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Title: Equipment Design Considerations for Glovebox Applications

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Los Alamos NATIONAL LABORATORY
EST. 1943

Equipment Design Considerations for Glovebox Applications

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Abstract:

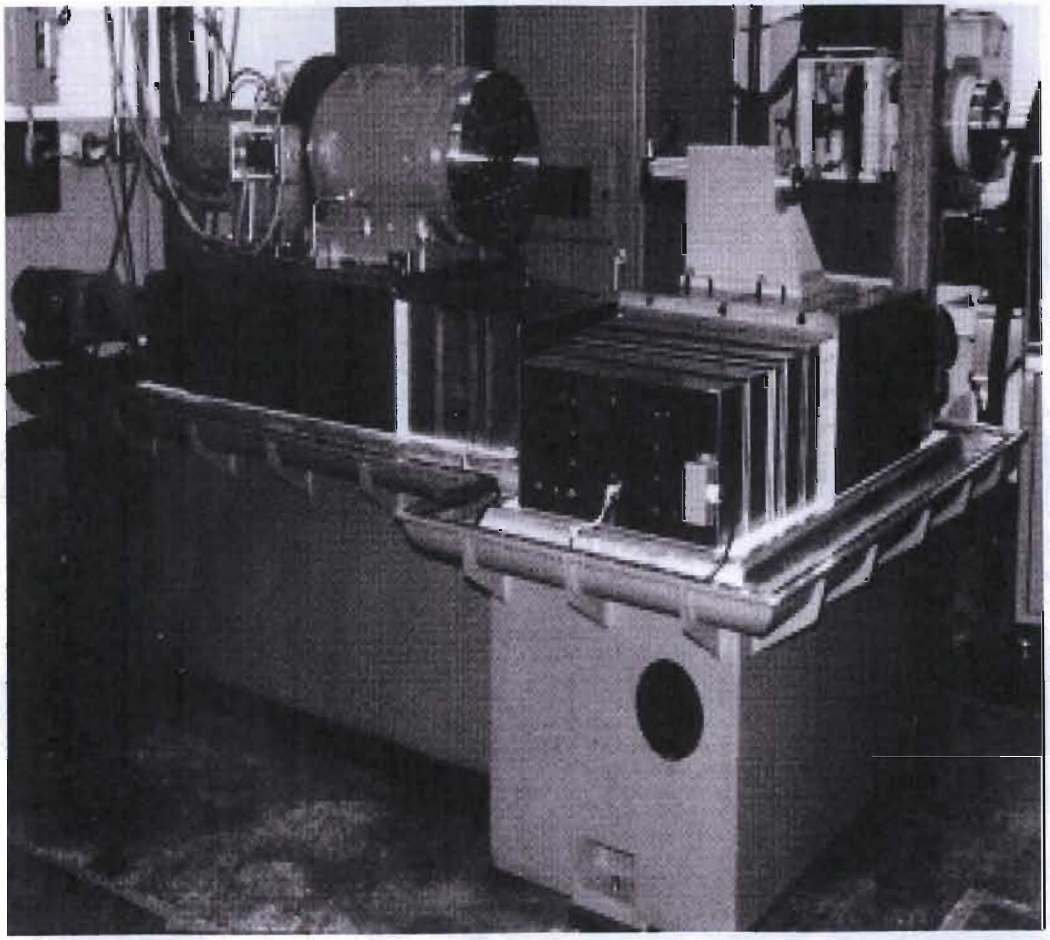
- In the past there has been little, if any interaction between the design of equipment intended for glovebox operations and the design of the glovebox itself. This lack of integration between the inherently linked equipment results in injuries to workers, difficultly in maintaining of equipment, and in the extreme case, failure of the process completely.
- The modeling and simulation software that is available today has allowed engineers to take a new and integrated design philosophy that enables the evaluation of the machine/glovebox as a system. Management and engineers now have the information needed to make decisions based upon quantitative evaluations and balance design tradeoffs that include ergonomics, exposure, maintainability, automation, and most importantly operations.

