Present Trends for Electrostatic Accelerators (The Pelletron)

National Electrostatics Corp

Greg Norton

In the beginning

A NU

14UD

JAEA-Tokai

20UR

ORNL – USA

25URC

(World's highest voltage)

Materials Modification

- 1970's ⟶ 1980's: Production MeV Implantation
  - Higher Current (Throughput)
  - Complete System: Not just an accelerator
  - 8 sold 1981-1985

- Now:
  - •Axcelis, Varian (production systems)
  - •NEC: research systems (>50 10kV raster scanners)

Materials Analysis

- 1980's ⟶ Present: Materials Analysis
  - RBS, ERD, NRA, channeling, PIXE, uRBS uPIXE
  - Computer Control
  - True Unattended Operation

Analysis – software

Analysis – hardware

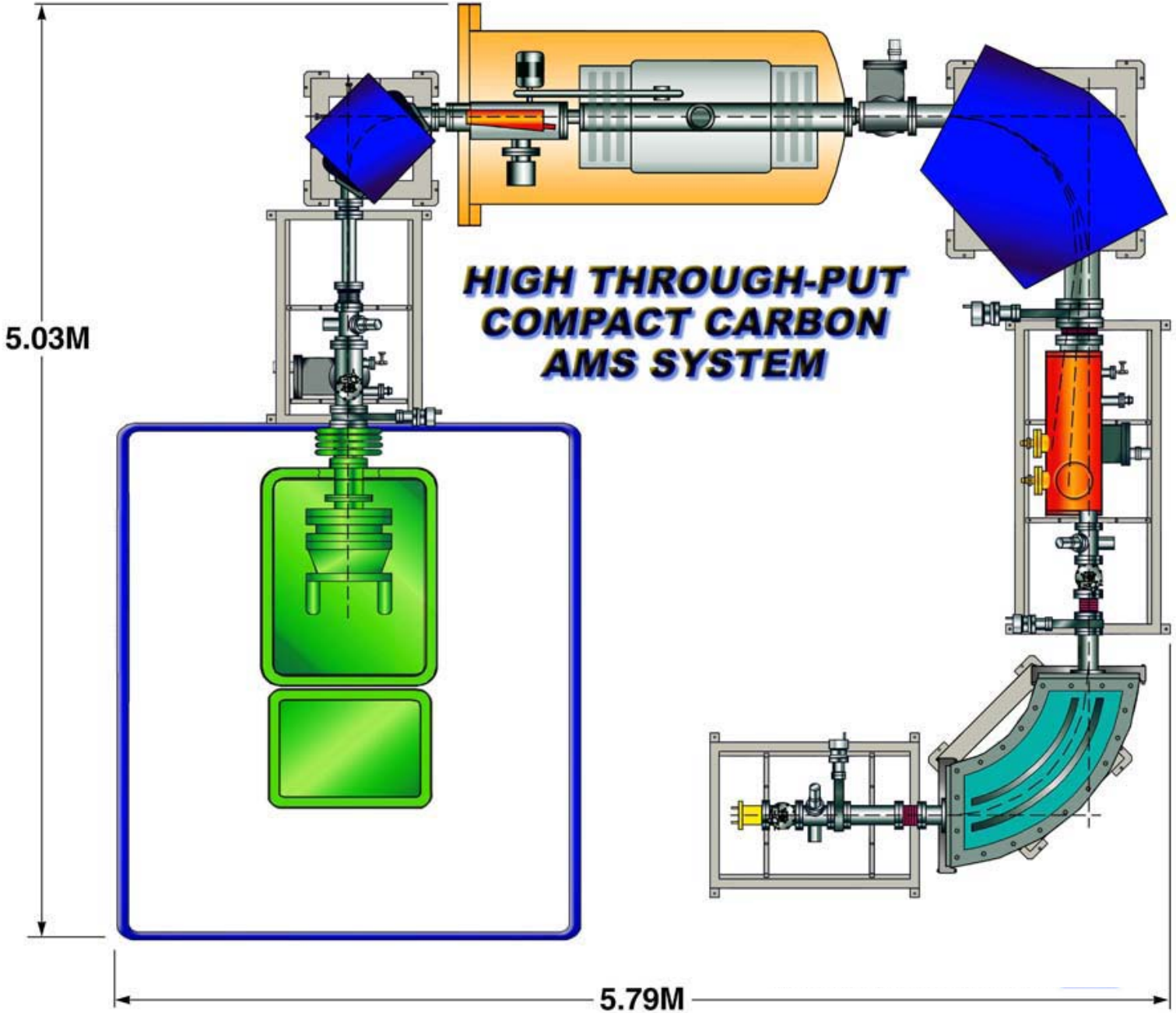
1MV to 3MV tandems with
Analysis End Stations

Now:
~50 Labs with microprobes

29 NEC Labs:
•10 NEC lens (10-20u)
•5 Melbourne
•5 Oxford
•9 Others

Radio Isotope Ratio Measurement

- 1990's ⟶ Present: Accelerator Mass Spectrometry (AMS)
  - Radio Isotope Ratio Measurement
  - Be, C, Al, Ca, Cl, I, actinides and others
  - Isotope Level Resolution
  - Beam scattering concerns
  - Equilibrium stripping
  - Fast and comprehensive parameter storage and control
- Biggest Impact on Accelerator Configuration
- Still a growing set of Applications


HIGH THROUGH-PUT
COMPACT CARBON
AMS SYSTEM
5.03M
5.79M

Applications for a Subset of AMS - Carbon

- Human dispersal
- Dietary habits of early man
- Age of corals
- Age of lava flows
- Extinctions
- Life span of marine organism
- Discover of the America's
- Chronology of ancient Egypt
- Study of the fossil record
- Global fallout studies
- Rise of atmospheric methane
- Rise of rice cultivation
- Rise of the iron age
- Paleoclimate changes
- 20th century global warming
- Details of ancient societies
- Bioindicators of occupational health
- Nuclear power - radiopollution

