# The First Beam - A Whirlwind Visual History - and Prehistory

**Michael Craddock, UBC and TRIUMF**

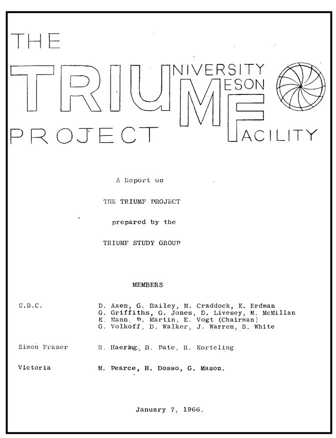
***Presented at the Annual General Meeting of the TRIUMF Users' Group***
***13 December, 1999***

The general idea of this talk is to present a quick history in pictures of how TRIUMF's first full-energy proton beam was achieved 25 years ago – covering not only the 30 days it took to coax the beam through roughly 1500 orbits from low energy at the centre of the cyclotron to 500 MeV at full radius, but also the 10 years of effort by several hundred people that was needed to bring us to that point.

**The First Beam – 10 Years in the Making**

| | | |
|---|---|---|
| 1965 | May | BC nuclear physicists agree on meson factory |
| 1966 | Jan | TRIUMF Project Report |
| | Apr | $100k from AECB |
| | Nov | TRIUMF Proposal |
| 1967 | Apr | $100k from AECB |
| 1968 | Apr | Federal approval – $19M over 5 years |
| 1969 | May | Opening Ceremony |
| | Oct | Office and lab building ready |
| 1970 | Jun | Excavation complete |
| 1971 | Jun | Main building complete |
| 1972 | Apr | Magnet & vacuum tank assembled |
| | May | Strike delays for 3 months |
| | Dec | Magnet coils completed – field surveys begin |
| 1973 | Jun | Central Region Cyclotron gives 100 μA at 2.5 MeV |
| | Aug | Magnet yoke shimming completed |
| 1974 | Apr | Magnet pole shimming completed |
| | Nov 15 | RF, cryopumping, probes, ISIS, beamline 4V, controls,........ installed and commissioned |
| | Dec 15 | Beam accelerated to 500 MeV and extracted |

After years of disagreement at UBC as to whether to go for a particle or nuclear physics project, following the failure of a 12 GeV proposal around 1960, the crucial decision to aim for the best of both worlds by going for a meson factory was miraculously reached at a subatomic faculty meeting in May 1965. From this point – TRIUMF's moment of conception – it took 3 years to obtain federal approval and funding, another 3 years to complete the main building, and a final 3 years to put together the cyclotron and all its ancillary equipment.


THE TRIUMF PROJECT — TRI UNIVERSITY MESON FACILITY

A Report on

THE TRIUMF PROJECT

prepared by the

TRIUMF STUDY GROUP

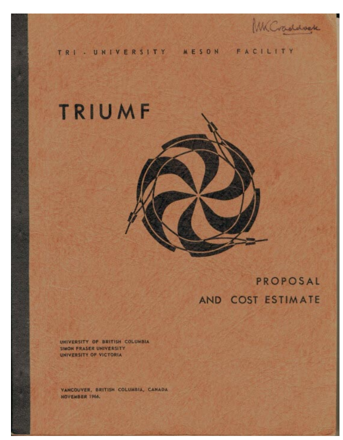
MEMBERS

U.B.C. D. Axen, G. Bailey, M. Craddock, K. Erdman
G. Griffiths, G. Jones, D. Livesey, M. McMillan
K. Mann, P. Martin, E. Vogt (Chairman)
G. Volkoff, D. Walker, J. Warren, B. White

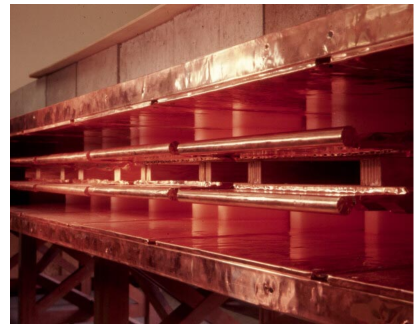
Simon Fraser R. Haering, B. Pate, R. Korteling

Victoria M. Pearce, H. Dosso, G. Mason.

January 7, 1966.

