Construction Plans for the LENS Proton Linac*

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LENS

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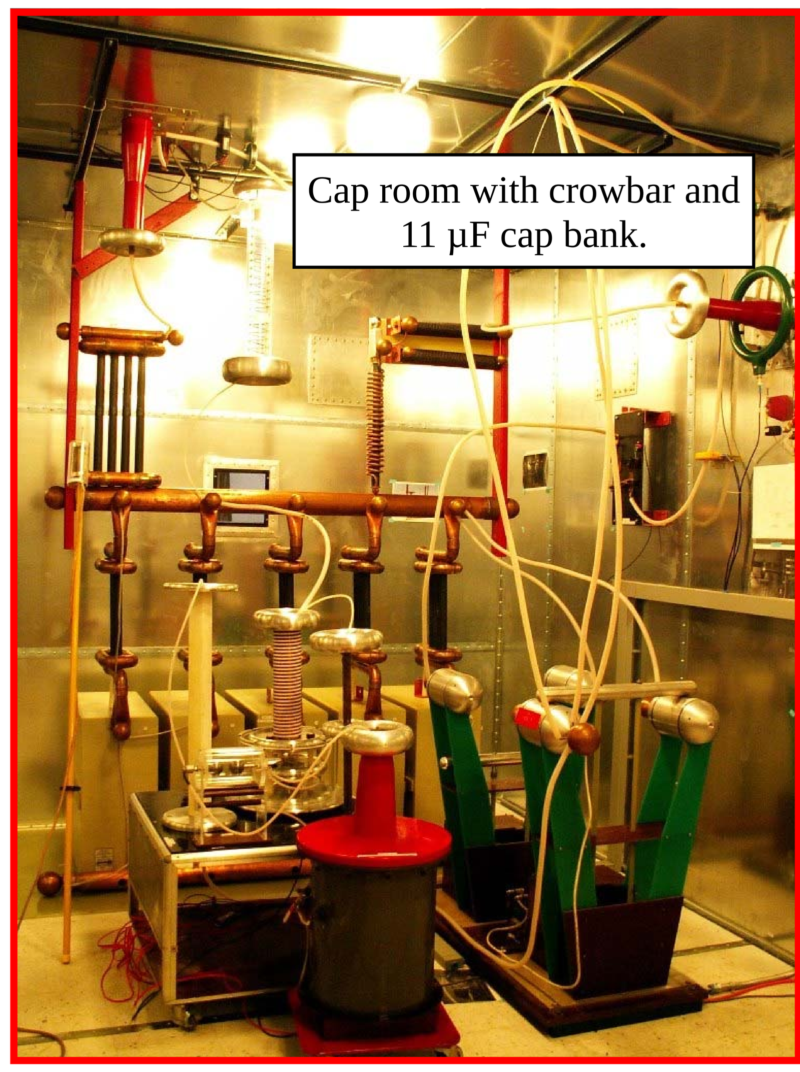
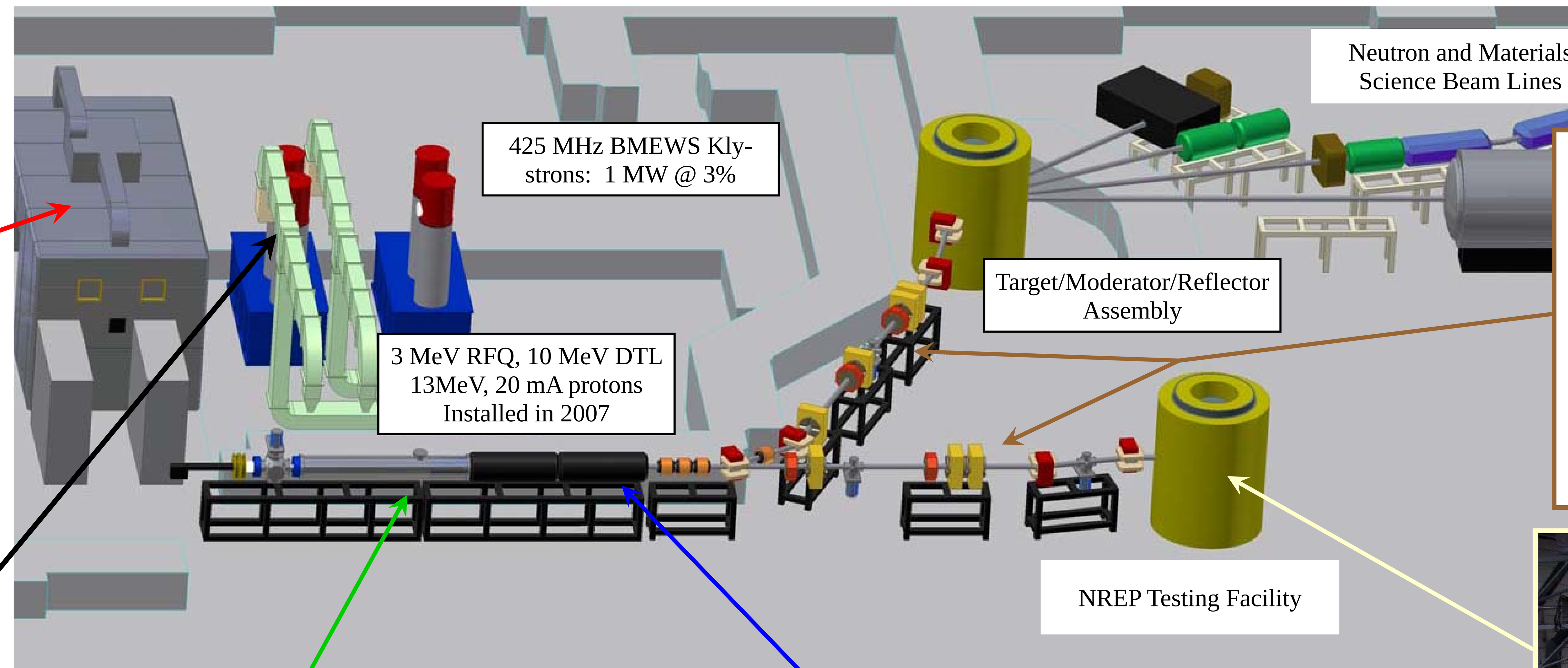
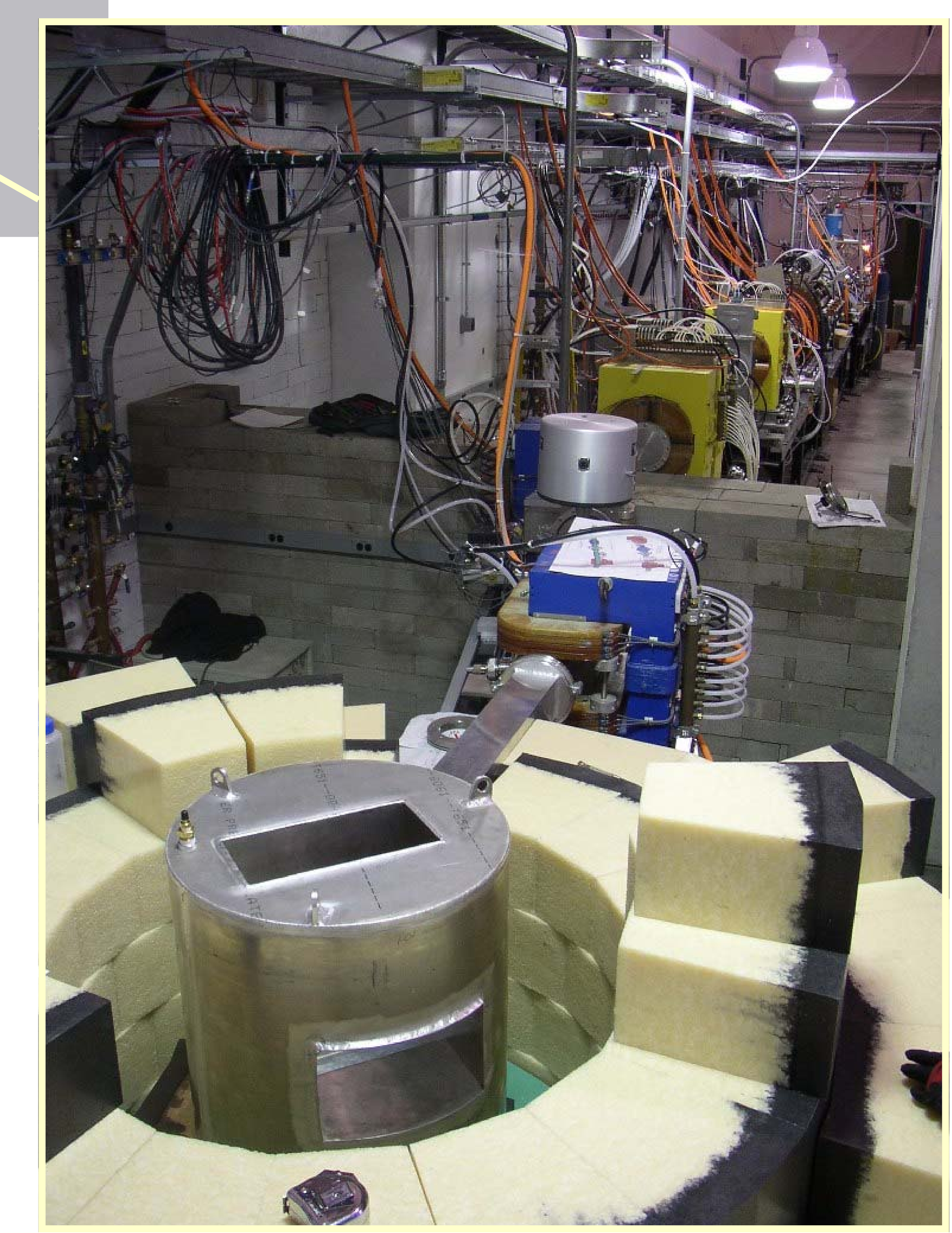
Abstract

