Production of Fast Neutrons With a Plasma Focus Device

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1. **The Plasma Focus Device.**
   (History, Physics)

2. **Neutron, X-Ray, Radioisotopes**

3. **Applications:**
   Radioisotopes
   Neutron interrogation
   (Interstellar propulsion)

Cape town, April 6, 2006

The Laboratory for Nuclear Science At Avery Point

Developments of Plasma Foucs

1. **Discovery of Plasma Foucs in Late 1950's early 1960's by Filippov and Mather.**

   J.W. Mather; Physics of Fluids 8, 336(1965).
   N.V. Filippov, T.I, Filippova, and V.P. Vinogradov IAEA Nuclear Fusion Suppl. 2, 577(1962).

2. **PF developed mostly in (Poland) Eastern Europe 1970's Transferred to Italy 1980's (Jan Brzosko).**

3. **Transferred to USA, Stevens Tech, Hoboken, NJ.**
   Knife Edge Discovered (Vittorio Nardi, Jan Brzosko).
   J.S. Brzosko, V. Nardi; Phys. Lett. A155, 162(1991).

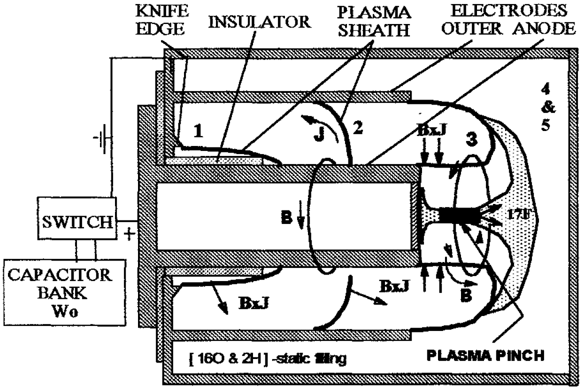
4. **Discovery of Accelerated Ions.**

5. **Los Alamos, Weapons simulations**
   Sandia National Lab, Z-machine 1 MJ achieved

6. **Future? Brazil, Poland…**

DIANA-HITECH, LLC (PF-50 x 2)

Plasma Focuse Neutron generator (10^{13} n/pulse)



X-Rays
Neutrons
Ions (<5 MeV/u)
(Backward Emission)

J.S. Brzosko, K. Melzaci, C. Powell, M. Gai, R.H. France III, J.E. McDonald, G.D. Alton, F.E. Bertrand, and J.R. Beene; Amer. Inst. Phys. **CP576**(2001)277

FIGURE 1. Conceptual drawing of the plasma focus header indicating the sequence of plasma sheath positions. The central electrode diameter is $\phi \approx 50$ mm, the chamber is filled with gas mixture at p = 0.1 – 7 Torr. Numbers refer to plasma development stages: 1 – the plasma sheath is formed, 2 - the plasma sheath moves toward the anode nozzle ($v \approx 10^5$ /s), 3 - the sheath arrives at the end of anode and rearranges itself into a cylinder with a conical opening, 4 - the plasma is compressed at the axis (10^{25} ions/m^3), 5 - the plasma column quickly develops instabilities associated with high-energy acceleration, high nuclear reactivity and X-ray emission.

Small (ϕ: 20 - ϕ: 300 μm) plasma domains are created. The domains have above solid state densities, $kT \geq 3$ keV and magnetic fields sufficient to trap ions of 5 MeV/nucleon.

