# A perspective from the “Google group”


Matt Trevithick


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23rd International Conference on Condensed Matter Nuclear Science


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What would happen if well-qualified, open-minded, academic scientists were given the opportunity to investigate cold fusion?

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Volume 570 Issue 7759, 6 June 2019
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Author's link: https://rdcu.be/bEAsT

PERSPECTIVE

https://doi.org/10.1038/s41586-019-1256-6

# Revisiting the cold case of cold fusion

Curtis P. Berlinguette[1,2,3,4]*, Yet-Ming Chiang[5], Jeremy N. Munday[6,7], Thomas Schenkel[8], David K. Fork[9], Ross Koningstein[9] & Matthew D. Trevithick[9]*

**The 1989 claim of 'cold fusion' was publicly heralded as the future of clean energy generation. However, subsequent failures to reproduce the effect heightened scepticism of this claim in the academic community, and effectively led to the disqualification of the subject from further study. Motivated by the possibility that such judgement might have been premature, we embarked on a multi-institution programme to re-evaluate cold fusion to a high standard of scientific rigour. Here we describe our efforts, which have yet to yield any evidence of such an effect. Nonetheless, a by-product of our investigations has been to provide new insights into highly hydrided metals and low-energy nuclear reactions, and we contend that there remains much interesting science to be done in this underexplored parameter space.**

nature SUPPLEMENTARY INFORMATION
https://doi.org/10.1038/s41586-019-1256-6

# Co-signatories to the Nature Perspective (information as of 27 May 2019)

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Mr. Ben P. MacLeod, Ph.D. Candidate
Dr. Brian Lam, Postdoctoral Fellow
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Dr. Arun Persaud, Staff Scientist

**Google:** Dr. Craig H. Barratt, Former SVP; Mr. John Giannandrea, Former SVP; Dr. Seid Sadat, Former Contractor


June 2017
MIT
MCMXVI
MASSACHVSETTS INSTITVTE OF TECHNOLOGY
Photo credit: Miki Chiang

# Project Charleston

## A sponsored research program to reevaluate cold fusion

IEEE SPECTRUM

18 Nov 2014 | 20:00 GMT

# What It Would Really Take to Reverse Climate Change

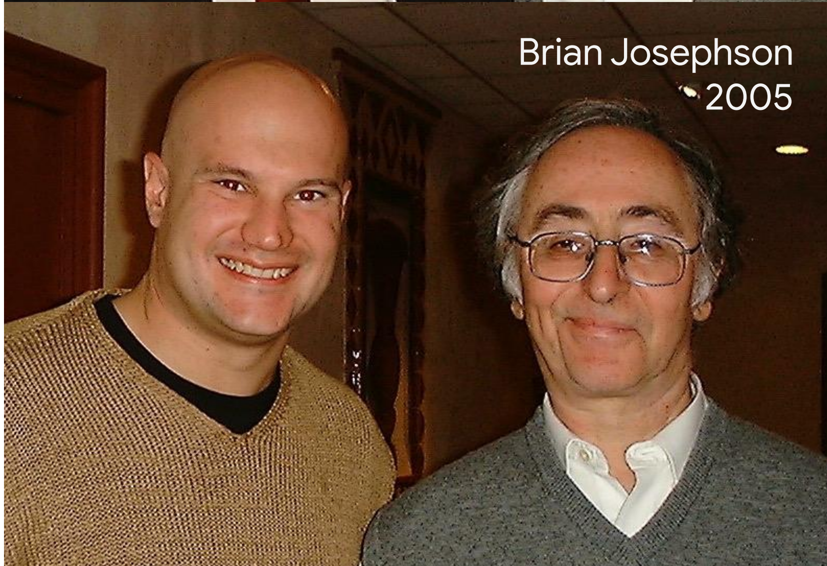
## Today's renewable energy technologies won't save us. So what will?

