Status Report: Irradiation Test of Maxim BJT's

Riko Wichmann

July 23, 1996

Contents

1 Devices

C-Pi Process		
device	emitter size	number of emitters
NPN2	1.0×7.2 μm^2	1
NPN8	1.0×7.2 μm^2	4
NPN32	1.0×31.2 μm^2	4
PNP2	1.0×7.2 μm^2	1
PNP8	1.0×7.2 μm^2	4
PNP32	1.0×31.2 μm^2	4

CB2 Process		
device	emitter size	number of emitters
NPN1	1.0×3.2 μm^2	1
NPN2	1.0×7.2 μm^2	1
NPN8	1.0×7.2 μm^2	4
NPN32	1.0×31.2 μm^2	4
PNP1	1.0×3.2 μm^2	1
PNP2	1.0×7.2 μm^2	1
PNP8	1.0×31.2 μm^2	1
PNP16	1.0×31.2 μm^2	2

2 Specification of Characterization

- reproduce characteristics from Maxim
  (IV-curves)

- common emitter characteristic
  - measure I_C as function of V_{CE} for fixed I_B
  - I_B = 260 nA - 120 μA (size 32)
  - V_E = 0 V
  - V_C = 0 V - 10 V

- forward gummel plot
  - measure I_B and I_C as function of V_{BE}
  - $V_B = V_C$ = 0 V
  - V_E = 0.3 V - 1 V

- minimum collector current for size 2 transistor: 1 μA
  maximum collector current for size 32 transistor: 10 mA

- scale currents according to transistor size

  NPN2: I_{min} = 1 μA I_{max} = 600 μA
  NPN8: I_{min} = 4 μA I_{max} = 3 mA
  NPN32: I_{min} = 16 μA I_{max} = 12 mA

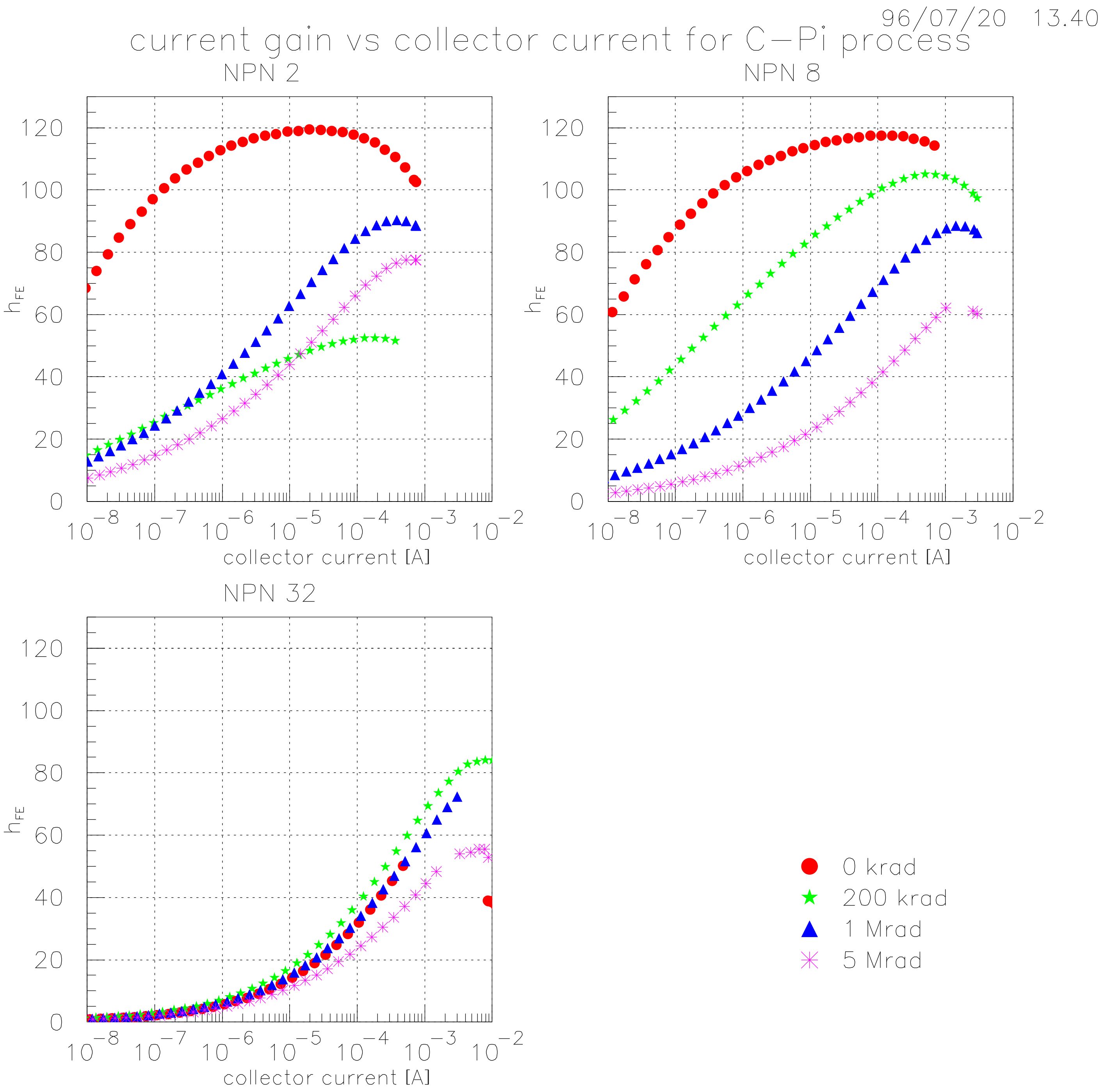
- DAQ system:
  HP4145B parameter analyzer with HP16058B test fixture
  readout with MacIntosh via GPIB

