ATLAS Physics Workshop

Lund, September 12^{th} – 16^{th}

Selected General and Level-1 related topics

Workshop Format

- No parallel sessions
  - 2 days of 8 hours+
  - 3 days of 4 hours+
- >100 talks, mostly about 15 minutes
- Divided into 15 sessions
  - 7 Physics working groups
    - SUSY, Higgs, Generators, QCD+EW, Top, B, Exotics
  - 6 Performance/Validation groups
    - Software, Inner Detector (b-tag), e/gamma, Jet/E^{t}, Muon, Trigger (PESA)
  - 2 General

Main Themes

- Post TDR changes to physics analyses due to:
  - Changes in detector design
    - Beam-pipe and Pixel layout
    - Calorimeter Endcap shift
    - Larger muon holes
  - Detector staging in 2006
  - New software (GEANT and Athena)
  - New algorithms
  - New physics channels

General talks

- Initial running and detector staging
- Prospects for SUSY at LHC
  - Likely particle spectra from recent constraints
- Highlights of Snowmass
  - Mainly future colliders
- Statistics and LHC
  - Optimising low statistic searches (cf LEP)
- Prospects for Super-LHC
- Conclusions

Which detector for the first LHC run in 2006 ?

Most recent LHC schedule

31-12-2005	Ring closed and cold
1-1-2006 to 31-3-2006	Machine commissioning (1 beam)
1-4-2006 to 30-4-2006	First collisions , pilot run L=5x10^{32} to 2x10^{33} , $\leq$ 1 fb^{-1} Start detector commissioning $\sim 10^5$ Z $\to \ell\ell$, W $\to \ell\nu$, tt events
1-5-2006 to 31-7-2006	Shutdown: continue det. installation
1-8-2006 to 28-2-2007	**Physics run : L=2x10^{33}, 10 fb^{-1}** Continue detector commissioning $\to$ start physics

Due to resource, technical and schedule constraints (additional costs, tight construction schedule for some detector parts, 9 month delay in cavern delivery by civil engineering), complete ATLAS detector will not be available in August 2006

⬇

Initial staged detector

(design guided strongly by physics)

-- Pixels : 2 layers (including B-layer)
-- Full SCT
-- TRT : outer end-cap missing
-- Full calorimetry (but no scintillator in the gap)
-- Muon system: EEL/EES MDT and part of end-wall MDT missing

Note: since $L \leq 2 \times 10^{33}$ cm^{-2} s^{-1} and to maximise discovery potential, preference given to angular coverage than to radial redundancy (ID and Muon spectrometer)
e.g. $H \to \gamma\gamma$ and $H \to 4\ell$ significances decrease ~ linearly with decreasing acceptance.
Full radial redundancy needed at high luminosity

Introduction

Physics studies carried out in Summer 2000 and 2001 in response to request from CERN management.

Joint studies with CMS (plus theorists in 2001)

Addressed physics impact of Luminosity and energy upgrades. $28\mathrm{TeV}$ and 10 times design luminosity.

Most activity focused on luminosity upgrade as this is less demanding for the machine and less costly

Convenors of study: F Gianotti, M Mangano, J. Virdee

ATLAS Physics members: Azuelos, Barberis, Hinchliffe, Jakobs, Polesello, Paige, Richter-Was, Weilers (many others contributed) + people in detector group

CMS Physics Members: Abdullin, Nikitenko, Stepanov

Theory: Ellis, Mangano, Matchev, Van der Bij

Machine issues

Ultimate Luminosity of 2.3×10^{34} could be achieved by current design but only in two experiments (ATLAS+CMS)
Further increases need mixture of

- Reduced bunch spacing, could go to 5 ns with current setup, shorter than this is desirable – continuous beams?. Difficult for Experiments (12.5 ns is working number)

- new $low - \beta$ quads; design exists

- smaller β^* or reduced bunch length;

- larger beam intensity; Needs new proton linac and booster or 2.2 GeV high power linac (could be useful for muon collider)

- New separation dipoles inside experiments.

