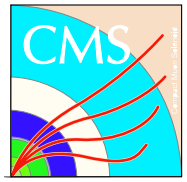


CMS - SLHC Bunch timing issues

Hardware effects

Physics issues

LHC performance and parameters

Parameter [units]	Nominal	Ultimate	Short bunch	Long bunch
No. of bunches n_b	2808	2808	5616	936
p^+ 5 bunch N_b [10^{11}]	1.15	1.7	1.7	6.0
Bunch spacing Δt_{sep} [ns]	25	25	12.5	75
Beam current [A]	0.58	0.86	1.72	1.0
E_{beam} [MJ]	366	541	1085	631
Beta at IP β^* [m]	0.55	0.50	0.25	0.25
Xing angle θ_c [μrad]	285	315	445	430
Bunch length [cm]	7.55	7.55	3.78	14.4
Piwinski ratio $\theta_c \sigma_s/(2\sigma^*)$	0.64	0.75	0.75	2.8
L lifetime τ_L [h]	15	10	6.5	4.5
L_{peak} [10^{34}cm^{-2}s^{-1}]	1.0	2.3	9.2	8.9
$T_{turnaround}$ [h]	10	10	5	5
Events per Xing	19.2	44.2	88	510
$\int_{\text{one year}} L\,dt$ [fb^{-1}]	66.2	131	560	410

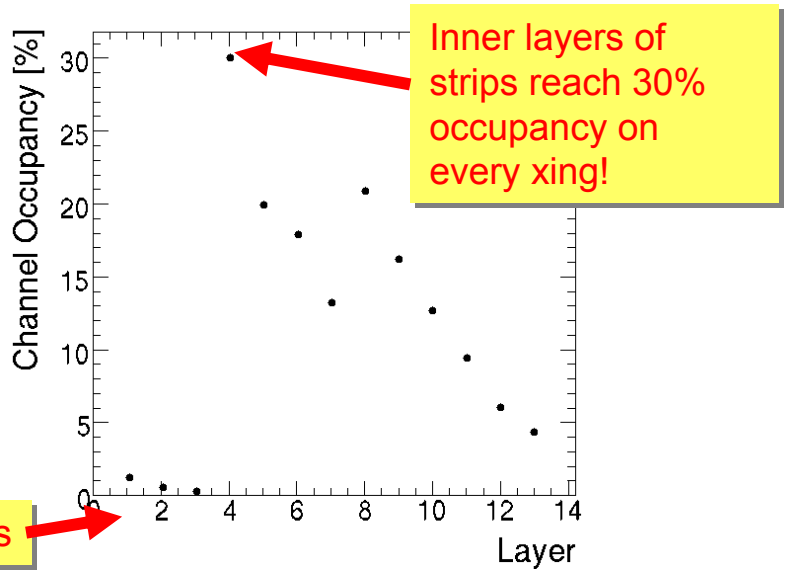
ε_n = 3.75 mm in all the options

CMS Upgrade Issues

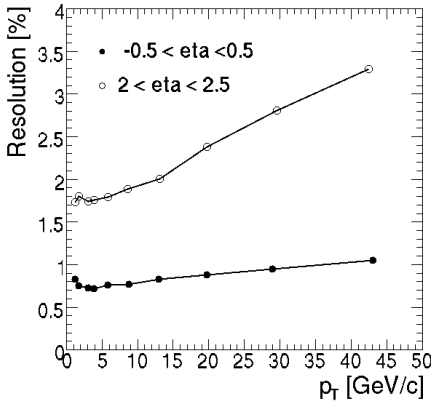
- These upgrade scenarios put different constraints on the detector
  - 12.5 ns or 75 ns beam crossings
    - 12.5 ns reduces the pile-up in the detector, although out of time pile-up is an issue for detectors (*cross-talk* from previous bunch)
    - 75 ns puts a very large pile-up, but is “easier” for some of the electronics to cope with (no out of time pile-up - use 25nsec electronics)
- Detector issues
  - Effects on Calorimetry
    - Noise from pile-up: Bkgd noise increases by 2-5 times
    - Jet and e,gamma resolution worse
    - Forward jet tagging - may be compromised by IR changes
  - Tracking
    - Pattern recognition, vertex resolution
    - B-tagging - how much worse with extreme pile-up?
  - Trigger
    - 12.5 ns pushes some of the front end capabilities

