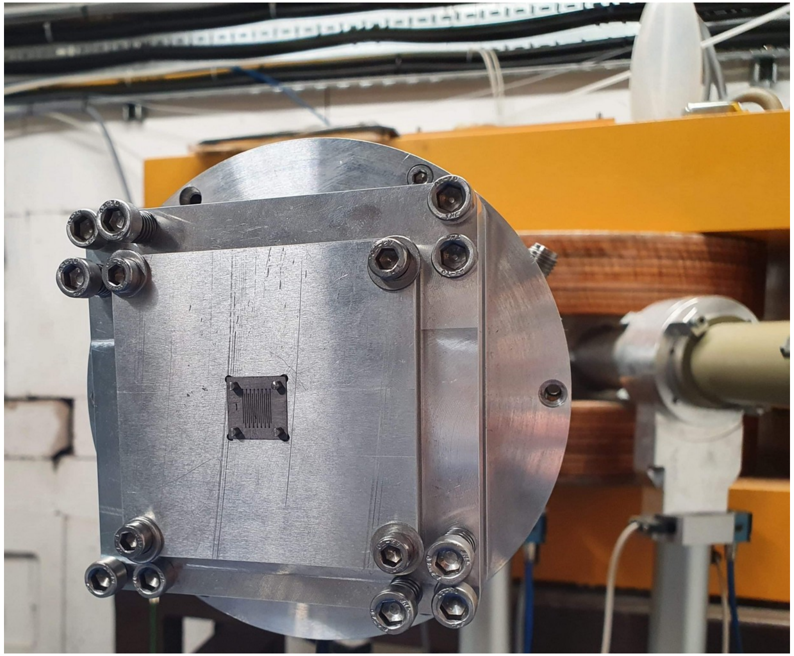
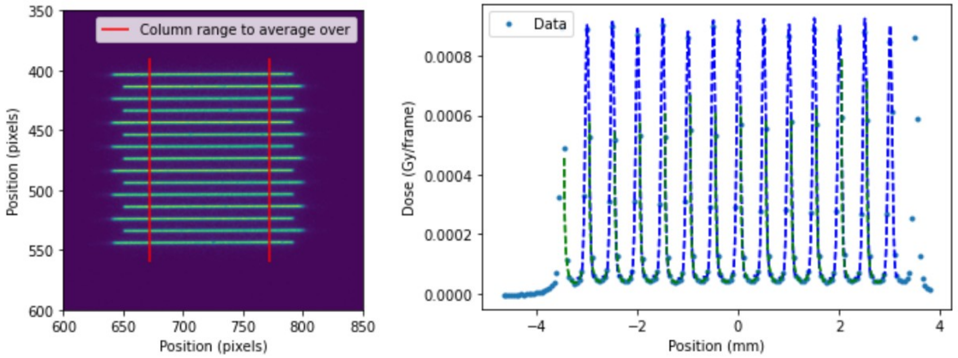
Implications of Low Energies at Stage 1 End-station

Dr Tony Price

2nd LhARA End-station consultation meeting

Microbeams @ UoB 36 MeV





(a) 0mm image showing columns averaged over between the two red lines.

(b) Gaussian fit to data averaged over column range highlighted in 11a.

Figure 11: 2D beam profile measured at 0mn corresponding Gaussian fit to the dose profile

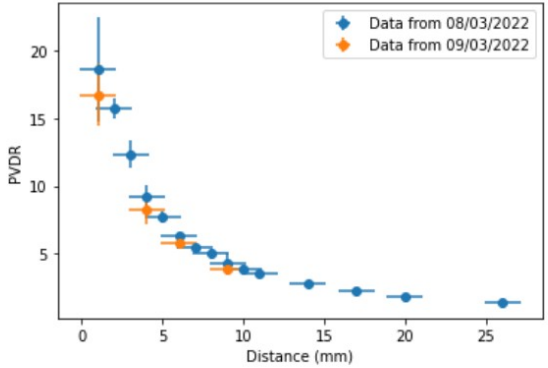


Figure 15: Peak to valley dose ratios for varying sensor to collimator distance in air. Data sets for both experimental days are shown.

