HIGGS

HIgh school students in proGramminG and Sciences

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Schedule

- Introduction round (15min)
- von D Research (15min)

break (5min)

- Setup Raspberry Pi
  - setup equipment (20min)
  - boot computer, basic commands (20min)
  - install camera (20min)

break (5min)

- Temperature sensor (30min)

break (5min)

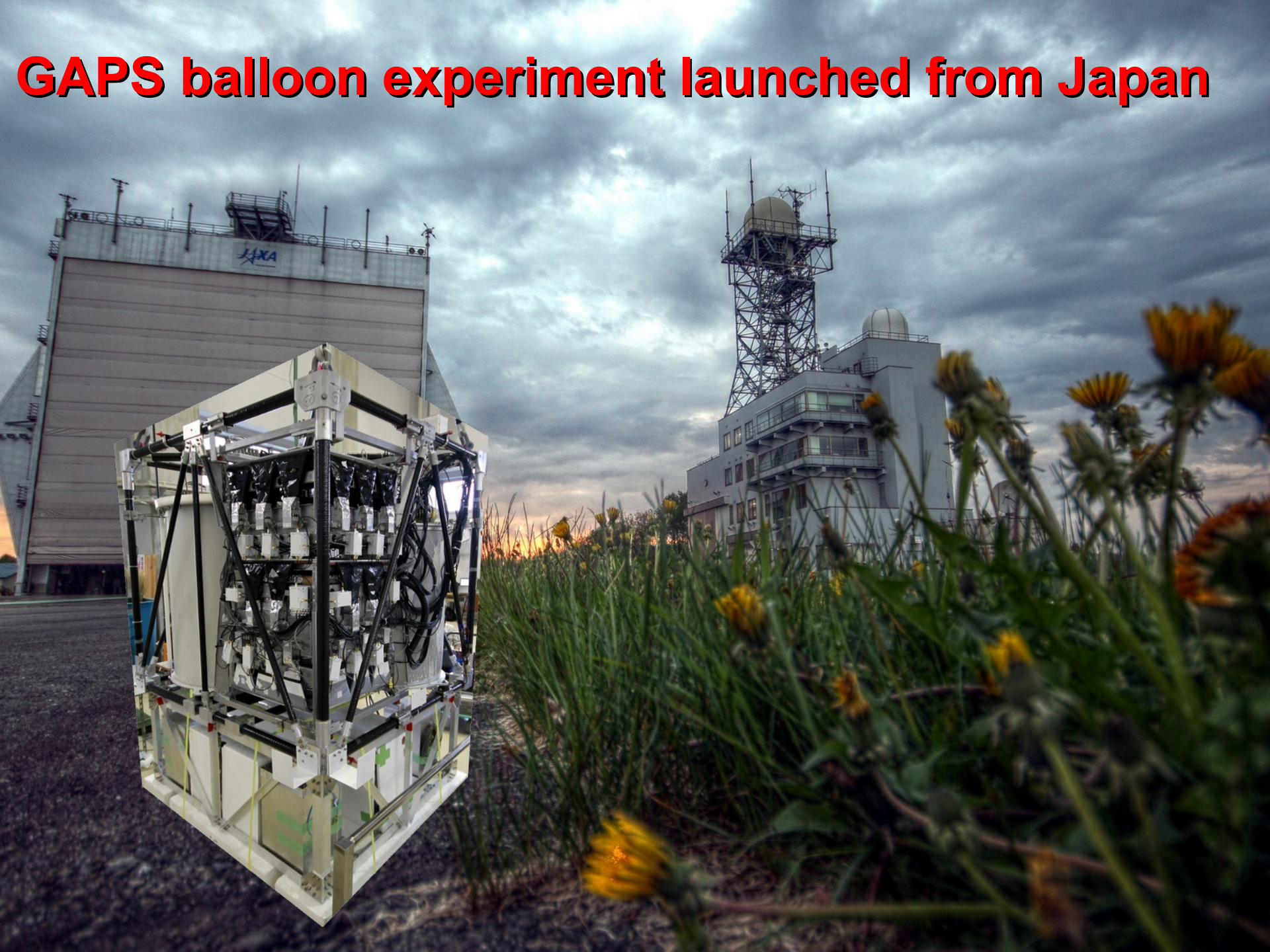
- Radioactivity
  - short lecture on radiation (10min)
  - Geiger counter (30min)

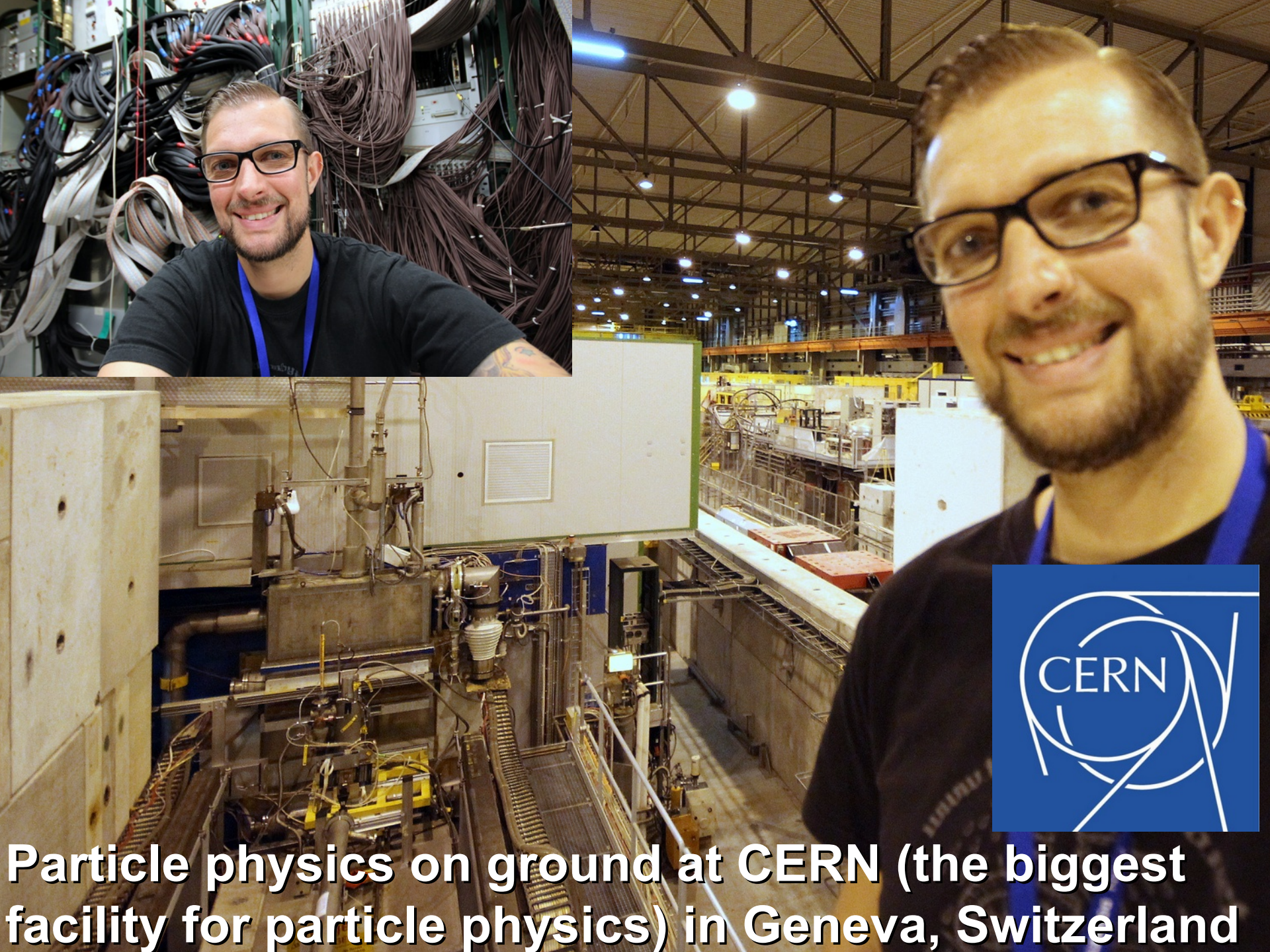
What got me started to become a physicist?
Earth is so small → What is out there?