By **Ross Koningstein and David Fork**

*"Incremental improvements to existing technologies aren't enough; we need something truly disruptive to reverse climate change."*

# This is my ninth ICCF

| | | |
|---|---|---|
| **2003** | **ICCF-10** | Cambridge, MA, USA |
| **2005** | **ICCF-11** | Marseille, France |
| **2008** | **ICCF-14** | Washington, DC, USA |
| **2013** | **ICCF-18** | Columbia, MO, USA |
| **2015** | **ICCF-19** | Padua, Italy |
| **2017** | **ICCF-20** | Sendai, Japan |
| **2018** | **ICCF-21** | Fort Collins, CO, USA |
| **2019** | **ICCF-22** | Assisi, Italy |
| **2021** | **ICCF-23** | Xiamen, China |

# Ross, Dave, and I joined forces in 2015 at Google

| | |
|---|---|
| Motivation | The unsettled status of "cold fusion" is unconscionable. Credible, current research would help inform this debate. |
| Goal | Find a reference experiment that can be studied, understood, and improved upon. |
| Recruit new scientists with... | • Expertise in disciplines relevant to cold fusion<br>• No prior position on cold fusion (for or against)<br>• Willingness to collaborate as a "Peer Group" and with Google<br>• **Commitment to publish what is learned** |

# Some statistics about our program

## 16 collaborations*

- 8 new academic groups
- 8 experienced LENR researchers/groups
- 6 more collaboration attempts were unsuccessful
- 12 calorimeter designs were qualified
- No lab work was conducted at Google

## $10 million invested in external sponsored research

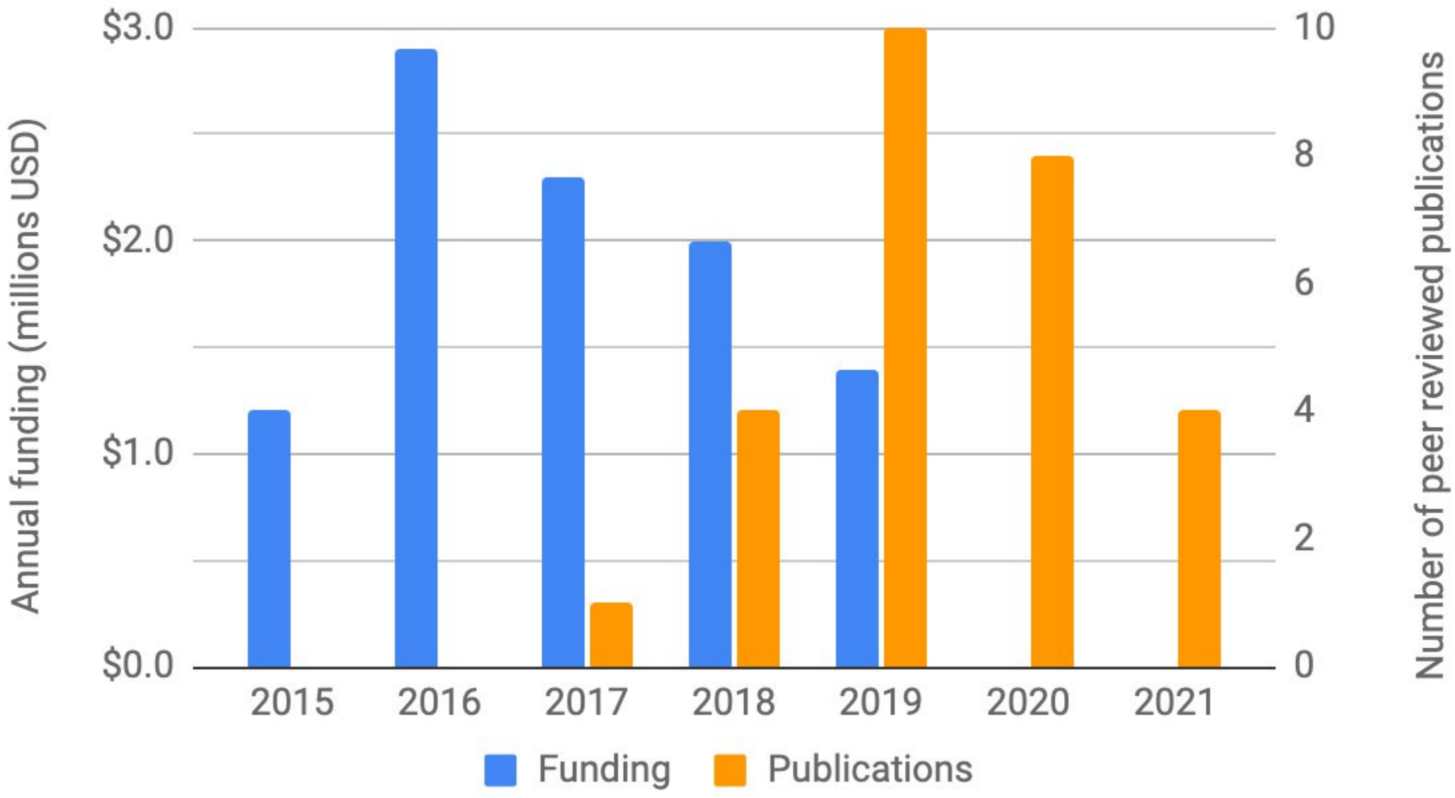
- Collaborations varied in duration and funding amount

