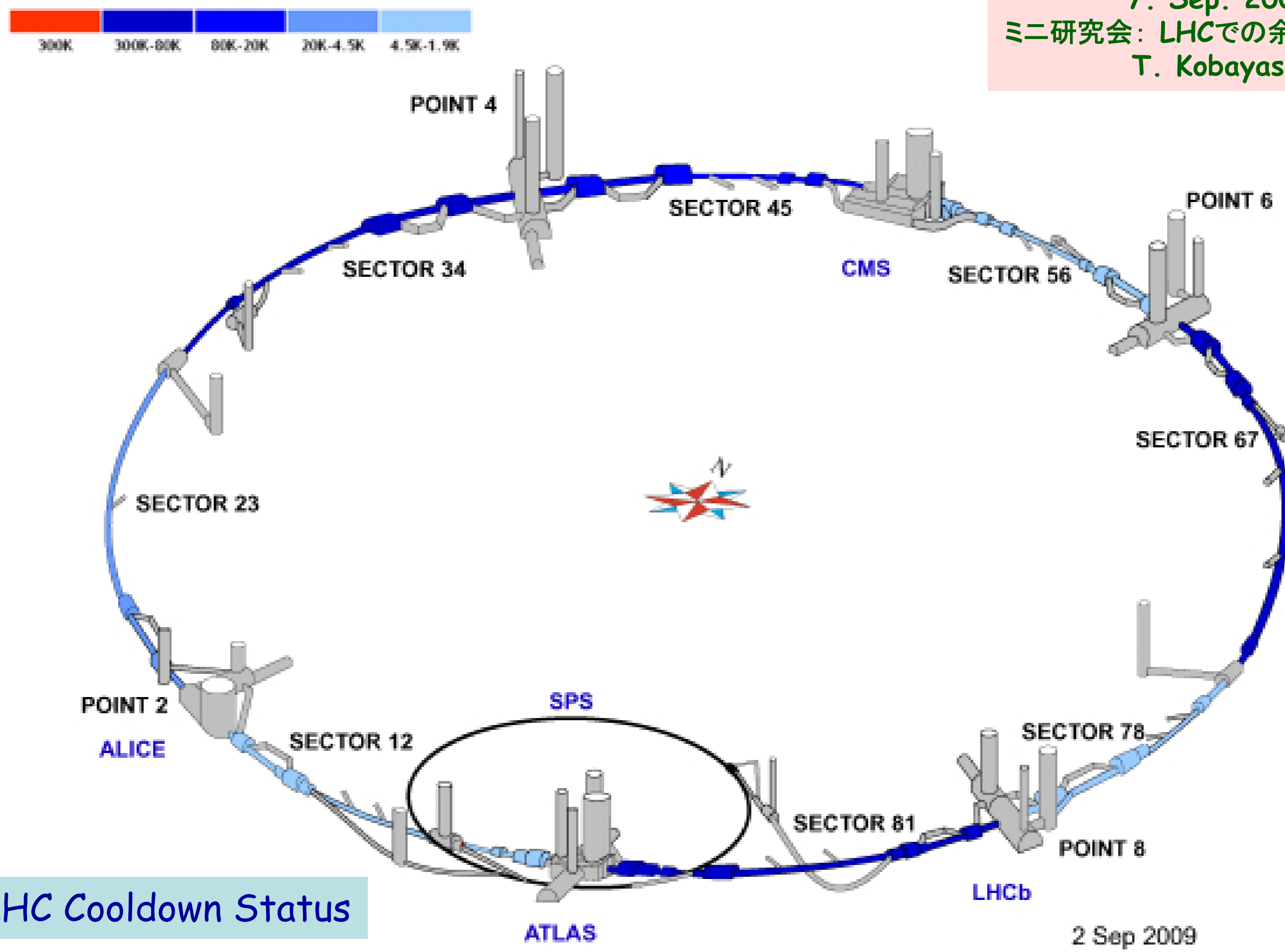
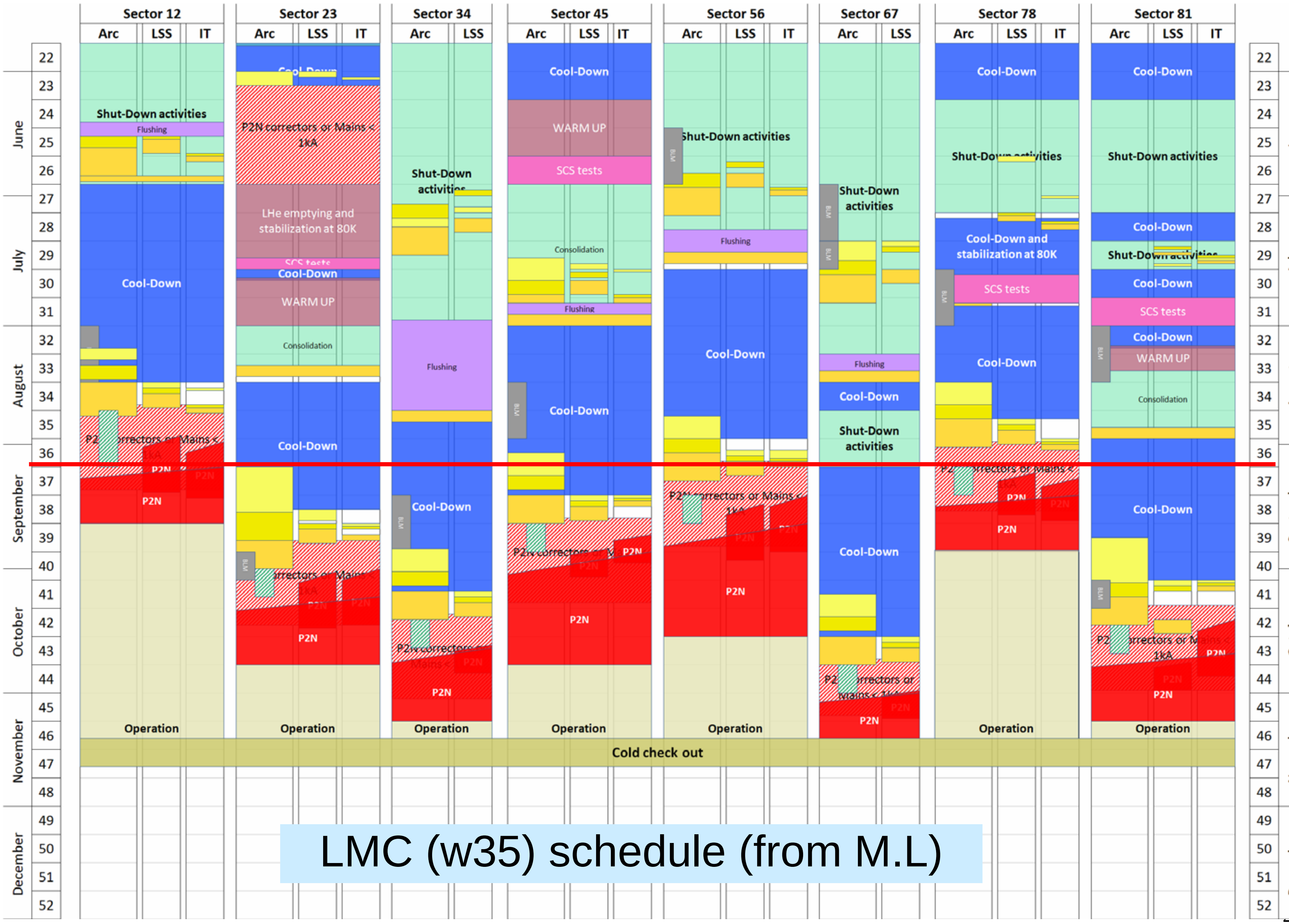
LHCの最新の状況と実験予定

