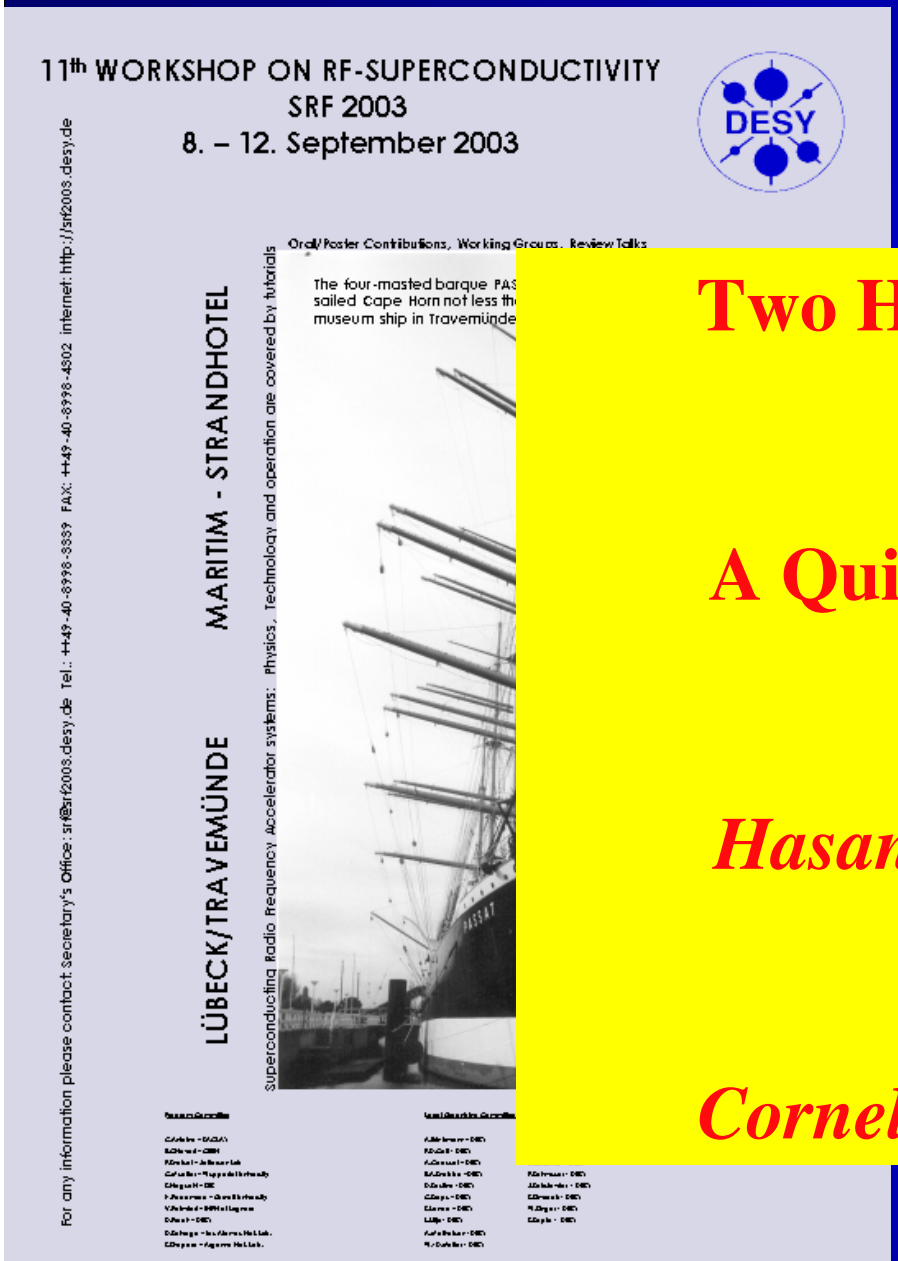
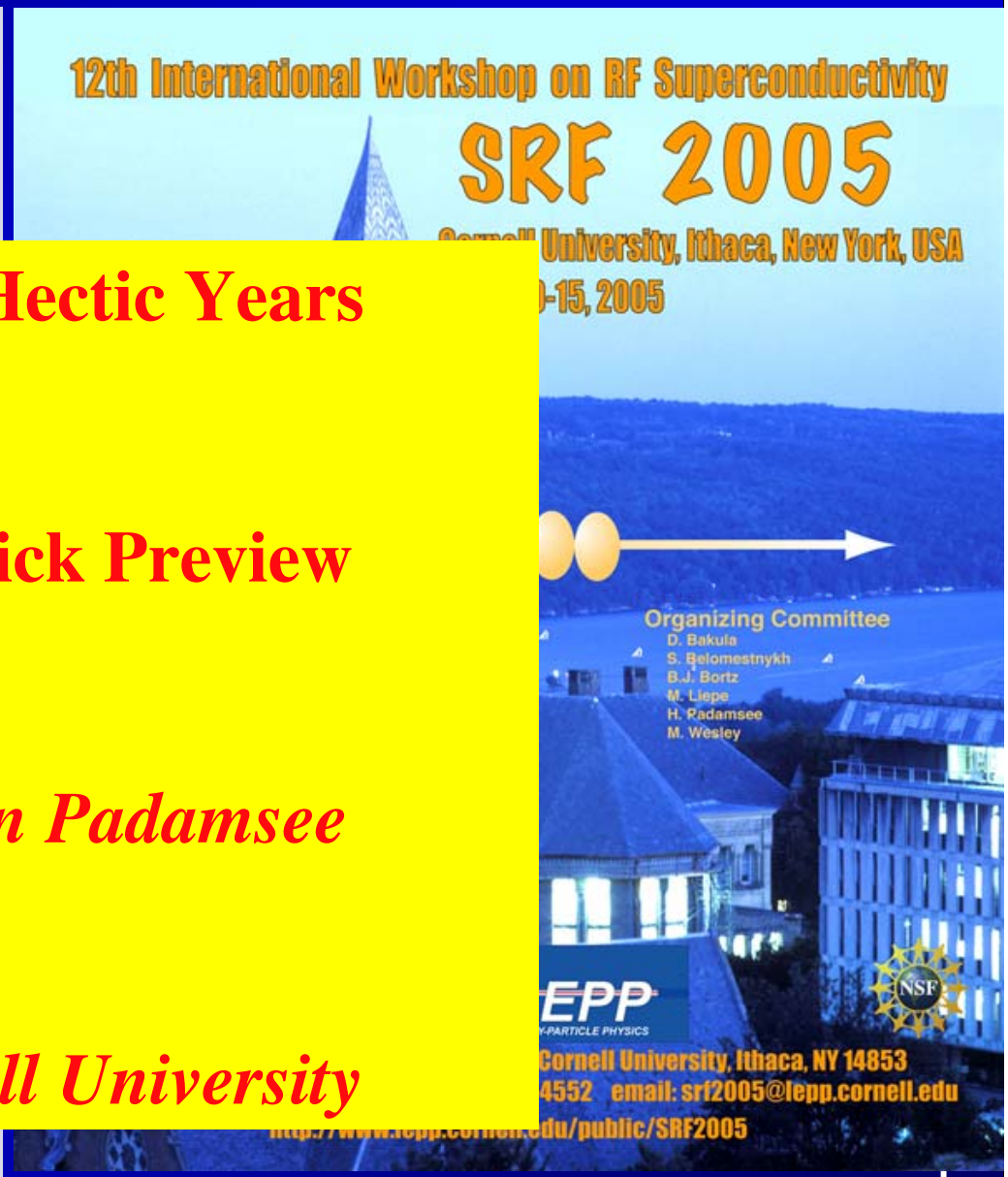




Two Hectic Years

A Quick Preview

Hasan Padamsee

Cornell University

Hectic Developments

- SNS on the way
- TTF - II on the way
- X-FEL approved
- Jlab upgrade started
- ITRP decision: ILC superconducting
- ERL reaches 1 MW beam power at Jlab
- ERL/FEL applications blossom
- 35 - 40 MV/m in cavities and cryomodules
- New cavity shapes, new materials
- New gradients/Q records : 46 - 47 MV/m
- Higher Operating $Q_{ext} > 10^8$
- Many new labs starting SRF activities

State of the SRF Union

White House photo by Paul Morse

Low Energy Nuclear Physics

10 Heavy Ion Linacs Completed

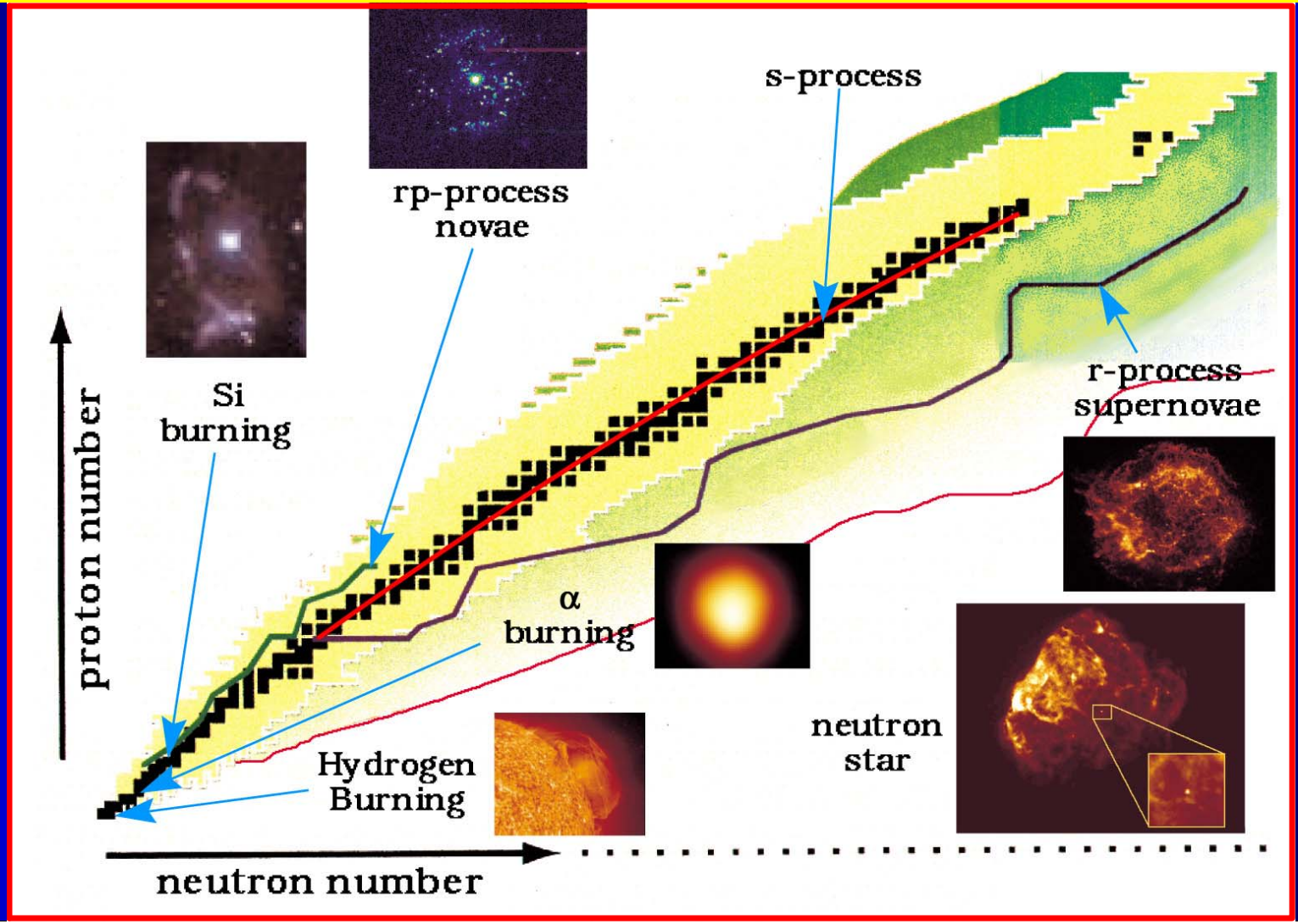
- **ATLAS (Argonne) US**
- **Stony Brook**
- **U. of Washington**
- **Florida State U**
- **Kansas State U**
- **Delhi U**
- **JAERI (Japan)**
- **ALPI (Italy)**
- **ANU (Australia)**
- **ISAC-II (TRIUMF-Canada)**

- > 270 SC structures
- 3-5 MV/m

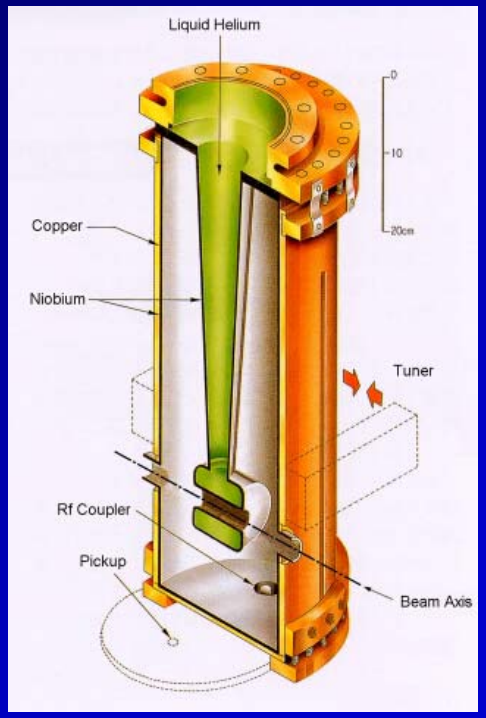
Future Plans: Nuclear Astrophysics

Rare Isotope Acccelerators - RIA, EURISOL…

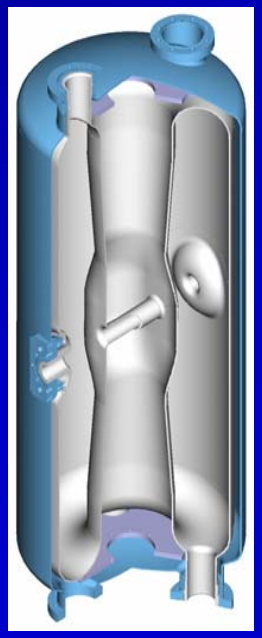
How do heavy elements form in explosive nucleo-synthesis in novae, x-ray bursts, and supernovae



Marvelous Opportunity for Low β, Medium β and High β Structures to Come Together



Quarter Wave

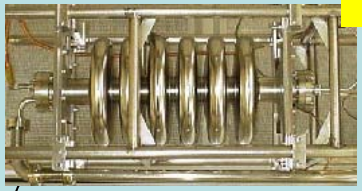


Half-Wave

Elliptical

Spokes

Hot Topic for Discussion
Which Way for medium β?

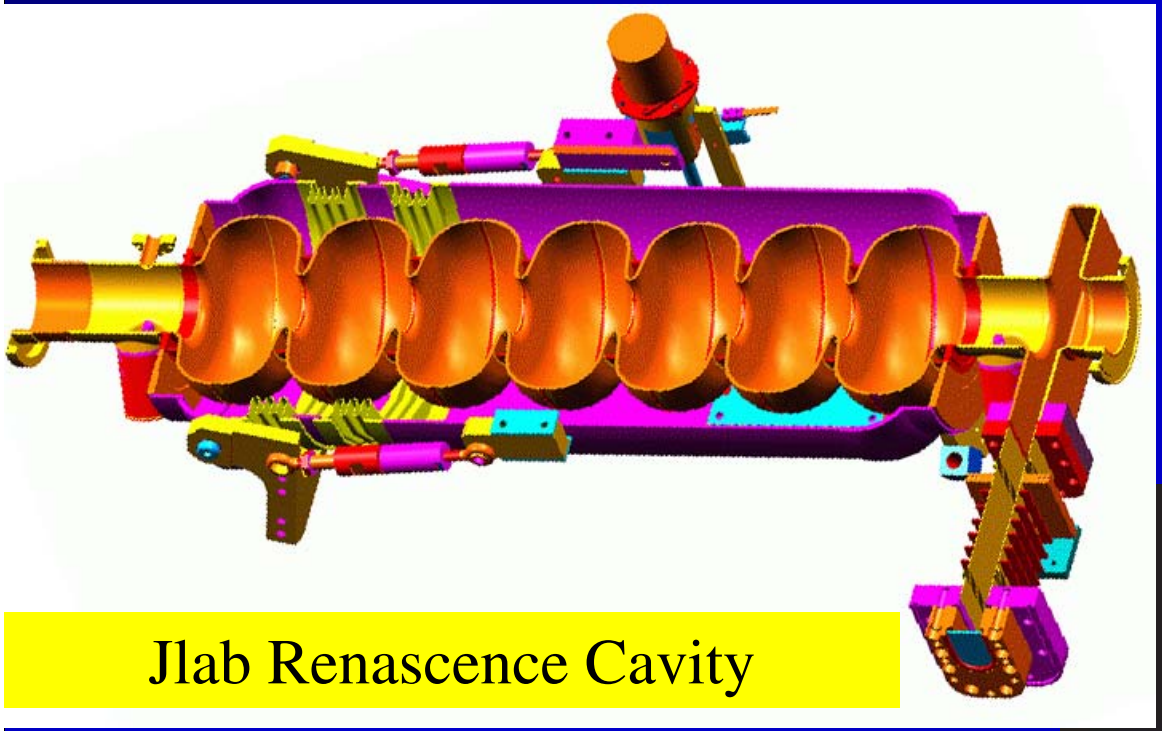


Elliptical

Spokes

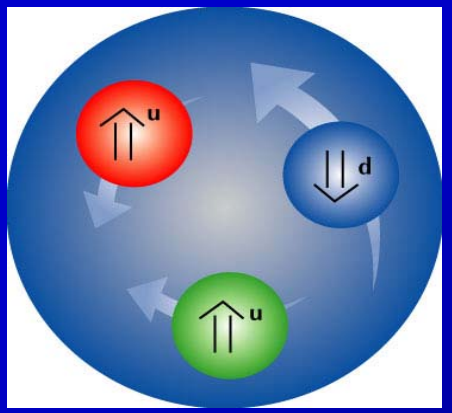
Medium Energy Nuclear Physics
Jlab Upgrade

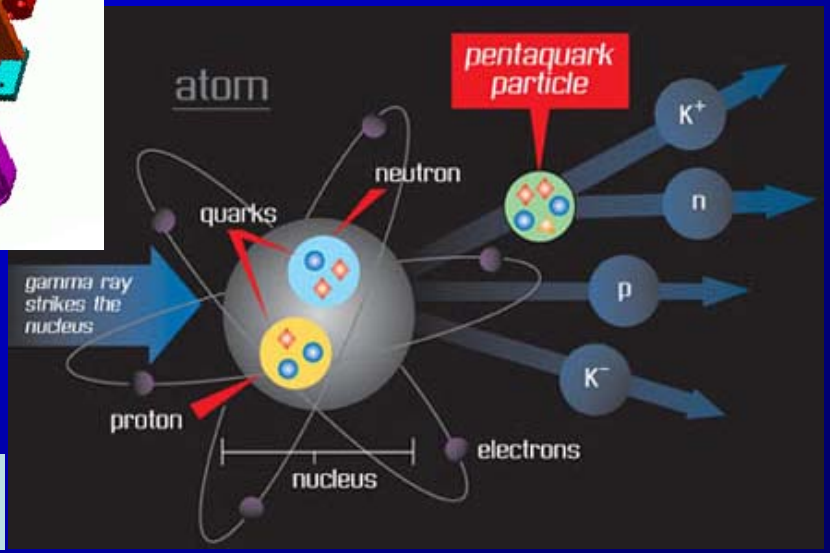
Understanding the quark-gluon structure of nucleus



Jlab Renascence Cavity

Distribution of nuclear spin





Exotic combinations - penta-quark

SRF Installed in Electron - Positron Storage Rings for HEP

- TRISTAN - Japan
- HERA - Germany
- LEP-II - CERN (Europe)
- CESR - USA
- KEK-B Japan

- Anticipated
- LHC- CERN
- Beijing Tau-Charm Factory

- 5 - 8 MV/m

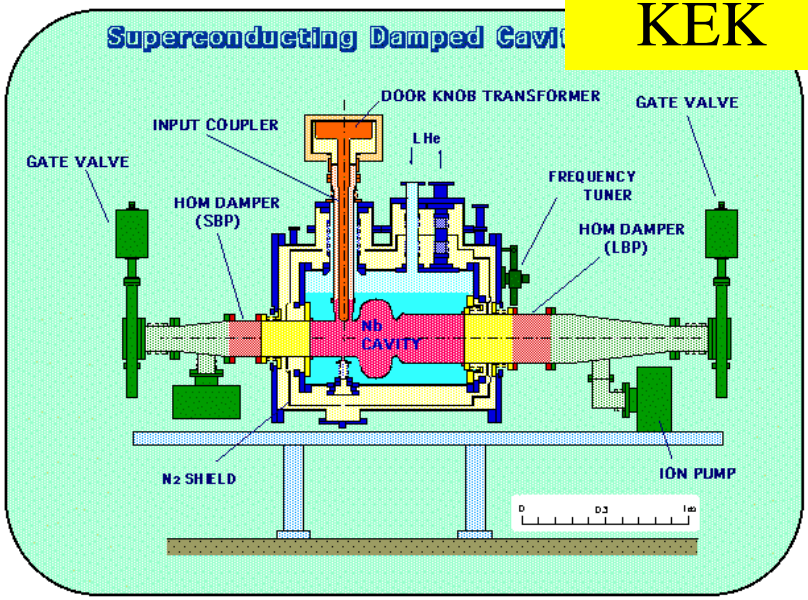
SRF in Electron Storage Rings Light Sources

- **Installed**
- **CESR/CHESS (USA)**
- **Canadian Light Source**
- **ESRF (France)**
- **Swiss Light Source**
  - **For life time increase**
- **ELETTRA (Italy)**
  - **For life time increase**
- **Taiwan Light Source**
- **6 - 8 MV/m**

- **Anticipated**
- **DIAMOND Light Source (UK)**
- **SOLEIL (France)**
- **Shangai Light Source**

Structures for Light Source Storage Rings

KEK



X-ACTLY SO !

The Roentgen Rays, the Roentgen Rays

What is this craze?

