

Evaluation of different methods for determining the magnitude of initial recombination in ionization chambers

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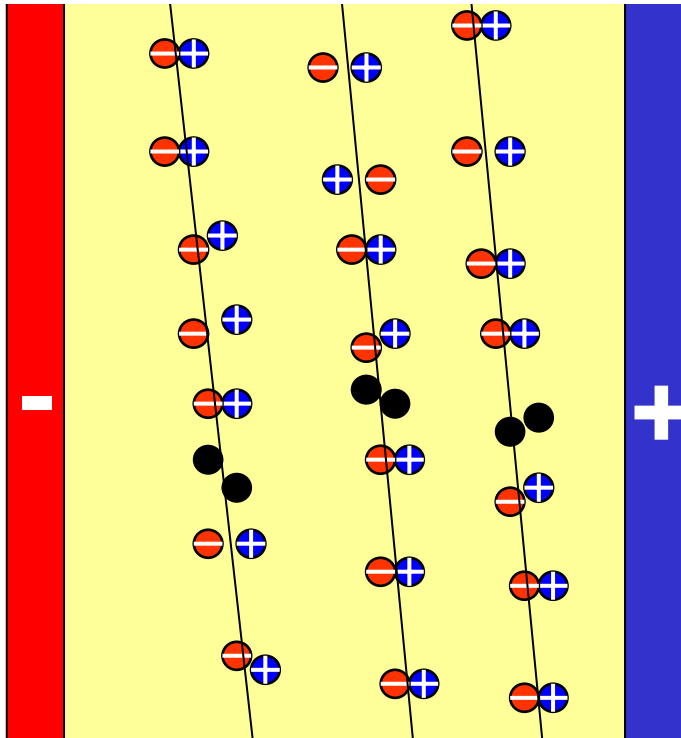
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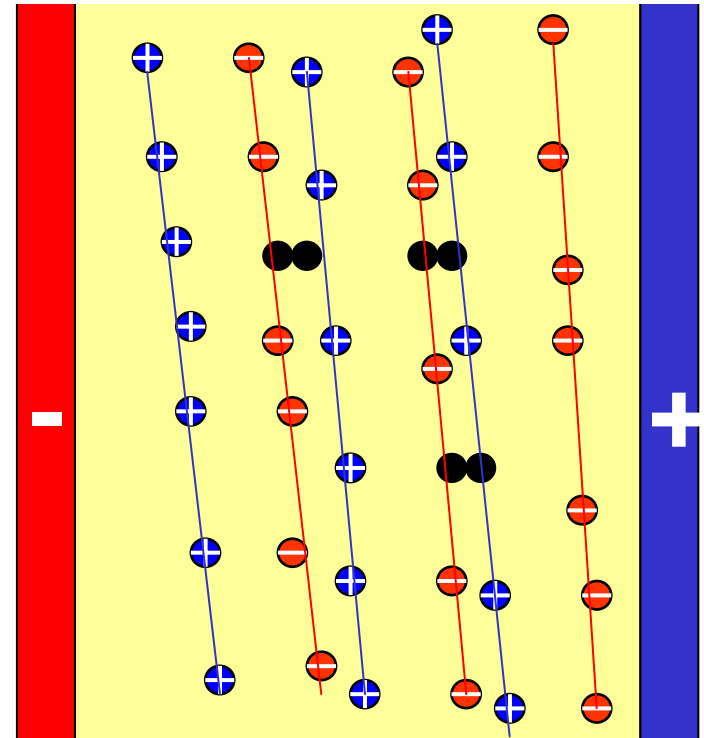
Mechanisms of Ion Recombination

initial recombination



independent on dose rate

volume recombination



depends on dose rate
to be corrected for

- ⊕ positive ion
- ⊖ negative ion
- recombined

Motivation

misleading statement in IAEA TRS 398 (section 4.4.3.4)

continuous beams:

