# R&D towards a polarized rf gun

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# Objective

- RF Guns are proven to deliver high brightness beams
- At Fermilab we explore the possibility of flat beam production (emittance ratio >100)
- Wouldn't it be attractive to combine this with spin polarization?

  **Or in other words:**

  **The above is useless for a collider without polarization!**

# Objective

- Polarized guns require NEA GaAs cathodes
- GaAs cathodes require excellent vacuum ($10^{-12}$ Torr)
- The vacuum in rf guns typically ranges around $10^{-9}$ Torr
- Need to improve the vacuum drastically

# Diagram

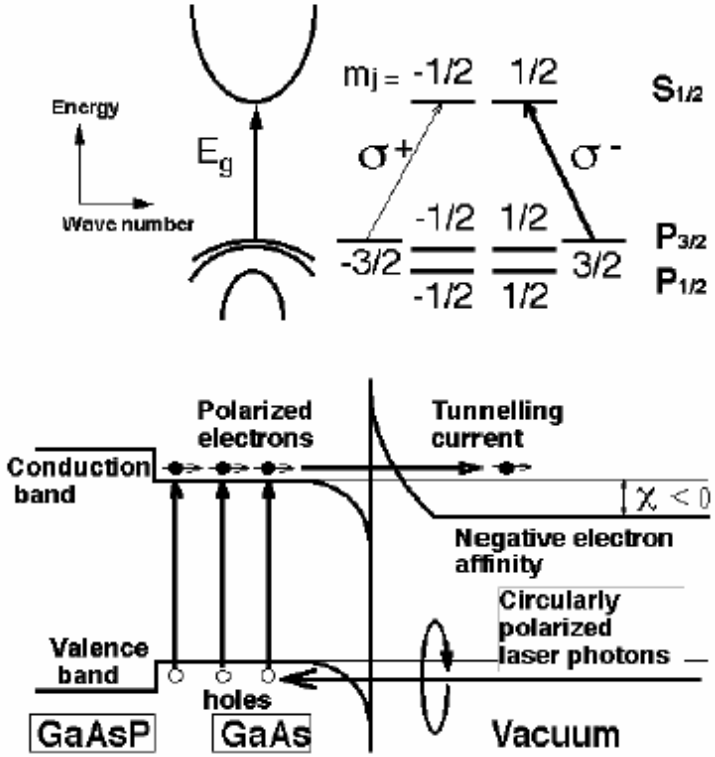



Fig. 1 : Principle of Strained GaAs-type PES

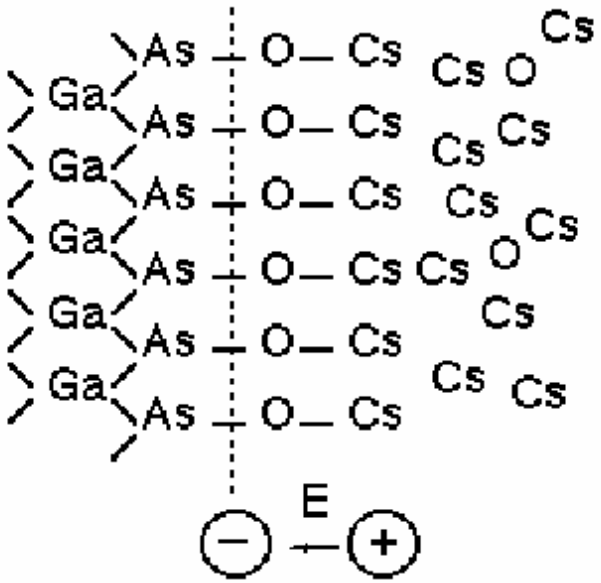



Fig. 2 : Microscopic view of NEA surface

# Dangerous Gases

- Oxygen
- Water
- Carbon monoxide and dioxide

# Options

- Change gun structure for more “open” design for better pumping

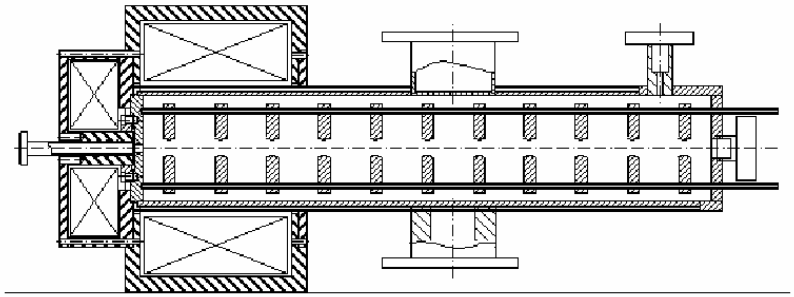


Figure 1: Schematic view of the PWT photoinjector.

- NEG coating

# Idea

- Operate the gun at cryogenic temperatures to lower the equilibrium pressure
- Superconducting gun prevents the use of solenoids -> ruled out
- Operate copper gun at liquid nitrogen temperature

