

An historic run

The SPS display proudly proclaims that the goal of more than 100 inverse nanobarns of integrated luminosity for proton-antiproton collisions has been surpassed.

(Photo CERN 98.6.83)

On 3 July, the high energy pulses of matter and antimatter circulating in opposite directions in the SPS ring at CERN were dumped, bringing to an end an historic period of physics experiment which will surely go down in the annals of science. No doubt the physics students of the 21st century will read avidly about the exploits of the machine specialists and the physics teams at CERN in 1983.

The scene was set with the SPS antiproton run at the end of last year. Over some two months, the big UA1 and UA2 experiments had been able to log proton-antiproton collision data at a substantial rate at 540 GeV, already the highest man-made particle collision energy ever achieved (see January/February issue, page 6).

During this time, the experiments amassed five hundred times the amount of data culled from the initial SPS proton-antiproton physics run in 1981, and hopes were high that important physics would emerge.

They did not have to wait long. Thanks to superb data handling techniques, the experiments were able to announce in January the discovery of the W boson, the particle which carries the electrically charged component of the weak force. These W particles had been predicted by the electroweak theory which unifies electromagnetism and the weak nuclear force, and the observed mass was in line with expectations (see March issue, page 43, and April issue, page 82).

The next step was to track down the companion Z⁰ particle, carrier of the electrically neutral current of the weak force, also predicted by the electroweak theory. However the Z⁰ was expected to be ten times harder to find than the W, and at least several times the amount of data collected in the 1982 run would be needed before the experimenters



would have a good chance of catching some.

The integrated luminosity (the measure of the number of proton-antiproton collisions to which the experiments had been exposed) produced in each of the two collision areas was some 28 inverse nanobarns. At the time this was considered a major achievement.

After the champagne and the celebrations, the machine specialists knew that they would have to find some more stops to pull out if the experimenters were to get their Z⁰ particles. The goal was 100 inverse nanobarns.

The 1983 SPS proton-antiproton run got under way on 12 April. At first, things took time to settle down and the number of clocked-up collisions began to fall behind the target rate. But performance improved towards the end of April, and the 100 inverse nanobarn goal began to look

attainable. Confidence grew, but there was still a long way to go.

On 16 May, the run was interrupted for a brief scheduled maintenance break. During all this time, the Antiproton Accumulator ring which stores the precious antiprotons (produced at the rate of about one per four million incident protons) had stored particles continuously for 808 hours — 33 days. This superb reliability assured the SPS ring of a steady supply of antimatter.

After the brief stop, the run soon got under way again. One standard trick used to boost the collision rate in storage rings is to use special (low beta) quadrupole magnets to squeeze the colliding beams together. By squeezing them tighter, the SPS luminosities (collision rates) began to creep higher. Soon, initial luminosities surpassed $1.3 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$, and a record figure of 1.6×10^{29} was achieved. On

6 June, the 100 inverse nanobarn target was reached, but still the machines marched on relentlessly.

Towards the end of June, technical difficulties coincided with the onset of the summer thunderstorms which periodically upset power supplies. The final integrated luminosity figure at the end of the run was 153 inverse nanobarns.

But this commendable achievement came as something of an anticlimax as the UA1 experimenters had already spotted their first Z^0 candidate events towards the end of May (see June issue, page 167). More Z^0 sightings followed in quick succession and the announcement of the Z discovery was made to the world's press on 1 June.

The big experiments at the SPS proton-antiproton collider were not the only beneficiaries of the antiprotons. Also at the SPS collider, the UA4 study of elastic and total cross-sections had a successful run. Antiparticles were fed into one ring of the Intersecting Storage Rings (ISR) for tests with the hydrogen gas jet target of a new experiment by a CERN / Genoa / Lyon / Oslo / Rome / Turin team. Another gas jet target is installed in the SPS by the UA6 group (CERN / Lausanne / Michigan / Rockefeller). Antiprotons were also decelerated for the new LEAR Low Energy Antiproton Ring, where 17 experiments will study the new physics frontier opened up by an abundant supply of low energy antiprotons.

What for the future? The next major proton-antiproton run in the SPS is scheduled for the autumn of next year, and a number of possible improvements could push the collision rate even higher. These include boosting the antiproton supply, increasing the number of colliding proton and antiproton bunches, and constricting the beams even tighter



by 'supersqueezing' with the low beta magnets. The latter technique was successfully tested during quiet moments of the latest run.

The stored beams in the SPS are held at 270 GeV, but the experts are looking at the possibility of coaxing this a little higher without overtaxing the machine. Even a modest energy increase could significantly boost the event rate for interesting physics.

A separate project is to approach 1 TeV collision energies by ramping the beams up to the SPS working energy of 400-450 GeV. However these energies would only be available in short bursts at low luminosity, the idea being to use the UA5 streamer chamber to look for signs of phenomena only seen so far in cosmic rays. These high multiplicity effects are not visible at 540 GeV.

Looking further ahead, a high yield magnetically focused target could intensify the antiproton supply. A new dedicated Antiproton Collector ring to work in tandem with the existing Accumulator is being studied, however this project is still on paper.

But with the physics rewards at the SPS proton-antiproton collider successful beyond all but the most optimistic of expectations, the end of the 1983 run is a welcome pause for all concerned to catch their breath and reflect on what has been surely one of the most productive periods of physics this century.

Nerve centre of all operations at the SPS — the control room.

(Photo CERN 169.6.83)

More Z^0 particles

It seemed a pity to dump such healthy particle bunches circulating happily in the SPS ring, and at the last minute the decision was taken to extend the proton-antiproton collider run. During this stay of execution, the UA2 experiment logged a gold-plated example of Z^0 production and decay into an electron-positron pair. In a preliminary analysis of the data from the combined 1982 and 1983 collider runs, UA2 has collected four 'grade one' Z^0 s and four 'grade two' events, where some of the selection criteria have been slightly relaxed. For the four grade one events, the Z^0 mass is centred on 91.2 GeV. The UA1 experiment reported its first Z^0 candidates in May. Between them, the two big SPS collider experiments have now collected an impressive sample of events including W and Z particles.