



RADIATION-HARD POLYCRYSTALLINE CdTe for LHC Luminosity Monitor

- High rate: 40MHz
- High dose: 10^8 Gy/year
- 10^{18} Neutrons/cm²
- 10^{16} Protons/cm²



- ◆ **Detectors adopted for LHC LUMINOSITY monitoring will sample the hadronic/electromagnetic showers produced by neutrons and photons in specifically designed protection absorbers**
- ◆ **These detectors will have to withstand extreme radiation levels and their long term operation will have to be assured without requiring human intervention.**



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1- Introduction

2- Speed test

3- Sensitivity measurement

4- High dose radiation tests

5- Conclusion



1-Introduction

a) Minimum Ionizing Particle (MIP) creates charges in semiconductor.

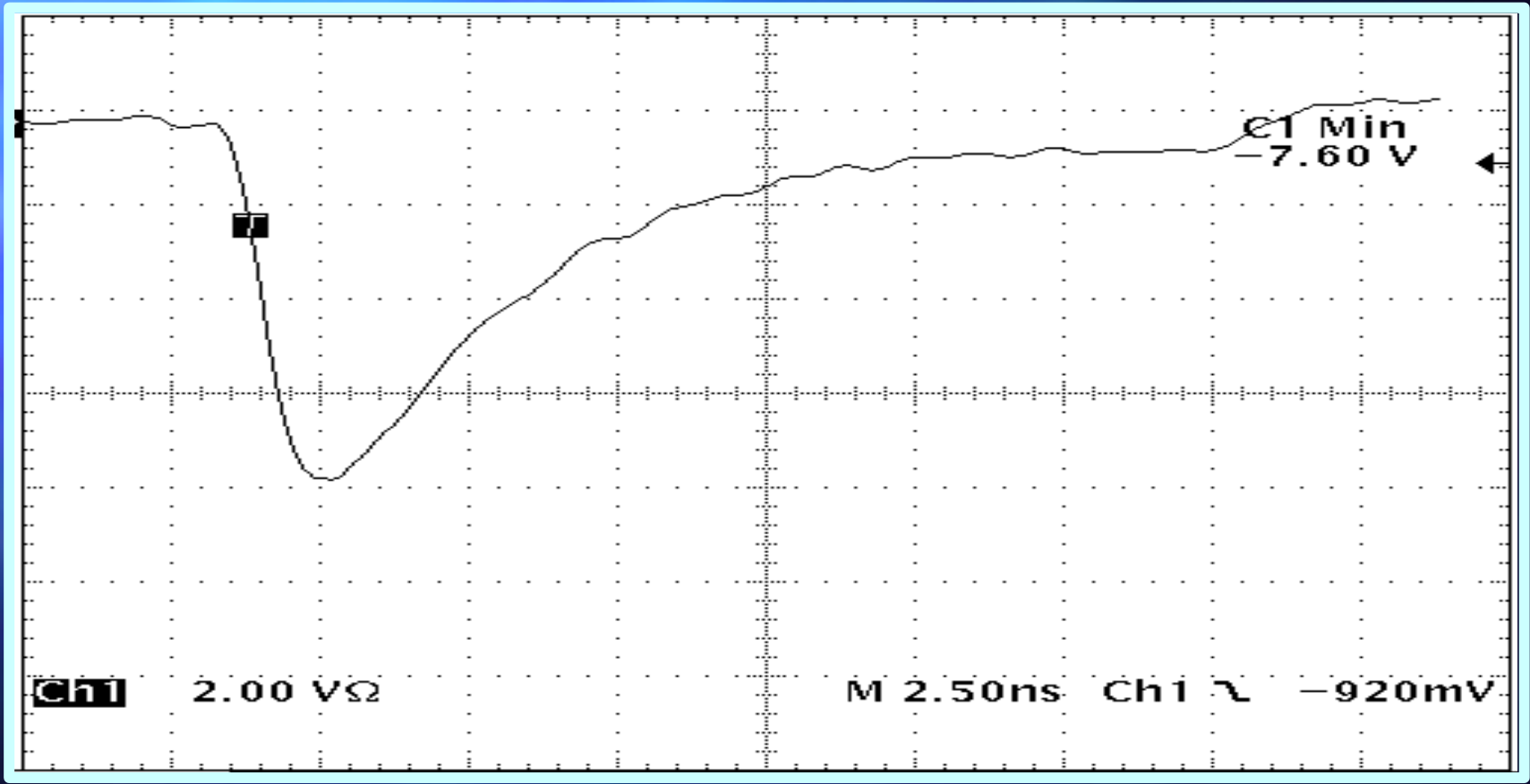
■ <u>Thickness 300 mm</u>	<u>CdTe</u>	GaAs	Si	Diamond
■ Density [g/cm ³]	5.85	5.32	2.33	2.88
■ Thickness : d [g/cm ²]	.176	.160	.070	.086
■ (dE/dx) _{min} [MeV/(g/cm ²)]	1.26	1.40	1.66	1.78
■ Ionisation potential : IO [eV]	4.43	4.2	3.61	13
■ Number of charges created	<u>50'000</u>	53'000	32'200	11'850