Particle physics *in Space*

Integration of AMS-02 at CERN with STS-134 astronauts

GAPS balloon experiment launched from Japan





Particle physics on ground at CERN (the biggest facility for particle physics) in Geneva, Switzerland

Cosmic rays - What is that?

At the end of their lifetime
→ stars can explode and accelerate their constituents to space

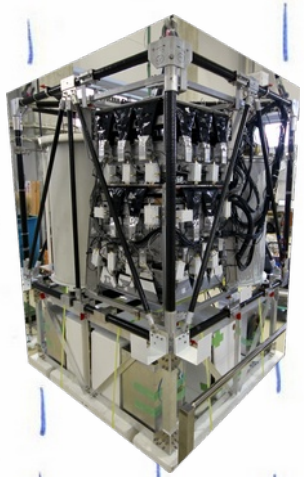
For example: protons and electrons (the matter we are made of)

Studying these elementary constituents of matter in space tells us about our stars, Galaxy, dark matter, fundamental laws of nature

Where to put such an experiment?

Imagine you wanted to collect rain...

too dry




The atmosphere acts as a roof for cosmic rays
atmosphere
Which is good to stay healthy, but bad to measure cosmic rays

Therefore put the experiment as high as possible!

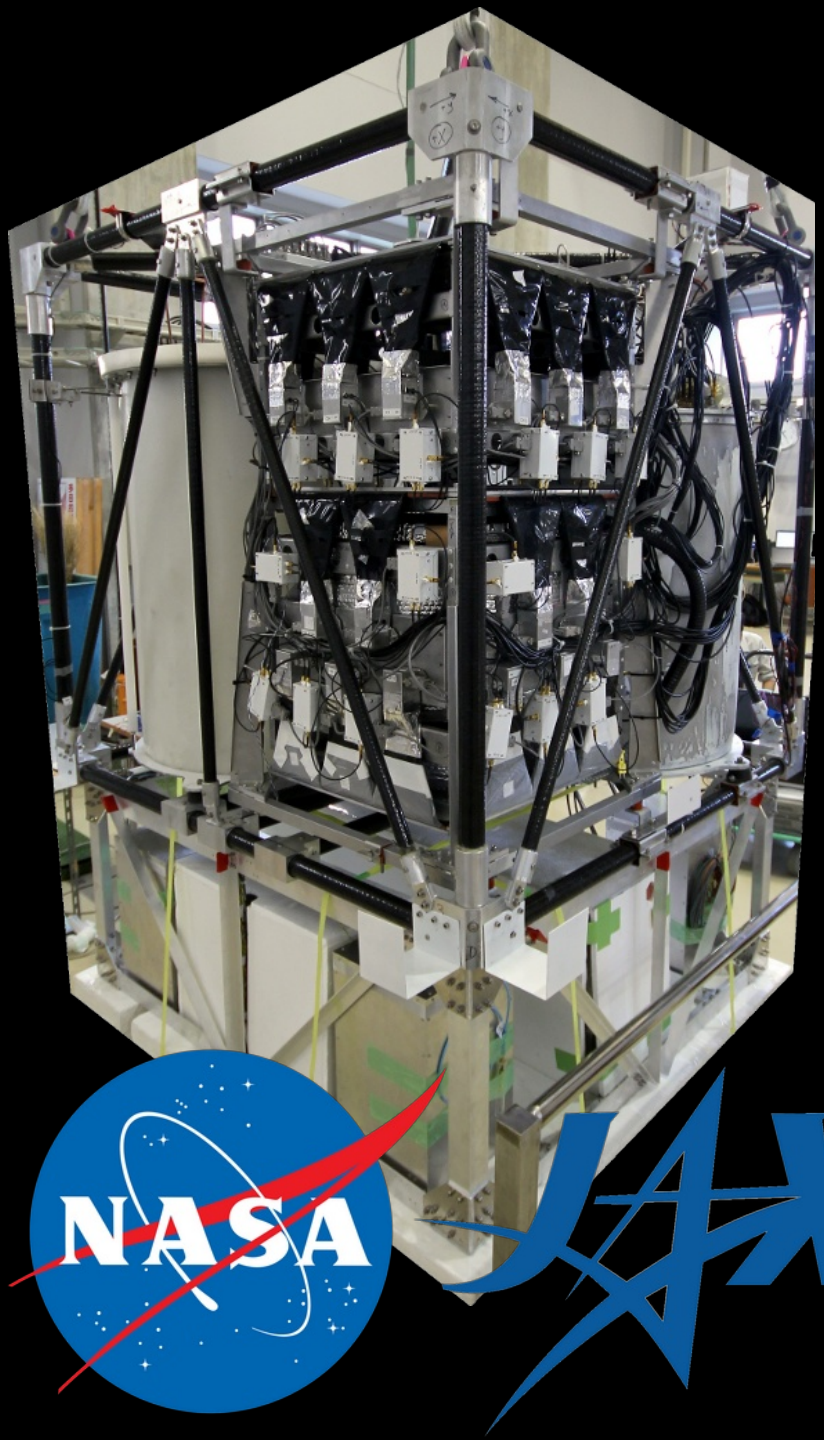
Space is great, but super expensive ($1,000,000 for 2lbs)