Tracking with 500 min Bias events

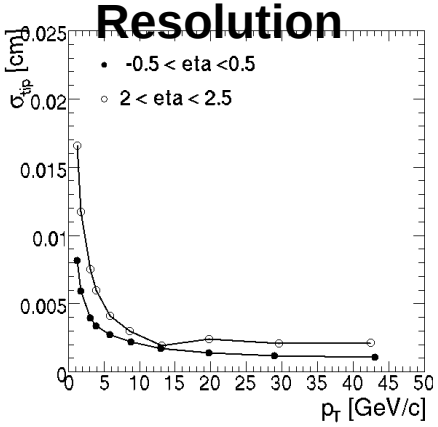
- Study of current CMS tracker for Heavy Ion events
- Track density very similar to 75ns running
  - $dn^{ch}/d\eta$/crossing ≈ 3000
  - Tracker occupancy very high
  - Need more pixel layers
- Tracking possible
  - When tracks are found they are well measured
  - Efficiency and fake rate suffer

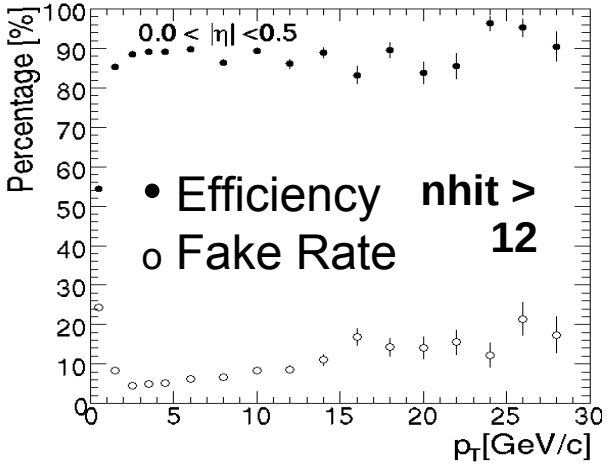


Momentum Resolution



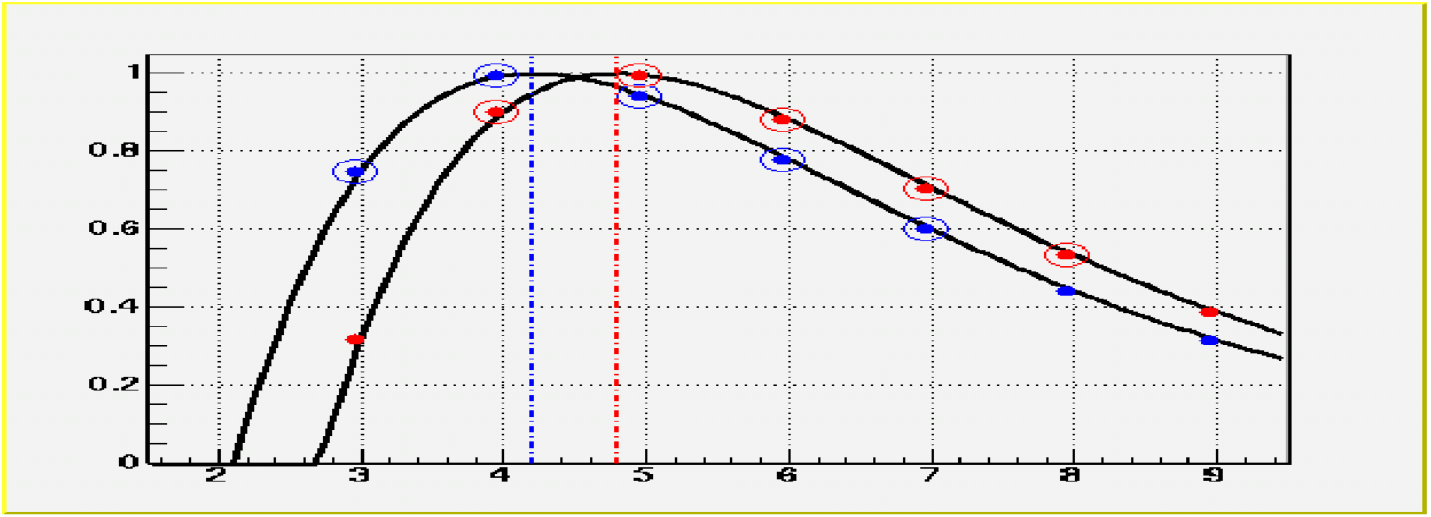
Transverse Impact Parameter Resolution





C. Roland

