LHC physics: experimental overview

Giacomo Polesello

INFN, Sezione di Pavia

LHC: pp Collider $\sqrt{s}$=14 TeV   Startup: end 2007

Main motivations:

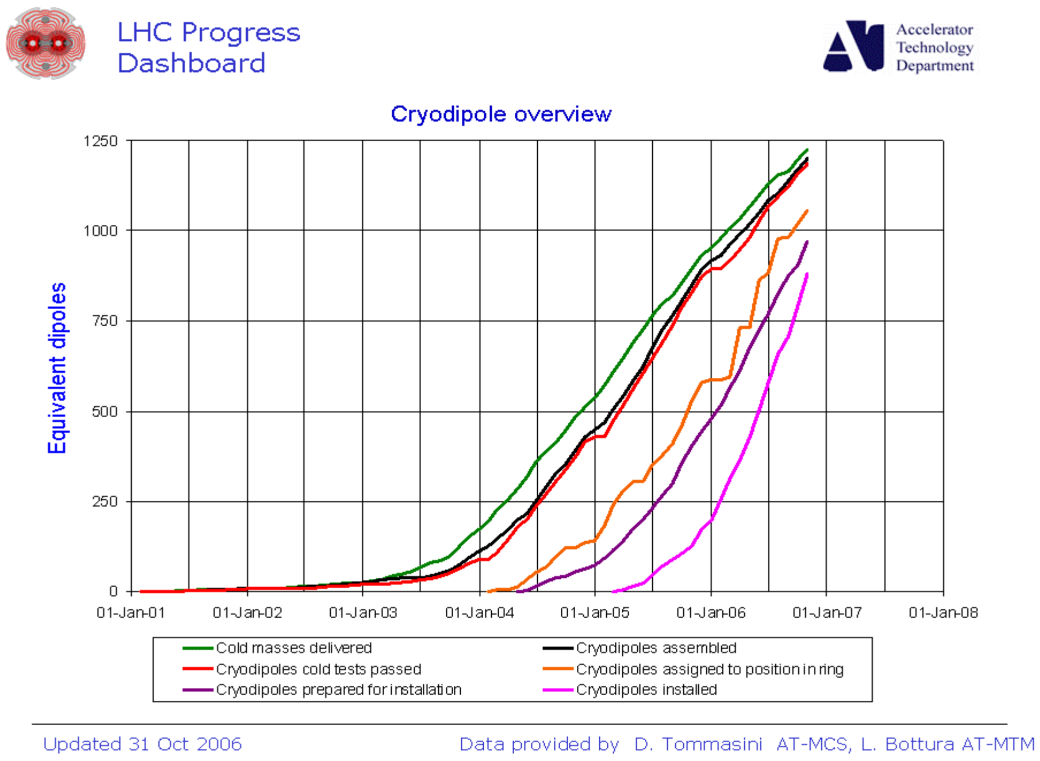
- Elucidate the mechanism of ElectroWeak Symmetry breaking:
  - Look for Higgs boson in allowed interval 100 GeV-1 TeV
  - In absence of low mass Higgs, study production of longitudinal gauge boson pairs.
- Find evidence for possible deviation from the Standard Model
  - Strong theoretical motivations to think that SM is only effective theory
  - In order to solve some of the theoretical difficulties with SM, deviations should be observable at $\sim$TeV scale

LHC Energy

$\sqrt{s} = 14$ TeV: explore the TeV scale, search for new massive particles up to 5 TeV

Maximum energy limited by the bending power needed to fit ring in 27 Km circumference LEP tunnel

$$p(\text{TeV}) = 0.3\text{B (T) R(km)}$$



LHC: $B = 8.4$ T:

$\sim$1300 superconducting dipoles working at 1.9 K

On track for closing the machine in 2007

Luminosity:

$$\mathcal{L} = \frac{N}{\sigma}$$

with $\mathcal{L}$: Luminosity N: event frequency, σ: cross-section

Two luminosity scenarios:

- peak$\sim 10^{33}$ cm^{-2}s^{-1} - initial "low luminosity": $\int \mathcal{L}\mathrm{dt} = 10\ \mathrm{f}b^{-1}$ per year
- peak$\sim 10^{34}$ cm^{-2}s^{-1} - design "high luminosity": $\int \mathcal{L}\mathrm{dt} = 100\ \mathrm{f}b^{-1}$ per year

Benchmark: ensure detection of Higgs boson in the range 100 GeV-1 TeV

$m(H) \sim 100 - 150$ GeV	$H \rightarrow \gamma\gamma$	$\sigma \times BR \times \epsilon \sim 10 - 20$ fb	$S/B \sim 1/50$
$m(H) = 1$ TeV	$H \rightarrow WW \rightarrow \ell\nu jj$	$\sigma \times BR \times \epsilon \sim 2 - 3$ fb	$S/B \sim 1/2$

Discovery when statistical significance for signal $S/\sqrt{B} > 5 \rightarrow$

Required integrated luminosity for discovery (no K-factors):

- $H \rightarrow \gamma\gamma$: $\sim$1000 events ~ 100 fb^{-1}
- $H \rightarrow WW$: $\sim$50 events ~ 20 fb^{-1}

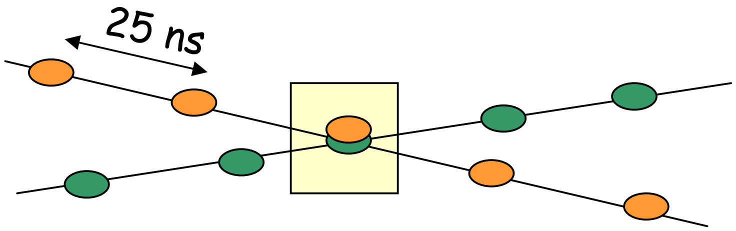
How is luminosity $\mathcal{L}$ achieved?

If two beams containing n_1 and n_2 particles collide with a frequency f:

$$\mathcal{L} = f \frac{n_1 n_2}{4\pi\sigma_{beam}^2}$$

with σ_{beam} gaussian transverse beam profile

LHC values: $n_1 = n_2 = 10^{11}$, and $\sigma_{beam} \sim 16 \times 10^{-6}$ m, determined by the physics of colliding beams.



To achieve $\mathcal{L} = 10^{34}$ cm^{-2}s^{-1}, LHC has to run with a bunch crossing every 25 ns

Inelastic proton-proton cross-section at $\sqrt{s} = 14$ TeV is ~ 70 mb $\Rightarrow$

LHC interaction rate at high luminosity: $\sim 7 \times 10^{-2} \times 10^{-24} \times 10^{34} = 7 \times 10^{8}$ Hz

40 MHz crossing frequency: $\Rightarrow \sim 25$ superimposed interactions per crossing (pile-up)

Characteristics of pile-up interactions

Soft partonic interactions: describe with non-perturbative phenomenological models

Collider jargon: "Minimum bias": experimental definition: depends on experiment's trigger. Usually associated to non-single diffractive events

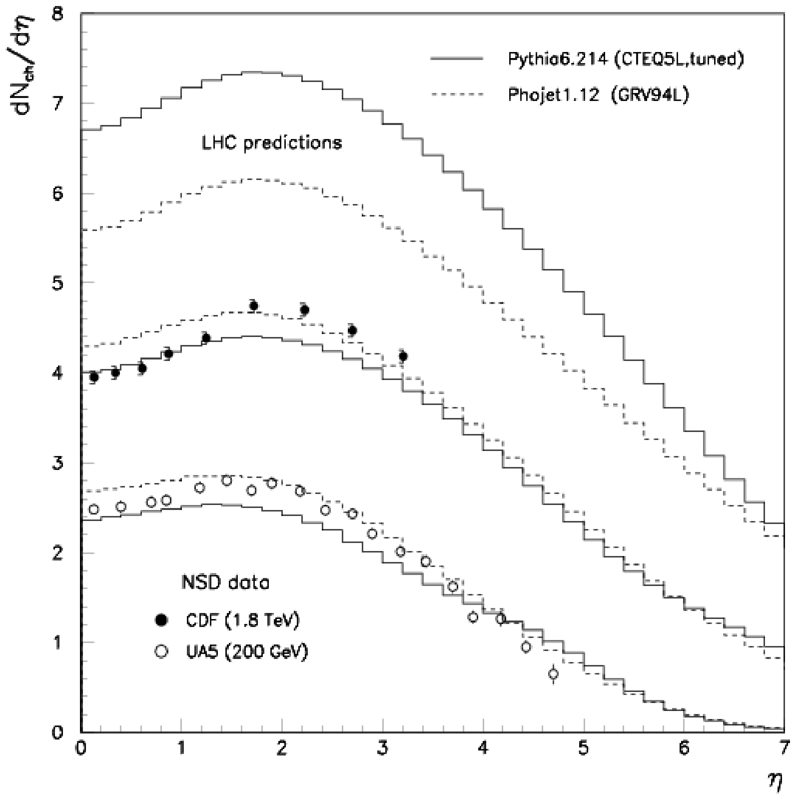
Measured at $S\bar{p}pS$ and Tevatron, large uncertainties in extrapolation to LHC

Main features:

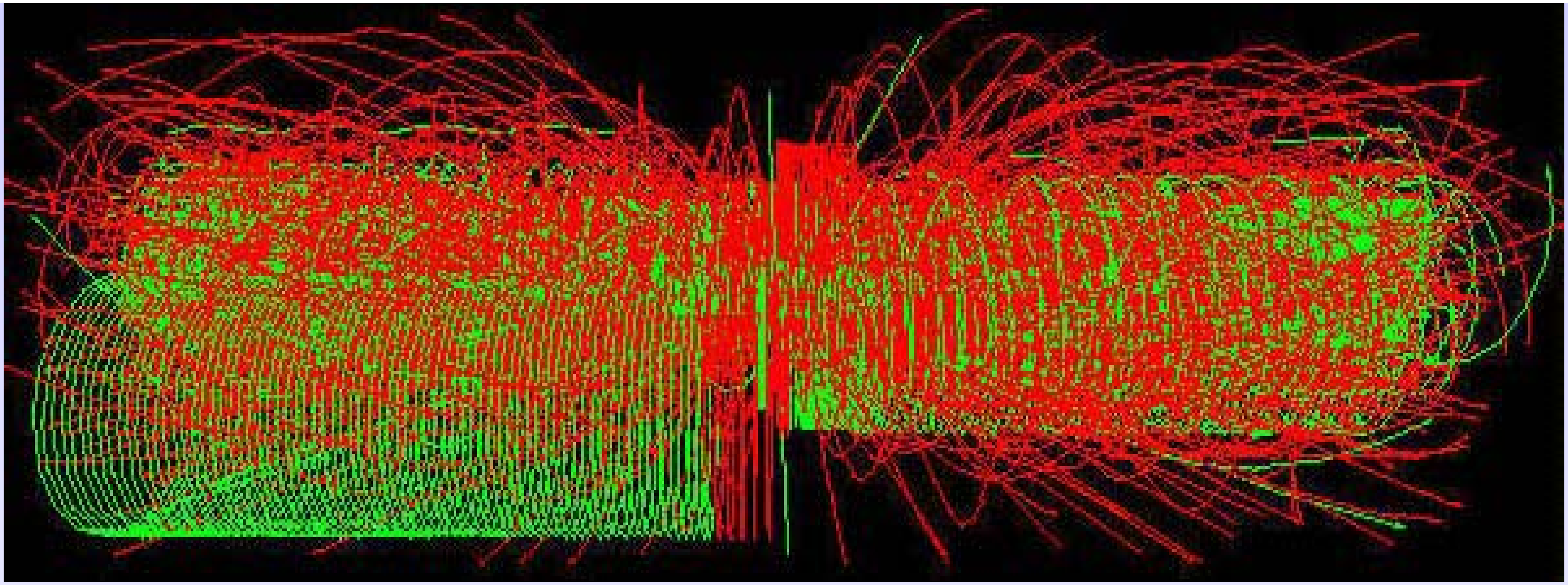
$\sim$7 charged particles per unit of rapidity$\Rightarrow$ ~ 100 charged particles over $|\eta| < 2.5$ per crossing at low luminosity

