Top items in ATLAS

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Top items in ATLAS

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Outline:

- **Motivations (SUSY iduced attention)**
- **Top quark properties**
- **Reconstruction of top in ATLAS**
- **Outlooks**

Intro

- The main goal is to search for signatures of Supersymmetry (SUSY) with the ATLAS detector at the CERN Large Hadron Collider (LHC) as well as methods for studying the properties of SUSY if it is discovered.

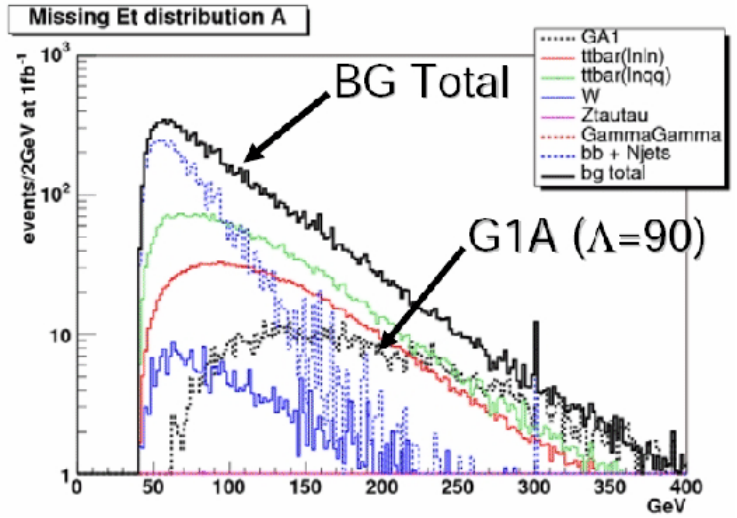
- Typical suggested SUSY event comprise large missing E_t (MET), one or several isolated leptons and/or multiple jets. For example GMSB G1a and G2a scenario which suggests following event topologies:

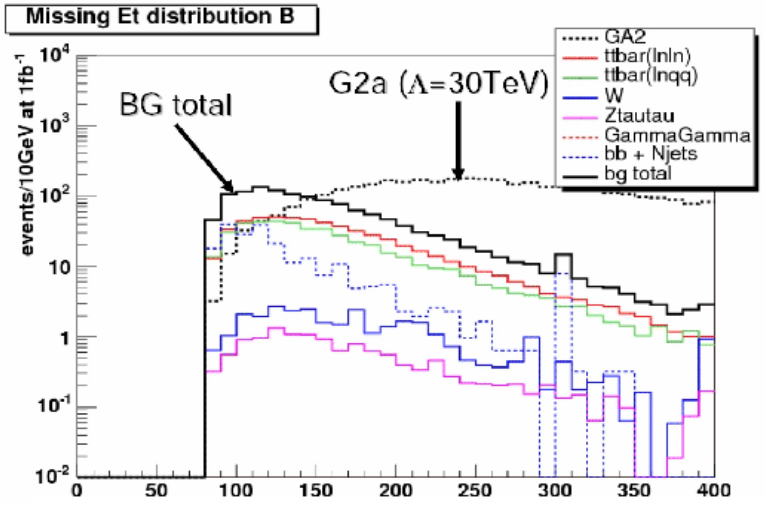
Scenario	Cross-Section	Signature
G1a	7.6 pb	multiple jets, large MET, at least 2 leptons, 2 photons
$\bar{\chi}_2^0 \to \bar{l}_R^{\pm} l^{\pm} \to \bar{\chi}_1^0 l^+ l^- \to \bar{g}_{3/2} l^+ l^- \gamma$		
G1b	7.6 pb	at least 4 jets, large MET, 2 OSSF leptons
$\bar{\chi}_i^0 \to \bar{l}^{\pm} l^{\pm} \to \bar{g}_{3/2} l^+ l^-$		

- Top quark pair production will be significant, and in many cases the major, Standard Model (SM) background to such searches.

Intro 2

- **For example for G1a and G2a scenarios:** $t\bar{t}(l\nu l\nu),\ t\bar{t}(l\nu qq),\ Z\tau\tau,\ b\bar{b}+Njets,\ W,\ \gamma\gamma+Njets.$





The plots are taken from the talk ''Background study and discovery potential'' given at ATLAS SUSY WG meeting 25.04.2006.

- **Therefore, to study various aspects of top production is an important link in probing physics beyond the SM.**
- **In addition, top events will be one of the main tools for the commissioning and calibration of the ATLAS detector. And the determination of the ttbar cross section will probably one of the first physics results of ATLAS.**

Top properties

- so far directly tested only at Tevatron (CDF,D0)
- m = 174± 3.3 GeV
- Decay width Γ~1.5 GeV (expected)
- Q = 2/3e (`D0 excluded Q=4e/3 @ 94% CL`)
- Spin ½
- σ(tot) = 833 pb (at ATLAS, NLO)
  `non-SM t-tbar production has been not observed`
- single top 40 % of the pair production
  `reacently measured at Tevatron`
- Decays almost entierly trough V-A process to bW (~100 %).
  `The results from CDF and D0 are in agreement with SM predictions`

Citation: W.-M. Yao *et al.* (Particle Data Group), J. Phys. G 33, 1 (2006) (URL: http://pdg.lbl.gov)

