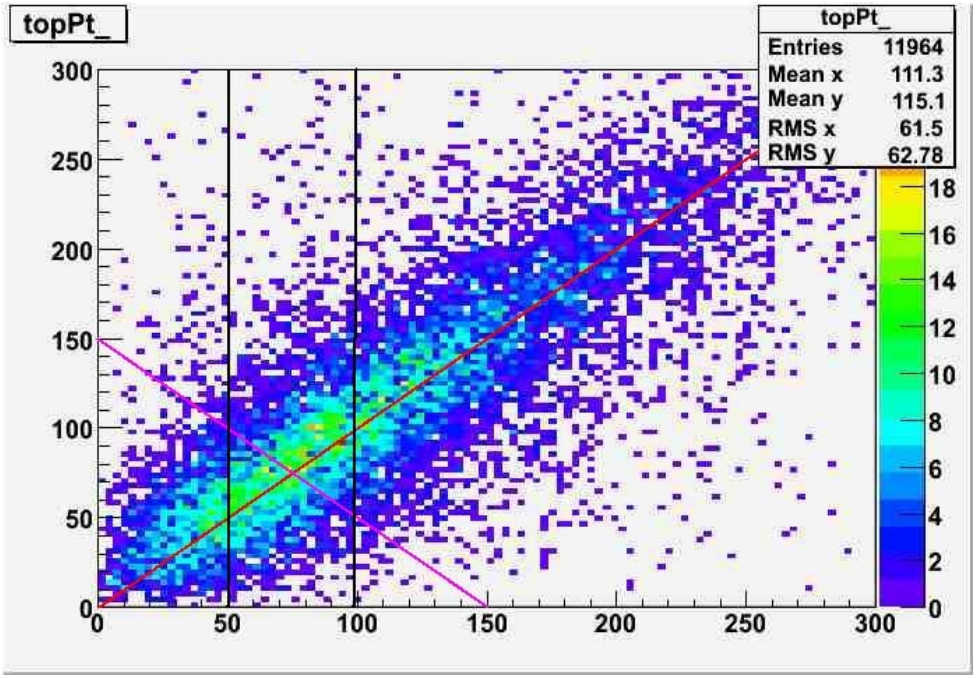


Example of Correlation plot & Projection

Y: Pt of Re-constructed Events

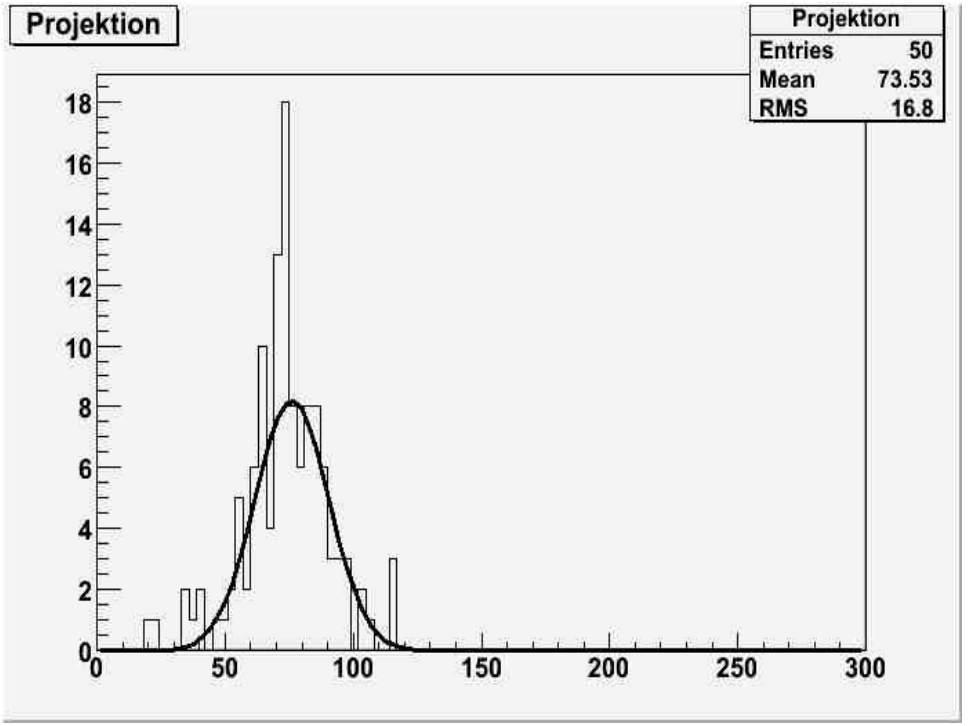


Example of Correlation plot & Projection



Condition

