Three New Electron Beam Facilities For Composite Curing and Bonding

Daniel Goodman and Catherine Byrne
Science Research Laboratory / Electron Solutions, Inc. Somerville, MA

Donald Klosterman
University of Dayton Research Institute, Dayton OH

William McMahon
NASA Marshall Space Flight Center, Huntsville, AL

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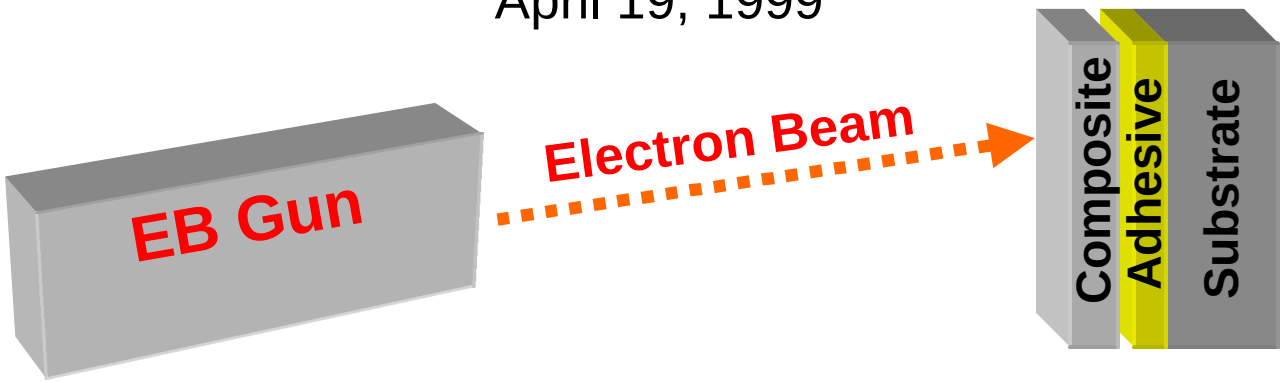