Project Description, Requirements, and Constraints

- Design a machine for the fabrication of plutonium components within a glovebox environment.
- Minimize the radiation exposure to the machinist during operations.
- Recover waste to within 0.5 grams.
- Reduce the number of injuries to machinist due to poor ergonomic design.
- Provide the ability to replace life-limited components within the glovebox environment.
- Plan for major component replacement with "dockable" support gloveboxes
- Minimize footprint ($10K/square foot)

Past Design Philosophy

- Accuracy was the primary design objective
  - 2 linear axis
  - Air bearing spindle
  - Non stacked axis
  - Custom built – hand scrapped surfaces
- Little if any factory support currently available
- No integration between machine and glovebox
- Drive motors and feedback system external to glovebox

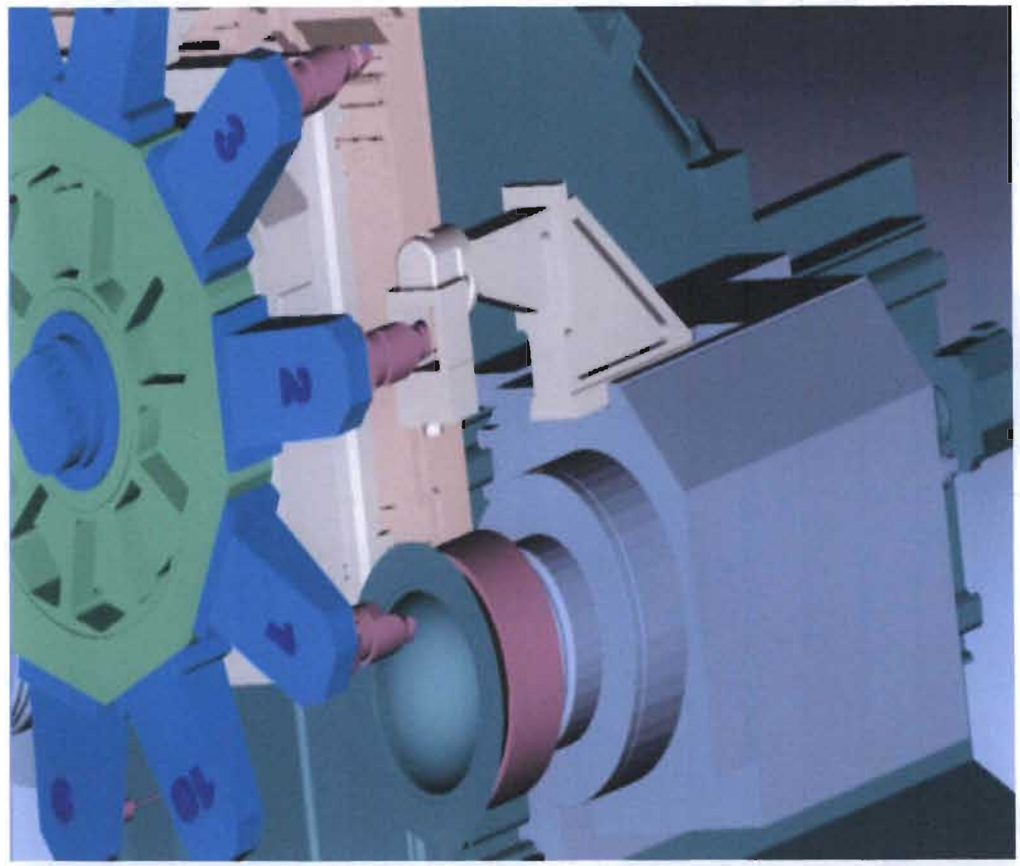


New Design Approach

- **Machine design based upon component tolerance requirements**
  - Error budget analysis determines machine accuracy requirements.
- **Integrated design between machine and glovebox**
  - Design review resulted in the modification of machine design to enhance ergonomics.
  - Machine design and fabrication – Hardinge Inc.
  - Glovebox design – Premier Technology.
- **Subject Matter Experts involved in design process**
  - Machine tool manufacturer
  - Glovebox manufacturer
  - Machinist
  - Ergonomist
  - Process Engineers
  - Maintenance personnel
- **Extensive use of modeling, simulation, and analysis software**

