Dynamic Studies of A Plasma Focus

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Dense Plasma Focus device parameter

- Mather type plasma focus device (UNU/ICTP)
- Driven by a 15kV, 30 μ F Maxwell capacitor (Peak current obtained is around 150kA)
- Energy 3.3kJ
- Electrode length 220mm
- Anode diameter 19 mm
- Cathode diameter 64 mm
- Deuterium gas used as the working gas

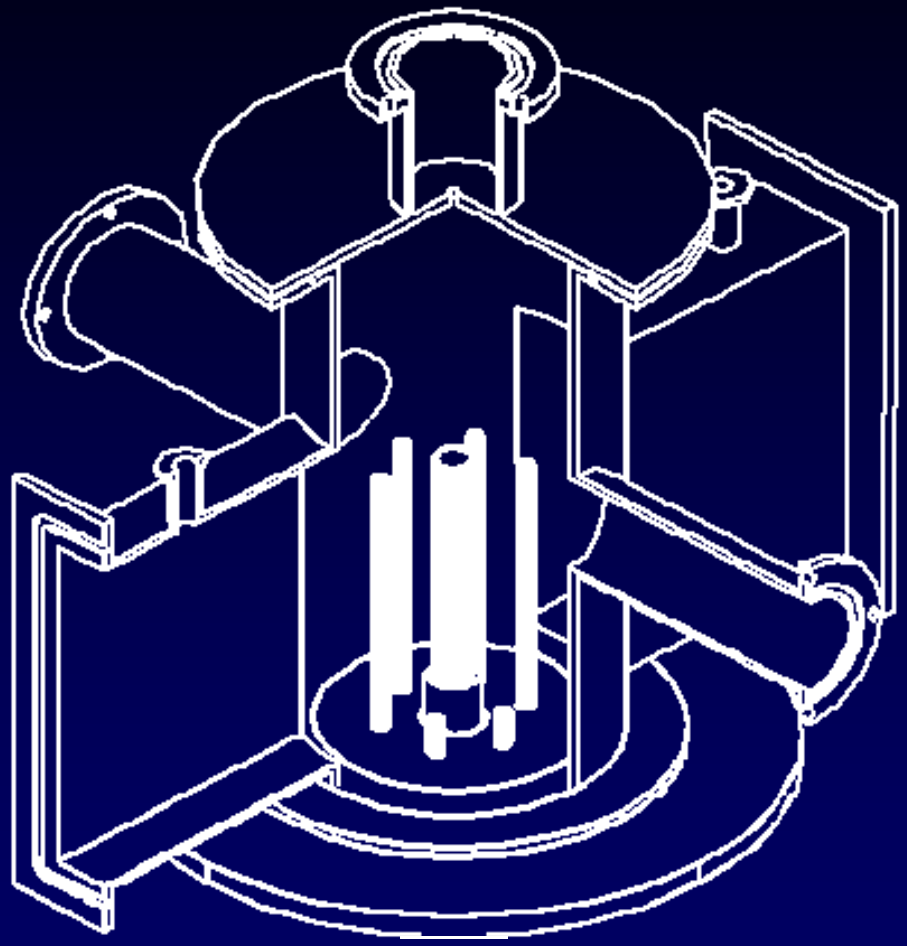


Figure 1 Schematic of the plasma focus device

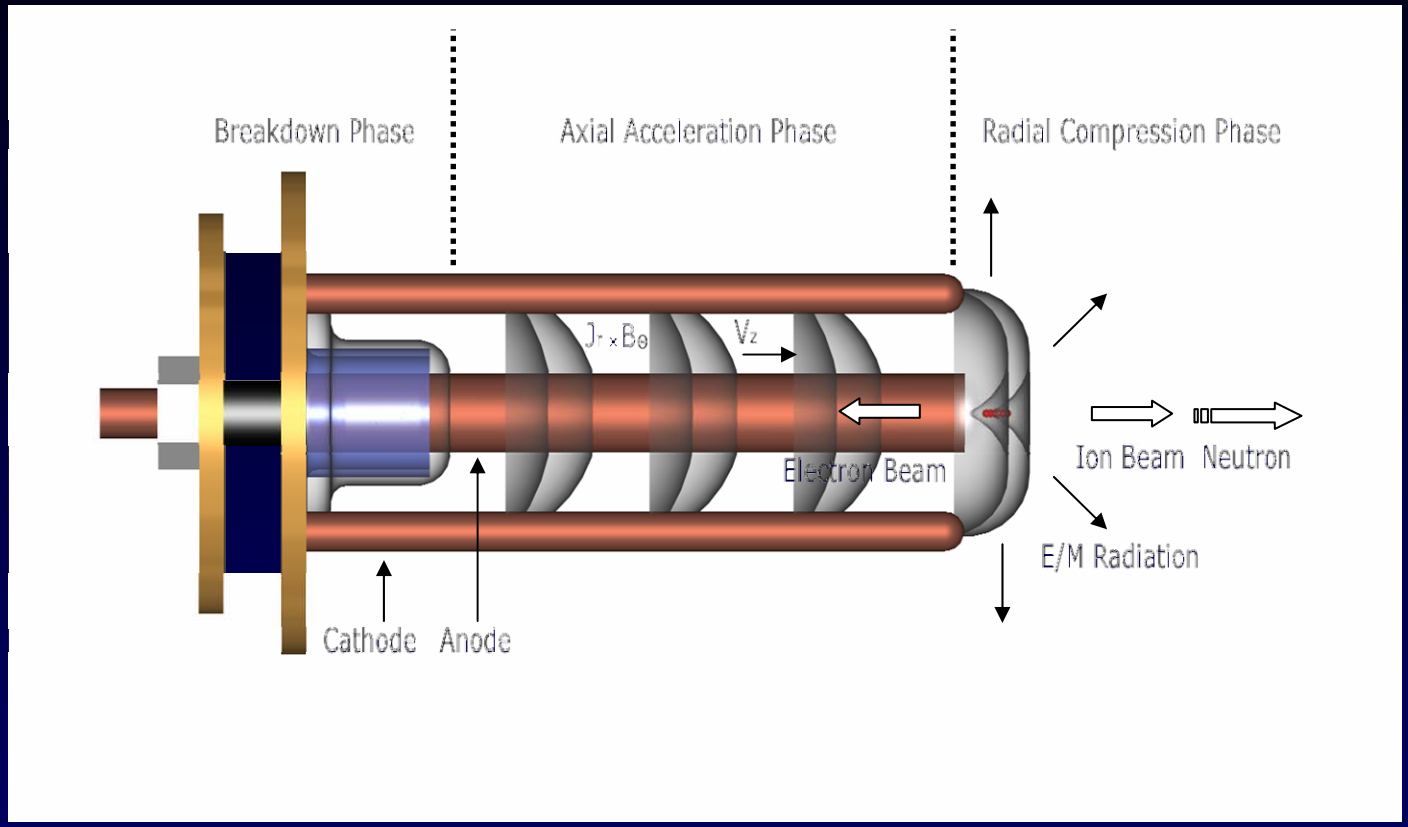


Figure 2 The schematic diagram showing a cross section of the plasma focus electrode system; a center anode, coaxial outer cathodes and insulator, and the possible radiation output from the plasma pinch.

