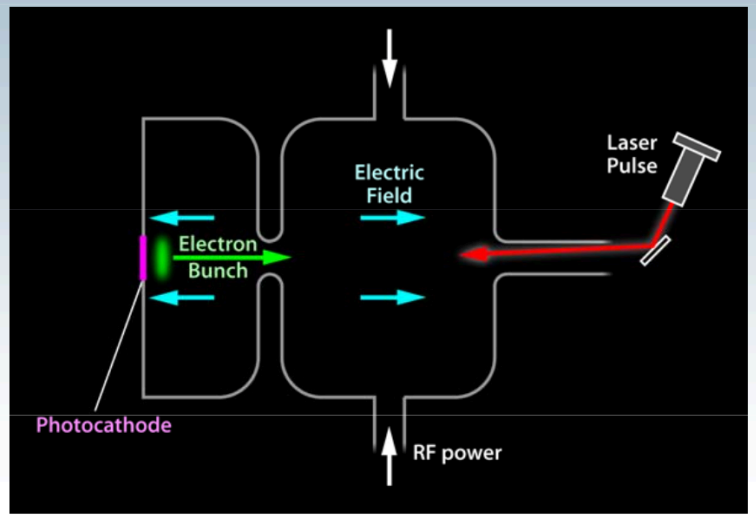
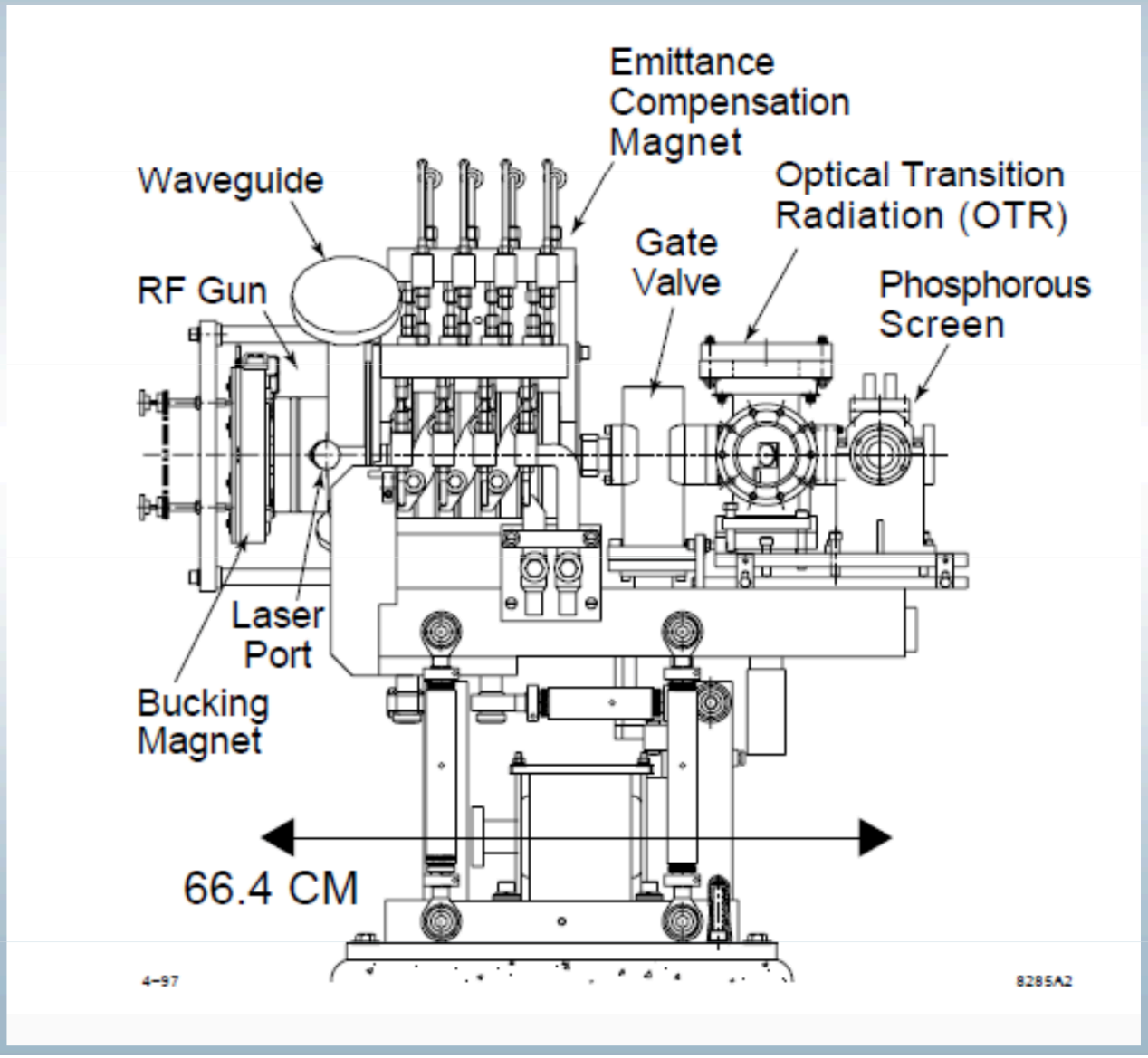
Photo-injectors