The Low Energy Neutron Source (LENS) at Indiana University will provide moderated neutrons in the meV energy range for materials and neutron physics research as well as MeV energy range neutrons for creating a high flux neutron test environment. Neutrons will be generated by colliding 13 MeV protons with a Be target. Since December 2004, using an existing AccSys PL-7 RFQ and DTL, we have been able to deliver a 0.5% duty factor, 10 mA, 7 MeV beam to a Be target mounted next to a 3.6K methane moderator. In 2007, an additional 7 MeV to 13 MeV DTL section will be added and klystrons will be used to power the RFQ and DTL sections. This will improve the output to about 3% duty factor with 20 mA at 13 MeV. A new 75 keV, 150 mA proton injector and 100 mA, high duty factor RFQ is being constructed to replace the original 3 MeV RFQ at a later date. The peak beam current available from the new injector and RFQ will increase to 50 mA with a duty factor of at least 5% or up to 100 mA with lower duty factor. In addition, a conceptual plan has been developed for a 13 MeV to 22 MeV DTL which will boost the maximum instantaneous flux available from the neutron source up to about 10^{12} n/s/cm2.

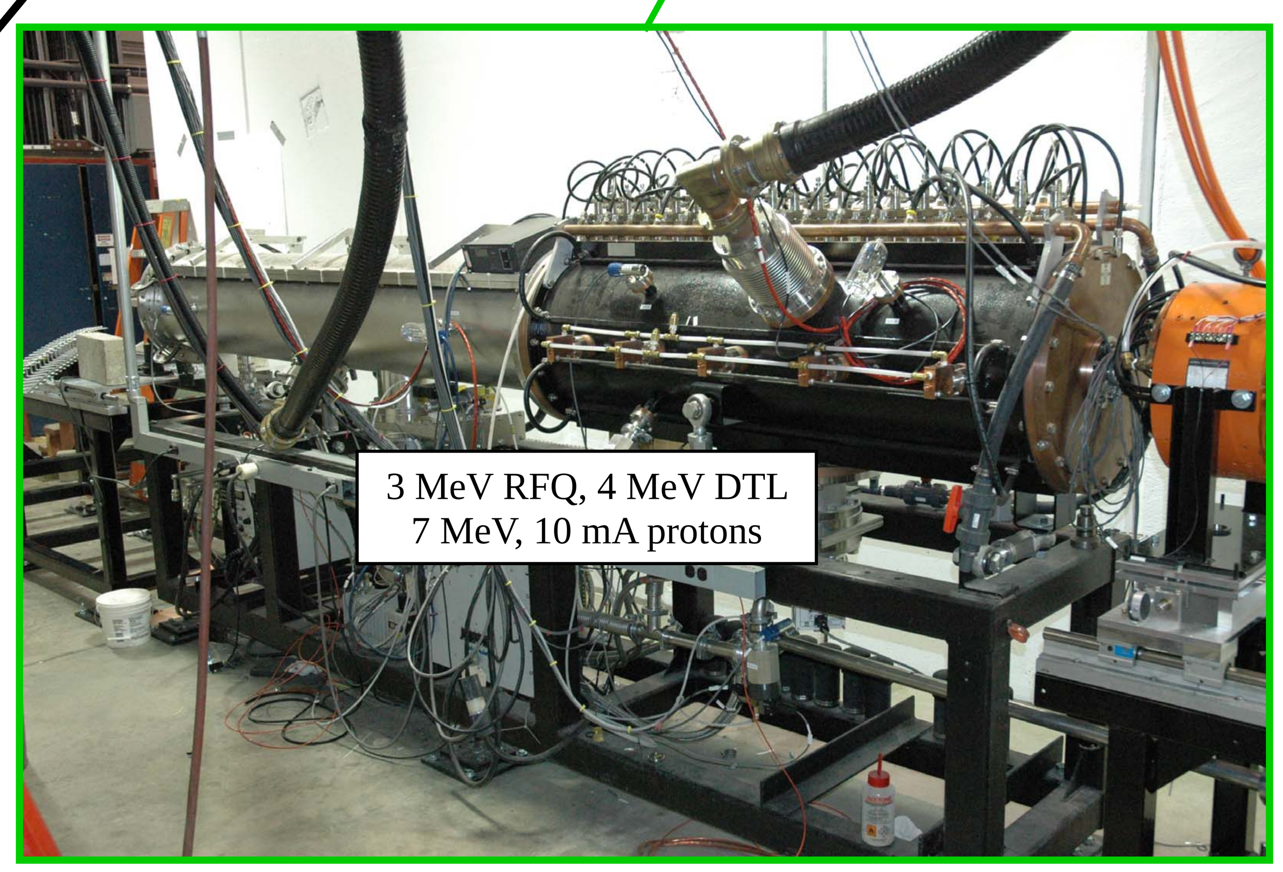




In order to minimize the thermal effects on the target of the full power beam, a non-linear beam line [2] has been constructed and is being tested as a method of spreading the beam uniformly over the Be target. At the highest average beam currents, there is a definite chance of melting through the Be target into the 30 gpm water cooling system.



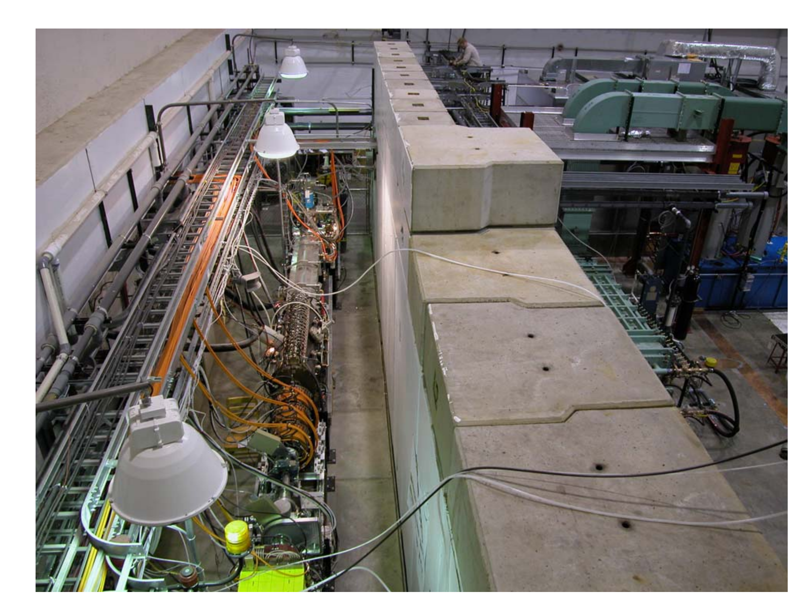
The LENS RF system currently consists of 2 Litton 5773 Klystron RF tubes which run at 425 MHz and 1 MW RF power each. These tubes are powered by a 1 A, 100 kV high voltage power supply which charges an 11 μF capacitor bank. This capacitor bank discharges 60 A as the klystron tubes fire. A high voltage crowbar protection system dissipates 99.9% of the stored energy by shorting the capacitor bank when a fault occurs. The 2 MW of RF power from the klystrons are delivered to the accelerator cavities in waveguide through RF circulators. The existing system has delivered RF power into dummy loads. A digital low level RF control system which will control the RF power levels, phase and frequency is being developed and tested.