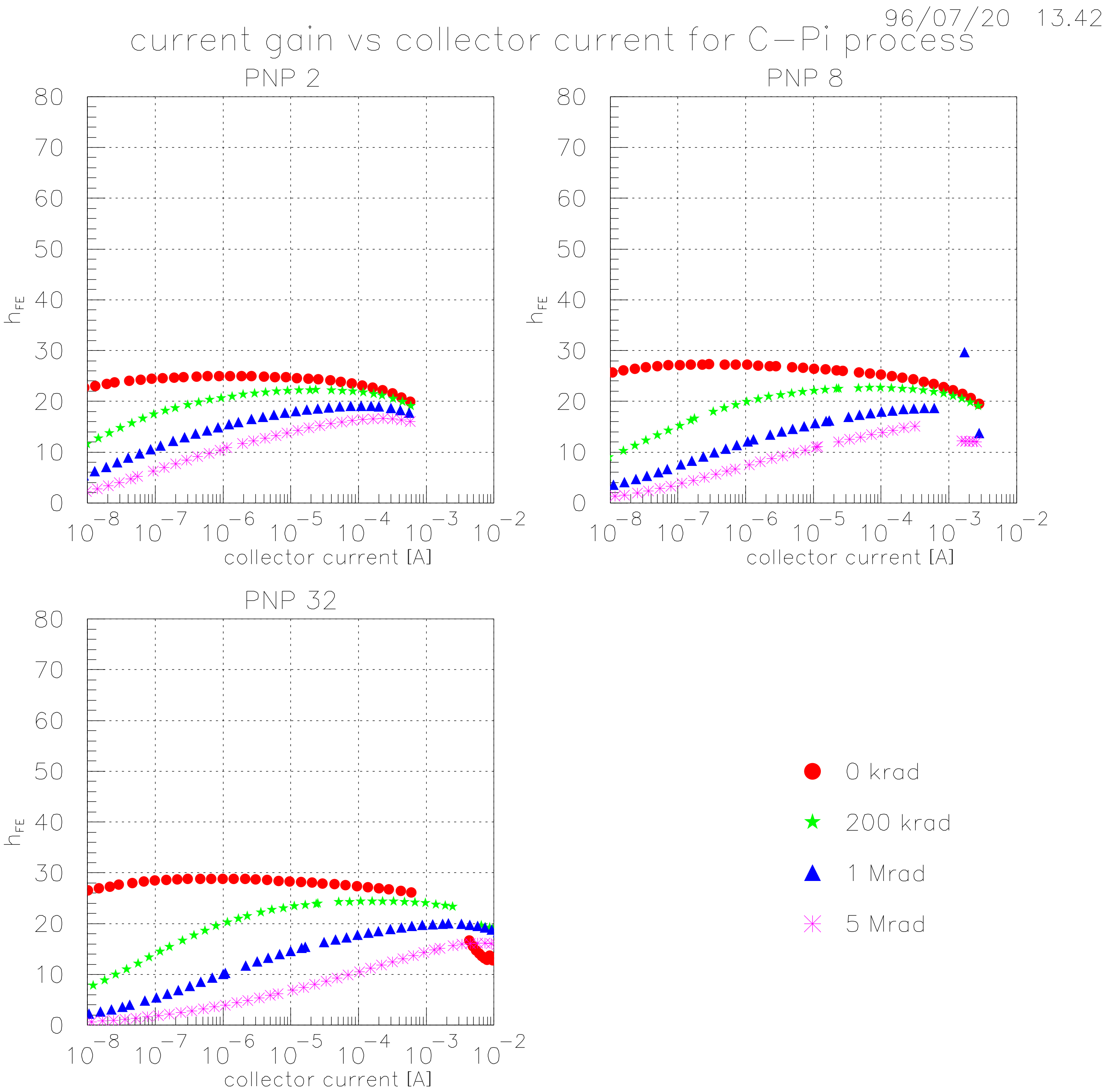
3 Tests

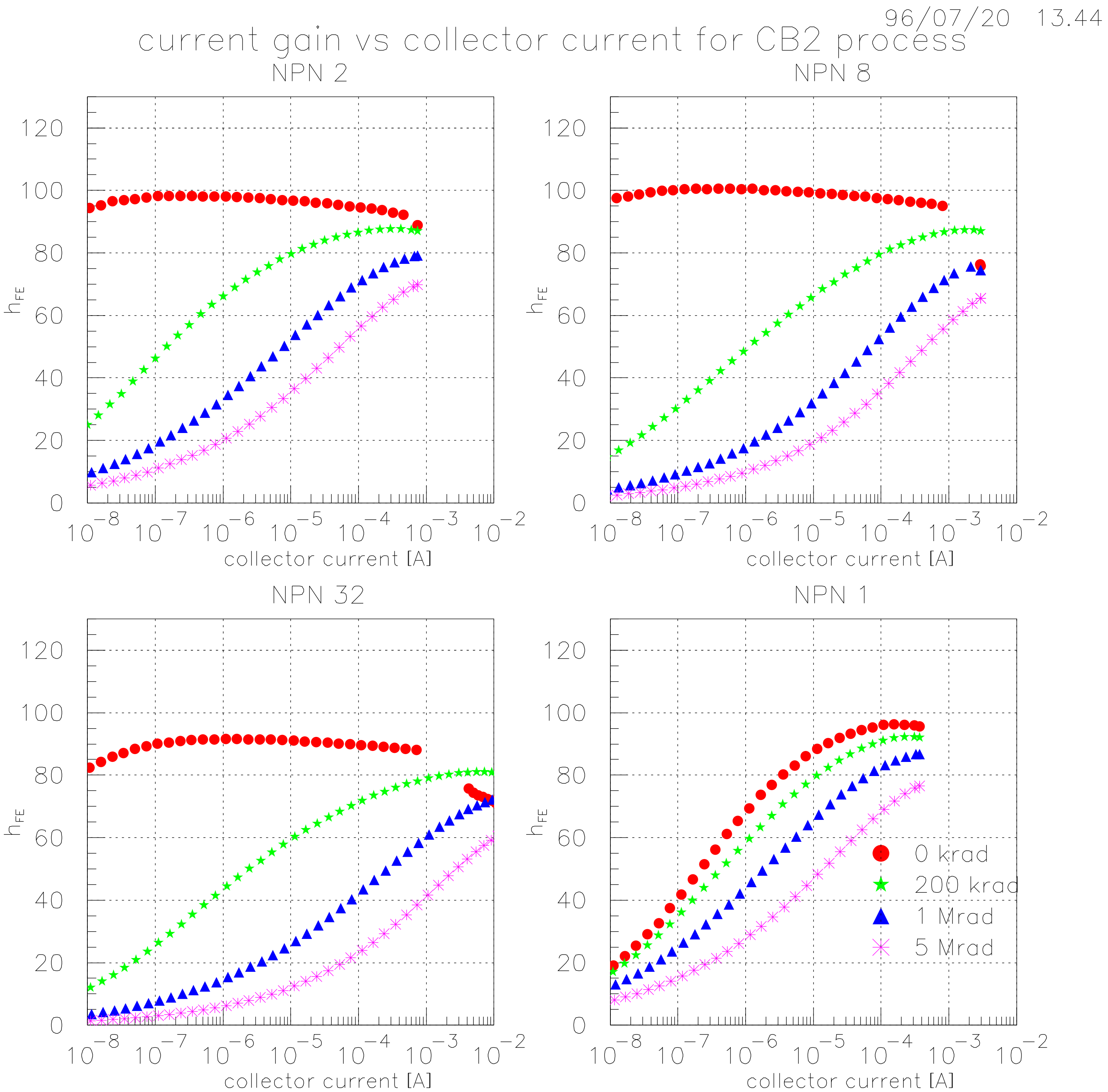
- photon irradiation
  - 1 chip of each process
  - in ^{60}Co source with rate 12 $\frac{krad}{h}$ at UCSC
  - biased during irradiation
  - measurements pre-rad, 200 krad, 1 Mrad, 5 Mrad (and 10 Mrad)
  - after each dose:
    forward gummel plot
    common emitter characteristic

