What Satellites See: Eyes Above the Skies

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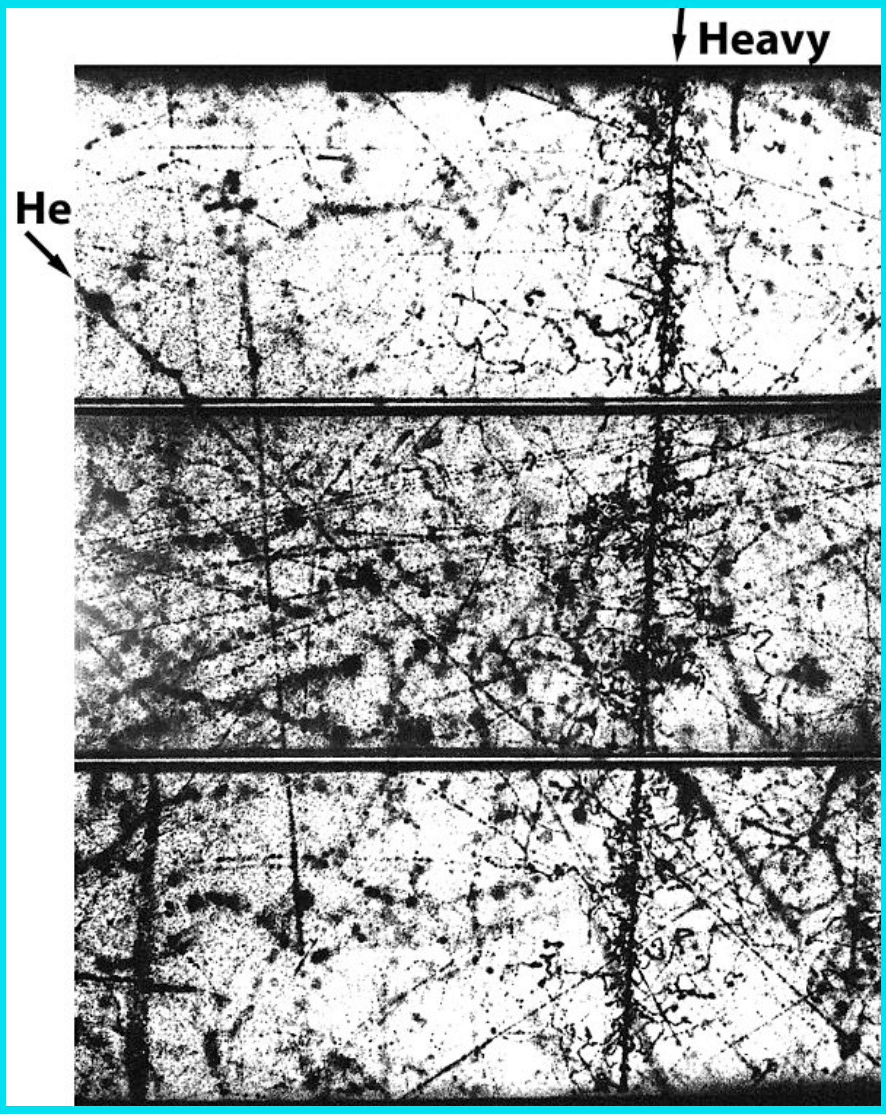
Wind Crest Learners
Academy for Lifelong Learning

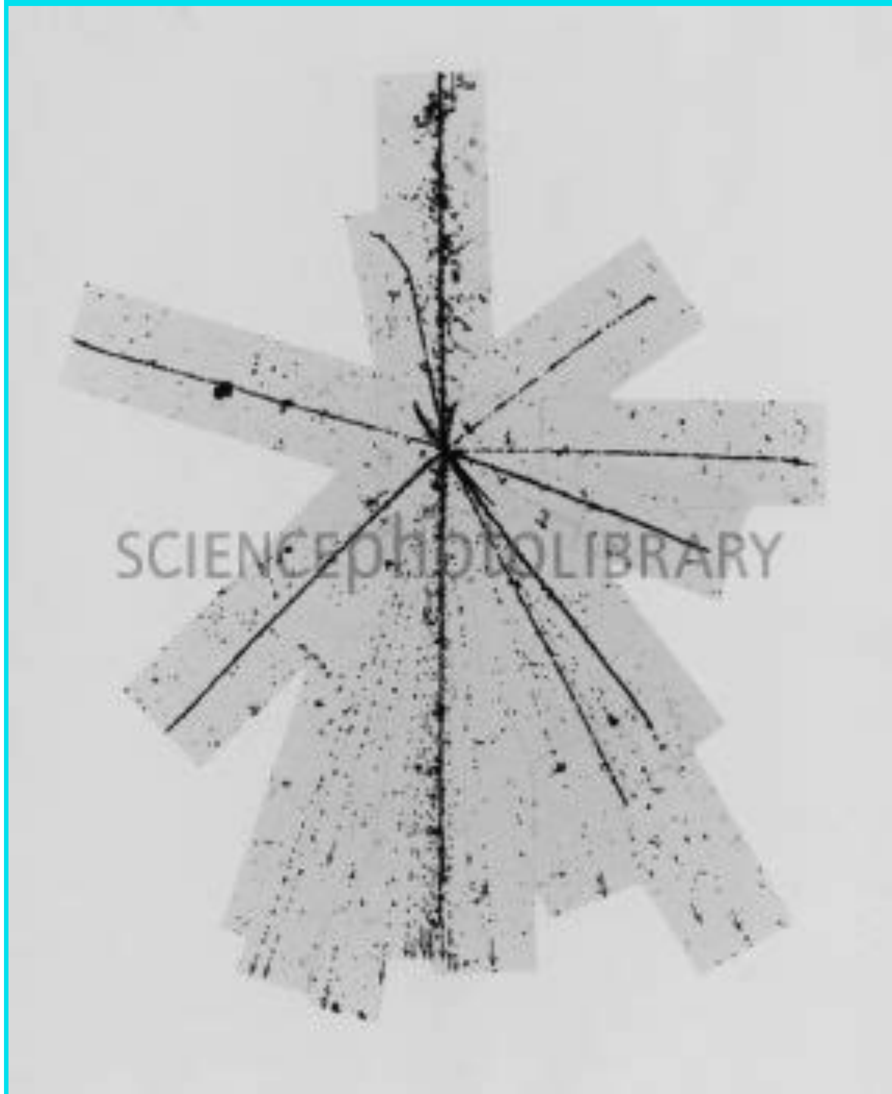
How to measure the energies of very high energy nuclei.



Heavy nuclei were discovered by people at the U of Minnesota before I arrived.

They put what was basically a pile of photographic emulsions on a balloon flight in 1948 and saw interacting protons like the one at the left and heavy nuclei that made denser tracks.

