

and Pollock (Indiana University), respectively.

A tour of the local TRIUMF facility was preceded by orientation talks on the 520 MeV cyclotron and the proposed KAON Factory. Dutto mentioned that the cyclotron has been improved by the addition of a fourth-harmonic cavity at large radius, increasing the energy gain per turn and thus reducing electromagnetic stripping losses. It can also be used in the flat-top mode to improve beam quality and extraction.

Craddock described the KAON accelerators and how the TRIUMF beam will be matched to the succeeding rings at 3 and 30 GeV. He pointed out how the support for KAON has been growing with the assistance of Dr. KAON and friendly government officials Mr. KAON and KAON Kim (see photo). During the tour visitors were taken above the cyclotron to be shown a quarter and a dime suspended from another quarter, demonstrating the power of the TRIUMF magnet and the collective strength of Canadian currency!

At the Conference dinner, master of ceremonies Mike Craddock extended the congratulations of the cyclotron community to three American Physical Society prizewinners: Henry Blosser and Bob Pollock, for the 1992 Bonner Prize, awarded for design and construction of superconducting cyclotrons and a cyclotron-injected light-ion cooler respectively; and Reg Richardson of UCLA and TRIUMF for the 1991 Wilson Prize, for demonstrating phase focusing, the first synchrocyclotron and the first sector-focused cyclotron.

Craddock pointed out this research has revealed two classes of accelerators, 'proper' and 'improper'. The former are of course cyclotrons, with the perfect rotational periodic symmetry of their sector structure.

Improper synchrotrons have frequent deviations from symmetry due to straight sections of unequal length.

The TRIUMF group put together an interesting and smooth-running conference, with Mike Craddock chairing the international and local organizing committees and Gerardo Dutto the scientific program committee. Details can be found in the 179 papers in the proceedings, published by World Scientific in December. The community looks forward to the next Conference, in 1995, to be hosted by NAC, in Cape Town, South Africa.

David J. Clark, Lawrence Berkeley Laboratory

Heavy ion fusion

With controlled thermonuclear fusion holding out the possibility of a prolific and clean new source of energy, the goal remains elusive after many years of continual effort. While the conventional Tokamak route with magnetic confinement continues to hit the headlines, other alternatives are now becoming competitive.

One possible solution is to confine the thermonuclear fuel pellet by high power beams. Current research and perspectives for future work in such inertial confinement was the subject of the 'Prospects for Heavy Ion Fusion' European Research Conference held in Aghia Pelaghia, Crete, last year. Its main focus was on the potential of heavy ion accelerators as well as recent advances in target physics with high power lasers and light ion beams.

Carlo Rubbia declared that high energy accelerators, with their high

efficiency, are the most promising approach to economical fusion energy production. However the need for cost saving in the driver accelerator requires new ideas in target design tailored to the particularities of heavy ion beams, which need to be pushed to the limits of high current and phase space density at the same time.

Dieter Möhl (CERN), describing performance achieved with CERN accelerators, showed that individual parameters have been close enough to what is needed for fusion, but no machine has pushed all parameters simultaneously to their limits, which is the real challenge.

According to Ingo Hofmann (GSI, Darmstadt) the SIS heavy ion synchrotron and adjacent ESR cooling storage ring have just opened a new chapter in heavy ion fusion. These machines provide unique possibilities for machine studies for reactor drivers as well as target work with the first dense plasmas to be produced by heavy ions.

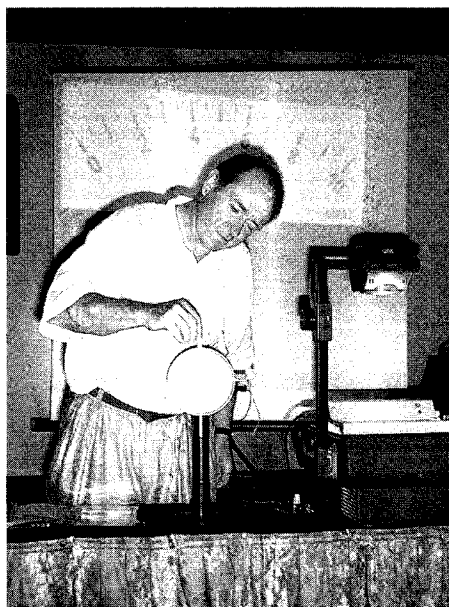
Problems of a full (five kilometre) reactor driver linac are under control, according to Horst Klein from Frankfurt, provided that target designers are not going to push the normalized emittance further down.

