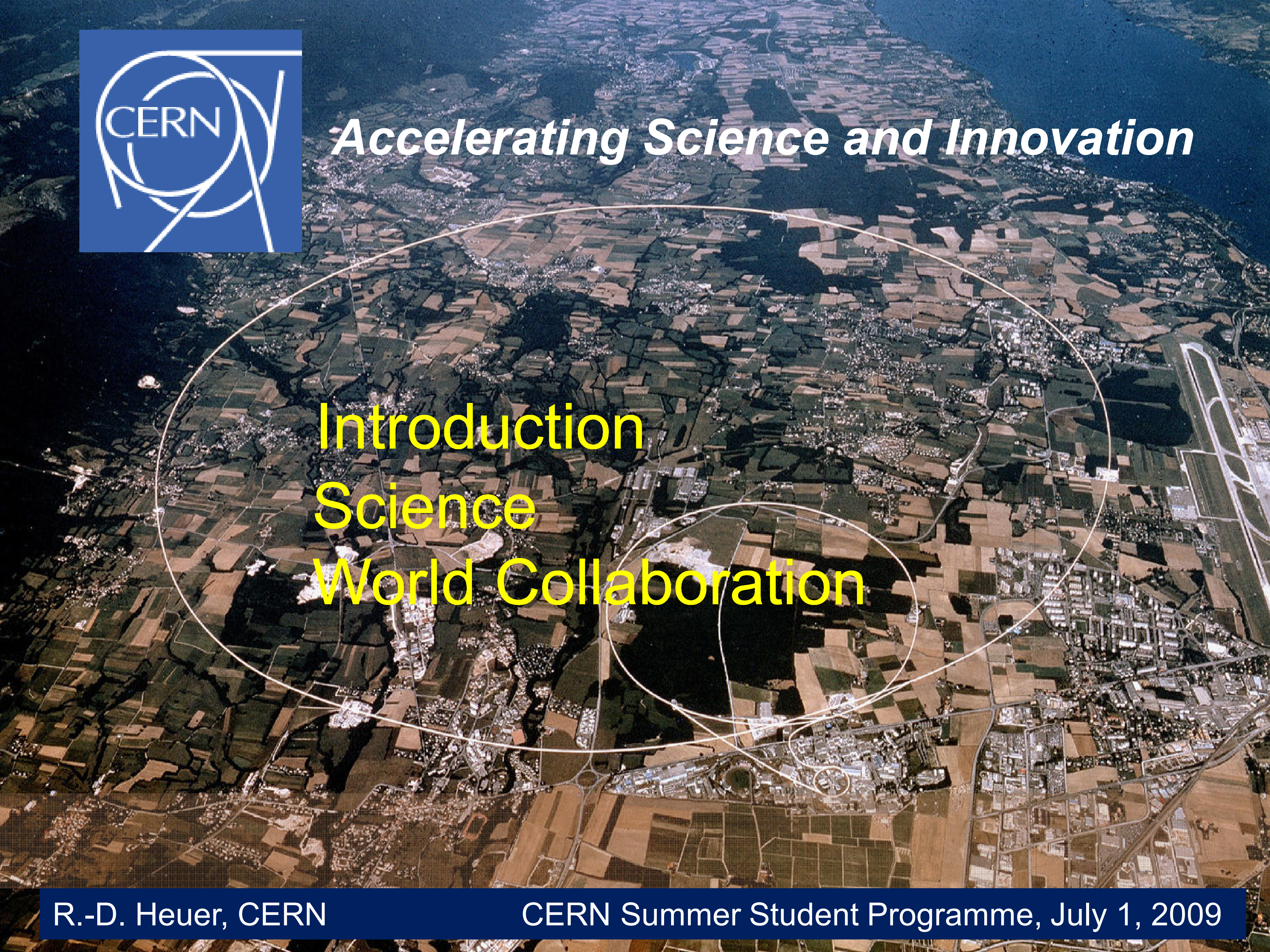
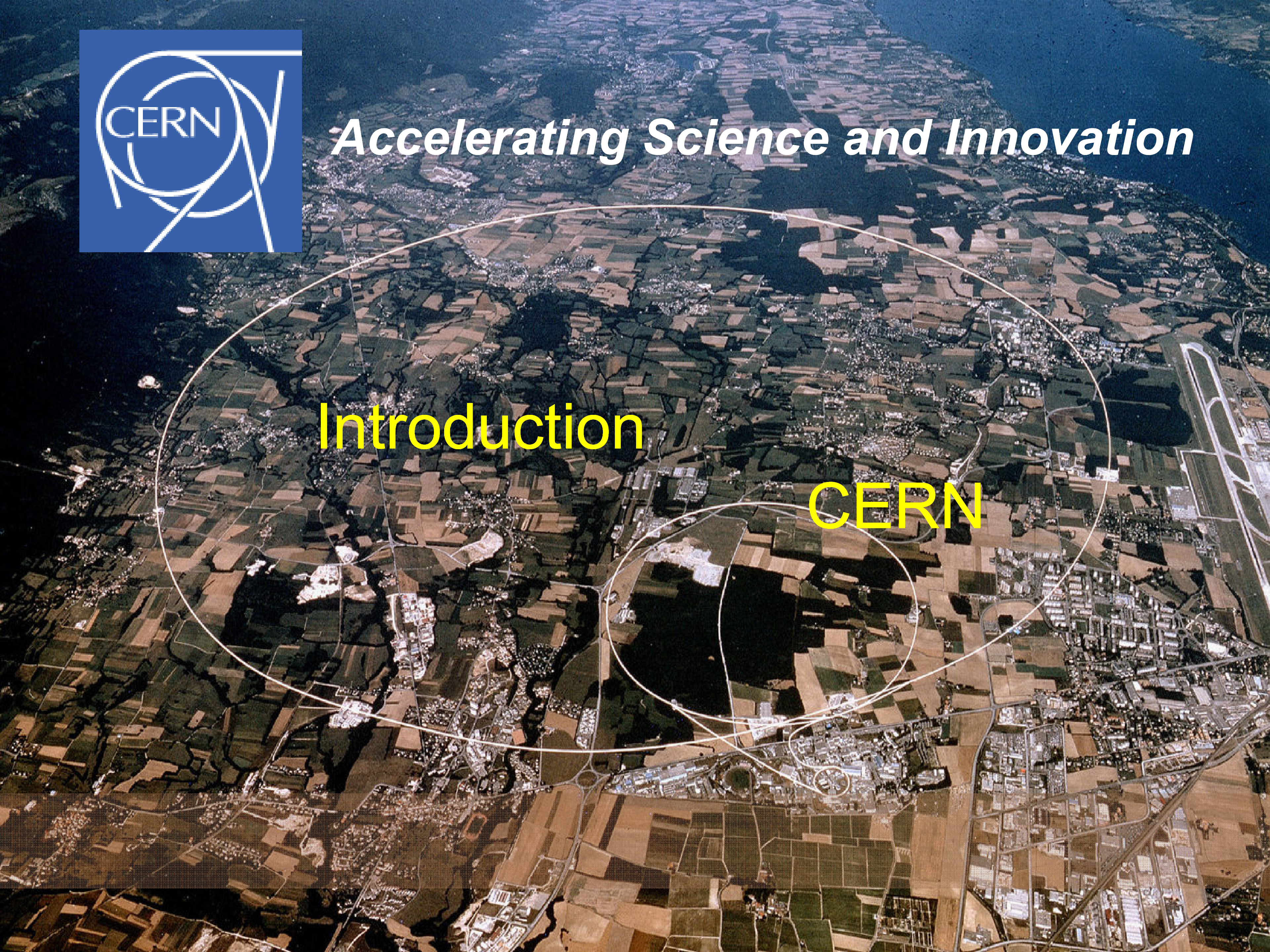


Accelerating Science and Innovation

Introduction
Science
World Collaboration

R.-D. Heuer, CERN

CERN Summer Student Programme, July 1, 2009

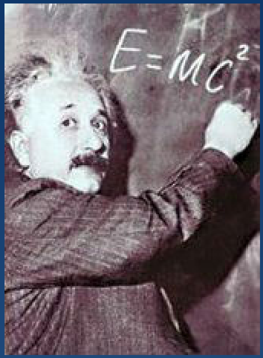

CERN
Accelerating Science and Innovation
Introduction
CERN

Innovation
Education
CERN
uniting people
Research

The Mission of CERN

- **Push back** the frontiers of knowledge

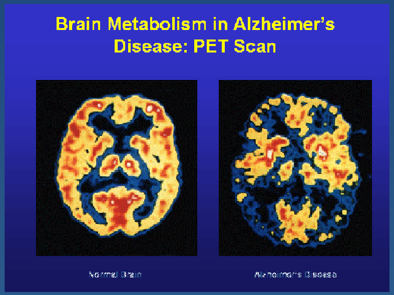
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?

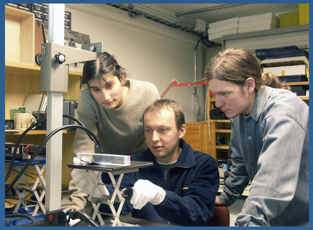
- **Develop** new technologies for accelerators and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy

- **Train** scientists and engineers of tomorrow




- **Unite** people from different countries and cultures

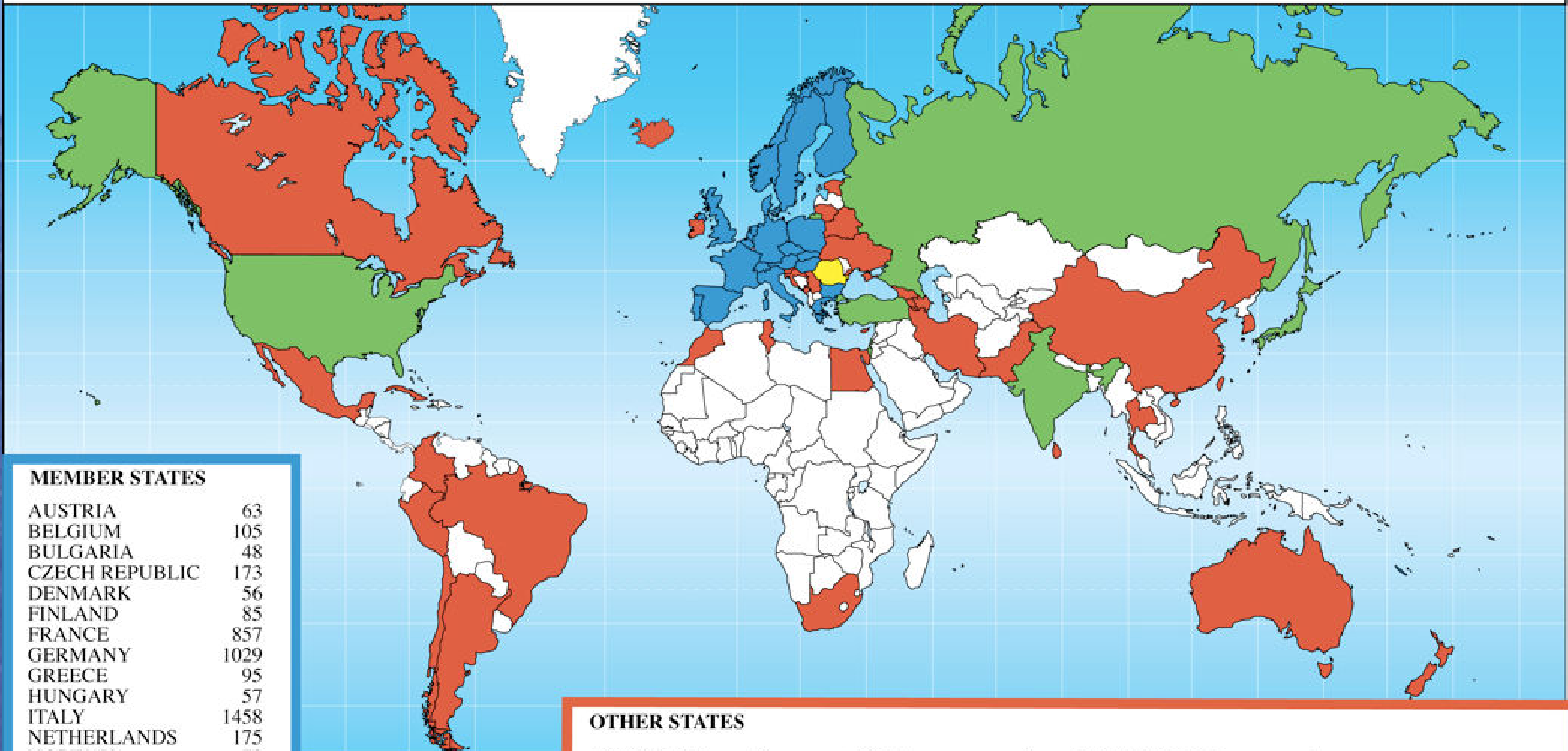
CERN in Numbers

- 2256 staff
- ~ 700 other paid personnel
- ~ 9500 users
- Budget (2009) 1100 MCHF

- 20 Member States: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.
- 1 Candidate for Accession to Membership of CERN: Romania
- 8 Observers to Council: India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and Unesco

CERN in Numbers

Distribution of All CERN Users by Nation of Institute on 17 February 2009



MEMBER STATES

AUSTRIA	63
BELGIUM	105
BULGARIA	48
CZECH REPUBLIC	173
DENMARK	56
FINLAND	85
FRANCE	857
GERMANY	1029
GREECE	95
HUNGARY	57
ITALY	1458
NETHERLANDS	175
NORWAY	72
POLAND	165
PORTUGAL	110
SLOVAKIA	48
SPAIN	291
SWEDEN	73
SWITZERLAND	332
UNITED KINGDOM	697

5989

OBSERVER STATES

INDIA	97
ISRAEL	54
JAPAN	200
RUSSIA	886
TURKEY	51
USA	1499

2787

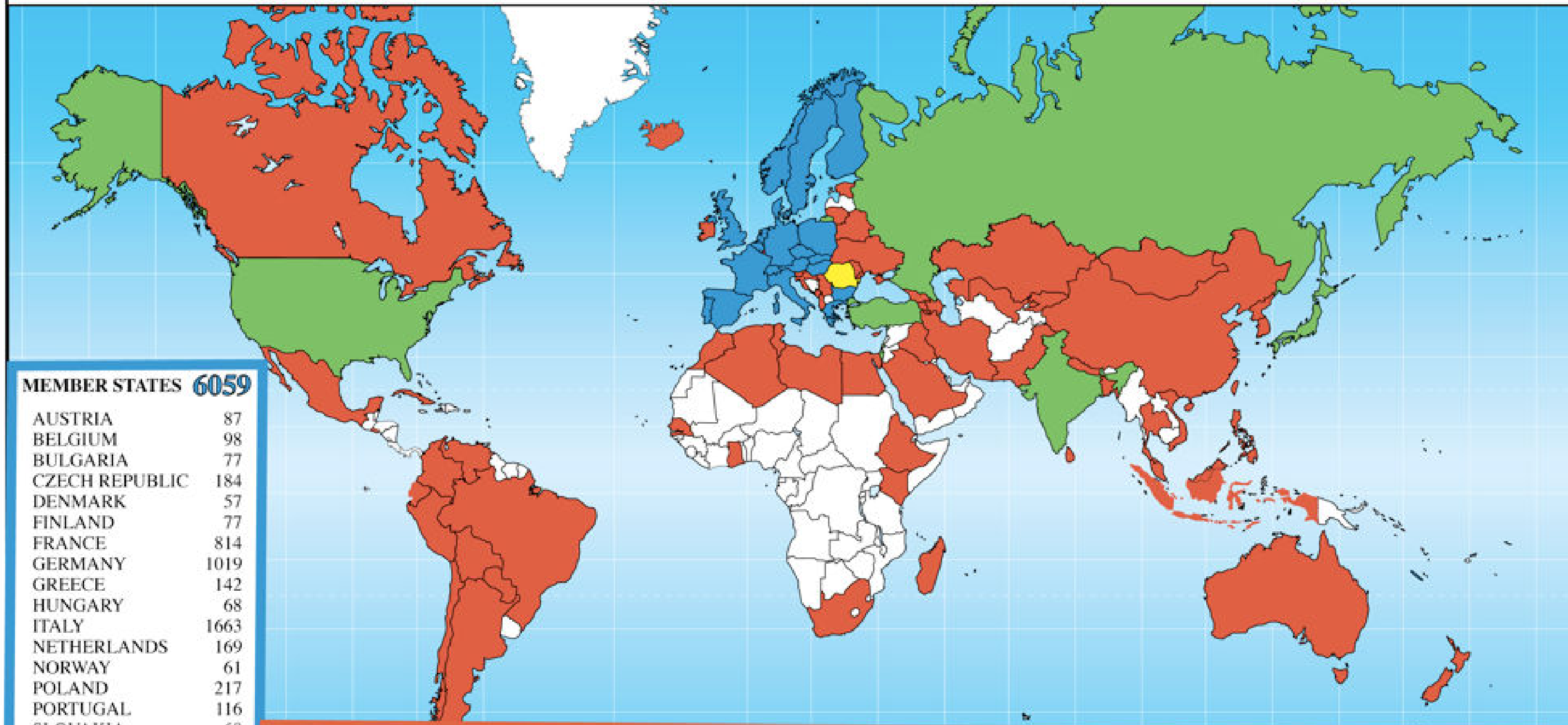
OTHER STATES

ARGENTINA	10	CUBA	3	MONTENEGRO	1	SRI LANKA	1
ARMENIA	14	CYPRUS	6	MOROCCO	5	TAIWAN	44
AUSTRALIA	13	EGYPT	1	NEW ZEALAND	5	THAILAND	1
AZERBAIJAN	1	ESTONIA	11	PAKISTAN	22	TUNISIA	1
BELARUS	19	GEORGIA	10	PERU	1	UKRAINE	18
BRAZIL	70	ICELAND	1	ROMANIA	50		
CANADA	137	IRAN	12	SERBIA	17		
CHILE	5	IRELAND	12	SLOVENIA	16		
CHINA	69	KOREA	52	SOUTH AFRICA	8		
COLOMBIA	13	LITHUANIA	9				
CROATIA	20	MEXICO	29				

