# エネルギー･フロンティア加速器の現状と展望

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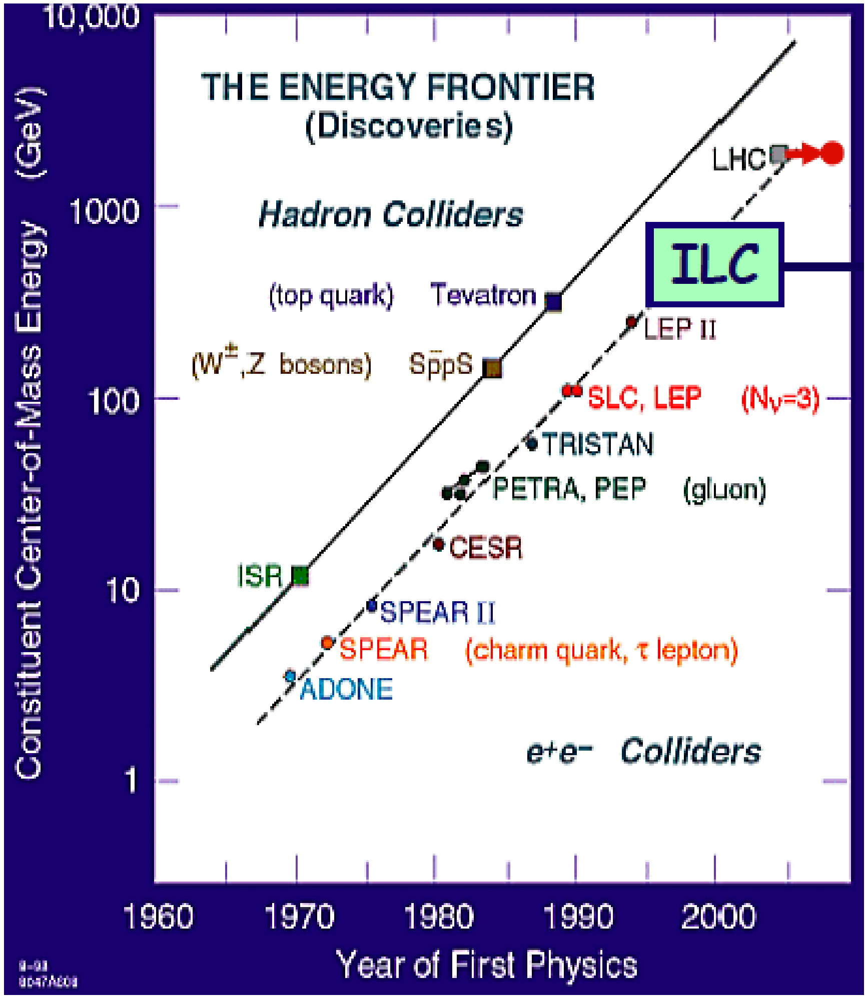
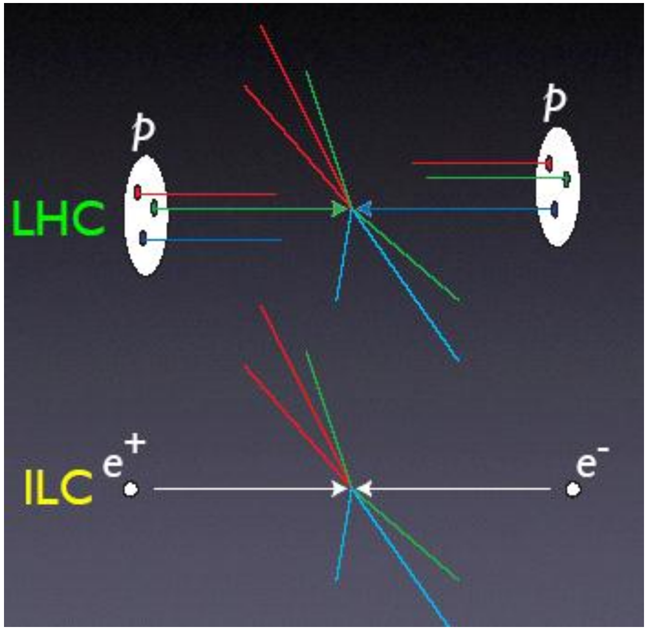
日本物理学会
2009年3月27日
立教大学

# Particle Accelerators

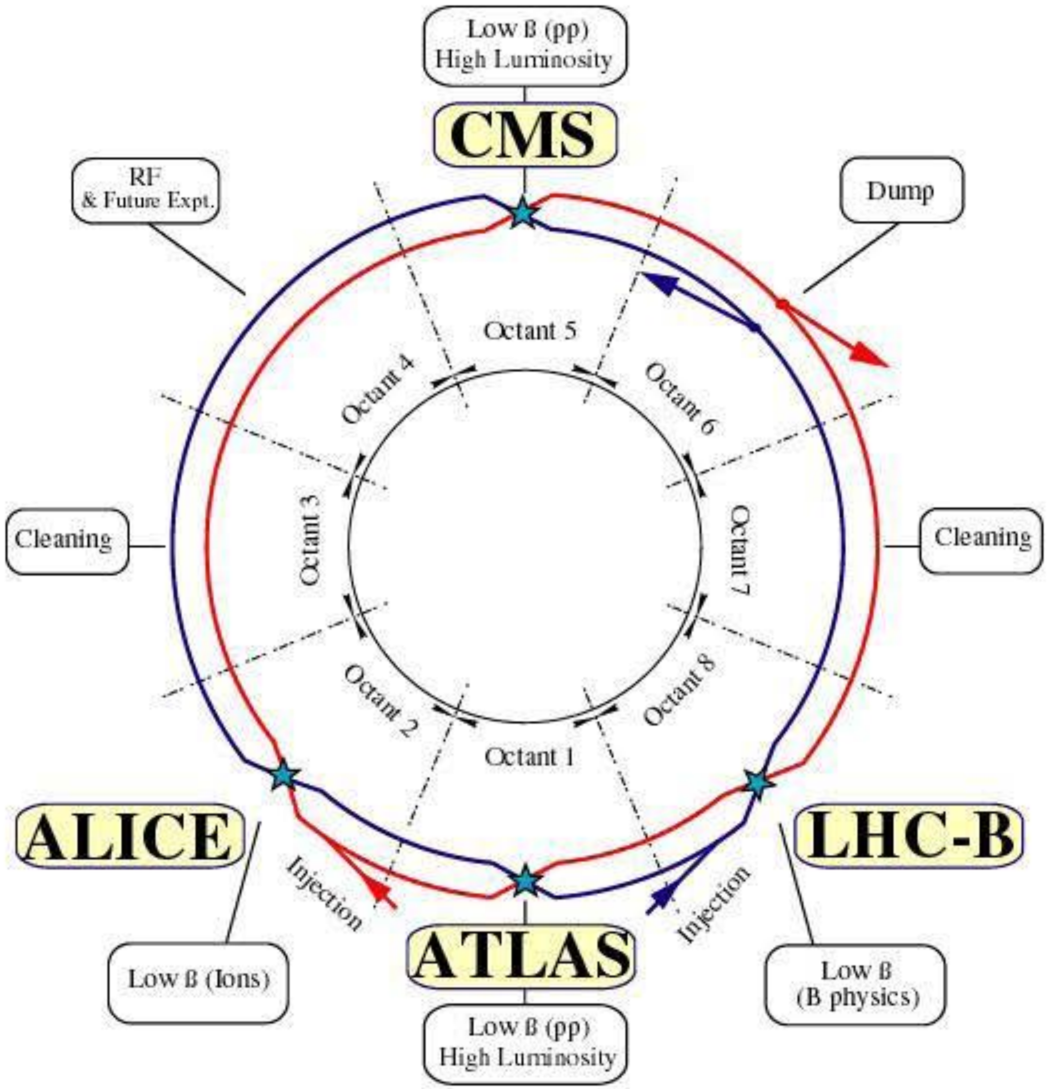
## Exploring Tera-scale



# LHC

# Large Hadron Collider (LHC)




**proton-proton collider**

**next energy-frontier discovery machine**

**c.m. energy 14 TeV (7x Tevatron)**

**design luminosity $10^{34}$ $cm^{-2}s^{-1}$ (~100x Tevatron)**

**start of beam commissioning in 2008**

***LHC nominal luminosity was pushed in competition with SSC***

key LHC parameters:

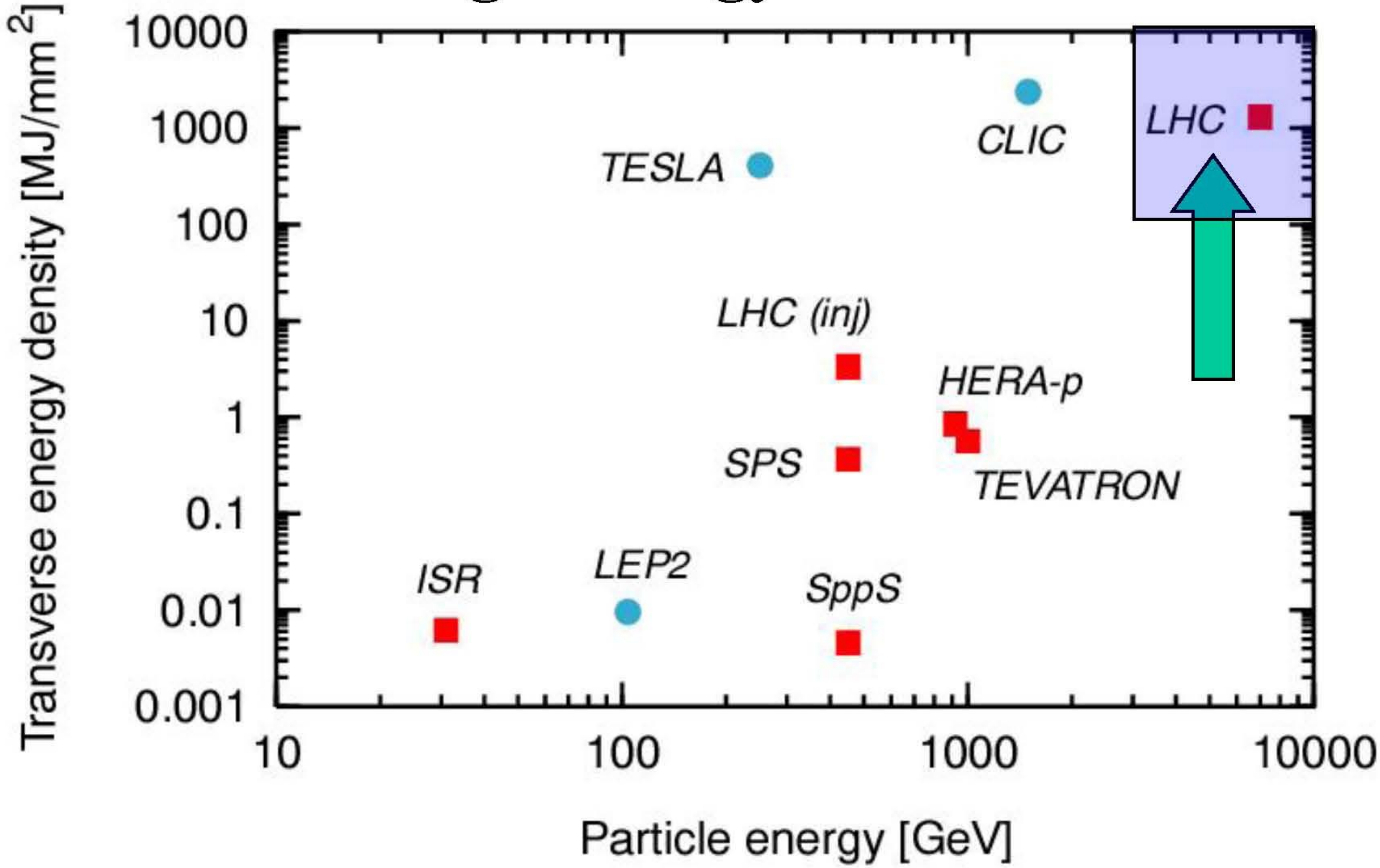
- $1.15 \times 10^{11}$ protons per bunch
- 2x2808 bunches, 25 ns bunch spacing
- 7 TeV proton energy
- energy stored in 2 beams: >0.7 GJ
- energy stored in magnets: ~10 GJ

→ machine & magnet protection crucial

→ many tests & checks necessary during hardware & beam commissioning

→ phased commissioning

# challenge: energy stored in the beam

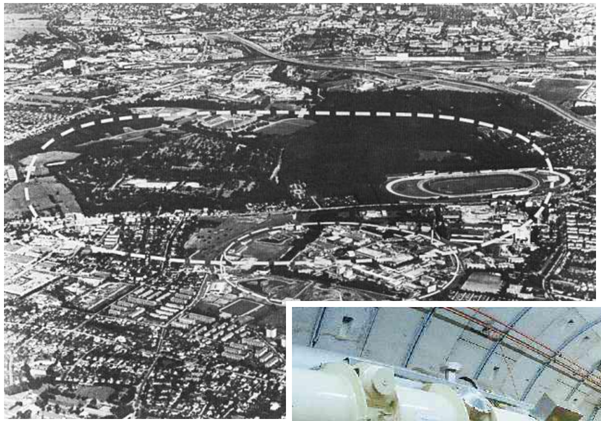


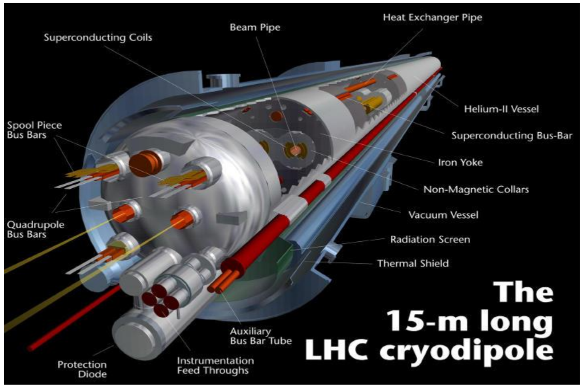

at less than 1% of nominal intensity LHC enters new territory.

R. Assmann, PAC2003


total stored energy=11 GJ
at 30 knots
K.H. Mess, Chamonix 01

# Superconducting Magnets and High Energy Proton Accelerators

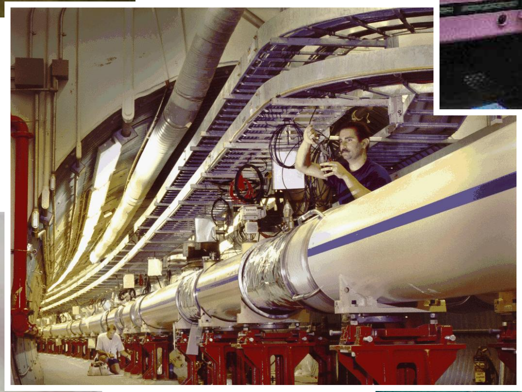





HERA

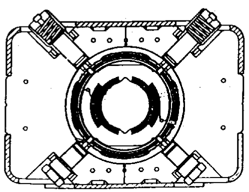
LHC

Tevatron

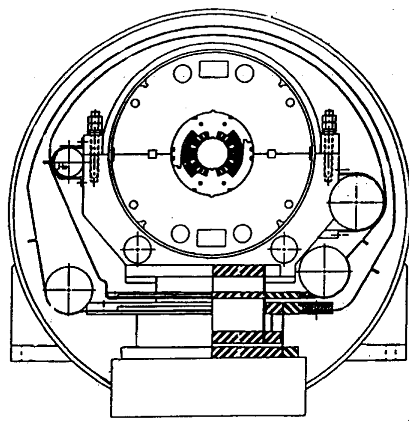


RHIC

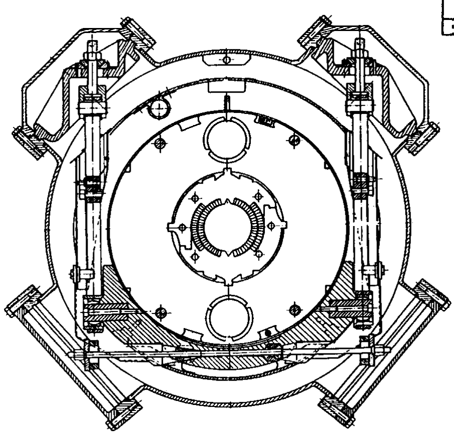
# The world's superconducting accelerator dipoles



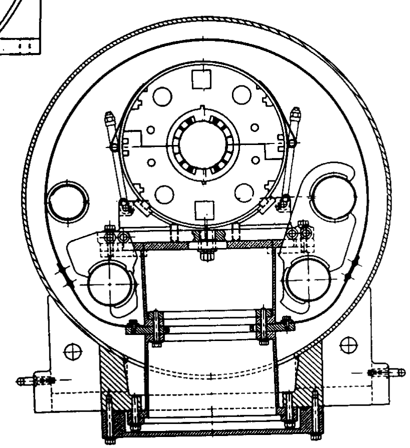
Tevatron



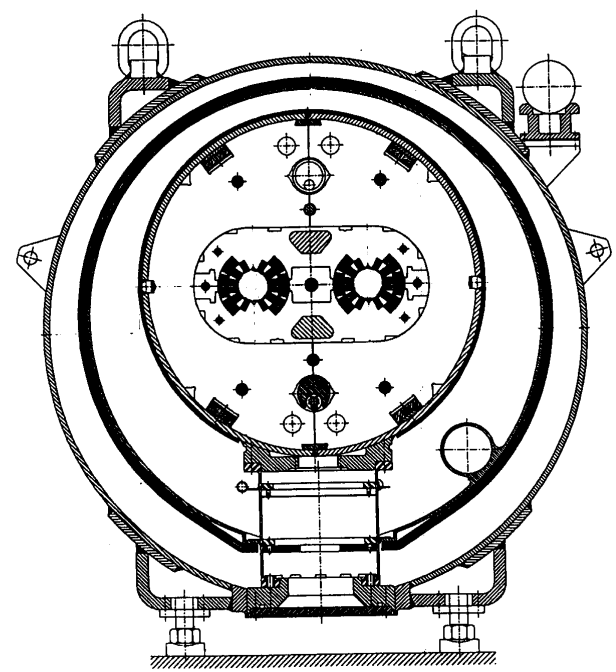
SSC



HERA



RHIC



LHC

# Progress in H.E. Proton Accelerators with Superconducting Magnets

| Accelerator | Tevatron | SSC | HERA | RHIC | LHC |
|---|---|---|---|---|---|
| Lab. | FNAL | SSC | DESY | US | CERN |
| Energy [TeV] | 0.9 | 20 | 0.82 | 0.1/anm | 7 |
| Radius [km] | 1 | 14 | 1 | 0.5 | 4.5 |
| Ring | 1 (p+p-) | 2 (p+p) | 1 (e+p) | 2 (p+p) & ion+ion | p+p |
| **B-dipole [T]** | **4.4** | **6.6** | **4.7** | **3.5** | **8.3** |
| G-quad [T/m] | 76 | 205 | 91 | 72 | 220 |
| R-coil [mm] | 38 | 25 | 37.5 | 40 | 28 |
| #Dipoles | 774 | 7986 (676) | 422 | 288 | 2x1232 |
| **Temperature [K]** | **4.5** | **4.4** | **4.5** | **4.5** | **1.9** |
| Complete year | 1985 | Canceled | 1990 | 2000 | 2008 |
| Note | First SC large Accelerator | Few training quench | First industrial contribution | Economical | Highest field SF-He |

# Magnetic stored energy

**Magnetic energy density** $$E = \frac{B^2}{2\mu_o}$$ at 5T $\boldsymbol{E} = 10^7$ Joule.m$^{-3}$ at 10T $\boldsymbol{E} = 4\text{x}10^7$ Joule.m$^{-3}$

**LHC dipole magnet (twin apertures)** $\boldsymbol{E = \frac{1}{2} LI^2}$ $\boldsymbol{L} = 0.12$H $\boldsymbol{I} = 11.5$kA E = 7.8 x $10^6$ Joules

the magnet weighs 26 tonnes

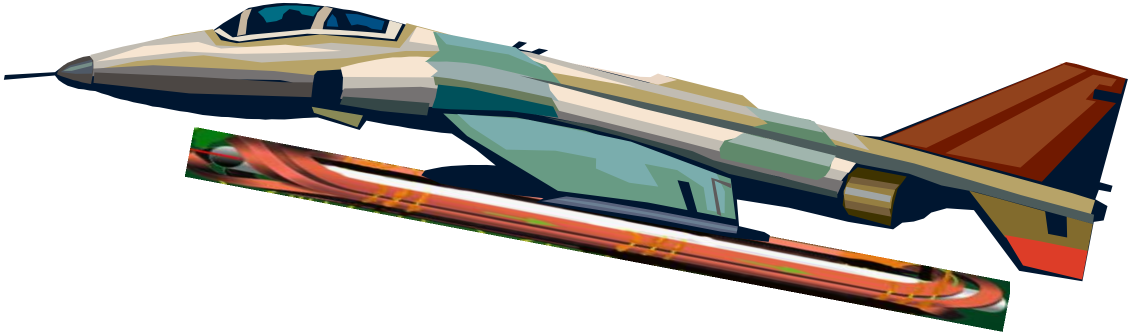
so the magnetic stored energy is equivalent to the kinetic energy of:-

