Plasma Wakefield Acceleration

FNPL Advisory Meeting, Oct. 14-15, 2002
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Prepared with OpenOffice

Outline:

Introduciton and Impressions from AAC2002

Plasma-related activities at FNPL

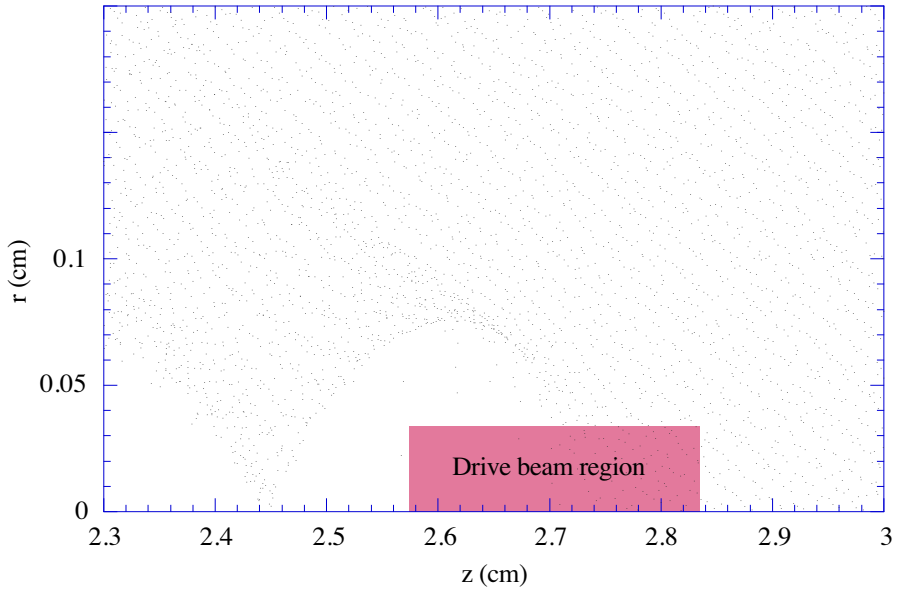
The plasma source - problems and solutions

Witness beam and beam loading

Introduction

Advantages of Plasma Wakefield Acceleration (PWFA):

- **Operates in intermediate wavelength range between RF cavities and laser-driven accelerators (our case: λ=3mm)**
- **Blow-out of plasma electrons provides linear focusing**



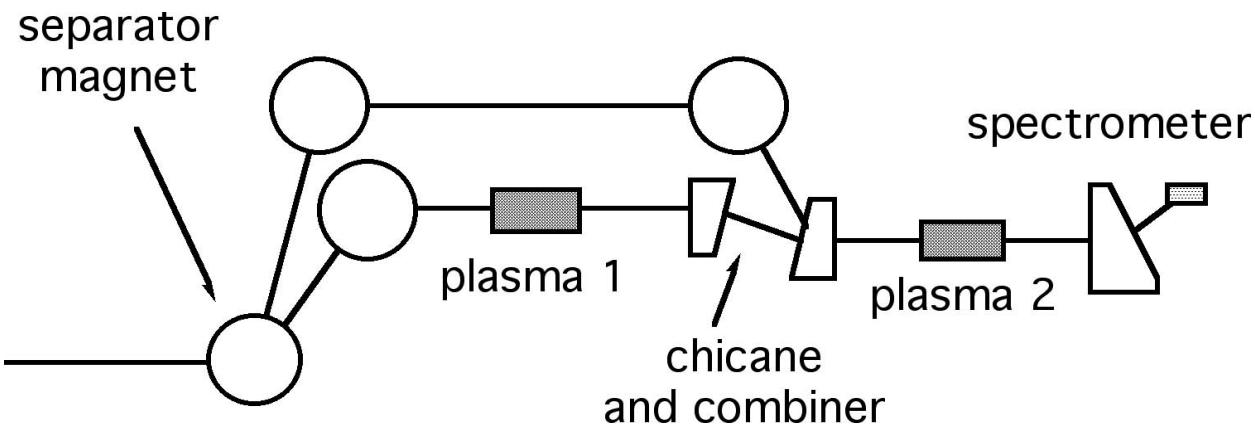
Impressions from AAC2002

- **Two approaches for future: the afterburner and staging.**

  afterburner-- single-pass plasma device at end of linac
  staging-- one work-horse linac drives many plasma stages

