Tagging Efficiency and Beam Polarisation Macros

D.G. Middleton*

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Mount Allison University, Sackville, Canada/
Institut für Kernphysik, University of Mainz, Germany

1 Introduction

I have written a macro that will determine the tagging efficiency and if applicable the degree of linear polarisation for tagging efficiency runs using the A2 AcquRoot DAQ and analysis software[1].

Some of the Root macros described here are adaptations of macros written by J.R.M. Annand [2]. I changed them a bit so that they would output histogram files where applicable and also to fit with the recent change to the A2 DAQ; I believe the originals are still distributed with the AcquRoot software [1]. Basically using them in conjunction with the output of the ugcal program [3] will allow the A2 tagger to be calibrated for energy and time alignment using data taken for tagging efficiency purposes. They are set up so that the output of one macro can be used with AcquRoot which should give an output that can be automatically used as an input to the next.

2 Ugcal

Ugcal is a program written by J.C. McGeorge [3] which determines a channel to energy calibration for the A2 tagger, the current version at time of writing is Version 2.u.d. Using the NMR reading of the tagger magnetic field in Tesla and the MAMI electron beam energy (including rest mass) the code outputs two files, the first gives many details on the tagger energy calibration while the second is more limited but is used as an input to the Root macros used to generate a 'Ladder' calibration file for the AcquRoot analysis code. The ugcal Fortran code distributed with this includes a Makefile which should be run to produce the ugcal executable; the CERN libraries are needed when making the program.

*middletn@kph.uni-mainz.de

3 Tagger Calibration Macros

3.1 LadderGen_DM.C

This macro has been adapted from the original LadderGen.C from J.R.M. Annand [2]. The macro requires at least two inputs, the first of which is the tagger channel-energy calibration file output from ugcal and the second of which is the MAMI beam energy (including rest mass) so that the correct energies for each channel can be determined in the Ladder calibration file. Ugcal outputs the photon energy for each tagger channel while the AcquRoot calibration file uses the electron energy as an input. The other optional inputs are the maximum number of tagger channels to be used and the ADC, TDC and scaler numbering convention for AcquRoot all of which have default values set. At the time of writing the main tagger ADC, TDC and scaler numbering is correct for the current version of AcquRoot and begin from 800, 1432 and 400 respectively, the default number of channels is 352. The output file is named "Detector_TaggerXXX.ua.dat" where XXX is the MAMI beam energy that was input to run the macro; the 'ua' represents an unaligned file. Default calibration values similar to those from [2] are included except for the individual TDC time offsets and global offset which, as things currently stand with the DAQ, should mean all prompt peaks from the tagging efficiency runs should be at an offset in the range 10 - 30 ns.

3.2 AlignTDC_DM.C

This macro has been adapted from the original AlignTDC.C from J.R.M. Annand [2]. The macro will fit the individual TDC channel prompt peak positions from a tagging efficiency run and align them all to a desired position and output an adapted Ladder calibration file with the new channel offsets.

After running AcquRoot with a Ladder calibration file generated using LadderGen_DM.C the output histogram file should contain the histograms necessary to run this macro. The histogram file name (including directory path) and the Ladder calibration file used to generate it are required as inputs. The other optional inputs are the lower and upper limits for the range to fit the prompt peak and the position the peaks should be aligned to, by default these are set at 0, 50 and 20 ns respectively. To check that the fitting has worked correctly two files are output, a pdf showing the individual TDC channels with the fits to the peaks and a Root histogram file containing these plots. An adapted version of the input calibration file is also output with the new TDC offsets included, the file is given a new name from the original. If the default name from LadderGen_DM.C has been used for the calibration file the output will be this with the '.ua' removed.

3.3 TDCAlign_Check_DM.C

This macro can be used to check an existing tagger TDC calibration. As above it needs an analysed tagging efficiency run with individual TDC time histograms and a Ladder calibration file as an input. The minimum and maximum and aligned peak position are the same as above by default but can be changed as desired. The macro will compare the current peak position and TDC offset with the desired position and output the difference to the terminal it is run from on a channel-by-channel basis. By default there is no other output from running the macro but if the differences are deemed to be significant enough that a new calibration file is necessary it can be run again with an output option selected when it will output a new calibration file as well as a pdf and Root file with the peak positions and their fits.

4 Tagging Efficiency & Polarisation Enhancement

The macro that will determine the tagging efficiency and polarisation enhancement is called TaggEff_DM.C. It takes one argument which is a configuration file described in more detail below. The macro will run through the listed files and produce a pdf and root file of histograms related to the tagging efficiency and if appropriate the linear polarisation enhancement from using a diamond radiator.

