

# CERN in the year 2000



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ICHEP 2000-OSAKA

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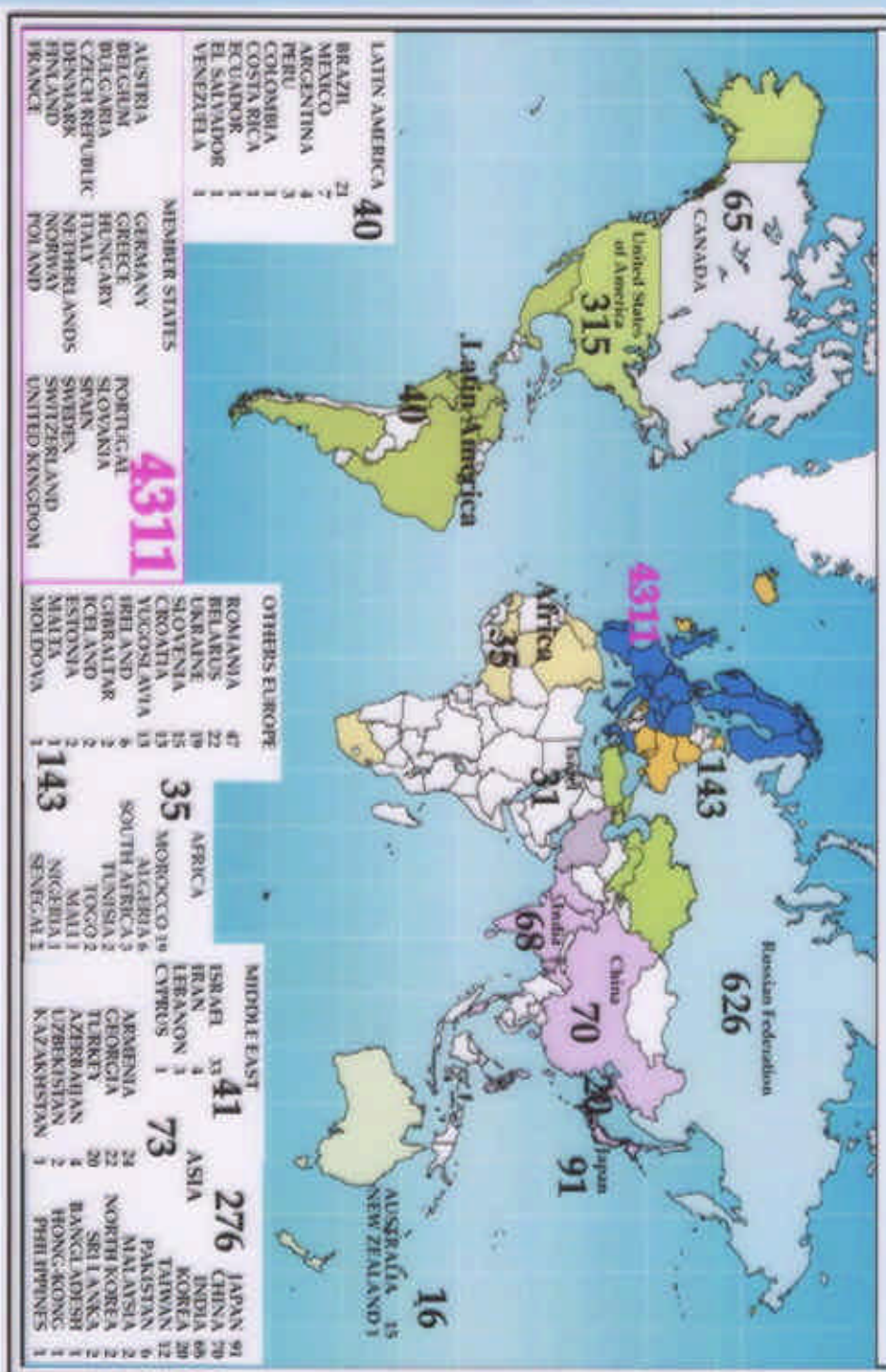
## After the successes of the Standard Theory...what remains?

- Electroweak Symmetry Breaking
- Neutrino masses
- CP violation
- Supersymmetry or Strongly Interacting Sector

### Summary

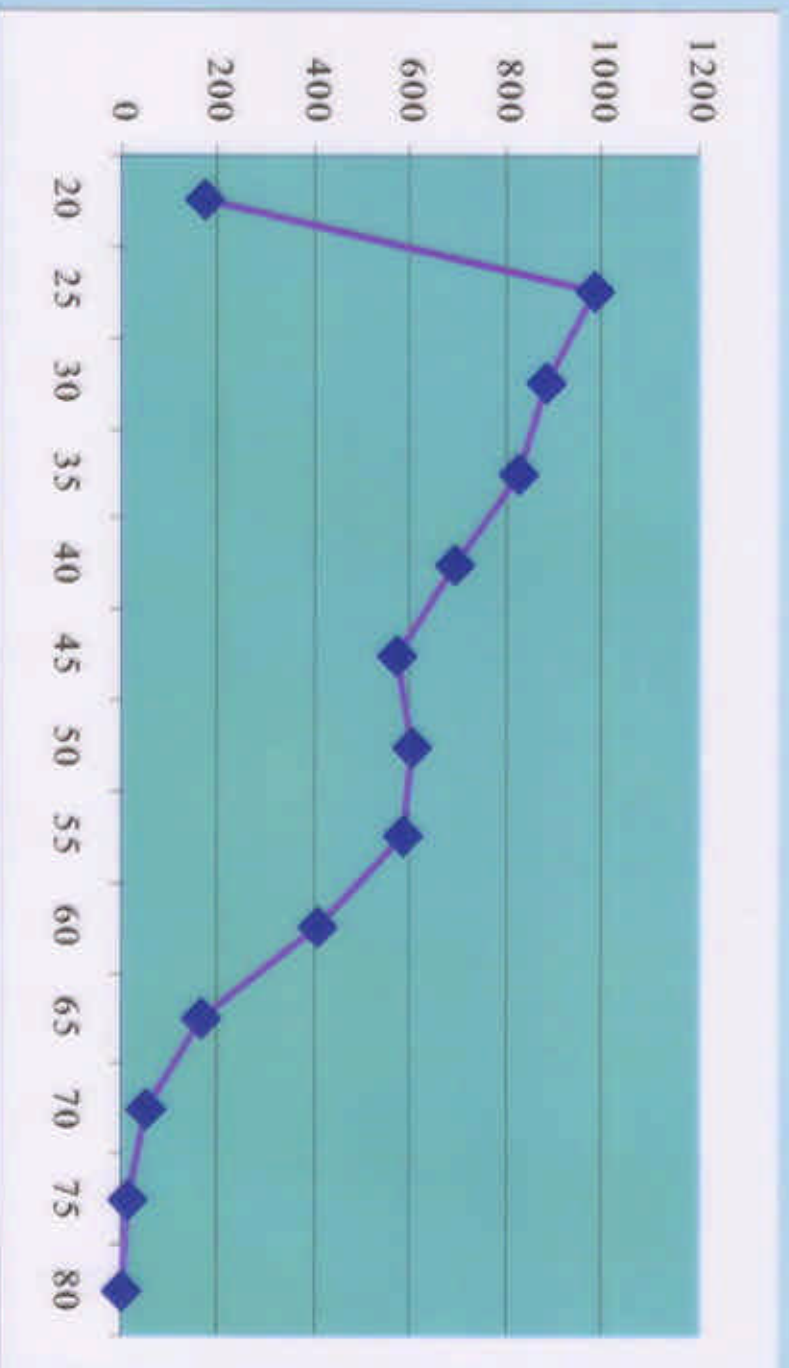
- LEP in year 2000
- The Large Hadron Collider (LHC)
- CERN experimental programme
- The LHC Computing challenge
- Japan @ CERN
- Preparing CLIC

