Probing with Heavy Ions the SET sensitivity of Linear Devices

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ONERA study under CNES contract

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Goals and motivations

Probing LM124 with High LET ions

Comparing heavy ion probing with laser probing & mapping

Correlate heavy ion and laser data

Validate the laser technique

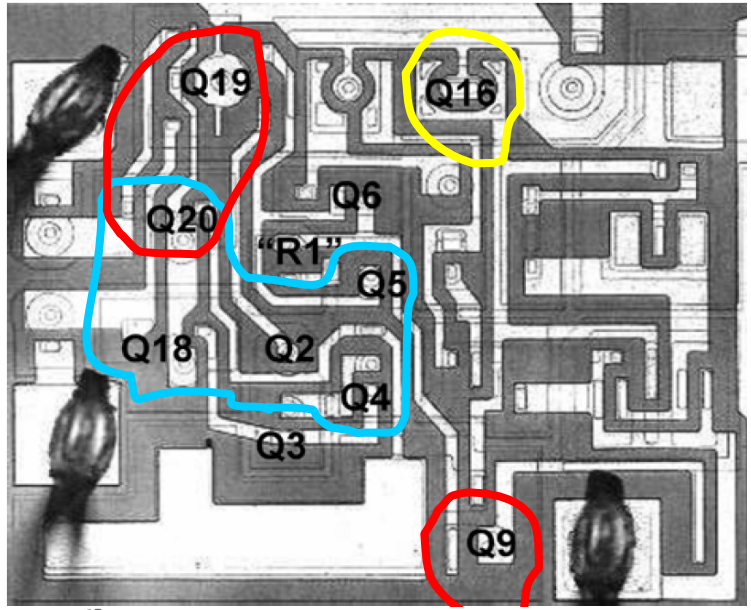
Comparison with laser can help defining the most appropriate conditions for heavy ion testing

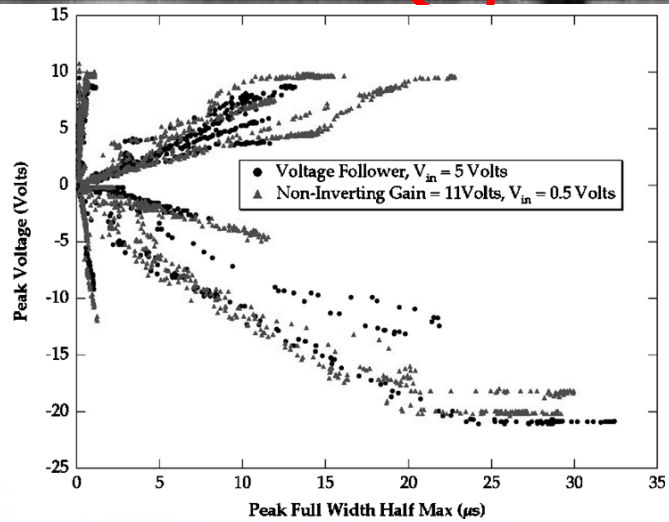
Help defining the appropriate methodology to be used for predicting SET rates (ex: SAC-D and JASON2 missions)

LM124 : 3 main families of SET events

SET type	*Transistors*
>0	Q2, Q4, Q5, Q18, Q20
<0	Q9, Q19, Q20
Bipolar	Q16

Ref. 6 – S. Buchner et al., "Comparison of Single-Event Transients Induced in an Operational Amplifier (LM124) by Pulsed Laser Light and a Broad Beam of Heavy Ions", IEEE Trans. Nucl. Sci., NS-51, N°5, p. 2776, October 2004.