New beam dump needed.
Energy upgrade is much more expensive; 16 Tesla dipoles. Proof of principle exists

Preliminary Conclusions

- Luminosity upgrade is achievable at modest cost ($< 500MSF$) after more accelerator R& D
- Reach for heavy particles extends by $\sim 30\%$.
  Impact of more pile-up detector degradation not serious here
- Significant improvements in precision for TGG, SUSY parameters, Higgs couplings
- Some new channels such as $H \rightarrow Z\gamma$ are possible
- But detector performance must be maintained including b-tagging; efficient lepton ID, energy/momentum resolution; forward jet veto/tag

Physics Working Groups

- Too much information
- Good introductions by group leaders
- Emphasis on post-TDR developments:
  - New channels
  - New algorithms and ideas
- All requested more effort

Conclusion

With 1fb one will be able to:

•probe a substantial part of the ‘preferred’ MSSM parameter space;

•Probe a large part of the GMSB parameter space.

Provided one has reliable measurement of the missing energy.

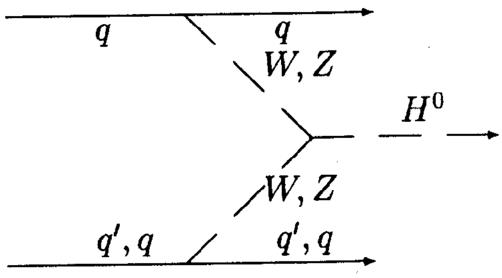
The muon spectrometer has a very limited use for this study.

One will have to:

•design tests that will enhance the reliability of the E_{miss} measurement;

•Further optimize the analyses.

Higgs production via Weak Boson Fusion



Motivation:

- Additional potential for Higgs boson discovery
- Important for the measurement of Higgs boson parameters
  (couplings to bosons, fermions (taus), total width)
- Detection of an invisible Higgs (talk by L.Neukermans)

proposed by D.Zeppenfeld et al. (several papers...)

Distinctive signature of:
- two high P_T forward jets
- little jet activity in the central region

possible channels:

qq H $\rightarrow$ qq WW $\rightarrow$ qq lν lν (talk by C.Buttar
$\rightarrow$ qq lν jj -Sheffield,Pisa,Mainz-)

qq H $\rightarrow$ qq τ τ $\rightarrow$ qq l l .... (talk by R.Mazini,
$\rightarrow$ qq l had .. -Bonn,Montreal-)

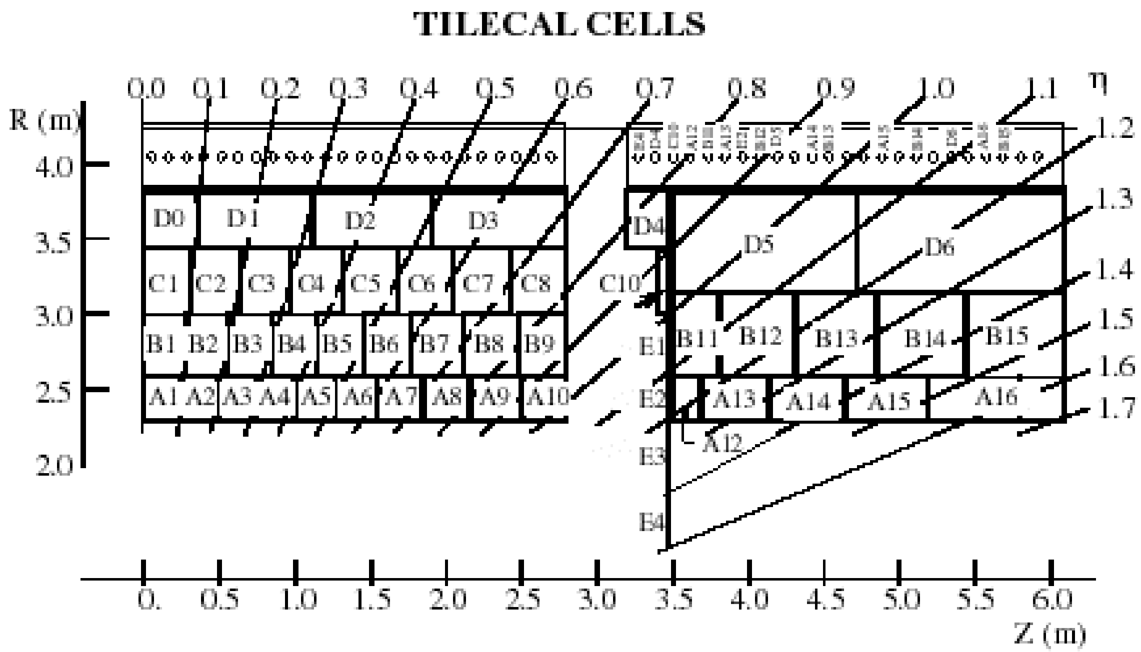
qq H $\rightarrow$ qq $\gamma\gamma$ (Belgrade)
qq H $\rightarrow$ qq bb (Japan)
qq H $\rightarrow$ qq ZZ* $\rightarrow$ qq bb ll (London)

