Cylindrical Energy Analyzer for Heavy Ion Beam Diagnostics for measurements in tokamaks and stellarators

Presented by
Ridhima Sharma

Heavy ion beam probe (HIBP): ISTTOK

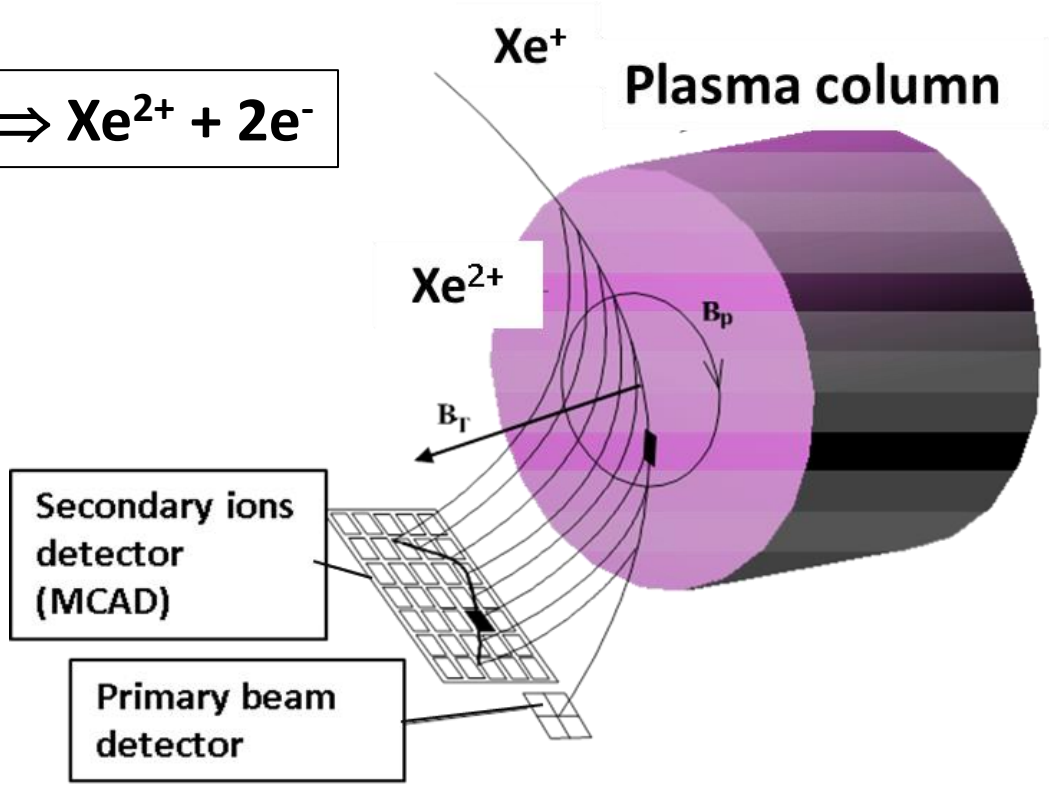
Tokamak ISTTOK :

R = 0.46 m, a = 0.085 m

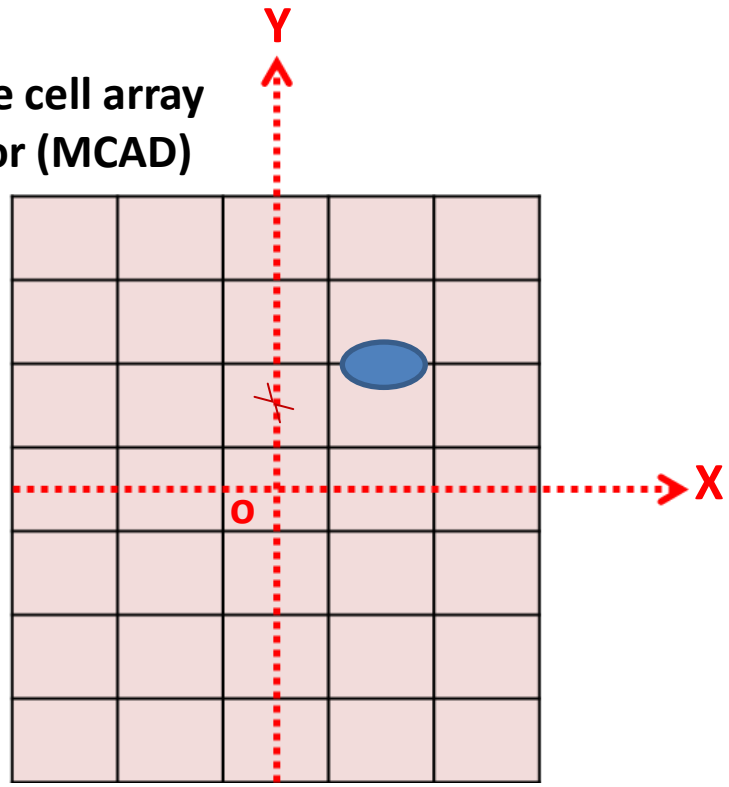
B = 0.5 T, I_p = 4-6 kA,

$\langle n_e \rangle = 5 \times 10^{18}$ m^{-3}, T_e = 120 eV

$$Xe^{+} + e^{-} \Rightarrow Xe^{2+} + 2e^{-}$$



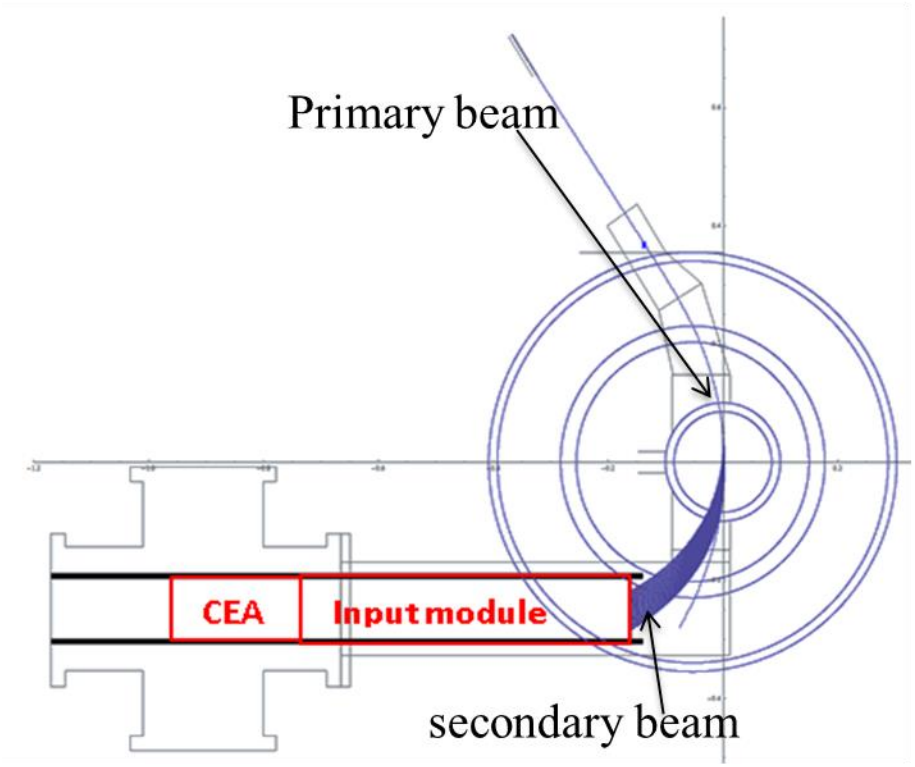
Multiple cell array detector (MCAD)

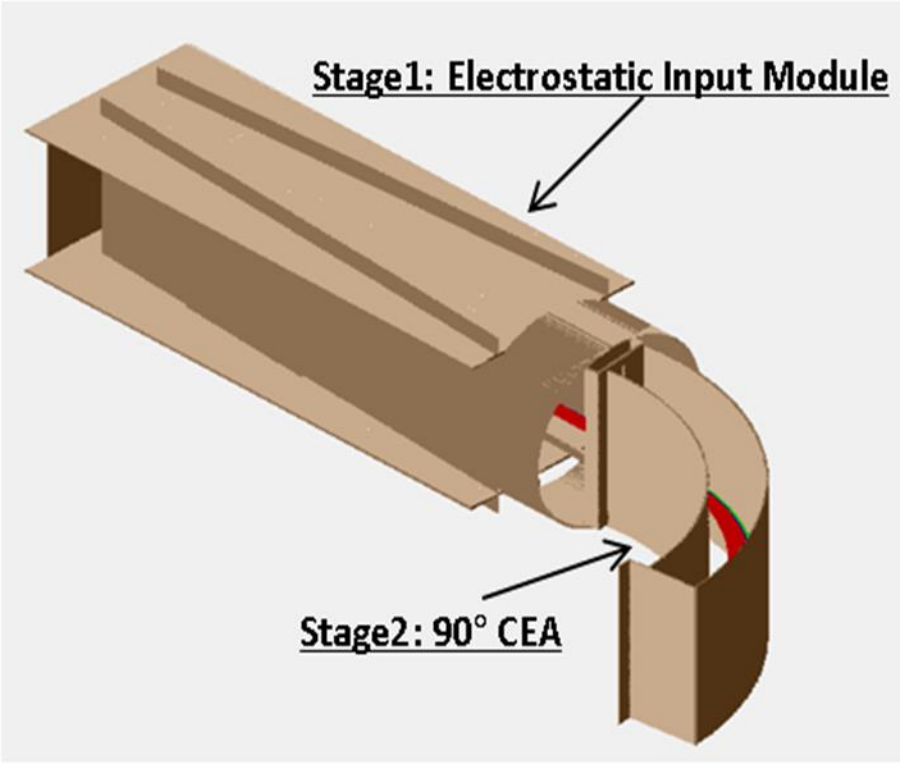


$$Xe^{+} + e^{-} \Rightarrow Xe^{2+} + 2e^{-}$$

Measurable	Plasma parameter
$I(Xe^{2+})$	$< n\sigma >$
ΔX	$\Delta \varphi$
ΔY	ΔB_P

