Observation of Anti-Deuterons by H1 at HERA.

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Overview

- Search made for inclusive heavy particle production in 6 pb^{-1} of 1996 minimum bias data. (Remaining data do not add much).
- Use Log Likelihood Method of Particle Identification - some improvement on the usual method.
- Significant anti-deuteron and anti-proton signals observed but nothing heavier in photoproduction.
- Cross sections for $\bar{d}$ production and $\bar{d}$ to $\bar{p}$ ratios are reported here and compared to ISR, Au-Au and other data.

Mass Identification - The Log Likelihood Method (LHM)

For each track, measure the distribution of $\Delta = dE/dx \cdot dx$. Get best value of dE/dx_0 using the LHM by maximum likelihood fit of measured distribution of Δ for each track to a parameterisation of Landau type distribution at a given p/M.

From $dE/dx_0 = f(p/M)$, determine p/M (iteratively). NB $f(p/M)$ is a parameterisation of Bethe-Bloch formula which allows for instrumental effects.

Get mass from p which is known from track curvature.

The track is identified as the particle with the nearest mass.

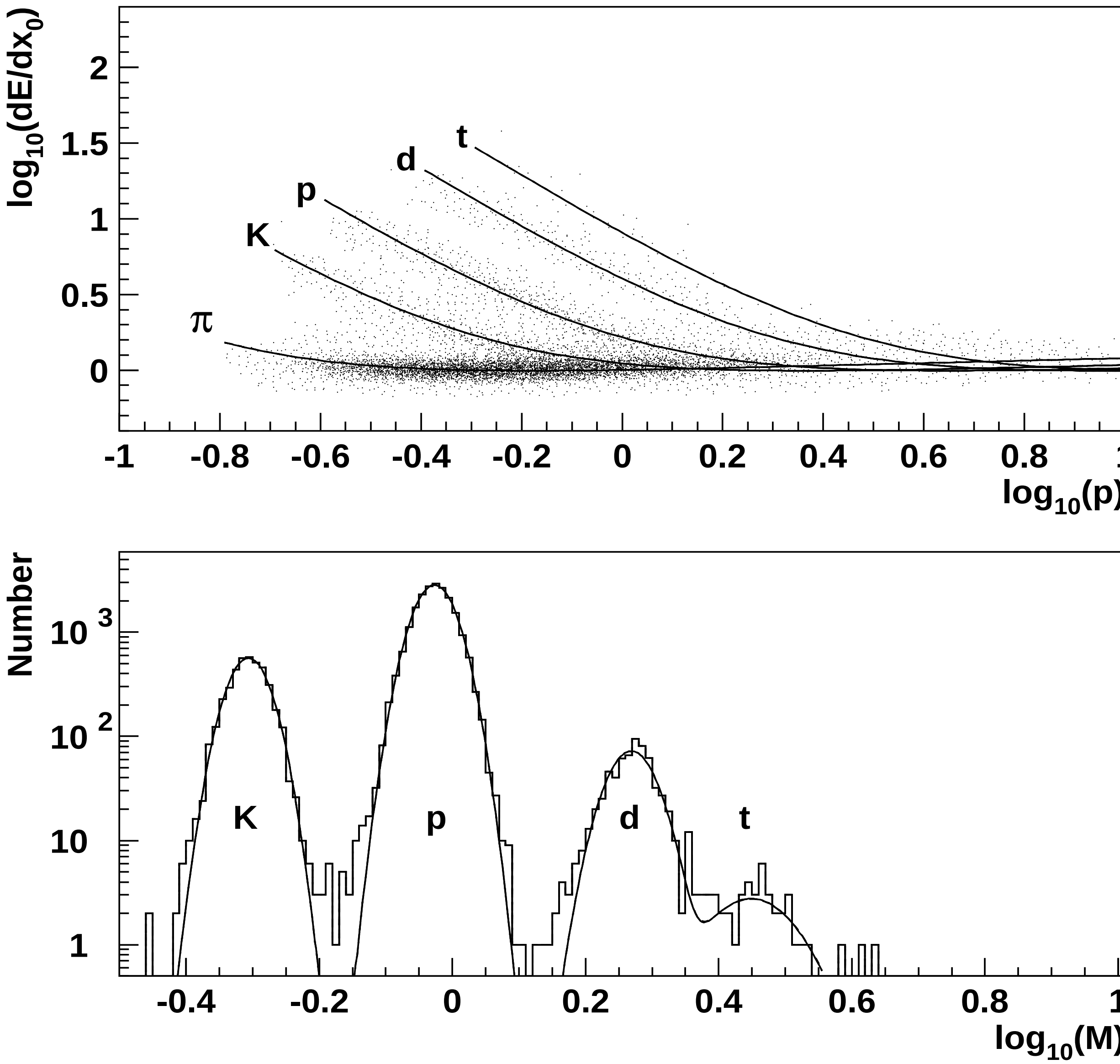


Figure 1: dE/dx vs p and observed mass spectra for a sample of positive tracks NB no cuts applied or background subtracted.

Correction for the Material Background

Subtract sidebands of DCA peak at zero to get signal.