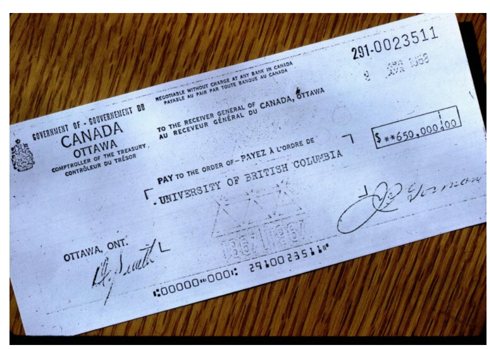



First, however, came the need to develop a proposal. By the end of 1965, a smaller version of Reg Richardson's UCLA proposal had been selected as our model, the name TRIUMF chosen, and a *Report on the TRIUMF Project* prepared by the "TRIUMF Study Group", composed of members of the three BC universities. This produced $100,000 from Ottawa in April 1966, with the help of which a full *TRIUMF Proposal and Cost Estimate* was submitted in November of that year. This money, worth about $650,000 today, and a similar sum in 1967, also enabled staff to be hired and equipment purchased for magnet and rf model studies. A power supply was bought so that field measurements could begin on a magnet model kindly loaned to us by UCLA, and TRIUMF's famous technique of building wooden radio-frequency cavities was born.

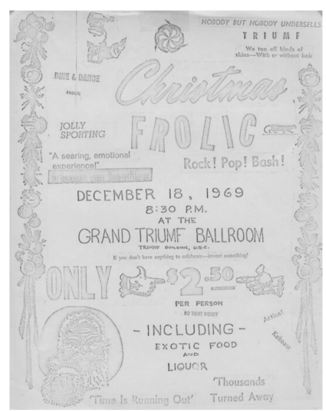
In the absence of any TRIUMF buildings, these studies were carried out in the UBC Physics Department. But the plan was always to locate TRIUMF on the south campus, which UBC had earmarked for research purposes. So when the trees were cleared and a dirt road pushed through south of 16th Avenue, it was natural for the growing staff to make an occasional excursion to inspect the favoured site. Perhaps you can recognize some of these youthful figures, who include Joop Burgerjon, and Erich Vogt, who were to become Chief Engineer and Associate Director respectively.

It was in April 1968 that the federal cabinet, urged on by George Laurence, president of AECB, approved $19M funding for the technical facility. In addition, funds for the buildings were provided by the universities, now four in number, as Alberta had joined the consortium. To us simple academics, the sight of the first cheque was tremendously exciting – and also a revelation into the ways of high finance, with the realization that million-dollar transactions were conducted on the same mundane little slips of paper as one's own modest bill payments.



The official opening of TRIUMF took place a year later in May 1969. You may be familiar with this picture of John Warren helping Jean-Luc Pepin, Minister of Energy, Mines and Resources, to plant a scion of the apple tree from Isaac Newton's home on the traffic circle – and have noticed that apples still thrive there. But you may not have realized the medieval splendour with which the ceremony was conducted – or that there was a large and well-dressed audience, ranging from George Volkoff to Gordon Shrum on one side, and from Reg and Louise Richardson to Bill Brobeck and Olaf Fredriksson on the other. Above their heads you can just make out the steel frame of the office building then under construction, but otherwise, after the crowds had dispersed, there was nothing to see but the lone apple tree and a large very muddy field, with only one extremely small inhabitable building.

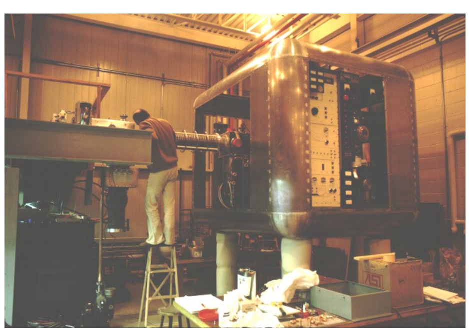
Nevertheless things began to move ahead quickly. By October that year we had moved into the office and lab building, and by December the staff was large enough to support a Christmas party in the Grand TRIUMF Ballroom – today's cafeteria – at the princely cost of $2.50 per person.

