LHC Accelerator Project

J. Strait
Fermilab

BPPAC   29 April 2003

Outline

LHC Technical Overview

Non-member state contributions

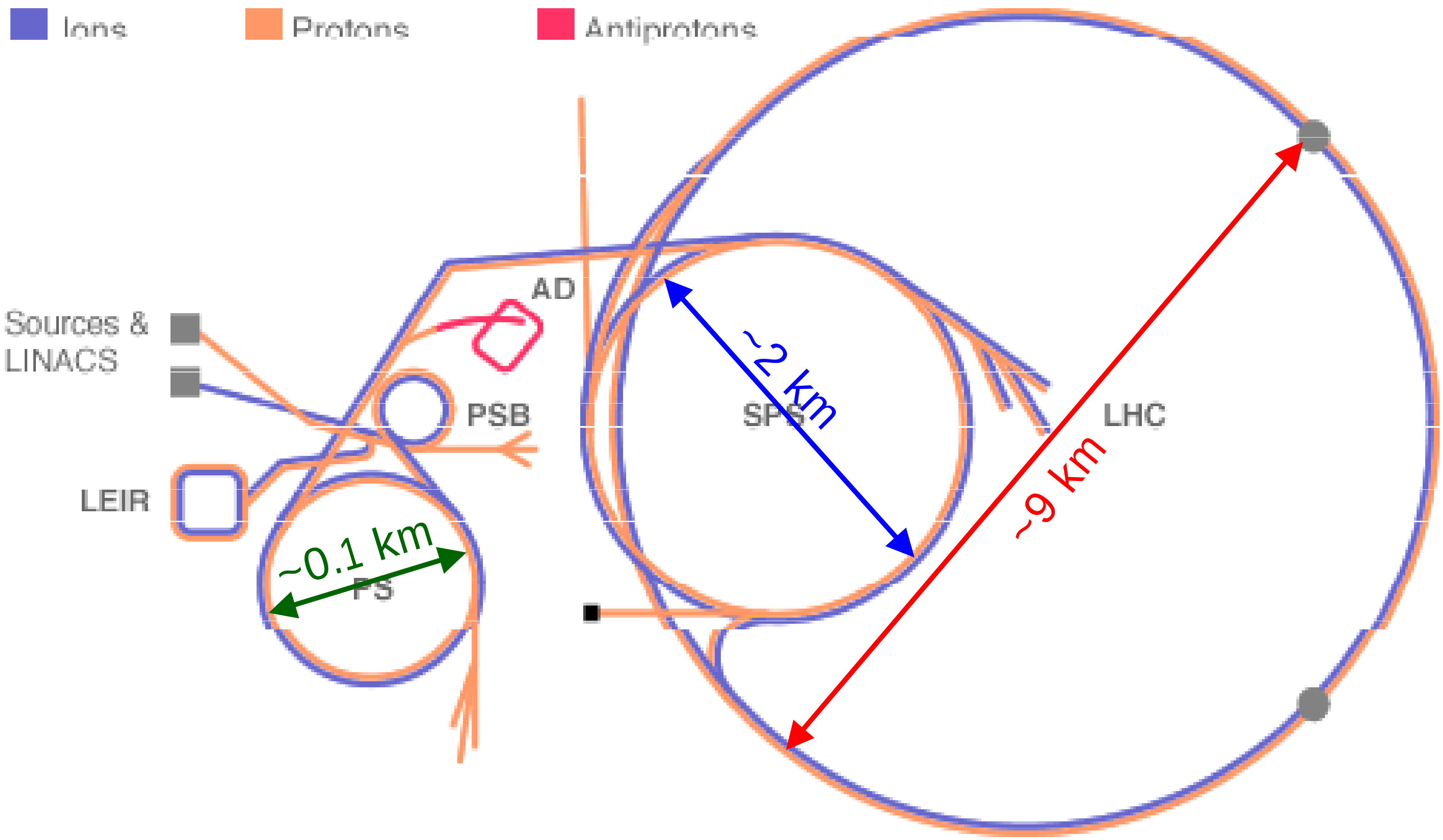
Schedule

Management

- CERN management structure
- Management of the US 3-Lab Project
- Coordination between US Labs and CERN

Extending the US-CERN collaboration

CERN Accelerator Complex



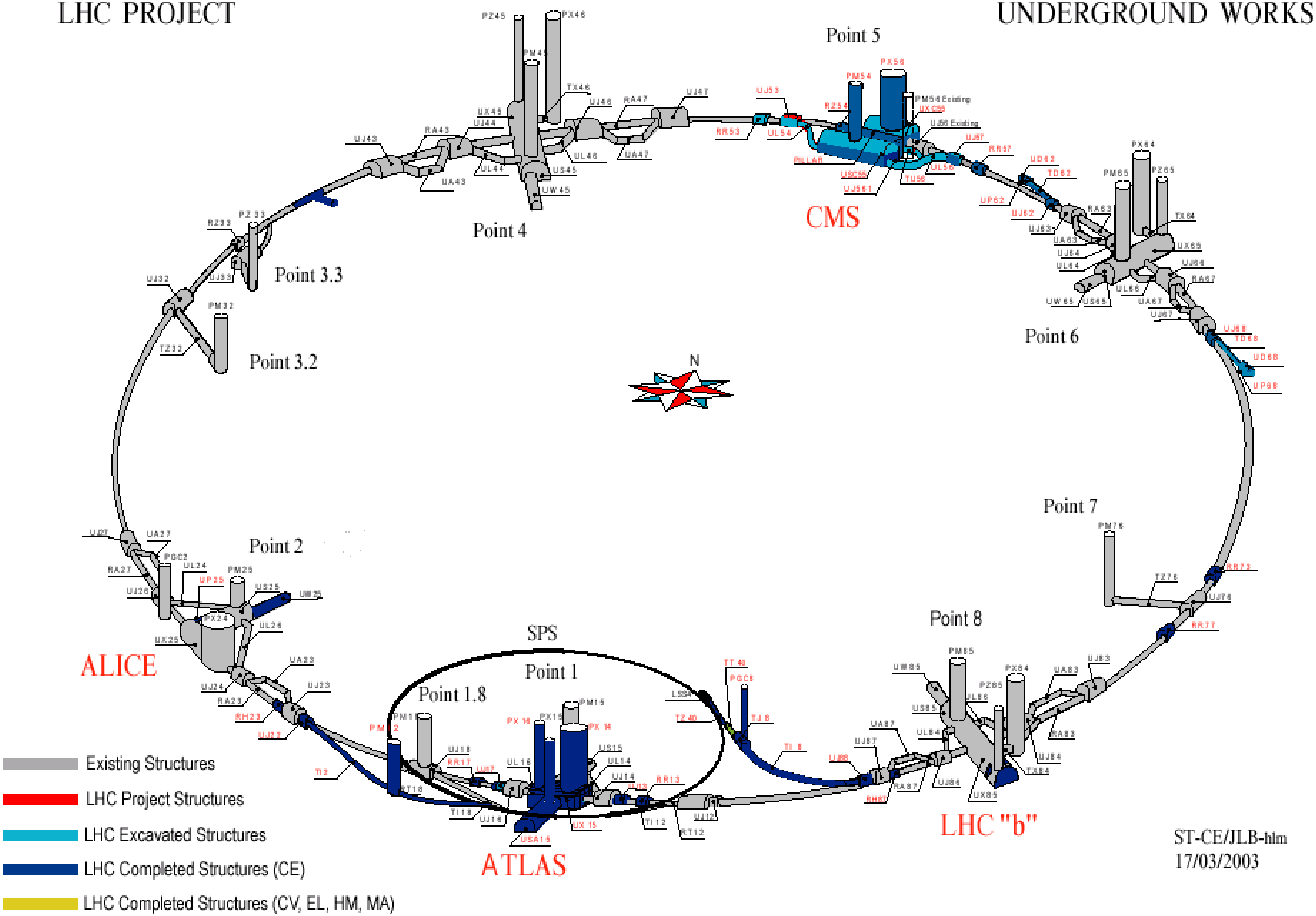
The LHC Accelerator Project

The LHC construction involves almost all of the CERN complex:

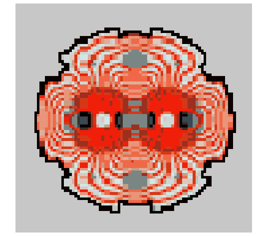
- Significant upgrades to the injectors (Linac through SPS)
- Dismantling existing LEP e^+e^- collider.
- Installation of four large 1.9 K refrigeration systems.
- New SPS to LHC beam transfer lines.
- Major civil construction
  - SPS to LHC beam transfer lines.
  - Modifications to existing LEP/LHC tunnel.
  - New collision halls for ATLAS and CMS.
- New superconducting accelerator in the existing LEP/LHC tunnel.
  - ~7,000 superconducting magnets of ~15 different types.
  - Superconducting RF system.
  - >60 km of high vacuum system.
  - State-of-the-art beam instrumentation and controls systems.

  …..

