

Analysis meeting #2

Nikita Zena van Gils

Recap and Overview:

Last time:

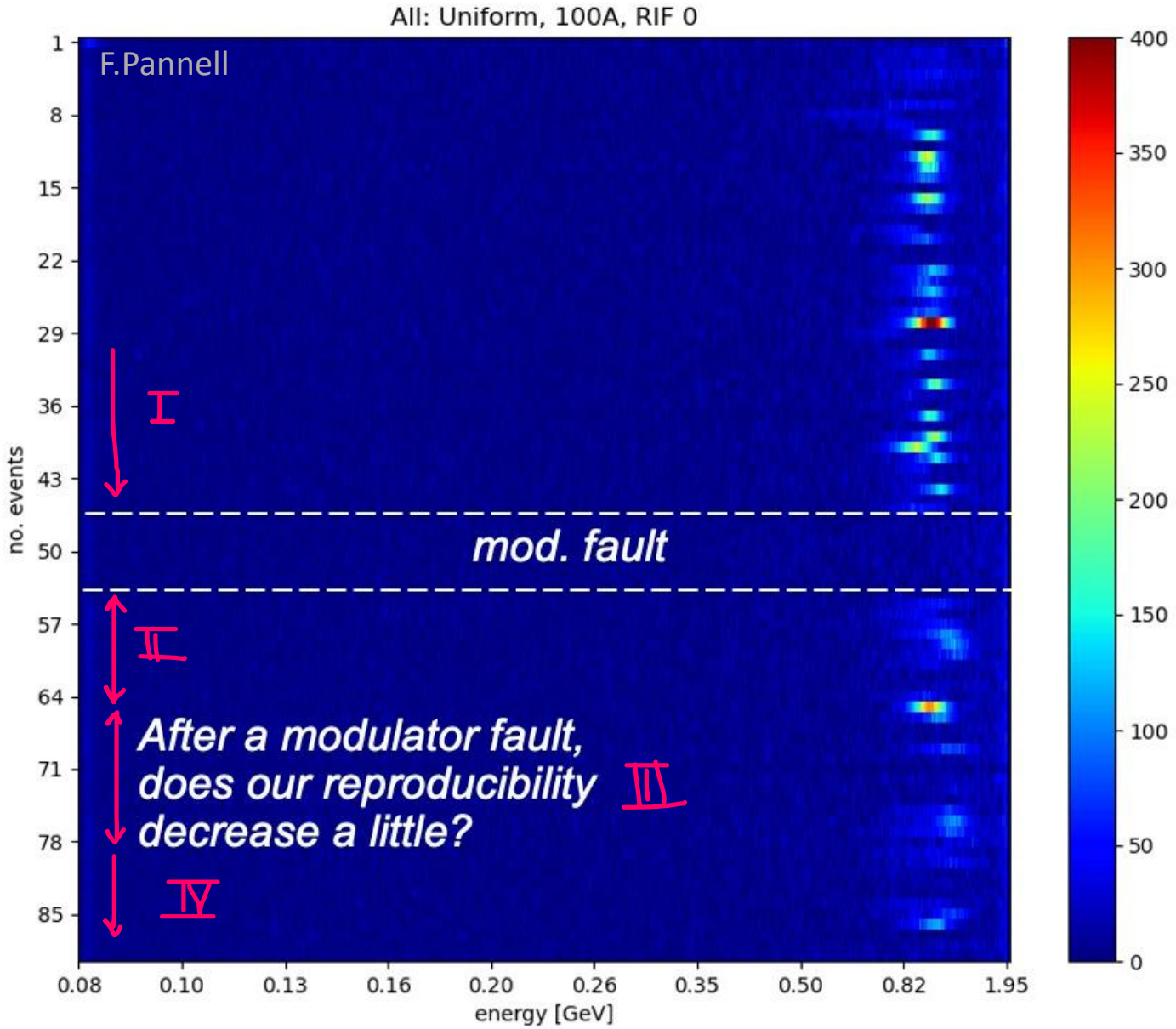
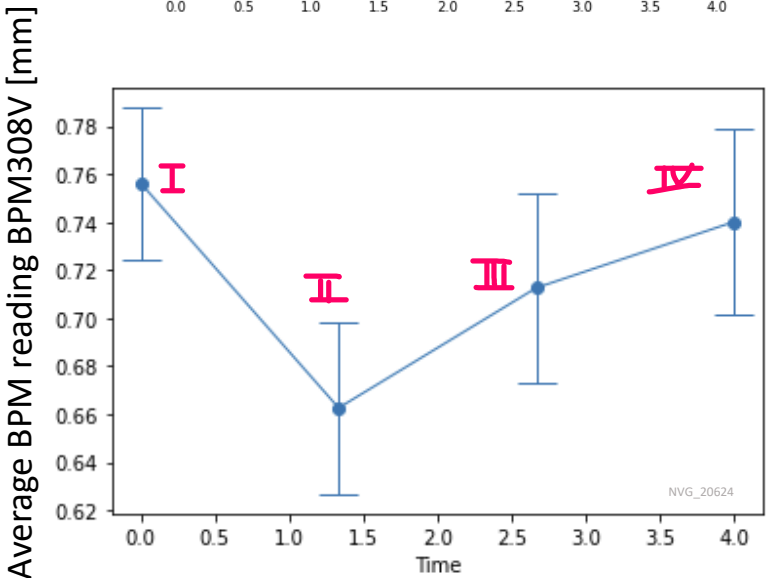
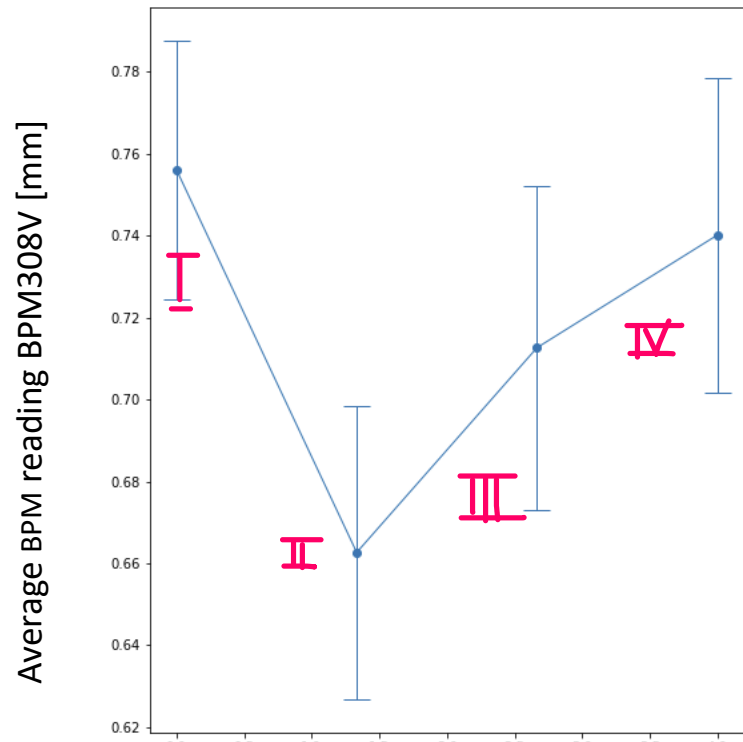
Cross checked:

- BPMs for drift, and variations along the line for beam/no beam, variations for beam/no beam
- Laser energy variations beam/no beam
- Proton intensity variations beam/no beam
- Halo shapes (assumed nice halo=> accelerated beam)?
- Saw increased reproducibility in May 2024 (vs previous days) => throughout whole day no significant drift of variation between beam/no beam (nothing above jitter), saw accelerated beam after repeated manipulation of the delay stage (and RF phase) and modulator faults

