Personal notes on Michel Borghini as mentor

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My first day at CERN was in March 1970. Borghini brought me to his small PT lab in CERN building 21, where he prepared a sample of BuOH+H2O with porphyrexide, loaded it in a 4He refrigerator designed by Pierre Roubeau, cooled down and polarised the protons in it in a few minutes to 50%. It was miraculous to me to follow the rapid growth of the NMR absorption signal on the screen of an oscilloscope. Everything was so practical and well prepared that the whole operation was completed in less than one working day. The day was full of intense learning for me, a complete novice in polarised targets.

While doing this, Borghini described to me his work on the dynamic cooling of the electron spin dipolar interaction reservoir, based on the earlier work of Redfield on nuclear spin systems and of Provotorov on electron spin systems. Both of these applied only to the high-temperature regime, where the density matrix of the spin system could be truncated after the first-order term of its Taylor expansion. Borghini had extended these models to low temperatures and made the bold hypothesis that the temperature of the dynamically cooled electron spin dipolar interaction reservoir could be transmitted to the nuclear spin systems in the material. It occurred to me only later that neither the previous work nor the work of Borghini had been widely understood and accepted at that time.

Essential to the DNP by cooling of the electron spin interactions was that the ESR line should be relatively broad and that the spin density should be relatively high. Such spin systems could be obtained by doping a hydrogen-rich liquid by a free radicals or other paramagnetic molecules, yielding materials much richer in hydrogen than LMN.

The work, described in Borghini's famous paper (Phys. Rev. Lett. 20 419, 1968), was much ahead of its time. His clever idea was that if a nuclear spin system cools to the temperature of electron spin interactions, all nuclear spins species should reach this same temperature, in strong contrast to the prediction of the "solid effect". The experimental proof at CERN was successful, and the conclusions allowed Borghini to speculate that much higher polarisations could be accessible at yet lower temperatures. Indeed, 3He cooled targets, pioneered first time by Akira Masaike and his colleagues at Saclay, had demonstrated that this may be true.

Further benefits were also in the mind of Borghini when he visited the Low Temperature Laboratory in Otaniemi in 1969, where I had just finished my diploma work and built a dilution refrigerator for solid state research using the Mössbauer effect. Dilution refrigeration would make it practical to cool the polarised target to such a low temperature that the nuclear spins would be frozen, due to their extremely long spin-lattice relaxation time. This led to the collaboration which resulted in the frozen spin target operated at CERN first time in 1974.

Other scientists working with Borghini in 1970 were Klaus Scheffler (a senior chemist from Tübingen), Fred Udo (an experimentalist from NIKHEF then developing NMR electronics), and Jean-Michel Rieubland (a cryogenics engineer just recruited from Saclay). A little later Willem de Boer and Kurt Guckelsberger joined as CERN Fellows. Borghini actively guided everyone, and all appreciated not only his knowledge, but also his calm way of communicating and his dry humour that was never offensive.