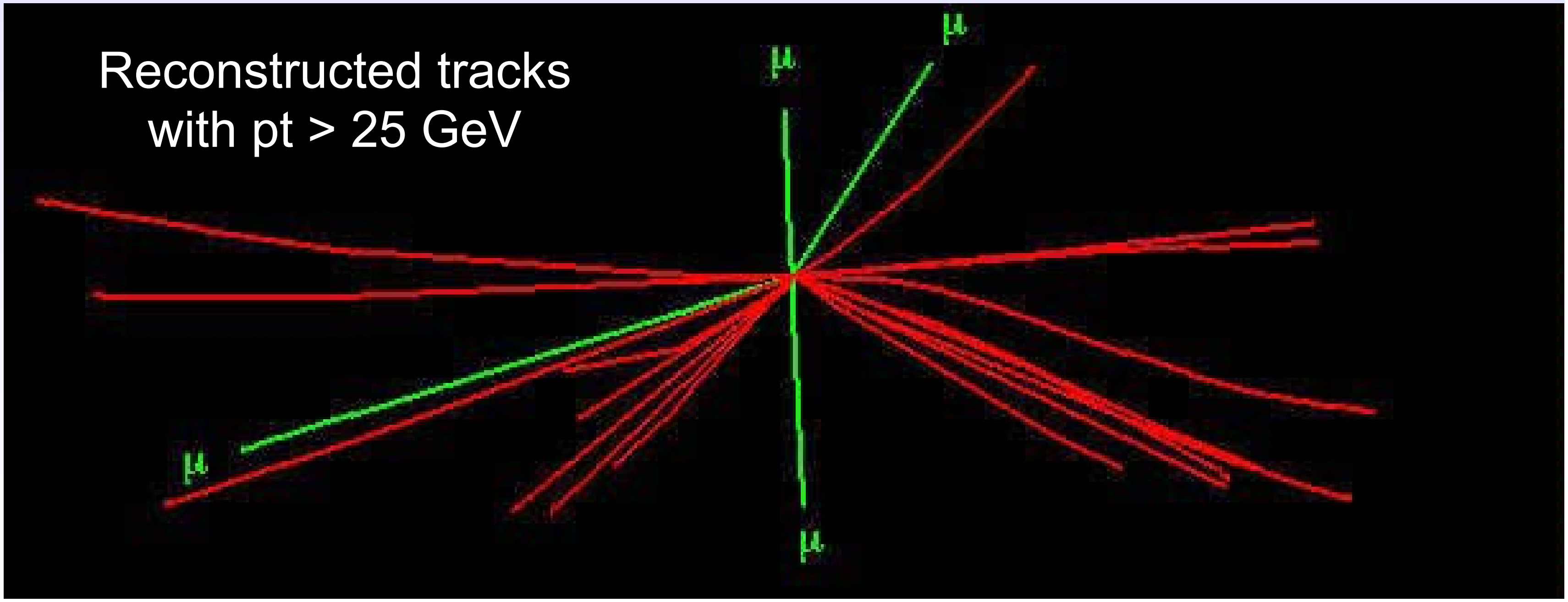
Significant radiation damage from interaction!

$< p_T > \sim 500$ MeV $\Rightarrow$ can select interesting particles by cut in p_T



Example: $h \rightarrow 4\mu$ event in CMS at high luminosity





Reconstructed tracks with pt > 25 GeV

Large impact on detector design:

- Speed:

  LHC detectors must have fast response otherwise integrate over too many bunch crossings

  Typical response time: 20-50 ns$\longrightarrow$ integrate over 1-2 bunch crossings

  $\Rightarrow$ very challenging readout electronics

- Granularity:

  LHC detectors must be highly granular to minimise probability that pile-up particles in same detector element as interesting object

  $\Rightarrow$ Large number of electronics channels

- Radiation hardness:

  High flux of particles from pp collisions $\Rightarrow$ high radiation environment

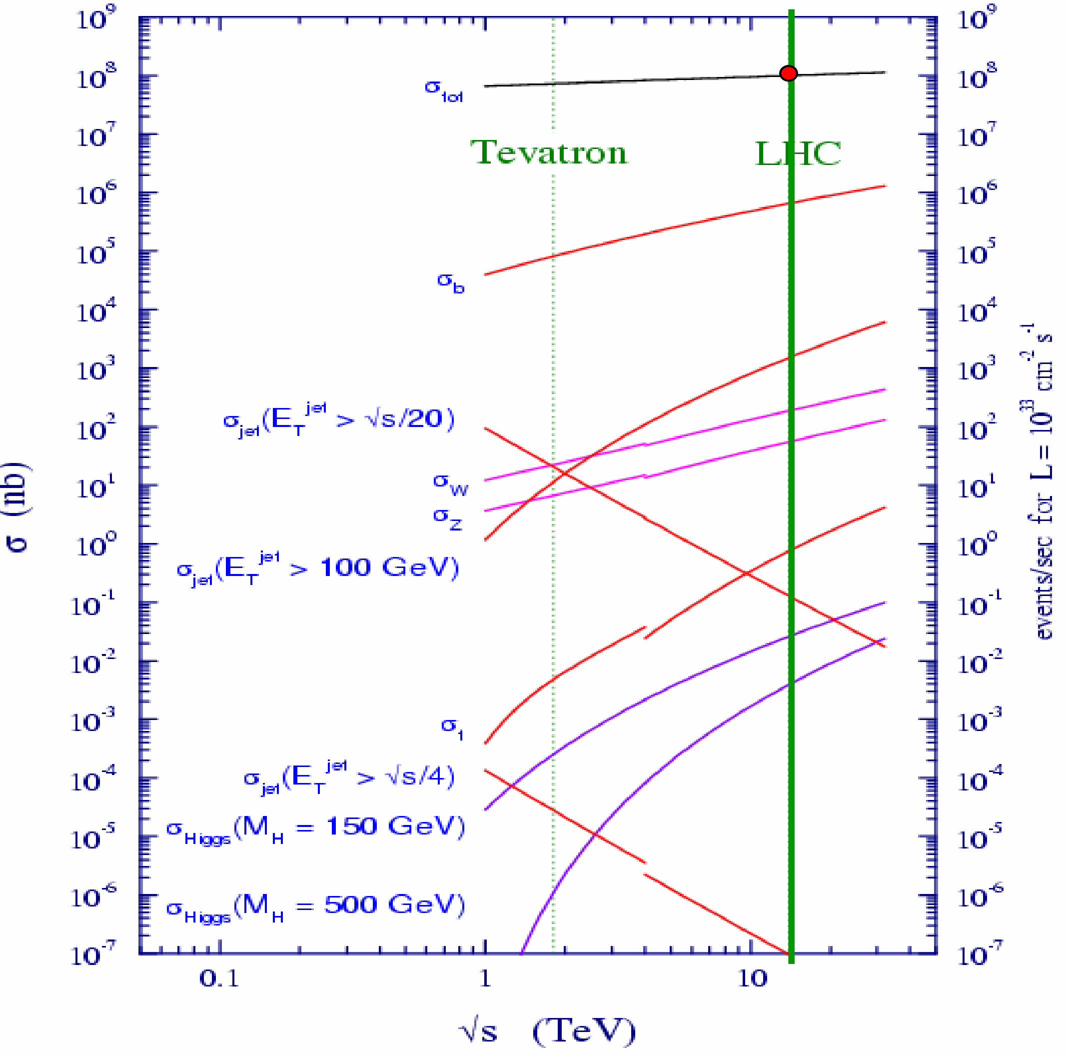
  In 10 years of LHC data: up to $10^{17}n$ cm^{-2}, up to 10^{7}Gy

  Radiation decrease like d^2 from beam: detectors near beam pipe mostly affected

  $\Rightarrow$ Need radiation resistant detector technologies especially at high $|\eta|$

  $\Rightarrow$ Need also radiation hard electronics

Backgrounds to discovery physics



High p_T events dominated by QCD jet production:

- Strong production
- Many contributing diagrams

$\sigma_{jet}(E_T^{jet} > 100\ \text{GeV}) \sim \mu\text{b}$

Signal processes rare:

- Involve heavy particles:

$\sigma_{\tilde{q}\tilde{q}}(m(\tilde{q}) \sim 1\ \text{TeV}) \sim \text{pb}$

- Have weak cross-section

$\sigma_{Higgs}(m(Higgs) = 100\ \text{GeV}) \sim 30\ \text{pb}$

QCD background from 5-6 orders of magnitude larger than signals

Overwhelming QCD backgrounds in exclusively hadronic channels

$\Rightarrow$ rely on final states involving γ, leptons, $\not{E}_T$, b-jets $\Rightarrow$ pay additional price in BR

Typical cross-section values:

Process	σ	Events/s	Events/year (low L)
$W \to e\nu$	15 nb	15	10^8
$Z \to ee$	1.5 nb	1.5	10^7
$\bar{t}t$	800 pb	0.8	10^7
$\bar{b}b$	500 μb	10^5	10^{12}
$\tilde{q}\tilde{q}$ (m$_{\tilde{q}}$ =1 TeV)	1 pb	0.001	10^4
Higgs (m$_H$ =0.8 TeV)	1 pb	0.001	10^4

Large statistics for discovery physics up to the TeV scale.

Large cross-section for Standard Model processes:

- Large backgrounds to discovery
- Large control samples to calibrate backgrounds

Precision measurements dominated by systematic effects

Collider detectors

Do not know how new physics will manifest itself:

⇒ Detectors must be sensitive to as many particles and signatures as possible:

$$e,\ \mu,\ \tau,\ \nu,\ \gamma,\ \text{jets},\ b-\text{quarks}$$

- Momentum/charge of tracks and secondary vertexes (e.g. from b-quark decays) measured in central tracker. Excellent momentum and position resolution required
- Energy and position of electrons and photons measured in electromagnetic calorimeters. Excellent position and energy resolution required
- Energy and position of hadrons and jets measured mainly in hadronic calorimeters. Good coverage and granularity required
- Muons identified and momentum measured in external muon spectrometer ($+$ central tracker). Excellent resolution required.
- Neutrinos "detected and measured" through measurement of missing transverse energy $\not{E}_T$. Calorimeter coverage over $|\eta| < 5$ needed

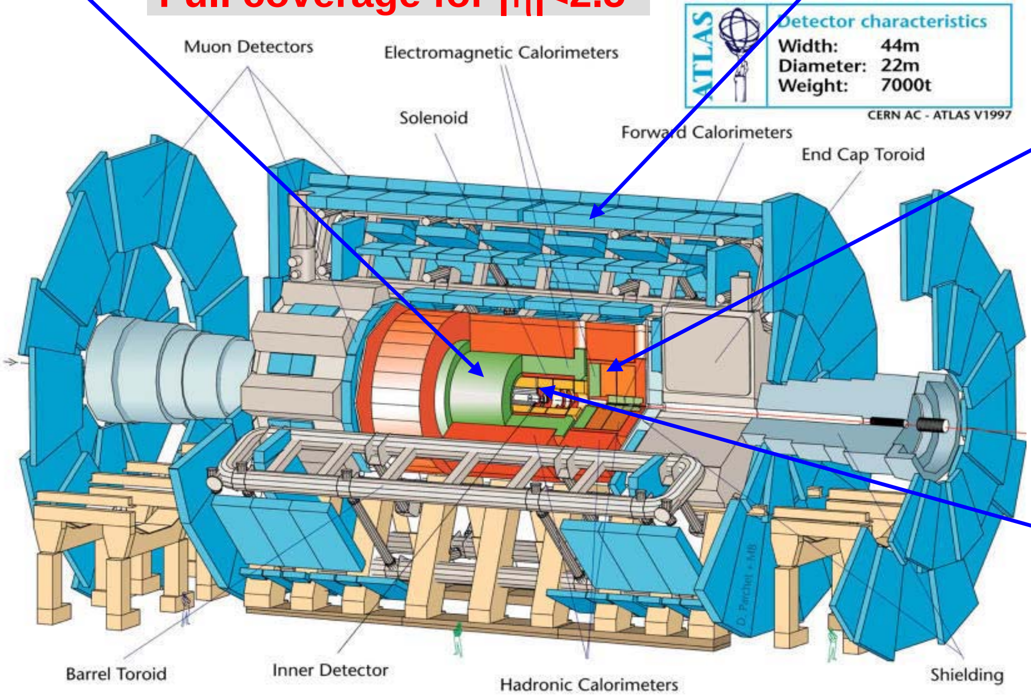
ATLAS detector

EM Calorimeters, $\sigma/E \approx 10\%/\sqrt{E(\mathrm{GeV})} \oplus 0.7\%$

excellent electron/photon identification

Good *E* resolution (e.g., $H \rightarrow \gamma\gamma$)

Full coverage for $|\eta|<2.5$



Precision Muon Spectrometer,

$\sigma/p_T \approx 10\%$ at 1 TeV/c

Fast response for trigger

Good *p* resolution

(e.g., $A/Z' \rightarrow \mu\mu$, $H \rightarrow 4\mu$)

Hadron Calorimeters,

$\sigma/E \approx 50\% / \sqrt{E(\mathrm{GeV})} \oplus 3\%$

Good jet and E_T miss performance

(e.g., $H \rightarrow \tau\tau$)

