Modelling electron flow

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The question:

*Can we **model** the **evolution of particles** through our **system of magnets**, accounting for a wide possible range of **multiple parameters**?*

Or in brief:

What happens when we change things?

What might we adjust?

- At this early stage:
  - Most parameters are free
  - So we want a general as simulation to explore any potential adjustment
- Anything that is specific needs be easy to change
- In the future:
  - Will consider likely errors,
  - e.g. a magnet in slightly the wrong place

Which tools are we using?

- Generating data → *Astra*
- Visualising data → *Post-Processor*

What is *Astra?*

- **A S**pace-Charge **Tr**acking **A**lgorithm
- Models an accelerator
- Calculates how particles will travel through it
- Easy to swap in/out components

Why use *Astra*?
Rather than an alternative?

- At low energies, the *space charge* effect is significant
- Electrons try to push away other electrons
- *Astra* can handle this,
  - but calculation time will be slower

Some of our *free parameters*

General:	Electron gun:	Cavities:	Magnets:
Positions of components	Current	Max field gradient	Field geometry
Aperture width	Emittance	Length	Peak field
	Energy	Travelling/standing wave	
	Distribution	Frequency	

Some of our *free parameters*

General:	Electron gun:	Cavities:	Magnets:
Positions of components	Current *(50mA)*	Max field gradient *(40V/m)*	Field geometry *(solenoid)*
Aperture width *(5mm)*	Emittance *(0.005 pi mrad)*	Length (0.28m)	Peak field *(0.225T)*
	Energy *(30KeV)*	Travelling/standing wave *(standing)*	
	Distribution *(uniform)*	Frequency *(3.1GHz)*	

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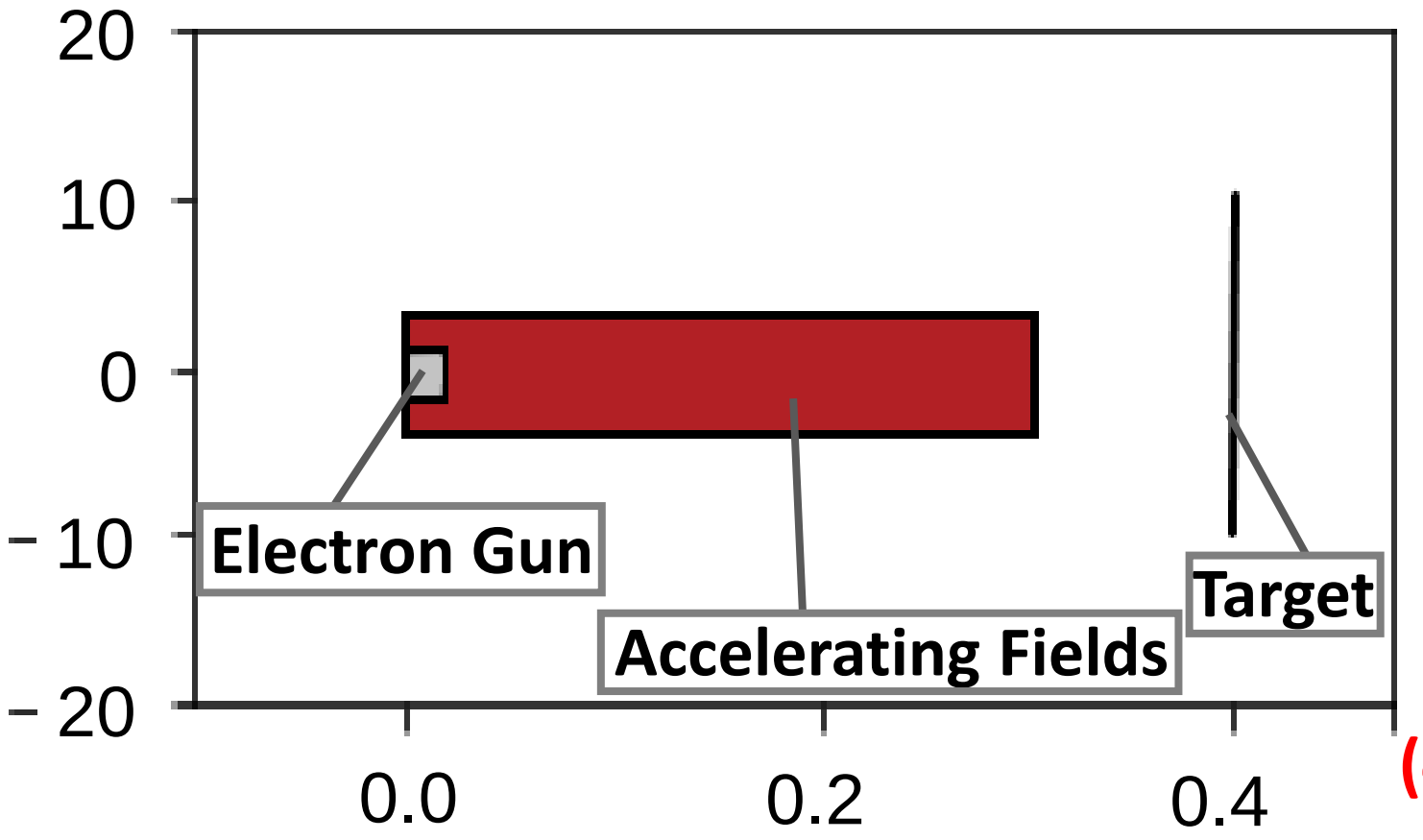
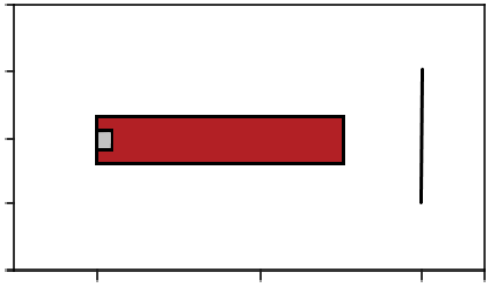
	Distribution *(uniform)*	Frequency *(3.1GHz)*	
Specified in:			
Main *Astra* input file	Input gun file	Input field file	Input magnets file

