CLEO – CESR SYMPOSIUM

May 31, 2008

EVOLUTION OF CESR

AND

ITS SIGNIFICANCE

ACKNOWLEDGMENTS

To the late Boyce McDaniel who guided the lab through the difficult birth of CESR

To the NSF Physics Div Officers, from two of whom you have just heard, for their courageous support over the years

To the many Students, Staff, Faculty and CLEO Collaborators whose ideas and energy made CESR a reality

To Karl Berkelman and "A Personal History of CESR and CLEO" from which I have taken many illustrations and remembrances.

To those individuals whose names I cannot mention but who had vital roles in realizing the concept – I ask forgiveness

EVOLUTION

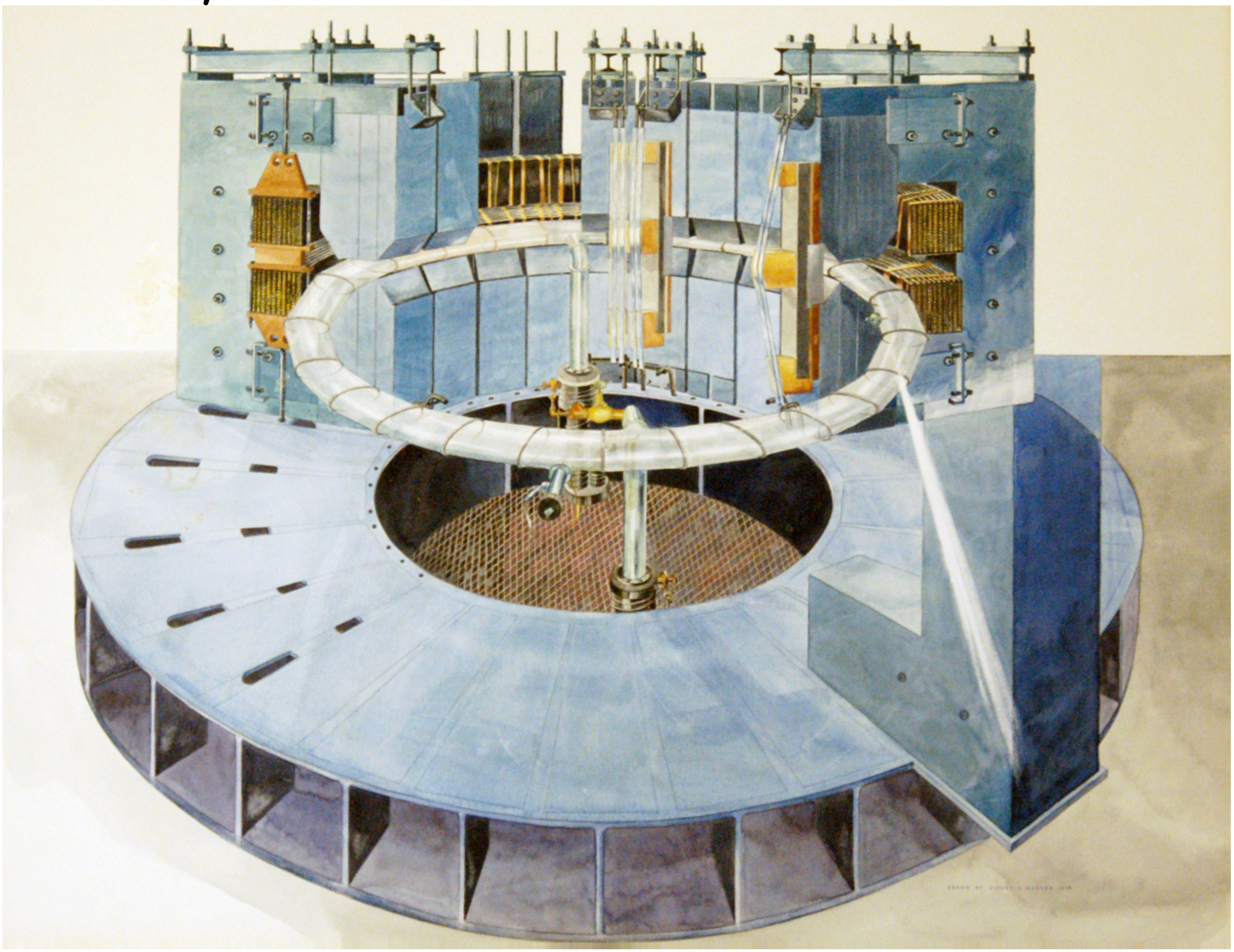
- CESR resulted from the coming together of ***two streams***:
  - the Cornell synchrotron accelerator sequence
  - the development of colliding beams elsewhere

A Bevy of Synchrotrons

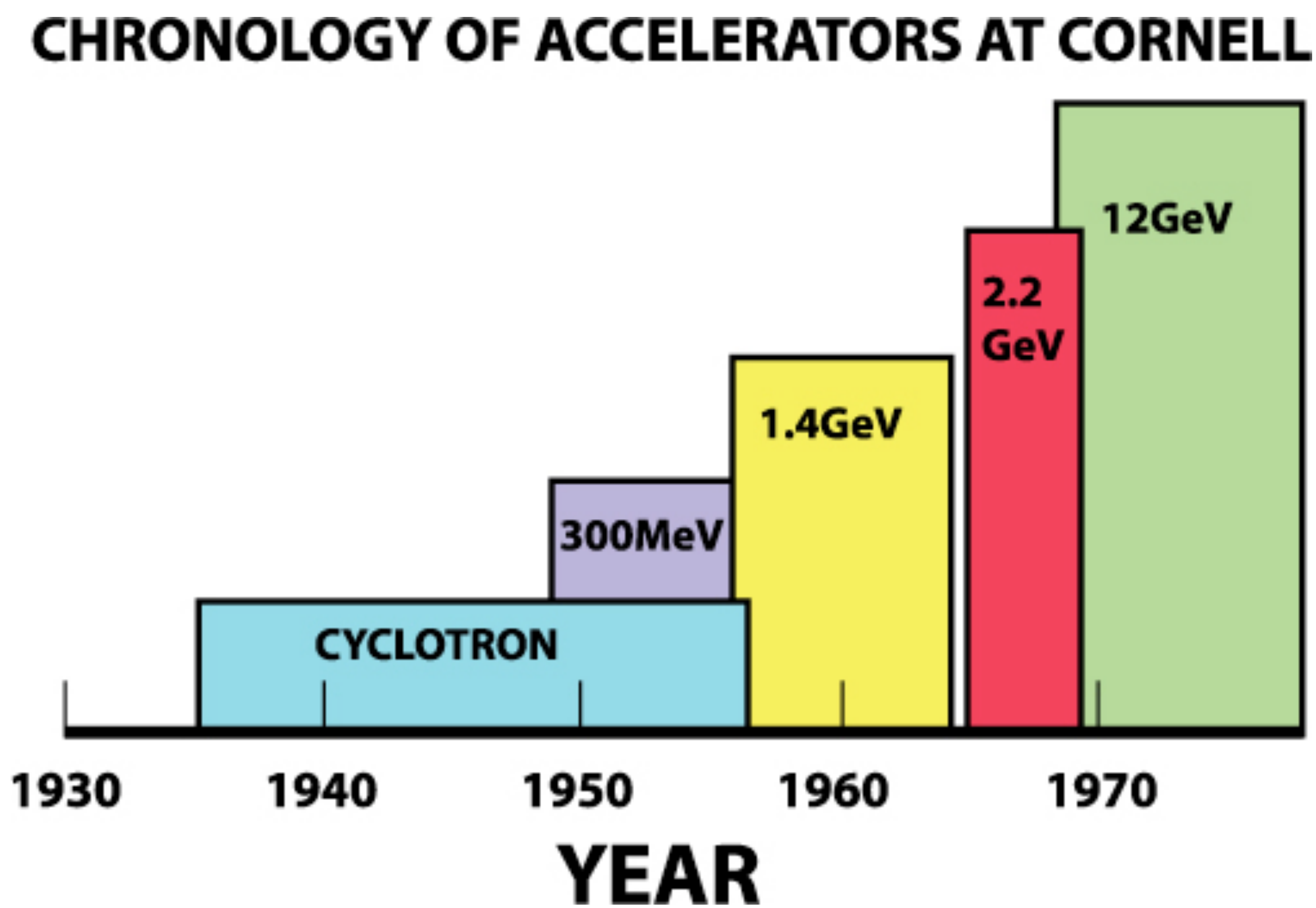
- The very beginning (a cyclotron) before "the war" (picture 1954)

- LNS founded in 1946 – beam in 1949 (Navy)

  First e-Synchrotron – 300 MeV – 2 m orbit diameter



- A series of four synchrotrons culminating in a 12 GeV machine that kept the lab and its collaborators at the fast moving particle physics frontiers into the early 70's