Ionization loss Z^2

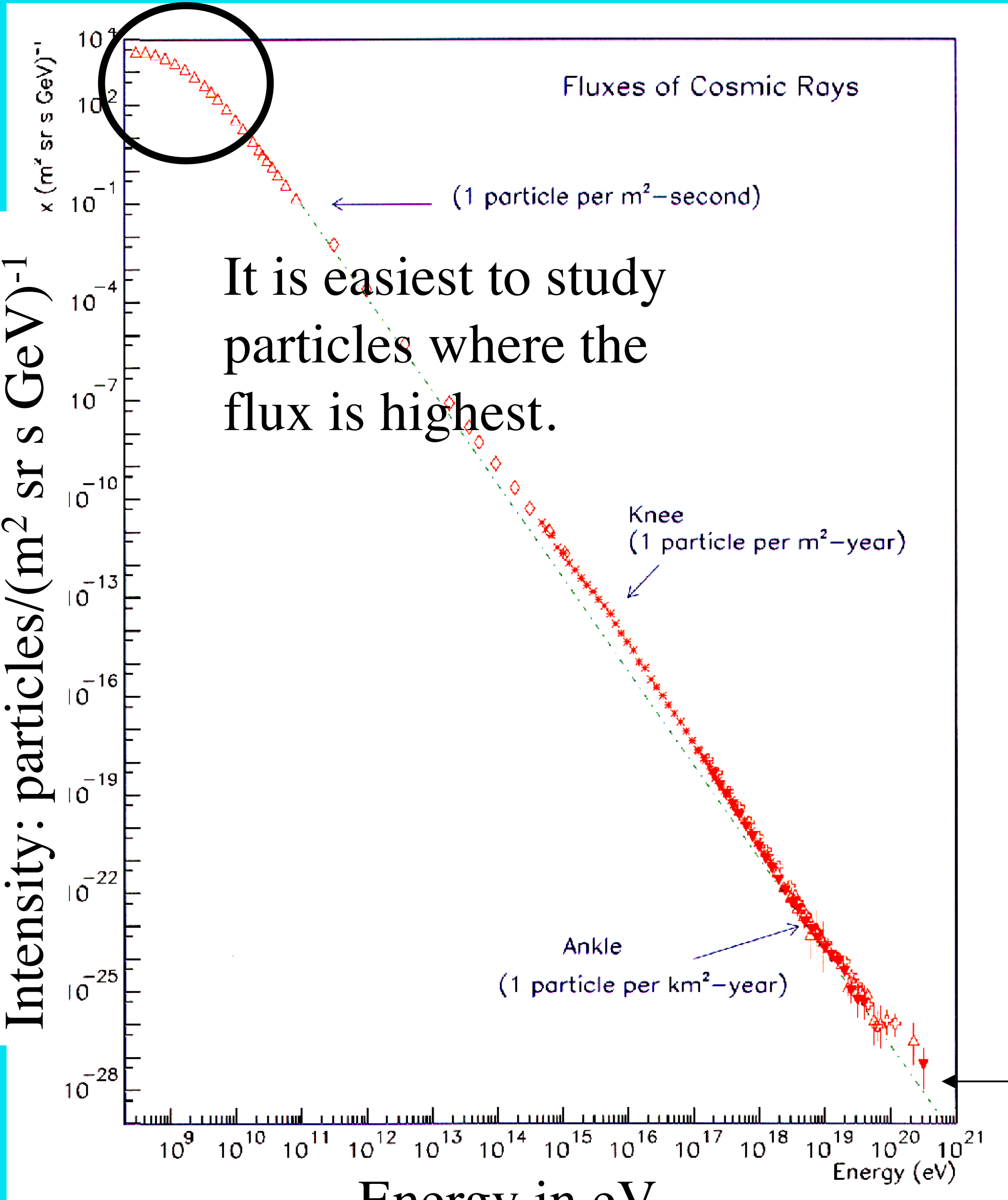


A “star” from a nuclear reaction – protons and other nuclei do interact with nuclei.

The heaviest tracks are due to heavy nuclei, the medium density tracks are due to low energy protons ejected in the collision with an emulsion silver nucleus. The very light tracks are due to mesons (-> muons).

Cover boy: the only cover I ever made

All particle spectrum



Intensity: particles/(m^2 sr s GeV)$^{-1}$

It is easiest to study particles where the flux is highest.

