Simulation of Charge Induction in an ILC Micromegas module

Shivam Joshi

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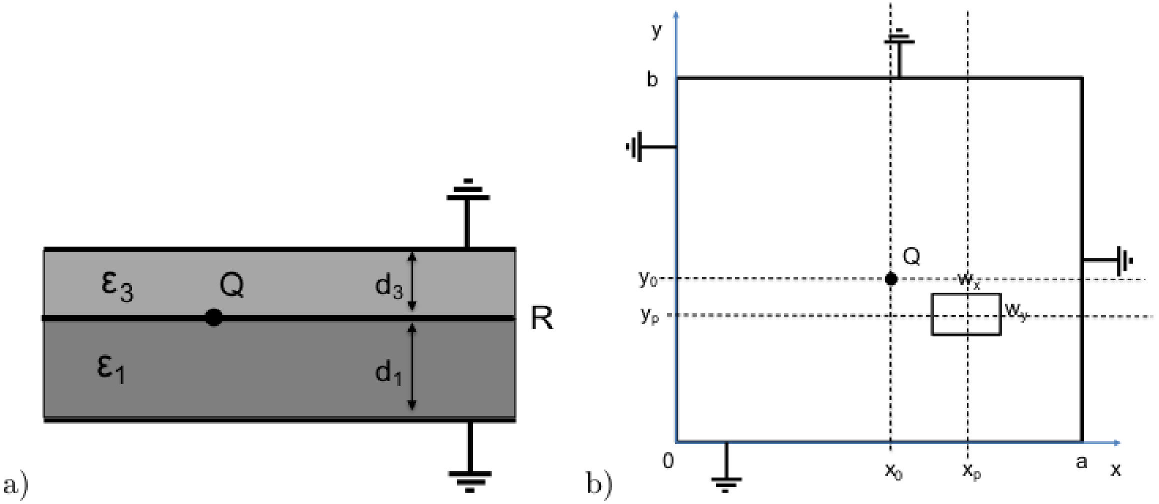


Figure 1: a) Side view. b) Top view

An excerpt from Werner Riegler's paper

$$Q^{ind}(x_0, y_0, t) = \Theta(t)\frac{16Q}{\pi^2}\sum_{\alpha=1}^{\infty}\sum_{\beta=1}^{\infty}\frac{\sin\left(\alpha\pi\frac{w_x}{2a}\right)\sin\left(\alpha\pi\frac{x_p}{a}\right)\sin\left(\alpha\pi\frac{x_0}{a}\right)}{\alpha}\frac{\sin\left(\beta\pi\frac{w_y}{2b}\right)\sin\left(\beta\pi\frac{y_p}{b}\right)\sin\left(\beta\pi\frac{y_0}{b}\right)}{\beta}h(k_{\alpha\beta}, t)$$

with $k_{\alpha\beta} = \pi\sqrt{\frac{\alpha^2}{a^2}+\frac{\beta^2}{b^2}}$ and

$$h(k,t) = \frac{\varepsilon_1\, e^{-t/\tau(k)}}{\varepsilon_1\cosh(kd_1)+\varepsilon_3\coth(kd_3)\sinh(kd_1)} \qquad \tau(k) = \frac{R}{k}\left(\varepsilon_1\coth(kd_1)+\varepsilon_3\coth(kd_3)\right) \qquad (1)$$

We see that the signal consists of an infinite sum of 'components' that decay with time constants

Values used in simulation:

a (Horizontal length of Module) = 216 mm
b (Vertical length of Module) = 168 mm
} Module dimensions

w_x (Horizontal length of Readout pad) = 3 mm
w_y (Vertical length of Readout pad) = 7 mm
} Readout pad dimensions (rectangle not keystone)