What does our model accelerator look like?

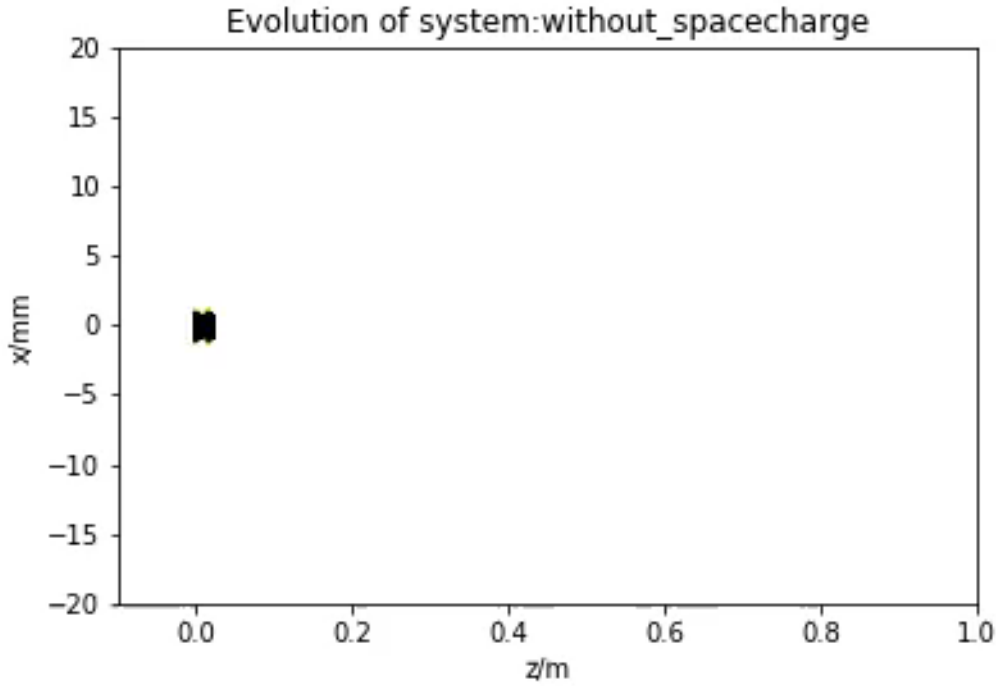


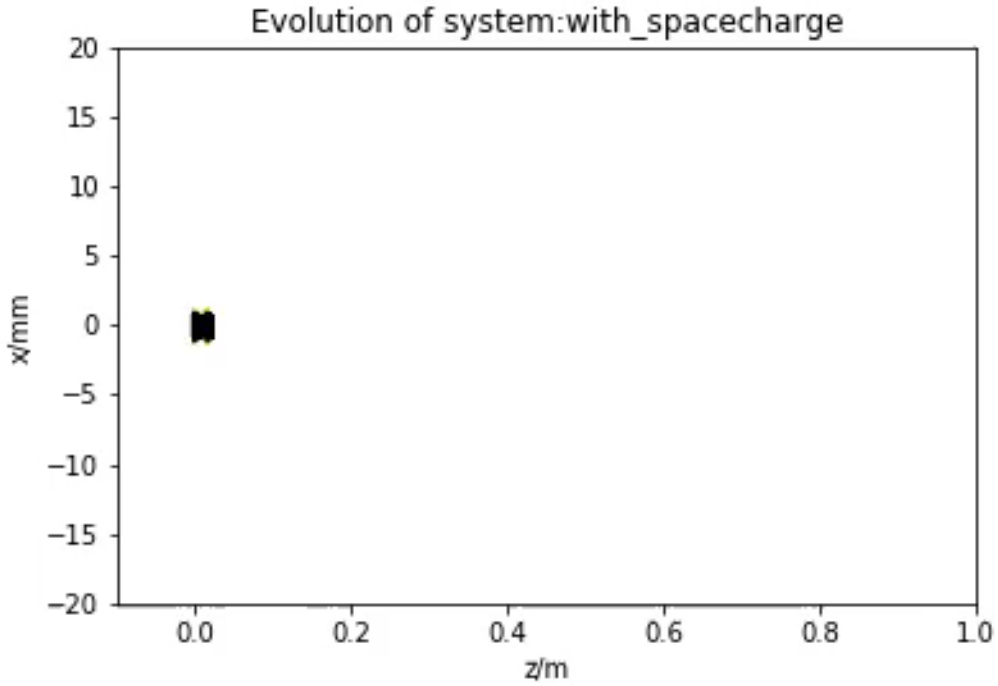
(4 MeV industrial Linac)

Does the *space charge* effect matter?

