Critical items for a LCTPC read-out technology choice

- Several aspects are important, but not critical because all three technologies - pads, micromegas and pixels - can meet them:
  - Minimize power consumption produced by detector and electronics
  - Sufficient cooling (little material, use e.g. CO_2 cooling)
  - Thin detector (radiation length)
  - Sufficient z resolution and absence of deformations in z < 0.3 mm
  - dE/dx resolution of 5% or better
  - Stable detector operation with T2K gas
- For these items it is hard to argue that because of a better z or dE/dx resolution for the pixels, one should choose that technology. The reason is that “it is nice to have” (so a plus) but in my opinion not a physics requirement.

Critical items for a LCTPC read-out technology choice

- Critical items are in my opinion the requirements in the bending plane of the detector. So the momentum resolution and the control of the resolution and systematics in the bending plane along the track and over the module. This means control over the mechanics of the module and electric fields (including E cross B) over the module.
- In order to match the tracking performance this implies a flatness of the residuals over the module (read-out plane) in the xy transverse plane of 10-20 microns.
  - Currently none of the three technologies has demonstrated this
  - For the pixels we put in considerable effort to reach very high precision mechanical mounting (to meet the required 10-20 microns) of the quad and 8-quad module.

Critical items for a LCTPC read-out technology choice

- On the method: it is further important that one should not correct for deformations. Only alignment corrections (shift and rotation) should be allowed.
- While constructing of the module, deformations should be kept less than 10-20 microns in the bending plane. Regions where this is not reached should be removed.
  - The reason for keeping this strict requirement is that many deformations are not constant in time e.g. not depend on varying quantities such as temperature, background rates, space charge etc.
  - Corrections larger that 100-200 microns should not be allowed (and these regions removed), because one needs to control them at the 10-20 microns level (factor 10).
- Yes, this is a tough requirement … but we compete with e.g. an all silicon detector

Critical items for a LCTPC read-out technology choice

- The precision of mounting the gating device
  - In the LCTPC WP 326 studies showed that in order to keep deviations/deformations smaller than 10-20 µm:
  - The potential difference dV over the gate should be kept very close to the nominal field plus/minus 0.1 V
  - This means that one should not tune the gate Voltage for the highest efficiency/transparancy, but keep the field constant
  - The central voltage of the Gate V_c should be precise up to 5-10 V
  - The gate should be mounted with a precision < 0.2-0.4 mm in z
- These specifications can be achieved with the ILC gating device
- This item is not critical for a technology choice, but still relevant for the ultimate performance of the TPC

Critical items for a LCTPC read-out technology choice

- The need for additional field shaping structures
  - For the readout plane the homogeneity of the Electric field needs special attention.
  - At the edges of (sub) modules but also of the pads and chips
  - This translates into requirements on the precision of the mounting in 3 dimensions (discussed above)
  - In case of the Pixel Module we need additional field shaping structures to keep the deformations low. Note that the deformations due to the presence of a ground plane can be simply calculated and minimized.
  - Also here the field shaping structures have to be mounted with high 3D precision. For the 8-Quad Pixel Module they follow the edges.
  - For other technologies field shaping structures might be needed too

Critical items for a LCTPC read-out technology choice

- Back to the requirement of 10-20 microns in the xy plane.
  - Currently none of the three technologies has demonstrated this
  - For the pixels we put in considerable effort to reach very high precision mechanical mounting (10-20 microns) of the quad and 8-quad module.

- Concerning the other technologies:
  - The mechanical precision of large micromegas modules and flatness of the surface achieved for the pad planes is about 100 microns or worse. This means in my opinion - based on the pixel mechanics - that systematical deformations could be a factor 5 worse than what is required.
  - NB This is also the reason I am skeptical of large(r) modules

Critical items for a LCTPC read-out technology choice

- If we agree on these criteria and the proposed method (no corrections), the next step is to measure with high precision in a test beam with a silicon telescope the deformations over a module for the different technologies
  - It is important to study these without and with B field; to get also a measurement of ExB deformations
  - This means we dive deeper than the pad/pixel resolution and study systematically deformations
  - Then we could see where we stand; identify what needs to be improved to meet the specifications
- These results should be an important input to decide on e.g. an optimal module size and the best suited technology.