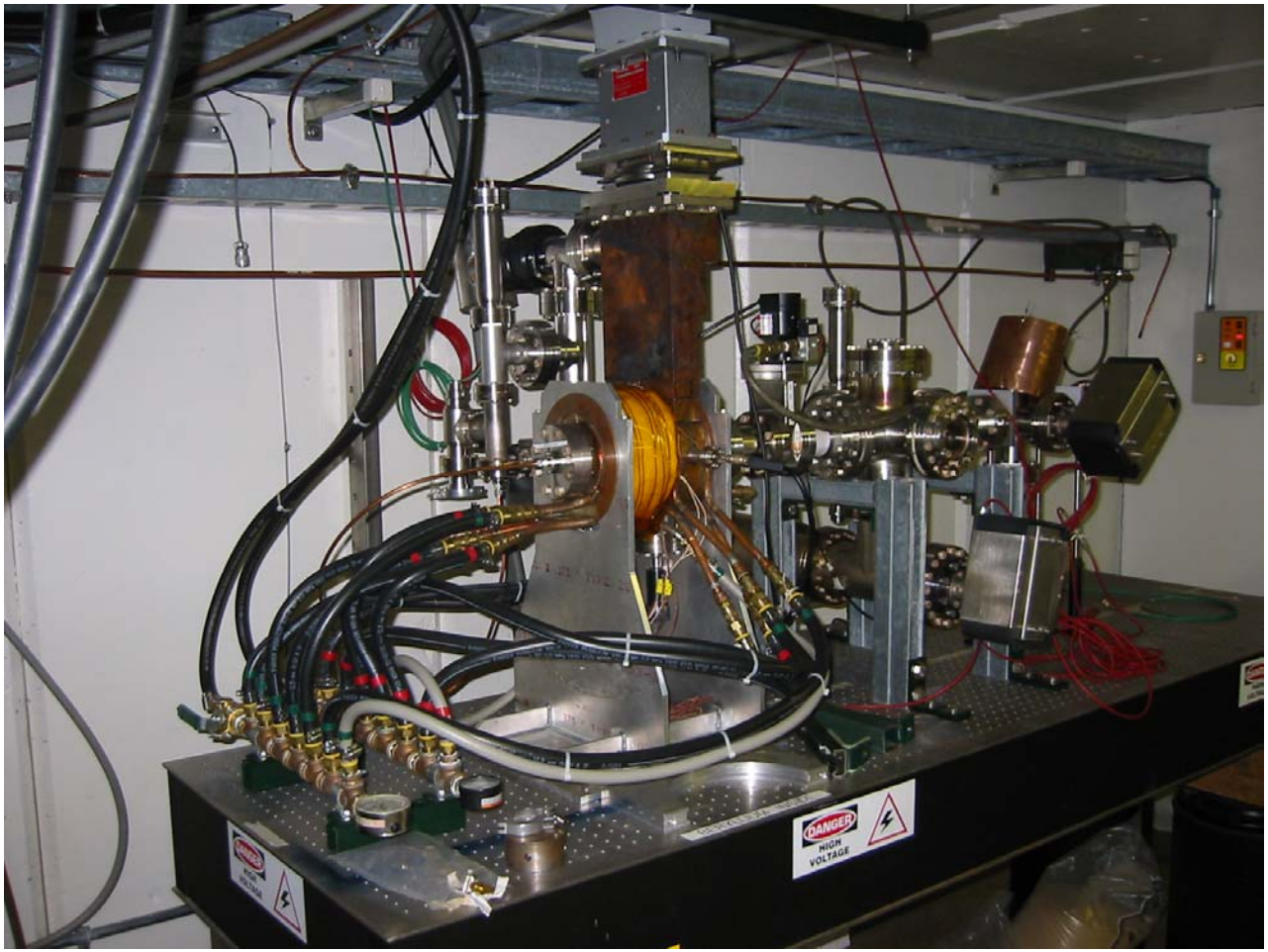
# Idea

- **Gas desorption strongly depends on temperature**

$$\frac{dN}{dt} \propto N \exp\left(-\frac{E}{RT}\right)$$

**for E≈10kJ/mol -> factor $10^5$!**

# Prototype Gun



# Prototype Gun

- **Prototype gun available at Fermilab:**
  **->1.6 cell L-band gun (1.3 GHz)**
  **-> at 35 MV/m dissipates 