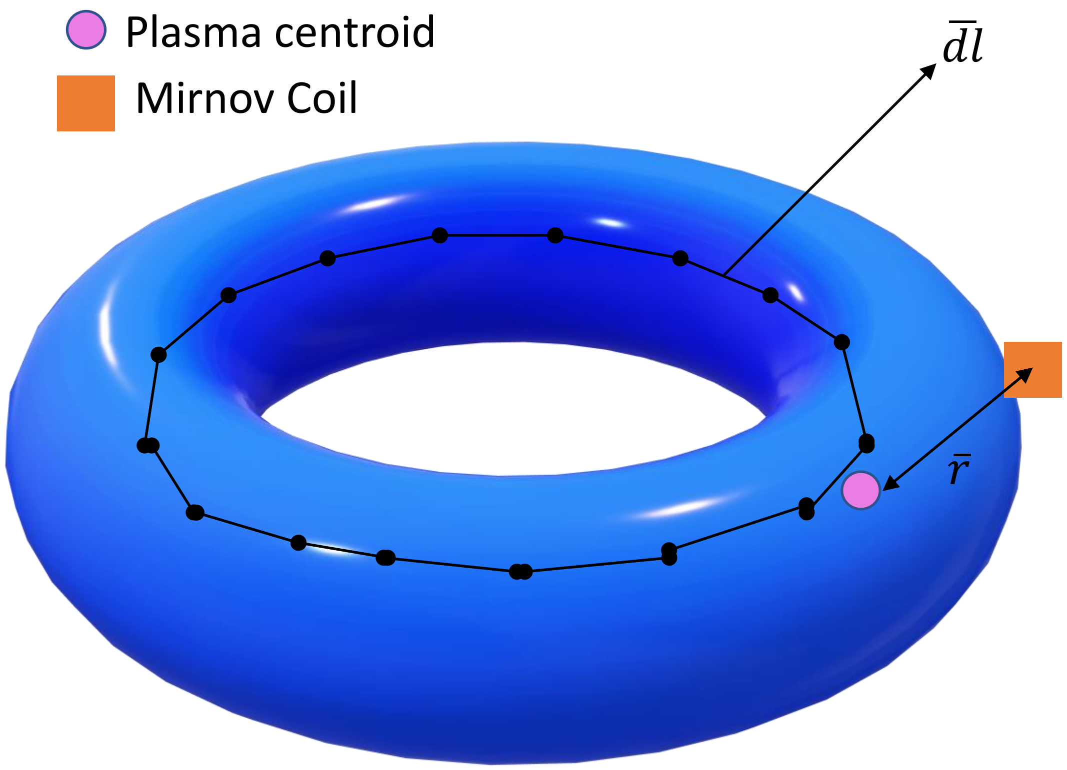
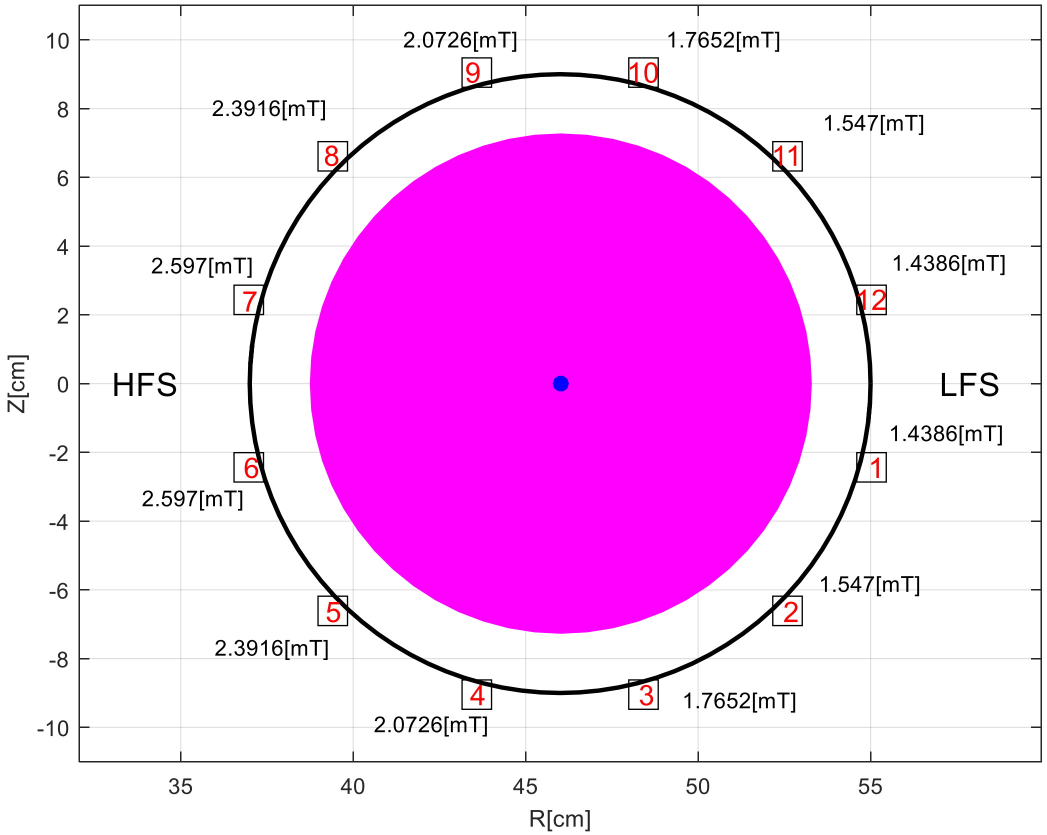
ISTTOK current centroid position