## 27 peer-reviewed articles published to date

- Including 6 Nature-family papers and 2 granted US patents
- Complete list here: [https://groups.chem.ubc.ca/cberling/charleston/](https://groups.chem.ubc.ca/cberling/charleston/)

* To ensure the privacy of all participants, our collaborations were under NDA. Full details can not be disclosed.

# Funding (input) and publications (output) over time



# Nature Perspective

Revisiting the cold case of cold fusion (May 2019)

# Our Principal Investigators and co-authors

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**Yet-Ming Chiang**
Materials Science

MIT · 24M · A123 SYSTEMS

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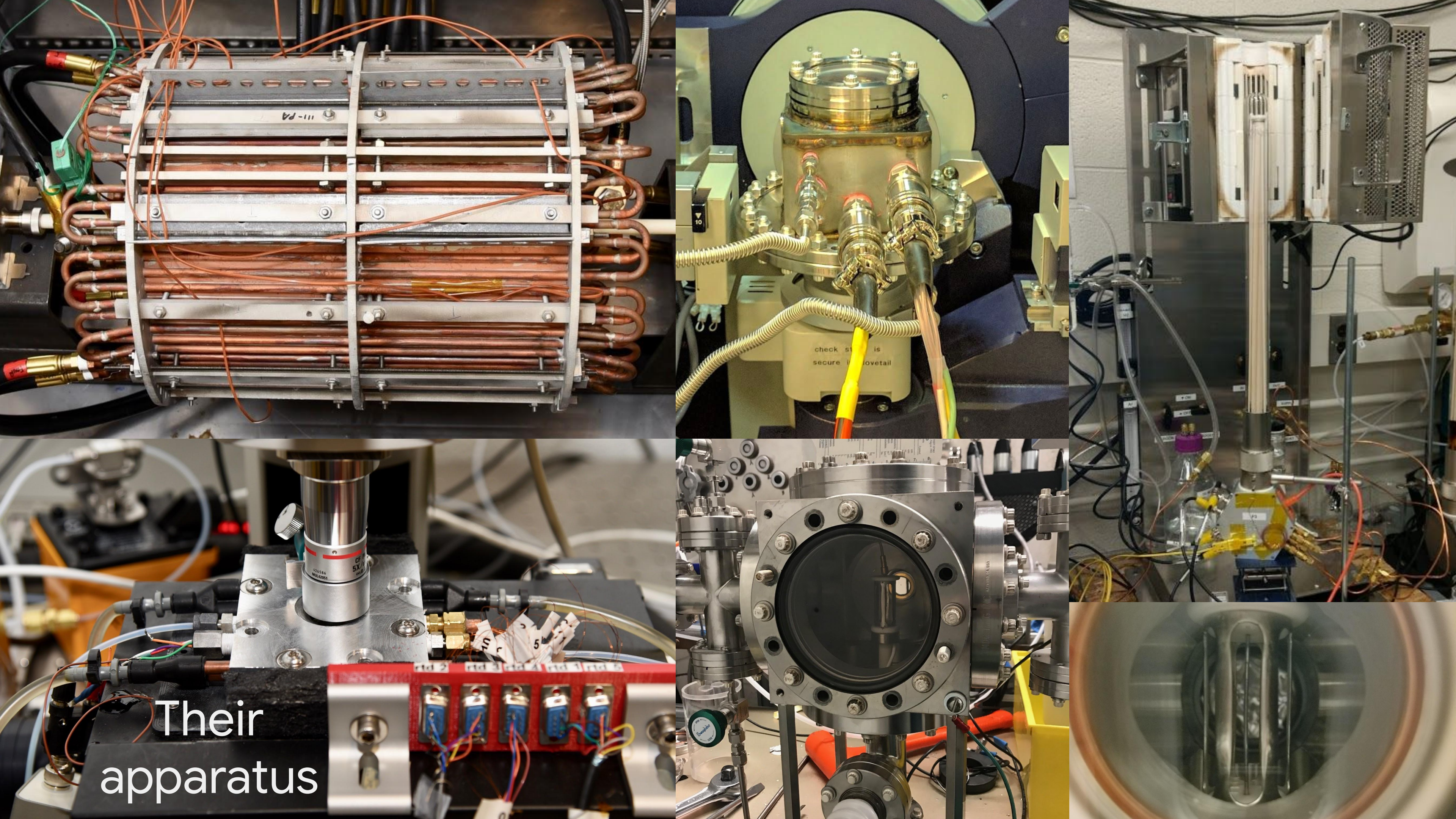
**Thomas Schenkel**
Physics

