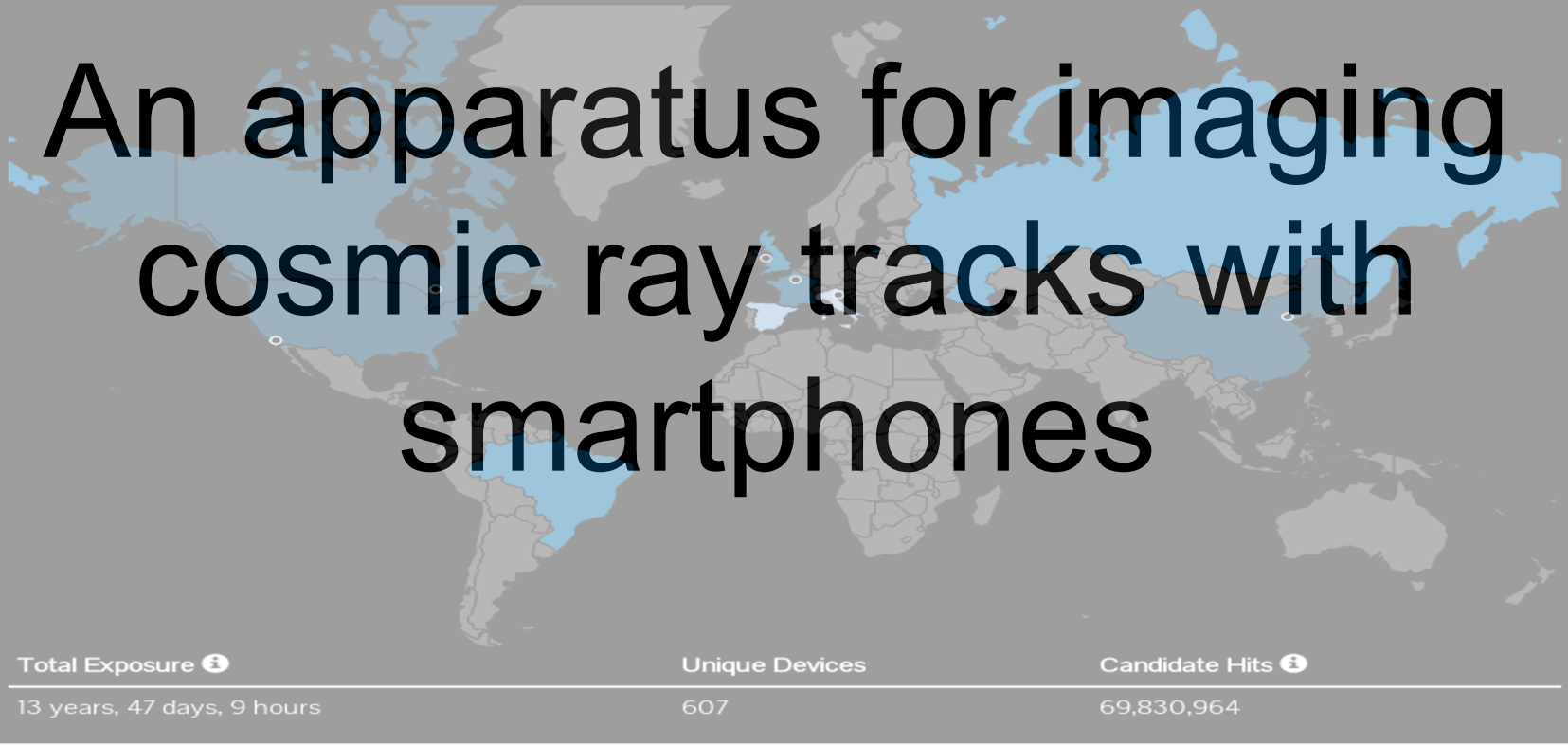
An apparatus for imaging cosmic ray tracks with smartphones



Total Exposure	Unique Devices	Candidate Hits
13 years, 47 days, 9 hours	607	69,830,964

A hobby physics software & hardware project by
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New York University
2017

High energy cosmic rays detection

- When cosmic rays strike the atmosphere, they produce extensive air showers
- The very high-energy cosmic rays (energy $> 10^{18}$ eV) are the rarest, with a flux of $\frac{1}{\mathrm{km}^2 \times 100\ \mathrm{years}}$

