Plasma and Two Photon Absorption Technique

F.R. Palomo[1], M. Moll[2]
M.Fernández[3],I. Vila[3],R.Montero[4] ,
fpalomo@.us.es
[1]Departamento Ingeniería Electrónica, Escuela Superior de Ingenieros
Universidad de Sevilla, Spain
[2]SSD Group, CERN, Geneva, Switzerland
[2]Instituto de Física de Cantabria, Santander, Spain
[4]Universidad del País Vasco,UPV-EHU, Bilbao, Spain

Introduction

1. Plasma Conditions in TPA
2. Plasma I-Scan
3. Theoretical Model
4. Results

Plasma Conditions

$$\lambda_D = \sqrt{\frac{\varepsilon_0 kT}{n_0 e^2}}$$ *Debye length*

This provides condition to determine if we have a plasma or not.

(i) the system must be large enough $\boxed{L >> \lambda_D}$, and
(ii) there must be enough electrons to produce shielding $\boxed{N_D >>> 1}$, where N_D is the number of electrons in a Debye sphere.

Introduction to Plasma Physics and Controlled Fusion F.Chen, 1983 Plenum Press, New York .

Measurements 1

Orthogonal Incidence

Wavelength 1500nm

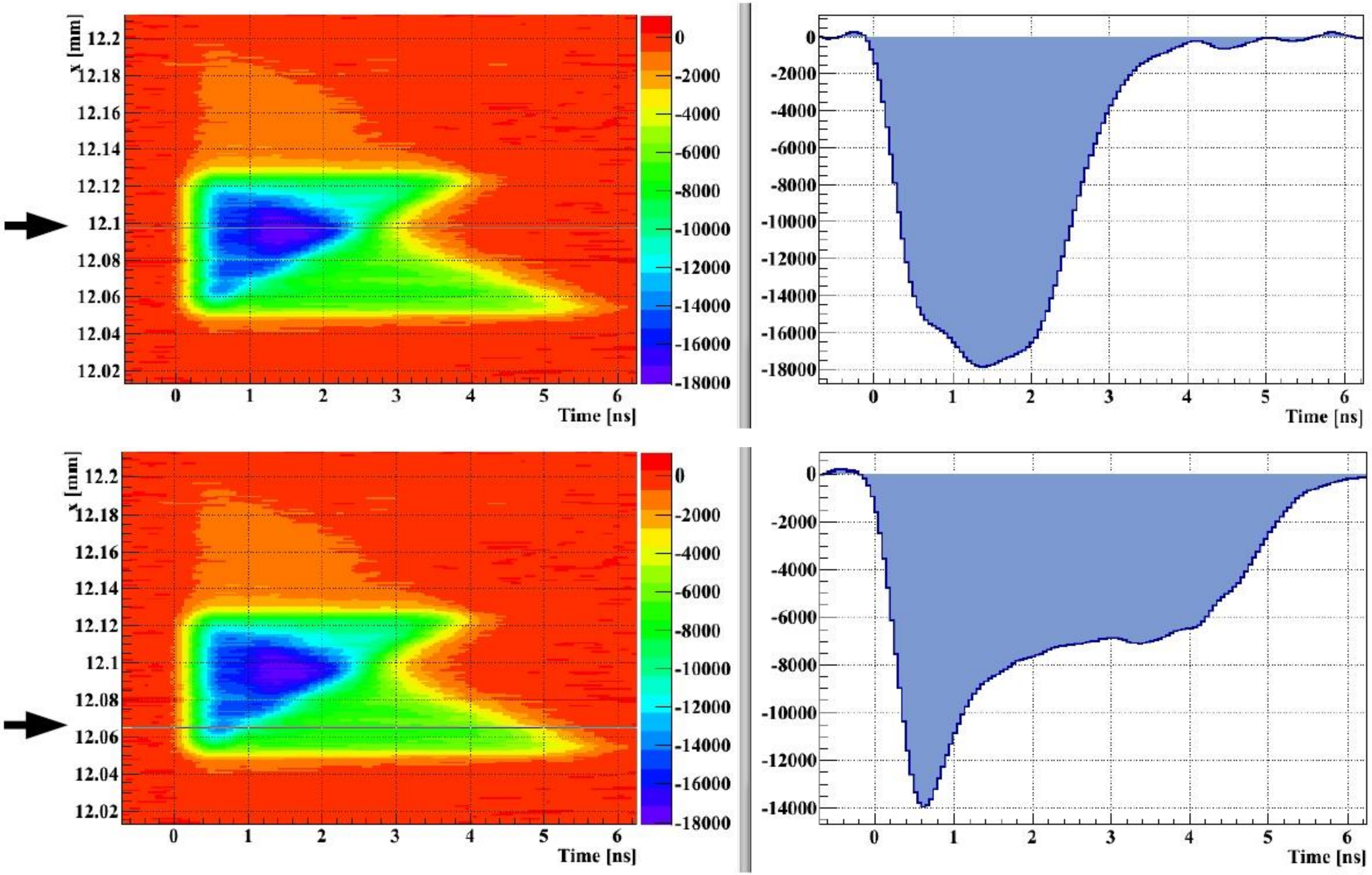
Pulse Length 250 ps

Pulse Energy 10 pJ

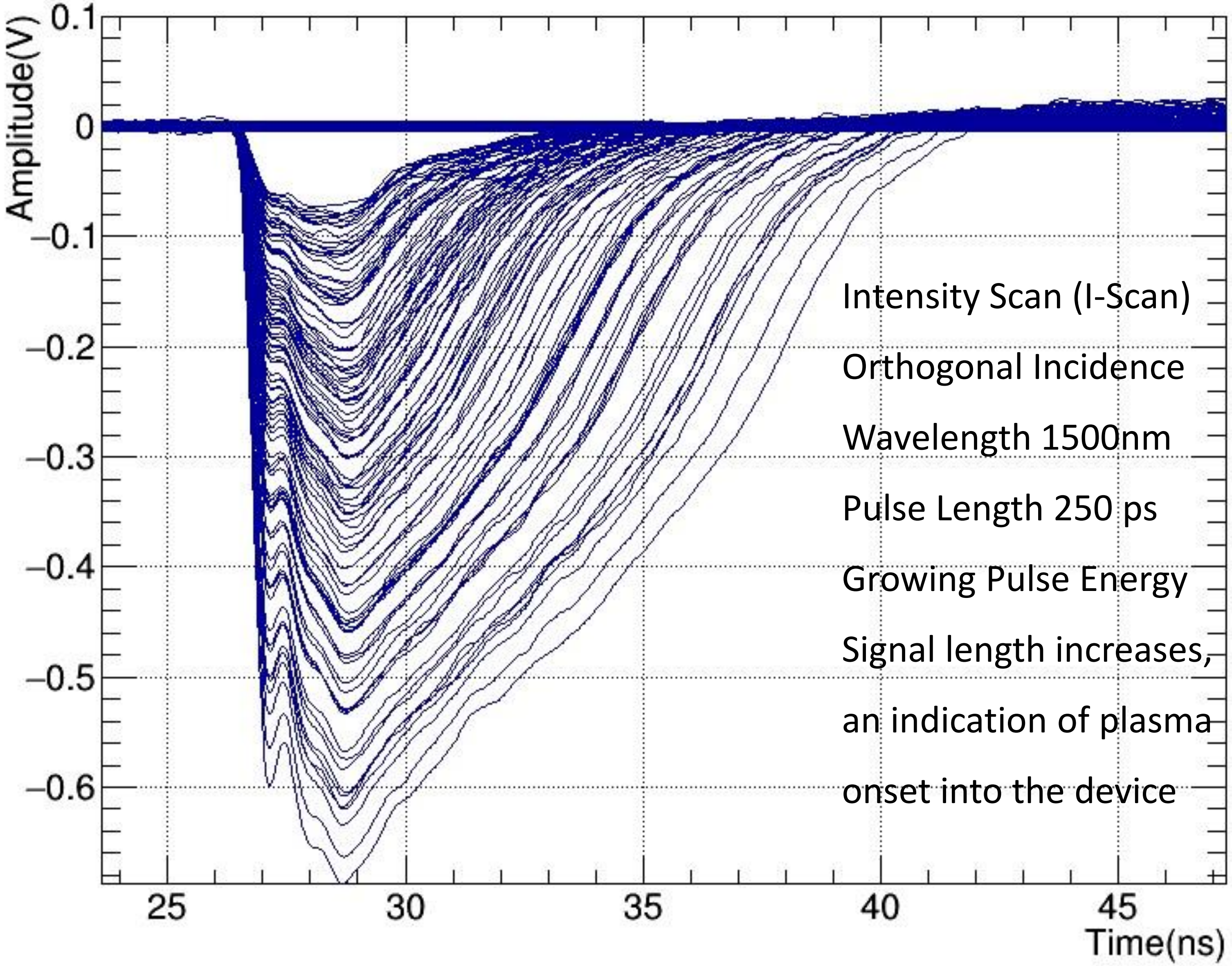
