Overview of results on charge collection in ATLAS strip detectors

by

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Outline

1. Motivation
2. Experimental setup
3. Collected charge
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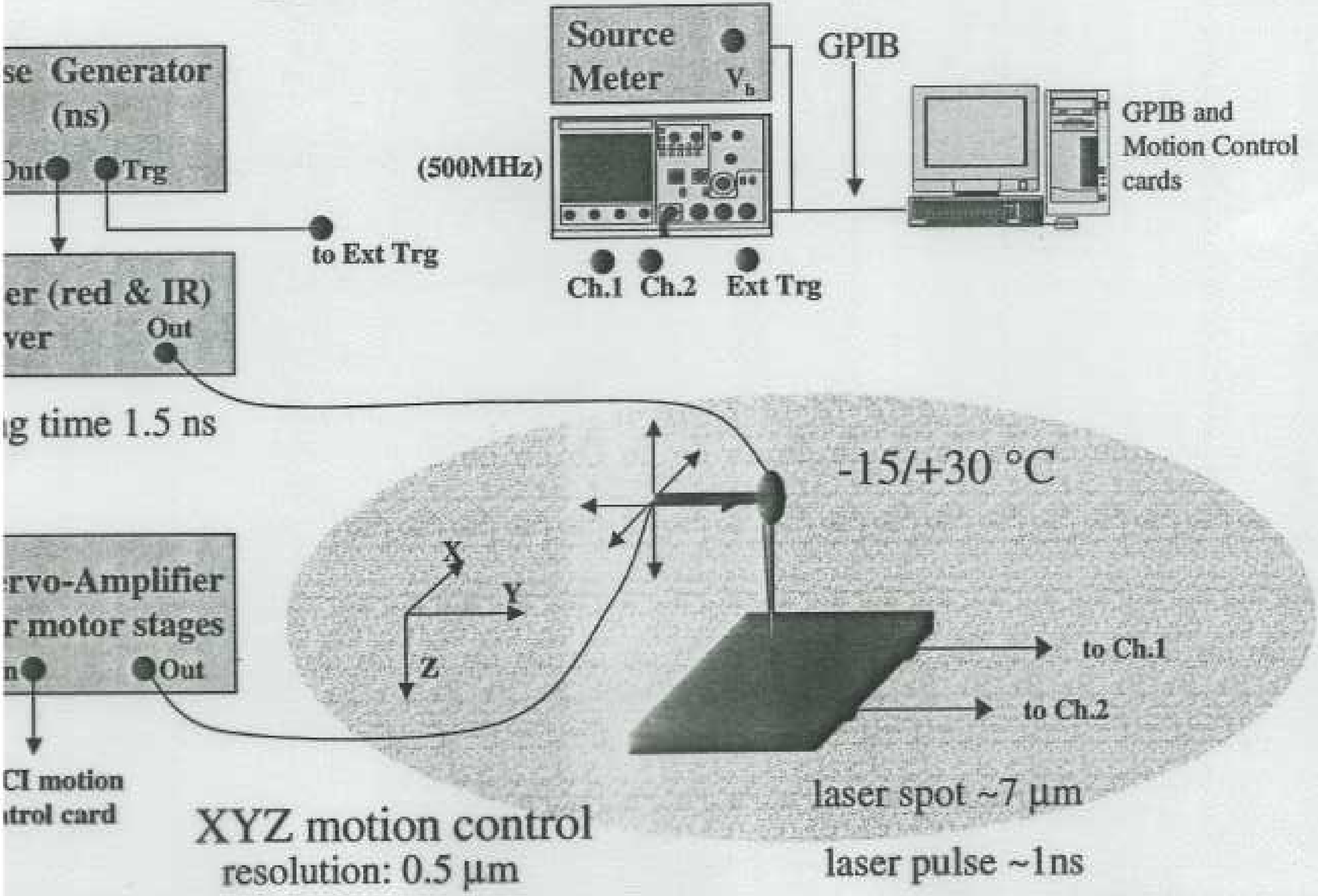
   - Cross strip scan
4. Transient current responce
5. Charge collection details
   - Induction delay
   - Returned charge
6. Conclusions

Motivation

1. Background for QA test program on fast timing with strip detectors
2. Background for understanding the irradiated strip/pixel detector operation
3. Importantfor development of CID segmented detectors

Experimental Set-Up



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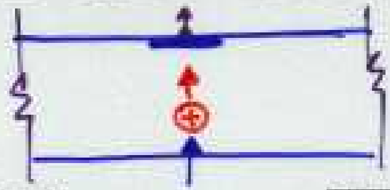
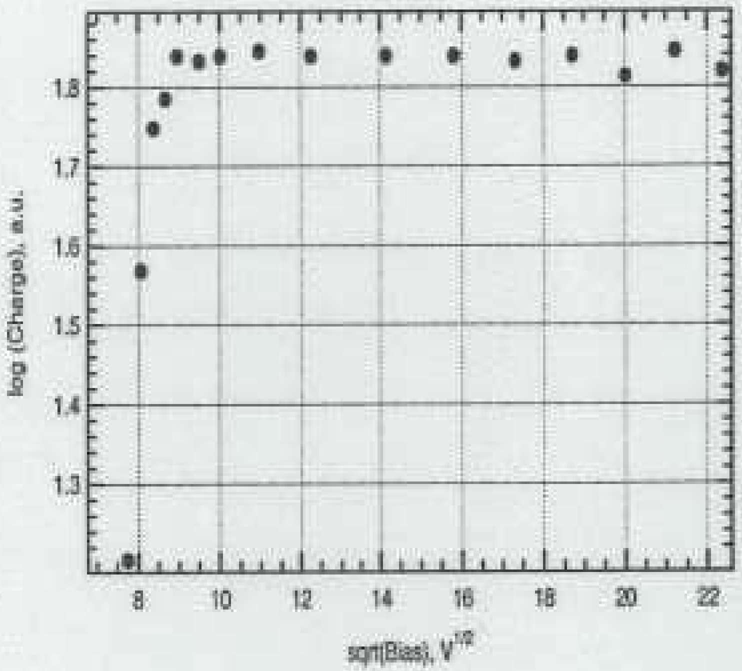
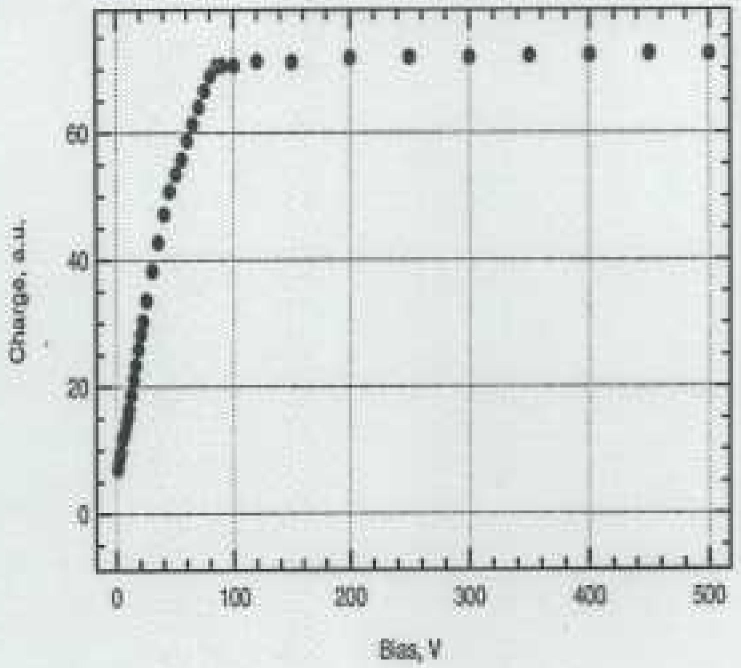
Full depletion of the sample with TChT





