August of 2020

Alvin and the Tevatron

Valeri Lebedev, Fermilab, Accelerator Division

I came to Fermilab at the beginning of 2001 – just at the beginning of Tevatron Run II. By this time, I was already involved into Muon collider and Neutrino factory project; and therefore, it was natural that the first time I met Alvin was at one of the Muon collider meetings. At that time, I did not know that Alvin was one of the "Tevatron fathers" and his contribution into launching the muon collider effort. However, I could see that Alvin was one of the intellectual leaders behind this endeavor. One of recollections of this time is a discussion on how to describe accurately coupling between the transverse and longitudinal degrees of freedom. This discussion motivated me to start working on the subject. Although it was not much in demand in the Muon collider project, it became extremely useful years later in building the theory for optical stochastic cooling which we are going to test experimentally within next few months. For all these years Alvin was behind the Muon collider effort. Here I would like to mention two important contributions. The first one is setting an effort in using warm superconductors for getting large magnetic field in the solenoids for ionization cooling; and the second one the work on considering arcing in the gas filled RF cavities produced by the beam. Once I came into his office and I was surprised seeing Alvin reading a thick book on the discharge in a gas. The book described the process in many details including chemical interaction of the ions. I do not know many physicists capable to read such advanced book even in their young years, but Alvin was already well behind his 80 at this time. Alvin was working on many different aspects of the Muon collider but may be one of the most important was fostering young scientists. Here I will mention just two of them which I was personally engaged to. They are Katsuya Yunehara and Ben Freemire. While the Muon collider never was a major subject of my work, to some degree, I was involved into the project for all these years and it was one of the projects where I frequently communicated with Alvin; and each time I was impressed by his very detailed approach to everything he was working on.

Another subject of my interaction with Alvin was Tevatron Run II. It was the major part of my work for 8 years (2001-2009). It was extremely ambitious and interesting project, and it presented many diverse subjects for studies and operational improvements. For me as well as for many of my friends and colleagues it was fantastic time. However, at the beginning the pace of luminosity improvements was well behind schedule. Alvin was extremely caring about the Tevatron and its success; and this slow pace at the Run II beginning was one of Alvin's headaches. My first serious discussion with Alvin about what to do happened in the linac tunnel in 2002 where we occasionally met. By that time it became clear that we are well behind

the promised pace and the question what needs to be done was painfully standing. After some discussion we agreed that we just need time. That the approach has to be based on a set of carefully thought through steps. That we do not need micro-managing of directorate and with time we will achieve the advertised goal in the luminosity. To the pleasure of many Run II participants it remarkably worked and by 2009 we achieved the luminosity goal. Here I would like to mention three studies where Alvin was strongly involved and where his participation was essential. They are: (1) study of proton scattering on the residual gas in Tevatron, (2) studies of intrabeam scattering in the Tevatron, and (3) the longitudinal profile monitor for Tevatron.

Study of proton scattering on the residual gas in Tevatron was actually aimed to find out if there is an emittance growth due to field noise in superconducting magnets. The measurements were carried out at the injection energy and the conclusion was that this noise does not contribute more than about 20% to the observed emittance growth. I need to mention here that Alvin was also supervising a graduate student L. Nicolas who was also working on this project with the goal to understand what is the gas composition in the Tevatron vacuum pipe. Although the gas scattering experiment did not show any considerable emittance growth due to magnetic noise at the injection energy, the conclusion was reversed at the collision energy where the gas scattering was greatly diminished. The studies of the intrabeam scattering carried out at the collisions reveled considerable contribution to the emittance growth coming from the noise in the superconducting magnets - the magnets which Alvin was designed more than 20 years before this study. The below figure (taken from [1]) shows that the longitudinal heating has almost zero intercept at zero bunch population, while the intercept in the transverse heating is significant and it cannot be related to the gas scattering which we already know in sufficient details.

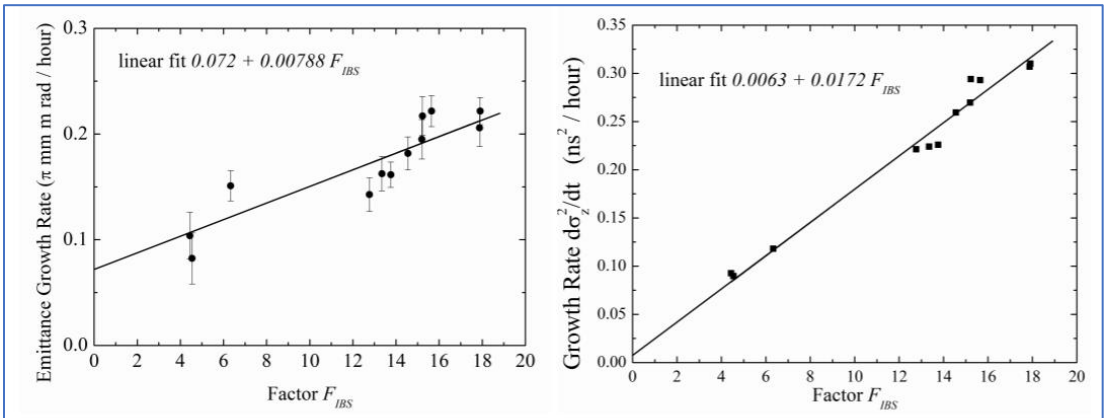

Figure 2. a) (left) Vertical emittance growth rates of proton bunches vs the IBS factor F_{IBS}; b) (right) the mean squared bunch length growth rates vs the IBS factor F_{IBS} (see in the text).

[1] V. Shiltsev and A. Tollestrup, "Emittance growth mechanisms in the Tevatron beams", 2011 JINST 6 P08001.

Later similar noise was found at the LHC commissioning. They called it “hump” at time it was observed. Knowing the reason it was not difficult to suppress this emittance growth in the LHC where, in difference to Tevatron, it represented a tremendous problem. The third project was the longitudinal profile monitor for Tevatron. Here Alvin’s leadership was absolutely essential. He came up with a novel algorithm for computation of the longitudinal distribution function and carried out all required corrections to the hardware related problems like the dispersion in the cable, reflections, and finite time resolution of the scope. As result, we not only could measure the longitudinal distribution function but also could see “parasitic” bunches which were a leftover of imperfect bunch coalescing and which intensity typically did not exceed ~1% of the intensity of main bunches.

At this day Alvin met his 80-th birthday

In conclusion I would like to share some details of our personal interaction. We (my wife Svetlana and me) were lucky to became friends with Alvin and Janine. Alvin had a fantastic personality. I consider this being not less important than the strength of Alvin’s mind. He had a great sense of humor which often was barely seen but that made it even more attractive. Through his life he was fostering many young and not very young scientists. He frequently repeated “Be good to your students. One of them can be your director”. He actually had a reason to state this because it really happened to him. For many years Alvin and Janine invited us in a middle of December for the New Year Tree decorating party. This has been a place where we met many Alvin’s friends from different corners of the lab ranging from the postdocs to the lab directors. This was a place where we met Leon Lederman: a former lab director and fantastically interesting person. It was where Alvin welcomed many scientists which came from abroad – including us.

Alvin lived fantastically productive, long and interesting life. He was working to the very last days. I am grateful to the fate that we met and became friends. The pictures below was taken in January of 2020 at a dinner we invited Alvin and Janine. In a month Alvin passed away. For me the whole epoch is gone together with Alvin, but the memory about this extraordinary person will always be with us.

Valeri Lebedev, Alvin, and Alexander Valishev.

Alvin and Janine