Energy Measurements of Trapped Electrons from a Plasma Wakefield Accelerator

July 12th, 2006

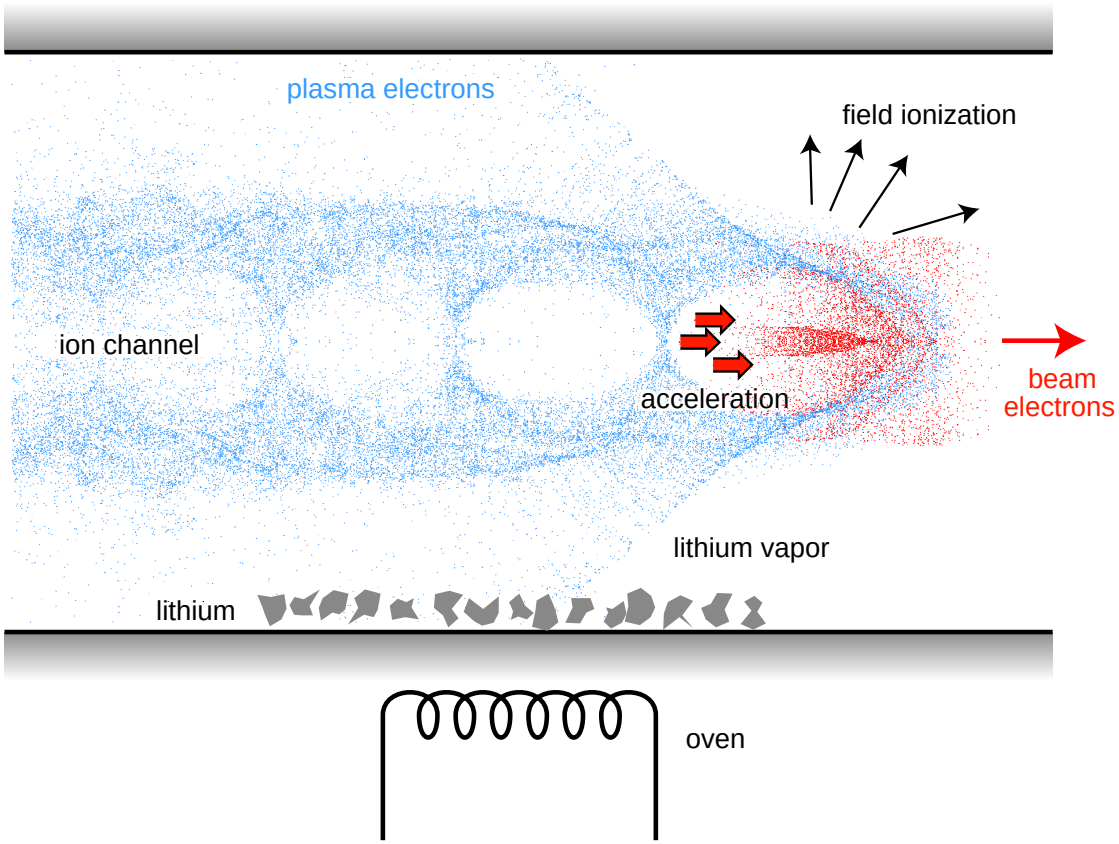
Neil Kirby

Summary

- Why we investigate trapped electrons.
- Trapped electron properties measured on energy spectrometers.

Trapped Electrons

- More charge comes out of the plasma than went in. Toroids showed as much as a factor of four increase.
- This extra charge results from trapping of plasma electrons.
- In addition to the extra charge, downstream OTR/Cherenkov diagnostics get blinded with light 10,000 times brighter than without the plasma.



Investigating Trapped Electrons

- It is important to understand what limitations trapped electrons have on plasma wakefield accelerators.
- The trapped electrons have properties that make them interesting all on their own.

