LANSCE SC R&D overview and RF development

DOE/NSF Workshop on RF Superconductivity
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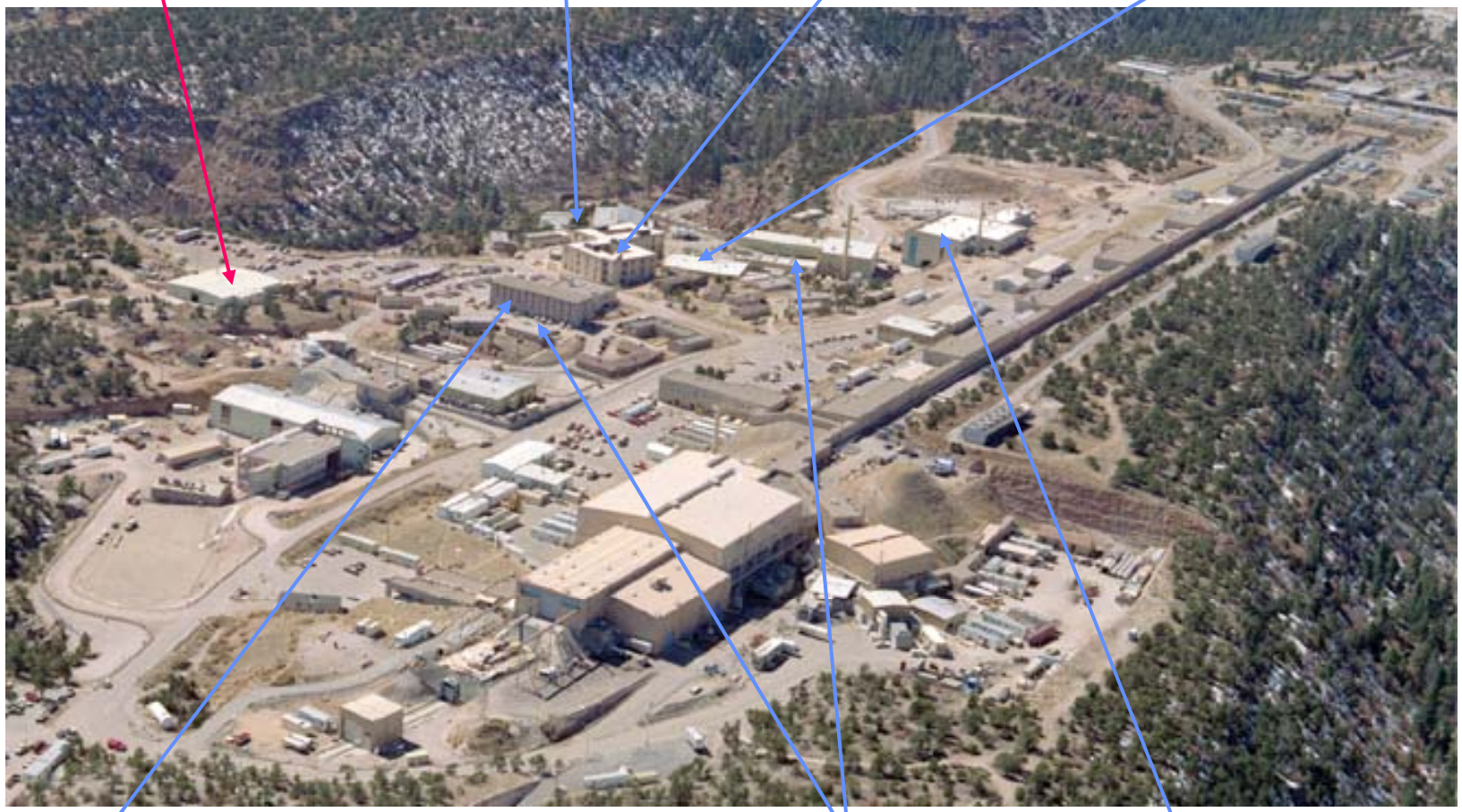
Outline

