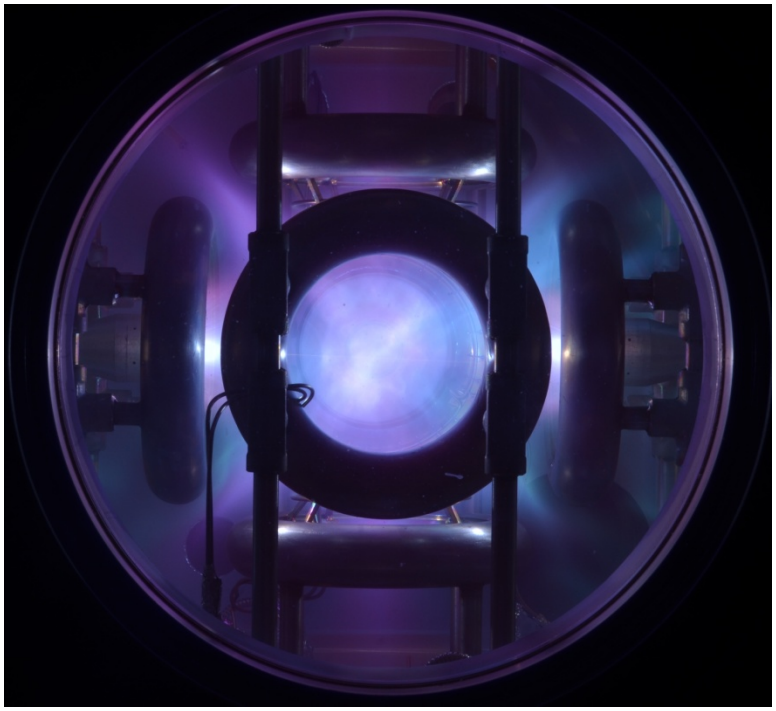
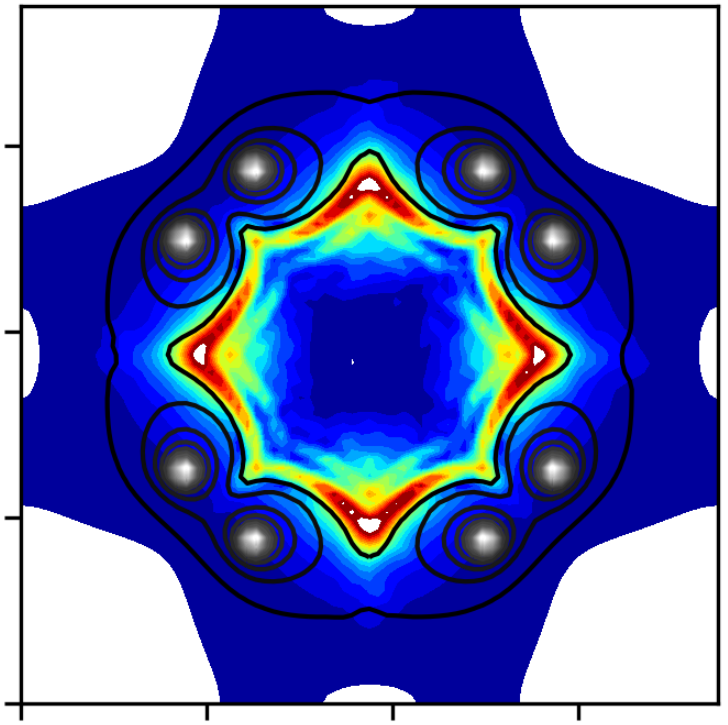
Polywell Fusion
Ready for Commercialization