A 13 MeV upgrade is under construction and will be completed in 2007. An AccSys Technology, Inc. [7] fabricated DTL will accelerate beam from the PL-7 up to 13 MeV. The DTL will connect directly to the PL-7 with no matching section. The 1.8 m long DTL section will consist of about 17 drift tubes and will require 450 kW of peak power at 425 MHz to reach operating field strengths. Additional power will be required for the beam. RF will be coupled into the Linac inductively using a water cooled drive loop. A third 1 MW 425 MHz klystron will be added and will deliver power through a waveguide isolator to a 3 1/8" coax adaptor and a length of coax to the drive loop. The DTL is designed to operate at a duty factor of up to 6% and accelerate at least 50 mA peak current of protons. The beam pulse width can be varied from a few microseconds up to 1.3 ms, limited by the operating capability of the klystrons. Initially the 13 MeV upgrade will be limited to a modest 1% duty factor.

Table 1. Upgrade Path for the LENS proton Linac. The upgrade to LENS Phase 2 will be completed in 2007.

Phase	Proton Energy	Comments	Peak Proton Intensity	Average Current	Duty Factor (beam)	Status	n-flux (n/s/cm^2) 1 MeV equiv.
1	7 MeV	Present Configuration	10 mA	0.03 mA	.004	Existing	1.0 x 10**8
2	13 MeV	Klystrons and DTL added	20 mA	0.15 mA	.010	Under construction	2.2 x 10**9
3	13 MeV	4 Ampere, 100 kV power supply added	20 mA	0.38 mA	.024	Future	5.0 x 10**9
4	13 MeV	New RFQ and 75 keV, 100 mA proton injector	50 mA	1.2 mA	.024	RFQ under construction	1.6 x 10**10



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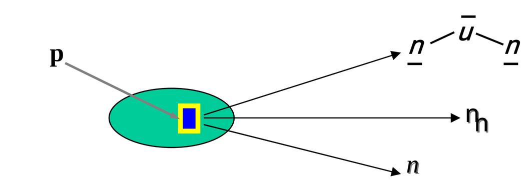
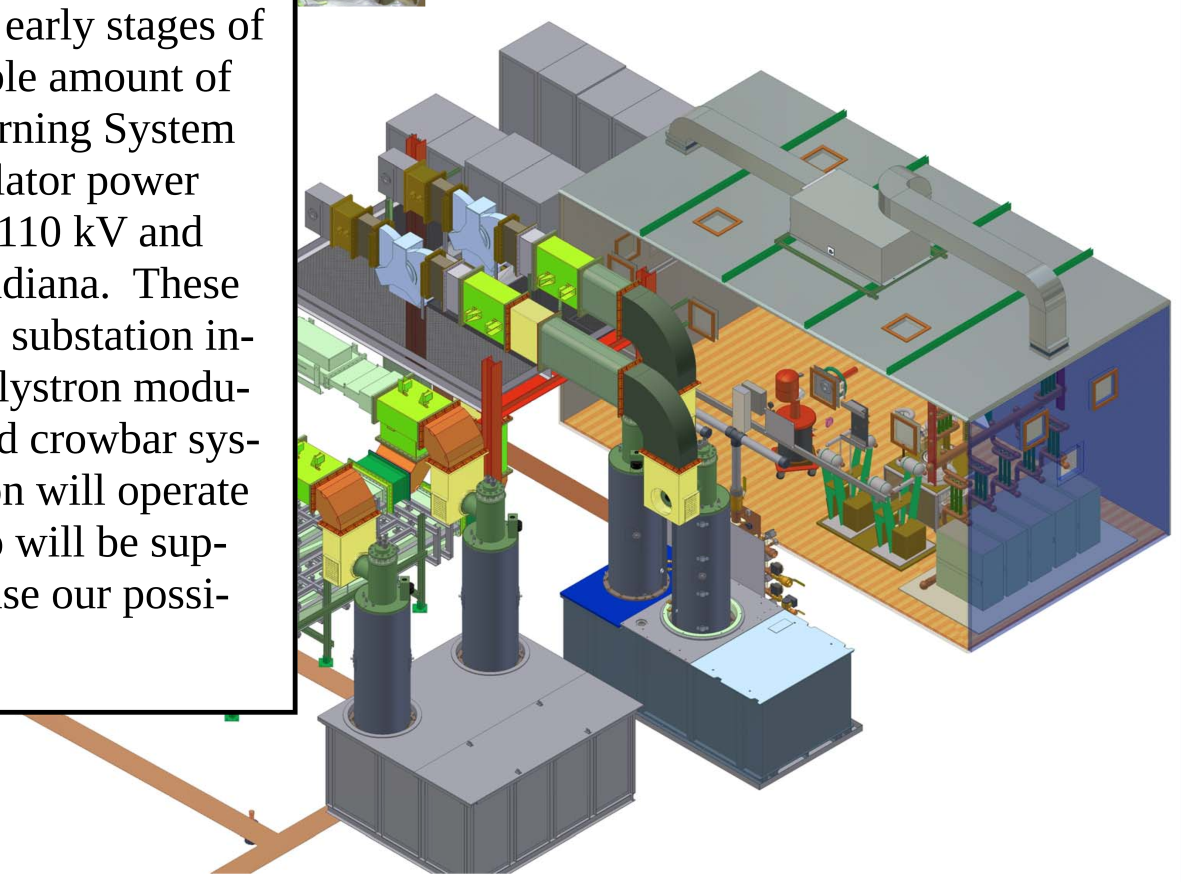
Construction Plans for the LENS Proton Linac (cont.)