**b) CdTe X- RAY detector
running in LEP for beam
emittance measurement was
daily used after
 10^{14} Gray total dose.**



-Time response of sample : 172c/ 100 V 2.5 ns/cm

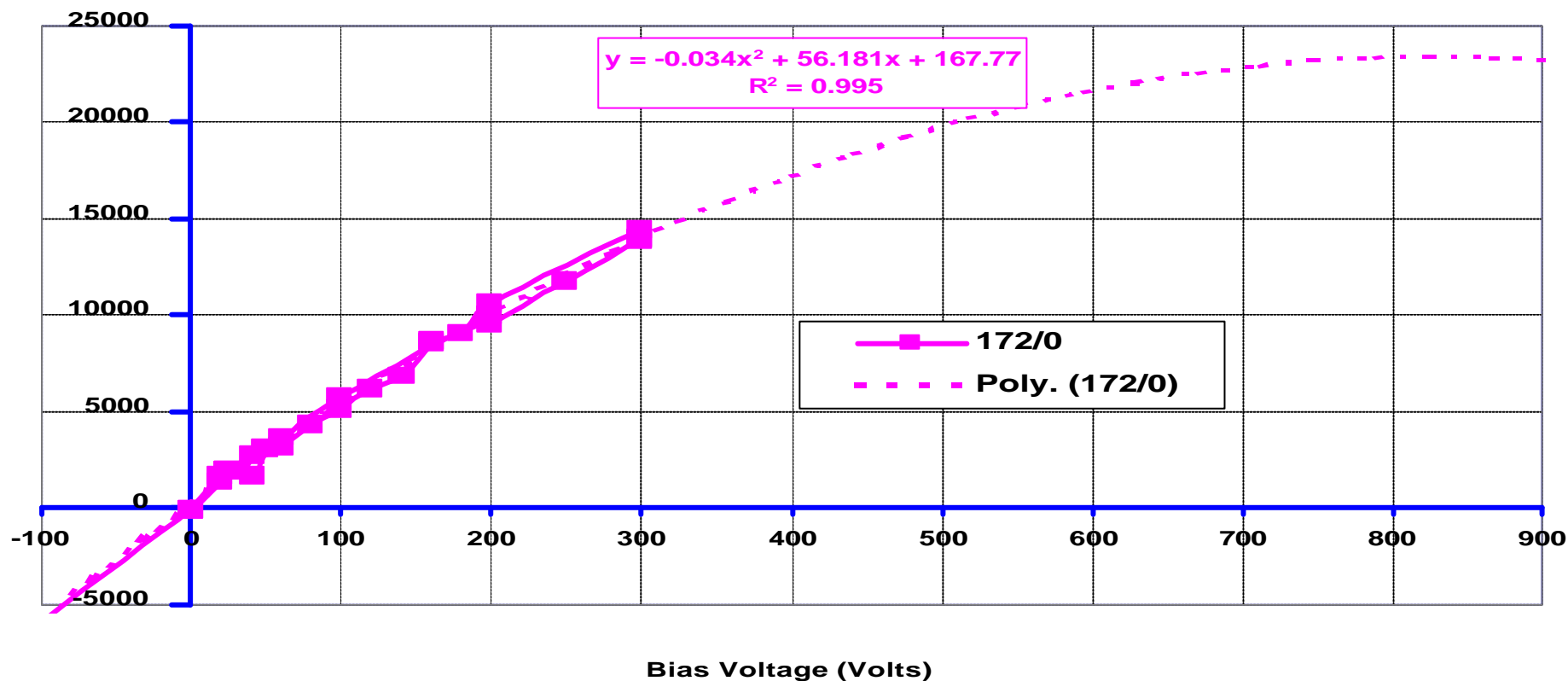


Test with MIP (Sr90)



