## The Pea Shooter

[Earth]

Ginny Okumbe was in grad school when she first had the idea about the Pea Shooter. In fairness, a lot of people had the idea, but her paper won the school’s [impact award], giving it sufficient publicity to have everyone associate it with her. The Feasibility Study of a Railgun Launch Facility happened at the right time, and the name stuck.

Nuclear fusion had become a reality a decade earlier, and fusion powerplants were popping up as fast as people could build them. The promise of truly clean energy with no radioactive waste was finally becoming reality. People were also starting to think again of larger projects – things that were previously too costly when electricity was scarce. Particle physics was experiencing a resurgence, with larger colliders and research facilities now within reach. People were talking about going beyond 10x with the next class of particle smashers, even up to 100x. The overall environment was one of optimism and ambition.

The physical world still held some surprises for us. Building a collider 100 times more powerful than anything previously accomplished was not a simple task. Power might scale up linearly, but the surprises from nature do not. 10x colliders came online first since they were simpler to construct and didn’t require as much land. The first of these was the Landen Beam Incidence and Collision Center, clearly having been named by Landen himself. Only a scientist would consider that a catchy name. Everyone just called it ‘the Landen’. Among its first outputs at these heretofore unseen energies was antimatter. Lots of it. Previous colliders also produced antimatter as a by-product of their primary research, but it was generally an afterthought and in such small quantities that nobody paid much attention to it.

No so at the Landen. Its main collision chamber was practically an antimatter generator, enough so that they had to add additional magnetic containment fields to hold it in. Antimatter, while an exotic type of particle, is not relegated to science fiction. It is very real, and when it re-combines with regular (so-called Baryonic) matter it annihilates itself, releasing a flash of energy. A big flash of energy, the kind that Einstein’s famous equation e=mc2 governs. When the particle in question is the size and energy of a single electron, this is nothing to worry about, the colliders were built with that in mind. However when it becomes a lot of them, or larger, more massive particles then the game changes.

The first such incident nearly shut down the Landen for good. The center is located in the heart of Kansas, equidistant from Kansas City and St Louis, and mostly underground. From above it still looks like endless corn fields everywhere except the entrance site. The rest of it is a ring of magnets and pipes about 50 miles around, with the occasional detection chamber [along the way]. After the accident of 22 January 2089 it became very visible. A quarter mile of smoking crater replaced Detection Chamber Beta.

Thankfully no one was hurt during the incident – the chambers are all fully evacuated during experiments – but it did serve as a very severe wake-up call, delivering a not-so-subtle message of ‘Things are Not the same as Before.’

People quickly realized that there is nowhere on Earth that is a good location for a collider in the 100x power range, so the focus turned to space. Lagrange Point 2, or L2 was the obvious choice for where to put a space-based collider, since it would get free shielding from cosmic rays by the Earth, and it was sufficiently far away that accidents would not endanger Earth. The problem was how to get it there.

We needed a new way to get things into space. Ships launched on top of combustion rockets were so small that they could barely do meaningful work and get back home. The current state of the art for launch vehicles had a yield of three percent, meaning that only 3% of the weight of the vehicle was useful as payload. The other 97% was propulsion. The mining industry was already grappling with this issue as well. They needed vessels capable of going somewhere after they get into orbit. In sailing terms we could only get dinghies or sunfish into orbit, small craft meant to hold a crew size from two to perhaps eight people. What mining folks needed were cargo ships in orbit, large ships that could travel to the asteroid belt, conduct mining operations on a commercially useful scale and return home. The research community now needed the same thing.

Megatons. We needed to get megatons into orbit.

Enter the railgun. The abundance of electricity made the cost per launch negligible for a railgun, and the yield was over 90% per vessel. Leaping from 3% yield to over 90% got everyone’s attention. Except that we still did not know how to make one that could get a craft to space in a condition other than as molten slag.

Ginny was a researcher in graduate physics at the University of Kansas at the time, having come to the states the year before from her native Nigeria. Her concept paper was the only one to solve the Atmospheric Buffering Problem, which was the last critical issue blocking the path to a feasible railgun.

