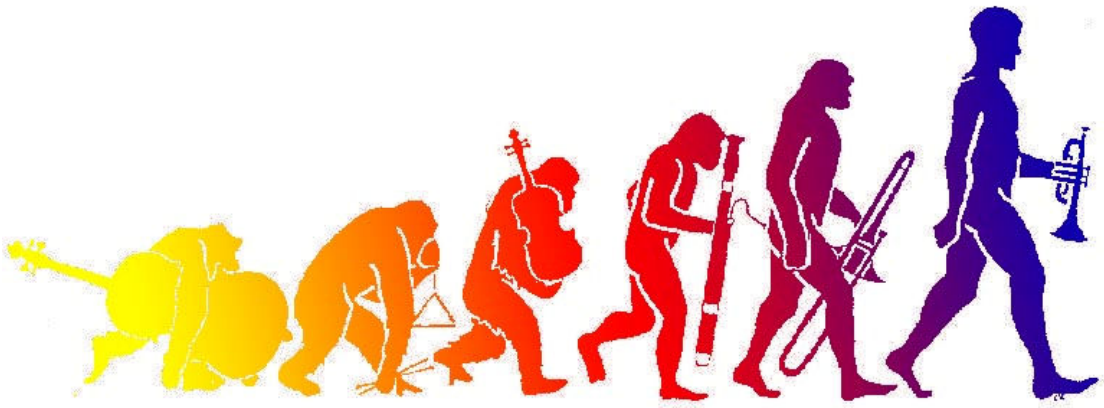
Evolution of the Run Plan



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Physics Reach at Different Energies

- Studies we have done
  - Chamonix
    - Generator-level and fast simulation
  - Post CSC 10 TeV studies
    - Particularly relevant are some fully simulated Top & SUSY studies
    - Validates Chamonix at the 10-20% level

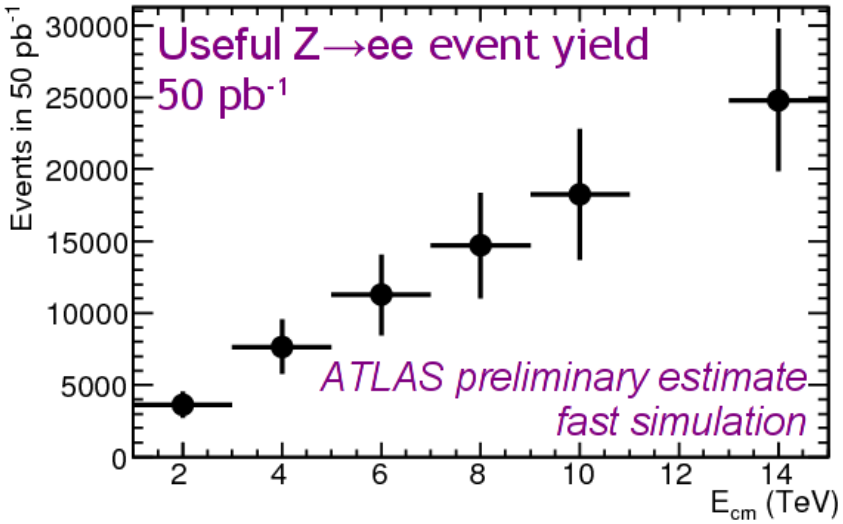
- What we don't know
  - The Luminosity profile for the different values of center-of-mass-energy
  - Non-trivial to guess: involves machine limitations, operational factors
    - Nevertheless, has a huge impact on the physics program