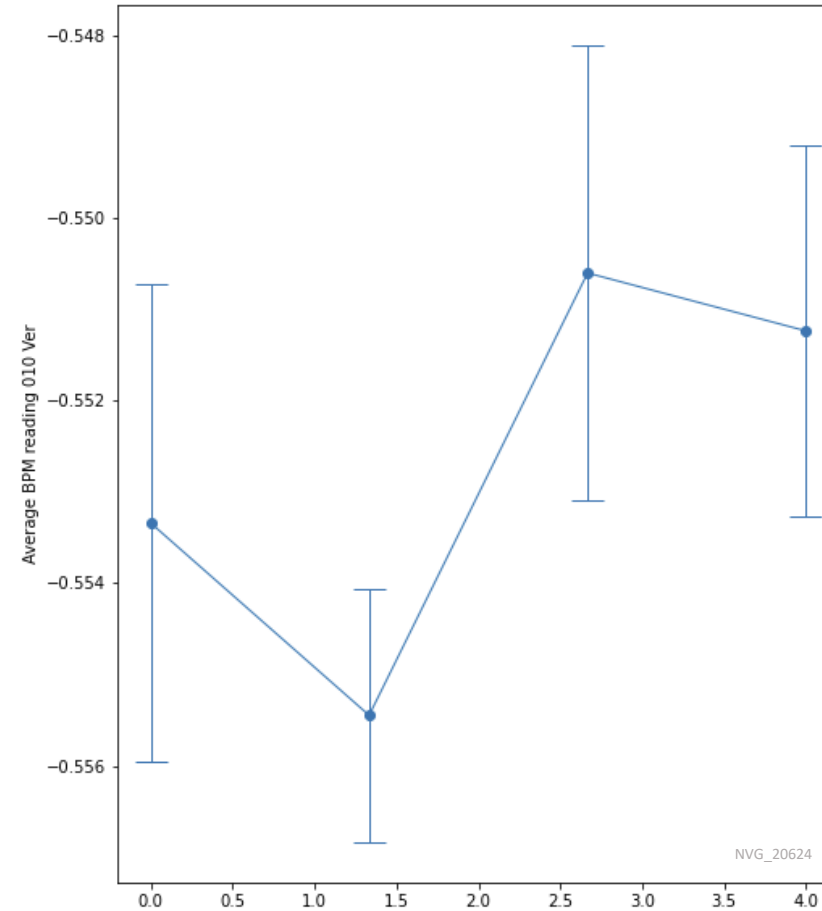
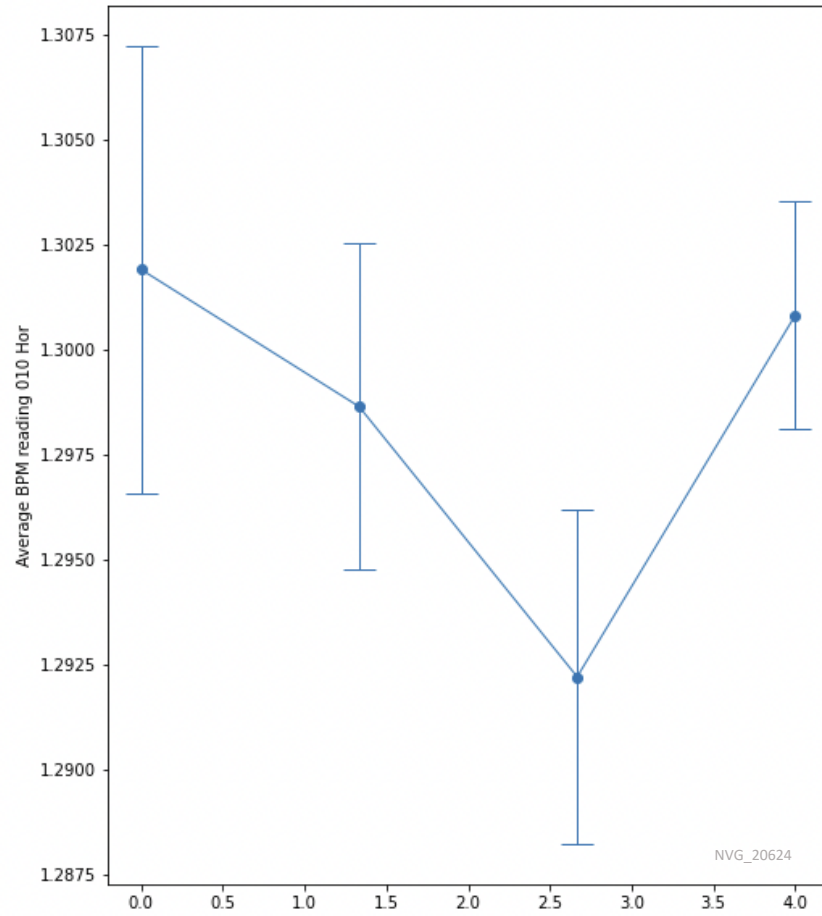
Now:

- Modulator fault and reproducibility (suggested by Fern's slide in the last meeting)
- Take events with symmetric halo and charge capture => look at BPMs => compare to BPMs with no charge capture and symmetric halos (as suggested by David).
- Possible indication of an effect of the electron bunch on the proton bunch (suggested by John)
- Possible insight into RHS vs LHS injection as seen on the Halo cameras
- Jitters in energy for charge capture events and halo shapes

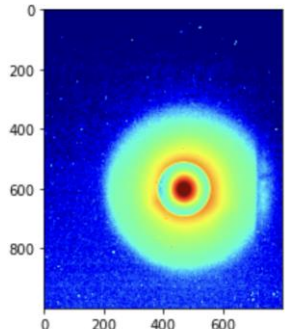
Modulator fault and last BPM on the electron line...



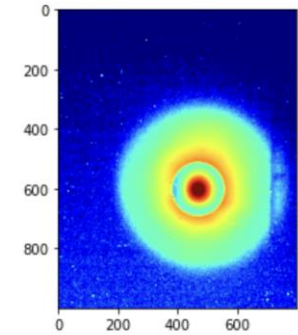
First BPM on the electron line...



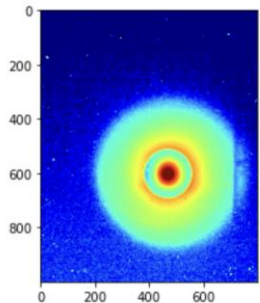
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There is laser
There are protons
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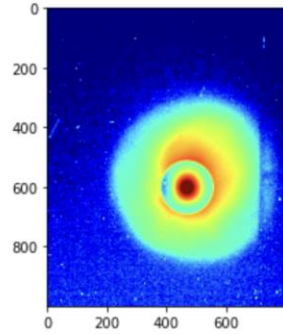
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There is laser
There are protons
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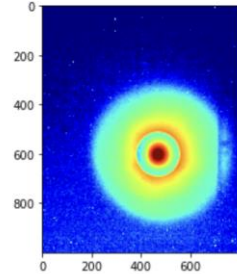
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There are protons
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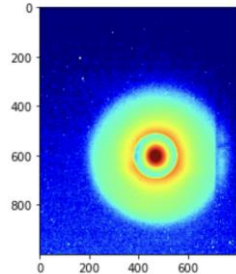
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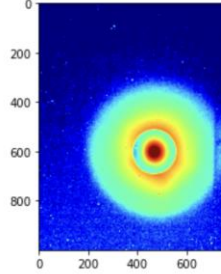
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There is laser
There are protons
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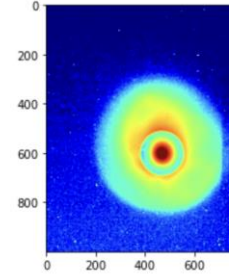
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There is laser
There are protons
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```
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There are protons
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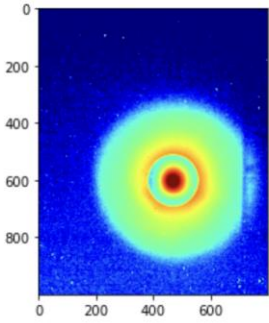