7. Sep. 2009
ミニ研究会：LHCでの余剰次元研究
T. Kobayashi



LHC Cooldown Status



LMC (w35) schedule (from M.L)

Excerpt from the message sent by to the CERN users DG on 6/8/2009

Press Release (06.08.2009)

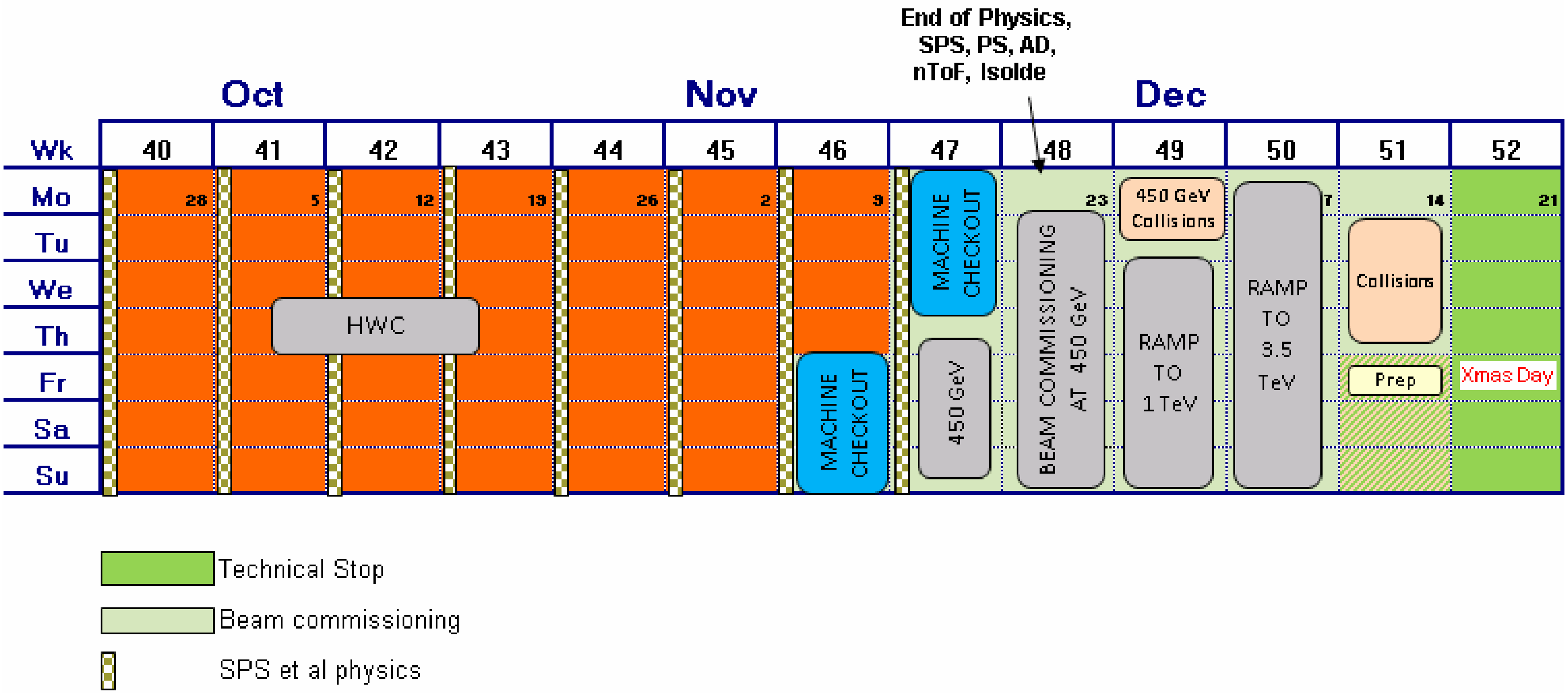
The LHC will run for the first part of the 2009-2010 run at 3.5 TeV per beam, with the energy rising later in the run.
That's the conclusion that we've just arrived at in a meeting involving the experiments, the machine people and the CERN management.
We've selected 3.5 TeV because it allows the LHC operators to gain experience of running the machine safely while opening up a new discovery region for the experiments.

