Exotics and Trigger

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Overview

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   - Analysis Strategy
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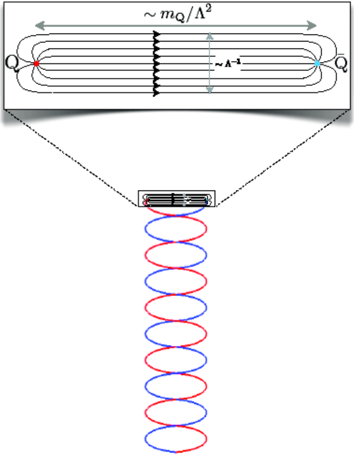
   - Signature
   - Analysis Strategy
3. Lepton-Jets
4. Mono-X
5. ATLAS/CMS Trigger Menus in 2012
6. ATLAS Trigger Upgrades

Quirks

- New confining gauge field, infracolor, forms strings between massive stable particles, quirks.
- Quirk mass larger than confinement scale prevents string from fragmenting as in QCD.
- String force of $\sim \Lambda_{IC}^2$ causes quirks to oscillate around center of mass, forming bizarre tracks
- Two important parameters:
  - Quirk mass mQ: considering 100 GeV 1 TeV range where discovery possible
  - Confinement scale IC: smaller than mQ; possible values range over many orders of magnitude
- Very long strings possible. Depends on IC, so strings could be subatomic or larger than detector.
- Assume quirks have electrical charge otherwise we can't see the tracks.

Jim Black and Tim Knelson



Kang & Luty, arxiv:0805.4642

Quirk Signatures

	Confinement scale	String length	Signature
Macroscopic	< 10 keV	$> 100\mu$m	Detector can resolve two non-helical tracks. Need special tracking algorithms.
Mesoscopic	10 keV to 1 MeV	10 nm to 100 μm	Quirk pair creates single track.
Microscopic	> 1 MeV	< 10 nm	Quirks annihilate within beampipe. Look for annihilation products.

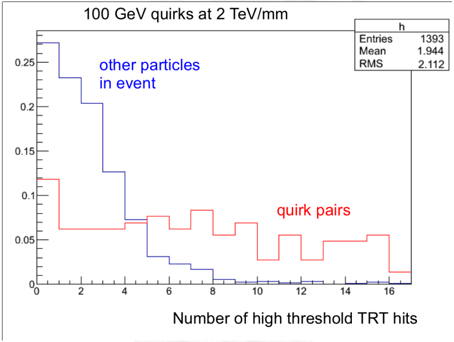
With SM color (Colored)
Larger cross sections but large theoretical uncertainties on observable cross section.

Without SM color (Uncolored)
Smaller cross sections but no QCD complications.

- Tackle simplest case first: mesoscopic string length, uncolored quirks
  - Very similar to other LLP searches such as R-hadron and low-Q multicharges.
  - DØ searched for these in 2010, set limit of $m_Q > 107$ GeV for SU(2) case; we now have enough data to search beyond this limit.
- Design search so it remains sensitive to colored quirks, and state results in theory-independent way.

Analysis Strategy

- Trigger
  - $\not{E}_T$ or jet + $\not{E}_T$ trigger a natural choice.
  - Quirks produced w/o associated jet have pT=0 and are lost down beampipe.
- Event selection
  - Looking for tracks with large (reconstructed) pT, dE/dx, and time of flight
- Signal simulation
  - Quirks interact with material via standard EM processes, but dE/dx is altered by their oscillating motion.
  - New code to simulate motion of pair of quirks in Geant4.
- Background estimation
  - Current plan: Estimate from data using ABCD method.



