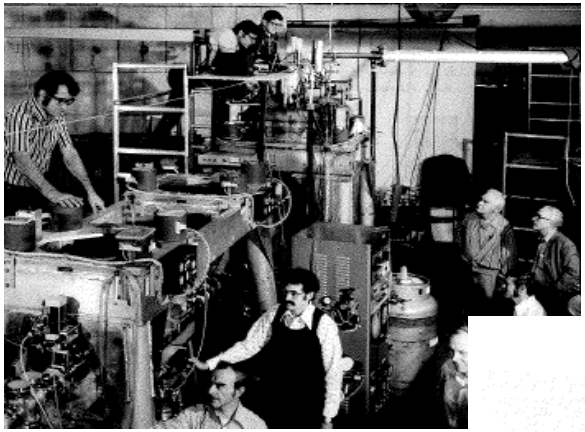
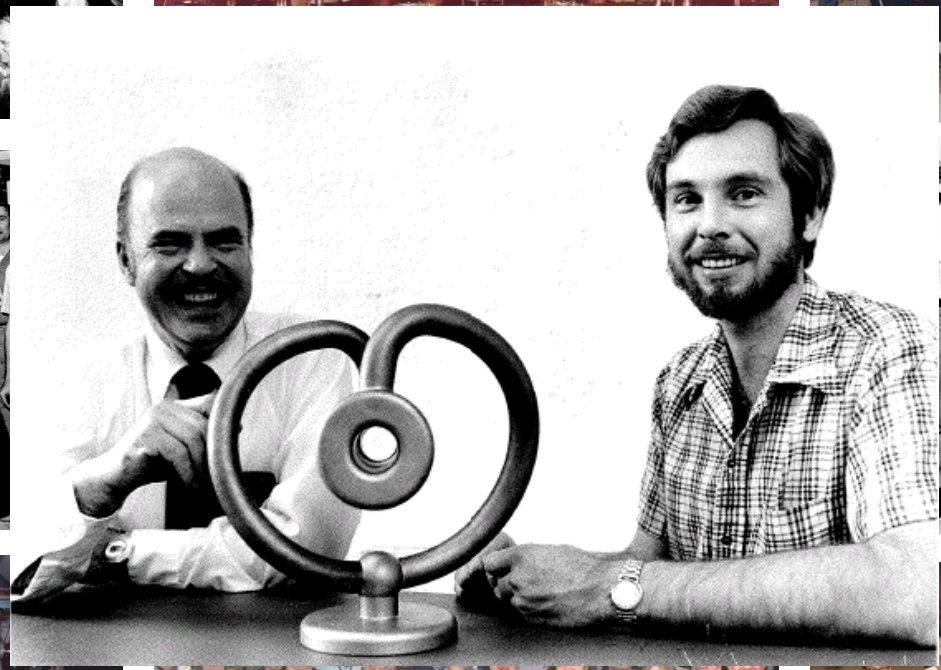
25 Years of ATLAS

Looking back, eight years ago ATLAS was nothing but an idea. And looking forward, in two years ATLAS will come alive, almost full grown. That's 10 years from conception to birth! But what a beautiful baby!

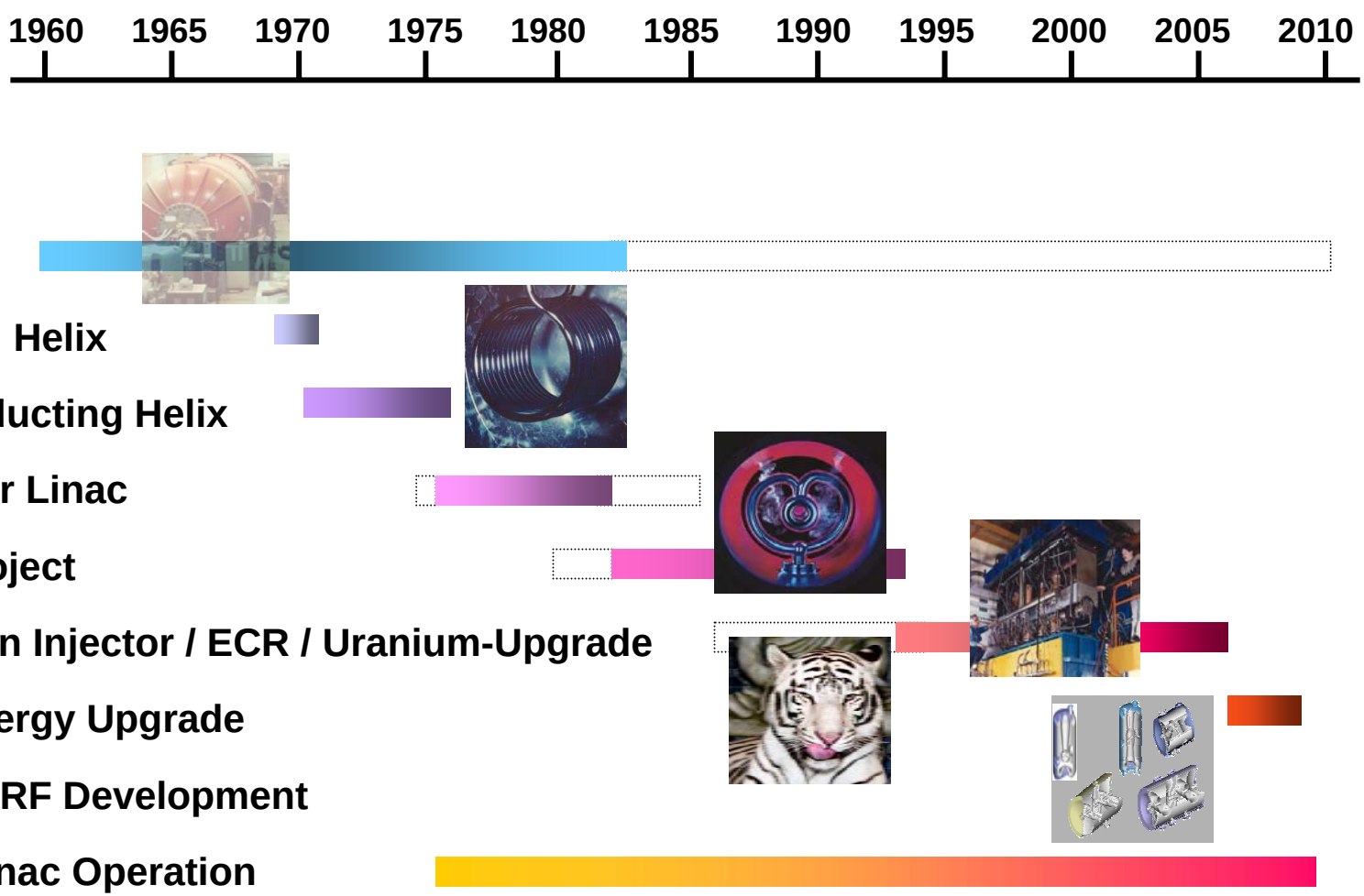
ry !!!





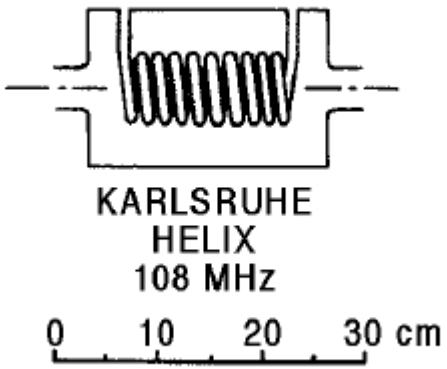

ATLAS

Super Conducting Linac Development at Argonne

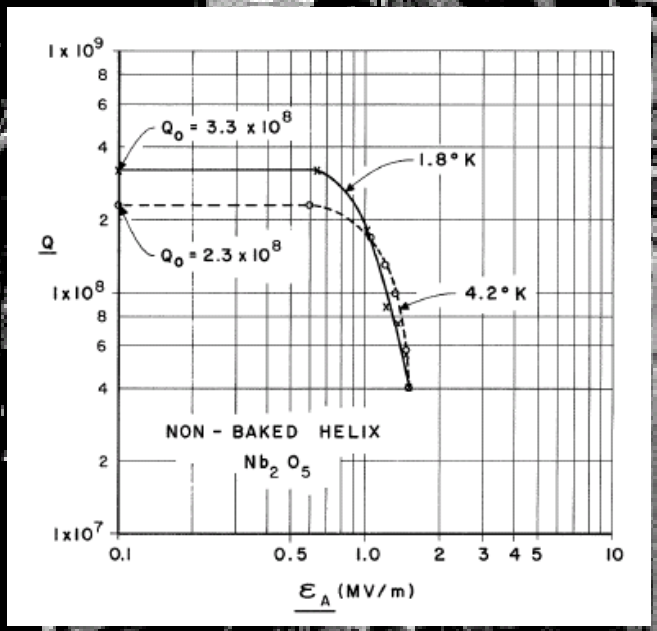


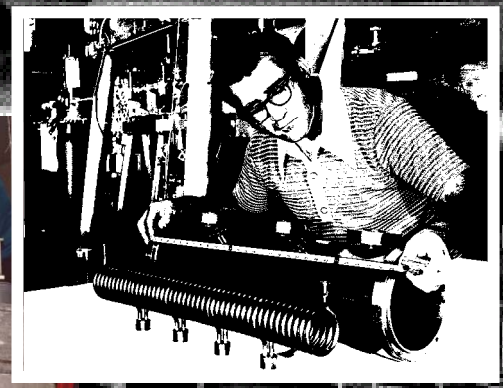
The HELIX Age

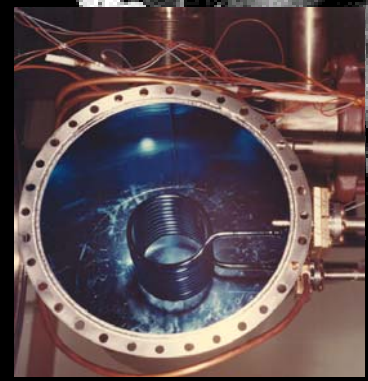
- 1969 H. Klein et al (Frankfurt University) propose a heavy-ion linac using normal-conducting helical accelerating structures (HELAC)
- HELAC loses out against C. Schmelzer's (Heidelberg University) UNILAC as the choice for the GSI heavy-ion facility
- Subsequently several laboratories start pursueing *superconducting* helical structures (Karlsruhe, Orsay, Argonne CHM)
- Good fields are achieved but stability and phase locking problems (though helix gets eventually used in a small sc accelerator at Orsay)
- Lowell Bollinger steps down as Division Director of PHY to fully pursue the helical superconducting heavy-ion linac at ANL