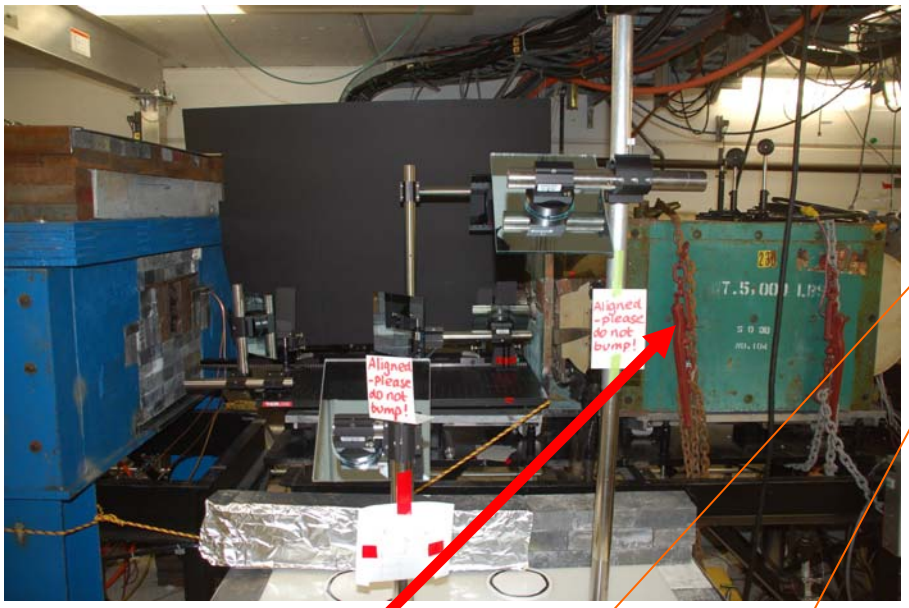
Trapped Electron Properties

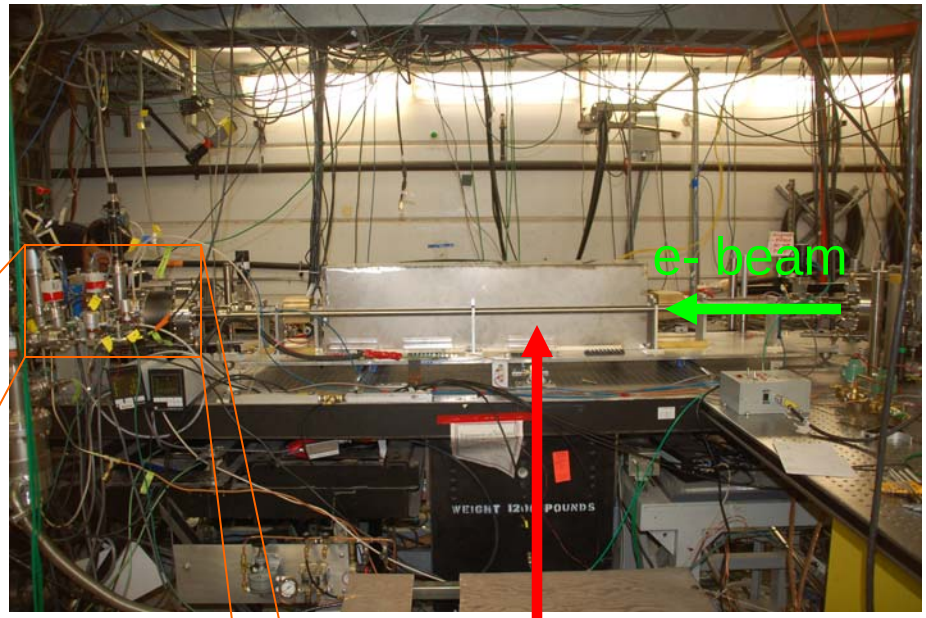
- Energies up to many GeV.
- When traversing a Cherenkov cell, emit 10,000 times more light. (distribution has a significant optical Fourier component along the direction of Cherenkov emission).
- Sub-micron features are showing up in a system with length scales >10um.

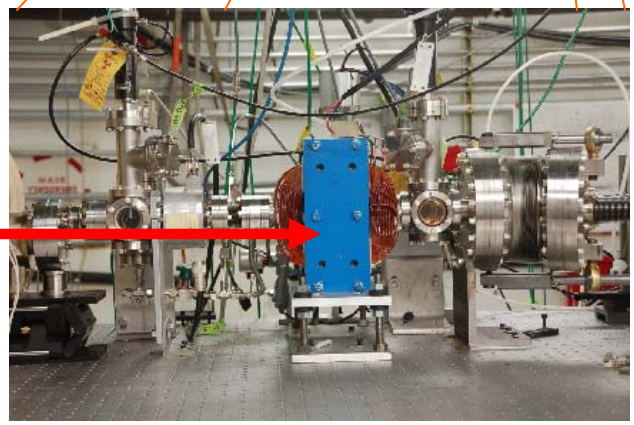
Energy Spectrometers

- We have studied these trapped electrons with a combination of three energy spectrometers.
- A low energy spectrometer (10-200 MeV)
- A Cherenkov cell spectrometer (80MeV-10GeV)
- A high energy spectrometer (>2GeV)