**26 tonnes travelling at 88km/hr**


coils weigh 830 kg

equivalent to the kinetic energy of:-

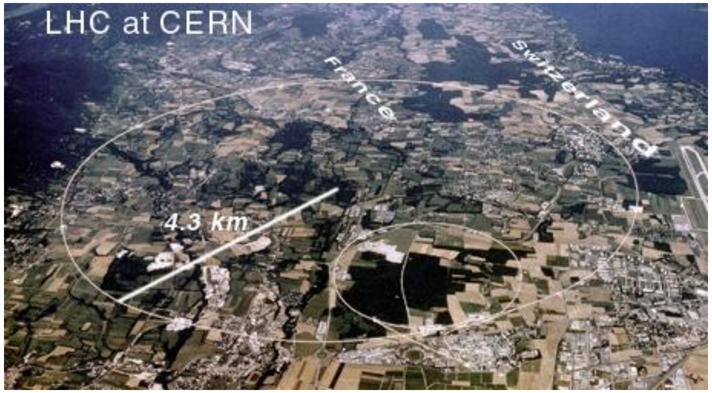
**830kg travelling at 495km/hr**

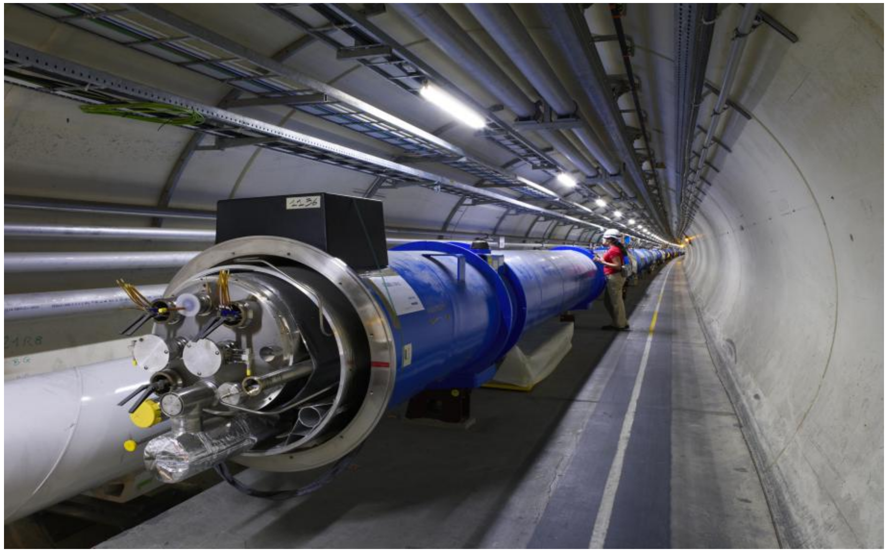


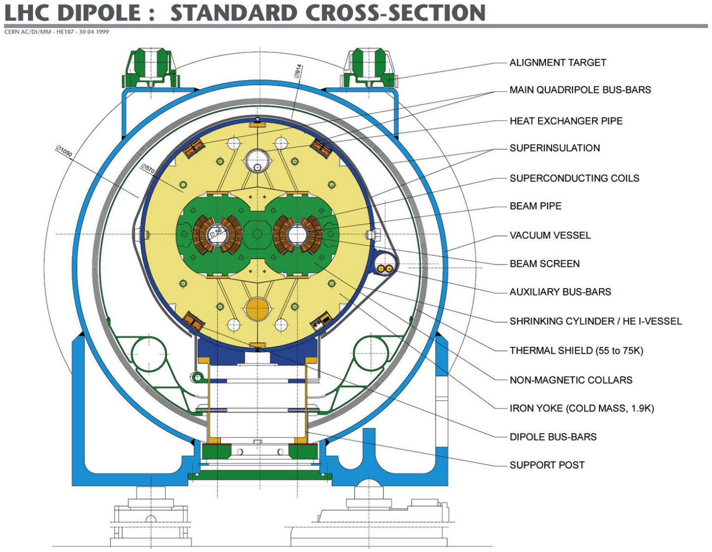
# LHC Superconducting Magnets

- Diameter: 27 km
- Energy 2 x 7 TeV

- SC Magnets 8.4 T, ~ 5,000 units

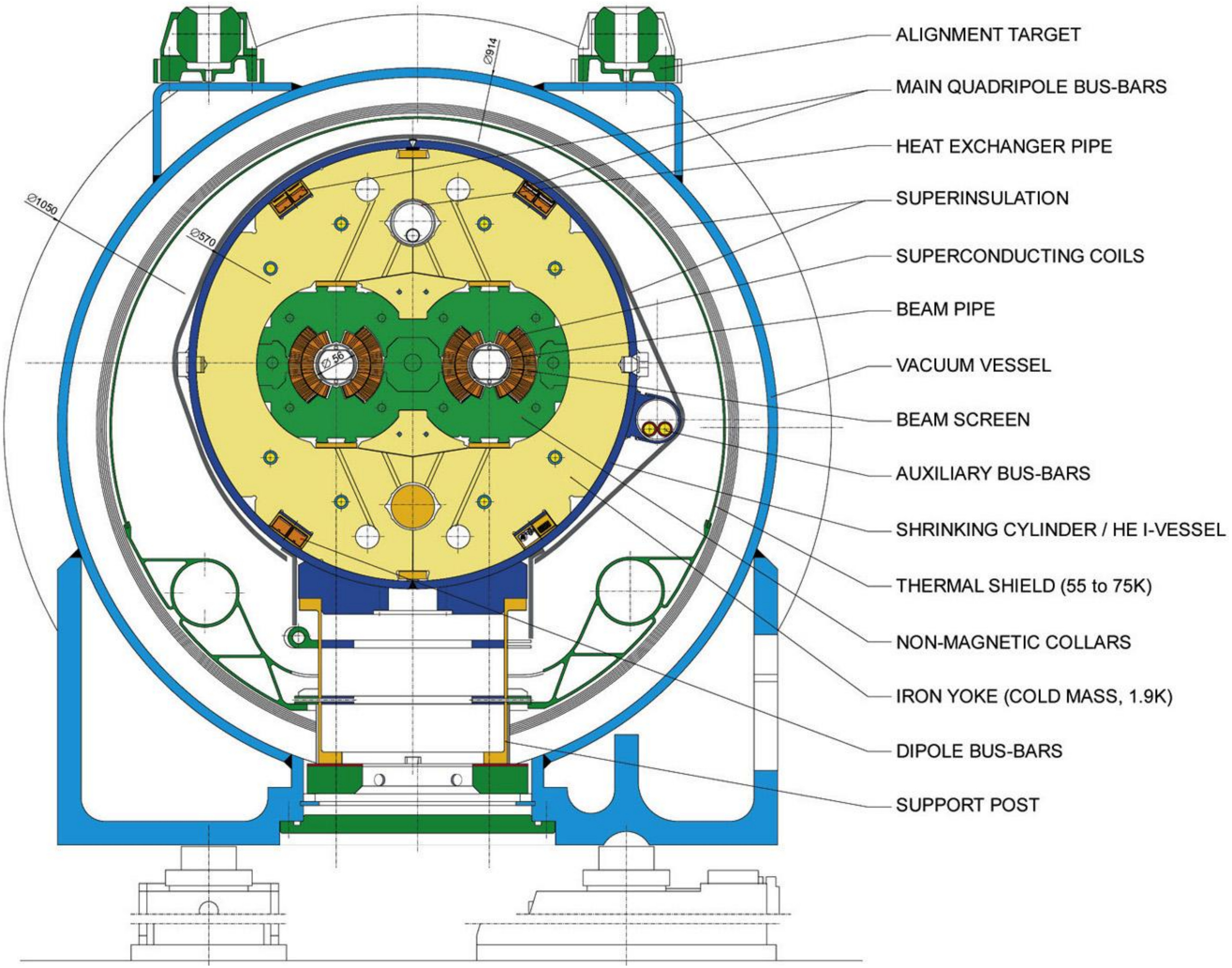




# LHC DIPOLE : STANDARD CROSS-SECTION

CERN AC/DI/MM - HE107 - 30 04 1999



# LHC dipole collars

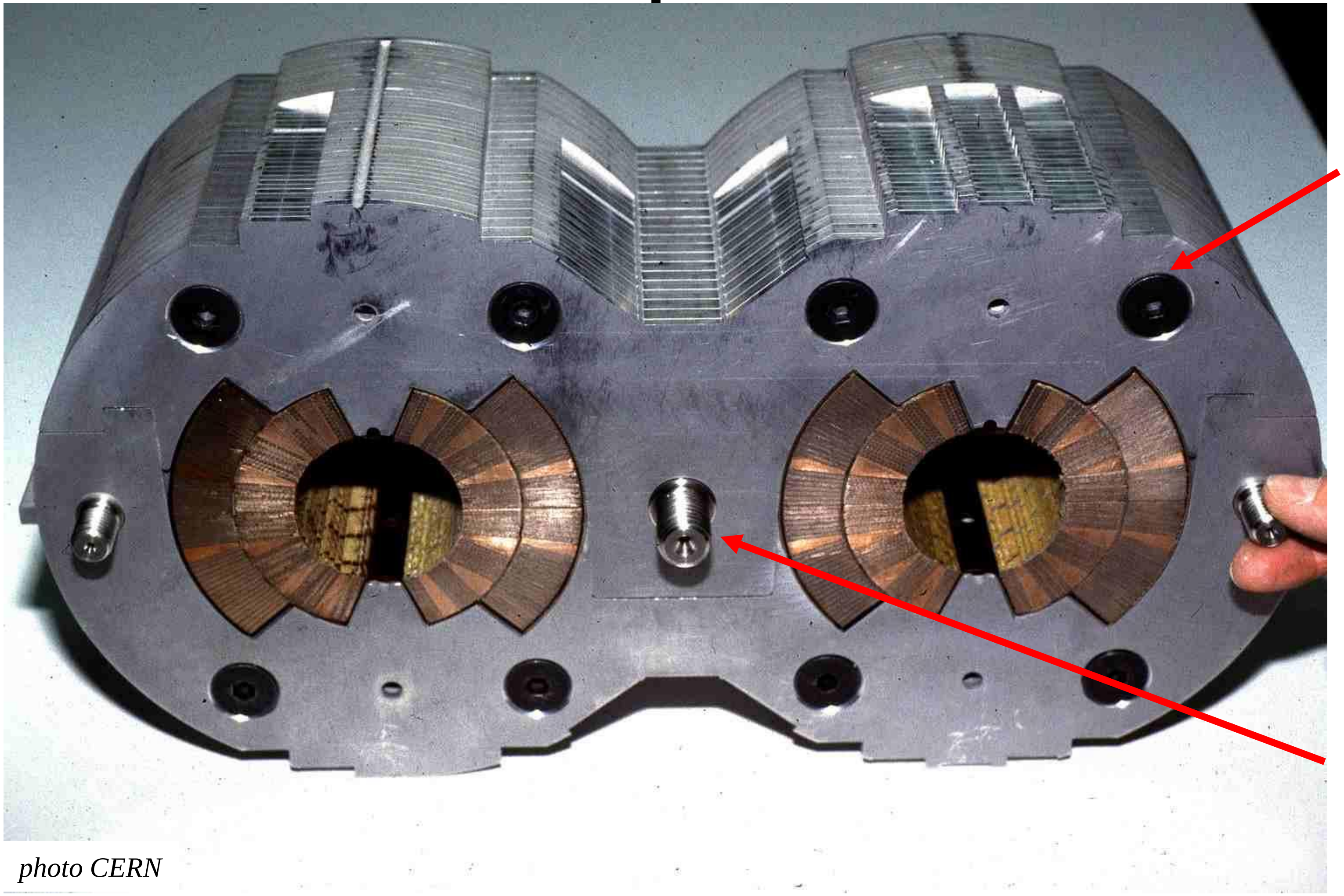
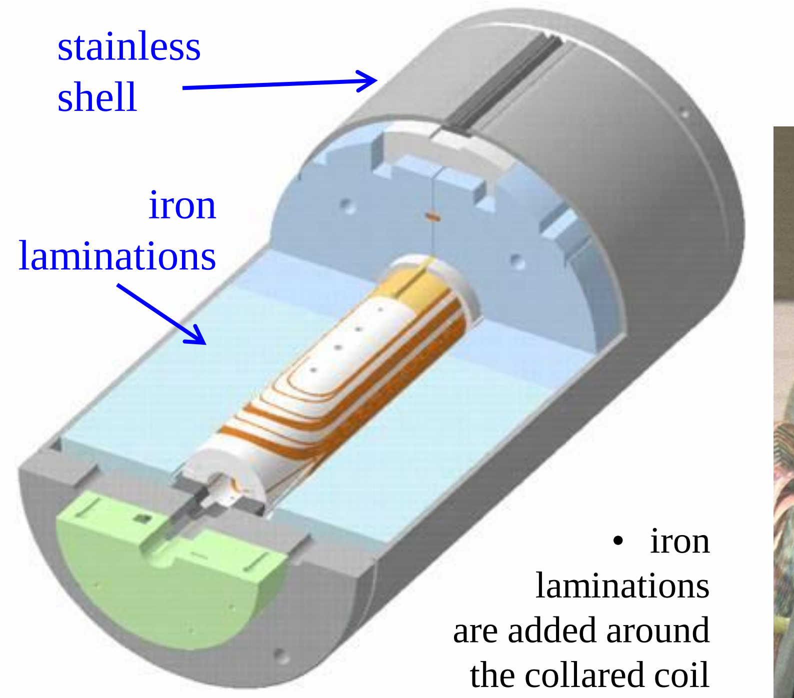


*photo CERN*

sub-units of several alternating pairs are riveted together

stainless rods lock the sub-units together




- iron laminations are added around the collared coil

# Adding the iron

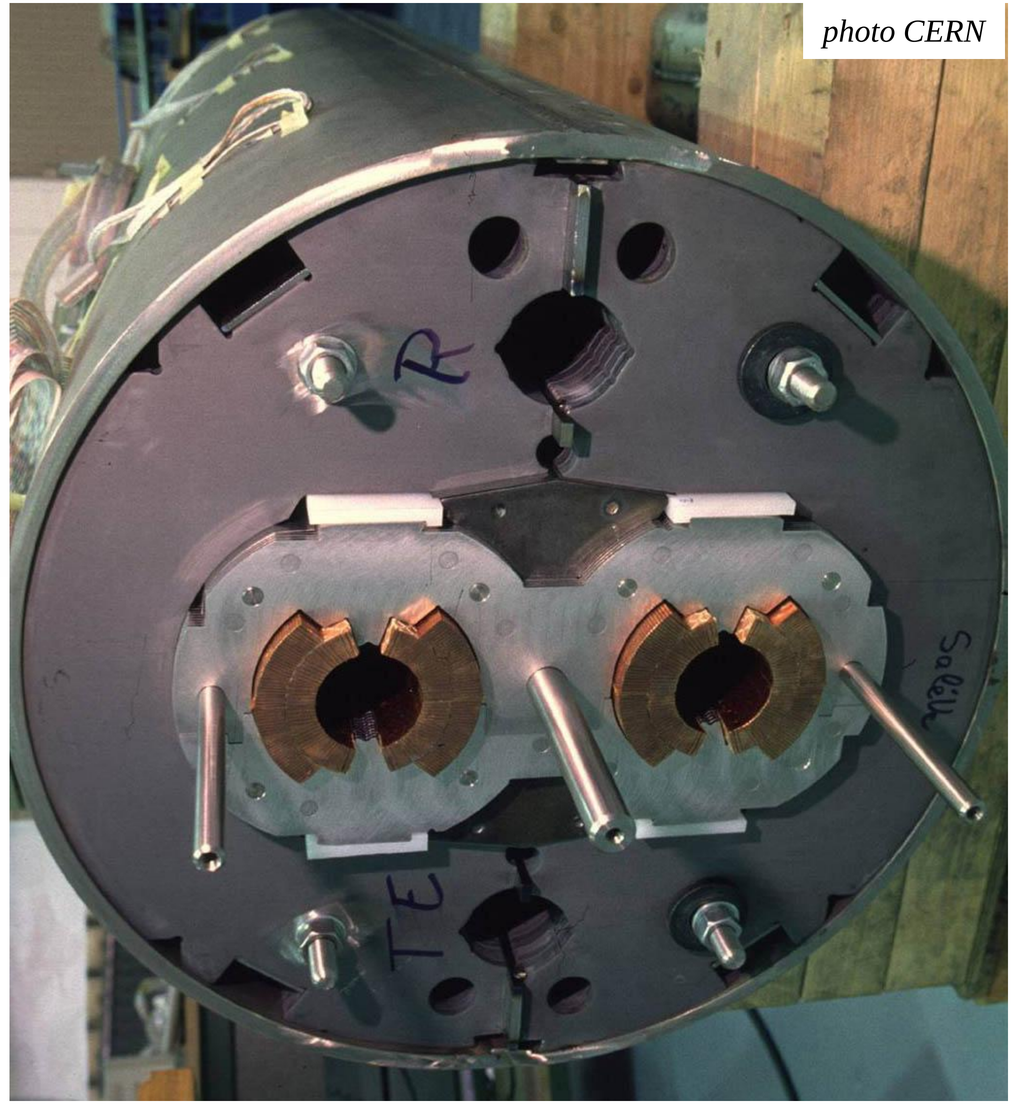
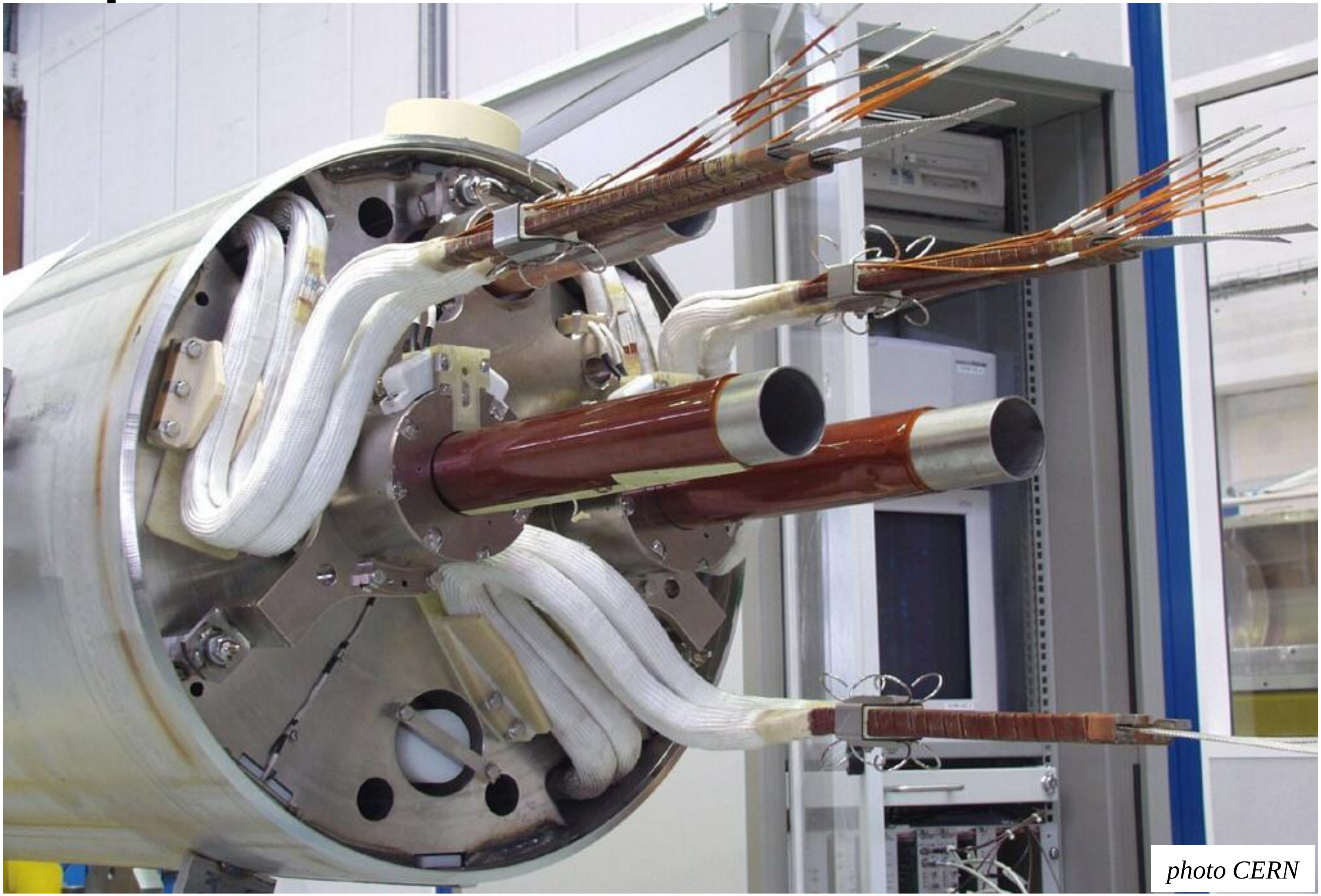


*photo CERN*

- they are forced into place, again using the collaring press
- remember however that pure iron becomes brittle at low temperature
- the tensile forces are therefore taken by a stainless steel shell which is welded around the iron, while still in the press
- this stainless shell can also serve as

  the helium vessel

# Dipole inside its stainless shell



# Complete magnet in cryostat

*photo CERN*

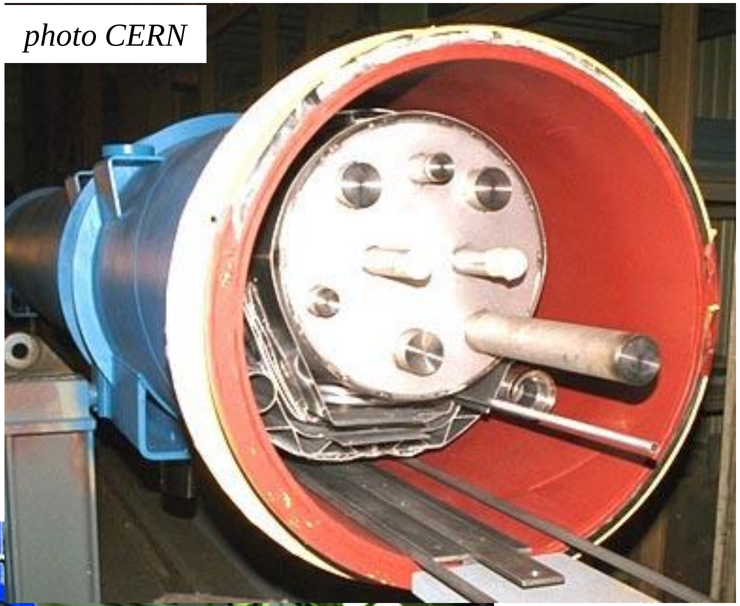


*photo CERN*

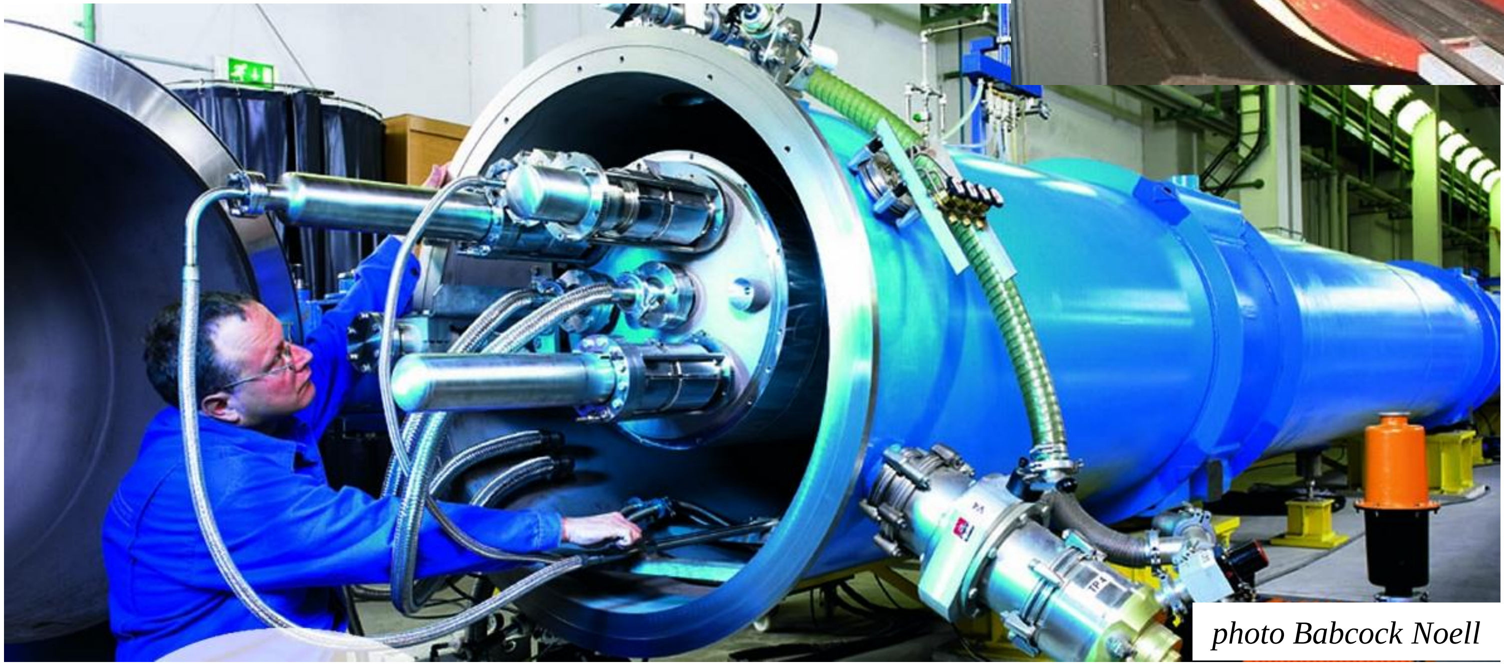
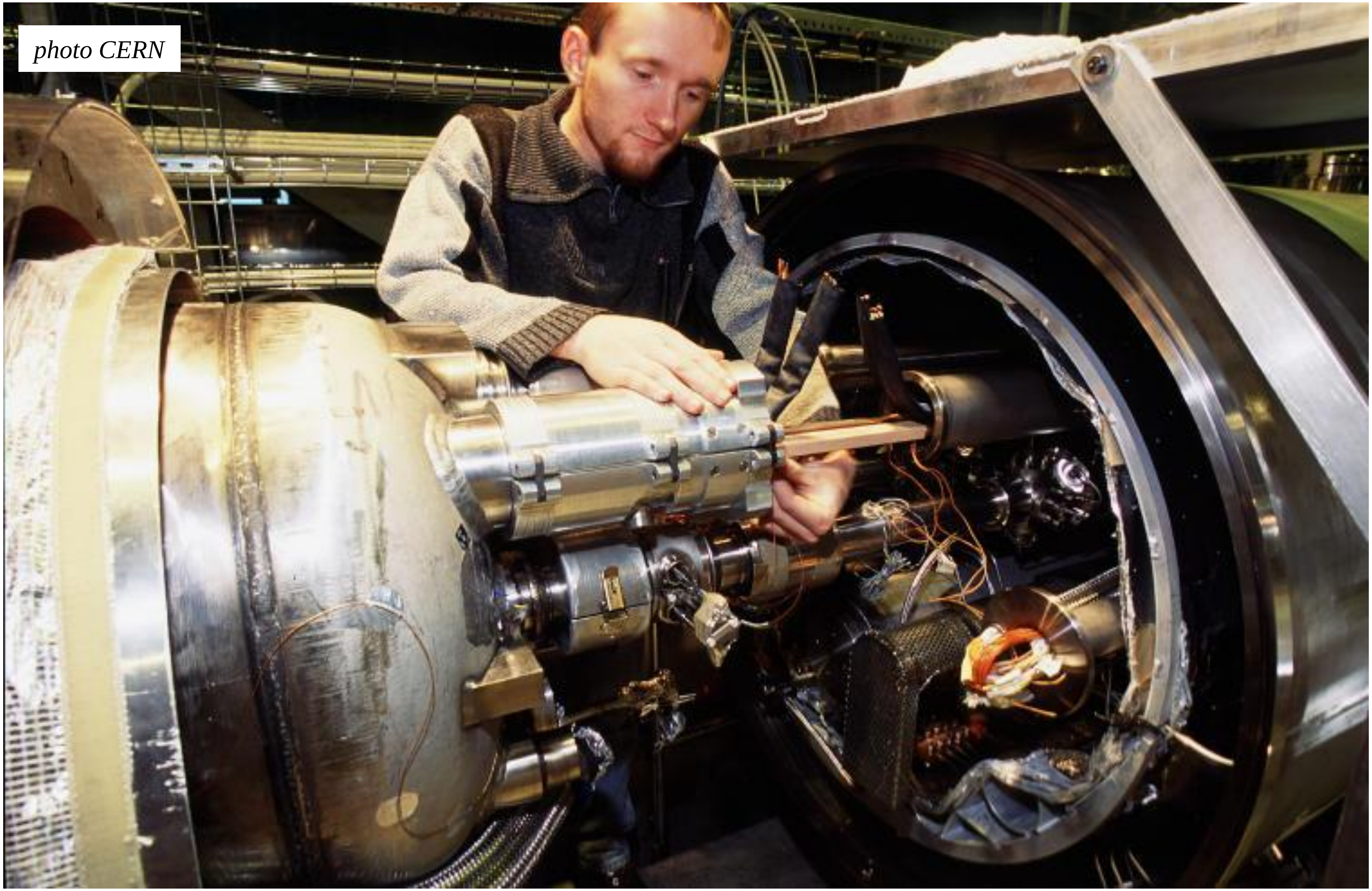
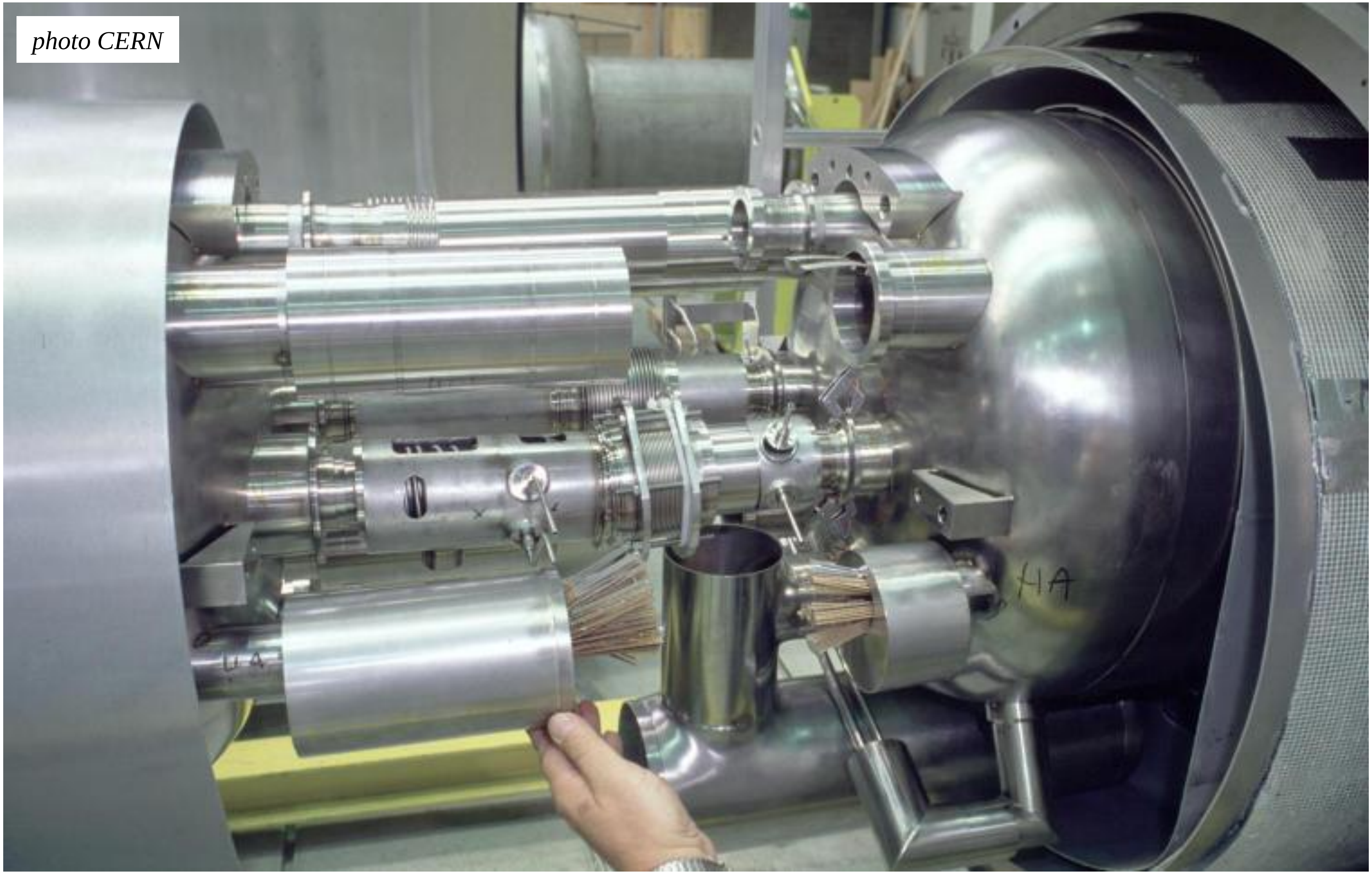