Radiocarbon 2009

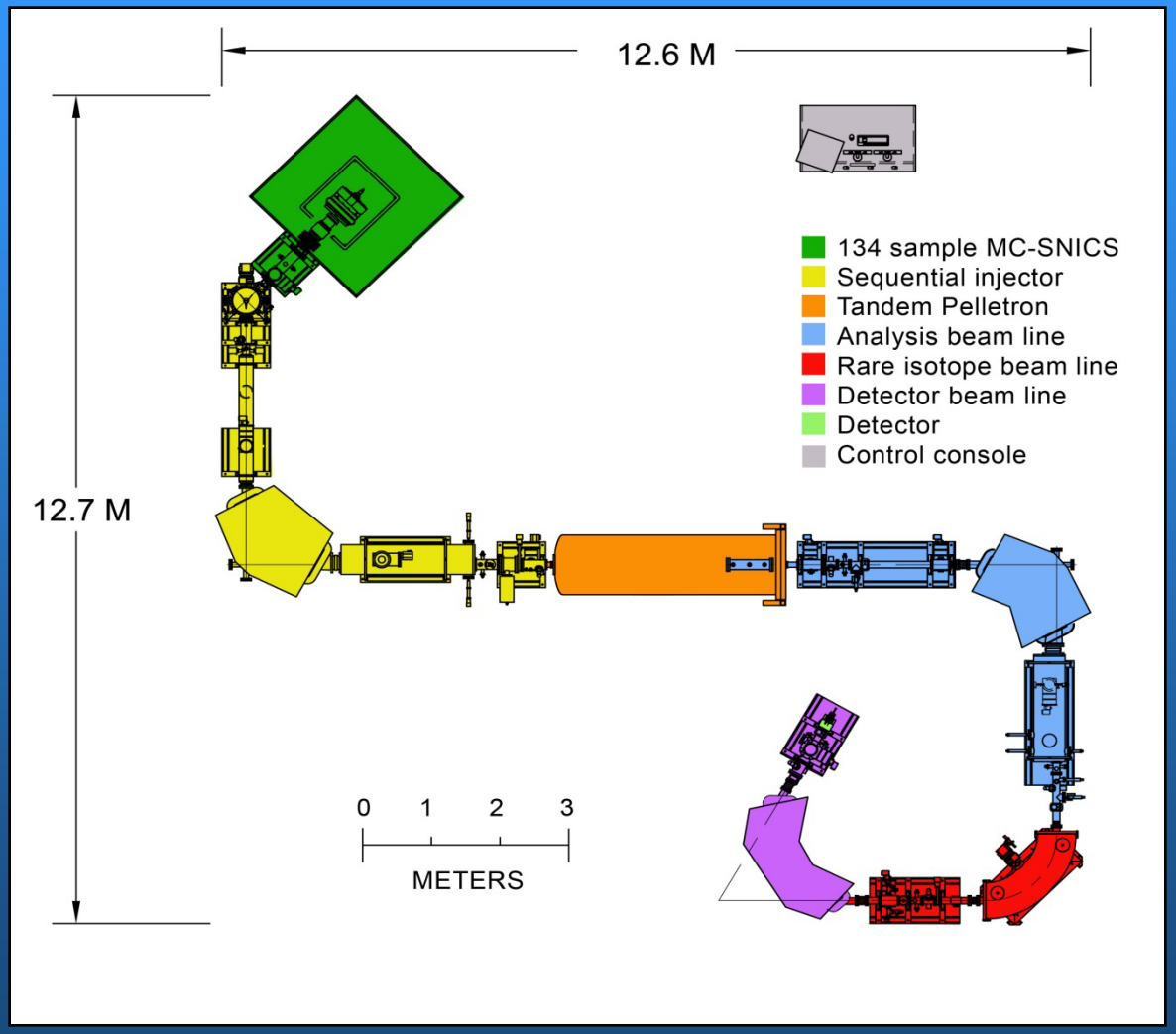
May 31 – June 5, 2009

Hawaii

Present Projects

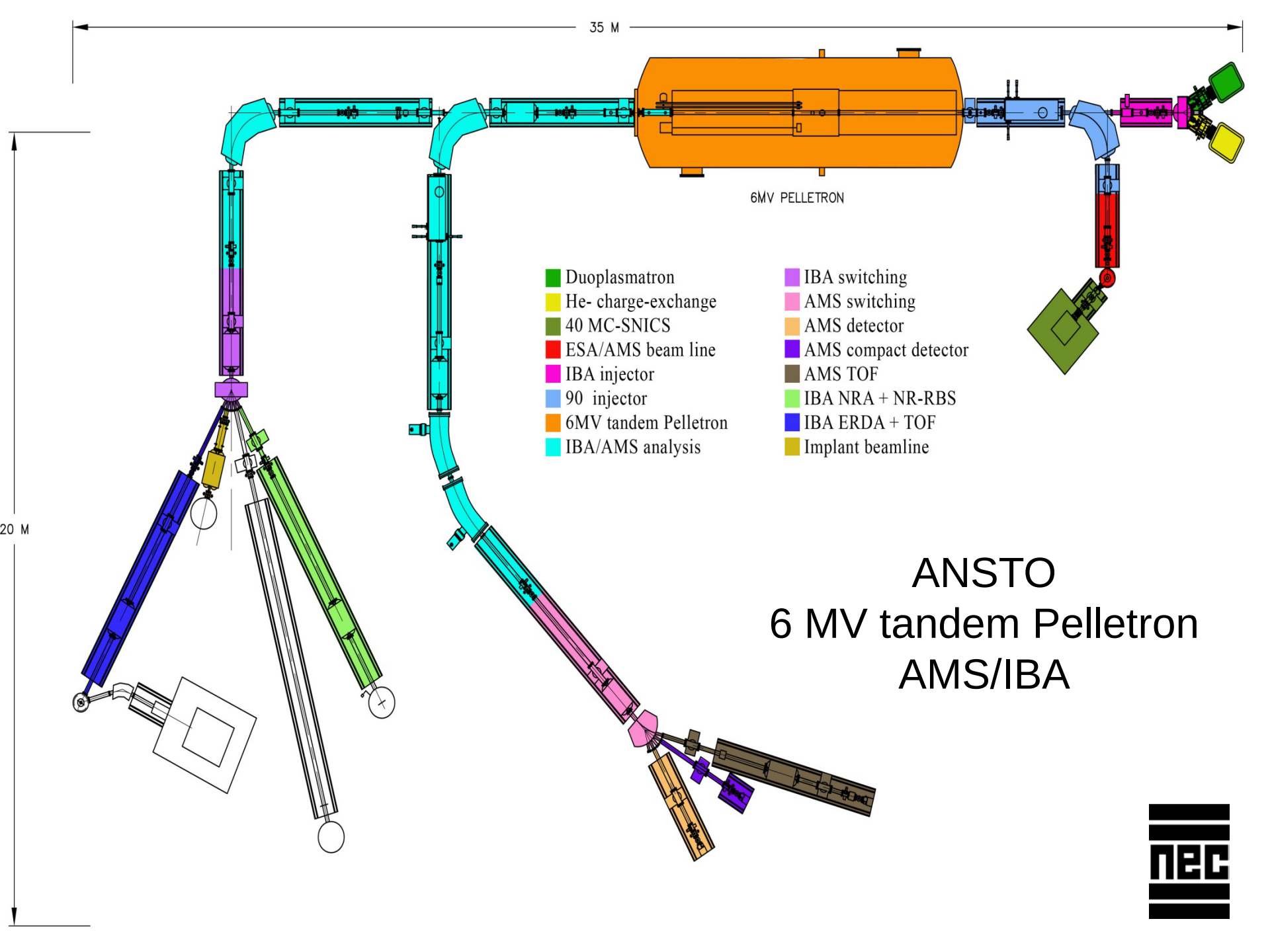
- AMS – 14 projects (6 carbon only)
  - 2 major upgrades + partial system
  - 11 complete systems