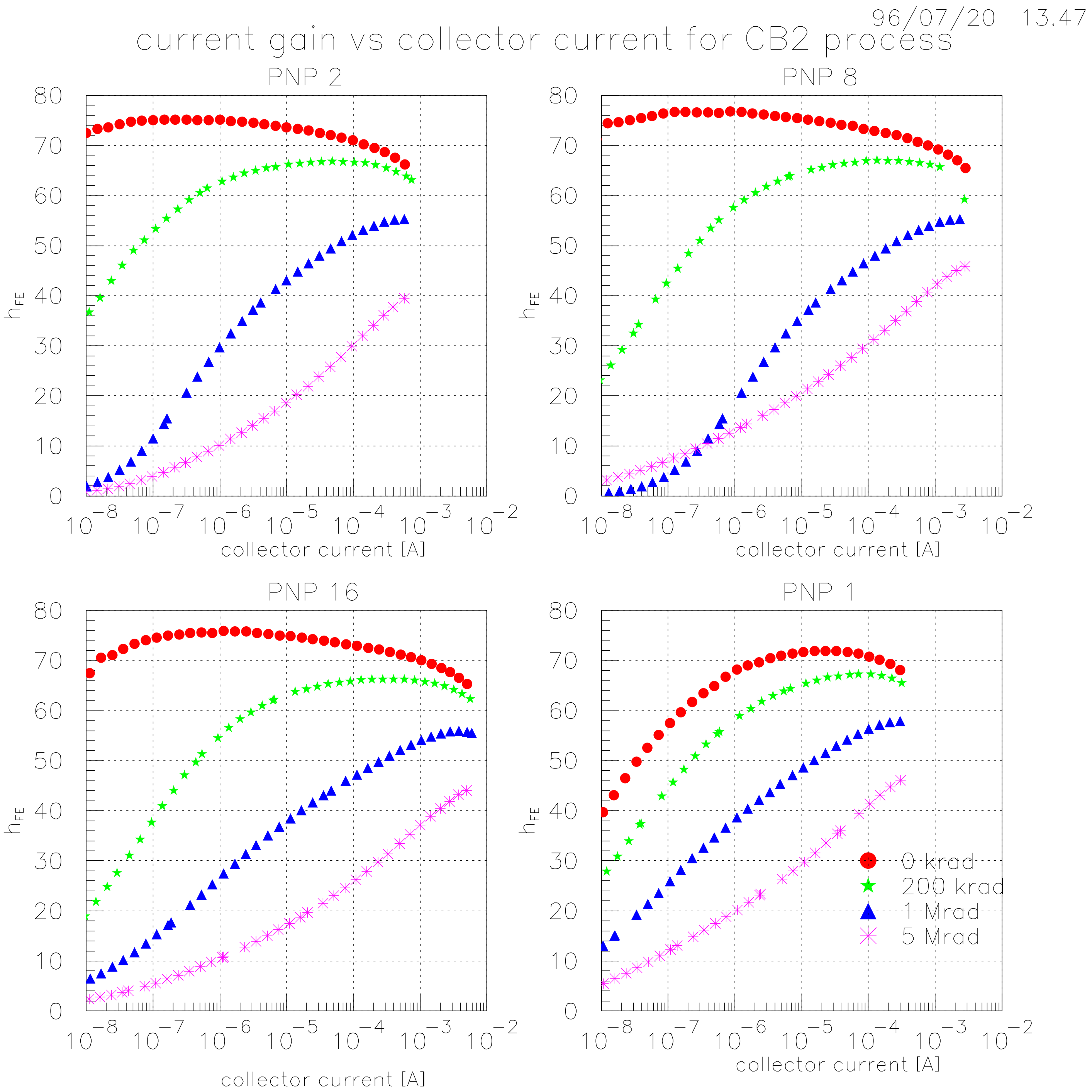
- proton irradiation
  - 2 chips of each process
  - 5×10^{13} cm^{-2} 55 MeV protons at LBL
  - biased during irradiation
  - stored at -20°C after irradiation
  - 1 set stored at -20°C since then
  - 1 set heated up to 100°C for 100h, 200h (and 300h)