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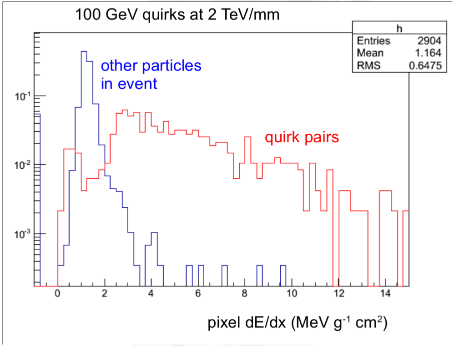
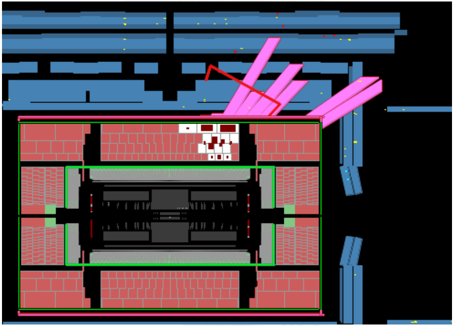


Stopped Gluinos

Search for metastable massive particles with electric and colour charge: long-lived gluino-based R-hadron.

Josh Cogan

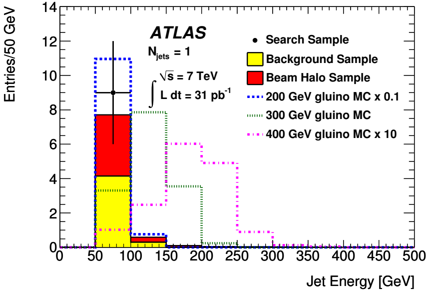


- $pp \to g^{\sim} g^{\sim}$, bind to SM quarks from vaccum $\to$ R-hadron
- Travel into the ATLAS detector volume
  - Loses energy through dE/dX and nuclear scatters
  - Can exchange charge via nuclear interactions
- Stop in the calorimeter
- Eventually decay several bc later
  - Detect decay in the empty bunch crossings.

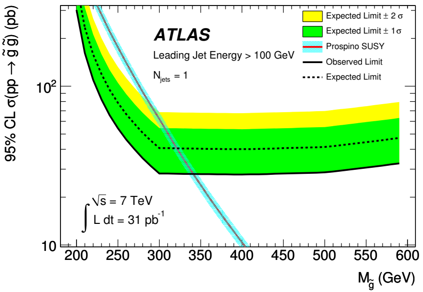
2010 Result

No excess of events observed

- Searched in 31 pb-1 @ 7TeV
- Studied 2 exclusive channels
- Single- and multi-jet both for leading jet > (50,100 GeV)
- Results consistent
- One jet > 100 GeV best
- 95% exclusions on models with > 3.5 events reconstructed



# Jets	# Events Exp (Obs)	Frac. Err. Sig (Bkg)
1	0 (0.3)	23 (106)
> 1	1 (0.6)	23 (106)

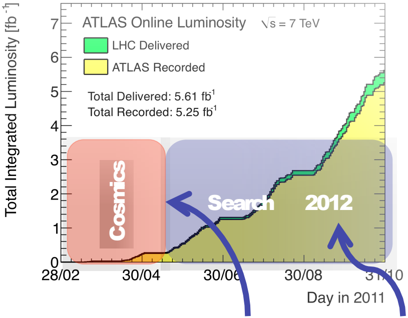


Eur. Phys. J. C72 (2012) 1965

8 TeV Analysis

Data Regions:

- Cosmic muon rate constant – does not change with luminosity!
- Estimate with early 2011 data



Many Cosmics
"No" R-hadrons

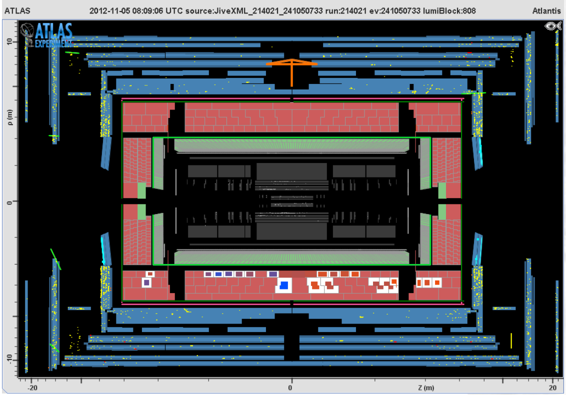
45x higher
S/B

- Jet Cleaning :
  Calorimeter noise rejection (factor of $\sim XX$)
- Muon Veto :
  Beam halo muons rejection (factor of ~ 30)
- Jet Energy :
  Calorimeter noise rejection (facto of ~ 5)

