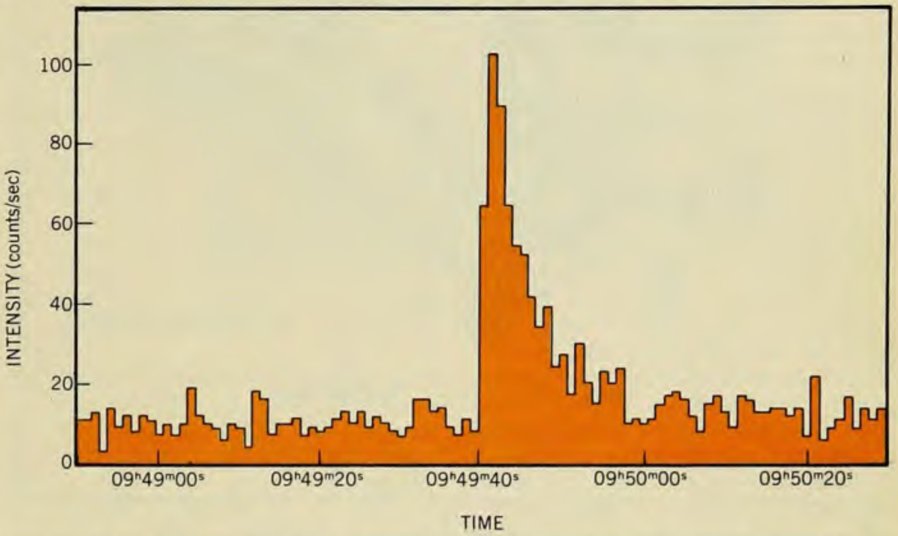
# search & discovery

## Five satellites observe short, intense x-ray bursts

"June is busting out all over," goes the old song. And now it seems that the x-ray sky is doing the same. In December a group using the Astronomical Netherlands satellite reported seeing x-ray bursts from a source in a globular cluster.[1] Soon after, an MIT group, using SAS-3, determined that the bursts from that source were roughly periodic. A Los Alamos team found what appear to be x-ray bursts in several spots. Then the MIT workers and a Harvard group found additional sources of x-ray bursts, some of which are close to the center of our galaxy.

A typical x-ray burst consists of a big increase in intensity (20- to 50-fold) occurring in 0.5–1 sec, which dies down in roughly 10 seconds. Such x-ray bursts have never been seen before, although it is possible that they are related to the gamma-ray bursts observed in 1973 by Los Alamos. Some x-ray astronomers are comparing the discovery of the x-ray bursts to the exciting time when pulsars were discovered.

An entirely new type of rapidly repeating, aperiodic burst—about a thousand per day—was announced by the MIT group early in March.




**First x-ray burst identified by ANS observers** was in data collected at 09h49m 28 September from 3U1820-30, which is in the globular cluster NGC6624. The histogram is an intensity profile as seen by a hard x-ray detector (1.3–7 keV) with 1-sec integration intervals.

**The ANS group** had been observing the x-ray source 3U1820-30, which is in the globular cluster NGC6624. (Five x-ray sources are known to be associated with globular clusters, which are symmetrical stellar condensations within a galaxy, each containing about $10^5$ stars.) The group consists of Jonathan Grindlay, Herbert Gursky and Herbert H. Schnopper (Center for Astrophysics, Harvard College Observatory/Smithsonian Astrophysical Observatory) and Daniel Parsignault (American Science and Engineering).

The source was observed in March and September 1975. Late in November, while analyzing the September data, Grindlay found an event in which the intensity increased by a factor of 30 in one second and then decayed exponentially over the next 10 seconds. The team then informed a group of Dutch observers, John Heise, A. C. Brinkman and Johan Schrijver (Space Research Laboratory, Utrecht), who also have an x-ray experiment aboard the ANS; they examined their production data and saw the same event.

