Final Focus Beamline Design

ARIES Meeting
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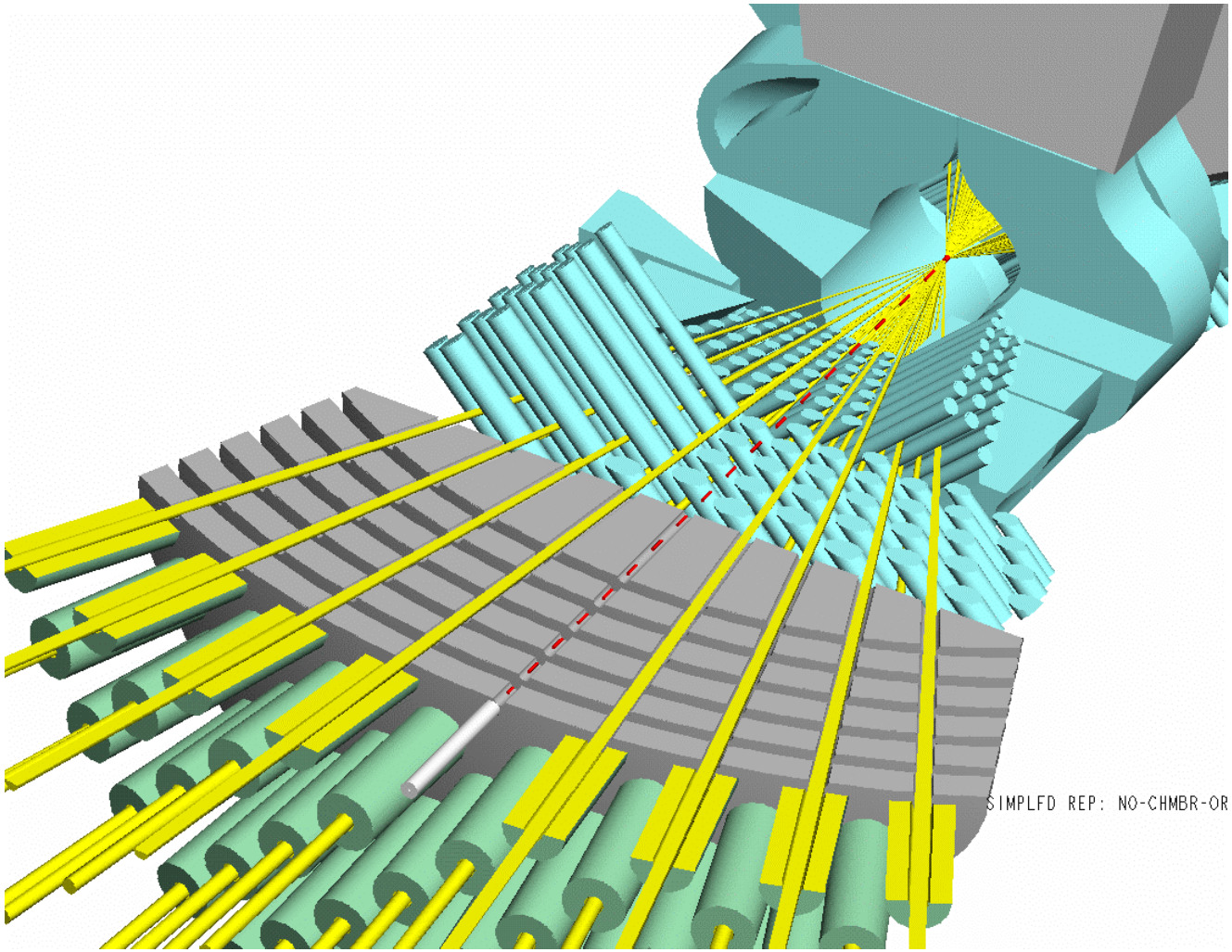
Collaborators:

J. Barnard, D. Callahan-Miller, C.Debonnel, P. Heitzenroeder, J. Latkowski, G. Logan, W. Meier, C. Olson, P. Peterson, D. Rose, W. Sharp, D. Vanecek, D. Welch,

Multiple beam paths around target chamber



Final Focus/chamber Interface Issues are Common to All Chamber Concepts and All Propagation Modes

- Final focus magnetic transport requirements:
  - well protected, high field, compact magnets
  - good vacuum (~ 10^{-6} torr)
  - clean metal surfaces - no surface flashover (must withstand self-field of ≤200kV/cm for ≥10ns)
- Pre-chamber neutralized drift section requirements:
  - plasma source for neutralization
  - differential pumping
  - shielding
  - debris removal (target and chamber material)
  - compact - (axially and radially)