use balloons

that go up very very high

→ 25 miles above ground

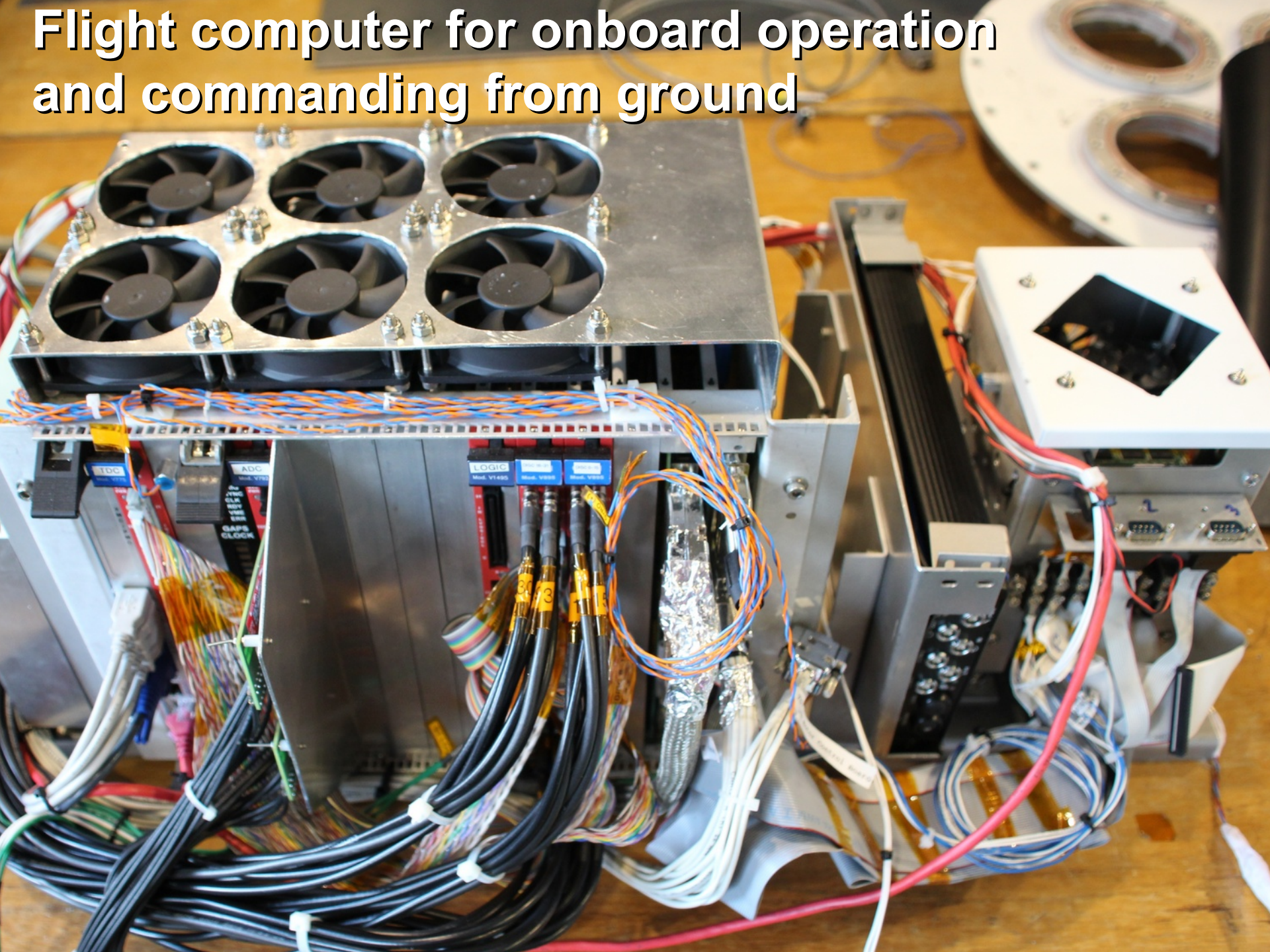

GAPS
GENERAL ANTIPARTICLE SPECTROMETER
NASA • JAXA



A lot of hands on work with all sorts of different tasks!

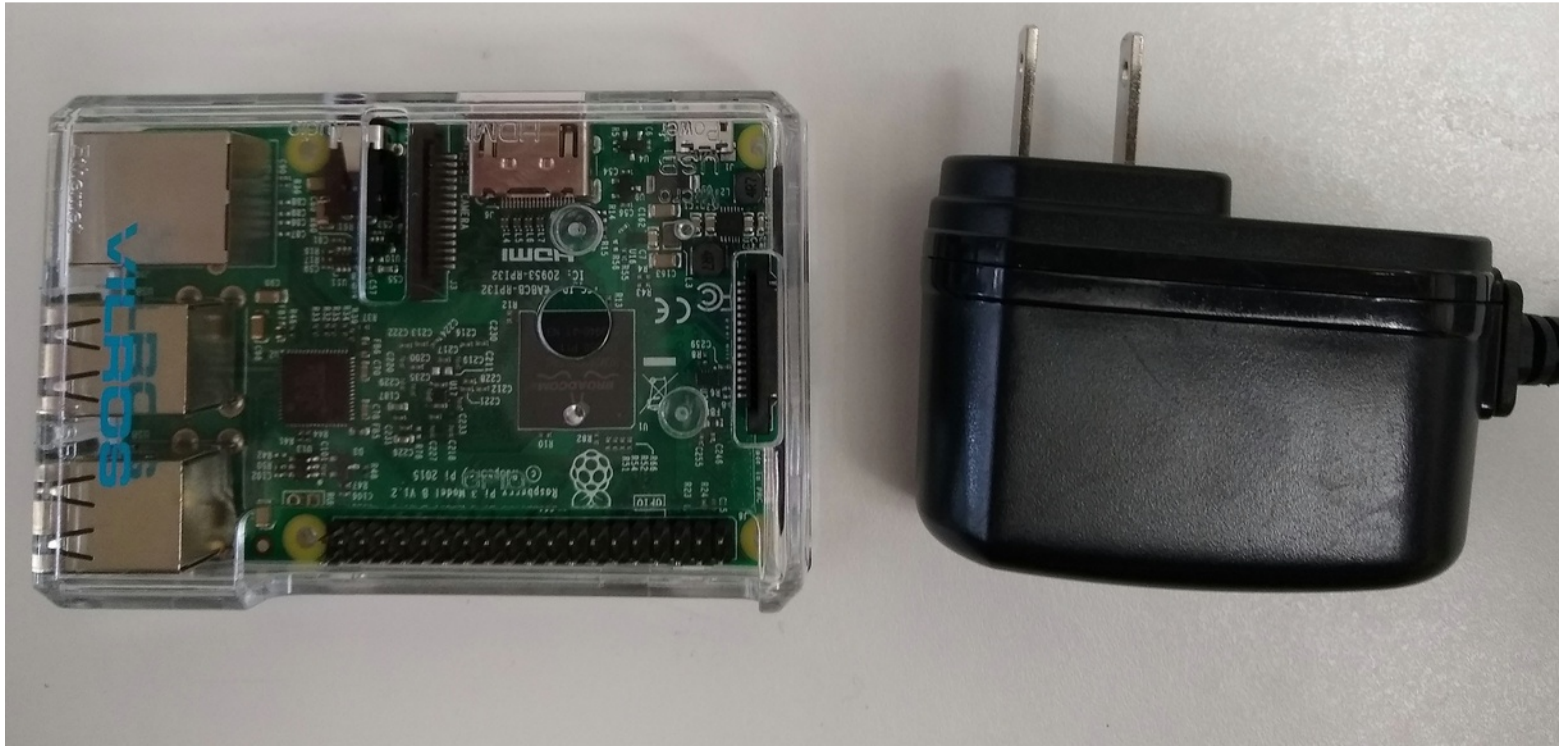
Playground for big kids

Flight computer for onboard operation and commanding from ground

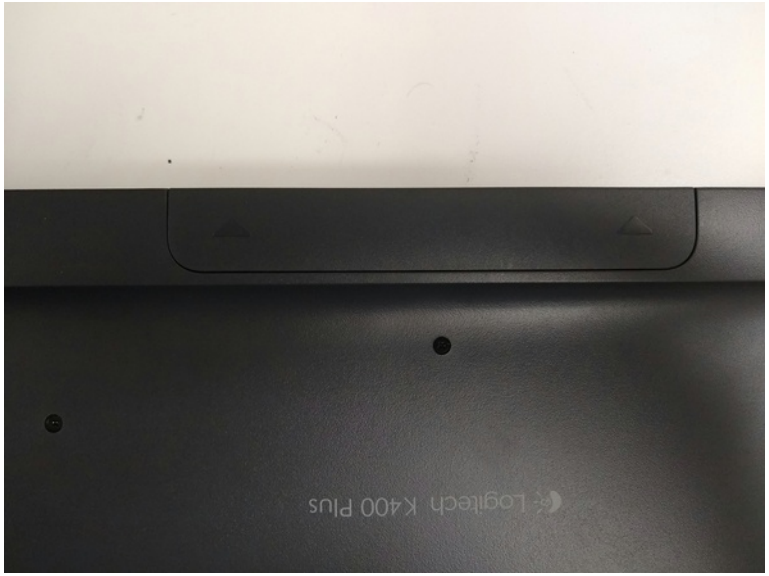


Raspberry Pi Computer

Let's mimick the computer operations for ballooning and space experiments with a **Raspberry Pi computer**



