Antibaryons

Matteo Negrini
INFN-Bologna

Antimatter

Existence of antiparticles established by discovery of the positron (Anderson 1932)
Do other particles have their own antiparticles?

There were counterarguments, such as:

- Nucleons have anomalous magnetic moment → internal structure
- Where are the anti-galaxies?

Experimental proof needed, motivating the energy choice at the Bevatron construction in 1955:
the chosen momentum 6.5 GeV above threshold for: $p\ p \rightarrow p\ p\ \bar{p}\ p$

Design experimental setup and detectors

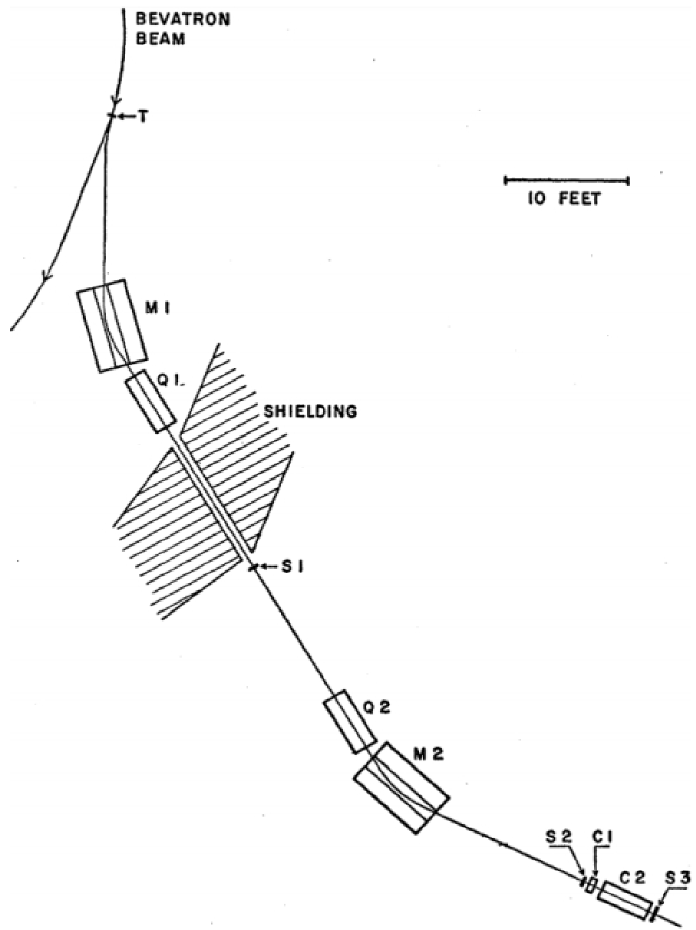
Bevatron (Berkeley)

Antiproton observation

Chamberlain, Segrè, Wiegand, Ypsilantis (1955)
Identify negative particles produced by interaction of a proton beam separating antiproton candidates from the huge π^- background.
Measurement of both momentum (magnetic field) and velocity (Cherenkov counters)

- Proton beam on copper target (T)
- Particles with momentum 1.19 GeV/c deflected by dipoles M1 and M2
- Q1, Q2: quadrupole focusing magnets
- S1, S2, S3: plastic scintillators
- C1, C2: Cherenkov counters

Velocity determination in 2 ways:
- Signal in C2 (special differential counter designed to detect antiprotons) but not in C1
- TOF between S1 and S"



