Early ATLAS Physics

Bridging the Gap between Detector Construction and Physics Results

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Outline

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Case study: A rusty LEP-1 Ph.D faces LHC start-up - I

1993-1998: DELPHI $Z \to b\bar{b}$, 2007-20??: ATLAS $X \to yz$

- Production process

  LEP: Fundamental e^+e^- collisions; $n_{\text{events}} = \text{Br} \cdot \sigma\mathcal{L}$
  LHC: Composite particles, PDF(x, Q^2), parton-$\mathcal{L}$

- Background environment

  LEP: Mis-identified, combinatorial; physics: tiny, well understood
  LHC: Underlying event, QCD, $t\bar{t}$...

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- Trigger system

  LEP: Any hadronic activity, 100% efficient
  LHC: Hi-p_{T} objects, BW limited, imposes physics cuts

- Analysis selection

  LEP: Leptons, hadron id, decay topology
  LHC: Hi-p_{T} objects, with trigger interference

- Detector status

  LEP: Aligned, mostly working hadron id
  LHC: Commissioning for physics about to start

…my LEP-1 background probably doesn't even count

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1999-2006: ATLAS TRT Hardware/electronics

- Well after detector optimization phase
- Prototype testing, production, integration
- Remote from physics performance (resolution, efficiency, TR. . .)
- Late '06 surface cosmics: TRT-EC HW meets SW
  - SW support long dead extended end-cap
  - SW implements mirror symmetric halves
  - HW actually built as two identical copies
- Perhaps all the other subsystems are perfectly organized?

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- Define the performance requirements
- Document how to achieve them

Post-TDR era:

- Detector construction and installation
- Code transition to C++, detector layout maturing
- Excellent notes and talks about commissioning and early physics: with a few days of data taking,...

As-built ATLAS detector paper:

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- Last magnet installed by March
- Machine closes in September
- All set for 450 GeV colliding beams in November
- LHC Magnet Test Failure

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ATLAS Installation and commissioning

Magnets: End-cap toroids ready for installation

Muons: Big wheels keep on turning

Calo: TileCal provides cosmic triggers

ID: End-caps, pixels ready for installation

Plumbing and Power remains Problematic

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How come the performance requirements?

- Measurements:
  - Most measurements must happen at low luminosity, ie 10fb^{-1}
  - Standard Model measurements are the primary performance pushers
- Discovery:
  - Some discovery channels only with ultimate luminosity
  - Bump hunting still requires excellent detector resolution

Case study: W mass measurements

- Equivalent contribution to constraining Standard Model m_H:

$$\Delta m_\mathrm{W} = 0.7 \cdot 10^{-2} \Delta m_\mathrm{top},$$

- ATLAS target: $\Delta m_\mathrm{W} = 20$ MeV
- Event selection: Isolated $\ell = e, \mu$, missing transverse energy, and no jets
- Measure transverse momenta of lepton and the hadronic recoil
- Extract m_W from fit to transverse mass distribution
- Need to know lepton energy scale to 0.02%
  - Calibrate in-situ with $Z \to \ell\bar{\ell}$ and extrapolate
  - Need to know magnetic field to 0.1%
  - Need to know Inner detector material to 1%

Case study: The top commissioning laboratory

- Decay channel: $t\bar{t} \rightarrow \mathrm{W}(\ell\nu)b + \mathrm{W}(u\overline{d})\overline{b}$
- Standard selection: $\ell = e, \mu$, four jets, with two b-tagged)
- Drop the b-tag criterion
- Resolve combinatorics without biasing
- B-tag efficiency/rejection calibration
- Hadronic energy scale @ m_{W}

Where to start?

- Identify an interesting physics channel
- Understand what are the critical commissioning/performance issues
- Find out how to start contributing practically, bottom-up

References I

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- Giokaris, N and Arabidze, G and Manousakis-Katsikakis, A and Vellidis, C, ATL-COM-CAL-2006-004

Organizing my thinking: Axes of advance

- Installation and commissioning timeline
- From detector subsystem to analysis objects
- Energy scale: $c\bar{c}$, $b\bar{b}$, W, Z, $t\bar{t}$
- Well-known to unknown: W/Z, pdfs, (NLO) QCD, top, Higgs? SUSY? extra-D?
- Statistics versus systematics (and back to statistics)

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