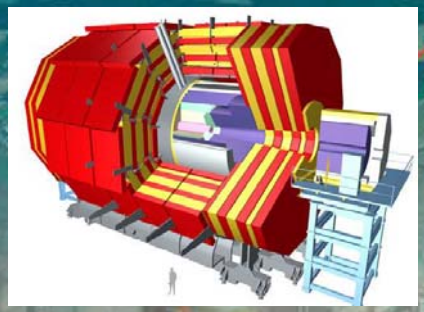
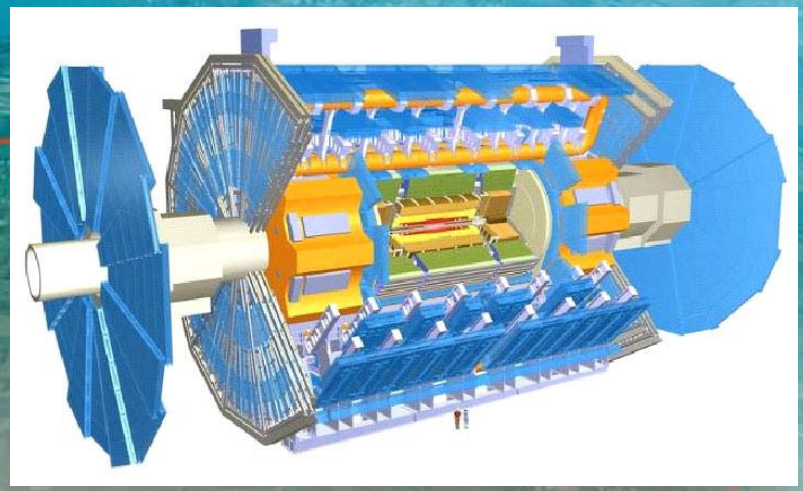
LHC計画の予定と物理成果の時期予測

特定領域「ヒッグスと超対称性」
総括班会議



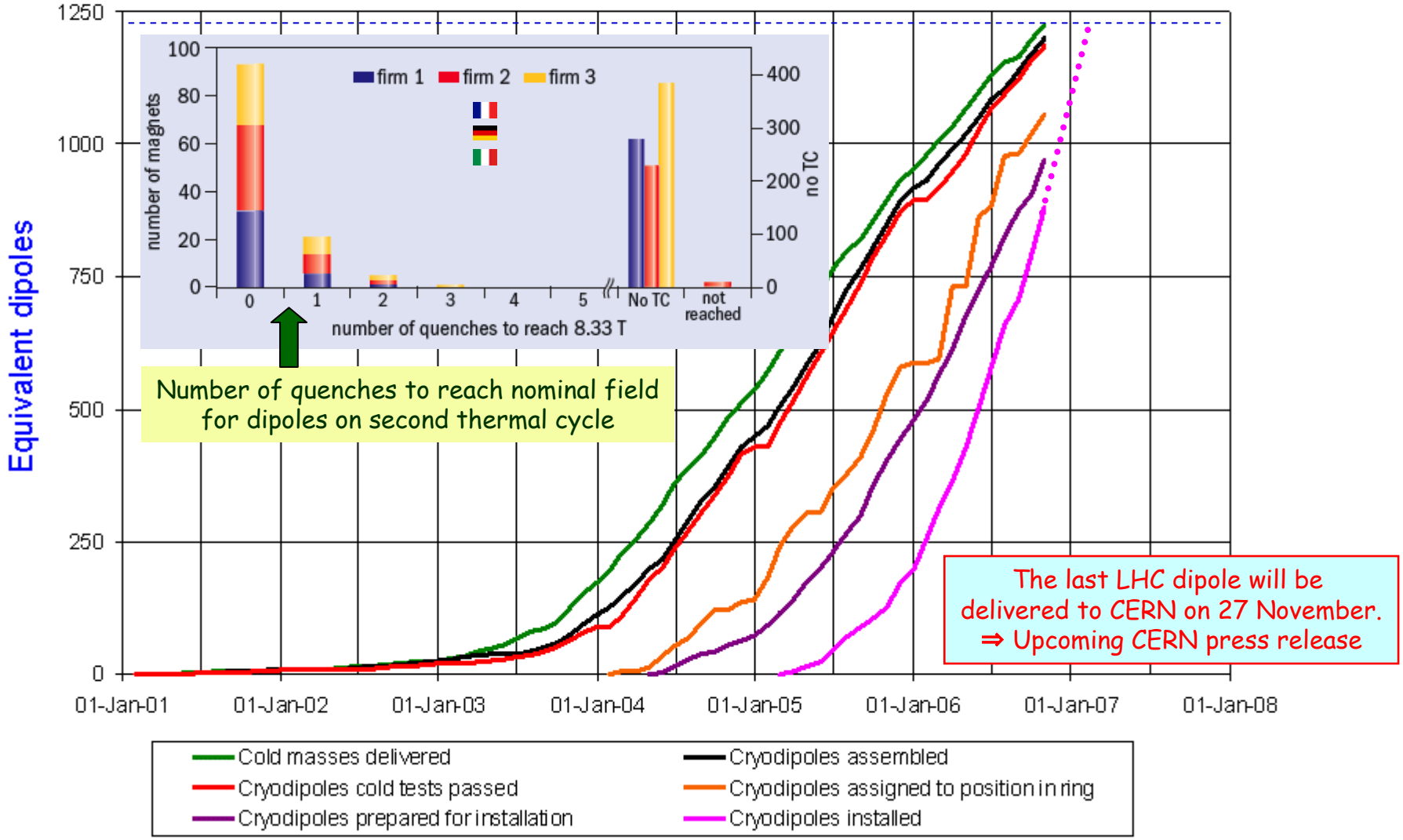


16. Nov. 2006
T. Kobayashi
(Univ. of Tokyo/ICEPP)

LHC Progress Dashboard

Accelerator Technology Department

Cryodipole overview



Updated 31 Oct 2006

Data provided by D. Tommasini AT-MCS, L. Bottura AT-MTM

(Revised) LHC schedule
as presented to CERN Council on 23 June 2006

- Last magnet installed : March 2007
  Machine and experiments closed : 31 August 2007
- First collisions ($\sqrt{s}$ = 900 GeV, L~10^{29} cm^{-2} s^{-1}) : November 2007
  Commissioning run at injection energy until end 2007, then shutdown (3 months ?)
- First collisions at $\sqrt{s}$=14 TeV (followed by first physics run): Spring 2008

Goal : deliver integrated luminosity of few fb^{-1} by end 2008

L. Evans, CERN Council, 23/6/2006

- Sectors 7-8 and 8-1 will be fully commissioned up to 7 TeV in 2006-2007.
  If we continue to commission the other sectors up to 7 TeV, we will not get circulating beam in 2007.
- The other sectors will be commissioned up to the field needed for de-Gaussing.
- Initial operation will be at 900 GeV (CM) with a static machine (no ramp, no squeeze) to debug machine and detectors.
- Full commissioning up to 7 TeV will be done in the winter 2008 shutdown

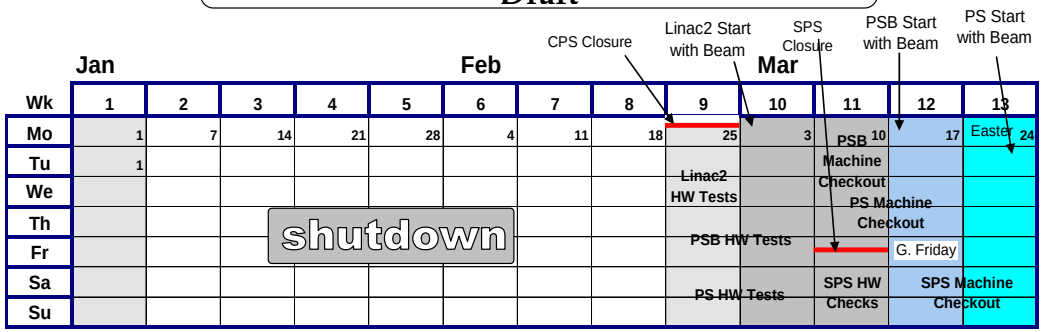
from end June 2008 (S. Myers)