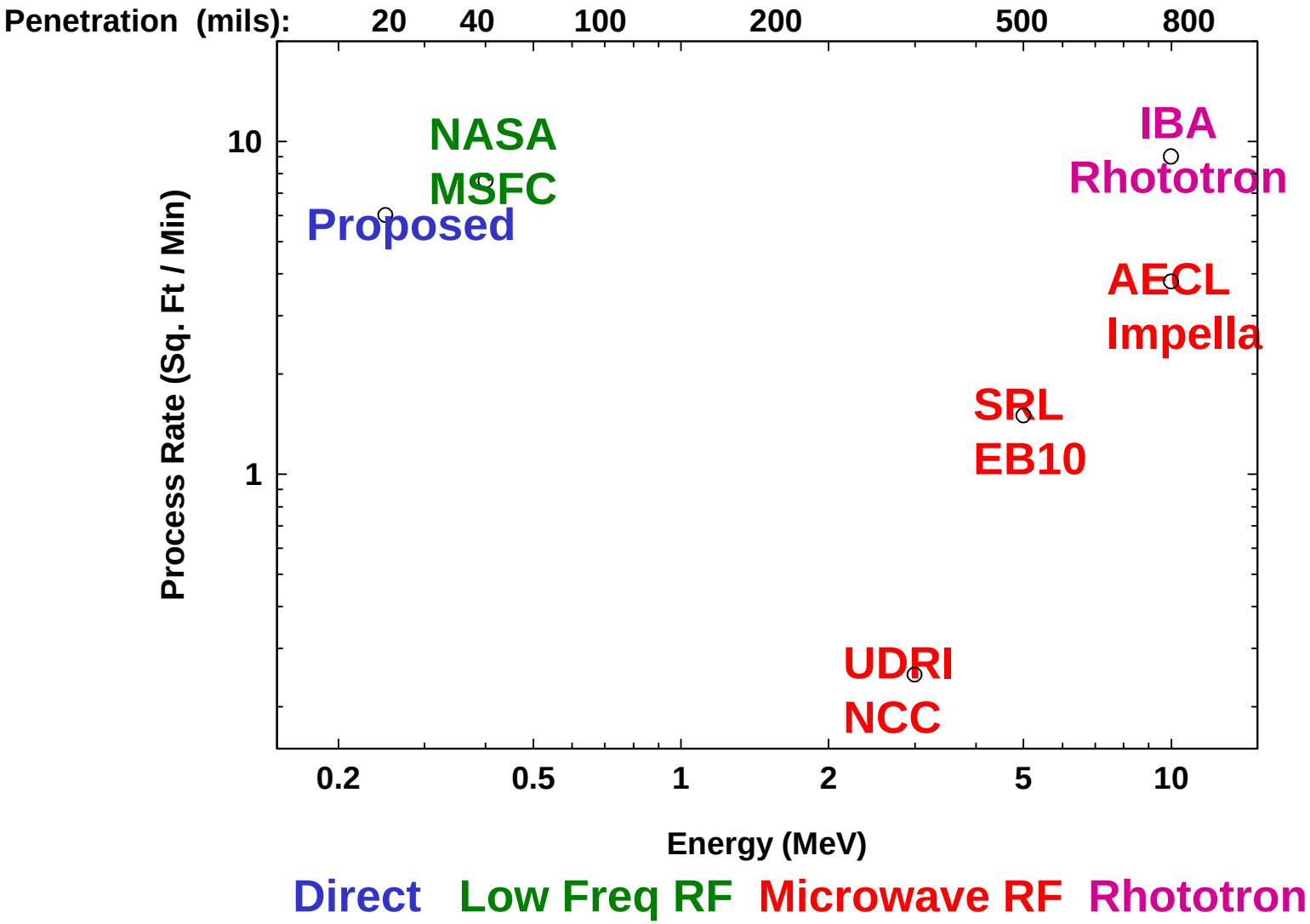
Outline

- **Introduction**
  - Three unique systems: System requirements
- **System Designs**
  - Design tradeoffs
  - Experimental setups
- **Experiments Planned and Underway**
  - Resins and adhesive development
  - Process development
- **Conclusions**
  - Plans and schedule

EB Curing System Requirements

	SRL EB-10 Somerville, MA	NASA MSFC Huntsville, AL	UDRI EB 3-1 Dayton, OH
Principal Uses	Curing and Bonding, EB Sterilization	ATP Process Demonstration	Material and Diagnostic Development
Special Requirements	Wide and Large Parts	Attach to Robotic Tape Placement Head	Flexible Diagnostics
Max Part Thickness (in)	0.50	0.040	0.25
Max Part Size (ft)	8 x 25	> 25	3 x 3
Beam Scanner Width (in)	24	4	20
Beam Energy (MeV)	5	0.25-0.40	3
Beam Power (kW)	10	0.50	1
Head Size (ft)	3 x 3 x 3	3 x 1.5 x 1.5	3 x 3 x 2

Energy Range Determines EB Gun Type, Energy and Power Determine Process Rate



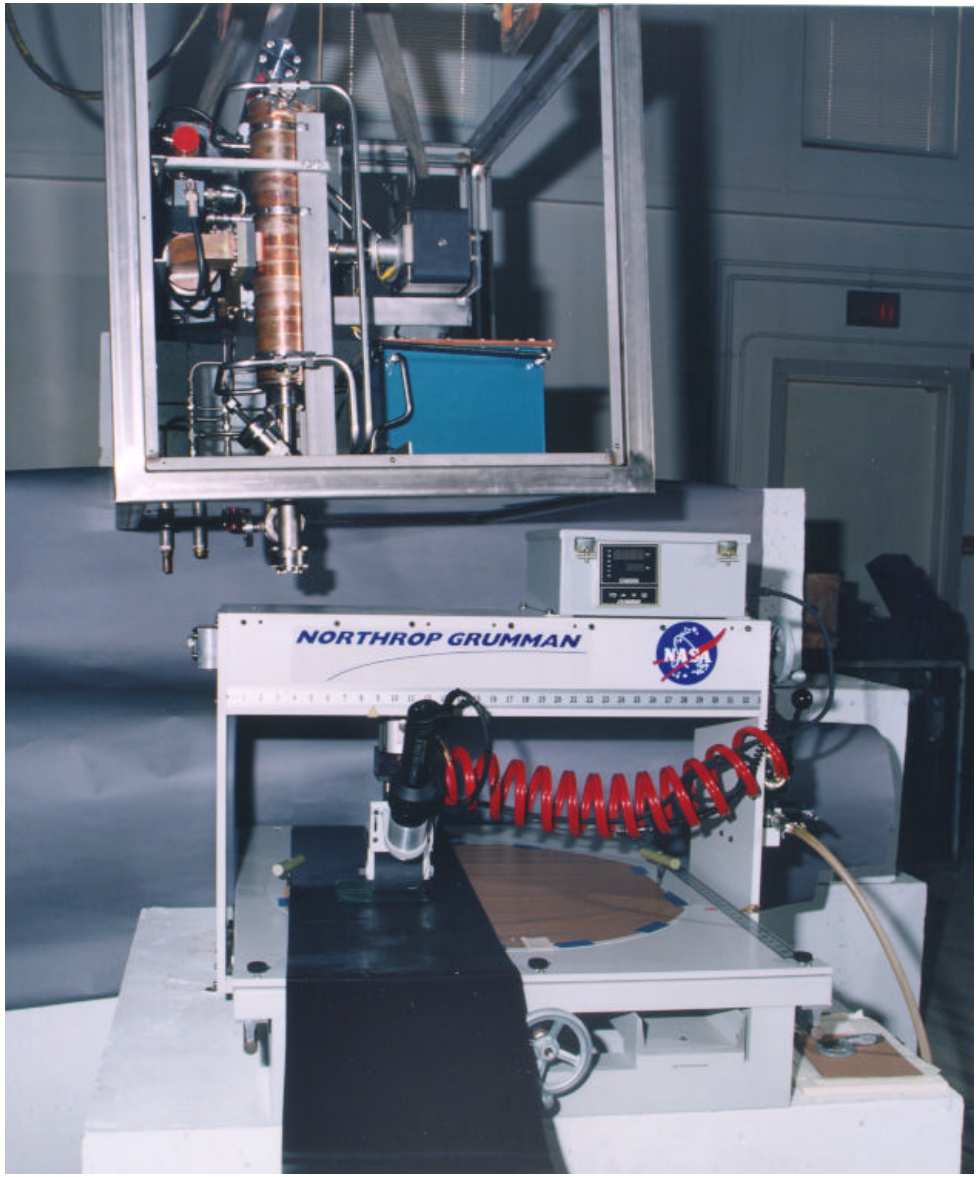
Direct Low Freq RF Microwave RF Rhototron