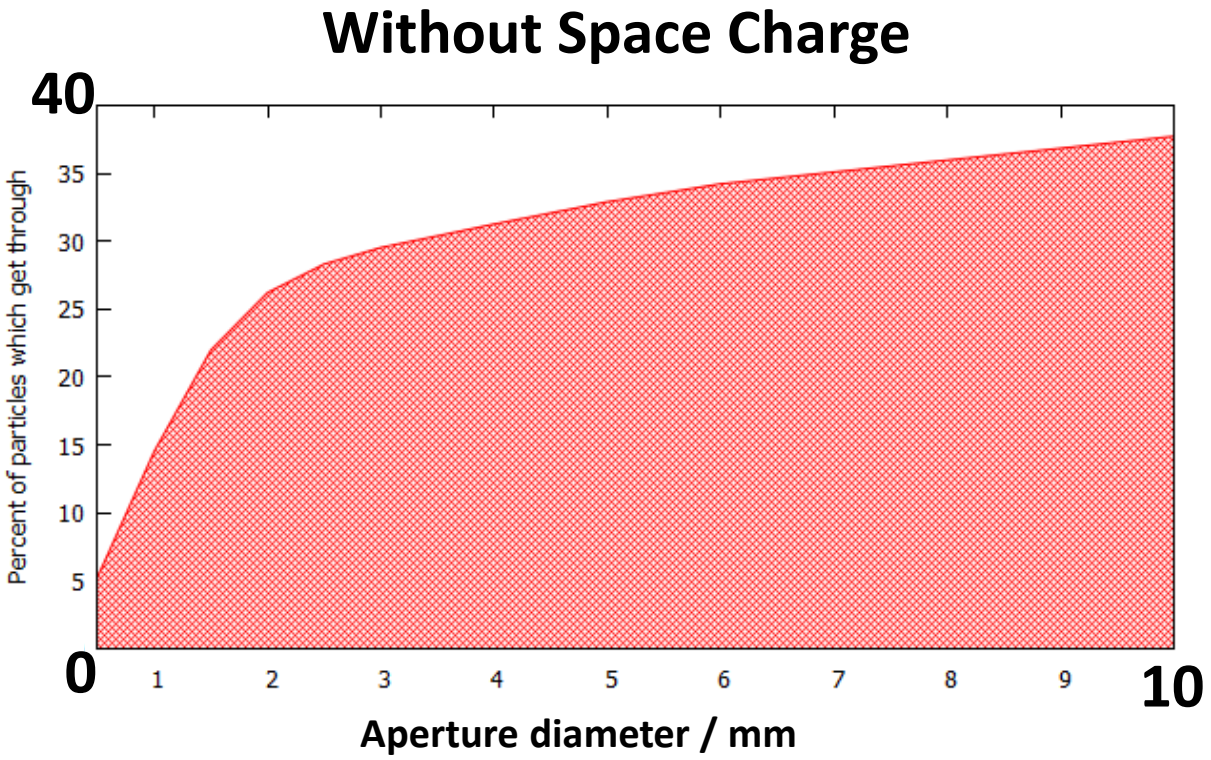


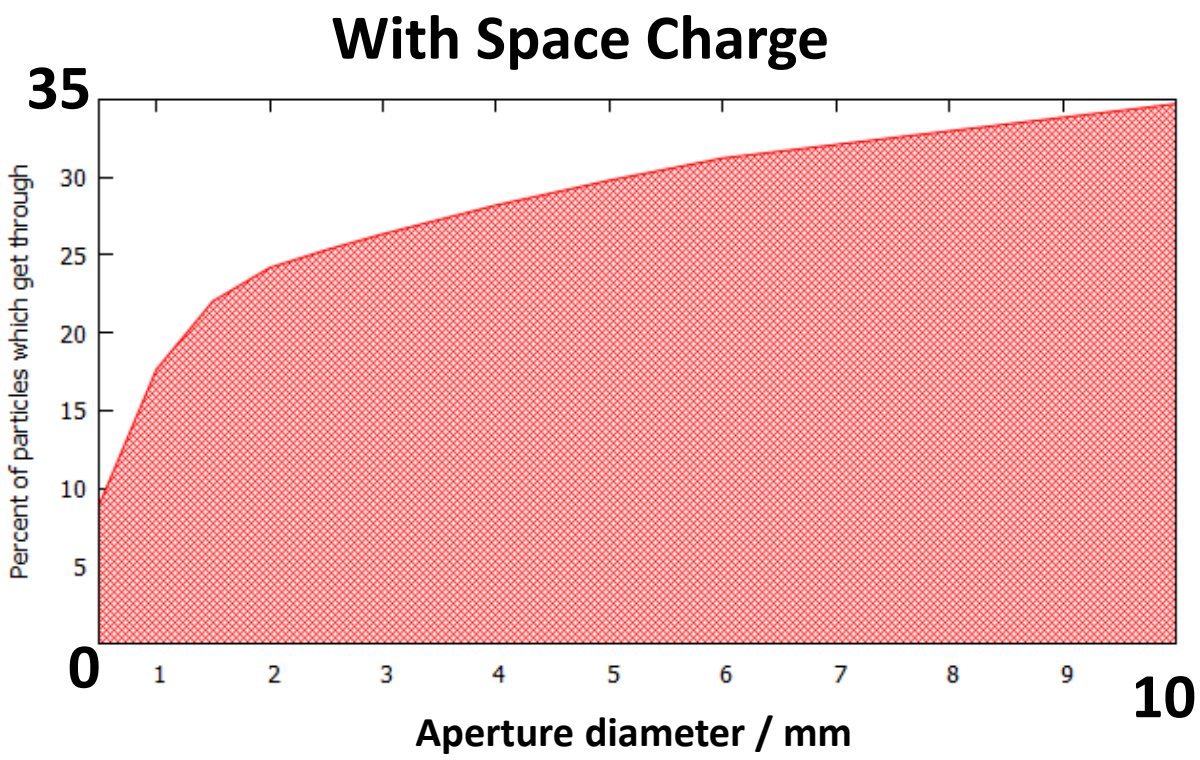
- Run 2 simulations,
  - 1 with space charge effects included
  - 1 without space charge
- Note:
  - Many particles go backwards or hit the aperture on the side of the cavity