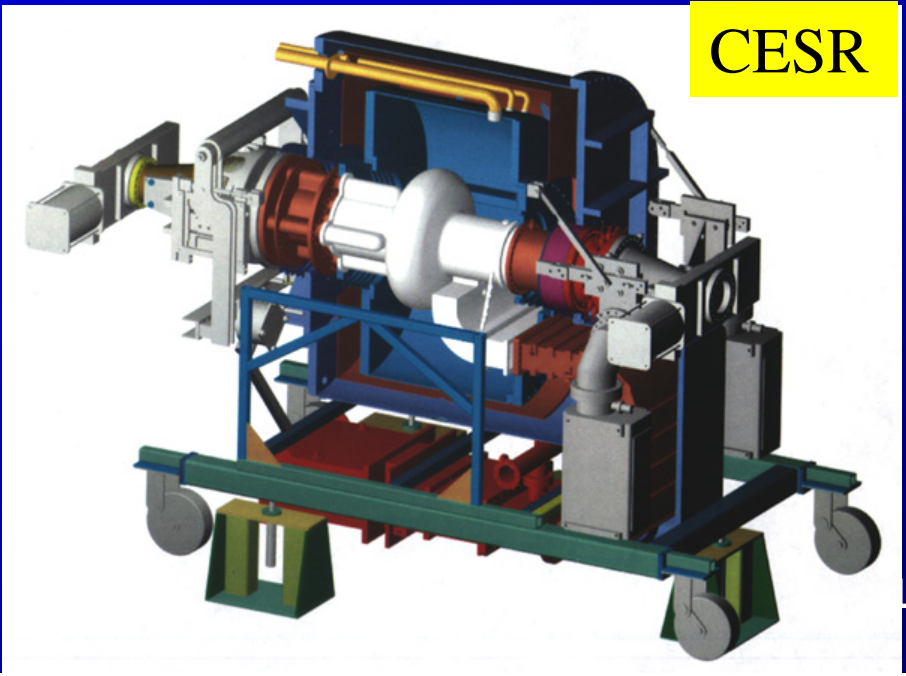
The town's ablaze

With the new phase

Of X-ray's ways

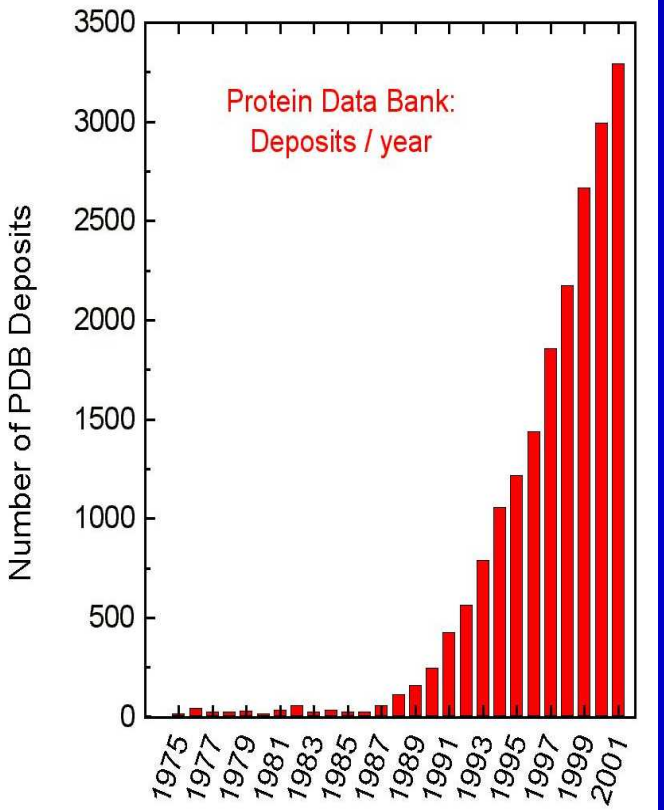
SOLEIL

CESR

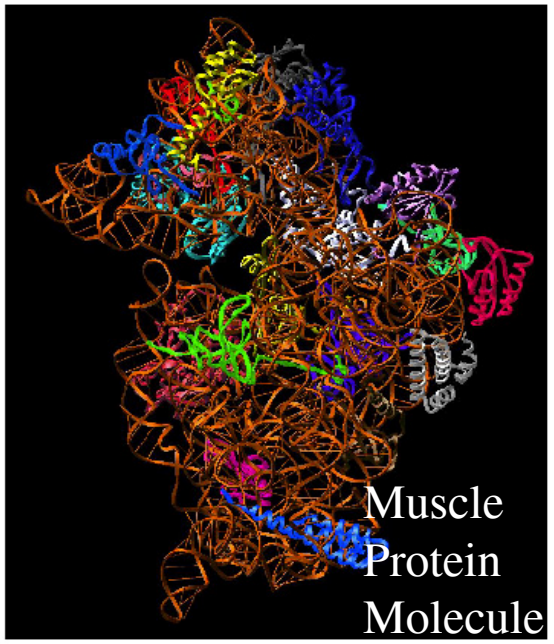


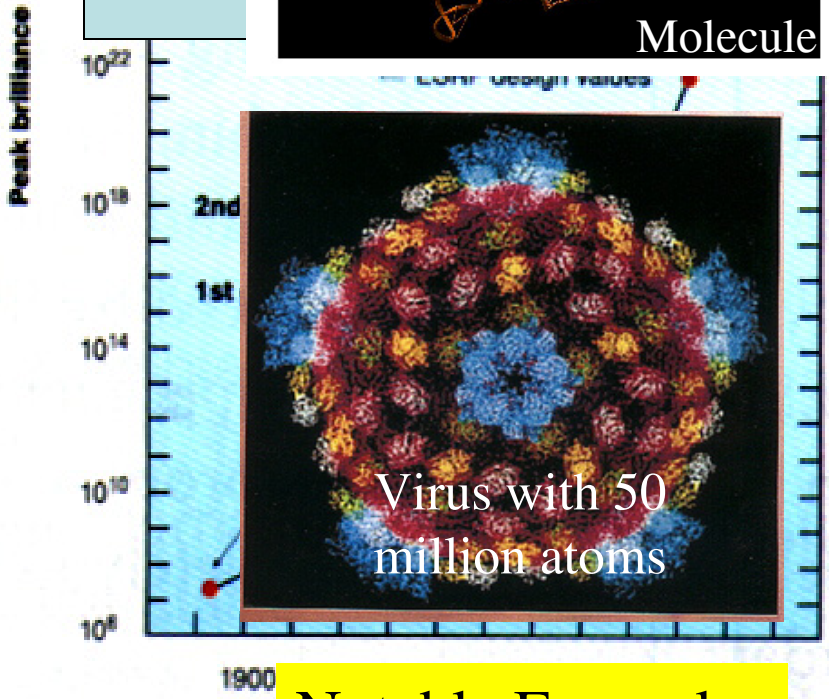
Synchrotron radiation (SR) is proving immensely important for the physical, biological, and engineering sciences.

The demand continues to grow, with new uses opening all the time.



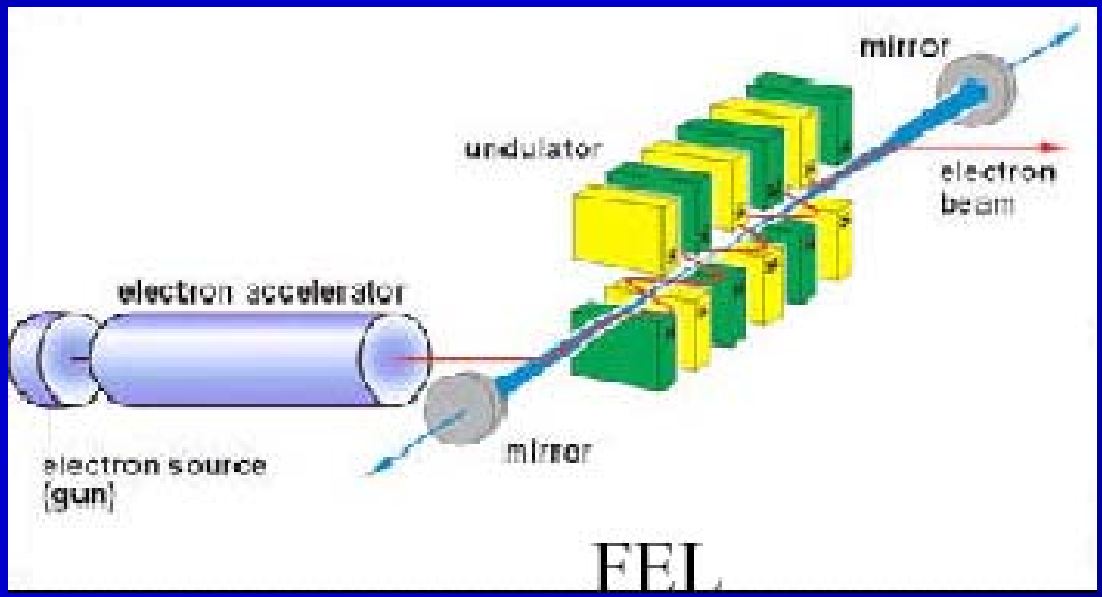
PDB depositions vs. year. Most due to SR.





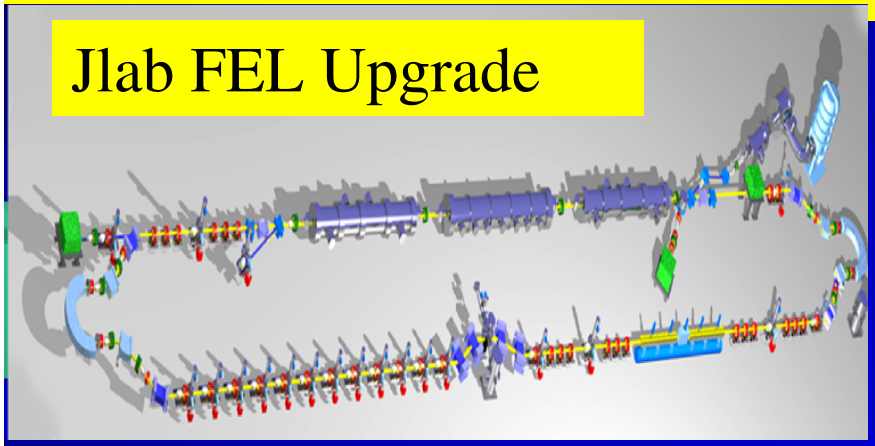
Notable Examples

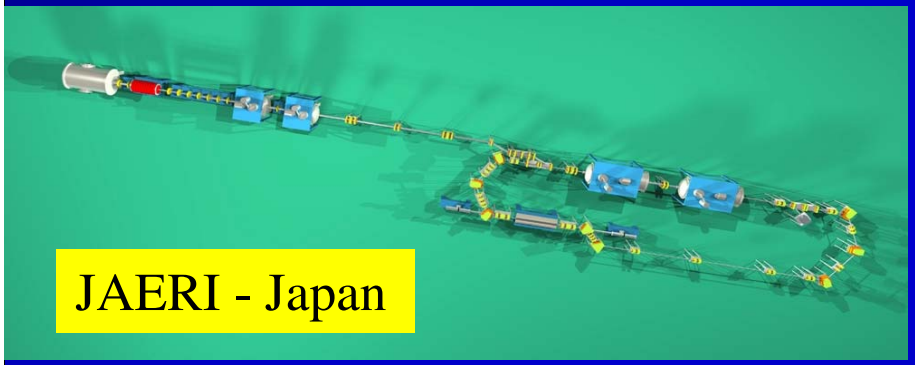
Lasers/FEL : Infra red, UV



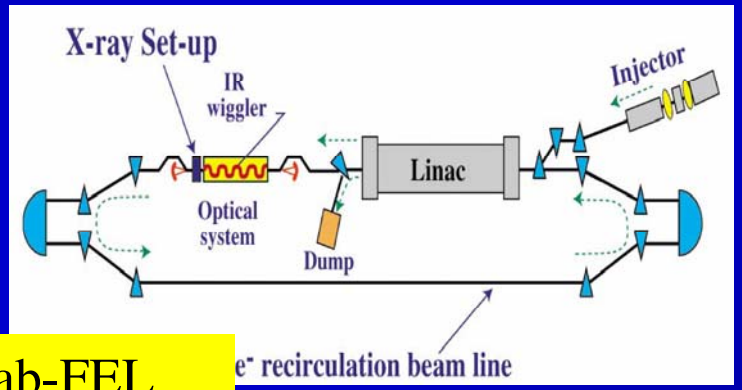
CW-FELs IR -> UV

Jlab FEL Upgrade

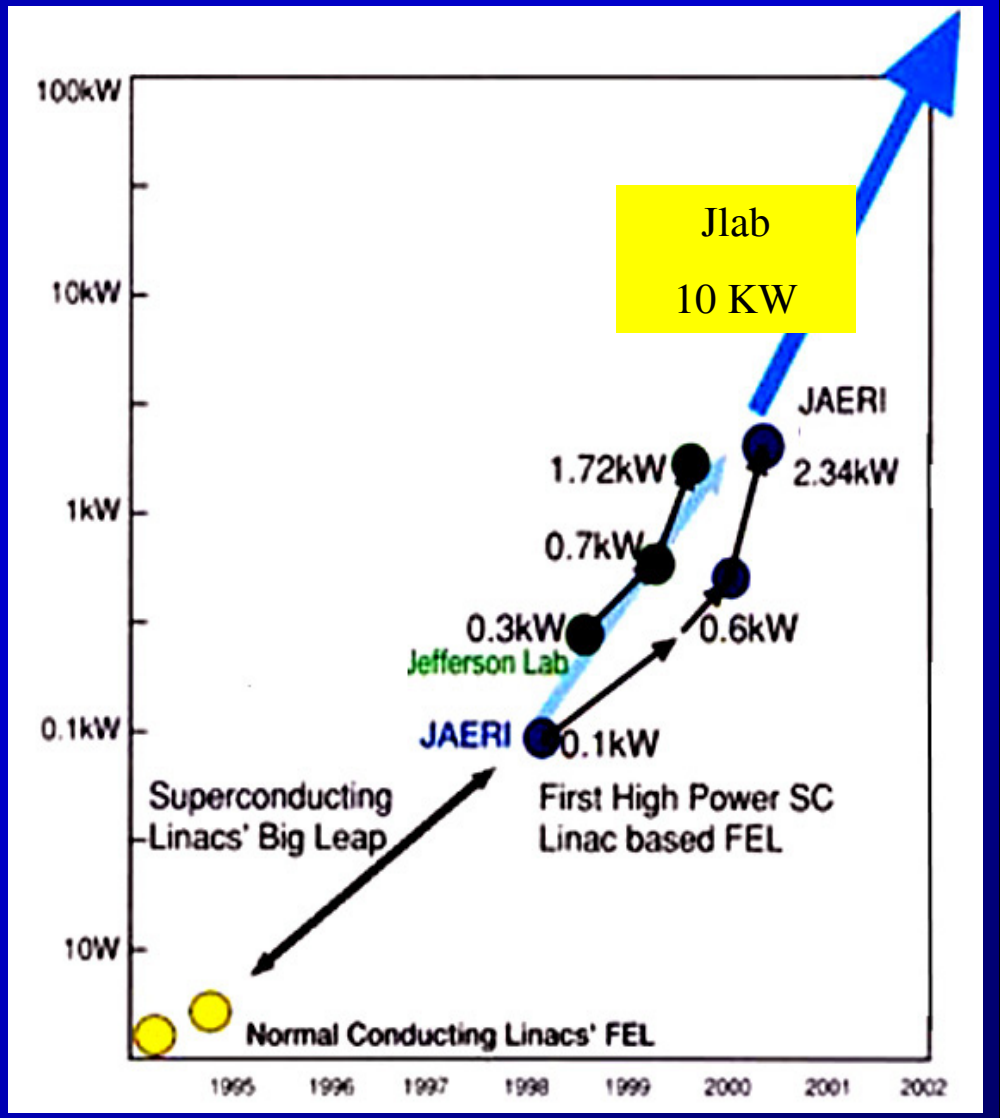




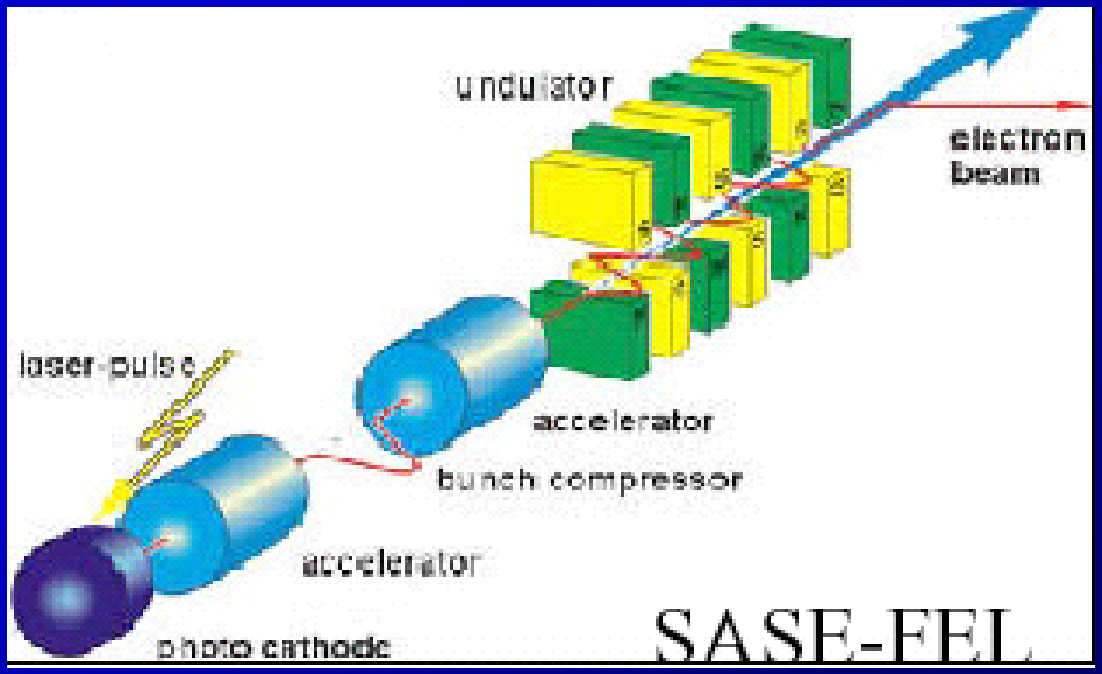
JAERI - Japan



Jlab-FEL



Look Ma! No Mirrors: SASE



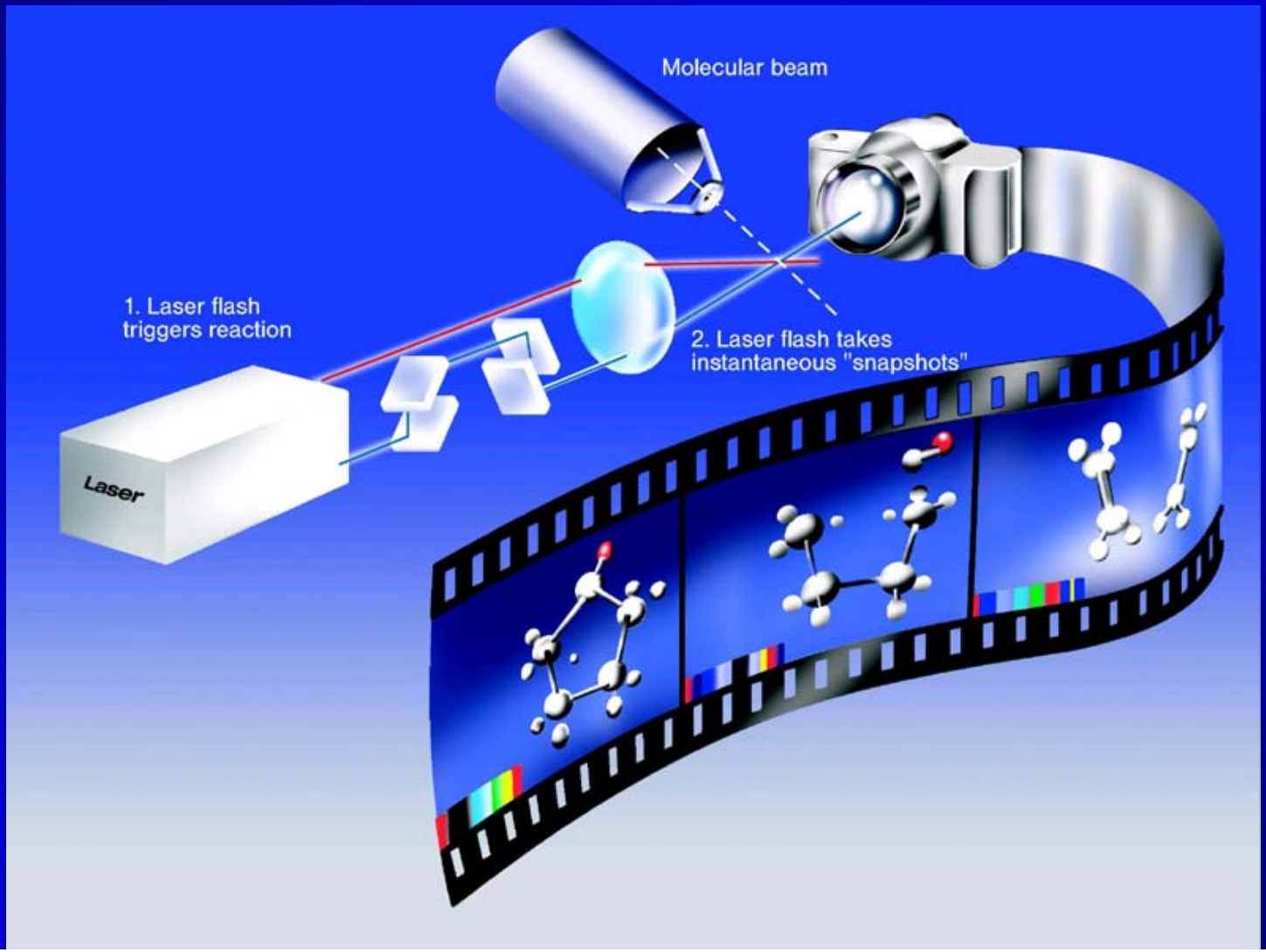
New Generation of Light Sources

X-Ray FELs and ERLs

- Single molecule processes
- Nanoscale objects
- Biological systems
- Magnetic spin/semiconductors
- Origins of life, extraterrestrial science
- Coherence phenomena, quantum information
- Attosecond electronic processes
- Superfluidity, Bose and Fermi statistics
- Molecular electronics

time dynamics will occupy a central role many of in these investigations

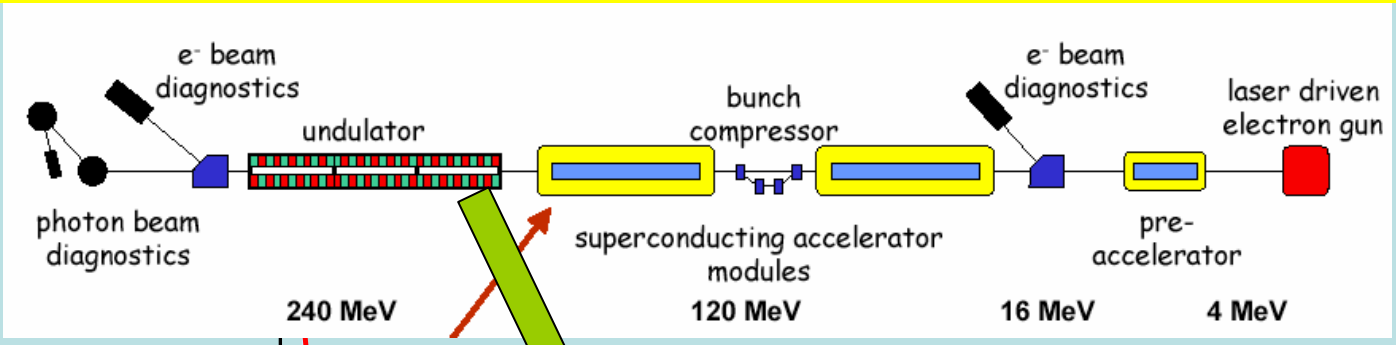
Short pulses, 100 fs, will see atomic structure of single molecules (crystallography not possible) and the dance of atoms.

