# ERRATA to ALERT run group proposals

July 17, 2016

## Overview

The proposals for the ALERT run group need to be amended due the inconsistent combination of luminosity, target, and beam currents. Effectively, the quoted beam current should be roughly a factor of 3 higher for all proposals. This does not change the projected results for the "Tagged EMC" and "Tagged DVCS" proposals. However, the projected results for the "Nuclear GPDs" proposal need updated due to the mistaken use of the luminosity *per nucleon*. Since the coherent processes are on the entire nucleus the projections are updated using the luminosity *per nucleus*. The requested beam time has not changed from what is in the original proposals and is summarized in the table below.

The outline of this document is divided into two parts. The first section will address the amendment common to all proposals. The last section is only relevant to the "Nuclear GPDs" proposal and contains updated projections.

# 1 Update to all proposals

We proposed 40 days (20 with helium target, 20 with deuterium) at a "low" luminosity of $3 \times 10^{34}$ cm$^{-2}$s$^{-1}$ per nucleon, and 10 days on a helium target at "high" luminosity of $6 \times 10^{34}$ cm$^{-2}$s$^{-1}$ per nucleon ($1.5 \times 10^{34}$ cm$^{-2}$s$^{-1}$ per nucleus). The physics rates and recoil drift chamber occupancies in the proposal were calculated using those luminosities and requested beam time, and therefore, remain unchanged.

However, a mistake was made when translating the luminosities into beam intensity. Adjusting the proposed beam currents to match the quoted luminosities would maintain the validity of the projections, and doing so results in 500 nA for low luminosity runs and 1000 nA for high luminosity (instead of the 150 and 500 nA originally quoted in the proposal).

Alternatively, if such high intensity is not possible, we can move to a 6 atm target. This option need to be studied in detail to understand its impact, if it turns out that it increases the energy threshold too much, we can change the target density only for the high luminosity run and use a beam of 500 nA all the time with 3 or 6 atm for low or high luminosity respectively. Only the Nuclear GPDs use the high luminosity data, and their kinematics of interest is largely above the detection threshold of the ALERT detector for $^4$He. We are sure higher pressure will not be an issue for these experiments. The latter option (different target pressures for low/high luminosity) would require more calibration work and is therefore not preferred.

In conclusion, the quoted luminosity and beam/target specifications in the proposal were inconsistent. However, the quoted luminosity can be completely recovered through current and/or target pressure adjustments.

| **Measurements** | **Targets** | **Beam time** (days) | **Luminosity**[1] **(cm$^{-2}$s$^{-1}$)** | **Beam current** |
|---|---|---|---|---|
| **Commissioning** | $^1$H and $^4$He | 5 | Various | Various |
| **Tagged EMC** | $^2$H and $^4$He | $20 + 20$ | $3 \times 10^{34}$ per nucleon | 500 nA |
| **Tagged DVCS** | $^2$H and $^4$He | $20 + 20$ | $3 \times 10^{34}$ per nucleon | 500 nA |
| **Nuclear GPDs** | $^4$He | extra 10 | $6 \times 10^{34}$ per nucleon | 1000 nA |
| **TOTAL** | | **55** | | |

[1] This luminosity value is based on the effective part of the target. When accounting for the target's windows, which are outside of the ALERT detector, it is increased by 60%

# 2 Updated Projections for Nuclear GPDs proposal

A misunderstanding within the run-group lead to luminosity values for *per nucleon* being used instead of *per nucleus* when projecting the coherent DVCS and DVMP expected results. The statistics are thus uniformly reduced by a factor of 4 for DVCS and DVMP channels compared to the original proposal. All relevant plots and calculations have been redone with the reduced luminosity and updated projections are shown below. We apologize to the reviewers for any inconvenience this has caused.