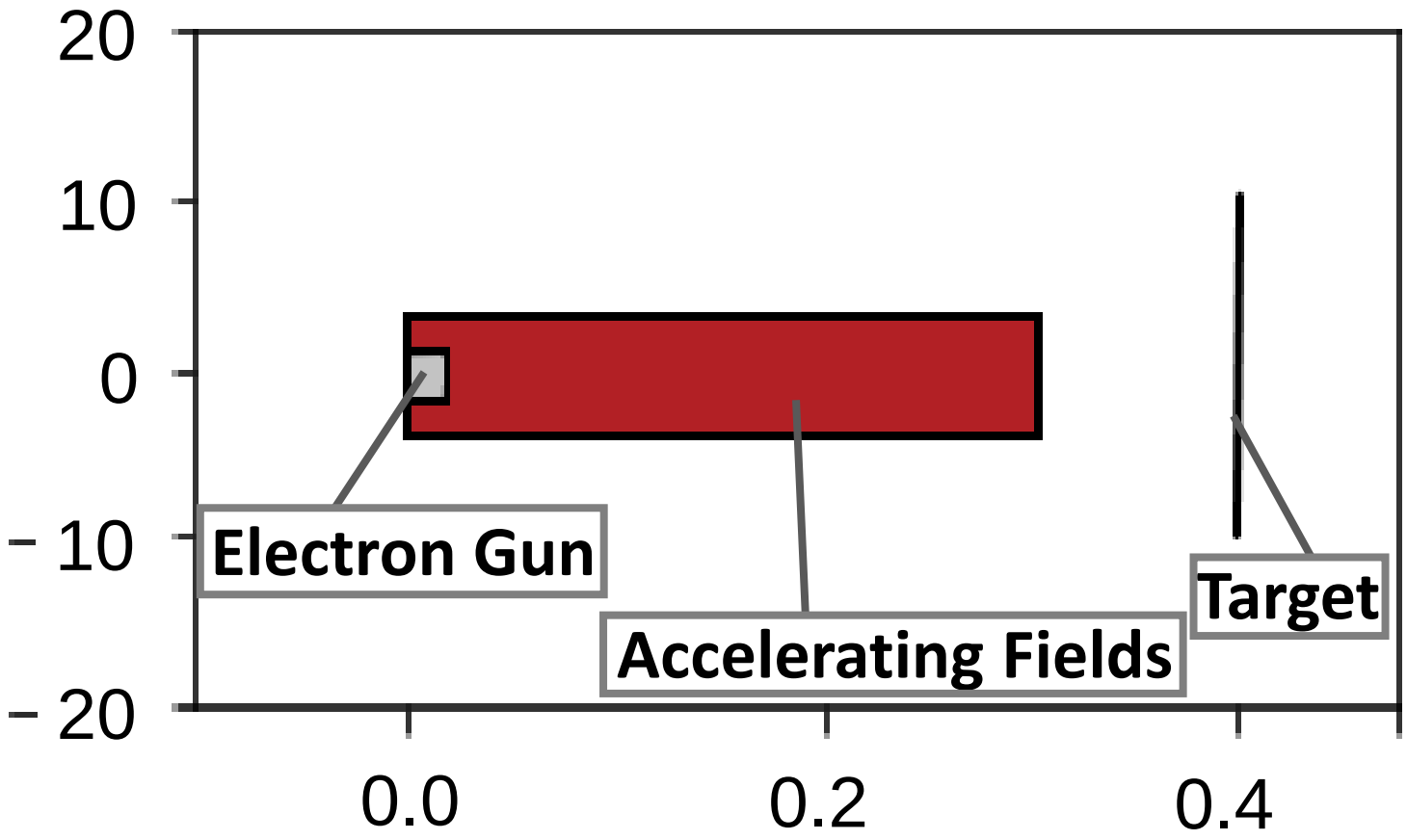
What do the *numbers* say?



