Cooling Channel Linac

201 Mhz

High Power RF System

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&
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Goal

To present the status of a preliminary design study for a 201 Mhz high power rf system given the following requirements:

Comparison to Present FNAL Linac

- First half uses 5 Megawatt Burle 7835 triode.
- Would require 150 stations at 5 Mwatt
- Requires large driver power (250 Kwatts)
- Multiple HV power supplies.
- Don't believe this is a manageable system.
- Total cost for 150 meters of 5 Mwatt every bit as much as klystron gallery.

Other possible power sources

- Single Beam Klystron
- Inductive Output Tube (IOT)
- Special Tetrodes
- Other unique devices

Preliminary Specification

Frequency:	**201 Mhz**
Rf Power:	**5 Mwatts per Meter**
Rf Pulse width:	**150 uSec.**
Duty Factor:	**0.226%**
Rep Rate:	**15 Hz.**
Length of Channel:	**~150 Meters**

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Plan

A 201 Mhz Multibeam Klystron capable of driving two meters of cavity.

- Requires 75 stations for 150 meter Linac
  or
  50 stations for 100 meter Linac
- RF output power is 10 Megawatts pk.

Multibeam Klystron

- Less risky than other devices at this time for >10 megawatts pk power at 201 Mhz.
- Low drive power.
- Should have a high MTBF.
- Size is an issue ~ 7.75 meters long.
- Large solenoid.
- Some R&D required.

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RF Power Source – Multibeam Klystron

Peak RF Power output:	**10 Megawatt**
Beam Voltage:	**~ 65 Kvolts**
Beam Current:	**~ 310 amps.**
RF Pulse Width	**150 uSec.**
Rep Rate:	**15 Hz**
Duty Factor:	**0.226%**
Efficiency:	**~ 50%**
Gain:	**~ 50 dB**
Rf output connection:	**14 inch diameter copper coax with EIA flange.**
Length of Klystron:	**~ 7.75 Meter**
Klystron weight:	**~ 12,000 lbs.**
Solenoid Power:	**~ 50 Kwatts**
Solenoid weight:	**~ 50,000 lbs. (25 Ton)**

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Modulator for Multibeam Klystron

With advances in high power solid state electronics, Insulated Gate Bipolar Transistors (IGBTs) are a very attractive solution for delivering high voltage to the Klystron.

Solid State Modulators have been built commercially for similar applications and are currently being considered for use in other high energy physics projects.

Voltage:	**65 Kvolts**
Peak Power:	**20 Megawatts**
Current:	**310 Amps**
Average Power:	**60 Kwatts**
Pulse Width:	**200 uSec.**
Size:	**1.2 x 1.2 x 2.4 Meter**
Rep Rate:	**15 Hz.**
Droop:	**~ 5%**