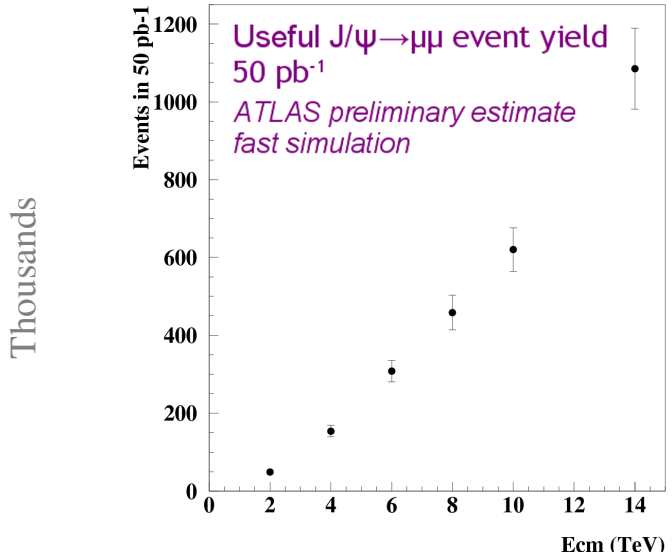
  Everything that follows will be expressed in terms of a constant integrated luminosity. CERN management will have to factor into their decision-making process what a realistic luminosity is for each center-of-mass energy.

  - The schedule for runs beyond 2010

Early Signals for Detector Understanding/calibration

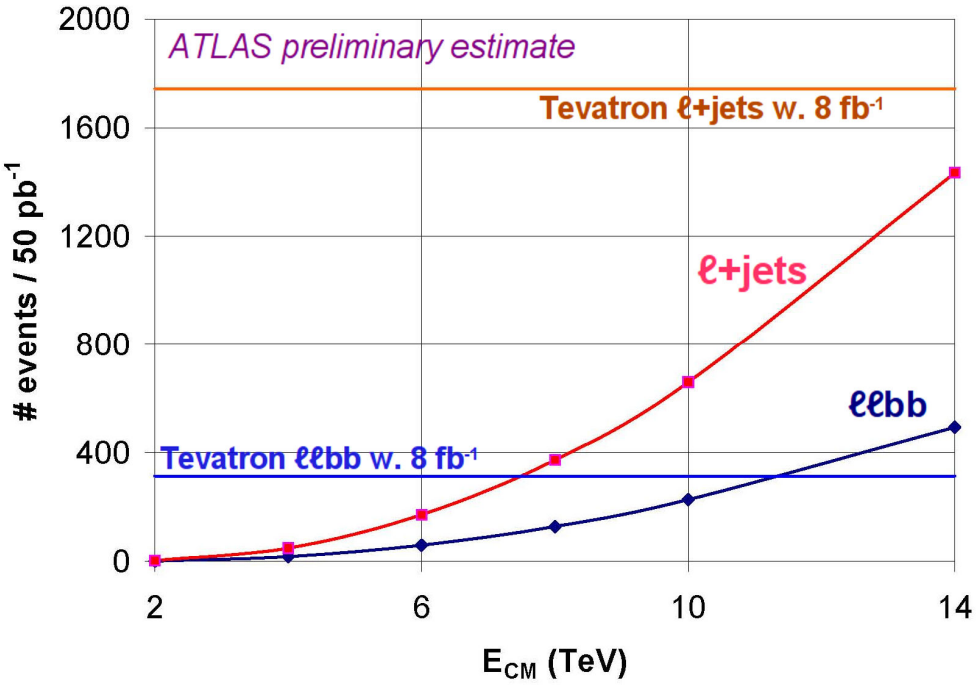
- For W's, Z's and J/ψ's, we are talking tens to hundreds of thousands of events
  - Enough for physics and calibration studies, provided you don't chop the data up into too many bins.
- W and Z production scales ~linearly with energy
- The J/ψ has a visible quadratic correction
  - Due to the interaction between the μ6μ4 trigger and the p_T(J/ψ) spectrum
  - At some point, μ4μ4 becomes feasible: increases yield by 30-50%





