Title: Status of the LHC and ATLAS

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Abstract: TBA

The LHC and ATLAS
A December 2010 Update

1. Introduction
2. LHC Status
3. First ATLAS Data
4. Sampling of Results
5. Plans for 2011
6. Summary

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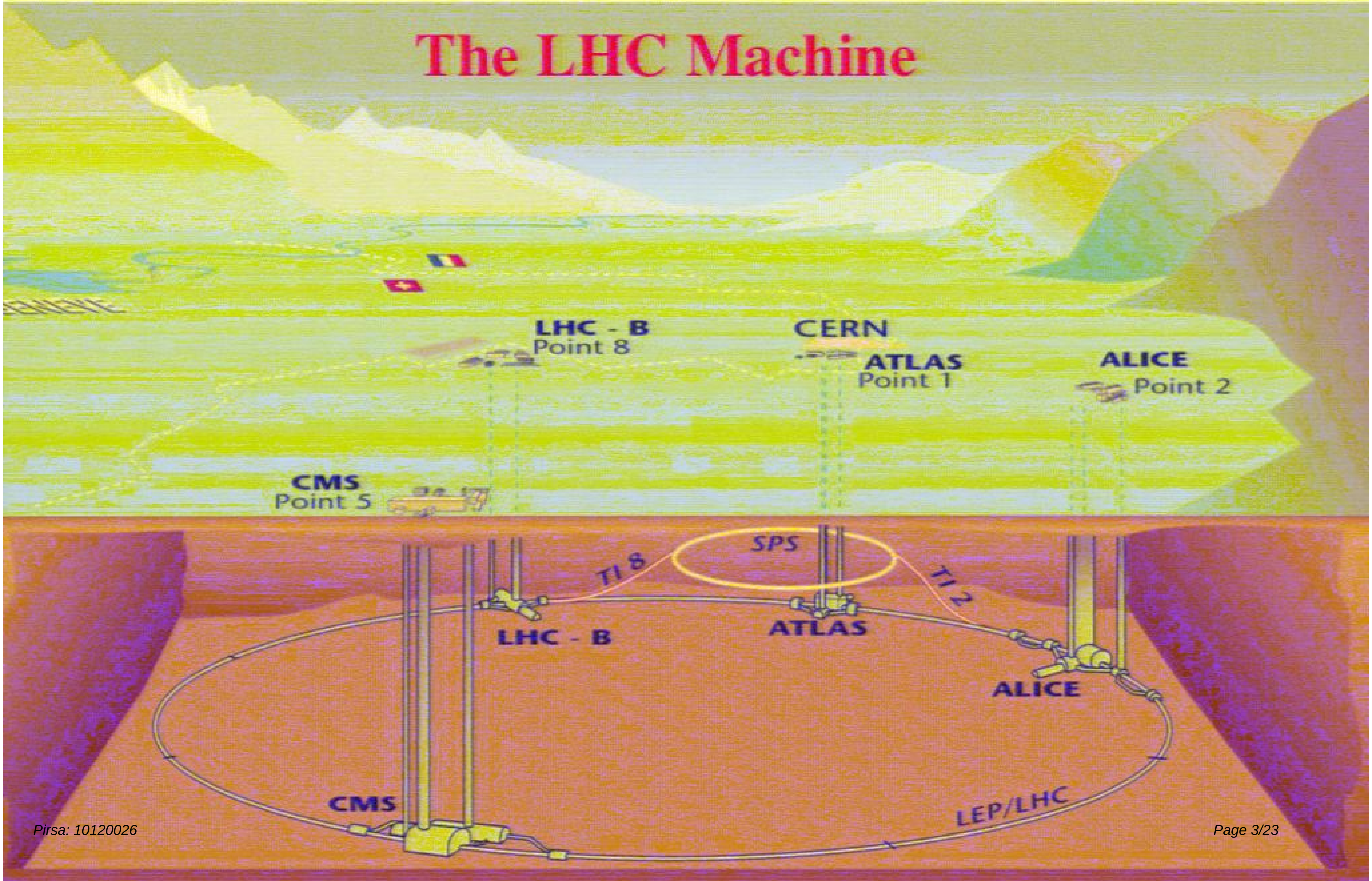
Rob McPherson, UVic
Pierre Savard, Toronto
Oliver Stelzer-Chilton, SFU
Isabel Trigger, TRIUMF

