Simulation for target cell

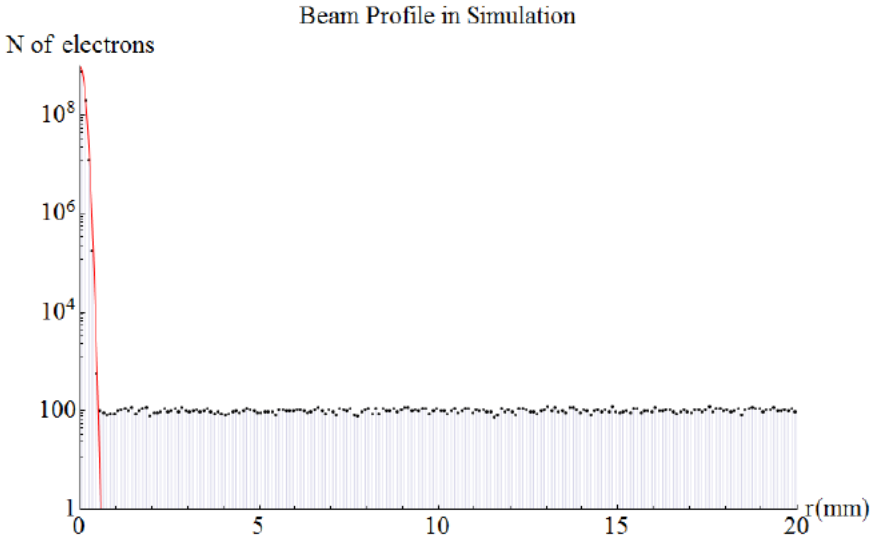
Chao Peng

Duke University

04/16/2014

Previous simulation

- Beam halo profile: 10^{-7} to the beam, uniform distribution until 20 mm
- High background from the target cell and its gas inlet (neck)

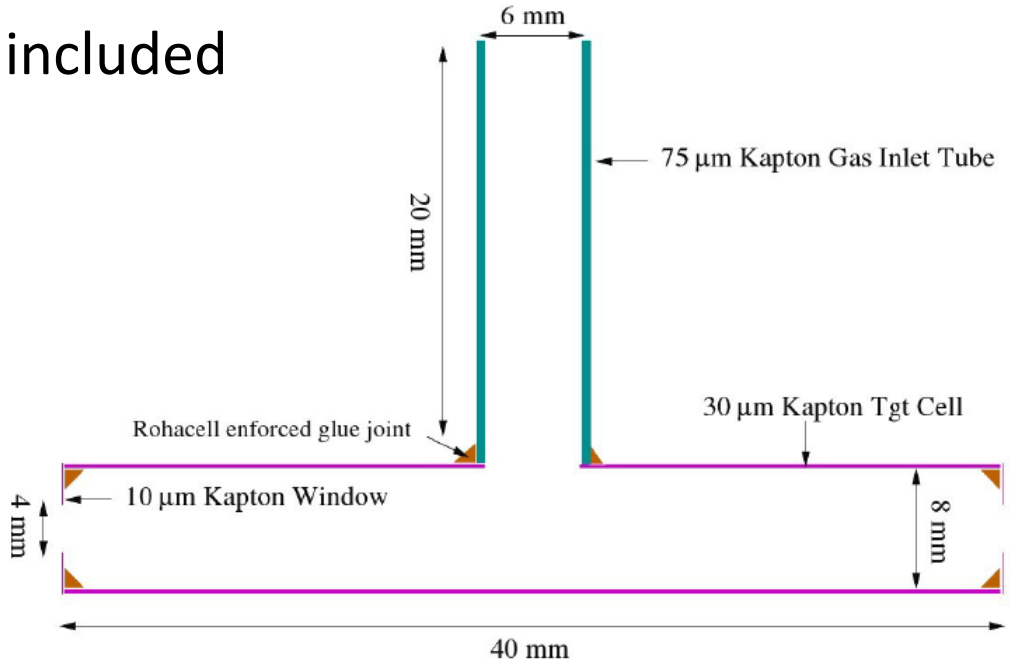


1.1 GeV Simulation	N_{Total}	$N_{\theta>0.8^\circ}$	Ep events ($\theta > 0.8^\circ$)	Moller events ($\theta > 0.8^\circ$)	Background for ep events
Only hydrogen gas	55515	10798	2157	5575	
Windows	79	6	2	0	<< 1%
Cell Background	20871	1695	313	138	14.5%
±7 mm halo Neck Background	1198	155	85	22	3.9%
±20 mm halo Neck Background	37523	566	263	132	12.2%

Simulation for target cell

- To determine how large the cell should be, several target cells with different size are tested in the simulation