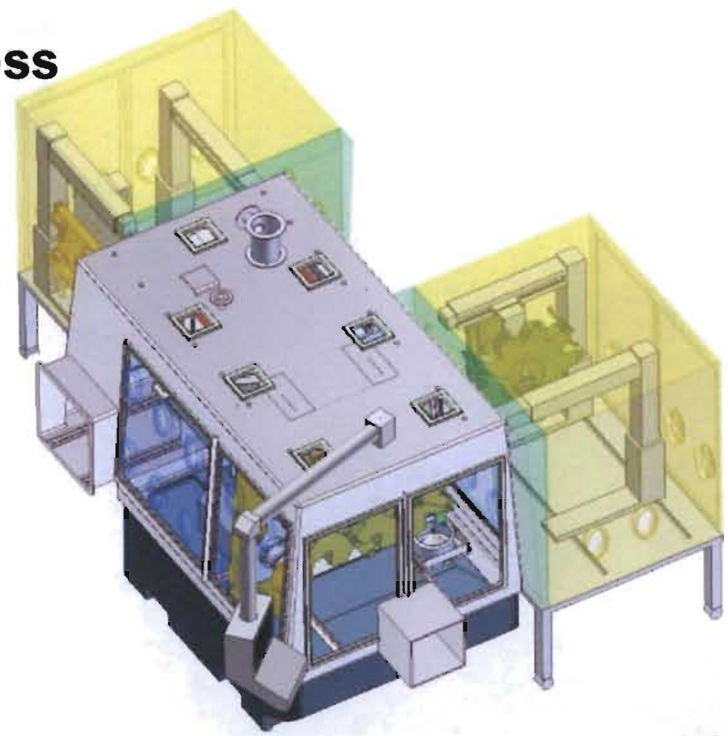
Modeling and Simulation Software

- **Process modeling – Vericut® (cgtech.com)**
  - Verify machining operations
    - Tool clearance and collision avoidance
    - Component fixture design
    - NC program verification
    - Process operation timing



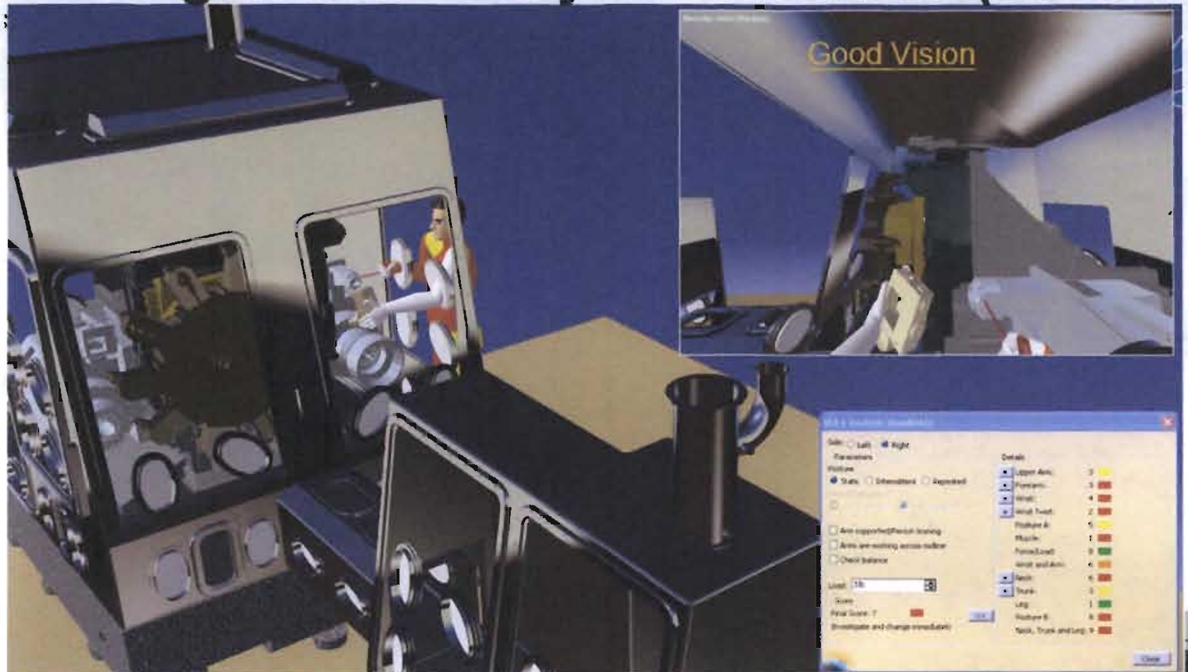
Integrated machine/glovebox design

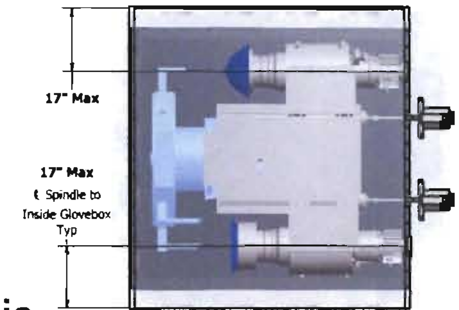
- **Conducted integrated design reviews between machine and glovebox manufacturers**
- **Component delivery to front of machine vs traditional side loading**
  - Enables cleaner glovebox floor to facilitate chip recovery
  - Provides consistent access to both spindles
- **Machine width increased to provide access**
- **Design for 3 major component failure access**