Experimental arrangement





90º Conventional cylindrical electrostatic analyser (CEA)

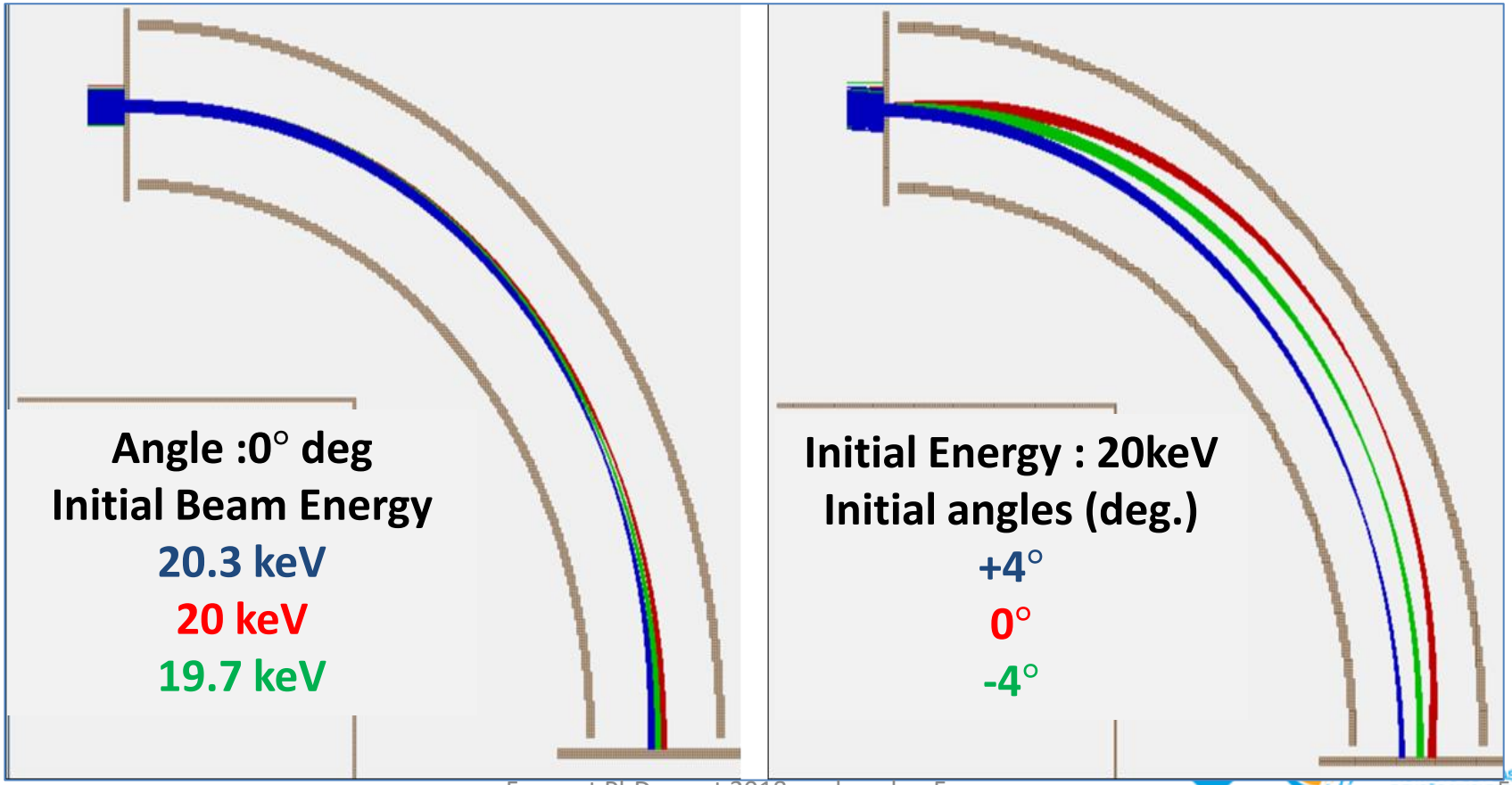
Normal mode operation

$$\Delta r = \delta r + C_E \delta E + C_\theta \delta\theta$$

V_{outer}/V_{inner}
+2.4 / 2.4 kV

Energy dispersion

Angular dispersion

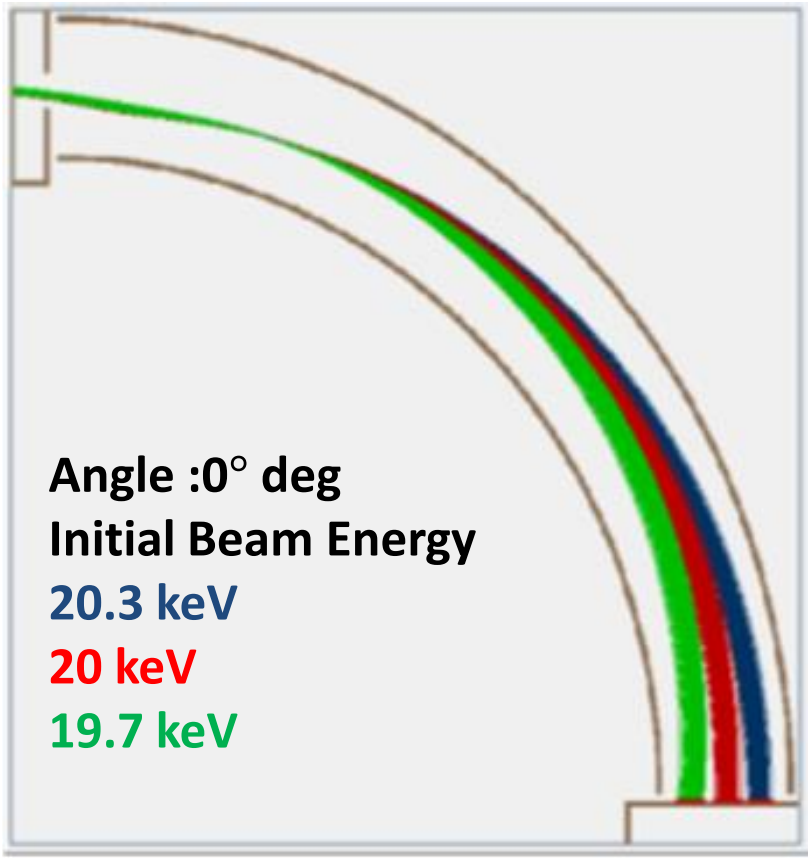


Noval retardation mode operation : 90º CEA

$$\Delta r = \delta r + C_E \delta E + C_\theta \delta\theta$$

Energy dispersion

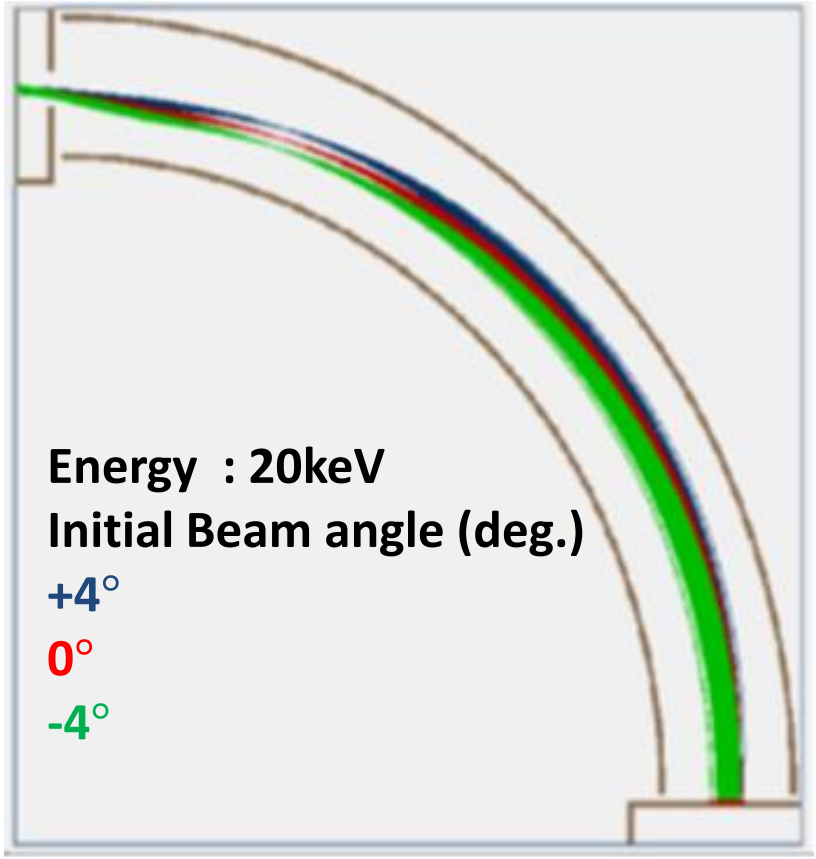
V_{outer}/V_{inner}
8.59/7.61kV
V_o/V_{end}
8.1/8.1 KV



