I.N.F.M.

Epitaxial SiC detectors : Charge collection efficiency and photoluminescence characterisation

M. Bruzzi, S. Lagomarsino, S. Miglio, S.Sciortino
Dipartimento di Energetica , Florence Italy

F. Nava, P. Vanni
Dipartimento di Fisica, University of Modena, Italy

G. Wagner
Institut fur Kristallzuchtung,Berlin, Germany

R. Schifano, A. Vinattieri
Dipartimento di Fisica, University of Florence

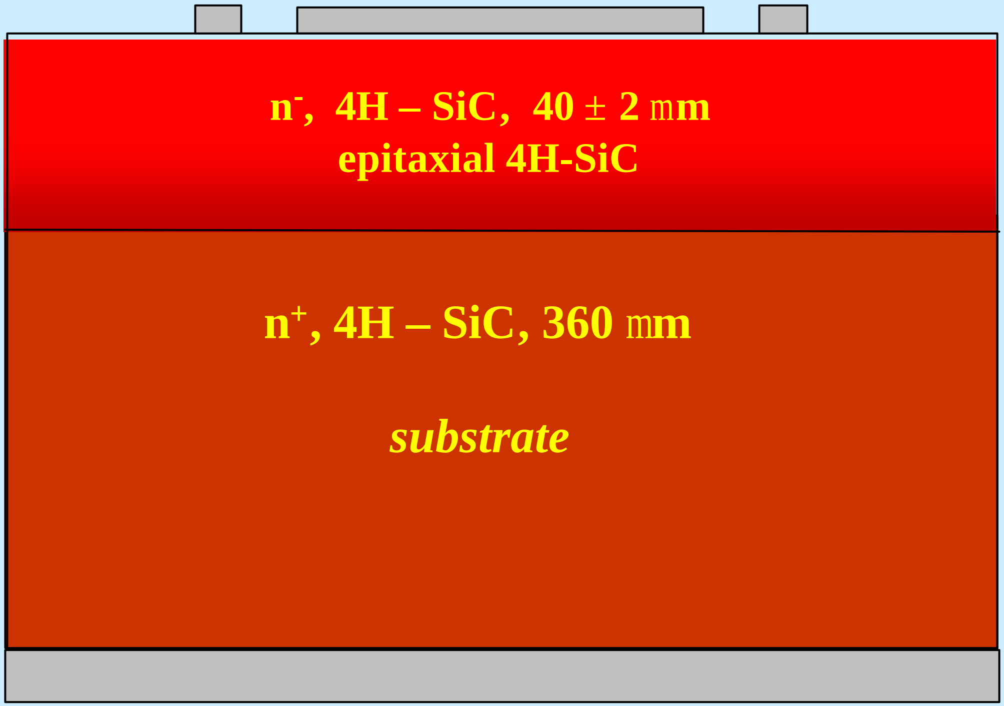
OUTLINE OF THE TALK

- Samples description
- CV, IV electrical characterization
- charge collection efficiency (cce) characterization under exposure to a ^{241}Am alpha source
- charge collection distance measurements under exposure to a MIP from a ^{90}Sr b source
- Near band-edge recombination as a probe of crystalline quality

Schematic of the IKZ samples

circular Schottky contact

Ni_2Si **f = 1.5 mm**

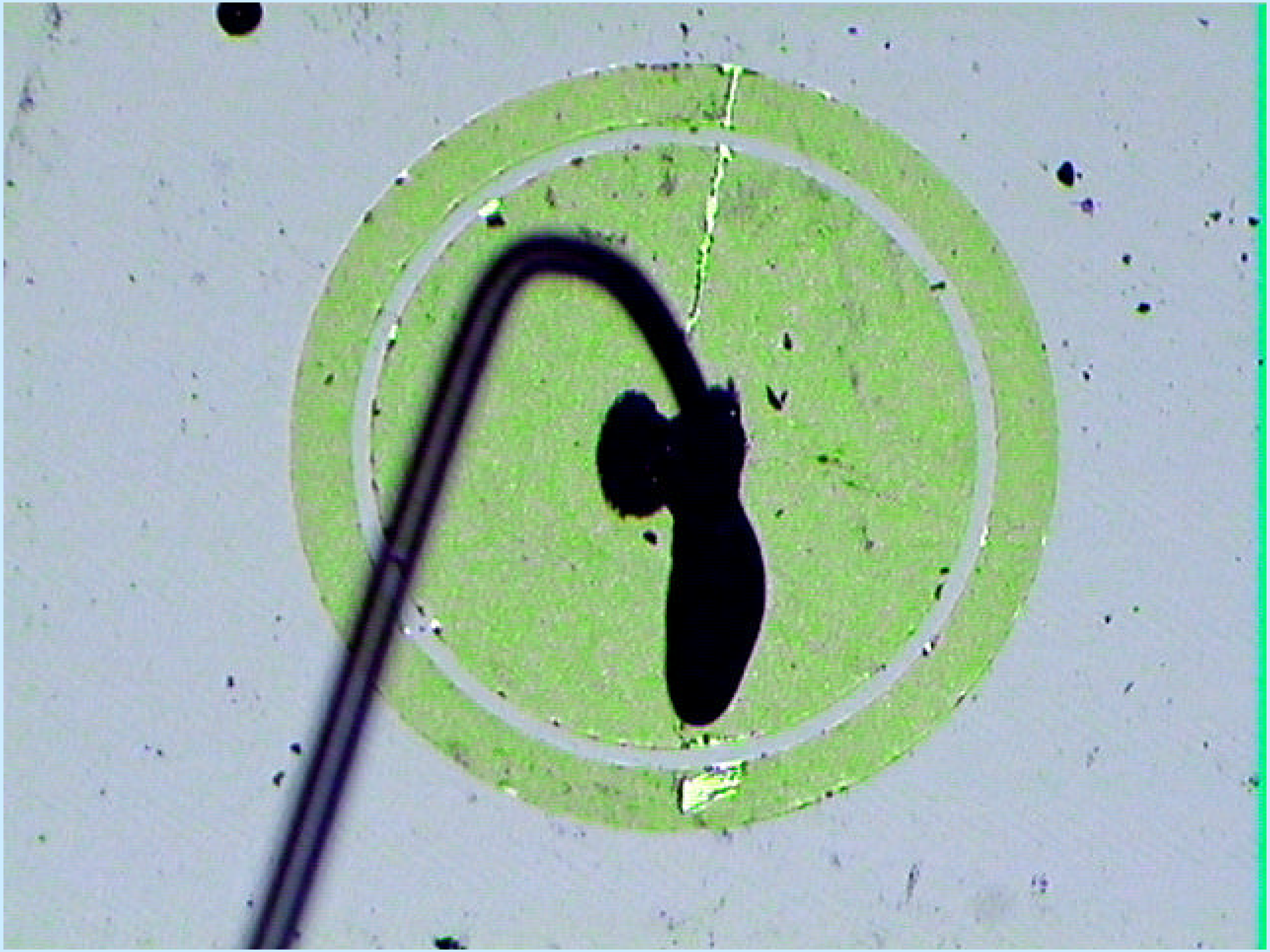


Ohmic contact -

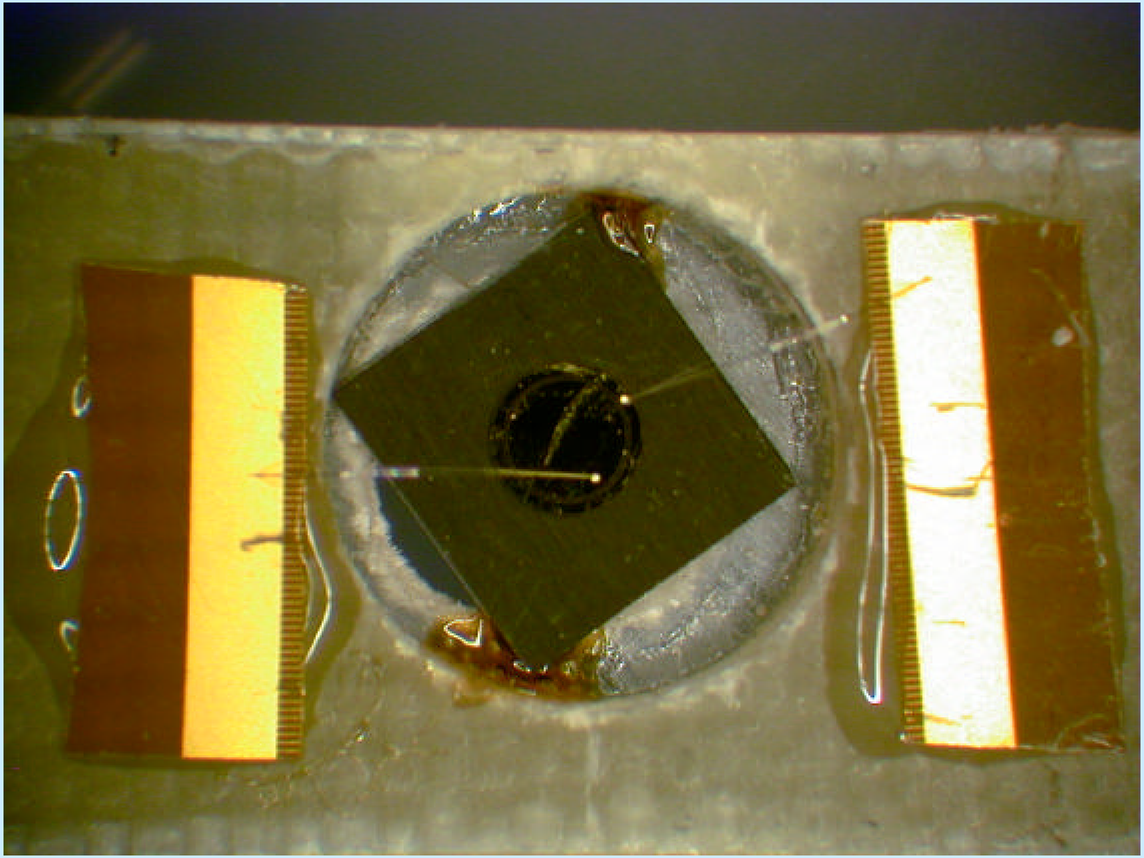
Ti/Pt/Au

- **Device produced by Alenia Marconi**
- **Optical measurement of thickness**
- **Ni_2Si metallisation: better adhesion, higer reproducibility**

