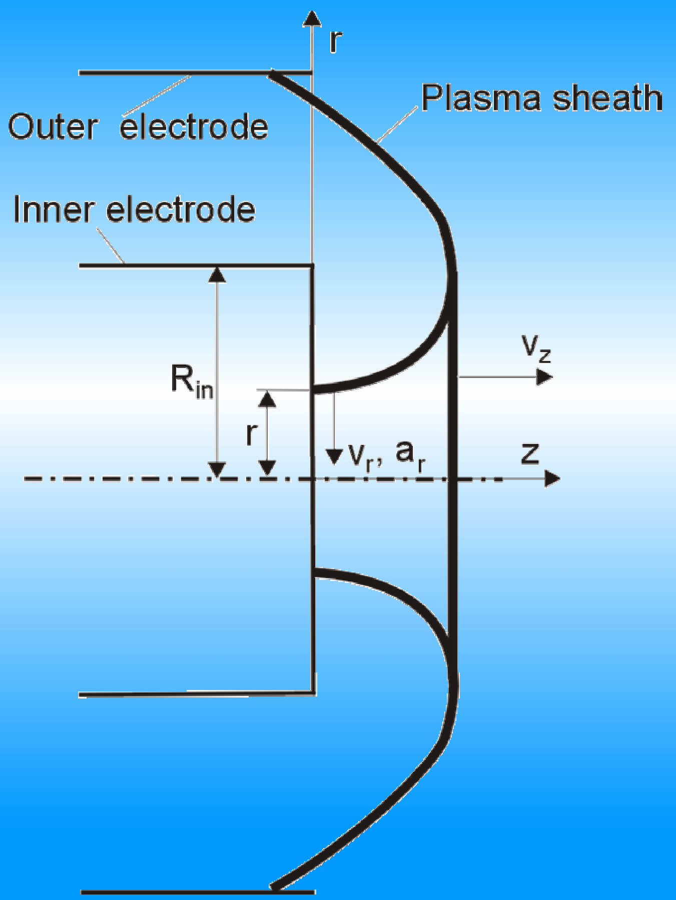
"Dynamics of the Plasma Sheath and Pinch Formation in Plasma Focus devices"