707

CERN in Numbers

Distribution of All CERN Users by Nationality on 17 February 2009



MEMBER STATES	6059
AUSTRIA	87
BELGIUM	98
BULGARIA	77
CZECH REPUBLIC	184
DENMARK	57
FINLAND	77
FRANCE	814
GERMANY	1019
GREECE	142
HUNGARY	68
ITALY	1663
NETHERLANDS	169
NORWAY	61
POLAND	217
PORTUGAL	116
SLOVAKIA	68
SPAIN	300
SWEDEN	72
SWITZERLAND	187
UNITED KINGDOM	583

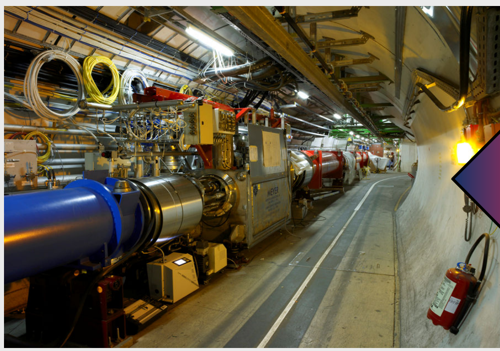
OBSERVER STATES	2350
INDIA	154
ISRAEL	59
JAPAN	221
RUSSIA	1010
TURKEY	70
USA	836

OTHER STATES	1112										
ALBANIA	1	CHINA	170	GIBRALTAR	3	LEBANON	6	NEW ZEALAND	6	SLOVENIA	20
ALGERIA	8	COLOMBIA	21	HONG KONG	1	LITHUANIA	12	PAKISTAN	40	SOUTH AFRICA	9
ARGENTINA	14	CROATIA	26	ICELAND	1	LUXEMBOURG	4	PALESTINIAN TERR., OCC.	1	SRI LANKA	5
ARMENIA	24	CUBA	3	INDONESIA	1	LIBYA	1	PARAGUAY	2	SYRIAN ARAB REP	2
AUSTRALIA	15	CYPRUS	10	IRAN	20	MADAGASCAR	2	PERU	3	TAIWAN PROV. OF CHINA	35
AZERBAIJAN	4	ECUADOR	2	IRAQ	1	MALAYSIA	5	PHILIPPINES	1	THAILAND	2
BANGLADESH	3	EGYPT	3	IRELAND	20	MAURITIUS	1	ROMANIA	95	TUNISIA	3
BELARUS	39	EL SALVADOR	1	KAZAKHSTAN	1	MEXICO	43	SAN MARINO	1	UKRAINE	39
BOLIVIA	2	ESTONIA	11	KENYA	1	MOLDOVA	1	SAUDI ARABIA	2	UZBEKISTAN	1
BRAZIL	69	ETHIOPIA	1	KOREA, D.P.R.	4	MONGOLIA	1	SENEGAL	1	VENEZUELA	3
CANADA	124	GEORGIA	33	KOREA REP.	70	MOROCCO	14	SERBIA	30	VIET NAM	4
CHILE	7	GHANA	1	KYRGYZSTAN	2	NEPAL	1	SINGAPORE	2		

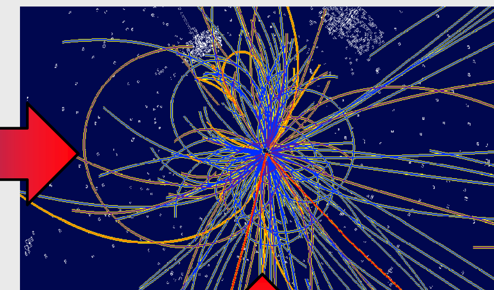
CERN Technologies - Innovation

Three key technology areas at CERN

Accelerating particle beams



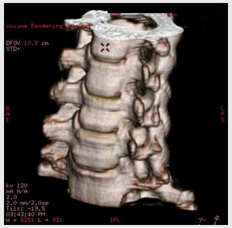
Detecting particles



Large-scale **computing** (Grid)

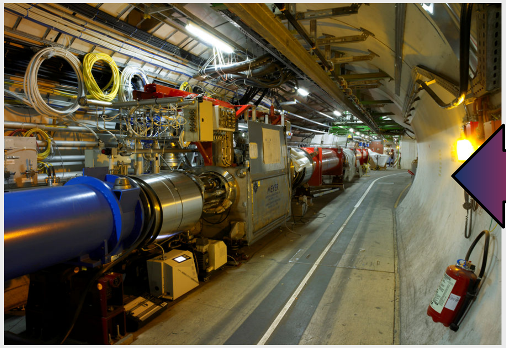
CERN Technologies - Innovation

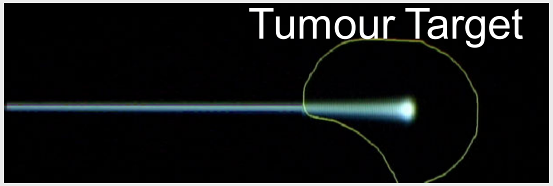
Medical imaging



Example: medical application

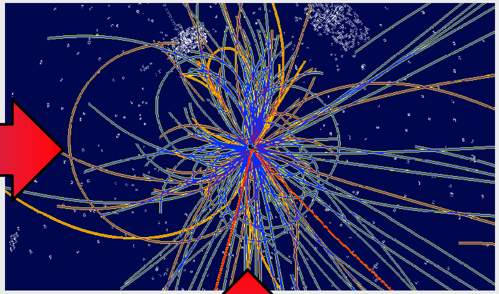
Accelerating particle beams

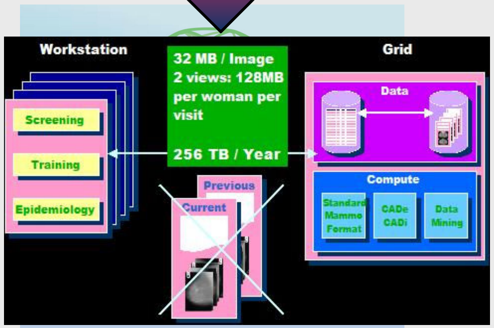




Charged hadron beam that loses energy in matter

Detecting particles





Large-scale **computing** (Grid)

Grid computing for medical data management and analysis

CERN Education Activities

Latin American School of High Energy Physics Chile, 2007

Scientists at CERN

Academic Training Programme

Young Researchers

CERN School of High Energy Physics
CERN School of Computing
CERN Accelerator School

School of Computing Norway, 2008

Physics Students

Summer Students Programme

CERN Teacher Schools

International and National Programmes

CERN

Accelerating Science and Innovation

Introduction

(some) Features of Particle Physics

Features of Particle Physics

Duration of large particle physics projects:

decade(s)
from science case
via concept, R&D, and design
to realisation and exploitation

Excellent training grounds
in particle physics,
accelerator and detector technologies,
computing

Duration of Projects

LEP Note 440

11.4.1983

PRELIMINARY PERFORMANCE ESTIMATES FOR A LEP PROTON COLLIDER

S. Myers and W. Schnell

1983

First LHC physics workshop 1984

LEP experiments: LoI 1982

1. Introduction

This analysis … the United States where very large $p\bar{p}$ … being studied at the moment. Inde… performance limitations of possible $p\bar{p}$ or …nel seems overdue, however far off in the future a … such a p-LEP project may yet be in time. What we shall …, in fact, rather obvious, but such a discussion has, to the best …our knowledge, not been presented so far.

We shall not address any detailed design questions but shall give basic equations and make a few plausible assumptions for the purpose of illustration. Thus, we shall assume throughout that the maximum energy per beam is 8 TeV (corresponding to a little over 9 T bending field in very advanced superconducting magnets) and that injection is at 0.4 TeV. The ring circumference is, of course that of LEP, namely 26,659 m. It should be clear from this requirement of "Ten Tesla Magnets" alone that such a project is not for the near future and that it should not be attempted before the technology is ready.

driving technology

long term stability and strategy

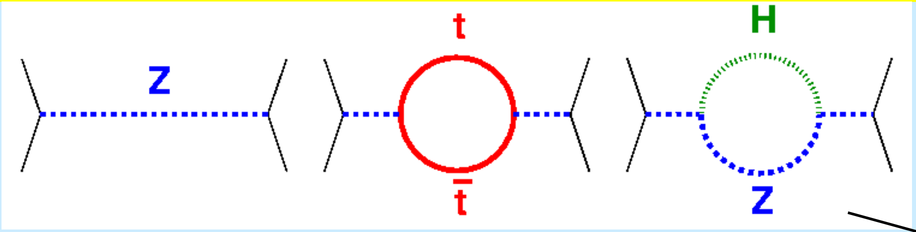
Features of Particle Physics

Interplay and Synergy

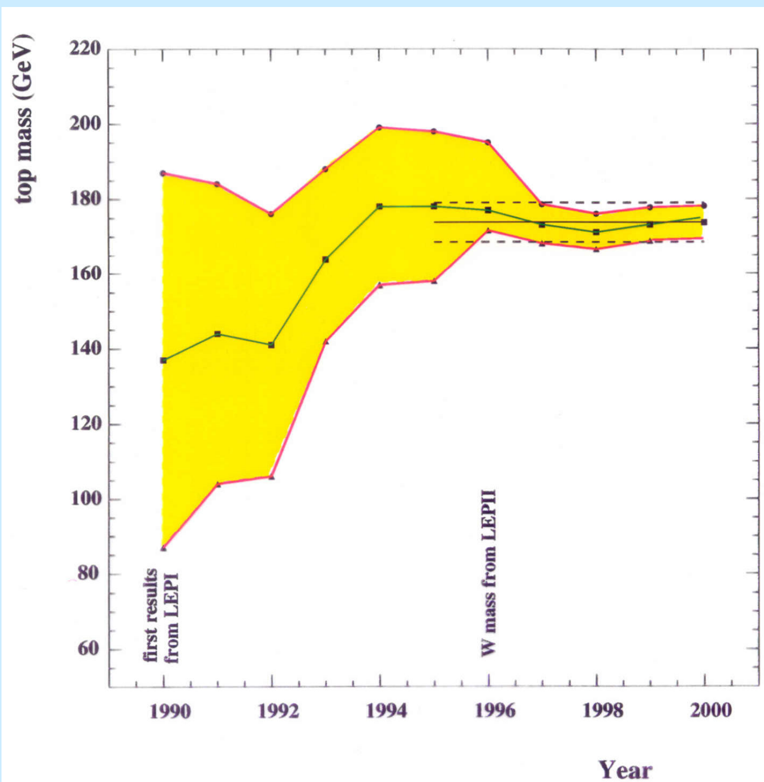
of different tools
(accelerators – cosmic rays – reactors . . .)

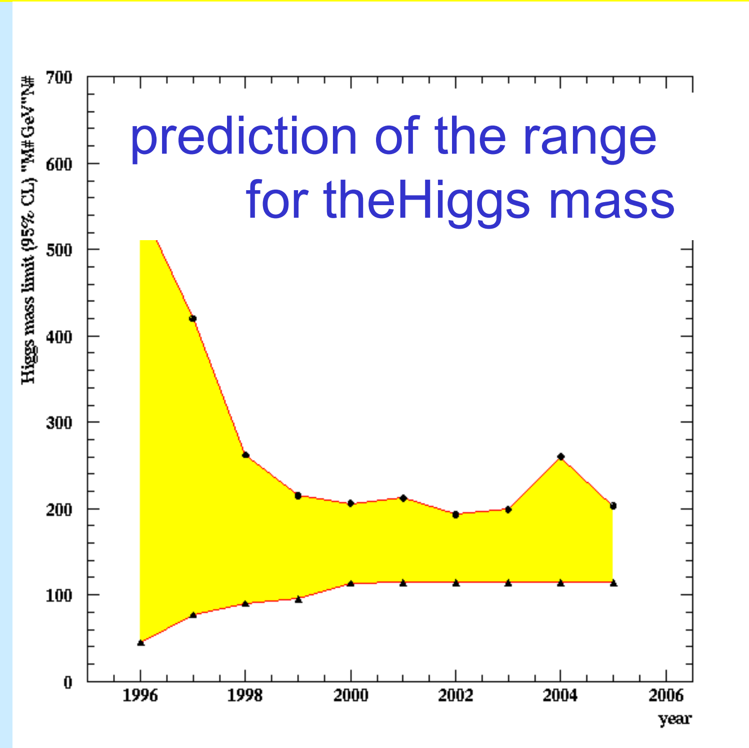
of different facilities
different initial states
lepton collider (electron-positron)
hadron collider (proton-proton)
lepton-hadron collider
at the energy frontier: high collision energy
and intensity frontier: high reaction rate

Test of the SM at the Level of Quantum Fluctuations



indirect determination of the top mass





possible due to

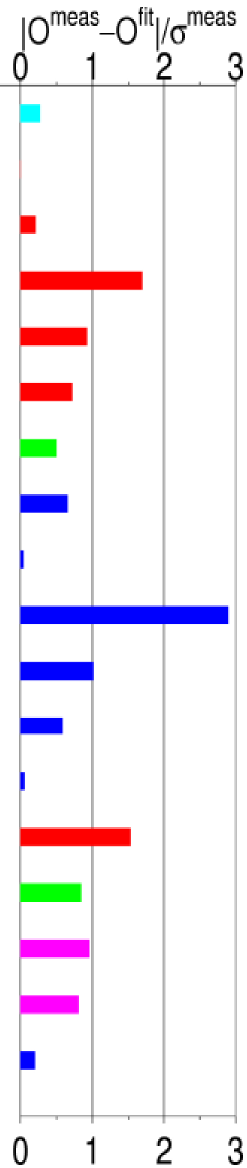
- precision measurements
- known higher order electroweak corrections

$$\propto \left(\frac{M_t}{M_W}\right)^2, \ln\left(\frac{M_h}{M_W}\right)$$

Status Summer Conferences 2007

Standard Model Analysis

	Measurement	Fit
$\Delta\alpha_{had}^{(5)}(m_Z)$	0.02758 ± 0.00035	0.02768
m_Z [GeV]	91.1875 ± 0.0021	91.1875
Γ_Z [GeV]	2.4952 ± 0.0023	2.4957
σ_{had}^0 [nb]	41.540 ± 0.037	41.477
R_l	20.767 ± 0.025	20.744
$A_{fb}^{0,l}$	0.01714 ± 0.00095	0.01645
$A_l(P_\tau)$	0.1465 ± 0.0032	0.1481
R_b	0.21629 ± 0.00066	0.21586
R_c	0.1721 ± 0.0030	0.1722
$A_{fb}^{0,b}$	0.0992 ± 0.0016	0.1038
$A_{fb}^{0,c}$	0.0707 ± 0.0035	0.0742
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
A_l(SLD)	0.1513 ± 0.0021	0.1481
$\sin^2\theta_{eff}^{lept}(Q_{fb})$	0.2324 ± 0.0012	0.2314
m_W [GeV]	80.398 ± 0.025	80.374
Γ_W [GeV]	2.140 ± 0.060	2.091
m_t [GeV]	170.9 ± 1.8	171.3



Fit to 17 high-Q^2 observables plus $\Delta\alpha_{had}$:

χ^2/ndof = 18.2/13 (15.1%)

Largest χ^2 contribution:
A_l(SLD) vs. $A_{fb}b$(LEP)

Decided in favour of leptons by MW

Afb(b) has largest pull: 2.9σ!

Without this point, the fit is *too* good!