# Nationality distribution of CERN Users (June 2000)

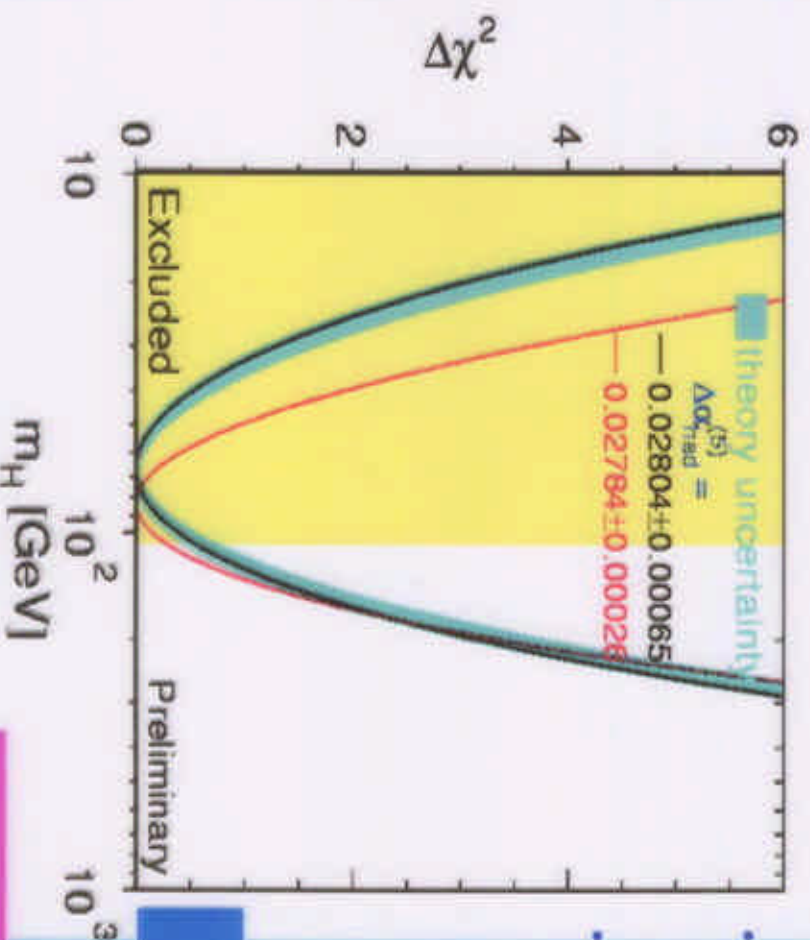




## Age distribution of CERN Users (June 2000)



# Precision Electroweak Measurements: $m_H$ prediction



- Includes all electroweak precision measurements;
- Constrained by **direct  $m_W$  and  $m_{top}$  determinations**;

$$m_H = (77^{+69}_{-39}) \text{ GeV}/c^2$$

**$m_H < 188 \text{ GeV}/c^2$  at 95% C.L.**

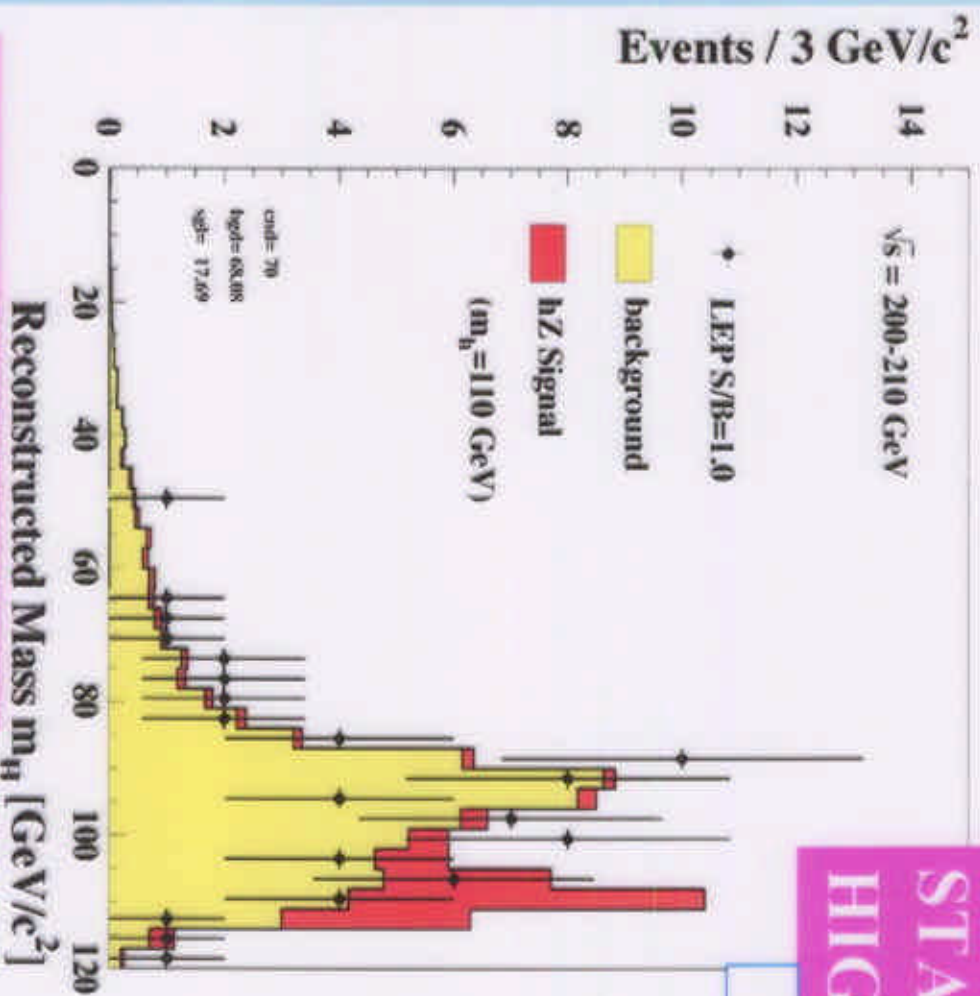
# LEP in Year 2000 STANDARD MODEL HIGGS BOSON