BERKELEY LAB · Lawrence Livermore National Laboratory · GOETHE UNIVERSITÄT FRANKFURT AM MAIN




Their apparatus

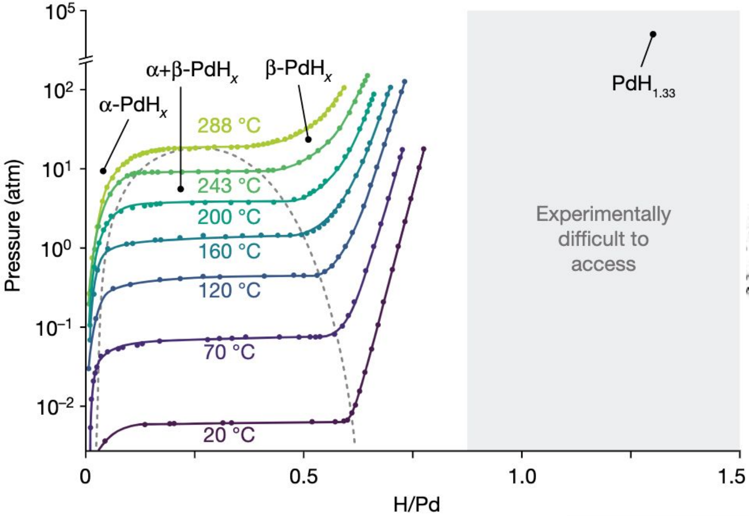
# 1. Highly hydrided metals

**Claim:** Cathode loading of PdHx where x ≥ 0.875 is required to produce excess heat.

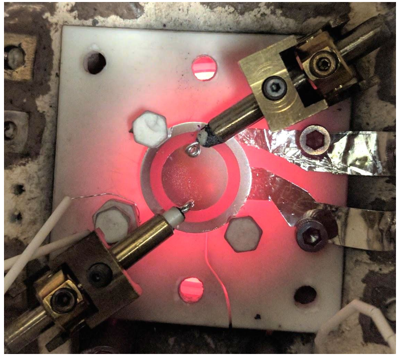
**Our experience:** Highly hydrided materials are difficult to produce. The dynamic equilibrium of hydrogen ingress and egress produces loadings far short of the thermodynamic limit. We achieved x = 0.96 ± 0.02 once.

Hydrogen loading is difficult to measure.
We found in situ XRD and stripping coulometry to be the most accurate methods.

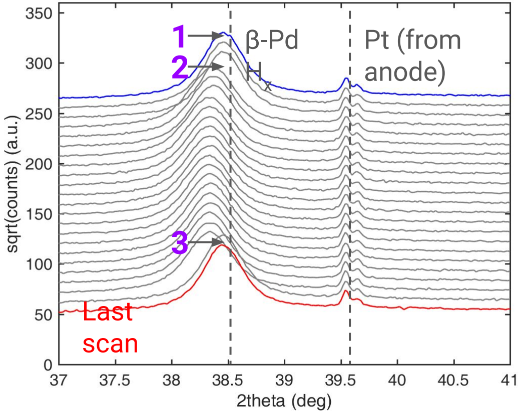
**Conclusion:** *"...more work is required to produce stable samples of PdHx where x ≥ 0.875 to comprehensively evaluate these claims."*