t

$I(J^P) = 0(\frac{1}{2}^+)$

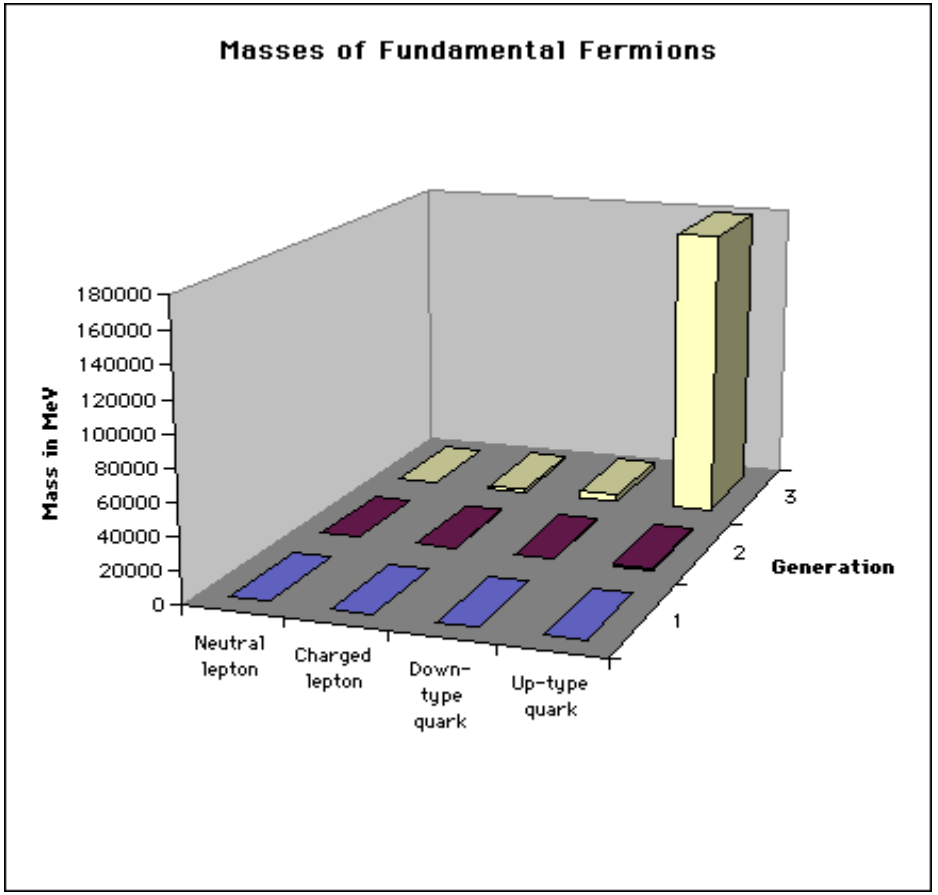
Charge = $\frac{2}{3}$ e Top = +1

Mass $m = 174.2 \pm 3.3$ GeV [b] (direct observation of top events)
Mass $m = 172.3^{+10.2}_{-7.6}$ GeV (Standard Model electroweak fit)

t DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$Wq(q = b, s, d)$				–
Wb				–
$\ell\nu_\ell$ anything	[c,d]	(9.4±2.4) %		–
$\tau\nu_\tau b$				–
$\gamma q(q=u,c)$	[e]	< 5.9 × 10^{-3}	95%	–
$\Delta T = 1$ weak neutral current ($T1$) modes				
$Zq(q=u,c)$	$T1$	[f] < 13.7 %	95%	–

Top properties

- m = 174.2 ± 3.3 GeV
  expected accuracy at ATLAS: $\delta \leqslant$ 2 GeV
- Decay width Γ_t~1.5 GeV (expected in SM)
- Q = 2/3e (proves that this is t)
- Spin ½
  t-tbar spin correlation at ATLAS -> lower limit on Γ_t
- σ(ttbar,tot) = 833 pb (at ATLAS),
  $\delta\sigma$ ~ 5-10%,
  provides insight into gluon densities,
  any deviation signal new phenomena
- single top (40% of σ(tot))
  Vtb measurement at 5 % level
- Decay: almost entierly trough V-A process to bW (~100 %) improved measurement (BR, W helicity)

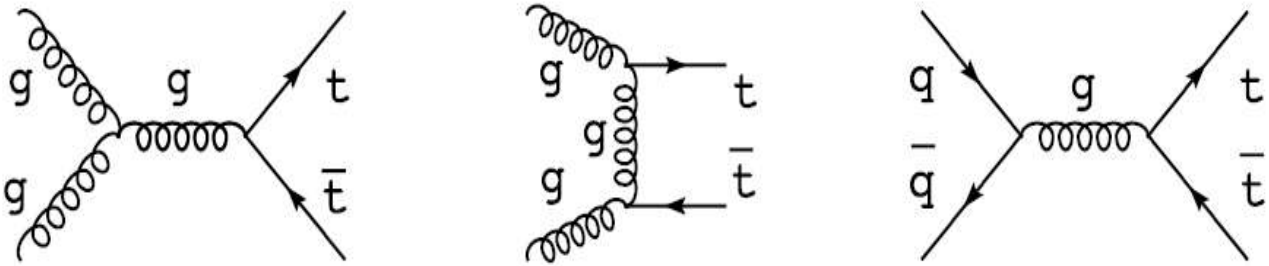


Precision measurements of top quark parameters and properties(e.g.coupling, rare decays etc) may reveal signatures of new physics!

Top production at LHC

QCD @ LHC

- **gg -> tt (90 %) qq->tt (10 %)**



Leading order diagrams for $t\bar{t}$ production in $p\,p$ collisions

EW @ LHC

- **single top production**

8 millions pairs + 3 millions single tops per low lumi year

($10\ fb^{-1}$)

tt event topology

t->bW (100 %). Final state signature determined by W decay

- **di-lepton channel (4×10^5 for 10 fb^{-1}):**

two high-p_t charged leptons (e,μ),

large MET, $\geqslant$2 jets (p_{Ti}>20 GeV)