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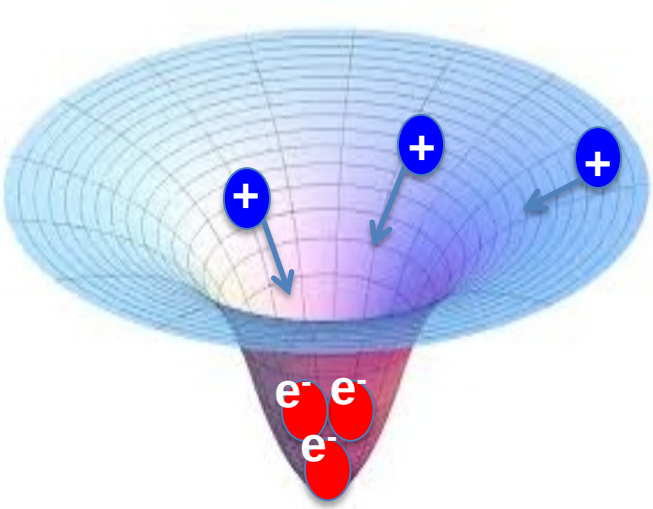
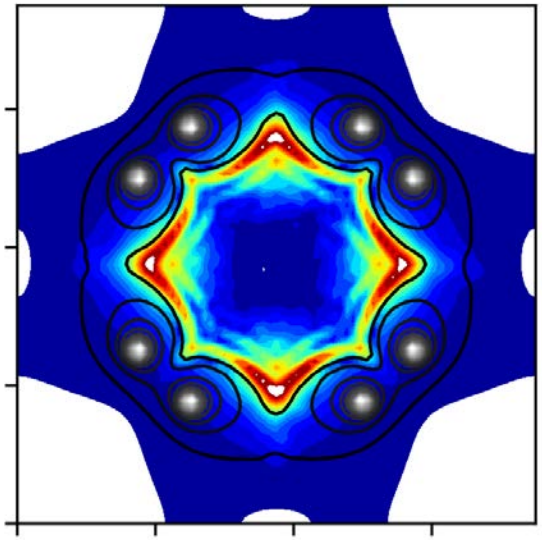
Energy Matter Conversion Corporation (EMC2)
Prepared for arpa-e ALPHA Annual Meeting
August 2017

Polywell Fusion Principle





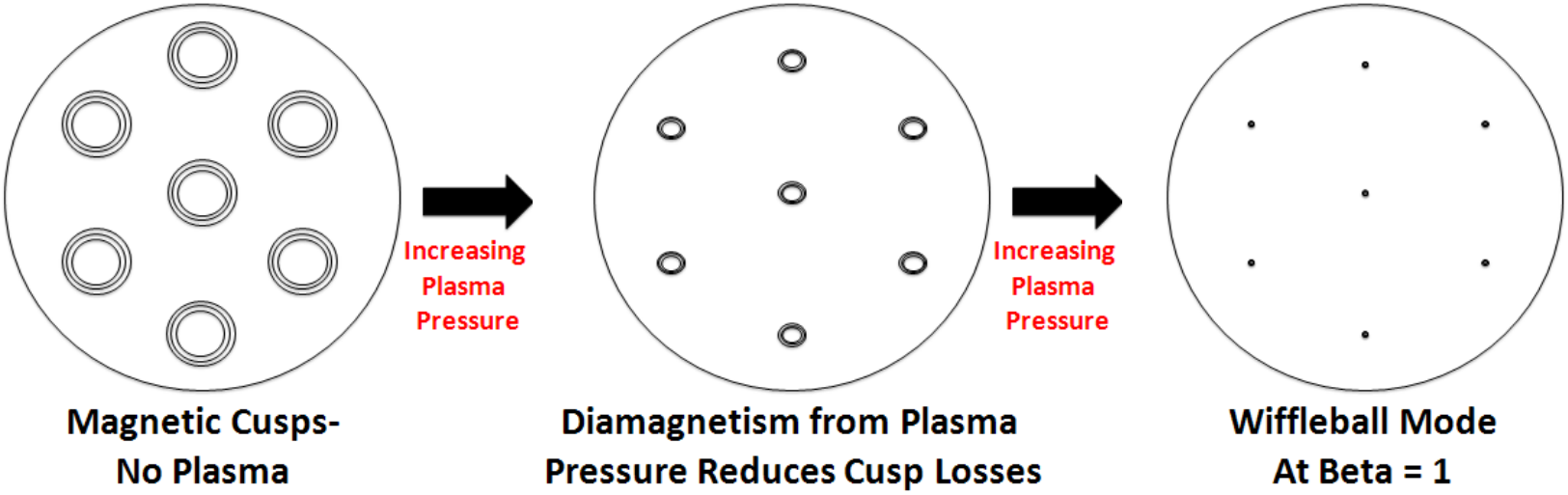
Fuel heating by electric field using electron beams
- Laboratory demonstrated in 1995

