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Homage to Francois Piuz

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Francois Piuz (1937–2022)

1. Introduction

Less than two months before the start of the RICH2022 conference, Francois Piuz passed away leaving a large void in the particle detectors community and a great sorrow in the friends and colleagues who had the privilege to work with him.

It is stamped in my memory the day I first arrived at CERN on June 21, 1990, and attended a meeting on the preparation of the RD26 proposal, where I met Francois, with his mustache and friendly appearance. I was impressed by his presentation and the enthusiasm with which he talked about the new project on the "Development of a large area advanced fast RICH detector for particle identification at the Large Hadron Collider operated with heavy ions". I started my career under Francois' supervision and continued to work with him for about 20 years, even after his retirement. Throughout those two decades I could appreciate his unique expertise in particle detectors, interest in new ideas and availability to provide help and support to colleagues.

In the following I will try to summarize his impressive career in detector R&D at CERN, and highlight some of his main achievements. For the first part of his career, until 1990, I used information reconstructed from short memories written by Francois himself, from comments received by some of his colleagues, and from literature. The third section concerns the period of our collaboration for the development of CsI photocathodes and of the ALICE HMPID RICH project.

2. 1968–80: early career, the MWPC and dE/dx age

Francois joined CERN in 1968 working in the NPA (Nuclear Physics Apparatus) division under the guidance of F. Rohrbach, performing studies on high voltage breakdown in vacuum, in relation to his PhD thesis on thin film coating in ultra-high vacuum. A first publication with F. Rohrbach's team concerns the development of streamer chambers using H_2 gas [1]. In 1970, he joined the group of A. Minten and G. Charpak where he contributed to the construction and operation of MWPC modules for the Split Field Magnet facility at the Intersection Storage Rings (ISR), the world's first proton–proton collider, which started operation in 1971. The SFM was a large multi-purpose spectrometer and the first large-scale application of the revolutionary Multi-Wire Proportional Chamber (MWPC) developed by G. Charpak, representing an incredible challenge at that time. The SFM facility covered the full solid angle with an unprecedented 300 m^2 detector surface, and 73000 wires and electronics channels [2,3]. At that time, in parallel, he worked also on novel discharge chambers (the multi-gap projections chambers) [4] the PhD topic of Amos Breskin, a new student joining G. Charpak's team, who established with Francois a solid professional and personal relationship lasting his entire life.

Major detector, electronics and software developments were needed to bring this project into operation in 1974. Olav Ullaland commented on the SFM period: "Francois was one of my first collaborators at CERN and more specifically in the Minten and Charpak group, the (in)famous Split Field Magnet Detector group. It was surely due to people like Francois, and Hans Gerhard Fischer, that we finally could take data with the instrument and get the first MWPC-dE/dx detector working". At the first Vienna Wire Chambers conference in 1978, the SFM group gave four presentations, in particular concerning the upgrade of the SFM detector to address acceptance loss issues, and the characterization of such a system for dE/dx measurements [5–8]. Another remarkable achievement of this period is represented by the accurate study of the energy loss mechanism and cluster counting in gases for the identification of relativistic charged particles reported in [9]. Theoretical evaluations of cluster size distributions in Argon have been made through complex Monte Carlo simulations at atomic

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level, performed by his young colleague Francis Lapique. The main inputs for such simulations consisted in the photo-absorption cross section and in the cross sections for the various processes triggered by the collisions of low energy electrons in the gas, in order to estimate the energy transfer spectrum. Then, rather than measuring the total deposited charge, subject to large fluctuations described by the Landau distribution function, one can count the number of primary collision clusters, which follow a Poisson distribution, and would thus result in better energy resolution. One spectacular use of this approach would be the X-ray photon detection system in Transition Radiation Detectors (TRD) [10], e.g. in the ALICE experiment's TRD at the LHC [11]. Cluster counting has become recently a candidate technique for high granularity dE/dx measurements in ILC and FCC applications [12,13]. I report here Jerry Va'vra's comment on this publication:"His cluster counting paper was one of the first crucial pioneering papers on this topic, from which we all learned". And Chris Fabjan remarks on this period:"His work on the concept of "ionization clusters" in the MWPC became a classic, crucial to the development of particle identification based on multiple measurements of ionization, which was subsequently exploited to great effect in many experiments".

Francois was also involved in the EMI (External Muon Identifiers) project for Gargamelle, another very large MWPC-based system consisting of 71 modules of $1{\times}3$ m^2 [14]. In this context he proposed and built a "Picket fence" detector to be located between the bubble chamber and the EMI system, in a limited area upstream and downstream the beam, to improve the background rejection [15].