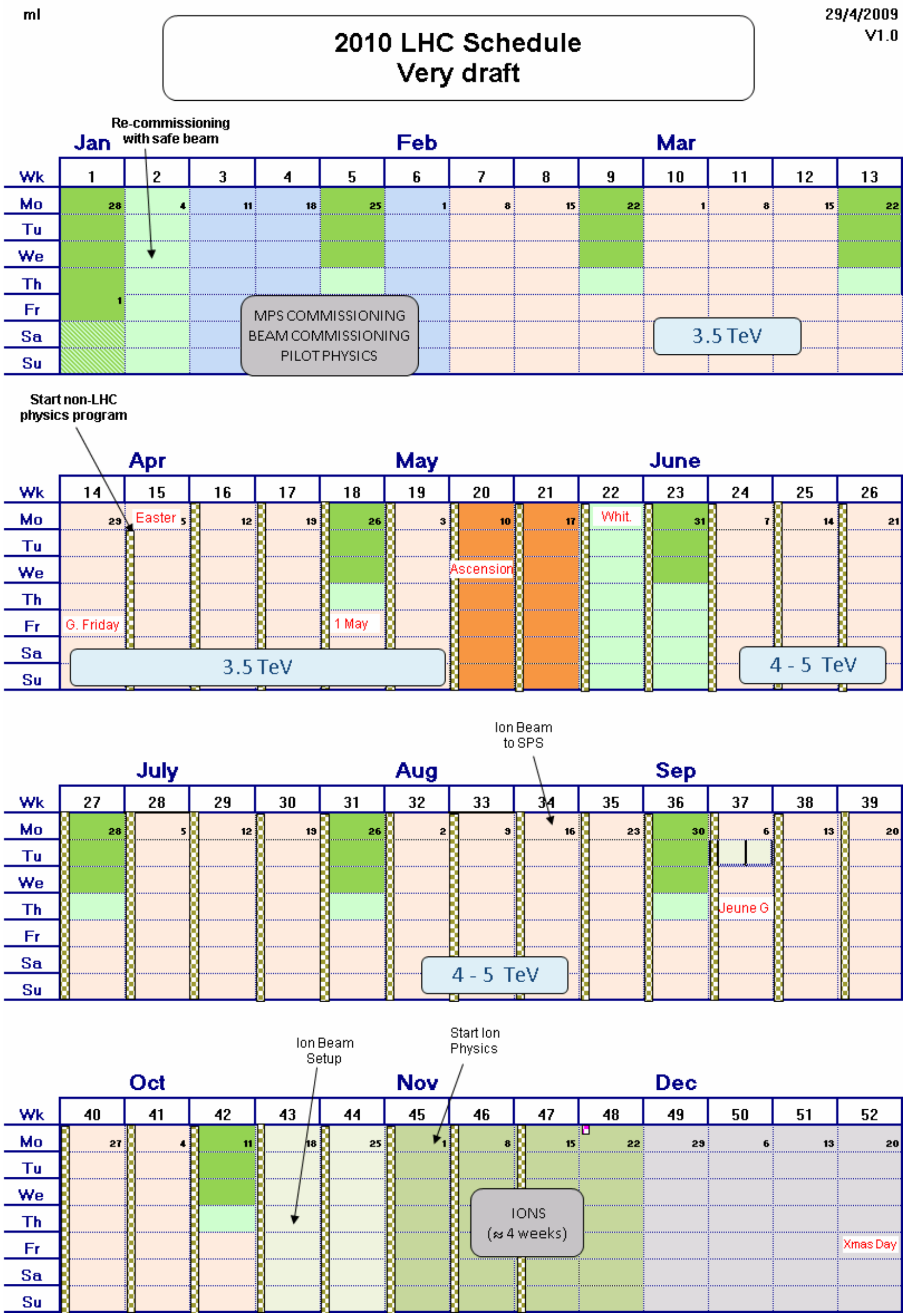
…………………………………

The procedure for the 2009 start-up will be to inject and capture beams in each direction, take collision data for a few shifts at the injection energy, and then commission the ramp to higher energy. The first high-energy data should be collected a few weeks after the first beam of 2009 is injected.
The LHC will run at 3.5 TeV per beam until a significant data sample has been collected and the operations team has gained experience in running the machine. Thereafter, with the benefit of that experience, we'll take the energy up towards 5 TeV per beam.
At the end of 2010, we'll run the LHC with lead-ions for the first time.

After that, the LHC will shut down and we'll get to work on moving the machine towards 7 TeV per beam.

LHC Schedule 2009





- **2010:**
  - **1 month pilot & commissioning**
  - **3 month 3.5 TeV**
  - **1 month step-up**
  - **5 month 4 - 5 TeV**
  - **1 month ions**

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	

Detector present status (after Winter 2008-2009 shut-down)

Sub-detector	Number of channels	Operational fraction (%)
Pixels	80 M	98.5
SCT Silicon Strips	6 M	99.5
TRT Transition Radiation Tracker	350 k	98.2
LAr EM Calorimeter	170 k	99.1
Tile Calorimeter	9800	99.5
Hadronic endcap LAr calo	5600	99.9
Forward LAr calorimeter	3500	100
MDT Muon Drift Tubes	350 k	99.3
CSC Cathode Strip Chambers	31 k	98.4
RPC Barrel Muon Trigger	370 k	~95.5 (aim >98.5)
TGC Endcap Muon Trigger	320 k	99.8

Concerns are long-term reliability of some components:
Low-voltage power supplies of Liquid-Argon and Tile calorimeters;
Liquid-Argon readout optical links;
Inner detector cooling.
Back-up solutions being prepared for installation in future shut-down.

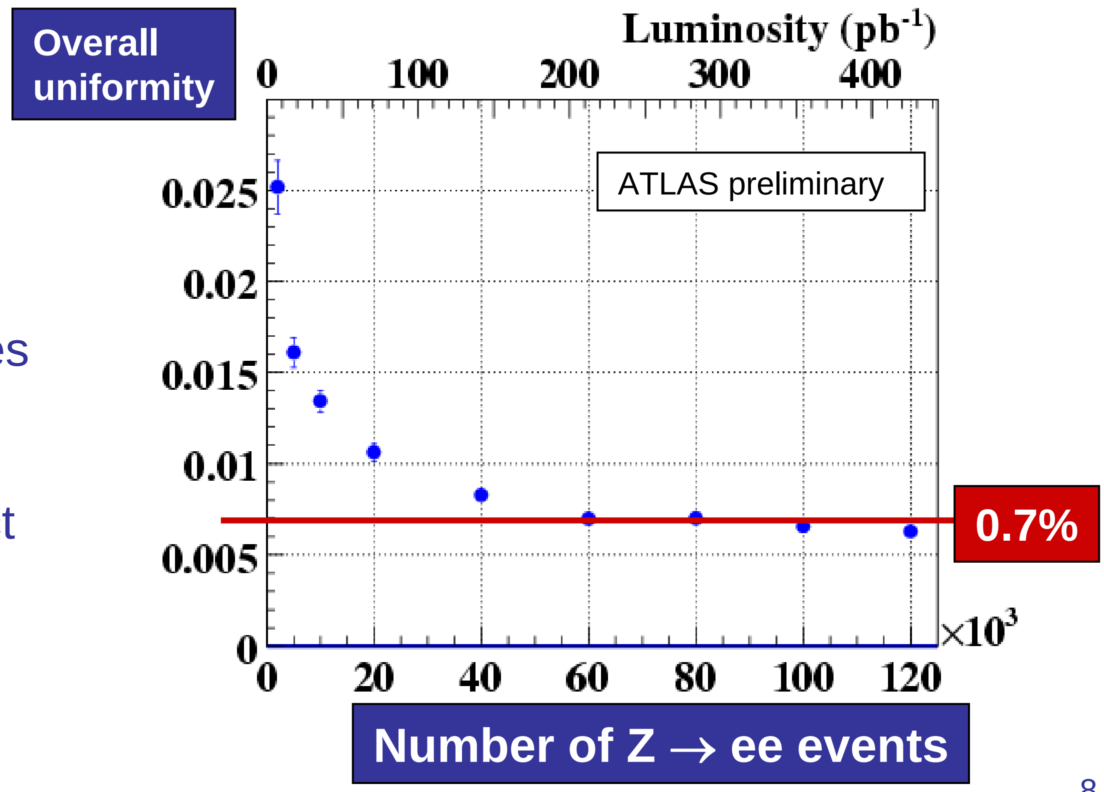
Expected ATLAS performance on "Day-1"