Noval retardation mode operation : 90º CEA

$$\Delta r = \delta r + C_E \delta E + C_\theta \delta\theta$$

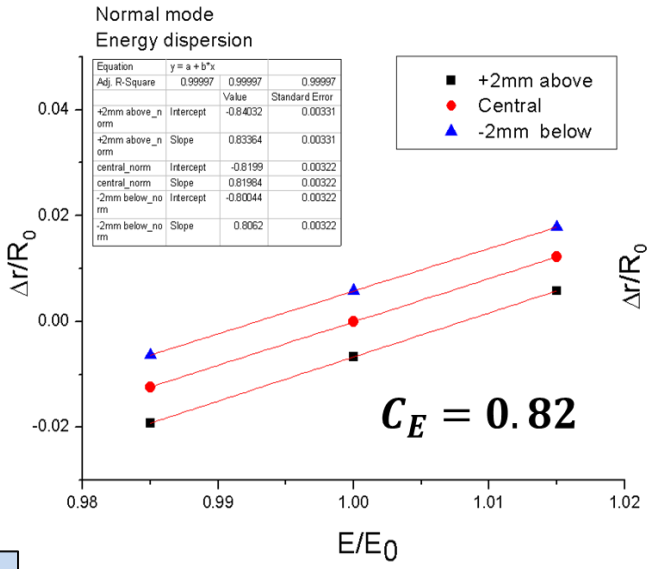
Angular dispersion

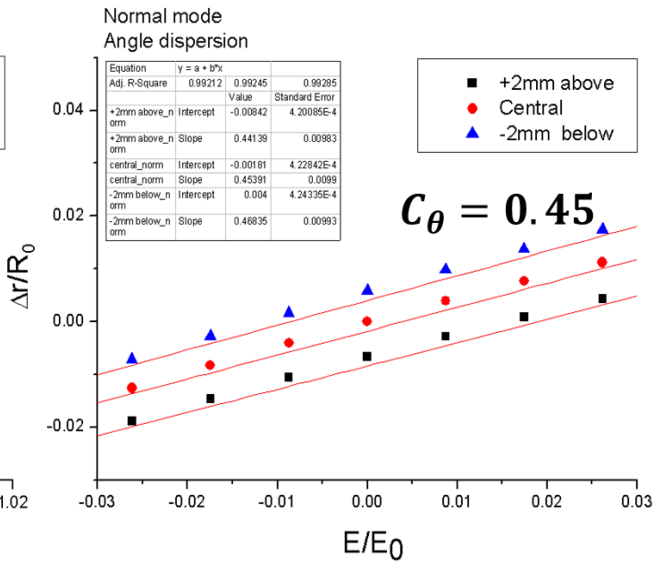


V_{outer}/V_{inner}
8.59/7.61kV
V_o/V_{end}
8.1/8.1 KV

ipfn INSTITUTO DE PLASMAS E FUSÃO NUCLEAR

Normal mode

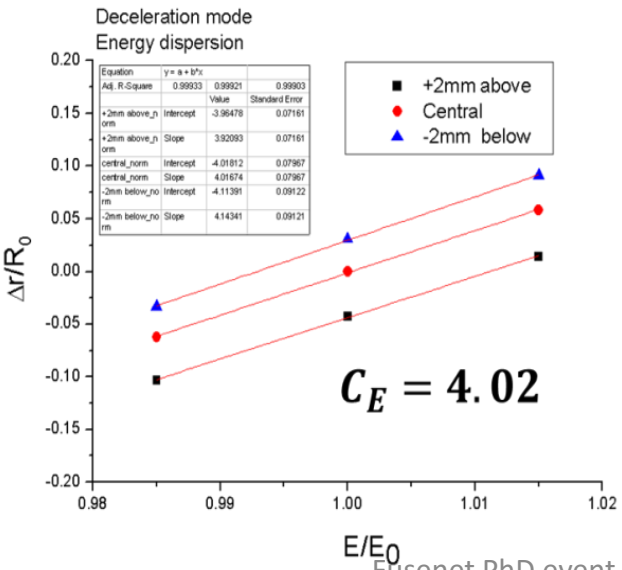


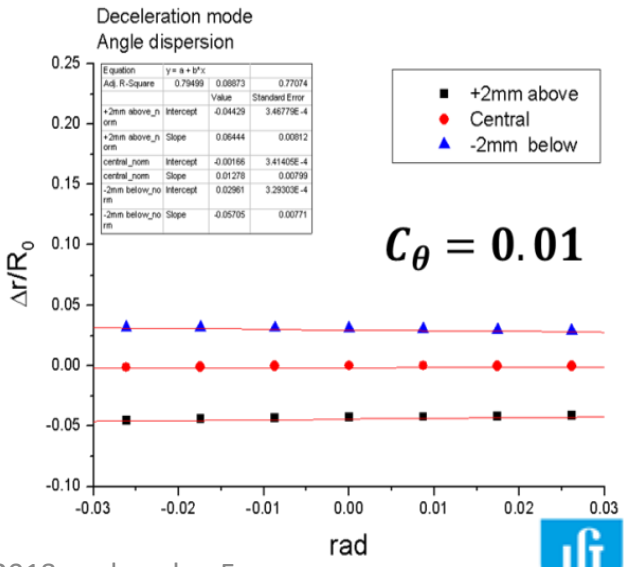


$\frac{(CE)_{DM}}{(CE)_{NM}} = 5$

$\frac{(C_\theta)_{DM}}{(C_\theta)_{NM}} = \frac{1}{45}$

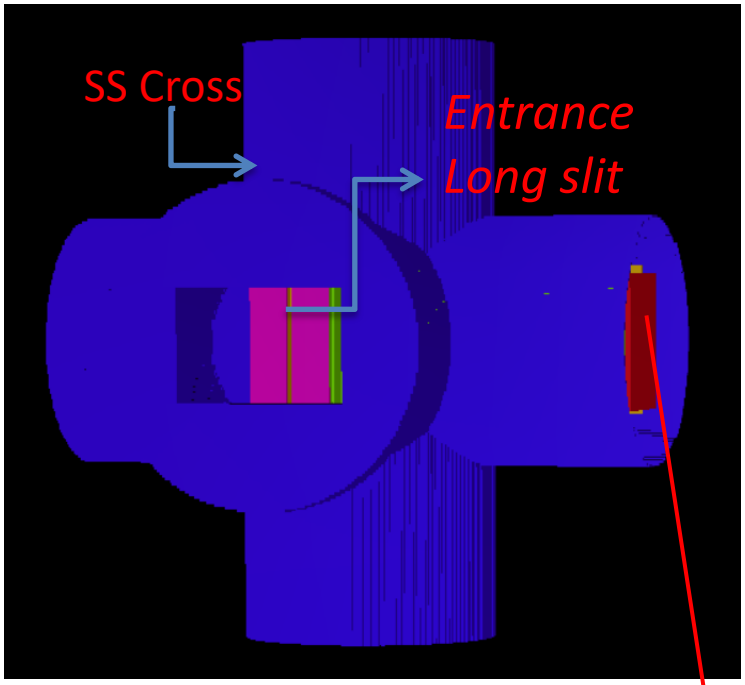