Pictures of the Setup





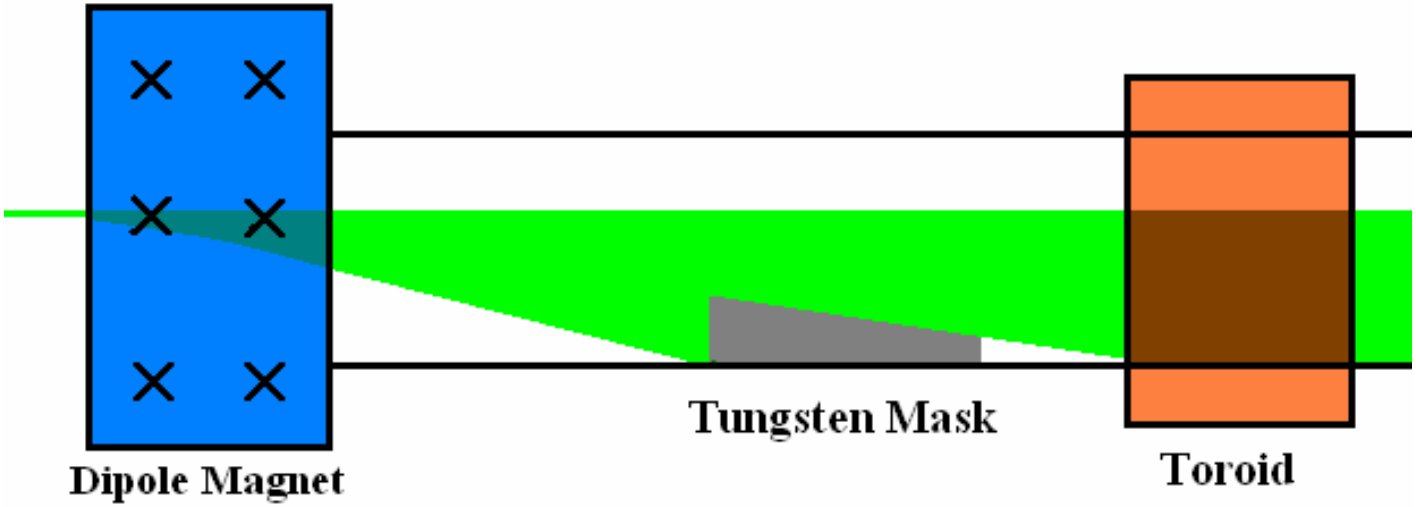


Big Dipole

Small Dipole

Plasma Oven

Low Energy Spectrometer(10-200MeV)