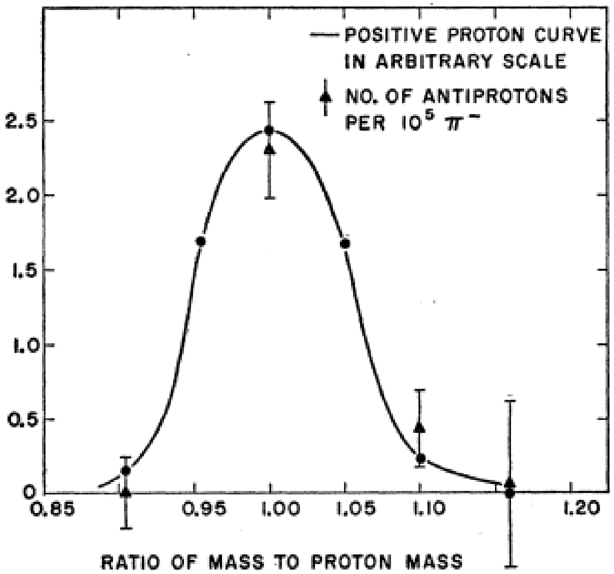
Antiproton observation

The selected momentum corresponds to β=0.78 for p and β=0.99 for π

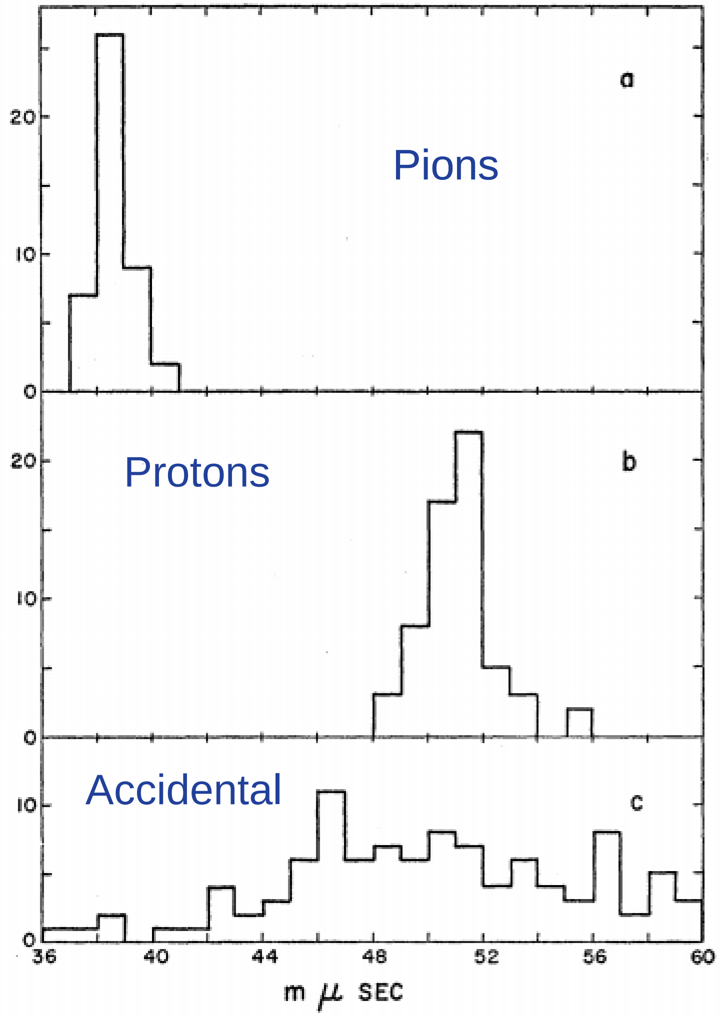
The TOF between S1 and S2 is 51 ns for p and 41 ns for π

Test of the apparatus done with protons
by reverting the magnetic fields of the dipoles

Mass calibration done by adjusting the system
for particles with masses around the proton
mass.
Tests done for both positive and negative particles



Time of flight S1-S2



Antiproton observation in emulsion

Chamberlain et al 1956

Exposed at Bevatron

Interavtion of negative particle

Visible energy release: 850 MeV consistent with rough expectations, considering neutral mesons and neutron productions