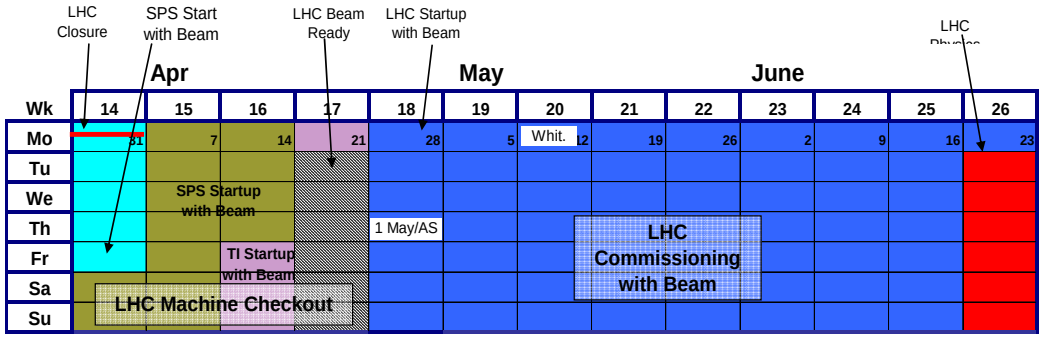
6. Oct. 2006
S. Myers

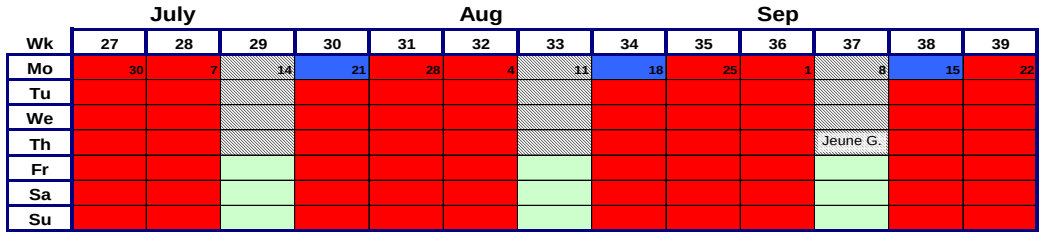
pc

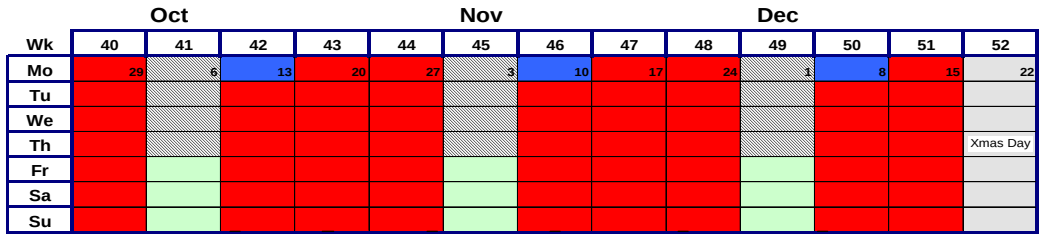
28/9/2006
V1.2

2008 Accelerator Schedule
Draft









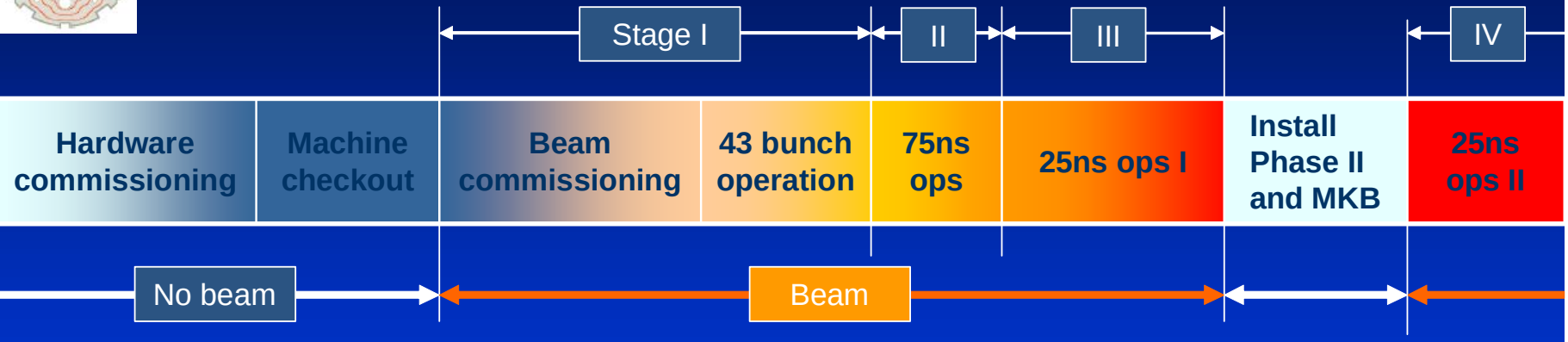
LHC Physics

LHC Machine Development

LHC Setup with beam

LHC Technical Stop

Staged commissioning plan for protons



I. **Pilot physics run**
   - First collisions
   - 43 bunches, no crossing angle, no squeeze, moderate intensities
   - Push performance (156 bunches, partial squeeze in 1 and 5, push intensity)
   - Performance limit 10^{32} cm^{-2} s^{-1} (event pileup)

II. **75ns operation**
   - Establish multi-bunch operation, moderate intensities
   - Relaxed machine parameters (squeeze and crossing angle)
   - Push squeeze and crossing angle
   - Performance limit 10^{33} cm^{-2} s^{-1} (event pileup)

2008

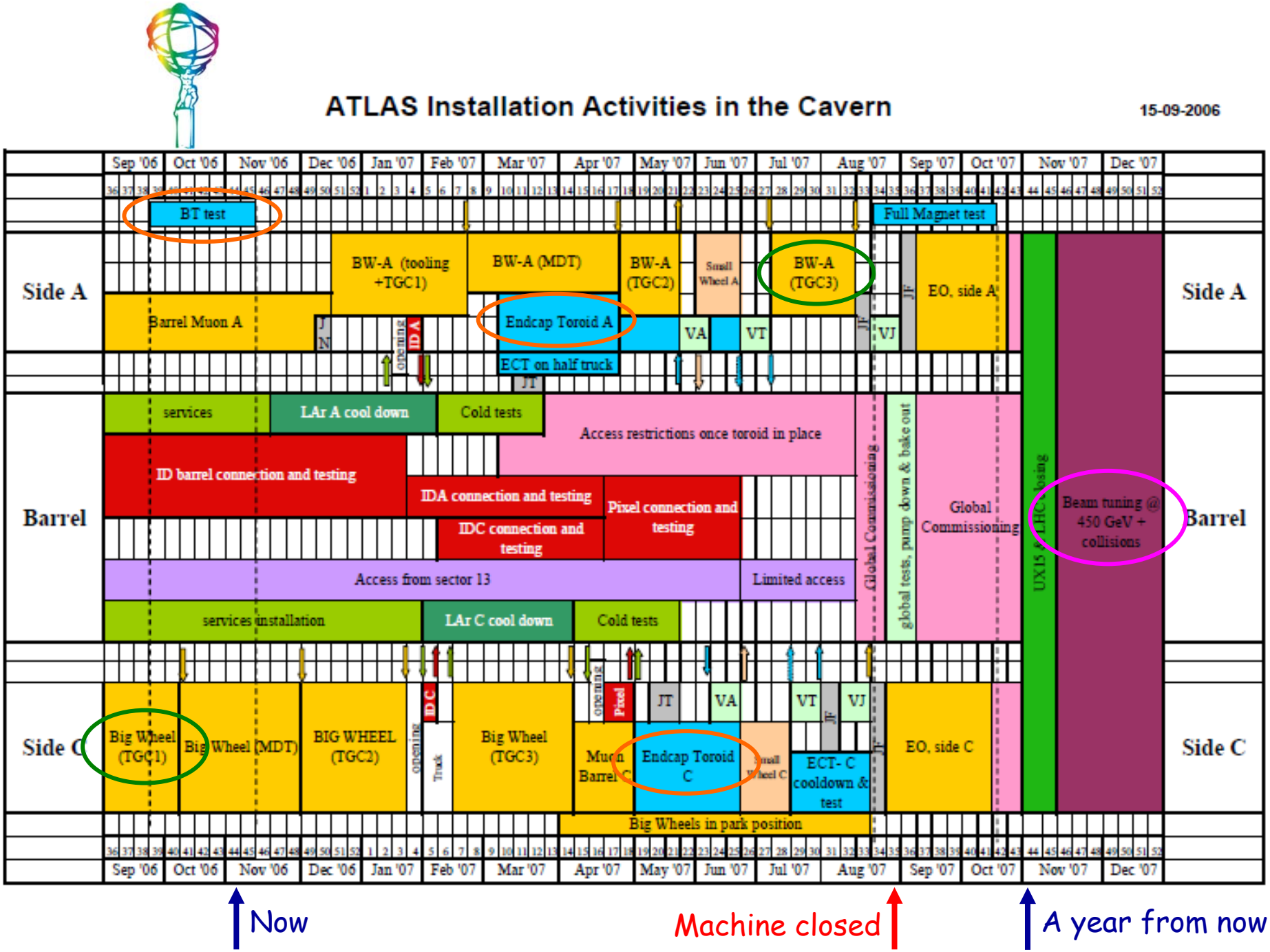
III. **25ns operation I**
   - Nominal crossing angle
   - Push squeeze
   - Increase intensity to 50% nominal
   - Performance limit 2 10^{33} cm^{-2} s^{-1}