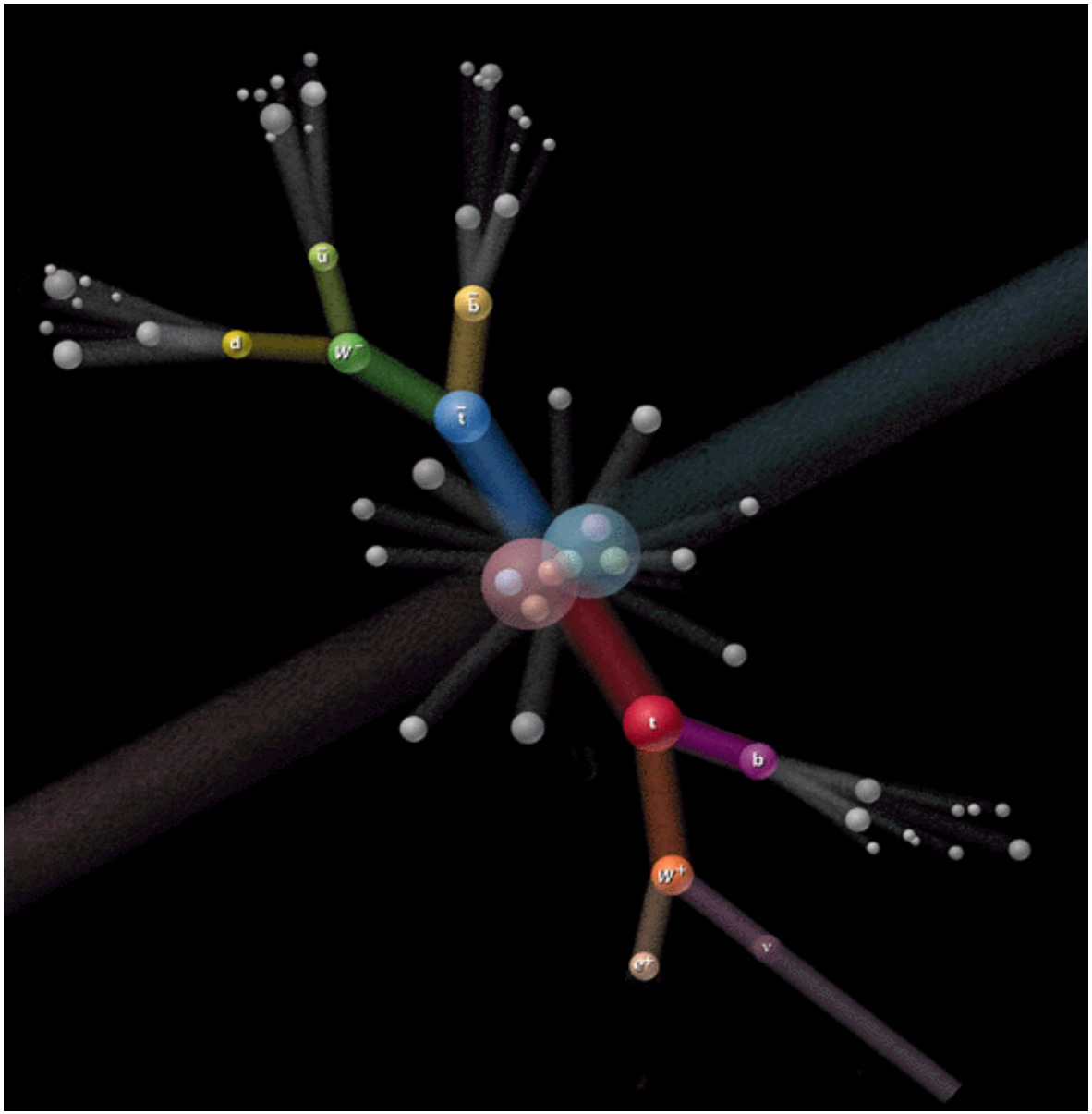
- **semi-lepton channel (2.5×10^6 for 10 fb^{-1})**

