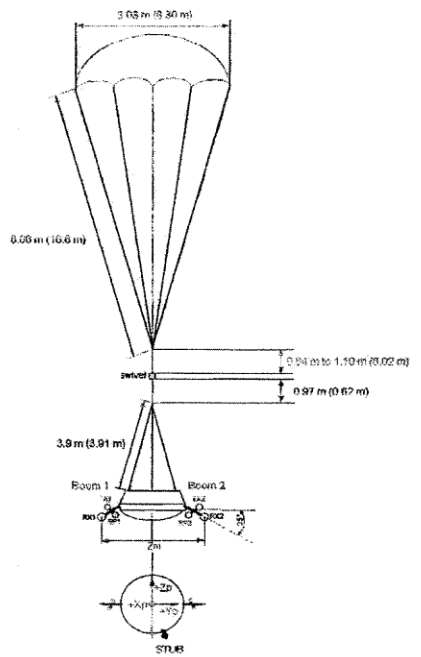
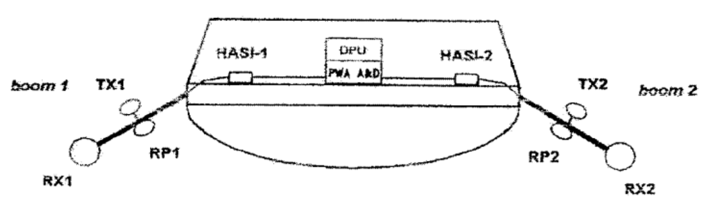
Presented at the COMSOL Conference 2010 Boston

Electrostatic Fluid Structure Interaction (EFSI) on the Huygens Experiment

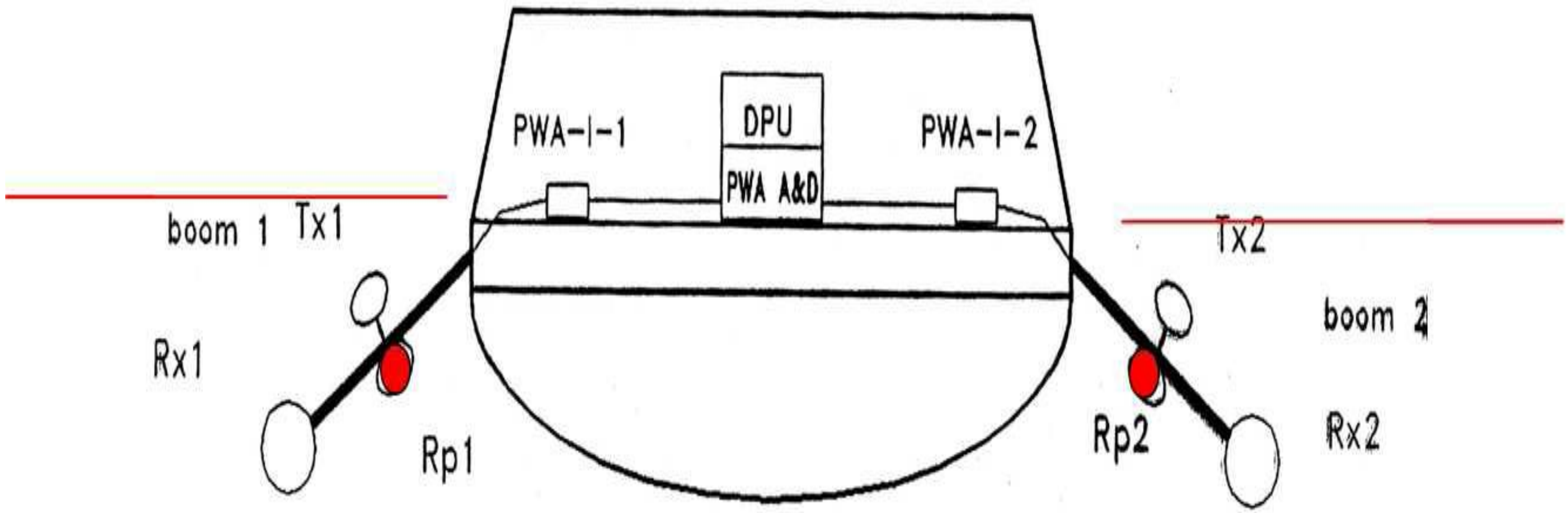
R. Godard, J. de Boer, N. Ibrahim,
G. Molino-Cuberas