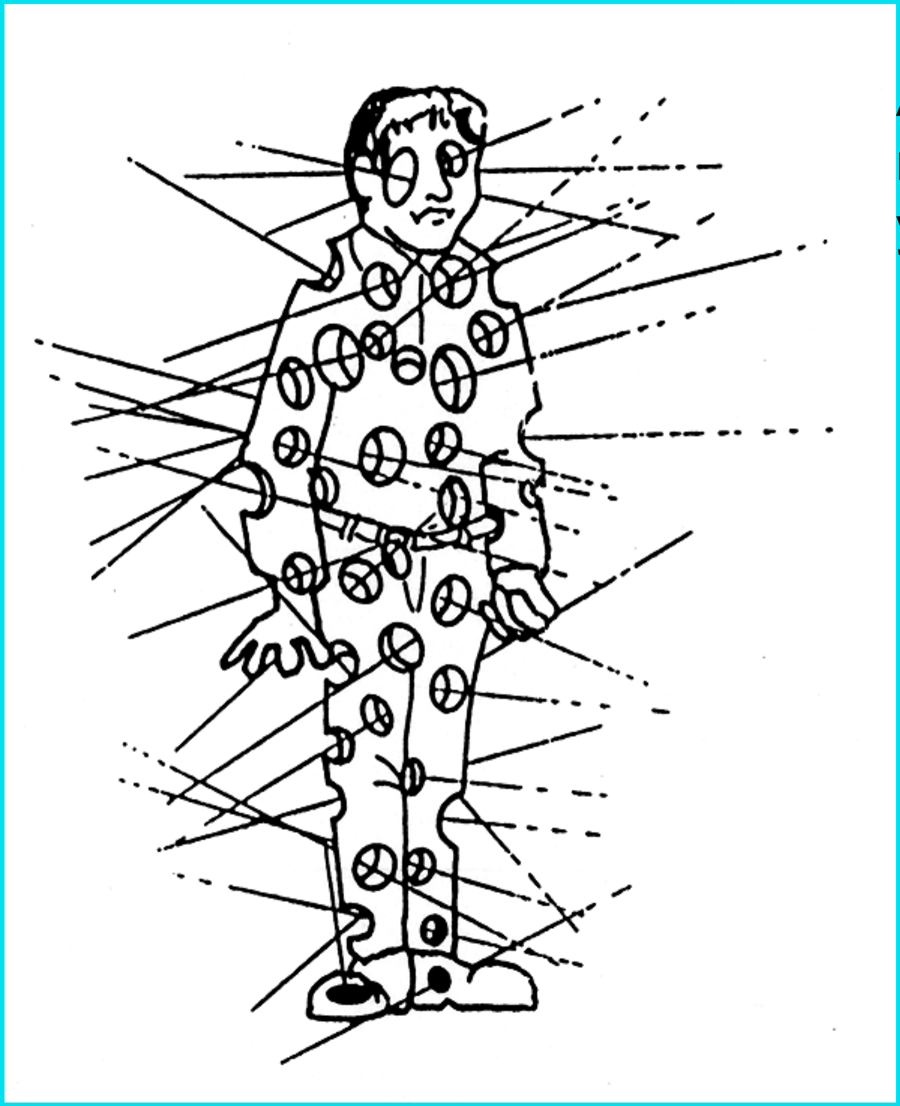
Energy in eV

Spectrum is the flux as a function of energy.

Flux is the number of particles passing through a given area per unit time.

1 particle per km^2 per millennium

Minnesota *Technolog* circa 1966



About 100,000 cosmic ray muons will pass through you each hour.

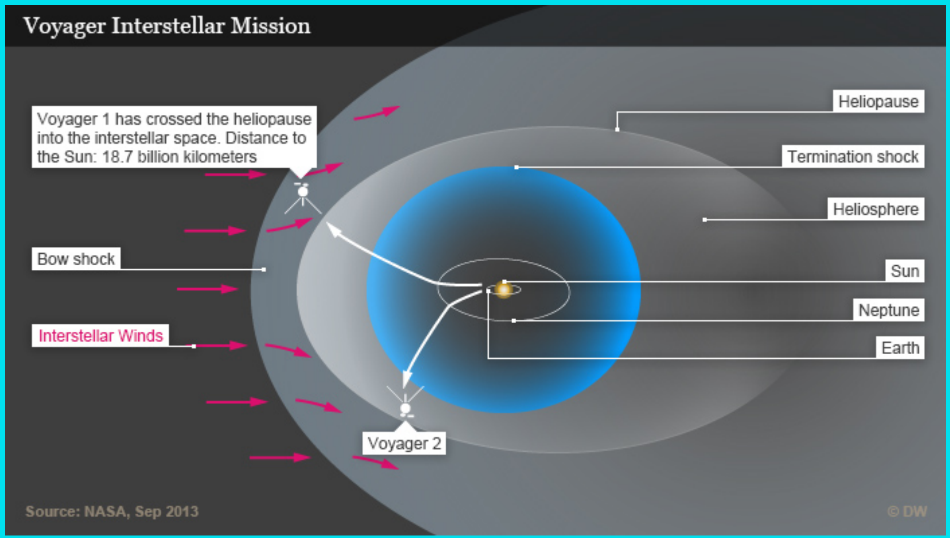
- **Fortunately, muons are "weakly interacting particles" and leave only an ion trail in their wake.**
- **They do not interact with your nuclei, leaving your basic chemistry un-affected.**
- **They do cause a background in CCD camera arrays!**

My Professor’s plan

- Measure the cosmic ray composition and spectra as a function of latitude at high altitudes on balloons.
- Balloons developed in Minneapolis by people at the physics dept. and a local company known as Winzen.
  - Polyethelene resin
  - Not affected by uv light
  - 0.0001 inches thick
- Small balloons were launched by ourselves from Minneapolis, Devil’s Lake, ND, Fayetteville, AK, and in Lake Country in northern MN, north of Hibbing
  - Latter payload was lost in a thunderstorm; never found.
- Project Skyhook flights from Ft. Churchill, Manitoba
- Then Tucuman, Argentina & Queensland, Australia

Part of team that studied data from the Voyager spacecraft showing it entered the interstellar medium

- 1977 Launch
- 2012 Voyager 1
- 2018 Voyager 2   124 AU



These are not weather balloons

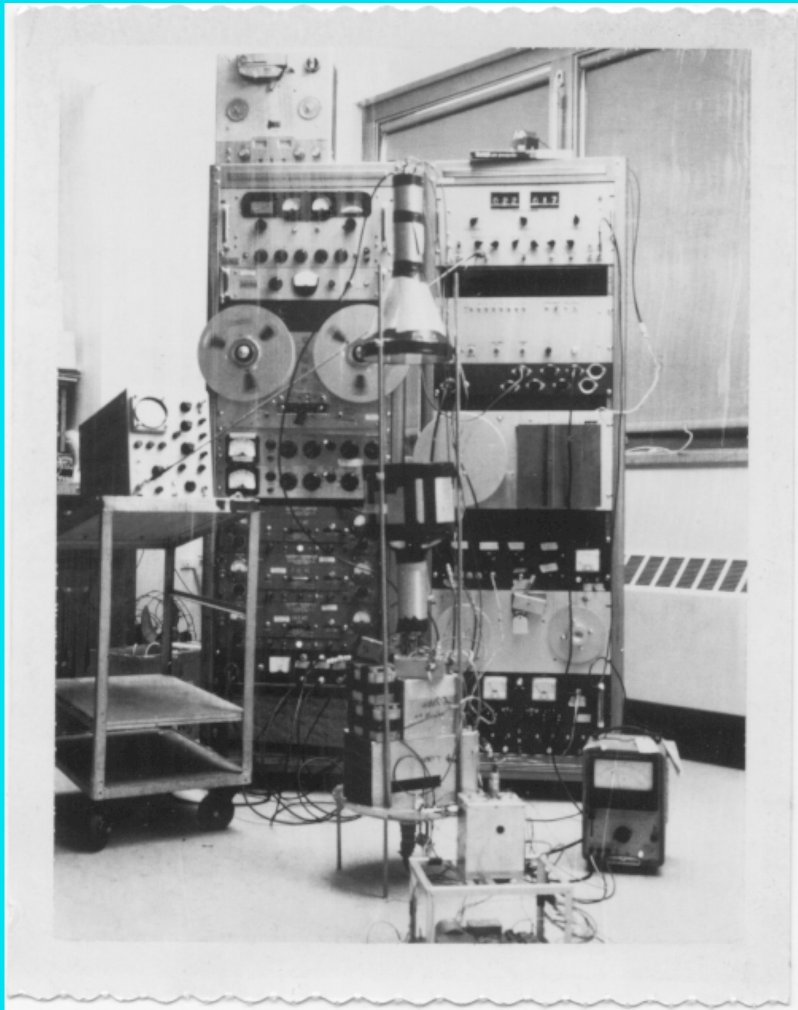
We did use these rubber balloons to find out what the stratospheric winds at above 120,000 ft altitude were doing.

