Time correlation between low-energy, high-energy x-rays and neutron emission in plasma focus in the context of nuclear fusion mechanisms

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Abstract

Neutrons along with x-rays emission have been reported in plasma focus (PF) devices, if the filled gas is deuterium [1]. The origin of neutron emission is the subject of debate, due to occurring of complex physical phenomena during pinch phase. Most of the PF scientific community believe that neutron production takes place due to beam-target fusion mechanism [2]. Some investigators reported a fraction of thermonuclear neutrons [3]. Neutrons emitted in axial direction were reported with the higher energies than that in radial direction [4] that makes thermonuclear fusion reactions suspicious in PF devices. Both nuclear fusion reactions, the beam-target and thermonuclear are considered at the time of pinch. To estimate the neutron origin time, it is mandatory to take into account all the time delays that neutrons take to reach the detector. If neutrons would have been originated during the pinch phase, the beam-target and/or thermonuclear fusion reactions could be the possible mechanisms. Otherwise, other processes should be included.

[1]. J Jain, J Moreno, D Morales, S Davis, B Bora, G Avaria, M J Inestrosa-Izurieta, and L Soto, Laser and Particle Beams 35, 656-662
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[3]. D. Klir, P. Kubes, M. Paduch, T. Pisarczyk, et. al. Plasma Phys. Control. Fusion 54, 015001 (2012).
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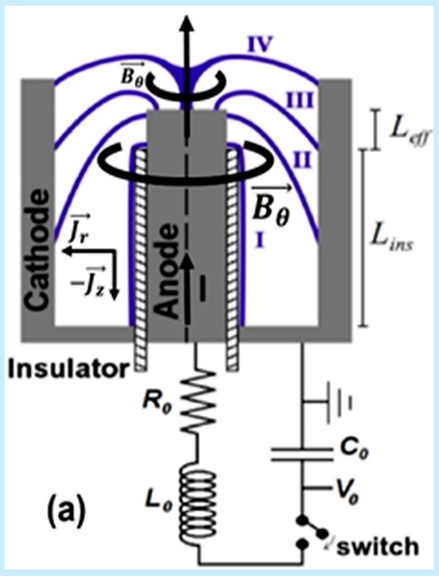
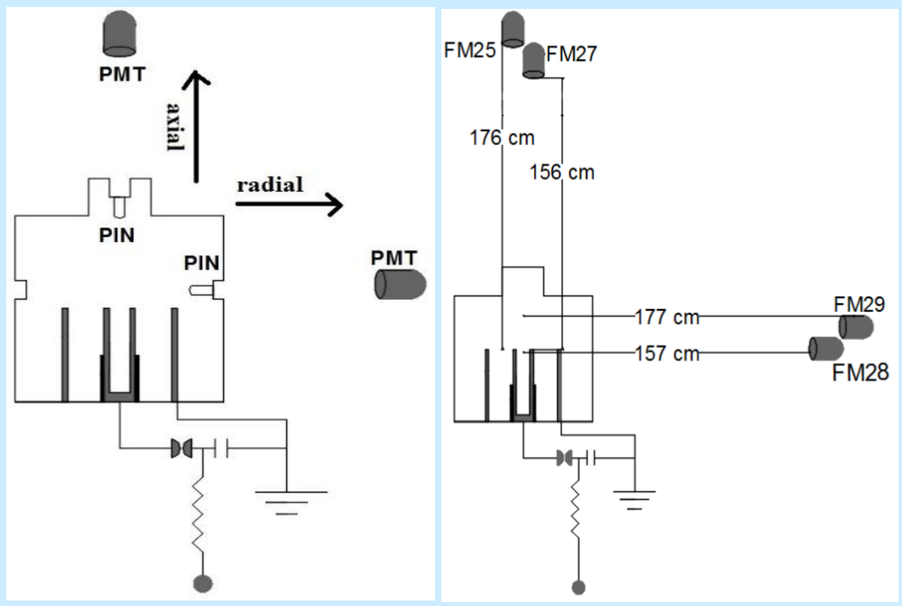
Plasma dynamics in plasma focus devices



