# HIGGS

# HIgh school students in proGramminG and Sciences

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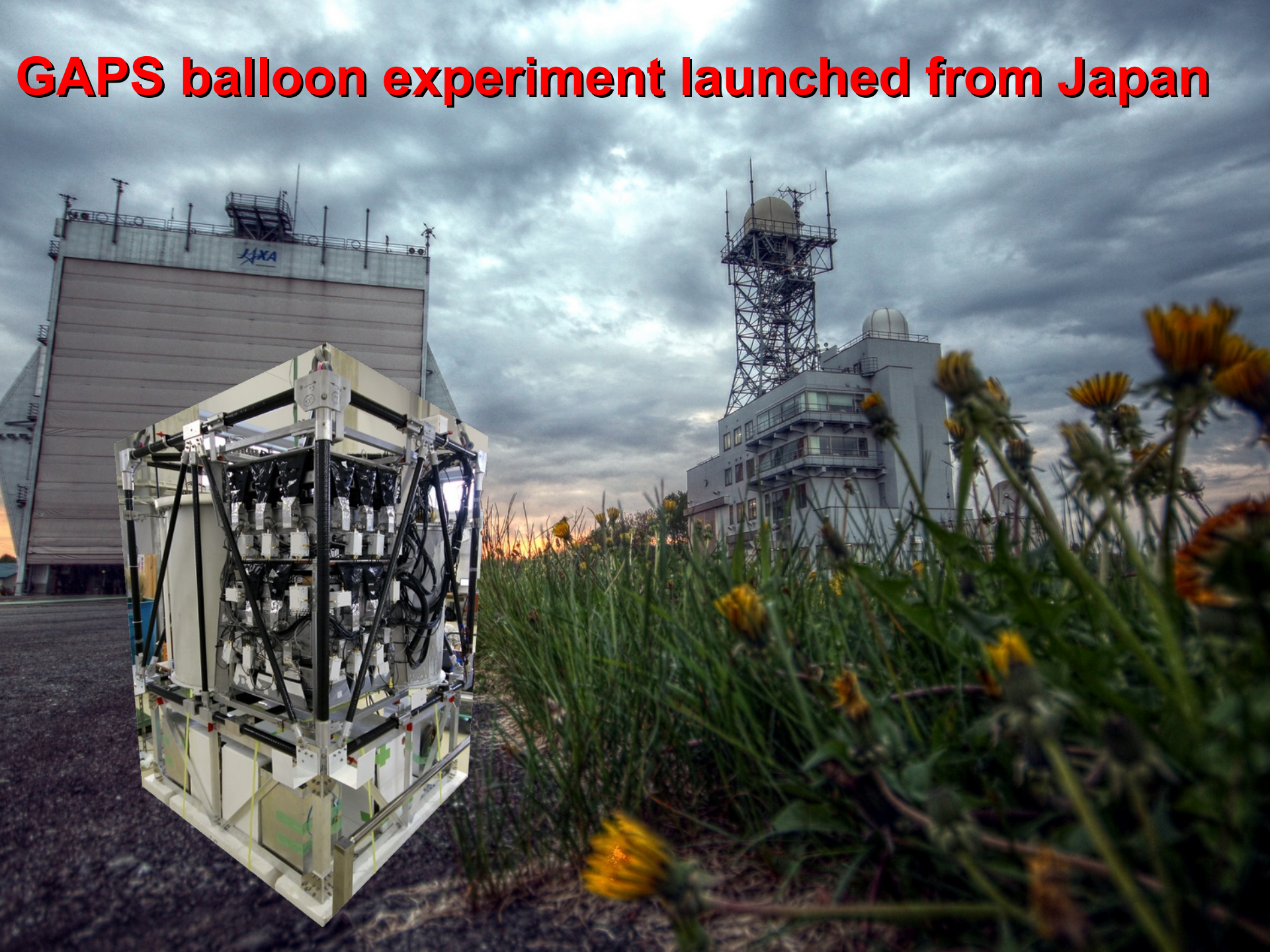
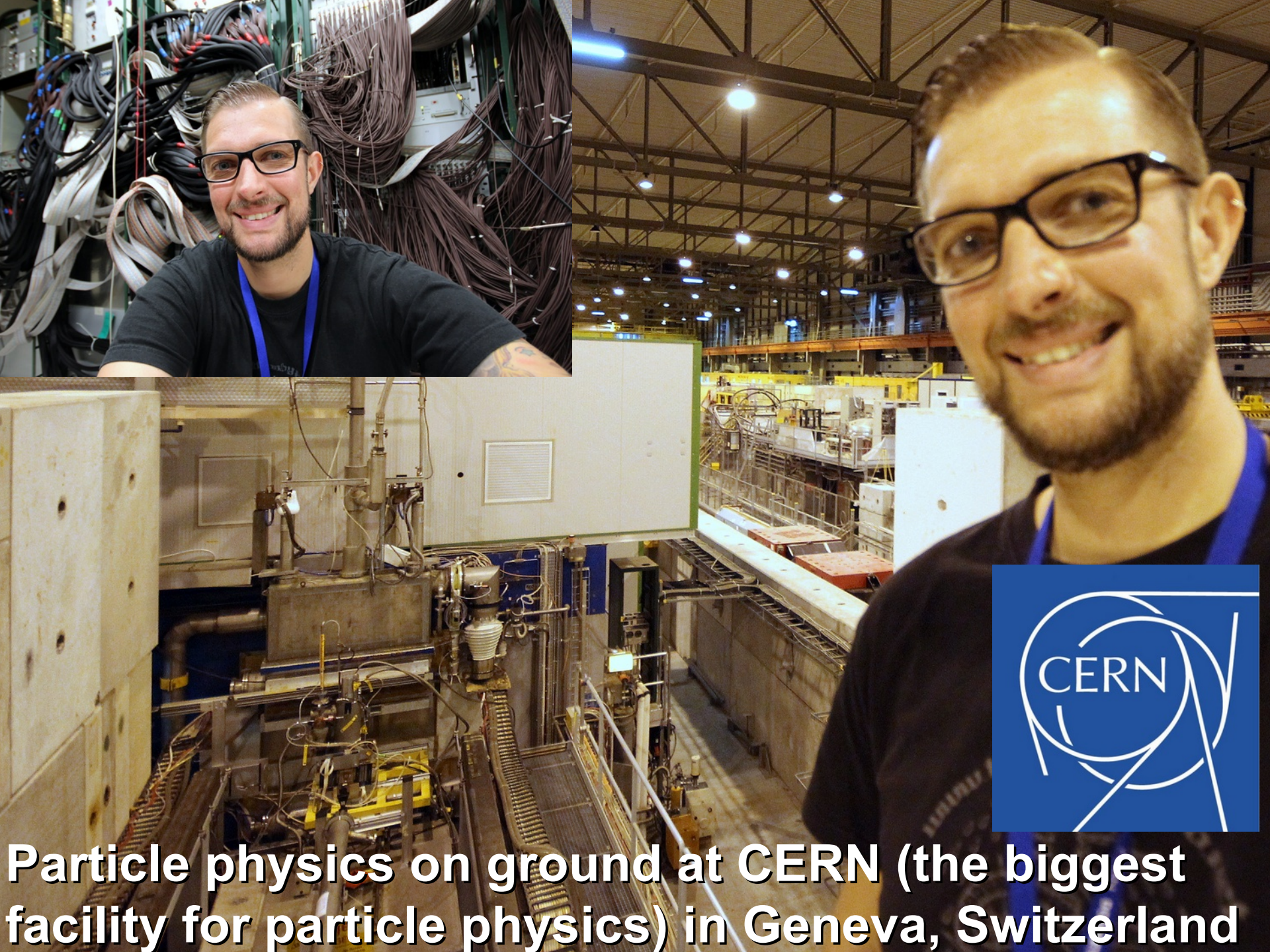
**What got me started to become a physicist?**
**Earth is so small → What is out there?**

