Determining the Trigger Efficiency for E08-027

Ryan Zielinski
University of New Hampshire
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Abstract

E08-027 requires trigger scintillator efficiencies to make an absolute cross-section measurement. Efficiencies were calculated on production, dilution and packing fraction runs from both high-resolution spectrometers. The left-HRS efficiencies are all above 99% with 1448 runs calculated in total. On the right-HRS efficiencies are above 99% for 929 out of 945 runs. The sixteen right-HRS runs with under 99% efficiency are dilution runs. Results have been uploaded into the MySQL experiment database.

1 Trigger Overview

The experiment used the standard Hall A electron singles triggers for each high-resolution spectrometer. For trigger purposes, each HRS detector package contained an S1 and S2m scintillator and gas Čerenkov counter. The scintillators consisted of segmented plastic scintillator readout on both sides via PMTs. The S1 detector had four PMTs per side (eight total) and S2m had eight PMTs per side (sixteen total). The Čerenkov detector contained gaseous CO_2 also viewed by PMTs. The detector configuration is seen in Figure 1.

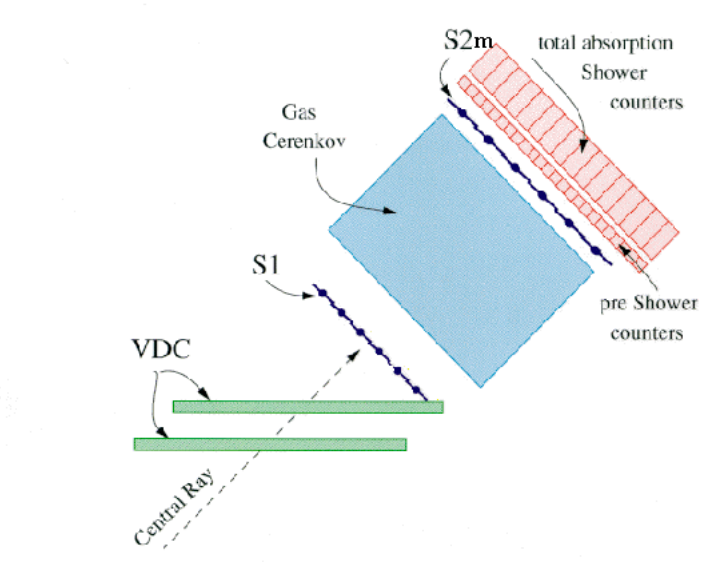

Figure 1: HRS detector package. Note on the LHRS the lead glass counters are not total absorbers. Reproduced from [1].

The experiment used two separate singles triggers. The main trigger for data acquisition was defined by an electron passing through both scintillator planes. It was formed as the logical AND of the following:

- The Left and Right PMTs of scintillator segment of S1 fire
- The Left and Right PMTs of scintillator segment of S2m fire
- The event causes both S1 and S2m to fire
- No restriction was made on which scintillator segments fired between S1 and S2m

The main trigger was named T_1 on the right spectrometer (RHRS) and T_3 on the left spectrometer (LHRS). A secondary trigger T_2 (T_4) for the RHRS (LHRS) measured the efficiency of the main trigger. Formed exclusive to the main trigger, the efficiency trigger was defined as the logical AND of the following:

- Either the S1 OR S2m scintillator planes fire but not both
- The event also led to a signal being detected in the gas Čerenkov

The first requirement excludes main triggers while the second defines events that should have been been detected by both scintillator planes.

After the triggers were formed they were sent to the trigger supervisor, which decided whether or not the data acquisition system recorded the event. The ability of the trigger supervisor to accept events is dependent on the event rate. It is useful to define a quantity called the DAQ deadtime which is the ratio of triggers received to triggers accepted. The DAQ deadtime can be decreased through prescaling the events. With prescaling the trigger supervisor only accepts one of every *ps* events, where *ps* is the (integer) prescale factor.

2 Determining Trigger Efficiency

The trigger efficiency is

$$Eff = \frac{T_{main}}{T_{main} + T_{eff}}, \tag{1}$$

where T_{main} and T_{eff} are the total number of trigger counts for the main and efficiency triggers respectively. These counts can be determined from either the trigger scalers or the trigger latch pattern. The trigger latch pattern is favored over the scalers because it is tied directly to recorded events and allows for cuts to be made in analysis. This correlation with recorded events also makes the trigger latch pattern susceptible to deadtime effects. The deadtime correction for the latched triggers is

$$T_{cor} = \frac{T_i ps_i}{1 - DT_i}, \tag{2}$$

where i is the trigger type (1-4), T_i is the accepted trigger count, ps_i is the prescale factor for the trigger and DT_i is the deadtime associated with the trigger.