Fuel confinement by magnetic traps (Wiffle-Ball, red areas indicate magnetic walls of WB)
- Laboratory demonstrated in 2013
- Computer simulated in 2017

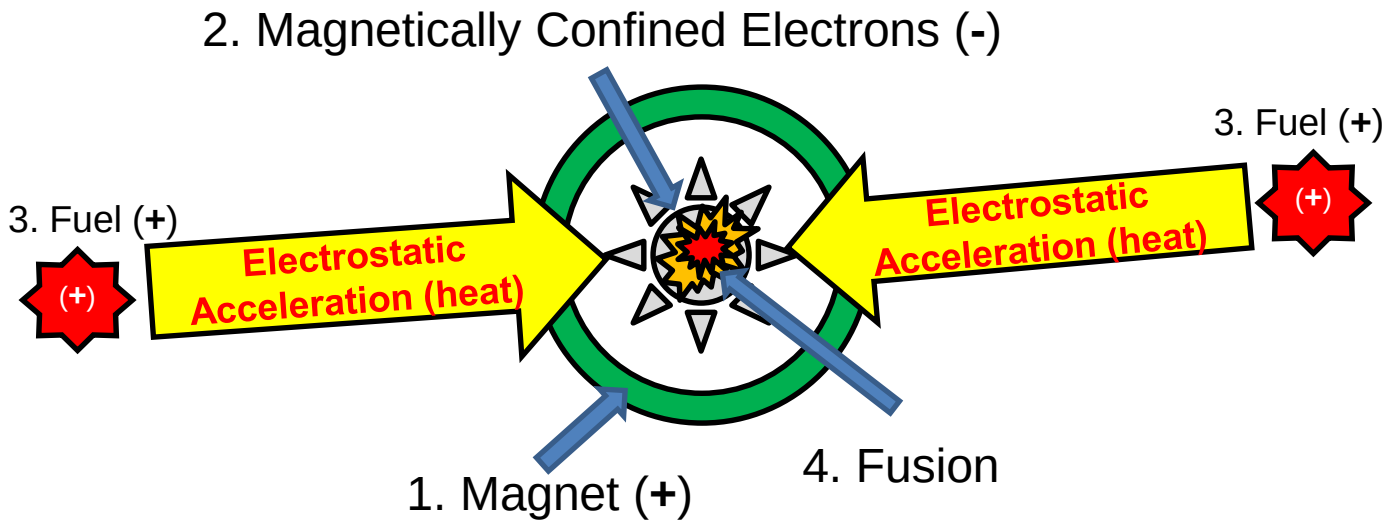
Combination of electrical heating & magnetic confinement → Key to fusion power