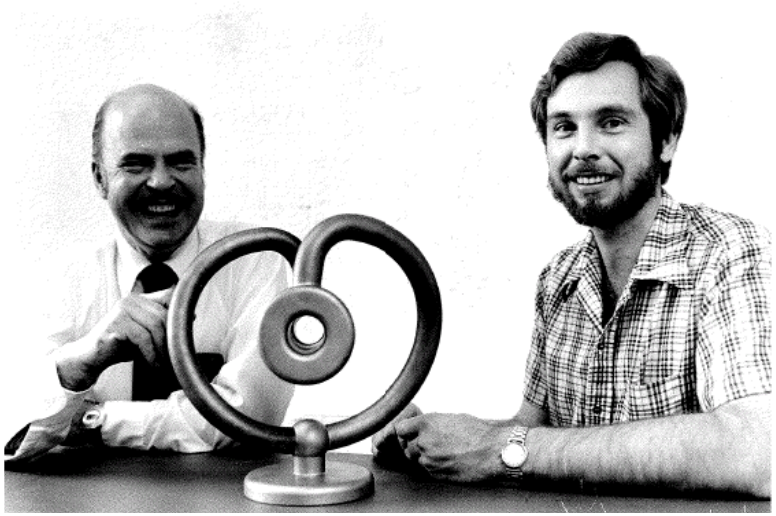
The SC Helix at ANL: PHY and CHM

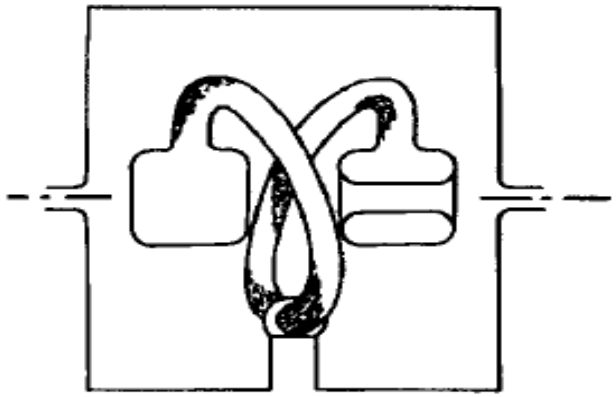




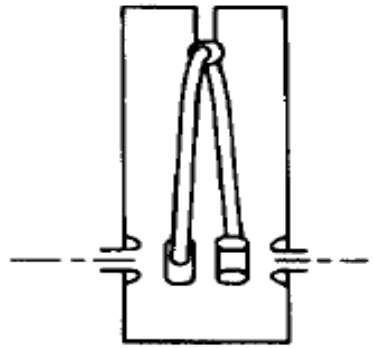


The SPLIT RING Age

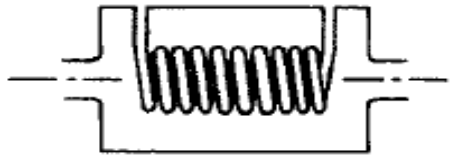




ARGONNE
NIOBIUM SPLIT RING
98 MHz

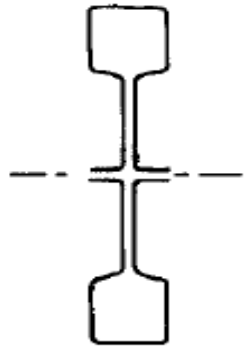


CAL TECH
LEAD SPLIT RING
150 MHz



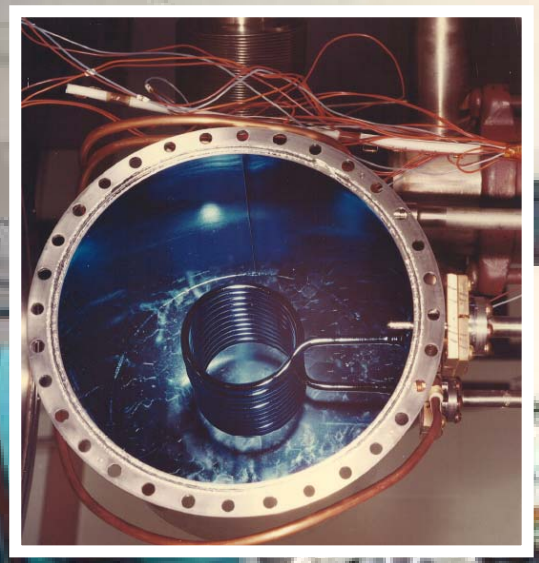
KARLSRUHE
HELIX
108 MHz

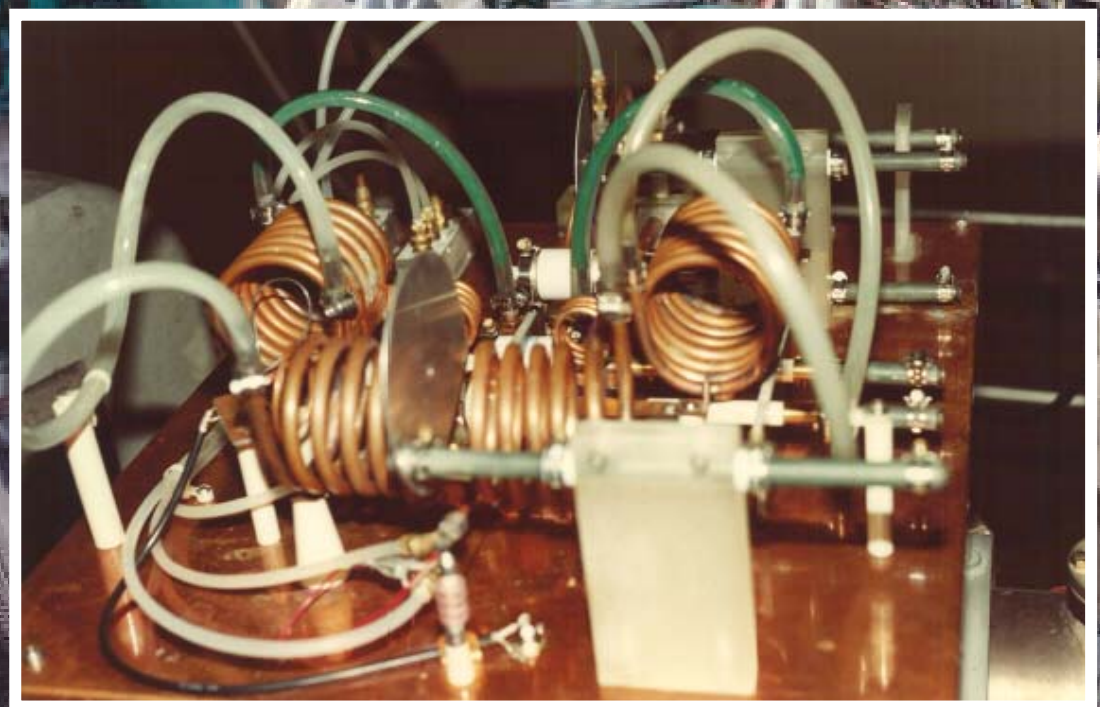
0 10 20 30 cm

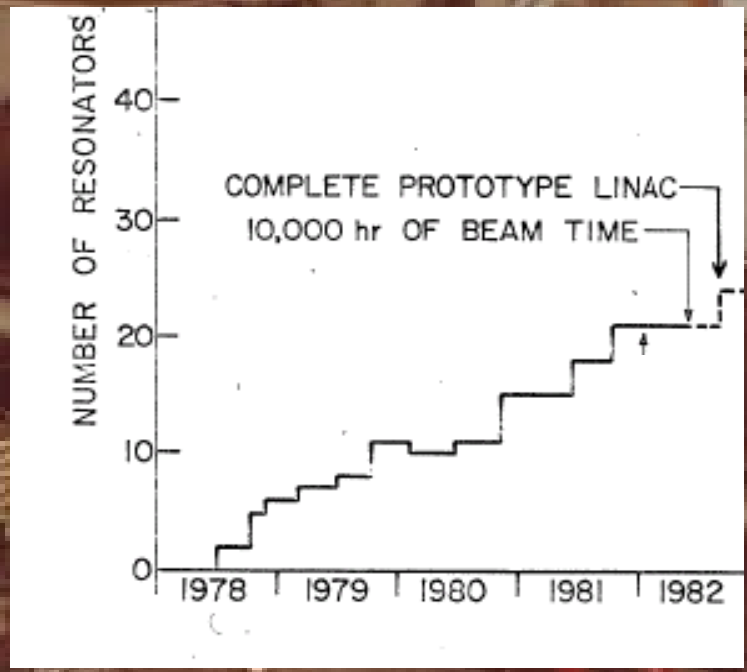


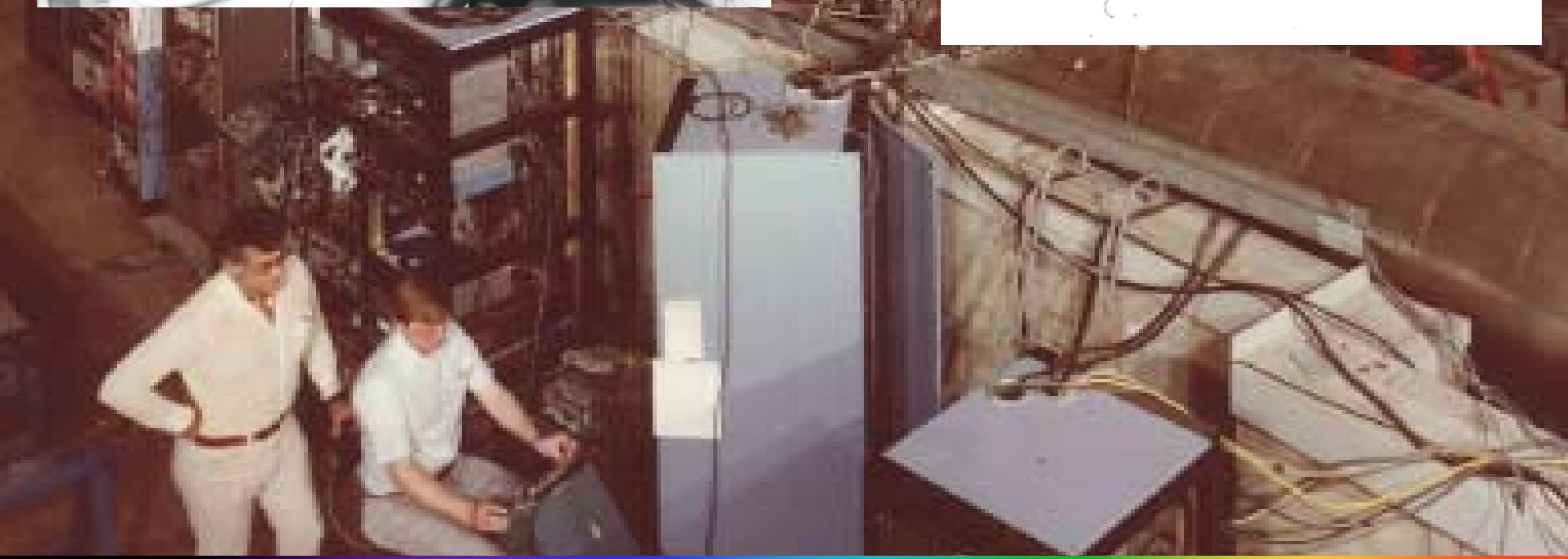
STANFORD
REENTRANT
CACITY 430 MHz

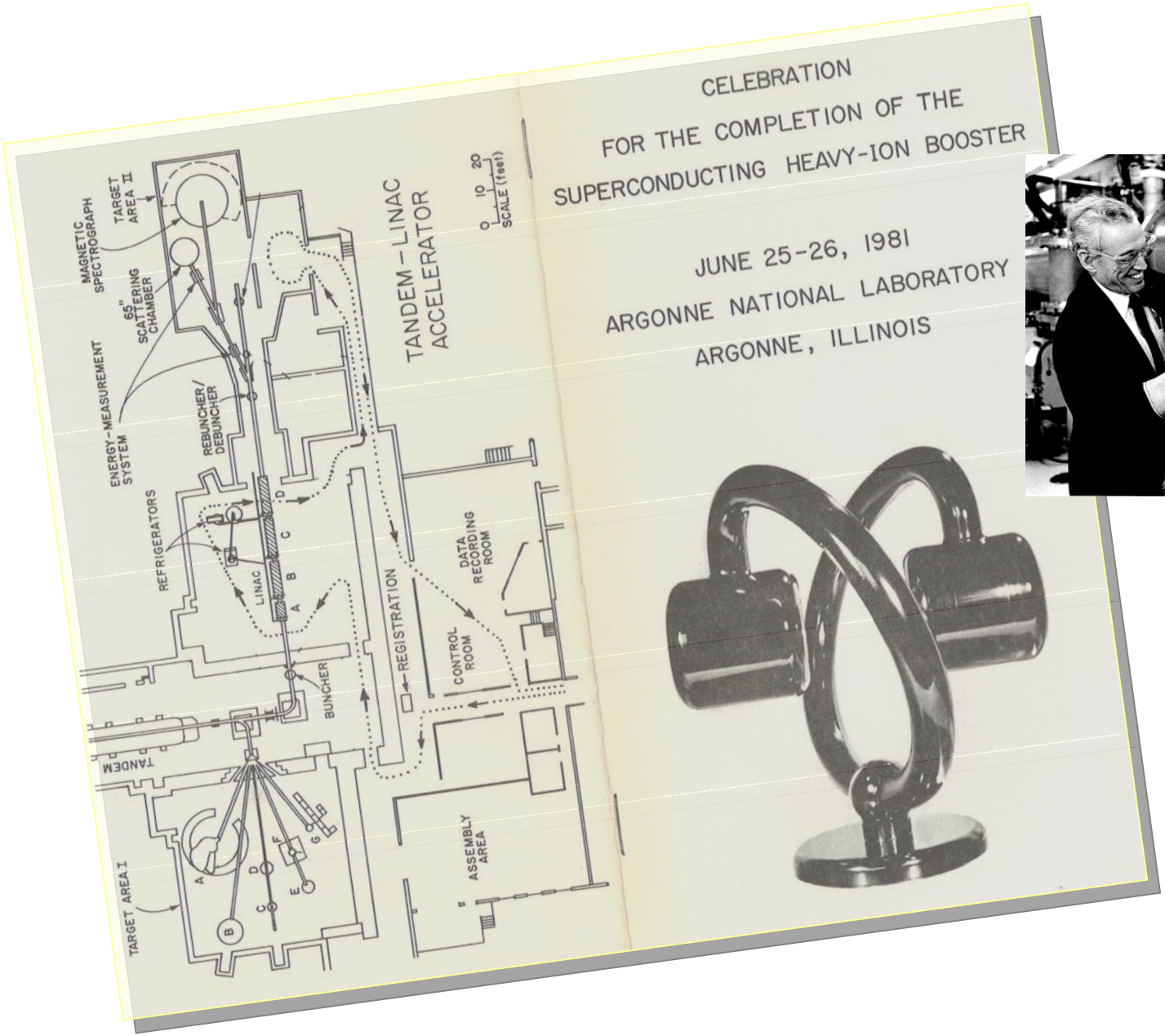

Quak, Quak..






NUMBER OF RESONATORS
40
30
20
10
0
COMPLETE PROTOTYPE LINAC
10,000 hr OF BEAM TIME
1978
1979
1980
1981
1982




TANDEM – LINAC ACCELERATOR
SCALE (feet)
0 10 20
MAGNETIC SPECTROGRAPH
TARGET AREA II
65" SCATTERING CHAMBER
ENERGY-MEASUREMENT SYSTEM
REBUNCHER/ DEBUNCHER
REFRIGERATORS
LINAC
BUNCHER
TANDEM
TARGET AREA I
REGISTRATION
CONTROL ROOM
DATA RECORDING ROOM
ASSEMBLY AREA
CELEBRATION
FOR THE COMPLETION OF THE
SUPERCONDUCTING HEAVY-ION BOOSTER
JUNE 25-26, 1981
ARGONNE NATIONAL LABORATORY
ARGONNE, ILLINOIS


ARGONNE HEAVY ION LINAC

SUPERCONDUCTING LINAC PROJECT

Project Management
Lowell Bollinger, Physicist (PHY)

Resonators and Cryostats
Ken Shepard, Physicist (PHY)
Bill Ball, Mechanical Designer (ENG)
Ralph Benaroya, Electrical Engineer (PHY)
Vince Patrizi, Technician (PHY)
Clem Scheibelhut*, Mechanical Engineer (ENG)
Ted Sterling, Mechanical Designer (ENG)

RF Control
Ken Johnson, Electronics Engineer (CHM)