Deceleration mode



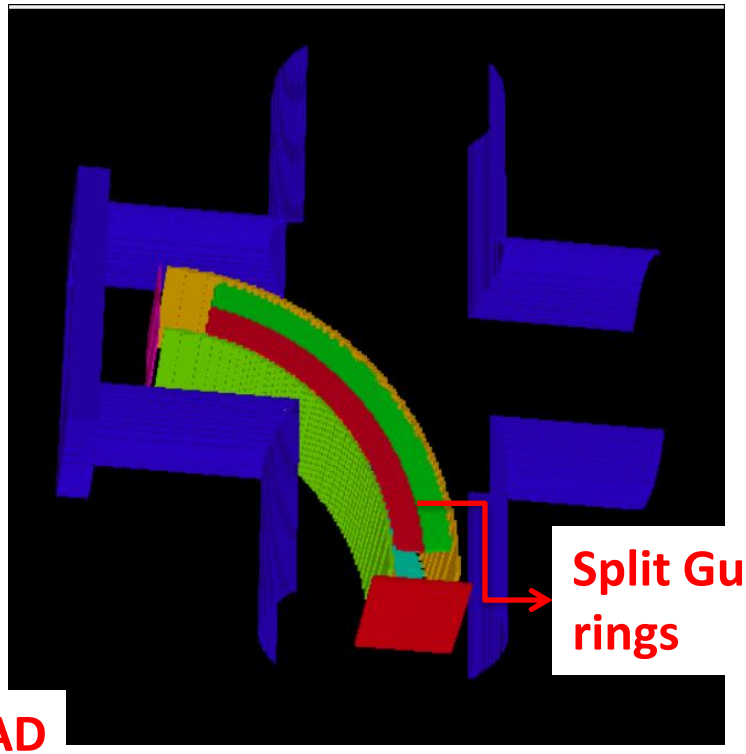


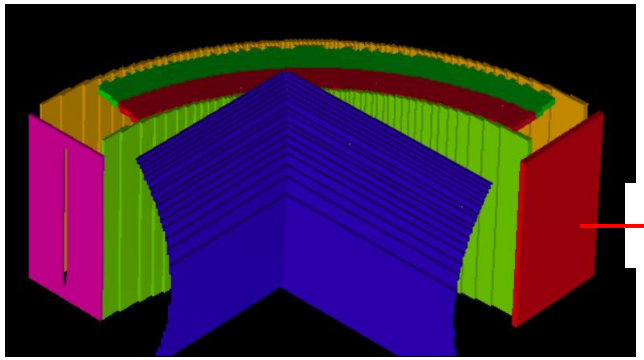
3D design in SIMION

Housing chamber



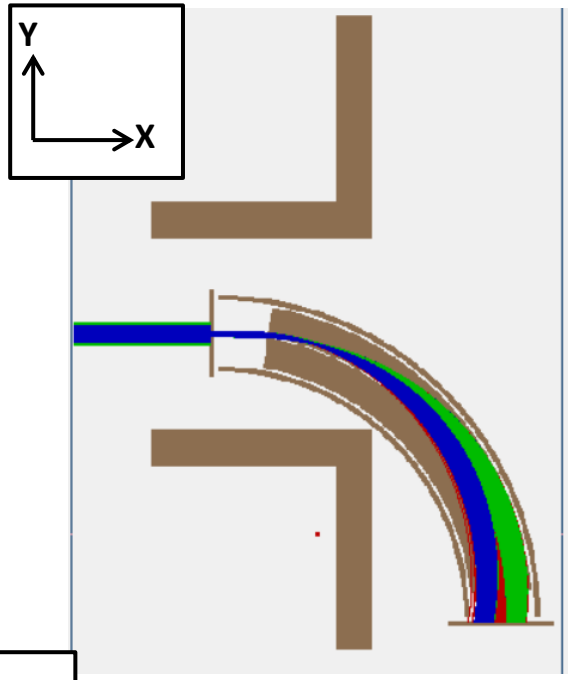
Guard rings

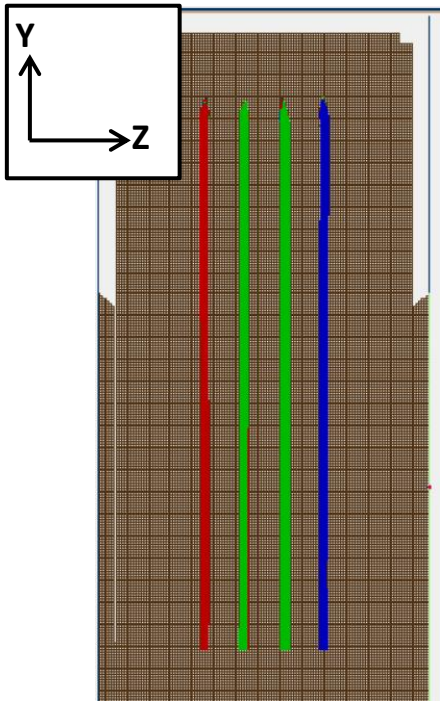




Optimised CEA:

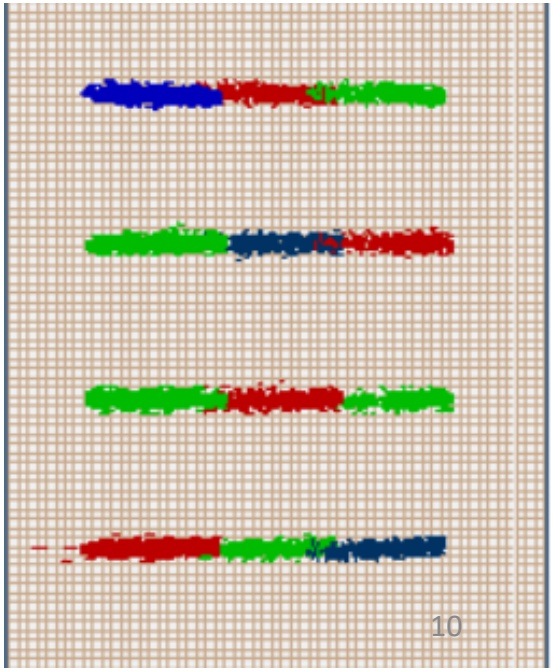
4 channels with energy 19.7 ,20, 20.3keV

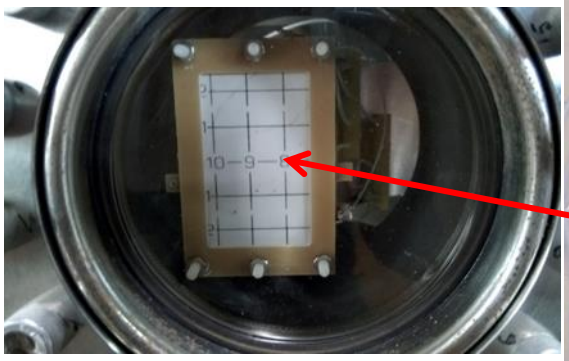




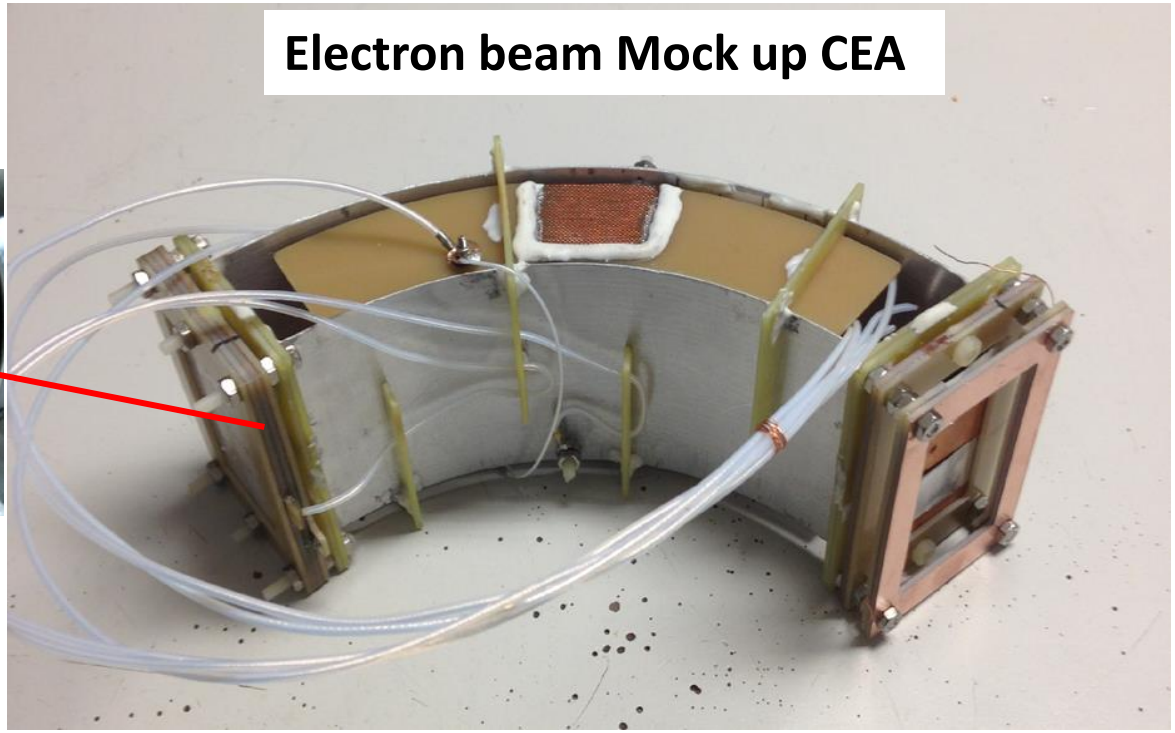
Electrode	Voltage(kV)
Analyser outer/inner	8.69/7.66
End MCAD	8.175
GR_inner:1 GR_outer:2	7.95 8.46