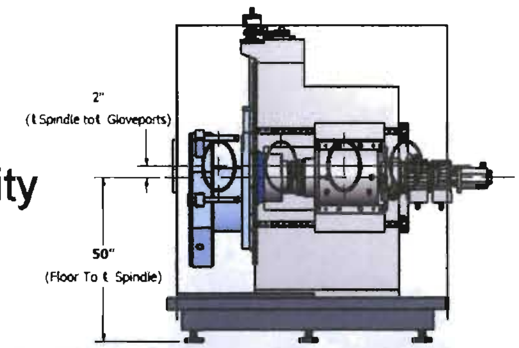
Modeling and Simulation Software (cont.)

- **Ergonomic Analysis – Delmia® (Dassault)**

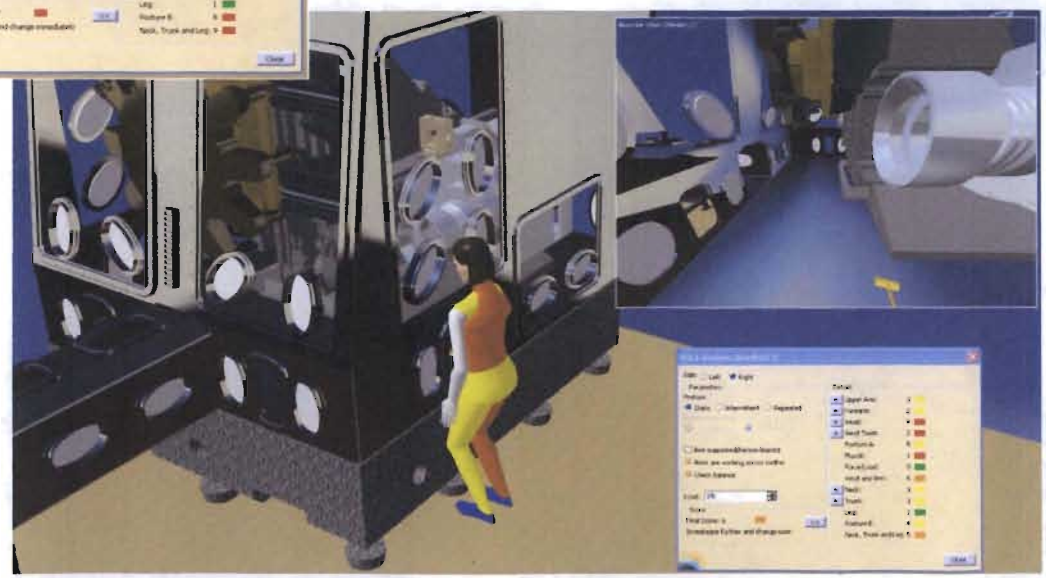




- Stress analysis
- Visibility
- Reach-ability



Using Group-Survey Personnel	Shoulder Height	Standing Elbow Height	Halfway Between Shoulder and Elbow	Shoulder Grip Length - 4" = max reach
	52	39	45 1/2	18 1/2
	53 1/4	39 3/4	46 1/2	19 1/2
	54	41 1/2	47 3/4	19 1/4
	57	43 1/4	50 1/8	21 3/4
	56	41	48 1/2	23 1/4
	56 1/2	42 1/4	49 3/8	23 3/4
	56 1/2	42 1/2	49 1/2	20 1/2
	56 3/4	42 1/4	49 1/2	22
	60	44 3/4	52 3/8	21 1/2
	57	45	51	22 1/2
	58 1/2	44 1/2	51 1/2	20 3/4
	58	43 3/4	50 7/8	19
	59	42 3/4	50 7/8	21 1/2
	59 1/2	44	51 3/4	21 1/2
	61	45	53	25 3/4
	61	45	53	24 1/2
	61	46	53 1/2	27 3/4
Survey Result Average	57 1/2	43	50 1/4	22
95% Male Nationally	61	46 8/9	54	24 1/2
85% Male Nationally	60 3/5	47 1/2	53 1/2	24
5% female nationally	48 1/5	37 1/5	42 5/7	18
5% survey result	53	39 3/5	46 2/7	18 8/9
Nation recommendations			48-52	5% female population
Results given to Jody (12-06) for Hardinge Design Criteria			50	18 (To exterior of GB)