DEVICE UNDER TEST



DEVICE UNDER TEST



Sample #Q exhibits a very low reverse current and its ideality factor is very close to one

SAMPLE	N_{eff} [10^{13}/cm^3]	qV_{bi} [eV]	n	REVERSE-CURRENT (at 300 V) [A]
P	6,25	1.55	1.17	High (4.0 x 10^{-9})
G	4.73	1.49	1.13	Medium (8.6 x 10^{-11})
E	5.68	1.51	1.13	Medium (1.0 x 10^{-10})
C	7.74	1.53	1.04	Very low (4.0 x 10^{-12})
O	7.66	1.60	1.54	Very high (2.8 x 10^{-6})
D	6.80	1.53	1.13	Medium (5.7 x 10-10
Q	4.73	1.56	1.00	Very low (2.0 x 10^{-12})
M	6.82	1.59	1.07	Very high (> 10^{-8})
H	8.13	1.59	1.07	Medium (4.37 x 10^{-10})

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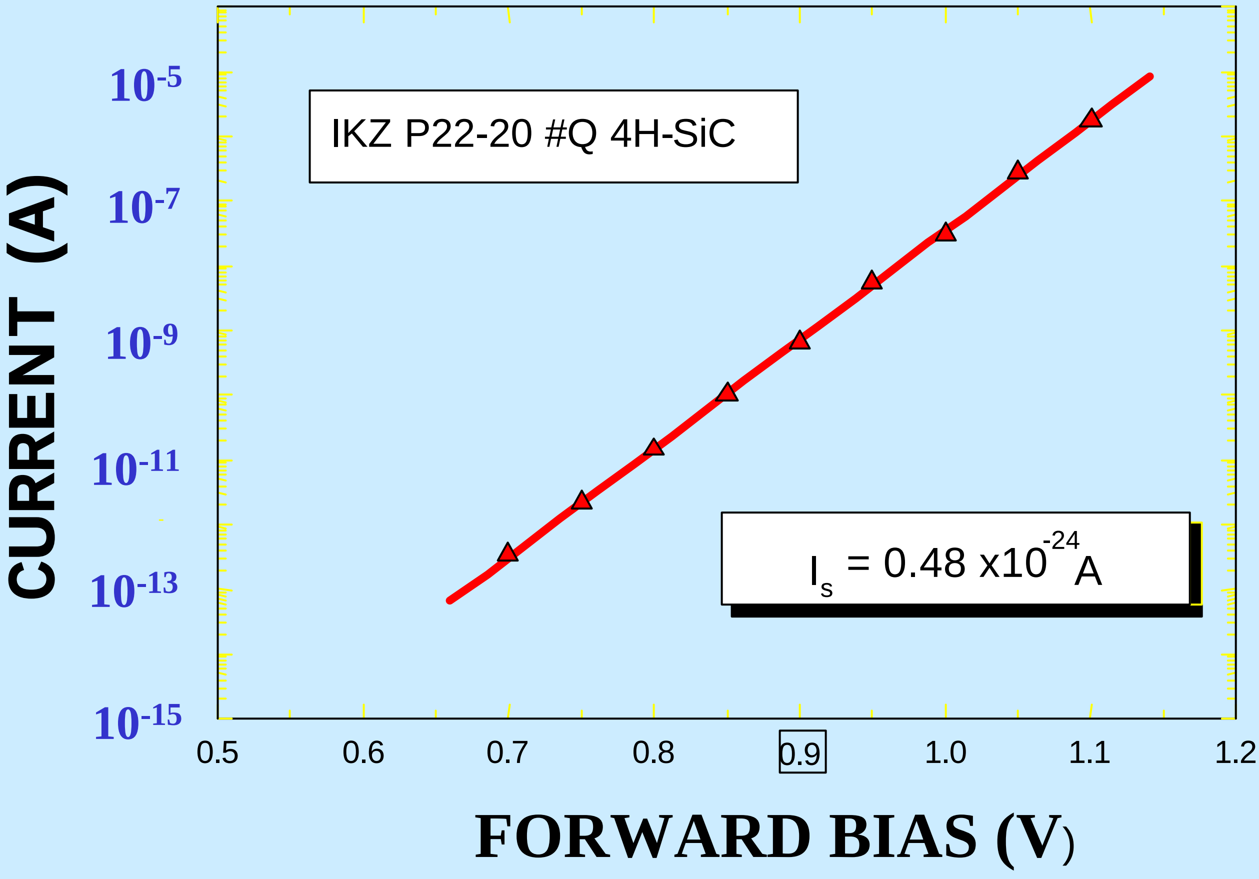
For extrapolation by forward IV measurements:

$I_0 = 0.48e^{-24}$A   n(ideality factor) = 1 Φ_{B0} barrier height = 1.77eV



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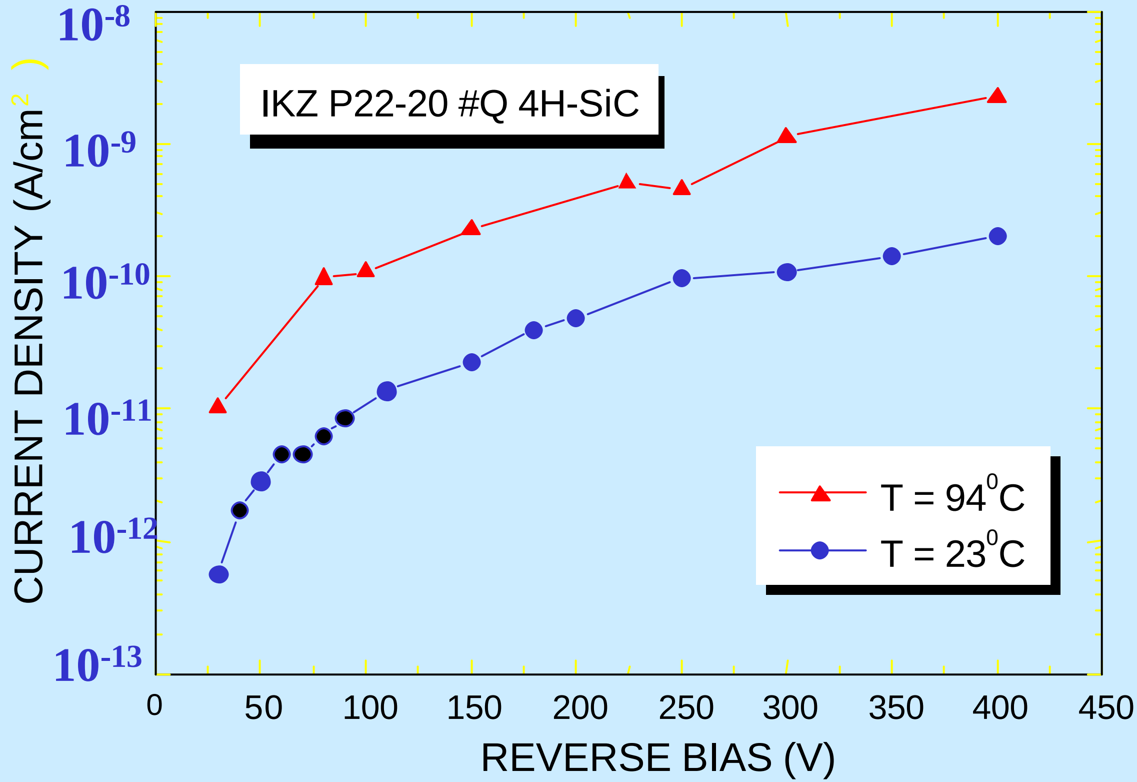
Inverse J_s measurements: low increment in dark current with increasing temperature