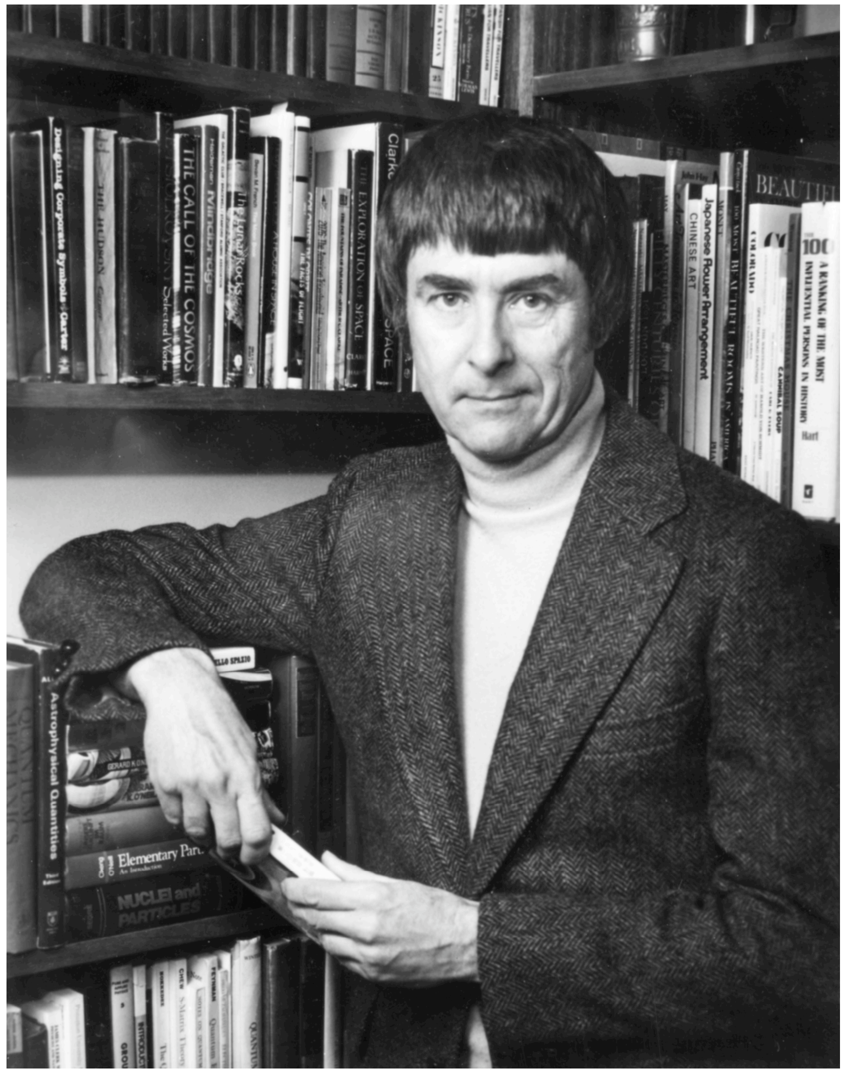
- There were many discussions about higher energy synchrotrons as a path to the future.

- These ideas were never very appealing because of the rapidly growing synchrotron radiation as beam energy increases and the enormous size the rings would take to have sufficient center of mass energy with a fixed target

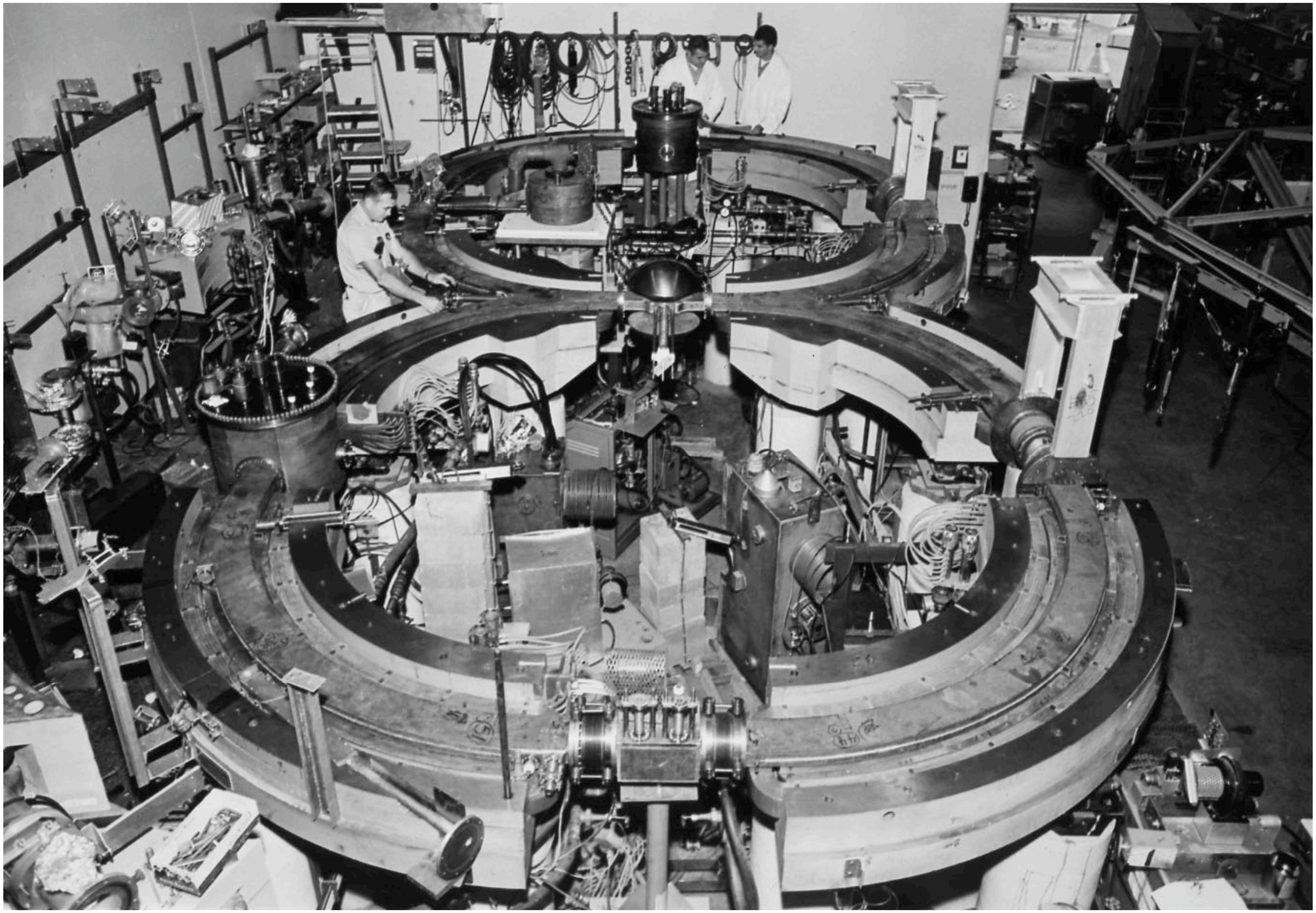
- However there were already new ideas rather far developed elsewhere – the second *stream* to which we referred earlier – colliding beams

- This approach gives great energy advantage compared to synchrotrons but is very challenging technically

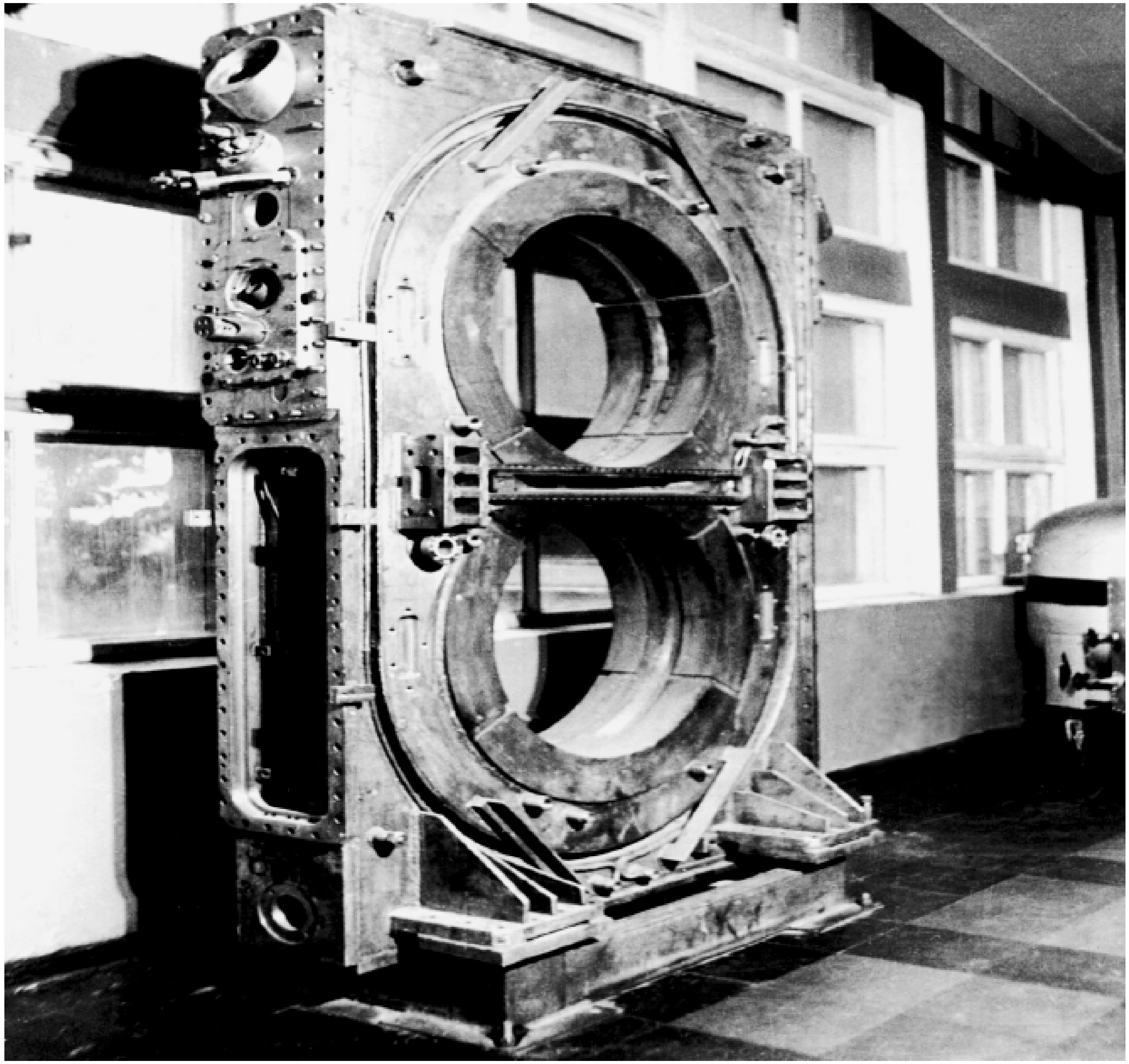
- Storage ring collider proposed by G.K. O'Neill Princeton in 1956 (D.W. Kerst et al propose colliding FFAG beams)