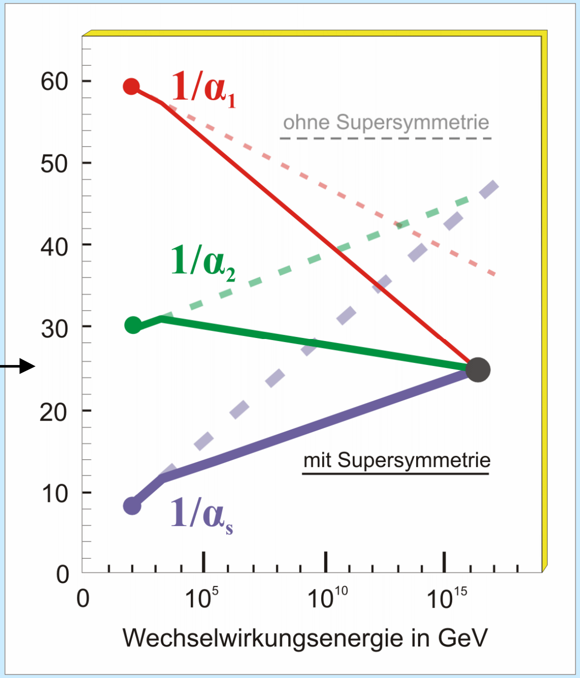
however . . .
. . . one piece missing
within Standard Model

plus many open questions

Key Questions of Particle Physics

origin of mass/matter or
origin of electroweak symmetry breaking

unification of forces



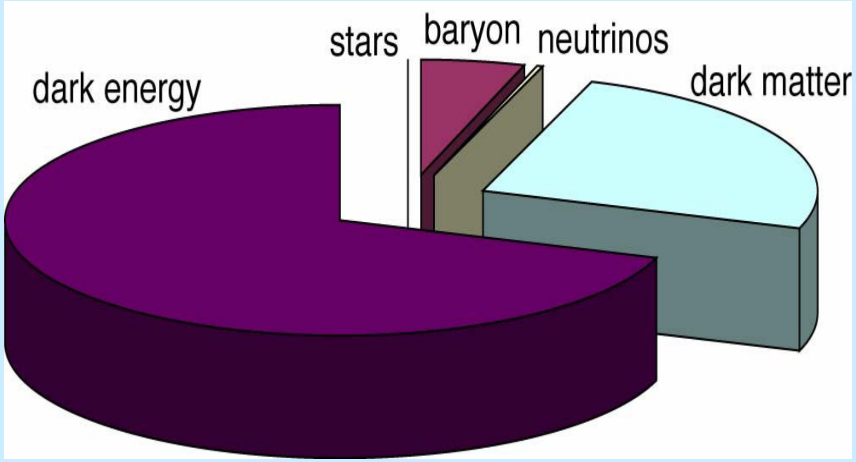
fundamental symmetry of forces and matter

unification of quantum physics and general relativity

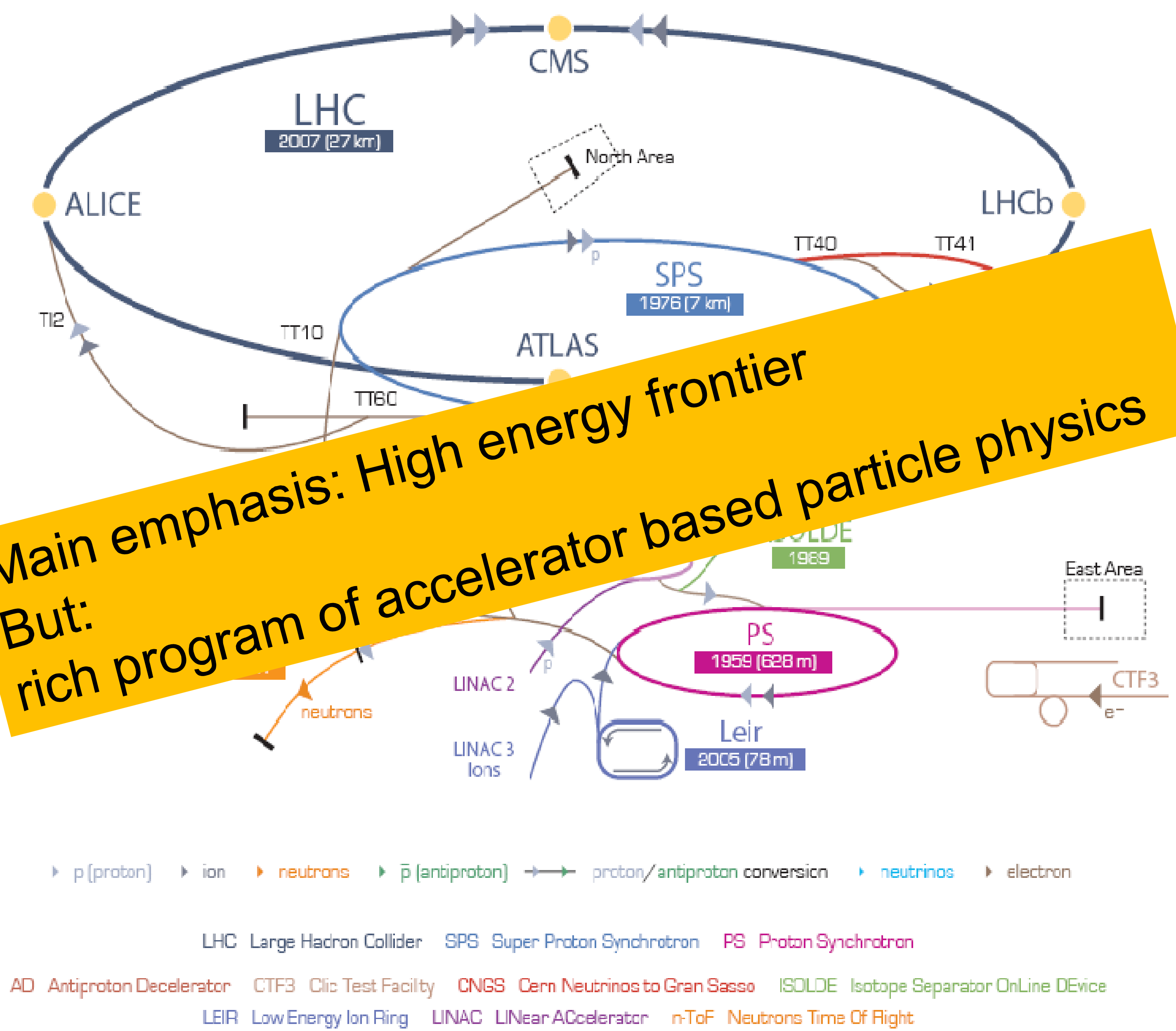
number of space/time dimensions

what is dark matter

what is dark energy




CERN
Accelerating Science and Innovation
Science
Particle Physics at CERN: Experiments and Theory
and
CERN and the European Strategy for Particle Physics



Main emphasis: High energy frontier

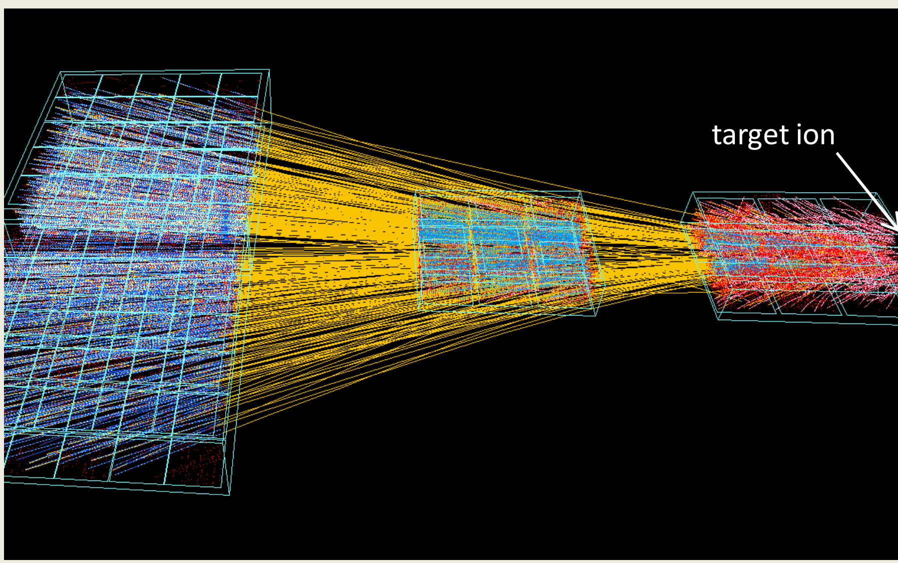
But:

rich program of accelerator based particle physics

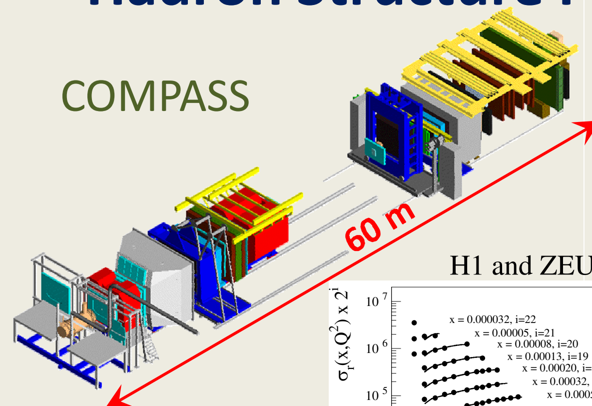
Fixed Target Physics

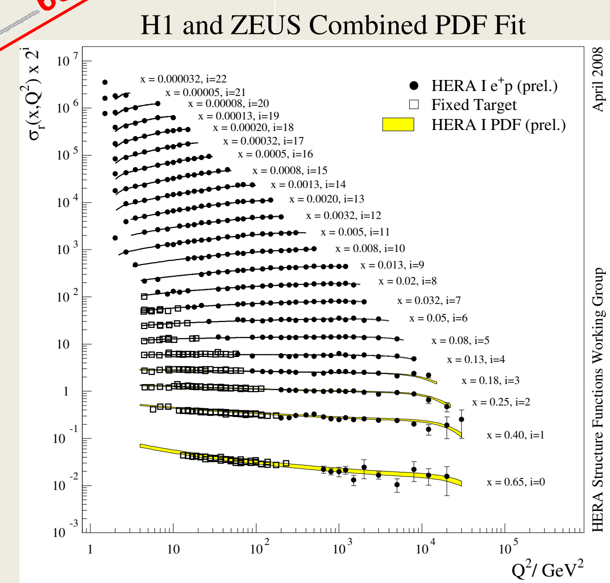
Heavy-ion Physics

- Heavy ion fixed-target physics
  - study of matter at extreme energy density
  - search for state of quasi-free partons
    quarks and gluons → quark-gluon plasma (QGP) **?**



Hadron Structure Physics





- spin structure of nucleon (w/ μ beam)
- uds + g QCD spectroscopy (w/ hadron beam)

Fixed Target Physics

Antiproton Physics

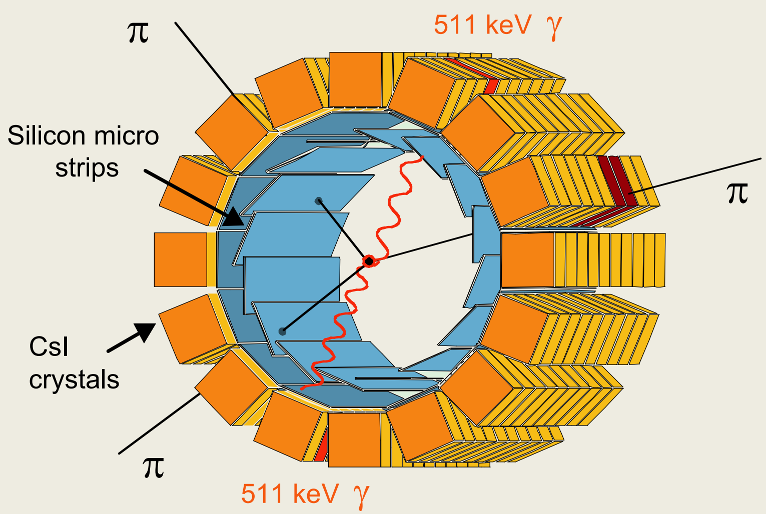
Cold antiprotons
("manufacturing anti-matter")

1. PS $p \rightarrow pp$ 10^{-6}/collision
2. AD deceleration + cooling
   stochastic + electron
3. Extraction @ ~ 0.1*c*
4. Produce thousands of *anti-H*

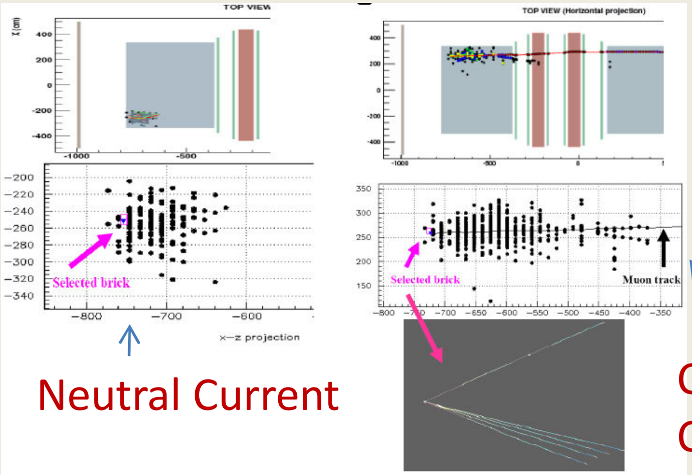
Anti-H annihilations detected

ATHENA (→ ALPHA)

anti-H (pe^+) + matter → $\pi^+\pi^- + \gamma\gamma$



Neutrino Physics

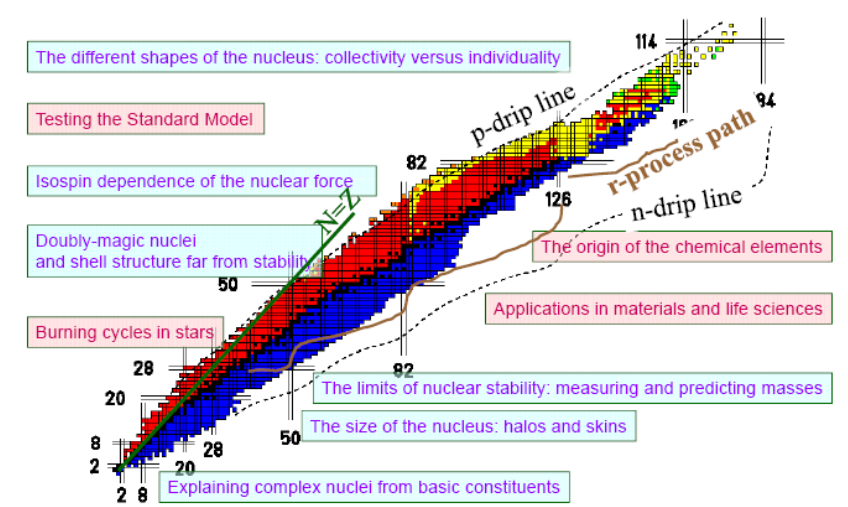


OPERA

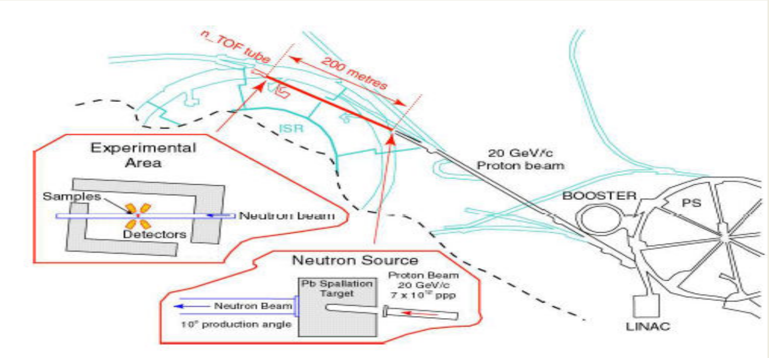
Charge Current

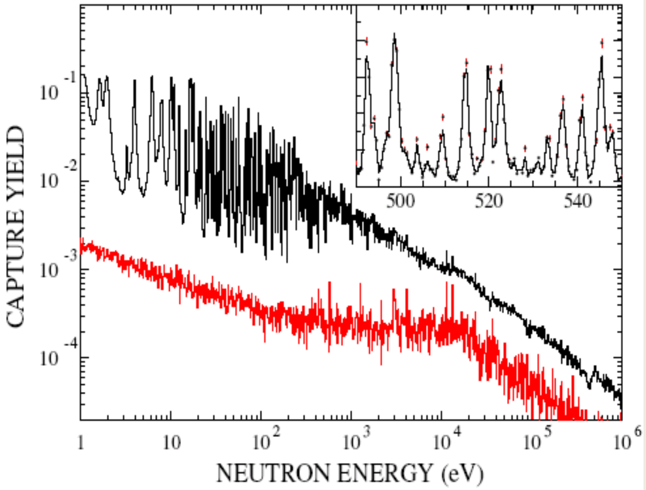
Fixed Target Physics

ISOLDE



nTOF





At thermal energy of kT=30 keV the Maxwellian averaged cross section of this 151Sm ($t_{1/2}$=93 yr) was determined to be 3100±160 mb, significantly larger than theoretical predictions. Nucleosynthesis in giant branch stars.