Proposed Approach to Meet ARIES Goals

Step I. Ongoing point design study (ballistic neutralized drift through thick liquid wall chamber) for self-consistent scenario:

- target design
- beam propagation (final focus to target)
- chamber dynamics
- neutronics
- technology (magnet, plasma source, pumping)

Step II. Generalization to other chamber concepts and propagation modes - broad scoping to map out operating windows

Status of Point Design Study (April '02) - 1st Iteration

- Point design parameters from systems code - W. Meier
- First design of magnetic lattice (beam optics) - J. Barnard
- First layout of beamline elements (schematic) - S. Yu, P. Peterson
- Neutralized drift simulation with LSP - W. Sharp, D. Welch, D. Rose
- Target for large cone angle and enlarged footpulse spot - D. Callahan-Miller
- Chamber debris generation and deposition along beamline - C. Debonnel
- Debris removal with deflecting dipole - D.Welch

Work beginning in,

- Magnet design - PPPL/L. Bromberg
- Neutronics calculations - J. Latkowski
- INTEGRATED ENGINEERING-PPPL

Basic beam parameters for the final focus design were obtained from W. Meier, running his code IBEAM

Total beam energy = 6 MJ; Main pulse = 4.4 MJ; Foot pulse = 1.6 MJ
Number of beams = 112; amu = 131 (Xenon); q = 1.
final ion energy = 2.531 GeV gamma = 1.02074 beta = 0.200569

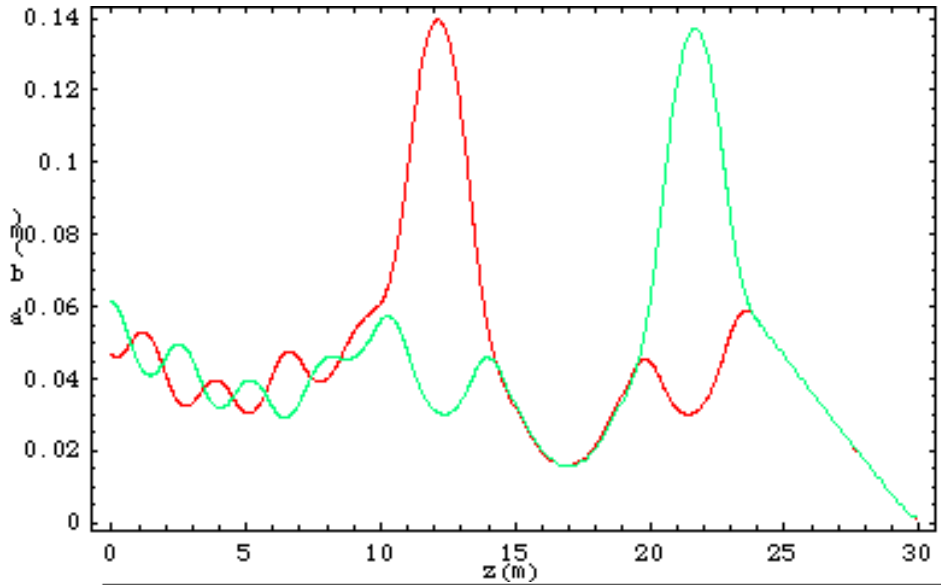
emittance (going into final focus) = 5.5 π mm-mrad (unnormalized)
normalized emittance (going into final focus) = 1.1 π mm-mrad (normalized)
(normalized emittance out of injector = 0.45 π mm-mrad (normalized))
(initial pulse duration= 30 μs; source radius = 3 cm)

current =2840 Amperes
perveance = 0.000162626
Neutralization factor (in chamber only) = 0.974

δp/p_rms = 0.00154
delta = 0.00533472 (full width, uniform distribution in δp/p)

