



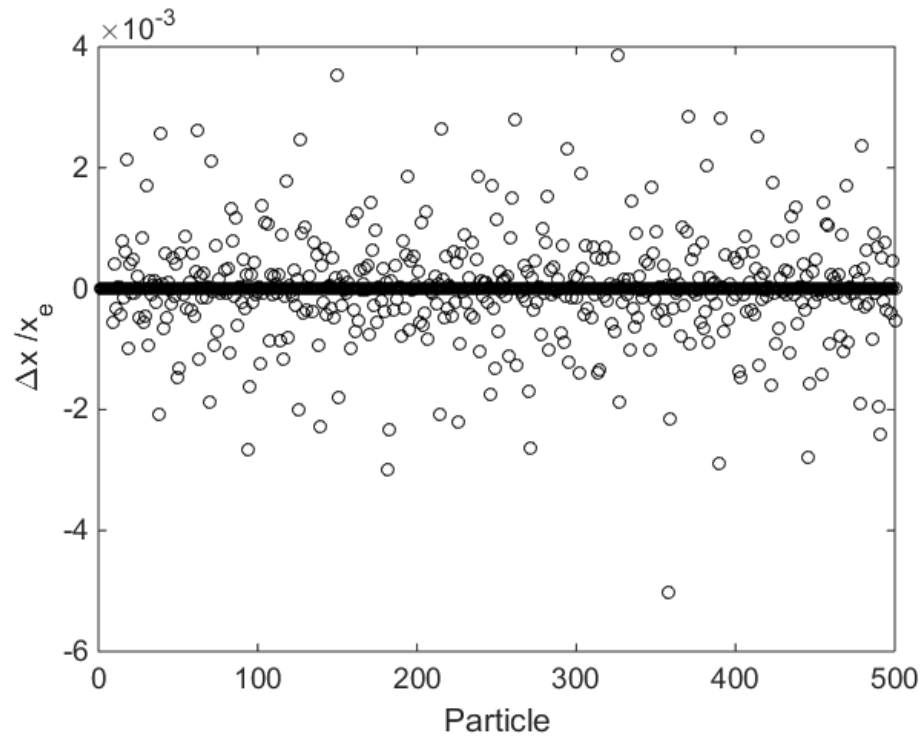
Using ASTRA to model the CLEAR photo-injector