LEP-Higgs working group July 20, 2000

$$e^+ + e^- \rightarrow Z + \dots$$

(with b tag)

<u>Data</u>	70 events
<u>Bgd</u>	68.1 expected
<u>Signal</u> ( $m_H = 110 \text{ GeV}$ )	17.7 expected



$m_H > 113.3 \text{ GeV}/c^2$  at 95% C.L.  
(20 July 2000)

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## The Large Hadron Collider in the LEP Tunnel



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# LHC Experiments

## ATLAS, CMS:

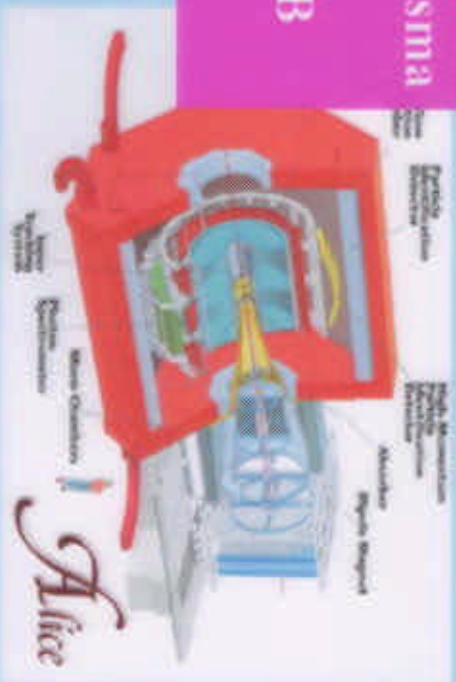
- Higgs boson(s)
- SUSY particles
- ...?

## ALICE:

## Quark Gluon Plasma

## LHC-B:

- CP violation in B





# LHC civil works



CMS building

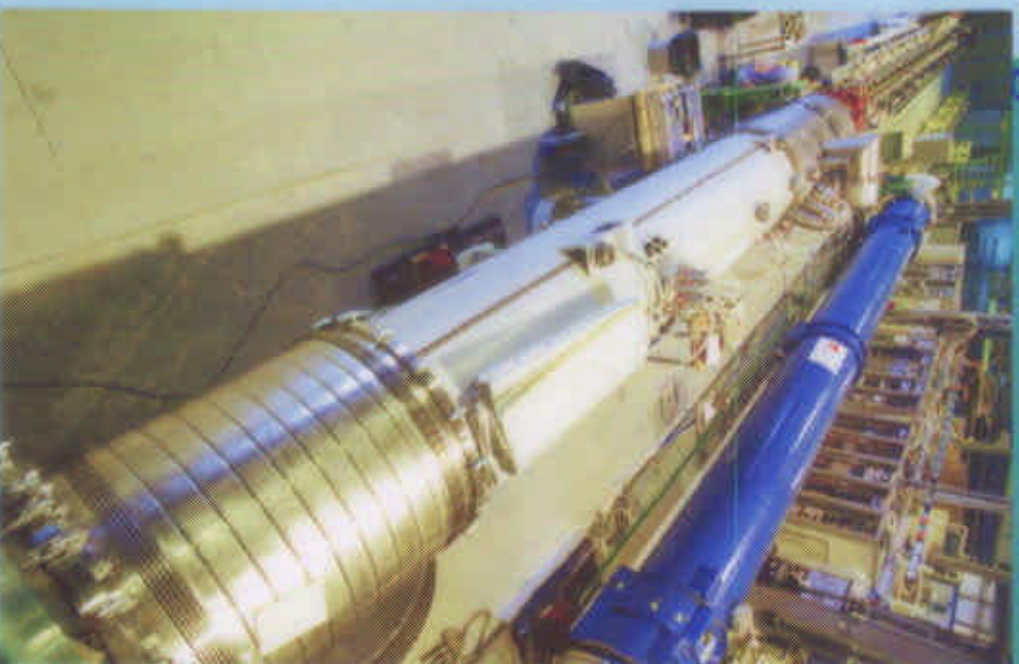


ATLAS service cavern

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## Dipole and quadrupoles superconducting magnets for the LHC on the test bench



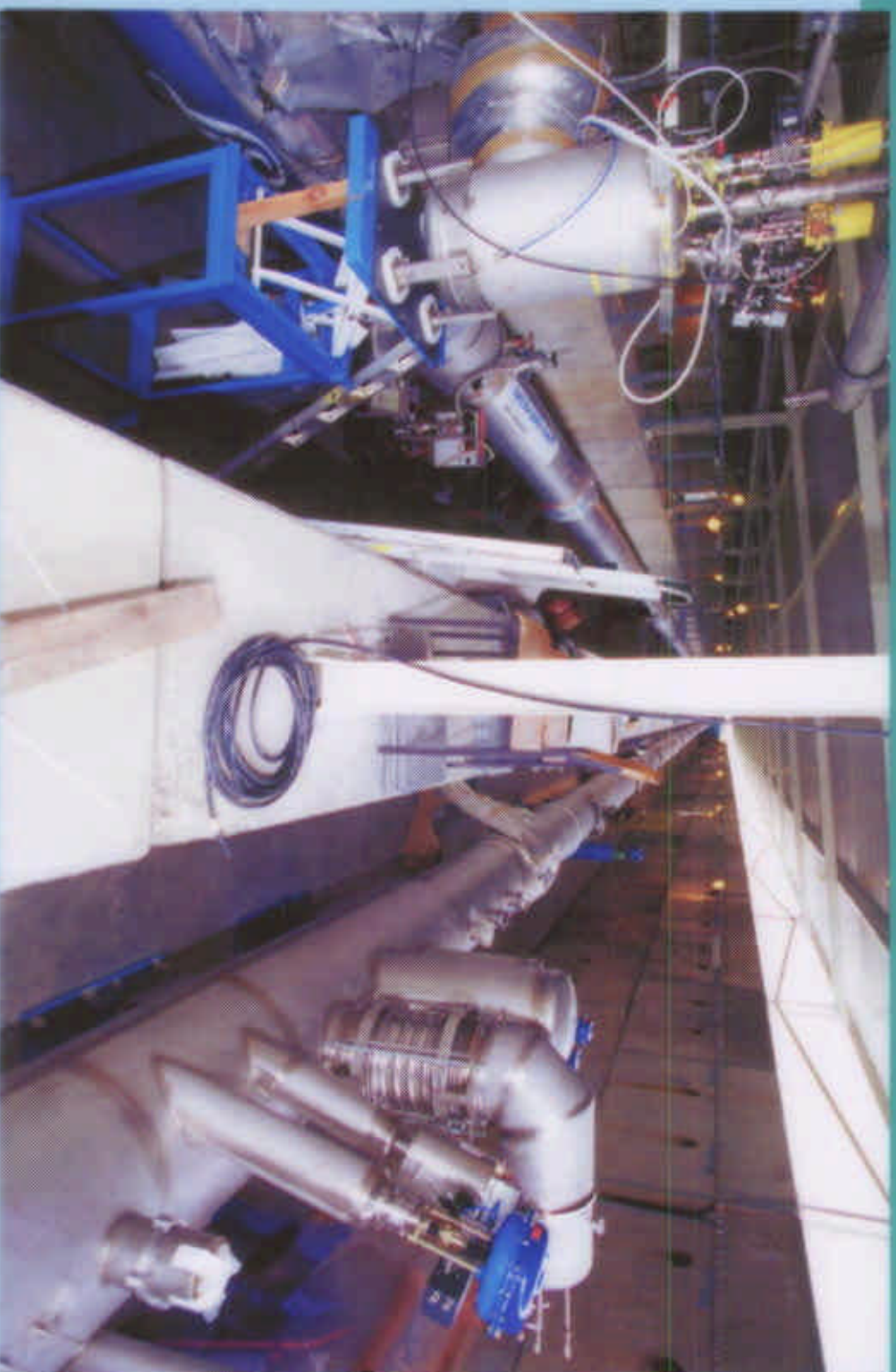
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# Cryogenics