Inner Detector:

Si Pixel and strips (SCT) &

Transition radiation tracker (TRT)

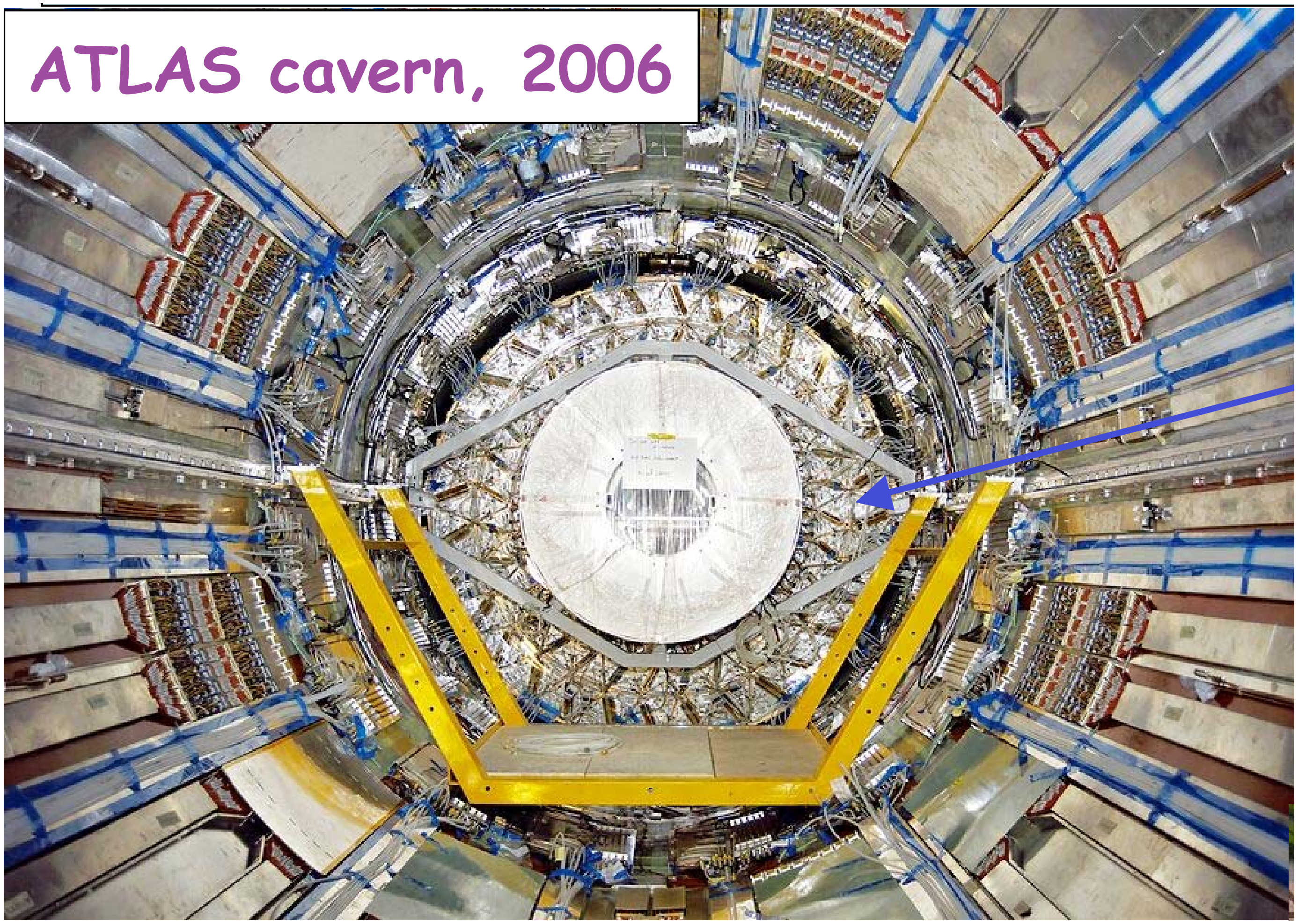
$\sigma/p_T \approx 5 \times 10^{-4}\, p_T \oplus 0.001$

Good impact parameter res.

$\sigma(d_0)=15\mu m@20GeV$ (e.g. $H \rightarrow bb$)

Magnets: solenoid (Inner Detector) 2T, air-core toroids (Muon Spectrometer) ~0.5T

ATLAS cavern, 2006

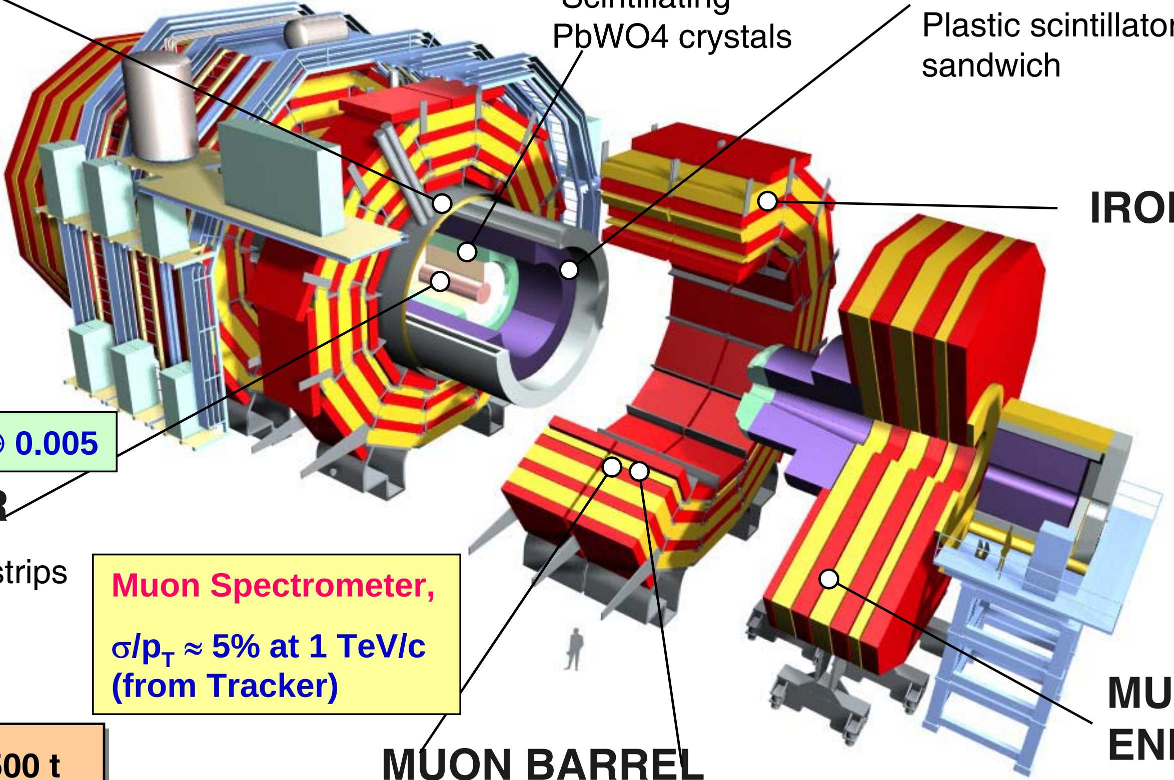


Recent milestones:

Inner Detector barrel (exc. pixel) inserted in solenoid and connected

Barrel toroid powered to full field

CMS detector



SUPERCONDUCTING COIL

EM Calorimeter,

$\sigma/E \approx 3\%/\sqrt{E(\mathrm{GeV})} \oplus 0.5\%$

Scintillating PbWO4 crystals

Hadron Calorimeter,

$\sigma/E \approx 100\% / \sqrt{E(\mathrm{GeV})} \oplus 5\%$

Plastic scintillator/brass sandwich

IRON YOKE

$\sigma/p_T \approx 1.5 \times 10^{-4}\, p_T \oplus 0.005$

TRACKER

Silicon Microstrips
Pixels

Muon Spectrometer,

$\sigma/p_T \approx 5\%$ at 1 TeV/c (from Tracker)

MUON ENDCAPS

Total weight : 12,500 t
Overall diameter : 15 m
Overall length : 21.6 m
Magnetic field : 4 Tesla

MUON BARREL

Drift Tube Chambers (**DT**)

Resistive Plate Chambers (**RPC**)

Cathode Strip Chambers (**CSC**)
Resistive Plate Chambers (**RPC**)

CMS cavern, 2006

Recent milestone:

First ring of detector lowered into cavern

	ATLAS	CMS
MAGNET (S)	Air-core toroids + solenoid in inner cavity Calorimeters outside field 4 magnets	Solenoid Calorimeters inside field 1 magnet
TRACKER	Si pixel + strips TRD → particle identification B=2T $\sigma/p_T \sim 5\text{x}10^{-4}\, p_T \oplus 0.01$	Si pixel + strips No particle identification B=4T $\sigma/p_T \sim 1.5\text{x}10^{-4}\, p_T \oplus 0.005$
EM CALO	Pb - liquid argon $\sigma/E \sim 10\%/\sqrt{E}$ uniform longitudinal segmentation	$PbW0_4$ crystals $\sigma/E \sim 3\text{-}5\%/\sqrt{E}$ no longitudinal segm.
HAD CALO	Fe-scintillator + Cu-liquid argon (10 λ) $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$	Cu-scint. (> 5.8 λ + catcher) $\sigma/E \sim 65\%/\sqrt{E} \oplus 0.05$
MUON	Air → $\sigma/p_T \sim 7$ % at 1 TeV standalone	Fe → $\sigma/p_T \sim 5\%$ at 1 TeV combining with tracker

A few examples of required performance:

- Lepton measurement: $p_T \sim \mathrm{GeV} \rightarrow 5\mathrm{TeV}$ ($b \rightarrow lX$, W', Z')
- Mass Resolution (m$\sim$ 100 GeV):

  $\sim 1\%$ $(H \rightarrow \gamma\gamma, 4l)$

  $\sim 10\%$ $(W \rightarrow jj,\ H \rightarrow bb)$

- Calorimeter coverage: $|\eta| < 5$ (E_T^{miss}, forward jet tag)
- Particle identification :

  $\epsilon_b \sim 50\%$ $R_j \sim 100$ ($H \rightarrow bb$, SUSY)

  $\epsilon_\tau \sim 50\%$ $R_j \sim 100$ $(A/H \rightarrow \tau\tau)$

  $\epsilon_\gamma \sim 80\%$ $R_j \sim 10^3$ $(H \rightarrow \gamma\gamma)$

  $\epsilon_e > 50\%$ $R_j \sim 10^5$

- Trigger: 40 MHz→ 100 Hz reduction

Crucial parameters for precision measurements

- Absolute luminosity: Goal: $< 5\%$

  Use: Machine, Optical theorem, Cross-Section for known processes

  (W, Z production, QED $pp \rightarrow pp\ell\ell$)

- Lepton energy scale: Goal: 0.1% (General)

  0.02% (W mass)

  Use: $Z \rightarrow \ell\ell$ (1 ev/s at low L)

  High precision possible for W, low mass h as mass close to Z

- Jet energy scale: Goal: 1%

  Use: $Z + jets(Z \rightarrow \ell\ell)$, $\gamma + jets$, $W \rightarrow jj$ from top decay, multi-jet balance

  Needed for for SUSY parameter, top mass, jet cross-section

  Limited by physics effects

Electron-photon identification (ATLAS)

Separate electrons/photons from the overwhelming background of QCD jets

Reject charged hadrons in jets through longitudinal and lateral energy deposition pattern (lateral and longitudinal segmentation). Identify EM object

Main remaining background : fragmentation of quarks/gluons where a π^0 carries away most of the momentum, with the decay $\pi^0 \to \gamma\gamma$

Distinguish two photons from π^0 decay from single photon through detailed study of EM shower in Calorimeter

High EM calo granularity crucial to separate two photons

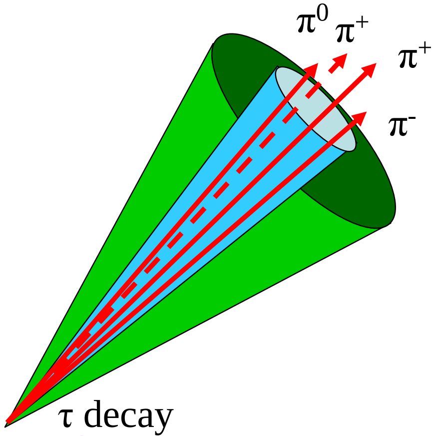
If track from $\pi^\pm$ superimposed to EM cluster can fake electron