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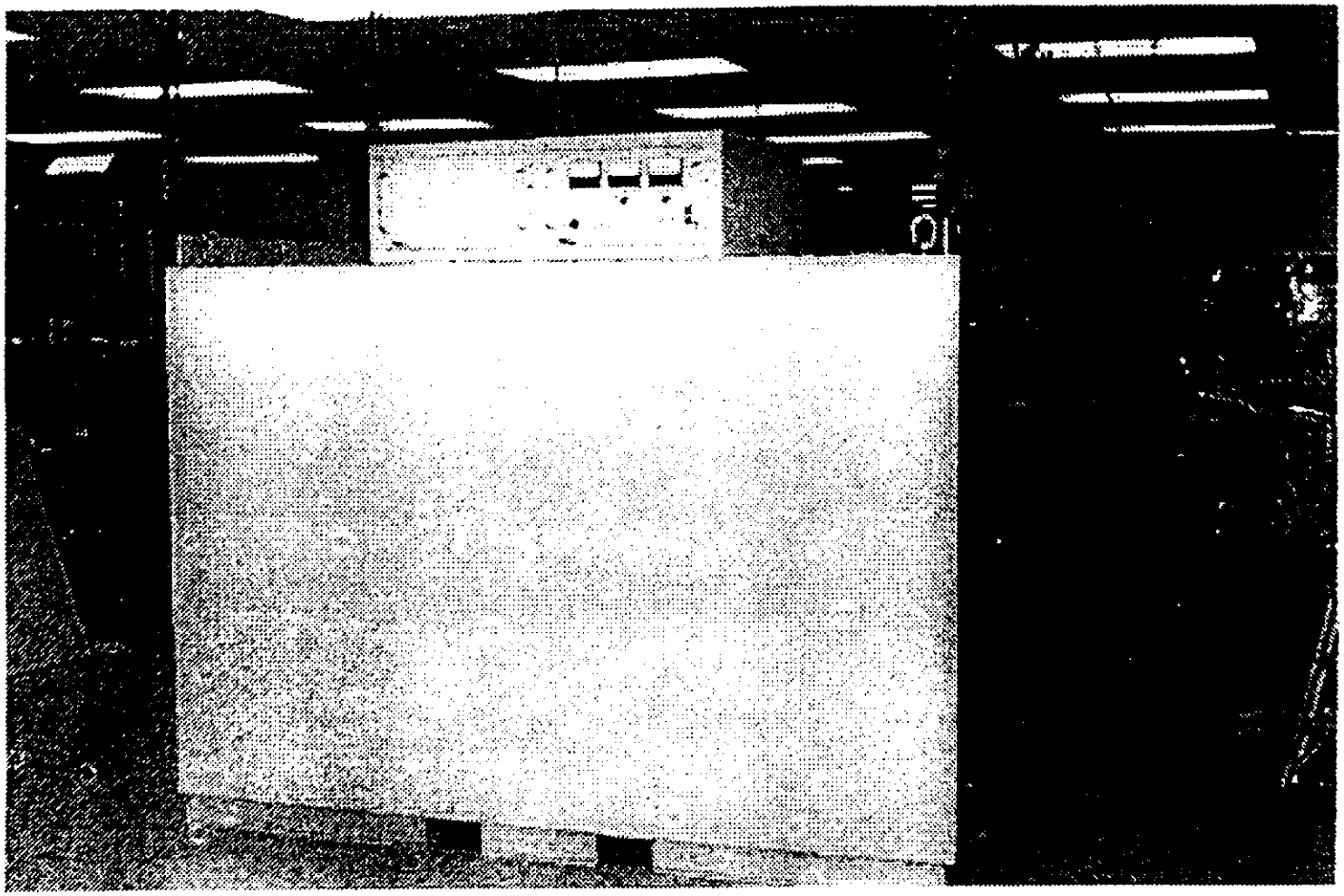

14 inch Diameter Coaxial Transmission

- Couple rf power from Klystron to cavity.
- Line will be pressurized with dry air to 0.5psig.
- Two rf windows

  One integral part of Klystron

  Other at cavity input

- Total electrical wavelength between Klystron and cavity will be adjusted to an integer number of half wavelengths.
- Standard rigid copper transmission line with EIA flanges.

Water Skid for Accelerating Cavity

- Used for temperature control of cavity structure.
- The water skid will supply tempered water for each two (2) meters of cavity.
- Each skid will have heaters, pumps, DI loop, and heat exchangers with primary cooling supplied from a central chilled water loop.
- Approximately 22.5 Kwatts of heat will be dissipated in each two (2) meters of cavity.
- Low conductivity water (LCW) of about 10 megaohms-cm resistivity.

Station Relay Racks

- Each rf station will have five (5) racks for housing controls, power supplies, LLRF, and a 250 watt solid state driver amplifier.

- Racks are the standard 24 inches wide by 30 inches deep and 86.5 inches high.

- **Controls - Digital I/O & Analog Mon.**

  Similar to the Main Injector's that use a local VME based system for local station applications and communication with the main control room (ACNET).

- **Power Supplies**

  Ion pump supplies for Klystron and cavity.

  Filament power supply for the Klystron.

- **LLRF**

  Each station will have a local feedback loop for phase regulation.

  Spark detection will include circuits to protect the Klystron, rf windows, cavity surfaces, and transmission line.

  A commercially available 250 watt solid state amplifier to drive the Klystron.

Utilities

Electrical Power

The AC power distribution will be by cable trench as shown on the building's floor plan. Only signal cables will be run in overhead cable trays.