2.2 MW**
  **-> TESLA parameters: 900 μs, 5 Hz**

# Prototype Gun

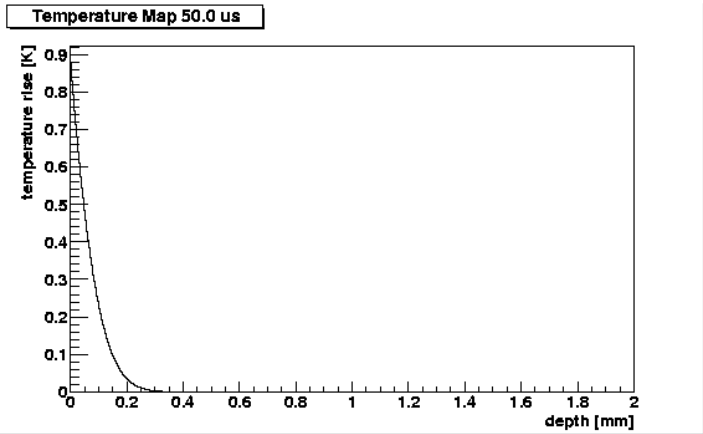
- At 80 K the dissipated power is reduced by a factor of 2.8
  - -> 780 kW peak power
  - -> 3.5 kW average power
  - -> Heat flux at cooling pipes 2.5 W/cm$^2$ (nucleate boiling limit 15 W/cm$^2$) maximum in iris with 3.1 W/cm$^2$