Top Quarks

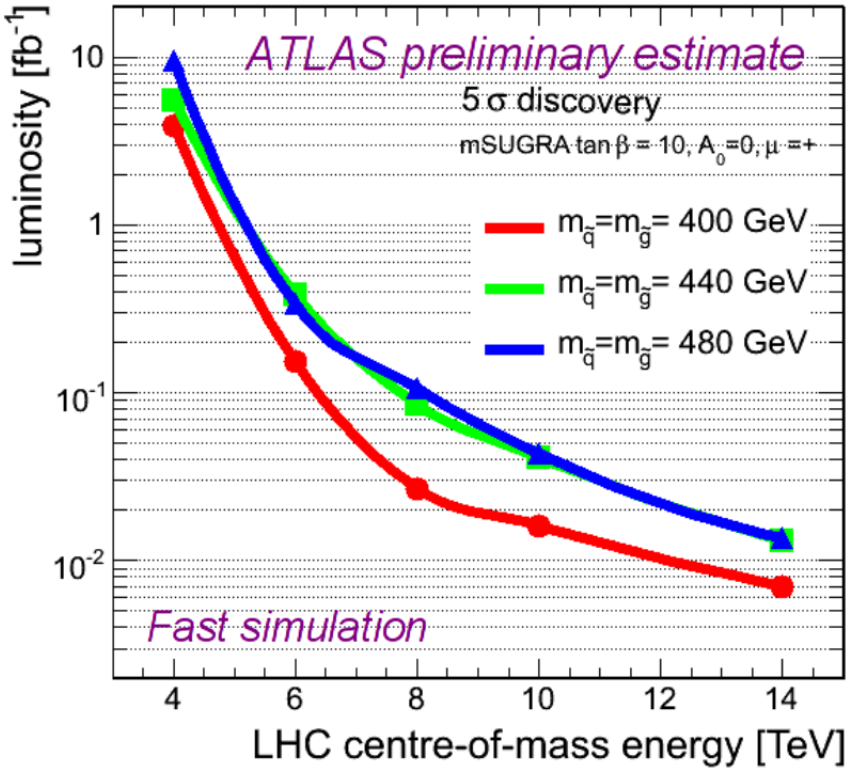
- ATLAS will tell us about top quarks – but top quarks will also tell us about ATLAS
  - These events contain all of the basic signatures: leptons, jets, missing E_T, and heavy flavor
- We would like thousands of events for this
  - We will probably have hundreds: enough to start, but statistics will be an issue, **at any energy**.
  - Below about 6 TeV, this shortfall will be particularly acute
- "Rediscovery" of top and early measurements will be possible.



Lepton plus jets is for a "medium" set of cuts – loose or tight cuts change yield by a factor of 2.

SUSY

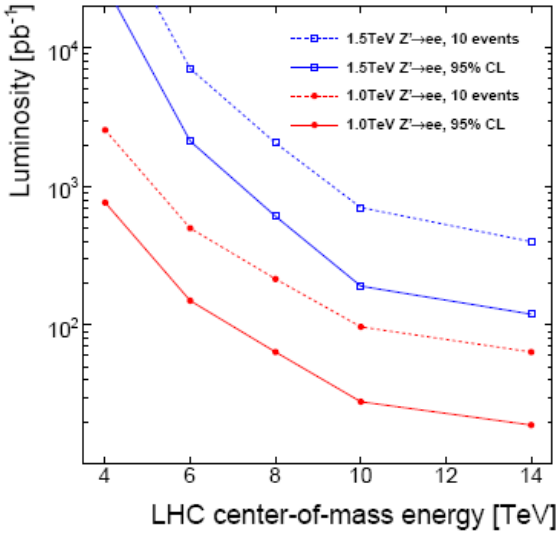
- This is a relatively favorable model
  - Decay signature is leptons + jets + MET
  - Present limit is 392 GeV
- ~100 pb^{-1} at 7-10 TeV allows us to search [substantially] beyond this point
- At 6 TeV our sensitivity is close to the present limit.