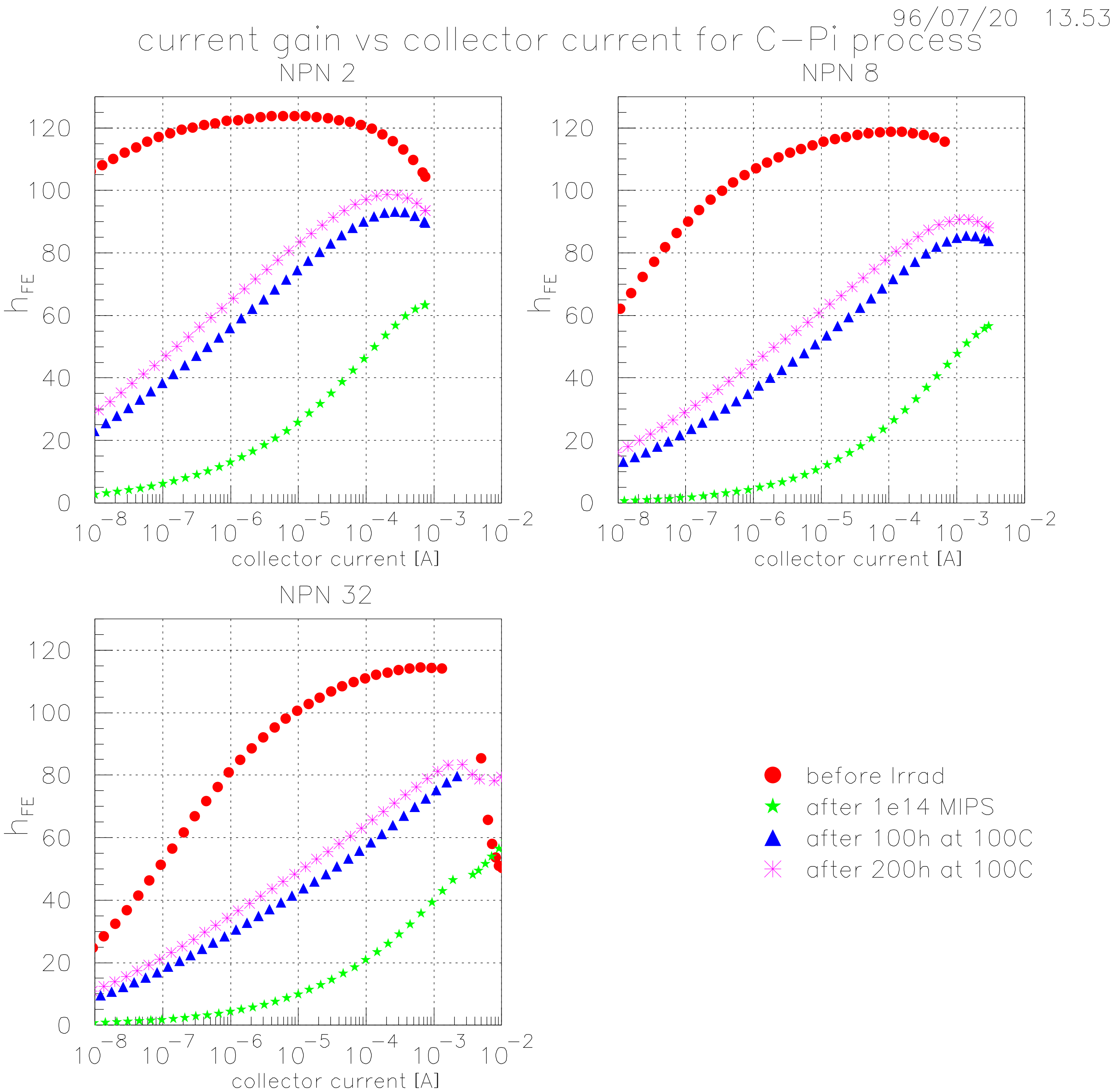
4 Results

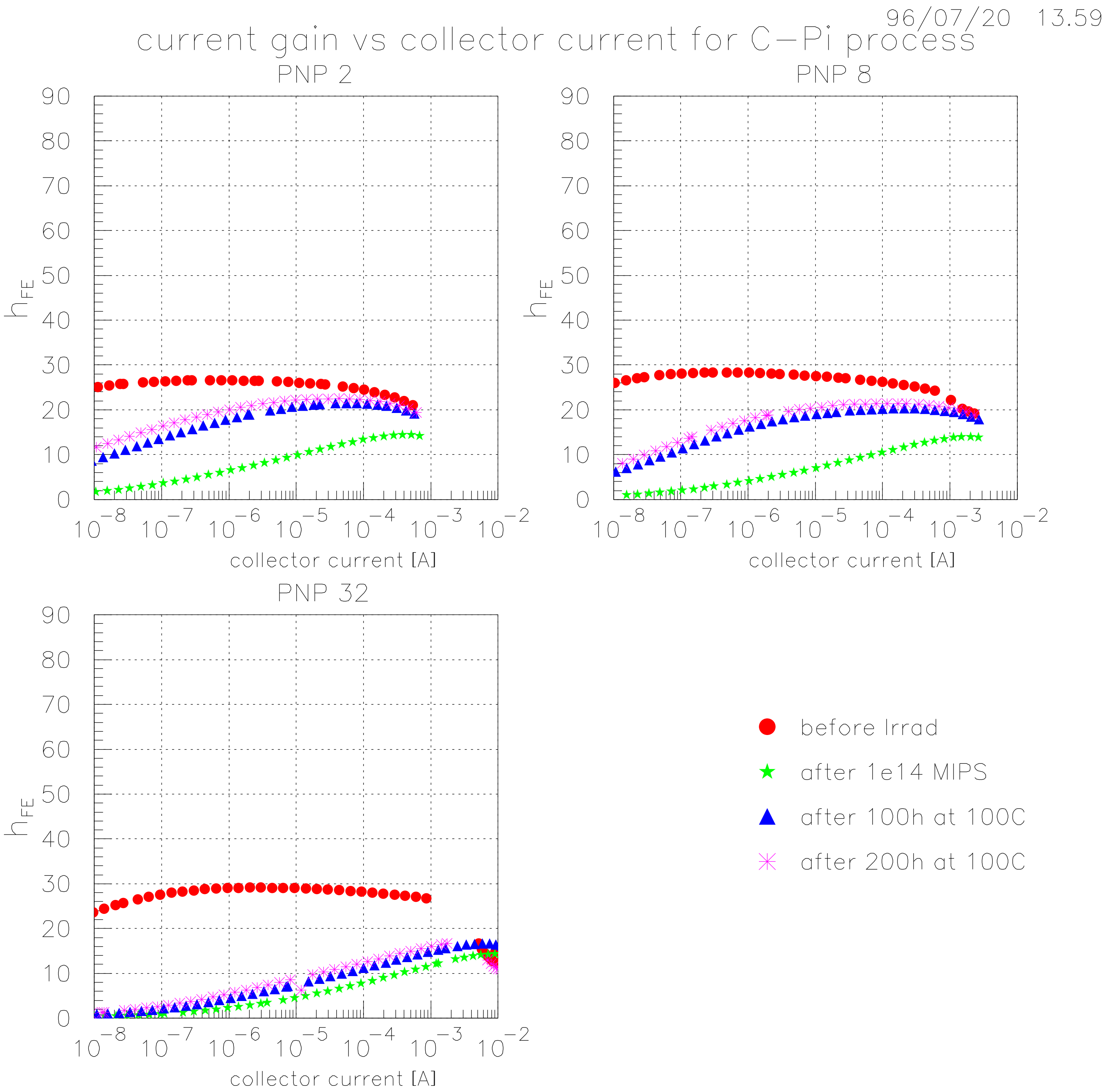

96/07/20 13.40
current gain vs collector current for C–Pi process
NPN 2
NPN 8
NPN 32
h_{FE}
collector current [A]
0 krad
