

# Large Signal Modeling of InP/InGaAs DHBT with $f_{\max}$ up to 0.5THz

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✓ *high Speed Digital:*  
Frequency divider  
MUX/DEMUX

✓ *Analog-Digital Combine:*  
ADC/DAC

✓ *Terahertz:*  
THz Amplifier



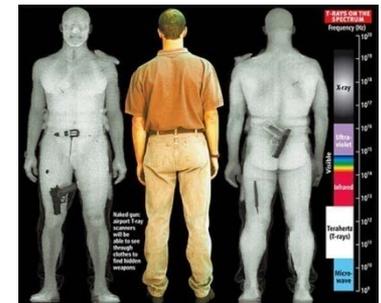
RF measurement facilities



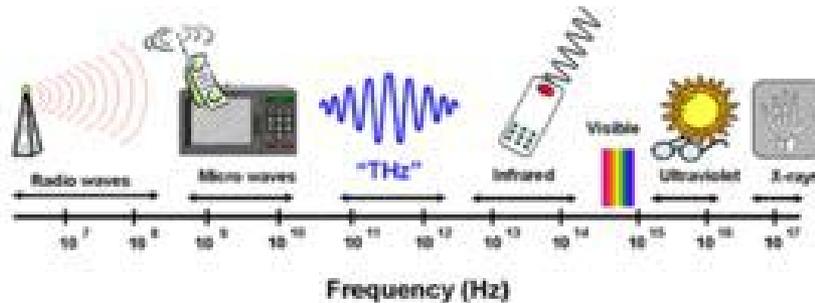
Optical Communication



Astronomy

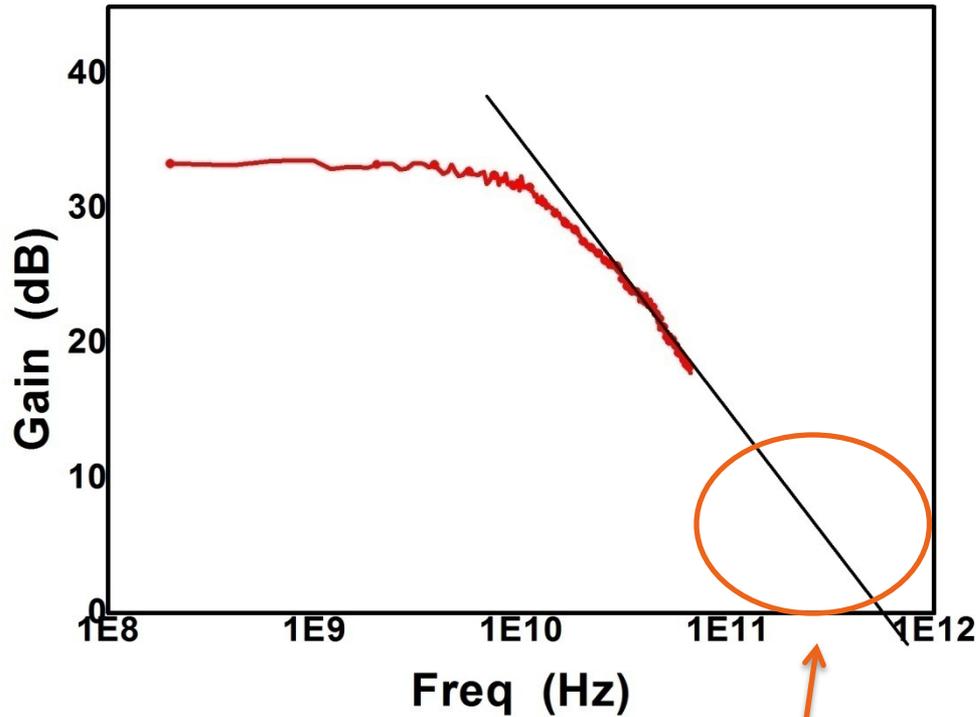


Security Check



THz: 0.3-3THz

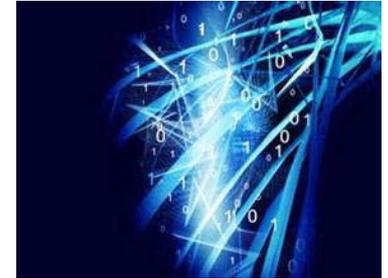
# Demand more *Gain*



More *Gain* in THz is needed!  
Higher  $f_{max}$  is needed!



