

HOW TO BUILD A DIGITAL GEIGER COUNTER?



WEDNESDAY,
15 JULY 2026



15:00

ROMANIA TIME (EEST)

INVITED SPEAKER:

RADU MOTISAN
CEO, MAGNASCI SRL



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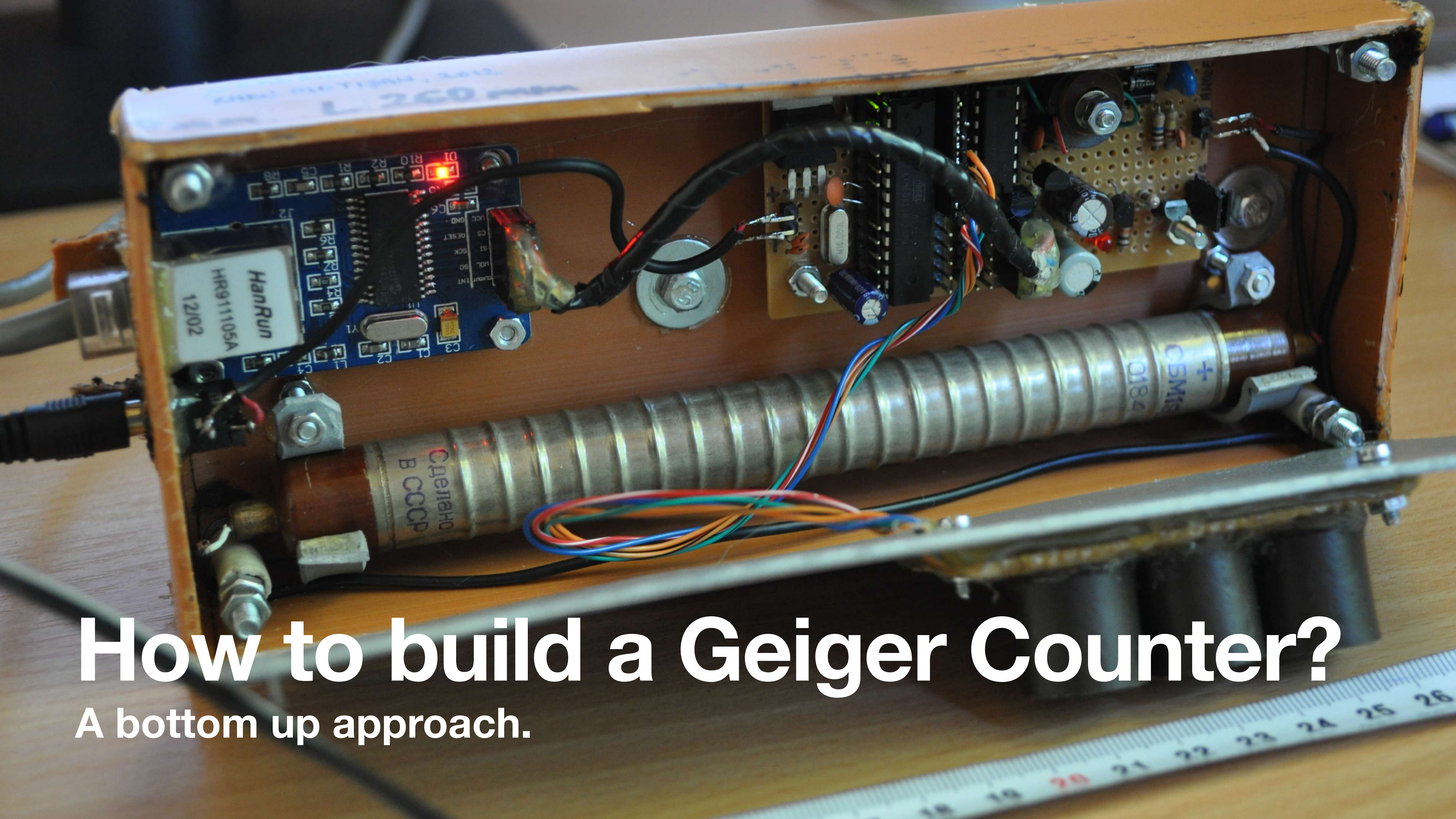
Radu Motisan is a software engineer and electronics enthusiast with a Master's degree in Computer Science from West University of Timișoara, whose hands-on passion for physics, chemistry and circuit design led him far beyond the screen.

After the 2011 Fukushima disaster exposed **the world's lack of accessible radiation data**, he began building DIY Geiger counters from scratch, designing PCBs, hand-soldering high-voltage circuits, and writing every line of firmware himself.

Those early experiments became **uRADMonitor**, now one of the world's first and **largest distributed environmental monitoring networks**, with over 4,000 sensors active in 60+ countries.

Today Radu will take us back to where it all started: the first circuits, the first tubes, and the engineering decisions that turned a personal project into **a global platform**.





How to build a Geiger Counter?