Performance and Validation

- Wide variety of talks:
  - Attempts at 'like for like' comparisons
    - difficult due to many changes
      - New GEANT
      - Detector changes
      - Move to Athena
  - Some very important topics
    - Track reconstruction
    - Track matching
  - Some seemingly meaningless
  - Many comments on experience with new software
    - Common themes - memory leaks, SRT, support

Motivation

- Approximately 20% of b-jets contain a muon. As muons penetrate large depth, they can be recognized in the outermost layer of the Tile Calorimeter.



Conclusion

- Identification of b-jet+μ in the outermost Tilecal layer is possible in the data even at small |η|. These results are based on testbeam data.

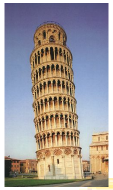
- LVL-1 trigger signal exhibits larger noise, selection of b-jet +μ over other jets is possible at larger |η|, especially in the Tilecal extended barrel region.

From SRT to CMT

- Really outside the scope of this talk, but highly visible and very important for everyone
- ATLAS SRT has been basis of release builds, setting up test releases and establishing run-time environment
  - Up to and including 2.0.2 release
- Migration to new tool (CMT) with 2.1.0 release
  - Based on 2.0.2 with several bug fixes
- Different philosophy and commands
- Preliminary "How To" available
  - http://ghez.home.cern.ch/ghez/Temp/doc
- But we're still learning so watch out for updates

PESA (Trigger Performance)

- Introduction
  - Recent work and work needed for HLT/DAQ/DCS TDR
  - Main area, improvement to rate estimates and additional triggers (pre-scale, monitoring, luminosity)
- Selection and Control Software
  - Very technical description of architecture
- HLT Algorithm Status
  - Included brief Level-1 Status, mostly about Level-2 algorithms
- Survey of pre-scaled triggers
  - Results from consultation about necessary background studies for physics/performance analyses
- Forward jet trigger at Level-1



New total HLT rate (low luminos.)

Selection (TP)	Present rates (Hz)	HLT TP rates (Hz)	Comments
B-physics	**~60**	100	Combined μ rec.
Electron (e25i, 2e15i)	**~ 20**	41	was (e20i,2e15i)
Photon (γ60i, 2γ20i)	**~20**	57	was (γ40i, 2γ20i)
Muon (μ20i)	**~15**	~15	
Jet (j360, 3j150, 4j100)	**~25**	~ 25	
J60+ xE60	**~20**	38	E_T^{miss} isolation
Total	**~160 Hz**	**275 Hz**	

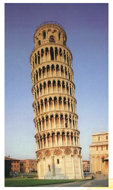
- Refinements
  - B-physics: use combined muon reconstruction
    - reject π/K decays and sharpen p_T threshold
  - e20i replaced by e25i
  - γ40i replaced by γ60i
  - add E_T^{miss} isolation to J60+xE60
- Note: NOT at similar 'quality standard' as TP
- And as before (TP)
  - no pre-scaled physics triggers
  - no calibration / monitor triggers
  - missing multi-object triggers (e.g. τ+xE, e+μ)

Level-1 Calo Algorithms

- 1st prototype version for a LVL1 EM/tau RoI available within Athena framework (Ed Moyse, A. Watson)
  - Runs within Athena framework
    - Geant3 cells
    - ATLFAST cells
  - Implements
    - Create trigger towers
    - Search for EM/tau RoI candidates
    - Make decision if RoI fulfills trigger criteria
    - Store EM/tau RoI's
  - Ongoing work more "realistic" than old Atrig code
  - Work on jet trigger code started