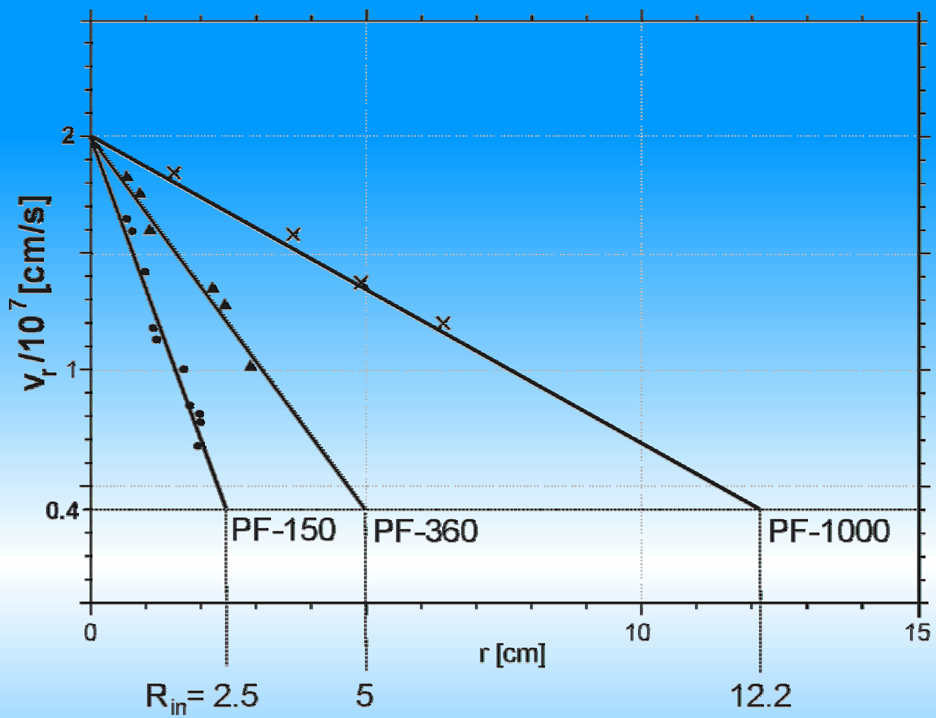
Ryszard Miklaszewski and the ICDMP team

	PF-150	PF-3600	PF-1000
Energy [kJ]	50 - 70	100 - 200	650 -1100
Dimensions of elecrodes [mm]			
inner (diameter)	50	100	224
outer (diameter)	100	200	368
lenght	200	300	550

Geometry of collapse



3 Tr



The radial velocity of the plasma sheath is the linear function of radius (r)

$$V_r = -A \cdot r + B$$ where A, B - constants

Using the following transformation:

$$dt = -\frac{dr}{V_r(r)}$$

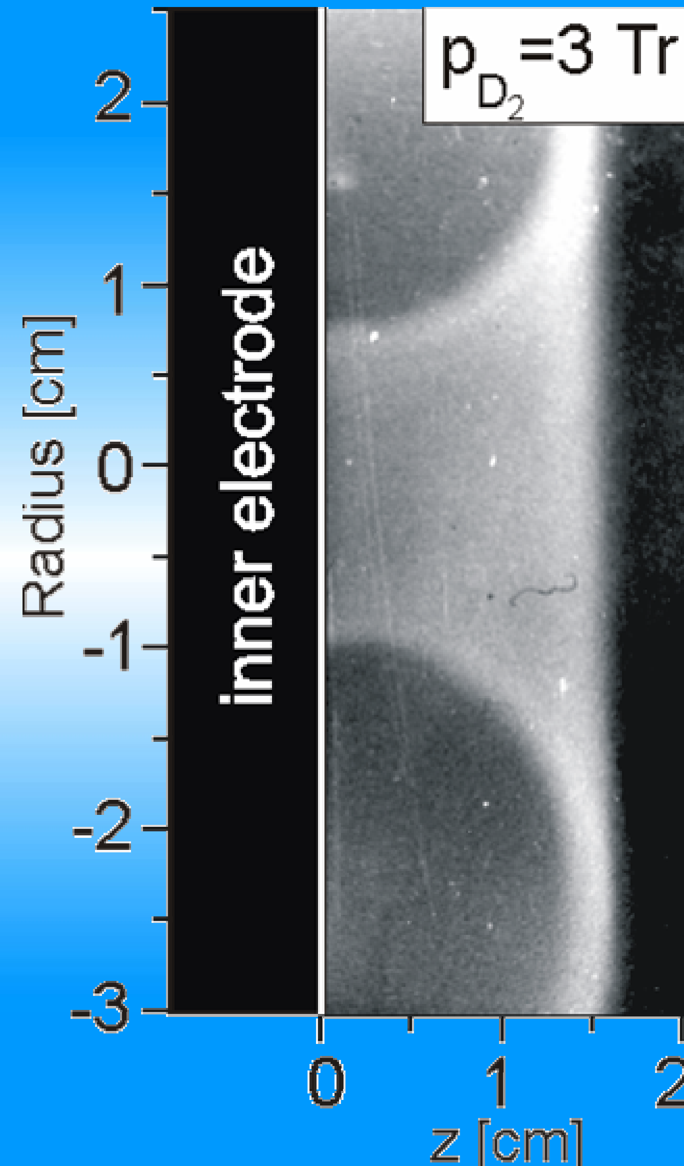
One obtain realtions for boths radial velocity and radial acceleration as functions of time