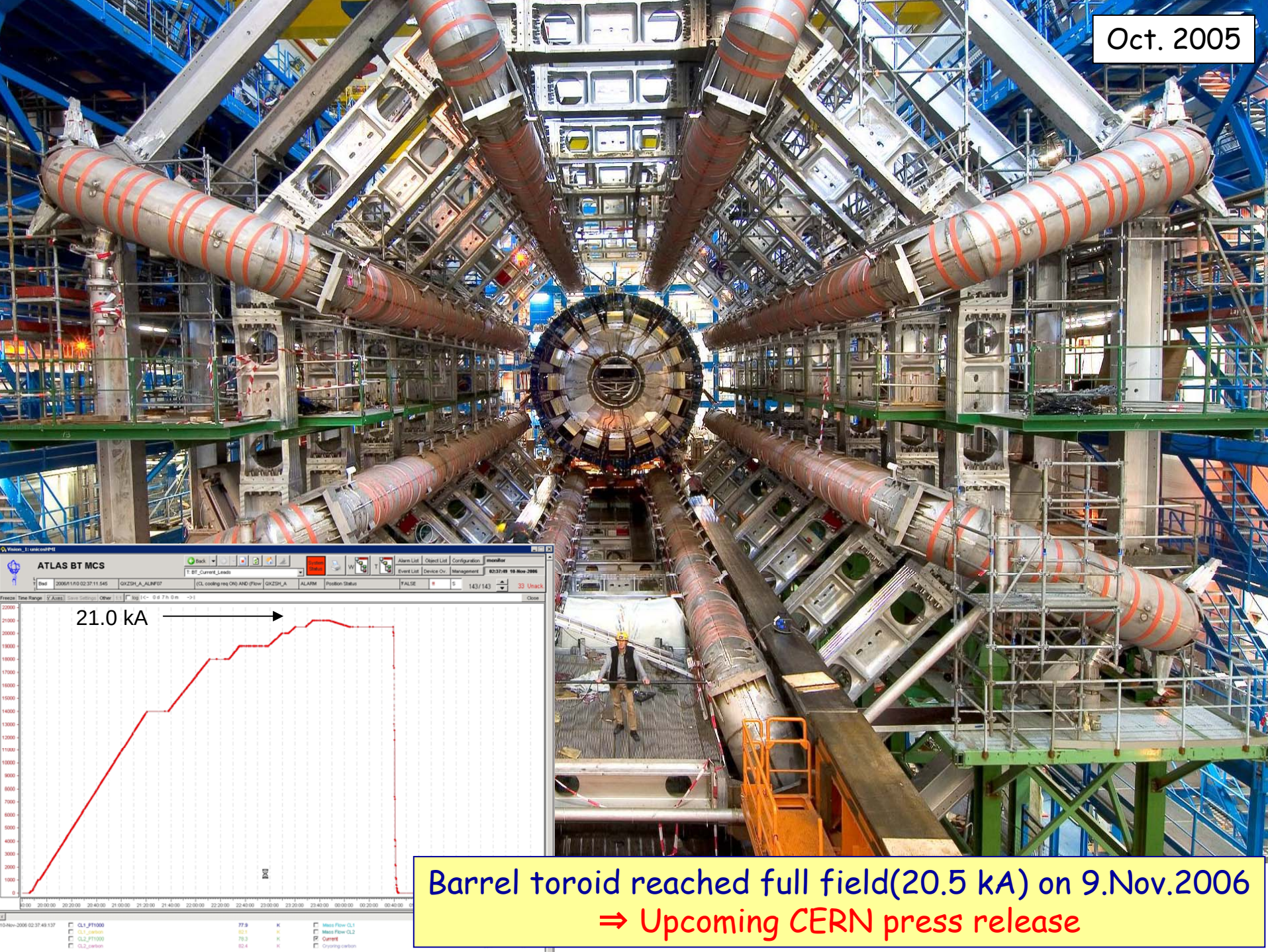
2008-2009 — up to 1-2 fb^{-1} end 2008, up to 10 fb^{-1} end 2009 ?

IV. **25ns operation II**
   - Push towards nominal performance

≥ 2010 — *O*(100) fb^{-1}

Note: dates and integrated luminosities are MY interpretation (F. Gianotti)


ATLAS Installation Activities in the Cavern
15-09-2006
Sep '06
Oct '06
Nov '06
Dec '06
Jan '07
Feb '07
Mar '07
Apr '07
May '07
Jun '07
Jul '07
Aug '07
Sep '07
Oct '07
Nov '07
Dec '07
Side A
Barrel
Side C
BT test
Full Magnet test
BW-A (tooling +TGC1)
BW-A (MDT)
BW-A (TGC2)
Small Wheel A
BW-A (TGC3)
JF
EO, side A
Barrel Muon A
JN
opening
IDA
Endcap Toroid A
VA
VT
VJ
ECT on half truck
JT
services
LAr A cool down
Cold tests
Access restrictions once toroid in place
ID barrel connection and testing
IDA connection and testing
Pixel connection and testing
IDC connection and testing
Global Commissioning
global tests, pump down & bake out
Global Commissioning
UX15 & LHC closing
Beam tuning @ 450 GeV + collisions
Access from sector 13
Limited access
services installation
LAr C cool down
Cold tests
Big Wheel (TGC1)
Big Wheel (MDT)
BIG WHEEL (TGC2)
IDC
Truck
Big Wheel (TGC3)
Pixel
JT
VA
VT
VJ
EO, side C
Endcap Toroid C
ECT- C cooldown & test
Big Wheels in park position
Now
Machine closed
A year from now