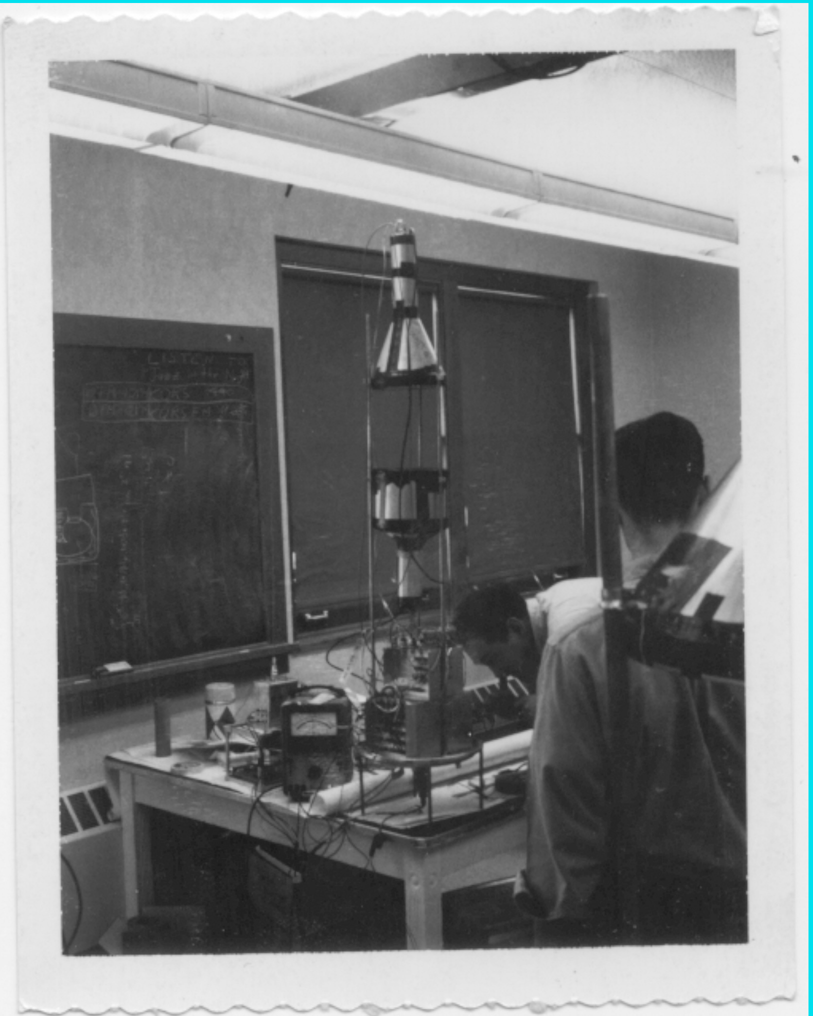
Winds at that altitude reverse direction once a year, setting optimal times for payload launches.

Sometimes a balloon carries multiple sensors

Upward force from this balloon is less than the weight (200 lbs?) of the man holding it.

Dissertation hardware
The two "goose" experiment





Join cosmic rays and see the world

- Fort Churchill, Manitoba, Canada
  - Skyhook
- Tucuman, Argentina
  - Recovery
  - Money exchange
- Queensland, Australia
  - Townsfolk
  - Hydrogen
  - Leave taking

Tucuman, Argentina

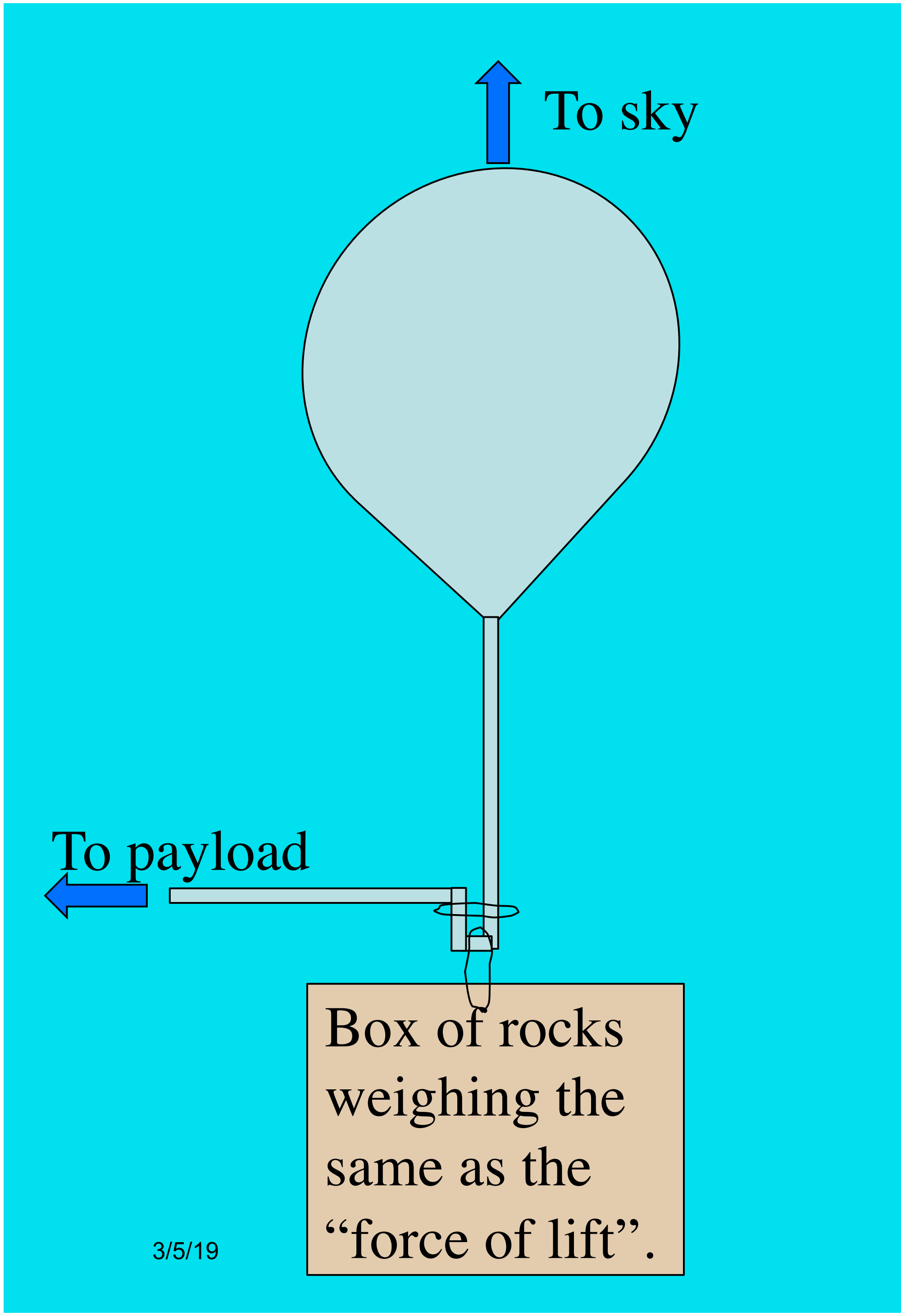
- Payload (about 6 ft tall and very thin -1.5 ft diameter) came down in very desert area (no rain for year and half) with thick thorny plants.
- Search plane landed. Crew found young girl who said she would take them to the payload. She crawled through and under leafless thorny bushes. The search crew followed. She found the payload after about 30 minutes. They gave her a $5 reward.
- The newspaper from the nearby town had a front page story about how a cash of armaments had been parachuted into the region to supply rebels in the area and how a little girl had been given an enormous bribe to keep it quiet.

