



# **Modellierung von 80 Ghz PNPs mit VBIC**

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## Outline

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- IHP Roadmap
- Complementary technology
- Basic PNP modeling
- 5 Terminal modeling
- Temperature and geometrical scaling
- Conclusion – future activities



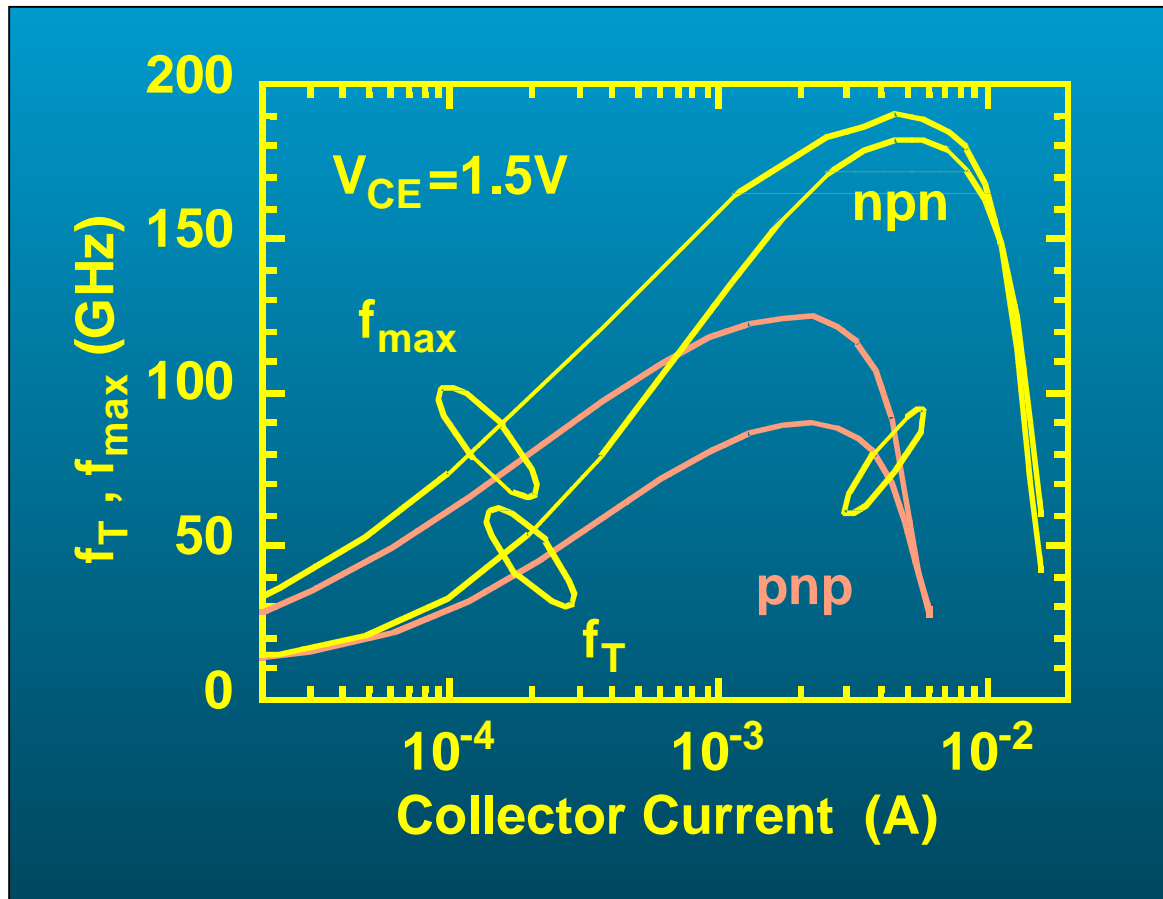
## Technology Roadmap (MPW service)