*photo Babcock Noell*

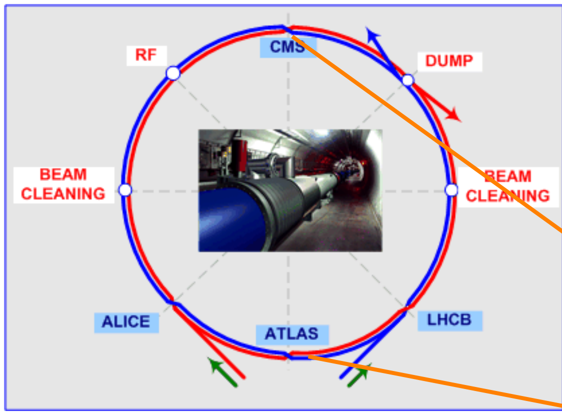
# Make the interconnections -

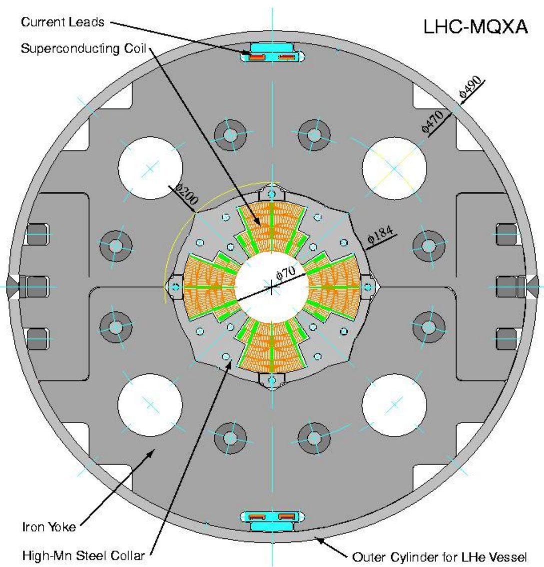


# Make interconnections -



# CERN-LHC Beam Interaction Region Focusing Magnets



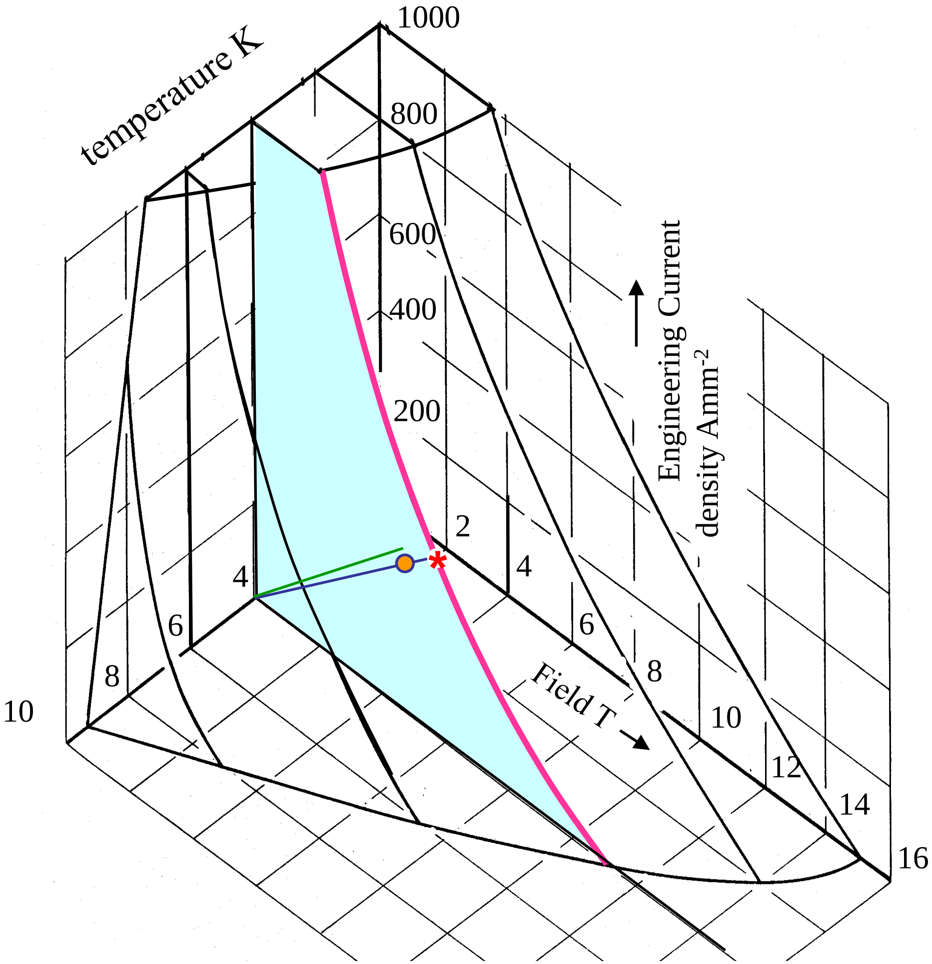


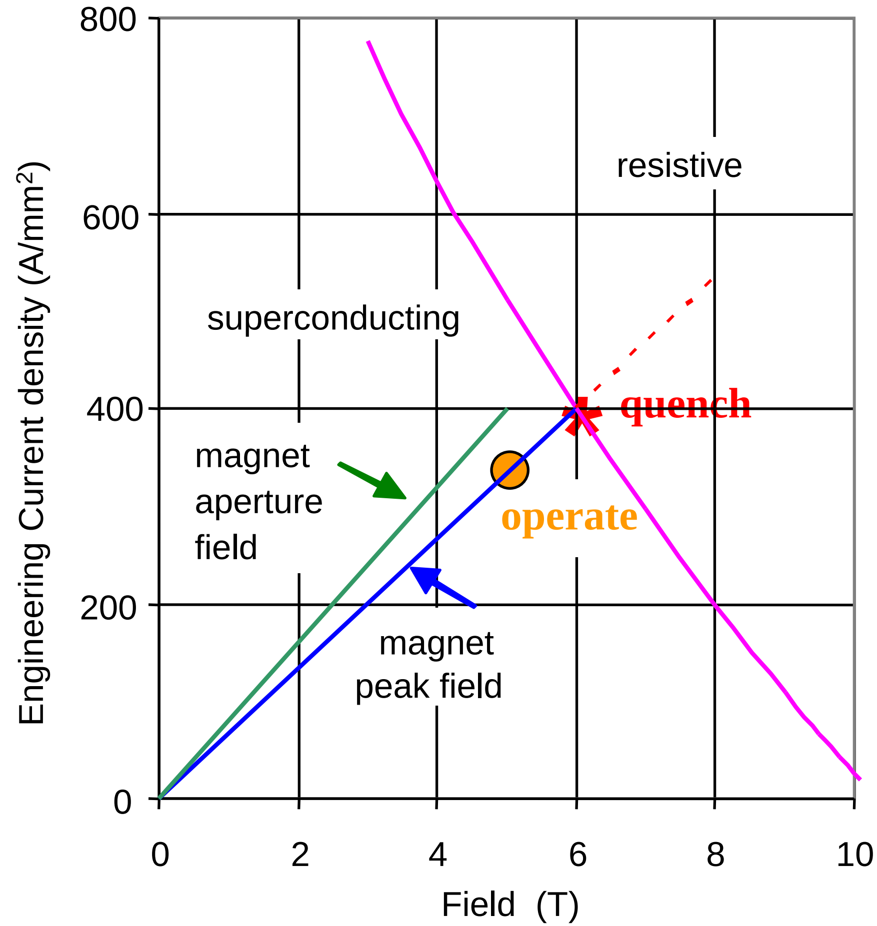
CERN KEK-Fermilab Coollaboration

- LHC dipoles achieve magnetic field of 8.4 Tesla, which is almost the maximum achievable magnetic field by NbTi cables.

- To reach above goal, large scale 2 K He II cooling is used at LHC.

# Critical line and magnet load lines

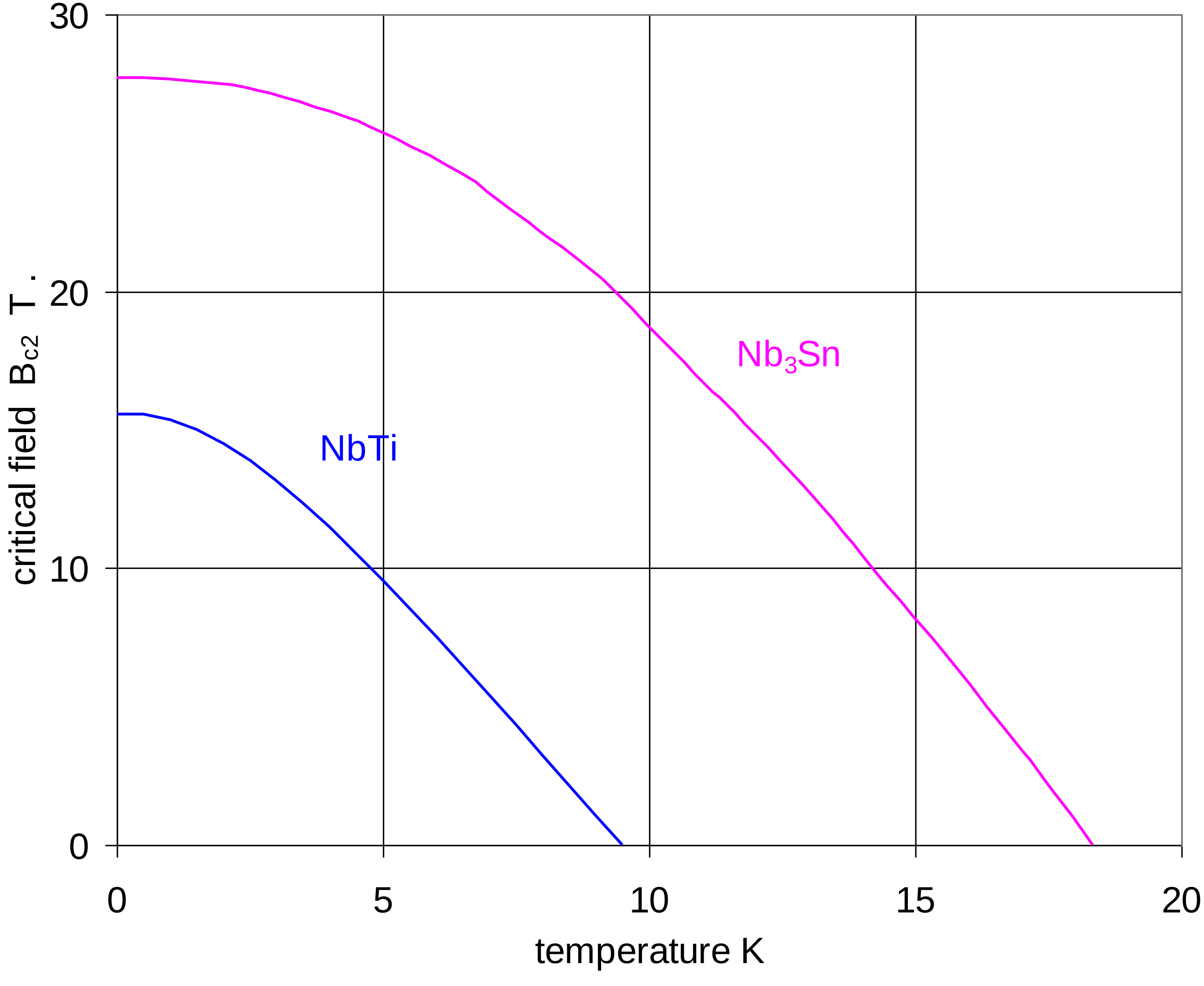



we expect the magnet to go resistive *'quench'* where the peak field load line crosses the critical current line *

usually back off from this extreme point and operate at

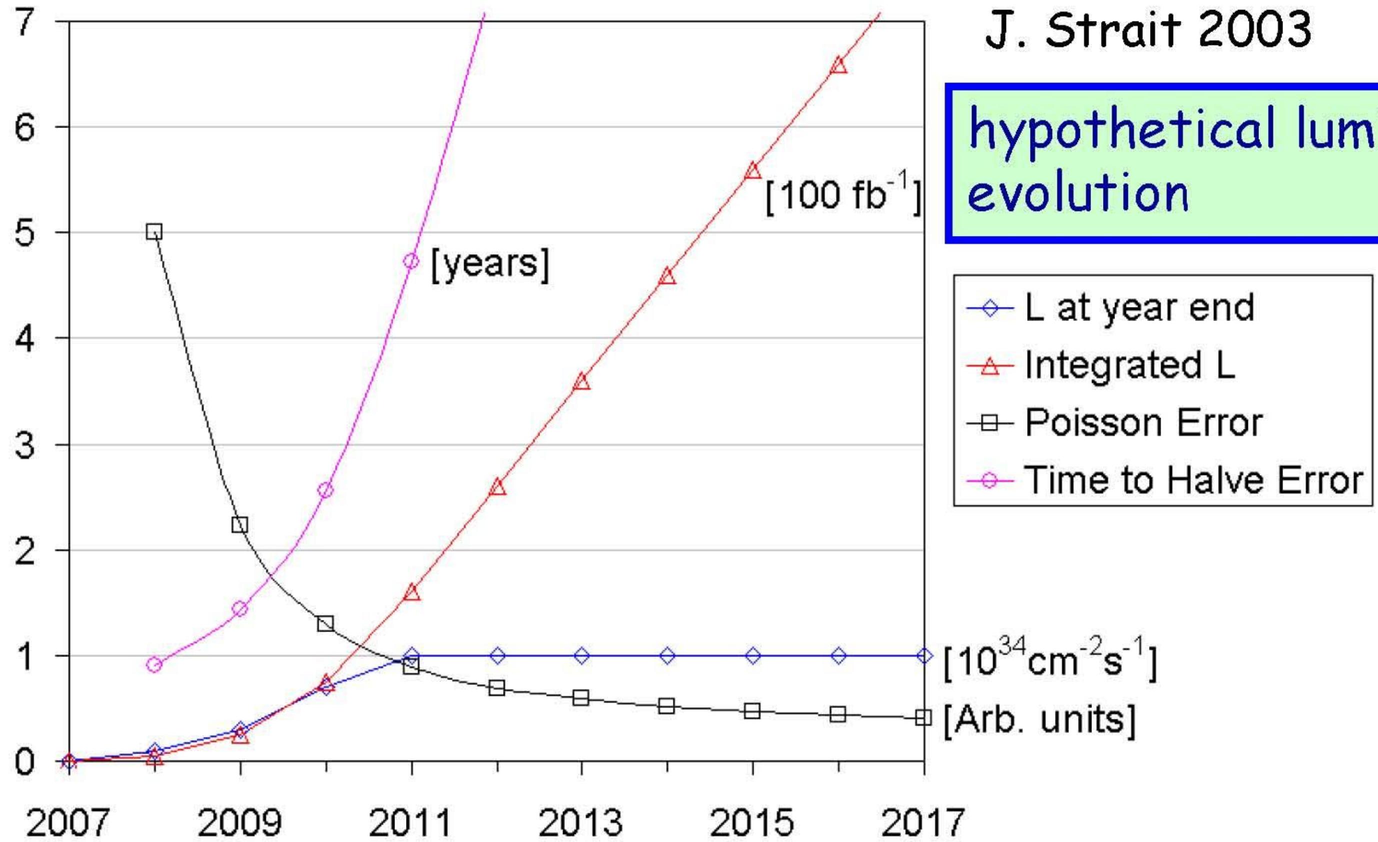
# Critical field & temperature of metallic superconductors




To date, all superconducting accelerators have used NbTi.

Of the intermetallics, only $Nb_3Sn$ has found significant use in magnets

# Two Strong Reasons for LHC Upgrade




J. Strait 2003

hypothetical luminosity evolution

1) after few years, **statistical error** hardly decreases
2) **radiation damage** limit of **IR quadrupoles** (~700 $fb^{-1}$) reached by ~2016

$\Rightarrow$ time for an upgrade!

# constraints

- collimation & machine protection
  - quenches, cleaning efficiency, impedance

  → limit on beam current
- electron cloud
  - heat load in s.c. magnets, instabilities, emittance growth

  → limit on beam current, bunch pattern
- beam-beam interaction
  - head-on, long-range (LR), crossing angle

  → LR compensators, crab cavities, ES dipoles

# staged approach to LHC upgrade

***"phase-1" 2013:***

new triplets, D1, TAS, $\beta^*$=0.25 m in IP1 & 5,
reliable LHC operation at ~2x luminosity;
beam from new Linac4

***"phase-2" 2017:*** ***+ injector upgrade***

target luminosity 10x nominal,
possibly$Nb_3Sn$ triplet & $\beta^*$~0.15 m

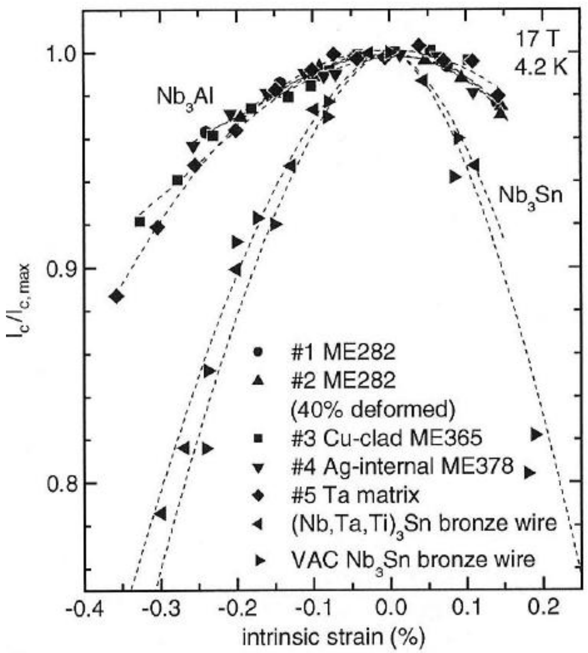
***complementary measures 2010-2017:***

e.g. long-range beam-beam compensation,
crab cavities, new/upgraded injectors, advanced
collimators, coherent e- cooling, e- lenses

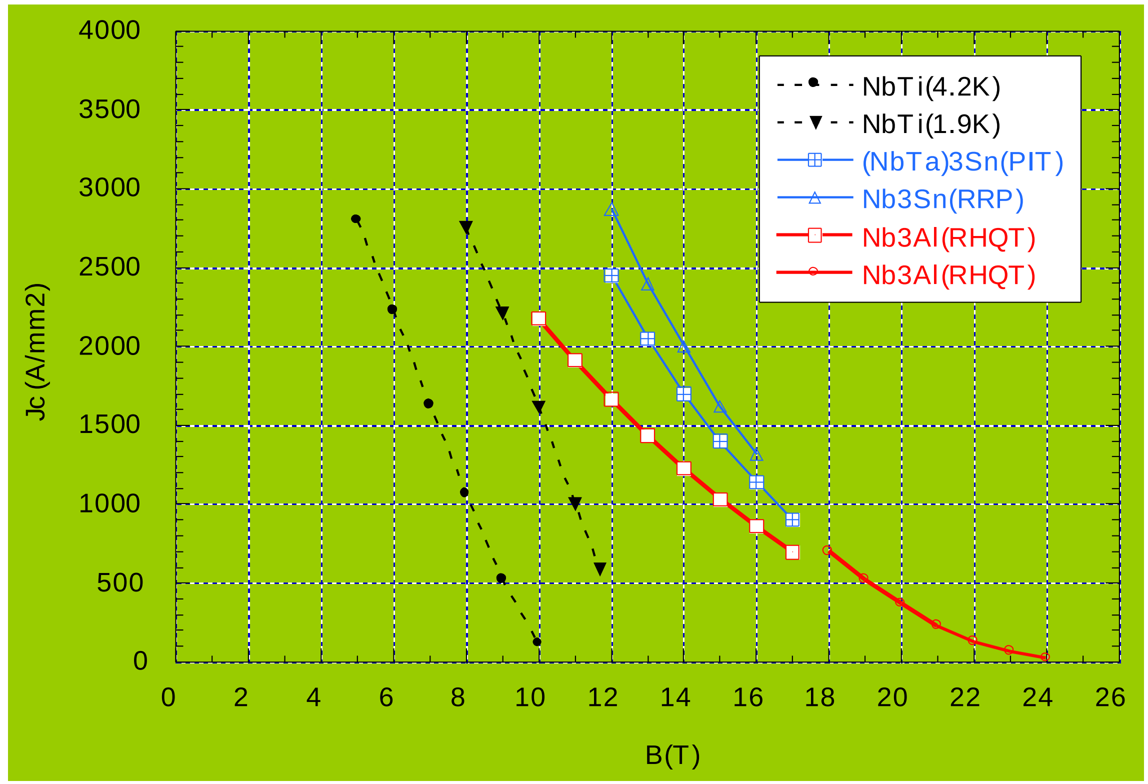
***phase-2 might be just phase-1 plus complementary measures***