1. New Multi-purpose Facility at SRL

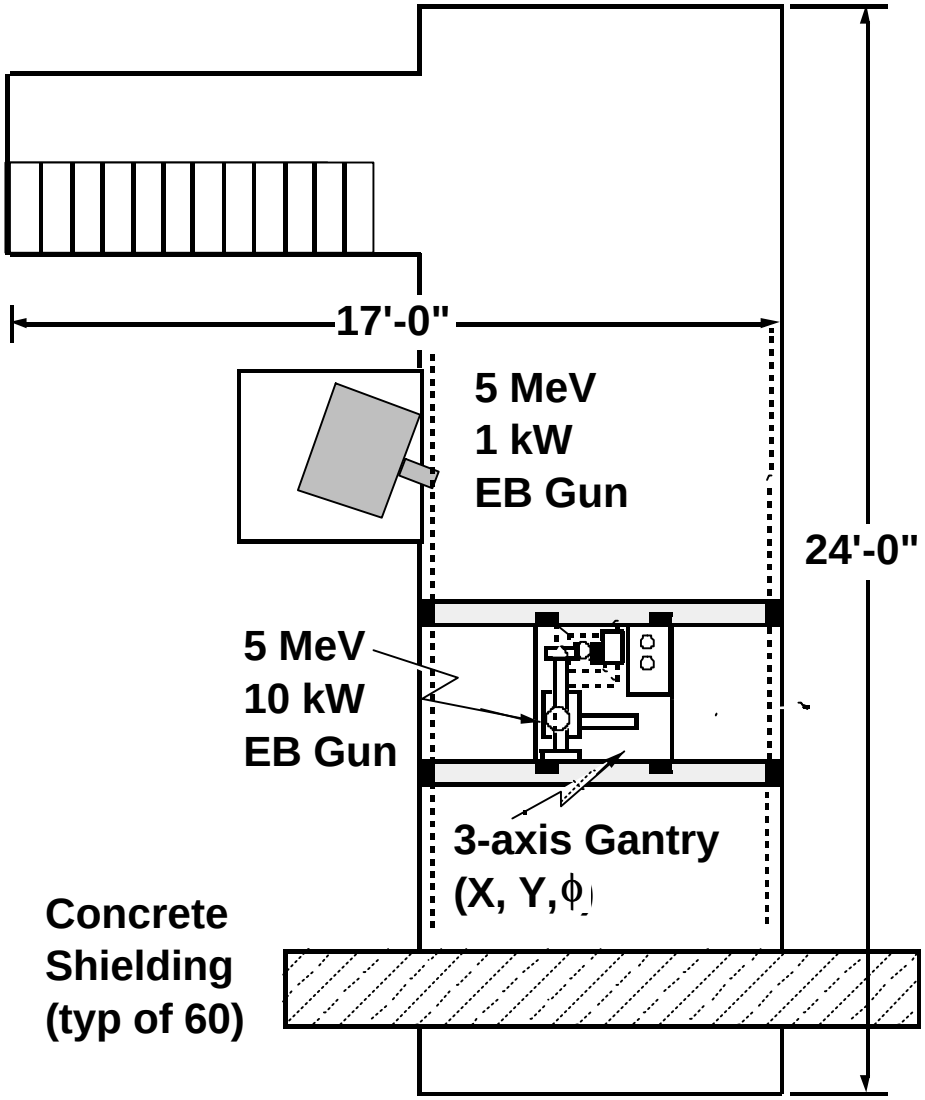
	SRL EB-10 Somerville, MA
Principal Uses	Curing and Bonding, EB Sterilization
Special Requirements	Wide and Large Parts
Max Part Thickness (in)	0.50
Max Part Size (ft)	8 x 25
Beam Scanner Width (in)	24
Beam Energy (MeV)	5
Beam Power (kW)	10
Head Size (ft)	3 x 3 x 3

