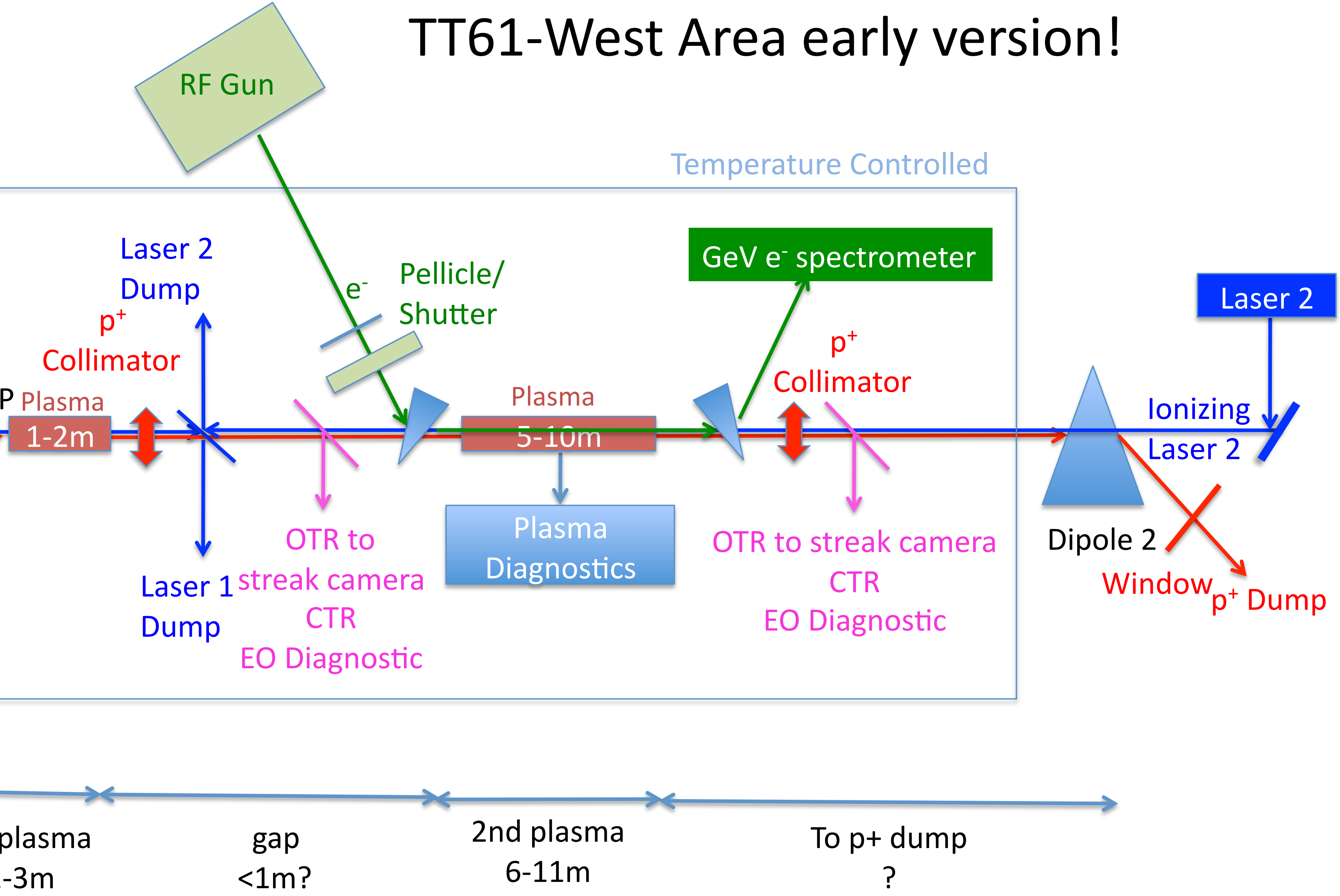
y of the nominal design

P. Muggli

ng collaboration discussions

TT61-West Area early version!

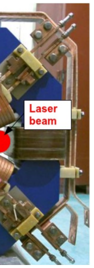


NOT TO SCALE!

