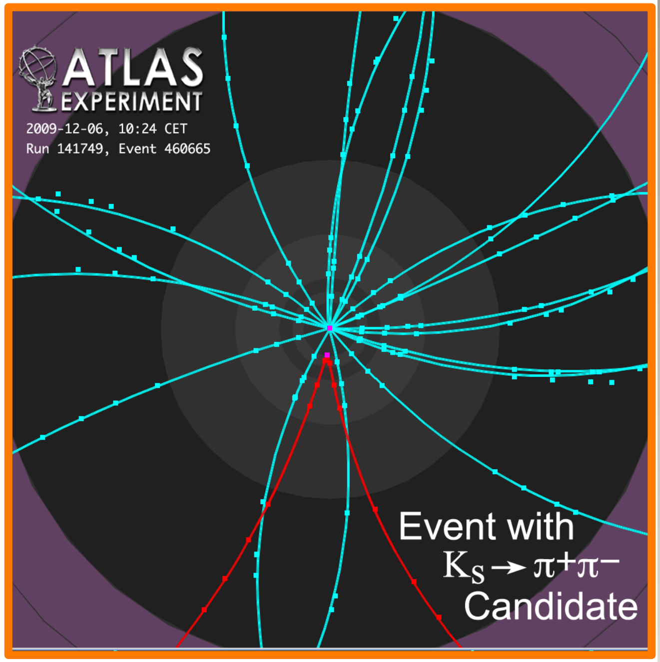
Detector limitations

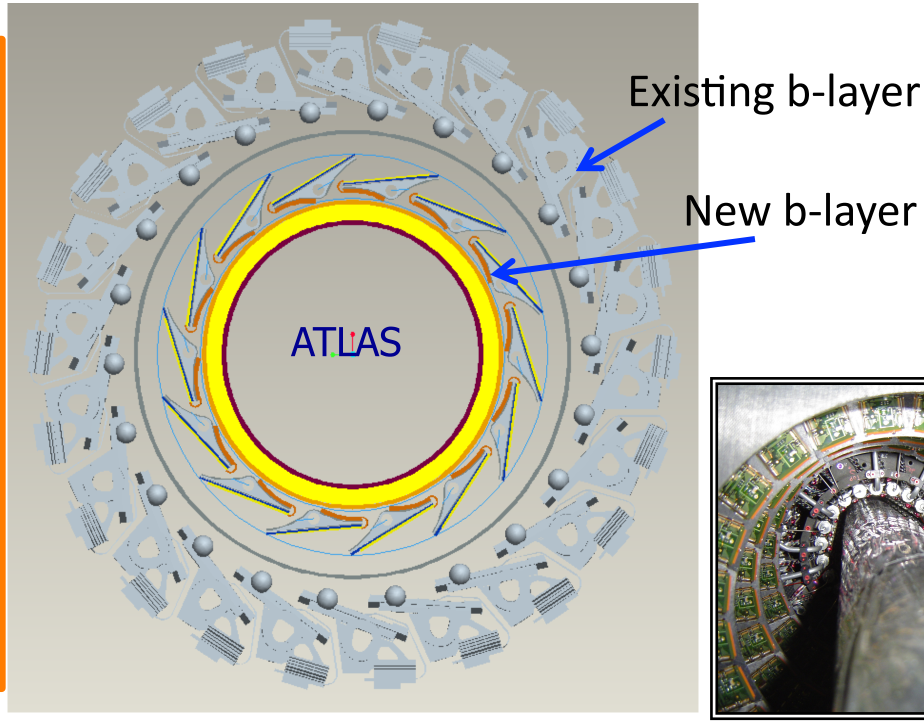
- Some detectors will age at a given integrated Luminosity (different case by case)
  - ATLAS b-layer PIXEL ~ L_{int} ~ 100-200 fb^{-1}
  - ATLAS Silicon Tracker (SCT + PIXEL) ~ L_{int} = 600-700 fb^{-1}
  - ATLAS LAr Hadron Calorimeter FE Electronics ~ L_{int} = 1000 fb^{-1}
  - ….

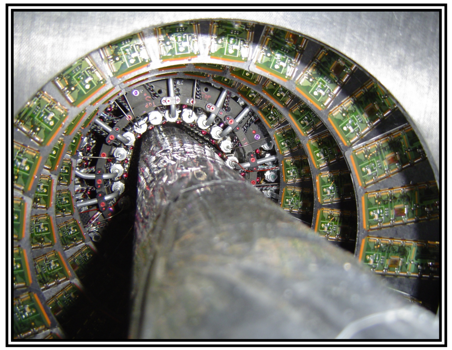
- Some detectors will become inefficient or problematic at a given peak Luminosity
  - ATLAS TRT (transition radiation tracker) ~ L = 2-3 10^{34}
  - ATLAS FCAL (forward calorimeters) ~ L = 2 10^{34}
  - ATLAS SS external beam pipes (activation) ~ L = 1 10^{34}
  - ATLAS Silicon trackers ~ L = 2-3 10^{34}
  - ATLAS LVL1 trigger sharpness ~ L = 1-2 10^{34}
  - …….

ATLAS innermost PIXEL layer (b-layer)

- Present Pixel detector, in particular the innermost layer (out of 3) might become inefficient (***100-200 fb^{-1}, L ~2-3 10^{34} cm^{-2} s^{-1}***)
- ATLAS has officially approved this project. TDR & MOU expected soon
- Ready for 2014