The European Strategy for particle physics

General issues

1. European particle physics is founded on strong national institutes, universities and laboratories and the CERN Organization; *Europe should maintain and strengthen its central position in particle physics.*

2. Increased globalization, concentration and scale of particle physics make a well coordinated strategy in Europe paramount; *this strategy will be defined and updated by CERN Council as outlined below.*

The European Strategy for particle physics

The process:

CERN Council Strategy Group established

Open Symposium (Orsay, Jan 31/Feb 1, 2006)

Final Workshop (Zeuthen, May 2006)

Strategy Document approved unanimously
by Council July 14, 2006

The European Strategy for particle physics

Unanimously approved by CERN Council July 14, 2006

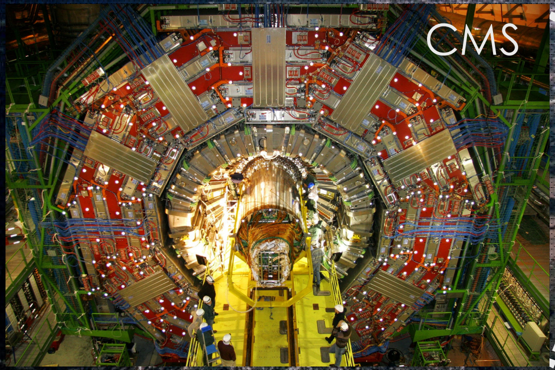
LHC

3. The LHC will be the energy frontier machine for the foreseeable future, maintaining European leadership in the field; *the highest priority is to fully exploit the physics potential of the LHC, resources for completion of the initial programme have to be secured such that machine and experiments can operate optimally at their design performance.* … luminosity upgrade (SLHC), motivated by physics results and operation experience, will be enabled by focussed R&D; *to this end, R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a luminosity upgrade by around 2015.*

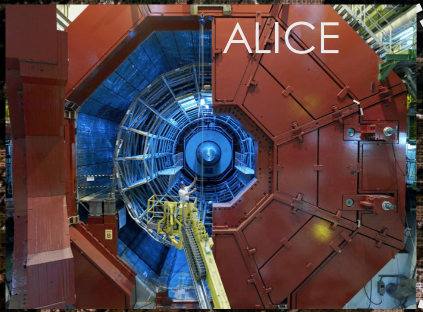
$L \sim 10^{34}$

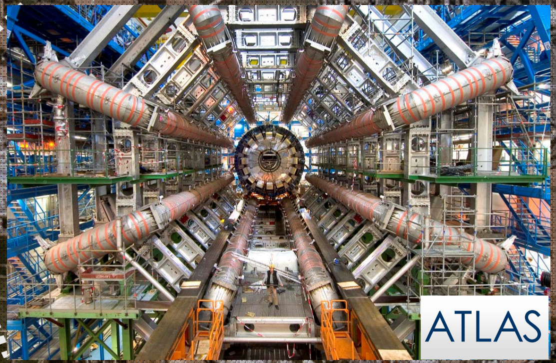
Enter a New Era in Fundamental Science

Start-up of the Large Hadron Collider (LHC), one of the largest and truly global scientific projects ever, is the most exciting turning point in particle physics.



Exploration of a new energy frontier
Proton-proton collisions at E_{CM} = 14 TeV





Large Hadron Collider (LHC)

A few characteristics:

The LHC features 1232, 15 m long, 9 T, superconducting dipoles
The tunnel is 27 km in circumference

protons can thus be accelerated to 7 TeV, allowing

14 TeV proton-proton collisions

in the centre-of-mass

The proton beams consist of compact bunches of 10^{11} protons each, 25 ns apart, leading to a collision rate normalized to the cross section of

Luminosity = 10^{34} $cm^{-2}s^{-1}$

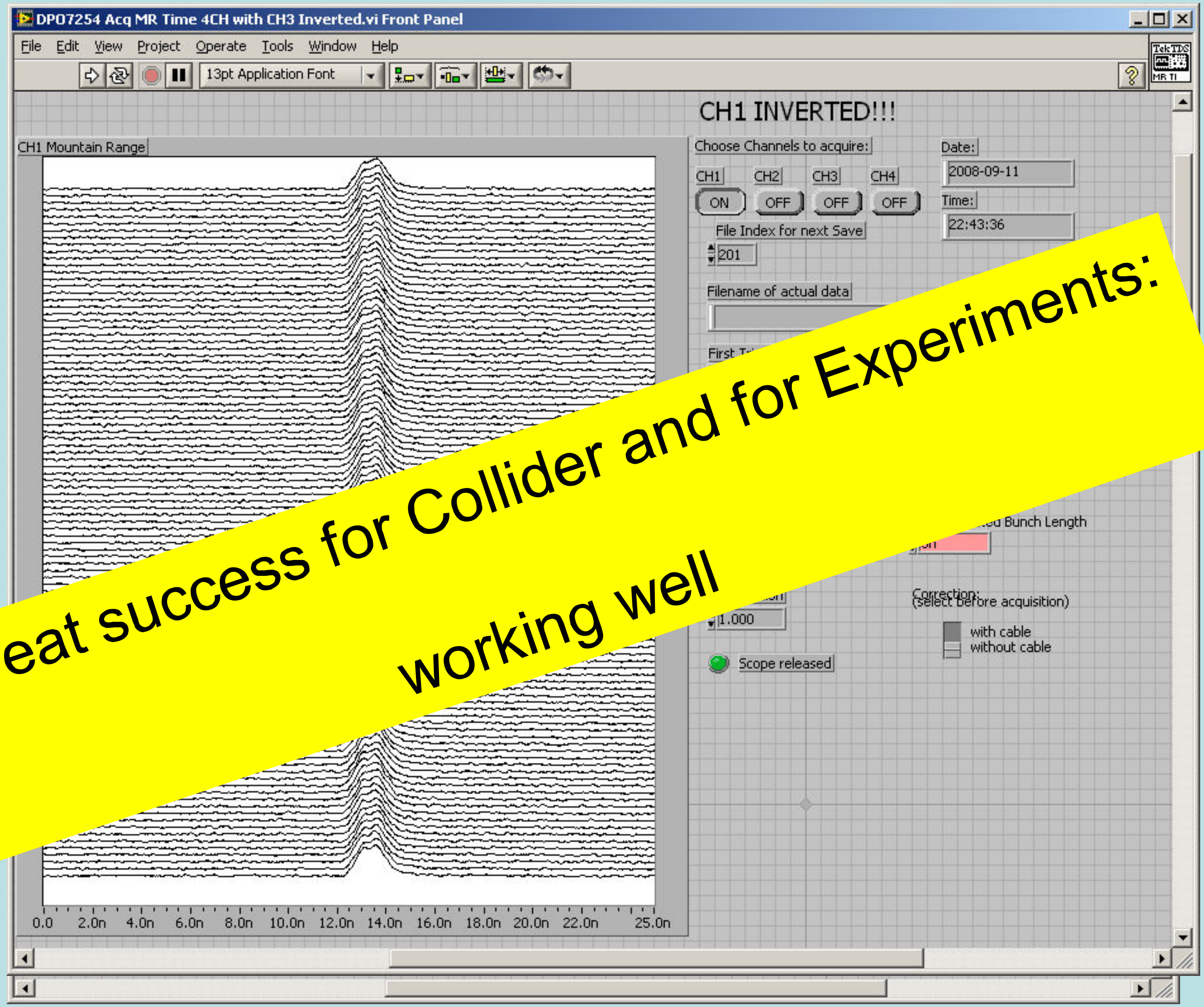
First beam around the ring Sept. 10, 2008

Incident Sept. 19, 2008

Inauguration October 21, 2008

Capture with optimum injection phasing, correct reference

September 10, 2008

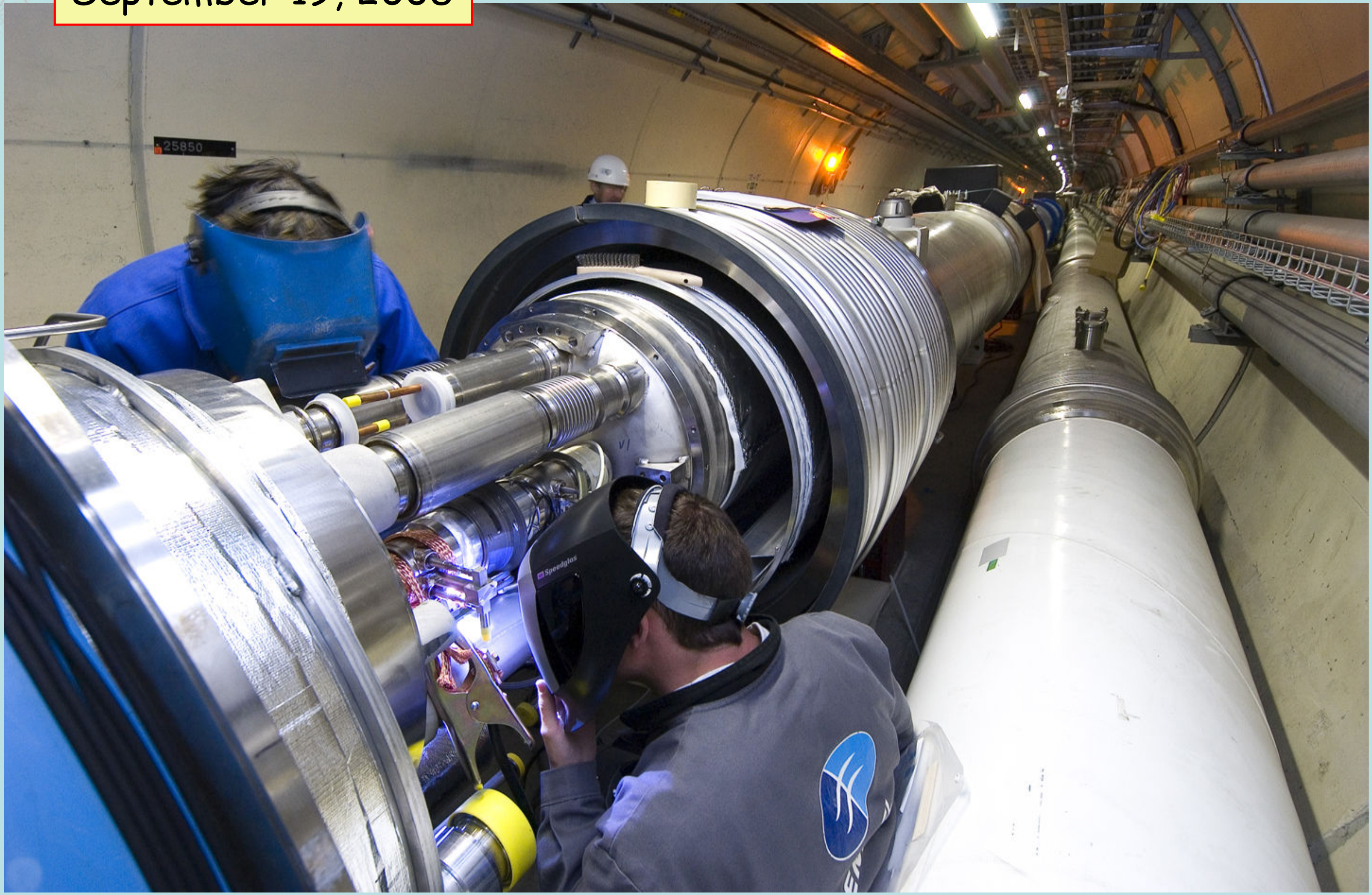


Great success for Collider and for Experiments: working well

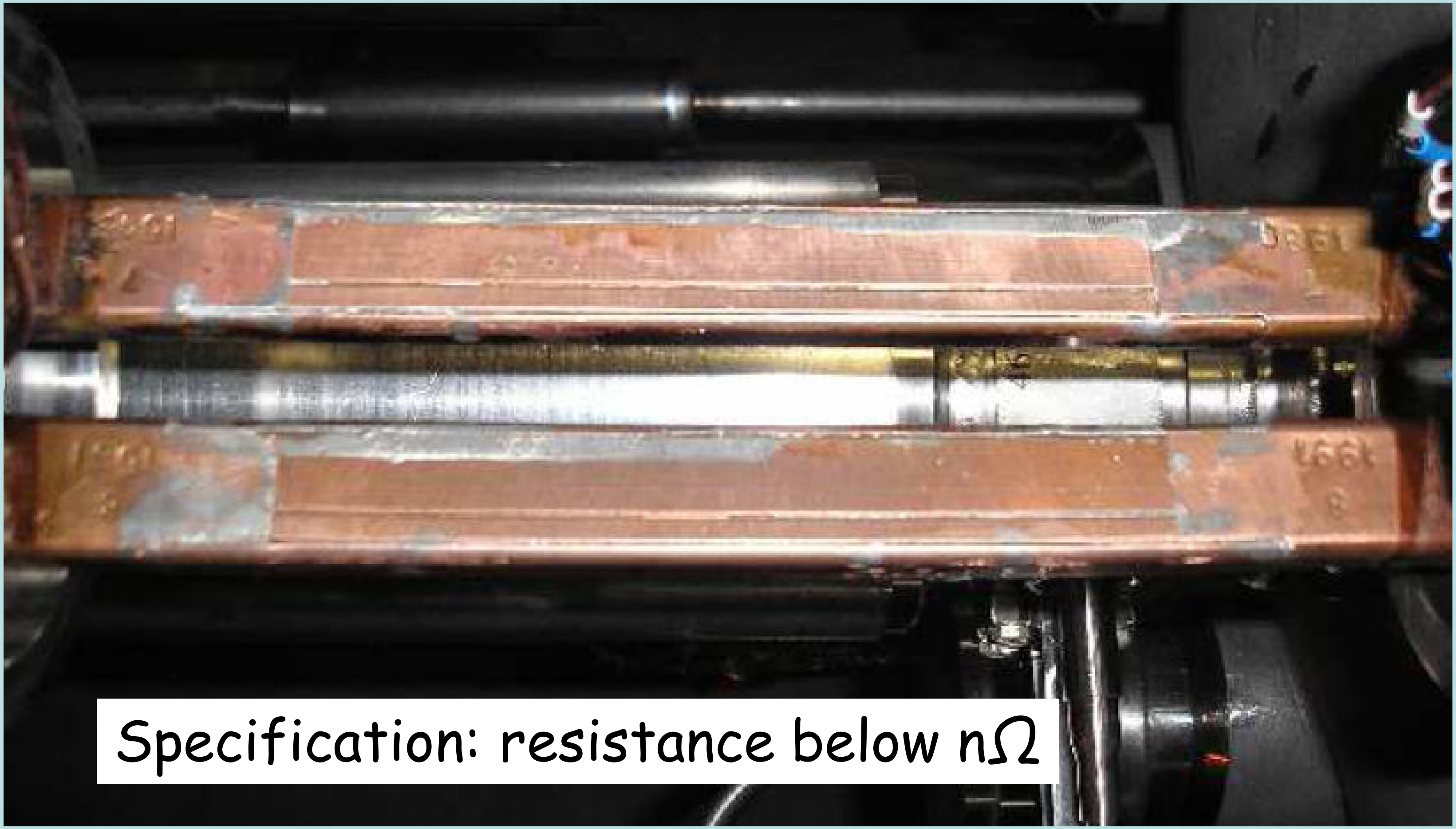
Courtesy E. Ciapala

Interconnects

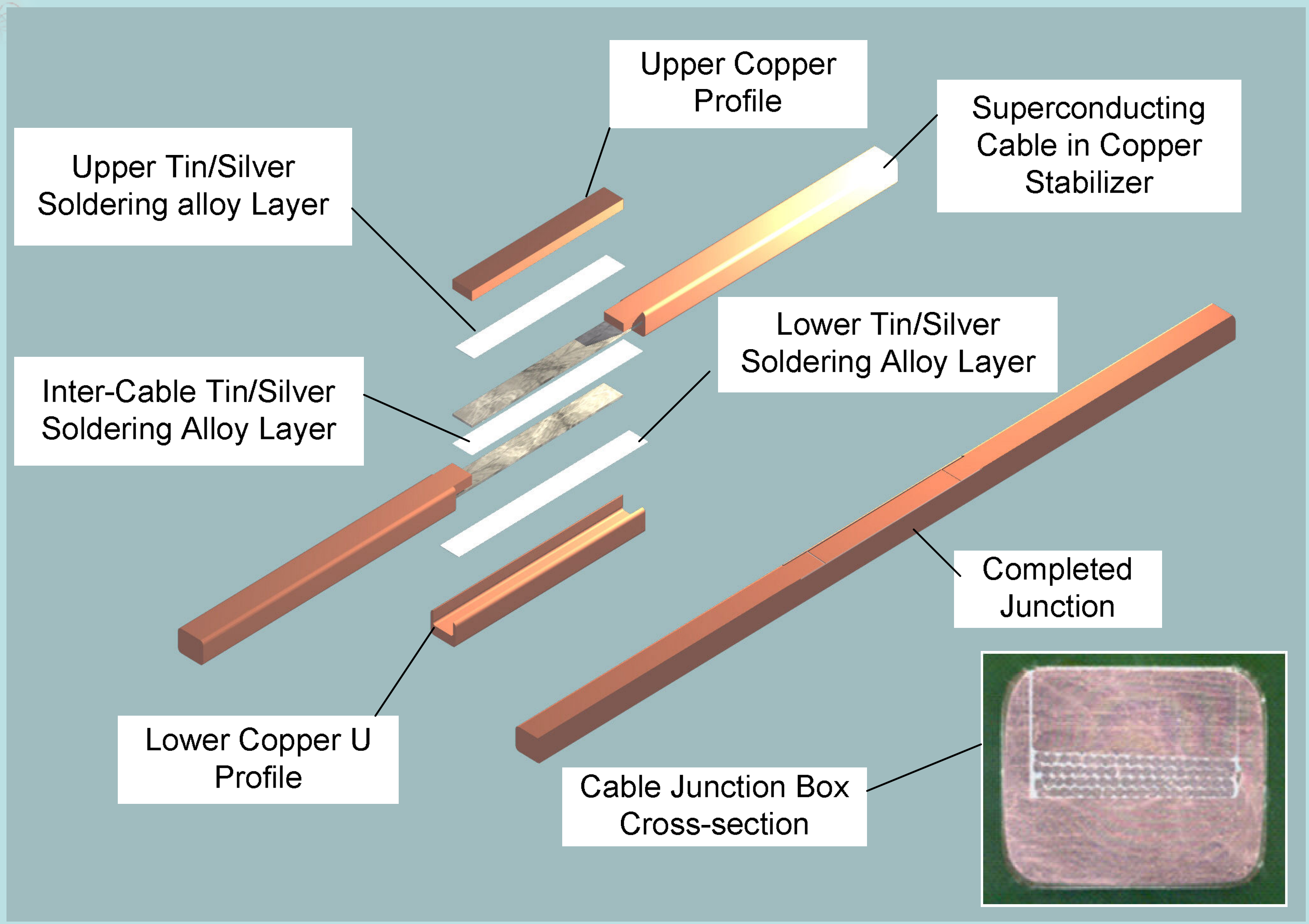
September 19, 2008



Busbar splice



Busbar splice



The Large Hadron Collider - Experiments

Two 'general purpose' 4π detectors for pp collisions at high L; some capabilities for PbPb
ATLAS and CMS

$$\int_0^{2\pi} d\phi \int_{-1}^{1} d\cos\theta = 4\pi$$

One dedicated PbPb detector with some capabilities for pp
ALICE

One dedicated detector for studying B mesons (CP violation; rare decays), produced in the forward (backward) hemisphere
LHCb

$$gg \rightarrow b\bar{b}$$

Precision (1%) measurement of total cross section (and more) TOTEM
Study of forward π^0 production LHCf