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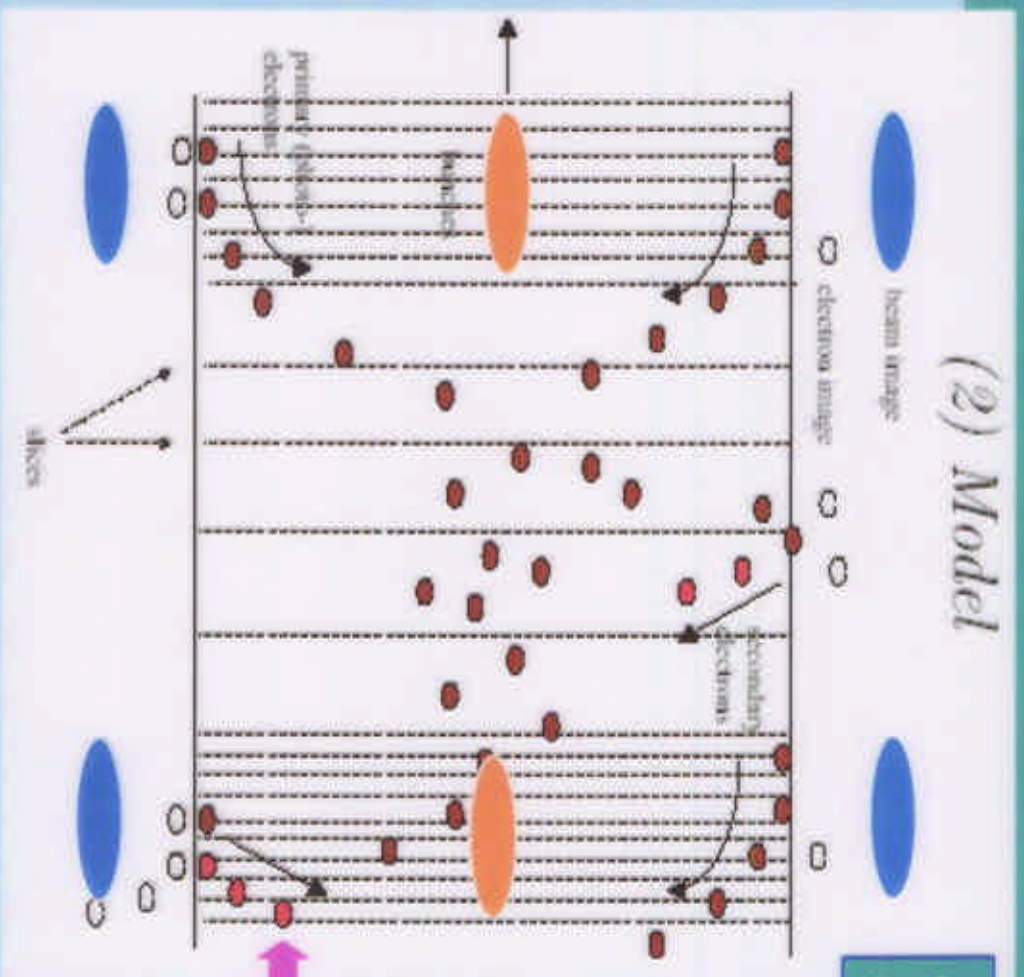
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# Synchrotron Radiation is back @ LHC!

## (2) Model



experimental studies  
at CERN and Novosibirsk

Numerical simulation:  
CERN, Trieste, Novosibirsk  
LBL, SLAC

secondary electrons

$\delta$ =yield  
coefficient

## LHC snapshot, summer 2000

- All orders are leaving CERN in schedule & within budget;
- With June adjudications, all parts of the magnets have been committed, except for phase 2 of the assembly of the main dipoles;
- Magnets: 740 MCHF committed, inside estimated cost;
- Collaboration with Laboratories in Non Member States is going extremely well;
- 5-6 MONTHS DELAY to the commissioning of both caverns...
- "working detectors" mid 2005 still possible !!
- NO DELAY on the critical path of LHC machine construction.

a new assessment of LHC commissioning schedule will be made at the end of 2000

## CERN Experimental Programme

- **@ Proton Synchrotron:**
  - Antiproton Decelerator **New!**
  - Neutron Time-of-Flight **New!**
  - ISOLDE **going**

- **@ SPS:**
  - Direct CP Violation in K decays (NA48) **going**
  - Ion High Energy Collisions **going**
  - COMPASS (DIS of muons): **in preparation**
  - Long Base Line  $\nu_\mu$  Beam: **construction starting**