d_1 (Distance b/w Resistive layer and Readout pads) = 125 μm

d_3 (Distance b/w Resistive layer and mesh) = 120 μm

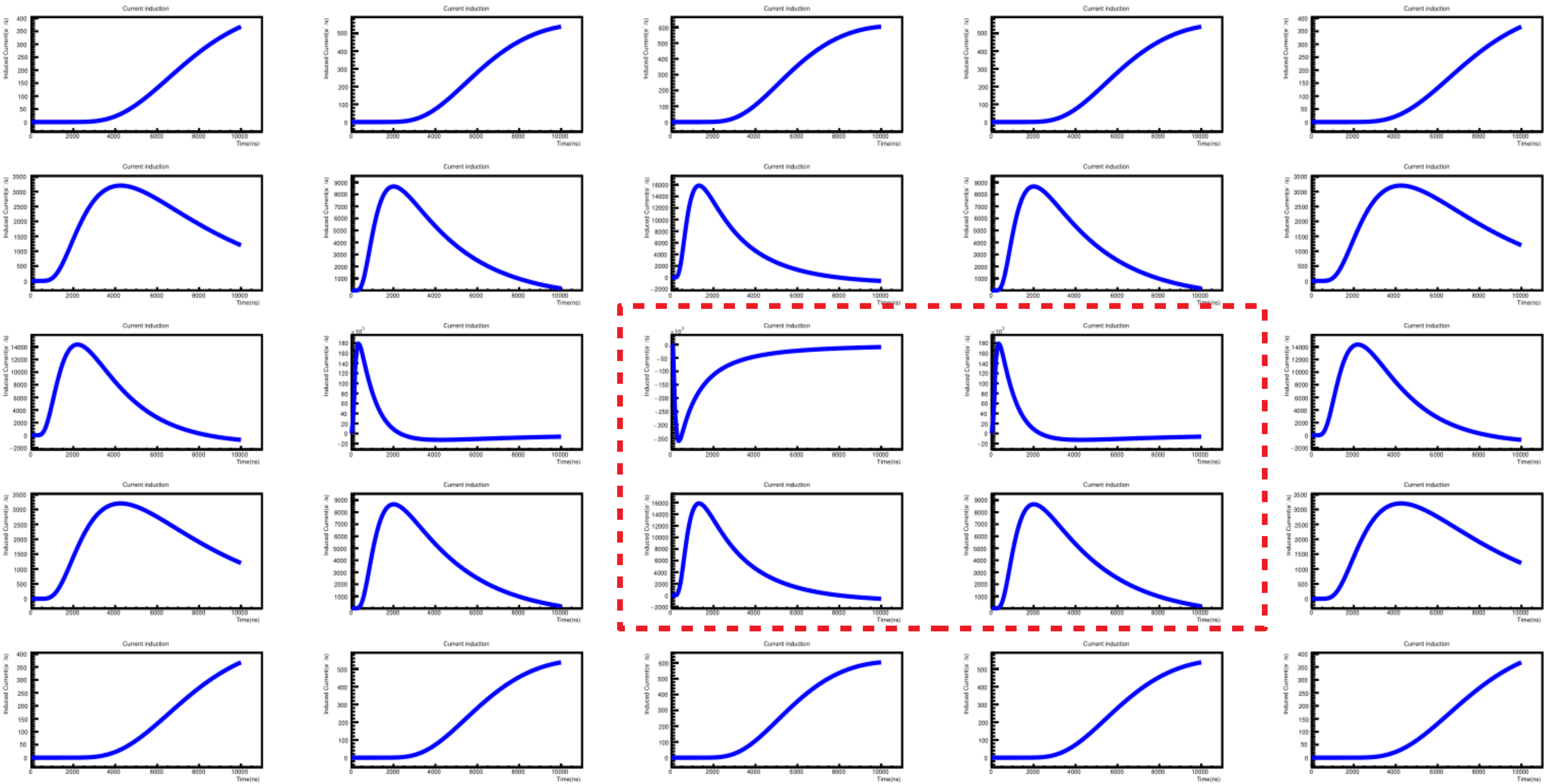
R (Surface resistivity of Resistive layer) = 2.5 $M\Omega/\square$

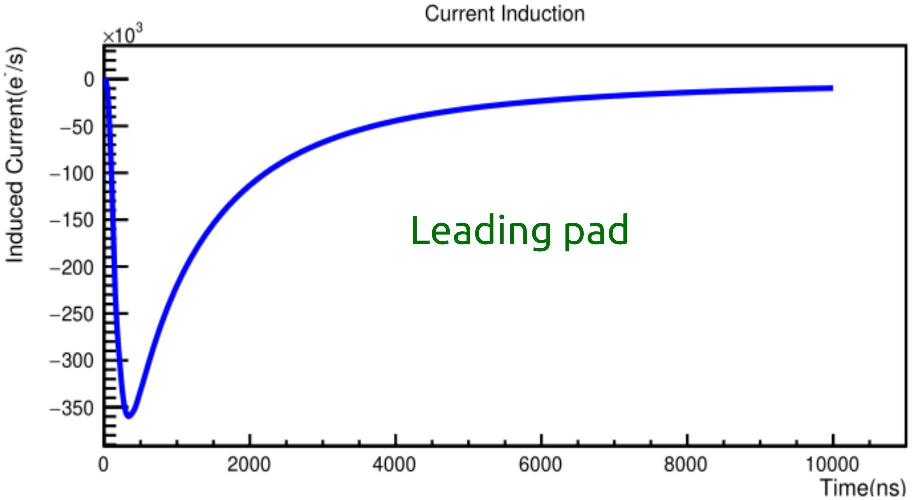
ε_1 (Permittivity of d_1 region) = 4* ε_0