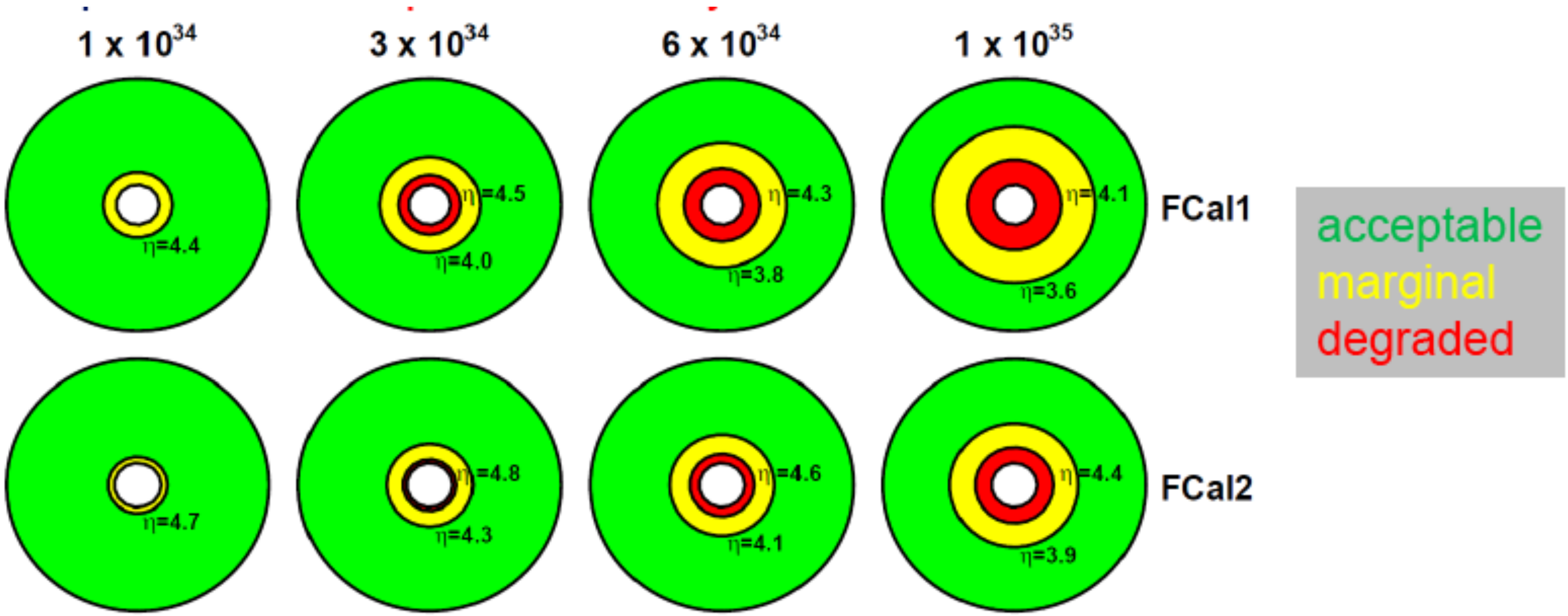






Add a new b-layer around a smaller beam pipe (in radius), stave structure, 160 MHz readout, CO_2 cooling

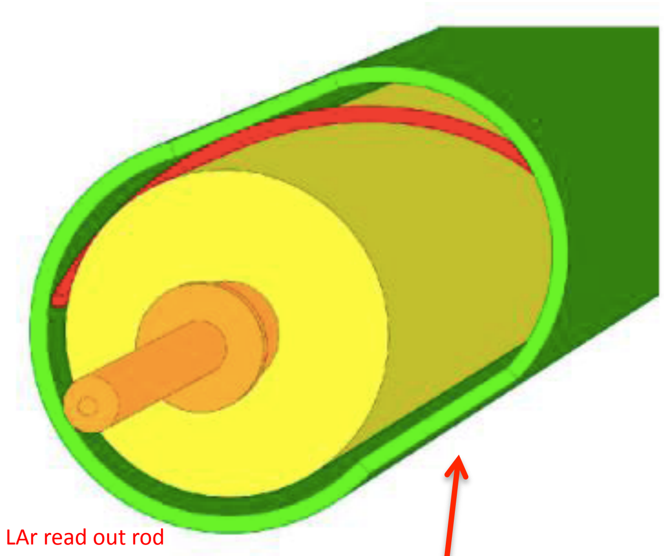
ATLAS LAr forward calorimeters

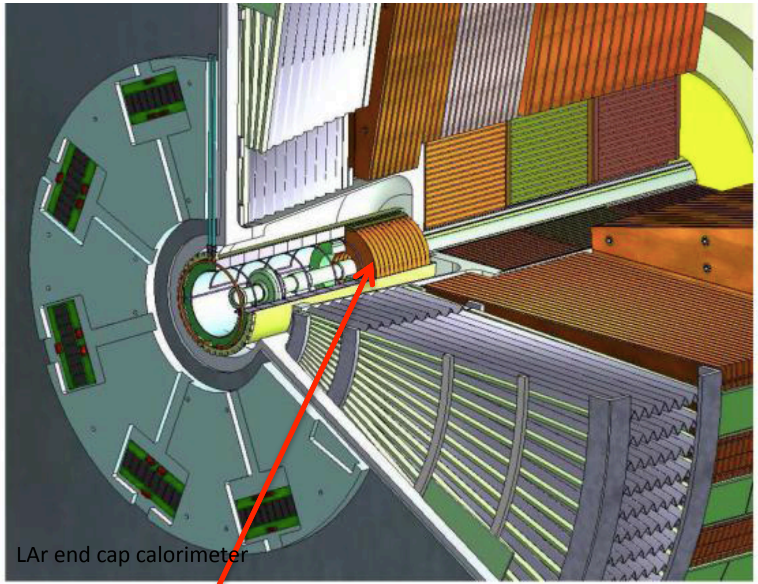


Currently FCal1 will work properly up to peak luminosities of $1{*}10^{34}cm^{-2}s^{-1}$

- The FCal1 will however not work efficiently above $2{*}10^{34}cm^{-2}s^{-1}$
  - positive Ar ions build-up leads to field distortion and to signal loss
  - high HV currents lead to voltage drop
  - heating of Ar and boiling (only at very high luminosities)

