LPPFusion Report
March 13, 2020

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Wefunder Campaign Ends—Over $600,000 Raised

Thanks to all of you for a second successful Wefunder campaign. **We raised $605,000** from 292 investors living in 22 countries. All 133 slots for new non-accredited investors were filled. For accredited investors, we will be continuing fundraising directly through our website. During the campaign, which began Nov.15, 2019 and ended March 1, 2020, we also raised $80,000 through our Reg D. offering. **We are still aiming to raise an additional $400,000 in the next two months** to fully fund our goals for 2020 and early 2021. Investments can still be made by accredited investors directly to LPPFusion, following instructions on our website.

During the campaign, the LPPFusion staff, coordinated by Director of Communications Ivy Karamitsos, posted dozens of updates, on the Wefunder website. Many will be of interest to the readers of this report. We especially call attention to our updates on the fusion transformation, the dangerous growth of charcoal use, and our "discovery" of an old video of FF-1's very first shots.

COVID-19 and Fusion

Like the rest of the world, we are focused right now on the spread of the coronavirus COVID-19. Rightly so, because this pandemic could kill millions. We at LPPFusion are taking what precautions we can. We will not participate in conferences, most of which are being cancelled in any case. We are disinfecting and practicing social distancing.

At first glance, this viral threat does not seem to have much to do with the long-term energy crisis the world faces, but in fact there are several important connections. First, the short-term threat of COVID-19 and the long-term threat of fossil fuels **both endanger the lives and health of millions of people worldwide**. While a pandemic like that in 1918 could kill millions, we know that air pollution due to fossil fuel consumption **will** kill over 7 million people in this year alone.

Second, the fossil fuel crisis actually makes COVID-19 worse. Medical studies have shown that high levels of air pollution, almost entirely due to fossil fuel combustion, weaken the lungs of both older and very young people, making them more vulnerable to pneumonia. This may be part of the reason that COVID-19 mortality rates are higher in the heavily industrialized—and heavily polluted—city of Wuhan, where the virus originated, than elsewhere.

In addition, the economic costs of high-priced fossil fuels divert trillions of dollars annually from the health expenditures needed to maintain the population and to prepare for epidemics. WHO has expressed deep concern for the spread of COVID-19 in Africa, where medical facilities are totally inadequate. Africa right now spends more on oil consumption alone than on health care. In the United States, despite high expenditures on health care, hospital beds per capita have been cut in half over the past four decades.

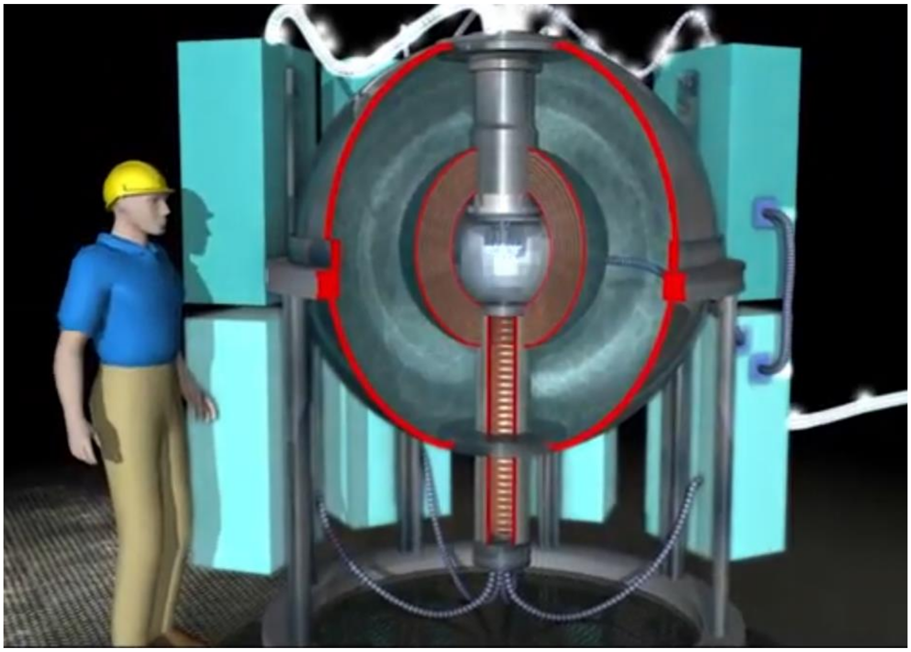
Last, and most important, **both threats require crash research and production programs**, coordinated by the world's major governments, which are not yet taking place. Leading health organizations like the WHO and CDC have warned that quarantines are unlikely to stop a disease as infectious as COVID-19. While the low infection rates in warm climates like Singapore give some hope that the disease may slow dramatically as spring arrives, it is also likely to roar back in the fall. The best way to stop such a virus is with a vaccine. But no government has yet initiated the sort of large-scale crash program that could develop a vaccine in time to help this year.