A railgun runs an electrical charge down a set of tracks that will pull along anything that will stick to a magnet. Picture a railcar on a set of train tracks being pulled by a magnet. That is the basic idea. Now picture the tracks inside a tunnel, and the magnet is a cylindrical set of coils in the walls running the length of the tunnel. The magnetic field can be pulsed to ‘flow’ down the tunnel at any speed – right up to the speed of light (almost). Electricity in a wire is nearly as fast as light in a vacuum, which means that for launch purposes it is more than fast enough.

Ok so now we have our launch tube and projectile the size of a railcar – so far so good. The problem is that the launch tube does not reach up into space. This means that our fast moving vehicle is going to slam into a wall of air as soon as it exits the launch tube. Any ship that attempted this would be crumpled flat like a soda can in a hydraulic press – zero chance of survival. This is known as the Atmospheric Buffering Problem, or the ABP to those in the industry.

The underlying assumption everyone made was that the launch tube must be evacuated – i.e. in a near total vacuum – for it to work. Accelerating a train sized lump of metal to escape velocity in a tube would be a whole lot simpler if it did not have a bunch of air to push out of the way. Making this assumption enabled rapidly functioning prototypes that gave useful data on power requirements, acceleration limits for live payloads, and a host of other domains of interest. It also led to the ABP.

Ginny thought this approach was short-sighted. It did no good to simply delay the issue until the end of the line at which point it is insurmountable. She realized the air must be dealt with along the entire route, ensuring there is no dangerous pressure gradient anywhere along the launch vector. She had been studying high-discharge capacitors for her thesis, and had noticed a curious phenomenon surrounding during experiments. A capacitor can hold and release electric charges very quickly – thousands of times faster than batteries. Her focus was to optimize discharge rates and yields as part of a joint effort with the local power company, so the effect of ionized air as a by-product went unnoticed at first. The capacitors at high energies would ‘leak’ a bit of charge into the surrounding atmosphere and thereby ionize the nearby air, leaving it with a distinct positive or negative charge. Initially she and some of the other grad students found ways to direct it around for fun, using fans and magnets to zap each other. At these levels the effect was similar to a static charge after shuffling one’s feet on a carpet in wool socks. Ginny had the idea to change this effect from a by-product to the primary goal of the capacitor.

“What would happen if we took the entire output of the capacitor and used it to ionize the air?” she asked Ali, another grad student.

“It would build up and arc like lighting, why?”

“Ok, what if we throttled it so that the air was highly charged but not quite to the level of arcing? How much power would that take and how long could we hold it?”

“What are you thinking? You are rarely one for random questions, and thus far this feels pretty random.”

Ginny exhaled and thought, ‘ok here goes.’

“I’m submitting a paper for the Railgun competition. What if we put a capacitor in the nose of the launch vehicle and aim it forward. Ionize the air in front, then use magnetic fields to divert the air around the craft. Keep a small layer of vacuum – say a few microns thick – around the craft to prevent heat buildup.”

“Whoa, that’s nuts. You’d need a ton of power to sustain that. We use gigawatts to generate the fields that evacuate the tunnels for current experiments.”

“But I don’t need to evacuate millions of cubic meters of tunnel. I need a micron thick by the surface are of the leading edge of the craft. For about 10 – 15 minutes.”

“Hmm, you’ve thought about this, so I’m not going to validate the math right now. Let’s assume one of your capacitors could hold the charge – I’m guessing that was your motivation, yes?”

“Totally. And I was thinking of modifying it to be a little thicker, to draw out the discharge period.”

“Would a vacuum layer of a few microns be sufficient to prevent the heat from gapping over?”

“I think so. There isn’t really any precedent for this so I’m borrowing some equations from thermodynamics and modifying them, but it’s still a swag. Theory says we could get down to a few atoms thick of true vacuum and that would be enough. I figured I’d better give some safety margin on that, so I multiplied by about a thousand and came up with a few microns thick.”

“Holy shit this could work. We gotta get this into one of the tunnels and see what happens.”

“I was hoping you’d say that. Can you put a word in with Professor Filamena?”

“Do I get my name on the paper too?”

“Of course, right after mine” she smiled.

“Sweet. I’m on it.”