The response fits with

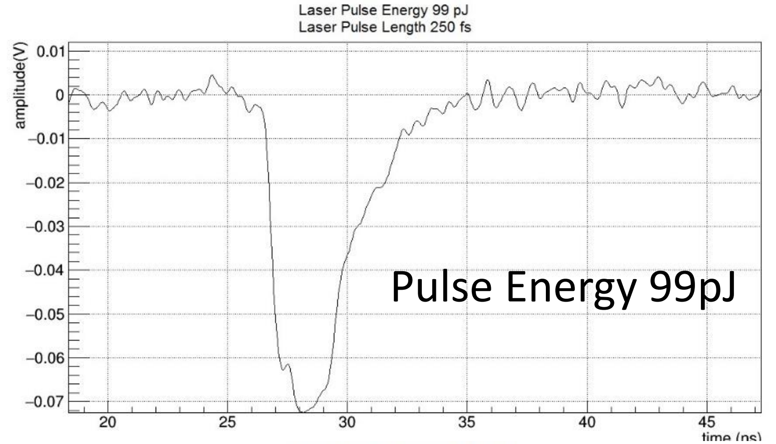
the Ramo Theorem

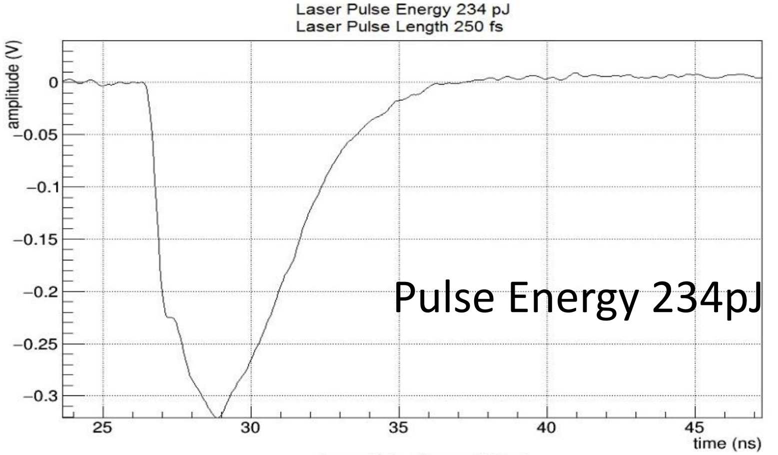
Typical signal length 6ns

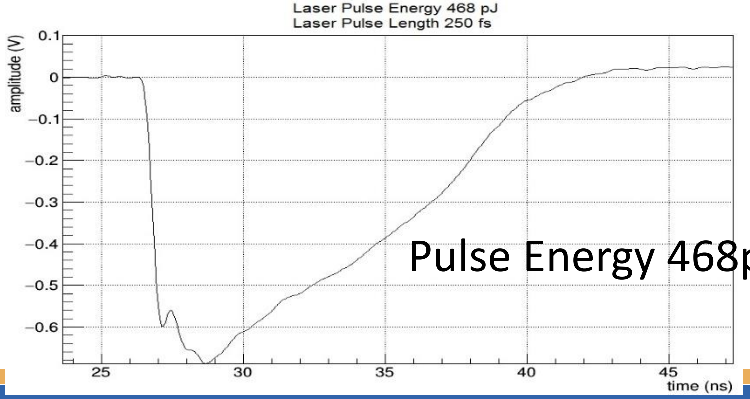


Measurements 2





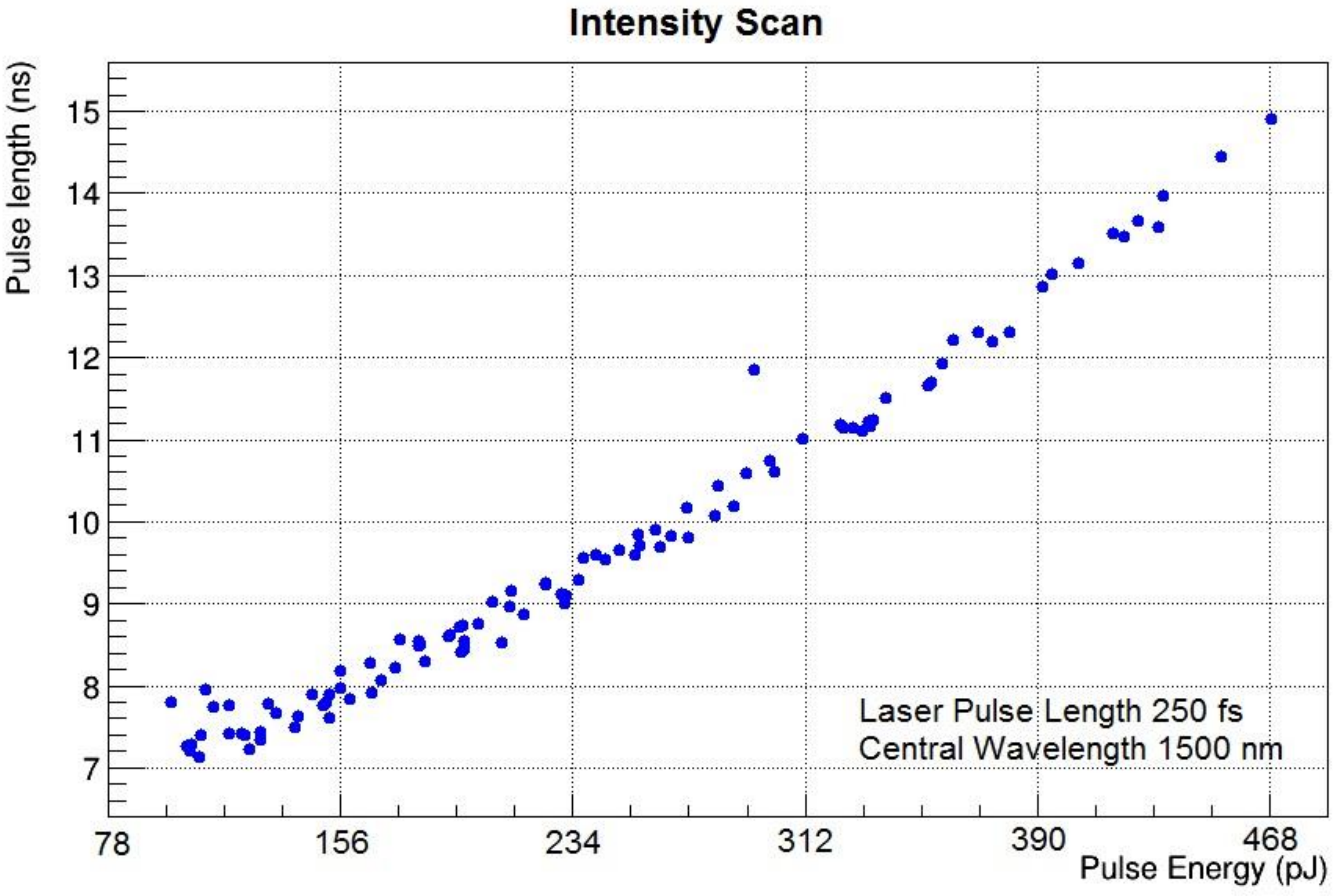




Measurements 3

Plotting Signal Pulse length vs Pulse Energy we saw clearly the plasma onset beyond 150 pJ.