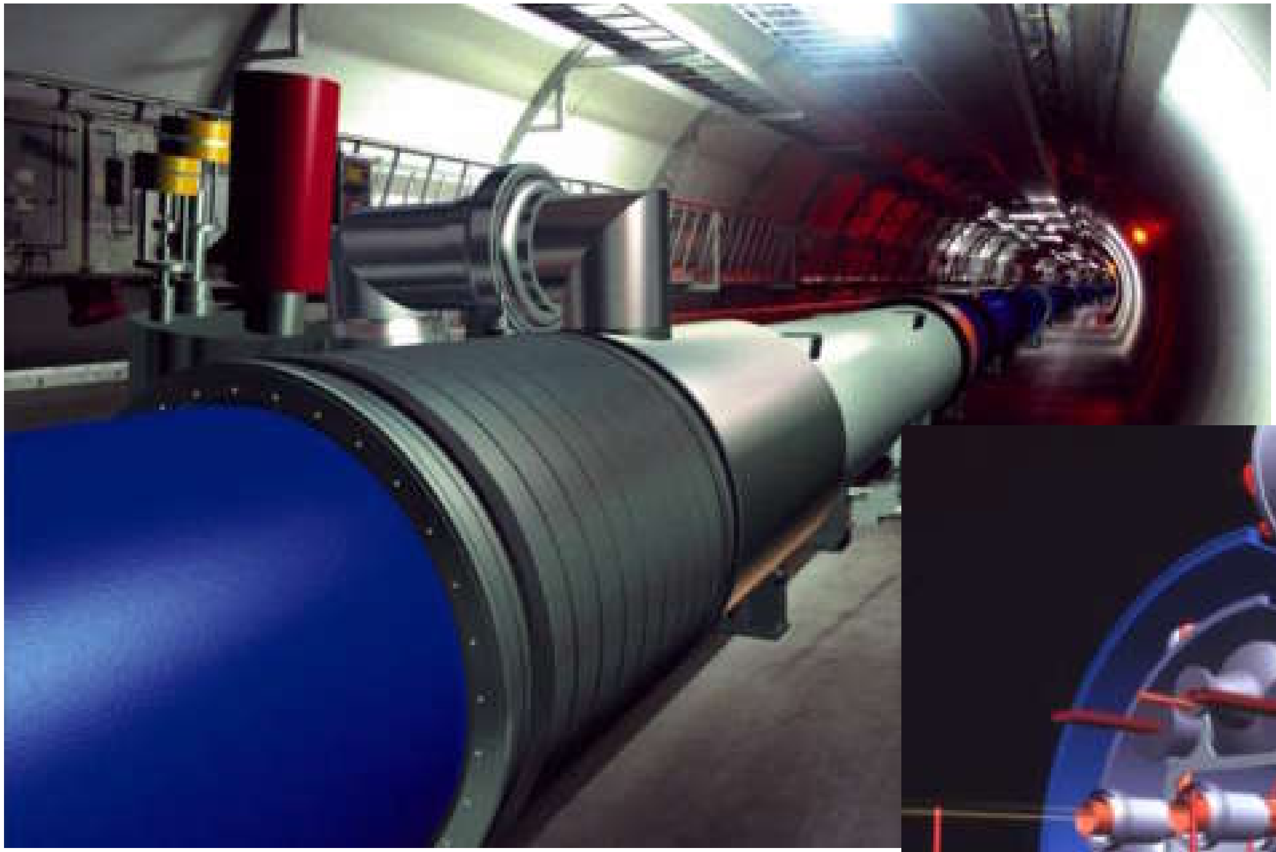
LHC PROJECT UNDERGROUND WORKS

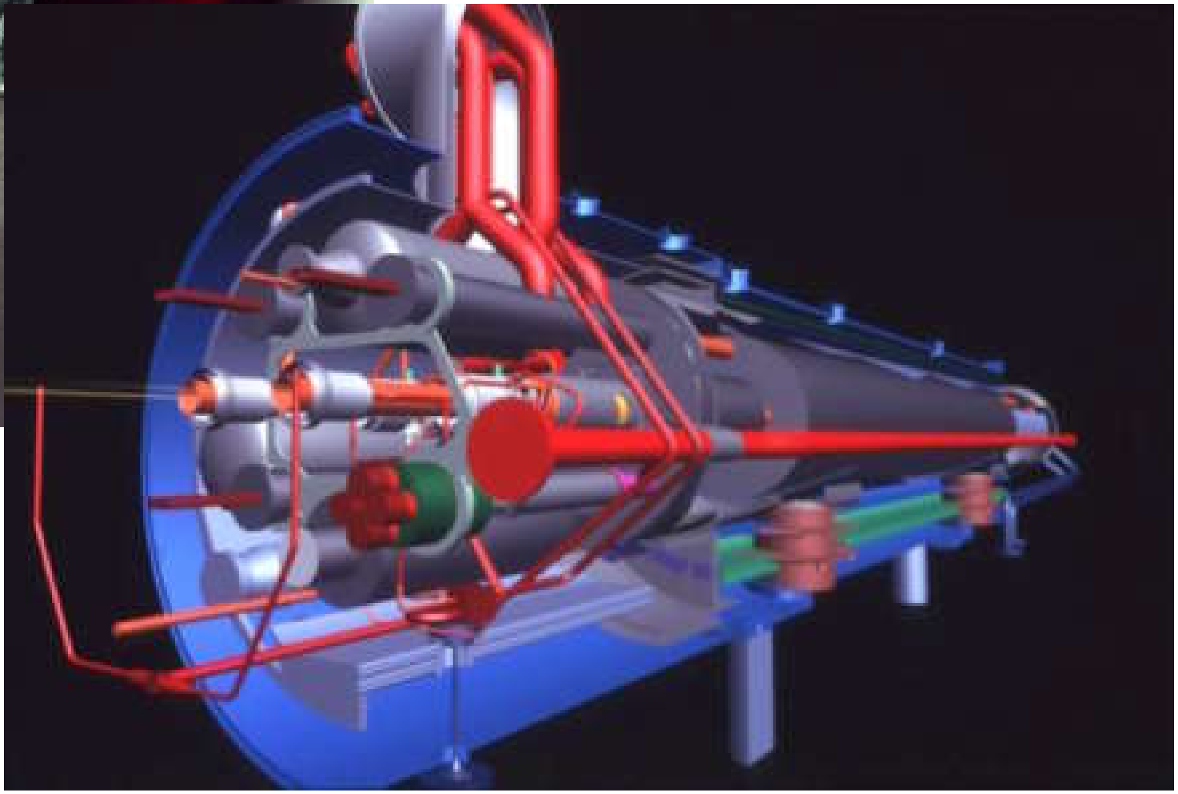


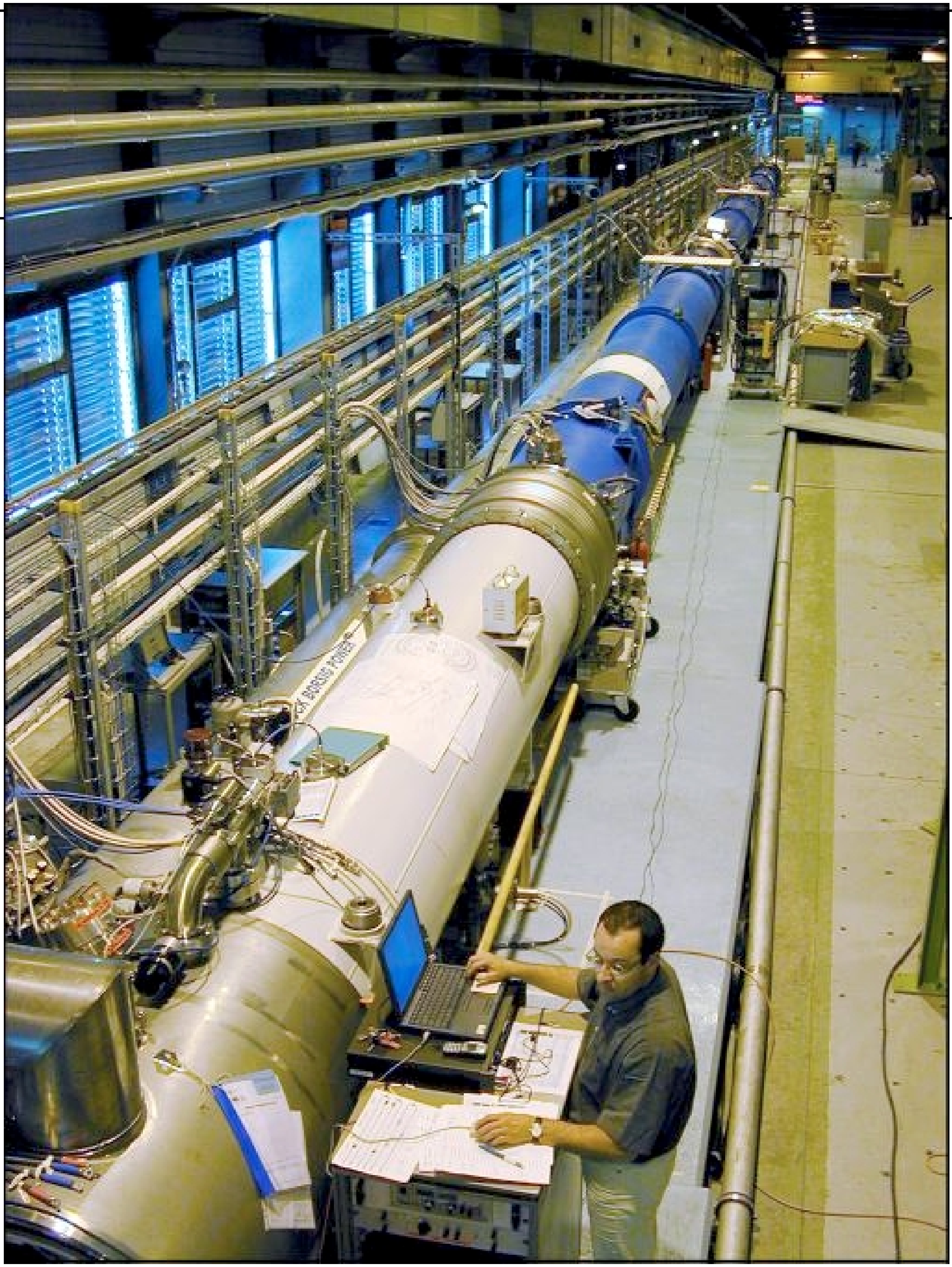
LHC Main Magnets



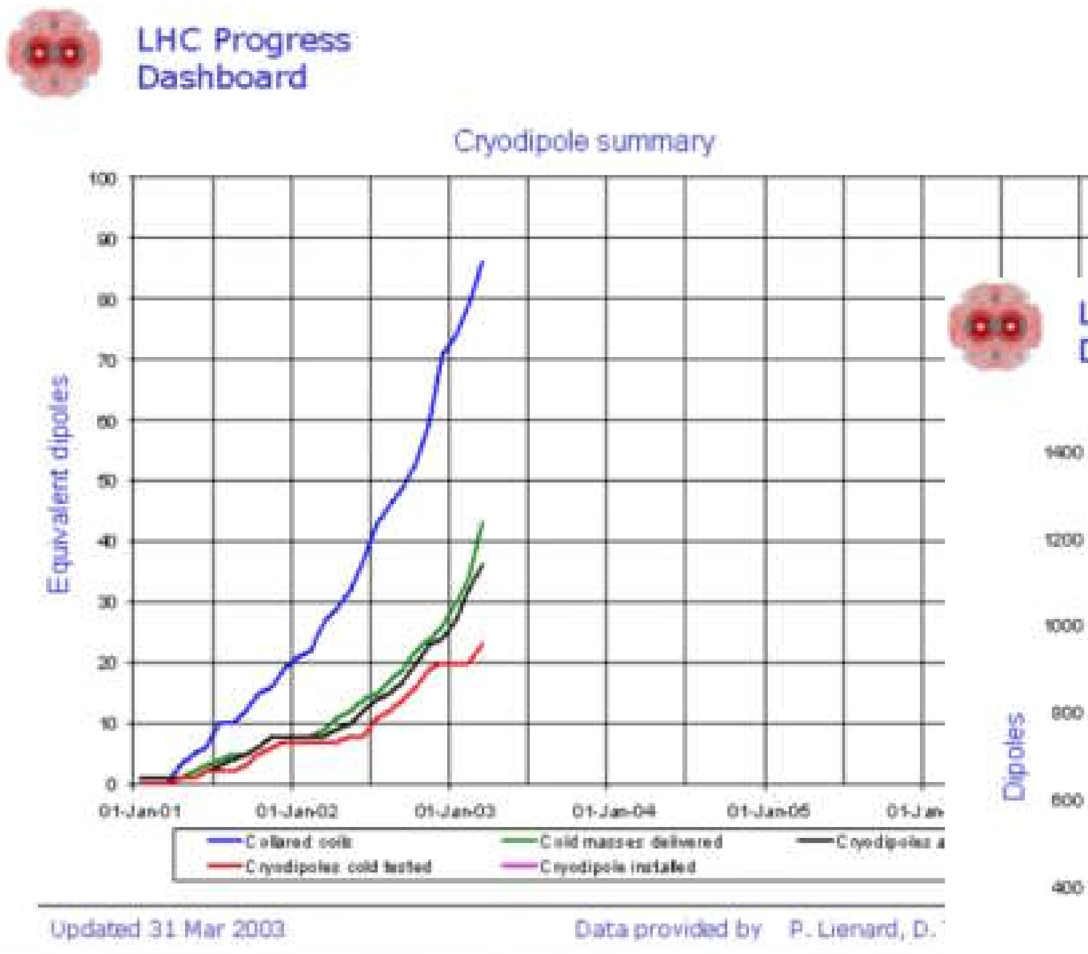
Name	Quantity	Purpose
MB	1232	Main dipoles
MQ	400	Main lattice quadrupoles
MSCB	376	Combined chromaticity/ closed orbit correctors
MCS	2464	Dipole spool sextupole for persistent currents at injection
MCDO	1232	Dipole spool octupole/decapole for persistent currents
MO	336	Landau octupole for instability control
MQT	256	Trim quad for lattice correction
MCB	266	Orbit correction dipoles
MQM	100	Dispersion suppressor quadrupoles
MQY	20	Enlarged aperture quadrupoles