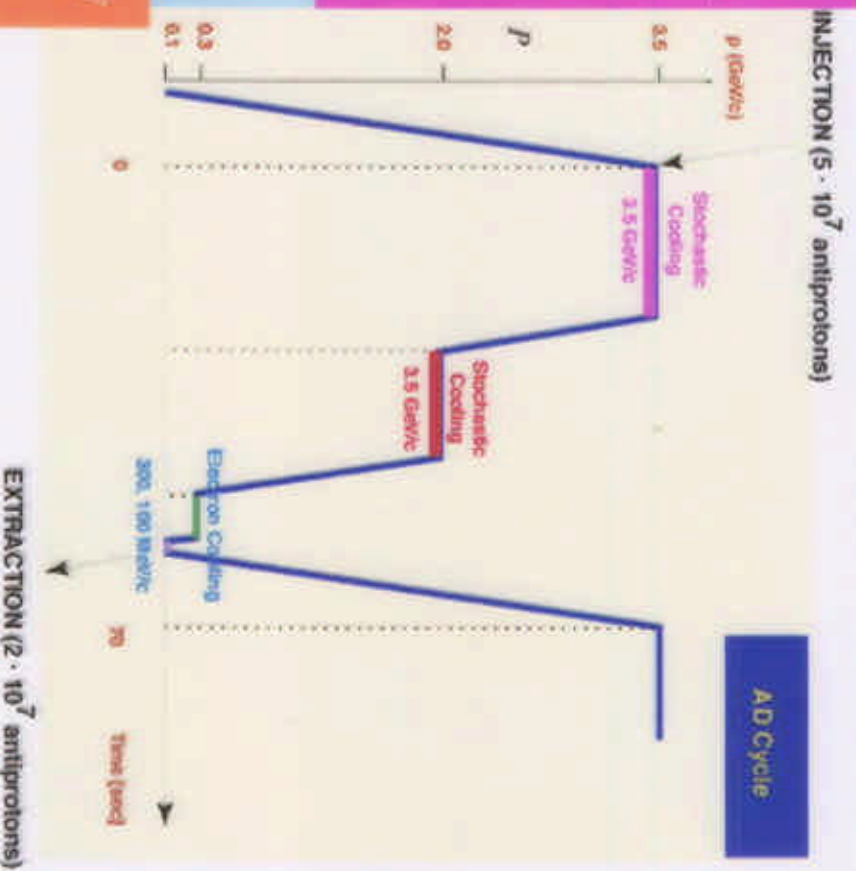


# ANTI-PROTON DECELERATOR

Provides intense antiproton beam of 100 MeV/c ( $\Rightarrow$  50 MeV/c) to:

- ATRAP ( $\frac{\Delta m(P - \bar{P})}{m} \rightarrow 10^{-11}$ )
- ATHENA (spectroscopy of anti Hydrogen)
- ASACUSA (anti-protonic Helium)

- commissioning now
- first physics



# ASACUSA



Atomic Spectroscopy And Collisions Using Cold Antiprotons

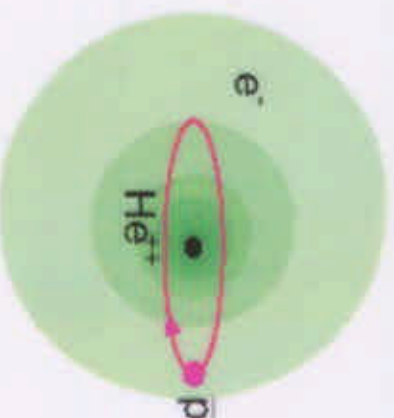


Phase I (currently taking data)

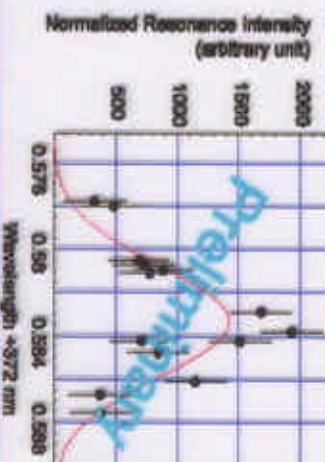
Studies antiprotonic helium "atomcule"

why?: tests CPT invariance assuming correctness of 3-body calculations including QED corrections

how?: high precision laser and microwave spectroscopy



Microwave radiation  
12.9 GHz



First physics result at the AD:  
new laser resonance observed at 372.583 nm

status: now taking data

## Neutron Time of Flight Facility

Intense beam of neutrons with:

- E from eV to 100 MeV;
- $\Delta E/E$  down to  $10^{-6}$  (via ToF determination);

Extremely rich physics programme

commissioning now





# COMPASS: high energy muons on polarized protons

Where does proton's spin come from???



Germany, Finland, Italy,  
Japan, Poland, Russia

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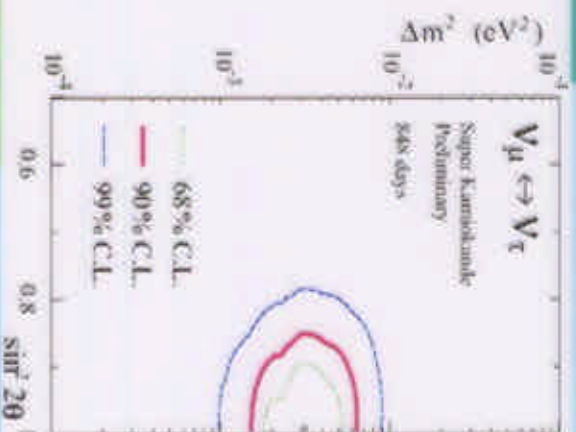
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RICH 1 in the COMPASS  
Experiment Hall



# Neutrino oscillations

K&SuperK  
discovery!!!