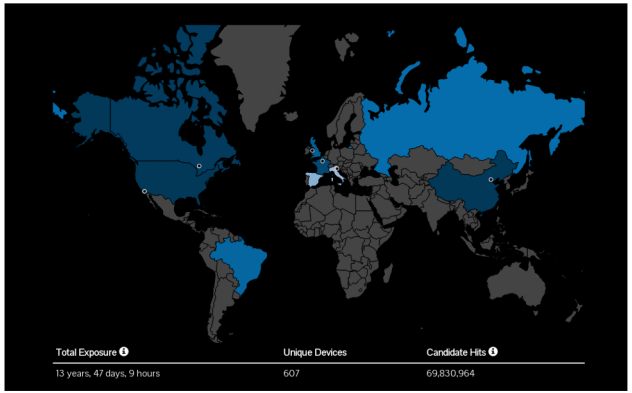
➡️ To detect them, we need a detector with very large surface area! How?

Artistic rendition of cosmic ray showers

The Crayfis project

- A citizen science project
- Uses the world-wide array of existing smartphones:
  - Camera CCD sensors as detector
  - GPS provides detection location
  - Data is uploaded through wi-fi
- Observes cosmic ray particles at the highest energies
- Is in beta testing (you can be a beta tester!)

CRAYFIS
cosmic rays found in smartphones



World wide test users map
(https://crayfis.io)

How to use the app to image cosmic rays?

Why? Collecting image data and science demo

Sequence of events:

🆕 Cosmic ray enters cloud chamber, leaving bright track

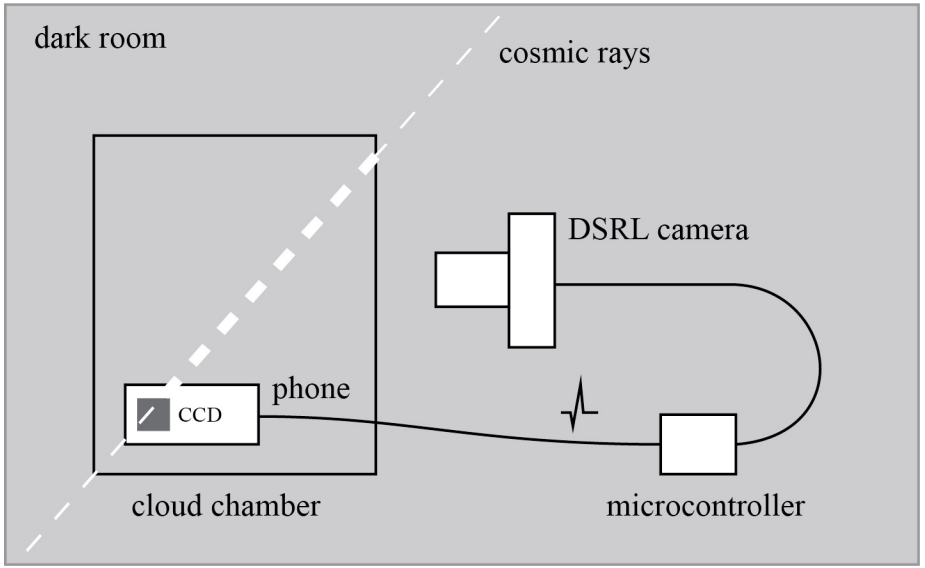
➡️ (If) ray hits CCD

➡️ App sends a pulse to microcontroller

➡️ Microcontroller amplifies the pulse and sends it to camera

➡️ Camera takes a picture

➡️ All must happen within a fraction of a second

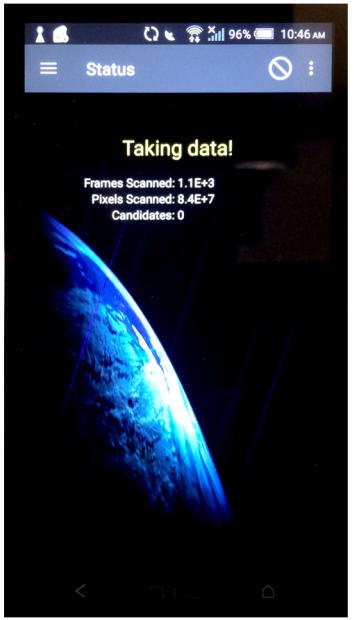


Experiment diagram. The cosmic ray creates a bright track in chamber

Software workflow

- Pulling source code from project on GitHub
- Learning Java and Android apps development
- Modify the source code to send out a pulse at detection

