Polarizer and analyzer efficiencies on NG-5 NSE

The polarizer on the NG-5 NSE is a Mezei cavity: a 1500 mm section of ^{58}Ni-equivalent guide that contains a polarizing supermirror "V" 1253 mm long. The polarizing "V" is made from 1 mm thick Si wafers that are coated on one side with $3\theta_c$ Fe/Si supermirror.

The polarizing elements have been installed by Cilas so that the supermirror is on the outside of the "V" (on the side closest to the guide section walls), with no overlap of the two arms at the tip of the "V". As a result, the center of the beam of is only slightly polarized, as can be seen in Figure 1.

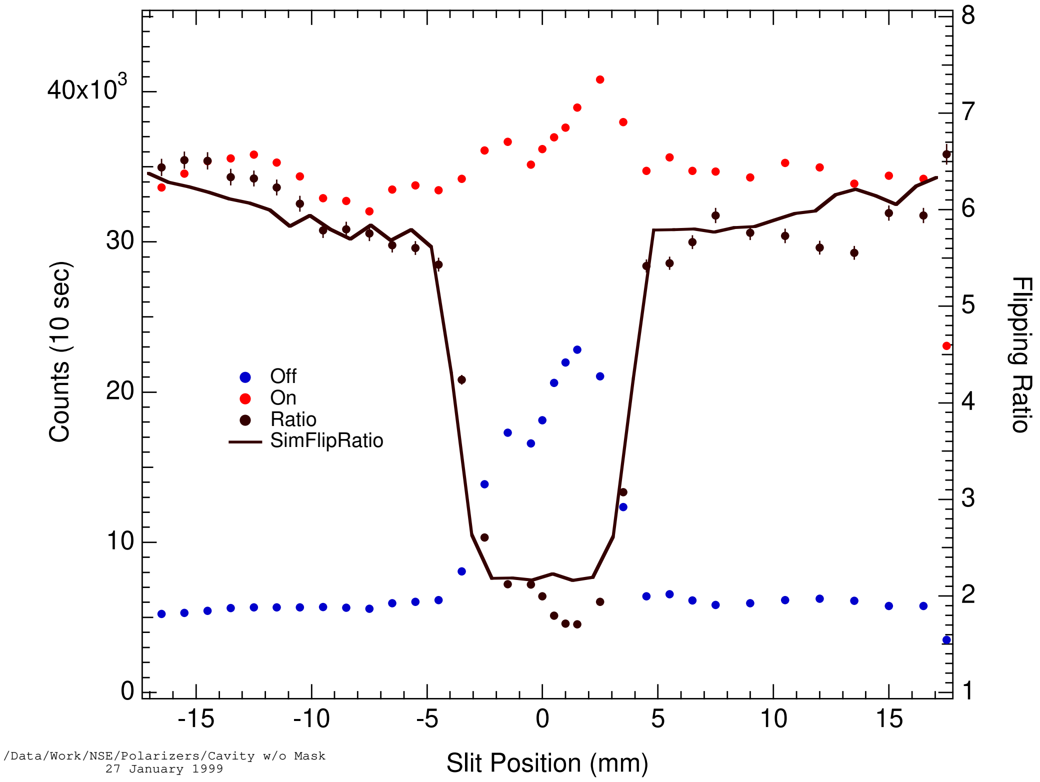

Figure 1: Measurement of the flipping ratio of the direct "polarized" beam with a 2 mm gap in the supermirror coverage at the tip of the "V", using a slit at the end of the guide, 1125 mm past the tip of the "V" and the detector in its normal position. The simulation line includes the effect of the reflectivity dip discussed in the text.

We removed this gap by placing a piece of B-loaded Al at the tip of the "V", thereby removing the worst of the effect, with only a slight decrease in the flipping ratio toward the center of the guide, as shown in Figure 2.