Gene Clifft, Engineering Specialist (CHM)

Liquid-Helium Distribution
Jack Nixon, Mechanical Engineer (CHM)
Bruce Millar, Technician (PHY)

Surface Treatment
Arthur Jaffey*, Chemist (CHM)
Paul Markovich, Engineering Specialist (CHM)

Beam Diagnostics and Control
Richard Pardo, Physicist (PHY)
Tom Wangler*, Physicist (PHY)

COMPUTER CONTROL SYSTEM

Bob Daley
Tim Hentsch
Joe Kulaga
Richard Pardo

LINAC FABRICATION*

Ralph Breuss
Walter Goliszewski
Gene Gutowski
Earl Johnson
Bruno Koproski
Clar Kotora
Leo Lach
Tony Lang
Bill Legatzke
Bob Macherey
Benny Mikols
Bob Mogil
Tony Rogers
Les Trater
Arnie Zahlit
Ole Beith
Dale Cassidy
Dave Compton
Harry Flom
Regis Franck
Jim Hunt
Elmar Koch
Ralph Kuechler
Ed Mus
Bob Nelson
Al Nemeth
Wynard Normand
Bob Reinhardt

PULSED-BEAM TECHNOLOGY

Bob Lewis
Frank Lynch
Walter Henning
Lowell Bollinger
Ben Zeidman

TANDEM UPGRADING AND OPERATION

Pete Bilquist
Pat DenHartog
Chuck Heath
Floyd Munson
Jan Yntema
Sam Craig
Andy Drabik
Joe Peregrin
Don Phillips
Bob Pope

EXPERIMENTAL SYSTEM

Russell Betts
Walter Henning
Teng Khoo
Dennis Kovar
Walter Kutschera
Bob Smither
Ben Zeidman
Charlie Bolduc
Bill Chyna
Bill Evans
Al Huston
Bob Kickert
Don Little
Bruce Nardi
Jim Worthington

CELEBRATION

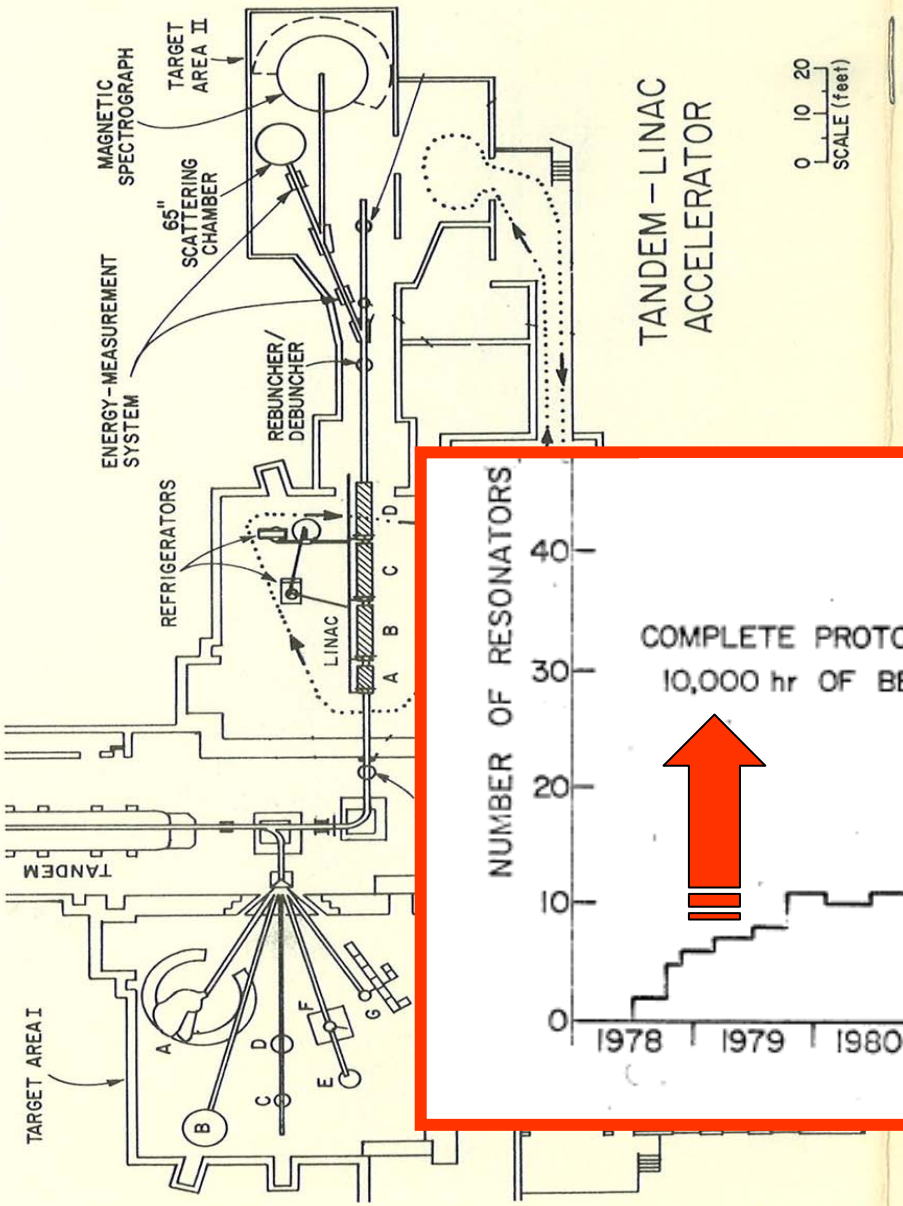
FOR THE COMPLETION OF THE

SUPERCONDUCTING HEAVY-ION BOOSTER

JUNE 25-26, 1981

ARGONNE NATIONAL LABORATORY

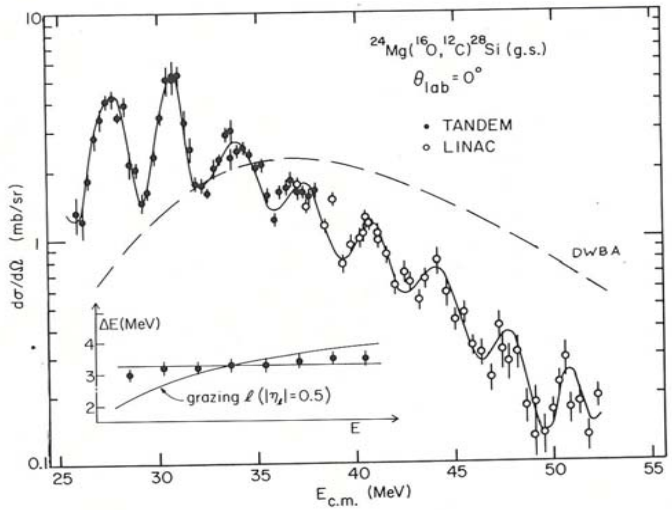
ARGONNE, ILLINOIS

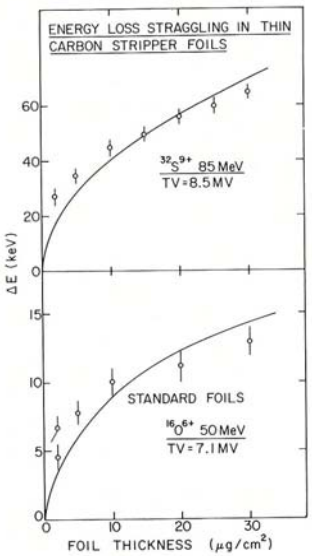


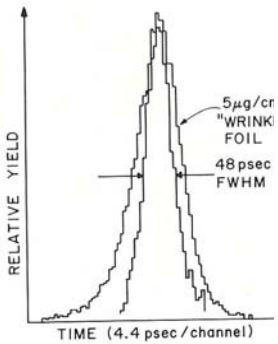
Superconducting RF (SRF) LINAC for Ion Beams