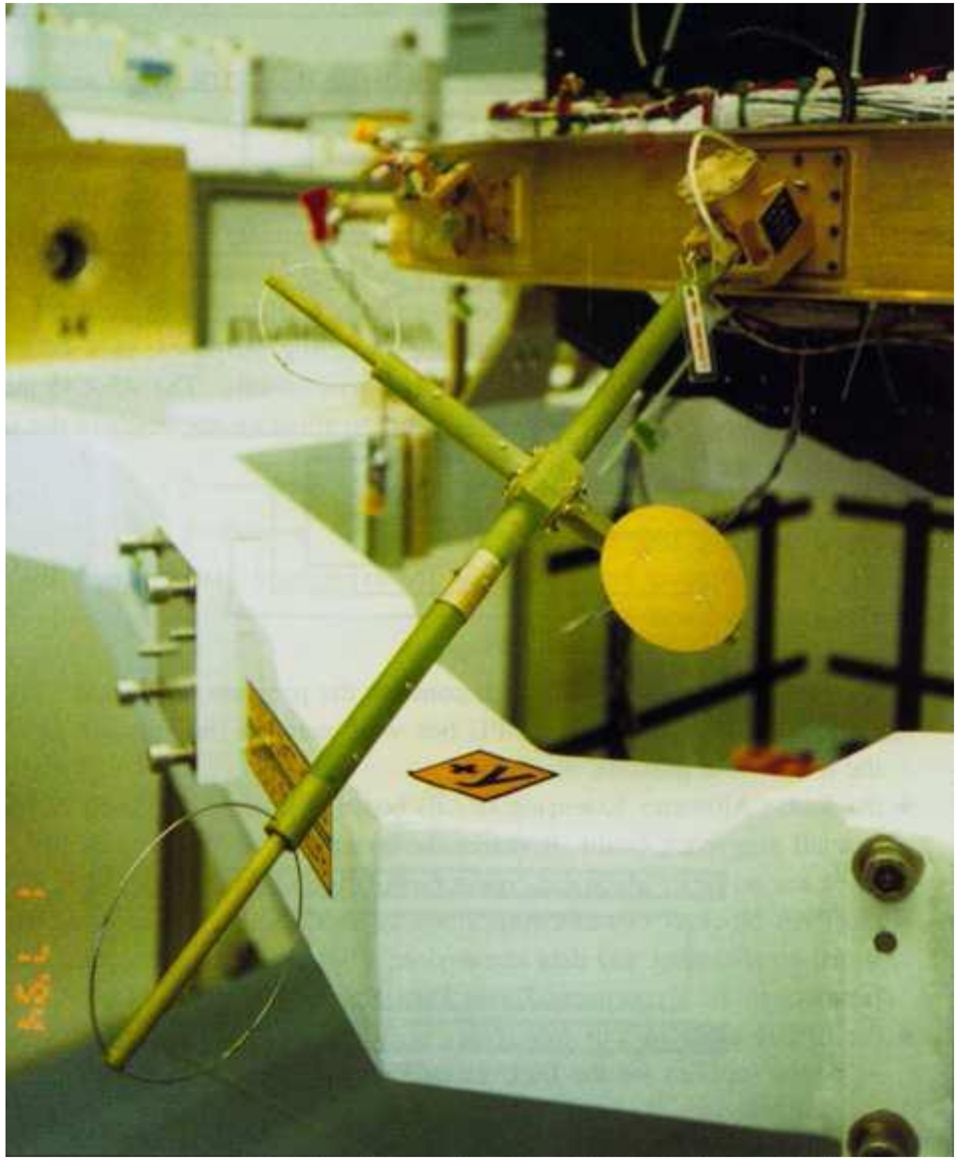
The Huygens vessel and the parachute

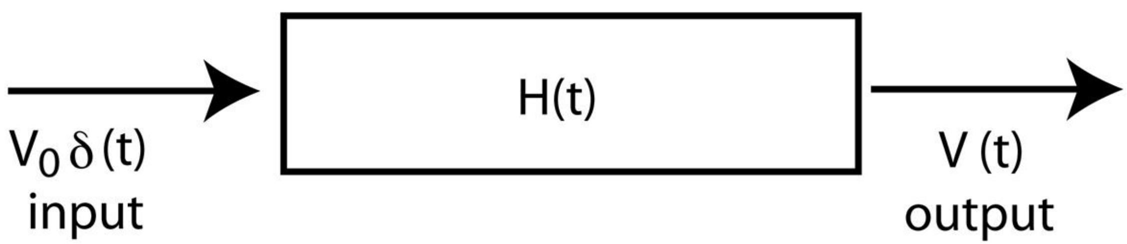


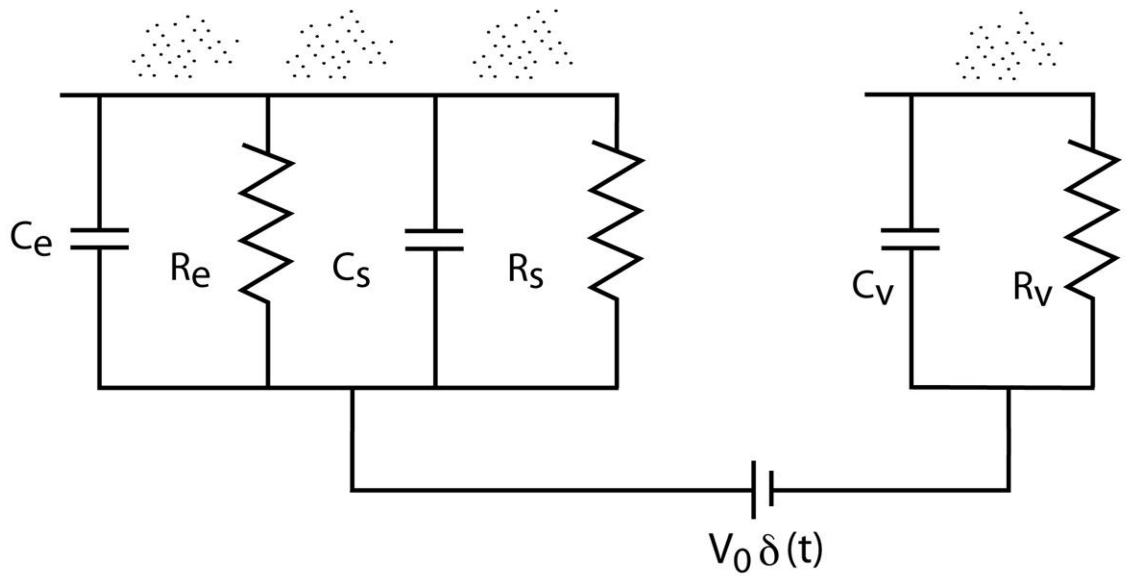