3. 1980–1990: high precision tracking with MWPC and silicon detectors for SPS experiments

At the beginning of the 80's Francois continued to develop and characterize an MWPC with cathode strip readout, in particular for tracking telescopes, pointing out centre of gravity (COG) systematic errors related to discrete sampling [16], or measuring the longitudinal diffusion of electrons in various gas mixtures [17]. The first contribution to a SPS experiment consisted in a set of 9 strip readout MWPCs for NA19, achieving 70 μm position resolution [18]. This system was built by a young technician, Thomas Dave Williams, who joined Francois' team in 1979 and contributed significantly to all new detector developments and construction, thanks to his outstanding skills for very high precision mechanics and assembly. Another highlight that came from his insightful understanding of MWPCs was the development of a novel drift chamber topology capable of measuring particles with exceptional spatial resolution and multi-track separation, as required for the SPS experiments starting at that time [19,20].

At the beginning of the decade, Francois collaborated also with Erik Heine on the pioneering development of silicon microstrip detectors [21]. Such work has been later acknowledged with the 2017 High Energy and Particle Physics Prize of the EPS for an outstanding contribution to High Energy Physics, awarded to Erik Heijne, Robert Klanner, and Gerhard Lutz "for their pioneering contributions to the development of silicon microstrip detectors that revolutionised high-precision tracking and vertexing in high energy physics experiments". Francois' contribution was mainly a system based on three MWPC strip chambers with COG readout, used both for external tracking and triggering, which was quite relevant for the assessment of the first micro-strip sensors performance. This experience allowed him to approach the field of silicon-based tracking systems, indeed he was then involved in various experiments for which he provided micro-strip detector (MSD) telescopes achieving single track resolution of 20 μm: a 16 planes MSD for the WA75 experiment [22], 11 planes MSD for NA34/HELIOS [23].

4. 1990–2002: The CsI-RICH for the ALICE experiment at LHC

At the end of the 90's, Francois contributed to the JETSET project [24], and moved back to PID working for the first time on a RICH detector, which will then remain the focus of the last part of his career. Thanks to his excellent expertise on gaseous detectors and the growing availability of VLSI front-end electronics (FEE) for the readout of pad segmented detectors, he proposed and tested a RICH prototype using a CaF_2 radiator coupled to a MWPC operated with photosensitive (methane+TEA) gas mixture [25]. The MWPC geometry (in particular the anode-cathode gap and the readout pads size) was optimized in order to provide the simultaneous detection of minimum ionizing particles and single photo-electrons with stable operation and sufficient spatial resolution. This was made possible also by the AMPLEX front-end electronics chip [26], featuring very low noise (1100 e-) and multiplexed analogue readout, and represented the basis of the following developments for the ALICE RICH.

J. Seguinot's pioneering work on the use of CsI photocathodes in gaseous detectors [27] provided one key ingredient for the implementation of the so-called fast-RICH concept, since the usage of a photoconverter film would overcome or at least mitigate the main limitations (photoconversion time jitter, parallax error, photon feedback) of photosensitive gas mixtures with slow TPC-like readout. The following step necessary to apply such a technology to HEP experiments was the scaling to large area systems, to reach large, uniform and reproducible quantum efficiency of CsI films deposited over surfaces up to 0.5 m^2. Francois was one of the main proponents of the RD26 project, started in 1992 with the aim of developing large area CsI-based MWPC photodetector and the related FEE, for applications at the next Large Hadron Collider (LHC) at CERN operated with heavy ions [28]. Several experts in particle detectors, in microelectronics and also in solid state physics were involved in the RD26 project, which achieved already in the first two years of activity excellent results [29], presented by Francois at the historical First Workshop on RICH detectors held in Bari (Italy) in 1993 [30] (Fig. 1).

The definition of the procedure for CsI film deposition on large area photocathodes (PCs) required an impressive effort on many fronts, from the development of an evaporation plant, with in-situ quantum efficiency measurements, for photocathodes up to 40 × 60 cm^2, to a dedicated pad PCB substrate production line with vacuum application standards to systematic studies of up to 40 CsI PCs in lab and beam tests. Thanks to the steady progress of the RD26 project, the High Momentum Particle Identification (HMPID) CsI-based RICH detector was included in the ALICE Technical Proposal in 1995 [31], and Francois reported a comprehensive summary of the project at the RICH95 Workshop in Uppsala [32]. A first application of the CsI technology in HEP outside ALICE is represented by the upgrade of the Threshold Imaging Cherenkov counter for the NA44 experiment at the CERN/SPS [33,34].

Despite the successful outcome of the R&D, Francois kept his prudent and cautious approach for the preparation of the Technical Design Report, for which he proposed to build an engineering module having the size of 2/3 of a final HMPID module, for a full validation of the technology [35] (Fig. 2).

After the TDR publication, the first in the series published by the various ALICE subsystems, the icing on the cake was the installation of this module in the STAR experiment at the BNL/RHIC, which would allow assessing the CsI-RICH performance in a real heavy-ion physics experiment, also representing the first application of such technology in HEP. That required a major logistic and technical effort, as one had to address issues related to the shipment by plane of a 1 m^2 MWPC, two quartz radiator vessels and four CsI PCs without exposure to air, as well as the re-mounting and re-commissioning of the detector. Francois managed this enterprise with great determination and finally the module was installed in the STAR experiment in autumn 1999 (Fig. 3) and successfully operated [36].