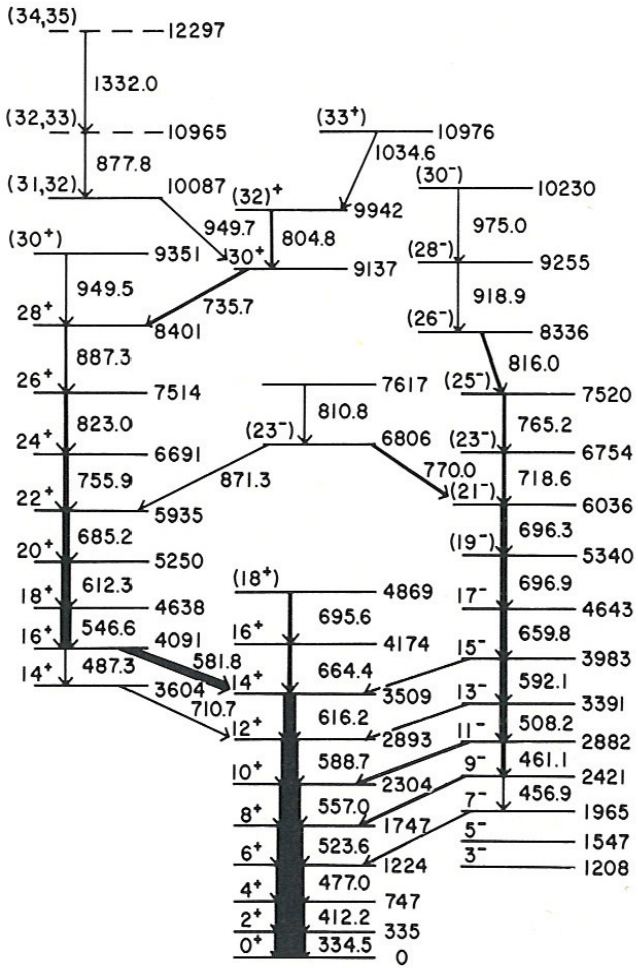
- few watts to kilo-watts provide several MV/m accelerating fields
- > cw !
- > independently phased resonators: high degree of flexibility; e.g.:
- > allows to optimize acceleration voltage
- > can compensate for malfunctioning resonators
- > with the first resonators in place one can start the research program, i.e. well before completion of facility
- > acceleration configuration easily changed: excitation functions, beam changes, charge-to-mass ratio
- > multi-charge state beams