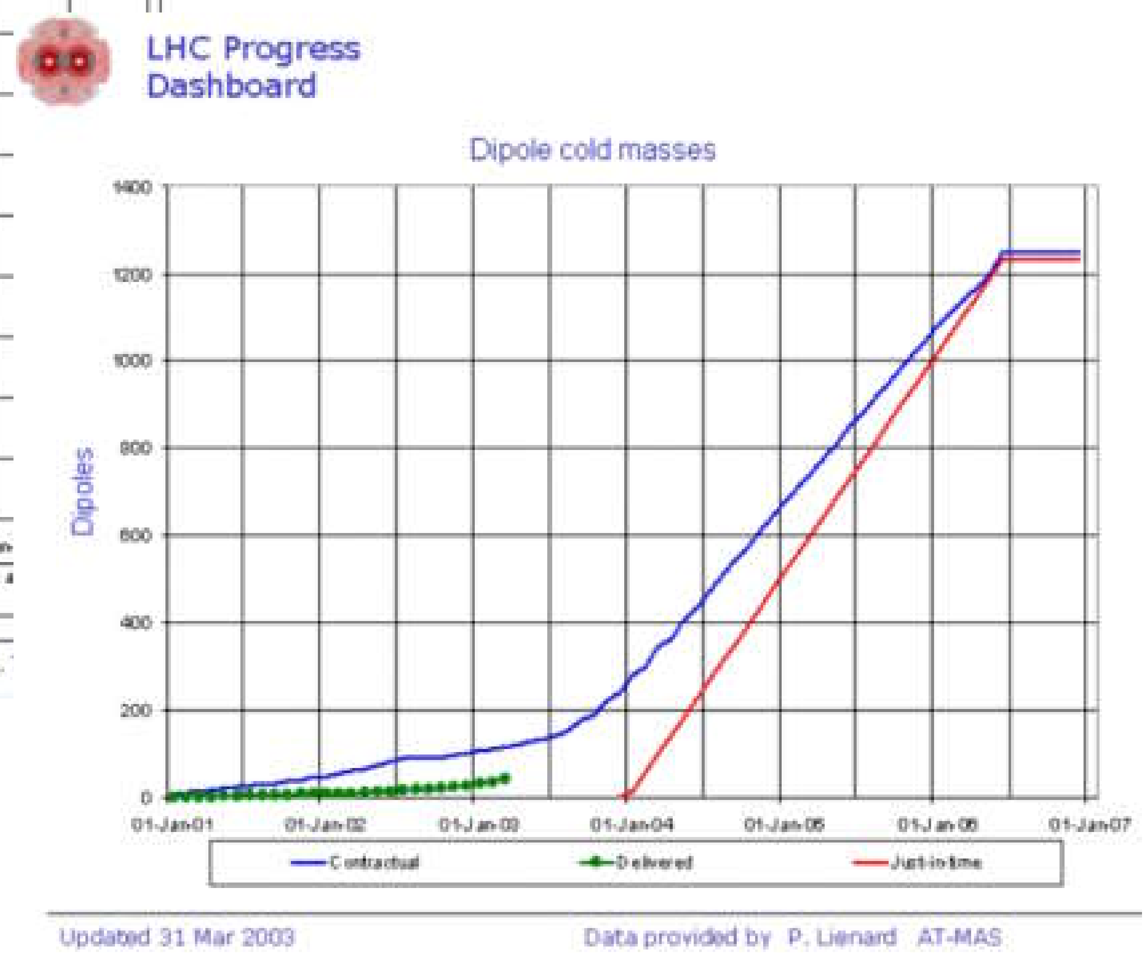




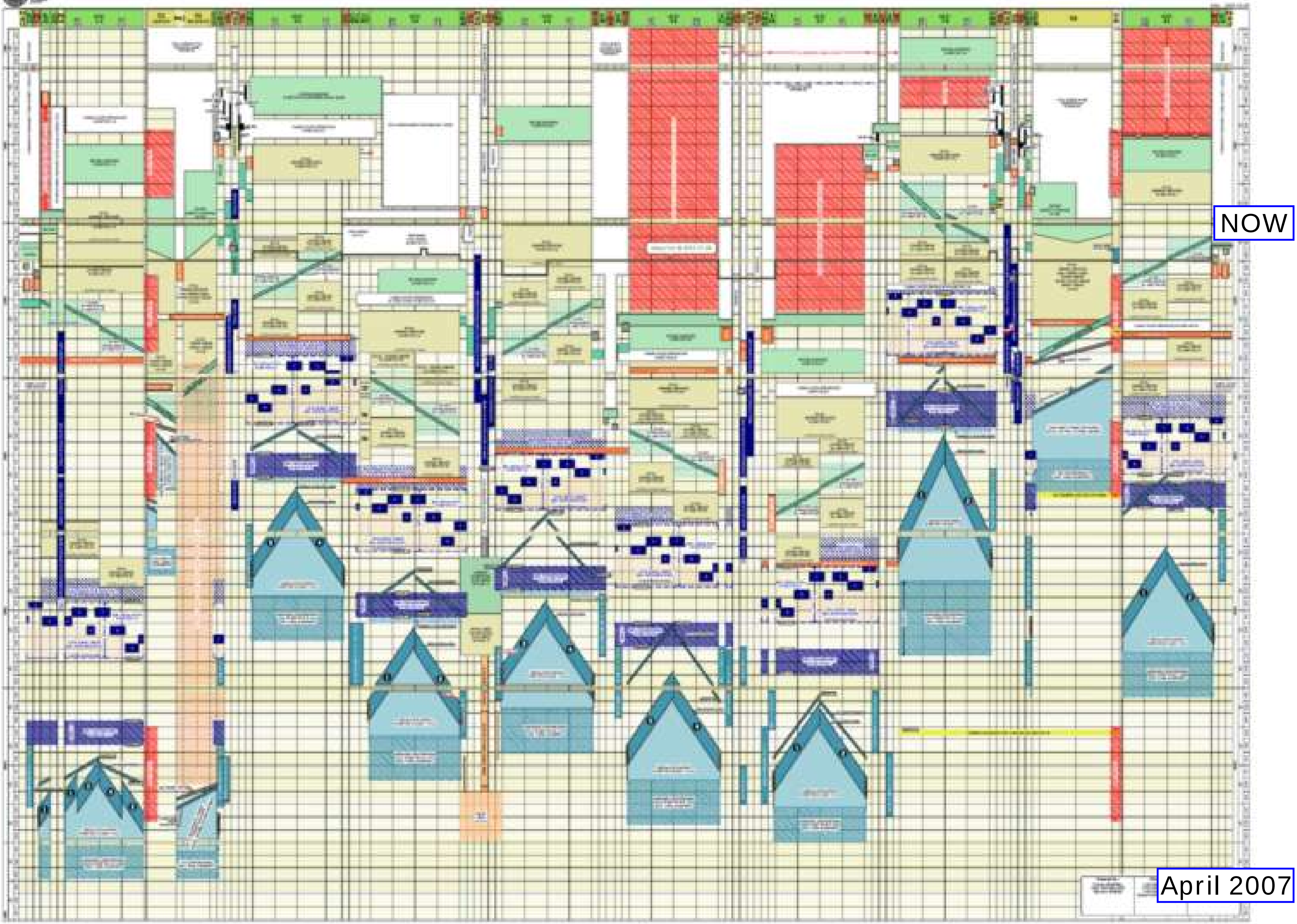


Main Dipole Production





LHC Construction and Installation
General Co-ordination Schedule



International Participation

Construction of LHC involves modest, but significant contributions from outside the 20 CERN member countries:

CERN	~90%
United States	~ 5%
Japan Russia Canada India	~ 5%

This is, however, clearly CERN's project, which the US and other non-member states are helping to build. It is not (yet) a truly global collaboration.

International Participation

http://info.web.cern.ch/info/Press/ 29 April 2003

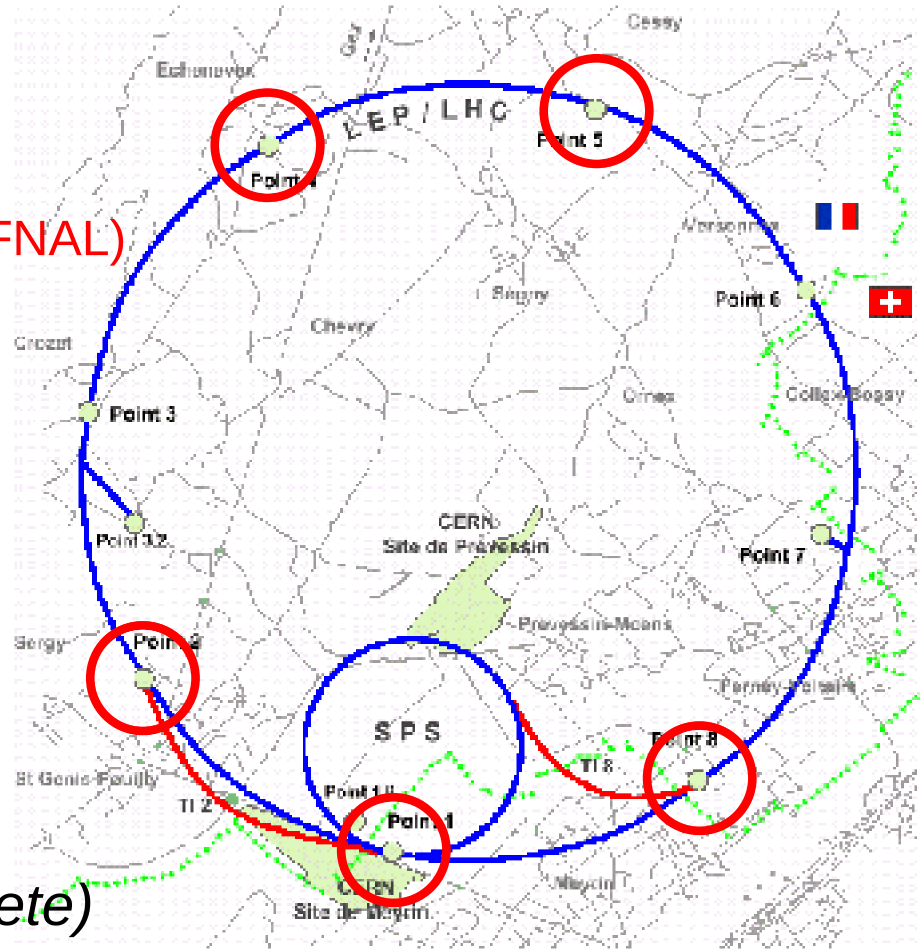
Non-Member State Contributions
United States