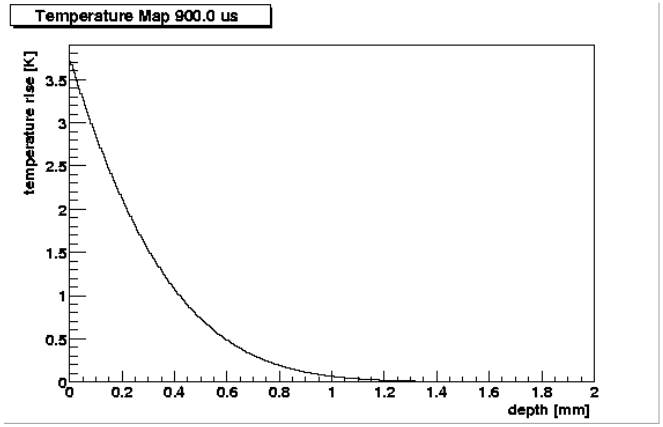
# Temperature Distribution

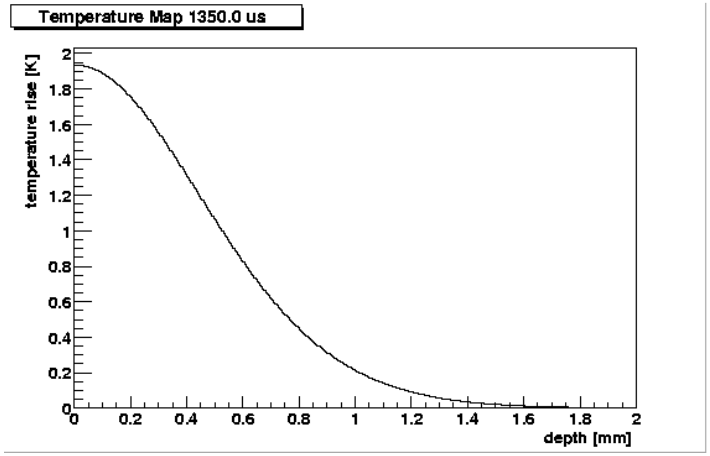
- **Temperature rises with**

$$T = I\sqrt{\frac{4t}{\pi\rho c\lambda}}$$

# Temperature Distribution



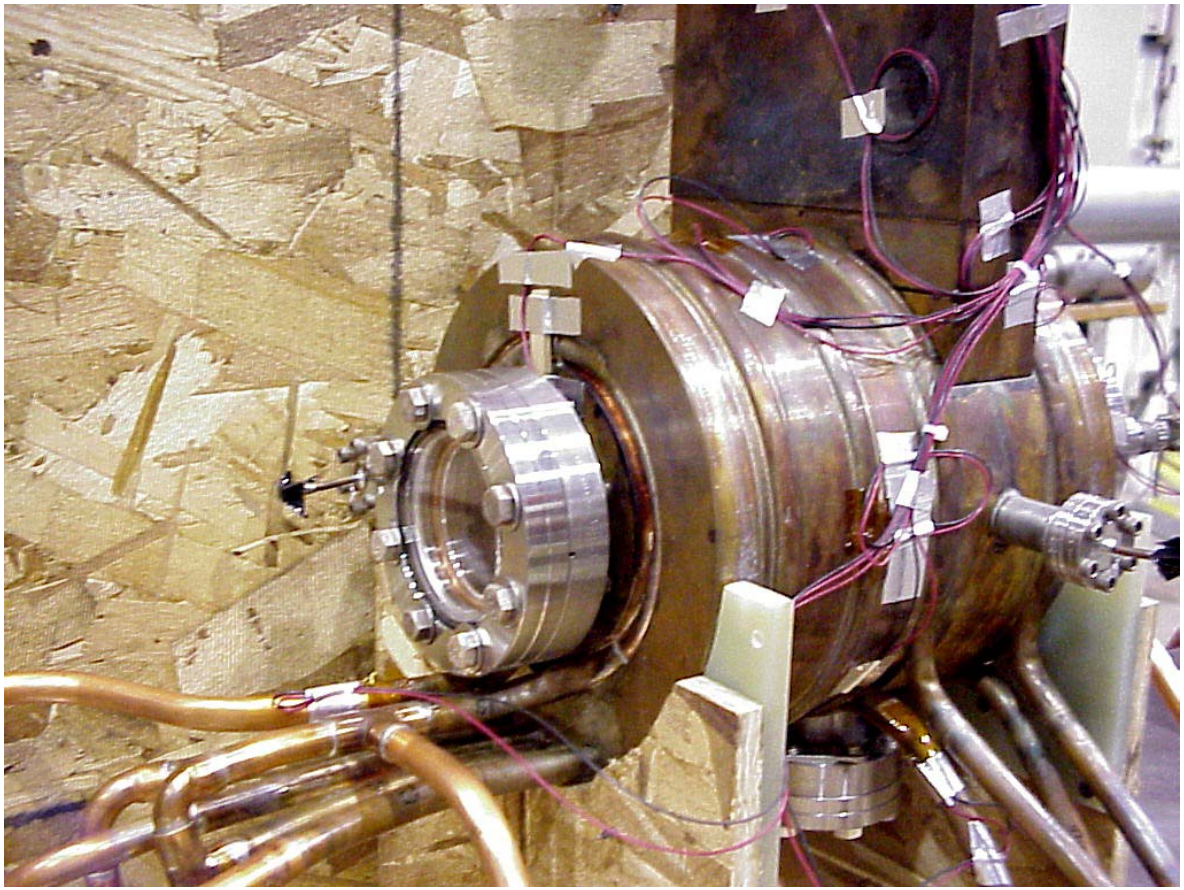