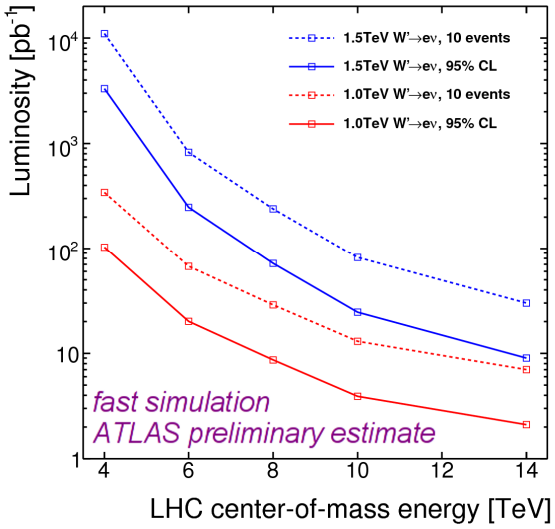


Non-trivial kinematics are responsible for the proximity of the blue and green curves.

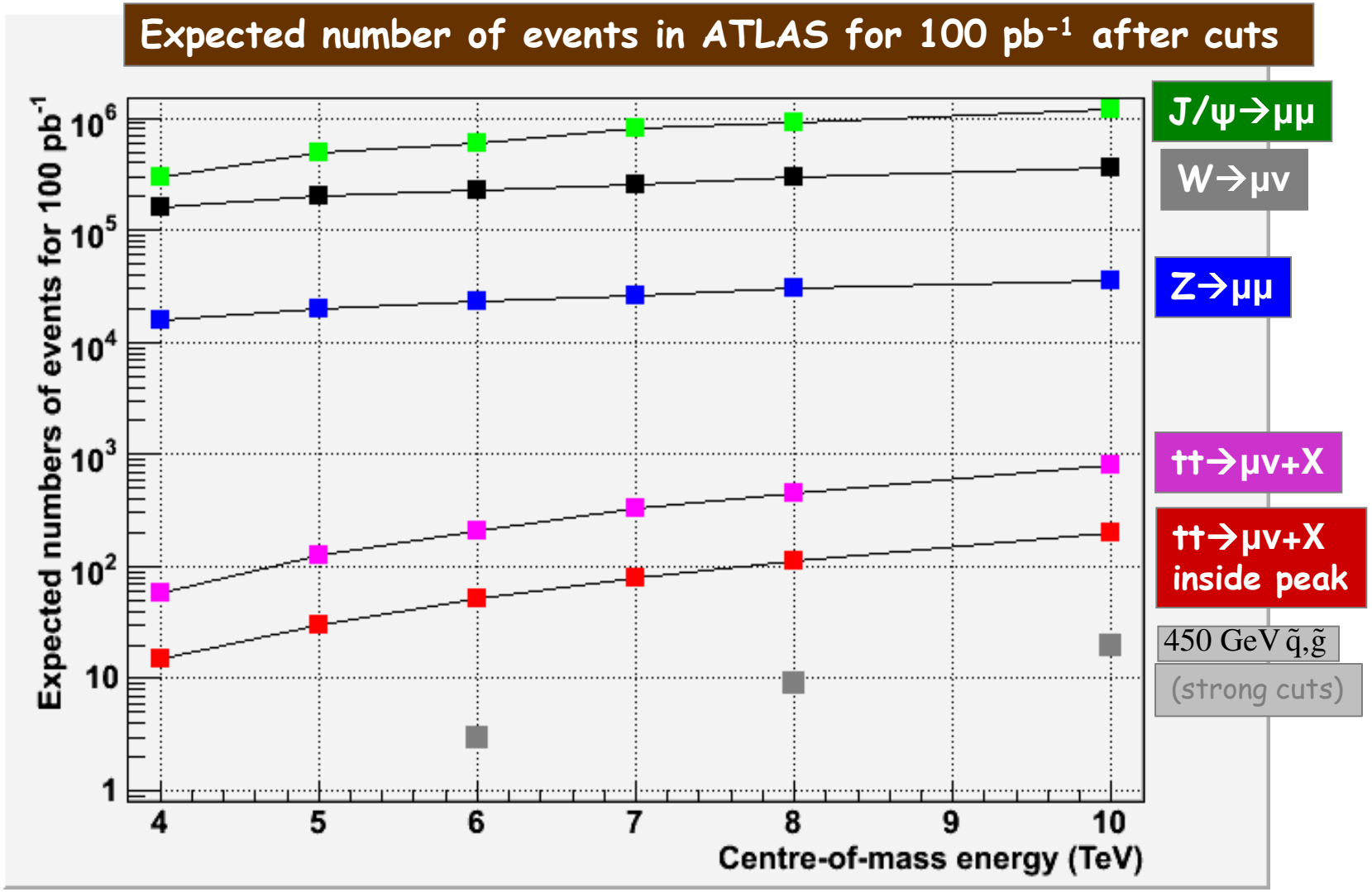
New Bosons: W', Z' and Higgs

- Discovery sensitivity beyond the direct limit for the Z' (PDG value is 923 GeV), requires ~100 pb^{-1} at 10 TeV.
  - Limits can be set to about 6 TeV
- Discovery sensitivity beyond the limit for the W' (PDG value is 1 TeV), requires ~10 pb^{-1} at 10 TeV.
  - It also requires a very good understanding of the detector
  - 100 pb^{-1} at 10 TeV lets us set a limit ~1.5 TeV
- Each TeV loss in center-of-mass energy reduces the sensitivity by about 100 GeV
- The Higgs was already marginal at 10 TeV and hundreds of pb^{-1}
  - Below 10 TeV, we're simply not sensitive





Yields vs. Center of Mass Energy



The LHC Safe Energy

- With the 50s dump time, the calculated safe resistance at 7 TeV is 120 μΩ per splice under conservative assumptions.
  - The worst ones found in the warm sectors were ~60 μΩ
    - Every one worse than 35 μΩ has been replaced
  - The cold sectors had noisy measurements, so the threshold of measurement was about ~80 μΩ
    - No splice this bad was found
- At 10 TeV, they need to move to a 68s dump time, and the safe resistance is 67 μΩ
