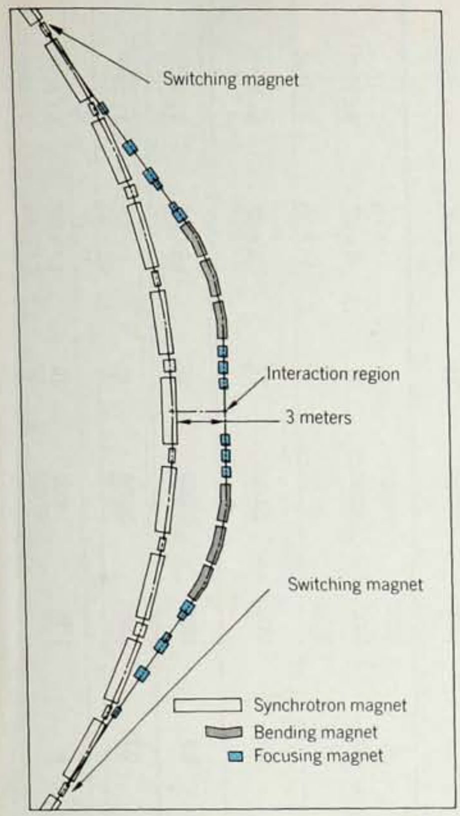


COLLIDING-BEAM EXPERIMENT. Cambridge Electron Accelerator will store counter-rotating beams of 3–3.5-GeV electrons and positrons. Each beam is switched to a bypass sector of dc magnets, is focused and then allowed to collide with opposing beam in the straight section.

committee recently recommended that the ring be built, it has not yet been authorized.

At CEA, rather than build a storage ring from scratch, physicists are performing an experiment to see whether they can use an existing accelerator as a storage ring. According to M. Stanley Livingston, director, CEA is the only laboratory to try such an experiment.

Electrons, preaccelerated to 100 MeV in a linac (in a radial tunnel), are injected into the synchrotron ring, where they orbit in one direction. By injecting electrons 60 times per second, CEA expects to produce in a few cycles a circulating electron beam with an average current of 100 mA.

To produce positrons, the electron linac beam will strike a target, and the positrons produced will be accelerated to 100 MeV in a second linac. The positrons will then be injected into the synchrotron ring, where they will orbit in the opposite direction. Multicycle injection is expected to accumulate a circulating positron beam of 100 mA in less than 30 sec.

The two beams will be separated by vertical electric fields.

Next the ac component of magnetic field will be turned off, and the beams will attain constant energy (half of the peak) in the dc field in a few seconds. This beam storage energy can be adjusted to any desired value up to 3.5 GeV.

Both beams will then be switched into a bypass sector of dc magnets outside the ring (see figure). Here they will be focused, by low-beta insertions, to very small size so that particle density and interaction rate can be much higher than they would be otherwise. Once focused, the beams will be made to collide in an experimental straight section.

Positron and electron beams will circulate through the bypass and the remainder of the synchrotron ring, where the 100-kW rf power supply will compensate for radiation losses. Kenneth Robinson and Gustav-Adolf Voss are the principal designers and planners of the colliding-beam system.

Beam lifetime, which depends on residual gas pressure, is expected to be about 30 min. Livingston notes that the design luminosity is $2 \times 10^{31}/\text{cm}^2/$ sec at 3.0 GeV, a rate comparable to that planned for other storage rings. He expects that counting rates for electromagnetic interactions of high scientific interest should be 1–1000 per hour.

The Cambridge experimenters have already stored low-intensity beams of electrons at energies up to 3.5 GeV for as long as 30 min. They have also observed the damping of beam oscillation amplitudes due to radiation loss, which is an essential feature of the scheme.

SLAC. The storage ring proposed for Stanford would take advantage of the SLAC linac, which is the most intense high-energy electron source available, to make 3-GeV electrons and positrons. The ring itself is to be located at the two-thirds point on the two-mile linac, so that positrons produced in a target at the one-third point can be accelerated to 3 GeV through one-third the length of the accelerator before being deflected into the ring. Diameter of the ring will be 70 meters.

The circulating beam currents would range from 1 to 25 amperes in each beam, depending on the energy. About 1 MW of rf power will be needed to supply the losses from synchrotron radiation.

At opposite sides of the ring there will be low-beta insertions like the ones developed for the CEA experiment.

