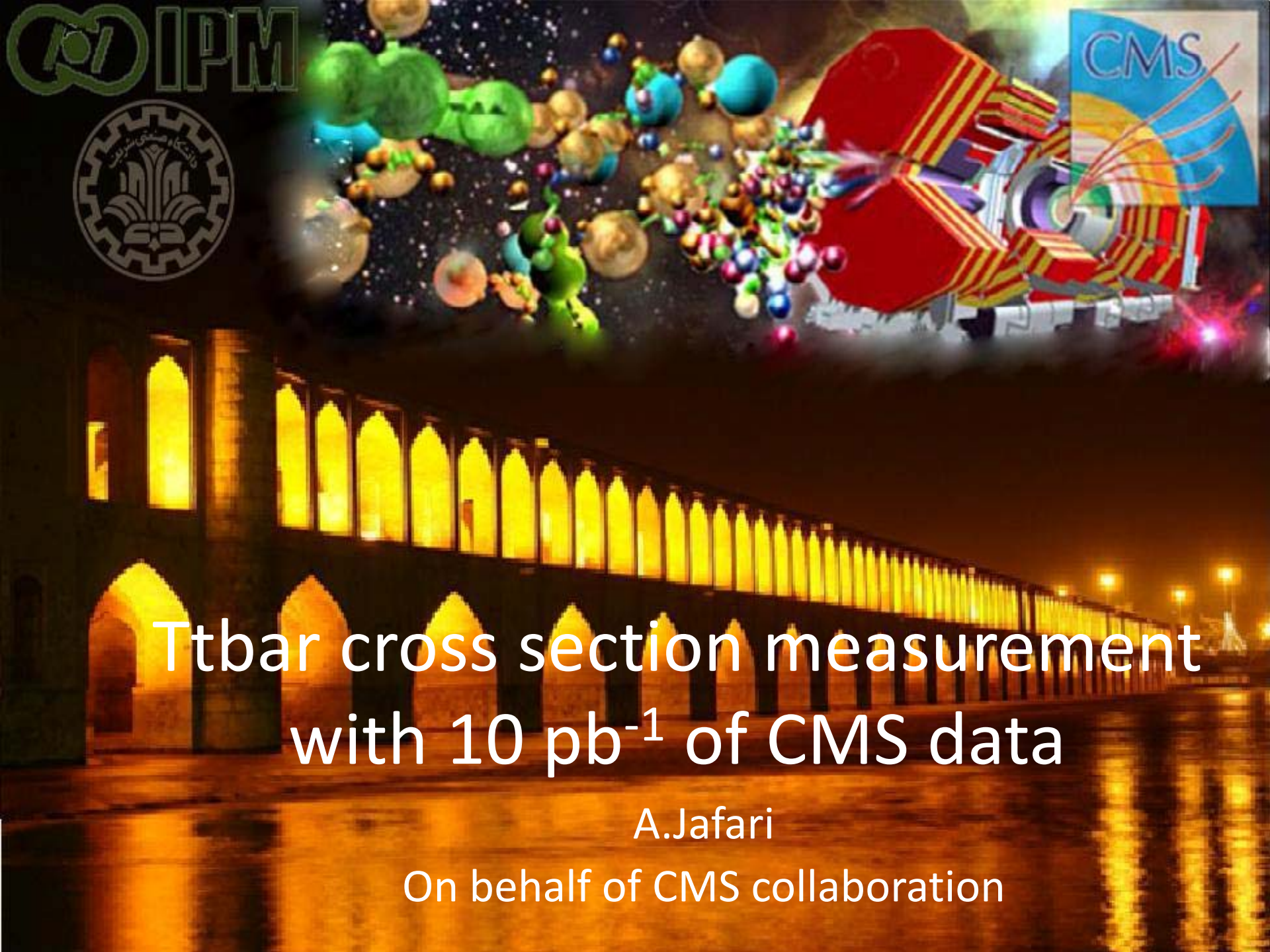

Ttbar cross section measurement with 10 pb^{-1} of CMS data

A.Jafari

On behalf of CMS collaboration

Outline

- top@LHC.cern.ch
- σ_{tt} with the first 10 pb^{-1} CMS data
  - Main physics backgrounds
  - Muon selection
  - Jet selection
  - Further QCD rejection
  - Results
- QCD estimation from data
  - ABCD Matrix method
- Conclusion