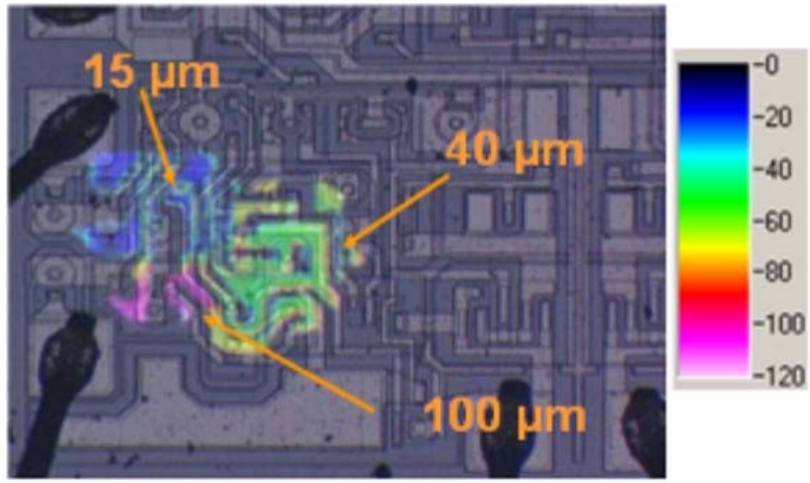


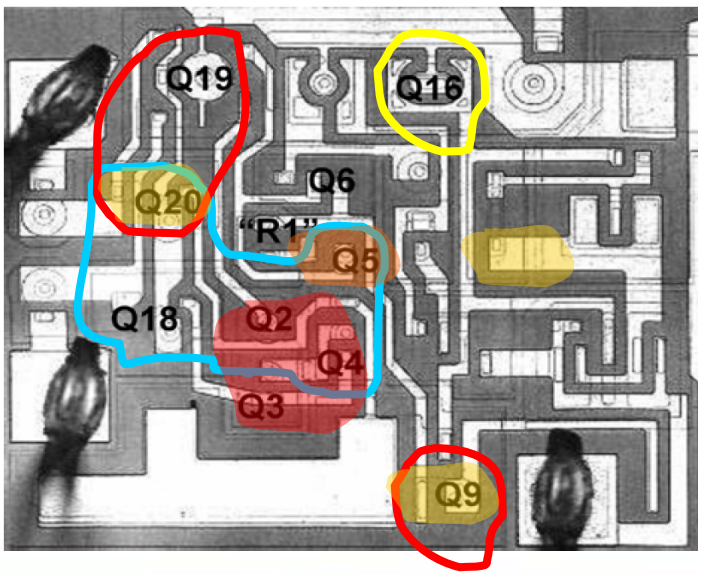


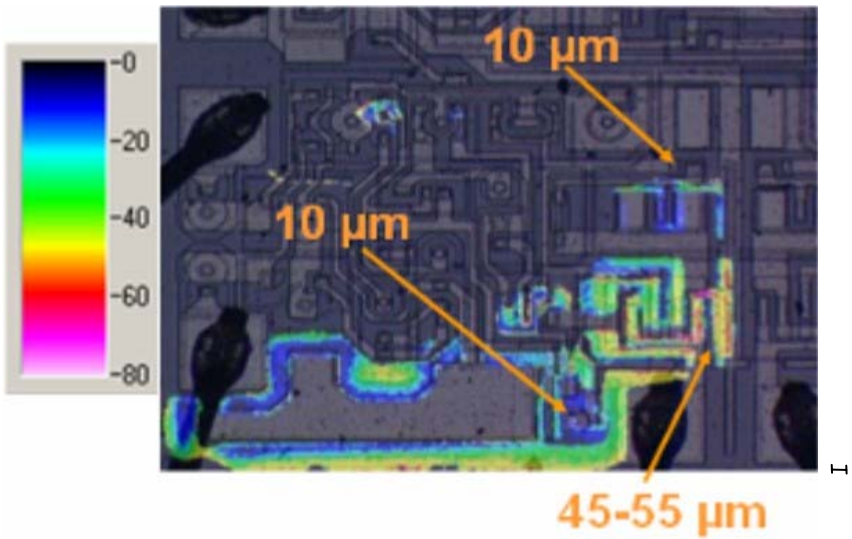
Laser Probing : some results

*Buried depth (µm) [*Ref. 2*] laser*	*Sensitive transistors (laser mapping* Ref. 2*)*
10-15	Q9/Q14, Q20
40-45	Q4/Q5, Q8/Q10 et Q15
100	Q2/Q3/Q4

Ref. 2 – C. Weulersse et al., "Probing SET Sensitive Volume in Linear Devices Using Focused Laser Beamat different wavelength", presented at RADECS 2007, Deauville (France), 10-14 September 2007.







Heavy ion probing : irradiation conditions

Ion species	E (MeV) Min/max	LET (MeV/mg.cm²) Max/min	Range (µm) Min/max
Br	25	22.8	7.5
	80	35	15.4
Ni	52	28	13
	210	29.5	35
Xe (E_0=35MeV/n)	500	64	38
	6000	26	708

Tandem Van de Graaff IPN (Orsay)

Synchrotron GANIL (Caen)

High LET ("Sat.")

Broad range

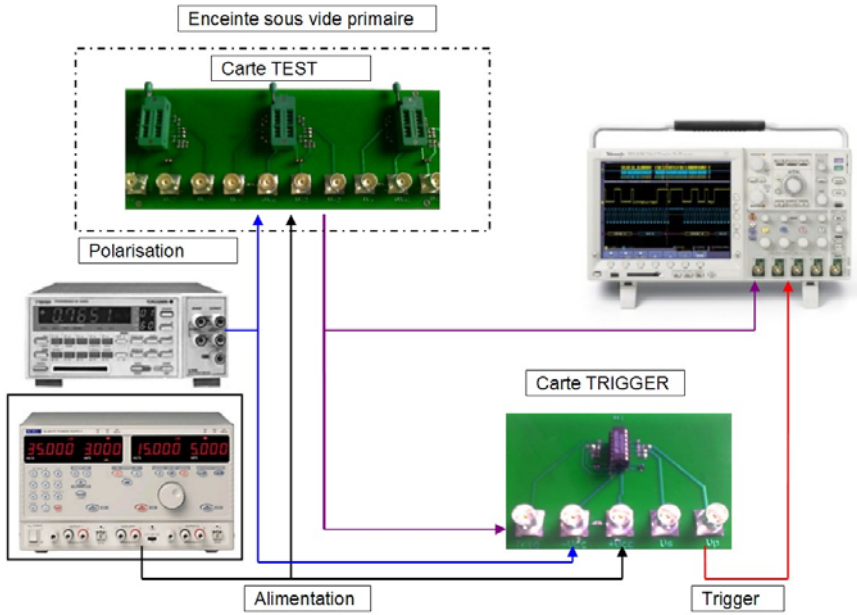
IPN => under vacuum, Ganil => in the air