(examples based on test-beam, simulation, and cosmics results)

	Initial Day-1	Ultimate goal	Physics samples to improve(examples)
ECAL uniformity	~2.5%	0.7%	Isolated electrons, $Z \to ee$
e/γ E-scale	2-3%	<0.1%	J/ψ, $Z \to ee$, E/p for electrons
Jet E-scale	5-10%	1%	γ/Z + 1j, $W \to jj$ in tt events
ID alignment	20-200 μm	5 μm	Generic tracks, isolated μ, $Z \to \mu\mu$
Muon alignment	40-1000 μm	30 μm	Straight μ, $Z \to \mu\mu$

ECAL uniformity:

- local uniformity by construction/test: 0.5%
- residual long-range non-uniformities (upstream material, etc.): ~ few percent
  → use Z-mass constraint to correct
  ~ 10^5 $Z \to ee$ events enough to achieve the goal response uniformity of ~ 0.7%



Conclusions

- The ATLAS experiment is in excellent shape
- The fraction of non-working channels is on the per mille level
- Analysis of ~600 M cosmics events, as well as single beam data in Sept 2008, shows better detector performance than expected at this stage
- Software and computing have proven to be able to cope with simulation, analysis and world-wide distribution of massive amounts of data
- After 20 years of efforts building all aspects of the experiment: **ATLAS is eagerly waiting for LHC collisions data …**

Conclusions

- During the autumn 2008 LHC beam & cosmics run, the sub-detectors, online, offline, computing and analysis systems all performed well.

- The ensuing shutdown included broad maintenance activities and a programme of carefully selected repairs interleaved with installation of the preshower detector.

- Much VERY useful information has been extracted from the CRAFT08 data. Plan to publish ~25 papers by end-Sept.

- The software, computing systems and analysis systems are being exercised in CRAFT09 and by generating, (and soon) distributing and analysing 200M events to update 10 TeV "physics analyses" (and soon 7 TeV) using s/w release intended for data taking.

- The experiment is now closed and is being used for a long magnet-on cosmics run to put it into "beam-ready" state.

- **CMS will (again) be ready, and eager, for LHC beam.**

Bottles of champagne to be offered by ATLAS to the LHC accelerator team

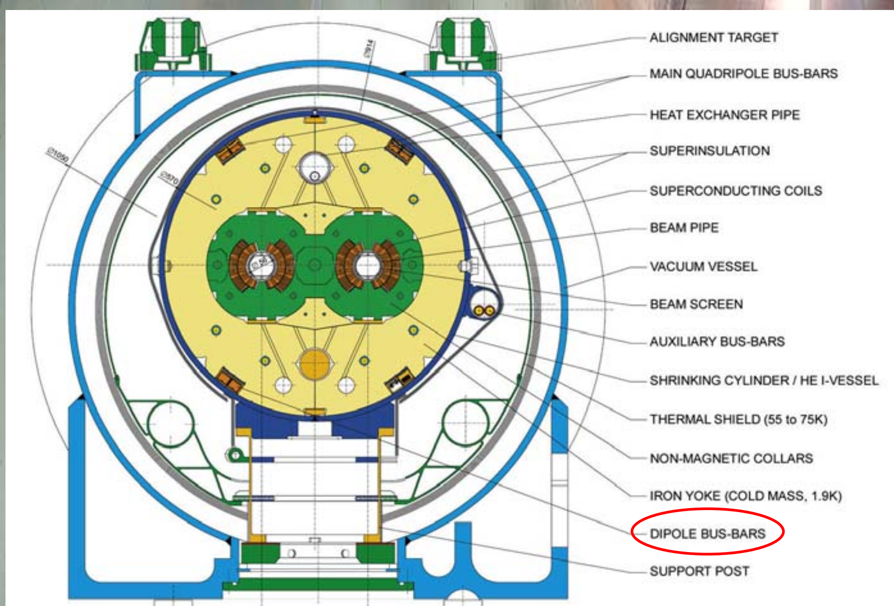
First one delivered …

Backup Slides

Large Hadron Collider (LHC) at CERN

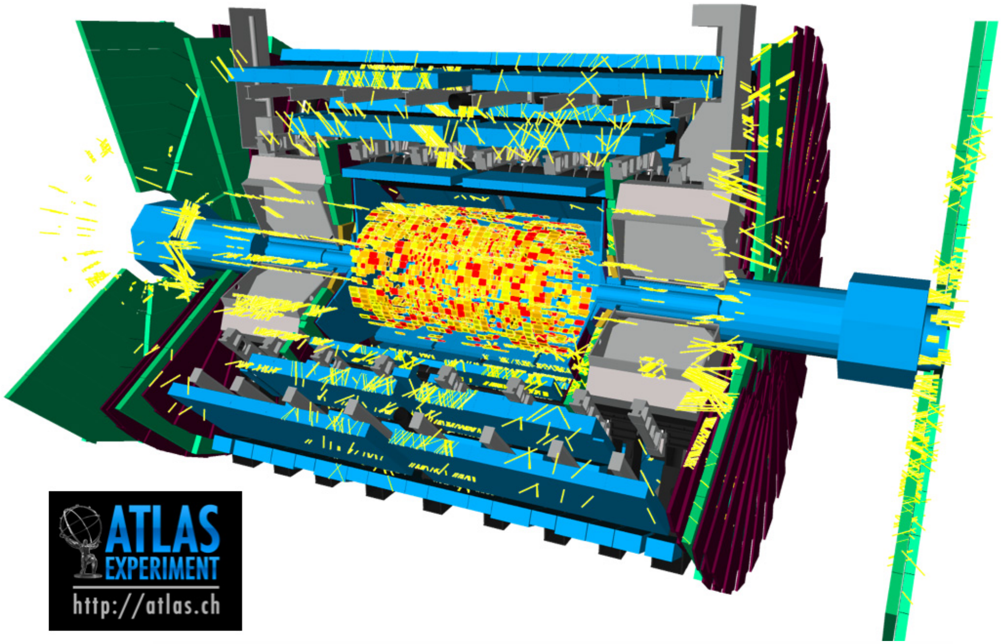
- 14 TeV の陽子・陽子衝突型加速器
- LEPトンネルを利用
- 建設に14年
- 総建設費は約5000億円
- 2008年9月10日first beam周回に成功