DIANA's PF-25

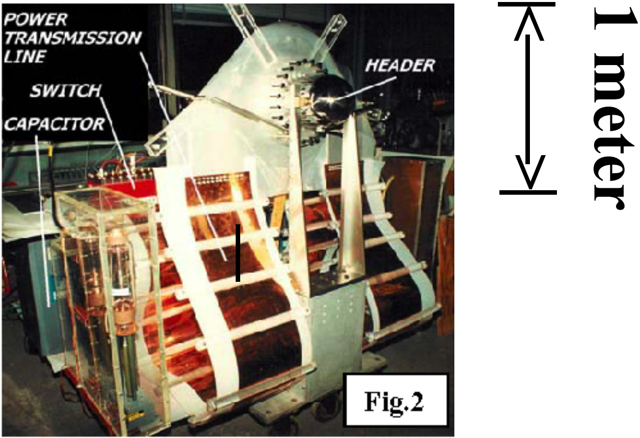


Fig.2

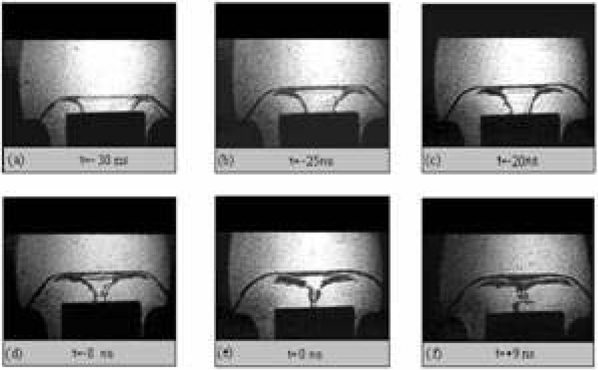
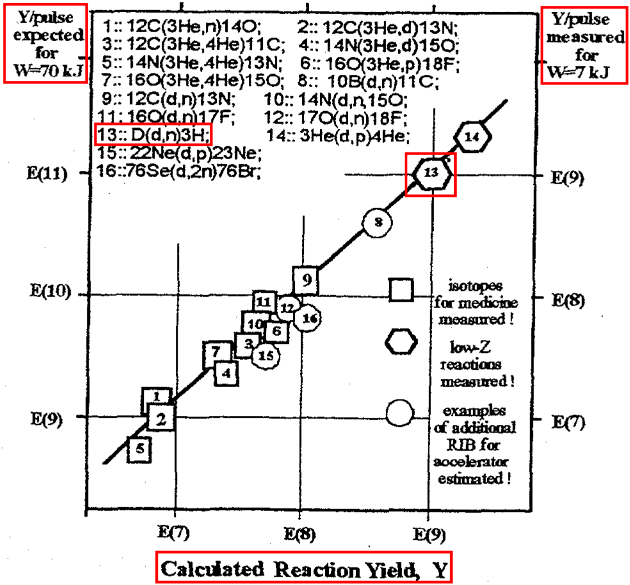
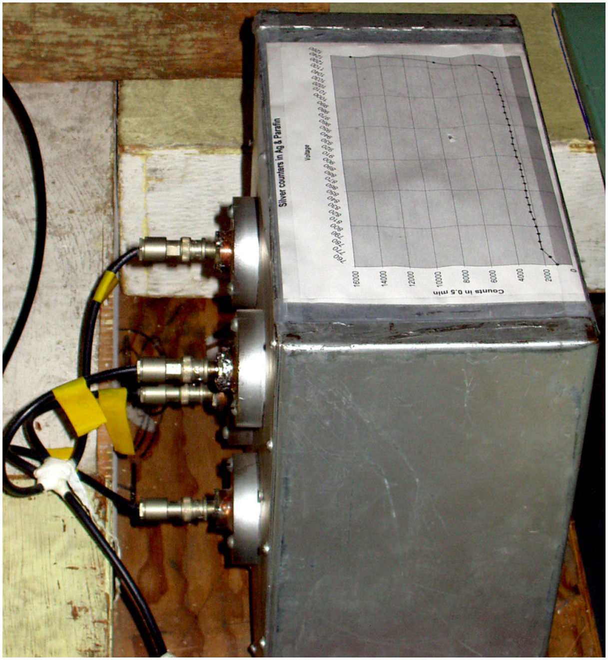


Fig 3. Sequence of compression in UNU/ICTP PFF at 4.0 mbar deuterium [20]

