**Considerations for EIC TOF AC-LGAD Sensor**

Requirements: 20 micron position resolution for one coordinate, 25 psec time resolution.

Also want to minimize the number of channels in total, consistent with specifications.

The requirements lead to several design choices.

1. The time resolution requirement based on the Landau fluctuation effect on time resolution requires a sensor of 35 micron thickness or less. A 35 micron thick sensor has a Landau fluctuations contribution of 20 psec. Will require a jitter value much less than this to get to a total of 25 psec. Given that a number of sensors with 35 micron thickness have been made and the time resolution measured for these agrees with expectations, this could be a safe choice. A 35 micron thick sensor should have a signal rise-time of about 350 psec, which will facilitate getting to a small jitter. Both the signal speed and noise requirements provide important constraints on the electronics.
2. The jitter term is given by the rise-time/signal-to-noise ratio. Indicates that a signal-to-noise of at least 30 is desired for a 35 micron thick sensor. For the AC-LGAD, a particle hitting the center between two strips results in a signal that is half of the total for each strip, this leads to a worse jitter by sqrt(2) after averaging both strip signals compared to a hit on a strip. Requiring a signal-to-noise of at least 30 and quick rise-time are both important to achieve the 25 picosecond goal for this configuration. Use of a thinner sensor, for example 20 microns, might allow a more comfortable margin for achieving the 25 psec goal.
3. The spatial resolution is ~ pitch/ signal-to-noise ratio for a sensor where the metal width is significantly less than the pitch. For a signal-to-noise of 30 a pitch of 500 microns should be a workable solution.
4. The sharing affects the position resolution and can be tuned by choosing the detector fabrication parameters and the metal strip width. A sharing to the nearest neighbor when a strip is hit of 15% would be a good choice to limit the sharing beyond the first neighbor. The less sharing the better the position resolution since the derivative of the signal with position is larger. With a signal-to-noise of 30, 15% of the signal is still well above the noise.
5. The metal strip width should be minimized to minimize the capacitance. However it also results in too much sharing if too thin. This has to be optimized in conjunction with the other sensor parameters such as the n+ resistivity (~2,000 ohms/sq is desirable) and oxide thickness (about 100 nm), where high resistivity and a thin oxide are best. A value of about 100 microns is a good choice for the metal strip width. Also would like to minimize the resistance of the strip.
6. The strip length also affects the capacitance. For a 100 micron metal, 35 micron thick sensor, a 5 mm strip length results in a capacitance of about 1.5 pF.

To summarize the numbers above: sensor thickness of 35 microns, pitch of 500 microns, strip metal width of 100 microns, strip length of 5mm is a good place to start. A signal to noise of a least 30 is crucial and a sharing to the nearest neighbor of 15% is a good design goal. The signal-to-noise is a key parameter and is affected by the sensor gain as well as capacitance. For a situation where radiation damage is not a big concern a gain of 30 should be achievable. It is perhaps good to aim at a signal-to-noise of 50, although in the above the choice was 30. A signal-to-noise of 50, which has been achieved before in tests, would make it much easier to achieve the sensor performance goals. A better understanding of the limitations from the sensor capacitance would be helpful.