Valeri Lebedev Retirement Symposium

Comments on Project X and PIP-II

Steve Holmes

I did not know Valeri well when he arrived at Fermilab in the early 2000s. Prior to his arrival I primarily knew of him by reputation – I do remember that Andrew spoke very highly of him and his critical role in the commissioning of CEBAF. I believe that this role, and the impending need to make Collider Run II a success, were the primary motivations for bringing him to Fermilab. If so, our faith in Valeri was amply rewarded as he was one of the leaders in the successful Run II campaign, as highlighted by Vladimir and Sasha.

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The origins of Project X, and its offspring, PIP-II, came via development activities aimed at the Muon Collider in the late 1990s/early 2000s. At that time, the facility required to generate the required multi-MW proton beam was known as the Proton Driver, and both linac- and synchrotron-based concepts were developed. Even at this early stage, the flexibility of a high-power linac to support a parallel kaon/muon program and/or neutrino factory was recognized, and so this approach was generally favored over the synchrotron approach.

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In the mid-2000s the Muon Collider was placed on the back burner and the particle physics community threw in its lot with a superconducting RF based linear collider. While the ILC was supported as the highest priority of the community, many of us at Fermilab believed that it would be prudent to develop a “Plan B”, based on a strategy of aligning with the technologies being developed for ILC to provide synergy between the R&D programs. Thus, was born Project X and the set of RF frequencies that persist to this day.

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Project X was envisioned as an 8-GeV superconducting proton linac, capable of supporting a multi-MW neutrino program while simultaneously delivering MW beams at 1-3 GeV for a variety of world-leading kaon, muon, and neutron programs. (Note that 1 GeV is sufficient for producing copious neutrons and muons, but at least 3 GeV is required to produce a useful yield of kaons). The concepts being developed at this stage were driven by Sergei Nagaitsev and Valeri, working closely with Bob Tschirhart who was in charge of developing the physics program.

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One of the more intriguing features of Project X was a beam splitting scheme that could deliver very high beam powers to multiple users, with differing bunch structures, simultaneously. This concept was inspired by the beam-splitting scheme employed at CEBAF but took it a step further by combining with a wideband chopper at the front end to create a uniquely flexible capability.

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Project X culminated in the release of the Project X Reference Design Report in advance of the “Snowmass on the Mississippi” meeting in the summer of 2013. The report was well-received by the particle physics community but ultimately deemed too expensive to implement all at once.

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In September 2013 Nigel Lockyer arrived as the Director of Fermilab and worked quickly to consolidate the positions of Project X and the LBNF/DUNE project, and to gain community support through the P5 process then underway. He was largely successful in this endeavor and these dual projects now form the long-range future of Fermilab. The first step on the accelerator side was to reduce the cost, i.e. scope, of Project X by about a factor of three, while preserving the long-term goals. Nigel also asked for a new name, and we came up with PIP-II.

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In the spring of 2014, the P5 report was issued, including a recommendation to proceed immediately with R&D for PIP-II, followed by construction. This was paired with a recommendation to proceed with LBNF/DUNE as an international project. Around this time Nigel appointed Sergei as head of the Accelerator Division with a priority of bringing the NuMI facility up to its full design goal. Sergei succeeded in this. Sergei had been serving as the “Project Scientist for Accelerator Facilities” on Project X up to this point, so we needed a new Project Scientist for PIP-II. Valeri was the obvious choice as he was both fully capable and up to speed.

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Over the next several years the PIP-II accelerator design as we now know it evolved under Valeri’s direction. He was personally involved in every aspect of the design and pretty much made all the technical decisions. The design is documented in the Conceptual Design Report, which was mostly written by Valeri. So, if for some reason it doesn’t work, we will know who to blame! But that’s not going to happen.

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Let me talk a little about some of the attributes that made Valeri uniquely qualified to play the leading accelerator design role in PIP-II. Most importantly, he had extensive experience with the operations of actual accelerators, both at CEBAF and in the Tevatron complex. He has an ability, which is rare, to make the connection between underlying physics and what is showing up on control room monitors. I have long believed that it is extremely important to have people designing new accelerators who have practical operational experience. Valeri was basically perfect for the design role on PIP-II.

I was continually amazed by the breadth of Valeri’s physical insight. He always had an inherent sense of what the underlying physics would dictate in terms of the performance of physical devices. And he was a complete ace at modeling physical processes – I think he used MathCad. I was often stunned when he would come into my office and show me a complete model of some physical process that he had developed overnight, following a prior day discussion – the optimal stripping injection/painting scheme for the Booster; a strategy for controlling microphonics in the PIP-II linac; the optimum arrangement of cavity types in the linac; the design of the helical chopper. All of these insights were incorporated into the PIP-II design. The work he did was more in the realm of modeling than in simulations; but the simulations always showed that his models were correct. As he developed the PIP-II design there was no detail that escaped his notice or was not subject to his analysis.

Valeri also kept totally up to date on what was going on in the rest of the world. In the midst of his PIP-II activities he correctly diagnosed what was causing anomalous beam losses and unexplainable beam optics in the SNS linac (as described by Sasha Aleksandrov). I was actually on the SNS Accelerator Advisory Committee at the time and was aware of the symptoms. But no one on the committee, including me, had any good advice to offer on the source. Then out of nowhere, Valeri, who is not on the committee, says it’s intra-beam stripping and presents a model that explains all their observations. It was brilliant!

Finally, Valeri holds strong opinions that are not easily dissuaded, and he always says what’s on his mind. While I certainly appreciated that, I will admit there were a few instances when we didn’t see eye-to-eye and he might have gone a little too far publicly to my consternation – I’m not saying anything more about that, so you’ll have to ask him about this at the bar later. I also remember an argument extending over many months on whether we should quote beta-geometric or beta-optimized for the PIP-II cavities. I never seemed to be able to win that argument, even though I was the boss! But these few episodes had no impact my level of appreciation for his capabilities.

Valeri left PIP-II about the time I retired. This was probably the best thing for him and would have happened even if I had stayed. He had taken the accelerator design as far as it could go. He had multiple other interests (like optical stochastic cooling) and also harbored some disappointment that we weren’t going for the full-bore Project X. There are other people who felt this way, and I understand that. In any event, the PIP-II design will remain Valeri’s legacy.

I would like to finish up with a few words about a very interesting concept Valeri was pursuing at the time of my retirement and his departure from PIP-II. He was convinced that if each of the super-periods in the Booster, of which there are 24, could be made truly identical, the space-charge limit in the Booster would be increased by a factor of 24. I think the concept is correct; but, as a practical matter I believe there would be difficulties in actually achieving the required level of reproducibility in the existing Booster. However, it seems highly likely to me that sometime in the 2030s a new RCS will be constructed to replace the Booster. The injection energy will probably be somewhere in the range 1-2 GeV. I would highly recommend that the designers of the PIP-III RCS revisit Valeri’s ideas on high super-periodicity optics as they develop the concept.

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Let me conclude by saying we are all highly appreciative of everything Valeri did for PIP-II, and for Project X, and for the Tevatron. For PIP-II he has designed a state-of-the-art superconducting linac that will serve the laboratory well for decades.

Valeri has a unique set of capabilities and he utilized them to the maximum extent throughout his career. He can look back on his many achievements with satisfaction and with the appreciation of many people.

So Valeri, congratulations on your retirement and good luck in your next journey!