High Power Modulator Upgrade

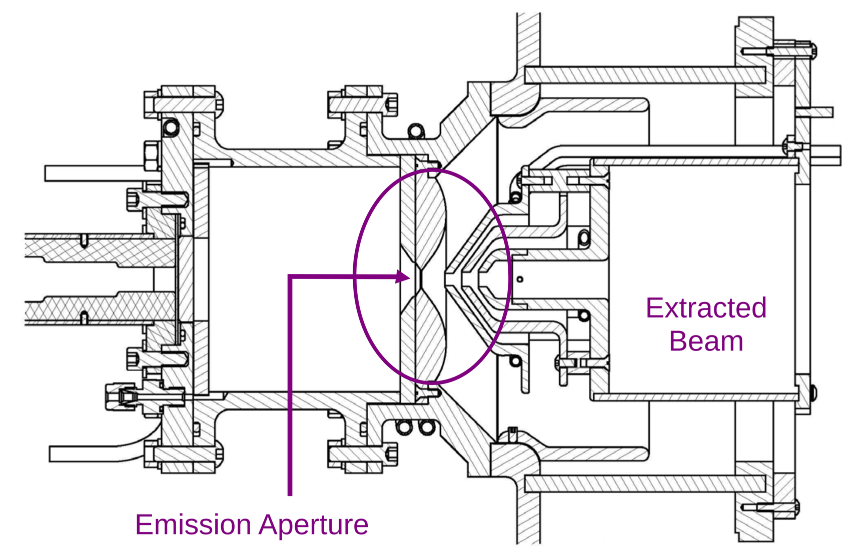
In order to realize an increase in the duty factor, a higher power modulator will be installed. During the early stages of the LENS project, IUCF salvaged a considerable amount of equipment from the Ballistic Missile Early Warning System (BMEWS) site at Clear AFS in Alaska. Modulator power supplies with an output voltage and current of 110 kV and 4 Amperes were obtained and transported to Indiana. These power supplies must be refurbished and an AC substation installed before they may be used to power the klystron modulators. In addition, a second capacitor bank and crowbar system must be installed. In this case, one klystron will operate with a 1 Ampere supply and the remaining two will be supplied with a 4 Ampere supply. This will increase our possible duty factor by 2 1/2 times.



The New 75 keV Proton Injector and 3 MeV, 100 mA RFQ

The new 75 keV, 150 mA [4]

- Design of source is based on work performed at Los Alamos [8].
- Design is complete, construction is in progress.
- Similar microwave type ion sources are used to deliver lower energy protons to the PL-7 and the IUCF cyclotrons.