Automation – Cell Trains

- High throughput means automation of cell dish loading, irradiation, unloading.
- Some users will want multiple cells, others will want fast access. System needs to be flexible
- I imagine a train like system where each sample is handled on its own for flexibility
- The “trains” will need to enter and leave the end-station whilst preserving the temperature and oxygen levels
- The stability is a key question from CM2
- One can imagine a long end-station such that end-effects of entry and exit are a small change to the whole environment
  - sample enters, moves to position, irradiated, moves out of endstations
  - Also opens up the opportunity to stage the samples before and after irradiation and remove all at once
- Again depends on the users time scales
- Trains then return to the radbio lab for analysis

End-station Mechanics

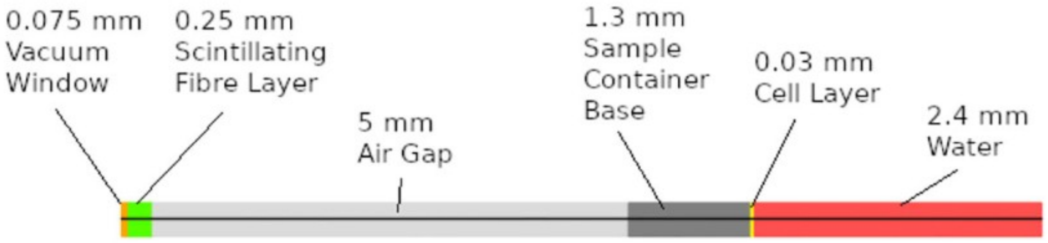
- A long end-station could become a large volume and take a long time to change properties within it.
- Want to minimise this as much as possible
- Currently I have a layout which is 100x20x10cm with 1cm thick Perspex walls
- Ideally the end-station would be coupled to the vacuum system and the vacuum window be the entrance window.
- Realistically, this might not be practical if we want to change the end-station for different uses / users
- Currently I am assuming
  - 25um Ti vacuum window (as we use at UoB)
  - Thinned Perspex window of diameter 8cm and thickness 100um for the beam to enter the end-station
  - These numbers roughly total the 75um vacuum window in the pre-CDR

Materials Within End-station

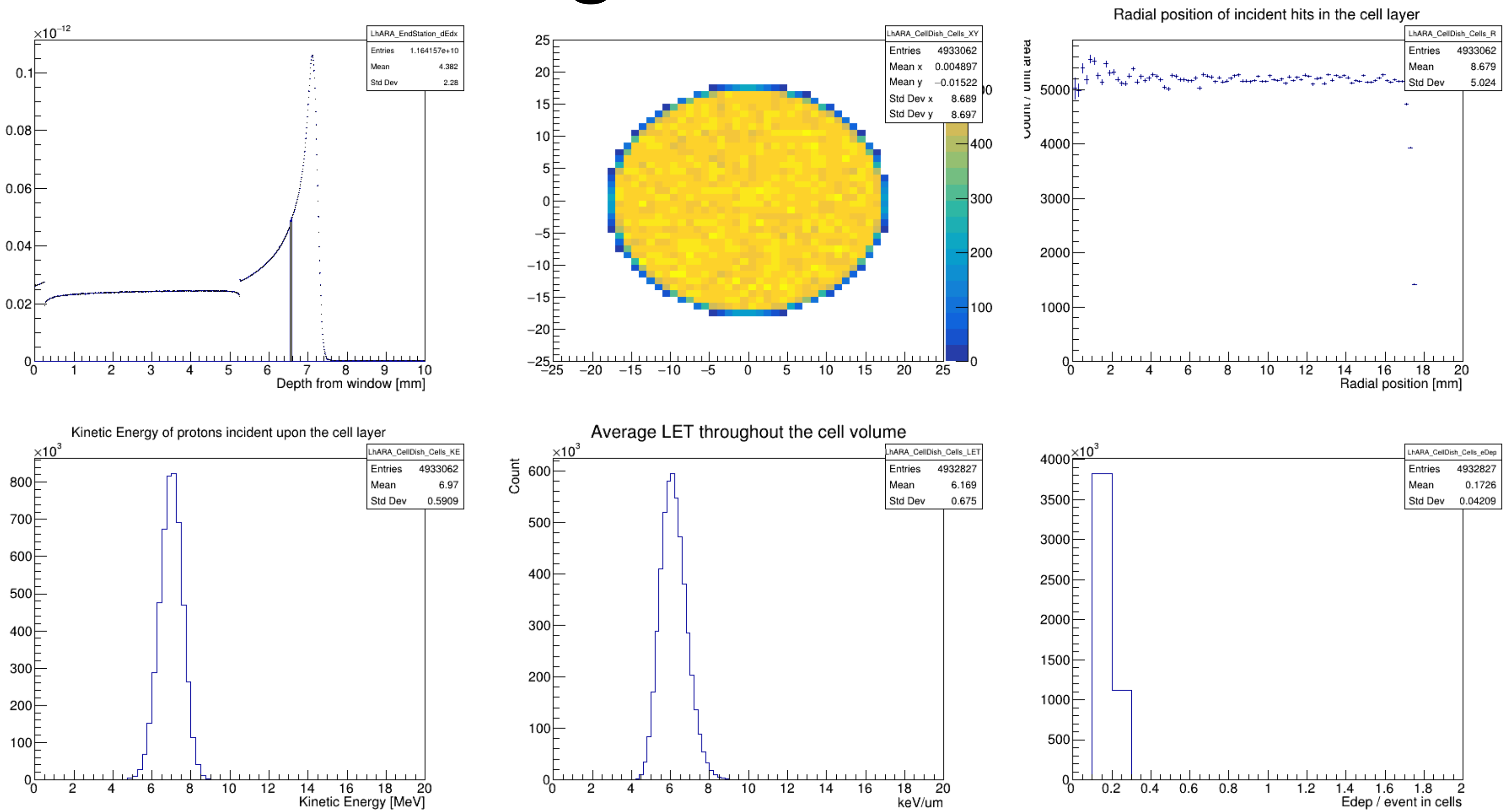
- In the pre-CDR there was 250um of scintillator before a sample as a beam monitor
- I have kept this in place and modelled it as Perspex for now
- Changed this to a 100um thick silicon pixel sensor to see the impact on the beam of other Beam Monitors