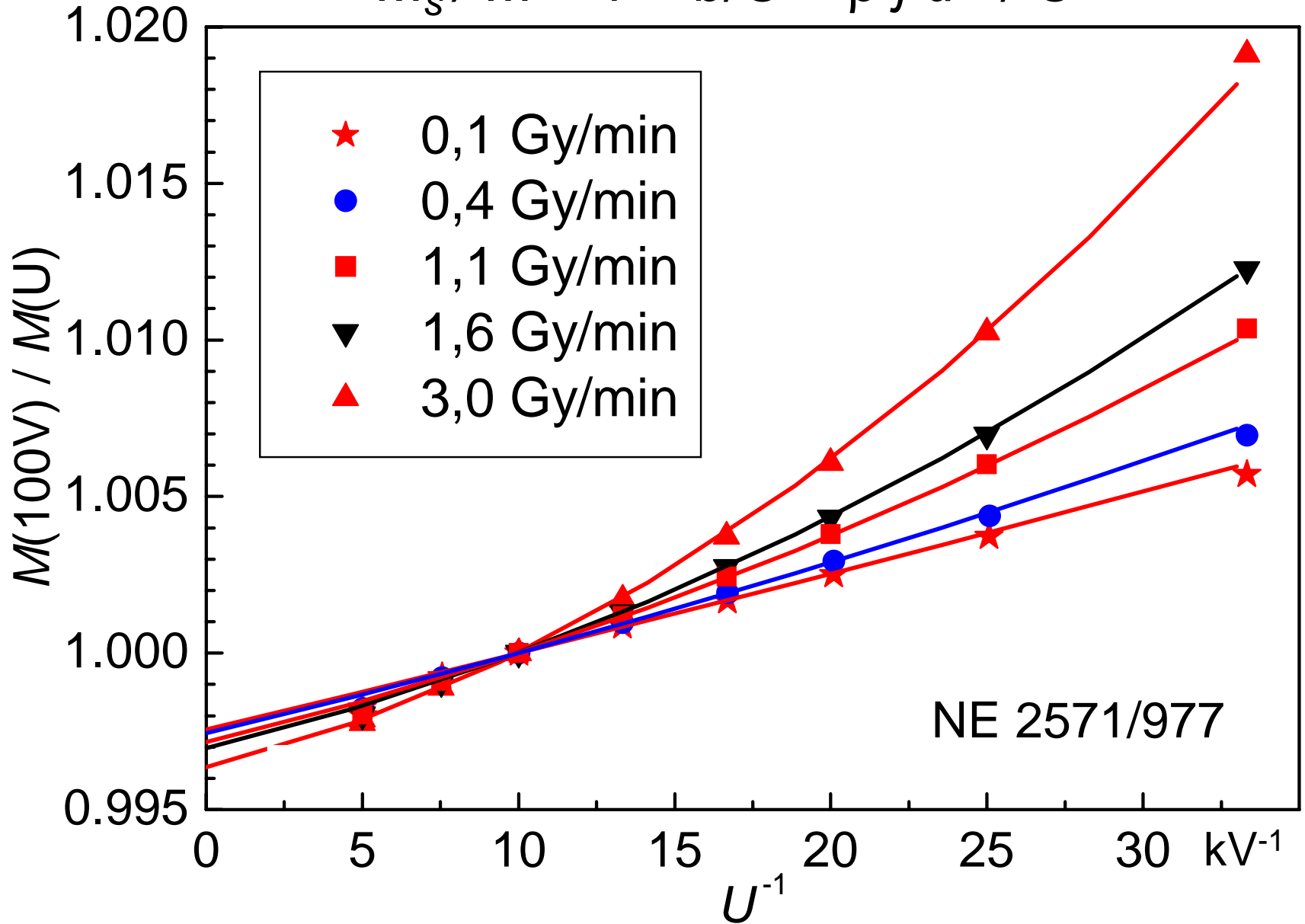
$$k_S = ((V_1/V_2)^2 - 1) / ((V_1/V_2)^2 - (M_1/M_2))$$

This relation is based on a linear dependence of $1/M$ on $1/V^2$.
The presence of initial recombination disturbs this linearity but
this is normally a small effect which may be neglected.