Barrel toroid reached full field(20.5 kA) on 9.Nov.2006

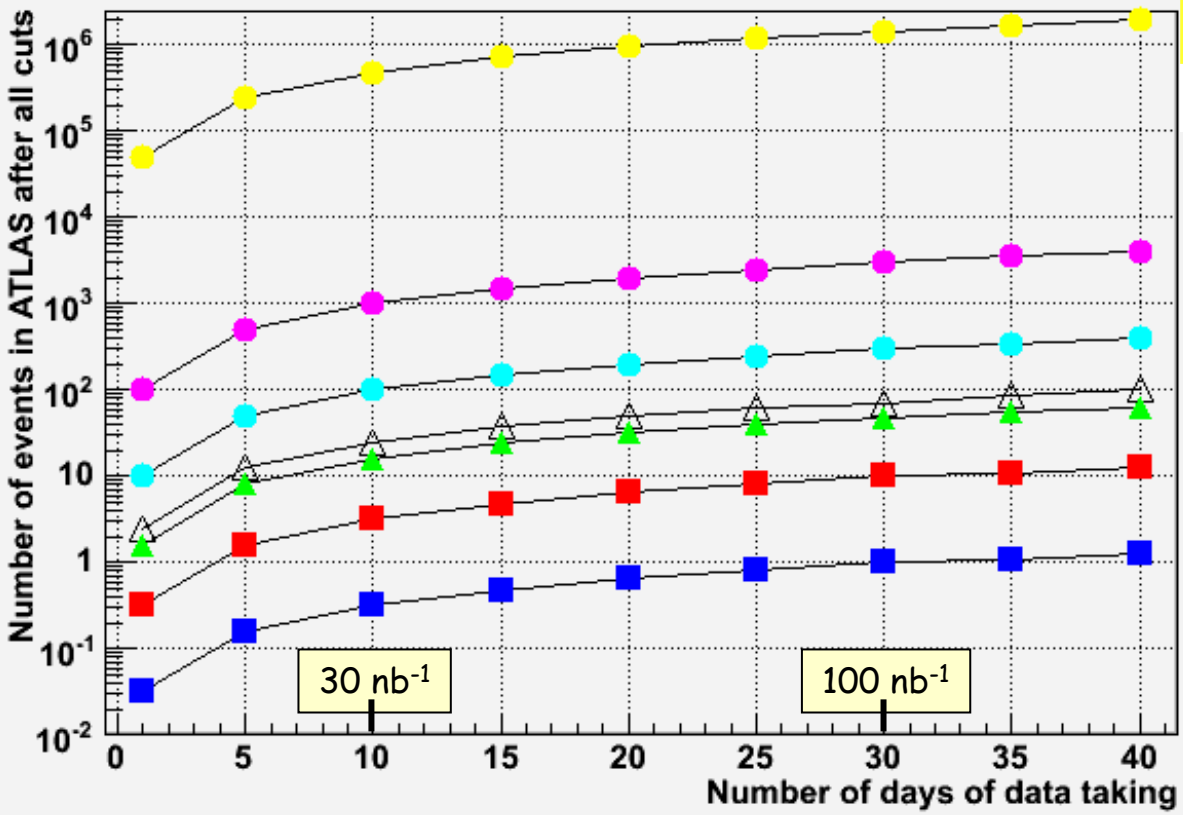
⇒ Upcoming CERN press release

What data samples in 2007 ?

30% data taking efficiency included (machine plus detector) Trigger and analysis efficiencies included

ATLAS preliminary

$\sqrt{s}$ =900 GeV, $L = 10^{29}$ cm^{-2} s^{-1}



Jets p_T > 15 GeV

(b-jets: ~1.5%)

Jets p_T > 50 GeV

Jets p_T > 70 GeV

$\Upsilon \rightarrow \mu\mu$

$J/\psi \rightarrow \mu\mu$

$W \rightarrow e\nu, \mu\nu$

$Z \rightarrow ee, \mu\mu$

+ 1 million minimum-bias/day

- Start to commission triggers and detectors with collision data (minimum bias, jets, ..) in real LHC environment
- Maybe first physics measurements (minimum-bias, underlying event, QCD jets, ...) ?
- Observe a few $W \rightarrow l\nu$, $\Upsilon \rightarrow \mu\mu$, $J/\psi \rightarrow \mu\mu$?

With the first physics run in 2008 ($\sqrt{s}$ = 14 TeV) ….

F. Gianotti
ICHEP @Moscow
02/08/2006

1 fb^{-1} (100 pb^{-1}) ≡ 6 months (few days) at L= 10^{32} $cm^{-2}s^{-1}$
with 50% data-taking efficiency
→ may collect up to 1-2 fb^{-1} per experiment by end 2008

Channels (examples …)	Events to tape for 100 pb^{-1} (per expt: ATLAS, CMS)	Total statistics from some of previous Colliders
$W \rightarrow \mu \nu$	~ 10^6	~ 10^4 LEP, ~ 10^6 Tevatron
$Z \rightarrow \mu \mu$	~ 10^5	~ 10^6 LEP, ~ 10^5 Tevatron
$tt \rightarrow W\,b\,W\,b \rightarrow \mu \nu + X$	~ 10^4	~ 10^4 Tevatron
QCD jets p_T > 1 TeV	> 10^3	---
$\tilde{g}g$ m = 1 TeV	~ 50	---

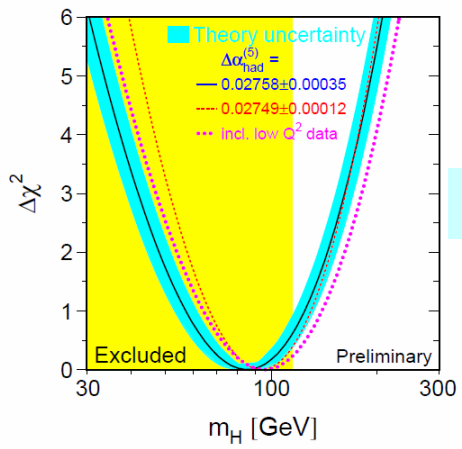
With these data:

- Understand and calibrate detectors in situ using well-known physics samples
  e.g. - $Z \rightarrow ee, \mu\mu$ tracker, ECAL, Muon chambers calibration and alignment, etc.
  - $tt \rightarrow bl\nu\ bjj$ jet scale from $W \rightarrow jj$, b-tag performance, etc.

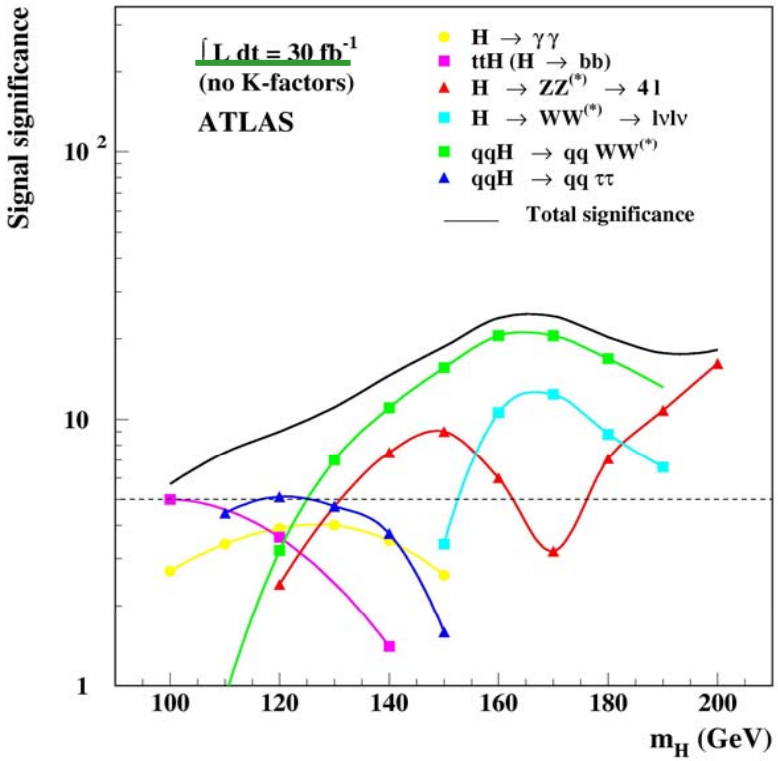
- Measure SM physics at $\sqrt{s}$ = 14 TeV : W, Z, tt, QCD jets …
  (also because omnipresent backgrounds to New Physics)

