

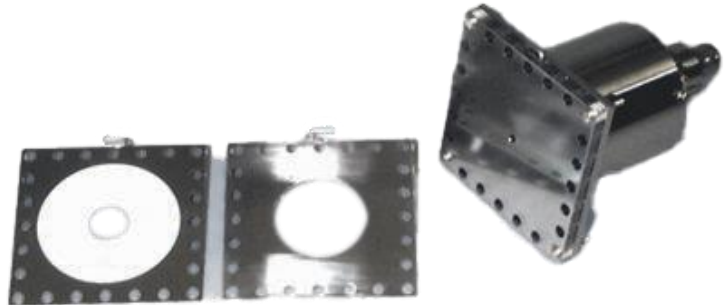
Faraday Cup FC-72

APPLICATIONS:

- Continuous Collection and Measurement of Charged Particle Current
- Measurement of Emitted Beam for Electron or Ion Gun
- Gun Alignment and Setting Operating Parameters

FEATURES / OPTIONS:

- 2" Plate with 11.28 mm Aperture
- Input Power Continuous up to 4 watts.
- Optional Energy Analyzing Grids
- Optional Rugged Phosphor Screen
- Custom Apertures Smaller Apertures



Faraday Cup FC-72

INTRODUCTION

The Kimball Physics model FC-71A Faraday cup, connected to an ammeter, is used to collect and measure charged particle current, such as the beam emitted from an electron or ion gun.

The FC-71 is UHV compatible and fully bakeable. The Faraday cup consists of a hollow stainless-steel cylinder closed at the base, with

an appropriately-sized aperture for collecting the electrons or ions. An outer, grounded cylinder provides shielding. An electrical connection is made to the base of the Faraday cup, terminating in a BNC. The current is then conducted to a vacuum feedthrough and so to an ammeter.

The FC-72 usually has a 11.28mm diameter aperture (1 cm² area) in a 2" inch square plate. Custom smaller aperture sizes are available.

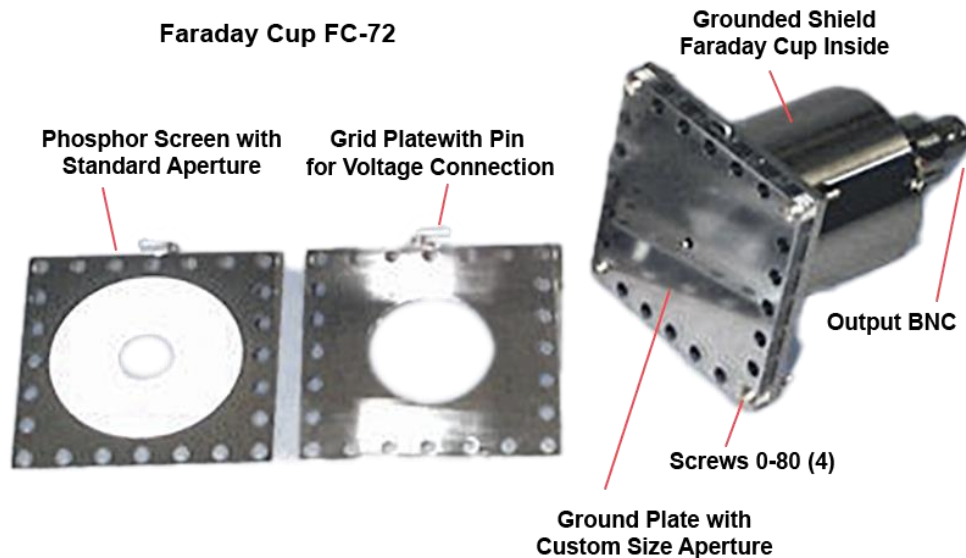


Figure 1. Faraday Cup FC-72 with optional phosphor screen and grid shown separately.

A 12 inch in-vacuum cable and BNC feedthrough on a 1.33" CF flange, or a custom-designed feedthrough, is available from Kimball Physics as a separate option.

For continuous measurement, the power entering the standard FC-72 Faraday cup must not exceed 4 watts. The Faraday cup temperature should not be raised above 350°C due to outgassing.

OPTIONAL GRIDS

The FC-72 Faraday cup can have a set of three grids so that it can be used as an energy analyzer. These grids are, in the order that the electrons or ions go through them: ground, retarding, and suppression, labeled G, R and S in the Fig. 2 schematic below.