Biot-Savart approximation

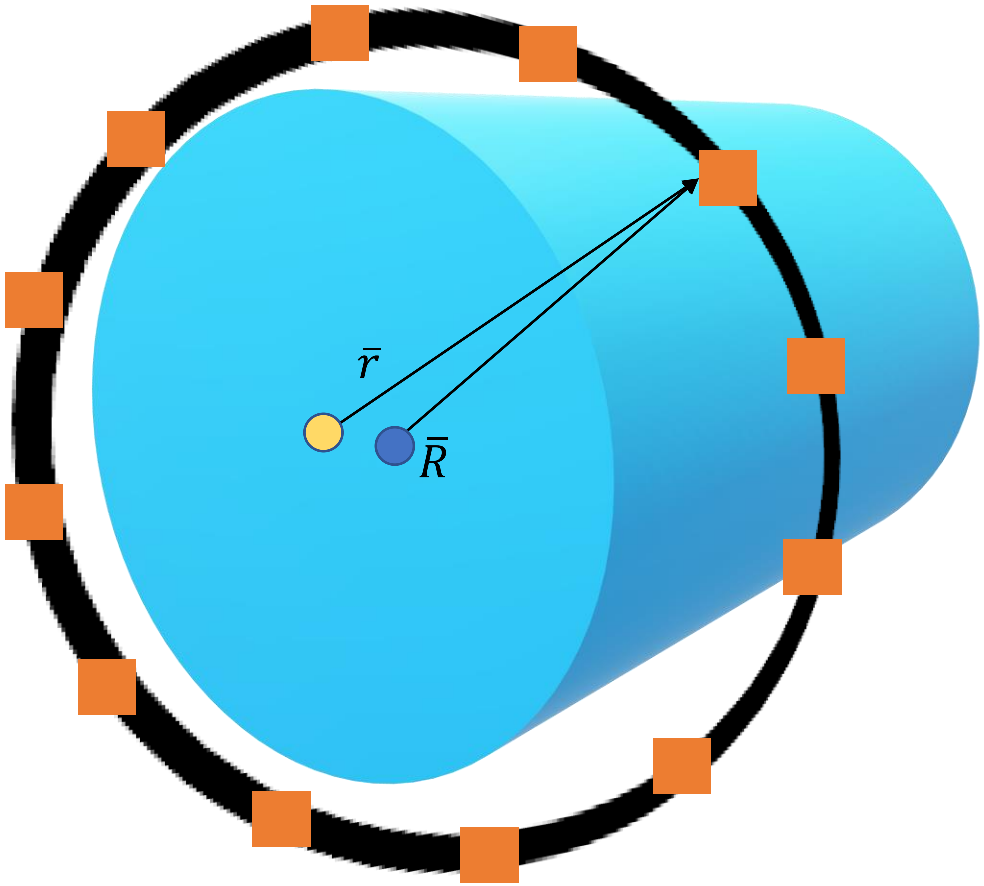
$$\overline{dB} = \frac{\mu_0}{4\pi}\frac{I\overline{dl} \times \hat{r}}{r^2} \qquad \bar{B} = \int \overline{dB}$$

