CT injector as a tool for near-term enhancement of NSTX plasma operations

Roger Raman
University of Washington, Seattle

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T.R. Jarboe (Univ. of Washington)
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The ability to inject CTs significantly expands NSTX experimental capability

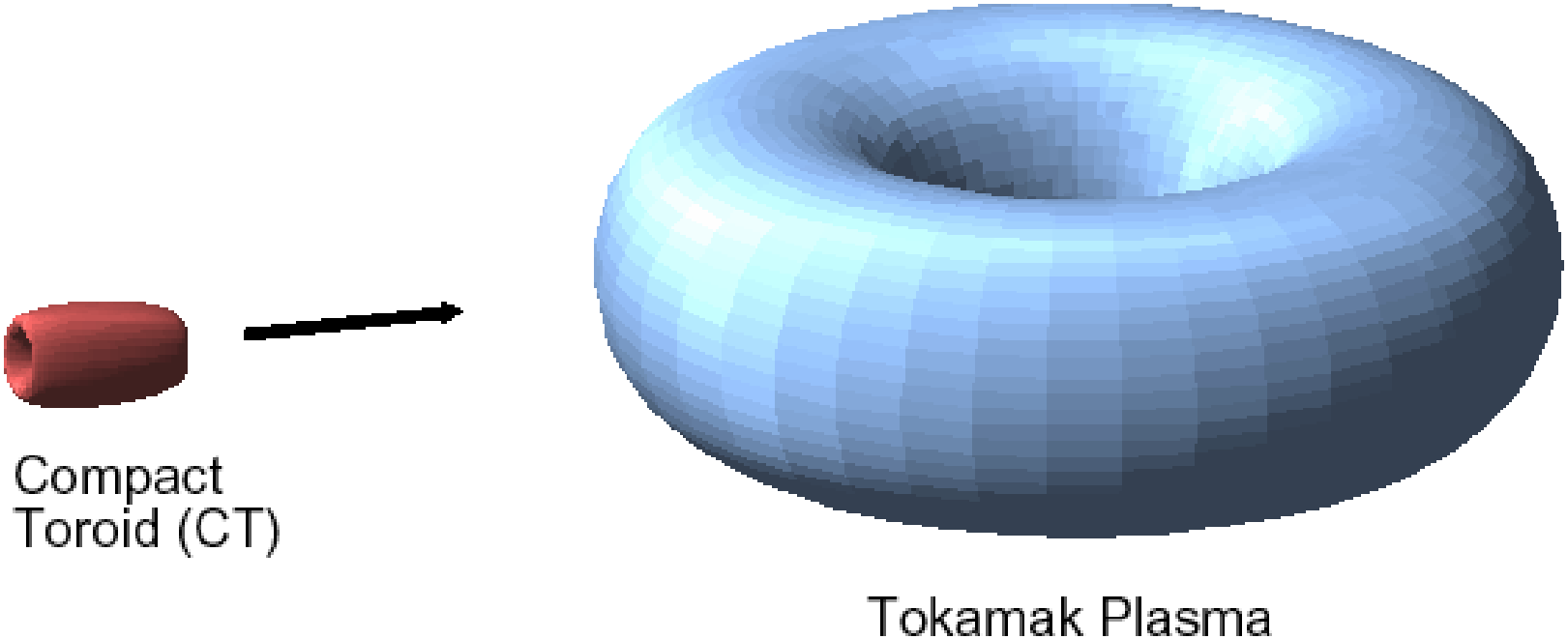
- **Single Pulse Injector (near term enhancement)**
  - –Available for immediate use following a short commissioning period

- **Multi Pulse Injector (needed for fueling high bootstrap fraction discharges under steady-state conditions)**

  - **–Momentum injection studies for transport barrier sustainment**
  - **–Density profile control needed for high performance SS discharges**

