We need to estimate the gas contamination after applying the psPACT cut.

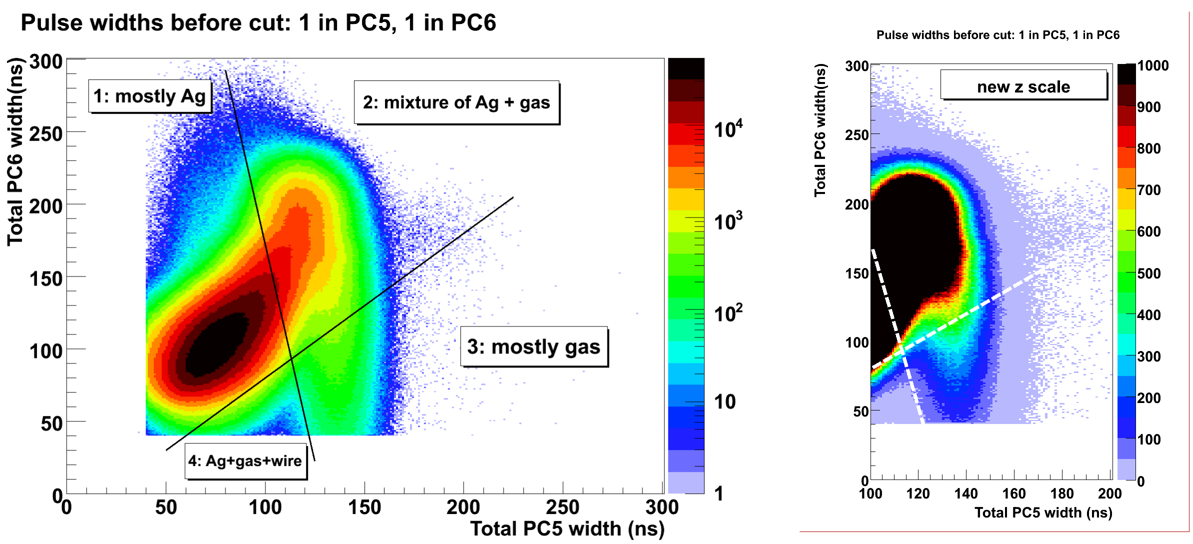
First of all, what DOESN'T work:

1. Using the simulation, since the PC response is not properly reproduced.
   See my previous posting on psPACT plots for different z-ranges in the simulation, which shows that the simulation does not reproduce the tail of gas stops:
   https://twist.phys.ualberta.ca/forum/view.php?bn=twist_software&key=1208815645

2. Trying to fit the sum of two exponential functions in the mostly-metal and mostly-gas zones.
   I tried an iterative fit (fit mostly-gas zone with lambda_metal fixed, then fit mostly-metal zone with lambda_gas fixed etc.), but the data does not have the necessary sensitivity.
   [Aside: We tried this in muSR where there were muons stopping in the metal target and the trigger scintillator]

Dick guided me through an alternative approach that uses **only the data**:

Consider the distribution of PC5 vs PC6 widths for s68-a3, chosen because the stopping distribution was peaked a little upstream ("1/3-stops"), maximising PC6 gas stops:



The nearly-vertical cut line runs parallel with the gas band. The gas band has a tail that leaks over this cut line – this is more obvious in the right hand figure, where the scale is changed. We need to estimate how much of the gas band leaks across the zone 1 / 2 boundary to estimate the systematic uncertainty for the psPACT. Specifically, this systematic is "how much gas contamination is left after the psPACT cut".

Three pieces of information are needed:

1. Depolarisation in the gas (lambda, and any fast depol).
2. Fraction of gas leaking across the zone 1 / 2 boundary.
3. Fraction of gas stops for PC6.

1. Depolarisation in the gas

A special treesum for **just zone 3** allowed the depolarisation in the gas to be determined.
For set 68 (Ag) the results were:

Zone	Lambda (per ms)	Pmu0
1	0.9 +- 0.2	0.9972 +- 0.0007
3	28 +- 3	1.00 +- 0.01

There are other posted results for set 83 (Al) that indicate a lack of fast depolarisation when selecting pure gas stops in PC6, but find ~4% change in pmu0 when selecting PC5/7/8 = gas+foil. See:
https://twist.phys.ualberta.ca/forum/view.php?site=twist&bn=twist_physics&key=1250713050

The difference in <Pmu> between the gas and metal can be calculated using the "lever-arm" method:

$$\frac{\int_{t_1}^{t_2} N(t)\cdot P_\mu(0)\exp(-\lambda_2 t)dt}{\int_{t_1}^{t_2} N(t)dt} - \frac{\int_{t_1}^{t_2} N(t)\cdot P_\mu(0)\exp(-\lambda_1 t)dt}{\int_{t_1}^{t_2} N(t)dt},$$