Keyboard



Setup

- Setup screen:
  - Connect HDMI cable
  - Connect power cable to screen and outlet
- Connect HDMI cable to Raspberry PI
- Connect keyboard USB adapter to Raspberry Pi USB
- Connect USB power adapter to Raspberry PI
- Open browser and connect Raspberry Pi to:

  meet.google.com/brs-wdac-gqz

Basic Commands

- Open the terminal
- List content in directory:

  ls

- Make a new directory:

  mkdir <name of directory (e.g., your firstname)>

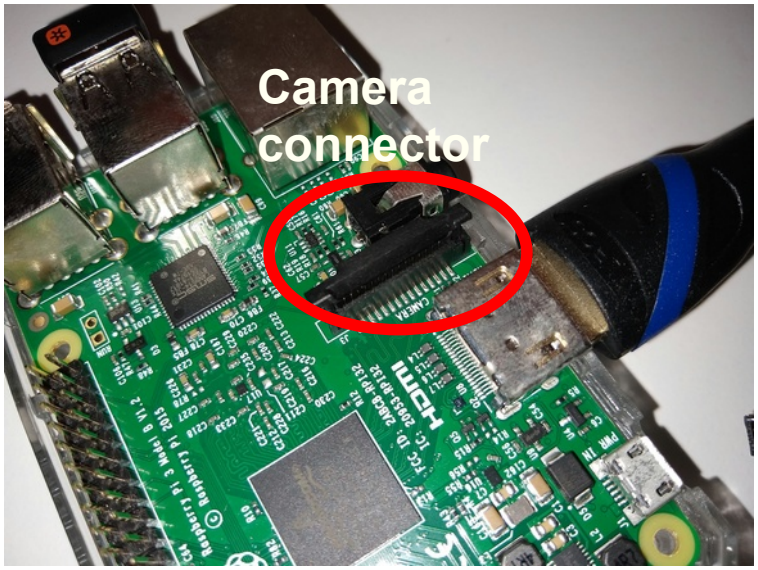
- Change into a directory:

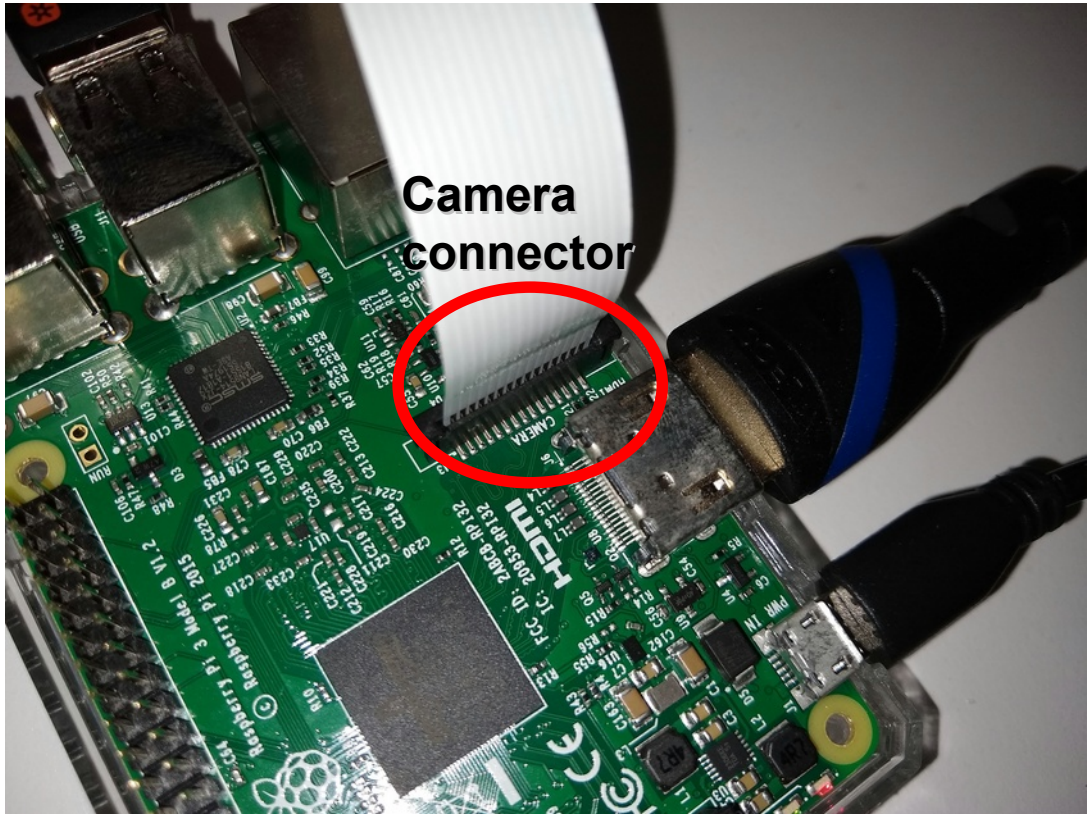
  cd <name of directory>

- Stop a running program:

  ctrl+c

Camera





- **Connection:**
  - **Shutdown computer**
  - Take off plastic lid
  - lift handles before inserting
  - silver connectors facing hdmi
  - then press down

- **Commands in the terminal:**
  - For taking pictures:

    raspistill -o image.jpeg

  - For taking videos:

    raspivid -o video.3g2 -t <miliseconds>

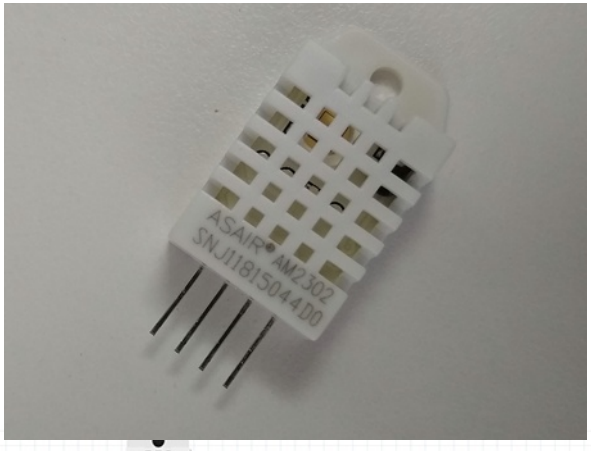
  - For watching videos:

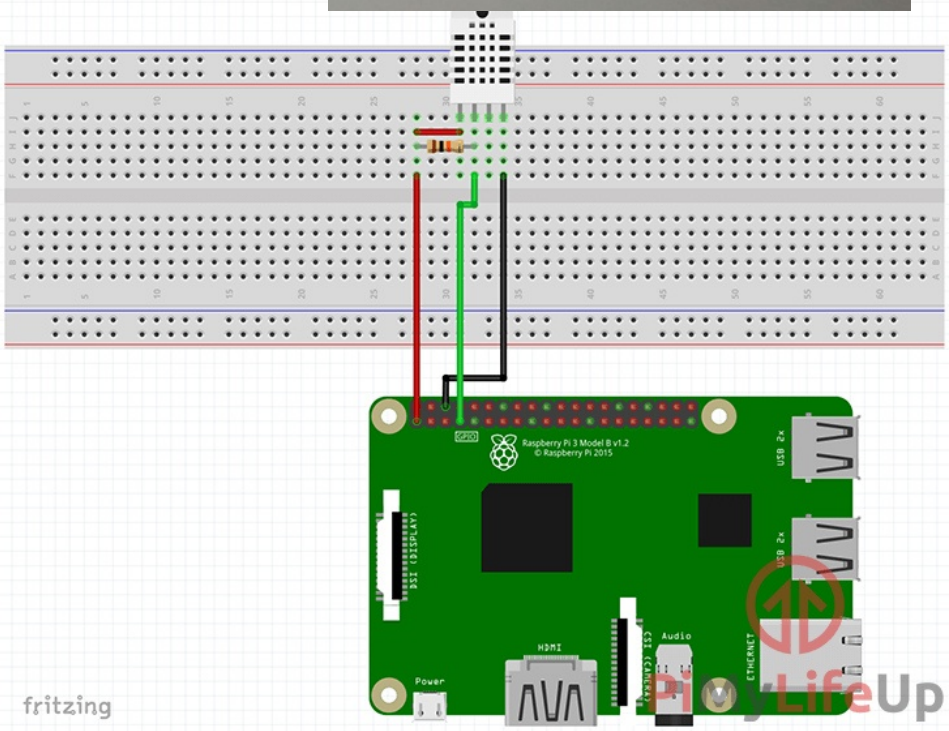
    omxplayer video.3g2

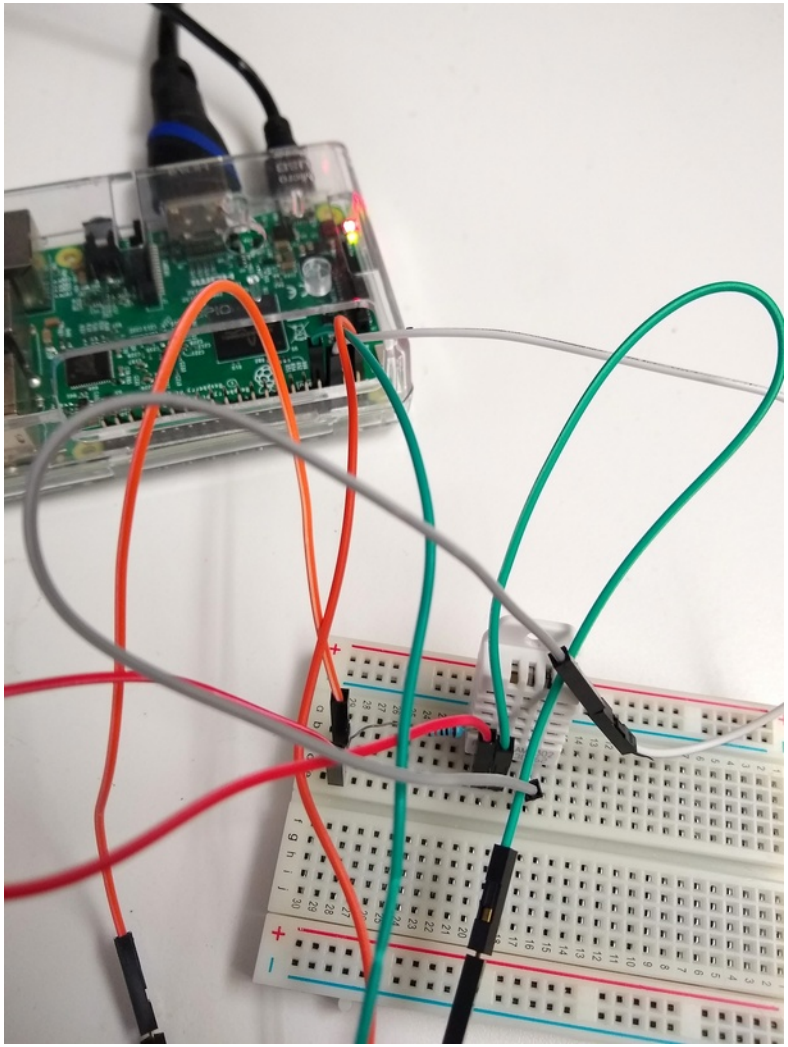
Shutdown computer before installing camera

Temperature Sensor

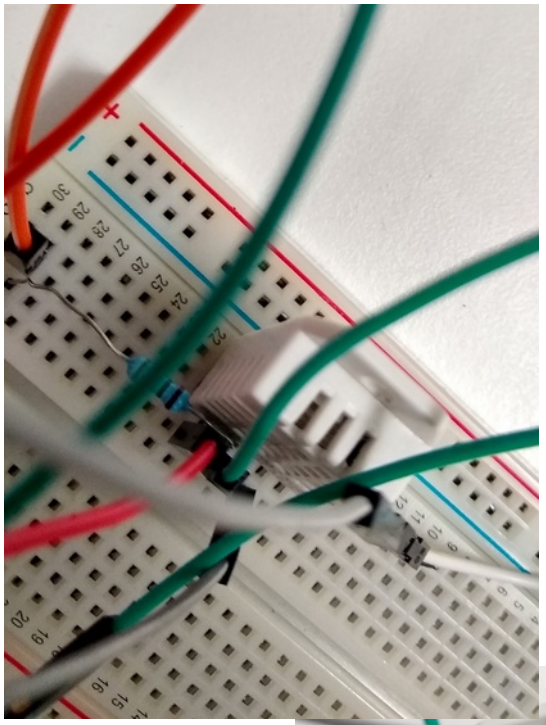
Shutdown computer before installing temperature sensor

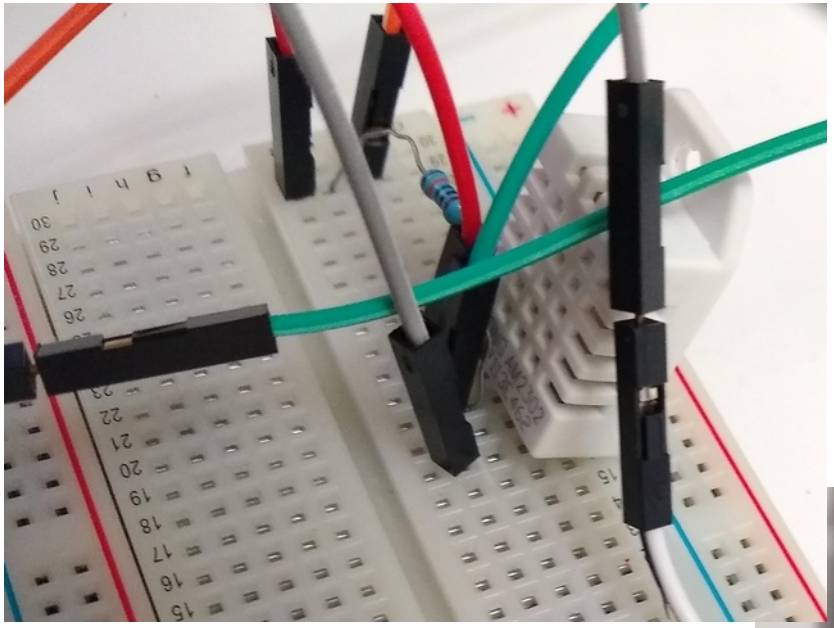


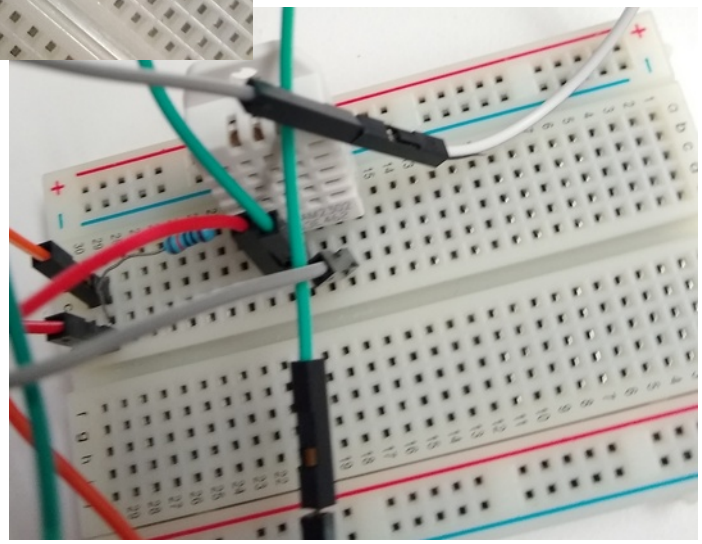




Temperature Sensor







Temperature Sensor

- Terminal commands:

  cd

  cd code/temp

  g++ -o dht22 dht22.cpp -lwiringPi

  sudo ./dht22

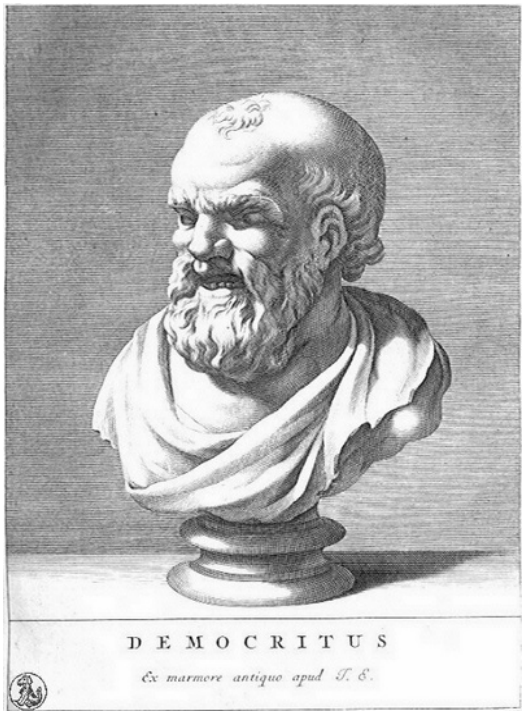
- Stop measurement by press *ctrl*+*c* at the same time

