50 YEARS WITH NUCLEAR FISSION

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FEASIBILITY OF BREEDING U-233 USING (D+D) "EXYDER" FUSION NEUTRON SOURCE

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ABSTRACT

The Indian Nuclear Power Programme plans for Th-233 to be converted into U-233 in LMFBRs for use in Th/U-233 reactors. We examine a near-term solution of using an alternate fusion system as the neutron source: a newly invented self-colliding beam device known as EXYDER (strong focusing migma), operating at $Q < 5$ and consuming net electrical energy; since it can store MeV ions, the D-D reaction will be used, circumventing tritium problems. A simulation with deuterons of 1.5 MeV, 1.6 A (beam power 2.4 MW), and stored ion density of 5×10^{14} cm^{-3} shows an n production rate of 1.1×10^{19} s^{-1} (in 4π) and energy cost of neutron production of 5 MeV per n. The net U-233 production rate from one 10 m^3 EXYDER is estimated to be 100 g/day of U-233 (35 kg/year).

"India has 360,000 tons of recoverable thorium against only 45,000 tons of natural uranium."

"Installing one or two exyder type mini breeders to serve each nuclear power plant operating on Thorium/U-233 cycle would eventually render the power station

self sufficient

as far as its fissile fuel requirement is concerned."

Computer simulation

Exyder module could economically produce 100 gram/day, 35 kg/year of U-233

electric energy cost $50/Kg vs $300/Kg for U-238 .

CANDU type reactor of 235 MWe burns 10 Kg of U-233/ year.

"Even 'sub-engineering' energy breakeven fusion systems

$$Q_{sci} = 4$$

$$Q_{eng} = 0.05$$

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WORLD'S STRONGEST MAGNET in its class 1975-1990

6 Tesla on coil, **3.2 Tesla** midplane **5,000 cc volume**

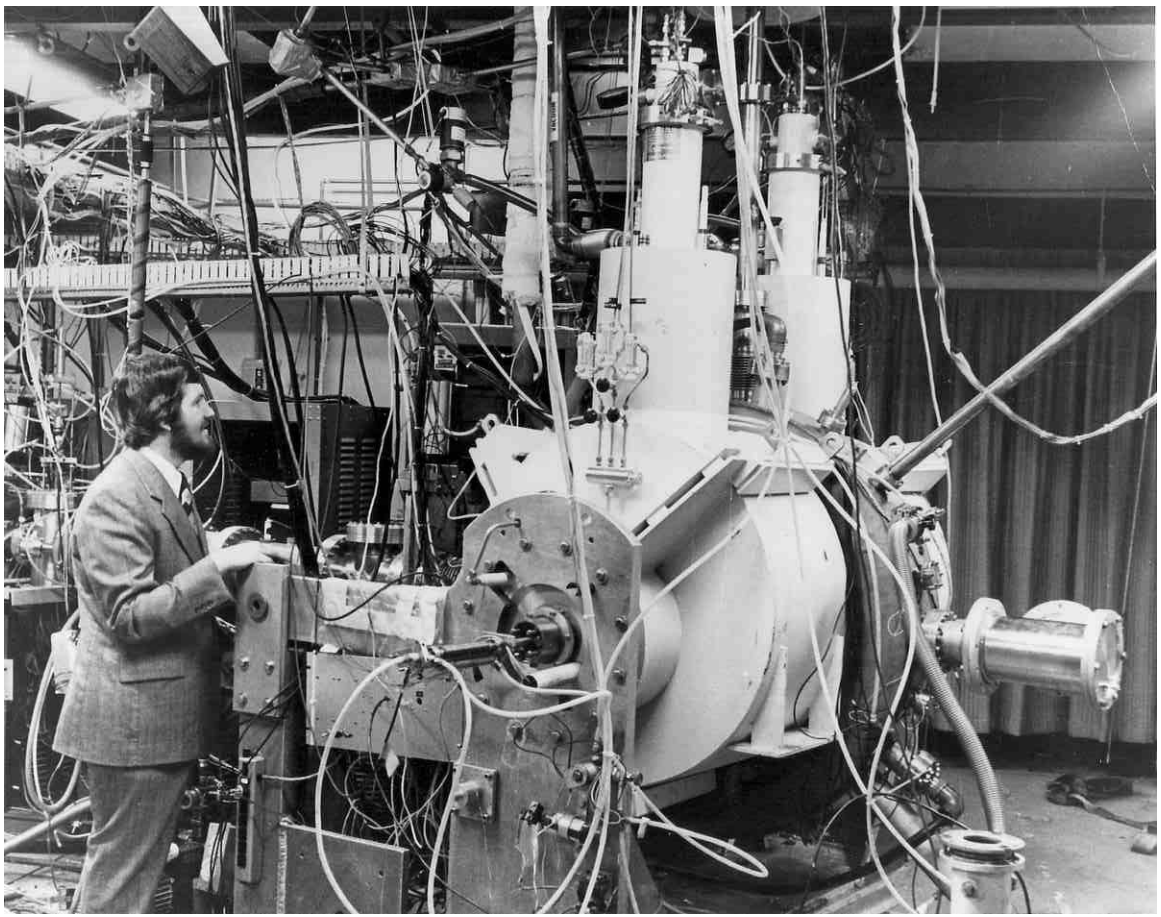
MIGMA-CELL 4 SUPERCONDUCTING Niobium-Titanium MAGNET

