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Comparison of balanced and unbalanced array designs

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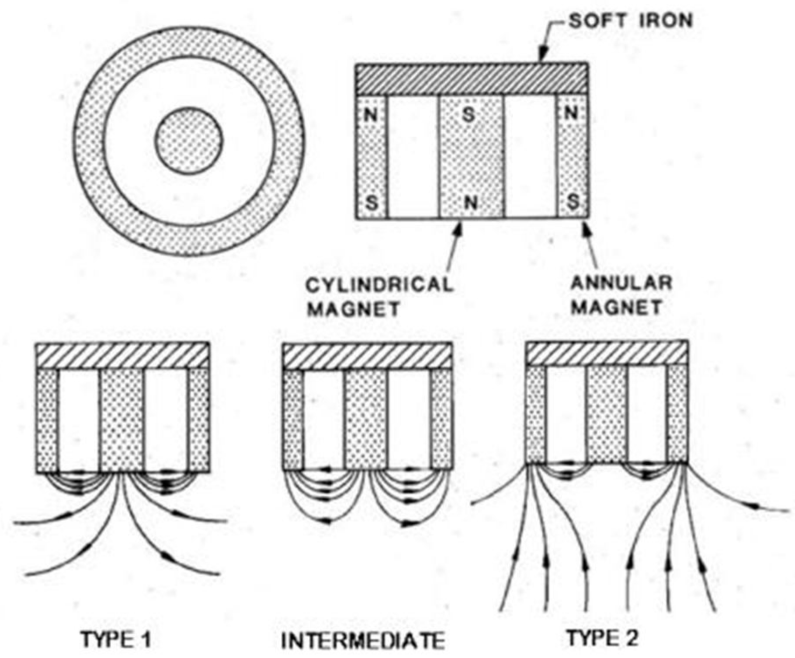
- The term of “balanced” and “unbalanced” magnetrons was first introduced by Windows and Savvides in 1986*.

(from original paper of Windows & Savvides)



The term in its original use was taken from the relative strength between the central and outer magnets, were the magnetic forces could balance each other or could be out of balance when one of those magnetic poles are stronger than the other. So on those days there were the type I and type II “unbalanced” configurations, and the intermediate “balanced” configuration.

*B Window and N. Savvides, J. Vac. Sci. Technol. A4(2), 196 (1986)

Difference between balanced and unbalanced magnetrons

- The term of “balanced” and “unbalanced” magnetrons soon after Windows & Savvides shifted towards the relative ion bombardment… “balanced” arrays would produce low bombardment while “unbalanced” arrays would produce higher ion bombardment.
- As Type I unbalanced produced very little ion bombardment then that type of array could not be called “unbalanced” any more. So, in reality Type II unbalanced would be what we call today an “unbalanced” array.

*B Window and N. Savvides, J. Vac. Sci. Technol. A4(2), 196 (1986)