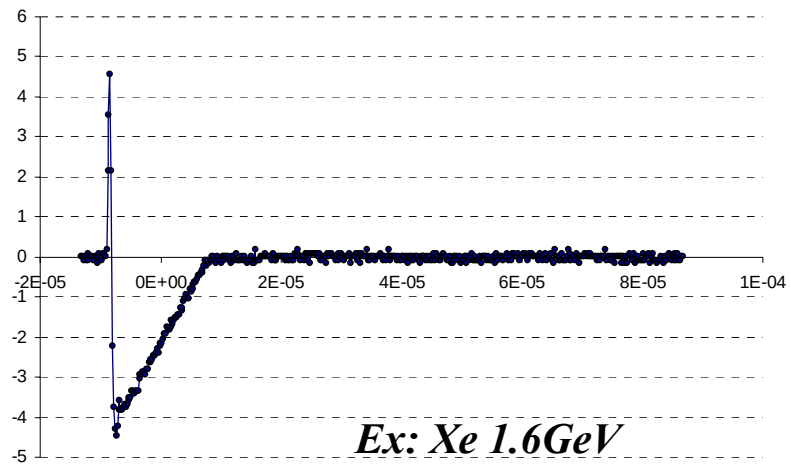
LET and range adjustment:

- *IPN: acceleration voltage*
- *GANIL : combination of air & aluminum foils*

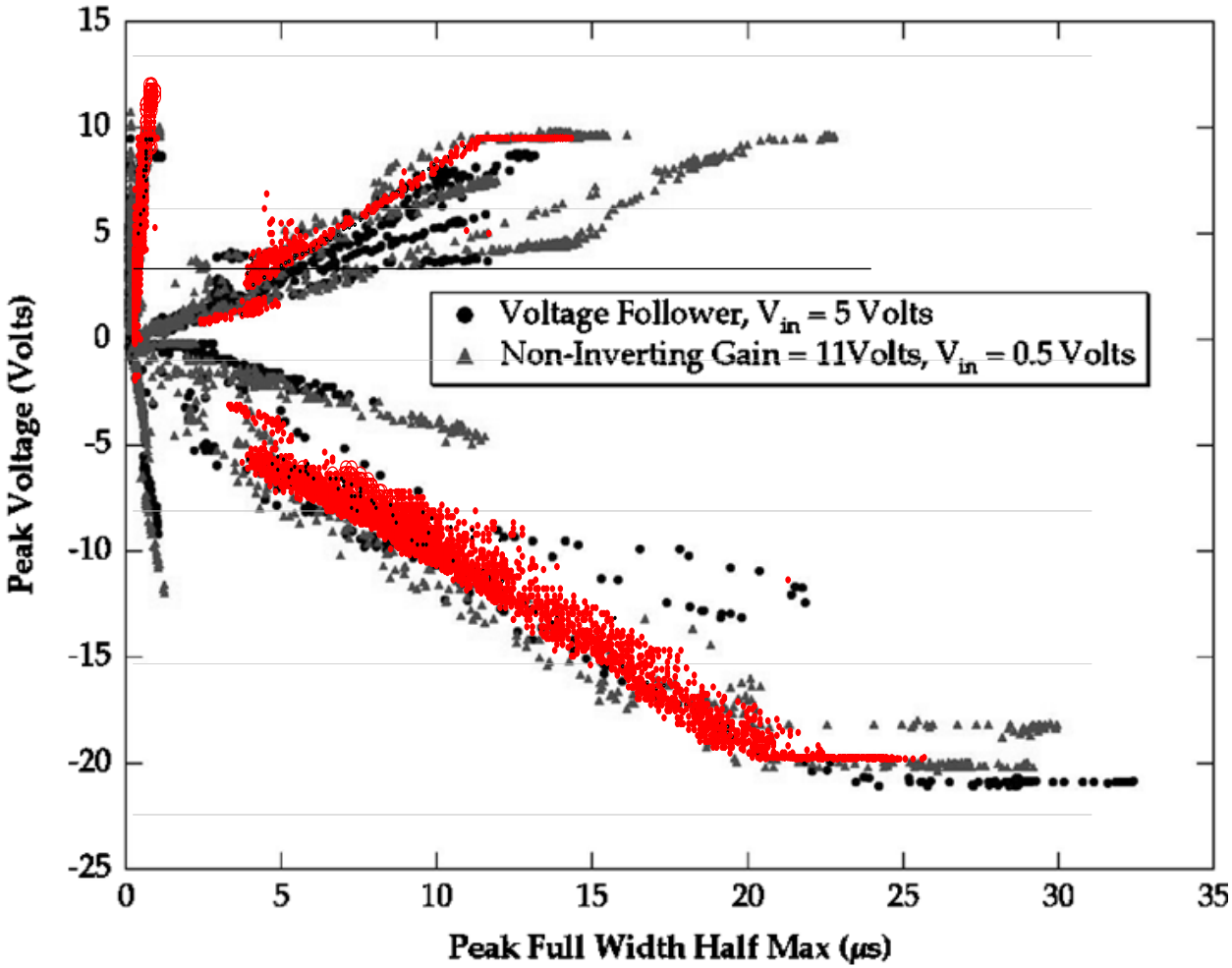
Experimental set-up and test conditions

- bipolar bias (Vcc=±15V)
- non-inverter conf. with gain x2 and Vin=10V
- coax. probe ≈ 1m long (slightly different configurations at IPN (test under vacuum => feedthrough) and Ganil (in air)
- SETs captured by digital oscilloscope on threshold detection (500mV)
- VB macro to extract amplitude/duration characteristics and construct dV(dT) plots
- 500 events max to limit TiD degradation (WC=7krad)