IR Final Focus Systems: Points 1, 2, 5, 8
- US-built quadrupoles (FNAL)
- Japanese-built quadrupoles (KEK)
- CERN-provided correctors
- Cryostats for all quadrupole assemblies (FNAL)
- US-built beam separation dipoles (BNL)
- US-built IR feed boxes (LBNL)
- US-built specialized absorbers (LBNL)

RF Region: Point 4
- Beam separation dipoles (BNL)

Wire and Cable for Main Magnets:
- Measurement of SC wire & cable (BNL)
- Cable production support (LBNL)

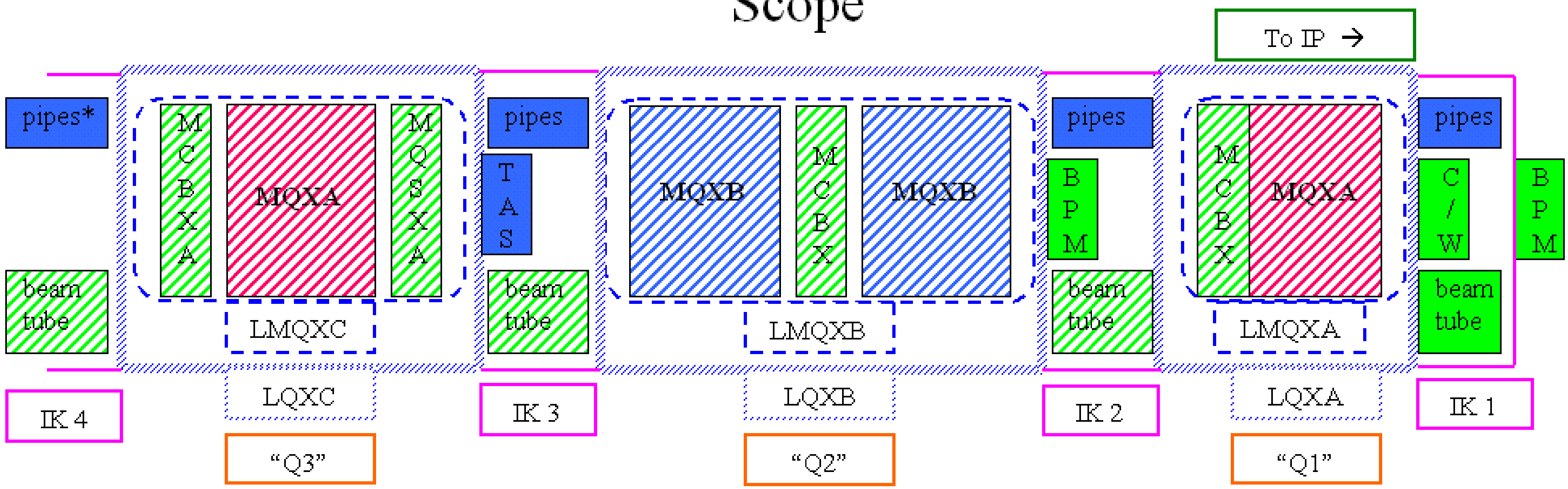
Accelerator physics (all 3 labs - complete)



Project management and oversight (FNAL)

IR Quadrupoles (FNAL)

Scope



Fermilab:

Designs, fabricates and tests the MQXB quadrupole magnet

Designs, fabricates, assembles and tests the LMQXx and LQXx Cryostats

Designs and procures portions of the Interconnect Kits, providing integration support for each

Provides Engineering and Test support for the DFBX

Provides Alignment and Energy Deposition Support for the inner triplet region

FNAL supplied

KEK supplied

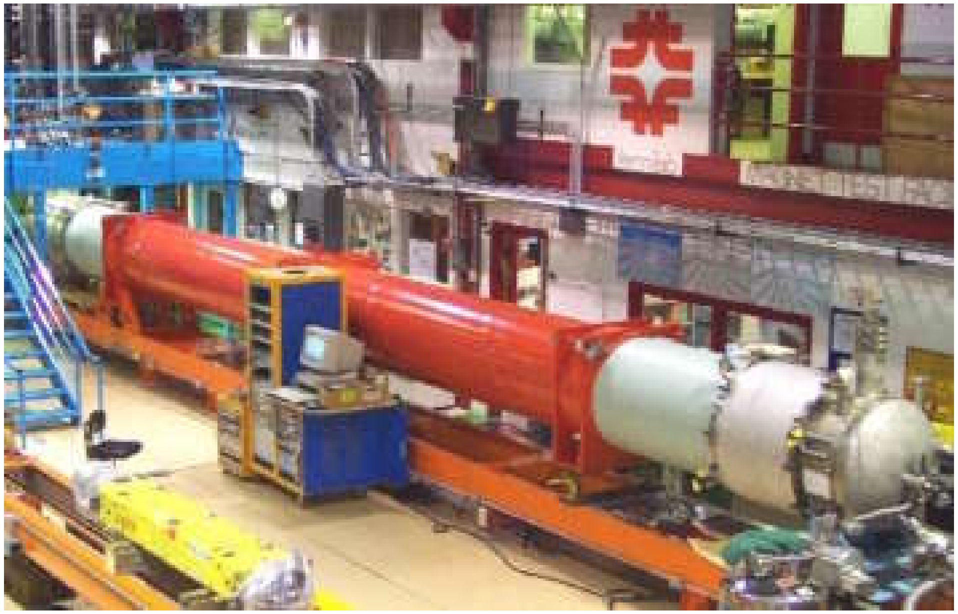
CERN supplied

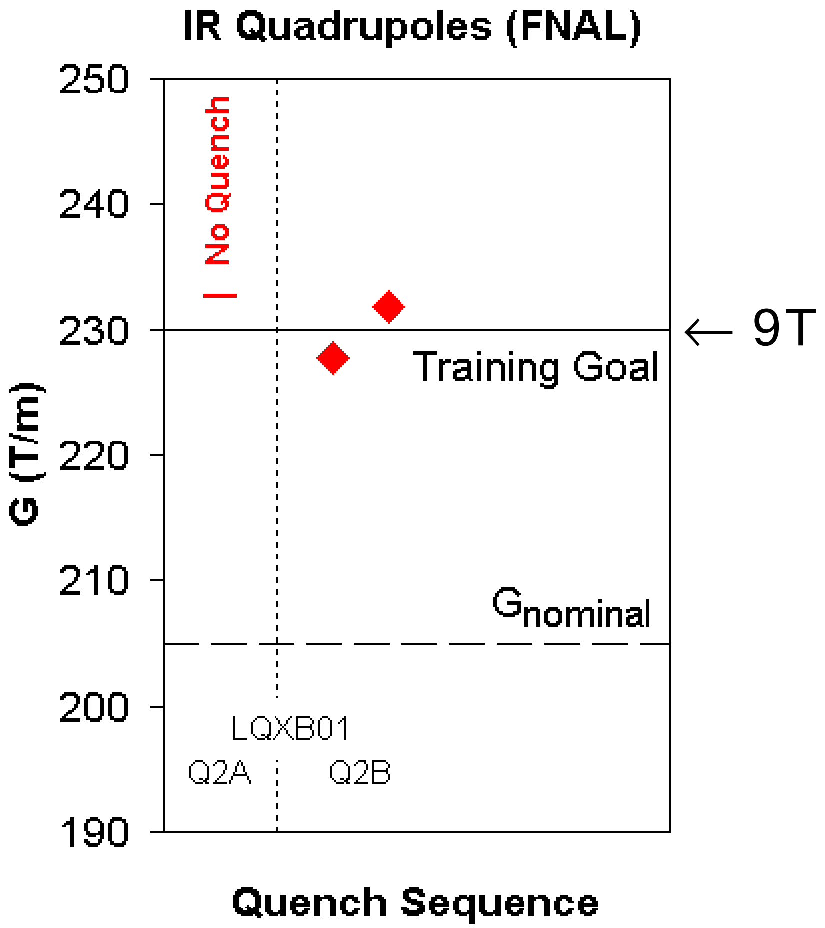
in production

IR Quadrupoles - Status

IR Quadrupoles are well into production.

- First complete Q2 (2 MQXB magnets) is a great success.
- Second Q2 is complete, to be tested soon.
- 5 more MQXB complete
  . . . half the production.
- 5 MQXA delivered from KEK
  . . . more on the way.





Non-Member State Contributions
Japan (KEK)

>9 of 18 IR quads (produced by Toshiba to KEK's design) are done*.*
Performance matches that of FNAL quads.

Cross Section

A. Yamamoto

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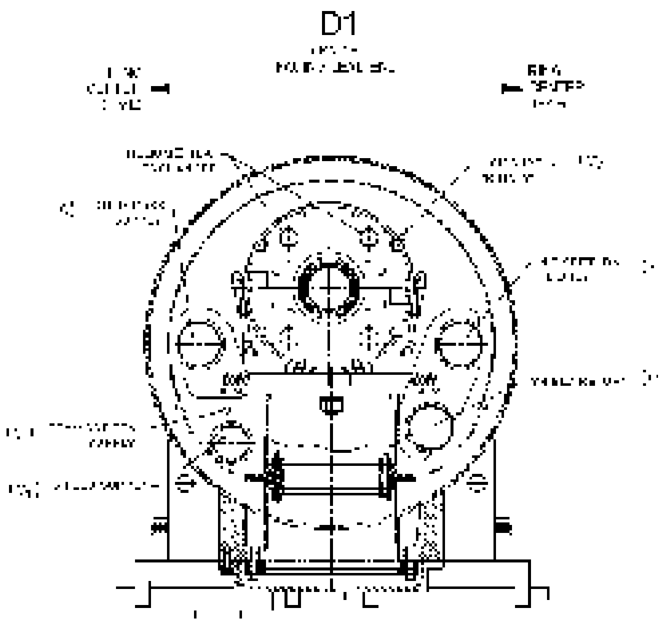
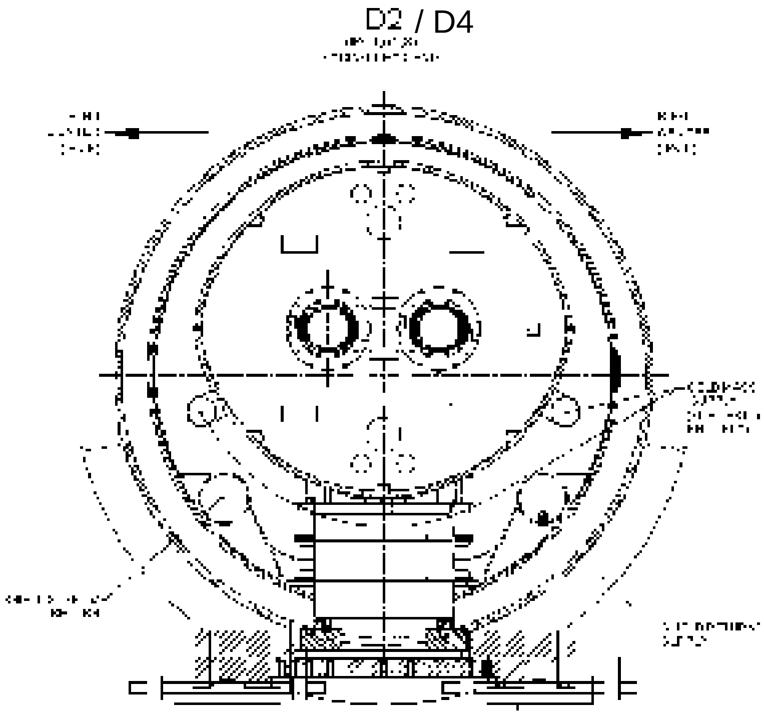
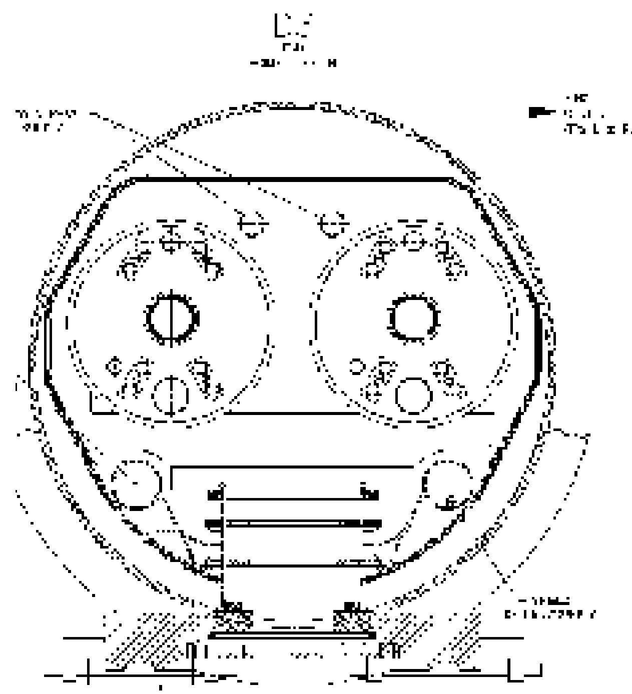
Beam Separation Dipoles (BNL)