***longer term (2020?): energy upgrade, LHeC,…***

# Nb3Sn and Nb3Al for Future Application



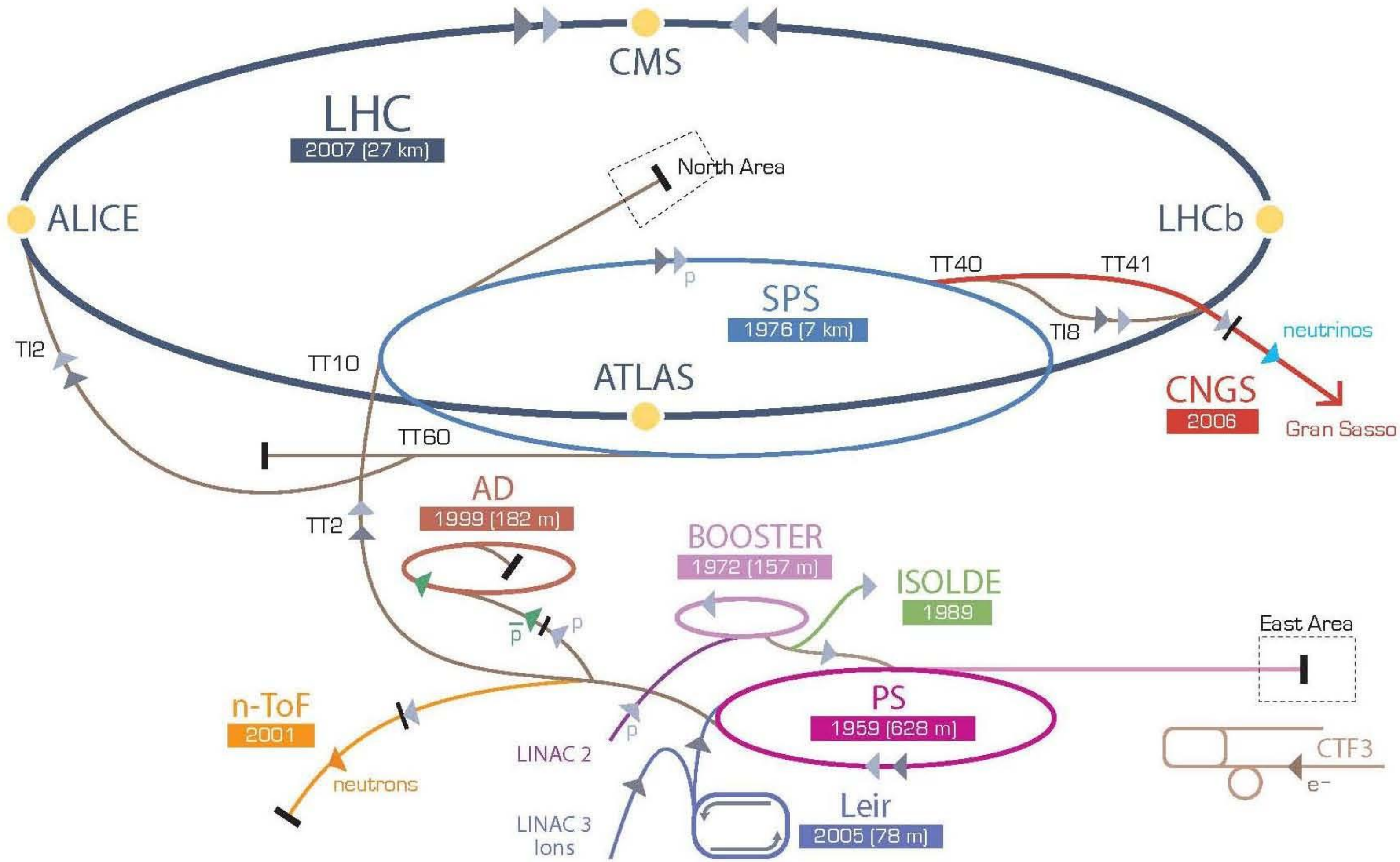

Supercond. Sci. Technol. 18 (2005) p. 284.
by N. Banno et al.




**Remark on Nb3Al**

- **Mechanical toughness** and potential for **"React and Wind"**
- High Jc in high magnetic field at **> 15 T**

# CERN accelerator complex

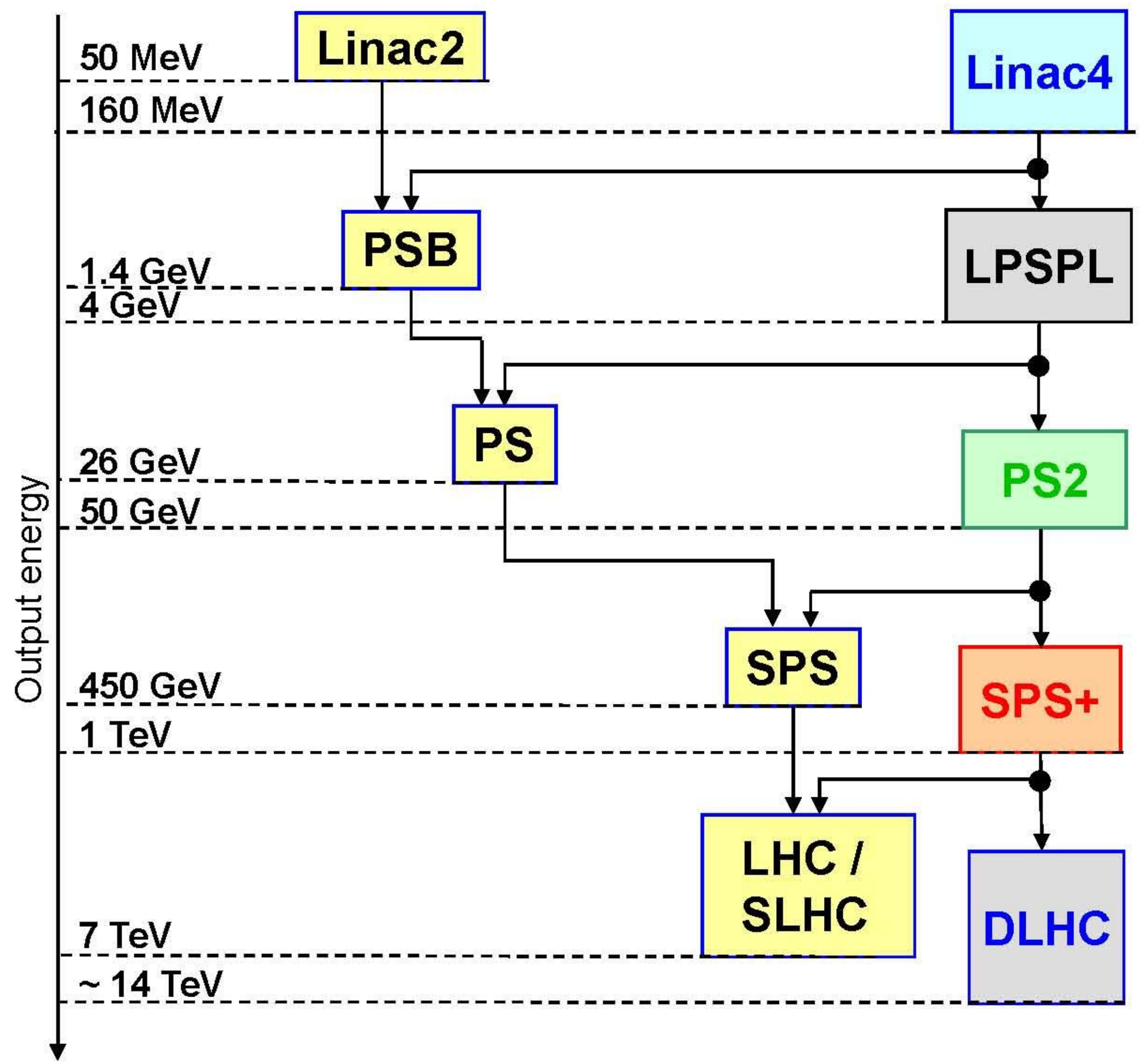



p (proton) ion neutrons p̄ (antiproton) proton/antiproton conversion neutrinos electron

LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron

AD Antiproton Decelerator CTF3 Clic Test Facility CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice
LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight

# upgrade components




Proton flux / Beam power

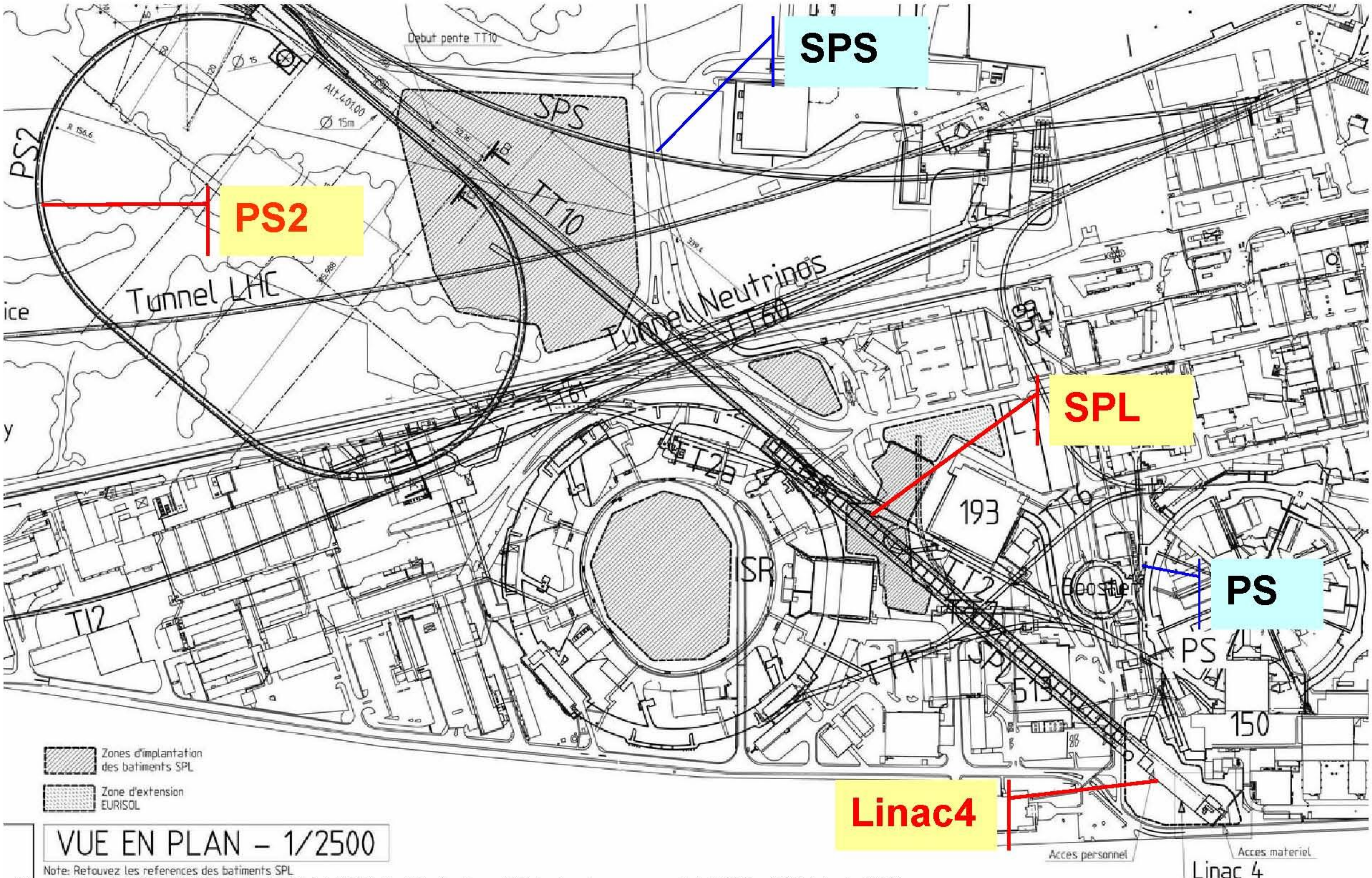
**LPSPL:** Low Power Superconducting Proton Linac (4 GeV)
**PS2:** High Energy PS (~ 5 to 50 GeV – 0.3 Hz)
**SPS+:** Superconducting SPS (50 to1000 GeV)
**SLHC**: "Superluminosity" LHC (up to $10^{35}$ $cm^{-2}s^{-1}$)
**DLHC**: "Double energy" LHC (1 to ~14 TeV)

injector upgrade:

- needed for ultimate LHC beam
- reduced turn around time & higher integrated luminosity
- $4x10^{11}$ protons spaced by 25 ns (now ~$1.5\ 10^{11}$)
- beam production:
  for ES & FCC straightforwar for LPA e.g. omitting last double splitting in PS (or PS2)
- numerous techniques for bunch flattening

R. Garoby, CARE-HHH BEAM07, October'07; L. Evans, LHCC, 20 Feb '08

# layout of the new injectors



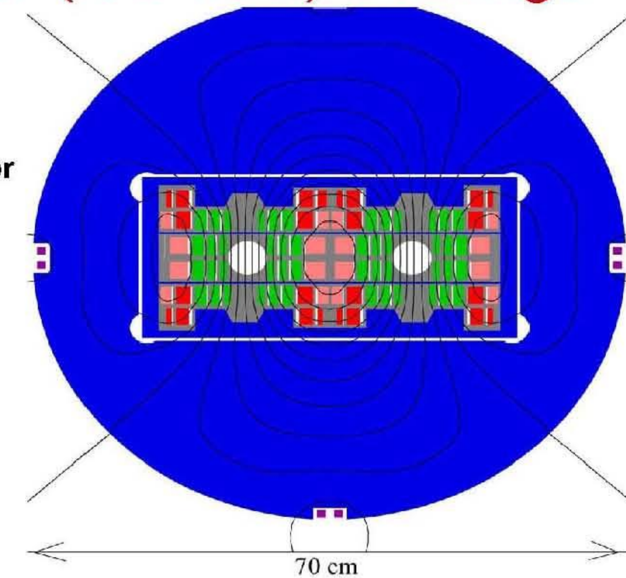

R. Garoby, "CARE-HHH BEAM07, October'07; L. Evans, LHCC, 20 Feb '08

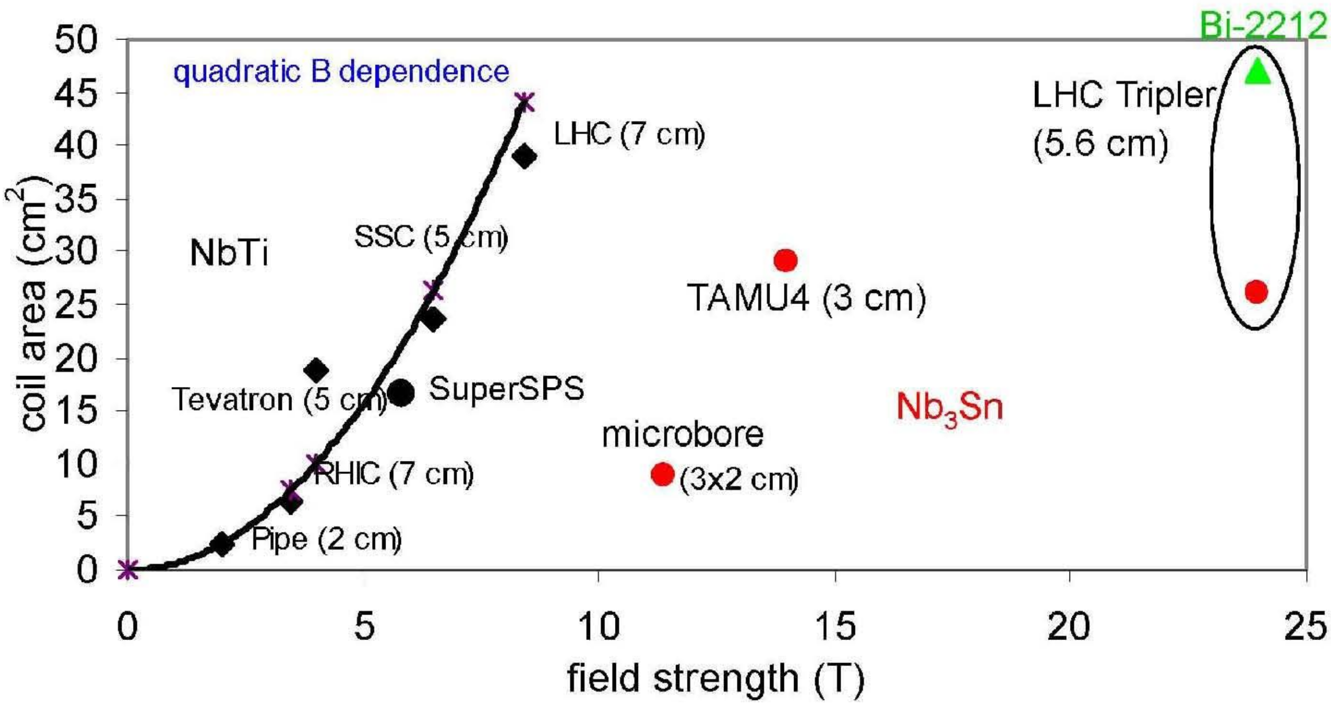
# future energy upgrade?

Bi-2212 in inner (high field) windings, $Nb_3Sn$ in outer (low field) windings

*proposed design of 24-T block-coil dipole for "**LHC energy tripler**"*

| | |
|---|---|
| Dual dipole (ala LHC) | |
| Bore field | 24 Tesla |
| Max stress in superconductor | 130 MPa |
| Superconductor x-section: | |
| $Nb_3Sn$ | 26 cm² |
| Bi-2212 | 47 cm² |
| Cable current | 25 kA |
| Beam tube dia. | 50 mm |
| Beam separation | 194 mm |