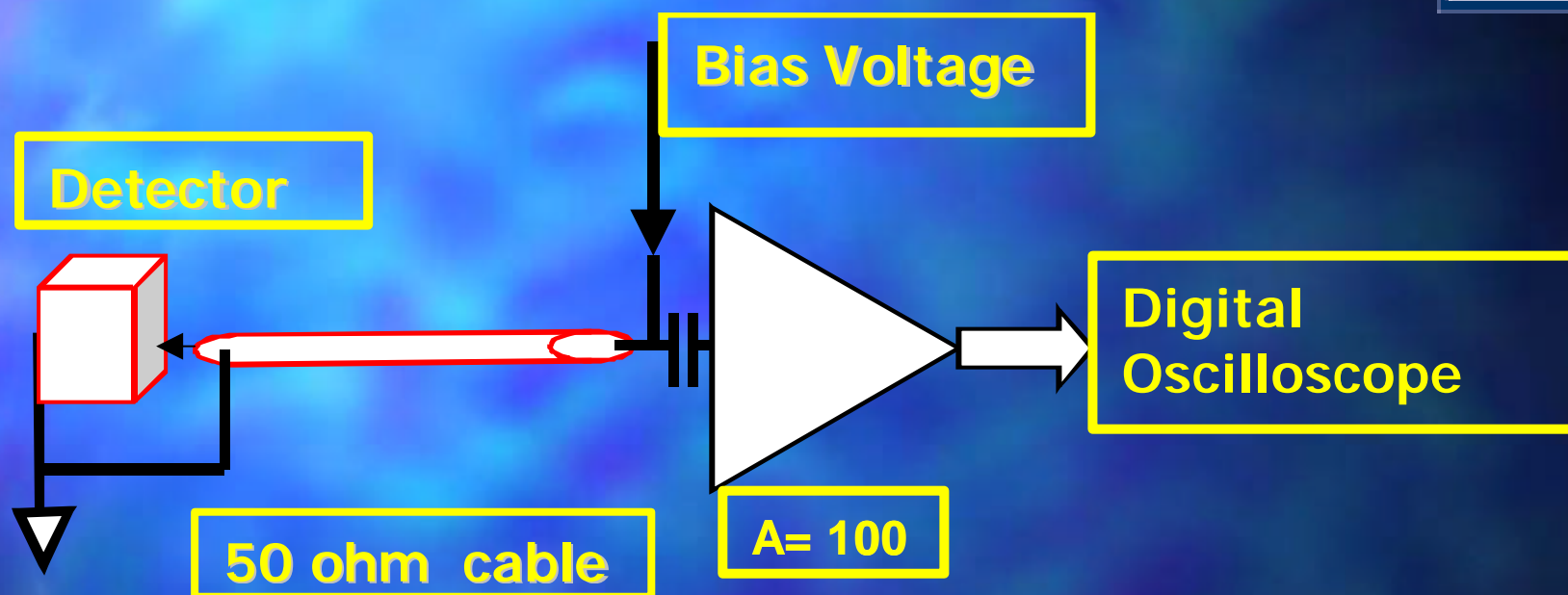
CdTe detector test with MIPS
sample ref 172/ 470 microns
(Integrating Amplifier: D. Meier Set-up)

Electrons collected
per MIP





Experimental set-up





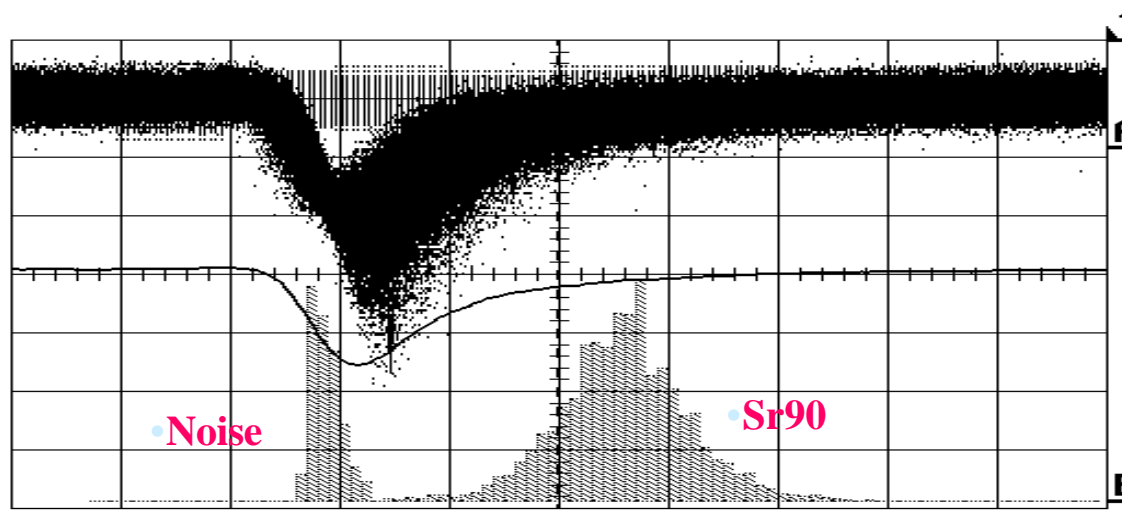
Test with fast preamplifier and 90Sr sample 172N 200V 2.7microamp

28-Mar-00
13:29:43

1 2 ns
5.0 mV

A: Average(1)
2 ns
5.0 mV
—2856 swps

B: Hamp1(1)
5 mV
55 #
<0%/>0%
—inside 2856



← 1.8 ns

2855 sweeps:		average	low	high	sigma
pkpk(1)		12.89 mV	0.16	26.25	6.51
mean(1)		-14.178 mV	-16.283	-9.254	2.028
sdev(1)		3.147 mV	0.074	5.147	1.436
rms(1)		14.558 mV	9.277	16.991	2.227
ampl(1)		11.99 mV	0.16	26.25	6.27