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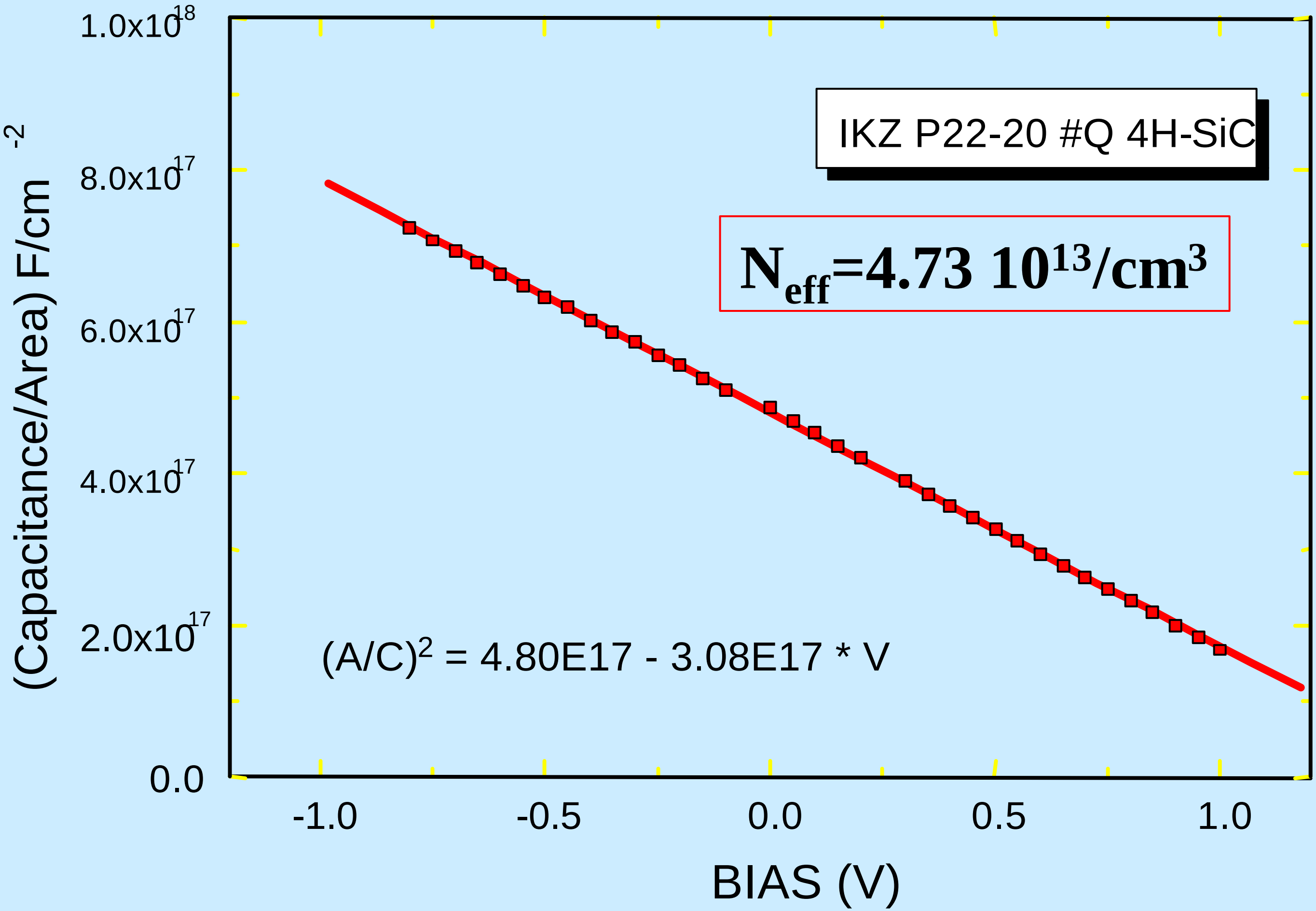
C-V measurements



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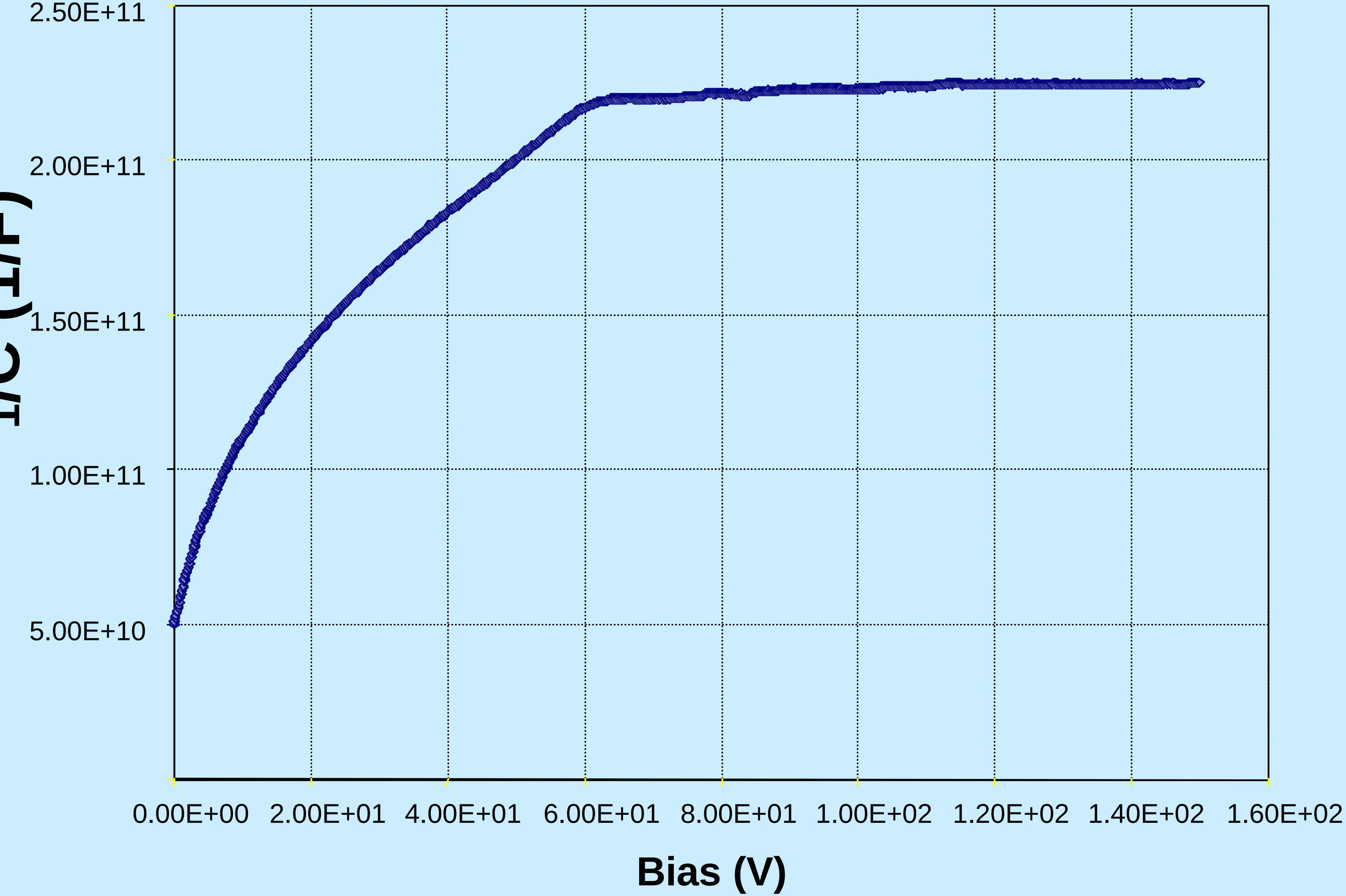