- **Development of a superconducting-linac capability at LANSCE.**
- **Development of RF systems for superconducting linacs**
- **Tsuyoshi Tajima will discuss cavity development**

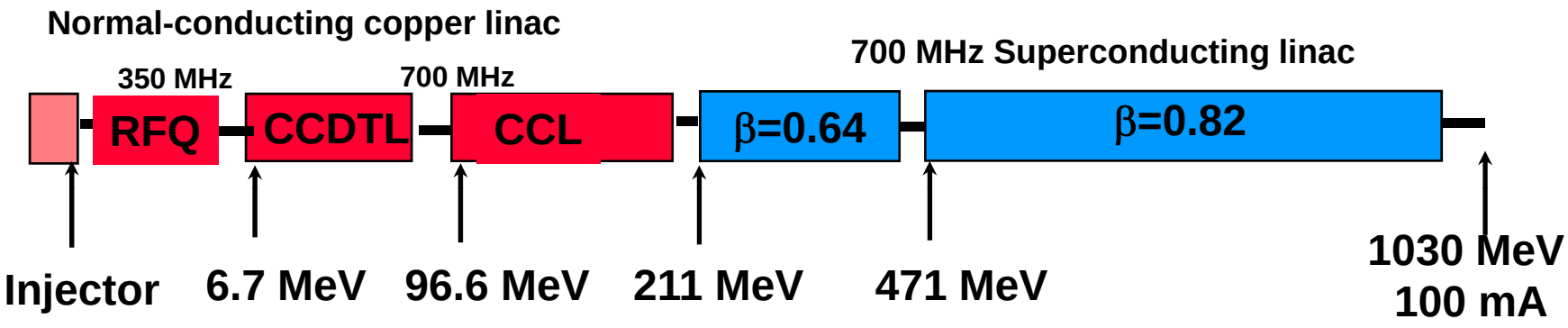
The SC Lab at LANSCE is located in a multi-purpose laboratory building



Superconducting capability at LANSCE has been developed over the past decade

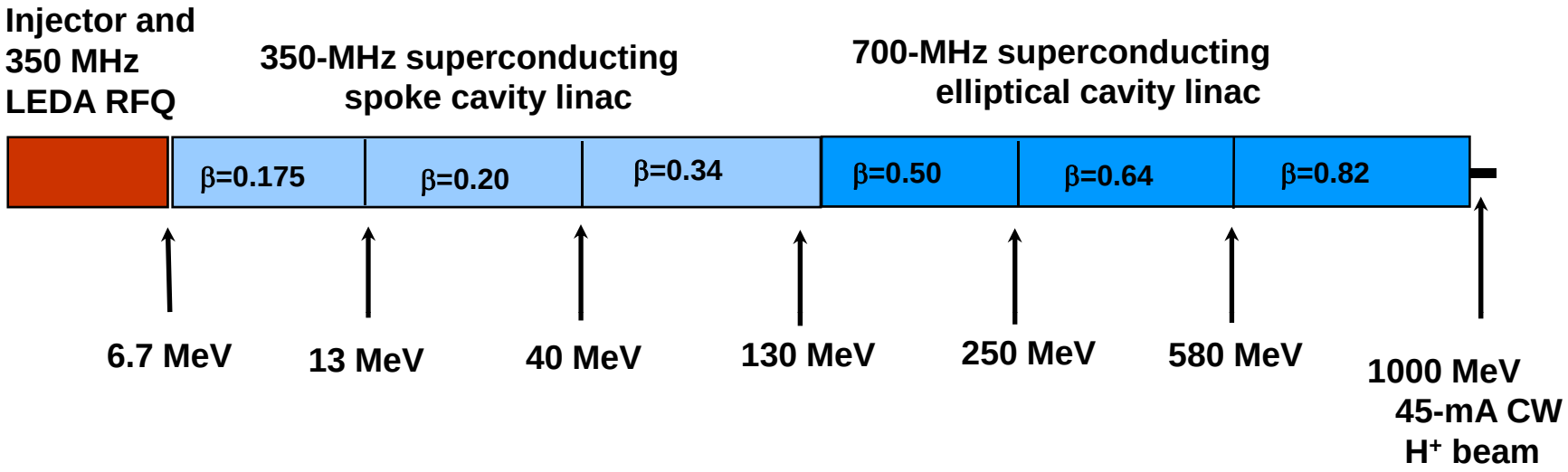
- LANSCE-1 is part of the diverse Los Alamos Neutron Science Center. Responsible for "Accelerator Physics and Engineering"; programs and LANSCE linac support.
- Began superconducting efforts in 88 as part of accelerator technology and to produce a pion-accelerating cavity (805-MHz). Measurements lab established with large cryostats and clean room.
- Accomplishments since:
  - Peak-surface-field record for 1.3 GHz cavity (85 MV/m)
  - First elliptical cavity with $\beta<1$ ($\beta=0.64$, $E_{acc}=12.4$ MV/m, 700 MHz)
  - Effect of radiation on cavity
  - 1-MW power coupler development
  - Low-β spoke-resonator cavity ($\beta=0.175$, $E_{acc}=13.5$ MV/m, 350 MHz)
- Sponsored by APT (tritium production) and AAA (waste transmutation) projects
  - Improved infrastructure (large clean room, HP rinse, test equipment)
  - Potential for LEDA add on