- Amplifier output
- Averaged output
- Histogram of amplifier output:

• Amplifier developed in GSI (De): GSI-DBA-II Diamond Broadband Amplifier: 0.003-2.3 GHz bandwidth

2 ns RIS

1 5 mV 50Ω

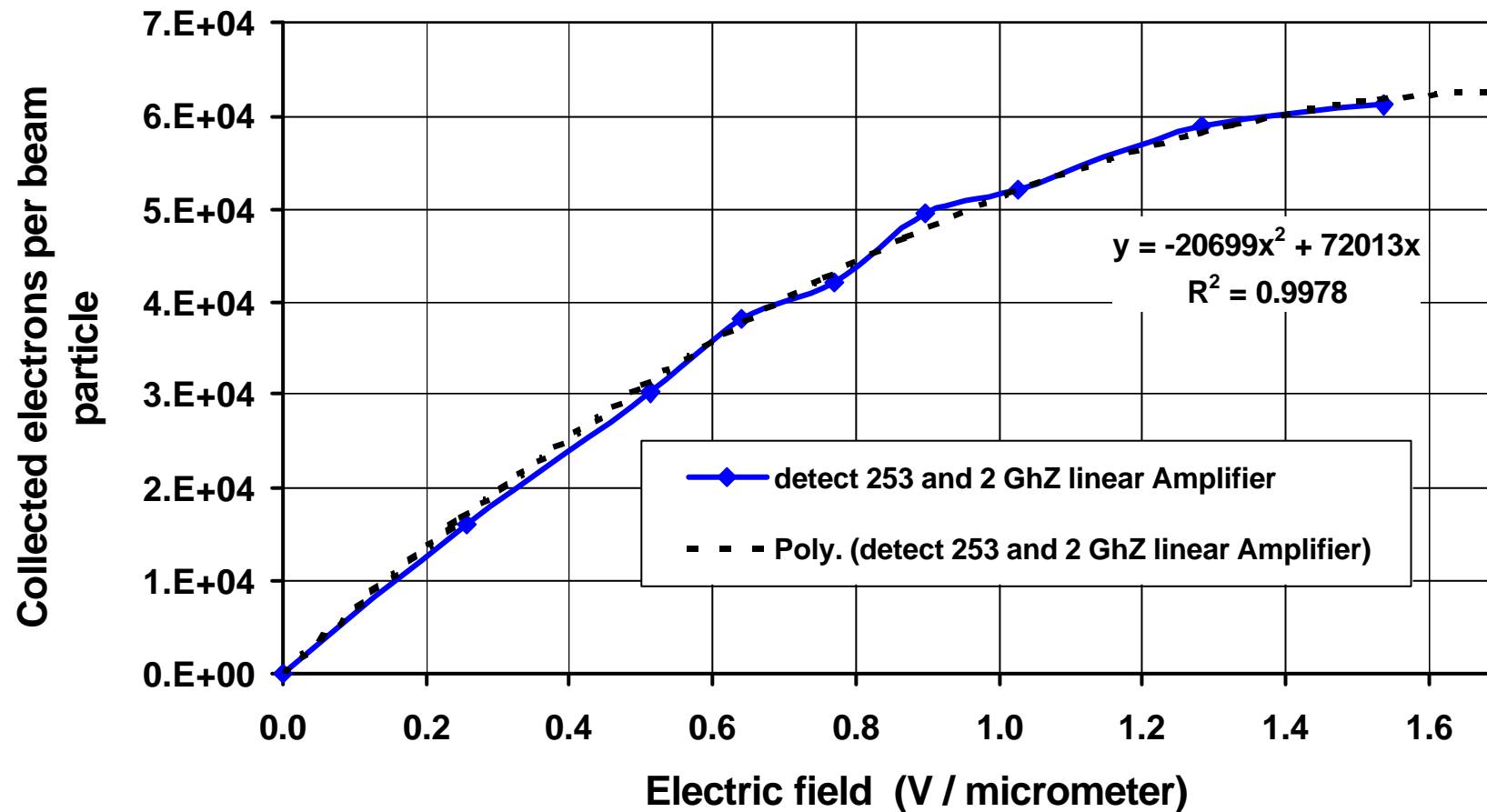