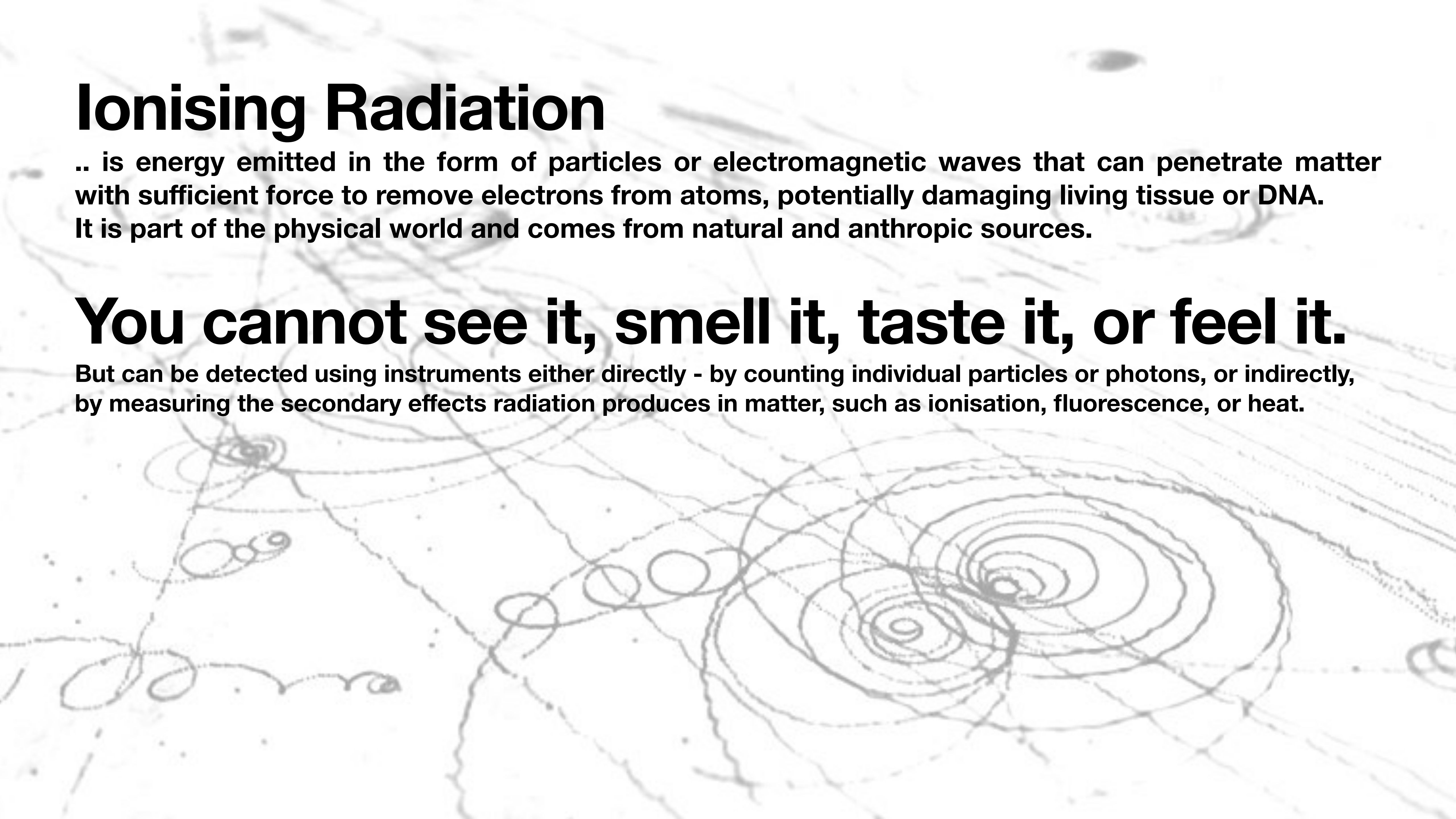
A bottom up approach.

Ionising Radiation

.. is energy emitted in the form of particles or electromagnetic waves that can penetrate matter with sufficient force to remove electrons from atoms, potentially damaging living tissue or DNA. It is part of the physical world and comes from natural and anthropic sources.

You cannot see it, smell it, taste it, or feel it.

But can be detected using instruments either directly - by counting individual particles or photons, or indirectly, by measuring the secondary effects radiation produces in matter, such as ionisation, fluorescence, or heat.