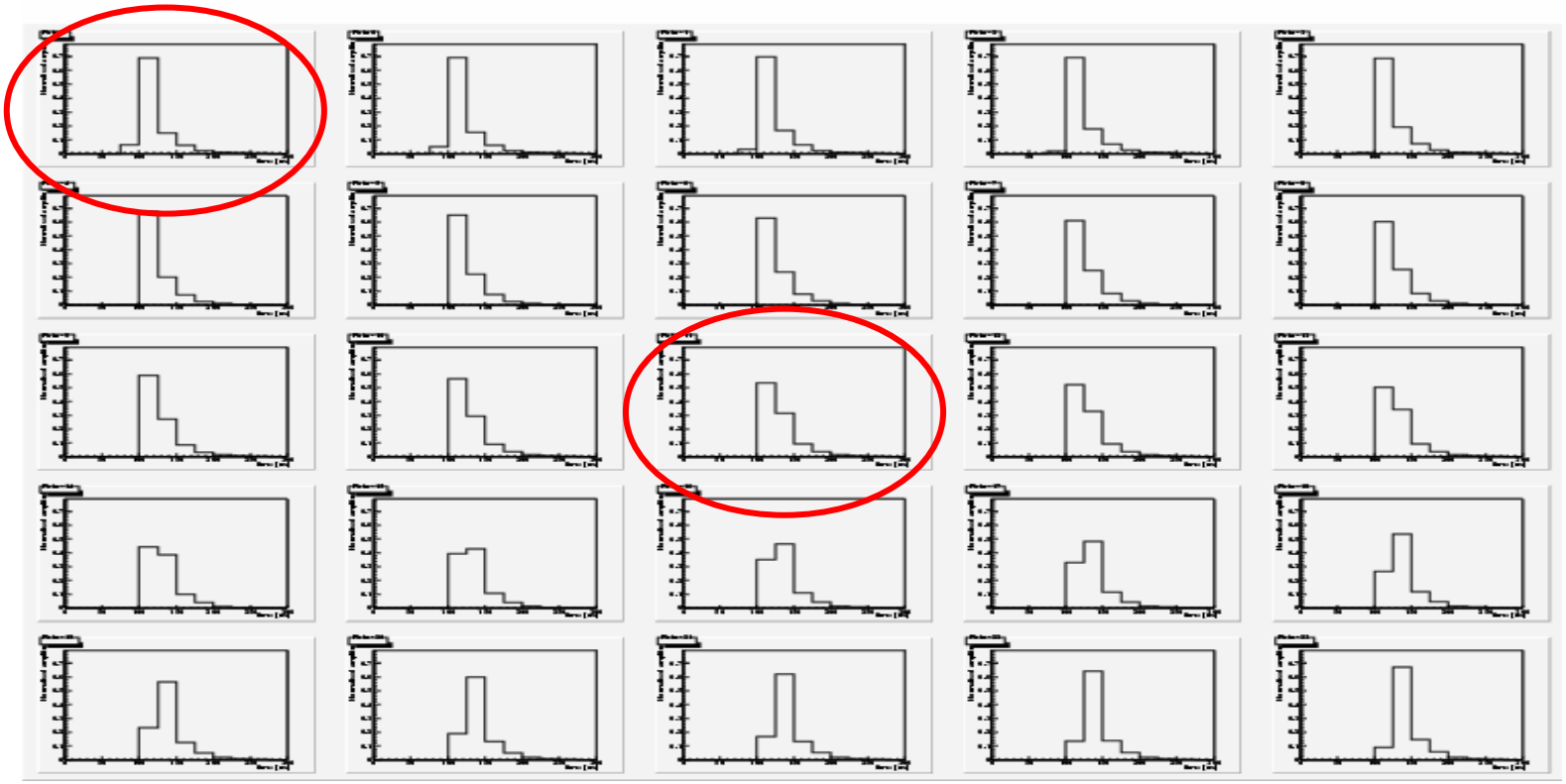
Issues with Bunch crossing timing



- Assume new tracker and trigger electronics can cope with the choice of bunch timing
- Electronics for other detectors
  - ECAL - not easily accessible
  - HCAL - can be changed
  - MUONS - can be changed
- Situation for 12.5ns or 25ns very different from 10ns or 15 ns
  - Electronics clocked at 40 Mhz
  - QPLL which synchronizes links to this clock has a very narrow frequncy lock
  - Can clock system at 40 Mhz and cope with 12.5ns
- 75 ns should not be a problem