400BC Atoms

Greek philosophers Democritus and Leucippus:

Matter is made of invisible particles called ***atoms.***

a(not) **tomos** (divided)



John Dalton

John Dalton (1766-1844):

- many chemical phenomena could be explained if atoms of each element are the building blocks of matter

→ **still indivisble**

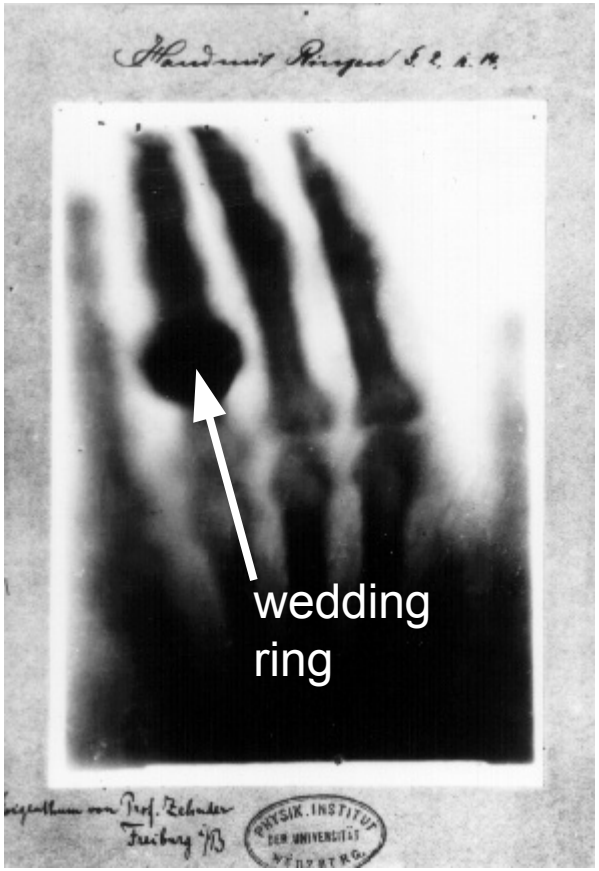
X-rays

- discovery by Roentgen (1845-1923) occurred accidentally at the University of Würzburg
  → new kind of radiation: **X-rays**

- first X-ray of his wife's hand

- dangers unknown

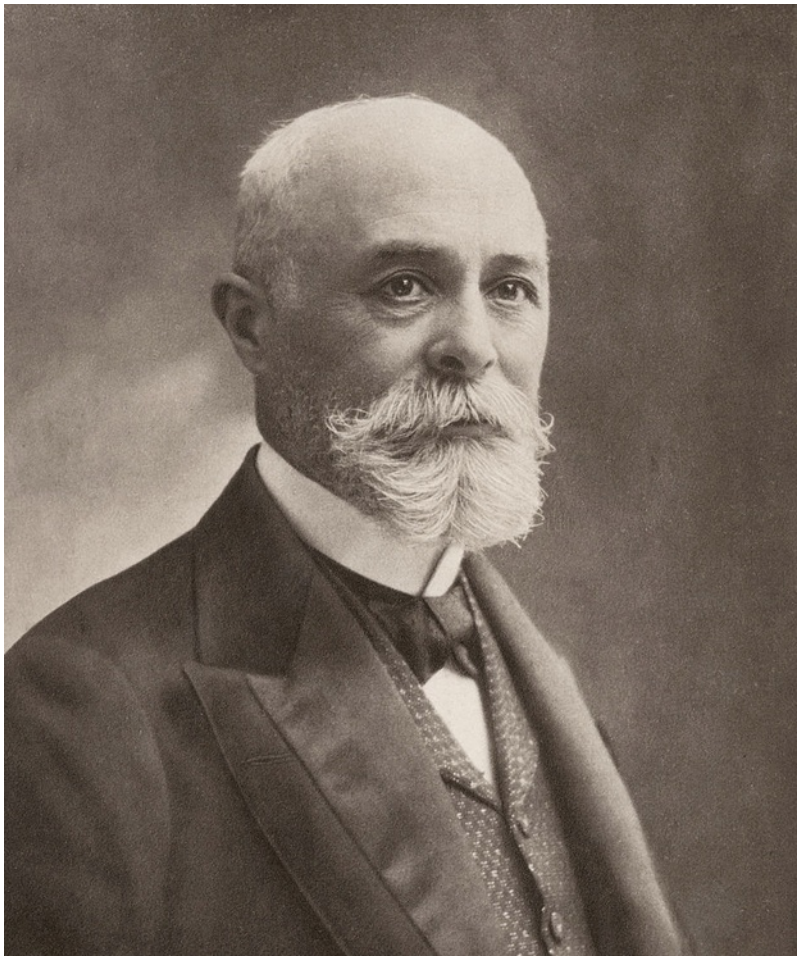
- 1901 first Nobel Prize in physics



Radioactivity

- Henri Becquerel: working with phosphorescent materials: glow in the dark after exposure to light
  → associated to X-rays?

- wrapped a photographic plate in black paper and placed various phosphorescent salts on it
  → uranium salts caused a blackening of the plate in spite of the plate being wrapped in black paper



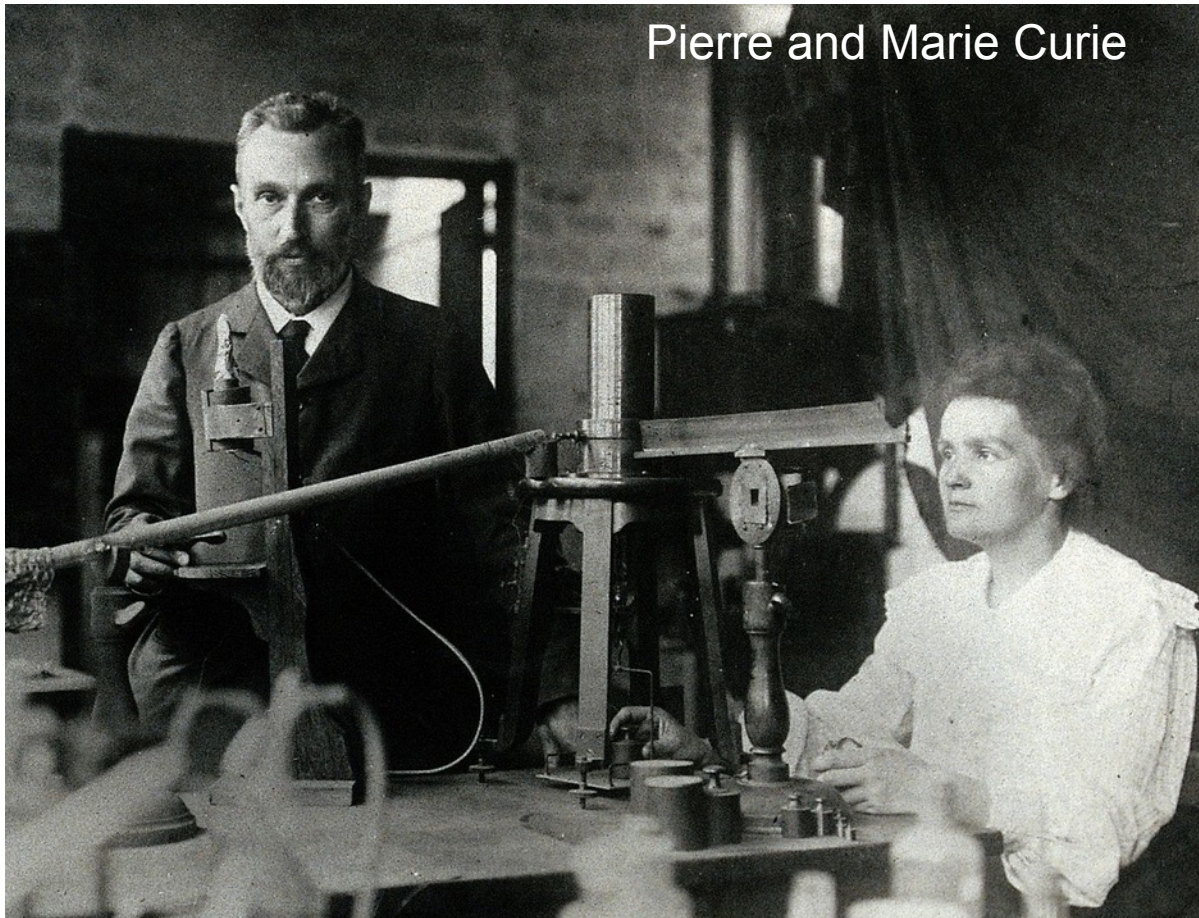
Antoine Henri Becquerel (1852-1908)