$$V_r(t) = C\exp(D \cdot t)$$

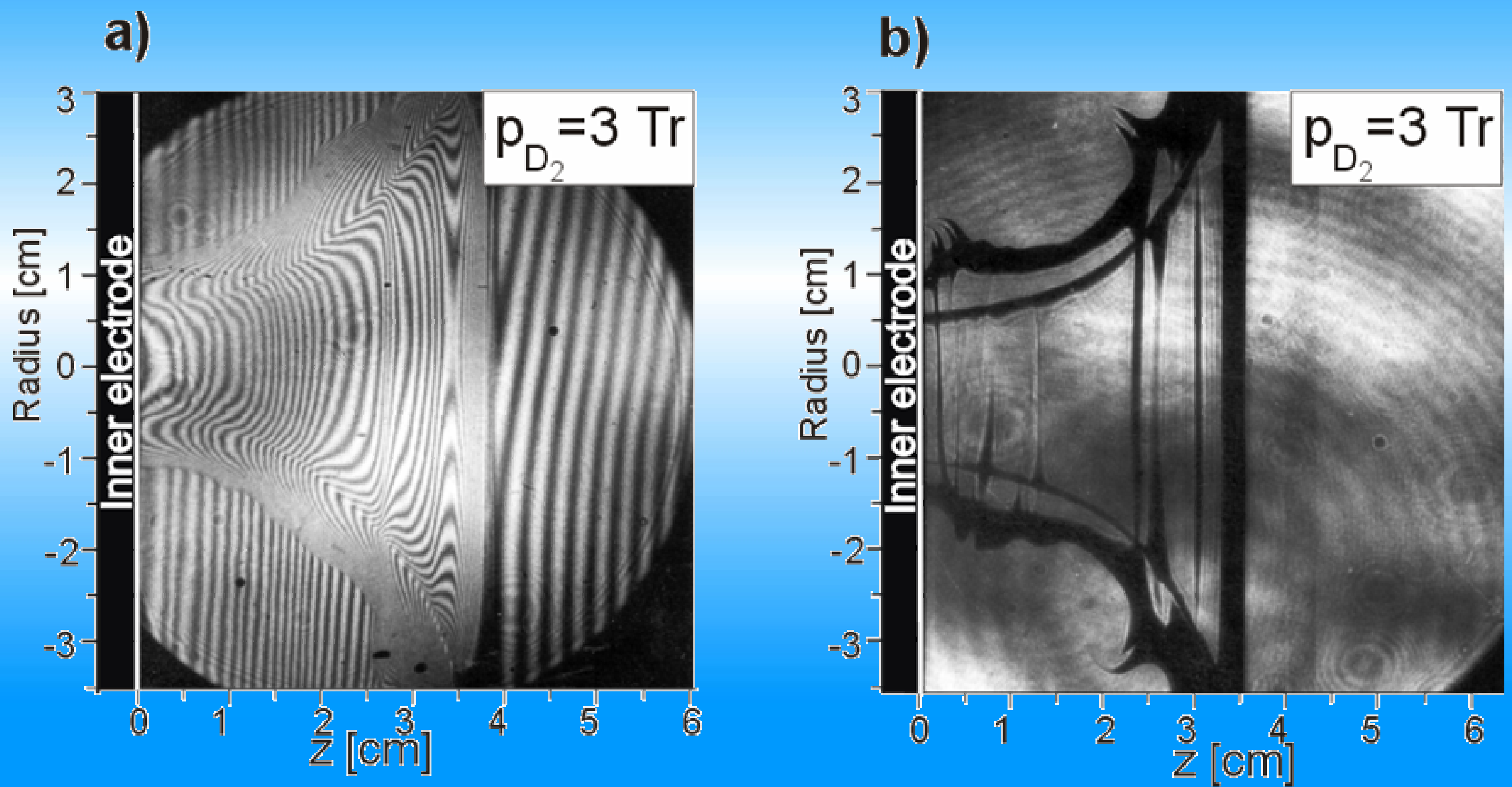
$$a_r(t) = E\exp(D \cdot t)$$