End MCAD



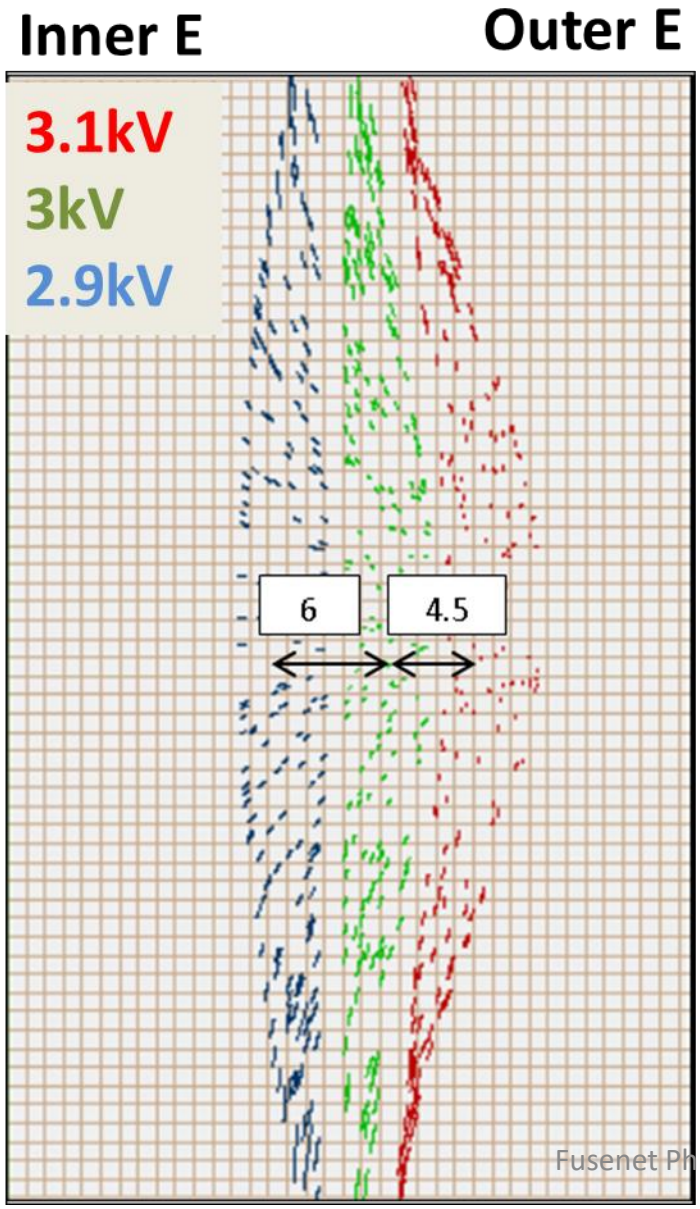


Phosphoras detection screen

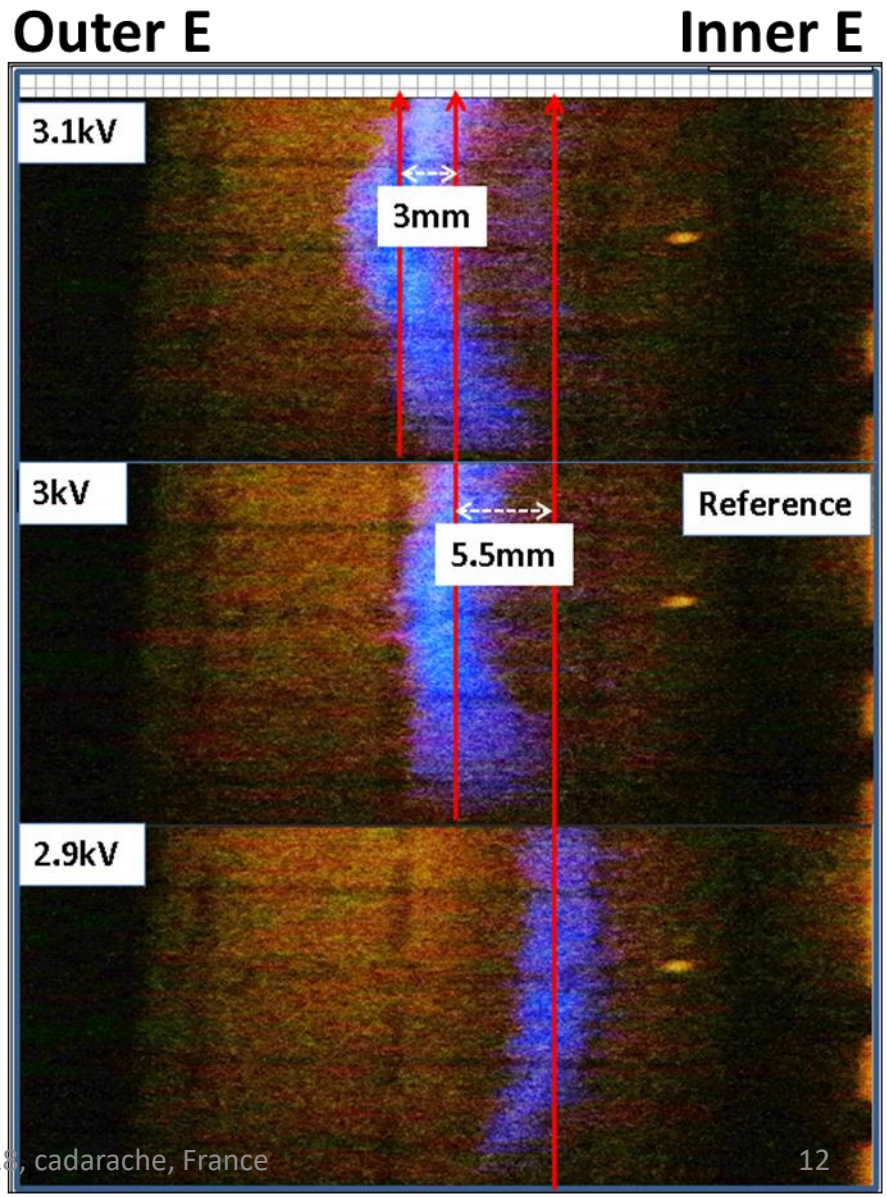


	Beam energy (keV)	V/mm	$\Delta E/E$ (experiment)	$\Delta E/E$ (SIMION)	Mesh voltage (kV)	Beam deccelration
90º CEA ($\bar{R} = 21.5cm$)	Cs^{2+} 20	24	-	1E-3	8	5
Tested CEA (electron) ($\bar{R} = 10.5cm$)	2.2	15	8.8 E-3	6.3 E-3	1.4	2.75
	3	25.7	8.5 E-3	6.5E-3	2.4	5
	2.7	29.5	1E-2	7.4E-3	1.1	1.7