V_{dep} = 60 V

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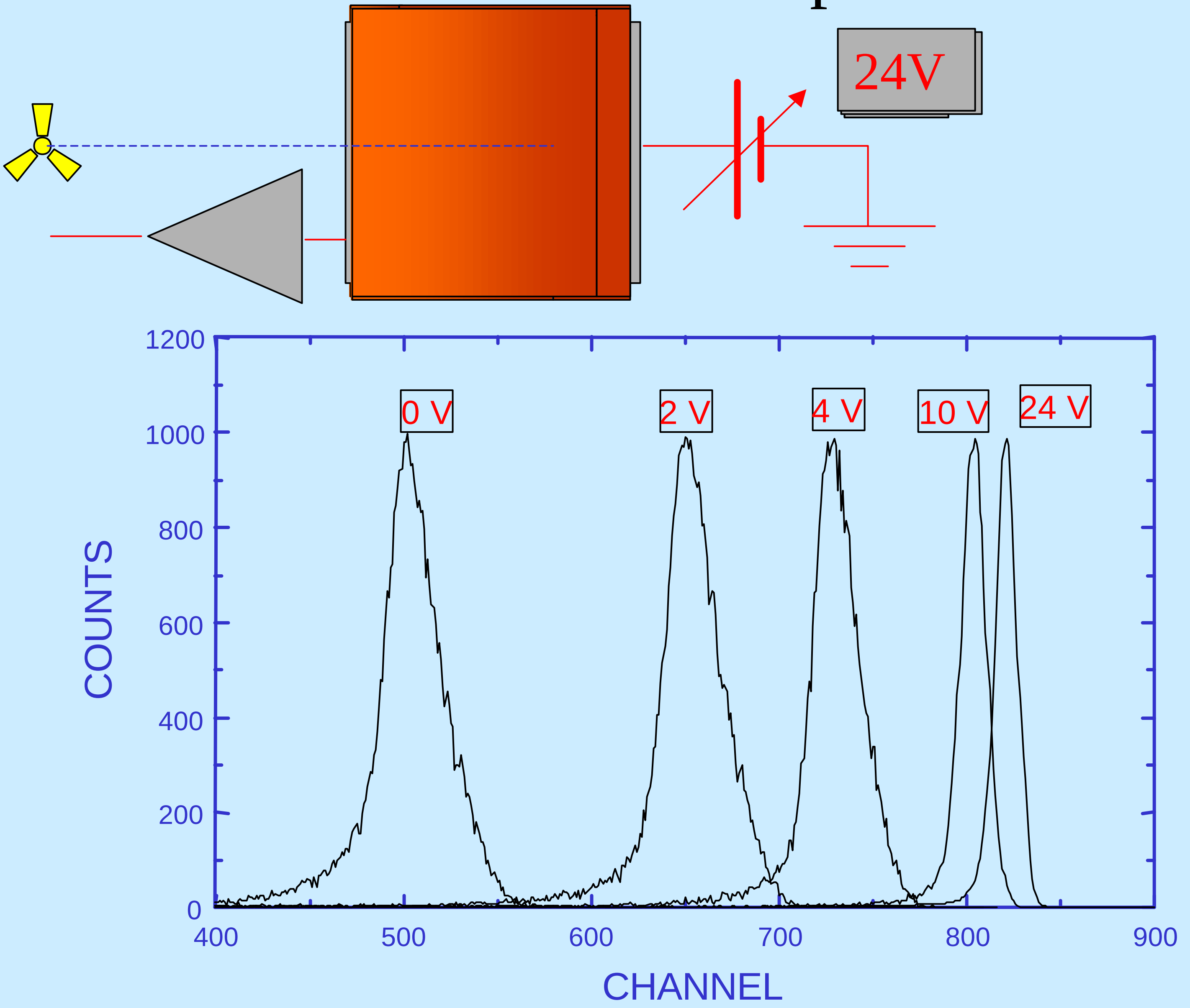
CCE under 5.346MeV α particle irradiation



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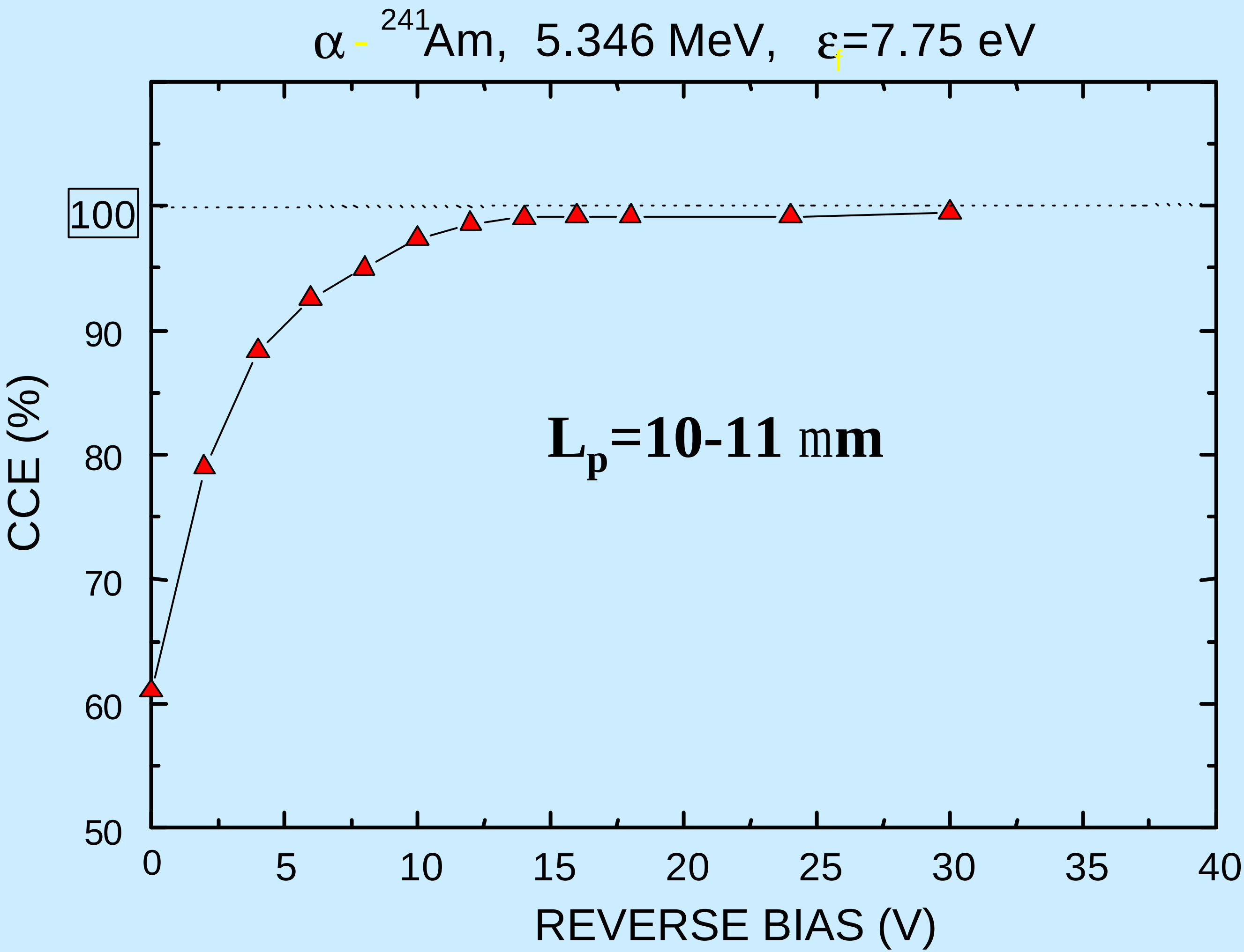
Saturation at 15÷20 V bias, depletion ≈20μm



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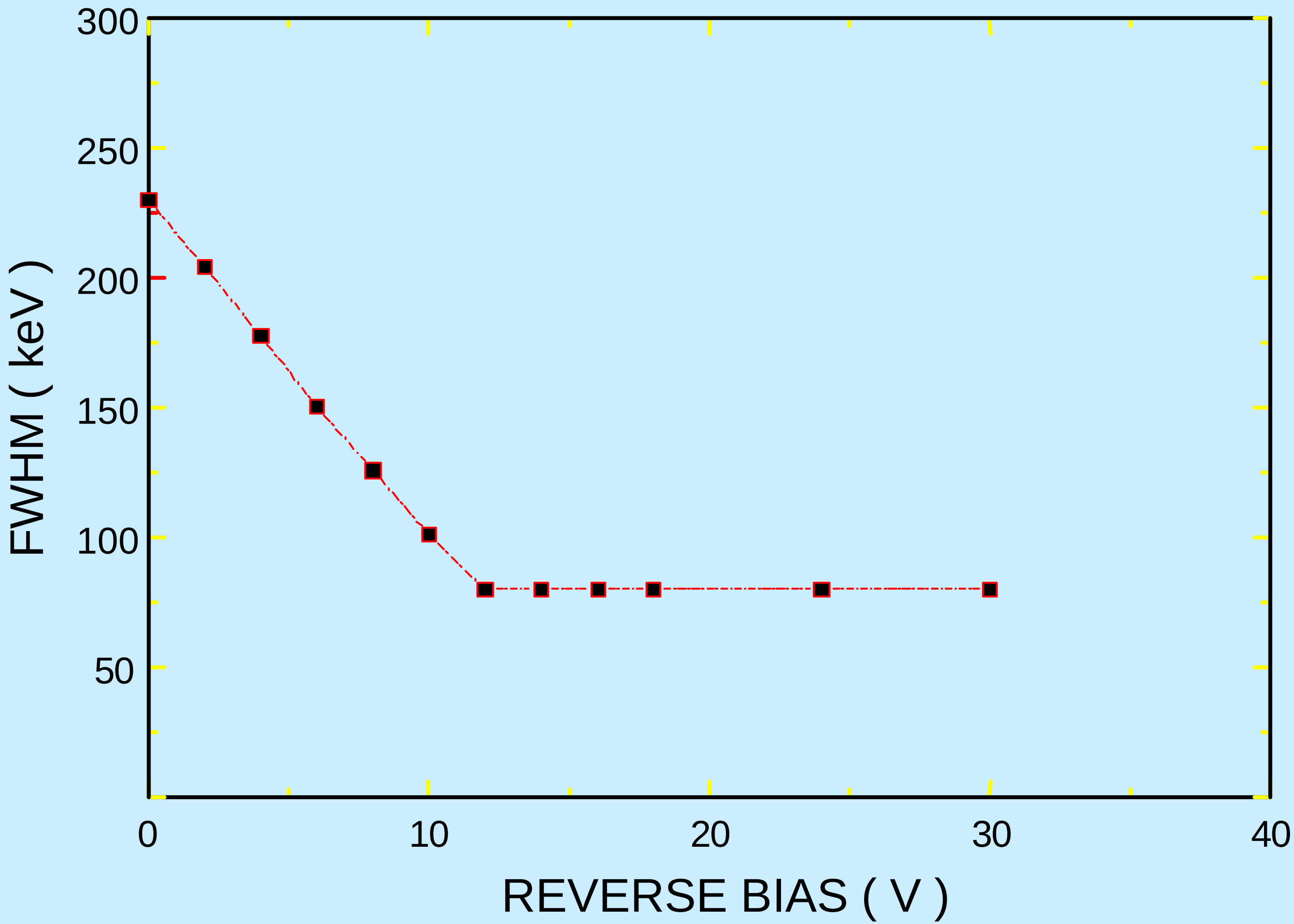
Saturation of FWHM above 10V