Experimental Challenge

High Interaction Rate: $N = L\sigma = 10^{34} \times 100 \times 10^{-27}$

pp interaction rate 10^9 interactions/s
data for only ~100 out of the 40 million crossings can be recorded per sec (100 – 150 MB/sec)
need fast, pipelined, intelligent electronics and sophisticated data-acquisition

High Energy and Large Particle Multiplicity

~ <20> superposed events in each crossing
~ 1000 tracks stream into the detector every 25 ns
need highly granular detectors with good time resolution for low occupancy
large detectors, a large number of channels

High Radiation Levels

radiation hard (tolerant) detectors and electronics

Physics Requirements

Follow from requirements to observe Higgs boson whether it is heavy or light, to observe Supersymmetry if it is there (missing energy), to find other new physics if it is there; all this in the presence of a huge background of standard processes (QCD)

Very good muon identification and momentum measurement

trigger efficiently and measure charge of a few TeV muons

High energy resolution electromagnetic calorimetry

~ 0.5% @ E_T~50 GeV

Powerful inner tracking systems

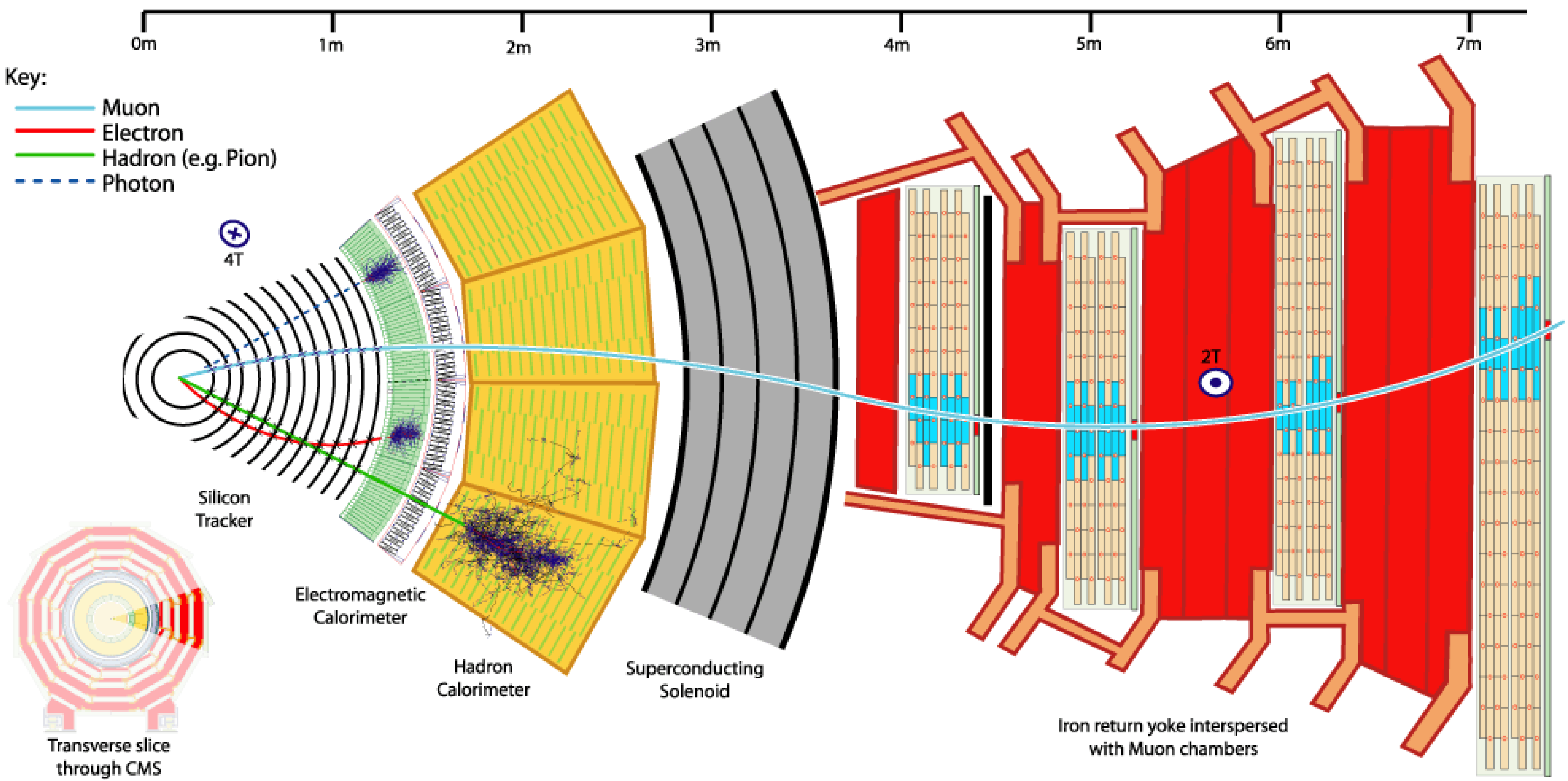
factor 10 better momentum resolution than at LEP

Hermetic calorimetry

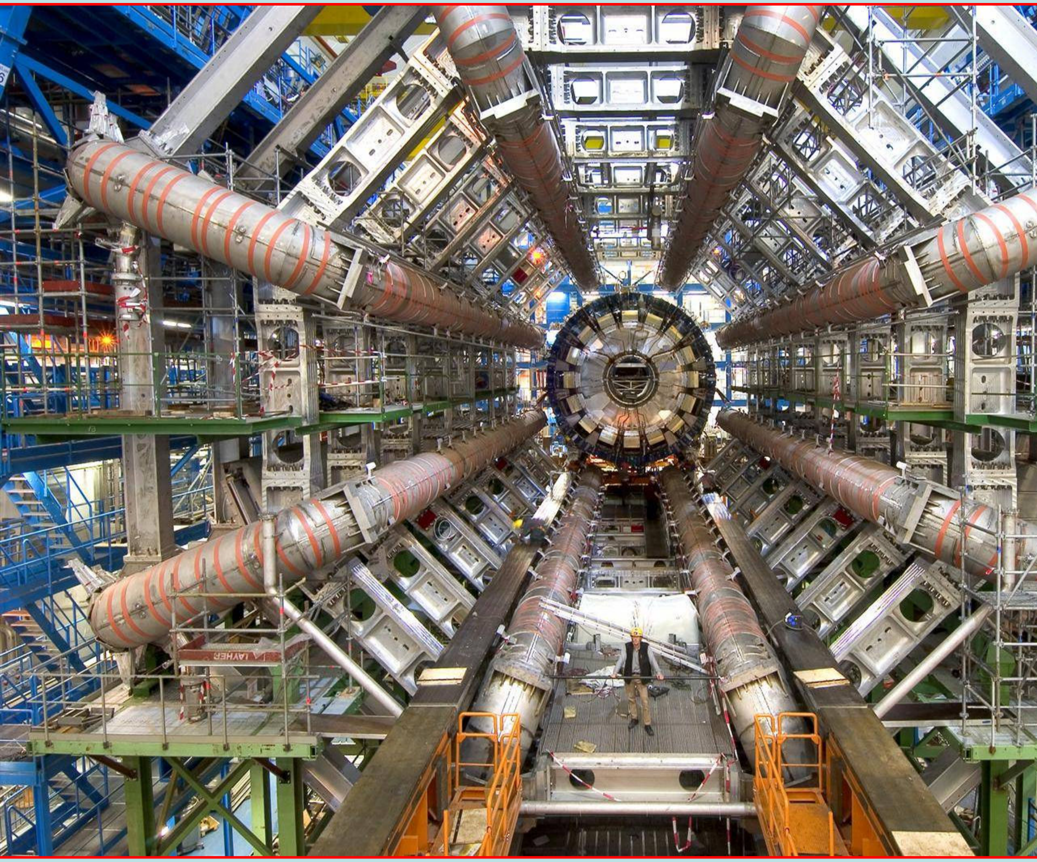
good missing E_T resolution

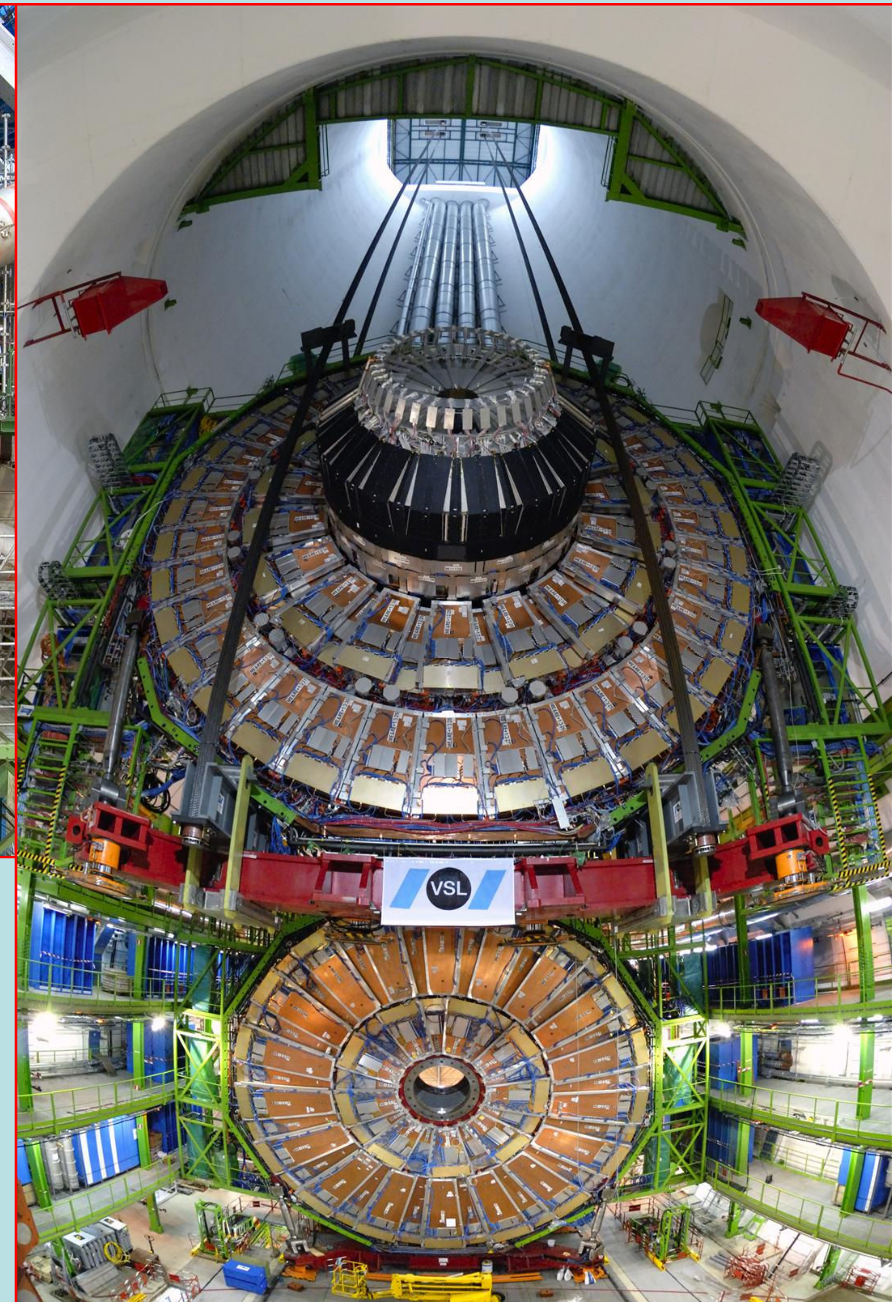
(Affordable detector)

‘Generic’ experimental set-up



Deflection ~ BL^2/p → need high B (s.c.) and large magnets; need high resolution position measurements (10 -100μ) at large p; also energy and position measurement through total absorption (photon, electron, hadron)




VSL

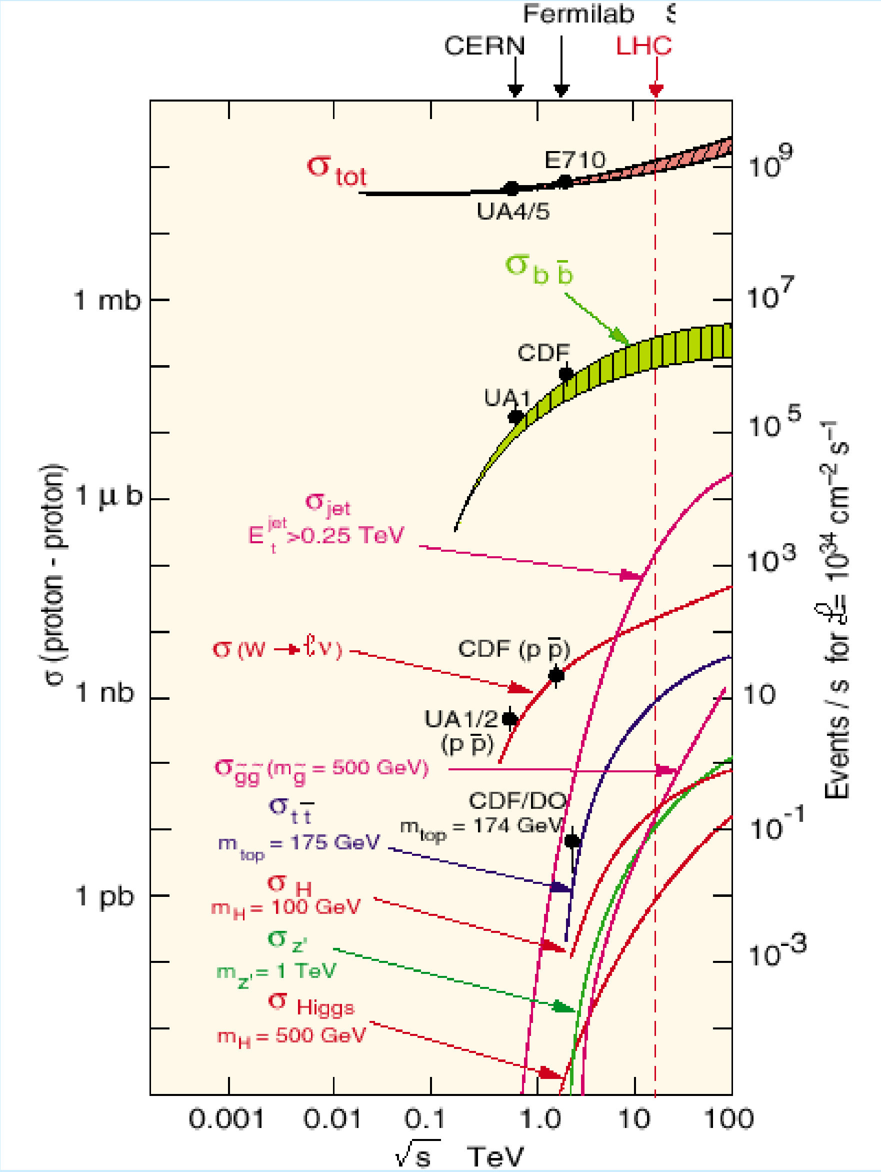
Selectivity - physics

Cross sections for various physics processes vary over many orders of magnitude

- **Inelastic: 10^9 Hz**
- **W$\rightarrow$ l ν: 10^2 Hz**
- **t t production: 10 Hz**
- **Higgs (100 GeV/c^2): 0.1 Hz**
- **Higgs (600 GeV/c^2): 10^{-2} Hz**

