# Development of A Low Energy Compact & Portable Plasma Focus Neutron Source

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## Abstract

We have developed a portable plasma focus neutron source of 302 J energy operated by a single Maxwell capacitor (20 μF, 6 kV). The device together with the capacitor has a diameter of 10 cm, height of 37 cm and a weight of 3.78 kg. It is capable of delivering a neutron yield of the order of $10^5$ neutrons per pulse with deuterium as fuel gas. For a single gas fill the device has a shelf life of 3000 shots recorded over a period of three years. Afterwards the yield is gradually deteriorated due to the deposition of sputtered kovar material on the insulator sleeve. However with a fresh gas fill the device can still serve as a source of neutrons in the lower edge of $10^4$ neutrons per shot.

## Introduction

- A Mather type plasma focus machine that produces neutrons through D-D fusion reactions
- Energy source is a single Maxwell capacitor operated at 5.5 kV
- Dimensions of the system are : Height = 37 cm, Diameter = 10 cm, weight = 3.78 kg
- Fuel gas is deuterium
- Energy is transferred to the system through open air trigger
- Anode is in the form of a feed through composed of kovar rod brazed with Alumina insulator sleeve which is further brazed with a rotatable kovar flange
- The anode feed through is coupled to the vacuum chamber and cathode through a copper gaskit

## Experimental Procedure

- Evacuation up to $10^{-8}$ mb for two days
- Baking of assembly at 300 ˚C for 16 hours
- Absorption of deuterium gas in the empty sites of the chamber and electrodes.
- Conditioning of the system for 100 shots before regular operation

## D-D Fusion Reactions

- ${}_1D^2 + {}_1D^2 = {}_2He^3 + {}_0n^1$ 3.27 MeV (Neutron Branch)
- ${}_1D^2 + {}_1D^2 = {}_1T^3 + {}_1H^1$ 4.03 MeV (Proton Branch)

## Neutron Detectors

- $BF_3$ detector (2" diameter)
- Plastic scintillator, NE-102 with PMT, Model-XP2020