ATLAS LAr forward calorimeters





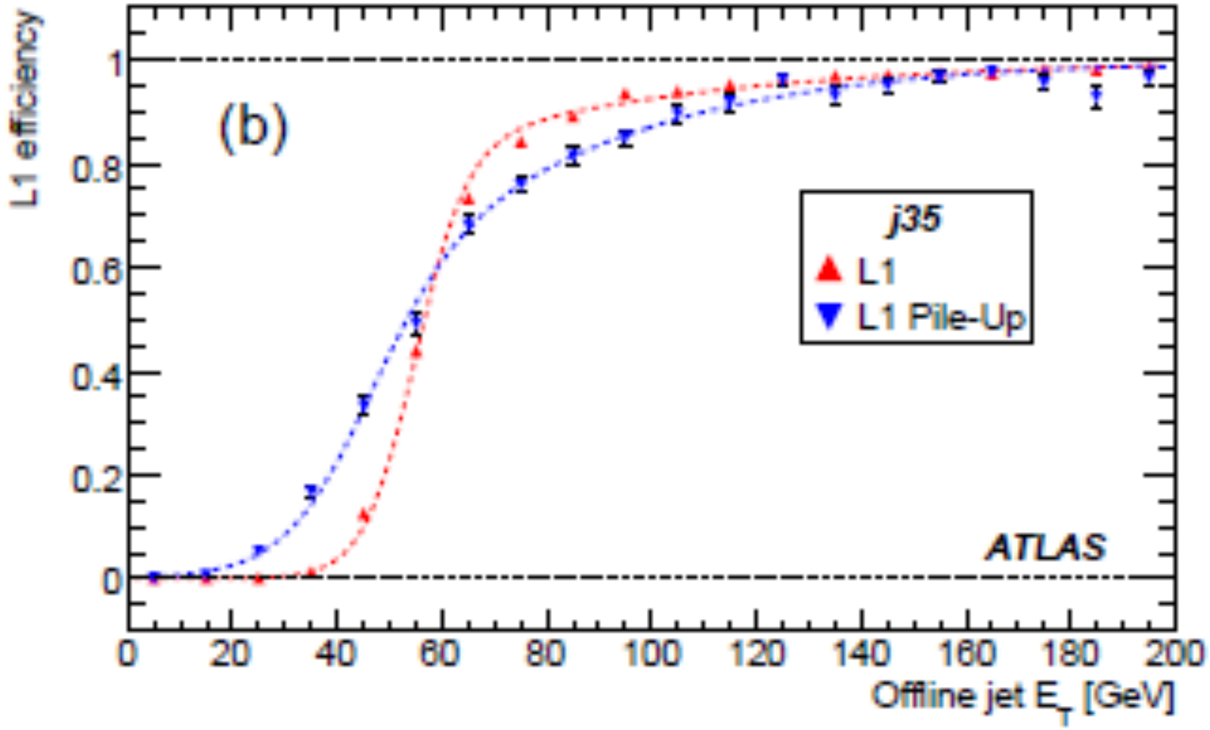
Two options:

- *new cold FCal1 with smaller gaps: 250 µm → 100 µm : this will require a major shutdown of ~ 15 months (2020 ?)*

- *new warm Mini-Fcal in front of current FCAL : this can be ready in phase I and will need a 8-9 months shutdown for installation*

The trigger LVL1 sharpness case

Already at 10^{33} we will see a pileup effect



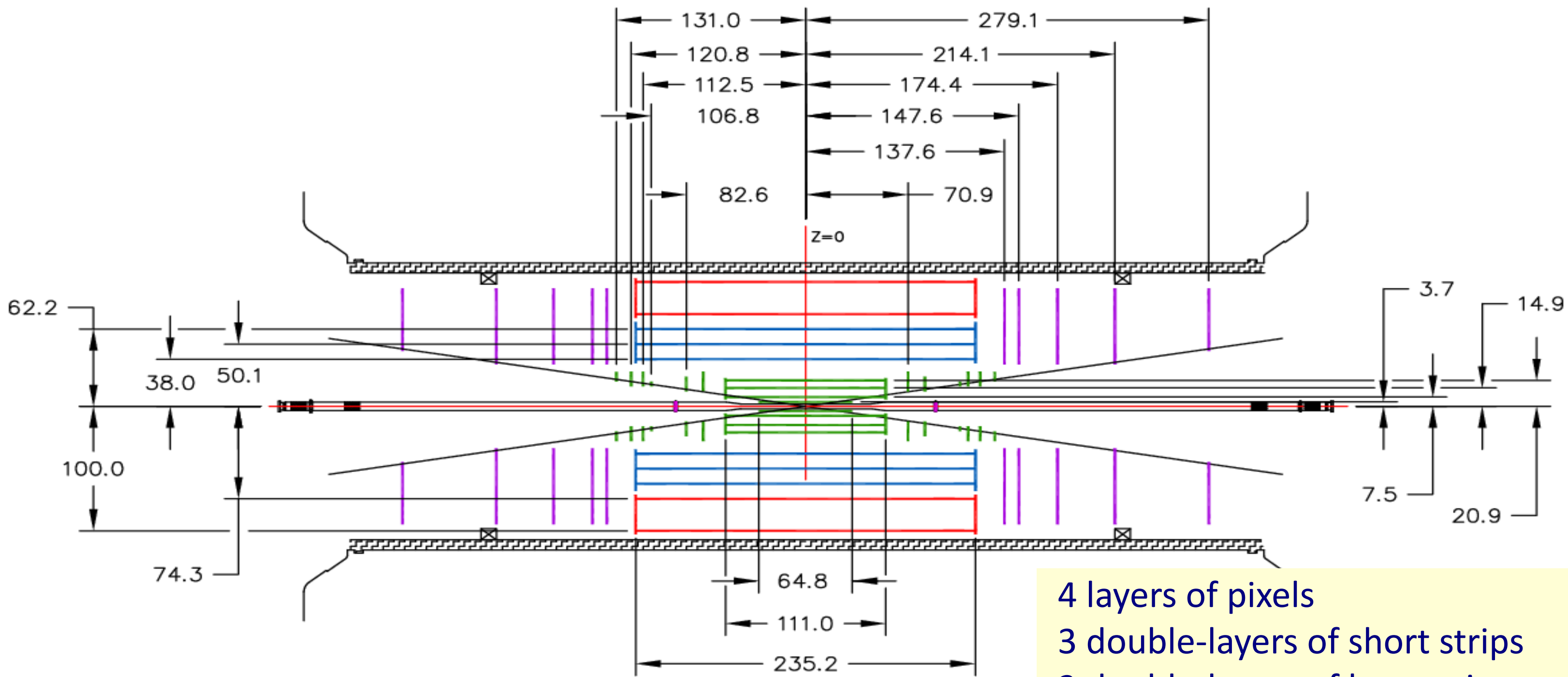
Two complementary approaches:

- *Use as much as possible all the space granularity of Calorimeters and Muon spectrometer in the trigger definition → requires new front-end electronics near to the detector and in some cases (muon forward) new chambers with more granularity*

- *Make the algorithms more complex, new central processors … more decision time*

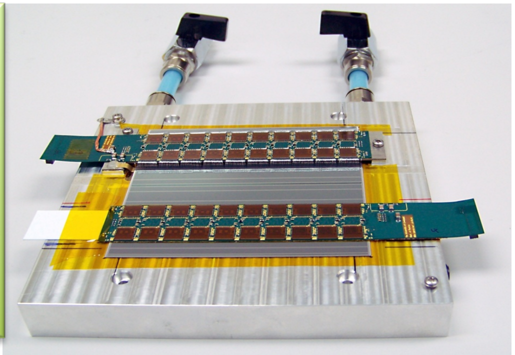
New ATLAS Inner Detector (1)

At ~ 300 fb-1 we will have to be ready with a completely new inner detector. To construct it and finish the R&D phase it will take ~8-9 years.