Selection needed: 1:10^{10-11}

- **Before branching fractions...**

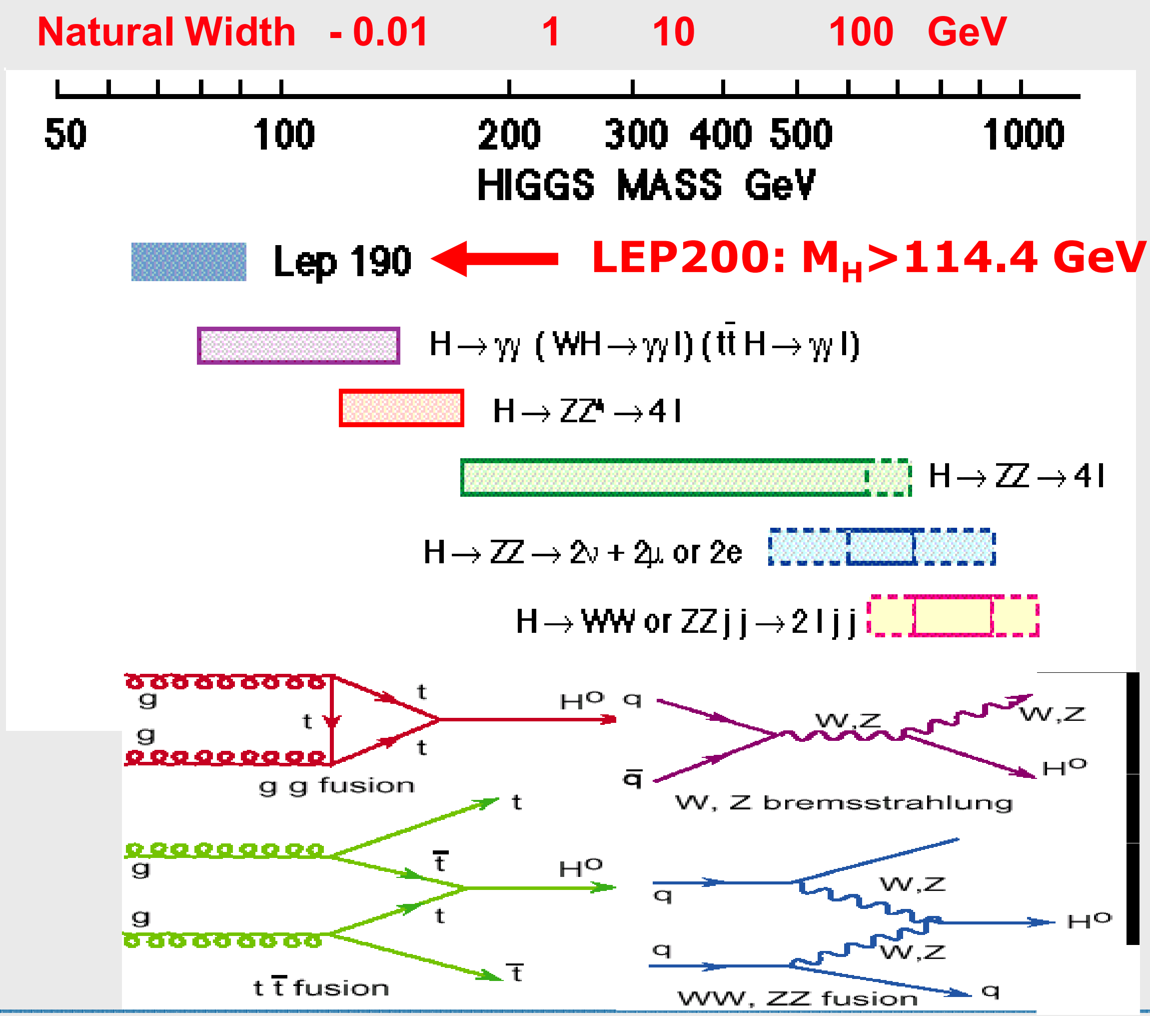


The GRID

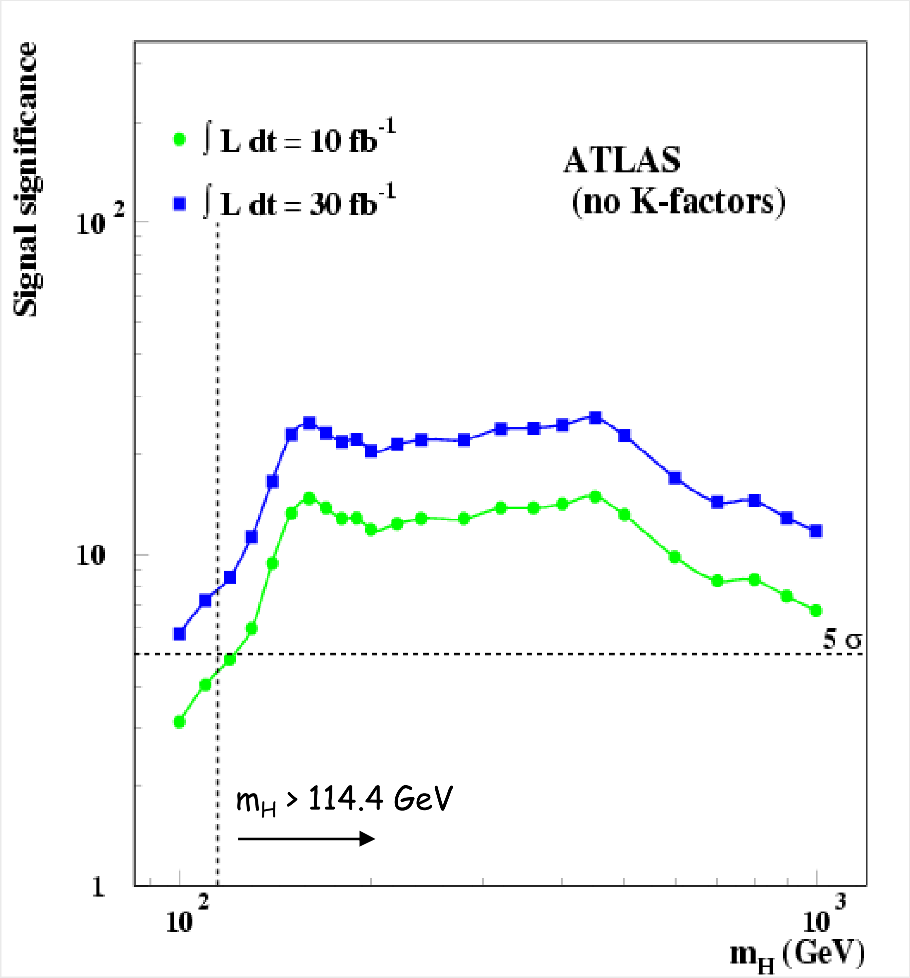
- CERN can only provide ~20% of the required computing capacity
- Therefore, the LHC relies on many computing centres around the world interconnected using Grid technology
- CERN leads two major global Grid projects:
  - WLCG: World-wide LHC Computing Grid Collaboration
  - EGEE: Enabling Grid for E-sciencE project for all sciences
- The LHC Computing Grid project launched a service with 12 sites in 2003. Today 200 sites in 40 countries with 20,000 PCs
- WLCG depends also on OSG and other Grid projects

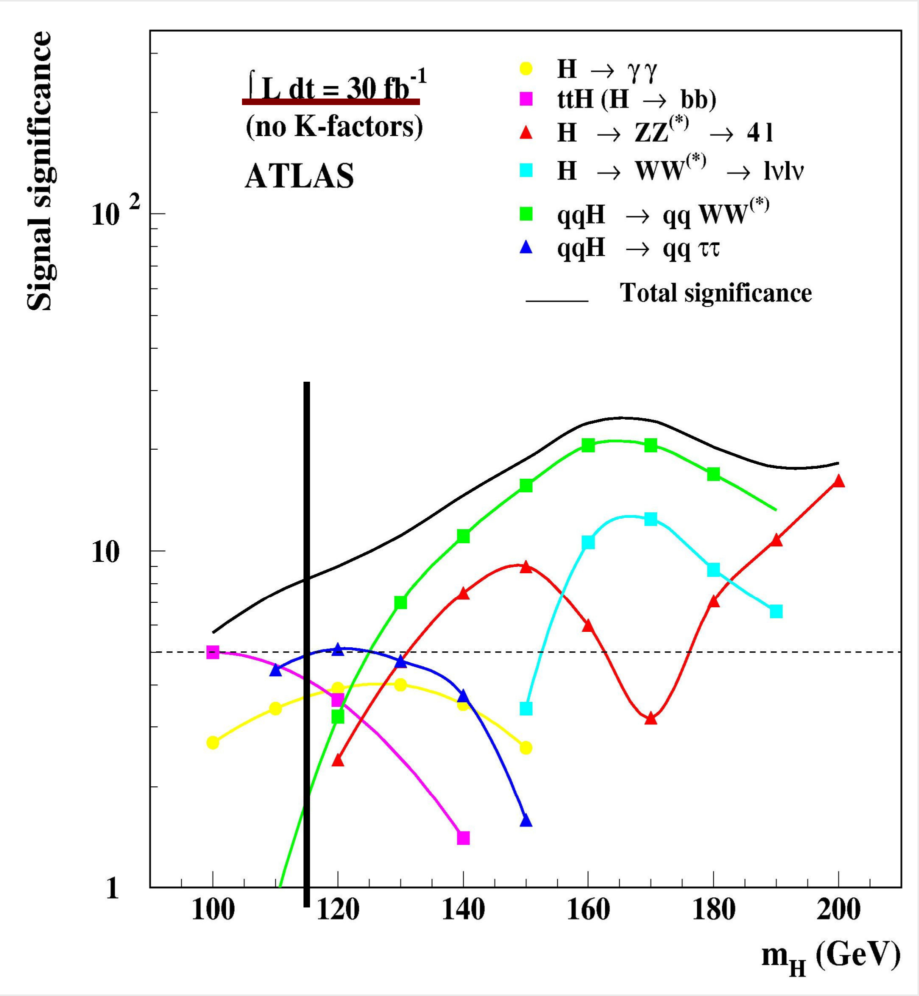
Physics Requirements

At the LHC the SM Higgs provides a good benchmark for the performance of a detector



Standard Model Higgs





Only with fully commissioned experiments we will be able to open the door to the new physics world!

1. Is there a Higgs?
2. What is the Higgs mass?
3. Is the Higgs a SM-like we
4. Is the Higgs elem
5. Is the stab ned by a symmetry or dyn
6. Is su effective at the weak scale?
7. Will w cover DM at the LHC?
8. Are there extra dimensions? Are there new strong forces?
9. Are there totally unexpected phenomena?
10. What is the mechanism of EW breaking?

Initial phase of LHC will tell which way nature wants us to go

Standard
Nearly Standard
Not at all Standard

Initial phase of LHC will tell which way nature wants us to go

Possible ways beyond initial LHC:

Luminosity upgrade (sLHC)

Doubling the energy (DLHC)
    new machine, R&D on high field magnets ongoing

Electron-Positron Collider
    ILC
    CLIC

Electron-Proton Collider
    LHeC

The European Strategy for particle physics

one possible way : luminosity upgrade

3. The LHC will be the energy frontier machine for the foreseeable future, maintaining European leadership in the field; *the highest priority is to fully exploit the physics potential of the LHC, resources for completion of the initial programme have to be secured such that machine and experiments can operate optimally at their design performance.* A subsequent major luminosity upgrade (SLHC), motivated by physics results and operation experience, will be enabled by focussed R&D; *to this end, R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a luminosity upgrade by around 2015.*

sLHC

$L \sim 10^{35}$

CERN 2008 – 2011: 240 MSFr additional funding

will partly be used to gradually increase performance of LHC, i.e. towards luminosity upgrade ($L \sim 10^{35}$) sLHC :

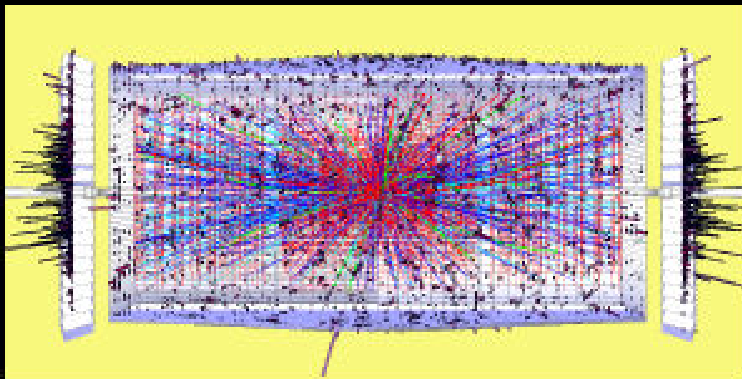
- New inner triplet -> towards $L \sim 2*10^{34}$
- New Linac (Linac4) -> towards $L \sim 5*10^{34}$
  construction can/will start now → ~ 2012/13

- New PS (PS2 with double circumference)
- Superconducting Proton Linac (SPL)
  start ***design*** now, ready for decision ~ 2011/12
  aimed for $L \sim 10^{35}$ around 2016/17 if physics requires

- Detector R&D (seed money)

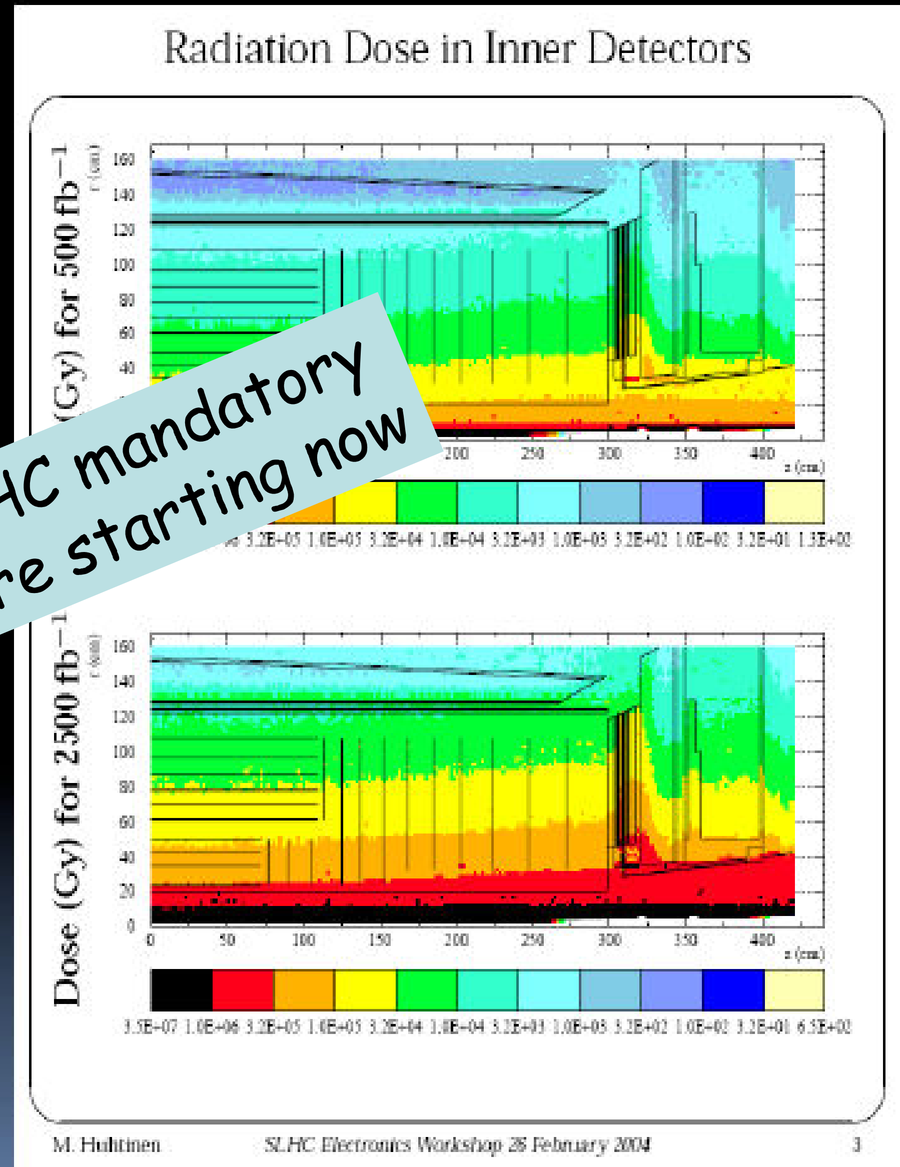
Important: international collaboration

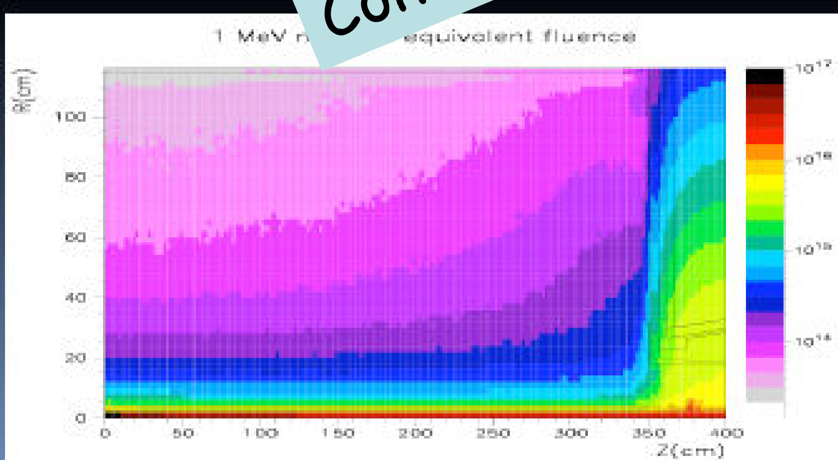
What are the conditions at SLHC?