200 krad
1 Mrad
5 Mrad

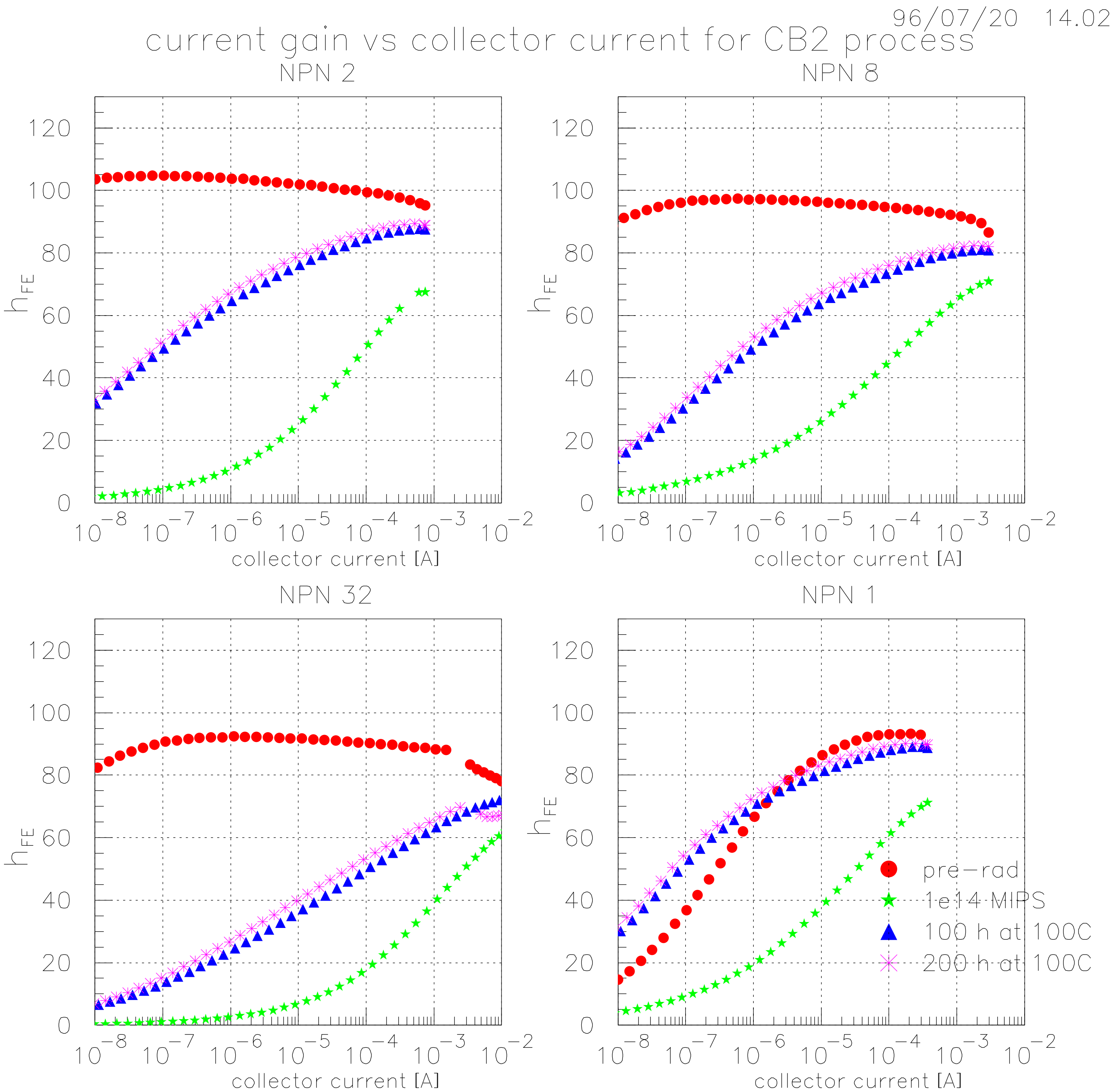

96/07/20 13.42
current gain vs collector current for C−Pi process
PNP 2
PNP 8
PNP 32
h_{FE}
collector current [A]
0 krad
200 krad
1 Mrad
5 Mrad