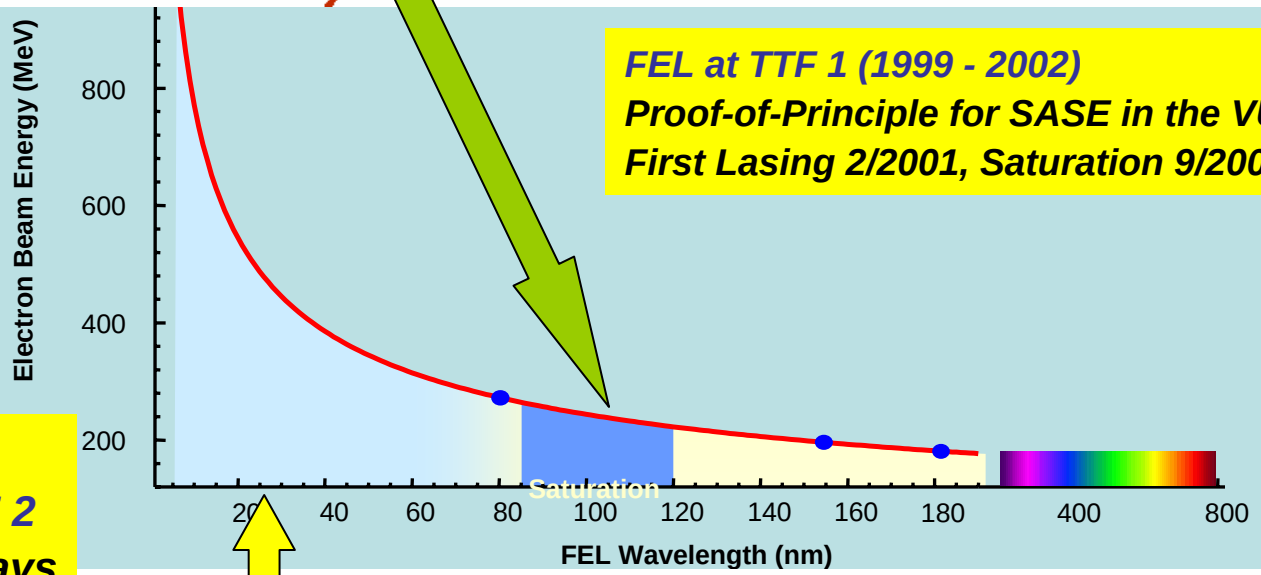


FELs Underway and Planned

- TTF-I
- TTF-II
- BESSY
- LBNL
- MIT
- Euro-FEL

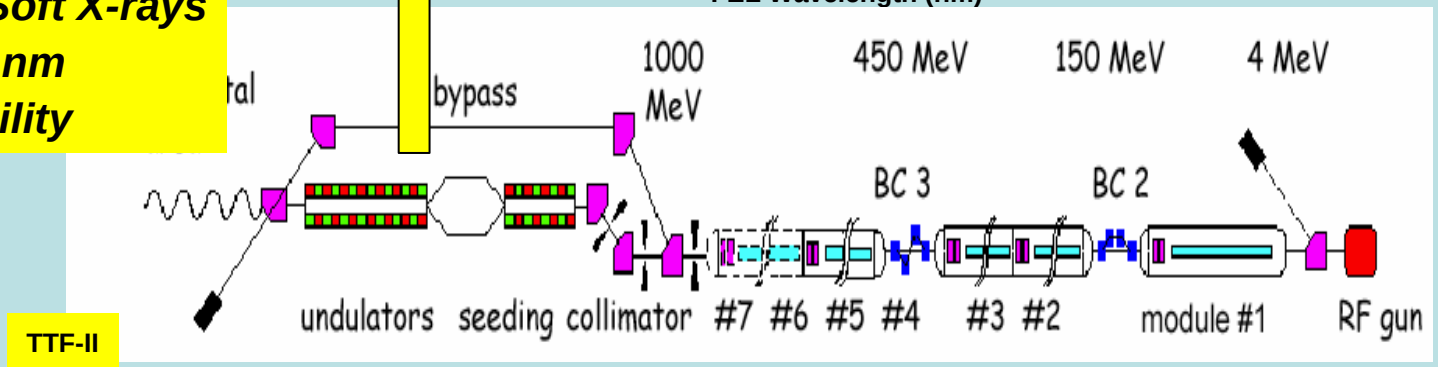
SASE-FELs VUV -> X-Rays





FEL at TTF 1 (1999 - 2002)
Proof-of-Principle for SASE in the VUV
First Lasing 2/2001, Saturation 9/2002

2004:
VUV FEL at TTF 2
VUV to Soft X-rays
: 100 - 6 nm
User facility

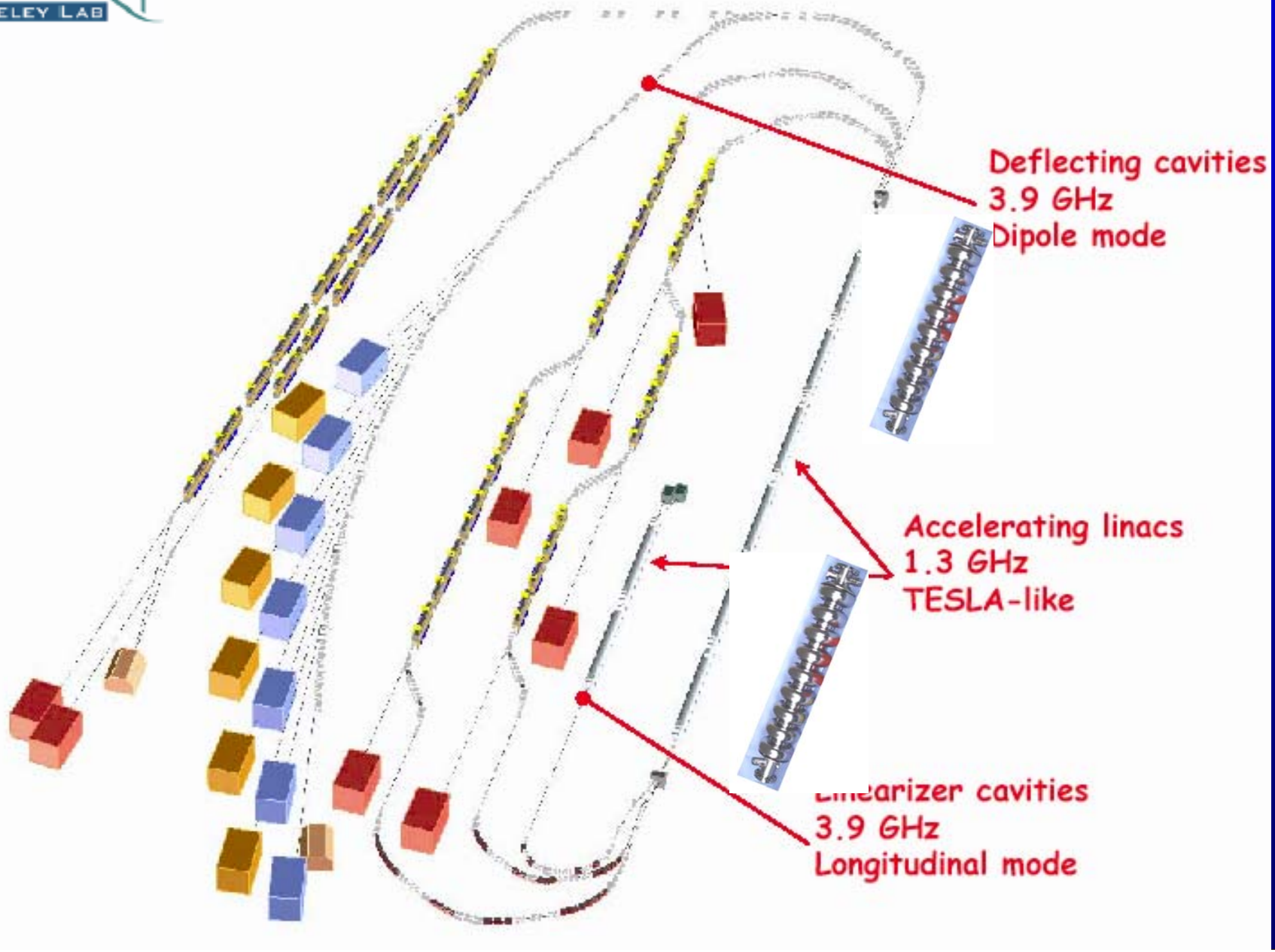


TTF-II

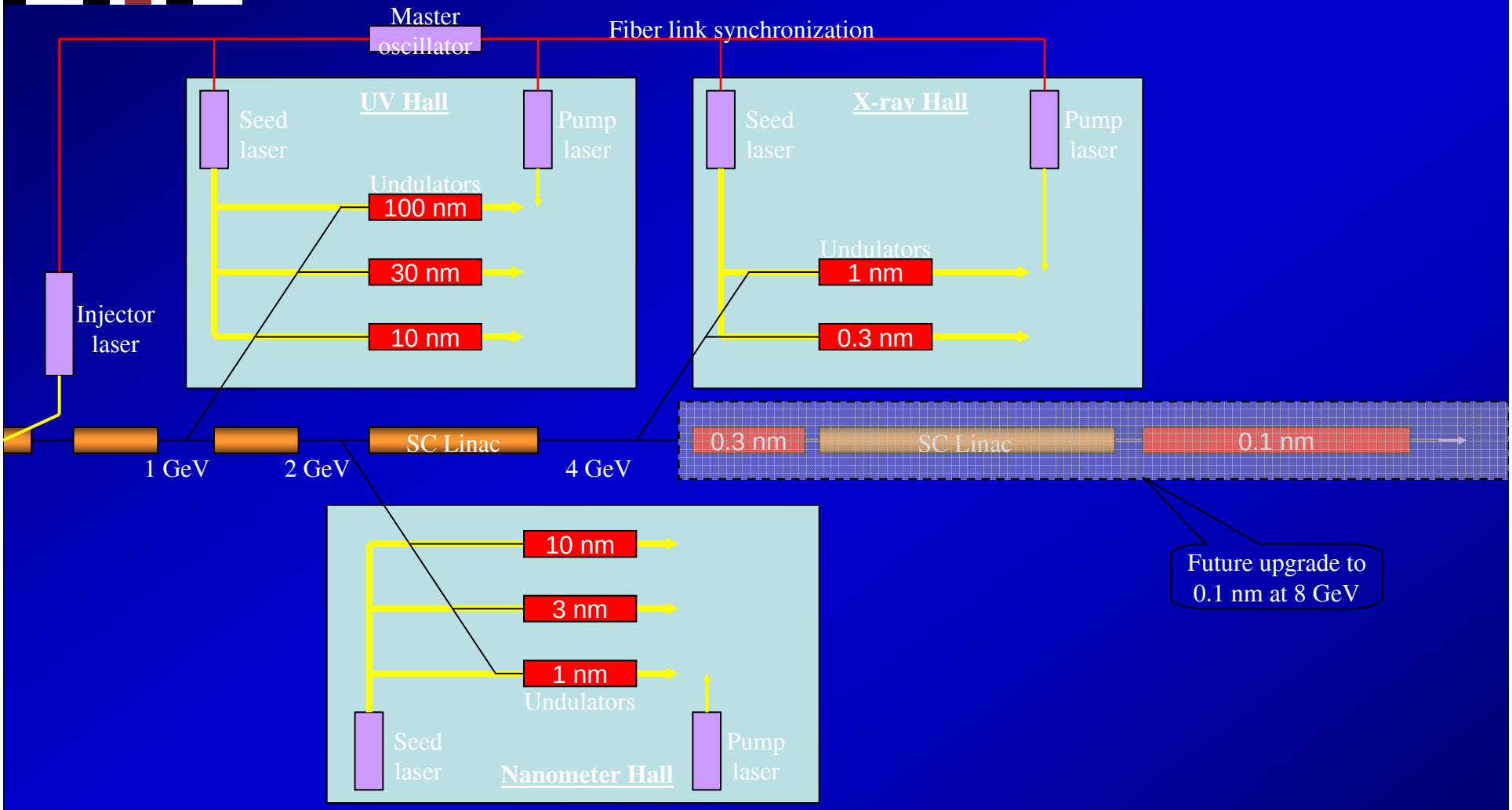
BESSY

1.5 - 2.2 GeV

2.5 - 3 GeV LUX
Linac-Based UltraFast Xray Facility

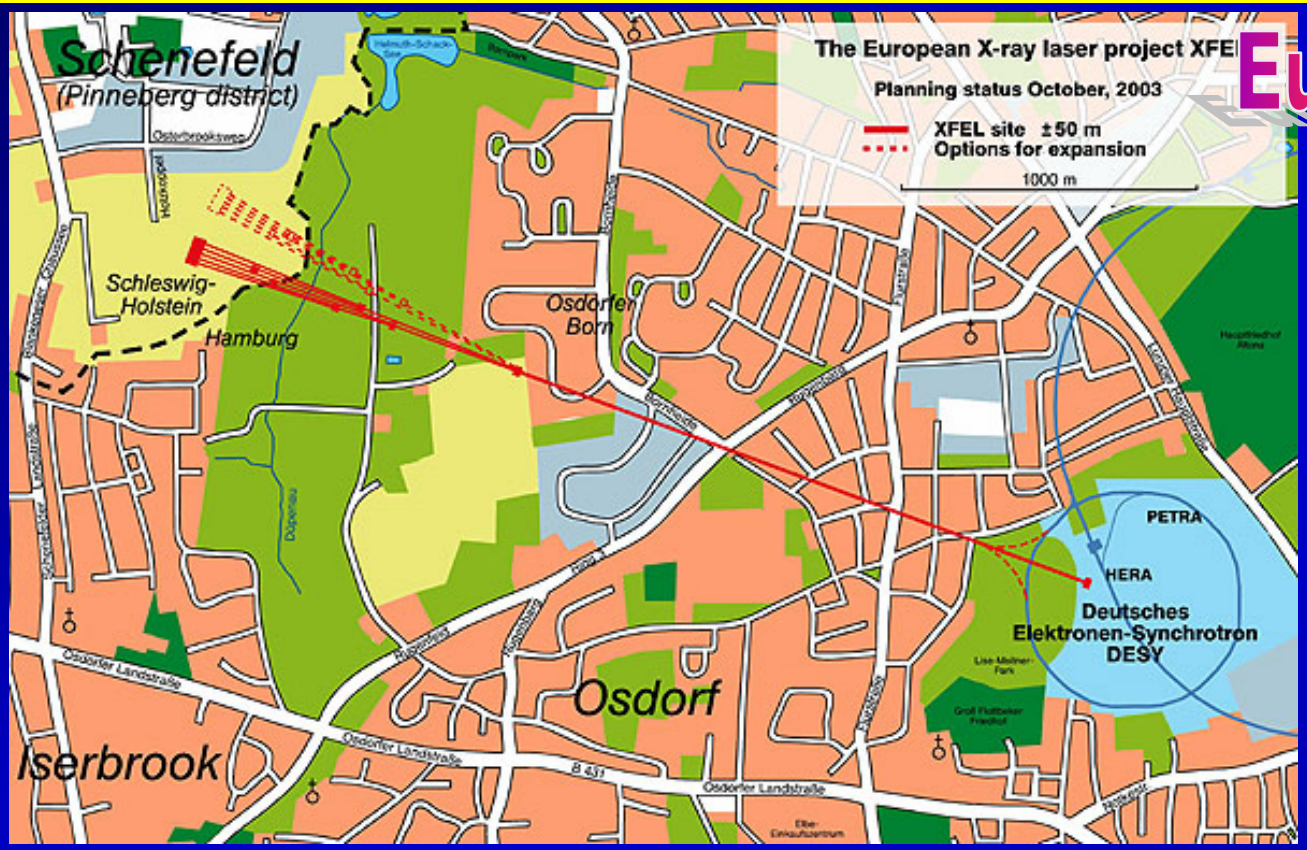


X-ray Facility at MIT



1 - 4….8 GeV

Revolutionary X-Ray Source



European X- FEL

25 GeV

Peak Brilliance
8 Orders of
Magnitude
Higher than
ESRF !

> 100

1000

ERL:
A New Class of Light Source

1986: Stanford SCA

1965: M. Tigner
Nuovo Cimento
37 (1965) 1228

1960

1970

1980

1990

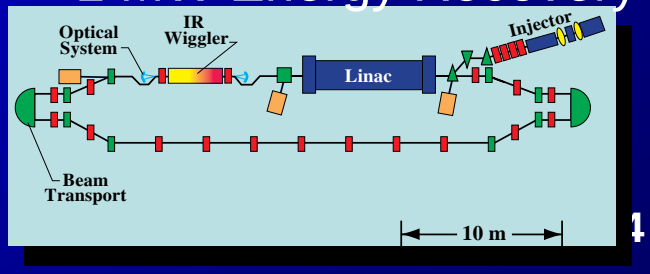
2000

1999: JLAB DEMO-FEL
2002: JAERI FEL

1990: S-DALINAC
(Darmstadt)

2004: JLAB FEL Upgrade

1 MW Energy Recovery



Energy Recovery Linacs Ambitions

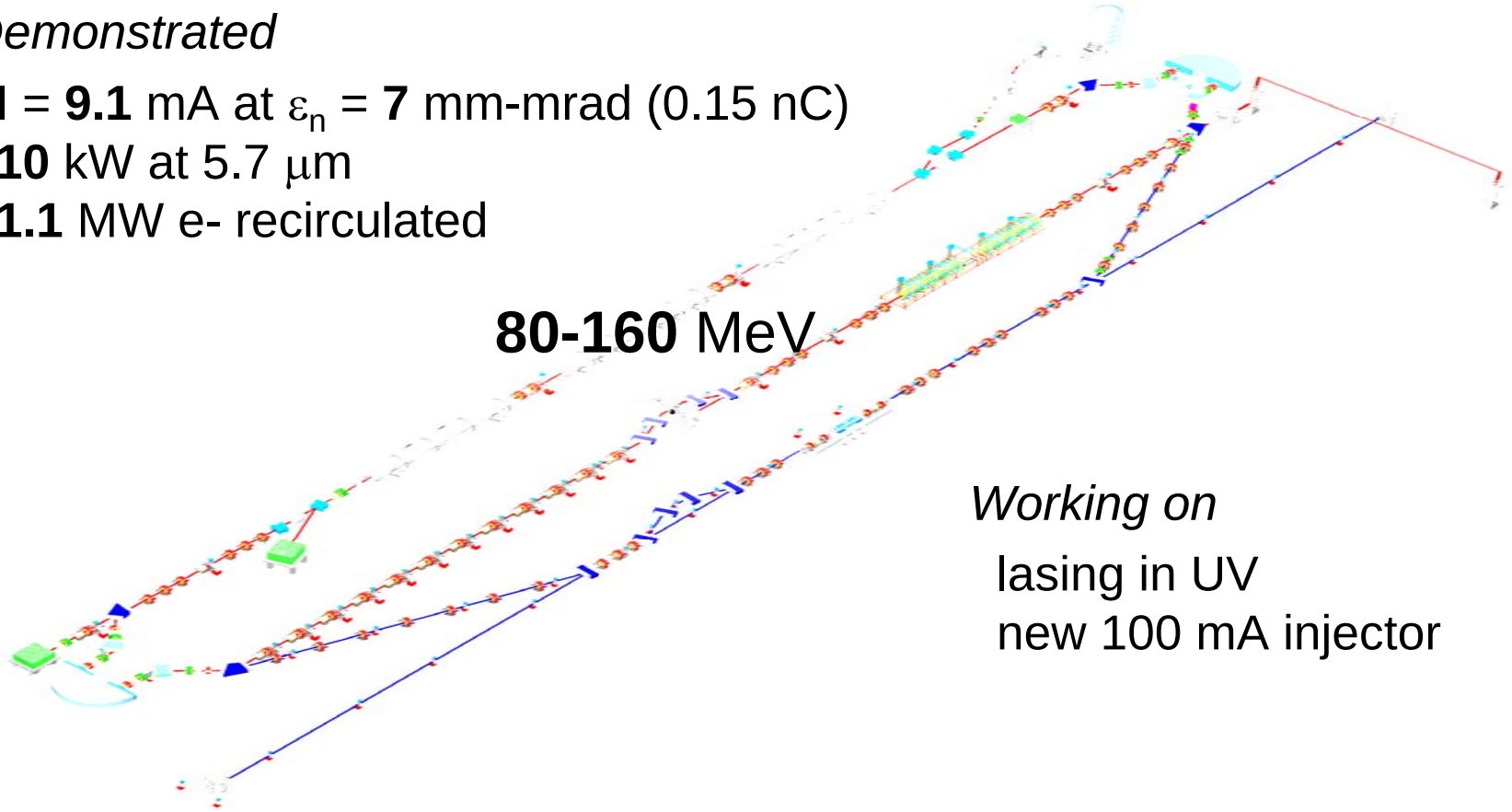
- Jlab
- Cornell
- Daresbury
- BNL
- France

JLAB FEL Upgrade
> 1 MW Energy Recovery Linac

Demonstrated

I = **9.1** mA at ε_n = **7** mm-mrad (0.15 nC)
10 kW at 5.7 μm
1.1 MW e- recirculated

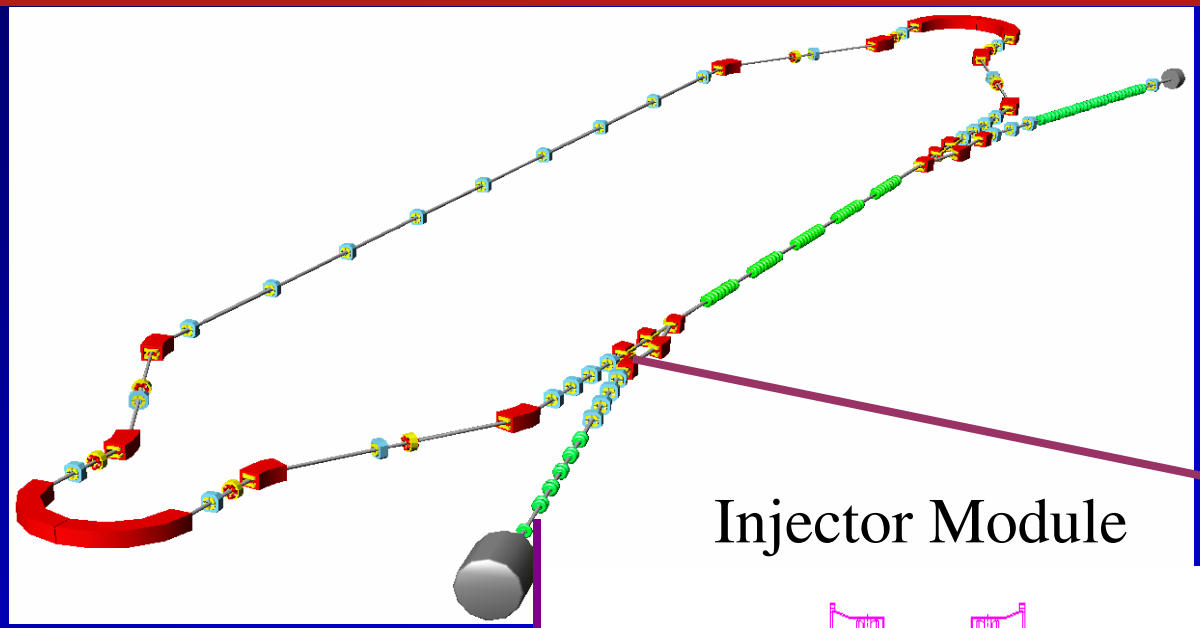
80-160 MeV



Working on

lasing in UV
new 100 mA injector

Cornell University ERL Prototype (Phase I a & b)