2 1 V 50Ω

3 2 mV 50Ω

4 5 mV 50Ω

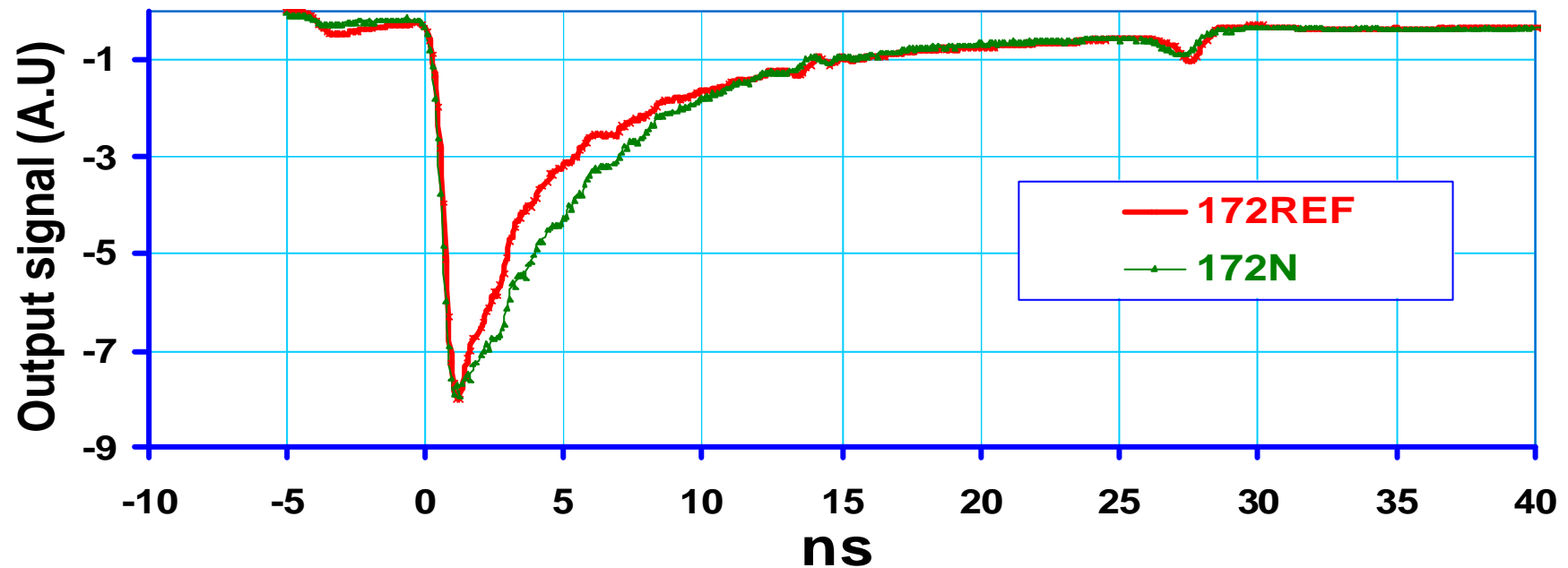
Store to Flpy

120 Gev Beam Detector 470 mm



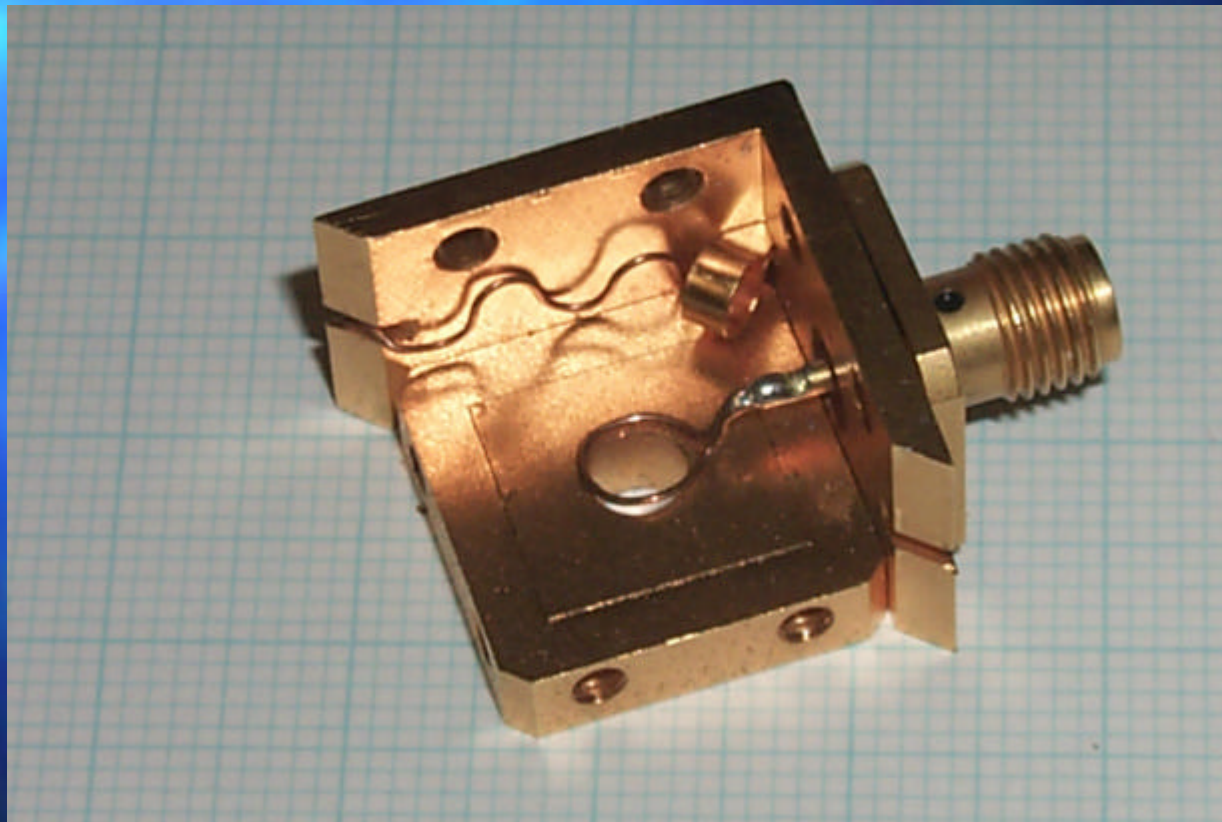
Irradiation test at 10^{15} neutrons/cm²