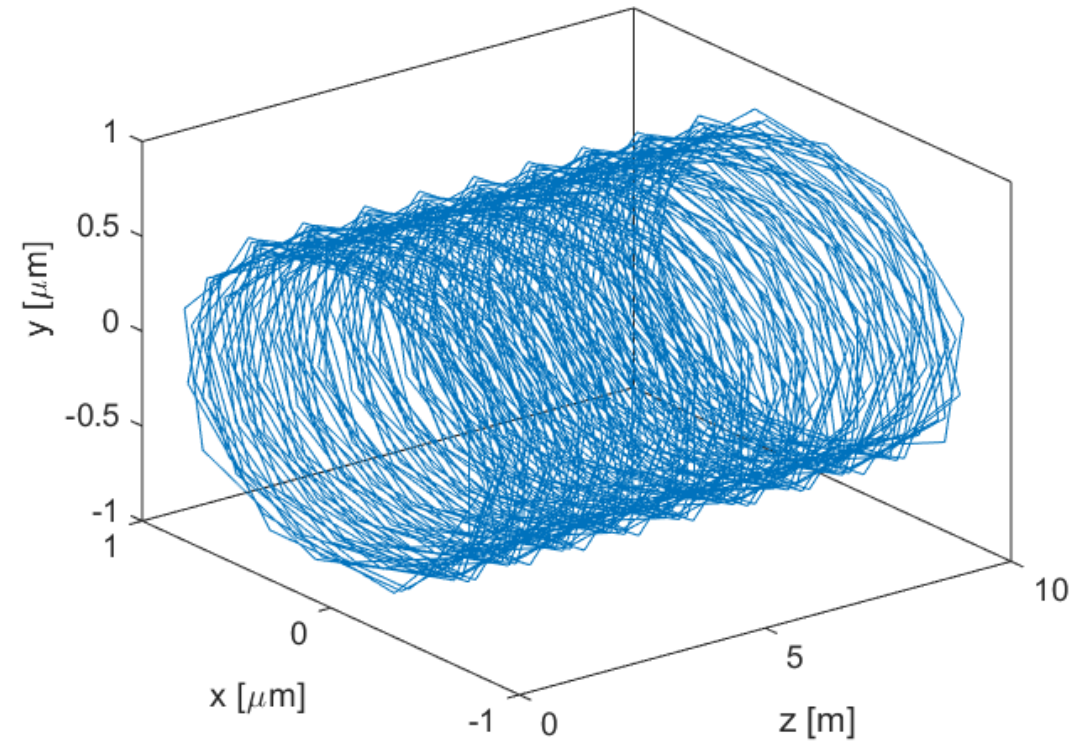
AIMEE ROSS
SUPERVISOR: PROF BURROWS

A Space-charge Tracking Algorithm

Drift tube



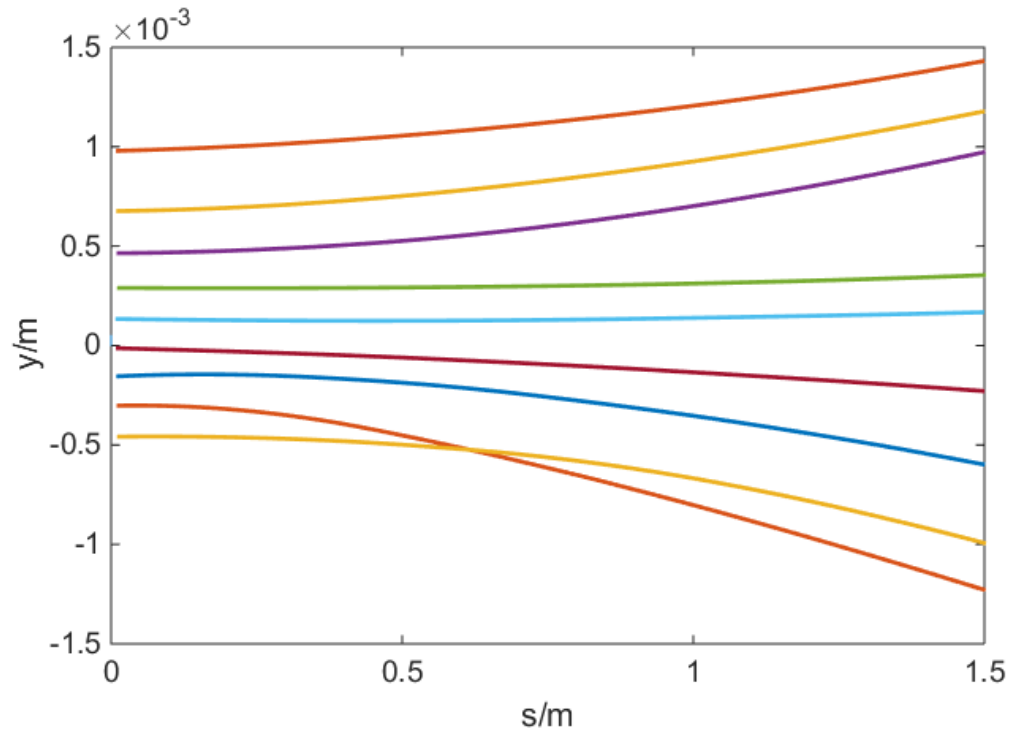
Constant B-field



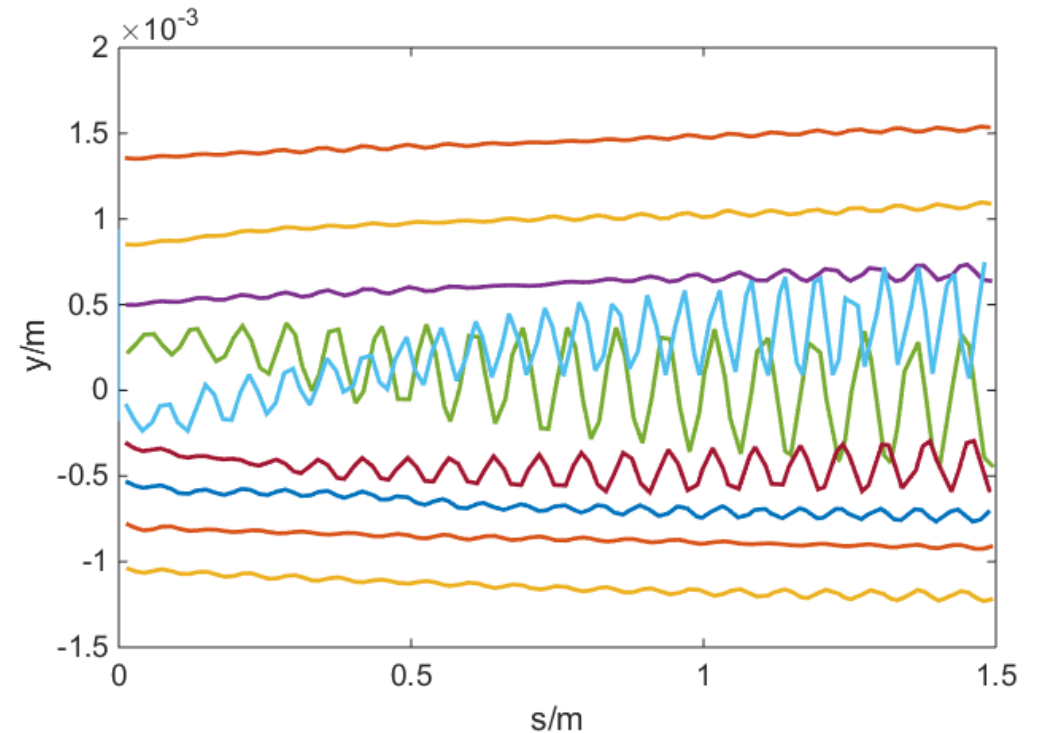
Space charge and solenoids