Use matching between position/momentum of track and position/energy of EM cluster to reject fake electrons

Require excellent EM energy and position resolution

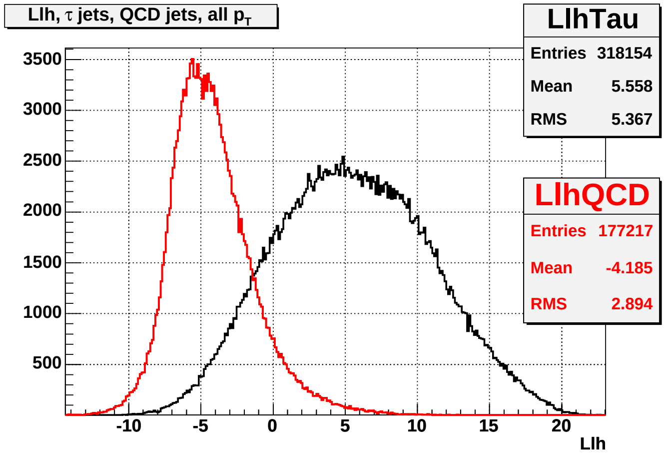
Identification of τ hadronic decays

Exploit difference between hadronic decays of τ's and QCD jets:

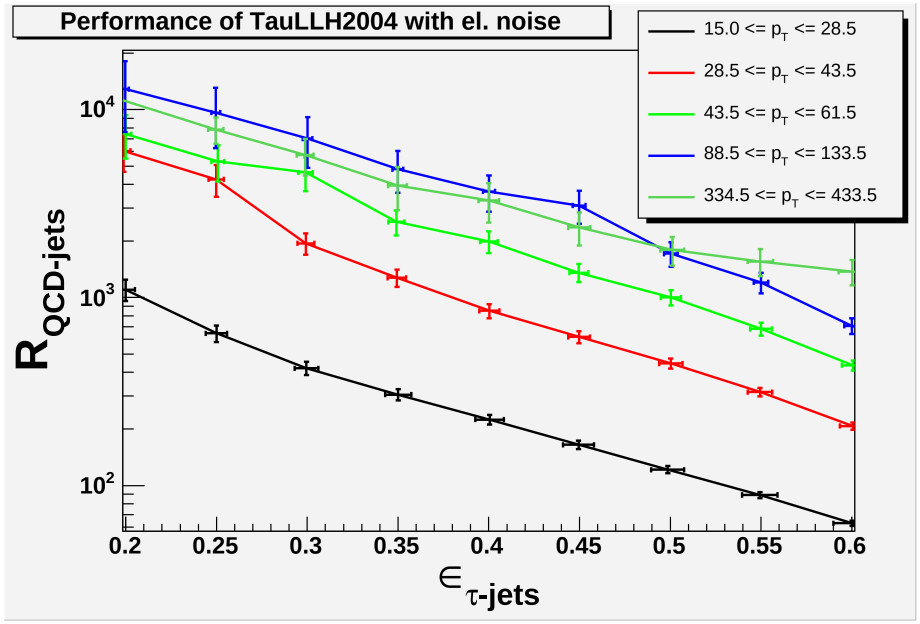


- Low track multiplicity ($1 < N_{tr} < 3$), charge
- Narrow jet in calo (Radius in EM calo, Number of strips in presampler)
- Impact parameter

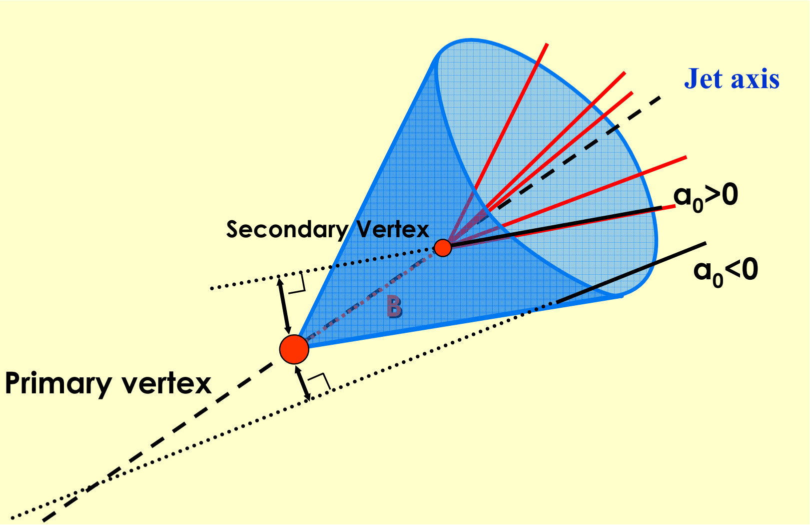
ATLAS study: build likelihood function in bins of jet P_T ($15 < P_T < 600$ GeV)



ATLAS preliminary



B-tagging

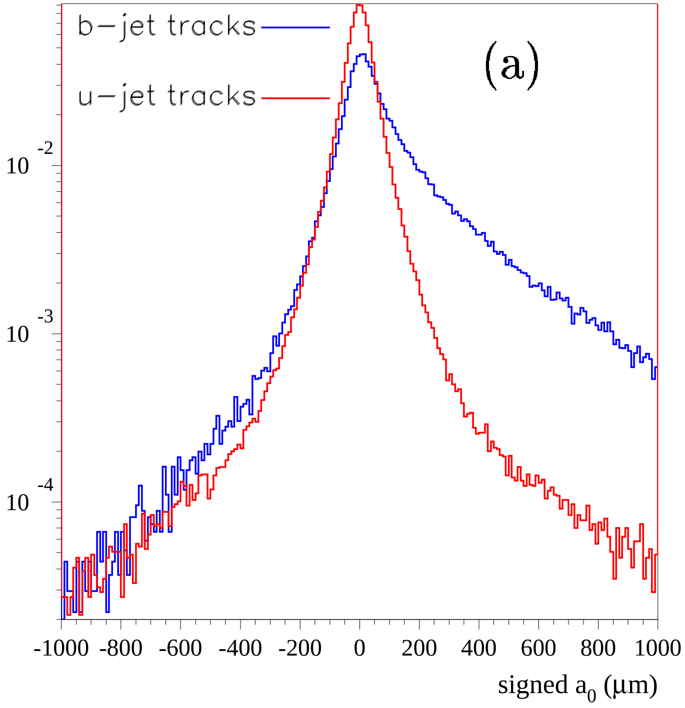


b-hadrons decay a a few mm away from interaction vertex

Measure decay path of b-hadrons through impact parameter: minimum distance from primary vertex

Distribution of impact parameter symmetric for tracks from fragmentation of light quarks

Significant enhancement of positive impact parameters for tracks from *b*-hadron decays

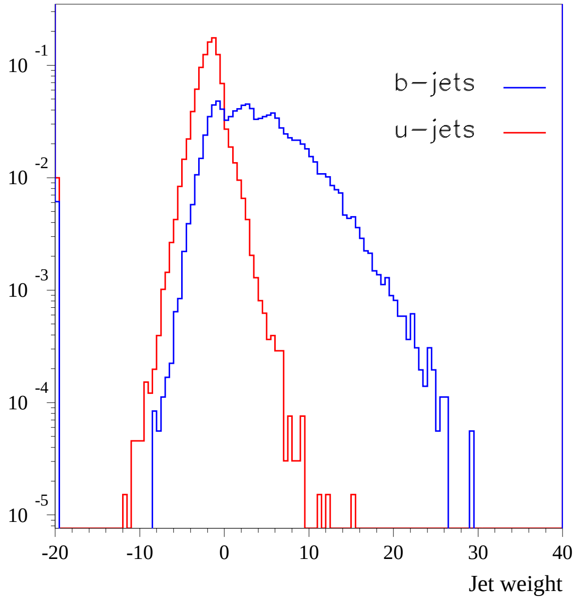


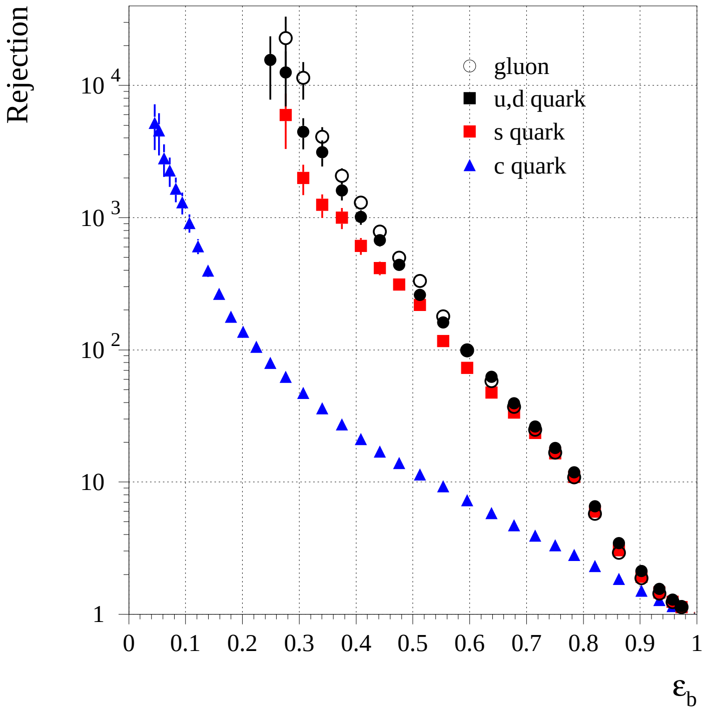
B-tagging (cont)

For a jet, build likelihood function from the impact parameter of the tracks associated to it

ATLAS: Study samples of fully simulated WH, ttH, $\bar{t}t$ events

Measure rejection on QCD jets as a function of tagging efficiency





ATLAS TDR: rejection factor of 100 on light jets for $\epsilon_b = 60\%$

Commissioning scenarios

In summary we need to address a very difficult problem:

- Complex detector with tens of millions of channels and many different subsystems
- Ambitious performance goals, based on complex algorithms involving the combined performance of all subdetector systems

Large amount of work (and time) required to control detector at desired level

Need however to be ready to optimally exploit the very first LHC data

Final understanding of detectors only with real collisions in LHC environment

Develop strategy to exploit time from now to collisions to achieve detector understanding adequate to fully take advantage of data from the first day

Main variables: readiness of detectors, time before LHC is running at full steam, building up of integrated luminosity

Tentative LHC schedule (CERN council June 2006)

• Last magnet installed	March 2007
• Machine and experiments closed	31 August 2007
• First collisions ($\sqrt{s} = 900$ GeV, $\mathcal{L} \sim 10^{29}\ cm^{-2}s^{-1}$)	November 2007
• Commissioning run at 900 GeV (~ 30 days)	until end 2007
• Shutdown	3-4 months (?)
• First collisions at 14 TeV (followed by physics run)	2^{nd} half June 2008