APT Project- SC Cavities were designed to accelerate protons at >211 MeV



102 β=0.64 and 140 β=0.82 700-MHz 5-cell elliptical cavities

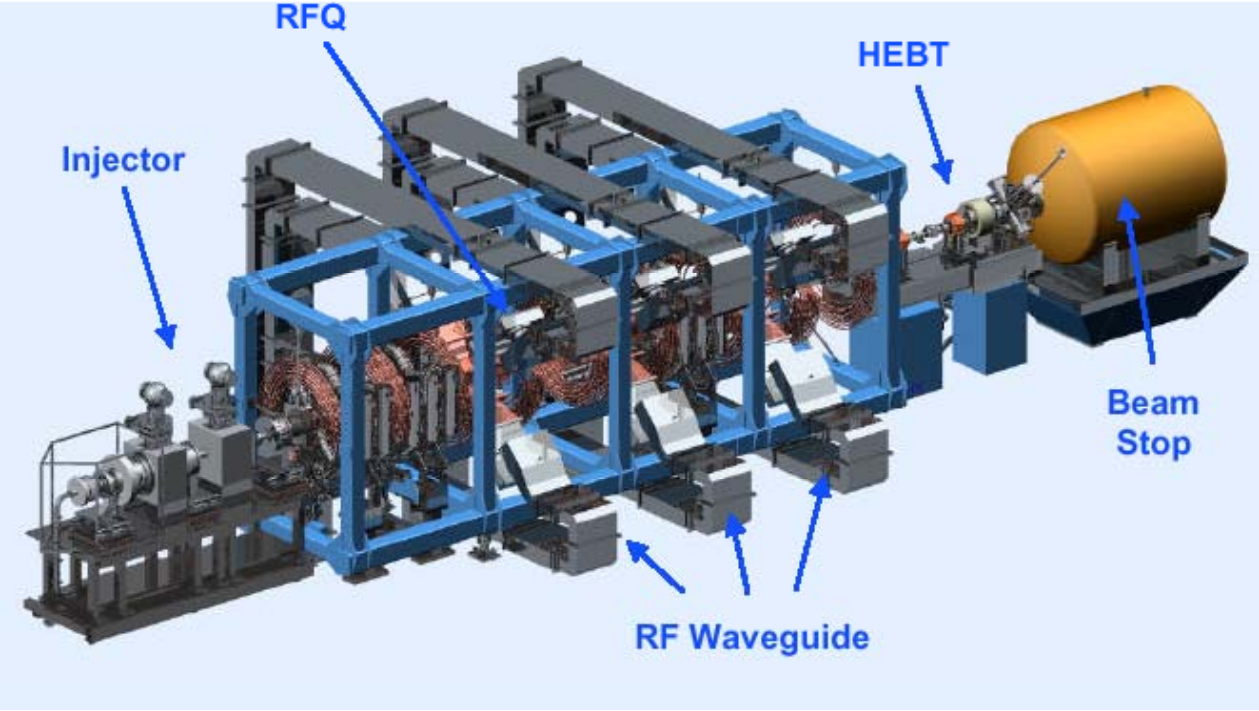
AAA project – SC cavities were designed to accelerate protons at >6.7 MeV