- **Three experiments that were reported on (SLAC E-162, LANL, FNAL) are all quoting gradients around 100 MeV/m**

FNAL can take a leading role in the staged approach



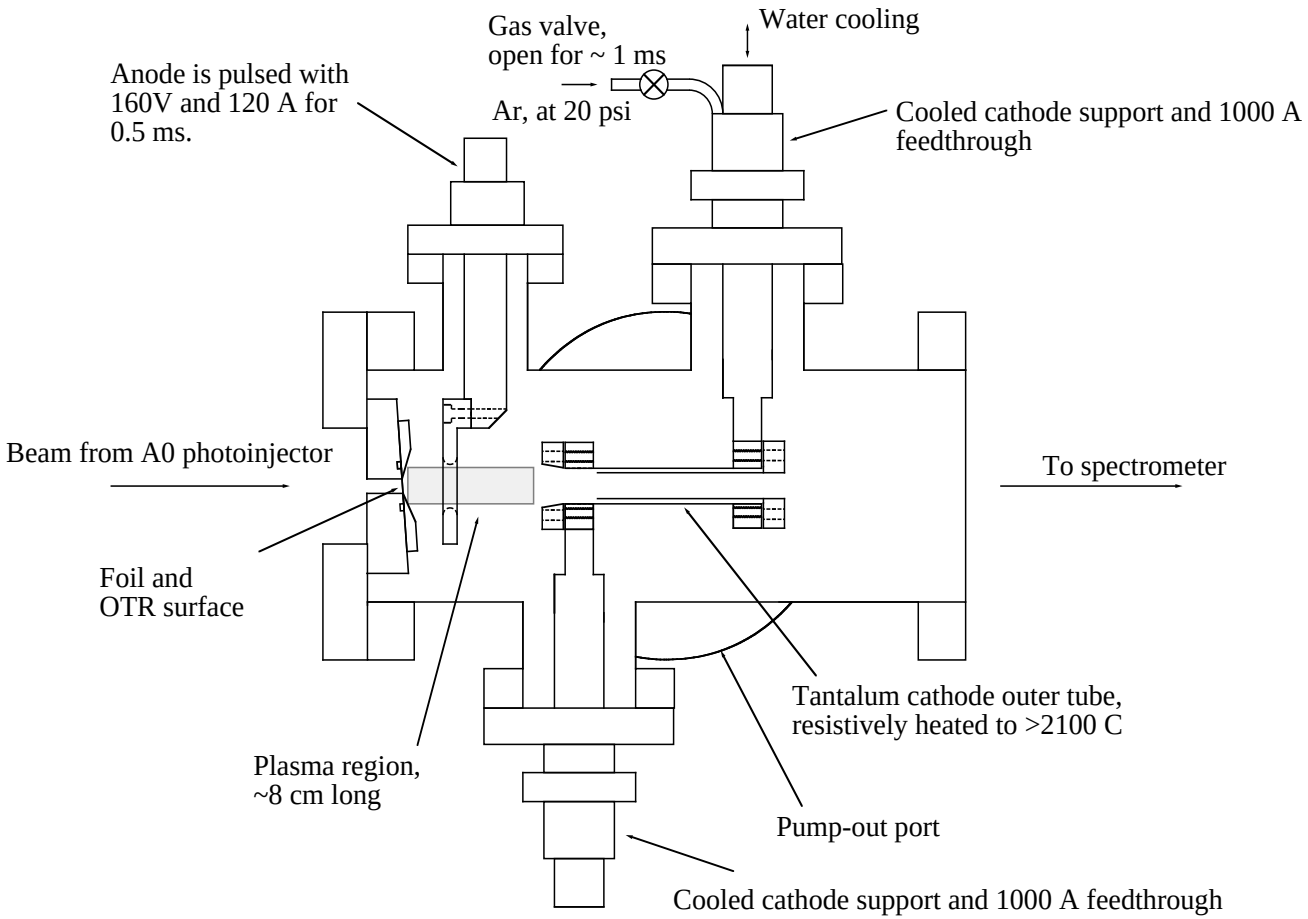
Present and future plasma activities

- **EOI's: Gennady Shvets - RF-driven plasma acceleration, Matt Thompson - Density transition trapping (collaboration with UCLA, J. Rosenzweig)**
- **Dan Bollinger (NIU student)**
- **Daniel Mihalcea**
- **Ioannis Sideris, computer cluster at NIU**
- **PWFA acceleration, deceleration, witness beam and beam loading studies**