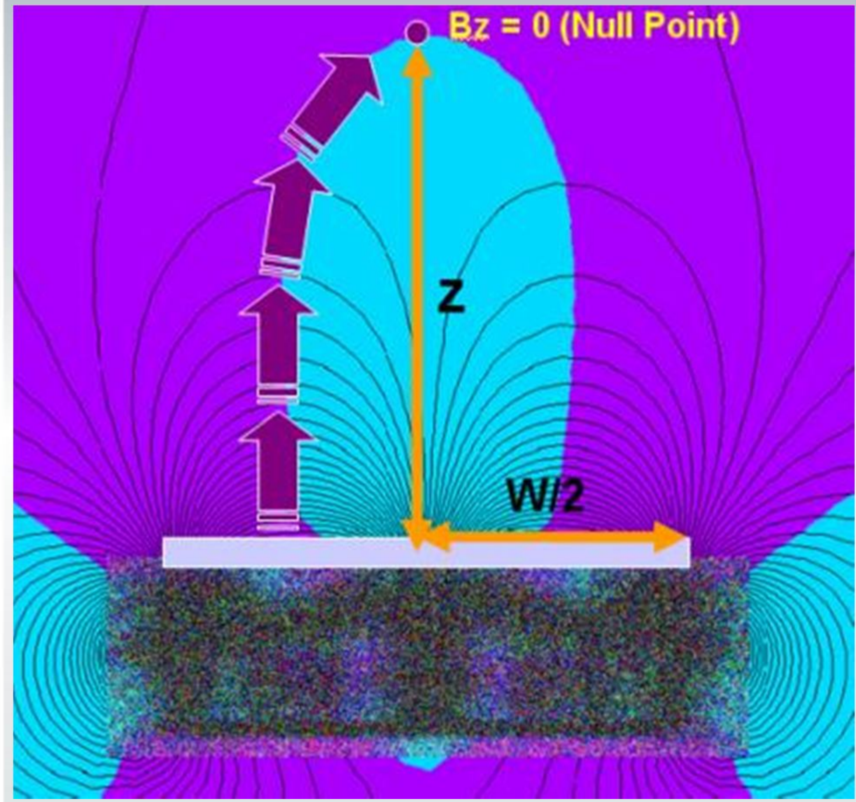
Difference between balanced and unbalanced magnetrons

- Balanced array - The field lines are well confined around the target racetrack with low release of plasma to the substrate. Substrate temperatures are lower for this type of array compared to unbalanced types since electron and ion bombardment is lower.

- The unbalanced magnetic array changes the shape of the magnetic field to allow release of some of the plasma electron towards the substrate to provide ion assistance for the coating process. This release can have different levels depending on how easy the electrons are able to reach the escape point.

Visit the following web for info on balanced/unbalanced arrays:
http://www.gencoa.com/balance_and_unbalance/

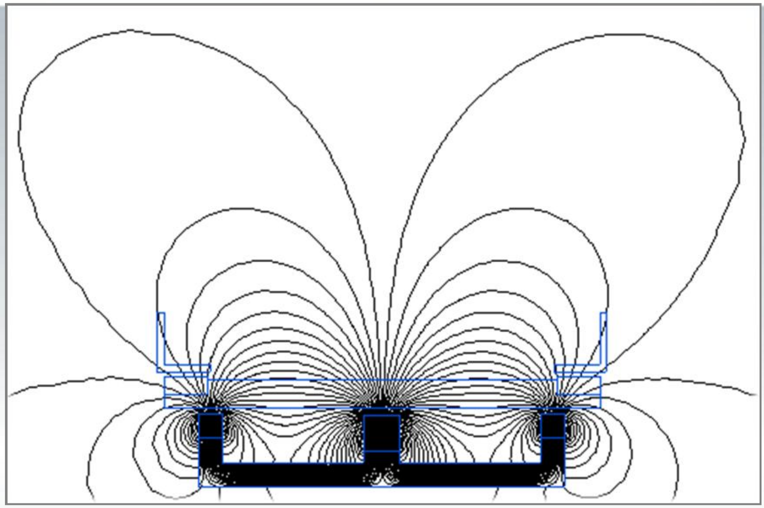
Gencoa Array Classification



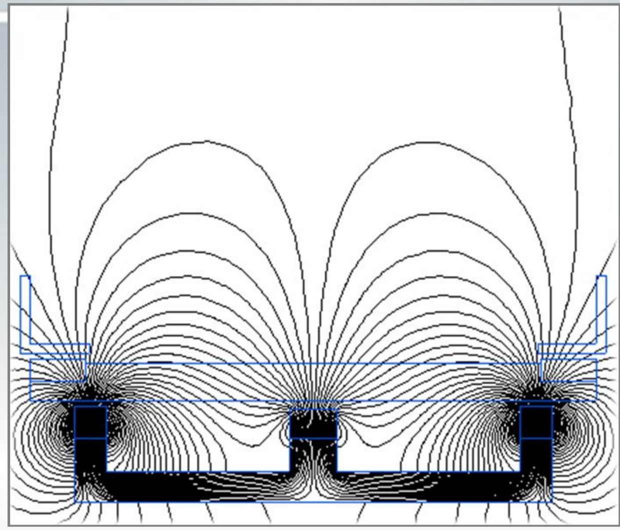
Gencoa use a simple method to determine the degree of unbalance and to classify magnetrons into 6 groups according to the value of g, which is the ratio, $Z_{Bz=0}:W_{1/2}$, Z is the distance to the null point and W is the target width, according to the accompanying figure and table:

Group Number	Group Description	$g=Z_{Bz=0}/W_{1/2}$
I	Extremely balanced	$g \geq 2.00$
II	Very balanced	$1.75 \leq g < 2.00$
III	Medium balanced	$1.50 \leq g < 1.75$
IV	Unbalanced	$1.25 \leq g < 1.50$
V	Very unbalanced	$1.00 \leq g < 1.25$
VI	Extremely unbalanced	$g < 1.00$

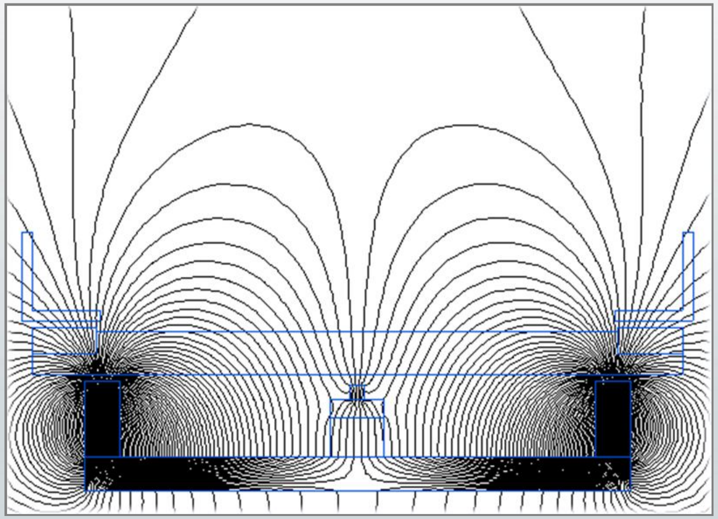
Examples of unbalanced degree



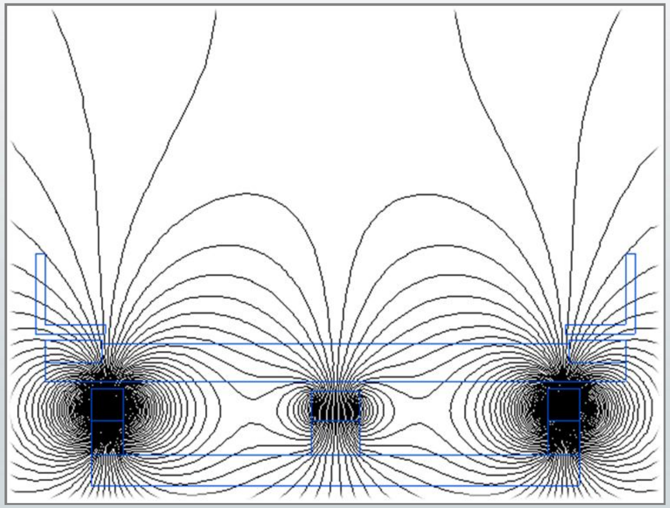
Extremely balanced



Balanced

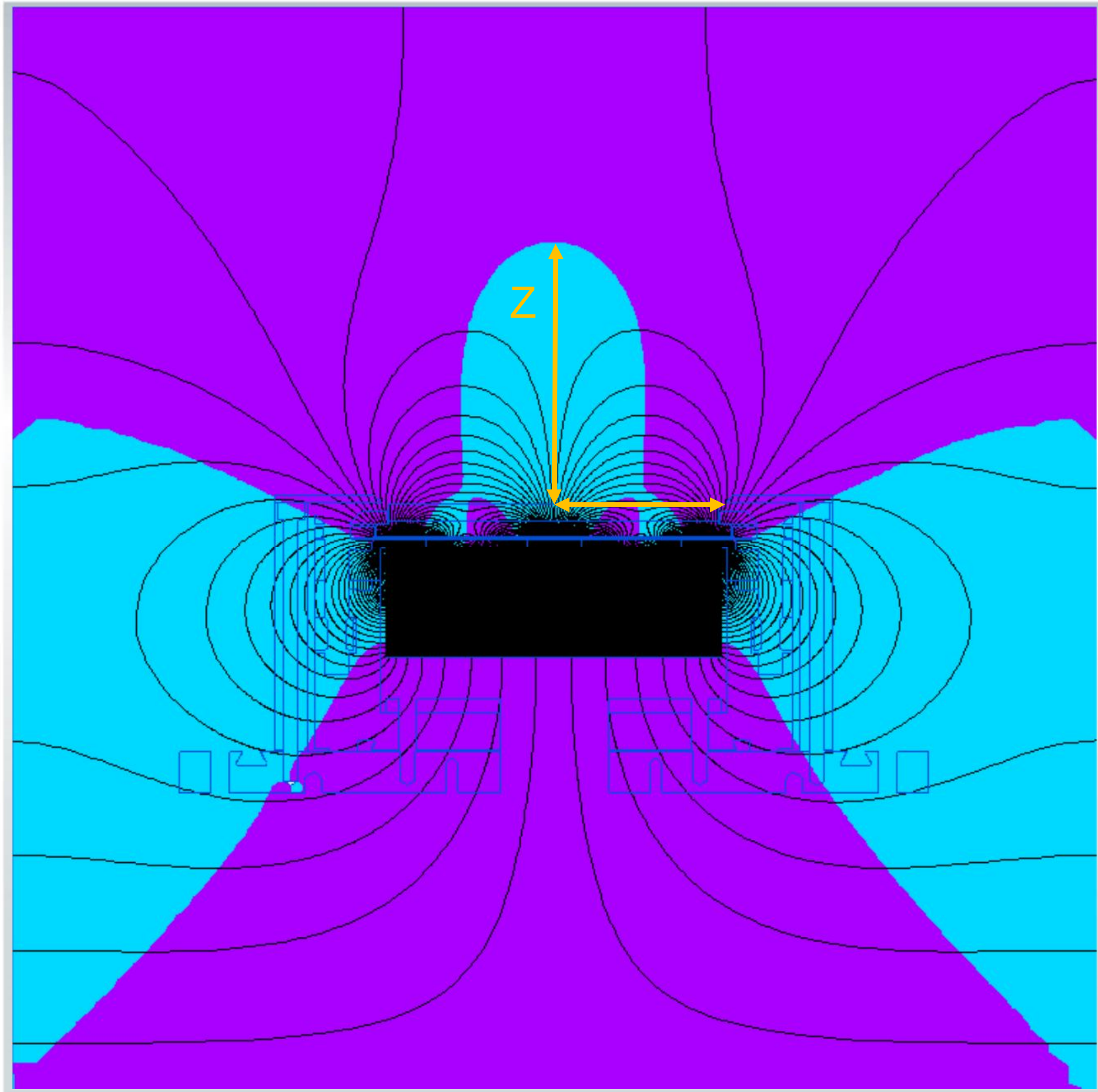


Unbalanced* (see next page)