Process	Features $f_T/f_{MAX}$ [GHz]/ $BV_{CE0}$ [V]	digital libs	2004				2005				2006				2007	
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
SGC25A	85/100/2.5, 60/90/3.2	yes	Qualified	Qualified	Qualified	Qualified	Phase out	Phase out	Phase out	Phase out	Phase out	Phase out	Phase out	Phase out	Phase out	Phase out
SGC25B	120/140/2.3	yes	Early access	Early access	CMOS	Qualified	Early access	Early access	Bipolar	Qualified	Phase out	Phase out	Phase out	Phase out	Phase out	Phase out
SGC25C	200/200/1.9	yes	Early access	Early access	CMOS	Qualified	Early access	Early access	Bipolar	Qualified	Phase out	Phase out	Phase out	Phase out	Phase out	Phase out
SGB25VD	75/95/2.4, 45/90/4, 25/70/7, LD MOS	no	Early access	Early access	Early access	CMOS	Early access	Early access	Bipolar	Qualified	Qualified	Qualified	Qualified	Qualified	Qualified	Qualified
SG25H1	200/200/1.9, 190/230/1.9	yes	Development	Development	Development	Early access	Early access	Early access	Early access	Bipolar	CMOS	Qualified	Qualified	Qualified	Qualified	Qualified
SG25H2	nnp 180/180/1.9, pnp 90/125/2.5	yes	Development	Development	Development	Development	Development	Early access	Early access	Early access	CMOS	Early access	Bipolar	Qualified	Qualified	Qualified
SG25H3	110/190/2, 100/190/2.4, 45/140/5 25/80/7	yes	Development	Development	Development	Development	Development	Early access	Early access	Early access	CMOS	Early access	Early access	Bipolar	Qualified	Qualified
BIP1	300, HV device		Phase out	Phase out	Phase out	Phase out	Development	Development	Development	Development	Early access	Early access	Early access	Qualified	Qualified	Qualified
SG13H1	300, HV device	yes	Phase out	Phase out	Development	Development	Development	Development	Development	Development	Development	Development	Development	Early access	Early access	Early access

Development
  Early access
  Qualified
  Phase out



## RF Characteristics (SG25H2)



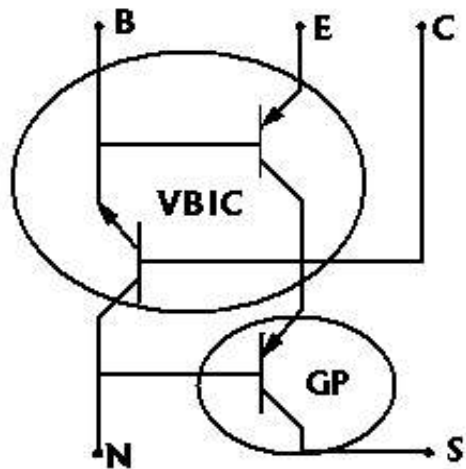
Drawn emitter size:  
 $2 \times (0.21 \times 0.84) \mu\text{m}^2$

Extrapolated at 30GHz with -20GHz/decade  
 $f_T/f_{MAX}$  (npn) = 180/185GHz; (pnp) = 90/125GHz

## Vertical PNP Modeling

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### Equivalent Circuit for VPNP Device



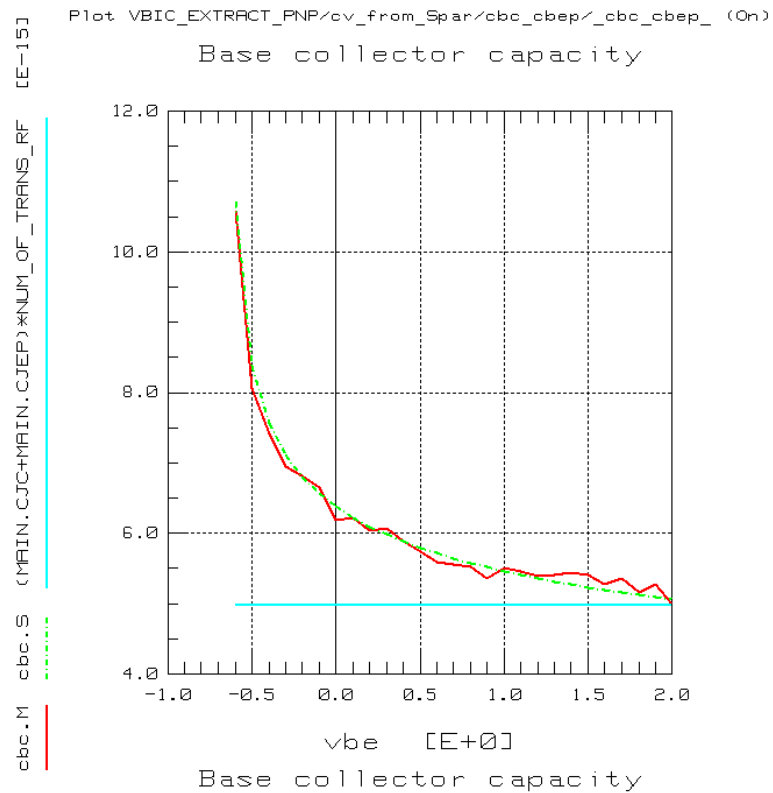
Reference:

Berkner, J.: "Modeling the Vertical PNP – Transistor using ICCAP and VBIC". European IC-CAP User Meeting Proceedings, June 1999 Marseille

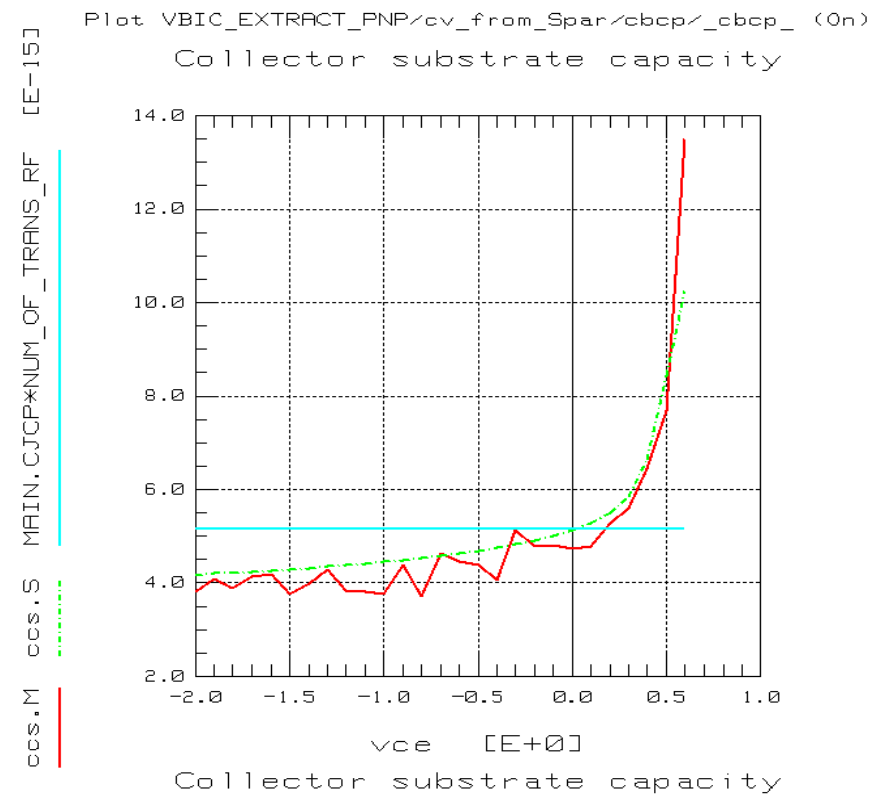
- Extraction strategy is integrated in ICCAP including temperature scaling and geometry scaling Simulator: Spectre 4.4.6
- 4 terminal measurements are performed at RF structures, 5 terminal measurements at DC structures