Experimental design




+Y


H(t)
V0 δ (t)
input
V (t)
output

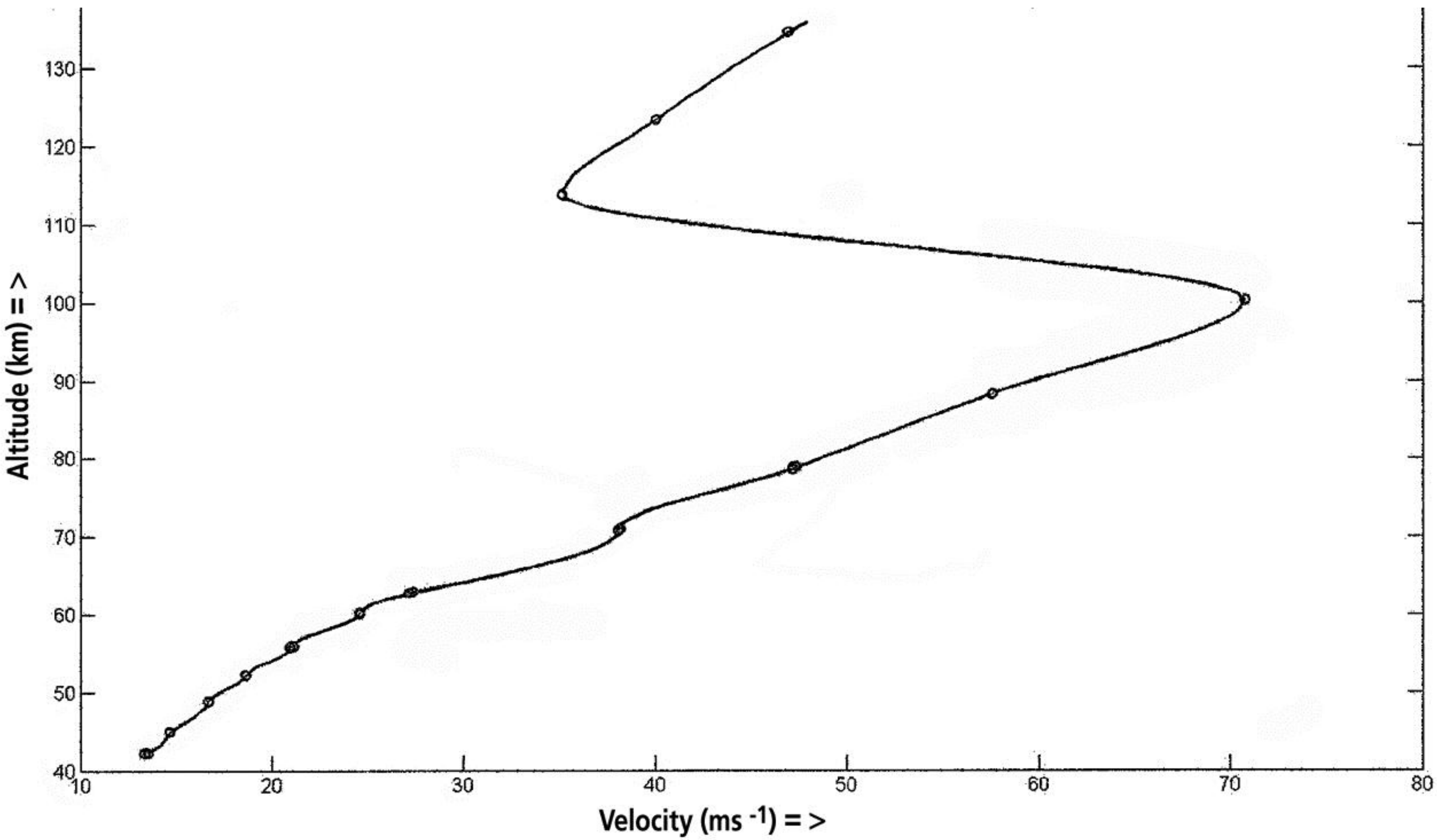


Ce
Re
Cs
Rs
Cv
Rv
V0 δ (t)