Envelope and Pipe Radius for a 6-Magnet Final Focus Lattice

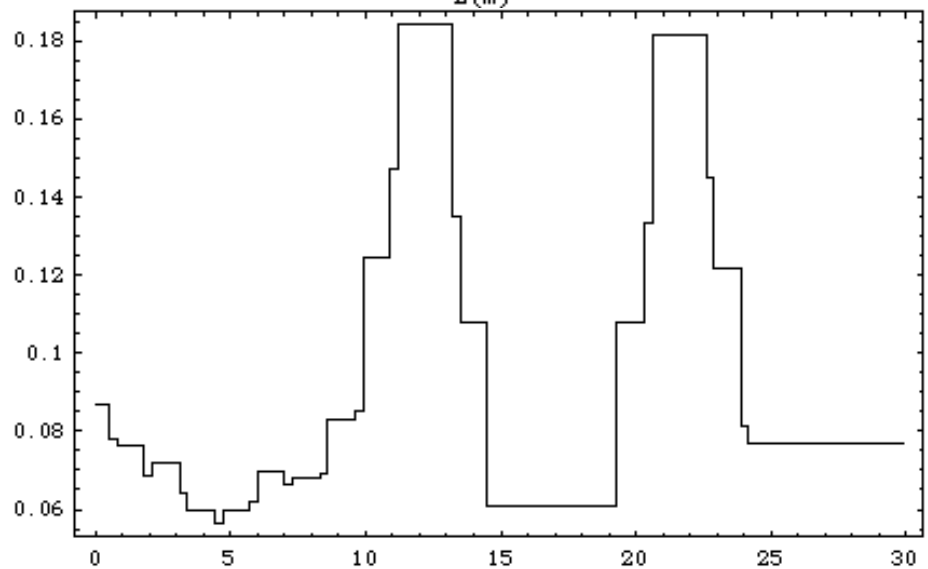
Beam envelopes in x and y



Final focus length = 6 m

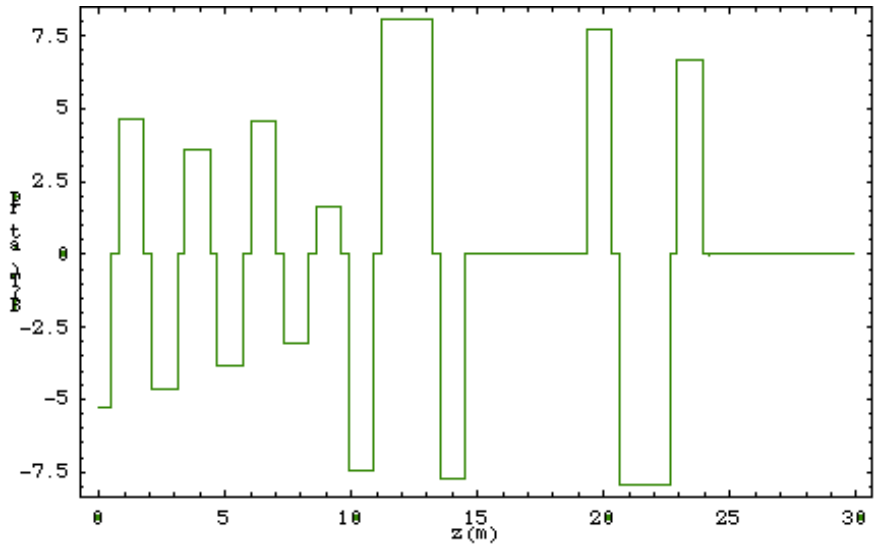
Final convergent angle θ = 0.010 rad

Pipe radius = 1.25*max(a,b in each section) + 1 cm

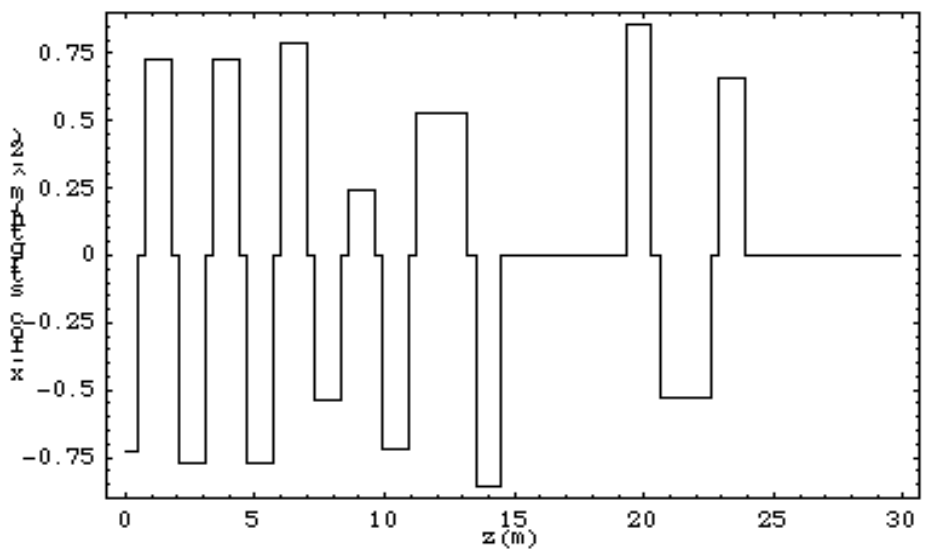


Quad magnetic field $B(r_p)$ and focusing strength ($B'/[B\rho]$)