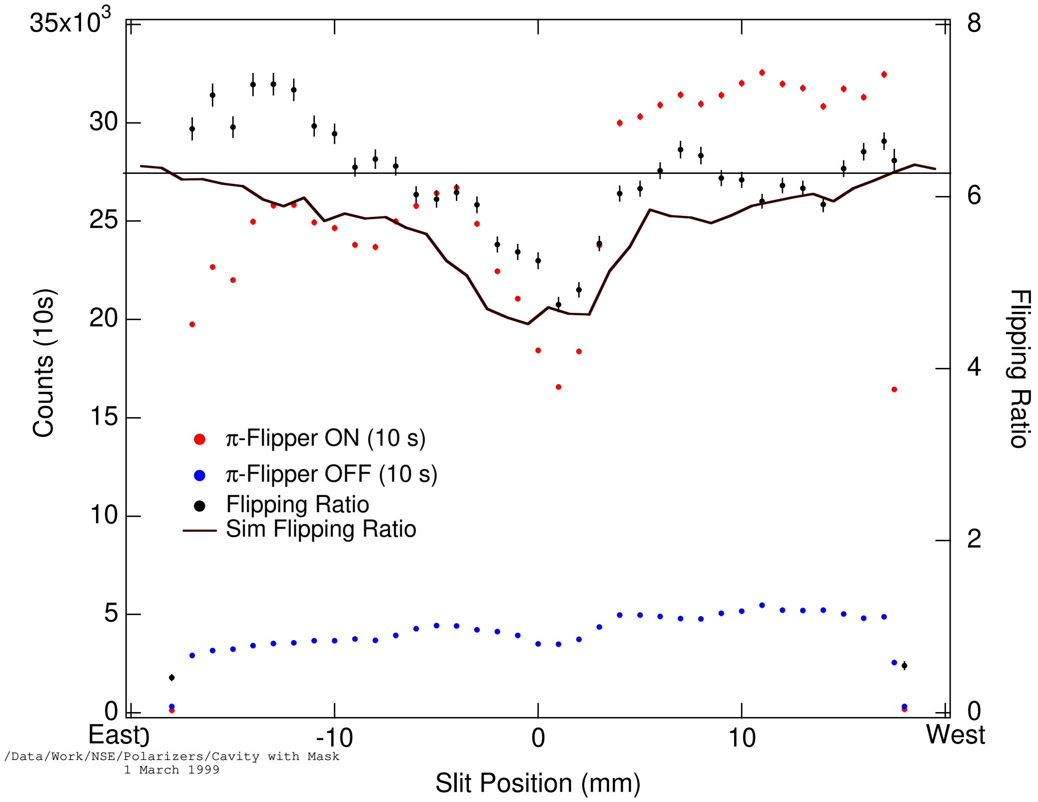

Figure 2: Measurement of the flipping ratio of the direct "polarized" beam with the 2 mm gap in the supermirror coverage at the tip of the "V" masked by a 2 mm wide by 1.75 mm thick piece of ${}^{10}B_{0.05}Al_{0.95}$, using a slit at the end of the guide, 1125 mm past the tip of the "V" and the detector in its normal position. The simulation line includes the effect of the reflectivity dip discussed in the text.

In testing a piece of ILL Co/Ti polarizer on the spectrometer (located in place of the analyzer), I found that the flipping ratio of an elastically scattered beam was much larger (R =12–13) than that of the direct beam ($R = 9$). I started to do some Monte Carlo simulations of the polarizing cavity to see if I could reproduce this behavior by mispositioning the mask .

The original simulations of the Mezei cavity had the polarizing supermirror on the inside of the "V", but simulations with the supermirror on the outside of the "V" and the neutrons first incident on the Si, showed that there were many low-divergence neutrons with the wrong spin state passing through the polarizing cavity. These are apparently due to a *dip* in the + spin state reflectivity at around the Si critical edge from our quality control measurements when the neutrons impinged on the supermirror through the Si substrate (see Figure 3). At the time, I thought that the effect of this