WORLD'S HIGHEST VACUU M in its class 1975 TO DATE

vacuum 10-11 Torr (static); 10^{-9} (beam in) **200 liter volume**

chamber is baked to 450°C 24 hours before injection

James Nering, Chief Engineer at Migma Institute of High Energy Fusion, Fusion Energy Corp., Princeton 1975.



•B. Maglich, Nucl. Instr. Meth. A271, 15 (1988); ibid., A271, 157 (1988).

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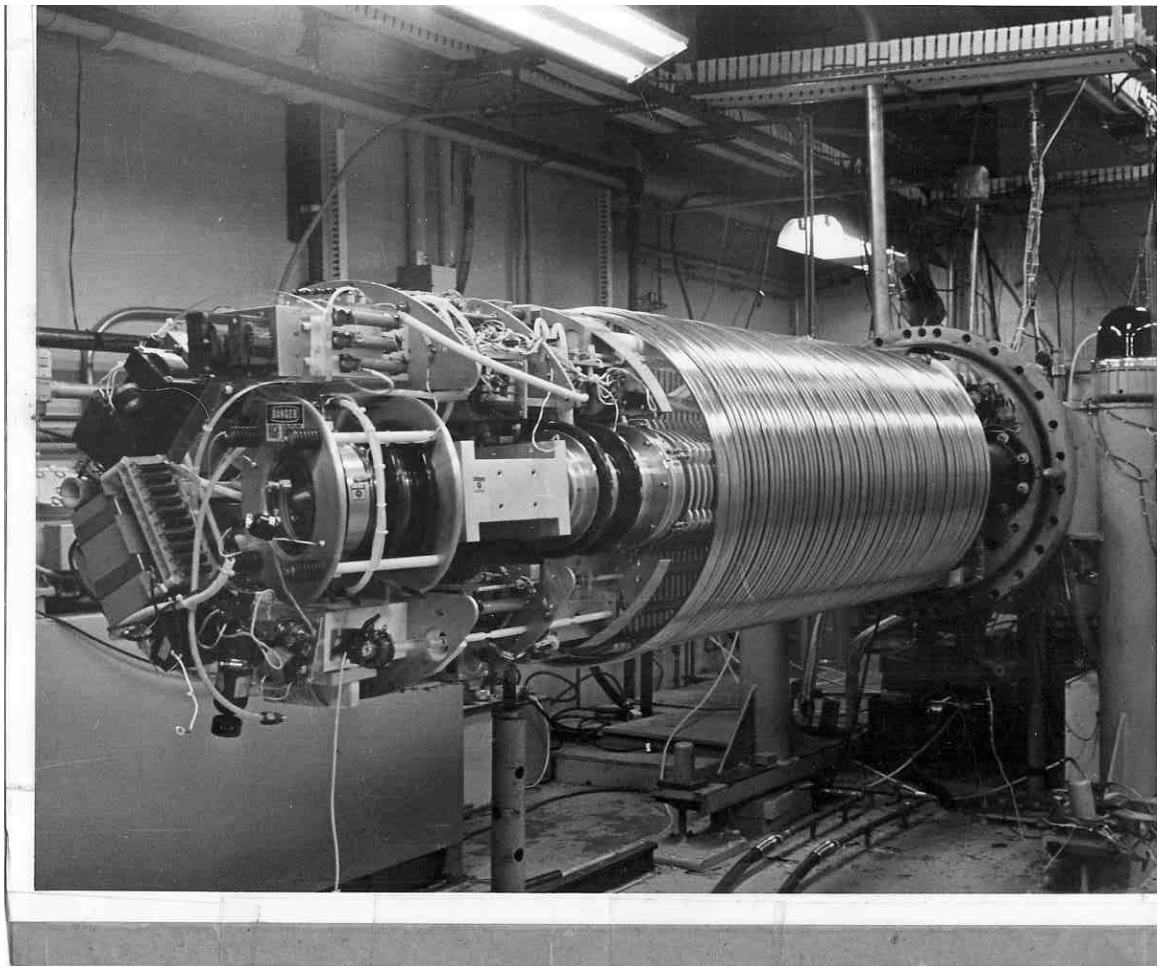
MIGMA-CELL 4 ACCELERATOR - INJECTOR