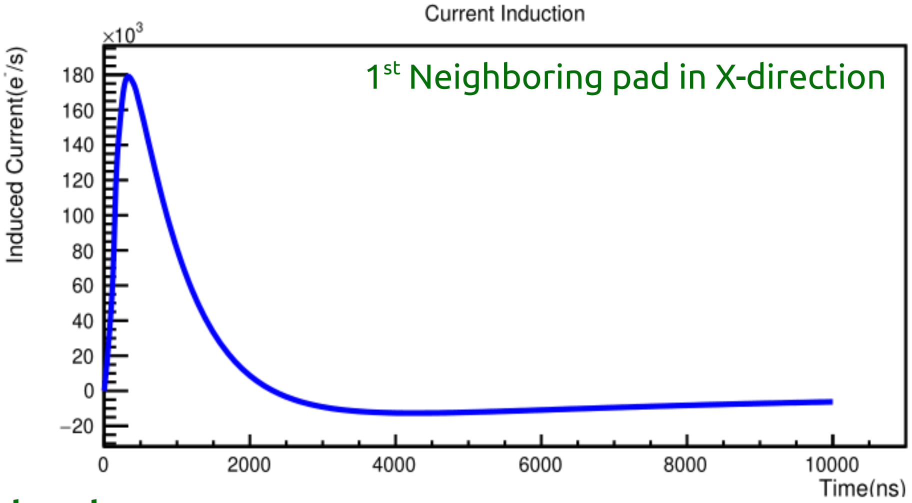
ε_3 (Permittivity of d_3 region) = ε_0

An electron is placed (x_0,y_0) on the resistive layer over the centre of a pad (x_p,y_p)

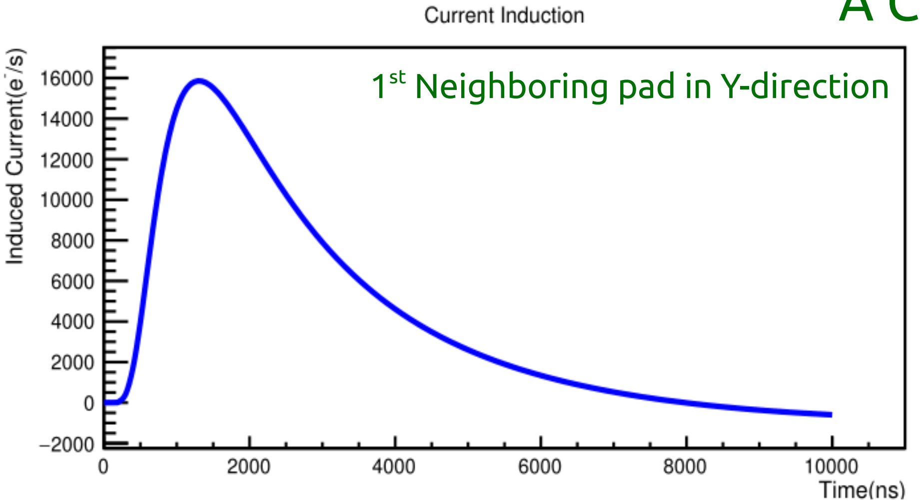
Note: Pad centre $(x_p , y_p) = (a/2 – w_x/2 , b/2 – w_y/2)$