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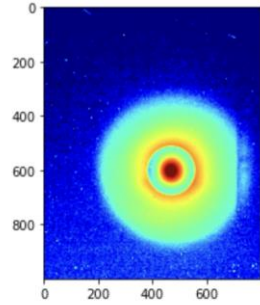


ELECTRONS: **NO**
PROTONS: YES
LASER: YES
CHARGE CAPTURE: **NO**
RIF:0
DENSITY: UNIFORM 3.68E14

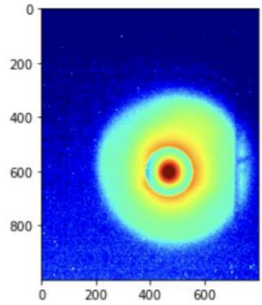
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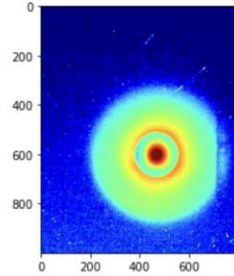
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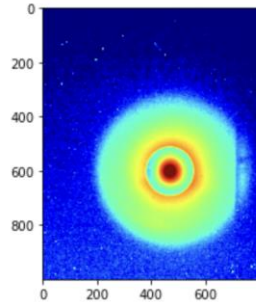
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 There is laser
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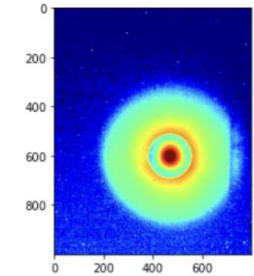
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 RIF= 0.0



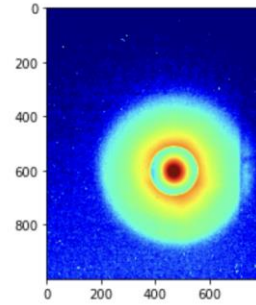
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 There is laser
 There are protons
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 RIF= 0.0



There are accelerated electrons
 There is laser
 There are protons
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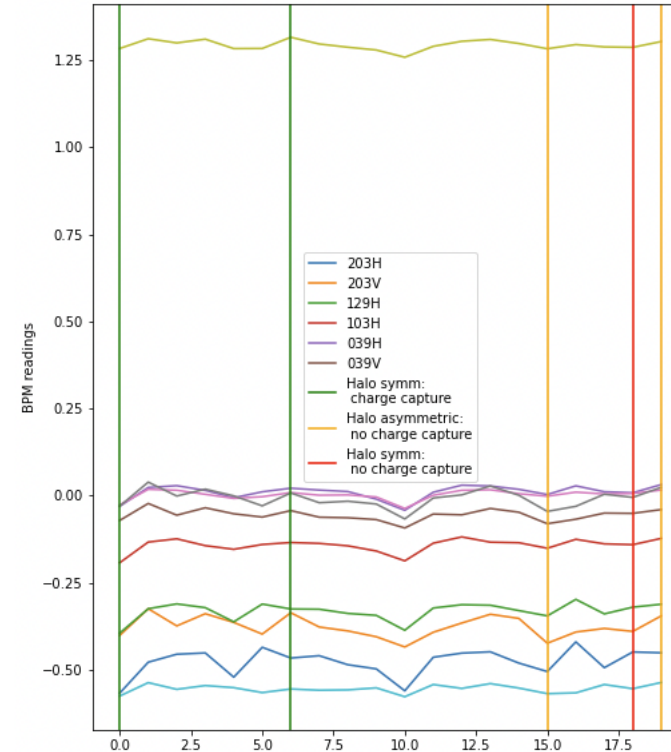


There are accelerated electrons
 There is laser
 There are protons
 <HDF5 file "1717331178135000000_Type0_1364_221.h5"
 RIF= 0.0



ELECTRONS: YES
 PROTONS: YES
 LASER: YES
 CHARGE CAPTURE: YES
 RIF:0
 DENSITY: UNIFORM 3.68E14

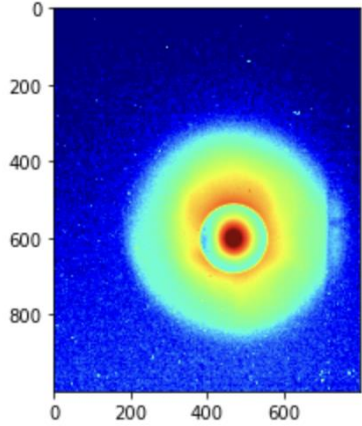
RHS injection



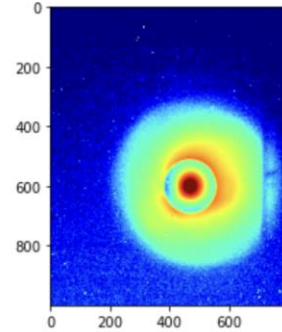
Halos and electrons and charge capture

RHS injection

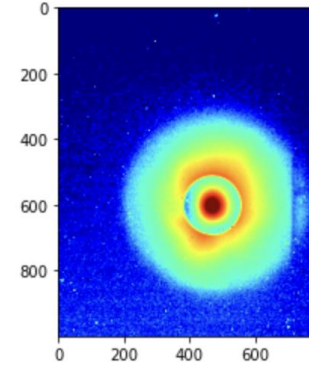
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There is laser
There are protons
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RIF= 0.0



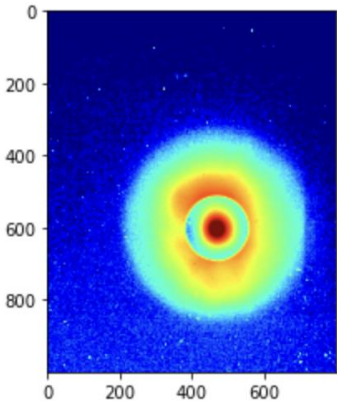
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There are protons
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RIF= 0.0



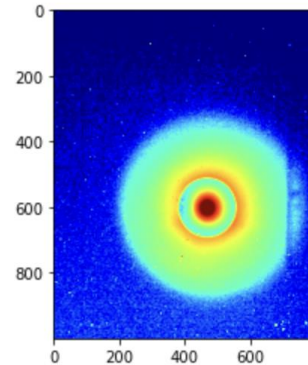
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There are protons
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RIF= 0.0



There are no accelerated electrons
There is laser
There are protons
<HDF5 file "1717331394135000000_Type0_1364_231.h5"
RIF= 0.0



There are no accelerated electrons
There is laser
There are protons
<HDF5 file "1717331437335000000_Type0_1364_233.h5"
RIF= 0.0



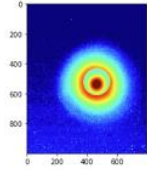
ELECTRONS: YES
PROTONS: YES
LASER: YES
CHARGE CAPTURE: NO
RIF:0
DENSITY: UNIFORM 3.68E14

Out of this...