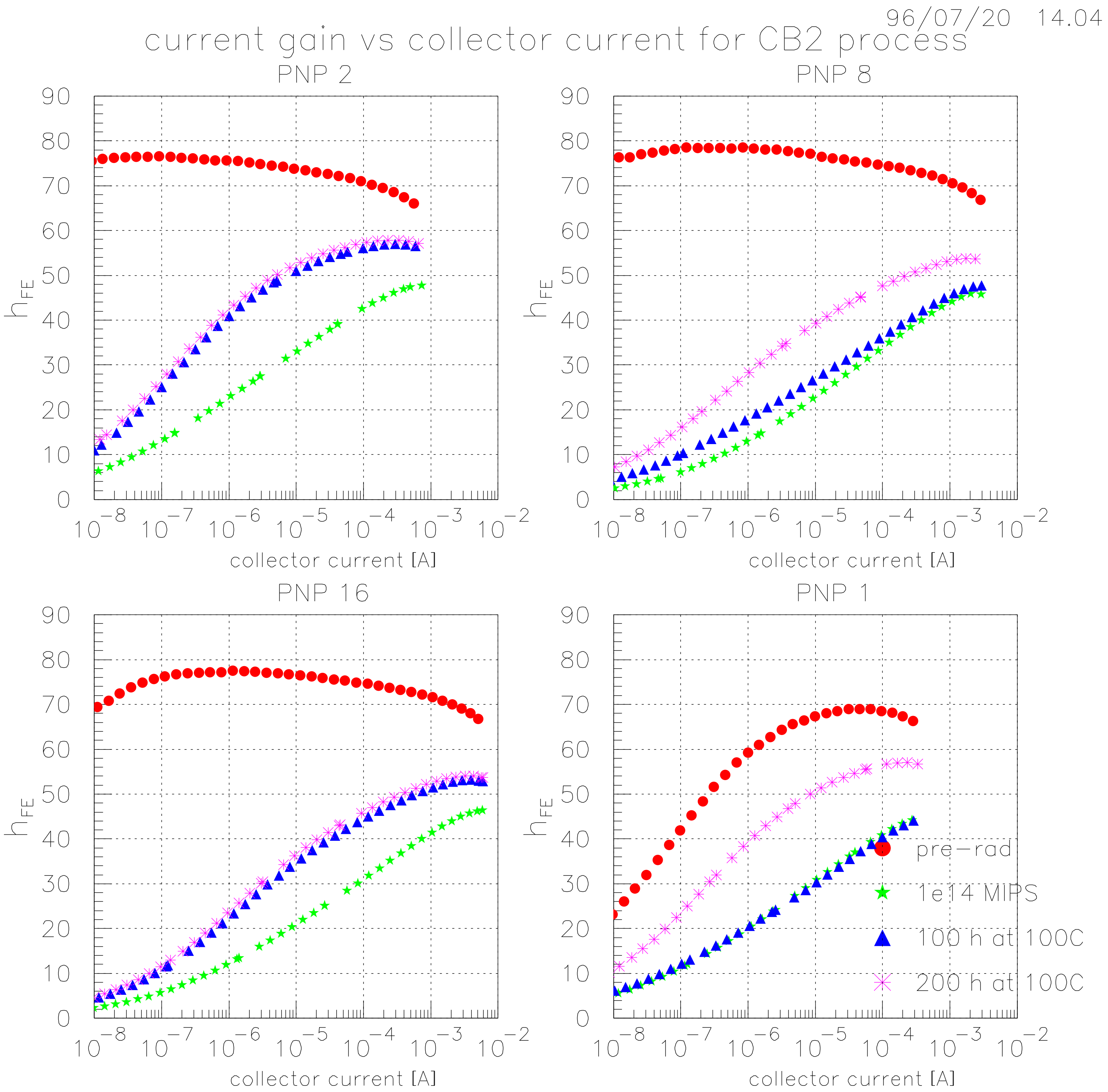

96/07/20 13.44
current gain vs collector current for CB2 process
NPN 2
NPN 8
NPN 32
NPN 1
h_{FE}
collector current [A]
0 krad
200 krad
1 Mrad
5 Mrad


96/07/20 13.47
current gain vs collector current for CB2 process
PNP 2
PNP 8
PNP 16
PNP 1
h_FE
collector current [A]
0 krad
200 krad
1 Mrad
5 Mrad