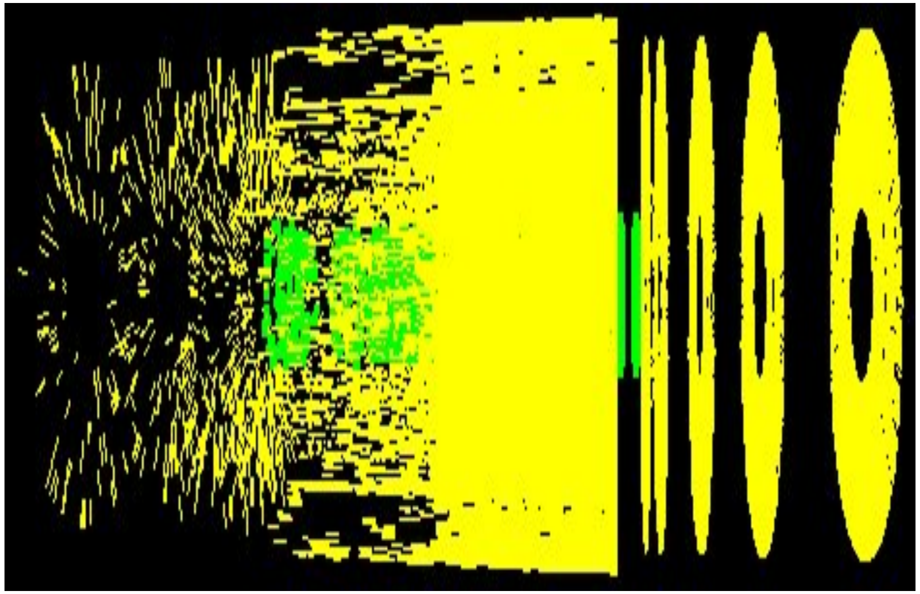


4 layers of pixels
3 double-layers of short strips
2 double-layers of long strips
Approx. 400 Million pixels (cf 80 Million now)
Approx. 45 Million strips (cf 6.3 Million now)

Prototype strip sensors (ATLAS07), read-out chips (ABCNext) and hybrids built into modules with excellent performance



ATLAS Inner Detector (2)



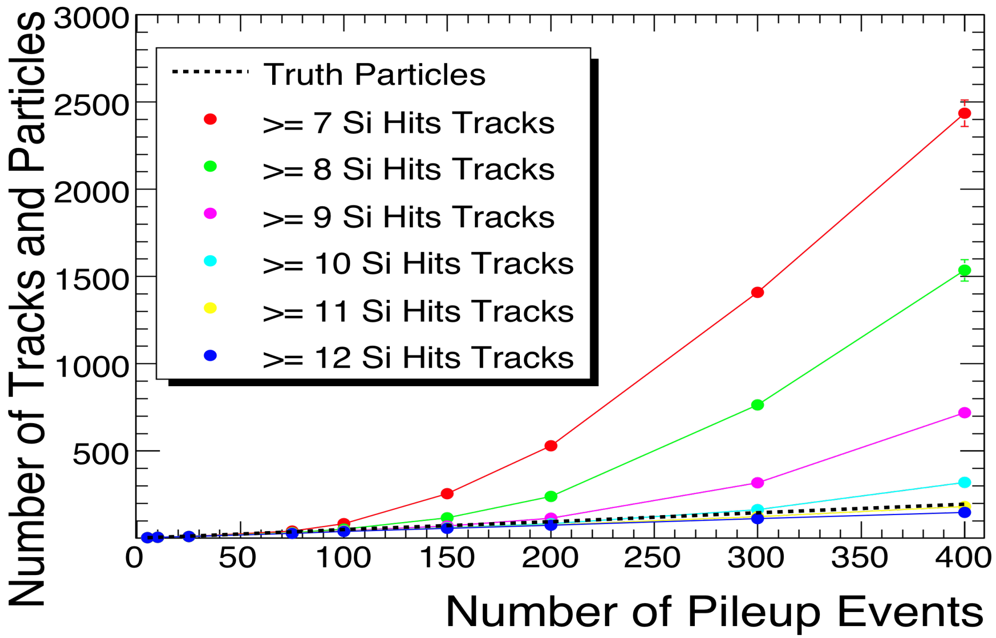
Very high track density

Picture shows hits in inner tracker from one bunch crossing with **400 pile up events**; only tracks in forward half of detector were generated.

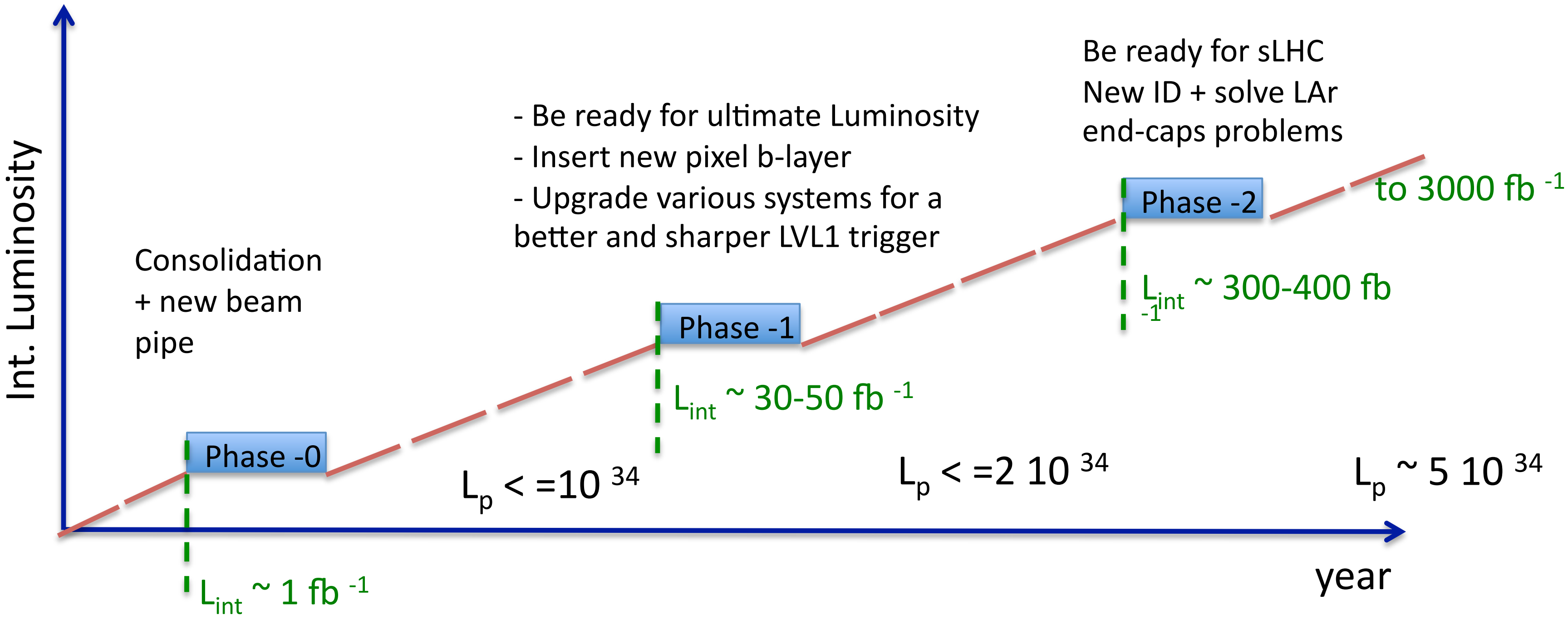
The inner tracker gets about **15,000 tracks** per bunch crossing (and a similar number of photons which can produce e^+e^- pairs)

