

The Large Hadron Collider

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2009 AAAS Annual Meeting, Chicago 15th February 2009



CERN in Numbers

2415 staff*

730 Fellows and Associates*

9133 users*

**Budget (2007) 982 MCHF
(610M Euro)**

*5 February 2008



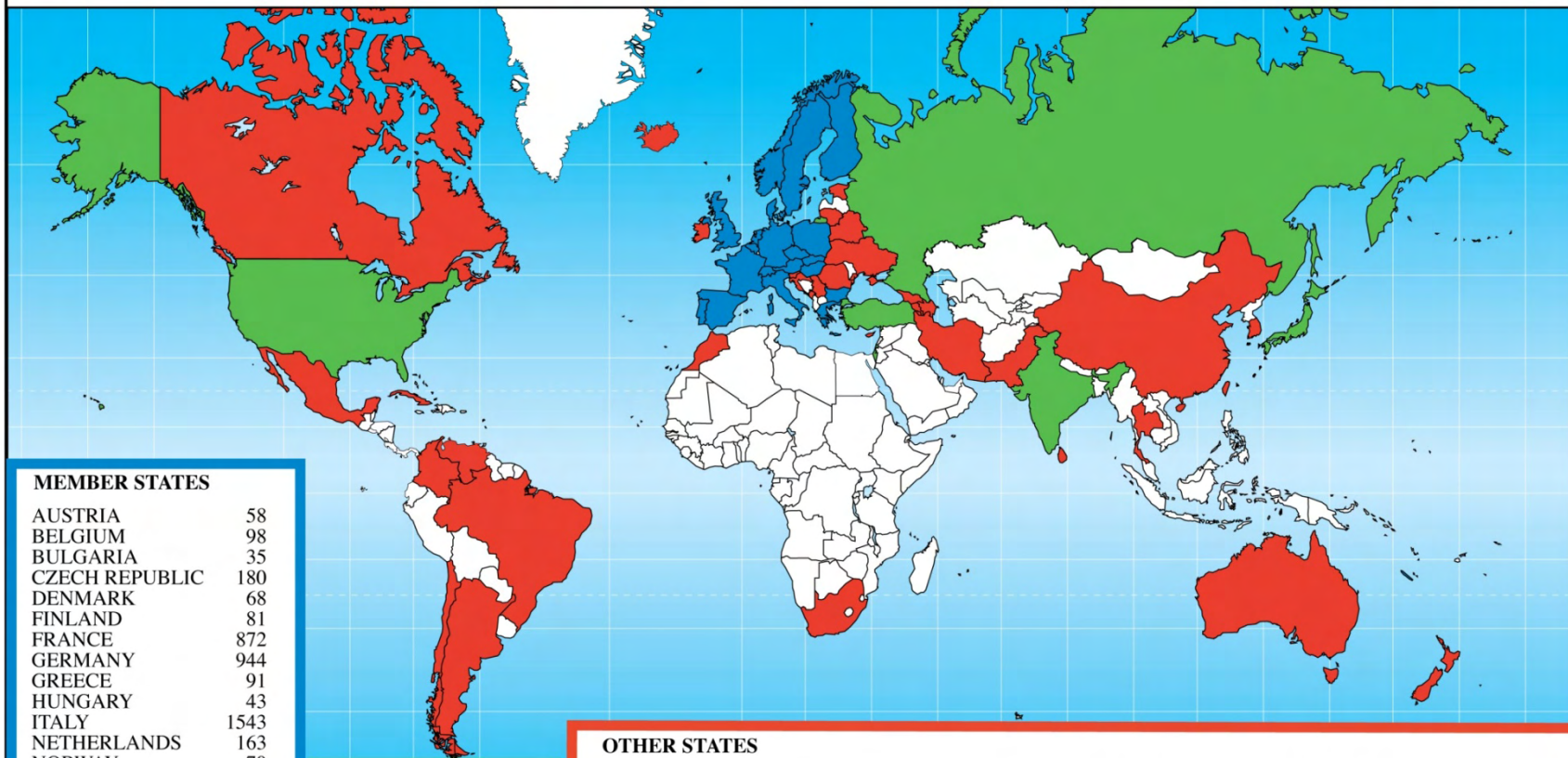
Member States: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Observers to Council: India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and Unesco

CERN Users



Distribution of All CERN Users by Nation of Institute on 5 February 2008



MEMBER STATES

AUSTRIA	58
BELGIUM	98
BULGARIA	35
CZECH REPUBLIC	180
DENMARK	68
FINLAND	81
FRANCE	872
GERMANY	944
GREECE	91
HUNGARY	43
ITALY	1543
NETHERLANDS	163
NORWAY	70
POLAND	175
PORTUGAL	109
SLOVAKIA	46
SPAIN	270
SWEDEN	74
SWITZERLAND	344
UNITED KINGDOM	645