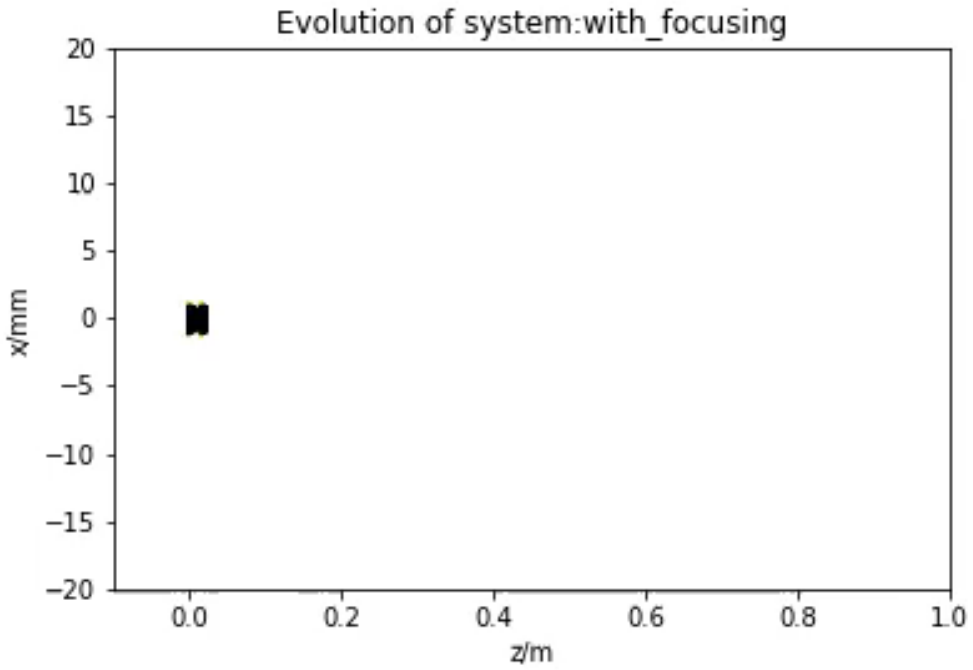


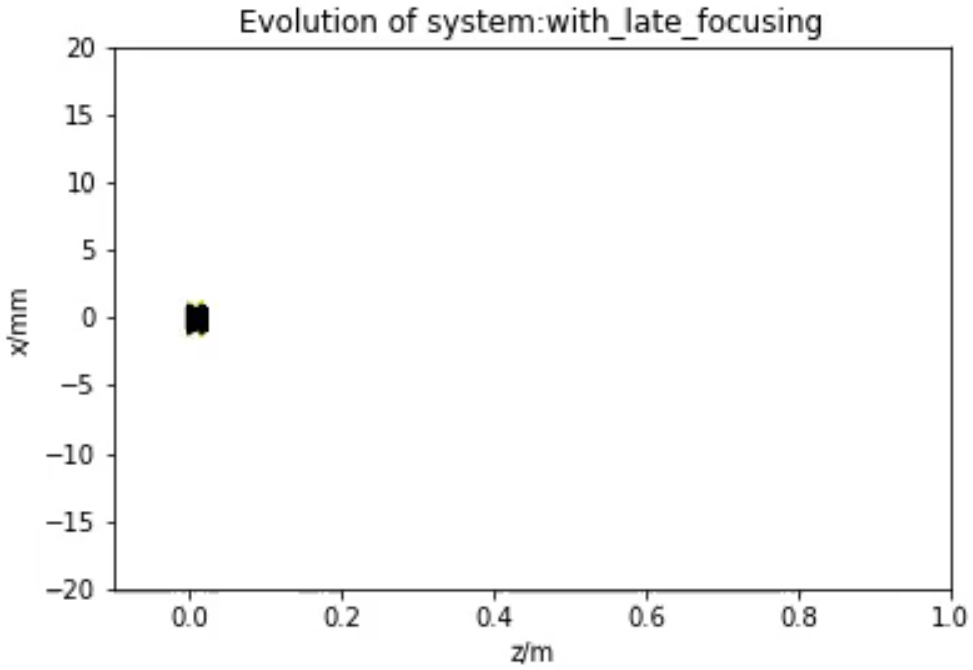
So space charge is significant (as expected)

