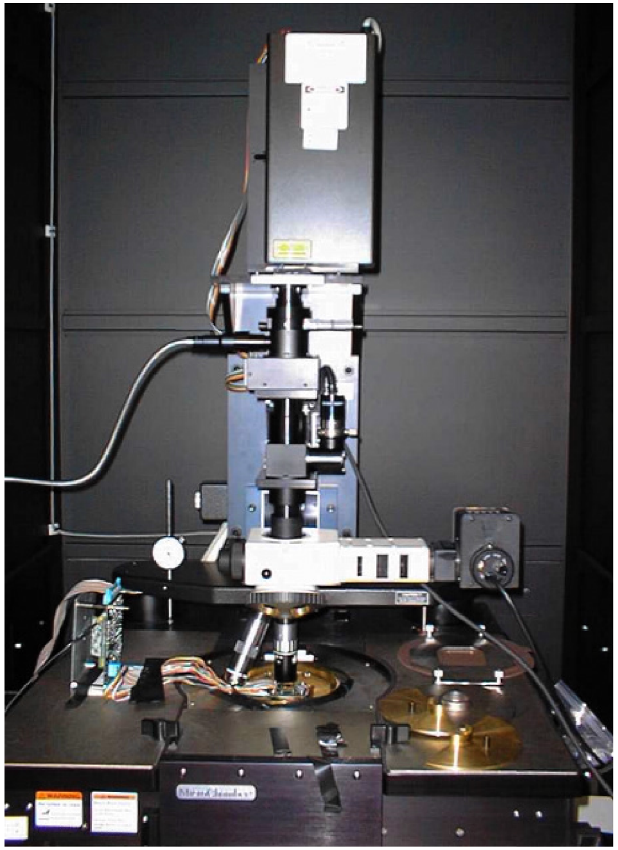
CCD Radiation Damage Test with 150 MeV Electrons

Y. Sugimoto, A. Miyamoto	KEK
G. Iwai, F. Fujiwara, K. Fujiwara,	
H. Takayama, N. Tamura	Niigata Univ.
K. Abe	Tohoku Gakuin Univ.
T. Terasawa	Tohoku Univ.
T. Aso	Toyama National College of Maritime Technology

CCD VTX R&D in Japan

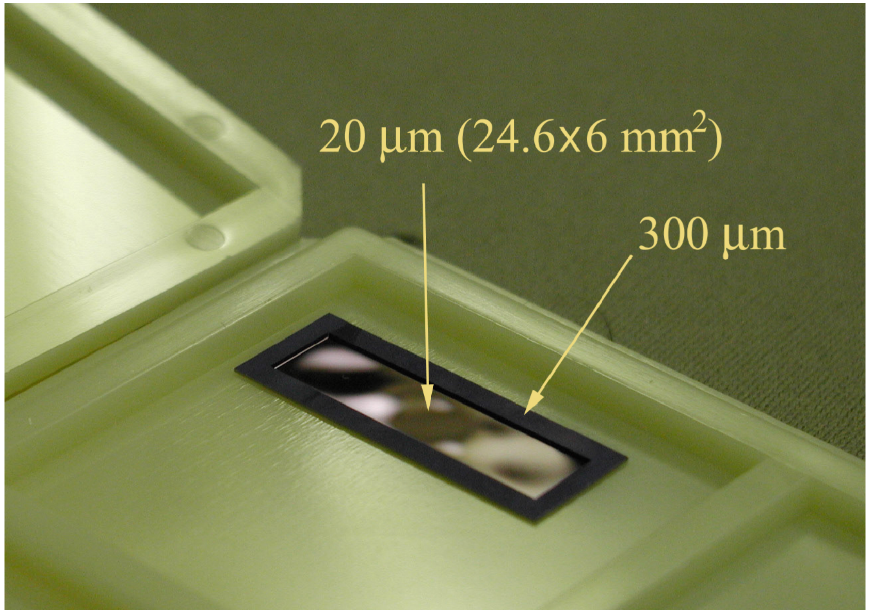


Spatial resolution study:

- IR Laser beam (2μm spot size) scanner at Niigata U.
- We will study the effect of radiation damage on the resolution.

Study of distortion of CCD wafer: challenge for thin detector

- Partially thinned CCD is obtained from HPK
- Try to get honeycomb structure wafer



CCD VTX R&D in Japan(Cont.)