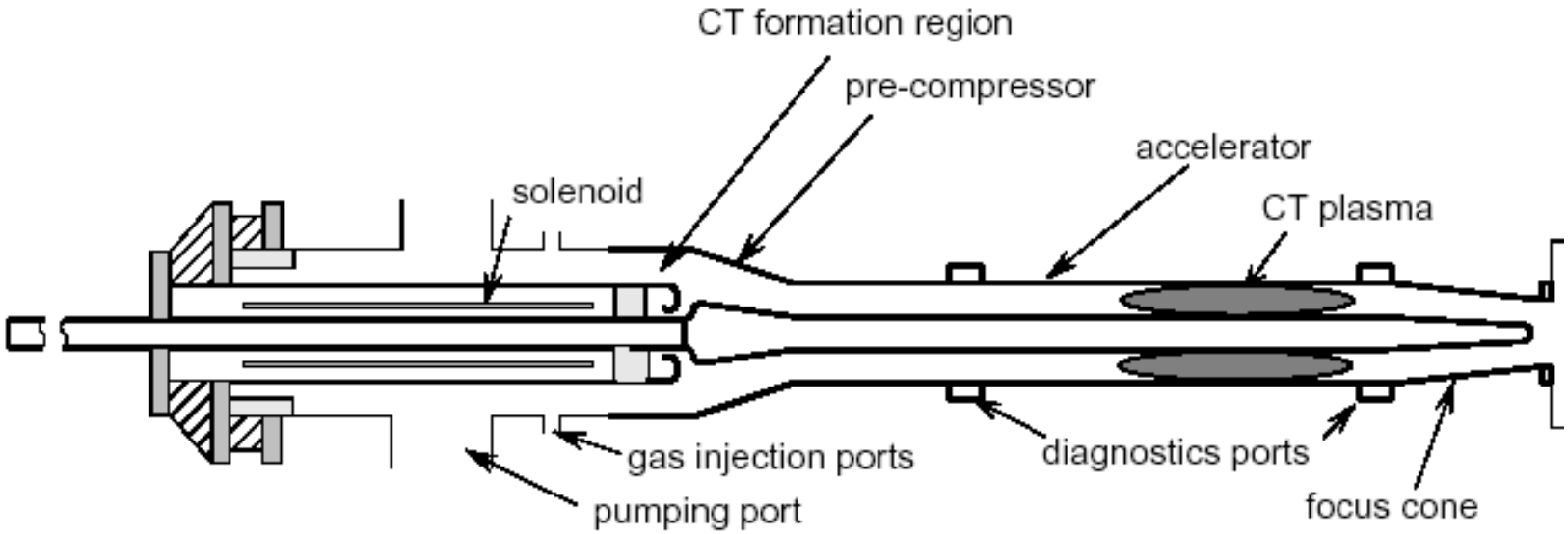
  - –Local current injection to suppress NTMs (Helicity injection)
  - –Reduced divertor pumping requirements (greater fueling efficiency)
  - –Possible extension of density limits

A CT is accelerated to high velocity and injected into the target plasma to achieve deep fueling



CT Penetration time: few µs
CT Dissociation time: < 100 µs
Density Equilibration time: 250 - 1000 µs
Variable Penetration depth: edge to beyond the core