Quad field at pipe radius $B(r_p)$ (T)



Focusing strength $K= B'/[B\rho]$



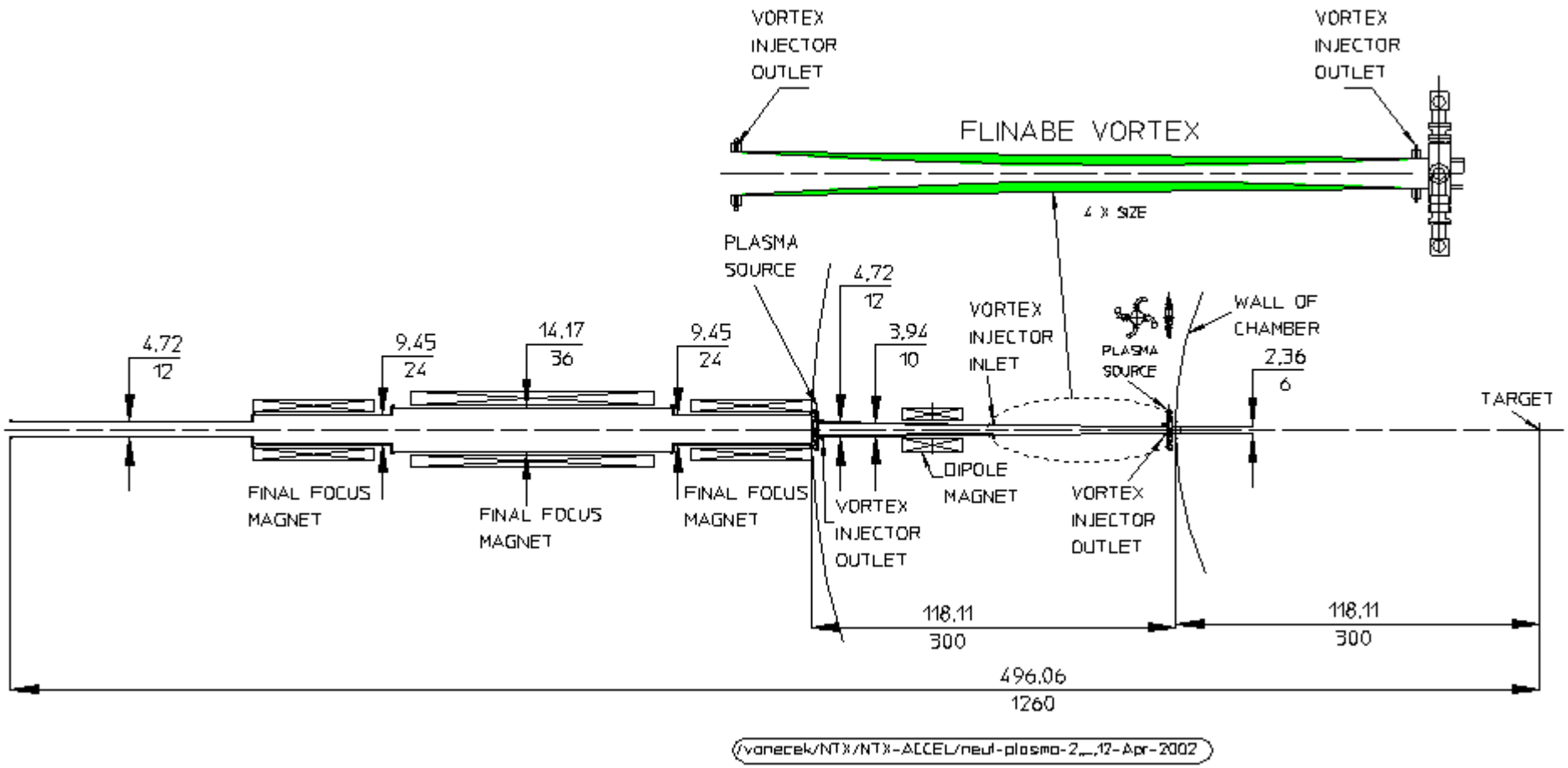