Low cost fast readout electronics:

- Evaluation of commercially available CCD Signal Processor (CSP) chip (CDS, VGA, 40MHz 10bit ADC, <1cm^2, $6/chip)

Radiation hardness of CCD:

- Irradiation with ^{90}Sr β-source and ^{252}Cf neutron source
- We have demonstrated the effects of
  - Notch cannel
  - Fat-zero charge injection

  on the reduction of CTI
- Neutron b.g. level depends on the design of the extraction line
  - => Need detailed simulation of the beamline
- Concerning the pair-background, lifetime of 3 years is expected under “A” option of JLC even at near room temperature. (with large ambiguity)
- Radiation damage by high energy (>10MeV) electrons is not studied yet
  - => Irradiation with 150MeV electrons

Radiaion damage by pair-background at LC

Pair-background simulation(CAIN):

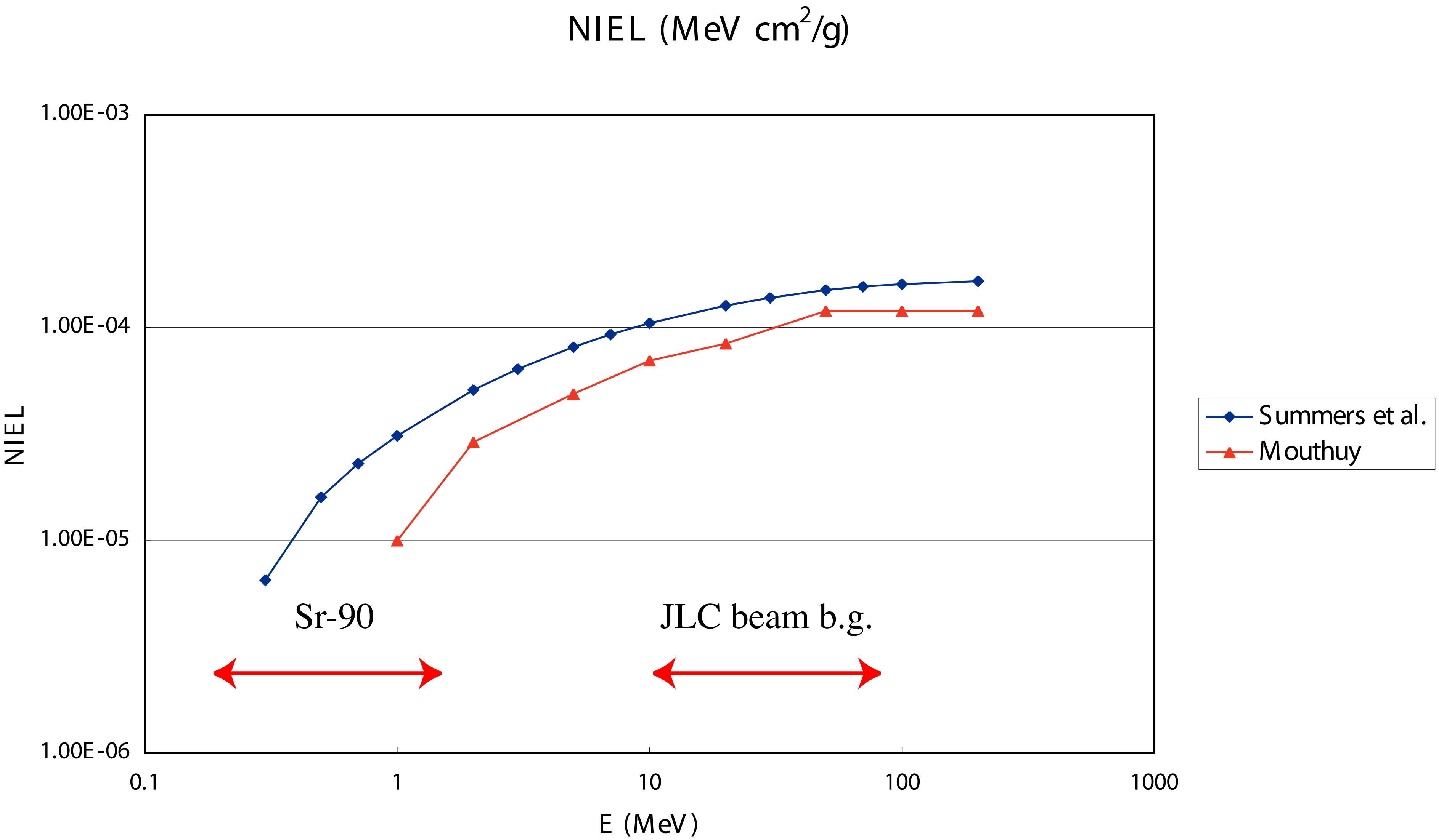
- ~10MeV to ~100MeV electrons/positrons hit the Vertex det.
- ~1.5×10^{11}/cm^2 y @B=2T, R=2.4cm, JLC A-option
- ~5×10^{11}/cm^2 y @B=2T, R=2.4cm, JLC Y-option