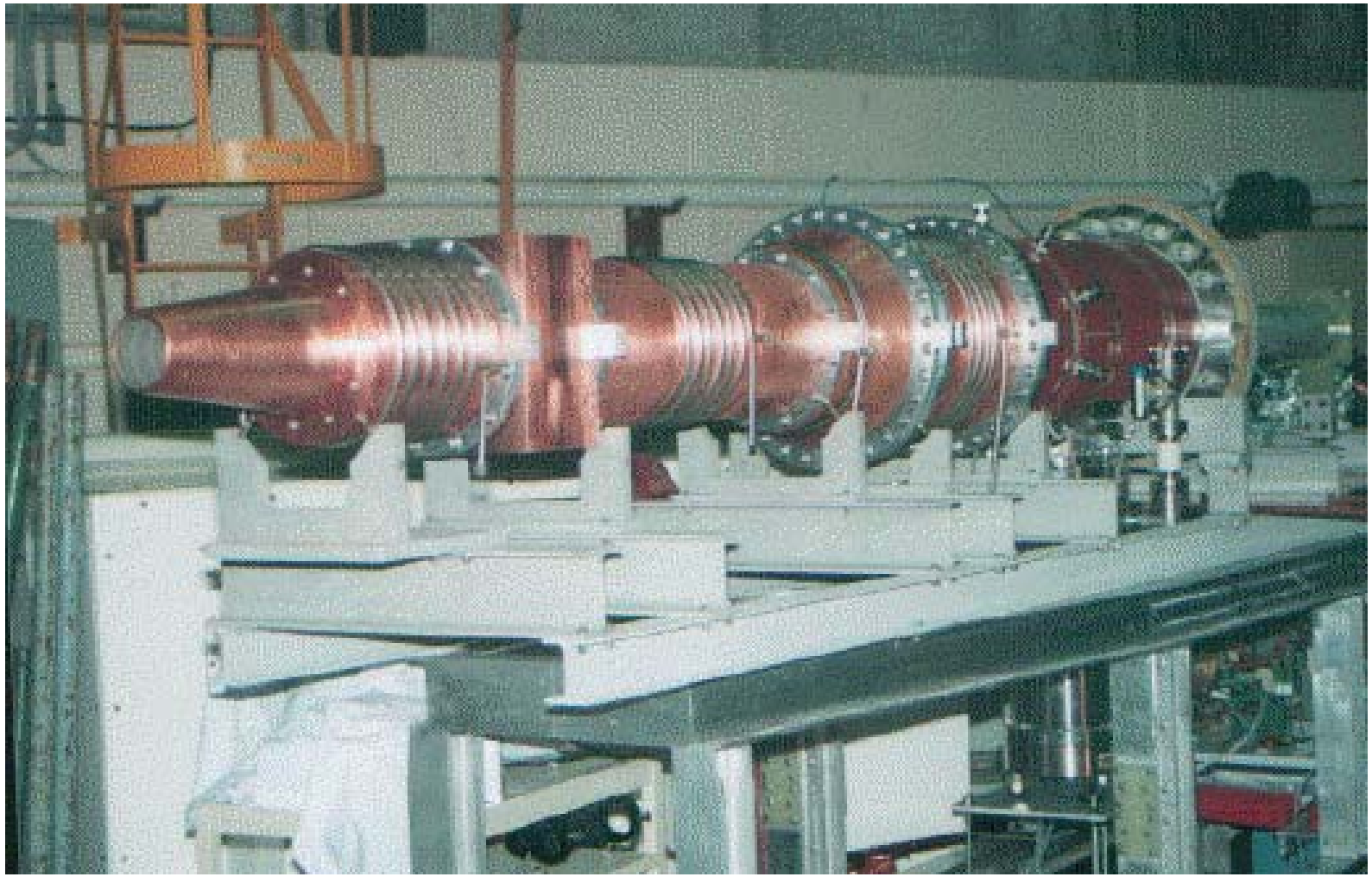
A CT Fueler forms and accelerates CTs in a coaxial rail gun in which the CT forms the sliding armature