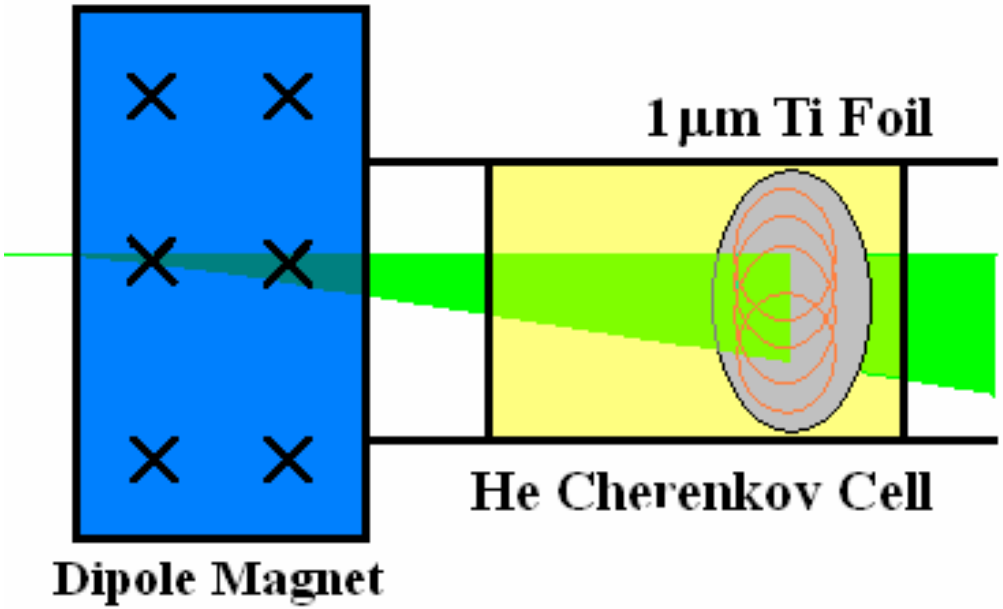


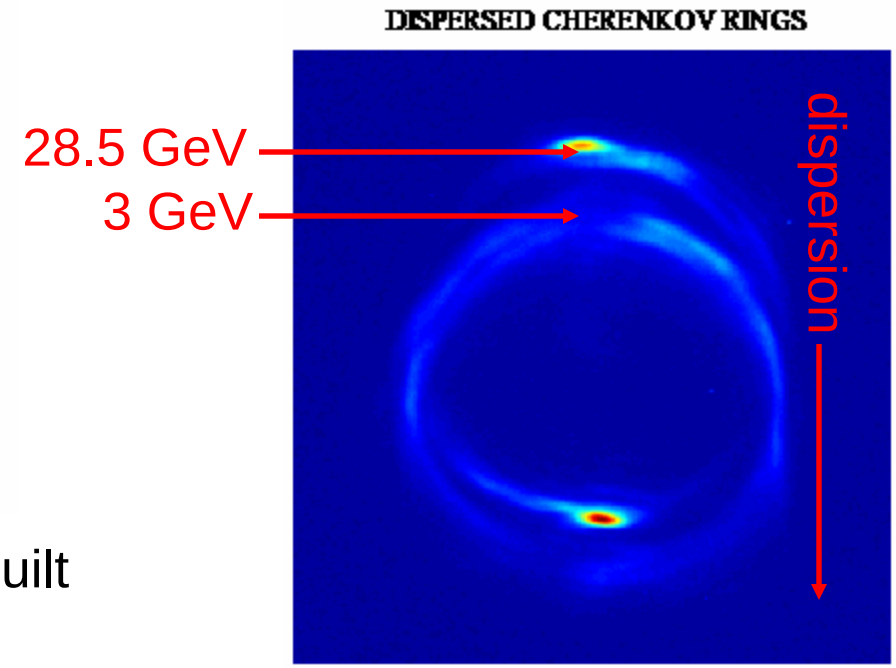
- We placed a tungsten mask in between a dipole magnet and toroid that were downstream of the PWFA.
- The amount of charge measured versus dipole field gives a measurement of the low energy trapped electrons.

Low Energy Spectrometer Data

- Data showed that most of the extra charge showed up with energies at or below the 10MeV level.

Cherenkov Cell Spectrometer(80MeV-10GeV)





- A Cherenkov cell spectrometer was built from a dipole, a gas filled cell, a thin titanium foil (mirror) , and a camera.
- This spectrometer was used in analyzing 10-30 cm plasma.
- The camera was set to image the far-field of the Cherenkov radiation that is reflected from the cell with a foil.
- Different energy electrons would then show up as Cherenkov rings displaced by different amounts.