- Does sometimes lack of charge capture in the wakefields cause asymmetries in the proton beam?
 - Problems with this:
 - Hard to decouple whether SSM develops well (symmetric halo) vs effect of electron bunch on this (possible convoluted regimes Mariana suggested)
 - Could test this by varying the electron beam charge => stronger effect on halo?
- Looked at possible effect of LHS vs. RHS injection
 - Problems with this:
 - Hard to compare data sets because:
 - Optics for the electron bunch were different
 - Plasma setup was either changing (e.g. density scan) or data not acquired for two equivalent configurations with LHS/RHS injection
 - Hard to decouple whether asymmetries caused by electron bunch or other effects (see asymmetric Halos without electrons)

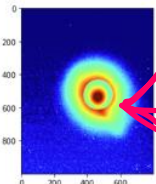
LHS injection

There are accelerated electrons
There is laser
There are protons
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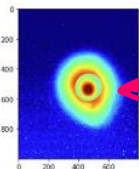


ELECTRONS: YES
PROTONS: YES
LASER: YES
CHARGE CAPTURE: no below yes above
RIF:0
DENSITY: 3%step at 1.75m 6.2E14

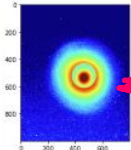
There is laser
There are protons
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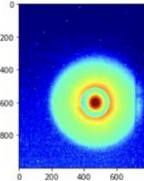
There are accelerated electrons
There is laser
There are protons
<HDF5 file "1697374335735000000_Type0_617_152.h5"



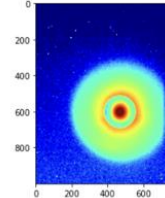
There are accelerated electrons
There is laser
There are protons
<HDF5 file "1697374342925000000_Type0_617_153.h5"



There are accelerated electrons
There is laser
There are protons
<HDF5 file "1717331891735000000_Type0_1364_217.h5"
RIF= 0.0

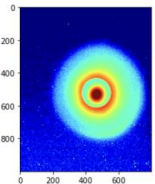


There are accelerated electrons
There is laser
There are protons
<HDF5 file "1717331156535000000_Type0_1364_220.h5"
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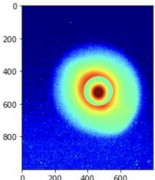


LASER: YES
CHARGE CAPTURE: YES
RIF:0
DENSITY: UNIFORM 3.68E14

There are accelerated electrons
There is laser
There are protons
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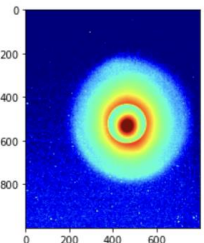
There are accelerated electrons
There is laser
There are protons
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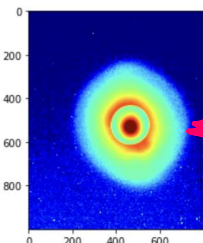
ELECTRONS: YES
PROTONS: YES
LASER: YES
CHARGE CAPTURE: no below yes above
RIF:0
DENSITY: 3%step 1.75m 3.7e14 7E14

LHS injection

There is laser
There are protons
<HDF5 file "1697968593735000000_Type0_696_31.h5"

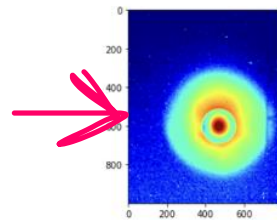


There is laser
There are protons
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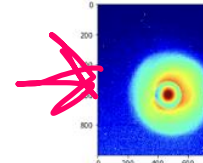


RHS injection

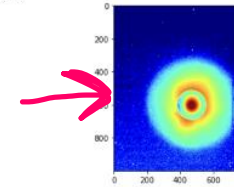
There are no accelerated electrons
There is laser
There are protons
<HDF5 file "1717331372535000000_Type0_1364_230.h5"
RIF= 0.0



There are no accelerated electrons
There is laser
There are protons
<HDF5 file "1717331415735000000_Type0_1364_232.h5"
RIF= 0.0

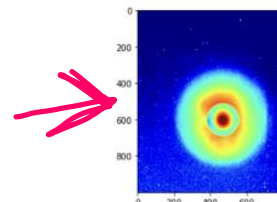


There are no accelerated electrons
There is laser
There are protons
<HDF5 file "1717331458935000000_Type0_1364_234.h5"
RIF= 0.0

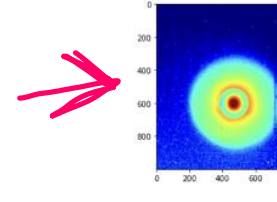


ELECTRONS: YES
PROTONS: YES
LASER: YES
CHARGE CAPTURE: NO
RIF:0
DENSITY: UNIFORM 3.68E14

There are no accelerated electrons
There is laser
There are protons
<HDF5 file "1717331394135000000_Type0_1364_231.h5"
RIF= 0.0



There are no accelerated electrons
There is laser
There are protons
<HDF5 file "1717331437335000000_Type0_1364_233.h5"
RIF= 0.0



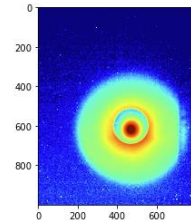
Halos for varying energies (jumps in energy)

- On the 2nd of June saw jumping energy while removing a density step.
- Previously we had a jumping seed (RIF at 0ps, +200ps every second event and saw alternating energy values)
- Then we had only seed 0ps but continued to see the variation in energy (from one spectro camera to another) => checked Halos for these events
 - Hard to decouple: what causes variations in energies:
 - Density step change
 - Injection jitter (timing or position)
 - Development of self-modulation (Halos)? ← this is what we looked at (to be compared to Fern's Waterfall plot)

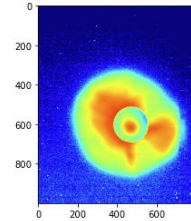
June 2nd: $4e14$, $3e11$, 400pC, RHS injection, step scan going up in % with a jumping seed

Y	YB		0
		YD?	200
	Y		0
		YD	200
	Y	Y	0
	Y		200
	Y		0
	YB		200

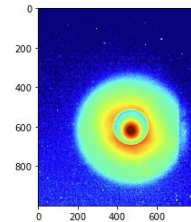
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There is laser
There are protons
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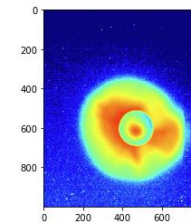
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There are accelerated electrons
There is laser
There are protons
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RIF= 200.0
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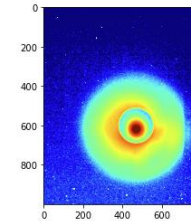
```
There are accelerated electrons
There is laser
There are protons
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RIF= 0.0
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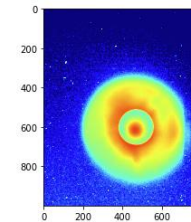
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There is laser
There are protons
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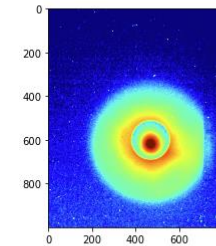
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There are accelerated electrons
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There are protons
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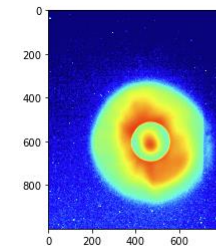
```
There are accelerated electrons
There is laser
There are protons
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RIF= 200.0
```