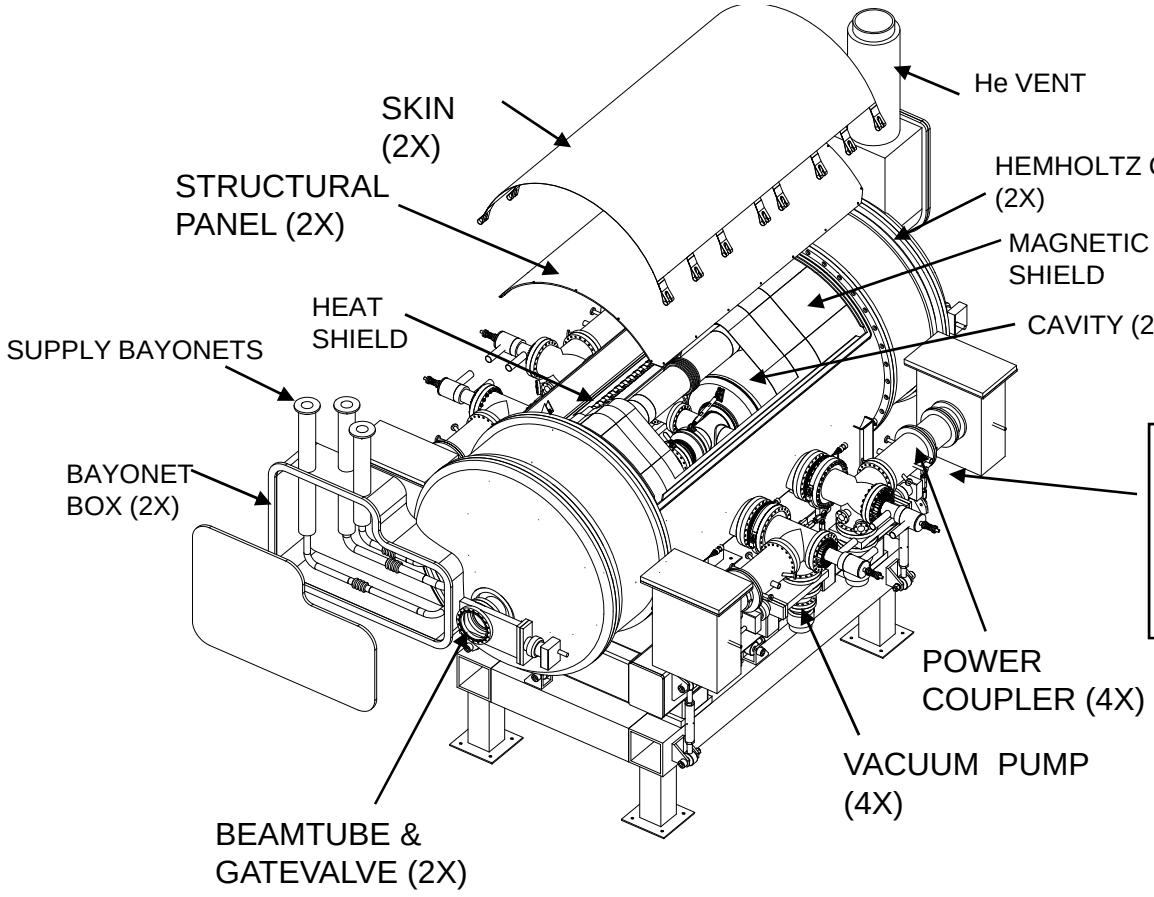
By replacing NC sections with SC spoke cavities, ~57 MW of AC power will be saved for 600 MeV, 13 mA case (Reduction of ~$2M annual operational cost!).