Magnet length: = 1 m

Exception: penultimate magnet length: = 2 m

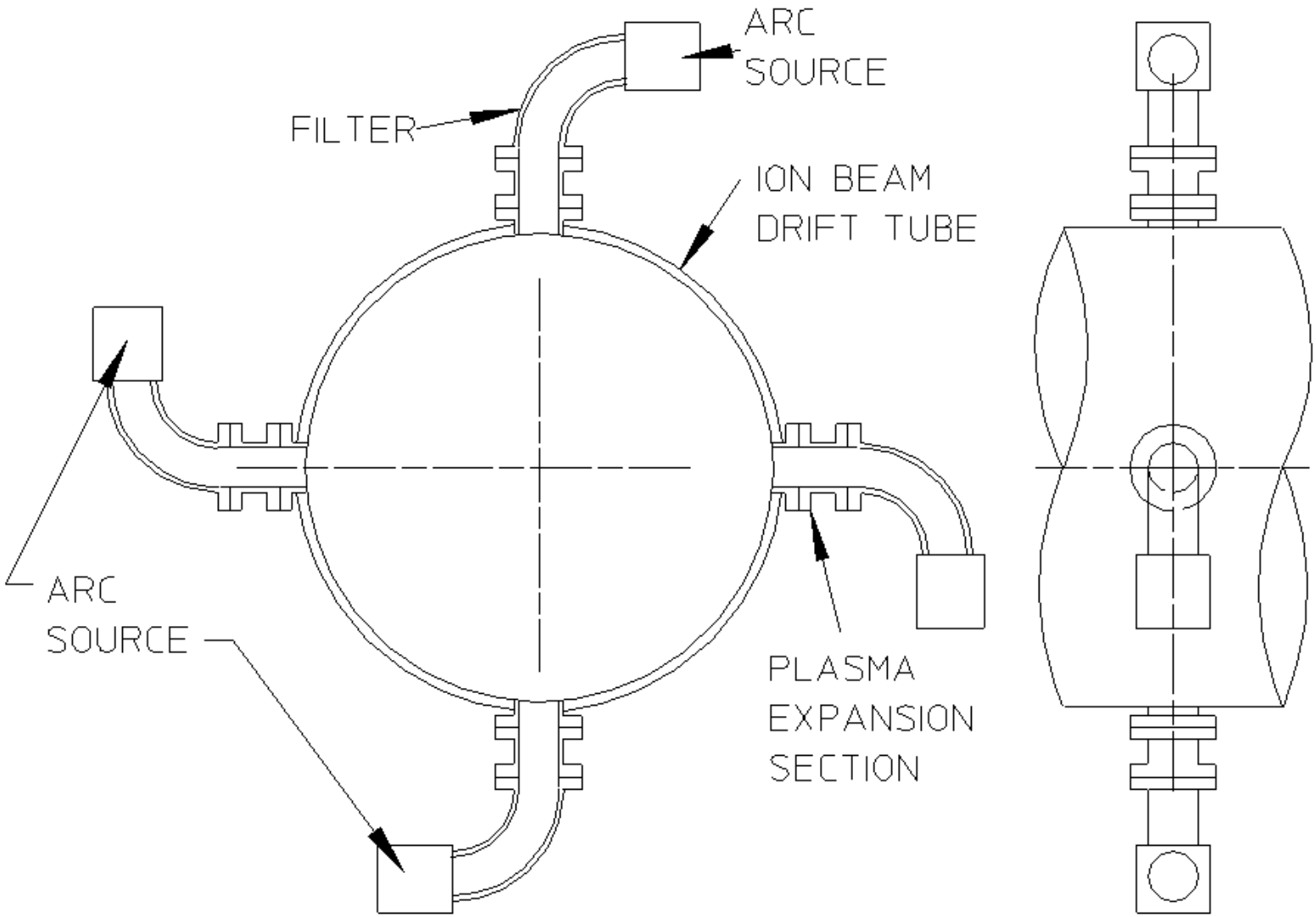
Spacing between magnets= 0.30 m