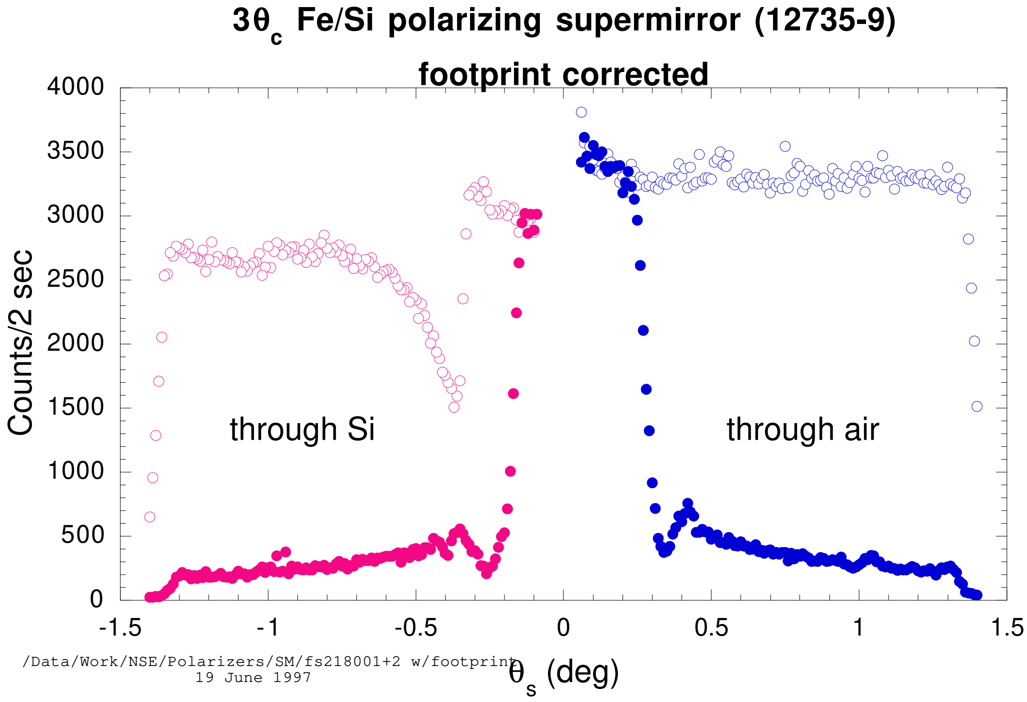

Figure 3: Measurement of the spin-dependent reflectivity for a "typical" Fe/Si supermirror with the neutron beam impinging on the supermirror from air and through the Si substrate. Note the dip near the Si critical edge for neutrons impinging throug the Si. The simulations described elsewhere in this report use a dip that is 45% the size of the dip shown here.

would solely be on average to reduce the polarization of the beam. Alas, no! The edges of the "V" are at 0.8° to the beam direction, so for a wavelength of around 8 Å, those neutrons that are travelling parallel to the beam direction are transmitted by the dip in the supermirror reflectivity, giving rise to a

Table 1: Comparison of observations and simulations of polarization for direct and scattered beams in various polarizer/analyzer configurations

	Direct beam		Scattered beam	
	Sim	Obs.	Sim	Obs.
Fe/Si pol. w/dip (0.873,0.920)				
Co/Ti analyzer ($P = 0.92$)	0.803	0.8	0.847	0.852
Fe/Si analyzer ($P = 0.77$)	0.672	0.666	0.708	0.714
Fe/Si pol. no dip (0.97)				
Co/Ti analyzer ($P = 0.92$)	0.892		0.892	
Fe/Si analyzer ($P = 0.77$)	0.747		0.747	

unpolarized component of the beam at a very small divergence. The details are such that polarization at the analyzer in the direct beam is 0.89, whereas the average polarization at the sample position is 0.925 (see Figures 4 and 5).

If we assume that the flipping ratio is 24 ($P = 0.92$) for the ILL test piece (as Ian Anderson reported) we then expect to observe flipping ratios of 12.1 ($P = 0.847$) for the scattered beam and 9.2 ($P = 0.803$) for the direct beam with the test piece, in good agreement with experiment.

We can then use the observed flipping ratio with the Fe/Si analyzer (in a too-small field) to determine that the analyzer polarization is 0.77, giving our observed flipping ratio of 6 in the scattered beam and 5.4 in the direct beam. If the Mezei cavity is flipped to remove this problem, we should get a cavity polarization of 0.97 and so a final polarization of 0.747, increasing the flipping ratio to 6.9. With the new analyzer polarization of 0.92, R = 17.6.