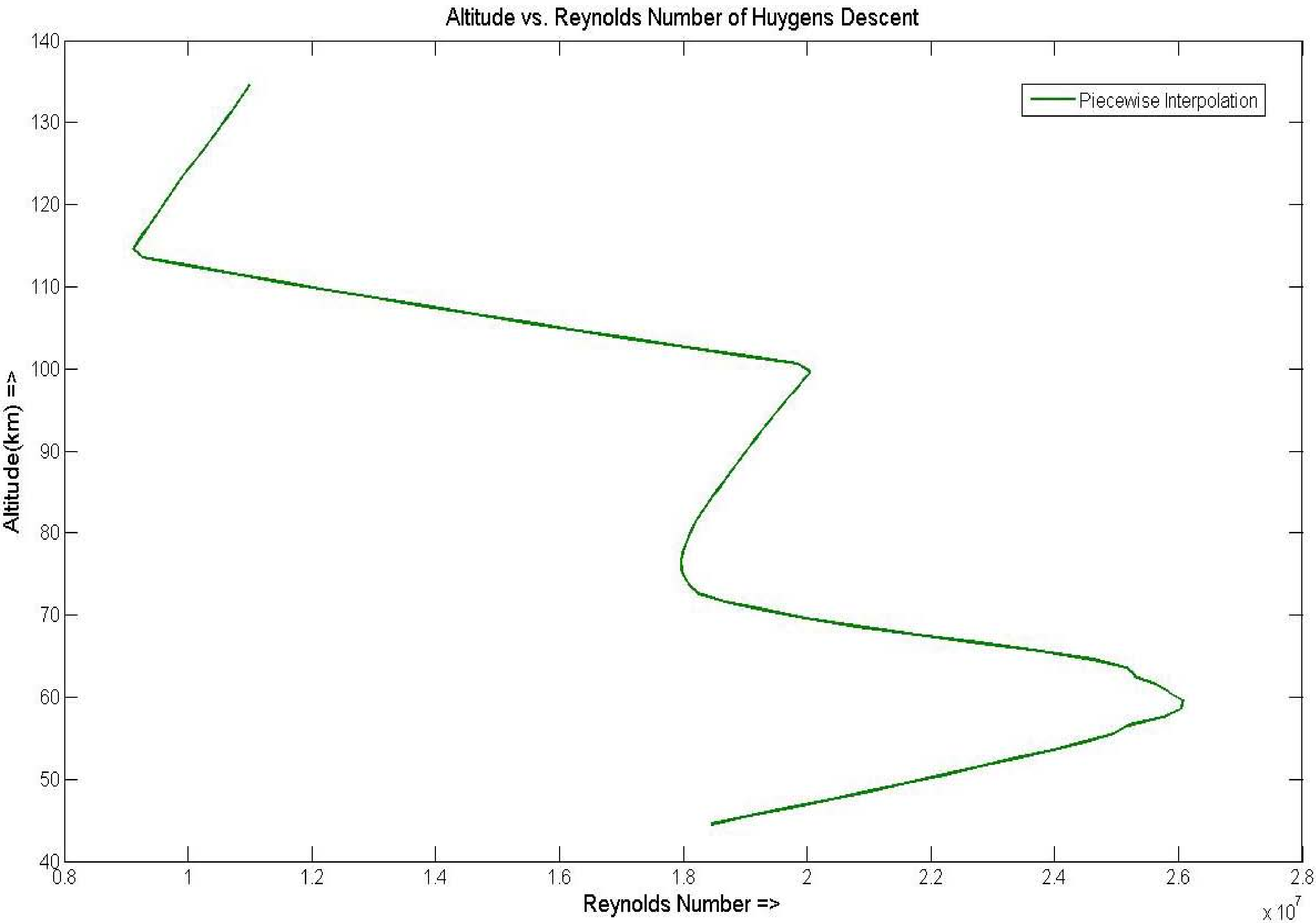
The RP circuit time constant

$$\frac{\sigma_e}{\varepsilon_0} = \frac{1}{R_e C_e}$$

The conductivity relation



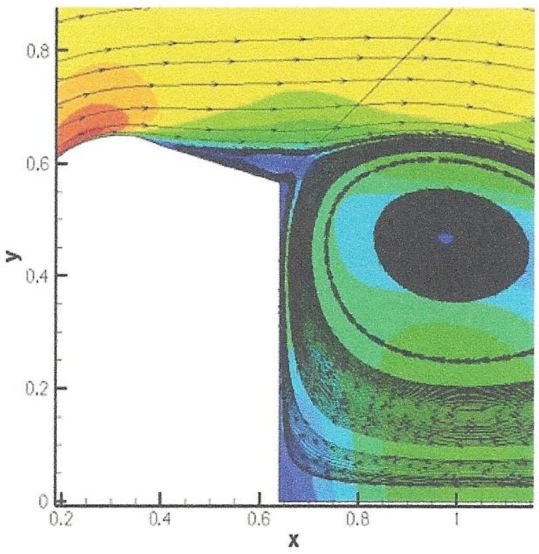
130
120
110
100
90
80
70
60
50
40
10
20
30
40
50
60
70
80
Altitude (km) = >
Velocity (ms -1) = >