# 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)

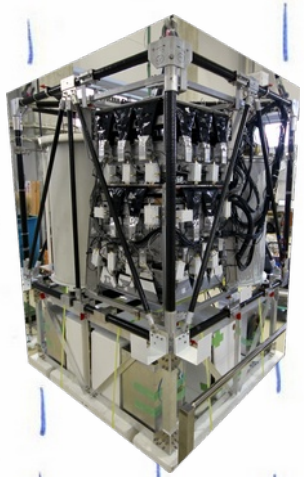
Studying these elementary constituents of matter in space tells us about our stars, Galaxy, dark matter, fundamental laws of nature

# 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!***

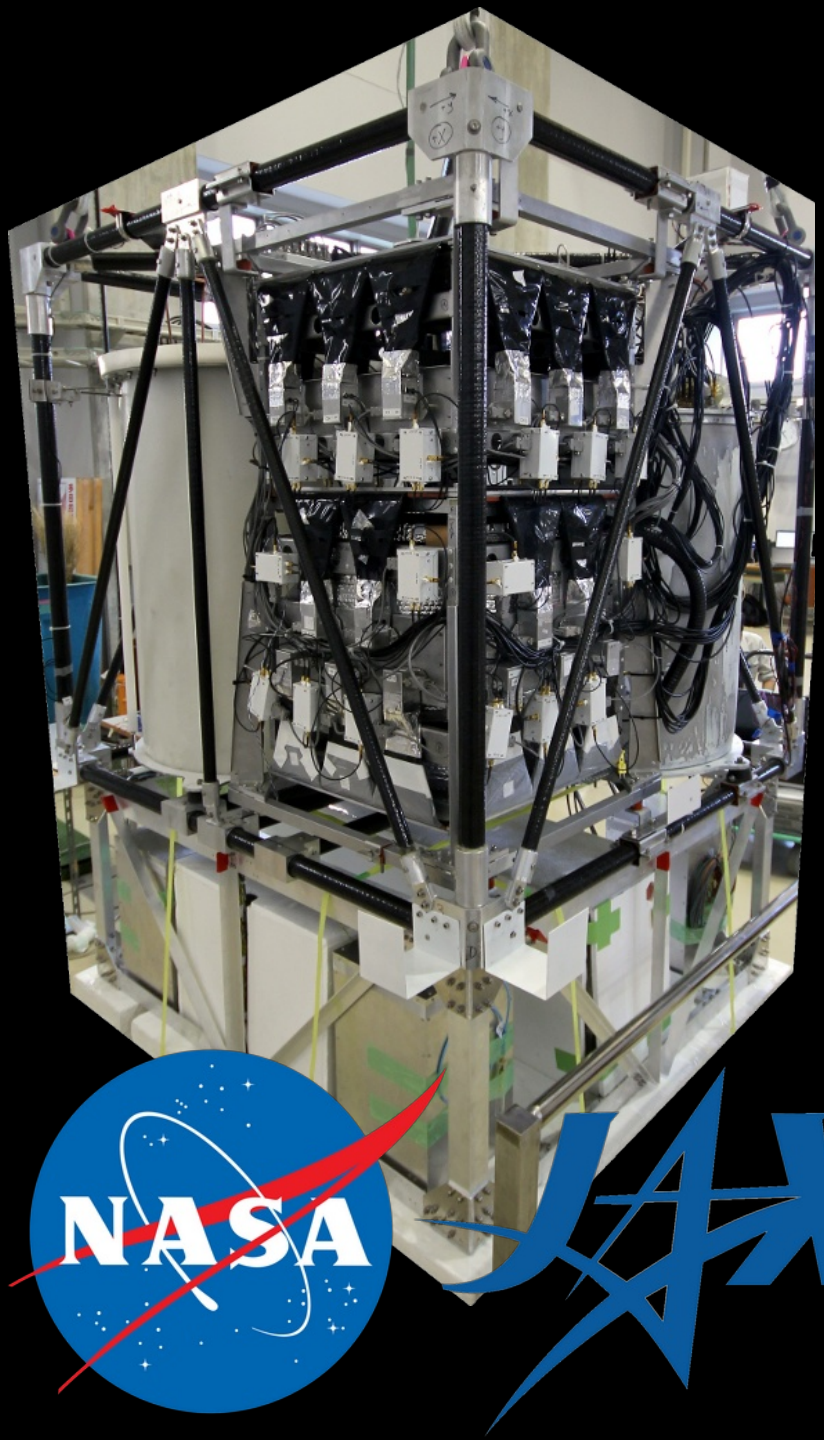
***Space is great, but super expensive ($1,000,000 for 2lbs)***

**use balloons**

**that go up very very high**

**→ 25 miles above ground**

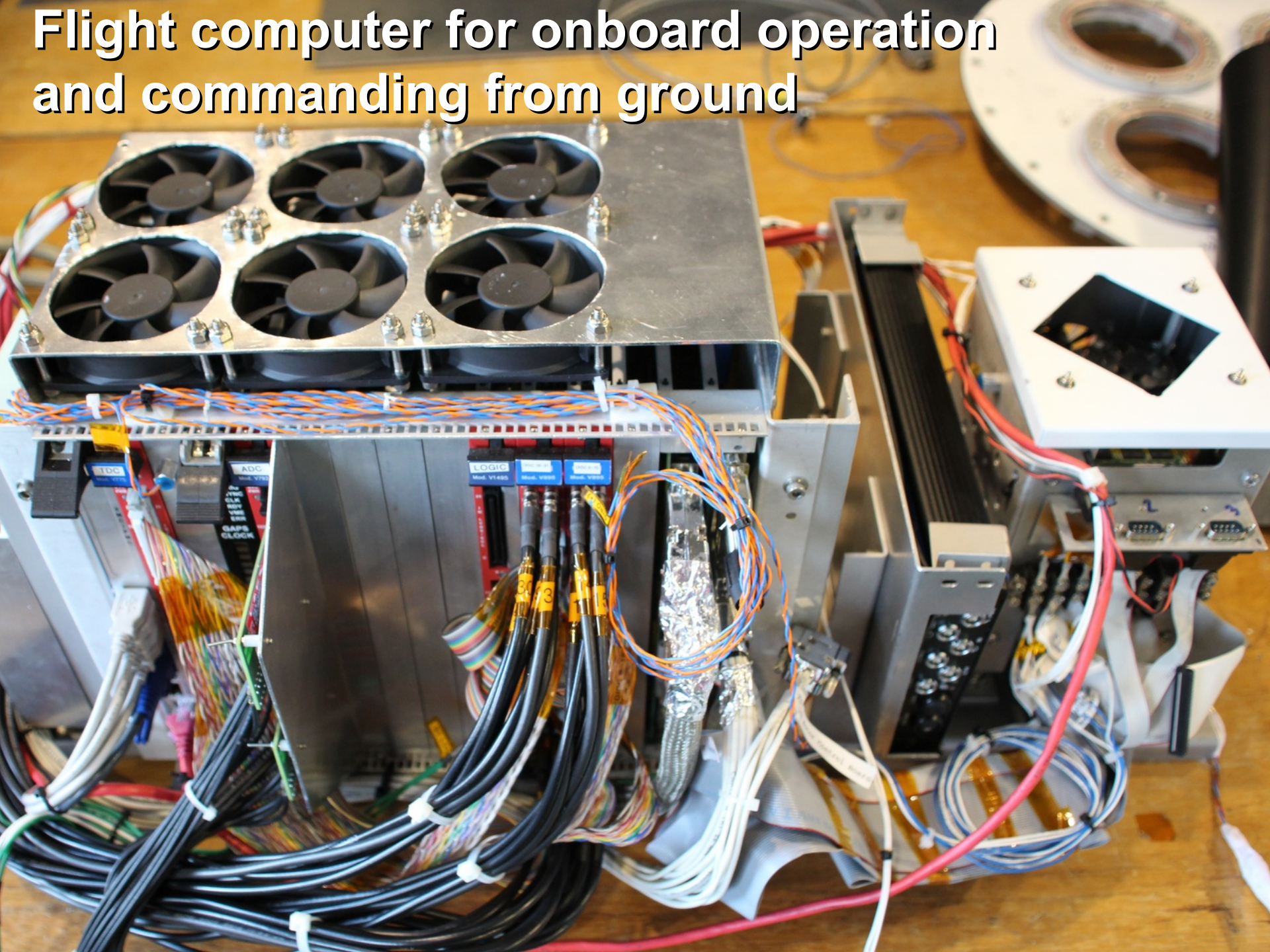
GAPS
GENERAL ANTIPARTICLE SPECTROMETER
NASA • JAXA