Actinide AMS
ANSTO

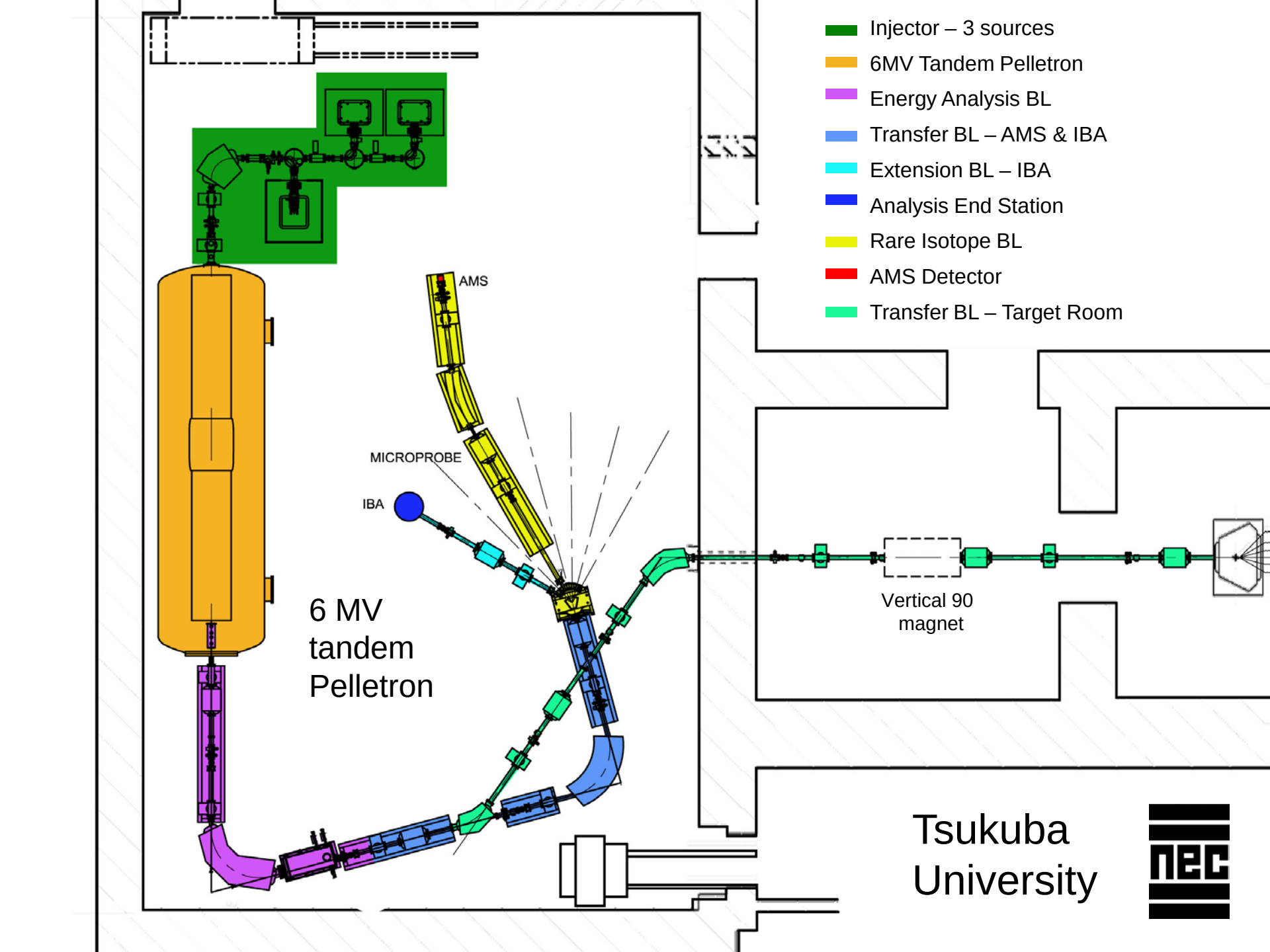


Simultaneous measurement of six ratio isotope ratios

All magnetic elements biased



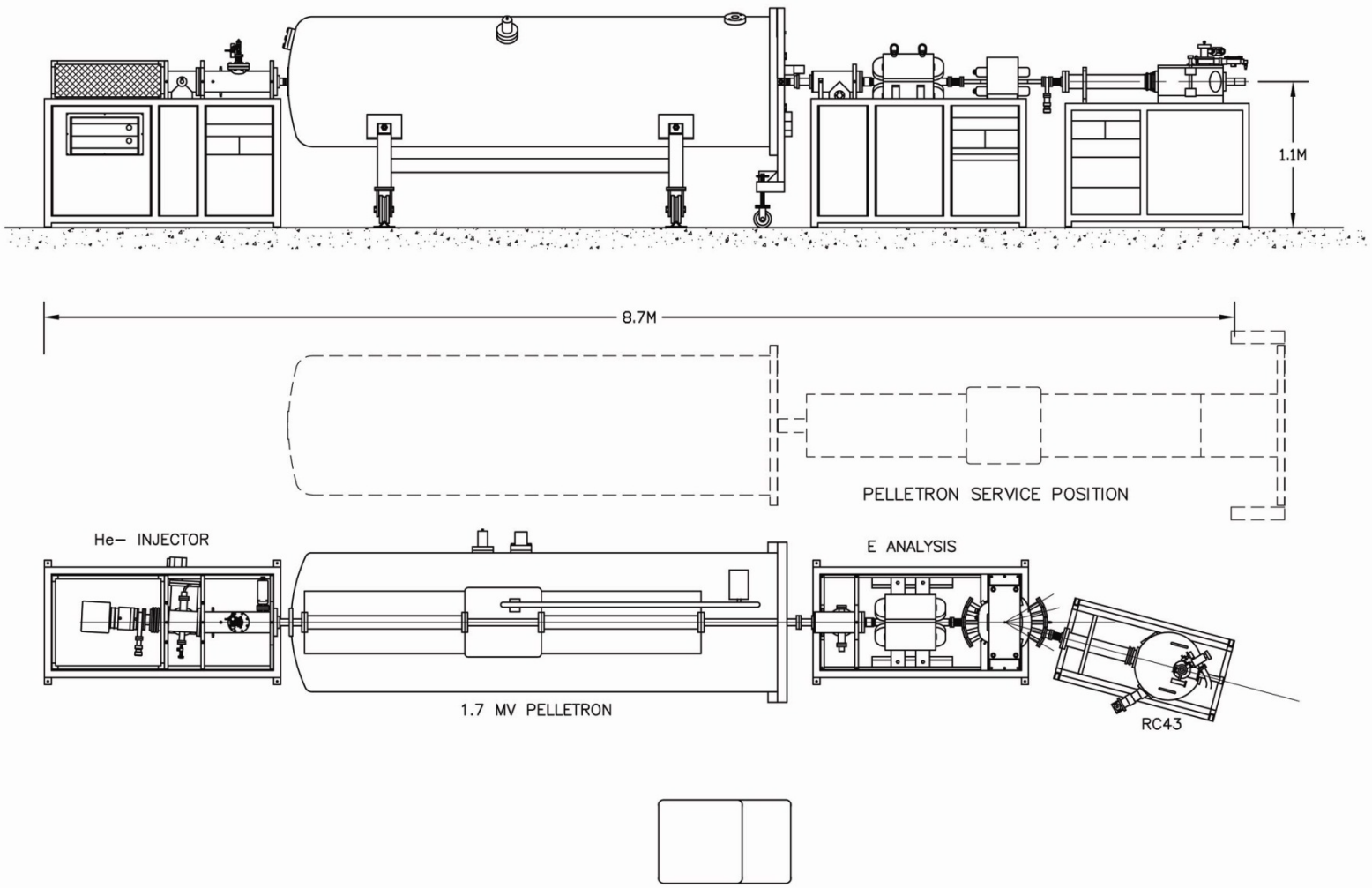
ANSTO
6 MV tandem Pelletron
AMS/IBA


Injector – 3 sources
6MV Tandem Pelletron
Energy Analysis BL
Transfer BL – AMS & IBA
Extension BL – IBA
Analysis End Station
Rare Isotope BL
AMS Detector
Transfer BL – Target Room
AMS
MICROPROBE
IBA
6 MV
tandem
Pelletron
Vertical 90
magnet
Tsukuba
University

Present Projects

- AMS – 14 projects (6 carbon only)
  - 2 major upgrades + partial system
  - 11 complete systems

- IBA (RBS, PIXE) – 4 complete systems

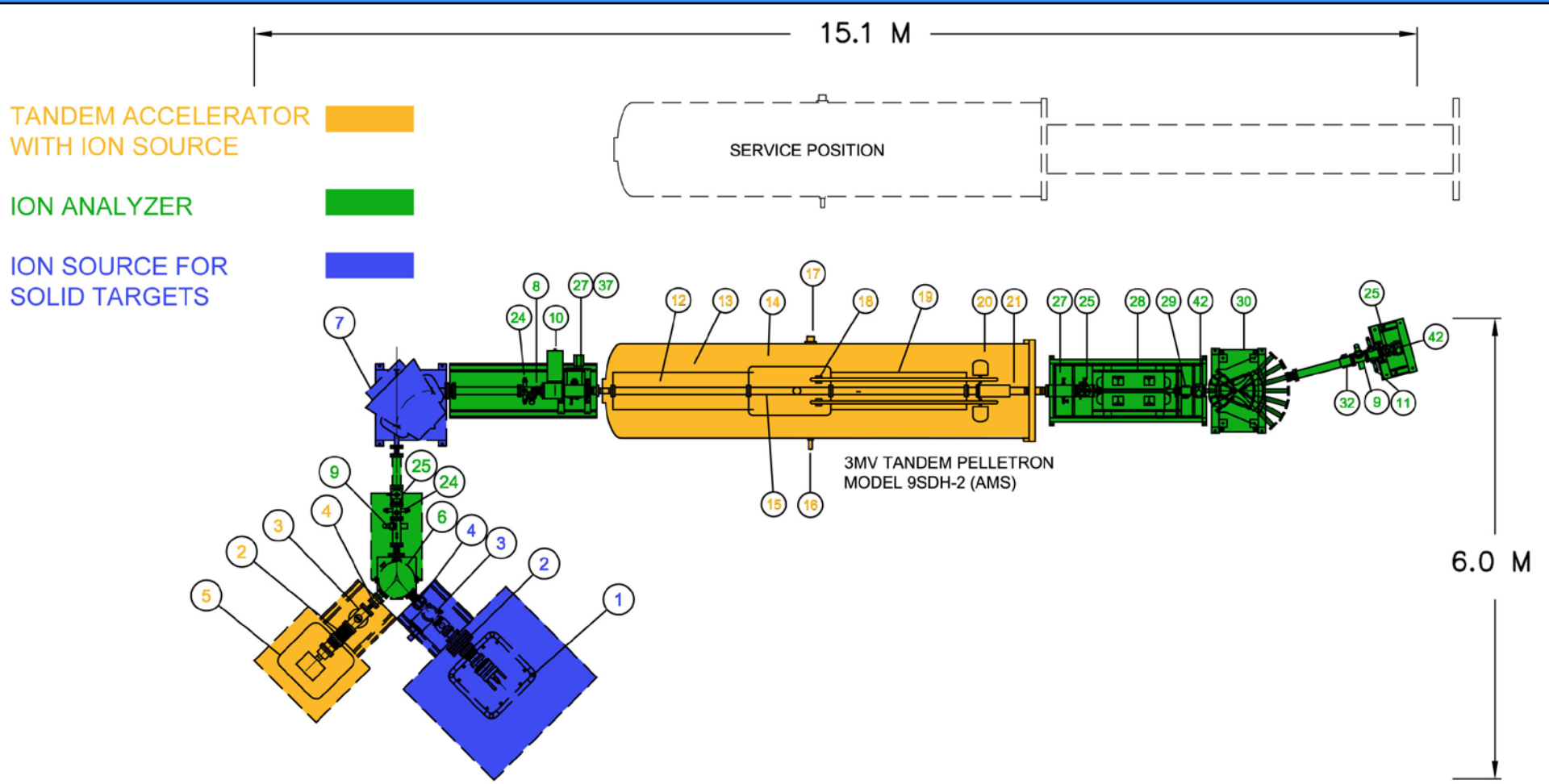


ION SOURCE IS AT HIGH VOLTAGE IN OPEN AIR. THEREFORE, HUMIDITY AND DUST MUST BE CONTROLLED.

DUST: FLOORS, WALLS AND CEILING SHOULD BE SEALED.
HUMIDITY: DEW POINT NOT TO EXCEED 15°C.
OPERATING TEMPERATURE: 15° TO 26°C.