Very unbalanced

Example of Balanced High Yield Array



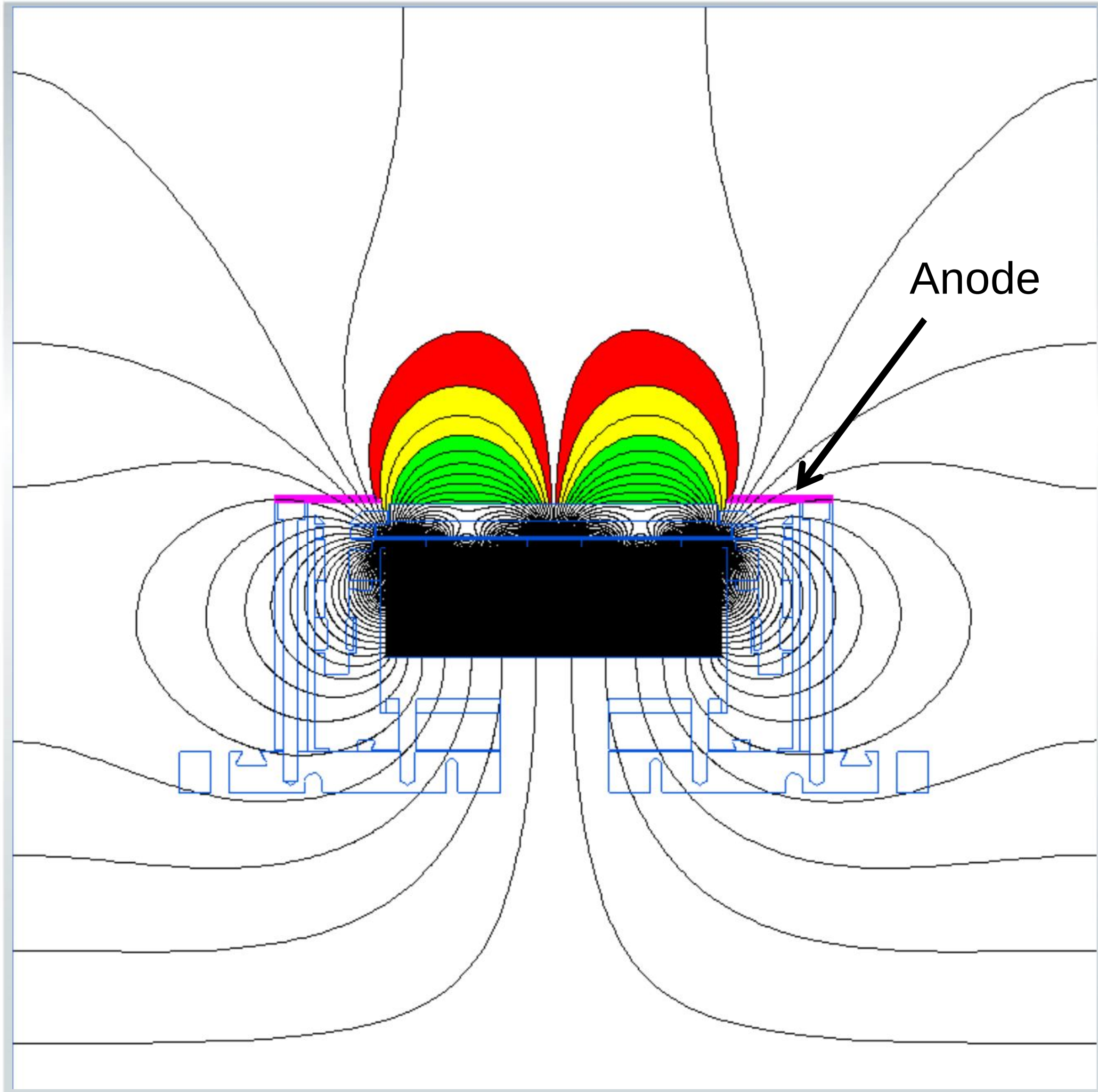
Magnetron width is 125
therefore w/2 is 62.5

Z is 96

Therefore g=96/62.5=1.536

Array design is Middle Balanced

Balanced High Yield Array



Unobstructed plasma trap on target surface

Unobstructed plasma trap

Zone of plasma interaction with anode

Electrons arrive to the anode before arriving to the escape point,.. which has a “balancing” effect.

