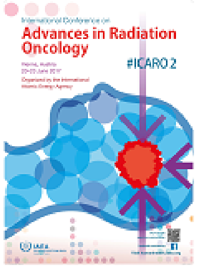

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Tunable compact monochromatic X-ray synchrotron radiation source based on inverse compton scattering for advanced radiological applications

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Radiation protection of patients and physicians are the main concern of radiation protection program adopted in any radiological facility. The usage of conventional X-ray sources in radiological facilities is usually associated with exposure to wide spectrum of X-ray energies although only a narrow band of the X-ray spectrum is used in diagnostic/treatment process, while the remained spectrum is considered to be parasitic and non avoidable.

In some radiological applications this parasitic portion contributes significantly to the total dose delivered to the patients as well as the physicians. Accordingly, developing and implementing new advanced diagnostic/therapeutic technology that use tunable mono-energetic (monochromatic) X-ray source without generating such parasitic portion of conventional X-ray sources will lead to significant decrease in the dose delivered to both patient and physician; this in turn will enhance the radiation protection program significantly. In that context, there were a plenty of research papers already proved the fascinating use of monochromatic X-ray synchrotron radiation in many radiological applications. Figure 1 represents an example of such outstanding applications of monochromatic X-ray radiation in early diagnostics of breast cancer; more details will be introduced in the full paper of this synopsis.

However, high brightness monochromatic X-ray synchrotron radiation is traditionally obtainable exclusively in giant facilities like 3rd generation light source when ultra relativistic electron beam (GeV) passes through a periodic magnetic structure (undulator). This unluckily limits the dissemination of the radiological applications of X-ray synchrotron radiation within the synchrotron facilities only.

In order to disseminate this technology worldwide, a novel and compact system should be developed in order to be hosted in ordinary hospitals. Many research efforts have been conducted during last decade to develop a compact system that offers the opportunity to produce high-brilliance X-ray synchrotron radiation with a laboratory-scale when a relativistic electron beam from linear accelerator (LINAC) collide with high power laser via Inverse Compton Scattering (ICS) interaction. Unfortunately, so far, no system has been produced in commercial scale due to some technological difficulties related mainly to the linear accelerator (LINAC) which is the main core of that system.

In this contribution we propose a certain compact ($\approx$ 1 m) traveling wave X-band (12 GHz) LINAC that can produces up to 50 MeV electrons suitable for ICS source. This X-band LINAC has been proposed in specific since a similar structure has been already designed and fabricated in cooperation with CERN, Paul Sherrer Institute (PSI) and Italian synchrotron facility ELETTRA; one of the authors has been involved in developing such LINAC. The CERN-PSI-ELETTRA structure is based on cutting edge technologies such as mode launcher and alignment monitors that overcomes the most known shortcomings associated with other versions of X-band LINACs; many unites are already fully functioning at the premises of aforementioned facilities without any significant technological problems; this nominates such X-band LINAC as a best solution for ICS source.

Usually, the output electron beam parameters will be significantly affected by the operating conditions of LINACs such as the field gradient, initial & final beam energy, length of LINAC & its type, operating mode, shunt impedance, etc. Accordingly the output electron beam parameters will be significantly different form purpose to another.

To prove the suitability of the proposed X-band LINAC to be used for ICS source, the LINAC resonance cavities

have been simulated using SUPERFISH code and the output electromagnetic field mappings have been used to investigate the electron beam dynamics along the LINAC using ASTRA code. Finally, the monochromatic X-ray that is produced by collision between the electron beam with Table Top Terra Watt (T3W) laser has been simulated using CAIN code.
The simulation results show that the resultant monochromatic X-ray is very convenient for many advanced radiological applications such as Dynamic Intra Venous Coronary Arterio Graphy, early diagnosis of breast cancers and Auger Cascade Radiotherapy. We conclude that, the CERN-PSI-ELETTRA X-band LINAC and similar LINACS proposed in this study is the best candidate for ISC source and eventually a quantum leap in achieving a stable and compact ISC source is at the reach of hands in very near future.

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