Worse, no government has tried to prepare for such an outbreak by building up the emergency capacity to both develop and mass-produce a vaccine in the case of a deadly outbreak. Nor have most governments, emphatically including that of the US, where our lab is located, built up **significant reserves of medical equipment.** It is not as if COVID-19 came out of the blue. This is the third coronavirus, along with SARS and MERS, to threaten a pandemic, and scientists have known of the threat for decades. But the crash program of research and production needed to develop an emergency response never occurred. **Such a program is urgently needed right now.**

To give a concrete example, for the 10% of coronavirus patients who get critically ill, ventilators to assist their breathing are the only way to preserve life. In the United States, health experts estimate that the need for ventilators may run into the millions at the height of the pandemic. But only 70,000 of these complex machines are available in the entire US. A crash production program, coordinated by the Federal government, might just possibly be able to produce machines that could save millions of lives. But nothing of the sort is being done. Indeed, where we are located there are no plans at the national, state, county or local level for what happens when the ventilators and intensive care units are all fully occupied. Unfortunately, the US government has not even been able to organize the sort of mass testing that has slowed the virus in South Korea. **There is not even discussion of the national mobilization required.**

A crash program for fusion research is also exactly what is needed to end the crisis of fossil fuel production as rapidly as possible. Only fusion energy can provide the cheap, clean, safe and inexhaustible energy needed to replace fossil fuels entirely. That would clean up the air and free up trillions of dollars for health care, and emergency reserves, among other critical needs. LPPFusion has long advocated an international government crash program to fund research for all possible routes to fusion.

Our Plan to Get to Net…Energy



During the Wefunder campaign, people have asked us: how can we expect to go rapidly from where we are to net energy—when we get more energy out of the device than we put in? We gave them an explanation. Since many people have told us how useful this information is, we are featuring it in this report. The information will remain available on our website.

Phase 1: Research to Achieve Net Energy Production in a Laboratory Device

Right now, our task in 2020 is to move our fusion yield up from the one quarter of a joule (J) we have achieved to the 30,000 J we need to get more energy out of the device than we put into it. This sounds like a huge jump. But it is feasible. Let's do the numbers!

First, we are talking about a very small amount of energy in total. Our goal of 30 kJ (30,000 J) per shot is less than the energy you get from eating 3 pistachios.

Second, **we are a lot closer than any other private fusion effort.** TAE, our closest rival, has to increase their yield a thousand times more than we do.

Third, our process gives us a lot of leverage to convert small gains in compression to large gains in yield. Our device produces a tiny ball of ultra-hot plasma called a "plasmoid". We have already gotten this plasmoid to the more than 2 BILLION degrees temperature we need. But we have to make it denser. Fortunately for every factor of two we improve the compression, and thus decrease the plasmoid radius, we get a factor of four increase in density. For every factor of four increase in density, we get a factor of 16 increase in fusion yield. In mathematical terms, **yield goes up as the compression ratio to the fourth power.**