EB-10 Installation and Testing, Somerville MA

Composite Curing with EB-10



Horizontal and Vertical EB Guns Provide Flexibility in New SRL Facility



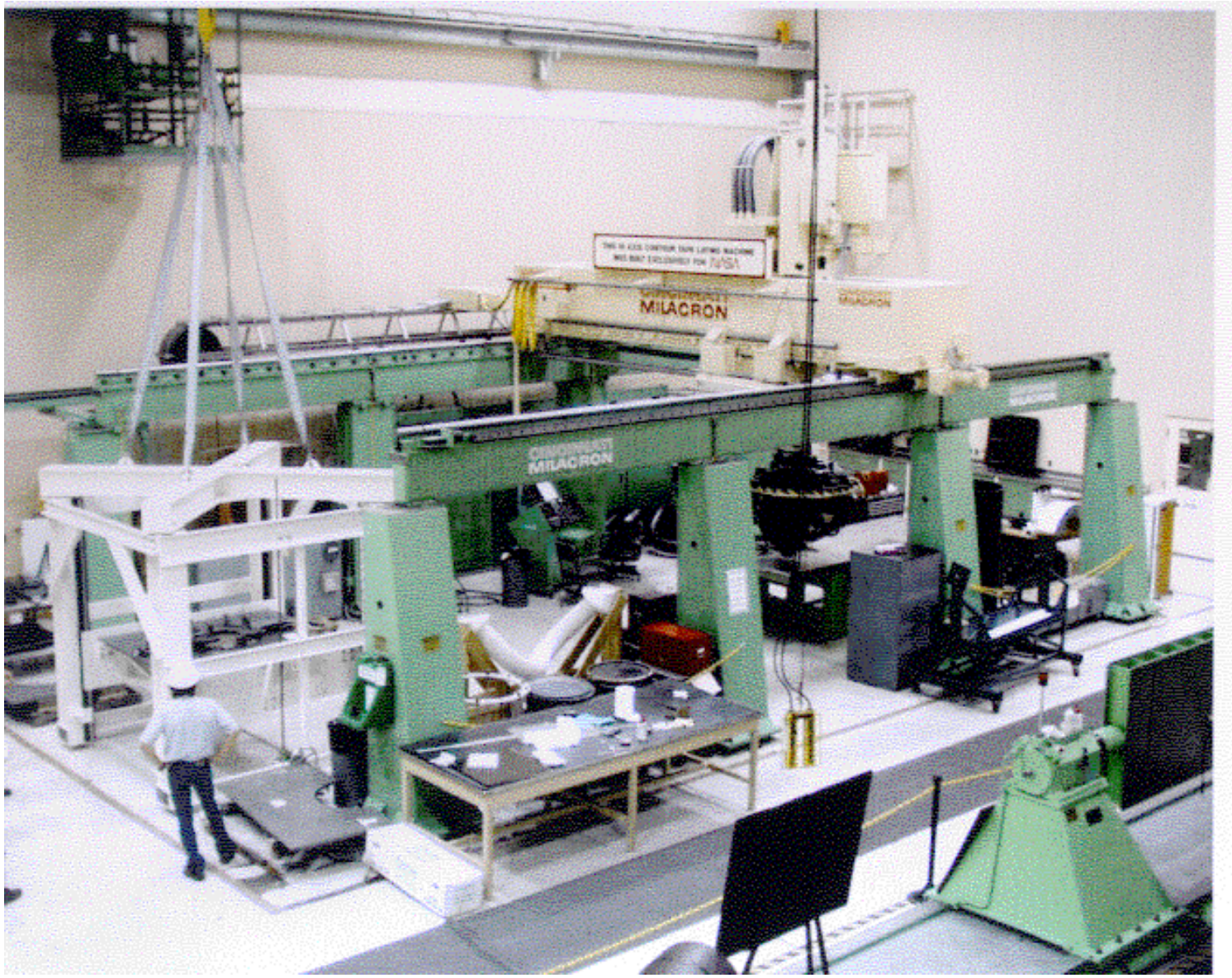
Item	Cost	Percent
Site Prep: Construction, Electrical, Ventillation	$57,000	9%
X-ray Shielding: Roof (160 ton = 86 yd^3)	$35,000	6%
Dual Energy EB Gun (1-5 MeV, 10 kW)	$500,000	82%
Handling: Gantry, Conveyer	$15,000	3%
Total Cost	$607,000	