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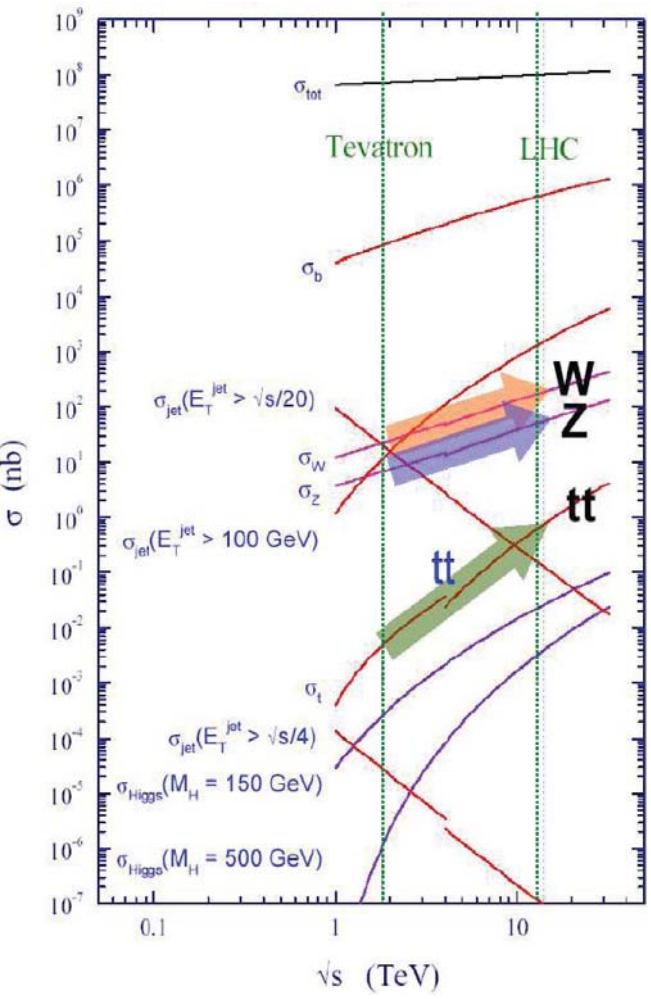
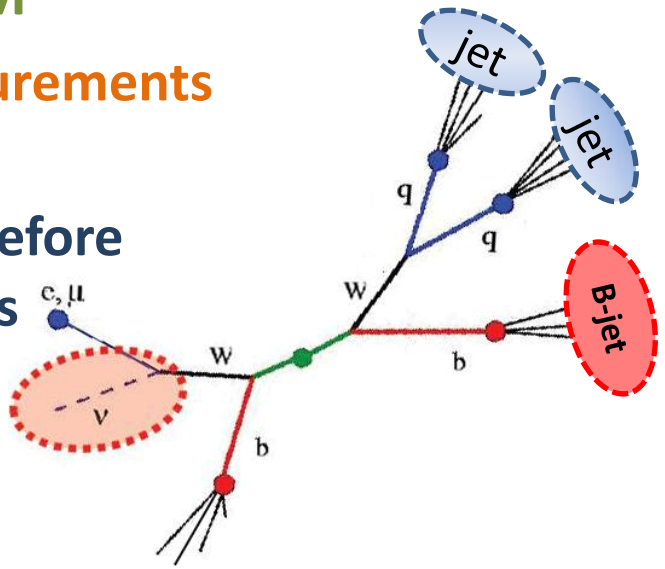


Rediscovery of the SM

More accurate easurements of m_t and σ_{tt}

Understand ttbar before claiming discoveries



Large cross section: top as calibration tool

Many relevant signatures: Jet, MET, leptons

B-tagging efficiency from ttbar events

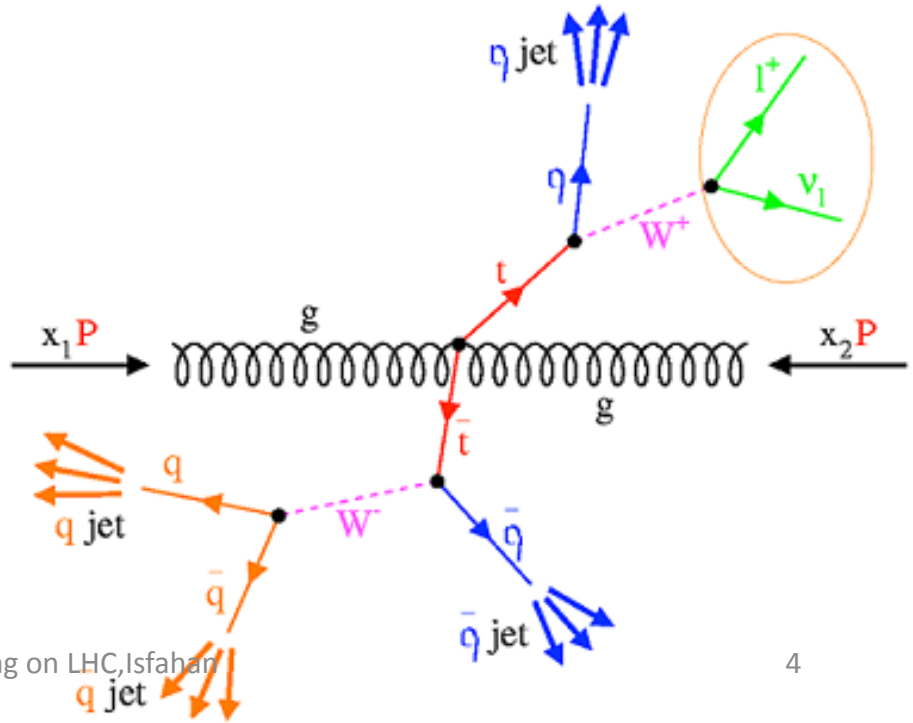
Jet energy scale calibration from ttbar events