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

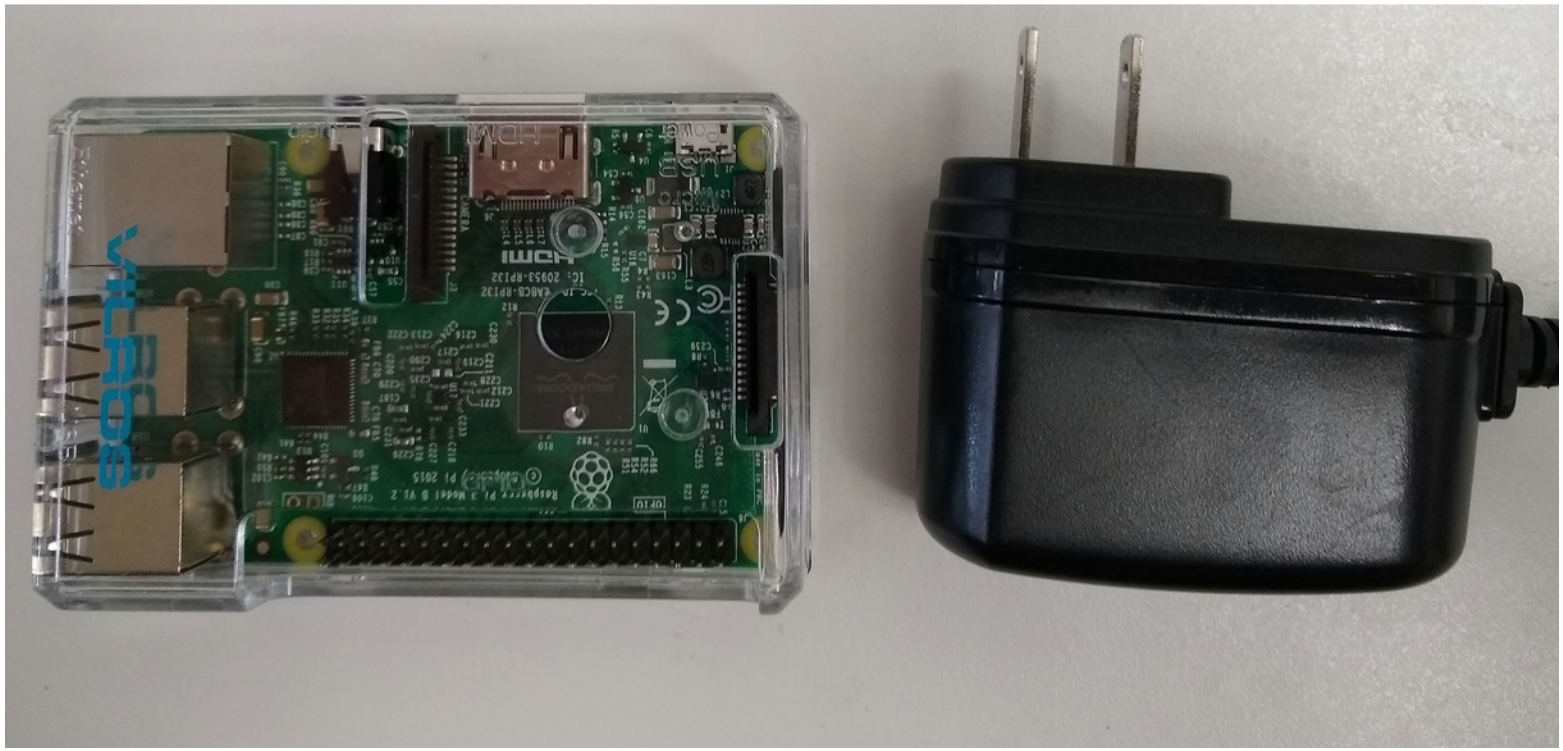
***Playground for big kids***

# 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**



# 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)>*

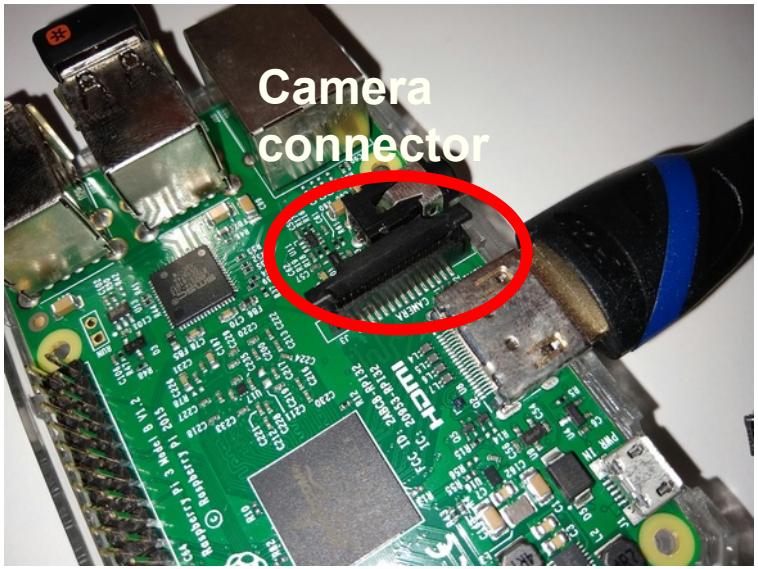
- Change into a directory:

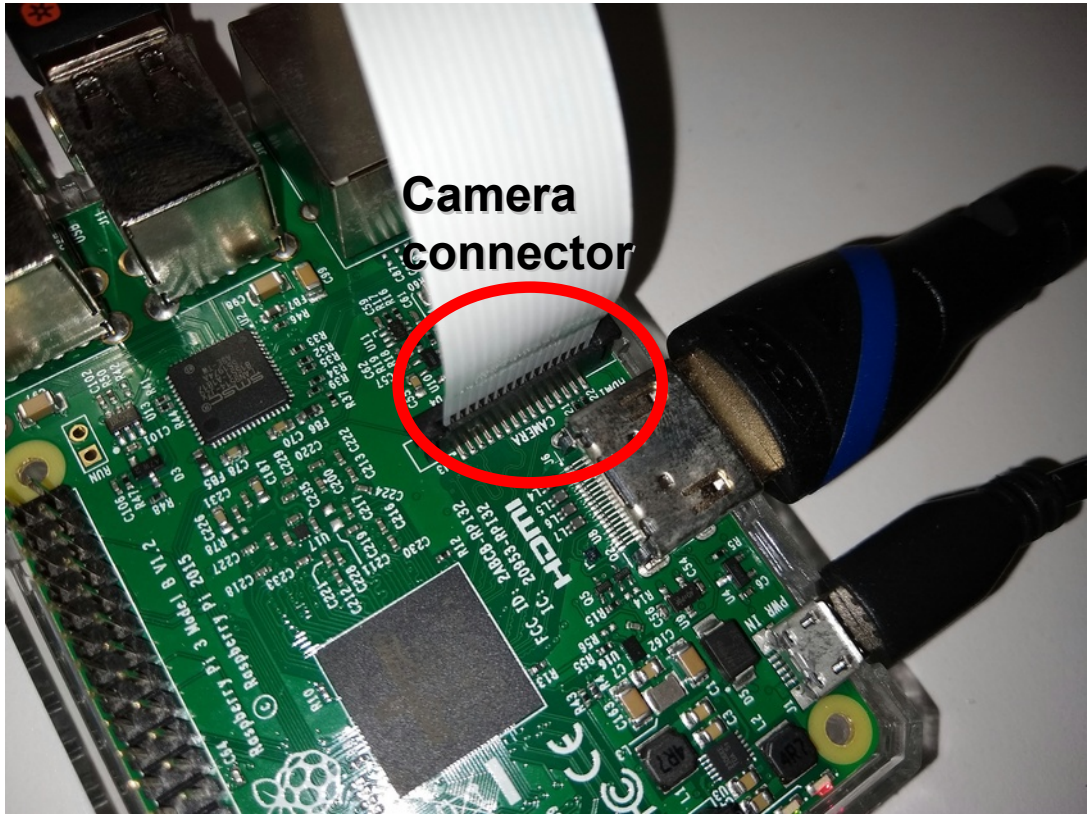
  *cd <name of directory>*

- 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>*

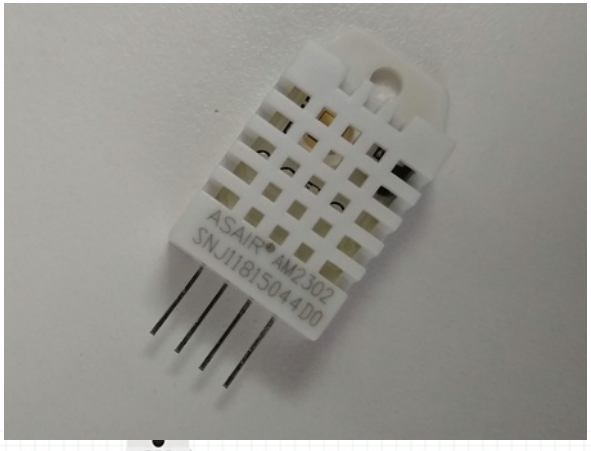
  - For watching videos:

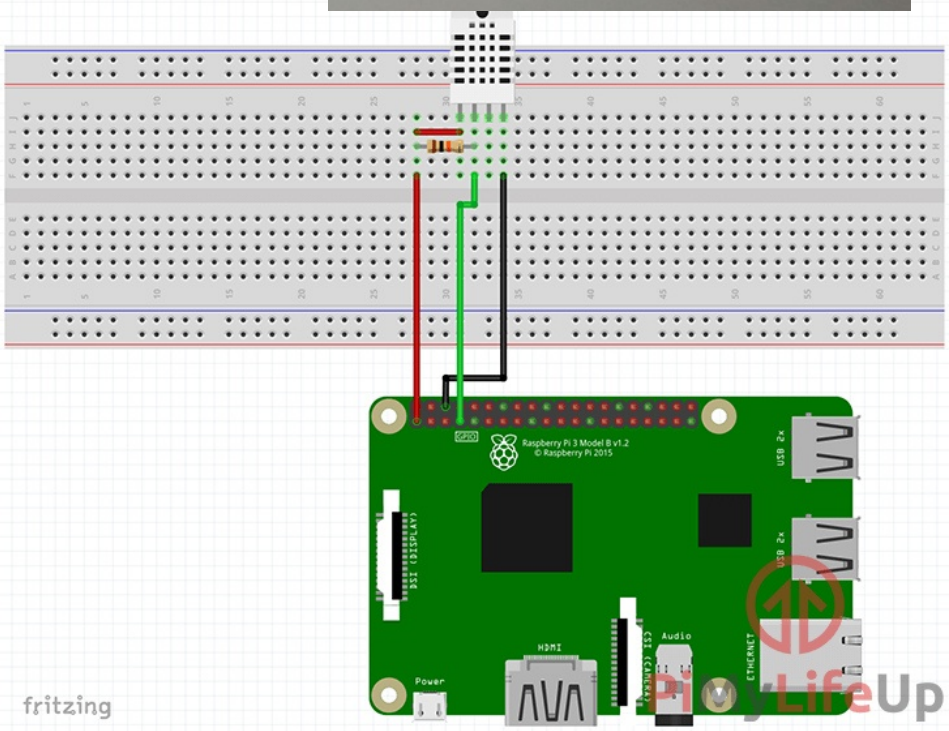
    *omxplayer video.3g2*

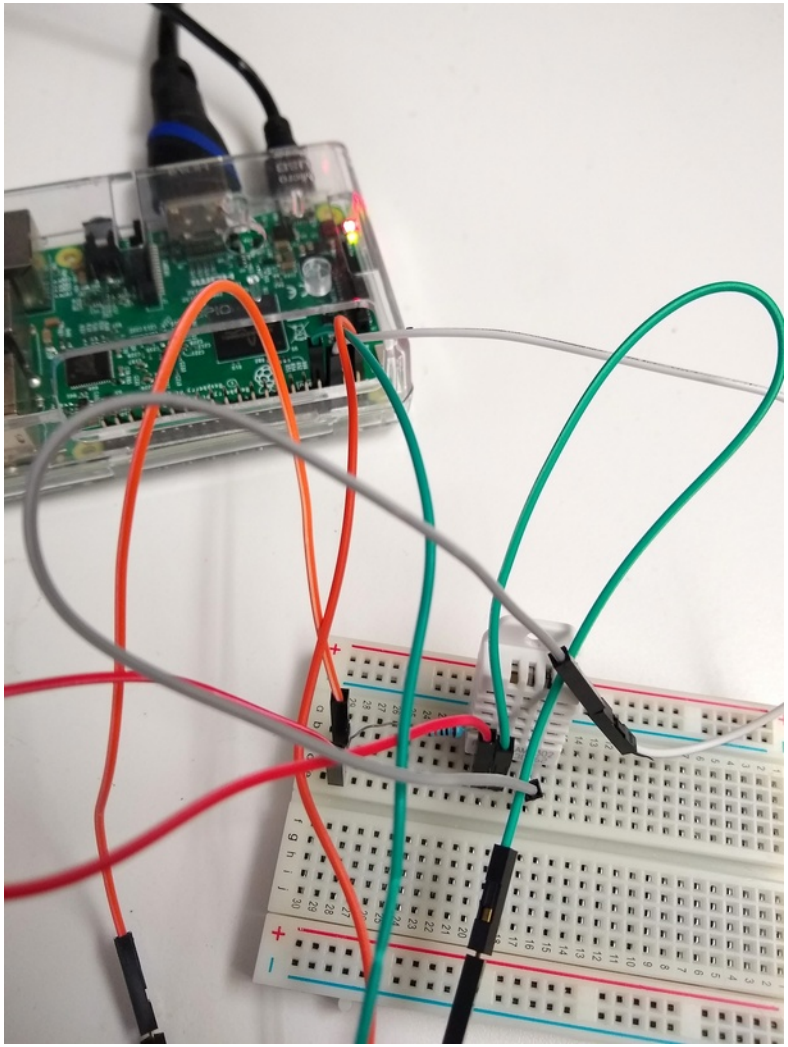
**Shutdown computer before installing camera**

# Temperature Sensor

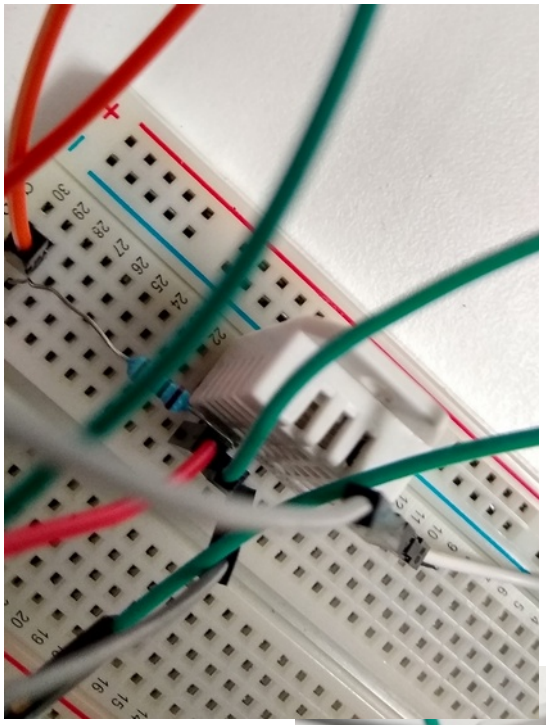
Shutdown computer before installing temperature sensor

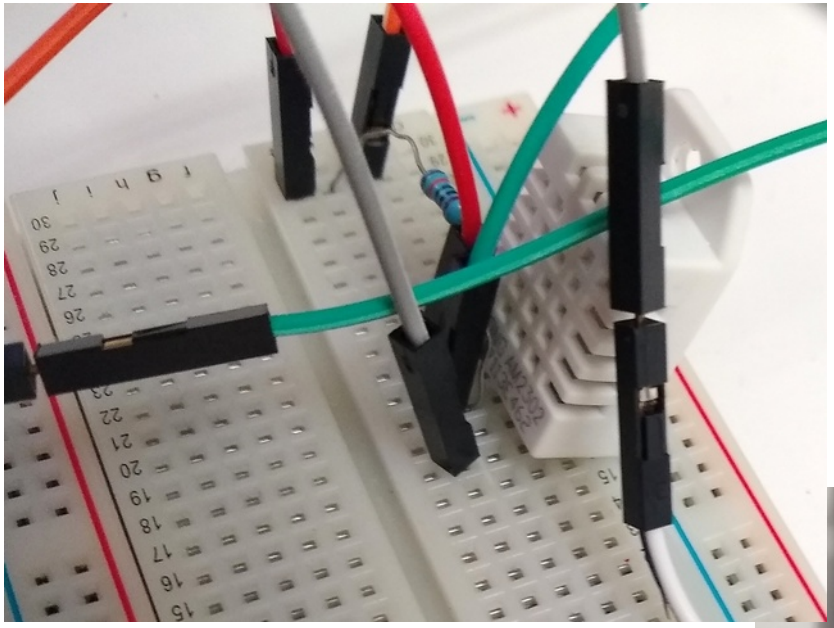


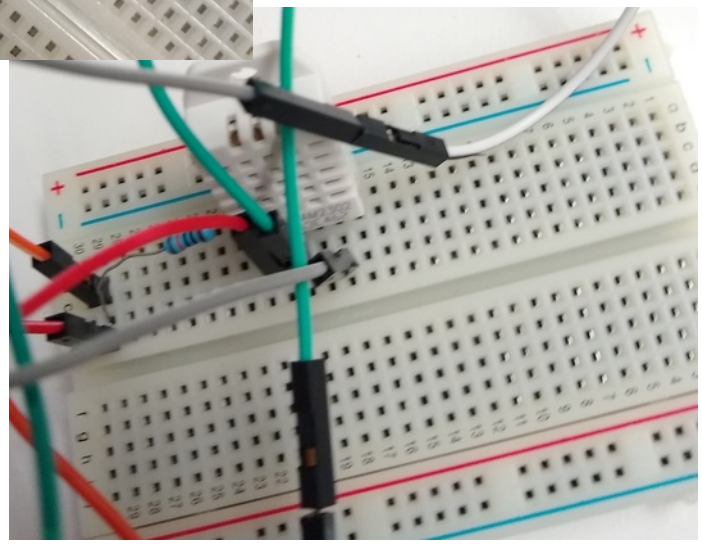



# Temperature Sensor







# Temperature Sensor

- Terminal commands:

  *cd*

  *cd code/temp*

  *g++ -o dht22 dht22.cpp -lwiringPi*

  *sudo ./dht22*

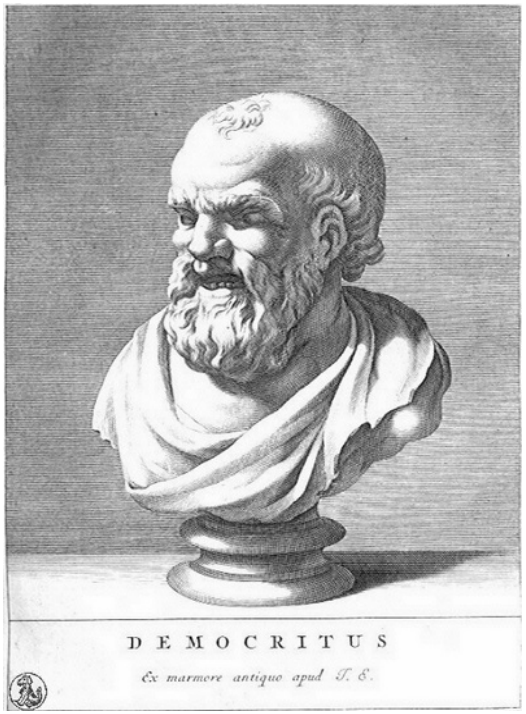
- Stop measurement by press *ctrl*+*c* at the same time