Radioactivity

- blackening was also produced by non-phosphorescent salts of uranium and metallic uranium
  → new form of invisible radiation that could pass through paper and was causing the plate to react as if exposed to light

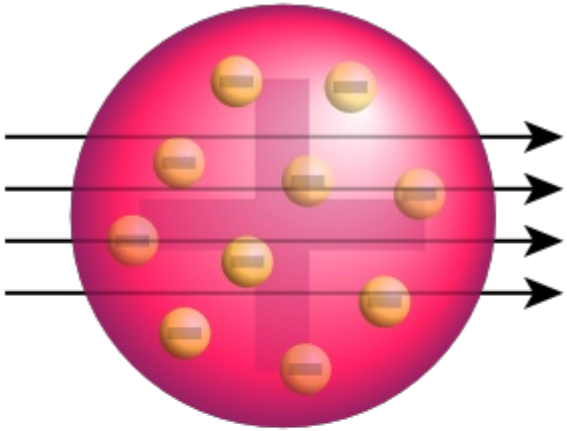
- more complicated than X-rays: alpha and beta decay (new radiation bent in magnetic field
  → radiation must be charged)

- many chemical elements have radioactive isotopes

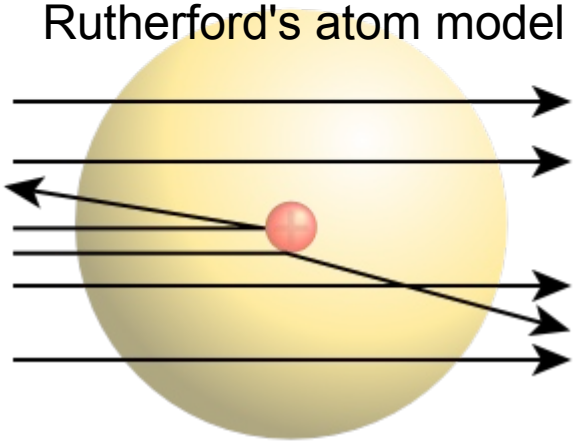

Pierre and Marie Curie

Rutherford's atomic model

Thomson's atom model



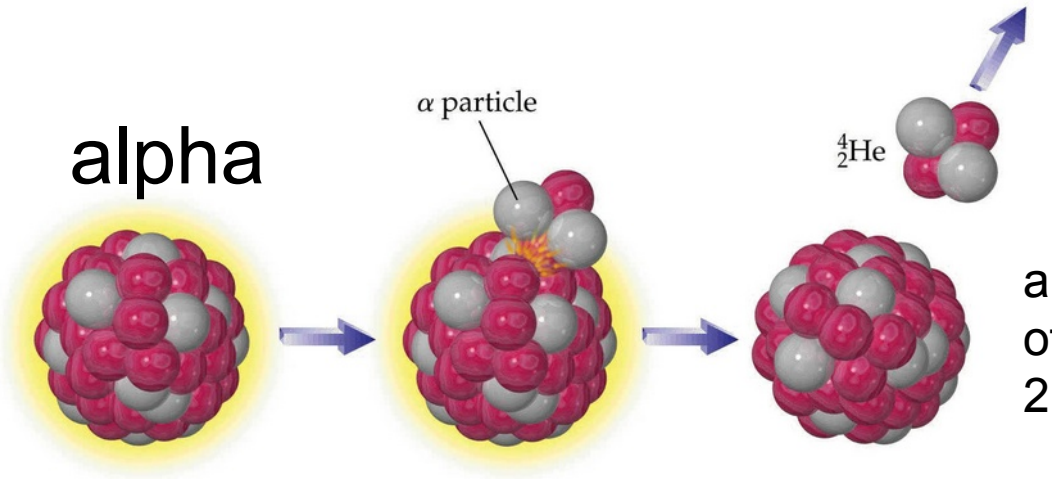
Rutherford's atom model



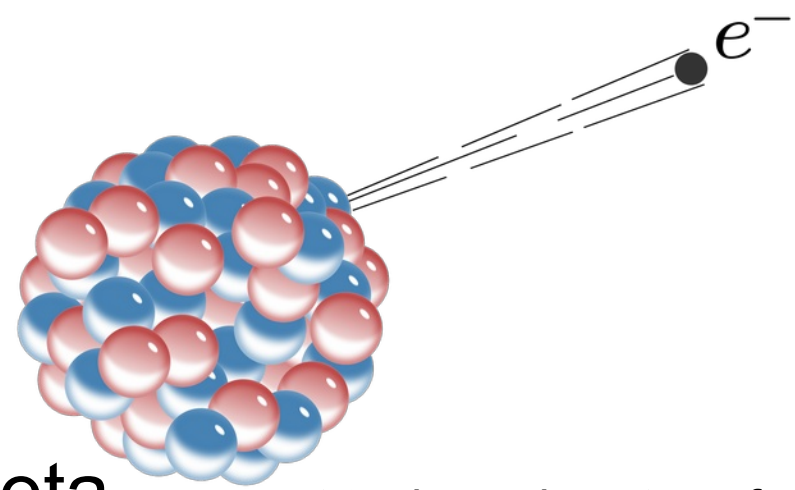
- experiment with alpha particles (from Bismuth-214)
- reflection on platinum plate
  ↔ contradiction that alpha particles cannot be deflected