Can we improve on this?



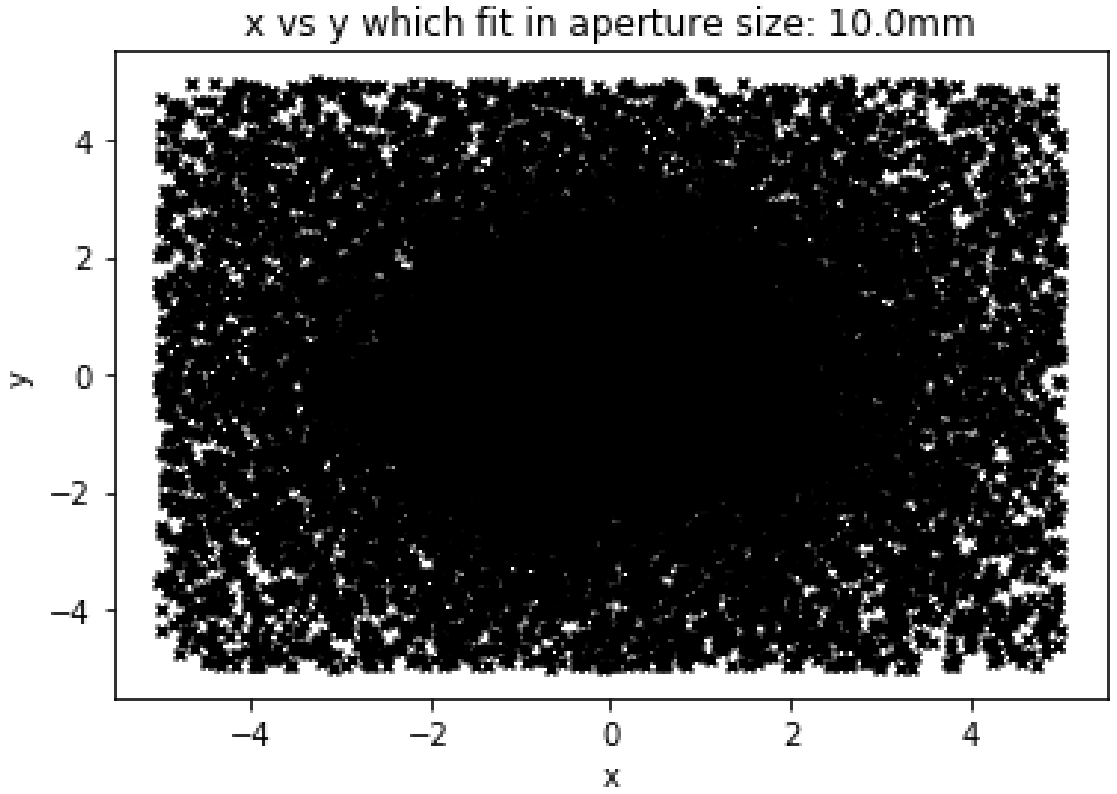
Does it matter where you put the focusing?