1 Meter

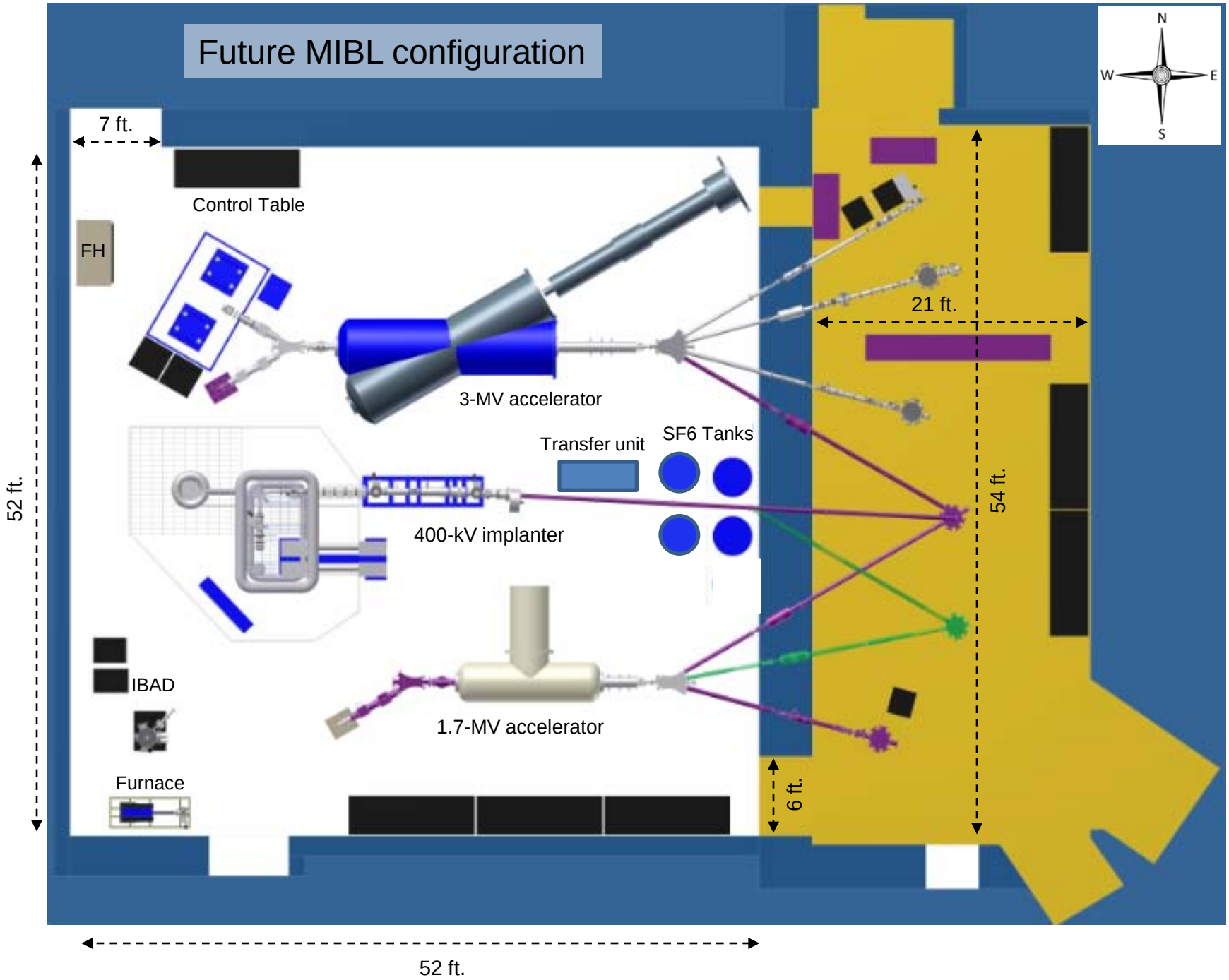
Tandem Pelletron Accelerator RBS

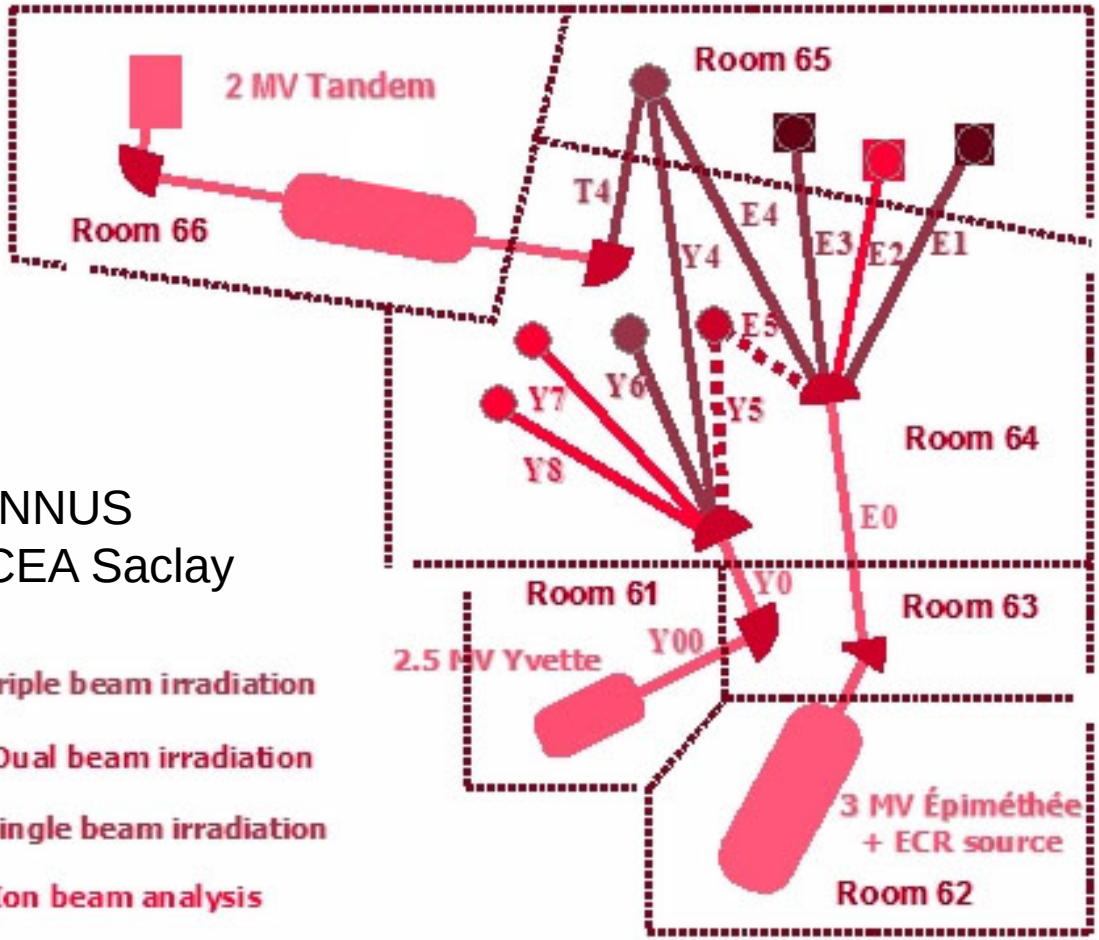

15.1 M
TANDEM ACCELERATOR WITH ION SOURCE
ION ANALYZER
ION SOURCE FOR SOLID TARGETS
SERVICE POSITION
3MV TANDEM PELLETRON
MODEL 9SDH-2 (AMS)
6.0 M

Present Projects

- AMS – 14 projects (6 carbon only)
  - 2 major upgrades + partial system
  - 11 complete systems

- IBA (RBS, PIXE) – 4 complete systems
- Damage Studies (triple beam) – 2 complete systems


Future MIBL configuration
7 ft.
Control Table
FH
3-MV accelerator
Transfer unit
SF6 Tanks
400-kV implanter
IBAD
1.7-MV accelerator
Furnace
21 ft.
54 ft.
6 ft.
52 ft.
52 ft.
N
W
E
S


2 MV Tandem
Room 65
Room 66
T4
E4
E3
E2
E1
Y4
E5
Y6
Y7
Y5
Y8
Room 64
E0
Y0
Room 61
Room 63
Y00
2.5 MV Yvette
3 MV Épiméthée
+ ECR source
Room 62
JANNUS
CEA Saclay
Triple beam irradiation
Dual beam irradiation
Single beam irradiation
Ion beam analysis

Present Projects

- AMS – 14 projects (6 carbon only)
  - 2 major upgrades + partial system
  - 11 complete systems

- IBA (RBS, PIXE) – 4 complete systems
- Damage Studies (triple beam) – 2 complete systems

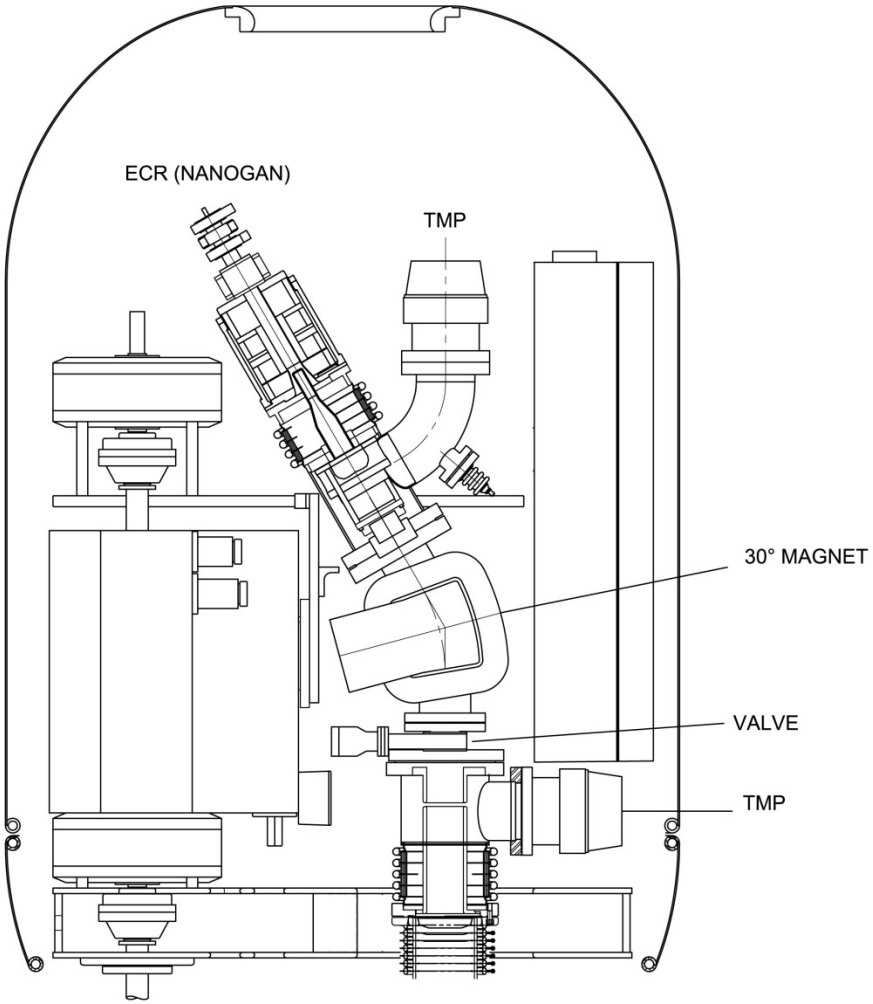
- High Charge State Positive Ions– 2 complete systems
  - Reverse Kinematics Astrophysics

Vertical Single Ended 5 MV Pelletron University of Notre Dame

- ECR Source in Terminal – high charge state positive ions

- Nuclear Astro Physics: stellar reactions
- Proton and Alpha reactions with heavy ions
- Reverse kinematics: H and He targets
- Near Coulomb barrier: low cross sections

5MV Terminal Pelletron Model 5U-4



	Beam particle current (microA)	Beam energy 5MV (MeV)
H^{+}	600	5
He^{+}	600	5
He^{++}	200	10
C^{+4}	10	20
O^{+5}	15	25
Ar^{+7}	7	35
Fe^{+8}	2.5	40
Ni^{+8}	1.0	40
Kr^{+10}	1.5	50
Xe^{+8}	6.5	40

(partial list)

Notre Dame
5U-4 Pelletron

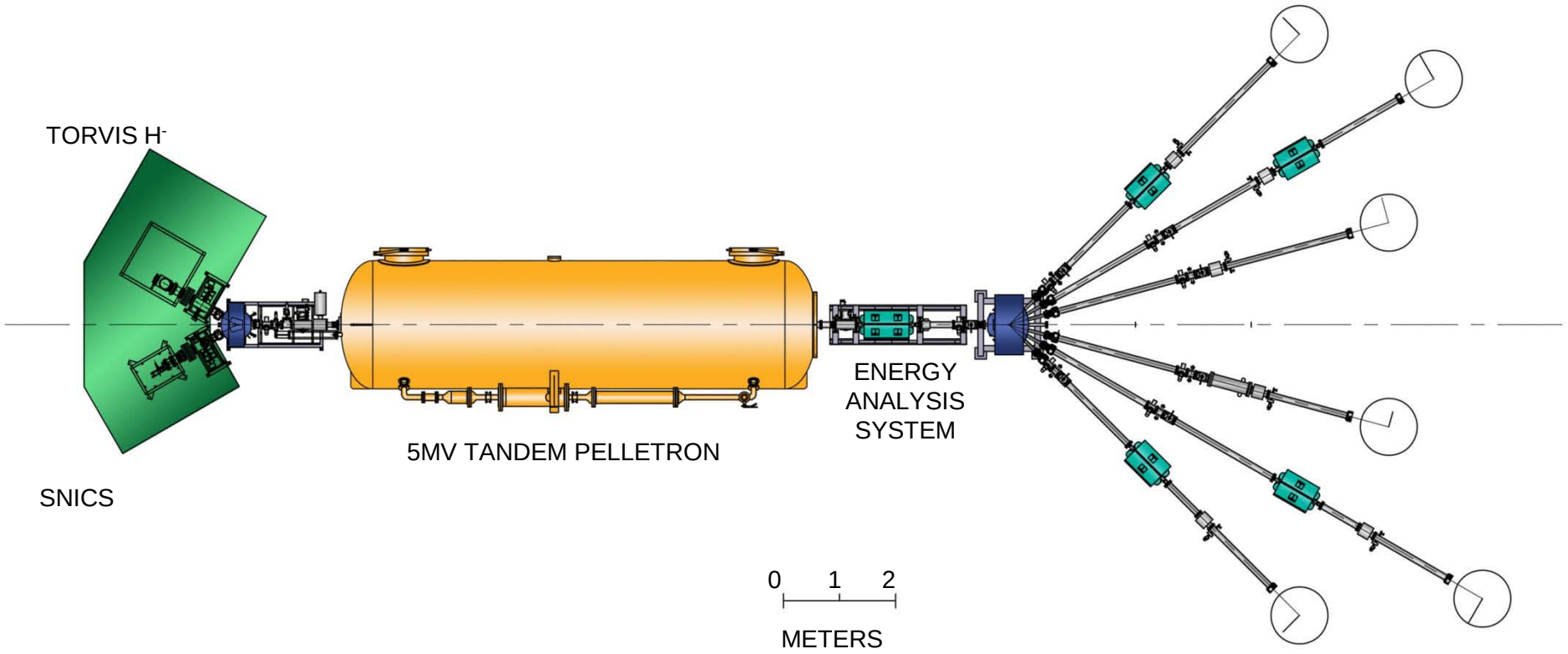
Present Projects

- AMS – 14 projects (6 carbon only)
  - 2 major upgrades + partial system
  - 11 complete systems