CMS HB Pulse Shape

100 GeV electrons. 25ns bins. Each histo is average pulse shape, phased +1ns to LHC clock



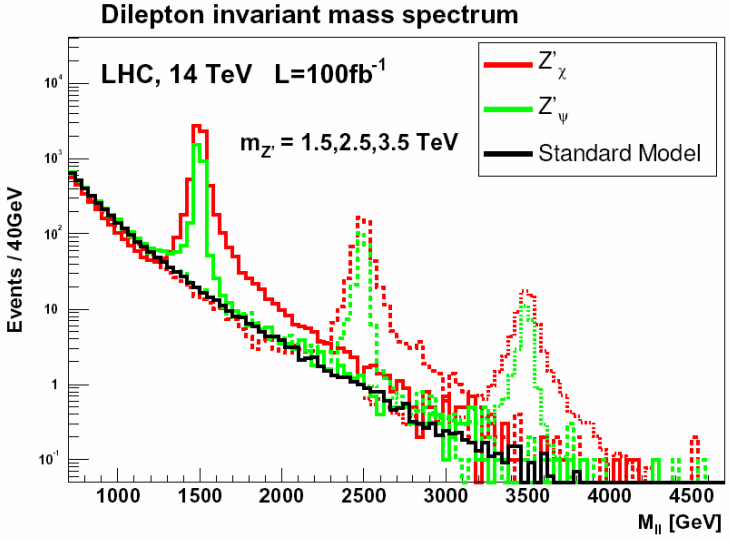
12 ns difference between circled histo's → no problem with bunch ID

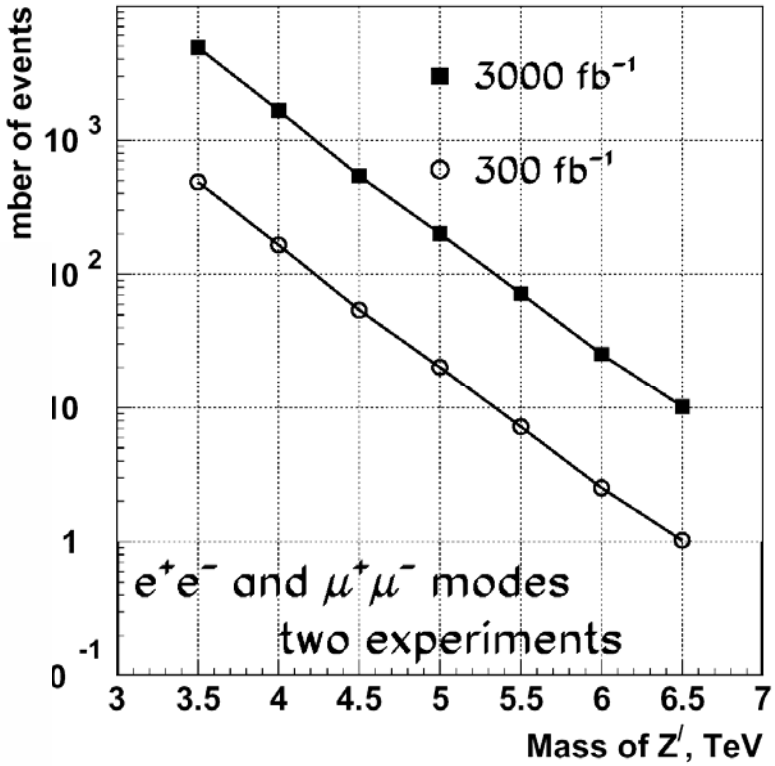
Benchmark processes

- Need to quantify physics risk associated with going to large number of events/x-ing
- Should establish a few benchmark processes
- Need to limit the scope of any studies
  - Can we reduce to 2 the number of options to study

SLHC Physics: Extra gauge bosons

- SLHC extends reach for Z'
  - Cross sections fall with E
  - SLHC gives access to higher E
- Good electron resolution required (including understanding saturation)