WORLD'S HIGHEST FUSION CHAMBER

INJECTION ENERGY: D_2^+ ions of 1.45 MeV, 2mA



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MIGMA-CELL 4 AUTO-COLLIDER

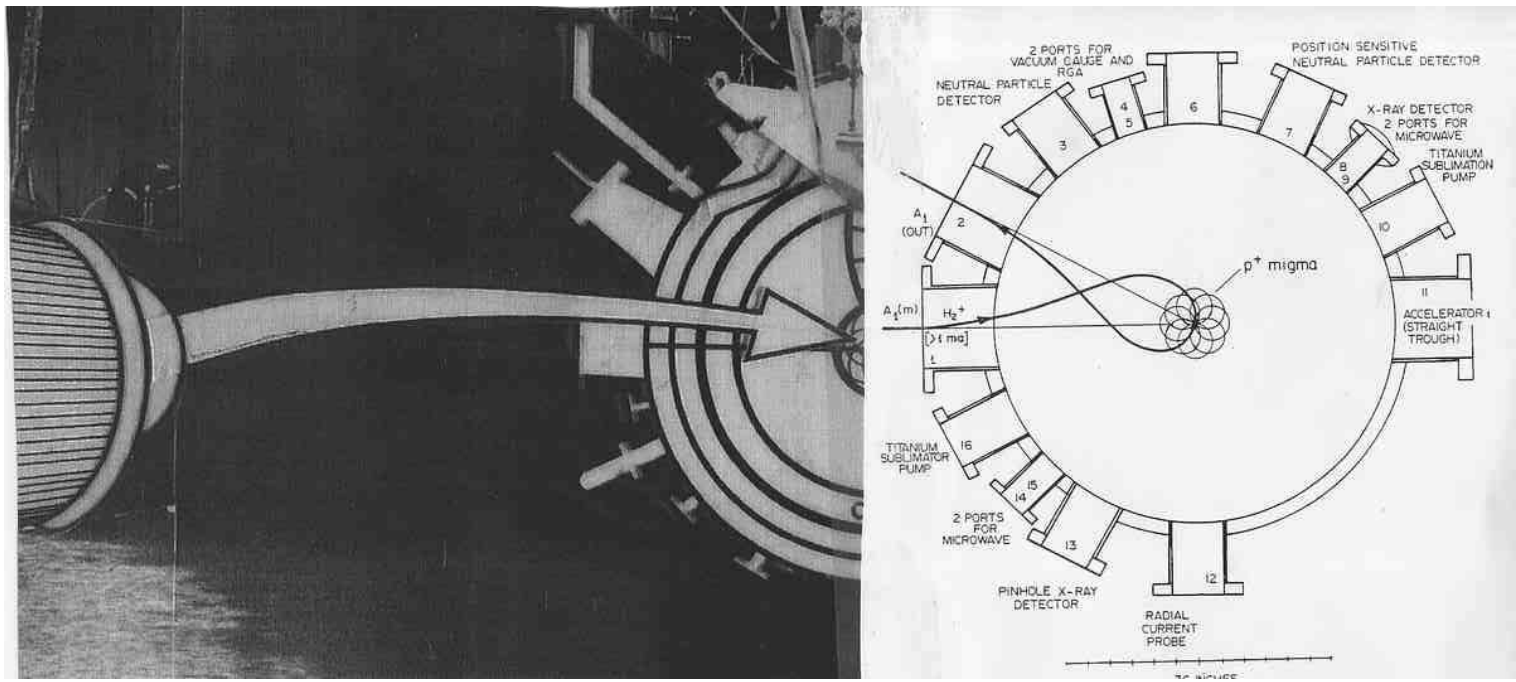
WORLD'S HIGHEST KINETIC TEMPERATURE

D_2^+ ions of 1.45 MeV are injected, dissociated in center to create self- colliding 725 KeV $D^+ + D^+$ migma corresponding to