one high-p_t charged lepton

(e,μ), large MET, $\geqslant$4 jets

- **all-hadron channel (3.7×10^6 for 10 fb^{-1})**

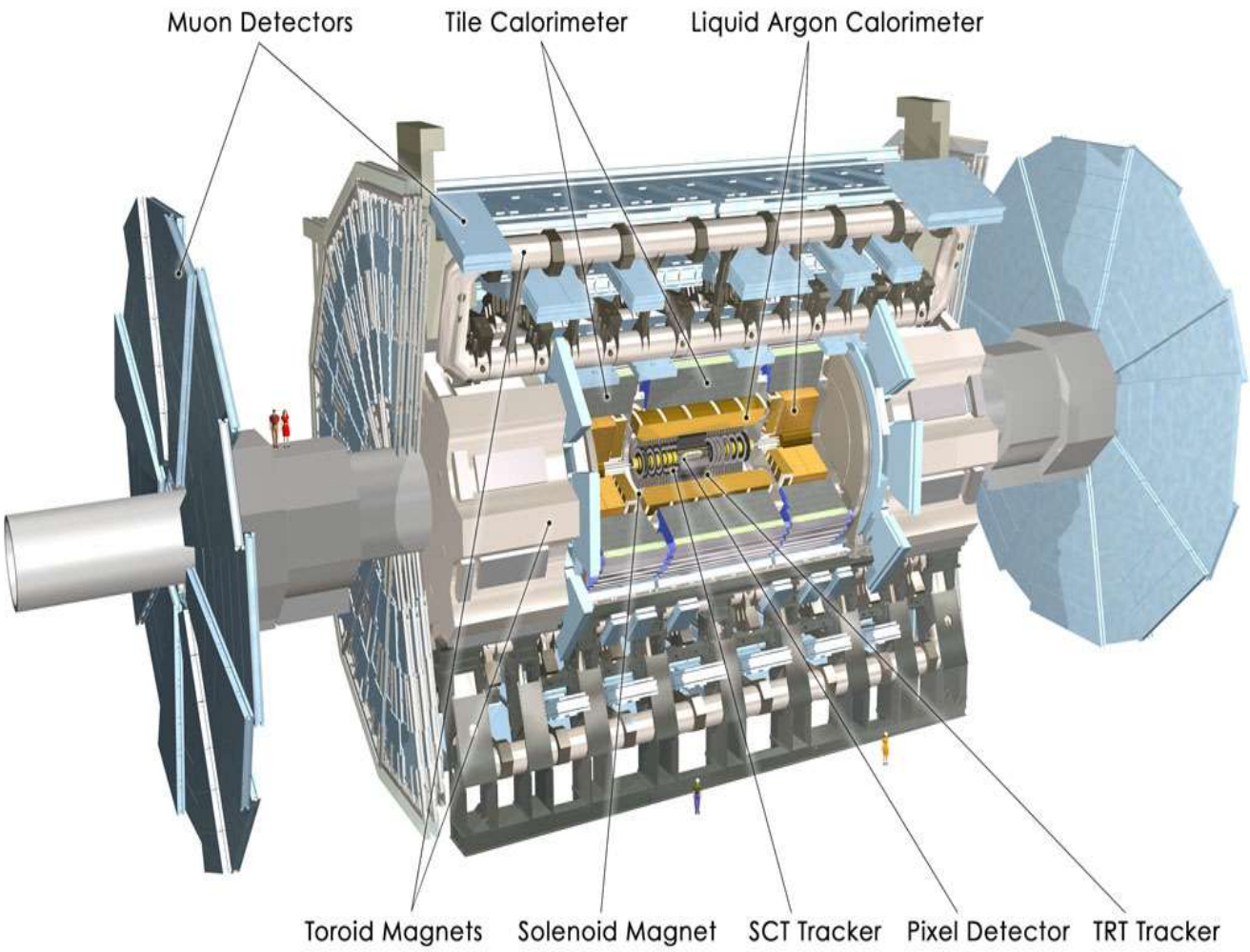
$\geqslant$6 jets



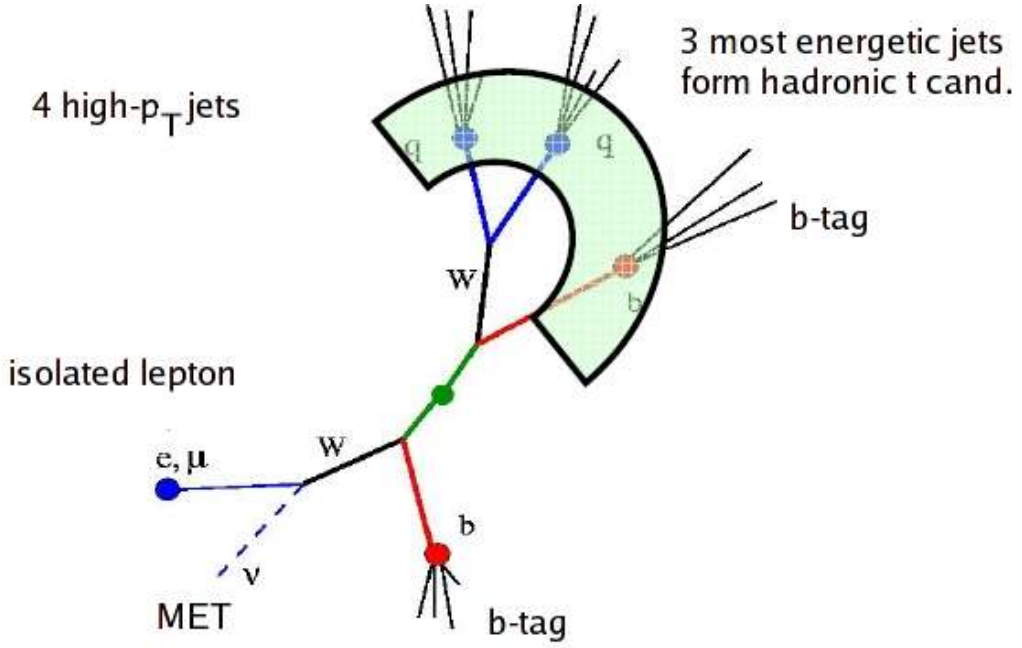
tt reconstruction in ATLAS

utilizes entire detector:

- **trackers (ID, MD)**
- **calorimetry (LAr,Tile)**
- **excellent jet reconstruction, lepton ID, MET determination, vertexig**
- **at one point could be reversed to study the detector performace**



Selection scheme



- e or μ from Electron or Muon collection (implies preselection cuts)
- lepton isolation: ΔR_{min}>0.2-0.6
- $p_T(\mu,e,jet)$>20-40 GeV, $|\eta_{\mu,e,jet}|$<2.5
- jet electron overlap removal

Lepton isolation. The cut may combine information from

- calorimeter, where the summed E_t in a cone around the lepton can be required to be smaller than a given threshold
- inner detector, where it may be required that no charged track with p_T larger than a given threshold is reconstructed in a cone around the lepton

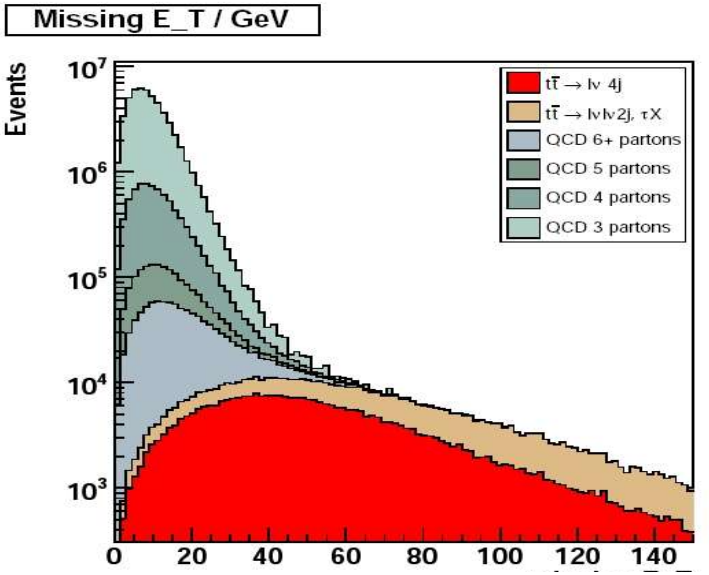
Overlap removal

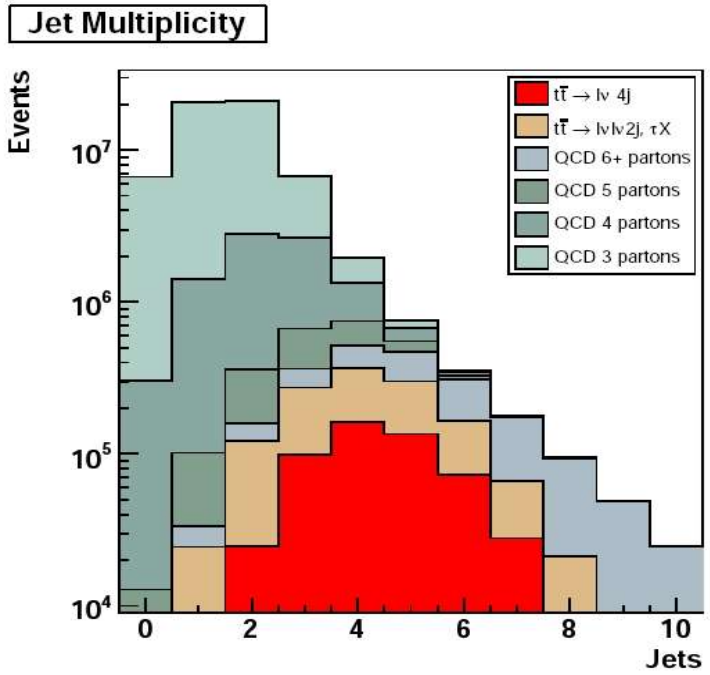
- a single physical object might be reconstructed by several algorithms and included in multiple AOD containers. This is what is meant by "overlap". It is important to avoid multiple use of thesame object (=remove the overlap). The subtelty is that the correct procedure is analysis-ependent.

MET, Jet multiplicity etc.