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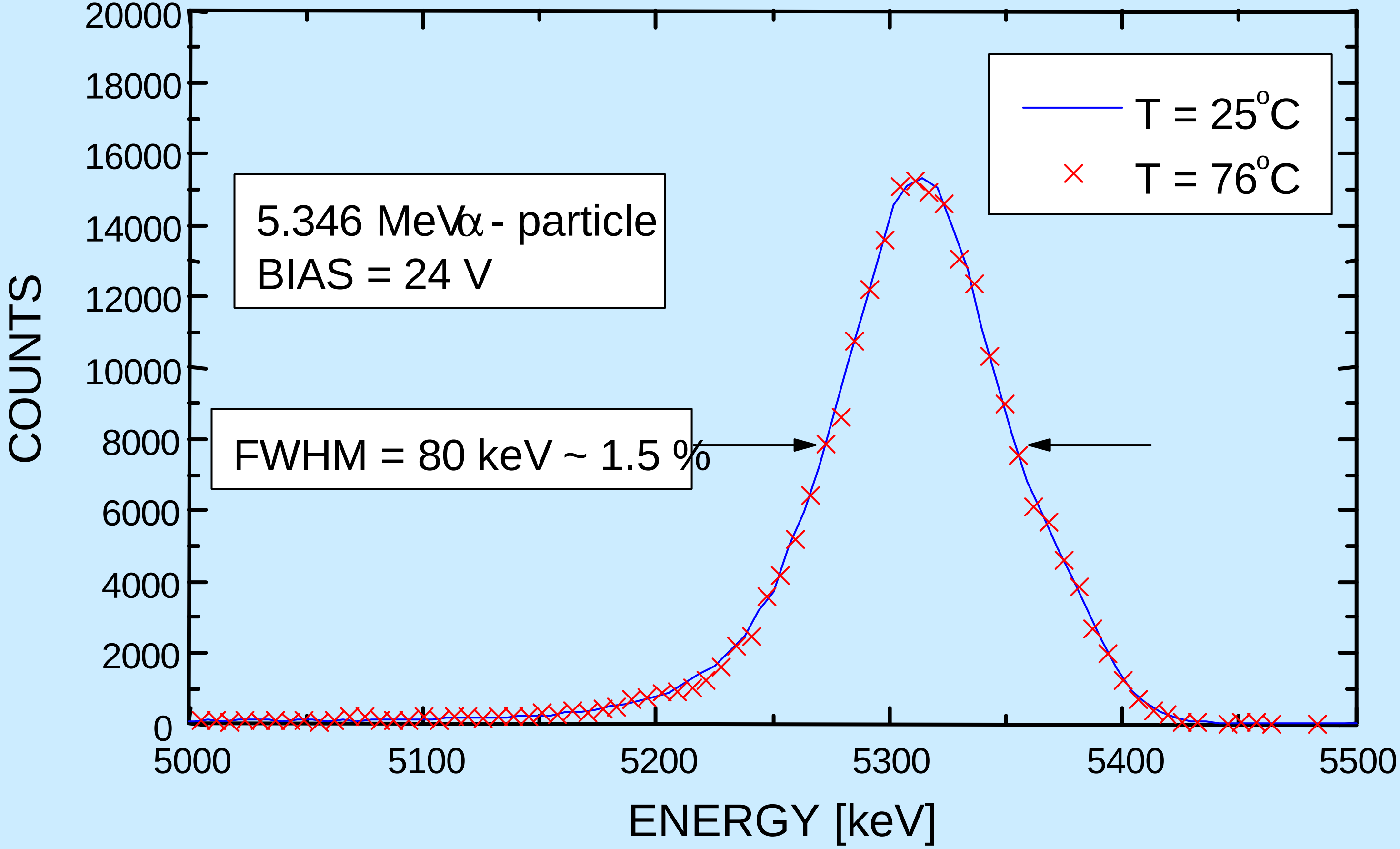
No relevant dependance of CEE Spectrum on temperature



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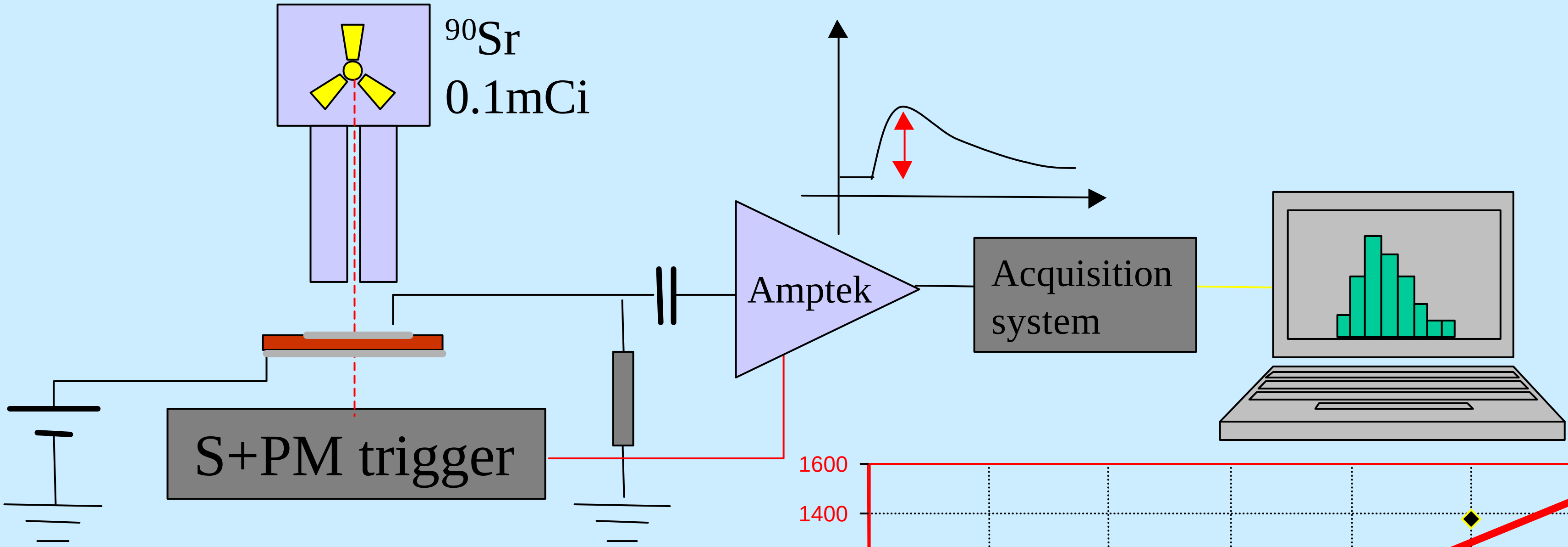
Measure of collection efficiency of b MIP