480 Volt 3-Phase	**Per station**	**Total 50**
Filament:	**5 Kwatts**	**250 Kw**
Modulator:	**60 Kwatts**	**3000 Kw**
Solenoid supplies:	**50 Kwatts**	**2500 Kw**
Solid State rf Amp	**2.5Kwatts**	**125 Kw**
Water Skid:	**20 Kwatts**	**1000 Kw**
Misc.	**10 Kwatts**	**500 Kw**
Pumproom		**750 Kw**

120/208 volts

Relay racks	**5 Kwatts**	**250 Kw**
Ion pump PS	**3 Kwatts**	**150 Kw**
Misc	**2 Kwatts**	**100 Kw**
Total	**157.5 Kwatts**	**8,625 Kw**

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Electrical Power

The AC power distribution will be by cable trench as shown on the building's floor plan. Only signal cables will be run in overhead cable trays.

480 Volt 3-Phase	**Per station**	**Total 75**
Filament:	**5 Kwatts**	**375 Kw**
Modulator:	**60 Kwatts**	**4500 Kw**
Solenoid supplies:	**50 Kwatts**	**3750 Kw**
Solid State rf Amp	**2.5Kwatts**	**188 Kw**
Water Skid:	**20 Kwatts**	**1500 Kw**
Misc.	**10 Kwatts**	**750 Kw**
Pumproom		**750 Kw**

120/208 volts

Relay racks	**5 Kwatts**	**375 Kw**
Ion pump PS	**3 Kwatts**	**225 Kw**
Misc	**2 Kwatts**	**150 Kw**
Total	**157.5 Kwatts**	**12,563 Kw**

Utilities

- Water Distribution

The water distribution system will be constructed using schedule 10 stainless steel pipe and valves.

	Per station	Total 50
95 degree cooling LCW:	75 gpm	3750 gpm
Industrial chilled water:	20 gpm	1000 gpm

Utilities

- Water Distribution

  The water distribution system will be constructed using schedule 10 stainless steel pipe and valves.

	Per station	Total 75
95 degree cooling LCW:	75 gpm	5625 gpm
Industrial chilled water:	20 gpm	1500 gpm

Conclusion:

It is clear form this study that the major cost driver for the high level rf system is the Klystron and its solenoid.

R&D effort is needed to develop an rf power source.

Klystron

Inductive Output Tube

Possible special tetrode??

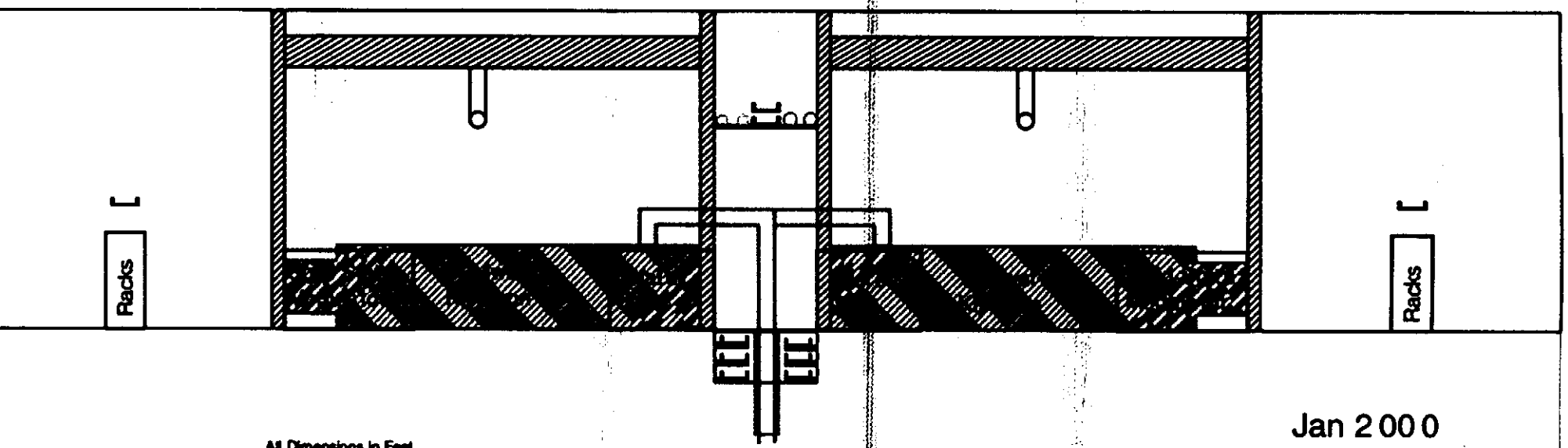
R&D Program

A three (3) year R&D program that would be adequately funded up front, to enable us to pursue the development and testing of 201 Mhz ultra high power rf sources (10 Mwatts or greater).

