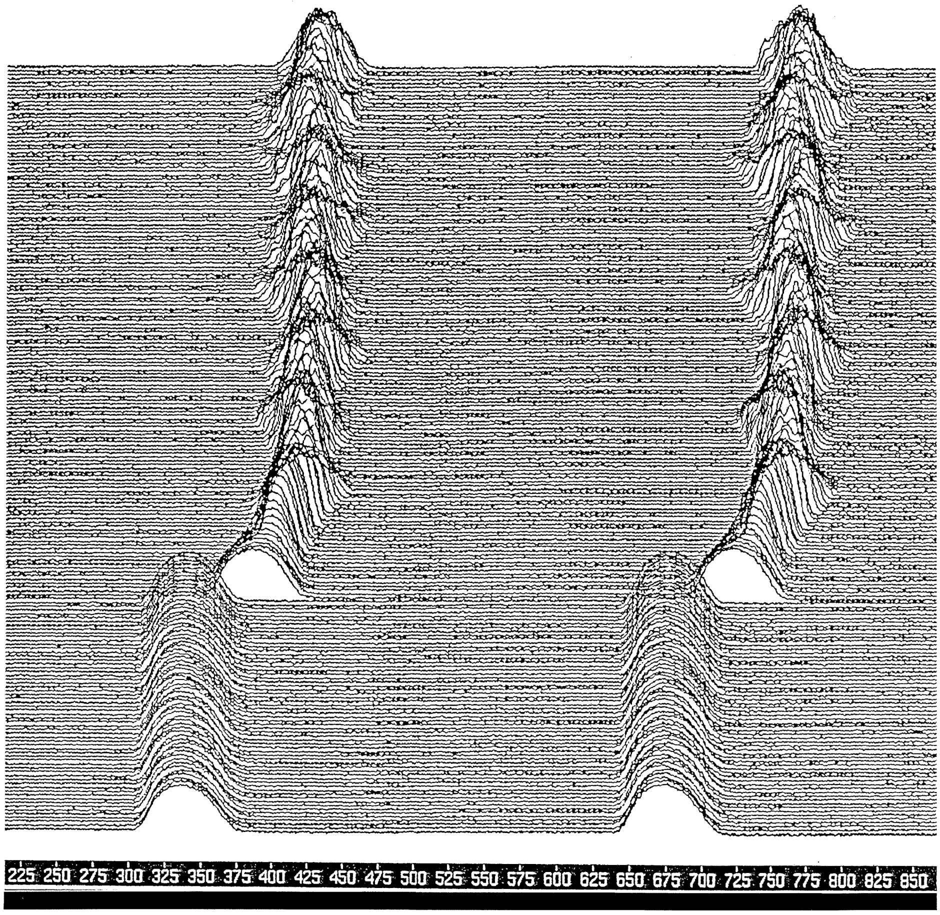


'Mountain range' display for two of the eight bunches in the Brookhaven Alternating Gradient Synchrotron (AGS). Each horizontal trace spans 700 nanoseconds and is repeated every 200 microseconds. The beam intensity is 7 x 10^{12} protons per bunch. The picture shows transition and the subsequent quadrupole-mode bunch oscillations.

positron collider from its present level around the Z resonance at 91 GeV to create pairs of W particles and explore new physics horizons (see page 6).

Bjarne Stugu of Bergen introduced the results of a recent ECFA survey on the sociology of large physics experiments. We will publish these interesting results in a forthcoming issue.

HERA progress

With first interesting physics results in hand, the immediate goal at DESY's HERA electron-proton collider is to push for the design luminosity of 1.5 x 10^{31} per sq cm per s. A major development in this direction was a switch last year to running with positrons, rather than electrons, sidestepping problems due to ionic contamination of the beam.

Running this year continues with positrons, and peak luminosity is expected to improve due to larger stored currents. However the goal is still to provide the advertised electron-proton physics, and new pumping solutions, using ion getter pumps, similar to those used in CERN's LEP ring, are being investigated. On the proton side, the DESY III synchrotron is supplying its design current, but not all of this can be transferred to the HERA ring yet. Improving the proton transfer lines should remove this bottleneck.

The major Zeus and H1 physics experiments at HERA have now been joined by the Hermes experiment employing a polarized gas target to shed further light on the origin of the nucleon spin (December 1993, page 19). Spin rotator magnets act on the transversely polarized HERA electron beam to groom it for Hermes collisions. Next year will see initial running in for components of the HERA-B detector (June, page 20).

Zeus and H1 continue to probe deeply into the structure of the proton, showing that the gluon content of the proton still increases steeply as x (momentum fraction) decreases. While this is interesting, it is also puzzling, as eventually the rise has to stop. The two big experiments also continue to study the 'rapidity gaps' - suggesting that the incoming electron 'bounces' off a pointlike object inside the proton which carries no colour. These events are of considerable interest.