T = 10 Billion Degrees Centigrade

10,000 times higher than in any fusion device

D. Al Salameh *et al.,* Phys. Rev. LeU. 54,796 (1985).



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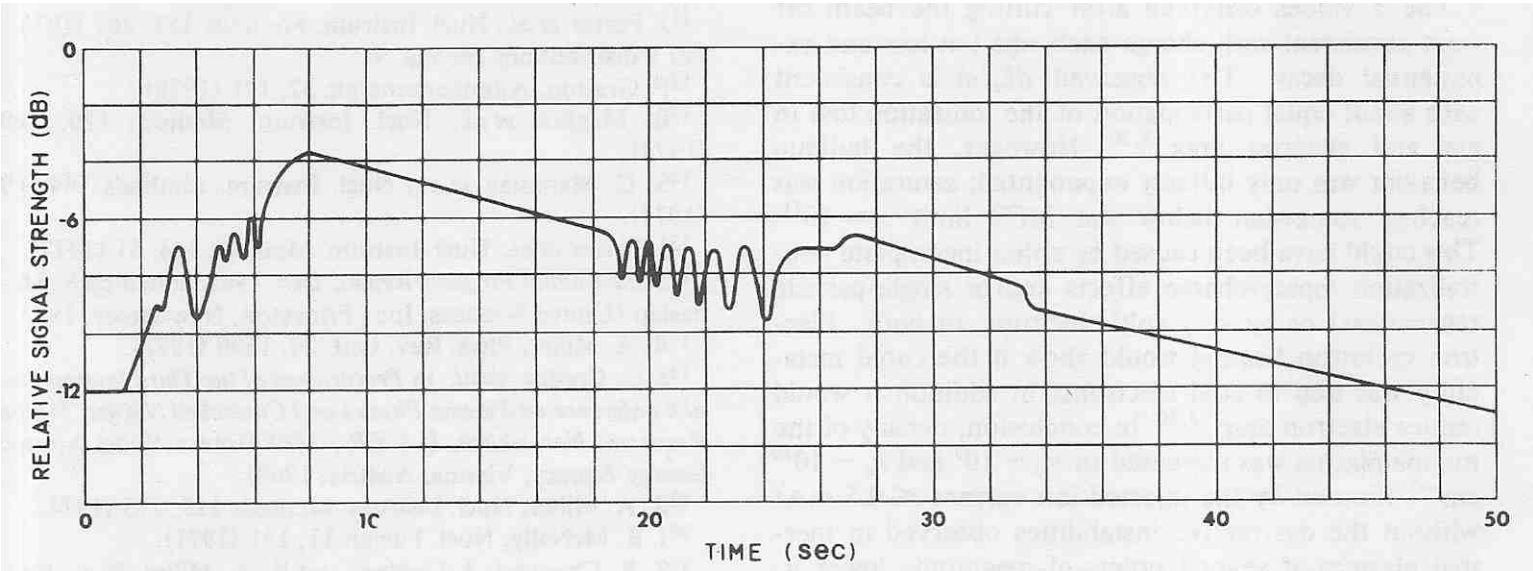
MIGMA-CELL 4 confinement

WORLD'S LONGEST ION ENERGY CONFINEMENT

$\tau_{1/e}$ = 34±4 sec

Stable confinement was achieved by (1) the new process of electron oscillations through the circulating ions, where the ions acted like a grid in a triode oscillator, and (2) ultrahigh vacuum of 10^{-11} Torr (no load), 10^{-9} Torr with in.

Non-linear stabilization technique: "Stabilization by electron oscillations of stored ions at densities in excess of space-charge limit" Phys. Rev. Lett. 70,299 (1993) US Patent. B. Maglich and S. Menasian.