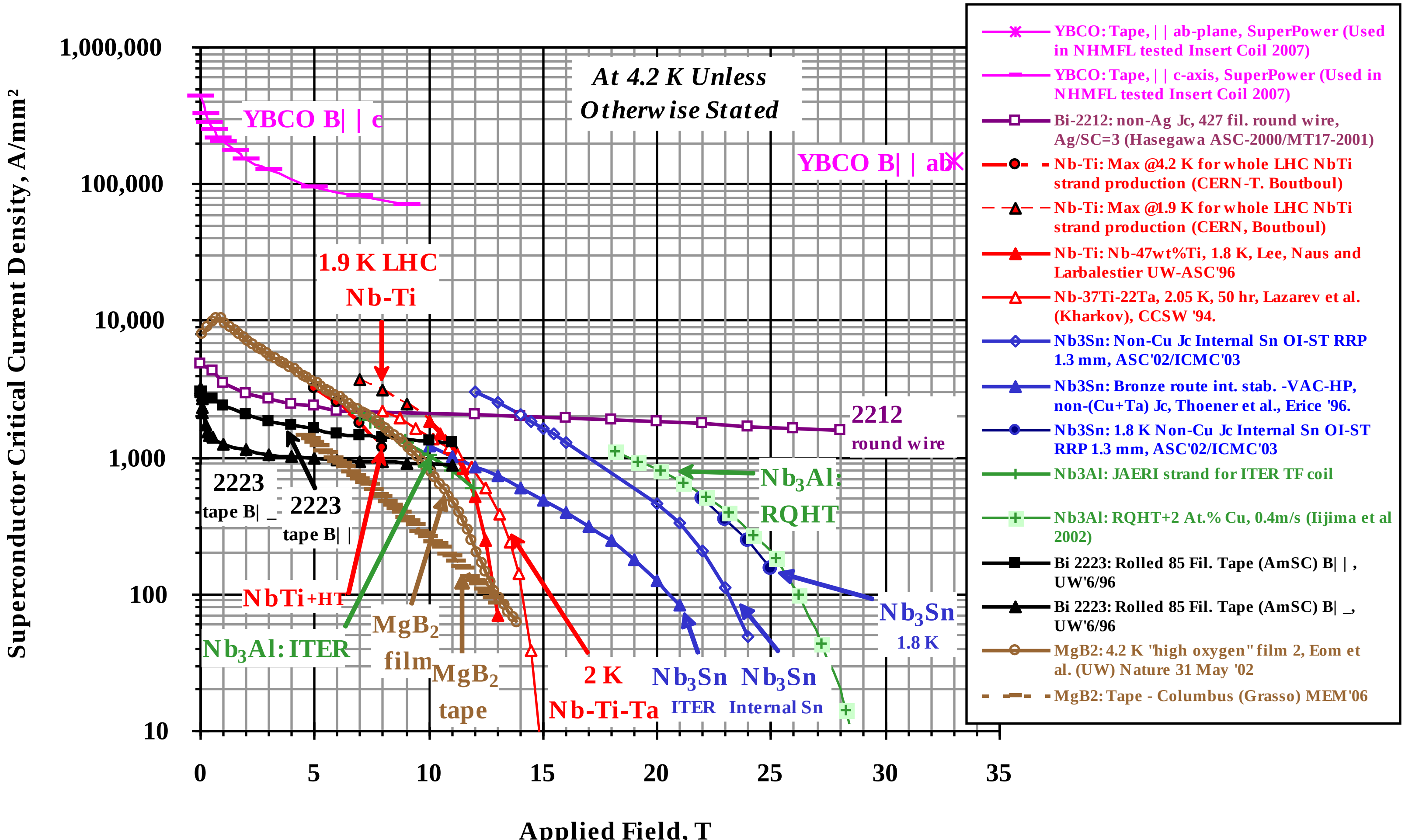



*magnets are getting more efficient!*

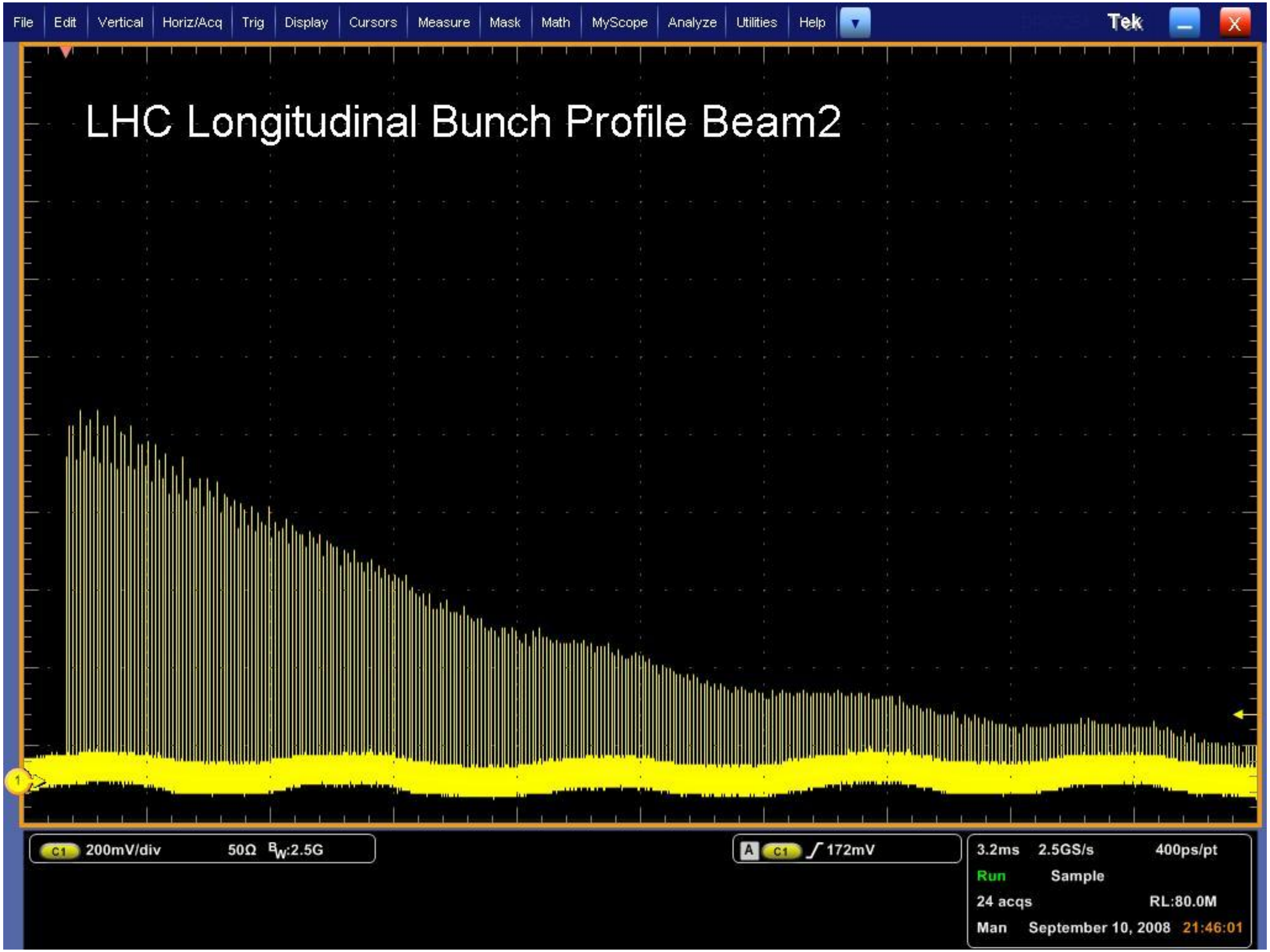
P. McIntyre et al, Texas A&M

# Latest $J_c$ vs. B Master Plot



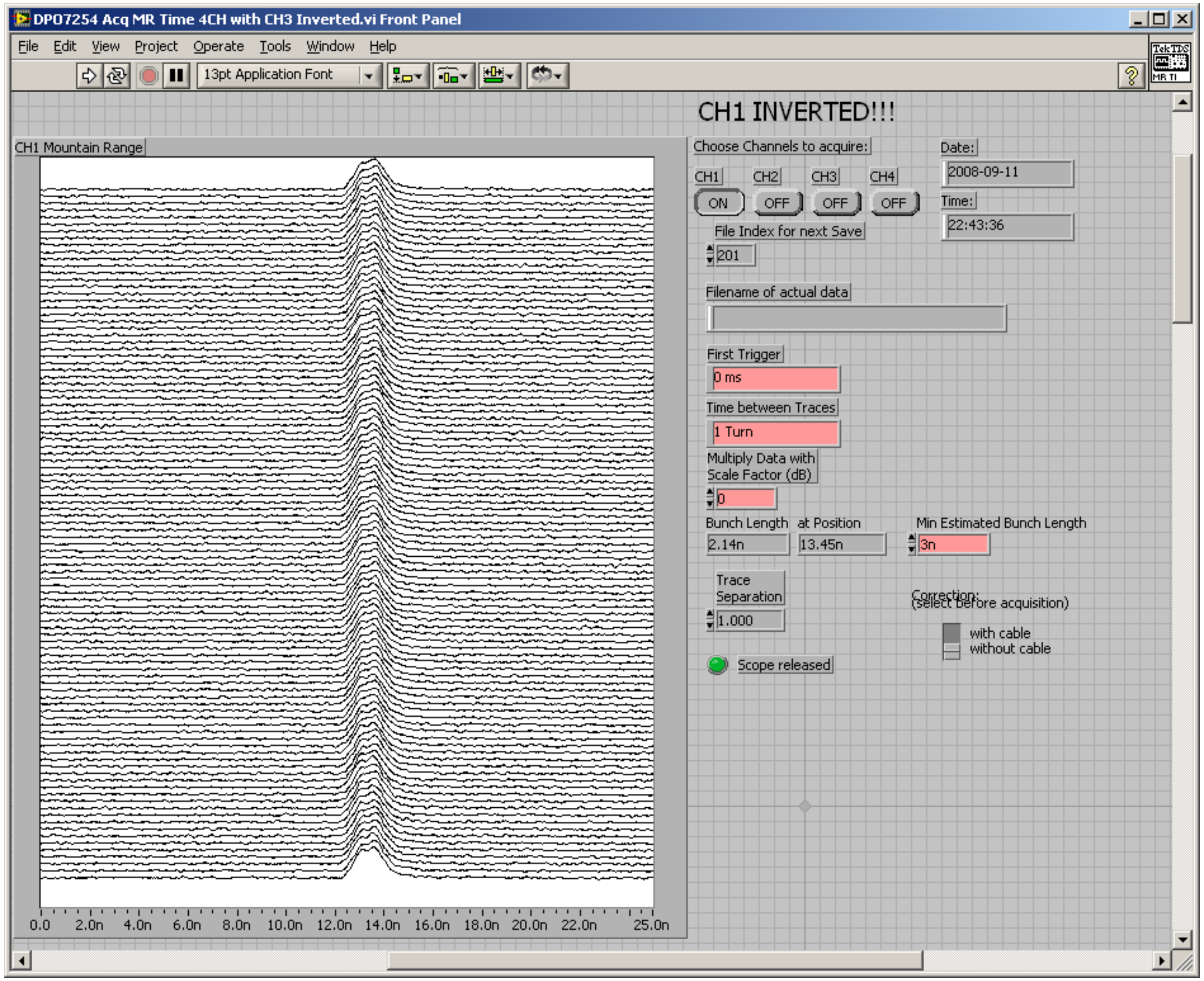

Updates at:
http://magnet.fsu.edu/~lee/plot/plot.htm

# Few 100 turns on September 10



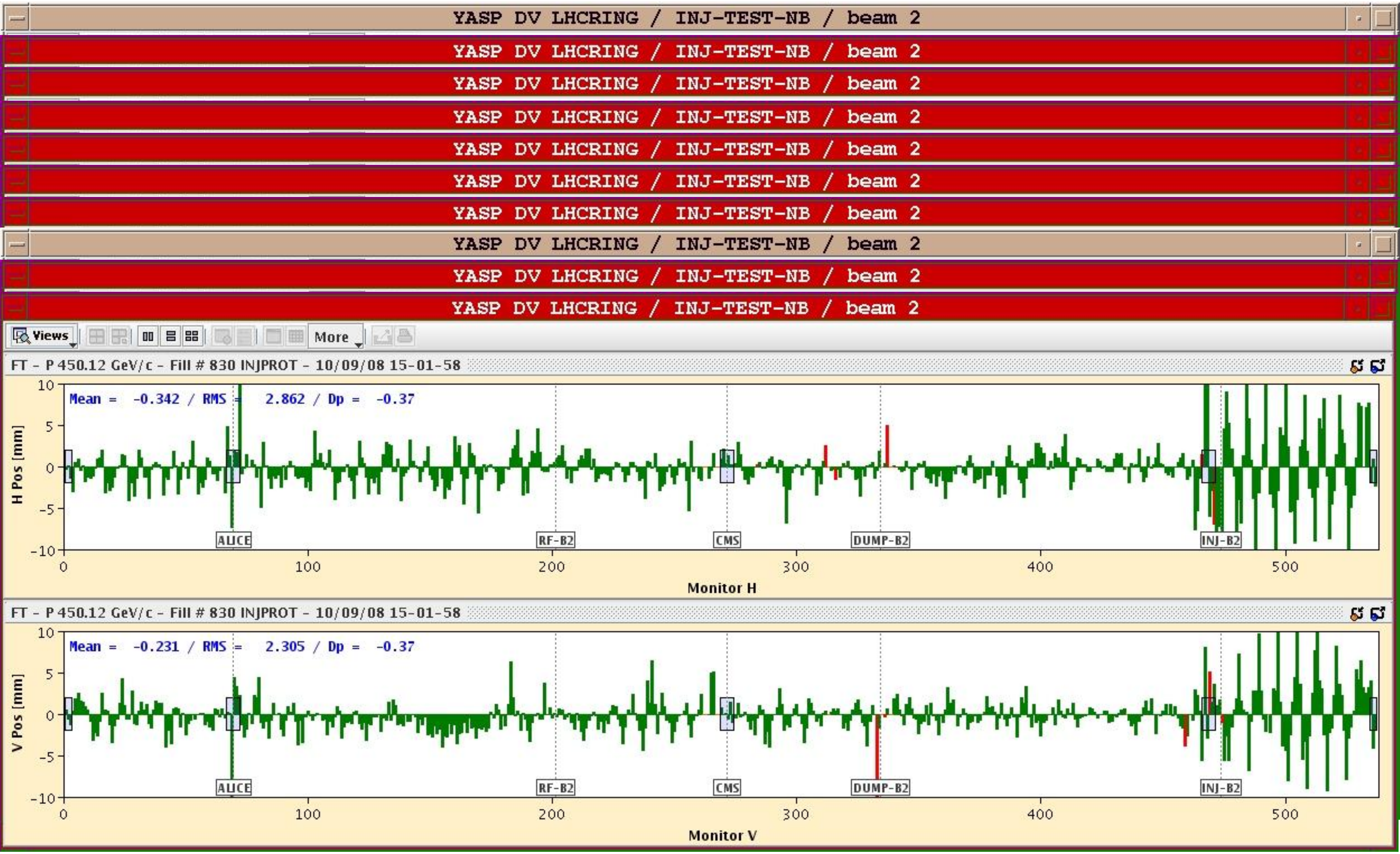

Courtesy R. Bailey

# Capture with optimum injection phasing, correct reference

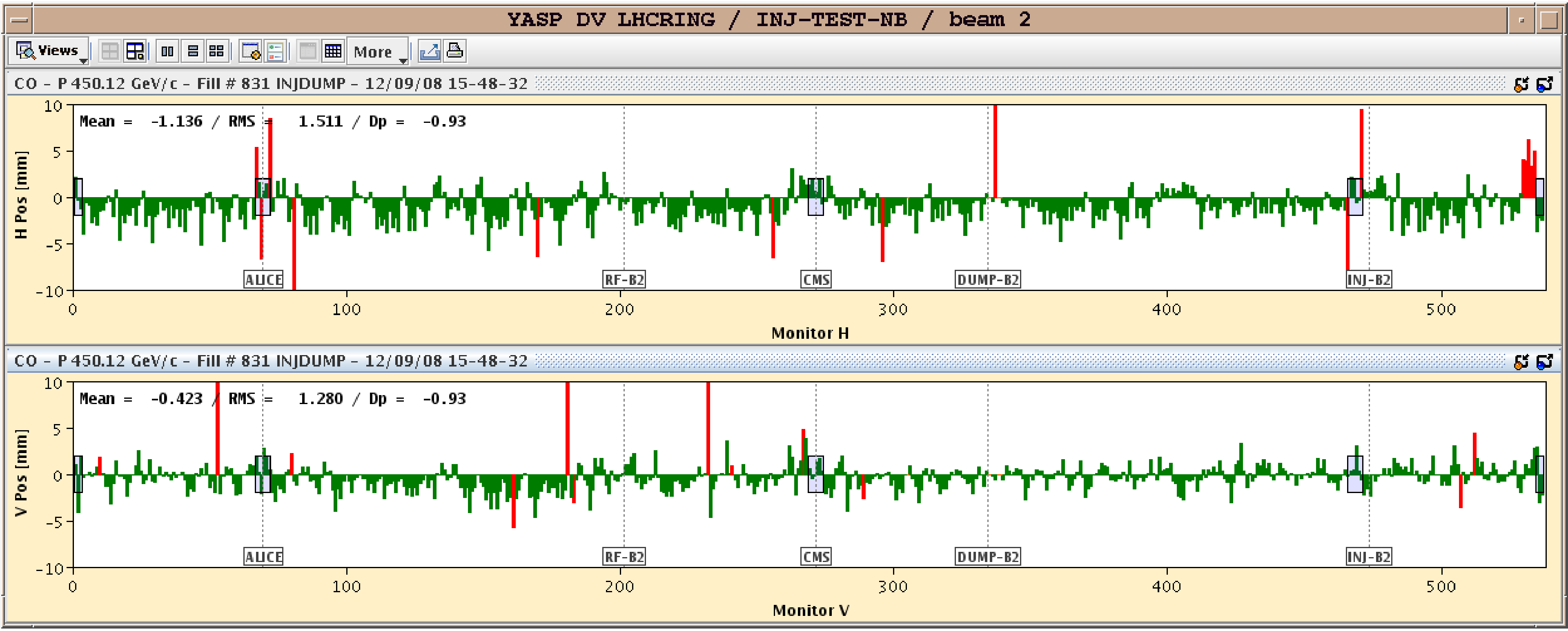



Courtesy E. Ciapala

# Beam 2 first beam – D-Day



# Corrected closed orbit on B2.
# Energy offset of ~ -0.9 permill due to the capture frequency.




Courtesy J. Wenninger

# September 19 Incident

- Due to bad connection of cables between C24 dipole and C24 quadrupole, connection part was heated up and finally evaporated.

- This lead to arching and made a hole to helium enclosure and made helium to go into insulation vacuum.

- High pressure of helium damaged ~50 magnets.

# Make the interconnections -

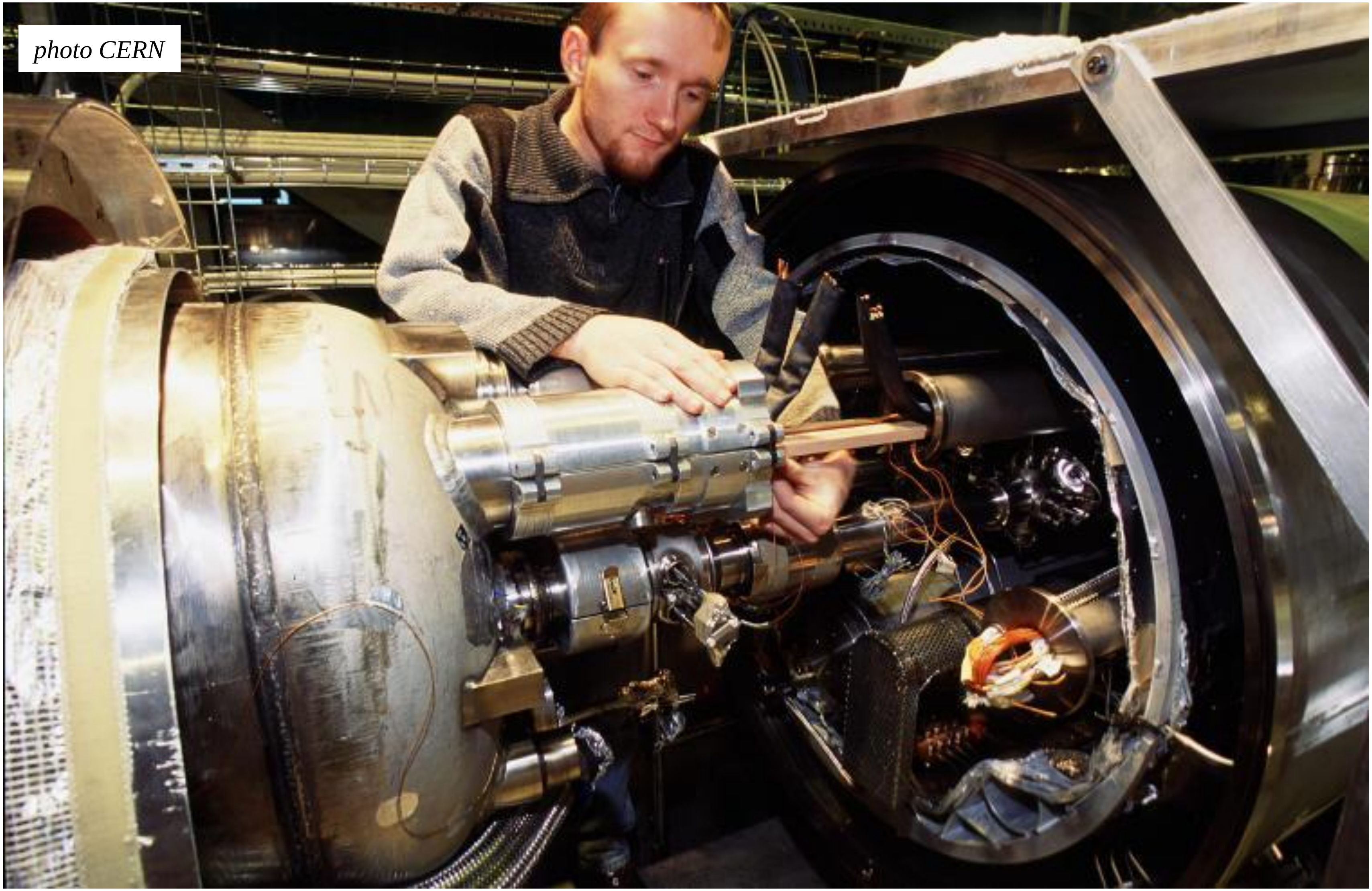
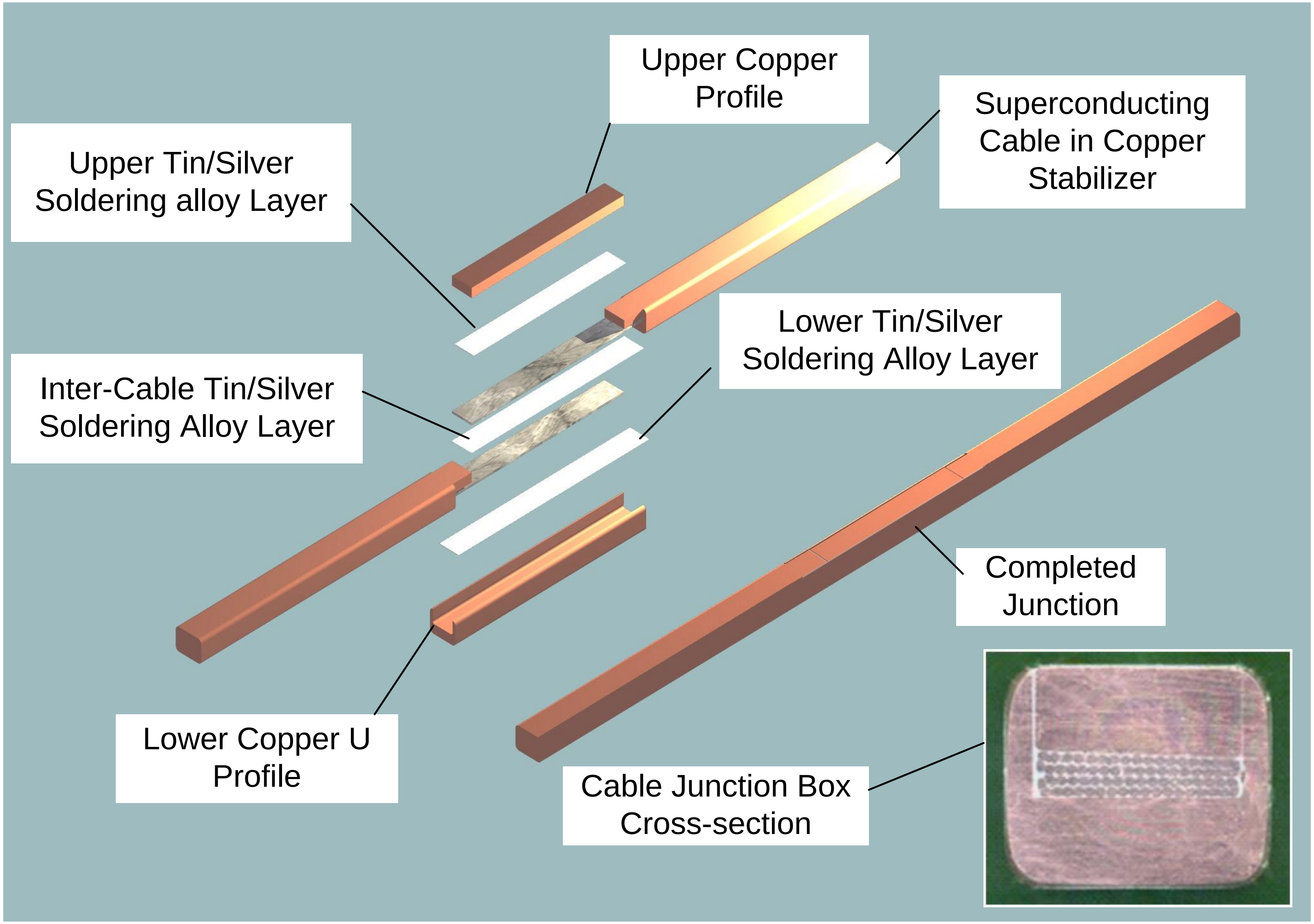


*photo CERN*

# Busbar splice



# Cryostat and cold masses longitudinal displacements

**Displacements status in sector 3-4 (From Q17R3 to Q33R3) ; P3 side**

Based on measurements by TS-SU, TS-MME and AT-MCS

| | Q17 | A18 | B18 | C18 | Q18 | A19 | B19 | C19 | Q19 | A20 | B20 | C20 | Q20 | A21 | B21 | C21 | Q21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cryostat | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cold mass | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | <5 | <5 | <5 | <5 | <5 | <5 | <5 |

| | Q21 | A22 | B22 | C22 | Q22 | A23 | B23 | C23 | Q23 | A24 | B24 | C24 | Q24 | A25 | B25 | C25 | Q25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cryostat | <2 | <2 | <2 | <2 | -7 | <2 | <2 | <2 | -187 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cold mass | <5 | <5 | <5 | <5 | -25 | -67 | -102 | -144 | <5 | -190 | -130 | -60 | <5 | <5 | <5 | <5 | <5 |

| | Q25 | A26 | B26 | C26 | Q26 | A27 | B27 | C27 | Q27 | A28 | B28 | C28 | Q28 | A29 | B29 | C29 | Q29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cryostat | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | 474 | -4 | <2 | <2 | 11 | <2 | <2 | <2 | <2 |
| Cold mass | <5 | <5 | <5 | <5 | <5 | 57 | 114 | 150? | -45 | 230 | 189 | 144 | 92? Vert | 50 | 35 | <5 | <5 |

| | Q29 | A30 | B30 | C30 | Q30 | A31 | B31 | C31 | Q31 | A32 | B32 | C32 | Q32 | A33 | B33 | C33 | Q33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cryostat | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | 188 | <2 | <2 | <2 | 5 | <2 | <2 | <2 | <2 |
| Cold mass | <5 | <5 | <5 | <5 | <5 | 19 | 77 | 148 | <5 | 140 | 105 | 62 | 18 | <5 | <5 | <5 | ? |

SSS with vacuum barrier

>0 Towards P4

[mm] Values are in mm

? Not measured yet

Cold mass displacement

Cryostat displacement

Open interconnection

Electrical interruptions

Dipole in short circuit

Electrically damaged IC

Buffer zones

Disconnected

Courtesy JP. Tock

# Q27R3

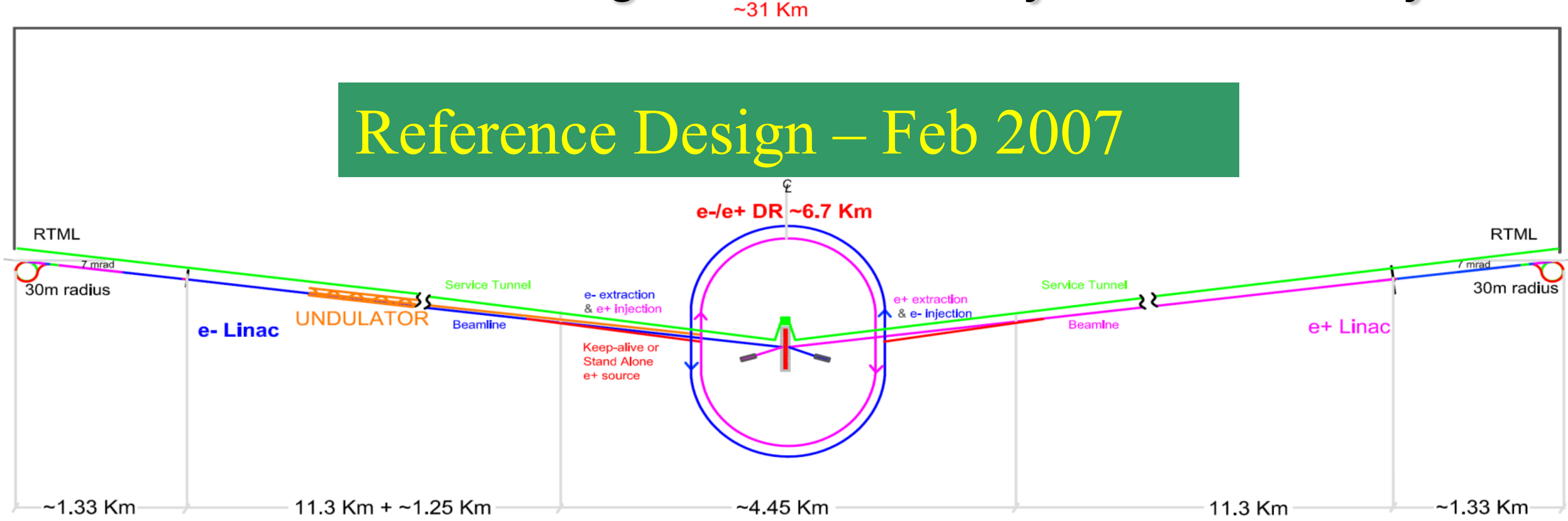
# LHC Summary

- LHC has succeeded in storing current at 450 GeV last September.
- September 19 incidence is a big tragedy (one interconnection error among ~10,000 has damaged a few x 10 magnets); however, CERN is working hard to repair the damaged magnets, and modified QPS, etc.  Beam will come coming autumn.
- 8.3 T dipole filed at 1.9 K is a great achievement of high-energy frontier accelerators (including large scale 2 K cryo-plant).
- I expect that luminosity of LHC will reach its design goal within 4-6 years.
- Future upgrade to reach higher luminosity is MUST for LHC and R&D is of great importance.