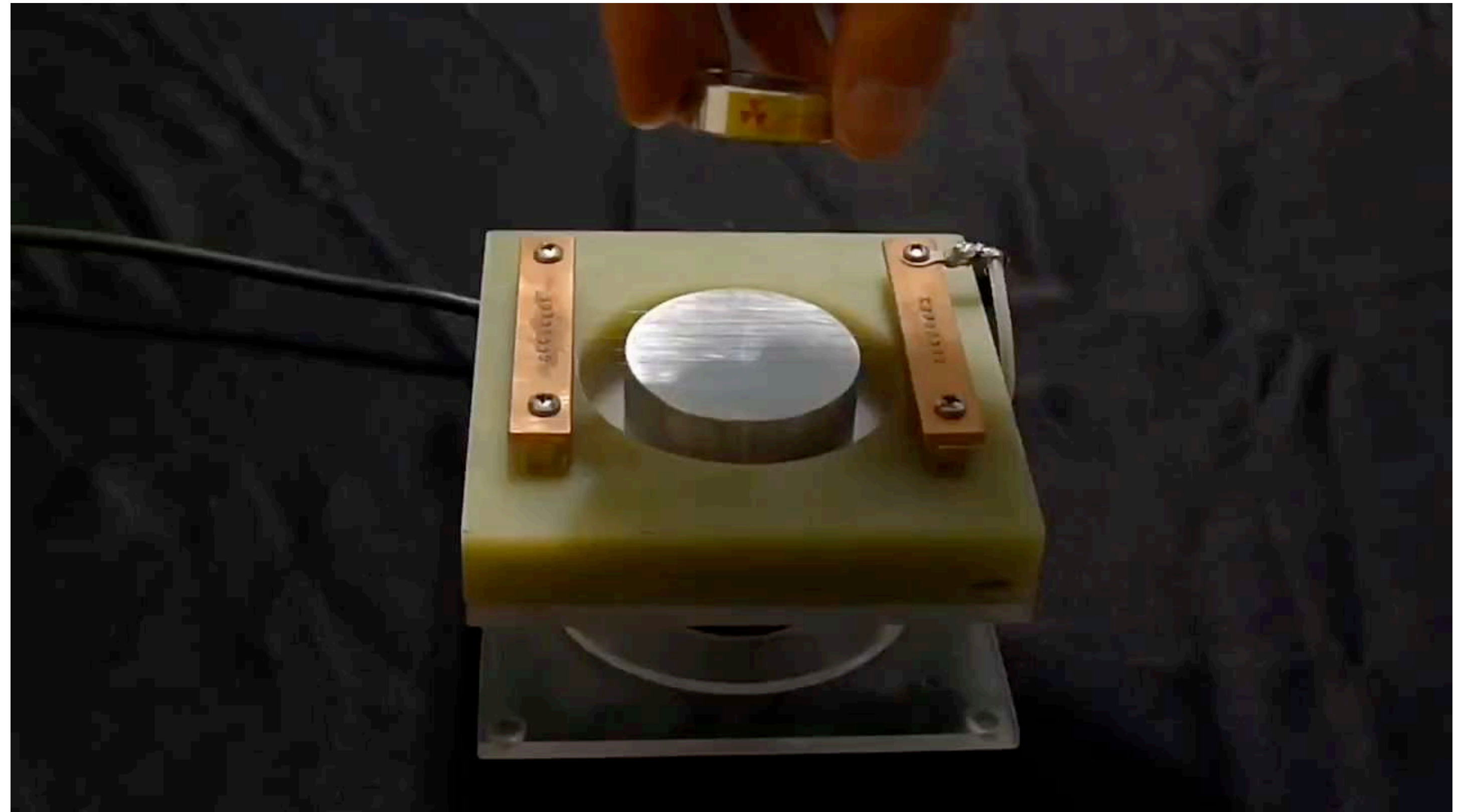


Spark Gap Alpha Radiation Detector

The detector consists of two closely spaced electrodes held at a voltage just below the breakdown threshold.

Alpha particles, despite their very short range in air, are highly ionising and create a dense trail of ion pairs along their path.

When a polonium-210 source is brought near the gap, the ionised air provides the conducting path that triggers a visible, audible spark for each individual alpha particle.



Carl Willis is an American nuclear engineer and radiation physics enthusiast well known in the DIY and amateur nuclear science community for his detailed technical work on radiation detection, nuclear instrumentation and more.

What is a counter?



A counter is a device that increments a running total by one with every detected pulse, click or trigger. See more:
<https://www.pocketmagic.net/diyhomemade-geiger-counter-2/>

Putting the *detector* and the *counter* together

It's not enough to know if radiation is present or not,
We need to know how much energy is deposited in a target over time.

The Radiation dose

A single alpha particle detected by our spark gap is harmless at a distance, but the same emitter with prolonged close exposure, deposits that energy directly into cells, and it is the total accumulated dose that determines whether damage occurs.

This is why counting alone is not enough: a meaningful radiation measurement must always consider both the number of events and the time over which they occur, giving us the dose rate that allows us to assess real-world health impact.

About the Geiger Counter and how to build it?

The Geiger Counter is instrument invented in the early 20th century that detects and measures ionising radiation by counting the electrical pulses produced when radiation passes through a *gas-filled tube*.

Geiger-Müller tube at the heart of the counter is a sealed cylindrical chamber filled with an inert gas, typically helium, neon or argon at low pressure, with a thin central wire anode running along its axis and the outer metal cylinder acting as the cathode, held at a high voltage of several hundred volts between them.

When a radiation intersects the tube and collides with a gas atom, it ejects an electron, which is then accelerated toward the anode by the electric field, gaining enough energy to ionise further atoms along the way - triggering an avalanche of ion pairs that produces a measurable electrical pulse. Like the spark gap.

Without a quenching mechanism, however, the positive ions drifting back toward the cathode would release secondary electrons upon impact, triggering endless additional avalanches and rendering the tube unable to detect the next particle.

This is solved by adding a small amount of quenching gas: typically a halogen such as bromine or chlorine, or an organic vapour, which absorbs the energy of returning positive ions through molecular