Injector Module

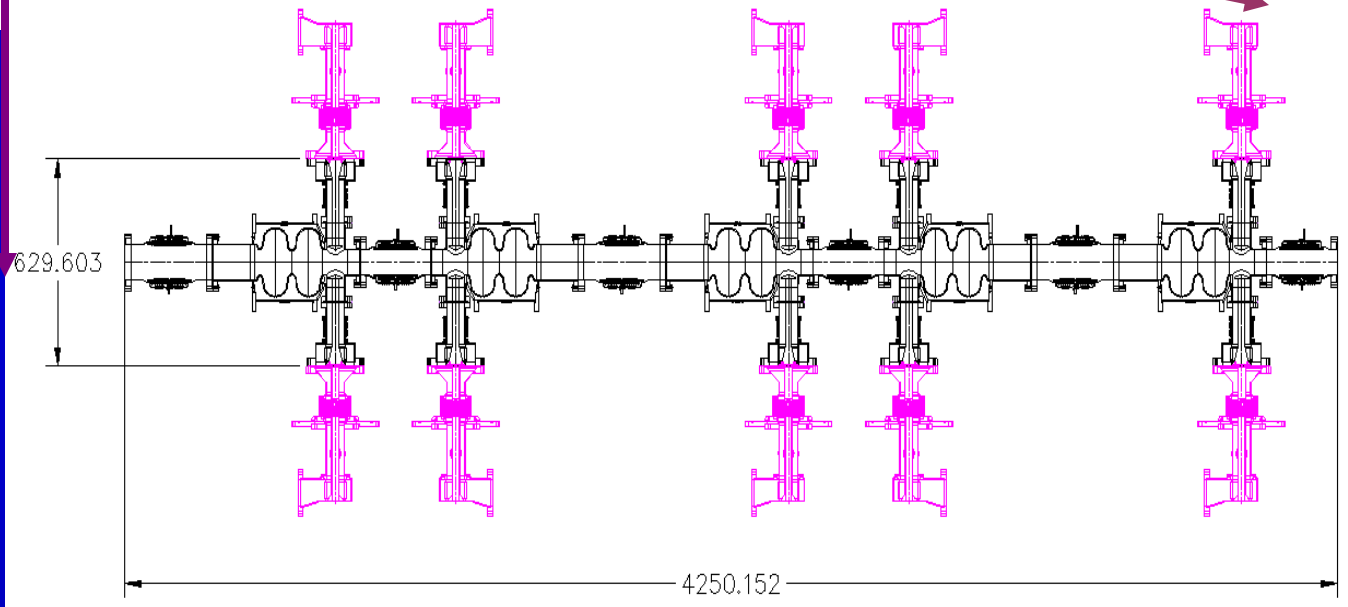
E = 5-15 MeV

beam power ≤ 0.5 MW

max current 0.1 A

q = 0.01-0.4 nC

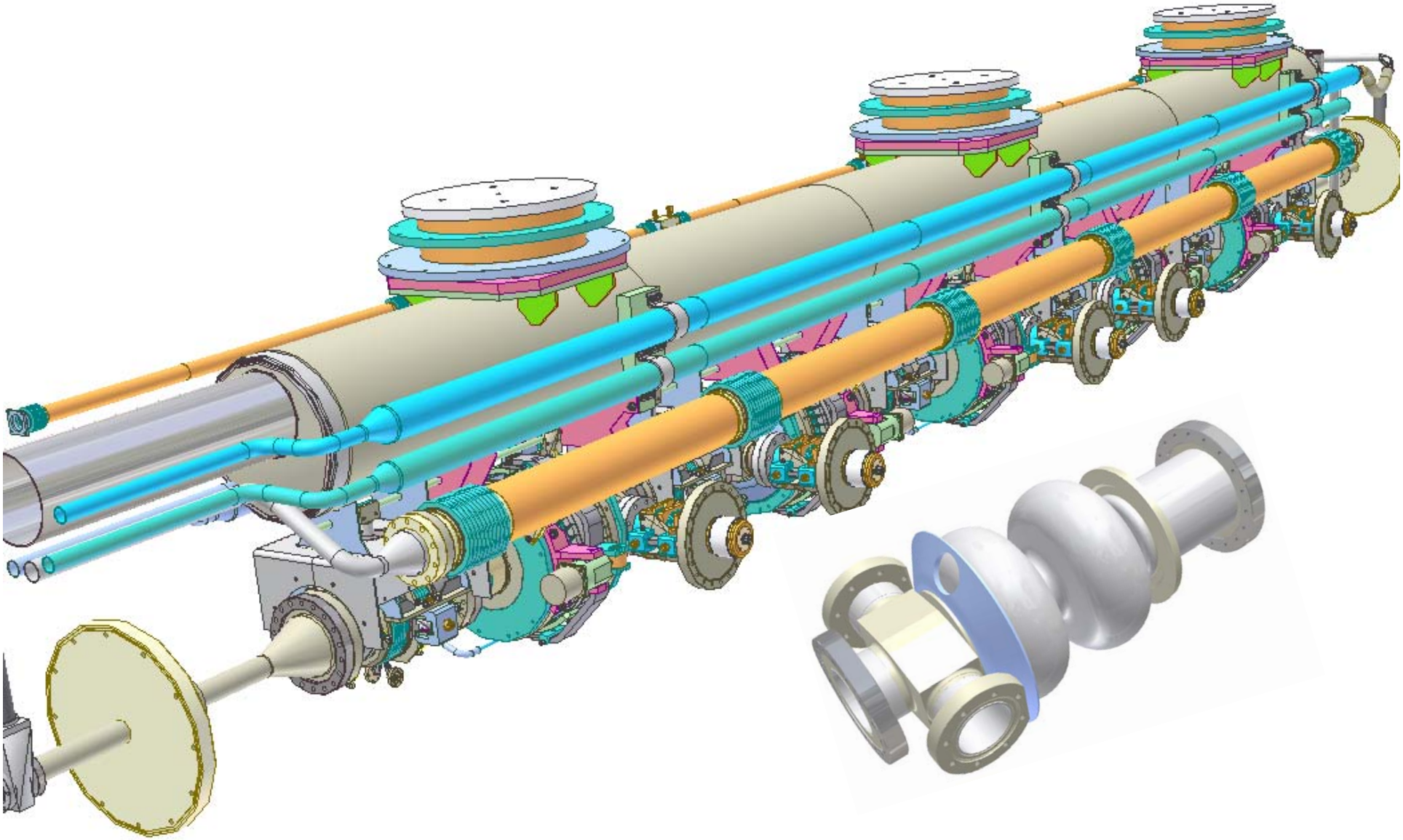
ε_n = 0.1-1 mm-mrad



Phase Ia- funded

Cornell University

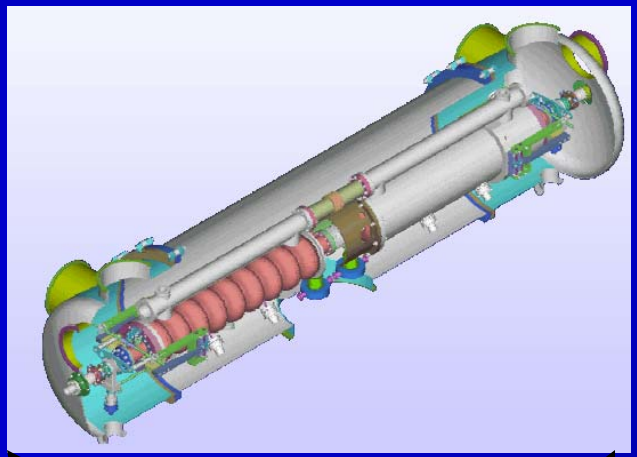
ERL Prototype (Phase I a & b)

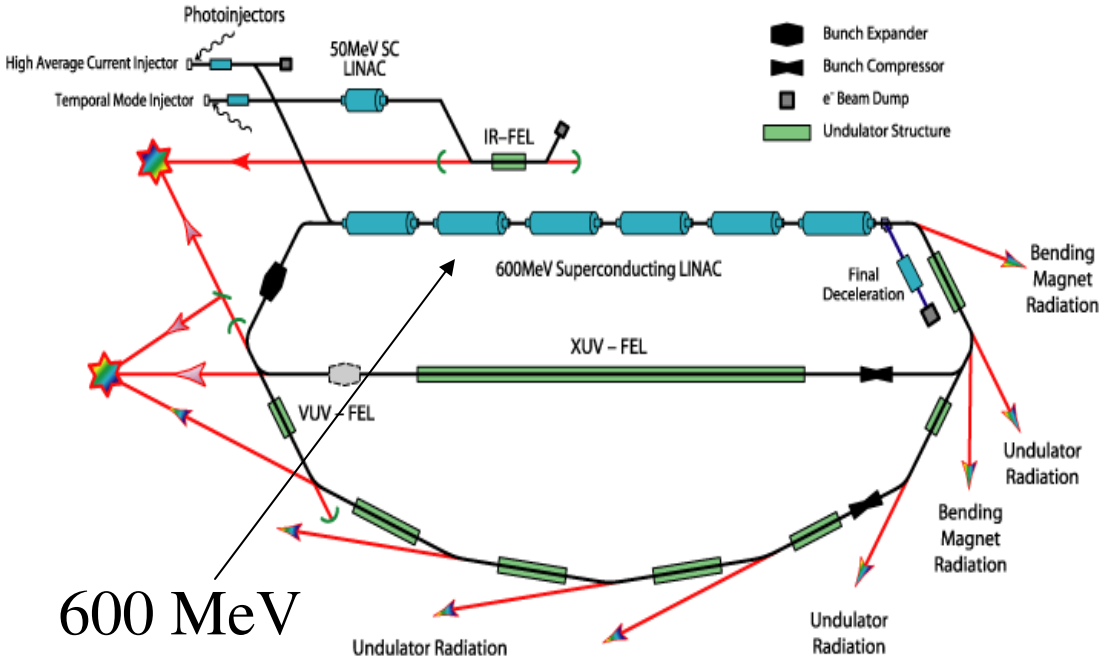


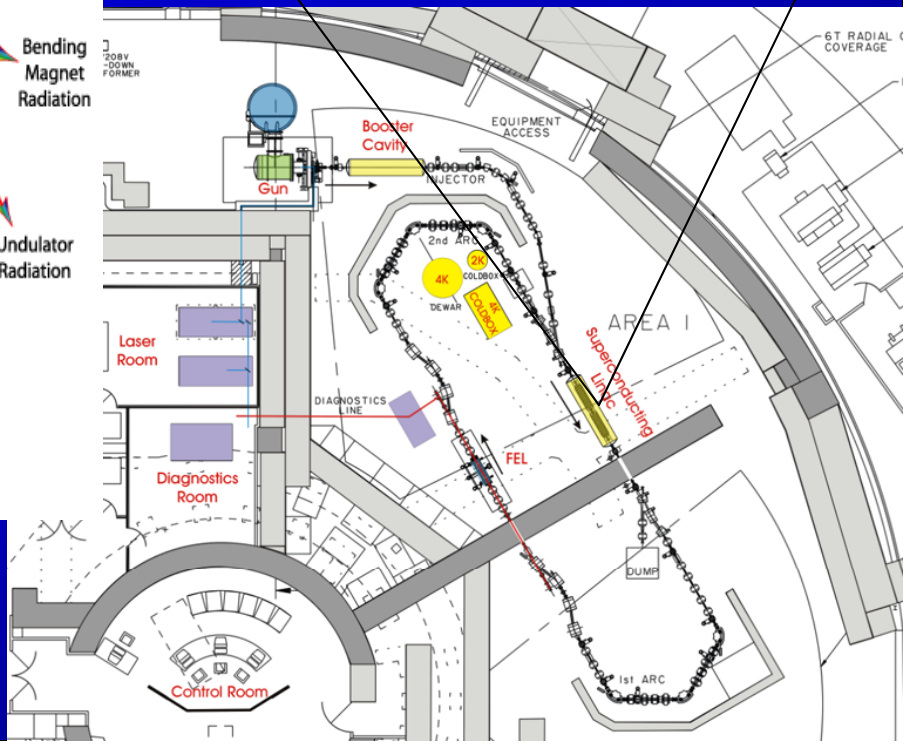
Daresbury

4GLS DARESBURY

ASTeC
accelerator science and technology centre



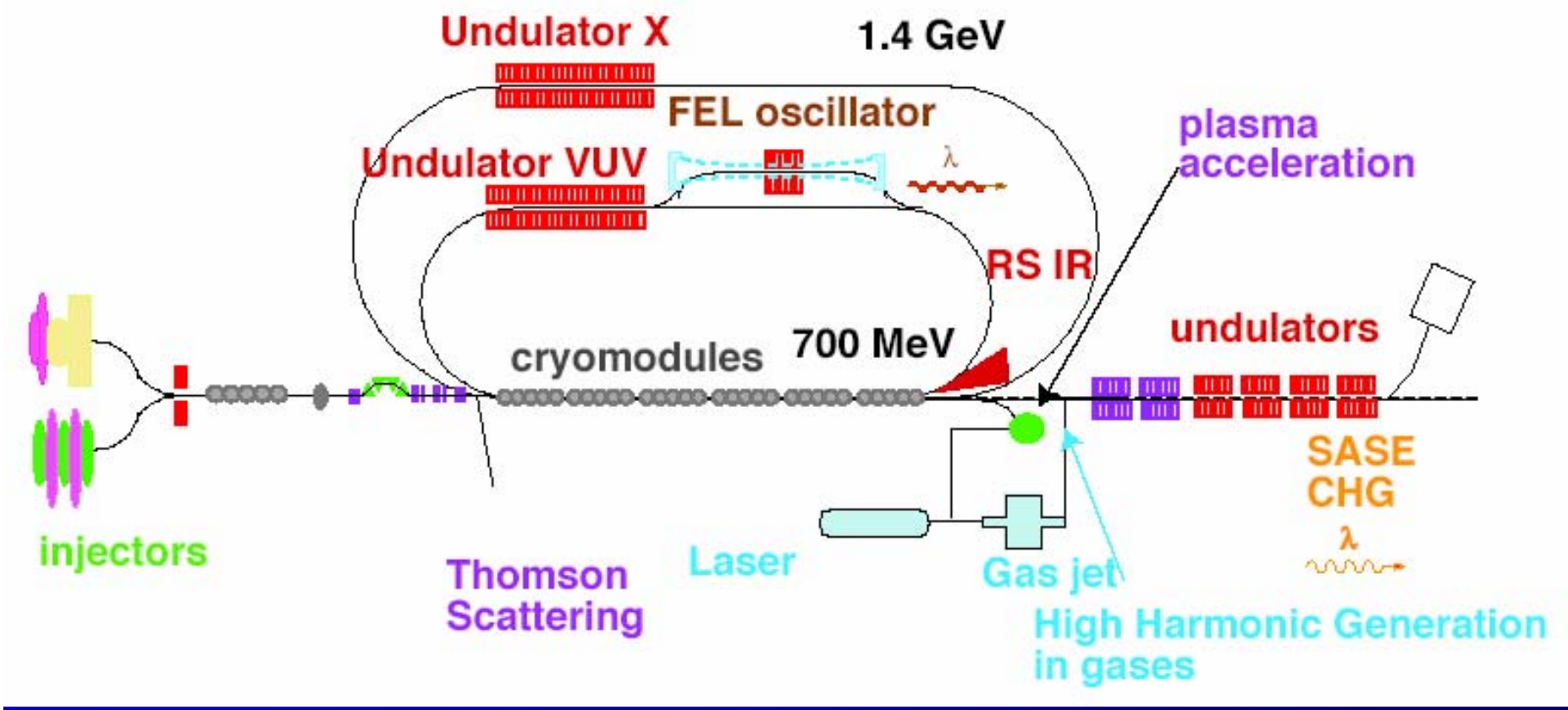




Funded Prototype 30 MeV

ARC-EN-CIEL
Accelerator Radiation Complex for ENhanced Coherent Intense Extended Light