$$\delta x = \frac{2\sigma}{\sqrt{2}} = \sqrt{2}\,\sigma$$

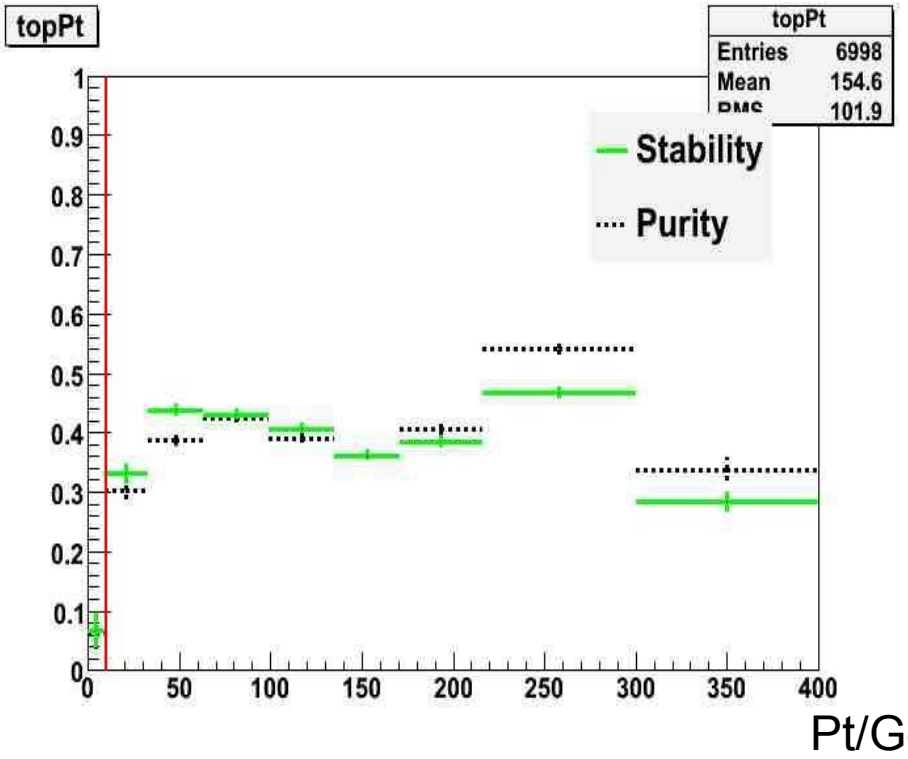


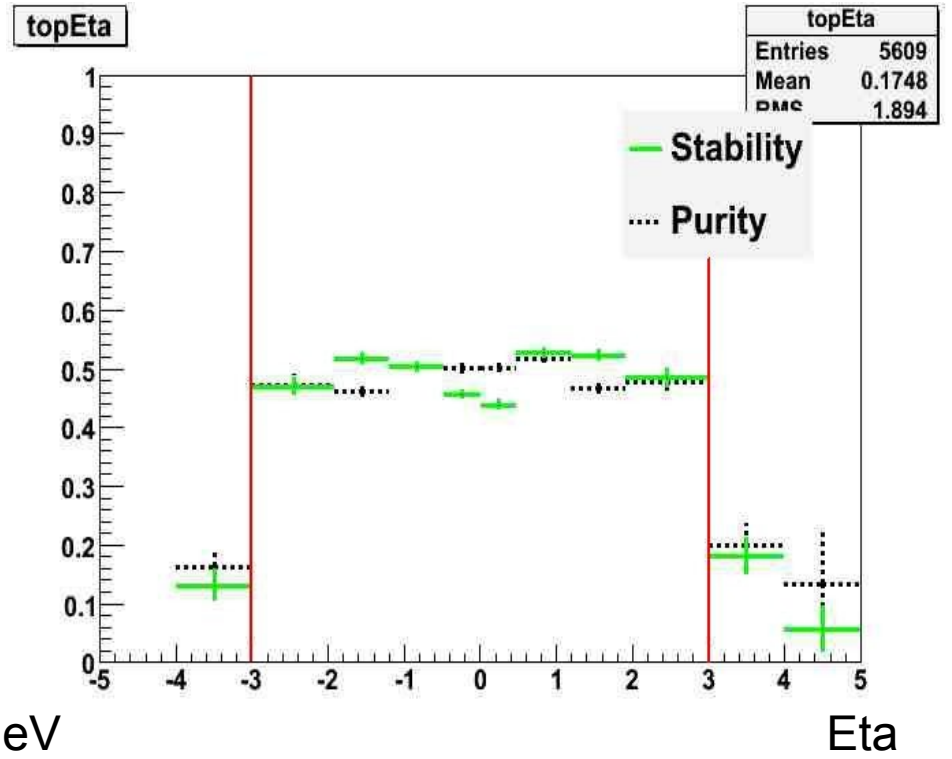
Example: Top Pt

Sqrt (2) * σ / GeV	Bin size / GeV	Bin setting / GeV
-	*10*	*0-10*
18,6	**25**	**10 – 35**
24,6	**30**	**35 – 65**
17,9	**35**	**65 – 100**
26,5	**35**	**100 – 135**
43,8	**35**	**135-170**
60,3	**45**	**170-215**
not significant	*85*	*215-300*

All bins fulfil the requirement , stability & purity are expected to be around 50%