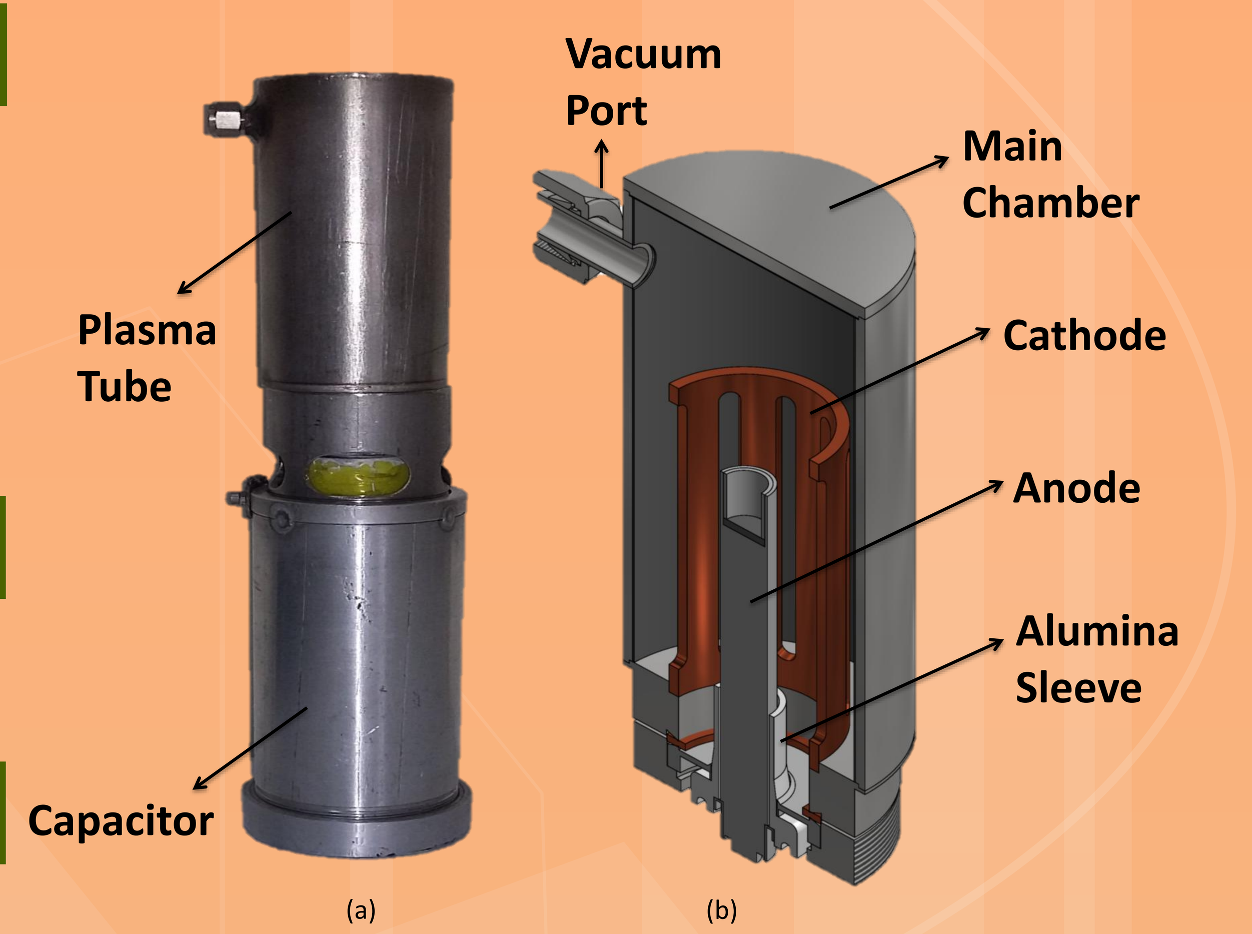


Figure 1: Portable Plasma Focus Device (a) Complete Assembly, (b) Cross-sectional View of Plasma Tube

## Results

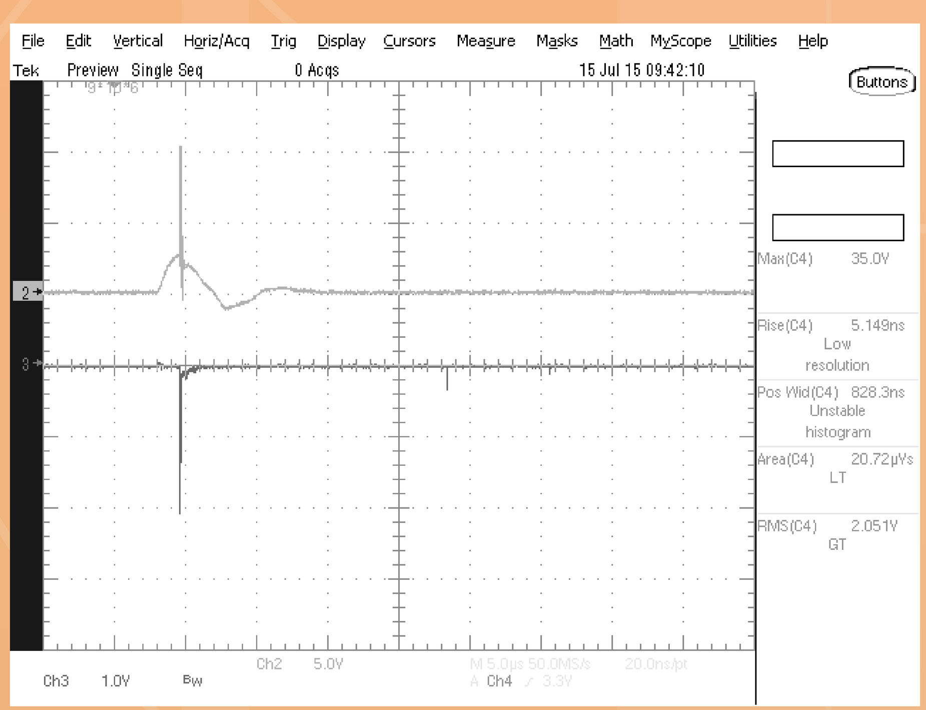

Figure 2: Rogowski Coil Current Derivative Signal (Upper), and Neutron Signal from Scintillator-PMT (Lower)

- FWHM of the neutron pulse recorded by scintillator is 38 ns
- A jitter of 300-400 ns is observed in the pinch pulse
- The pinch spike shows focus phenomenon at anode tip