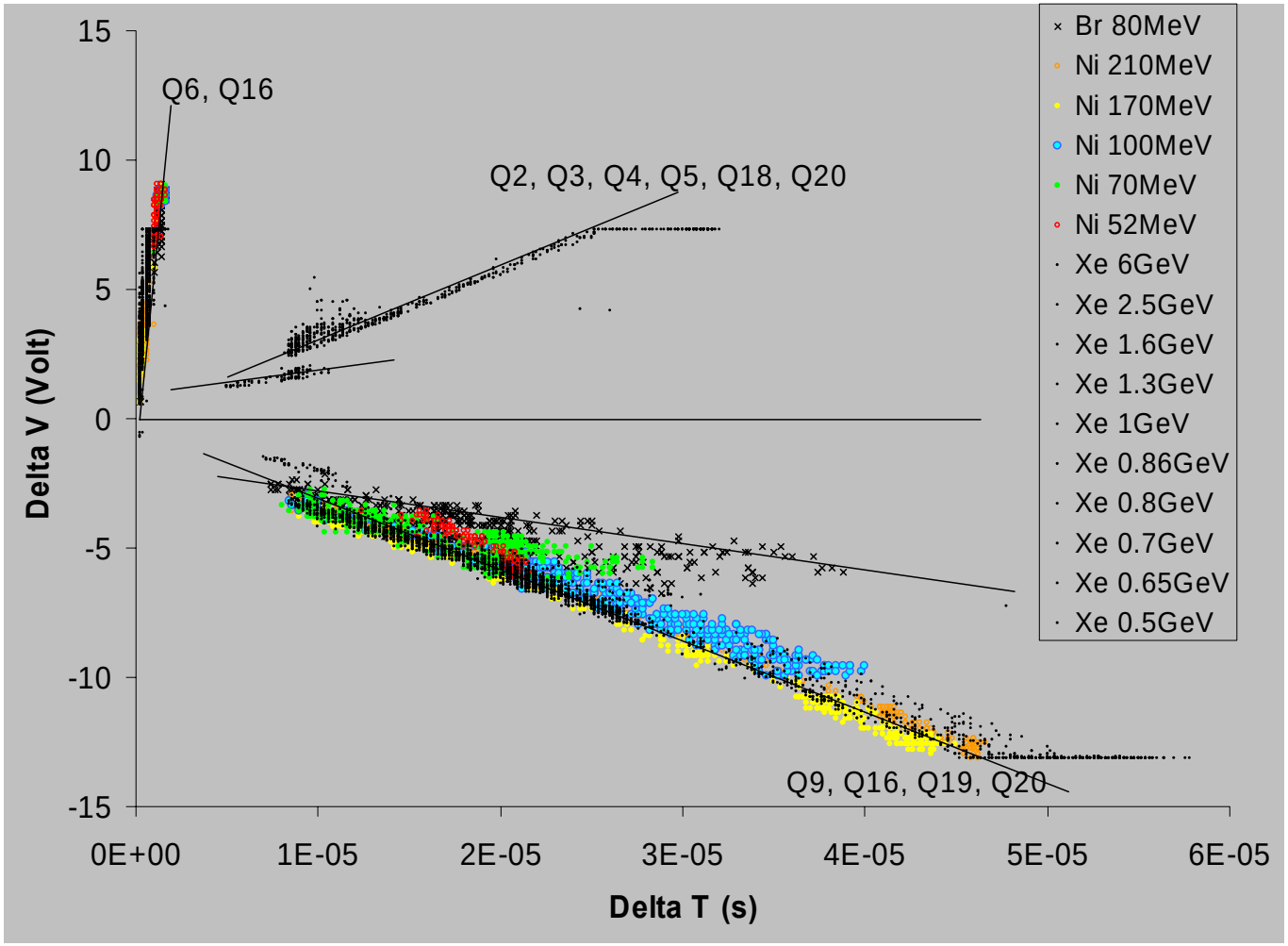




ΔV vs ΔT plots

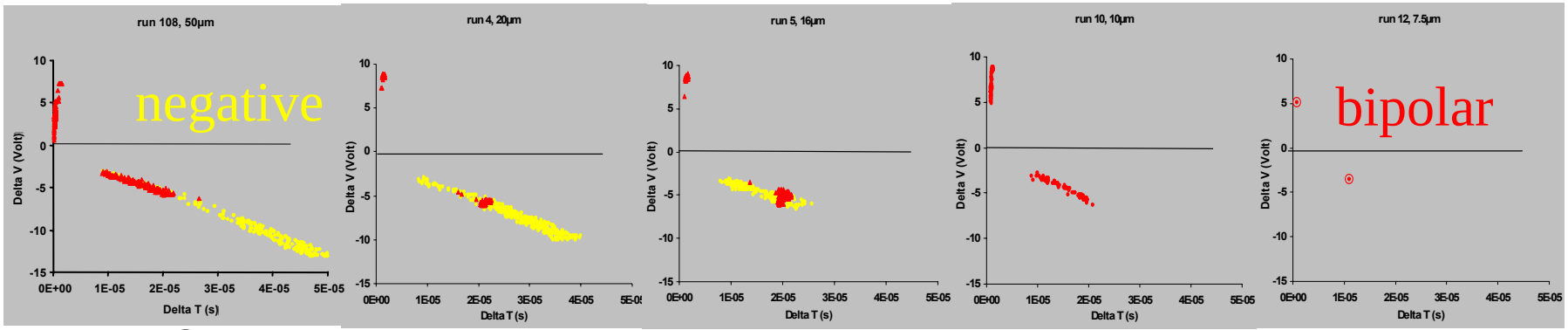


ΔV vs ΔT plots : IPN and Ganil