- Need long er
  (>10m?)
- Entire systen
  Dipole 2) unc
- Length of fin
- Need quadru
- What distanc
- e- injection a
- Is the laser d
- Can the p+ b

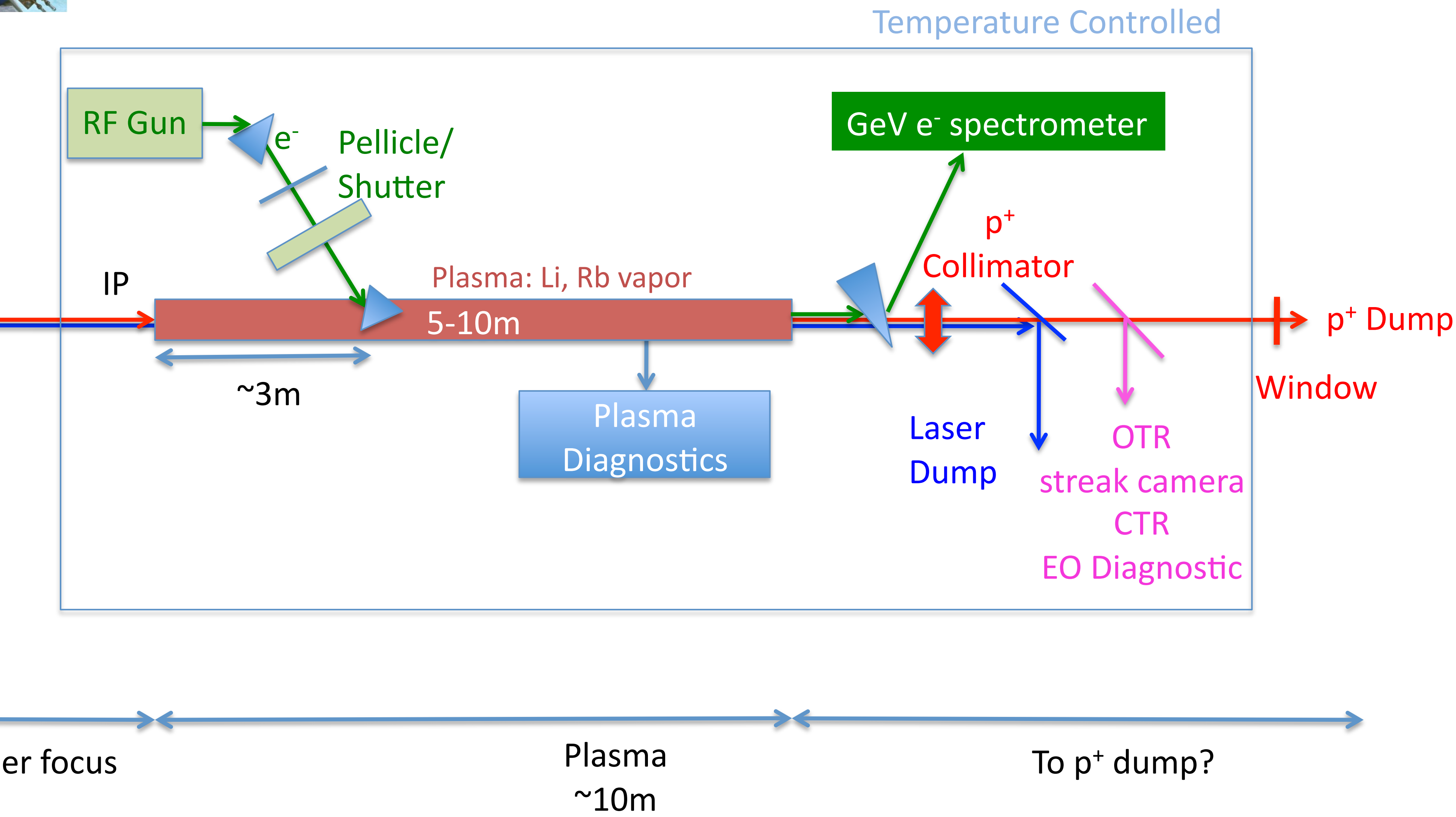
Critical iss

Plasma de
Resonant



A. Petrenko

TT61-West Area version!