NE 2571_(200V) at 1 Gy/min

volume recombination	$\Delta Q/Q = 7 \cdot 10^{-5}$
initial recombination	$\Delta Q/Q = 1 \cdot 10^{-3}$

$$M_s / M = 1 + b/U + \beta j d^4 / U^2$$



PTB does not correct

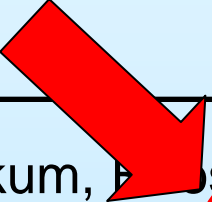
$$N_{D,w,^{60}\text{Co}}$$

for recombination losses

$N_{D,w,^{60}\text{Co}}$: absorbed dose to water calibration factor for ^{60}Co radiation

$N_{D,w}$ accounts for ion loss independent on dose rate
(i. e. ion diffusion and initial recombination)

Ion Loss in Pulsed Beams



Derikum, <i>Phys. Rev. Lett.</i> PMB 38 755 (1993) $Q_s/Q = 1,001 + 0,15 d^2 q / U$	Seuntjents et al. <i>MP</i> 27 2763 (2000) measurements
NE 2571 : 1,0021	1,0022
NE 2611A : 1,0022	1,0023
PR06-C : 1,0018	1,0015
Exradin A12 : 1,0020	1,0019

Formula describes result of extrapolation within 0.1 % .

Constant term attributed to initial recombination .

Measuring the amount of initial recombination

Method 1: fitting $M/M_s = 1 - \mathbf{b}/\mathbf{U} - \beta j d^4 / \mathbf{U}^2$
 (^{60}Co) simultaneously for various dose rates

Method 2: fitting $M/M_s = 1 - \mathbf{b}/\mathbf{U} - \beta j d^4 / \mathbf{U}^2$
 (^{60}Co) at dose rate < 0.1 Gy /min

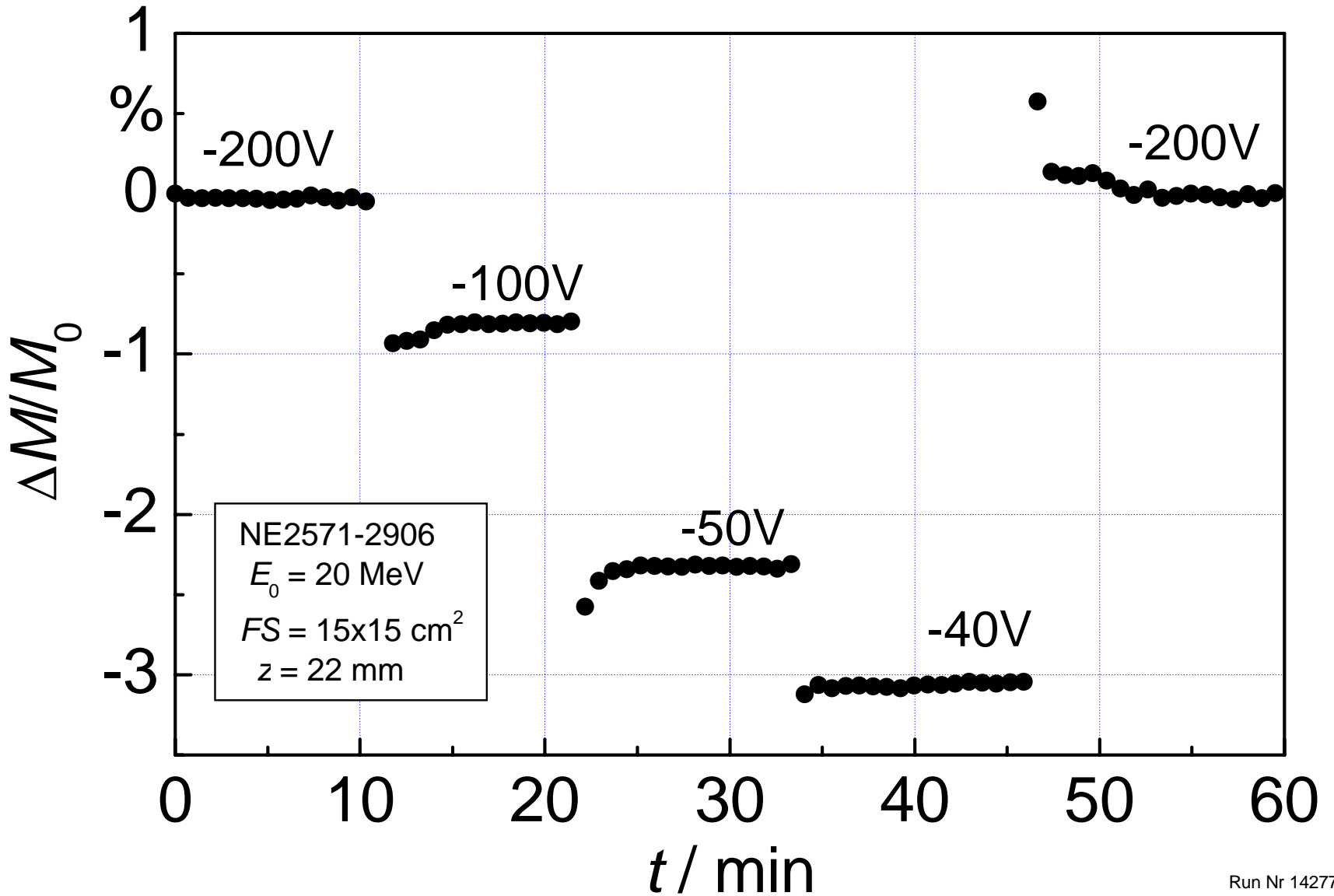
Method 3: 3.1: fitting $M/M_s = 1 - \mathbf{a}/\mathbf{U}$
 (Linac) for various doses per pulse
 3.2: fitting $M_1/M_s = 1 - \mathbf{b}/V_1 - \mathbf{c} \mathbf{q}$