  - Today's measurements indicate (some energy above) 8.5 TeV is safe
  - If the cold splices are the same as the warm splices, 10 TeV is safe.
- These are based on conservative calculations
  - They will be replaced by measurements
    - FRESCA test bench
    - QPS measurements during operations
- Lower energy is not necessarily safer
  - The risk of damage per quench goes down
  - The probability of a quench goes up (because the beam is larger and needs a larger aperture)

A 7 TeV Run Model

Plugging in the numbers – 3.5 TeV

Month	OP scenario	Max number bunch	Protons per bunch	Min beta*	Peak Lumi	Integrated	% nominal	events/X
1	Beam commissioning							
2	Pilot physics combined with commissioning	43	3×10^{10}	4	8.6×10^{29}	~200 nb^{-1}		
3		43	5×10^{10}	4	2.4×10^{30}	~1 pb^{-1}		
4		156	5×10^{10}	2	1.7×10^{31}	~9 pb^{-1}	2.5	
5a	No crossing angle	156	7×10^{10}	2	3.4×10^{31}	~18 pb^{-1}	3.4	
5b	No crossing angle – pushing bunch intensity	156	1×10^{11}	2	6.9×10^{31}	~36 pb^{-1}	4.8	1.6
6	partial 50 ns – nominal crossing angle	144	7×10^{10}	2-3	3.1×10^{31}	~16 pb^{-1}	3.1	0.8
7		288	7×10^{10}	2-3	8.6×10^{31}	~32 pb^{-1}	6.2	
8		432	7×10^{10}	2-3	9.2×10^{31}	~48 pb^{-1}	9.4	
9		432	9×10^{10}	2-3	1.5×10^{32}	~80 pb^{-1}	12	
10		432	9×10^{10}	2-3	1.5×10^{32}	~80 pb^{-1}	12	
11		432	9×10^{10}	2-3	1.5×10^{32}	~80 pb^{-1}	12	