SIMION simulation

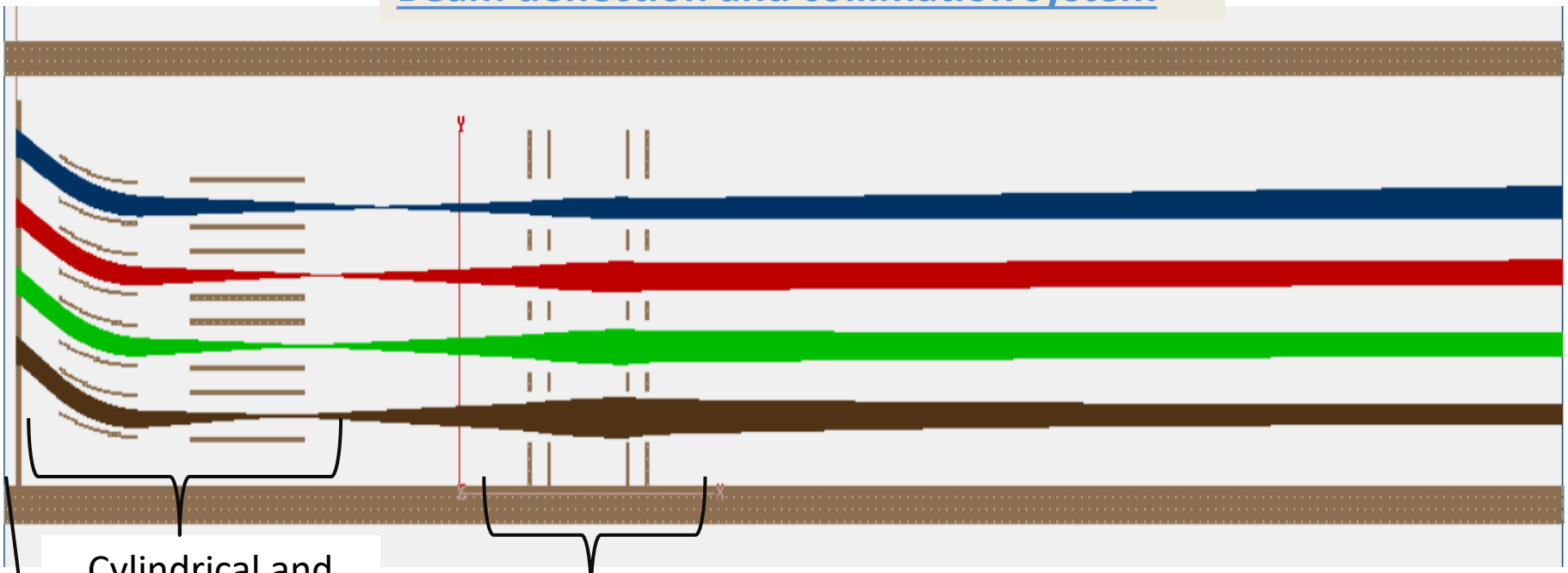


Experimental



Stage 1: Electrostatic input unit

Beam deflection and collimation system

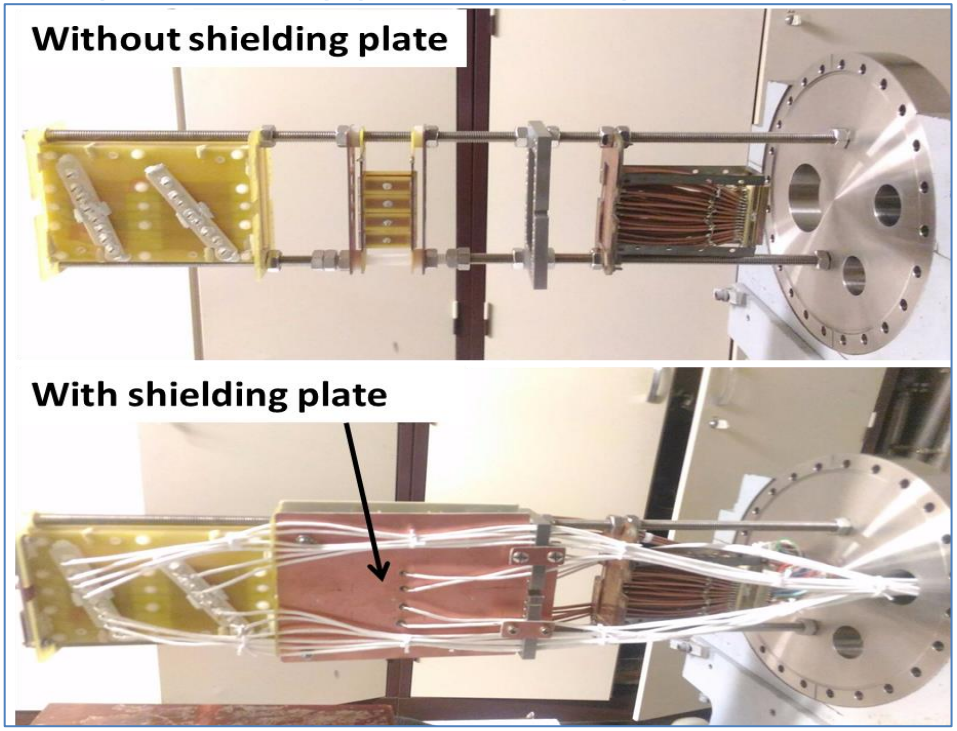


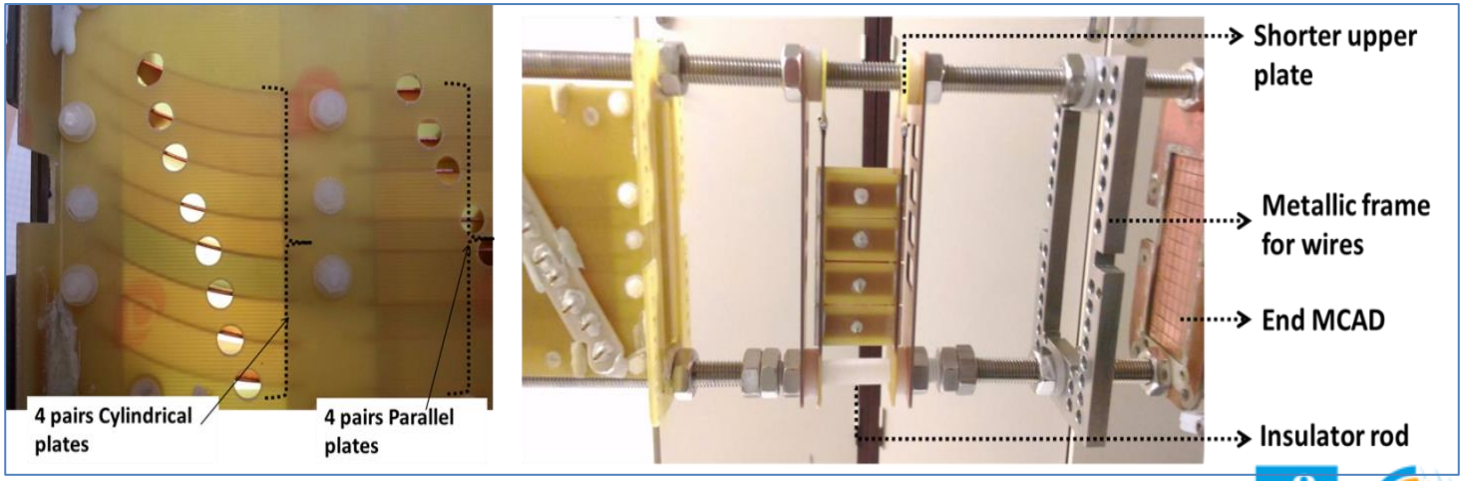
Cylindrical and parallel plates

Einzel lens

Front Input decector

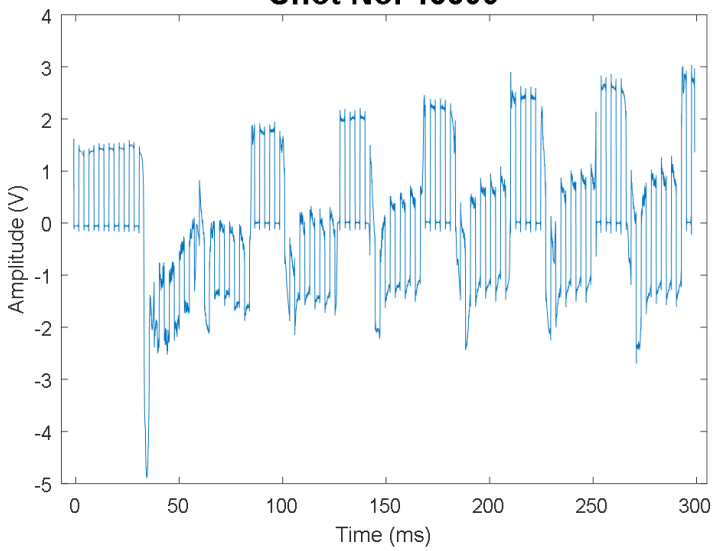
EIM prototype & Experimental setup



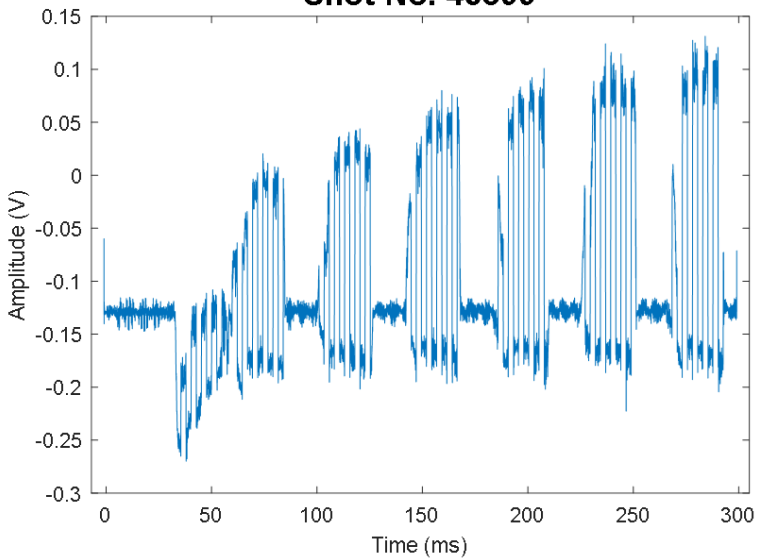


Experimental data from EIM

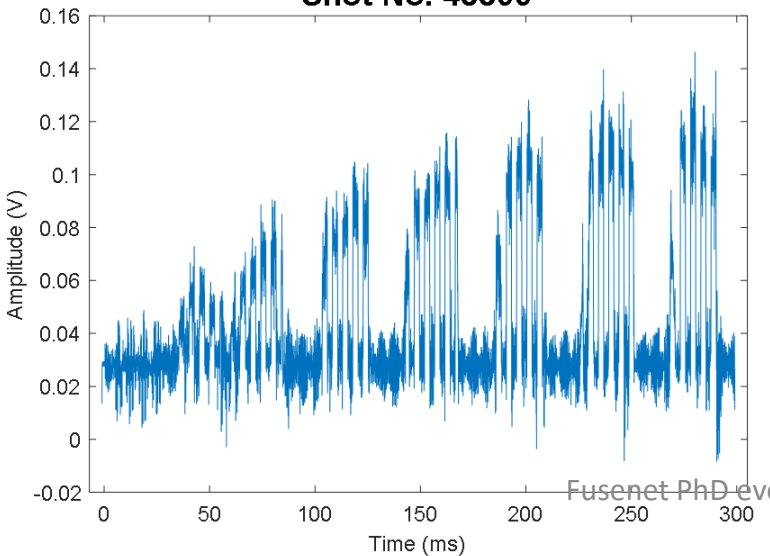
Primary signal
Channel No. 28
Shot No. 43899



