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ORIGINAL PAPER

# Pinch Current and Soft X-Ray Yield Limitations by Numerical Experiments on Nitrogen Plasma Focus

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**Abstract** The modified version of the Lee model code RADPF5-15a is used to run numerical experiments with nitrogen gas, for optimizing the nitrogen soft X-ray yield on PF-SY1. The static inductance $L_0$ of the capacitor bank is progressively reduced to assess the effect on pinch current $I_{pinch}$. The experiments confirm the $I_{pinch}$, limitation effect in plasma focus, where there is an optimum $L_0$ below which although the peak total current, $I_{peak}$, continues to increase progressively with progressively reduced inductance $L_0$, the $I_{pinch}$ and consequently the soft X-ray yield, Ysxr, of that plasma focus would not increase, but instead decreases. For the PF-SY1 with capacitance of 25 μF, the optimum $L_0 = 5$ nH, at which $I_{pinch} = 254$ kA, Ysxr = 5 J; reducing $L_0$ further increases neither $I_{pinch}$ nor nitrogen Ysxr. The obtained results indicate that reducing the present $L_0$ of the PF-SY1 device will increase the nitrogen soft X-ray yield.

**Keywords** Plasma focus SY1 · Pinch current limitation · Soft X-ray · Nitrogen gas · Lee model RADPF5.15a

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## Introduction

The plasma focus is well known as a source of fusion neutrons and X-rays. Besides being a ready source of hot dense plasma and fusion neutrons, the focus also emits plentiful amounts of soft X-rays, especially when operated with high $Z$ gases rather than deuterium. Because of its simple construction, cost-effectiveness and easy maintenance, the plasma focus appears to be a promising device for X-ray generation, with enhanced efficiency. The nitrogen plasma focus is used as an emitter of the X-ray radiation [1–3].

The total current $I_{total}$ waveform, which is a "fingerprint" of the plasma focus discharge, is easily measured using a Rogowski coil, and from experience, it is known that the current trace of the focus is one of the best indicators of gross performance [4–9]. The focus pinch current $I_{pinch}$, which is defined as the value of the plasma sheath current at the start of pinch, is difficult to measure and this is the reason that the total current $I_{peak}$ is experimentally used instead of $I_{pinch}$, despite the fact that yields should more consistently be scaled to the focus pinch current $I_{pinch}$, since it is $I_{pinch}$ which directly powers the emission processes. The numerical method to consistently deduce $I_{pinch}$ from any measured trace of $I_{total}$ was developed in numerical experiments using the Lee Model [4–9].

For enhancing of the neutron and X-ray yields from plasma focus devices, many experiments have been investigated by some modifications on the bank, tube and operating parameters of the devices; for example, the two plasma focus devices UNU/ICTP PFF and the NX2 both have capacitance of about 30 μF and maximum operating voltage $V_0$ of 15 kV. The UNU/ICTP PFF has $L_0$ of 110 nH whilst the NX2 was designed for much higher performance with $L_0 = 20$ nH. As a result of the much