ATLAS

The LHC Machine



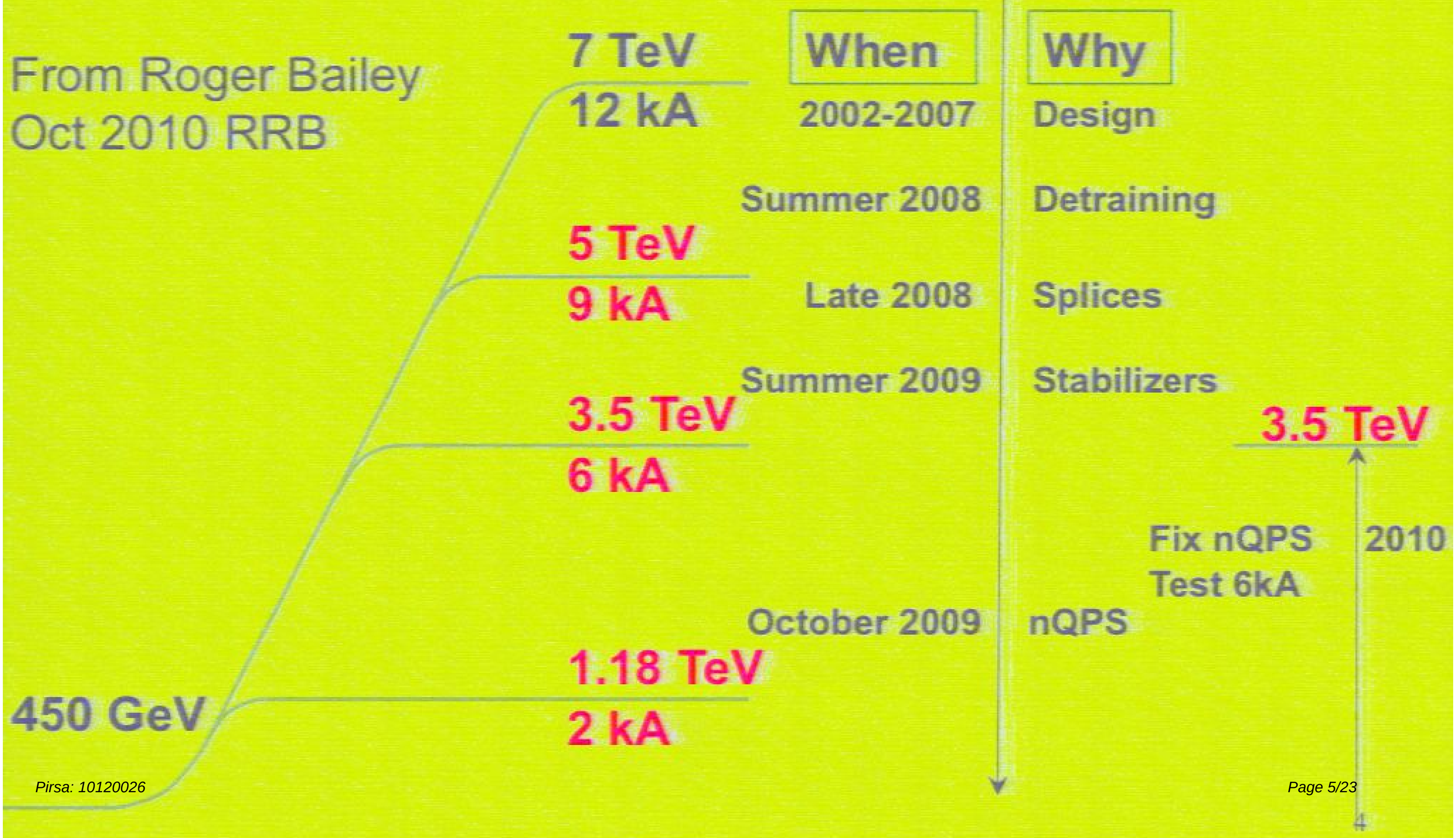
ATLAS 2010 Run

- **LHC Designed to be Discovery Machine**
  - Beam energy of 7 TeV
    - X 7 above Tevatron
  - Luminosity of 10^{34} $cm^{-2}s^{-1}$
    - X 30 over current machines
- **Key challenge**
  - Stored energy in machine
  - Run the device without breaking it or detectors
- **An aggressive commissioning plan now toned down**
  - Much more cautious
  - Sep 2007 "incident" a searing memory to many

Nominal settings	
Beam energy (TeV)	7.0
Number of particles per bunch	1.15 10^{11}
Number of bunches per beam	2808
Crossing angle (μrad)	285
Norm transverse emittance (μm rad)	3.75
Bunch length (cm)	7.55
Beta function at IP 1, 2, 5, 8 (m)	0.55,10,0.55,10

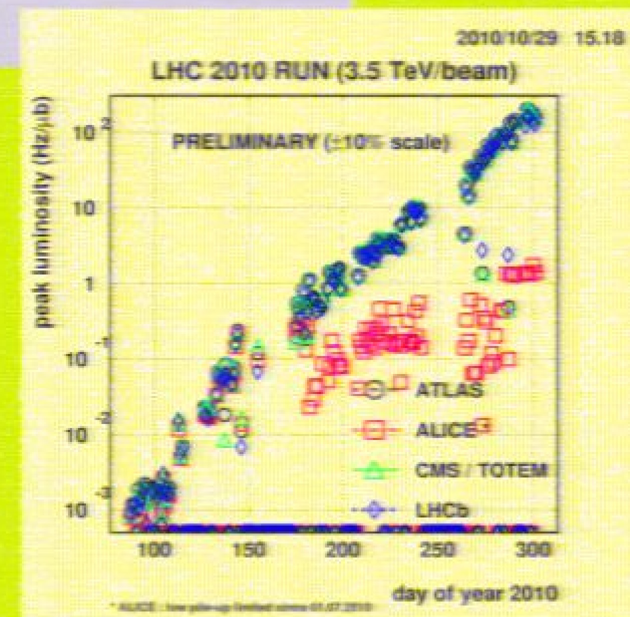
Derived parameters	
Luminosity in IP 1 & 5 (cm^{-2} s^{-1})	10^{34}
Luminosity in IP 2 & 8 (cm^{-2} s^{-1})*	~5 10^{32}
Transverse beam size at IP 1 & 5 (μm)	16.7
Transverse beam size at IP 2 & 8 (μm)	70.9
Stored energy per beam (MJ)	362

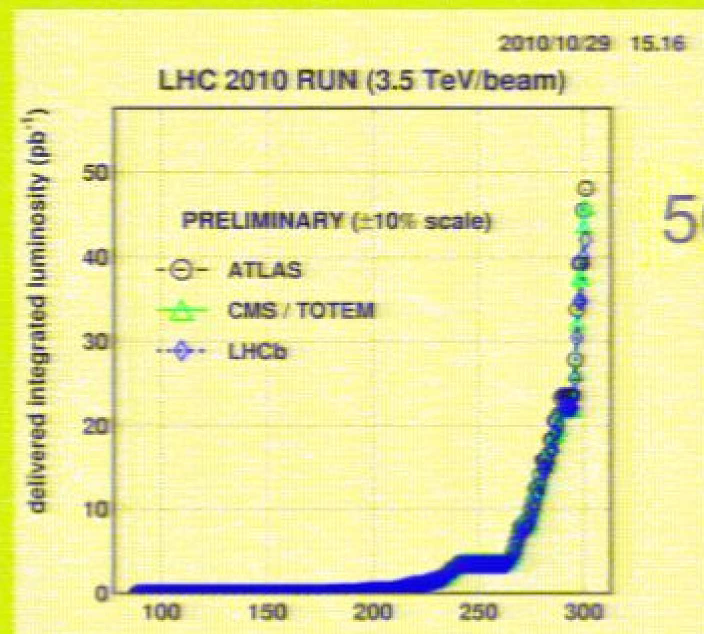
Evolution of Target Energy for Commissioning



