CERN: Views for the Future

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OECD Consultative Group

CERN, June 29, 2001

SUMMARY

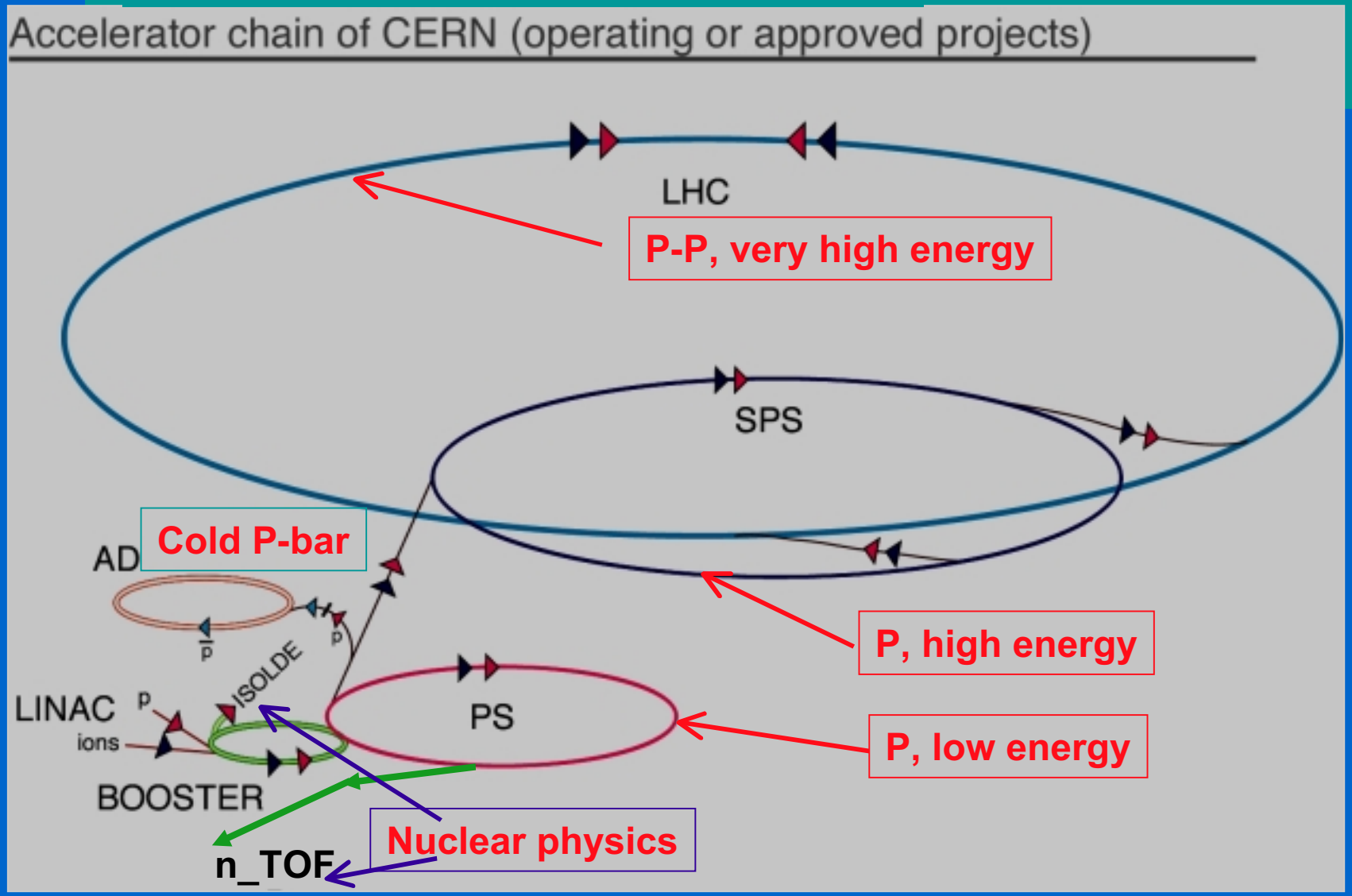
- CERN in the Medium Term (2001-2005);
- LHC:
  - main targets,
  - what will be left out ?
- Ongoing accelerator R&D;
- CLIC @ CERN ?
- A forward look

The twenty Member States of CERN

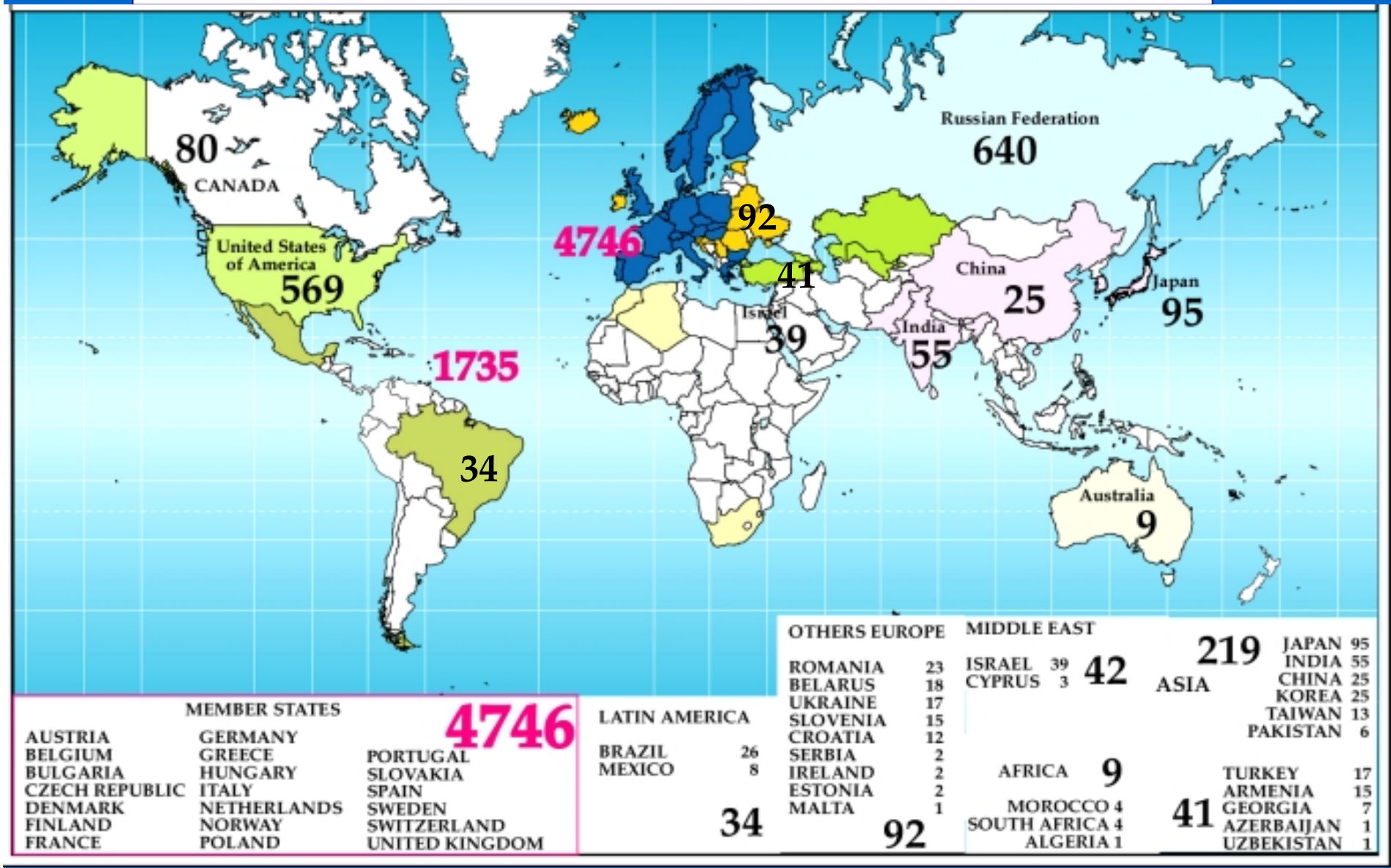
OBSERVERS:
- UNESCO
- EU
- Israel
- Turkey

SPECIAL OBSERVERS (for LHC):
- USA
- Japan
- Russia

Accelerator chain of CERN



Distribution of CERN users, May 1, 2001



MEMBER STATES			4746
AUSTRIA	GERMANY	PORTUGAL	
BELGIUM	GREECE	SLOVAKIA	
BULGARIA	HUNGARY	SPAIN	
CZECH REPUBLIC	ITALY	SWEDEN	
DENMARK	NETHERLANDS	SWITZERLAND	
FINLAND	NORWAY	UNITED KINGDOM	
FRANCE	POLAND		