- 300 – 400 pile-up events at start of spill (unless luminosity leveling)
- Want to survive at least 3000 fb-1 dat
- B-layer at 37 mm:
  - ~30 tracks per
  - >10^16 1 onising
  - Few 10^5

Detector R&D for sLHC mandatory
Concerted efforts are starting now





The European Strategy for particle physics

4. In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; *a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

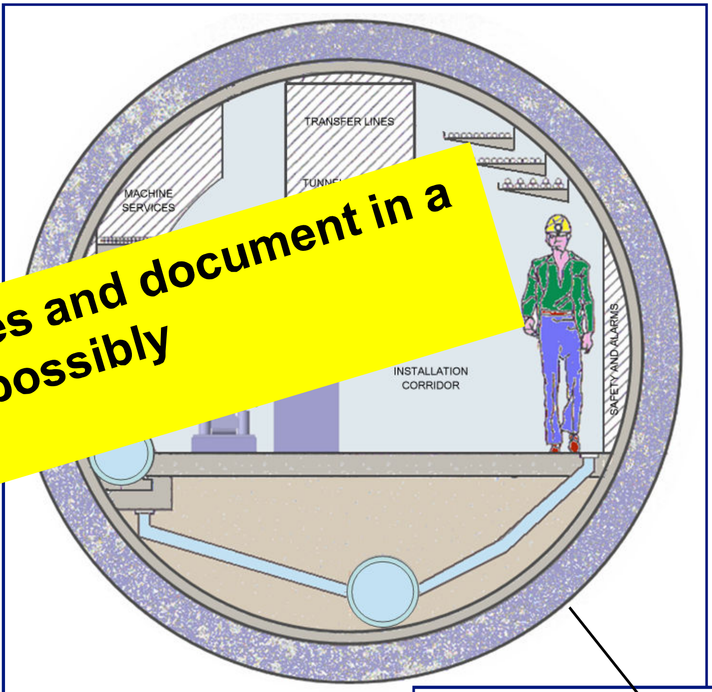
5. It is fundamental to complement the results of the LHC with measurements at a linear collider. In the energy range of 0.5 to 1 TeV, the ILC, based on superconducting technology, will provide a unique scientific opportunity at the precision frontier; *there should be a strong well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.*

High Energy Colliders: CLIC (E_{cm} up to ~ 3TeV)

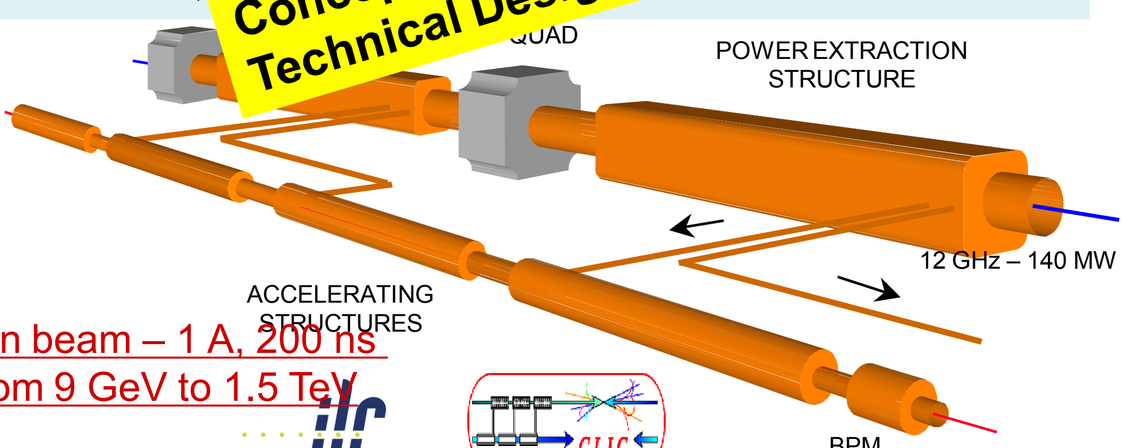
- **High acceleration gradient: ~ 100 MV/m**
  - "Compact" collider – total length < 50 km at 3 TeV
  - Normal conducting acceleration structures at high frequency
- **Novel Two-Beam Acceleration Scheme**
  - Cost effective, reliable, efficient
  - Simple tunnel, no activ...
  - Modular, easy e... stages

Aim: Demonstrate all key feasibility issues and document in a Conceptual Design Report by 2010 and possibly Technical Design Report by 2015 + ?

CLIC TUNNEL CROSS-SECTION



4.5 m diameter



Drive beam - 95 A, 300 ns from 2.4 GeV to 240 MeV

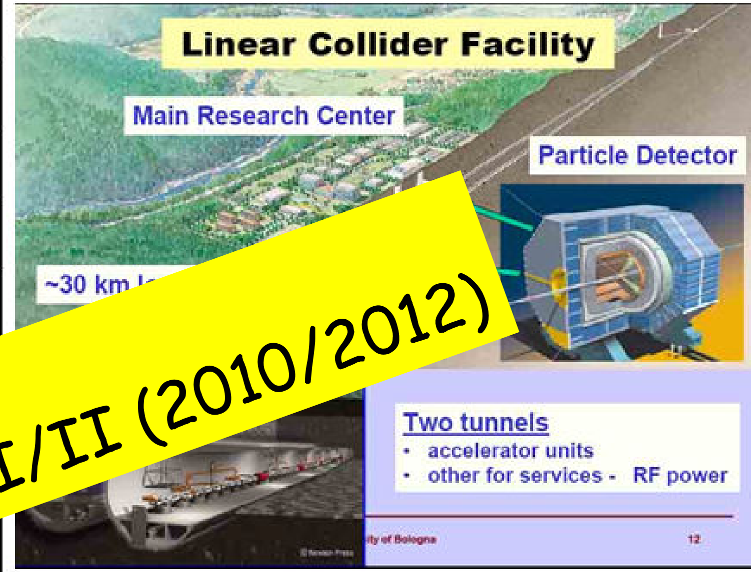
Main beam – 1 A, 200 ns from 9 GeV to 1.5 TeV

High Energy Colliders: ILC (E_{cm} up to ~ 1TeV)

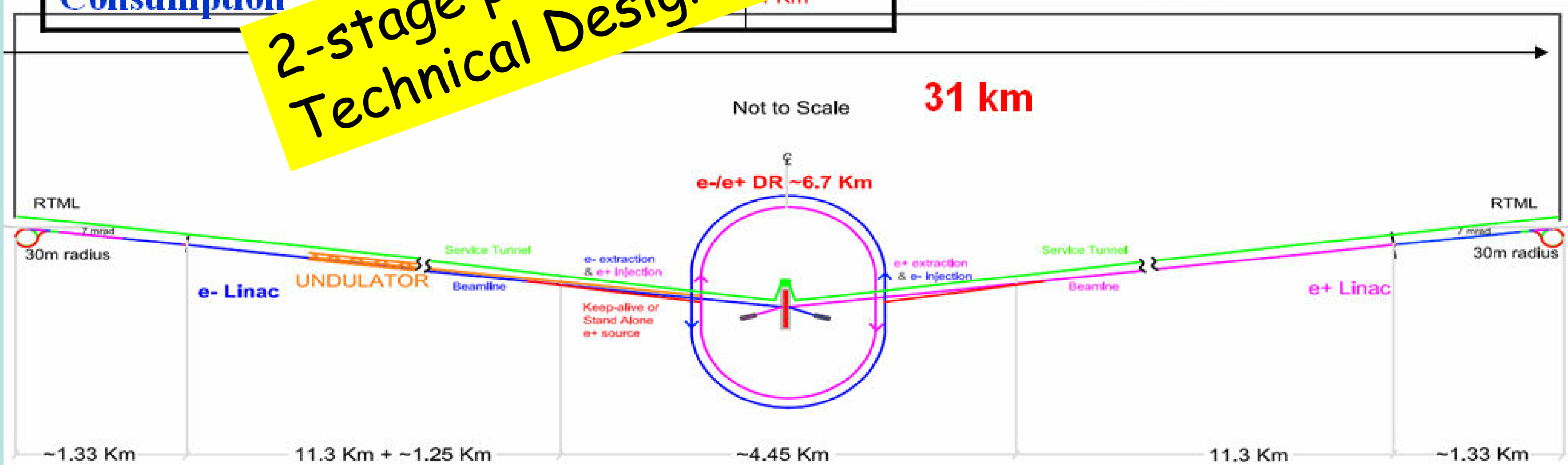
ILC @ 500 GeV

ILC web site: http://www.linearcollider.org/cms/

Max. Center-of-mass energy	500	GeV
Peak Luminosity	$\sim 2\times10^{34}$	$cm^{-2}s^{-1}$
Beam Current	9.0	mA
Repetition rate	5	Hz
Average accelerating gradient	31.5	MV/m
Beam pulse length	0.95	[illegible]
Total Site Length	[illegible]	[illegible]
Total AC Power Consumption	[illegible]	[illegible]

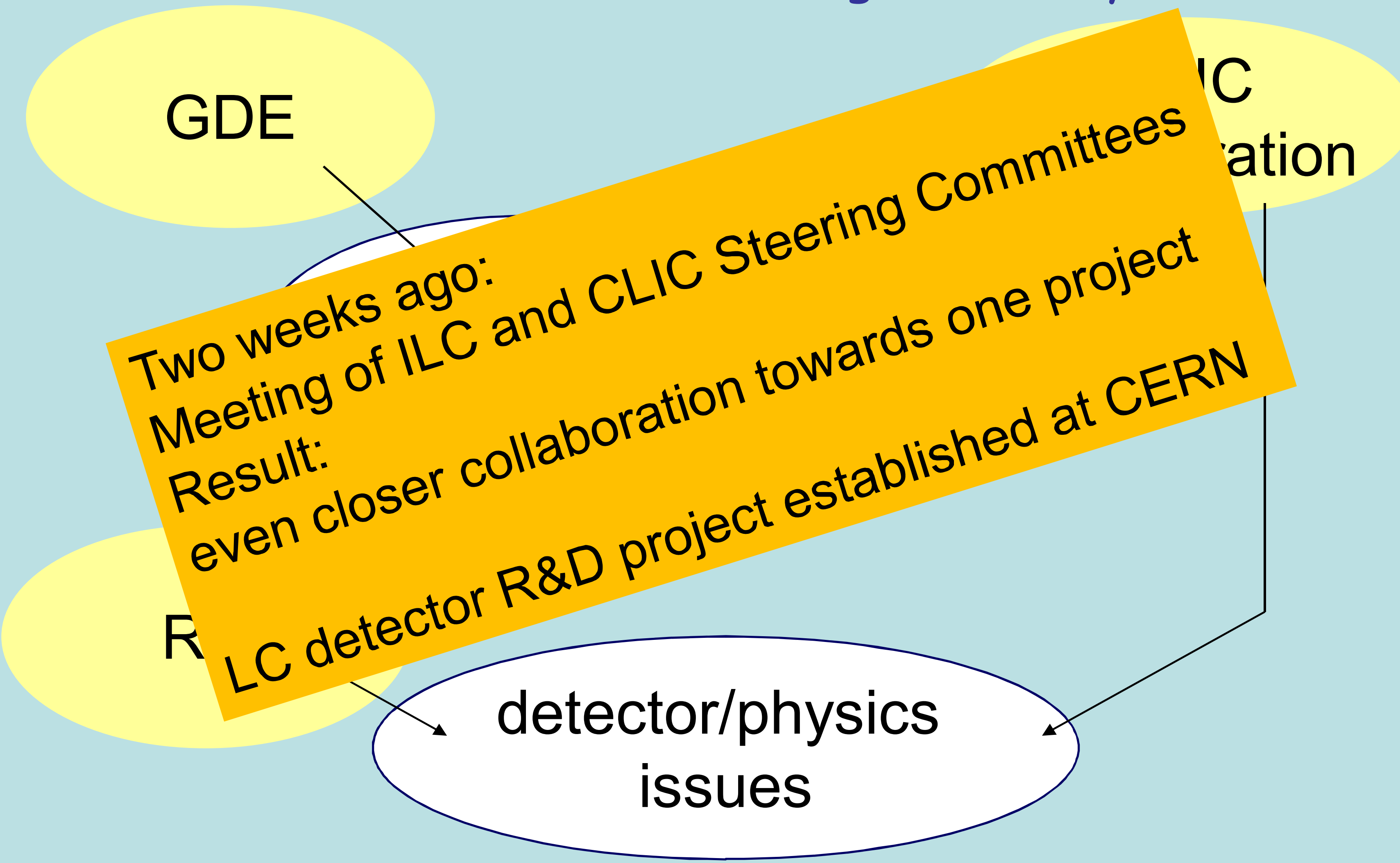


2-stage process
Technical Design Phase I/II (2010/2012)



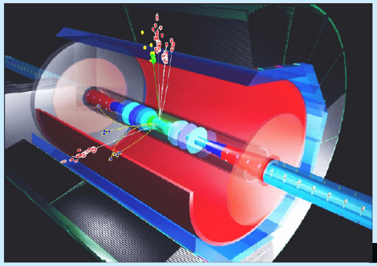
Strategy to address LC key issues

Recent progress: much closer collaboration
first meeting: February 08



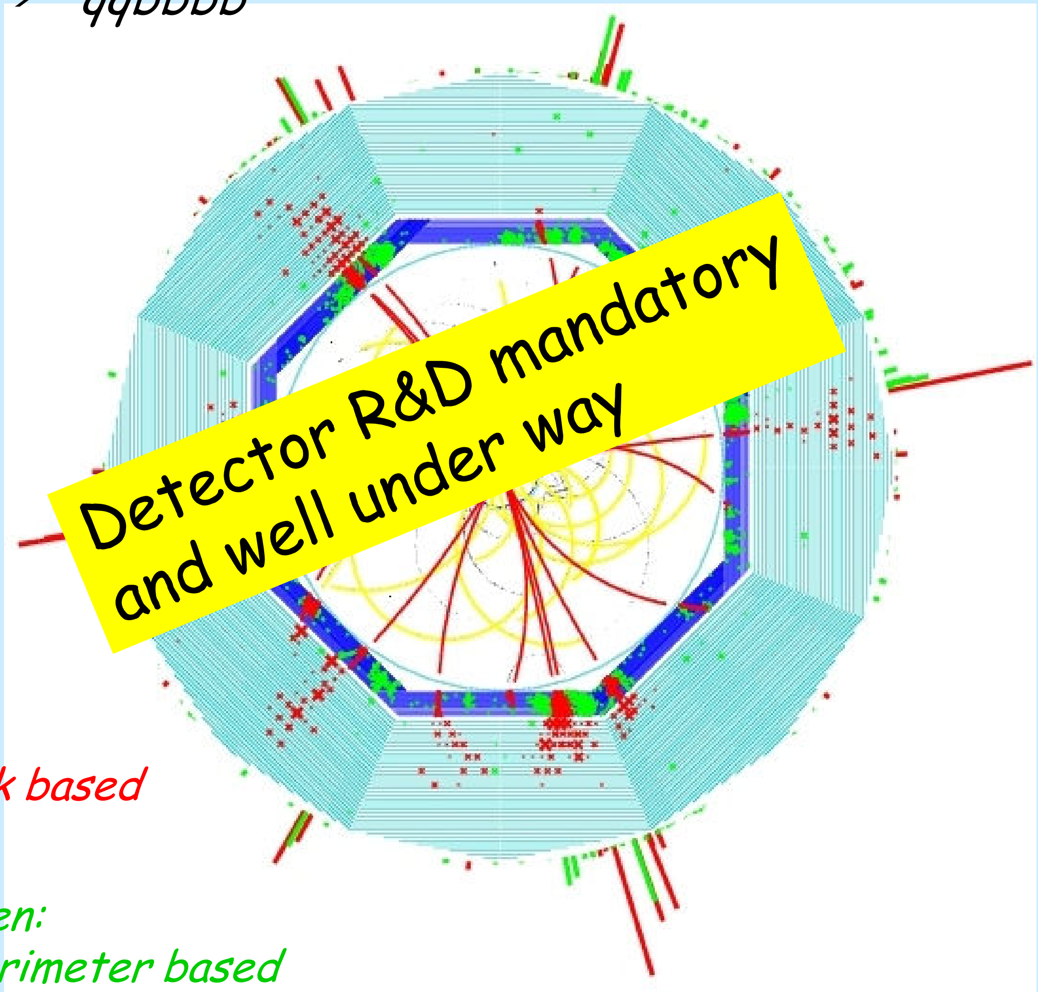
Two weeks ago:
Meeting of ILC and CLIC Steering Committees
Result:
even closer collaboration towards one project

LC detector R&D project established at CERN



LC Detector challenges: calorimeter

ZHH → qqbbbb



red: track based

green: calorimeter based

High precision measurements demand new approach to the reconstruction:

particle flow (i.e. reconstruction of ALL individual particles)