σ_{tt} with the first 10 pb^{-1} CMS data

- Identify top pairs with the lowest possible integrated luminosity
- Non-optimal alignment of the silicon tracker and muon detector for early data taking
- Non-optimal calibration of electromagnetic and hadronic calorimeter, early data phase
- Simple, robust selection in muon+jet channel
  - No likelihood, neural network, etc.
  - No b-jet identification

$$pp \to t\bar{t} + X \to bq\bar{q} + b\mu\nu_{\mu} + X$$

- experimental signature
  - **An isolated and high Pt lepton (μ)**
  - **At least four jets**
  - **Missing transverse energy**



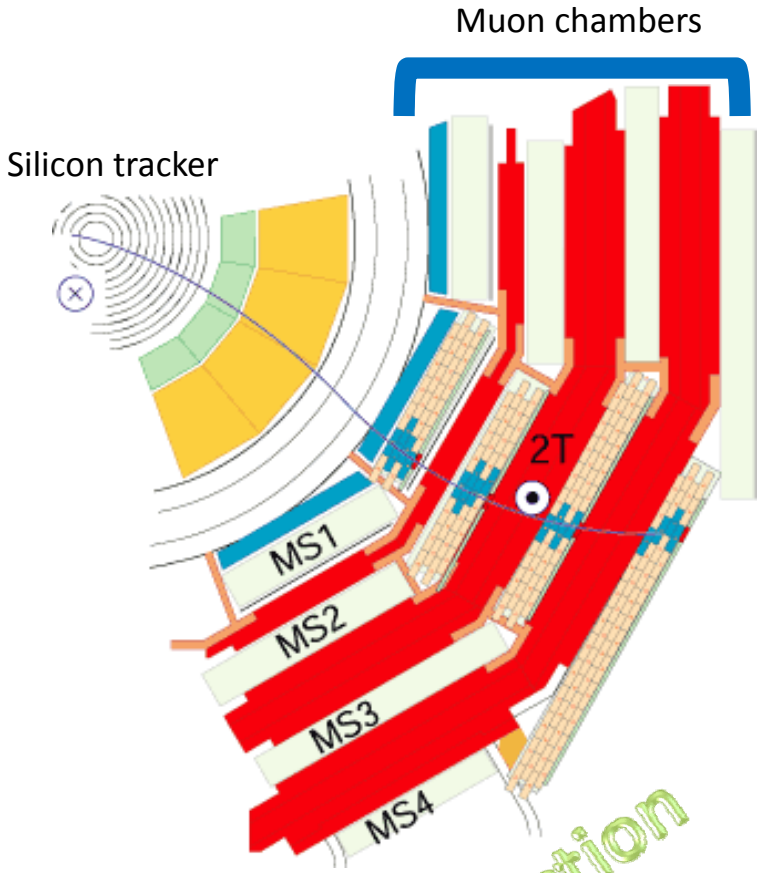
- **Main physics backgrounds**
  - **W bosons associated with extra jets**
    - **If W decays to lepton and neutrino, the signature will be very similar to ttbar**
  - **Z boson plus extra jets**
    - **Z decays to two leptons one of which is not reconstructed/in acceptance range ($|\eta_{lepton}|>2.4$)**
  - **QCD, Several jets and a lepton passes the selection cuts**
    - **Real lepton e.g. from semileptonic decays of hadrons containing c and b quarks**
    - **Fake lepton**

- **Difficult to model using Monte Carlo**
  - **Large number of events**
  - **Very sensitive to details in the tail of the simulated distributions.**
- **Simulation can give an idea of the size of this background in the absence of data**

Muon selection

Muon candidate

muon track segments in the *muon chambers*, matched with a track reconstructed in the *silicon tracker*

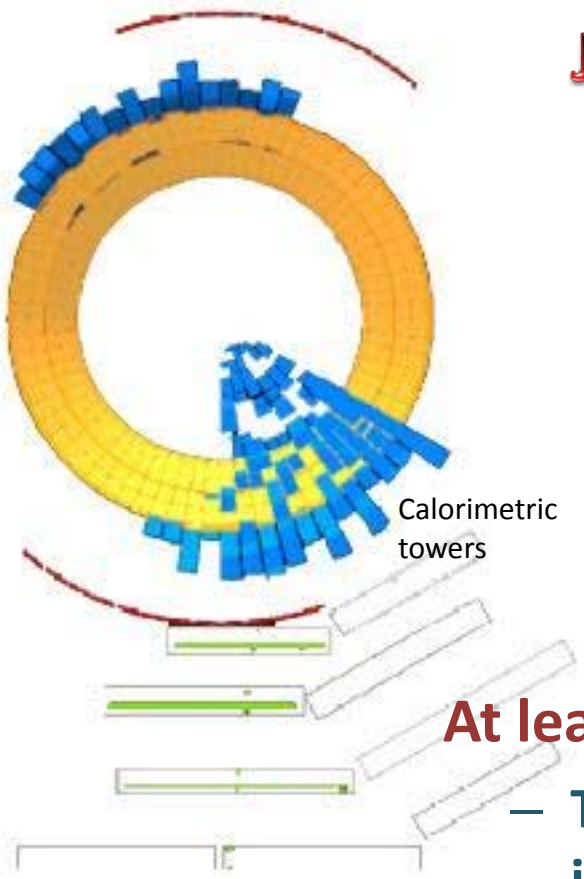


Exactly one muon candidate

- Isolated in tracker
- P_T >30 GeV
  - Reduce backgrounds with fake muon (e.g. QCD)
- $|\eta|$<2.1
  - Tracker acceptance of muon trigger
- Having just one muon rejects di-leptonic events