$$F = \frac{e \lambda r}{\gamma^2 2 \pi \epsilon_0 a^2}$$

Particle paths with space charge on



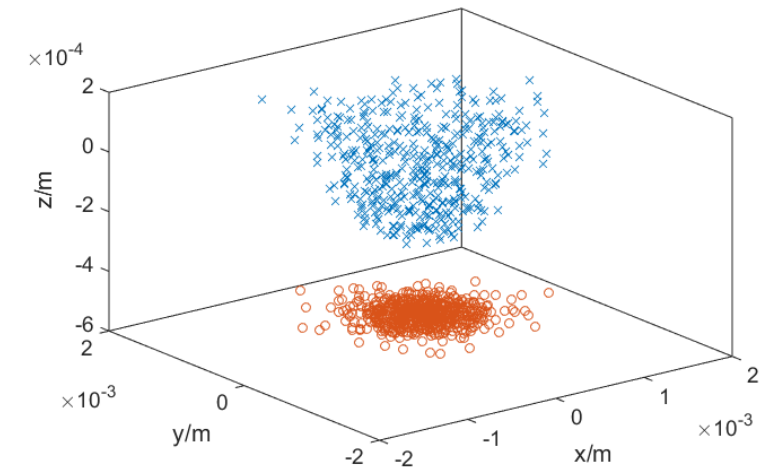
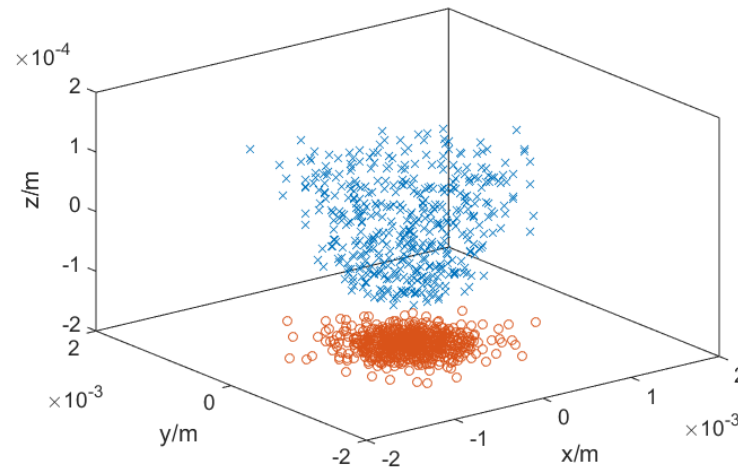
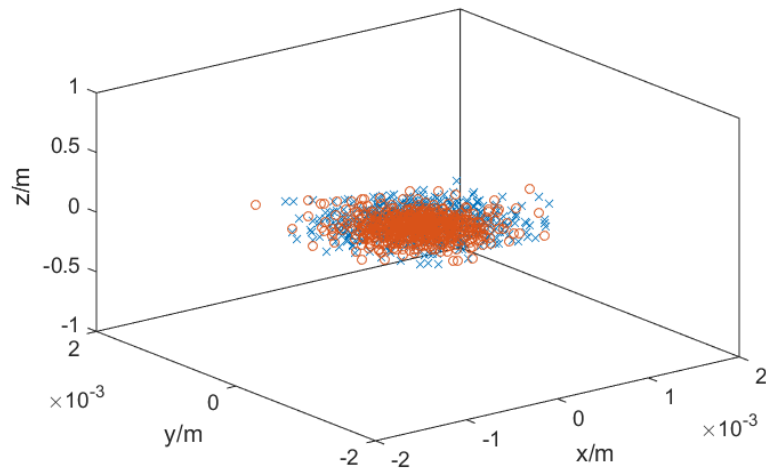
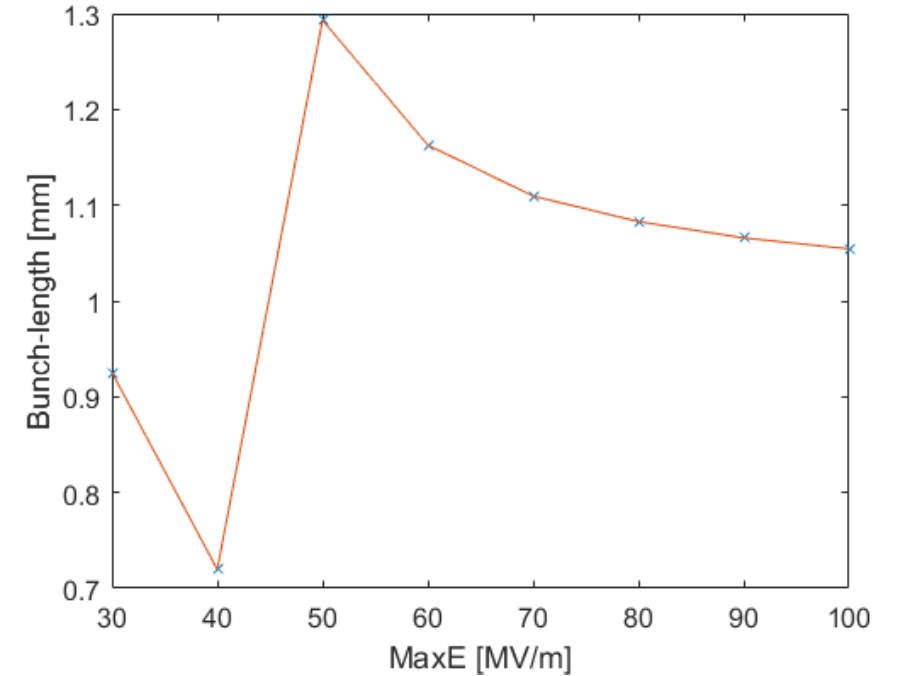
And with B-field