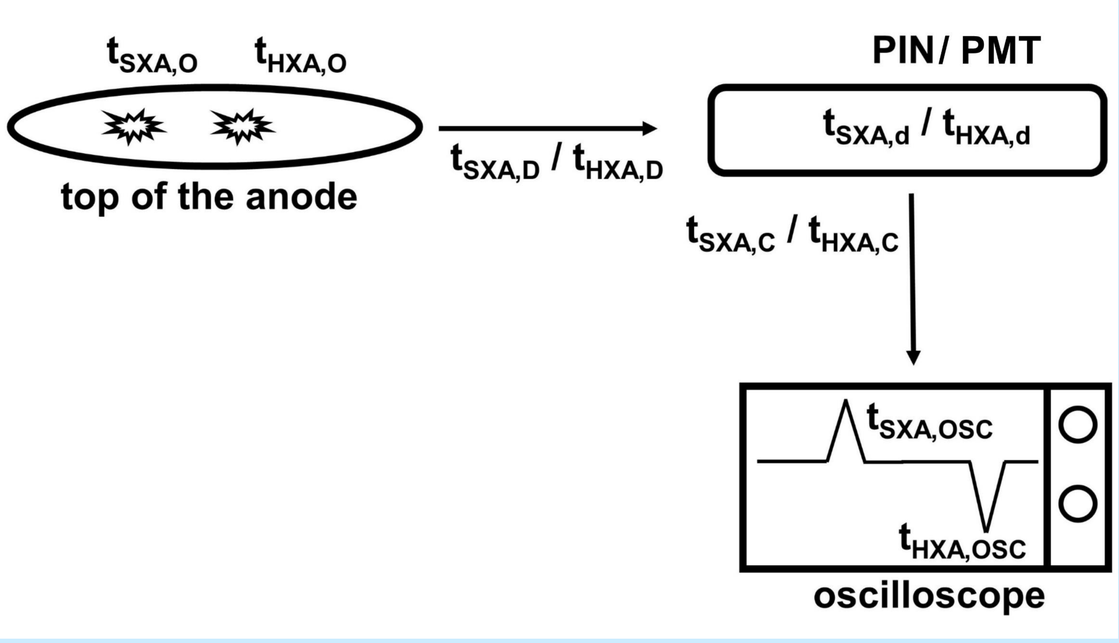
1. At first gas breakdown takes place between the bottom cathode and the anode, forms a plasma current sheet (PCS) over the insulator (Phase I).
2. Under the action of Lorentz force the PCS expands and runs over the effective length of the anode (phase II).
3. At the open end of the anode, the PCS compresses and forms a plasma column knows as pinch (phases III & IV).
4. The pinch disruption produces axial plasma shock and metallic jet.

Experimental Setup

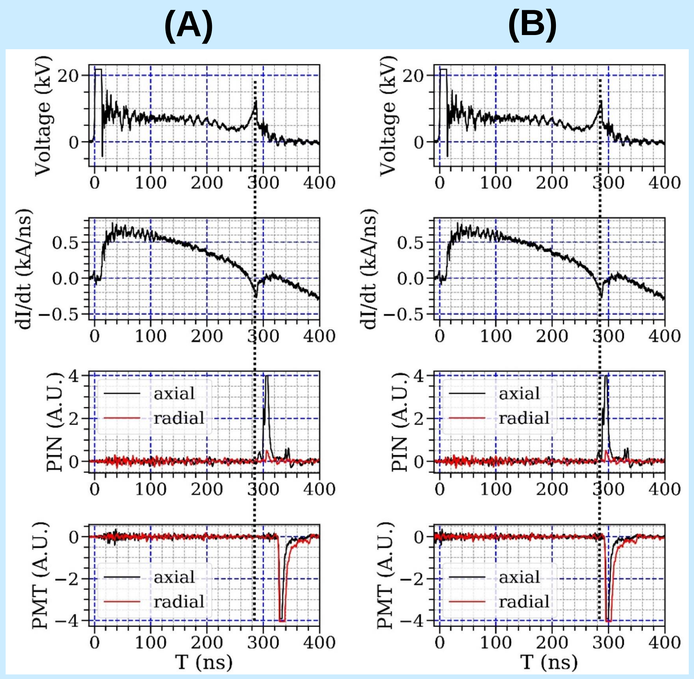


- At first a temporal correlation between low and high-energy x-ray was established.
- To estimate the neutron kinetic energy the time of flight method was used.