Dipole/drift section between tripletts: =4.8 m

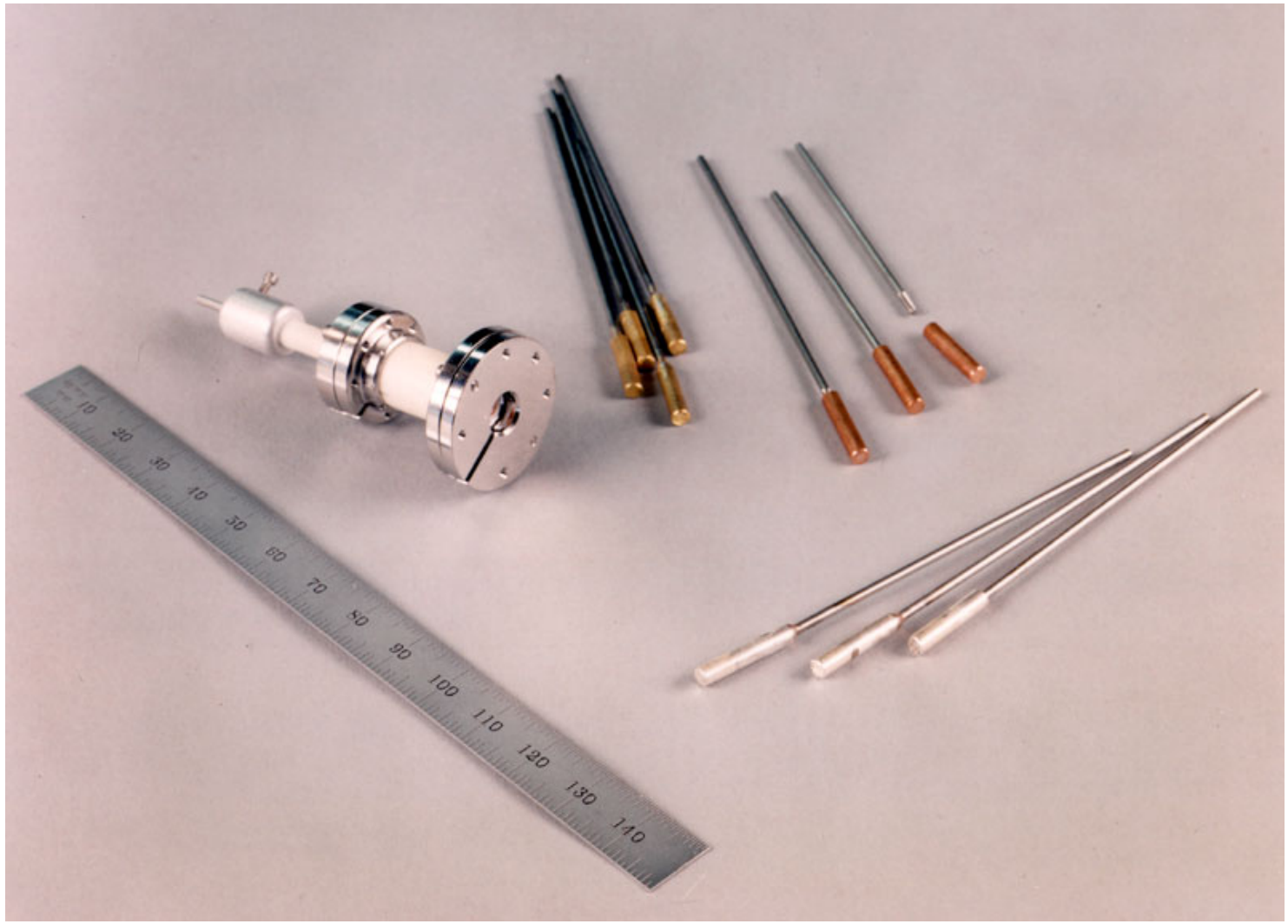
Final Focus Beamline Layout (April '02)