Electric fields

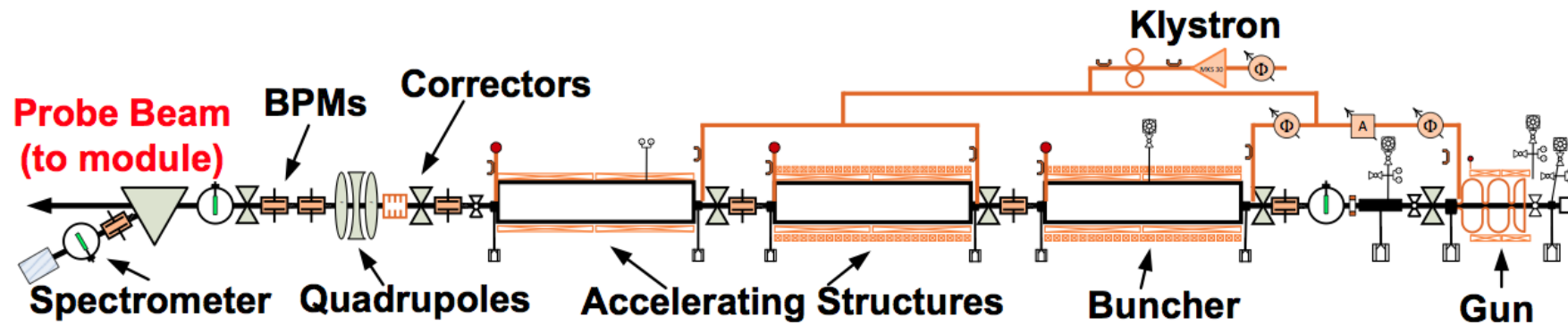
Child-Langmuir law

Plots shown below are for ref particle at 0.0mm, 0.2mm and 0.6mm from cathode

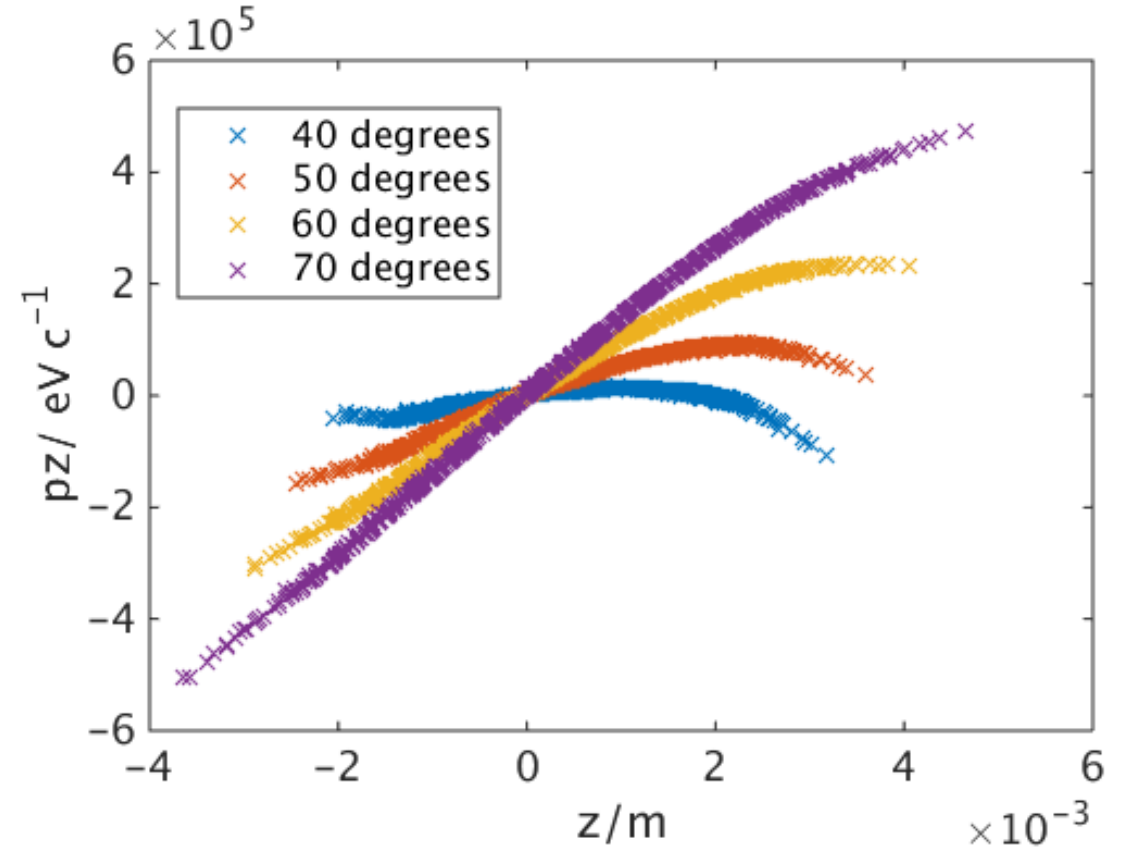
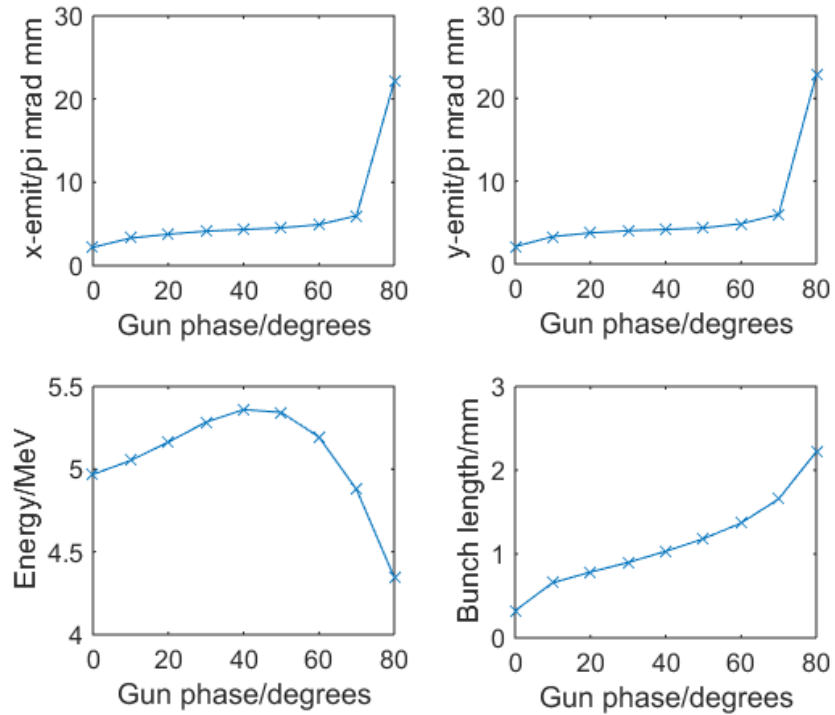