To get better compression, we first have to achieve a high degree of symmetry, so that the filaments of current in our machine arrive together at the same point at the same time, so that they will twist up tightly into the plasmoid (see our video). The better the symmetry, the smaller the plasmoid, the more the density. We need to make sure the electrodes are clean of any metal specks and we have to get rid of any remaining oscillations in our current. We need to optimize the amount of gas, the mixture of gases and the magnetic field that gives our plasma an initial small twist. Each of these steps will only improve the compression by 15-20%, but together they will more than double the compression—shrinking the plasmoid by a factor of a bit more than 2, increasing yield by about a factor of 25 to 10 J. **These are the steps we are working on right now.**

Next, during the summer of this year, we intend to install **new switches** that are twice as small and twice as numerous as our present switches. This will allow us to initially increase the electric current in our device by about 40%. We get leverage with that as well, increasing yield by a factor of 4 to 40 J.

We will then turn on the **full power** of our capacitor bank, going up from eight capacitors to twelve and from 40 kV to 45 kV. That will increase our current and compression by more than 60% and our yield by 8 to about 300 J.

Then we will take the biggest step—**changing the fuel in our vacuum chamber from deuterium to our final fuel—pB11, hydrogen-boron.** We'll start mixing in a bit, but we hope by around the end of the year to be running with pure B11. Once we have optimized it, we expect to get a four-fold boost in yield because this fuel burns twice as fast as deuterium; a 3-fold boost in yield because each reaction produces three times more energy than deuterium. In addition, we'll get 40% better compression, giving another 4-fold boost in yield. Finally, our confinement time will increase 4-fold because much of the fusion energy we produce will be initially recycled back into the magnetic field that holds the plasmoid together. That gives us another 4-fold boost in yield. So, switching from deuterium to pB11 will altogether give us 2x3x4x4 or nearly 100 times the yield. This will therefore bring us all the way up to the 30 kJ we need.

To summarize:

- **A 3-fold increase in compression will give us a 75-fold increase in yield**
- **A 2-fold increase in current will give us a 16-fold increase in yield**
- **Switching to pB11 fuel will give us a 100-fold increase in yield**

¼ Jx75x16x100 = 30 kJ. This is how we can make a huge jump—in not too many steps.

Phase 2. Developing a Working Prototype Generator Ready for Manufacture

In Phase 2, we will develop the Focus Fusion device as a repetitively pulsed generator, pulsing up to a few hundred times a second, develop the conversion devices to convert the ion beams and X-rays to electricity, and perfect the cooling system and general electrical control system. We will also optimize the fusion energy generation efficiency. At the end of Phase 2, which we estimate will take another 3-4 years, we plan to have the world's first functioning fusion generator producing 5 MW of net electricity. It will be ready for mass production. We estimate the budget for this phase to be about $100 million, to be raised from a combination of government and private sources.

Phase 3: Commercialization

We believe that the fastest and lowest-risk method of generating income from the fusion generator is through selling non-exclusive licenses on the technology. We will be protecting its intellectual property rights with a series of patents. Likely initial licenses agreements will be with large international companies already in the power generation sector and with large governmental energy organizations. The up-front money from the sale of such licenses will generate a relatively large income stream initially that will be supplemented when royalties begin to flow after actual production is begun. We also intend to initiate our own production facilities in order to have the manufacturing expertise needed to aid licenses.

Our plan is that, early in Phase 3 when we have reached profitability, we will organize an IPO to become a public company.

FF-2B Recovers from Minor Accident

While we would love to cheer our readers with some exciting news form the lab, this past month we have been held up by a minor accident and our (mostly successful) efforts to recover from it. On Jan. 20, at 4:00 AM, on a holiday, our lab suffered a brief power outage. Although all our computers have back-up power, our vacuum pumps did not (our mistake, which is now remedied). When power came back on, the main scroll pump did not restart, needing a manual reset. Air started leaking slowly back through the stopped scroll pump into the vacuum chamber, even though some other valves were closed due to the power outage.

By the time we arrived at the lab the following morning, there was nearly one third of an atmosphere of pressure inside the chamber. While we pumped the gas out rapidly, the water vapor in the gas adsorbs (clings) onto the surface of all the metal parts. We needed to get rid of the water because water is mostly composed of oxygen. If we fired a shot with oxygen in the chamber, our beryllium electrodes would oxidize. That would be bad, as beryllium oxide is an electrical insulator. In the second shot, the oxide would be vaporized by the current, eroding our electrodes and creating lots of dust.