```
There are accelerated electrons
There is laser
There are protons
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RIF= 0.0
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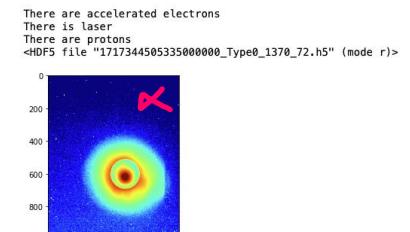
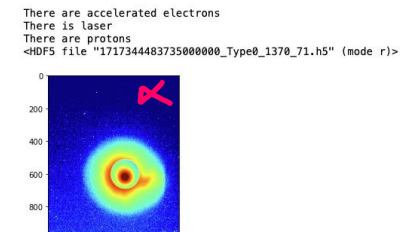
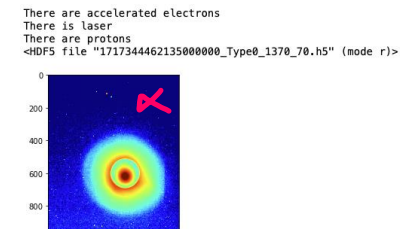
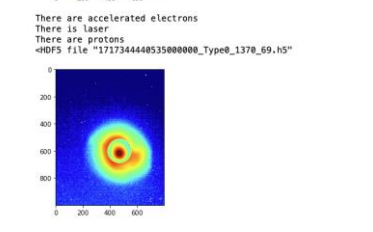
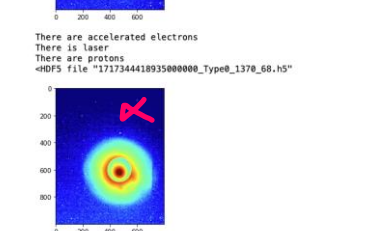
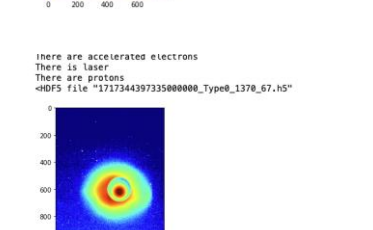
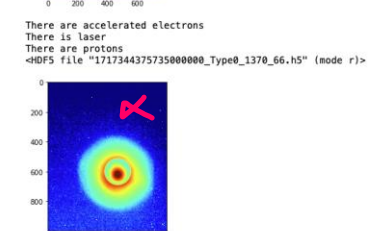
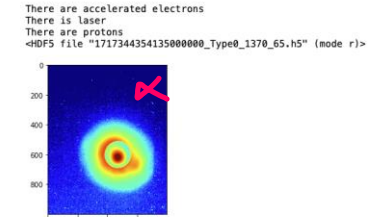
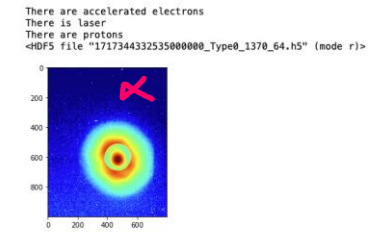
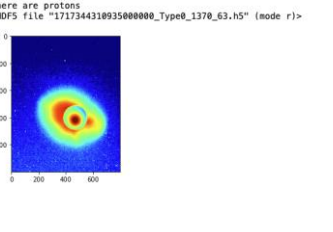
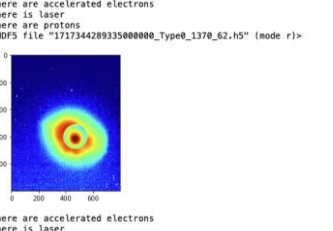
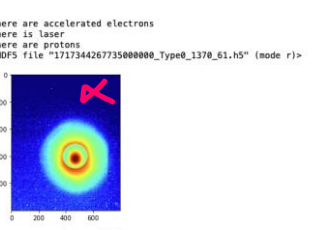
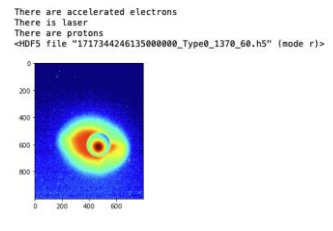
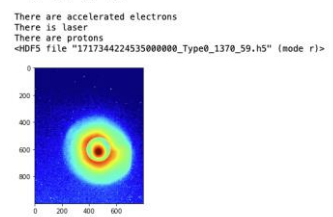
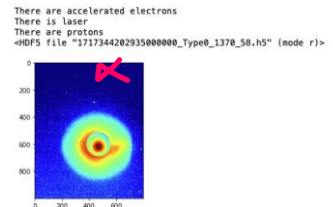
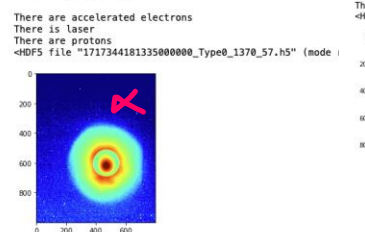
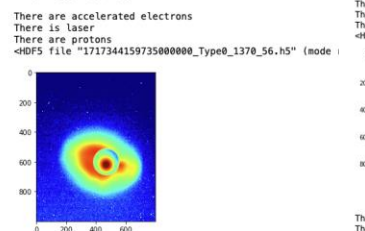
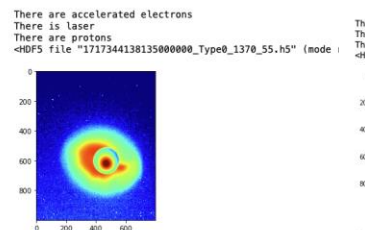
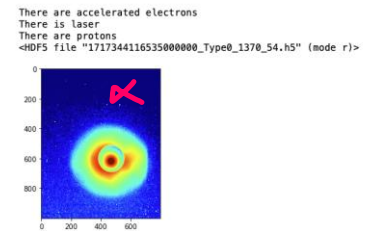
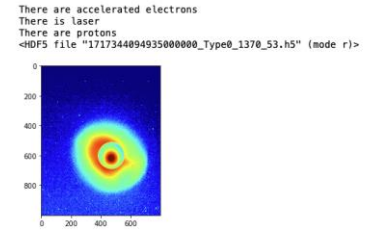
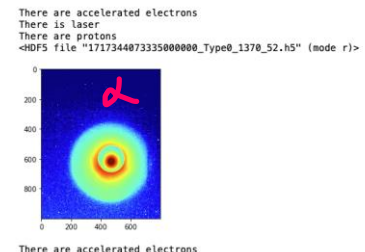


```
There are accelerated electrons
There is laser
There are protons
<HDF5 file "1717343122935000000_Type0_1370_8.h5" (mode r)>
RIF= 200.0
```



Step scan continued % with a fixed seed

47				
48		Y		YD
49		Y		
50				YD
51				
52	✗	Y		
53				YD
54	✗	Y		
55				YD
56				YD
57	✗	Y		
58	✗	Y		
59				
60				YD
61	✗	Y		
62				YD
63				YD
64	✗	YW		
65	✗	Y	Y	
66		Y		
67				YD
68	✗	Y		
69				
70	✗	Y		
71	✗	Y		
72	✗	YW		
73				
74		Y	Y	



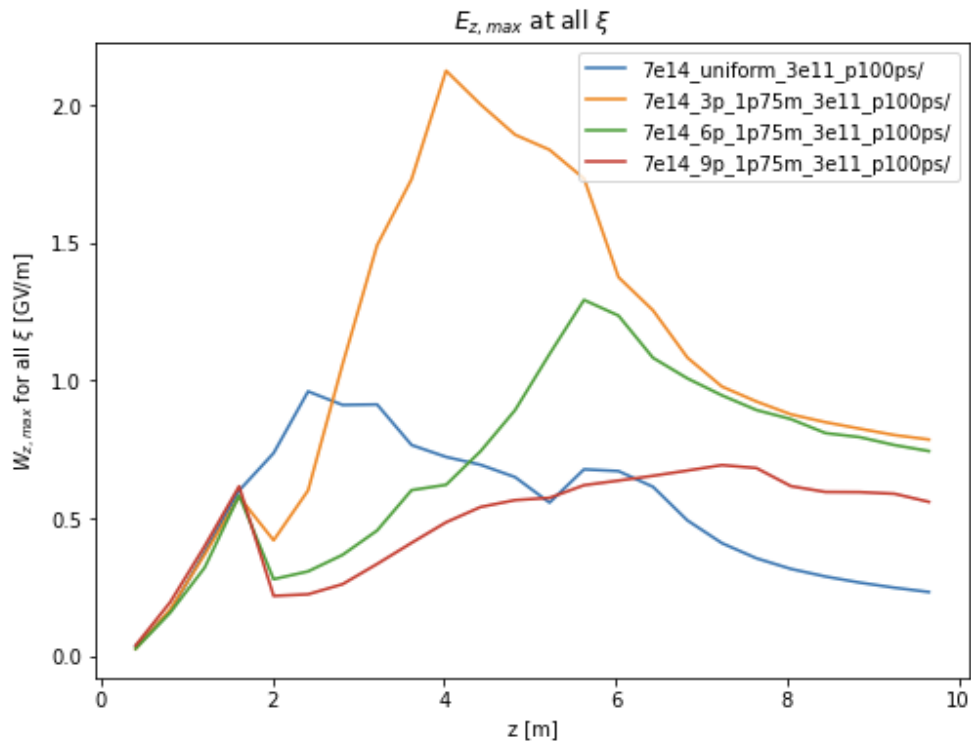
What have we learnt (given the limited statistics) for the upcoming run:

- BPMs along the electron line show no significant drifts during longer data sets (always to keep an eye on during operation)
- Varying timing of electrons showed no significant drifts (this was also shown outside the run by measuring UV on cathode and electron bunch positions and beamsizes on screens prior to the entrance aperture while moving the delay stage)
- Halo symmetry to clearly define whether there is charge capture or not => did not find evidence in the data
- Potentially jitters in energy for charge capture events can be linked to halo shapes (hinted towards from the step scan /but additional parameter was varied (step %))
- Modulator fault recovers RF to original setting and alignment, however, does require a period of adjustment (all within BPM jitter)
=> stop acquiring data for this time period?
- We saw higher reproducibility in June (see Fern's Waterfall plots), could this be due to half the input charge (worth considering for optimisation of injection)?
- No clear indication of RHS vs LHS injection on the halo; perhaps worth investigating by keeping the injection fixed and varying the charge of the electron bunch (if there is an effect this would scale with Q , suggested by Mariana).

How do we classify a good step?

AMPLITUDE STABILITY

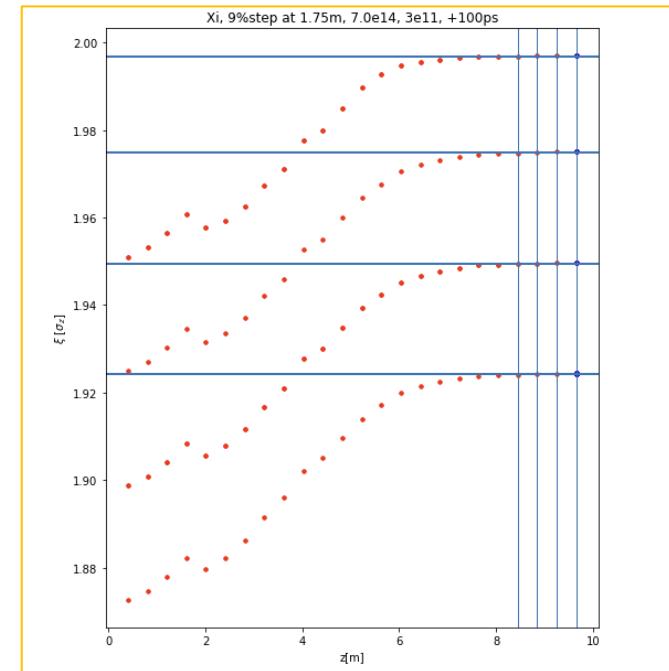
UNIFORM: drop amplitude = 0.09GeV/m
3% step: drop in amplitude = 0.22 GeV/m
6% step: drop in amplitude = 0.13GeV/m
9% step: drop in amplitude = 0.06GeV/m