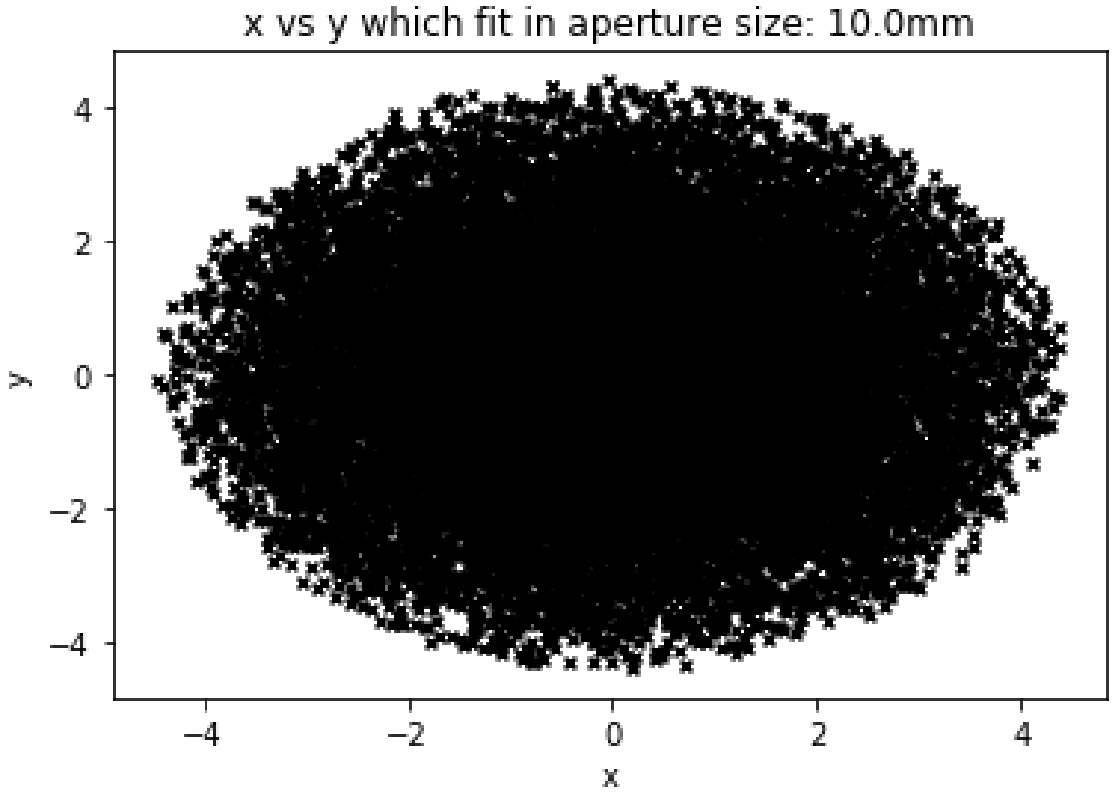


Looks different on the target?