Plasma Arc Source



Arc Source Components

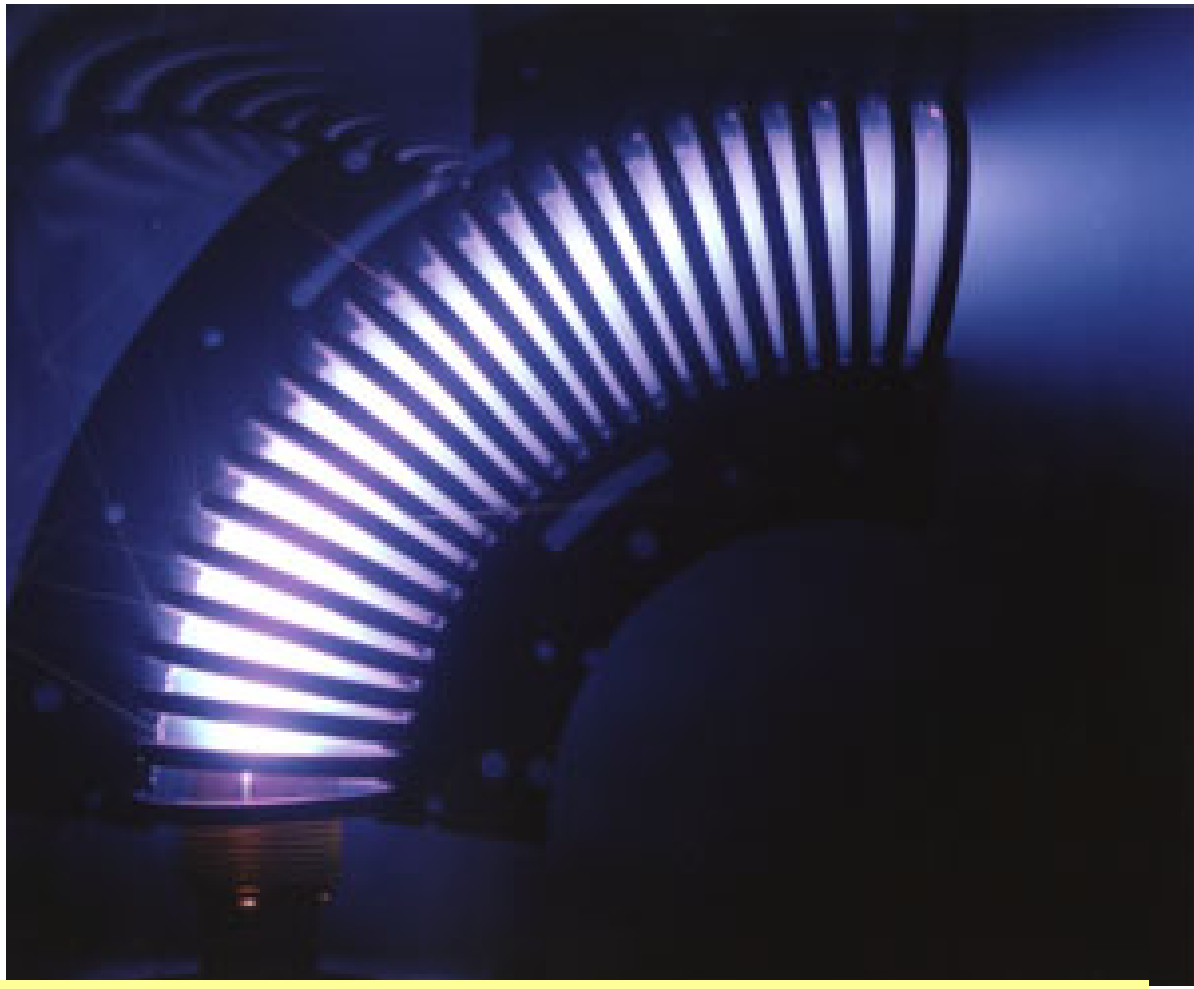


Open Plasma Filter

open 90° filter

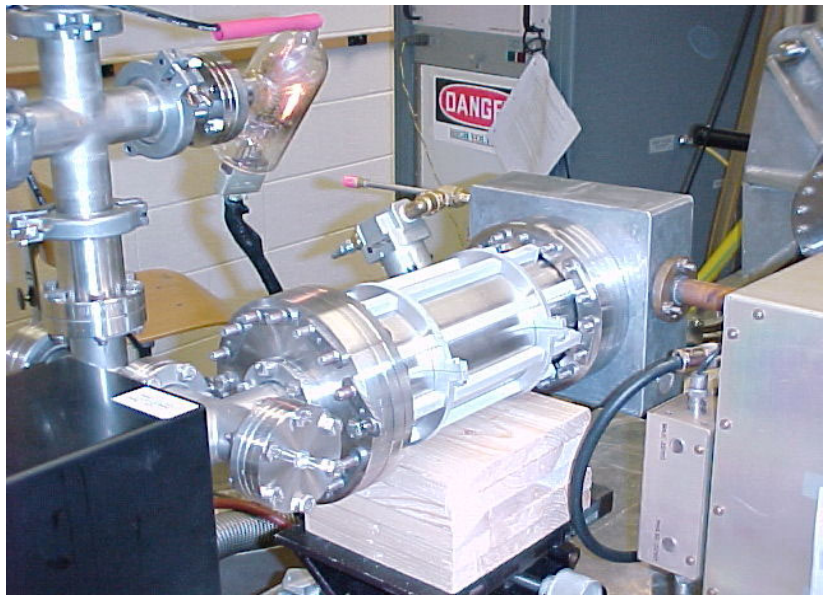
High current required (e.g. arc current in series)

Openings allow macroparticles to leave the filter volume



[A. Anders, Surf. Coat. Technol. **120-121** (1999) 319]

Neutralized Transport Experiment (NTX): RF Plasma Source



Neutralized Transport Experiment (NTX): RF plasma source.