- Plasma current : 4000 [A] single wire in the center of the chamber





"Center of mass" approach



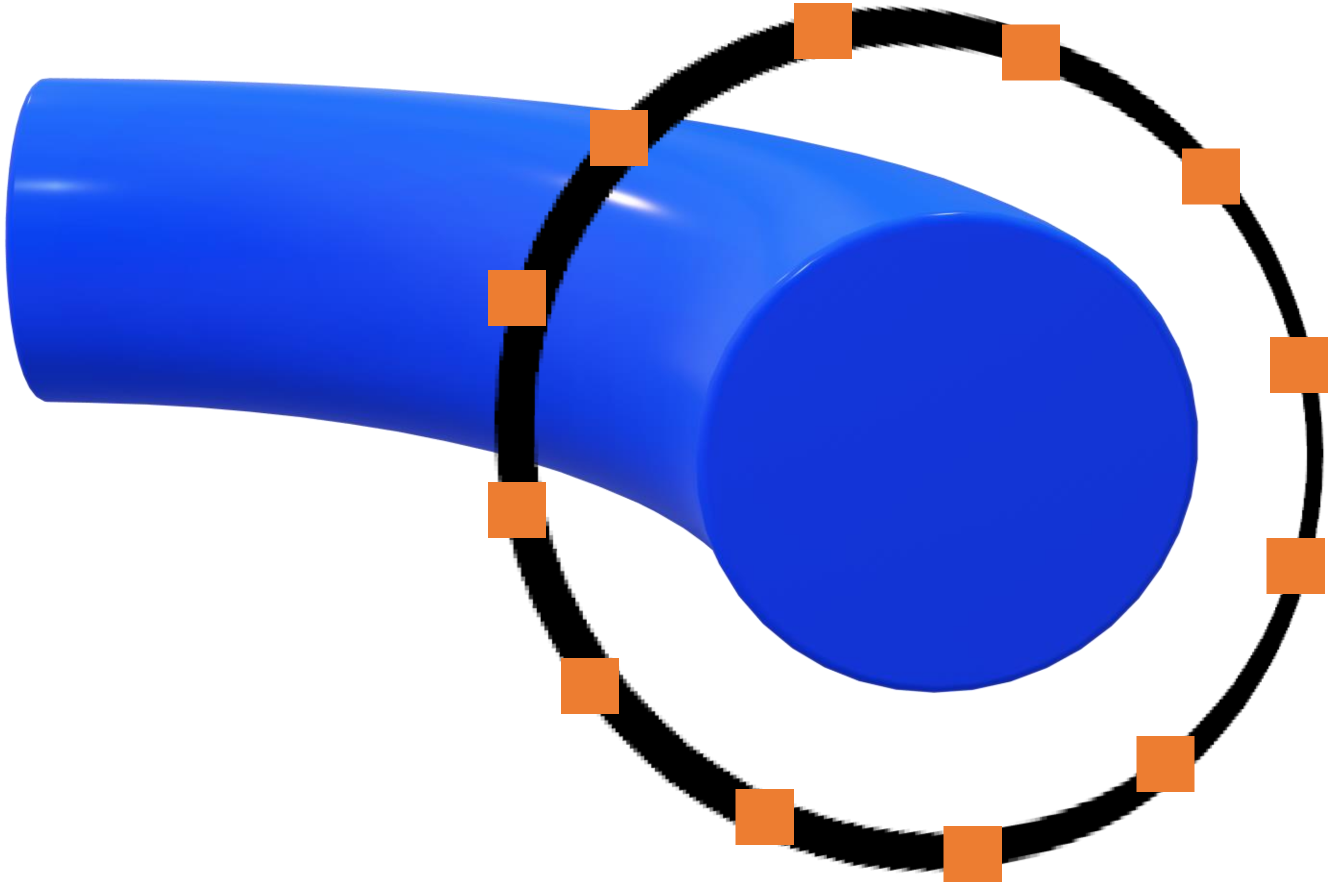
Let's suppose a cylinder of plasma where the centroid is the unique point at a center of a distribution of "mass" in space. The weighted position vectors (Magnetic field measured at the mirnov coils) relative to the centroid of the plasma sum zero.