5909

OBSERVER STATES

INDIA	93
ISRAEL	64
JAPAN	182
RUSSIA	940
TURKEY	35
USA	1278

2592

OTHER STATES

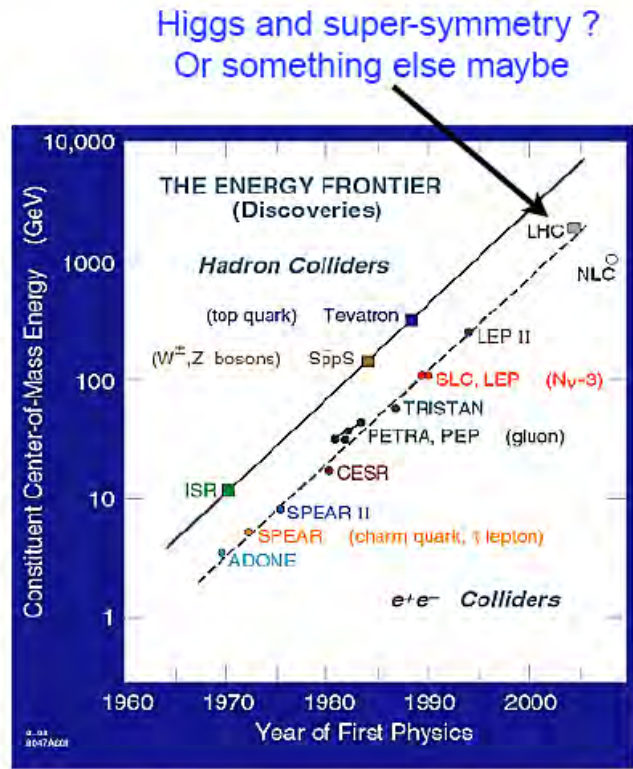
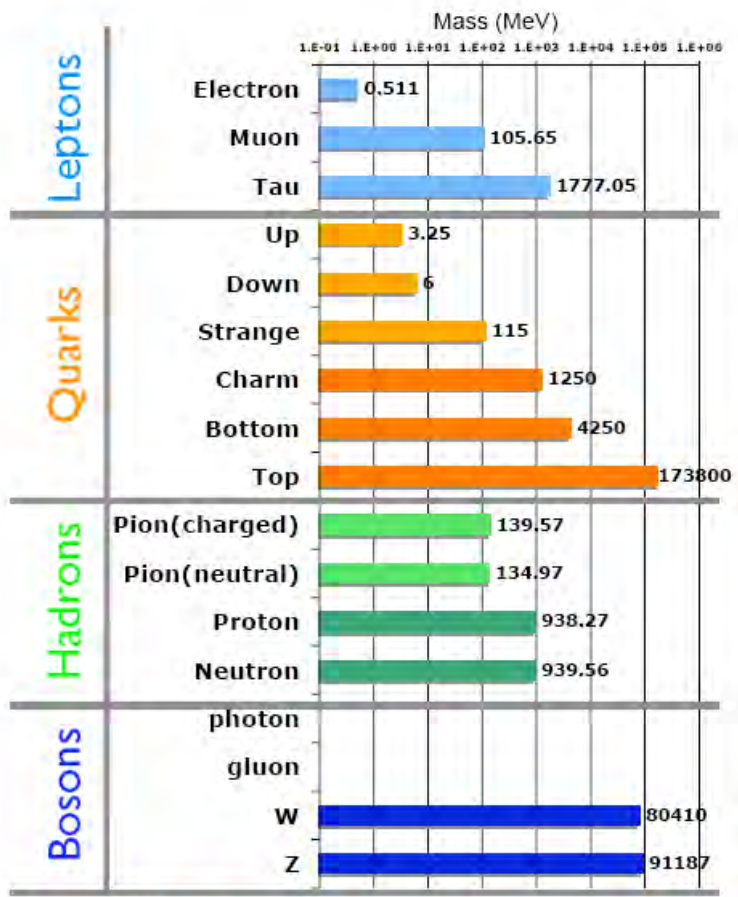
ARGENTINA	8	CROATIA	17	MEXICO	23	TAIWAN	40
ARMENIA	17	CUBA	3	MONTENEGRO	1	THAILAND	1
AUSTRALIA	13	CYPRUS	6	MOROCCO	6	UKRAINE	17
AZERBAIJAN	1	ESTONIA	10	NEW ZEALAND	7		
BELARUS	23	GEORGIA	9	PAKISTAN	23		
BRAZIL	68	ICELAND	1	ROMANIA	46		
CANADA	119	IRAN	6	SERBIA	16		
CHILE	4	IRELAND	14	SLOVENIA	16		
CHINA	60	KOREA	44	SOUTH AFRICA	2		
COLOMBIA	5	LITHUANIA	5	SRI LANKA	1		

632

The LHC ring



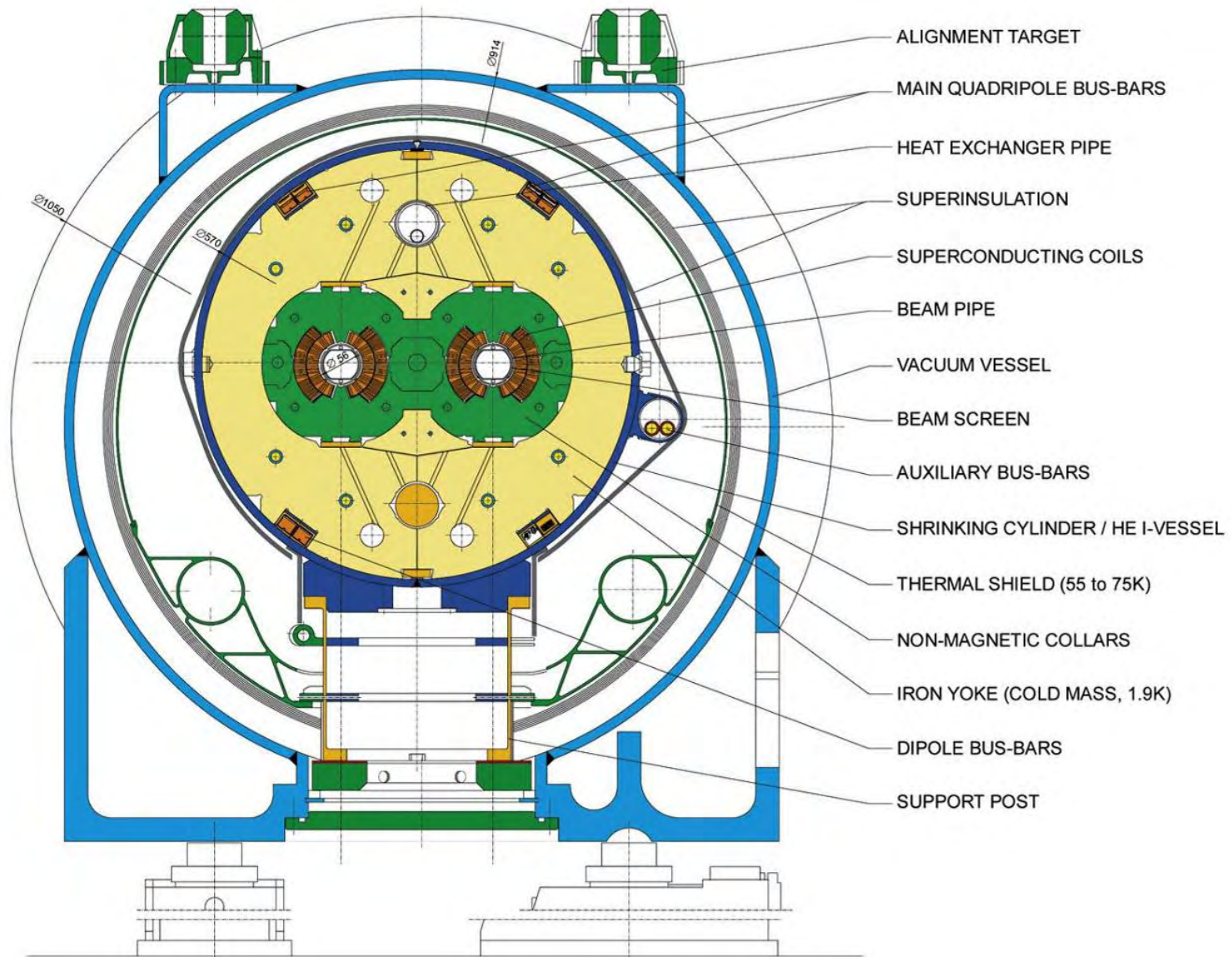
History/energy line vs discovery



Behind the history plot is hidden the technological development required for each step