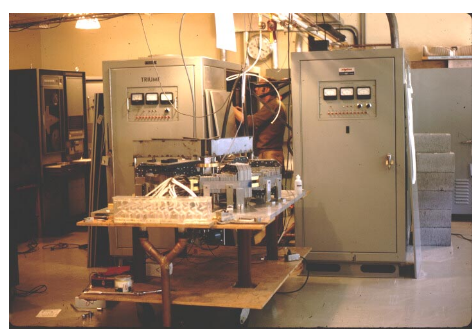



By June 1970 the excavation for the cyclotron and the experimental halls was complete – 60,000 cubic metres of glacial till had been removed to leave a 120 m by

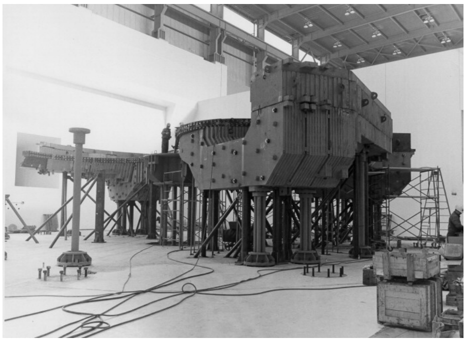
30 m hole 13 m deep. At this point, a province-wide lockout of construction trades delayed activity for two months, but then great cranes began to breed across the site, wooden forms and forests of rebar began to grow, and lines of cement trucks arrived to fill the foundations and walls of the main building – 20,000 cubic metres of concrete in all. By March 1971, the cyclotron vault was essentially complete, and by August the superstructure had been completed, the roof installed over the whole building, and the two 50 ton cranes made operational.

Meanwhile plenty had been going on in the laboratory. A full-scale model of the central region of the cyclotron was assembled, including a 300 kV HT set for the $H^-$ ion source and a long electrostatic injection line. This provided an opportunity for all the technical groups (magnet, rf, vacuum, probes, ion source and controls) to show that their hardware would actually work. In fact no significant problems arose, and beam was successfully accelerated to full energy (2.5 MeV) in June 1972, and to full 100 μA intensity a year later. Studies of the main cyclotron magnet also continued via field measurements on an accurate 1/10th scale model.

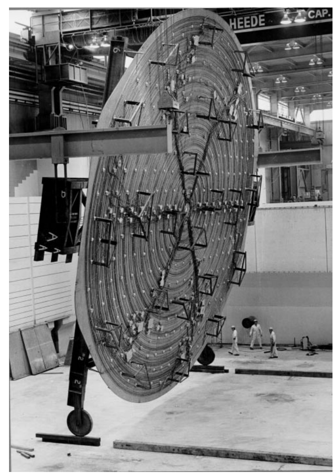




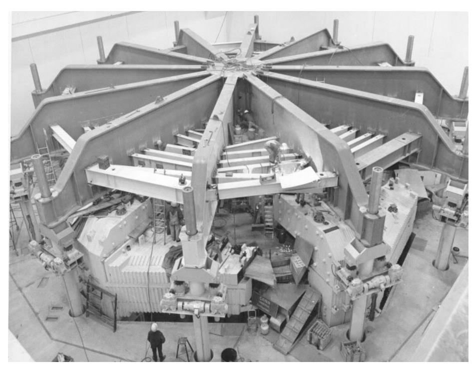
Back in the main building the real magnet was being assembled, and in January 1972 it was possible to gather all the staff on the lower six sectors for this famous group photograph. What you may not have paid much attention to in this picture are the 1600 or so bolts decorating the edges of the magnet sectors and awaiting the heroic arrangement and rearrangement of steel shims which Erich referred to in his talk.

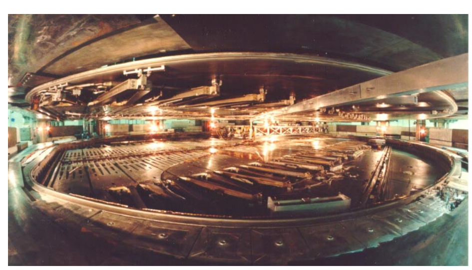


Meanwhile in the Meson Hall the 16-m diameter vacuum chamber was being assembled by Ebco. You will notice how it is festooned in coils – both for adjusting the magnetic field and for water cooling – and indeed the 54 circular trim coils were Reg's crucial tools for tuning the beam to full energy. In February 1972 the tank was lifted over the wall and lowered on to the magnets, and by April the upper half of the magnet and its huge steel supporting spider (also preventing the vacuum tank from collapsing) had all been assembled. What were still missing, however, were the connections between the 60˚ coil segments, and unfortunately a general labour dispute prevented their being welded together until the Fall.