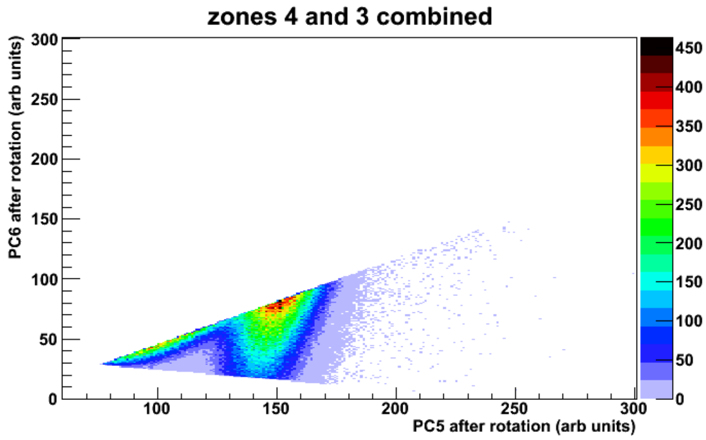
where $N(t) = N(0)\exp(-t/\tau_\mu)$ and τ_μ is the muon lifetime, and λ_1 and λ_2 are the relaxation rates

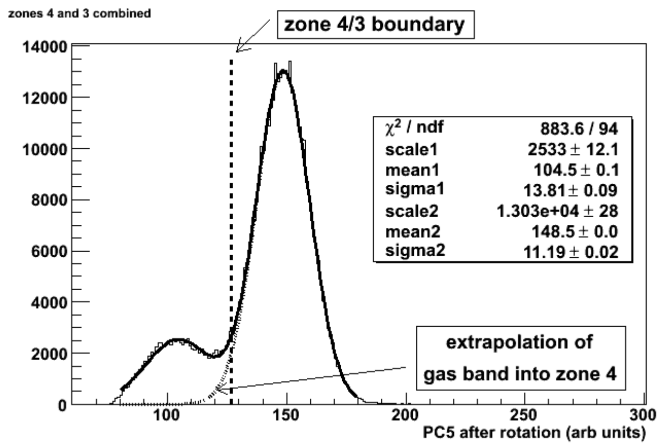
This gives **7.7% as the depolarisation (<Pmu>) in gas.**

2. Fraction of gas leaking across the zone 1 / 2 boundary.

The metal and gas distributions are on top of each other in zone 2, so we can't easily isolate the gas distribution in this zone and see how much leaks into zone 1. However, the gas band continues roughly parallel to the nearly-vertical cut line with about the same width, so the contamination of zone 3 into zone 4 will be about the same as the zone 2 / 1 contamination.

A special treesum was produced that selected zones **3 and 4**, with the 45-degree cut line lowered to conservatively remove metal stops from zone 3. The projection (parallel to the nearly-vertical cut line) is shown below, along with a fit to two Gaussians:





Integrating the Gaussian for the gas stops:

range (arb rotated PC5 units)	ncounts (1E3)
-500 < PC5' <127	9.9
127 < PC5' < 500	355.6

Therefore the % of gas distribution leaking over the cut line is 9.9/(9.9+355.6) = **2.7 %**

3. Fraction of gas stops for PC6

Previously Blair used the simulation to determine that 2.5% of muons stop in the PC6 gas, and the rest in the metal target.

For the modern data, we know that PmuXi changes by 44e-4 between psPACT on/off. See
https://twist.phys.ualberta.ca/forum/view.php?site=twist&bn=twist_physics&key=1249411865

Since the depolarisation in gas is <Pmu>=7.7%, this suggests that 0.0044 / 0.077 = 5.7% of the muons in PC6 stop in the gas.

Estimate of systematic

Now we have all the information.

Let N_1^g and N_2^g be the number of muons stopping in the gas (g) in zones 1 and 2.

If we conservatively assume that all zone 2 stops are gas, then we know that

$$N_1^g + N_2^g = [5.7\%]\, N^{total} \qquad (1) \qquad \text{(we know 5.7\% of PC6 muons stop in gas)}$$

$$N_1^g = [2.7\%]\, (N_1^g + N_2^g) \qquad (2) \qquad \text{(from the double Gaussian fit)}$$

(1) and (2) give $N_1^g / N^{total} = [2.7\%] \times [5.7\%]$

The depolarisation in gas is 7.7%, leading to a systematic uncertainty of [2.7%] x [5.7%] x [7.7%], which is 1.2e-4. This is an upper limit since we have made the conservative assumption of 100% gas stops in zone 2.

The stability of the 2.7% result should be checked for other sets.