CCD radiation damage study by ^{90}Sr:

- We have irradiated CCDs with 10mCi ^{90}Sr β-source and found that CCDs can be used up to 5×10^{12}/cm^2 electron irradiation at near room temp.

Expected damage by high energy electrons:

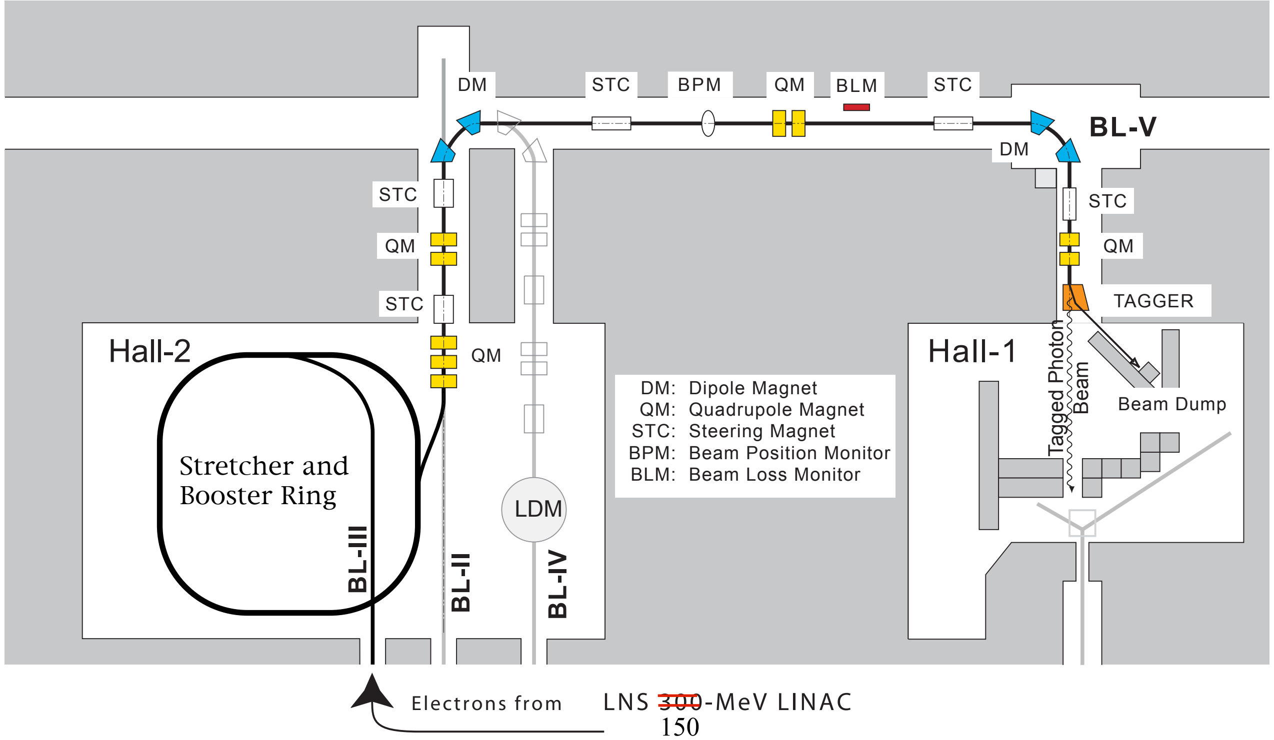
- Assuming NIEL(non-ionizing energy loss) hypothesis and <E> (^{90}Sr)=1 MeV, we inferred that the effect of radiation damage by pair-background is 10 times larger than that of Sr-90 β-ray.
  => CCD is durable up to 5×10^{11}/cm^2 pair-background
- However, there is large ambiguity
  => Damage test by high energy electron is necessary