The center of mass (plasma centroid) is the mean location of a distribution of mass (magnetic field) in space.

$$\bar{R} = \frac{\sum_1^{12} r_i\, B_{mirn(i)}}{\sum_1^{12} B_{mirn(i)}} \qquad \bar{z} = \frac{\sum_1^{12} z_i\, B_{mirn(i)}}{\sum_1^{12} B_{mirn(i)}}$$

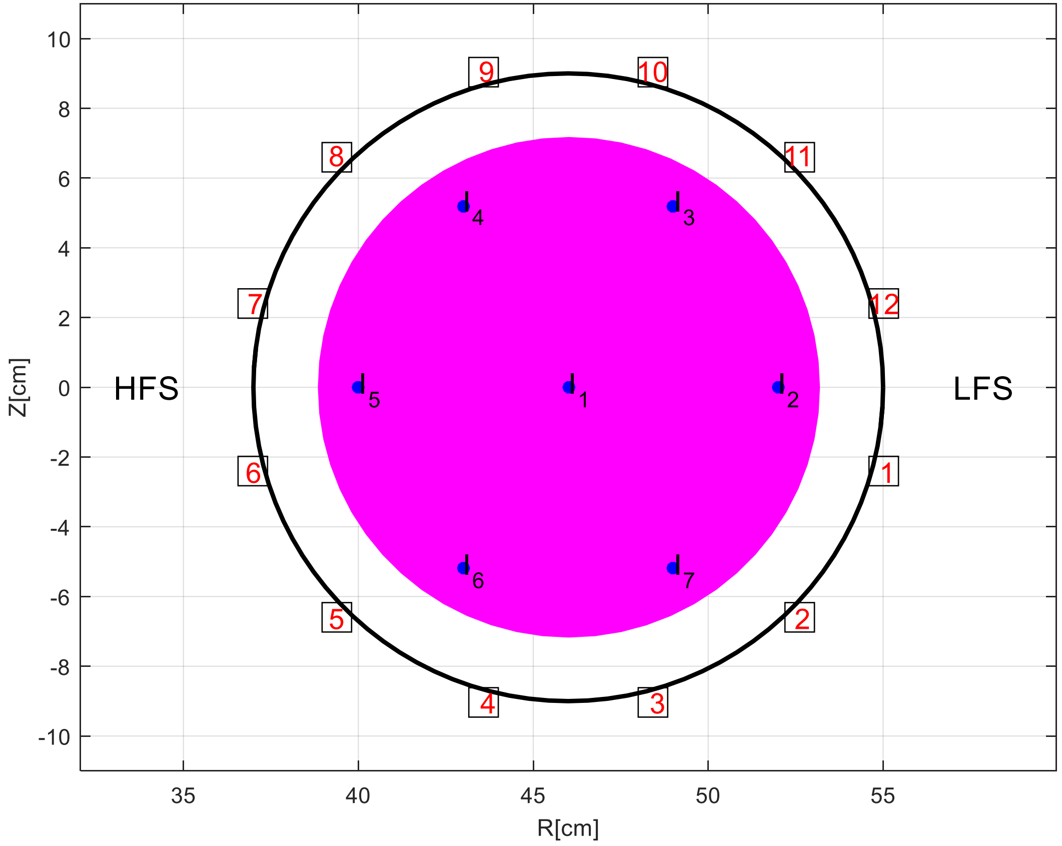
•Ivo Carvalho, *Real-time control for long ohmic alternate current discharges*, Phd thesis, 2013

"Center of mass approach" Considering toroidicity



	Multiplicative Factor
Mirnov 1	1.3059
Mirnov 2	1.2144
Mirnov 3	1.0643
Mirnov 4	0.9065
Mirnov 5	0.7855
Mirnov 6	0.7234
Mirnov 7	0.7234
Mirnov 8	0.7855
Mirnov 9	0.9065
Mirnov 10	1.0643
Mirnov 11	1.2144
Mirnov 12s	1.3059

Filamentary currents model



$$i_{p,f} = M_{fp}^{\dagger}\, f_p$$

M_{fp} Matrix whose *ij*-element gives the contribution to the measurement *i* of a unitary current in the filament *j*

f_p Represents the measurement vector where the contribution given by the poloidal field coils has been subtracted

$$f_p = \emptyset_{mirnv} \quad \Rightarrow \quad i_{mirnv} = \frac{\emptyset_{mirnv}}{L_{mirnv}}$$