Long Base-Line  
 $\nu$  beams

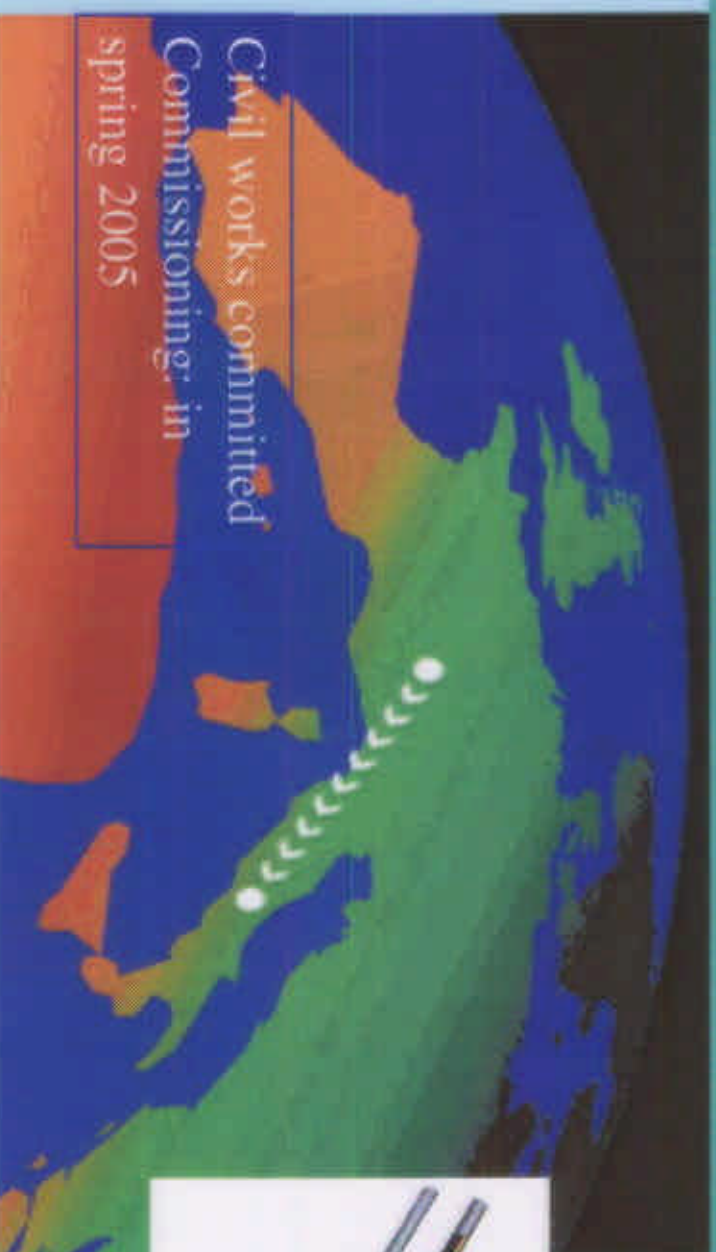
K2K (runs now!)  
Minos @ Fermilab  
CERN to Gran Sasso

$$m^2 = \left[ \frac{g < \phi >^2}{\Lambda} \right]^2 =$$

$$= 1.6 \cdot 10^{-3} \text{ eV}^2 \left[ g \left( \frac{< \phi >}{200 \text{ GeV}} \right)^2 \left( \frac{10^{15} \text{ GeV}}{\Lambda} \right) \right]^2$$

Other oscillation signals:  
- Solar  $\nu$ 's ( $?10^{-4} \text{ eV}^2$ )  
- LSND ( $?1 \text{ eV}^2$ )(????)