Obs: you can notice different particle species used in the different colliders
electron-positrons and hadron colliders (either \bar{p} -p as Tevatron, p-p as LHC)

Cross-section of LHC cryodipole



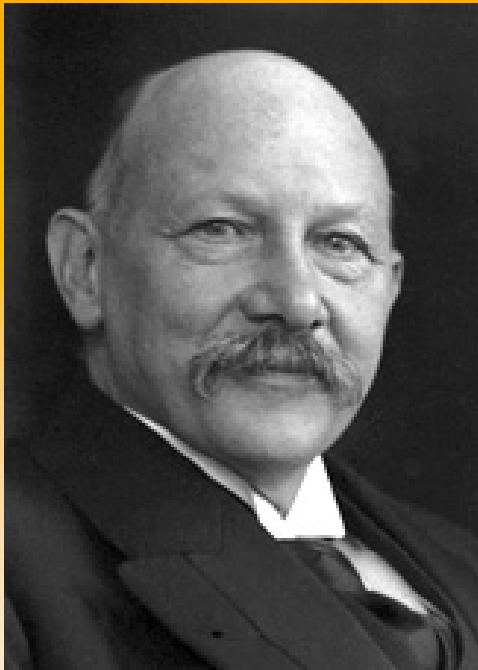
If the LHC did not use superconductivity...

The LHC has a circumference of 26,7 km, with 20km filled with superconducting magnets operating at 8.3 T. The refrigerators producing the liquid helium to cool the magnets consume 40 MW of power.

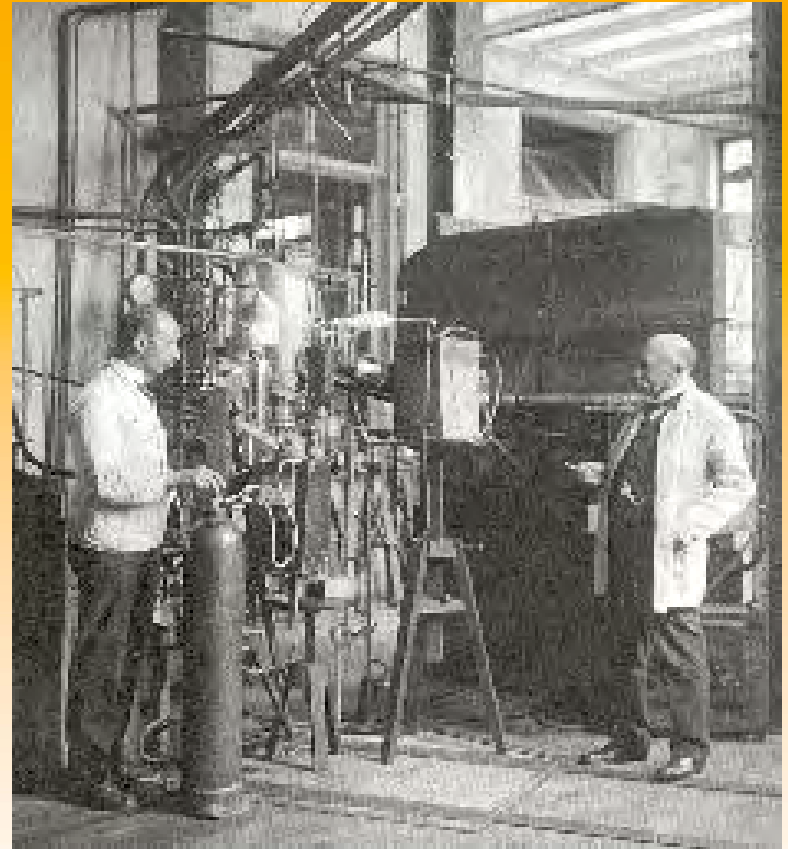
An equivalent machine with classical electromagnets would have a circumference of 100 km and would consume 1000 MW of power.

...at the physics laboratory of Leyden, helium was first liquified

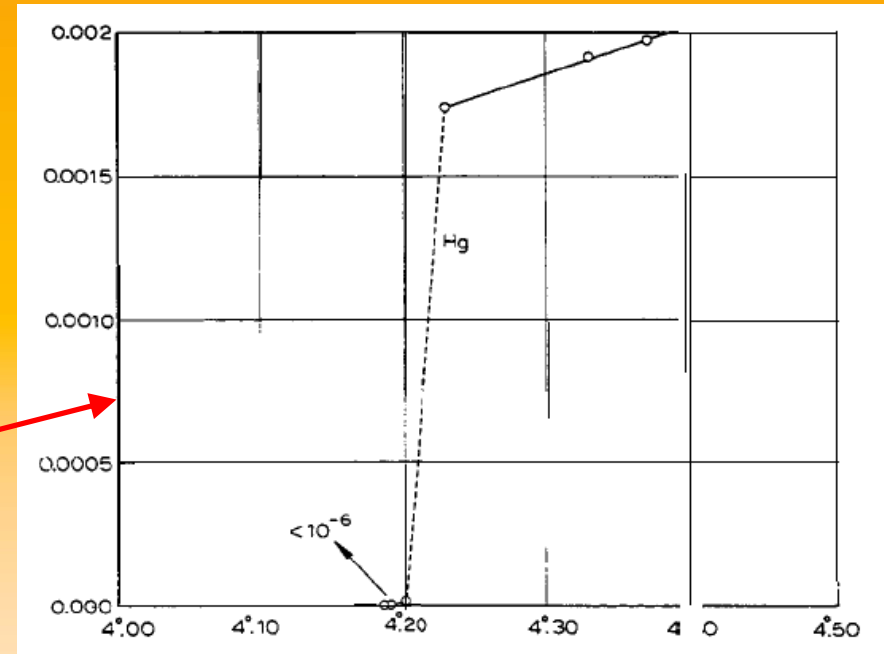
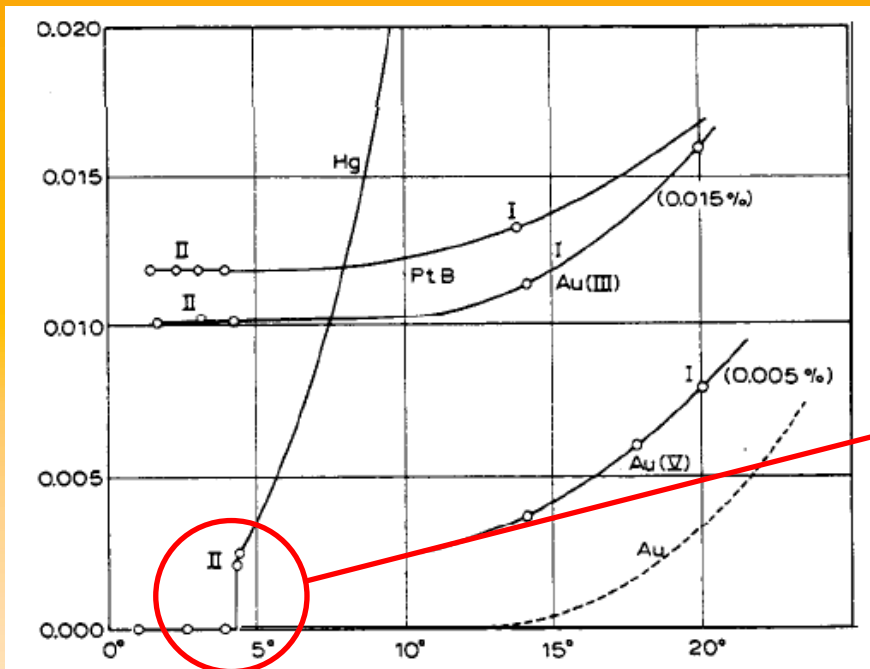
Heike Kamerlingh Onnes