This would include the procurement of a single beam Klystron, a Multibeam Klystron, an Inductive Output Tube (IOT), and solid state Modulator.

The end result would be an operating model for the production rf power sources. Careful consideration will be given to cost reduction techniques and the capability to commercially mass produce these devices.

Cross Section - Cooling Channel Linac
Equipment Gallery



Sketch I

Cooling Channel Linac Equipment Gallery Layout

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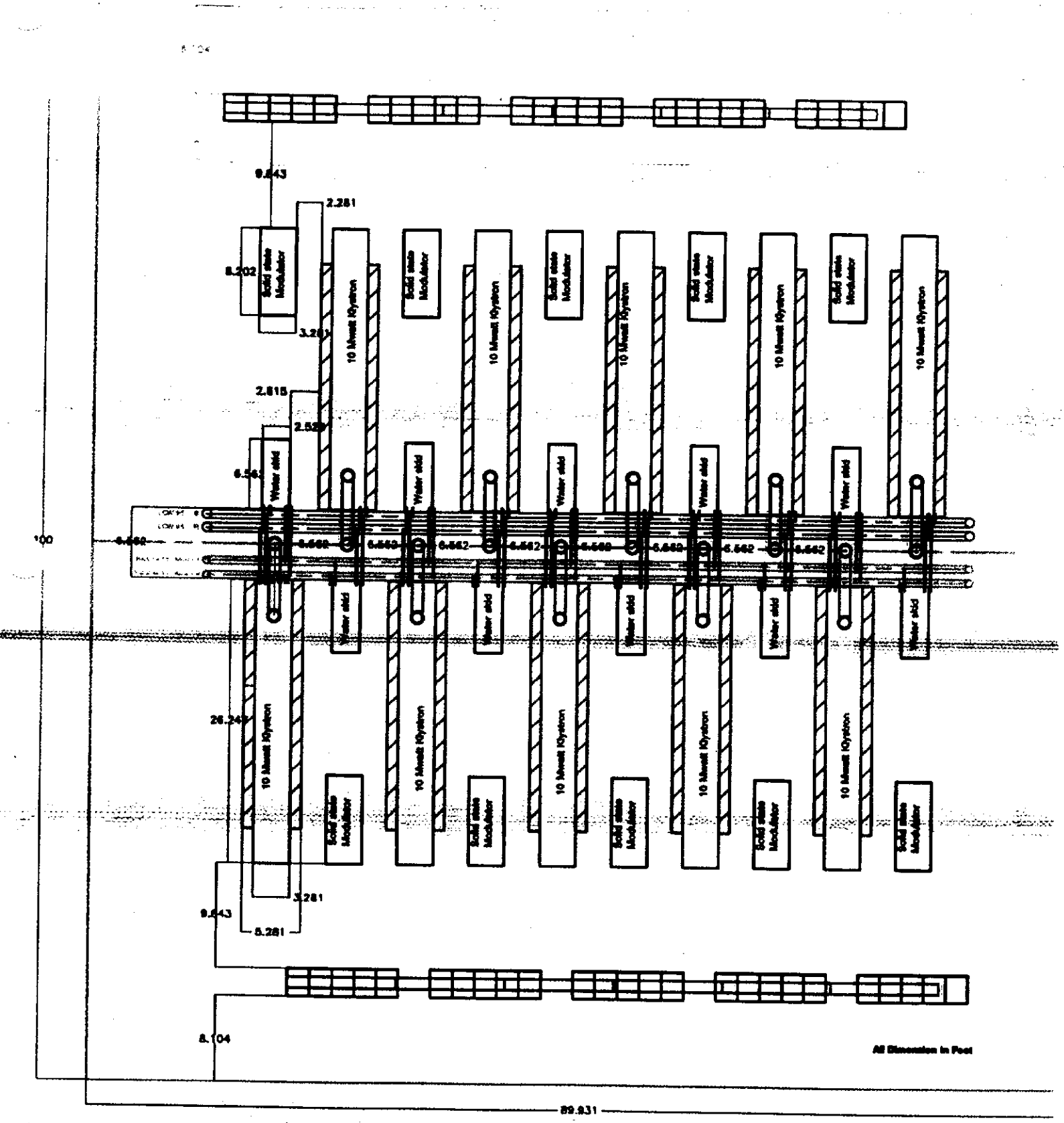

Sketch II