Red Laser*



Infrared Laser

* V. Eremin et al., NIM A 372 (1996) 388

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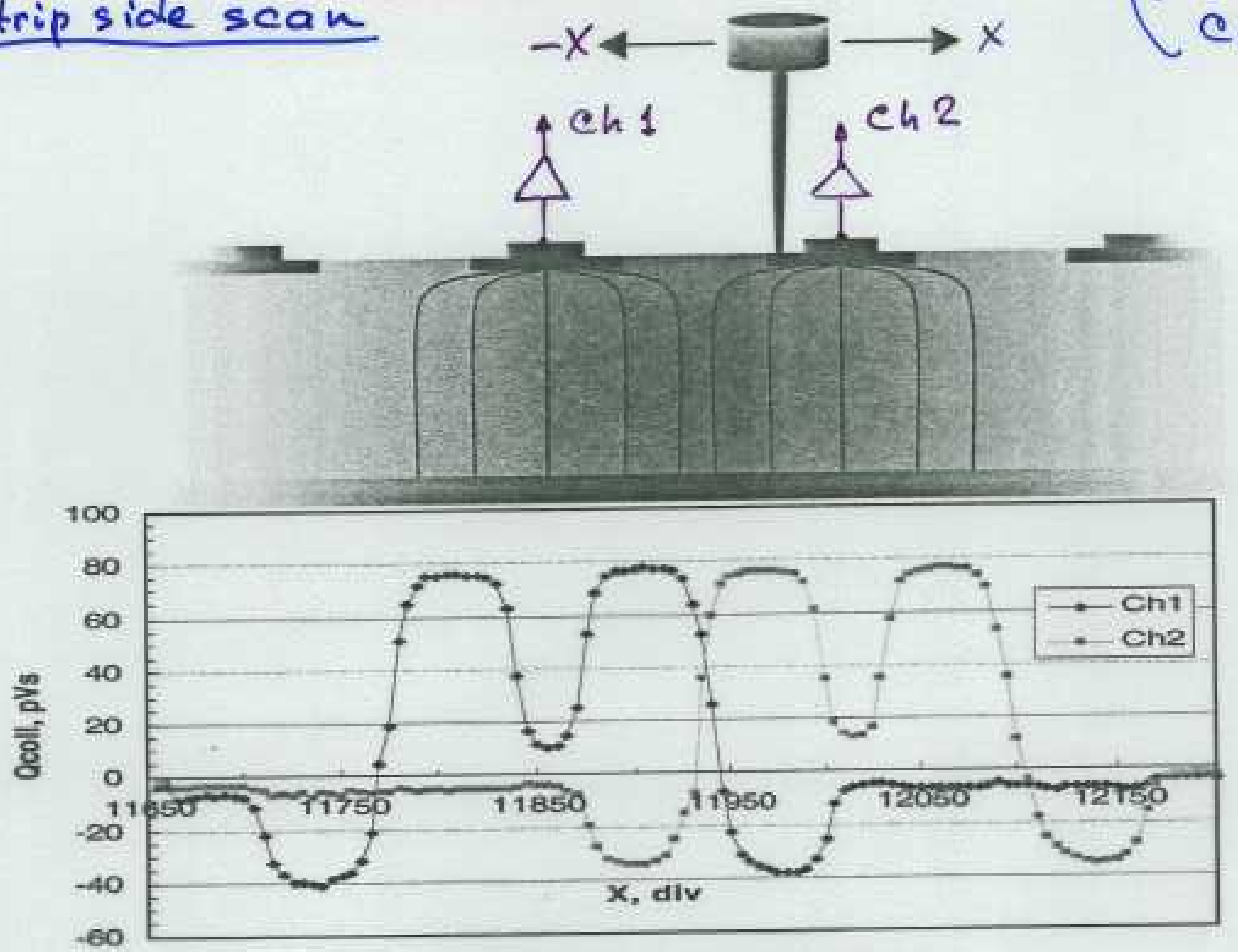
Red Laser

Strip side scan

(ELECTRON collection)