Front MCAD: Secondary signal
Channel No. 29
Shot No. 43899

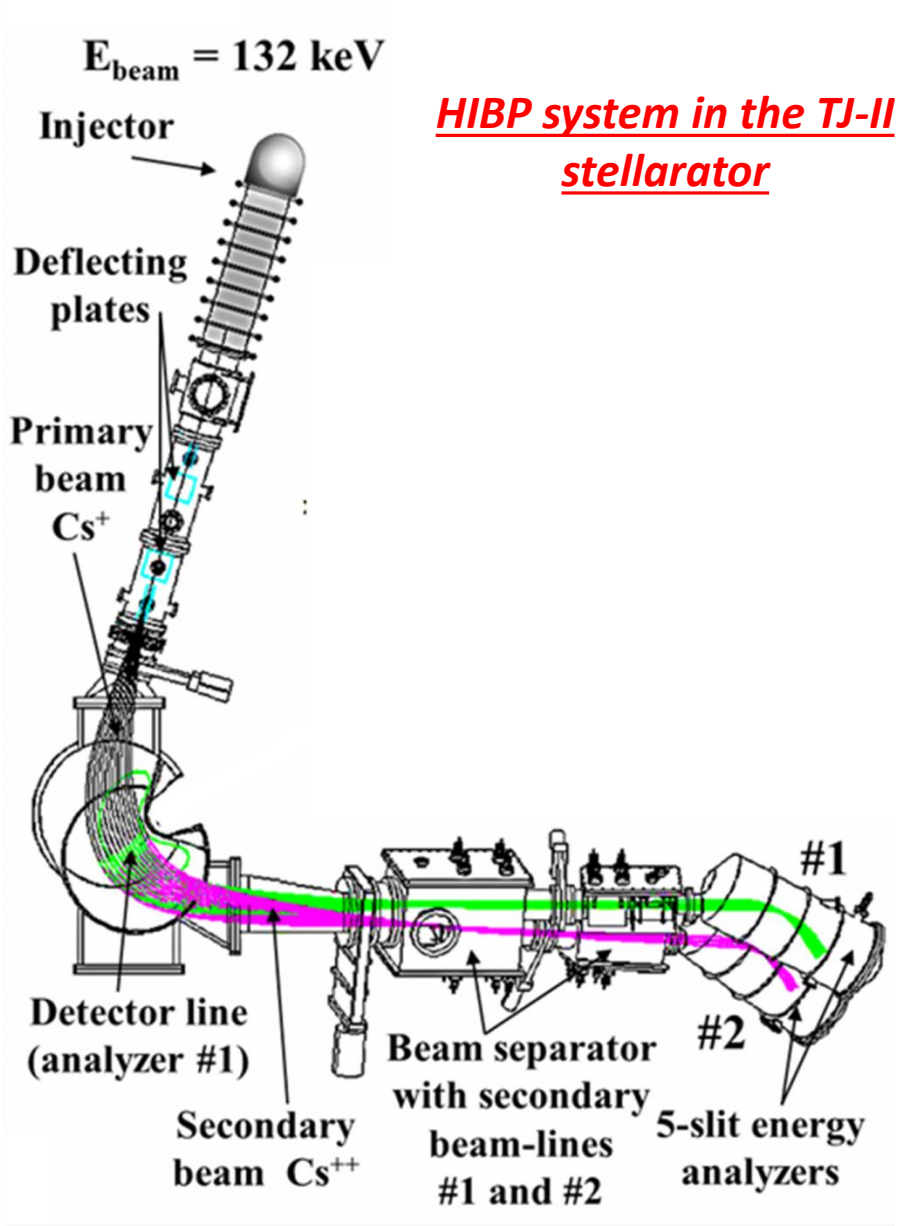


Back MCAD: Secondary signal
Channel No. 11
Shot No. 43899



EIM Optimistion of channel 2	
Electrode	Voltage(V)
Cylindrical plates	1700/-1700
Parallel plate	660/0
Einzel strip plate	433

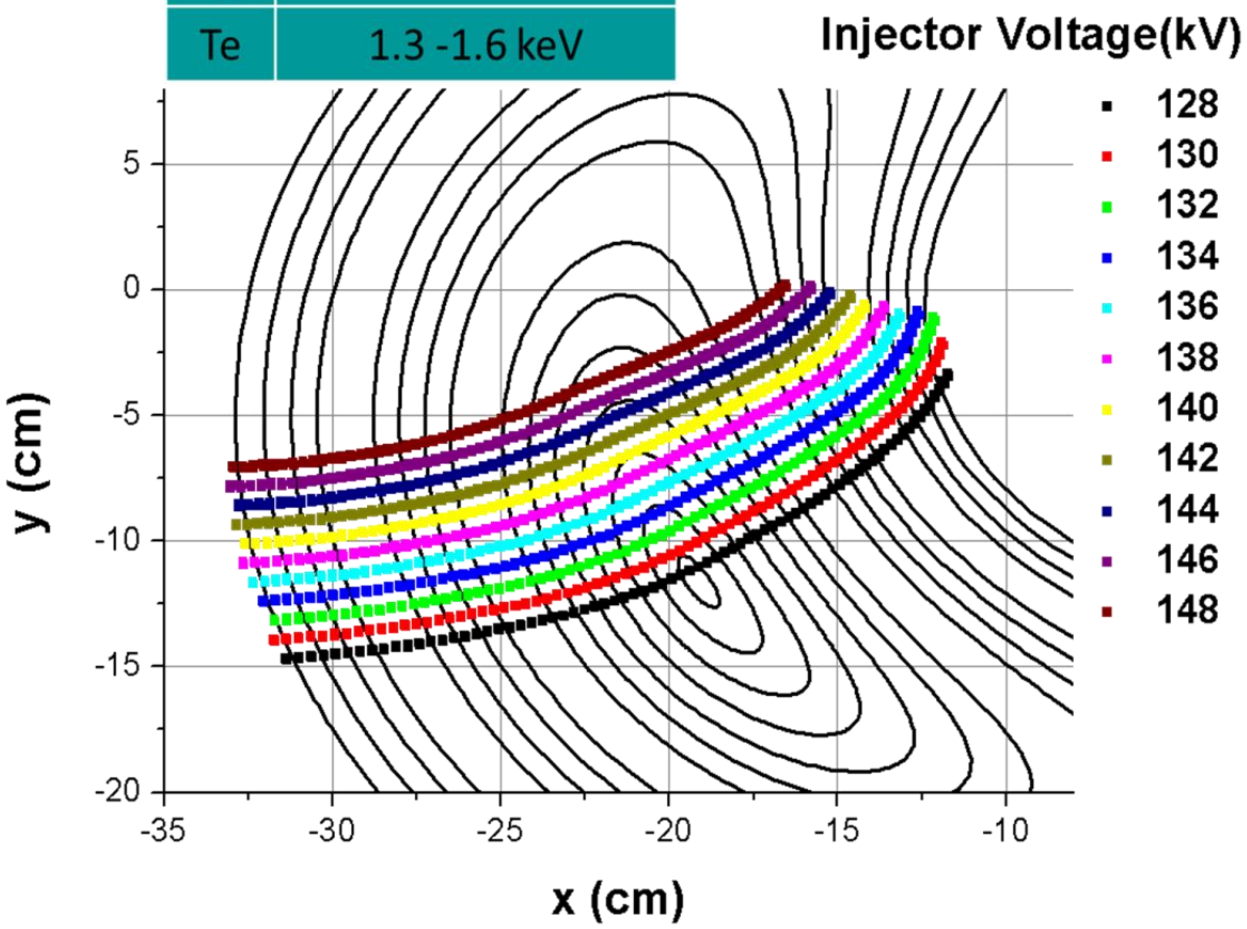
2D poloidal profiles of plasma potential and density