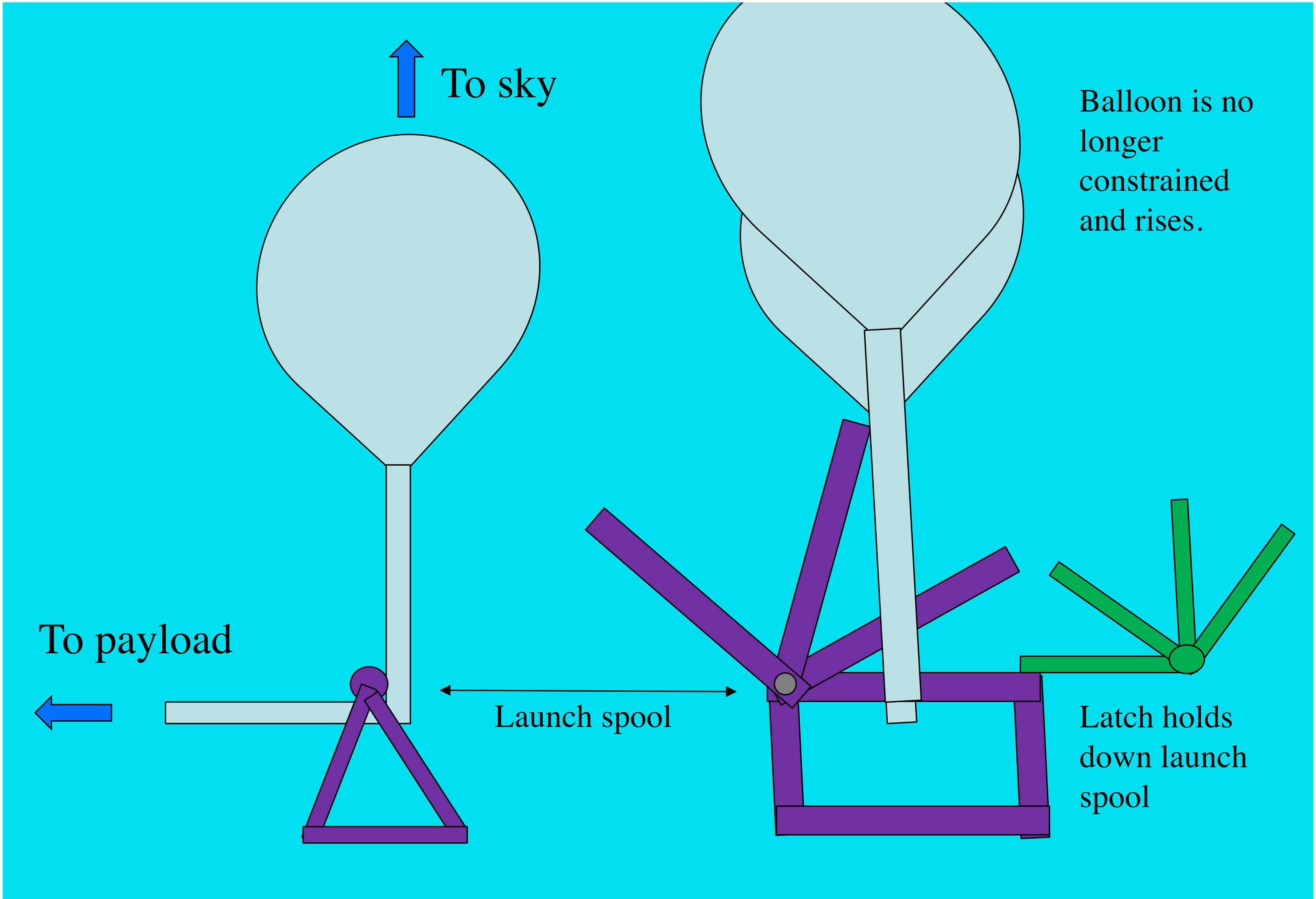

TAA THE NATION'S JETLINE
TAA
LADIES

A-frame balloons launched

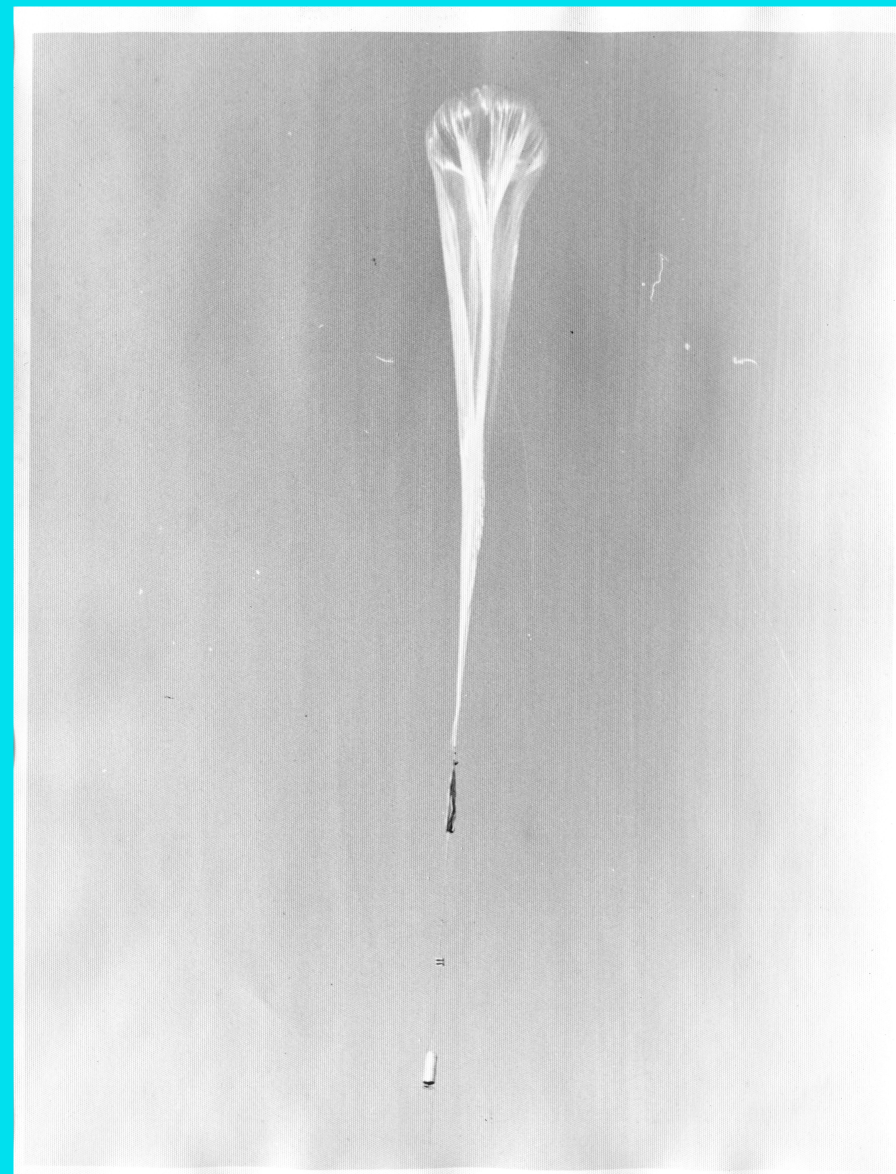
- We used balloons up to 600,000 cubic ft in volume.
- Balloons went up to about 110,000 ft
- Sometimes the balloon would stall when the temperature changed too rapidly.
  - Carried iron ballast to drop, reducing the load and giving it a “push” upward.
- Payloads of up to 1000 lbs of detector, electronics and batteries and ballast (small beads of iron that burn up in the atmosphere).