D1 - IR 2 and 8

D2 - IR 1, 2, 5 and 8

D4 – IR 4

D3 - IR 4

Beam Separation Dipole Status

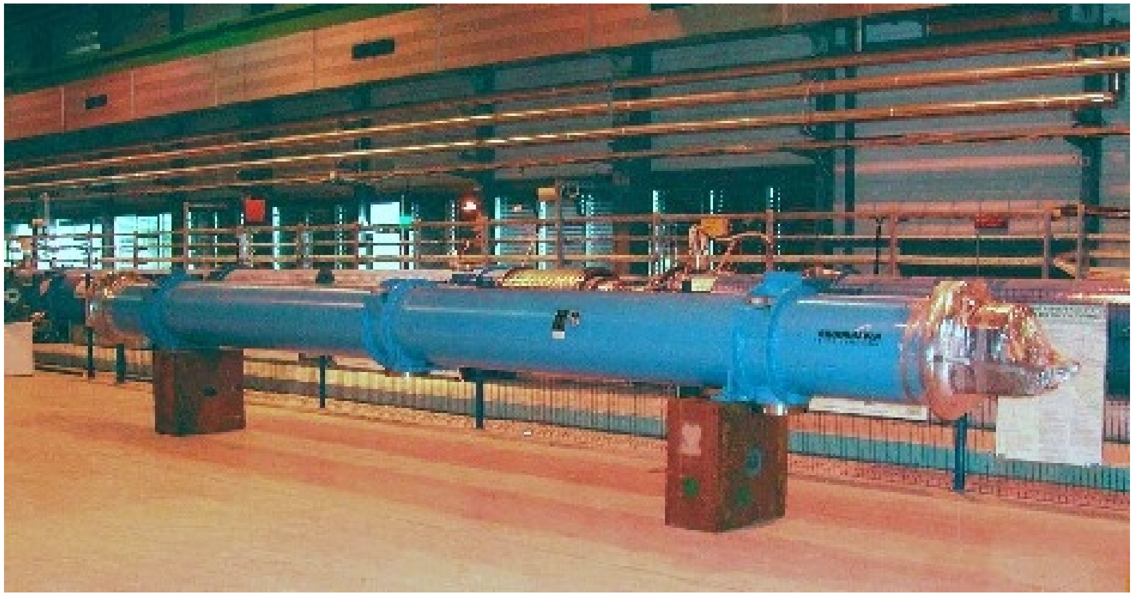
Beam separation dipoles well into production.

D1 - Construction and testing of all 5 D1's is complete.
- Two are at CERN, remaining 3 are being prepared to ship.

D2 - Construction of all 9 D2's is complete.
- First 4 have been tested and the 5th is under test.

D4 - One cold mass complete.
- Coils collared for remaining 2.

D3 - All coils wound.
- Four of six magnets collared.



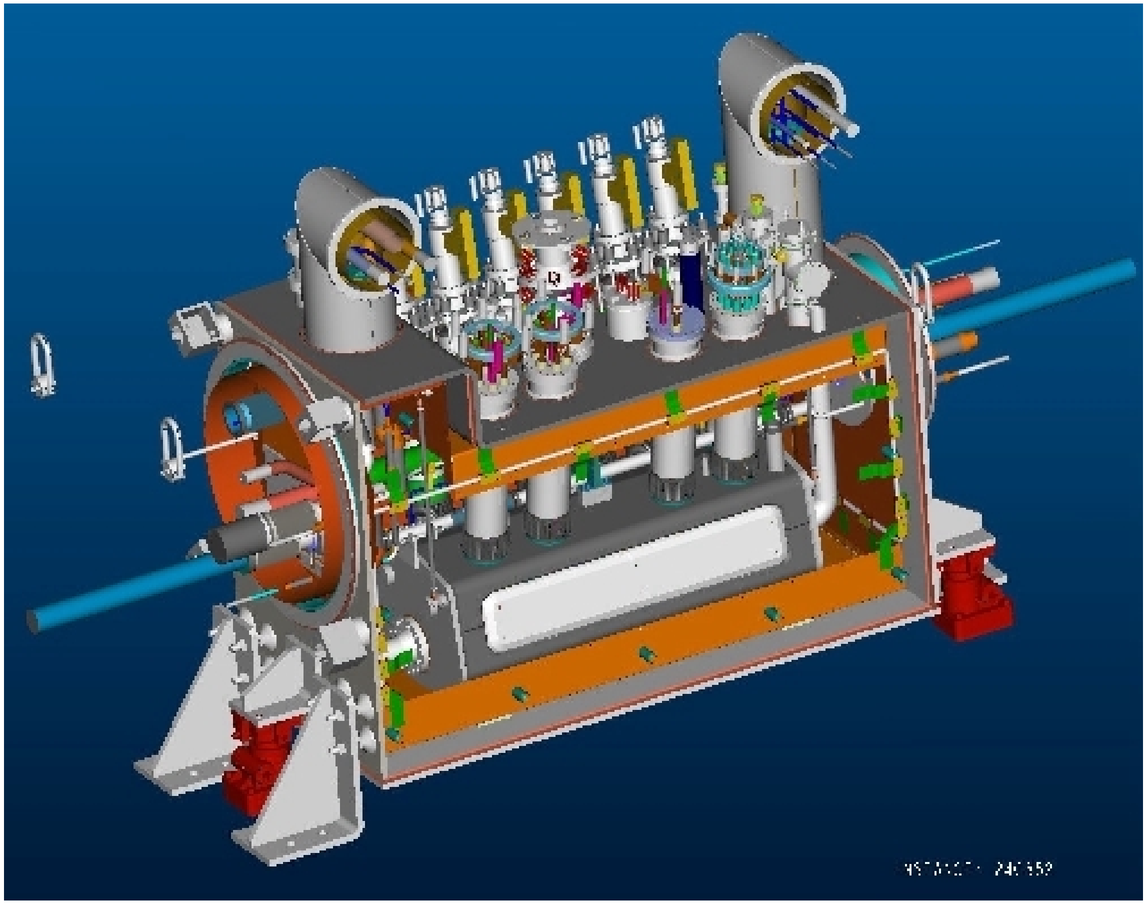
IR Feed Boxes (LBNL)

Recently signed big contract for feedbox assembly.

- Highly qualified vendor … near Fermilab.
- Complex assembly … requires close communication with vendor.
- HTS leads being delivered to Fermilab for testing.
- Vapor cooled lead contract signed.
- Fabrication of lab-provided components has started.

But

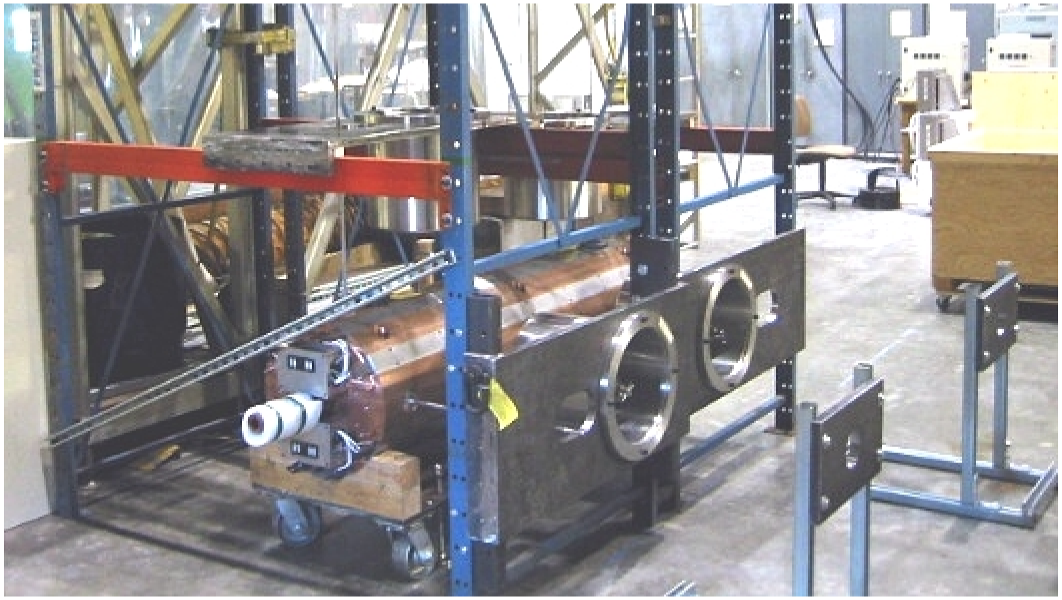
- Schedule for completion of the job is tight.



IR Absorbers (LBNL)

IR Absorbers production assembly nearing completion.

- Last major component – TAN beam tube – being e-beam welded.
- Final assembly and test of TAS is under way.
- Plan to ship all absorbers by June 2003.



Russian In-kind Contributions

Protocol

In-kind contribution up to 110 MCHF

Protocol is linked to a Fund

Fund

CERN contributes one third of value* to a Fund that is dedicated to:

- Support of Russians at CERN
- Contributions to LHC experiments
- Materials & tools for Addenda.