## 2.1 Updated projections for DVCS channel

Figure 1 shows the slight modified binning in $x_B$ and $-t$. The simulated data is integrated over the full $Q^2$ range. The data has been binned into three bins in $x_B$, 8 bins in $-t$, and 13 bins in $\phi$. The statistical error bars are calculated for 20 days at a luminosity of $0.75 \times 10^{34}$ cm$^{-2}$s$^{-1}$ per nucleus (jointly with Tagged EMC proposal request), and 10 days at a luminosity of $1.5 \times 10^{34}$ cm$^{-2}$s$^{-1}$ per nucleus in a configuration specifically dedicated to this proposal. Figure 2 shows the reconstructed beam-spin asymmetries as a function of the angle $\phi$ for two bins in $-t$ at a fixed $x_B$ value presenting a high and a low statistic bins. The projected precision of $A_{LU}$ at $\phi$ equal to 90° for the different bins is presented in Figure 3. The projected uncertainties on the reconstructed real and imaginary parts of the CFF is shown in Figure 4. Figure 5 (left) shows a fit to the extracted imaginary part of the $^4$He CFF, $H^A$, as a function of $-t$ in a fixed $x_B$ range. The new extracted transverse density profiles are shown in Figure 5 (right).

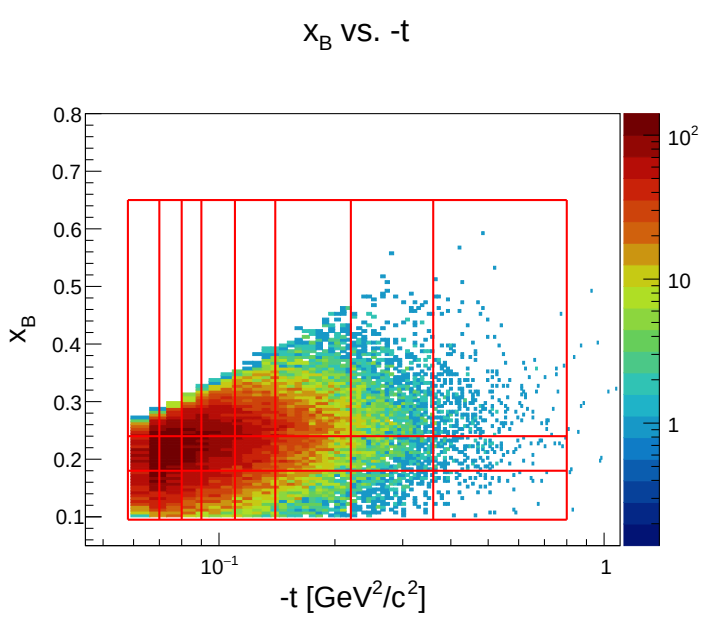


Figure 1: (Update for figure 5.14 in the original proposal) The binning in $-t$ at fixed values of $x_B$.