Theory has to explain this trend



Plasma Time Theory

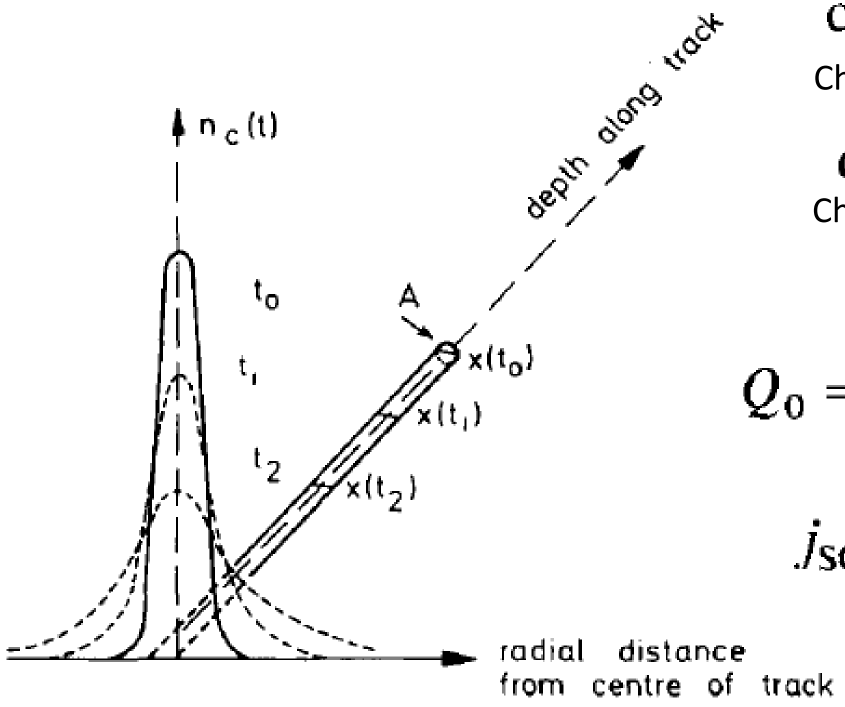


Fig. 1. Diffusion and current erosion of plasma track.

$$n_c(t) = n_l / 4\pi D_a t$$

Carrier density in the plasma column

$$dQ = qAn_l dx / 4\pi D_a t$$

Charge in a dx column segment at dt

$$dQ/dt = j(t)A$$

Charges extracted by erosion current

There are erosion currents diluting the plasma (in ambipolar diffusion conditions) in response to the ambient Efield. This theory supposes that the currents are Space Charge Limited Currents (SCLC).Plasma Time is define as the time needed to expose all carriers to the ambient field. The formula for tp comes from the total charge integral.

$$Q_0 = \int_0^1 q n_l dx = 4\pi D_a \int_0^{t_p} t j(t) dt$$

$$t_p = \frac{1}{F}\left(\frac{3 Q_0 q n_l A}{32\pi^3 \mu (\varepsilon\varepsilon_0)^2 D_a^2}\right)^{\frac{1}{3}}$$

$$j_{SCLC} = 2\pi\mu\varepsilon\varepsilon_0 F^2$$ SCLC [2]

$$\delta = \varepsilon\varepsilon_0 F / q n_c$$ Plasma Sheath formula[2]

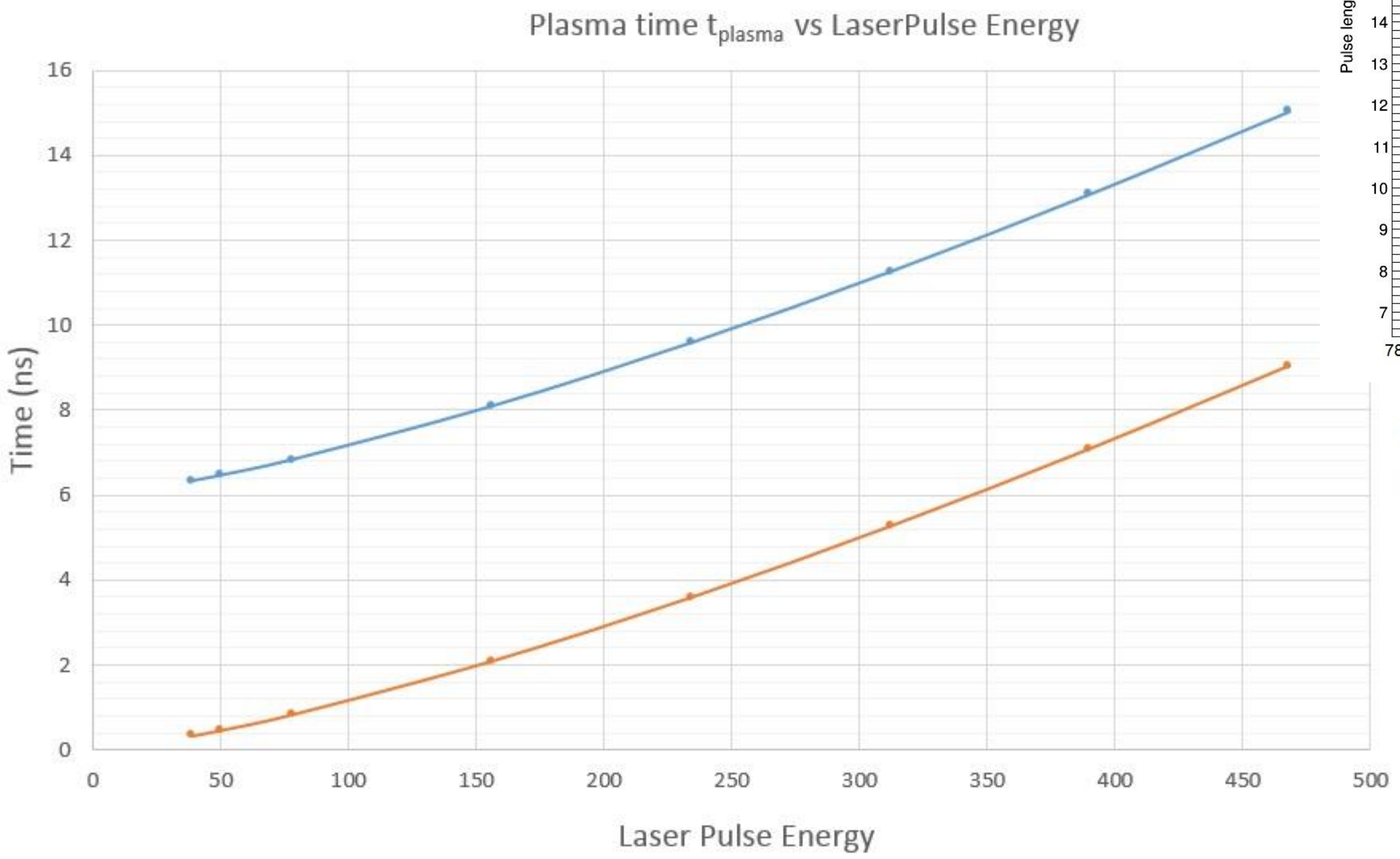
$$i_T = 2\pi\mu\varepsilon\varepsilon_0 F^2 \delta = 2\pi\mu(\varepsilon\varepsilon_0)^2 F^3 / q n_c$$