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A 7 & 10 TeV Run Model

Plugging in the numbers with a step in energy

Month	OP scenario	Max number bunch	Protons per bunch	Min beta*	Peak Lumi	Integrated	% nominal	events/X
1	Beam commissioning							
2	Pilot physics combined with commissioning	43	3×10^{10}	4	8.6×10^{29}	~200 nb^{-1}		
3		43	5×10^{10}	4	2.4×10^{30}	~1 pb^{-1}		
4		156	5×10^{10}	2	1.7×10^{31}	~9 pb^{-1}	2.5	
5a	No crossing angle	156	7×10^{10}	2	3.4×10^{31}	~18 pb^{-1}	3.4	0.8
5b	No crossing angle – pushing bunch intensity	156	1×10^{11}	2	6.9×10^{31}	~36 pb^{-1}	4.8	1.6
6	Shift to higher energy: approx 4 weeks	Would aim for physics without crossing angle in the first instance with a gentle ramp back up in intensity						
7	4 – 5 TeV (5 TeV luminosity numbers quoted)	156	7×10^{10}	2	4.9×10^{31}	~26 pb^{-1}	3.4	
8	50 ns – nominal crossing angle	144	7×10^{10}	2	4.4×10^{31}	~23 pb^{-1}	3.1	1.1
9	50 ns	288	7×10^{10}	2	8.8×10^{31}	~46 pb^{-1}	6.2	
10	50 ns	432	7×10^{10}	2	1.3×10^{32}	~69 pb^{-1}	9.4	
11	50 ns	432	9×10^{10}	2	2.1×10^{32}	~110 pb^{-1}	12	

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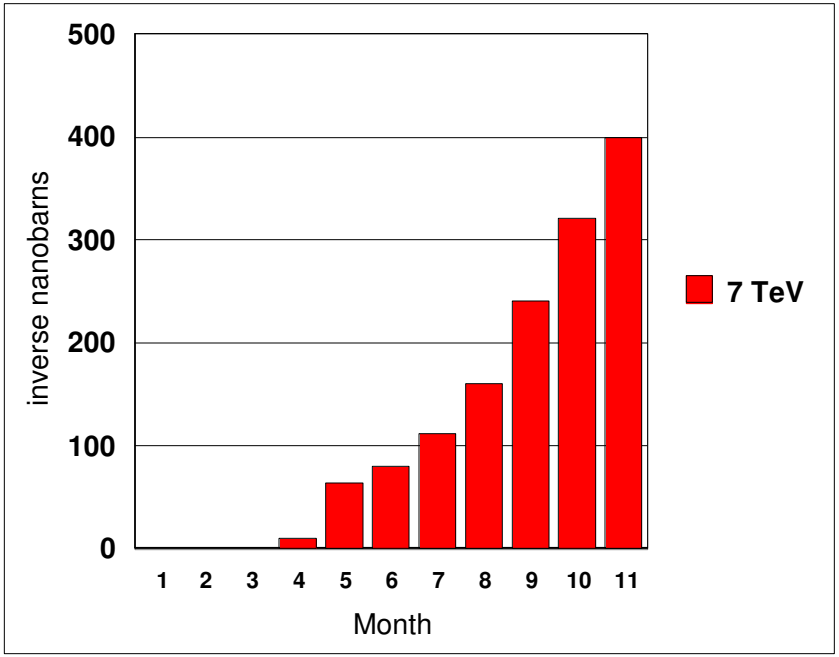
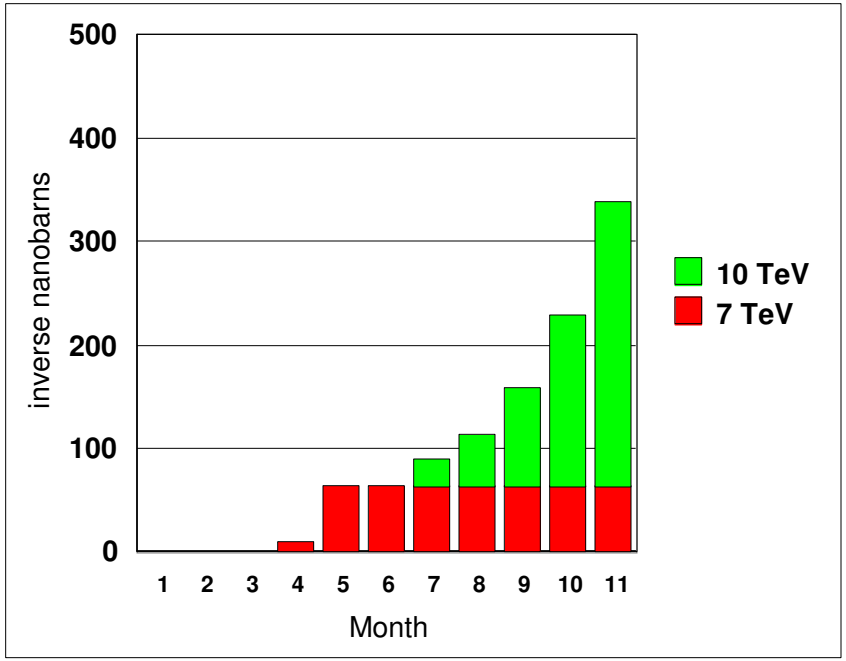
Run Models