## Base collector



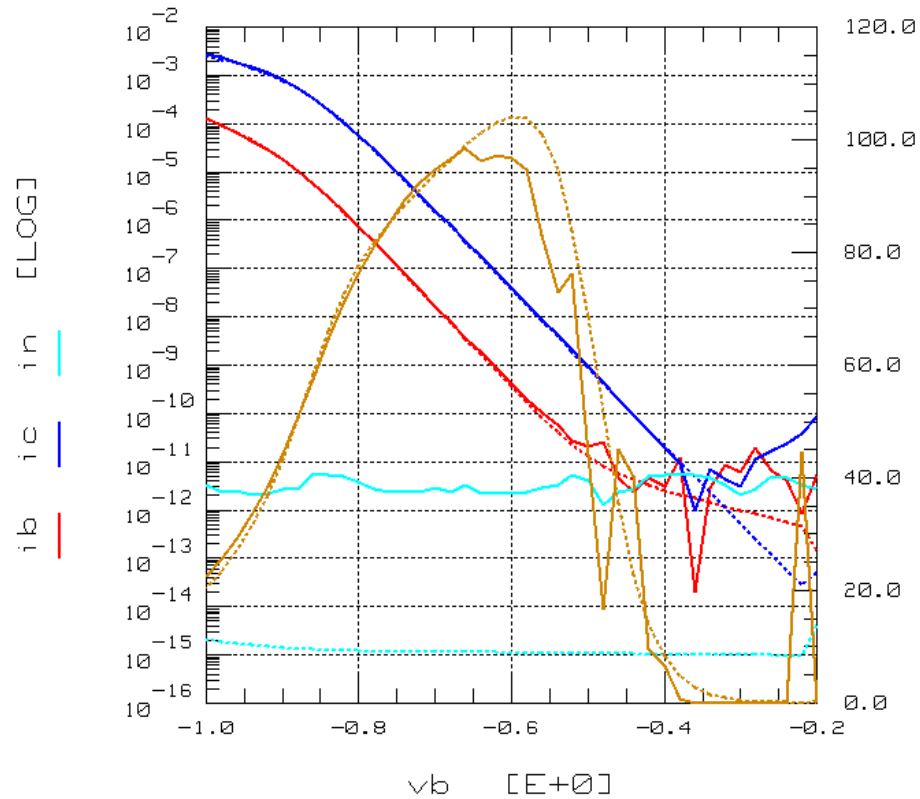
## Collector to N isolation





## Forward Gummel plot

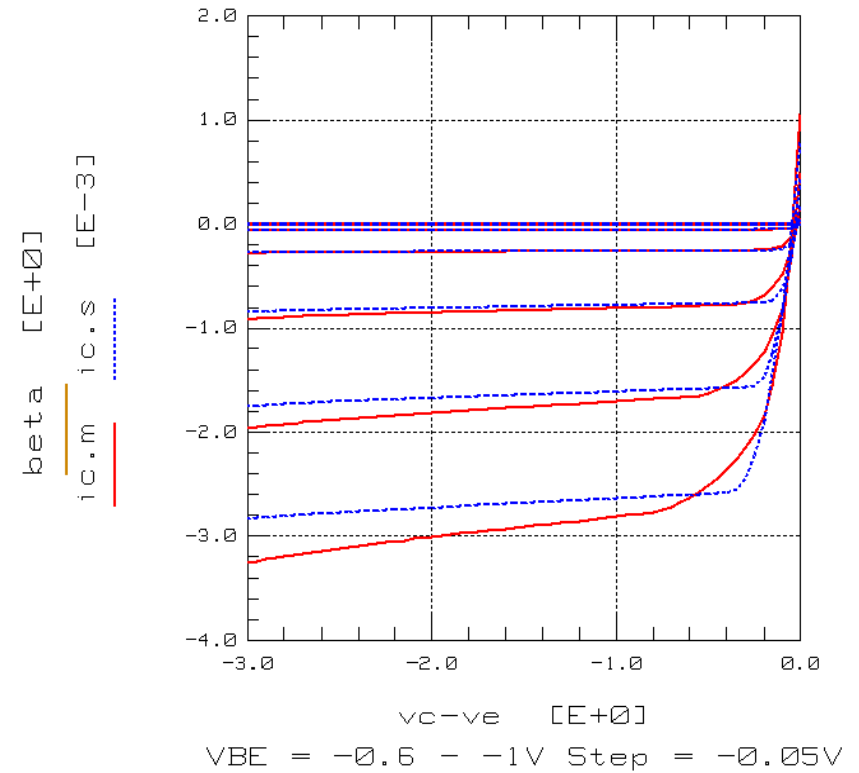
Plot VBIC\_EXTRACT\_PNP/dc\_gummel\_RF/fgummel\_vcb0/ibic\_vbe (On)



## Output characteristic vb forced

Plot VBIC\_EXTRACT\_PNP/dc\_out\_RF/foutput/ic\_vce\_lin (On)

Forward output characteristic vb controlled (RF Probes)