First Experiments with the Booster Linac



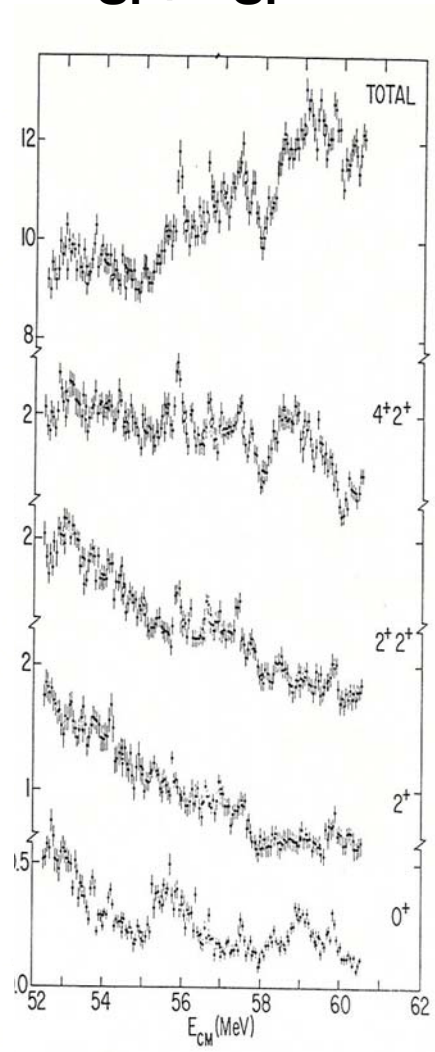




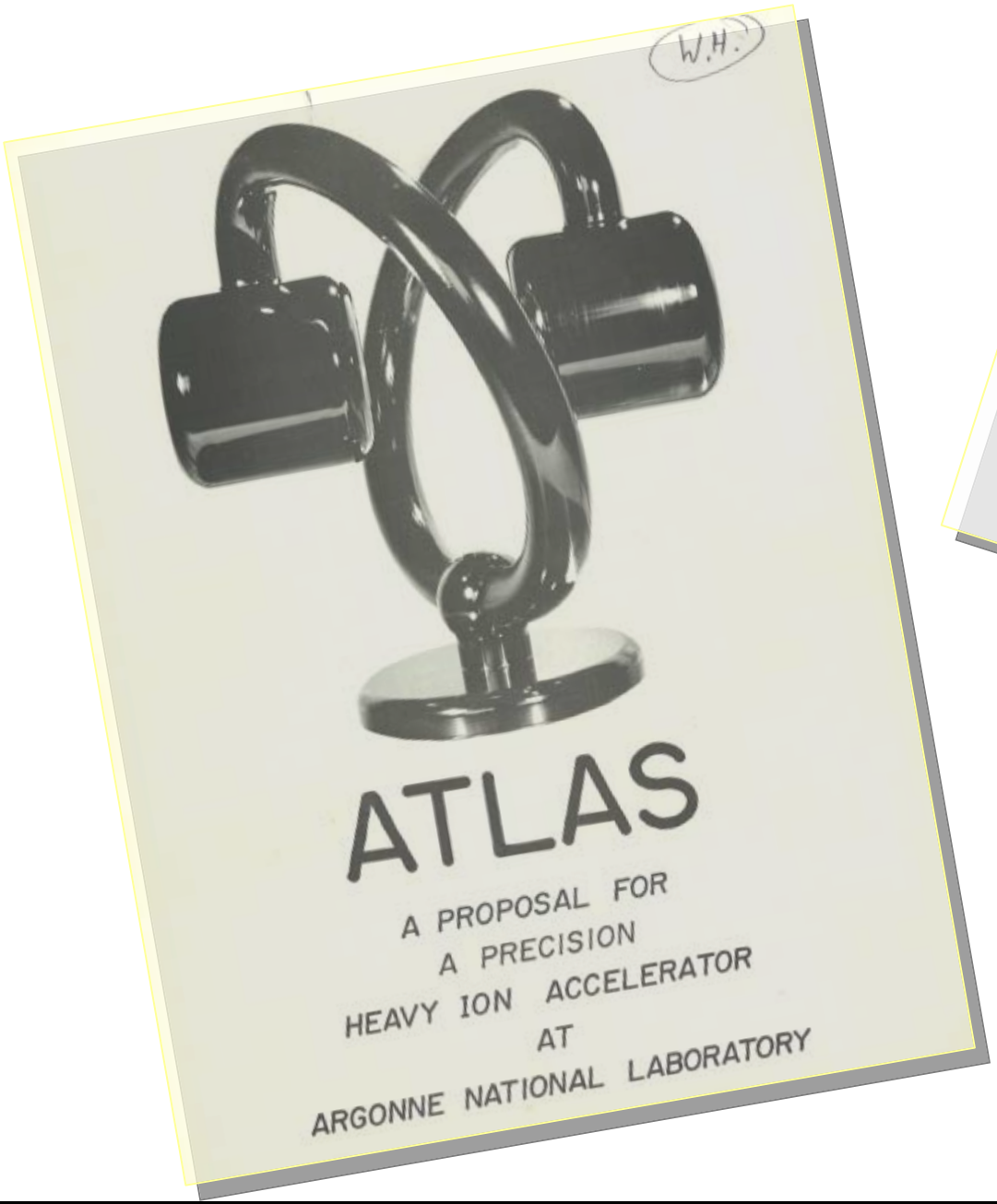


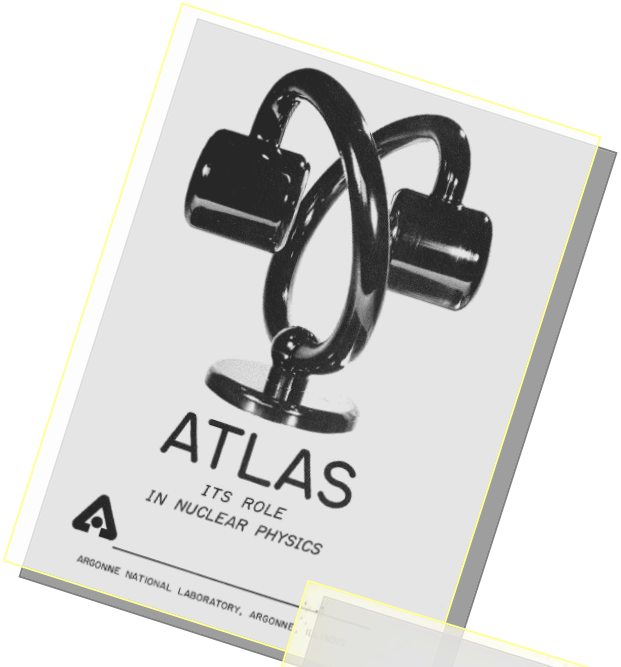
^{154}Dy

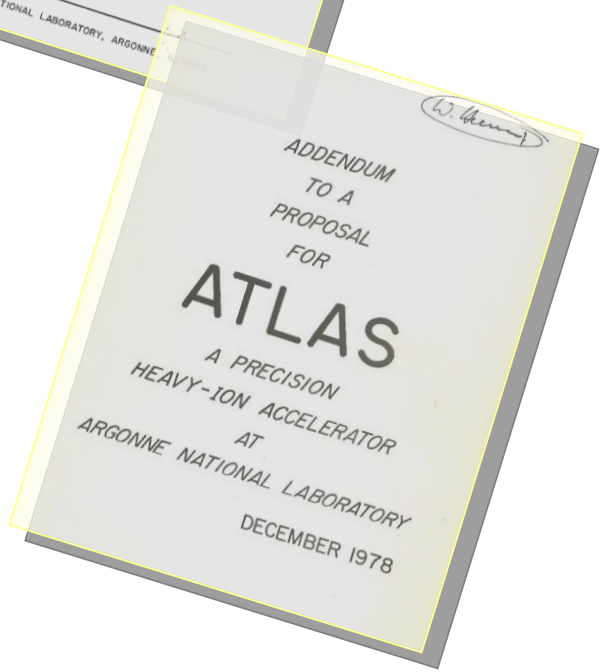
^{28}Si + ^{28}Si

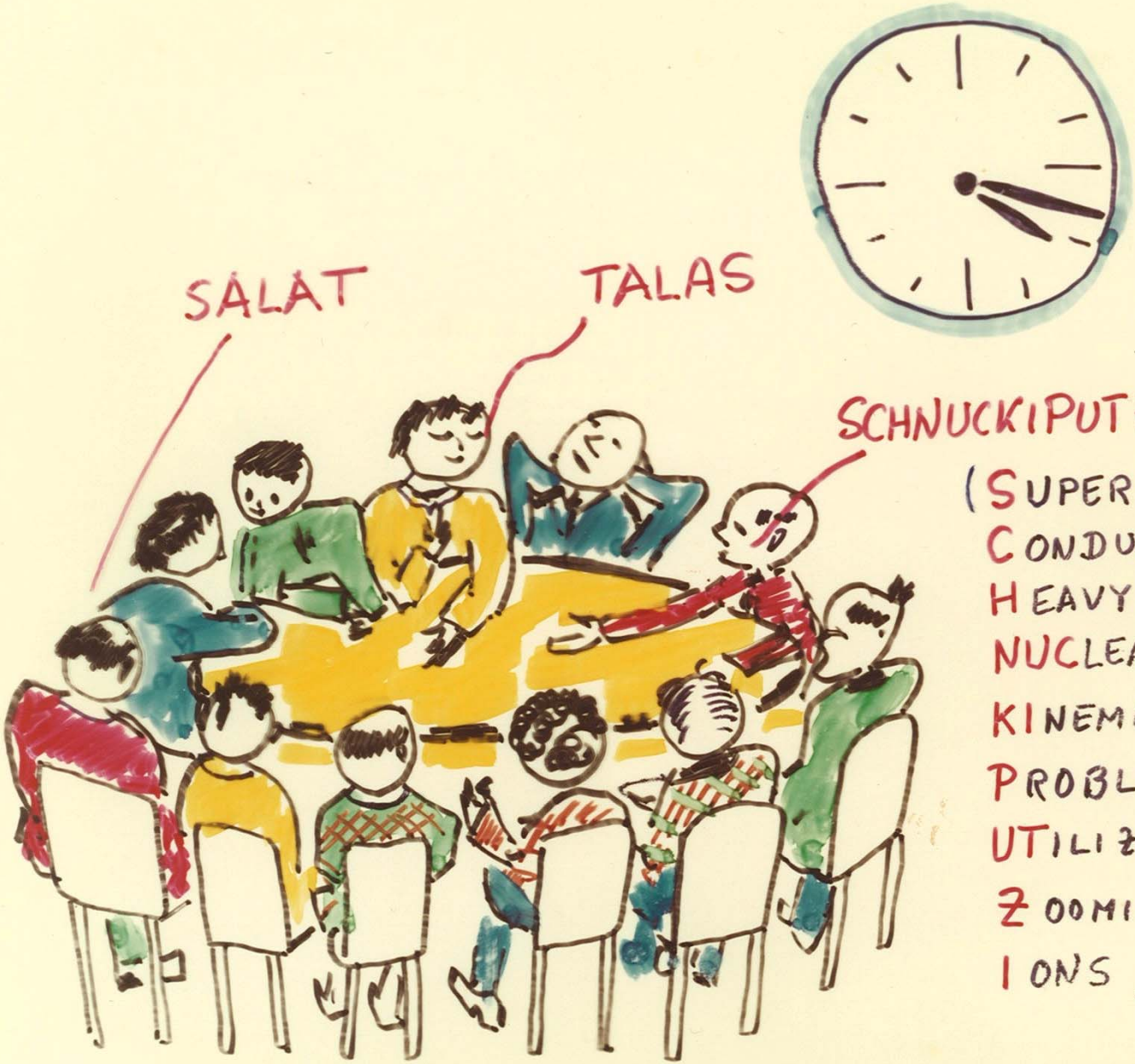


…and many others……..


W.H.
ATLAS
A PROPOSAL FOR
A PRECISION
HEAVY ION ACCELERATOR
AT
ARGONNE NATIONAL LABORATORY

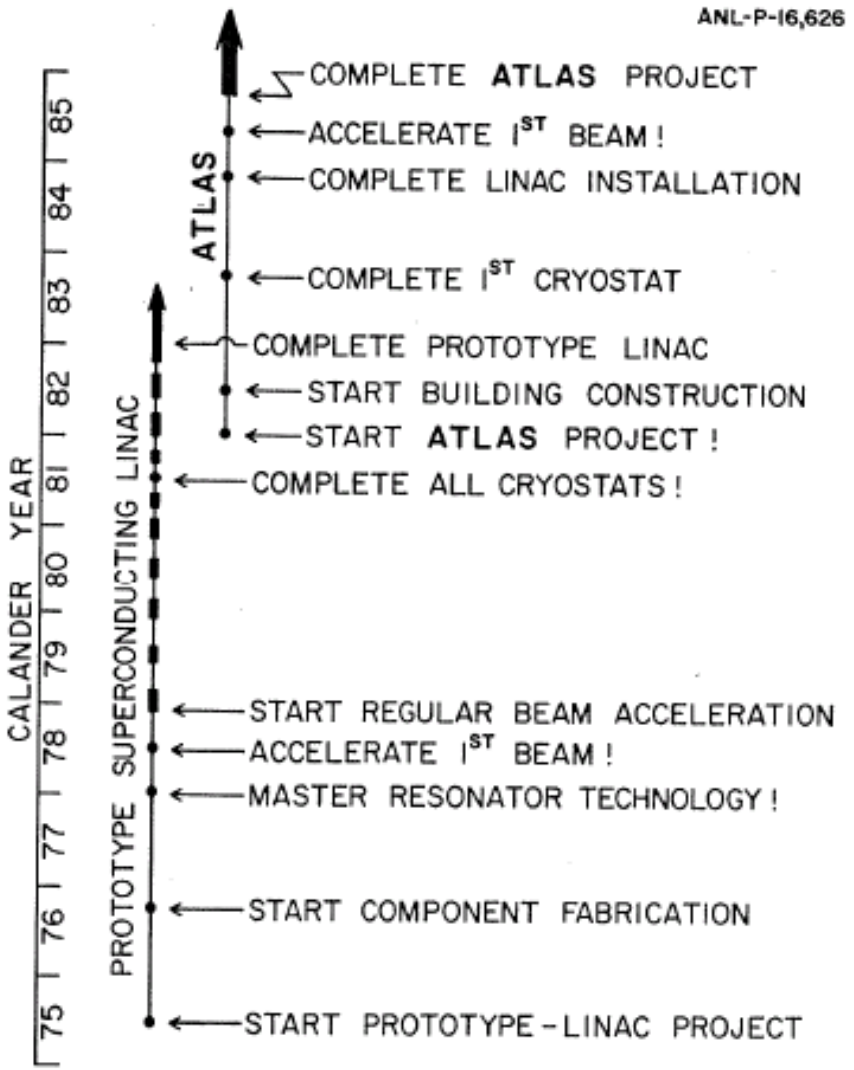

ATLAS
ITS ROLE
IN NUCLEAR PHYSICS
ARGONNE NATIONAL LABORATORY, ARGONNE

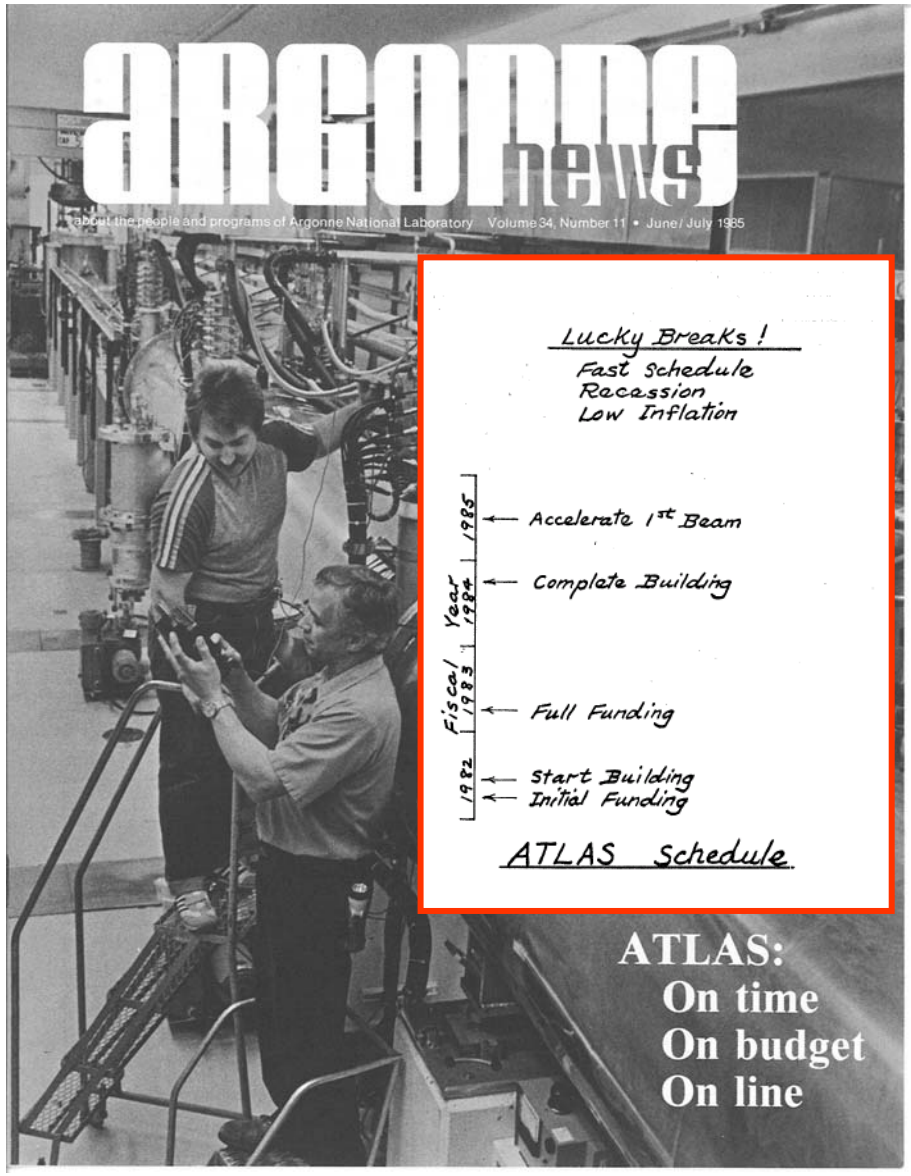

ADDENDUM
TO A
PROPOSAL
FOR
ATLAS
A PRECISION
HEAVY-ION ACCELERATOR
AT
ARGONNE NATIONAL LABORATORY
DECEMBER 1978



(SUPER
CONDUCTING
HEAVY ION
NUCLEAR ACCELERATOR FOR
KINEMATIC
PROBLEMS
UTILIZING
ZOOMING
IONS)

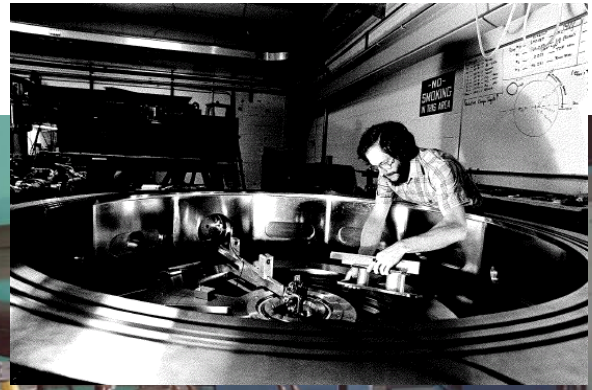
Before ..... and .....After

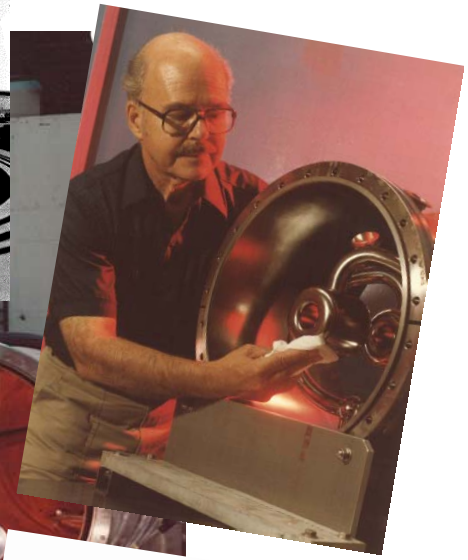


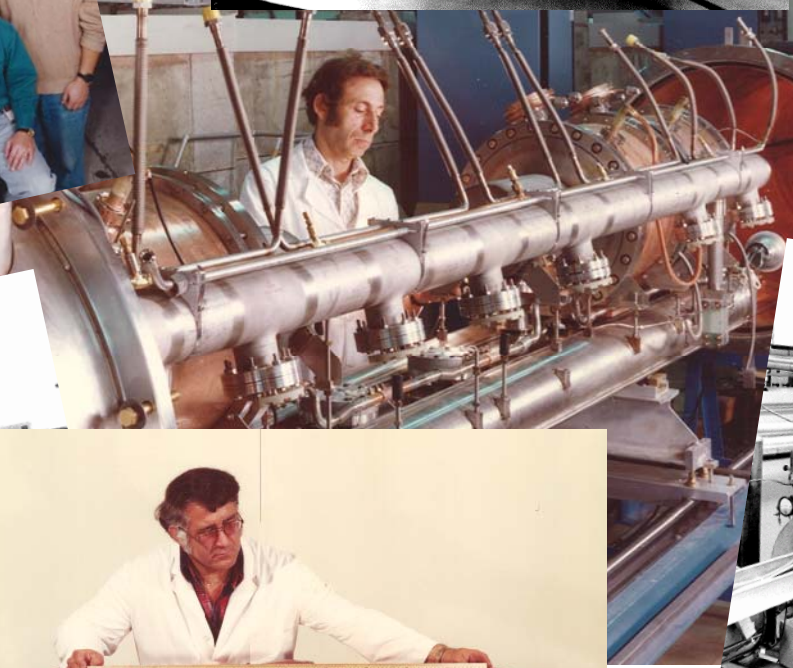



3 Cryostats in

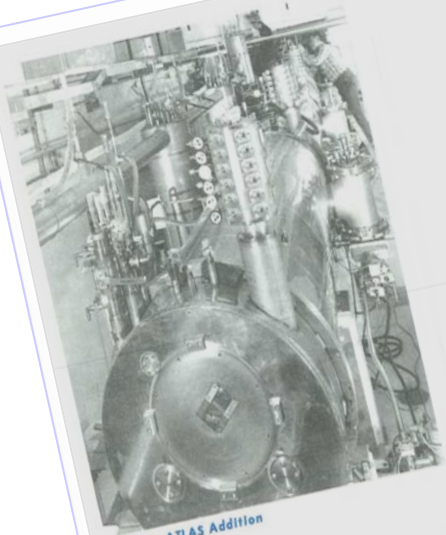

ATLAS


-NO-
SMOKING
IN THIS AREA





ATLAS



The New ATLAS Addition

The construction for the expansion to the complete ATLAS system began in 1982 with the development of the very high beta resonators. A total of 18 new resonators were needed for ATLAS. The new accelerator sections have

Lowell M. Bollinger is manager of Argonne's ATLAS project. He is a nuclear physicist who has spent the last 10 years developing the Argonne superconducting linac.