We have a leaky bucket



In situ X-Ray diffraction




Source: Nature Perspective

# 2. Calorimetry under extreme conditions

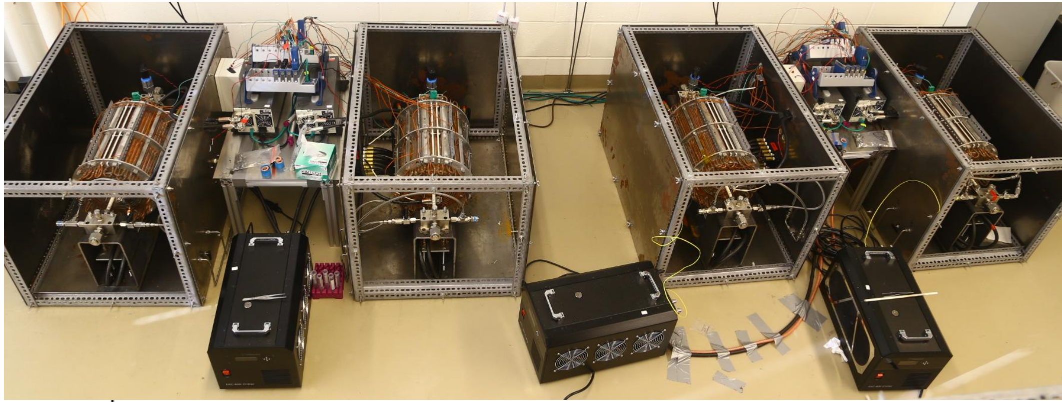
**Claim:** Certain metallic powders, such as nickel and lithium aluminium hydride, produce excess heat when heated in hydrogen gas.

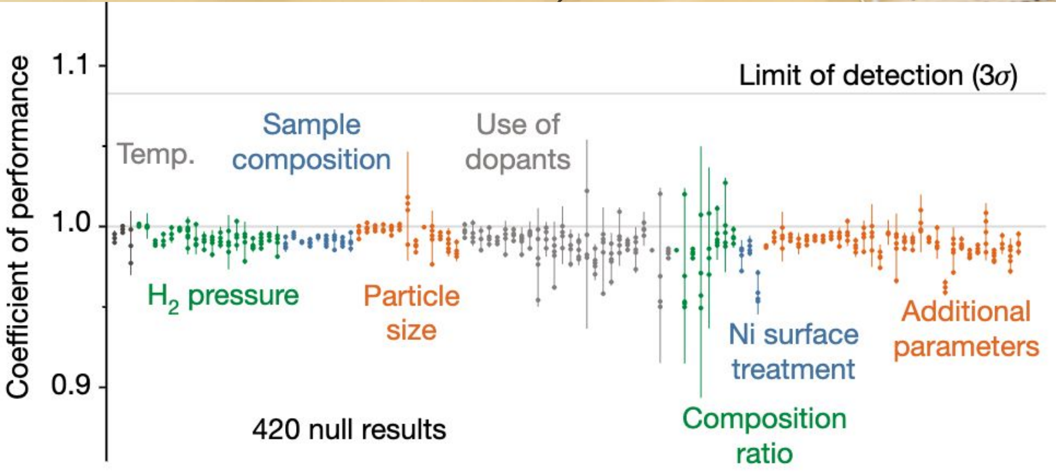
**Our experience:** We designed a calorimeter capable of operating at 1,200 °C and 33 atm with less than 2% measurement uncertainty.

To detect ≥ 10% excess heat events with 98% confidence, each experiment was run 4 times in parallel in identical calorimeters.

For 16 months, we evaluated the effects of temperature, pressure, sample composition, particle size, and surface treatment.

**Conclusion:** *"...none of the 420 samples we evaluated provided evidence of excess heat."*






Source: Nature Perspective

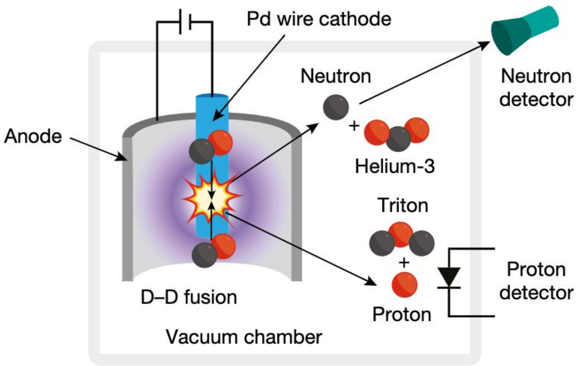
# 3. Low-energy nuclear reactions

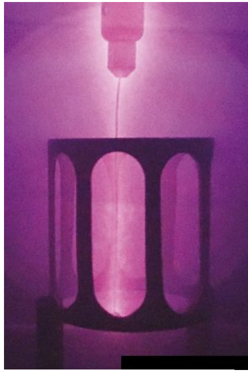
**Claim:** Nuclear by-products, such as tritium, can be generated in low energy pulsed plasma experiments.