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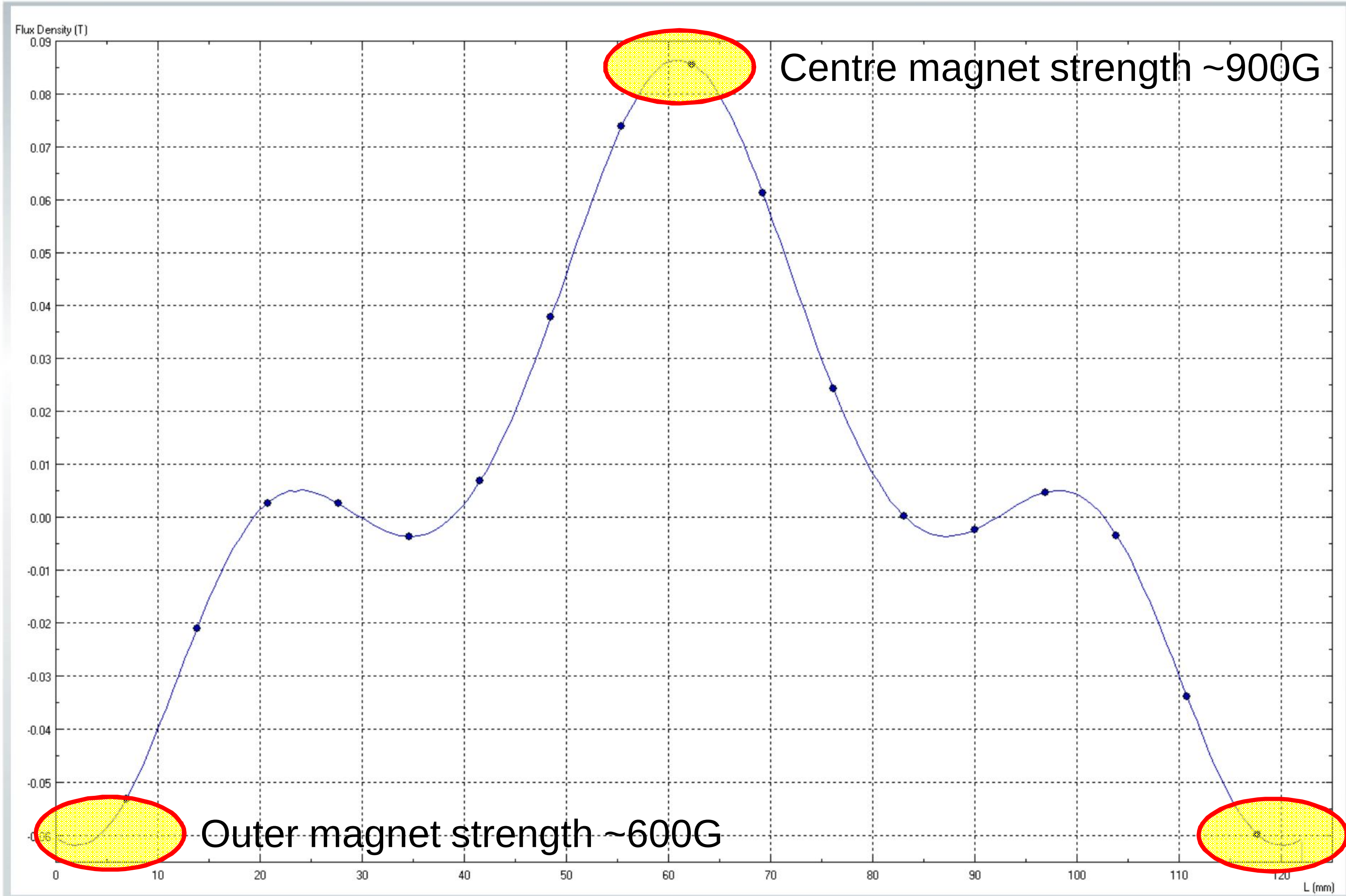