The World's First Superconducting Accelerator For Heavy Ions

Argonne National Laboratory operated by The University of Chicago for the U.S. Department of Energy under Contract W-31-109-Eng-38

ATLAS DEDICATION

June 3-4, 1985

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS
Operated by THE UNIVERSITY OF CHICAGO
for the U. S. DEPARTMENT OF ENERGY
under Contract W-31-109-Eng-38


ATLAS
ATLAS


ATLAS


ATLAS

By Lowell M. Bollinger

From the beginning, our new machine — the world's first superconducting accelerator for projectiles heavier than the electron — had everything against it. It started with a difficult, failure-prone technology, a shortage of funds, a seemingly impossible schedule, and

From the beginning, our new machine . . . had everything against it.

an inexperienced and understaffed development team. To many people, the new machine had little or no chance of working. But it did, and it does, and it will soon grow up to be ATLAS (the Argonne Tandem-Linear Accelerator System), a national nuclear-physics research facility.

When completed, ATLAS will be a world class machine. Scientists from all over the world will use it to expand the boundaries of research into the forces that hold together atomic nuclei. The Argonne-developed technology on which it is based is already enabling universities and other organizations to upgrade their experimental programs inexpensively by adding superconducting accelerator modules to their existing tandem Van de Graaff accelerators.

The story of ATLAS began in the early 1970s. About this time, nuclear-physics programs at Argonne and other leading institutions were feeling the limits of then-current accelerator technology. The range of particle sizes and energies from the major nuclear-physics tools of the time — tandem Van de Graaffs and cyclotrons — were too limited for the kinds of experiments needed to further expand research frontiers.

The standard solution was tried first: we sought funds for larger and better tandems and cyclotrons. In the end these efforts failed, and it became clear that a bolder ap-

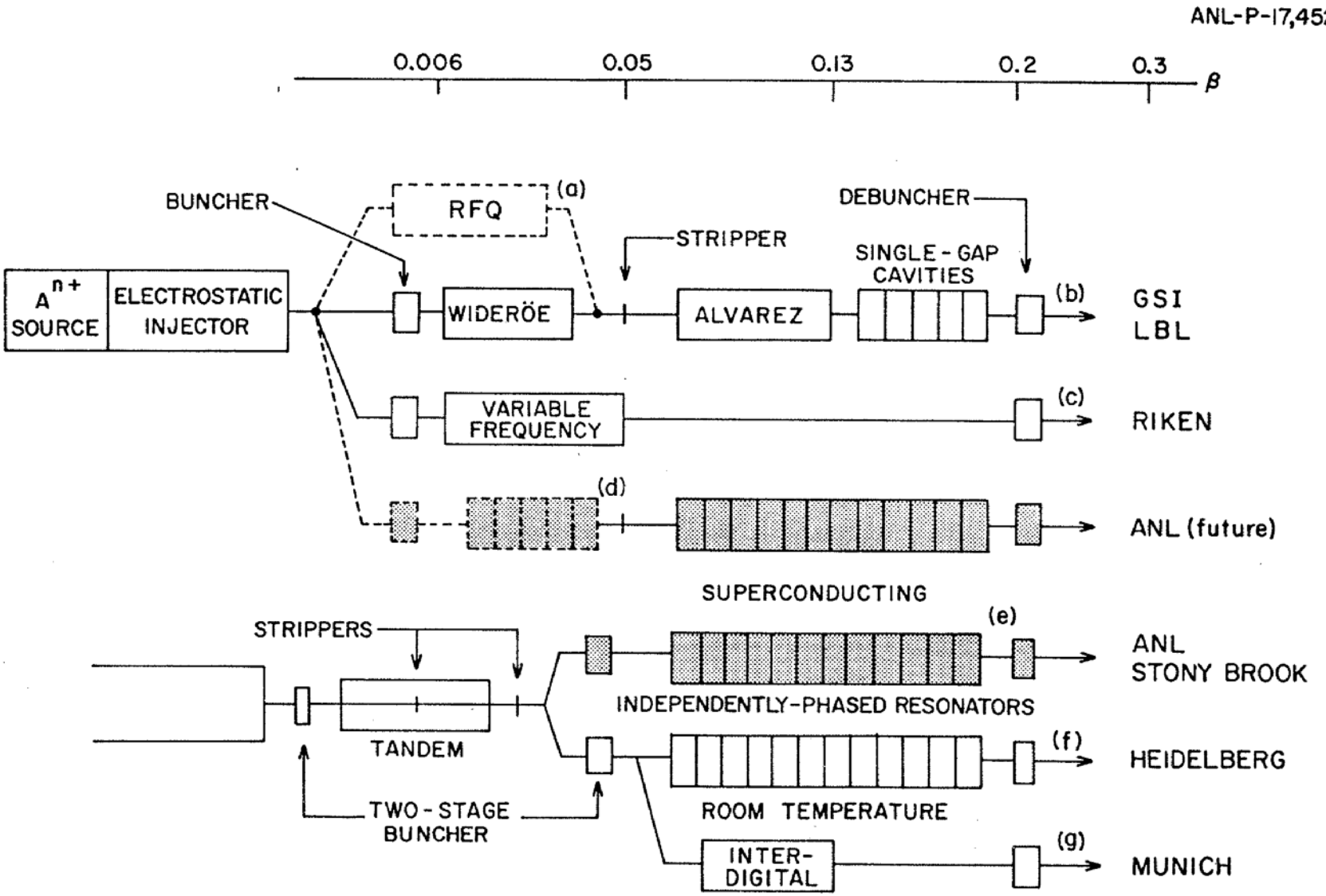
Division of Nuclear Physics

The 1986 Tom W. Bonner Prize

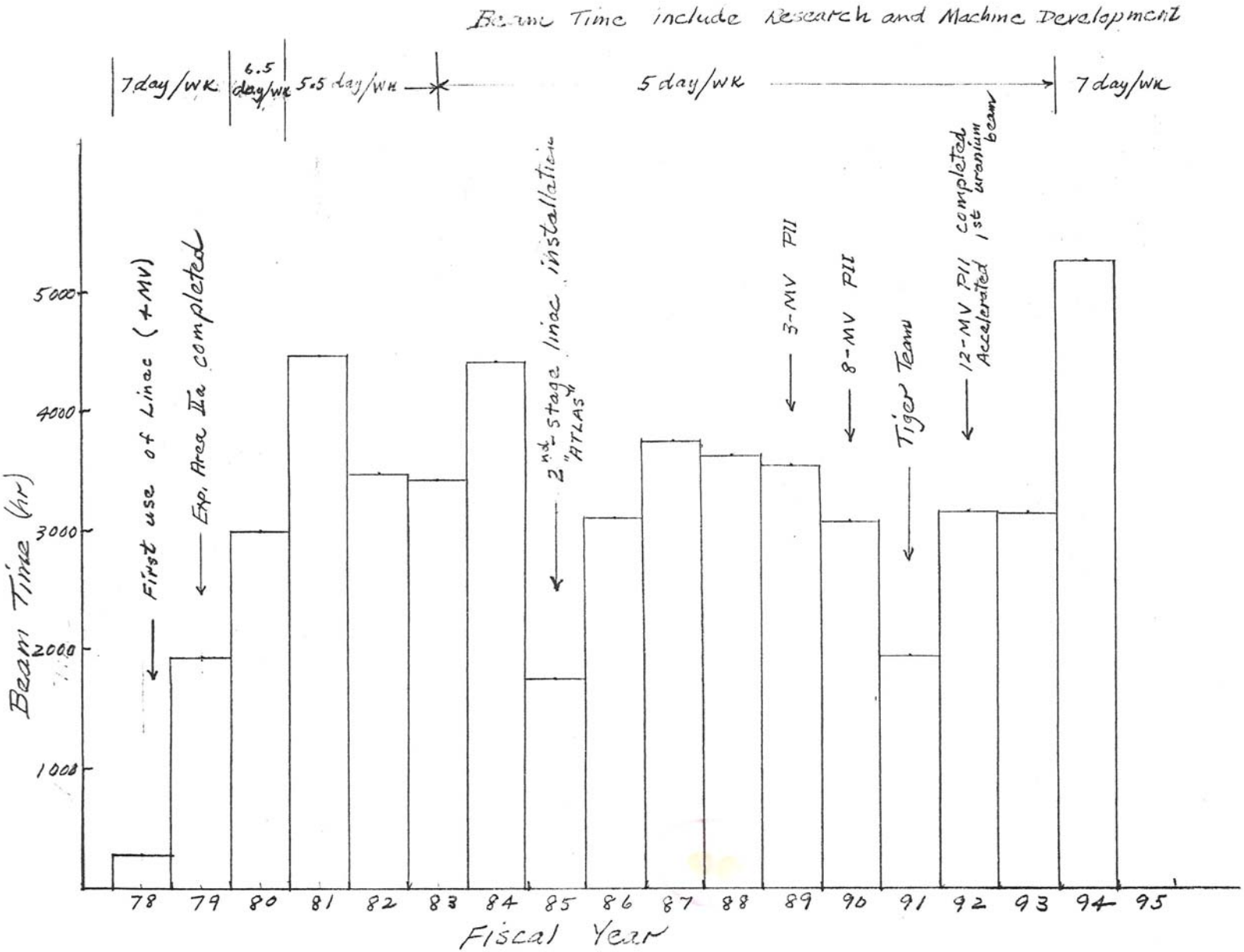
Lowell M. Bollinger

For his contributions to and leadership in the development of the superconducting linear accelerator for the production of high-quality ion beams, a new technology that broadens the base for nuclear structure research."