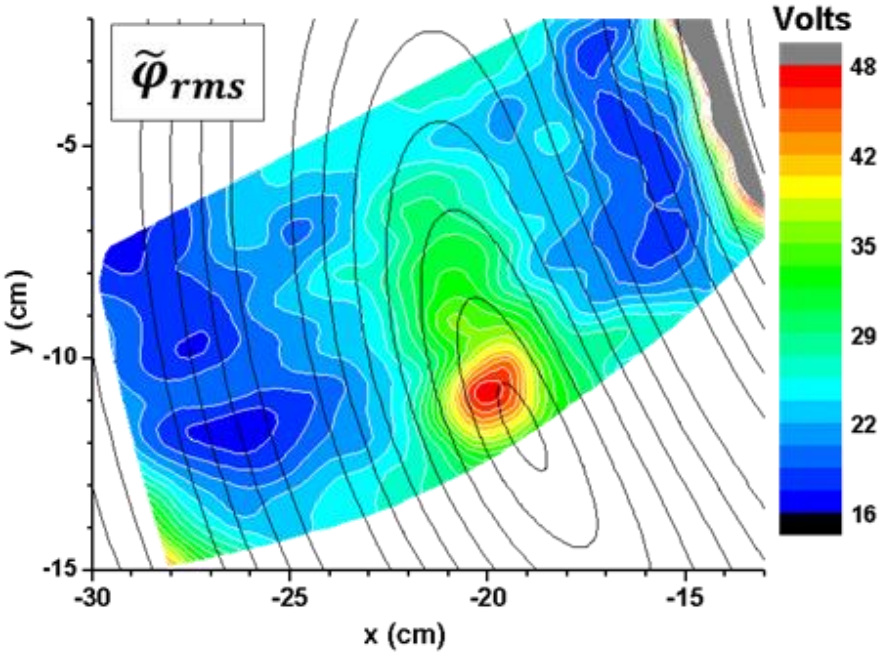
HIBP system in the TJ-II stellarator

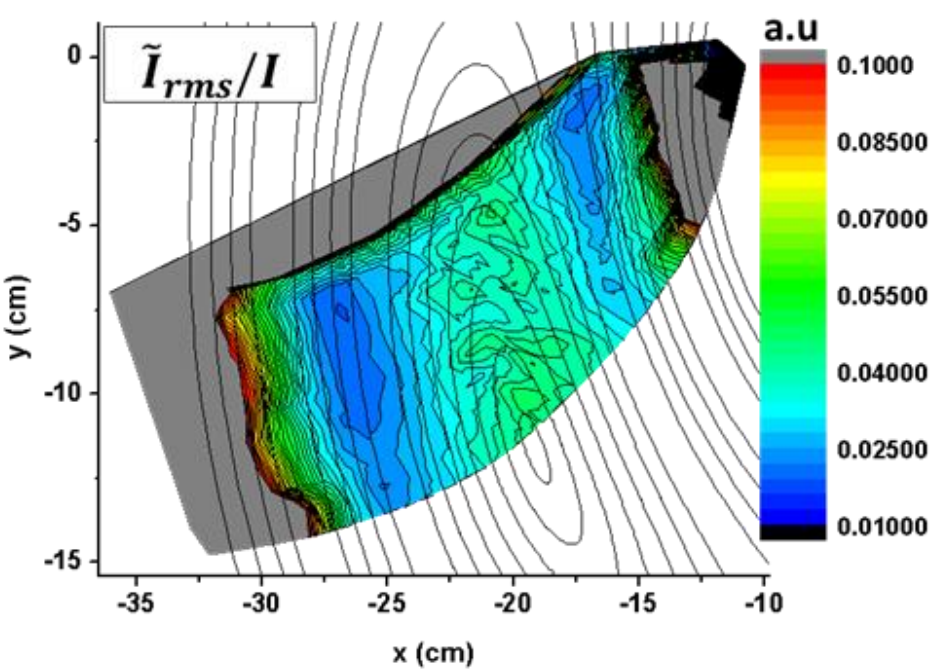
Plasma volume scanned in TJ-II

P_E	300 kW
n_e	0.36-0.47 $\times 10^{19}$ m^{-3}
Te	1.3 -1.6 keV



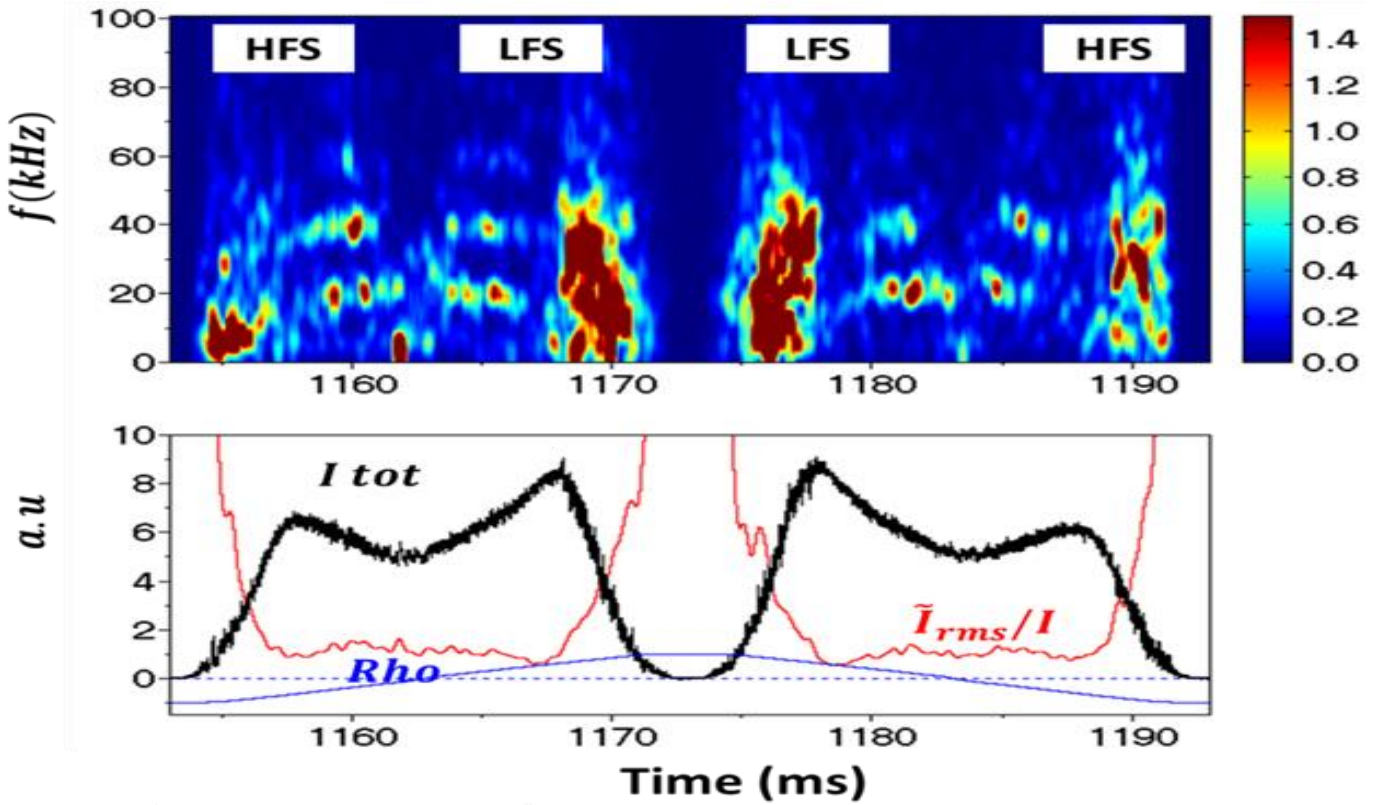
2D contour plots

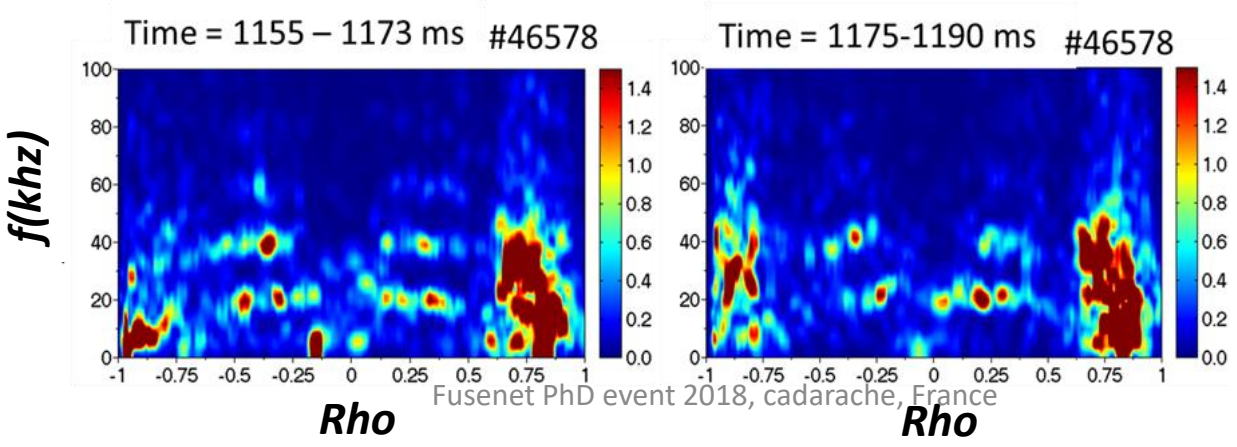




Effect of positive and negative density gradient on fluctuation

#46578 Off-axis ECRH



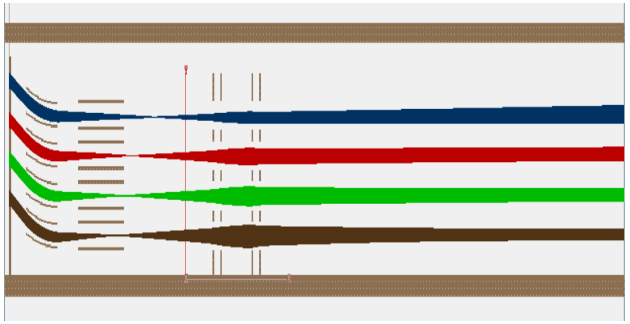


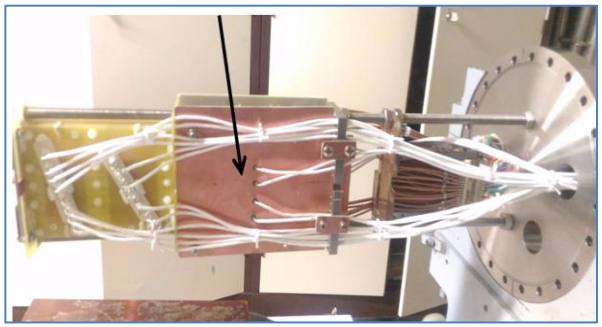
Summary

Simulation/design

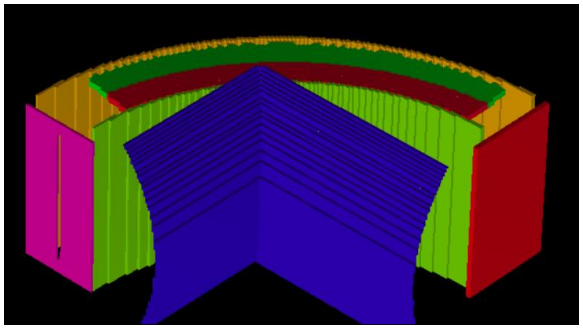
Experimental

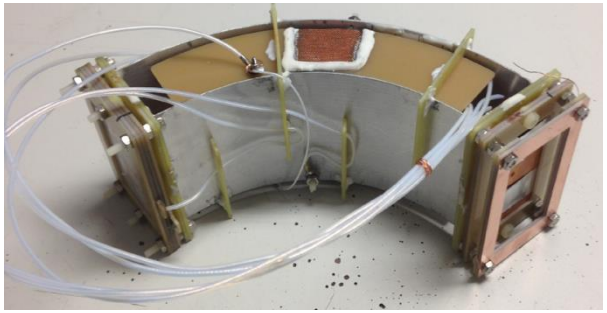
Electrostatic Input module





Electrostatic analyser





Experimental Result

2D poloidal contour for TJII plamsa fluctuation