**“Door meten tot weten”
To knowledge through
measurement**

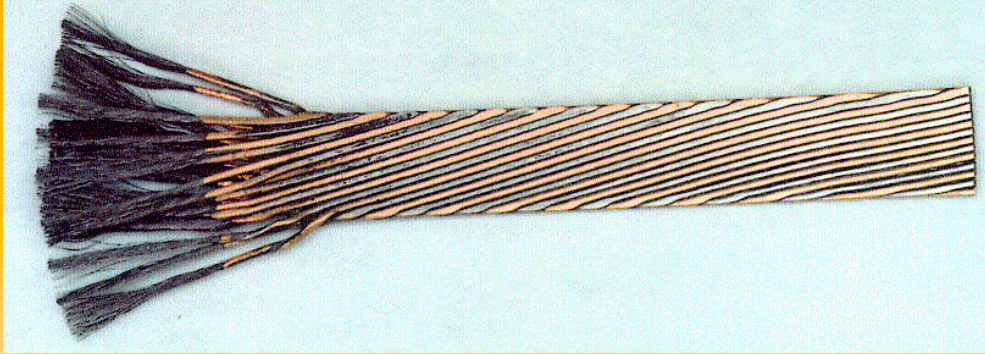


Discovery of superconductivity (1911)

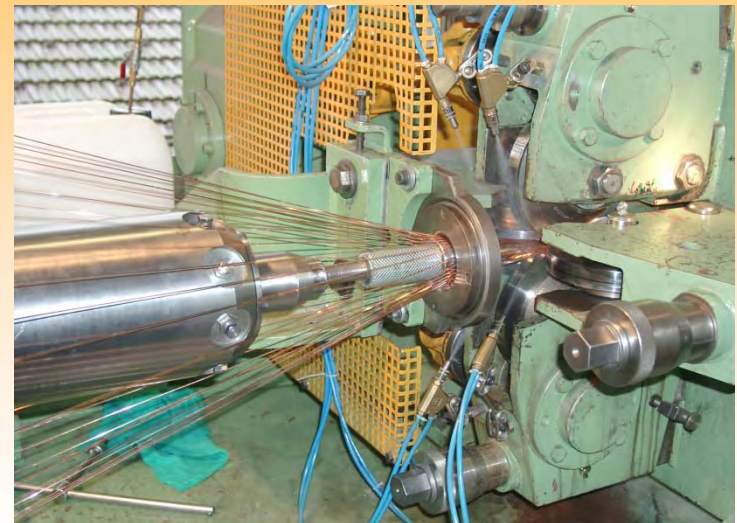
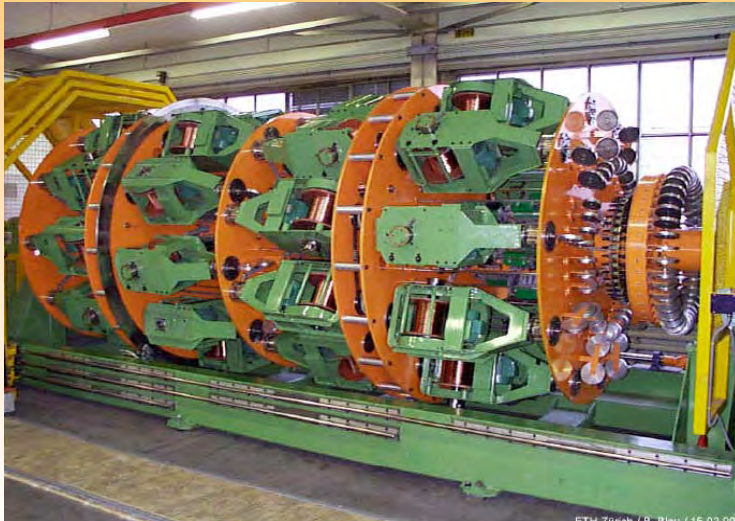


Thus the mercury at 4.2°K has entered a new state, which, owing to its particular electrical properties, can be called the state of superconductivity.