The challenge is to find all the tracks, without also finding many fake tracks from random combinations of hits.

Work in progress; we can cope with 400 events, but it requires a tight cut of at least 11 hits on a track (yellow line) to control the fake rate. Then the number of tracks found follows the black dotted line of actual number generated, but with some inefficiency.



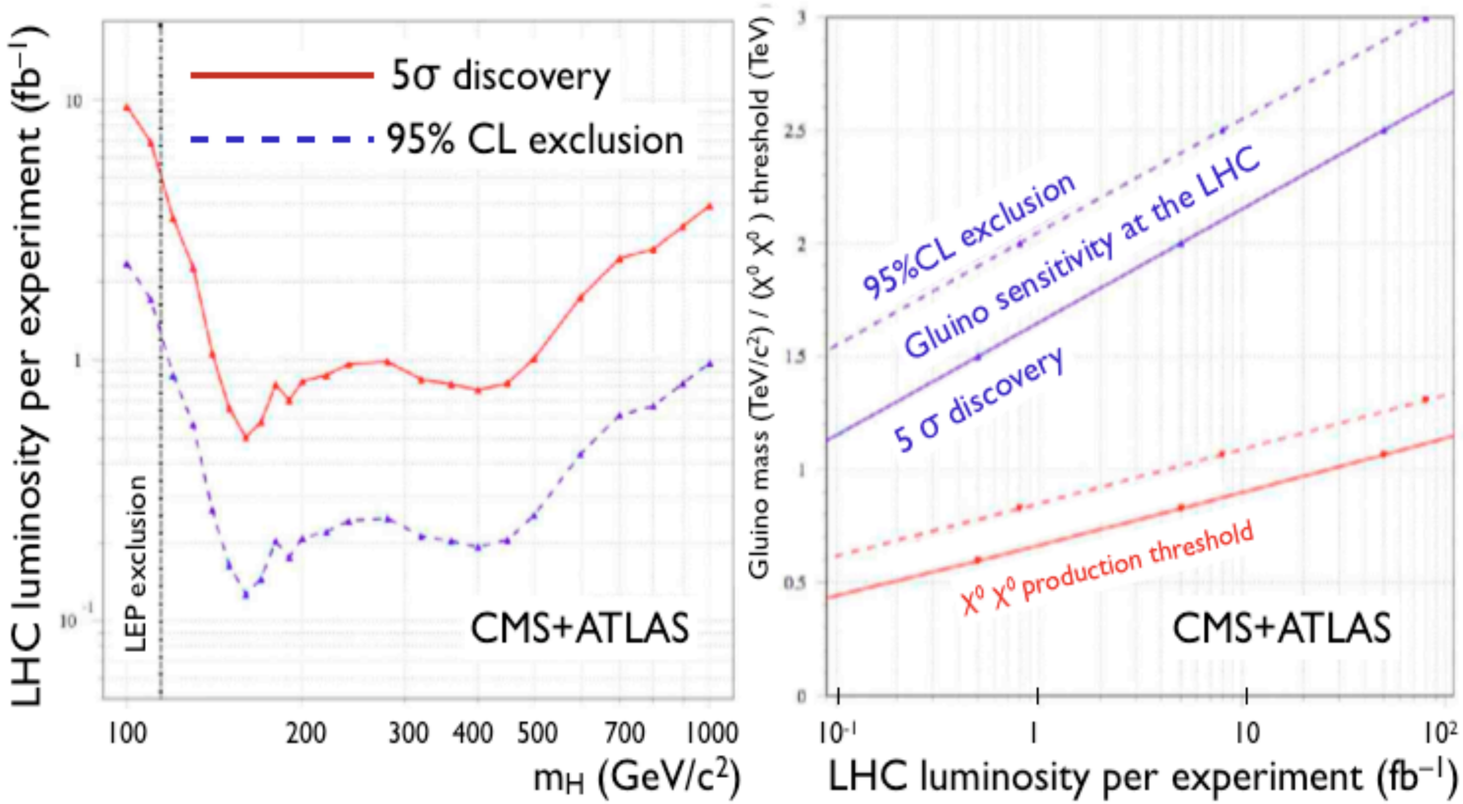
Our strategy !?



Shutdown requirements :

Phase-0 : 12-14 months (defined by the LHC consolidation)
Phase-1 : 9-10 months (time necessary to install at least the new pixel b-layer)
Phase-2 : 18-20 months to install and debug the new ID detector