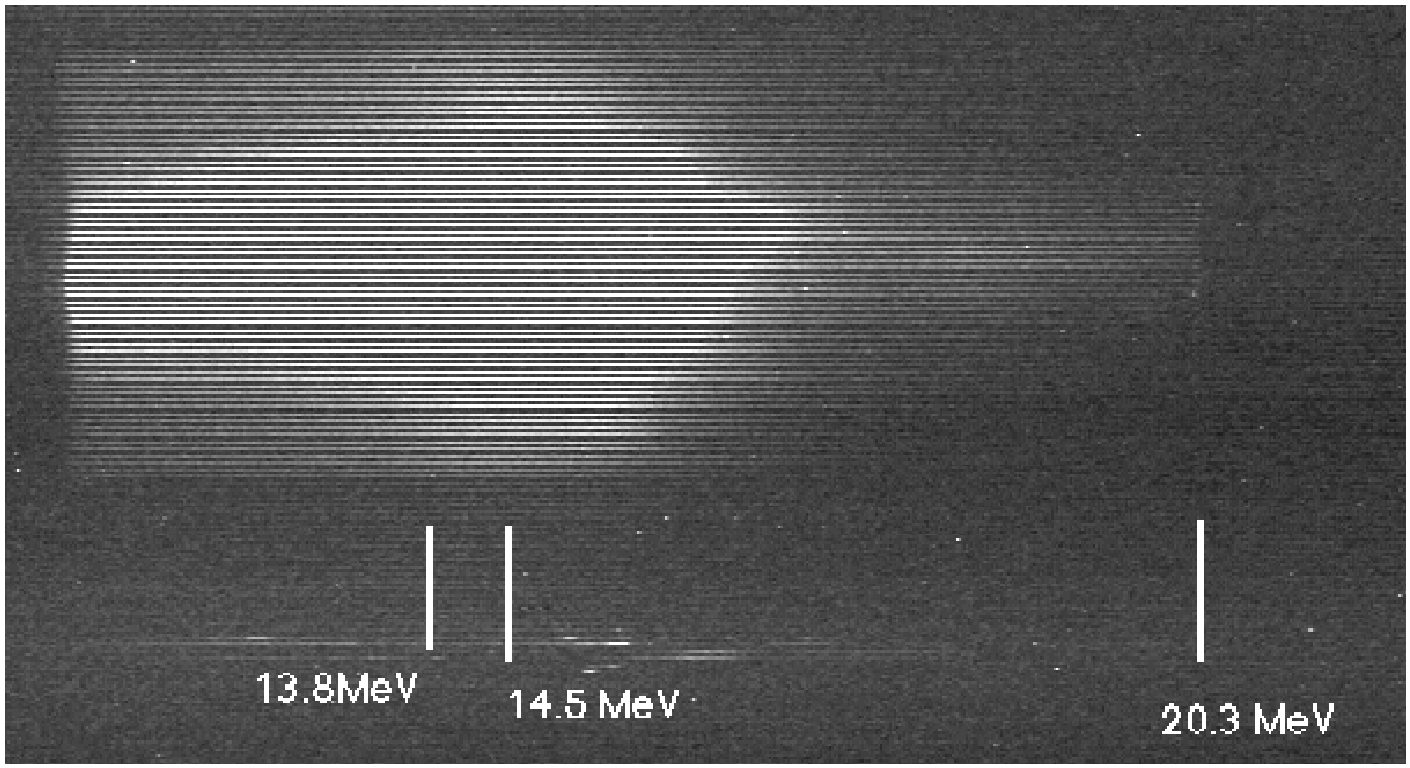
Plasma experiment timeline

3/2000(?) Photoinjector kept from being shut down in order to finish plasma experiment
8/2000 Plasma installed in beamline
9/2000 Huge deceleration of the drive beam recorded with some electrons being nearly stopped
6/2001 Last advisory meeting
9/2001 Window failure
9/01-present: Rebuild and test source; energy loss theory