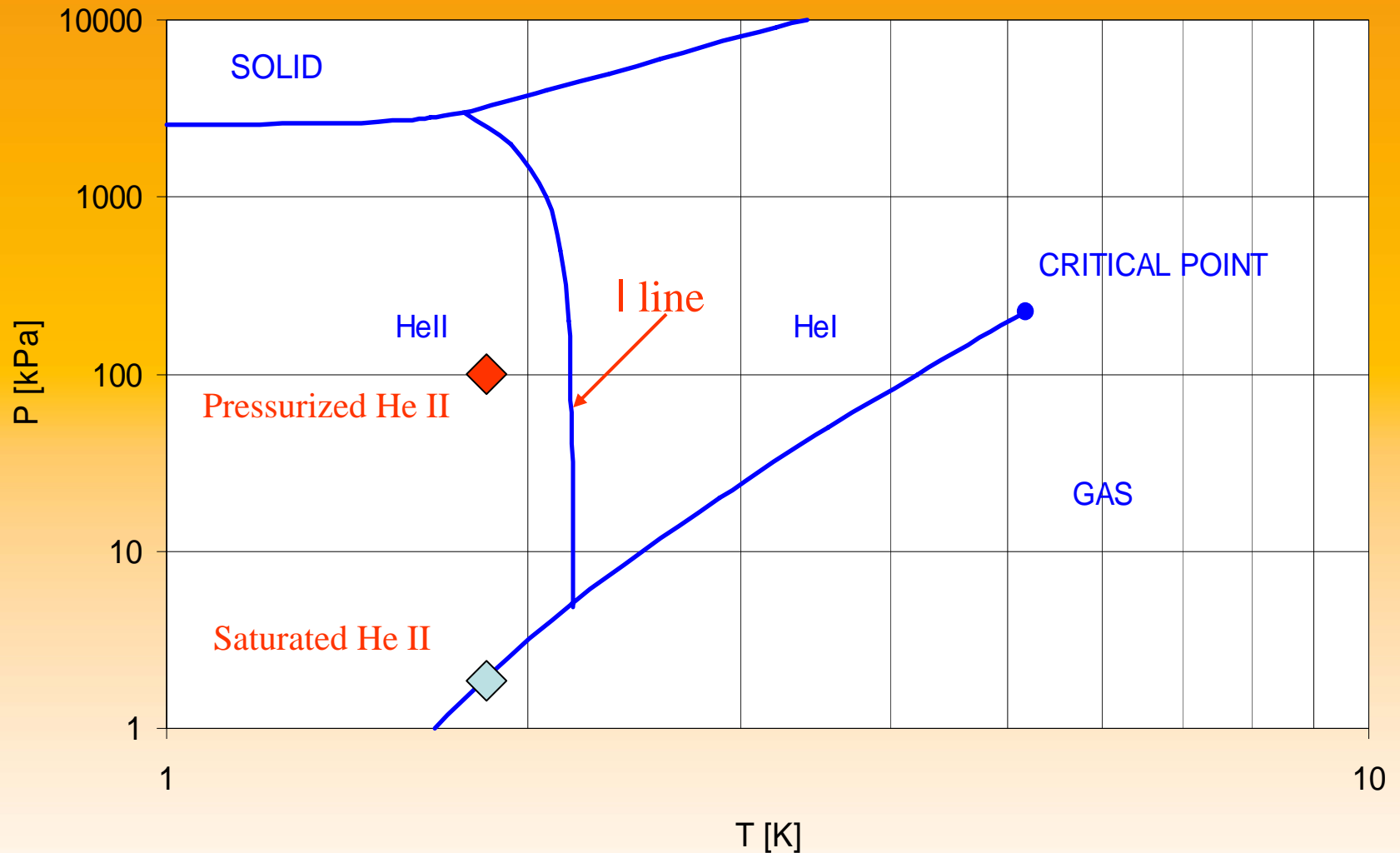
7000 km of superconducting cable Nb-Ti



Production of superconducting wires & cables



Phase diagram of helium



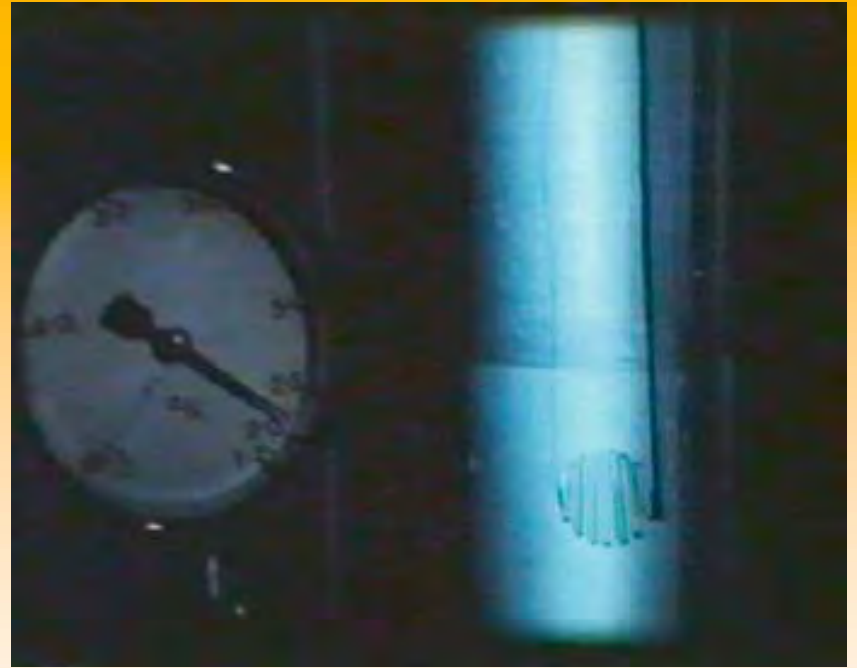
Discovery of superfluidity in He II (1938)

J.F. Allen & A.D. Misener (Cambridge)
P.L. Kapitsa (Moscow)

Vaporization of liquid helium



He I ($T=2.4$ K)