Transfer line dipoles – major in-kind contribution

Fund

CERN contributes half of the value.

ind contributions

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P. Bryant

Canadian In-kind Contributions

Protocol

In-kind Contribution via TRIUMF*:

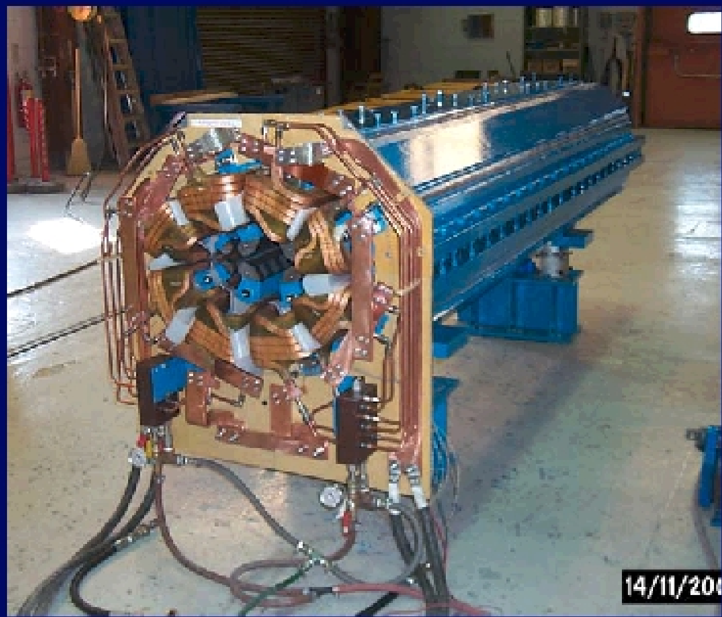
- $19M equipment.
- $11M salaries.

(equiv. to 33 MCHF)

Extension

$11.5 M (equiv. to 12.6 MCHF)

Warm twin-bore quadrupoles for the collimation insertion – a major contribution



Tasks

Beam dynamics studies	Completed
Instrumentation for SPS	-"-
Power equipment for PS upgrade	-"-
Magnets for PBS and PS linac	-"-
Kickers for PS injection	-"-
40 MHz cavity for PS	-"-
52 warm twin-aperture quads for collimation insertion	Underway
66 kV converters for LHC injection	-"-
PFNs for LHC injection	-"-
LHC beam monitoring electronics	-"-
Collimation studies	

* Values are given in Canadian dollars.

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P. Bryant

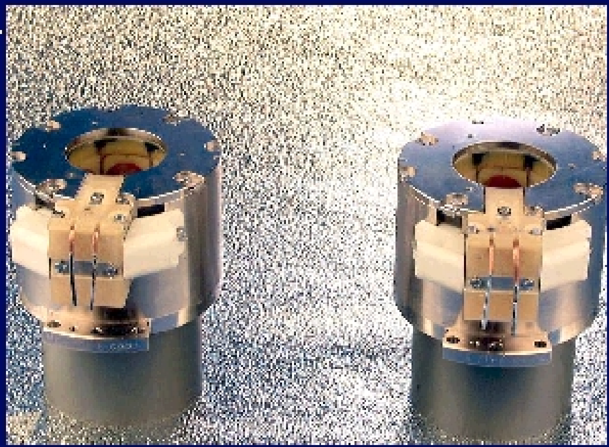
Indian In-kind Contributions

Protocol
In-kind Contribution up to 34.4 MCHF.

Protocol is linked to a Fund

Fund
CERN contributes one half of the value* to a Fund that is dedicated to:
- Support of Indians at CERN.
- Contributions to LHC experiments.
- Occasional purchase of material.

Superconducting sextupole correctors - major in-kind contribution



Addenda (Tasks)

	Approved [MCHF]	Delivered [MCHF]
Addenda (20)	23.96	5.66

Extension (new)
Approved 26 MCHF

Fund
CERN contributes half of the value.

*Values are given by the estimated European value of the In-kind contributions

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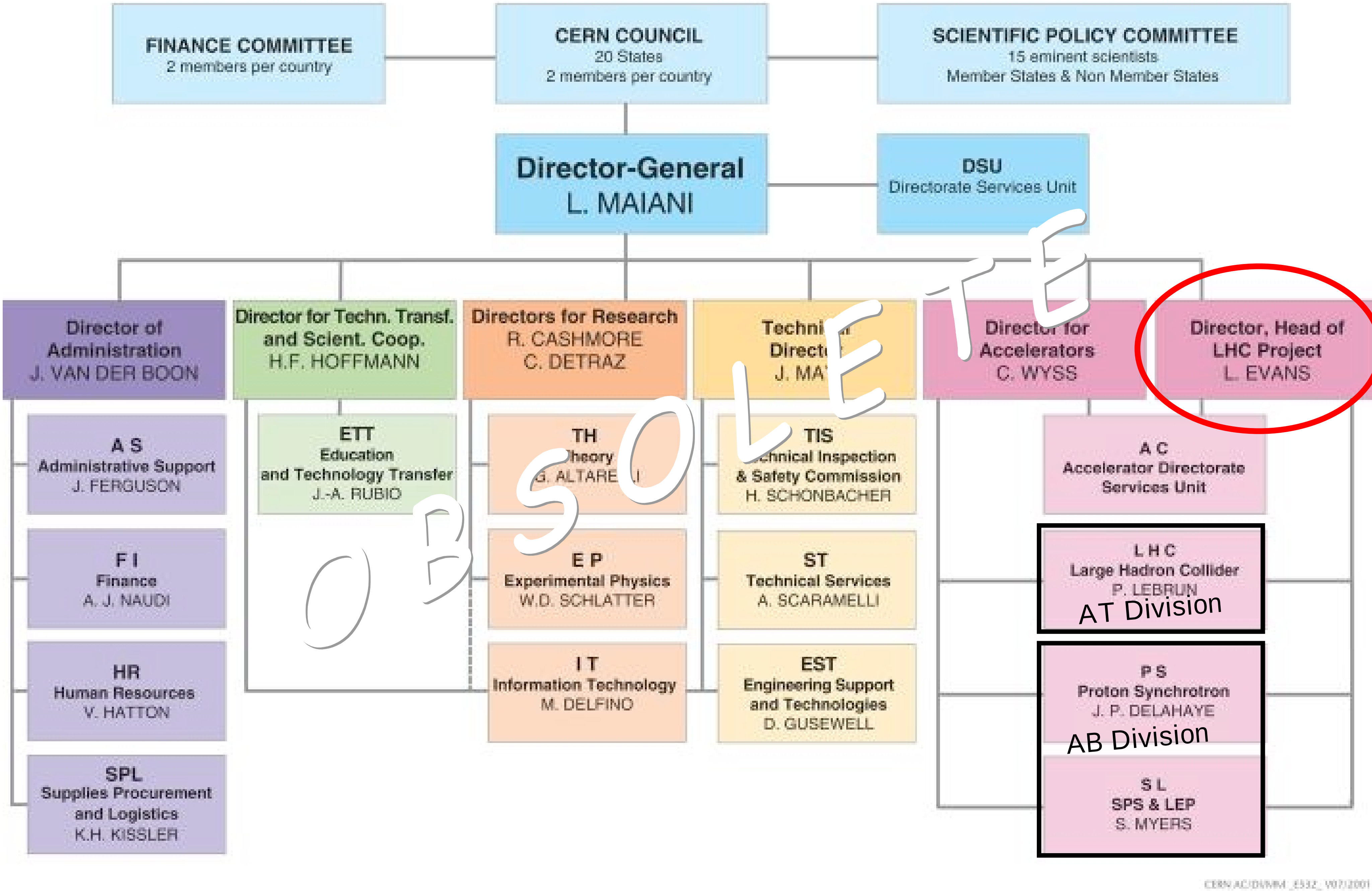
P. Bryant

CERN ORGANISATIONAL CHART 07/2001



LHC Project Organization

Project Management

L. Evans	Project Leader
P. Bryant	Contracts and Non-Member States collaborations
P. Ciriani	EST Division Leader
A. Faugier	Project Safety Coordinator, INB
P. Lebrun	AT Division Leader, Collaboration with France and India
S. Myers	AB Division Leader
K. Potter	Experiment linkperson
P. Proudlock	Technical Coordination and Planning
A. Scaramelli	ST Division Leader
H. Wenninger	Special studies

Project Leader's Office

L. Evans	Project Leader
P. Bonnal	Cost and schedule
A. Brissonnaud	Finance
P. Bryant	Contracts and Non-Member States collaborations
J. Karlson Forestier	Secretariat
P. Proudlock	Technical Coordination and Planning

Supporting Divisions

AB	Accelerator Beams
AC	Accelerator Directorate Unit
AS	Administrative Support
AT	Accelerator Technology
DSU	Directorate Services Unit
EST	Engineering Support and Technologies
FI	Finance
IT	Information Technology
SPL	Supplies, Procurement and Logistics
ST	Technical Support
TIS	Technical Inspection and Safety

Committees

TB

LEMIC | LTC | MARIC | SC | TCC

Working groups / Sub-projects

TB	LHC Technical Board
LEMIC	LHC Experiments Machine Interface Committee
LTC	AB Division - LHC Technical and Commissioning Cttee
MARIC	AT Division - Main Ring Committee
SC	LHC Specification Committee
TCC	LHC Technical Coordination Committee

Collaborations

- Canada
- Host States
- India
- Japan
- Russia
- USA

EDMS Document No. 371495

LHC Project Working Groups

LHC Sub-projects.
Archives for non-active working groups.
Magnet Evaluation Board home page.
Cryodipole Coordination home page.

	Working Groups	Chairman	Reporting to
AIWG	Access and Interlock	A. Faugier	TCC
WGA	Alignment	J.B. Jeanneret	MARIC
BISPEC	Beam Instrumentation Specification	J.P. Koutchouk	LTC
CEIWG	Control Electronics Integration	R. Rausch	TCC
EEWG	Electrical Engineering	K.H. Mess	TCC
FQWG	Field Quality	L. Walckiers	MARIC
HCWG	Hardware commissioning	R. Saban	TCC
HLWG	Heat Load	L. Tavian	MARIC
INWG	Insertions	R. Ostojic	MARIC
IWG	Instrumentation for equipment	R. Schmidt	MARIC
ILU	Intensity Limitations and Ultimate performance	F. Ruggiero	LTC
LEADE	LHC Experiment Accelerator Data Exchange	E. Tsesmelis	LEMIC
LEBWG	Experimental beampipes	R. Veness	LEMIC
MIWG	Machine Integration	C. Hauviller	TCC
MPWG	Machine Protection	R. Schmidt	LTC
PIWG	Powering Integration	R. Valbuena	TCC
PSIWG	Pits and Service areas Integration	R. Valbuena	TCC
QAWG	Quality Assurance	M. Mottier	TCC
RADWG	Radiation component	T. Wijnands	TCC
S3WG	Short Straight Section	V. Parma	MARIC

LHC Project - Sub-projects

LHC Project Working Groups.
Archives for non-active working groups.
Magnet Evaluation Board home page.