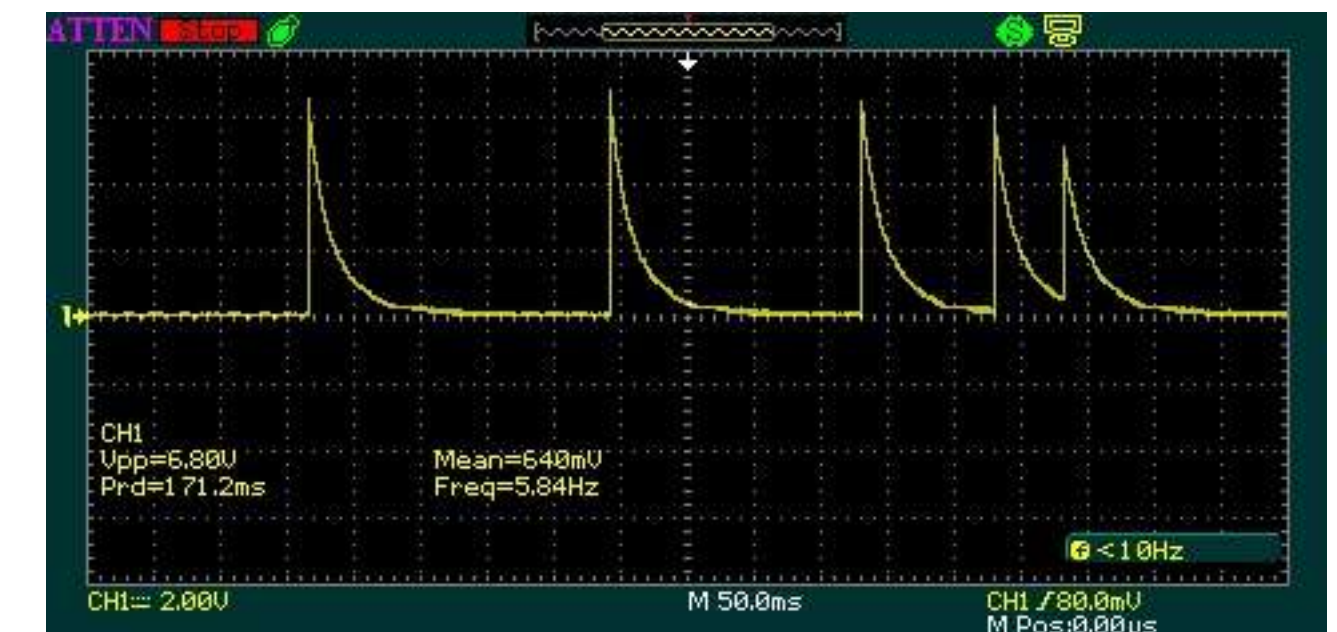
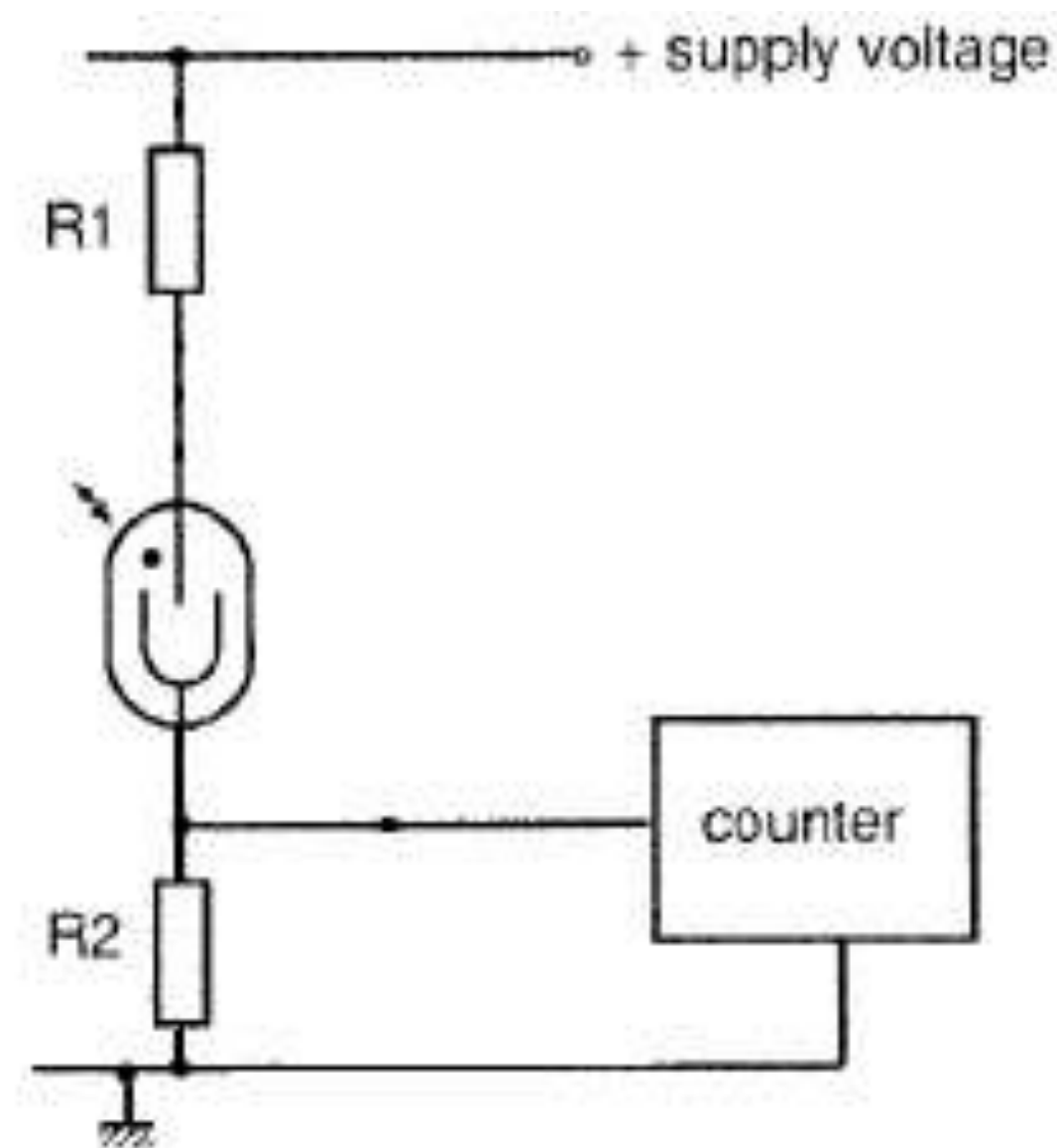