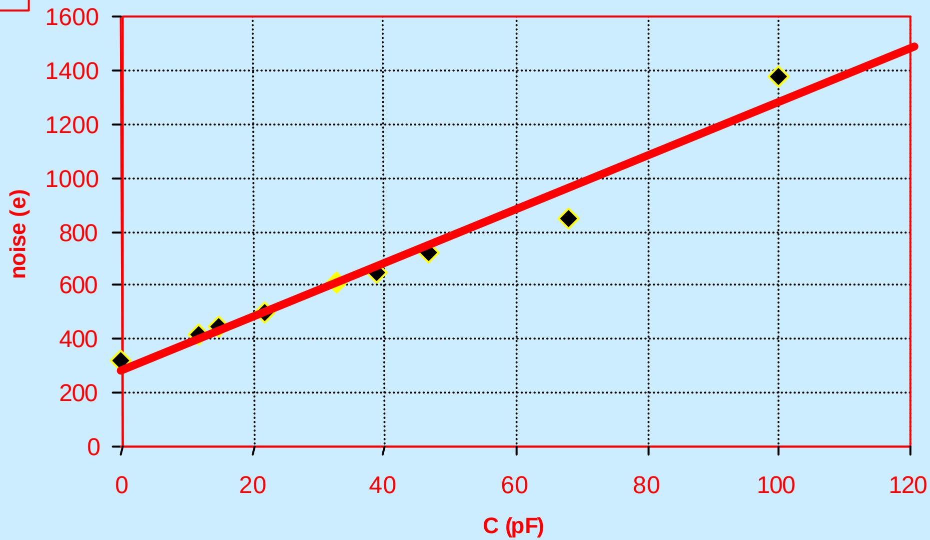
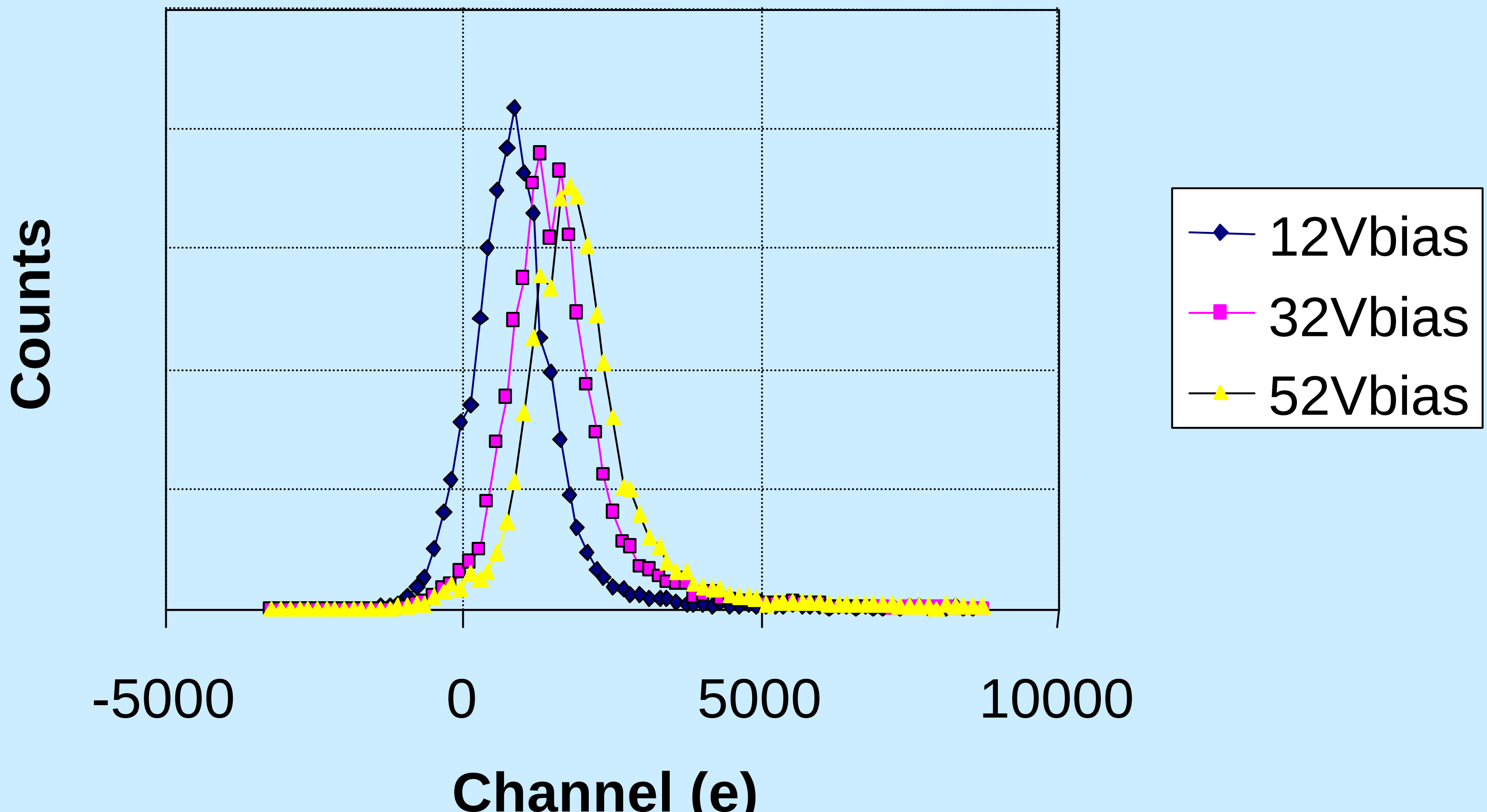


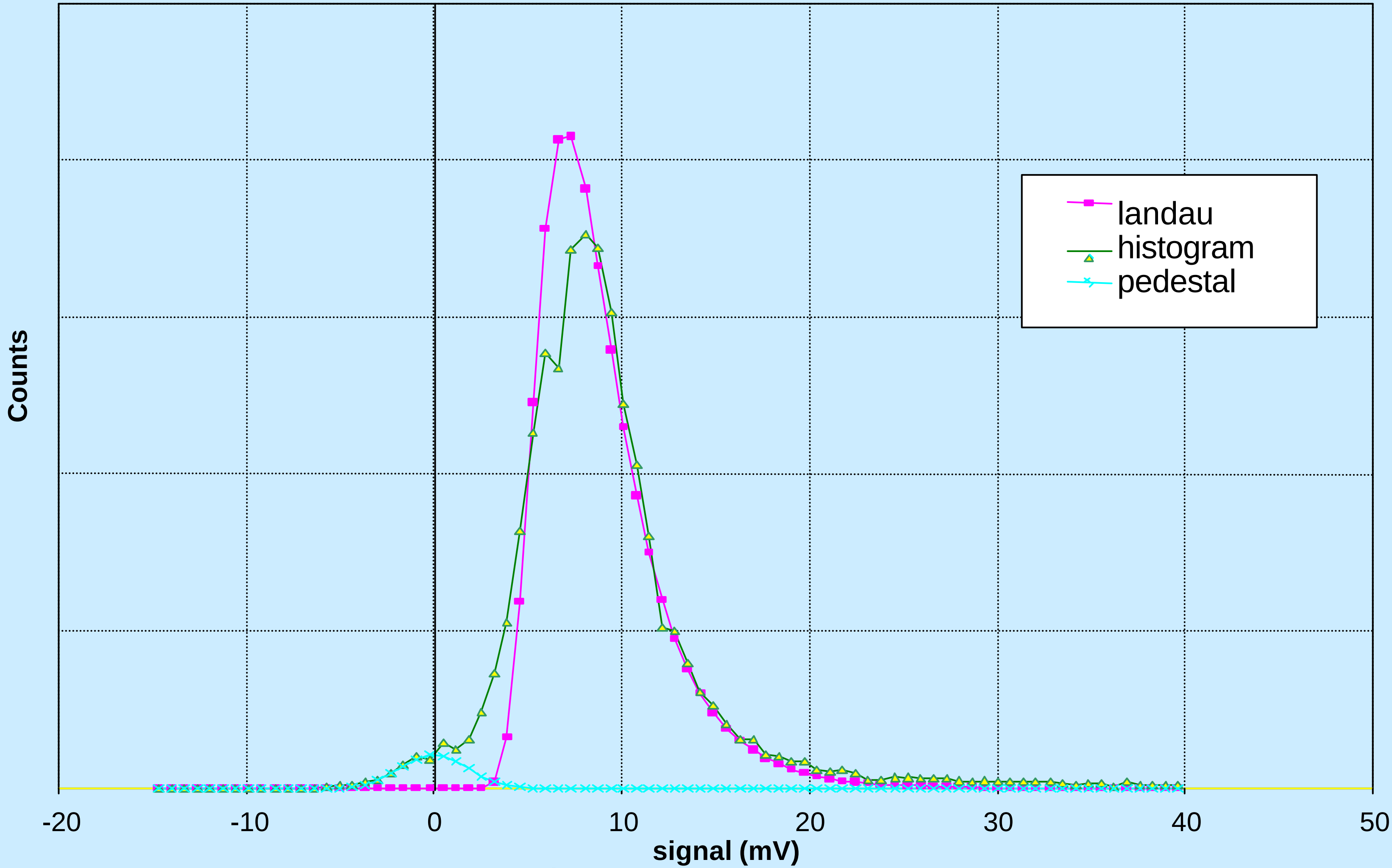
Figure of merit of the apparatus:

Series noise =300e+10e/pF

PULSE HEIGHT SPECTRUM AT DIFFERENT FIELDS



DECONVOLUTION AT SATURATION
LANDAU CLEARLY SEPARATED FROM PEDESTAL



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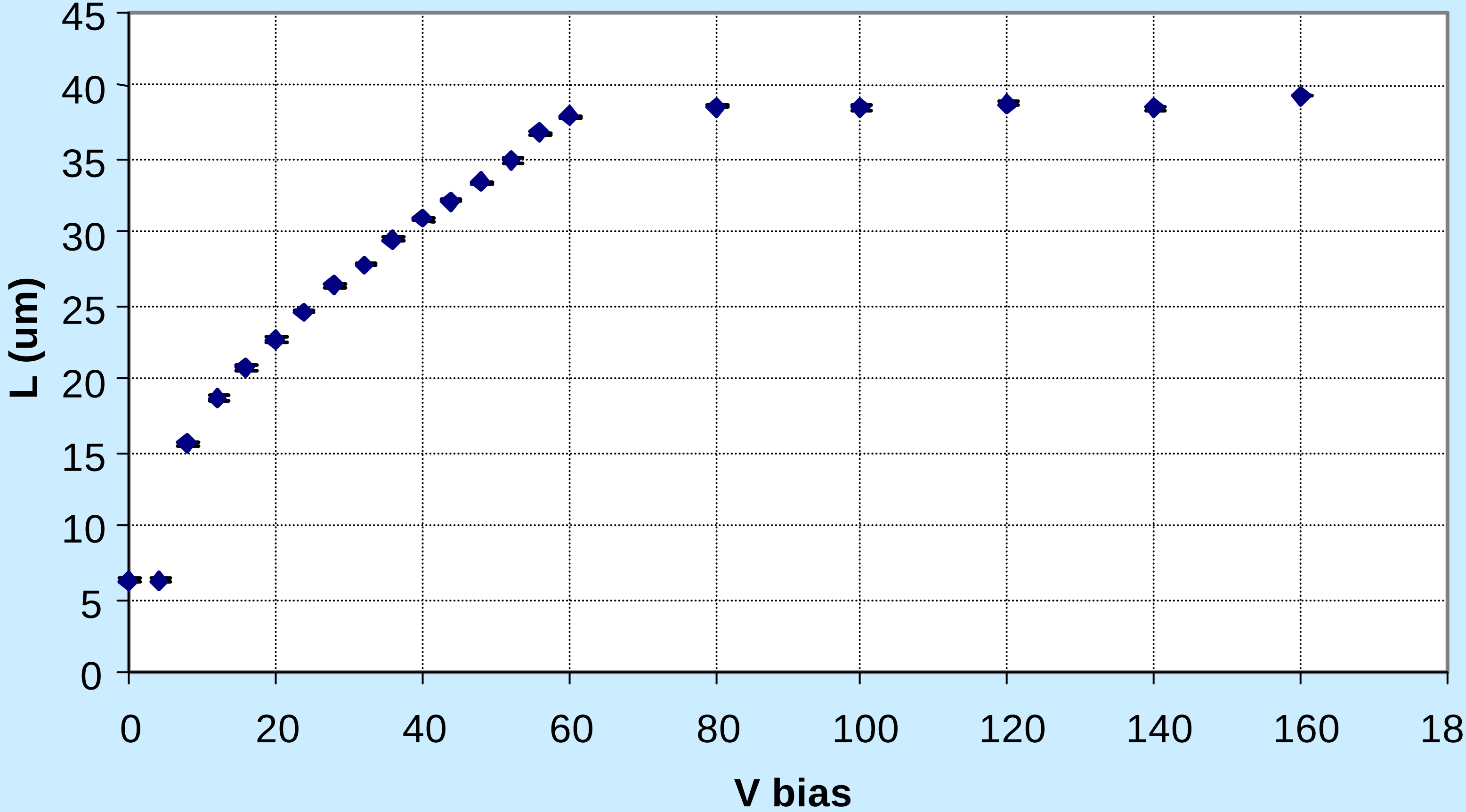
electrons/55 per μm

The cce MIP meaurements are consistent with the other characterization: Vsat =60V N_{eff}= 4 10^{13}/cm^3

100% efficency



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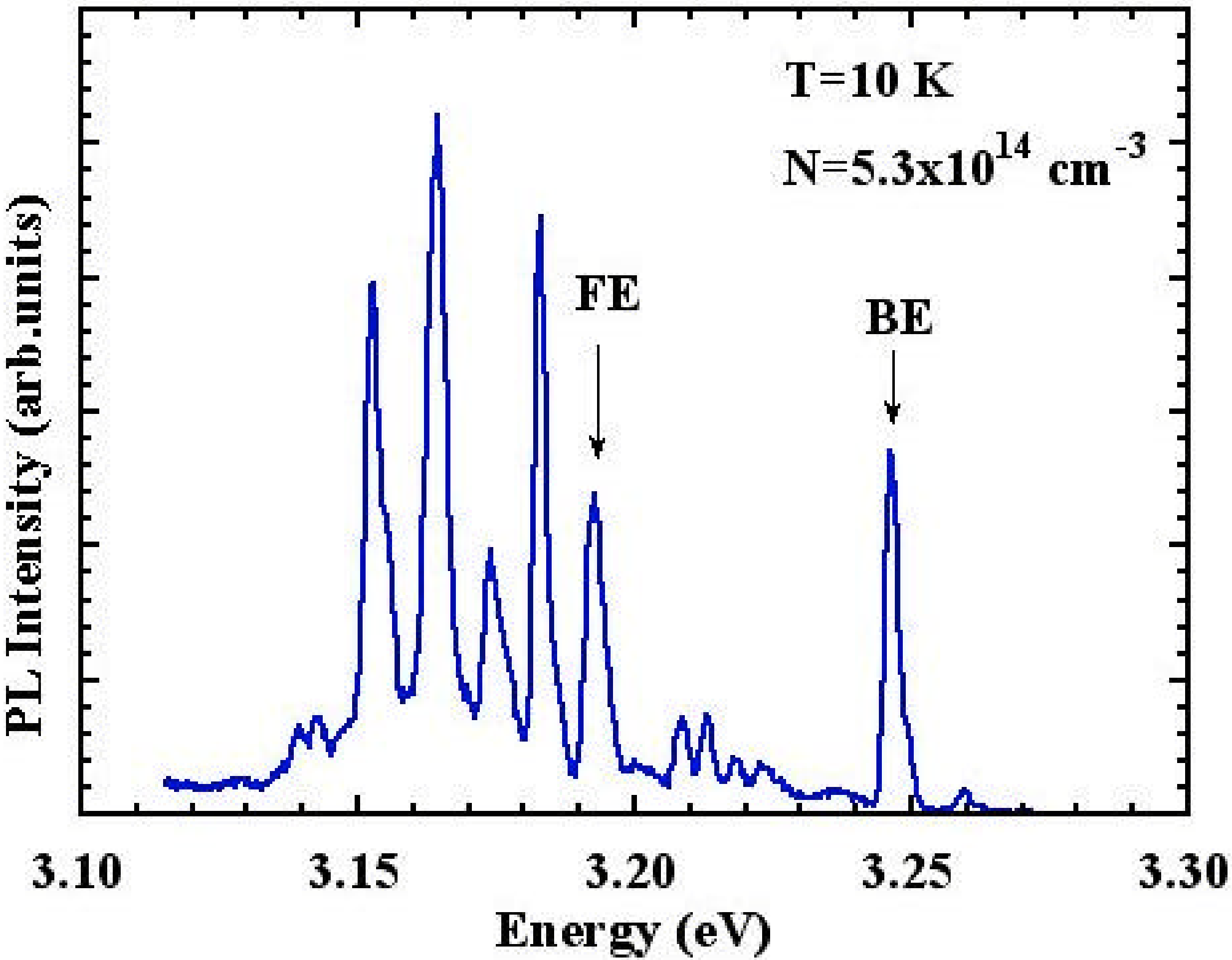
Photoluminescence measurements

- Sample excitation by means of a frequency-doubled ps dye-laser (average power at 300 nm 5 mW, rep rate 76 MHz)
- PL detection by means of a standard time-integrated photon counting



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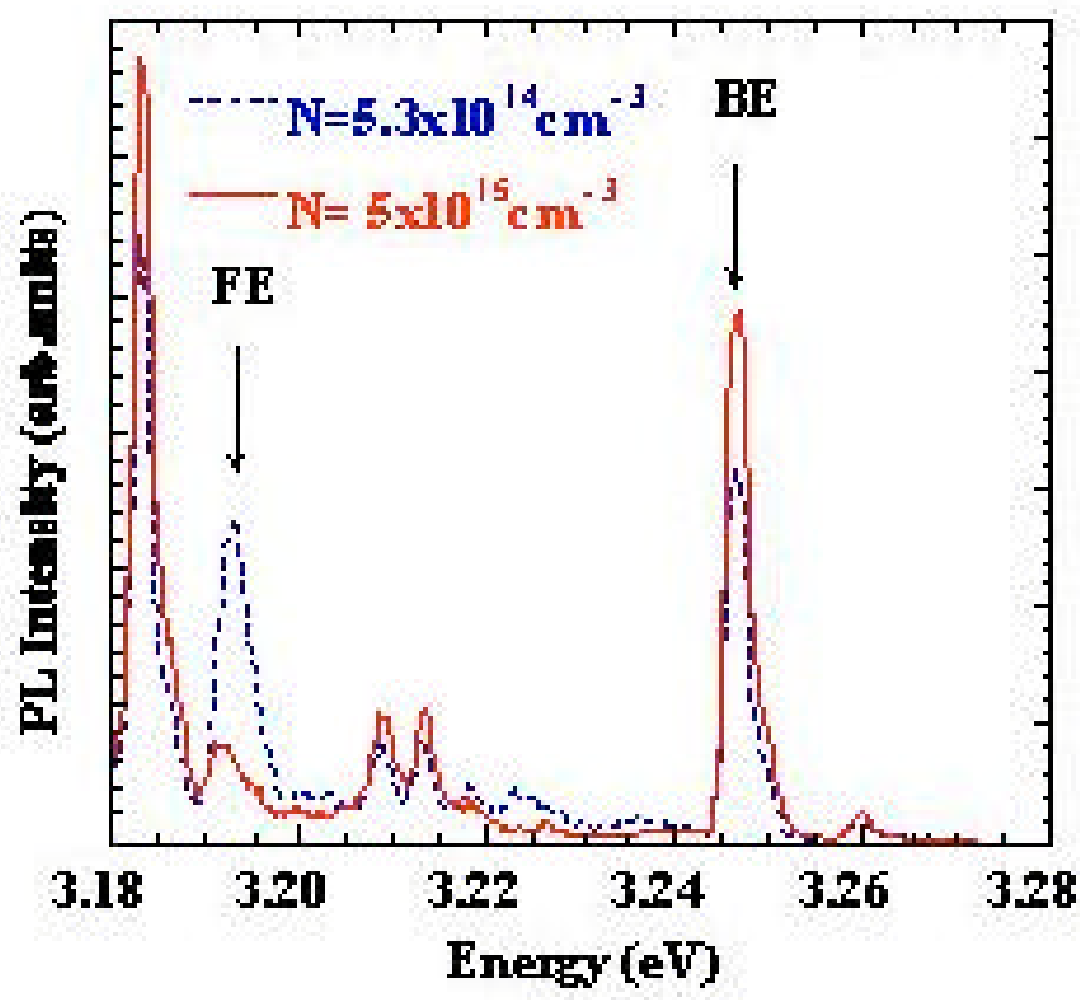
Photoluminescence main result