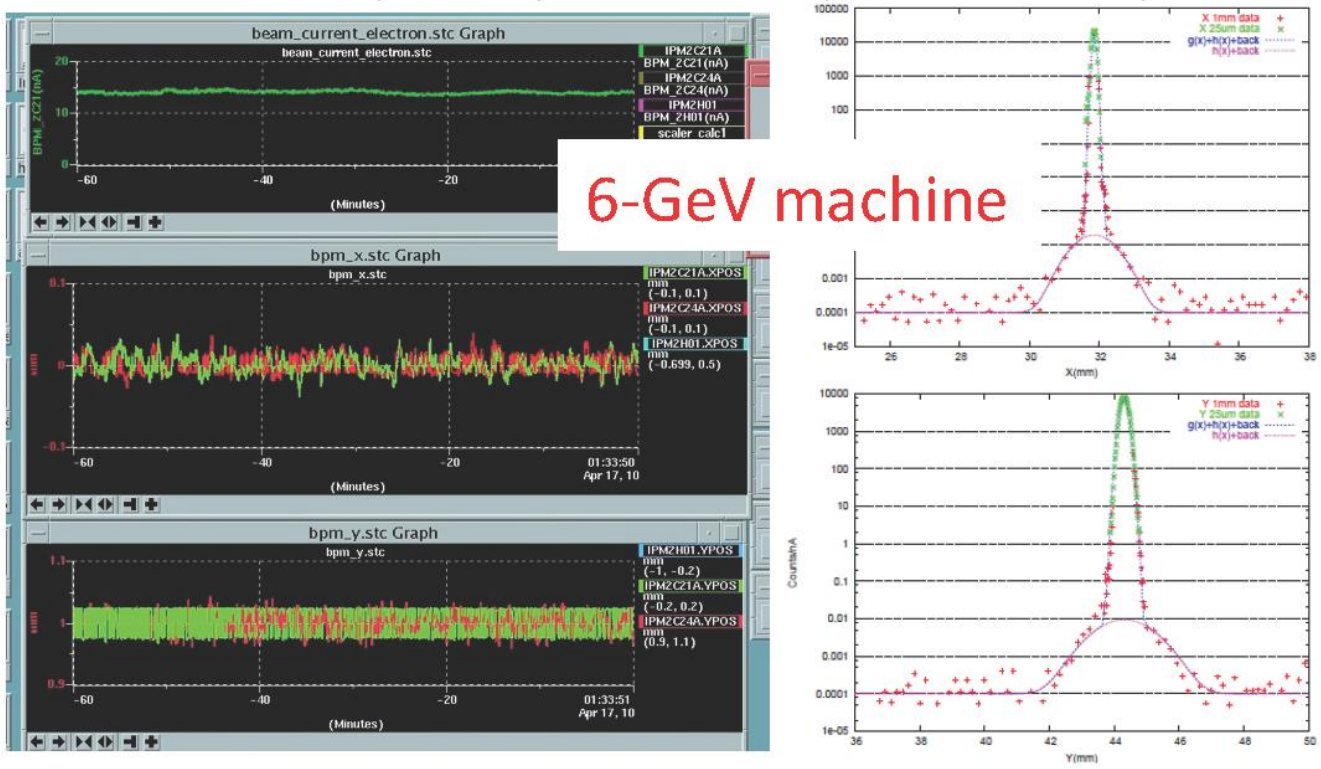
- Gas inlet (neck) is not included



Update of the beam halo

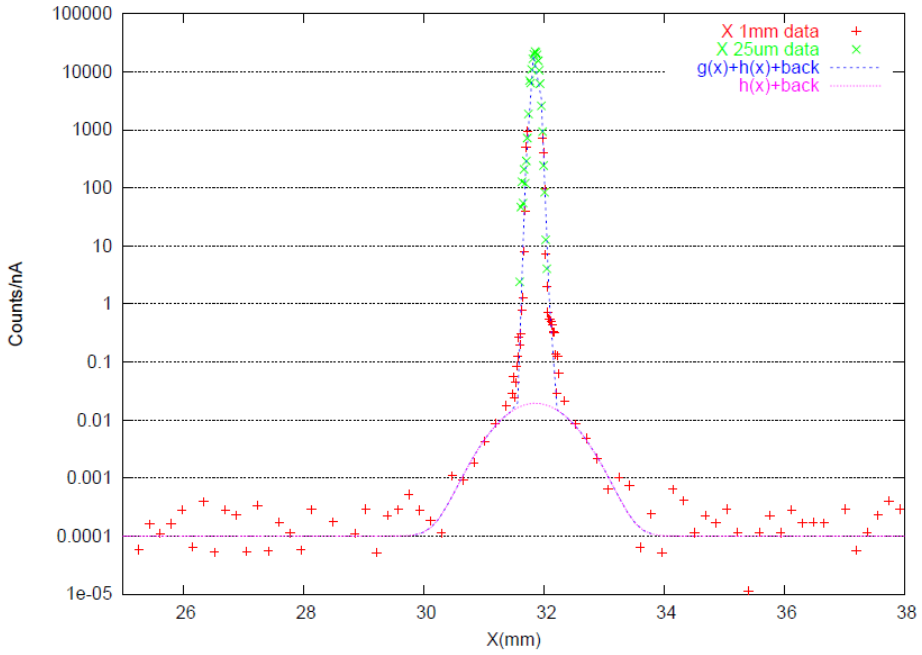
- Previous beam test at Hall B, 6 GeV beam

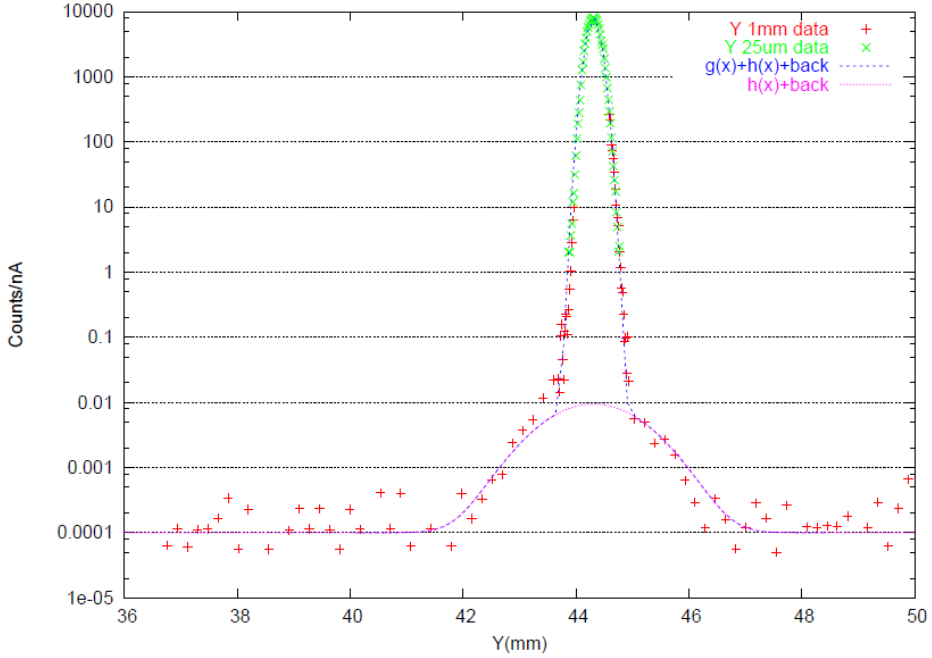
Beam current and position position stability, and the beam profile