→ prepare the road to discovery …… it will take time …

SM Higgs Boson Search

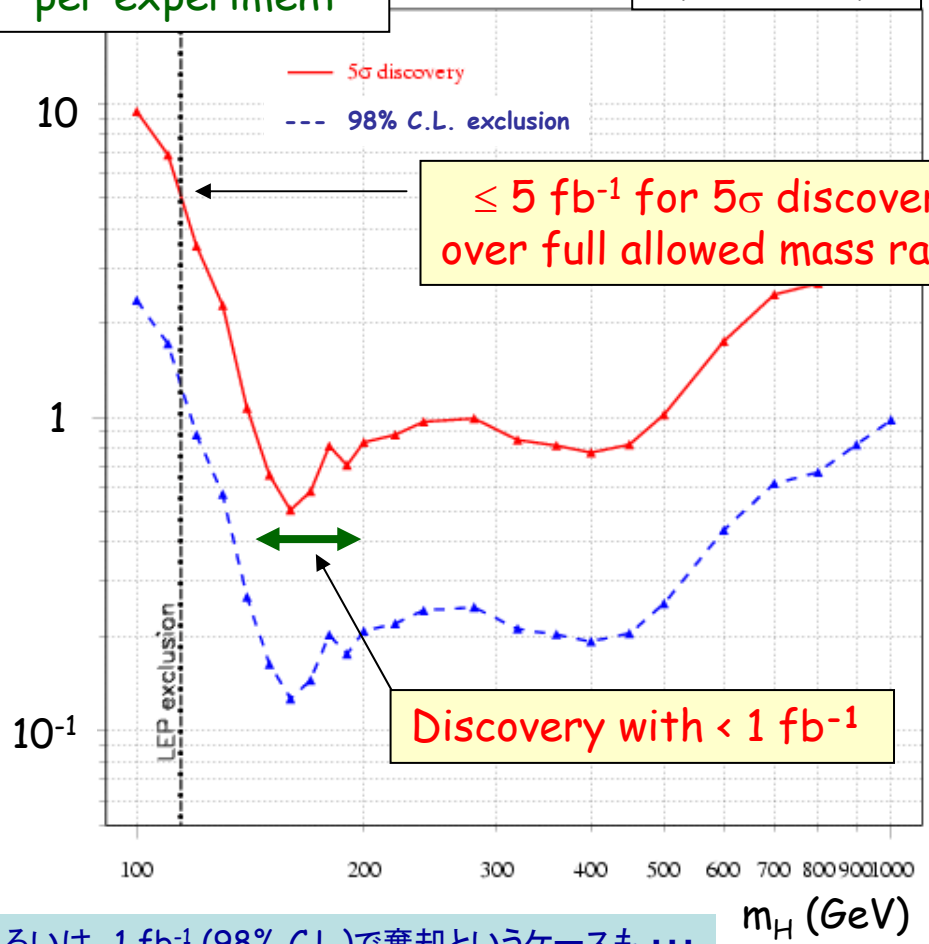


114 GeV < m_H < 200 GeV



Needed ∫Ldt (fb^{-1}) per experiment

ATLAS + CMS preliminary



≤ 5 fb^{-1} for 5σ discovery over full allowed mass range

Discovery with < 1 fb^{-1}

あるいは、1 fb^{-1} (98% C.L.)で棄却というケースも ・・・

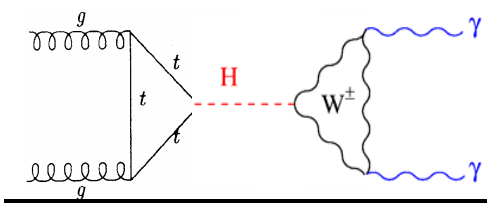
Light Higgs : more difficult …

m_H ~ 115 GeV 10 fb^{-1} : S/√B ≈ 4 ATLAS

K-factors ≡ σ(NLO)/σ(LO) ≈ 2
for H →γγ NOT included (conservative)

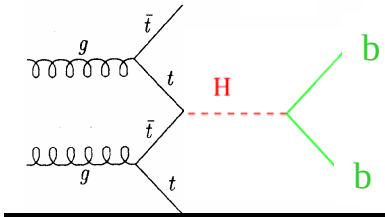
3 (complementary) channels with similar (small) significances:

H → γγ



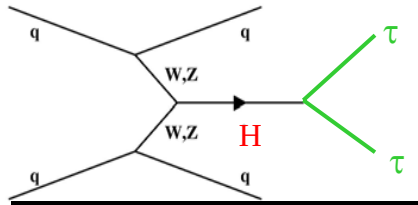
S=130, B=4300, S/√B=2

ttH→ttbb → blνbjjbb



S=15, B=45, S/√B=2.2

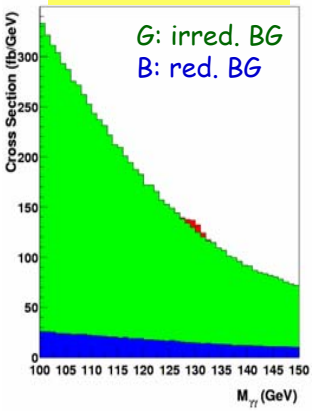
qqH → qqττ



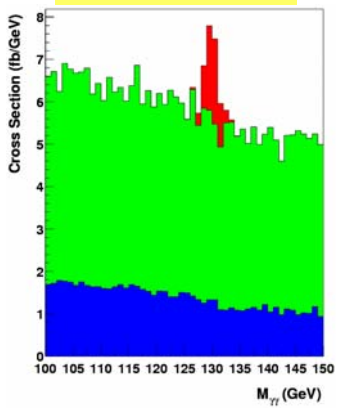
S=10, B=10, S/√B=2.7

All three channels require very good understanding of detector performance and background control to 1-10% → convincing evidence likely to come later than 2008 …