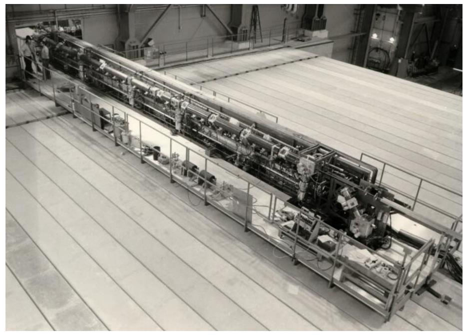


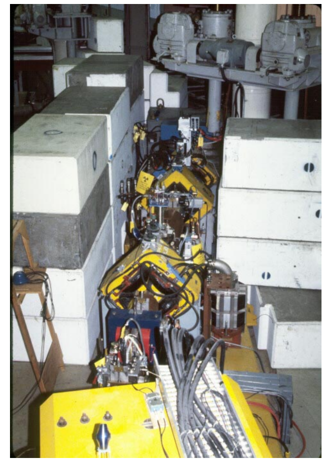
Power was first run to the magnet in December 1972, and then began the long shimming saga, to which almost everyone in the lab contributed in some way over the next year or so. Over the final six months, the magnetic field strength or its gradient were measured almost every day at up to 40,000 points, shim changes at up to 800 locations were predicted overnight (regrettably tying up the UBC computer system), and teams of volunteers – initially enthusiastic – removed and replaced the steel plates as required. By April 1973, the field's radial variation, its focusing effects, and its freedom from harmonics and vertical asymmetry, were all judged to be satisfactory, and work began on installing the radio-frequency cavities, cryogenic pumping panels, diagnostic probes and extraction mechanisms.

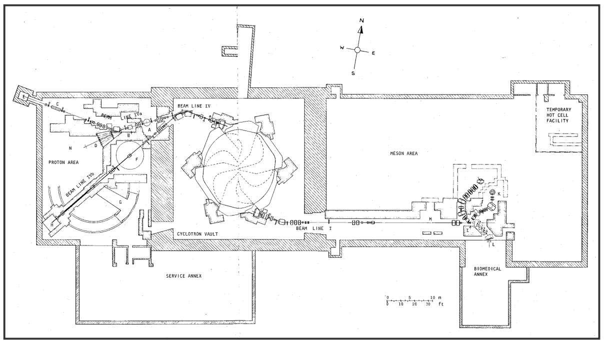




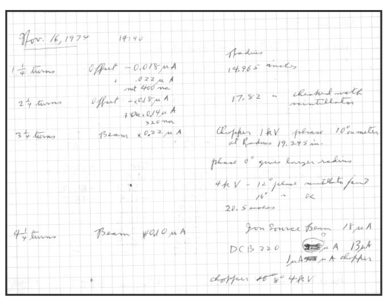
Above the cyclotron three layers of concrete beams were installed for shielding, and on top of them the electrostatic injection line from the ion sources. Within the cyclotron vault the extracted beam lines had been installed, and outside it the proton lines were complete, but the meson hall still looked very bare.

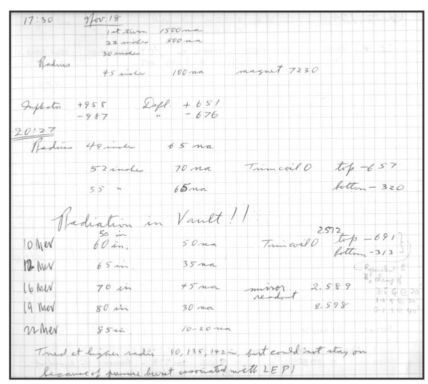






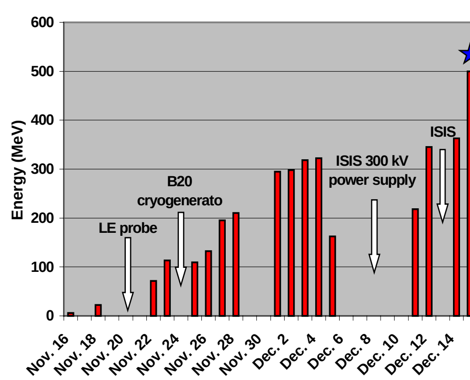

By mid-November all the cyclotron components had been tested individually, including the control system, and the director, Reg "two-hands" Richardson, was at last able to sit down at the control panel ready to tame his gigantic invention, perhaps under the fond illusion that the knobs were directly connected to the equipment, rather than going through a battery of suspect computers.