# 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**

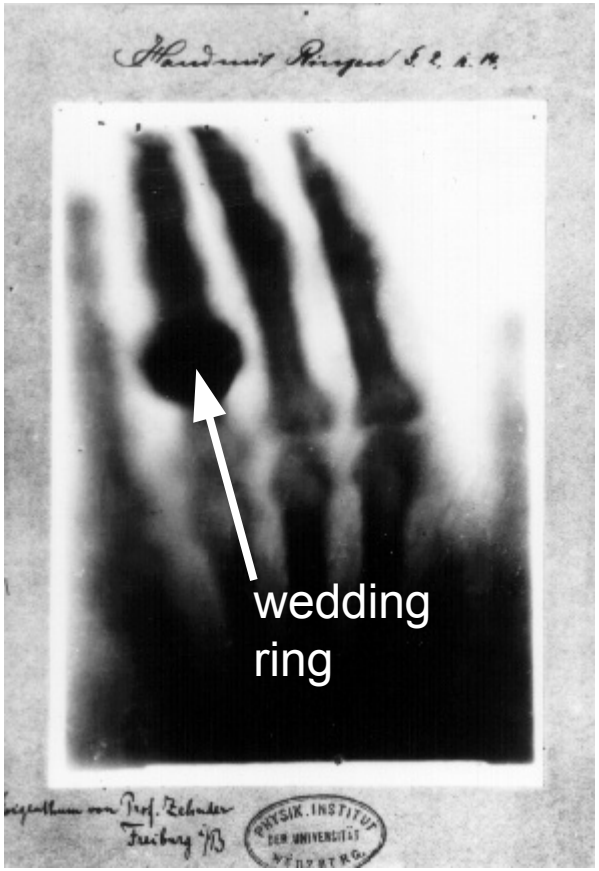
# X-rays

- 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

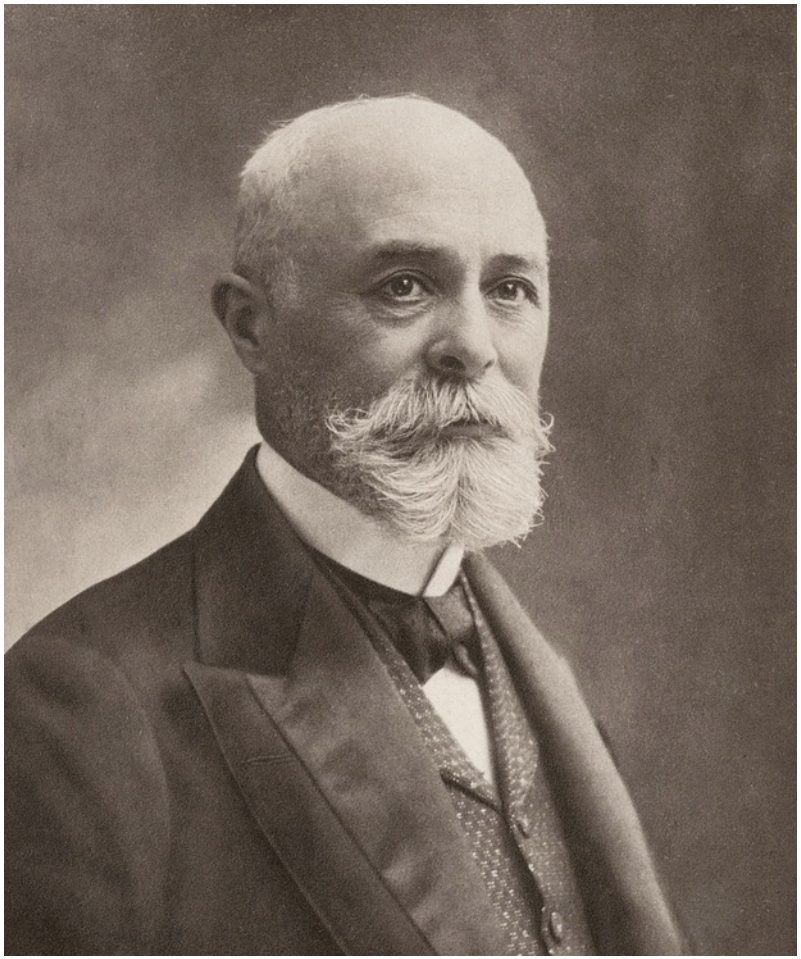
- 1901 first Nobel Prize in physics



# 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



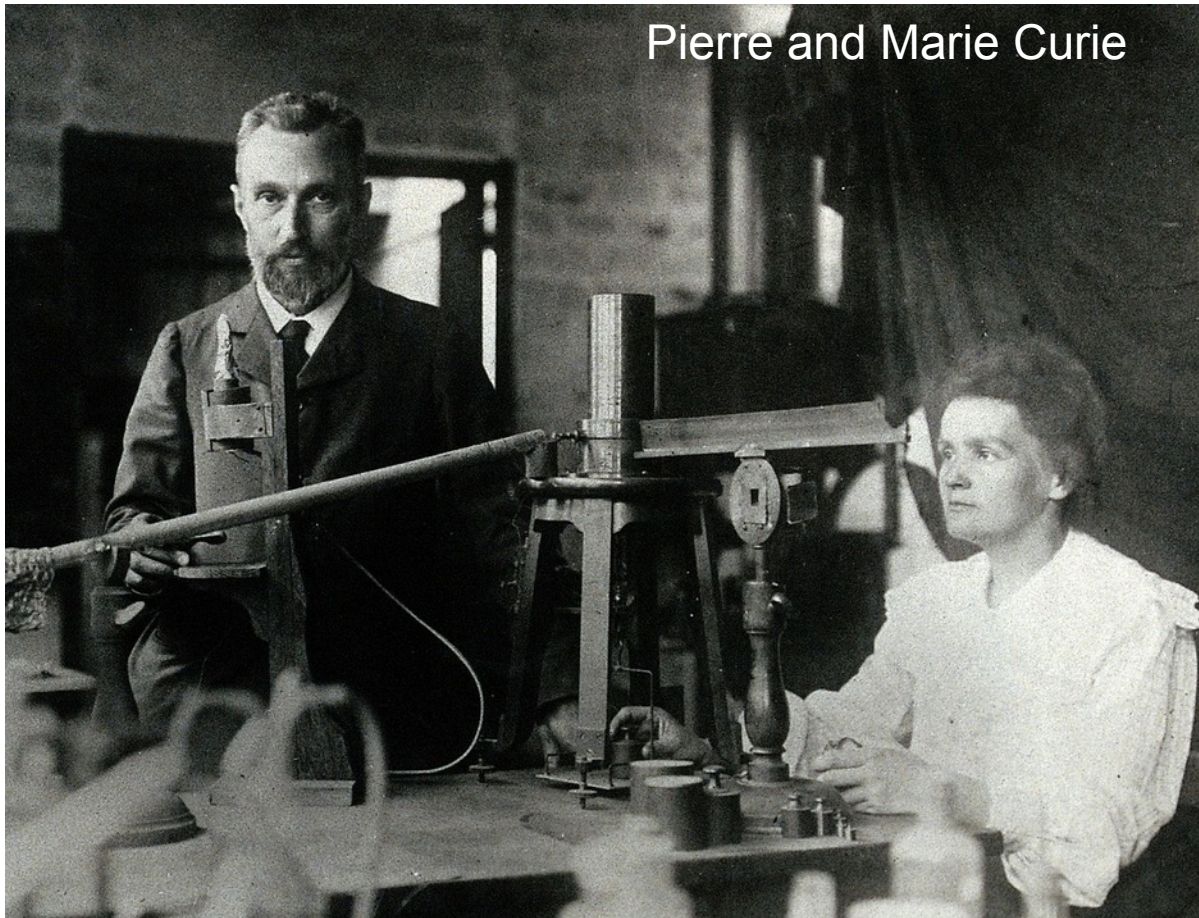
Antoine Henri Becquerel (1852-1908)