H → γγ +0j

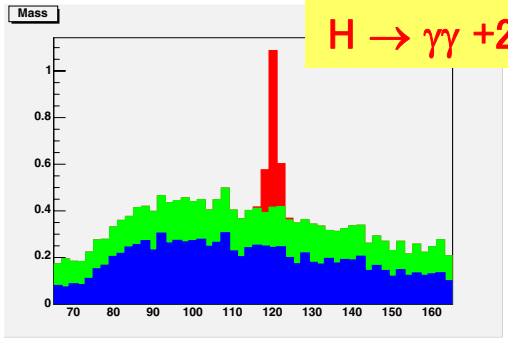


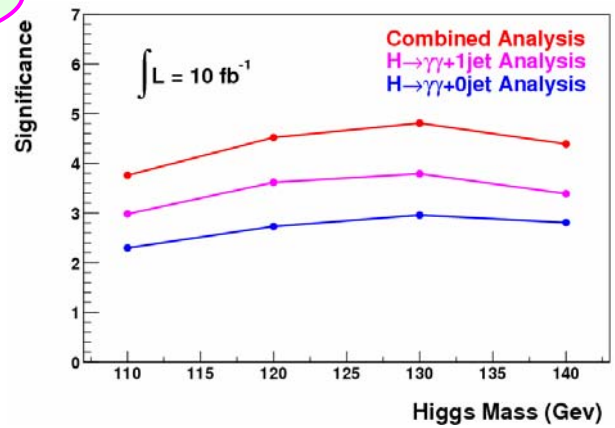
H → γγ +1j



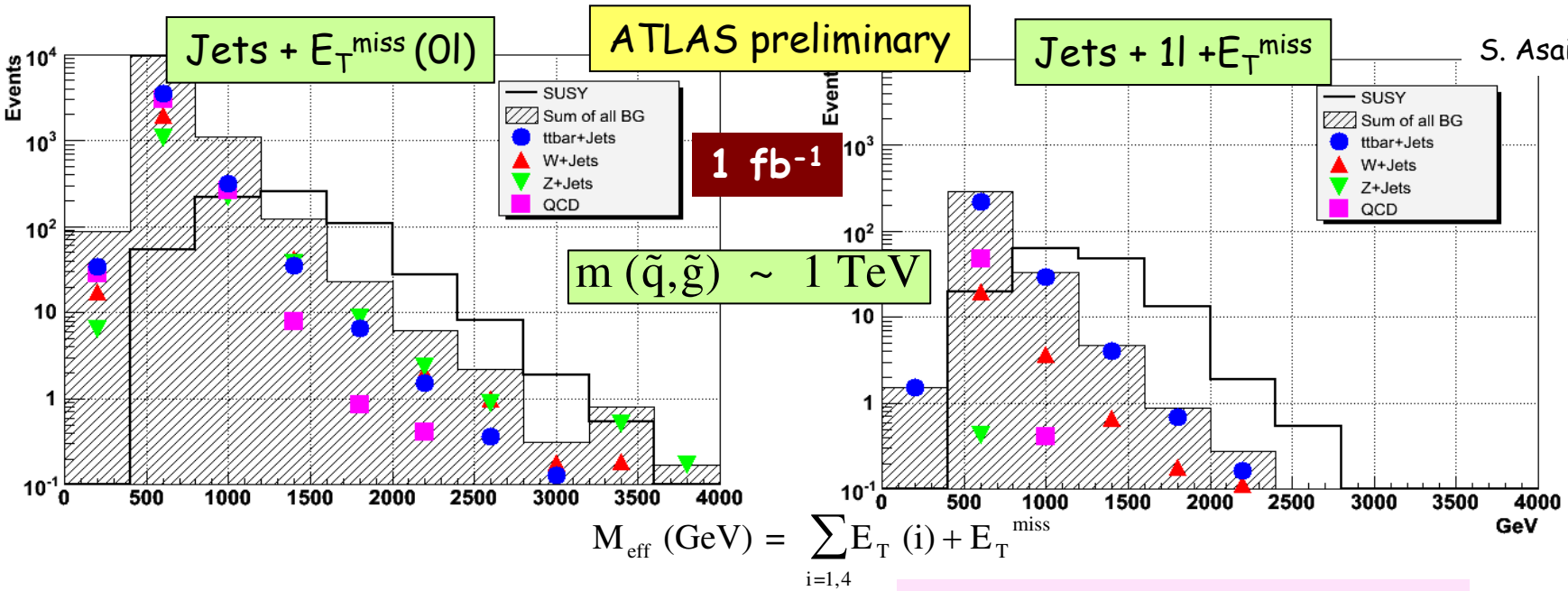
ATLAS preliminary

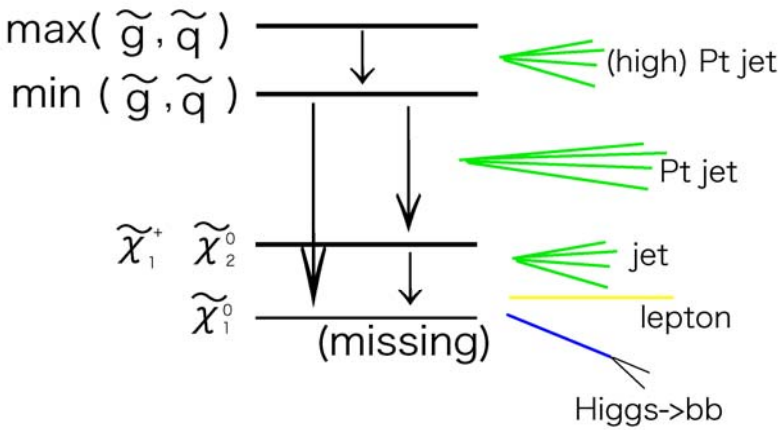
H → γγ +2j



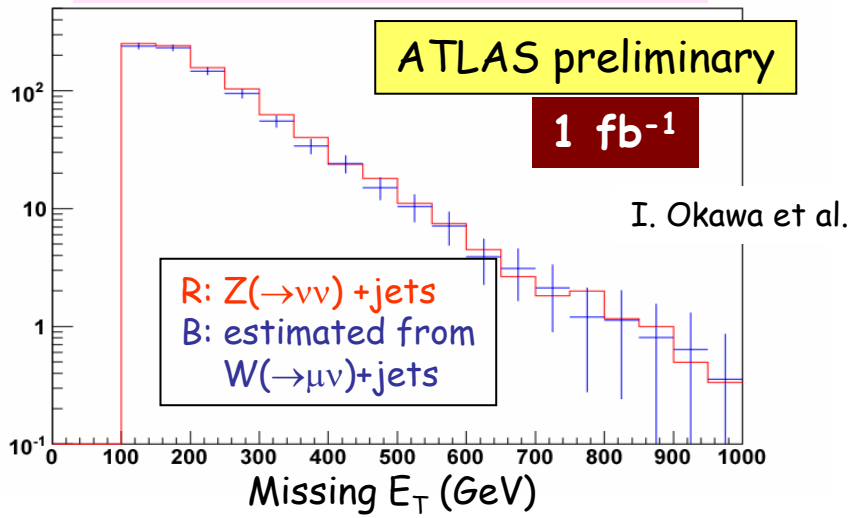


Search for SUSY : Understanding of BG is important





Estimate physics backgrounds using data (control samples)

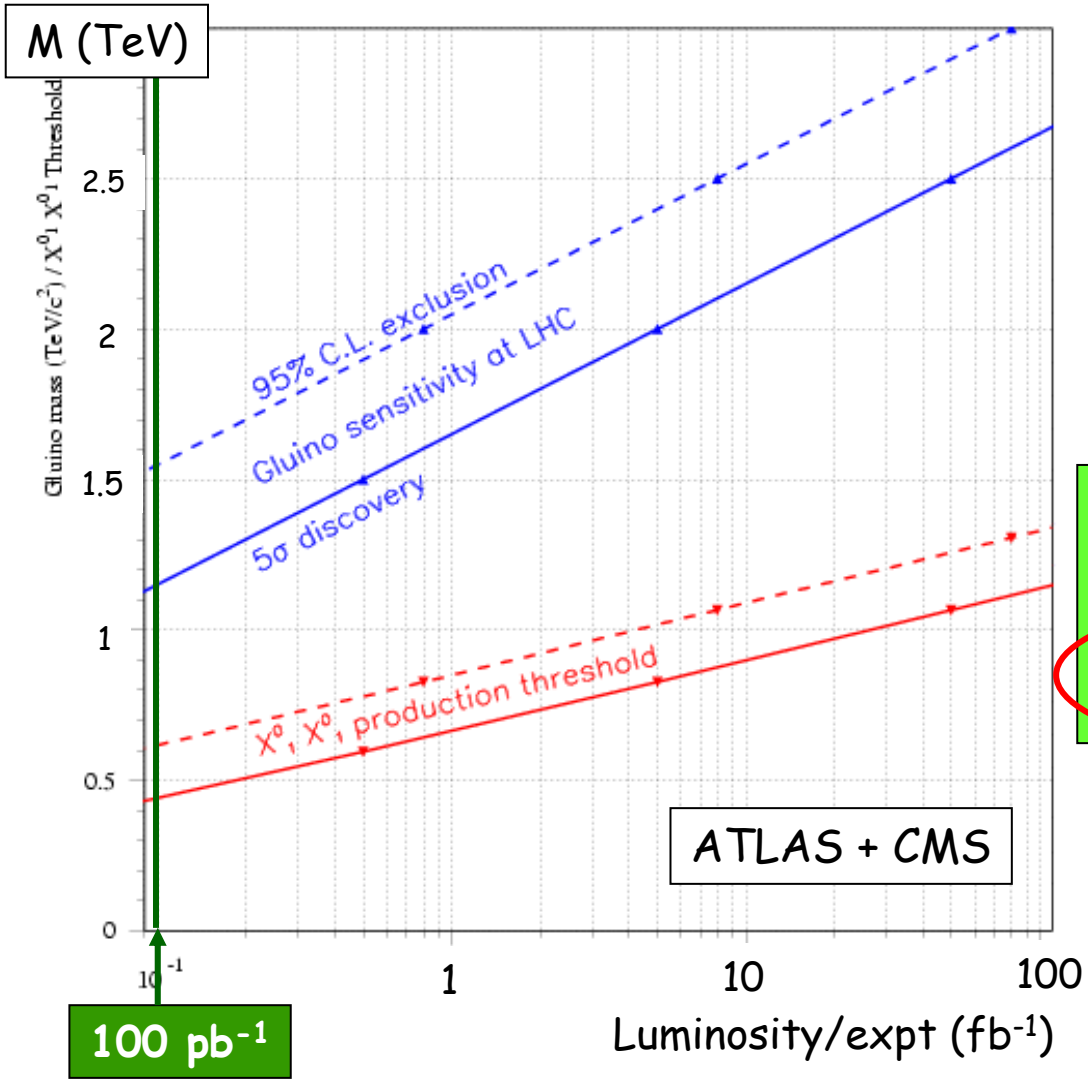


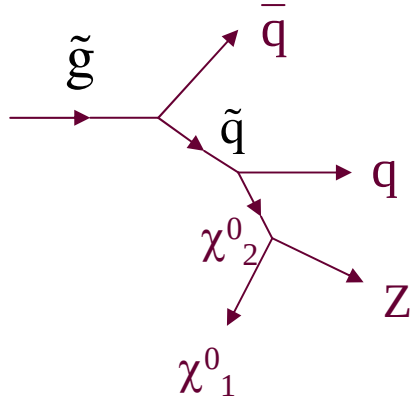
Example of "early" discovery: Supersymmetry ?

F. Gianotti
ICHEP @Moscow
02/08/2006

If SUSY at TeV scale → could be found "quickly" .... thanks to:

- large $\tilde{q},\tilde{g}$ cross-section → ≈ 10 events/day at 10^{32} for $m(\tilde{q},\tilde{g}) \sim 1$ TeV
- spectacular signatures (many jets, leptons, missing E_T)