Top kinematic variables

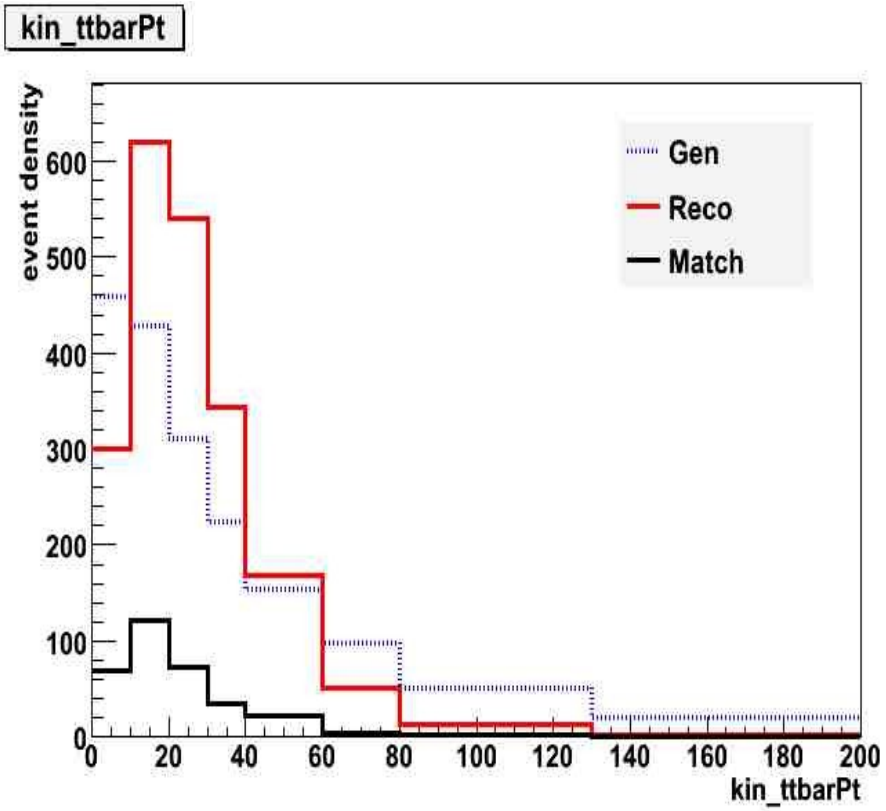


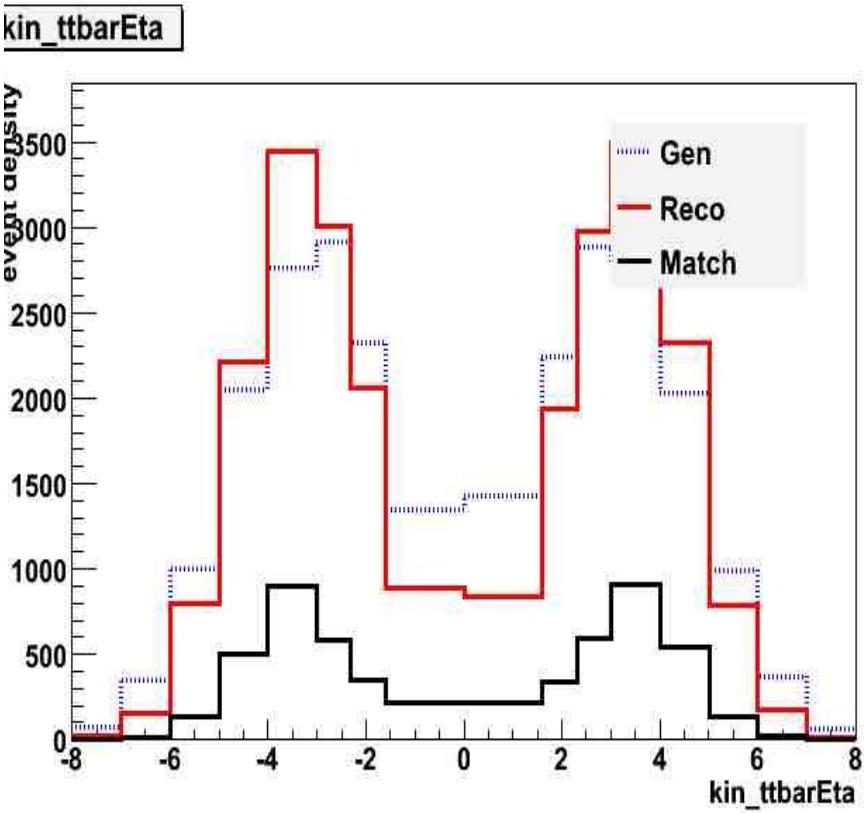


- Low stability of the first bin gives a second reason to discard it

- In the visible range high Purity & Stability
- Bin to bin corrections allowed
- -> Diff. X sections

