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Hadronic Monte Carlo Transport: A *Very* Personal View

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1 Introduction

Much to the disappointment of many, our distinguished speaker for the initial plenary session has been unable to attend our conference. I was prevailed upon by the conference organization to present a talk which, as prescribed, will be of a historical nature, but as the title describes, will also be a *very personal view*. Perhaps the opinions expressed will find sympathy with my associates around the world who have devoted their efforts to and found some satisfaction with providing the code tools for radiation transport to a large, and occasional anxious, community of users.

2 How LANL (and I) Got into the Business

The original request was made in 1979 by Gary Russell (now LANSCE) to adapt the ORNL code HETC[1] to use MCNP tracking and to interface with MCNP[2] for neutron transport. The primary motivation was neutron source target and facility design which, over the years, became the LANSCE facility. It was felt to be advantageous to have a locally supported computational capability closely associated with the experimental program and with in-house experience with the MCNP code.

Our "peer group" in this area was the International Collaboration on Advanced Neutron Sources (ICANS), the members of which were primarily using HETC and developing local versions of that code. The "LANL version of HETC" featured MCNP geometry, a secondary neutron interface file for input to MCNP and new output editing capabilities developed for local application. That was the first of three adaptations of MCNP geometry coding for use with HETC/LAHET over the years - a laborious procedure, which was one major motivation for actually merging the codes into MCNPX[4].

US Air Force funding in the mid-1980's allowed some collaboration (2 of us!) on model development (including the multistage preequillibrium exciton model) and the construction of the LAHET Code System[3] that was eventually released. With Yair Yariv in residence at LANL, the ISABEL physics package was included in LAHET. (Our sponsors insisted on a name change – LAHET rather than the "LANL version of HETC".)

Detector design for the ill-fated SSC project led Avigdor Gavron and Laurie Waters to make the first extension of LAHET to high energies. Just as important,

a new peer group came about, leading to frequent interaction with Alfredo Ferrari (FLUKA code) and Nikolai Mokhov (MARS code).

3 Beg, Borrow and Bargain ... or How to Provide Code Without Funding or Manpower

Until the Accelerator Production of Tritium (APT) project arrived (and the MCNPX development program), the LANL code development effort was strictly a low-budget operation and much dependent on the good will of others. Over the years, new capabilities came about by the procedure of

- "Dear Tony (Gabriel), can I have your code?"
- "Dear Detlef (Filges), could you send me ..."
- "Dear Alfredo (Ferrari), may I please use your ..."
- "Dear Nikolai (Mokhov), ..."

However, some of the features developed for LAHET have also found their way around the world, in many cases to be improved, so perhaps we have also given something back to the international community.

With that history in mind, this talk provides an opportunity to offer some thanks to those who, among many, directly and indirectly contributed to the LANL effort to establish a general Monte Carlo radiation transport capability:

- Tony Gabriel, Tut and Fran Alsmiller (ORNL)
- Tony Armstrong (SAIC)
- Yair Yariv (SOREQ)
- Detlef Filges and associates (Fz-Jülich)
- Francis Atchison (PSI)
- Alfredo Ferrari and Paola Sala (CERN)
- Nikolai Mokhov (FNAL)

4 Growing Codes

High-energy transport codes of the world have evolved downward in energy toward our conventional neutron transport capability. Our medium energy codes have been extended upward in energy, but have always been closely linked to neutron codes (MORSE, MCNP, etc.). Merging medium- and high-energy capabilities directly into MCNP in effect is growing the code upward from thermal energies. During the SSC period, applications included liquid hydrogen moderators and cryogenic magnets, so that the computational range under consideration involved over 17 decades in energy!

The manner in which code development has evolved does produce "culture clashes." Monte Carlo code development for particle physics and accelerator applications is largely characterized as simulation and is inherently analog. Our neutron transport codes use Monte Carlo for a solution of the integral transport equation and are filled with variance reduction methods. The methods that

have evolved tend to be nonanalog and it may be hard to reverse that process. In addition, the physics content is fixed in the form of massive data libraries. Unfolding these features to perform, for example, a pulse height tally from a neutron source becomes a very difficult task in MCNP (or MCNPX).

A consequence of merging philosophies as well as code is that many details must be treated that do not have a simple representation in the coding being adapted; an example is producing trackable recoil protons from nucleon elastic scattering when using library data for ^{1}H. Although adding a new procedure to create the protons is simple enough, doing the job was overlooked and has produced many questions from health physics users of MCNPX. Getting the energy deposition tally correct in this case requires more effort. In general, trying to estimate energy deposition correctly in MCNPX is always going to be hard since the contributions are so diverse and the logic so complex. It is a positive development that nuclear engineering students with MCNP experience are now doing research on accelerator applications and may be expected to be major contributors to code development efforts in the future.

5 We Don't Need No ... Muons!

The above title is a reflection of the fact that many things will not be included in a code until a demanding user appears. At LANL, we have never had a "customer" with an interest in detailed muon transport, so the code capability in this regard has never evolved beyond the limited treatment included in the original HETC code.

However, if a request arrives with *real funding*, then priorities get radically revised. Otherwise, so many features that make a "complete" radiation transport code just wait, and wait, and wait, even when the modeling can be "borrowed" from FLUKA or MARS or another friendly source.

6 Merging Code at LANL

As suggested above, the effort to merge the LANL Monte Carlo radiation transport codes is long overdue. Retrofitting LAHET to include newer MCNP features is very nonproductive. The APT program (L. Waters) and proton radiography have provided the means and motivation to proceed with the code merger. A single code is more easily modernized and can take better advantage of computer science development. Improved structure to "compartmentalize" physics code packages will encourage model developers to test new physics and features in a transport code environment. One may hope that the MCNPX effort (MCNP + LAHET + new physics) will become "institutionalized" in the general framework of the ongoing MCNP program.

One may look to the GEANT collaboration over the years and find much to be admired:

- a continuous "center of development;"

- a widespread network of contributors;
- a structure that accommodates imported code packages, physics or otherwise.

The continuing MCNP effort shares some of these features, and code modernization and code merger based on MCNP are evolving others. Perhaps conferences such as this one will stimulate increased interaction between the GEANT collaboration and LANL code development.

7 Conclusion: Regrets and Rewards

There has been no general support for radiation transport across the complex of US Department of Energy laboratories and consequently very little US model development in recent years. Historically, code development work follows project funding, so desired features for our codes only become available after most project design and development is done. It is really satisfying to be able to provide calculation support when the proposal is being written!

Being able to provide code support for LANL efforts in space science has been very rewarding, but so much more could be done with a real project commitment and perhaps even a funded collaboration with NASA. Knowledgeable users and applications for our codes abound in the fields of medical accelerators and radiation dosimetry; examples in this field were presented at this conference as tutorials by with Jeff Siebers (VCU) and Wayne Newhauser (MGH). It is a regret that we do not have a charter to support these fields. On the other hand, it is a rewarding experience to be able to encourage and support CEM2K development by Stepan Mashnik at LANL.

It is a privilege to participate in the MC2000 conference this week, where model developers, code developers and users in design and experimental areas may interact and communicate. New collaborations, formal and informal, will be initiated. It is my hope that the methods we develop and the codes we produce will be applied far beyond our customary fields in accelerator applications.

References

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