X scan / charge collection at 350V

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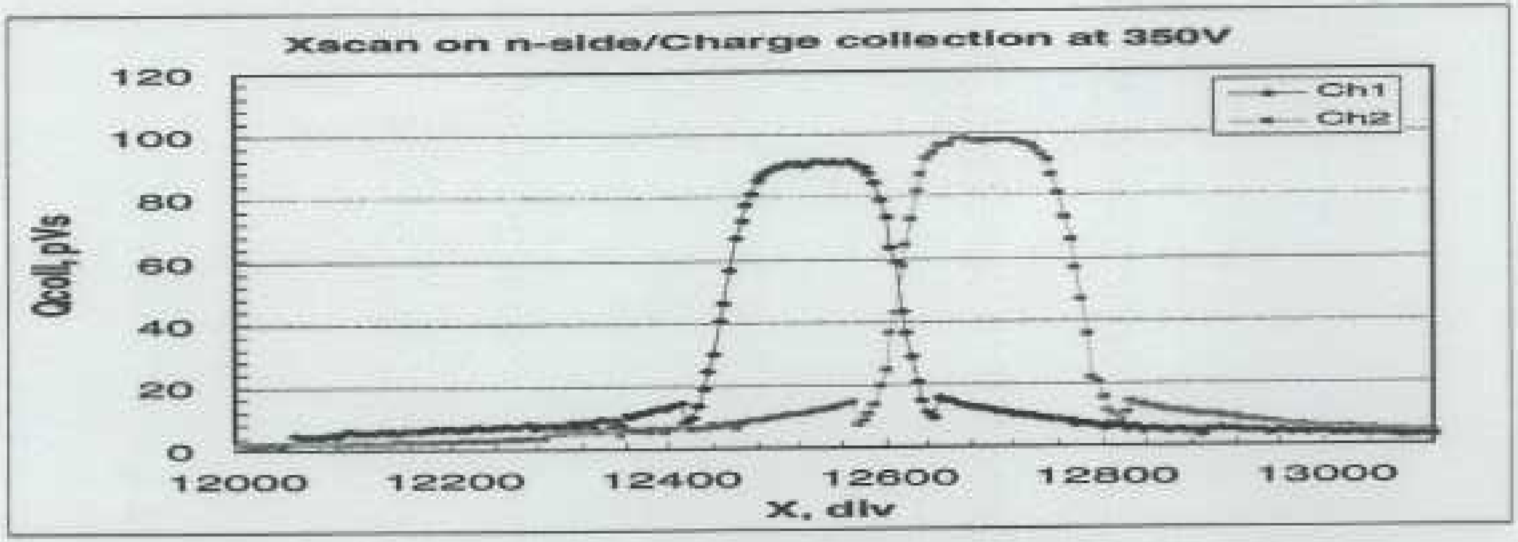
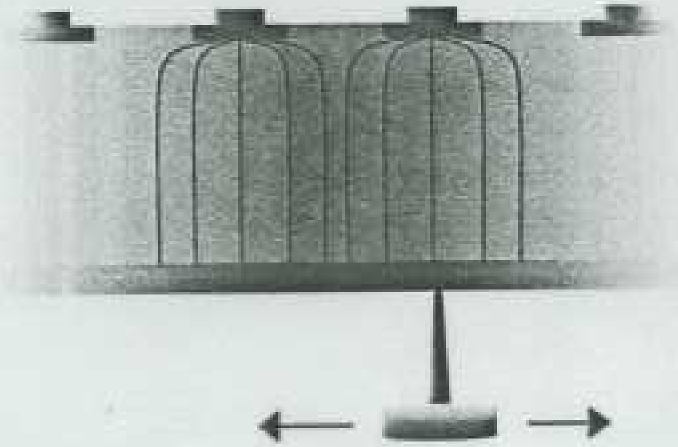
...and the hole collection?

Red Laser





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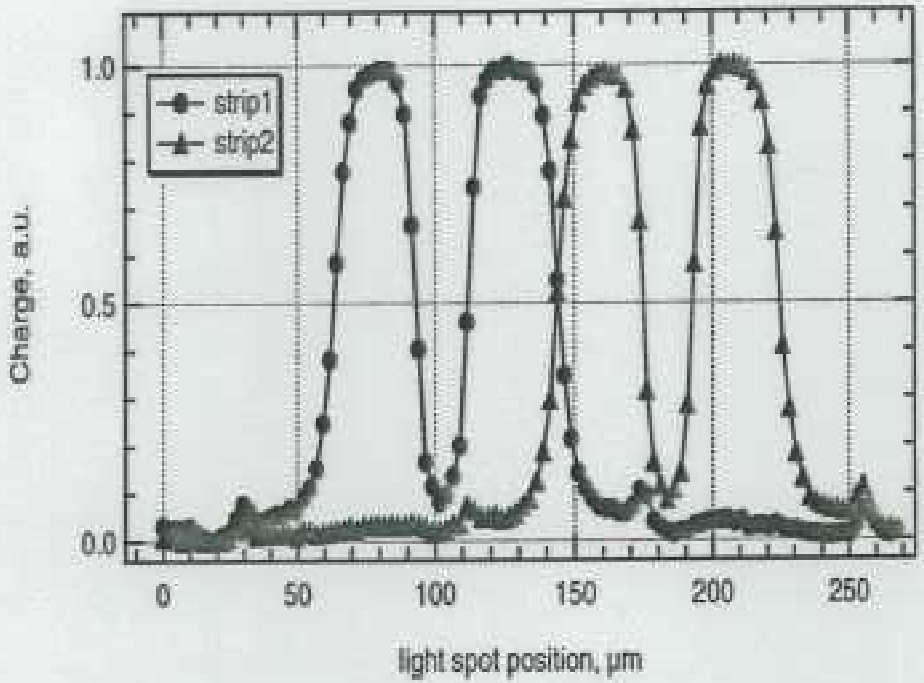
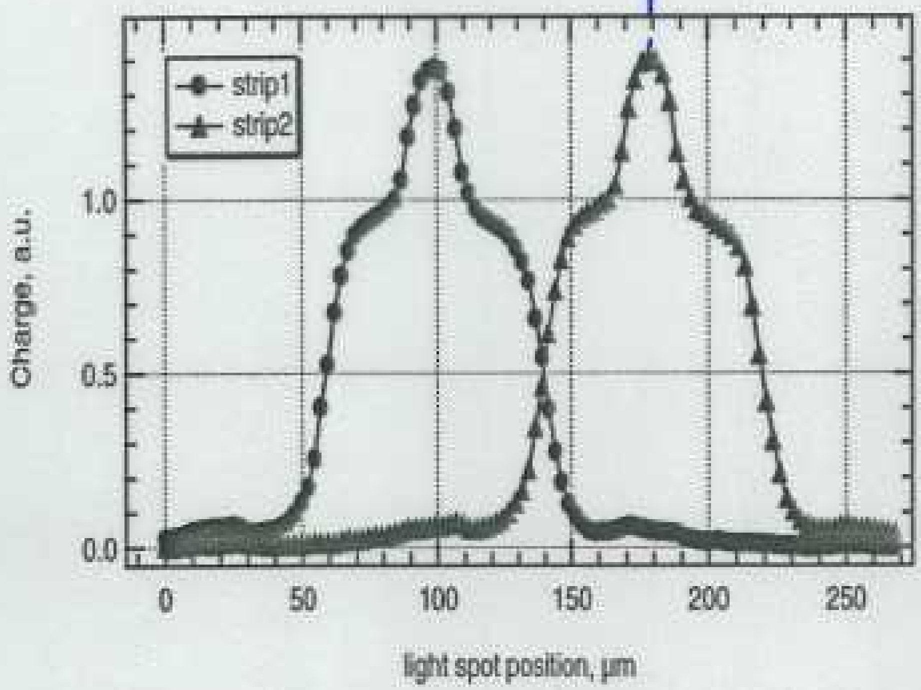
Charge Collection with infrared laser (1060nm)