Loose selection

Jet selection



Jet candidate

Reconstructed using iterative cone jet algorithm with a cone radius of R = 0.5, using calorimeter towers as input.

Selection

higher order diagrams , parton showers

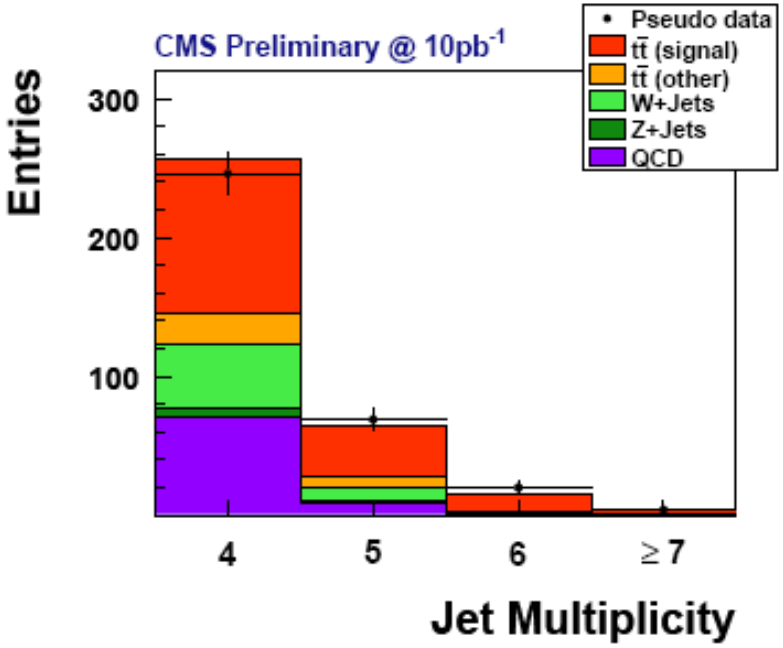
→ *Ttbar products are accompanied by extra jets*