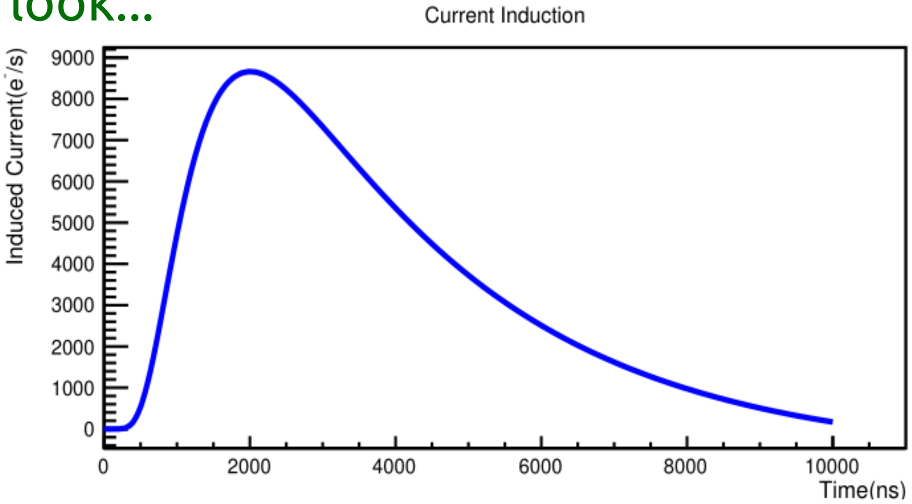

Current induction
Induced Current(e⁻/s)
Time(ns)