SET count vs range of ions

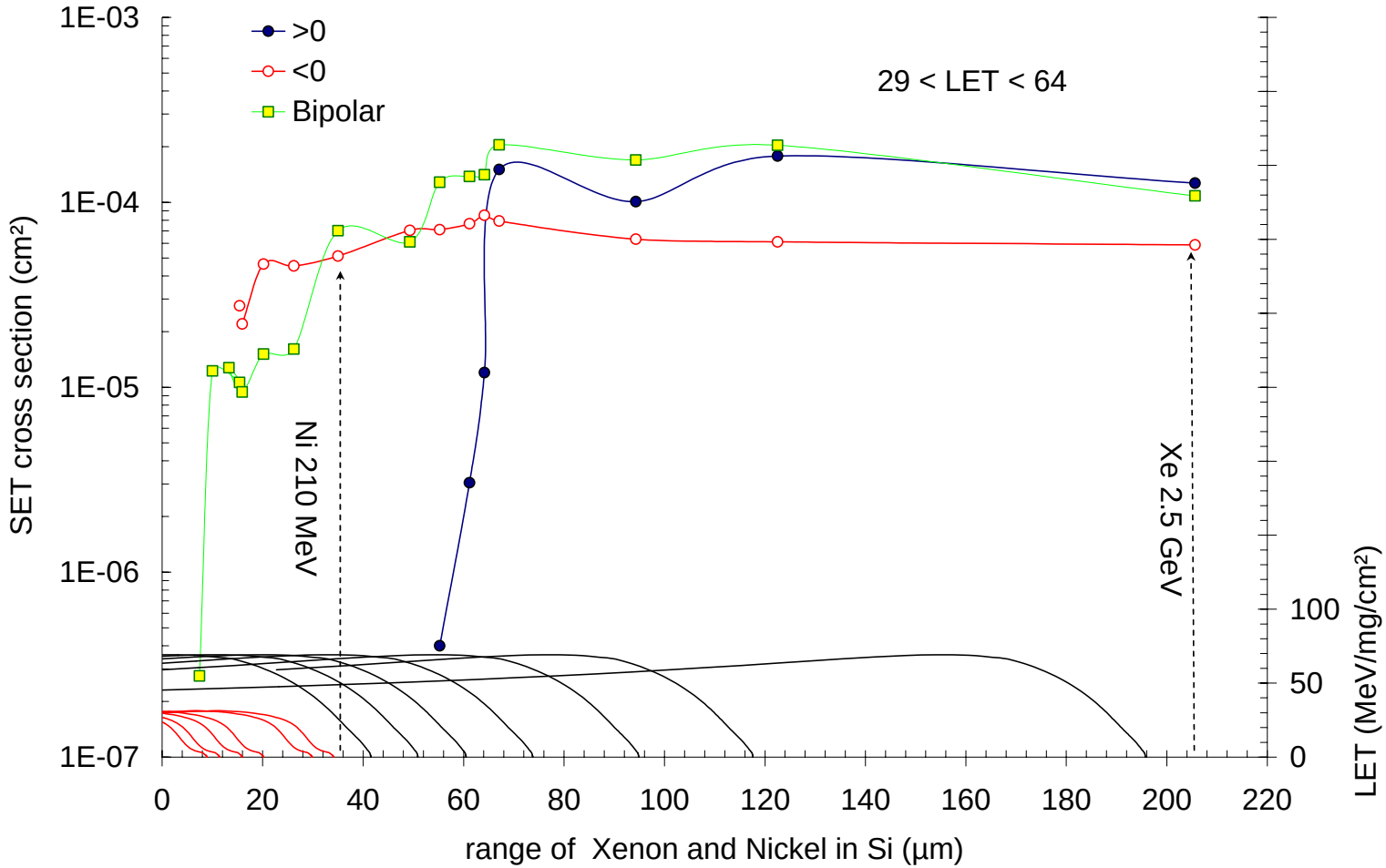
Xe 650MeV	Ni 100MeV	Ni 70MeV	Br 40MeV	Br 25MeV
50 µm	20 µm	16 µm	10 µm	7.5 µm