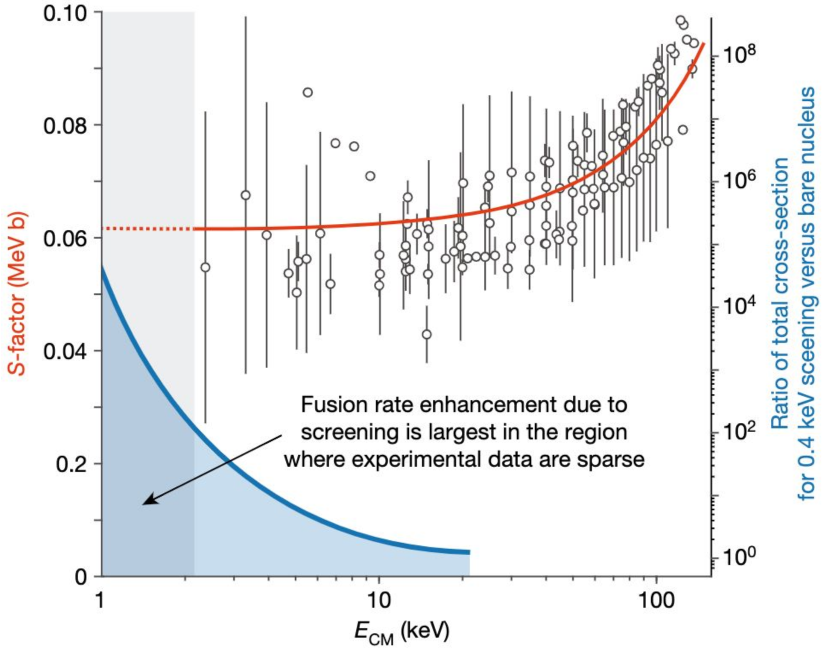
**Our experience:** We used pulsed plasmas (20 µs, 50 Hz, 1-5 keV, 1 A peak) in deuterium gas environments to drive deuterions into palladium wire targets. After prolonged irradiation (hours to weeks), ex situ measurements of the targets indicated no enhanced tritium production.

More work is required to rigorously evaluate mechanisms to enhance fusion rates < 2 keV, such as electronic screening.

**Conclusion:** *“We are enthused by the possibility of obtaining reaction cross-section and S-factor data in the grey shaded region [of the figure on the right]...”*






Source: Nature Perspective

# Key takeaways

## Did we find a reference experiment? **No.**

*“So far, we have found no evidence of anomalous effects claimed by proponents of cold fusion that cannot otherwise be explained prosaically”*, but *“**the search for a reference experiment for cold fusion remains a worthy pursuit**”*.*

## Is cold fusion research compatible with mainstream academic practice? **Yes.**

Incentives and interests of researchers and sponsors can (and must) be aligned. Committing to publish in high impact, peer reviewed journals helps achieve that.

* Quotations from our Nature Perspective.