Relate story of filling the balloon with an Australian accent in Argentina.


To sky
To payload
Box of rocks weighing the same as the "force of lift".

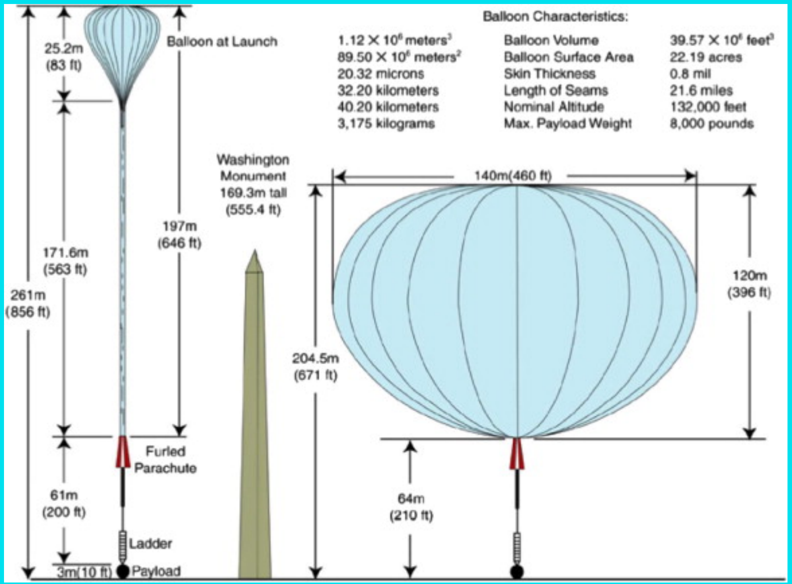


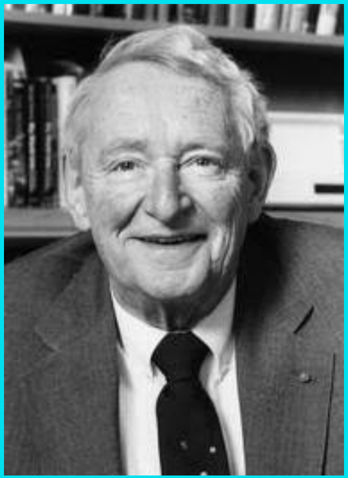
A-frame launcher held down by sandbags



Gondola
6 ft tall,
about 1½ ft
in diameter.

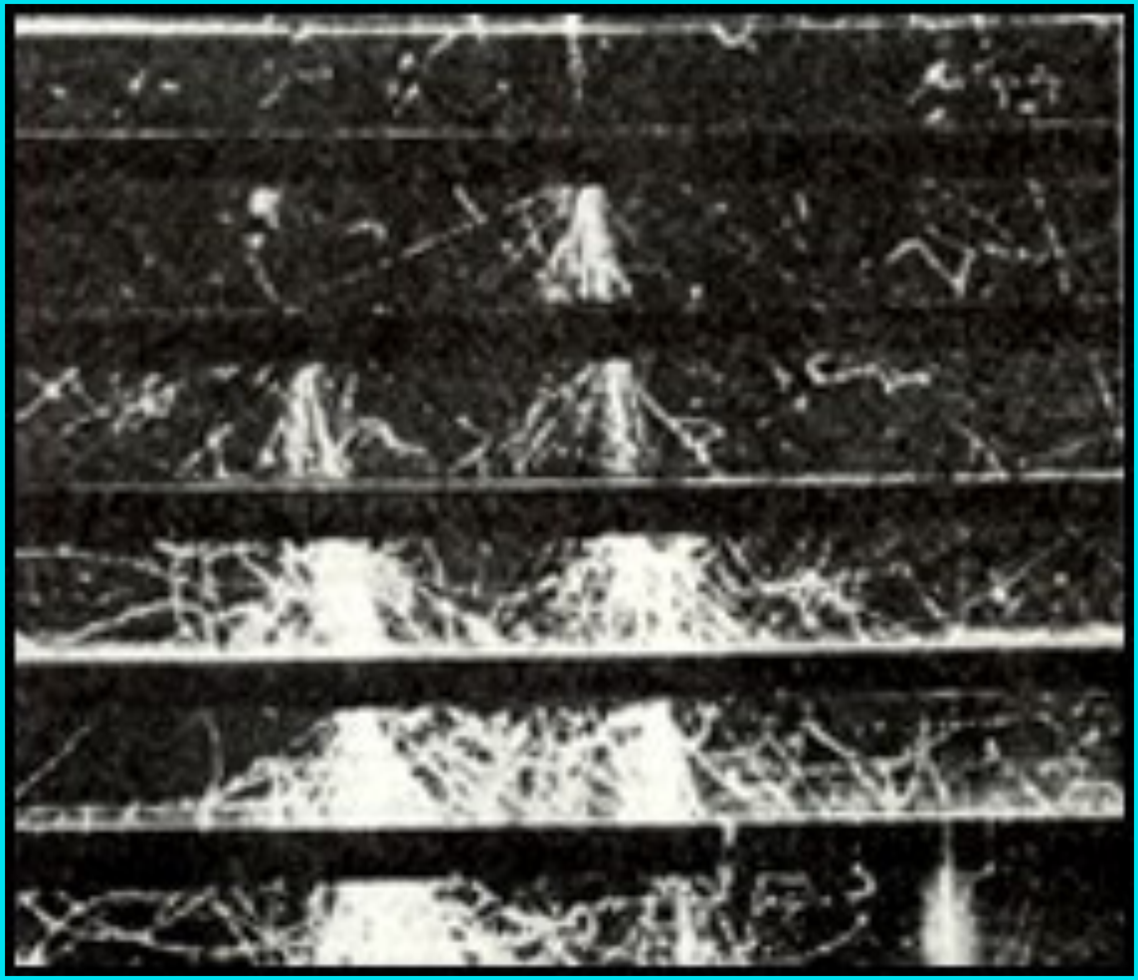
Recovery of the payload was often an adventure in itself.