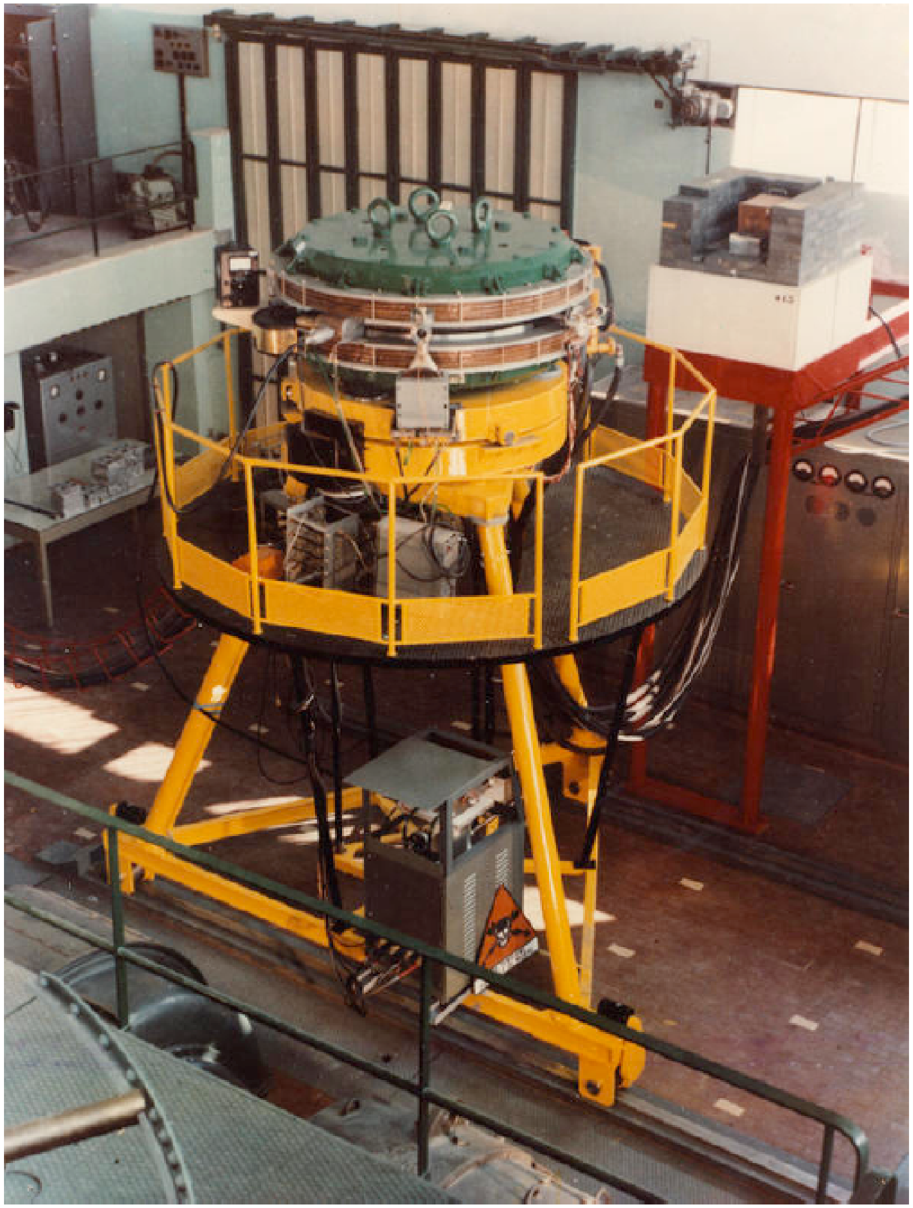
- The first two ring e-e-versions came in a collaboration of Princeton and Stanford–the 500 MeV collider 1963



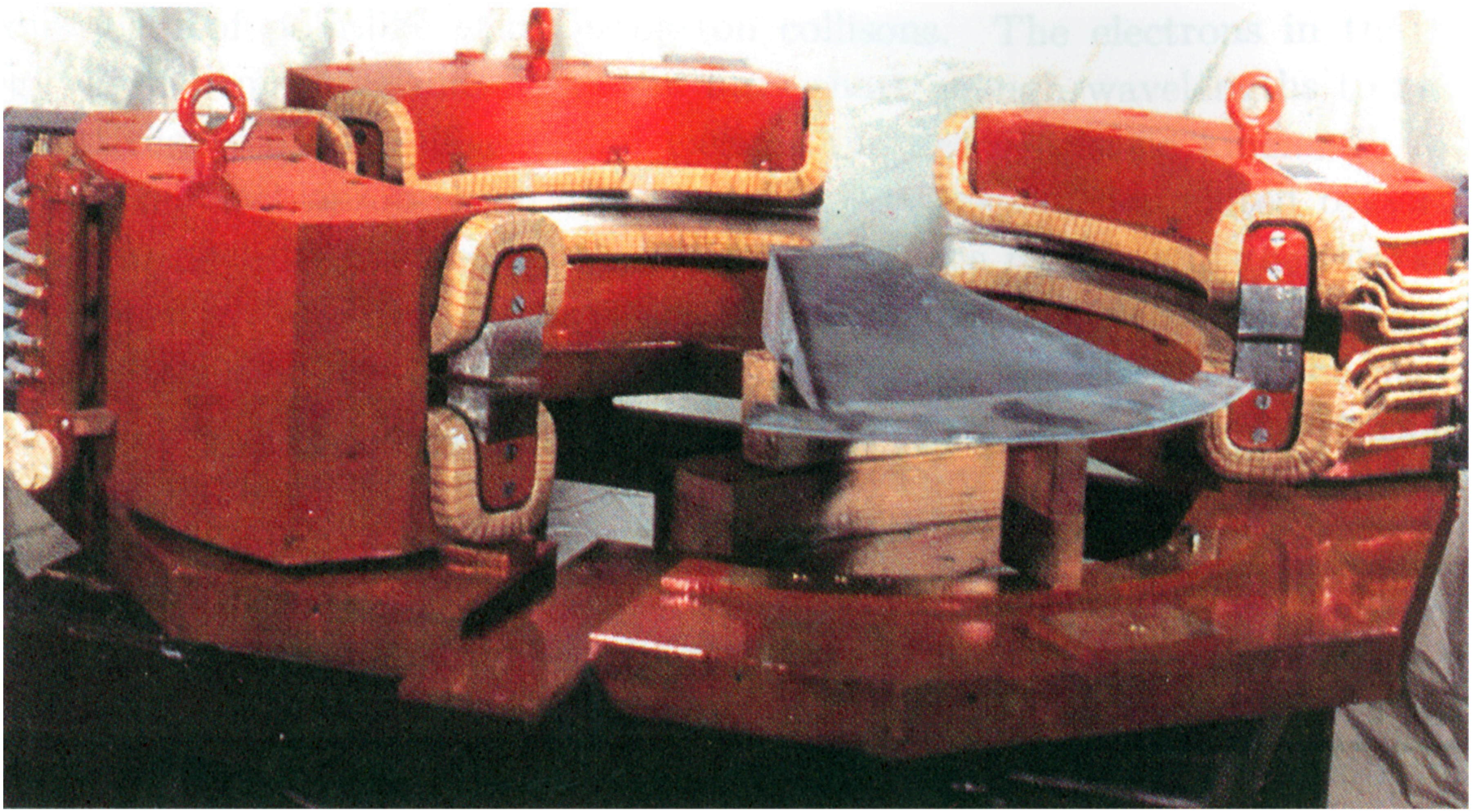
and VEP-1 @ BINP



- A daring implementation of an e+e- collider was built almost simultaneously at Frascati – AdA - 1962



- Knowing that these things were in the offing, Bob Wilson started a small colliding beam machine ~ CSR, here at Cornell – begun 1959, photo circa 1961