CLEAR

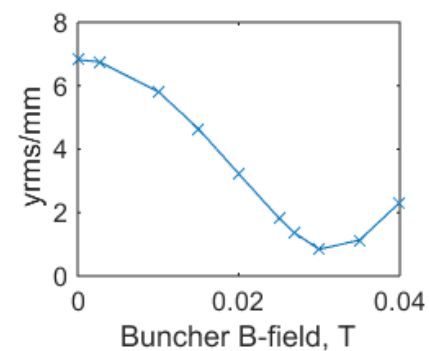
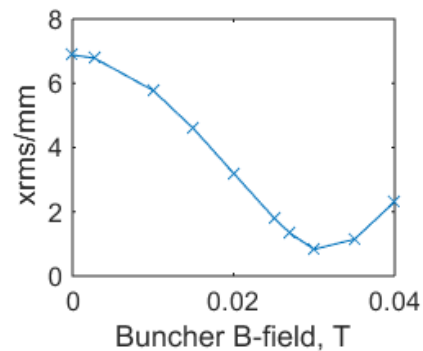
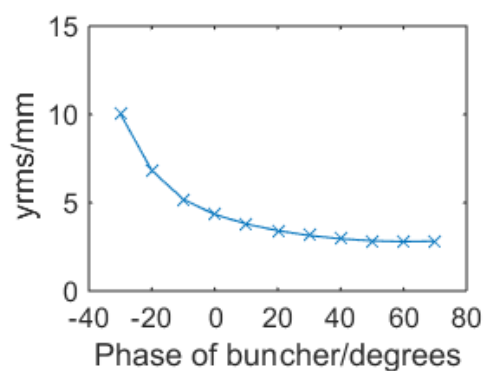
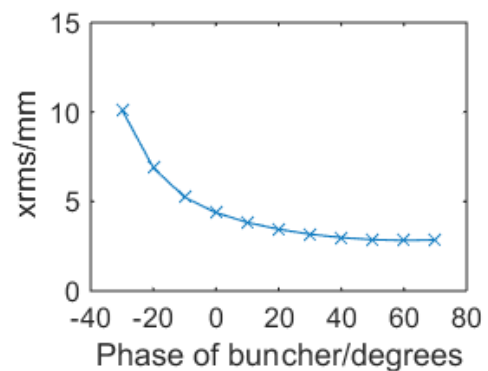
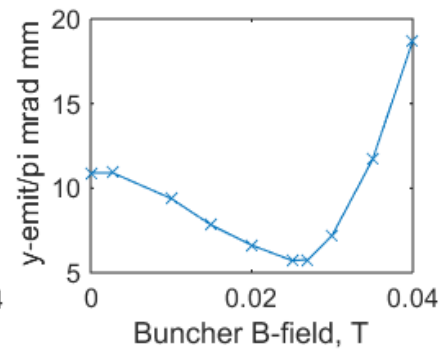
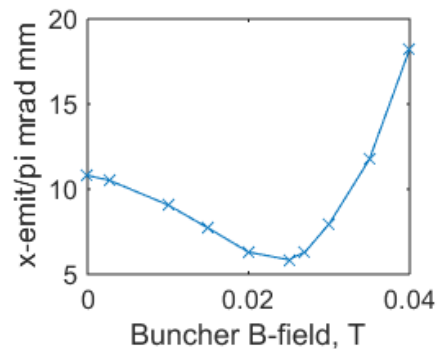
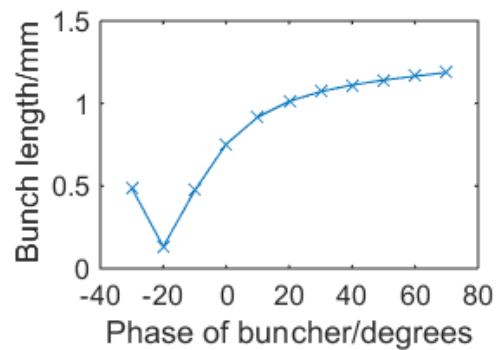
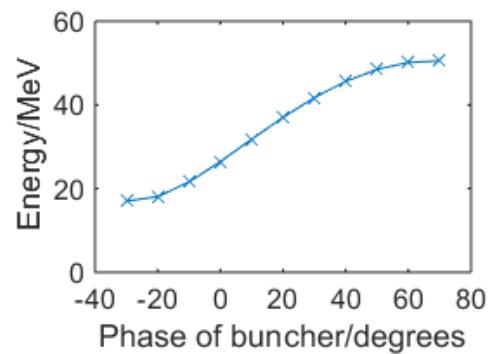
CERN Linear Electron Accelerator for Research