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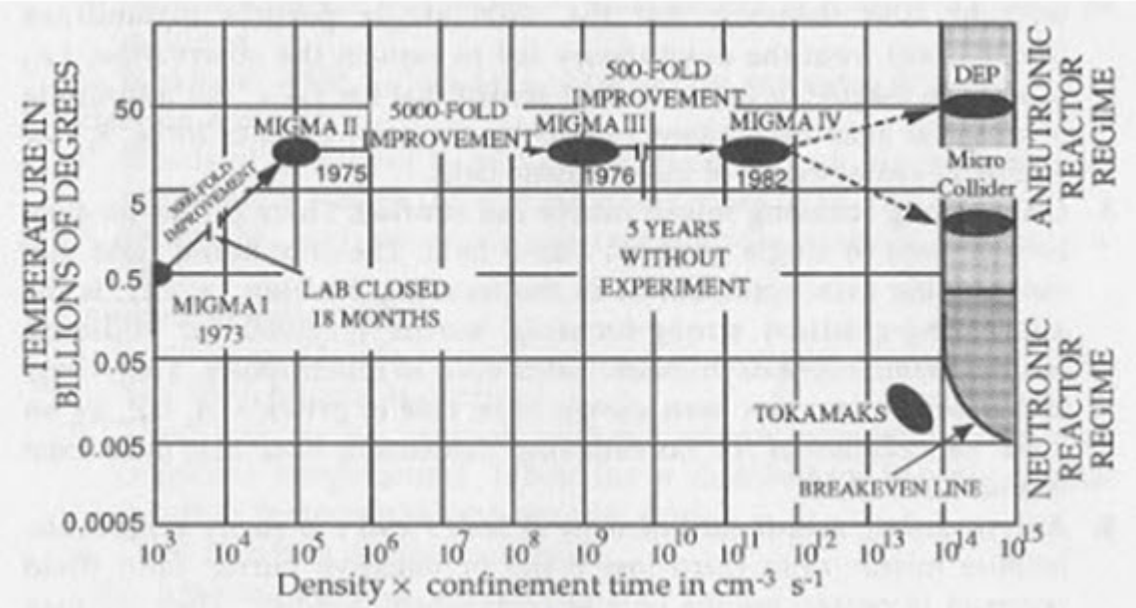
Progress of migma system (black dots) from 1973 through 1982.
Temperatures in 10^9 ^oC (abscissa) vs. product $n\tau$ ($cm^{-3}s$).



From proceedings of the International Symposium of the Feasibility of Aneutronic Power: Review of Searches for Nonradioactive Non Proliferating Nuclear Energy held at the Institute for Advanced Study, Princeton, 1987
NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RESEARCH A 271, Volume 1
ENTIRE VOLUME DEDICATED TO COLLIDING BEAM FUSION

•B. Maglich, Nucl. Instr. Meth. A271, 15 (1988); ibid., A271, 157 (1988).

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SUPERCONDUCTING MAGNETIC FIELD for EXYDER