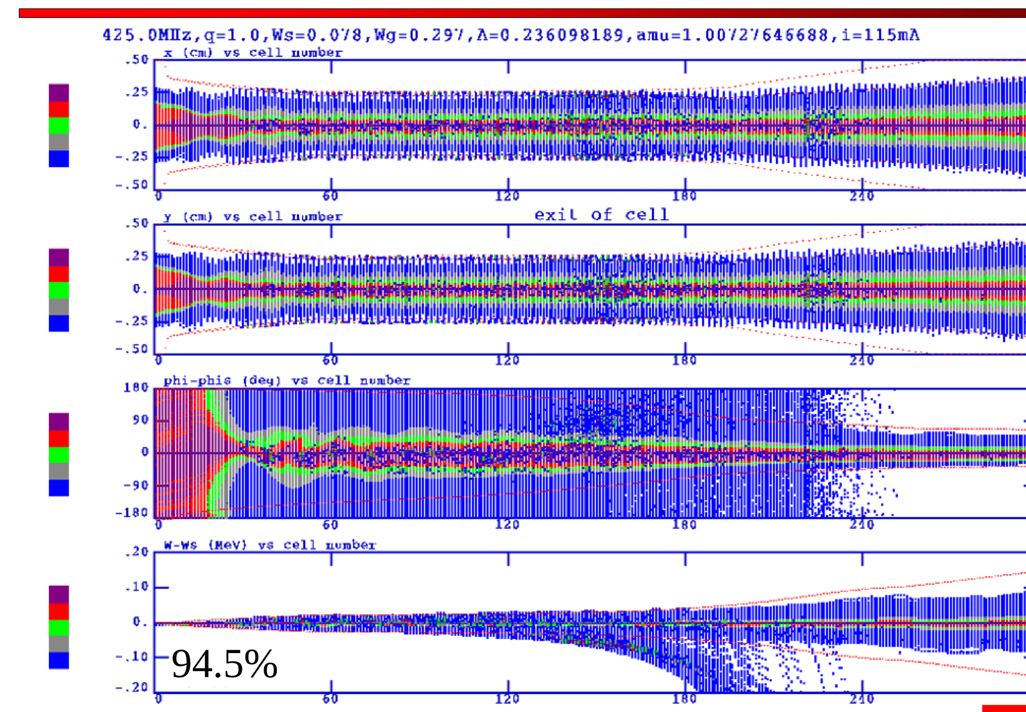


Scintillation light of a 25 keV, 30 mA beam from the proton injector for the PL-7.

The new 3 MeV, 100 mA RFQ

- New 75 keV proton injector with 150 mA peak current.
- 3 MeV, 100 mA RFQ designed by TechSource, Inc. (Lloyd Young) and fabrication by Accel, GmbH.
- Length = 3 meters, 425 MHz and 1 MW peak power with beam.
- Designed choke current = 200 mA.
- Fabrication will be complete in early 2007.
- Installation date is dependent on available funds.

BEAM TRANSMISSION THROUGH RFQ USING 114 mA SIMULATED INPUT DISTRIBUTION.