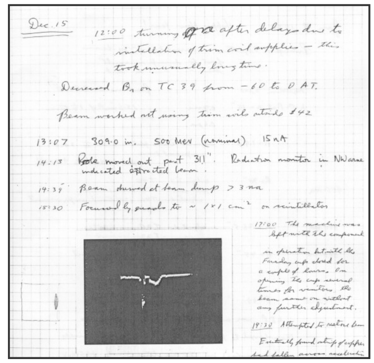

On the first day, November 16th, 1974, good progress was made through the tricky first turns, and two days later the beam had been guided out to 2-m radius orbits, at an energy of 22 MeV, with the excited entry in the logbook, "Radiation in vault!!"

The chart shows steady gains in energy through November, though there were numerous interruptions caused by unreliable components. On December 1st we reached 295 MeV, but then our luck seemed to run out. Over the next three days we could only get to 320 MeV, and this was followed by a serious breakdown of the ISIS power supply. Replacing it took a week, and even then progress continued to be slow, so that by December 14th, the energy was still only 363 MeV. At these higher energies, where the orbits are closer together, the tuning of the trim coils becomes much more sensitive, and there were times when Reg was sufficiently frustrated to



allow the beam physicists to try out their computer solutions while he went off for a lunch or dinner break. I like to think that this assistance was beneficial. At any rate, when the beam was injected at noon on December 15th, it miraculously took little more than an hour for Reg to tune through the remaining 140 MeV to the long-awaited goal of 500 MeV.


But how easy would it be to extract the beam? Well, $H^-$ stripping turned out to be as simple and effective as claimed. The stripper was moved into place, the beam line 4V magnets were turned on, and when the internal beam probe was withdrawn at 2:13 p.m., radiation was immediately seen near the beam line. Half an hour later a 3 nA beam had been steered to the beam dump and by 3:30 p.m. it had been focused to a 1x1 $cm^2$ spot on the scintillator screen.



Dec. 15

12:00 turning on after delays due to installation of trim coil supplies – this took unusually long time.

Decreased $B_n$ on TC 39 from −60 to 0 AT.

Beam worked out using trim coils outside #42

13:07 309.0 in. 500 MeV (nominal) 15 nA

14:13 Probe moved out past 311". Radiation monitor in NW area indicated extracted beam.

14:39 Beam observed at beam dump > 3 na

15:30 Focused by quads to ~ 1×1 $cm^2$ on scintillator

17:00 The machine was left with the component in operation but with the Faraday cups closed for a couple of hours. On opening the cups several times for visitors, the beam came on without any further adjustment.

19:30 Attempted to restore beam

Eventually found strip of copper had fallen across accelerati[illegible]

It would be hard to exaggerate the relief and exhilaration everyone felt at having finally achieved the aim we had been working towards for so many months and years. Of course the news spread like wildfire and the Control Room was soon inundated with visitors from both inside and outside the lab, many of them thoughtfully bringing refreshments for an impromptu celebration. The cyclotron continued to run stably through the afternoon, but it turned out that we had been very fortunate to achieve 500 MeV when we did. When an attempt was made to restore the beam after supper, it was found that a strip of copper had fallen from the dees, blocking the beam path in the cyclotron. To clear this required raising the lid of the vacuum tank, so that if it had happened only 7 hours earlier, the delay might well have prevented 500 MeV being achieved within the calendar year 1974, to the detriment of the lab's reputation.

In later years Reg would recall that month of beam commissioning as one of the highlights of his career – a magical and even romantic experience. Coming into TRIUMF through the dark and dismal December forest to find the lights glowing in the laboratory buildings like a fairy palace – then to sink into his director's chair (brought over from his office) at the controls of the largest cyclotron ever built – a wonderful crowning achievement to his career.  For all of us who participated in the construction and commissioning, these were marvellously exciting and rewarding years, which we are never likely to forget.  For the TRIUMF Users of course it was only the beginning – theirs was the challenge to put this powerful tool to effective use – and 25 years of highly productive research in a wide variety of fields show how well they have succeeded.