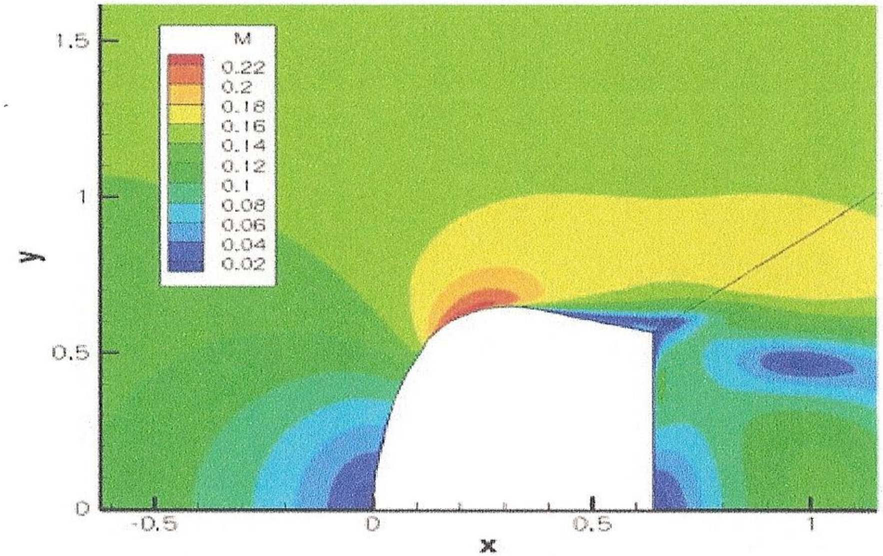
Altitude vs. Reynolds Number of Huygens Descent
Piecewise Interpolation
Altitude(km) =>
Reynolds Number =>
x 10^7
140
130
120
110
100
90
80
70
60
50
40
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8

Streamlines around Huygens Probe in a turbulent flow at 100*km* altitude

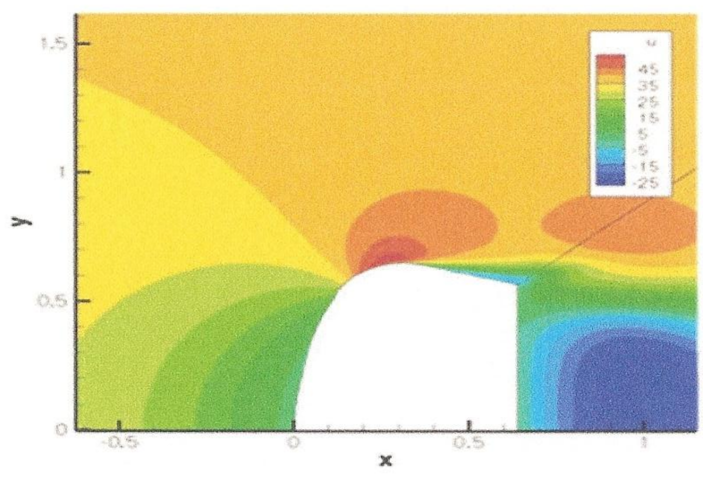
$$t = 145K, P = 0.954kPa, Ma = 0.1445$$



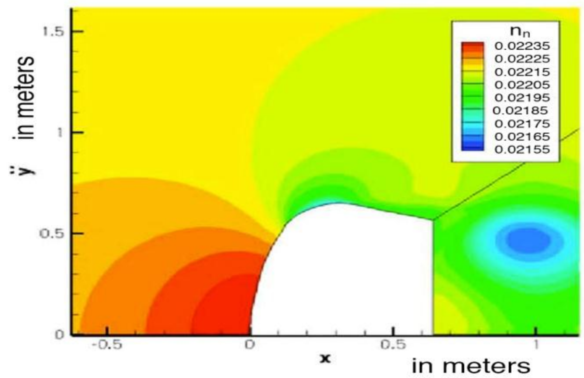
Mach number distribution
in a turbulent flow at 100km altitude



Velocity (u) distribution for Huygens probe in a turbulent flow at 100*km* altitude