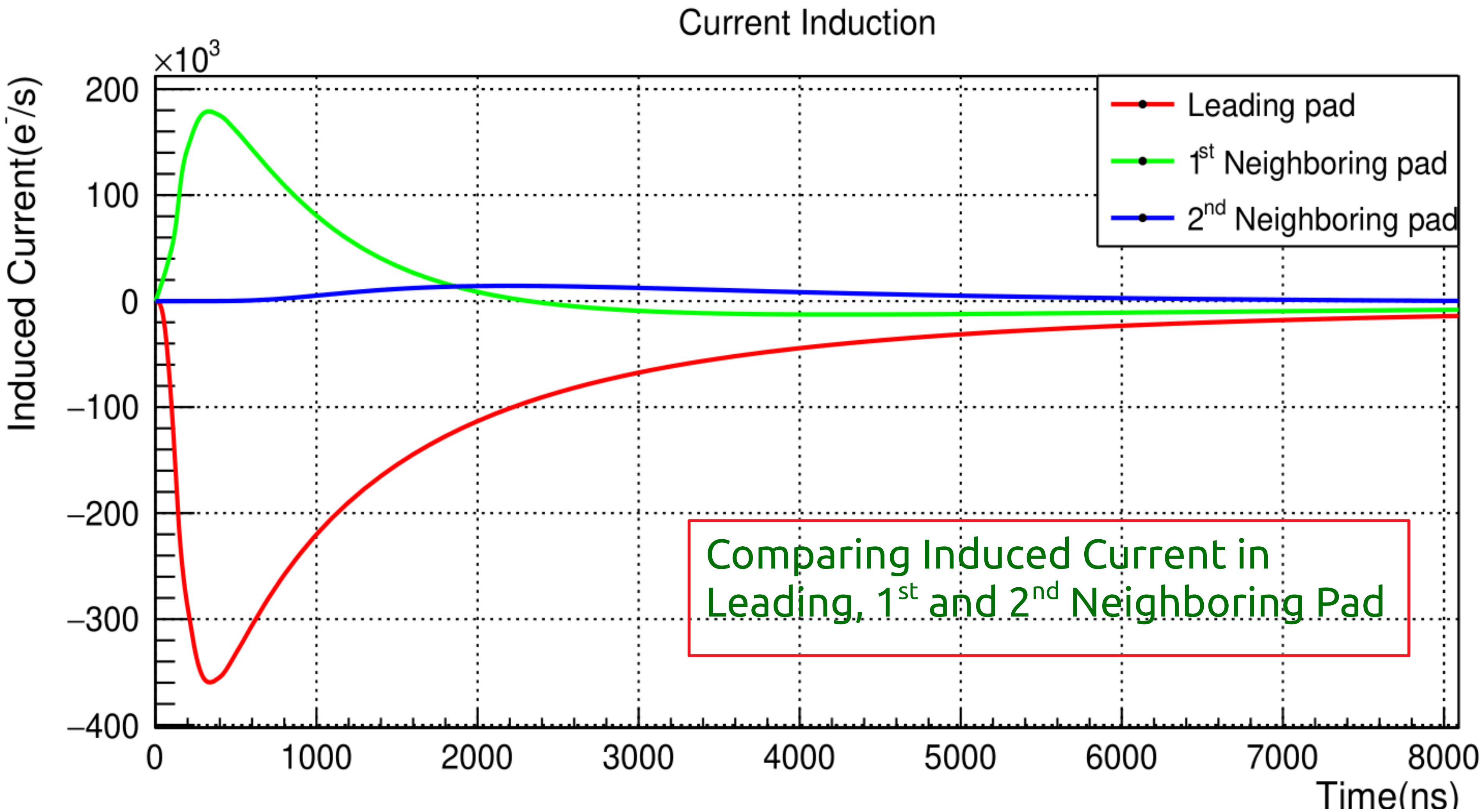


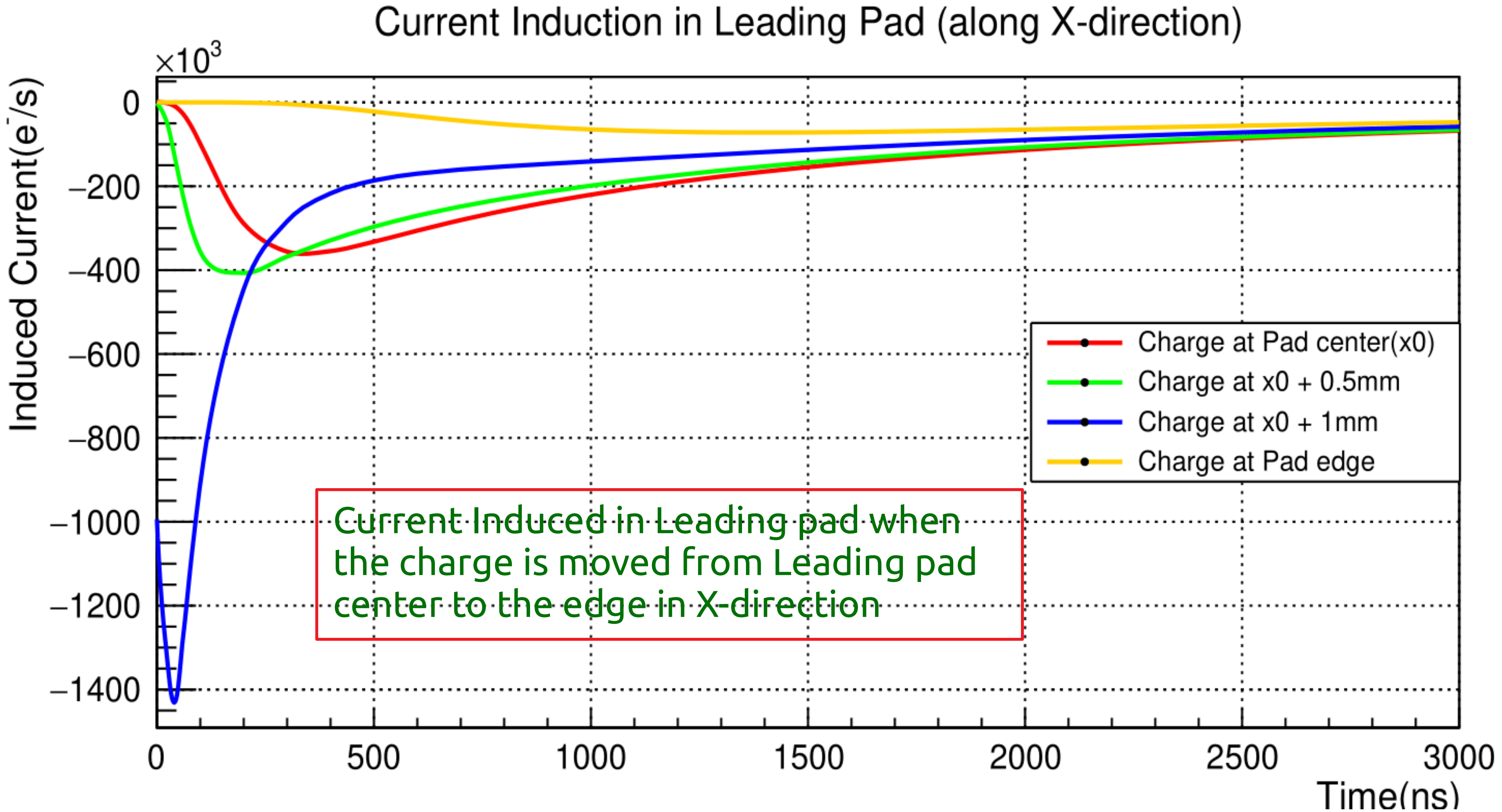


A Closer look…

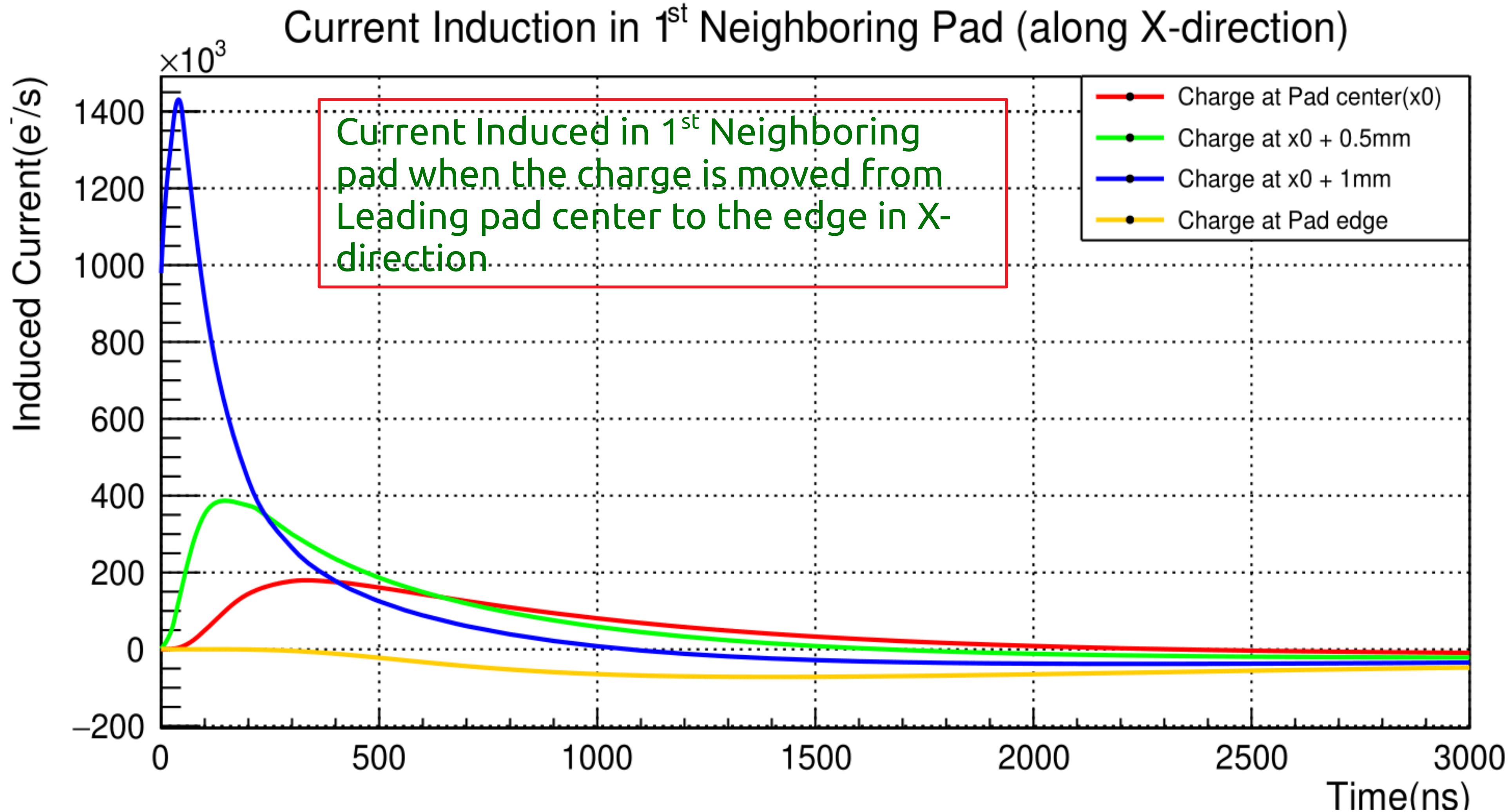





Current Induction
×10^3
Induced Current(e⁻/s)
200
100
0
−100
−200
−300
−400
0
1000
2000
3000
4000
5000
6000
7000
8000
Time(ns)
Leading pad
1st Neighboring pad
2nd Neighboring pad
Comparing Induced Current in Leading, 1st and 2nd Neighboring Pad