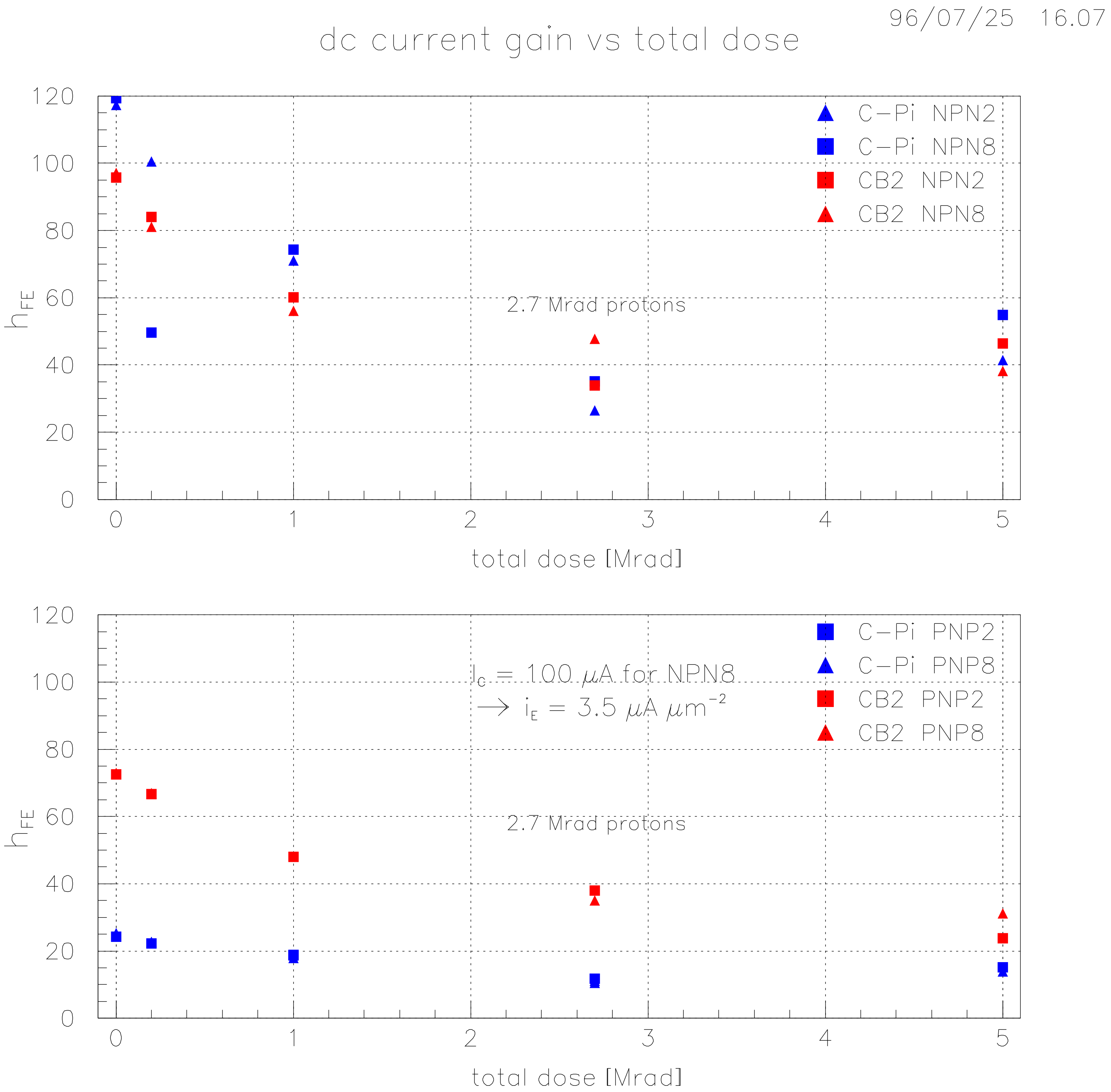

96/07/20 13.53
current gain vs collector current for C−Pi process
NPN 2
NPN 8
NPN 32
h_{FE}
collector current [A]
before Irrad
after 1e14 MIPS
after 100h at 100C
after 200h at 100C

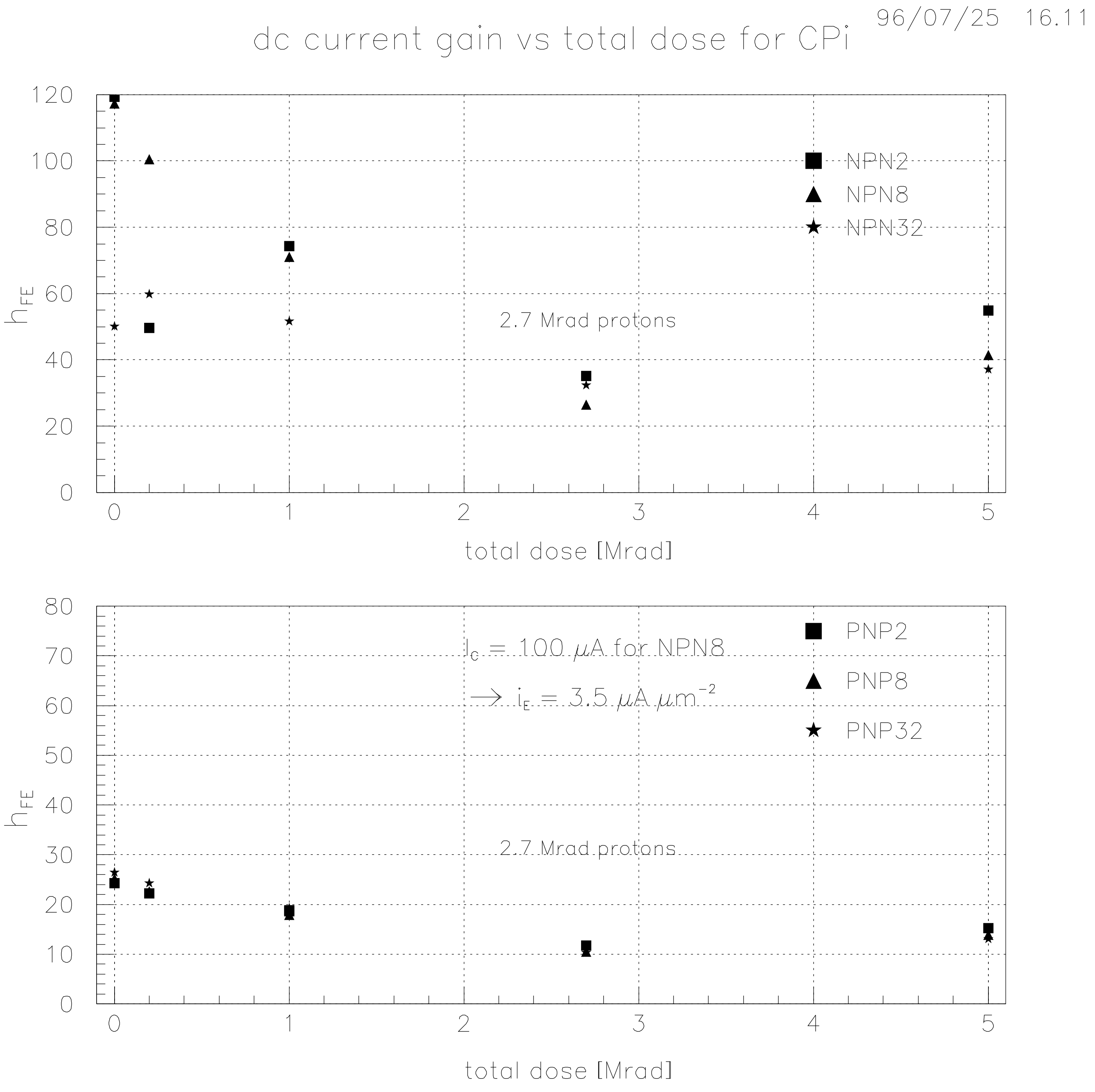

96/07/20 13.59
current gain vs collector current for C–Pi process
PNP 2
PNP 8
PNP 32
h_{FE}
collector current [A]
before Irrad
after 1e14 MIPS
after 100h at 100C
after 200h at 100C