France



BNL R&D: Other Applications of ERL

q ~ 20 nC

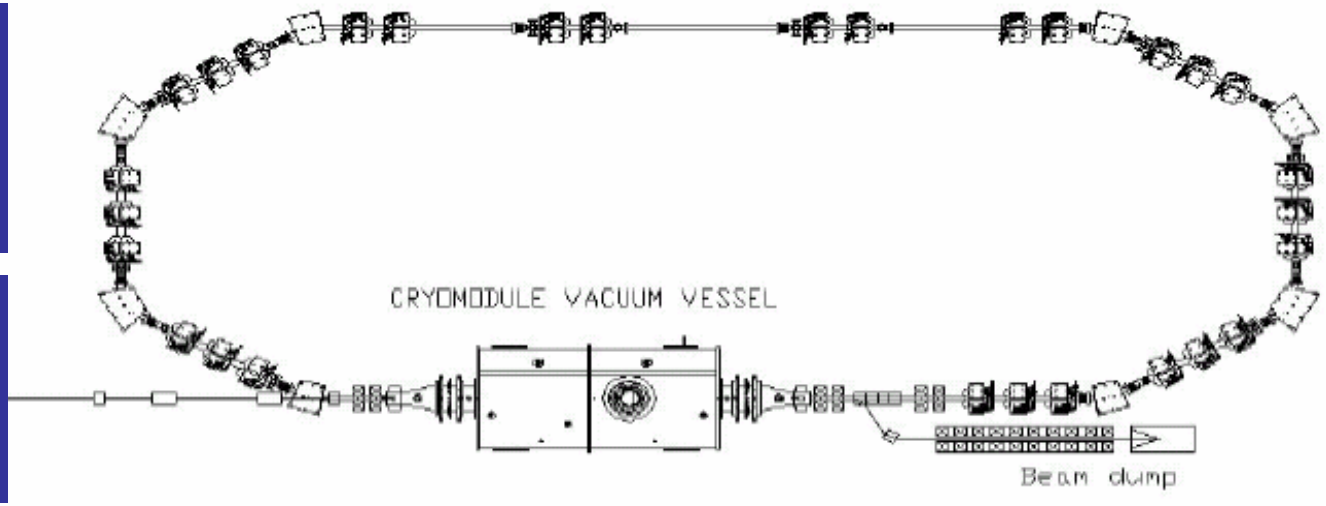
ε_n ~ 30 mm-mrad

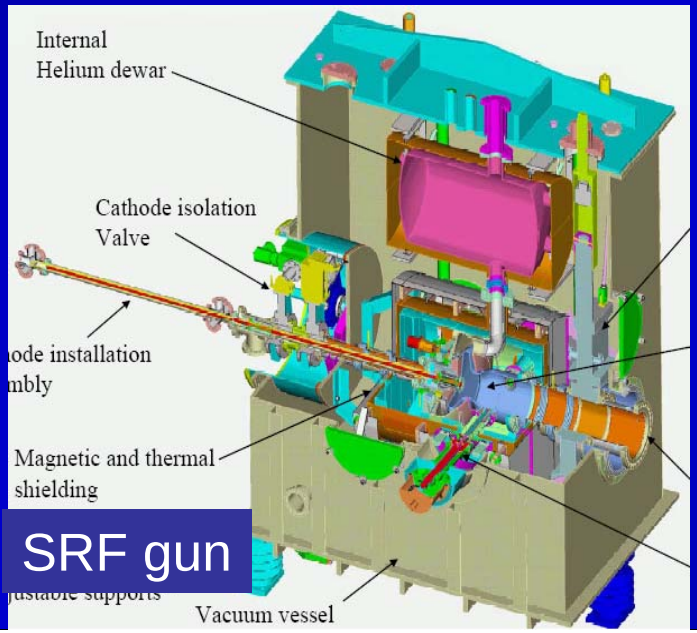
I_{max} = 0.2 A

q ~ 1.3 nC

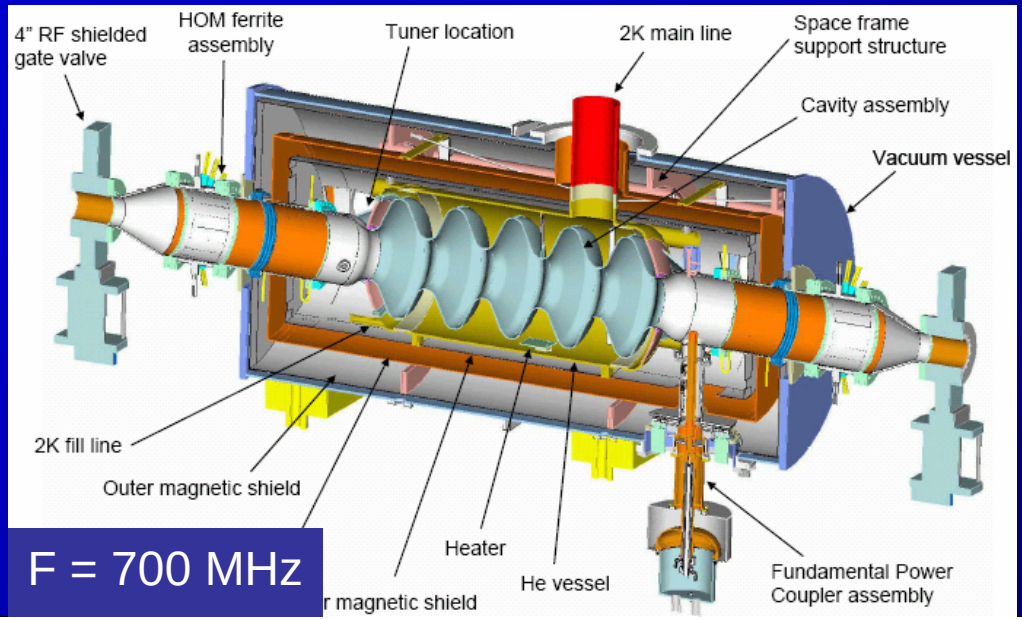
ε_n ~ 1-3 mm-mrad

I_{max} = 0.5 A



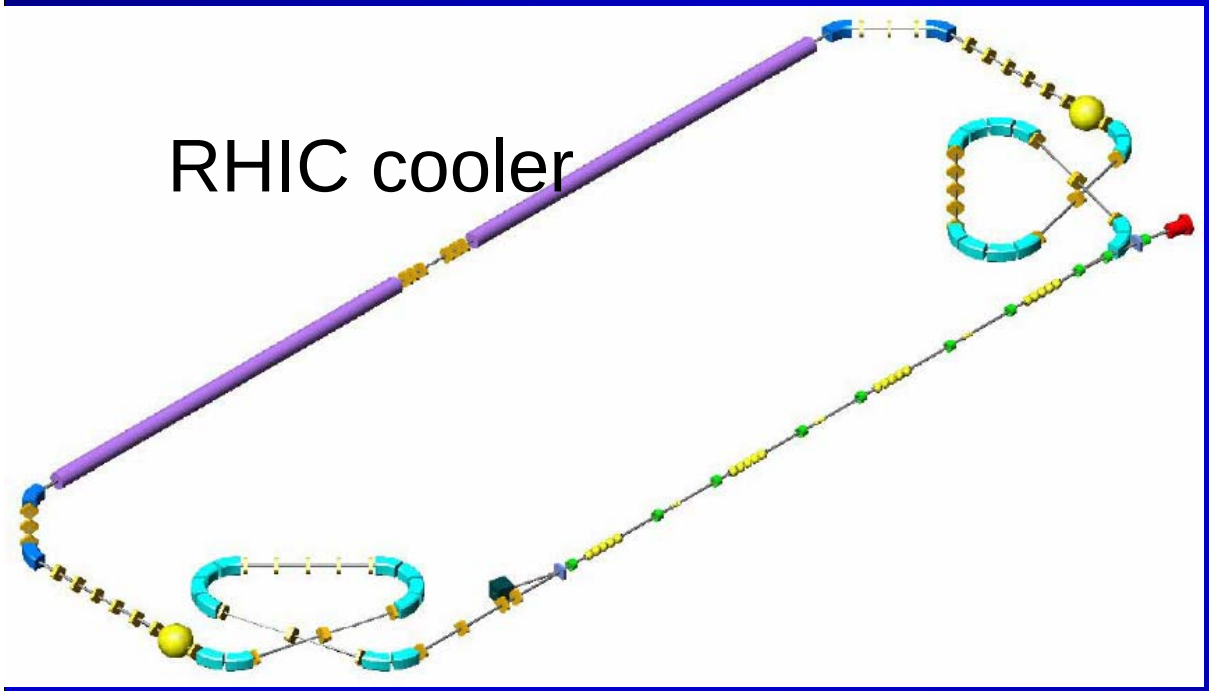


SRF gun



F = 700 MHz

Electron Cooling for RHIC Upgrade



E = 55 MeV

I = 200 mA

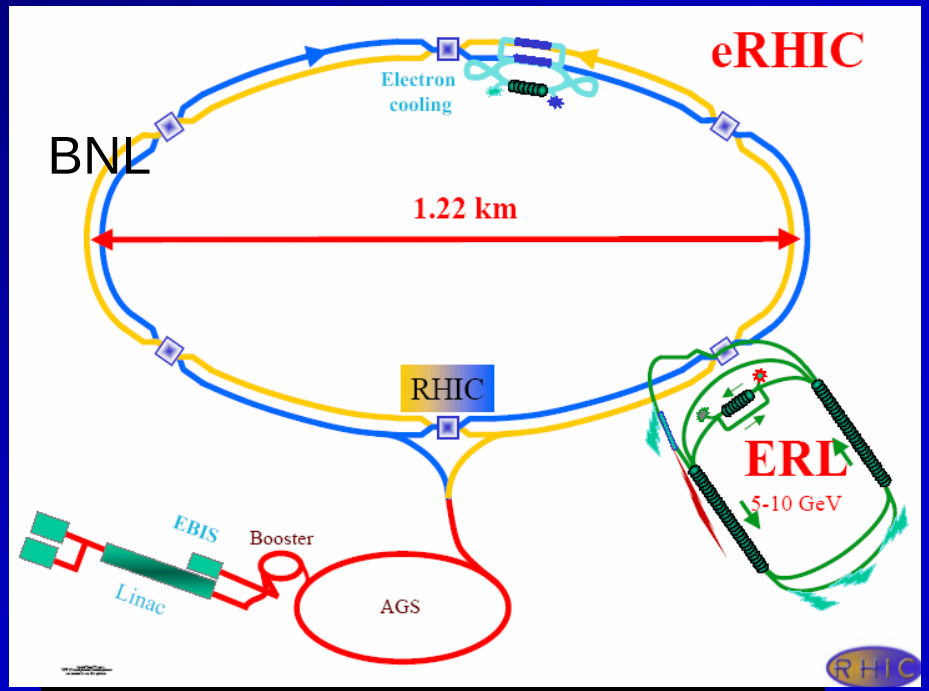
$\varepsilon_n \leq 40$ mm-mrad

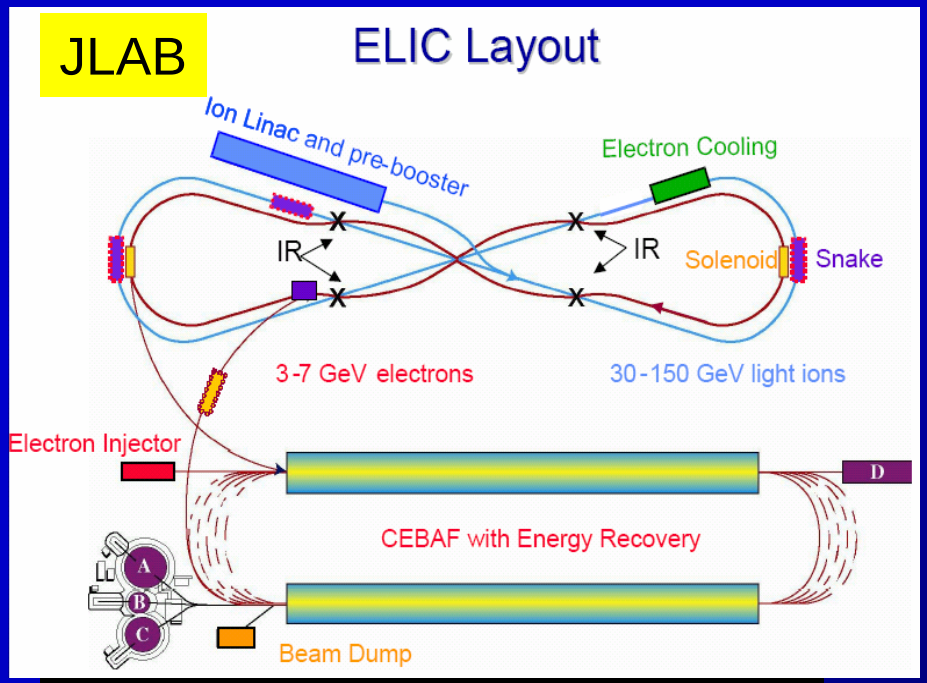
q = 20 nC

$\Delta E/E \leq 3\times10^{-4}$

magnetized beam

Future Electron-Ion Colliders



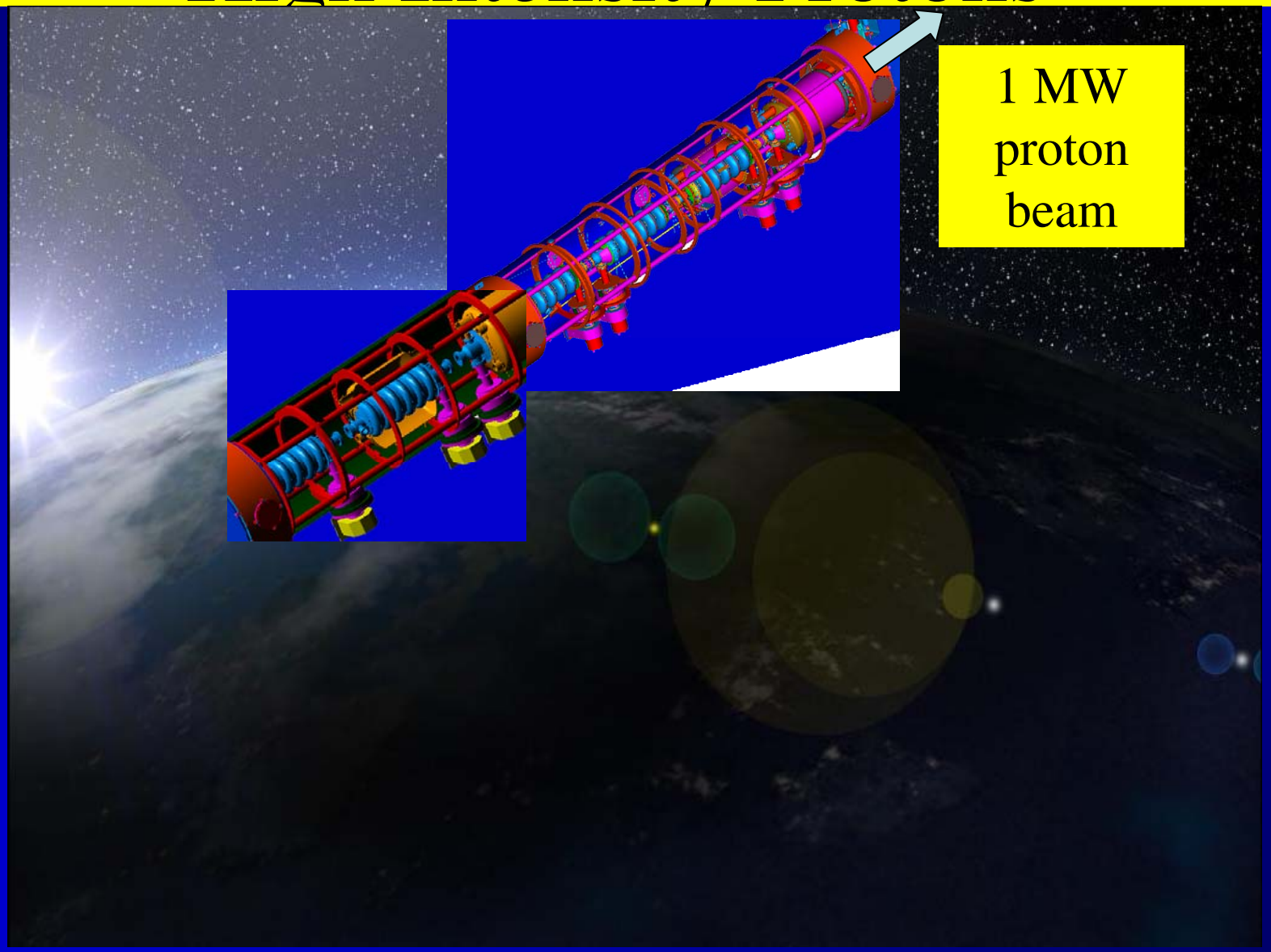


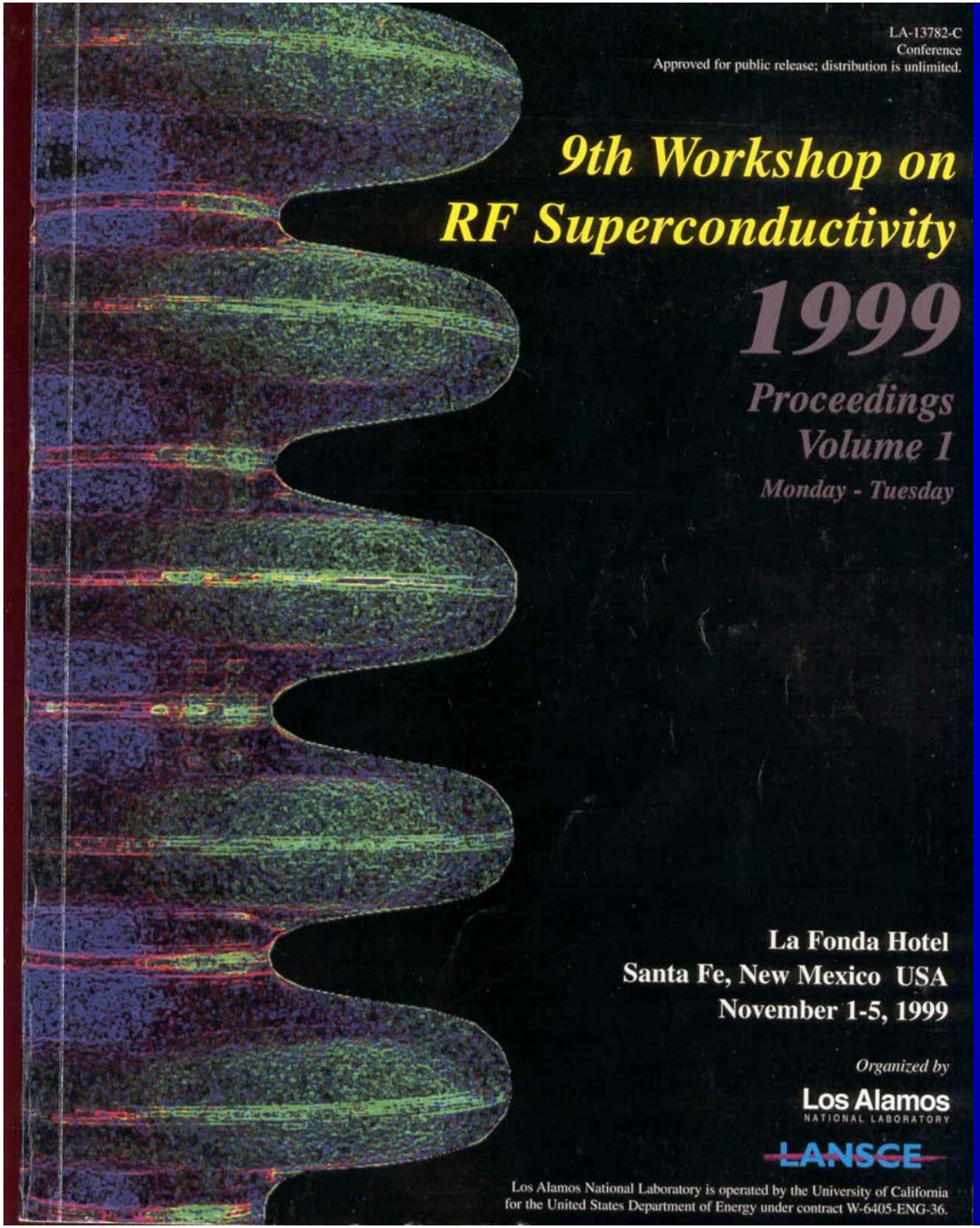
E = 2-10 GeV I ~ 100 mA ε_n ~ 10 mm-mrad

polarized beam from the gun

A New Frontier Has Opened

High Intensity Protons





Think back:
Hot Topic
at
the 9th
Workskhop
Should SNS
switch to SRF?

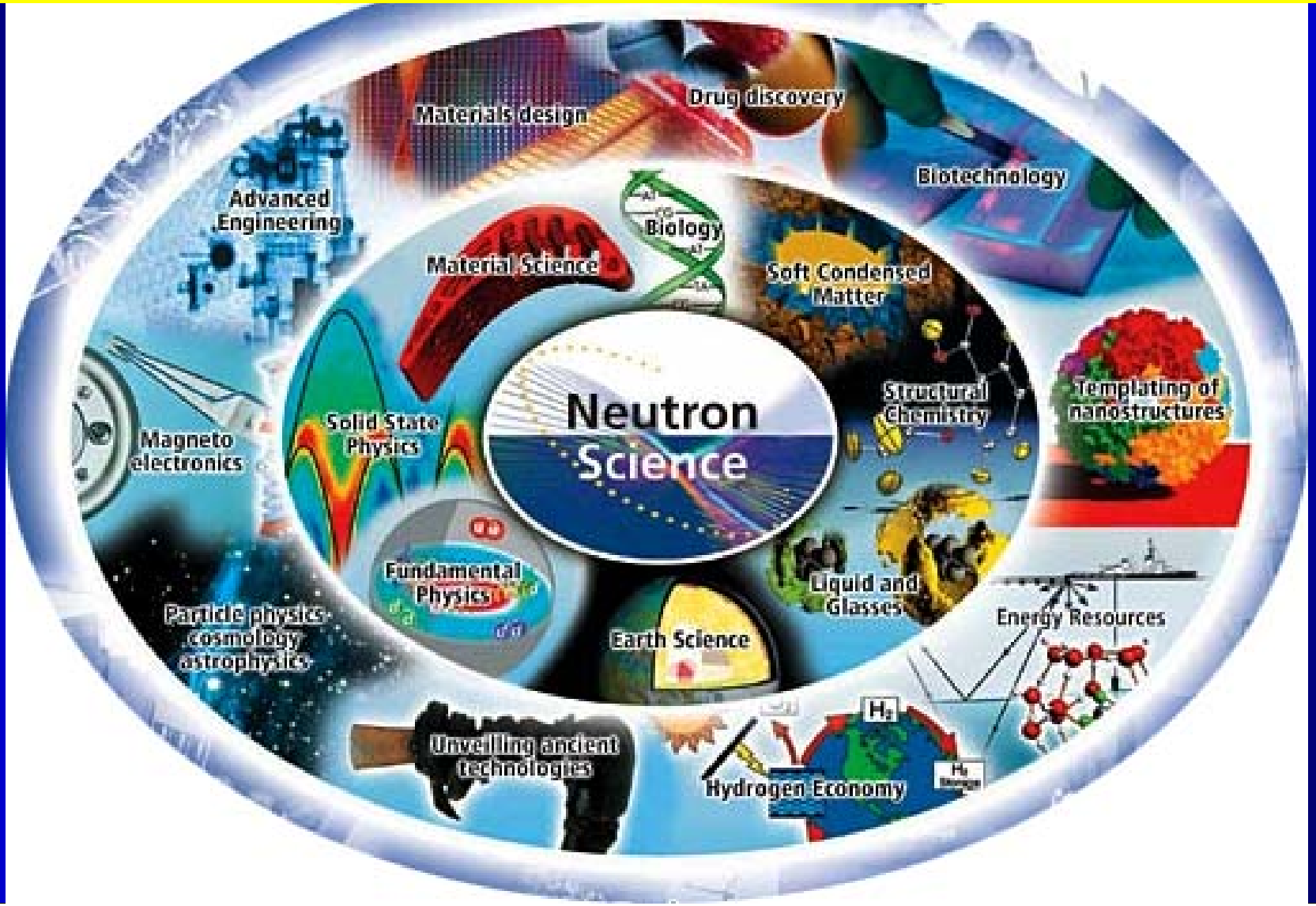
6 years later

SNS Cryomodules in the Linac Tunnel

11 medium beta installed

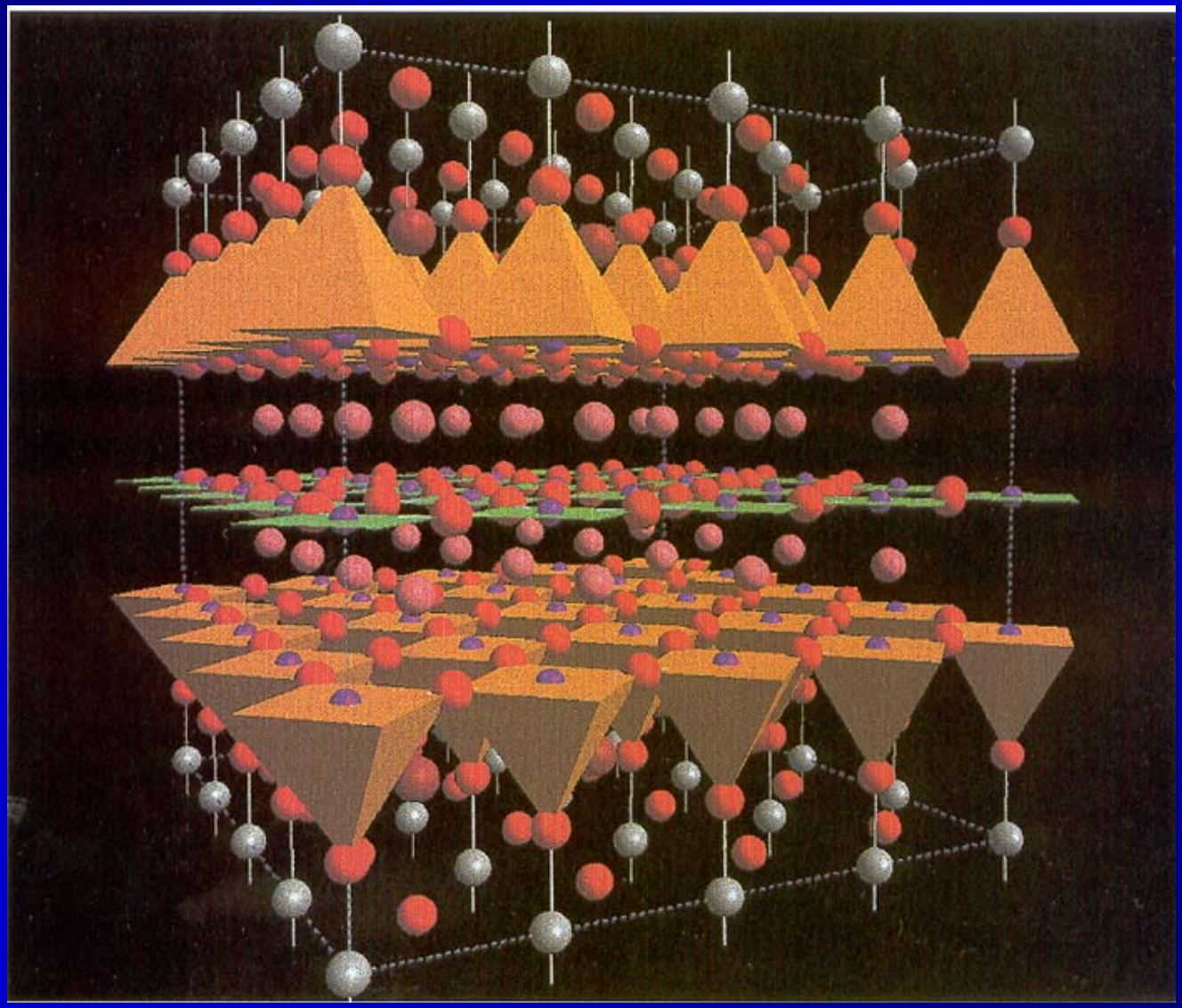
10 (of 12) high beta in place, G > 15 MV/m

Ready for the Many Dimensions of Neutron Science



Famous Example:

Neutrons helped elucidate crystal structure of YBCO



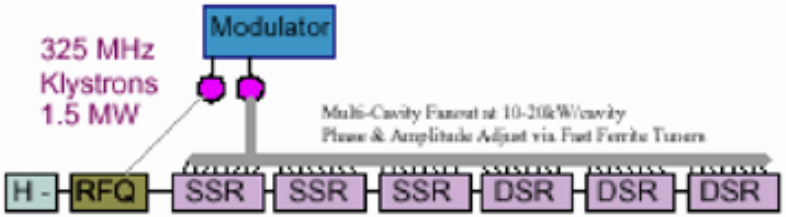
From SNS -> Future High Current Proton Linacs Anticipated

More Opportunities for Low β, medium β and high β together

- Proton Driver (Fermilab)
- SPL (CERN)
- XADS, EUROTRANS… (Europe)
- Joint Project Upgrade (Japan)
- AGS - Upgrade (BNL)

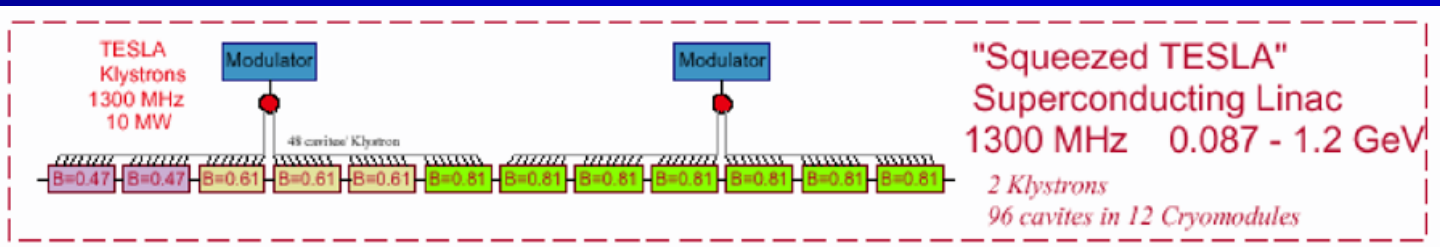
Fermilab Proton Driver

8 GeV SC Linac: Based on TESLA and RIA Technologies

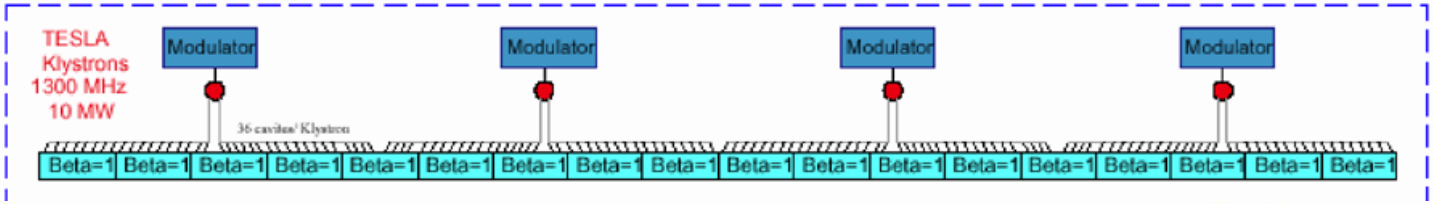


"Pulsed RIA"
SCRF Linac
325 MHz
0 - 120 MeV

8 GeV 0.5 MW LINAC
12 Klystrons (2 types)
11 Modulators 20 MW ea.
1 Warm Linac Load
54 Cryomodules
~550 Superconducting Cavities