Results: Analysis and Discussion

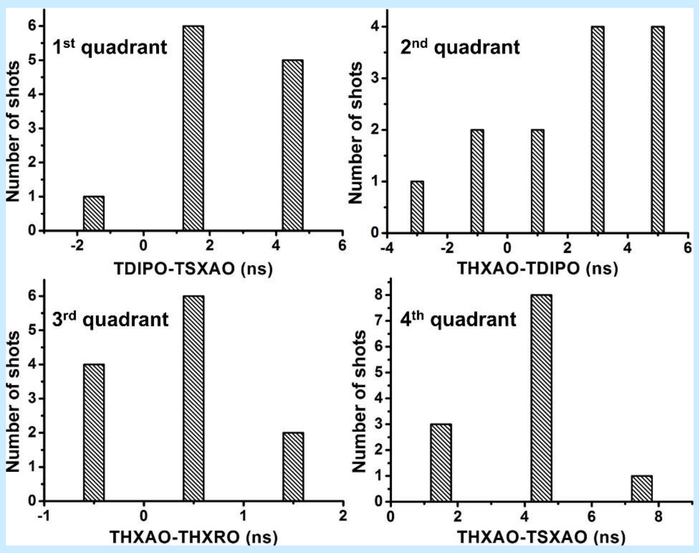


Time history analysis: The low and high-energy x-rays are originated at some time. They take some time to reach the detectors and detectors have their processing time. The detectors are connected to the oscilloscope using equal length cables. Therefore, the time that in the oscilloscope will be the sum of the above mentioned time.



(A) Before time correction the low and high-energy x-ray seem to appear after pinch in the dI/dt signal.

(B) After time correction, it can be seen that the x-ray coincide with the pinch.



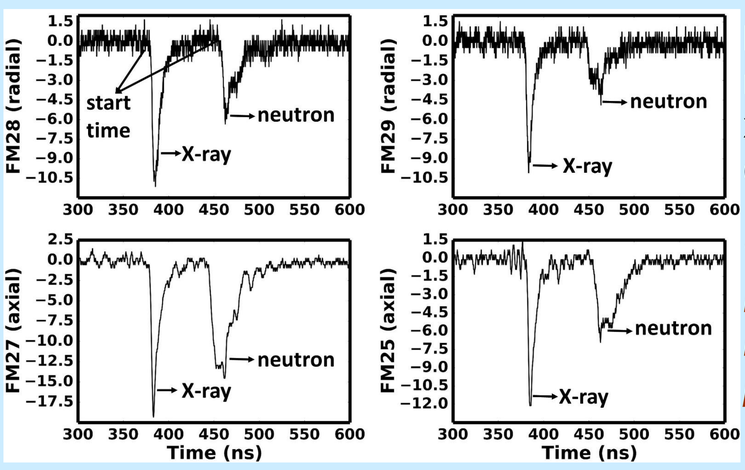
TDIPO: time @ dip in dI/dt.

TSXAO: time @ low-energy x-ray axial direction.

THXAO: time @ high-energy x-ray axial direction.