# ILC

# ILC Reference Design

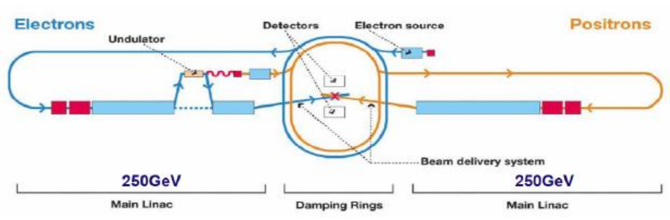
- 11km SC linacs operating at 31.5 MV/m for 500 GeV
- Centralized injector
  - Circular damping rings for electrons and positrons
  - Undulator-based positron source
- Single IR with 14 mrad crossing angle
- Dual tunnel configuration for safety and availability

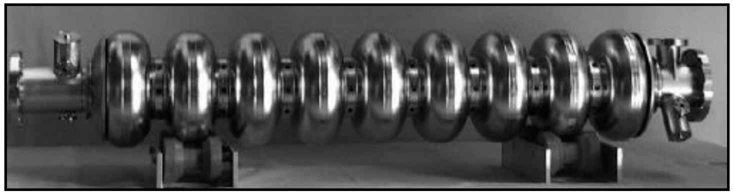



Schematic Layout of the 500 GeV Machine

# SCRF Technology Required

| Parameter | Value |
|---|---|
| C.M. Energy | 500 GeV |
| Peak luminosity | $2x10^{34}$ $cm^{-2}s^{-1}$ |
| Beam Rep. rate | 5 Hz |
| Pulse time duration | 1 ms |
| Average beam current | 9 mA (in pulse) |
| **Av. field gradient** | **31.5 MV/m** |
| **# 9-cell cavity** | **14,560** |
| **# cryomodule** | **1,680** |
| **# RF units** | **560** |



# Technical Design Report

## to be completed by 2012



*ILC Research and Development Plan for the Technical Design Phase*

**Release 2**

**June 2008**

ILC Global Design Effort

Director: Barry Barish

Prepared by the Technical Design Phase Project Management

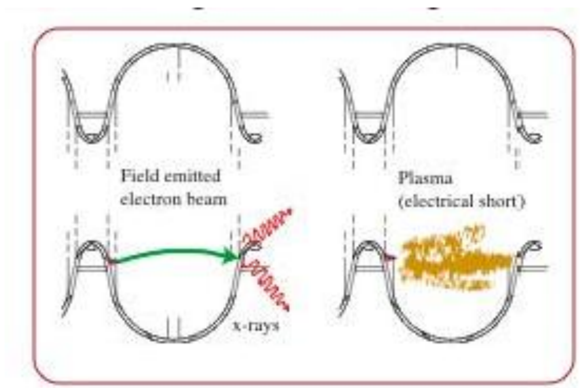
Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

Reference Design, 2007 >> Technical Design Phase, 2008-2012

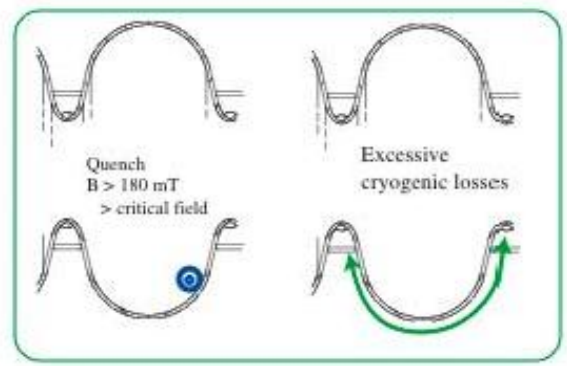
We are now at the stage of progressing from the RD to TD

# Why Field Gradient Limited in SC Cavity ?

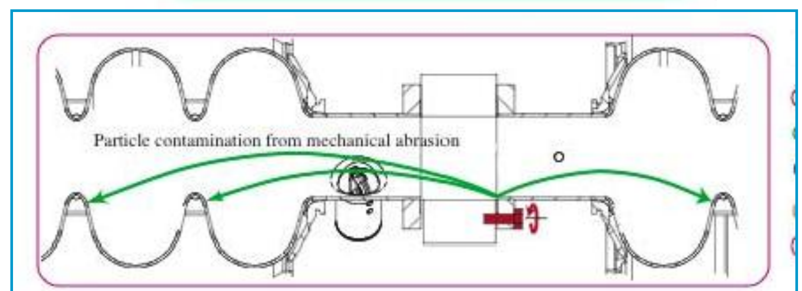
- **Field Emission**
  - due to high electric field
    - around "Iris"




- **Quench**
  - caused by surface heating from dark current, or
  - magnetic field penetration.
    - around "Equator"



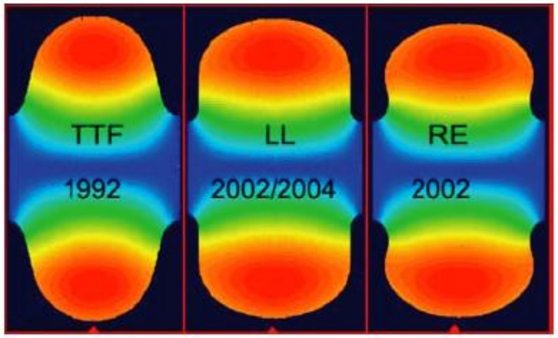

- **Contamination**
  - during assembly

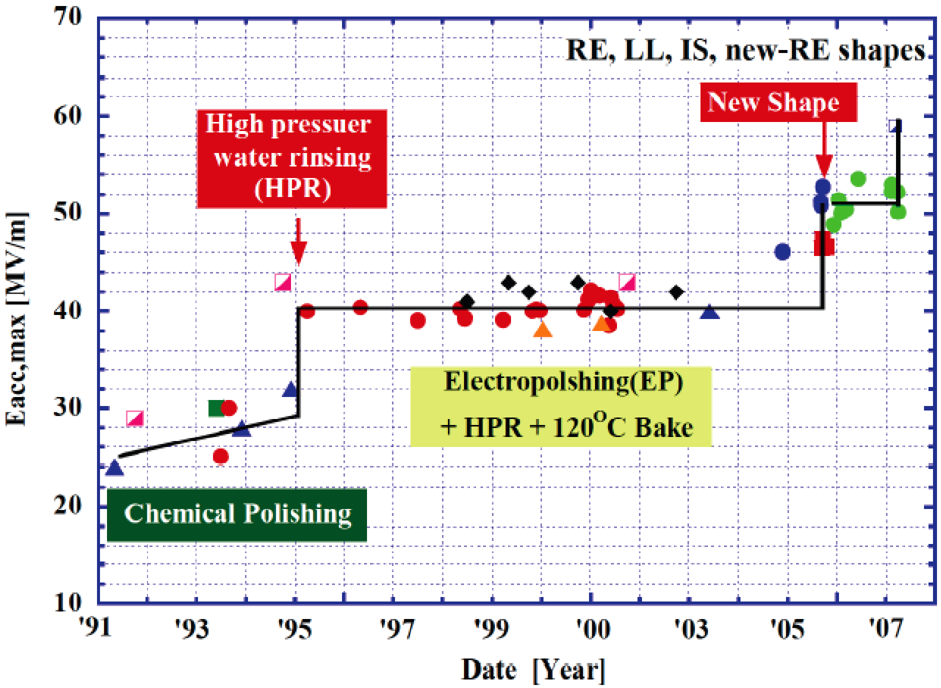


# Progress in Single Cell Cavity

TABLE II. CAVITY SHAPES STUDIED FOR THE ILC.

| Parameter | TESLA | LL/IS | RE |
|---|---|---|---|
| Iris aperture (mm) | 70 | 60/61 | 66 |
| $E_{peak}/E_{acc}$ | 1.98 | 2.36/2.02 | 2.21 |
| $B_{peak}/E_{acc}$ (mT/(MV/m)) | 4.15 | 3.61/3.56 | 3.76 |
| Char. shunt impedance: R/Q (Ω) | 114 | 134/138 | 127 |
| Geometric factor: G (Ω) | 271 | 284/285 | 277 |
| $G \times R/Q$ $(\Omega \times \Omega \times 10^5)$ | 3.08 | 3.80/3.93 | 3.51 |




- Record of **59 MV/m** achieved with the RE cavity with EP, BCP and pure-water rinsing with collaboration of Cornell and KEK

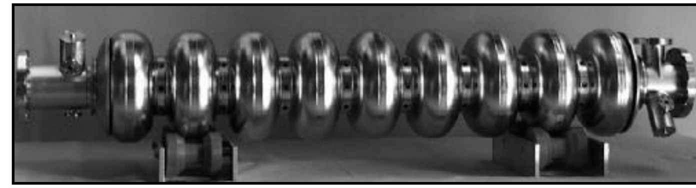
# Standard Procedure Nearly Established

| | Standard Fabrication/Process | (Optional action) |
|---|---|---|
| Fabrication | Nb-sheet purchasing | |
| | Component (Shape) Fabrication | |
| | Cavity assembly with EBW | (tumbling |
| Process | EP-1 (Bulk: ~150um) | |
| | Ultrasonic degreasing (detergent) or ethanol rinse | |
| | High-pressure pure-water rinsing | |
| | Hydrogen degassing at 600 C (?) | 750 C |
| | Field flatness tuning | |
| | EP-2 (~20um) | |
| | Ultrasonic degreasing or ethanol | (Flash/Fresh EP) (~5um)) |
| | High-pressure pure-water rinsing | |
| | General assembly | |
| | Baking at 120 C | |
| Cold Test (vertical test) | Performance Test with temperature and mode measurement | Temp. mapping |

## Key technology

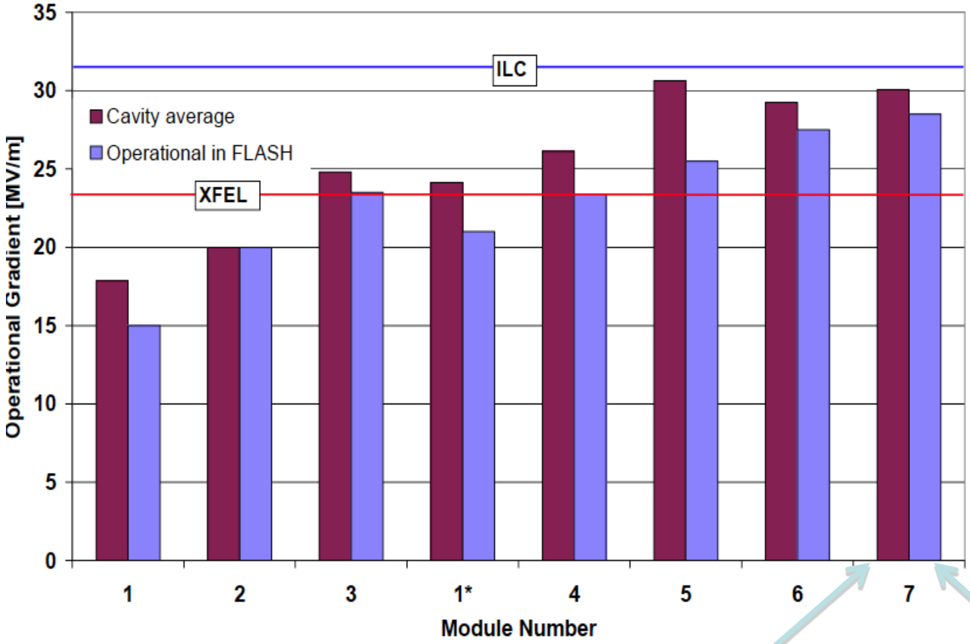
- **Fabrication**
  - Material
  - EBW
  - Shape
- **Process**
  - Electro-Polihsing
  - Ethanol or
  - Ultra sonic. + Detergent
  - High Pr. Pure Water cleaning

# Status of 9-Cell Cavity



- **Europe (DESY, Saclary)**
  - Gradient: > ~ 40 MV/m (max) , and ~ 31.5 MV/m (av/)
  - Industrial (bulk) EP demonstrated ~ 36 MV/m (av.)
  - Field emission reduced with ethanol rinsing
- **Americas (Jlab, Cornell, FNAL/ANL)**
  - Gradient: > ~ 40 MV/m (max), and widely scattered at 20- 40 MV/m
  - Field emission reduced w/ Ultrasonic Degreasing & Detergent
- **Asia (KEK, China, India)**
  - Gradient: 36MV/m (LL, KEK-JLab), 32 MV/m (TESLA-like, KEK)
  - More global cooperation of Indian institutions with
    - Fermilab, Jlab, DESY, and KEK

# 9-Cell and Cavity String Field Gradient Progress at DESY

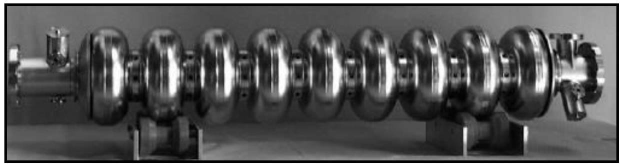



ILC operation :

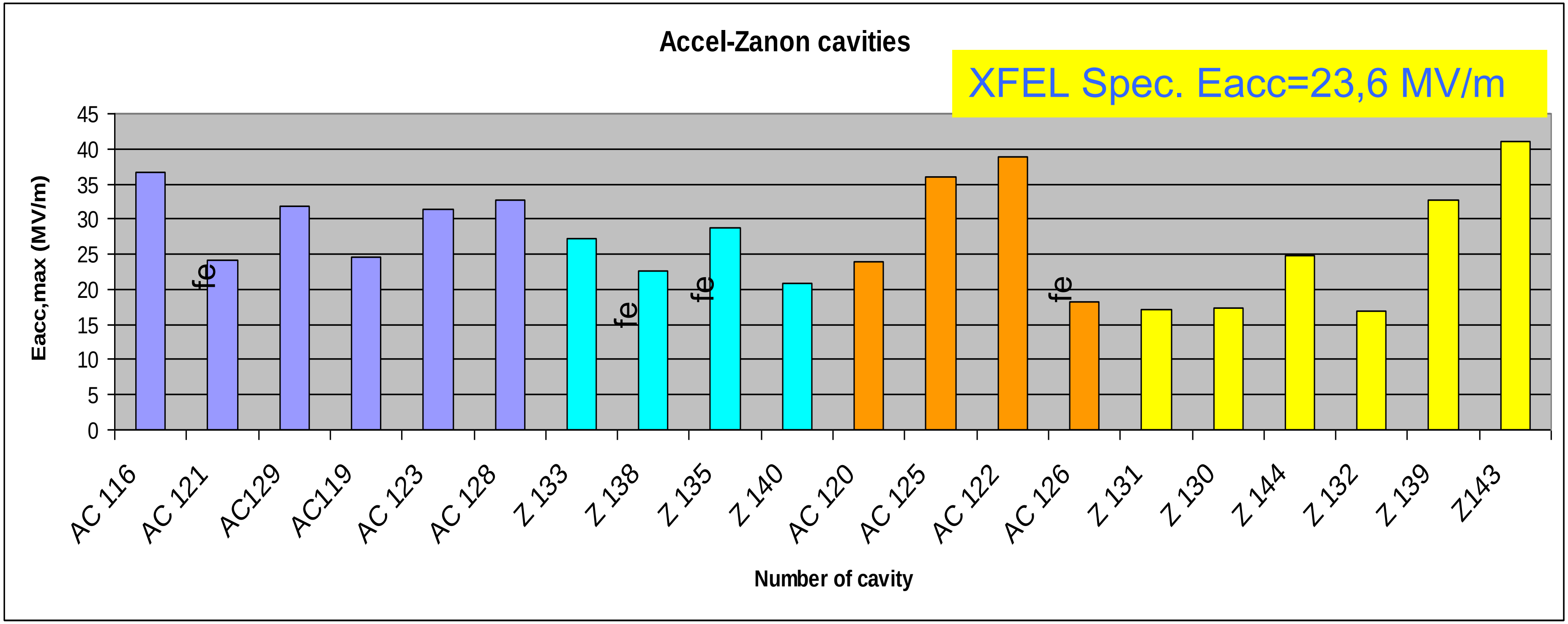
- <31.5> MV/m

R&D Status :

- ~ 30 MV/m to meet XFEL requirement



**•20 % improvement required for ILC**




AC BCP Flash $E_{acc}$=30,2 +/- 4,9

Z BCP Flash $E_{acc}$=24,9 +/- 3,8

AC EP $E_{acc}$=29,3+/- 9,7

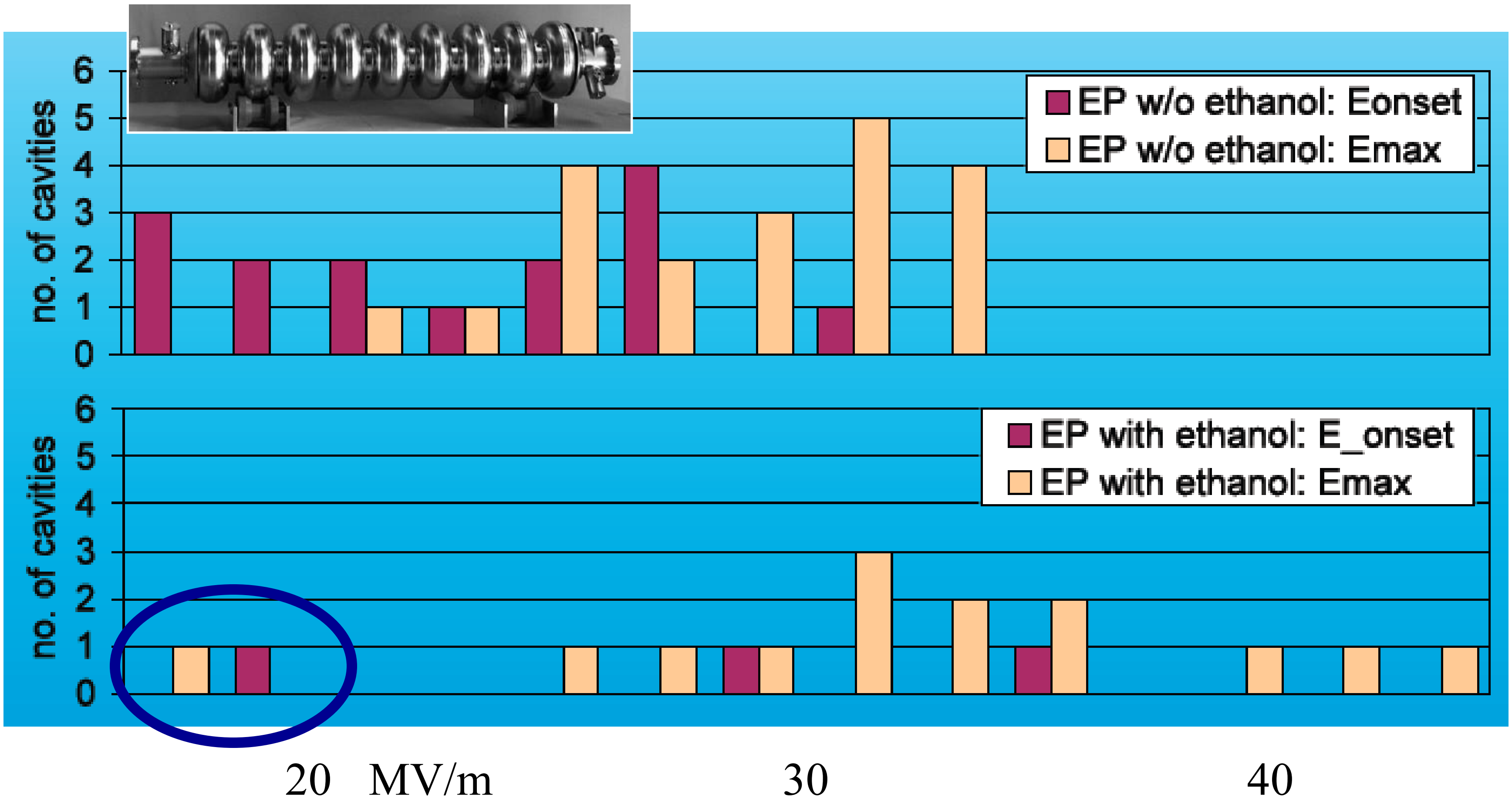
Z EP $E_{acc}$=24,9+/- 4,4

- Max gradient, FE marked, if starts below 20 MV/m
- With He-vessel
- Without HOM pick up

Remark: some Z-Cavities might have suffered from fabrication problems so that the shown result could be independent of the final surface preparation process, i.e. wait for final analysis