	Sub-Projects	Leader	Reporting to
LBDS	Beam Dump	B. Goddard	xxx
CWG	LHC Collimation	R. Assmann	xxx
COMIN	LHC Communication Infrastructure	P.S. Anderssen	TCC
LHC-CP	LHC Controls	R. Lauckner	LTC
SLI	SPS as LHC Injector	P. Collier	AB TC
PS-LHC	PS as LHC Pre-Injector	K. Schindl	
PS-Ions	PS Ions for LHC	K. Schindl	
LHCOP	LHC Operation	R. Bailey	LTC
String2	String 2	R. Saban	TCC/MARIC
LTI	LHC Transfer Lines and Injection	V. Mertens	AB TC

Governing US-CERN Agreements

INTERNATIONAL CO-OPERATION AGREEMENT

between

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

and

THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA

and

THE NATIONAL SCIENCE FOUNDATION OF THE UNITED STATES OF AMERICA

concerning

SCIENTIFIC AND TECHNICAL CO-OPERATION

ON LARGE HADRON COLLIDER ACTIVITIES

1997

INTERNATIONAL CO-OPERATION AGREEMENT

CONCERNING

SCIENTIFIC AND TECHNICAL CO-OPERATION

ON LARGE HADRON COLLIDER ACTIVITIES

ACCELERATOR PROTOCOL

between

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

and

THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA

1997

Signed by CERN, DOE and NSF

[illegible]

IMPLEMENTING ARRANGEMENT

to

THE ACCELERATOR PROTOCOL

between

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

and

THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA

concerning

SCIENTIFIC AND TECHNICAL CO-OPERATION ON LARGE HADRON COLLIDER ACTIVITIES

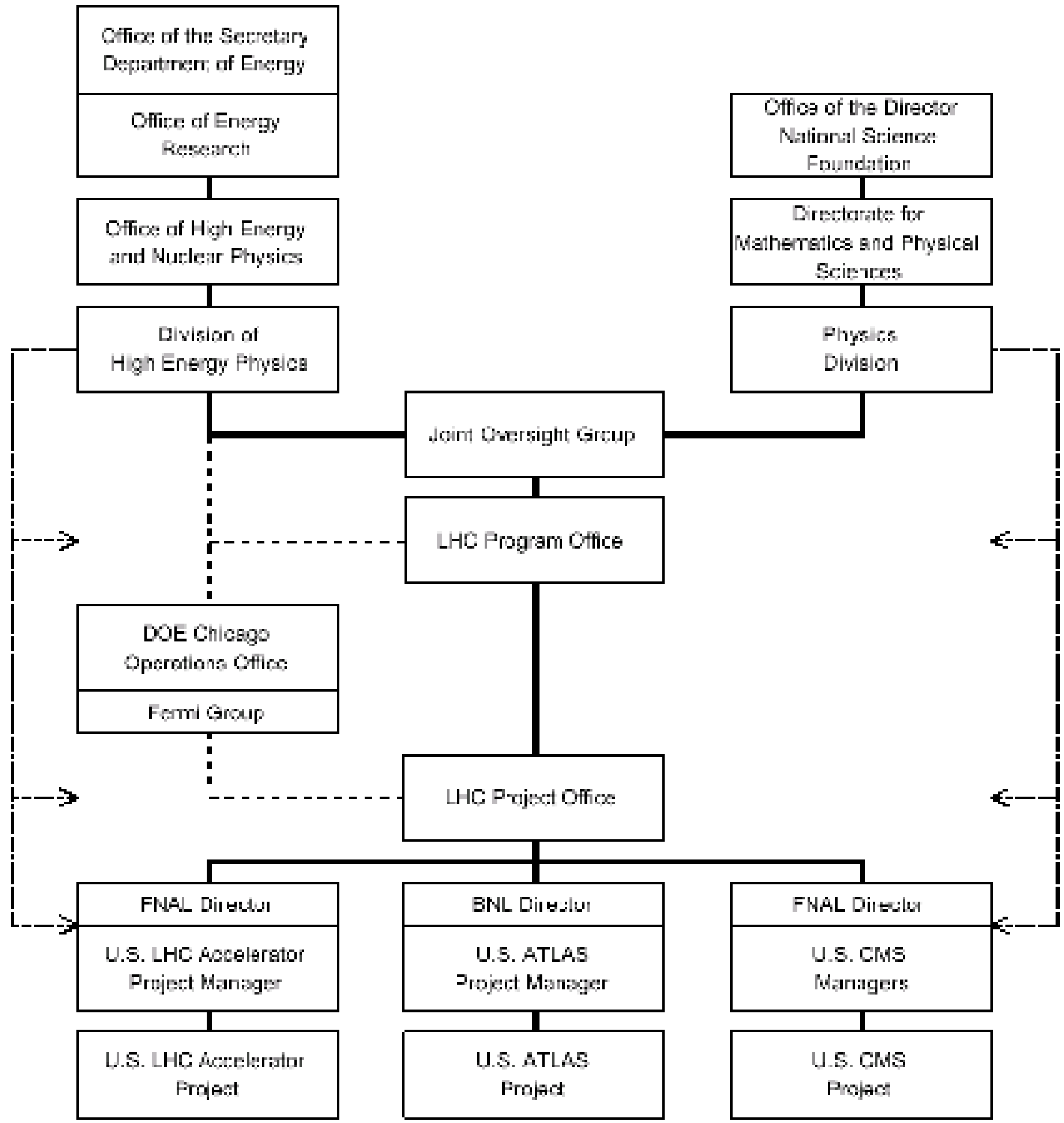
May 2002

Signed by CERN and US Labs

Management of US Project

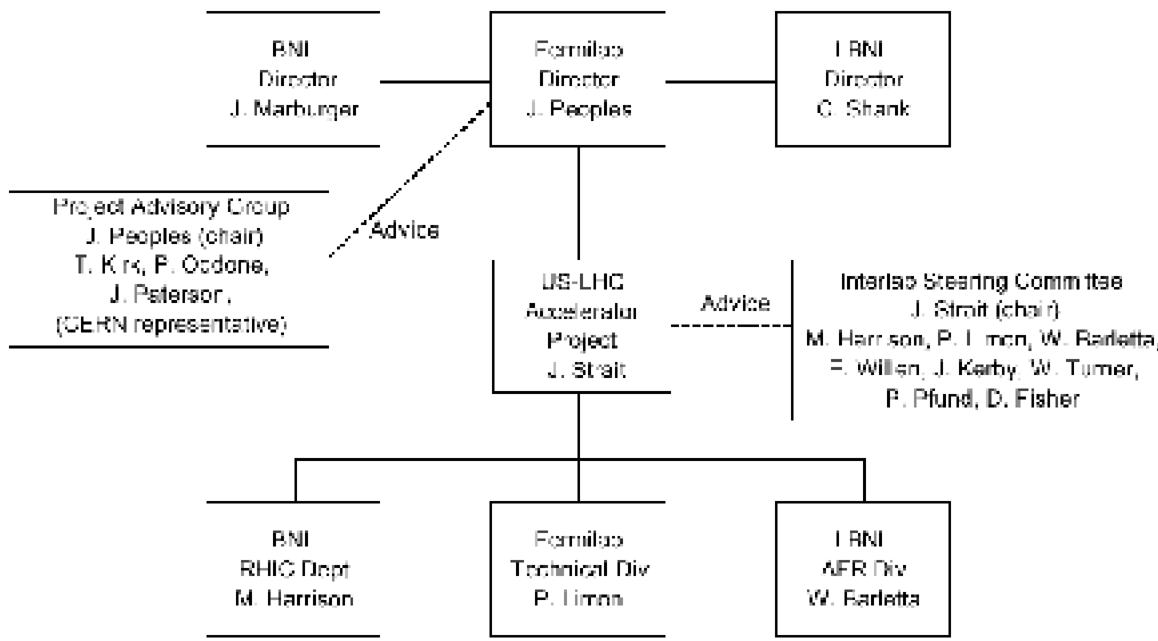
Organized as a classic DOE construction project:

- Formal lines of authority and responsibility.
- Established work scope, budget, schedule and contingency.
- Earned value analysis and reporting.
- Change control procedures.
- Etc….



Special features of a multi-lab project:

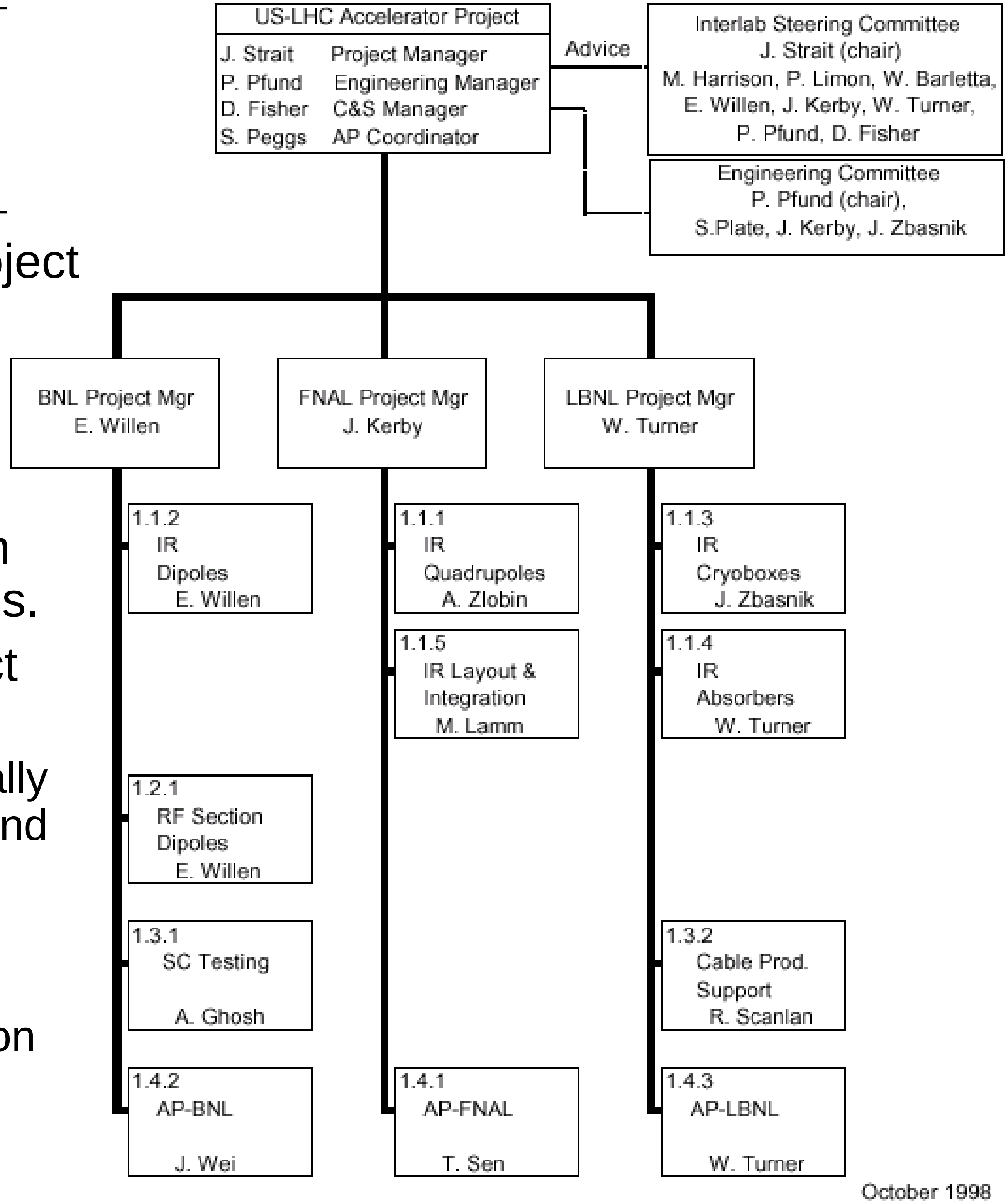
- One lab – that with the biggest long-term stake in the program – assigned as Lead Lab
  - Formally puts Director on the hook.
  - Provides backup for Project Manager.
  - Coordination with other Lab Directorates mainly through committee of relevant Deputy/Associate Directors.
  - All 3 Directors sign the Implementing Arrangement to formally commit their labs to the Project.