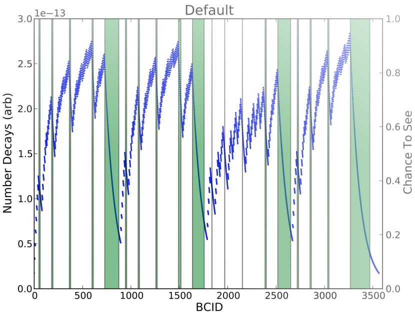
Low statistics final state

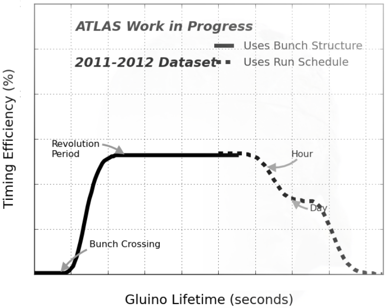
Beam Halo Muons

- Scales with vacuum, colimators
- Filling scheme
- Estiamte with unpaired bunches.
- Use unpaired to estimate muon segment veto fraction



Efficiency Vs Lifetime





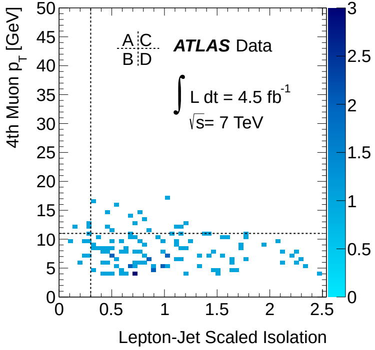
- # of R-hadrons increases with luminosity delivered
- Detect them in the empty crossings (green bands)

- No efficiency for very short lifetimes (which decay in filled bunches)
- Detect those which live long enough to average over the bunch structure.
- Not sensitive to those which decay outside of the run (when not collecting data).

Lepton-Jets

Broad category of models can produce collimated pairs of leptons

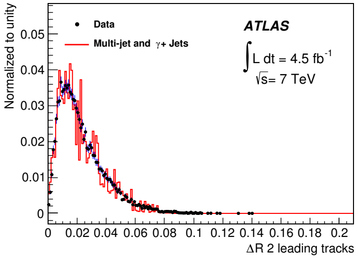
- Background estimation using modified ABCD-method
  - Four data regions, fit to a product of poisson functions.



Emanuel Strauss

2011 analysis in exclusive channels (electron-jets, muon-jets) (Phys. Lett. B 719 (2013) 299-317)

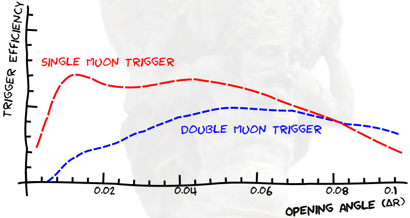
- Reconstruction of tracks at the edge of detector resolution (e.g. TRT straws are 4mm in diameter).



Analysis Strategy

Improving generality of the next result:

- Use a particle-gun to fully parametrize di-lepton efficiency (e.g. as a function of boost)
- Include multi-flavor lepton-jets to pick up extra radiation in dark sector, R-parity violation, etc…



Mono-X

New SLAC effort (Emanuel Strauss, Michael Kagan)

- ATLAS public result for mono-jet: ATLAS-CONF-2012-147, 8 TeV result in the pipeline.
- First ATLAS mono-W ($W \to qq$) result in the pipeline
- Brainstorming how to improve the analyses and combine the interpretation of the final states.
- Appealing for many reasons, not least of which is that mono-W is fertile testing ground for an in-house W-tagger (Josh, Michael, Ariel, Emanuel)