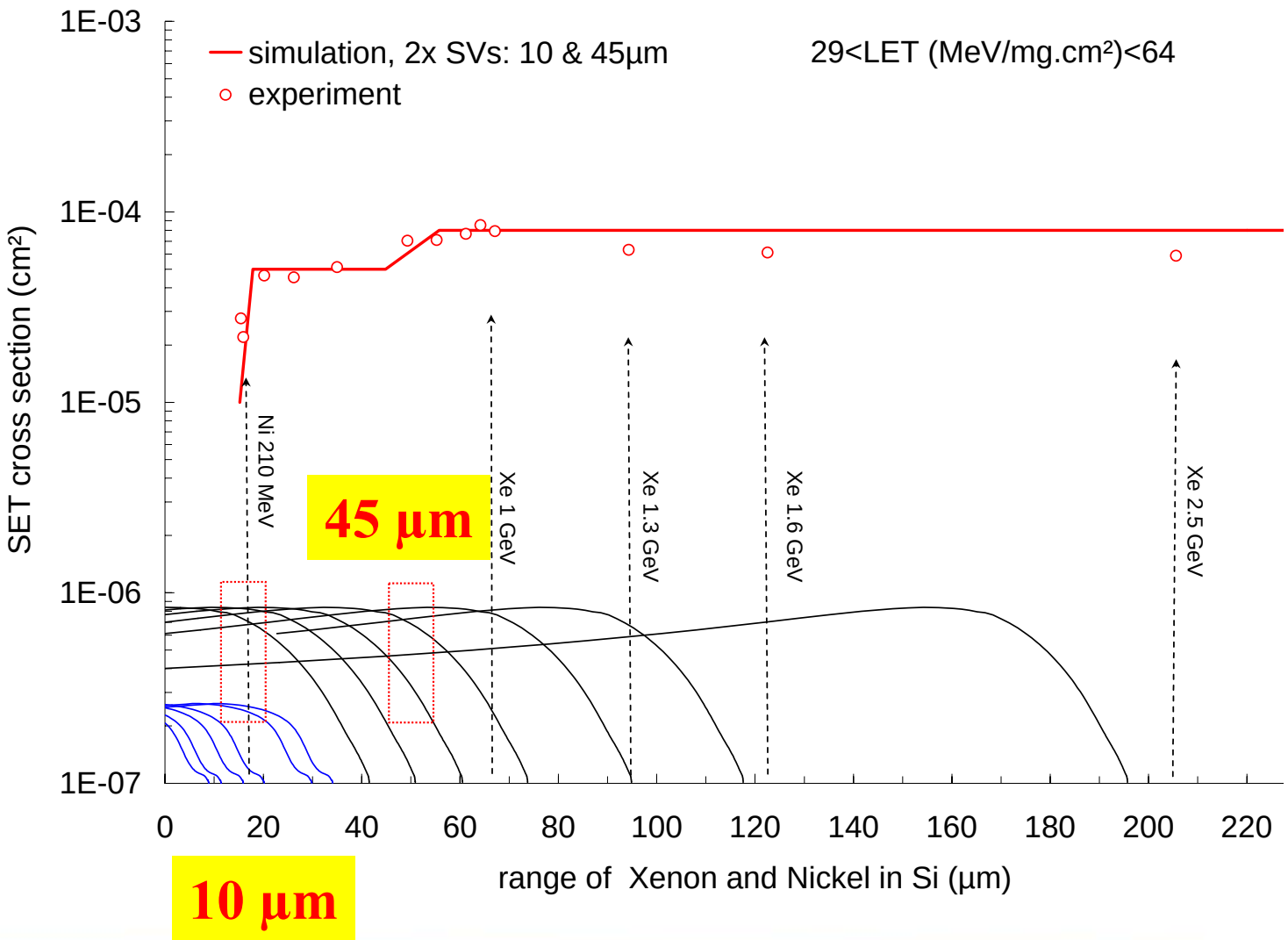
SET Cross section

LET ≈ cst.