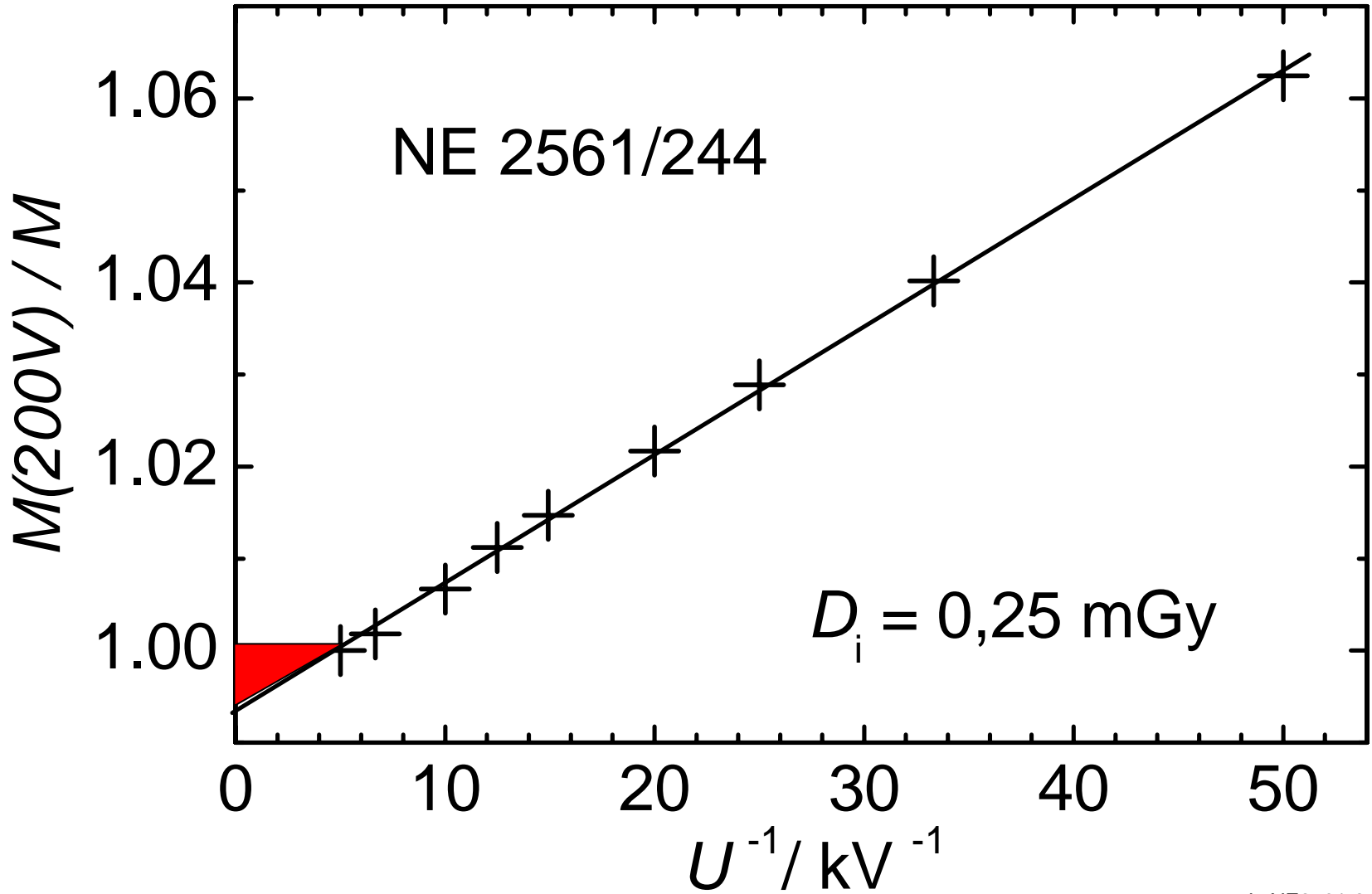
(parameter - variable)