The Stanford ring will not only be capable of studying quantum electrodynamics but has been specifically designed for the study of strongly interacting final states, for which cross sections are expected to be small, according to Wolfgang Panofsky, director of SLAC. The design luminosity depends on the operating energy and is greater by a factor 5–300 than that of the CEA project.

Other rings. Three storage rings are now operating: the Stanford electron-electron ring with 550 MeV per particle and two electron-positron rings both now running at 380 MeV per particle; one is at Orsay and the other at Novosibirsk. The electron-electron ring is now being used to extend the limits of quantum electrodynamics to much higher energy than previously investigated. The positron-electron rings are turning out data on the electromagnetic coupling constant of the rho meson.

Within the next few months an electron-positron ring with 1.5 GeV per particle will start operating at Frascati. And at CERN a pair of storage rings is being built to store 28-GeV protons.

With electron-positron storage rings one can study electromagnetic and nuclear processes at interaction energies in the center-of-mass system much larger than are available with existing or planned accelerators.

Wide-Range Device Measures Electron and Proton Energies

Scientists at Rice University, Houston, Tex., have developed a single instrument that can measure electrons and protons over the energy range of 50 to 100 000 eV. Code named SPECS (Switched Proton Electron Channeltron Spectrometer) the device is suit-

Selector guide to RCA Photomultipliers for scintillation counting and radiation measurement

For more detailed information see your RCA Industrial Tube Distributor or write: Commercial Engineering, Section J159-Q RCA Electronic Components and Devices, Harrison, N.J.

THE MOST TRUSTED NAME IN ELECTRONICS

							MAXIMUM RATINGS Supply Voltage				TYPICAL CHARACTERISTICS	SENSITIVITY			
Nom. Size	No. of Stages	Dynode Material	Type	DESCRIPTION	Spectral Response	Wave-Length of Max. Spectral Response angstroms	Between Anode & Cathode volts	Between Anode & Final Dynode volts	Between Dynode No. 1 & Cathode volts	Average Anode Current mA	Supply Voltage (E) Between Anode & Cathode dc volts	Radiant @ Wavelength of Peak Response amp/watt	Luminous (2870°K) amp/lumen	Current Amplification	Equiv. Anode-Dark Current Input (25°C) lumen
½″	9	Cs-Sb	8571	Small "Ruggedized" side-on type having semi-flexible leads.	S-4	4000	1250	250	250	0.020	1000	73000	75	2.1×10^6	5×10^{-10}
¾″	10	Be-O	4460	Small "Ruggedized" head-on type having semi-flexible leads.	S-11	4400	1500	300	400	0.5	1250	6000	7.5	1.25×10^5	8×10^{-10}
¾″	10	Be-O	4516	Small head-on type having semi-flexible leads.	(a)	4000	1800	300	300	0.5	1500	32000	27	4.5×10^5	4×10^{-11}
¾″	10	Be-O	7767	Small, head-on type having semi-flexible leads. For use in probes, in underground geological exploration, and biological tracer studies.	S-11	4400	1500	300	400	0.5	1250	12800	16	2.67×10^5	5×10^{-10}
¾″	10	Be-O	8644	Small head-on type having semi-flexible leads. For miniaturized low-level light detection and measurement systems and laser detection.	S-20	4200	2100	300	400	0.5	1500	5100	12	8×10^4	4×10^{-11}
¾″	10	Be-O	8645	Same as 8644 except it is encapsulated with an insulating plastic material in a magnetic shield with an integral voltage divider network.	S-20	4200	1800	300	—	0.5	1500	5100	12	8×10^4	4×10^{-11}
1½″	10	Cs-Sb	4438 4439 4440	"Ruggedized" head-on types having flat faceplates. For missile and satellite applications. Type 4438 has semi-flexible leads. Type 4439 has base attached to semi-flexible leads. Type 4440 is supplied with a base.	S-11	4400	1250	250	300	0.75	1000	22000	27	6×10^5	8×10^{-10}
1½″	10	Cs-Sb	4441A	"Ruggedized" head-on type with special photocathode connection which assures continuous cathode contact under rough usage.	S-11	4400	1250	250	300	0.75	1000	22000	27	6×10^5	8×10^{-10}
1½″	10	Be-O	4517	Head-on, flat-face type for pulse counting and other low level detection and measurement systems.	(a)	4000	1800	250	400	0.5	1500	39000	33	5.5×10^5	3×10^{-11}
1½″	10	Cs-Sb	6199	Head-on, flat-face type having small size for use in portable scintillation counters.	S-11	4400	1250	250	300	0.75	1000	36000	45	1×10^6	2.3×10^{-10}
1½″	10	Be-O	4461	Head-on, flat-face type supplied with base attached to semi-flexible leads. For scintillation counting and visible radiation measurements.	S-11	4400	1500	250	400	1	1250	8000	10	1.7×10^5	5×10^{-10}