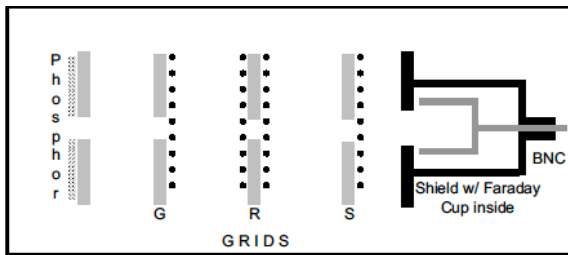


Figure 2. Schematic of Faraday Cup FC-72 with optional grids and phosphor screen.

The ground grid is attached to the phosphor screen / initial aperture plate, and both are grounded by being connected to the shield. There is also a final, non-grid plate as part of the grounded shielding cylinder.

A variable potential is applied to the retarding grid to analyze the energies of electrons or ions. The grid voltage is negative for electrons/negative ions, or positive for positive ions. The current into the Faraday cup is measured while the retarding grid voltage is varied from zero to a voltage which cuts off the current completely.

This is illustrated in the graph show in Figure 3, where the technique is used to analyze the energy spread of ions from a typical ion gun. The Faraday cup current at any given retarding grid potential represents the total current due to ions with energy greater than that potential. The data in Fig. 3 can be differentiated to yield an energy profile (Fig. 4) that indicates the ion energies present in the beam. The standard Faraday cup can have up to 1000 V applied to the retarding grid; for higher voltages, optional larger insulators are available.

When a low voltage is applied to the suppression grid, it can be used either to suppress secondary and scattered electrons or to suppress scattered ions, so that current is not lost. The suppression grid also reduces the capacitive coupling between the retarding grid and the Faraday cup.

OPTIONAL PHOSOPOR SCREEN

A phosphor screen made with high luminosity P22 phosphor (ZnS: Ag) is available as an option on the front plate of the FC-72 Faraday cup. The use of a grounded phosphor target screen is helpful as it allows visual, real-time observation of the spot. The phosphor screen

Faraday Cup FC-72	
APERTURE SIZE	11.28 mm \varnothing , 1 cm ² area Custom smaller diameters available
PLATE SIZE	5.08 cm (square)
LENGTH	7.16 cm
OPERATING TEMPERATURE	350°C Max
INPUT POWER CONTINUOUS	4 Watts maximum recommended
GRID VOLTAGE	1000 V maximum retarding voltage
MOUNTING	Mounting bracket

emits a pale blue light (photons) when bombarded by high energy particles (threshold value approximately 500 eV for electrons and 1000 eV for ions).

The screen can be used for gun alignment and to set the proper operating parameters necessary to obtain maximum beam uniformity or minimum spot size. Note that excessive current or exposure may cause phosphor screen damage.

BIASING THE FARADAY CUP

The Faraday cup can be electrically biased to reduce scattering of electrons or ions collected in the Faraday cup and to reduce secondary electron emission. For electrons or negative ions, +50 V is typically adequate, and for positive ions, 50 V. This can be accomplished by placing a battery between the vacuum feedthrough and the ammeter.

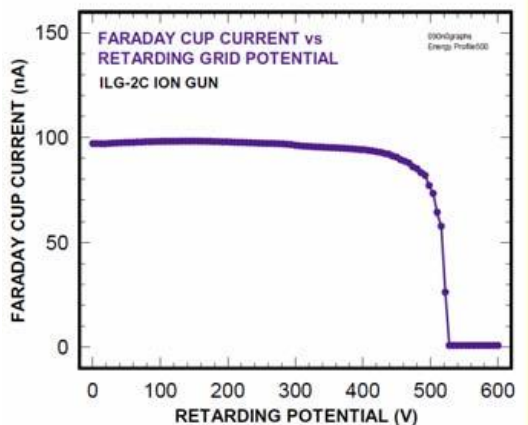


Figure 3. The use of the Faraday Cup as an energy analyzer measuring ion beam current.

POWER INPUT CAUTIONS

For continuous measurement, the maximum beam power recommended into the standard FC-72A Faraday cup is 4 watts. The Faraday cup temperature should not be raised above 3500 C due to outgassing.