on the p-side



on the n-side



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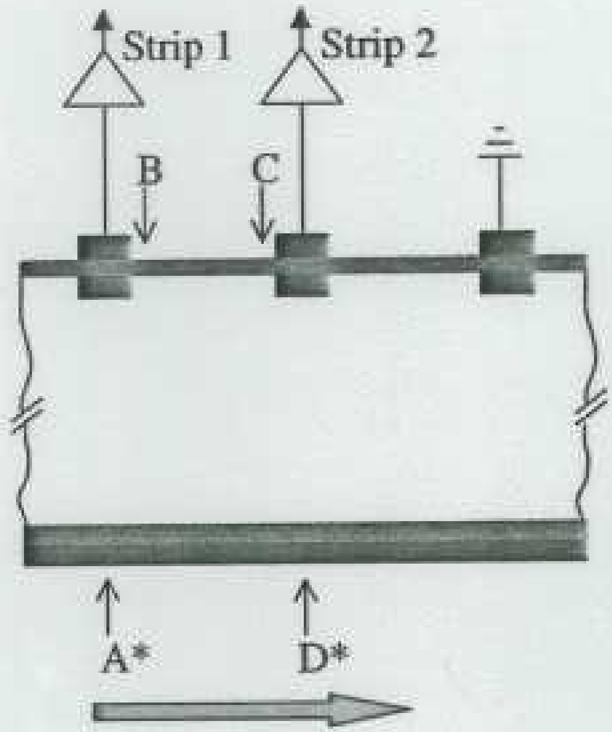
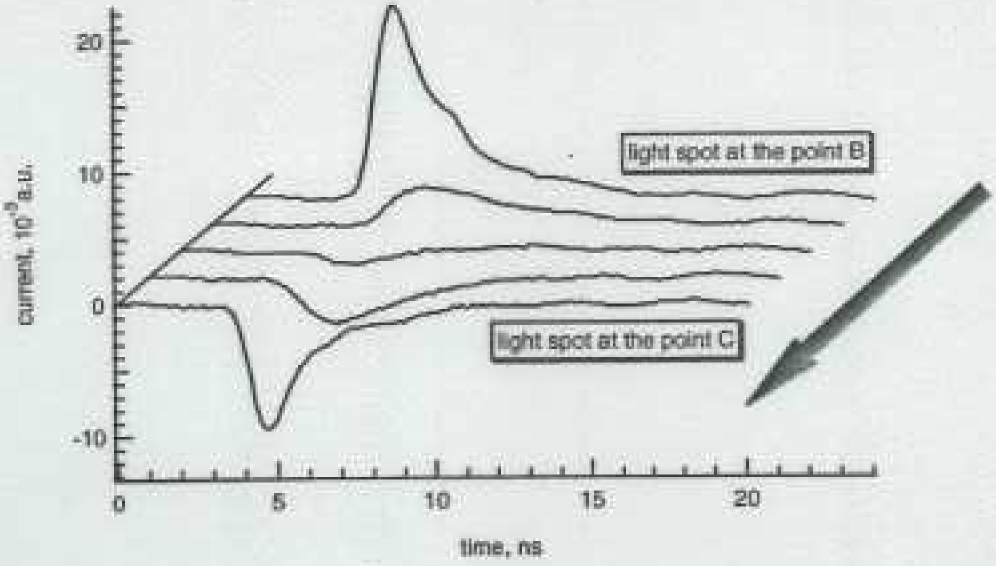
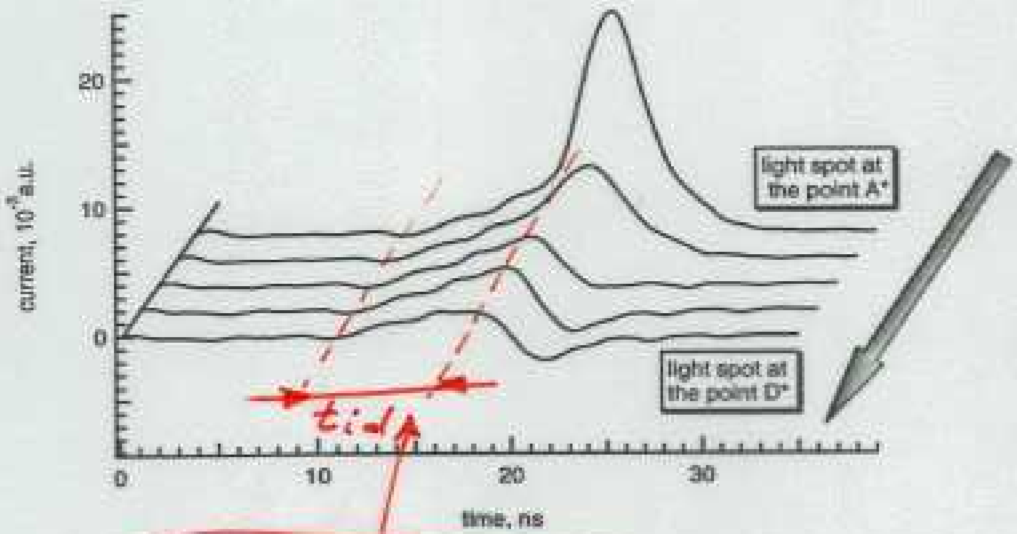
Current Pulses (from Strip1)