2″	10	Be-O	4463	Head-on, flat-face type employing venetian-blind dynode structure. For general scintillation counting and radiation measurements.	S-20	4200	2500	300	600	1	2000	11000	25	1.6×10^{5}	4×10^{-10}
2″	10	Be-O	4518	Head-on type intended for pulse counting and other low light level detection and measurement applications.	(a)	4000	1800	250	300	0.5	1500	39000	33	5.5×10^{5}	3×10^{-11}
2″	10	Be-O	4523	Head-on type intended for pulse counting and other low light level detection and measurement applications.	(a)	4000	2000	300	600	0.5	1500	39000	33	5.5×10^{5}	3×10^{-11}
2″	10	Be-O	6342A	Head-on, flat-face type with focusing electrode. Especially useful for fast coincidence scintillation counting.	S-11	4400	1500	250	400	2	1250	25000	31	3.9×10^{5}	2×10^{-10}
2″	10	Cs-Sb	6655A	Head-on, flat-face type with focusing electrode. For use in fast coincidence scintillation counting.	S-11	4400	1250	250	300	0.75	1000	96000	120	1.6×10^{6}	3×10^{-10}
2″	14	Be-O	6810A	Head-on, flat-face type with focusing electrode. Especially useful for fast coincidence scintillation counting.	S-11	4400	2400	400	400	2	2000	2400000	3000	4.3×10^{7}	5×10^{-10}
2″	14	Be-O	7265	Head-on, flat-face type useful in scintillation counters, flying-spot scanners, and photometers.	S-20	4200	3000	500	500	1	2400	1300000	3000	2×10^{7}	2×10^{-10}
2″	10	Be-O	7326	Head-on, flat-face type useful in scintillation counters, flying-spot scanners, and photometers.	S-20	4200	2400	500	500	1	1800	9600	22.5	1.5×10^{5}	5×10^{-11}
2″	10	Be-O	7746	Head-on type with spherical faceplate. For use with Cerenkov and other nuclear radiation. Has typical pulse height resolution of 8.5 per cent.	S-11	4400	2500	400	600	2	2000	960000	1200	1.7×10^{7}	9×10^{-10}
2″	12	Be-O	7850	Head-on type with spherical faceplate. For use with Cerenkov and other nuclear radiation. Has typical pulse height resolution of 8.5 per cent.	S-11	4400	2600	400	600	2	2300	21000000	26000	3.7×10^{8}	4×10^{-10}
2″	12	Be-O	4459	Similar to type 7850 but employs multialkali photocathode.	S-20	4200	2800	400	600	1	1800	4.3×10^{4}	100	6.6×10^{5}	1×10^{-10}
2″	10	Be-O	8053	Head-on, flat-face type employing a venetian-blind dynode structure. For general scintillation counting applications.	S-11	4400	2000	300	600	2	1500	34000	42	6×10^{5}	4.4×10^{-10}
2″	12	Be-O	8575	Head-on type having a photocathode of high Quantum efficiency and an in-line electrostatically focused dynode structure.	(a)	3850	3000	800	800	0.2	1100	880	0.8	1×10^{4}	5×10^{-12}
3″	10	Be-O	4464	Head-on, flat-face type employing venetian-blind dynode structure. For general scintillation counting and visible radiation measurements.	S-20	4200	2500	300	600	1	2000	11000	25	1.6×10^{5}	2×10^{-10}
3″	10	Be-O	4524	Head-on type employing a venetian blind dynode structure.	(a)	4000	2500	300	600	0.5	1500	24000	20	3.3×10^{5}	4×10^{-11}
3″	10	Be-O	8054	Head-on, flat-face type employing a venetian-blind dynode structure. For general scintillation counting applications.	S-11	4400	2000	300	600	2	1500	35000	43	5.4×10^{5}	4.4×10^{-10}
5″	10	Be-O	4465	Head-on, flat-face type employing venetian-blind dynode structure.	S-20	4200	2500	300	600	1	2000	11000	25	1.6×10^{5}	2×10^{-10}
5″	10	Be-O	4525	Head-on type employing a venetian blind dynode structure for general scintillation counting applications.	(a)	4000	2500	300	600	0.5	1500	24000	20	3.3×10^{5}	8×10^{-11}
5″	14	Be-O	7046	Head-on, flat-face type with 4-7/16″-diameter cathode and two focusing electrodes. Especially useful for gamma-ray spectrometry.	Extended S-11	4200	3400	400	—	2	2800	1400000	1750	2.9×10^{7}	2×10^{-9}
5″	10	Be-O	8055	Head-on, flat-face type employing a venetian-blind dynode structure. For general scintillation counting applications.	S-11	4400	2000	300	600	2	1500	35000	44	4×10^{5}	4.4×10^{-10}