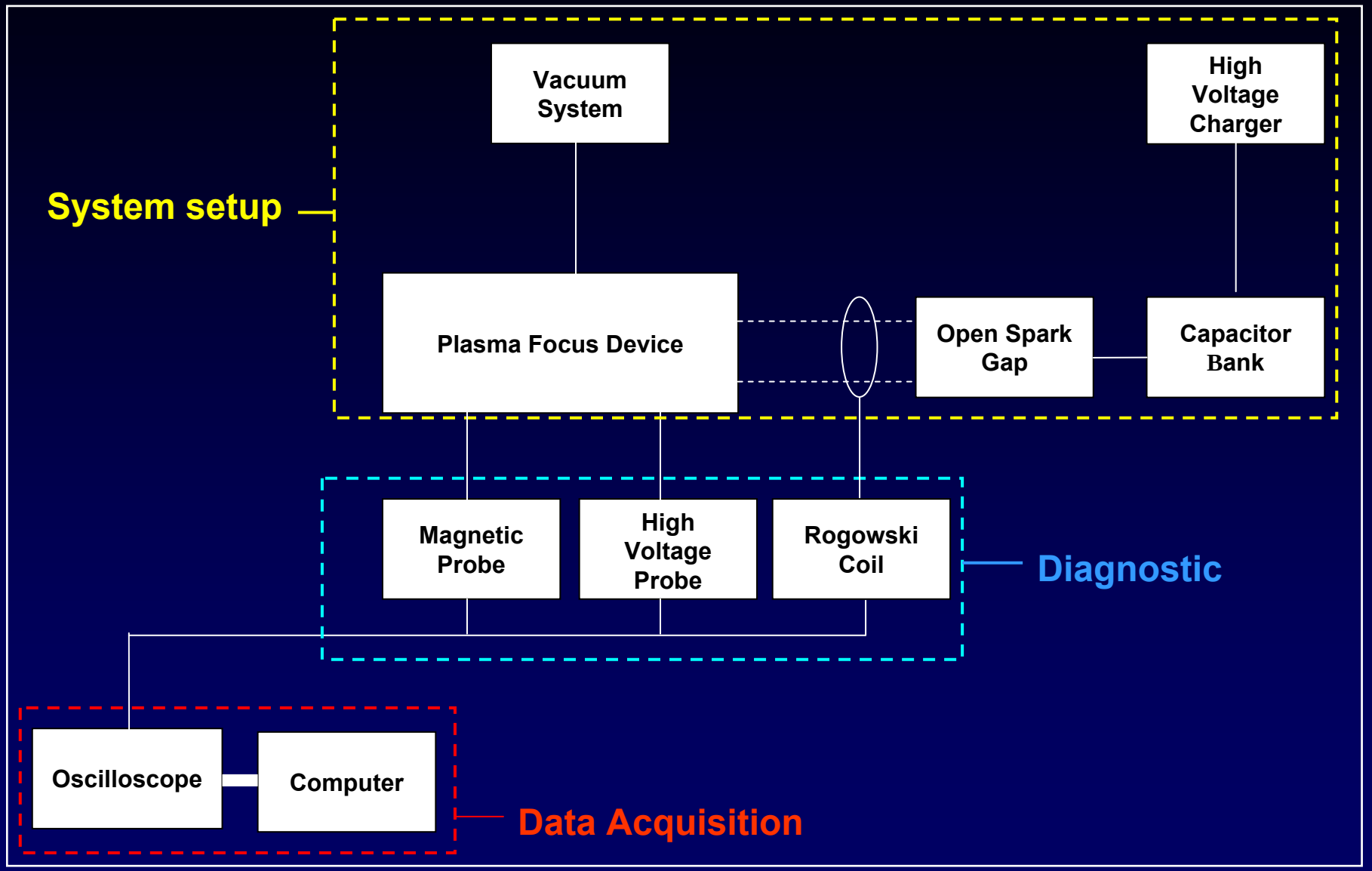


Figure 3 The Block Diagram of the Entire Plasma Focus Device and the Diagnostic Setup

DPF Operating Pressure

- Obtained optimum pressure based on significant voltage signal for different pressures.
- The effect of the filled pressure to the dynamics of the current sheath is analyzed based on the average velocity of the current sheath obtained at different pressures.
- The optimum operating pressure was 0.5 – 1.0 mbar.
- 90% of the shots are getting the focusing shots
- average speed for the current sheath was around 7 to 10cm/us