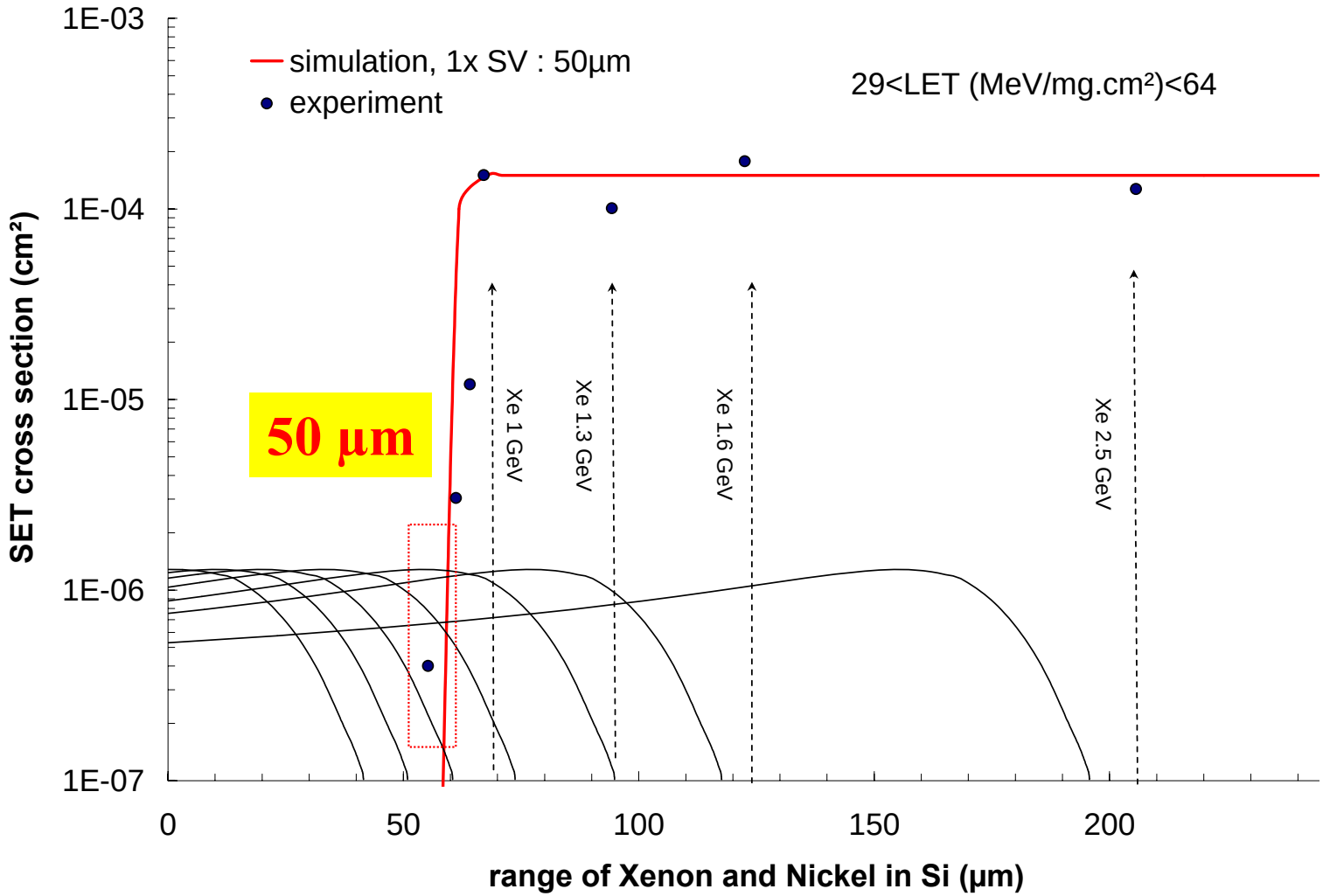
Evolution of measured cross-section with range