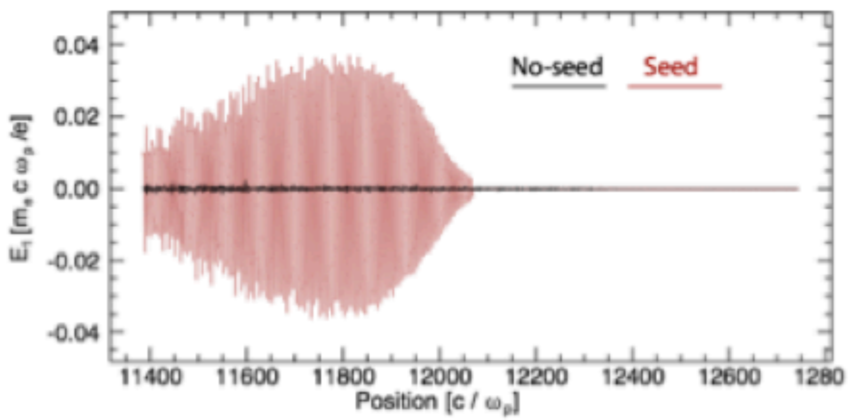


NOT TO SCALE!

- Need long er
- Entire systen
- Length of fin
- Need quadru
- e^- injection a
- Energy in the
- Spectromete
  particle dete
- Is the laser d
- Can the p^+ bu
  (alternative t
- p^+ collimatio

proton bunch simultaneously

Laser seeding of SMI in OSIRIS



Equation for the laser envelope
Ponderomotive guiding center

Equation for laser pulse envelope:

$$\partial_\tau a = \frac{1}{2 i \omega_0}\left[\left(1+\frac{1}{i\omega_0}\frac{\partial}{\partial \xi}\right)+\nabla_\perp^2 a\right]$$

τ=t; laser frequency; ξ=x-ct; laser envelope

D. Gordon, W. Mori, T. Antonsen, IEEE-TPS, **28** 1135-1143 (2000).

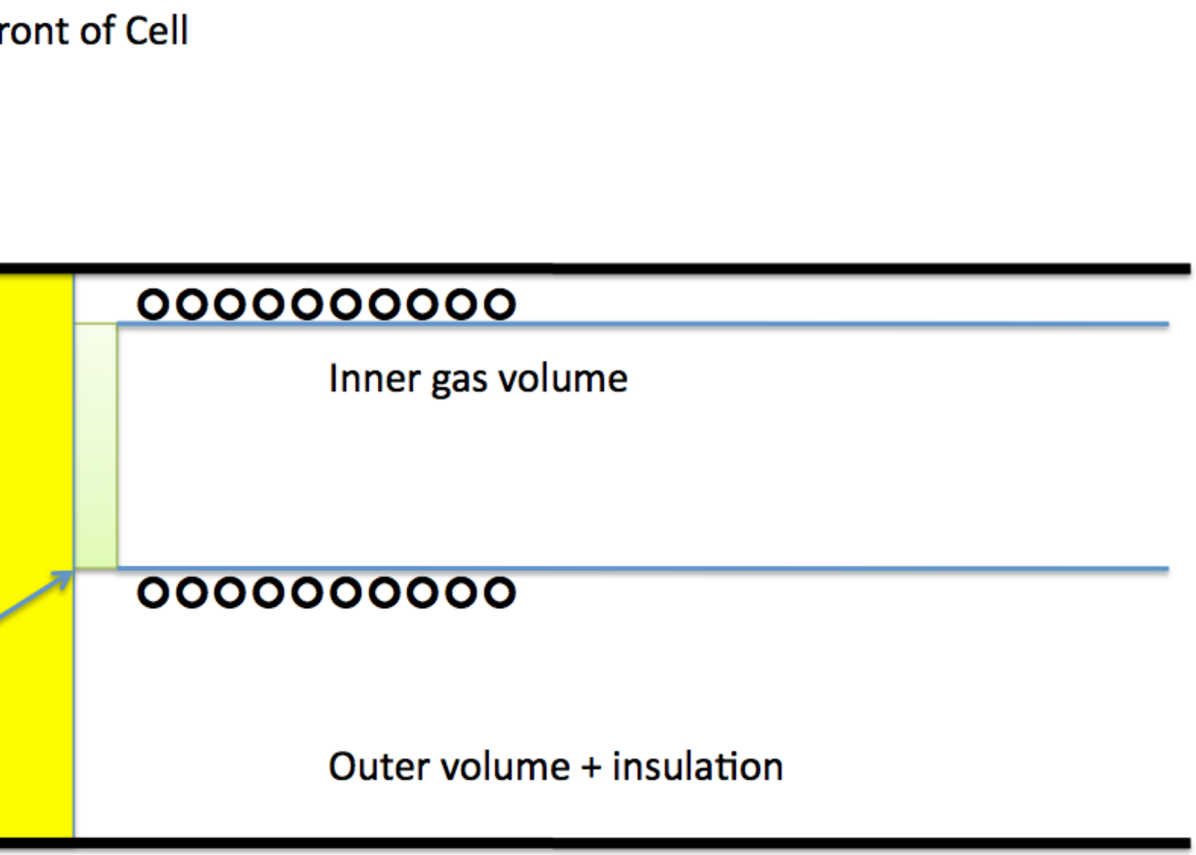
Self-modulation seeding:

Needed for injection of the e^- to be accelerated

Short ($<\lambda_{pe}\sim$1.5mm), co-propagating ionizing laser
- Minimum time evolution of the plasma density
- Best all together

Note: other seeding options were considered
- Cut beam
- Preceding short laser pulse
- Preceding short e^- bunch (seed hosing)

Determine plasma radius (laser pulse energy $\sim r^2$)
Take into account vapor index of refraction (Li λ=67
Laser wavelength?
Avoid inner e^- ionization



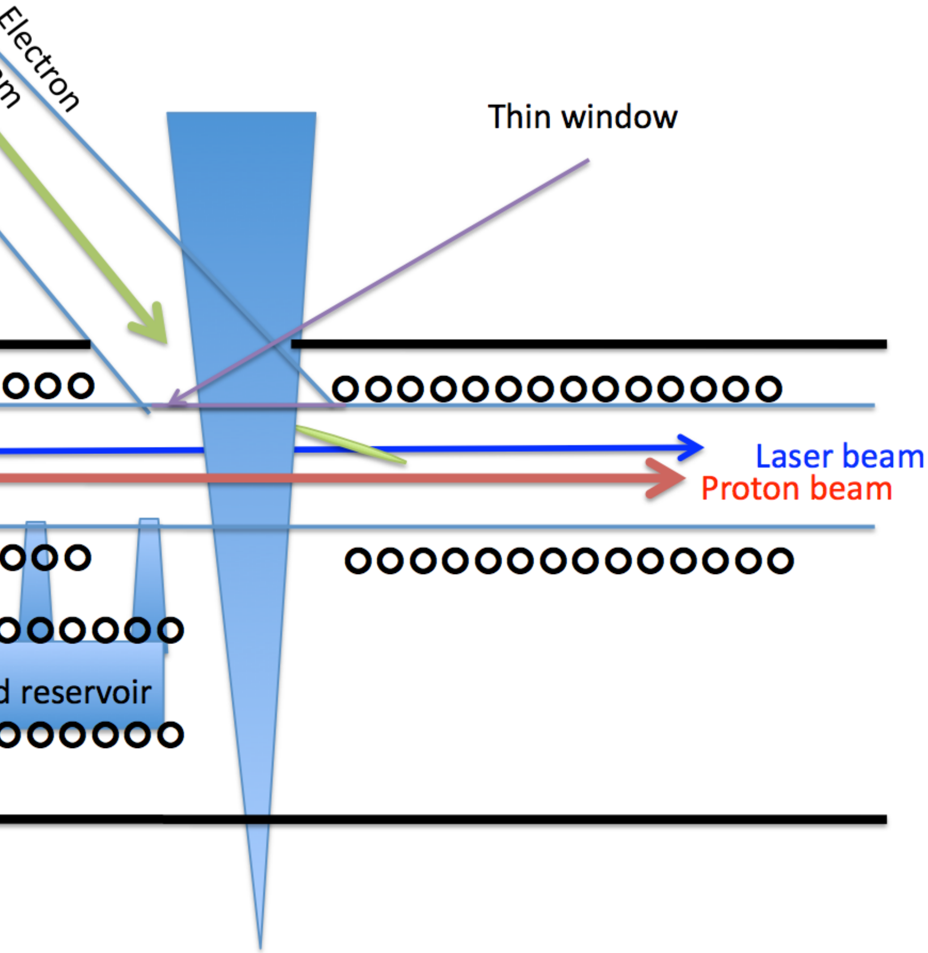
Density uniformity requirements: 0.1%!!!