- ECR source with homogeneous field produced plasmas at pressures down to 0.5 mTorr & 5e11 cm^{-3} density. Simulations & literature indicate a lack of confinement prevents lower pressure operation.

- Octopole cusp configuration for better radial confinement and operation at lower base pressure (February, 2002).

- Electrostatic rinng electrodes will be added to provide axial confinement (March, 2002).

Differential Pumping with FLINABE Vortices

- Low temperature FLINABE is very effective getter
- ASSUMING perfectly absorbing boundaries, density at last magnet (n_f) is given by

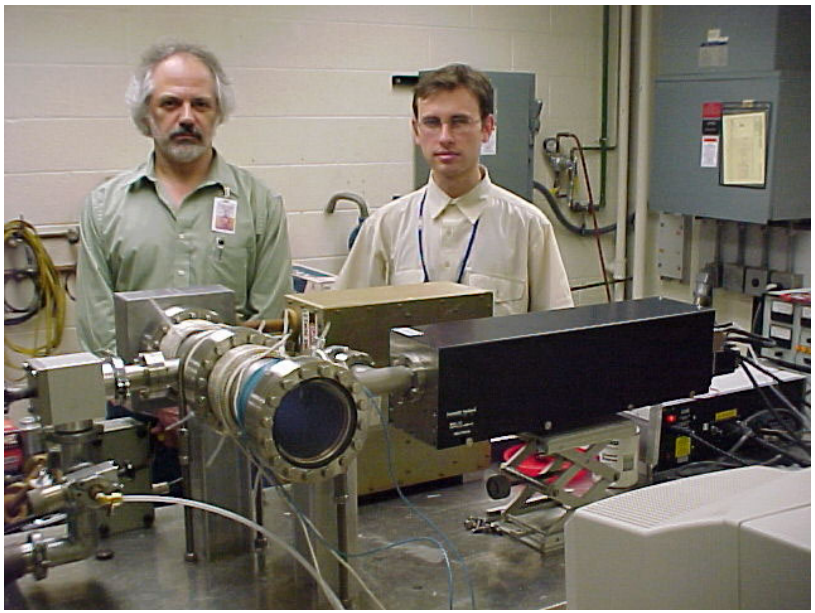
$$n_f = \frac{n_o}{2}\left(\frac{R_o}{L}\right)^2$$

Where n_o = ambient density in chamber
R_o = chamber port radius
L = distance from last magnet to chamber entrance

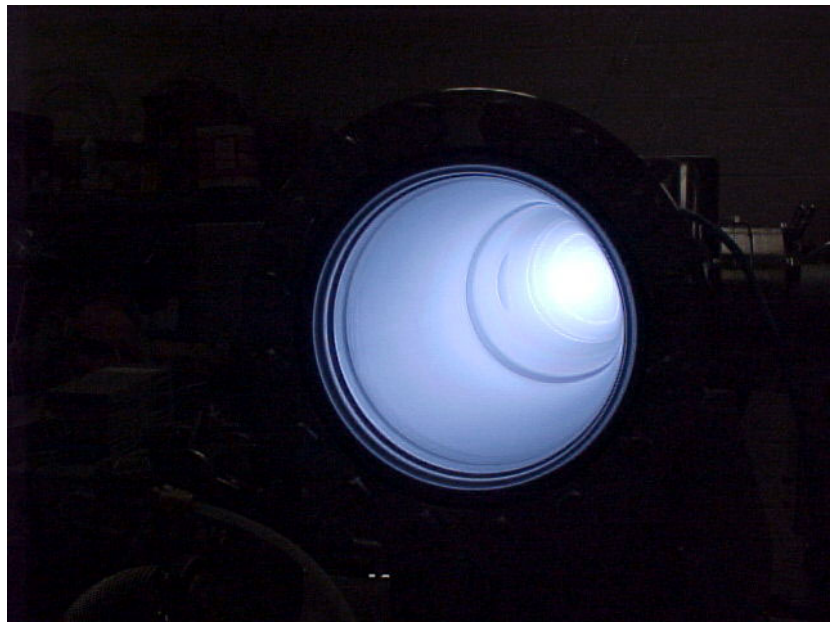
- For chamber at ~1 mT, L=3m, vacuum in magnetic section can reach 10^{-7} torr range

Extra Slides

ECR Plasma Source Works Reliably



Plasma source with Langmuir probe.



ECR Plasma at 0.5 milliTorr and Argon gas.