# Phase I: Vacuum Tests

- Cool down to 80 K
  -> measure pressure, RGA
- Apply RF
  -> measure pressure, RGA
  -> measure dark current

# Phase I: Vacuum Tests



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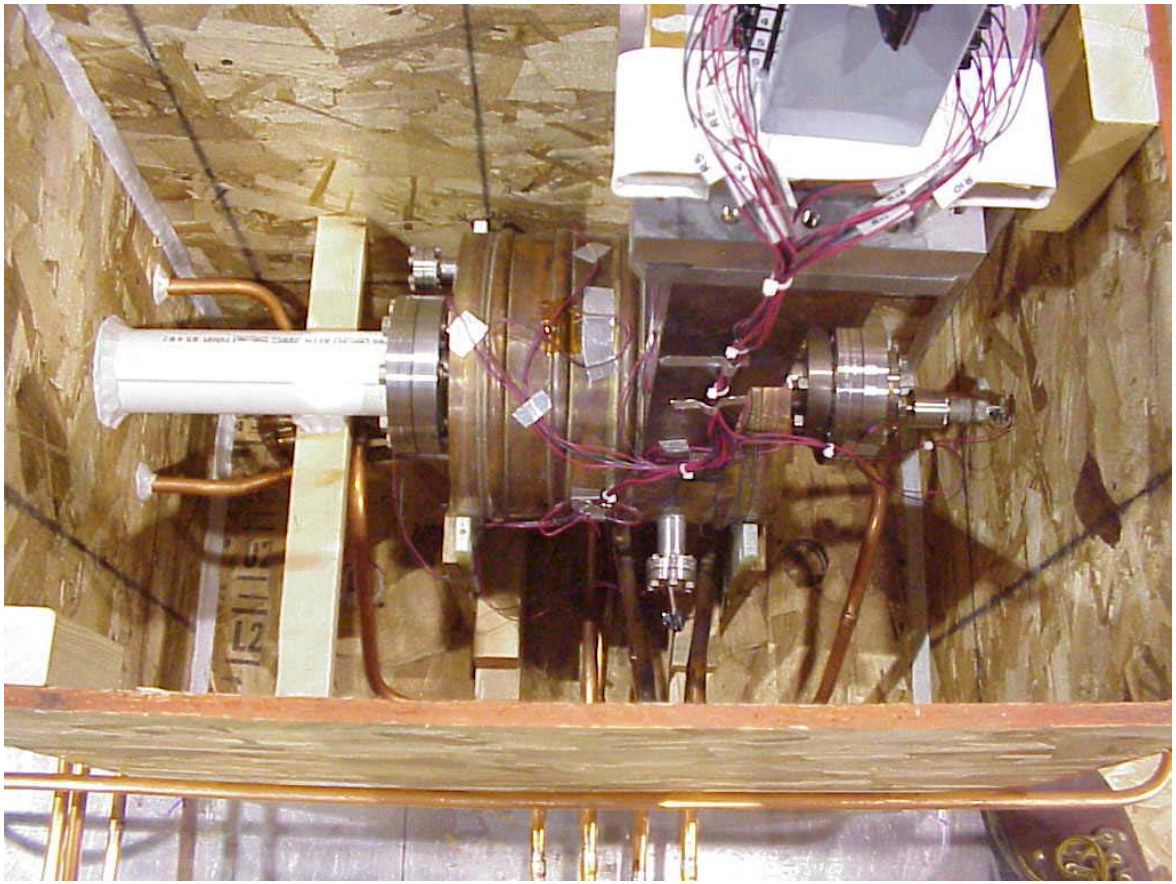