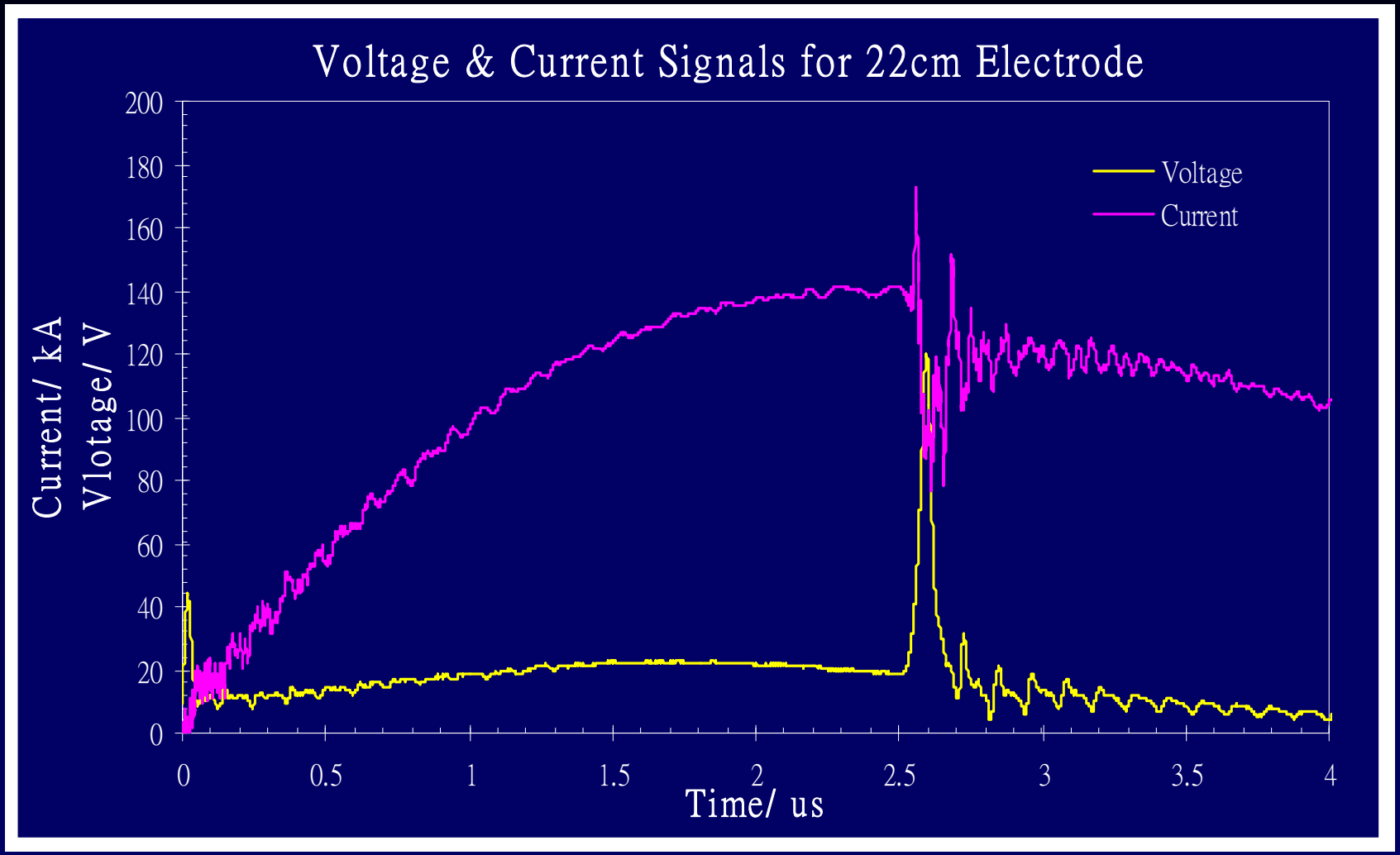


Figure 4 Typical Current and voltage signals at 0.5 mbar deuterium discharge.

Magnetic Probe

- Dynamic of the current sheath in the axial acceleration phase were investigated by using magnetic probe.
- The magnetic probe enclosed in a glass tube that was inserted from the top plate of the chamber.
- Located in between of the center anode and the outer electrode.
- Magnetic probe located started from 1cm to 22cm from the back wall of the chamber were changed in step of 1cm in the vertical direction.
- Arrival time of the current sheath will be registered at the magnetic probe position.

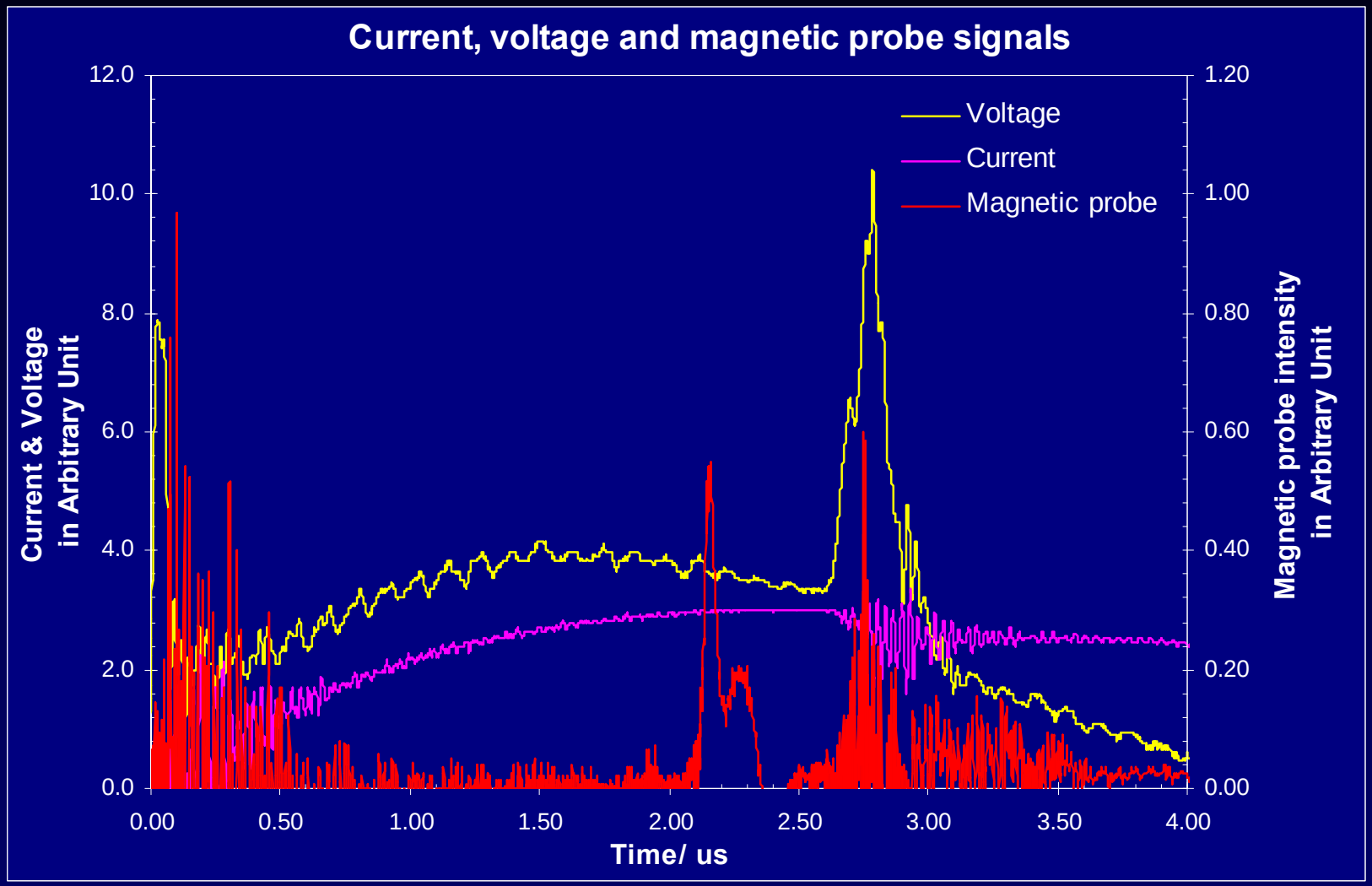


Figure 5 Signals of the current, voltage and the magnetic probe which placed at 10 cm from the back wall of the chamber.