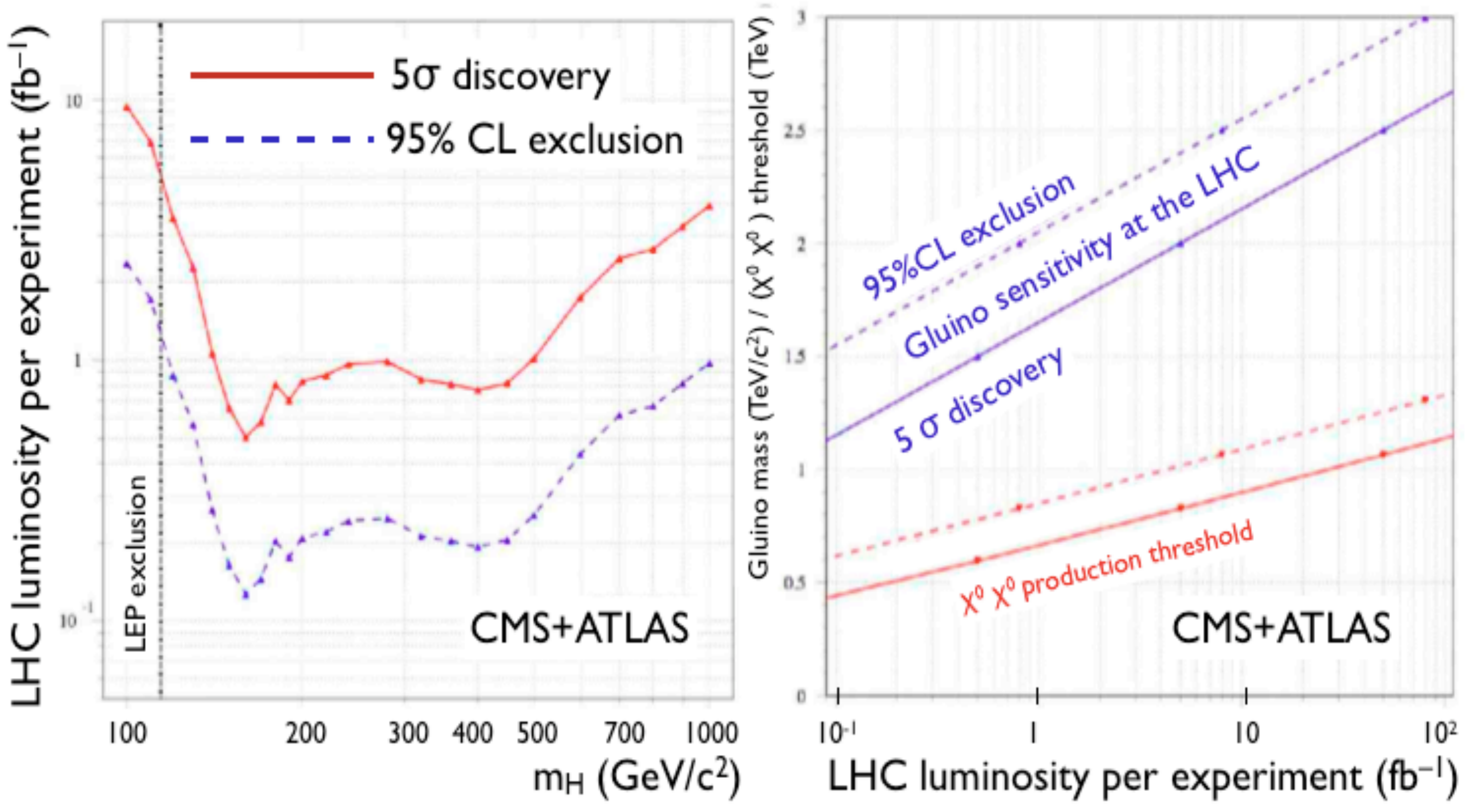
Why should we go beyond 300 fb^{-1} ?



With 10fb^{-1} the LHC will either discover or exclude the SM Higgs and Gluinos up to 1.8-2 TeV.
This probably after 2 years of running at 14 TeV and at 10^{33} $cm^{-2}sec^{-1}$

Whatever the results will be, we will be left with a lot of new questions and problems to solve. There will be no limit to the need of accuracy after that!

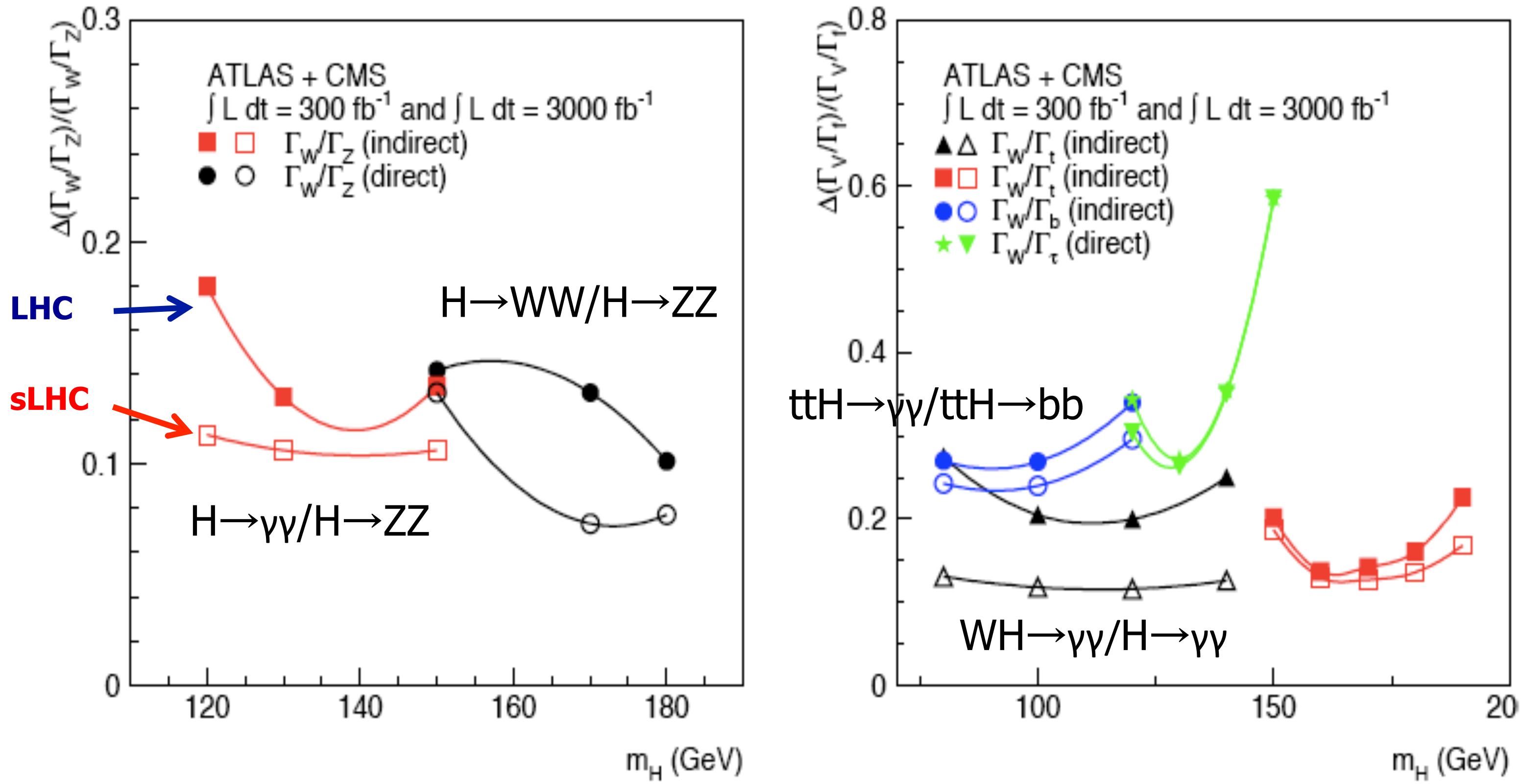
Why should we go beyond 300 fb^{-1} ?