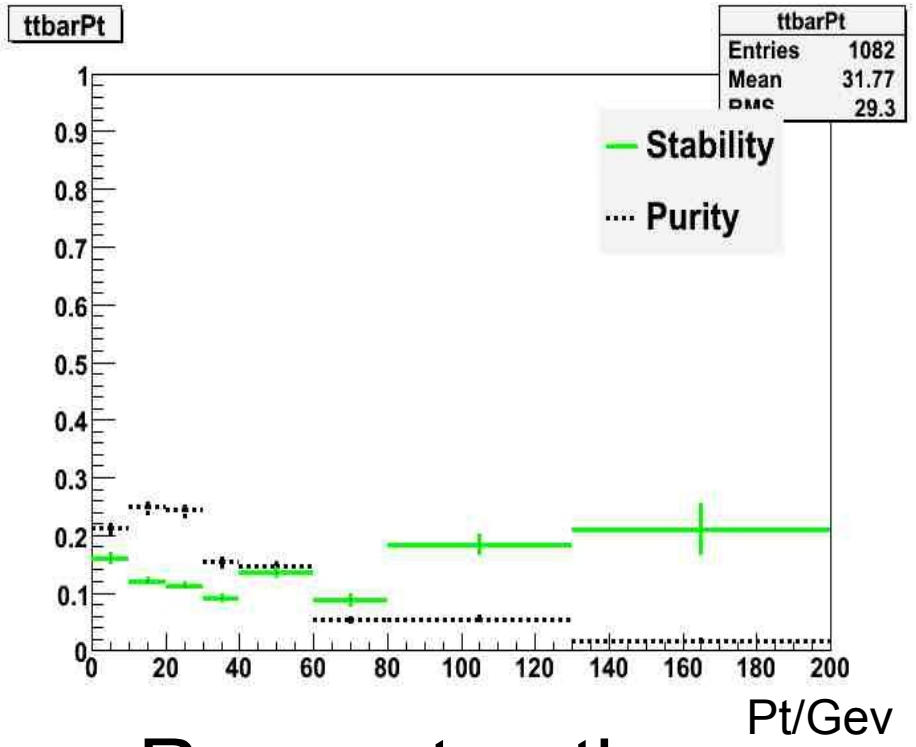
T T-bar kinematic variables



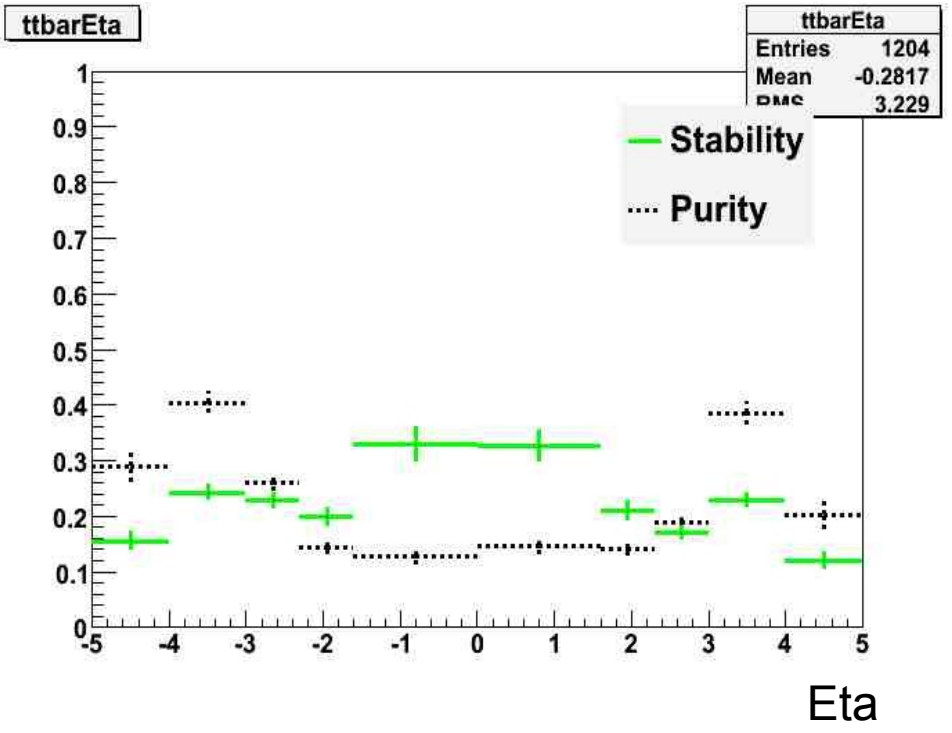


- Interesting the t t-bar Eta boost
- 1 Unit Eta <-> difference of one order of magnitude in parton (gluon) momentum