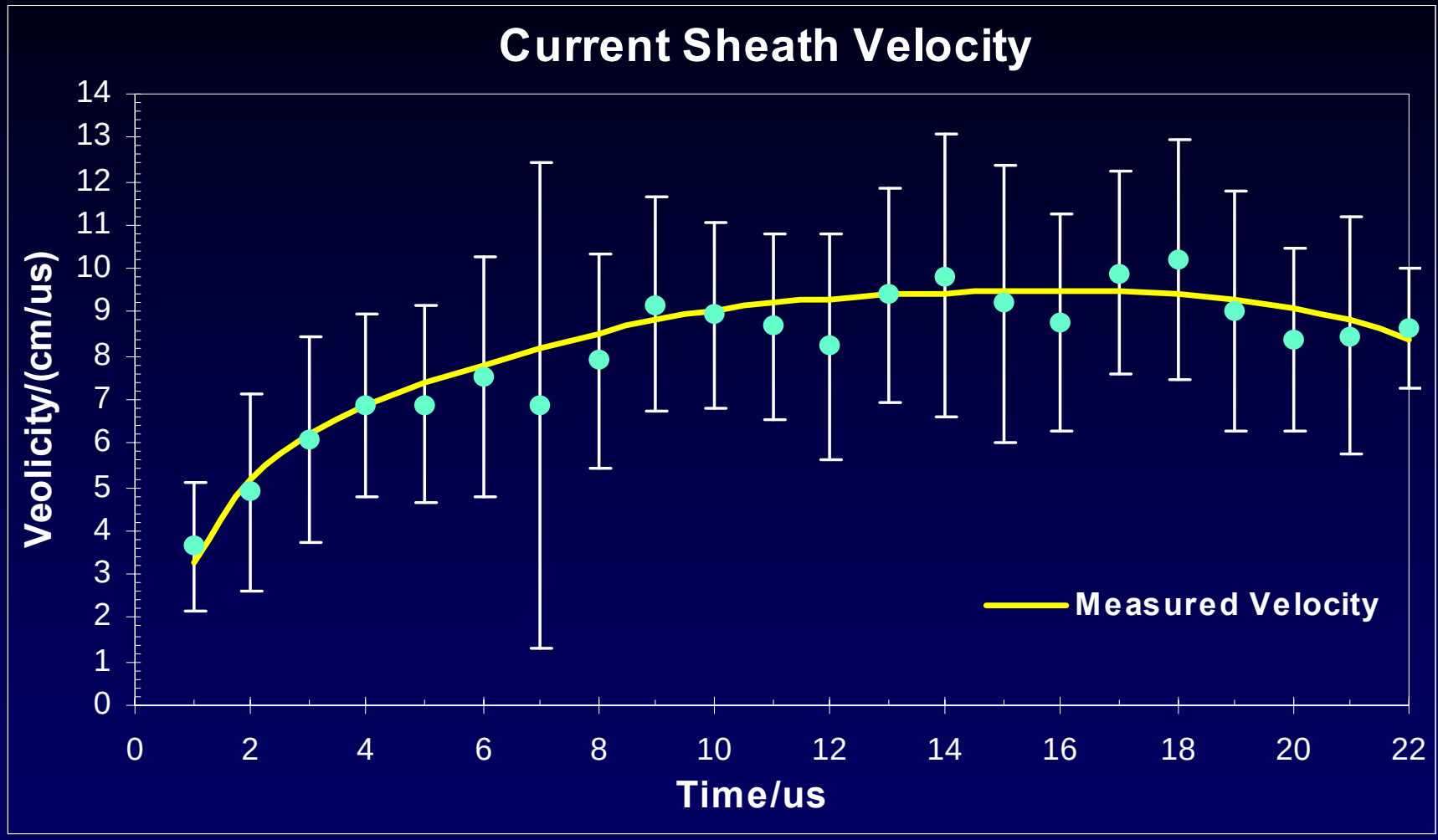


Figure 6 Current sheath velocity obtained on 0.7 mbar.

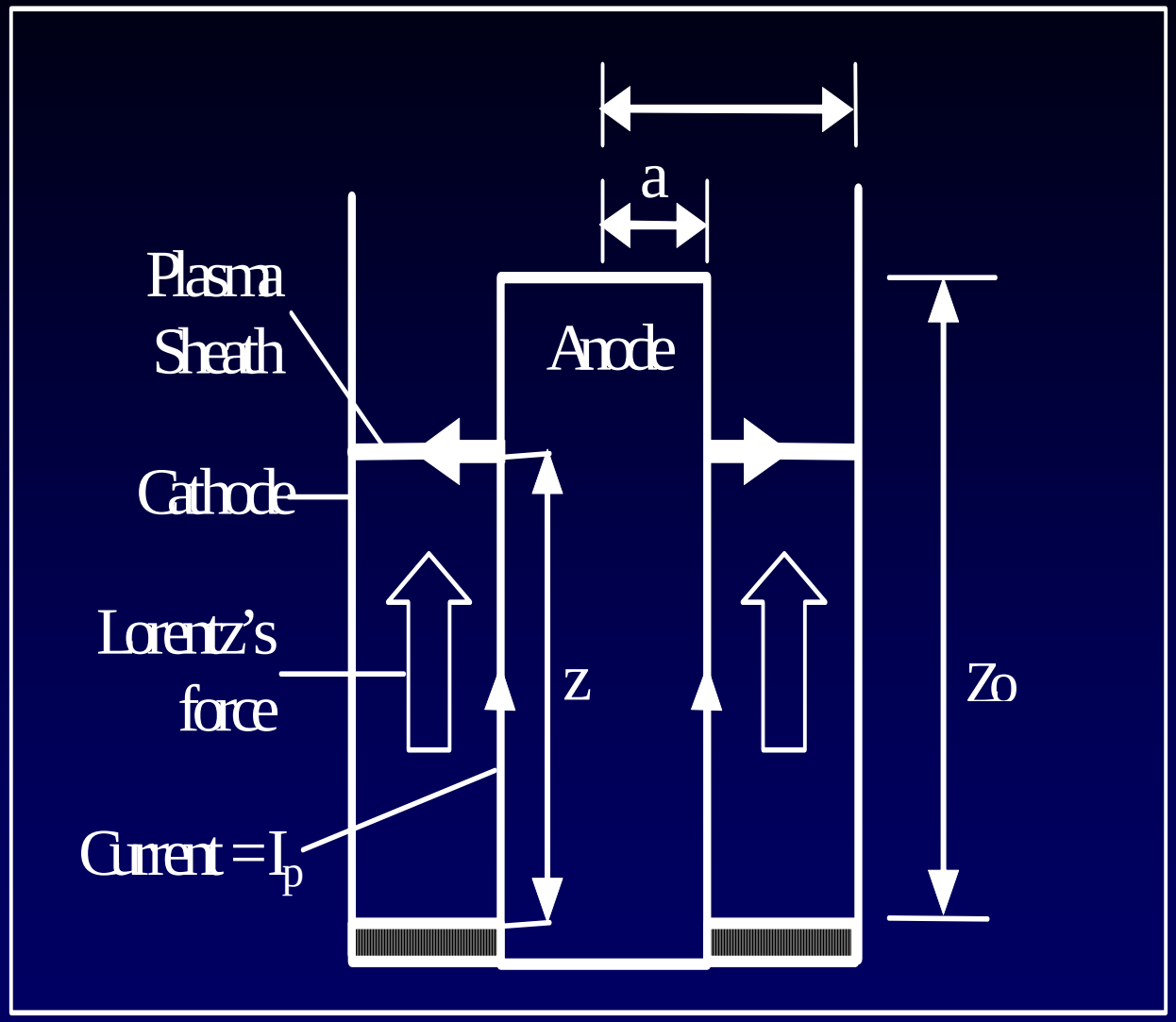


Figure 7 Diagram of a model of the current sheath during axial phase of a plasma focus.