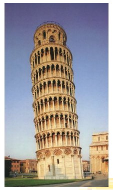
Conclusions

- We're on our way, but still lots of uncertainties due to
  - Dependencies with event data model
  - Dependencies with "non-existing" reconstruction data model
  - Limited manpower, Volunteers?
  - Suitability of Athena in online
- Lots of work to be done before trigger TDR submission end of 2002



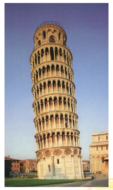
Rate sharing: Tevatron examples

- at maximum luminosity (run I experience)
  - ➜ 25% of total rate for monitoring & calibration
    - mostly for electron efficiency determination, including minimum and zero bias events
  - ➜ 20% of total rate for pre-scaled physics triggers
    - dominated by selection for $W \rightarrow e\nu$
  - ➜ 2% of total rate for forced accepts
- D0 did not change thresholds during a fill
    - only adjustments of pre-scale factors
  - ➜ at lower luminosities
    - ❍ bandwidth filled (up to 85-90%) with other pre-scaled physics triggers (QCD, B-physics and $W/Z \rightarrow \mu\nu$ / $\mu\mu$)
      - and more monitor/calibration triggers
- For CDF about 35% of triggers are pre-scaled
    - includes physics triggers and calibration triggers
    - ❍ less than 10% of "diagnostic" triggers



Some issues for consideration

- Not yet addressed in PESA: how to adapt the selection to changes in luminosity during a fill?
  - ➜ Keep thresholds fixed?
    (esp. for the un-prescaled triggers)
    and give more bandwidth to pre-scaled triggers
  - ➜ Introduce additional triggers as luminosity goes down
    - ❍ Effectively change pre-scale factor from '∞' to a finite number
  - ➜ Dynamic change of pre-scale factors or have a few sets (3-5) to be applied after a certain threshold has been passed
    - ❍ Good book-keeping needed in all cases
- Reduce the event size for selected samples
  - ➜ Only store information for one sub-detector
    - ❍ Do we want to do this from the very beginning?
- How to determine trigger efficiency from data alone?
  - ➜ Might define the need for additional trigger selections
    - ❍ How to best obtain orthogonal trigger selections?



Pre-pre-preliminary compilation

- baseline items / new items / additional rate

baseline items	new items		additional rate
➜ $\mu 20$	$\mu 6$ /xxx	$\mu 4.5$ /xxx	5 Hz
➜ e25i	e20i /10	e20i+E_T^{miss}30	9 Hz
➜ γ60i	γ40i /200	γ30i /600	0.6 Hz
➜ j360	j180 /100	j90 /2500	5 Hz
➜ 3j150	3j75 /100	3j38 /2500	6 Hz
➜ 4j100	4j50 /100	4j30 /2500	3 Hz
➜ j60+E_T^{miss}60+isol	j60+xE60 /20		2 Hz
➜	τ40+E_T^{miss}35+isol		20 Hz ??
➜	τ20+E_T^{miss}30+isol/100		4 Hz ??
➜ B-physics			
➜	Z($\tau\tau$) ??		XXX
➜	γXX+jXX		XXX

- Total rate (no overlaps taken into account for additional items!!)
  - ➜ 160 Hz + $\approx$ **50 Hz(?)**

Minimal cut set

Core identification cuts for WBF: jet tagging cuts

2 tagging jets

+ $p_T^j > 40\ GeV$

+ $|\eta_j| < 5.0$ + $\eta_{j1} * \eta_{j2} < 0$ + $|\eta_{j1} - \eta_{j2}| > 4.4$

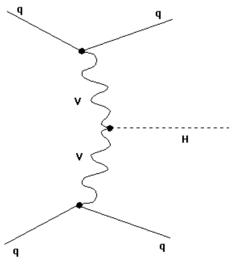
Signal specific cuts for QCD multi-jet reduction

+ $M_{jj} > 1200$ GeV

+ $\not{p}_T > 100\ GeV$

Signal specific cut for Wjj and Zjj reduction

+ $\phi_{jj} < 1$



Conclusions

- **A total background rate of ~ 0.22 Hz looks promising, even if off by a factor 10 (how well we know the forward region?)**

- **The drastic change in S/√B when cutting at 3.2 in η suggests that:**
  - **the FCAL needs to be included at LVL1**
  - **even without dividing coverage in regions**
  - **but with forward and backward counting**

(j1 + j2 + E_T miss)