Time response of CdTe samples
before irradiation: sample **172REF**
after irradiation sample **172N** (10^{15} n/cm²)



Laser-test (1047 nm, 60 ps FWHM, 500_mJ/CM²)

Detector box for On-line measurement during irradiation test



1st Workshop on Radiation hard
semiconductor devices for very high luminosity
colliders CERN 28-30 November, 2001

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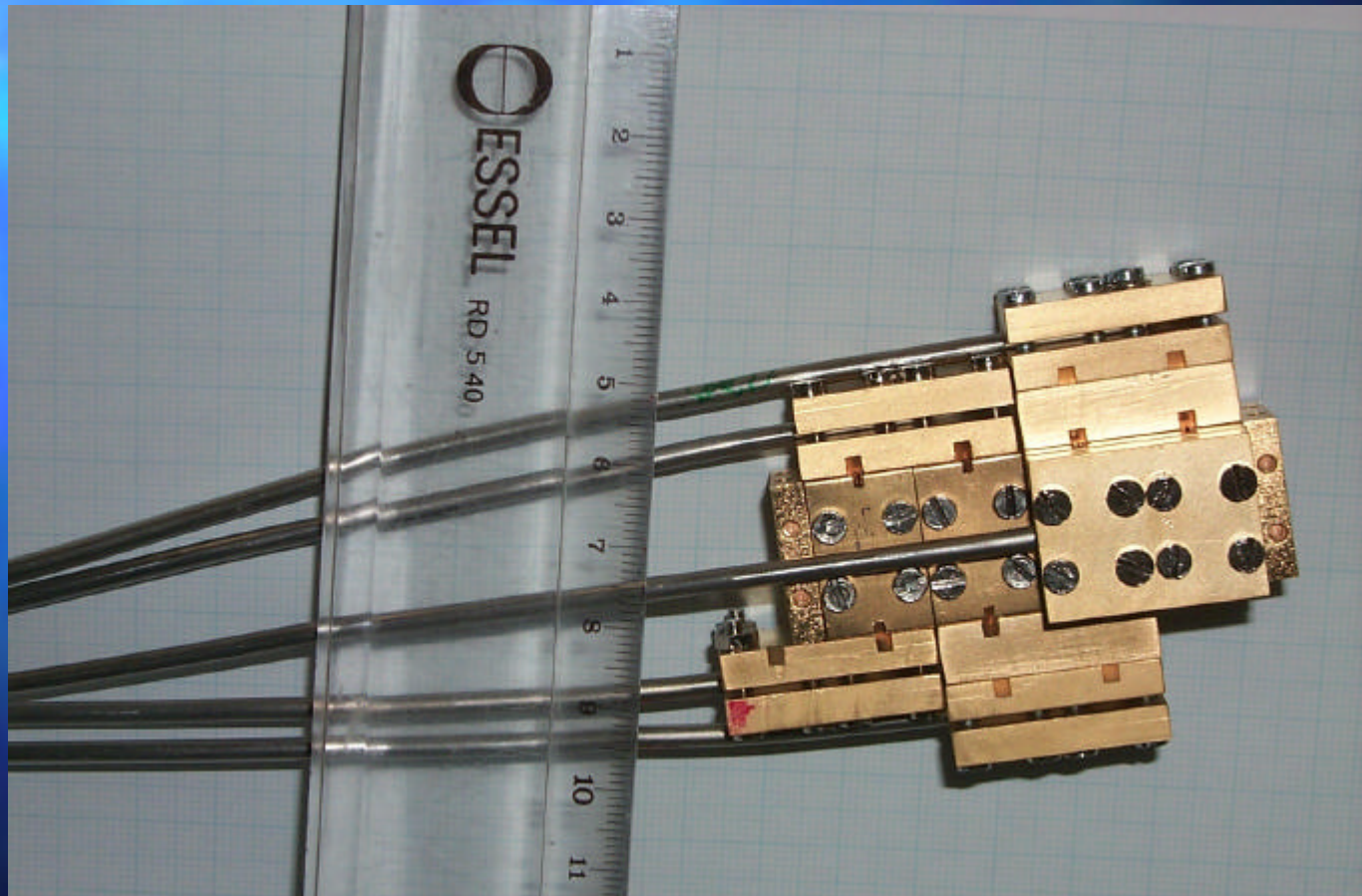
Detector box for On-line measurement during irradiation test