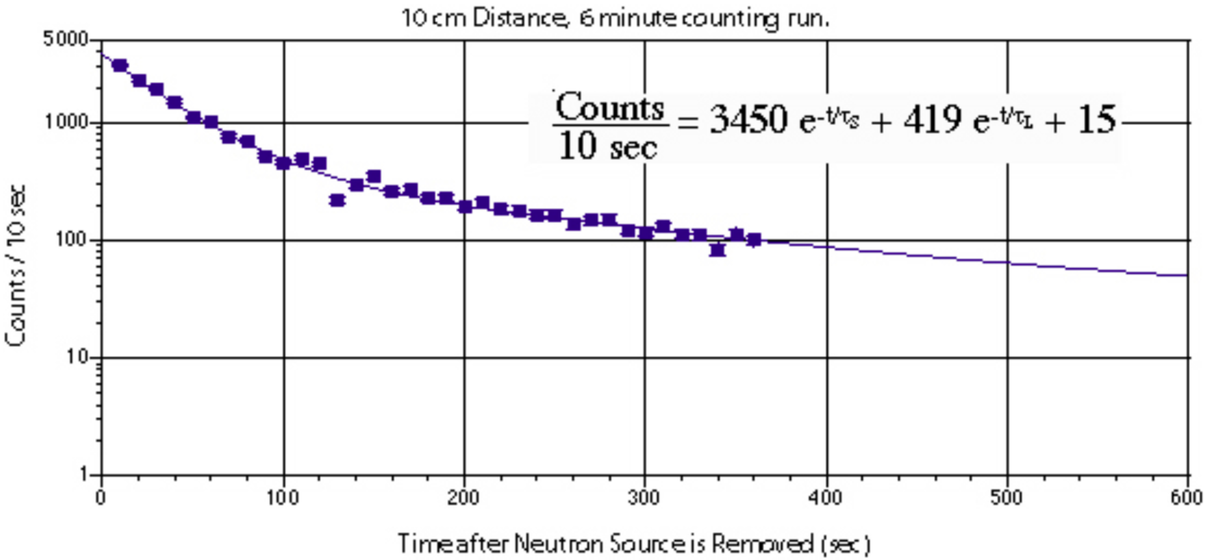
Reaction Yield from Hot-Magnetized Plasma-Target of the Plasma Focus