LATIN AMERICA		34
BRAZIL	26	
MEXICO	8	

OTHERS EUROPE		92
ROMANIA	23	
BELARUS	18	
UKRAINE	17	
SLOVENIA	15	
CROATIA	12	
SERBIA	2	
IRELAND	2	
ESTONIA	2	
MALTA	1	

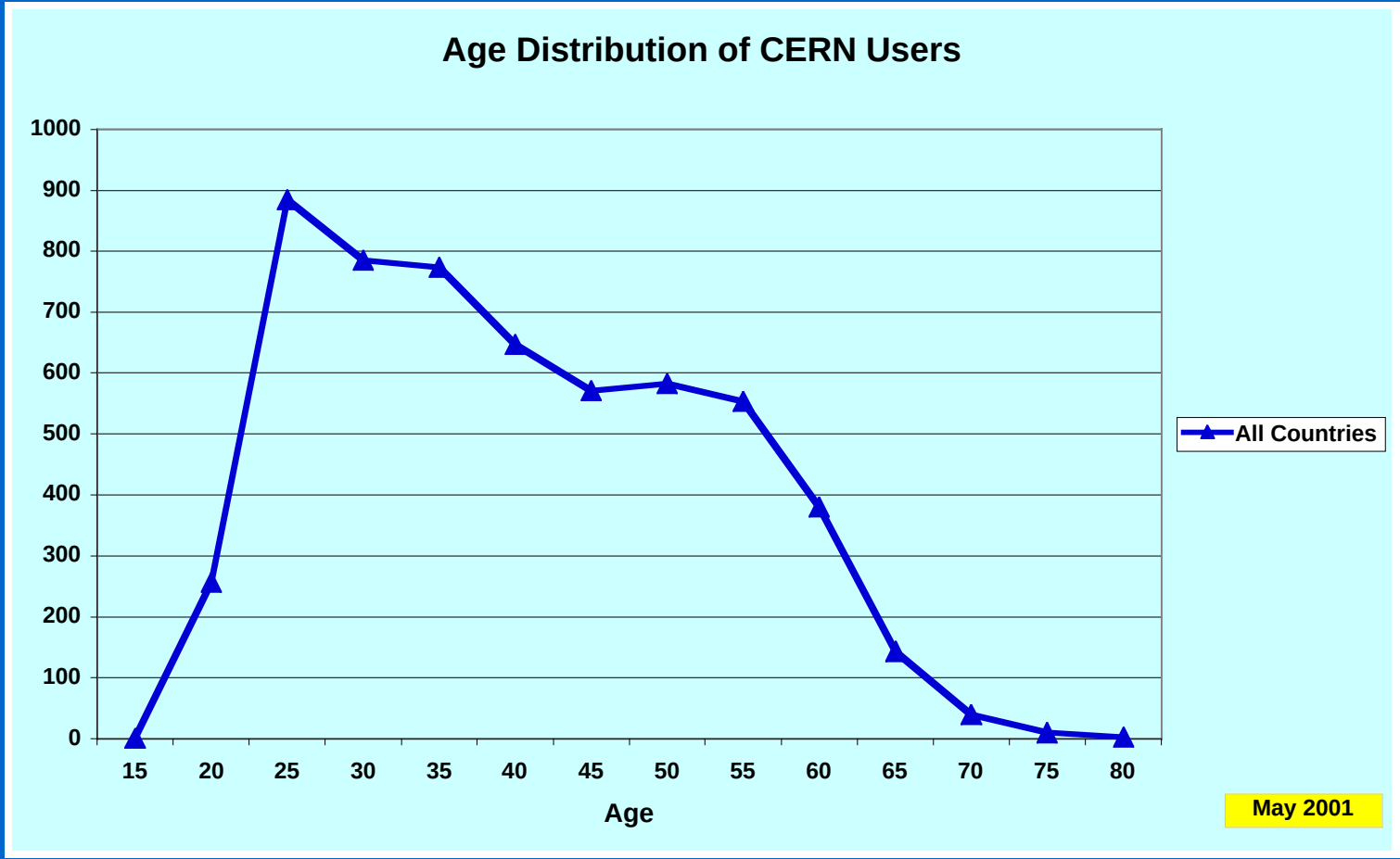
MIDDLE EAST		42
ISRAEL	39	
CYPRUS	3	

AFRICA	9
MOROCCO	4
SOUTH AFRICA	4
ALGERIA	1

ASIA		219
JAPAN	95	
INDIA	55	
CHINA	25	
KOREA	25	
TAIWAN	13	
PAKISTAN	6	

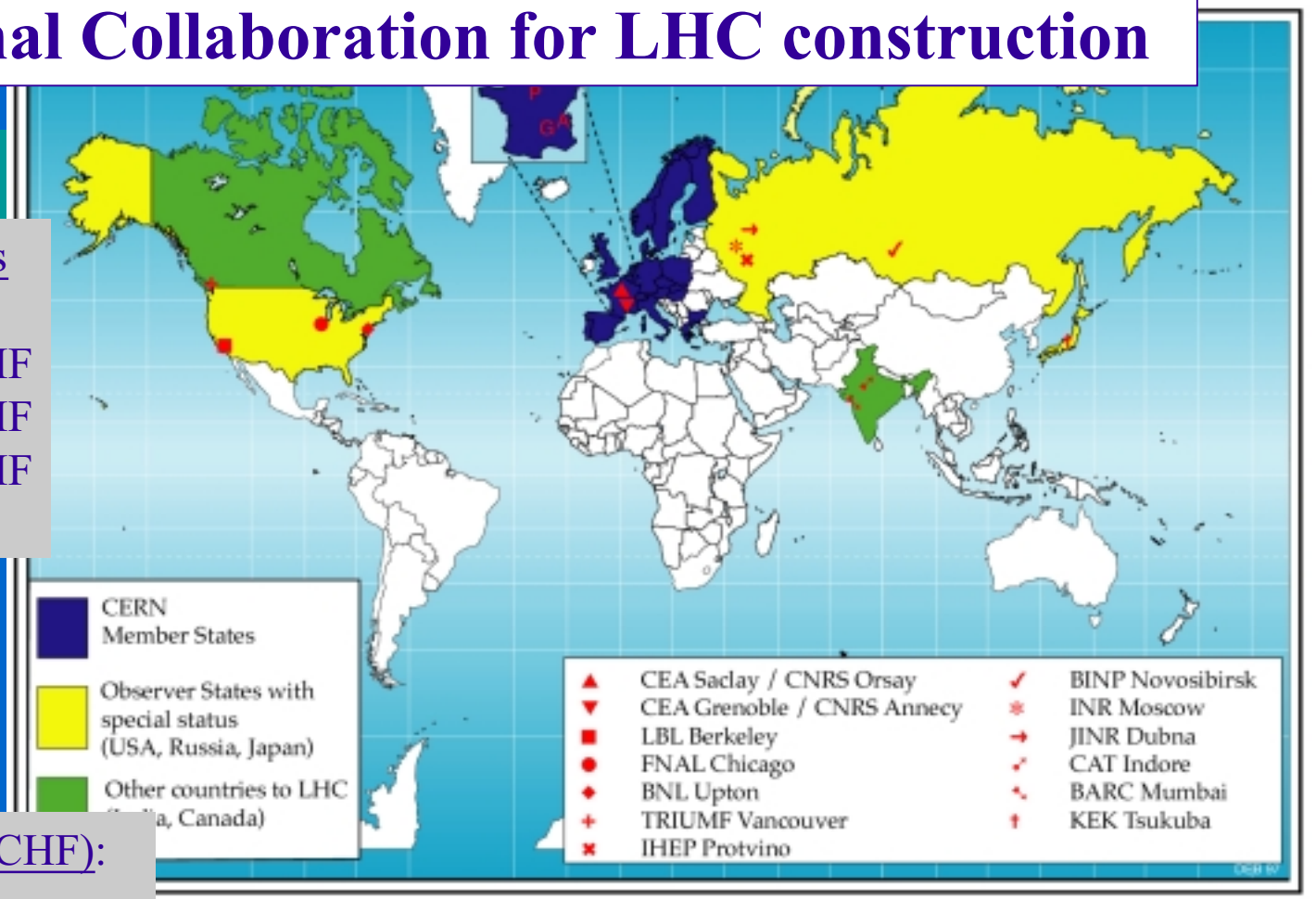
		41
TURKEY	17	
ARMENIA	15	
GEORGIA	7	
AZERBAIJAN	1	
UZBEKISTAN	1	

Age Distribution of CERN Users (May, 2001)



International Collaboration for LHC construction

Gross NMS contributions		
US:	200	M$
Russia:	100	MCHF
Japan:	170	MCHF
Canada:	30	MCHF
India:	25	M$



Cost sharing for LHC (BCHF):	
MS, Material:	2.1
MS, Personnel:	1.1 (approx.)
Host States:	0.2
NMS (net):	0.6 (≈15%)
	4.0

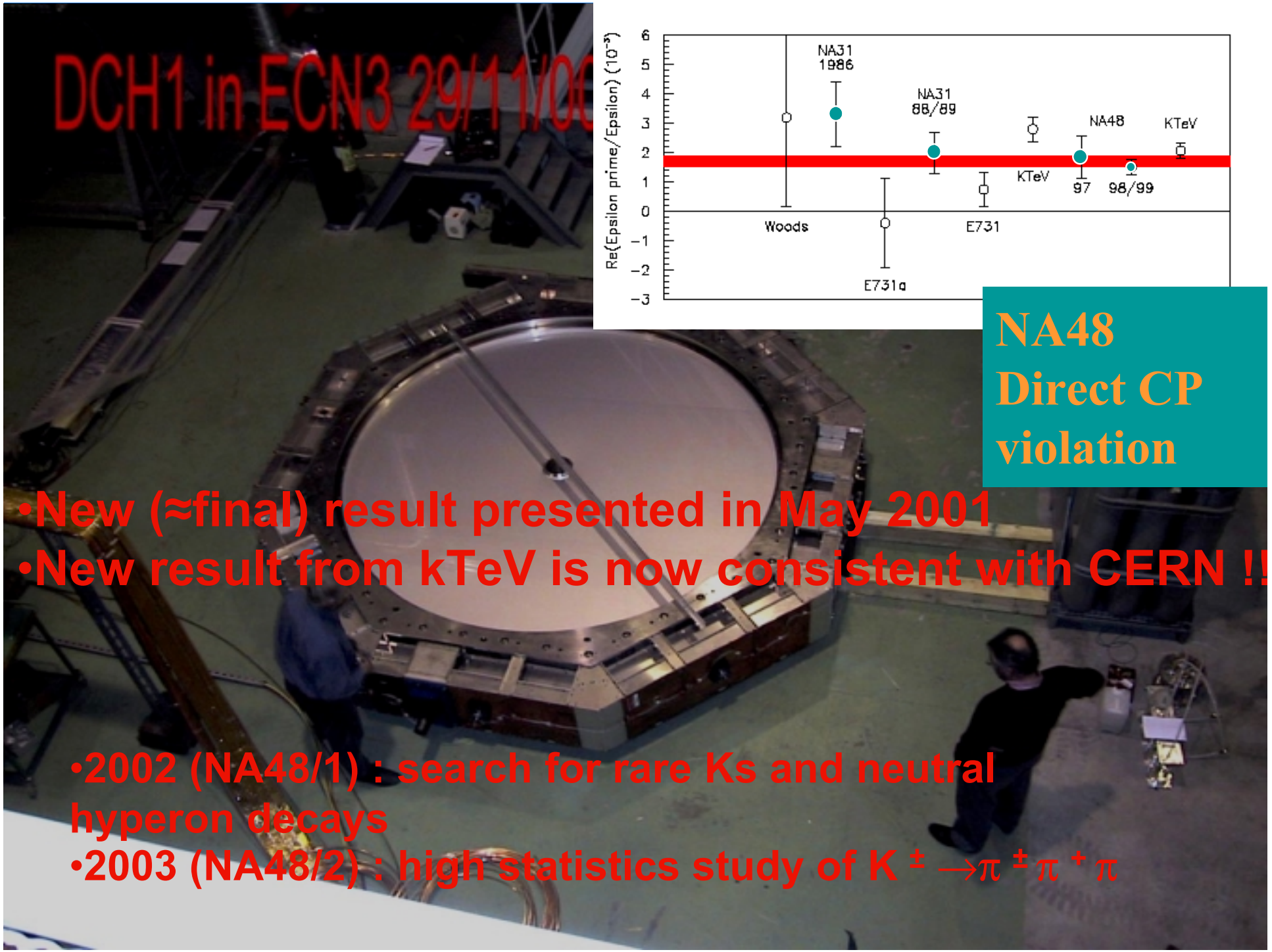
USA, Japan, Russia: participate in the decision process for LHC in Committee of Council
Free access to LHC experiments

Institutional aspects

- In Council: one country-one vote
- Contributions according to GDP
- No just return clause
- but:
  - Finance Committee recommends important financial decisions (Budget…) only with a majority of 70% of contributions;
  - specific rules (alignment) facilitate the equilibration of the industrial return of each country, which is closely monitored.

1. CERN in the Medium Term (2002-2005)

- NA48
- COMPASS
- CNGS
- HARP
- DIRAC
- Antiproton Decelerator
- Nuclear Physics (ISOLDE, n-ToF, Heavy ions)
- CAST



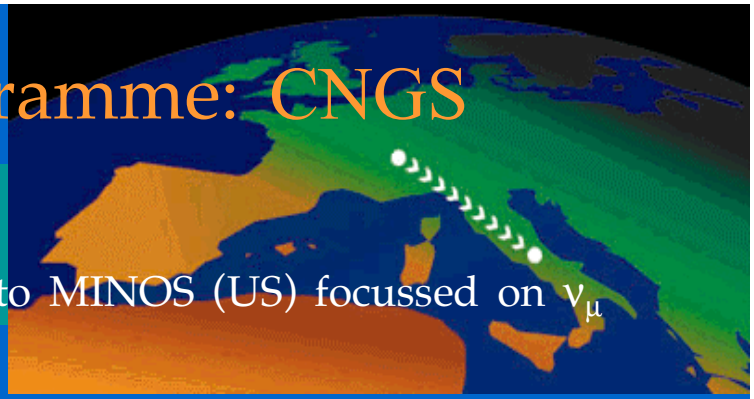
NA48 Direct CP violation

- New (≈final) result presented in May 2001
- New result from kTeV is now consistent with CERN !!

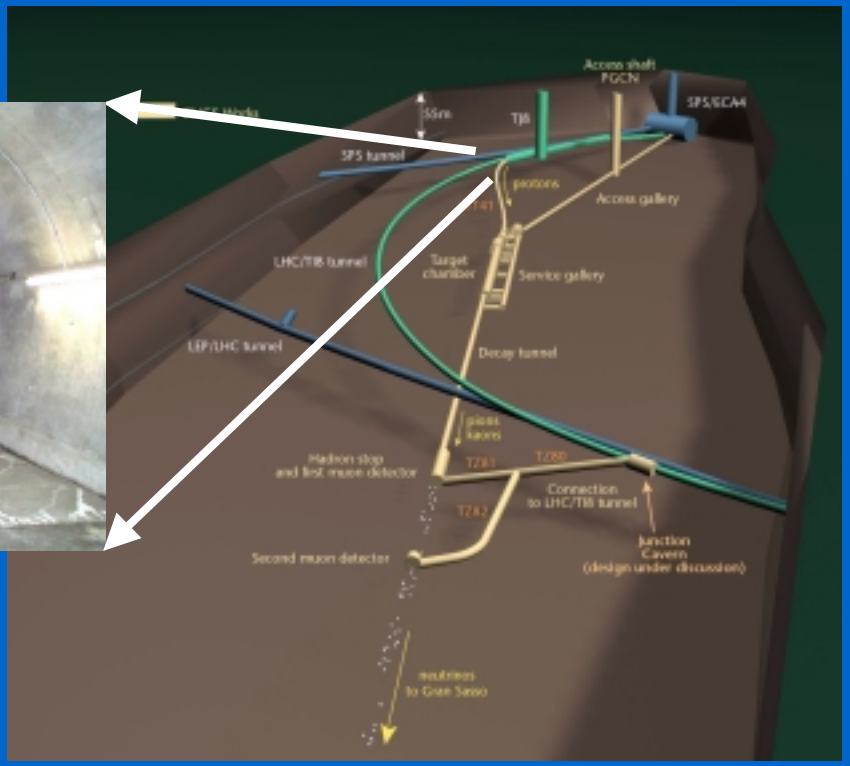
- 2002 (NA48/1) : search for rare Ks and neutral hyperon decays
- 2003 (NA48/2) : high statistics study of $K^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi$


COMPASS
muon beam (100 & 200 GeV/c)
• Spin structure of the nucleon
• measurement of gluon-polarisation (ΔG/G) using
• open charm
• high p_T hadrons
• vector meson production (QCD factorization tests/ OFPD)
New High Rate Experiment – double magnetic spectrometer
2000 – 1st installation run
2001 - Technical run + 1st Physics run
2002-2006 Data Taking and completion of spectrometer
Bielefeld, Bochum, Bonn, Burdwan, JINR Dubna,
Erlangen, Freiburg, CERN, Heidelberg, Helsinki,
Mainz, Mons, Moscow,
München, Nagoya , Osaka, Protvino, Saclay,
Tel Aviv,. Torino, Trieste, Warsaw