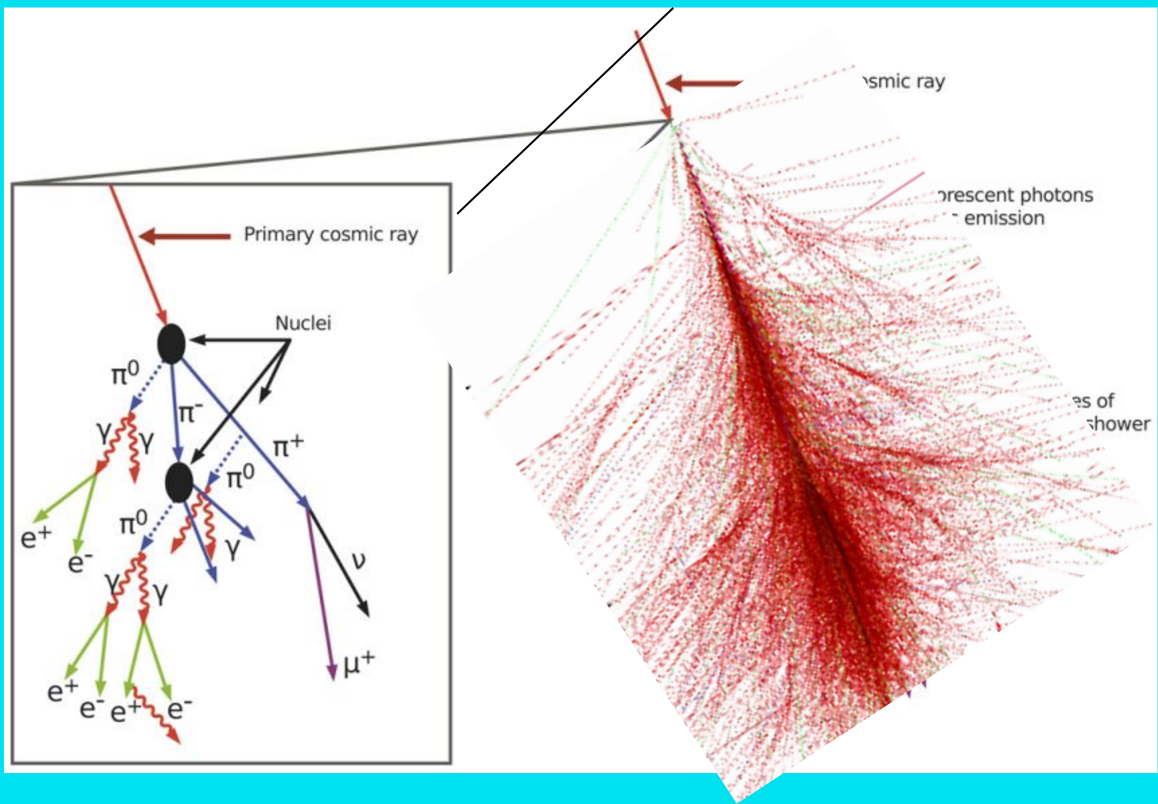
Ed Nye

Later key figure in infrared astronomy



The Wilson cloud chamber picture hints at what I was hired to do at GSFC – something called calorimetry.

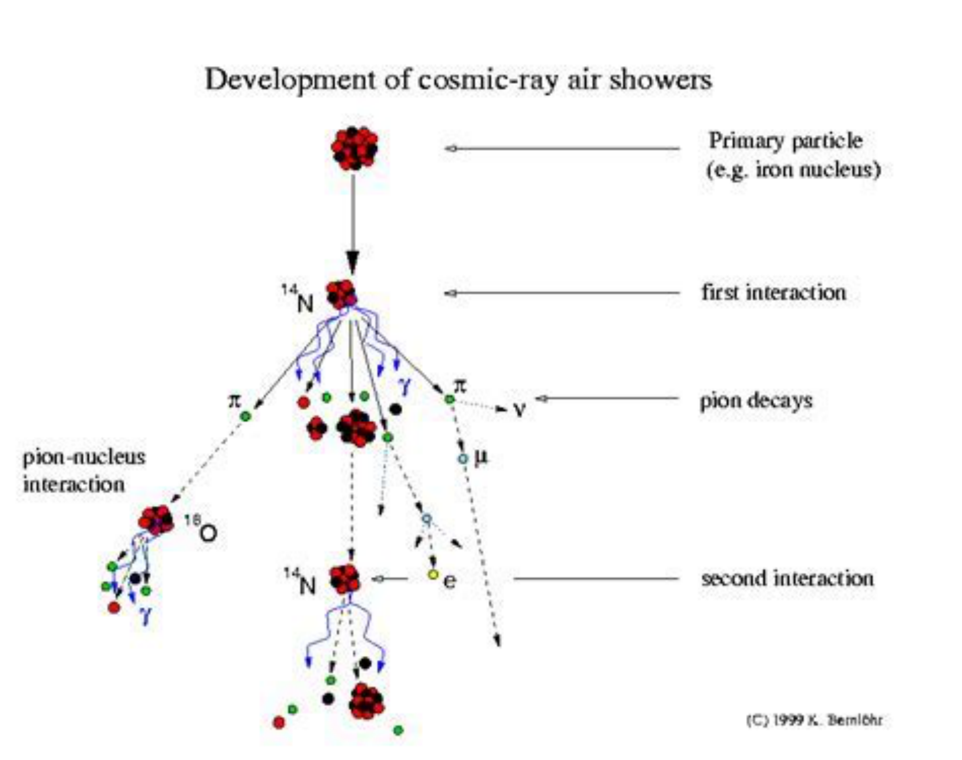
How to measure the energies of very high energy nuclei.