2. Portable EB Gun + Automated Tape Placement at NASA

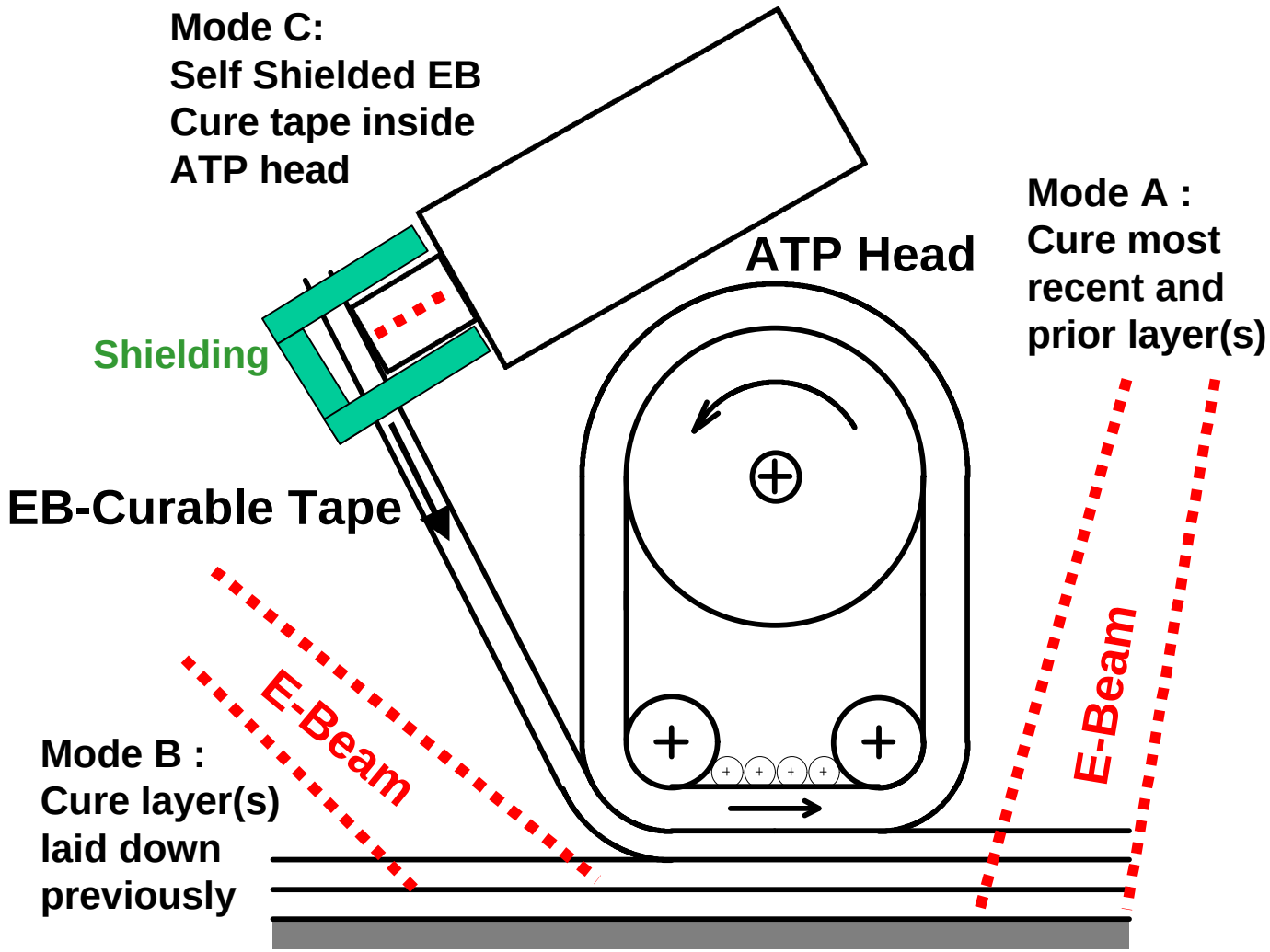
	NASA MSFC Huntsville, AL
Principal Uses	ATP Process Demonstration
Special Requirements	Attach to Robotic Tape Placement Head
Max Part Thickness (in)	0.040
Max Part Size (ft)	> 25
Beam Scanner Width (in)	4
Beam Energy (MeV)	0.25-0.40
Beam Power (kW)	0.50
Head Size (ft)	3 x 1.5 x 1.5

