Possibilities for an Inverse Compton Scattering (ICS) setup using Indus Synchrotrons facility at RRCAT, Indore for creating MeV Gamma ray beams based Nuclear Facility (ICSNF)

Ajit Kumar Sinha
UGC-DAE Consortium for Scientific Research, DAVV Campus, Khandwa Road, Indore 452001
** email: director@csr.res.in*

Introduction

The RRCAT, DAE at Indore has been running successfully the INDUS Synchrotrons with large number of beam line facilities which are concurrently used for a very large number of experiments in science conducted by universities and other national institutes of higher learning. The Indore Centre of the UGC DAE Consortium for Scientific Research has the mandate for supporting experiments using the RRCAT facilities and a large variety of these experiments in the most prolifically pursued field of Materials Science. Exploring to use the RRCAT Synchrotron facilities for some nuclear physics studies has been attempted more than a decade back some time near 2005 whereas Bremsstrahlung radiation produced by energetic electron beams from a Microtron (for example) are used quite well for photo nuclear/fission reactions/ applications.

I learnt about the early efforts for employing Synchrotrons from Dr L M Pant, BARC around 2005 [1] and then later perhaps around 2015 from Dr C Rangacharlu (presently at Canada) and Dr Pushpendra Singh (presently at IIT Ropar) in this direction. I admit I am imprecise and not exhaustive with respect to this information. However, it is envisaged to have soon, a focused discussion meeting with the interested nuclear physics groups in our country regarding the facility.

Nevertheless, it has been felt worthwhile to present the preliminary possibilities for possible facility at RRCAT, DAE in this DAE NP symposium platform where a dedicated new-facility session has been thoughtfully planned by the Organizers.

I had a good opportunity to have a round of discussions with the Synchrotron specialists at RRCAT and the preliminary possibilities evolved based on these discussions are being presented here. If we get serious about this facility, we need to get approval from the RRCAT, DAE to go ahead to prepare project documents with DPR which will require a sustained group effort. The preliminary presentation here covers the idea in a qualitative way only.

Preliminary Outline of the idea

We are concerned here around the possibility of using the photon back scattering in the collision involving photons (produced and transported in a preferably time matched fashion from a conventional laser setup set up outside the ring) with the relativistic electron beams at the Indus Synchrotrons storage rings to produce MeV-gamma rays suitable for some interesting nuclear- physics/astrophysics studies.

One of the critical requirement for such a setup is to contain (limit) any possible deterioration of the phase space of electron beams in the storage ring induced by the inverse Compton scattering process.

The storage ring (Indus 2) has been designed with its accelerating and transporting components accommodating up-to a percent of deviation in phase space from the mean optic trajectory. Thus a change of energy which goes beyond 1% of the 2.5 GeV, i.e. 25 MeV is not

desirable to avoid possible loss of longevity and stability of the electron current in the storage ring.

It may be mentioned that some of the interesting nuclear/astro-physics experiments do not envisage very high energy gamma rays and in fact may desire to have energies of gamma rays near and above particle emission thresholds out of interest from near threshold nuclear cross section measurements while invoking principle of detailed balance for inverse reaction. Another region of the interest for the gamma ray energies is that which overlaps with the broad GDR (giant-dipole resonance) energies and thus lies in the ballpark of 15 to 25 MeV.

In the above scenario, use of a carbon-dioxide laser with λ=10.6 Micron emission and the resulting back-scattered photons from the 2.5 GeV electron beam of the Indus-2 synchrotron fall in the range of around 11 MeV. The resulting energy loss from the electrons from such a back scattering process does not adversely affect the Indus storage-ring stability as the energy change is less than the critical acceptance limit of 1%.

There were also other preliminary level discussions about possible location(s) in the storage ring where laser photon and electron interaction could be taking place. The possibility (1.) is the straight section wherein a wiggler is to be set up at some time shortly. The possibility (2.) is based on the critical insight regarding the Indus storage ring design by RRCAT group and is at the injector path of the ring.

The gamma rays are actually emitted within a very narrow angle in-line of the direction of the electron beam. This angular spread in radians is of the order of fraction of a milli-radians for the 2.5 GeV beams from Indus-2. If one extends the line coinciding with the direction of motion of electrons at the above proposed option (2.) point near the injector path, this direction (line) will emerge adjacent to the beamline 1 of INDUS -2 which is a beamline already allocated and used for UGC-DAE CSR. Although this is adjacent to the beamline 1 of Indus-2, there exists presently no hole along this particular direction/line in the shielding wall.

The other issue relates to the (CO_2 and other) laser systems and need of reliable operating system for this laser. It is thought we may have to discuss with the Laser- groups at RRCAT to optimize in this direction.

As mentioned above, the ICS Gamma rays from relativistic electrons actually scatter back within a milli-rad of the direction of motion of the Electron beam and they travel with minimal attenuation in air. This may not require any vacuum line. However, when these gamma rays reach the experimental site, a suitable shielded arrangement and detector-setups and associated electronics systems have to be installed there.

With respect to the possibility (1.) mentioned above of using the section of Indus-2, there will be no need to drill a hole in the shielding wall but this arrangement may be of a temporary nature at best as a project for setting up wrigglers is underway for this straight section of Indus-2.

Briefly there was also a discussion about using Indus-1 for its 450 MeV electron beam and this was not completely ruled out. However, the energies which would be available if we use a UV laser, the gamma ray energy maximum could be around in similar energy range.

I acknowledge the suggestions received in discussion with the expert RRCAT groups based on which only it has been possible to present preliminary ideas here. In particular, many of the ideas mentioned here are based on suggestions during a recent discussion with Dr A D Ghodke, Head, APS, RRCAT; Dr. R K Sahu, Indus Operation Division, RRCAT; Dr. A. Rahim, Accelerator Physics Section, RRCAT, Dr. Tapas Ganguli Head, SUS, RRCAT, Dr. D M Phase, UGC-DAE CSR.

I also acknowledge the kind concurrence from the Director RRCAT for discussing above ideas in this forum of DAE NP Symposium.

References

[1] L M Pant, “Tagged photon facility at Centre for Advanced Technology, Indore: Possible scenarios”, Pramana, 66, 5 (2006) p. 903