Plasma chamber

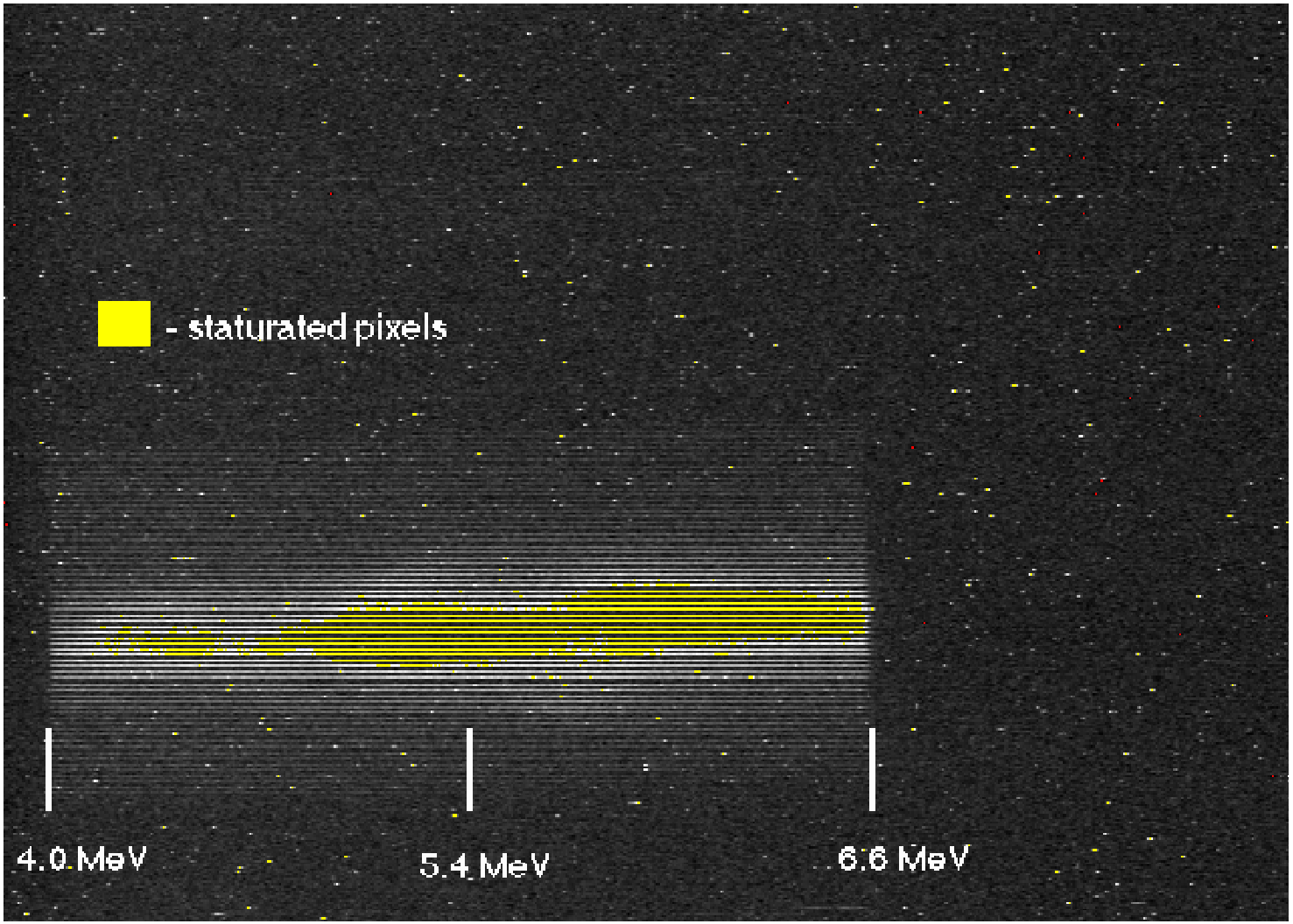


Results: acceleration

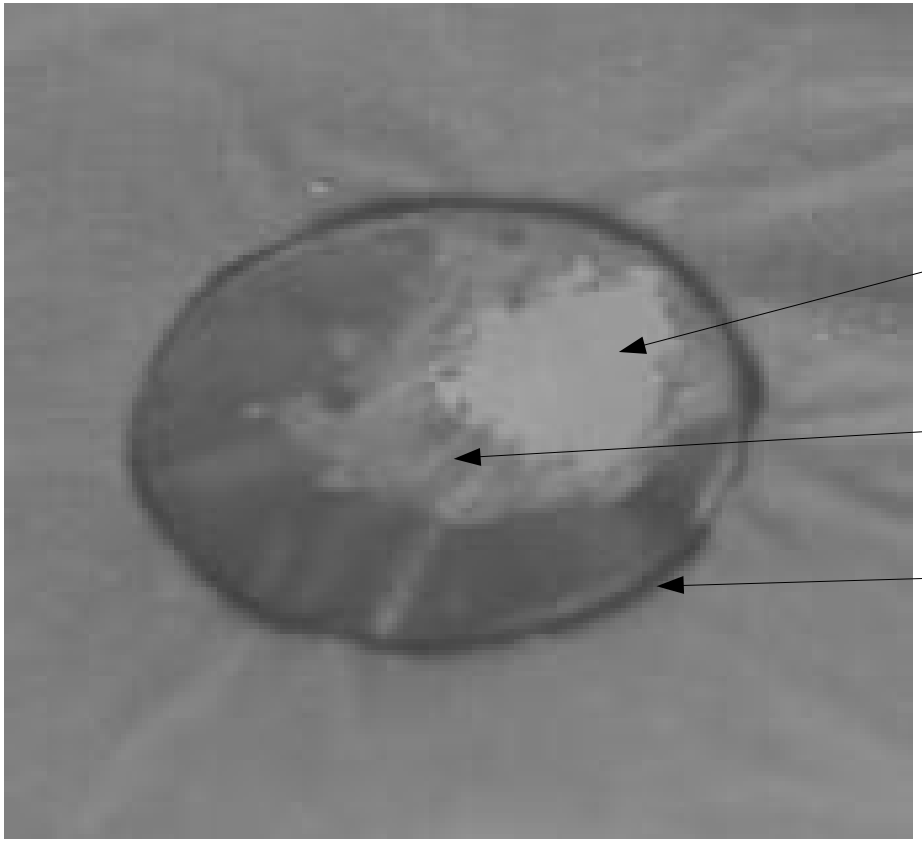