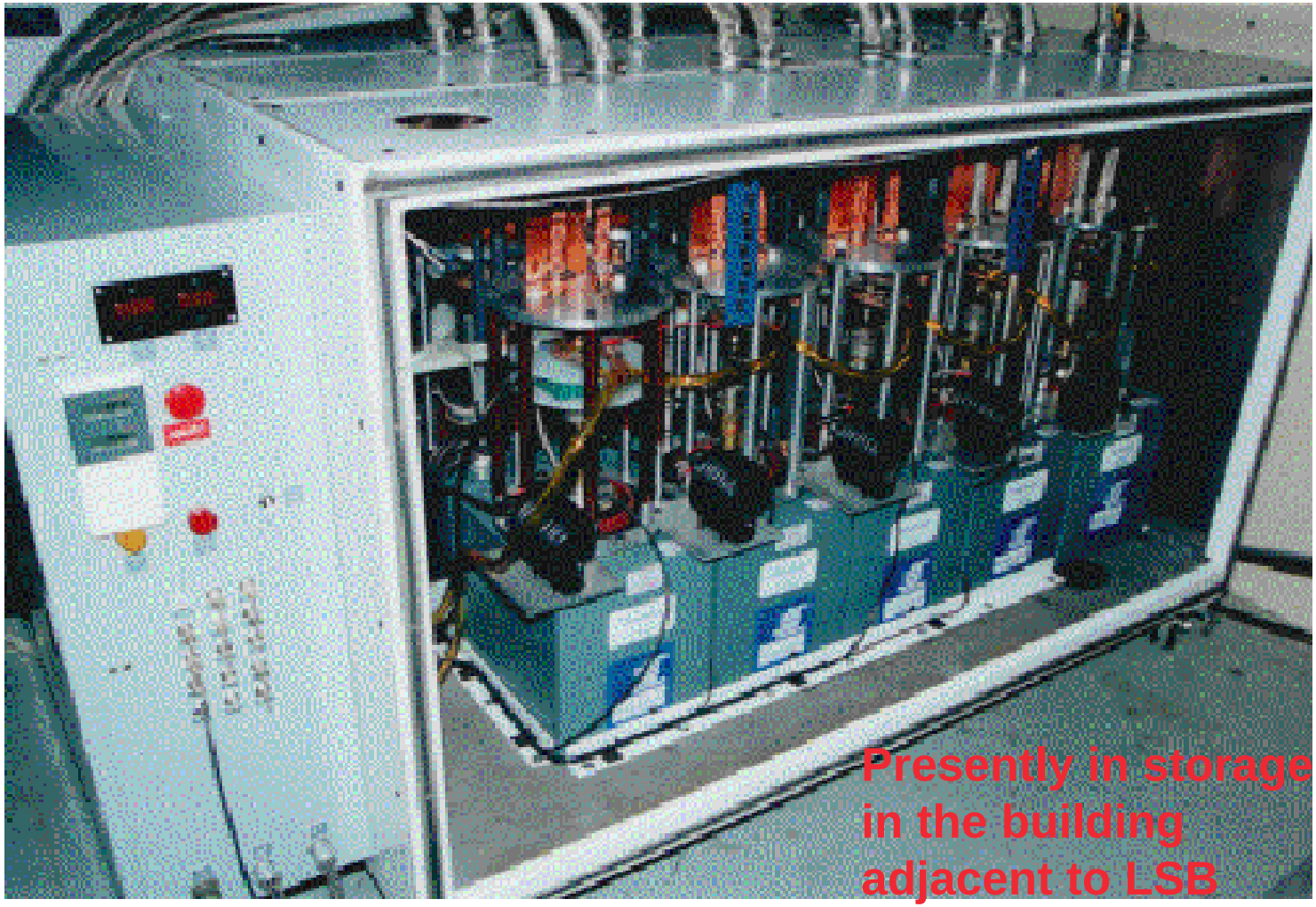
Raman et al., Fusion Techn., **24**, 239 (1993)

Amount of gas injected controls CT density
Applied voltage controls CT velocity
Control system specifies fuel deposition location for each pulse

The CTF-II injector **(presently in storage at PPPL)**



The CT Formation bank power supply (110VAC input)



The ability to inject single pulse CTs significantly enhances near-term NSTX experimental capability

- **Single Pulse Injector (near term enhancement)**
  - Local plasma injection to aid PF only startup
    - (Re: M. Ono XP, J. Menard XP)
  - Initiate Ohmic H-mode
    - (Re: C. Bush XP)
  - Clarification of the edge barrier seen during Neon injection
    - (Re: D. Stutman XP)
  - Precise H-mode initiation capability valuable for on-going XPs
    - (Re: C. Skinner and other XPs)
  - Transport studies by isotopic impurity tailoring
    - (Transport related XPs)
  - Prompt density injection to avoid locked modes
    - (General NSTX use for many XPs)
  - Electron Transport Barrier studies
    - (beneficial to be be able to trigger transport barriers under a wider range of operating conditions)
  - Reconnection studies - an important aspect of PPPL research

Conclusions

- A single pulse CT injector can make **immediate** contributions to the NSTX program
  - Local plasma injection for outer PF startup XPs
  - Precise H-mode triggering capability useful for present XPs
  - Transport studies

- Experimental data from single pulse CT will reduce cost of a multi pulse CT power power supply