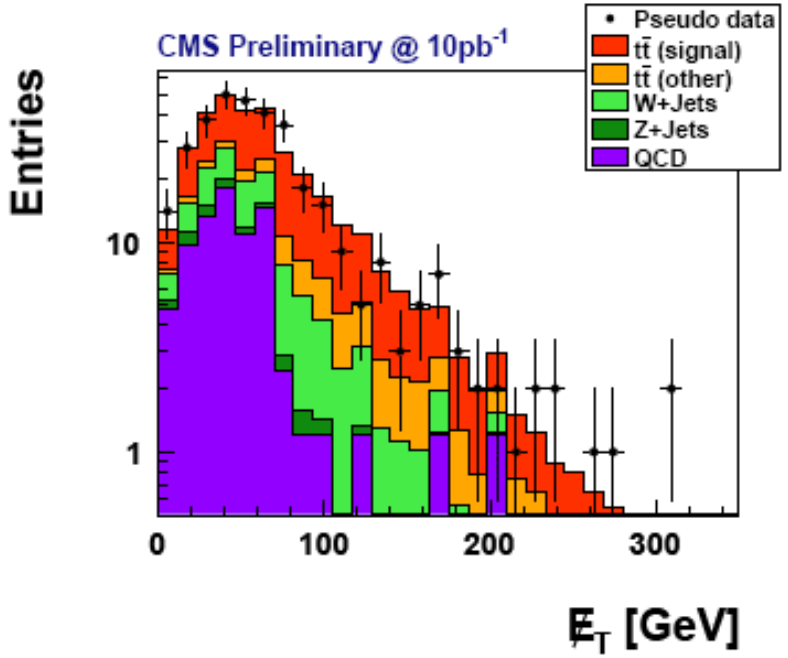
At least 4 jets, $|\eta|<2.4$

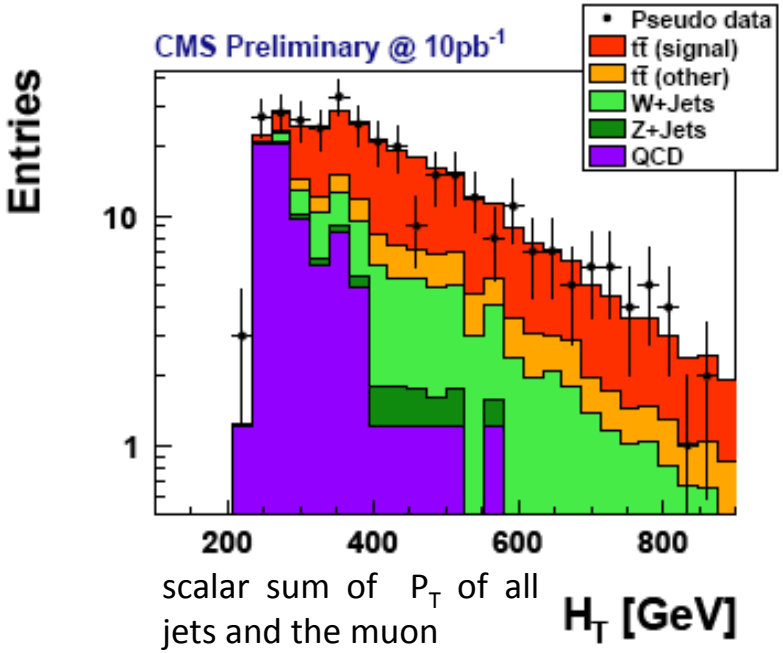
- Tracker acceptance range for possible b-jet identification
- For the jet with highest E_T , E_T > 65 GeV
- Other jets, E_T > 40 GeV

Loose selection

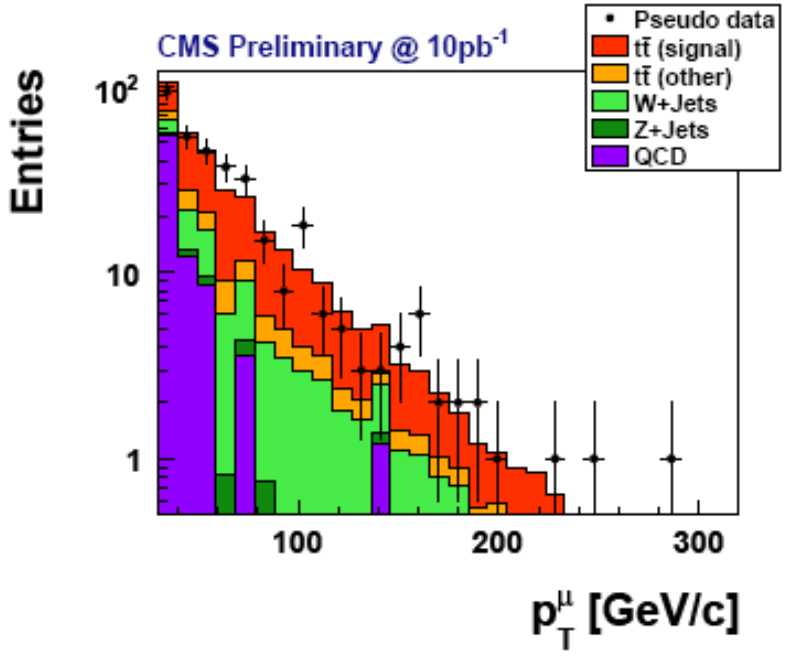
After loose selection







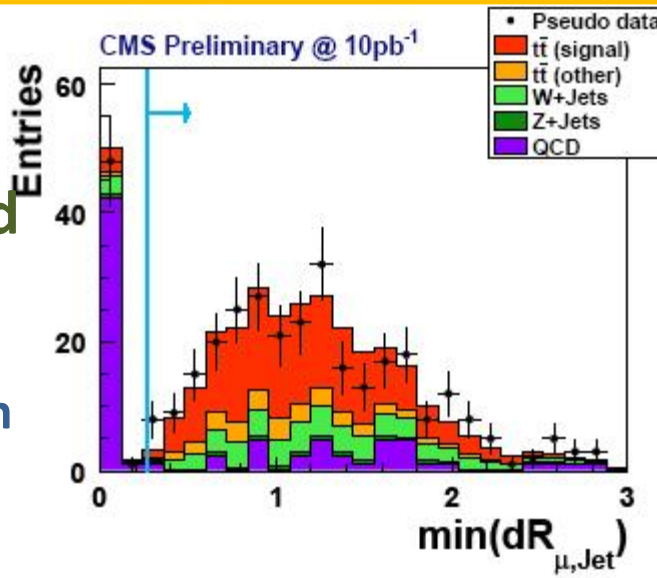
scalar sum of P_T of all jets and the muon