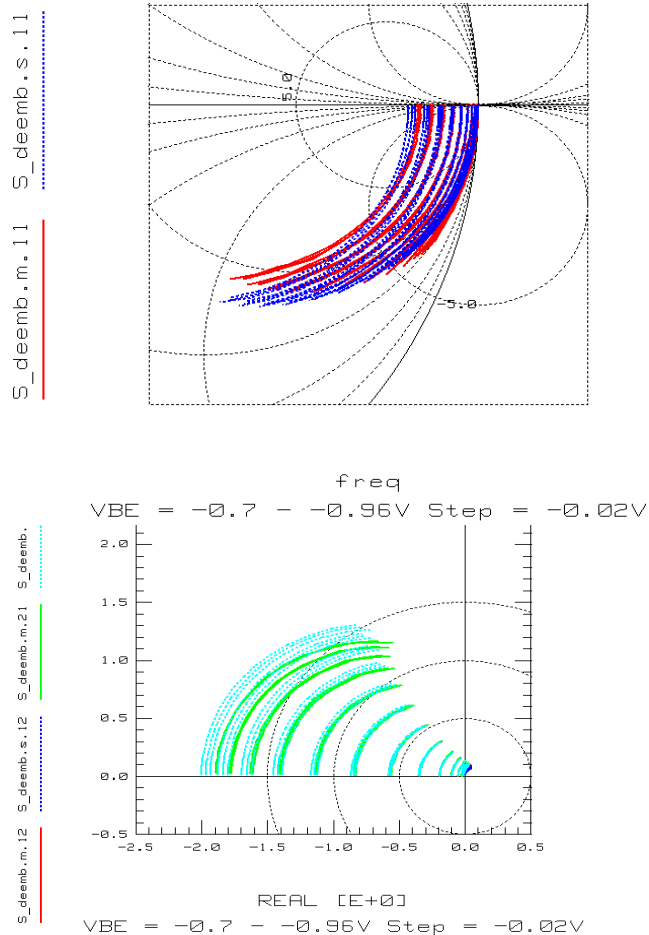




# Single device results - RF

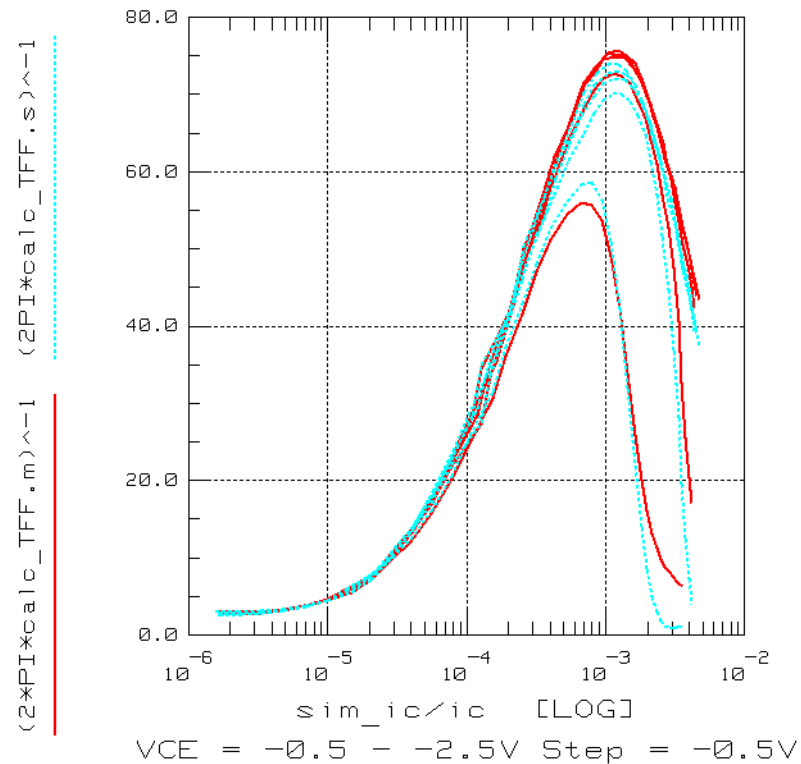
## S parameter

Plot VBIC\_EXTRACT\_PNP/nwa\_extr/fwd\_biased\_Spar/Sxx (Off)  
S11 and S22 parameter