Fig. 1. Francois Piuz at the First Workshop on RICH detectors in Bari (Italy), 1993.

Fig. 2. Francois Piuz next to the HMPID engineering module at the SPS testbeam in 1998.

The publication of the HMPID TDR marked the end of the RD26 project, which achieved excellent results on all aspects. I share Amos Breskin's comment on this project:"He was the moving force behind. Based on his meticulous R&D on detector and electronics, and success, other teams moved to CsI-based detectors, learning from him a great deal". Indeed various experiments exploited the CsI technology developed by RD26: NA44 and COMPASS at the CERN/SPS, HADES at GSI, HALL-A at JLAB, PHENIX at the BNL/RHIC. In the last years before the retirement in 2002 Francois provided a last fundamental contribution to the HMPID project, supervising the finalization of the detector design and the organization of the assembly, which started in November 2001. At the RICH2002 Workshop in Pylos he gave a review

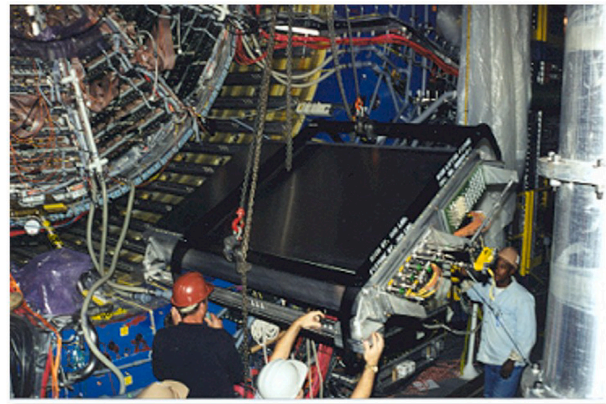

Fig. 3. The installation of the HMPID engineering module in the STAR experiment in 1999.

Fig. 4. Francois checking the FEE mounted on a HMPID module.

talk on CsI-RICH detectors, and the related proceedings represent an outstanding overview of that technology at that time [37]. It is worth to mention that François was also involved in coordinating test-beam activities, which were instrumental to the R&D for all ALICE detectors.

After his retirement, Francois continued to actively participate to the construction, installation and operation of the HMPID (Figs. 4–6), which, nearly two decades after its construction, continues to operate at higher rates, compared to the original design, for LHC Run 3 [38].

In addition, already before the start of LHC operation, the collaboration started the R&D for the so-called VHMPID (Very High Momentum PID) detector, aiming to extend the charged hadrons track-by-track PID to the 5–25 GeV/c range. This would be achieved by using pressurized C_4F_{10} gas as Cherenkov radiator, coupled to CsI-based micro-pattern gaseous photo-detector [39,40]. Francois contributed with his usual enthusiasm to the detector design and to the beam tests of various prototypes. The successful development brought to the publication of the Letter of Intent for the ALICE VHMPID Upgrade [41].

5. Conclusions

Francois Piuz was a talented physicist, with a very meticulous approach and the desire to understand the functioning of new detectors at the fundamental, microscopic level. Francois' remarkable scientific and engineering capability, and ability to envision solutions to complex problems, were key to the success of the many detector projects that he worked on. He was always interested in new ideas and ready to

Fig. 5. The HMPID team in front of the detector prior to installation in ALICE cavern.

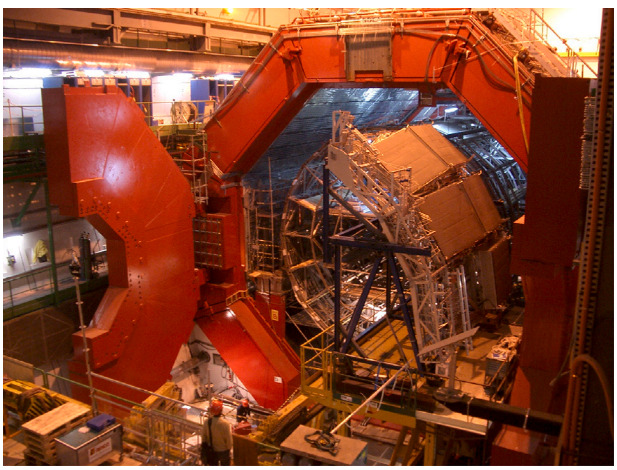

Fig. 6. The installation of the HMPID detector in ALICE in 2006.

provide help and support to colleagues. These qualities, combined with a playful sense of humour, made Francois a very friendly and charismatic personality. Last but not least, Francois had a strong passion for visual arts. He was an excellent photographer: nature, and mostly rocks. Lately, he started painting, mainly copying, with amazingly great skill, works of Picasso, Matisse and other modern masters.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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