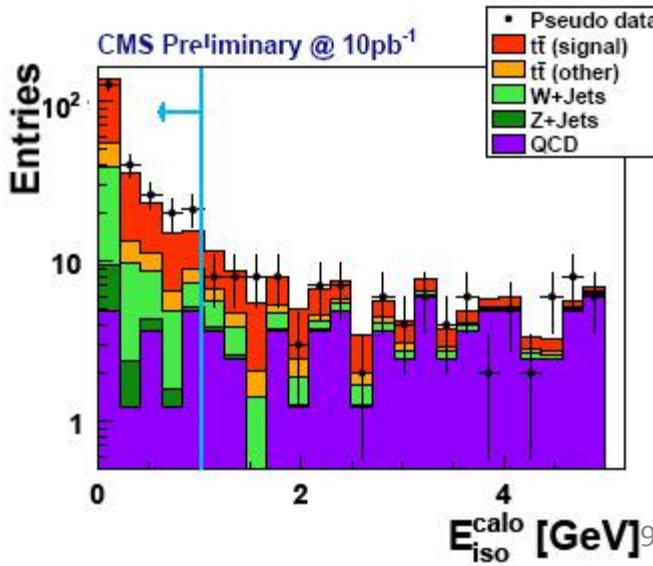


	$t\bar{t}$ (signal)	$t\bar{t}$ (other)	W+jets	Z+jets	QCD	S/B(QCD)	S/B
Preselection	749	527	7474	1430	–	–	–
4 Jets $p_T > 65/40/40/40$ GeV	236	135	83	16	–	–	–
1 Muon $p_T > 30$ GeV	163	32	57	8	110	1.48	0.79

Further QCD rejection

- Many variables and scenarios were studied
  - Tighter cuts on lepton
  - Cut on missing transverse energy
  - Cut on scalar sum of P_T's of all jets and the lepton (H_T)
  - ....
- Selected requirements
  - Separation between μ and the closest jet in $r\varphi$ plane
  - Lepton isolation in calorimeter



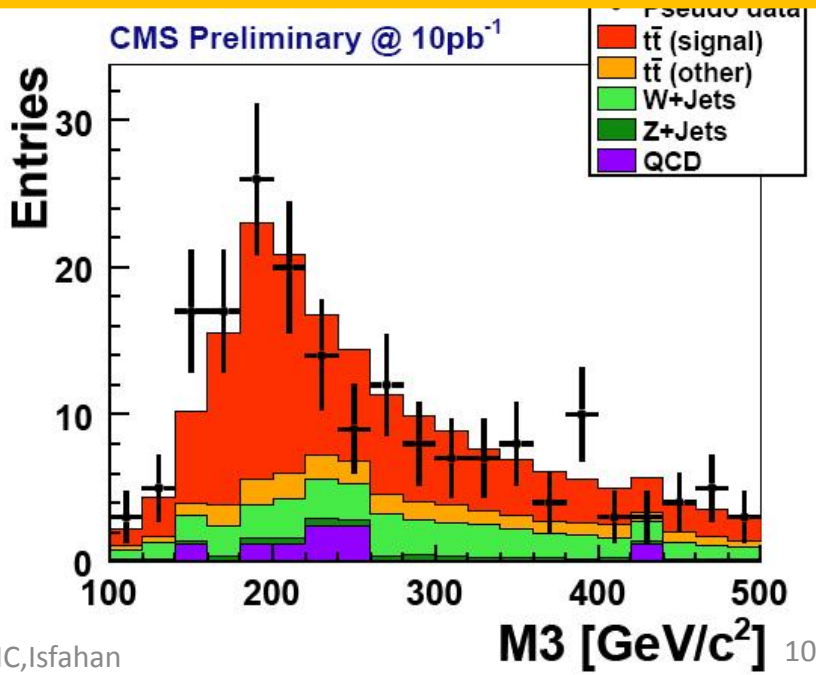


S/B : 11.6

Signal rejection: 20%

	$t\bar{t}$ (signal)	$t\bar{t}$ (other)	W+jets	Z+jets	QCD	S/B(QCD)	S/B
$\not{E}_T > 20$ GeV	151	31	53	7	91	1.66	0.83
$\not{E}_T > 30$ GeV	138	29	47	6	76	1.82	0.87
$\not{E}_T > 60$ GeV	87	23	28	2	29	3.04	1.07
$H_T > 300$ GeV	153	30	54	8	50	3.09	1.08
$H_T > 400$ GeV	104	22	39	6	14	7.27	1.27
$p_T^{\mu} > 40$ GeV	131	24	46	9	32	4.11	1.18
$p_{T,jet4} > 50$ GeV	94	19	27	4	20	4.76	1.35
$p_{T,iso}^{tracker} < 0.5$ GeV	134	26	47	7	61	2.22	0.95
$E_{iso}^{calo} < 3$ GeV	157	30	55	8	56	2.79	1.04
$E_{iso}^{calo} < 1$ GeV	131	25	47	7	17	7.91	1.37
$dR_{min} > 0.5$	152	30	52	8	44	3.44	1.14
$dR_{min} > 0.3$	159	31	54	8	48	3.28	1.12
$dR_{min} > 0.3$ & $E_{iso}^{calo} < 1$ GeV	128	25	45	7	11	11.62	1.47

- For 10 pb^{-1} , 128 signal events is expected
- Selection efficiency is 10.3%
- The number of QCD background has a large uncertainty



QCD estimation from data

Difficulties with MC modeling

➡ **QCD will be determined from data**

Different methods are under study at CMS

Fake rate method*, *ABCD Matrix method*, *Template fit method

- **Two variables, V_1 and V_2 that characterize signal and QCD background**
- **Assumed to be uncorrelated for QCD**
- **Define in the 2D histogram (V_1 and V_2) the signal region *C* and background dominated regions *A,B* and *D***