LEDA has demonstrated high linac peak current 6x LANSCE beam

- 100 mA peak current, cw beam
- Developed diagnostics for beam measurement
- Developed rf control
- Led to experimental understanding of halo formation



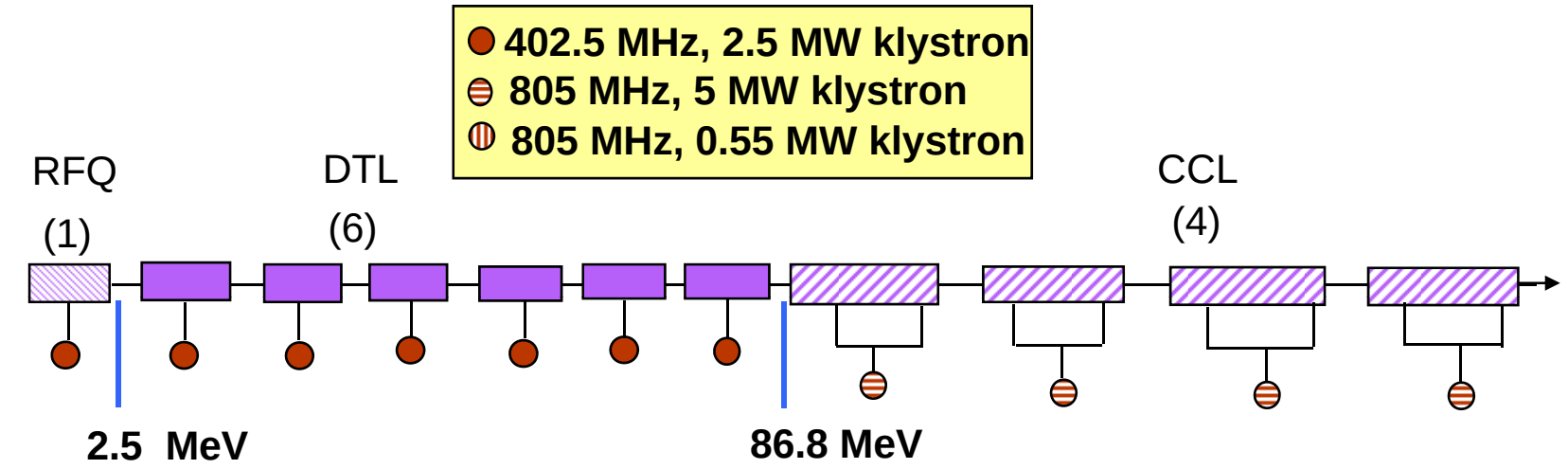
Cryo-module constructed for APT cavities