- IBA (RBS, PIXE) – 4 complete systems
- Damage Studies (triple beam) – 2 complete systems

- High Charge State Positive Ions– 2 complete systems
  - Reverse Kinematics Astrophysics

- Chemistry – 1 complete system



University of Manchester

Dalton Nuclear Institute

Dalton Nuclear Institute

- Horizontal Tandem, High Current H^- and He^- source
  Heavy ion source

- Nuclear Chemistry – Chemical reactions induced by ionizing radiation

- Beam Test:

H^+	100 microA	at 5MV
He^{++}	15 microA	at 5MV
C^{+6}	0.15microA	at 5MV

Present Projects

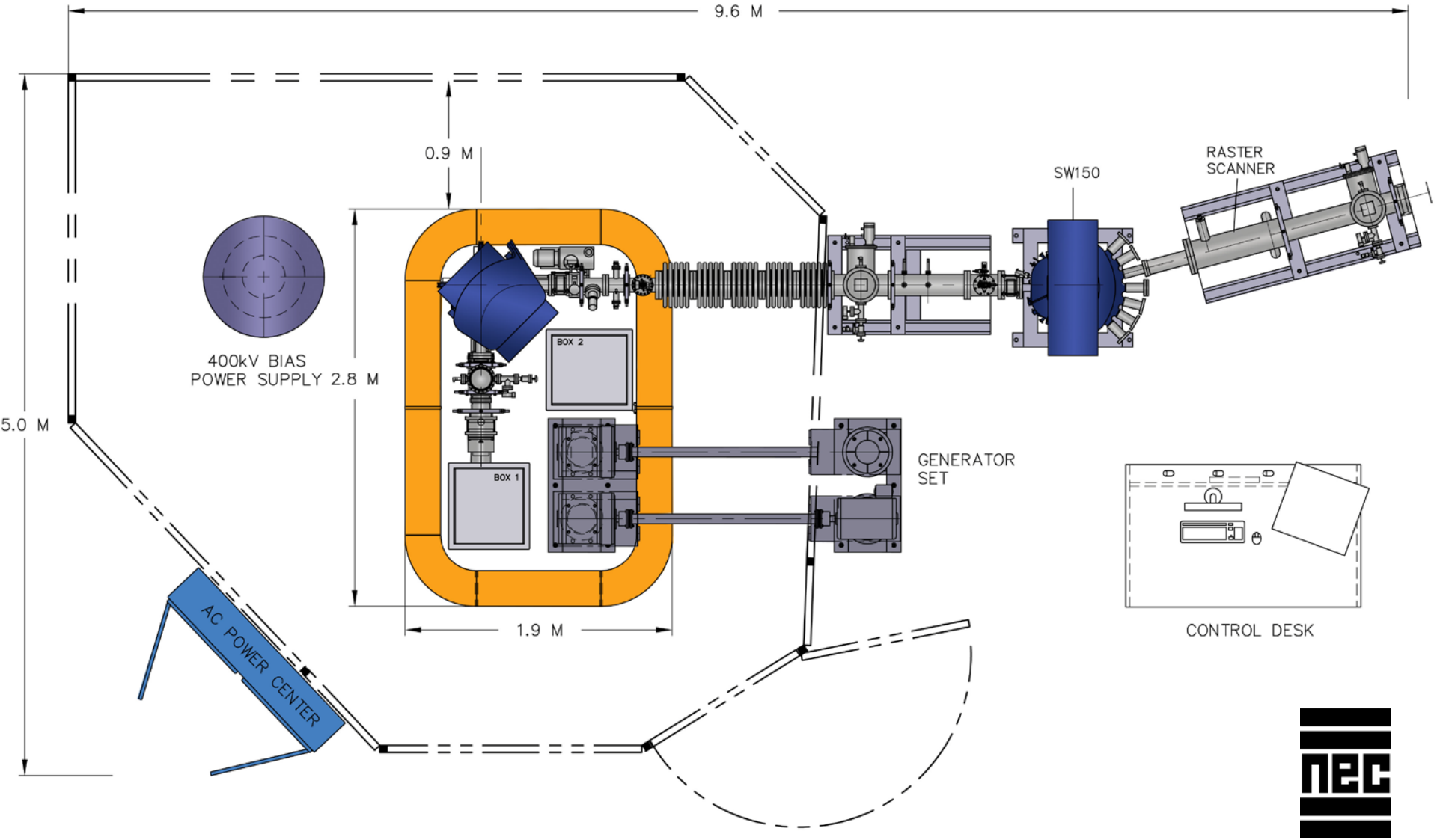
- AMS – 14 projects (6 carbon only)
  - 2 major upgrades + partial system
  - 11 complete systems

- IBA (RBS, PIXE) – 4 complete systems
- Damage Studies (triple beam) – 2 complete systems

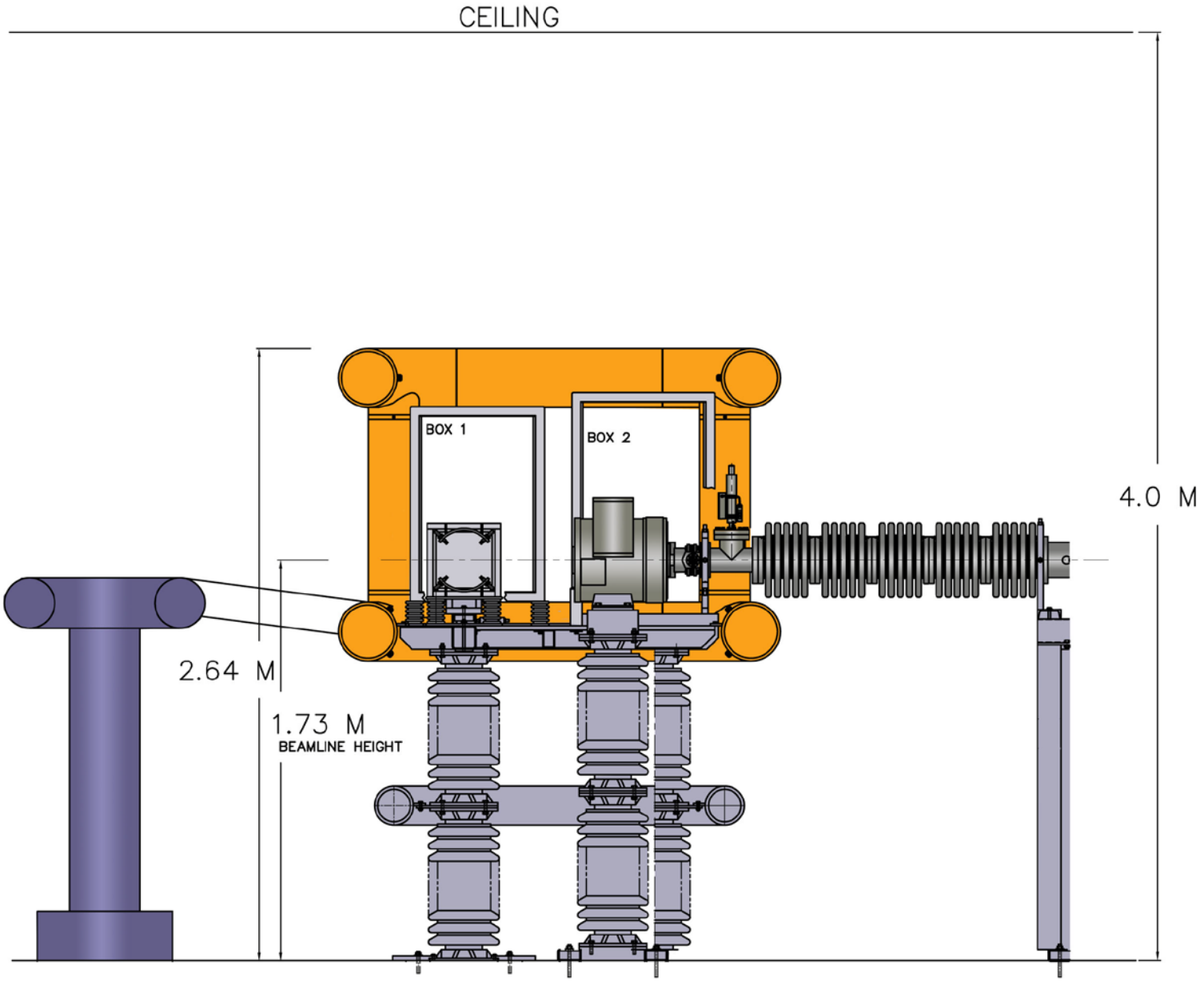
- High Charge State Positive Ions– 2 complete systems
  - Reverse Kinematics Astrophysics