# What has happened since May 2019?

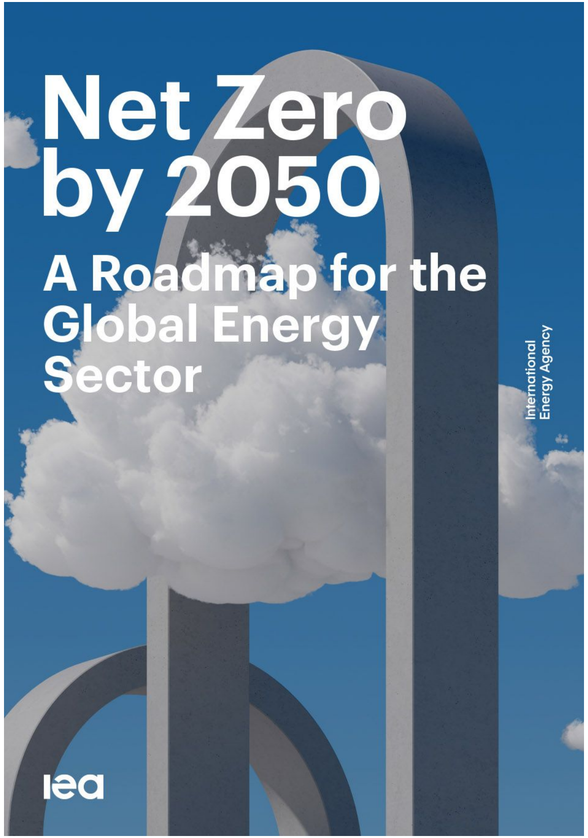
# We were hit with a global pandemic

# The cost of transitioning to a low carbon economy is sinking in

Clean energy investment worldwide must increase to **$4 trillion annually** to reach net-zero emissions by 2050 and limit temperature rise to 1.5°C by 2100.

Faced with the prospect of having to invest **$100 trillion by 2050** to transform the global energy system, influential people are interested to learn about all available options.

**Interest in fusion energy has increased notably** since December 2020.




www.iea.org/reports/net-zero-by-2050

# Our Nature Perspective is having its intended impact

## 20k article accesses

This article is in the $99^{th}$ percentile (ranked $1{,}186^{th}$) of the 275,787 tracked articles of a similar age in all journals and the $84^{th}$ percentile (ranked $145^{th}$) of the 944 tracked articles of a similar age in *Nature**

> *… the main motivation for this work is based on the recent Nature perspective "Revisiting the cold case of cold fusion".*
>
> – EU Horizon 2020 HERMES project description, Breakthrough zero-emissions heat generation with hydrogen-metal systems (November 2020)

> *"We got our impetus from the Google paper appearing in Nature," says Carl Gotzmer, Indian Head's Chief Scientist.*
>
> – IEEE Spectrum, Whether Cold Fusion or Low-Energy Nuclear Reactions, U.S. Navy Researchers Reopen Case (March 2021)

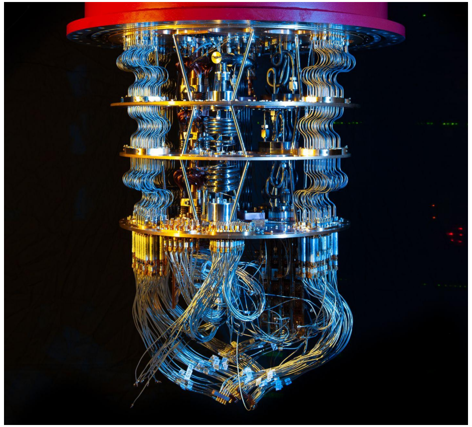
* https://www.nature.com/articles/s41586-019-1256-6/metrics

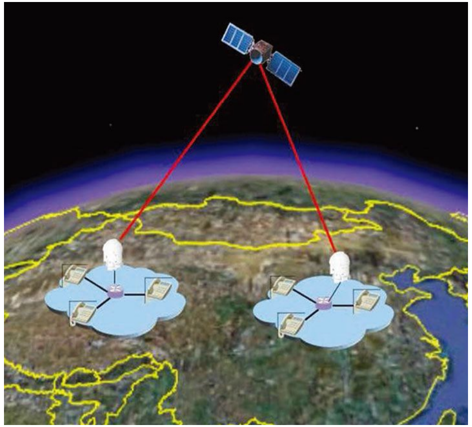
# Collective quantum effects are enabling new technologies

*"Quantum 2.0 refers to the development and use of many-body quantum super-position, entanglement, and measurement to advance science and technology."**

Examples include:

- Quantum computing
- Quantum communications
- Quantum sensing
- **Quantum energetics**





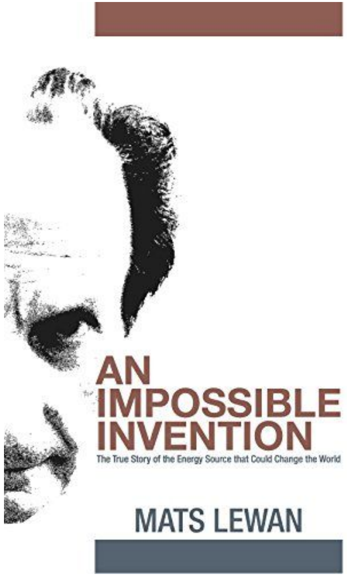
LENR research might get a boost from these emerging capabilities.