Density distribution at 100*km* altitude

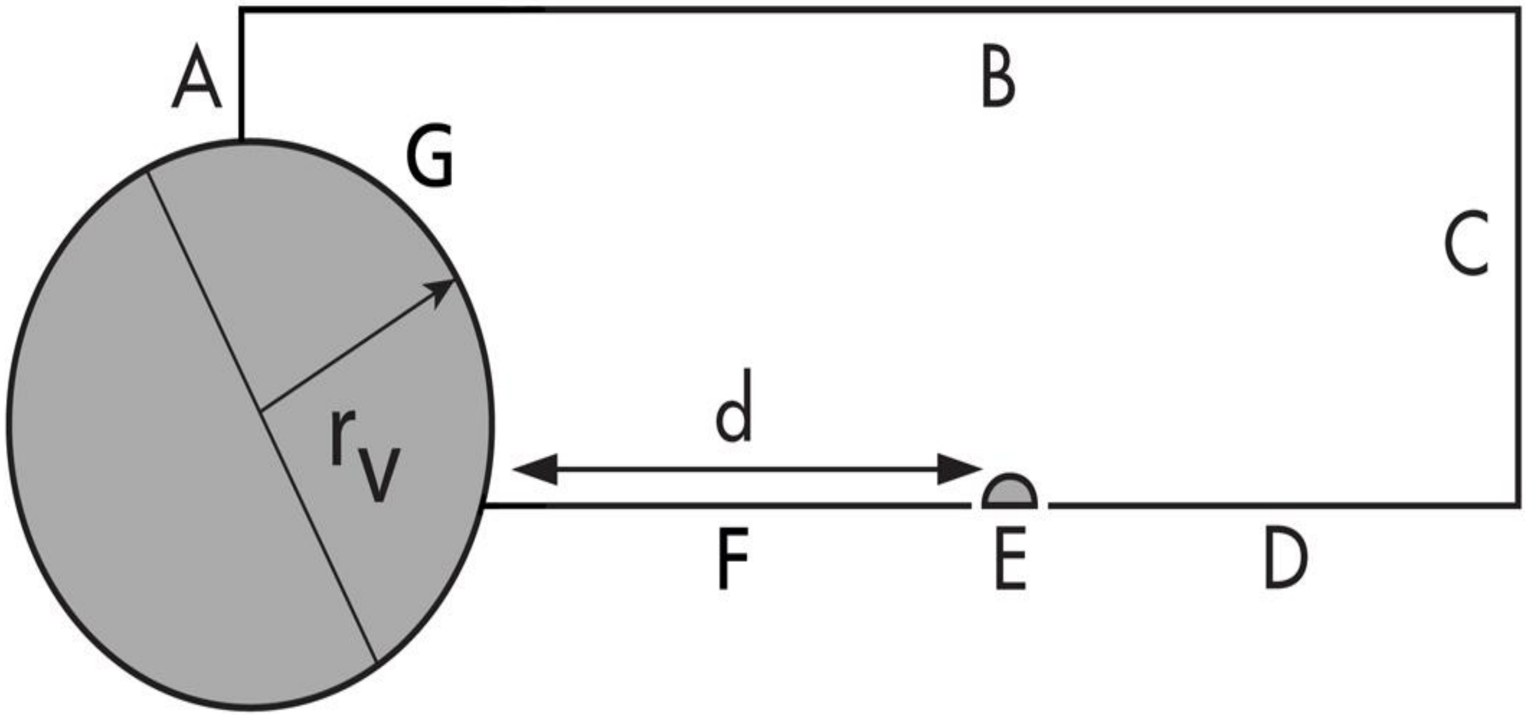


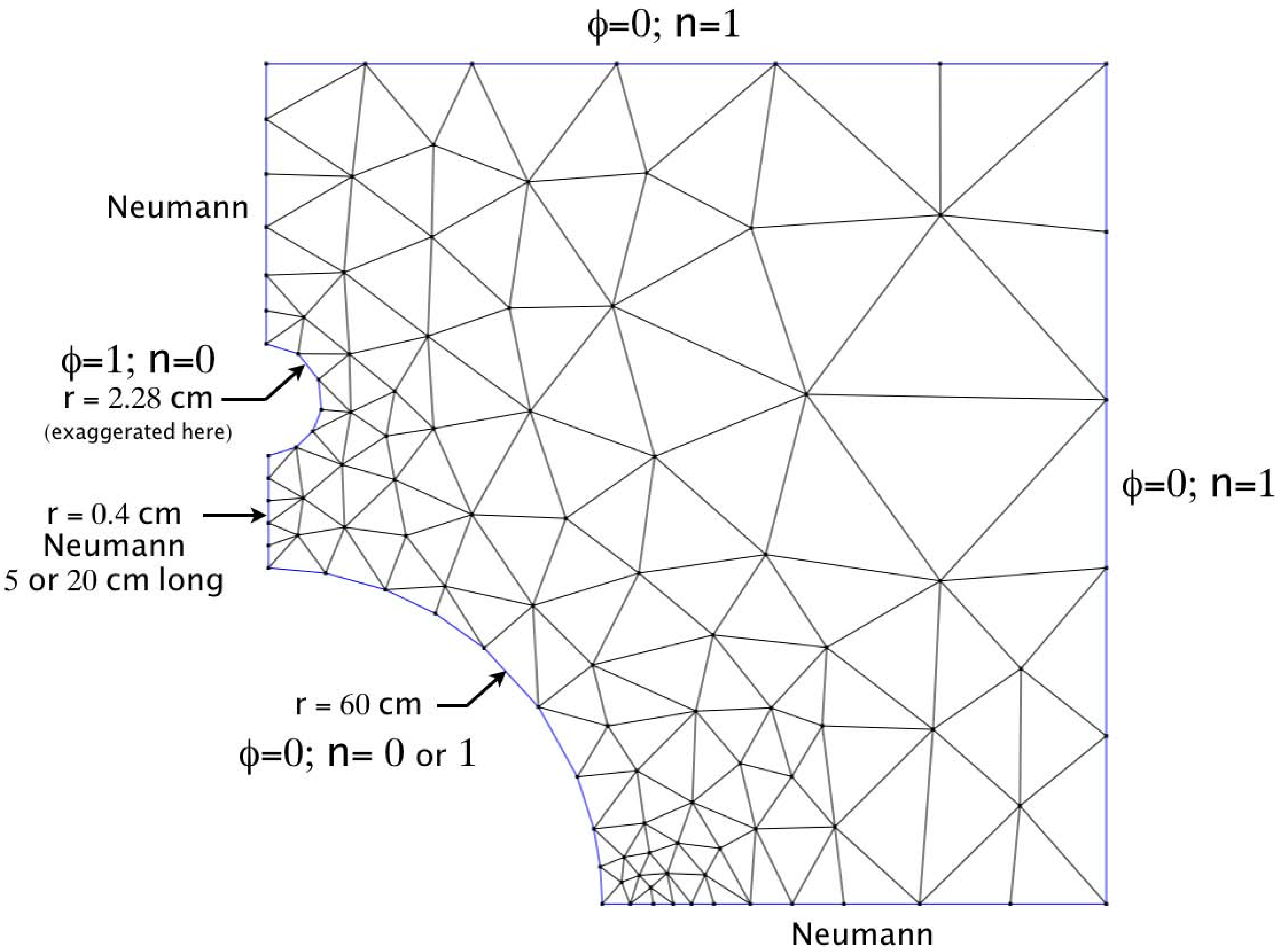
Mathematical model: fluid model