- Chemistry – 1 complete system
- Implanter – 1 complete system

Proposed 400keV Ion Implanter



Proposed 400keV Ion Implanter



Beam Tests at University of Michigan

- H^+ 400keV 25microA (50)
- He^+ 400keV 15microA
- O^+ 10keV 10microA
- O^+ 400keV 50microA
- Si^+ 400keV 30microA
- Ne^+ 400keV 100microA
- Ar^+ 10keV 20microA
- Ar^+ 400keV 100microA
- Co^+ 400keV 50microA

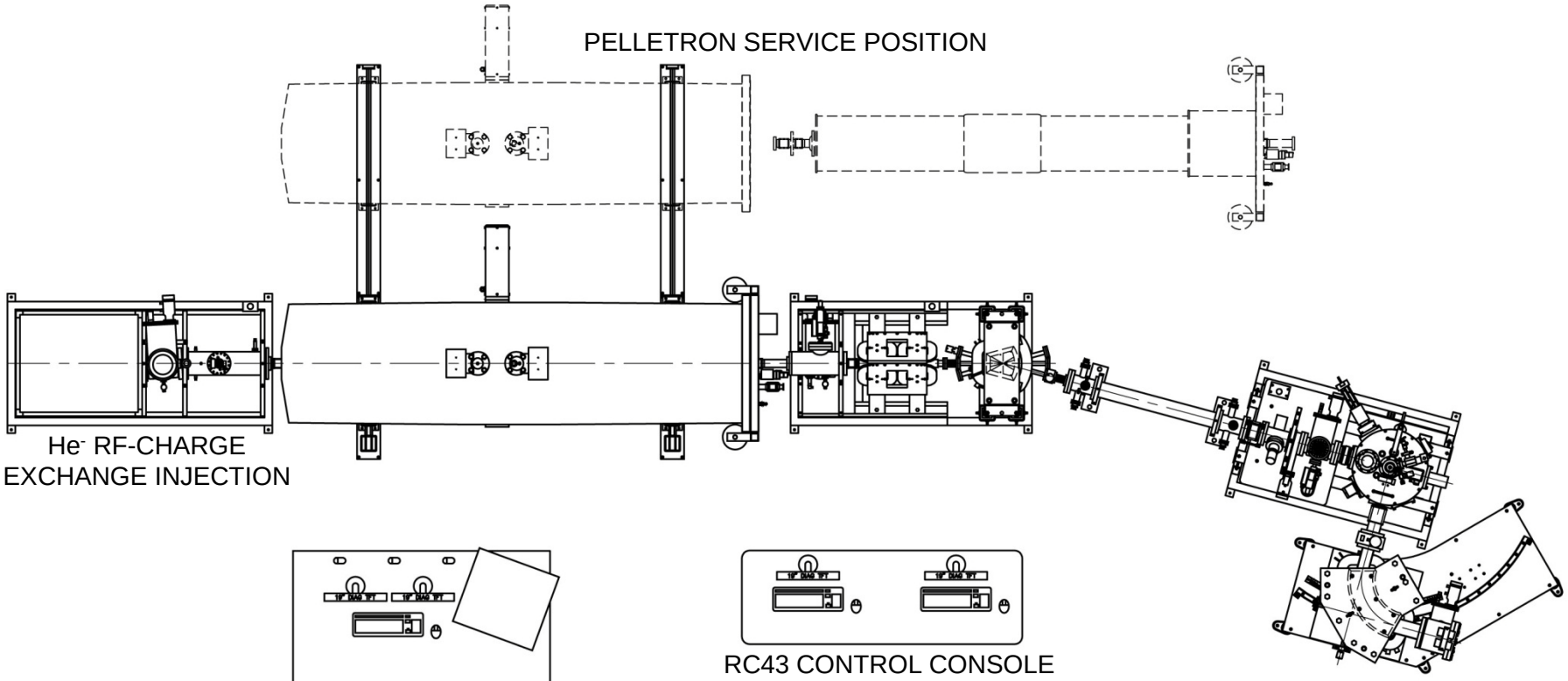
Present Projects

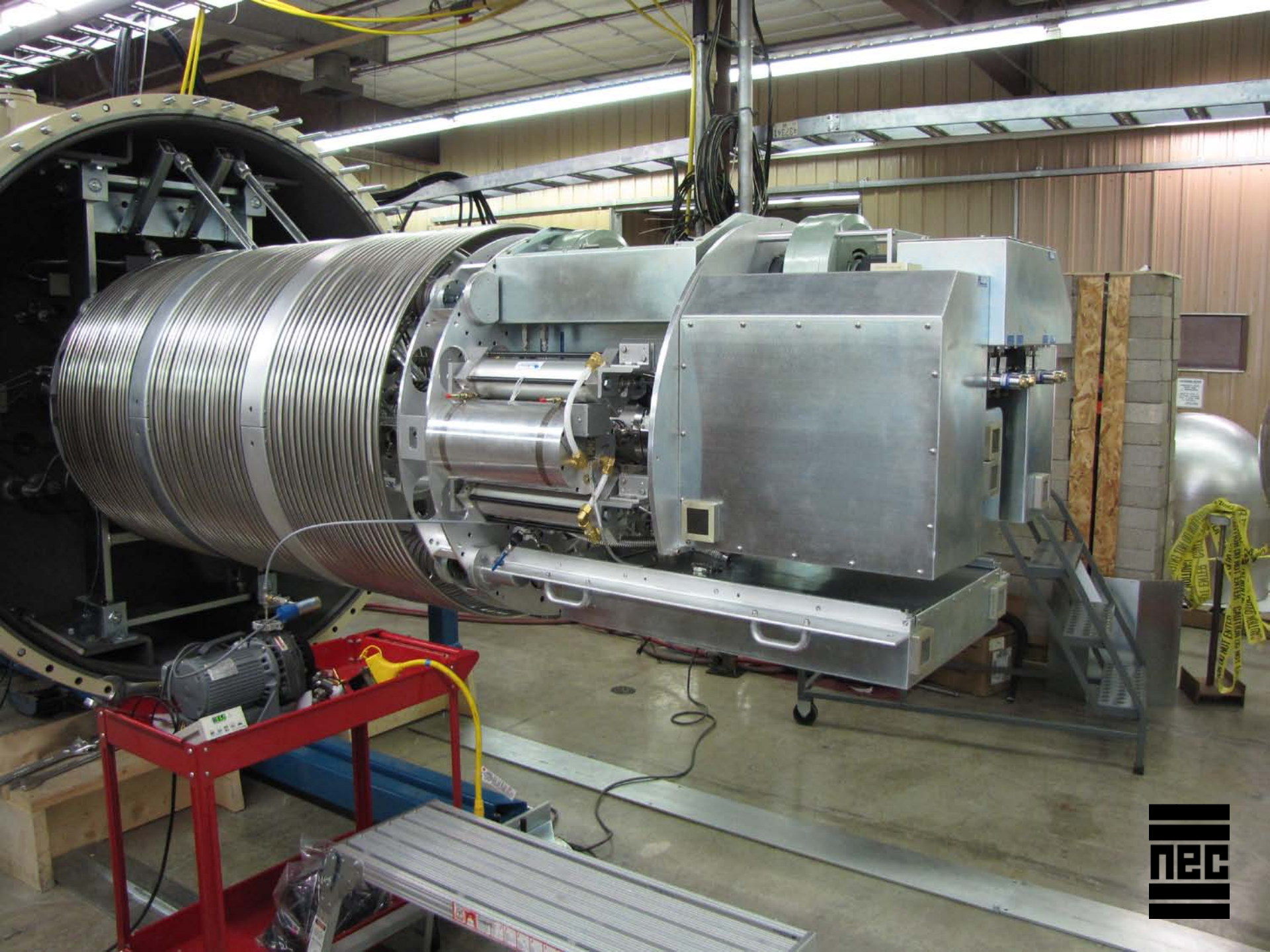
- And
  - Compressed geometry tube for the 20UD at CNEA, Argentina
  - EN chain conversion Bruyeres le Chatel France

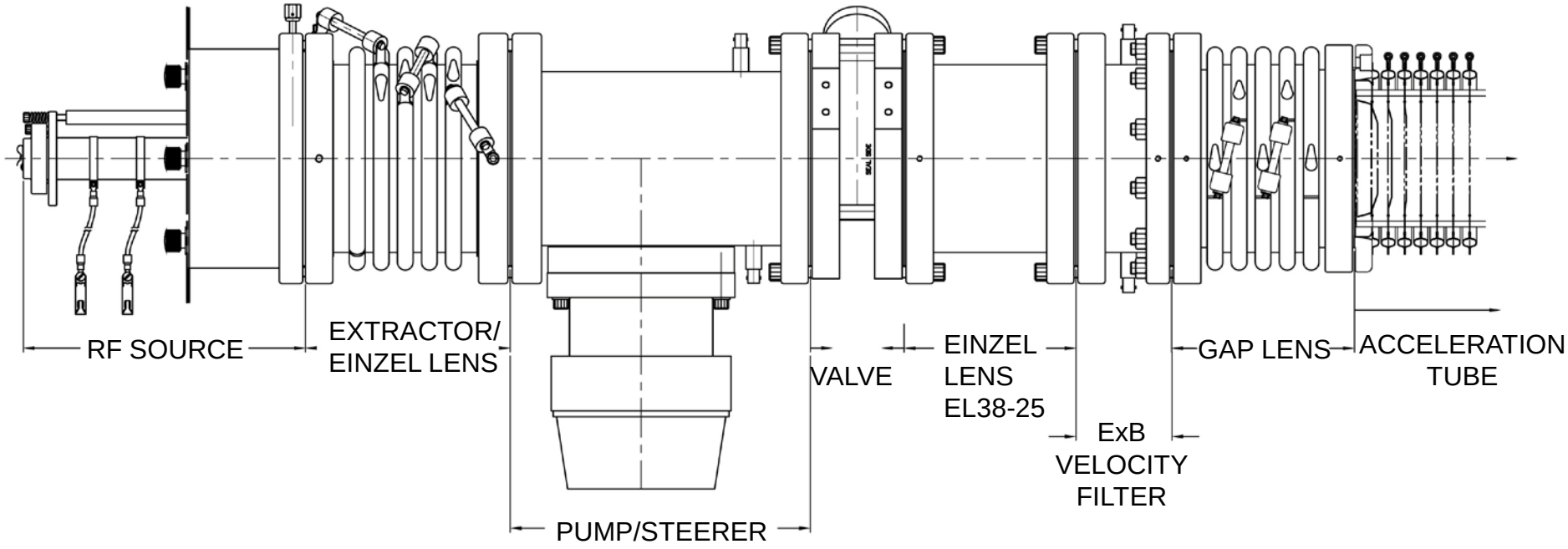
Future

- Demand is strong for the foreseeable future
- Applications driven – complete systems