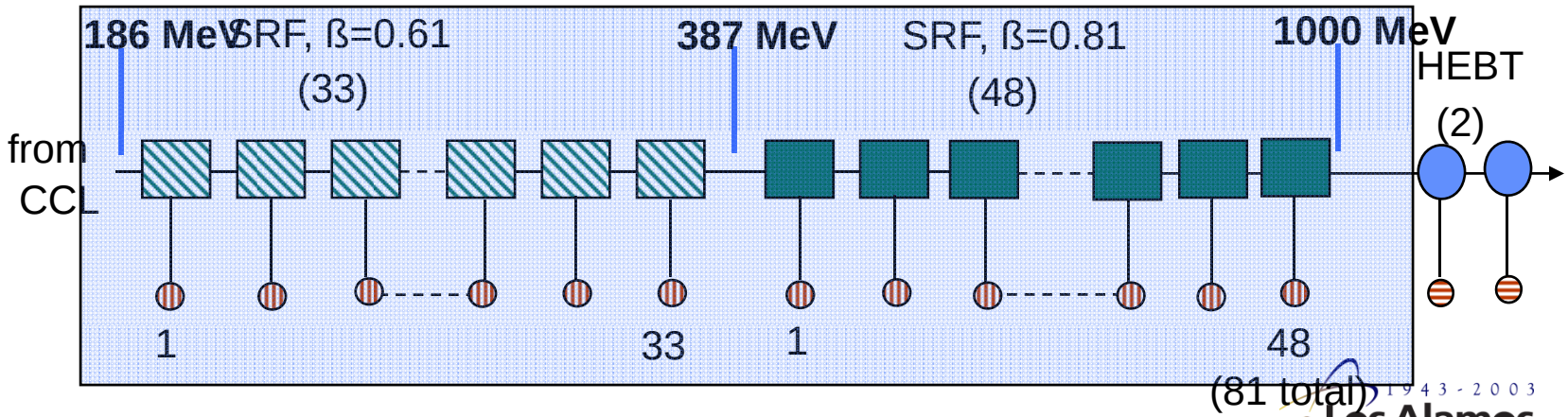


- **Complex seeming, but per MeV a good deal**
- **Concept used in several applications around the world**

1-MW power coupler developed

LANSCE is providing the RF for the SNS LINAC including 81 klystron stations for the SC LINAC