6-8 nC, 10^{14}/cc plasma, 1 mm σ_z

Results: deceleration

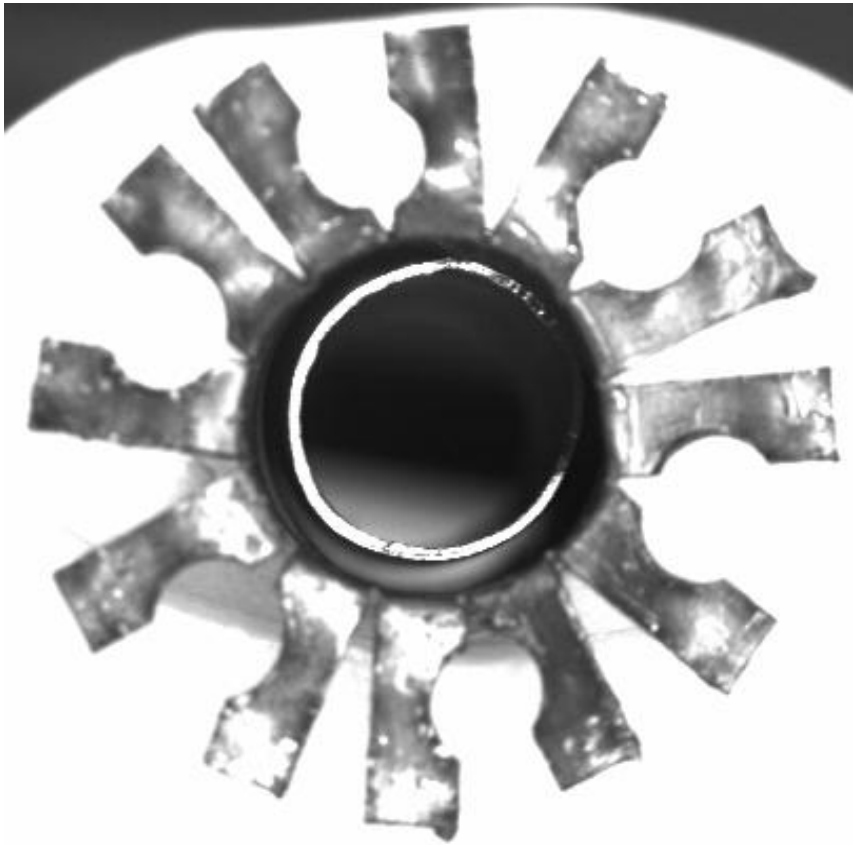


Window break