Two sectors fully commissioned up to 7 TeV in 2006-2007

If other sectors commissioned to to 7 TeV no circulating beam in 2007

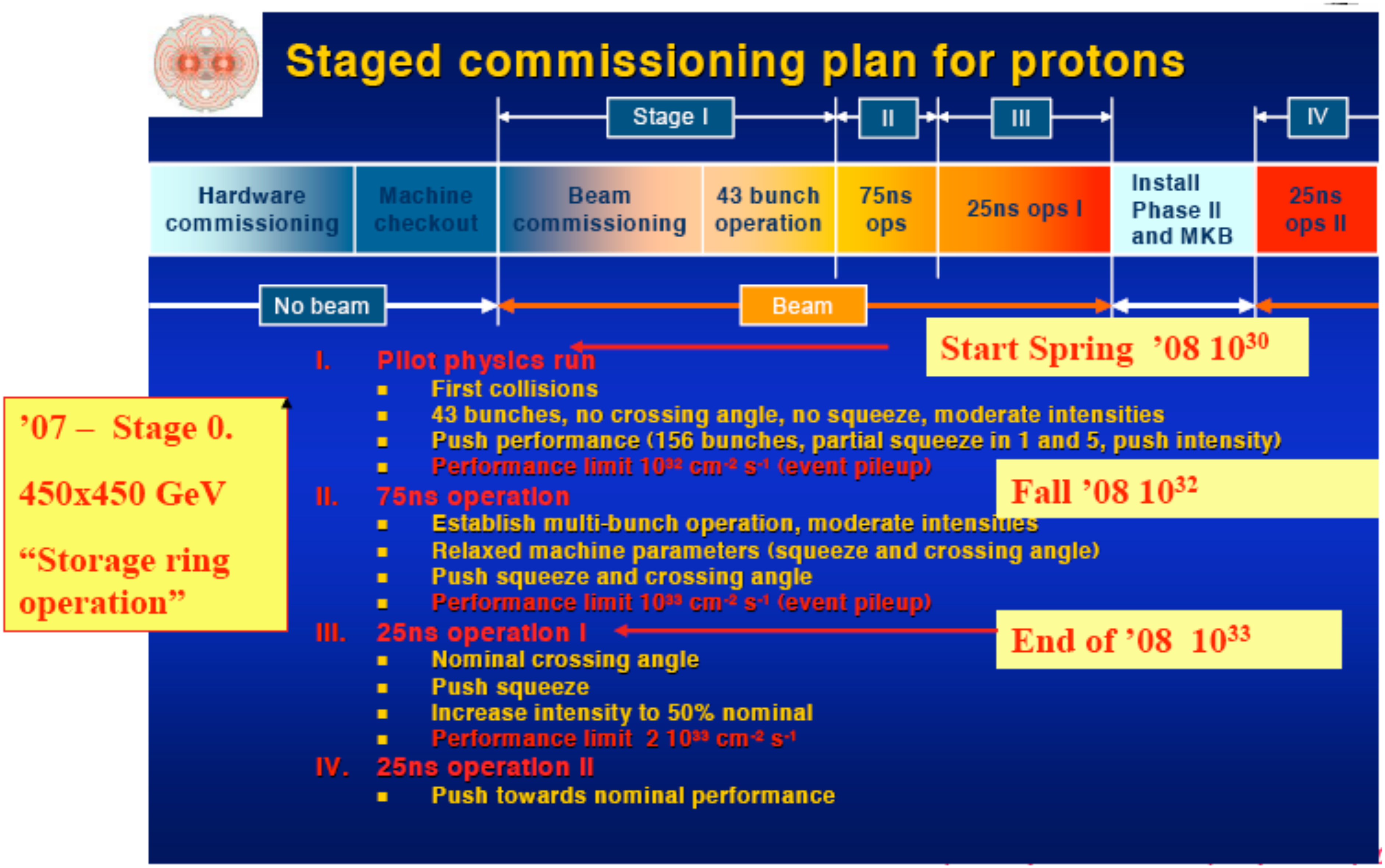
⇒ commission other sectors up to field needed for degaussing

Initial operation at 900 GeV (CM) with static machine (no ramp, no squeeze)

→ use for debugging of machines and detectors

Full commissioning up to 7 TeV during winter 2008 shutdown

Possible scenario for machine startup (machine presentation)



Staged commissioning plan for protons

Stage I | II | III | IV

Hardware commissioning | Machine checkout | Beam commissioning | 43 bunch operation | 75ns ops | 25ns ops I | Install Phase II and MKB | 25ns ops II

No beam | Beam

I. Pilot physics run
- First collisions
- 43 bunches, no crossing angle, no squeeze, moderate intensities
- Push performance (156 bunches, partial squeeze in 1 and 5, push intensity)
- Performance limit 10^{32} cm^{-2} s^{-1} (event pileup)

II. 75ns operation
- Establish multi-bunch operation, moderate intensities
- Relaxed machine parameters (squeeze and crossing angle)
- Push squeeze and crossing angle
- Performance limit 10^{33} cm^{-2} s^{-1} (event pileup)

III. 25ns operation I
- Nominal crossing angle
- Push squeeze
- Increase intensity to 50% nominal
- Performance limit 2 10^{33} cm^{-2} s^{-1}

IV. 25ns operation II
- Push towards nominal performance

Start Spring '08 10^{30}

Fall '08 10^{32}

End of '08 10^{33}

'07 – Stage 0.

450x450 GeV

"Storage ring operation"

Integrated luminosities and dates: presentation by H. van der Schmitt

Based on this information develop start-up strategy

- Last few years: extensive test-beam activities with final detector components
  - Standalone Detector test beams: Basic calibration of calorimeter modules, test of electronics and alignment procedures
  - ATLAS combined test-beam of full slice of detector: test in real life particle ID algorithms, procedures of inter-detector alignment, validation of detailed simulation
- Now, extending up to most of 2007:
  - Computing System Commissioning (CSC), Calibration Data Challenge (CDC): Develop software tools for performing calibration and alignment and perform analysis on non-ideal detector: asymmetric, misaligned, miscalibrated.
  - Cosmics data taking: detector timing and alignment

- From first injections: beam-halo and beam-gas interactions. More specialised alignment work
- 900 GeV interactions: First shake-down of detector with real collisions, some physics measurements (Minimum bias, jets)
- First 14 TeV interactions:
  - Understand and calibrate detector and trigger in situ using well-known physics samples:
    - $Z \to ee, \mu\mu$: tracker, ECAL, muons system
    - $tt \to b\ell\nu bjj$: Jets scale, b-tag performance, $\not{E}_T$
  - Understand basic SM physics at 14 TeV: first checks of MonteCarlo
    - jets and W, Z cross-section top mass and cross-section
    - Event features: Min. bias, jet distributions, PDF constraints
  - Prepare road to discovery: background to discovery from tt, W/Z + jets.

Physics with early data

Realistic approach: assume low selection efficiency for interesting events

Process	$\sigma \times BR$		Events selected for 100 pb^{-1}
$W \to \ell\nu$	20 nb	$\sim 20\%$	~ 400000
$Z \to \mu\mu$	2 nb	$\sim 20\%$	~ 40000
$\bar{t}t$ (semileptonic)	370 pb	$\sim 1.5\%$	< 1000

Jets and minimum bias statistics only limited by allocated trigger bandwidth

Already in autumn 2008 probably enough statistics for physics studies

It is mandatory to demonstrate that we understand LHC physics through SM measurement before going for discovery physics

Nobody will believe we have an excess in a channel with $\not{E}_T$+leptons+jets if we can not show that we can perform measurements on jets, W, Z, top

Show today plans for some early measurements which will probably be the first physics publications from the LHC

Minimum bias and Underlying Event studies

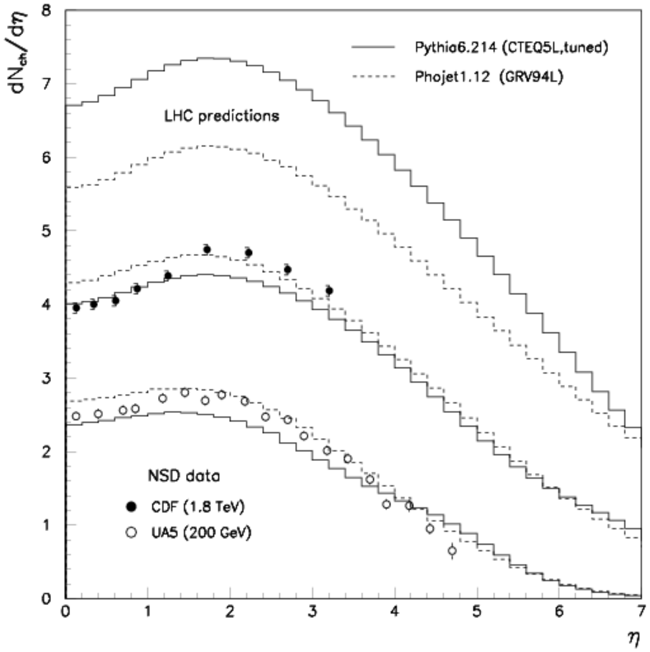
Hadronic interactions:

- Hard processes (high p_T): well described by PQCD
- Soft interactions (low p_T): require non-perturbative phenomenological models:
  - Minimum bias: non single-diffractive events: $\sigma \sim 60 - 70$ mb
  - Underlying event: everything except two outgoing hard scattered jets

First physics available at the LHC

Interesting *per se*

Modeling of minimum bias pile-up and underlying event necessary tool for high P_T physics



Large uncertainty in prediction of track multiplicity when extrapolating from Tevatron data

Measuring minimum bias with early data (ATLAS preliminary)

Number of charged tracks N_{ch} as a function of η ($dN_{ch}/d\eta$) and p_T ($dN_{ch}/d\eta$)

On fully simulated events compare reconstructed to generated distributions

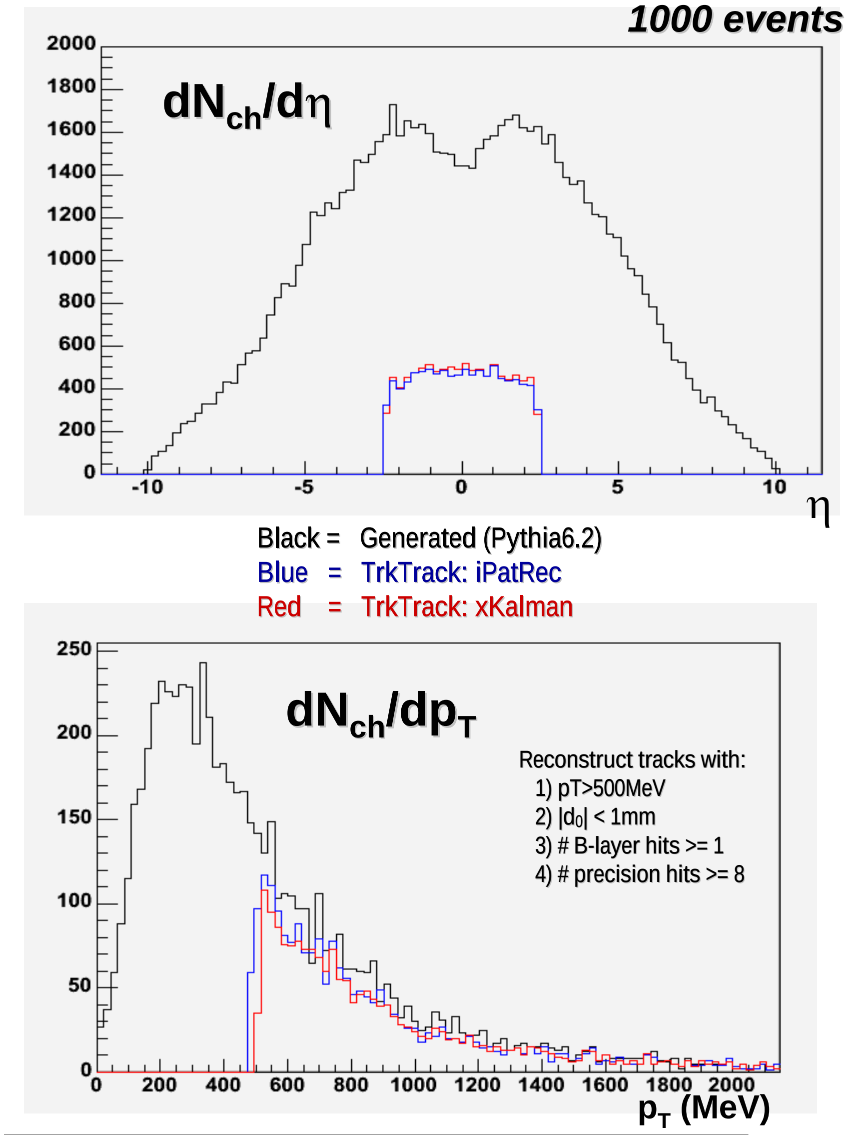
Very few events required

Only a fraction of tracks reconstructed:

- Limited rapidity coverage
- Can only reconstruct track p_T with good efficiency down to ~500 MeV

Need to apply correction factor from MonteCarlo to subtract minimum bias: systematic uncertainty

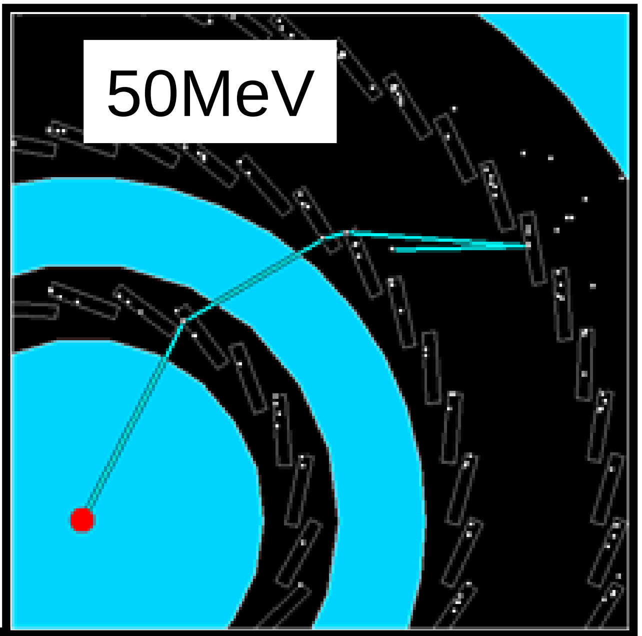
Explore extending tracking down to lower p_T