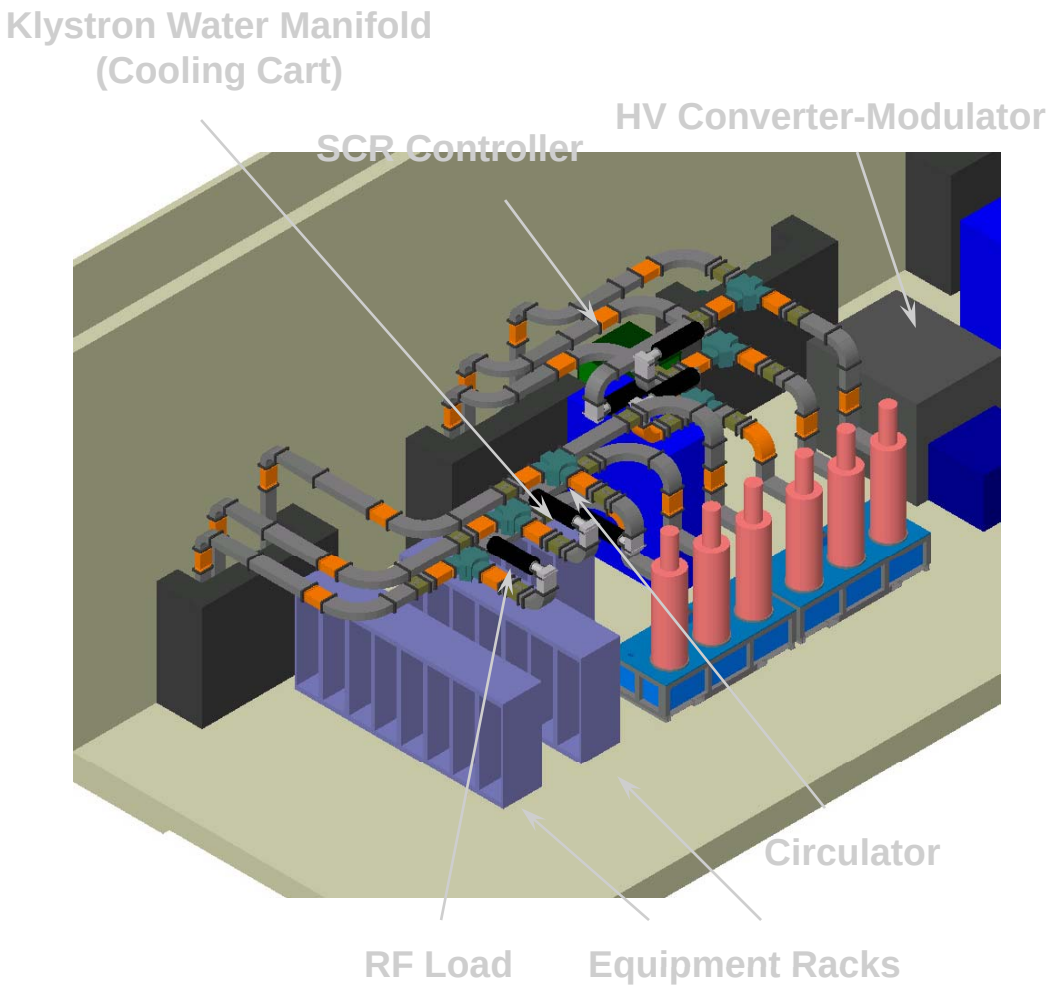




SC LINAC

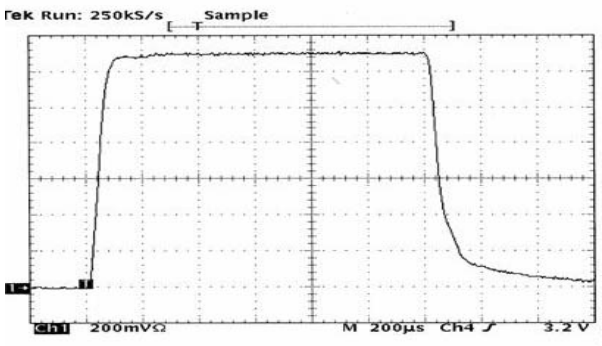
SNS SC LINAC RF-System Topology

- One klystron and LLRF control system per cavity
- High Efficiency Klystrons (65%)
- 60 Hz, 1.3 msec RF pulse
- Klystrons are protected by circulators
- Klystrons are cathode pulsed (no modulating anode) with new power system topology called a converter modulator developed for SNS.
- One set of support equipment for 6 klystrons
- One HV power source for 12 klystrons.



The SNS Pulsed Converter-Modulator operates to 11-MW peak, and 1.1 MW average power

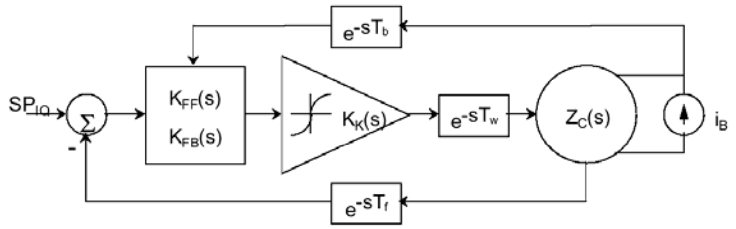
- Can operate to 140 kV
- Can operate To 1.1 MW average power
- No capacitor rooms or high voltage crowbars required
- Extensive use of proven traction motor components
  - self clearing capacitors
  - Insulated Gate Bipolar Transistors
- 20-kHz power conversion with nanocrystalline transformer cores
- Closed loop regulation
- Excellent solid state reliability
- Compact and efficient
- Design easily optimized for various loads



80-kV Waveform From The Prototype HVCM With Adaptive Feedback Control

Rf control sophistication has increased with experience

- **Models were developed based on local and DESY control experience. System modeling aids in cavity design and RF-system design (e.g. HVPS ripple specifications).**



- **The RF control system design philosophy includes a fast nearly all digital system based on downconverted in-phase and quadrature field components.**
- **RF-control-system hardware real-estate reduction has been 16-fold in the past 14 years.**
- **Future work to include**
  - **Work to higher accuracy in control levels, e.g., 0.1% amplitude,1º phase**
    - » **sophisticated feed forward**
    - » **fast tuning schemes**
  - **System control with a high-power source controlling several cavities**
  - **Experience with beam is needed**

Summary

- **LANSCE has a strong program in accelerator technology. Its experience has been in high-current linacs, accelerator engineering, high-order optics, beam dynamics, and design codes**
- **LANSCE has developed substantial facilities and expertise in superconducting rf technology**