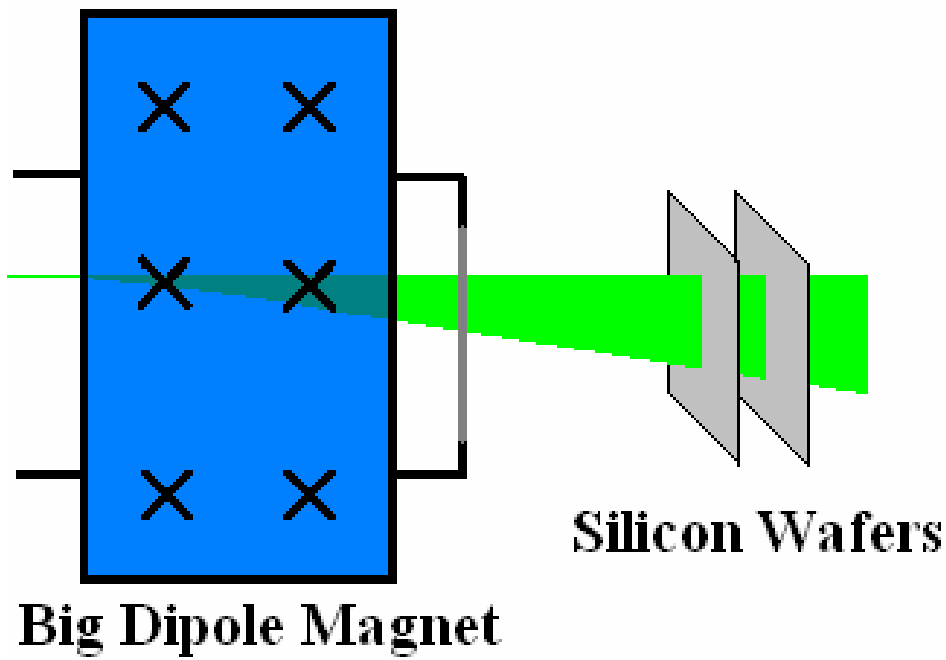
Cherenkov cell energy-length scaling

- We used the spectrometer on different plasma lengths.
- The data showed that the secondary trapped electron ring had an energy scaling with plasma length.

Sub-micron Features

- There are sub-micron features on the trapped electrons, so the amount of charge isn’t proportional to the amount of light.
- Cherenkov cell spectrometer can’t get an accurate number for the amount of charge at these energies.

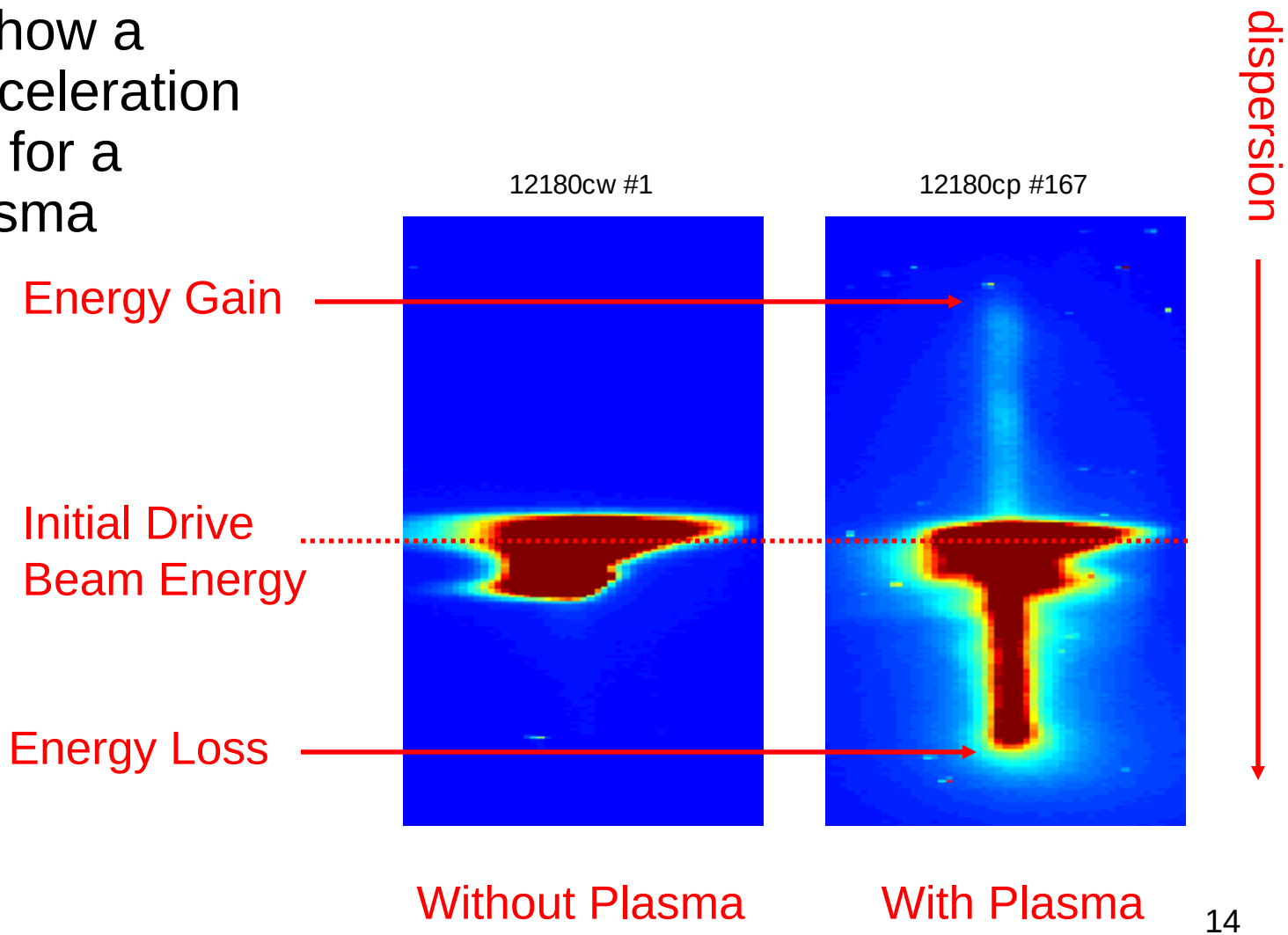
High Energy Spectrometer (> 2 GeV)