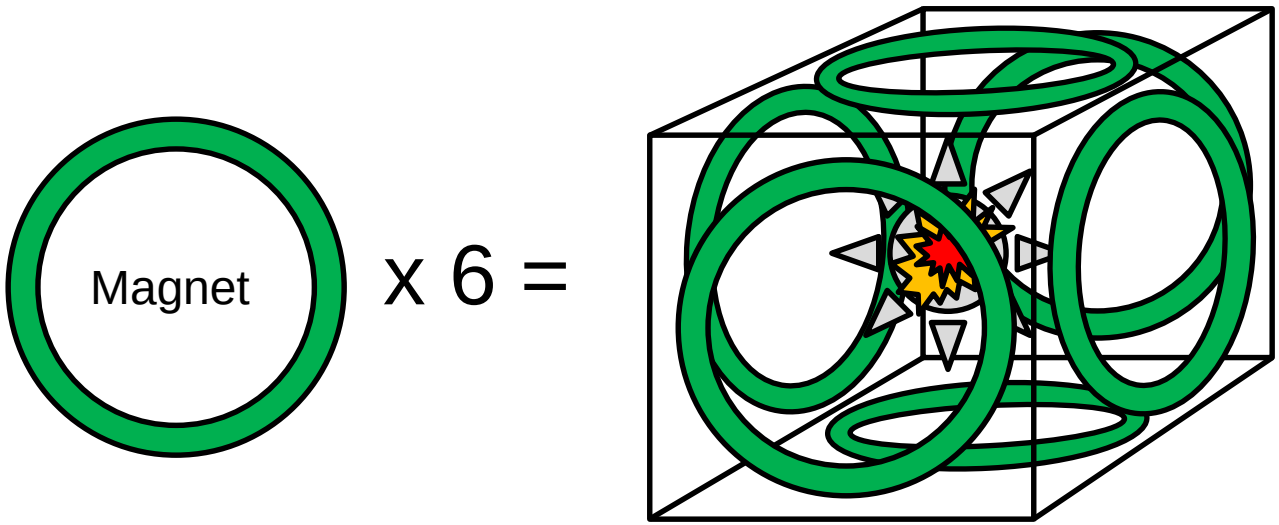
WiffleBall: Dr. Bussard's prediction

"The enormous flux of electrons at the center exhibits "diamagnetic" properties. This pushes back the magnetic field and constricts the cusp holes (leading to greatly enhanced plasma confinement)."



Polywell Fusion Device





Company Overview

1985: Energy Matter Conversion Corporation (EMC2) founded by the late Dr. Robert Bussard, a highly regarded nuclear engineer, to develop a revolutionary fusion power technology (Polywell) to harness fusion energy.

Polywell technology is based on fusion fuel heating with electron beams combined with a proprietary magnetic confinement of plasma called the "Wiffle-Ball". EMC2 offers clean, sustainable fusion power in a small reactor at a low cost.

1992 – 1995: First Polywell device was built with DARPA funding. Successfully demonstrated fuel heating using electron beams.

1995 -2013: EMC2 continued R&D efforts utilizing a series of 19 test Polywell devices to demonstrate and examine Wiffle-Ball (WB) plasma confinement backed by the US Navy.

2013: Successful formation of WB and demonstration of enhanced confinement.

2014-2017: EMC2 filed two patents, published a peer-reviewed paper, and provided public disclosures of the Polywell technology.

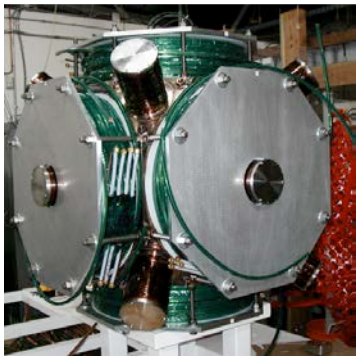
2017: EMC2 developed a first-principle based computer code to validate and optimize the Polywell technology.

EMC2 plans to commercialize Polywell fusion technology in the next 3 years and demonstrate fusion power within the next 10 years.