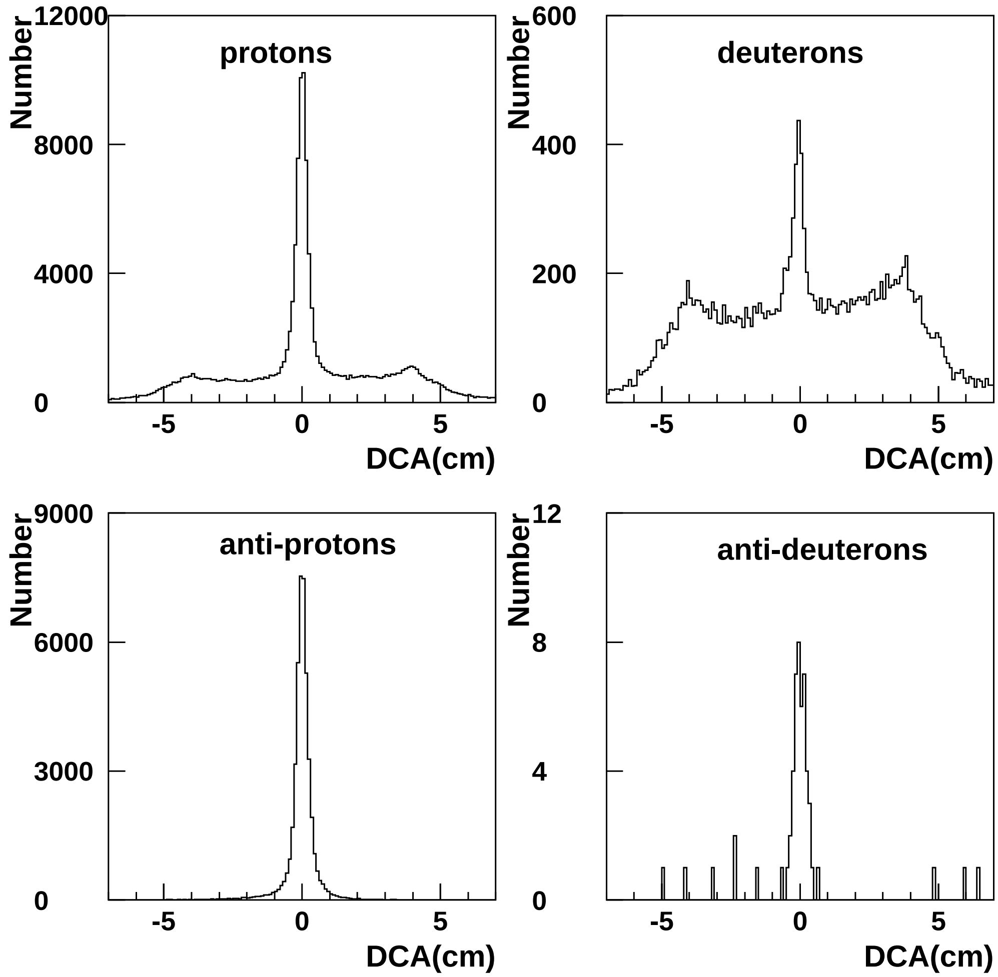


Figure 2: DCA distributions. The peak is from γp and beam gas interactions. Smooth background is from spallation products from photoproduced particles. The background under the $\bar{p}$ and $\bar{d}$ signals comes mainly from albedo particles. NB The approach of p and d distributions to zero for DCA > 5 indicates that most of material background is from the beam pipe.