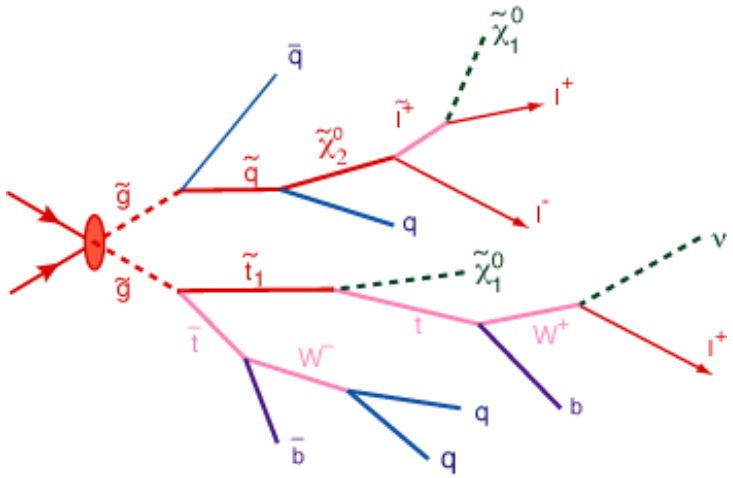




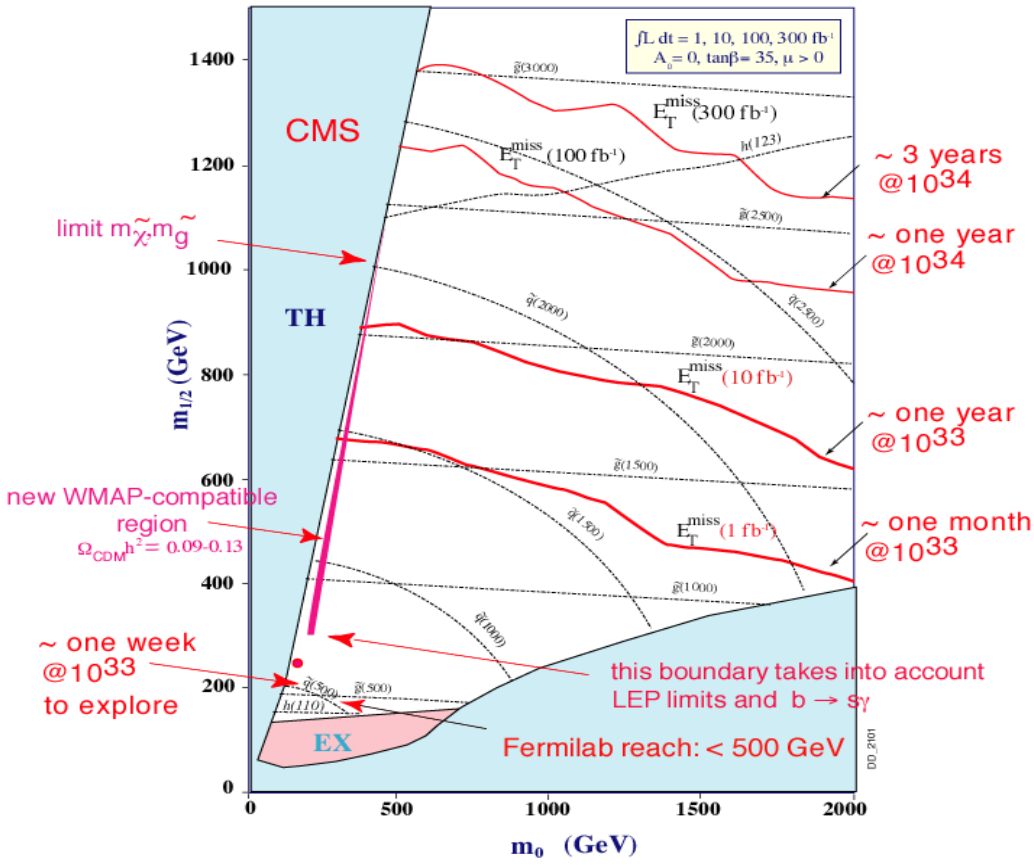
Z' mass (TeV)	1	2	3	4	5	6
$\sigma(Z' \to e^+e^-)(fb)$	512	23.9	2.5	0.38	0.08	0.026
$\Gamma_{Z'}$ (GeV)	30.6	62.4	94.2	126.1	158.0	190.0

SUSY searches - measurements

- SLHC statistics will be vital in reaching understanding of complicated SUSY channels
  - Sparticles seen, but statistics for reconstruction limited at LHC
- Performance of the detector here is vital
  - B-tagging
  - Lepton id