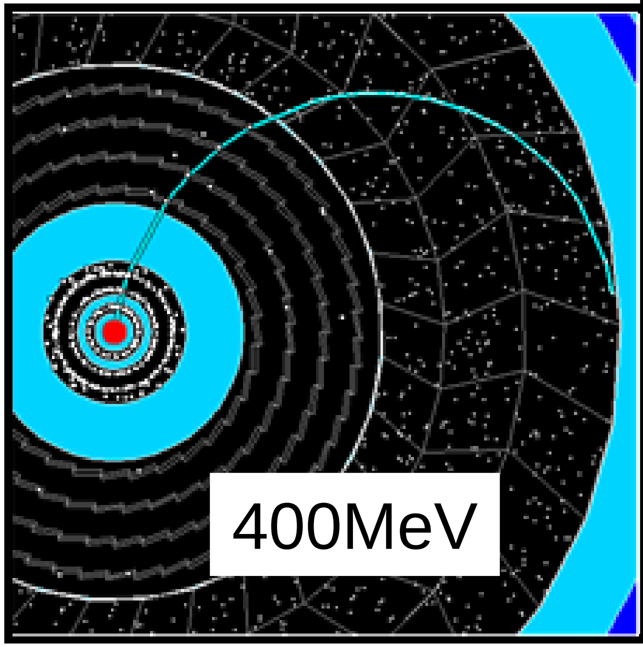
Preliminary exploration of low-pt track reconstruction in ATLAS ID

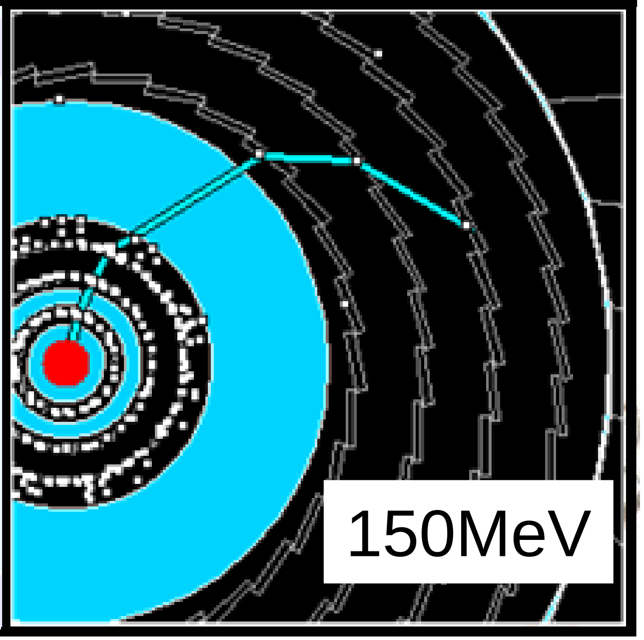
- Tracker is in principle sensitive to soft tracks
  - Pt = 400 MeV - tracks reach end of TRT
  - Pt = 150 MeV - tracks reach last SCT layer
  - Pt = 50 MeV - tracks reach all Pixel layers

- Event graphics using Fatras simulation
  - Tools are there to tune for such tracks

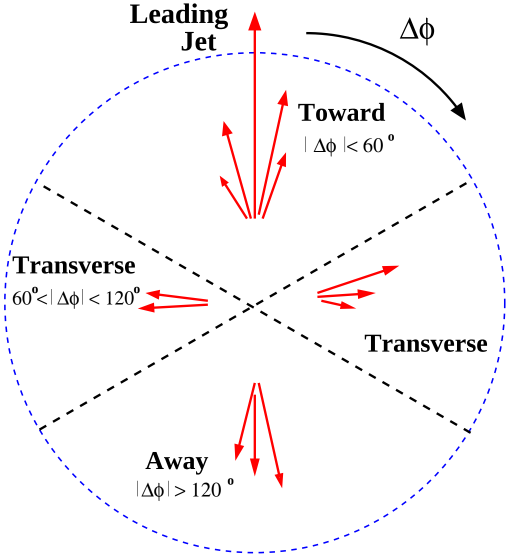


A.Salzburger





Measuring Underlying Event at the LHC



Perform measurement by looking at tracks in the “transverse” region with respect to jet activity

On fully simulated events compare reconstructed and generated multiplicity

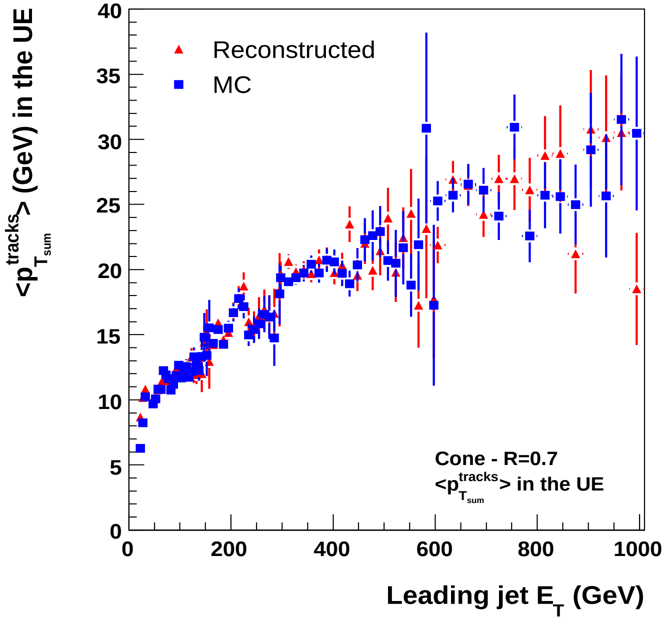
Select:

$N_{jet} > 1 \quad p_T^{jet} > 10 \text{ GeV} \quad |\eta_{jet}| < 2.5$

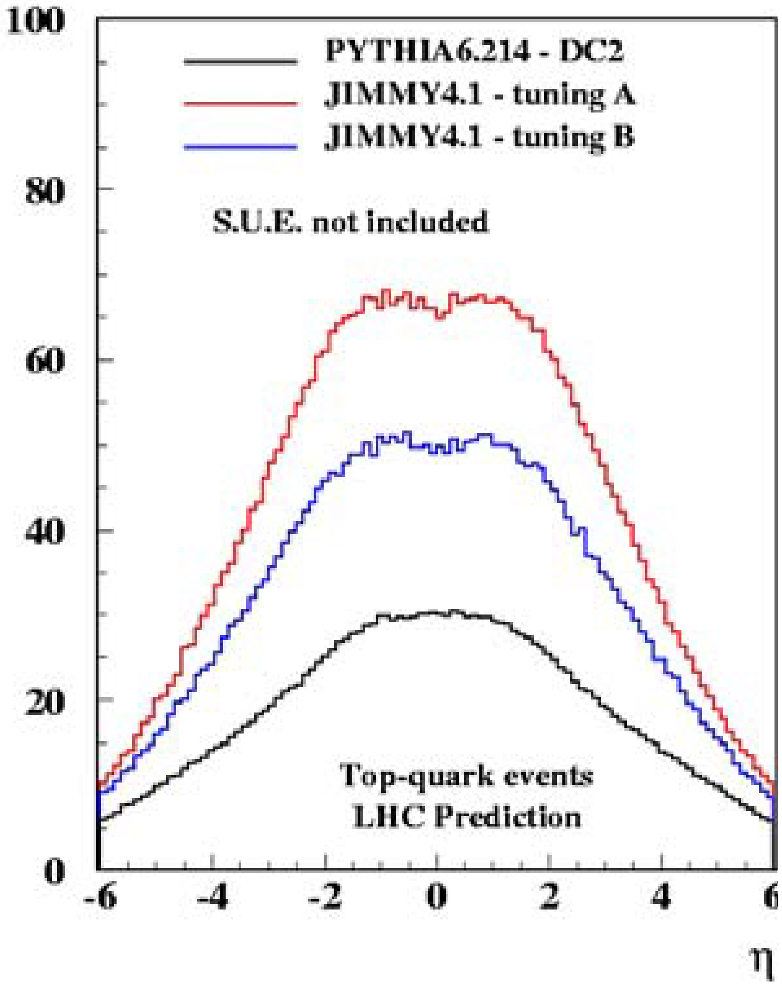
$p_T^{track} > 1.0 \text{ GeV} \quad |\eta_{track}| < 2.5$

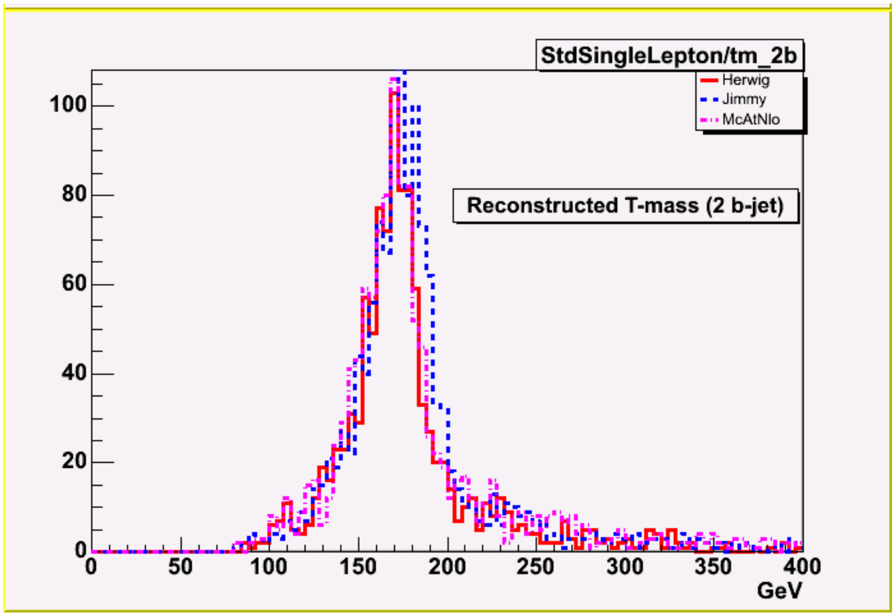
Good agreement reconstructed/generated

Can use to tune MonteCarlo



Example: Impact on top mass measurement





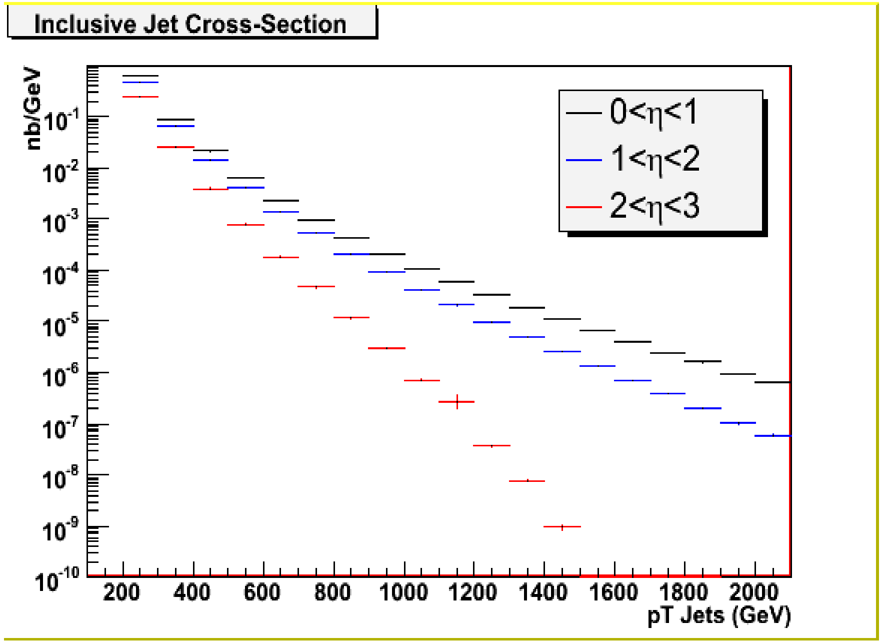
Different UE models can shift top mass by up to 5 GeV