Solution:?
Metal vapor (no liquid/vapor interface, ver
Laser pulse field ionization (threshold proc
SMI seeding by ionization front inside the p

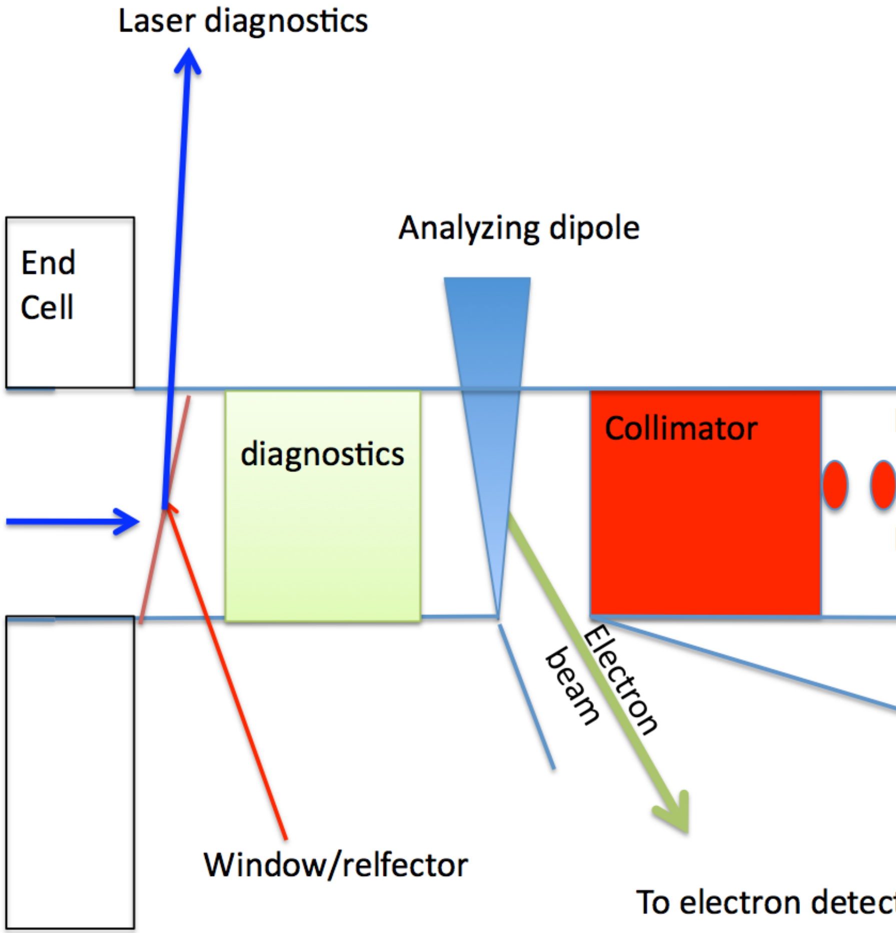
Options:
Fast valves
Buffer gas to slow expansion/rarefaction, c
Larger volume near the ends

Issues:
Valve operation at high temperature (~250
Valves opening time (as short as possible)
Pressure/shock wave

e^- injection



Plasma en



Beam diagnostics:
Optical transition radiation (OTR) + fs stre
Electro-optic sampling (O. Reiman, R. Tarl
Photon acceleration

osed solution (V. Yakimenko)

d to include:

nostic ~0.75m long

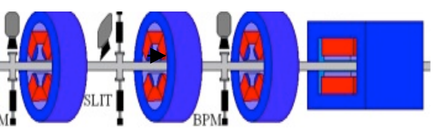
doublet ~1.75m

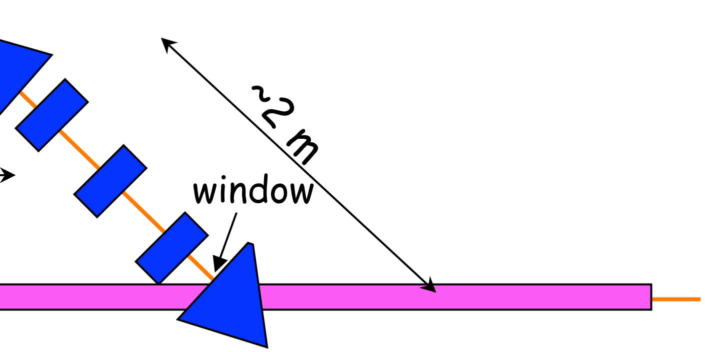
~1.5m offset

p to 300G/cm (trivial, air cooled)