## Ft extracted at 6.5 GHz

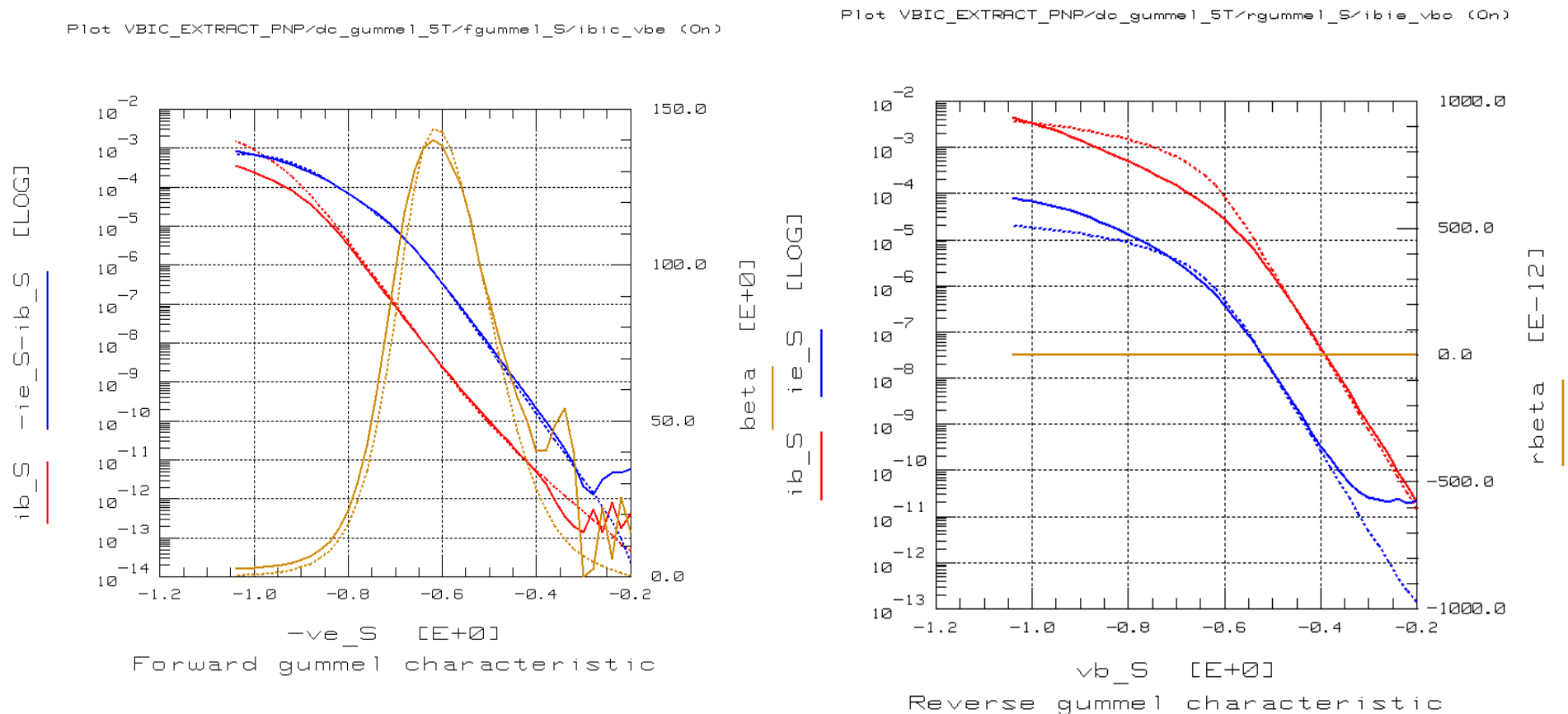
Plot VBIC\_EXTRACT\_PNP/nwa\_extr/tf\_vbe\_vce/ftvsic (On)  
ft versus ic extrapolated from 6.49 GHz