Radioactive Decay

alpha

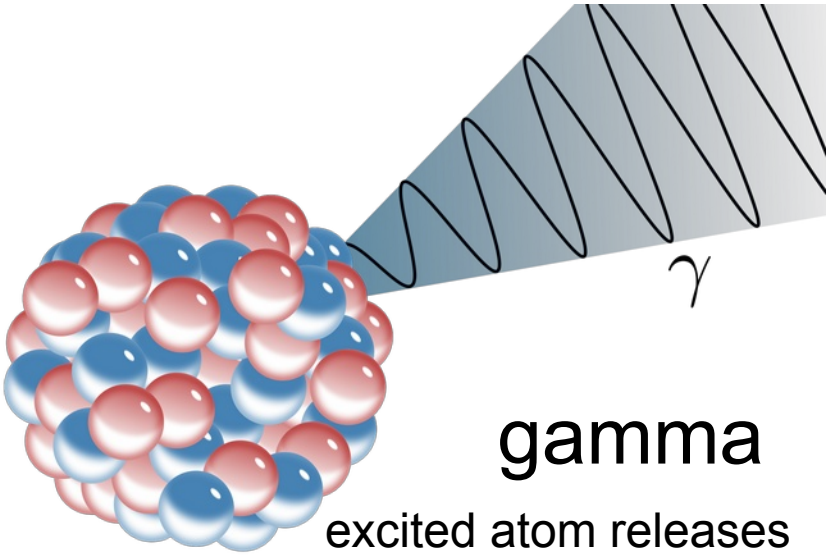


alpha particles “tunnels“ out of the nucleus: consists of 2 proton & 2 neutron



beta

neutron in nucleus transforms to protons and creates an electron in the process

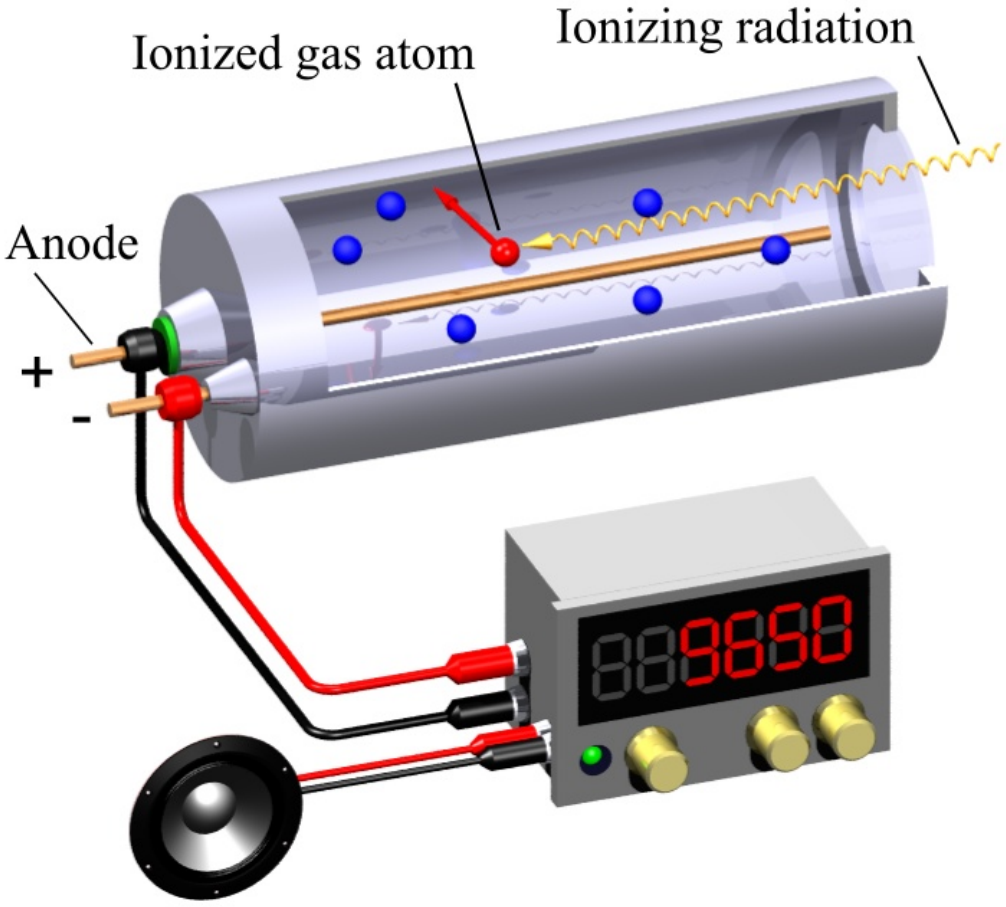


gamma

excited atom releases energy in form of photons to get to the ground state

Geiger-Mueller counter

- filled with an inert gas such as helium, neon, or argon at low pressure
- high voltage is applied between anode wire and surrounding cathode
- tube conducts electrical charge when a particle or photon makes the gas conductive by ionization
- ionization is amplified by avalanche effect (accelerated electrons and ions create more ionization)



Dose

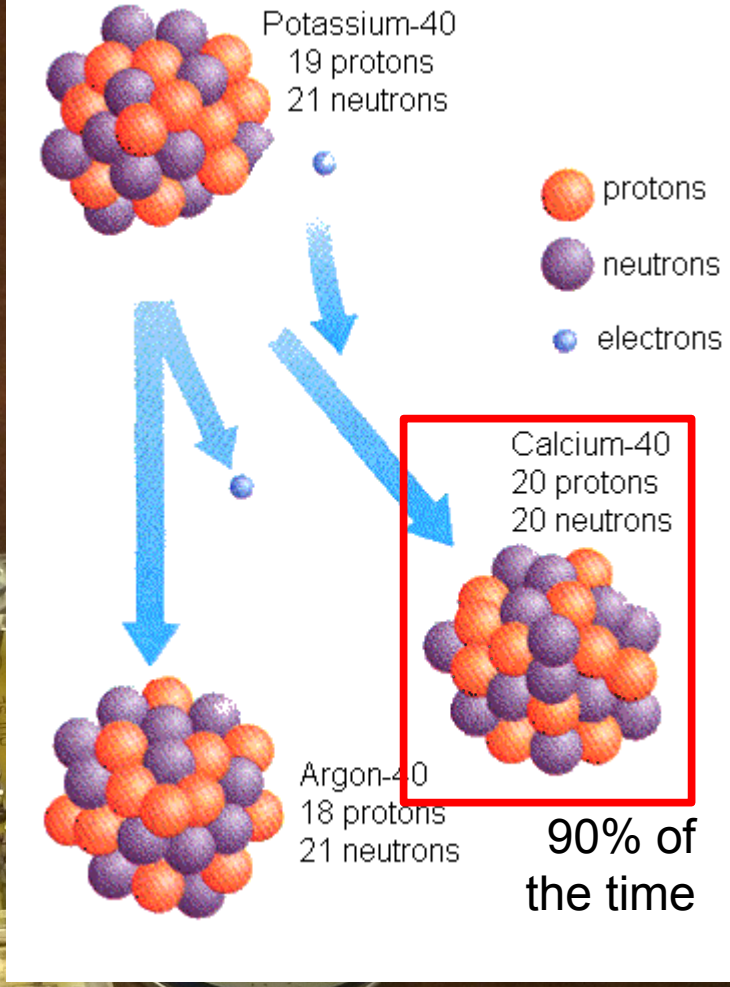
- 0.098μSv: banana equivalent dose
- 0.25μSv: U.S. limit on effective dose from a single airport security screening
- 0.035 to 0.170mSv: full-mouth dental X-rays
- 1.5 to 1.7mSv: annual dose for flight attendants
- 50mSv: occupational dose limit, total effective dose equivalent, per year
- 68mSv: estimated maximum dose to evacuees who lived closest to the Fukushima I nuclear accidents
- 80mSv: 6 months stay on the International Space Station
- 250mSv: 6-month trip to Mars - radiation due to cosmic rays
- 1Sv: Maximum allowed radiation exposure for NASA astronauts over their career
- 4 to 5Sv: Dose required to kill a human with a 50% risk within 30 days (LD50/30), if the dose is received over a very short duration

- 0.27μSv/h: Human exposure to natural background radiation, global average
- 2.7μSv/h: Natural background radiation at airline cruise altitude

Potassium Decay

- ^{40}K is the largest source of natural radioactivity in animals including humans
- 70kg human body contains about 160g of potassium → 0.0187g of ^{40}K

Geiger-Mueller counter



~0.3Hz count rate natural background
~1.0Hz count rate with nu-salt

Geiger Counter

- Take the Geiger counter
- Connect USB cable to Raspberry Pi
- Turn Geiger Counter on
- Commands in the terminal:

make

cd ~/code/geiger

./geiger /dev/ttyUSB0