Machine Progress over 2010

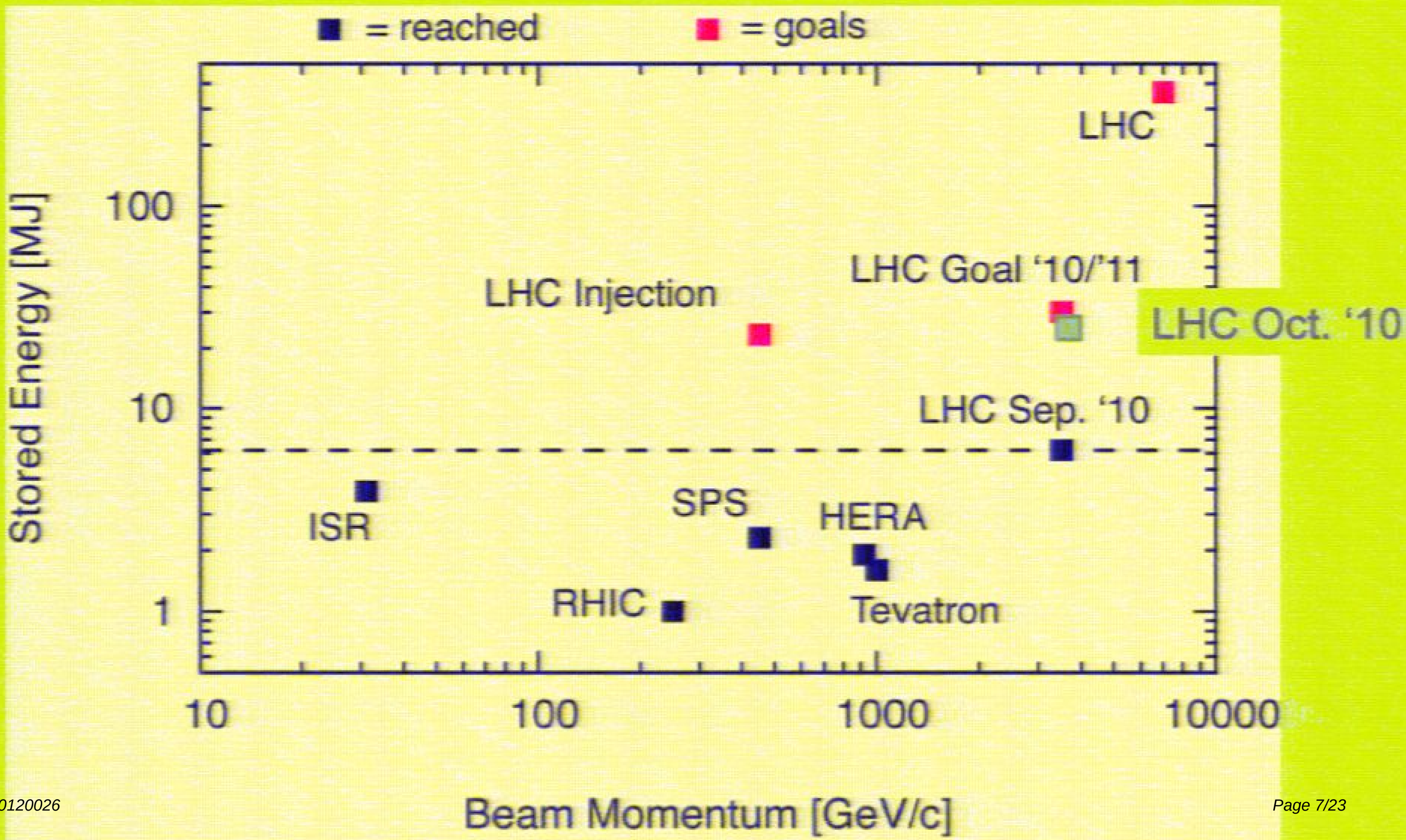
- **Significant progress in machine commissioning**
  - Increases in proton bunch intensities
  - Implement bunch trains
  - Yielded 10^5 improvement in luminosity in 200 days
- **Biggest improvement comes from increasing bunches**
  - Started with 3 x 3 bunches in May
  - Moved quickly to 8 x 8 end of May
  - 25 x 25 by July -> L ~ 3 x 10^{30} $cm^{-2}s^{-1}$
  - 50 x 50 by August -> L ~ 10^{31} $cm^{-2}s^{-1}$
- **Bunch trains started in Oct**
  - 248 x 248 bunches, 233 colliding pairs
  - Reached 9 x 10^{31} $cm^{-2}s^{-1}$





50 pb^{-1}

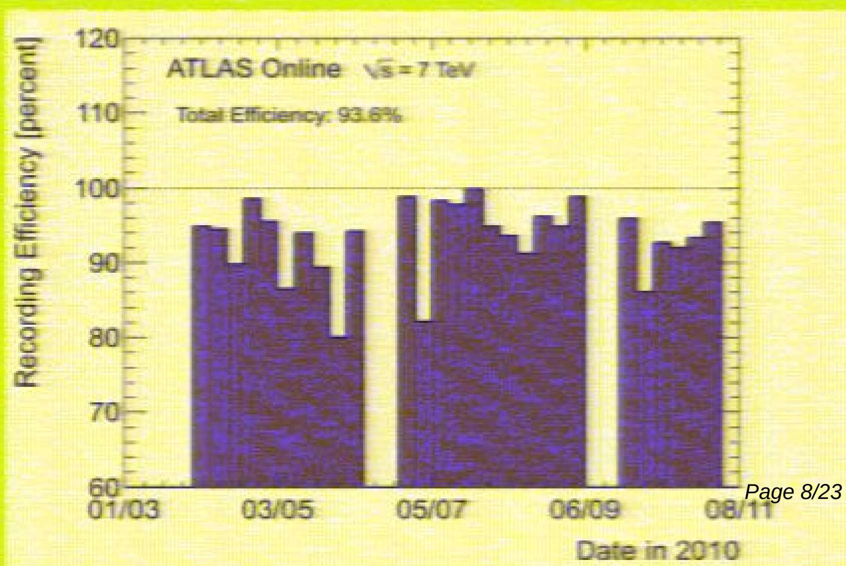
Managing the Monster



ATLAS Detector

- **ATLAS detector has started up very well**
  - Almost all detector elements have "up time" fraction of 99-98%
- **Learned how to operate and maintain**
  - Requires ~20 8-hour shifts a year from each collaborator
- **For ATLAS/Canada, ~40 FTE physicists for ops**
  - Physics analysis doesn't count!

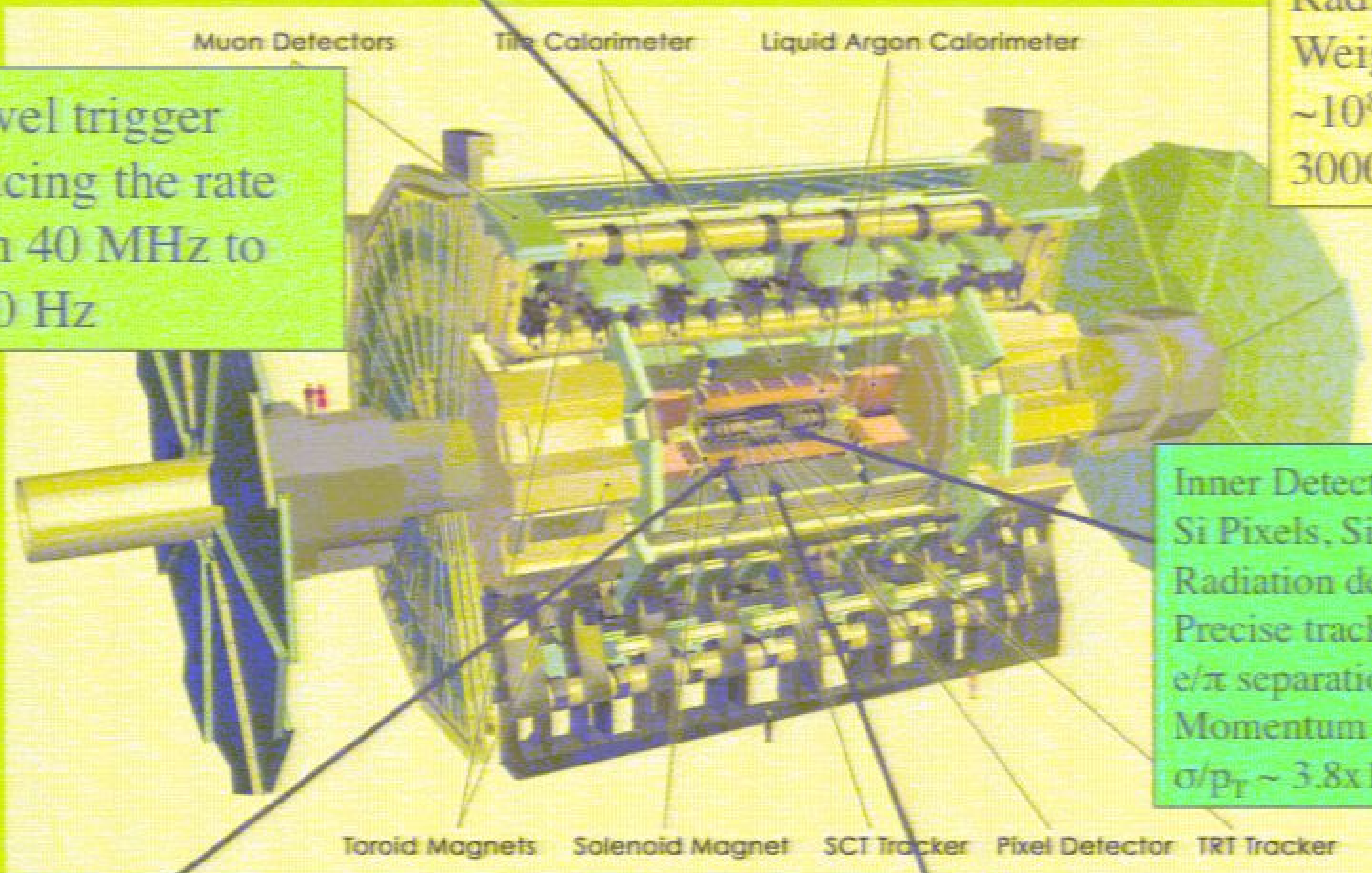
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.3%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	97.1%
LAr EM Calorimeter	170 k	97.9%
Tile calorimeter	9800	96.8%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.5%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	98.4%