More particles in the Higgs sector? Is the Higgs boson elementary or composite?
Origin of fermion masses ?

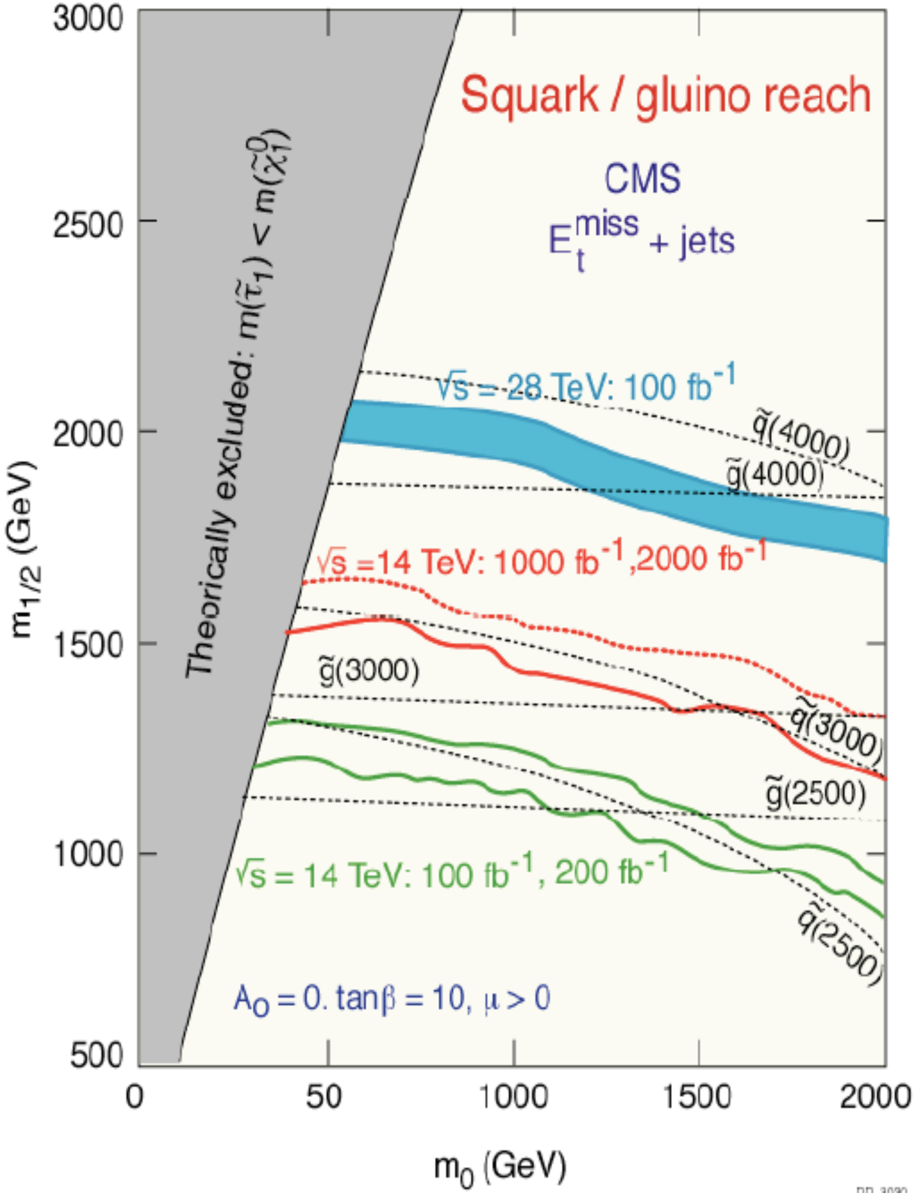
Extend the mass reach of new particles ! Determination of SUSY masses and parameters !

Precision measurements of the SM



- Higgs couplings to fermions, gauge bosons
- Rare decay modes : H-> Zγ (~10^{-3} BR), H-> μμ (10^{-4} BR)
- Self couplings λ : H -> HH -> WWWW -> lνlνjjj (sLHC 20-30%)
- ….

SUSY mass reach !



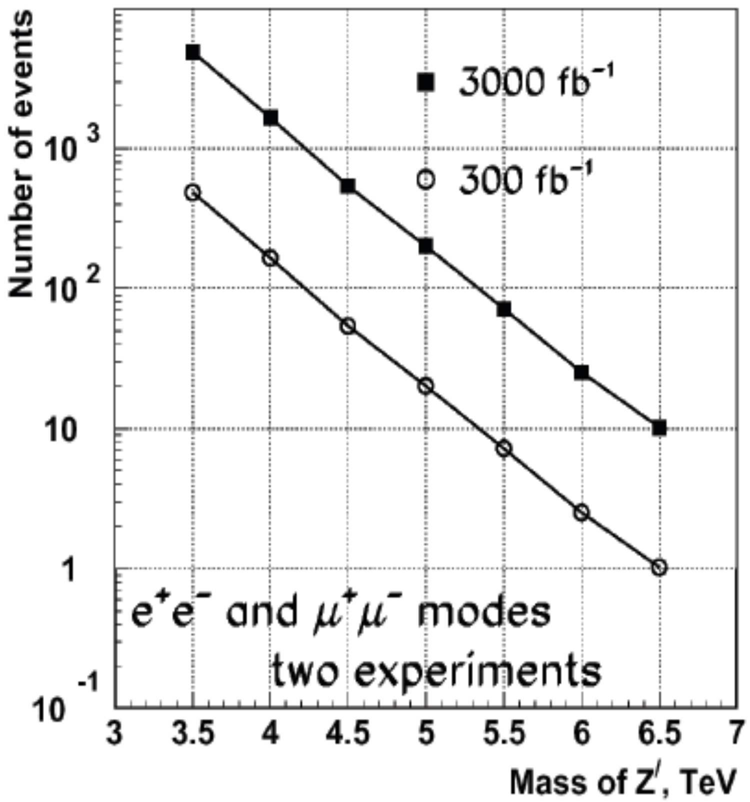
The mass sensitivity grows logarithmically with the statistics