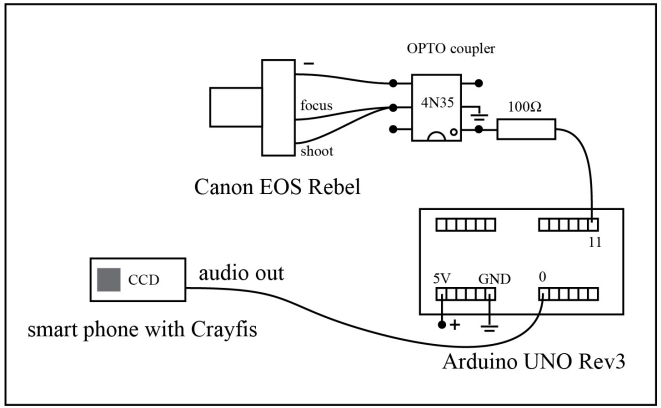
- Test and debug
- Create a pull request



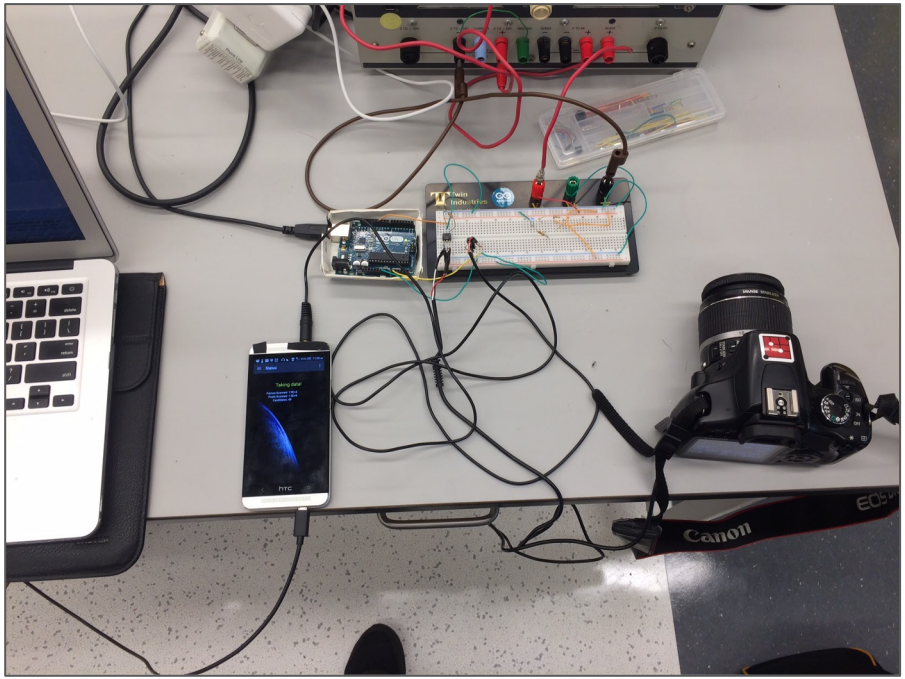
The Android GUI

Electronics

- Use a 16 MHz Arduino Microcontroller
- Input: audio pulse from phone
- Output: trigger signal to DSLR camera



Wiring diagram



The electronics

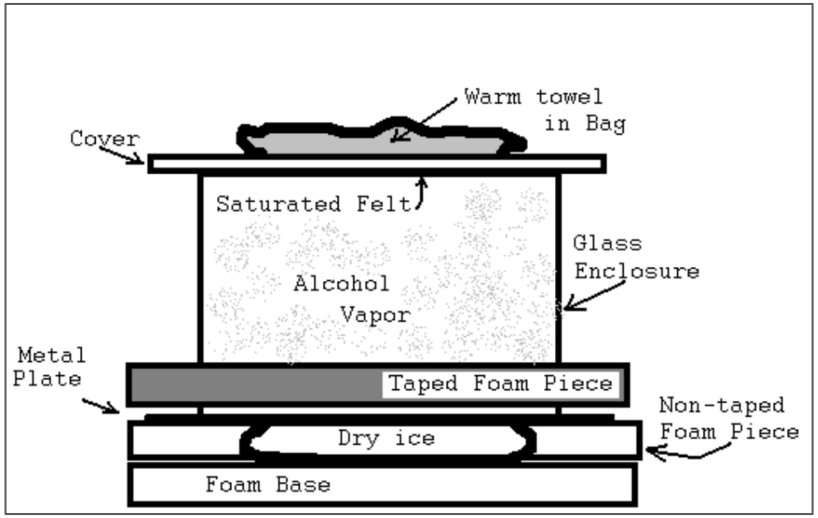
The cloud chamber: The most difficult part