Update of the beam halo

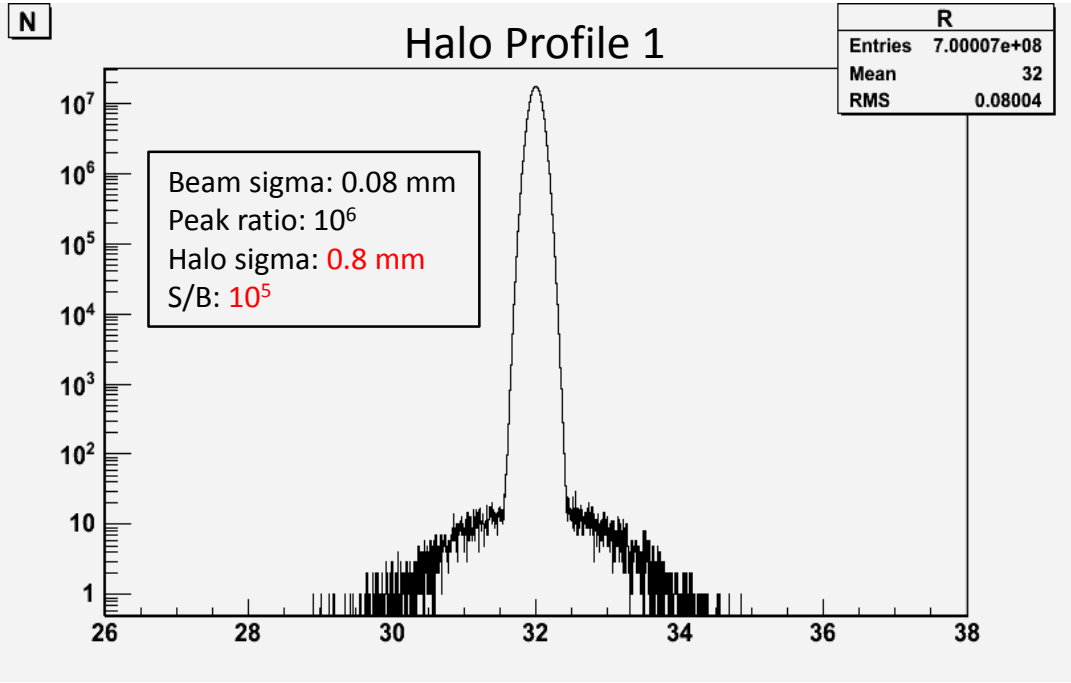
- Gaussian halo with a sigma of about 0.8 mm, peak ratio to beam is about 10^6
- Greater ratio of beam to uniform background, ~ 10^8