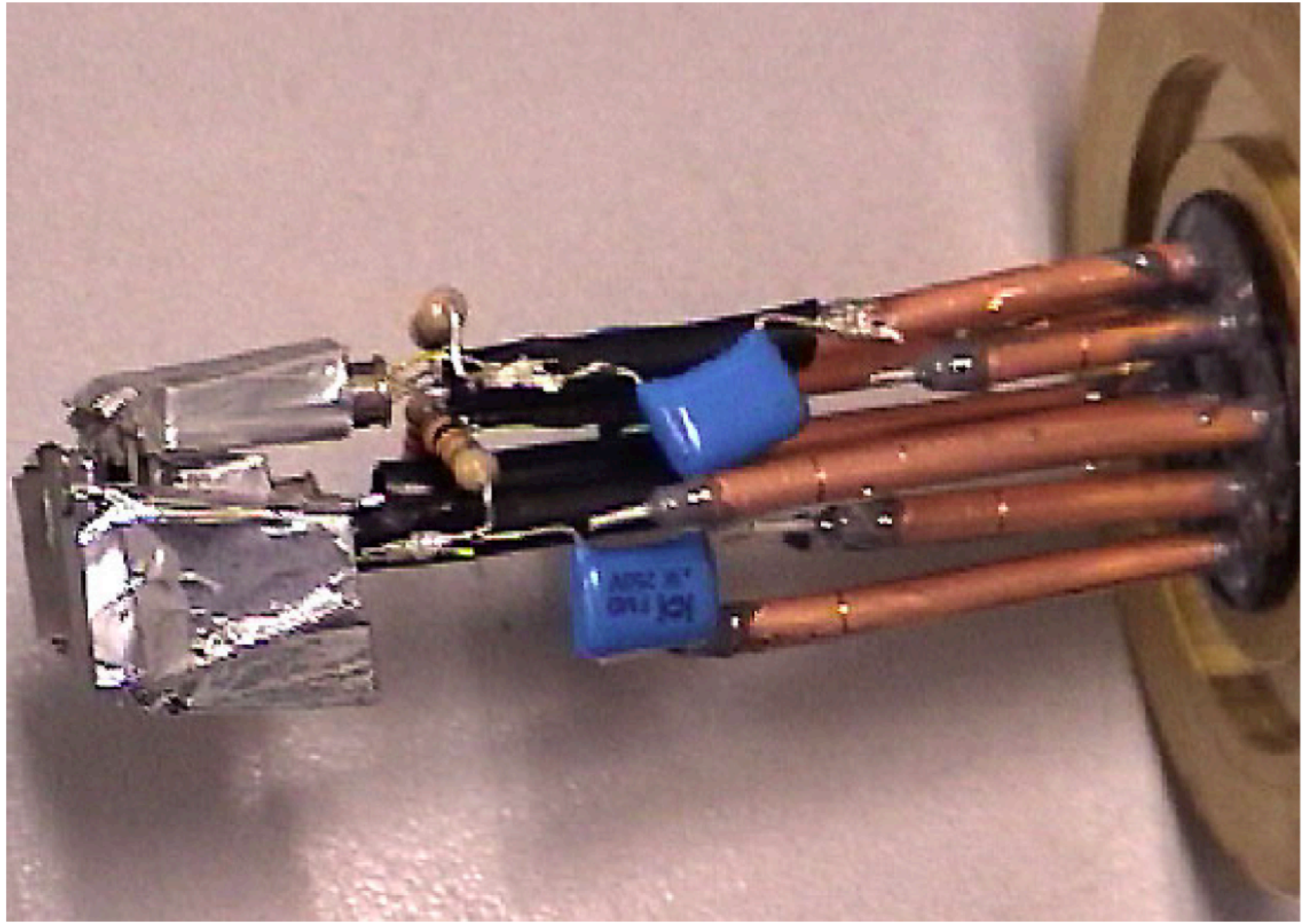


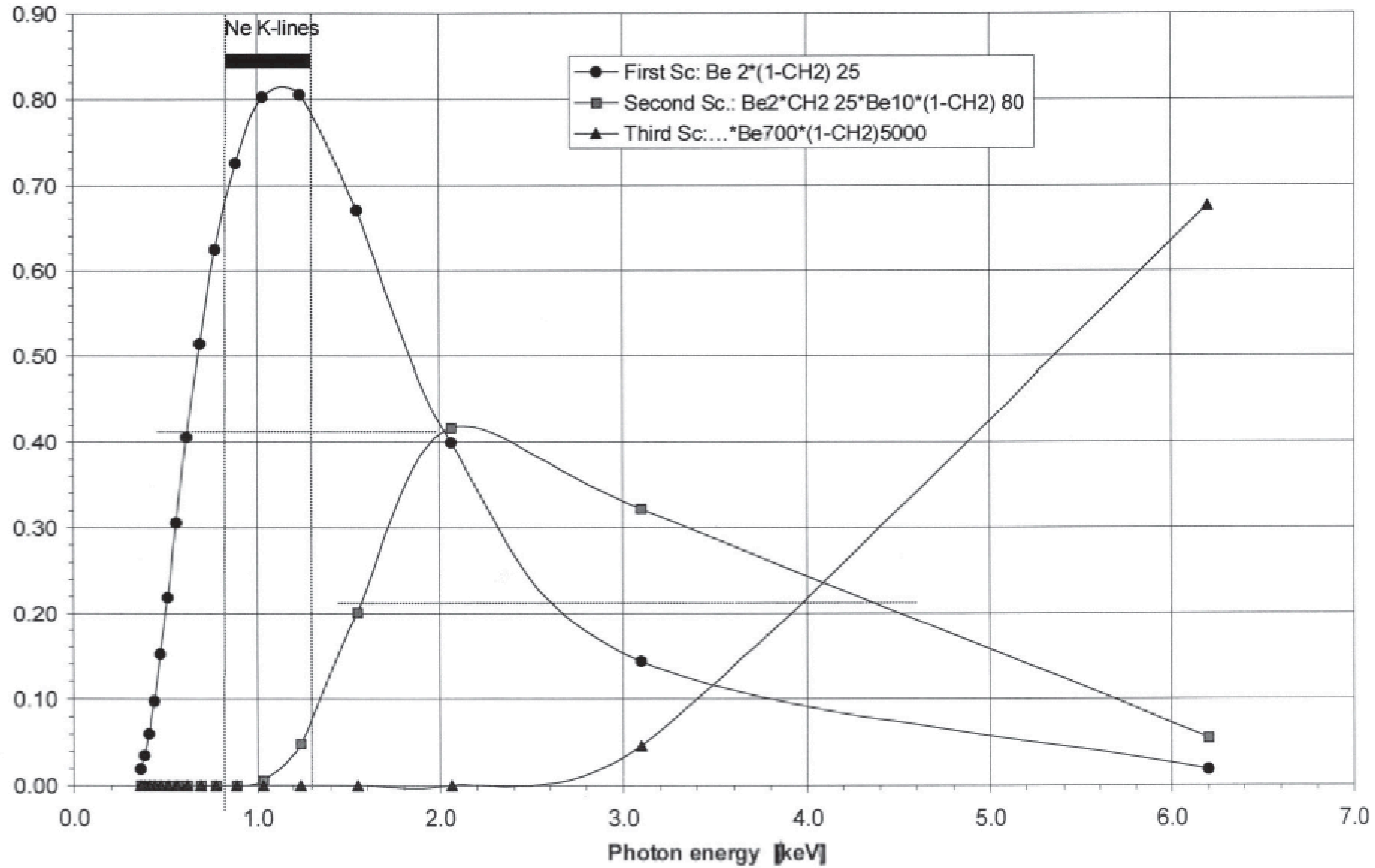


^{108}Ag: = 2.41 min

^{110}Ag: = 24.6 sec







0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Ne K-lines