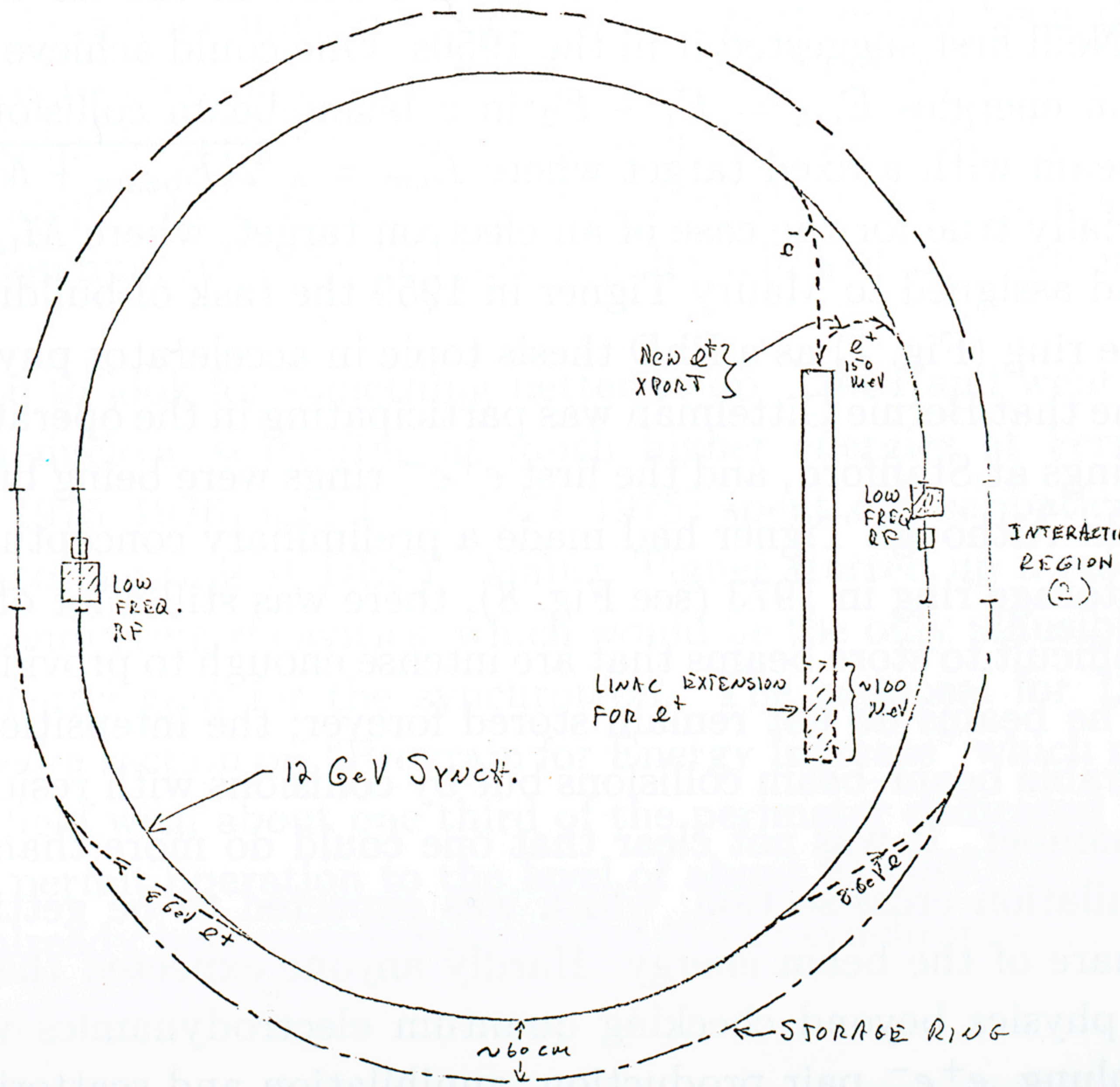
- These electron machines didn't do much particle science but, together with their successors in the late 60's, helped to mature the technology and relevant accelerator science:

  - Adone LNF
  - VEPP I&II BINP
  - ACO LAL

The Streams Come Together

- In the period 1973 – 1975 three of us spent a year at DESY where the e+e- two ring machine DORIS was just finishing and coming into operation and were much influenced by this experience

- Naturally we began to think about how we might realize such a physics instrument at Cornell but the contagion spread slowly. First picture extant of a possible storage ring in the synchrotron tunnel was dated 1973


New e+ XPORT
e+ 150 MeV
e−
LOW FREQ RF
INTERACTION REGION (2)
LOW FREQ. RF
LINAC EXTENSION FOR e+
~100 MeV
12 GeV SYNCH.
8 GeV e+
8 GeV e−
~60 cm
STORAGE RING

- Initially – considerable skepticism: could one make enough anti-matter (positrons) for good interaction rate; would there be significant particle science to be learned even if you could.

- The latter was partly answered in 1974 with discoveries at BNL and Stanford of the “J/psi” that brought in the era of quark studies – although doubting Thomases remained.

- The former, making lots of e+, seemed a problem for us since we had been taught to believe that only a very powerful linac could fill enough positrons into a single bunch to feed a storage ring. We had only a small linac plus synchrotron.

- We realized, however, that if one looked at the total number of positrons needed, our little linac with its long pulse of many bunches could do the job. We then thought of a trick for turning many bunches into one and we were off

The CESR Proposal - 1975

- After inviting and receiving community criticism of our idea, we were encouraged to submit a proposal to the NSF for construction of an 8 GeV per beam, single ring, e+e- collider in the 12 GeV tunnel – submitted spring 1975

- Running the gauntlet of a HEPAP sub-panel in the summer of 1975 was a requirement. We were up against PEP, ISABELLE and the Energy Doubler/Saver, all DoE projects.

- Given the complex political alignments and circumstances, CESR came in fourth, damned with faint praise – another bump in the road to which we had become accustomed

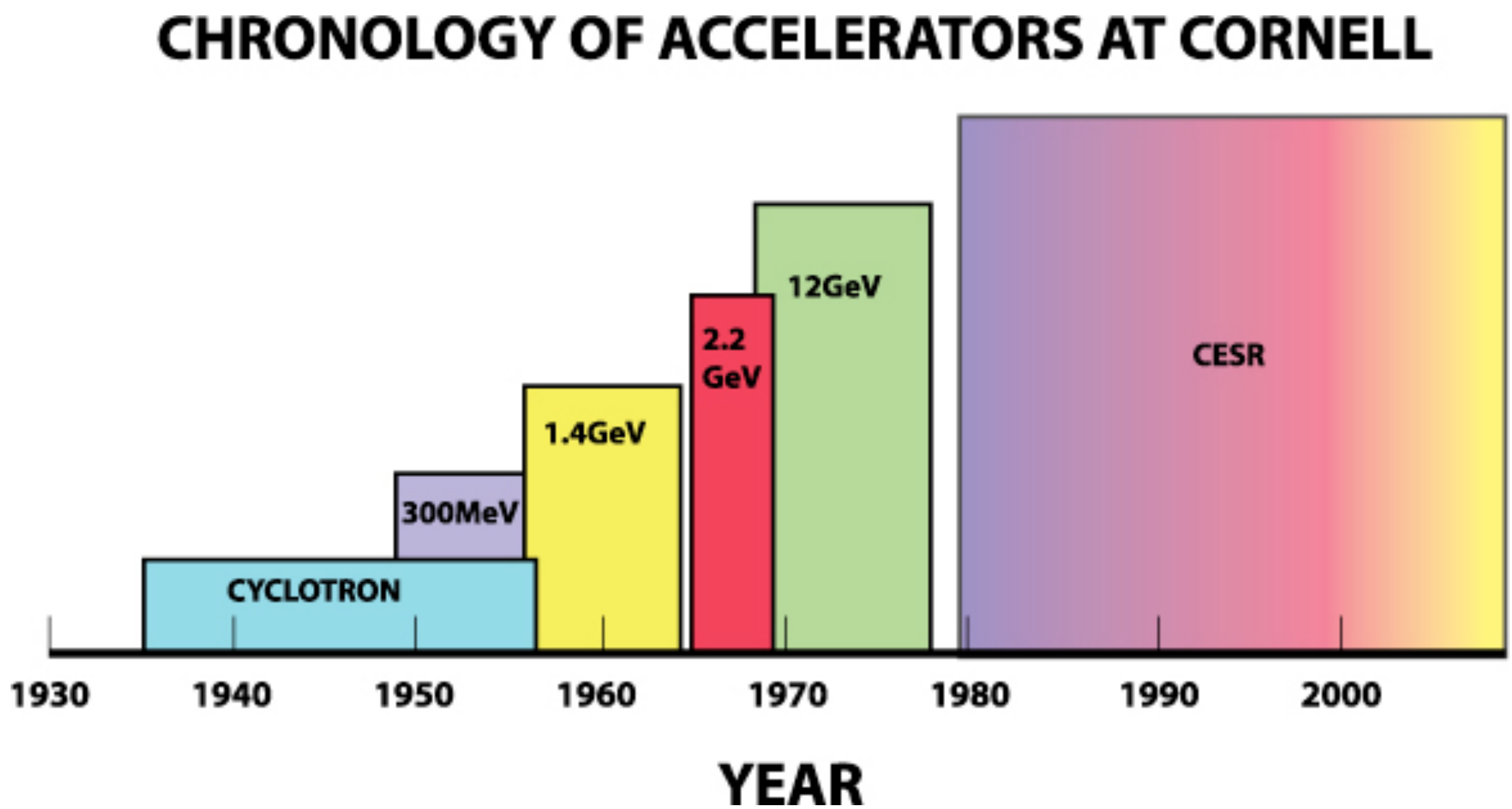
- Our response, supported by our potential collaborators, was – as accustomed – not to give up. Two lines of activity saved our bacon:
-
  - 1) after funding of PEP was approved, Mac was able to get positive support from many of the HEPAP sub-panel members – a marvel!

  - 2) we were ENORMOUSLY fortunate in having inspired support from the NSF. Alexander Abashian and the late Marcel Bardon worked tirelessly behind the scenes gathering support for a *conversion* of the 12 GeV synchrotron facility. Sufficient R&D was made available to keep moving ahead so that when approval finally came in 1977 we were ready to roll