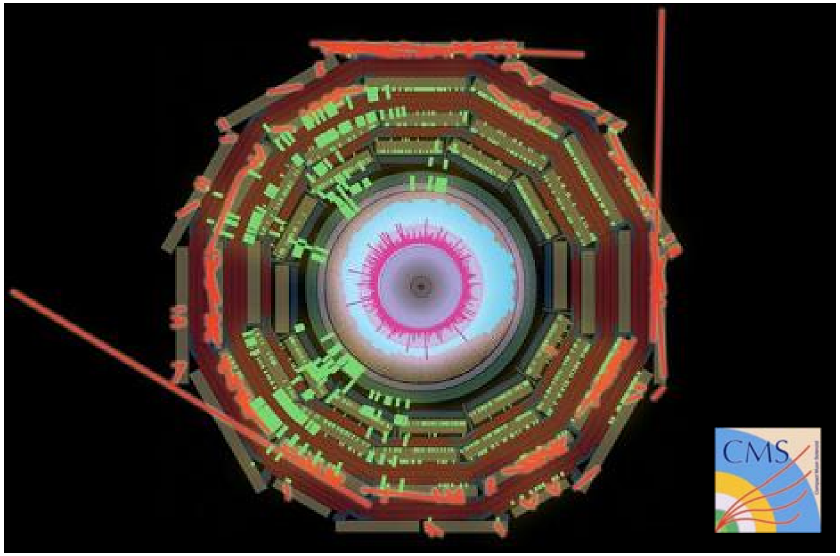
＊ CERNのLEP(e^+e^-)は 200 GeV
＊ 米国フェルミ研究所のTevatron($p\bar{p}$)は 2 TeV

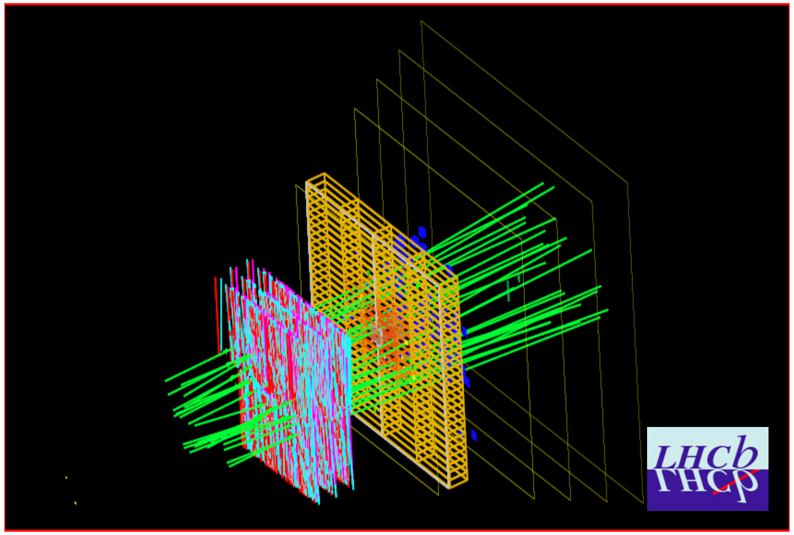


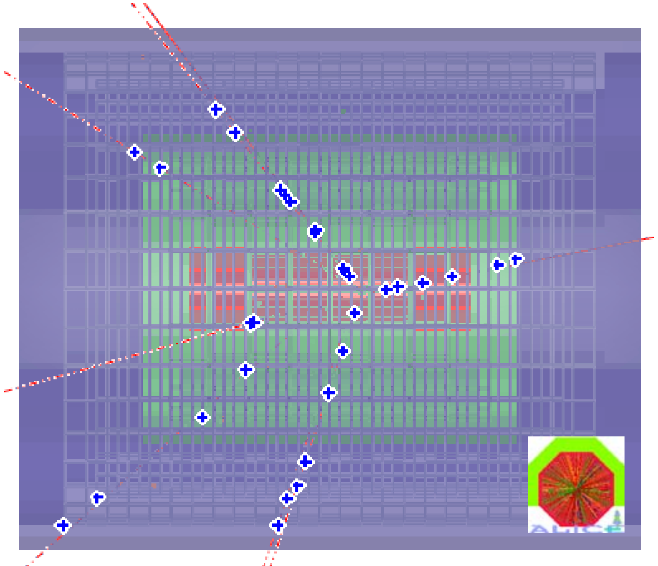
2-in-1超伝導ダイポールマグネット:
磁場強度 8.3T、超流動ヘリウム温度 1.9K、長さ 14.3m、1232台

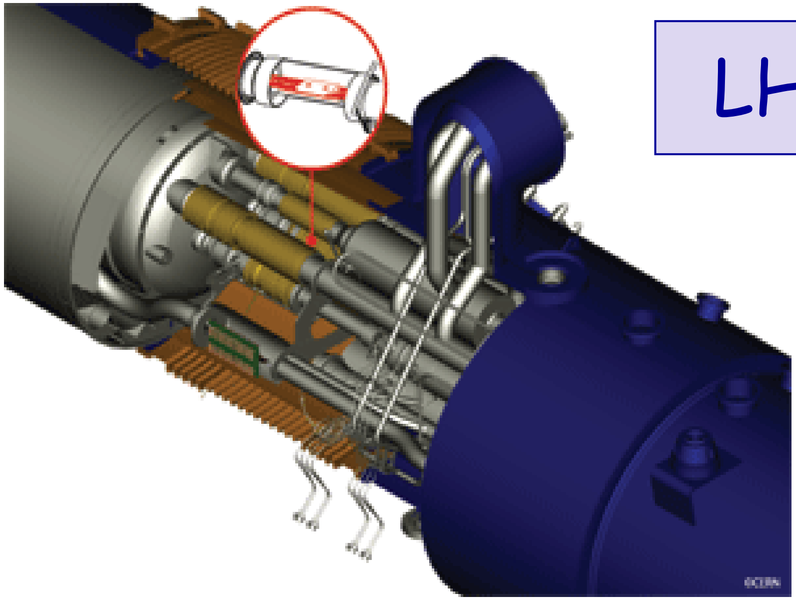
Splash events on Sep.10, 2008
(LHC first beam circulation)