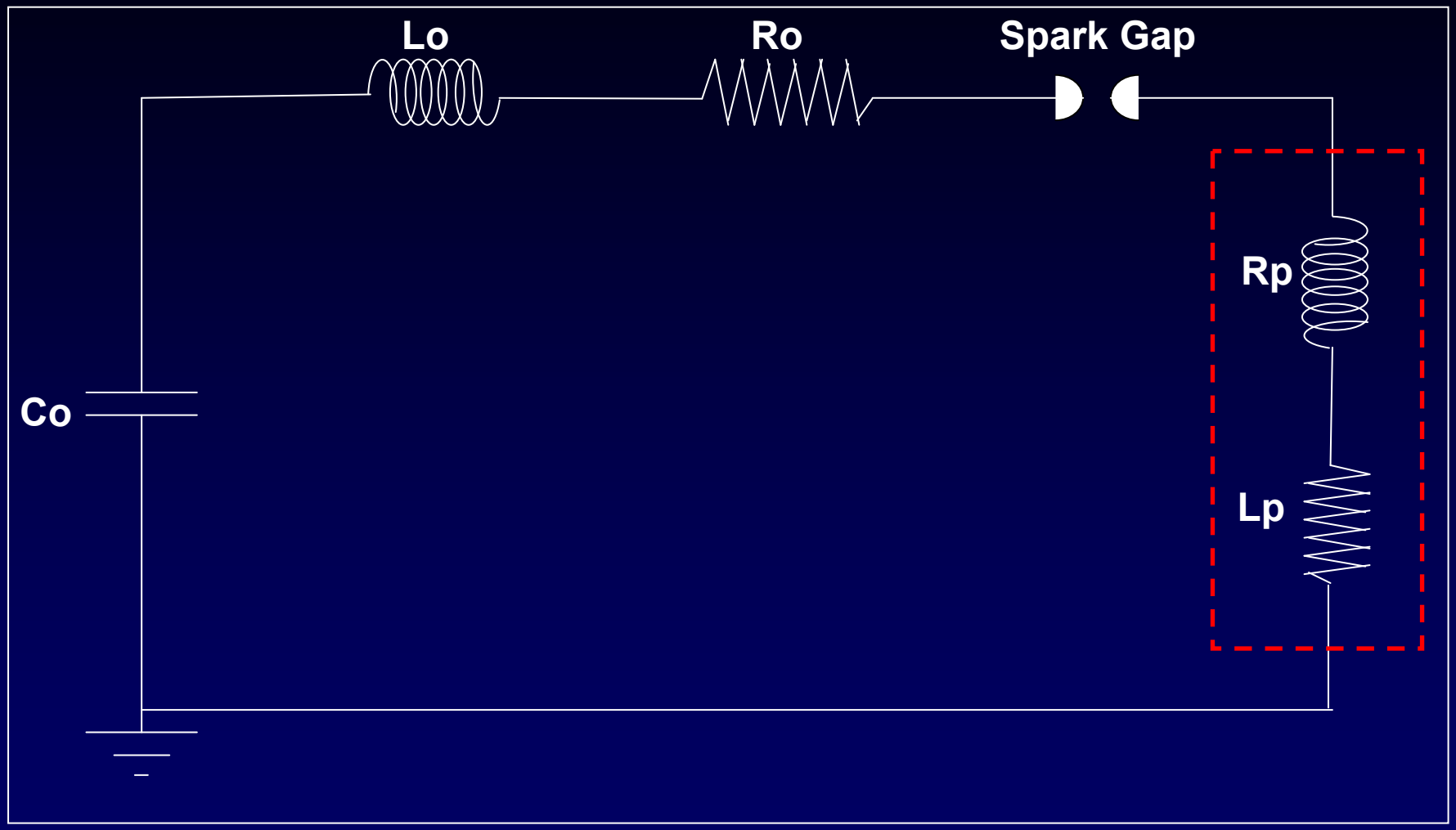


Figure 8 Equivalent Circuit of Plasma Focus Discharged

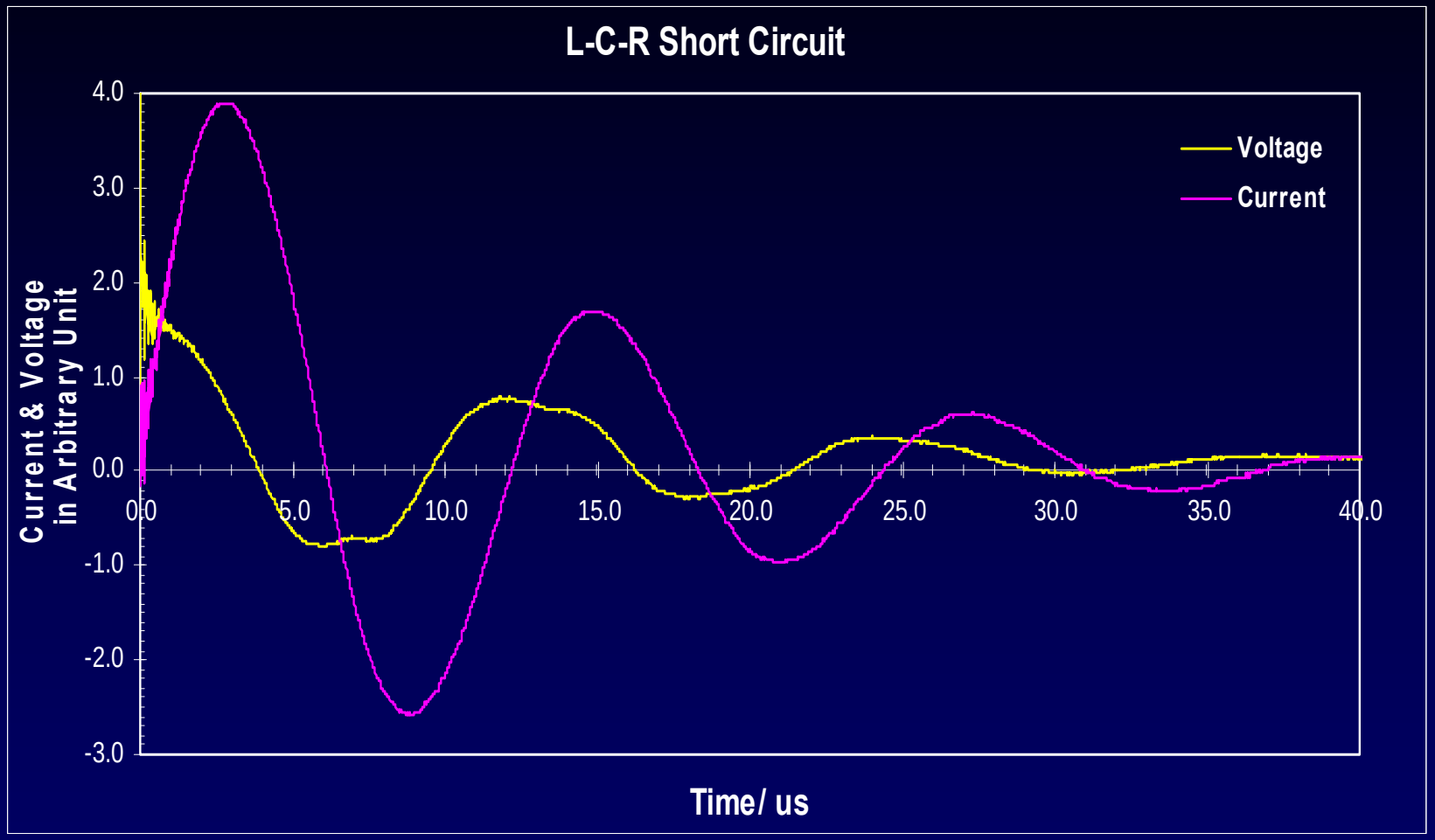


Figure 9 Light damping LCR discharge signals obtained at the high pressure of 20 mbar with total current of 229 kA. The DPF inductance and stray