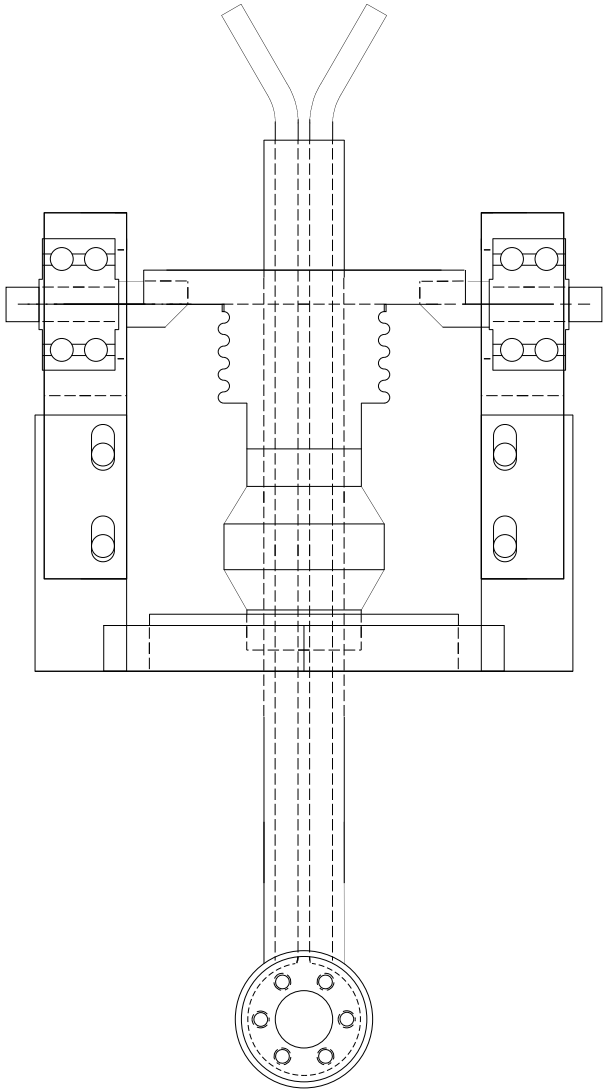


Ion bombardment on window will be reduced by biasing the cathode at -30 V (box has been built)