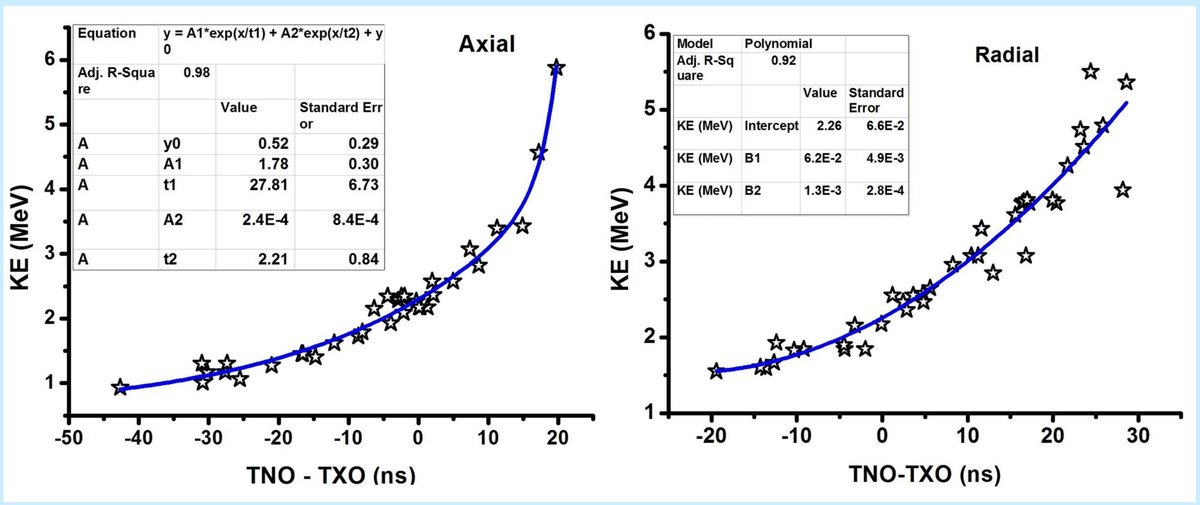
THXRO: time @ high-energy x-ray radial direction.

Low/high-energy x-ray origin time coincide with the dip in current derivative signal.

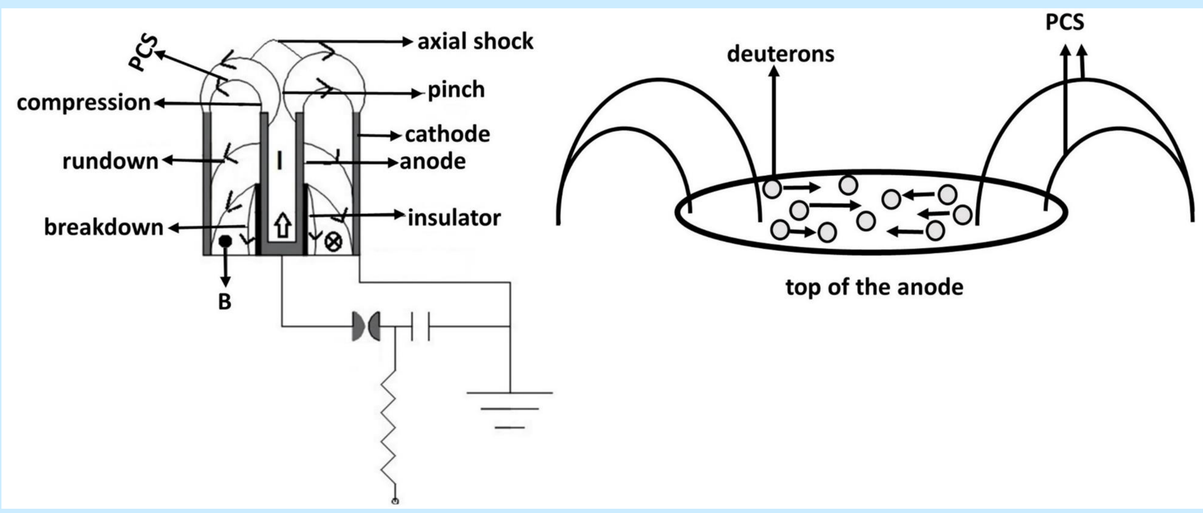


Before time correction the neutron signals appear after x-ray in the axial and radial directions.

Time correction yielded that neutron originated before x-rays and therefore before pinch.



- **Neutron energies increase gradually during pre-pinch to post pinch time [1].**
- **More than one nuclear fusion mechanisms may be involved [1].**



Acknowledgments

Work financially supported by the ANID-FONDECYT Postdoctoral grant N°3190184, the ANID PIA/Anillo ACT-172101 grant, the ANID-FONDECYT Regular project 1190677.