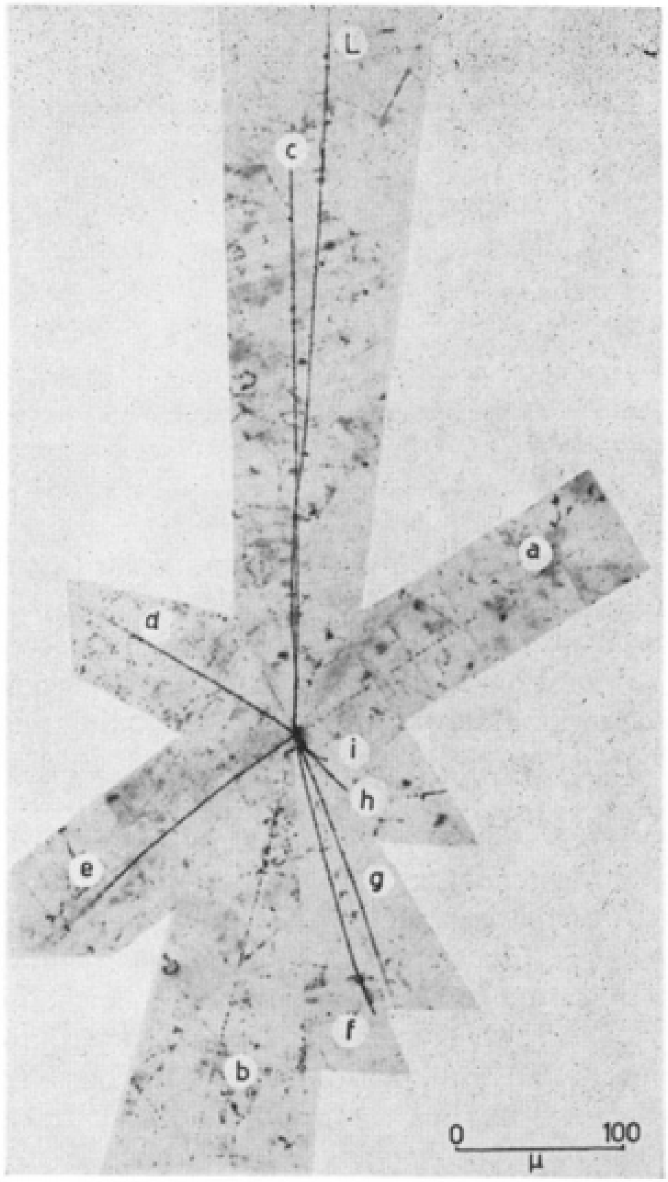


FIG. 1. Reproduction of the star. *L* is the incoming track (9.31 cm of range). For the explanation of the other tracks see Table I.

Antineutron

Cork, Lambertson, Piccioni, Wenzel (1958)

At Bevatron, look for interaction $p \bar{p} \rightarrow n \bar{n}$

Experimental technique:

- antiproton beam
- look for interactions with large energy release (such as the antiproton ones)
- originated by neutral particles (veto event with charged particles)
- energy calibration: antiproton beam in the detector

INFN

Antineutron

Antiproton beam at Bevatron

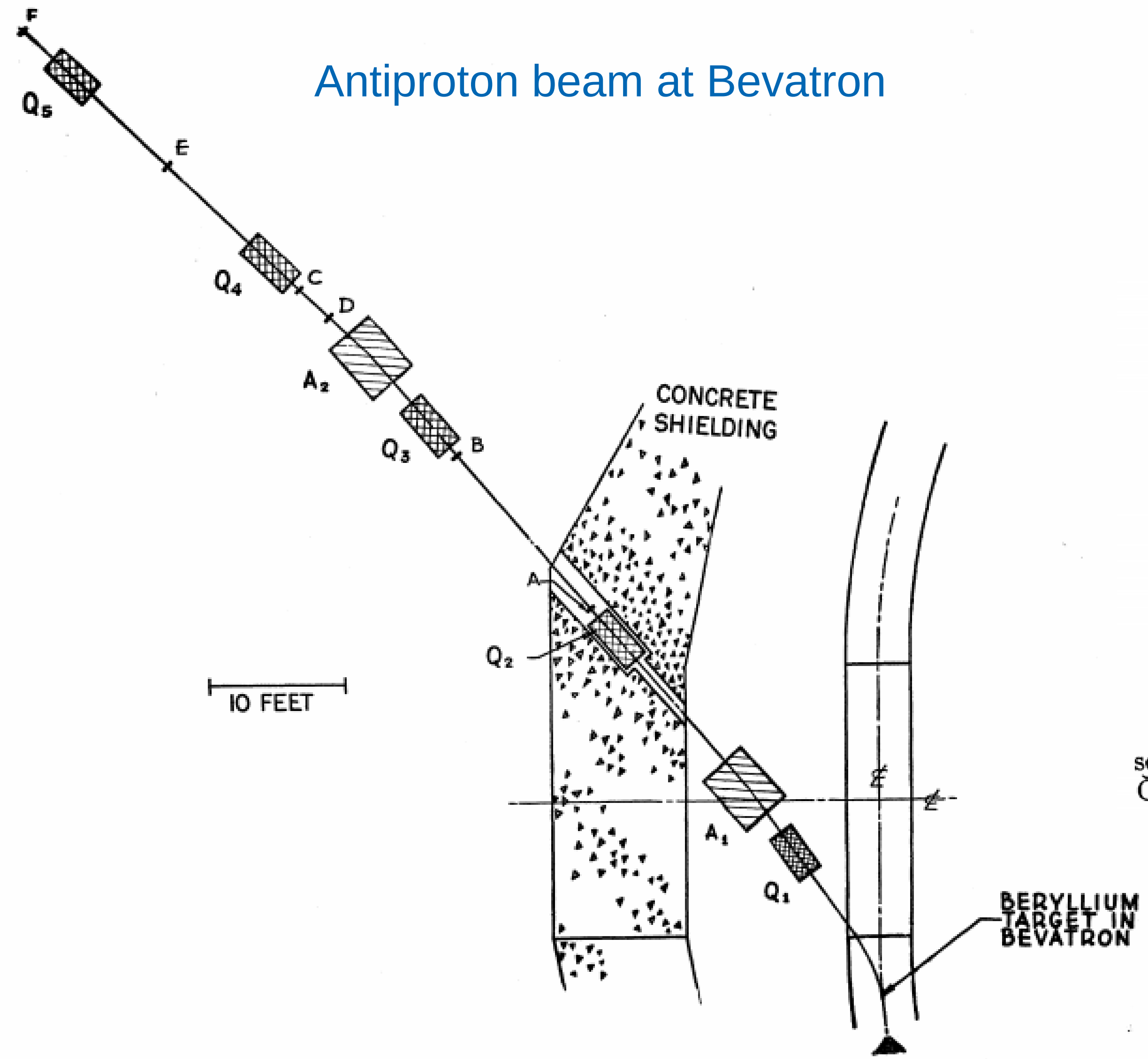


FIG. 1. Antiproton-selecting system. Q_1 through Q_5 are focusing quadrupoles. A_1 and A_2 are analyzing magnets. A through F are 4-by-4-by-½-inch scintillators.