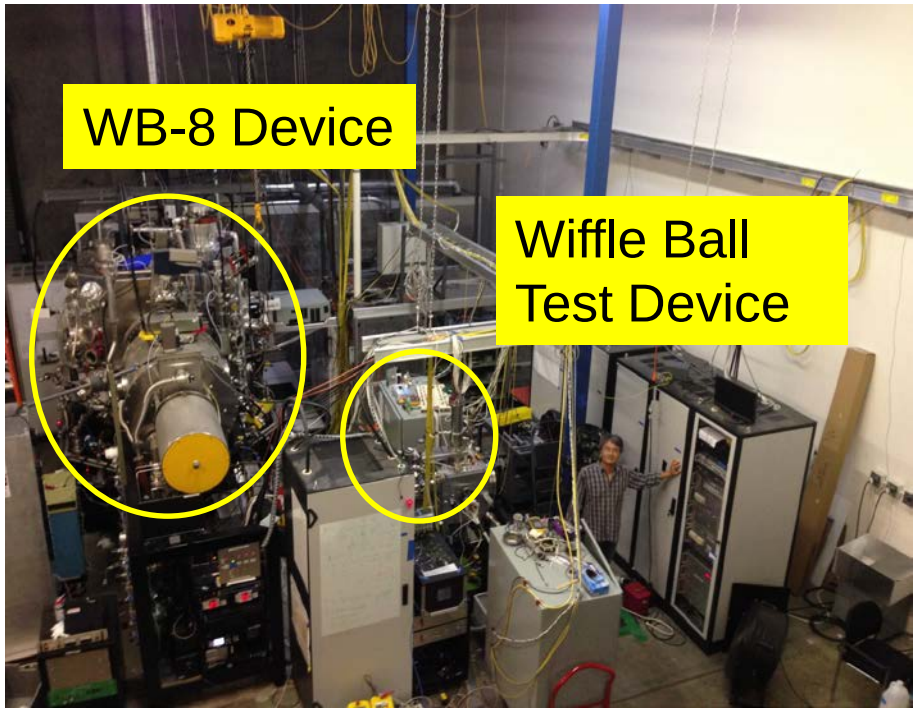
Navy Supported EMC2 Efforts in Magnetic Confinement (WB)

WB-6 WB-4

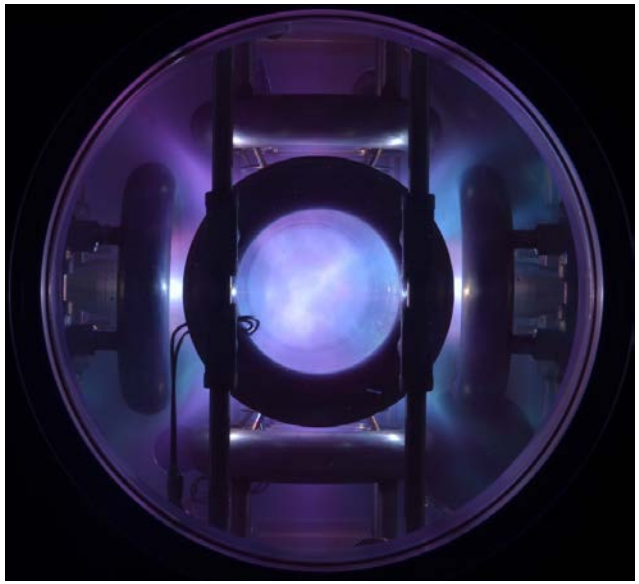
WB-5 WB-7



Since 1996, EMC2 has built and operated 19 test devices exploring magnetic confinement or Wiffle-Ball (WB) in the Polywell configuration, leading to a breakthrough in WB demonstration in 2013