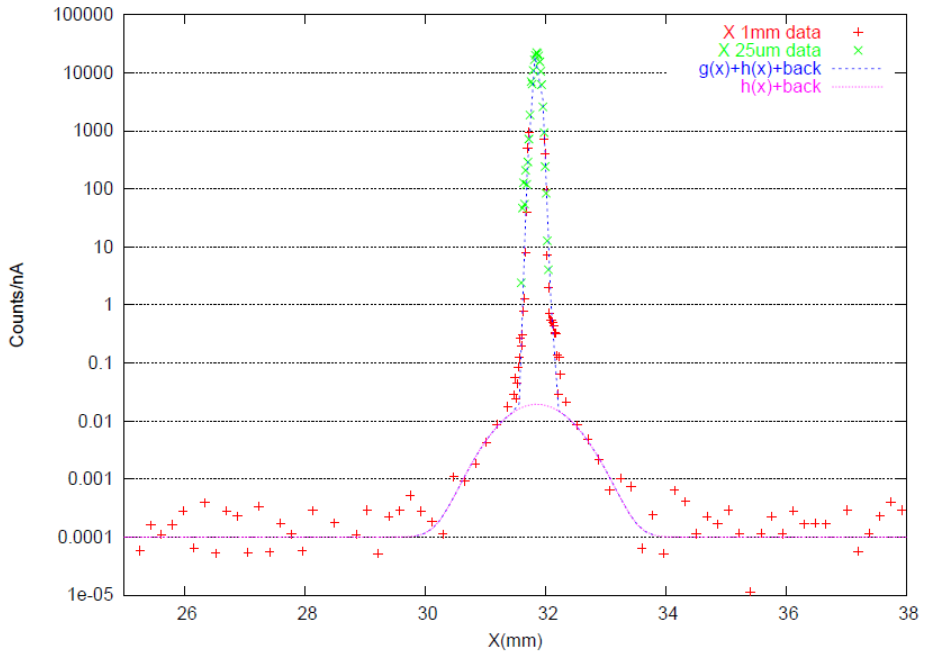




New beam halo profile in simulation

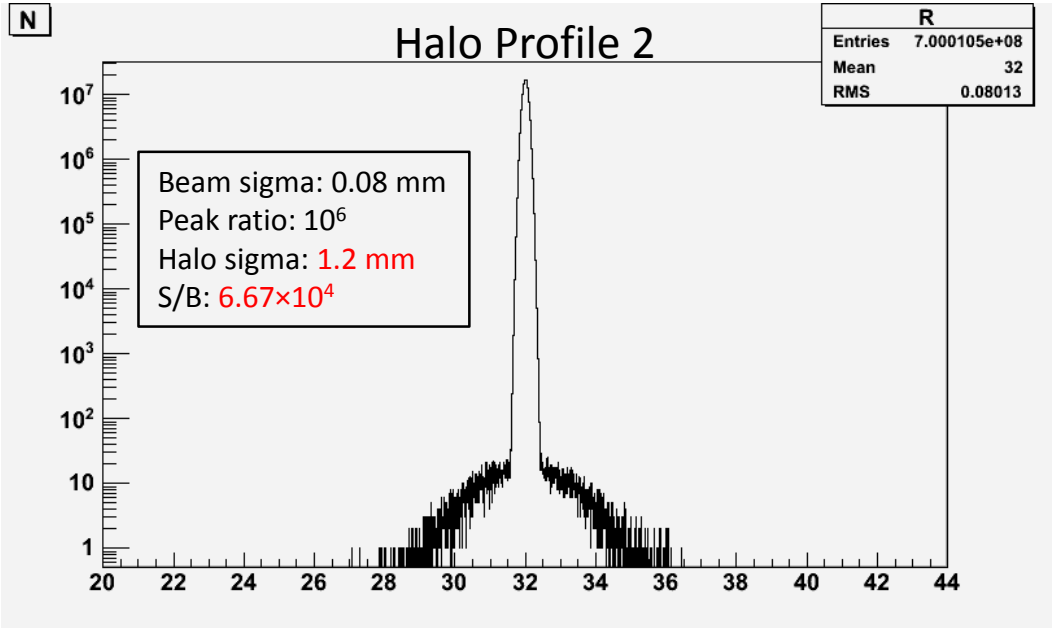
- Flat signals are “ambient noise” (suggested by FX and Arne Freyberger), it is now neglected in the simulation.
- The halo is now in Gaussian shape, different parameters are tried in the simulation.
- S/B is $\frac{Number\ of\ beam\ events}{Number\ of\ halo\ events}$, peak ratio is the $\frac{Height\ of\ beam\ distribution}{Height\ of\ halo\ distribution}$

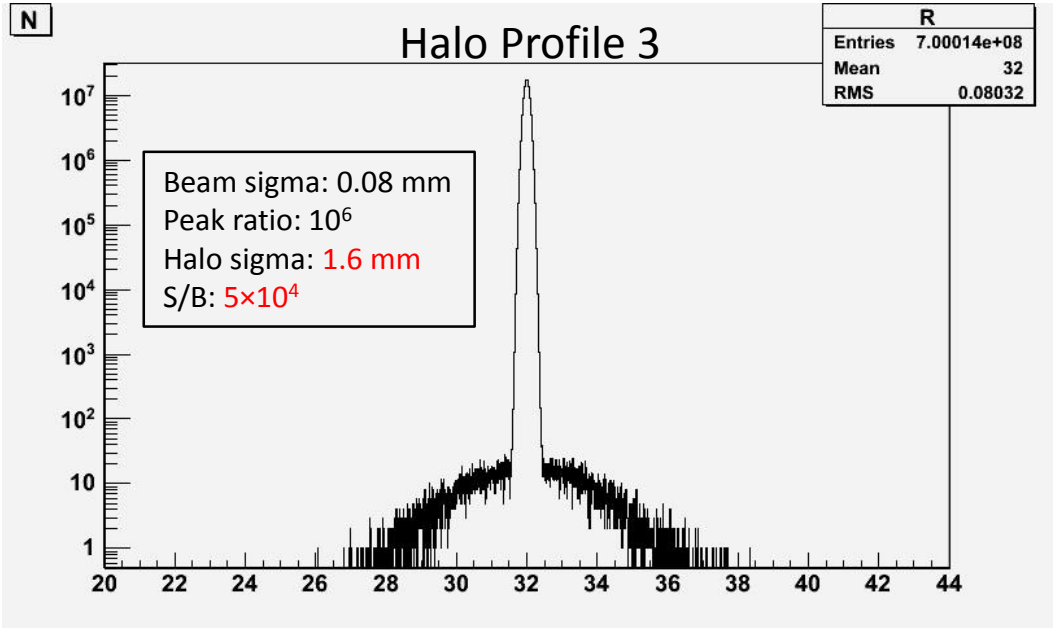




New beam halo profile in simulation

- For possible “worse case”, wider halos (1.5x and 2x) are tried in the simulation.