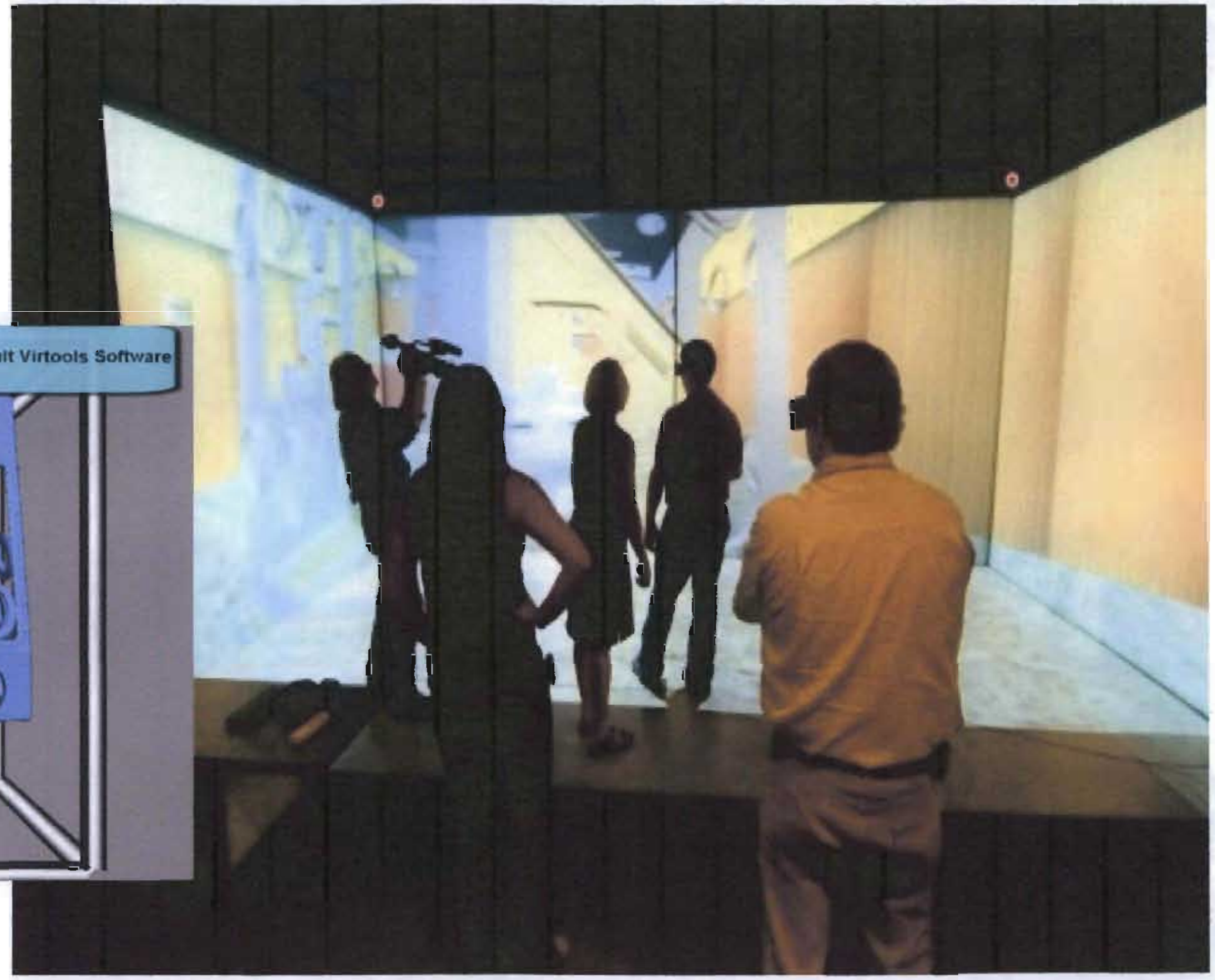


- Applied to operations and maintenance functions

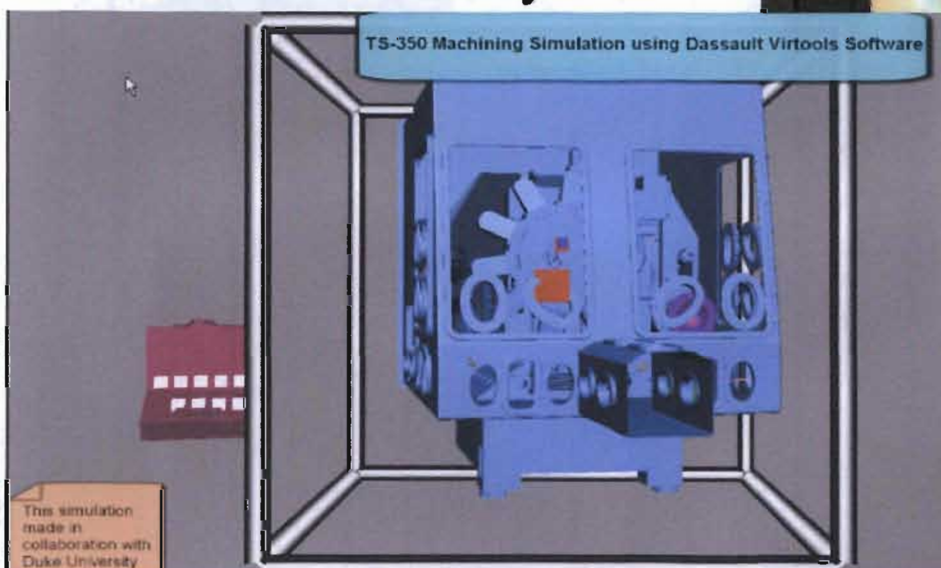
Modeling and Simulation Software (cont.)

- **Immersive environments:**