Thank You

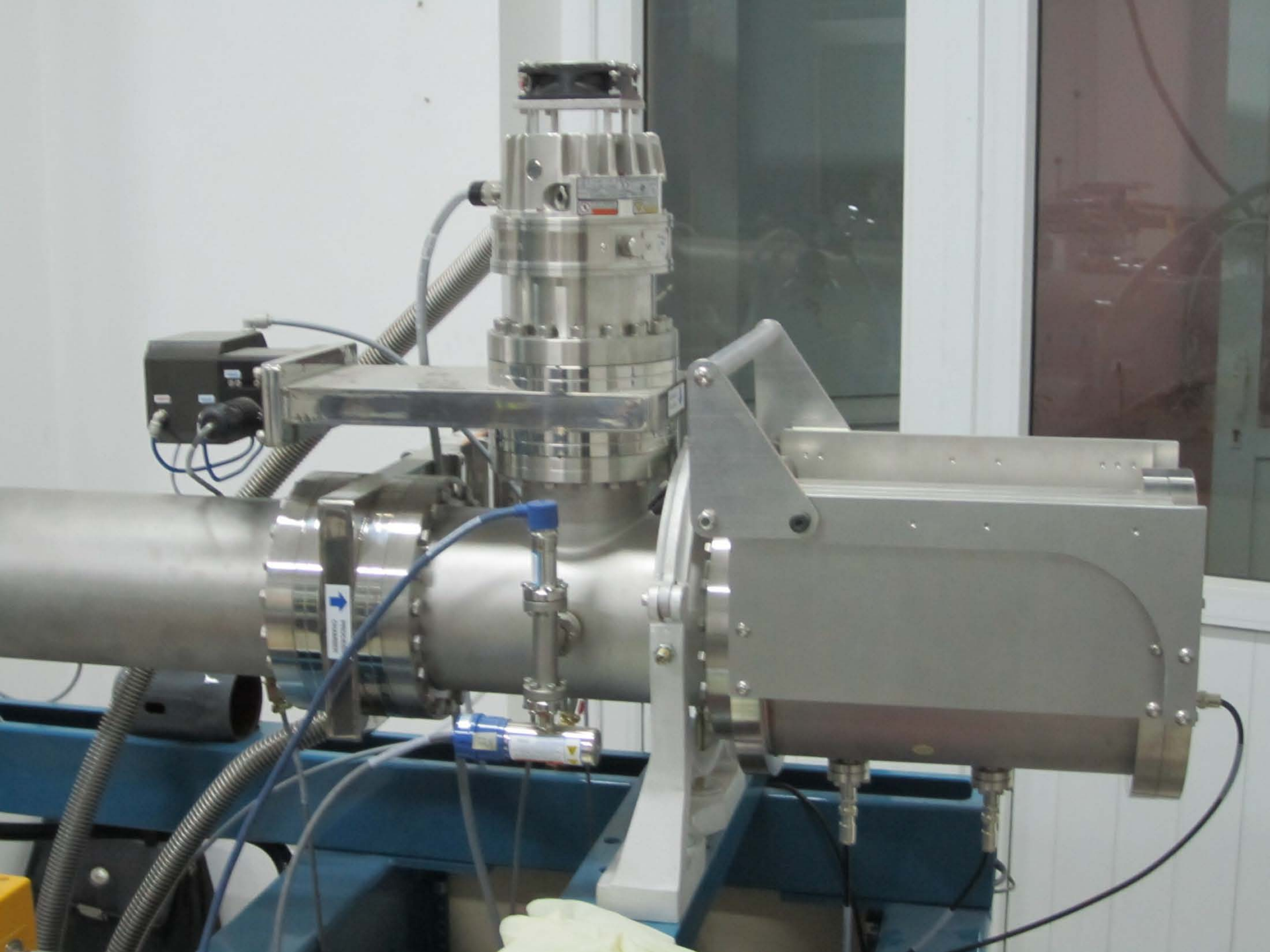

PELLETRON SERVICE POSITION
He- RF-CHARGE
EXCHANGE INJECTION
CONTROL CONSOLE
RC43 CONTROL CONSOLE
HIGH RESOLUTION
RBS SYSTEM
0
1
2
METERS





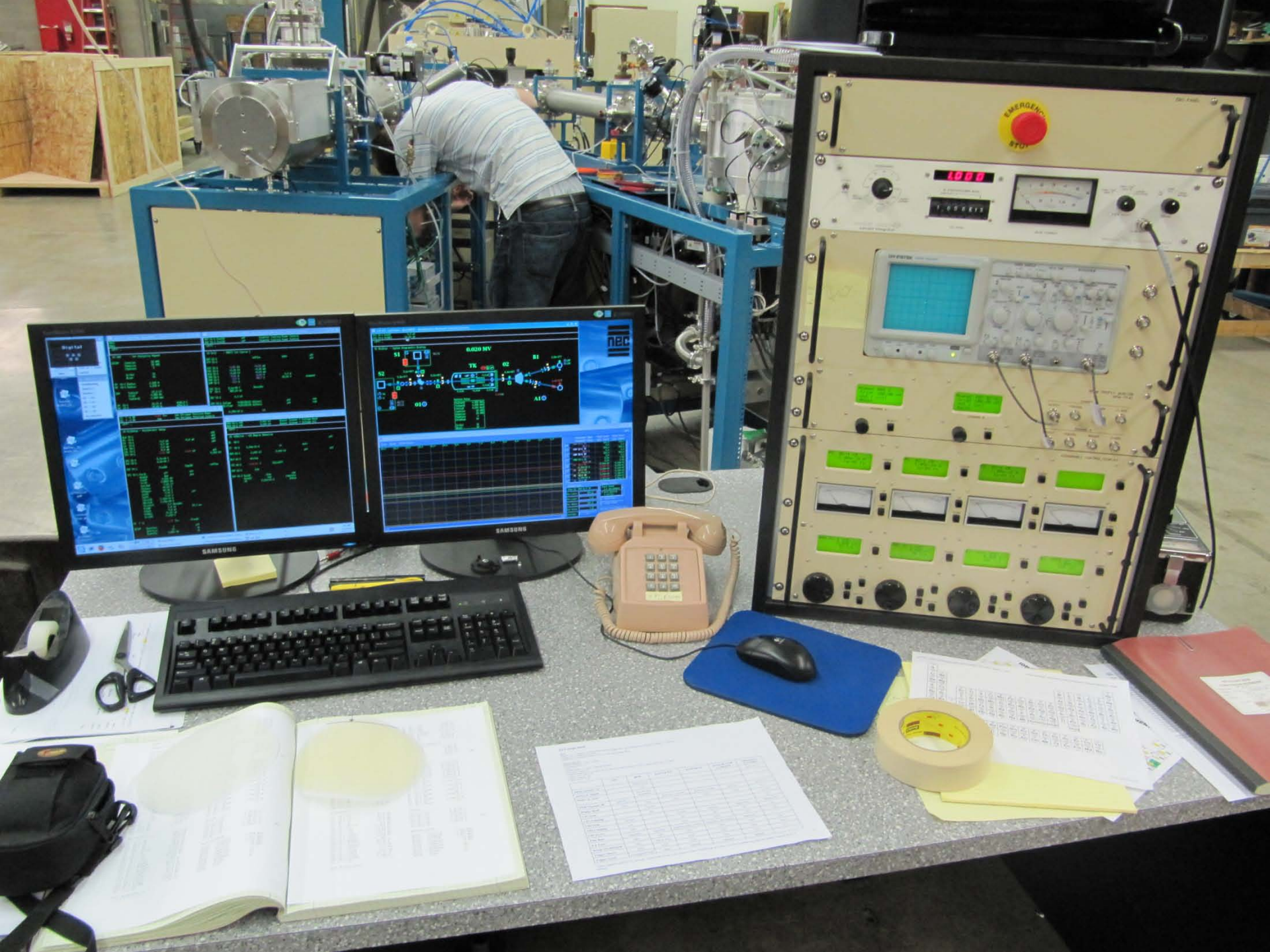
At 3MeV: 15 A/m^2 rad^{2}eV

900 picoA with 600 nm resolution
Reported by SNL
IBA 2011
With Oxford Microprobe System