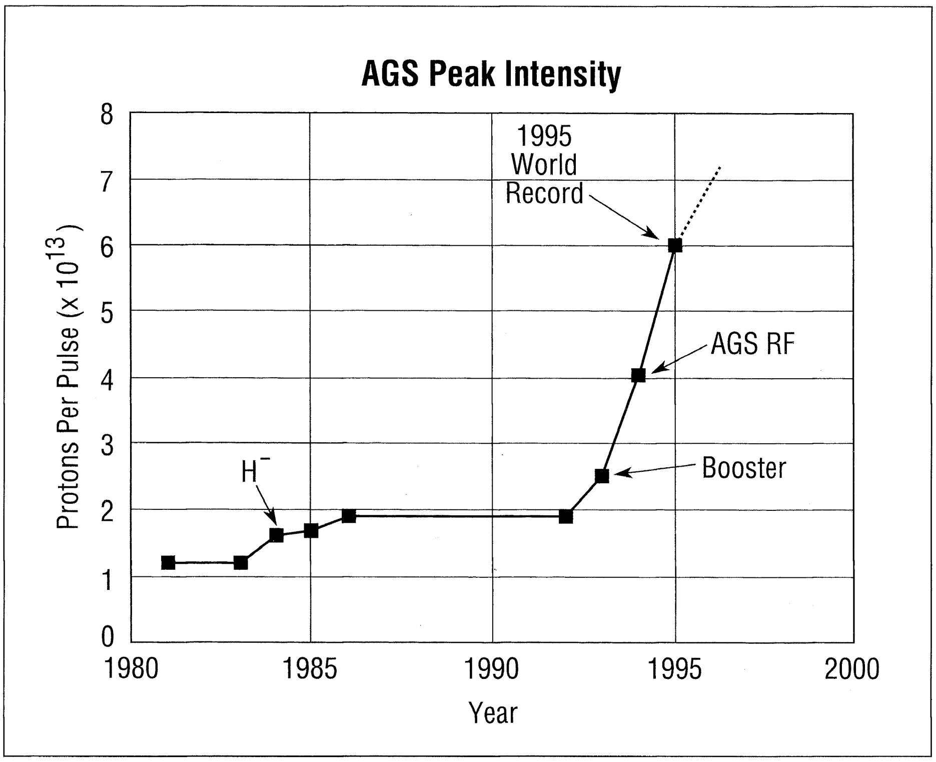
(A forthcoming workshop will look at future HERA physics - see page 54).

BROOKHAVEN Proton goal reached

On March 30 the 35-year old Alternating Gradient Synchrotron (AGS) exceeded its updated design goal of 6 x 10^{13} protons per pulse (ppp), by accelerating 6.3 x 10^{13} ppp, a world record intensity. This goal was set 11 years ago and achieving it called for the construction of a new booster and the reconstruction of much of the AGS.

The booster was completed in 1991, and reached its design intensity of 1.5 x 10^{13} ppp in 1993. The AGS reconstruction was finished in 1994, and by July of that year the AGS claimed a new US record

Brookhaven Alternating Gradient Synchrotron (AGS) peak intensity record. The intensity has increased largely through hardware improvements such as negative hydrogen ion injection, Booster injection, and AGS upgrades. The average operating intensity is only 5 or 10 percent below the peak intensity.



intensity for a proton synchrotron of 4 x 10^{13} ppp, using four booster pulses. Reaching the design intensity was scheduled for 1995.

In 1994, the AGS had seemed to be solidly limited to 4 x 10^{13} ppp, but in 1995 the operations crew, working on their own in the quiet of the owl shift, steadily improved the intensity, regularly setting new records, much to the bemusement of the machine physicists. The physicists, however, did contribute. A second harmonic radiofrequency cavity in the booster increased the radiofrequency bucket area for capture, raising the booster intensity from 1.7 to 2.1 x 10^{13} ppp.

In the AGS, new radiofrequency power supplies raised the available voltage from 8 to 13 kV, greatly enhancing the beam loading capabilities of the system. A powerful new transverse damping system successfully controlled instabilities that otherwise would have destroyed the beam in less than a millisecond. Also in the AGS, 35th harmonic octupole resonances were found. The fringe field of the extraction septum magnet, which is operated dc to reduce mechanical stresses, contributes about half of the strength of these resonances. A full octupole correction system will be installed, but meanwhile two very small octupole magnets were available and fortunately reduced the losses until the design goal could be reached.

The accompanying 'mountain range' figure shows what is taken to be the next intensity limit. The picture starts shortly before transition, with smooth and uniform bunches. After transition quadrupole-mode bunch oscillations develop for the protons within the radiofrequency bucket. These oscillations result from the rapid changes that must be applied to carry the beam cleanly through transition. While visually dramatic and technically fascinating, these oscillations themselves have no present effect on the beam intensity but the underlying phenomena causing them is expected to limit further increases until it is removed.

CORNELL
Bunch trains provide higher luminosity

The new colliding beam technique - "bunch trains" - at Cornell's electron-positron Storage Ring (CESR) has led to a new world record for colliding beam luminosity - 3.3 x 10^{32} $cm^{-2}s^{-1}$.

In the bid to increase reaction rate for any particular process, this luminosity is pushed as high as possible. Once all other luminosity-increasing cards have been played, the only practical way of making a large gain in luminosity is to increase the frequency of bunch-bunch collisions by increasing the number of bunches stored in the ring.

However this is not without its own problems:

- If the two beams travel the same orbit, the n bunches in one beam collide with the n bunches of the other at 2n points around the ring, and the resulting cumulative nonlinear beam-beam effect (tune shift) severely limits the luminosity attainable at any interaction point.
- The destabilizing wakefield effects of bunches on each other increase as the number of bunches increases and the spacing between them decreases.
- The synchrotron radiation emitted by the beams becomes a severe problem as the total beam current is