$$-\nabla^2 n_e + \nabla n_e . \nabla \varphi + n_e \nabla^2 \varphi = 0$$

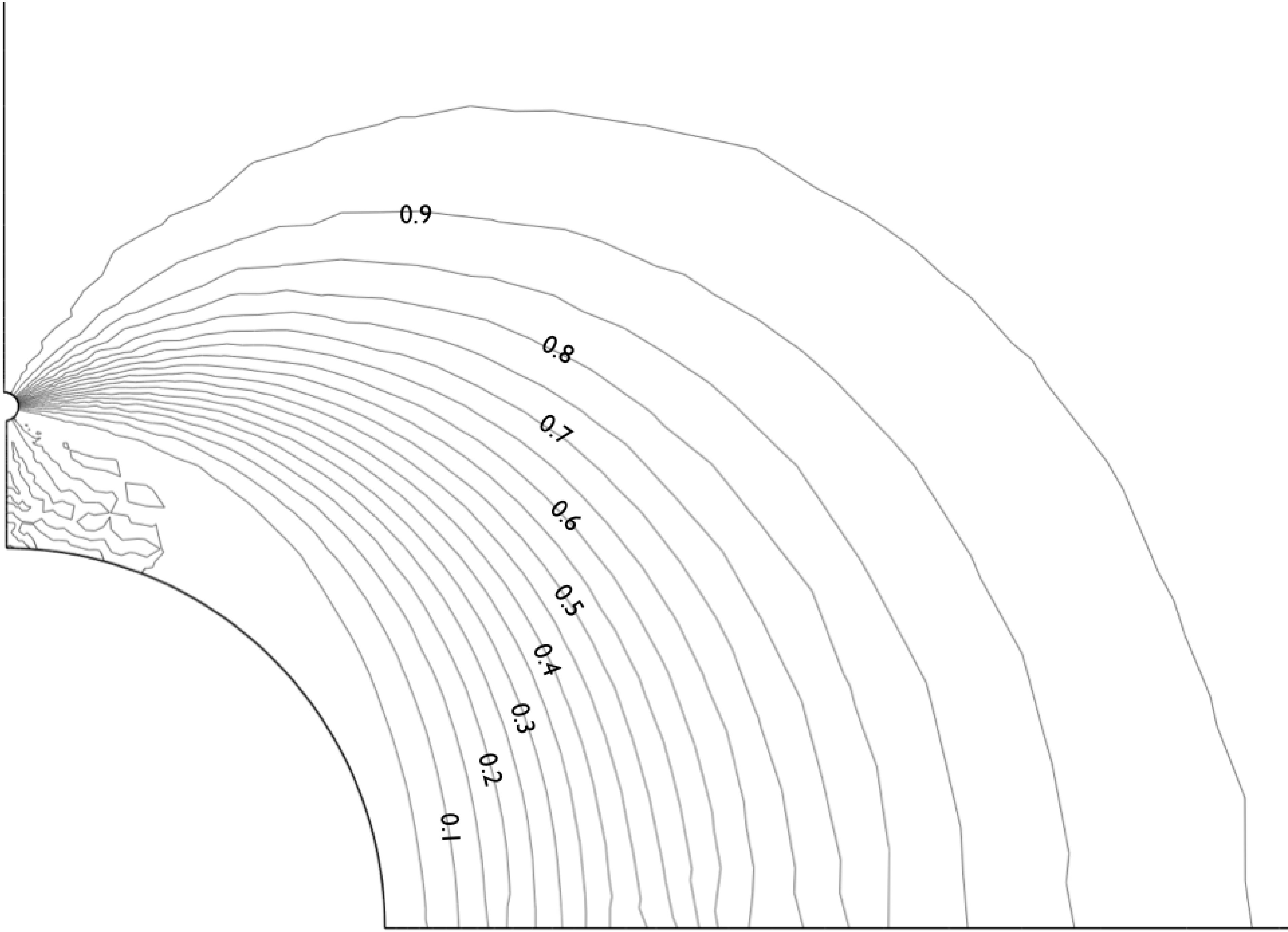
$$\nabla^2 \varphi = -D_\lambda^2 (n_i - n_e)$$