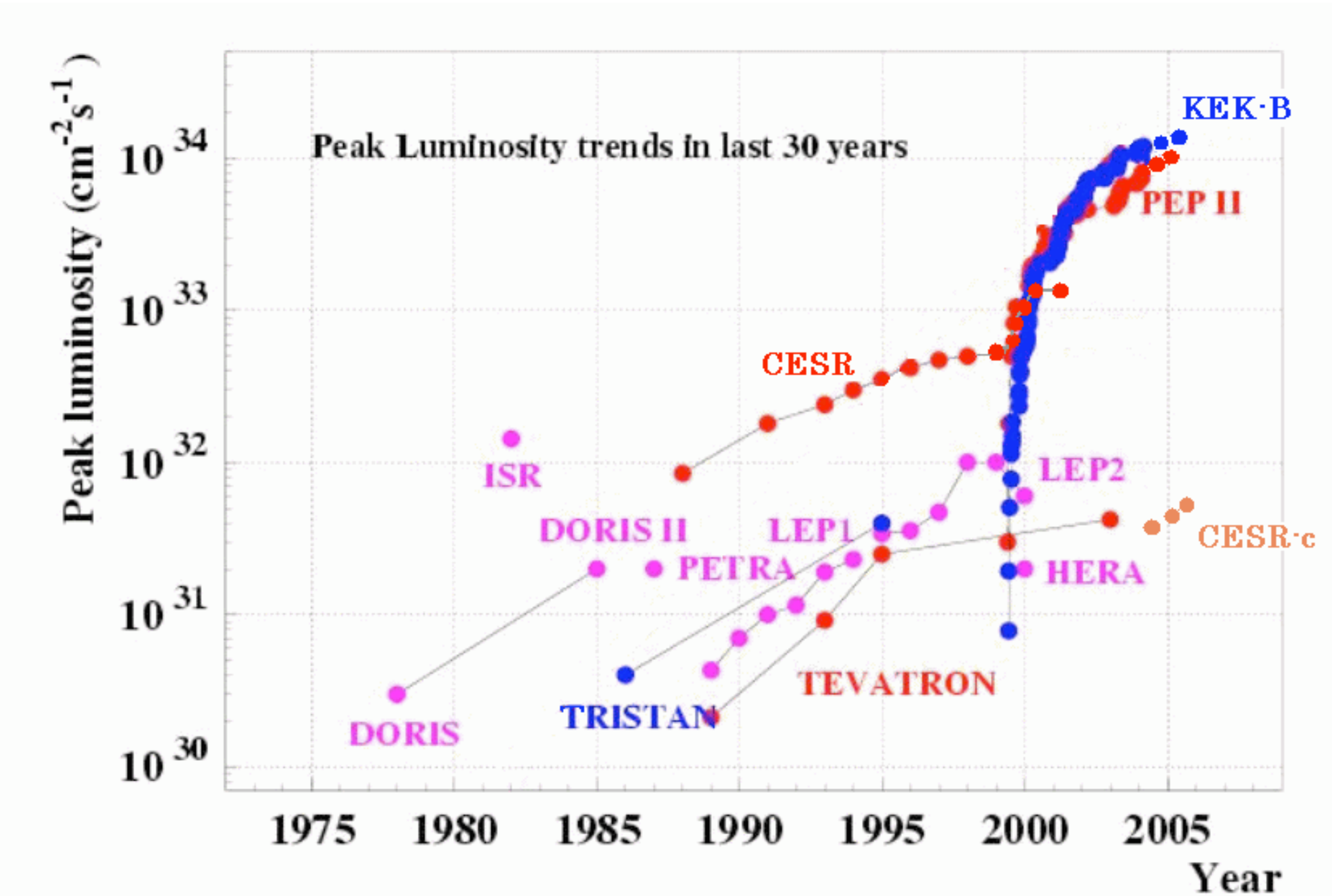
Of this process our mentor Al Abashian has said:

“History notes that the birth of Julius Caesar was a particularly difficult one for his mother and ultimately necessitated the adoption of radical measures”

Behold – CESR as a child



- With the continual innovations to be described, the CESR folk were able to achieve the luminosity history below (nb simultaneous use for x-ray science from early on)



Peak Luminosity trends in last 30 years
Peak luminosity (cm^-2 s^-1)
10^34
10^33
10^32
10^31
10^30
KEK-B
PEP II
CESR
ISR
LEP2
DORIS II
LEP1
PETRA
CESR-c
HERA
TEVATRON
TRISTAN
DORIS
1975
1980
1985
1990
1995
2000
2005
Year

A New Track

- With the advent of the “B-factories” at KEK and SLAC it was clear that a new direction was called for. After much study and discussion the CLEO/CESR collaborators decided to move operations to the lower “charm” threshold energy to fill an important role in exploring that region at luminosity not previously possible.

- Thus was born CLEO-c and CESR-c, the latter requiring significant technical innovation and modification – more of that later.

- With the continuing luminosity history shown, we were able to make many more important contributions

The End of an Era

- By prior agreement with the NSF, data taking for CLEO was to end this year. The vagaries of the federal budget and NSF priorities worked to bring the end of CLEO data taking

<u>March 3, 2008</u>

We recognize that event today and look forward to continuing use of the intellectual and physical infrastructure for many further transformative contributions to accelerator based science.

The SIGNIFICANCE of CESR

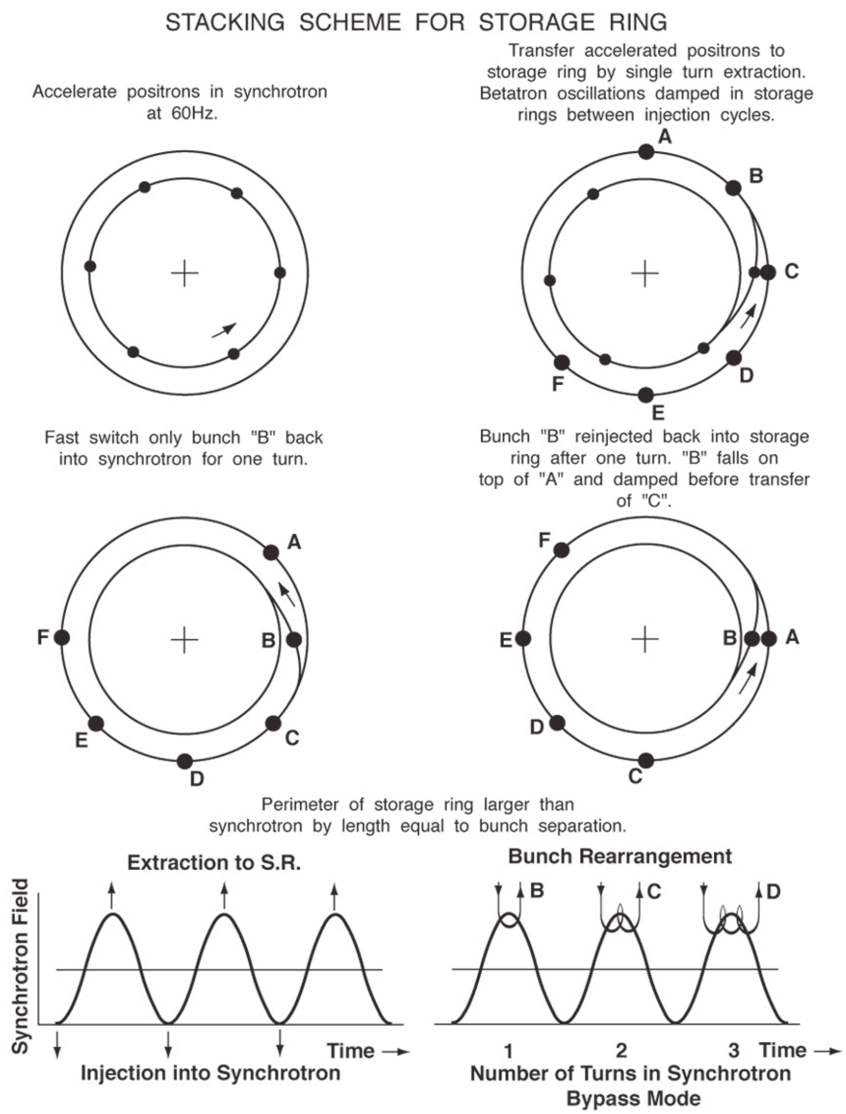
One could decompose a discussion of the significance of CESR into 4 parts:

1. for Particle Science
2. for Accelerator Technology directly relevant to storage ring colliders
3. for Technology developments more widely applicable
4. for workforce enhancement

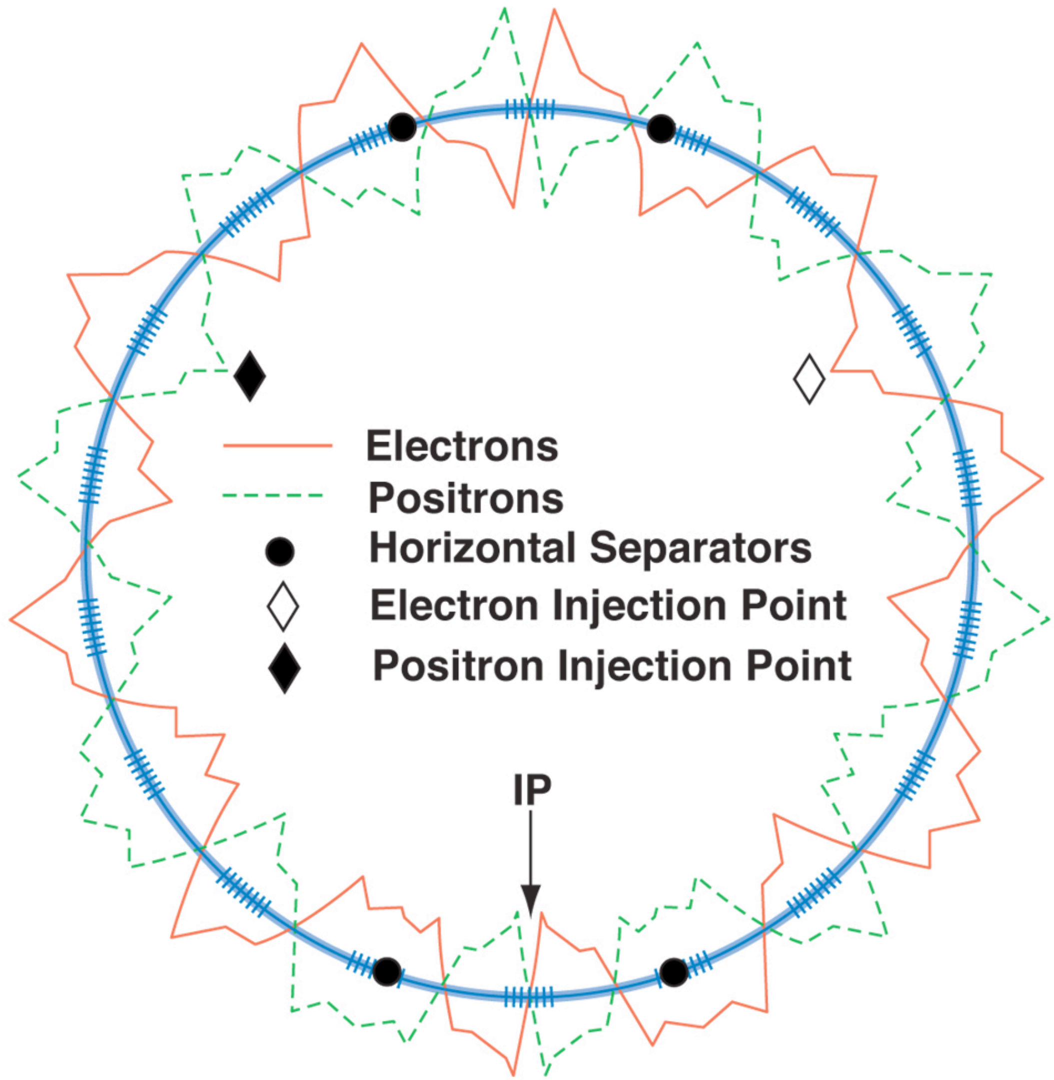
Particle science impact will be dealt with by following speakers