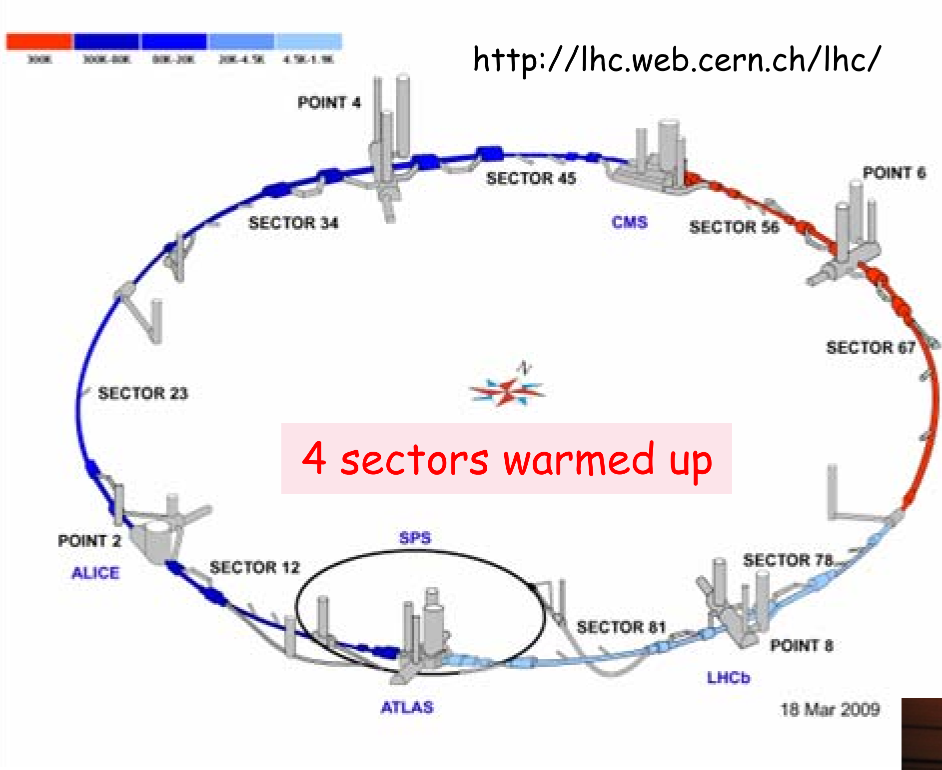


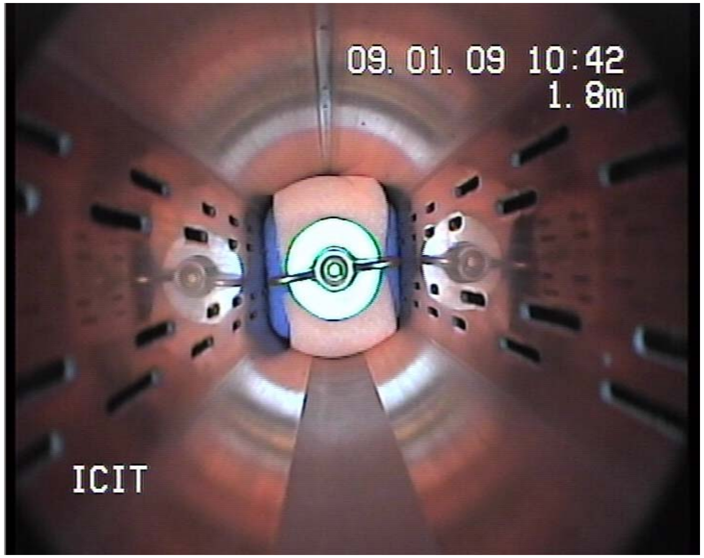
LHC Incident (19 Sept. 2008)

1. Sector34のパワーテスト中、dipoleとQ-magnetの超伝導ケーブルバス結線部の抵抗値が増加
   → 温度上昇 → クエンチ → クエンチ保護回路作動
2. 電源トリップが作動したものの、アーク放電が発生
   → 真空（断熱）容器に穴
3. 真空容器内およびビームパイプ内にヘリウムが流出
   → shock wave
4. 減圧排気バルブが開放されたが、
   → 真空隔壁が破壊、いくつかのマグネットが動かされ
   → 6トンのヘリウムがトンネル内に流出（15t/sector）

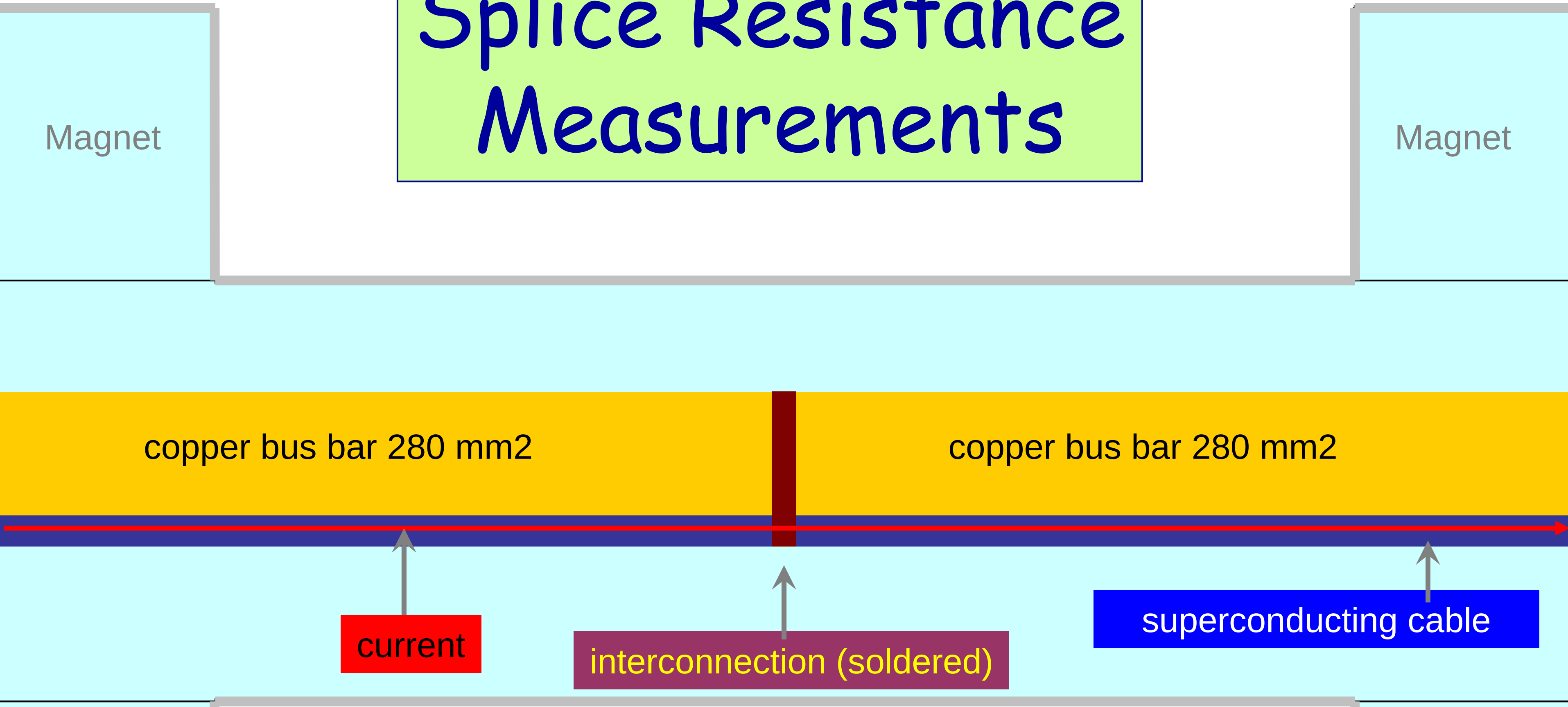
対策

- ・53台のマグネット（39 diploles +14 quadrupoles）を地上に持ち出して修理・チェック
- ・クエンチ検出、異常な電圧や熱の検出システムの改善
- ・安全開放バルブの容量と数を増強
- ・ビームパイプの掃除
- ・真空隔壁を備えたQ-magnetのサポートを強化