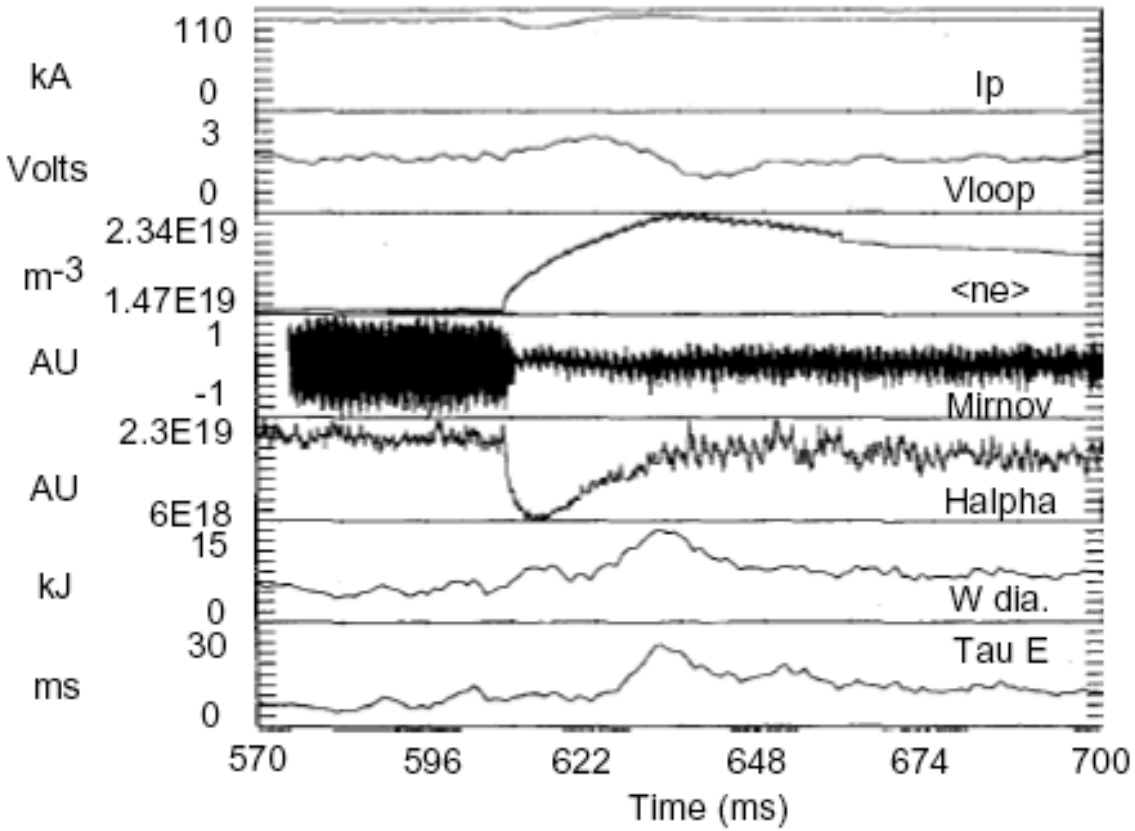
- The CT is also a source of momentum input and has the potential to sustain transport barriers

IPPA goals relevant for CT Fueling

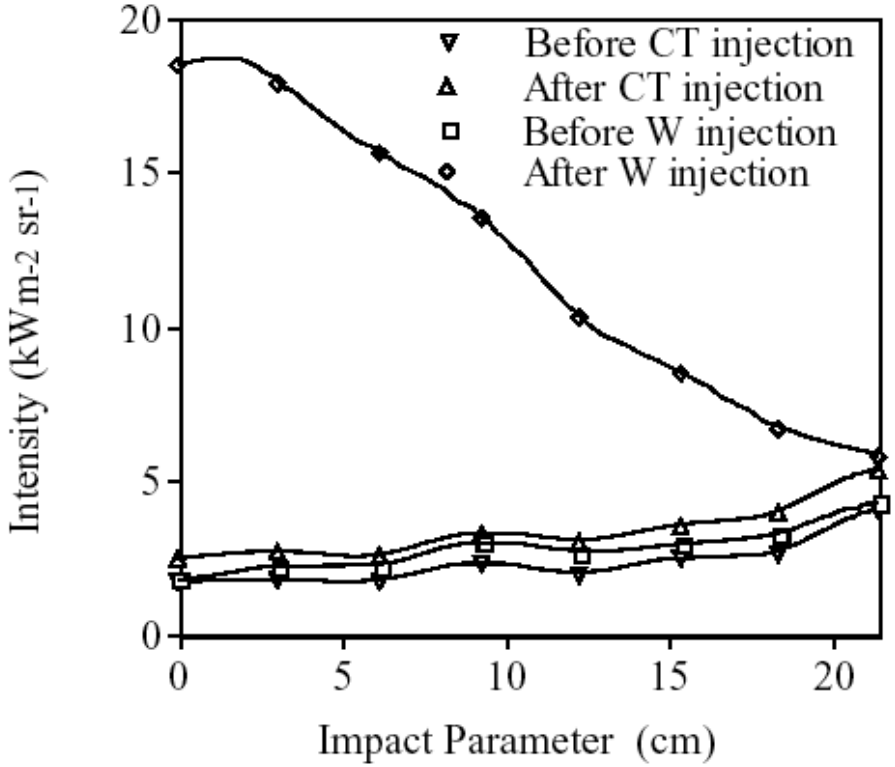
- 3.4.1.2 Fueling Technologies: "Develop systems and fueling techniques that are capable of providing a reliable, flexible particle source for controlling core plasma density and density gradients at acceptable fueling efficiencies; ...”