- MET > 20-30 GeV
- ≥4-6 jets
- lepton isolation cut: ΔR_{min}>0.6 between selected lepton and b-jet
- HT cut, HT=p_T(l1)+p_T(l2)+p_T(j1)+p_T(j2))
- lepton ordered p_T cut, e.g

  >50 GeV for the leading and
  > 30 GeV for the second leading
- B-tagging (1 or 2 tagged jets)

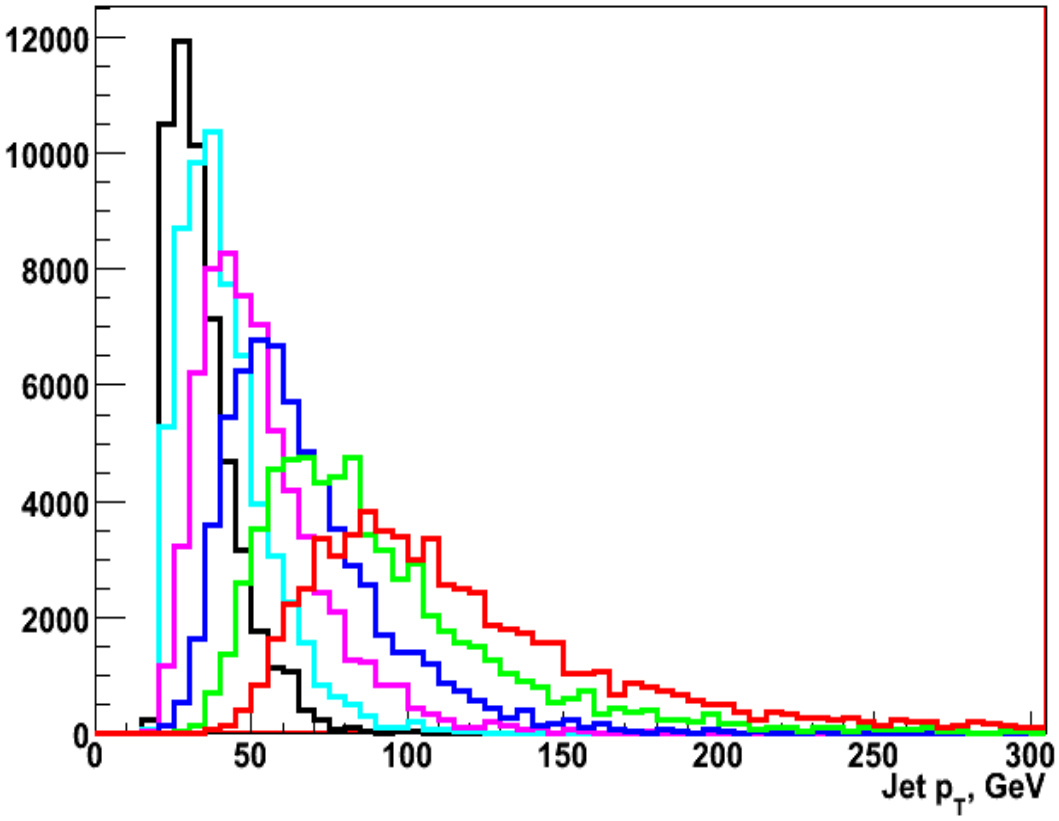




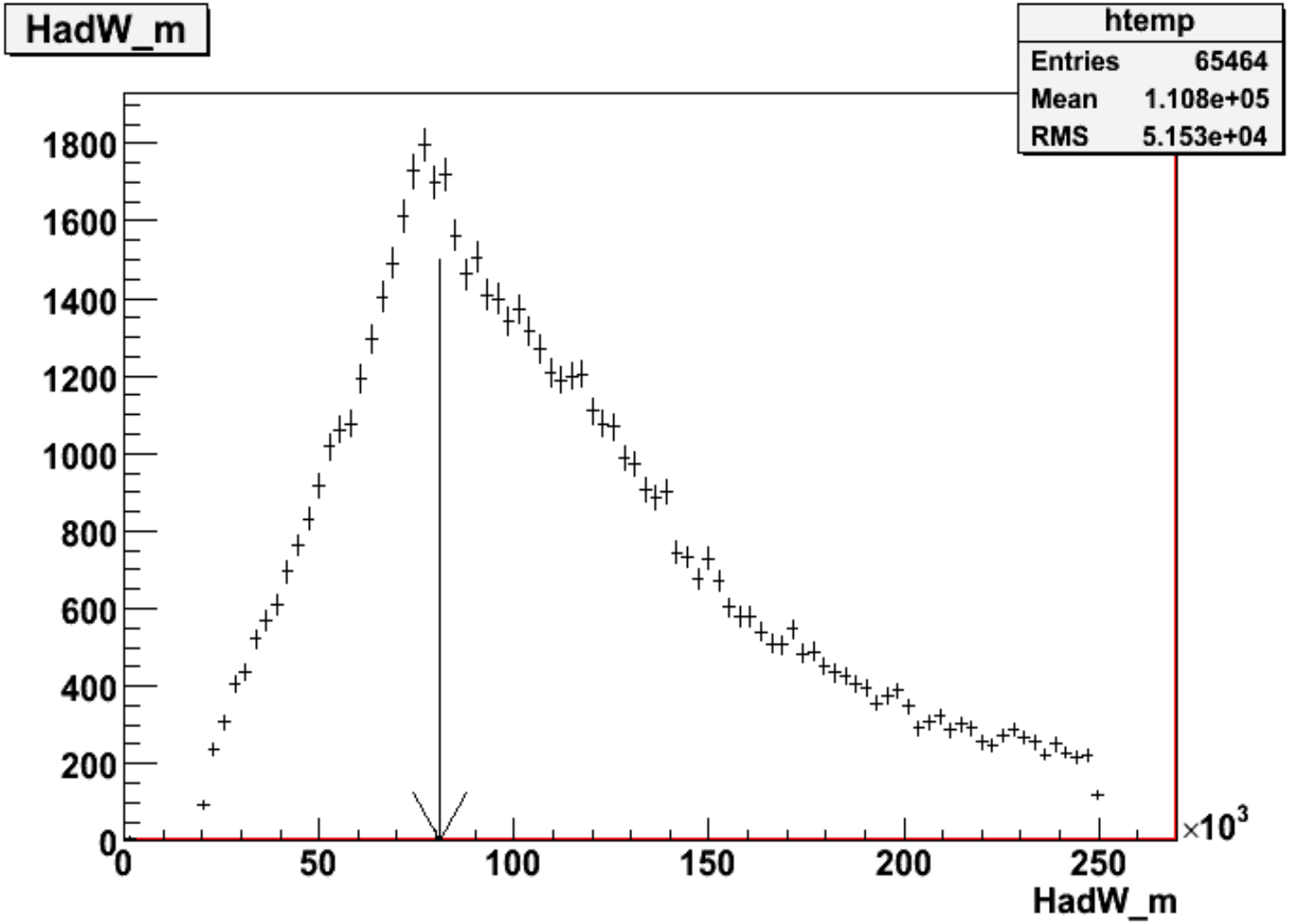
Plots by R.Mameghani, TOP meeting 21.02.2007