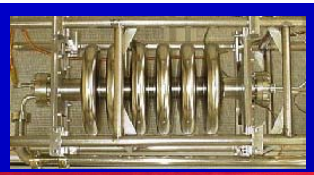


"Squeezed TESLA"
Superconducting Linac
1300 MHz 0.087 - 1.2 GeV
2 Klystrons
96 cavites in 12 Cryomodules

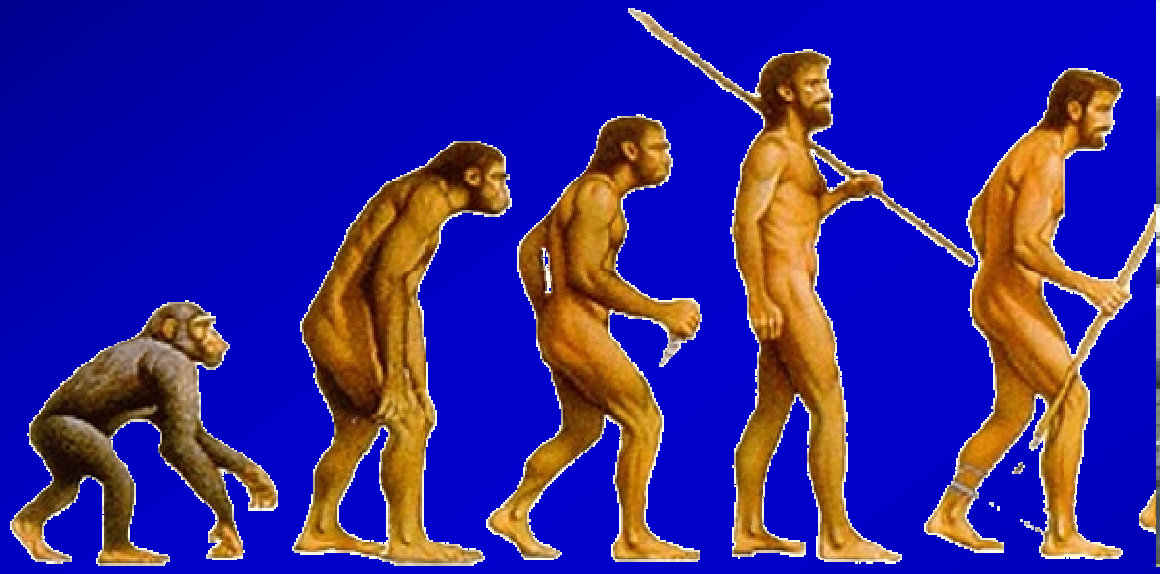


"TESLA" LINAC 1300 MHz Beta=1

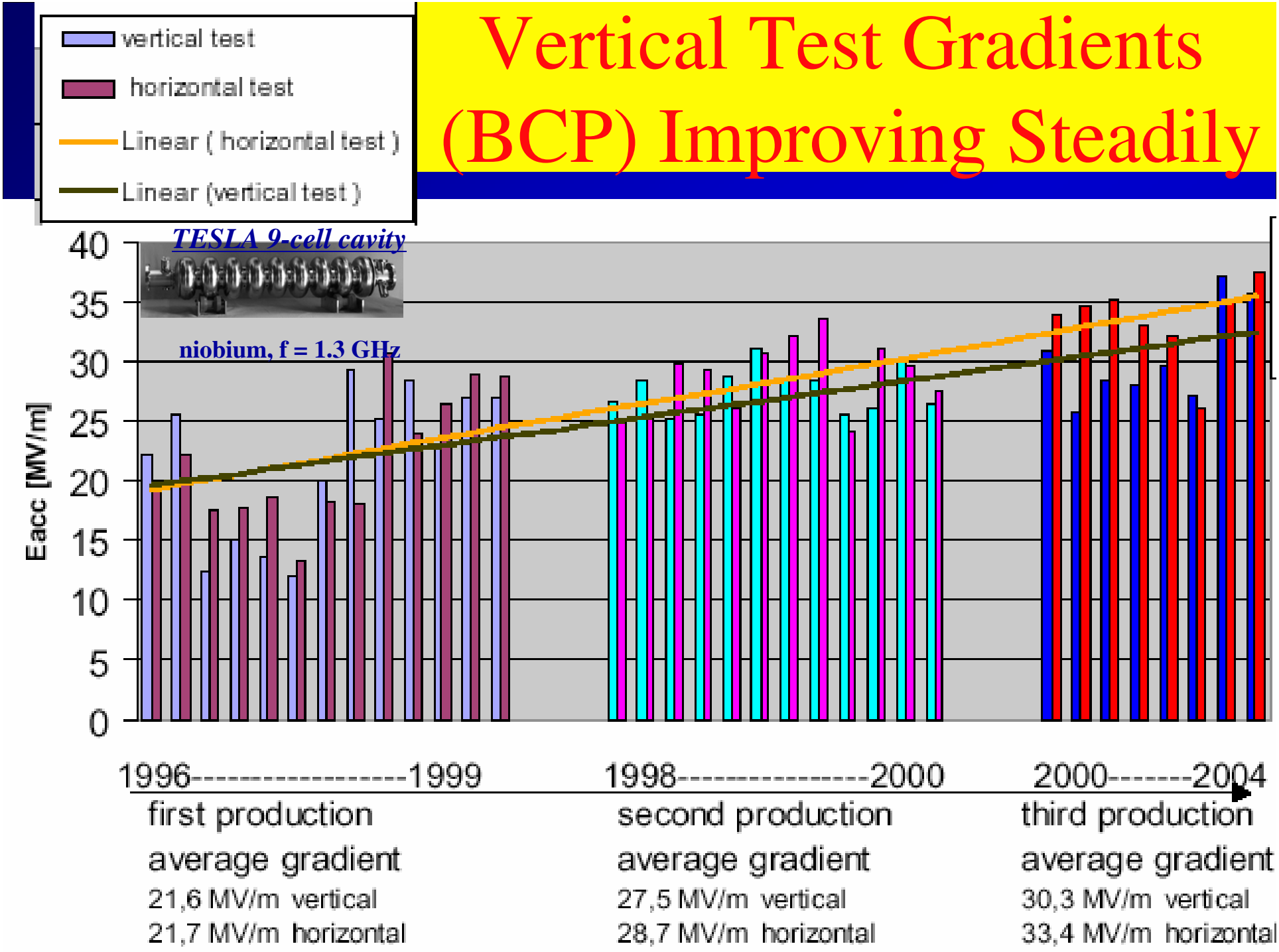
8 Klystrons
288 cavites in 36 Cryomodules



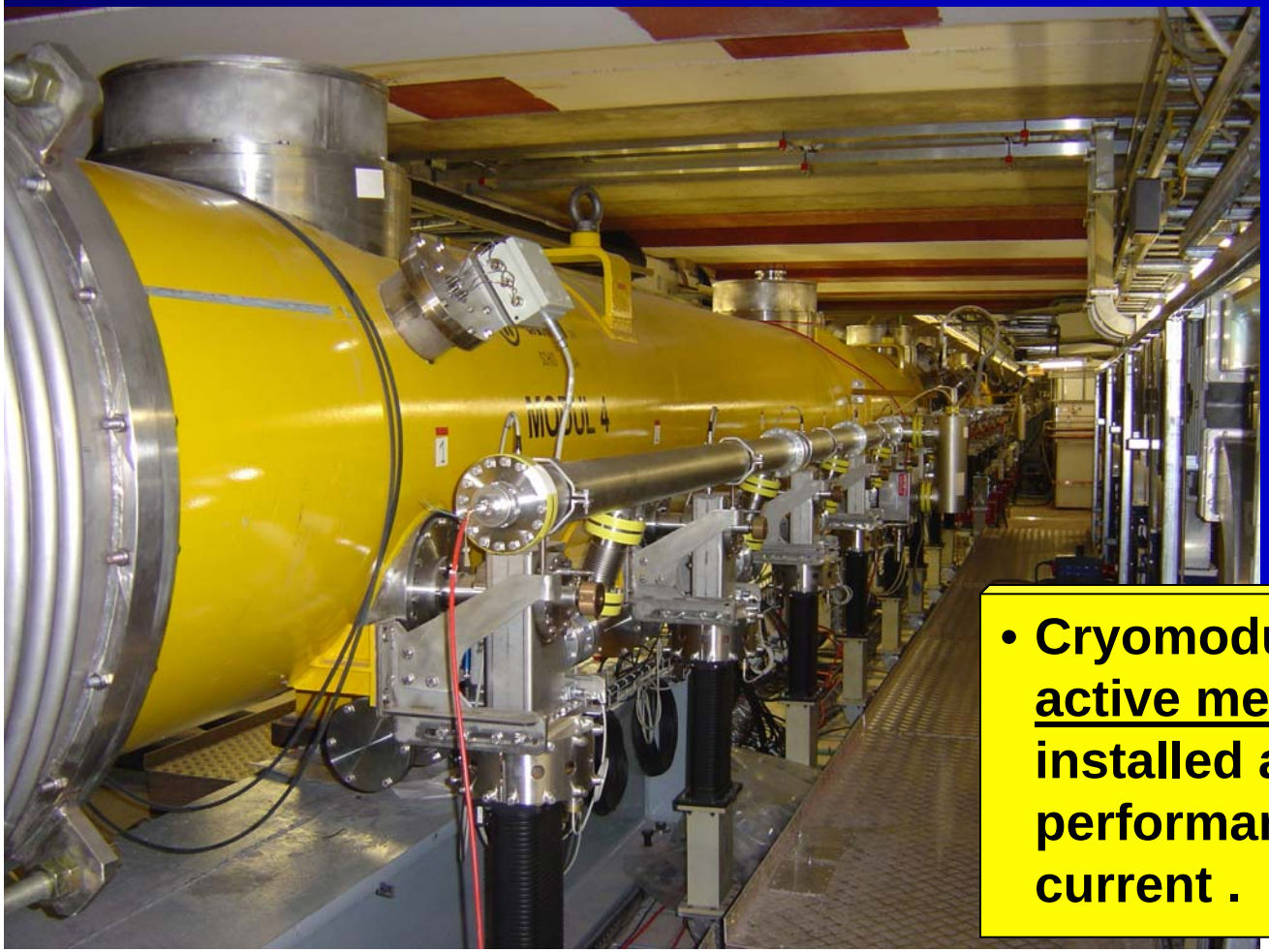
How SRF Technology Continued to Evolve Over Last Few Years



Vertical Test Gradients (BCP) Improving Steadily

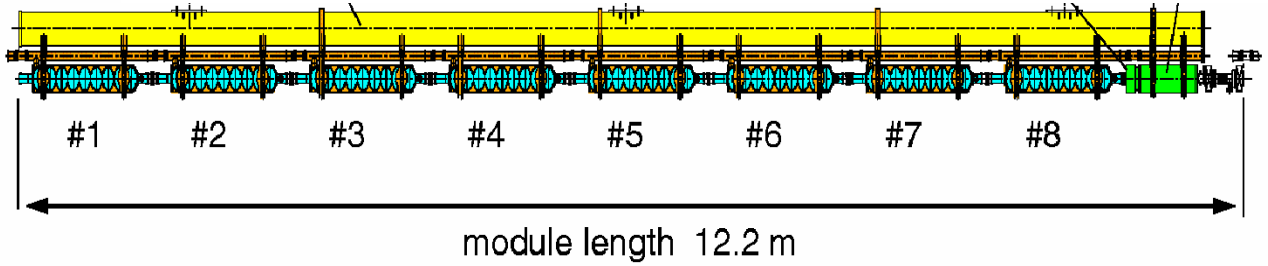


Cryomodule Gradients Keep Up with Vertical Tests

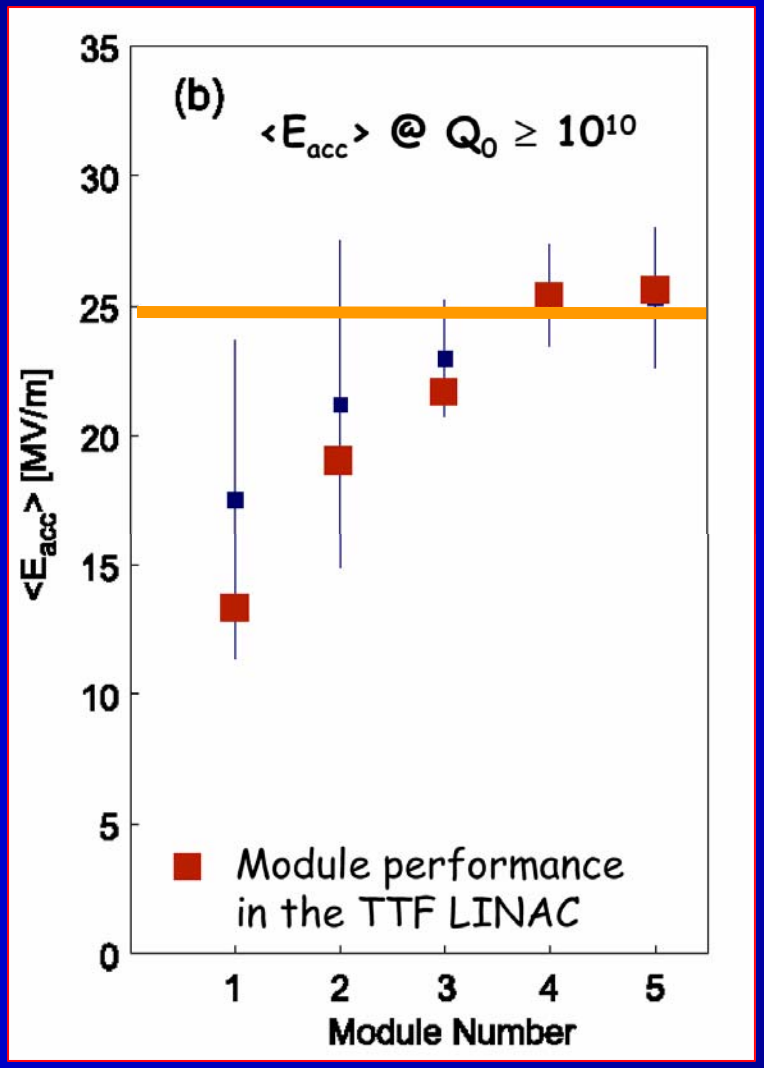


TTF-II

- **Cryomodules 4 and 5 with <u>16 active meters</u> of cavities installed and tested to 25 MV/m performance and low dark current .**



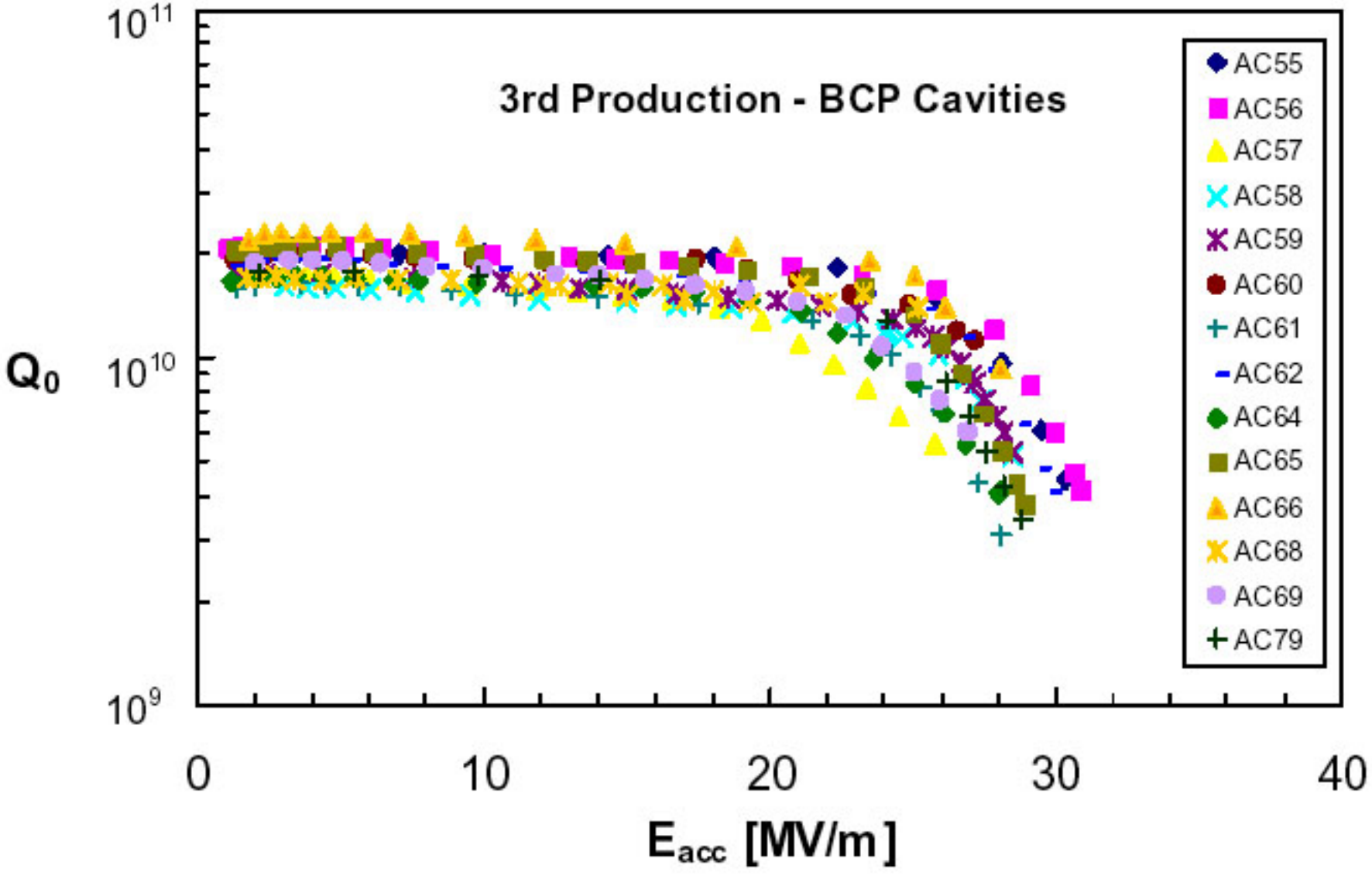
TTF Cavity-Module Performance (Pulsed Operation)



Spread comes down

But There Is a High Field Q-slope !

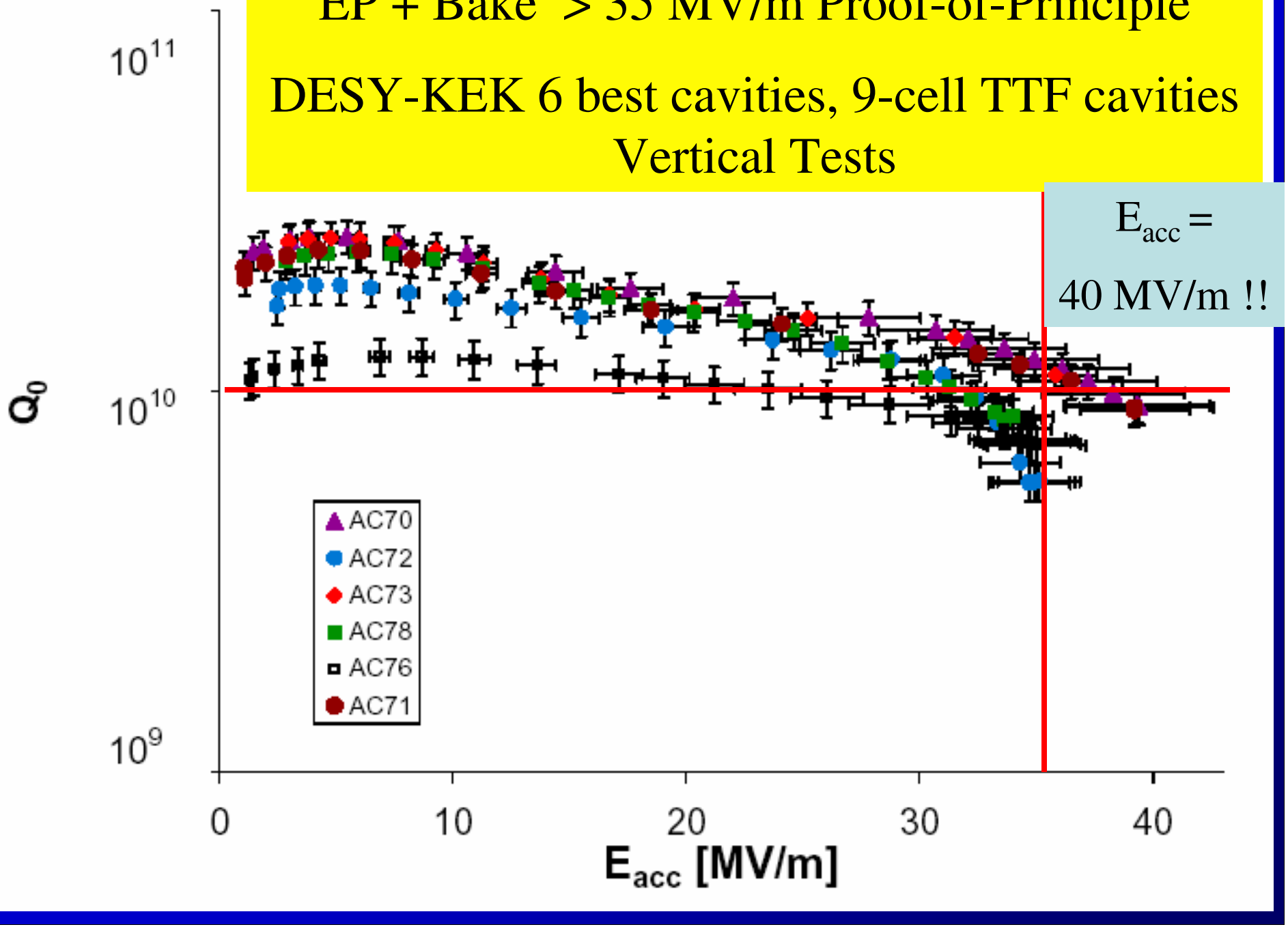
Kenji Saito calls it the European Headache !



Kenji finds the real cure for the European headache !