- Evidence of a strong correlation between the doping level and the bound (BE) and free exciton (FE) emissions.
- In particular an increase in the doping level significantly reduces the intrinsic (FE) radiative recombination.



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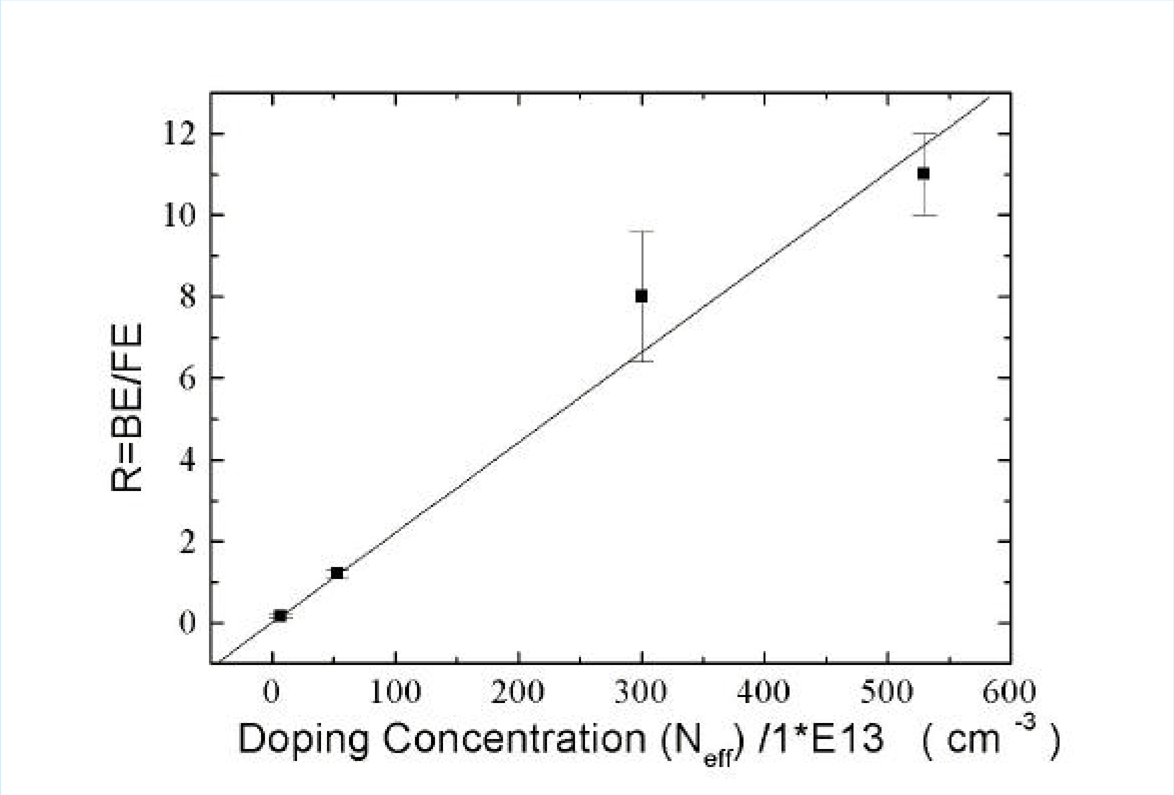
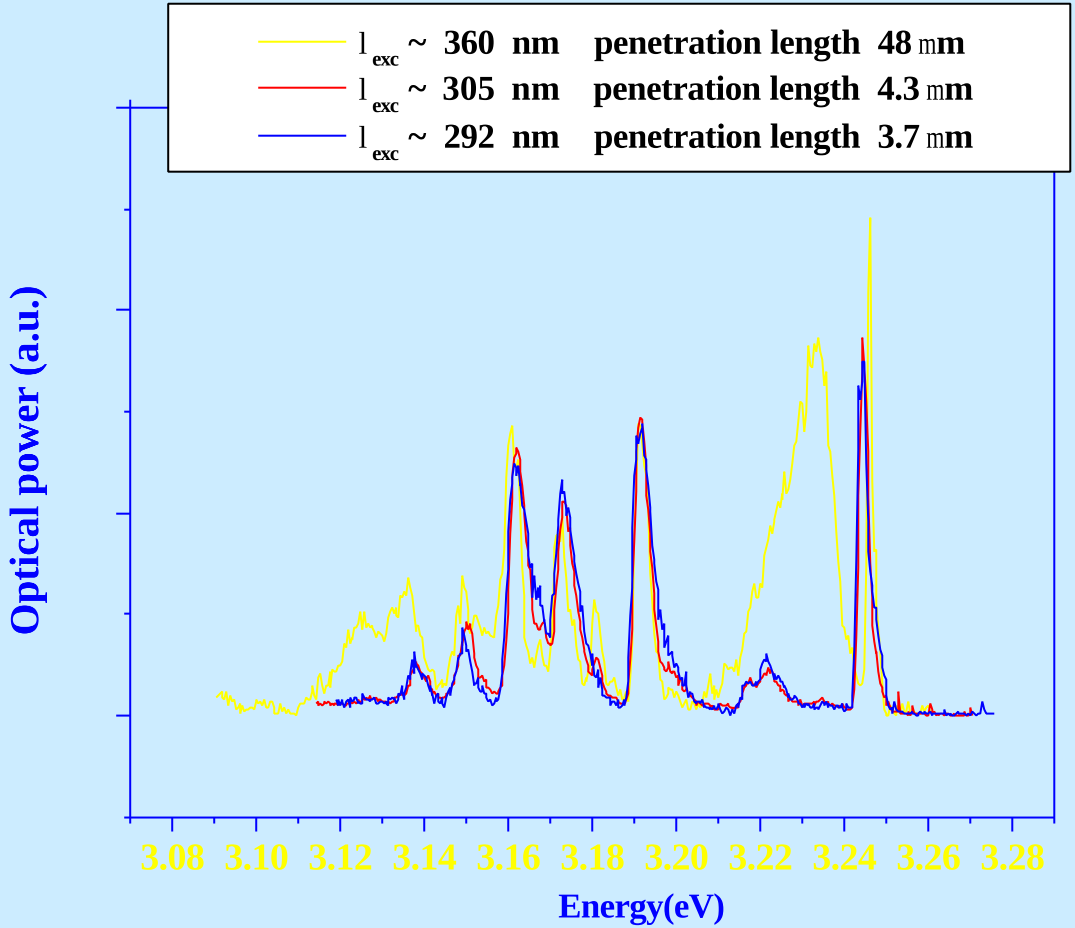
Correlation suggested by
I.G. Ivanov et al. J.Appl. Phys. 80 (1990) 3504



Slope A=4.5 10^{14} cm^{-3} to be compared with the value reprted by Ivanov (5.2 10^{14} cm^{-3})
The difference can be ascribed to the different samples temperature in the two analyses

By tuning the excitation wavelength the penetration depth can be changed. When the probe reaches the bulk the BE feature increases and a luminescence band is strongly enhanced.



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Conclusions

- IKZ compares favourably with CREE
- lower doping level, higher thickness, more reliable metallization, high diffusion length
- higher compensation introduces disuniformity in the N_{eff} profile: test with excitonic recombination are foreseen before metallization , need of a buffer layer
- Independence of temperature of the device response
- Landau MIP spectrum resolved from the pedestal

Future Plans

- Test samples of 100 μm thickness and low doping level ~$10^{13}/cm^3$
- Study the homogeneity with optical measurements
- Radiation hardness study, possibly increasing the sensitivity of the cce MIP measurements