Selection for all-hadron mode. Example

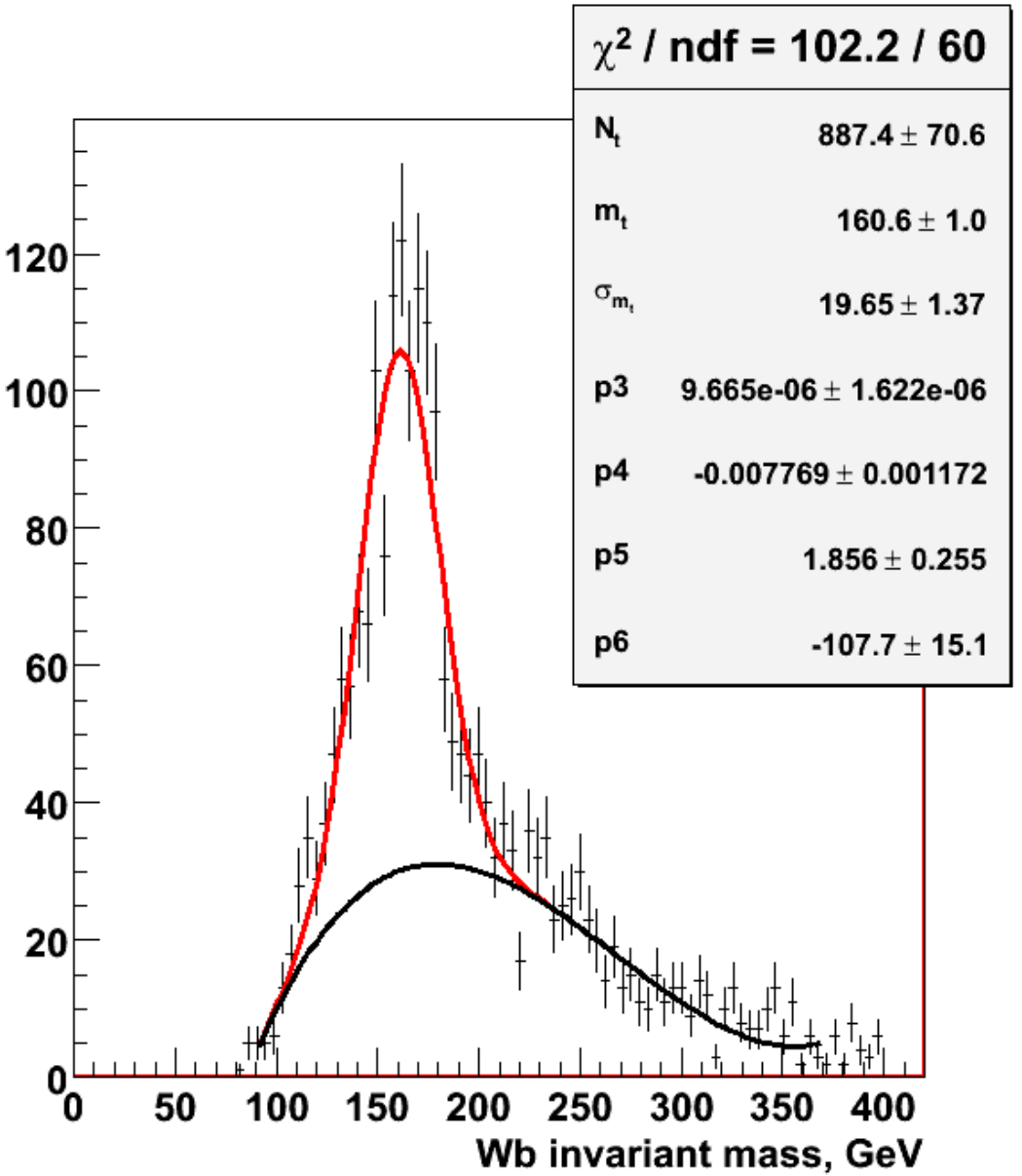
- ≥6 jets in $|\eta|<3$
- consider only 6 jests with highest p_T
- ordered jet p_T cut, e.g. p_T>85,65,50,20,20,20 GeV
- W kinematics determined from jets
- find nearest to W b-tagged jet
- combine W and b and calculate invariant mass using
- m_W window cut



W candidate: 2j invariant mass

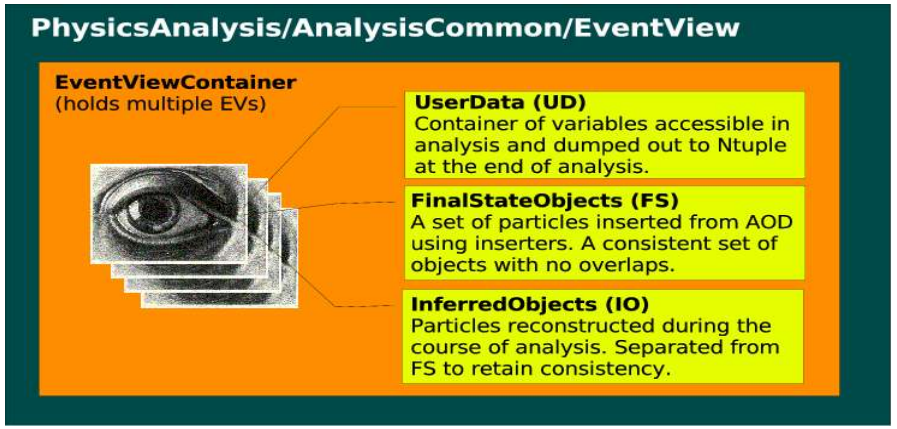


Wb invariant mass



- all-hadron mode
- MC@NLO + Jimmy (Herwig) all-hadron decay mode
- m_t(thruth)=175 GeV