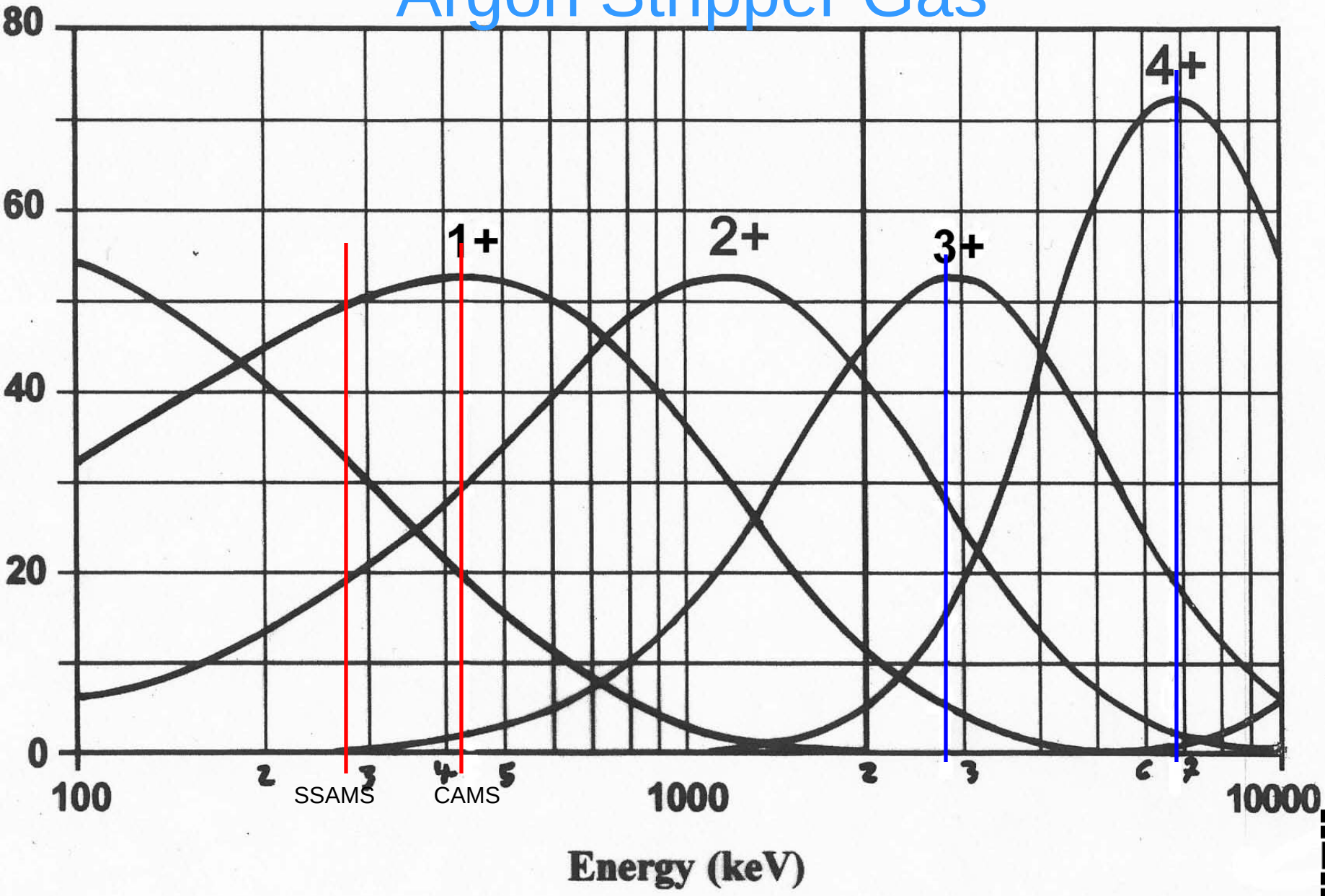


NEC AMS Control System

- Scientific Linux based with Xwindows
- AccelNET software (NEC)
  - All parameters monitored and controlled
  - Fully automated sample running by events, precision, or time
  - Except vacuum – monitor only
  - Save and Restore for all parameters
  - True remote operation, web interface allows factory customer support
  - Labview interface
  - Assignable knobs and analog meters
  - Multiple control consoles allowed
  - Flat topping routines
  - Bending magnets, energy and mass determined
  - Faraday Cup Sequencer (beam current save)
  - Strip chart recorder

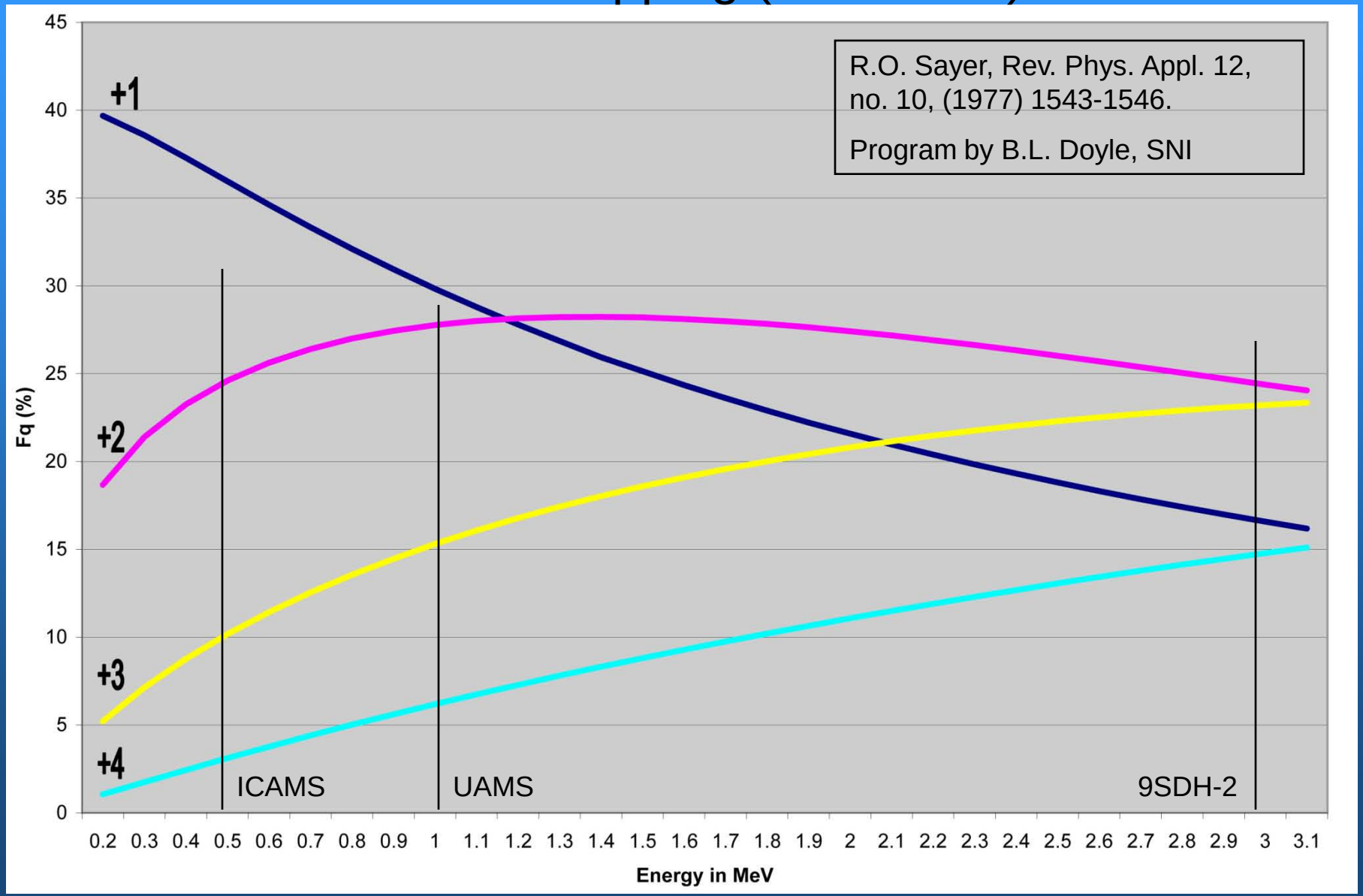

EMERGENCY
STOP
SAMSUNG
SAMSUNG
nec

Charge State Distribution of ^{14}C Ions in Argon Stripper Gas



Charge State Distribution of ^{127}I Ions

Ar Gas Stripping (calculated)



Research Project

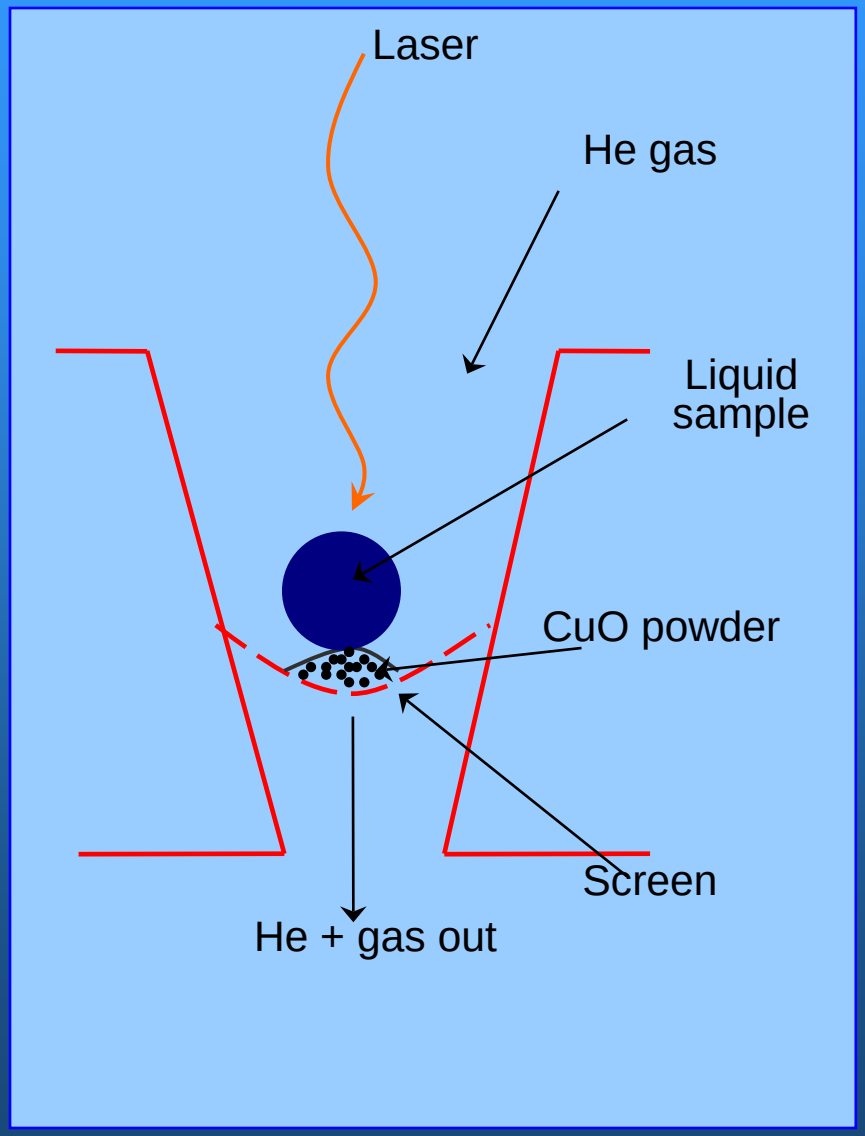
Present Research – Compound Specific AMS

Pharmacokinetics:

A	Availability
D	Distribution
M	Metabolite
E	Elimination

Mass fraction From LC → Liquid samples → AMS source

In Line Combustion



Liquid Chromatograph ⟶ AMS