- Major components:
  - **Photocathode** that releases picosecond bunches when irradiated with optical pulses from a ultrafast laser
  - **Electron gun** that acceleates electron from the rest
  - **Solenoid** to properly focus the beam
  - **Drive laser** to gate the emission of the electrons from the photocathode
  - **Linear accelerator** to further accelerate electrons
  - **Diagnostic tools** such as Faraday cup or deflecting cavity

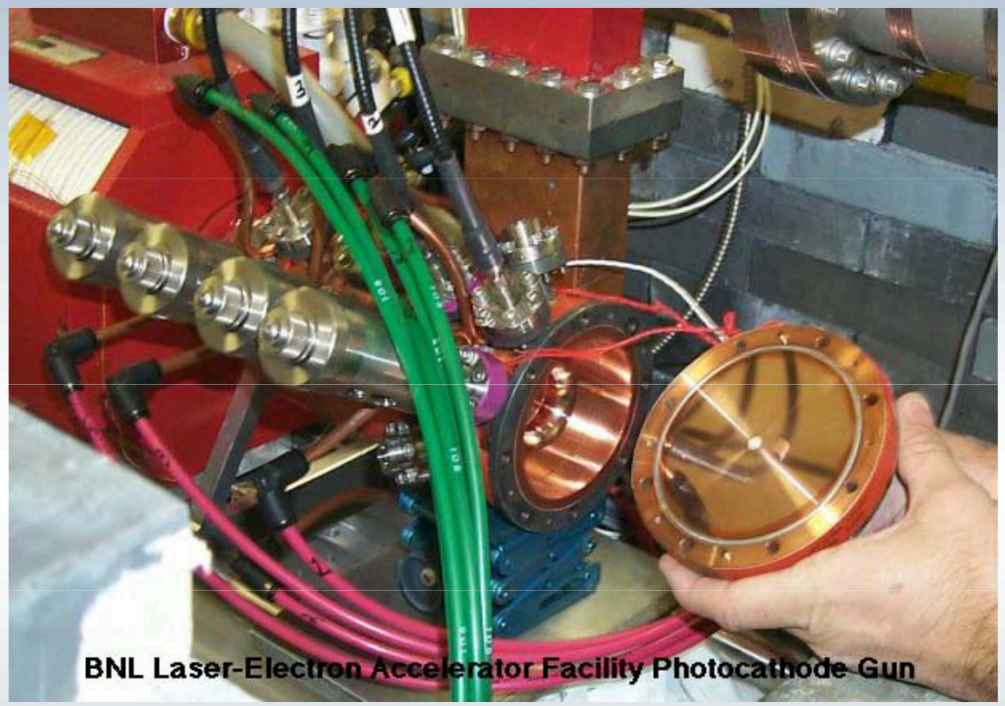
ATF photo-injector layout



ATF Parameters

- 1.6 cell copper cavity
- 2856 MHz (S-Band)
- Cu cathode with QE=4.5x10^{-5}
- Max rf gradient 110-130 MV/m
- Nd:YAG laser energy 30 microJ at 266 nm
- Laser spot size on cathode: 1 mm
- Charge: 0.001 -3 Nc
- Energy: ~ 5 MeV