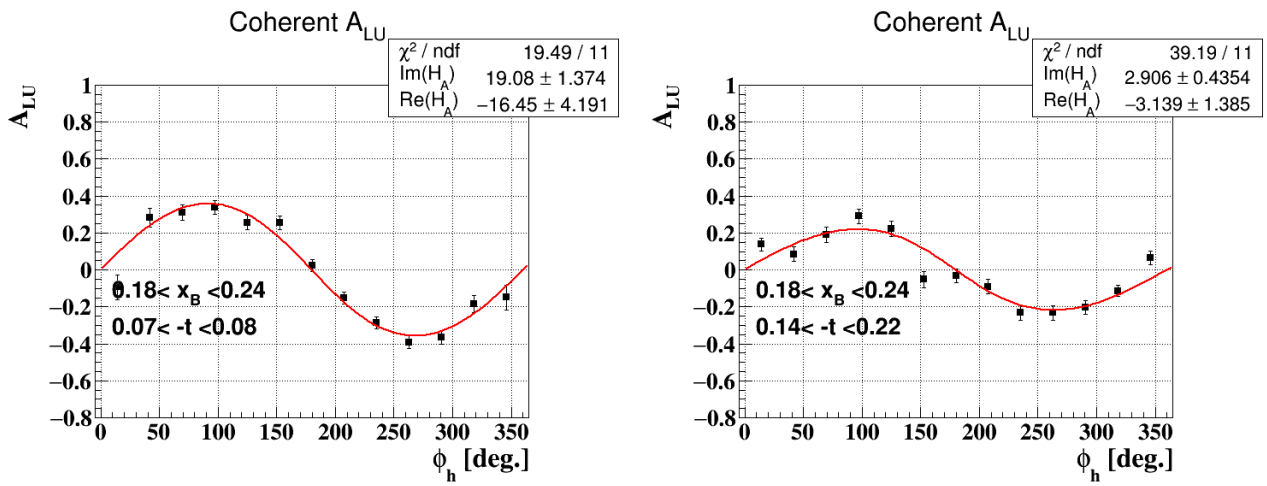


Figure 2: (Update for figure 5.15 in the original proposal) The coherent beam-spin asymmetry projections as a function of the angle $\phi$ between the leptonic and the hadronic planes, for two different bins $-t$ at the same $x_B$ range. The red solid curves represent a fit to the data in the full form of the asymmetry, equation 2.7 in the proposal, with the real and the imaginary parts of the CFF as the free parameters of the fit.

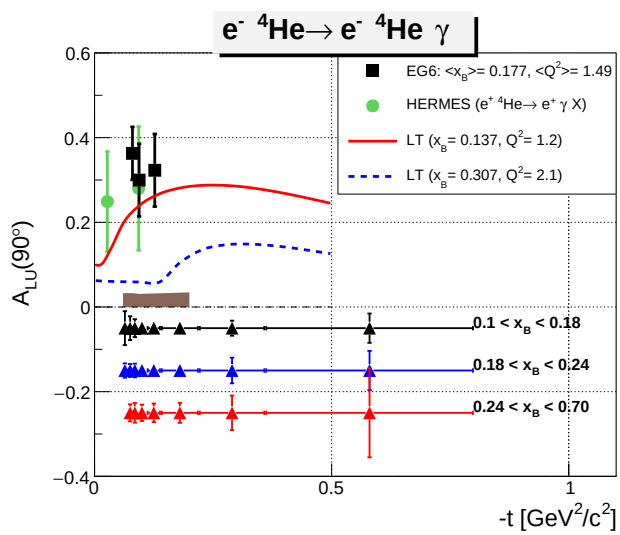


Figure 3: (Update for figure 5.16 in the original proposal) Projected precision for the $A_{LU}$ (90°), from the fit, for coherent DVCS on $^4$He versus $-t$ compared to the previous measurements from CLAS-eg6 (black squares), HERMES (green circles) and spectral function calculations (LT curves).