## Single device results – parasitic PNP

### Forward Gummel plot parasitic PNP Reverse Gummel plot parasitic PNP

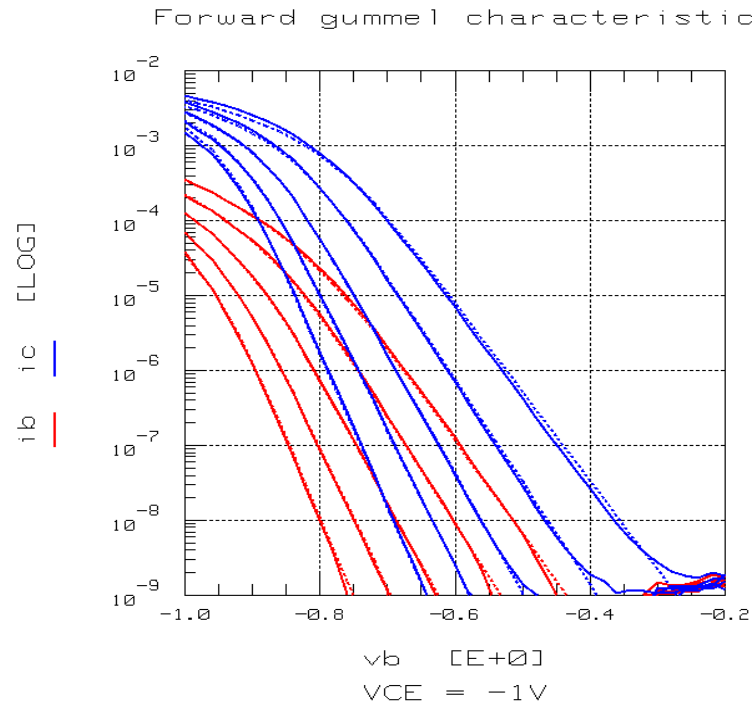


# Temperature modeling

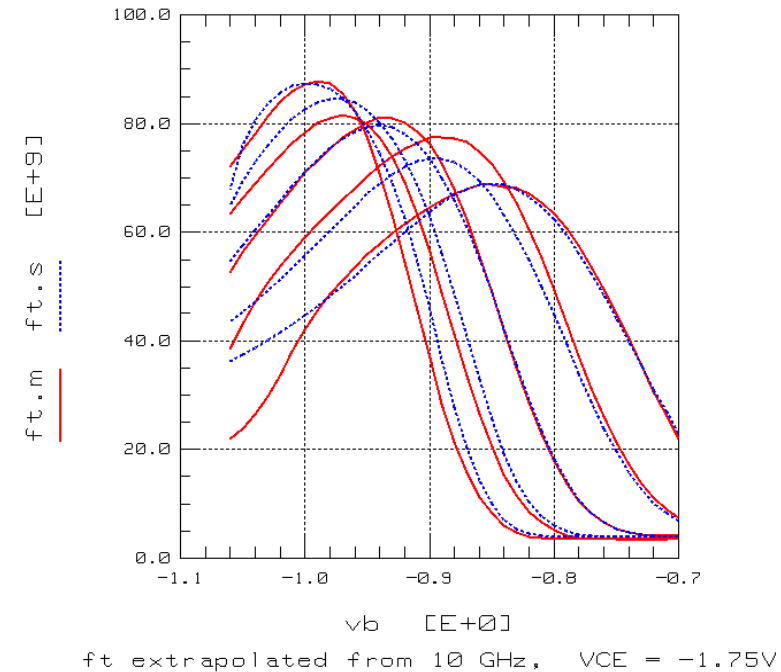


Temperature dependence at  $-40^{\circ}\text{C}$ ,  $-10^{\circ}\text{C}$ ,  $27^{\circ}\text{C}$ ,  $75^{\circ}\text{C}$ ,  $125^{\circ}\text{C}$

Plot VBIC\_TEMP\_EXTRACT/dc\_gumme1/fgumme1\_medium\_vce/ib1c\_vbe (Off)



Plot VBIC\_TEMP\_EXTRACT/nwa\_extr/tf\_vbe\_vce/ftvsvb (On)