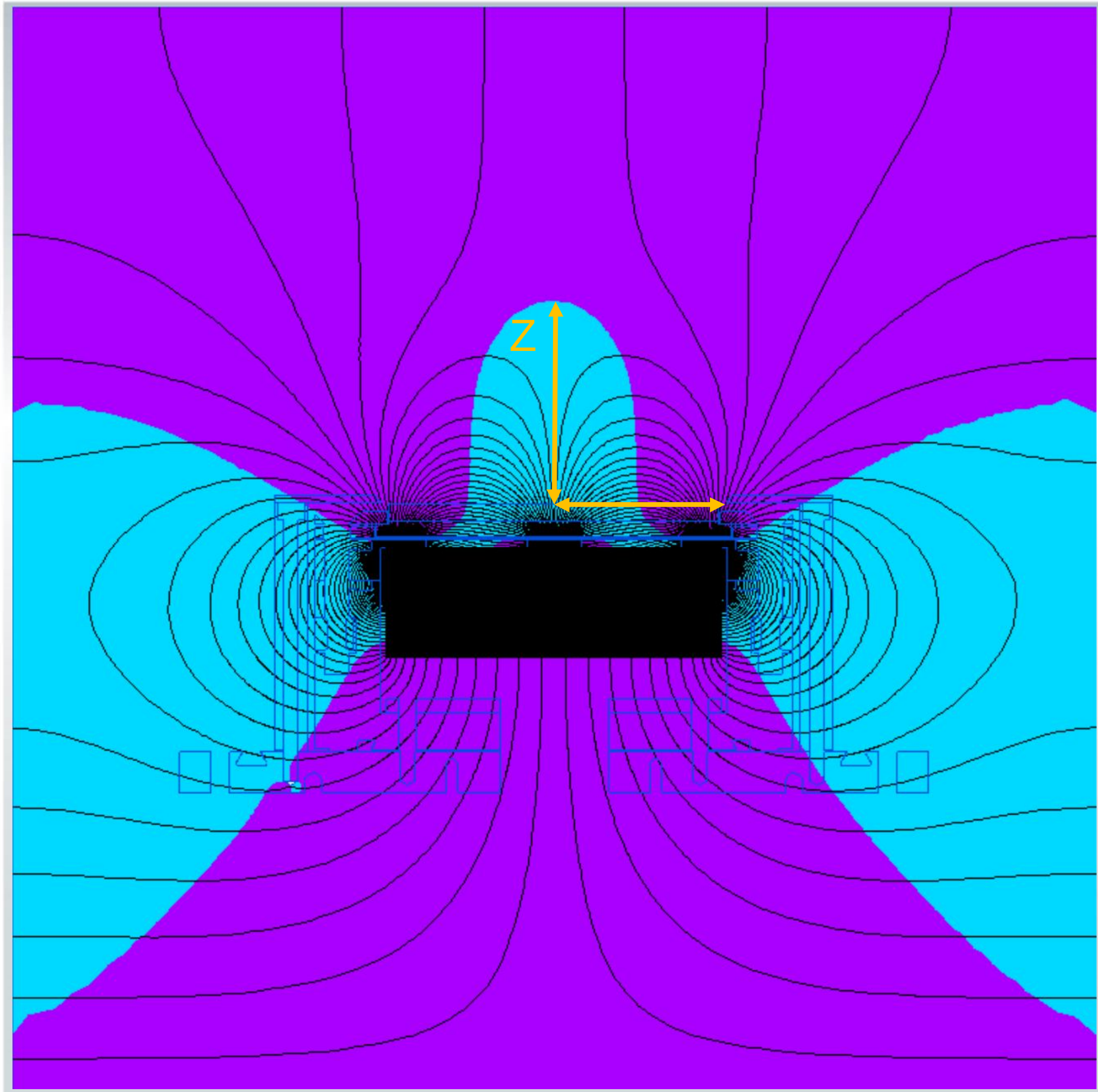
Balanced High Yield Strength