The deadtime is determined from the livetime (LT) with DT = 1 - LT. The livetime is then the ratio of accepted triggers to total triggers adjusted by the prescale factor such that

$$LT = \frac{ps_i T_i^{acc}}{T_i^{tot}}, \tag{3}$$

where the accepted triggers are determined from the latch pattern and the total trigger count is from the trigger scalers.

3 Analysis Cuts

The main advantage to using the latched triggers is being able to make event by event cuts on the data. The cuts are used to insure that only good electron events are being input into the efficiency calculations. Initially four cuts were used in the analysis but this was relaxed to three after a small test calculation of a few runs.

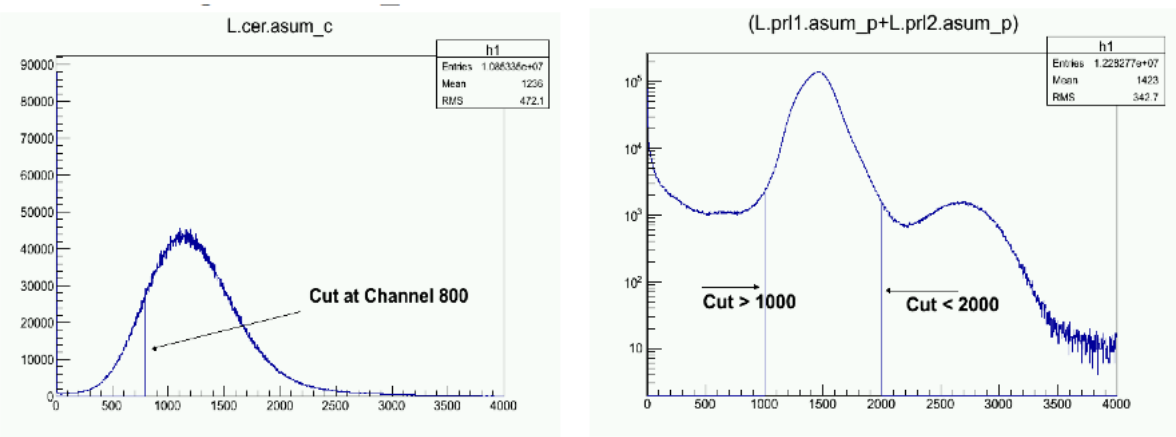

Figure 2: **Left**: Left-HRS cerenkov cut made at channel 800. Right-HRS cut was at channel 500. **Right**: Left-HRS pion rejector cut isolating the good electron peak for runs 3294, 3444 and 3445. The secondary peak to the right of channel 2000 is because this is an uncalibrated sum.

The first cut used was on the trigger latch pattern itself to select the appropriate triggers. The trigger information is stored in a bit-wise manner. Each trigger then is denoted as 2^i where i is the desired trigger. A simple tracking cut was applied on the vertical drift chambers to ensure that there was only one track through the VDC for each event. Particle identification cuts were used to eliminate pions. Initially both a cut on the gas Čerenkov and pion rejectors was used.

At the start of the trigger efficiency analysis the detector calibration was finished for the gas Čerenkov. This allowed for the universal (across all energy and momenta) application of a Čerenkov cut. This cut for the left-HRS is found in Figure 2.

4 Small Sample Test Analysis

Prior to a full replay and analysis of the data a small sample analysis was conducted for proof of principle and also to check the effect event cuts had on the trigger efficiencies. Three left-HRS runs were used at a beam energy of 2.253 GeV (2.5 T target field) and the dipole set to elastic at 2.228 GeV.

Table 1: Three run trigger efficiency (percentage). The two cut efficiency calculation had a one-track VDC cut as well as a Čerenkov cut. The three cut efficiency had a one-track VDC, Čerenkov and pion rejector cut. The no-cut efficiency matches the efficiency calculated from a scalar analysis.

Run Number	No Cut Eff	2 Cut Eff	3 Cut Eff
3294	99.81	99.95	99.98
3444	99.80	99.95	99.98
3445	99.80	99.95	99.98

The results from Table 1 show an insignificant effect in the efficiency from the inclusion of a pion rejector cut (Figure 2), and therefore it was not included in the final analysis. This exclusion also sped up the analysis. The lead glass counter calibration was not finished at the start of this study, so eliminating a pion rejector cut eliminated the need to update such a cut for each energy and momenta setting.