Information provided by W. Singer

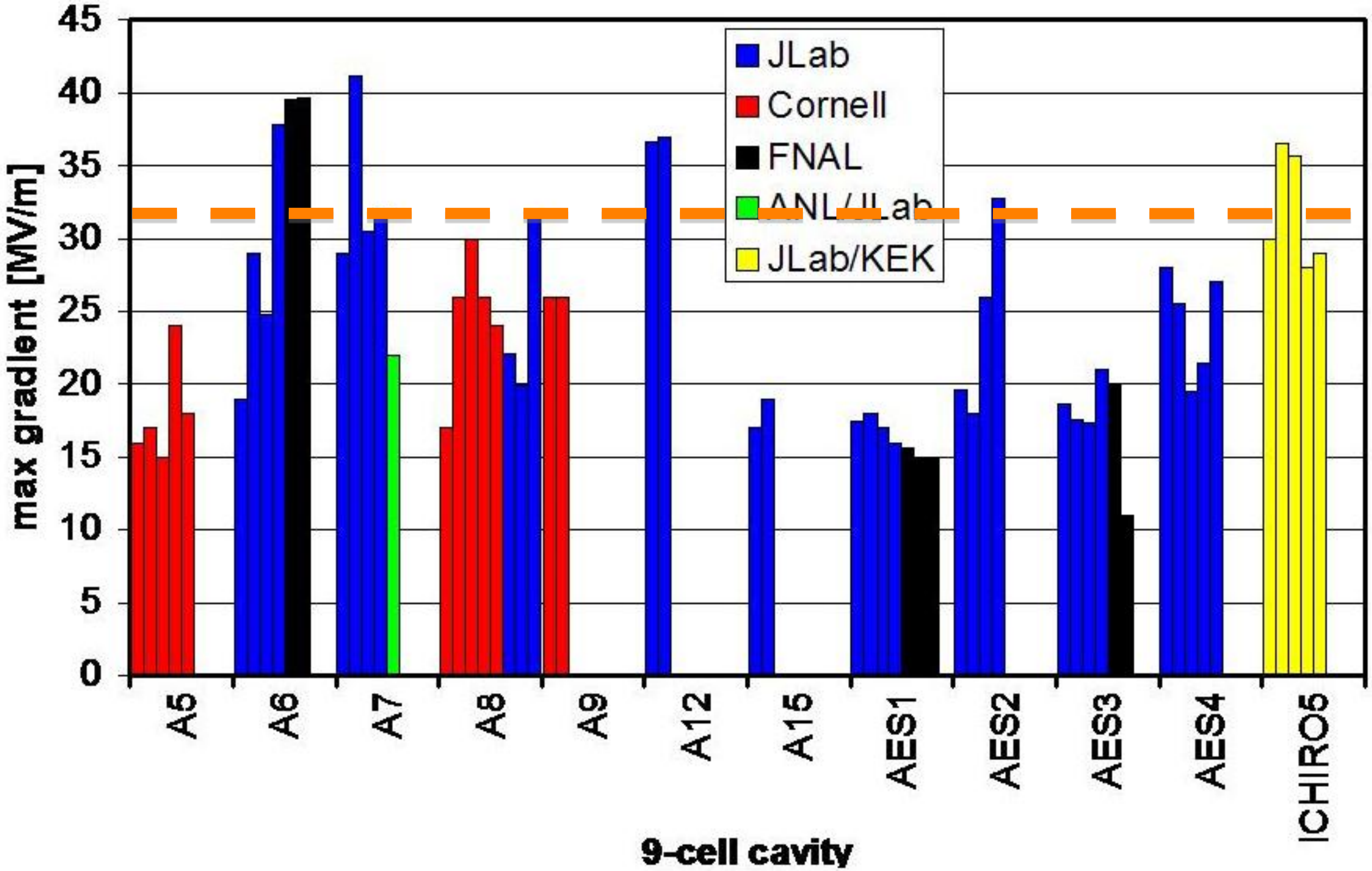
# DESY: Ethanol Rinse Effect




**Cavity gradient may be improved by 'ethanol rinse', and**
**Field emission significantly reduced.**

# 9-cell Progress in Americas

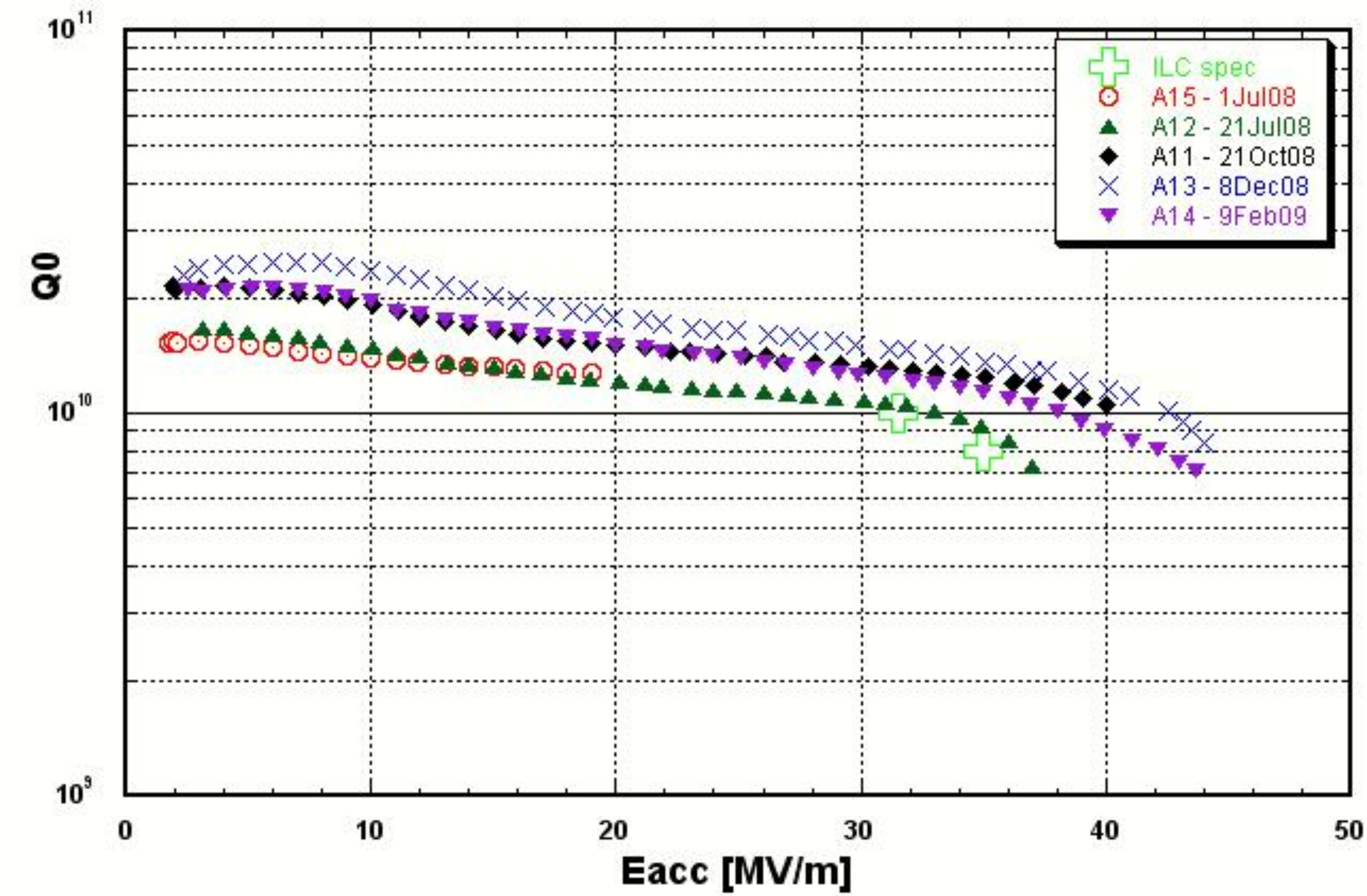
with Japanese contribution for ICHIRO-5




A (Accell), AES: TESLA shape, ICHIRO: LL shape

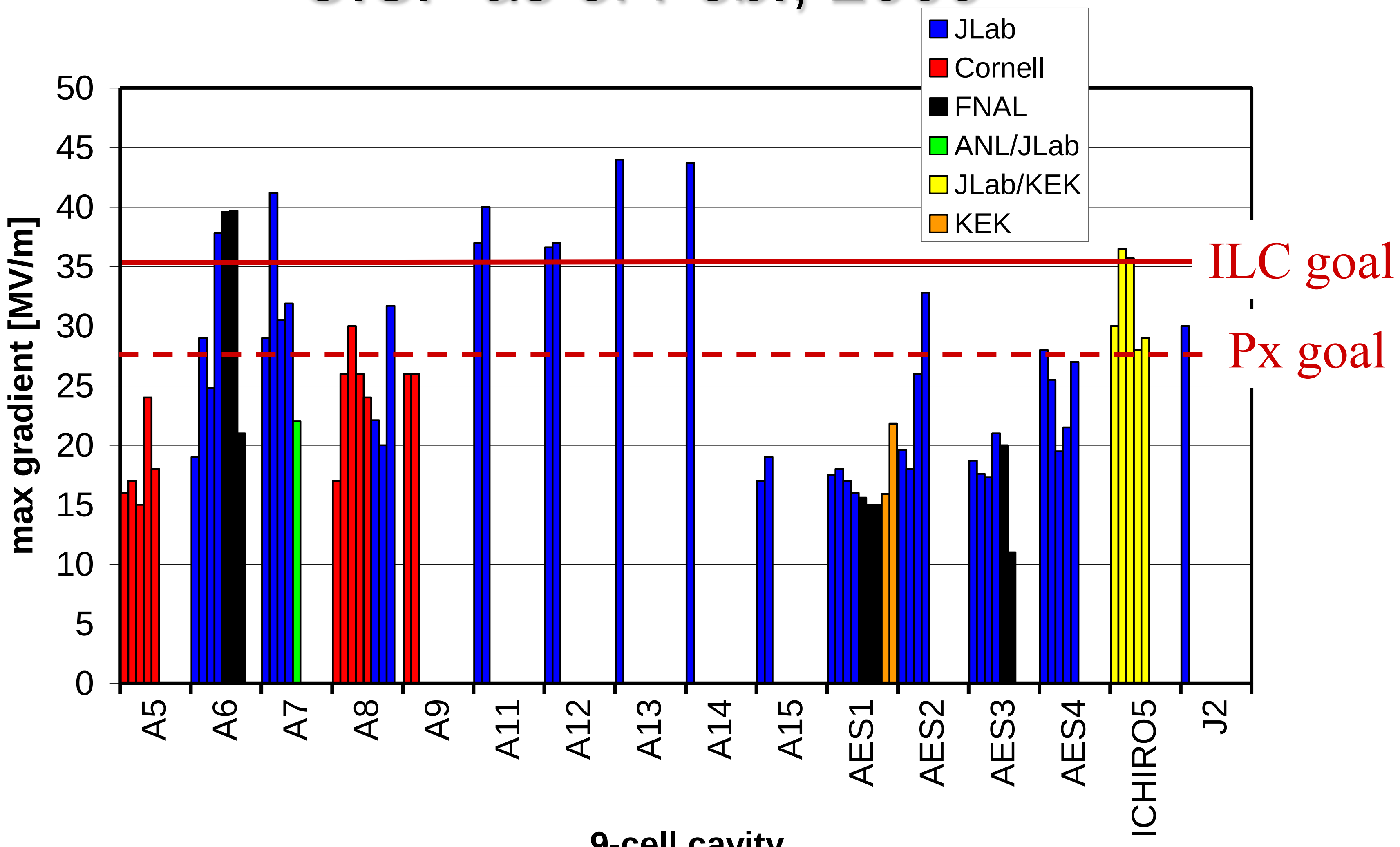
# Most Updated Results from Jlab

as of Feb. 18. 2009



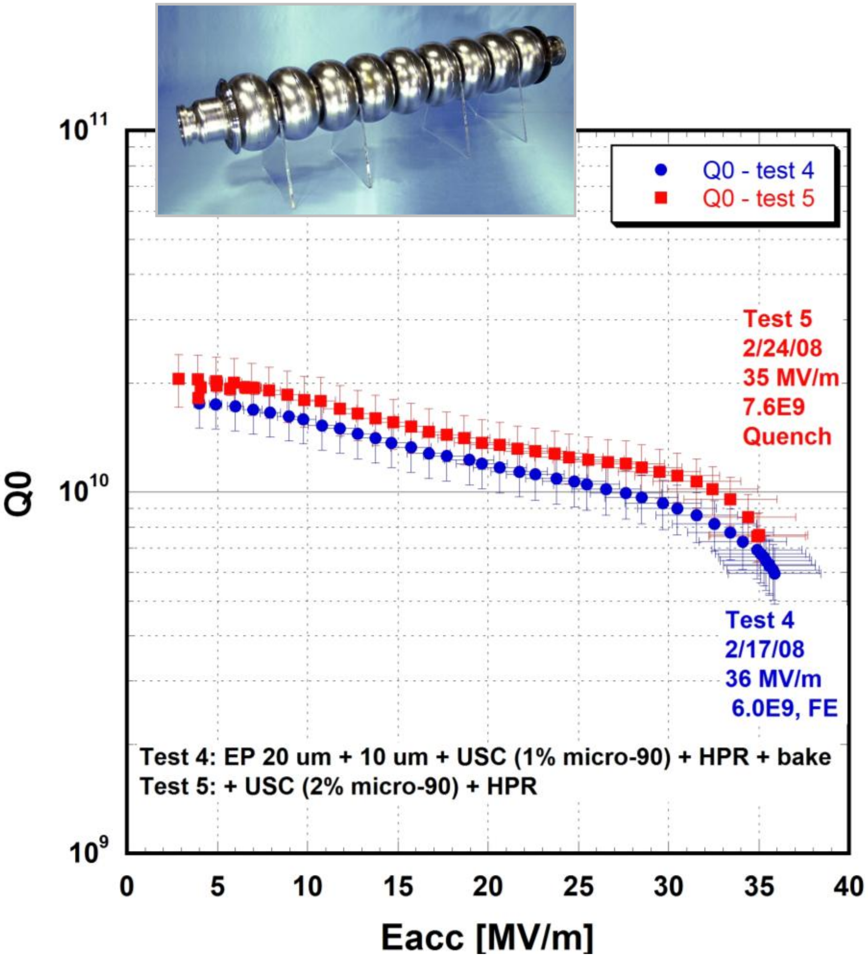

- Five 9-cell cavities: built by ACCEL, and processed/tested at Jlab.
- All of them processed with one bulk EP followed by one light EP and by ultrasonic pure-water cleaning with detergent (2%).

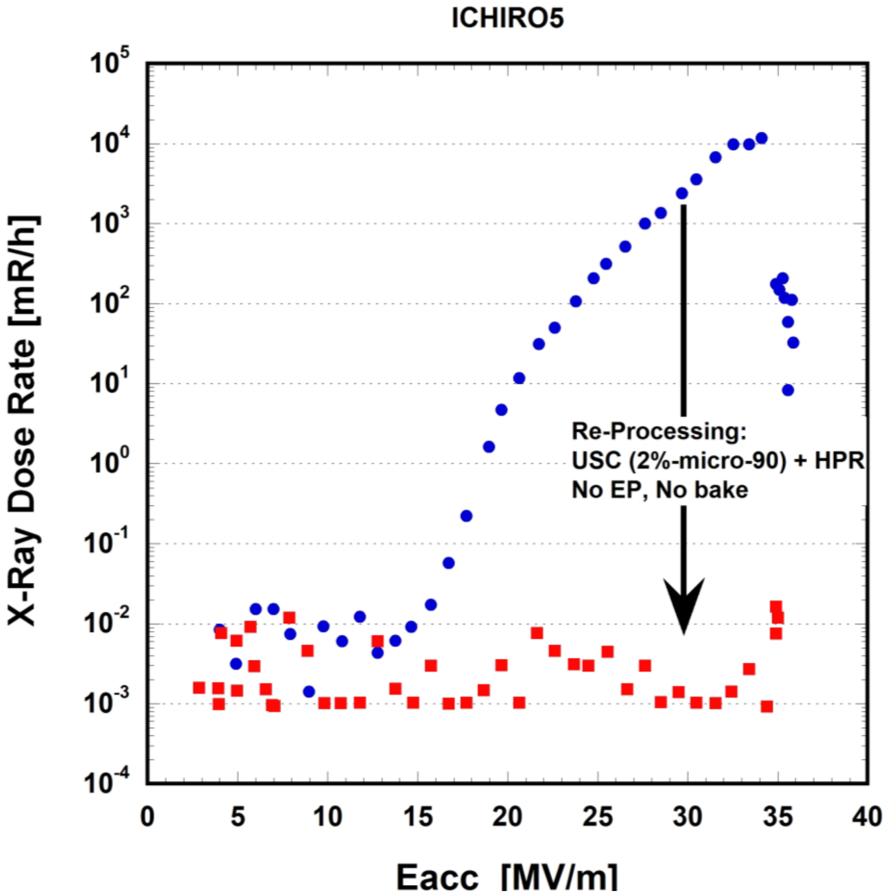
# Summary of 9-cell Vertical Tests in U.S. as of Feb., 2009



# JLab: Effective Ultrasonic Degreasing

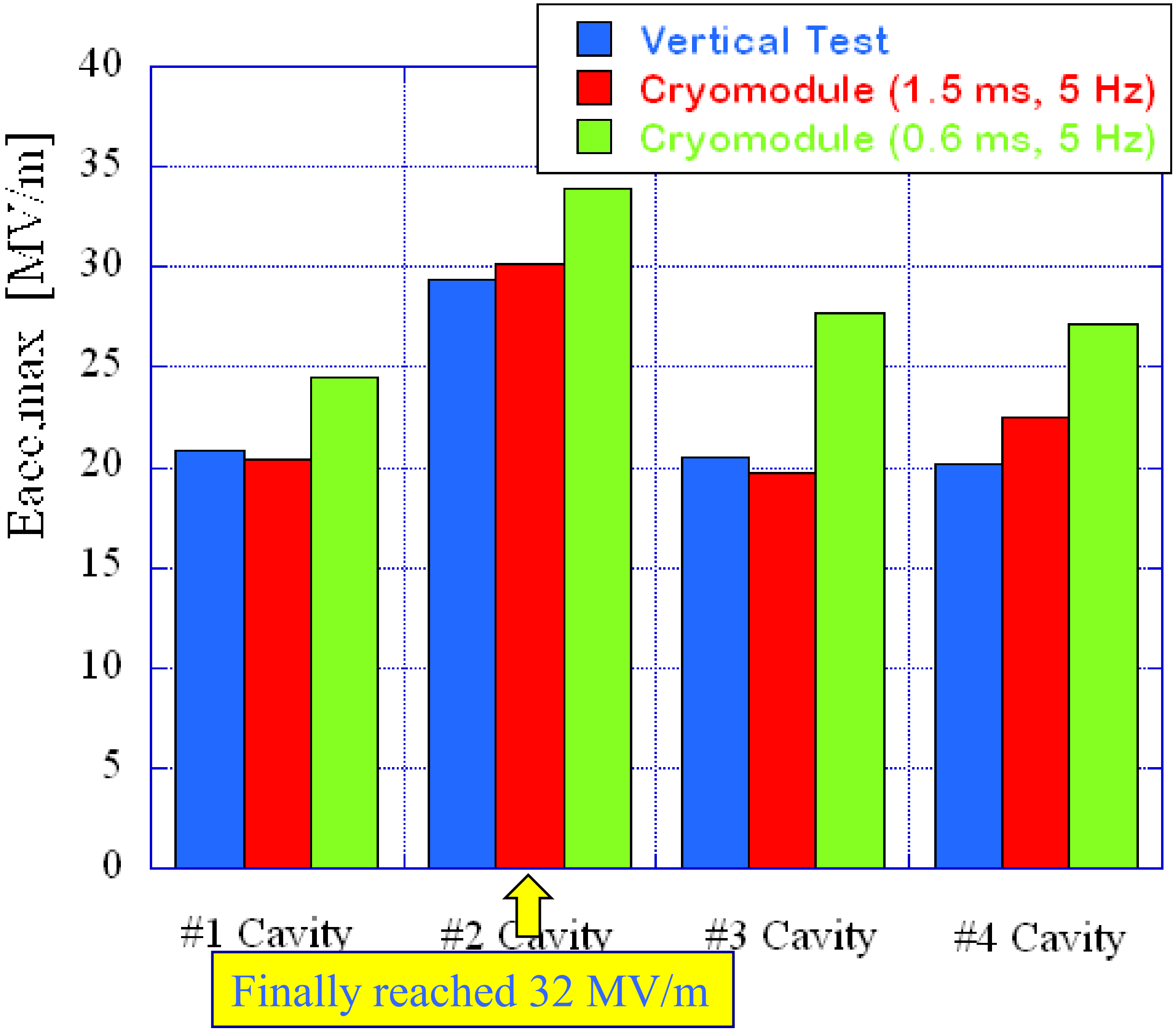
"KEK-ICHIRO-5" 9-cell cavity  Processed/Tested at Jlab




Ultrasonic Cleaning with degreaser effective to reduce field emission

# KEK: 9-cell Cavity in VT/Cryomodule





high power test, one by one

high power test, with 4 cavities

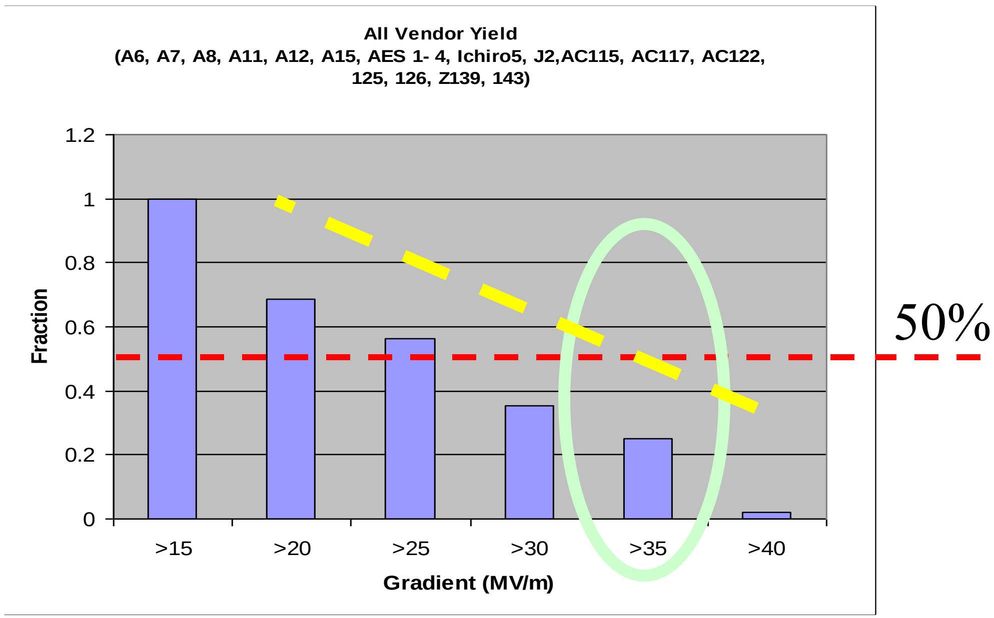
# Global Yield of Cavities Recently Tested at Jlab and DESY

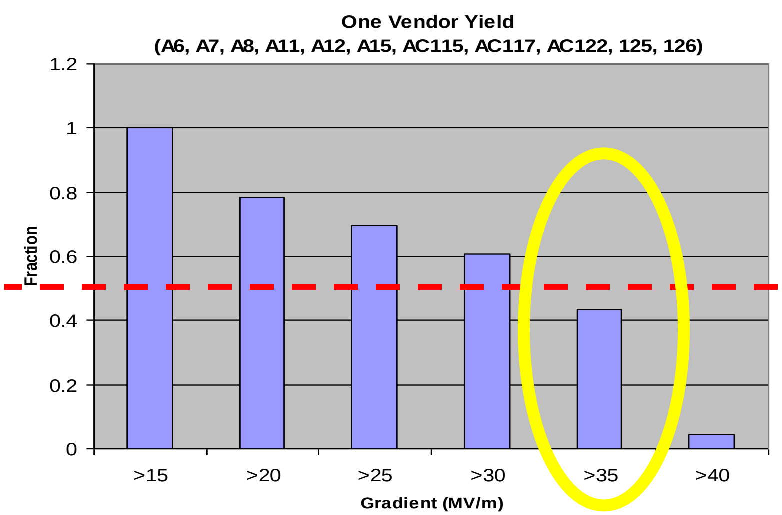
**48 Tests, 19 cavities**

ACCEL, AES, Zanon, Ichiro, Jlab

**23 tests, 11 cavities**

One Vendor

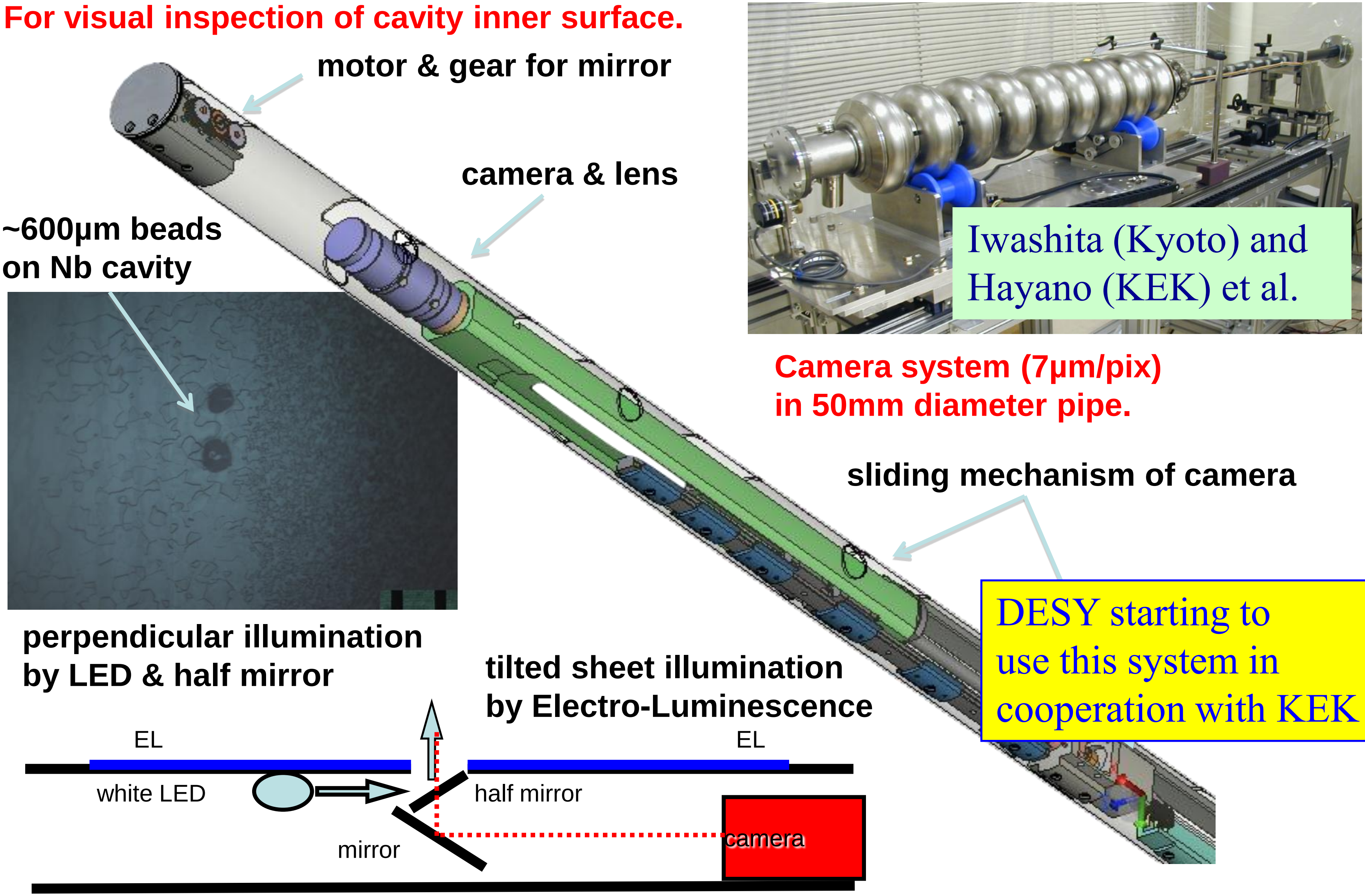



Yield 45 % at 35 MV/m being achieved by cavities with a qualified vendor !!

A Summary from TTC-08 (IUAC), ILC-08 (Chicago) by H. Padamsee

For visual inspection of cavity inner surface.