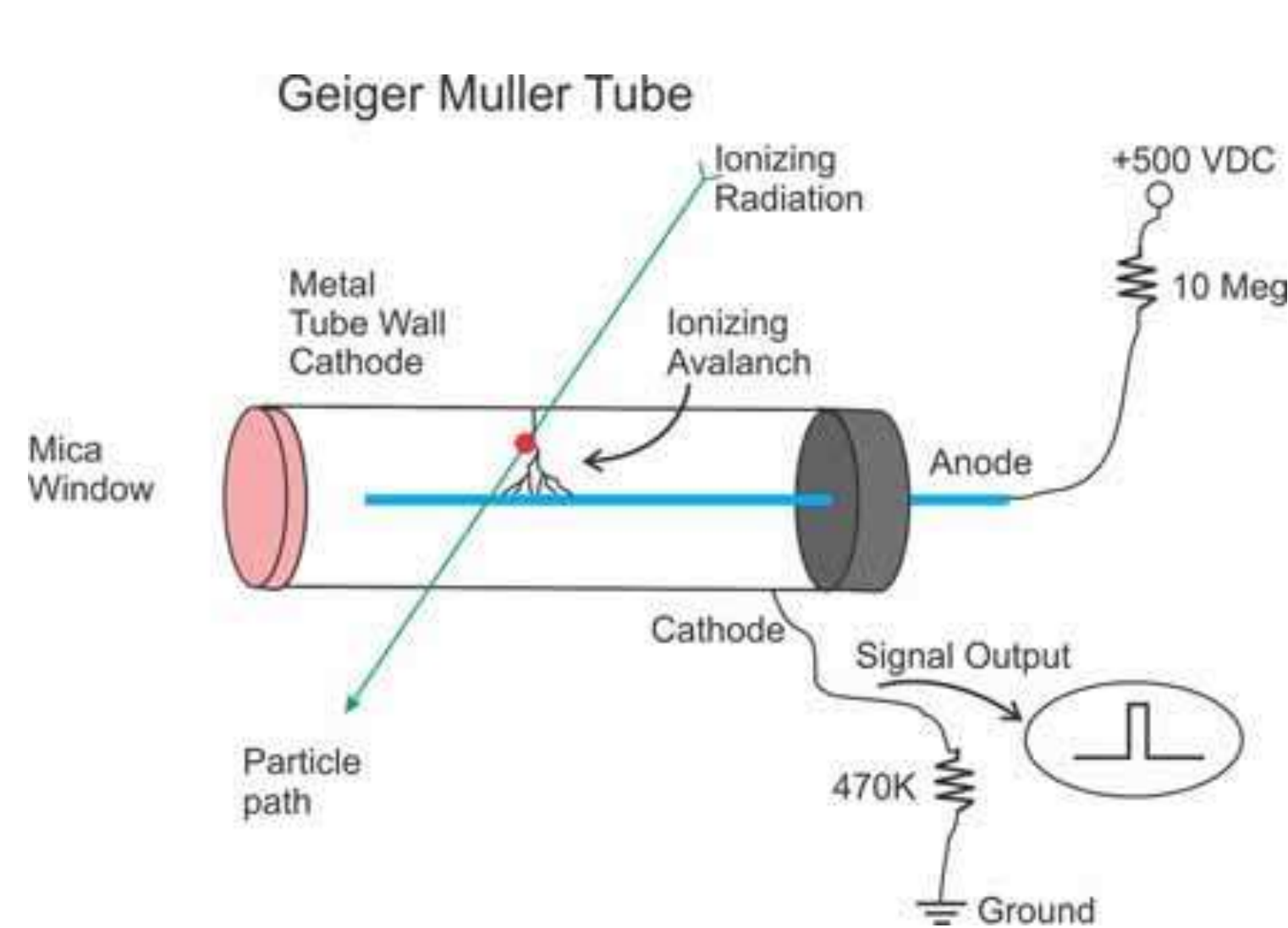
Resources:

Blog: <https://www.pocketmagic.net/diyhomemade-geiger-counter-2/>

Centronic's Geiger Tube Theory: https://www.pocketmagic.net/wp-content/uploads/2026/07/Centronic-Geiger-Tube-Theory-ISS1_compressed.pdf

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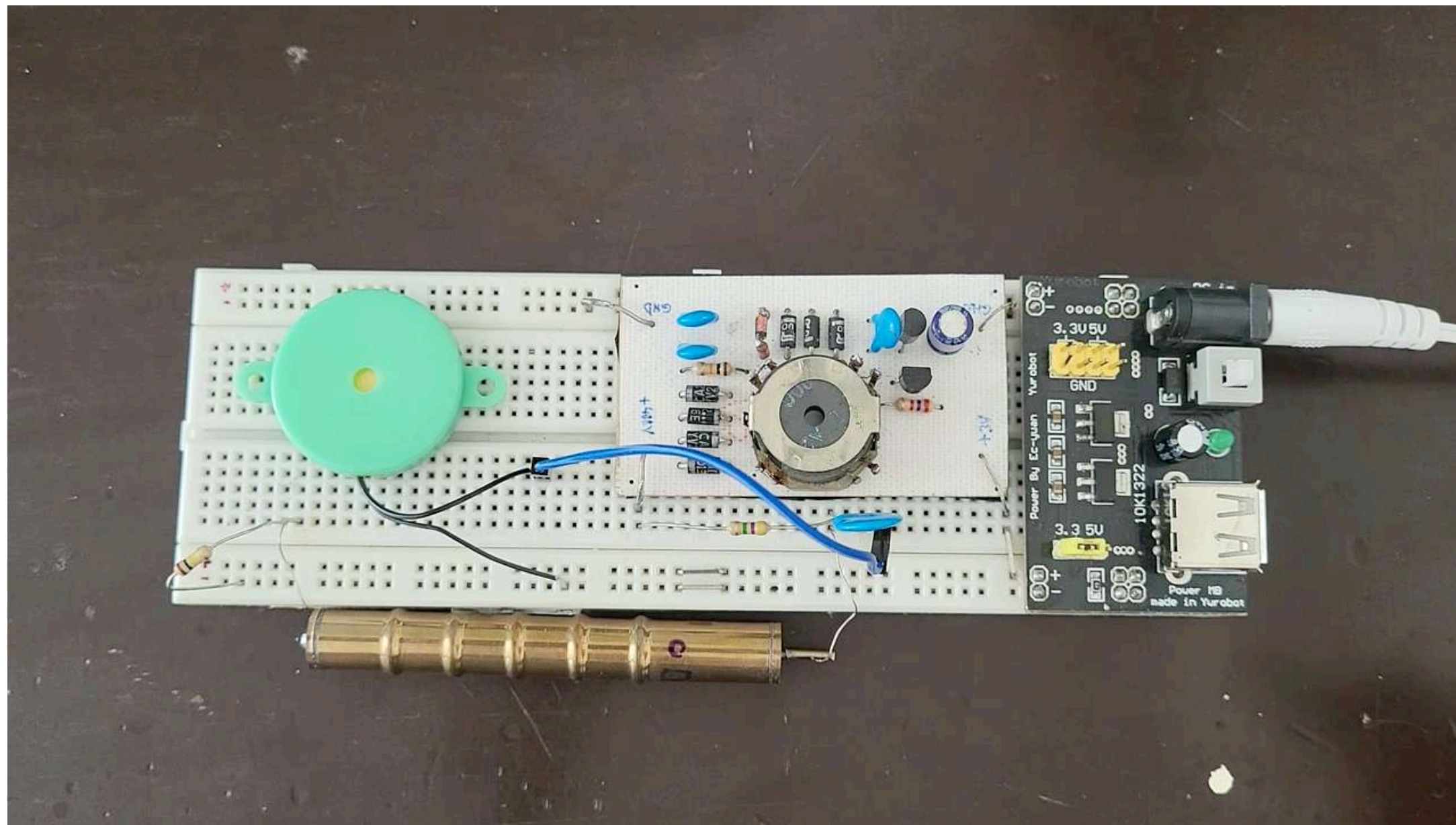
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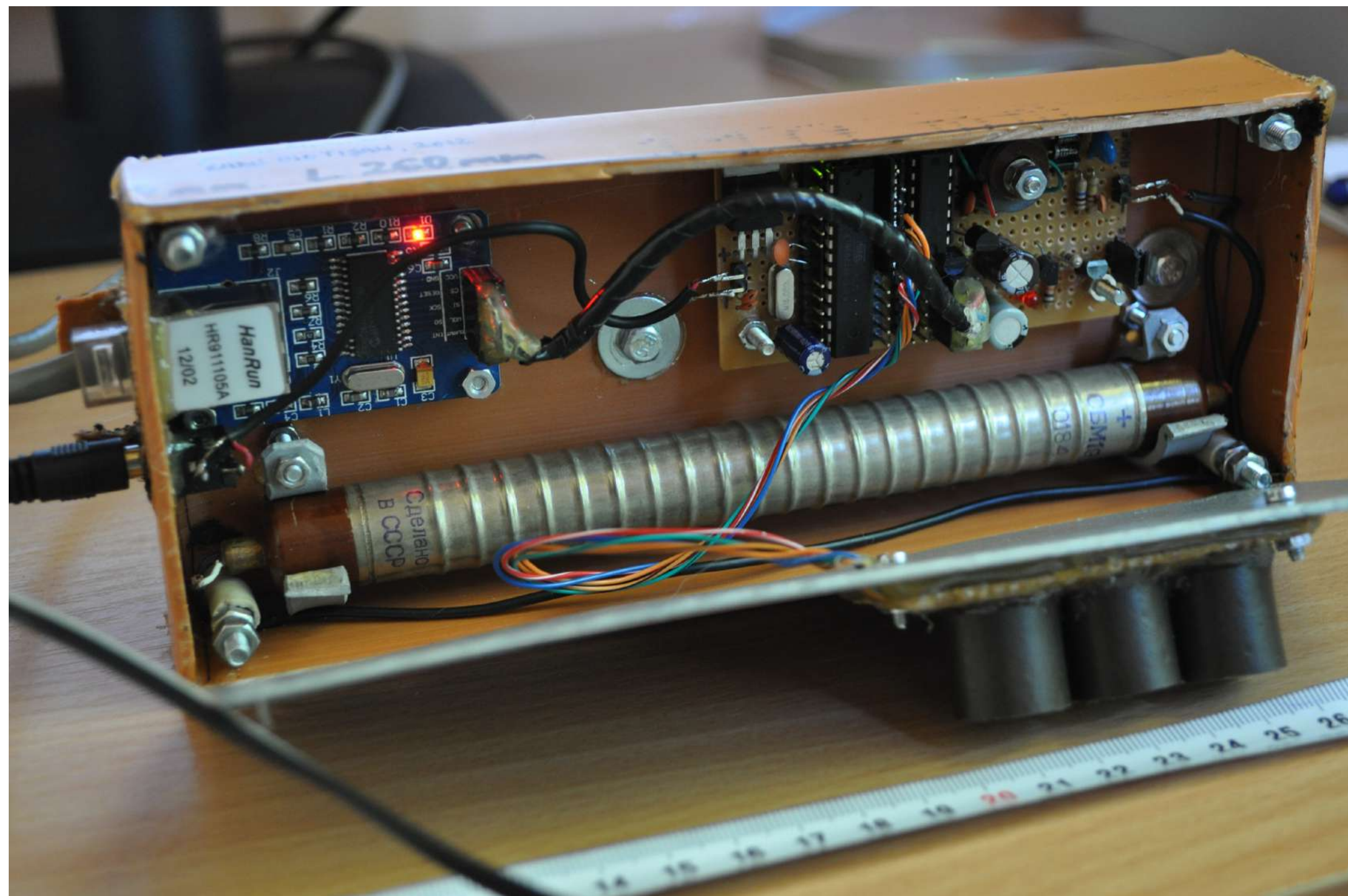
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<- A simple demo