•Pironti A., *Magnetic Control of Tokamak Plasmas*, 2nd ed. Springer, 2016

$$
M_{fp} = \begin{bmatrix}
0.7294 & 0.7938 & 0.8966 & 0.8249 & 0.6450 & 0.5791 & 0.6523 \\
0.7843 & 0.8482 & 0.9619 & 0.8917 & 0.6982 & 0.6235 & 0.6982 \\
0.8949 & 0.9551 & 1.0911 & 1.0273 & 0.8080 & 0.7138 & 0.7899 \\
1.0508 & 1.1002 & 1.2670 & 1.2204 & 0.9692 & 0.8444 & 0.9179 \\
1.2125 & 1.2443 & 1.4403 & 1.4211 & 1.1452 & 0.9851 & 1.0501 \\
1.3167 & 1.3338 & 1.5462 & 1.5490 & 1.2635 & 1.0794 & 1.1357 \\
1.3167 & 1.3338 & 1.5462 & 1.5490 & 1.2635 & 1.0794 & 1.1357 \\
1.2125 & 1.2443 & 1.4403 & 1.4211 & 1.1452 & 0.9851 & 1.0501 \\
1.0508 & 1.1002 & 1.2670 & 1.2204 & 0.9692 & 0.8444 & 0.9179 \\
0.8949 & 0.9551 & 1.0911 & 1.0273 & 0.8080 & 0.7138 & 0.7899 \\
0.7843 & 0.8482 & 0.9619 & 0.8917 & 0.6982 & 0.6235 & 0.6982 \\
0.7294 & 0.7938 & 0.8966 & 0.8249 & 0.6450 & 0.5791 & 0.6523
\end{bmatrix}
$$

Considering all mirnov probes have same properties (size and # of turns)

$$
A = USV^* = [U_1 U_2] \begin{bmatrix} S_1 & 0 \\ 0 & 0 \end{bmatrix} [V_1 V_2]^*
$$

$$
A = U_1 S_1 V_1^*
$$

$$
A^{\dagger} = V_1 S_1^{-1} U_1^*
$$

$$
M_{fp}^{\dagger} = 1 \times 10^5 \begin{bmatrix}
0.0535 & -0.1089 & 0.0877 & -0.0467 & 0.0197 & -0.0053 & -0.0053 & 0.0197 & -0.0467 & 0.0877 & -0.1089 & 0.0535 \\
-1.9783 & 3.9966 & -3.1594 & 1.6273 & -0.6614 & 0.1729 & 0.1729 & -0.6614 & 1.6273 & -3.1594 & 3.9966 & -1.9783 \\
1.0361 & -2.1165 & 1.7063 & -0.8978 & 0.3700 & -0.0971 & -0.0971 & 0.3700 & -0.8978 & 1.7063 & -2.1165 & 1.0361 \\
-0.7701 & 1.6000 & -1.3351 & 0.7378 & -0.3196 & 0.0866 & 0.0866 & -0.3196 & 0.7378 & -1.3351 & 1.6000 & -0.7701 \\
1.2098 & -2.5358 & 2.1604 & -1.2377 & 0.5616 & -0.1575 & -0.1575 & 0.5616 & -1.2377 & 2.1604 & -2.5358 & 1.2098 \\
-2.3301 & 4.8139 & -3.9961 & 2.2227 & -0.9871 & 0.2745 & 0.2745 & -0.9871 & 2.2227 & -3.9961 & 4.8139 & -2.3301 \\
2.7700 & -5.6228 & 4.5016 & -2.3766 & 0.9996 & -0.2685 & -0.2685 & 0.9996 & -2.3766 & 4.5016 & -5.6228 & 2.7700
\end{bmatrix}
$$

•Pironti A., *Magnetic Control of Tokamak Plasmas*, 2nd ed. Springer, 2016

Mirnov auto-inductances

$$L_{mirnv} = \begin{bmatrix} 15.922 \\ 15.922 \\ 15.922 \\ 16.42 \\ 16.716 \\ 16.447 \\ 16.476 \\ 15.702 \\ 16.435 \\ 8.555 \\ 16.252 \\ 14.787 \end{bmatrix} [\mu H]$$

Calculated through a LR circuit and a signal generator

$$r_0 = \sqrt{\frac{\sum_{k=1}^{\mu} i_{p,f_k} r_{p,f_k}^2}{\sum_{k=1}^{\mu} i_{p,f_k}}}$$

$$z_0 = \frac{\sum_{k=1}^{\mu} i_{p,f_k} z_{p,f_k}}{\sum_{k=1}^{\mu} i_{p,f_k}}$$

Where $\left(r_{p,f_k}, z_{p,f_k}\right)$ and i_{p,f_k} are the position and the current of the filament $k, k = 1,2, \ldots, \mu$, respectively.

•Pironti A., *Magnetic Control of Tokamak Plasmas*, 2nd ed. Springer, 2016