T T-bar kinematic variables



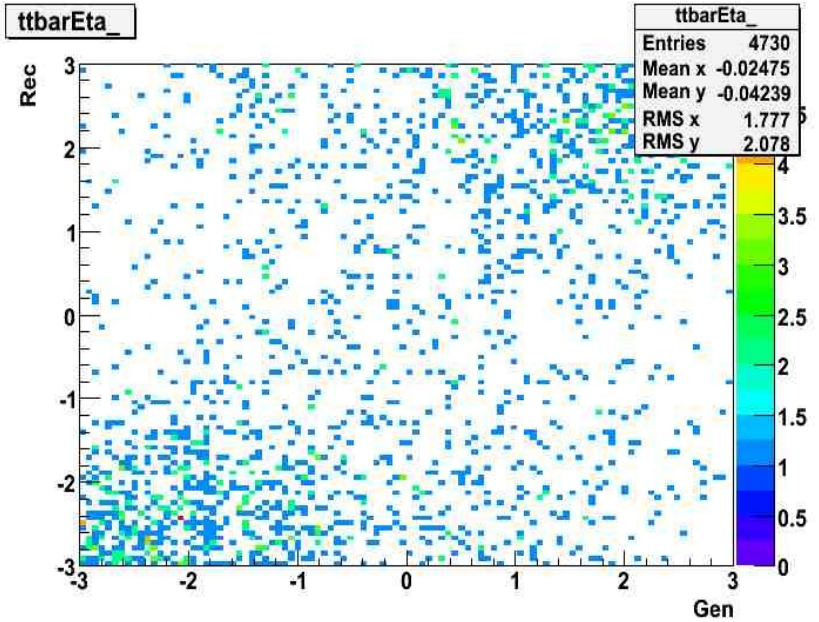
- Reconstruction problems
- migration to lower Pt values

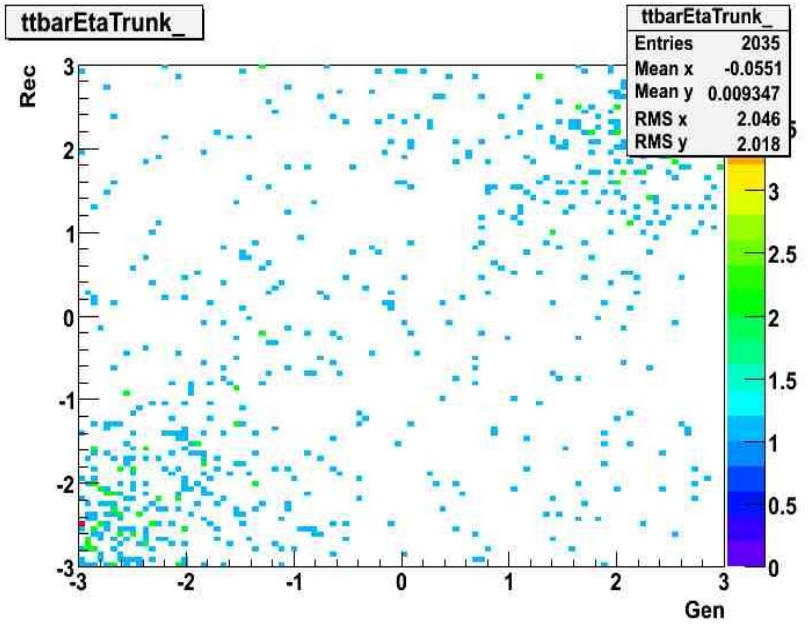


- Obvious biasing migration

Correlation improvement

Pt range / GeV	Correlation Factor
full range	0,55
0 – 10	0,48
10 – 20	0,60
20 – 40	0,60
40 – 60	0,78
60 – 80	0,52
> 80	0,50