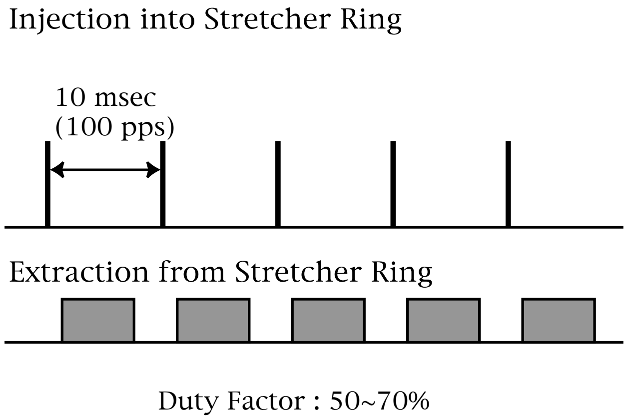

NIEL (MeV cm^2/g)
1.00E-03
1.00E-04
1.00E-05
1.00E-06
NIEL
0.1
1
10
100
1000
E (MeV)
Sr-90
JLC beam b.g.
Summers et al.
Mouthuy

Electron irradiation set-up

- 150 MeV electron beam of LNS at Tohoku Univ.
  100 pps
  50%~70% duty
  Intensity adjastable from few MHz to few nA(~10^{10}e/sec)

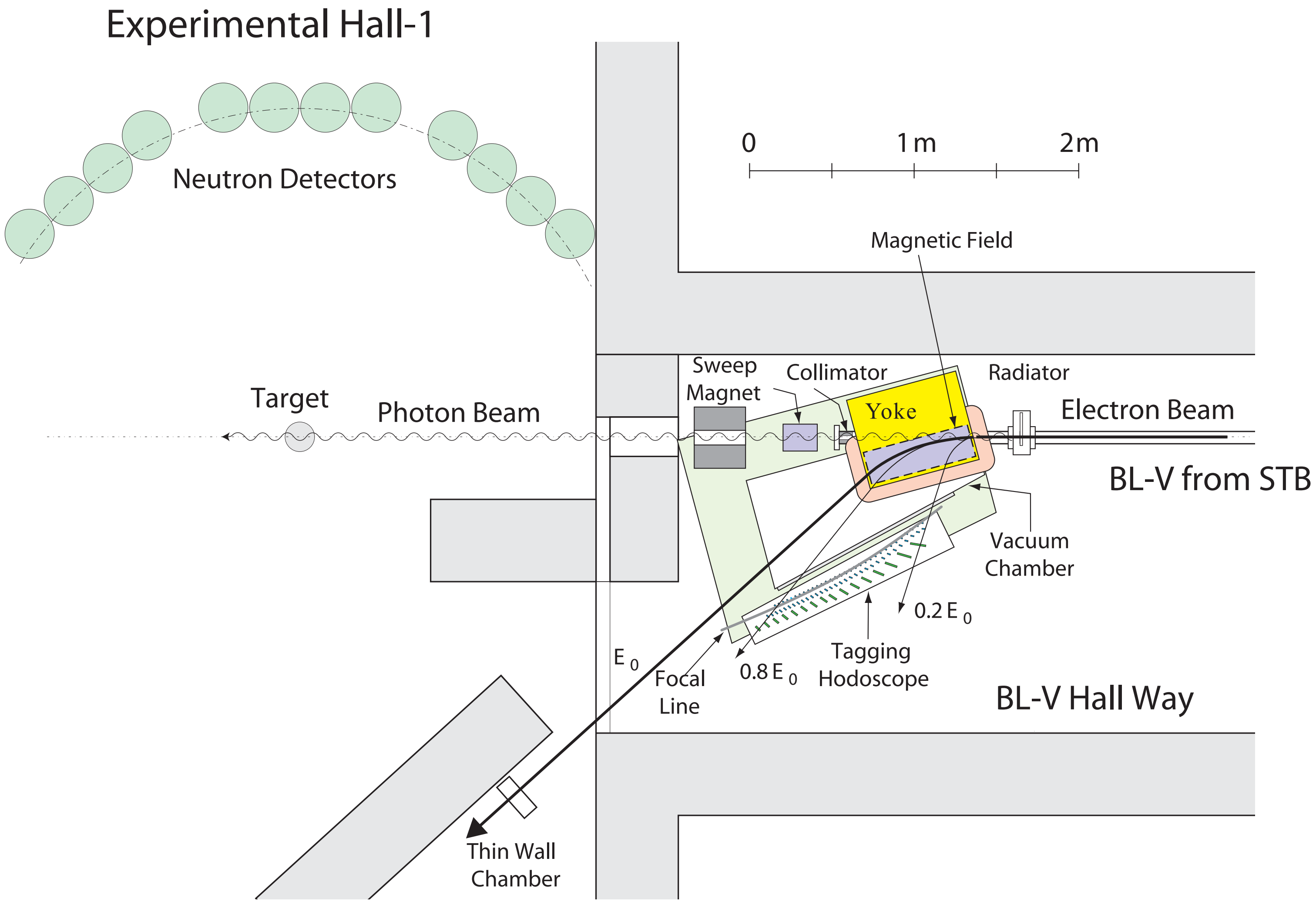
- Beam is broadened by a radiator of ~$0.01X_0$





