Vector meson production with linearly polarised photons at Jefferson Lab.

K. Livingston

Dept of Physics & Astronomy, University of Glasgow, Glasgow G12 8QQ, Scotland

Abstract. A Coherent Bremsstrahlung facility for the production of tagged, linearly polarised photons has recently been installed in Hall B at Jefferson Lab. The first production running with this facility will be in June/July 2001 when the g8 programme of experiments on vector meson production will take data. We will measure the decay products from the vector meson resulting from the reaction $\vec{\gamma}p \rightarrow VN$ in the energy range of $1.1 \leq E_\gamma \leq 2.2$ GeV. Here, $V = (\rho, \omega, \text{or } \phi)$. In a practical sense, we will be measuring the angular momenta, and thus the spin density matrix elements $\rho^j_{\alpha\beta}$, which determine the angular distribution of the daughter spin-0 mesons that decay from the parent vector meson. With linearly-polarized photons, one has access to six more independent spin density matrix elements than can be obtained in an unpolarized vector meson photoproduction experiment. By using the CEBAF Large Acceptance Spectrometer (CLAS) and the photon tagger, we will accurately measure the decay angular distribution (and hence the spin density matrix elements) as functions of the scattering angle and the incident photon energy with high precision.

Several new and upgraded devices will be commissioned prior to production running. A report on the results of the commissioning and the status of the running experiment will be presented.

Experimental setup

In the coherent bremsstrahlung technique an electron beam incident on a diamond radiator can be used to produce tagged, linearly polarised photons. The energy and plane of polarisation of the photons can be selected by adjusting orientation of the crystal relative to the electron beam [3]. The g8 programme of experiments on vector

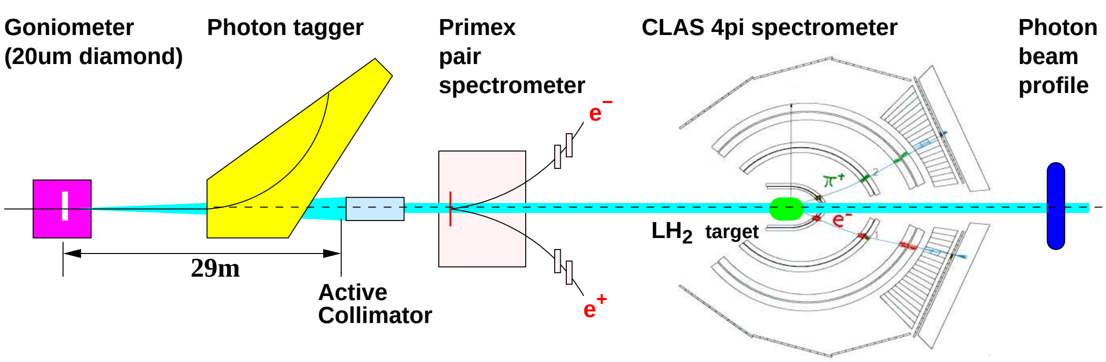

FIGURE 1. The experimental setup

meson production was the first experiment to use this technique at Jefferson Lab. The experimental setup is shown in figure 1. With the exception of the CLAS detector itself all other devices shown are new, or were substantially upgraded for g8 running, and were commissioned at the beginning of the run period. A brief description of the components is given below.

Diamond radiator. Several techniques have been developed by the Glasgow Group for selecting crystals, including examination with a petrographic microscope and measurement of rocking curves at a synchrotron light facility. The rocking curve measures the width of the Bragg peak, and gives a very good indication of the quality of the diamond. Figure 2 shows the result of these measurements made on a 100μm synthetic crystal. The fact that the width of the Bragg peak is close to the theoretical value indicates that the crystal has a very low mosaic spread. On the basis of this, the crystal was ground down to less than 20μm for use in the experiment.

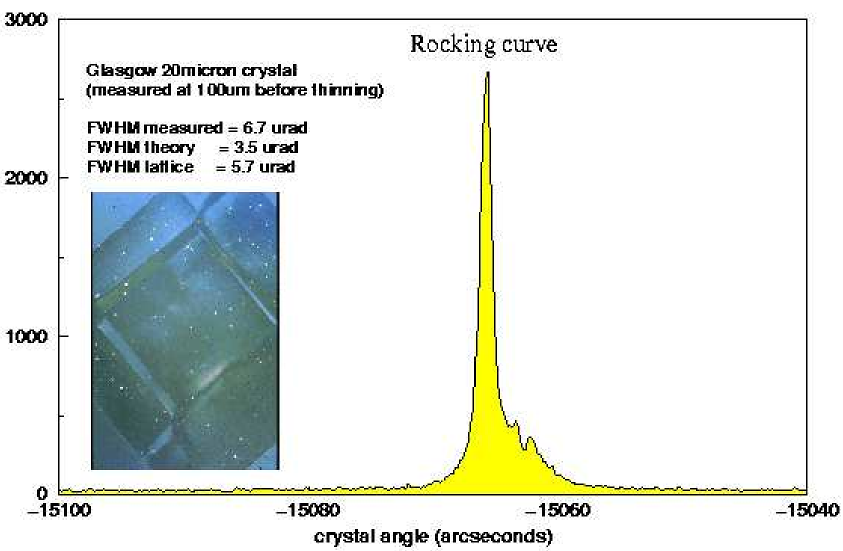

FIGURE 2. Measurements made on the crystal

Goniometer. This was provided and installed by the group from George Washington University. It is capable of orienting the crystal to a precision of better than 10μrad.