Photo-cathode



- Cathodes are a fundamental part of electron sources
- The gun performance will depend on the QE of the cathode
- QE is defined as the number of photo-emitted electrons per photon impinging ton the cathode

Photo-emission principle

- Photon absorption by electron
- Electron motion toward the crystal surface
- Electron escape through the potential barrier

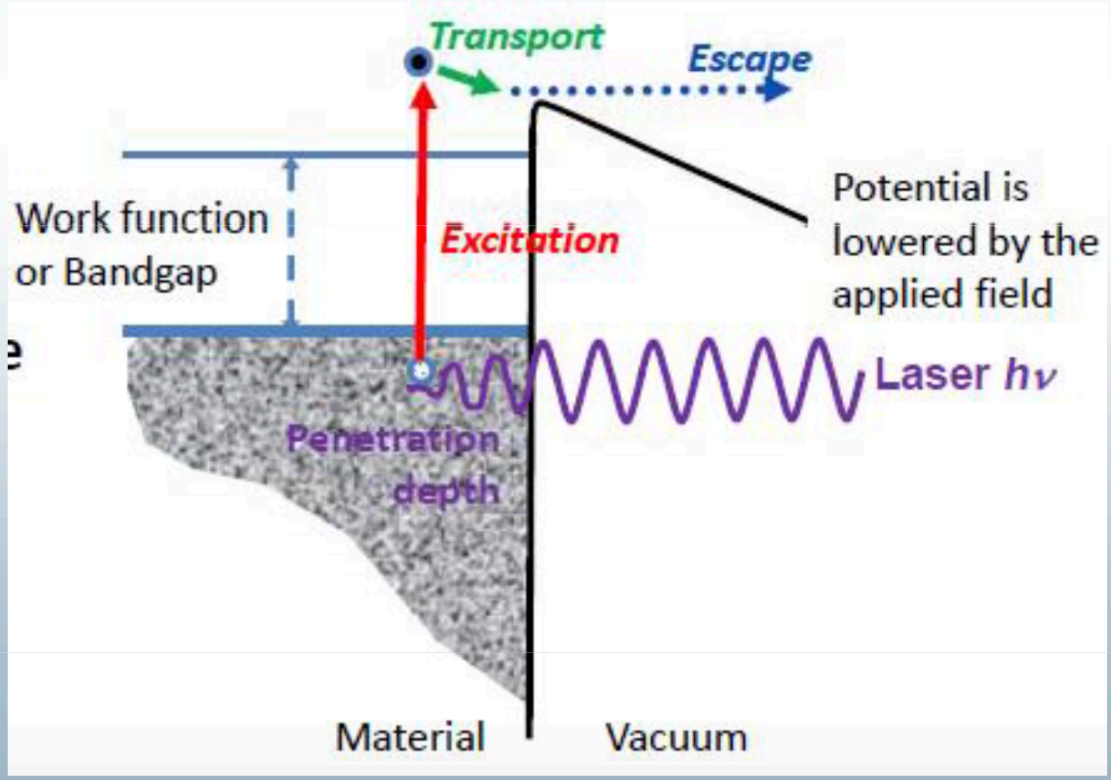


Photo cathode Quantum Efficiency

Quantum efficiency ("QE") is the number of photoelectrons emitted from the photocathode divided by the number of incident photons, and is usually expressed as a percent.

$$QE[\%] = \frac{N_e}{N_{ph}} \cdot 100$$

https://www.hamamatsu.com/us/en/technology/innovation/photocathode/index.html
http://www-spires.slac.stanford.edu/cgi-wrap/getdoc/slac-pub-13535.pdf

Examples of photo-cathodes

- Metal: Cu
  - Low QE ~ 10^{-5}
  - Example: ATF injector at BNL
- PEA semiconductor: Cesium Telluride
  - Robust
  - High QE > 5%
- NEA semiconductor: Gallium Arsenide
  - High QE > 10%
  - Allows polarized electrons
  - Example: Gatling gun at SBU