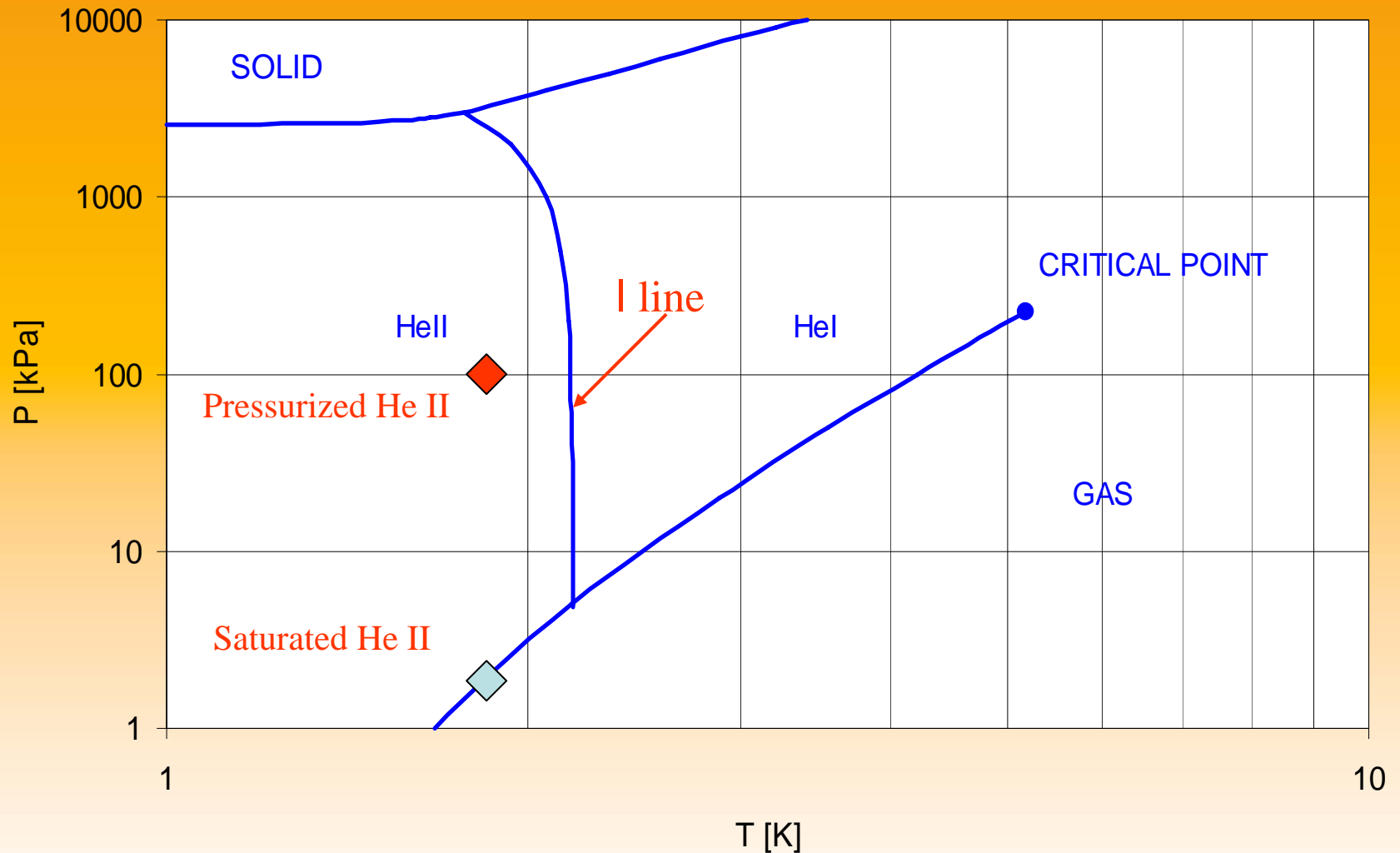


He II ($T=2.1$ K)

Hint of a quantum effect...?

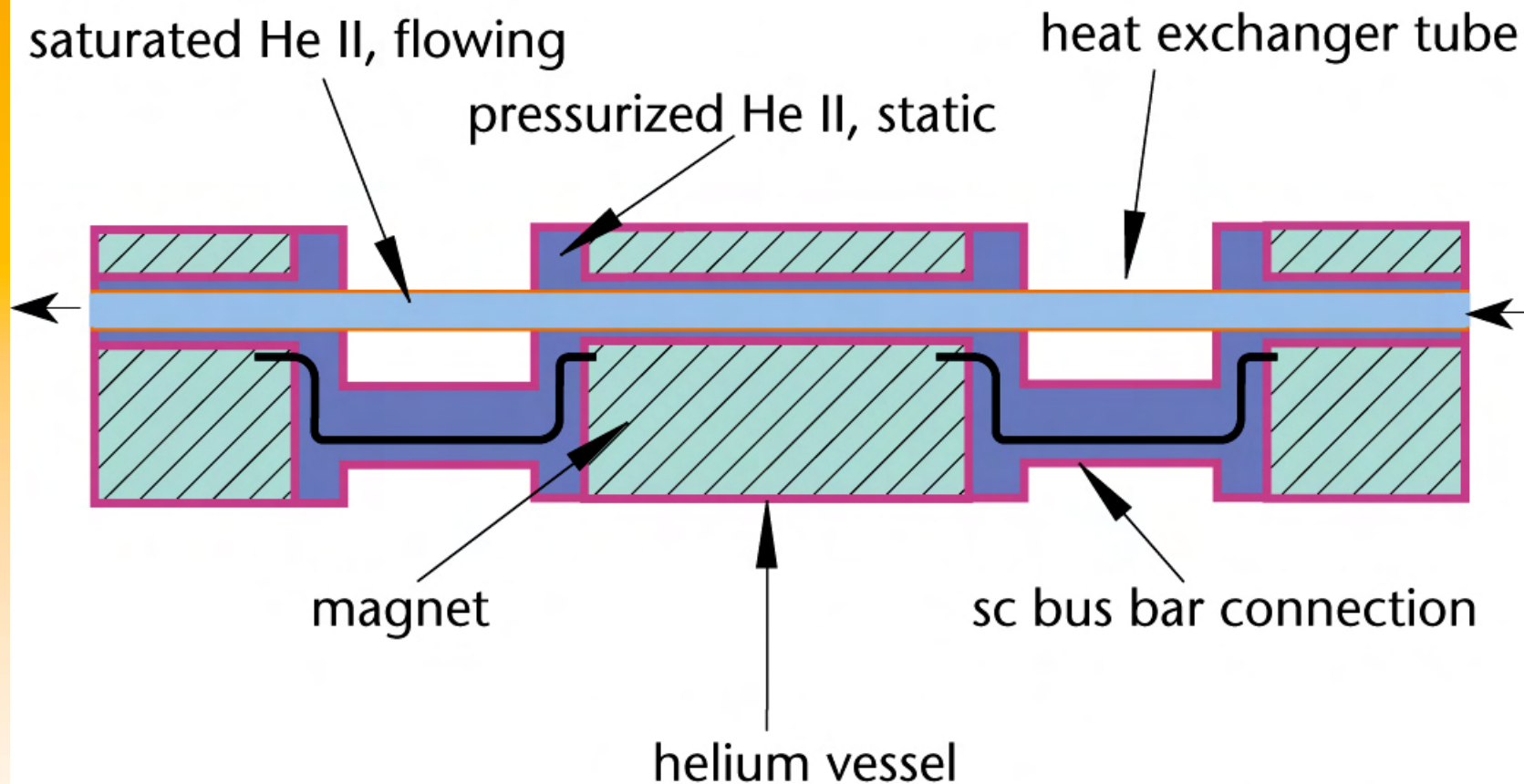
It is very noticeable that the experiments indicate that the density of the helium, which at first quickly drops with the temperature, reaches a maximum at 2.2°K approximately, and if one goes down further even drops again. Such an extreme could possibly be connected with the quantum theory.