The power input can be calculated by multiplying the beam current by the electron acceleration voltage; for example, 1mA at 20 keV gives 20 W, which is much too high for continuous measurement. The temperature of the Faraday

cup increases approximately linearly with the power input. A 2 W input results in approximately 150°C, and a 4 W input results in 300°C.

To use the Faraday cup at high power, measure currents briefly and then let the Faraday cup cool down before repeating the measurement. Due to heat capacity of the cup, a 20 W input for 10 sec into the FC-71A will raise the cup temperature by approximately 150°C. The cup will cool from 200°C to room temperature in about 15 min.

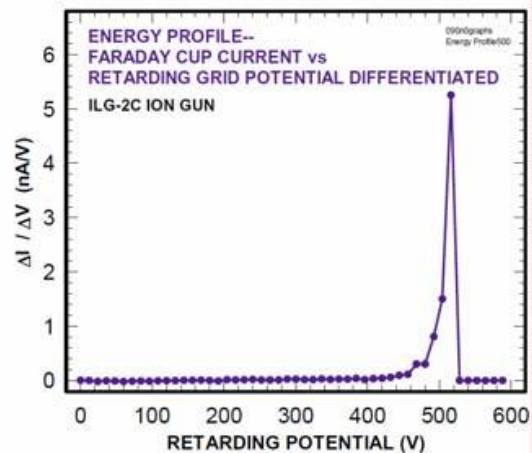
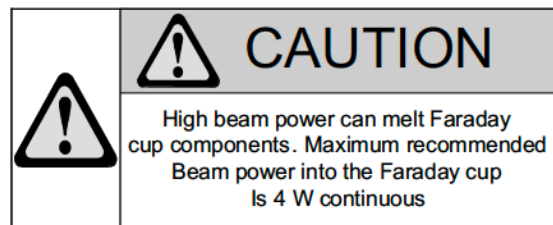


Figure 4. Calculated energy profile of ions in beam (Graph derived from data previous graph)

Care must always be exercised with a highly focused beam, as a high-power density can bring the Faraday cup to melting temperature in the impact area of the beam.

For example, an electron gun with an output of 1 mA at 10 keV focused to a spot size of 1 mm has a power density of approximately 13 kW/cm². Assuming no heat flow, this would bring the Faraday cup stainless steel at the spot to its melting point in only 11 sec.



INSTALLATION AND OPERATING PROCEDURE

1. Position the Faraday cup in the target area inside the vacuum chamber.
2. Connect the output BNC on the back of the Faraday cup to an electrical feedthrough on the vacuum system (an in vacuum coaxial cable / CF flange / BNC assembly is available from Kimball Physics).
3. Connect the feedthrough to a suitable user-supplied ammeter. **NEVER collect beam current in the Faraday cup unless the cup output is connected to an ammeter or grounded.** Without proper termination, the Faraday cup terminal will charge up to full beam energy and discharging will result.
4. Optional Faraday cup grids:
 - a. For the retarding grid (R in Fig. 2): Connect a 0 to 1000 V power supply (negative for electrons or negative ions, and positive for positive ions) through a vacuum electrical feedthrough to the pins on the second grid plate using Teflon-coated stainless steel wire with a spring connector end.

- b. For the suppression grid (S in Fig. 2): Similarly connect a 0 to 50 V power supply to the pin on the third grid plate.

5. Calculate the expected power input into the Faraday cup and check that it is within the acceptable range. See the discussion of power input cautions.

6. Measure electron or ion current with the ammeter.

REPLACEMENT OPTIONAL APERTURE PLATES, GRIDS OR PHOSPHOR PLATES

1. Loosen the four 0-80 gold plated, socket head screws on the front plate of the Faraday cup and remove the nuts.
2. Lift off the Faraday cup from the back, keeping the plates and insulators (ceramic spacers) in order on the screws.
3. Replace the desired aperture plate, grid or phosphor screen, then reassemble.



References

For more information about Kimball Physics Detectors, please visit our website:
Kimball Physics Detectors

Notes:

1. Cautions:

- Silver Plated Bolts or Equivalent Lubrication must be used.
- Please measure the hole depth and other flange / copper ring /part thicknesses
- Choose a correct bolt length such that the bolt doesn't bottom in the tapped hole prior to tightening the structure.

2. Specifications Subject to Change Without Notice.

3. DE Altobelli, DT Taylor 01/17/2023

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