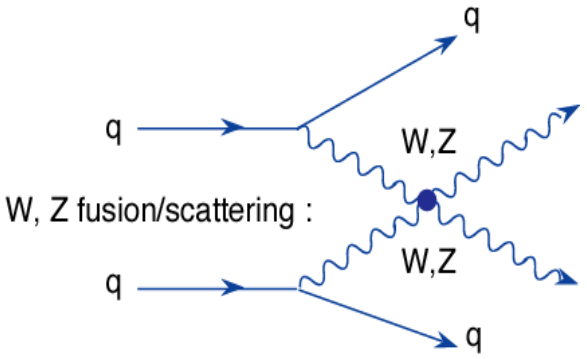


Reach vs luminosity, jets + E_t^{miss} channel

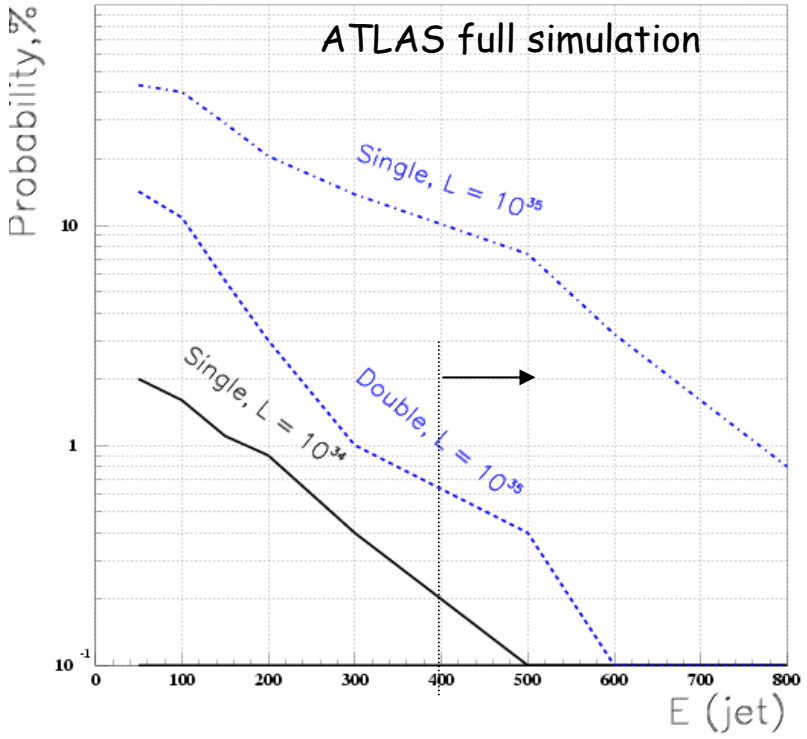


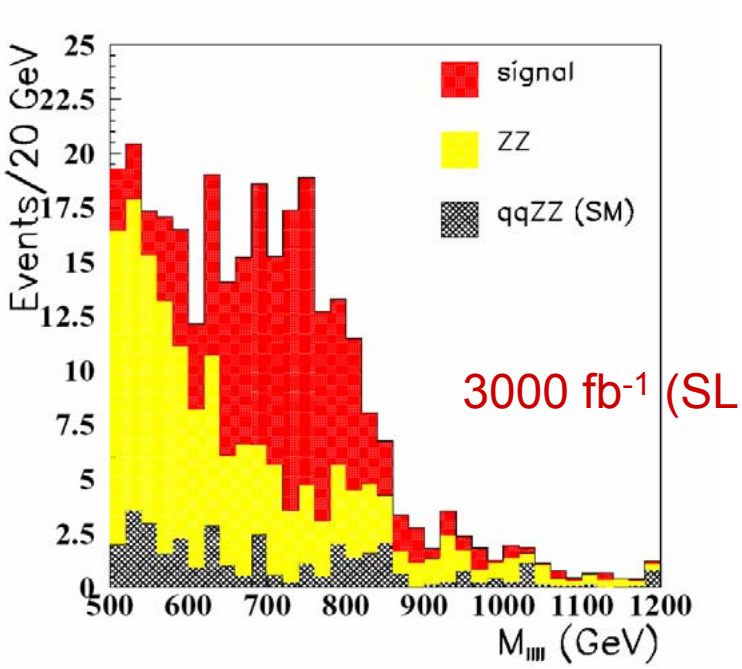
What if no Higgs is found?

- Will need to look at WW scattering
  - Some mechanism required to avoid unitarity violation
- Forward Jet Tagging Essential



Fake fwd jet tag (|η| > 2) probability from pile-up (preliminary ...)





3000 fb^{-1} (SLHC)