Phase diagram of helium

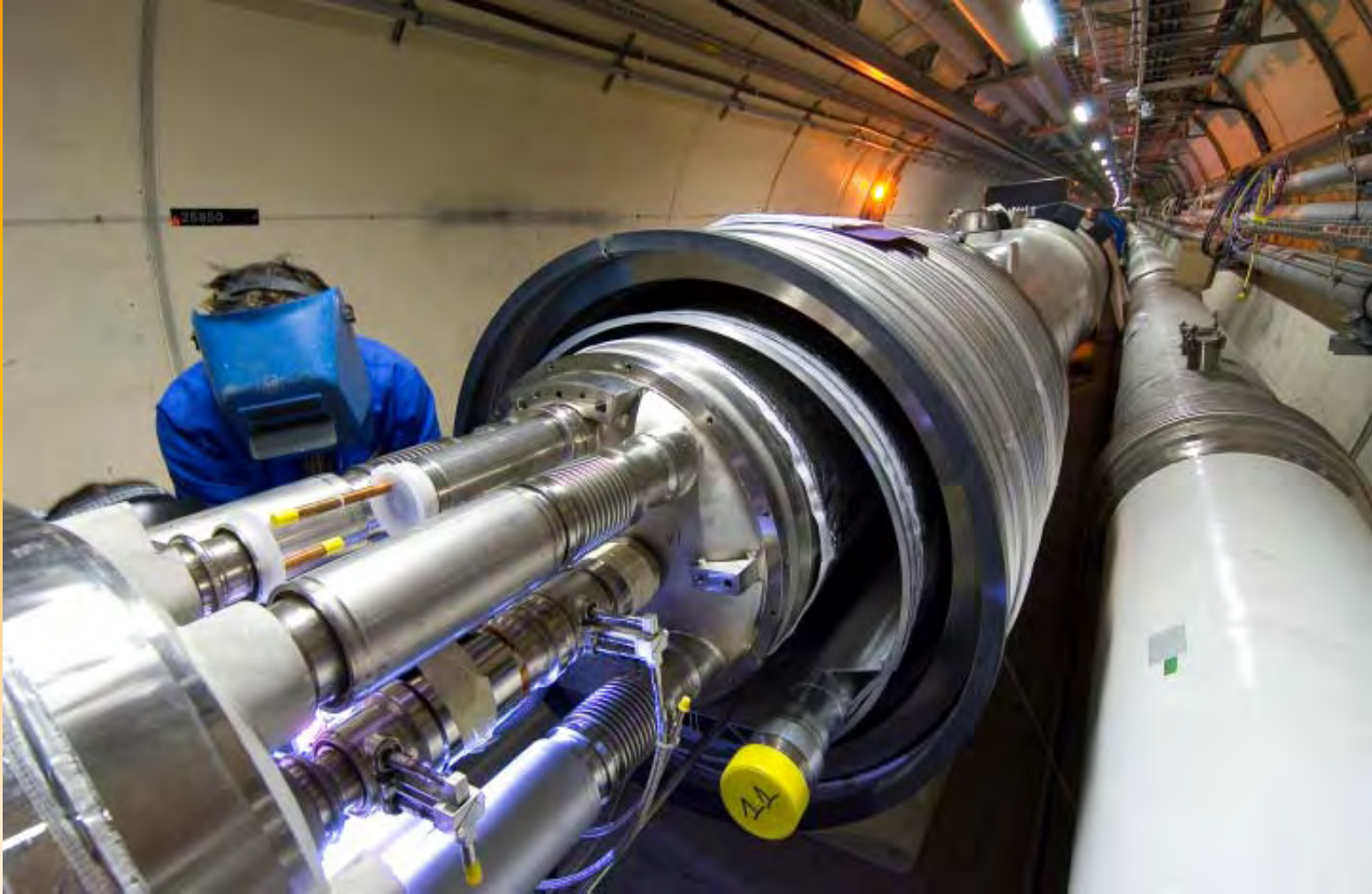


Linear heat exchanger

LHC magnet string cooling scheme



Dipole dipole interconnect



Manufacturing of superconducting coils



Industrial manufacturing of magnets



ALSTOM, NOELL, ANSALDO

Magnet cryostating at CERN



Cryogenic test benches



Magnet descent into the tunnel



***Transport in
the tunnel
with an optical
guided vehicle***



Transfer on jacks



Electrical splice



Electrical quality assurance in the tunnel



23 km of superconducting magnets



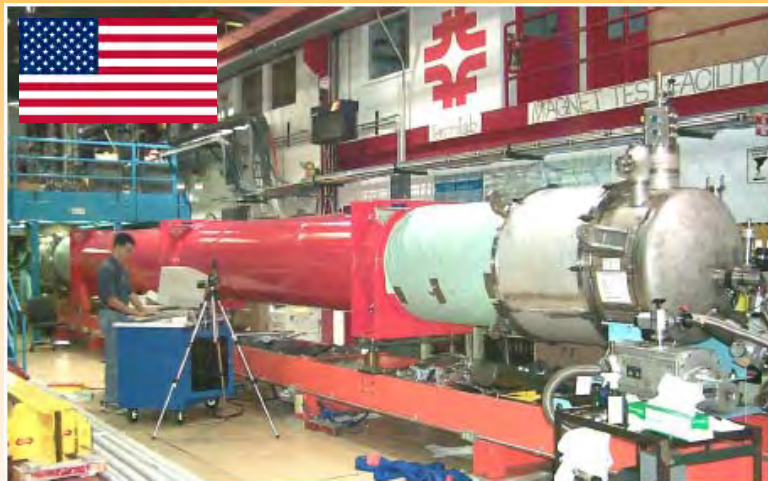
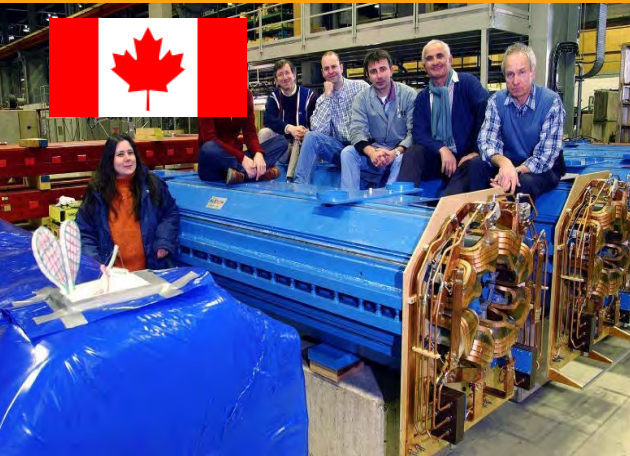
Inner triplet magnets