Gun phase scan

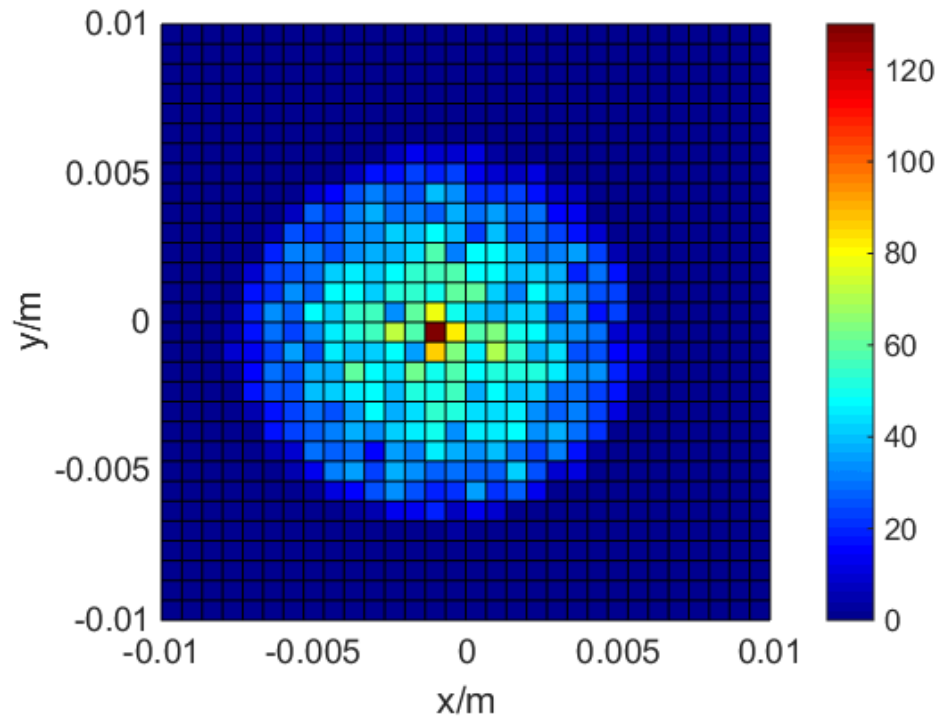


Buncher phase scan

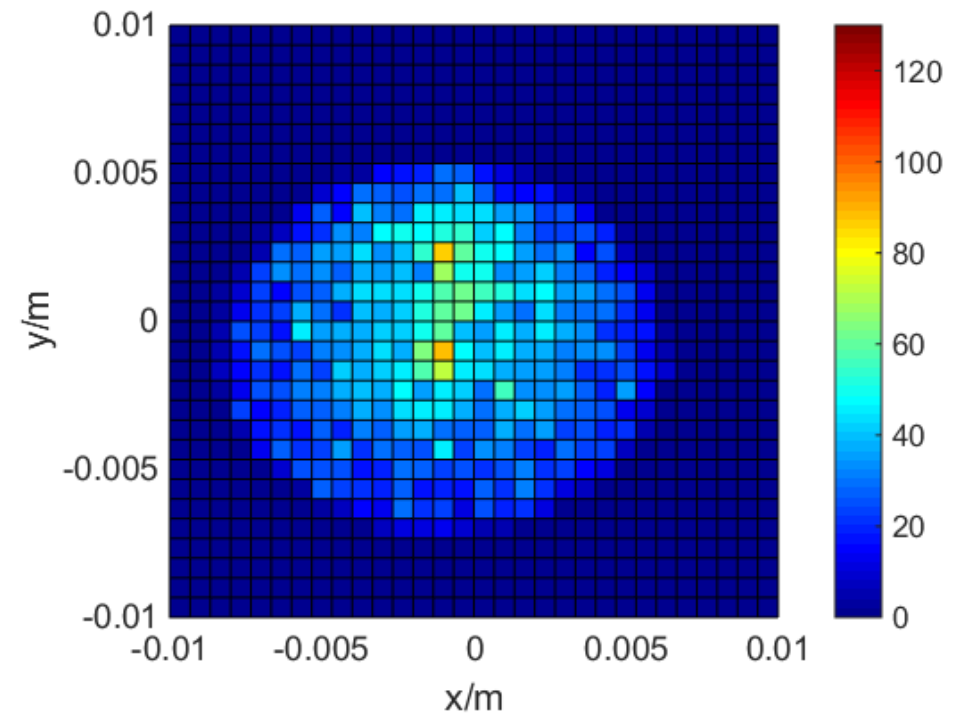


Offsets

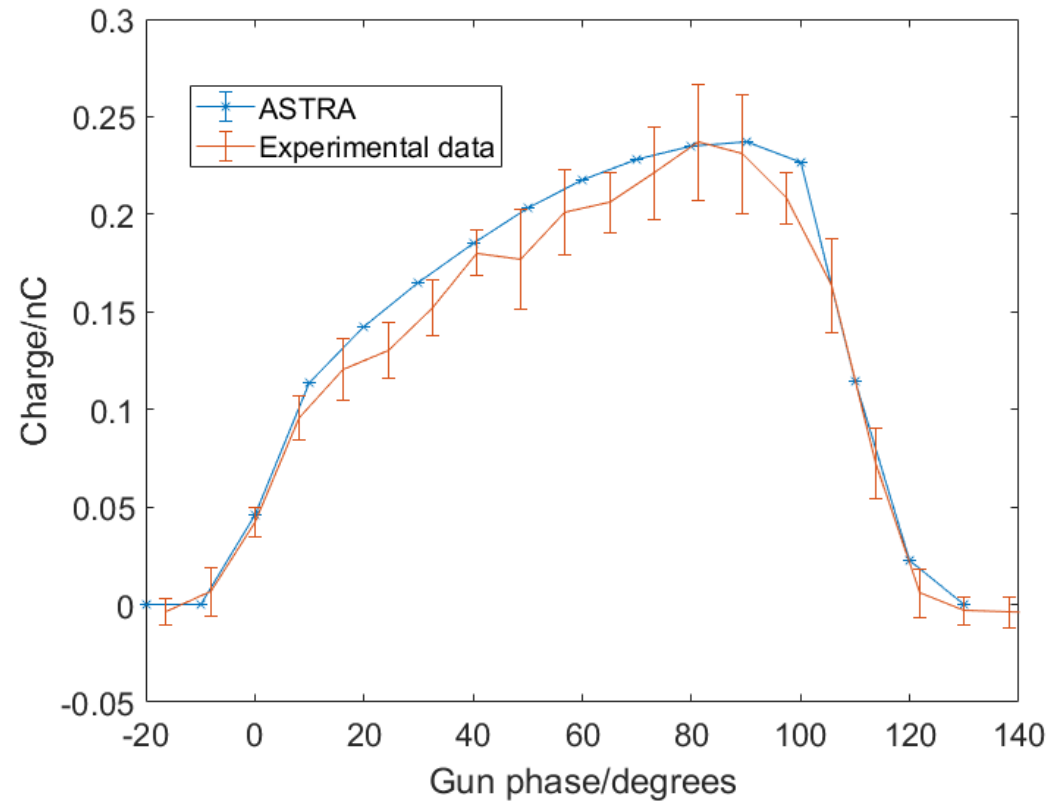
On axis



2mm offset in y



Machine runs



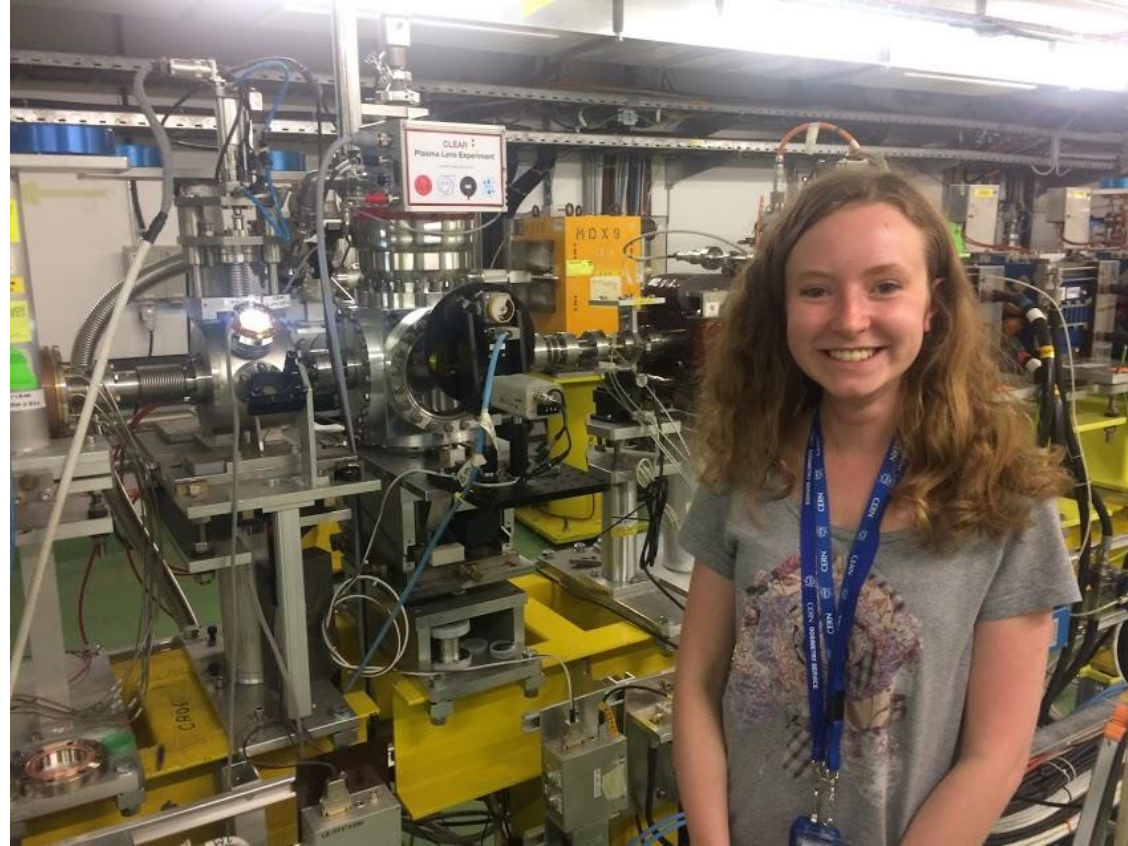
Summary and Outlook

ASTRA looks promising for CLEAR photo-injector

More phase-space to be explored and compared to machine

Interesting work to be done on using the buncher

Thank you



Back up

Original values

Parameter	Value
Energy (MeV)	E-6
Energy spread (keV)	E-3
Width of Gaussian (mm)	0.399
Transverse emittance (π mrad mm)	0.61
Bmax of solenoid (T)	0.26
E _{max} of gun (MV/m)	80
E _{max} of 1 st ,2 nd ,3 rd TWS (MV/m)	14
Frequency of gun (GHz)	2.999
Total Charge (nC)	0.27
Length of Beamline	18m