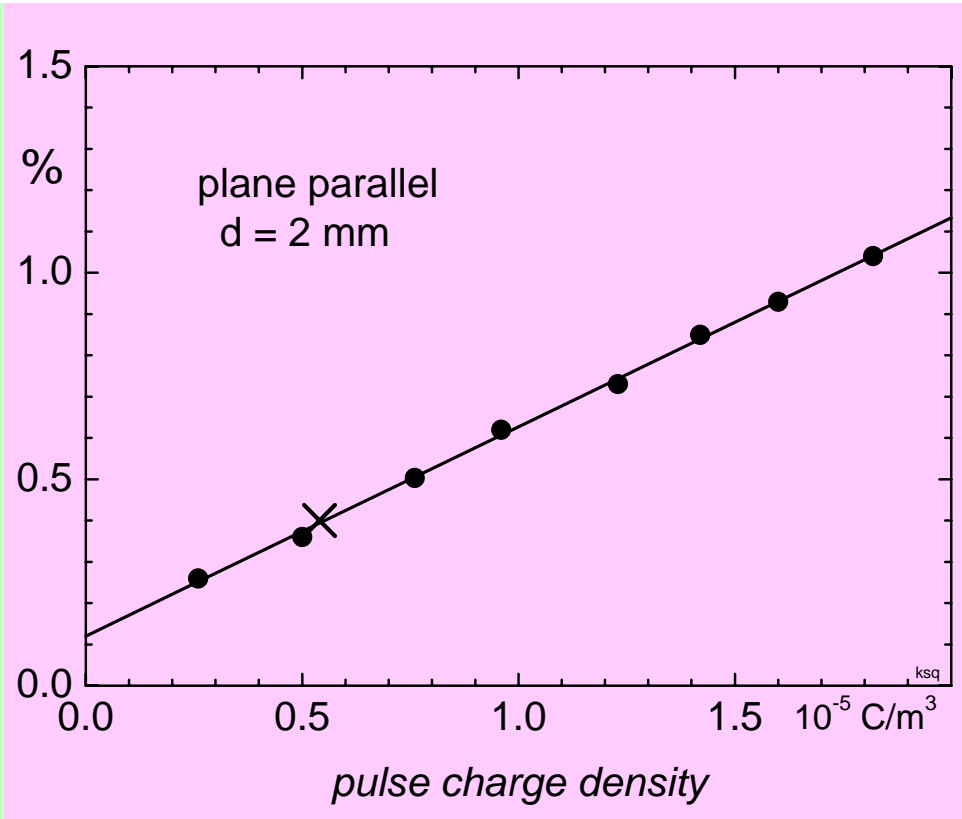
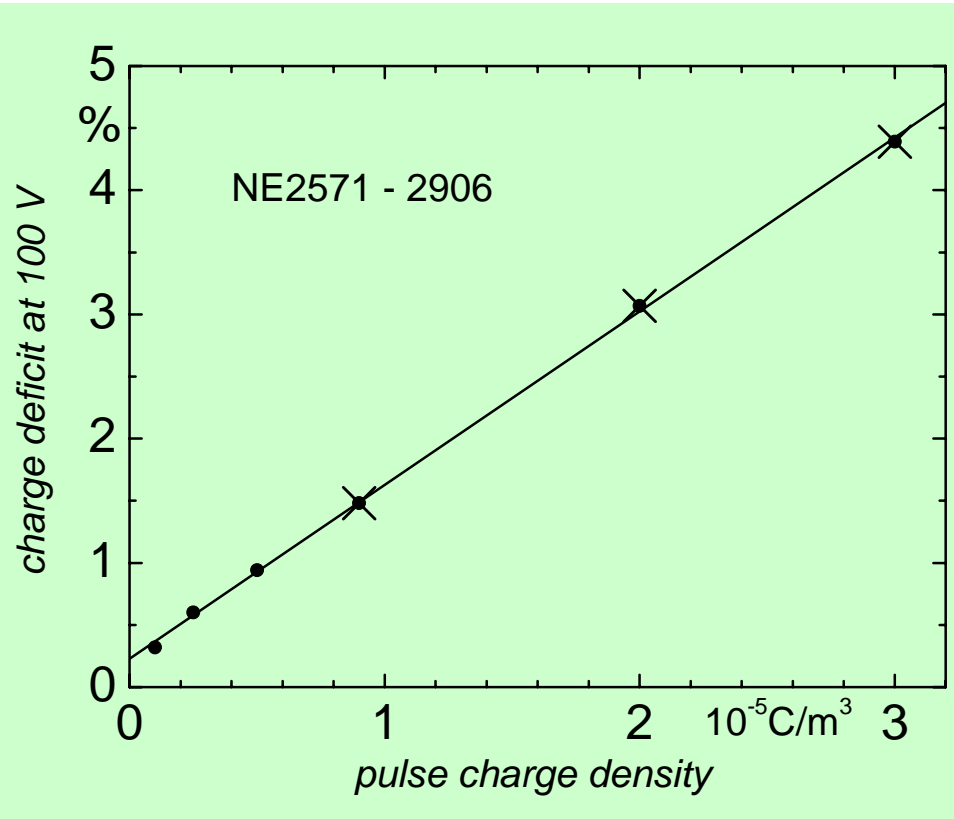
Results from fitting simultaneously