# 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

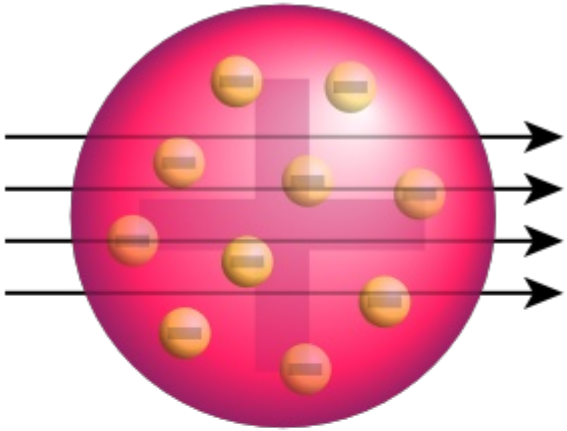
- more complicated than X-rays: alpha and beta decay (new radiation bent in magnetic field
  → radiation must be charged)

- many chemical elements have radioactive isotopes

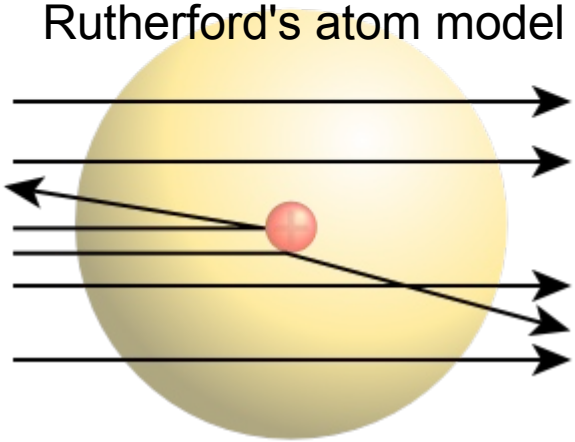

Pierre and Marie Curie

# Rutherford's atomic model

Thomson's atom model



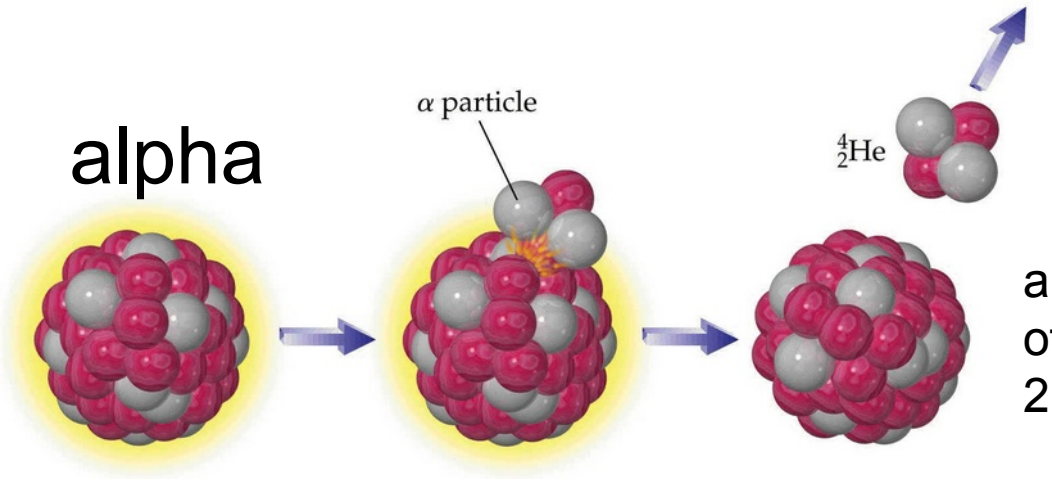
Rutherford's atom model



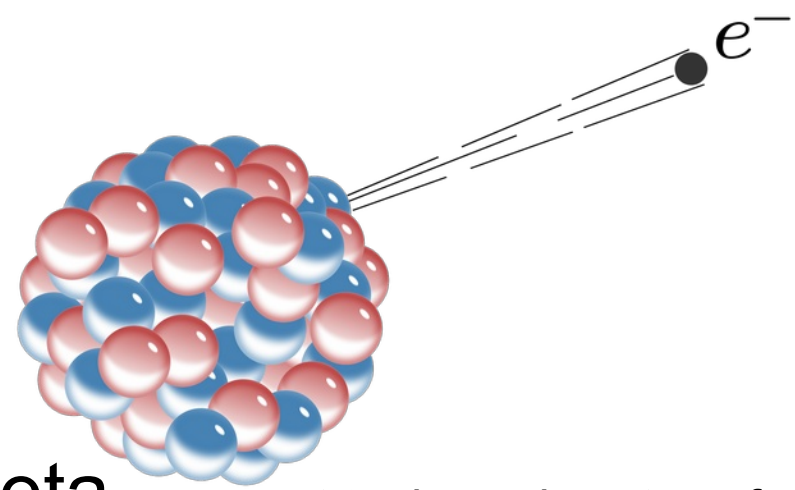
- experiment with alpha particles (from Bismuth-214)
- reflection on platinum plate
  ↔ contradiction that alpha particles cannot be deflected