- Role of Division Heads is also important … They control the people.

Special features of multi-lab project

- Try to have independent work packages at each lab.
- Assign local project manager at each lab. Success depends *strongly* on having the right people for this.
- Need to have a strong Project Office.
  - Define specifications, especially interfaces between US labs and between US and CERN.
  - Coordinate interactions with CERN.
  - Keep regular and close tabs on work at all labs.



Management of US Project

Problems specific to a multi-lab project:

- Difficulty of controlling work done at another lab.
- Different motivations of different labs … and tension between what is good for the project and what is good for each lab.
- Competition for the best people with other projects (not necessarily in HEP), which may have higher local priority.
- Difficulty of moving work from one lab to another.
- Local lab manager may be more in thrall to his Division Head than to the Project Manager.
- …

=> Costs are (probably) modestly higher than if all work done within a single lab.

US-CERN Coordination

Special features of International Collaboration.
(Or at least of dealing as a junior partner in someone else's project.)

- Add formal links to responsible CERN people. *Informal, personal relationships are equally important*.

Implementing Arrangement to the Accelerator Protocol
Between CERN and the U.S. DOE
Concerning Scientific and Technical Cooperation on the LHC

Appendix 1
CERN Official Points of Contact for Technical Information

WBS	Task	Point of Contact
1	U.S. PART OF THE LHC ACCELERATOR PROJECT	Thomas Taylor
1.1	INTERACTION REGIONS	Ranko Ostojic
1.2	RF STRAIGHT SECTION	Ranko Ostojic
1.3	SUPERCONDUCTING STRAND AND CABLE	Daniel Leroy

- Scope and schedule not fully under our control.
  Our change control procedures have to interact with theirs.
- Mis-match in schedules for completing designs.

  => *Extra contingency must be allowed for "external" changes.*
- No way to move funds between CERN and US labs to deal with changes that draw on contingency… Only "currency" is work scope.

Extending the US-CERN Collaboration

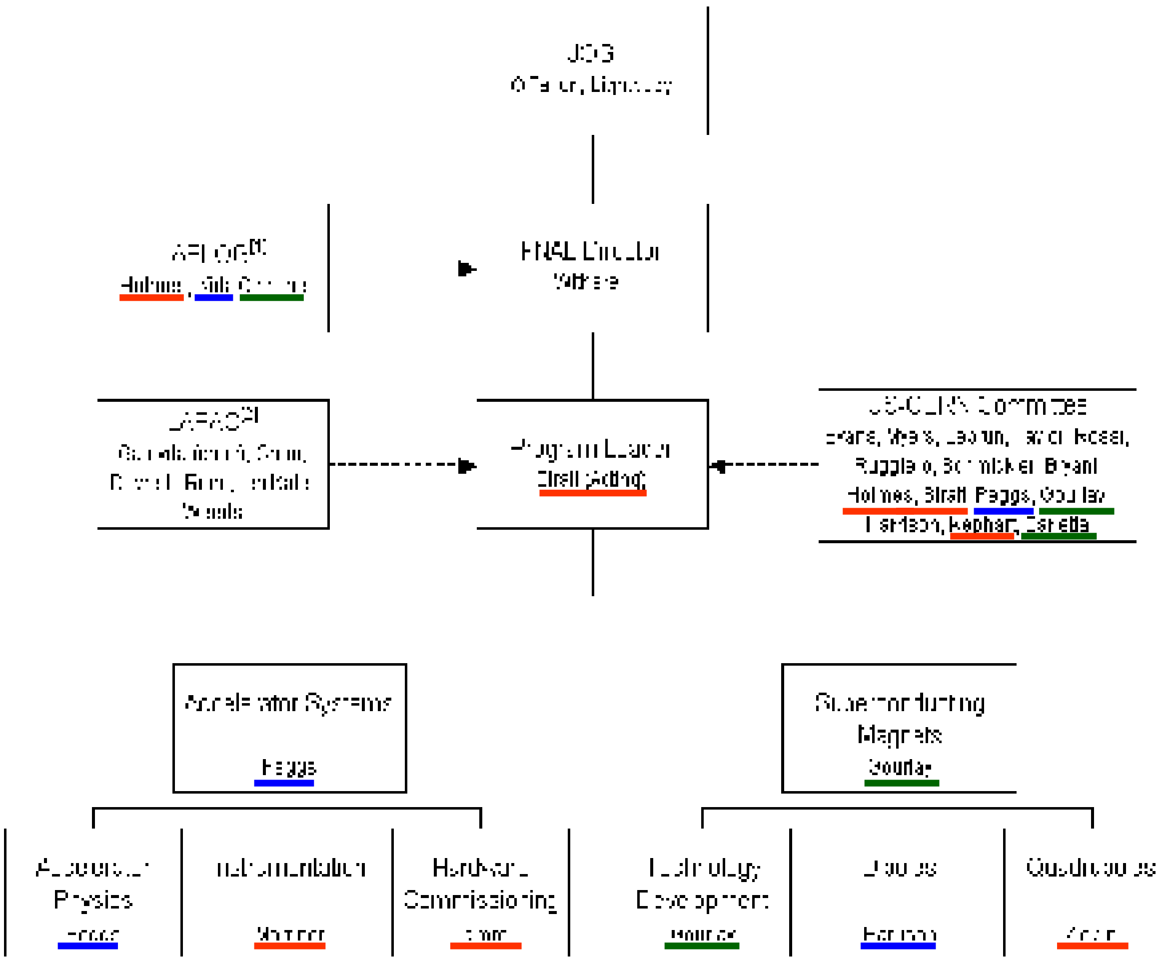
The US responsibility for LHC construction ends with the successful delivery of our equipment to CERN.

We are planning to extend to extend the US-CERN collaboration into the commissioning and operational phases of LHC.

- Commissioning:
  - o Commissioning the US-provided hardware systems.
  - o Helping commission the LHC as a whole with beam.
- Operational phase:

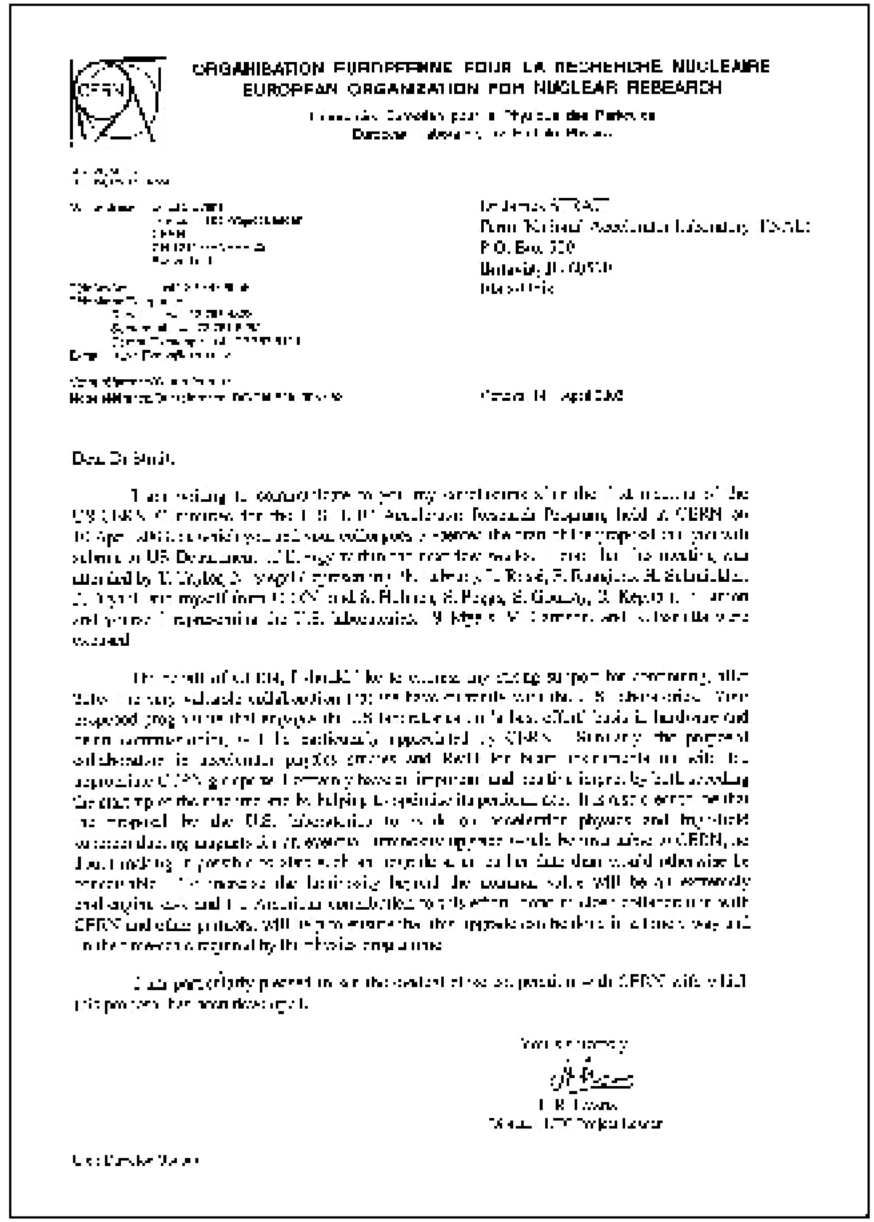
  We do not plan to take real responsibility for operations; rather we will do R&D to extend the LHC performance for (US) HEP.
  - o Machine development studies and fundamental accelerator research.
  - o Development of advanced beam diagnostics.
  - o R&D for a luminosity upgrade (dominantly advanced SC magnets).

Organization for the Next Phase



Program Direction and Reporting
Advice

[1] US LHC Accelerator Program Leadership Oversight Group
[2] US LHC Accelerator Program Advisory Committee


ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Dear Dr Strait,

Summary

LHC represents an important step towards global collaboration in the construction of large scientific instruments.

- Construction is proceeding towards machine startup in 2007.
- Management systems for US-CERN collaboration are working well.
  - The determination of the people involved to make the collaboration work is just as important as the management systems.
- Multi-lab US Project is generally working well.
  - But this is less efficient than a single lab project.
  - Management relations among the labs must be carefully defined.
  - Strong Project Office is required.
- We are currently working to “invent” the structures to extend the US-CERN collaboration for machine commissioning and R&D to extend the LHC performance as a tool for (US) HEP.