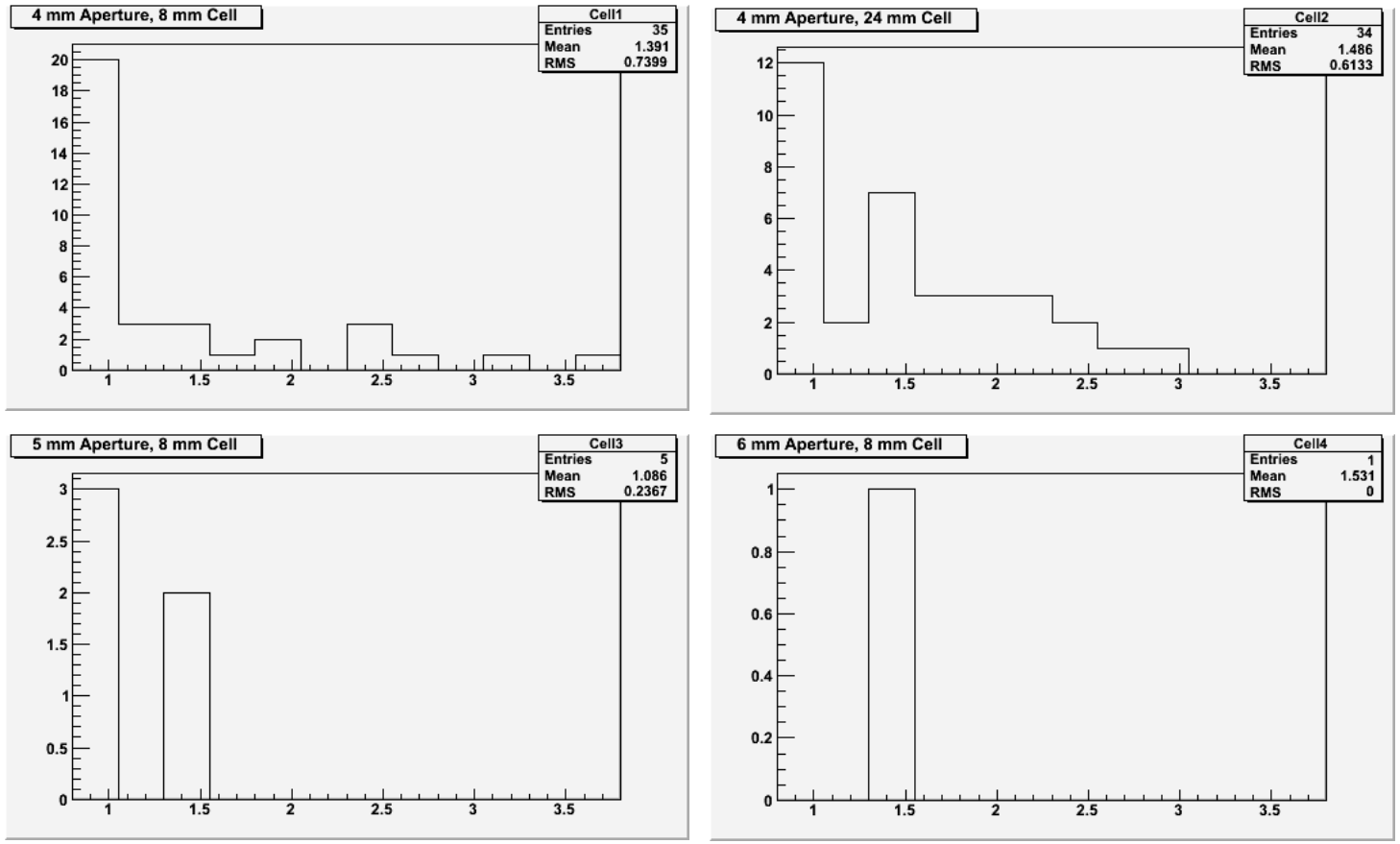




0.8 mm halo

- Halo events 10^8
- Beam events 10^{13} (beam time 160 s)
- Trigger 500 MeV, reconstructed angle range 0.8 to 3.8 degree

Events from different target cell and windows



0.8 mm halo

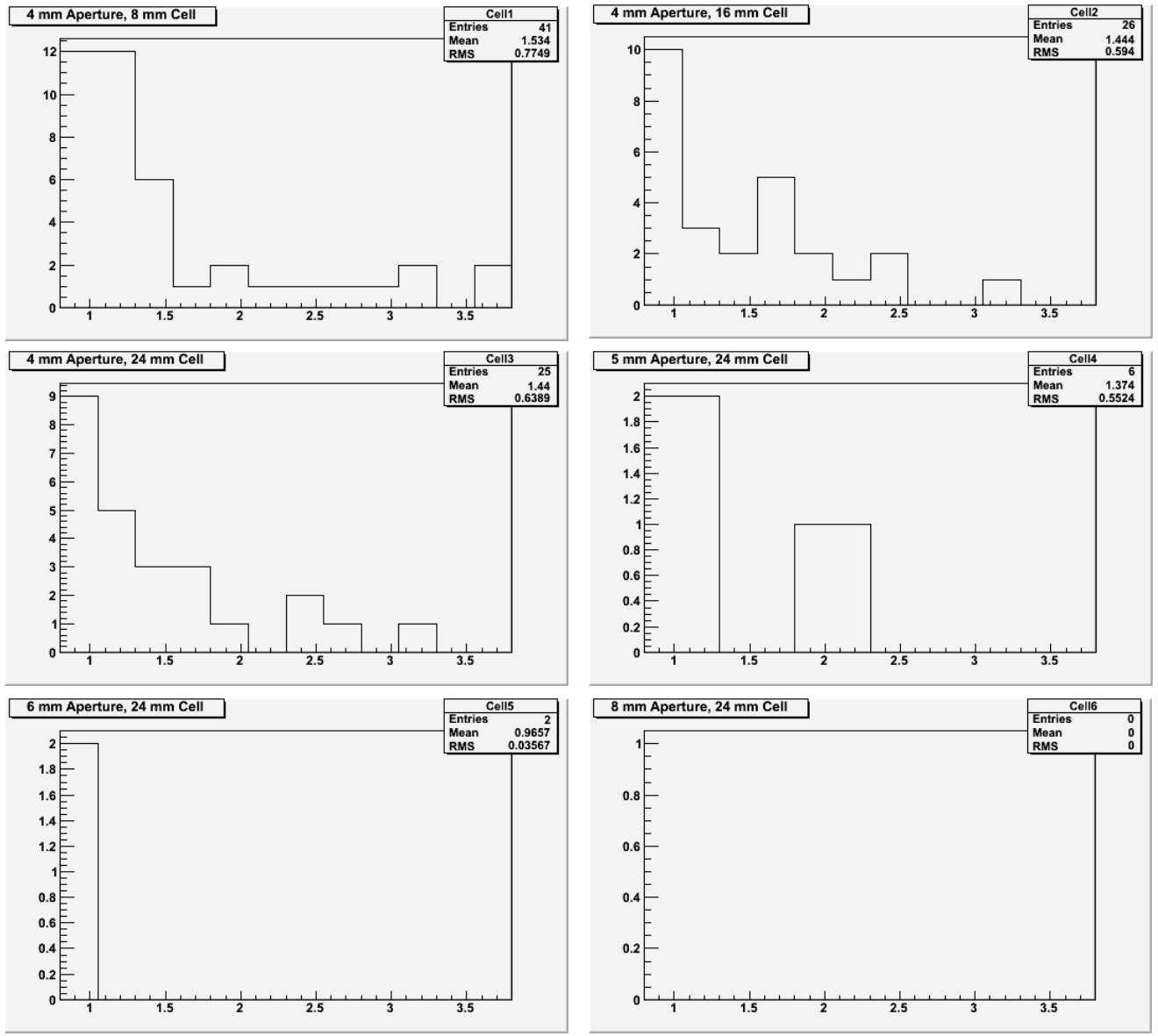
- Beam time 160 s
- If the sigma of halo is 0.8 mm, 8 mm cell is large enough to avoid the halo
- The background are all come from windows, hence insignificant
- A larger aperture is effective to reduce the background