resistance are estimated from the discharge current at about 130 nH and 24 mΩ.

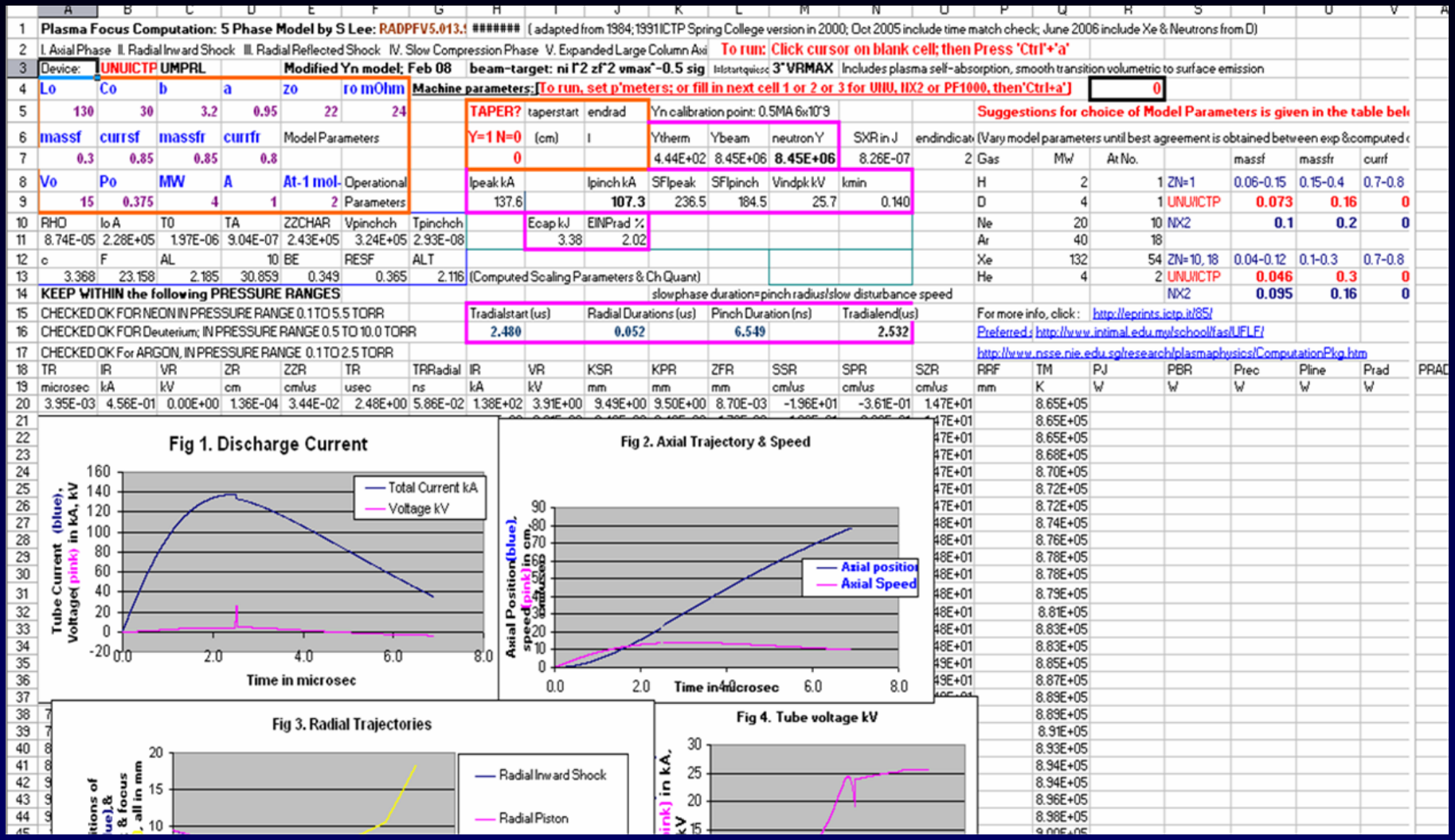


Figure 10 Print screen of the computation results obtained by using the plasma focus modeling package: Lee Model version 13.9b. Ratio of I_{pinch}/I_{peak}~0.78