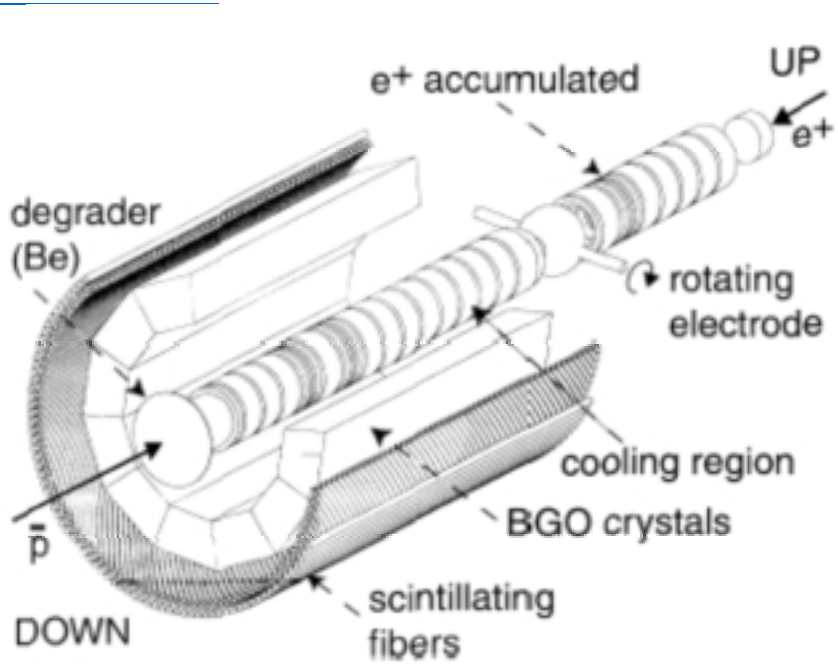
Long-Baseline Neutrino Programme: CNGS



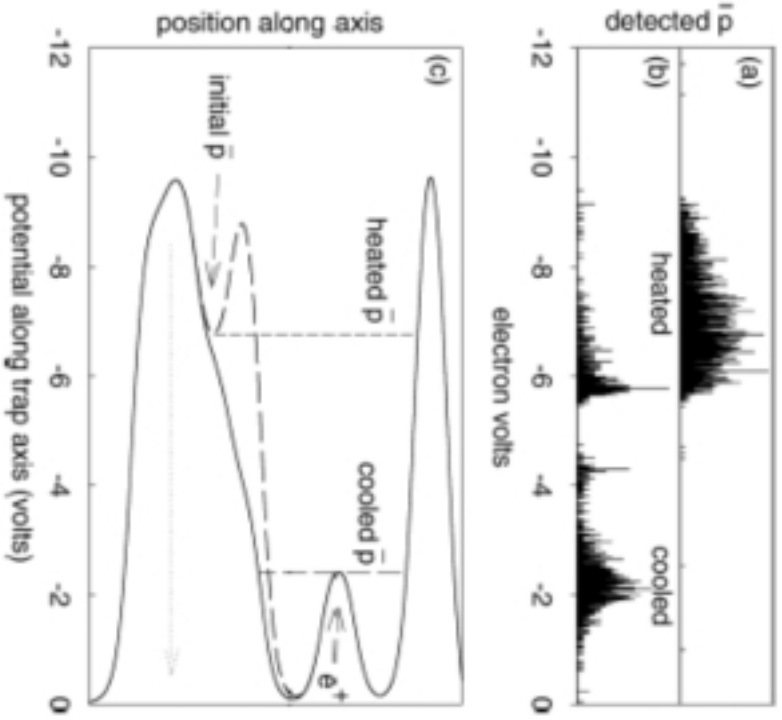
- To observe the appearance of tau leptons;
- complementary to the lower-energy K2K (Japan) and to MINOS (US) focussed on ν_μ disappearance;
- OPERA approved by the CERN Research Board and by INFN (Jan. 2001);
- CERN will support a in-house group in OPERA, building on the experience accumulated in CHORUS and NOMAD.



ATRAP: cooling antiprotons with positrons

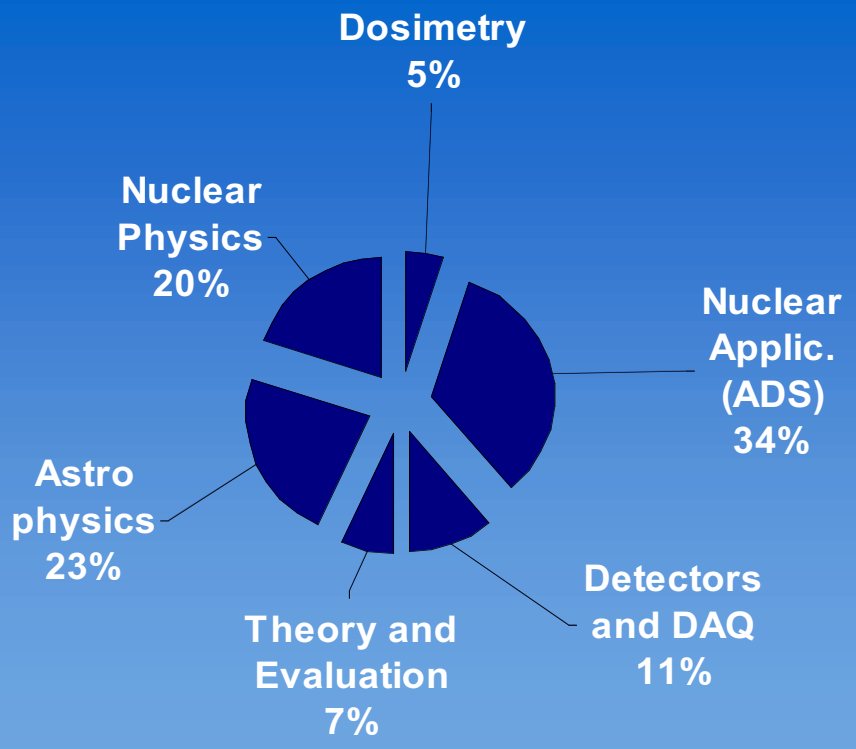


The ATRAP collaboration's antimatter trap: will it someday trap the $H\bar{H}$ molecule?



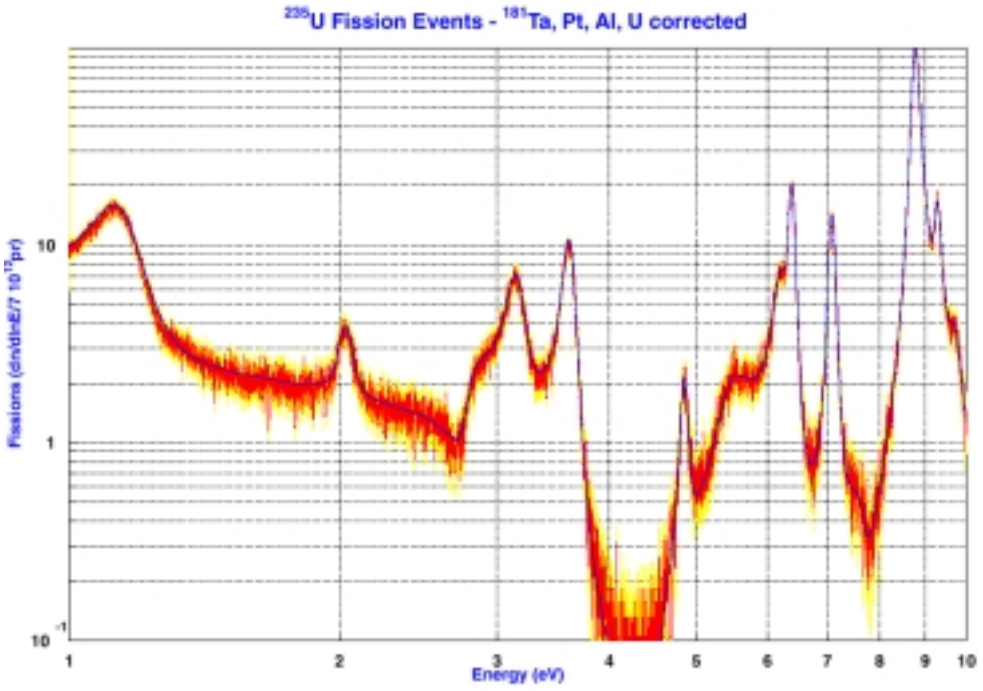
Neutron Time of Flight Facility

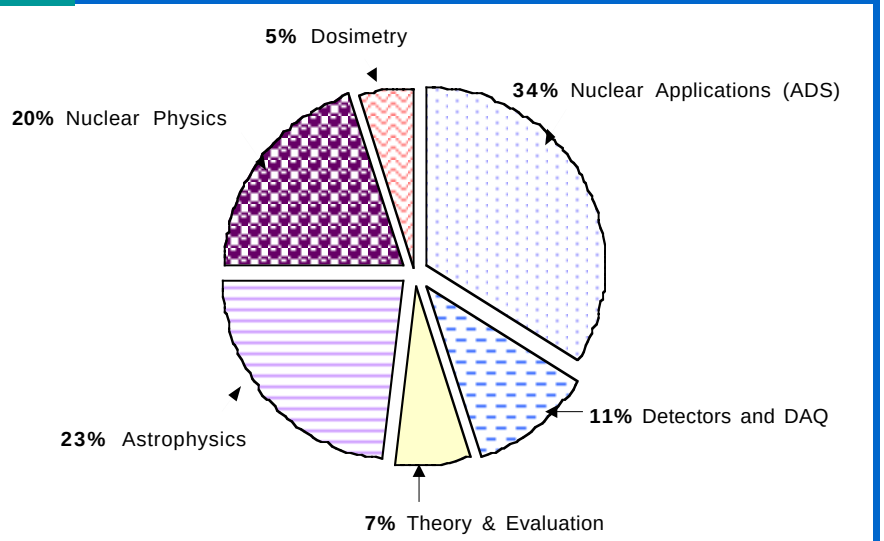
Intense beam of neutrons:
$\Phi > 7.\ 10^5$ n/cm^2 /pulse
- E = 0.1 eV to 100 MeV;
- $\Delta E/E = 7\ 10^{-5}$ (by ToF determination);
A rich physics programme