Tape Placement at NASA MSFC

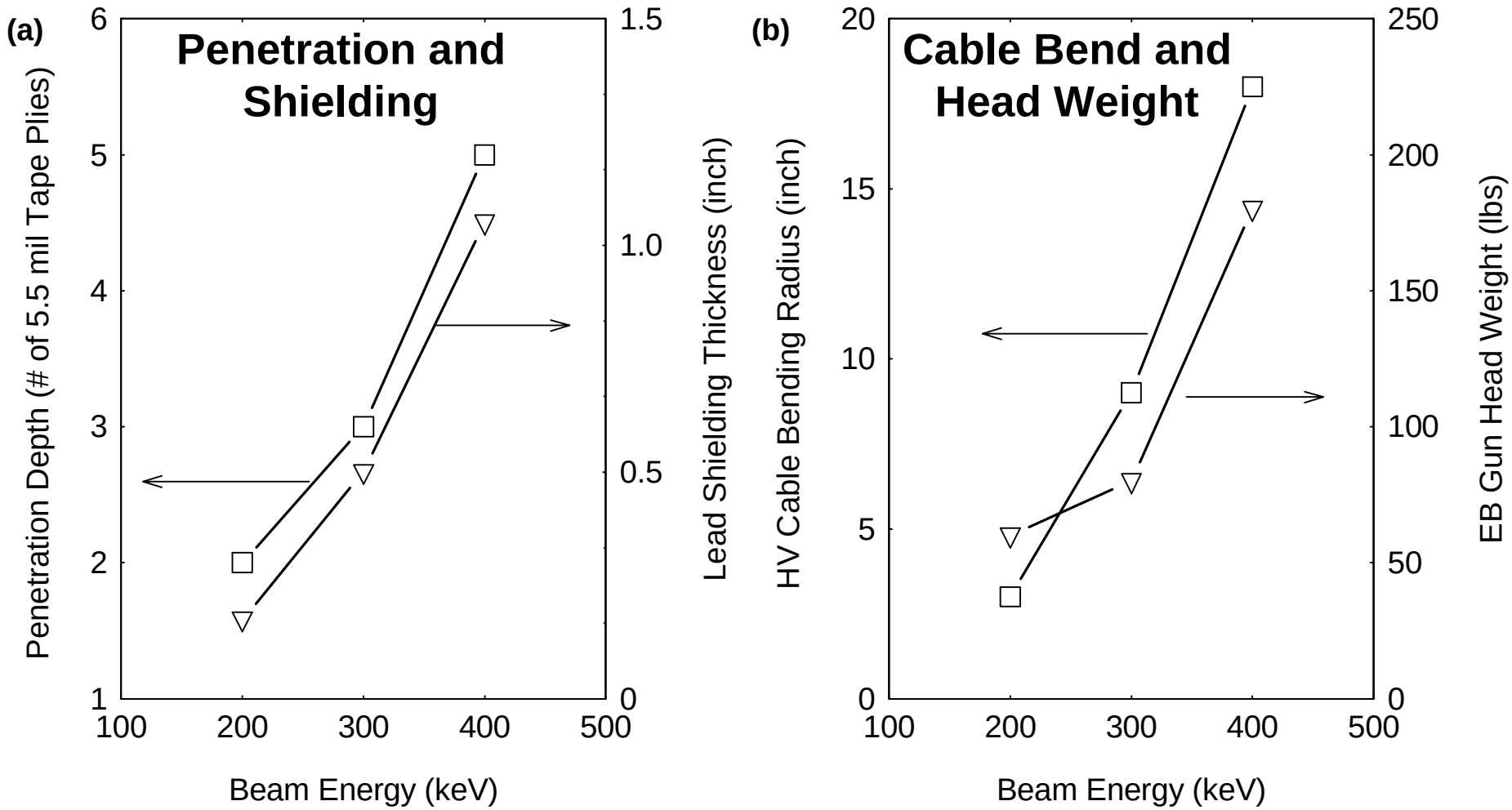
Tape Laying and Fiber Placement Cell at NASA MSFC