If we can somehow count the number of particles in block of matter, we can get an estimate of the energy.

Relate number of particles to energy by "calibration" at a ground based high energy particle accelerator.

How to measure the energies of very high energy nuclei.



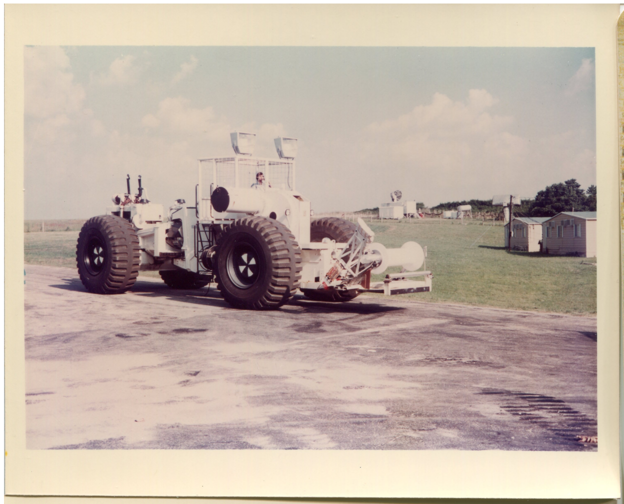
We used blocks of iron and in between we put layers of scintillators whose light output was proportional to the number of particles.

To identify what nuclei were incident we used scintillators in which the signal was proportional to the square of the charge.

At NASA we had access to much larger stratospheric balloons

Requirements

- Large area detectors due to the ever decreasing intensity as energy increased.
- “As long as possible” balloon flights.
- Weight was constrained (3000 lbs – 8000 lbs)
  - This changed over time as balloon technology improved
  - Balloons failed and had to be redesigned
- We had to enclose the apparatus in approximately 1 atmosphere of air to protect electronics.
  - We did experiment with apparatus designed to work in zero pressure, but the pressure at which we were expecting to take data was exactly the worst pressure for our light detecting tubes.



My best technician

- WWII vet; Italian campaign
- Always willing to work
- Farm in N. Carolina
  - Barn story
- Dedicated to me and our science

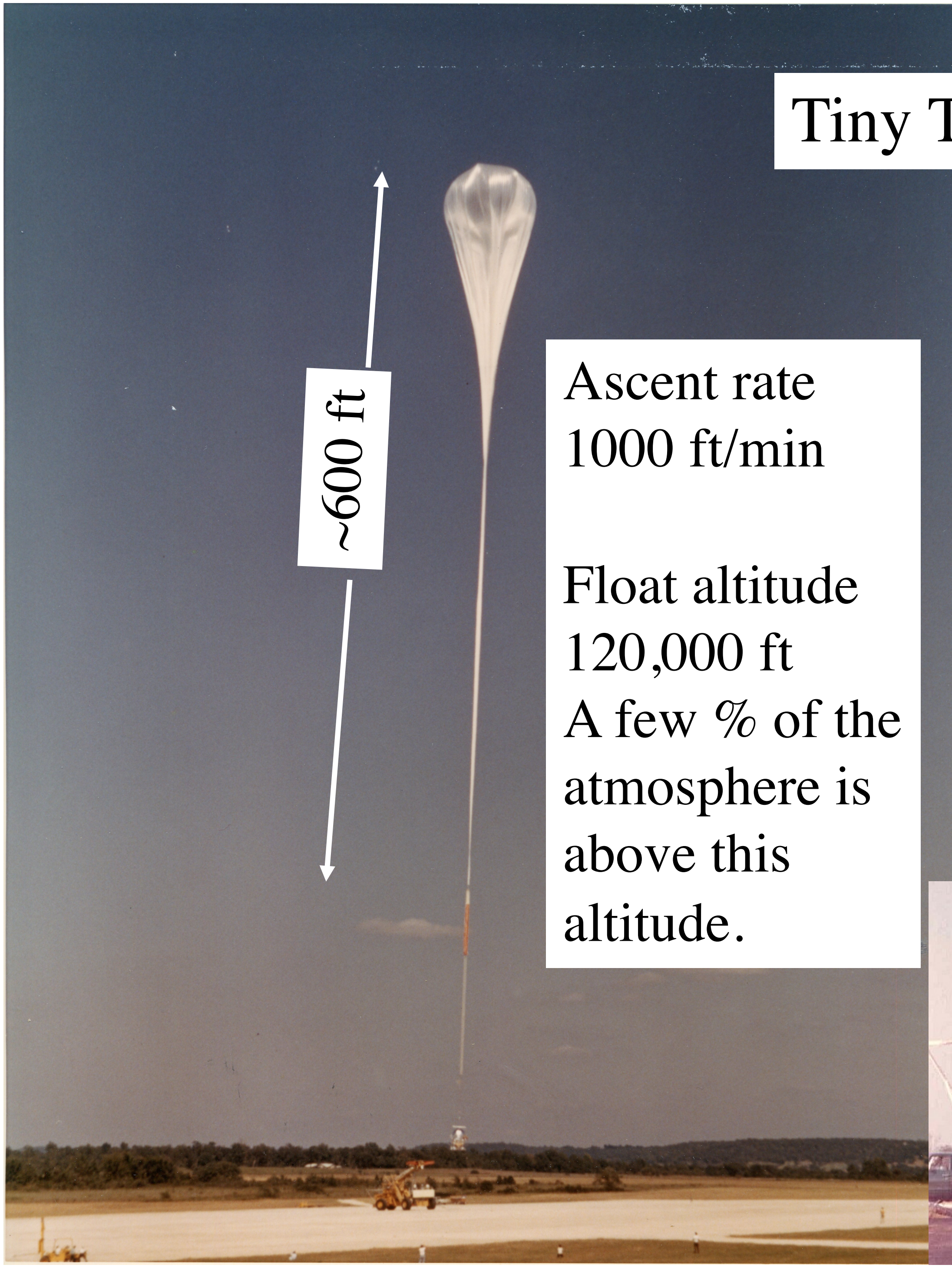
On left: top top bottom

- The spool truck
- Payload without gondola
- Balloon in a box

From my photo collection


wind

Tiny Tim



Ascent rate
1000 ft/min

Float altitude
120,000 ft
A few % of the atmosphere is above this altitude.

Just before payload release. Payload is hanging from Tiny Tim’s jaws.

Source of Balloon Launch videos

https://www.nasa.gov/scientificballoons/videogallery

Sunrise and Super Tiger videos