N ToF

- machine commissioning ongoing
- first phase of experiments approved

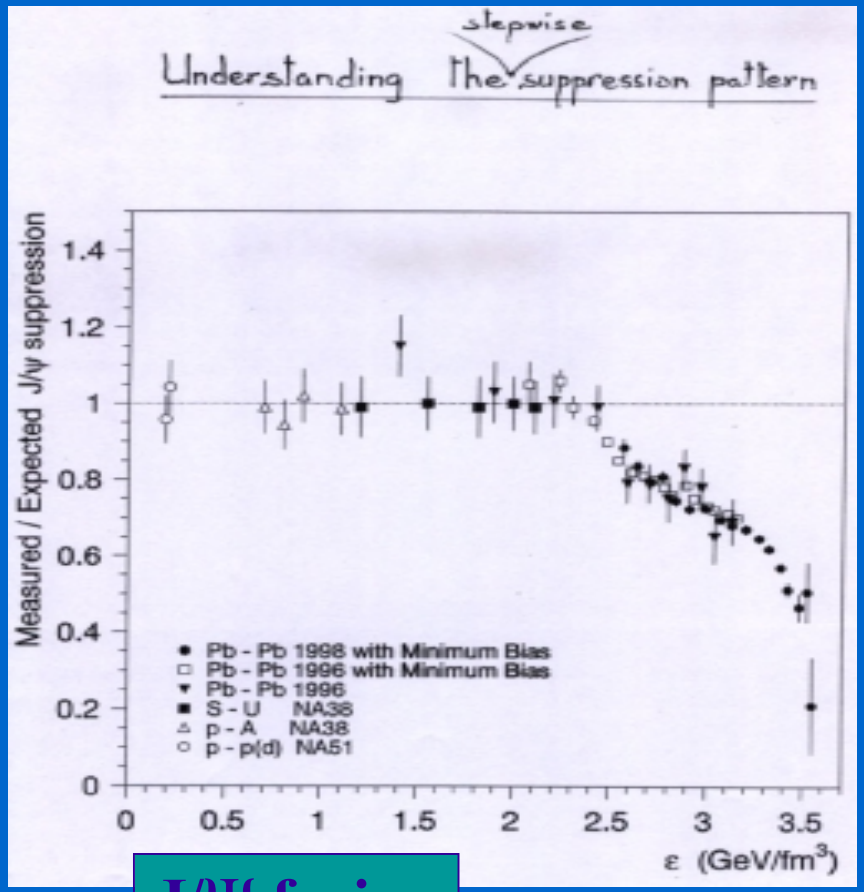




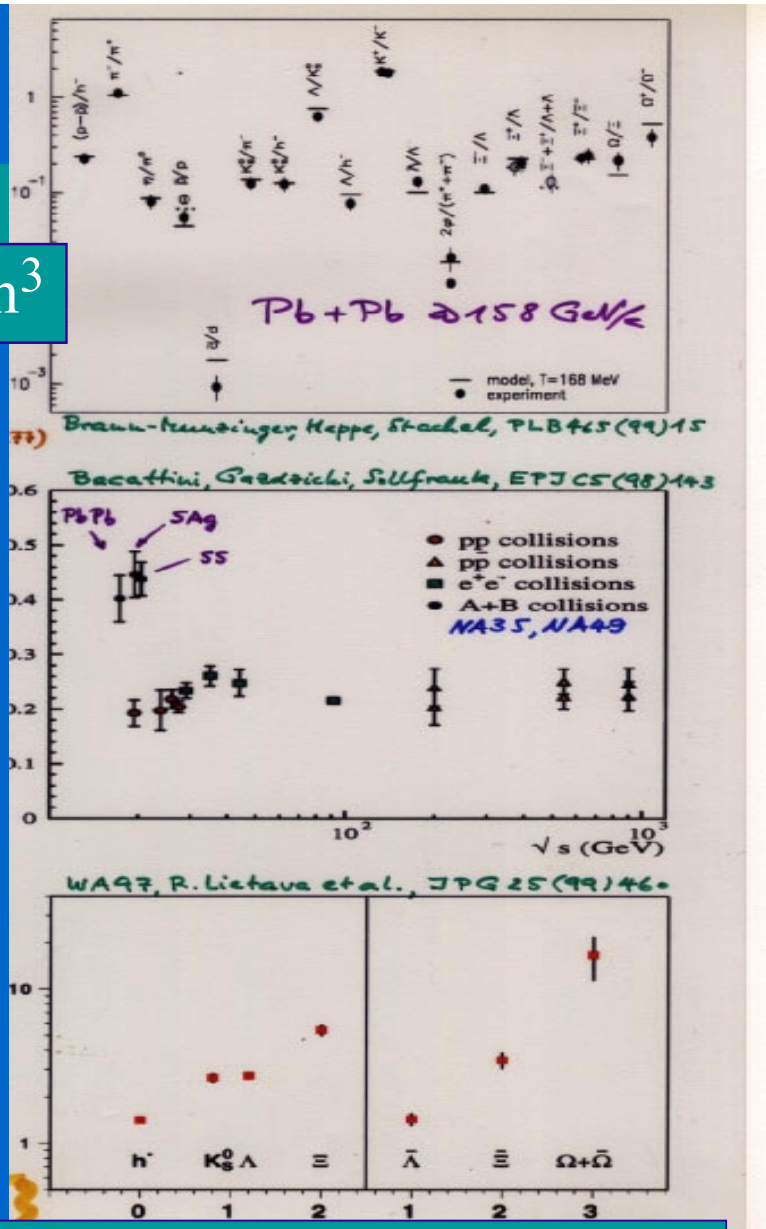
Research Activities of the N-ToF Collaboration

Fighting with background…

Evidence for Unconfined Nuclear Matter ?
CERN, Feb. 2000
consistent with: $T \approx 170\,MeV$, $\varepsilon \approx 2\ GeV/fm^3$



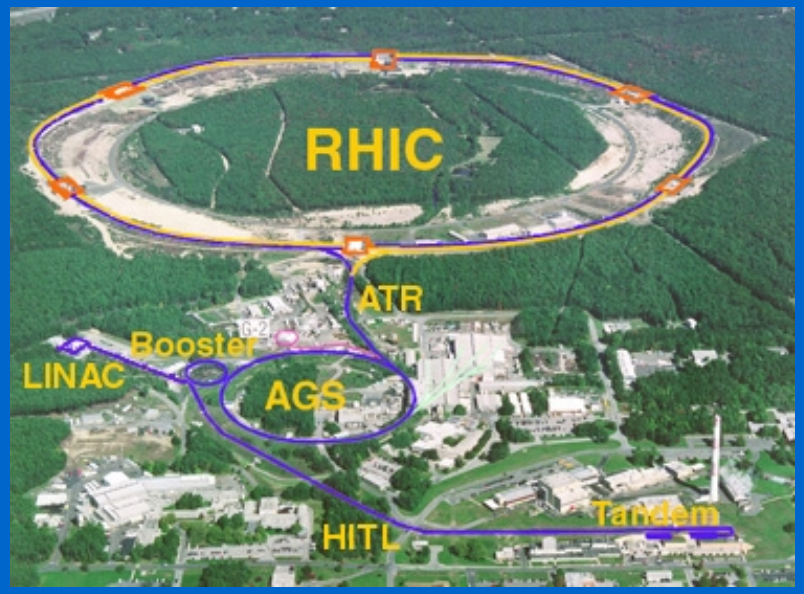
J/Ψ fusion



Strange Particles Enhancement

Quark Gluon Plasma Hunting is now at RHIC

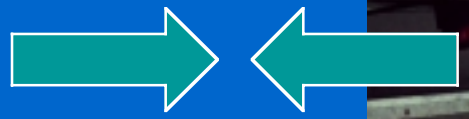
.. the SPS programme shall continue
in 2002-2003 for particular aspects
(open charm production, energy dependence..)