ATLAS/CMS Trigger Menus in 2012

ATLAS

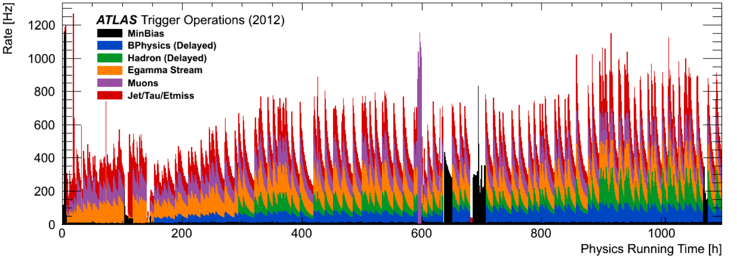
- Three level trigger system
  - L1 Hardware and Firmware
  - L2 Fast software, (mostly) RoI based, first level with tracking.
  - EF Full detector information

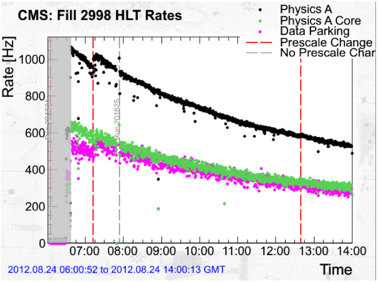
CMS

- L1 Hardware and Firmware
- HL Software, full event reconstruction at L2, large data throughput.

- Ultimately, very similar performance
- Trigger bandwidth limited by the detectors not the trigger system (mostly).
- Very similar trigger menus
- Both highly robust against pile-up.

Data Throughput





- HLT Average Rates:
  - 400 Hz (prompt) + 100∼200 Hz (delayed) = 500-600 Hz for ATLAS
  - 400 Hz (prompt) + 400 Hz (delayed) = 740 Hz for CMS
- Peak Rates:
  - 800 Hz (prompt) + 200 Hz (delayed) = 1 kHz for ATLAS
  - 650 Hz (prompt) + 550 Hz (delayed) = 1.1 kHz for CMS

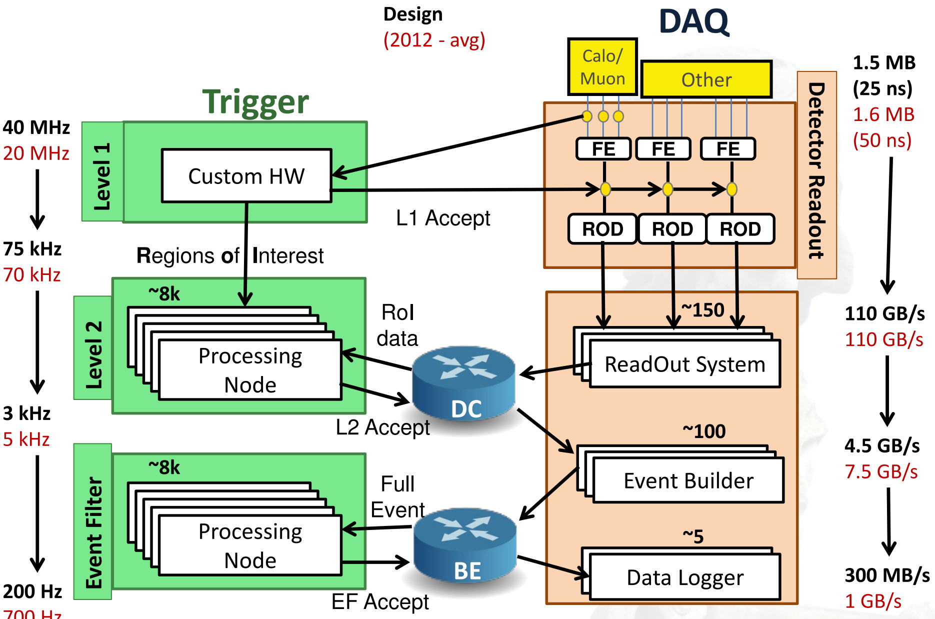
Trigger Menus

	ATLAS [GeV]	CMS [GeV]
L1 single μ	15	12
L1 double μ	2x10	2x10
HLT single μ	24	24
HLT double μ	2x13	18,8
L1 single e	18	20
L1 double e	2x10	13,7
HLT single e	25	27 (80 w/o isolation)
HLT double e	2x15	17,8
HLT single γ	120	150
HLT double γ	2x20	36,22
L1 single τ	40	?
L1 double τ	11,15	?
HLT single τ	115	80
HLT double τ	18,27	2x65
L1 single jet	75	128
L1 multi-jet	4x15	4x36
HLT single jet	360	320
HLT multi-jet	4x80 (4x65 delayed)	4x80 (4x50 delayed)
L1 $\not\!\!E_T$	60	40
HLT $\not\!\!E_T$	80	120