First Sc: Be 2*(1-CH2) 25
Second Sc.: Be2*CH2 25*Be10*(1-CH2) 80
Third Sc:...*Be700*(1-CH2)5000
Photon energy [keV]

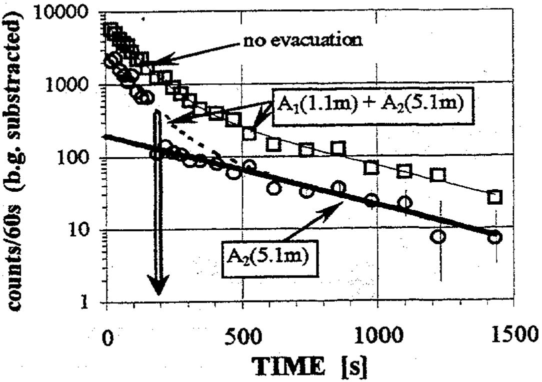
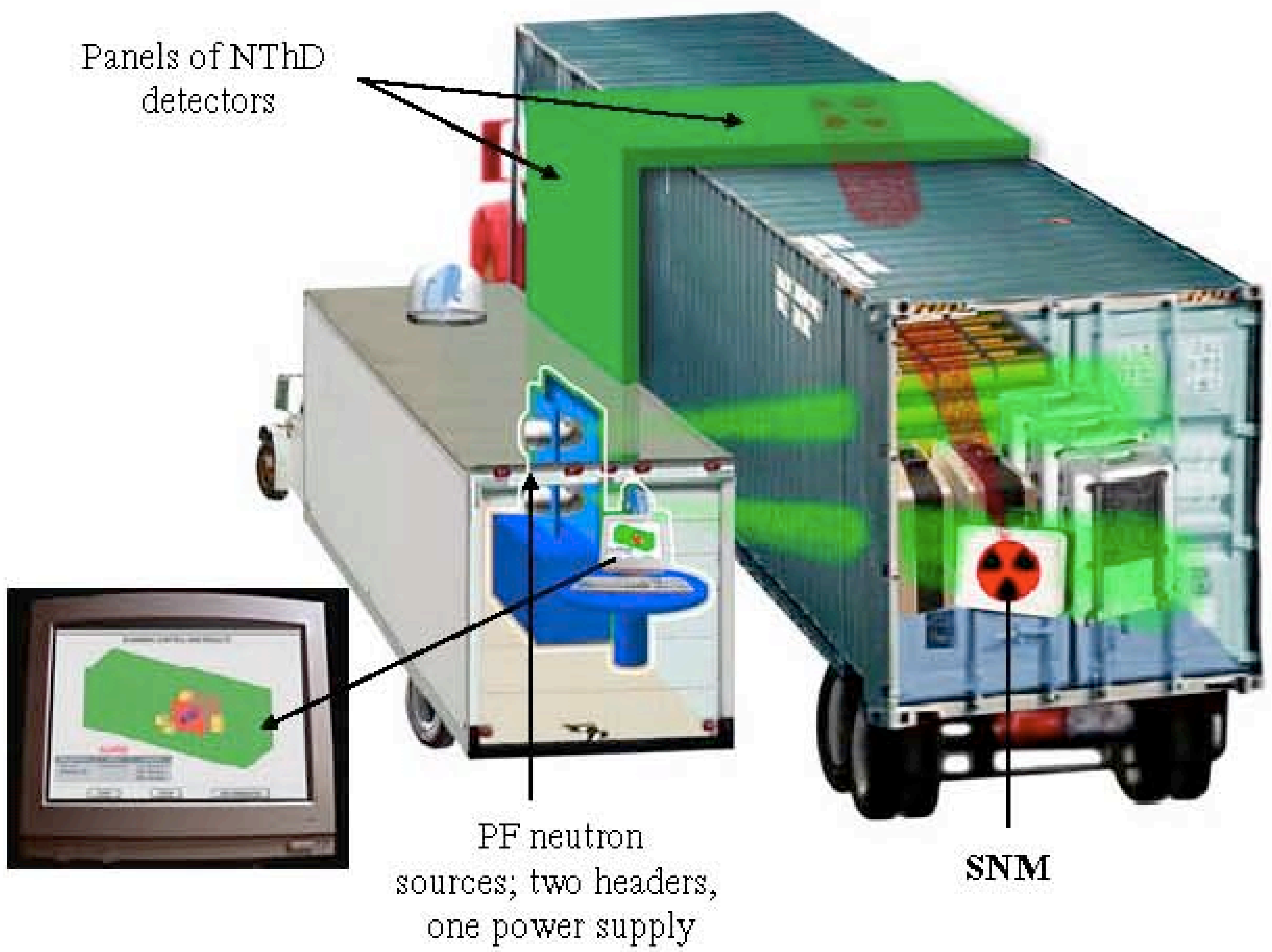