Cell	Cell diameter	Aperture diameter	Background events	After cut	Compare to ep events
Cell 1	8 mm	4 mm	265	35	0.33%
Cell 2	24 mm	4 mm	300	34	0.32%
Cell 3	8 mm	5 mm	47	5	0.048%
Cell 4	8 mm	6 mm	5	1	0.0095%

1.2 mm halo

- Halo events 10^7
- Beam events 6.67×10^{11} (beam time 10.67 s)
- Trigger 500 MeV, reconstructed angle range 0.8 to 3.8 degree

Events from different target cell and windows



1.2 mm halo

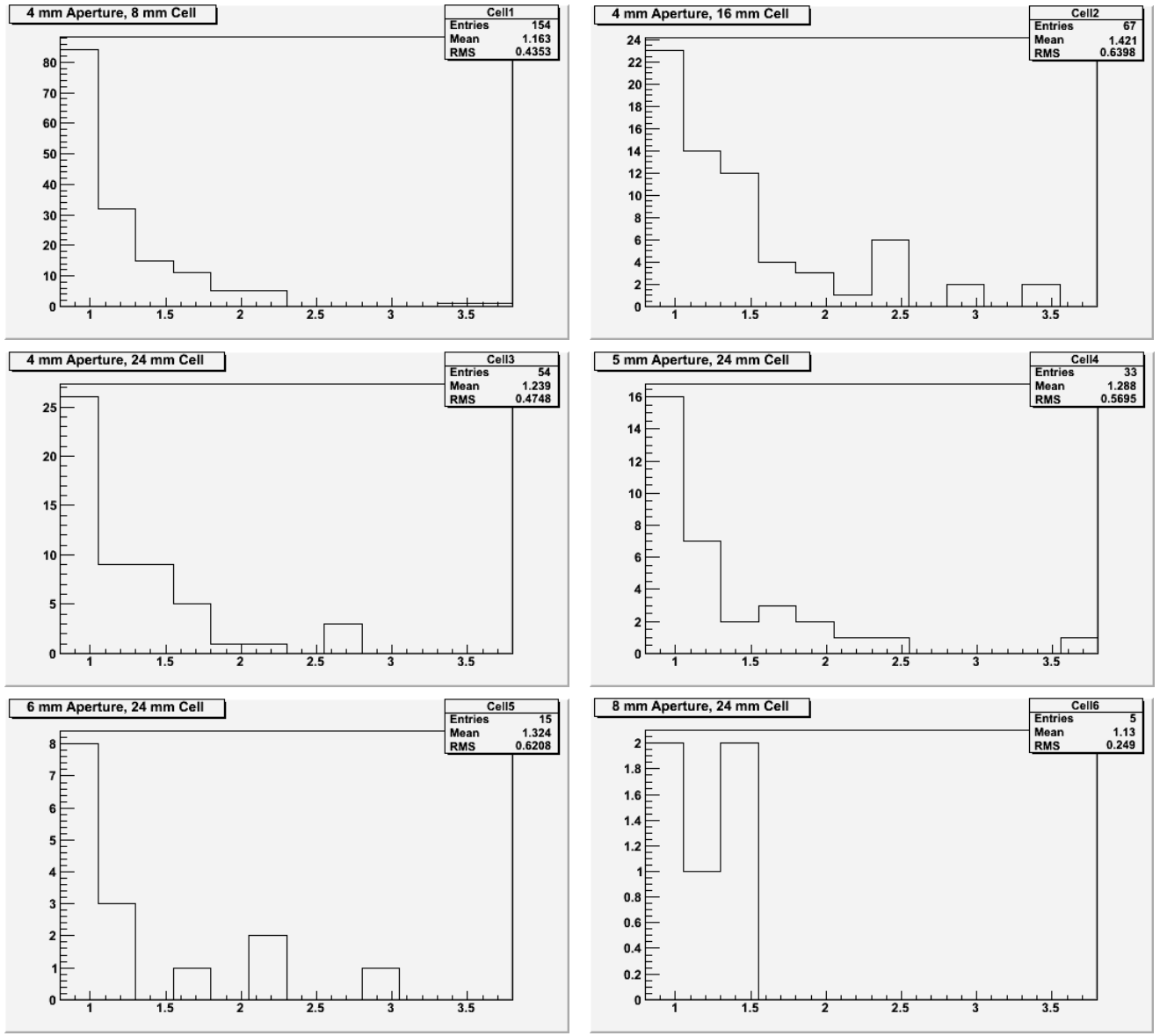
- Beam time 10.67 s
- If the sigma of halo is 1.2 mm, 16 mm cell is large enough to avoid the halo
- Window background is higher than it is in the previous study
  - Due to a greater ratio of halo to beam (10^{-6}, instead of 10^{-7} in the previous study)
- A larger aperture is effective to reduce the background