Antineutron detecting system

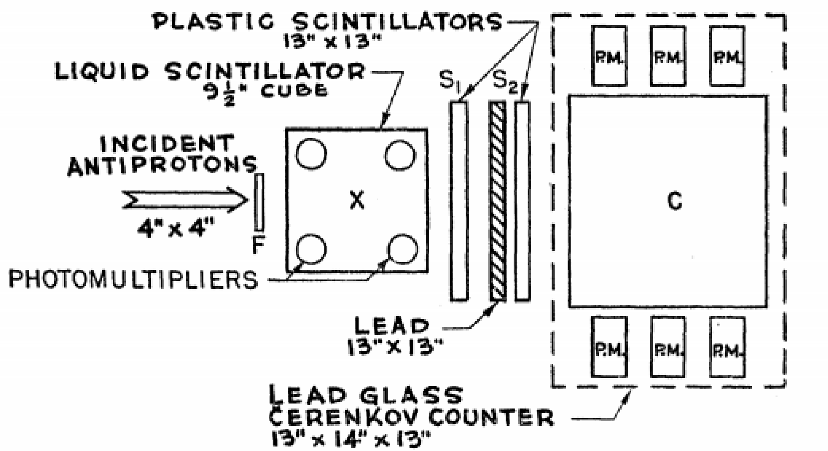


FIG. 2. Antineutron-detecting system. X is the charge-exchange scintillator; S_1 and S_2 are scintillation counters; C is a lead-glass Čerenkov counter (later a large scintillator).

Antineutron

Antineutrons interactions inside the large Cherenkov counter (or plastic scintillator) → energy release similar to the one by antiprotons

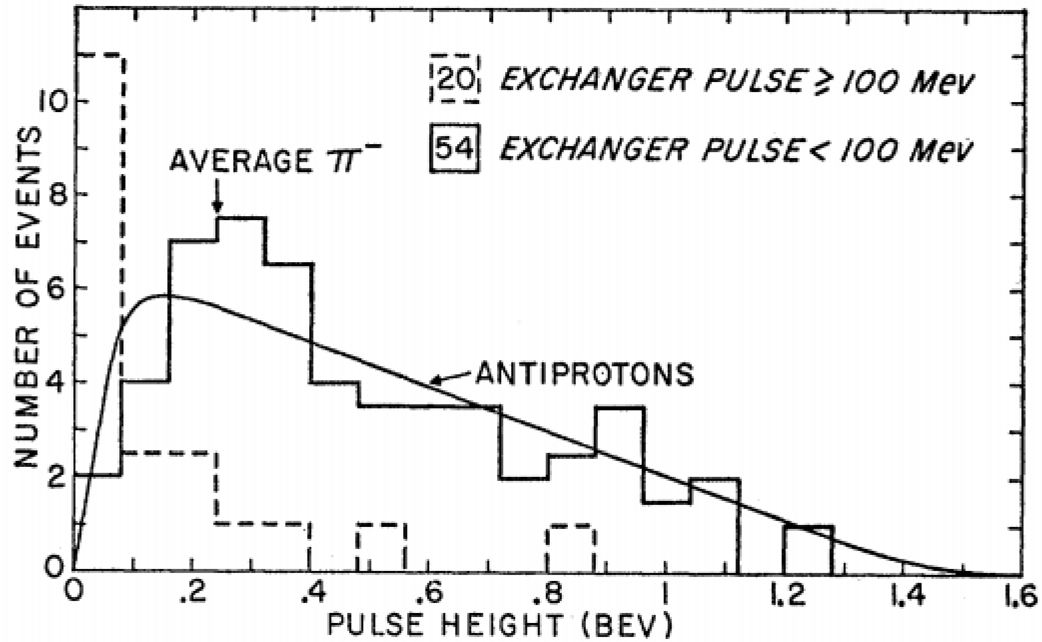


FIG. 4. Pulse-height spectrum in lead glass counter for neutral events. The solid histogram is for 54 antineutron events (energy loss in charge-exchange scintillator less than 100 Mev). Dashed histogram is for 20 other neutral events. Smooth solid curve is for antiprotons and is normalized to the solid histogram.