H1 does spectroscopy

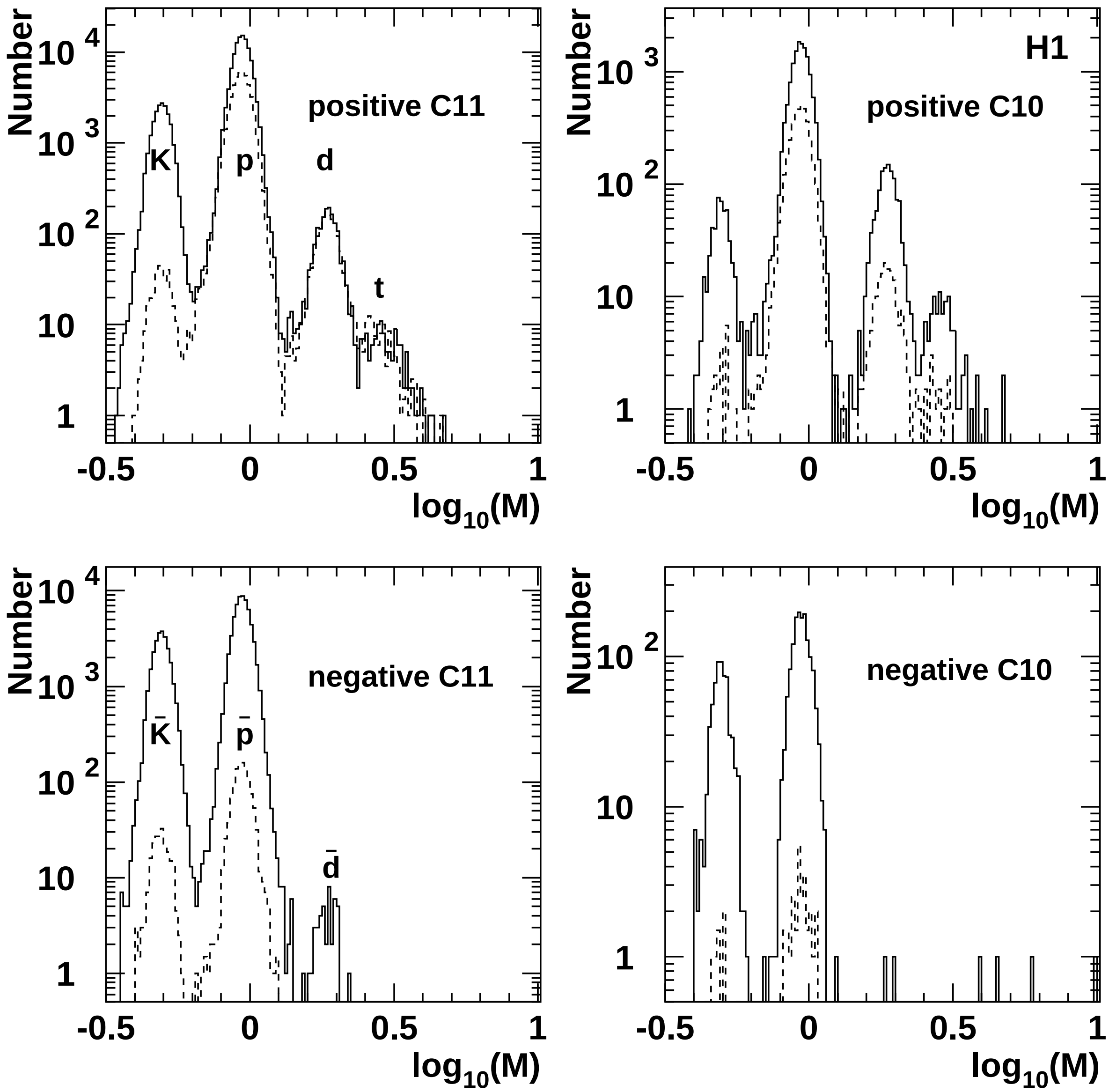


Figure 3: Observed distributions - solid curves. Measured material background - dashed curves.

Compare H1 with pp and Au-Au central production data.

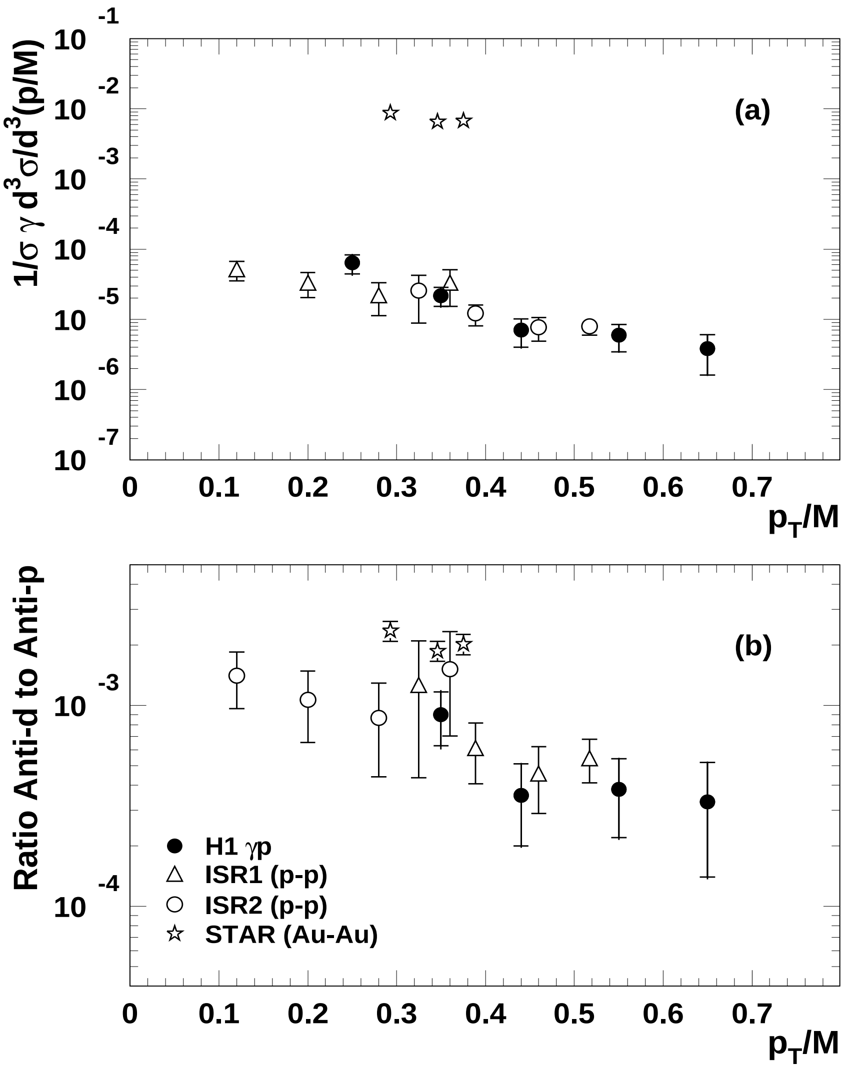


Figure 4: p_T dependence of invariant cross section and $\bar{d}$ to $\bar{p}$ ratio. More copious $\bar{d}$ production in Au-Au collisions than in γp and pp interactions although $\bar{d}$ to $\bar{p}$ ratio is similar.