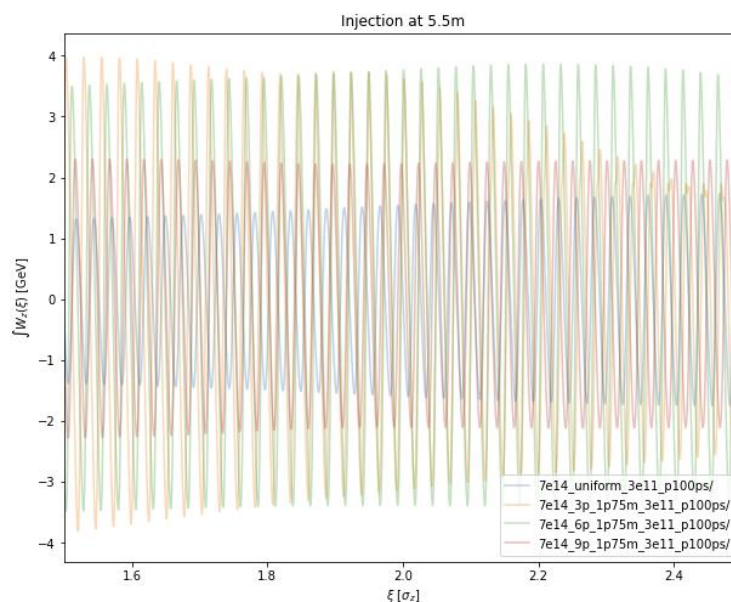
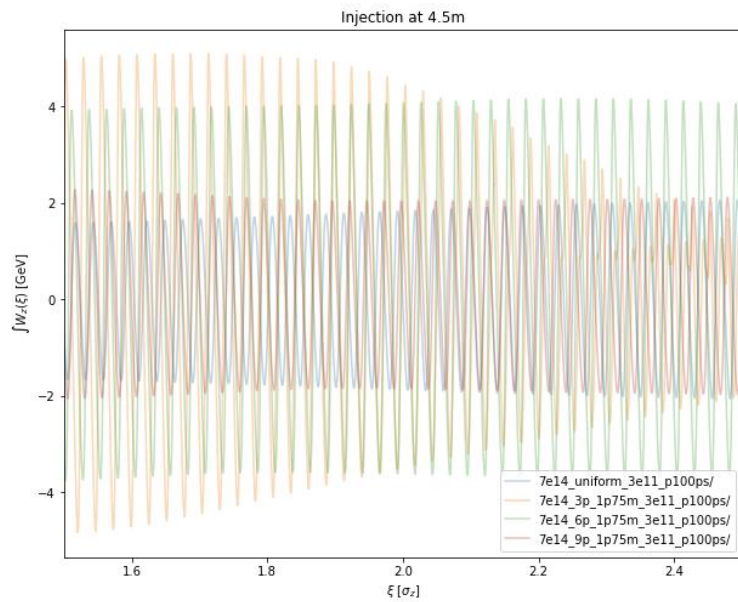
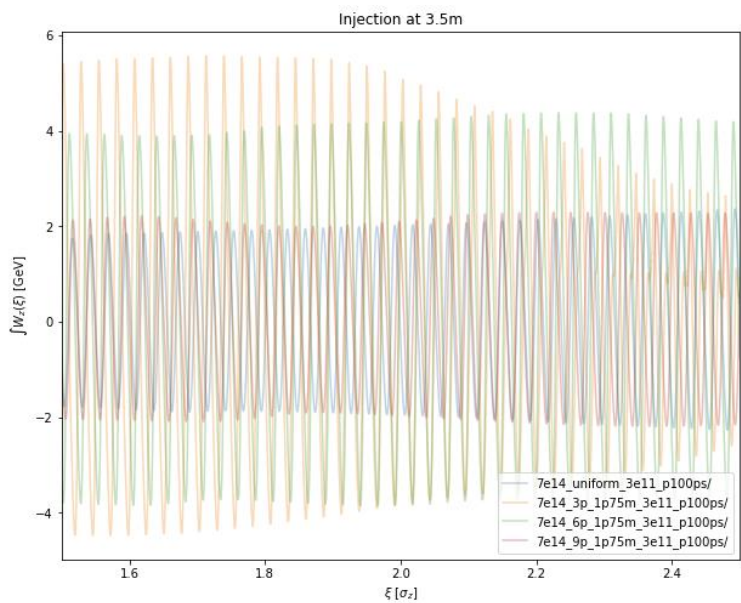
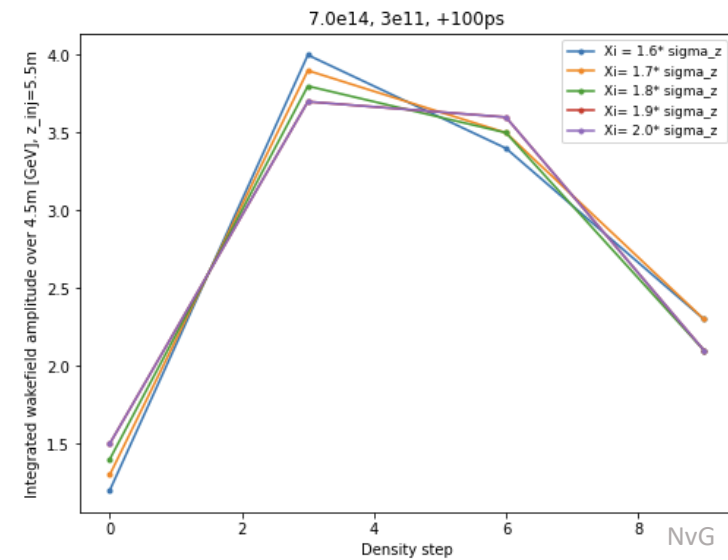
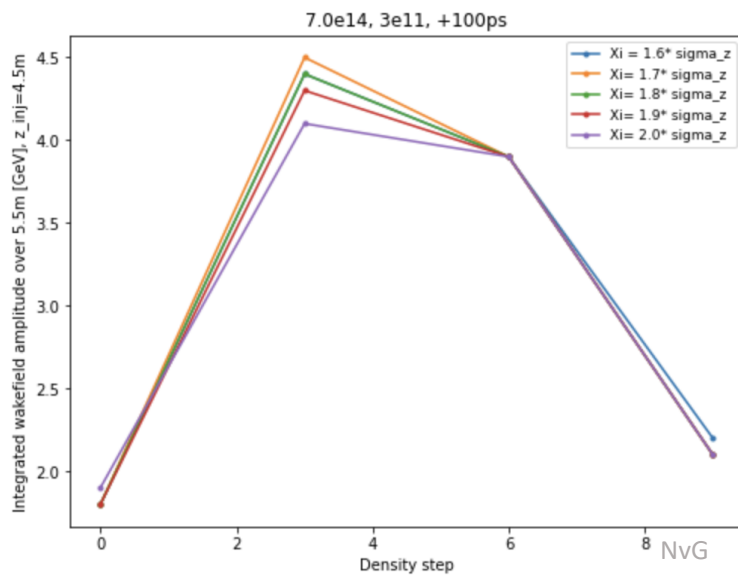
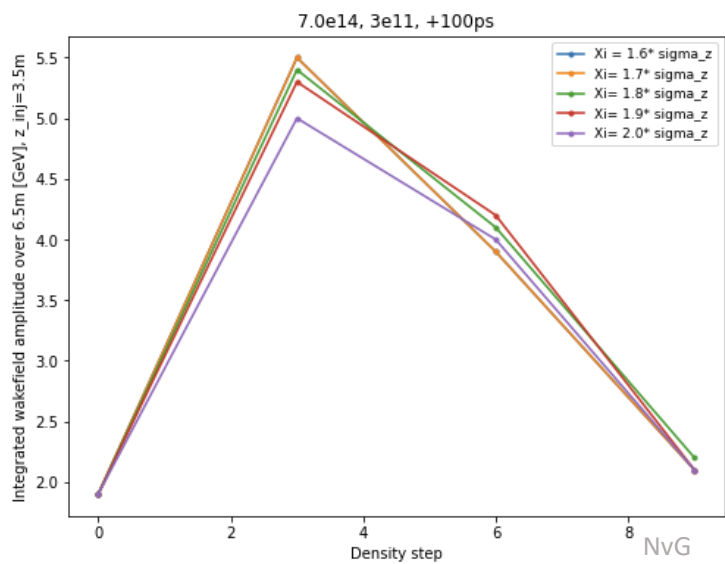
PHASE STABILITY

For 9% the following ξ_i are stable
In phase starting at $z = 8.5\text{m}$

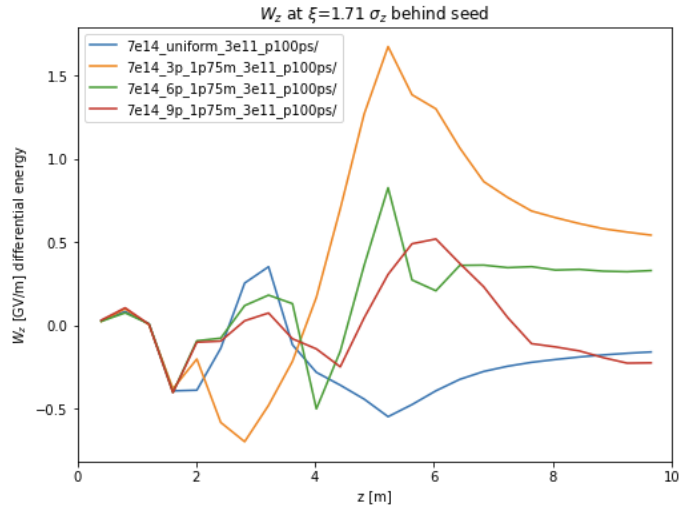
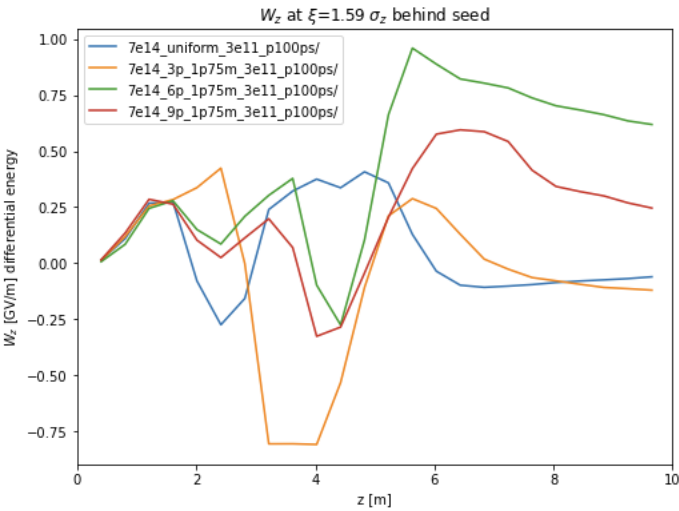
(1.6, 2) σ_{z_i}