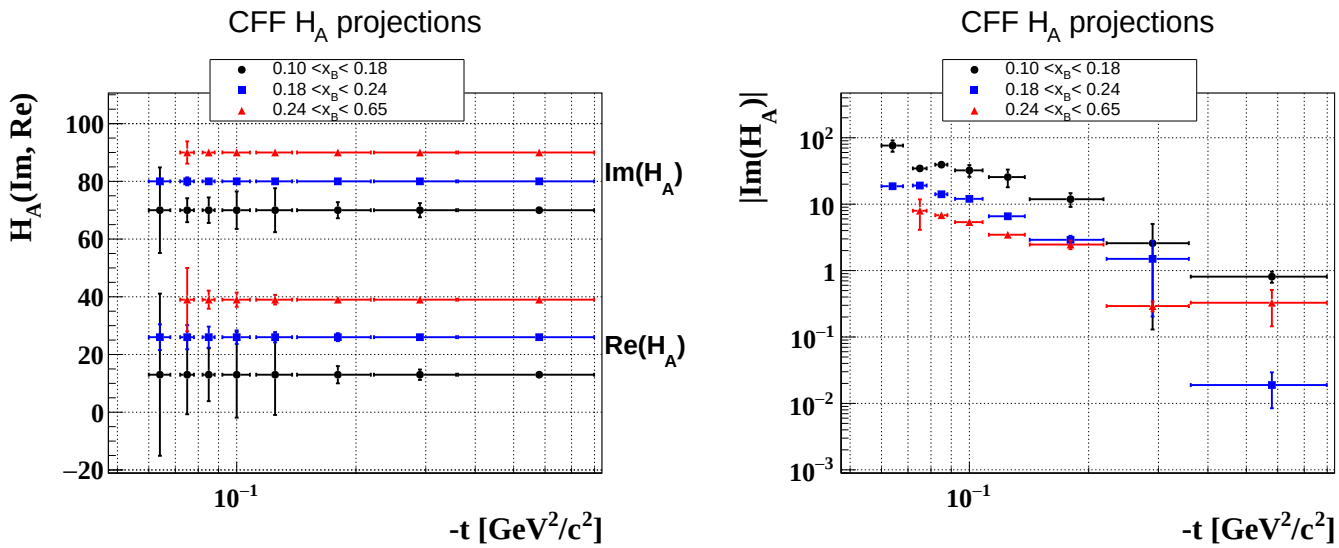


Figure 4: (Update for figure 5.17 in the original proposal) On the left, the projected statistical uncertainties for the real and imaginary parts of the CFF $H_A$, from the fits, as a function of $-t$ at fixed ranges in $x_B$. On the right, the projected statistical uncertainties of the absolute value of the imaginary part in logarithmic scale.

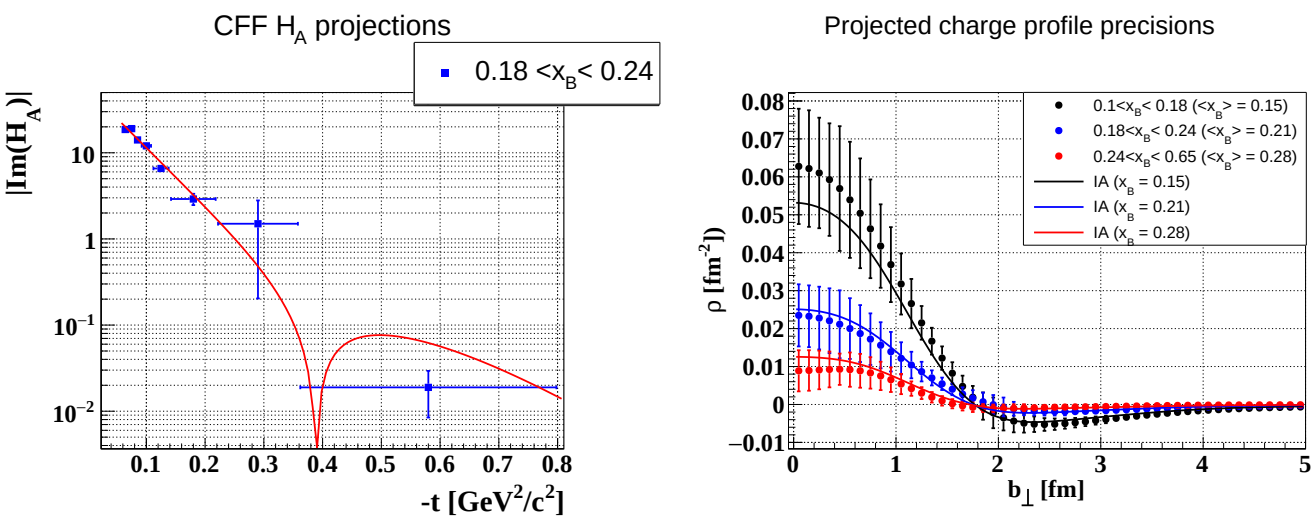


Figure 5: (Update for figure 5.18 in the original proposal) On left, a fit to the extracted absolute value of the CFF imaginary part $H_A$ as a function of -t in the $x_B$ range [0.18, 0.22]. On the right, the extracted parton density profiles as a function of the impact parameter, $b_\perp$, are compared to the Impulse Approximation (IA) calculations at the mean $x_B$ values in the different bins.