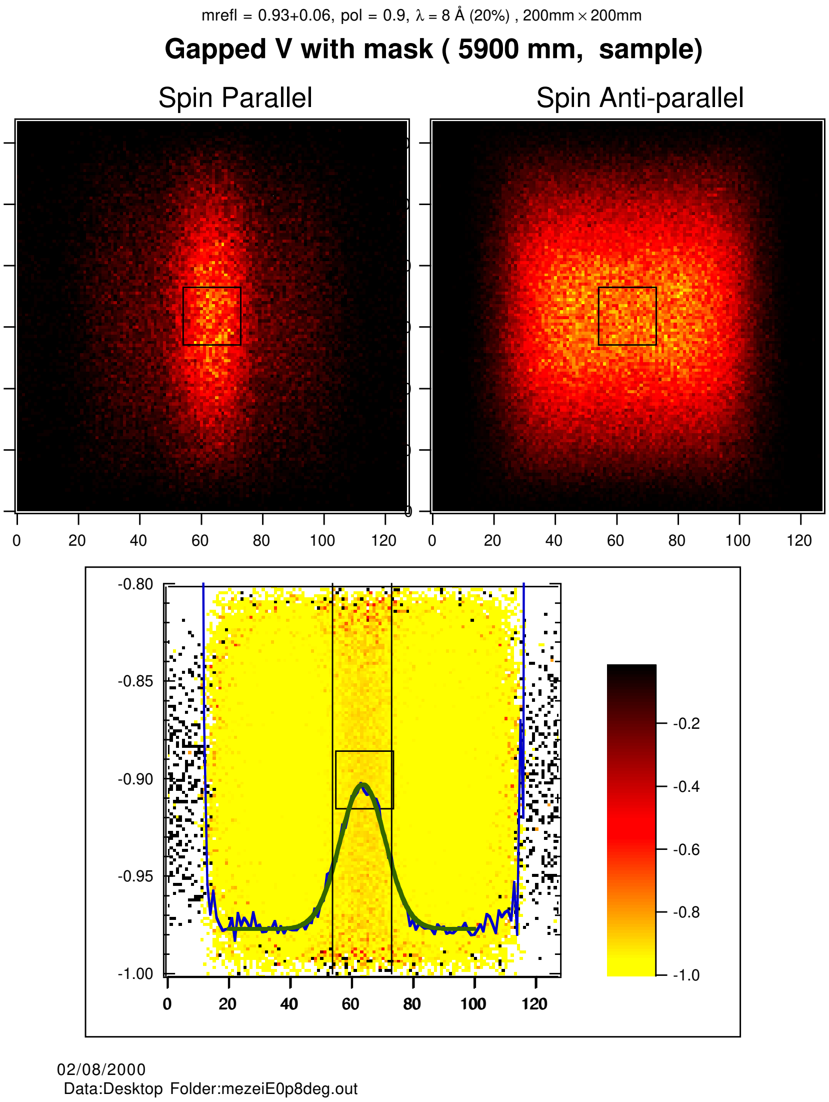

Figure 4: Simulation of masked gapped-"V" with dip in supermirror reflectivity. The top images, taken at the sample position, indicate the parallel (left) and anti-parallel (right) spin states. The image shows in color the polarization of the entire beam, while the line indicates the 1d-integration along the vertical height of the sample. The rectangle indicates the position and dimensions of a typical 3 cm×3 cm sample.

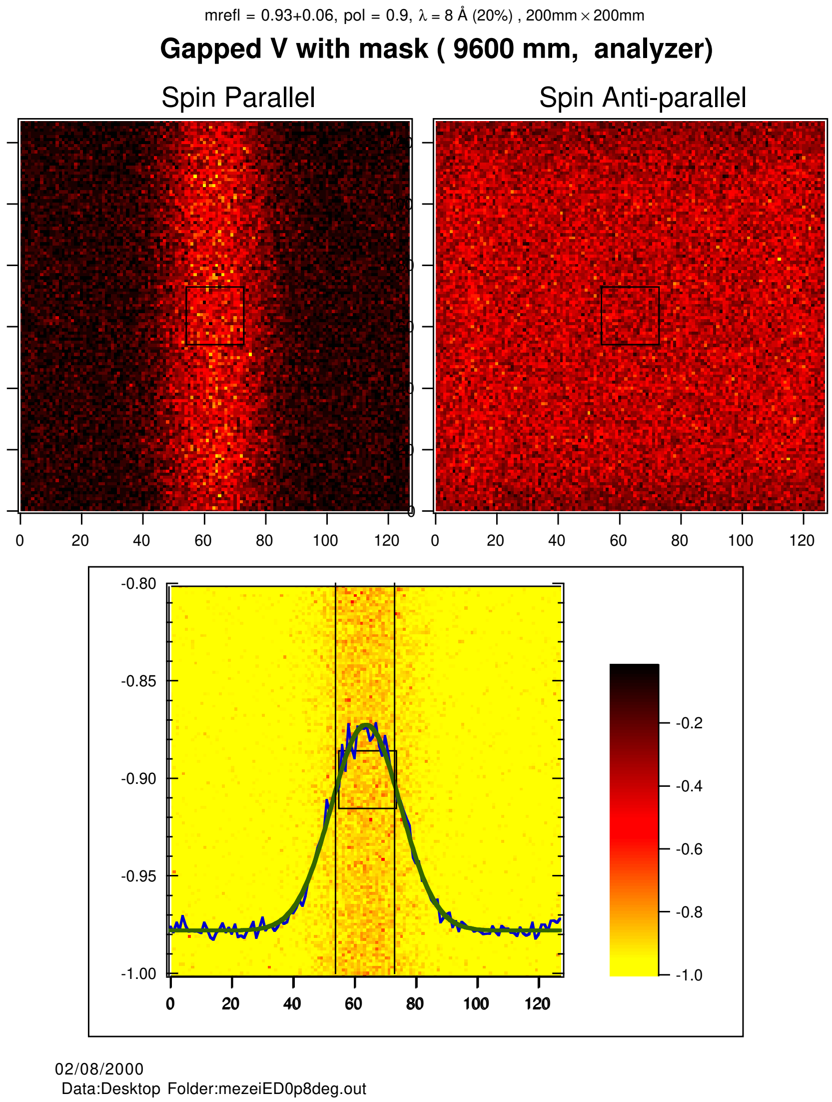

Figure 5: Simulation of masked gapped-"V" with dip in supermirror reflectivity. Image at Analyzer position. The top images, taken at the analyzer position, indicate the parallel (left) and anti-parallel (right) spin states. The image shows in color the polarization of the entire beam, while the line indicates the 1d-integration along the vertical height of the image.