4.1 Input file

In the input file various things related to the analysis can be defined and an example file is shown in figure 1. The inputs are as follow:

- File-Directory: The path to the data files that have been analysed in AcquRoot.
- Energy-File: A channel-to-energy calibration file from ugcal. This is the second file output from ugcal and is the same format which is used with the LadderGen_DM.C macro. At present this is only relevant for measurements which use a linearly polarised photon beam and if defined the polarisation enhancement will be determined as a function of the photon energy.
- Output-File: A label for the files that will be output. If this is not defined a default of 'TaggEff_analysis' will be used.
- Prompt-Correction: Whether to an accidental subtraction for the focal plane 'Hits', default is 1.
- Clock-Histogram: The histogram where the clock scalers are defined, the default is "SumScalers190to191".
- Clock-Histogram-Bin: The bin number of the above histogram which contains the inhibited clock data.
- File: This defines the files to be analysed and takes four arguments in the following order:
  - <file name>: name if the data file.
  - <status>: data/junk, anything other than data will be ignored.
  - <type>: the type of run: background: *BG*; Amorphous: *amor*; Diamond parallel: *para*; Diamond perpendicular: *perp*.
  - <run no.>: the number of the tagging efficiency measurement starting at 0.

The various definitions can be commented out using a '#' as with AcquRoot or can be left out from the file if not relevant. At least one amorphous file must be defined for each data set for the macro to do anything. Presently the macro can only handle two background files, if more have been taken you should either combine their histogram output with Root or in the AcquRoot analysis or select the two best ones.

When executed the macro will read in the input files and then analyse the histogram files that are defined there. By default the macro analyses the hits with an accidental subtraction using the 'prompt' and 'accidental' coincidence regions defined during the AcquRoot analysis. If hall background runs are defined a background correction will be applied to the scaler counts using the inhibited clock information for normalisation; if the clock information is missing a warning will be given. To determine the polarisation enhancement the ratio of hits for a diamond radiator setting to the amorphous hits is determined.

The macro outputs two files, a pdf of various plots described below and a Root histogram file which contains all of the histograms used to make up the pdf. An example page from the pdf output is shown for an amorphous radiator in figure 2. The various plots shown are as follows:

```
File-Directory: data/
Energy-File: 1402_EnaG_n.plot.dat
Output-File: 1402_TaggEff

File: TaggEff_1993.out.root     data    BG      0
File: TaggEff_1994.out.root     data    para    0
File: TaggEff_1995.out.root     data    perp    0
File: TaggEff_1996.out.root     data    amor    0
File: TaggEff_1997.out.root     data    BG      0

File: TaggEff_2029.out.root     data    BG      1
File: TaggEff_2030.out.root     data    para    1
File: TaggEff_2031.out.root     data    perp    1
File: TaggEff_2032.out.root     data    amor    1
File: TaggEff_2033.out.root     data    BG      1

File: TaggEff_2062.out.root     data    BG      2
File: TaggEff_2063.out.root     data    para    2
File: TaggEff_2064.out.root     data    perp    2
File: TaggEff_2065.out.root     data    amor    2
File: TaggEff_2066.out.root     data    BG      2

File: TaggEff_2101.out.root     data    BG      3
File: TaggEff_2102.out.root     data    amor    3
File: TaggEff_2103.out.root     data    BG
```

Figure 1: Example input file for the TaggEff_DM.C macro.

- Top row:
  - Coincidence time plot.
  - Scaler counts from 1st background run.
  - Scaler counts from 2nd background run.
- Middle row:
  - The prompt (red) and accidental (blue) hits (in most cases the accidental contribution is too small to be seen).
  - The scalers counts (yellow) with the sum of the hall background contribution (green).
- Bottom row: The tagging efficiency as a function of tagger channel.

If there are diamond runs as well as amorphous the page for these will also include the polarisation enhancement as a function of tagger channel. If an energy calibration file is defined the tagging efficiency and polarisation enhancement will be be determined as a function of photon energy. The tagging efficiency histograms will only be produced in the Root output file but the polarisation enhancement plot will be shown on an extra page of the pdf file so that one can check that the polarisation peak is where it is expected.

5 Suggested Use

1. Produce a tagger calibration file using ugcal.
2. Use the output from ugcal with LadderGen_DM.C to generate a ladder calibration file.
3. Change the AcquRoot analysis files provided with these macros to include the ladder calibration file and a data file that was taken with beam. Put the 'Finish.C' macro somewhere where AcquRoot can find and execute it. Make sure a directory "$acqu/out" is defined. Run AcquRoot and analyse your chosen file.
4. Using the output of the AcquRoot analysis and the ladder calibration file run AlignTDC_DM.C to generate a new ladder calibration file with the TDC aligned. Check the histograms to make sure the fits have worked correctly and if necessary correct any errors.
5. Replace the original ladder calibration file with the aligned one in the AcquRoot data directory.
6. Analyse all your tagging efficiency data files and create your input file for TaggEff_DM.C including what you wish as appropriate. Use the example provided as a basis if you wish.
7. Run TaggEff_DM.C and then check your output. Update the input file as more data is collected. If there are any files missing or wrongly defined the macro will crash; exit Root and fix the problem.
8. If it looks like there is a shift in the prompt peak or it starts to become messy use the TDCAlign_Check_DM.C to check for any changes/drift.