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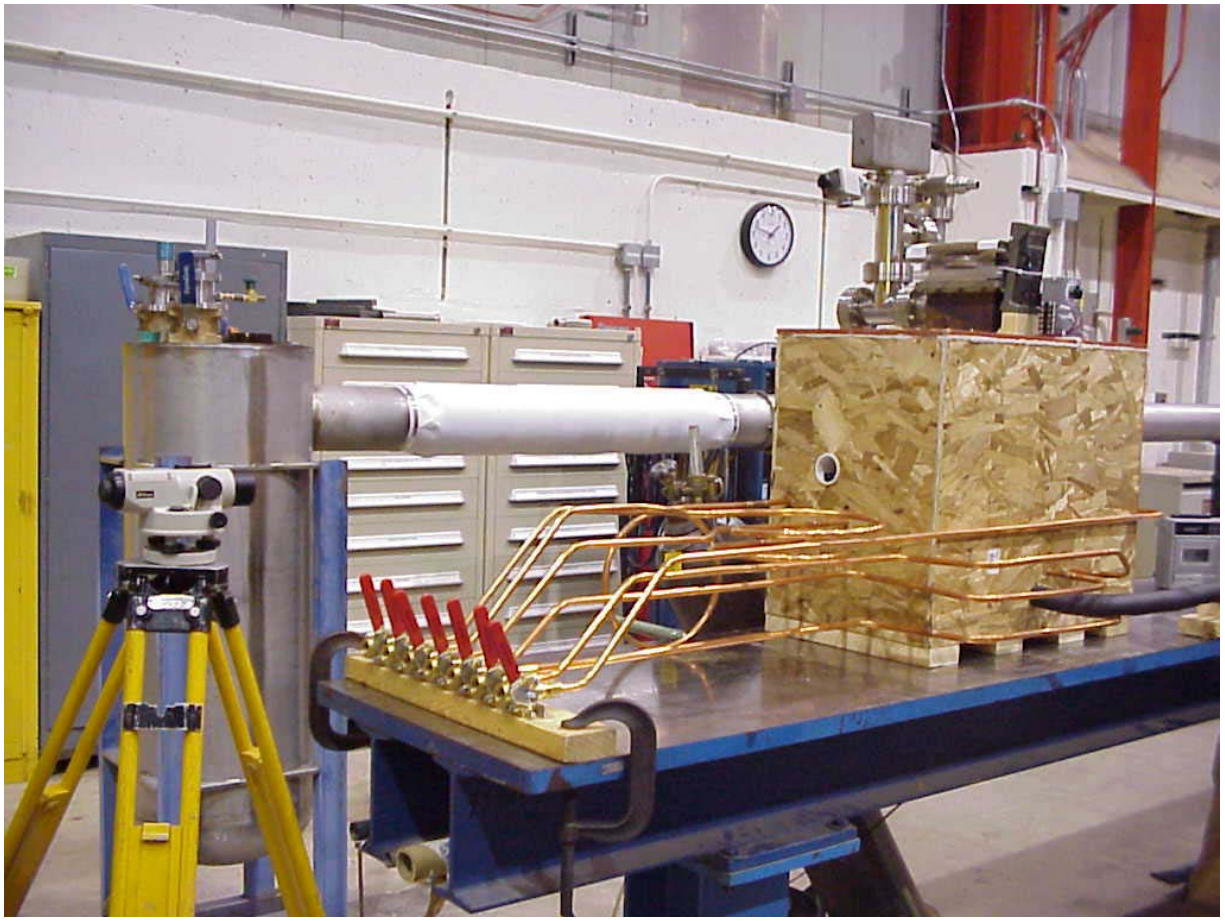