Splice Resistance Measurements



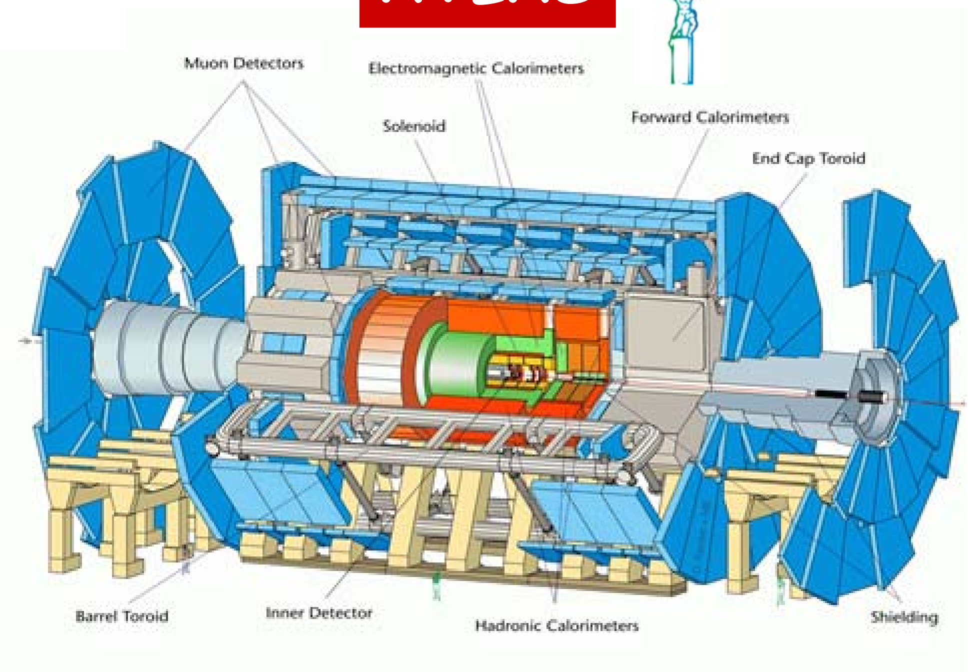
We must be sure that the joint between the sc cables is good. Measurements of nano-Ohms at 1.9K

We must be ensure that the copper stabiliser is continuous. Measurements of micro-Ohms at warm

General purpose detectors for pp collisions

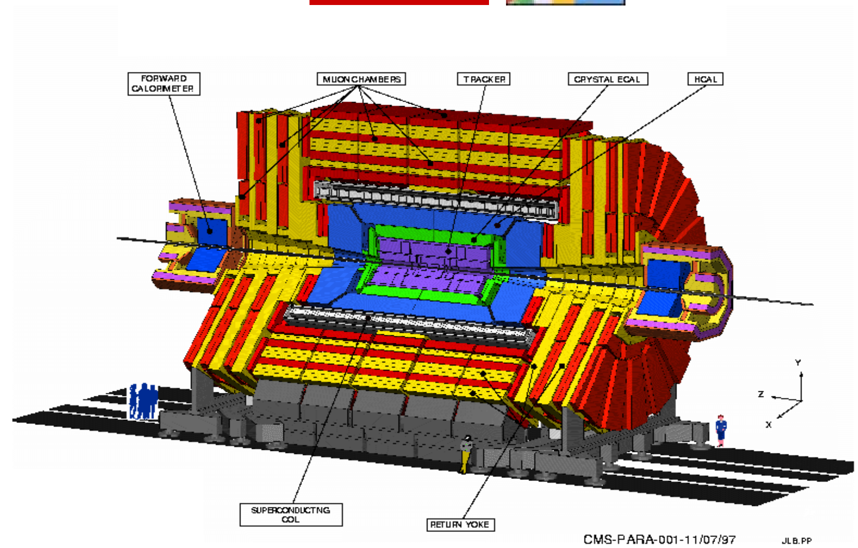
+ LHCb, ALICE, TOTEM, LHCf

ATLAS

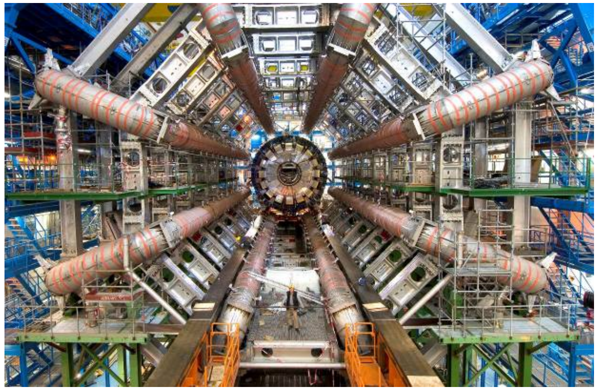


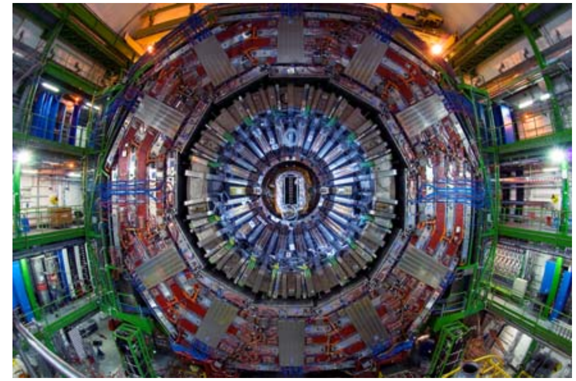
Length : ~45 m
Diameter : ~24 m
Weight : ~ 7,000 tons
Electronic channels : ~ 10^8
Solenoid : 2 T
Air-core toroids

CMS



Length : ~22 m
Diameter : ~14 m
Weight : ~ 12,500 tons
Solenoid : 4 T
Fe yoke
Compact and modular