## 2.2 Updated projections for $\phi$ production channel

Some important notes concerning the original $\phi$ projections:

**1)** All projections shown here and in the original proposal only consider the detected $K^+$ missing $K^-$ channel, as this is the dominant channel statistically. Still, there is a significant contribution from the other channels combined: $K^+$ $K^-$ exclusive, $K^0_S \to \pi^+\pi^-$, and $K^-$ missing $K^+$. This is a small contribution at low $t$, but could double or triple the counts at higher $t$.

**2)** Very conservative estimates were placed on the Kaon detection efficiency of CLAS12, and the $^4$He detection efficiency of the ALERT detector. A 50% inefficiency was placed on both in addition to the expected efficiencies of the detectors. While it is important to be conservative in one's calculations, the quoted rates are likely underestimated by as much as a factor of 4.

For fair comparison to the original proposal, all projections shown here are the result of a uniform reduction of rate by a factor of 4. This reduction in statistics primarily changes the proposed analysis procedure by modifying the bin-size of the analysis. An updated binning over the phase-space is shown in Fig. 6. Note that this is one possible binning, and the specific binning may change to accommodate differences in the true measured distributions versus the projected distributions here.

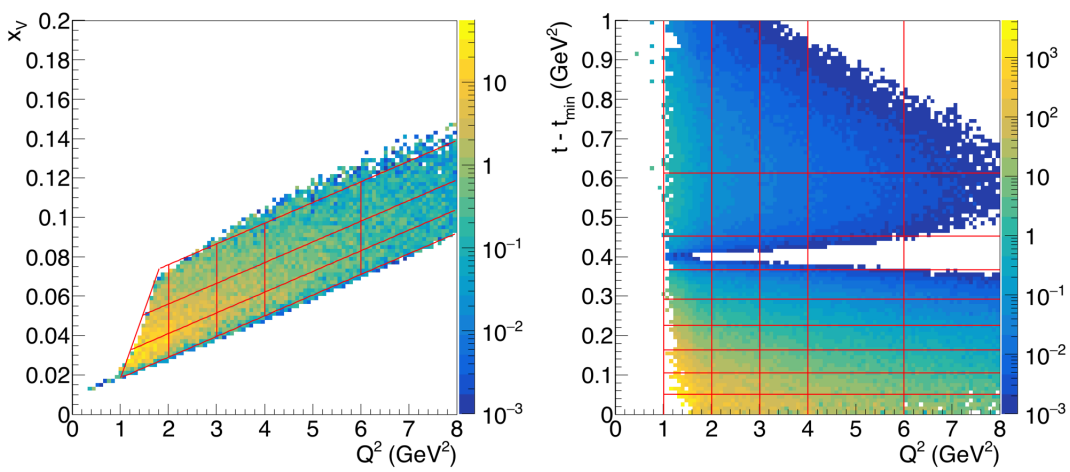


Figure 6: (Update for figure 5.20 in the original proposal) A possible binning over the accepted phase-space for gluon GPD extraction with $\phi$ production. The Z-axis shows the integrated cross-section per bin.

The largest impact seems to come from the extraction of R for a given x, $Q^2$ and t bin. For the highest populated bins, the expected statistics now drops to under a thousand events. An updated extraction of the SDME $r^{00}_{004}$ is shown in Fig. 7 below. The statistical uncertainty

is reflected in the size of the error bars for the plot. The systematic uncertainty is reflected in the deviation of the fit from the "truth" value before smearing and acceptance. The impact of uncertainty from this calculation comes in the form of well $R_L$ can be isolated, or conversely, how much $R_T$ contaminates the $R_L$ calculation.