# Radioactive Decay

alpha

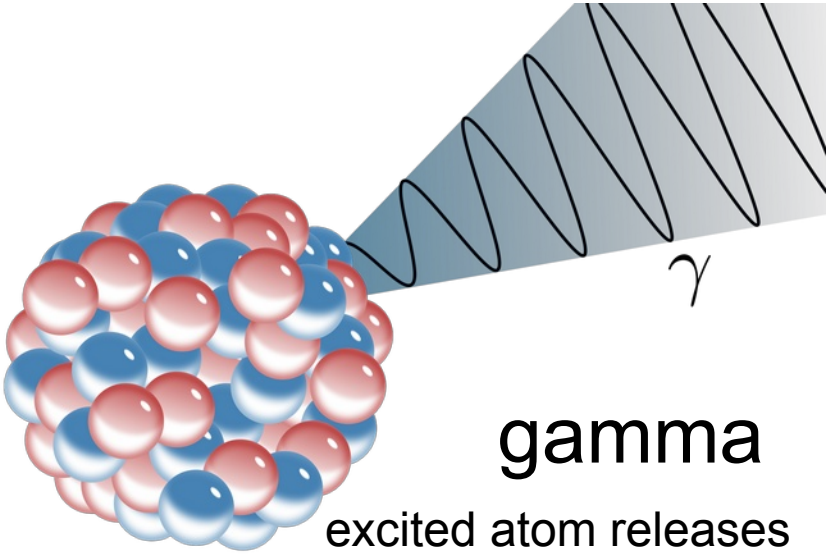



alpha particles “tunnels“ out of the nucleus: consists of 2 proton & 2 neutron




beta

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

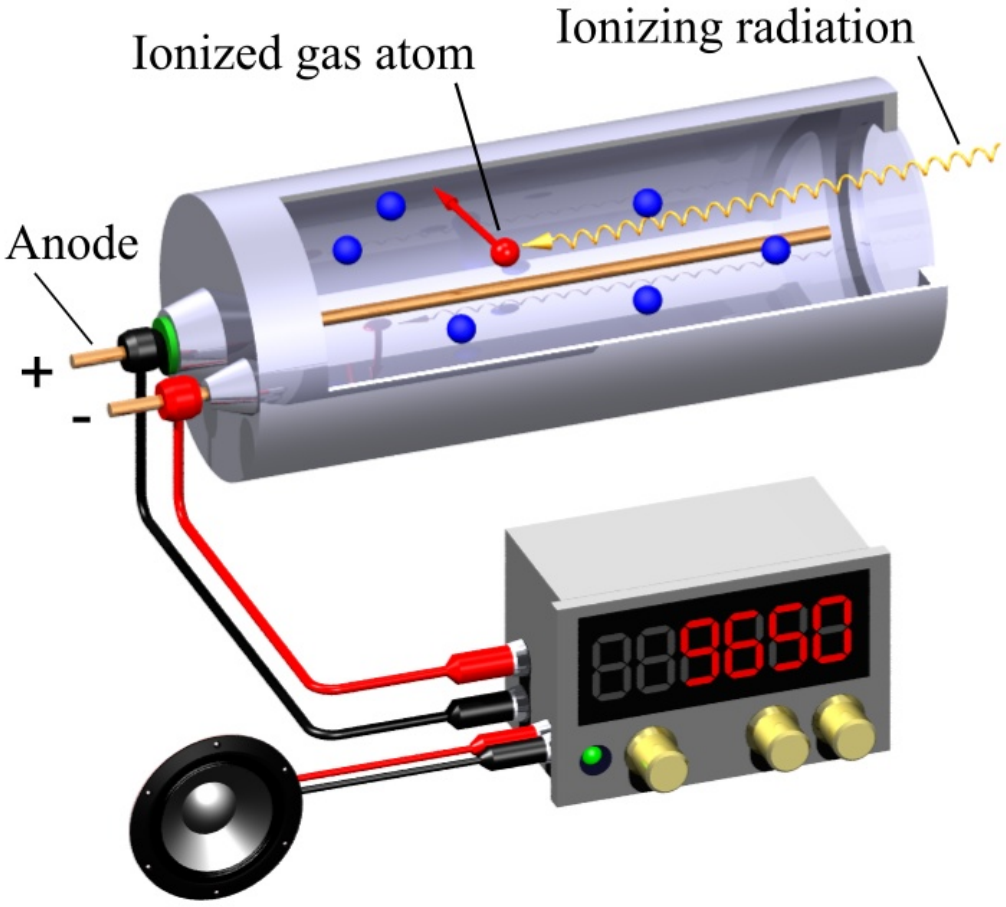



gamma

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)



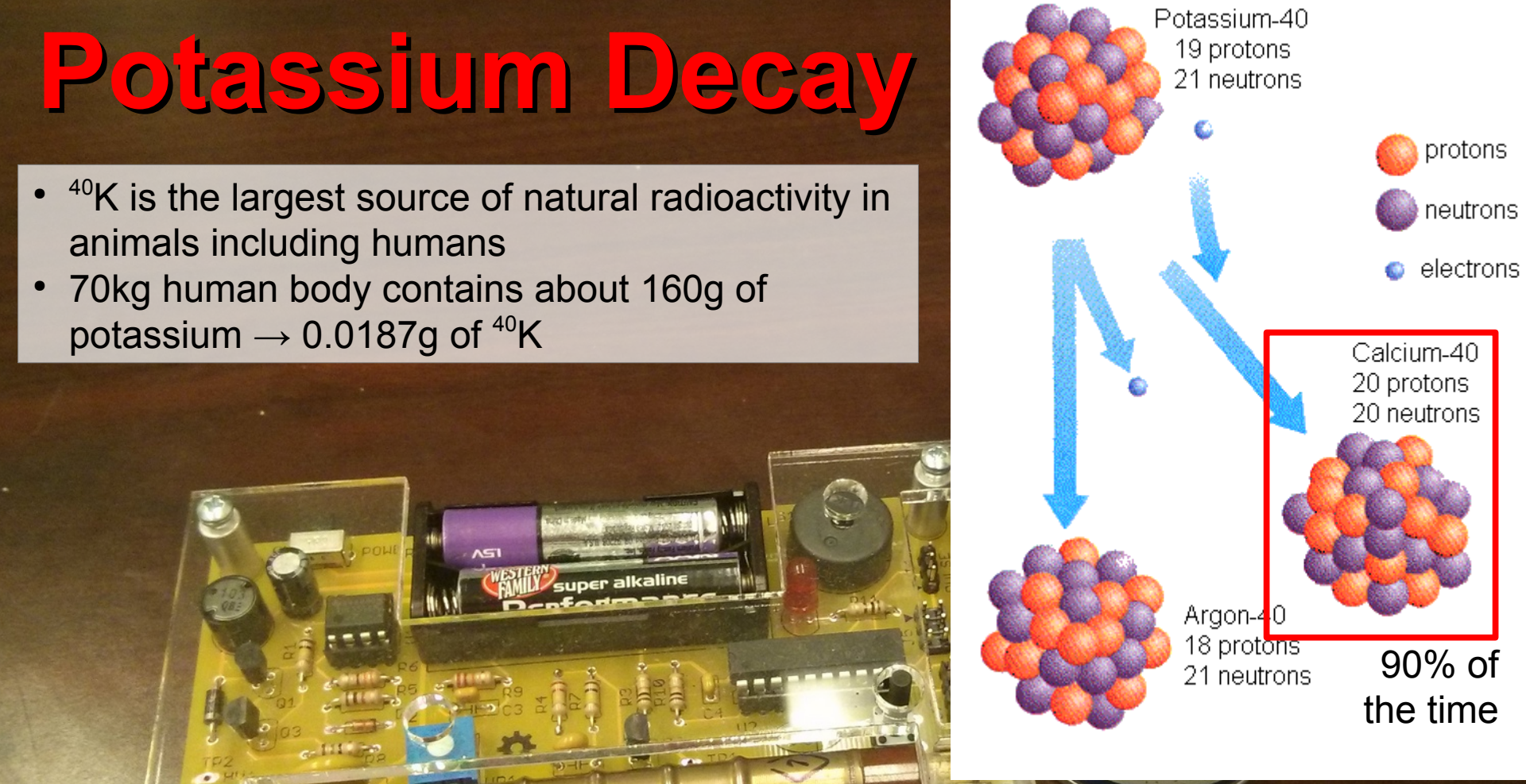
# Dose

- 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*