Laboratory of Nuclear Science (LNS) at Tohoku University

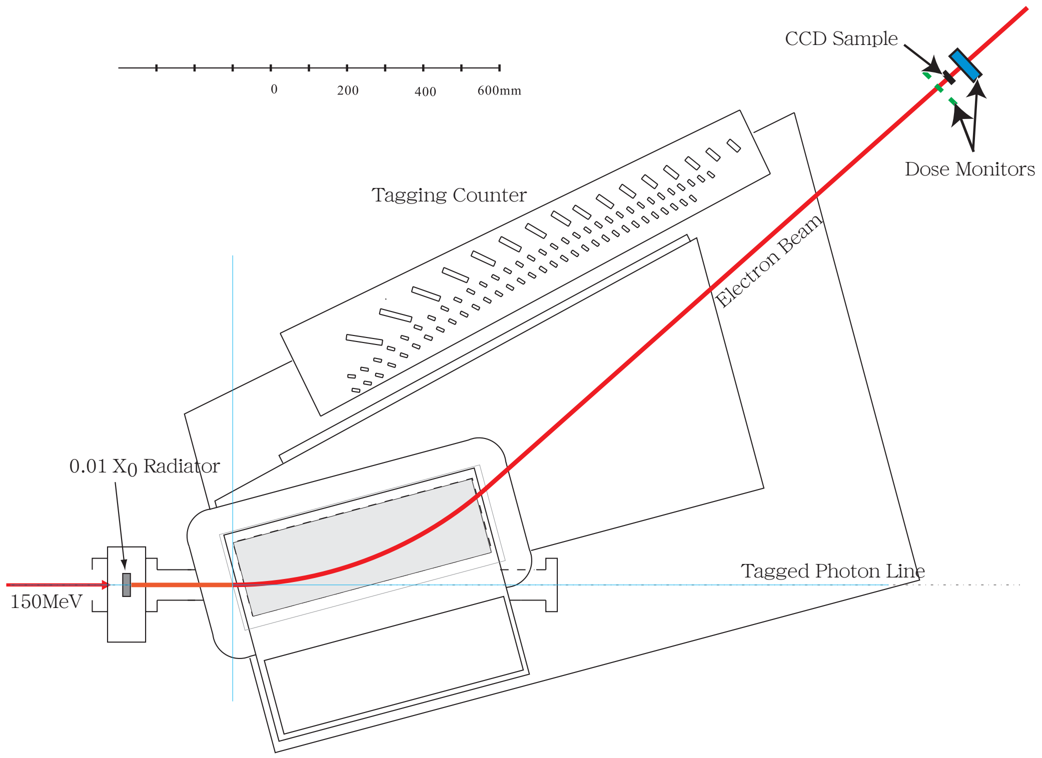
LNS Tagged Photon Beam Line



Electron irradiation set-up (Cont.)

- Dose monitor:
  RADFET (REM CC-5) ; for accumulated dese
  Array of PIN PD ; for intensity and profile monitor by current measurement

- CCD sample (HPK, 256x256 pixels) was irradiated with ~4x10^{10}e/cm^2 (~1 krad)



Future plan

- Characteristics of irradiated CCD is under study now
    - Dark current
    - Flat-band voltage shift
    - CTI
    - Spatial resolution

- We will repeat irradiation/measurement process up to 10^{12}e/cm^2 in 2003