Working principle:

- Contains supersaturated alcohol vapor
- Traveling charged particles ionize a path of alcohol molecules.

➡️ alcohol condensation

➡️ visible particle track

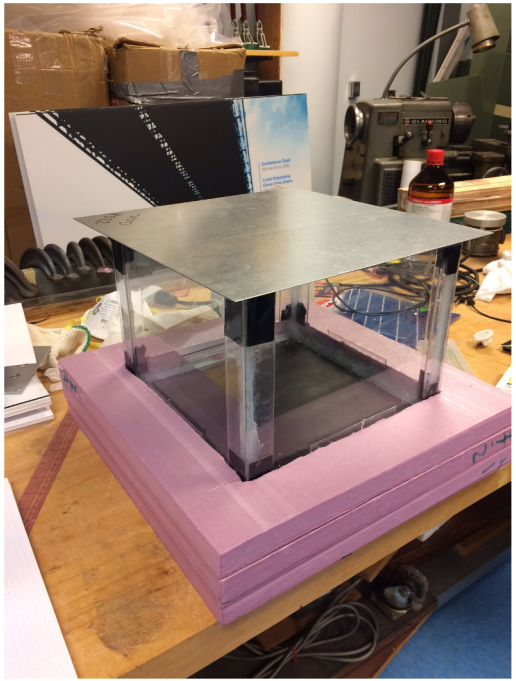


Cloud chamber design
(25 x 25 x 20 cm)

Chamber parts, total cost ~ $300

Items			
#	Description	Quantity/Size	Supplier and Approx Cost
1	Galvanized steel plate, 22 gauge or thinner	One 12" x 12" sheet, from 12" x 24" split in two	Local hardware $10.00
2	Sheet ¾"-thick insulating foam. (Try to find the kind that doesn't flake into bits.)	Enough to make three 15" x 15" square pieces	Local hardware $7.00
3	Aquarium sealant (100% silicone)	Two standard-sized tubes	Local hardware $6.50 x 2
4	Disposable thin rubber gloves, for smoothing the silicone sealant	One pair	Local hardware $2.00
5	Double stick tape	One roll (~20")	Local hardware $3.00
6	Clear plastic corner guard with sticky strip	Two 4-foot pieces	Local hardware $3.00 x 2
7	Heavy-duty scouring pad	One	Local hardware $4.00
8	Black duct tape (Flat black is best if you can find it.)	One roll	Local hardware $6.50
9	Black felt	One square 12" x 12"; extra can be used to help block ambient light.	Local fabric store $4.00
10	Wood shims (Paint stirrers work fine.)	Four	Local hardware $0.00
11	Flat black spray paint or primer	One can	LustreKote® or Zynolyte® $12.00
12	Terry-cloth hand towel and 1-gallon Zip-loc® bag	One	Supply cabinet
13	Isopropyl or ethyl alcohol, 200 proof (100%)	~6 ounces	Chemistry supply cupboard
14	Precut picture glass	Four 8" x 10" pieces; one 12" x 12" piece	Local hardware ~$15.00
15	Optional: large shop lamp with spring clamp	8 ½" diameter; 30-watt bulb	Local hardware
16	Dry ice	Slab ~1-inch thick, ~10" x 10" (or equivalent volume); also may have to use chips or pellets.	Meijer®, local butcher shops or ice creameries $15.00

The shopping list



The built chamber

Results

- Software: successful!
- Electronics: successful!
- Cloud chamber: mostly successful

May be the location wasn’t great (lower floor, with a lot of concrete above)

Improvements:

- Cloud chamber needs to be more stable
- Adjust light to get better pictures

A captured cosmic ray track