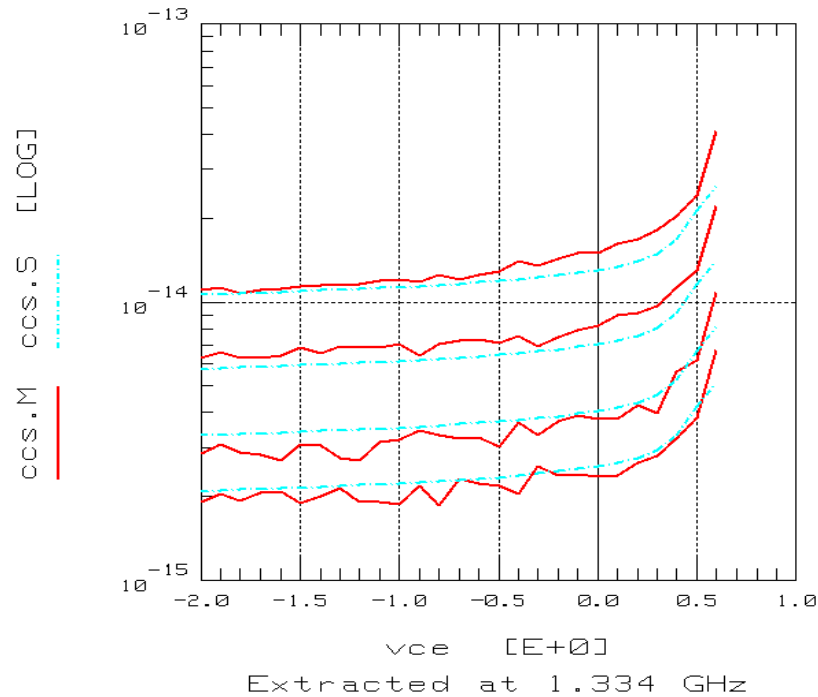
# Geometry scaling



Multiple finger devices 1, 2, 4, 8

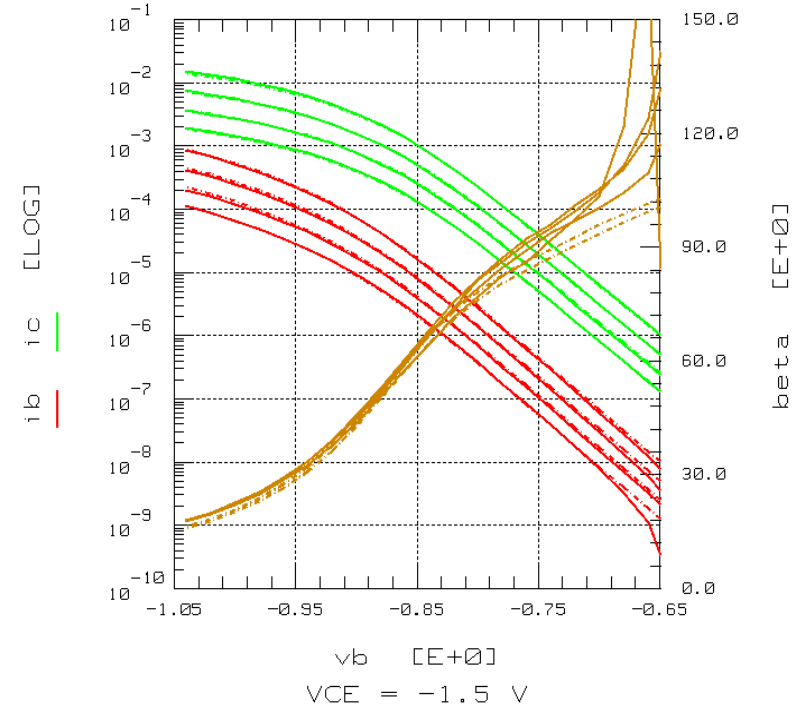
## Collector to N isolation

Plot VBIC\_AREA\_SCALE/cv\_from\_Spar/cbcp/\_cbcp\_ (On)  
Collector substrate capacity for different transistor sizes



## Forward Gummel plot

Plot VBIC\_AREA\_SCALE/dc\_gummel/fgummel\_medium\_vce/ibic\_vbe (Off)  
Forward gummel characteristic for different transistor sizes





## Conclusion - To Do

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- VBIC sufficient to model high performance vertical PNP
- Starting point for Circuit development
  
- Check splitting of VBIC GP parameters (resistors)
- Improve of extraction strategy
- CV and RF characterisation of parasitic PNP (GSSG structures)
- 1/f and RF noise modeling
- Model verification