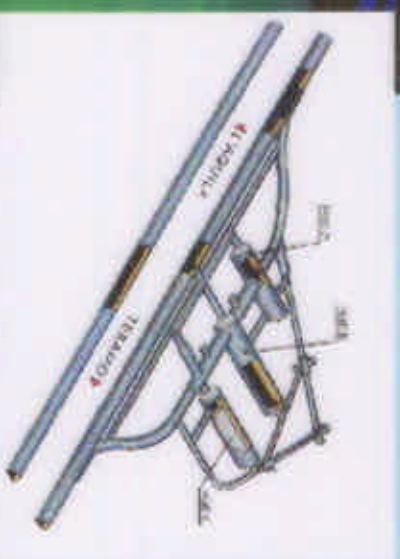
# CERN neutrino beam to Gran Sasso



Civil works committed  
Commissioning: in  
spring 2005

$$E_\nu \approx 20 \text{ GeV}$$

optimized for  
 $\tau$  detection

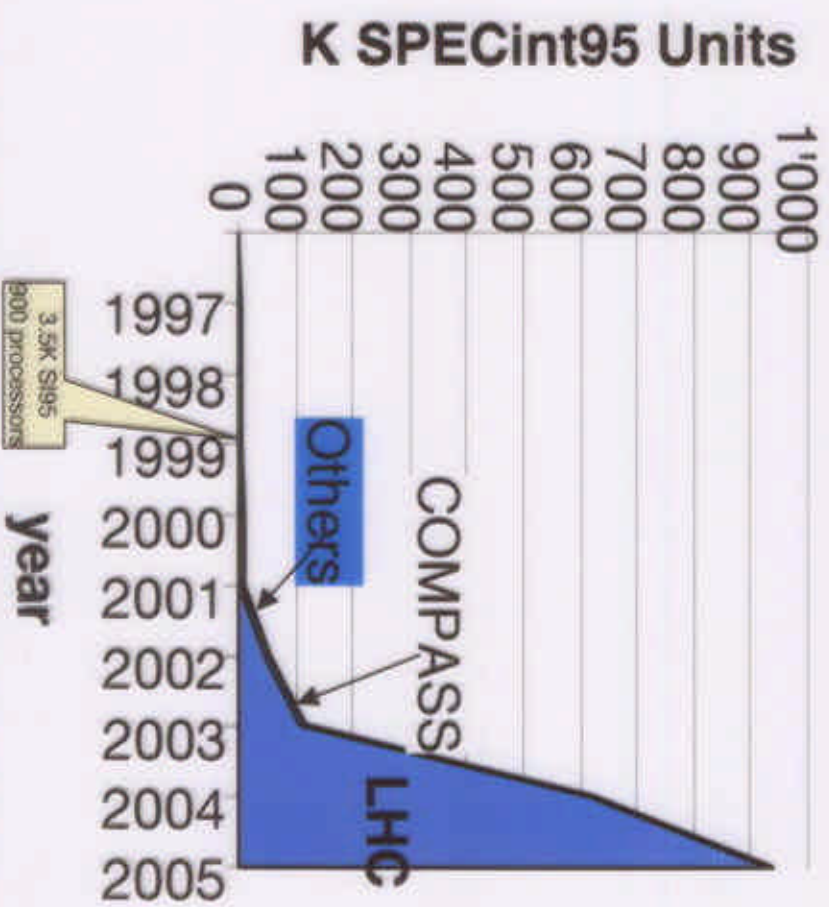


Experimental proposals:  
OPERA  
ICARUS(NOIE??)  
to be examined in September



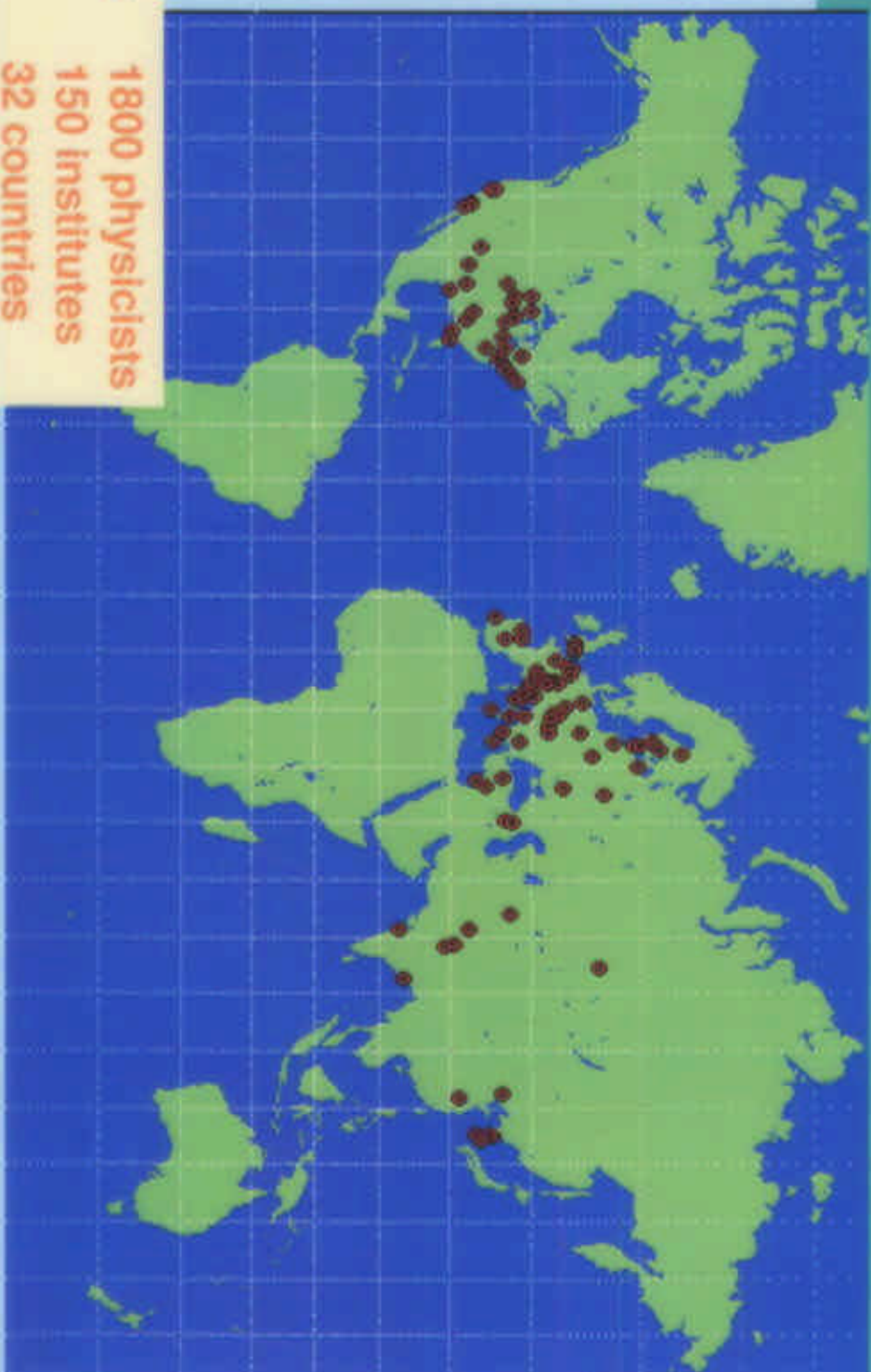
# The LHC computing challenge

## Evolution of Computing Capacity - SPECint95



## *World Wide Collaboration*

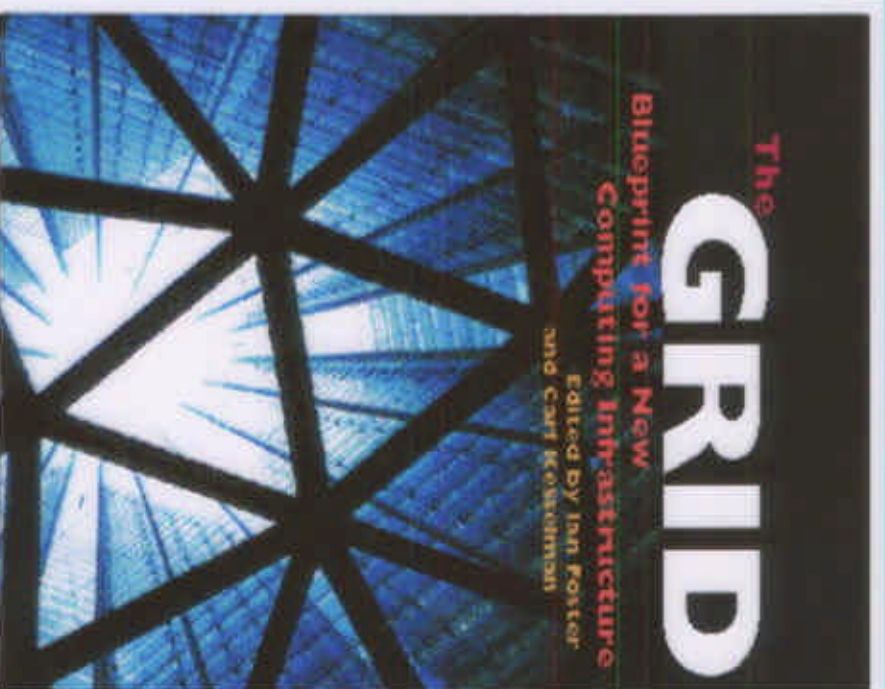
*⇒ distributed computing & storage capacity*



**CMS:**  
1800 physicists  
150 institutes  
32 countries

## Five Emerging Models of Networked Computing From *The Grid*

- **Distributed Computing**
  - // synchronous processing
- **High-Throughput Computing**
  - // asynchronous processing
- **On-Demand Computing**
  - // dynamic resources
- **Data-Intensive Computing**
  - // databases
- **Collaborative Computing**
  - // scientists



Ian Foster and Carl Kesselman, editors, "The Grid: Blueprint for a New Computing Infrastructure," Morgan Kaufmann, 1999, <http://www.mkp.com/grids>