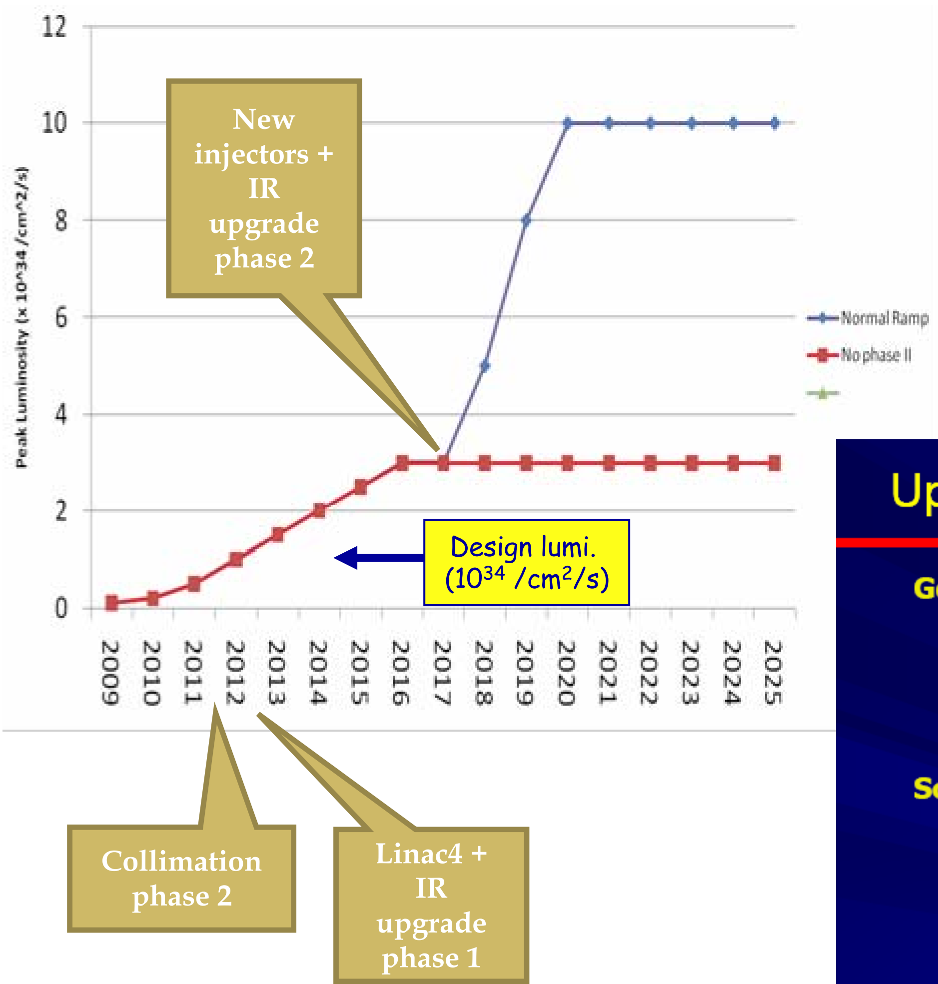


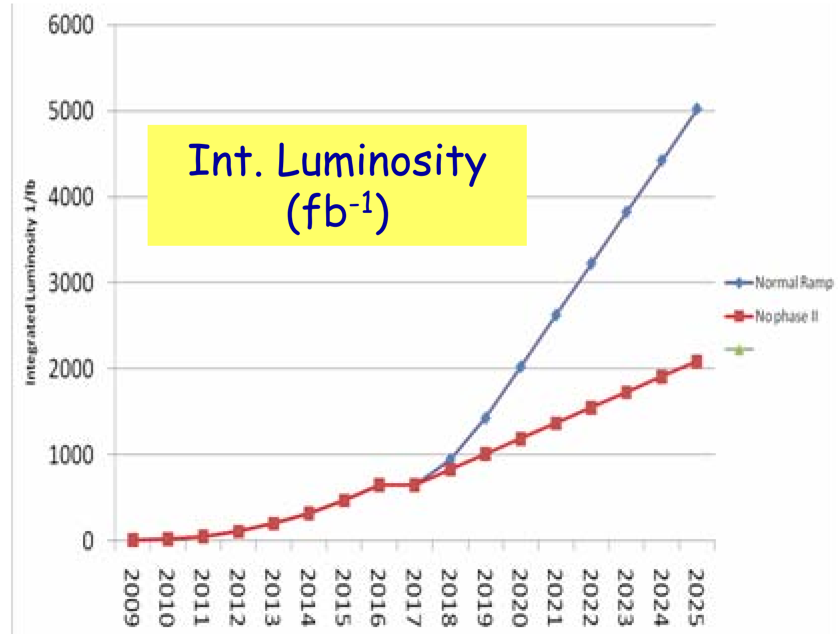


	ATLAS	CMS
TRACKER	Si pixels + strips TRT → particle identification $\sigma/p_T \sim 4\text{x}10^{-4}\, p_T \oplus 0.01$	Si pixels + strips No particle identification $\sigma/p_T \sim 1.5\text{x}10^{-4}\, p_T \oplus 0.005$
EM CALO	Pb-liquid argon $\sigma/E \sim 10\%/\sqrt{E}$ uniform longitudinal segmentation	$PbWO_4$ crystals $\sigma/E \sim 2\text{-}5\%/\sqrt{E}$ no longitudinal segmentation
HAD CALO	Fe-scint. + Cu-liquid argon ($\geq 10\ \lambda$) $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$	Brass-scint. ($\geq 5.8\ \lambda$ + catcher) $\sigma/E \sim 100\%/\sqrt{E} \oplus 0.05$
MUON	MDT, CSC, RPC, TGC $\sigma/p_T \sim 7\ \%$ at 1 TeV standalone	DT, CSC, RPC $\sigma/p_T \sim 5\%$ at 1 TeV combining with tracker

Peak Luminosity

(2008年夏の時点での予想)





2011年： 14TeVでO(1) fb^{-1} (?)
2012年： O(10) fb^{-1} (?)

Upgrade of the LHC insertions: "Phase I"

Goal of "Phase I" upgrade:

Enable focusing of the beams to β^*=0.25 m in IP1 and IP5, and reliable operation of the LHC at 2 10^{34} $cm^{-2}s^{-1}$ on the horizon of the physics run in 2013.

Scope of "Phase I" upgrade:

1. Upgrade of ATLAS and CMS experimental insertions. The interfaces between the LHC and the experiments remain unchanged at ± 19 m.
2. Replace the present triplets with wide aperture quadrupoles based on the LHC dipole cables (Nb-Ti) cooled at 1.9 K.
3. Upgrade the D1 separation dipole, TAS and other beam-line equipment so as to be compatible with the inner triplet aperture.
4. The cooling capacity of the cryogenic system and other main infrastructure elements remain unchanged.
5. Modifications of other insertion magnets (e.g. D2-Q4) and introduction of other equipment in the insertions to the extent of available resources.

(R.Aymar, Plenary ECFA)