5 Results

Trigger efficiency analysis was carried out on all good production, dilution and packing fraction runs on the left and right HRS using two cuts to select good electrons. Good runs were denoted by either a two or three value in the run quality flag in the MySQL experiment database. Runs flagged as a "3" are production/dilution/packing fraction runs with no obvious problems. Runs flagged as "2" have minor problems (i.e. one BCM not working) that may require extra attention during later analysis. Further information on the database can be found in the $g_2^p wiki$.

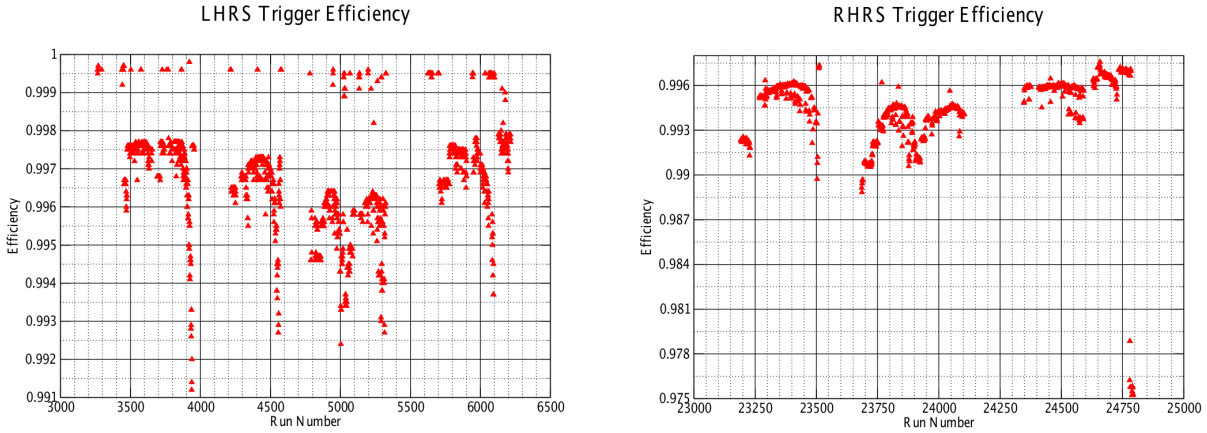

Figure 3: HRS trigger efficiency results for all runs

Left-HRS efficiency results are shown in Figure 3 and separated by energy and momenta in Figure 4. Overall results show efficiencies higher than 99.1% although there is some substructure in the data. There is tendency of the efficiencies to drop at lower momenta, but still the trigger inefficiency remains less than a 1% (2% at one-hundred percent uncertainty) correction to any cross-section measurement.

As a final check, a few runs were selected to test the effect of a pion-rejector cut at different momenta. Two sets of runs were selected that represented a low efficiency ($\sim 99\%$) and a middle-of-the-range efficiency ($\sim 99.5\%$). The results of this study are summarized in Table 2. The percent difference between the two methods is less than a quarter of a percent.

Table 2: The effect of a pion-rejector cut at different momenta.

Run Number	E0 (GeV)	P0 (GeV)	2 Cut Eff	3 Cut Eff	% Diff
3907	2.253	0.582	99.66	99.83	0.17
3908	2.253	0.582	99.66	99.83	0.17
3909	2.253	0.582	99.66	99.83	0.17
3931	2.253	0.724	99.45	99.62	0.17
3932	2.253	0.724	99.28	99.49	0.21
3934	2.253	0.724	99.26	99.49	0.23

Right-HRS efficiency results are show in Figure 3 and separated by energy and momenta in Figure 5. These results are mostly consistent with those seen on the left-HRS. There a few runs where the efficiency drops below 99% and they have been flagged as potential problem runs in the MySQL database. These runs are all dilution runs and the run list is reproduced in Table 3. No efficiencies were calculated for the right-HRS at 2.253 GeV and a 2.5 T target field. The efficiency trigger, T_2, was broken during this run period.

Table 3: Dilution runs where the trigger efficiency falls below 99%. A shower and pre-shower sum cut was also applied to these runs to try and improve the efficiency but it had no effect.