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## JAPAN @ CERN

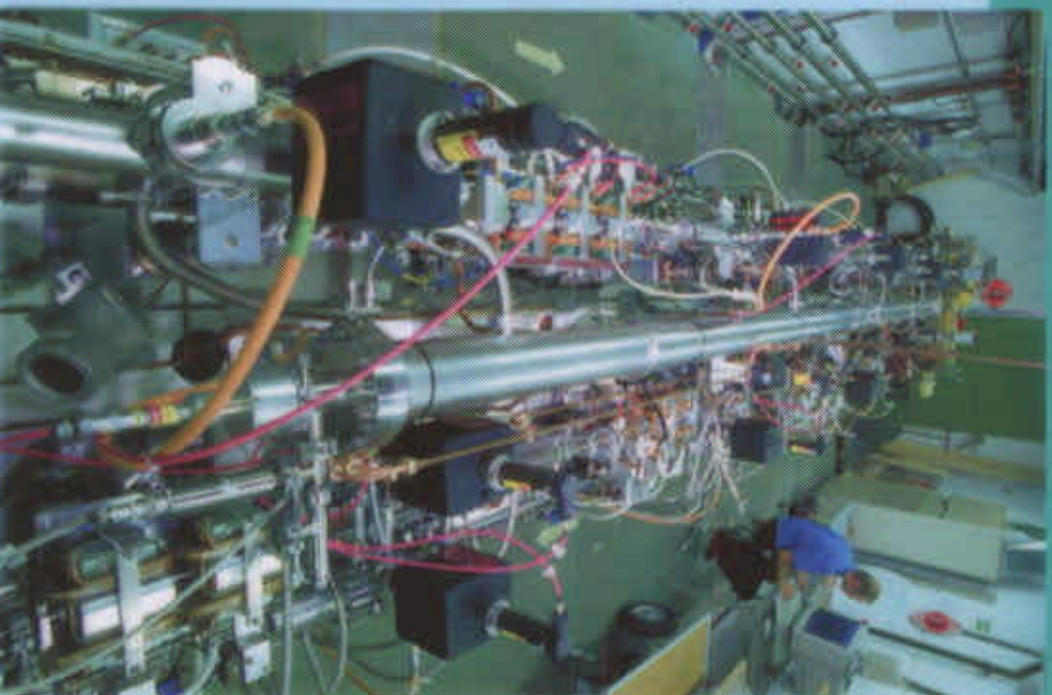
- Important participation in:
  - LEP (OPAL)
  - LHC (ATLAS + LHC construction) ← *CHORUS*
  - Antiproton Decelerator (ASAKUSA)
  - COMPASS
  - Neutrino to Gran Sasso (OPERA)

## Compact Linear Collider (CLIC)

### Overall view of the CLIC Test Facility n.2



### ASSET structure



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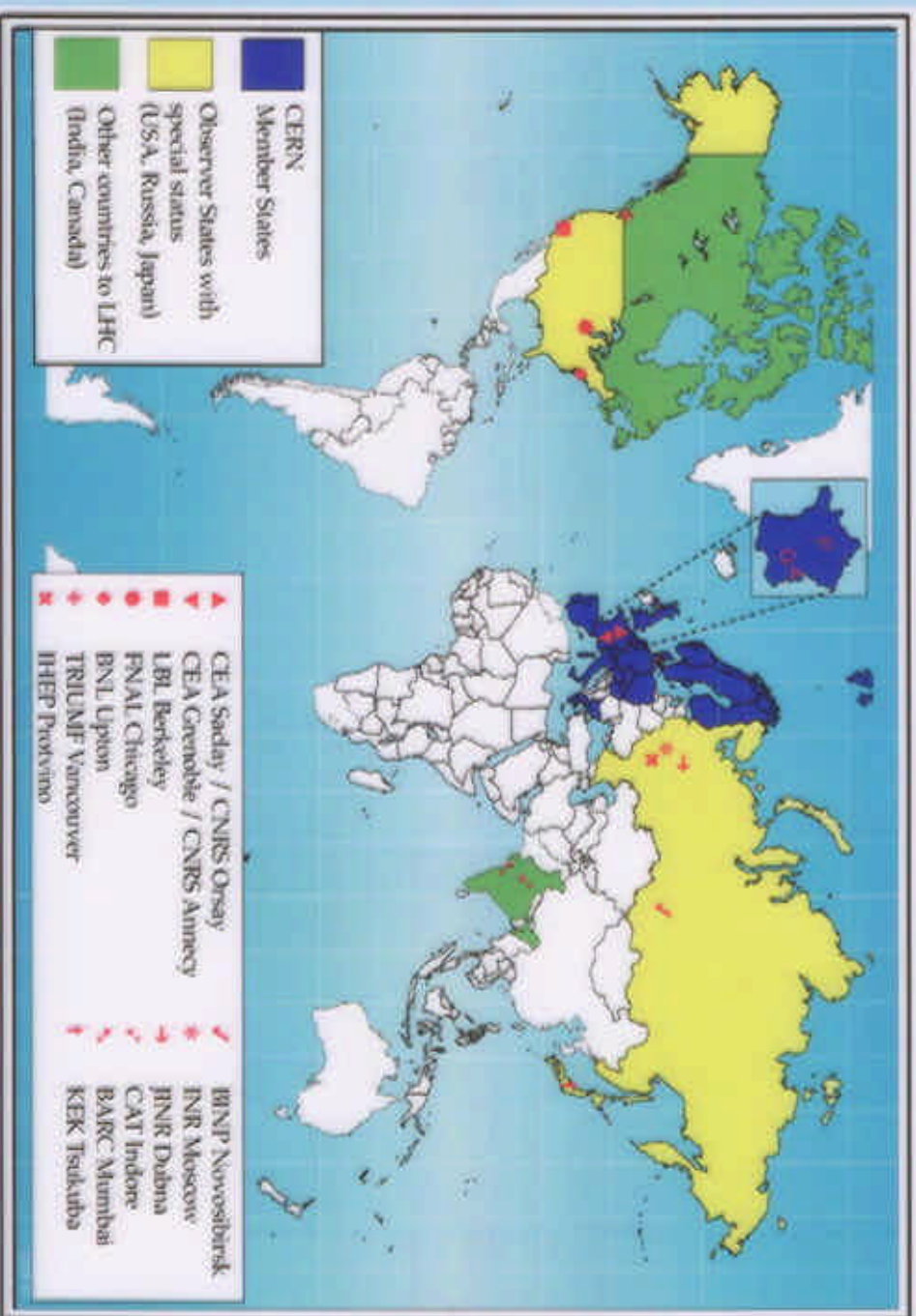
## Is there life beyond the LHC?

- **High Energy frontier does not stop with the LHC ( $E_{\text{eff}} \approx 1 \text{ TeV}$ )**
- **Exploration of SUSY or new Strongly Interacting Sector require:  $E_{\text{eff}} \approx \text{multi-TeV}$ ;**
- **To be ready at the end of LHC exploitation (2005+10/15 years) Accelerator R&D must start NOW!**
- **CLIC project (two-beam acceleration for 3-4 TeV  $e^+e^-$  collider) is developed with CLIC Test Facility n.3 (from 2001)**
- **other line: high intensity proton beams ( $\nu$ -factory,  $\mu$ -collider..)**

international collaboration on a larger scale than LHC is required for future facilities!



# International Collaboration for LHC construction



## CONCLUSIONS

- CERN, at the beginning of the new Century, is trying to:
  - carry on LHC construction, **within budget and as fast as possible**
  - keep significant and differentiated physics (ISOLDE, AD, n-ToF, CNGS, ...)
  - Technology Transfer and Education
  - prepare for future programmes, beyond the LHC

Come to work with us