(a) High quantum efficiency (29%), low-noise type suitable for photon counting able for space missions because of its small mass (0.9 or 1.6 kg) and low power requirements (about 1 watt). 18-point differential-energy-spectrum measurements for both electrons and protons include parts of the lower ends of the spectra that have been relatively neglected by plasma and penetrating-radiation physicists.

The basic component is the "channeltron" secondary-emission multiplier. It is a thin tube whose interior is coated with a semiconductor material that emits secondary electrons. When a potential difference of 3500 volts is applied across the ends of the tube, an axial electric field is formed. Secondary electrons, produced when a charged particle hits the inner surface of the aperture (at ground potential), are accelerated down the tube. Simultaneously, the electron drifts across the tube with whatever lateral velocity is acquired in the ejection process. When these free electrons gain enough energy from the electric field between encounters with the surface that, on the average, more than one secondary electron is generated at each encounter, this process cascades, resulting in a gain of about 10^8.

In SPECS, five 270-deg channeltrons are mounted on top of each other adjacent to a helical "funneltron." The beam of entering particles is collimated and then passes through a pair of deflection plates kept at a variable potential. At specific voltages across the deflection plates, particles of certain energies entering the channeltrons and the funneltron are counted. When the polarity of the deflection plates is reversed, the particles switch position and, for example, the protons enter the channeltrons and the electrons enter the funneltron.

Since a satellite, in an orbit close to the earth, can pass over an auroral arc in one second, the simultaneous measurement of electrons and protons and the greater sensitivity to small particle intensities are advantageous features of SPECS. A number of small units have been flown on Javelin rockets, and the larger ones will be orbited in the Owls 1 and 2 and Aurora satellites. Another set will be placed on the lunar surface by astronauts.

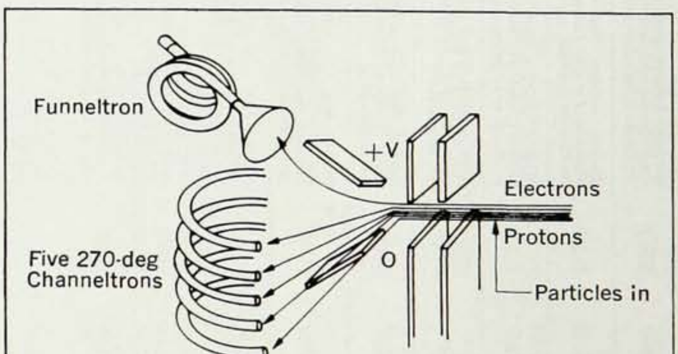
This development is reported in an article by Brian J. O'Brien, Foster Abney, James Burch, Richard Harrison, Robert LaQuey and Tadeus Winiecki in *Rev. Sci. Instr.* **38**, 1058. —MLL

1.02-Meter Bubble Chamber Starts Operating at Stanford

At the Stanford two-mile accelerator a 1.02-meter hydrogen bubble chamber recently began running. The third largest in the US, it is probably the last of its generation to be built, according to Joseph Ballam, who directs the SLAC research division. Most of the big high-energy laboratories now want larger, room-size chambers. A 4-meter chamber is being built at Argonne, and a 4.3-meter chamber for Brookhaven was recently recommended by the Weisskopf high-energy physics committee.

The Stanford \$2.5-million chamber, made of stainless steel, is 1.02 meters in diameter and 0.51 meter deep. It has a bellows-operated piston that pulses twice a second in a 24-kG field.

Unlike its predecessors the SLAC chamber has no elaborate refrigeration



SPECS measures electron and proton energies. With deflection voltage +V electrons are deflected into funneltron and protons of suitable energies are deflected into the five channeltrons.