▪Full Scale visualization during design reviews- LANL



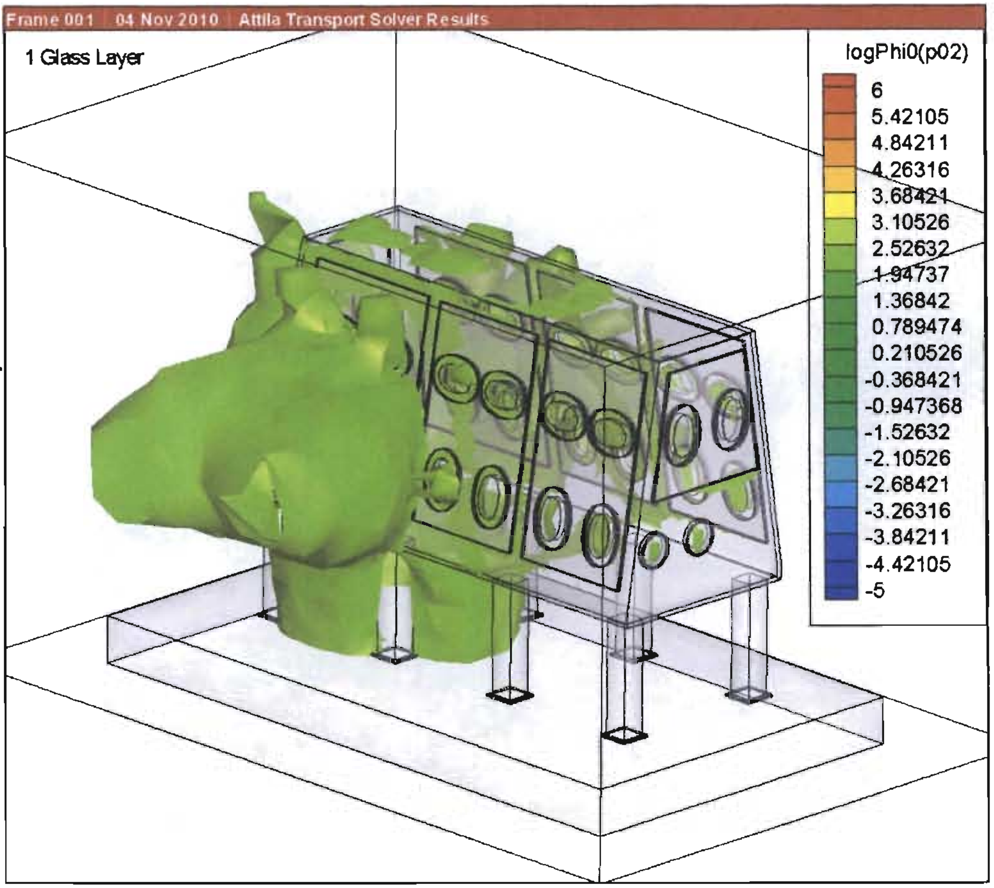
▪Full Scale visualization with Duke University



Modeling and Simulation Software (cont.)