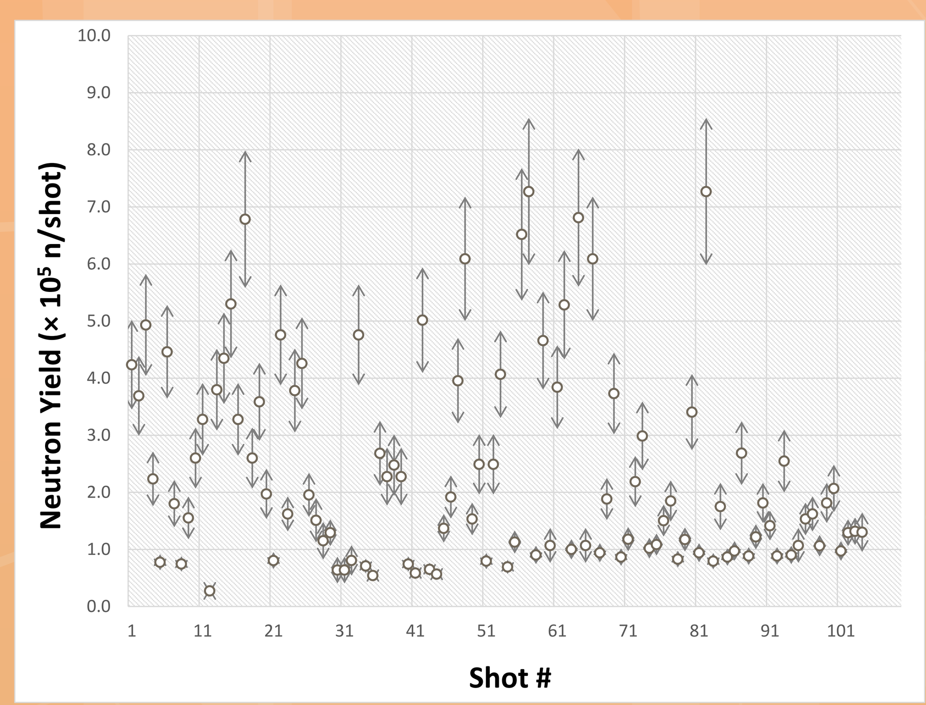


Figure 3: Neutron Yield Measured Vs. No of Shots With a $BF_3$ Detector

- Neutron yield of the system is of the order of $10^5$ neutrons per shot
- Shelf life of the system is 3000 shots/ gas fill for a period of more than three years. After one shelf life neutron yield is degraded by an order of magnitude

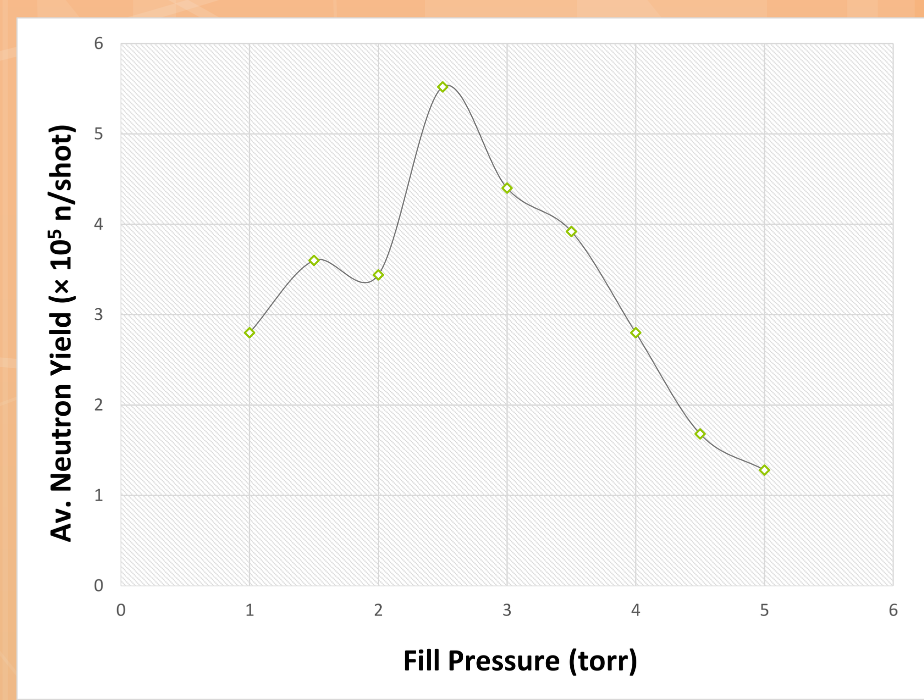


Figure 4: Determination of Optimum Pressure

- The optimum pressure of the DPF system was found to be 2.5 torr
- Peak Average yield of 5.5 × $10^5$ n/shot was observed at optimum pressure

## System Parameters

| Energy (J) | Current (kA) | Operating Voltage (kV) | Capacitance (μF) | Inductance (nH) | Resistance (mΩ) | Pressure (torr) | FWHM (ns) | Anode Radius a (mm) | Cathode Radius b (mm) | Anode Length (mm) | Ratio b/a |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 302 | 69 | 5.5 | 20 | 69 | 40 | 2.5 | 38 | 7.5 | 20.5 | 90 | 2.7 |

## References

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