Top left is a “Clicker” a simple assembly with a 400V supply, a Geiger Tube and a piezo speaker to click when radiation intersects the tube volume.

Bottom left is a similar construction, you can see the circular ferrite core of the inverter, but this time connected to a digital counter that also tracks time and an Ethernet adapter to upload data online, in real time. *This is the first uRADMonitor sensor.*



<- A not-so-simple demo

The digital Geiger Counter

- We keep the high voltage supply, but this time it is a digital supply, where the microcontroller generates the PWM for the inverter and monitors the output, adjusting the duty cycle permanently to keep the output voltage steady.
- We keep the counter, but we use an interrupt pin on the microcontroller, counting pulses shaped with a preamplifier.
- We add a digital clock, based on a quartz crystal for accuracy.
- We compute the CPM using time and counts and either display it or send it via the Internet to a central server.

Open source uRADMonitor source code:
https://github.com/radhoo/uradmonitor_kit1

```
// int0 interrupt handler, triggered each time a rising edge is detected on INT0, which on a ATmega8 is PD2
ISR (INT0_vect) {
    if (geigerPulses < MAX_UINT32) geigerPulses++; // count this pulse
}

// event to be executed every 2.048ms here with 8MHz crystal every 1.024ms here with 16MHz crystal
void TimeCounter::TimerEvent() {
    millis ++;

    if (millis < (F_CPU / 16384)) return; // small timing error: 488.28125 exact value for 8MHz, 976 for 16MHz

    total_sec++;

    if ((total_sec>0) && (total_sec % 60 == 0)) {
        total_min++;
        if (ptrFuncMin != 0) ptrFuncMin();
    }
    if (ptrFuncSec != 0) ptrFuncSec();

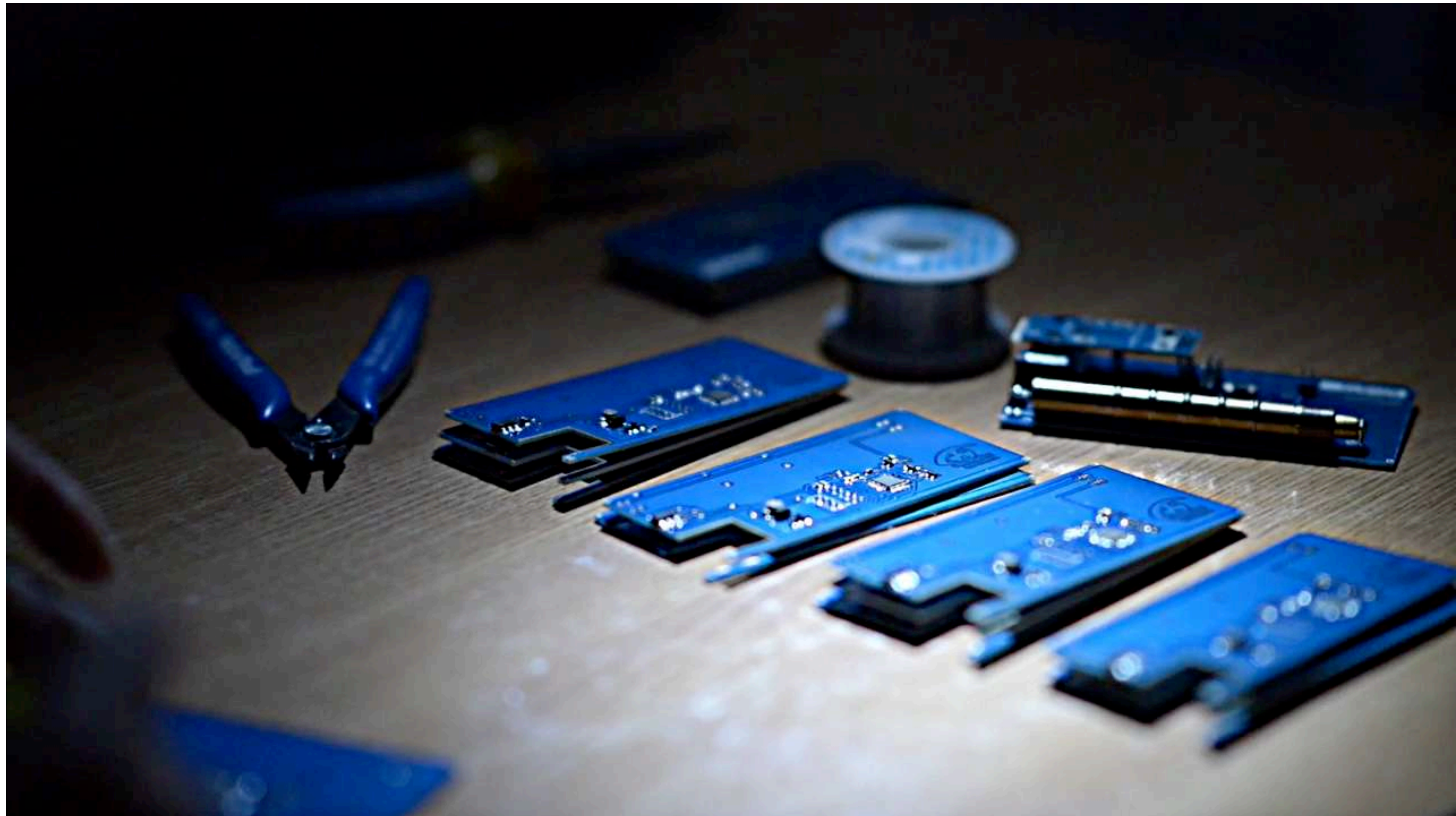
    // reset counter
    millis = 0; // 488 x 2.048ms ~ 1000 ms = 1sec for 8MHz , 976 x 1.024ms ~ 1000 ms = 1 sec for 16MHz
}

// called on elapsed second
void callback_timeSecond() {
    uint32_t localTime = devices.time.getTotalSec();

    if (devices.time.getTotalSec() % READ_INTERVAL == 0) {
#ifdef SENSOR_GEIGER
        // compute partial CPM, using time counter 3, that keeps all seconds since last geigerPulses reset to 0
        if (devices.time.getCount(TimeCounter::TIME_COUNTER_3) > 0) {
            devices.geiger.setCPM((60 * geigerPulses) / devices.time.getCount(TimeCounter::TIME_COUNTER_3));
        }
#endif
        // read rest of sensors
        devices.cmdRead = READ_COMMAND;
    }

    // we are finally ready to send data
    if (devices.time.getTotalSec() > WARMUP) {
        uint16_t timeInt = devices.sendInterval;
        // issue SEND command every given interval
        if (devices.time.getTotalSec() % timeInt == 0 && devices.time.getTotalSec() > 0) {
#ifdef SENSOR_GEIGER
            // compute partial CPM, using time counter 3, that keeps all seconds since last geigerPulses reset to 0
            if (devices.time.getCount(TimeCounter::TIME_COUNTER_3) > 0) {
                devices.geiger.setCPM((60 * geigerPulses) / devices.time.getCount(TimeCounter::TIME_COUNTER_3));
            }
            // reset geigerPulses to 0
            geigerPulses = 0;
#endif
            // reinit counter 3, to compute the partial CPM
            devices.time.startCount(TimeCounter::TIME_COUNTER_3);
            // re-set HTTP code
            devices.lastHTTPCode = 0;
            // ask to send data online
            devices.cmdSend = 1;
        }
    }
}
```