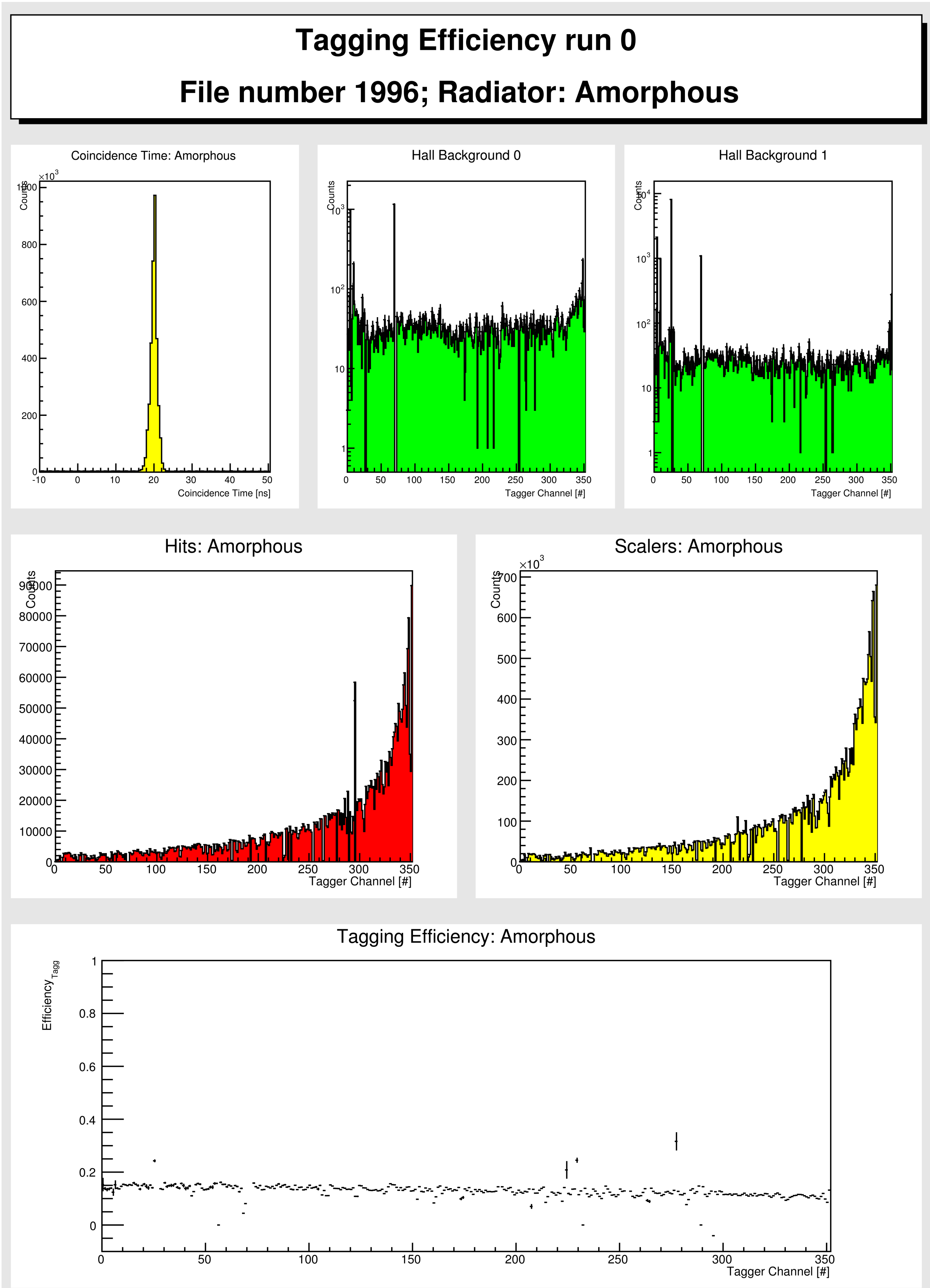

Figure 2: Example of the pdf output for an amorphous radiator.

References

[1] J.R.M. Annand. *Data Analysis within an AcquRoot Framework*, 09.11.2008. AcquRoot Version 4v3.

[2] J.R.M. Annand. *The Glasgow/Mainz Bremsstrahlung Tagger Operations Manual*, 02.10.2008.

[3] J.C. McGeorge. "ugcalv2ua". <j.mcgeorge@physics.gla.ac.uk>, 26.10.2010. Private Communication.