- These are run *models*, not run *plans*.
  - The run plan will evolve as we gain experience
- Taking these at face value, we can ask what we will expect
  - 400 pb^{-1} for a 7 TeV only run, and 65 pb^{-1} + 275 pb^{-1} for a 7+10 TeV run





More on Models

- It's difficult to compare different center-of-mass energies
  - Different physics processes have different scalings
  - I will use an average of top quarks, Z primes, and SUSY here, and try and equate this to 10 TeV equivalent luminosity
    - Reminder: 100-200 pb^{-1} at 10 TeV is where we start to have sensitivity substantially beyond present limits
- A few models:
  - 7 TeV only: 115 pb^{-1} equivalent
  - 7 TeV, then 10 TeV: 300 pb^{-1} equivalent
  - Run 7 TeV until we get 100 pb^{-1}, and then run 10 TeV: 130 pb^{-1} equivalent
  - 7 TeV, then 8.5 TeV: 160 pb^{-1} equivalent
  - Commission 15% slower: 115 pb^{-1} equivalent
  - Commission 15% faster: 500 pb^{-1} equivalent

Variations are substantial, but not orders of magnitude

Our Best Inkling of a Run Plan

- LHC becomes cold on Week 47 (mid-November if you're not on metric time)
  - They are still holding to this, although the schedule contingency isn't what it once was
- Single beams ~a week later
- 450 on 450 GeV Collisions ~a week after that
  - One or two days. We expect 10-15 million events.
- Christmas shutdown
- 3.5 on 3.5 TeV collisions starting in January
  - The present schedule has them for the last 3 days in December
- Decision point in late spring/early summer
  - Do we stay at 7 TeV?
  - If we go to higher energy, when do we do this?
  - If we go to higher energy, which energy?
- Switch over to lead ions at the very end of the run
- A shutdown of indeterminate length

We will have a lot more operational experience to answer these questions nine months from now.

Conclusions

- We have a sketch of a run plan now
  - This has evolved and will continue to evolve as we gain experience.
- Expect 900 GeV data this year.
- At the end of the 2009-2010 run, run models show ATLAS having sensitivity at or beyond the Tevatron for multiple processes.
  - If one is optimistic, substantially more
- I didn't talk about 14 TeV running
  - Depends on too many things we don't know