Run Number	E0 (GeV)	P0 (GeV)	2 Cut Eff
23503	1.71	0.5719	98.97
23685	1.15	1.017	98.91
23686	1.15	1.017	98.88
23687	1.15	1.017	98.94
23688	1.15	1.017	98.97
23689	1.15	1.017	98.97
23690	1.15	1.017	98.96
24779	3.35	1.945	97.62
24780	3.35	1.945	97.58
24781	3.35	1.945	97.58
24788	3.35	1.945	97.52
24789	3.35	1.945	97.55
24790	3.35	1.945	97.58
24791	3.35	1.945	97.58
24792	3.35	1.945	97.52
24793	3.35	1.945	97.53

6 Conclusion

Trigger scintillator efficiencies are calculated for all applicable runs on the left and right high-resolution spectrometers. The efficiency and deadtime results were added into the MySQL database for all the runs calculated. Results show that this efficiency is almost always less than a one-percent effect. For the cases where the efficiency is larger than this one-percent, the runs can easily be reexamined at a later date if need be. If necessary a pion-rejector cut could also be added in after the detector calibrations are finished.

References

[1] "HRS Electron Arm Detectors." Experimental Hall A. Ole Hansen. Jefferson Laboratory. 3 Dec. 2012 <http://hallaweb.jlab.org/equipment/detectors/det_electrons.html>.

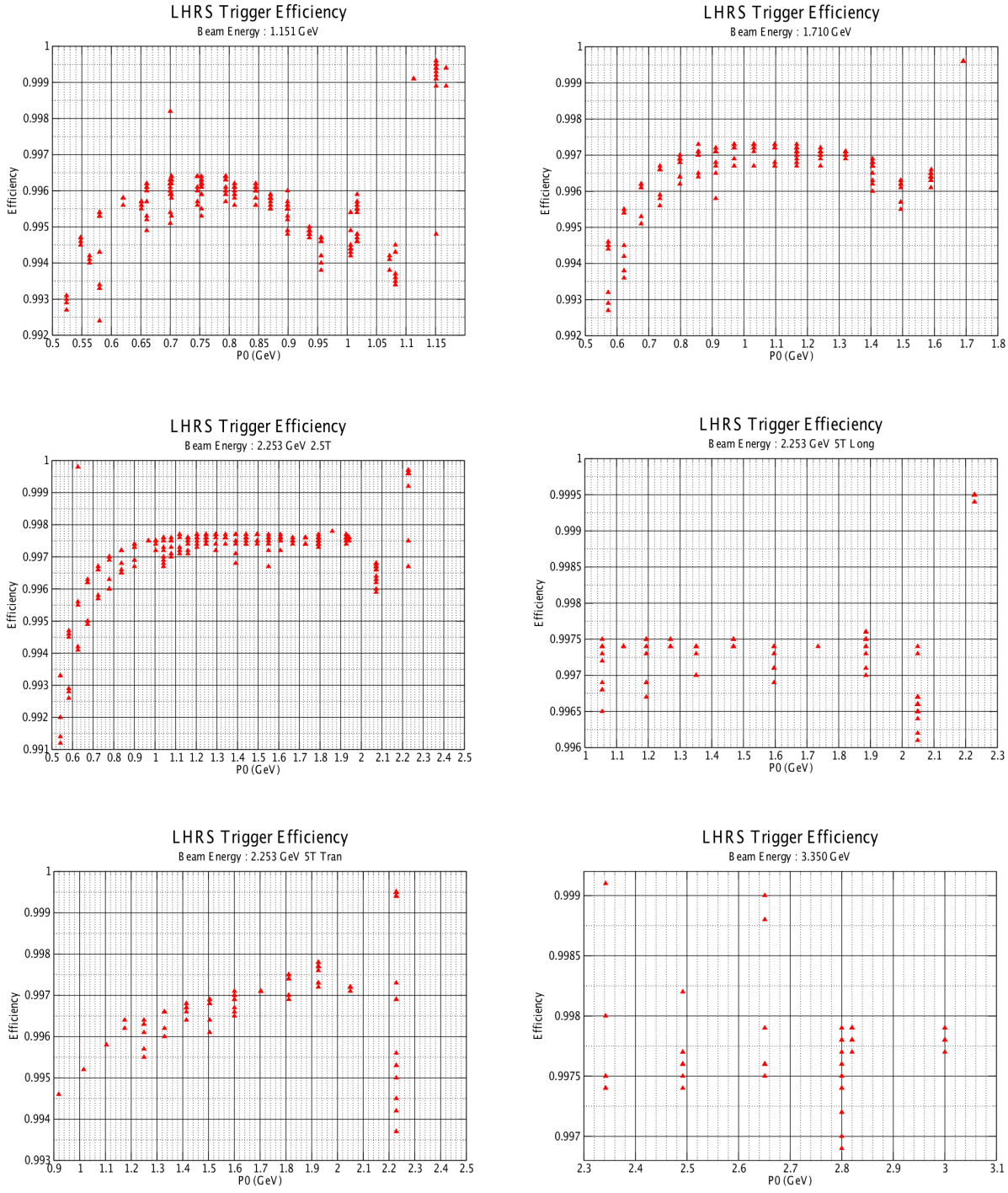

Figure 4: Left-HRS efficiency results separated by energy and then momentum.