2. The Large Hadron Collider in the LEP Tunnel : main targets; what will be left out

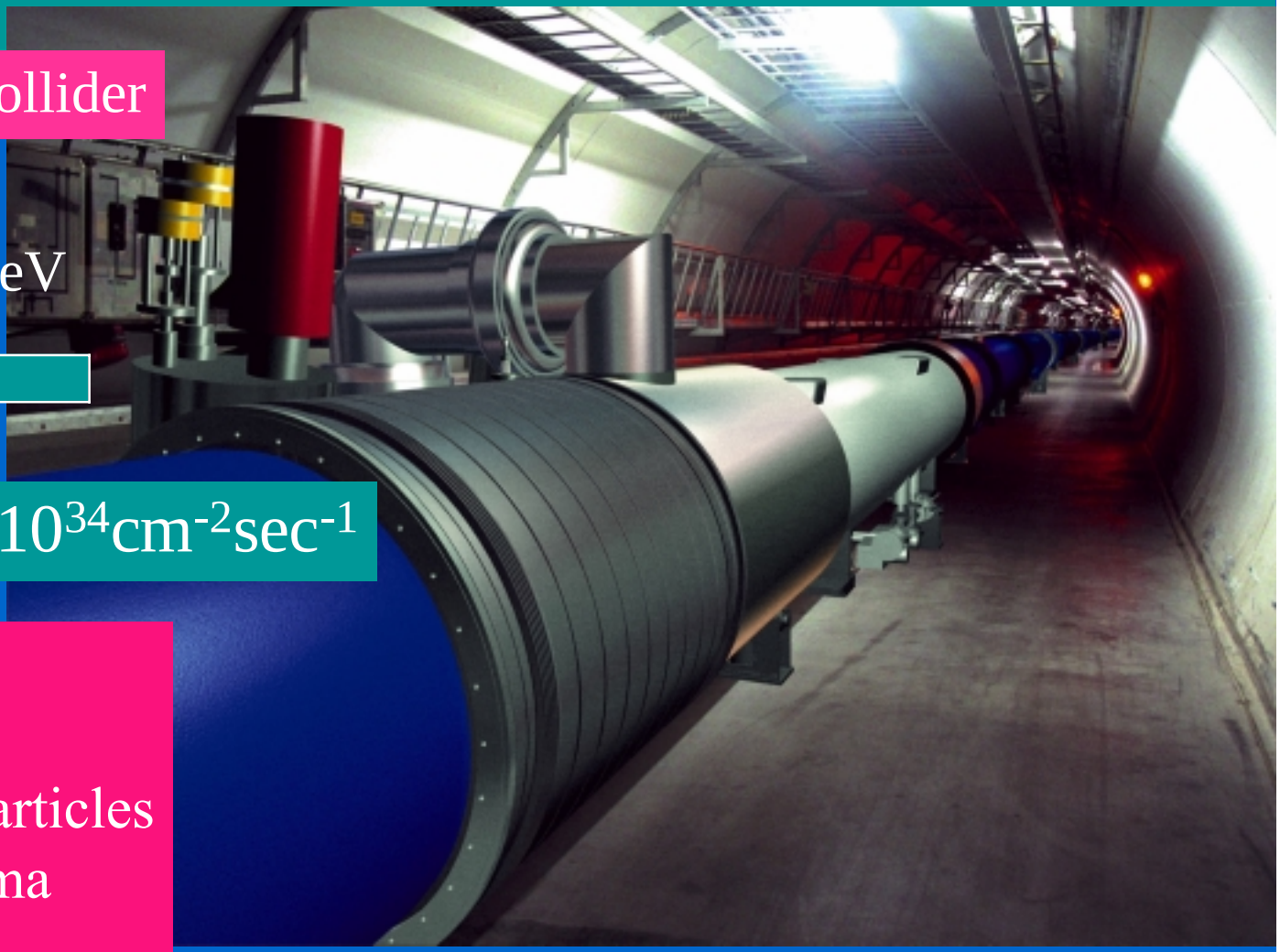
Proton- Proton Collider

7 TeV + 7 TeV

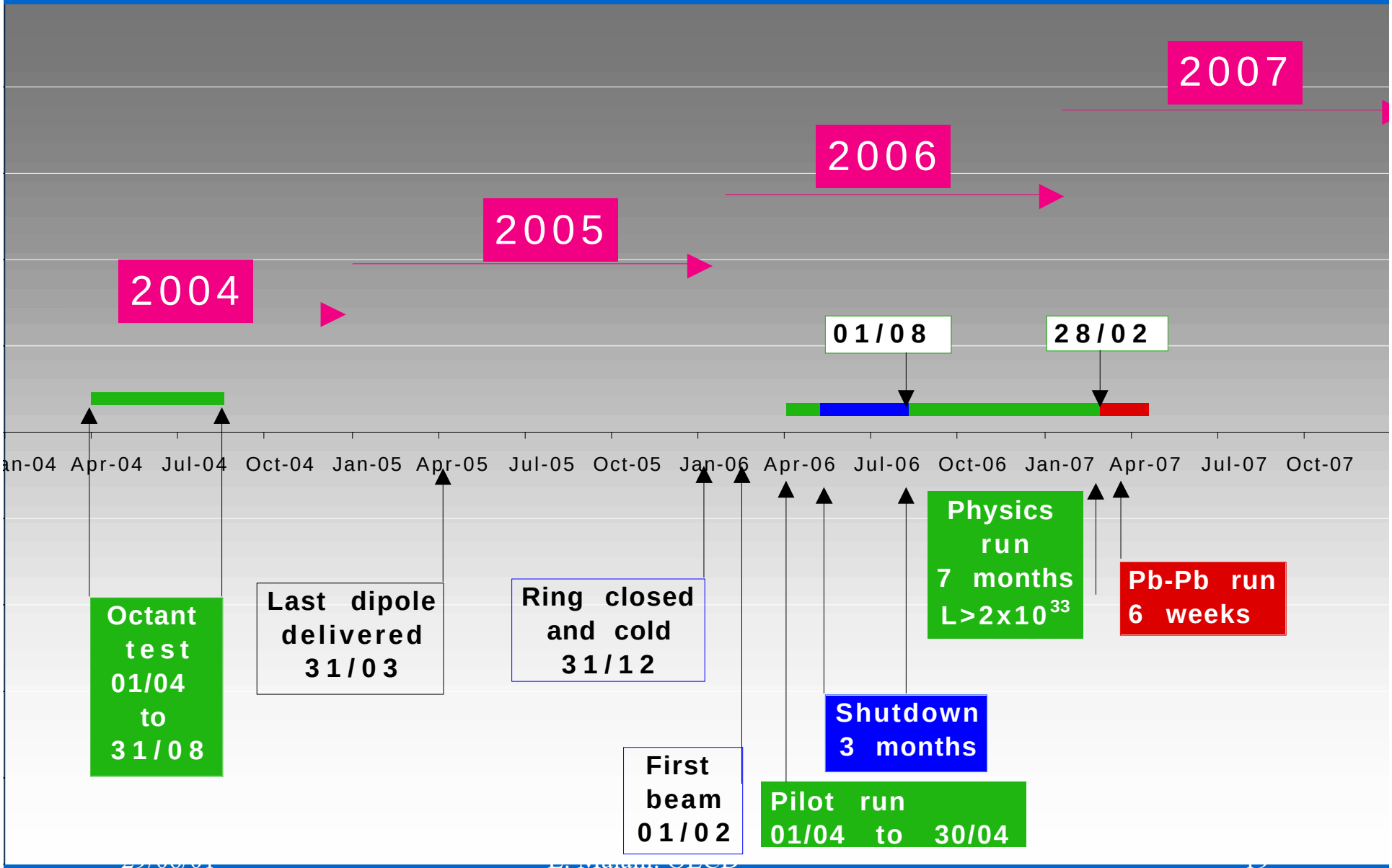


Luminosity = $10^{34}cm^{-2}sec^{-1}$

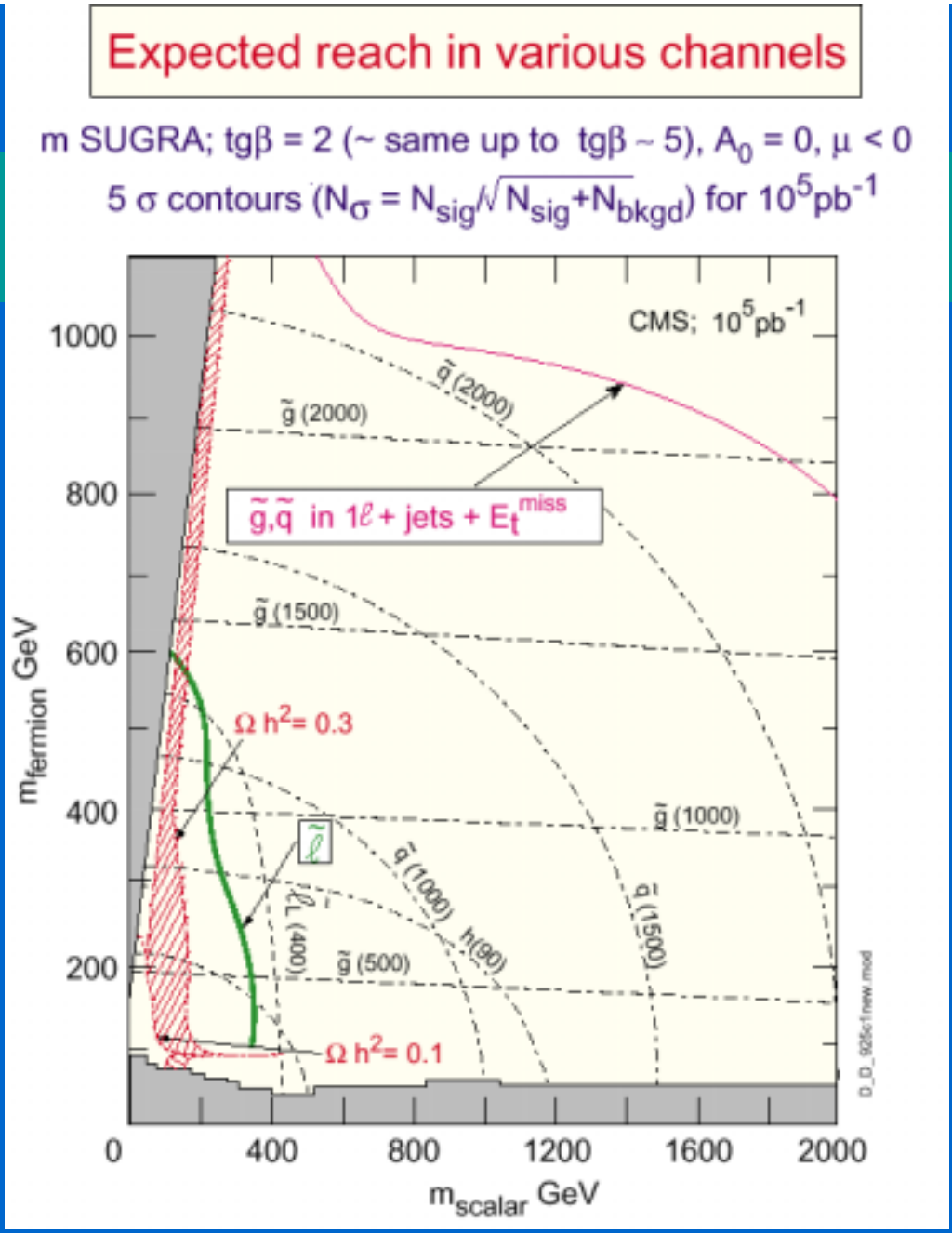
first targets:
- Higgs boson (s)
- Supersymmetric Particles
- Quark-Gluon Plasma
- CP violation in B



LHC commissioning schedule



Expected CMS reach in various channels & Cosmological parameters



…on the High Energy Frontier, beyond the LHC….

- elucidation of Higgs boson(s) spectrum & spontaneous Symm. Break.
- elucidation of SUSY spectrum (if any)
- direct signals of extra dimensions (extra vector bosons, KK tower…)
- contact interactions as signal of new energy scales beyond the TeV

Light Higgs

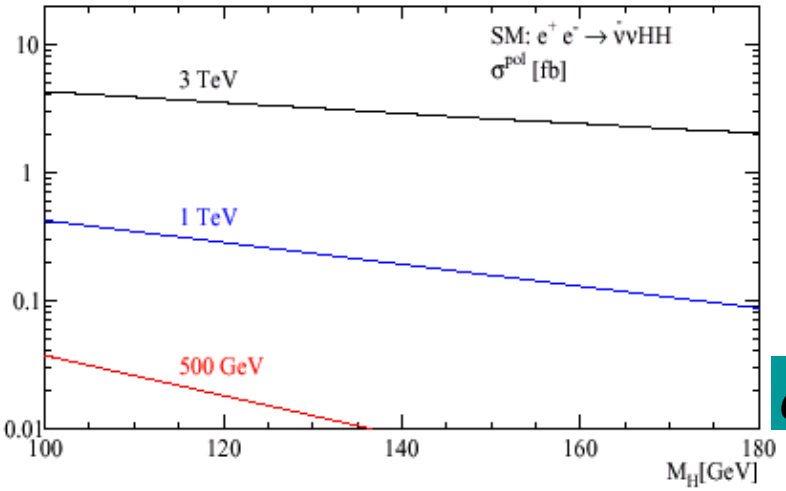
$\sqrt{s} \simeq 3$ TeV to Complement LHC + LC-500 Physics Reach

$\sqrt{s} > 1$ TeV needed to fully understand a 115 GeV/c^2 Higgs Boson: probe shape of the Higgs potential through triple and quartic couplings:

$$V = \lambda v^2 H^2 + \lambda v H^3 + \tfrac{1}{4}\lambda H^4$$

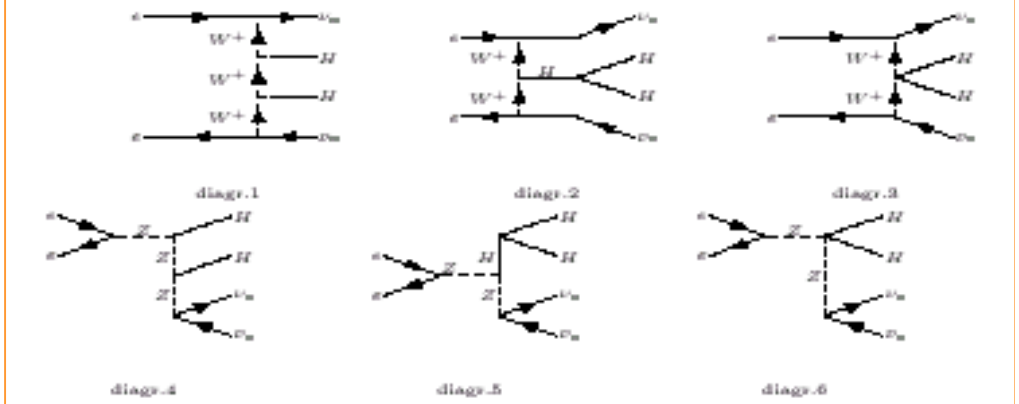
$$M_H = \sqrt{2\lambda} v$$

M. Muehlleitner

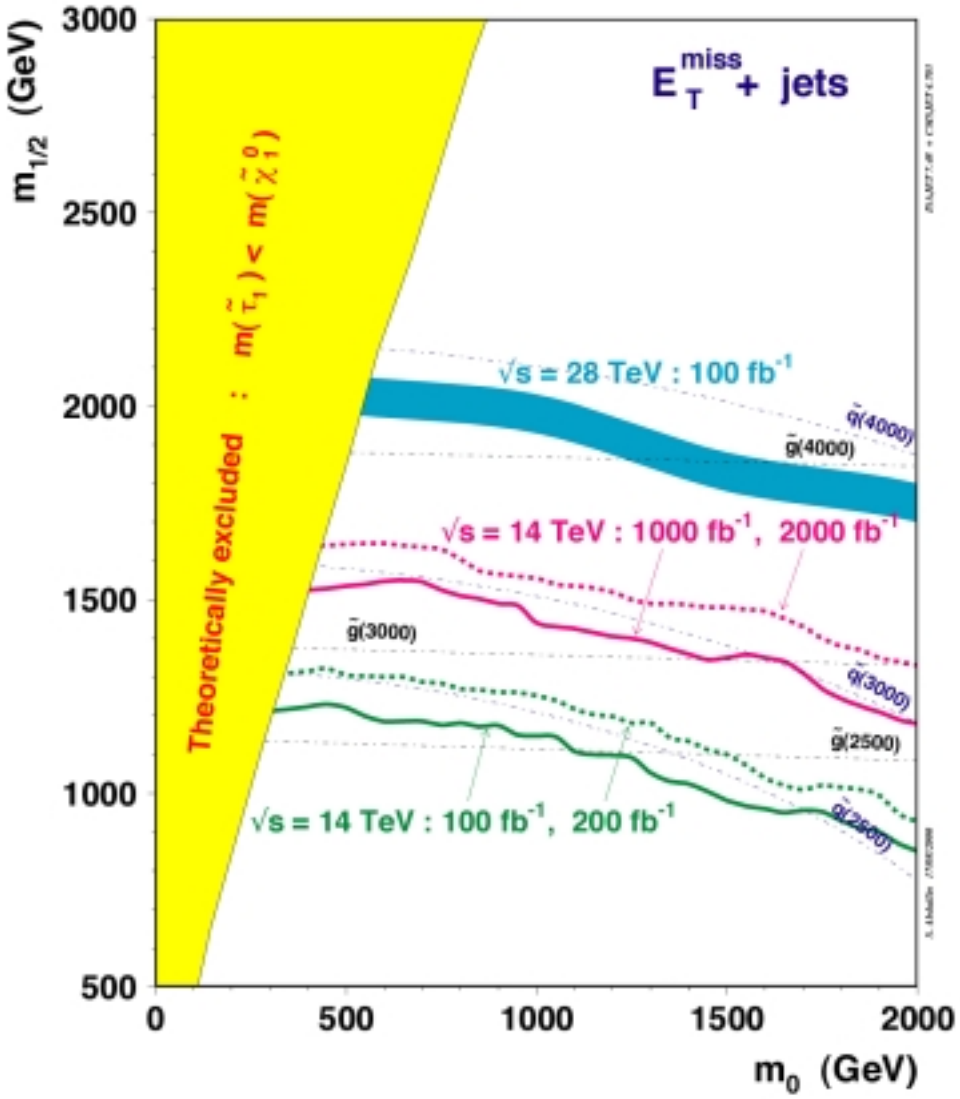


Triple Higgs coupling

Extract λv from σ(e+e-→νν̄HH) for M_H from ≈ 115 to 200 GeV



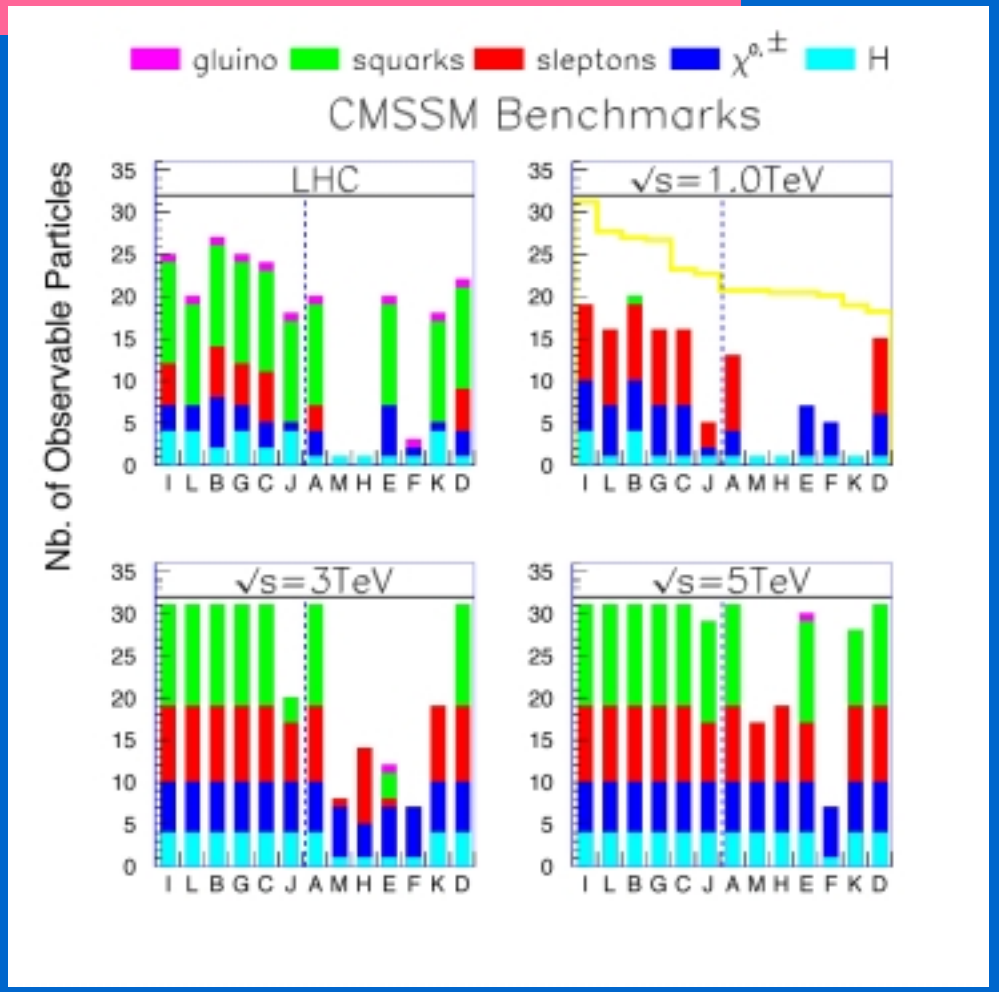
$$e^+e^- \to \bar{\nu} + \nu + H + H$$



Energy reach for SUSY particle searches of a PP collider vs E&Lum.