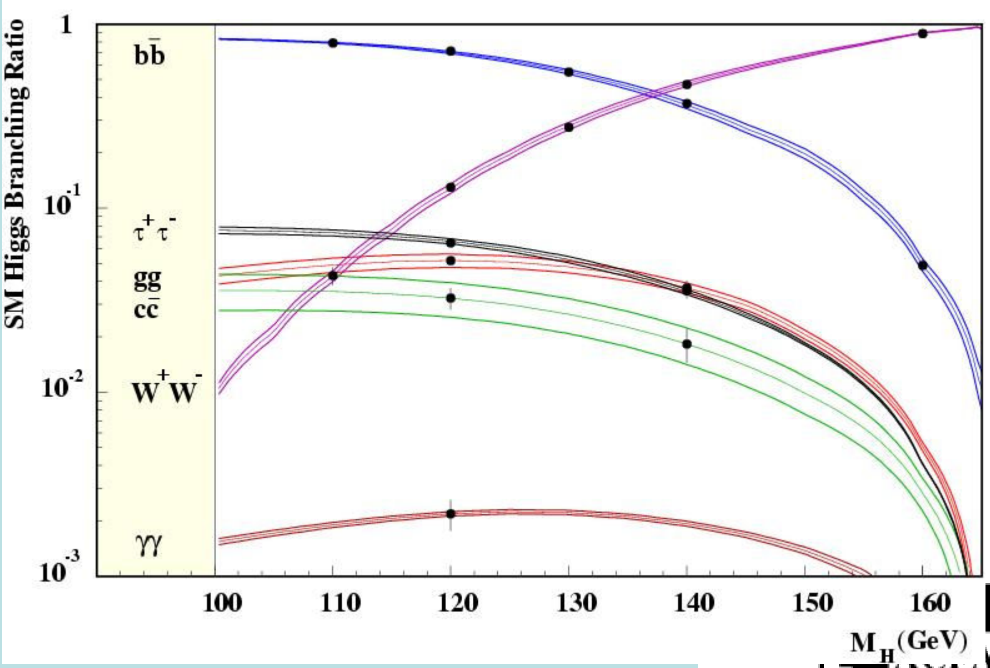
this requires

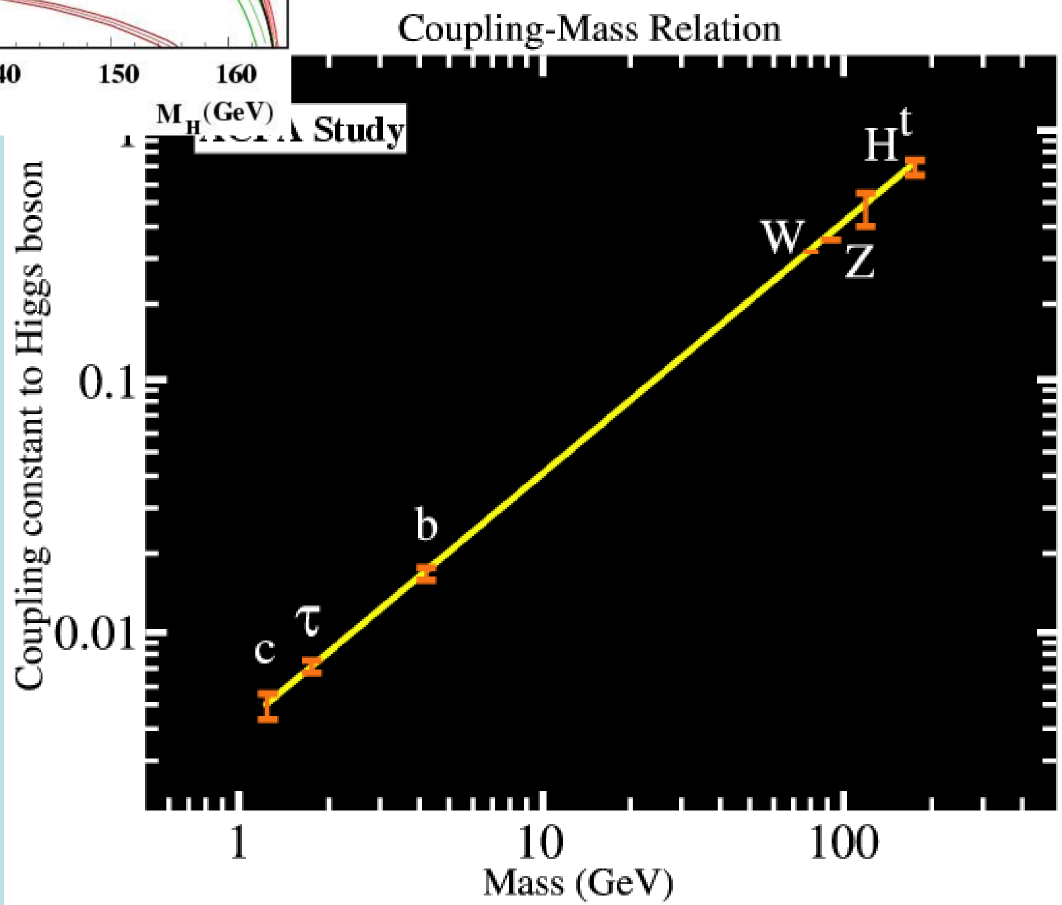
unprecedented granularity

in three dimensions

R&D needed now for key components

Precision Higgs physics

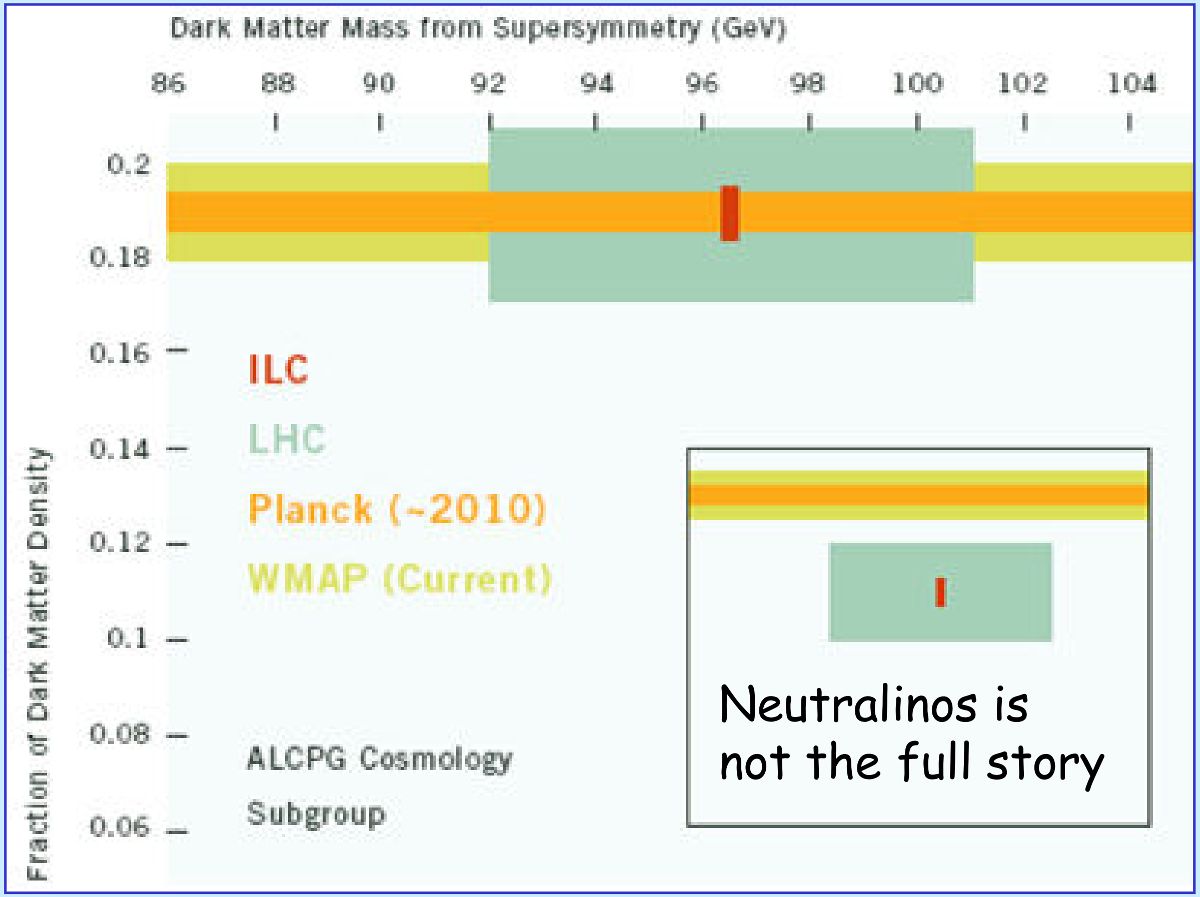




Determination of absolute coupling values with high precision

Dark Matter and SUSY

- Is dark matter linked to the Lightest Supersymmetric Particle?



LC and satellite data (WMAP and Planck):

complementary views of dark matter.

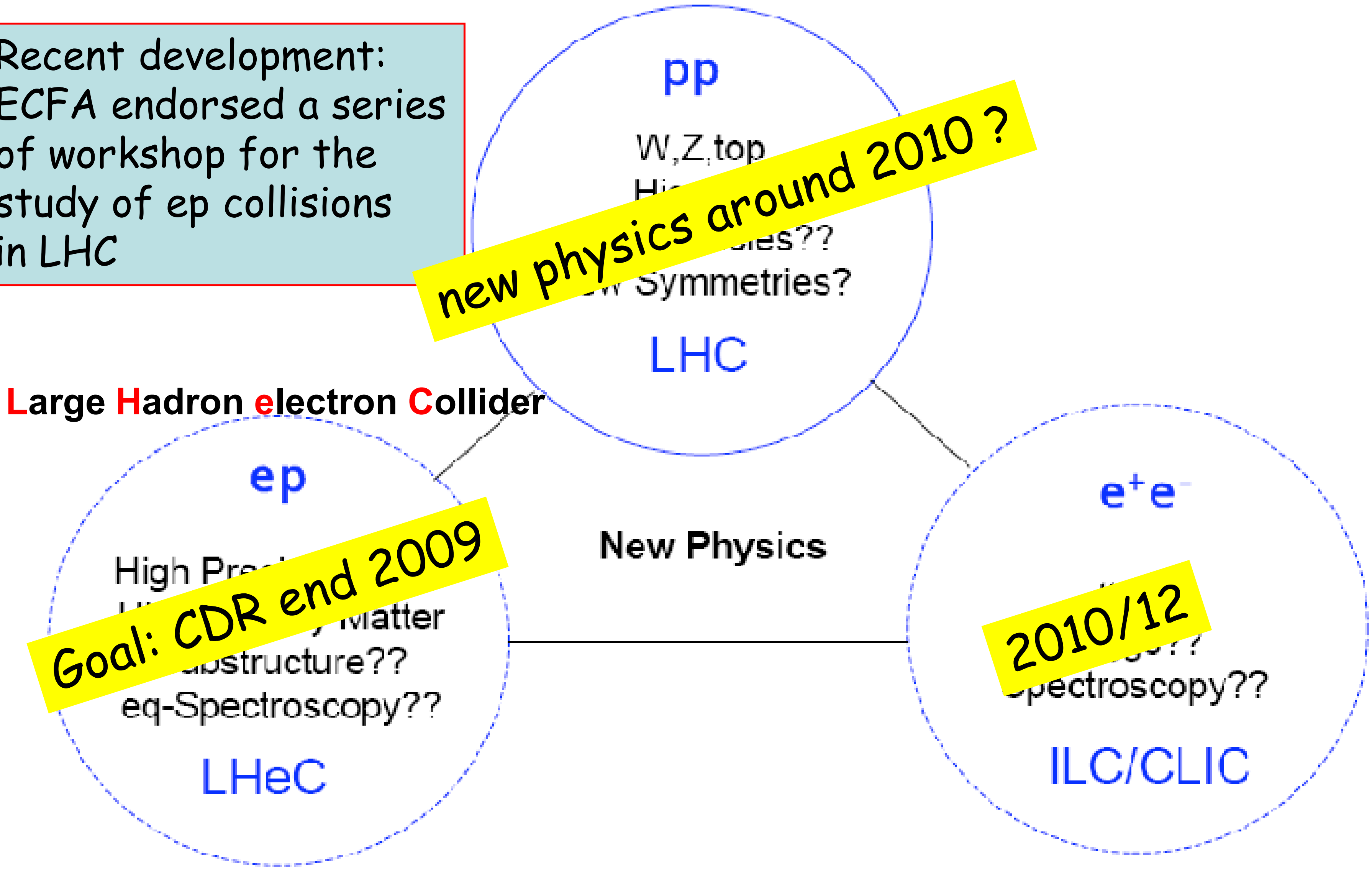
LC: identify DM particle, measures its mass;

WMAP/Planck: sensitive to total density of dark matter.

Together with LHC they establish the nature of dark matter.

The TeV Scale [2008-2033..]

Recent development:
ECFA endorsed a series of workshop for the study of ep collisions in LHC



IPMU

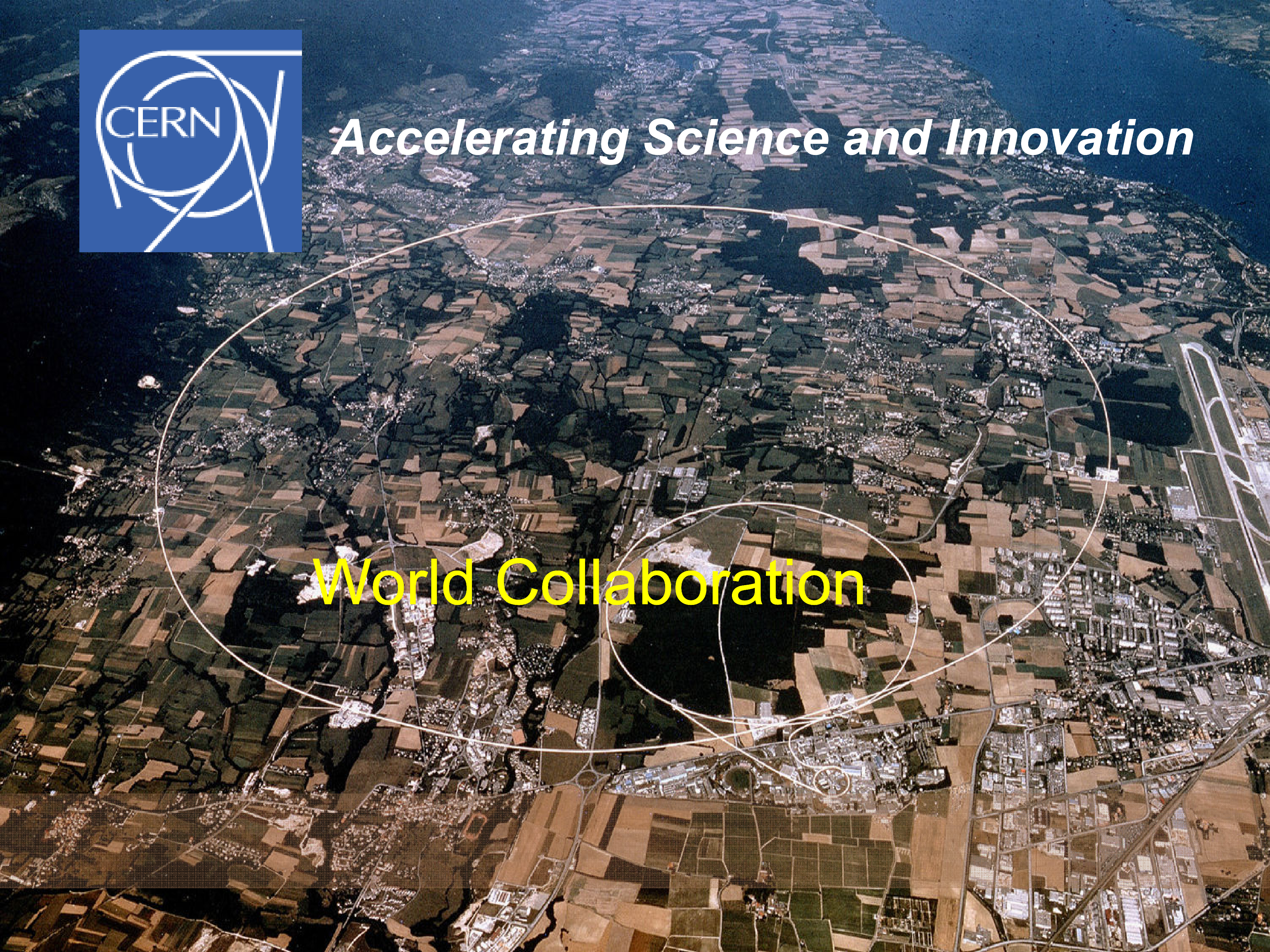
BERKELEY CENTER FOR THEORETICAL PHYSICS

Bottom line: Synergy

- *Big questions = ambitious questions*
- *Need to clear the cloud of T…*
  physics to obtai…
- *Ma… …e*
  to r…
- *Har… , but conceivable*
- *No single experiment would achieve it, need a broad program*

Great opportunities ahead

Window of opportunity for decision on the way forward 2010-2012 (?)


CERN
Accelerating Science and Innovation
World Collaboration

Cooperation works rather well world wide, so…any changes needed for the future?

facilities for HEP (and other sciences) becoming larger and expensive

funding not increasing

fewer facilities realisable

time scales becoming longer

laboratories are changing missions

→ more coordination and more collaboration required

Outlook: Enhancing World Collaboration

Key message

Future major facilities in Europe and elsewhere require collaborations on a global scale; *Council, drawing on the European experience in the successful construction and operation of large-scale facilities, will prepare a framework for Europe to engage with the other regions of the world with the goal of optimizing the particle physics output through the best shared use of resources while maintaining European capabilities.*

from CERN Council Strategy Document

We are NOW entering a new exciting era of particle physics

Turn on of LHC
allows particle physics experiments
at the highest collision energies ever

Expect
- revolutionary advances in understanding the microcosm
- changes to our view of the early Universe

CERN
unique position as host for the LHC

Results from LHC will guide the way

Expect

- period for decision taking on next steps in 2010 to 2012 (at least) concerning energy frontier
-(similar situation concerning neutrino sector Θ_{13})

We are NOW in a new exciting era of accelerator planning-design-construction-running

and need

- intensified efforts on R&D and technical design work to enable these decisions
- global collaboration and stability on long time scales (reminder: first workshop on LHC was 1984)

Particle Physics can and should play its role as spearhead in innovations as in the past

now and in future