So, we started a bake-out, heating the chamber and the vacuum system up to 100 °C while maintaining a vacuum to pump out the water. Unfortunately, we then encountered more problems created by the initial accident. First, we found that after a few days, we could no longer reach our goal of several-microtorr pressures (around a ten millionth of an atmosphere). We suspected a leak in our turbo-pump, which pumps down to low pressures. Indeed, we found one, caused by the reverse flow of air during the accident. However, once the pump was repaired, the pressure still did not fall below a few millitorr.

After further tests and consultations with manufacturers of our equipment, we found that both our pressure gauges had failed and could not report pressures below a few millitorr. This had misled us, since the two gauges were agreeing with each other. But both had contamination from water vapor. We then repaired one of the gauges.

But with gauges and pumps working we discovered a small but significant leak in the flange which attached our new upper vacuum chamber to the anode plate on top of the device. Mechanical stress during the bake-out evidently caused the seal to fail. We now see that it needs re-design to be more robust. We’re doing that re-design now and hope to fix the leak and be back to firing by the end of March.

LPPFusion Briefs the Nuclear Industry Council's Summit

In our last conference and travel for a while, LPPFusion's President and Chief Scientist Eric J. Lerner traveled to Knoxville, TN on February 12 to help brief about 150 engineers and managers in the nuclear industry on the status of fusion energy research. His presentation was part of a panel at the United States Nuclear Industry Council's Advanced Reactor Summit. Other participants on the panel were Dr. Stephen Cowley, Director of the Princeton Plasma Physics Laboratory, (seated on the left in this photo, after the presentations), and Matt Miles, VP of General Fusion (seated center). Lerner contrasted the small size and rapid progress of our Focus Fusion approach, with the ITER experiment, which is so huge that, as Dr. Cowley pointed out, the price of concrete was a significant factor in the project's $25 billion cost. ITER will weigh 400,000 tons when completed. LPPFusion's FF-2B weighs just 3 tons and a generator based on our approach would weigh about the same.

New Podcast Series on Cosmic Connection

In LPPFusion's new video series, the [Real Crisis in Cosmology](), we're looking at the scientific evidence that shows that the Big Bang theory is not valid, that there is a different history of the universe than that described by the Big Bang. In this accompanying podcast, The Cosmic Connection, we're stepping back and asking—why does it matter? What difference does it make for life here on earth in the year 2020 whether the universe started 14 or 40 billion years ago or never had a beginning at all?

In the first episode, Eric Lerner introduces the podcast series and describes what will be discussed. What is the connection between the cosmos and us? A big part of the connection between cosmology and society is that, over the centuries, people have generally projected their ideas about society onto the structure and history of the cosmos—and conversely have used ideas about the cosmos to understand what is happening, or even what should happen in society.

There is also a real scientific connection. We ourselves are a product of cosmic evolution—our sun and earth emerged from this process and biological and social evolution are also part of the evolutionary processes occurring in the universe. Learning in an accurate way about cosmic evolution can help us understand the evolution of our own society in the here and now. We're not separate from the cosmos—we're part of it.

Since we are part of the universe, the physical processes we observe in the universe are the same ones that can occur here on earth on a much smaller scale. In the hugely important effort to harness fusion energy as the next source of energy for humanity, what we learn from cosmic phenomena are the key to success. Indeed, the very existence of fusion energy was first discovered in the search for the source of energy of the sun and other stars.

The Big Bang theory tells a story of a universe that was "wound up" at the beginning by a giant explosion and has been running down like an old watch since then, a universe whose future is preordained as one of expansion and cooling to nothingness, to a state of final equilibrium. But once we realize that the Big Bang story is simply not true and not supported by scientific evidence—which we detail in our video series—then we are looking at a very different story. We are instead looking at a universe that observations tell us is "running up", a universe characterized by accelerating evolution.

Listen to the podcast on Soundcloud or Youtube.