EP + Bake > 35 MV/m Proof-of-Principle

DESY-KEK 6 best cavities, 9-cell TTF cavities
Vertical Tests

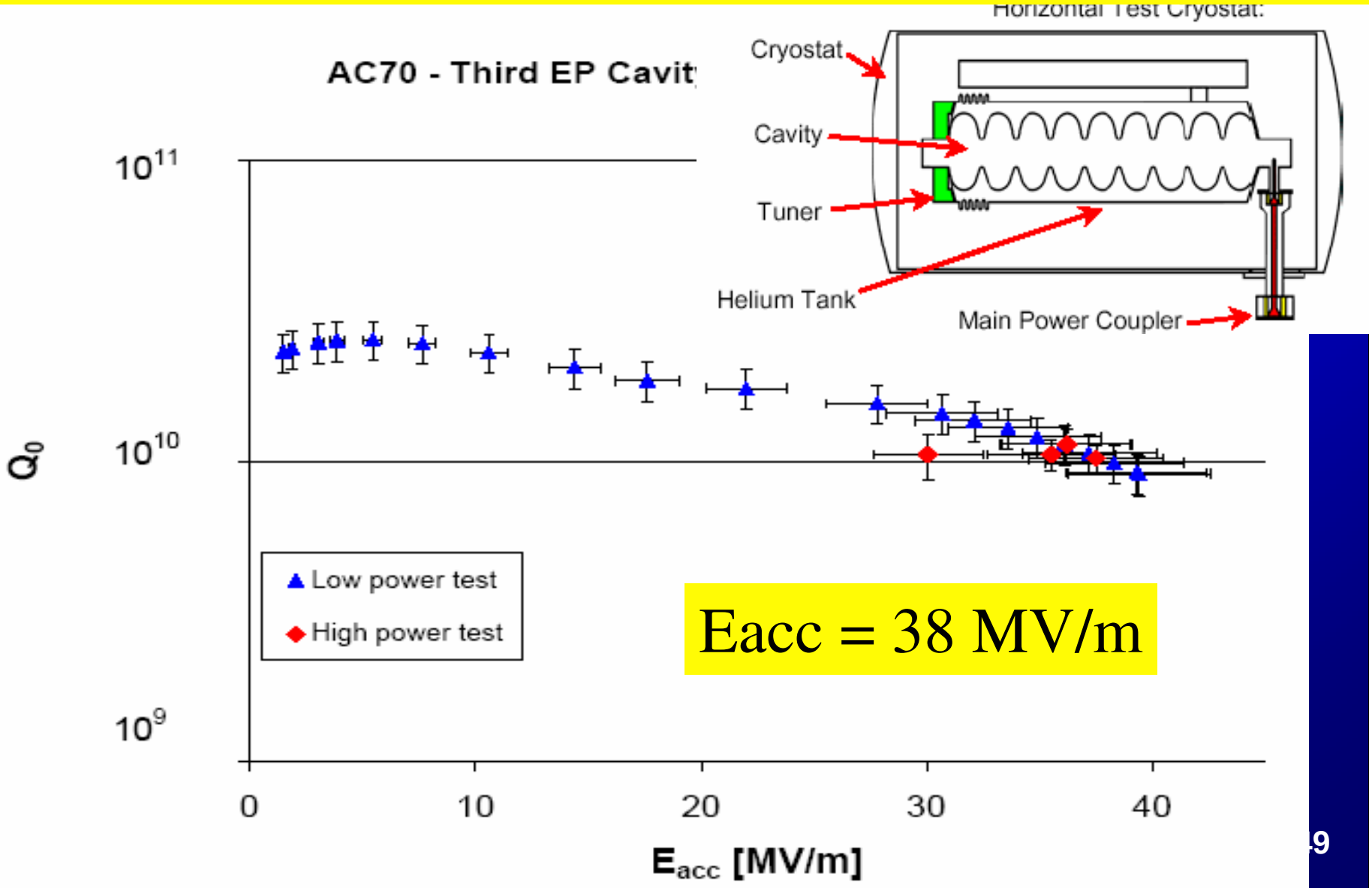


Do we have an understanding of Q-Slope ?

Another Hot Topic For Discussion:

Fully Dressed Cavities

Single Cavity Cryomodule Results

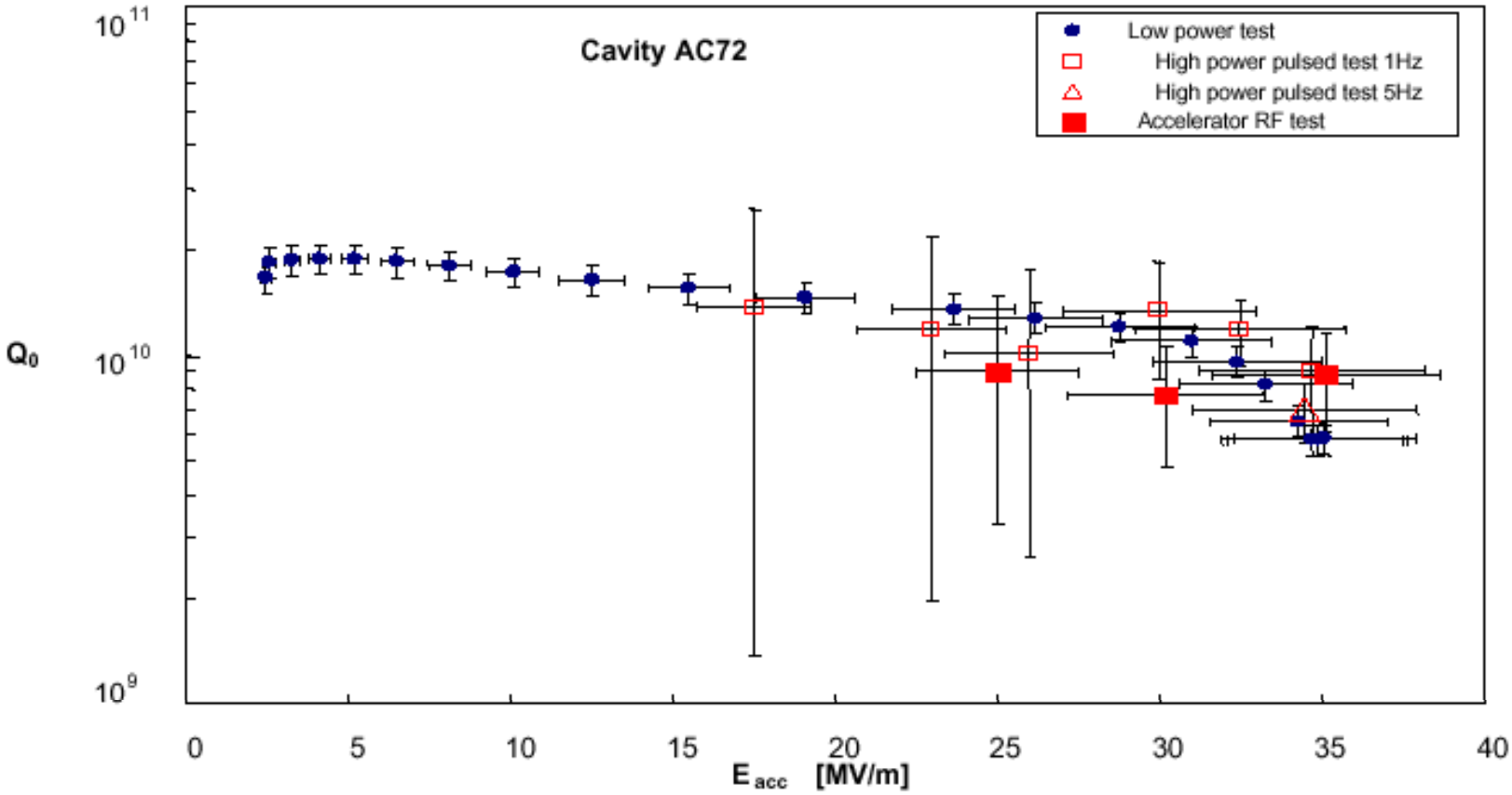


Existence Proof :

35MV/m reached
in one 9-cell cavity inside a complete cryomodule

Cavity Test Inside a Module

- Standard X-ray radiation measurement indicates radiation-free up to 35 MV/m
- LLRF operational at 30 MV/m
- Active compensation of Lorentz-force detuning

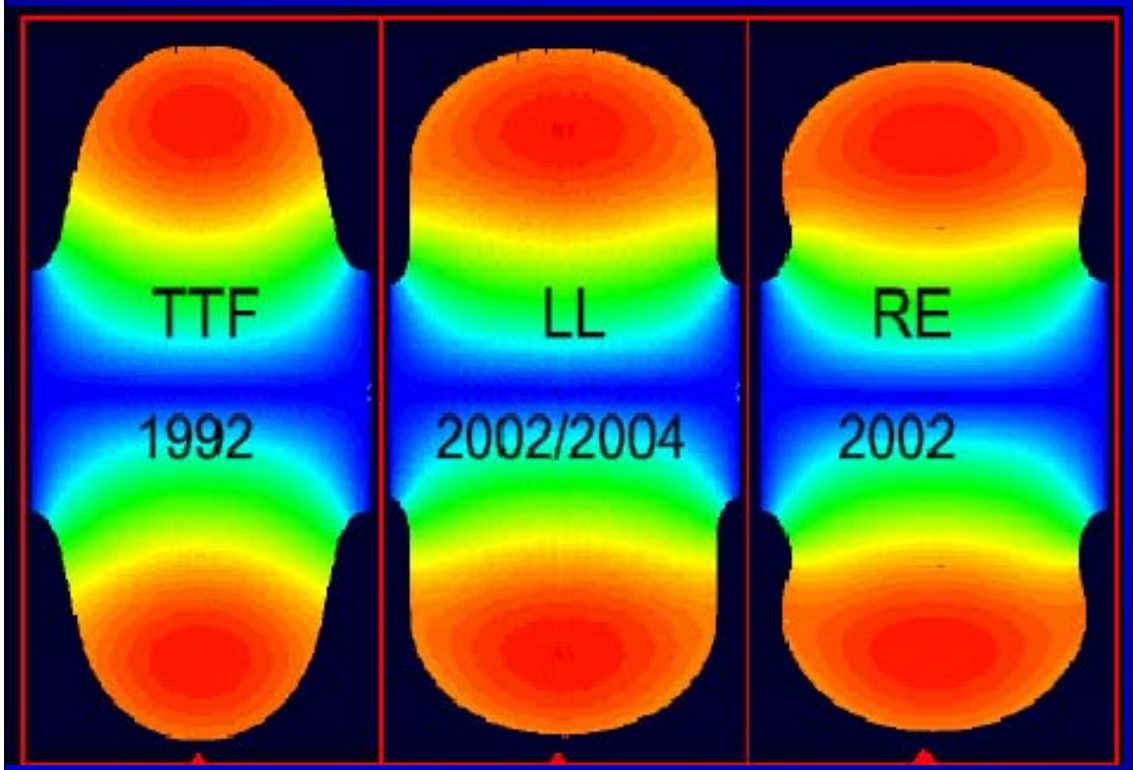


New Shapes for Higher Gradients

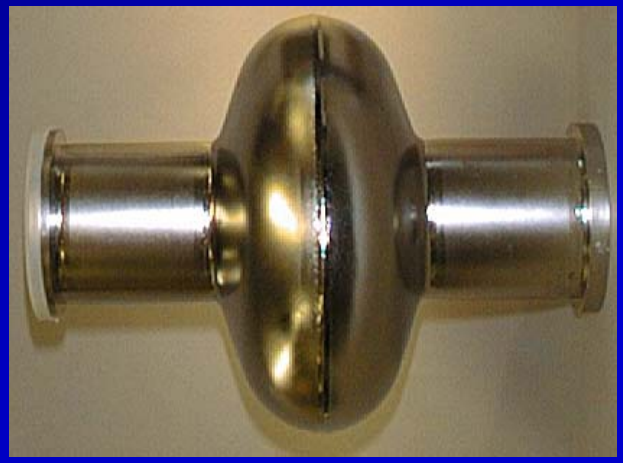
Philosophy

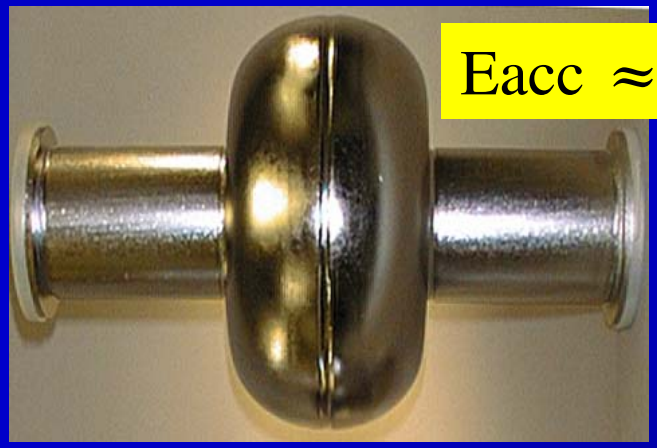
Critical magnetic field is a brick wall near 1800 Oe.

- Lower Hpk to avoid Q-Slope and Quench
  - Even if we must raise Epk

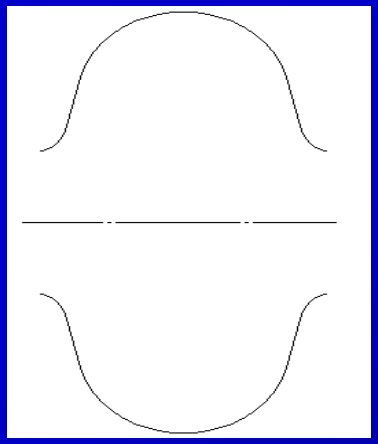


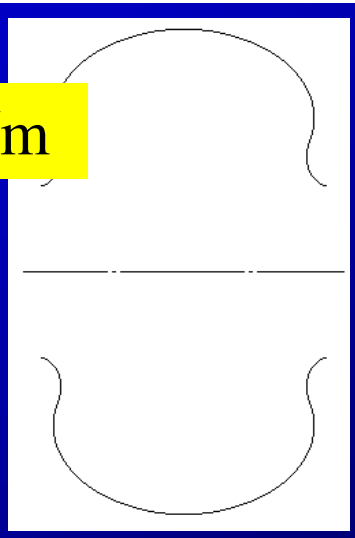
Cornell Single Cell : Comparison of TTF and Re-entrant Shape





Eacc ≈ 46 MV/m





Similar Hopes for LL Cavity

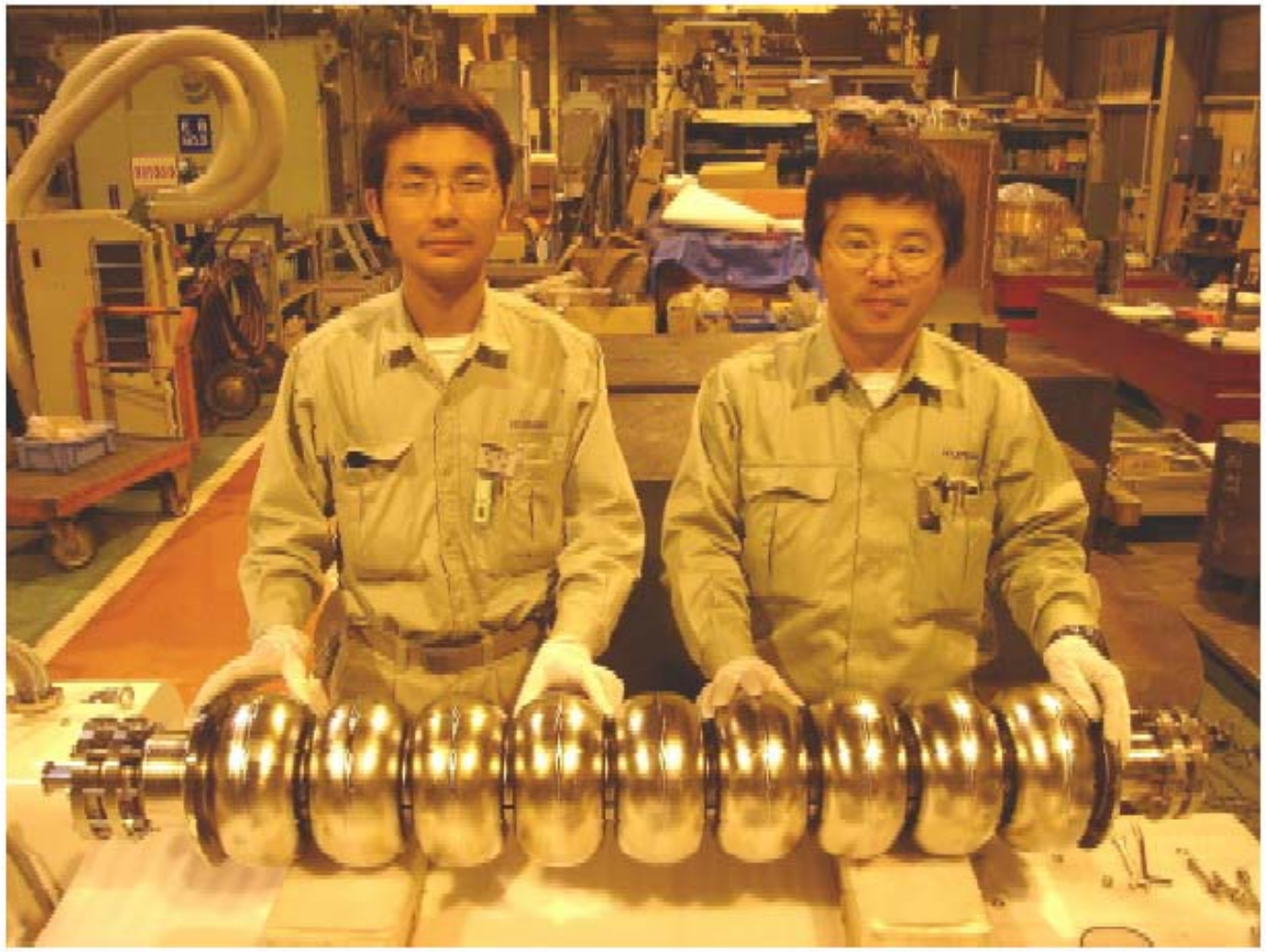
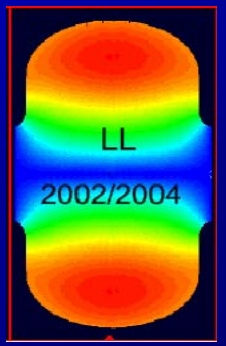


Fig. 5: ICHIRO 9-cell 1st cavity
Completed at Kuroki Industries Corporation in Himeji on 3 May 2005

4

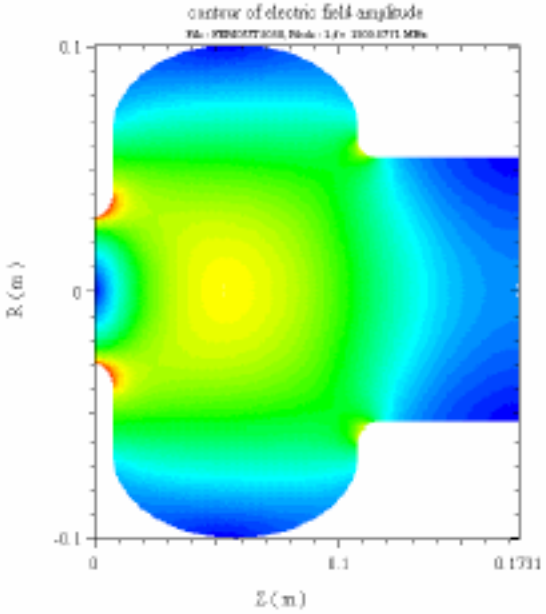
Why call it ICHIRO?



Most famous Japanese baseball-player.

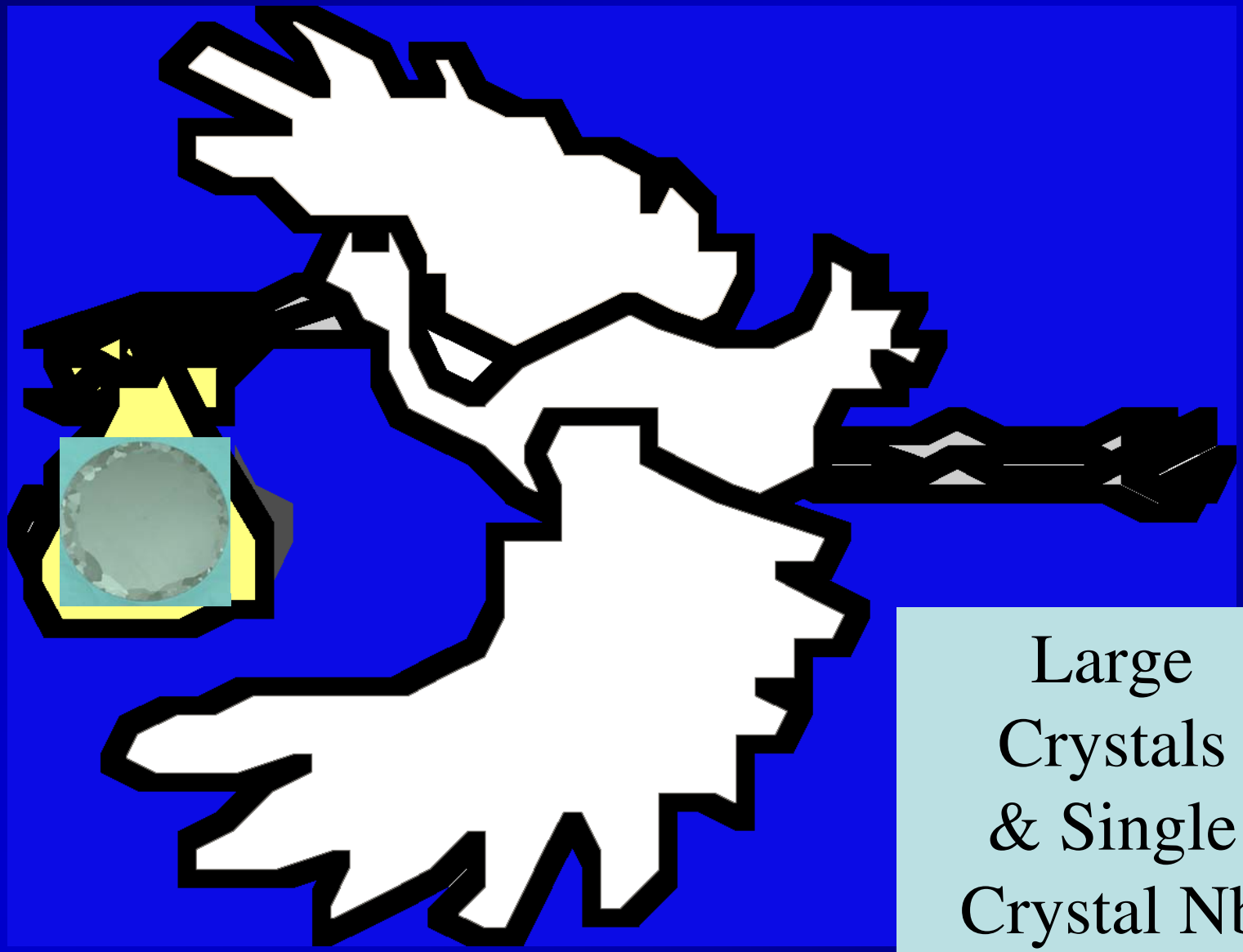
Record breaker, 262 hits in single season.