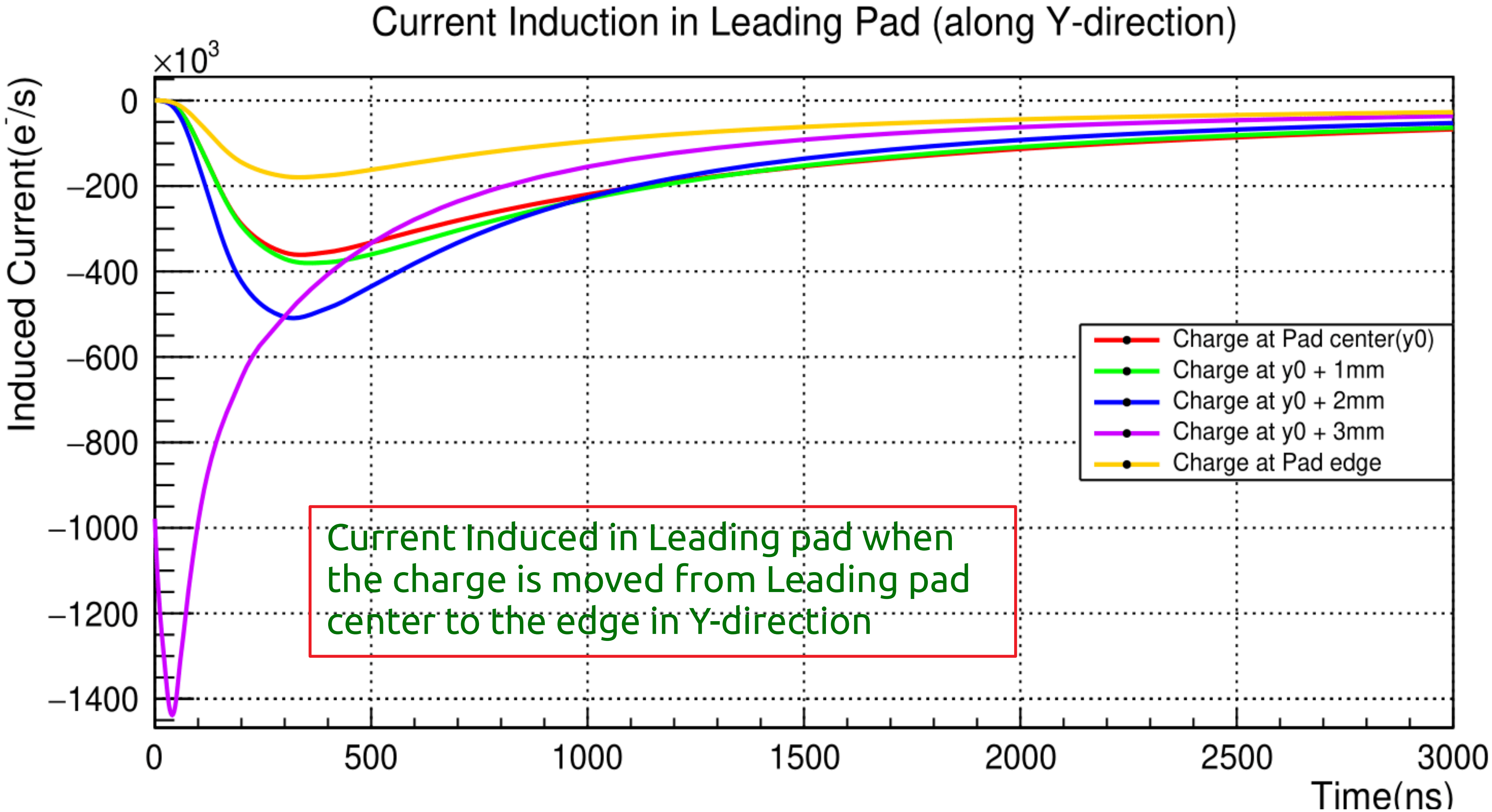


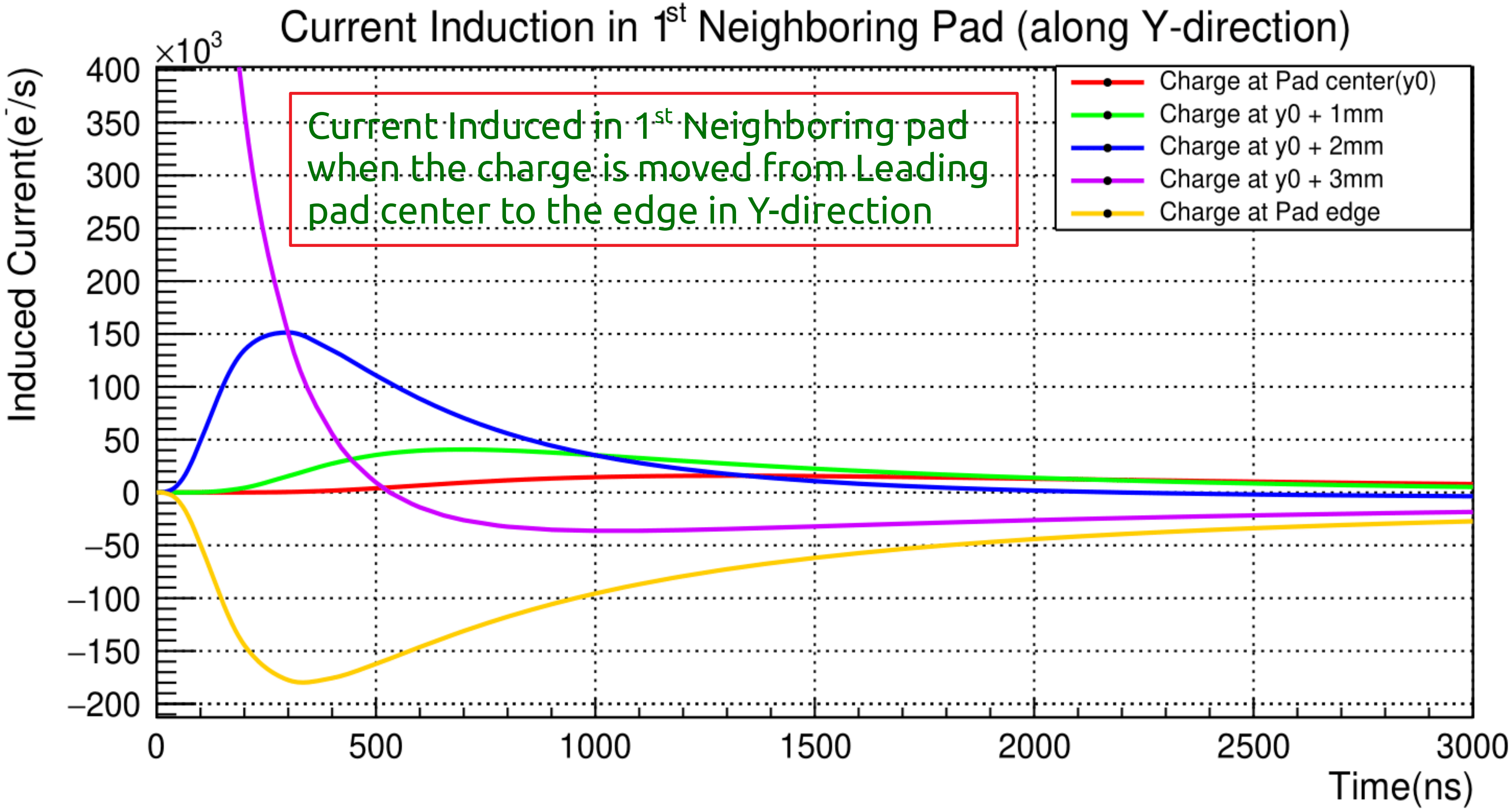
Current Induction in Leading Pad (along X-direction)
×10^3
Induced Current(e⁻/s)
0
−200
−400
−600
−800
−1000
−1200
−1400
0
500
1000
1500
2000
2500
3000
Time(ns)
Charge at Pad center(x0)
Charge at x0 + 0.5mm
Charge at x0 + 1mm
Charge at Pad edge
Current Induced in Leading pad when the charge is moved from Leading pad center to the edge in X-direction



Current Induction in 1st Neighboring Pad (along X-direction)
×10^3
Induced Current(e⁻/s)
1400
1200
1000
800
600
400
200
0
−200
0
500
1000
1500
2000
2500
3000
Time(ns)
Charge at Pad center(x0)
Charge at x0 + 0.5mm
Charge at x0 + 1mm
Charge at Pad edge
Current Induced in 1st Neighboring pad when the charge is moved from Leading pad center to the edge in X-direction

End


Current Induction in Leading Pad (along Y-direction)
×10^3
Induced Current(e⁻/s)
0
−200
−400
−600
−800
−1000
−1200
−1400
0
500
1000
1500
2000
2500
3000
Time(ns)
Charge at Pad center(y0)
Charge at y0 + 1mm
Charge at y0 + 2mm
Charge at y0 + 3mm
Charge at Pad edge
Current Induced in Leading pad when the charge is moved from Leading pad center to the edge in Y-direction



Current Induction in 1st Neighboring Pad (along Y-direction)
×10^3
Induced Current(e-/s)
400
350
300
250
200
150
100
50
0
−50
−100
−150
−200
0
500
1000
1500
2000
2500
3000
Time(ns)
Charge at Pad center(y0)
Charge at y0 + 1mm
Charge at y0 + 2mm
Charge at y0 + 3mm
Charge at Pad edge
Current Induced in 1st Neighboring pad when the charge is moved from Leading pad center to the edge in Y-direction