➡ **MET and lepton isolation for top analysis**

An example: ABCD matrix method

E_1 = Event of passing the cut on V_1
E_2 = Event of passing the cut on V_2

Assuming the two variables are uncorrelated:

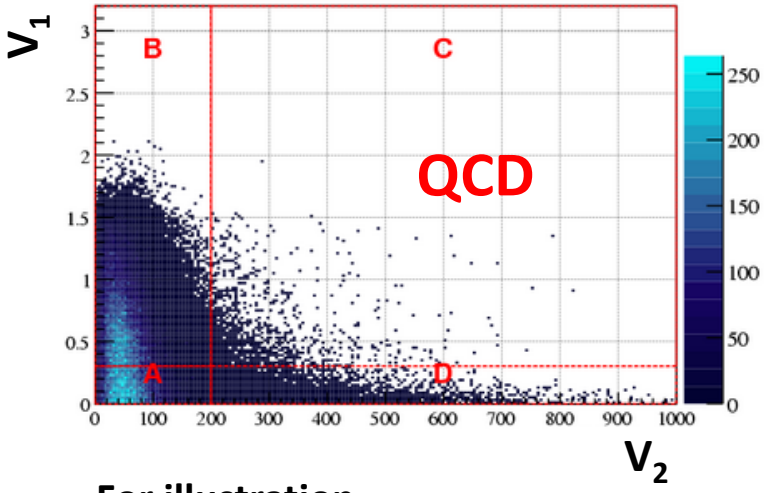
$$P(E_1 \mid E_2) = P(E_1)$$

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

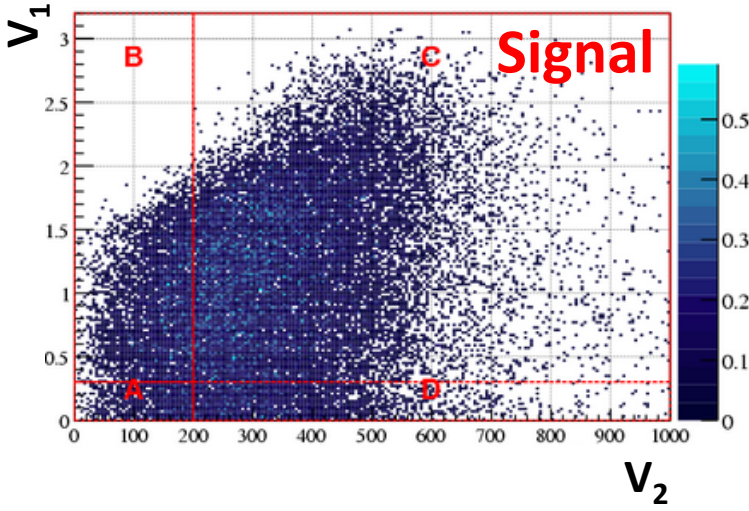
$$N_C N_A = N_B N_D \Rightarrow N_C = \frac{N_B}{N_A} N_D$$

So the number of QCD background events in signal region can be estimated

For illustration



For illustration



Conclusion

- CMS is preparing well for looking at first top events
- Ttbar signal could be established in first $10pb^{-1}$ of CMS data
  - 128 ttbar signal events
  - 25 other ttbar, 45 W+jets, 7 Z+jets, 11 QCD
  - 10.3% signal selection efficiency
- Methods to estimate QCD background from data are under study to be ready for the time of LHC collision
- Analyses are ongoing on to improve and fully validate MC, using data like techniques for both electron and muon channels

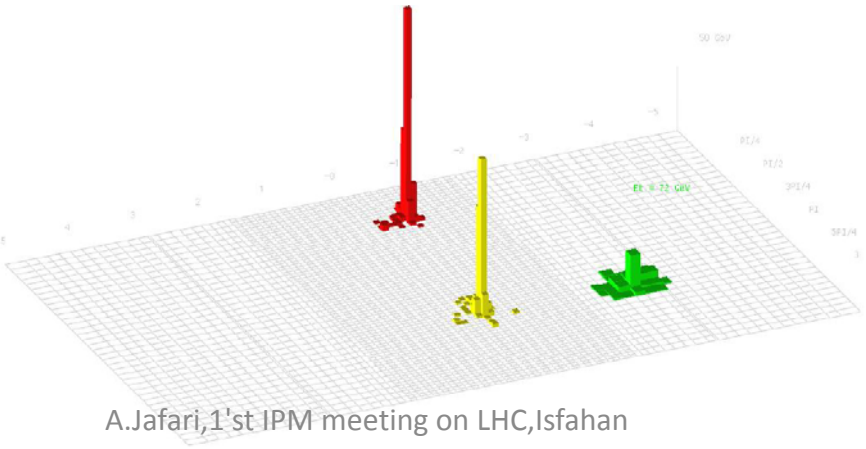
Back up

- Tower :

  Readout cells in hadronic calorimeter, HCAL, are arranged in a tower pattern in η-ϕ space.