where: C,D,E - constants

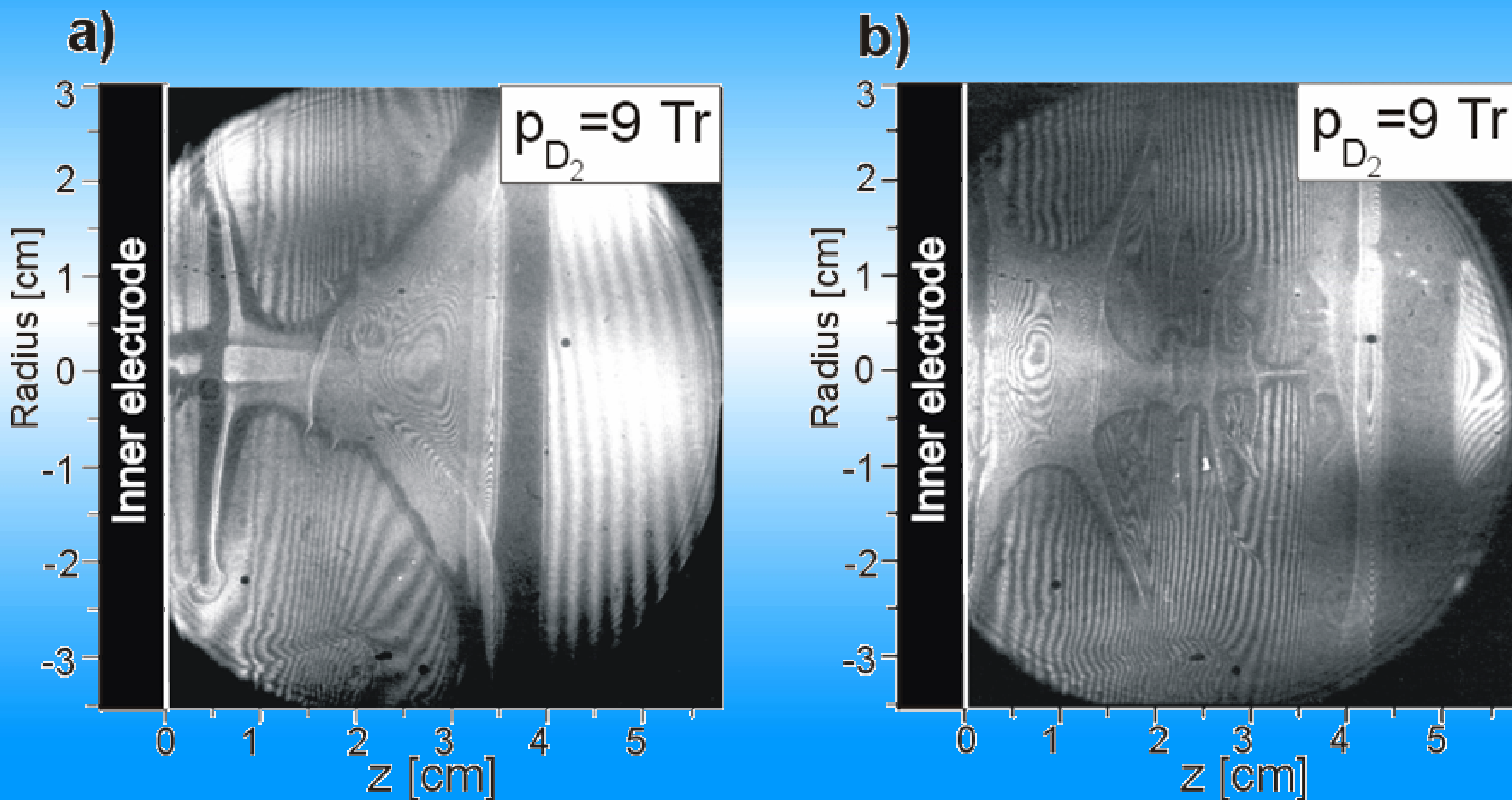
PF-150



PF-360

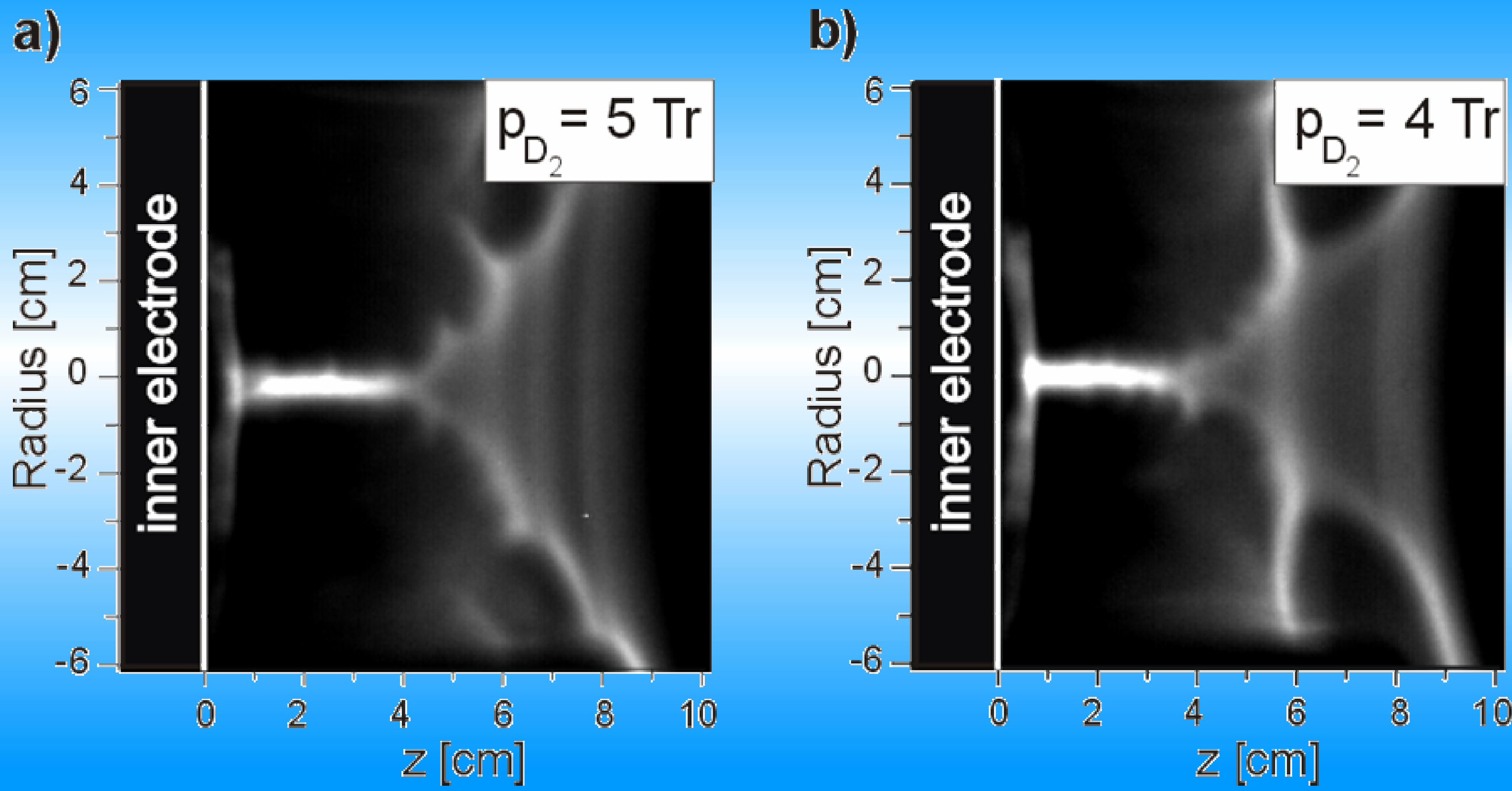

a)
b)
p_{D_2}=3 Tr
p_{D_2}=3 Tr
Inner electrode
Inner electrode
Radius [cm]
Radius [cm]
z [cm]
z [cm]