Cell	Cell diameter	Aperture diameter	Background events	After cut	Compare to ep events
Cell 1	8 mm	4 mm	525	41	5.8%
Cell 2	16 mm	4 mm	209	26	3.7%
Cell 3	24 mm	4 mm	207	25	3.6%
Cell 4	24 mm	5 mm	80	6	0.86%
Cell 5	24 mm	6 mm	37	2	0.29%
Cell 6	24 mm	8 mm	2	0	0

1.6 mm halo

- Halo events 10^7
- Beam events 5×10^{11} (beam time 8 s)
- Trigger 500 MeV, reconstructed angle range 0.8 to 3.8 degree

Events from different target cell and windows



1.2 mm halo

- Beam time 8 s
- If the sigma of halo is 1.6 mm, 16 mm cell is almost large enough
- A larger aperture is effective to reduce the background

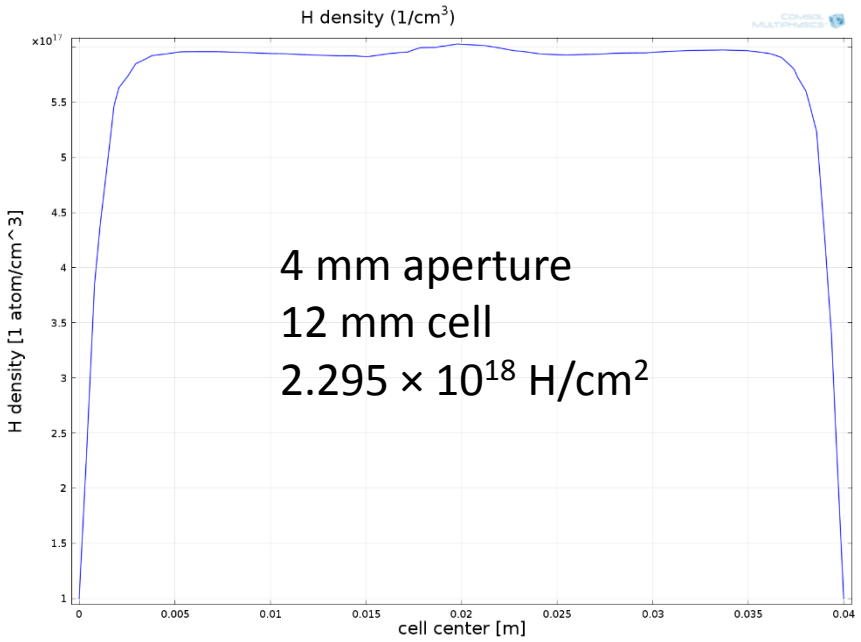
Cell	Cell diameter	Aperture diameter	Background events	After cut	Compare to ep events
Cell 1	8 mm	4 mm	3226	154	47%
Cell 2	16 mm	4 mm	447	67	20%
Cell 3	24 mm	4 mm	429	54	16%
Cell 4	24 mm	5 mm	247	33	10%
Cell 5	24 mm	6 mm	128	15	4.6%
Cell 6	24 mm	8 mm	37	5	1.5%

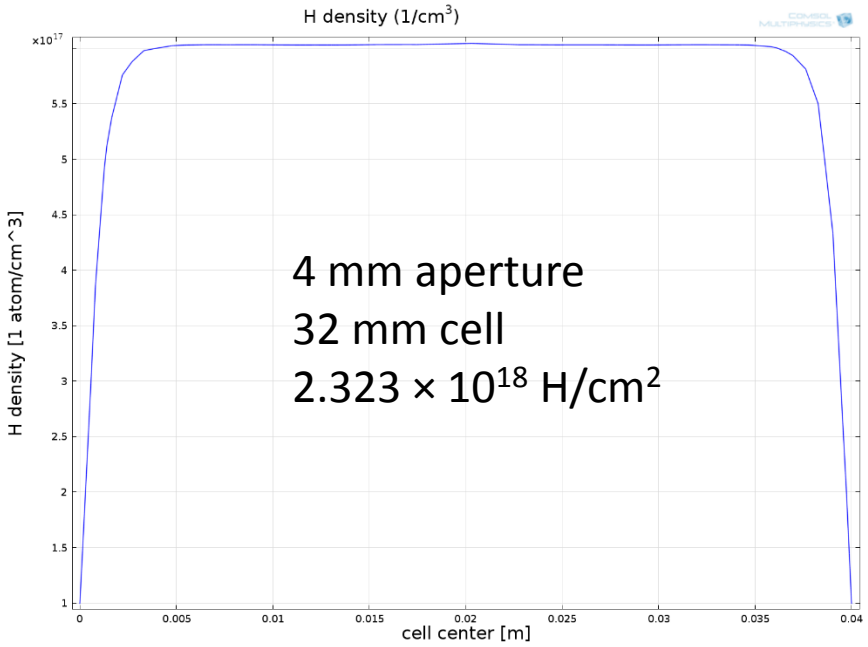
Summary

- The background level is highly dependent upon the range of the halo
- If the Gaussian shape halo is similar to the one from the previous beam test (about 0.8 mm sigma, and 10^{-6} peak ratio), the background is safe with the current design of target cell
- If the halo is larger, we need a larger cell to avoid it
  - If its width is 1.5 times (1.2 mm sigma) of the original one, it will be good to have a 24 mm diameter cell, and a larger aperture (diameter > 5 mm)
  - If its width is 2 time (1.6 mm sigma), we need a much larger aperture
- It is also good to have a larger cell and a larger aperture, considering the halo size might be unstable