Parallel to the European efforts with radiofrequency linac and storage ring technology, the technologically innovative induction accelerator approach is pursued by Lawrence Berkeley Laboratory (presented by Tom Fessenden). They are awaiting funding of their next \$60M ILSE project.

Conversion of beam energy into soft X-rays ('indirect drive') seems to be the magic key now for target physicists. The X-rays are confined in a radiation case ('hohlraum') with the actual fusion pellet at its centre. Due to multiple reflections the X-rays

At the 'Prospects for Heavy Ion Fusion' European Research Conference held in Crete last year, laser physicist Richard Sigel of Munich's Max Planck Institute for Quantum Optics demonstrates the principle of indirectly

driven 'hohlraum' (radiation enclosure) targets by a simple optical analogue – the radiation near a lamp, measured by a photocell, increases dramatically inside a highly reflecting cavity.



'forget' the spatial nonuniformity of primary heavy ion or laser beams, and a spherically symmetric compression of the pellet becomes possible.

The physics of radiative hydrodynamics under conditions normally present in stellar matter is now a great challenge for theorists developing simulation programs, evidenced by Jürgen Meyer-ter-Vehn (Munich), Stefano Atzeni (Frascati) and Mihail Basko (Moscow).

The biggest obstacle having to wait for declassification of US work in inertial fusion, but this could be relatively imminent. The relative openness of presentations by leading physicists from classified laser laboratories (Livermore, Sandia and Rochester in the US and Limeil in France) was surprising and welcome.

Milestones were reported by C. Yamanaka from Osaka, home of the only unclassified dedicated inertial fusion programme. They have achieved 600 times compression of solid matter (producing 10^{13} neu-

trons), near to what is required for fusion.

According to Erik Storm from Livermore an upgrade of their existing NOVA laser facility could achieve ignition (by indirect drive) with fusion gain exceeding 10 by around the year 2000, provided the required \$400M were made available in time. Inertial fusion with lasers is now as close to reaching ignition as magnetic fusion.

More good news came from D. Cook, Sandia Laboratories (New Mexico), who reported on recent success with the PBFA II pulsed power facility shooting about 50 kilojoules of 9 MeV lithium on hydrocarbon foam obtaining conversion into X-rays. The need for reducing beam divergence is a major issue for future development.

With European collaboration in magnetic confinement well established, and with a strong inter-regional collaboration in magnetic fusion heading towards ITER as a next step, collaboration in inertial

fusion does not yet exist on any international scale. 'Should there be a European programme on inertial fusion?' asked a panel discussion chaired by Rudolf Bock (GSI). There was a consensus that lasers to demonstrate ignition and heavy ions to make an efficient driver are in the same boat – yet there was no doubt that coming together doesn't necessarily increase the funds. Who would lead such a programme in Europe? What is the cost of a dedicated heavy ion accelerator facility to study target physics close to fusion parameters?

The meeting was in the spirit of traditional US Gordon conferences with no proceedings, tutorial introductions encouraged before each talk and enough time for discussion. About 70 people attended, with a good number of younger people bringing in new blood. The chairman was J. Meyer-ter-Vehn, Max-Planck-Institute for Quantum Optics, Munich, and the meeting was sponsored by the European Science Foundation in association with the European Physical Society.

A tribute was made to strong focusing pioneer Nick Christophilos in whose home country the conference took place. Strong focusing and later on construction of the Astron (electron) induction accelerator have both been fruits of his inventive mind.

From Ingo Hofmann