$$M/M_s = 1 - b/U - \beta j d^4 / U^2$$

chamber	b	β
NE 2561/244	0,27 V	$7,7 \cdot 10^{13} \text{ V}^2/(\text{A m})$
NE 2561/293	0,27 V	$7,9 \cdot 10^{13} \text{ V}^2/(\text{A m})$
NE 2561/297	0,27 V	$6,0 \cdot 10^{13} \text{ V}^2/(\text{A m})$
<i>Burns, Rosser PMB 35 (1990)</i>	<i>0,28 V</i>	
NE 2571/977	0,24 V	$9,3 \cdot 10^{13} \text{ V}^2/(\text{A m})$
NE 2571/2906	0,22 V	$7,6 \cdot 10^{13} \text{ V}^2/(\text{A m})$
FC 65-G/771	0,17 V	$7,3 \cdot 10^{13} \text{ V}^2/(\text{A m})$
	<i>Boag (1987) :</i>	<i>$6,7 \cdot 10^{13} \text{ V}^2/(\text{A m})$</i>







x = electron beam, • = photon beam

Linac vs. ^{60}Co

$$f_i = 1 - b/U$$

	b / V	
	pulsed beam	^{60}Co
NE 2561	0.30	0.27 (0.28)
NE 2571	0.23	0.23
PR06C	0.3	-
PTW23331/2	0.3	-
Roos-type	0.12	-
FC65-G	-	0.17

Conclusions

Consistent results obtained by different methods.
(uncertainties $< 0.05\%$, $k = 2$, prelim. guess)

Initial recombination in high energy beams
does not depend on beam quality.
(^{60}Co , pulsed photon, pulsed electron)

Charge loss is negligible if corrected appropriately.
(needs coordinated practice)

thank you