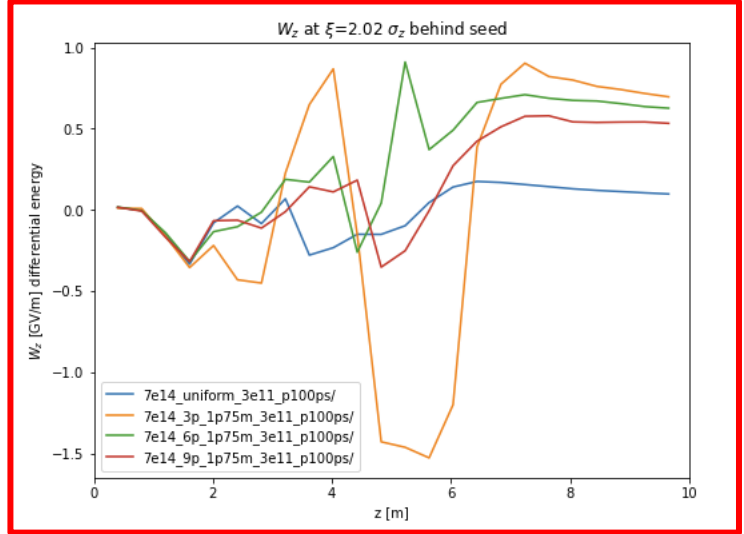
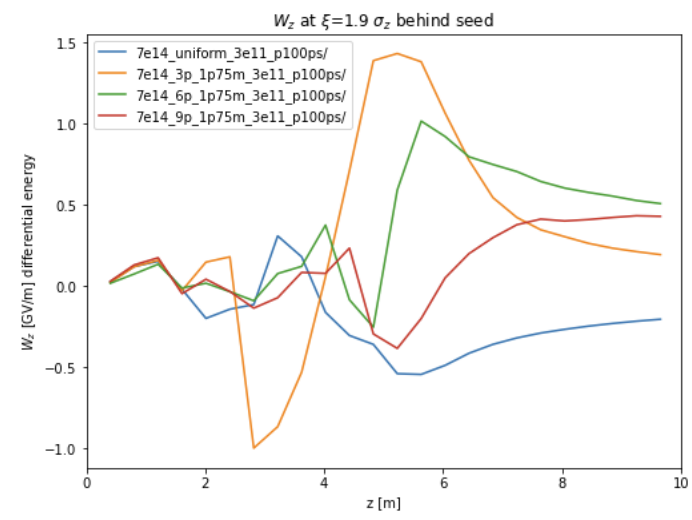
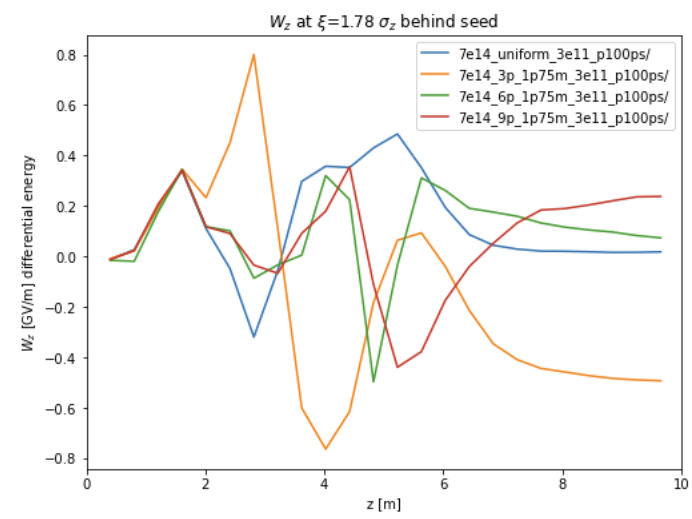
9% step at 1.75m phase stable after 6m for ξ_i in (1.6, 2) σ_z ; for z_{inj} = 3.5m, 4.5m, 5.5m



Differential energy gain...



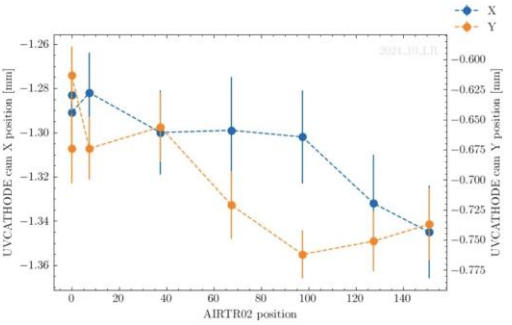
For a fixed ξ how does W_z develop along the plasma. If below zero slipping into another phase has occurred.



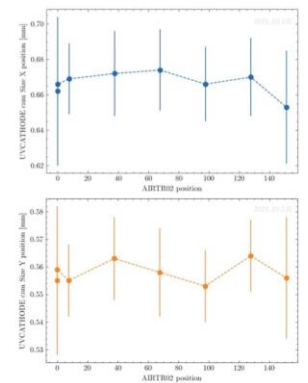
DELAY SCAN ON WITH UV ON CATHODE (IRIS FULLY OPEN)

6.03.24

Position XY

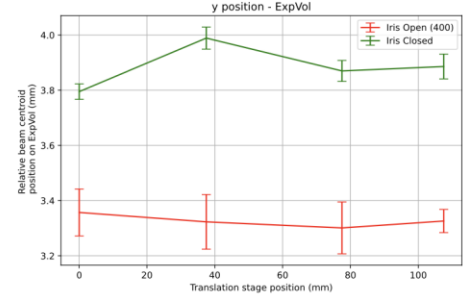
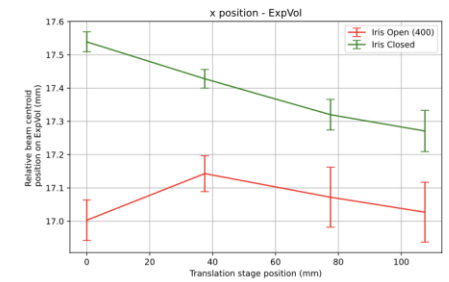
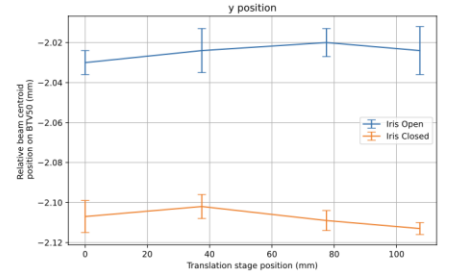
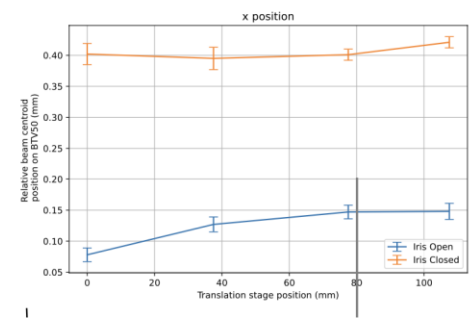


Size XY



UV position on cathode moves by < 100 um when moving translation stage. Size is ~500um

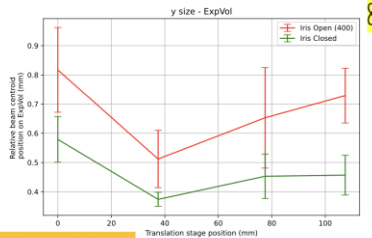
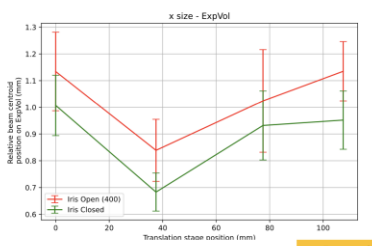
8.03.24



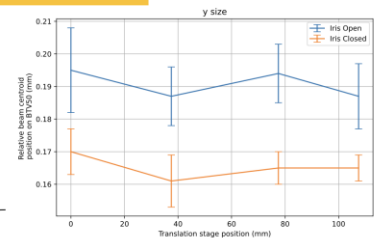
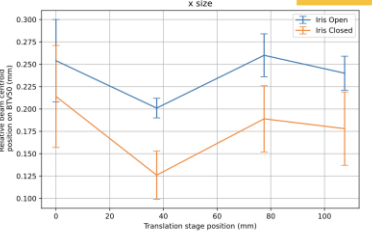
• Electron beam position moves by < 50 (50) in x (y) when focused on BTV50, and < 300(200) in x (y) when focused on ExpVolBTV

• Relative to beamsize this movement is small

8.03.24



Beamsize stable <100 um variation



It is possible to correct this effect with the RF phase shifter and with realignment of the UV laser on the cathode=> **further tests** required to determine whether reproducible procedure is possible