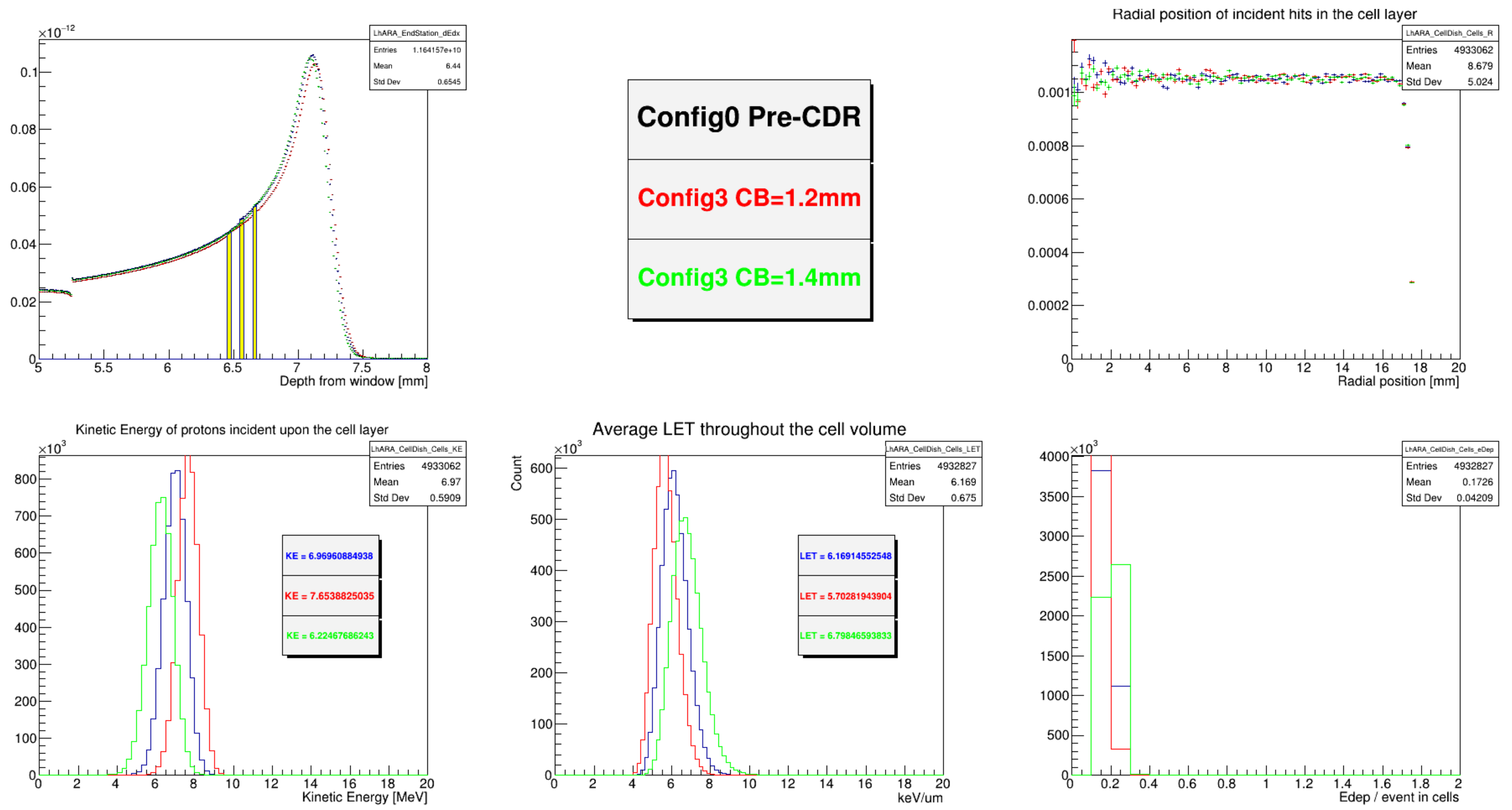
- Range shifter made of Perspex placed in the middle of the 5mm air gap
- Cell dish
  - Base: Perspex 1.3mm
  - Media: ICRU tissue 30um
  - Water: 2.4mm