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Set-up for On-line measurement during irradiation test



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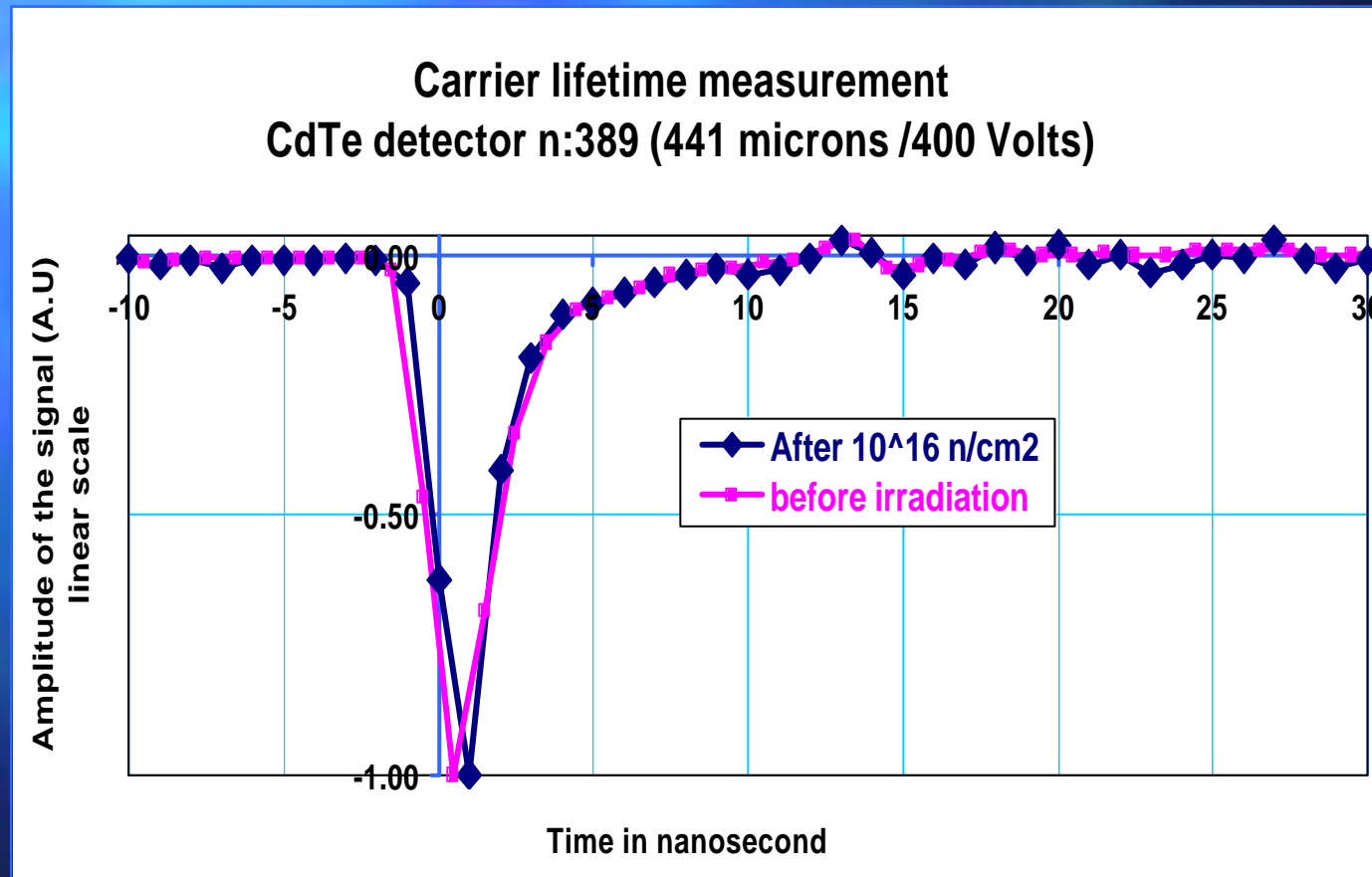
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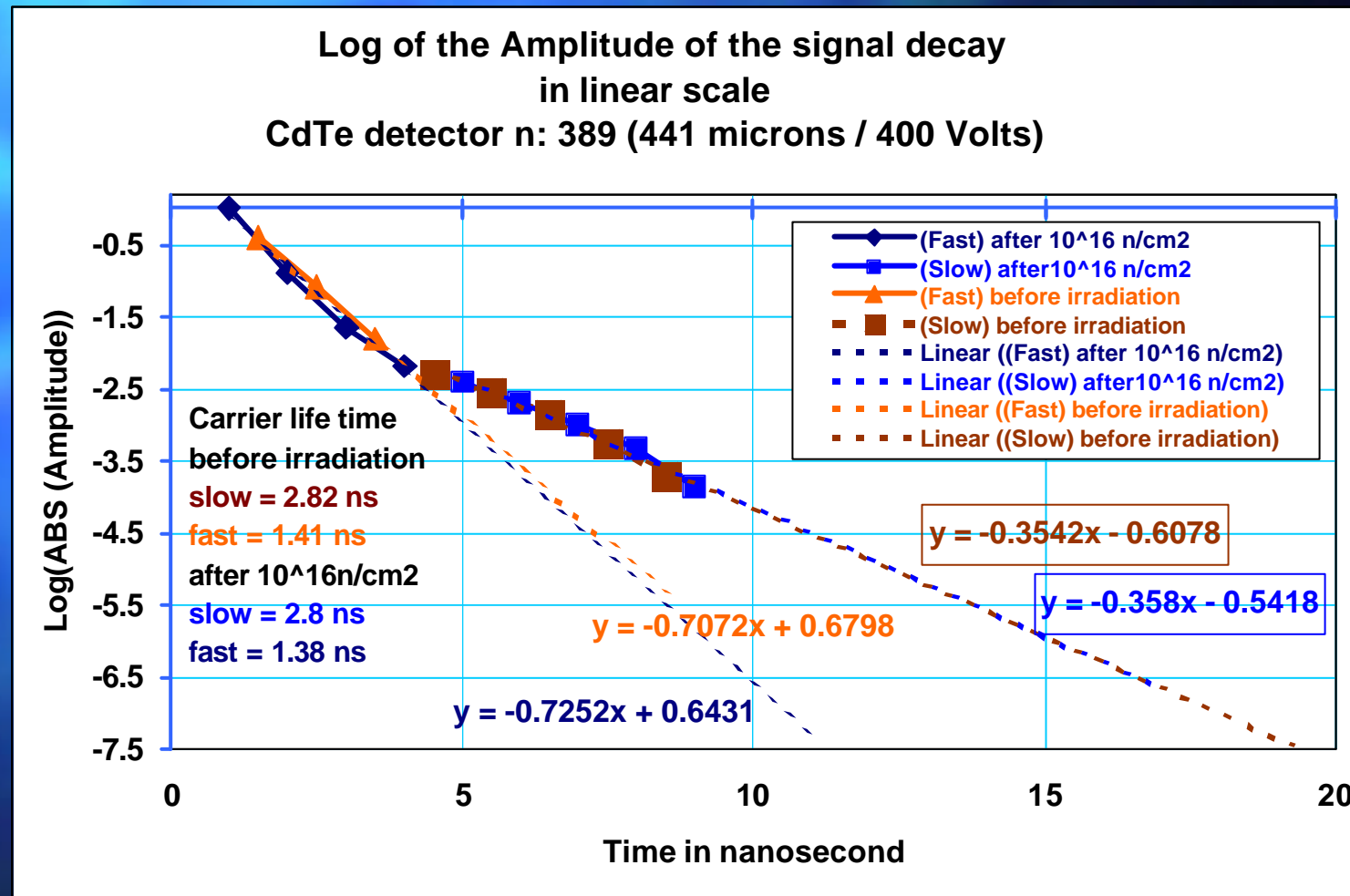
Irradiation Tests