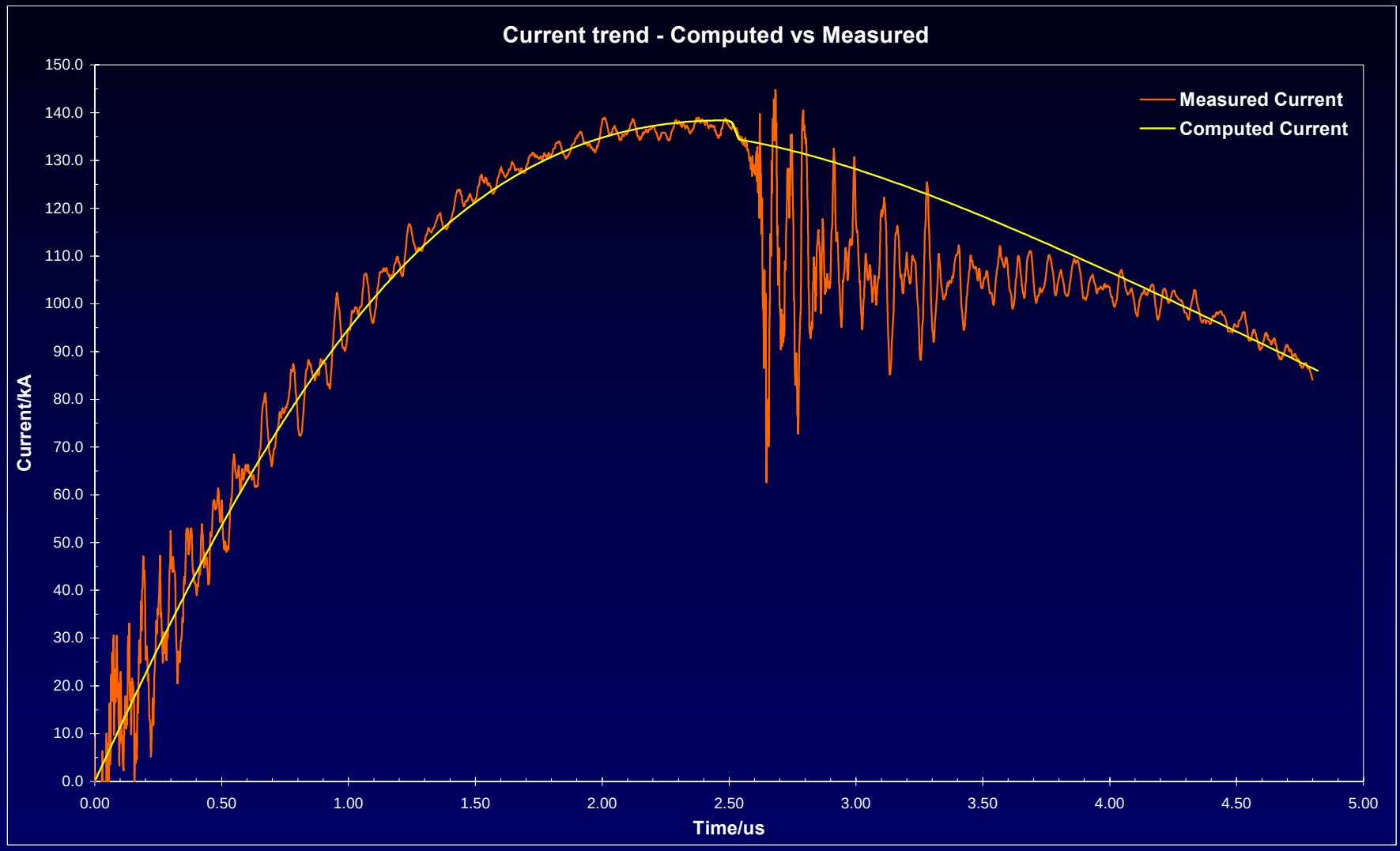


Figure 11 Fitted computed current to measured current waveform of DPF UNU/ICTP 3.3kJ with electrodes length 22cm. The Model parameters massf, currsf, massfr, currfr are 0.3, 0.85, 0.8, 0.8 respectively.

Result and Discussion

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Plasma Focus Computation: 5 Phase Model by S Lee: RADPFV5.013.9b							10-Apr-08	(adapted from 1984;1991 ICTP Spring College version in 2000; Oct 2005 include time m						
2	I. Axial Phase	II. Radial Inward Shock		III. Radial Reflected Shock		IV. Slow Compression Phase		V. Expanded Large Column Axi:			To run: Click cursor on blank cell; the				
3	Device:	UNUICTPP	ICDMP Poland		Modified Yn model; Feb 08			beam-target: ni I^2 zf^2 vmax^ -0.5 sig			I=Istartquiesc	3*VRMAX		Includes plasma self-abs	
4	Lo	Co	b	a	zo	ro mOhm	Machine parameters:	To run, set p'meters; or fill in next cell 1 or 2 or 3 for UNU, NX2 or PF1000							
5	130	30	3.2	0.95	22	24		TAPER?	taperstart	endrad	Yn calibration point: 0.5MA 6x10^9				
6	massf	currsf	massfr	currfr	Model Parameters			Y=1 N=0	(cm)	€	Ytherm	Ybeam	neutron Y	SXR in J	endindica
7	0.3	0.85	0.8	0.8				0			6.02E+02	8.06E+06	8.06E+06	6.63E-07	
8	Vo	Po	MW	A	At-1 mol-	Operational		Ipeak kA		Ipinch kA	SFIpeak	SFIpinch	Vindpk kV	kmin	
9	15	0.375	4	1	2	Parameters		137.6		107.3	236.5	184.4	26.4	0.140	
10	RHO	Io A	T0	TA	ZZCHAR	Vpinchch	Tpinchch		Ecap kJ	EINPrad %					
11	8.74E-05	2.28E+05	1.97E-06	9.04E-07	2.43E+05	3.34E+05	2.84E-08		3.38	1.99					
12	c	F	AL		10 BE	RESF	ALT								
13	3.368	23.158	2.185	31.809	0.349	0.365	2.118	(Computed Scaling Parameters & Ch Quant)							
14	KEEP WITHIN the following PRESSURE RANGES										slowphase duration=pinch radius/slow disturbance speed				
15	CHECKED OK FOR NEON IN PRESSURE RANGE 0.1 TO 5.5 TORR							Tradialstart (us)		Radial Durations (us)		Pinch Duration (ns)		Tradialend(us)	
16	CHECKED OK FOR Deuterium; IN PRESSURE RANGE 0.5 TO 10.0 TORR							2.480		0.050		6.353		2.531	
17	CHECKED OK For ARGON, IN PRESSURE RANGE 0.1 TO 2.5 TORR														
18	TR	IR	VR	ZR	ZZR	TR	TRRadial	IR	VR	KSR	KPR	ZFR	SSR	SPR	SZR
19	microsec	kA	kV	cm	cm/us	usec	ns	kA	kV	mm	mm	mm	cm/us	cm/us	cm/us

