A NEW CODES GENERATION FOR LINAC BEAM DESIGNING

B.I.Bondarev, A.P.Durkin, B.P.Murin, G.T.Nikolaishvili

Moscow Radiotechnical Institute
Warshawskoe shosse, 132, 113519, Moscow, Russia

LIDOS.Advisor is a new generation of linac codes - Image-Based Codes. Advisor helps the designer find the region of linac parameter space most likely to satisfy his design requirements. The process is fast because the beam simulation has not used for large arrays of possible configuration. Advisor is an expert system, so it can not only solve ion equations of motion, but gives also the user an intellectual advise and helps him to come to the best linac version by the shortest way. The LIDOS. Advisor includes RFQ, DTL, High-Beta Linac etc. It permits users to make choice of channel optimal parameters and tolerances, to carry out matching of different channel parts and to simulate beam dynamics with space charge as well. The new language GIA for shell codes are developed. The meta-language GIA gives a simple and convenient way of adapting the codes for user's requirements.

High-energy high-current accelerators are needed for solution of new scientific problems. An accelerator-driven transmutation technology is one of examples where 1.5 GeV 250 mA CW linac is used. The main conceptual problem for such linac is lossless operating with high beam quality. Linac operation terminates in failure of accelerating structure or gives rise to linac radioactive contamination even with small losses of particles.

Traditionally, the investigators seek to account as many factors as possible and with this in mind generate complex models with many macroparticles and use supercomputers. They take into account an external field nonlinearity, channel parameter deviations, details of beam distribution and so on.

There is another way of looking at considered problem. For solution of the complex tasks given above the main accelerating/focusing channel parameters must be optimizing in order to minimize the beam quality degradation due to influence of any perturbations.

The authors have gained experience on high-energy linac beam dynamics studies taking into account random and any other channel parameter perturbations. The results of analytical and numerical investigations contain in works [1-4], where the channel sensitivities with respect to perturbations are defined. Gained experience forms the basis of the codes package LIDOS [5], which helps in determination of the accelerating/focusing channel optimal version.

LIDOS presents users the possibilities:
- to choose the fashions of parameter variation for optimal accelerating/focusing channel generation;
- to calculate linac parameters taking into account the real distributions of accelerating and focusing fields;
- to calculate beam motion in the linac version chosen by user and to make output beam parameter estimations.

The first LIDOS part named LIDOS.Advisor has a novelty and aroused a considerable interest. It corresponds to the first of cited possibilities and works in user-computer dialogue mode. These codes must help the user to find the shortest way to optimal linac version.

LIDOS.Advisor has separate parts according to different types of accelerating/focusing channels (RFQ, Beam Transport, DTL and so on) [6-8]. Each part contains set of codes and calculations are performed in a logical sequence ordered by shell codes (scenario).

LIDOS.Advisor provides:
- operating in prompt user-computer dialogue mode;
- the maximum permissible information about output results based only on input data analysis;
- representing of input data and output results in convenient form easy to understanding;
- using of mathematical methods of optimization.

The LIDOS.Advisor codes must base on the simplest models and covers only the fundamental features of physical process. The designer is presented with graphical and numerical information which allows him to select the better version of channel. In some case he can optimized parameters automatically by mathematical methods.

The computation of the accelerating/focusing structures is performed in each case by scenario allowing the user to discard unhappy version at the early stage.

The procedure of channel current version estimation is based on visual Images. User must be a specialist for which Images have the physical meanings. The Image behavior suggests to user what and how he must correct in order to achieve the required beam quality.

RFQ is a much used initial part of high-energy linac. Let us consider LIDOS.Advisor.RFQ scenario as an example of codes operating.

The accelerating/focusing channel parameter optimization consists in choosing the fashions of following parameter variation along the linac:
- vane modulation m(n),
- synchronous phase Fs(n),
- average bore radius R(n),
- intervane voltage U(n).

Optimal fashions of channel parameter variations must achieve the required beam capture and required effective emittance of output beam.

The behavior of channel parameters are represented in the form of parametric curves. Any dependence which is of interest for user can be achieved by parameter variations.

After filling the input data table (RF-frequency, ion charge and mass, beam current and emittance and so on) the input in- formation preliminary analysis has been obtained by user. It contains: optimal domains for intervane voltage (Kilpatrick limit as criteria) and for focusing parameter (from 0.3 to 0.6). User can return to previous stage and correct situation if parameter choice is inadequate.

At the next step an information about linac length, cell number, accelerating efficiency and all curves with parameter behaviors are indicated as function of longitudinal coordinate Z, cell order number N and beam energy W.

The Mathie equation two stability diagrams in (focusing, defocusing) and (focusing, beam current phase density) coordinates are indicated on the screen at the next stages. The operating point behavior on stability diagram (with isolines of transverse oscillations, beam matching radii and beam envelope modulations as well as lines of simple and parametric resonances) is an Image of most interest for user. There are another screen page with added information about ratio between equilibrium crossection radius and minimal bore radius. Thus we can estimate the suitability of considered version long before beam dynamics simulation.

The beam dynamics simulation starts from filling the table of input information. User can define input beam phase portrait variously and has influence on the speed and the accuracy of calculations. The designer can used the input matching section and automatically preset input beam phase portrait as matching one for equilibrium crossection. After the input data preliminary analysis Advisor prompts both an expect form of effective emittance and a value of its growth and the same ones for optimal case.

The Image which can present the real cause of beam losses is a phase portrait on the background of separatrix of periodic channel starting from the current period. The particle exits from stability domain means that they have been loosed. Viewing the curve which has described particle proportion within the separatrix on the background of E(n) and Fs(n) variation curves the designer understands how these curves must be corrected in order the beam phase portrait to be will within the separatrix. This correction would give the designer the chance to increase the output current or accelerating rate. The other LIDOS.Advisor parts are operating in a similar manner with its own scenarios. In parts when long focusing channels are used the channel sensitivity with respect to perturbations has been analyzed in order to find a channel with minimal sensitivity.

LIDOS. Advisor codes can be used for express estimations of accelerating/focusing channels. Its scientific visualization makes possible to use LIDOS.Advisor as codes for education and training.

REFERENCES

1. B.P.Murin et al, Particle Accelerators v.6, 27(1974)

2.B.I.Bondarev et al, Journal of Technical Physics v.49,1662(1979) (in Russian)

3. Ion Linear Accelerators (Atomizdat, Moscow, 1978) p.264 (in Russian)

4.B.P.Murin et al, 1992 Linear Accelerators Conference Proceedings v.2, 731(1992)

5. LIDOS User Manual (Version 4), S&T Center ELEON, Moscow, 1994.

6. B.P.Murin et al, 1992 Linear Accelerators Conference Proceedings v.2, 734(1992)

7.B.I.Bondarev, A.P.Durkin, G.T.Nicolaishvili, O.Yu.Shlygin "LIDOS - Unconventional Helper for Linac Beam Designing", Computational Accelerator Physics, AIP Conference Proceedings 297, AIP Press, N.Y.,1994, pp.377-384

8.B.I.Bondarev, A.P.Durkin, G.T.Nicolaishvili, O.Yu.Shlygin "Multiion Transport System", Computational Accelerator Physics, AIP Conference Proceedings 297, AIP Press, N.Y.,1994, pp.131-134.