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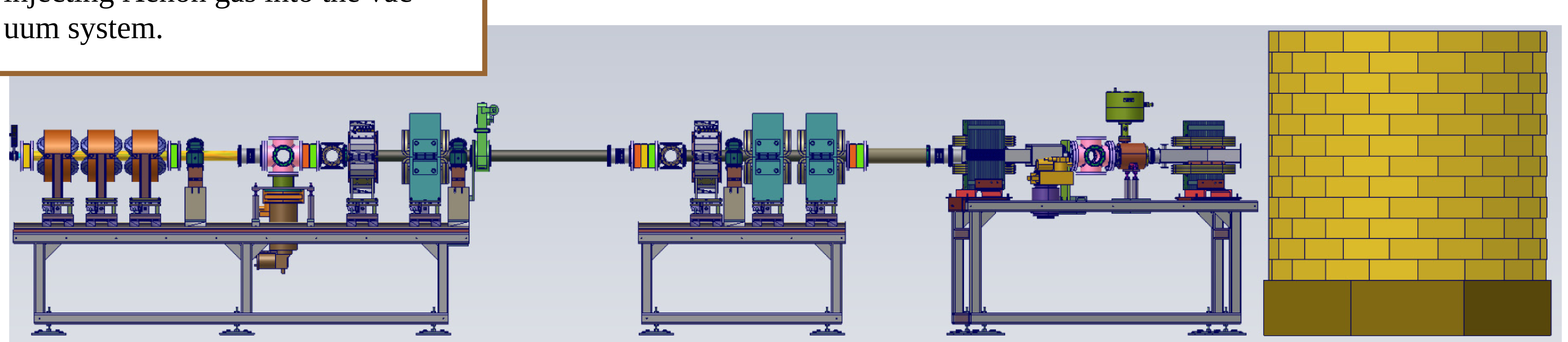
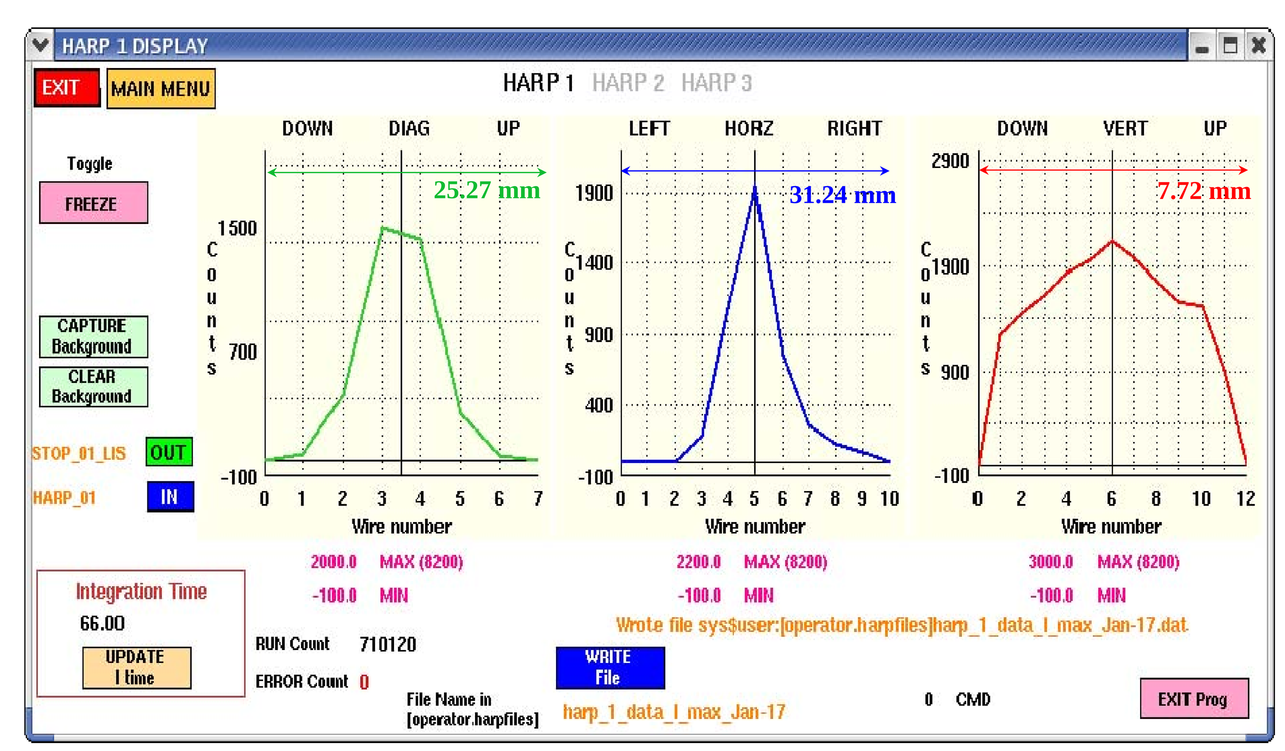
Beam Transport and Diagnostics

- The beam line uses a combination of octupoles and quadrupoles to spread the beam on the target.
- A combination of wire harps, beam position monitors and viewing the beam using scintillation light is used to develop the beam line.
- When phase 4 is implemented, we will rely on profile monitors based on the scintillation light emitted by injecting Xenon gas into the vacuum system.

Real time parameters of the proton beam hitting the Be target is the essential information for analysis of the LENS performance. A Bergoz Current Transformer (CT) installed in the location close to the Be target will provide such an information. This CT and another CT installed at the end of the DTL are planned to be a part of the Beam Spill Control System (BSCS). The BSCS is supposed to detect any unwanted beam loss and take action to save the equipment.





We have designed and are using wire harps to monitor the beam size and shape (Figure 2) albeit with very low duty factor. This diagnostic, used with a beam stopping viewer and several beam position monitors gives information necessary to develop the octupole beam spreading system.

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[10] Accel Instruments GmbH, Friedrich-Ebert-Strasse 1, D-51429 Bergisch Gladbach, Germany.

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