Fig 6. Plasma Temperature

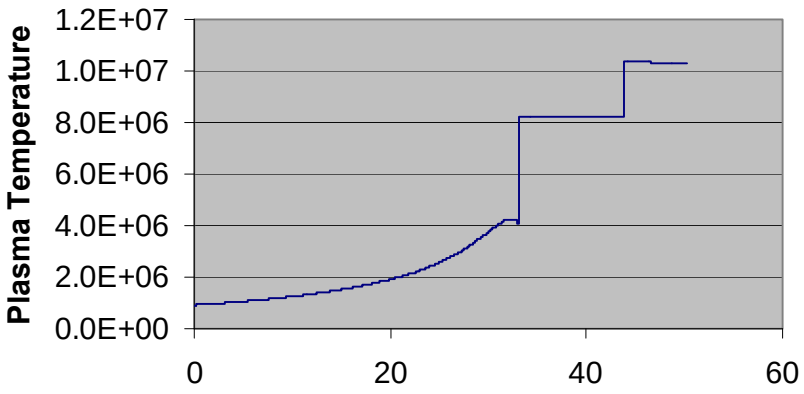
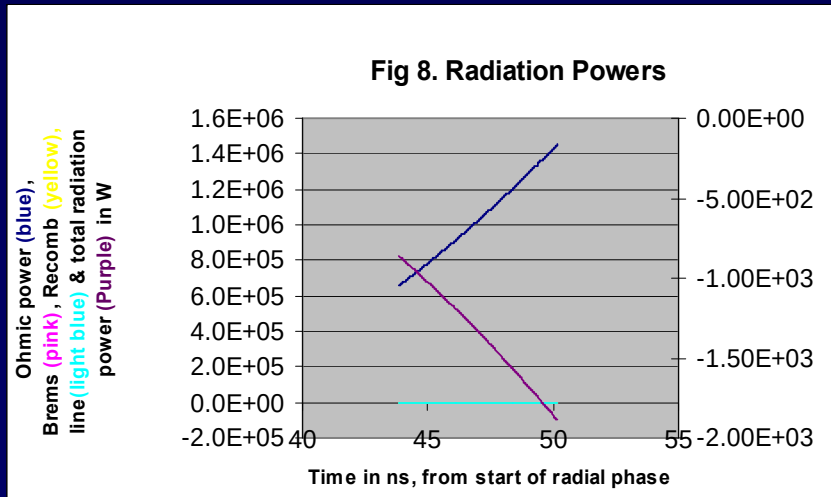


Fig 8. Radiation Powers



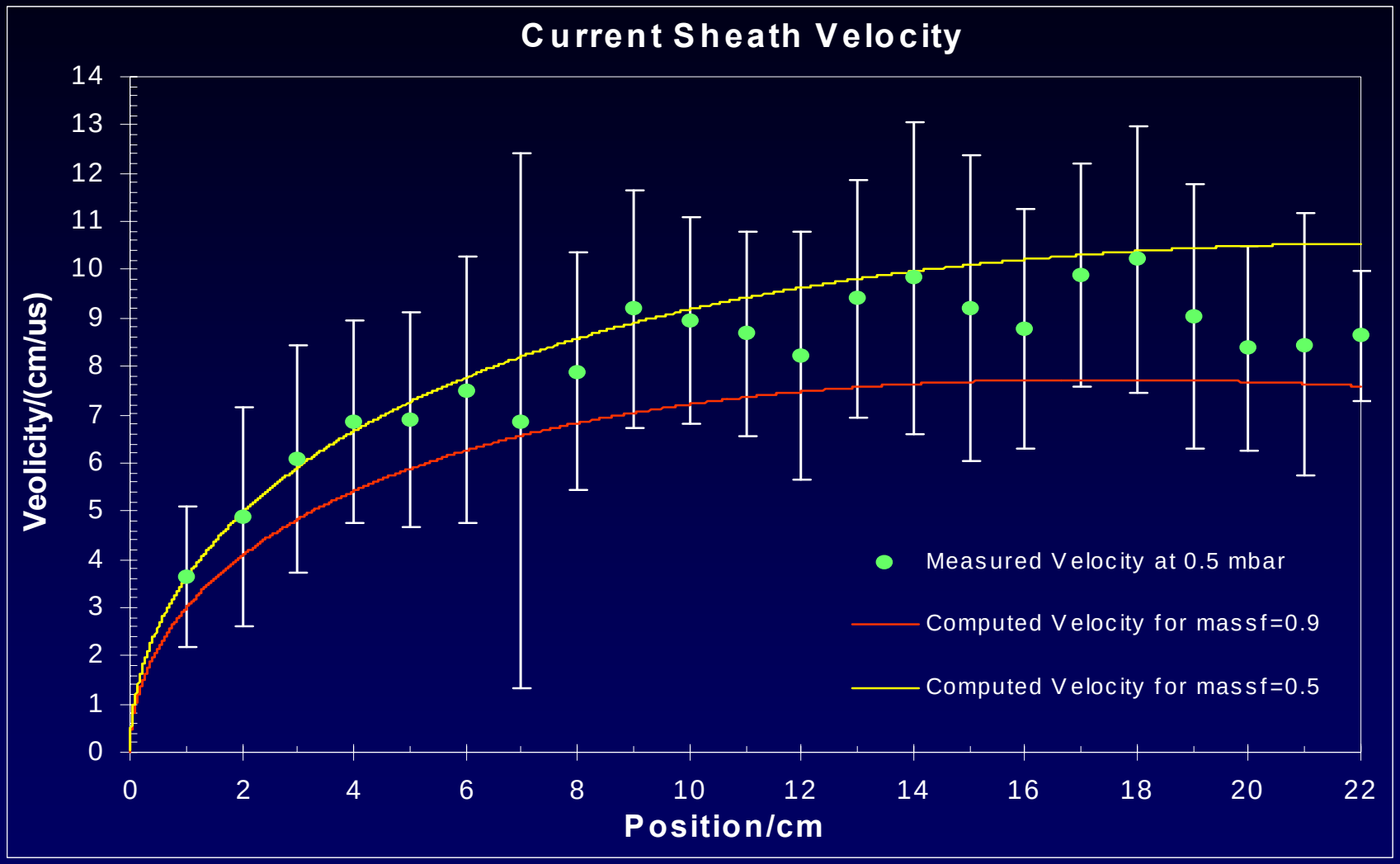


Figure 12 Comparison of the measured current sheath velocity with the computed current sheath velocity. The massf for measured current sheath in between 0.5 to 0.9 for 0.7 mbar.

CONCLUSION

- Dynamic of the current sheath for 22cm in the axial acceleration phase shown that the maximum velocity was around 10 cm/us.
- The high speed of current sheath is favorable for a good pinch effect.
- A possible enhancement of mass sweep of the current sheath when operating at low pressure.
- A good fitted for the axial phase were obtained with model parameters massf and currsf are 0.3 and 0.85 respectively.


THANK YOU !