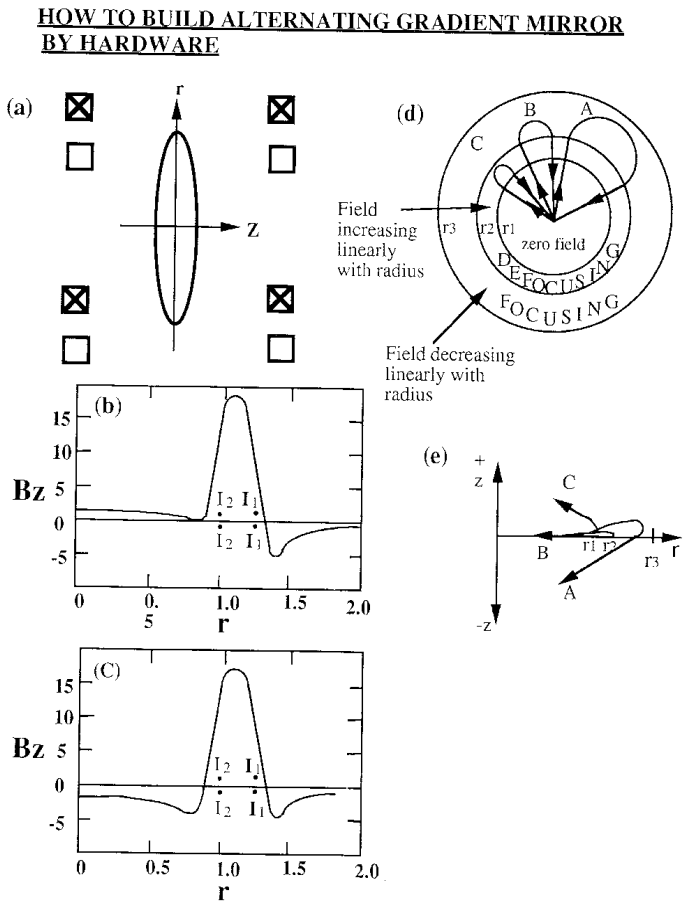

Fig. 6. Making of AGM field with two pair of coils: (a) Geometry of the AGM coil configuration in the (r, z) plane. (b) $B_z(r)$ for $-I_2 = 0.6I_1$. (c) $B_z(r)$ for $I_2 = -I_1$. (d) Orbit in x-y plane. Orbits (a) and (b) would be stable while (c) is axially ejected. (e) orbits in r-z plane.

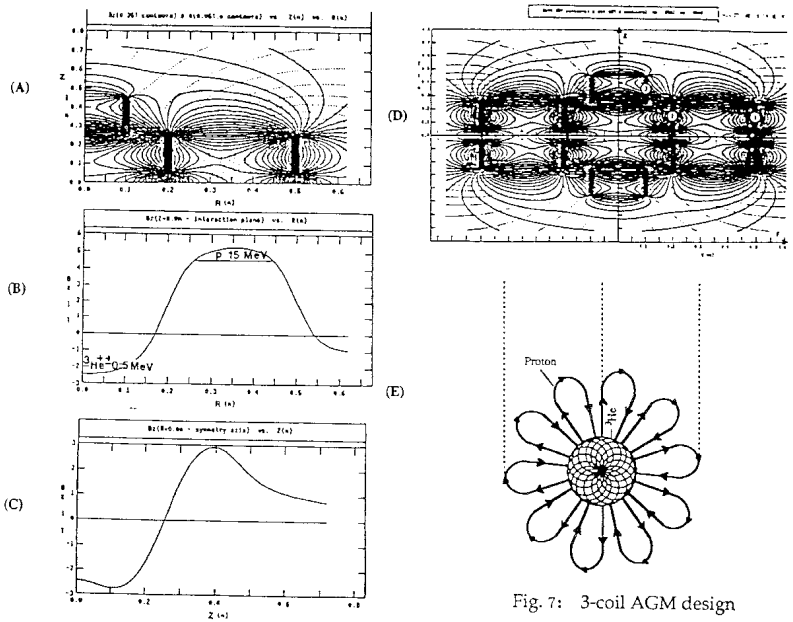

Fig. 7: 3-coil AGM design

From B.C. Maglich, Modern Magnetic Fusion, AIP Conf. Proc. 311 pp.292 – 319 (1993)