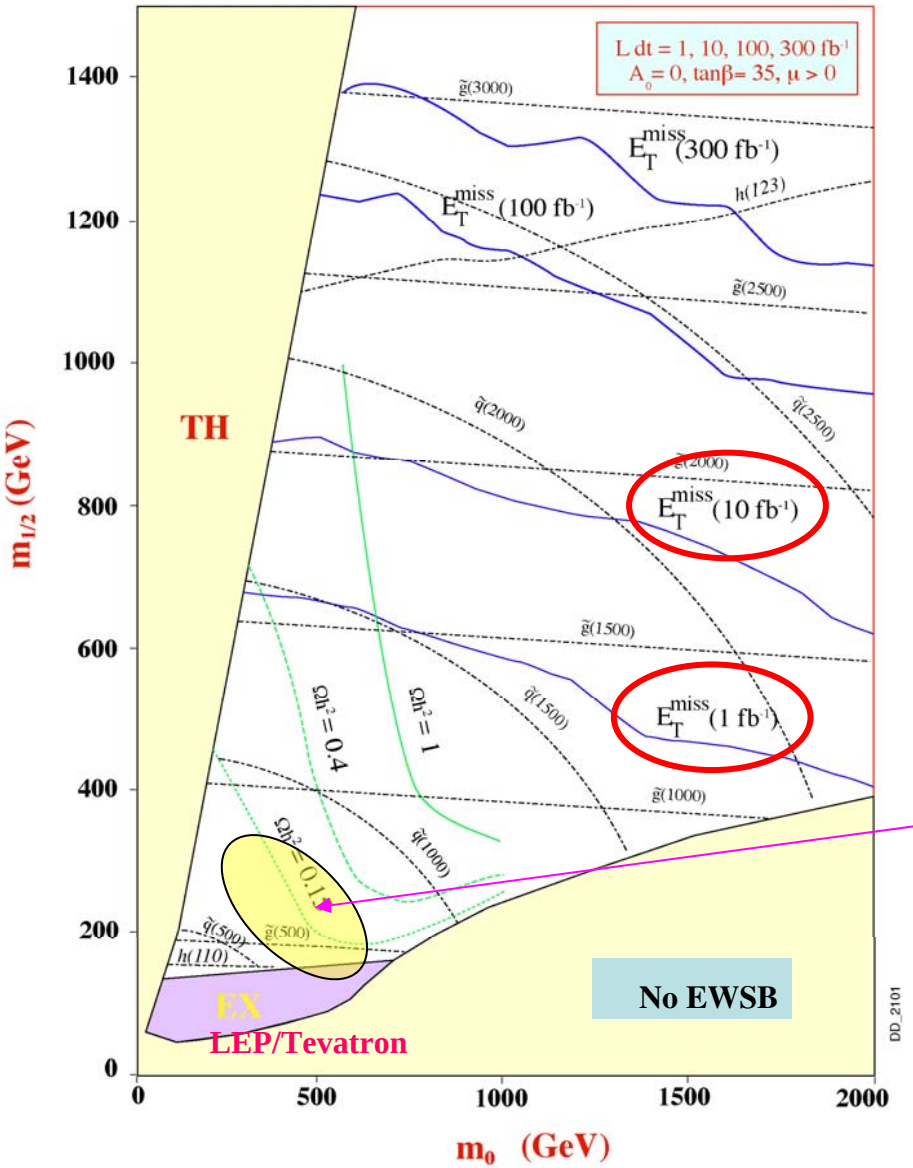




Our field, and planning for future facilities, will benefit a lot from quick determination of scale of New Physics. E.g. with 100 (good) pb^{-1} LHC could say if SUSY accessible to a ≤1 TeV ILC

BUT: understanding E_T^{miss} spectrum (and tails from instrumental effects) is one of the most crucial and difficult experimental issue for SUSY searches at hadron colliders.

Discovery Potential of SUSY (mSUGRA)



$m_{1/2}$: universal gaugino mass at GUT scale
m_0: universal scalar mass at GUT scale
tanβ: vev ratio for 2 Higgs doublets
sign(μ): sign of Higgs mixing parameter
A_0: trilinear coupling

- If low energy Supersymmetry exists, LHC will almost certainly observe it
- Squarks and Gluinos detectable up to 2.5-3 TeV mass with 300 fb^{-1}

Need only a short time to cover the interesting region for Cold DM

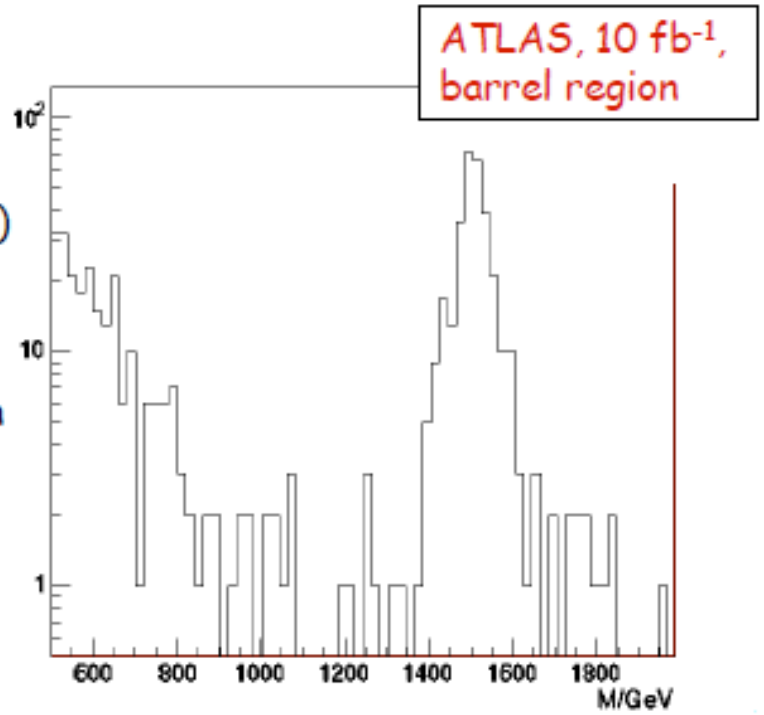
An "easy case" : Z' of mass ~ 1 TeV with SM-like couplings

$Z' \rightarrow ee$, SSM

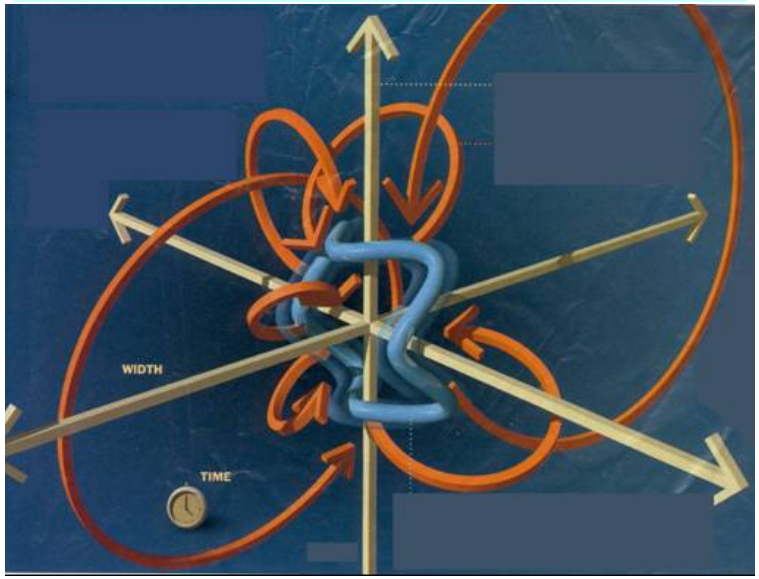
Mass	Expected events for 1 fb^{-1} (after all cuts)	$\int L\,dt$ needed for discovery (corresponds to 10 observed evts)
1 TeV	~ 160	~ 70 pb^{-1}
1.5 TeV	~ 30	~ 300 pb^{-1}
2 TeV	~ 7	~ 1.5 fb^{-1}

- large enough signal sample with $\int L\,dt \sim 100$ pb^{-1} up to $m \approx 1$ TeV if "reasonable" Z'ee couplings
- dominant Drell-Yan background small (< 0.2 events in the region 1400-1600 GeV, 100 pb^{-1})
- signal as mass peak on top of background

$Z \rightarrow ll$ +jet samples and DY needed for E-calibration and determination of lepton efficiency



Extra Dimensions



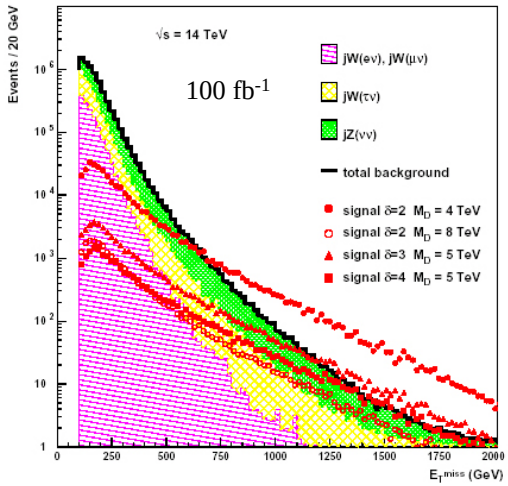
Large Extra Dimensions (ADD)
- Gravity in bulk / flat space
- Missing energy / interference / black holes

