

# Plasma Acceleration with Proton Beams

Max Plank Inst (Munich)

# The Idea (A.Caldwell et al)

---

- Plasma is a good energy transformer: if you have a drive beam with Energy  $E$ , witness bunch can get upto  $3E$
- Drive electron beam energy is limited to 10-25 GeV (thus staging is needed for TeV scale)
- Proton beam energy could be much larger (Tevatron 1 TeV, LHC 5-7 TeV)
- Use proton beams to drive plasma and accelerate electrons to TeV energies in one stage:
  1. Need p-bunch length  $\sim$  plasma wavelength  $\sim 100$   $\mu\text{m}$
  2. The stage is few hundreds of m long



*PAC'09 paper*

Table 1: Parameters in the simulation

	Symbol	Value
Drive Beam		
Protons in drive bunch [ $10^{11}$ ]	$N_p$	1
Proton energy [TeV ]	$E_p$	1
Initial proton momentum spread	$\sigma_p/p$	0.1
Initial longitudinal spread [ $\mu\text{m}$ ]	$\sigma_z$	100
Initial angular spread [mrad ]	$\sigma_\theta$	0.03
Initial bunch transverse size [mm ]	$\sigma_{XY}$	0.4
Witness Beam		
Electrons in witness bunch [ $10^{10}$ ]	$N_e$	1.5
Energy of electrons [GeV ]	$E_e$	10
Plasma Parameters		
Free electron density [ $\text{cm}^{-3}$ ]	$n_p$	$6 \times 10^{14}$
Plasma wavelength [mm ]	$\lambda_p$	1.35
External Field		
Magnetic field gradient [T/m ]		1000
Magnetic length [m ]		0.7

LIFETRAC head-on eLens  
LHC  $\xi=0.0075/\text{IP}$ , RHIC



Get 0.7- >1 TeV electrons

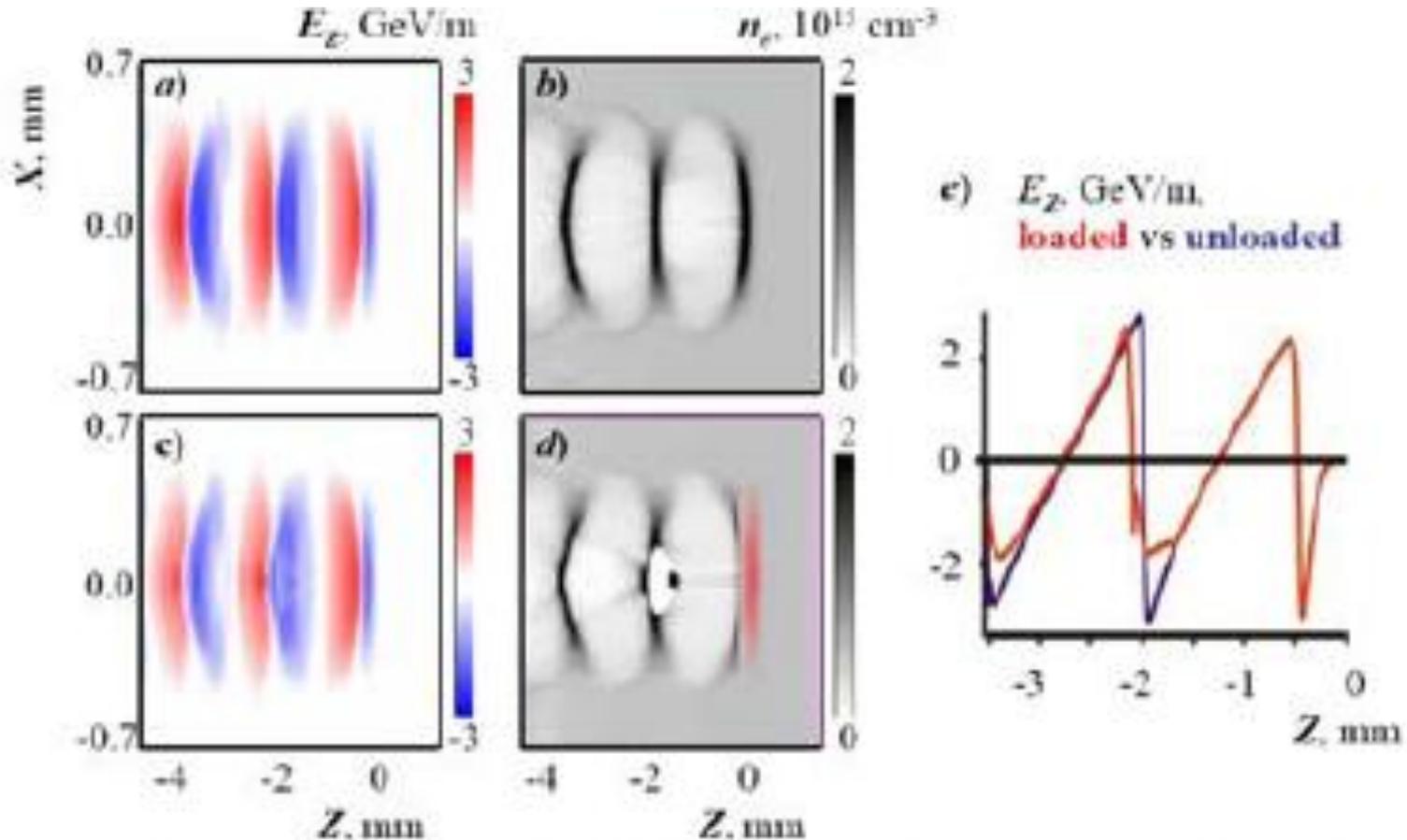


Fig.2: Plasma wakefield driven by a proton bunch.



- Proton bunches are "long" 10-(30+) cm
- Bunch compression of TeV beams costly/(impossible?)
- Can long proton bunches be modulated/chopped at the plasma wavelength (0.1-1 mm  $\rightarrow$  100-1000 ubunches)
- Will such system effectively accelerate  $e^-$  (need high-Q system)?
- Users -?