- Under the description of Section 3.4.1 Plasma Technologies: "The main issues for fueling technologies are to *understand and exploit advanced fueling physics (such as high field side launch) and demonstrate the performance (i.e., pellet speeds, density of compact toroids and repetition rates) required to effect adequate control of the density profile shape and high fueling efficiency*"

Edge fueling of limited plasmas also shows a sharp reduction in Mirnov coil oscillations

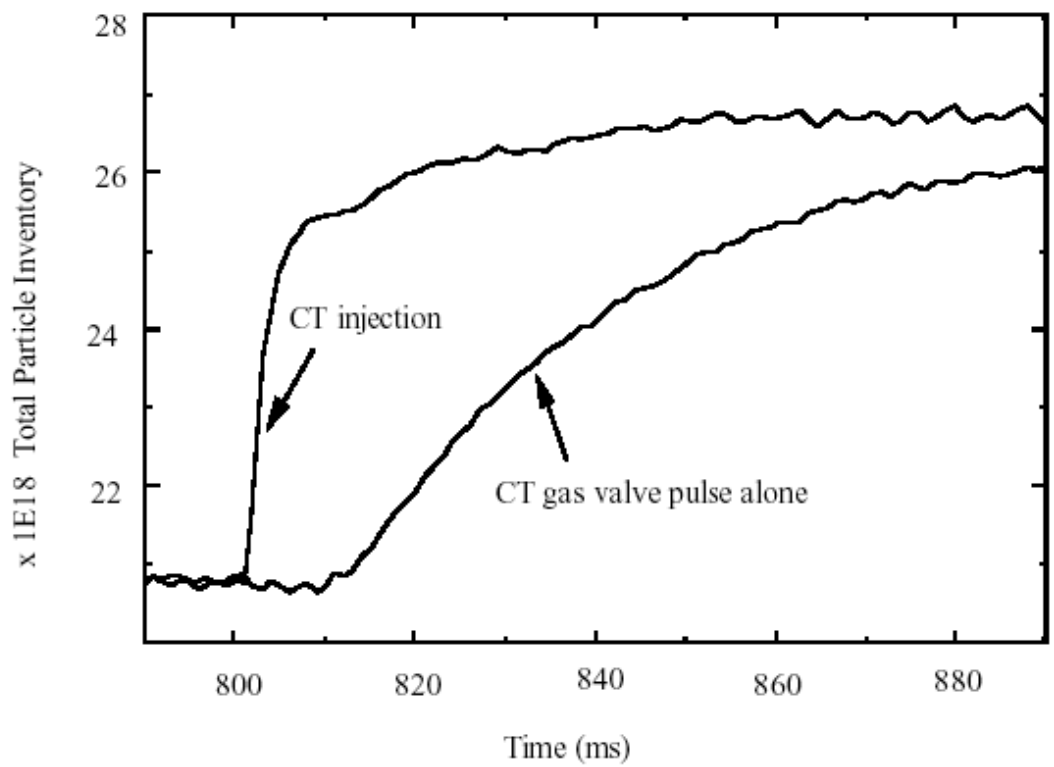


No evidence for metallic impurity contamination of TdeV



R. Raman et al, NF **37**, 967 (1997)

TdeV tokamak discharges beneficially fueled by CTs, without causing any adverse perturbation



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TdeV

R = 0.86m

a = 0.25m

B_T = 1.4T

Ip = 160kA