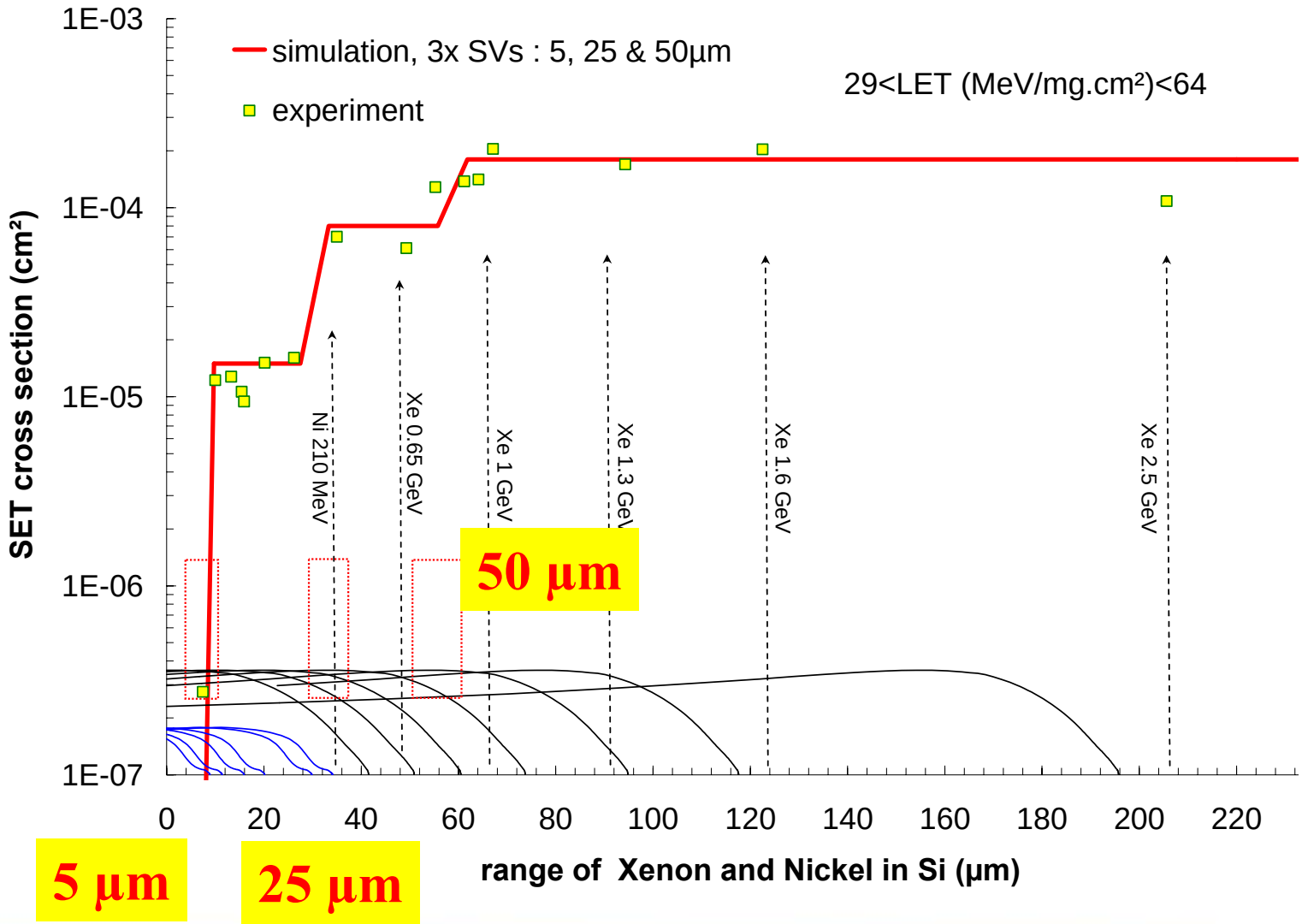
Correlation measurement/RPP calculations: SET<0



Correlation measurement/RPP calculations: SET>0



Correlation measurement/RPP calculations: Bip. SETs



Correlation laser/heavy ion data : sensitive depths

SET	*Laser Depth (in µm) [Ref. 2]*	*Heavy ion depth: RPP calculations (in µm)*	*X-section (cm²/dev.)*
>0	15 40 100	/ 50 /	$1.5\ 10^{-4}$
<0	10 45	10 45	$5\ 10^{-5}$ $8\ 10^{-5}$
bipolar	Not measured	5 25 50	$1.5\ 10^{-5}$ $8\ 10^{-5}$ $2\ 10^{-4}$

Conclusions

- The overall laser/heavy ion data correlate quite well

- By this work, it was confirmed that the laser technique can be used for probing device SET sensitivities and measure sensitive depths in order to help defining the appropriate geometrical parameters for prediction

- The heavy ion data also provide important insight on the test procedures to be applied for SET testing and x-section measurements. It has been shown that the main SET types could be triggered even with low range beams (down to about 15µm). However, beam ranges much greater than 50µm have to be used for characterization purpose and defining worst case conditions.