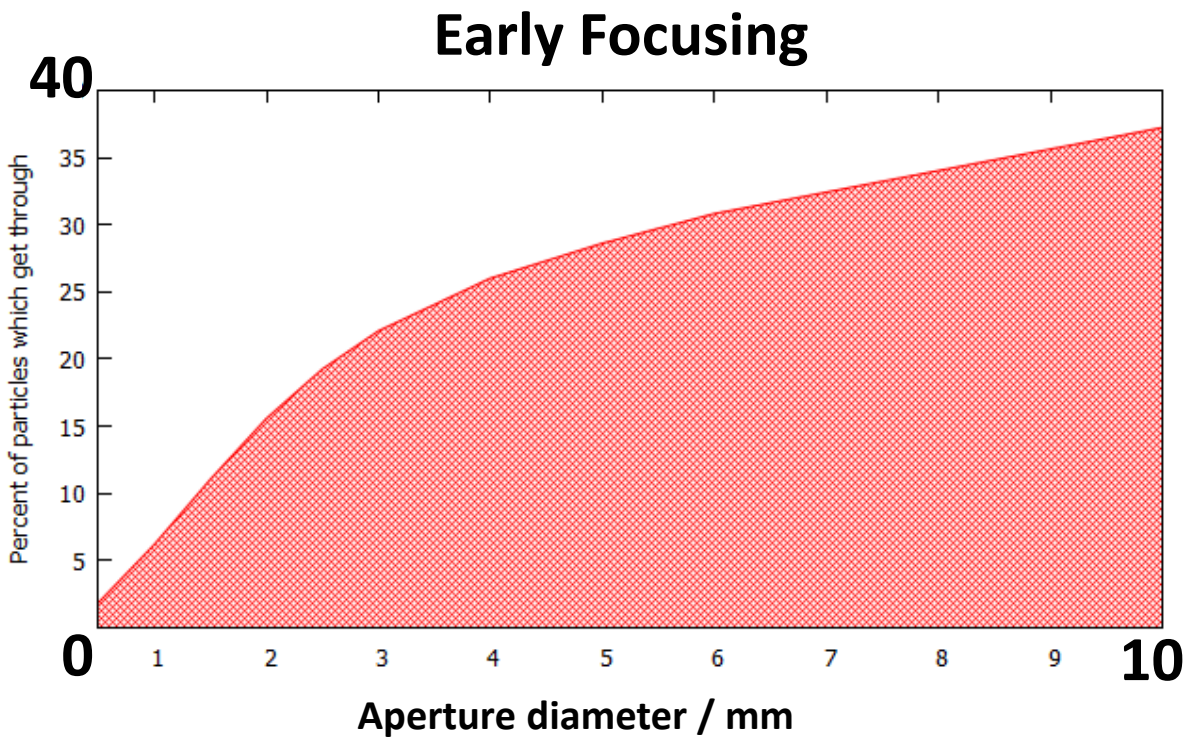
Early focusing

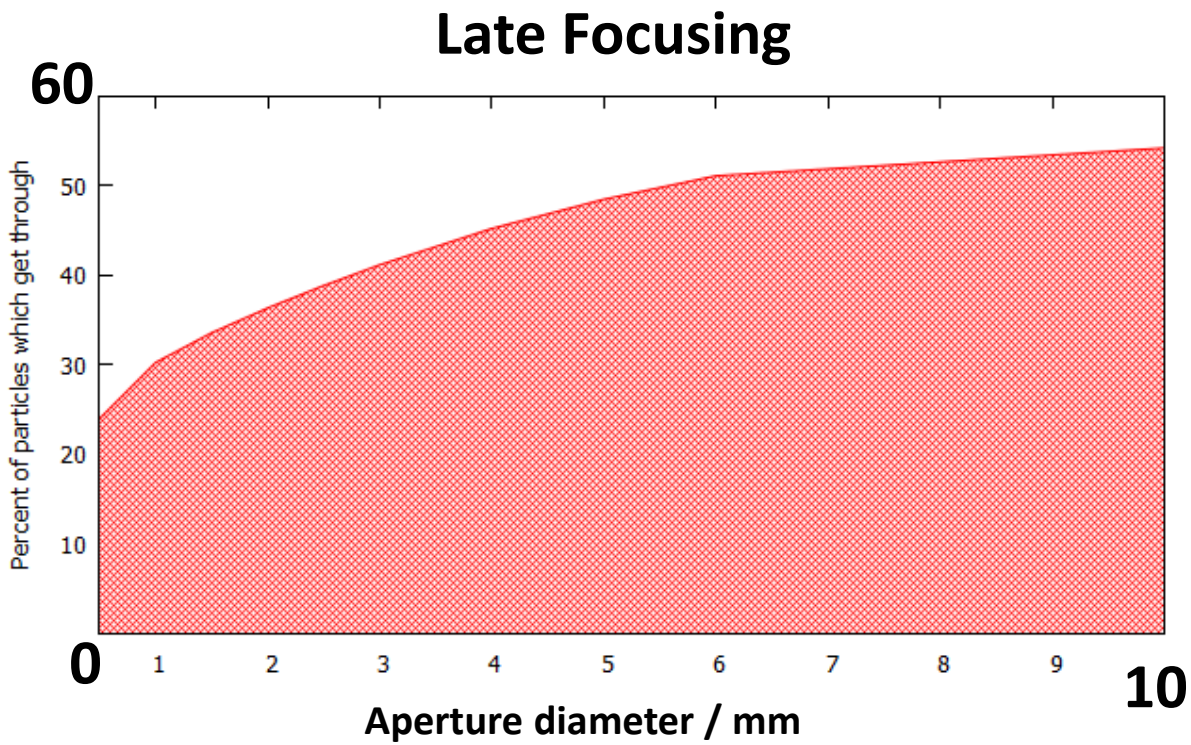


Late focusing



The *numbers* make it all clear





With these parameters, late focusing is more effective

What do these results tell us?

- Directly, these results don’t mean much, as we have so many free parameters that *will* change
- This is a *tool* that lets us test parameters quickly and easily
- *Chop and change* philosophy

In summary:

- We have *a lot* of free parameters
- At this stage, we want to keep as many options open as possible
- The next step is to focus in and compare our options
- This tool will help us to quickly and easily test out ideas

Thank You