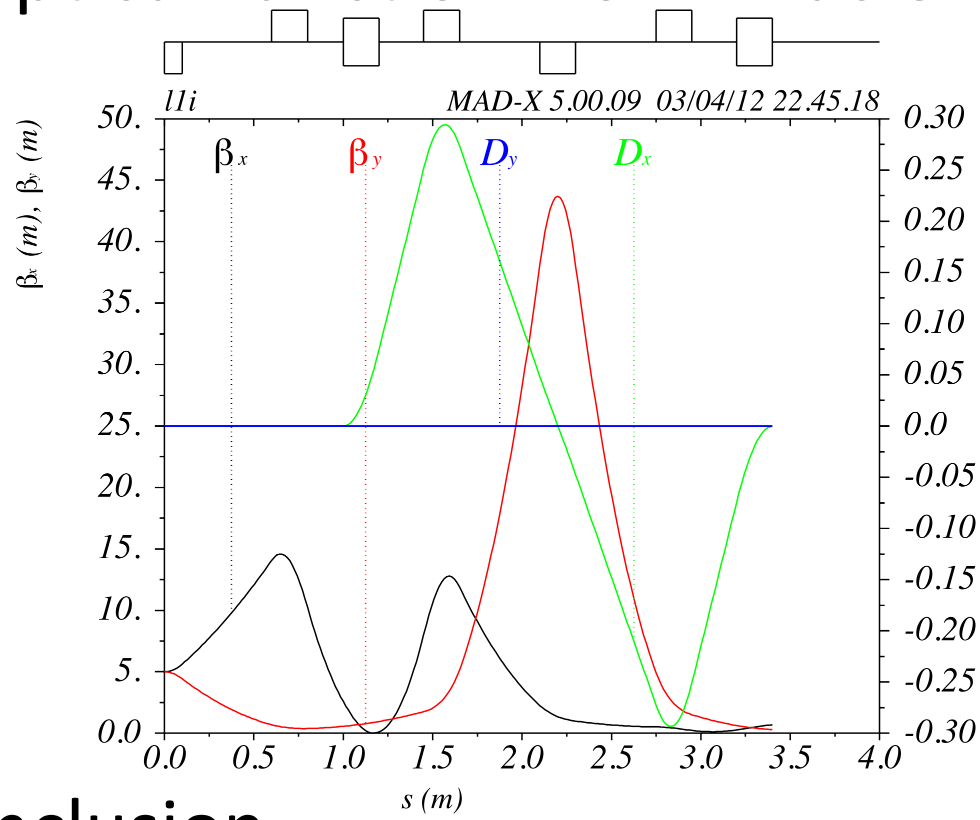
G, R~13cm, 20 cm long. Not trivial

by a single 20 MW klystron



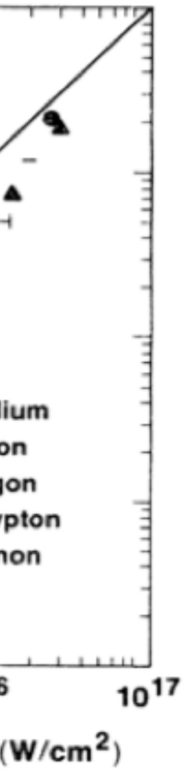


Optical function from linac exit



Conclusion

- Scattering in the window located 20 cm from the injection point will lea ~3mrad angular spread (RMS) (nice Gaussian distribution).
- Non trivial/custom injection dipole. (design depends on the plasma cel
- Window need to be investigated: 1mmx 0.5 mm x 2micons was used at (at room temperature!).
- Window can be installed at the entrance of the first dipole and collimat beam size at the injection point at the cost of intensity. (difficult for e^-



termined and
sing a simple
ct agreement.