Red Laser







induction delay

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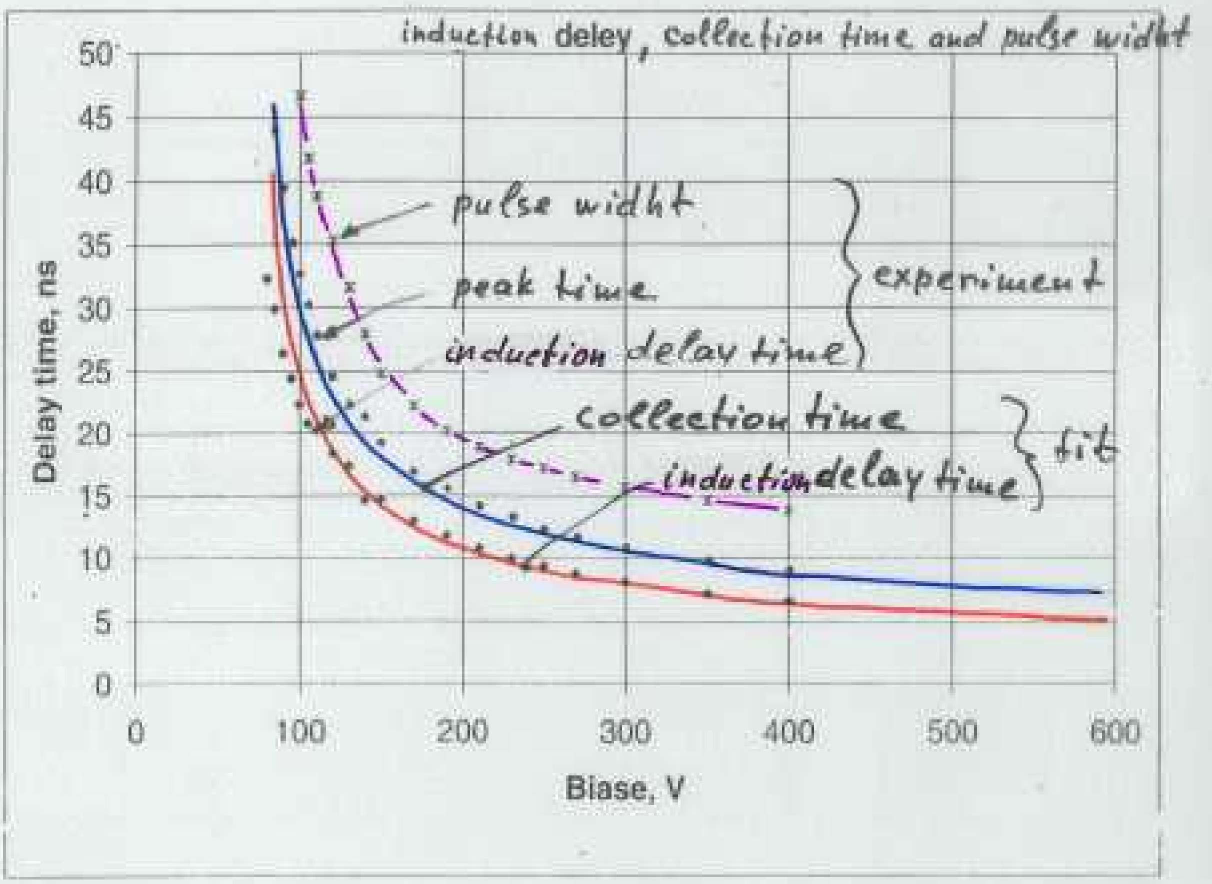
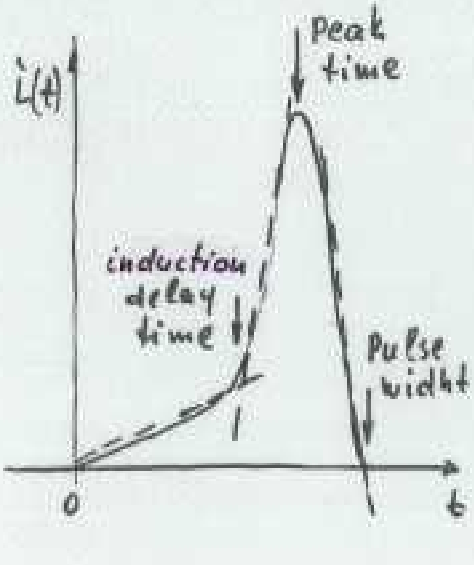
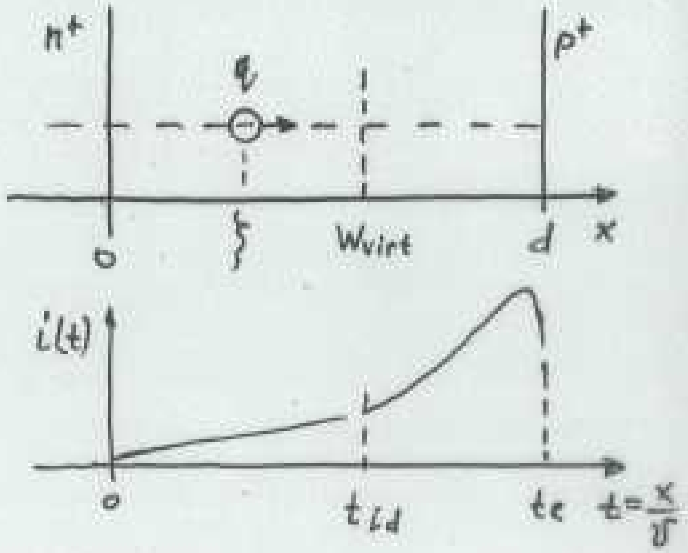
Dependence of charge collection parameters on the detector bias voltage







Experiment

Model

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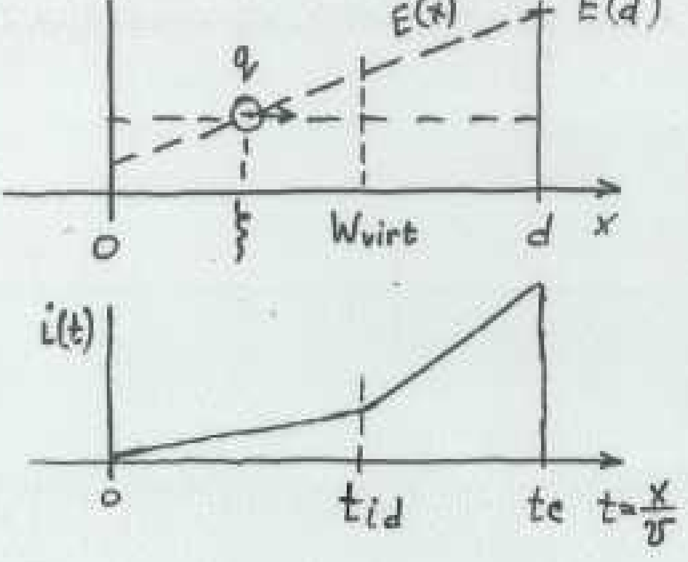
The main equations



induction delay time:

$$E(x) = E^*(d)\left(\frac{x}{d}\right) + E_{od}$$

$$v(E) = \frac{v_s}{\left(1+\frac{v_s}{\mu E}\right)}$$

$$t_{id} = \frac{W_v}{v_s} + \frac{d^2}{2\mu V_{fd}} \ln\left[\left(2V_{fd}\frac{W_v}{d} + V - V_{fd}\right) / \left(V - V_{fd}\right)\right]$$

$$t_c = \frac{d}{2\mu V_{fd}} \ln\left[\left(V+V_{fd}\right)\left(V-V_{fd}\right)\right]$$