CLEAR beam line description

Energy	130 - 220 MeV (down to 60 MeV with upgrade)
Bunch charge	0.01 - 0.5 nC
Normalized emittances	3 μm for 0.05 nC per bunch 20 μm for 0.4 nC per bunch (in both planes)
Bunch length	\sim 500 μm -1.2 mm
Relative energy spread	< 0.2 % rms (< 1 MeV FWHM)
Repetition rate	1 - 5 Hz (25 Hz with upgrade)
Number of micro-bunches in train	1 and more than 100
Micro-bunch spacing	1.5 GHz

A Space Charge Tracking Algorithm

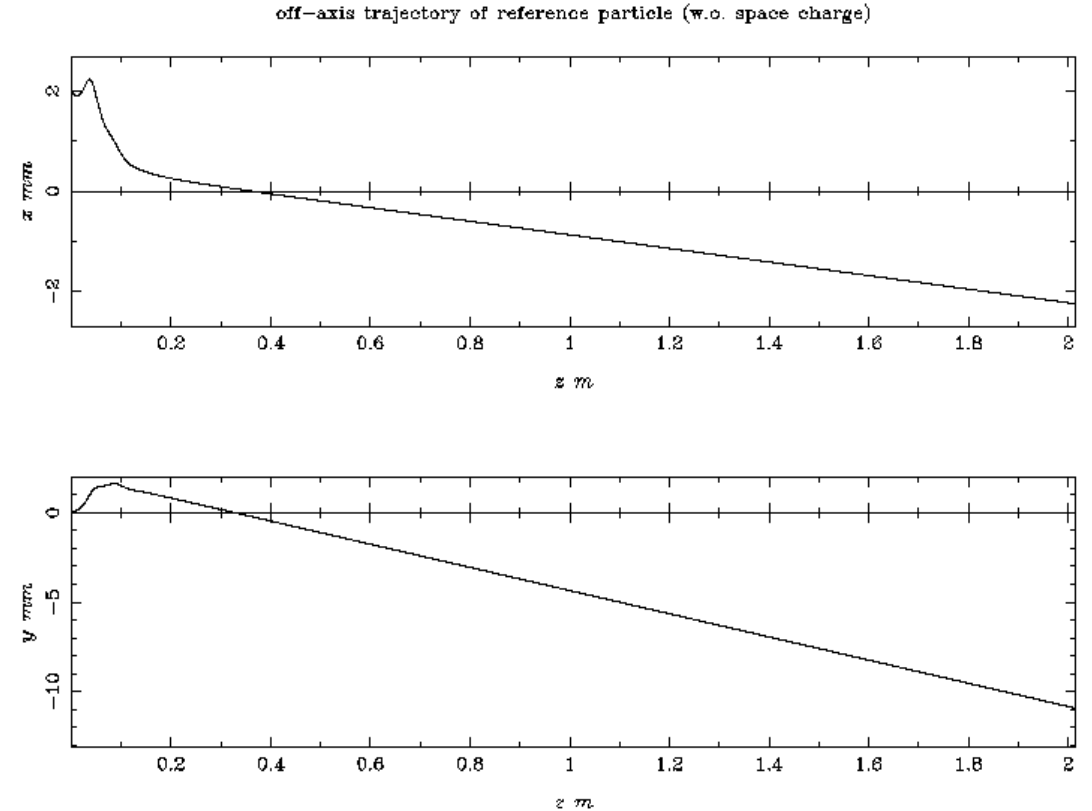
```
&NEWRUN  
  
Head='Awake photo injector'  
  
RUN=9  
  
Distribution = 'AwakeGauss.ini',   Xoff=0.0, Yoff=0.0,  
  
TRACK_ALL=T,   Auto_phase=T  
  
  
H_max=0.001,   H_min=0.00  
  
/  
  
&OUTPUT  
  
ZSTART=0.0,   ZSTOP=1.7  
  
Zemit=50,   Zphase=10  
  
RefS=T  
  
EmitS=T,   PhaseS=T  
  
Lsub_rot=T, Tr_emitS=T
```

```
&CHARGE  
  
LSPCH=T  
  
Nrad=20, Cell_var=2.0,           Nlong_in=30  
  
min_grid=0.0  
  
Max_Scale=0.05  
  
/  
  
&SOLENOID  
  
LBField=T,  
  
File_Bfield(1)='solenoidfield2.txt', S_pos(1)=0.0   MaxB(1)=0.275, S_smooth(1)=10  
  
/  
  
&Cavity  
  
LEfield=T  
  
File_Efield(1) = 'Phin3.txt', Nue(1)=2.998, MaxE(1)=100.0, Phi(1)=3.0, C_pos(1)=0.2,  
  
/
```



Aperture on CLEAR

Offsetting the beam by 1mm in x at the cathode seemed to shift the beam position at $s=7\text{m}$ in both x and y



Refs

- **Plasma Physics: An Introduction to Laboratory, Space, and Fusion Plasmas** By Alexander Piel – P253 for Child-Langmuir