- A camera imaged an air gap that was downstream of a large dipole (1.2 Tm).
- This was used in analyzing 85cm plasma data.
- Could identify trapped electrons from the drive beam because of smaller transverse sizes than the drive beam.

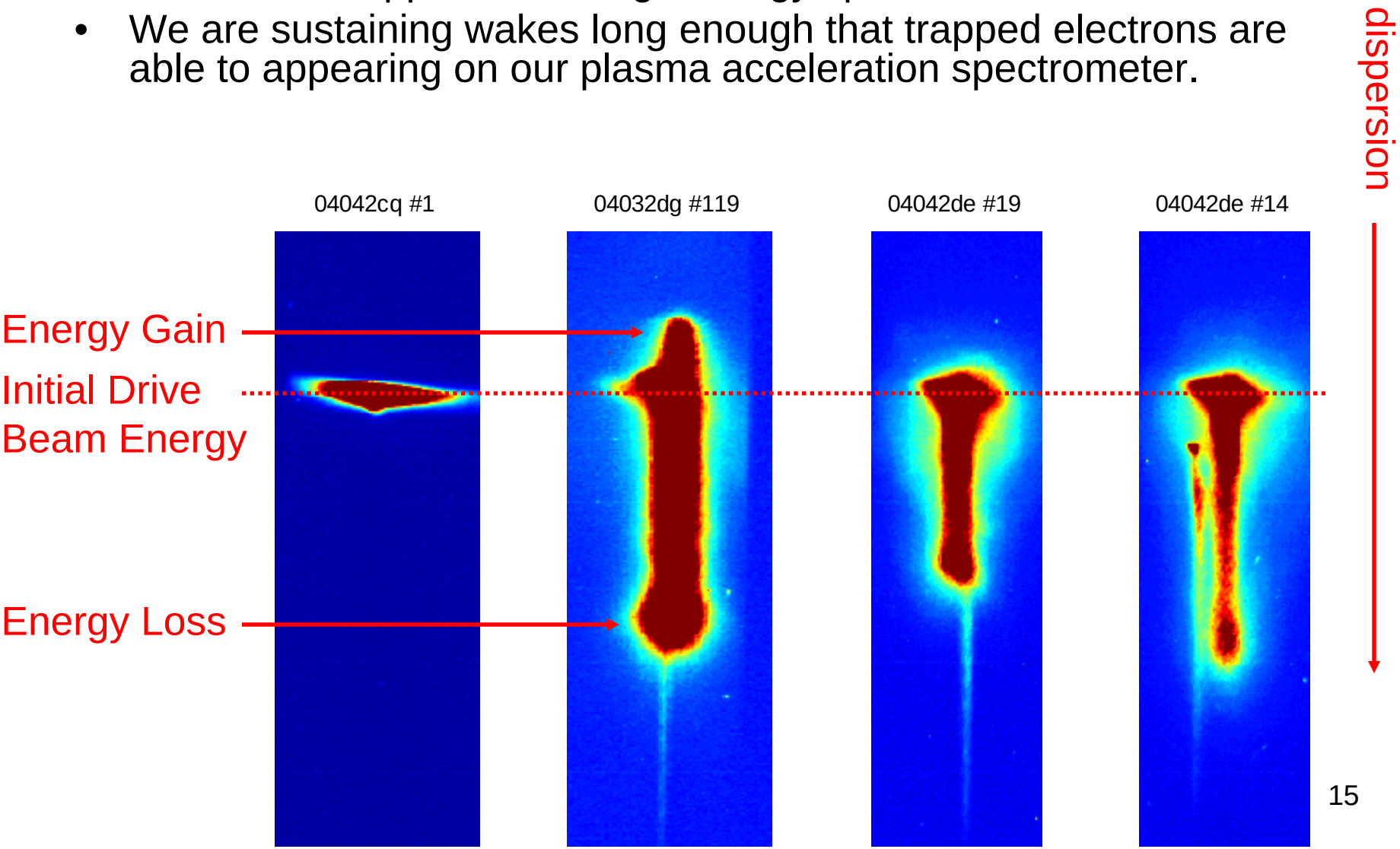
PWFA Acceleration