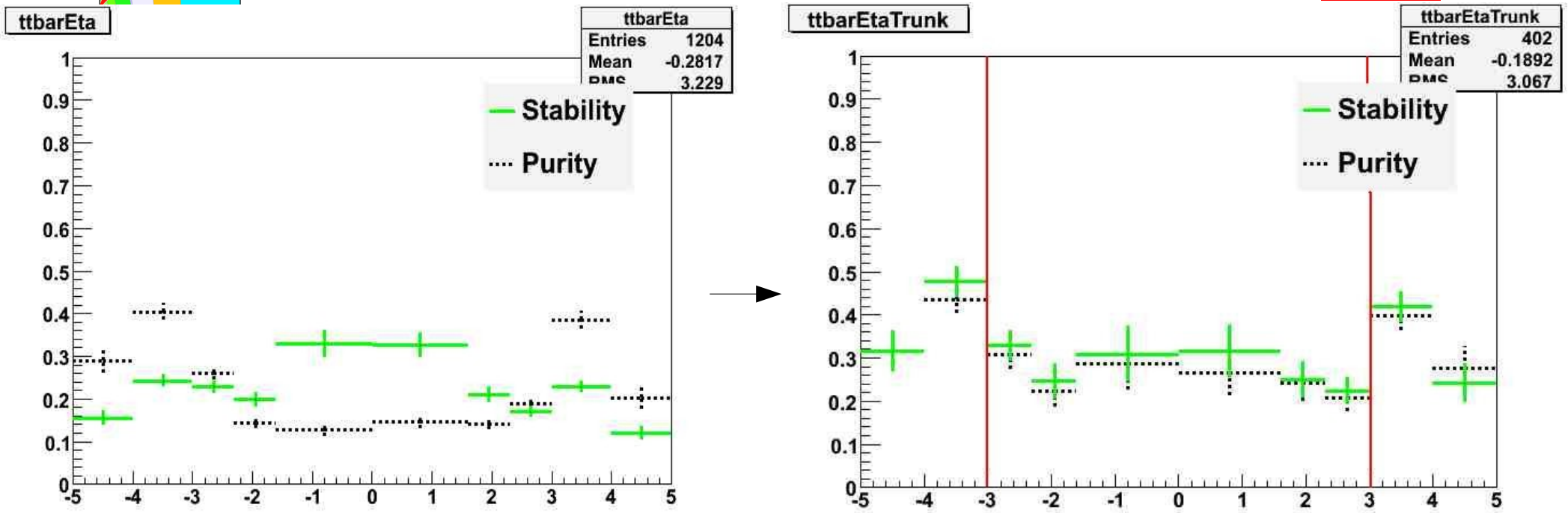


Example

Range 10 – 60 GeV
with correlation factor 0,68

Balance between correlation and population

New T T-bar Eta

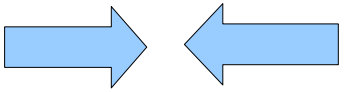


- In the Eta range -3 to 3 Stability & Purity can be brought on a similar level
- This cut is applied on Generator level, the Pt cut range has to be adapted to a realistic event
- The correlation can be improved on Reco level as well

Conclusion

- The Top quark kinematic variables with high stability & purity allow bin to bin corrections in the calculation of the Diff. XS
- The resolution of 6 to 8 bins is satisfactory
- There are problems with the T T-bar variables
- Eta can be improved by applying a Pt cut
- The proper Pt range has to be found depending on the reconstruction algorithm and the systematic Pt error
- The other T T-bar variables also require more sophisticated deconvolution methods

Stability & Purity



$$\text{Stability} = \frac{\text{Matched Events}}{\text{Rec Events}}$$

$$\text{Purity} = \frac{\text{Matched Events}}{\text{Gen Events}}$$

Deconvolution “Unfolding”

$$\chi^2 = (Ax - y) \cdot W[y] \cdot (Ax - y)^T$$

$$x = \int W[y](Ax - y)^T dy$$

- W[y] is the inverse of the covariance matrix of measured quantity y
- Minimise the chi^2
- Convolution of W with the transfer matrix A