TopView

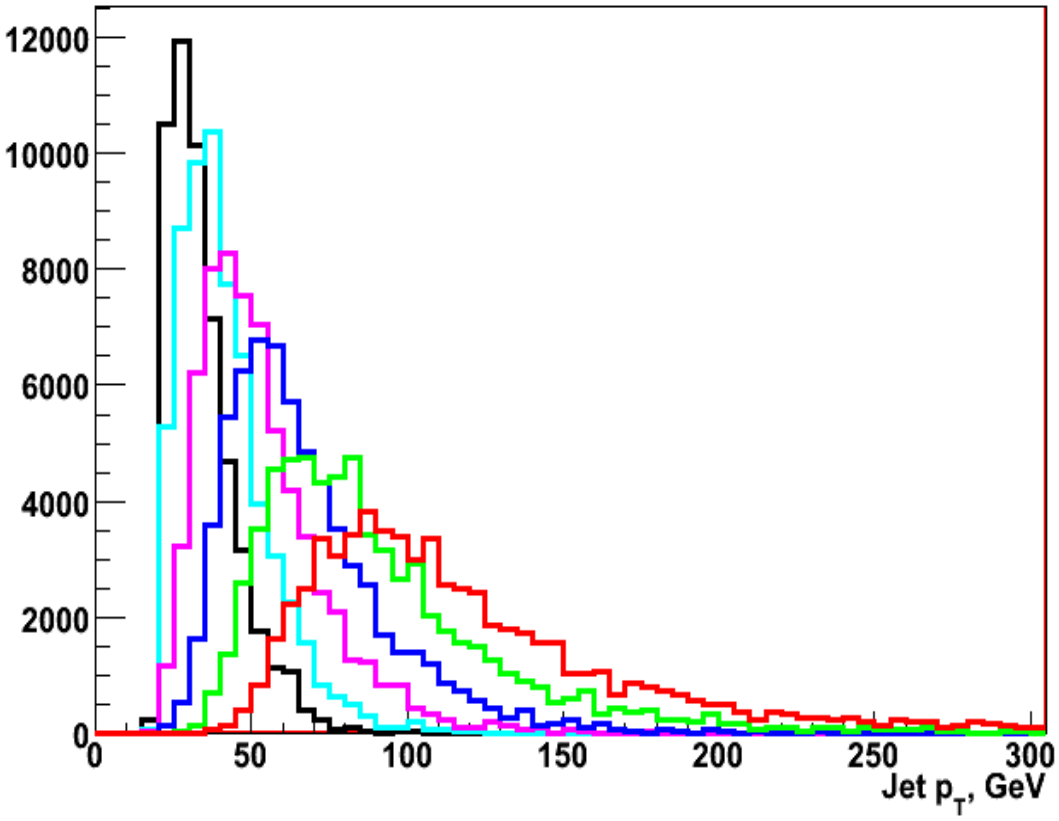


the application of EventView analysis framework specialized in Top quark physics

- *a helpful tool to deal with the ttbar events, and not only*
- *many useful features:*
- *preselection, overlap removal, variable and kinematic calculation tools*
- *ease to start with*
- *nice documentation*
- *nice base for the advanced analysis (SUSY also)*
- *provides a common ground for the member of the group to publish their analysis as tools that can be shared and compared*

Selection for all-hadron mode. Alternative Example

- ≥6 jets in $|\eta|<3$
- consider only 6 jests with highest p_T
- ordered jet p_T cut, e.g. p_T>85,65,50,40,40,40 GeV
- W,t kinematics determined from jets
- m_W window cut
- valid kinematic fit & χ^2 cut, e.g χ^2 < 10



Take 2 jets whose invariant mass is closest to the W mass (80.4 GeV). Take 3d jet that gives the resulting invariant mass close to top mass.

kinematic fit

Jet parton assignments relay on the combination that minimizes:

$$\chi^2 = (m_{jjb} - m_t)^2/\sigma^2(m_{jjb}) + (m_{l\nu b} - m_t)^2/\sigma^2(m_{l\nu b}) + (m_{jj} - m_W)^2/\sigma^2(m_{jj})$$

- **The fit utilized theconservation fo energy and momentum along with the m_W equal to the known and $m_t = m_{tbar}$**
- **Executed event by event**
- **Chosen solution is that which best satisfies ttbar hypotethis**
- **MET & jet energy scale study, b-tagging performace...**

work in progress...

Top in Analysis at EPF or Outlook

Search for SUSY (possibly GMSB like) which includes

- **handling of top events (the start point) in the meaning of ttbar background estimation**

`extracted from the data: the ttbar cross section from first data should help to minimize uncertainties on ttbar production as well as confirm absense/presense of the effects of possible new physics; explicit reconstruction of top decays as a method to measure ttbar yield and estimate the ttbar contribution to the high MET region; control samples for the SUSY analyses with energetic jets, MET and two leptons, di-lepton and tri-lepton analyses; background subtraction techniques;`

- **performance study for jet, MET scale, electron reconstrruction, jet/e separation**

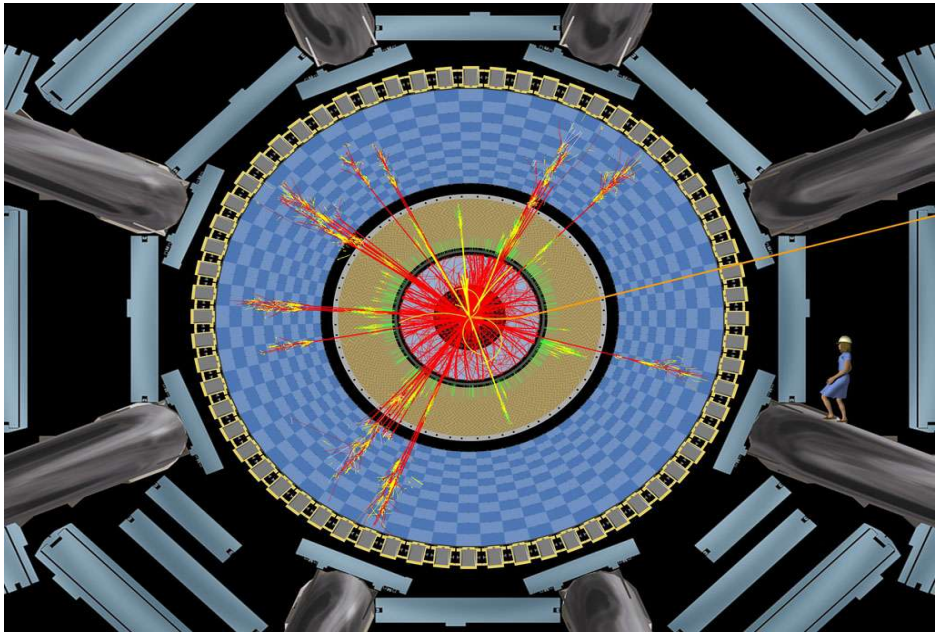
`ttbar events are good candidates (large production cross-section, kinematic constraints)`