* OSA Quantum 2.0 Conference website

# Given what we now know (collectively), what should we do next?

These forward looking statements are the personal opinions of the speaker.
They are not to be construed as the official position of Google.

# There were reasons to be optimistic in 2015




Andrea Rossi (E-cat)


Tom Darden (Industrial Heat)

Bill Gates (Texas Tech University)

- NEDO nano-metal hydrogen energy (MHE) project (Japan)
- Sidney Kimmel Institute for Nuclear Renaissance (USA)
- Current Science: Special Section: Low Energy Nuclear Reactions (India)

Image/photo credits: Amazon.com, Cold Fusion News, New Energy Times

# So what happened?

There is a heated debate in the LENR community about the degree to which anomalous effects are already “proven”.

However, truly independent replications are lacking.

Our experience is that **the LENR community** either **can not teach** or **will not teach**.

**Failure to share the best** of what is known has impeded scientific progress.

> *“Collectively we have the answer, individually none of us does!”*
> - Michael McKubre, ICCF-20, Sendai, Japan (2017)

# Two constituencies. Two messages.

## There is a place in history for the person or group who successfully enables truly independent replication of their claimed anomalous effect.

For the good of the planet and the health of this field, let's aspire to have **one set of claims independently verified and published in a peer reviewed journal by ICCF-24**.

## Let's recruit 100 new scientists to this field. We will learn from them.

As the abstract of our Nature Perspective concludes, "...***we contend that there remains much interesting science to be done in this underexplored parameter space.***"

## Let's go exploring!

# A perspective from the "Google group"


## Matt Trevithick


June 9, 2021 **ICCF-23**

23rd International Conference on Condensed Matter Nuclear Science

# Project Charleston publication list

In chronological order as of June 9, 2021

1. MacLeod, B. P. *et al.* High-temperature high-pressure calorimeter for studying gram-scale heterogeneous chemical reactions. *Rev. Sci. Instrum.* **88**, 084101 (2017).
2. Sherbo, R. S. *et al.* Accurate coulometric quantification of hydrogen absorption in palladium nanoparticles and thin films. *Chem. Mater.* **30**c 3963–3970 (2018).
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8. Fork, D. K., Munday, J. N., Narayan, T. & Murray, J. B. Target structure for enhanced electron screening. *US Patent 10264661B2* (2019).
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14. Johnson, N. J. J., Lam, B., Sherbo, R. S., Fork, D. K. & Berlinguette, C. P. Ligands affect hydrogen absorption and desorption by palladium nanoparticles. *Chem. Mater.* **31**, 8679–8684 (2019).

15. Schenkel, T. *et al.* Investigation of light ion fusion reactions with plasma discharges. *J. Appl. Phys.* **126**, 203302 (2019).

16. Fork, D. K., Munday, J. N., Narayan, T. & Murray, J. B. Enhanced electron screening through plasmon oscillations. *US Patent 10566094B2* (2020).

17. Jansonius, R. P. *et al.* Strain influences the hydrogen evolution activity and absorption capacity of palladium. *Angew. Chem. Int. Ed Engl.* **59**, 12192–12198 (2020).

18. Jansonius, R. P. *et al.* Hydrogenation without $H_2$ using a palladium membrane flow cell. *Cell Rep. Phys. Sci.* **1**, 100105 (2020).

19. Kurimoto, A., Sherbo, R. S., Cao, Y., Loo, N. W. X. & Berlinguette, C. P. Electrolytic deuteration of unsaturated bonds without using $D_2$. *Nat. Catal.* **3**, 719–726 (2020).

20. Berlinguette, C. P. From cold fusion to pharmaceuticals. *Nature Chemistry, 'Behind the Paper'* (2020).

21. Gong, T. *et al.* Emergent opportunities with metallic alloys: From material design to optical devices. *Adv. Opt. Mater.* **8**, 2001082 (2020).

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25. Young, D., Jackson, A., Fork, D., Sadat, S., Rettenwander, D., Benck, J. D., Chiang, Y.-M., An operando calorimeter for high temperature electrochemical cells. *J. Phys.: Energy*, **3**[3] (2021).

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