Parameter	30 fs, 800nm	1 ps, 1057 nm
ϕ_{ioniz} [eV]	4.177	*
I_{ioniz} [Wcm^{-2}]	1.67×10^{12}	*
σ_{rb0} [μm]	200	*
$N_{\sigma_{rb0}}$	4	*
$N_{\sigma_{rl0}}$	$1/\sqrt{2}$	*
σ_{rl0} [μm]	1273	*
z_R [m]	6.37	4.81
z_{ioniz} [m]	6.78	5.13
I_0 [Wcm^{-2}]	2.14×10^{12}	*
L_p [m]	5	*
$V_{ionized}$ [cm^{-3}]	0.054	0.055
n_e [cm^{-3}]	6×10^{14}	*
E_{ioniz} [mJ]	21.5	22.3
E_{I_0} [mJ]	0.26	8.6
$E_{tot} = E_{ioniz} + E_{I_0}$ [mJ]	21.7	30.8
P_{ioniz} [TW]	0.73	0.031

Table 1: Parameters for the ionization of a rubidium vapor for two laser pulse lengths and wavelengths. The *s indicate the same value in both cases.

Parameter	30 fs, 800nm
ϕ_{ioniz} [eV]	5.392
I_{ioniz} [Wcm^{-2}]	4.63×10^{12}
σ_{rb0} [μm]	200
$N_{\sigma_{rb0}}$	4
$N_{\sigma_{rl0}}$	$1/\sqrt{2}$
σ_{rl0} [μm]	1273
z_R [m]	6.37
z_{ioniz} [m]	6.78
I_0 [Wcm^{-2}]	5.95×10^{11}
L_p [m]	5
$V_{ionized}$ [cm^{-3}]	0.054
n_e [cm^{-3}]	6×10^{14}
E_{ioniz} [mJ]	27.7
E_{I_0} [mJ]	0.71
$E_{tot} = E_{ioniz} + E_{I_0}$ [mJ]	28.4
P_{ioniz} [TW]	0.95

Table 2: Parameters for the ionization of a lithiur lengths and wavelengths. The *s indicate the sam

$E_{ioniz} \propto \sigma_{rl0}^2$ Need to determine required plasma radius ...!!!!

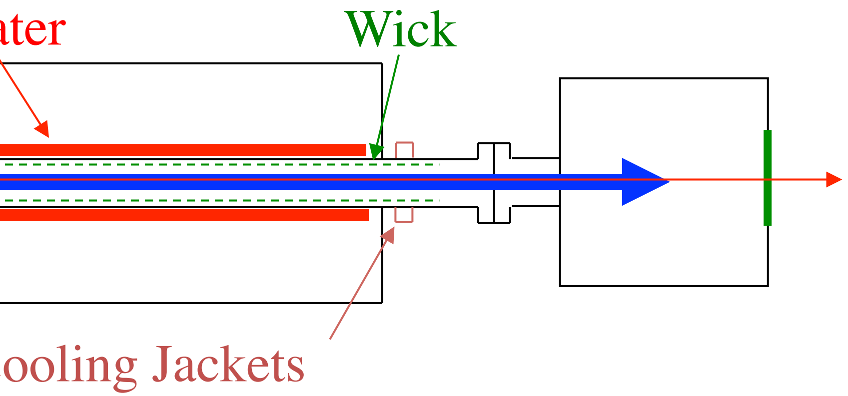
Options:

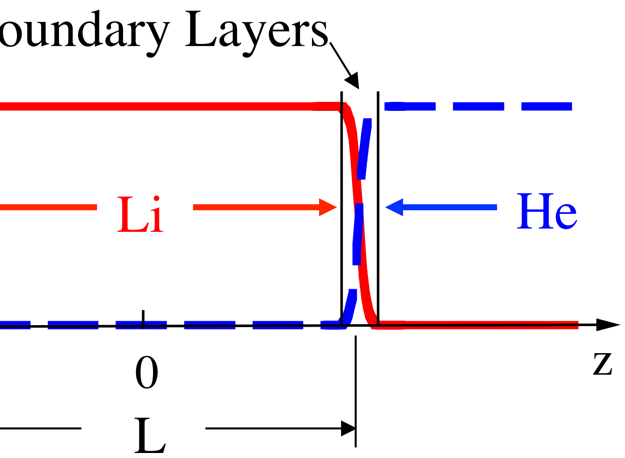
Ti:sapphire laser, more difficult to operate, maintain, but more versatile