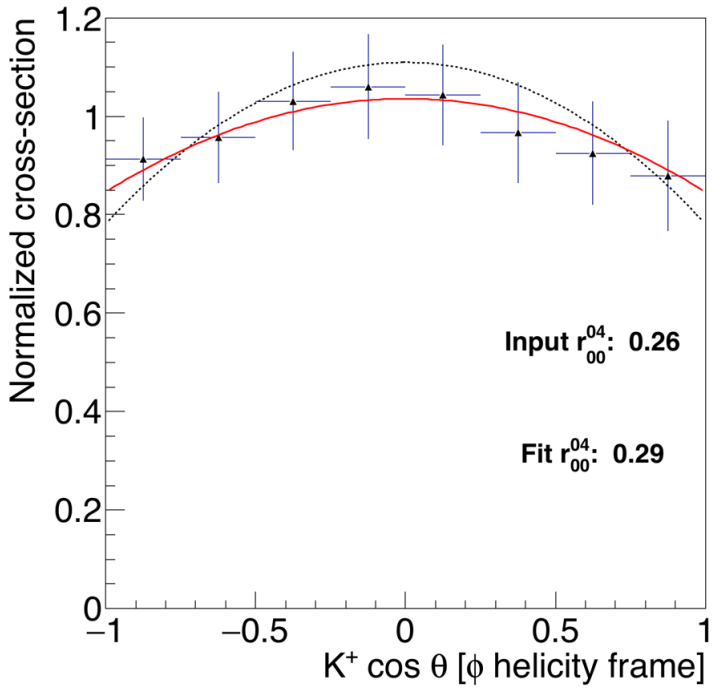


Figure 7: (Update for figure 5.21 in the original proposal) A fit to the $\cos(\theta)$ distribution of the $K^+$ in the reconstructed $\phi$-helicity frame within a bin of values of values $[0.02 < t - t_{min} < 0.04\,GeV^2]$, $[0.025 < 0.05]$, and $[1.5 < Q^2 < 2.0\,GeV^2]$. The dashed line shows the distribution that was generated. The data are then fitted after acceptance and resolution smearing for comparison to the generated values. This plot assumes a maximum momentum resolution of 10% for the $^4$He detected in ALERT.

The gluon density profile is the extracted from the normalized $\sigma_L$ differential in $\sqrt{-t}$ as shown in Fig. 8. The primary contributing factor to the uncertainty of the extraction comes from the momentum resolution of the ALERT detector, and is therefore mostly luminosity independent. The large $b_T$ calculation comes primarily from the low $t$ measurements, which still have good statistics after dividing by a factor of 4.

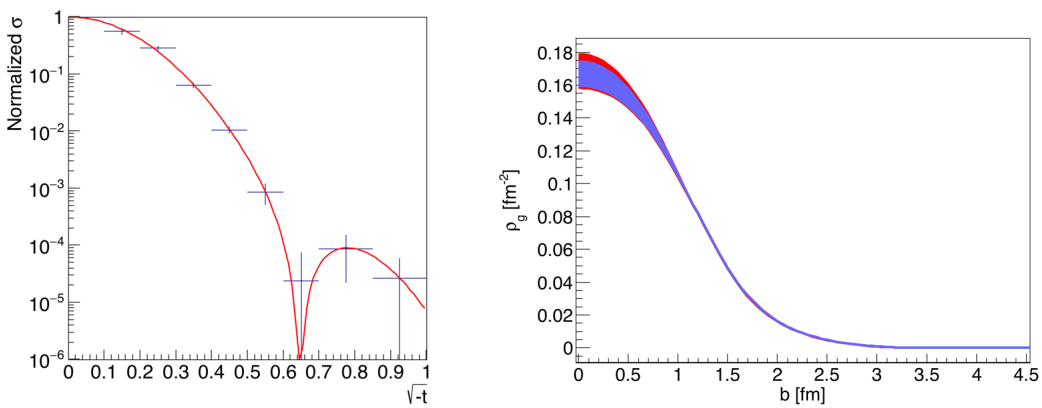


Figure 8: (Update for figures 5.23 and 5.24 in the original proposal) A fit to the normalized $\sigma_L$ calculation (left plot) which is then used to extract the gluon density profile (right plot). The right plot shows the latest projection (red curve) along with the original projection for the same binning (blue curve). Systematic and statistical uncertainties are shown in the width of the curves.