Damaged components

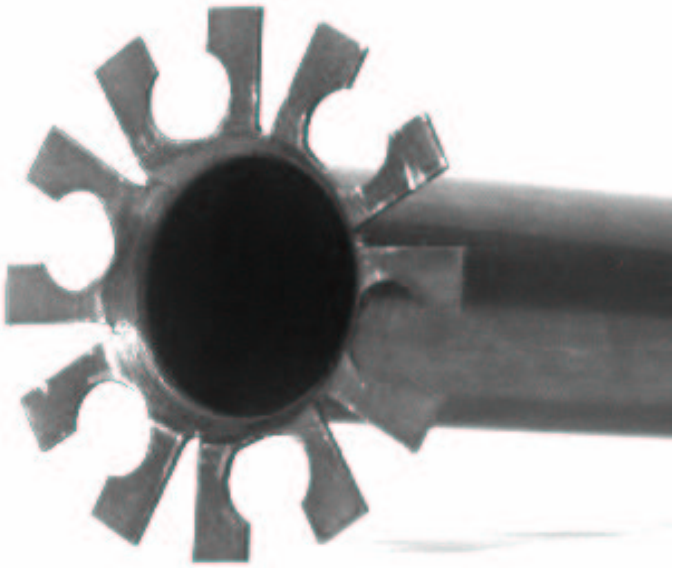


Improvements

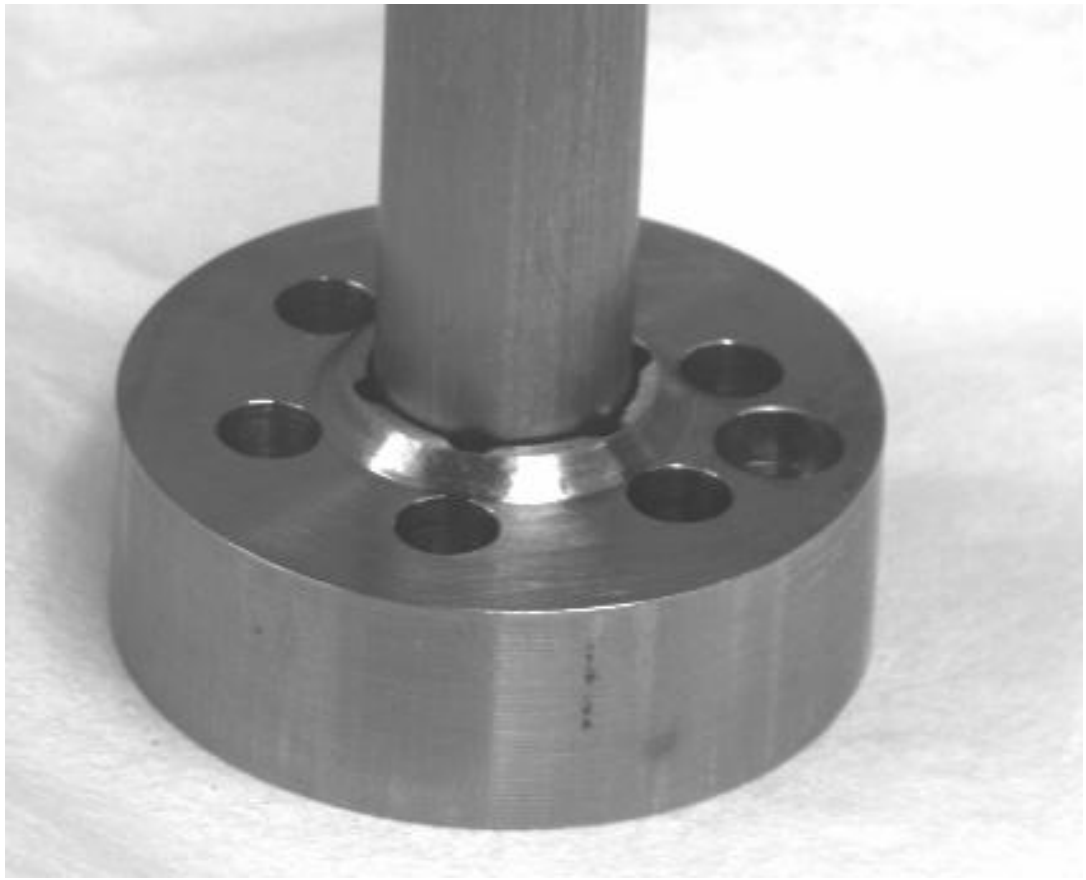


Bearings allow for heat expansion

EDM procedure simplifies fabrication



Improvements II



Redesigned flange after plasma operation (not much damage)

Copper heat sink draws heat toward water cooled area

Vacuum: 5×10^{-8} Torr at full cathode temperature

Conclusions

Initial results are very encouraging