https://www.frontiersin.org/articles/10.3389/fphy.2020.567738/full

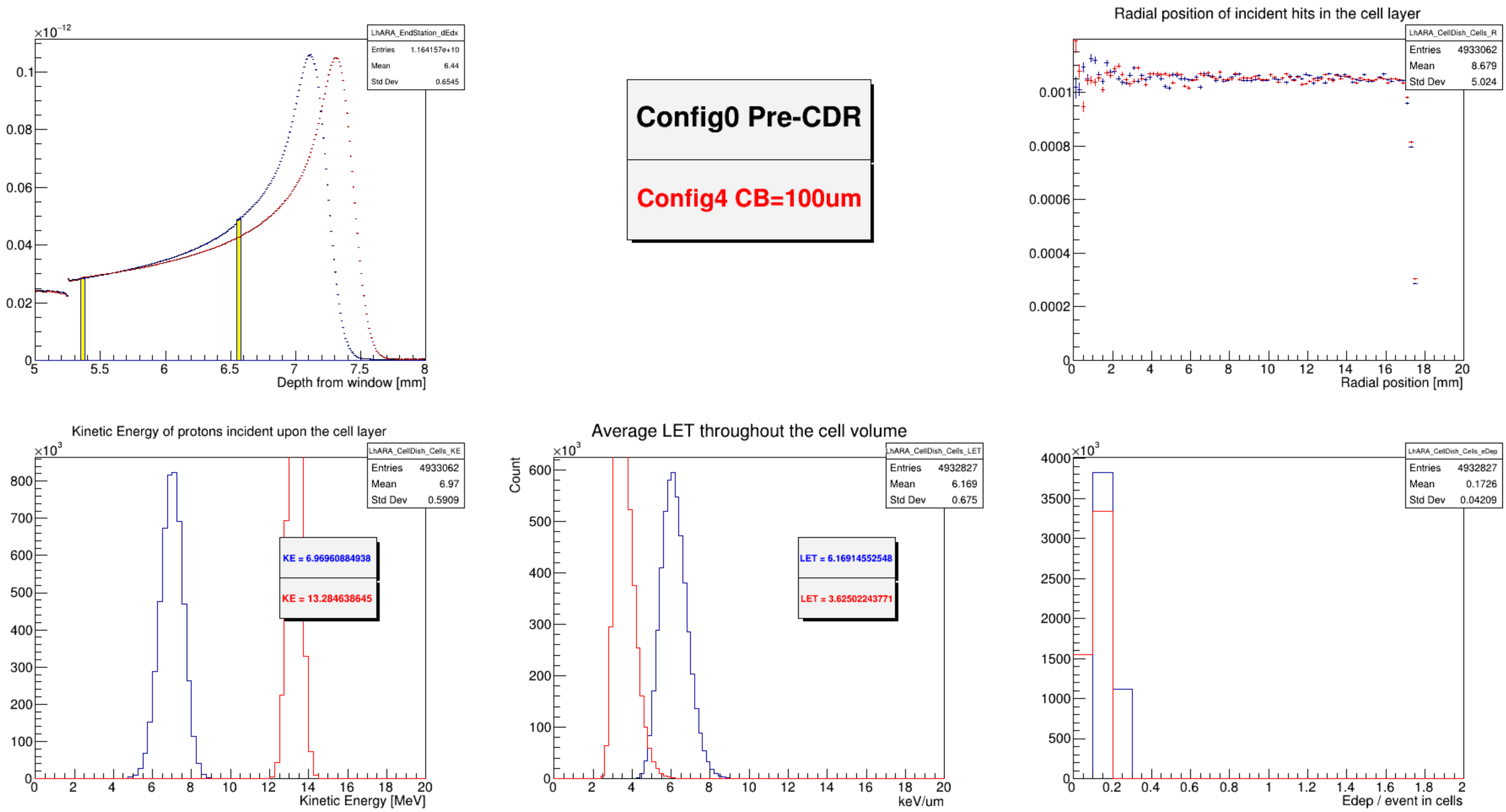


Config-0 Pre-CDR





LhARA_EndStation_dEdx
Entries 1.164157e+10
Mean 6.44
Std Dev 0.6545
Depth from window [mm]
Config0 Pre-CDR
Config3 CB=1.2mm
Config3 CB=1.4mm
Radial position of incident hits in the cell layer
LhARA_CellDish_Cells_R
Entries 4933062
Mean 8.679
Std Dev 5.024
Radial position [mm]
Kinetic Energy of protons incident upon the cell layer
LhARA_CellDish_Cells_KE
Entries 4933062
Mean 6.97
Std Dev 0.5909
KE = 6.96960884938
KE = 7.6538825035
KE = 6.22467686243
Kinetic Energy [MeV]
Average LET throughout the cell volume
LhARA_CellDish_Cells_LET
Entries 4932827
Mean 6.169
Std Dev 0.675
LET = 6.16914552548
LET = 5.70281943904
LET = 6.79846593833
Count
keV/um
LhARA_CellDish_Cells_eDep
Entries 4932827
Mean 0.1726
Std Dev 0.04209
Edep / event in cells



LhARA_EndStation_dEdx
Entries 1.164157e+10
Mean 6.44
Std Dev 0.6545
×10^-12
Depth from window [mm]
Config0 Pre-CDR
Config4 CB=100um
Radial position of incident hits in the cell layer
LhARA_CellDish_Cells_R
Entries 4933062
Mean 8.679
Std Dev 5.024
Radial position [mm]
Kinetic Energy of protons incident upon the cell layer
LhARA_CellDish_Cells_KE
Entries 4933062
Mean 6.97
Std Dev 0.5909
KE = 6.96960884938
KE = 13.284638645
×10^3
Kinetic Energy [MeV]
Average LET throughout the cell volume
LhARA_CellDish_Cells_LET
Entries 4932827
Mean 6.169
Std Dev 0.675
LET = 6.16914552548
LET = 3.62502243771
Count
×10^3
keV/um
LhARA_CellDish_Cells_eDep
Entries 4932827
Mean 0.1726
Std Dev 0.04209
×10^3
Edep / event in cells

Conclusions

- 36 MeV proton microbeams in UoB show significant scattering so must be kept in mind.
- Scattering at these energies seems to be negligable due to the distances involved in the initial end-station design.
- Standard cell dishes are the dominant energy loss > Beam monitors and restrict the LET of study to that of a 7 MeV beam ~6keV/um
- Using a reserved 10% uncertainty on the thickness of the cell dish impacts the LET and energy. Is the community happy with this?
- Can change beam energy from selection or degraders without impacting beam uniformity.