+ The Poisson equation

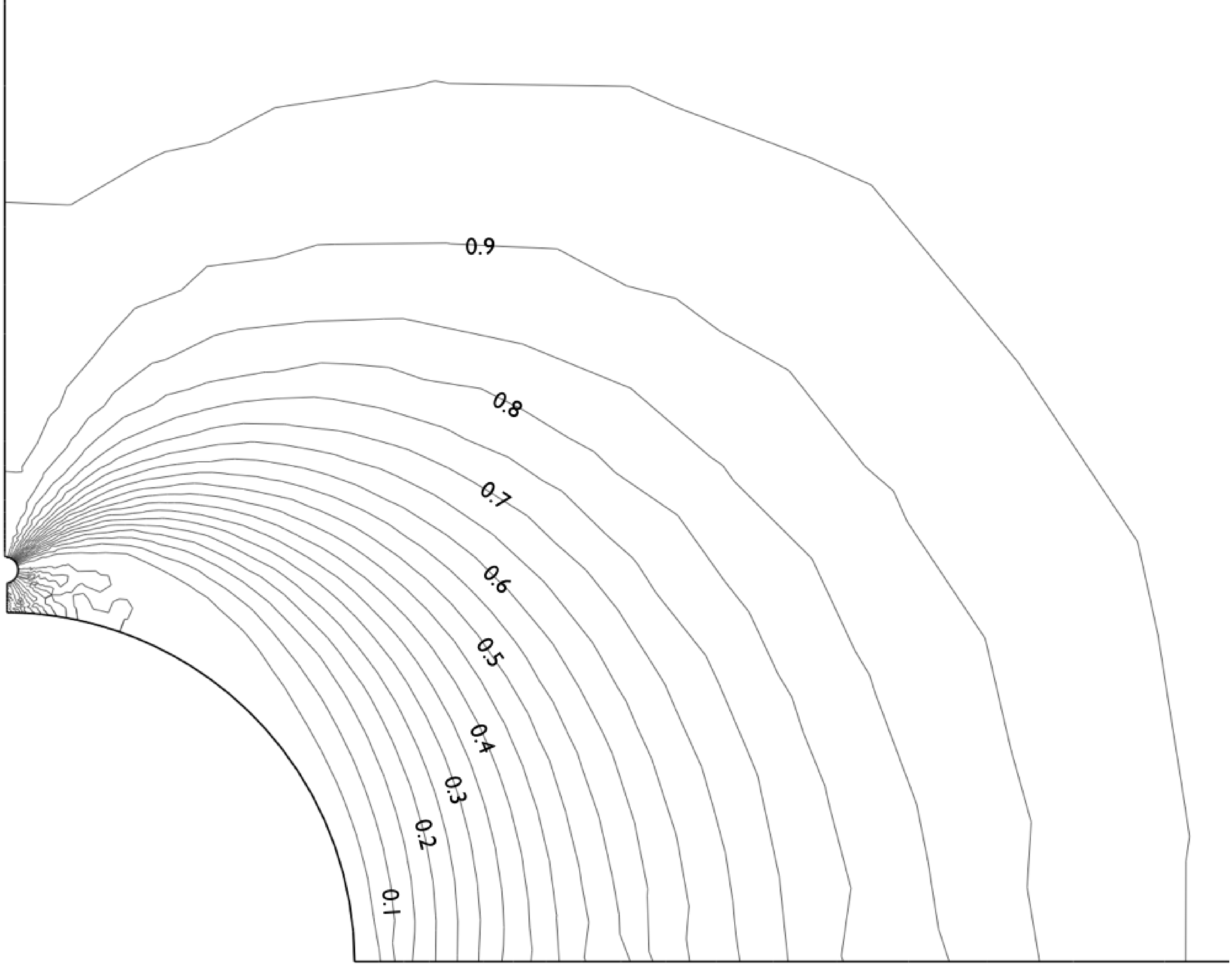

A
B
G
C
d
r_V
F
E
D



ϕ=0; n=1
Neumann
ϕ=1; n=0
r = 2.28 cm
(exaggerated here)
r = 0.4 cm
Neumann
5 or 20 cm long
ϕ=0; n=1
r = 60 cm
ϕ=0; n= 0 or 1
Neumann



0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1



0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

Numerical results

phi_p=500	**Capacitance**	**Vessel B.C.**	**Flux**	**Resistance**	**RC**	normalized R
units:	epsilon_0 * 1 m		[n_e] * 1 m	[phi_P / flux]		
5 cm boom	0,3363	n_v=1	167,3	2,99	1,01	1
		n_v=0	22,76	21,97	7,39	7.34
20 cm boom	0,3002	n_v=1	149,7	3,34	1,00	1
		n_v=0	51,27	9,75	2,93	2.92

Electron current balance equation

$$4\pi a_{RP}\sigma_e k_B T / q_e (1+\varphi_{RP}{}^{\beta_e}) =$$

$$4\pi a_V \sigma_e k_B T / q_e (1+\varphi_V{}^{\beta_V})$$

A power-law model

potential relation

$$\varphi_V \,\Box\, \frac{a_{RP}}{a_V}\varphi_{RP}$$

depends upon the ratio of radius

Conclusion: optimal design

-RP located at 40-50 cm of
vessel surface

-guard ring