- **start to use TMVA (multivariate classification method; to be ready to extract the maximum information from data at the presence of small signals and huge backgrounds)**

- **...**

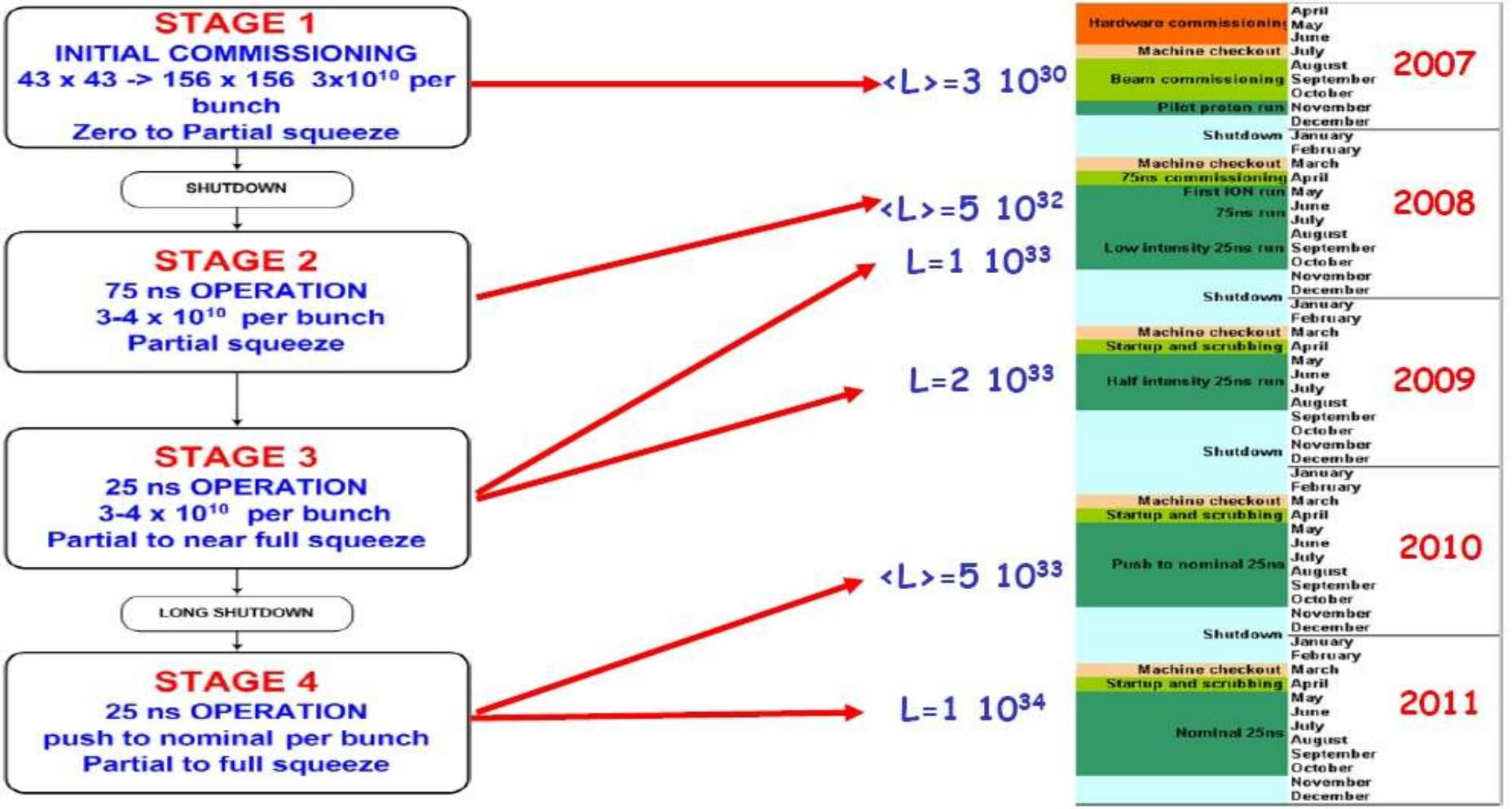
about jets and MET

- Jets are initiated by quarks & gluons (partons) that spray(hadronise) in jet of hadrons. The hadrons interact with the detector and produce energy clusters.
- The parton kinematic parameters are estimated usid reconstructed jet kinematics (key issues for many studies).
- Several jet clustering algorythms: Cone & Kt
- **Default jet collections**: ΔR=0.4, ΔR=0.7, K_t D=0.4, K_t D=0
- ETMiss is calculated from the energy deposed in all calorimeter cells and from muons. A correction is applied for the energy lost in the cryostat (MET_EtMissFinal).



- jet and MET calibration is the key issue for SUSY searches. Large ttbar production x-section suggest that these events may be used to study the performace of jet and missing transverse energy reconstruction as well as B-tagging

LHC planning



From F.Hubaut talk at Rencortres de Moriond, 18-25.03.2006

back up slides

- top quark (antiquark) electric charge Q: +2e/3 (-2e/3)
- top quark izospin I: 0
- top quark third component of the izospin Iz: 0
- tponess: T +1 (-1)
- barion number BN: +1/3(-1/3)
- Q = Iz+ (BN+T)/2 = +2/3(-2/3)
-
- ....

back up slides

- **Meaning of the isEM:**
- **For all egamma candidates the candidate has to pass a series of cuts based on the shower shape properties in different compartments of the calorimeter as well as variables combining ID and Calo informations. If a cut is not passed, then a bit is set in the isEM flag (see egammaRec/egammaPIDdefs.h for the definition of the bits). For candidates with a track attached to it, identification cuts based on the Tracking information have to be passed. Thus if isEM==0, then this is a good electron or photon.**