The Coalescence Model .

A model based on the assumption that $\bar{p}$ and $\bar{n}$ fuse into a $\bar{d}$ if relative separations in momenta and space are small enough.

From this one can predict that

$$E_{\bar{d}} \frac{d^3\sigma(\bar{d})}{\sigma_{tot} d^3 p_{\bar{d}}} = B_2 (E_{\bar{p}} \frac{d^3\sigma(\bar{p})}{\sigma_{tot} d^3 p_{\bar{p}}})^2$$

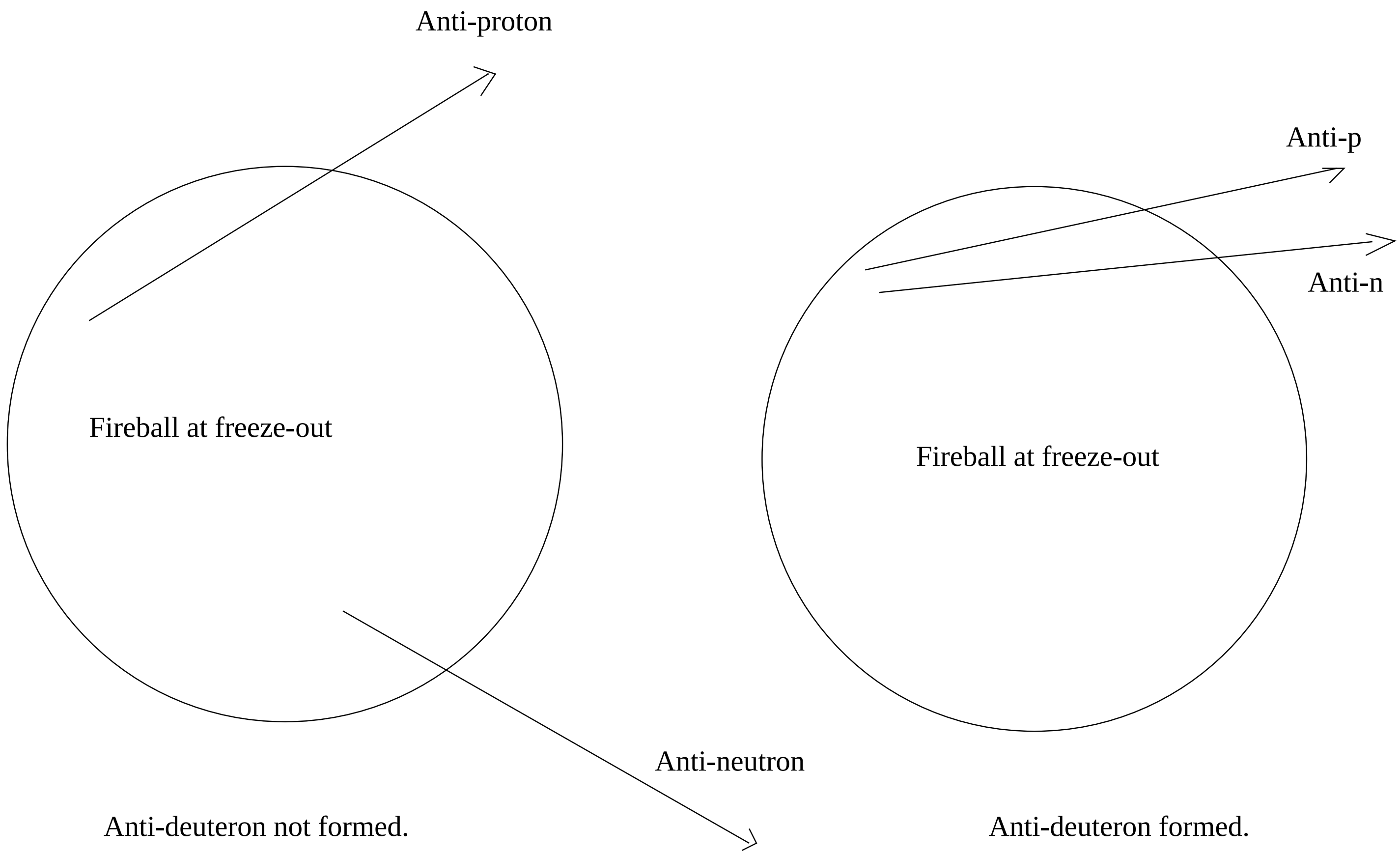
B_2 depends on the relative momentum of the $\bar{p}$ and $\bar{n}$