- Triga type reactor
(Ljubljana, Slovenia)
- Irradiation steps
 - 🕒 10^{13} n/cm²
 - 🕒 10^{15} n/cm²
 - 🕒 10^{16} n/cm² activation of all set-up
 - ↪ next step 10^{17} n/cm²

Irradiation test at 10^{16} n/cm²



Carrier lifetime measurement after 10^{16} n/cm²



Conclusion



- The signal response of Thick-polycrystalline-CdTe is even better than required for 40 MHz event rate measurement.
- The sensitivity above 100 electrons per micron/MIP and the fast 50 ohms-preamplifier allows simple design.
- Test with Beam confirms the laser and SR90 test.
- Irradiation-test up to 10^{16} Neutrons/cm² have demonstrated no significant loss in speed.
- New experiment up to 10^{17} n/cm² is in preparation.



References

- W.C. Turner, "Instrumentation for the Absorbers in the Low-beta Insertions of the LHC," *LBNL-42180*, Aug. 1988.
- R. Jones *et al.*, "Real time display of the vertical beam sizes in LEP using the BEXE X-ray detector and fast VME-based computers", Proc. DIPAC'99, Daresbury, UK, 16-18 May, 1999.
- E. Rossa *et al.*, "CdTe photoconductors for LHC luminosity monitoring"
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- M. Placidi, E. Rossa, H. Schmickler, "A CdTe Detector for Muon Transverse Profile Measurements", CERN-NUFACT-Note 068, Feb. 2001.
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