PF-360



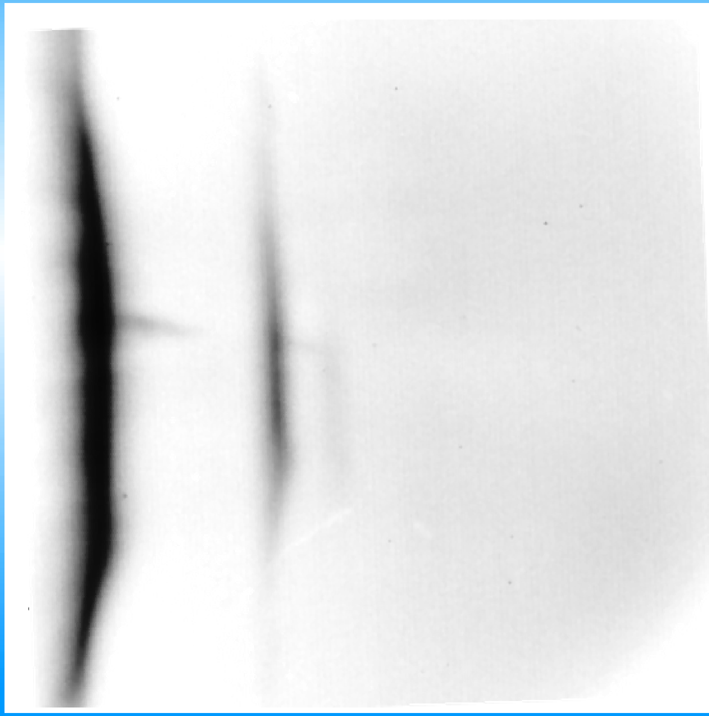
a)
b)
p_{D_2}=9 Tr
p_{D_2}=9 Tr
Inner electrode
Inner electrode
Radius [cm]
Radius [cm]
z [cm]
z [cm]

PF-1000



IPP&LM, Warsaw, Poland

Consequence of the instabilities for pinch and post-pinch phase



Equation sets of ideal HD and MHD -
do not contain characteristic length and time scales

Non-ideal case - two characteristic lenght scales appeare

λ - mean free path

r_c - gyroradius

Analysis of hydrodynamical instabilities in the collapse phase

for ideal HD: $$\gamma \approx \frac{1}{\lambda}$$

for non-ideal HD: $$\gamma_{\max} = \omega \left(\frac{a^2 \rho}{\eta} \right)^{1/3} \qquad \lambda_{\max} = \kappa \left(\frac{\eta^2}{a\,\rho^2} \right)^{1/3}$$

where:

$\gamma_{\max}$ - maximum value of the increment

$\lambda_{\max}$ - instability length corresponding to $\gamma_{\max}$

η - plasma viscosity $\left(\approx T^{5/2}\right)$

ρ - density of the plasma

a - accelaration of the plasma sheth

Treating the plasma sheath as a schock wave one can assume:

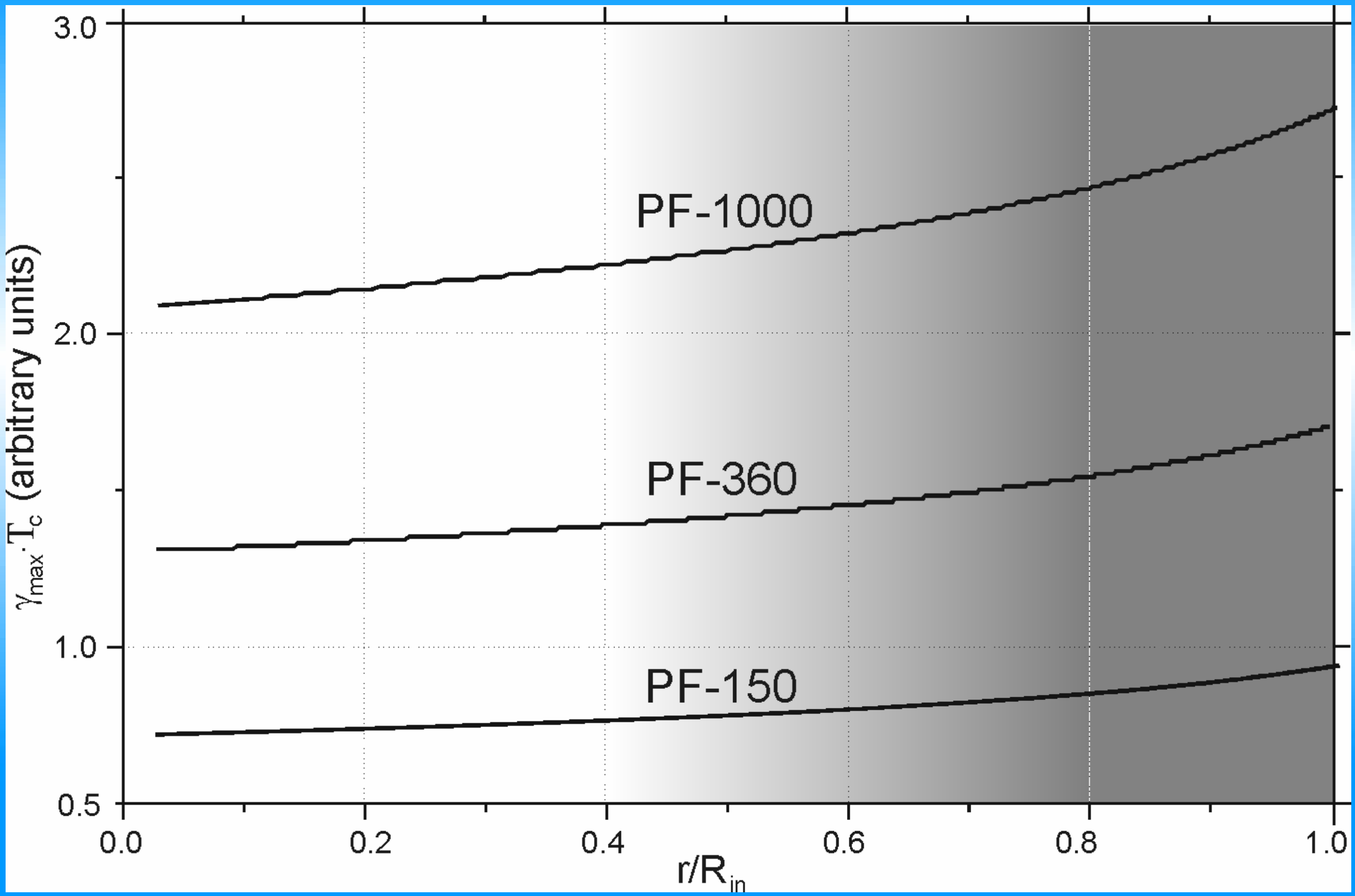
$$p \approx \rho_0 V_r^2 \qquad \text{thus} \qquad \eta \approx V_r^5 / \delta^{5/2}$$

where: $\delta = \rho / \rho_0$

and finally:

$$\gamma_{\max} = \omega \left(\frac{a_r^2 \rho \delta^{5/2}}{V_r^5} \right)^{1/3} \qquad \lambda_{\max} = \kappa \left(\frac{V_r^{10}}{a_r \rho^2 \delta^5} \right)^{1/3}$$

Increment x collapse time vs. radius



Available sheath length / instability length