In heavy ion collisions it depends inversely on the volume of the fireball at thermal freeze out (Schiebl and Heinz).

i.e. when final state interactions become unimportant.

In pp and γp collisions where the fireball should be much smaller the important size is expected to be the volume of the deuteron.

The Coalescence Model.



Compare H1 with ISR and Au-Au central production data selecting central data i.e. $|x_F| < 0.3$.

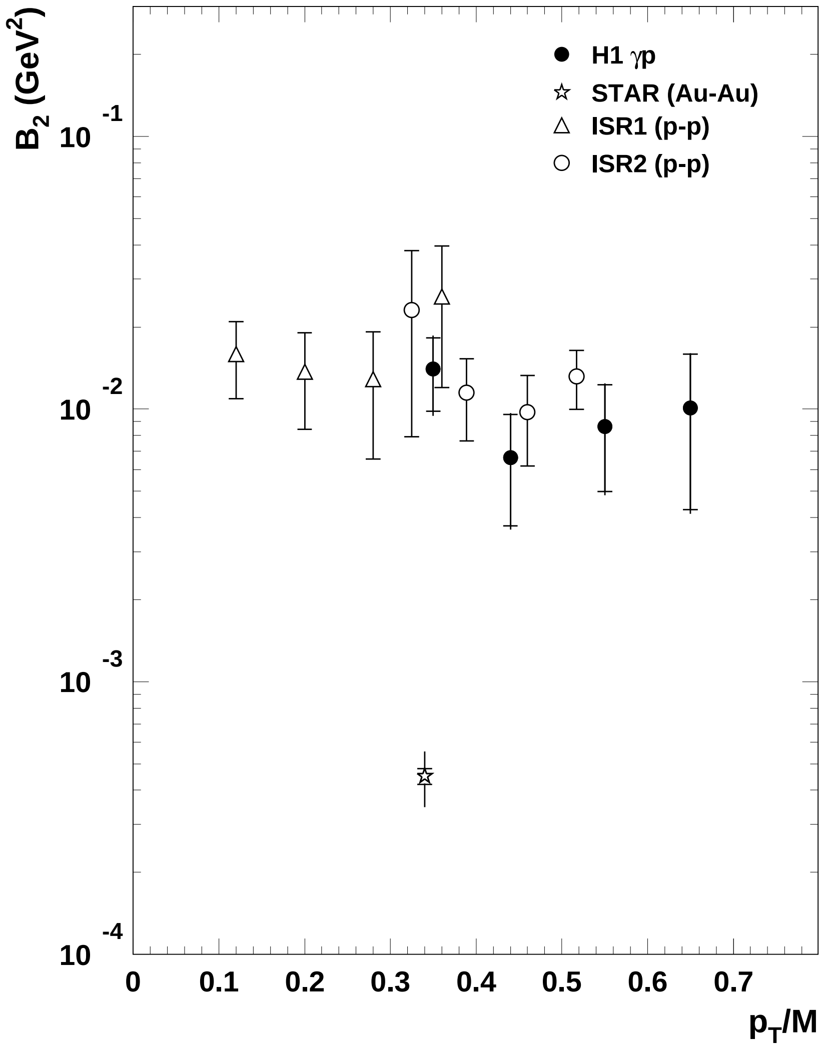


Figure 5: Dependence of B_2 on p_T/M for γp and pp data compared with the measured value in Au-Au collisions from STAR at RHIC.