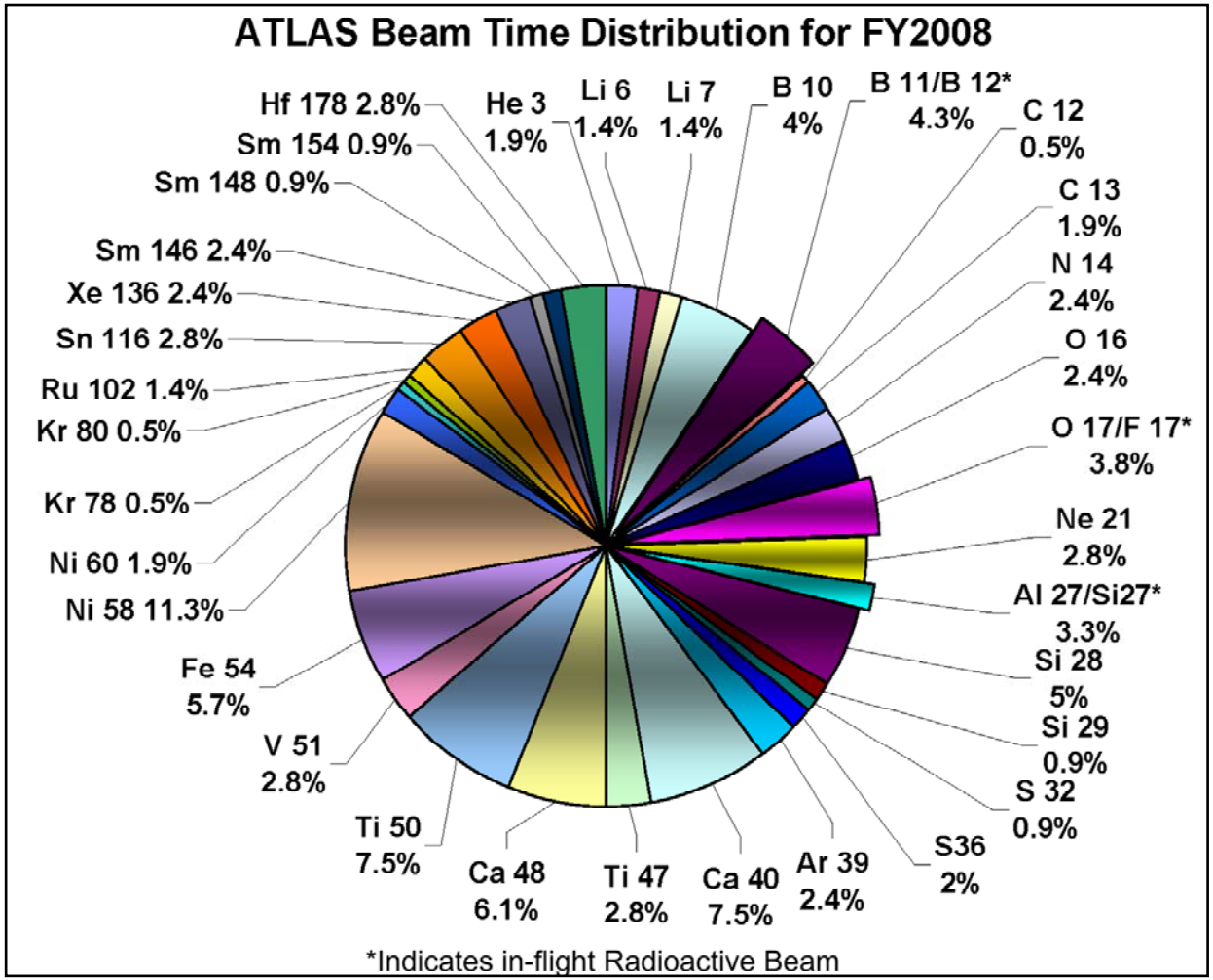
THIRD WORKSHOP ON RF SUPERCONDUCTIVITY
September 14-18, 1987
Argonne National Laboratory
Argonne, Illinois U.S.A.



Bollinger Bash 1993



ATLAS Delivered Beams for FY2008



34 Different Isotopes

***11.6%(650 hours) of beam time for Exotic Beams**

1994 was a record year for ATLAS

The Argonne Tandem Linear Accelerator System (ATLAS) is now accelerating ions for a broad range of physics experiments 24 hours a day, seven days a week, stopping only for holidays.

The Argonne Tandem Linear Accelerator System (ATLAS) set a record for hours of operation in fiscal year 1994, with nearly 5,300 hours of beamtime available for research — a 60 percent increase over 1993.

ATLAS is now accelerating ions for a broad range of physics experiments 24 hours a day, seven days a week, stopping only for holidays.

"It's a big increase in time-on-target," said ATLAS Operations Manager Richard Pardo. "And seven-day operation is much more efficient than starting and stopping once a week." It takes most of a day to restart the machine, a string of magnets and accelerator segments winding almost 500 feet (150 meters) through a maze of large rooms in Building 203.

ATLAS is the world's first heavy-ion accelerator to use superconducting elements for beam focusing and acceleration. Superconducting resonators in ATLAS make a continuous beam possible. Traditional materials would produce too much heat, requiring a pulsed beam to allow the accelerator components to cool between pulses.

Housed in building 203, ATLAS provides nuclear scientists with beams of ions (atoms minus one or more electrons) as heavy as uranium-238 to energies as high as 1.5 billion electron volts. Physicists use the machine to probe the structure of atomic nuclei under extreme conditions by studying the gamma rays and particles emitted when ATLAS beams smash into targets.

The accelerator's flexibility is a strong attraction for researchers interested in medium-energy physics. The device offers hundreds of possible beam energies and combinations.

"At Fermilab, for example, you can have any beam you want, as long as you want protons," Pardo said. "At ATLAS experimenters can ask for neon, tin, gadolinium, all the way up to uranium."

A second, more powerful heavy ion injector has been approved, and construction of some components is under way. The entire project should be completed in about two years.

A user facility, ATLAS was host to 161 scientists from 22 U.S. universities, five national laboratories and 16 foreign institutions in 1994. Twice as much time on the machine has been requested as is available.

— Dave Jacqué

BEAM TEAM — At right, ATLAS operations employees pose for a group photo after their record year.

NEW CONTROLS — Engineering Specialist Iain Tilbrook (PHY) keeps watch on ATLAS with a new control system now being phased in. The "point-and-click" system will eventually replace much of the large rack-mounted array of toggle switches and dials at right, which date back to the late 1970s. (Note the gaps where obsolete equipment has already been removed.) The large monitor shows the status of ATLAS resonators. The operator can adjust beam energies, troubleshoot, or get status messages from almost any element of the accelerator. "Satellite" control stations allow operators to monitor and control ATLAS from several places along the machine's nearly 500-foot (150-meter) length.

Argonne News

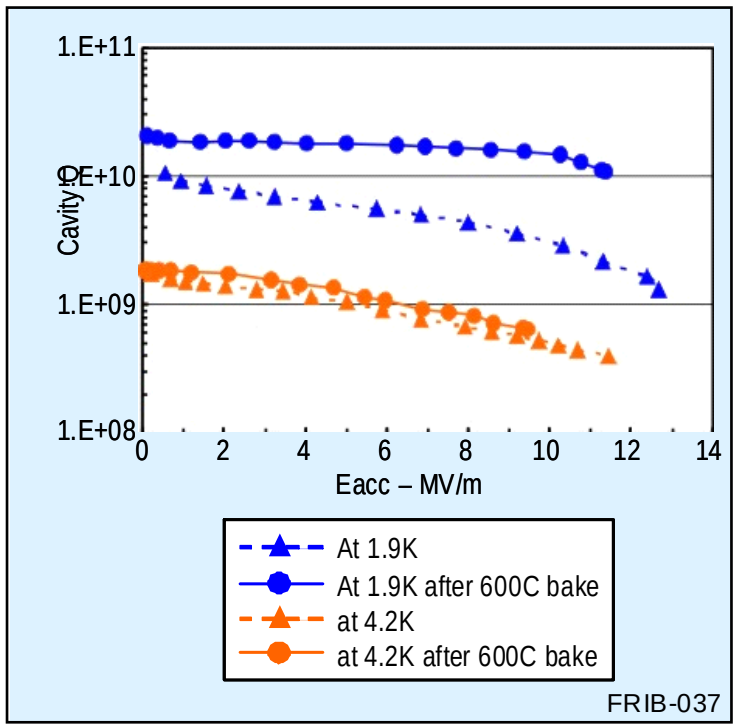
4

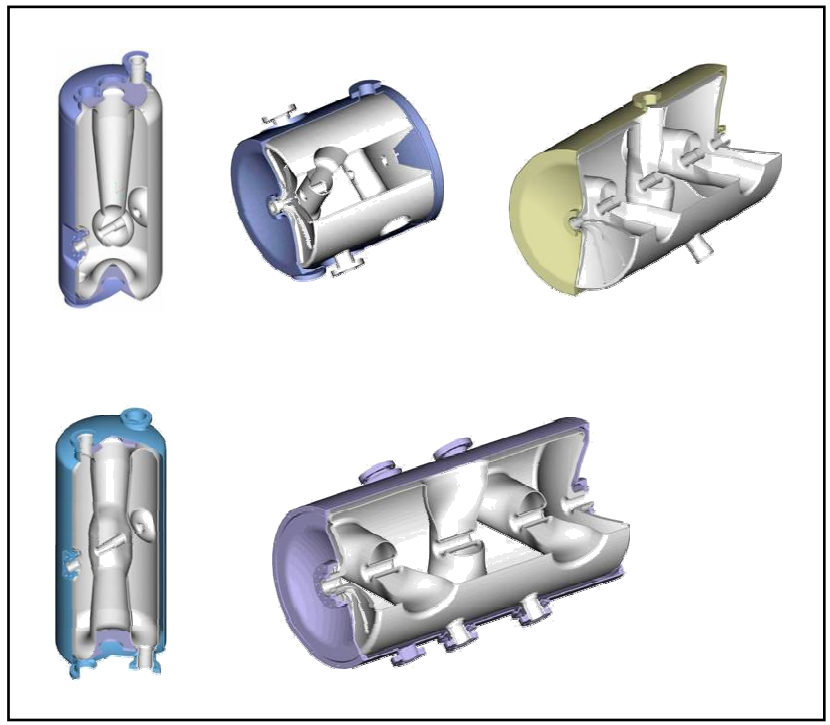
The modern times of HI SRF linacs

- ANL (Jerry Nolen) proposes a SRF proton linac for rare isotope production
- The ANL concept grows to include heavy-ion beams: C/O -> Kr -> Xe -> U by 1999
- RIA R&D

Five Prototyped Cavities for FRIB

- SC cavities covering the velocity range 0.12 < v/c < 0.8 have been developed and tested
- Demonstrated surface processing procedures have reduced refrigeration power consumption by a factor of 2, a 4 MW savings





Superconducting Resonator Processing Facilities

- Joint Argonne/Fermilab surface treatment facility constructed at Argonne
  - A general-purpose facility with chemical polish, electro-polish, high-pressure rinse, and clean assembly capability
- Used for ILC R&D, the ATLAS energy upgrade, FRIB resonator development, ARRA etc.

1994 was a record year for ATLAS

The Argonne Tandem Linear Accelerator System (ATLAS) is now accelerating ions for a broad range of physics experiments 24 hours a day, seven days a week, stopping only for holidays.

The Argonne Tandem Linear Accelerator System (ATLAS) set a record for hours of operation in fiscal year 1994, with nearly 5,300 hours of beamtime available for research — a 60 percent increase over 1993.

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"It's a big increase in time-on-target," said ATLAS Operations Manager Richard Pardo. "And seven-day operation is much more efficient than starting and stopping once a week." It takes most of a day to restart the machine, a string of magnets and accelerator segments winding almost 500 feet (150 meters) through a maze of large rooms in Building 203.

ATLAS is the world's first heavy-ion accelerator to use superconducting elements for beam focusing and acceleration. Superconducting resonators in ATLAS make a continuous beam possible. Traditional materials would produce too much heat, requiring a pulsed beam to allow the accelerator components to cool between pulses.

Housed in building 203, ATLAS provides nuclear scientists with beams of ions (atoms minus one or more electrons) as heavy as uranium-238 to energies as high as 1.5 billion electron volts. Physicists use the machine to probe the structure of atomic nuclei under extreme conditions by studying the gamma rays and particles emitted when ATLAS beams smash into targets.

The accelerator's flexibility is a strong attraction for researchers interested in medium-energy physics. The device offers hundreds of possible beam energies and combinations.