Fiber laser (~100fs), turn key, no maintenance, but less versatile

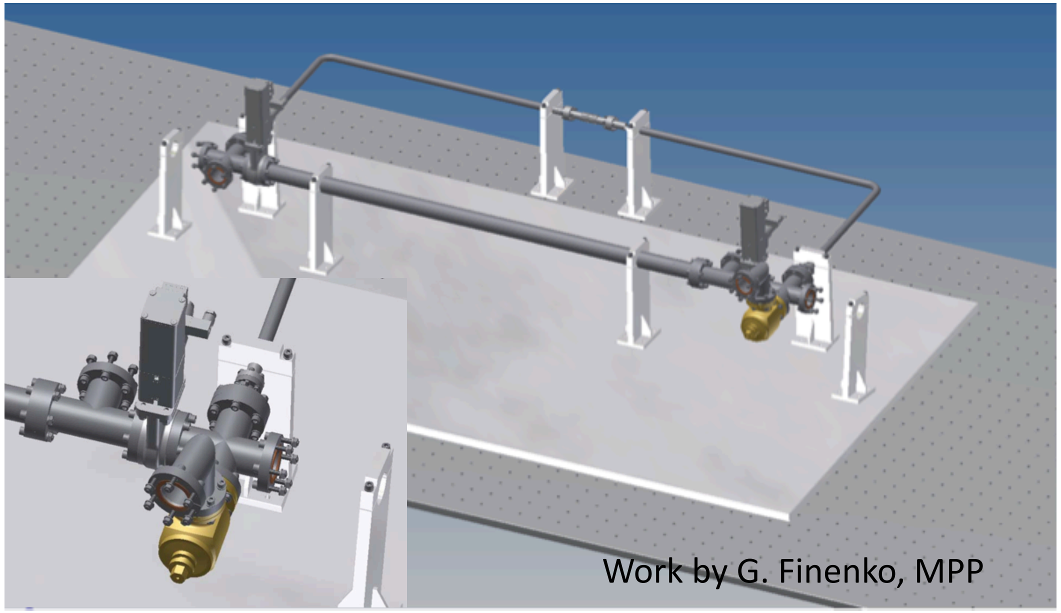
ASMA SOURCE”

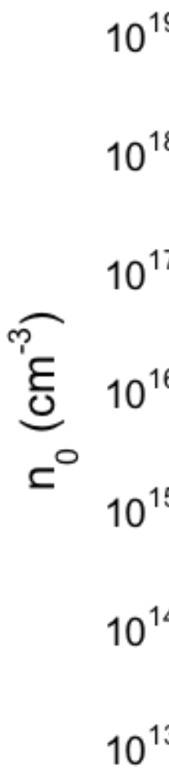
Choices:
Lithium: IP=5.45eV, T_{melt}~184°C, T~500-600°C, Z=3, A=7, ligh
Rubidium: IP=4.18 eV, T_{melt}~39°C, T~130-200°C, Z=37, A=85
Cesium: IP=3.89eV, T_{melt}~28.5°C, T~130-200°C, Z=55, A=133,
(needs refrigeration)





n_0=2-4×10^{15} cm^{-3}
T=700°C
L=1.4 m
P_{He}≈300 mT





4 eV<$h\nu_{laser}$=6.5 eV (λ=1.93 nm)

e 12 µs

(at n_e≈10^{14} cm^{-3})

PS (1999)

No

Loc

ONS & OPEN ISSUES

ng from this initial design concept:

eeded for the sub-ps scale laser ? (Patric has
n - see his note).

on beamline dipoles ? Will the laser pulse pass

e valves at the front of the plasma cell ? (Vi-

e windows at the rear of the plasma cell ? (Er-

nd or horizontal ? (discuss with Brennan God-

n before the dump or will this cause too much

gned ?

sity of the plasma cells having only one pulse
ble ?

n monitors ?

ate perturbations which throw off alignment,

sity variation with time, ...

Major issues so far:

- Choice of beam line (TT61-CNGS)
- Design of the metal vapor source
  - Choice of metal (Li, Rb)
  - Front/end, valves, vapor uniformity
  - Ionization: laser propagation stability, laser paramete
- e^- beam injection