Tagging spectrometer. The focal plane of tagging spectrometer has 384 plastic scintillators (e-counters) which provide signals to scalers and TDCs [1]. A major upgrade of the focal plane took place proir to running, since a high quality, low noise photon spectrum is essential to determine the degree of linear polarisation. The spectrum derived from the scalers gives rapid feedback on the uncollimated photon spectrum while the spectrum derived from the TDC (started by a downstream detector) shows the photon spectrum beyony the collimator.

Active collimator. Tight collimation can strongly enhance the ration of coherent / incoherent bremsstrahlung, and hence increase the polarisation. A 2mm diameter collimator was used. This also had 4 embedded scintillators at the front end to provide an asymmetry measurement to monitor the position and stability of the beam.

Pair spectrometer. The pair spectrometer has been installed for the Primex experiment and is used to for photon normalisation [2].

Results of Commissioning

To produce polarised photons 2GeV from a 6GeV electron beam it is neccssary to have an angle of approximately 1μrad between the beam and the crystal lattice. Hence, a major part of setting up a cohent bremsstrahlung facility is the initial alignment of the crystal, where its default orientation relative to the beam is measured. The process used at Jlab is an extension of that developed by Lohman et al. [5], where a series of scans are taken. A scan consistes of a sequence of small angular movements of the crystal and the corresponding accumulation of a photon energy spectrum. Figure 3 shows the result of a scan where a series of sinusoidal steps in horizontal and vertical rotation axes are used to set the [100] crystal axis at 60mrad from its default position and sweep it though a 360° cone on the azimuthal axis.

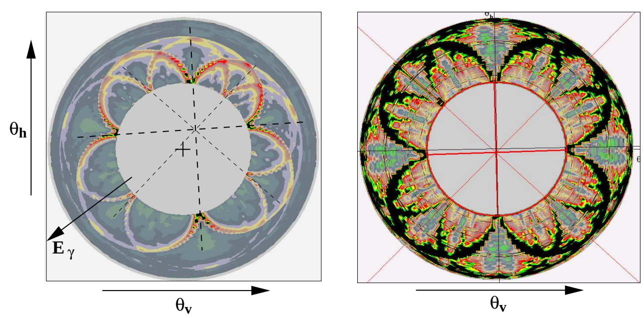

FIGURE 3. Simulated scan illustrating the method of aligning the crystal

The ridges on the plot show the energy of the coherent peak changing as the angle between the beam and crystal changes. As can be seen in the figure, the orientation of the beam relative to the crystal can be found by fitting a template (shown with dashed lines) consisting of 8 lines separated by 45°. These lines must coincide with the points at which the ridges touch the inner circle (corresponding to the lowest tagged photon energy). The offest, in θ_v, θ_h coordinates, between the center of the template and the centre of the circle gives the angular offset between the beam and the default crystal position, and the angle of the template gives the default azimuthal orientation of the crystal.

Figure 4a shows a scan taken during the alignment. There is almost a 4-fold symmetry, which shows that the crystal is aligned almost prefectly with the beam. This allowed the coherent peak to be positioned at any desired photon energy. Figure 4b shows the a photon spectrum with the coherent peak set at 2GeV, and a fit carried out using a coherent bremsstrahlung code [4], giving a maximum polarisation in the peak of 73%. However, this data was obtained from free running scalers on the tagger e-counters, and as such does not show the effect of collimation. With the effect of the collimator included in the calculation, the predicted maximum polarisation is increased to 84%. This was the anticipated degree of polarisation for the the production running, which began at the time of presentation of this paper.

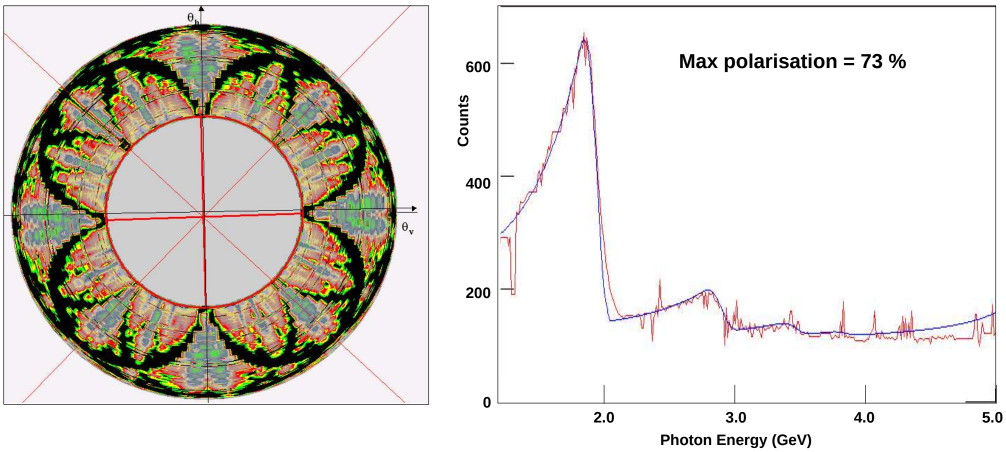

FIGURE 4. a) Scan with the crystal almost perfectly aligned. b) Coherent bremsstrahlung spectrum obtained online

ACKNOWLEDGMENTS

Thanks to all members af the g8 run group, and to all those from the CLAS collaboration, GWU and Catholic University, Washington who helped get the system up and running.

REFERENCES

1. D.Sober et al., *Nucl. Inst. and Meth.*, **A440** 263 (2000).
2. D. Dale et al., *Proposal E-99-014*, URL `http://www.jlab.org/exp_prog/generated/apphallb.html`.
3. U. Timm, *Fortschritte der Physik* **17** u765 (1969).
4. A. Natter, *ANB Code*, URL `http://www.pit.physik.uni-tuebingen.de/~natter/software/brems-anb.html`
5. D. Lohman, M Schumacher et al., *Nucl. Inst. and Meth.*, **A343** 494 (1994)