 **Fermilab**

 **KEK**
高エネルギー加速器研究機構

A global project



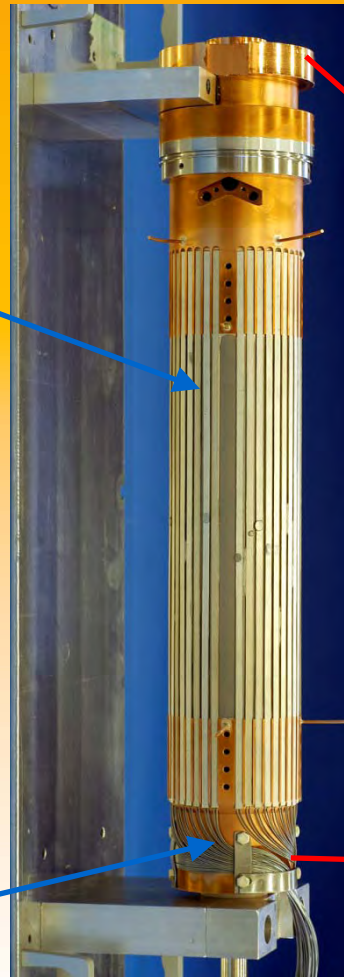
LHC current leads use high-temperature superconductor



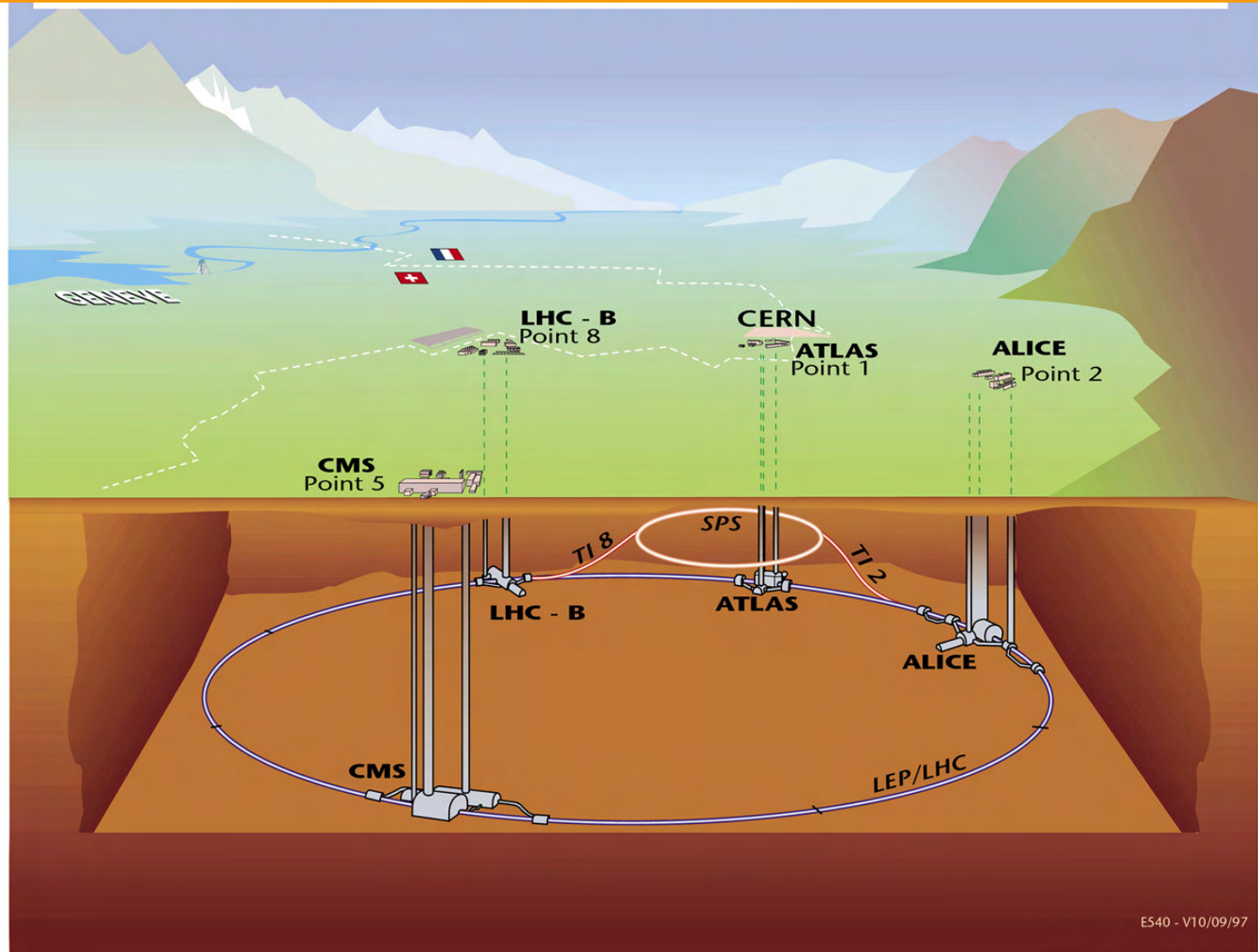
13 kA current leads using HTS superconductor

BSCCO 2223 tapes

Nb-Ti wires



The LHC and its detectors



Aerial view of Point 5 Gallo-roman vestiges (1998)



Roman coins found during archeological excavations at Point 5



Bringing Nations Together



**“...the promotion of contacts
between, and
the interchange of, scientists...”**

Reconciling different views on basic science

The sole end of science is the honor of the human mind

Carl Gustav Jacobi

The greatest economic benefits of scientific research have always resulted from advances in fundamental knowledge rather than the search for specific applications

Margaret Thatcher