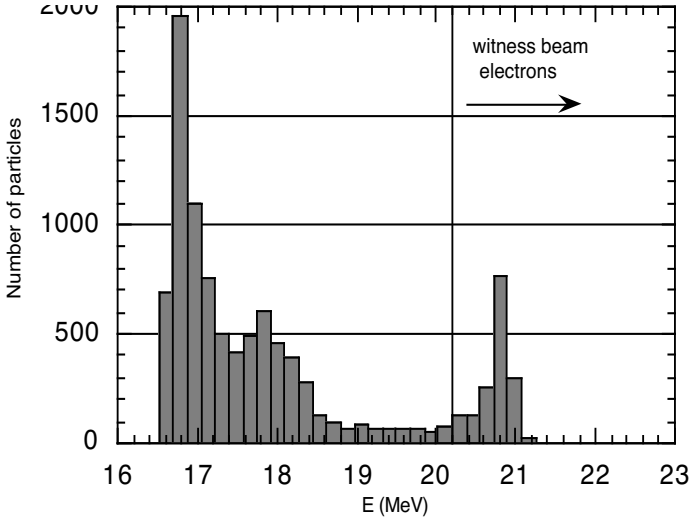
Reliability problems have largely been addressed

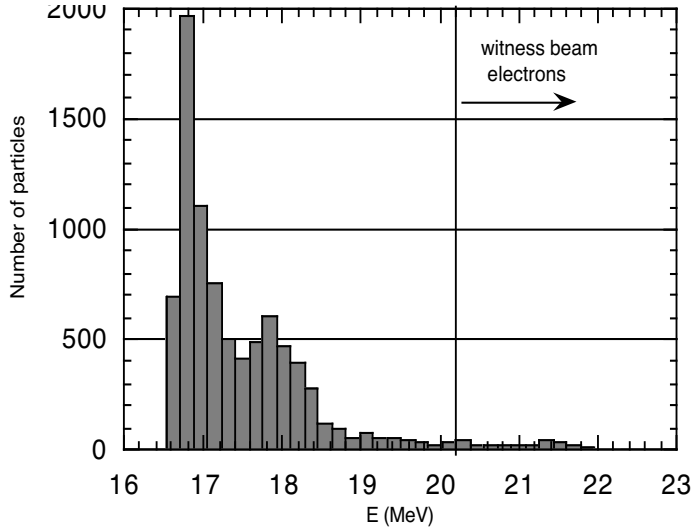
Next step: witness beam and beam loading

New experiments (Matt Thompson's talk)

Future studies: Beam Loading

The plasma wave has no 'crest', so the way to limit energy spread is through beam loading.





6.7 nC driver,
1.3 nC witness (1.1 ps σ_t)

6.7 nC driver,
170 pC witness