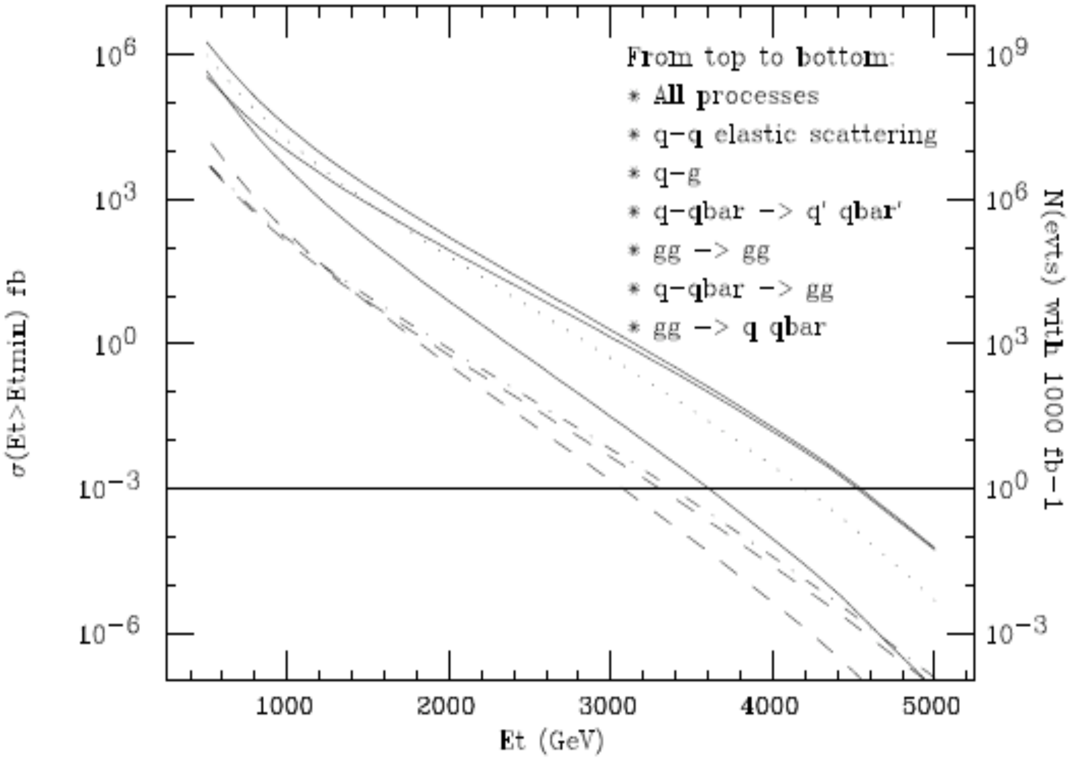
A factor 10 in Luminosity -> 500 GeV

This will increase the mass reach around 3.0-3.3 TeV at sLHC

M reach ~ 500 GeV more than LHC

New forces (Z', W') ? , Compositeness ?



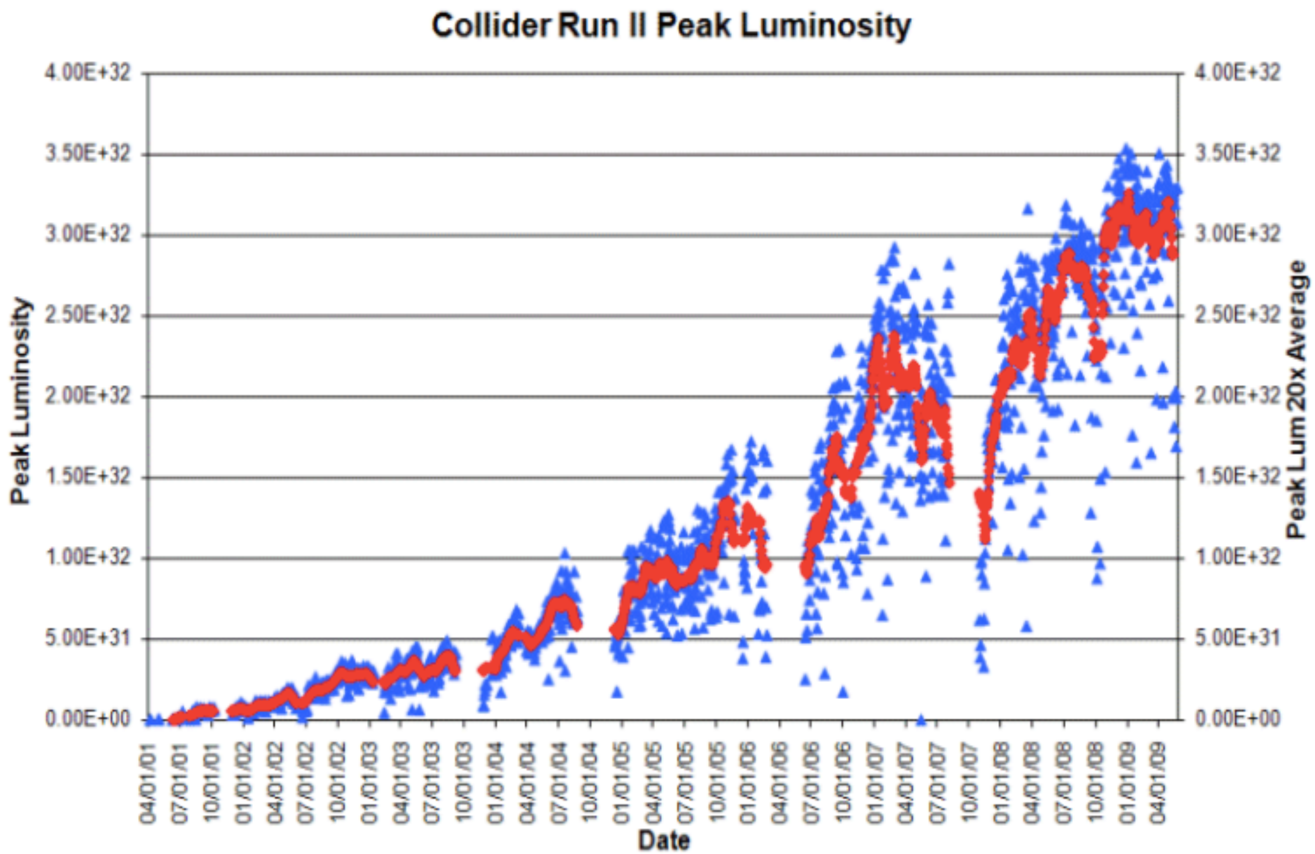


The mass reach can be pushed by ~ 1.1TeV to 6.5 TeV

$\Lambda >$ 40 TeV limit at LHC

$\Lambda >$ 60 TeV limit at sLHC

Lesson from the Tevatron



The lesson from the Tevatron is that once data are available, the experimental ingenuity can deliver the "impossible" (M.Mangano)