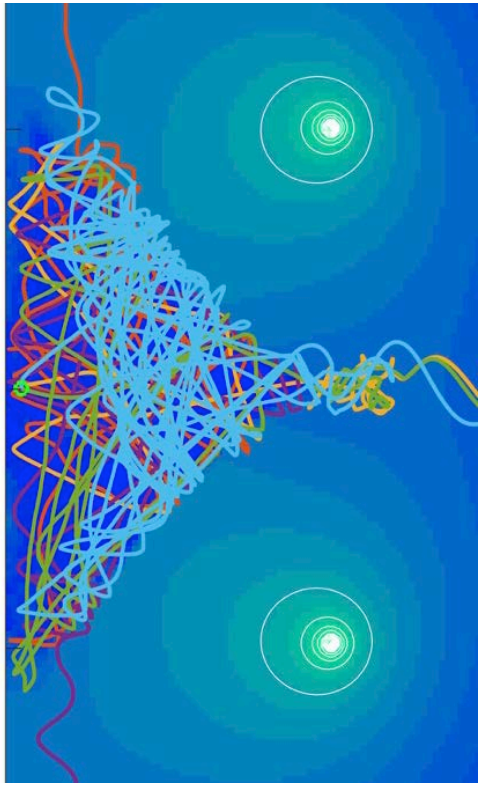
A Breakthrough: Wiffle-Ball



Wiffle Ball Test Device (2013)

"High-Energy Electron Confinement in a Magnetic Cusp Configuration". J.Park, et al, **Phys. Rev. X 5, 021024**. Published 11 June 2015

Navy Sanctioned Expert Review: "**EMC2 has made a major breakthrough.** It has clearly and repeatedly demonstrated so-called Wiffleball plasma formation with dramatically enhanced plasma confinement, **a major achievement and a prerequisite to concept success**."



Successful simulation of WB confinement by the reflecting magnetic wall – **first-principle plasma simulation using 1000 – 4000 core super computer (2017)**

Computer Animation of Wiffle-Ball Formation

- Left panel: magnetic field lines illustrating formation of magnetic trap

- Right panel: plasma pressure illustrating a role of plasma pressure in WB formation

Note the dramatic drop in magnetic filed leakage on the left panel (note: electron motion is tied to magnetic field), as the plasma builds pressure in the right panel, resulting in a magnetic trap (i.e. WB) from the self-generated plasma currents.

“The holes are closed”

Commercialization Strategy of Polywell Technology

Phase 1

WB Simulations for performance optimization (6-12 Months)

If confinement time increases with B^2 (Efficient use of Magnetic Field)

Success

Phase 2

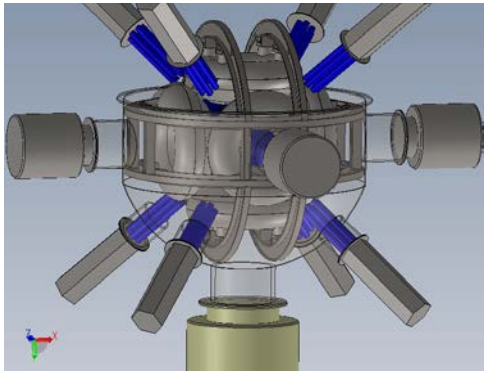
Development of Commercial prototype (2-3 years)

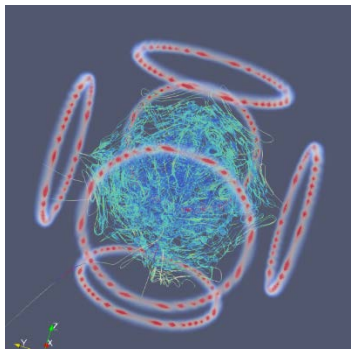
If fusion yield is 1-10x10^{12} fusions/s (Efficient use of Beam Injection)

Success

Goal: Technology licensing revenue in 3 years (neutrons, medical isotope, etc.)

Path to Polywell Fusion Power





1 s

(Confinement time)

10^{-5} s

Net power Polywell 10 years

Today

Final Proof-of Principle device

2 kG
10 cm
7 keV

(Magnetic field)
(Reactor size)
(Electron Heating)

5 T
2 meter
80 keV

Summary

- After 30 years of R&D, EMC2 is ready to commercialize the Wiffle-Ball technology.
- Final Proof-of-Principle will allow harnessing clean, sustainable fusion power based on Polywell technology.
- Polywell fusion applications include neutron radiography and radiation therapy, medical isotope production, and sustainable electricity generation.