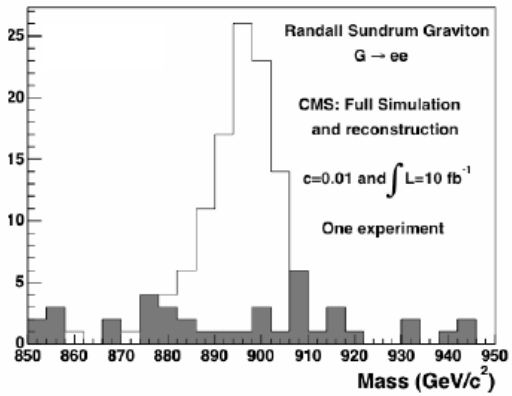
Warped Extra Dimensions (RS)
- Gravity in bulk / curved space
- Spin 2 resonances in >TeV range / black holes

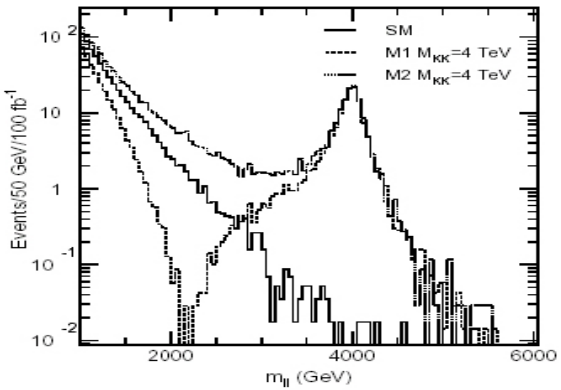
TeV Scale Extra Dimensions
- Gauge bosons / Higgs in bulk
- Spin 1 resonances in >TeV range
- Interference with Drell-Yan

Universal Extra Dimensions
- Everybody in the bulk!
- Fake SUSY spectrum of KK states

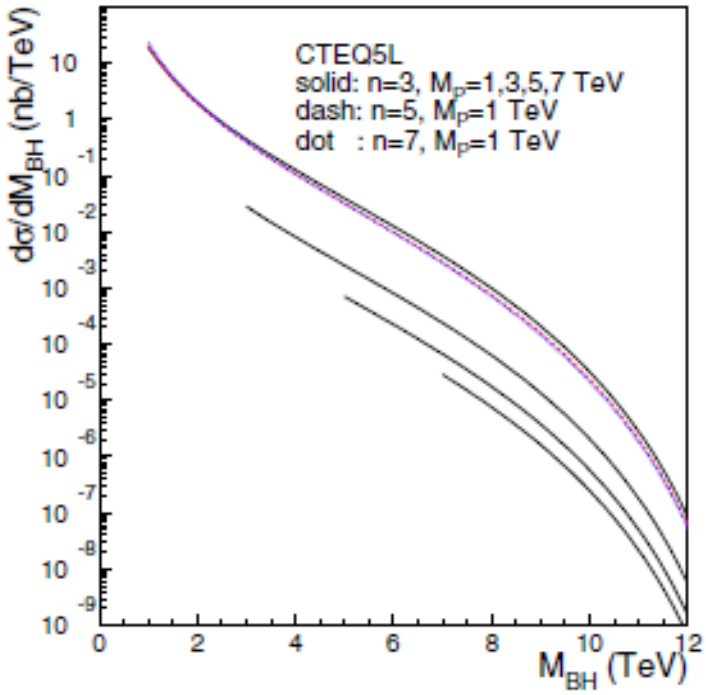
$E_T(jet) > 1$ TeV

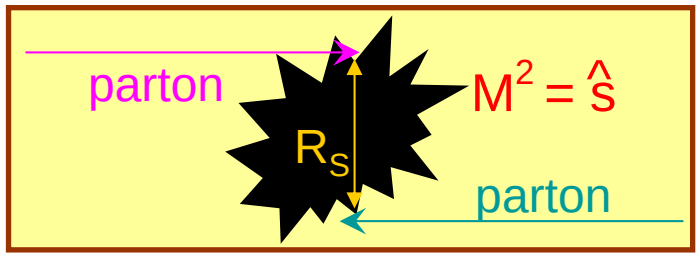


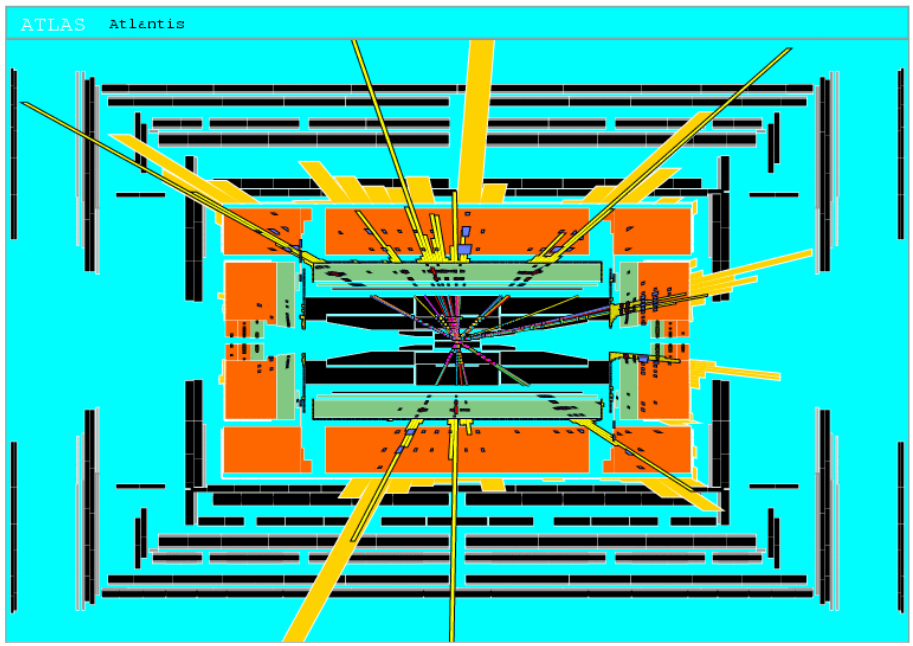




Black Hole Production at LHC







J. Tanaka et al.
Eur Phys J C **41**, s02, 19-33 (2005)

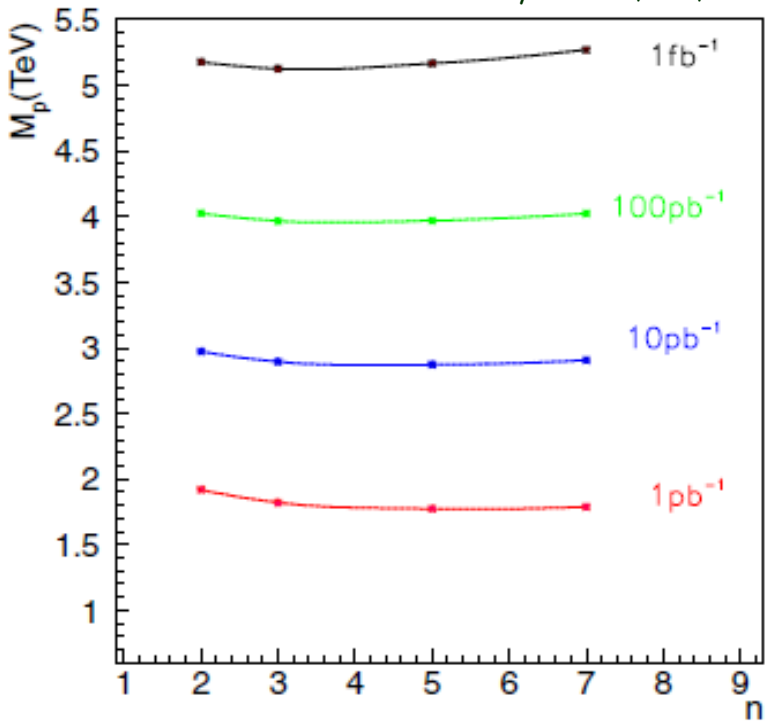


Fig. 12. Contours of $\int \mathcal{L}_{\text{discovery}} dt$ in (M_P, n) plane

Stephen HawkingがCERNを訪問

CERN Courier（今月号）

"Superpartners would be very important
and I estimate a 50% probability.
Black holes would also be very important.
The Higgs would not be so important,
and rather probable."

"I think the chance that you will find
mini black holes is less than 5%.
I haven't booked my ticket to Stockholm yet."

Discovery/Luminosity Roadmap?