"At Fermilab, for example, you can have any beam you want, as long as you want protons," Pardo said. "At ATLAS experimenters can ask for neon, tin, gadolinium, all the way up to uranium."

A second, more powerful heavy ion injector has been approved, and construction of some components is under way. The entire project should be completed in about two years.

A user facility, ATLAS was host to 161 scientists from 22 U.S. universities, five national laboratories and 16 foreign institutions in 1994. Twice as much time on the machine has been requested as is available.

— Dave Jacqué

BEAM TEAM — At right, ATLAS operations employees pose for a group photo after their record year.

NEW CONTROLS — Engineering Specialist Iain Tilbrook (PHY) keeps watch on ATLAS with a new control system now being phased in. The "point-and-click" system will eventually replace much of the large rack-mounted array of toggle switches and dials at right, which date back to the late 1970s. (Note the gaps where obsolete equipment has already been removed.) The large monitor shows the status of ATLAS resonators. The operator can adjust beam energies, troubleshoot, or get status messages from almost any element of the accelerator. "Satellite" control stations allow operators to monitor and control ATLAS from several places along the machine's nearly 500-foot (150-meter) length.

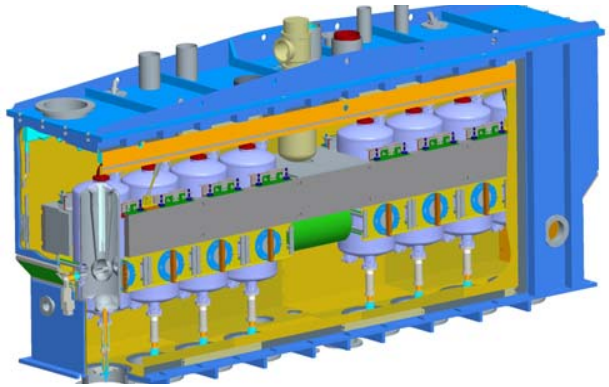
Argonne News

4

The modern times of HI SRF linacs

- ANL (Jerry Nolen) proposes a SRF proton linac for rare isotope production
- The ANL concept grows to include heavy-ion beams: C/O -> Kr -> Xe -> U by 1999
- RIA R&D
- FRIB decision!
- New activities at ANL

ATLAS Energy Upgrade (completed)



ARRA Intensity Upgrade (under construction)

Applications of high-intensity SRF linacs

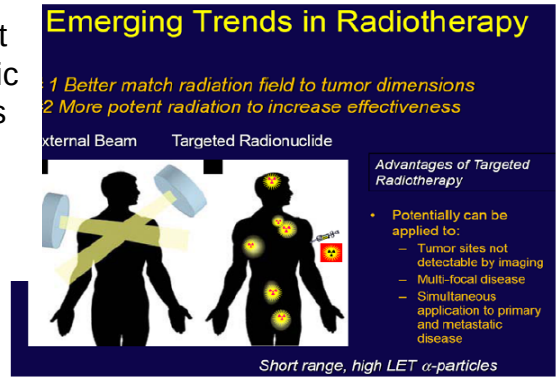
Nuclear Medicine:

Radioisotopes for diagnostics and treatment

- Established diagnostics (e.g., ^{99}Mo, plus... 110 radioisotopes sold by CORAR): critical shortage expected due to aging reactors
- New radioisotopes (e.g., ^{225}Ac, ^{213}Bi...) for research and clinical trials

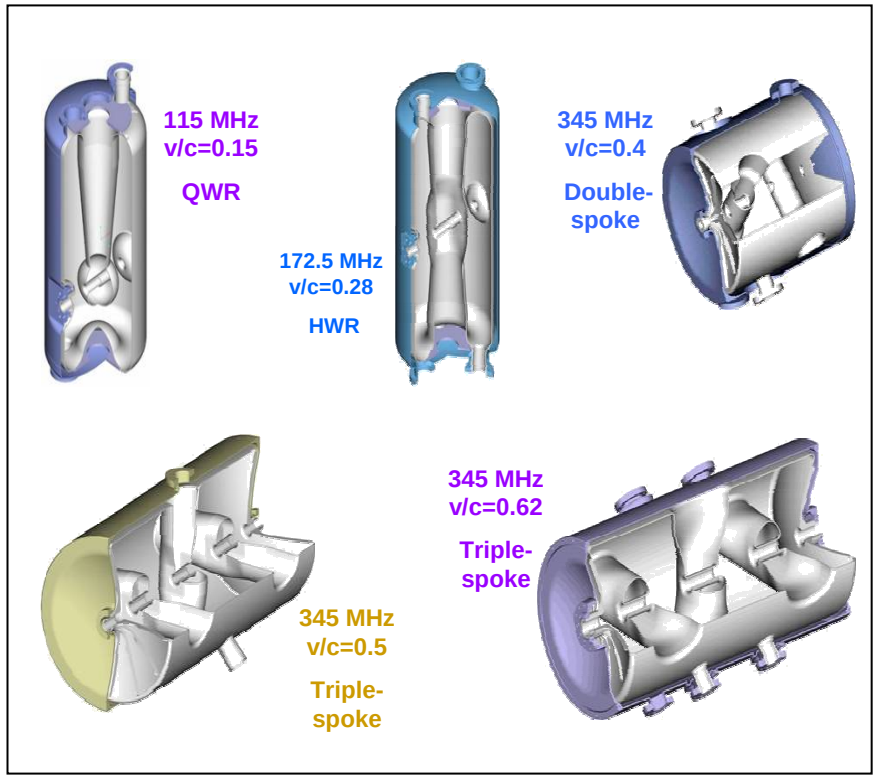
E.g., localized cytotoxicity (pairing short range of alpha particles with cell-specific molecular targeting). Shortage impedes full implementation of targeted radiopharmaceutical therapeutics

[National Cancer Institute, April 2008; DOE/NSAC Isotopes Sub-Committee, www.sc.doe.gov/np/nsac/docs, April 2009].



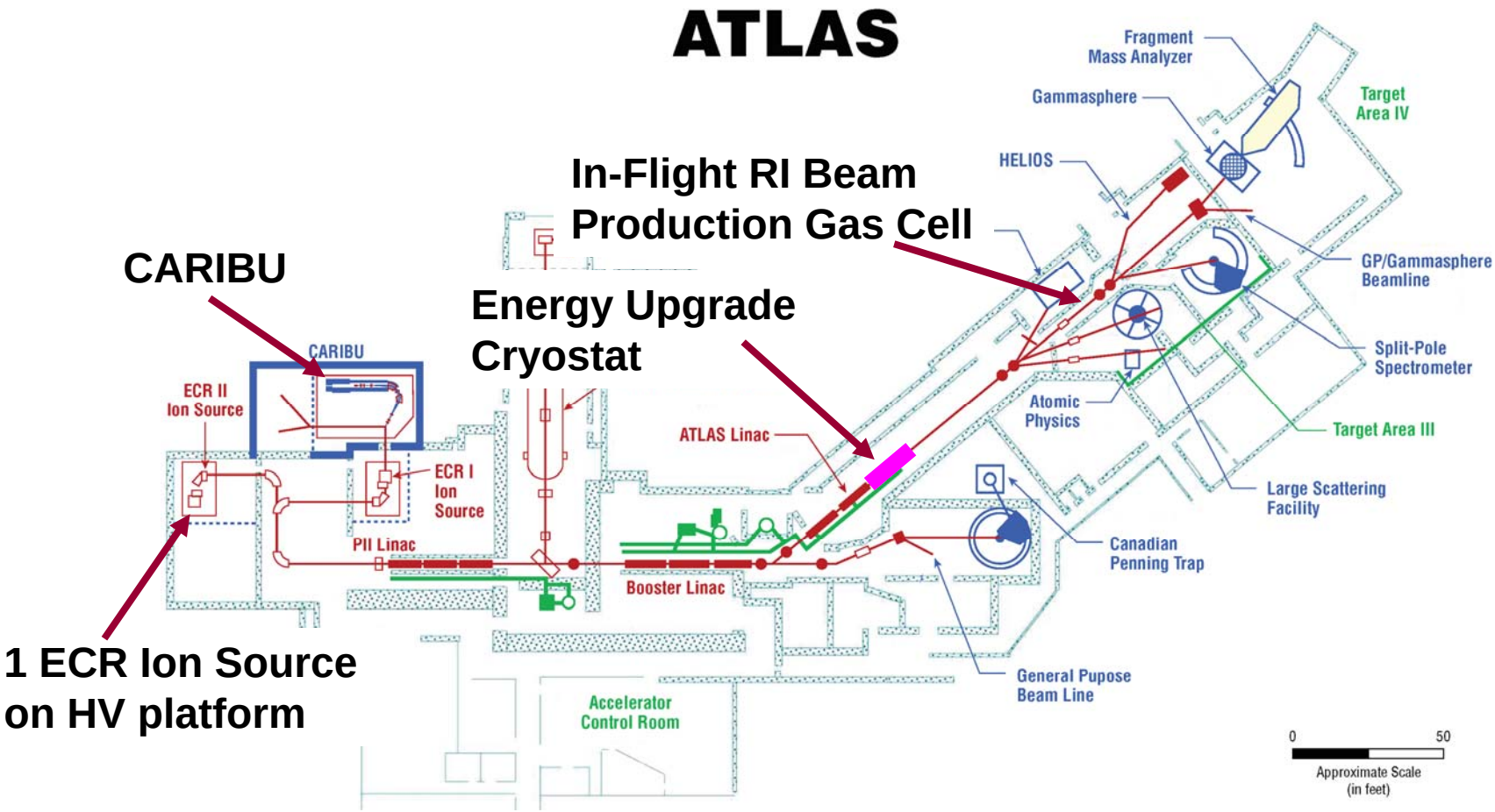
Superconducting Ion-Beam Linacs – Technology for Science and Applications

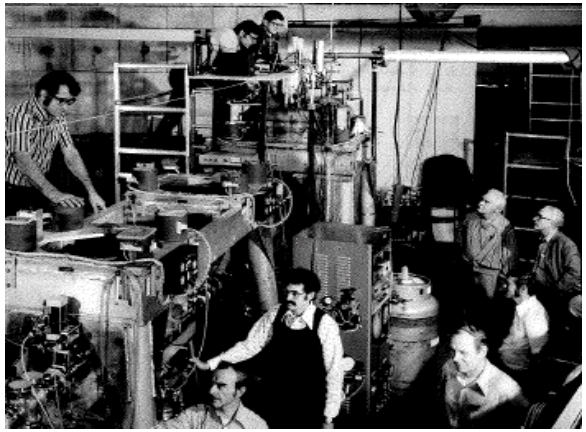
- SRF technology for ion-beam linacs now efficient, reliable, cost-effective
- High-power light-ion (proton) beams for the full MeV to GeV range
- Medium and high beam energies require excellent cavity performance (Q, E_{acc}, B_{surf}, ...)
- Use of SRF linacs well-established in scientific research
- Less so for applications in the private sector and industry

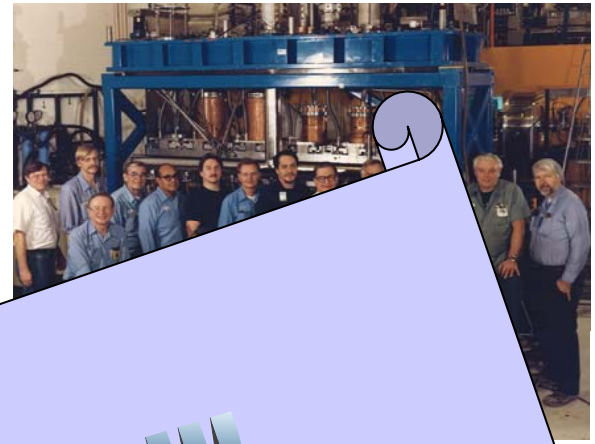


ATLAS: A National User Facility for Low-Energy Heavy-Ion Research

World's First Superconducting Accelerator for Ions












Happy Anniversary !!!