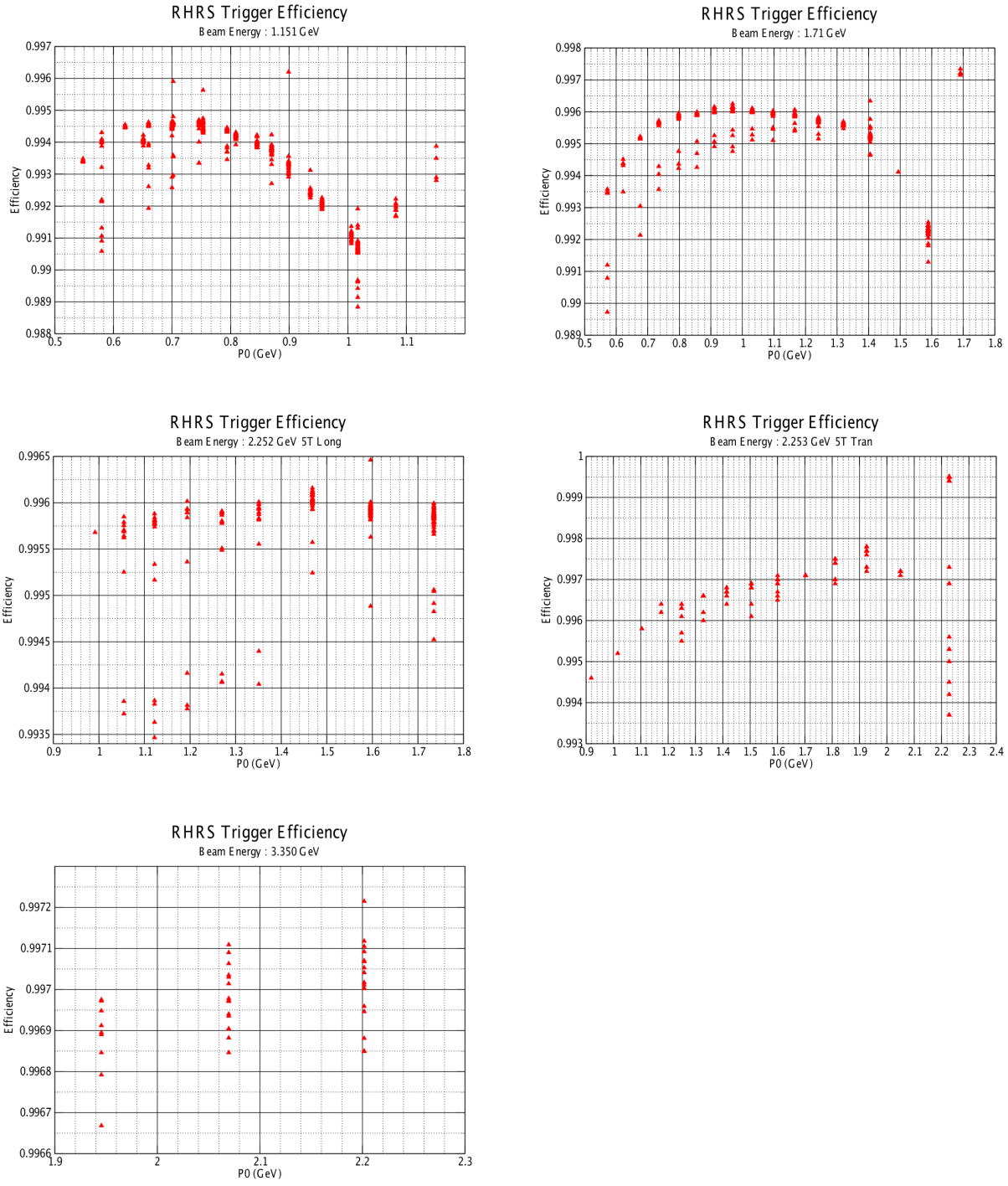

Figure 5: Right-HRS efficiency results separated by energy and then momentum.