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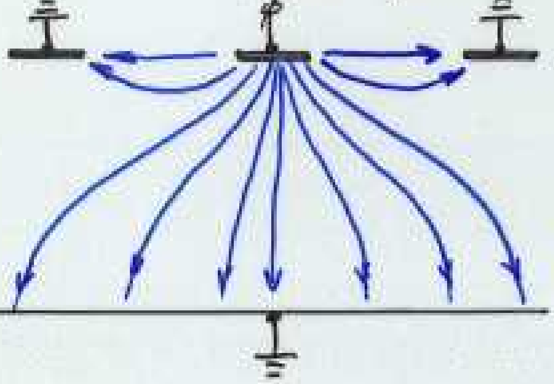
Weighting Potential / Electric field

$$\varphi, \ \varphi_w^* = \frac{\varphi}{\varphi} = 1$$

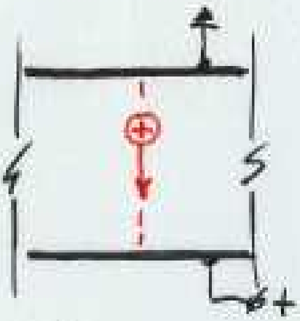


$$\varphi_w^* = \frac{\varphi(x,y,z)}{\varphi} \quad \text{at:} \qquad \rho = eN_{eff} = 0$$

$$\mathcal{E}_w^* = \frac{d\varphi_w^*}{dx} \qquad \Delta Q = q\,\Delta\varphi_w^*$$

$$i = q\,\mathcal{E}_w^* \cdot v_{dr}$$

Planar detector



$$\mathcal{E}_w^* = \frac{\varphi^*}{d} = \frac{1}{d} \qquad i = q\frac{1}{d}\mu E$$

$$\varphi_w^* = \frac{1}{d}x$$

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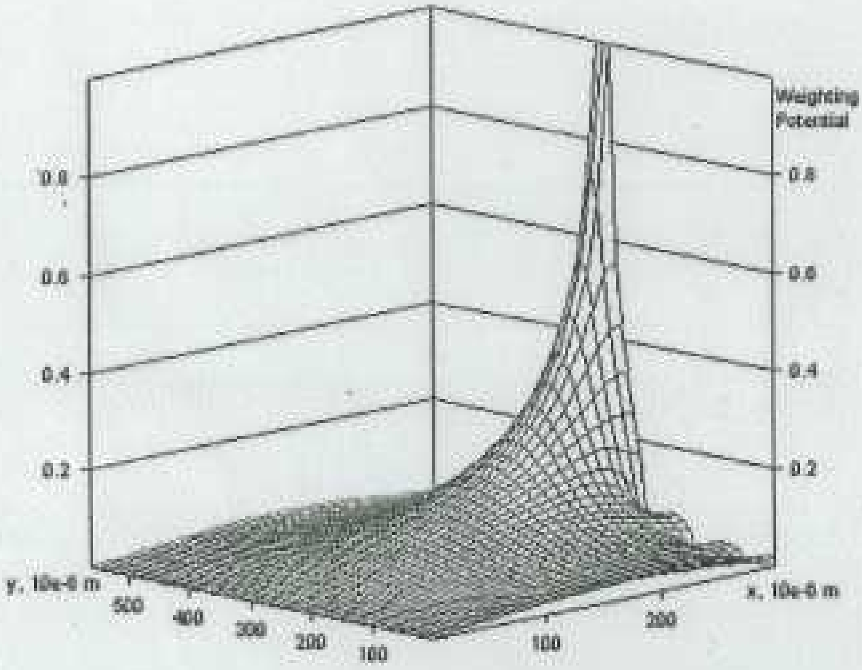