Exploration of Multi TeV region is necessary to fully understand the Supersymmetry spectrum: the case of e^+e^- LC

M. Battaglia, A. De Roeck, J. Ellis, F. Gianotti, K. Matchev, K. Olive, L. Pape and G. Wilson, CERN – TH/2001-150



Further steps in neutrino oscillations: superbeams

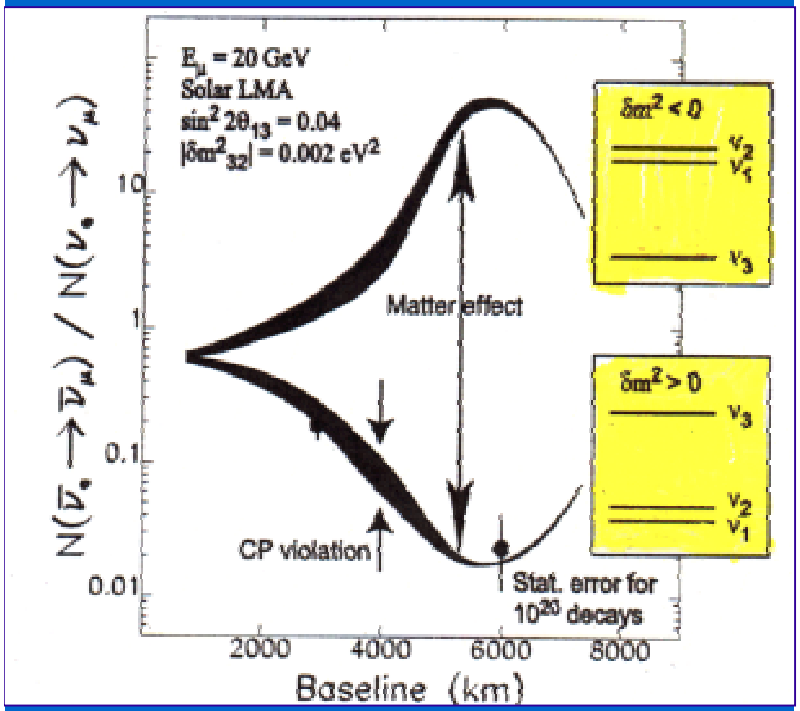
- Most of the phase space covered by FNAL + CERN
- Sensitivity to s13. $\sin^2(2\theta_{13}) \approx 10^{-2} - 10^{-3}$
  - One to two orders of magnitude better than MINOS/OPERA
  - Two orders of magnitude worst than NuFact
- Sensitivity to δ. $\sin^2(2\theta_{13}) \approx 10^{-4} - 10^{-5}$
  - Still to be fully evaluated
  - Limited by
    - Beam background
    - Systematic errors on cross sections

half way from ν factory !

2/27/2001 Juan José Gómez Cadenas Neutrino Telescopes, Venice, March, 20001 31

Search for long-baseline detector laboratories

Best long baseline is around 3000km for CP violation + matter effects.



search for possible underground sites (H. Wenninger et al)
Gran Canaria (Spain); Spitzbergen (Svalbard,Norway);
Center for underground physics Pihäsalmi(Finland)

P. Gruber

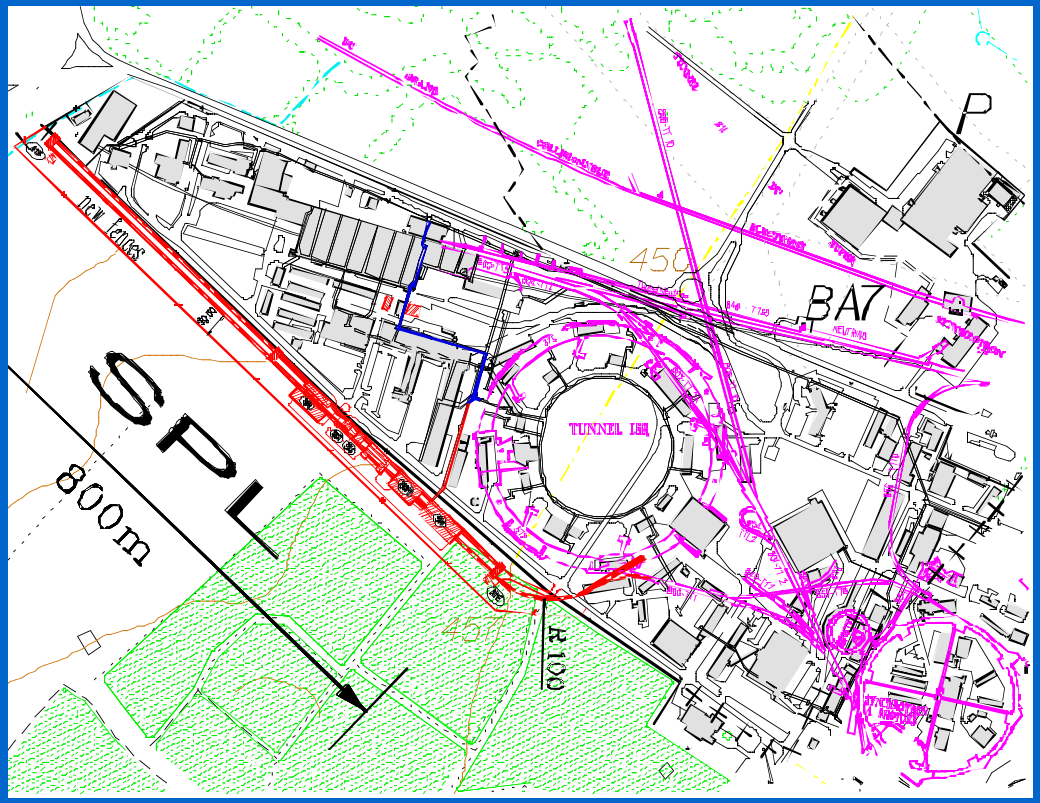
3. R&D in the Medium Term

(What are we doing?)

- PS&SPS upgrading for CNGS
- High intensity proton driver (Superc. Proton Linac-SPL)
  - ν_μ superbeam, towards a ν factory
- LHC 2nd phase (higher luminosity, just started)
- CLIC :
  - Accelerator study (CTF3)
  - Physics study

Not sufficient resources : we are asking a manpower increase to Council

Superconducting Proton Linac: layout on the CERN site



Linac + klystron gallery parallel to the fence of Meyrin site (Route Gregory)

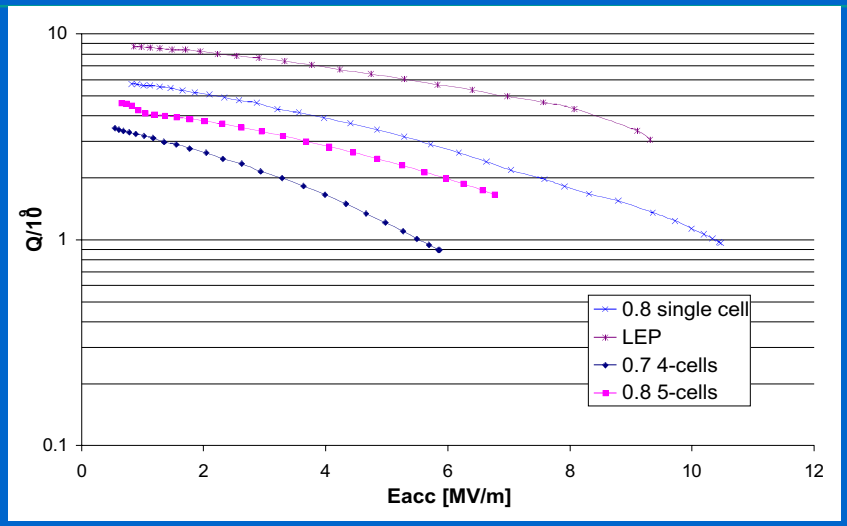
- Economic trench excavation
- Geological advantages (tunnel on“molasse”, no underground water)
- Minimum impact on the environment (empty field)
- Simple connection to PS & ISR via existing tunnels
- Use some of the old ISR infrastructure (electricity, cooling)

The SC cavities for $\beta < 1$

The β=0.7 4-cell prototype

☆ CERN technique of Nb/Cu sputtering for β=0.7, β=0.8 cavities (352 MHz):

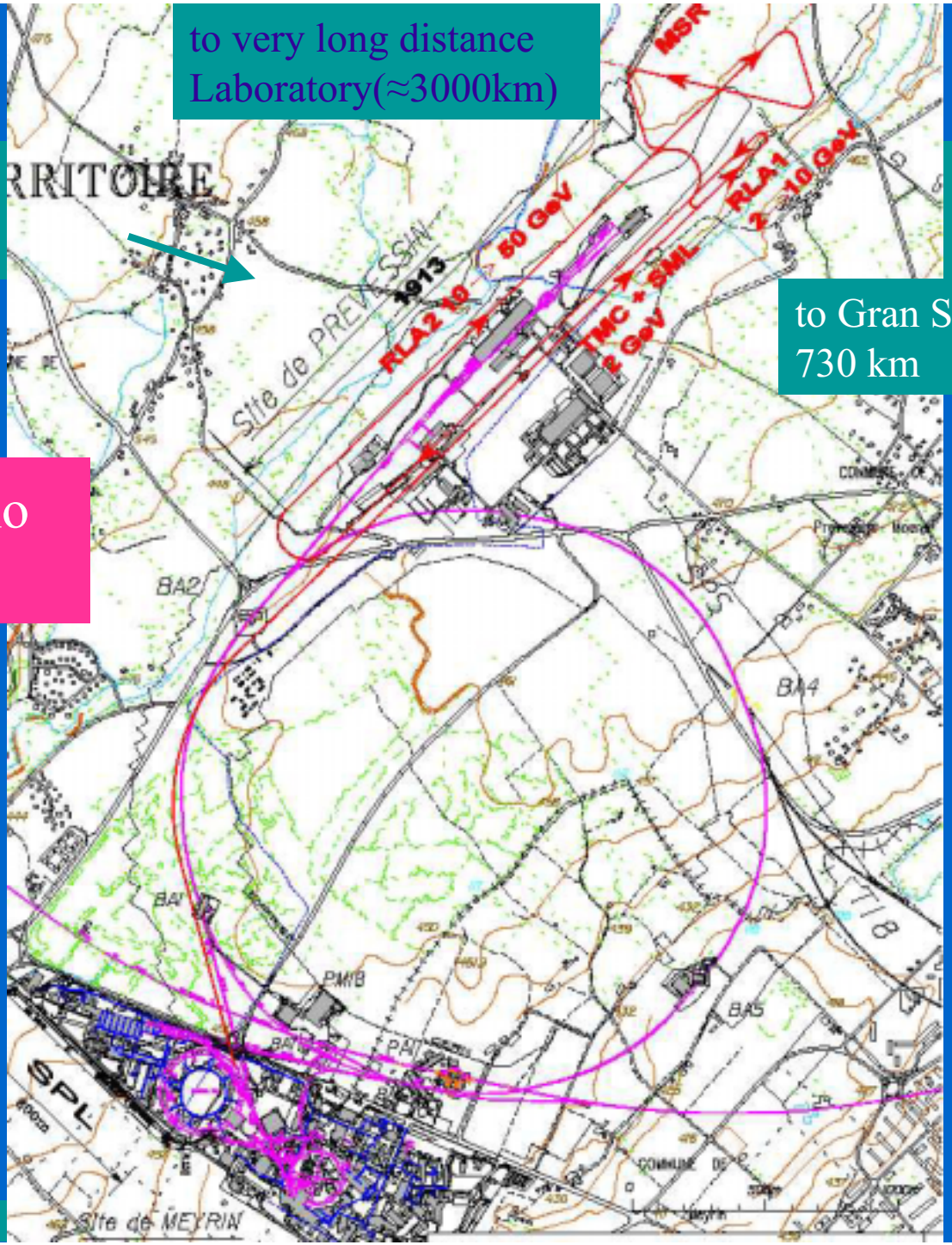
- excellent thermal and mechanical stability (**very** important for pulsed systems)
- lower material cost, large apertures, released tolerances, 4.5 °K operation with $Q = 10^9$



☆ Bulk Nb or mixed technique for β=0.52 (one 100 kW tetrode per cavity)

CERN design of a Neutrino Factory

4MW on target



29/06/01

Nu-factory status

- A truly international effort (e.g. FermiLab and B NL studies)
- substantial investment required (proton driver only ≈20%): more emphasis on CNGS2 ?

- @ CERN:
  - studies have started (proton driver, high power target, HARP…)
  - European collaboration started (CEA, IN2P3, INFN, RAL…)
  - Co-ordination among Int.'l Laboratories is being proposed (to FNAL, LBL, BNL, Cornell, KEK+ EU laboratories)

LHC phase 2?