FIGURE 4. An example of the decay curves each composed of two half-lives: $T_{½}$ = 1.1 min (^{17}F) and 5.1 min (^{66}Cu). Three min after the discharge ($\rho_{HZ}/\rho_{LZ} \approx 0.1$), the chamber was pumped-out (radioactive gas evacuation) after which the plasma-induced radioactivity ($T_{½}$ = 1.1 min) disappeared. A decay curve, measured after another discharge and without gas evacuation, is shown for comparison.

DIANA HI-TECH LLC
5/03/2004

BAA Number: 04-02
TTA: 6:AAISS Part: B

Title: Direct Detection of Special Nuclear Materials with Single Pulses of Fast Neutrons



Parameter	AFNIT	BAA 04-02 requirements
M_{SNM}: Mass of detected ^{235}U, ^{239}Pu,... [% of Nuc. WMD]	< 5%	"limited quantities"
Direct elemental detection and position	yes	required
Chemical form of SNM	any	not adressed
Volumetric dilution of M_{SNM} within inspected slot	any	not adressed
Type of cargo load	any	not adressed
Sensitivity to clandestine shielding	none	none
Total cost of one container inspection	$80	low
Scan time for 8x10x40 ft cargo container [s]	20	20
Detection rate per SNM [%]	99.9	70
Nuisance & false alarm per container [%]	0.01	?????
Operation from mobile platform	yes	yes
Architecture open for upgrade and integr.	yes	yes
Decision and data transmission	automatic	automatic

Operational Capability:

Comments:

1. Nuisance & false alarm reduction is due to immediate second inspection of container slot when SNM is detected. Present systems (and TTA-3 solutions) have no detection capacity for shielded SNM.
2. Inspection cost includes capital investment and 2 years of operation costs.
3. SNM mass is indicated vaguely for security reason.
4. Architecture is open for adding high energy γ-detectors to detect chemical explosives and an advance high energy X-ray radiology for 3D imaging

Proposed Technical Approach: Active inspection for SNM occurs in steps. Neutrons from Plasma Focus PF) source (~10^{13} n/pulse; $\Delta\tau \leq$ 50ns) are aimed at a volumetric slice of the cargo container (2'×6'). Neutrons are moderated by the content of the cargo container, absorbed by cargo nuclei and re-emitted fast neutrons from prompt-fission. Neutron threshold detector, NThD, (property of scintillator, not an electronic) is set outside of the container walls and gives unique information about presence of SNM. DIANA has already built PF-sources operating in lab. conditions and cross-checked with Monte Carlo simulations (LLNL and DIANA effort) that the fast-fission-neutrons information can be selectively recorded in a strong field of gamma and thermal neutrons and that PF-source has sufficient yield to support fast inspection. Phase-IA: Definition of system parameters and feasibility evaluation of: PF-source, threshold detectors. Phase-IB: Experimental feasibility of PF pre-prototype and NThD fragment performance and PDR. Phase-II: Construction of complete prototype in lab. technology (PF, NThD, decision software) and validate SNM signature, accuracy, throughput, safety and CDR. Phase-III: Convert technology from laboratory to field prototype. Construct and test in field full system ready to go for serial production.