- Figures show a typical acceleration signature for a 30cm plasma oven.



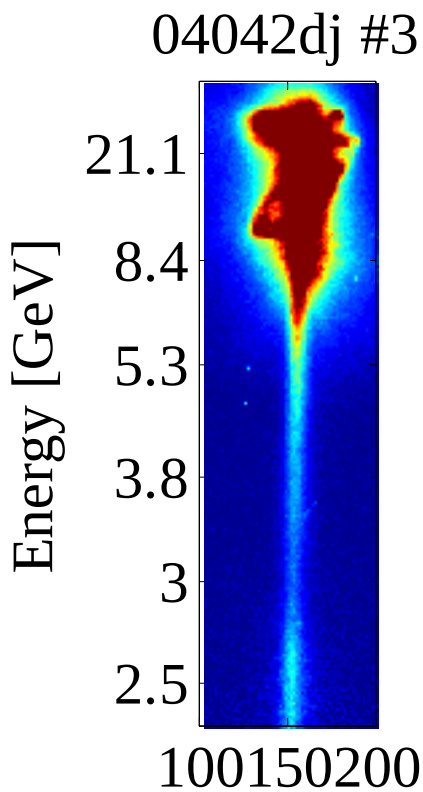
High Energy Trapped Electrons?

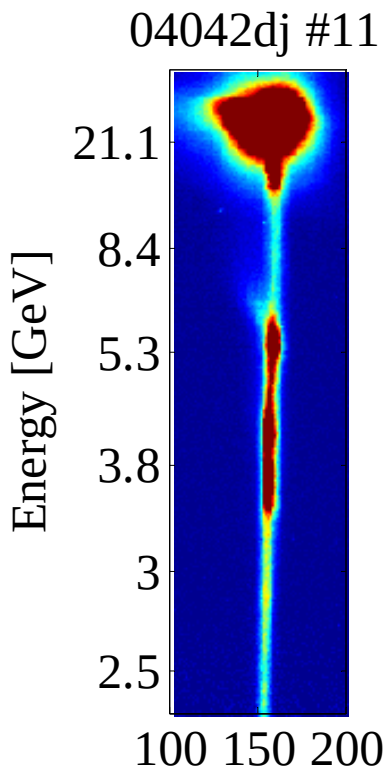
- Thin streaks appeared on high energy spectrometer.
- We are sustaining wakes long enough that trapped electrons are able to appearing on our plasma acceleration spectrometer.