Some Technology Contributions

- vernier bunch coalescing – many bunches into one



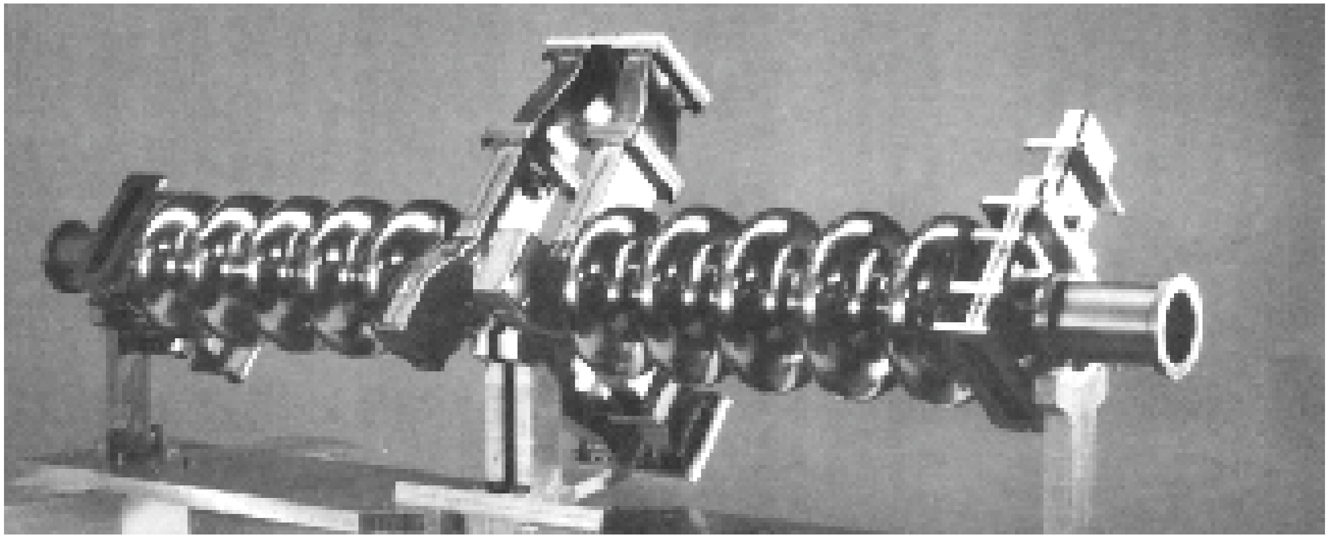
- From early on it was appreciated the having only one bunch was limiting for the luminosity – 2 innovations in a solution



more

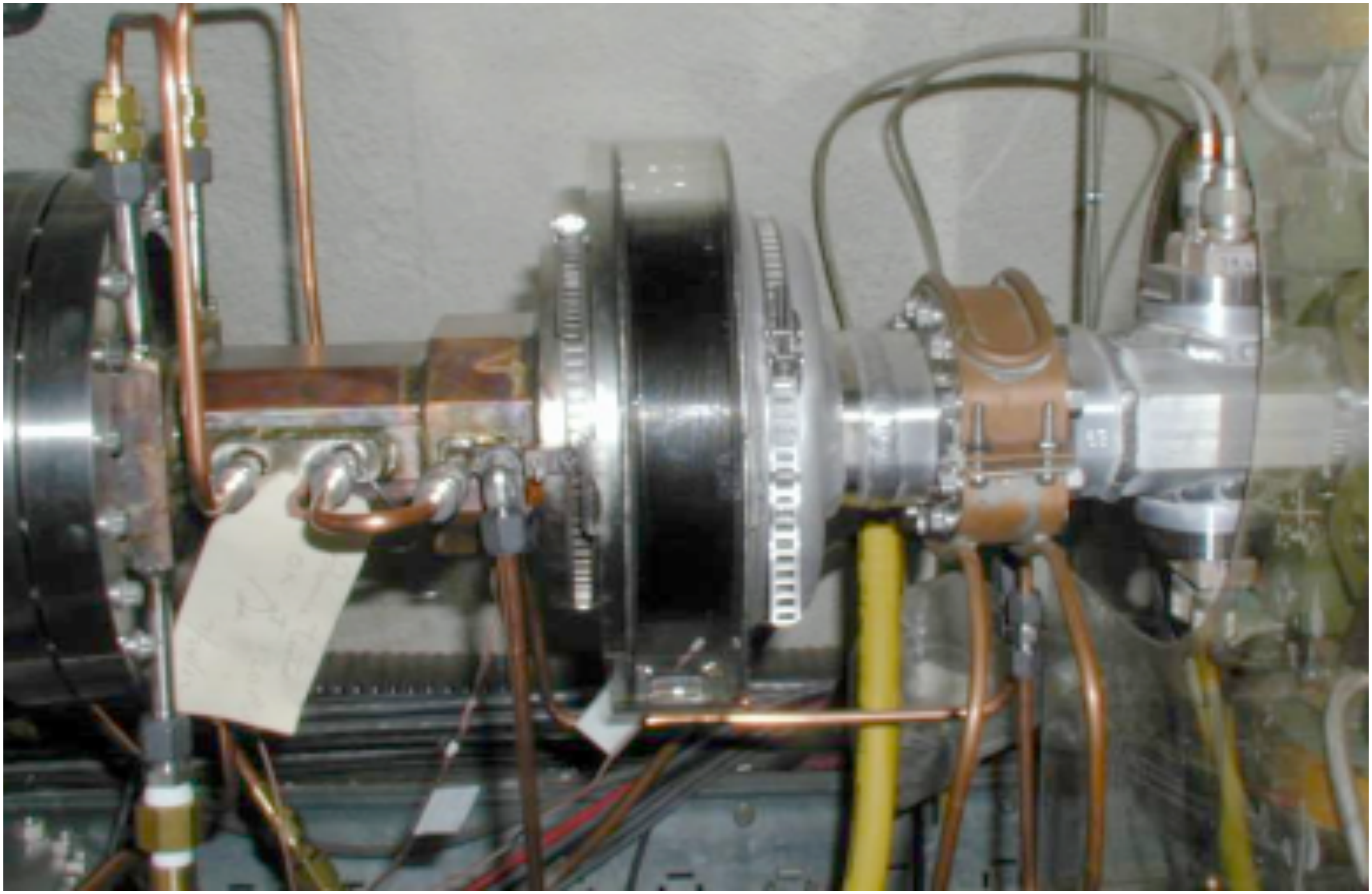
- 1st Individual articulation of all focusing elements using a common bus with chopper regulated current controls