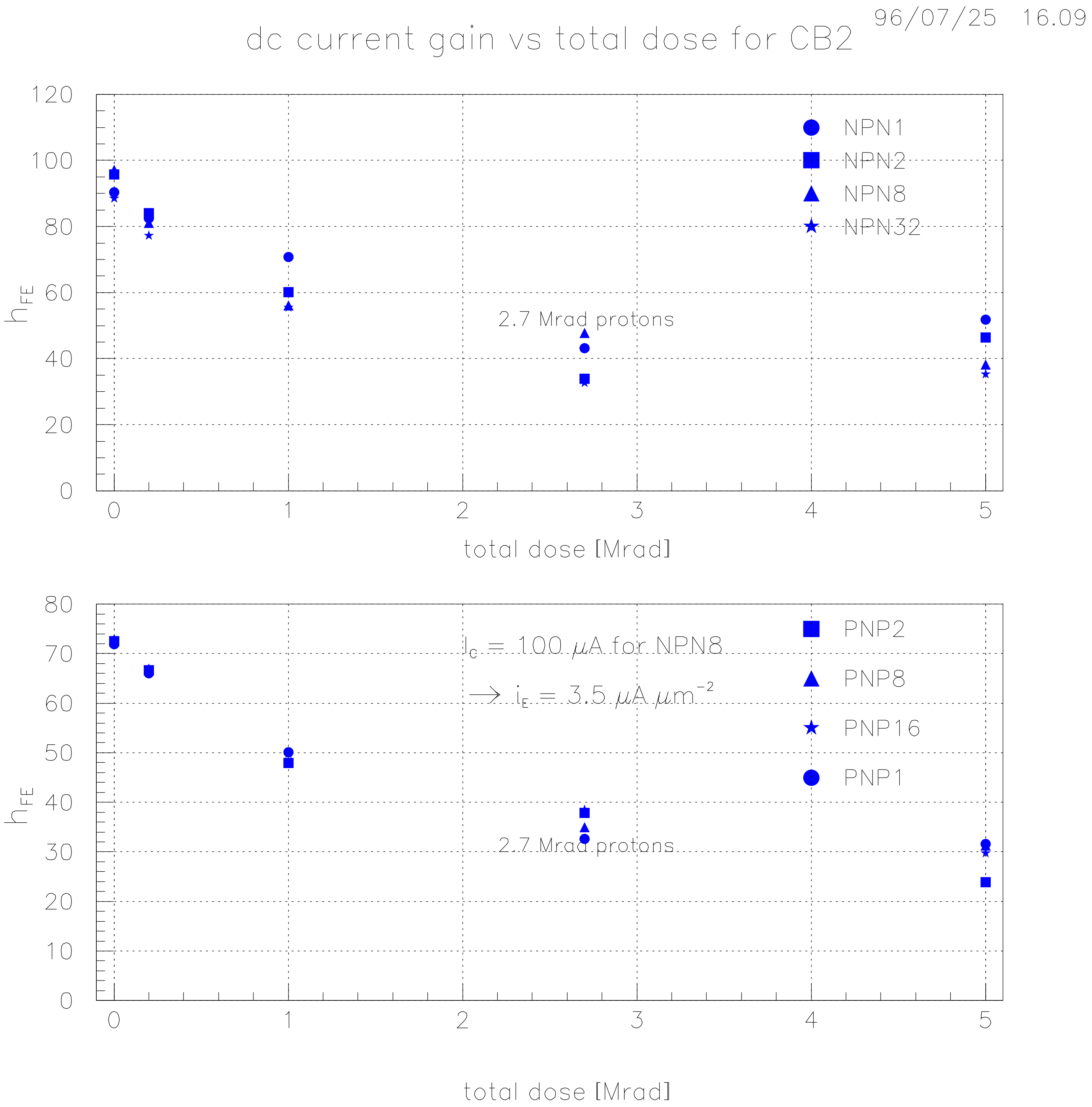

96/07/20 14.02
current gain vs collector current for CB2 process
NPN 2
NPN 8
NPN 32
NPN 1
h_{FE}
collector current [A]
pre−rad
1e14 MIPS
100 h at 100C
200 h at 100C



96/07/20 14.04
current gain vs collector current for CB2 process
PNP 2
PNP 8
PNP 16
PNP 1
h_{FE}
collector current [A]
pre−rad
1e14 MIPS
100 h at 100C
200 h at 100C


96/07/25 16.07
dc current gain vs total dose
C−Pi NPN2
C−Pi NPN8
CB2 NPN2
CB2 NPN8
2.7 Mrad protons
h_{FE}
total dose [Mrad]
C−Pi PNP2
C−Pi PNP8
CB2 PNP2
CB2 PNP8
I_C = 100 μA for NPN8
$\rightarrow$ i_E = 3.5 μA μm^{-2}
2.7 Mrad protons
h_{FE}
total dose [Mrad]


96/07/25 16.11
dc current gain vs total dose for CPi
120
100
80
60
40
20
0
h_{FE}
0
1
2
3
4
5
total dose [Mrad]
NPN2
NPN8
NPN32
2.7 Mrad protons
80
70
60
50
40
30
20
10
0
h_{FE}
0
1
2
3
4
5
total dose [Mrad]
PNP2
PNP8
PNP32
I_C = 100 μA for NPN8
$\rightarrow$ i_E = 3.5 μA μm^{-2}
2.7 Mrad protons


96/07/25 16.09
dc current gain vs total dose for CB2
NPN1
NPN2
NPN8
NPN32
2.7 Mrad protons
h_{FE}
total dose [Mrad]
PNP2
PNP8
PNP16
PNP1
I_C = 100 μA for NPN8
$\rightarrow$ i_E = 3.5 μA μm^{-2}
2.7 Mrad protons
h_{FE}
total dose [Mrad]

5 Summary

	C-Pi		CB2	
	NPN	PNP	NPN	PNP
h_{FE}^{max} pre-rad	120	30	100	80
h_{FE} at 3.5 $\frac{\mu A}{\mu m^2}$	115	25	95	70
at 3.5 $\frac{\mu A}{\mu m^2}$				
h_{FE} (200 krad)	100 (-13%)	22 (-12%)	82 (-14%)	67 (-4%)
h_{FE} (1 Mrad)	72 (-37%)	17 (-32%)	57 (-40%)	47 (-33%)
h_{FE} (5 Mrad)	40 (-65%)	12 (-48%)	40 (-58%)	30 (-57%)
h_{FE} (proton)	30 (-75%)	10 (-60%)	40 (-58%)	35 (-50%)

- h_{FE} (CB2 PNP) $\approx 3 \times h_{FE}$ (C-Pi PNP)
- h_{FE} (CB2 NPN) $<$ h_{FE} (C-Pi NPN) for smaller total dosis
- h_{FE} (CB2 NPN) $\geq$ h_{FE} (C-Pi NPN) for larger total dosis
- CB2 harder than C-Pi against displacement damage
- CB2 and C-Pi comparable regarding ionization effects