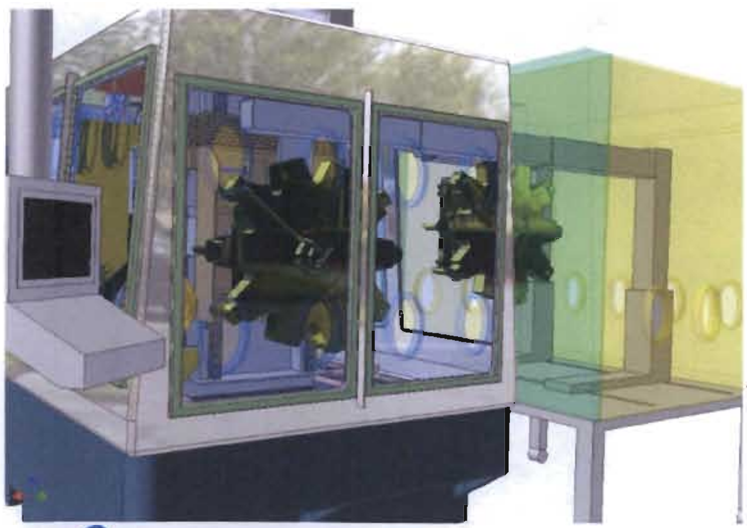
- **Radiation transport - Atilla (Transpire Inc.)**

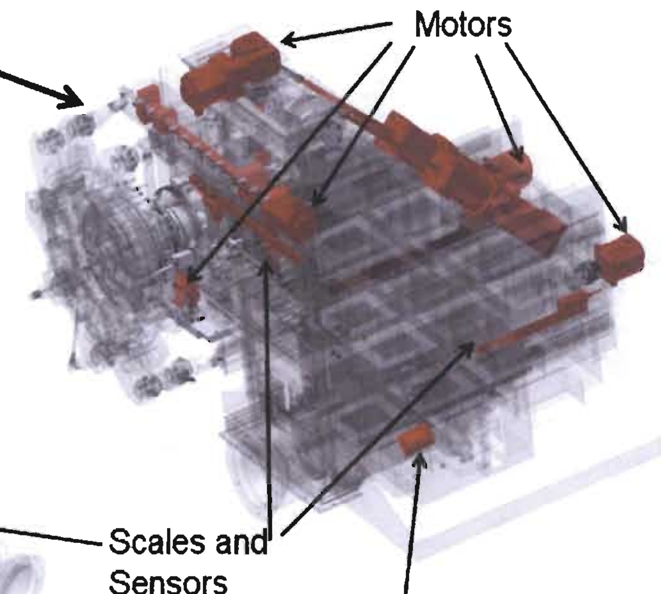
- Machinist exposure
  - Timing for exposure calculations determined from process modeling calculations
  - Glovebox shielding design tradeoffs - exposure vs visibility
  - Machine automation evaluation – complexity vs reduced exposure
  - Software validation accomplished by empirical and numerical methods