- 1st Demo. of superconducting cavities in storage ring

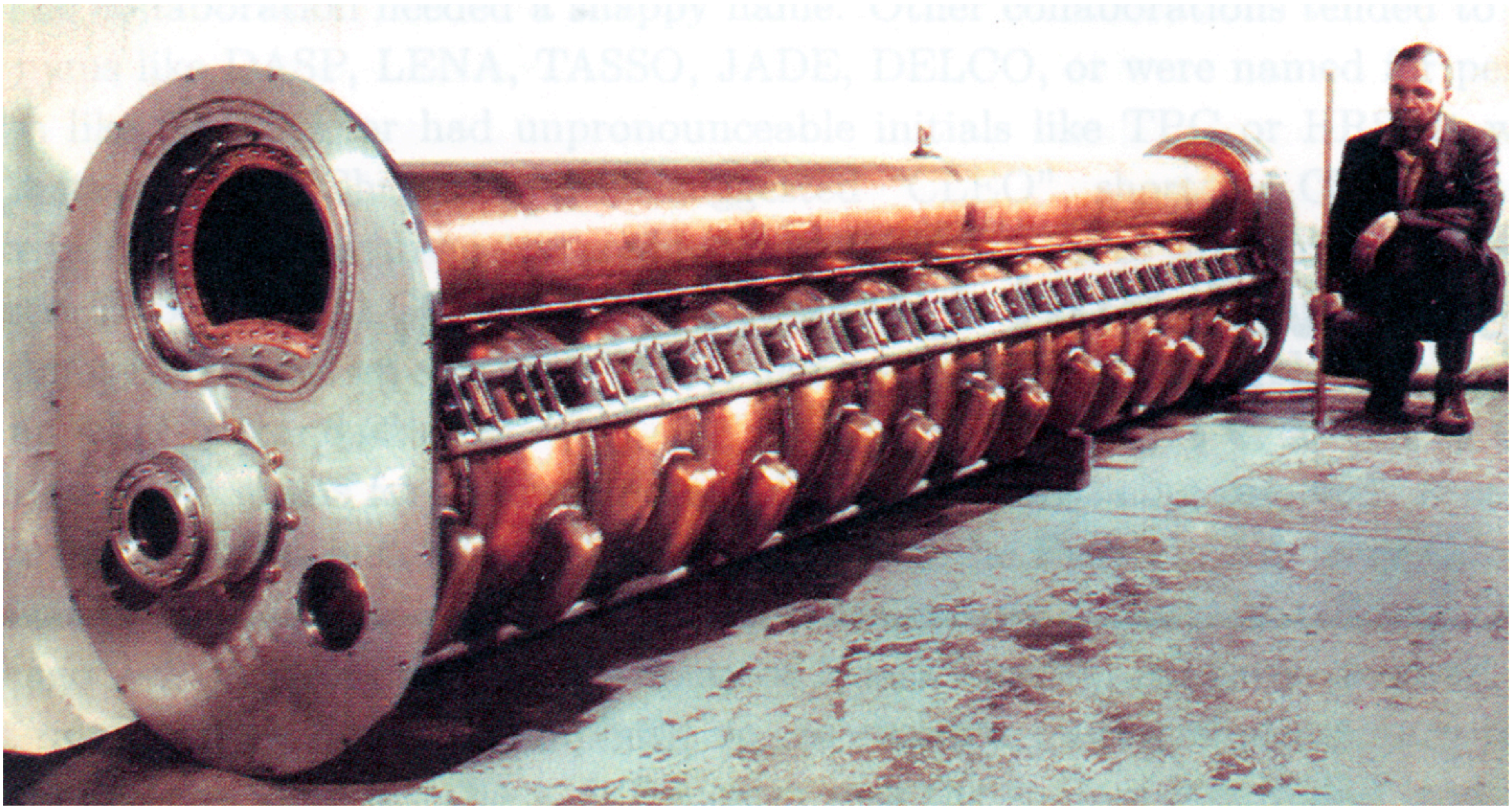


Subsequently chosen as basis for CEBAF accelerator

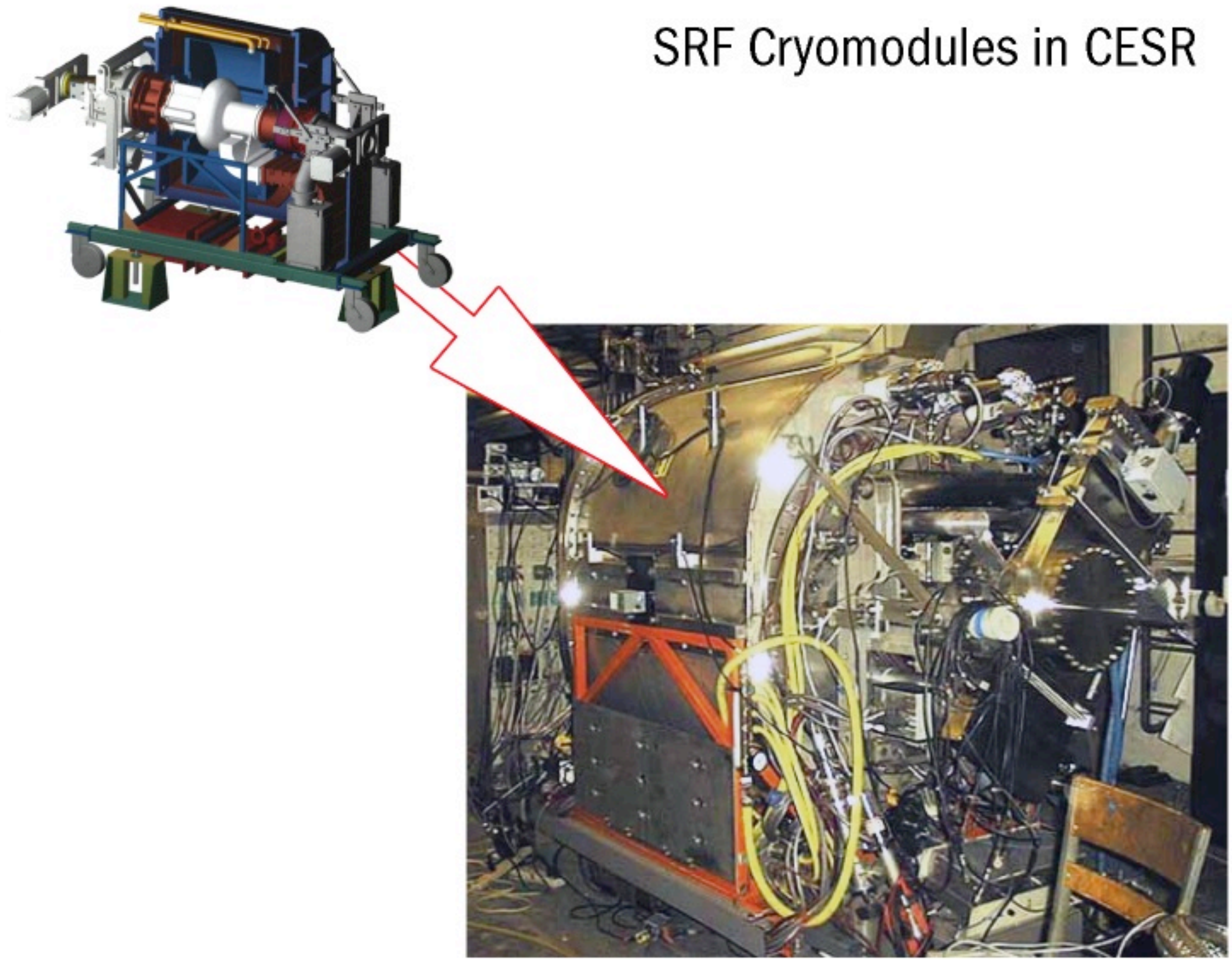
- 1st impedance controlled electron storage ring – discontinuities in vac chamber minimized, e.g. sliding joints



- 1st waveguide coupled multicell storage ring cavity with polarization and Higher Order Mode extraction