luon Spectrometer ($|\eta|<2.7$) : air-core toroids with gas-based muon chambers
luon trigger and measurement with momentum resolution < 10% up to $E_\mu \sim 1$ TeV

Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~10^8 electronic channels
3000 km of cables

3-level trigger
educing the rate
rom 40 MHz to
~200 Hz



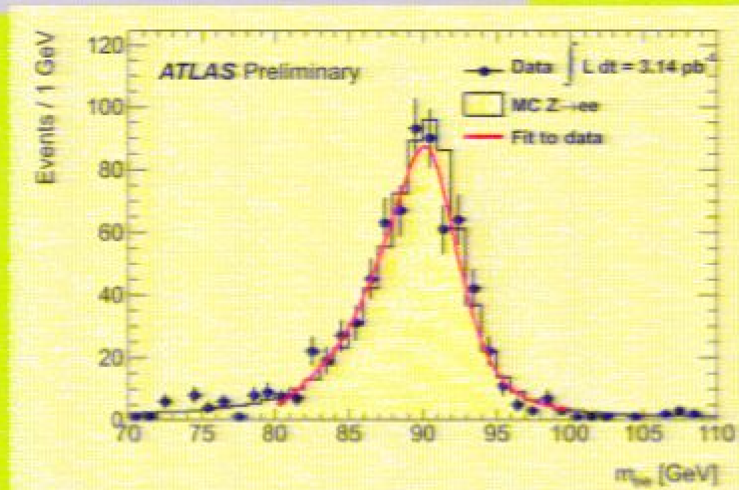
Inner Detector ($|\eta|<2.5$, B=2T):
Si Pixels, Si strips, Transition
Radiation detector (straws)
Precise tracking and vertexing,
e/π separation
Momentum resolution:
$\sigma/p_T \sim 3.8\times10^{-4}\, p_T(\mathrm{GeV}) \oplus 0.015$

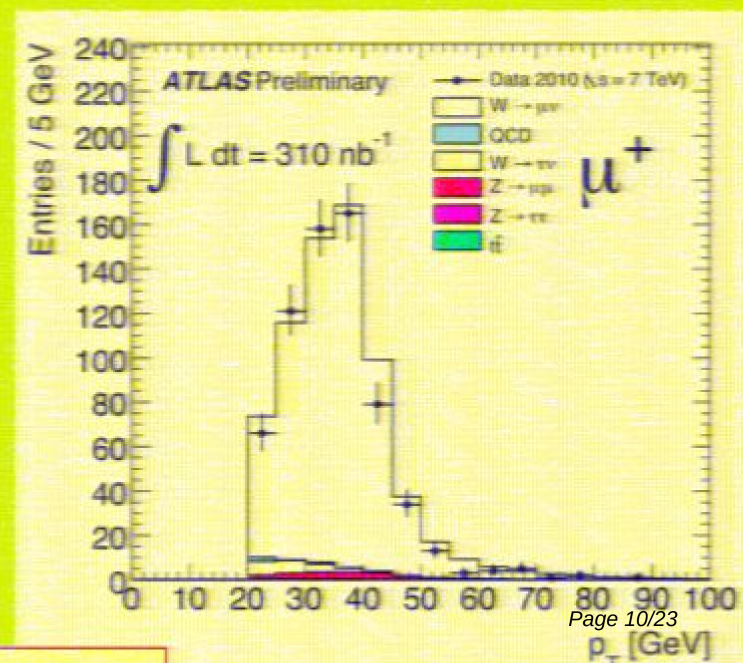
EM calorimeter: Pb-LAr Accordion
e/γ trigger, identification and measurement
E-resolution: $\sigma/E \sim 10\%/\sqrt{E}$

HAD calorimetry ($|\eta|<5$): segmentation, hermeticity
Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
Trigger and measurement of jets and missing E_T
E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$

ATLAS Physics Has Started

- **Collaboration has worked to be quick "off the mark"**
  - First goal has been to understand detector performance
  - Calibrate energy scales, resolution
- **Early results surprised even the most optimistic**
  - Detector performs very well
  - 9 publications in the pipeline describing performance
- **Clear SM signals**
  - W/Z signatures readily observed
- **Real goal is to look for new physics!**





Accepted Phys. Rev. Lett.

he ATLAS Experiment at the CERN Large Hadron Collider	JINST 3 S08003 (2008)
eadiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions	Accepted by EPJC
rift Time Measurement in the ATLAS Liquid Argon Electromagnetic Calorimeter using osmic Muons	Accepted by EPJC
he ATLAS Inner Detector commissioning and calibration	Accepted by EPJC
he ATLAS Simulation Infrastructure	Accepted by EPJC
erformance of the ATLAS Detector using First Collision Data	JHEP 1009:056,2010
ommissioning of the ATLAS Muon Spectrometer with Cosmic Rays	Accepted by EPJC
eadiness of the ATLAS tile calorimeter for LHC collisions	Accepted by EPJC
tudies of the performance of the ATLAS detector using cosmic-ray muons	Submitted to EPJC (30 Nov 2010)