Example of Unbalanced Array



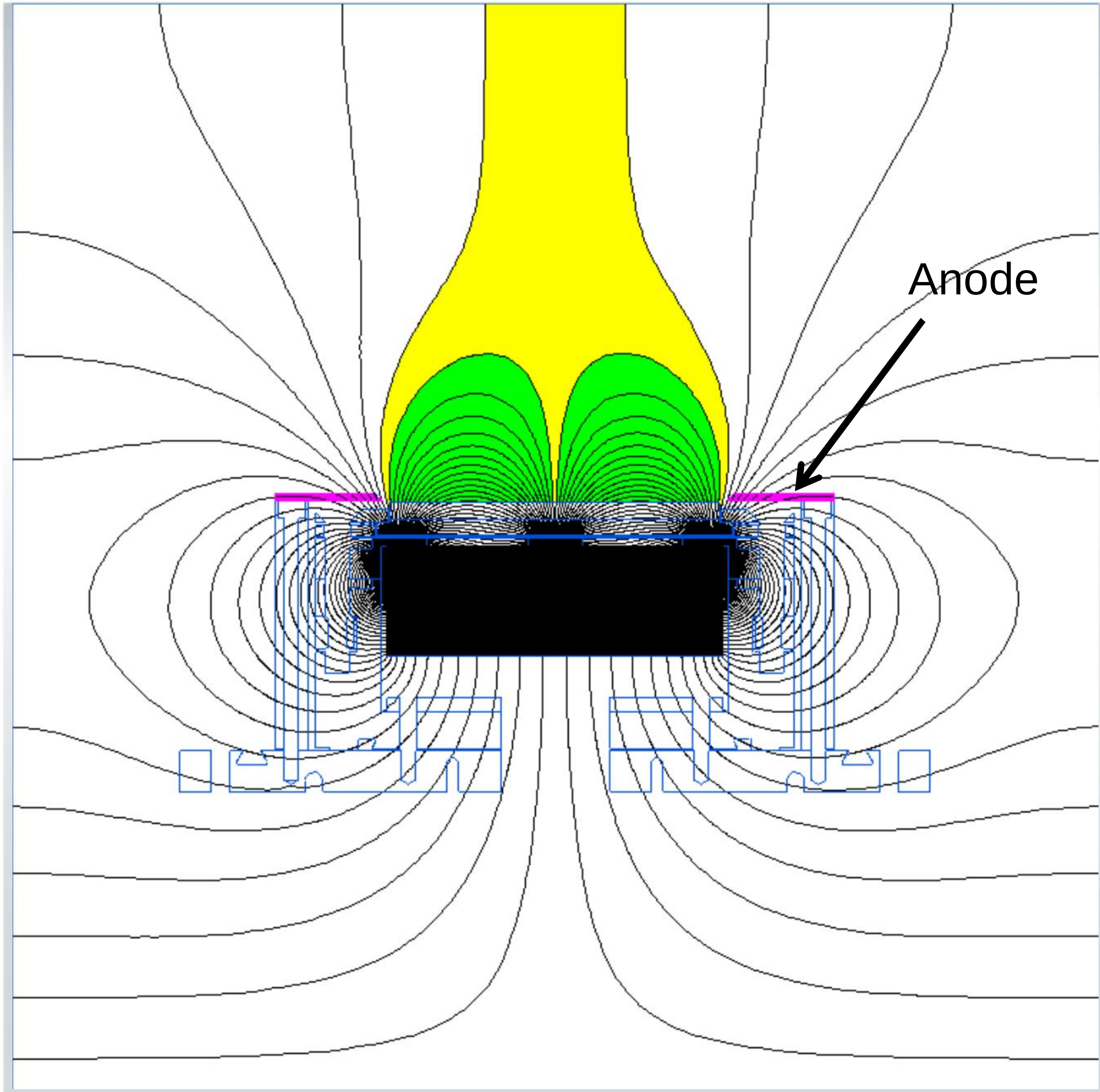
Magnetron width is 125
therefore w/2 is 62.5

Z is 74

Therefore g=74/62.5=1.184

Array design is Very Unbalanced

Unbalanced Array



Unobstructed plasma trap on target surface

Zone of no plasma interaction with anode

Plasma bombardment of substrate

Electrons are prevented from arriving to the anode before arriving to the escape point.

Unbalanced strength