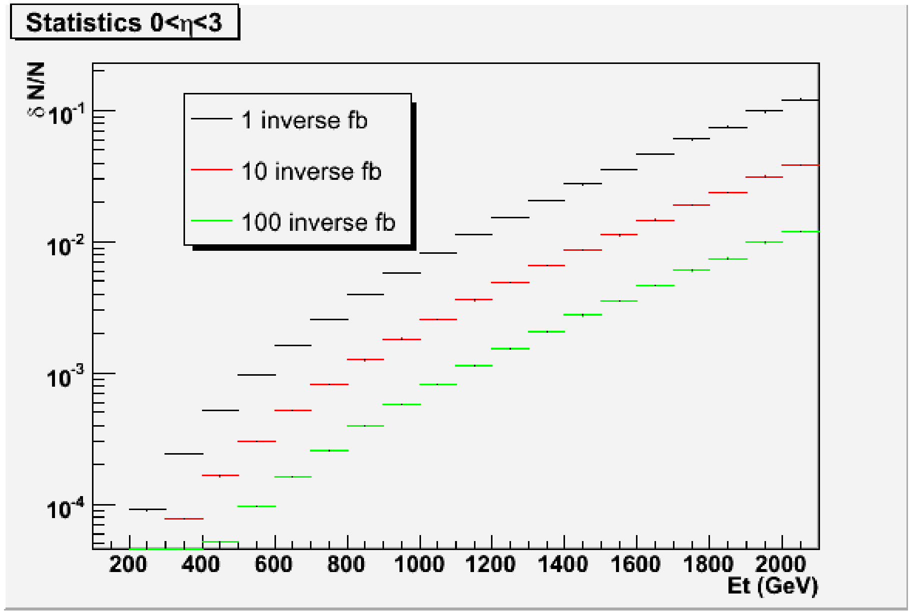
Need excellent UE modeling to perform subtraction

Inclusive Jet cross-section measurement

Concerns all events containing jets, the bulk of high p_T events at the LHC

Show preliminary investigation of ATLAS Glasgow group assessing relative weight of possible error sources





Statistical error

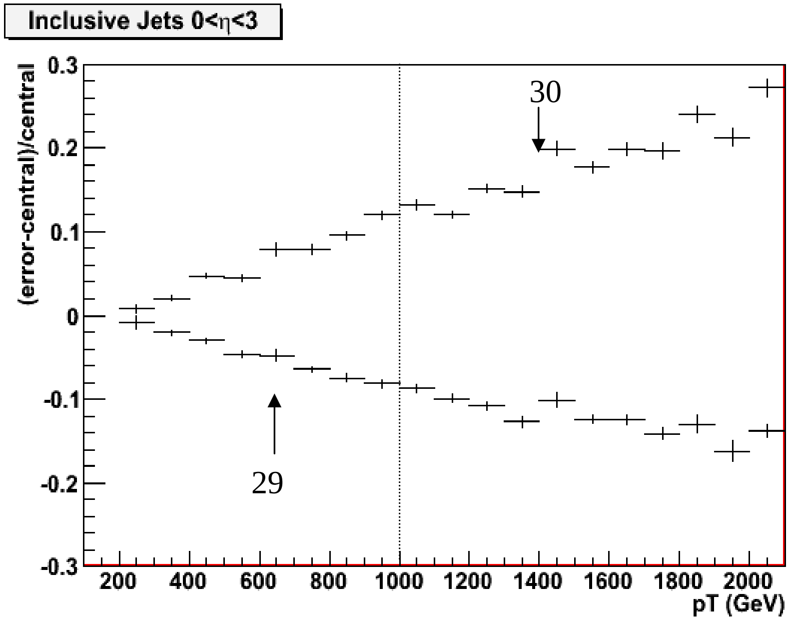
Naive estimate: take error as $\sqrt{N}$, with N number of events for a given integrated luminosity

Plot relative error $\sqrt{N}/N$

For 1 fb^{-1} 1% error for $P_T(jet) \sim 1$ TeV

For 100 pb^{-1} 1% error for $P_T(jet) \sim 0.8$ TeV

Theoretical uncertainties



Use LHAPDF error estimate

Study relative change of NLOJET X-S for the extreme sets of the CTEQ6 PDF

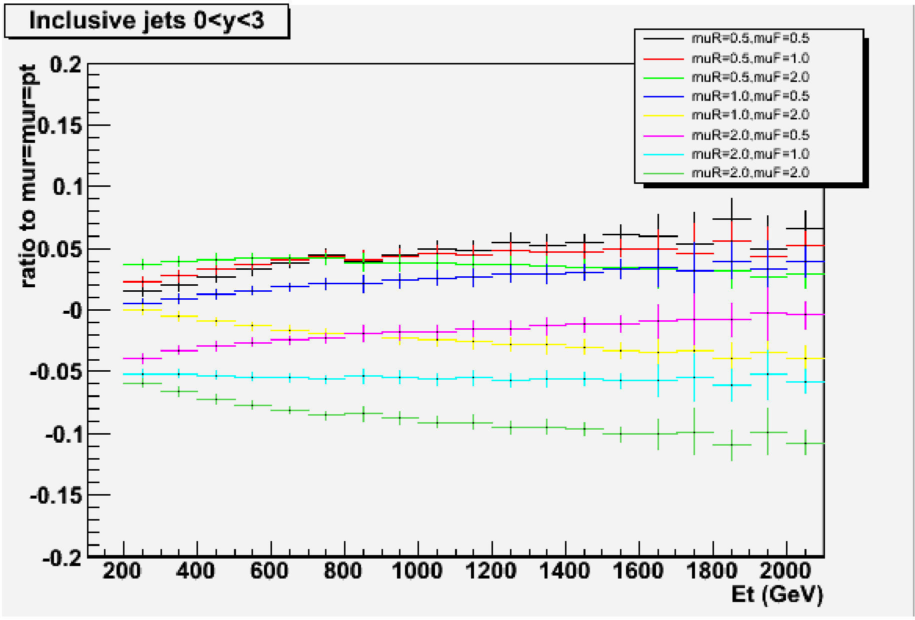
For a jet p_T of 1 TeV errors are approx 10 to 15%

Dominated by high-x gluon uncertainty

Vary renormalisation (μ_R) and factorisation scale (μ_F) between $0.5E_T$ and $2E_T$

Relatively small variation due to use of NLO cross-sections

Uncertainty of 5 to 10% on inclusive jet cross-section for jet p_T of 1 TeV

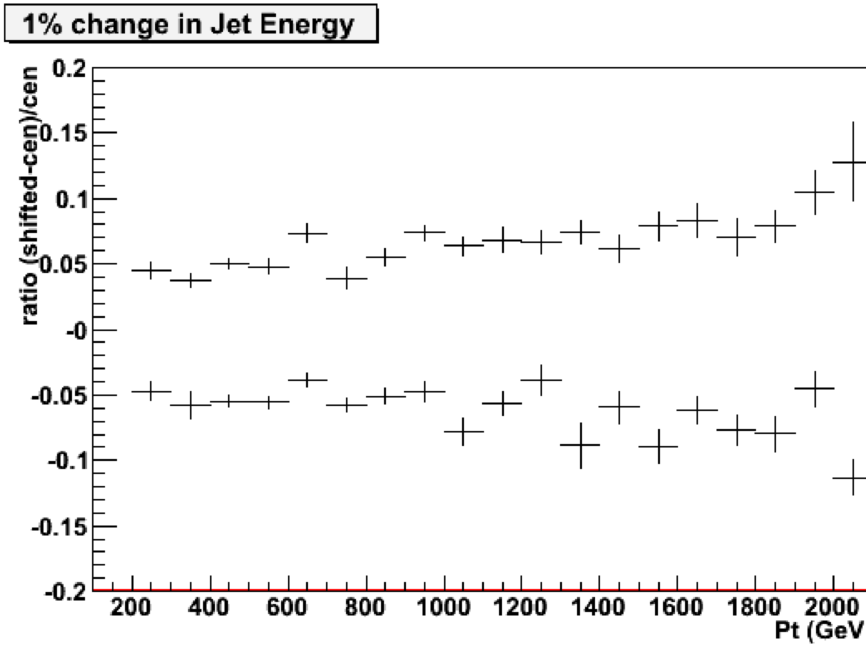


Experimental errors

Many possible sources of experimental errors:

- Jet energy scale,
- Linearity of calo response
- Jet resolution, UE subtraction, trigger efficiency....
- Luminosity determination

Focus on jet energy scale, dominant in Tevatron analyses



Uncertainty on jet scale of 1% yields error on σ(jet) X-s of 6%

Uncertainty on jet scale of 5% yields error on jet σ(jet) of 30%

Jet scale must be known to $\sim 1\%$ in the TeV region: $\Rightarrow$ control of linearity to carry to high energy scale established at 100 GeV.

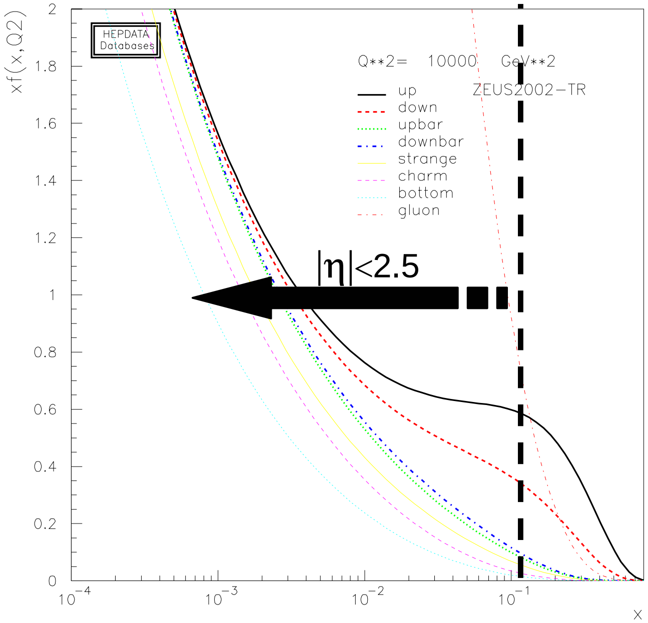
Requires studies of many control samples: tt, γ+jets, Z+jets,... likely to be the dominant factor in determining the time of publication

Studies of W and Z production

W and Z production cross-section precisely predicted by QCD

Measuring them is one of first basic physics checks at the LHC

Eventually can be used as a luminosity measuring device if theoretical and experimental uncertainties down to ∼3%



Main theoretical uncertainty: PDF parametrisation

For W and Z production at the LHC:

- Dominant sea-sea parton interactions at low x
- At $Q^2 = M_Z^2$ sea distributions driven by gluon
- Low x gluon has large uncertainty

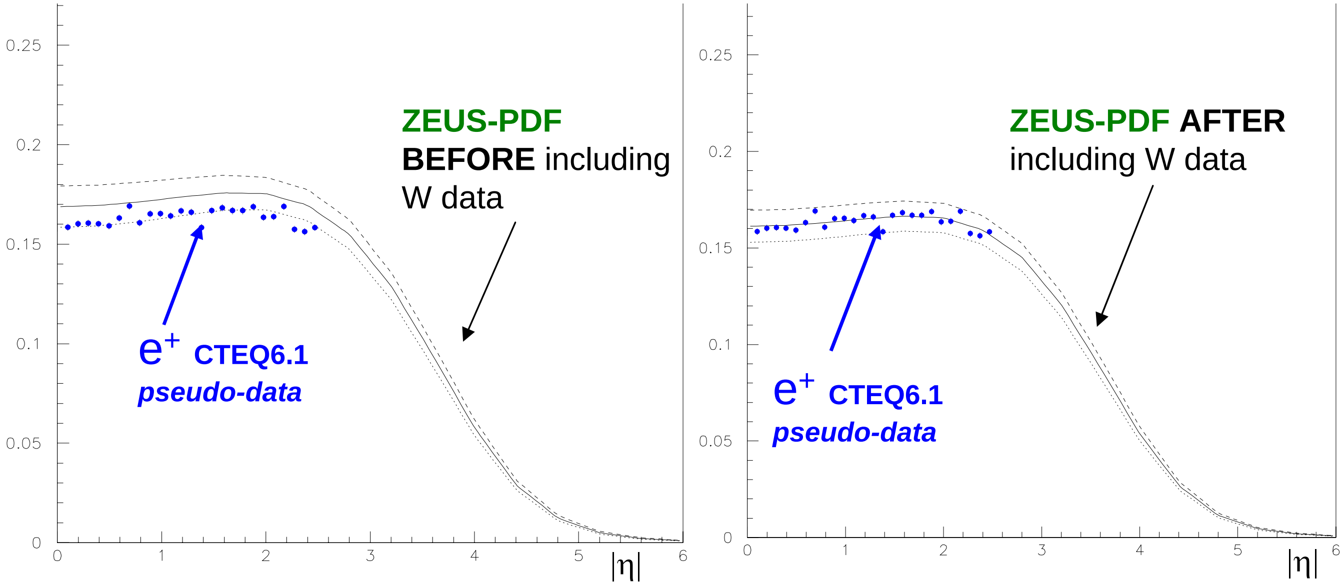
Studying W and Z production can increase our knowledge of gluon SF