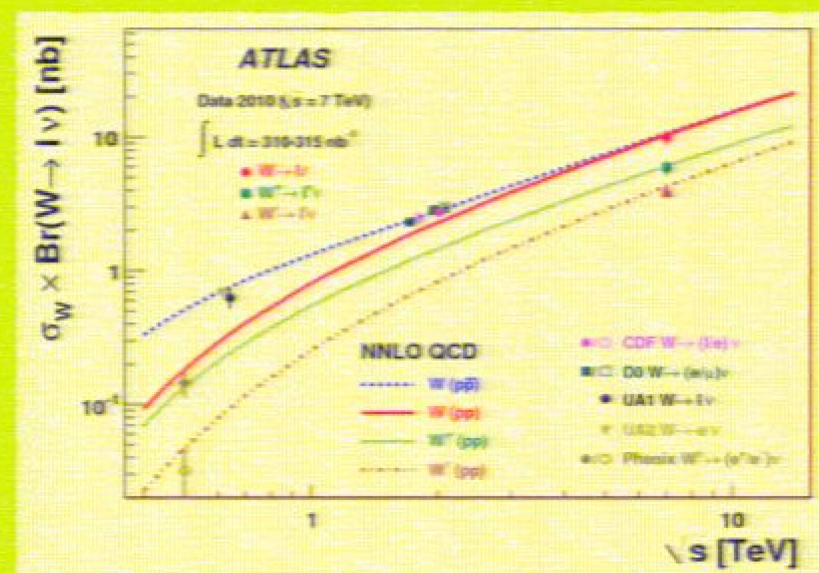
harged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS etector at the LHC	Phys Lett B 688, 1, 21
earch for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the TLAS Detector at the LHC	Phys. Rev. Lett. 105, 161801
earch for Quark Contact Interactions in Dijet Angular Distributions in in 7 TeV Proton-Proton ollisions with the ATLAS Detector at the LHC	Accepted by PLB
easurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV entre-of-mass energy with the ATLAS detector	Accepted by EPJC
easurement of the $W \rightarrow l\nu$ and $Z/\gamma^* \rightarrow ll$ production cross sections in proton-proton collisions t sqrt(s) = 7 TeV with the ATLAS detector	Accepted by JHEP
bservation of a centrality-dependent dijet asymmetry in lead-lead collisions at sNN=2.76 TeV ith the ATLAS detector at the LHC	Accepted by Phys.Rev.Letters (25 Nov 2011)

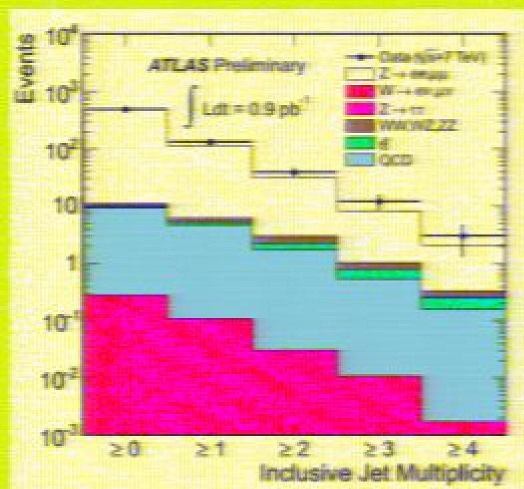
A Sampling of Results

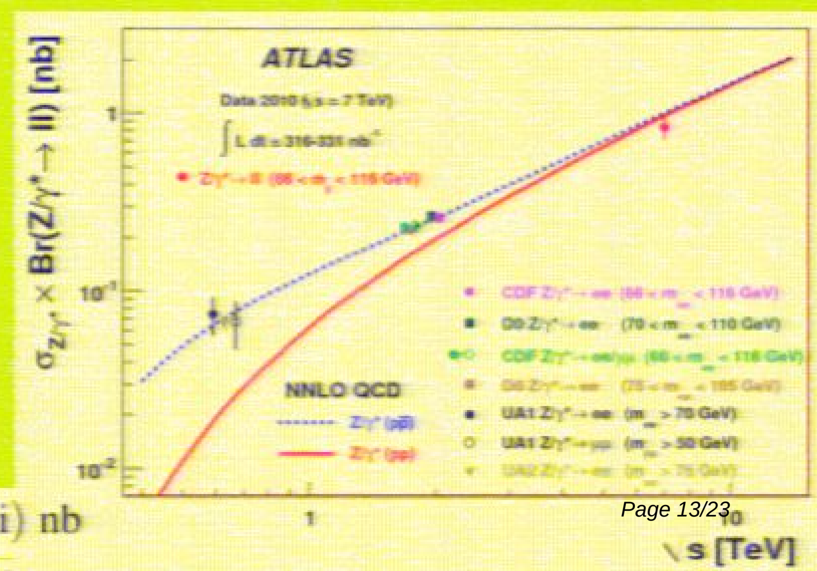
- **ATLAS/Canada has leadership role in several searches**
  - Dijet resonance search
  - Search for quark compositeness
  - High Invariant mass, Multi-Object Search
  - Jets + Missing ET Searches (Monojet)
  - Search in diphoton + ETMiss final states
- **See several today presented by the physicist doing the analysis**
  - Canadians have had leadership roles in these studies
  - In particular, developing data-driven techniques
- **Focus my time on a few examples:**
  - W/Z observation
  - Top quark observation
  - Sensitivity to Higgs in the "low-mass" region

W/Z Cross Sections

- Observing and measuring W/Z essential first step
  - Validated lepton ID
  - Missing E_T
  - Luminosity measurements
- Access to "standard candles"
  - Used in numerous measurements to estimate backgrounds or efficiencies



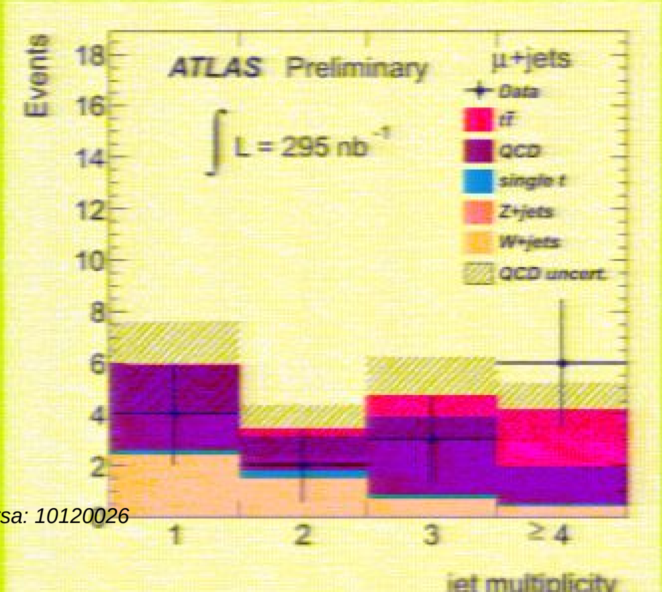




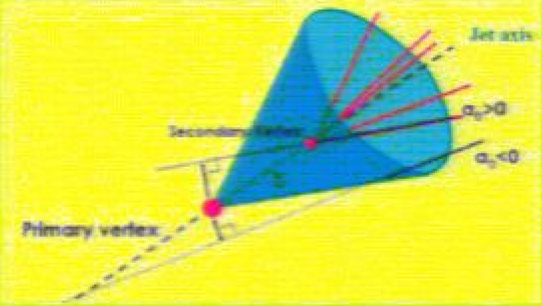
$\sigma_W^{tot} \cdot BR(W \to \ell\nu) = 9.96 \pm 0.23(\text{stat}) \pm 0.50(\text{syst}) \pm 1.10(\text{lumi})$ nb