Processes Combine EB with Tape Placement

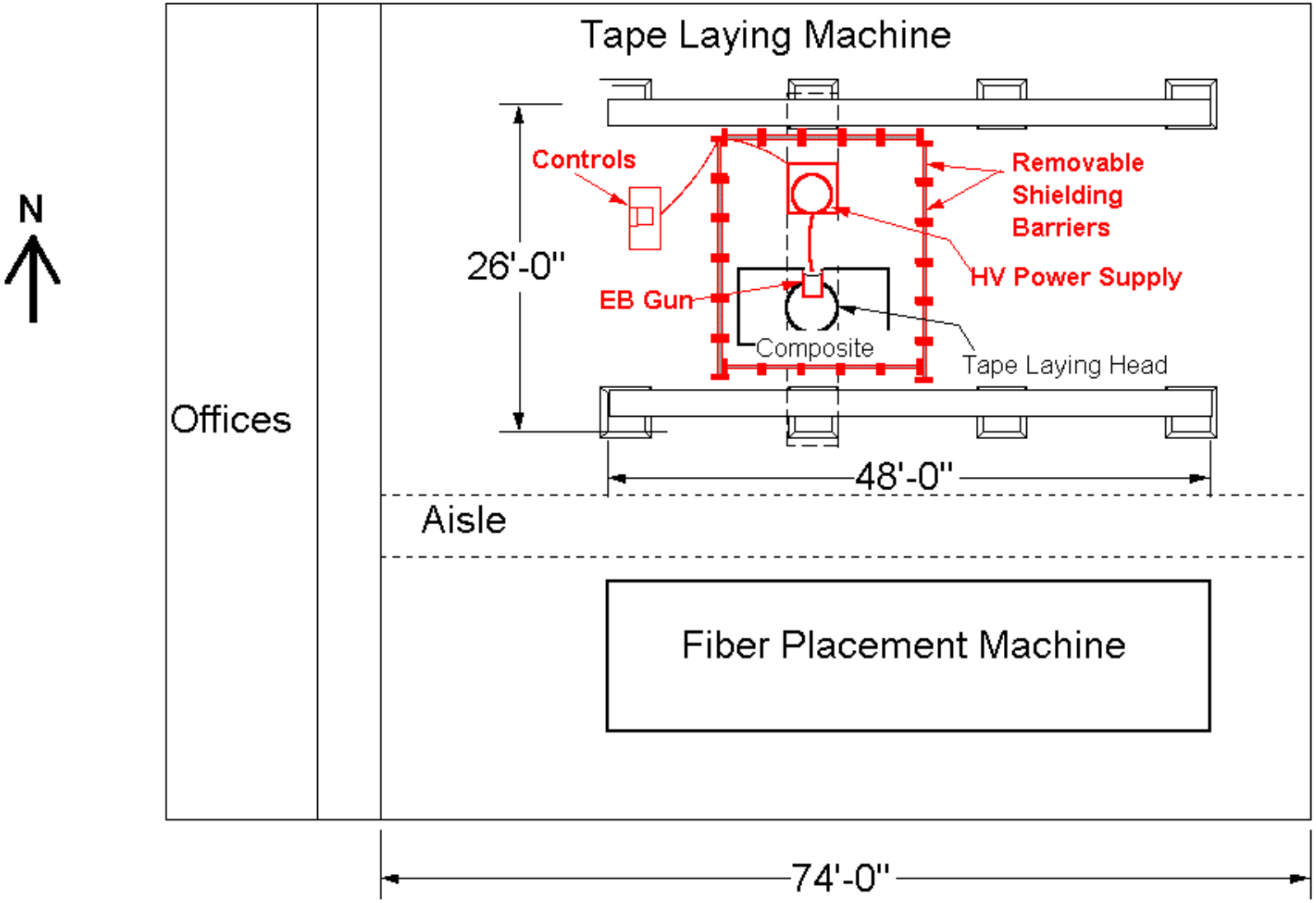


Design Tradeoffs for Low Energy EB Systems

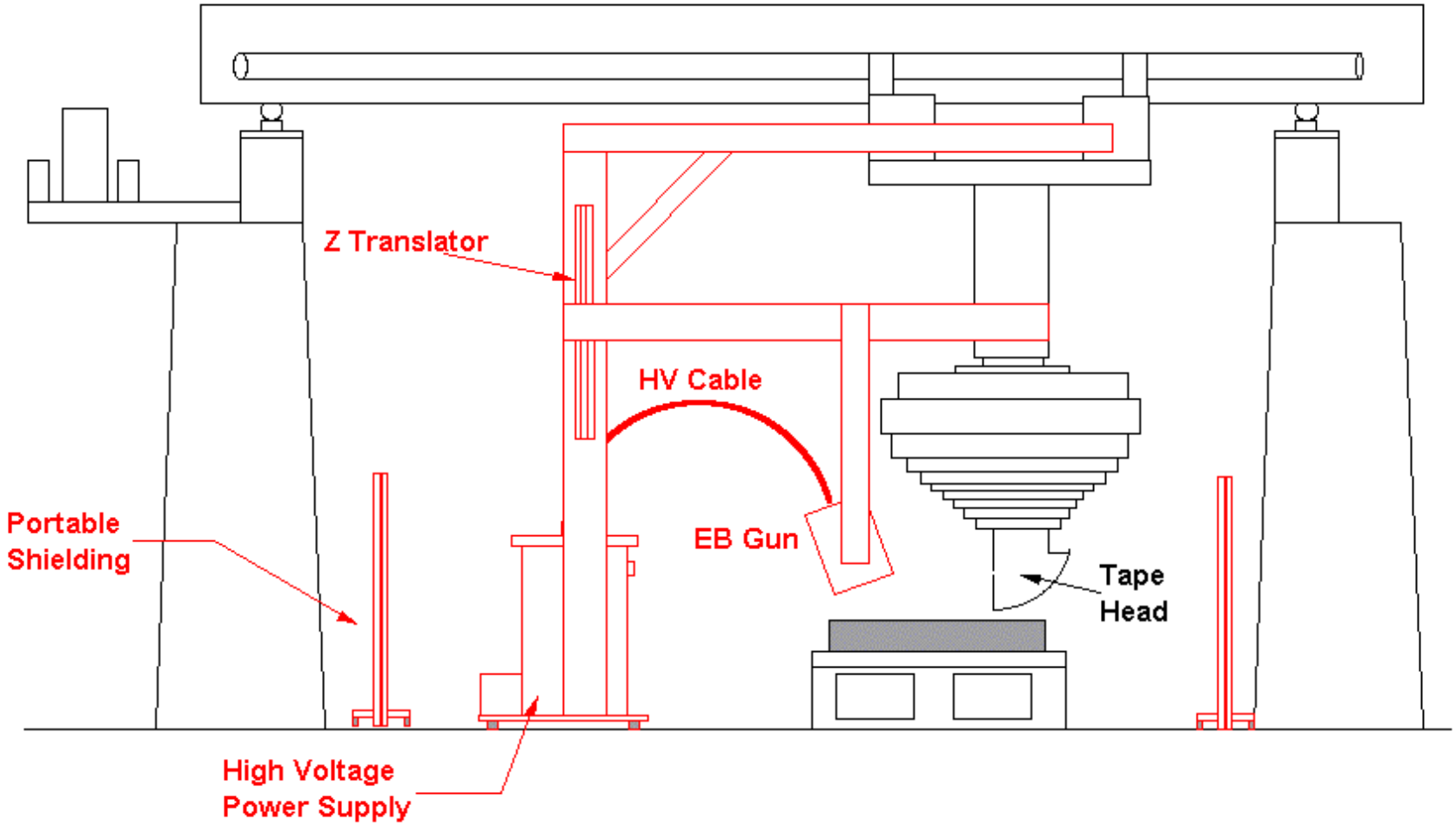


- **Design Tradeoffs Favor 300 keV Beam Energy**

Proposed Low-Energy EB Facility for NASA MSFC



Three Axis Low Energy EB System



- **300 keV, 3.5 kW for Radiation Safety and Cure Speed**

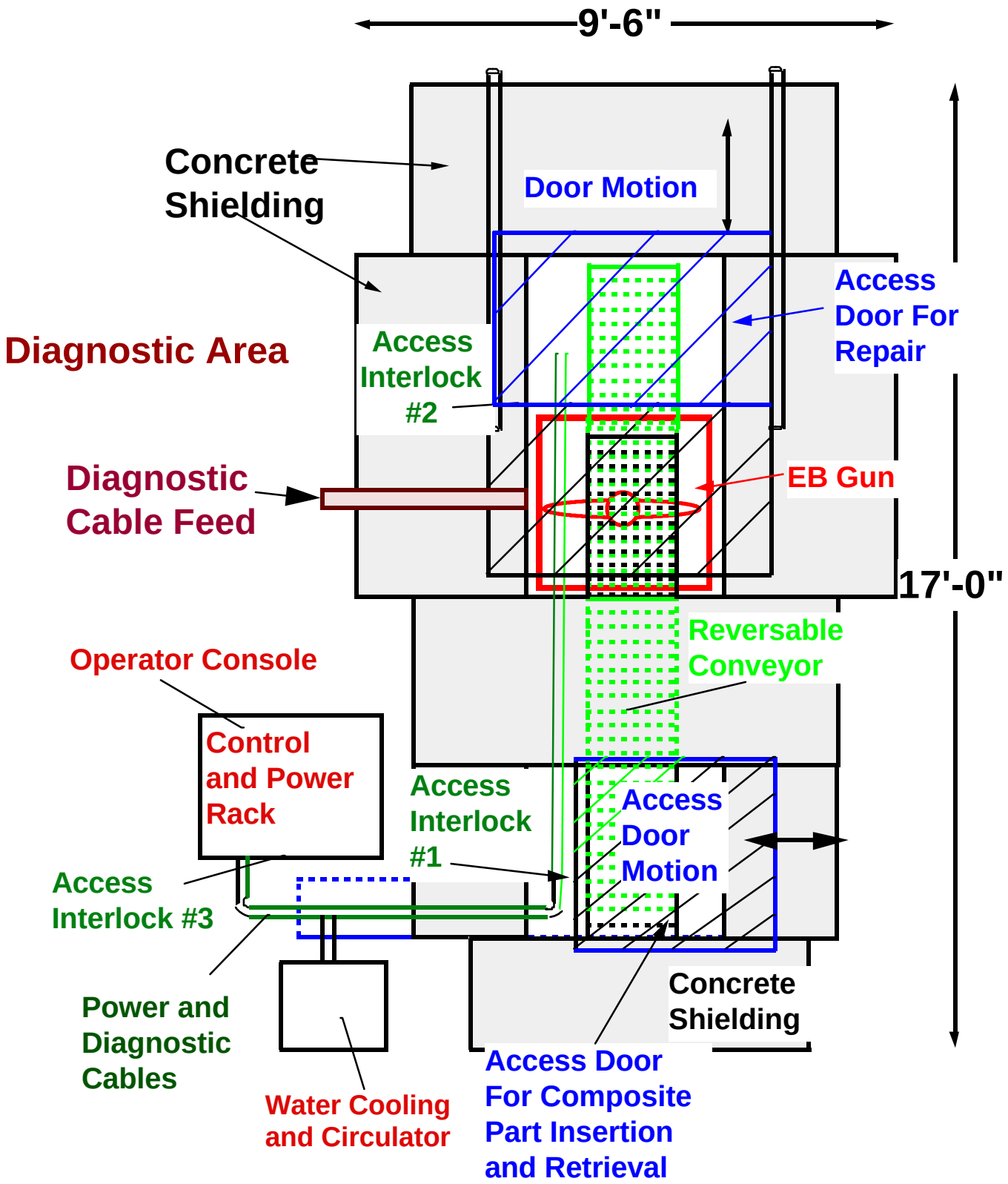
Low Energy EB Requires Only Portable Shielding

- 1/2 inch thick lead sheets weight 30 lb/sq.ft.
- 3x6 foot rolling shield with plywood supports cost ~$600 ea.
- EB Gun will be interlocked to require shielding in place.

3. Electron Beam University Research Facility at UDRI

	UDRI EB 3-1 Dayton, OH
Principal Uses	Material and Diagnostic Development
Special Requirements	Flexible Diagnostics
Max Part Thickness (in)	0.25
Max Part Size (ft)	3 x 3
Beam Scanner Width (in)	20
Beam Energy (MeV)	3
Beam Power (kW)	1
Head Size (ft)	3 x 3 x 2

Compact EB System with In-situ Monitoring



Conclusions

- **Three Dedicated EB Facilities for Composite Curing**
  - SRL EB10 Nearing Completion
  - UDRI and NASA MSFC Systems to be operational by early next year
- **Specialized Designs**
  - **SRL**: Flexible facility for large parts
  - **UDRI**: Easy access and real-time diagnostics for chemistry and processing development
  - **NASA MSFC**: Lightweight Portable EB gun adapted to ATP head, low energy for minimal x-ray shielding