Trapped Electron Streaks

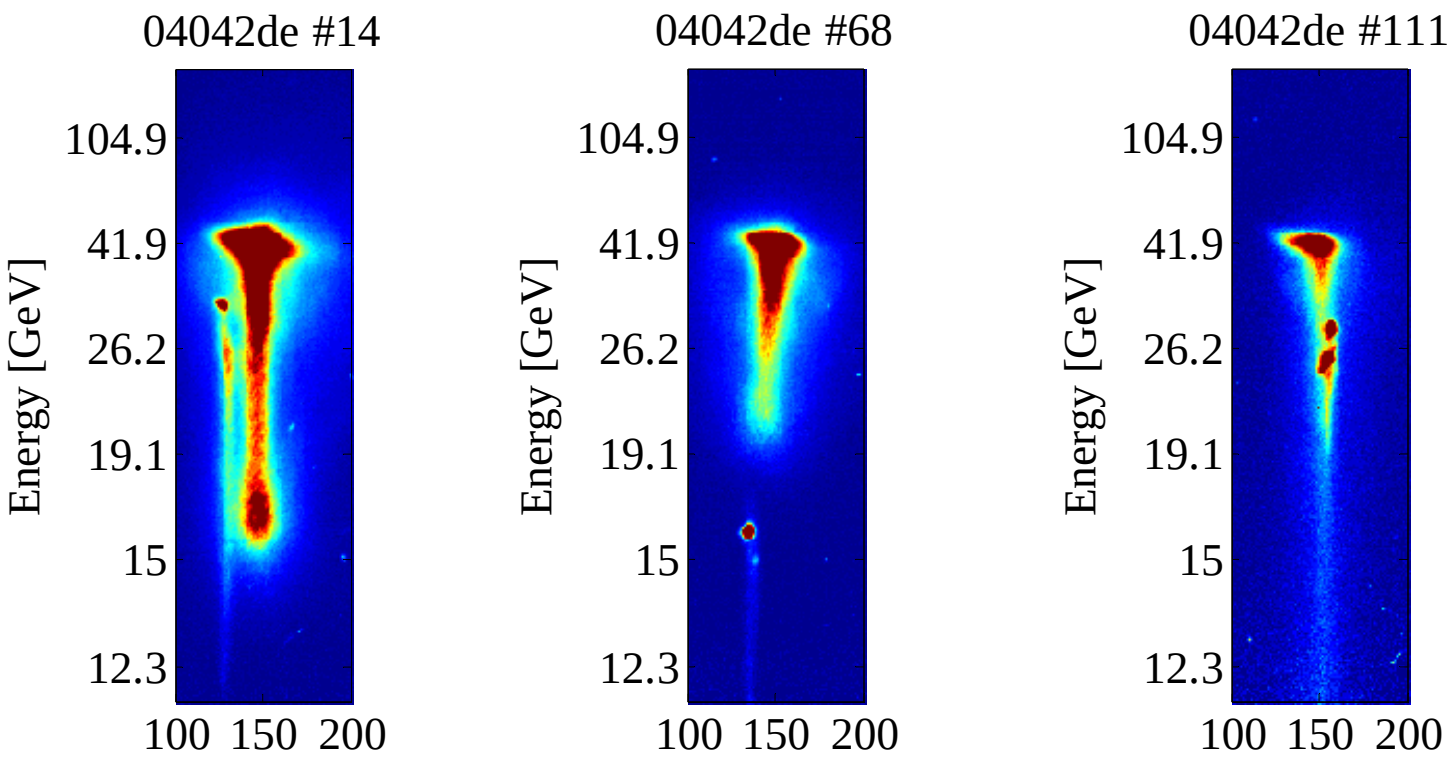
- Trapped electron streaks extend from 10's of GeV down to at least 2 GeV..





Mono-energetic bunches

- Mono-energetic bunches appeared.



Conclusion

- Most of the extra charge has energies at or below the 10 MeV level.
- There are trapped electron streaks with energies of a few GeV to tens of GeV.
- There are mono-energetic trapped electron bunches that appear with tens of GeV in energy.

M. Berry, I. Blumenfeld, F.-J. Decker, P. Emma, M.J. Hogan, R. Ischebeck, R.H. Iverson, N. Kirby, P. Krejcik, R.H. Siemann, and D. Walz*
Stanford Linear Accelerator Center

C.E. Clayton, C. Huang, D. Johnson, C. Joshi, W. Lu, K.A. Marsh, W.B. Mori, and M. Zhou*
University of California, Los Angeles

S. Deng, T. Katsouleas, P. Muggli and E. Oz*
University of Southern California

Work supported by Department of Energy contracts DE-AC02-76SF00515 (SLAC), DE-FG03-92ER40745, DE-FG03-98DP00211, DE-FG03-92ER40727, DE-AC-0376SF0098, and National Science Foundation grants No. ECS-9632735, DMS-9722121 and PHY-0078715.