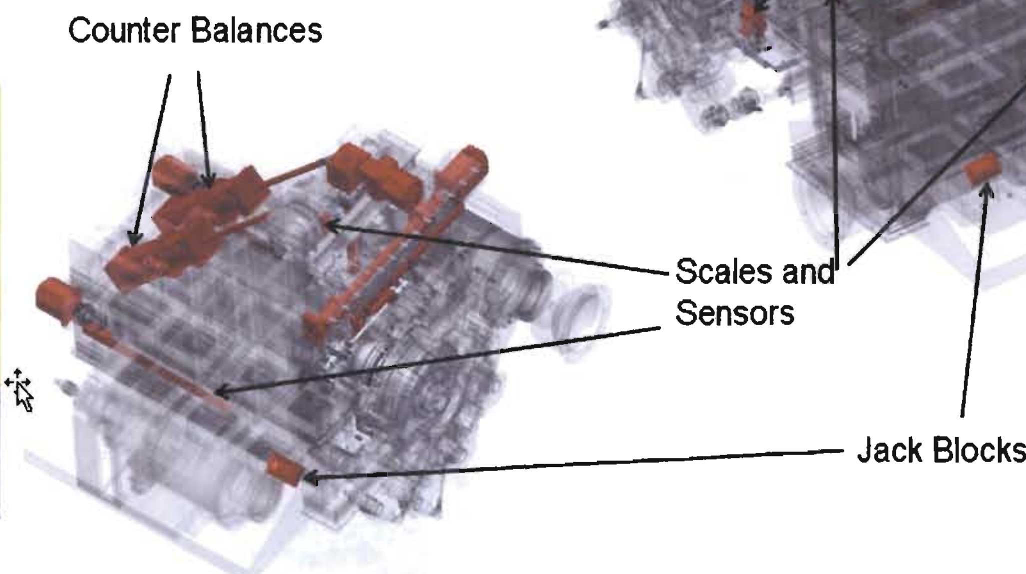


The New Machine Design Results

- Commercial off the shelf subsystems
- 4 linear axis with two spindles
- Multi-station cutting tool turret
- Drive motors and feedback system within glovebox environment
- Manufacture identified maintenance locations
- Significant improvement in ergonomics
- Components delivered to front of machine

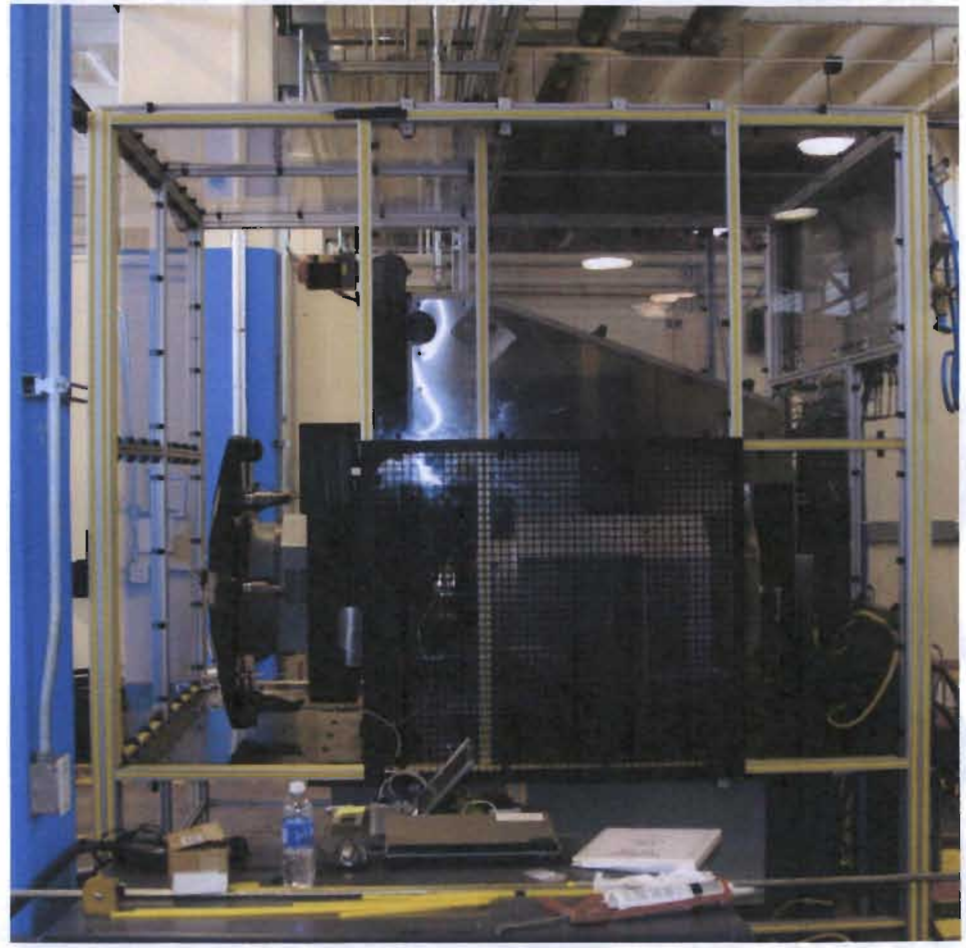






Project Status

- **Machine delivered to Los Alamos and installed**



- **Glovebox through preliminary design**

Conclusion:

- The glovebox should not be an afterthought, it's an integral part of the process equipment.
- Spend the time to know where your most likely failure points will be and design for access.
- Early on, get everyone who has a stake in the process (glovebox workers to project managers) involved in design review process.
- Use modeling, simulation and analysis software to review designs as they evolve.
- Use AGS guidelines to help with design.

- Questions?