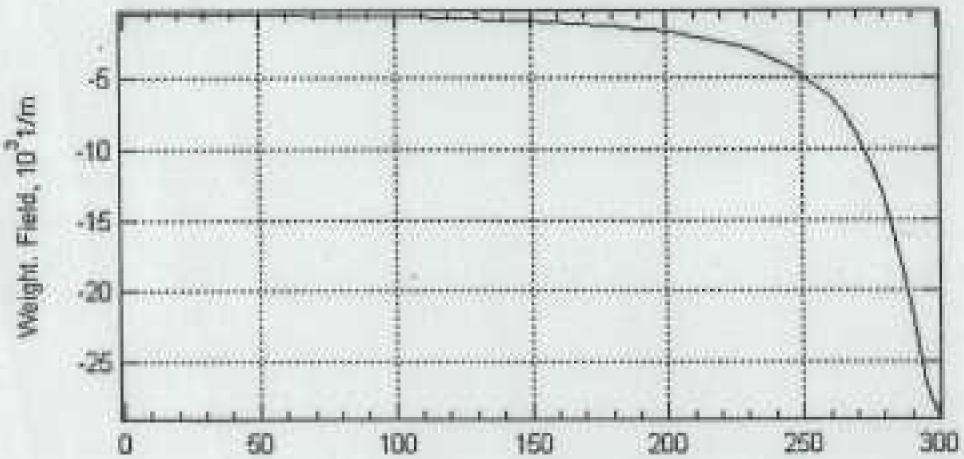

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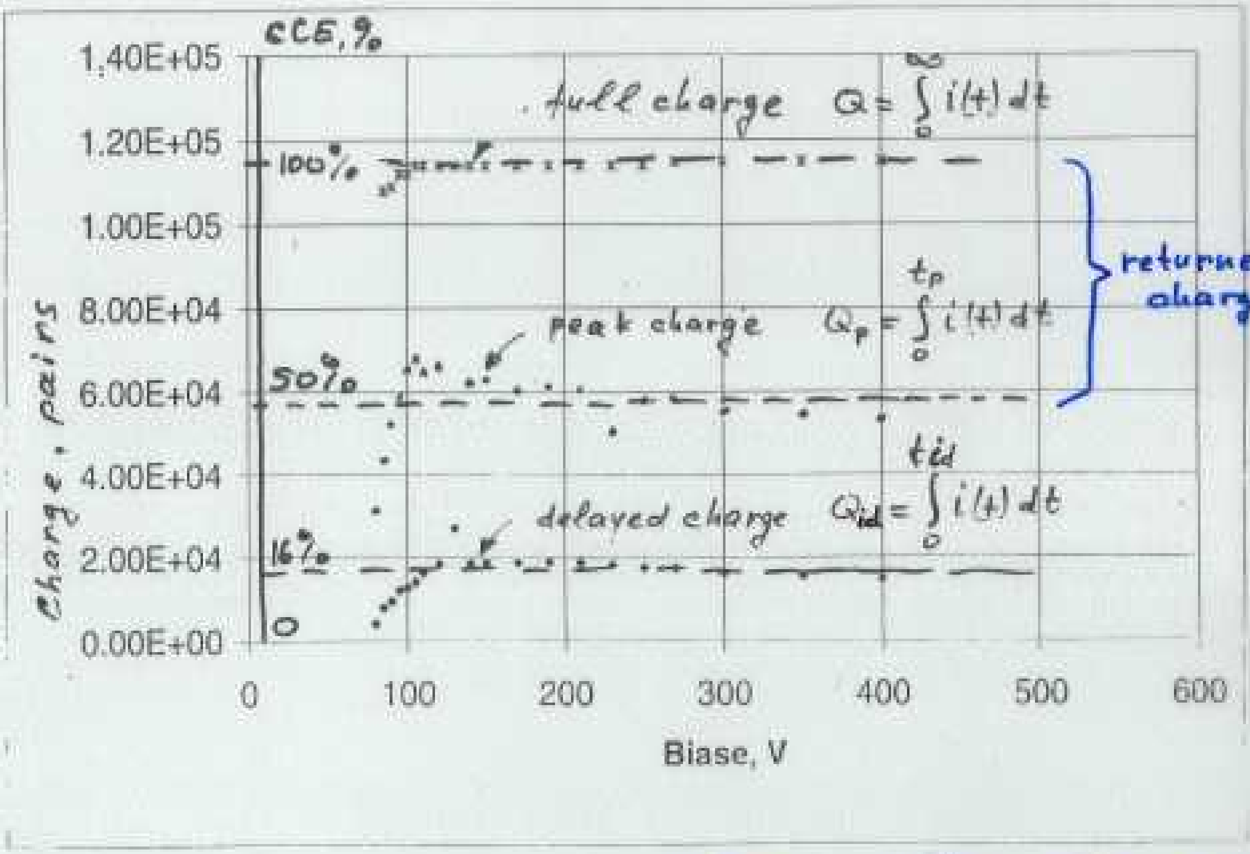
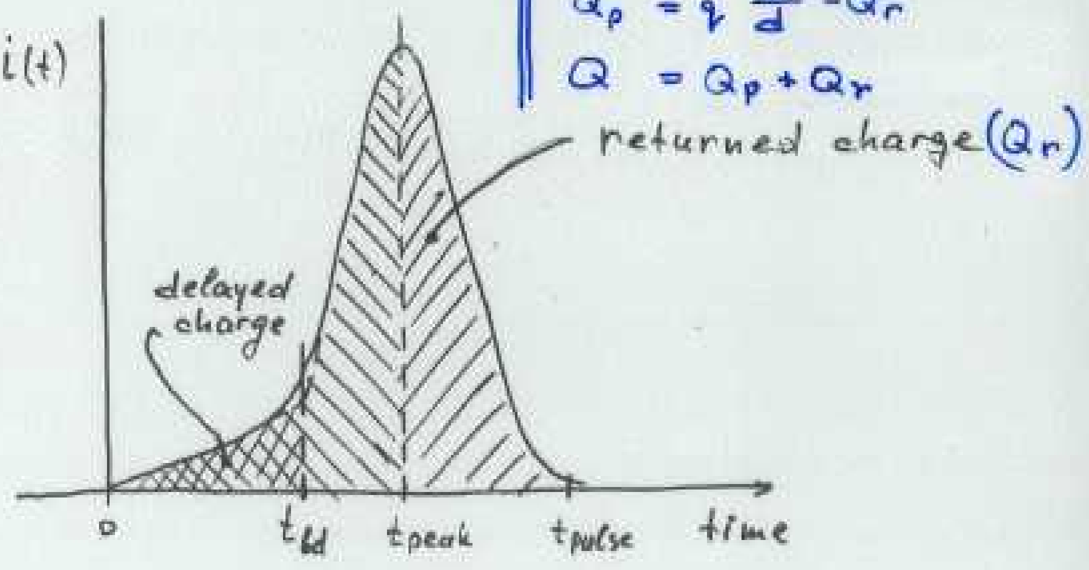
Dependence of collected charge on the bias voltage



$$Q_{id} = q\,\frac{W_{id}}{d} \quad \text{(Ramo's theorem)}$$

$$Q_p = q\,\frac{d}{d} - Q_r$$

$$Q = Q_p + Q_r$$



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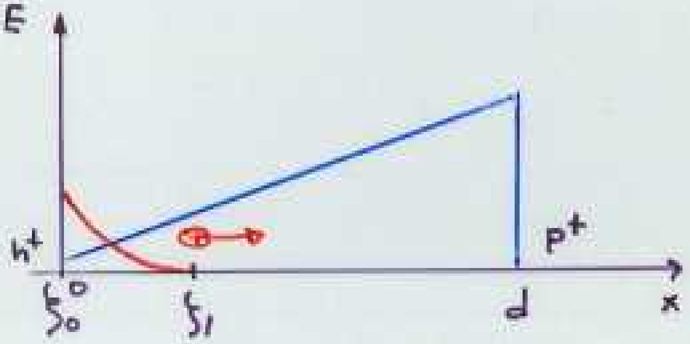
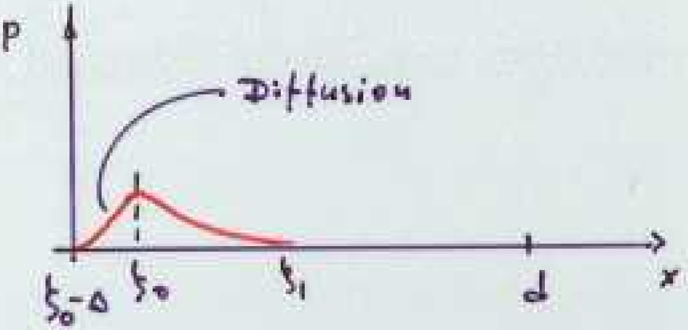
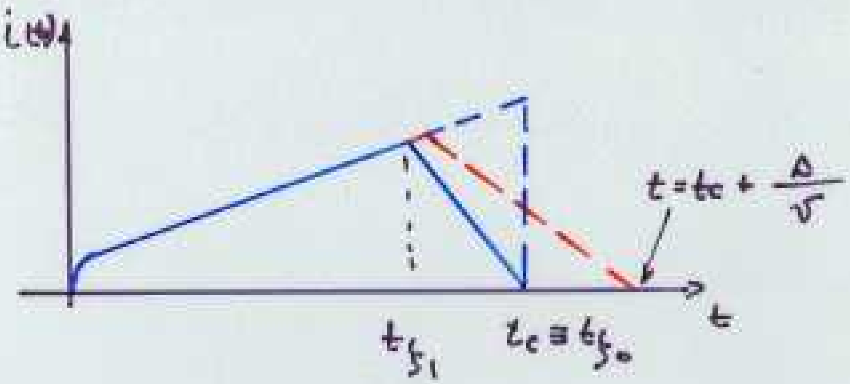
Current pulse at carriers generation at low E contact