Top Physics

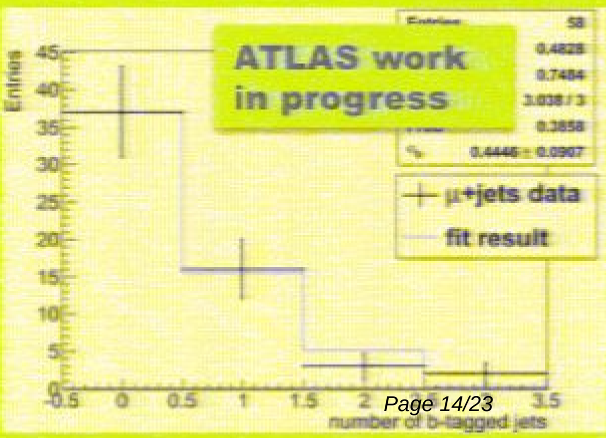
- **Have shown evidence of a top quark signal**
  - More challenging given rate (~160 pb) & backgrounds
  - Need to calibrate b-tagging as well
  - Presented lepton+jets background study in July



- **Combining all channels:**
  - See significant excess, as expected
  - A paper about to hit the streets using all channels
- **Big focus on data-driven approaches**



- B-tagging good example
- Use top l+jets & dileptons to calibrate -- < 5% uncertainty?

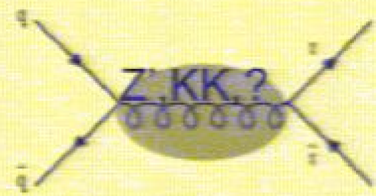


High pT top of Particular Interest

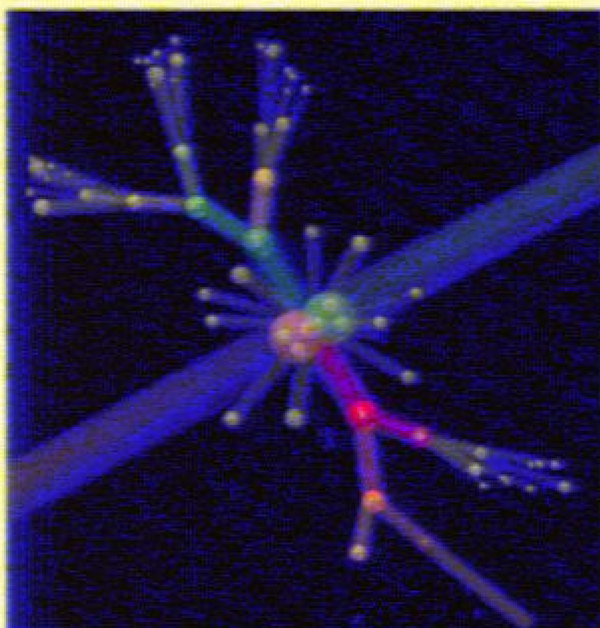
- **Active effort on several fronts:**
  - **Resolved final states**
  - **Boosted jets**
  - **Partially resolved topologies**

- **Recent talk by Oliver Stelzer-Chilton**

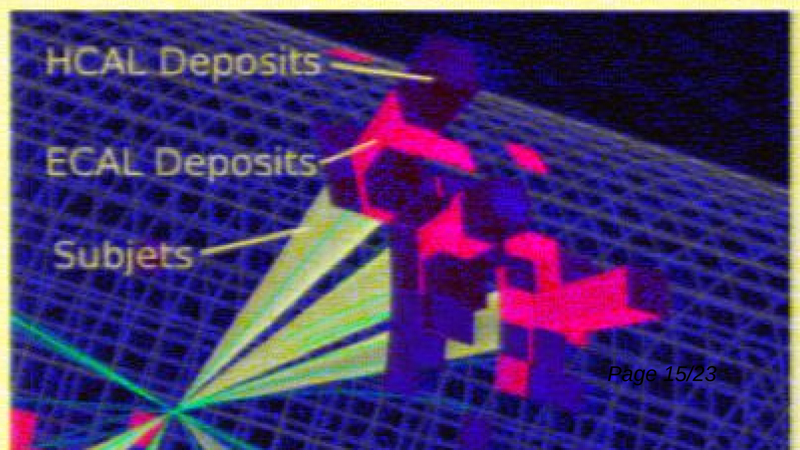
- Resonance production of X->$t\bar{t}$ is predicted by several new physics models with enhanced branching fraction
  - Top color assisted technicolor with leptophobic Z'
  - Randall Sundrum KK-gluons, colorons, etc..



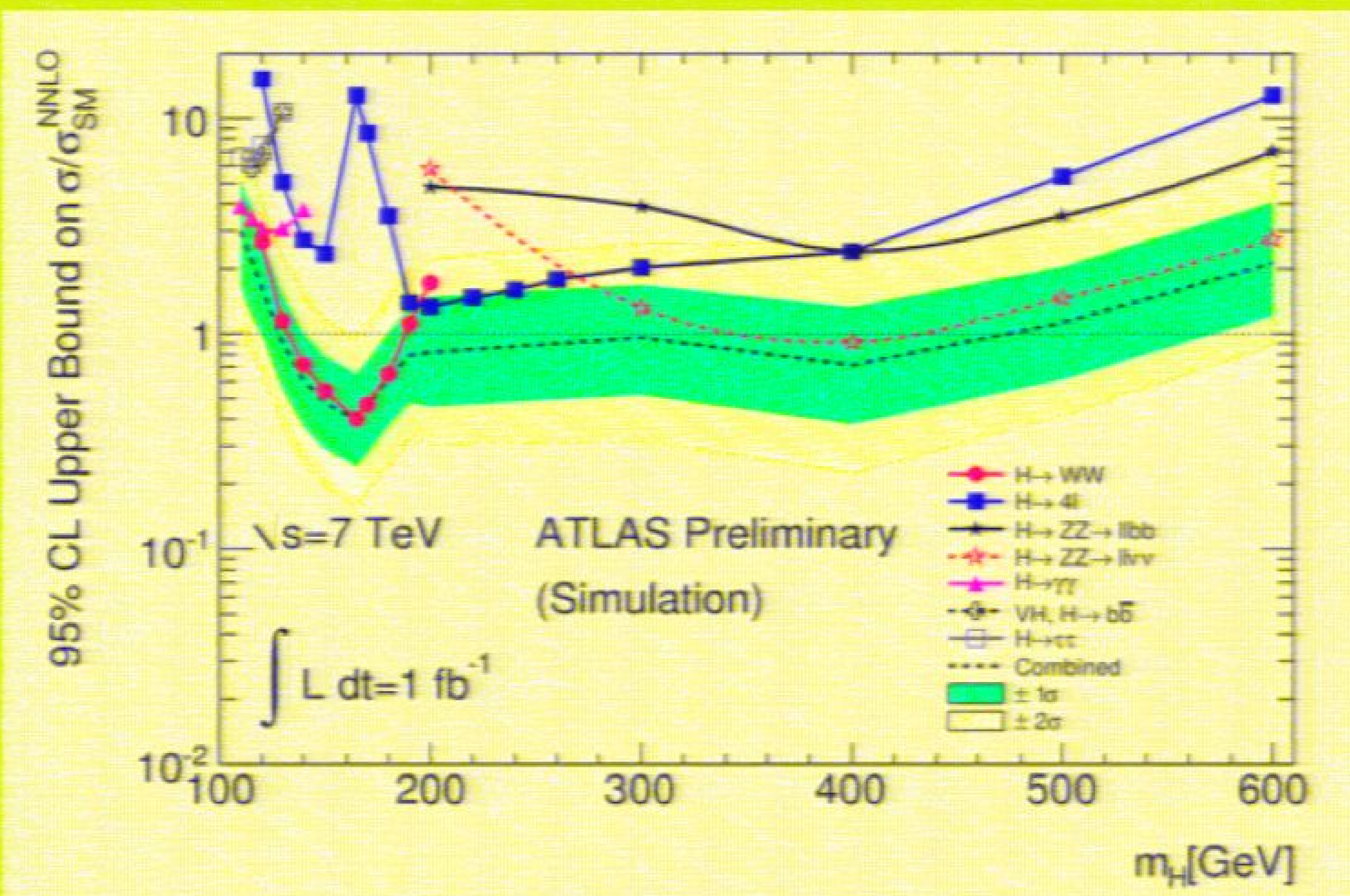
- Current best limits from Tevatron: M_X> 820 GeV at 95% C.L. (for top color assisted technicolor benchmark model)