ICHIRO
(ILC LL) Cavity



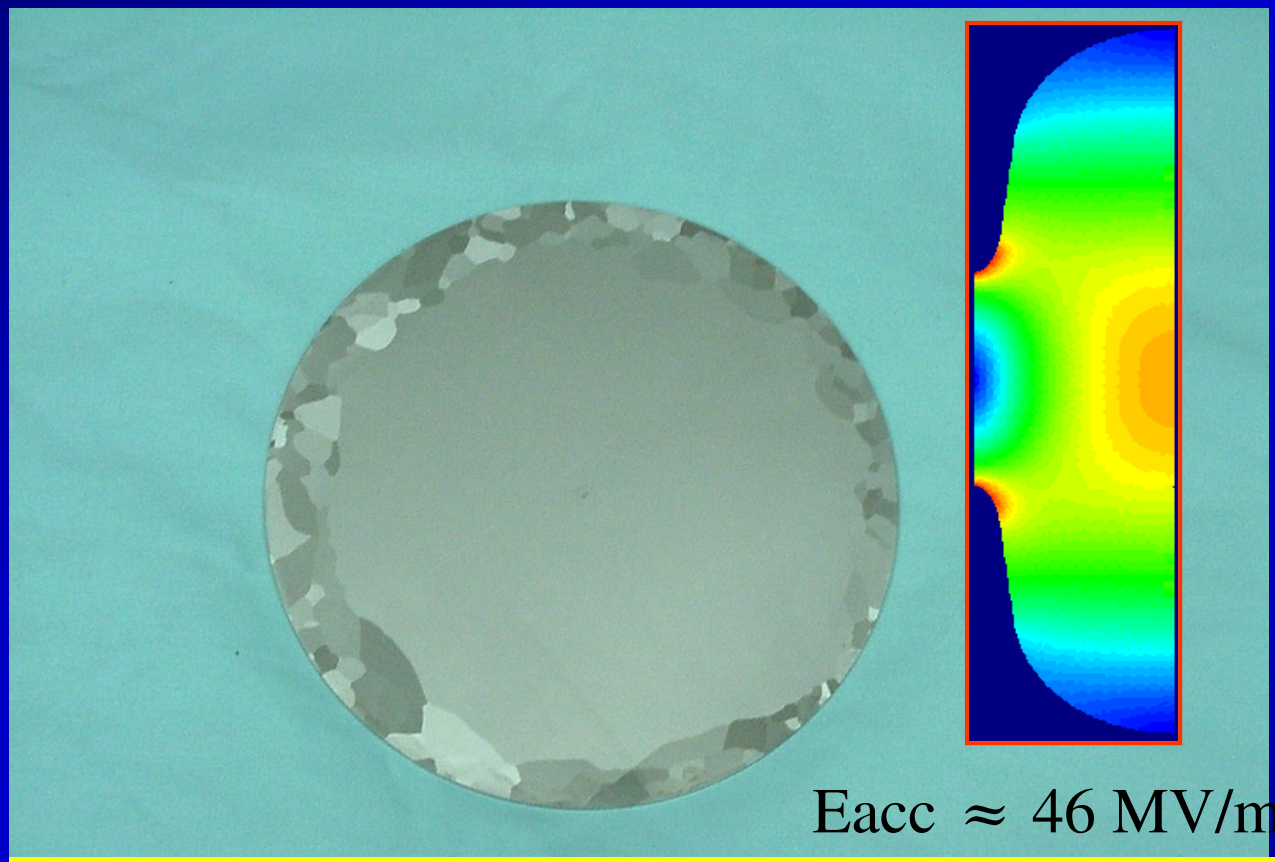
Goal is 51 MV/m!

Materials: A New Idea is Born

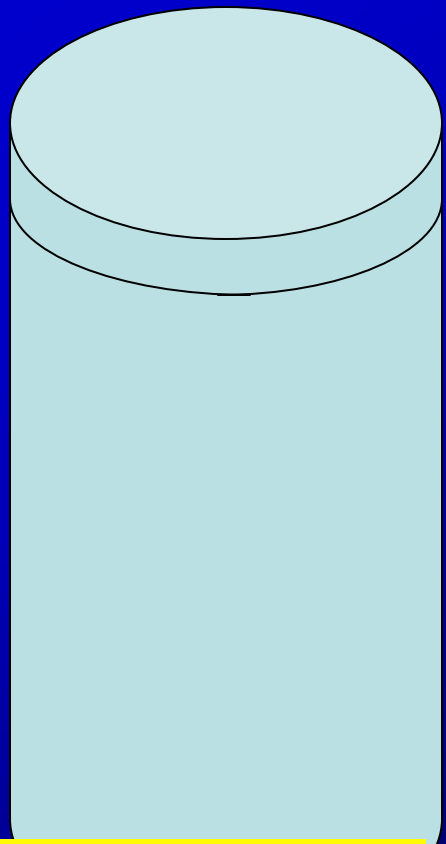


Large
Crystals
& Single
Crystal Nb

Jlab Large Crystals & Single Crystal RRR Niobium Directly sliced from niobium ingot by (EDM)



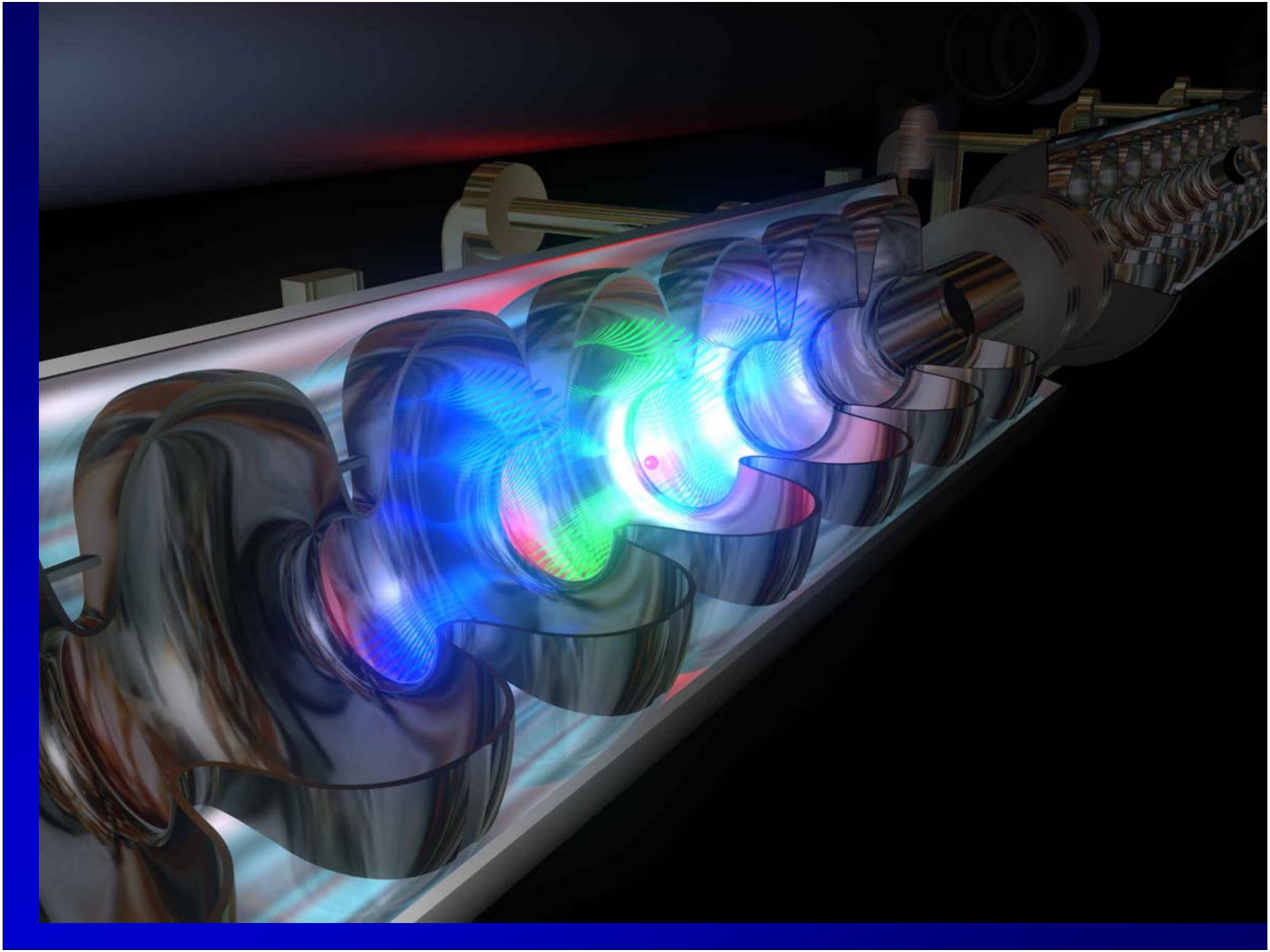
Eacc ≈ 46 MV/m



Many Attractive Features

Linear Collider Ambitions Take Flight

ITRP Makes a Choice



ILC? What's it good for?

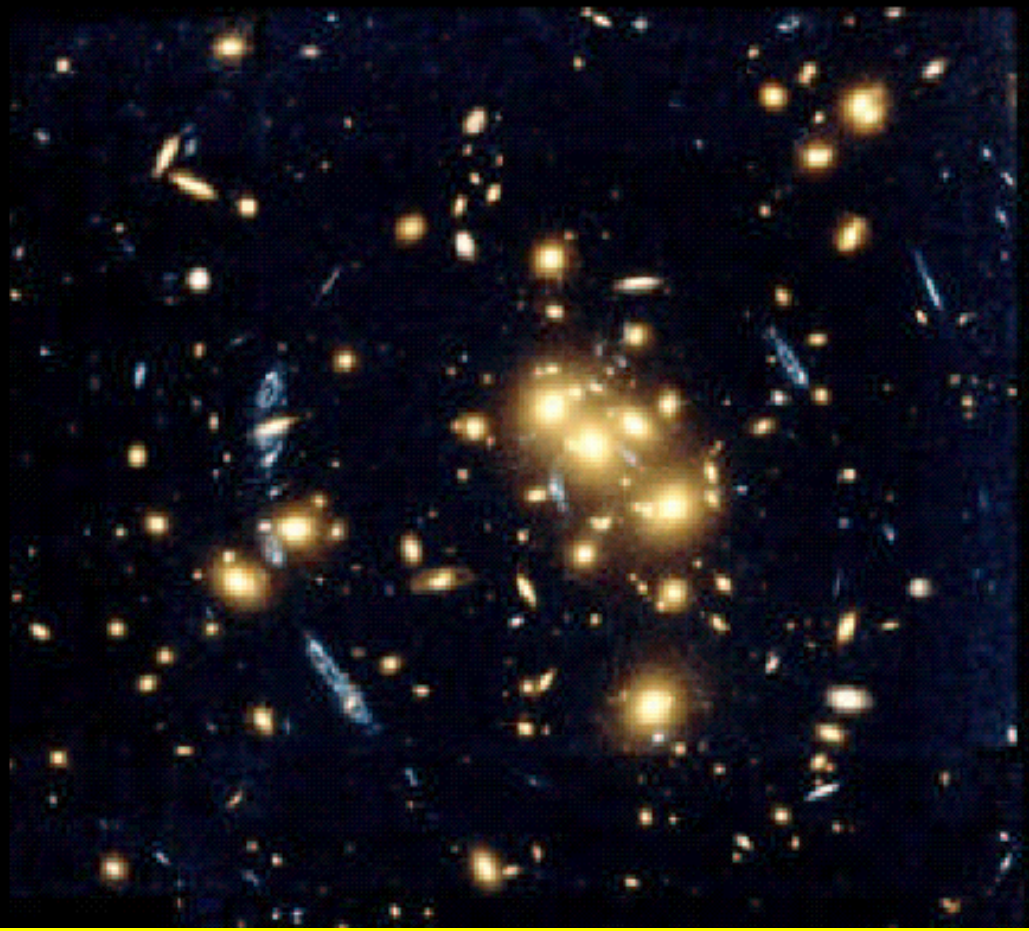
"6 billion bucks! What's this *thing* for?"

Does it make oil?

No! But it might make Dark Matter !

Borrowed from Neil Calder

Evidence for non−baryonic dark matter comes from many sources. One example: gravitational lensing.



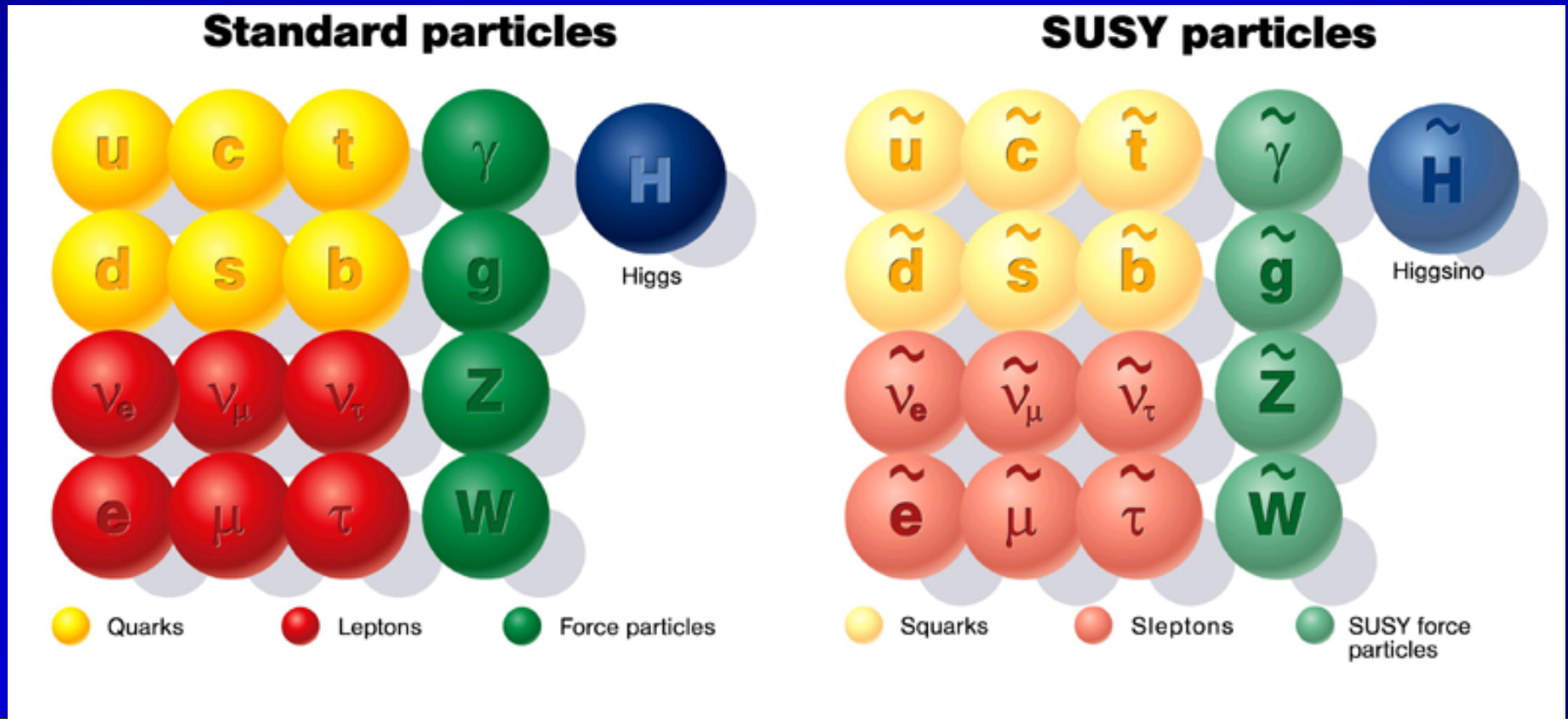
Hubble Space Telescope: Multiple Images of the same galaxy

What is dark matter? Prevailing Idea

For Every Particle There Is a Super-symmetric Partner

For Every Fermion There Is a Boson Super-symmetric Partner

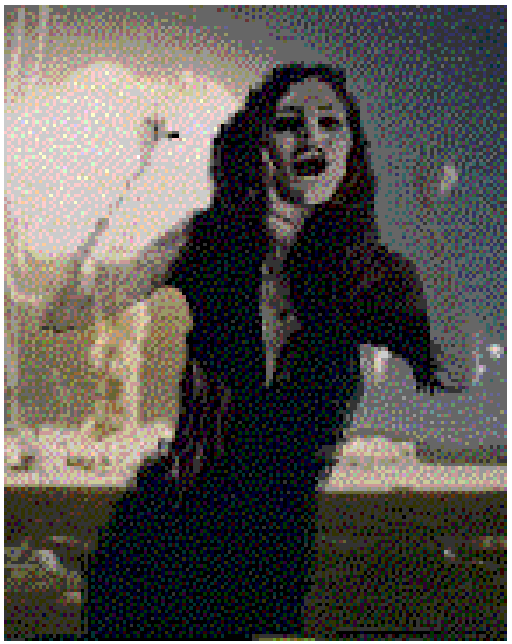
Lightest Supersymmetric Particle = Dark Matter Candidate



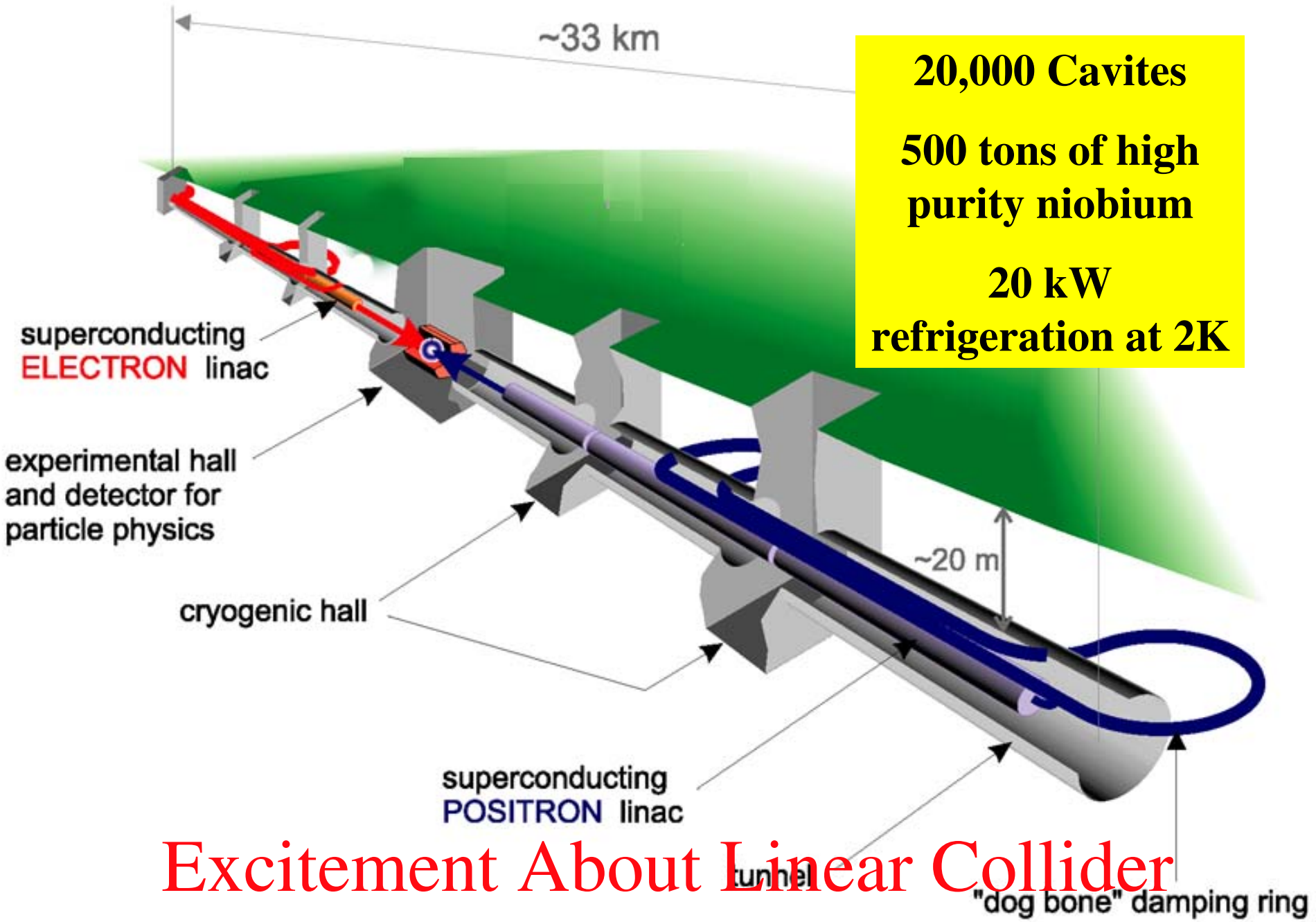
Poet's View: George Gershwin classic written and performed by Lynda Williams… Physics chanteuse

S'wonderful, s'marvelous
Supersymmetry!
S'awful nice, S'paradise
Supergravity!

Is this the Theory of Everything
I feel pulling on my super-
heart-strings?
S'wonderful, s'marvlous
Supersymmetry!



S'wonderful, s'marvelous,
superparntering.
S'what it takes:
sparticles
for symmetry breaking.



20,000 Cavites

500 tons of high purity niobium

20 kW refrigeration at 2K

Excitement About Linear Collider

Support is Building for the

International Linear Collider

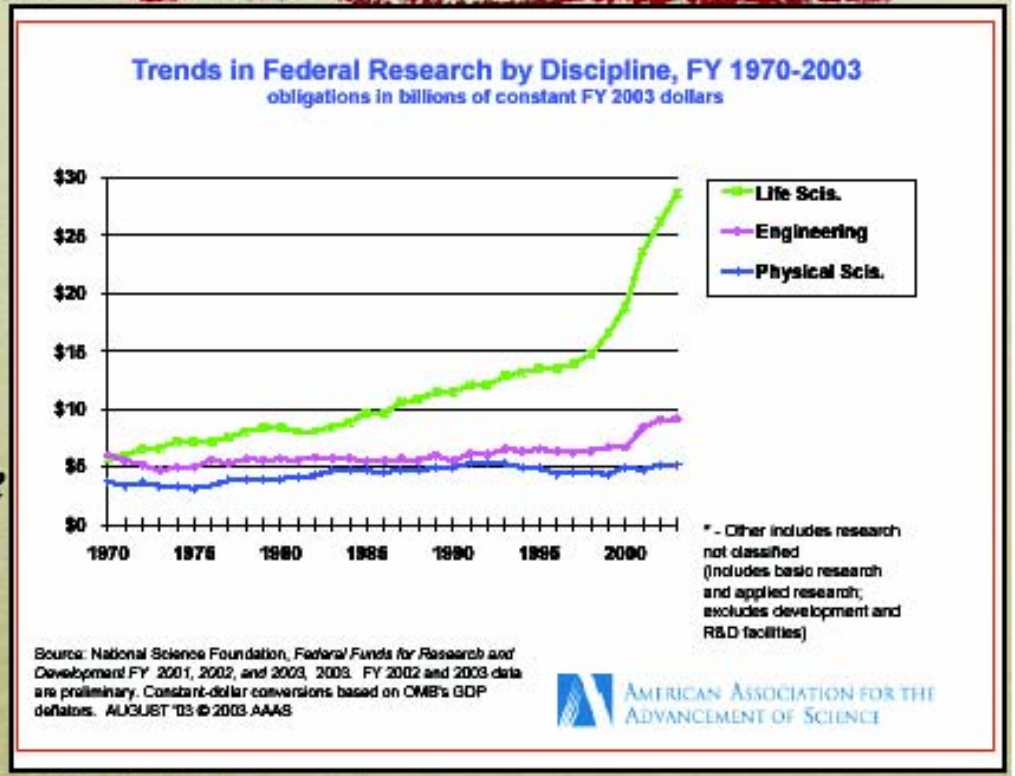
WORLD LEADERS ARE DISCCUSING IT AT EVERY OPPORTUNITY

Borrowed from
Jim Brau

Can We Get the Funding ??

US Budget in Basic Research

- *US budget in physical sciences effectively declined over many years*
- *Need boost to the entire physical sciences*



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Above all,
We must not rule out

DIVINE INTERVENTION

Welcome Message for 12 th Workshop

Have a Rocking good time !