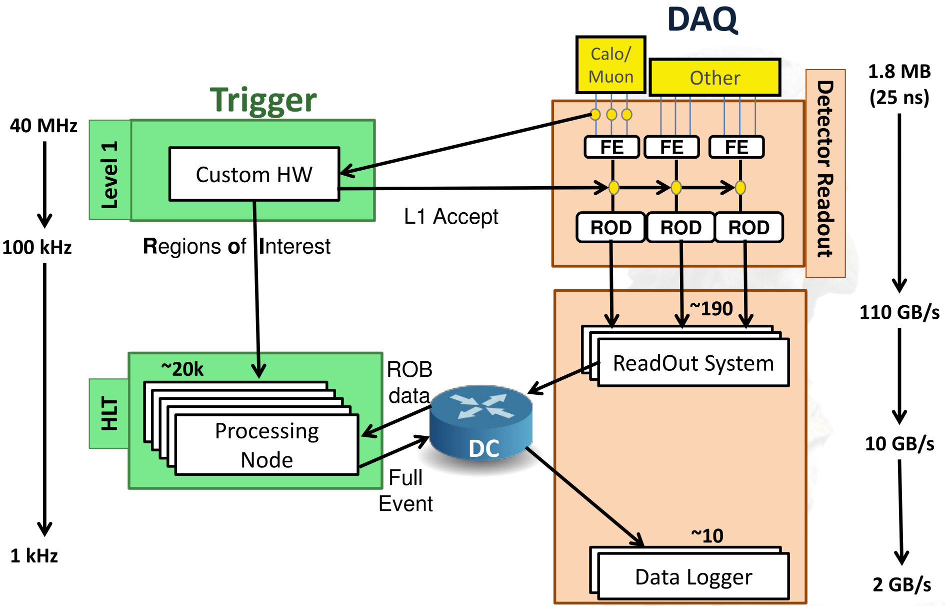
ATLAS Level 1 Upgrades

- Improved digitization and extraction of calorimeter signals
  - Dynamic pedestal correction
  - EM and JET specific calibrations
  - Improved noise filtering and BCID
- Topological Trigger
  - Calculate $\Delta\phi$, $\Delta\eta$, ΔR, H_T on L1 RoIs
  - Limited by large amount of input data, and time-intensive tasks, but powerful ability to calculate global quantities.

DAQ/HLT Upgrade



DAQ/HLT Upgrade



HLT Evolution

- L2, EB & EF farms become a unique HLT farm
  - Automatic balancing of L2/EF resources
  - Potentially incremental event building
- Merge L2 and EF processing steps on a single node
  - 1 Data Collection Manager + n Processing Units per node
  - Event processing starts with L2 like algorithms, requesting data based RoIs.
  - Steering decides to switch to an EF like processing
  - Flexibility for HLT strategies
- A single application per node responsible for all data transfers

Thresholds in 2015

Trigger	1E34 [%]	2E34 [%]
Single EM	30	60-120
Di-EM	50	50
Single μ	30	30
Di-μ	0	10
τ	25	50-270
Di-τ	100	170
Jet	30	30
4-Jet	30	30
$\not{E}_T$	25	50

Percent increase in L1 threshold (approximate)

Final numbers still under debate. Input at this stage will have the most impact.

- Target L1 rate for 2015 is 100 kHz.
- Single lepton-triggers are extremely expensive ($\sim 50\%$) of the bandwidth.
- Hard eptons produced from pileup is expected to become significant (reduces rejection power of multi-object triggers).
- Can sacrifice thresholds on leptons to increase bandwidth for topological triggers.
- L1 triggers should be generic (limited number of slots), but will make use of dedicated triggers (e.g. for exotic-type analyses).

Summary

- I've never liked the concept of summary slides (why repeat myself?)
- Any questions?