(pad detector)



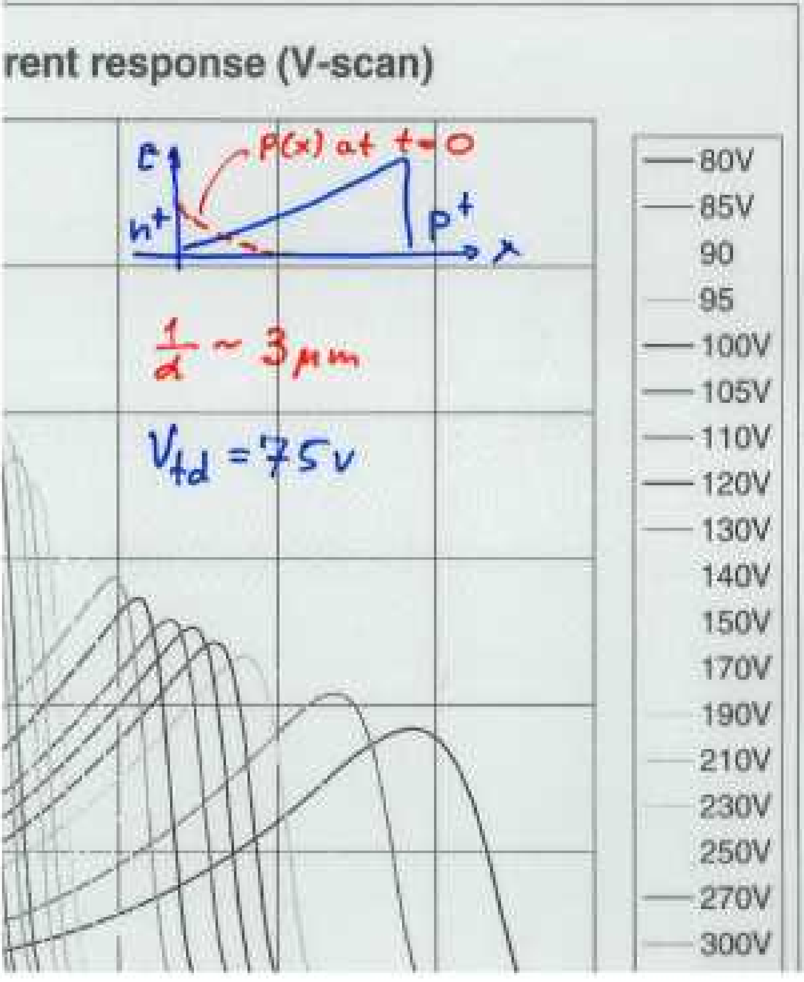


$$X \sim \mu E t \simeq t$$



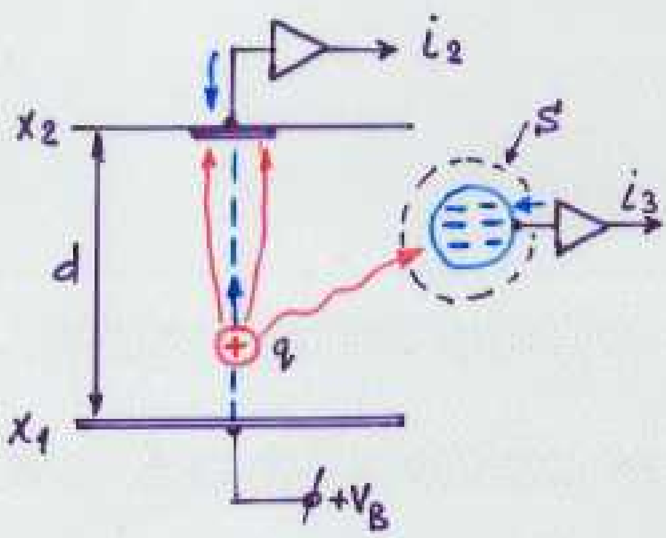
$$\Delta \simeq \sqrt{D \cdot t_c} \sim \sqrt{20 \cdot 4 \cdot 10^{-8}} \sim 10\,\mu m$$

rrent responses for hole
rom low electric field
tact) of Si detector



Grounded/floating electrode in detector

Grounded electrode



$$Q_3(x_1) = \int_S E(x_1)\, ds$$

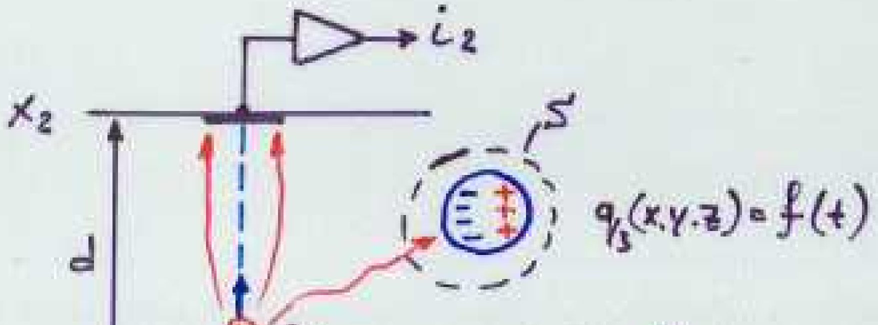
$$Q_3(x_2) = \int_S E(x_2)\, dx$$

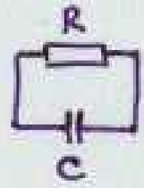
$$Q_3(x_1) - Q_3(x_2) = 0$$

$$d = \int_0^{t_{dr}} v(t)\, dt$$

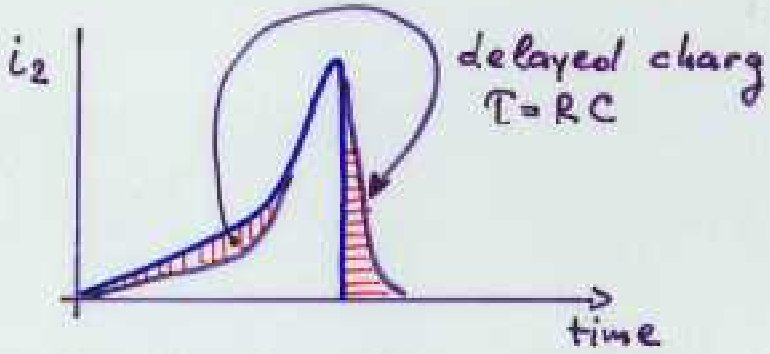
$$\underline{Q_3^+ = Q_3^-}$$

Floating electrode





$\Rightarrow \tau = R \times C$



Model of returned charge fraction in the strip detector responce