# Phase I: Vacuum Tests

- Cleaning: Done
- Bake-Out: Underway
- Test with RF: This fall
- Decision to proceed: Thereafter

# Phase II: Quantum Efficiency

- Built a cathode system (load-lock)
- Obtain a (set of) cathode(s)
- Laser diode for Q.E. measurements
- Cryostat
- Measure Q.E. lifetime, dark current

# Phase III: Gun Design

- Design a “usable” gun
- Incorporate into accelerator facility
  -> produce a real beam
  -> measure polarization
  -> measure emittances
- Options for reduction of average rf power?
  -> reduce heat load
  -> reduce dark current

# Phase III: Gun Design

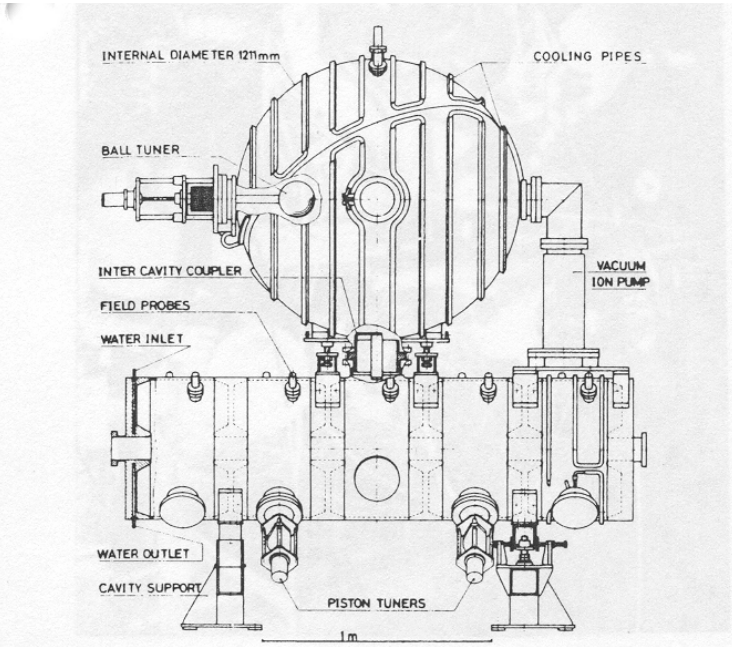


Fig. 5. Arrangement of coupled cavity system for LEP

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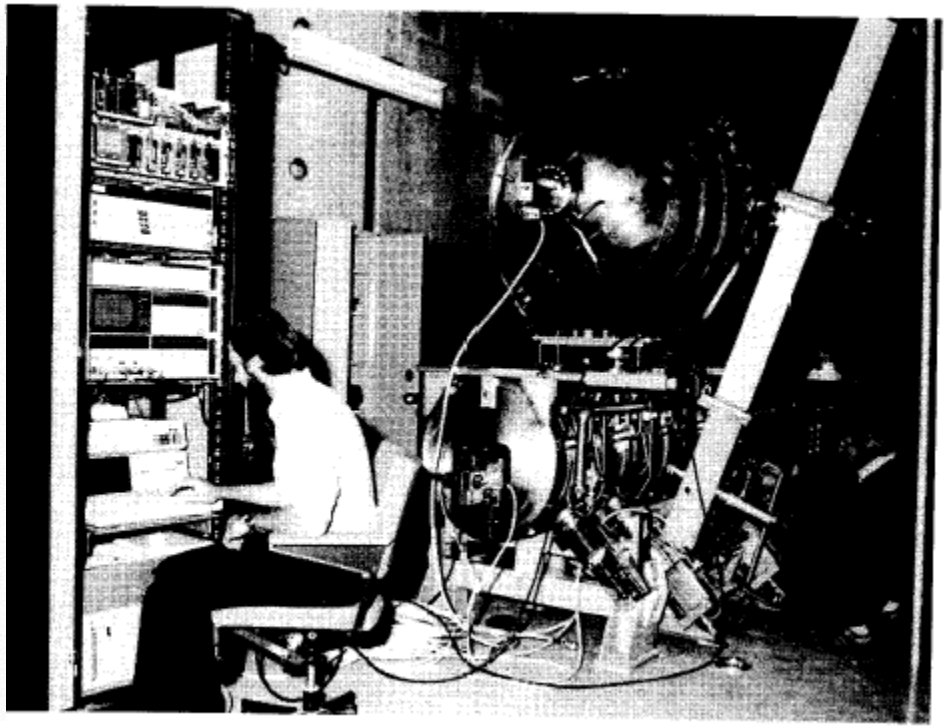
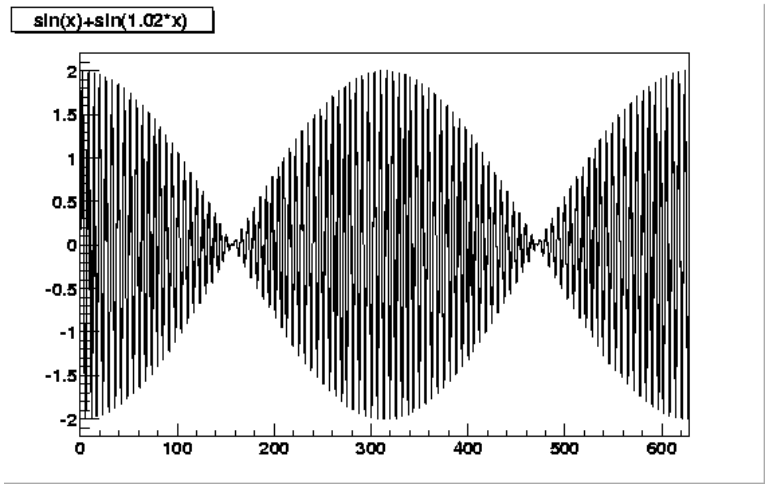


Fig. 7. Arrangement for coupler adjustments

LEP Note 570

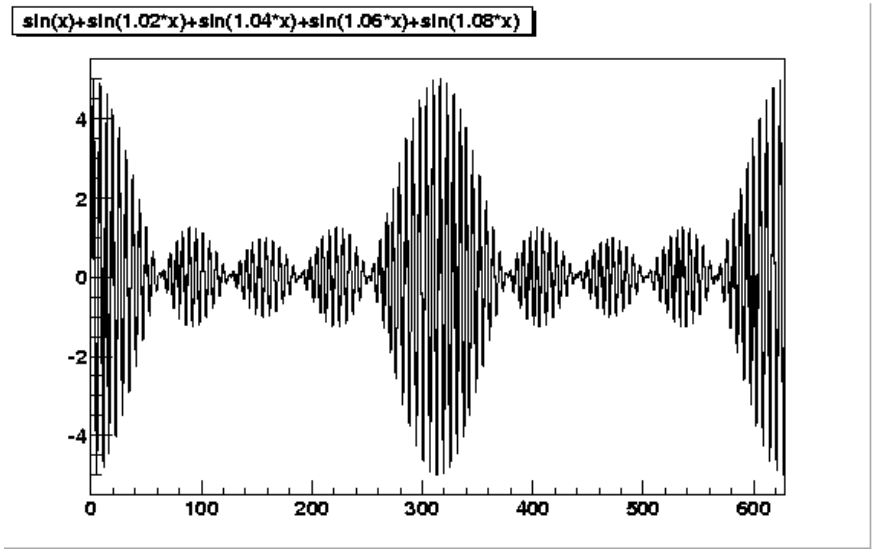
# Phase III: Gun Design

- Coupled acceleration and storage cavity



# Phase III: Gun Design

- More than one storage cavity
- Go CW?




- Storage cavity superconducting
- Storage cavity on axis

# Thank You

# Required Beam Parameters

- Large bunch charge (>1nC)