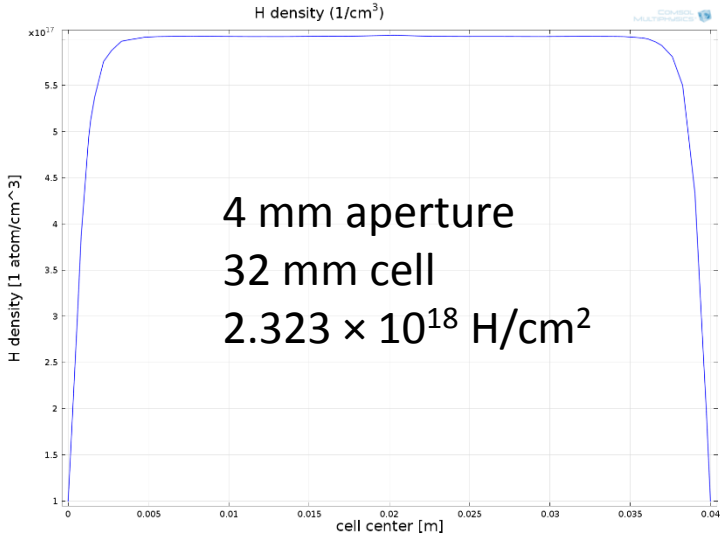
Aperture vs. gas density

- Simulation from Yang Zhang (Duke University)
- The gas density inside the cell is almost irrelevant to the cell size (but the distribution is)
- The gas density depends on the size of the aperture.

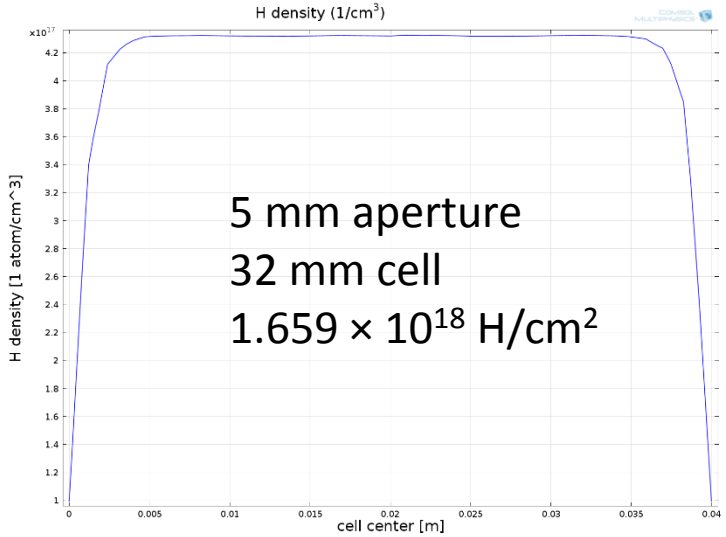




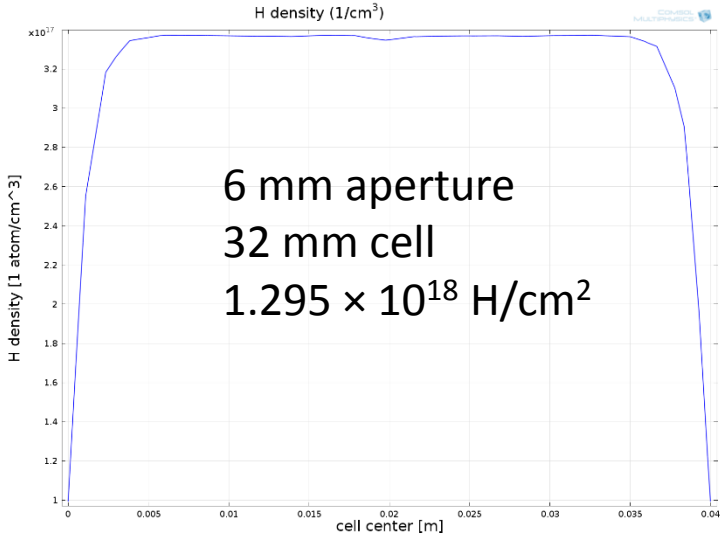
Aperture vs. gas density



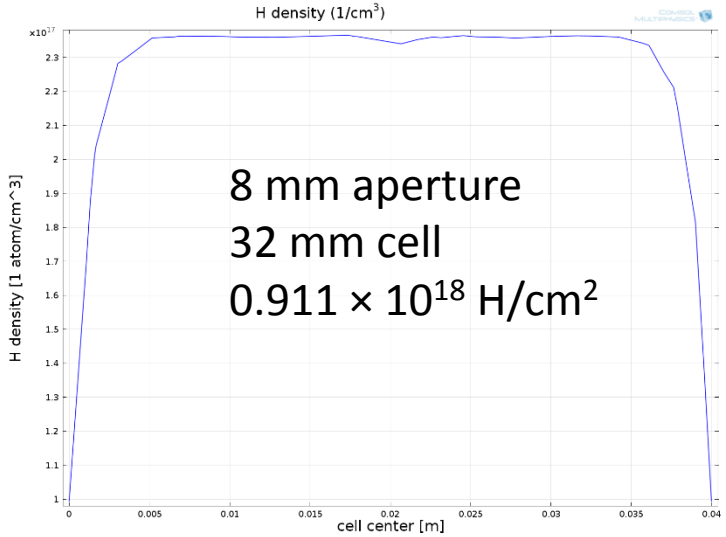
4 mm aperture
32 mm cell
2.323×10^{18} H/cm^2



5 mm aperture
32 mm cell
1.659×10^{18} H/cm^2



6 mm aperture
32 mm cell
1.295×10^{18} H/cm^2



8 mm aperture
32 mm cell
0.911×10^{18} H/cm^2