ROM Cost and Schedule:

Phase	Task	Main Activity	month	COST in M$	DELIVERABLE
Ph-IA&B	1	Monte Carlo (MC) simulation of SNM signature	6 & 12	0.36 & 0.45	Signature & source yield
Ph-IA&B	2	Simulation/design of the PF engineering	6 & 12	0.27 & 0.35	Conceptual design
Ph-IA	3	Concept devel./design of the NThD engineering	7	0.98	3 options of concept. design
Ph-IA	4	Techn. concept of eng. Devel., pricing, suppliers	7	0.55	Final Report
Ph-IB	5	MC simulation/design of radiation safety for tests	15	0.45	Safety procedures
Ph-IB	6	Build and test PF meeting Ph-IA definitions	18	1.7	PF source; (not rugged)
Ph-IB	7	Build and test NThD meeting Ph-IA definitions	18	1.15	1 segment of detecting panel
Ph-IB	8	PDR, exp. concept validation, Ph-II eng. Program	19	1.38	Final Report
Ph-I	1-8	Feasibility studies; A- concept, B- experiment	7 & 19	2.16 & 5.5	*Prove of principles &scaling*
Ph-II	9-16	Prove of performance, eng.param. for field	31	7	*Lab. prototype*
Ph-III	17-21	Field prototype: constr., tests, documentation	43	7-10	*Complete field prototype*

Corporate Information:

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- For Northrop Grumman Program Manager: Neil Siegel; (310)764-3003; Neil.Siegel@ngc.com

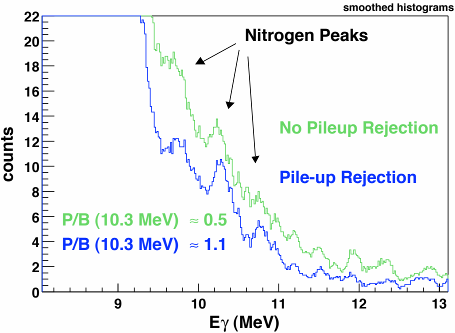

Fig. 4 : Spectrum of a melamine sample irradiated with the ^{252}Cf *source at the bunker of LNL for a NaI(Tl) EXPLODET detector. The upper panel show the complete spectrum, the lower one shows in more detail the nitrogen peaks energy region.*

May 8, 2005 NY Times

WASHINGTON, May 7 - After spending more than $4.5 billion on screening devices to monitor the nation's ports, borders, airports, mail and air, the federal government is moving to replace or alter much of the antiterrorism equipment, concluding that it is ineffective, unreliable or too expensive to operate.

U.S. SENATOR • ARIZONA

JOHN McCAIN

http://mccain.senate.gov

PRESS RELEASE

Wednesday, July 24, 2002
FOR IMMEDIATE RELEASE
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McCain Voices Opposition to FY'02 Supplemental Appropriations Bill

Washington, DC – U.S. Senator John McCain (R-AZ) today entered the following statement into the Congressional Record regarding the FY'02 Supplemental Appropriations Bill:

Other questionable provisions regarding the TSA should also be mentioned. For example, in the Statement of Managers, the appropriators have earmarked money for the field testing of a particular security technology referred to as Pulsed Fast Neutron Analysis (PFNA). There is only one company that has developed this technology: Ancore Corporation of Santa Clara, California. Unfortunately, earlier this month, the National Research Council (NRC) concluded that PFNA is not ready for airport deployment or testing. Even though the main role for PFNA is the detection of explosives in full cargo containers, the appropriators are directing money for field testing on checked bags. This earmark could be a total waste of critical research money that should be contributing to our effort to increase aviation security.

1. **The Plasma Focus Device, pulsed source:**
   Neutron: 10^{11}, 10^{13} /pulse @ 2.5, 14 MeV
   20-50 nsec pulse duration (up to 5 Hz)
   X-Ray
   Radioisotopes
   Accelerated ions
   Safe (Can be turned off)

2. **It's a pity it will not be developed further.**

3. **It's a pity we will not know if it is applicable for HLS etc.**

Cape Town, April 6, 2006