After carefully examining the remaining data at nearly the same time, Grindlay and Heise found a second event that had occurred eight hours earlier; it had similar characteristics. At that point Grindlay and Heise sent out an IAU astronomical telegram. Unfortunately for Gursky and his collaborators, and despite the advice of the scientific community, ANS was turned off early in December before the discovery of the x-ray bursts was announced. The great interest in the bursts resulted in a reversal of the Dutch decision, however, and ANS was turned on again on 1 March to conduct pointing observations of globular clusters for a final six-week period.

**Vela.** Independently, R. D. Belian, J.

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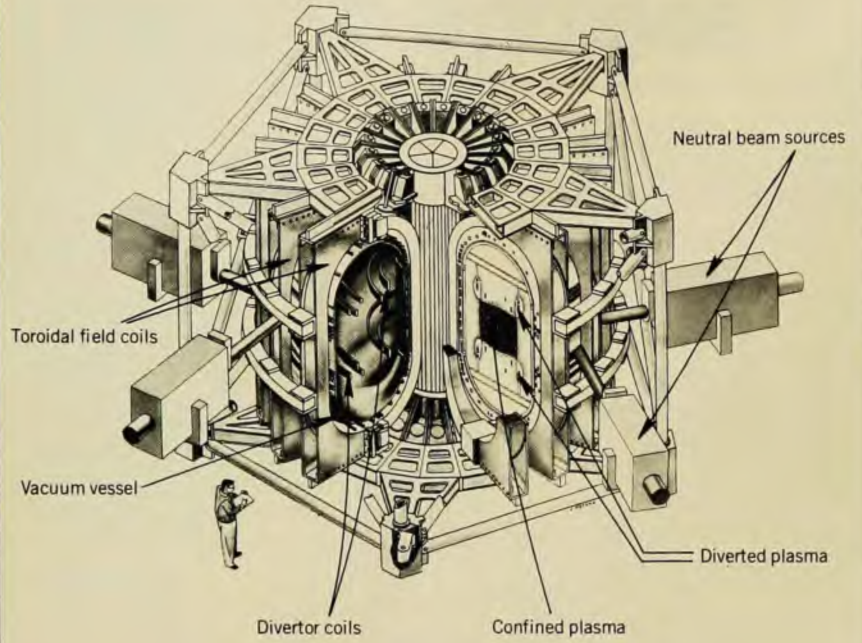
## Poloidal divertor experiment

Construction has begun on the Poloidal Divertor Experiment at Princeton University's Plasma Physics Laboratory. The $18-million device, expected to begin operation by December 1977, will be used to test the effectiveness of poloidal field divertors and magnetic limiters to control impurities in tokamaks.

The major toroidal radius and the plasma minor radius for the PDX—1.5 meters and 0.45 meters, respectively—will be similar to those of the Princeton Large Torus, an earlier magnetic-confinement device with a 50-kilogauss toroidal field. The PLT was activated last December. Compared to the PLT, the 25-kG PDX is quite vertically elongated; its vacuum vessel is five times greater in volume than the PLT's, in order to accommodate changes in the shape of the poloidal field as coil current is varied. Plasma current will be about 0.5 megamp.

The function of a divertor is to prevent impurties from entering the confined plasma. Impurity atoms are generated near the plasma surface when hot plasma bombards the vacuum-vessel wall of a tokamak. These impurities are not fatal to plasmas produced in present-day facilities, because so far the experiments involve only short pulses of a few tenths of a second. Plasma contamination, however, remains an energy-loss mechanism, and effective elimination of impurities will be essential to the operation of long-pulse fusion reactors.

Divertors, which channel impurities away from the plasma confinement region




**Poloidal Divertor Experiment,** under construction at Princeton. Divertor coils inside vacuum vessel provide a poloidal field to direct impurities away from the plasma confinement region.

and into a "burial chamber" outside the confinement area, were first proposed 20 years ago. The Princeton lab tested the concept with their Model-C Stellarator in the last decade; a toroidal divertor, located in asymmetric fashion at a point along the torus's edge, functioned as intended. In the PDX, the plasma is to be confined with magnetic separators and the poloidal divertor field will be axially symmetric to help maintain plasma stability. The plasma size as a function of time will be adjustable, to prevent skin-effect problems associated with the plasma-current buildup.