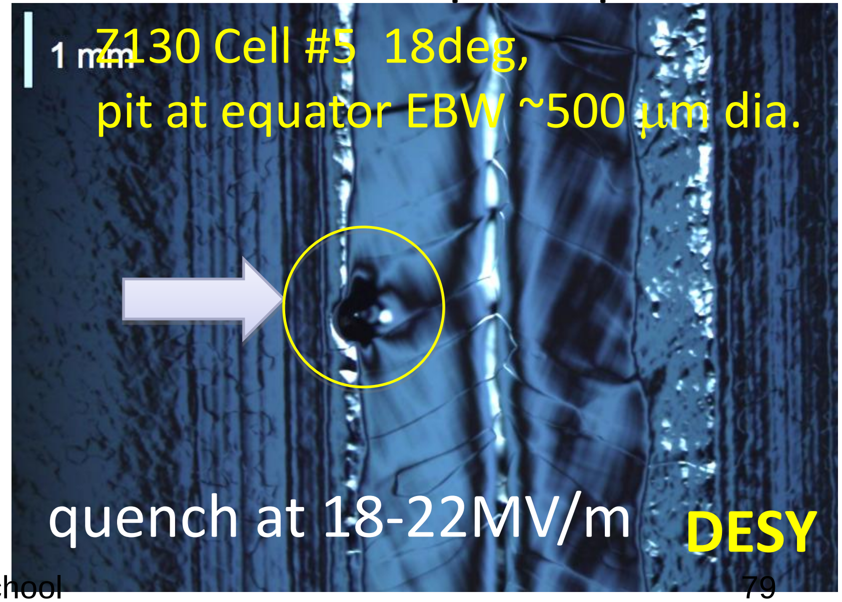


# Understanding of Sources for Quench

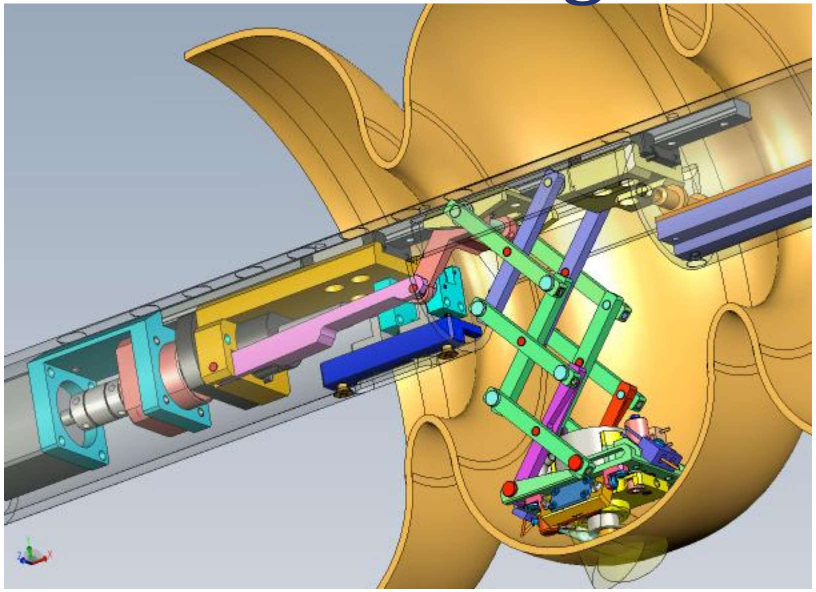
A Summary from TTC (H. Padamsee)

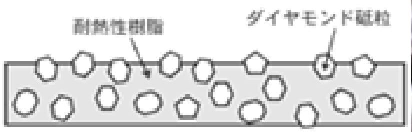
- Sources for quench below 25 MV/m have been identified
- Thermometry first used to locate quench regions followed by optical inspection.
- Quench sites are predominantly bumps and pits on the equator e-beam weld (EBW), or in the heat affected zone of that weld.

Picture example reported

# Grinding Effort at KEK



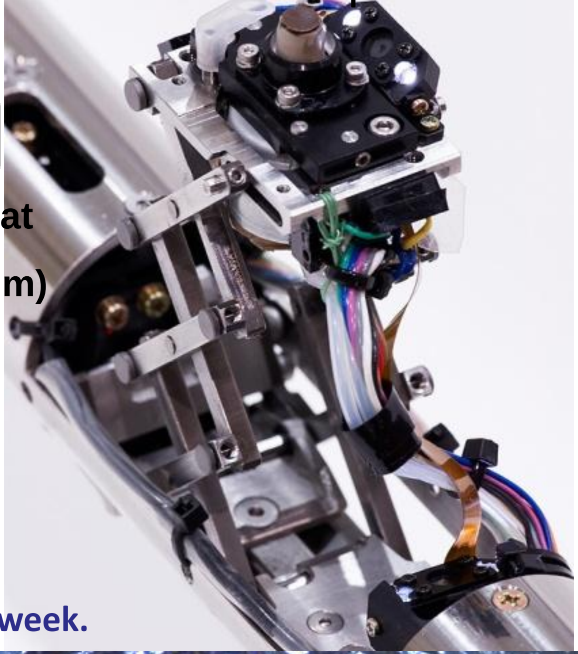



**Diamond compound seat**

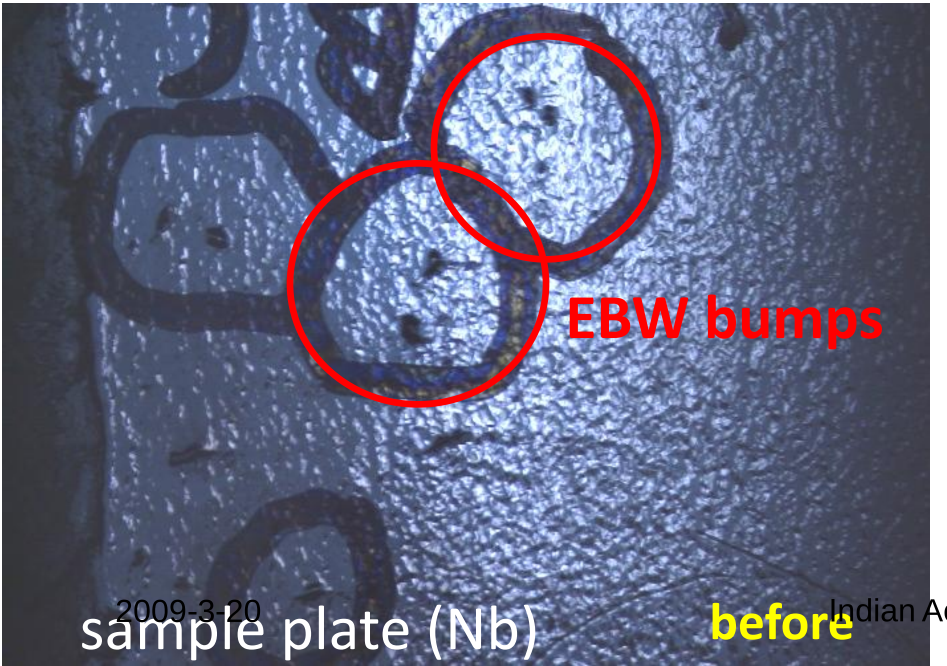
**#400 (size = 40 ~ 60 um)**

**as for 1st test**

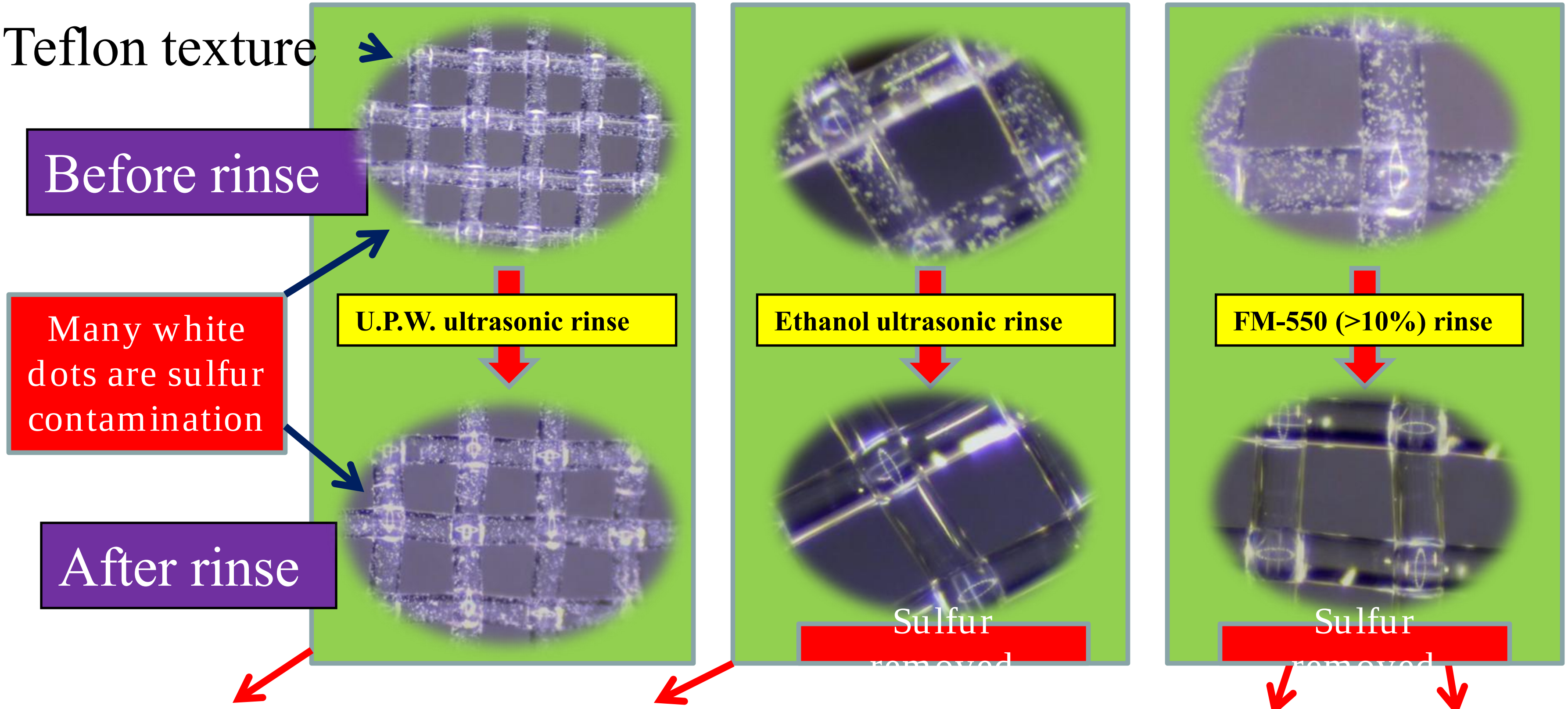
Grinder Head with Diamond compound seat



**Grinding machine was delivered in last week.**

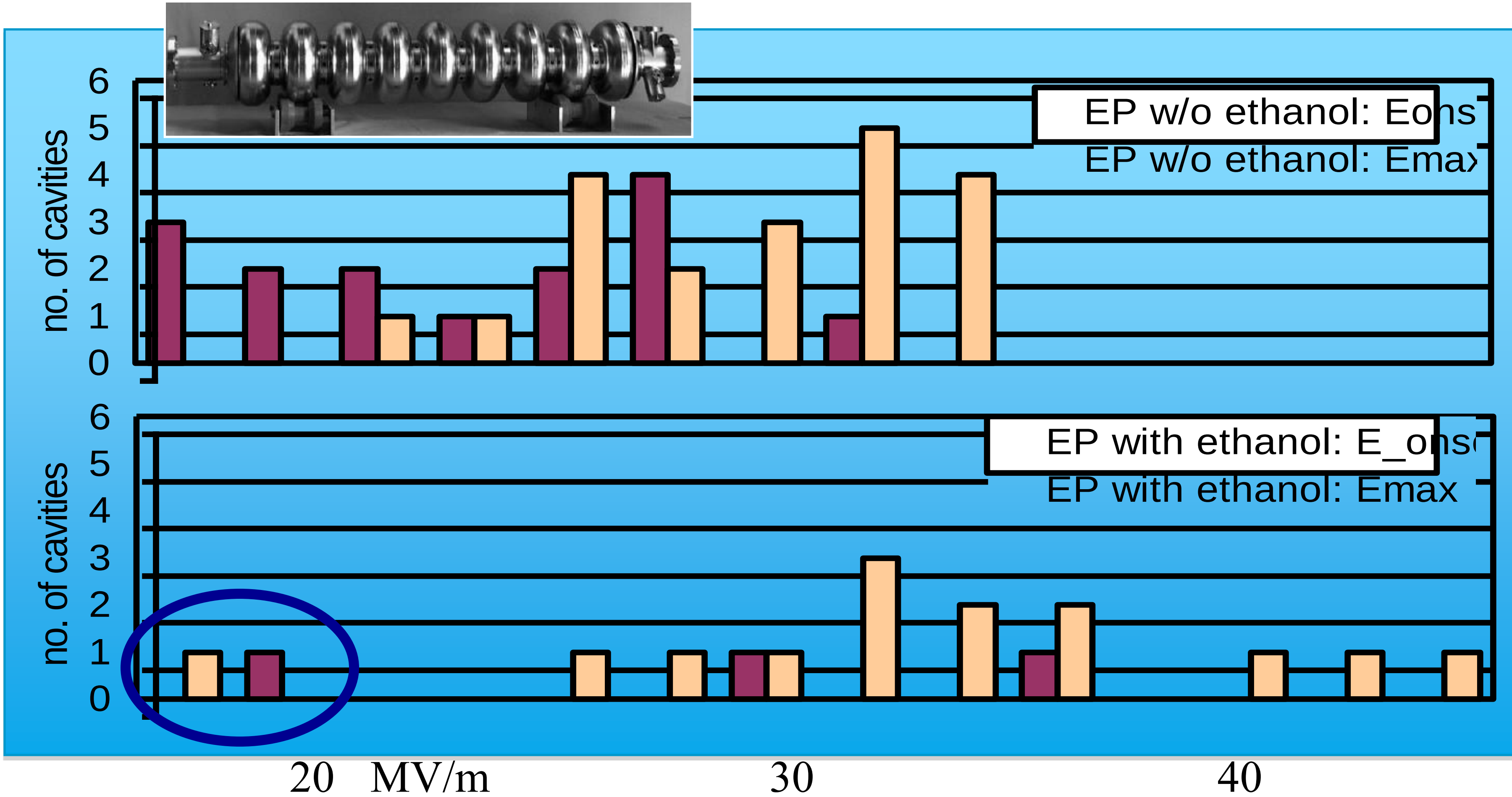



# Rinse Effect to Remove
## Sulfur precipitation/contamination




| | U.P.W. ultrasonic rinse | Ethanol rinse (vibration) | Ethanol ultrasonic rinse | Detergent FM−550 2 % | Detergent FM−550 5 % | Detergent FM−550 10 % | Detergent FM−550 20 % |
|---|---|---|---|---|---|---|---|
| Cleaning Result | × | △ | ○ | △ | △ | ○ | ○ |

# DESY: Field Emission Analysis

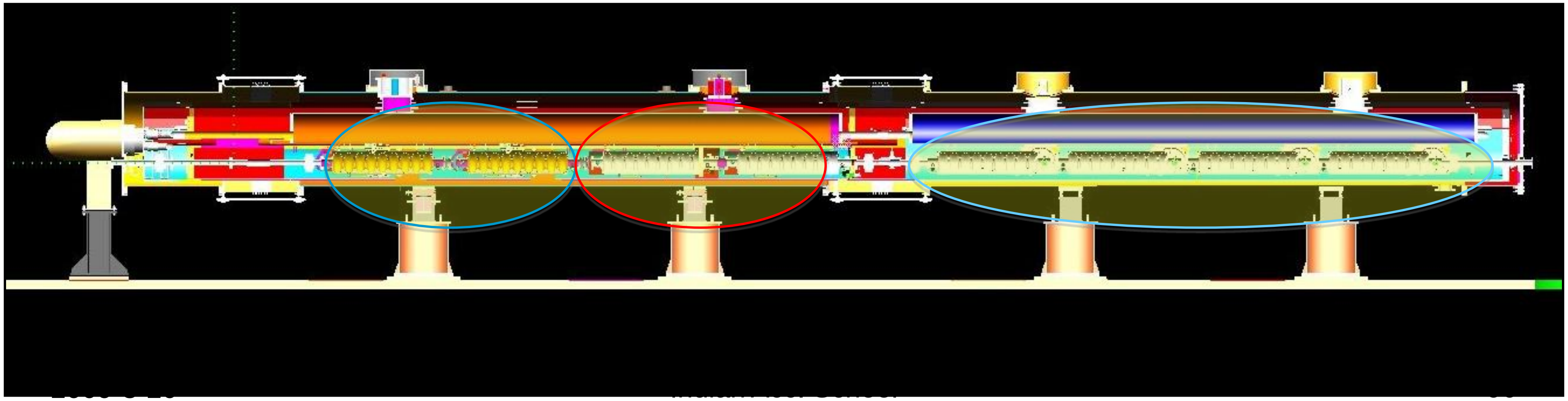


# Summary of R&D Efforts/Subjects

- Establish technology for defect-free production, with "quick" feedback using inspection camera results
  - Upgrade "inspection camera", and
  - Develop other inspection tools,
- Identify, more accurately, origin of field emission after surface treatment
  - Research and improve "surface-analysis": XPS, SEM ,,,
- Establish and Demonstrate countermeasures:
  - The final treatment to remove FE source such as sponge wipe, degreaser rinse, ethanol rise,
  - Repair method such as grinding tool for curing damaged cavities

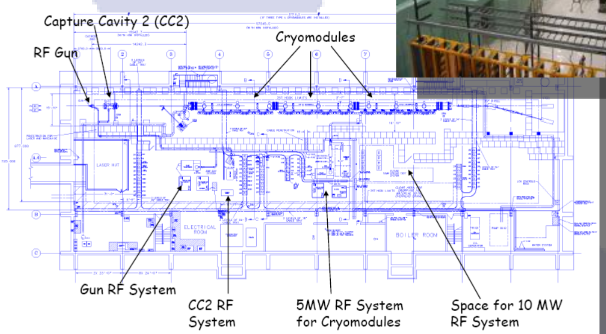
# Cavity String Test in Cryomodule with Plug Compatibility

- **Cavity integration and the String Test to be organized as a global cooperation (S1-Global):**
  - 2 cavities from EU (DESY) and AMs (Fermilab)
  - 4 cavities from AS (KEK (and IHEP))
  - Each half-cryomodule from INFN and KEK
- **A practice for the plug-compatible assembly**



# SRF Test Facilities

FNAL

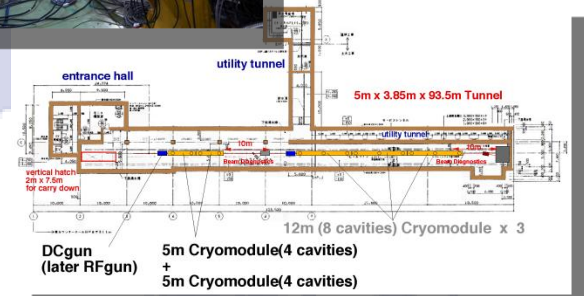




NML facility
Under construction
first beam 2010
ILC RF unit test

DESY

TTF/FLASH
~1 GeV
ILC-like beam
ILC RF unit
(* lower gradient)

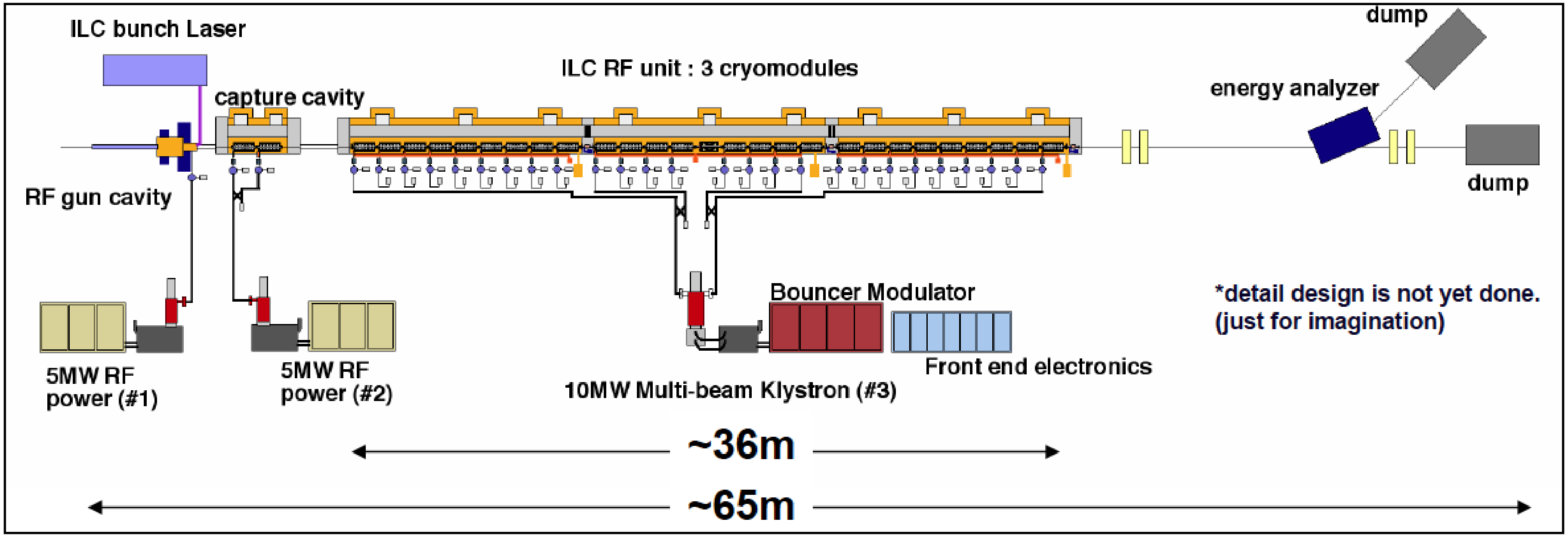
KEK, Japan




STF (phase I & II)
Under construction
first beam 2011
ILC RF unit test

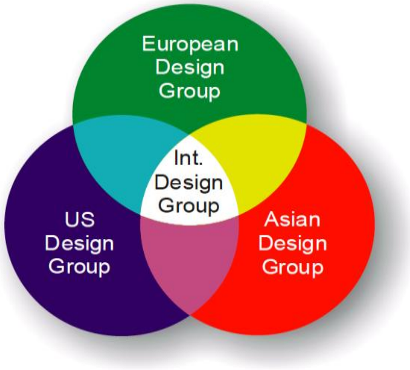
# Beam Acceleration Test Plan

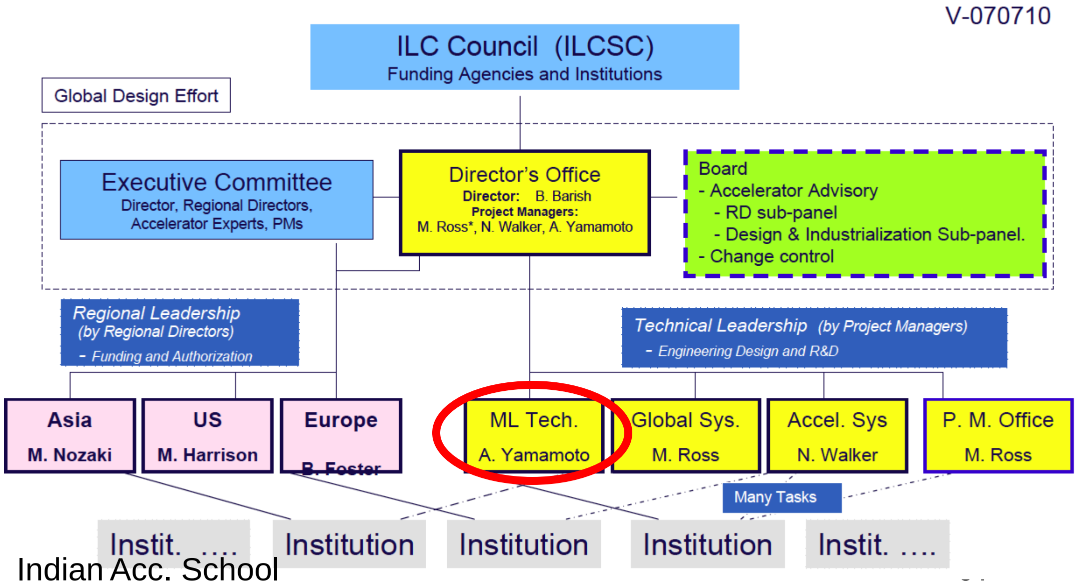
## with RF unit at Fermilab and KEK in TDP-2



# International Linear Collider : ILC

- Construction
  - One in the world
- Development
  - Americas, AS, EU:
    - Three region's cooperation
  - Asian Team-Work to be crucially important
- GDE
  - Global design effort
  - Technical Areas
    - SCRF
    - CF&S
    - AS



# Global Plan for SCRF R&D

| Calender Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Technical Design Phase | **TDP-1** | | | **TDP-2** | | |
| Cavity Gradient R&D to reach 35 MV/m | | Process Yield > 50% | | Production Yield >90% | | |
| Cavity-string test: with 1 cryomodule | | **Global collab.** **For <31.5 MV/m>** | | | | |
| System Test with beam 1 RF-unit (3-modulce) | | FLASH (DESY) | | | STF2 (KEK) NML (FNAL) | |

# Global Plan for SCRF R&D

| Calender Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
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| Cavity-string test:<br>with 1 cryomodule | | **Global collab.**<br>**For <31.5 MV/m>** | | | | |
| System Test with beam<br>1 RF-unit (3-modulce) | | FLASH (DESY) | | | STF2 (KEK)<br>NML (FNAL) | |

# ILC Summary

- We have witnessed much progress toward 35 MV/m (31.5 MV/m) ; however, progress is rather slow.
- To understand basic phenomena of cavities, such as field emission, quench, effect of contamination, is of crucial importance. Much effort is concentrated for this direction.
- Global coordination should be much more strengthened, among regions and especially within Asia.
- We need tremendous effort to start the real construction of ILC not long after the completion of Technical Design Pase.

*Thank you for your attention !*