The final result: not one sensor but a network of many



IOT & New Tech = Window of opportunity

1.The problem was always there: the timing was the insight

uRADMonitor did not invent a new problem, it recognised that the convergence of cheap microcontrollers, internet connectivity and global awareness created a window where a solution finally became possible. **The entrepreneurial insight was not the idea itself, but the timing of its execution.**

2.Fukushima did not create uRADMonitor - it revealed the need

The 2011 disaster did not give Radu a new skill set. The electronics knowledge, the curiosity, the blog posts on Geiger counters , all of that already existed. The disaster simply made the absence of a solution visible to the entire world simultaneously. **Great entrepreneurship often means being technically ready when the world suddenly needs what you already know how to build.**

3.The first product does not need to be perfect but it needs to exist

The first prototype was hand-soldered, ran on a microcontroller with 2KB of RAM, and transmitted data over an Ethernet cable. It was not easily scalable, not manufacturable, not certified. But it worked on October 21, 2012 and that **early date matters more than any of its limitations.**

4.Open data as a competitive moat

Making all measurements publicly accessible was not just an ethical choice , it was a strategic one. Open data attracted researchers, municipalities and citizens who became advocates, validators and eventually customers. **Radical transparency can be a more powerful differentiator than any patented technology today.**

5.IoT before IoT was a category

In 2012 the term Internet of Things was barely used outside academic papers. Being early in a category that later becomes mainstream is one of the most powerful competitive advantages available , but it requires **the confidence to build for a future others have not yet imagined.**

6.Hardware is hard , and that is exactly the point

A working hardware product with calibrated sensors, custom enclosures, reliable firmware, a cloud backend and a validated global network is not easy to copy. Every difficulty uRADMonitor faced was simultaneously a barrier to entry for anyone who might want to replicate it. **The difficulty of the problem is part of the value of solving it.**

7.Iteration is not failure , it is the method!

The MODEL A4 is now on its 5th hardware version. The A3 went through more than 10 iterations. None of these revisions represent things that went wrong , they represent a systematic process of learning from deployment and improving. **The students who will build the most impactful things are not those who get it right the first time, but those who are willing to get it wrong nine times and keep going.**

8.Innovation is not invention , it is recombination under pressure

Geiger tubes existed since 1928. Microcontrollers since the 1970s. The internet since the 1980s. What uRADMonitor did was recombine them at a specific moment, for a specific unmet need, and execute that recombination with enough technical depth to make it reliable, scalable and trustworthy. This is what innovation almost always looks like in practice: **not a lightning bolt, but a deliberate synthesis of existing knowledge applied to a problem whose time has come.**

Thank you for your attention: Radu Motisan, radu@uradmonitor.com