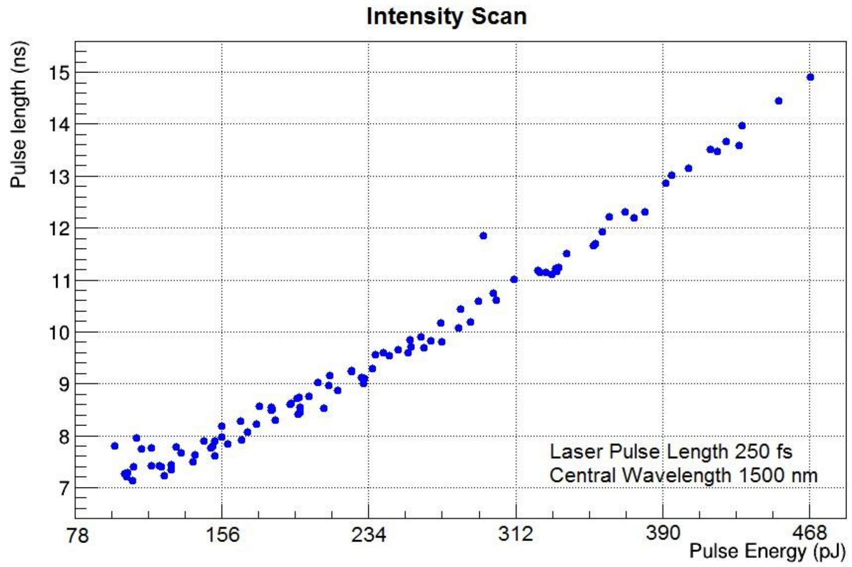
$$j(t) = i_T / A$$

Q_0:total charge
n_l: linear density
A: erosion área
D_a: ambipolar diffusion coefficient
F: Ambient Electric Field

1. ***Charge Collection in Silicon Detectors for Strongly Ionizing Particles,*** W. Seibt, K.E.Sundström, P.A.Tove, Nuclear Instruments and Methods 113 (1973), 371-324
2. ***Plasma Effects in Semiconductors Detecto***rs, P.A. Tove and W. Seibt, Nuclear Instruments and Methods 51 (1967) 261-269

Results





Theory agrees reasonably well with data, Erosion Area Radius 0.055 µm

Total time= Plasma time + Collection time (6ns obtained in the callibration phase)

Conclusions

- Experimentally it is easy to find the plasma threshold in TPA with an Intensity-Scan
- Plasma Erosion Current theory shows a reasonable agreement with experiments

Thanks for your attention

fpalomo@us.es