- Calorimetric tower:

  Formed by addition of a 5×5 array of crystals in electromagnetic calorimeter to the corresponding individual HCAL tower



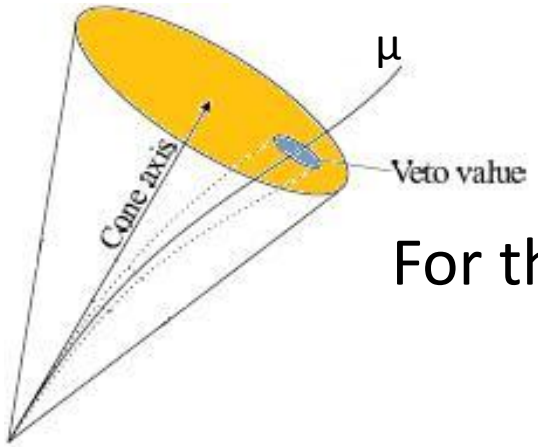
Back up

- Iterative cone algorithm of jet reconstruction
  - An E_T-ordered list of input objects (particles or calorimeter towers) is created.
  - The first object should have E_T larger than some threshold
  - A cone of size R in η-ϕ space is cast around that first object.
  - Objects inside the cone are used to calculate a “proto-jet” direction and energy. The computed direction is used to seed a new proto-jet
  - The procedure is repeated until
    - the energy of the proto-jet changes by less than 1% between iterations
    - the direction of the proto-jet changes by R < 0.01

Back up

- Isolation in tracker

Making a cone around the track of electron, and apply a very loose cut on the Pt of all other tracks inside, one can sum over the Pt of them (except electron's itself). It should be less than some cut value.



Isolation value, absolute: $\sum_{tracks} P_T$

Isolation value, relative: $\frac{\sum_{tracks} P_T}{P_T^{electron}}$

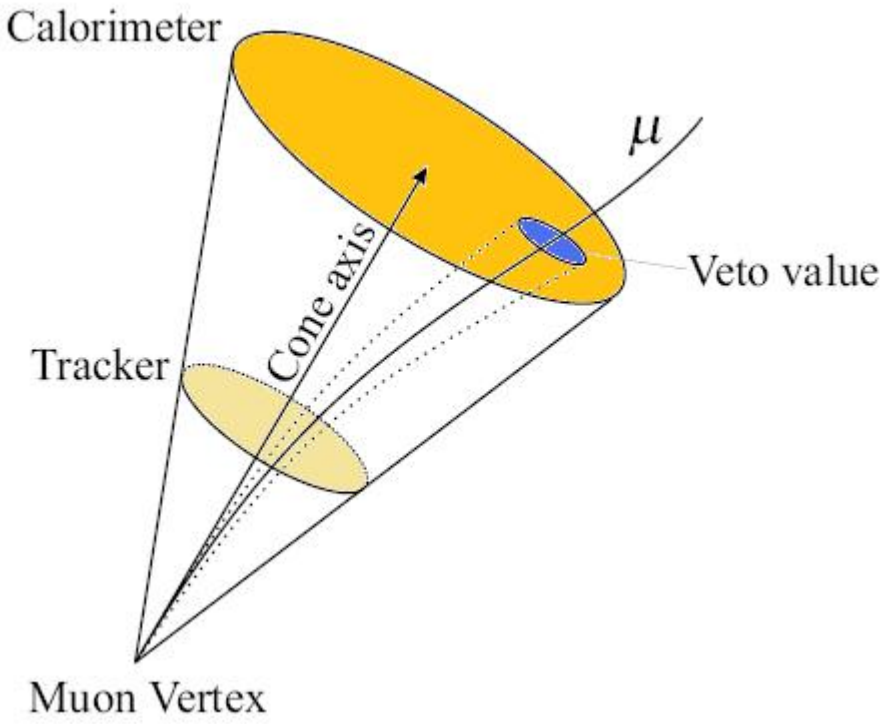
For this analysis:

Outer cone radius: 0.3

inner cone radius: 0.15

absolute tracker Isolation cut value: 3.0

Back up



Back up: Fake rate method

- The isolated lepton fake rate (both from mismeasurements as well as real non-isolated leptons) can be determined from a sample of QCD events
- Measuring the fraction (differentially in pT, *h etc.)* of isolated leptons with respect to all (loose) lepton candidates.
- This fake rate can then be applied to a selected sample signal events with loose lepton cuts in order to determine the background fraction.

Back up: Template fit method

- by fitting a combination of templates for signal and background to a discriminating distribution such as MET or MT,W measured in data.
- For tt signal and W/Z+jets background templates can be obtained from Monte Carlo.
- For QCD, a sample of data events has to be selected which can be used as a template.

Back up

- **Pre-selection in cross section analysis:**
  - Non-isolated single muon trigger
  - One muon with Pt>20
  - At least one jet with un-calibrated Pt>30

- **Selection efficiency of signal:**
  - 836.4×10×(12/81) ttbar produced
  - 128 events are selected