- Traditional top reconstruction up to M_X~0.75 GeV
- Efficiency drops rapidly beyond that
- New development: "Tagging of *boosted* top jets"

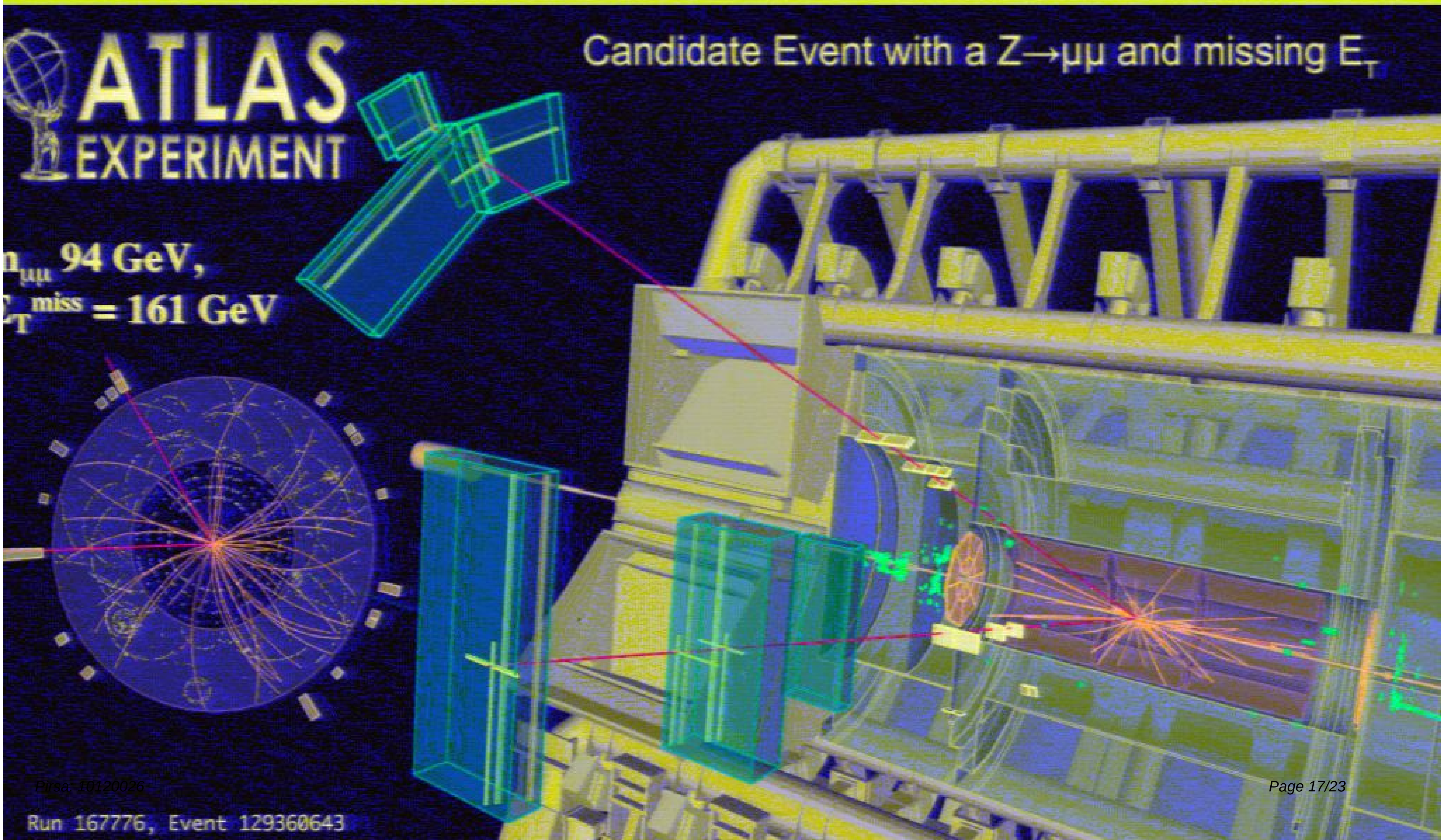


Higgs Exclusions – 1 fb^{-1}



- Have > 50% chance of excluding Higgs with $129 < M_H < 460\ GeV/c^2$

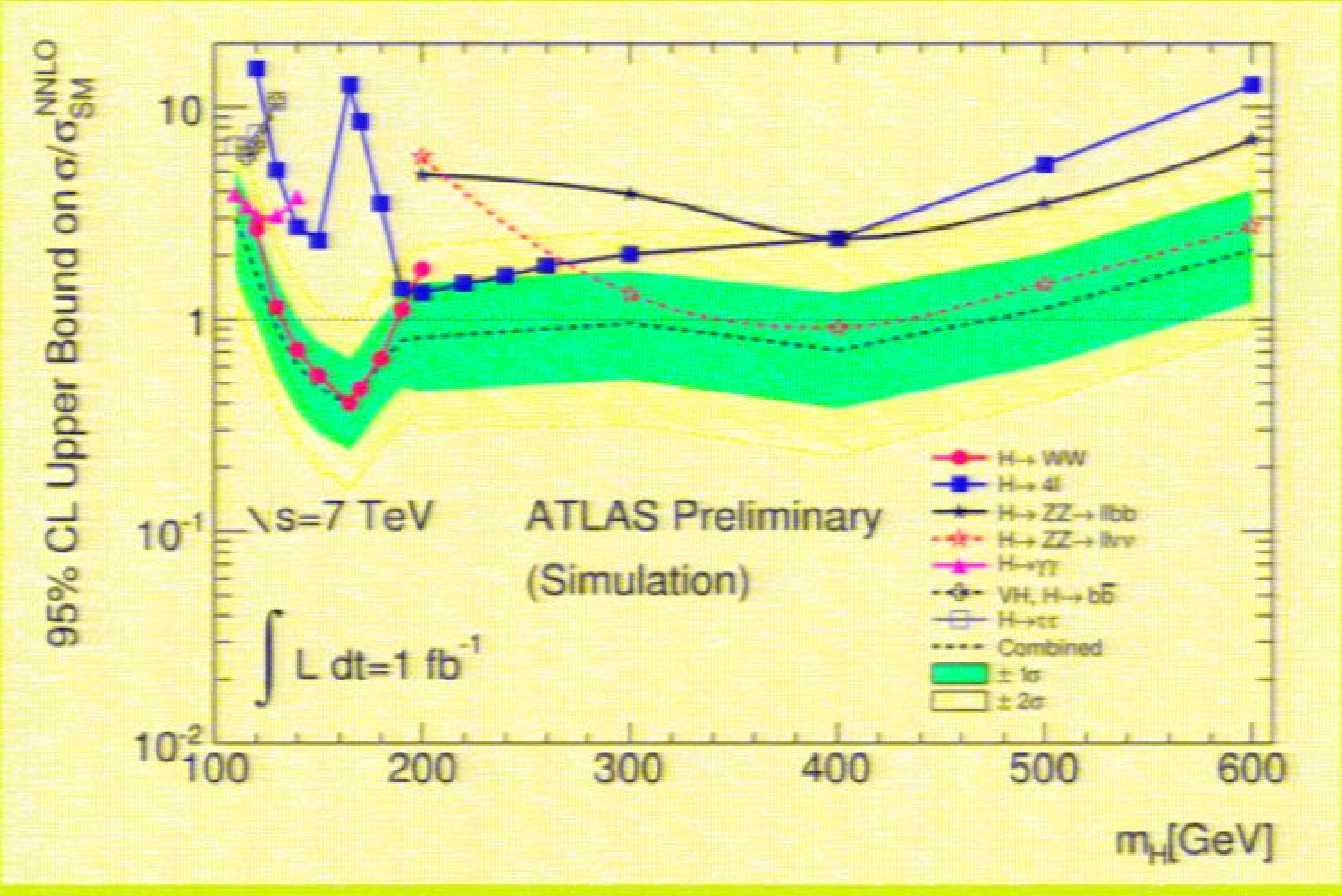
Candidate for ZZ→μμνν



2011 LHC Schedule

- **Start operations late Feb**
  - Proton running by Mar 2011
  - Expect ~200 days of protons
  - Switch to Heavy Ions – 4 weeks
- **ATLAS will take advantage of 11 week shutdown**
  - Open both ends of detector to access calorimeters
  - Fix various readout & on-detector power supply problems
  - Get ready for extended run

Higgs Exclusions – 1 fb^{-1}



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LHC Running Goals for 2011

- "Reasonable"
  - 4 TeV /beam
  - 936 bunches (75 ns)
  - 3 micron emittance
  - 1.2×10^{11} p/bunch
  - $\beta^* = 2.5$ m, nominal crossing angle

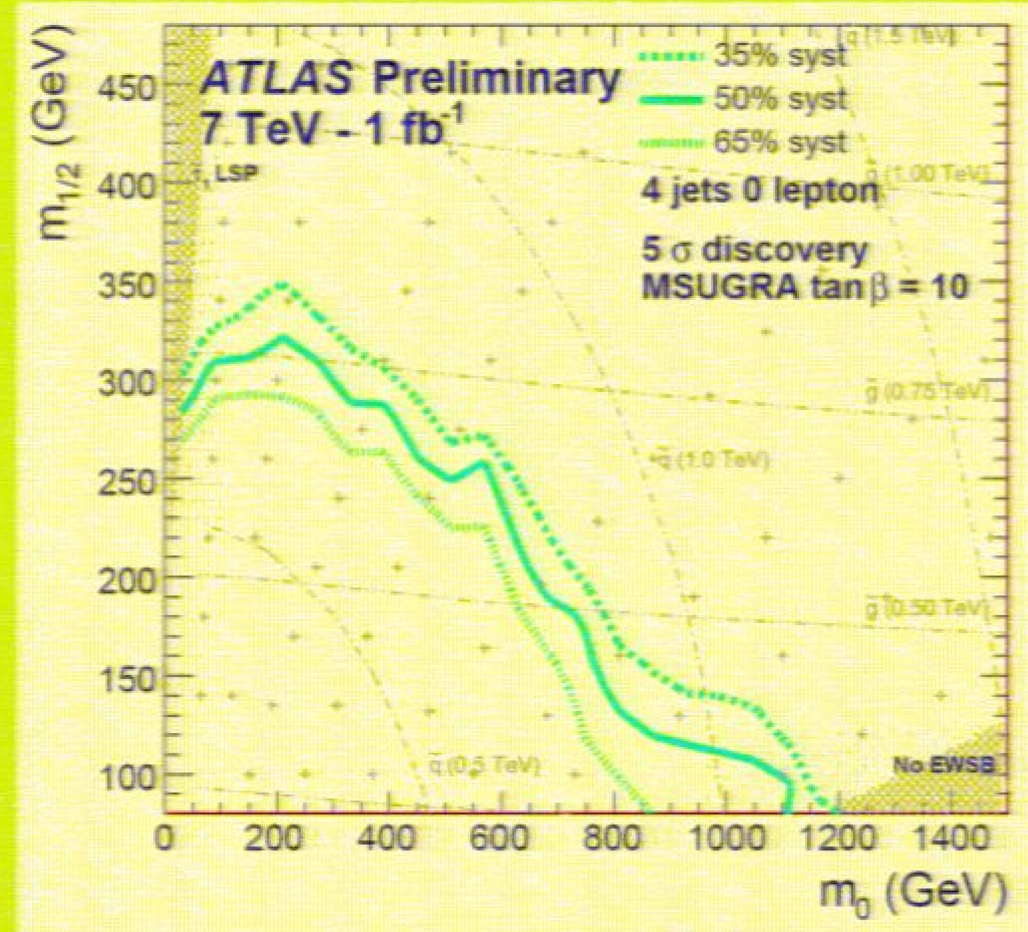
Peak luminosity	6.4×10^{32}
Integrated per day	11 pb^{-1}
200 days	2.2 fb^{-1}
Stored energy	72 MJ

- "Optimistic"
  - 4 TeV /beam
  - 1400 bunches (50 ns)
  - 2.5 micron emittance
  - 1.5×10^{11} p/bunch
  - $\beta^* = 2.0$ m, nominal crossing angle

Peak luminosity	2.2×10^{33}
Integrated per day	38 pb^{-1}
200 days	7.6 fb^{-1}
Stored energy	134 MJ

ATLAS Plans for 2011

- **With an ~1 fb^{-1} of data**
  - Push well beyond Tevatron energy regime
  - Higgs becomes within reach, probably exceeding Tevatron sensitivity
- **The goal is to extend sensitivity to physics beyond SM**
  - Key question will be what it will look like
  - SUSY is just one framework, right?



Summary

- **LHC and ATLAS explorations now well underway**
  - Early studies show capacity to access SM physics
  - First data analyses show good access to high p_T phenomena
- **Challenge:**
  - Understand what are most sensitive ways of analyzing data
  - Need greater understanding of phenomenology
- **There will certainly be surprises**
  - First Heavy Ion run a good example
  - "Jet quenching" was dramatic observation