- Advances in technology may allow detectors to stand luminosity in eccess of the nominal LHC lum. (e.g. 10^{+35} cm $^{-2}$ s $^{-1}$);
- « Luminosity vs. Energy trade »: LHC potential could be extended to >1TeV;
- this MAY BE interesting, depending on LHC findings;
- Intensive R&D is needed for accelerator AND detectors;
- exploratory study is starting;
- High Luminosity requires high field sc- quads (Nb3Sn superconductor ?), which can be good also for a VLHC.

Projet 240 km - Variantes Est et Ouest

SITUATION

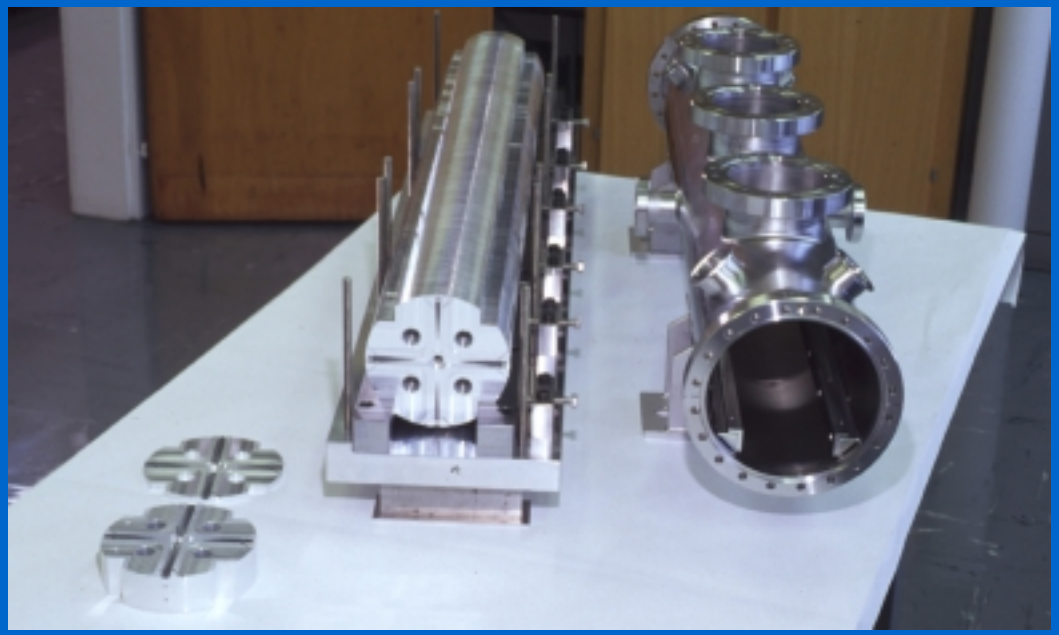
GADZ
GEOTECHNIQUE
APPLIQUEE
DERIAZ S.A.,
CH-1213 PETIT-LANCY 2

Pr. J.C. Fourneaux

VLHC at CERN?
(Circ. = 240 Km)

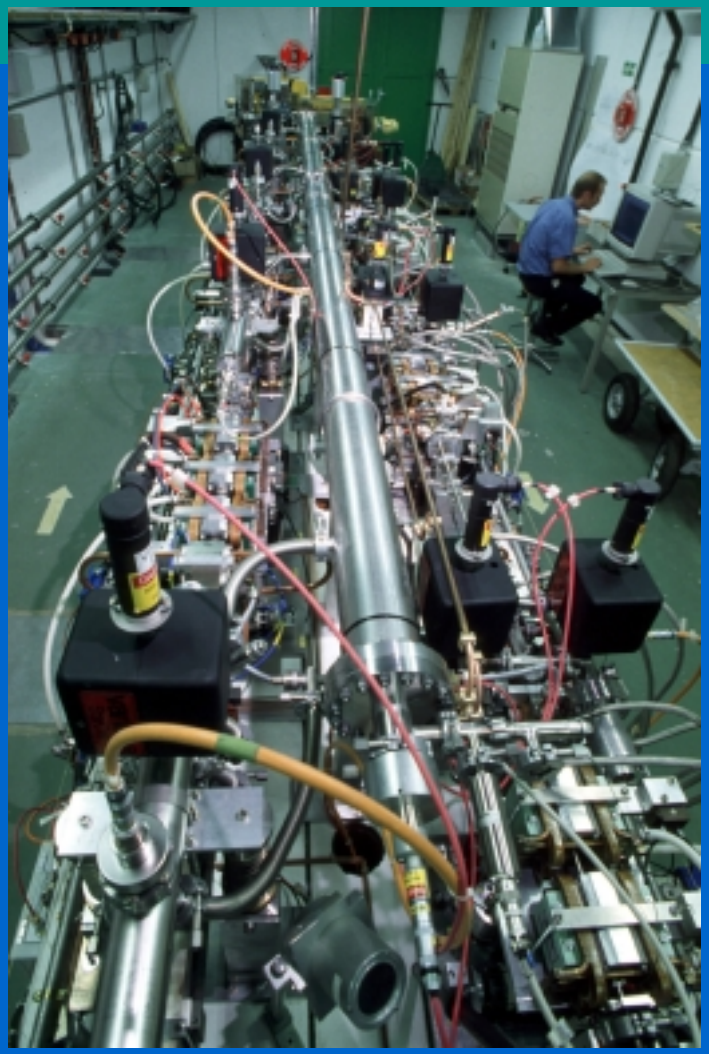
Exploratory study shows prohibitive tunnel cost

Compact Linear Collider (CLIC)

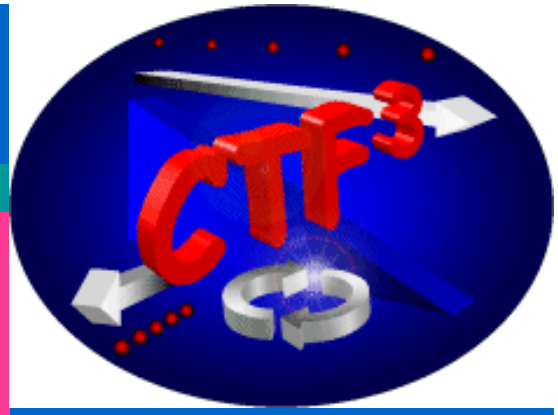


ASSET structure

Overall view of the CLIC Test Facility n. 2

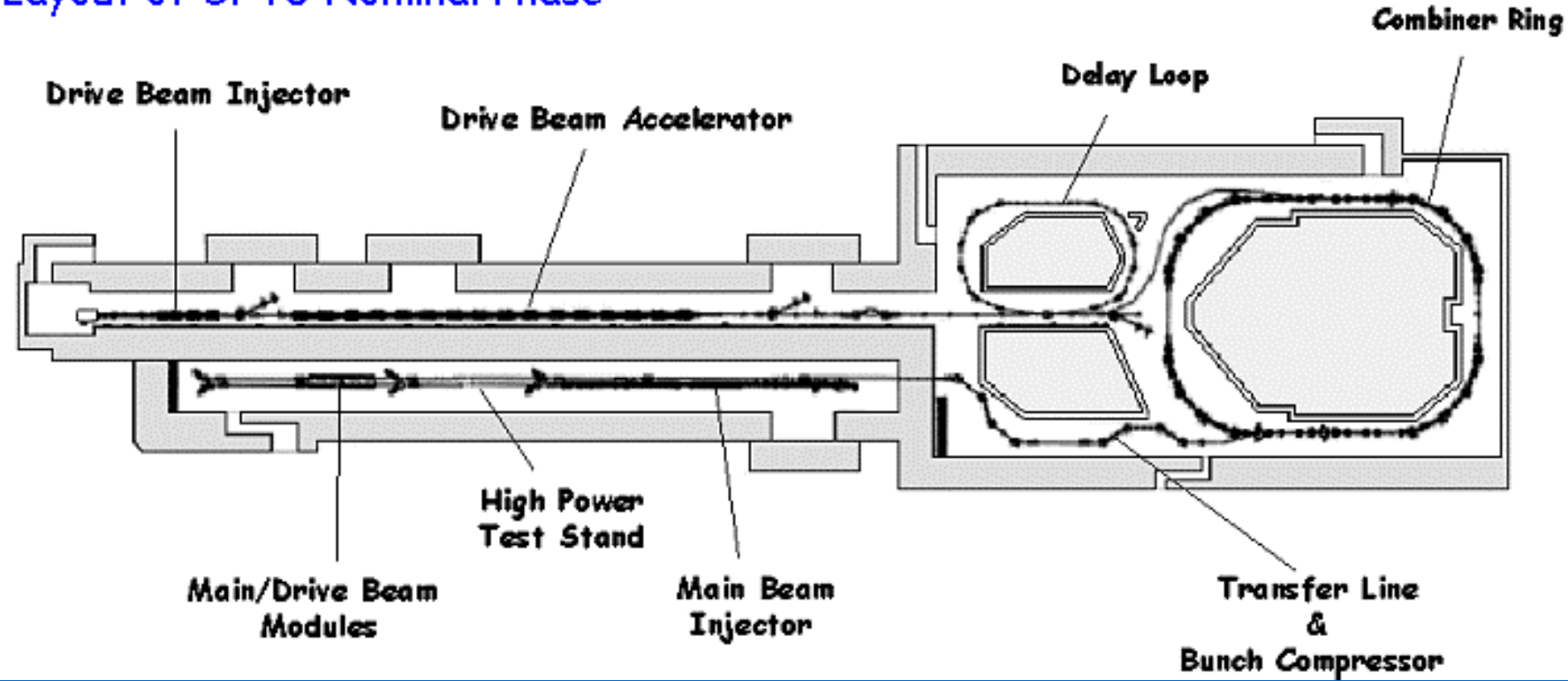


CLIC Test Facility 3



Housed in LEP Pre-Injector building
Construction 2001-2003

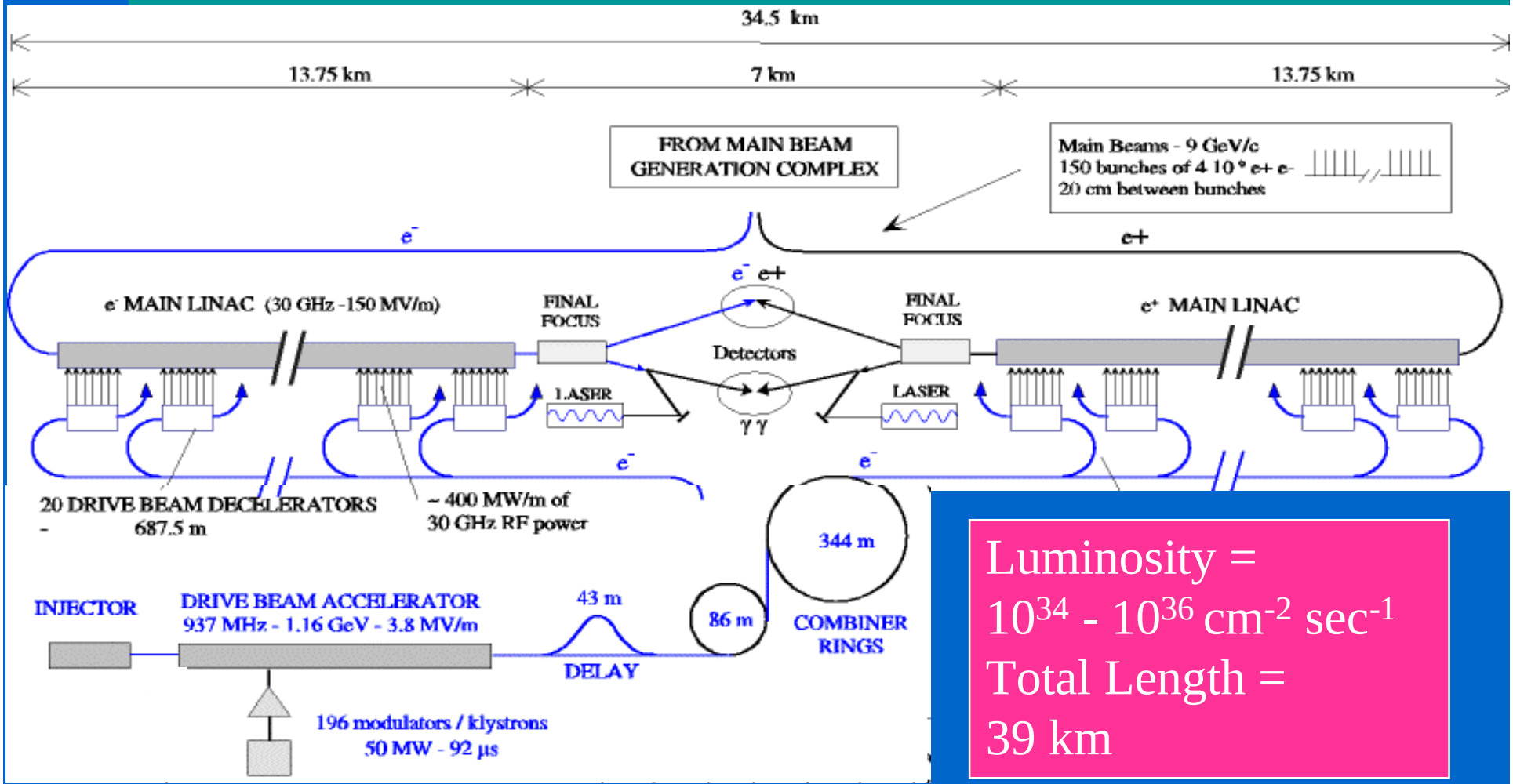
Layout of CFT3 Nominal Phase



CLIC test facility n.3

- to demonstrate a novel concept of drive-beam generation
- to provide the nominal rf power to a few accelerating sections which in turn will operate with the nominal accelerating gradient.
- CTF3 will be a unique 30 GHz high-power rf source for the tests of all the rf components.
- CTF3 will evolve in a staged approach where construction phases alternate with beam test periods. The plan is to have CTF 3 fully exploited by 2005.