Show study performed by ATLAS Oxford group (see talk by A. Tricoli)

PDF constraining potential of ATLAS

Exercise: generate 1M ATLAS pseudo-data (ATLFAST) with CTEQ6.1 PDF's, correct back for acceptance effects, and include in ZEUS PDF fit

Statistics corresponds to $\sim$100-200 pb^{-1}



To simulate experimental uncertainties impose a 4% random error on data points

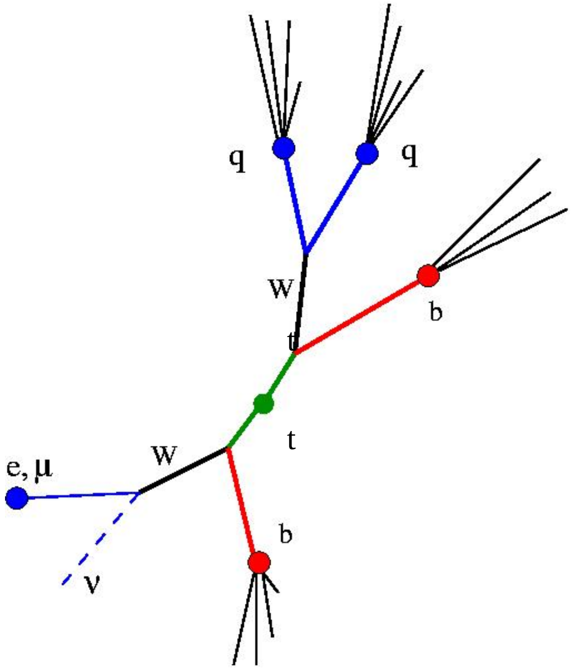
Low-x gluon distribution determined by shape parameter λ ($xg(x) \sim x^{-\lambda}$)

Observe 35% error reduction λ when ATLAS pseudo-data included in fit

Early top physics in ATLAS

Top production is ideal laboratory for initial studies

Very high cross-section at the LHC: $\sigma_{\bar{t}t} = 830$ pb



Semi-leptonic signature: $\bar{t}t \rightarrow b\ell\nu bqq$:

Easy to trigger on and to extract

involves many detector signatures:

lepton-id, $\not{E}_T$, Jet reconstruction and calibration, b-tagging

Three main aspects of early top studies:

- Initial measurements of mass, σ_{tt}, possible deviations due to new physics
- Use as a calibration tool
- Learn how to control top as a background

Commissioning scenarios

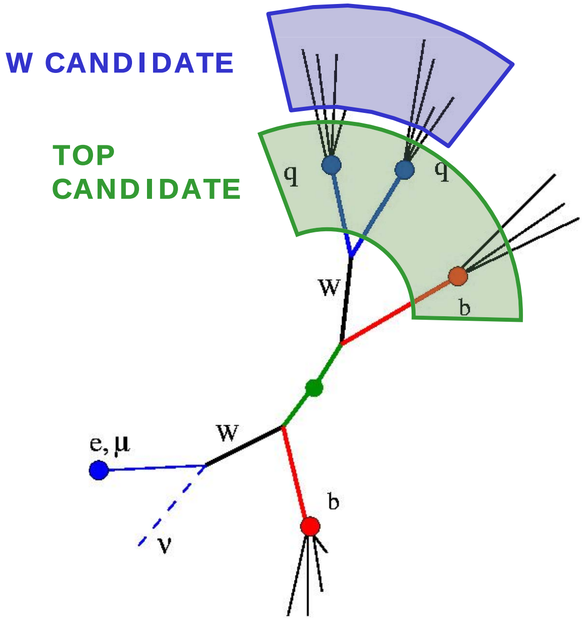
Several months to achieve pixel alignment necessary for nominal b-tagging

Study separation of sample of top events from background without b-tagging

- Use high multiplicity in final state
- hard p_T cuts to clean sample and minimize contribution of additional jets

Even with a 5% selection efficiency still have ~10 events/hour at 10^{33}

Full simulation study by the ATLAS NIKHEF group



Jet assignment:

Hadronic top:

Three jets with highest $\sum \vec{p}_T$ as top decay products

W boson:

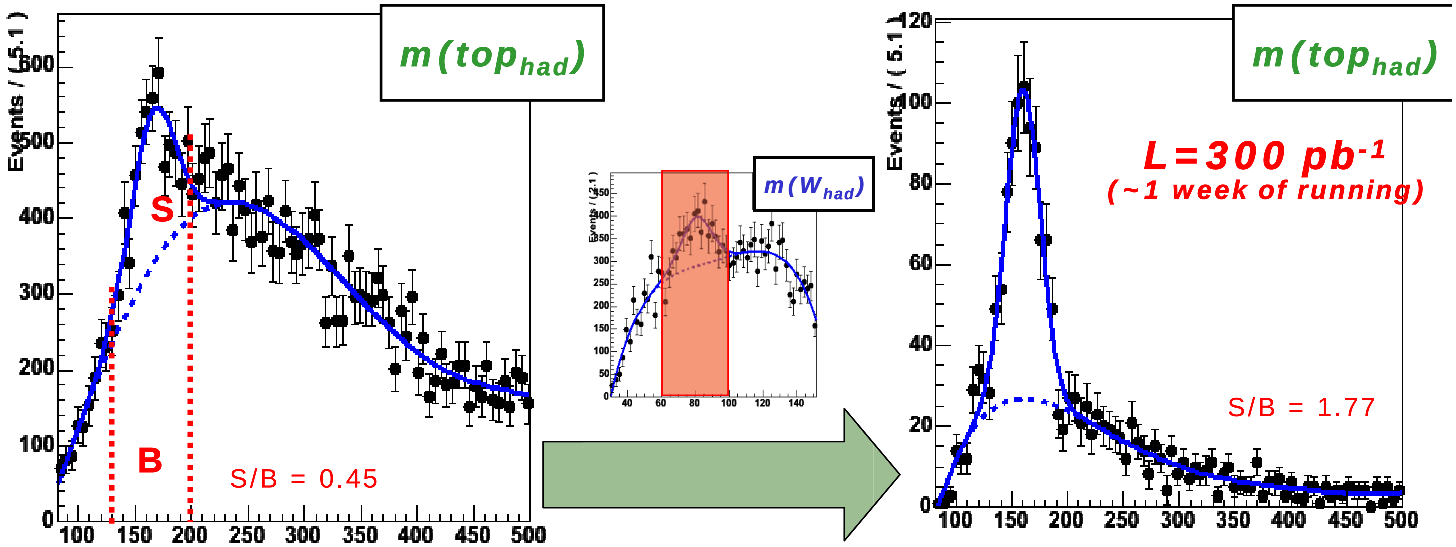
Two jets in hadronic top with highest momentum

in reconstructed jjj C.M. frame

Signal + W+jets background

Exploit correlation between $m(top_{had})$ and $m(W_{had})$ to clean top signal

Show $m(top_{had})$ only for events with $|m(jj) - m(W)| < 10$ GeV



A clear top signal can be observed even at low statisitcs

Expect a statistical error on cross-section between 5 and 10%, depending on cuts

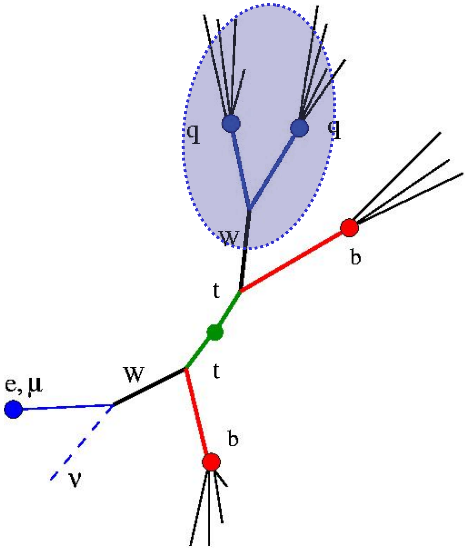
Error on $m(top)$ already dominated by systematic effects

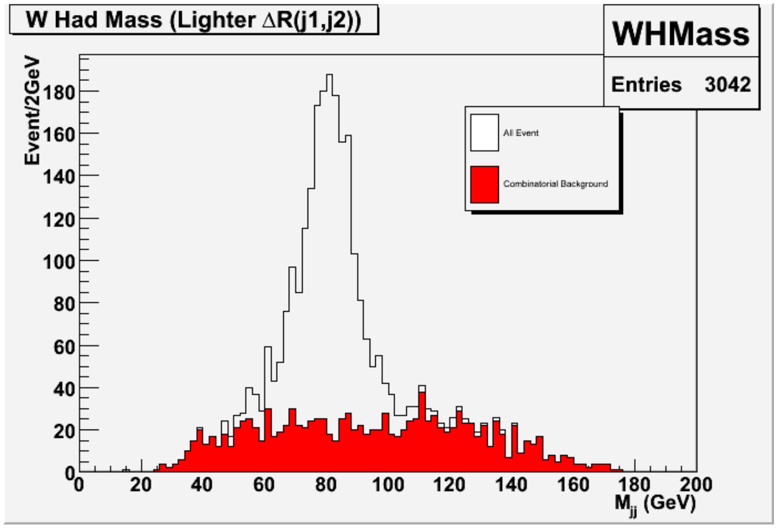
Using ttbar events: jet energy scale from W

Preliminary exercise on ATLAS full simulation (D. Pallin)

Use top semileptonic decay: select two light jets from W decay, and calibrate to W mass

Selection with 1 or 2 b tags Typically 3000(6000) W/fb^{-1} for 2(1) b-tag, $\epsilon_{btag} = 60\%$





W mass distribution ATLAS full sim, 500 pb^{-1}.

Using both b-tagging and kinematic constraints achieve purity of 80-90%

Cover jet energies from 40 to 400 GeV

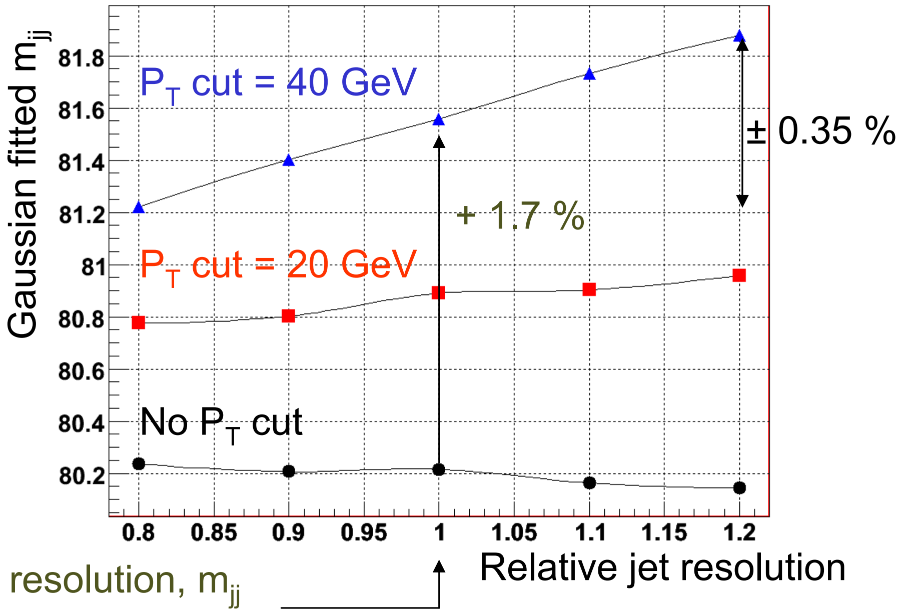
Use a naive jet scaling method for equating the peak position to the nominal W mass

Expect to achieve a 1% calibration level with 1 fb^{-1}

Systematic effects

Two main sources of systematics being studied (Saclay group):

- Dependence on selection cuts applied to define the W sample
- Dependence on assumed jet resolution, skewing the lower energy jets



For a given P_T cut, m_{jj} depends on the jet resolution

For a given resolution, m_{jj} depends on P_T cut

More sophisticated methods being developed to take into account these effects

Conclusions

LHC startup will require a long period of development and understanding for both machine and detectors

Detailed commissioning plan for detectors: plan to achieve baseline 'reasonable' calibration and alignment before collisions using cosmics and machine development periods

As soon as interactions at 14 TeV happen, interesting physics available in data

Parallel processes of using data to further 'technical' detector understanding and to perform benchmark SM physics measurements

Goal is to arrive at high statistics (few fb^{-1}) data-taking ready to go for early discovery physics