Centre of mass energy dependence of B_2.

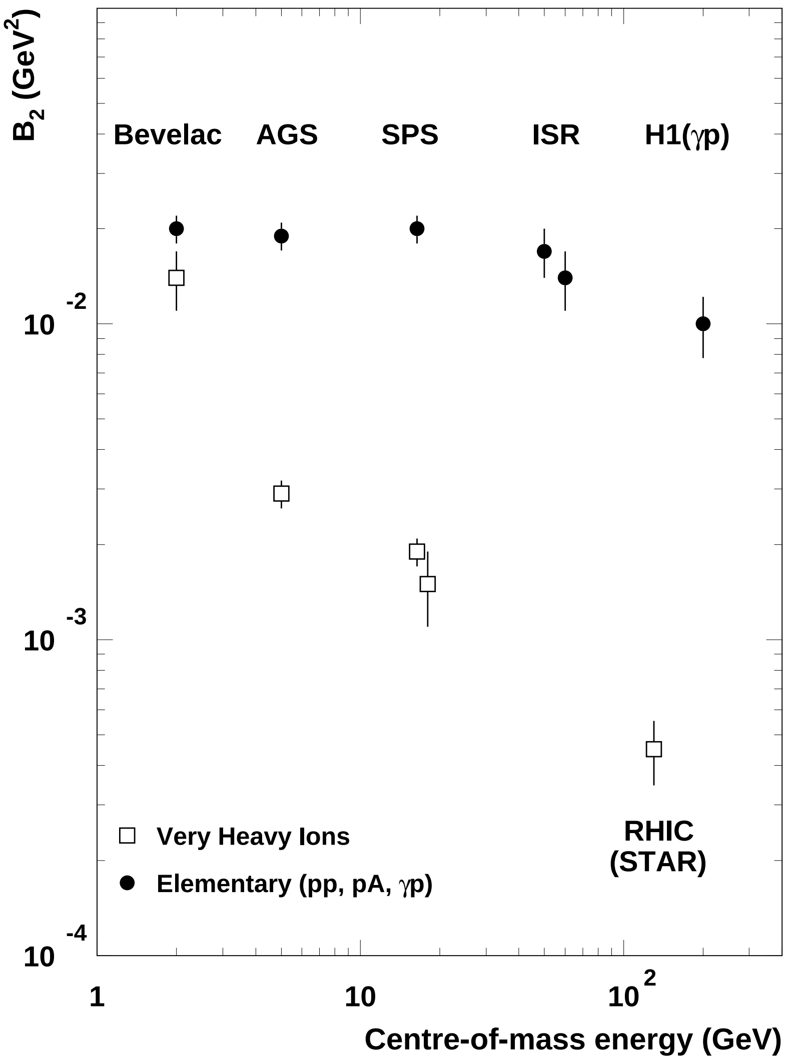


Figure 6: The dependence of B_2 on centre of mass energy for very heavy ion collisions (open squares) and interactions of more elementary particles (closed circles). The heavy ion data are the Bevelac Ne-Au data, the E886 (AGS) Au-Pt data, the SPS Pb-Pb data of NA44 and NA52 and the RHIC Au-Au data of STAR. The “elementary” data are pA data at low energies, pp data (ISR) and H1 γp data.

CONCLUSIONS

Inclusive photoproduction of anti-deuterons has been measured.

The ratio of the number of $\bar{d}$ to $\bar{p}$ is $5.0 \pm 1.0 \pm 0.4\ 10^{-4}$ and the value of

and $B_2 = 0.010 \pm 0.002(\mathrm{stat}) \pm 0.001(\mathrm{sys}) \pm 0.002(\mathrm{theory}).$

The production rate of anti-deuterons per event in pp and γp collision is similar but is orders of magnitude smaller than in Au-Au collisions.

The value of B_2 is much larger in pp and γp collisions than in very heavy nuclear collisions, reflecting the fact that the size of the fireball at thermal freeze out is much smaller in pp and γp collisions.