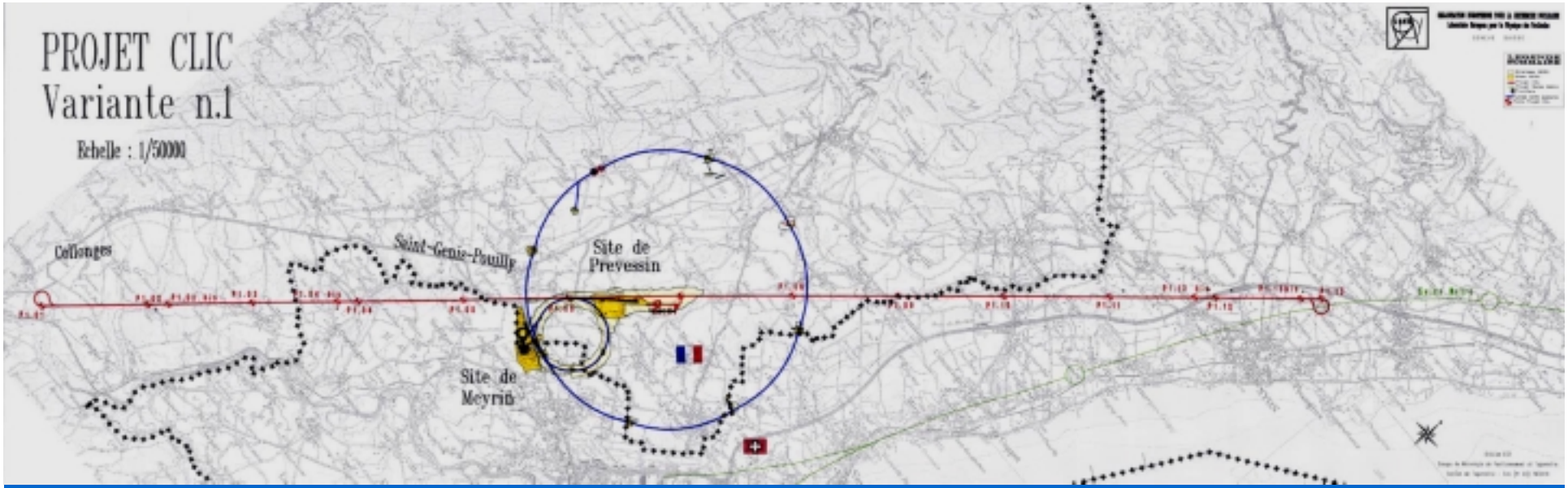
Overall Layout of the CLIC complex at E_{tot}= 3 TeV



Luminosity =
10^{34} - 10^{36} cm^{-2} sec^{-1}
Total Length =
39 km

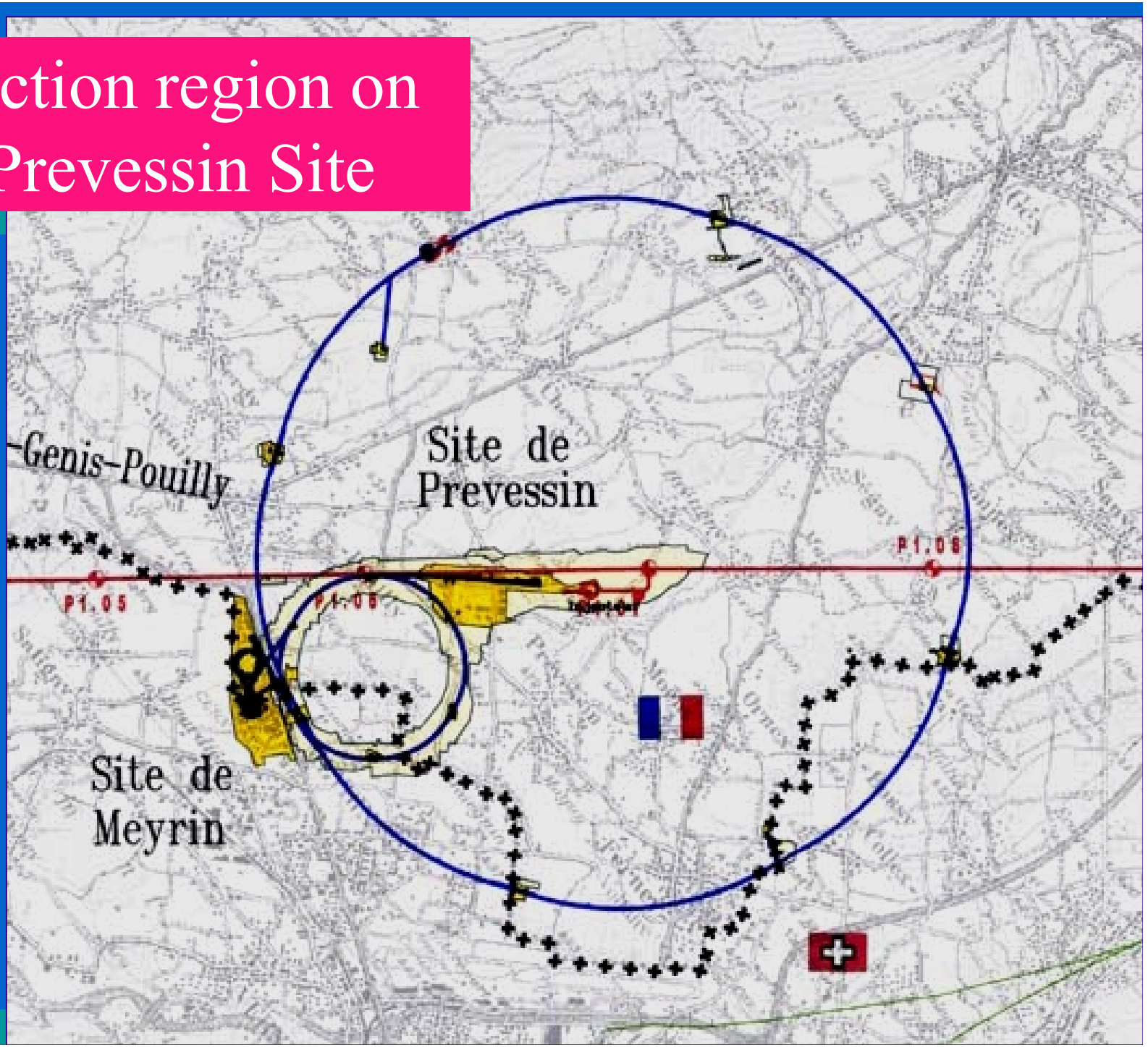
CLIC status

- CTF3 construction started;
- Collaborations with INFN, IN2P3, SLAC are active;
- Closer collaboration with European Laboratories is being discussed (Orsay, Frascati, RAL(?), …);
- CLIC physics studies started at CERN

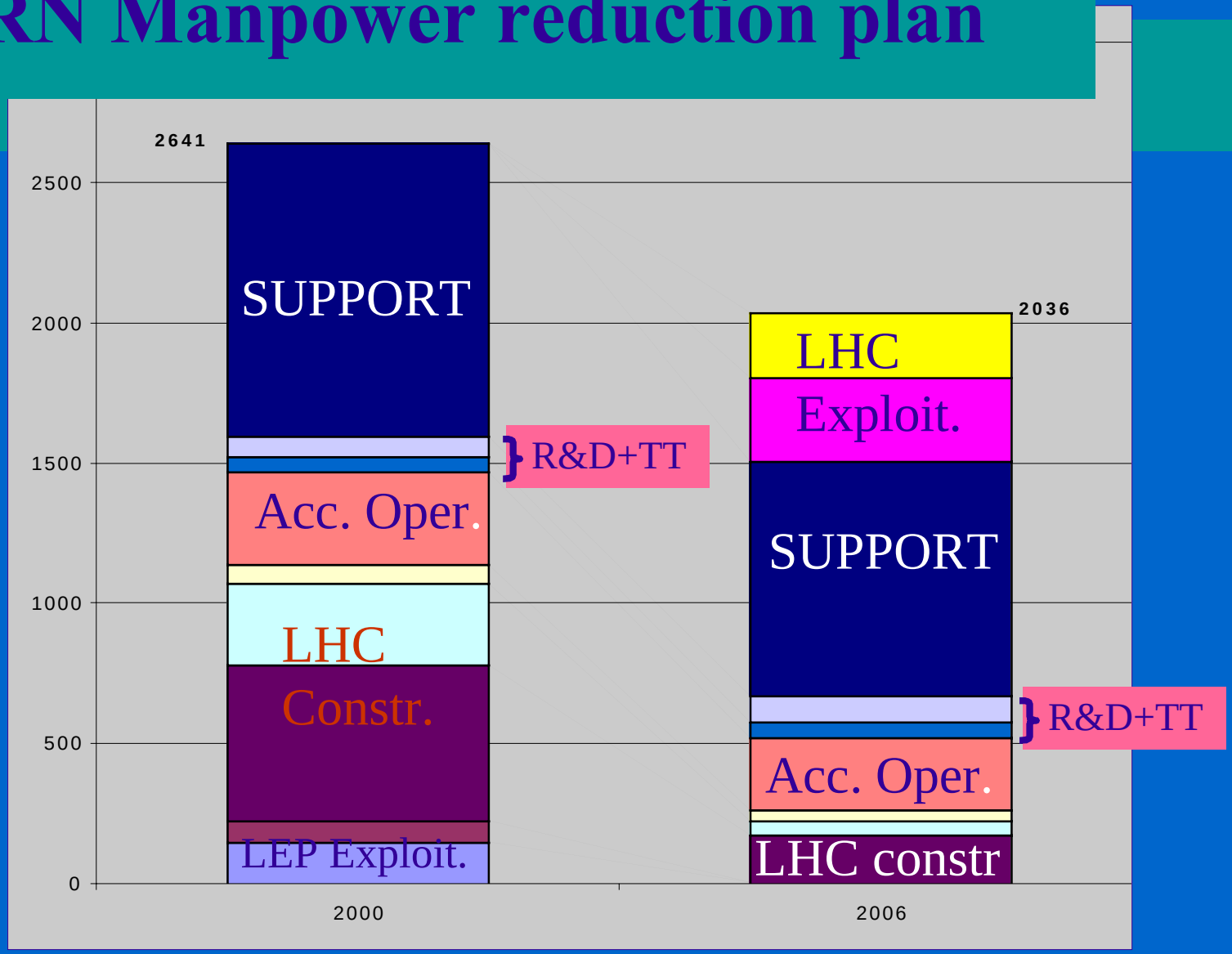


Fitting CLIC at CERN

Interaction region on the Prevessin Site



CERN Manpower reduction plan



A forward look: (1) CERN in 2001-2010

- The LHC programme has been quite tightly funded (contingencies: “time”, “staging & descoping”)
- It is vital for CERN and for Particle Physics that the LHC is completed (within reasonable time and budget) and fully exploited

THIS IS OUR MAJOR CONCERN

•Some R&D is possible -we are asking Council for more manpower;

•No resources are available for other commitments (tight budget & manpower reduction).

A forward look : (2) The long term future

- There are many fascinating problems in the High Energy Frontier and in Neutrino Physics.
- Particle Physics Programme:
  - i. LHC(phase 1+2), NLC/JLC/TESLA: TeV exploration
  - ii. CLIC, VLHC: multi-TeV (muon-collider later?)
  - ιιι. ν -superbeams, ν -factory
- This would allow for a full exploration of the world beyond the Standard Theory as we can conceive it today

Side programmes as gate-ways to other sciences & industrial applications:

- Free Electron Laser
- Neutron Spallation sources
- Data Grids

•After the LHC, CERN will have the aspiration and the capability to be a major player in (ii) and (iii);
•R&D done today leaves open all possibilities.

The long term future (cont'd)

- A project "in the house" is needed, to keep CERN together: CLIC is (today) the best runner;
- Not everything will/can be done at CERN (VLHC better located at FermiLab ?): participaton of CERN to outside projects is likely/necessary.

Rather than "The World Laboratory", I prefer to imagine a Network of Laboratories to plan, organise, finance and realise *The World Programme* sketched above

CAN WE DO IT ????