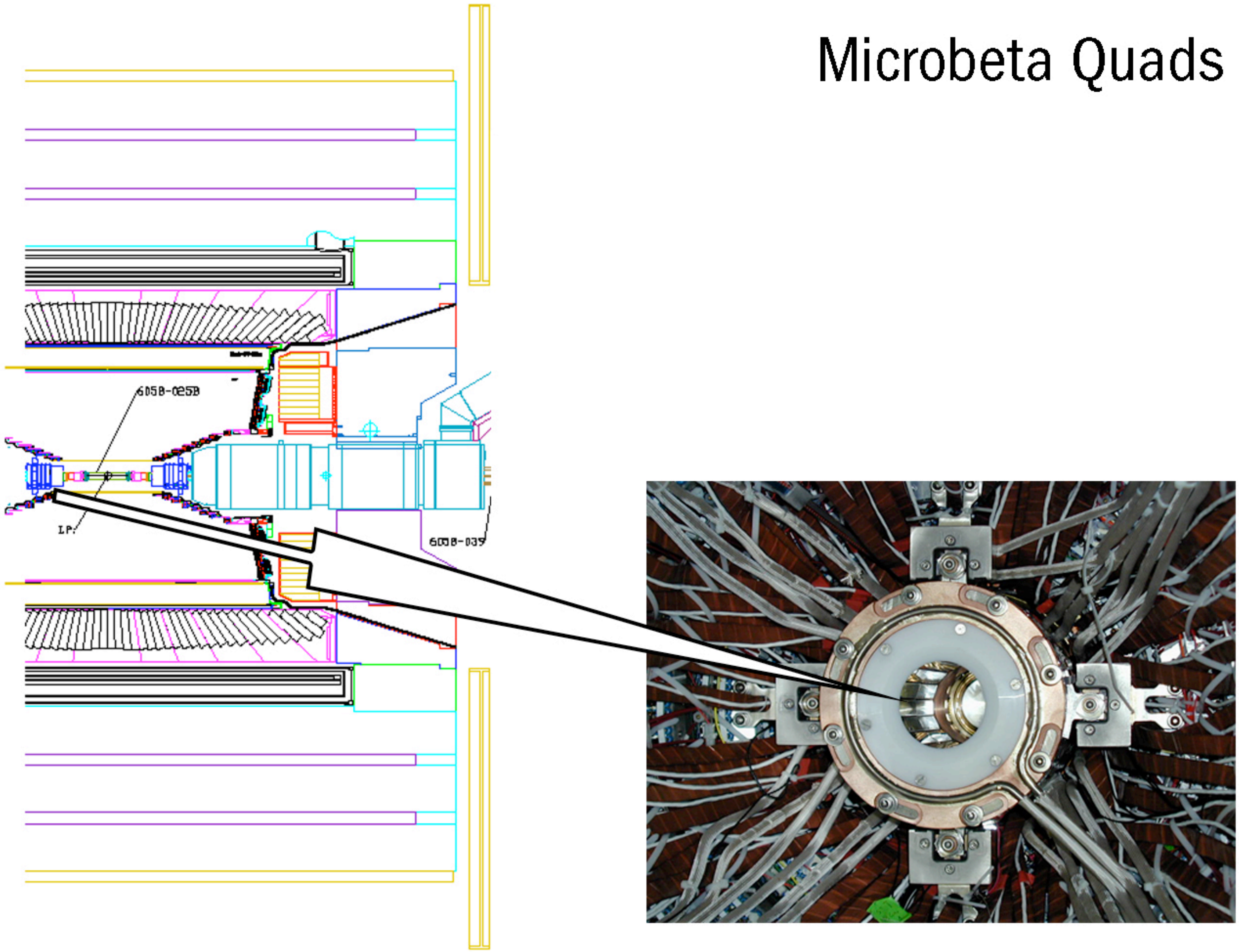


- 1st low impedance, single cell SC storage ring cavity

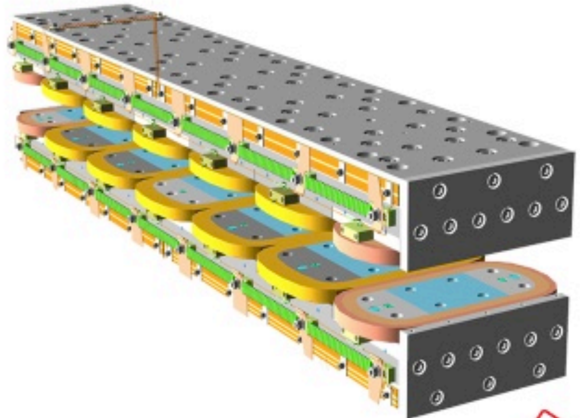


commercialized and now in use around the world

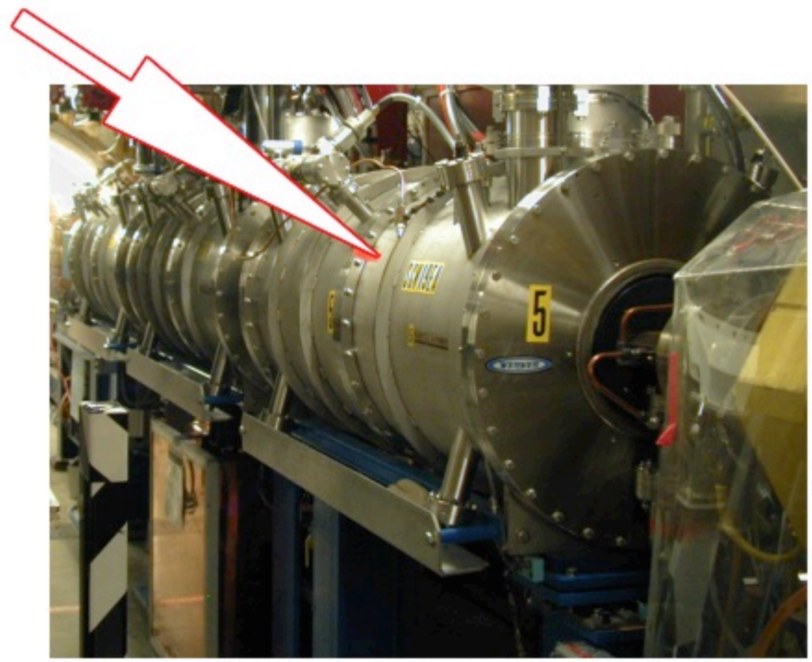
- 1st microbeta with magnets inside the detector



- Post B-factory begin, the CESR and CLEO collaboration decided to shift operations to the charm region requiring wigglers to provide the needed radiation damping CESRc



Single Superific Wiggler



Wider Impact

- As already noted there have been direct impacts of the work enabled by the existence of the CESR program for other accelerator based science activities
  - CEBAF based on SC cavities developed for storage ring
  - LEP used and Tevatron uses pretzel orbits for luminosity enhancement
  - KEK uses angle crossing at the IP
  - Micro-beta with quads inside the detector widely used
  - CESR superferric wiggler (figure immediately above) chosen for baseline design of the ILC damping rings
  - CESR single cell SC cavities used now in Europe, Asia and the Americas for x-ray science storage rings

- Significant contributions to the ILC R&D program with firsts in multicell cavities meeting TESLA criteria, world record gradient in SC single cell (59 MeV/m) (KEK collaboration)
- 1^{st} 200 MHz SC neutrino factory/muon collider style cavity (11 MeV/m) (CERN collaboration)
- 1^{st} SC cavity cryomodule for 500 kW, high brightness, high current beams - 5 to 15 MeV
- Living proof that university groups can accomplish large projects comparable in scale to national laboratories

People

Some students, research associates and former faculty now in service elsewhere

Ahrens, Lief	BNL, AGS operation Dir.
Byrd, John	ALS, Group Leader
Blum, Eric	BNL
Chen, Tong	Teledyne
Kersevan, Roberto	ESRF
Decker, Glen	ANL
Dixon, Roger	FNAL, Division Head
Edwards, Don	FNAL/DESY
Edwards, Helen	FNAL/DESY
Erickson, Roger	SLAC
Framowitz, Daniel	KAPL
Gibbard, Bruce	BNL
Hartung, Walter	MSU, Adjunct Prof.
Henderson, Stuart	SNS, Technical Director
Herb, Steven	DESY
Irwin, John	SLAC

Jackson, Gerald	President, Hbartech
Kneisel, Peter	JLAB
Knoblloch, Jens	BESSY
Krishnagopal, Srinovas	RRCAT, Group Leader
Milton, Stephen	Trieste, project Director
Phillips, Larry	JLAB
Peggs, Stephen	BNL, Group Leader
Proch, Dieter	DESY, Group Leader
Seeman, John	SLAC, Assist. Director
Siemann, Robert	SLAC, Professor
Sinclair, Charlie	JLAB, Assoc. Director
Smith, Jeff	SLAC
Sundelin,Ronald	JLAB, Group Leader
Sutter, David	DOE
Young, Elizabeth	Raytheon

THE FUTURE

- Owing to the quirks of history and the lab's energetic tradition there are future possibilities being actively pursued – more "wider impact" you might say
- More projects are underway:
  - Cesr TA, a use of the storage ring for R&D on the electron cloud effect which affects operation of high current storage rings with closely spaced bunches (most future rings, particularly the ILC damping rings, LHC, Project X….)
  - Dedicated operation of CESR for x-ray science (600 user visits last year) hope to expand soon
  - R&D for a new type of x-ray source based on CESR as part of the beam path –Energy Recovery Linac or ERL

- This ultra high brightness x-ray source idea came from early studies of linear collider possibilities using superconducting cavities in 1965

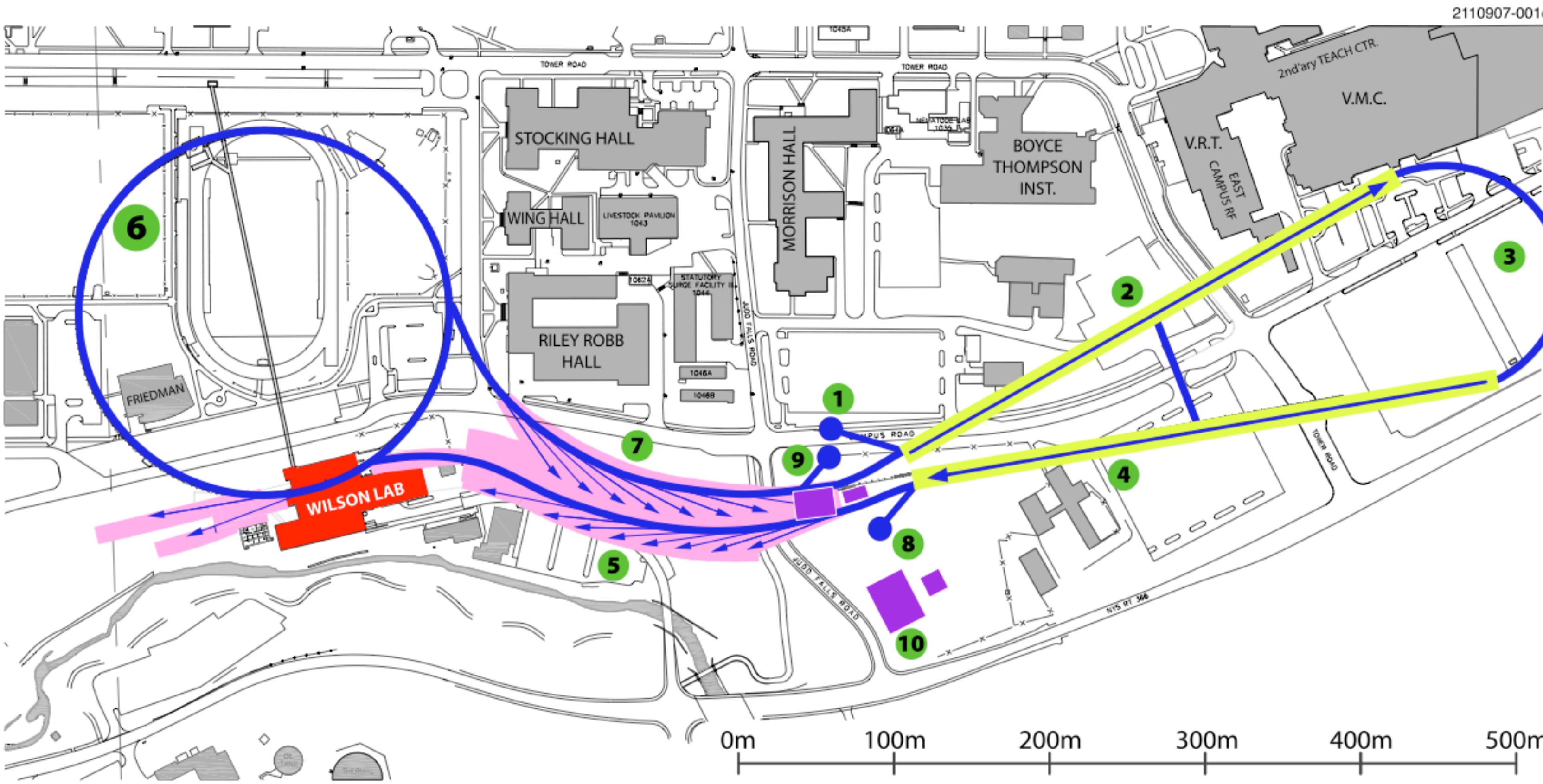


Figure 1. Schematic ERL layout incorporating the existing Cornell Electron Storage Ring (CESR). Electrons are injected (1) and are accelerated to the right in a 2.5 GeV linac (2), loop through a turn-around arc (3), and accelerate to the left through an additional 2.5 GeV linac (4) to 5 GeV. X-ray beamlines are in the pink/red areas. Bunches then pass clock-wise around CESR (6) where bunches may be compressed to <100 fs and through more undulators (7) before being uncompressed, energy recovered in second passes though linacs (2) and (4), and finally dumped at (8) or (9). The location of the cryo plant is shown in purple in four component parts (10).

- A prototype of the injector is coming together at Wilson lab now (come and see) and a proposal for construction of the facility in the schematic above is expected before the end of this calendar year.

In Conclusion

CESR has already had a 35 year history of pioneering in elementary particle science, x-ray science and accelerator science and technology. We look forward to another 35 years of serving accelerator based science and making unique contributions to the American workforce