The PDX will lend itself to another scientific objective as well: to study equilibrium properties of assorted plasma configurations and thereby to determine the optimum plasma cross section for a tokamak. Plasma behavior will be compared for circular and elongated cross sections, which could be D-shaped or even rectangular.

The PDX—proposed in late 1973 and initially funded in FY 1975—represents yet another link in the chain of experimental fusion devices at the Princeton lab, a chain researchers hope will lead to a demonstration fusion-power plant. Princeton's Model-C Stellarator was transformed in 1969 into the ST Tokamak. The PLT followed after the lab's Adiabatic Toroidal Compressor, used to demonstrate that heating by compression could be employed in a plasma in a tokamak.

Larger than but similar to the PLT will be Princeton's Tokamak Fusion Test Reactor, which will eventually be operated with deuterium–tritium burning. It is scheduled for completion in 1981 at a total estimated cost of $228 million. Ebasco Services Corp, in association with Grumman Aerospace Corp, recently became Princeton's subcontractor for the building of the TFTR. —FCB

## Neutrino search to go deep undersea?

A group of physicists, oceanographers and oceanographic engineers is studying the possibility of using the oceans to detect neutrinos originating in Earth's atmosphere and beyond. The group, which has organized itself under the acronym DUMAND (Deep Underseas Muon and Neutrino Detector), is now planning a second summer workshop this year.

The detection of extraterrestrial neutrinos—neutrino astronomy—from extragalactic supernovae (10–20 MeV) and from collisions between cosmic-ray protons and intergalactic and galactic gas requires enormous detectors in the megaton range. It is not at all clear that such giant devices can be constructed with the required low background or at a reasonable cost, but the DUMAND group considers the prospects sufficiently promising to justify further study.

Chairman of the DUMAND executive committee is Frederick Reines (University of California, Irvine), who, together with Clyde L. Cowan, was the first to observe neutrinos experimentally. Reines remarked that it has been recognized for many years that the extraordinary penetrating power of a neutrino, measured in light years of solid matter, makes it a unique tool for the investigation of stellar interiors as well as providing other information uninhibited by intervening matter.

The first serious foray into low-energy neutrino astronomy was made by Raymond Davis and his collaborators (Brookhaven National Laboratory), whose search for low-energy (about 1 MeV) neutrinos from the Sun has so far yielded negative results. In fact the Davis experiment has underscored our ignorance of stellar interiors, Reines notes, and shows the importance of information one might hope to obtain from neutrino astronomy.

Consideration of expected neutrino fluxes and the strength of the neutrino interaction suggests that one would need a very large detector, possibly in the range $10^6$–$10^9$ tons. Economic factors suggest using clean sea water, both as target and detector. (A fast charged particle, secondary to the neutrinos, produces light pulses in the form of Cerenkov radiation, which can be observed with photomultiplier tubes.) Such a large detector would be overwhelmed by ordinary cosmic rays at Earth's surface; thus a deep, underwater location—about 5 km—is under consideration.

At last summer's workshop, held at Western Washington State College in Bellingham, Washington, the group evaluated the possible role of such a deep underwater muon and neutrino detector in high-energy physics in the supra-accelerator region (greater than $10^{12}$ eV) and the problems associated with the detection of supernovae and other cosmic sources.

Plans are now being formulated for a second summer workshop, which would be directed by executive-committee member Arthur Roberts (Fermi National Accelerator Laboratory). Participants will study the detailed design of a detector in the 1–10 TeV range. They will consider whether or not one can build a photomultiplier collecting apparatus that can detect antineutrinos from a supernova. Another question is whether one can study neutrinos produced in high-energy cosmic-ray proton collisions with interstellar or intergalactic gas and collisions with the 3-K blackbody radiation and distinguish