J. P. Blewett, Nucl. Instr. and Meth. A271, 214 (1988); Part. Accel. 34, 13 (1990).

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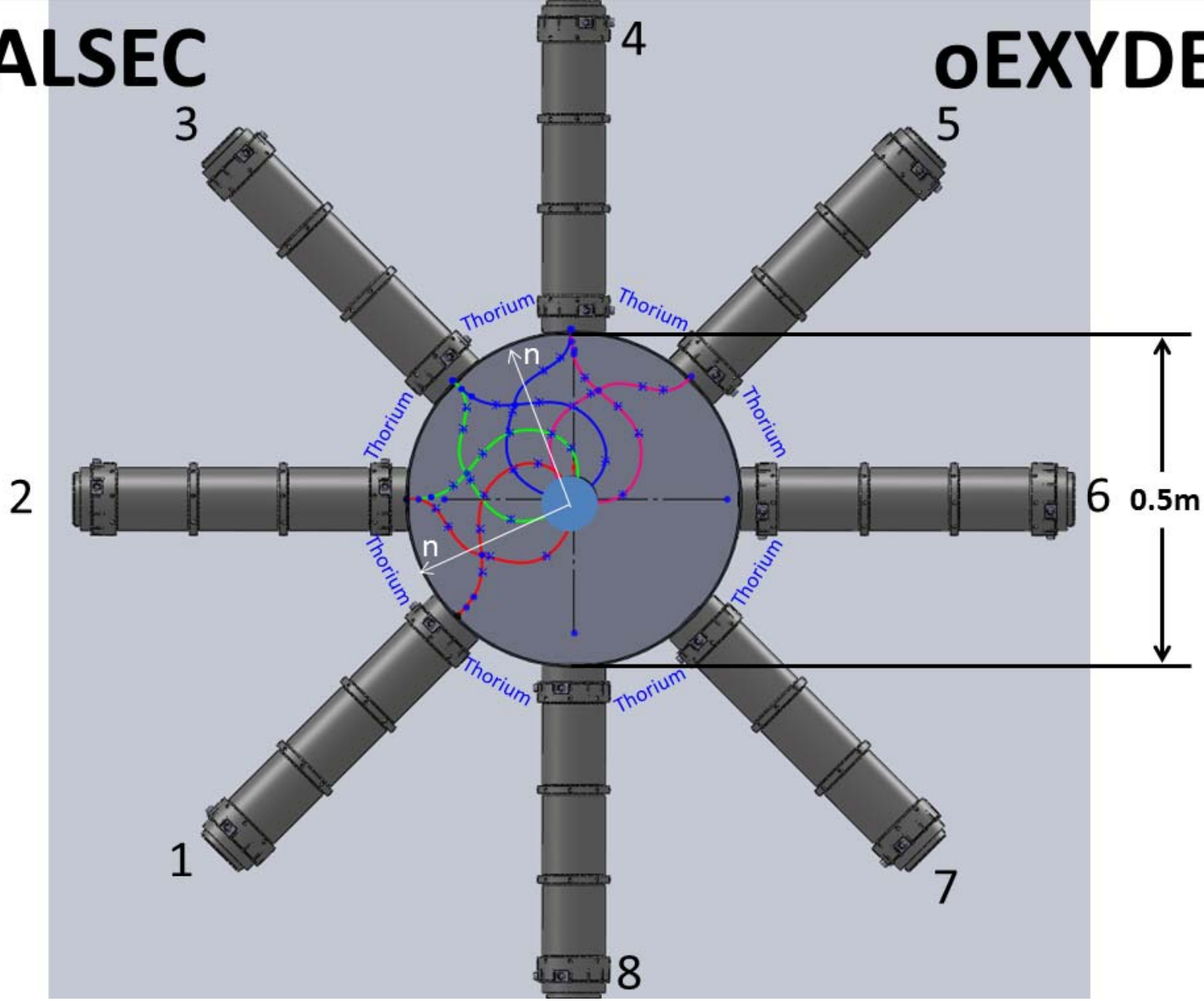

Ion sources not shown

US & International Patent pending 2011

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Glen T. Seaborg (standing) and
Bogdan Maglich (at Board)
presenting Exyder
Irvine, California, 1993

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TABLE

Cost & Gain Parameters for Production of U-233, Helium-3 and Tritium

	EXYDER
1. Volume	10,000 Liter = 30 units 330Liter ea.
2. Electric Power Input, P_{in}	6MWe (0.65)=9.2MWe
3. Charged Particle, Electric Power Input	3.32MWe
4. Neutron Production Rate	1.1 x $10^{19}s^{-1}$=66mg/h
5. Gross Energy Cost per Neutron	3.48MeV/ (0.65)/n= 5.36 MeV/n
6. Gross Energy Cost / Dollar Cost per Gram of Neutrons	140 MWh/g $8,360/g
7. Energy generated in fusion per Neutron	0.86MeV/n
8. Net Cost of Energy N / Per g of N (#5 - #7)	4.5MeV/n=119MWh/g $7,140g
9. Overall Scientific Power Gain $Q = P_{tot}/P_{in}$	4.8
HELIUM-3	
10. Net Energy Cost per Helium-3 per g of Helium -3 Liter / g Cost per liter of He-3	4.5 MeV/n $2,380/g 7.46L/g $319/L
TRITIUM	
11. per Tritium per g of Tritium Liter / g Cost per Liter of Tritium	4.5 MeV/n $2,380/g 7.46l/g $319 / L
SUMMARY	
12. Gross Energy Cost per gram	$8,360
13. Value of 1 g n	$14,000
14. Value of 3g He-3	$7,140
15. Value of 3g T	$7,140
16. (#13 - #15)	$38,200
17. Gain (316 - #12)	$19,920 / g
18. Net gain / day (#17x100)	**$1,992,000 / 100g**

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