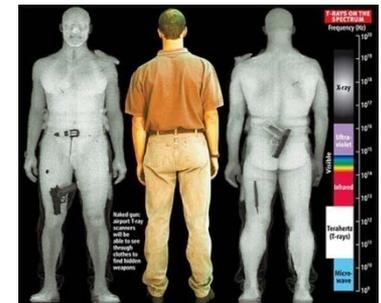
RF measurement facilities



Optical Communication

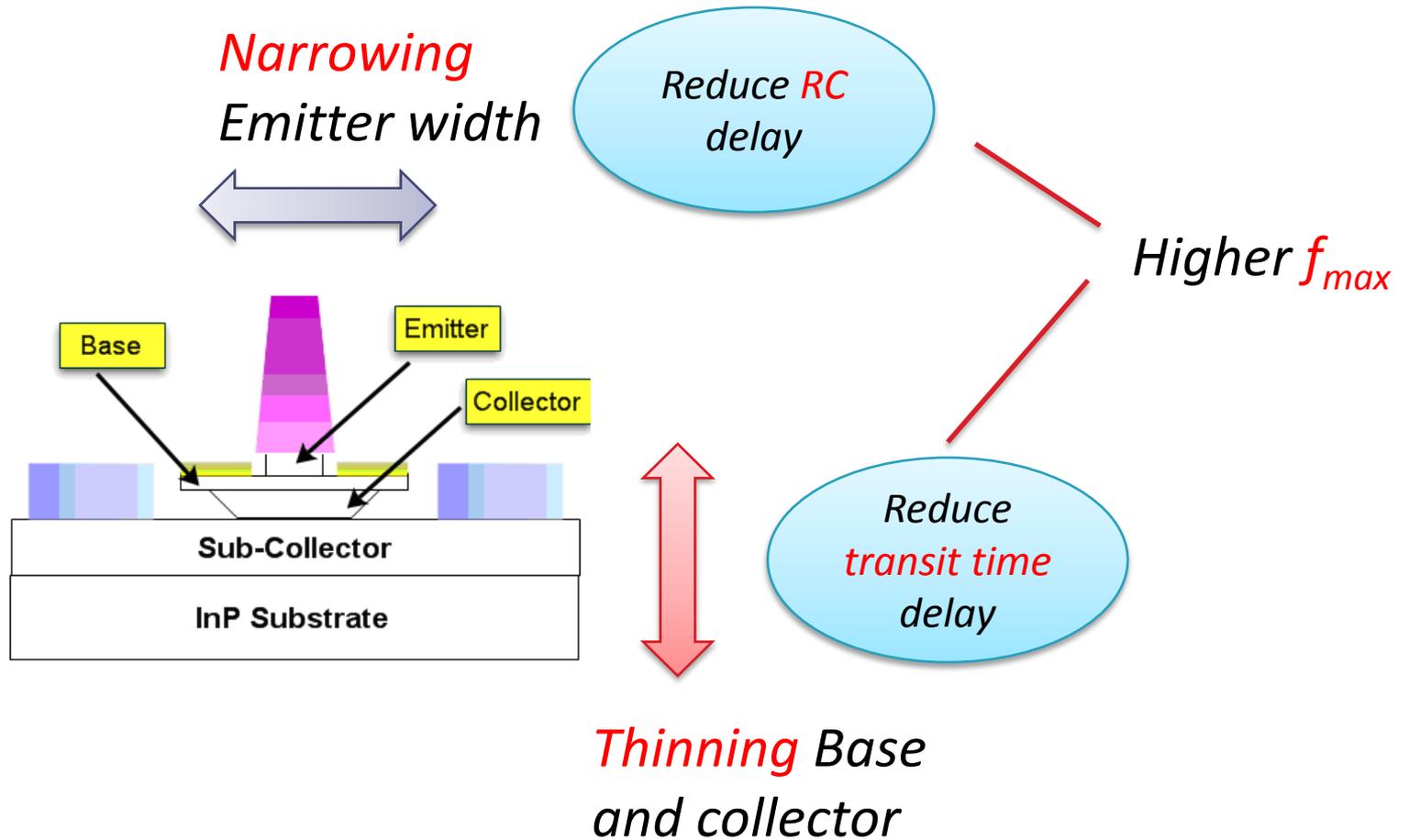


Astronomy Discovery

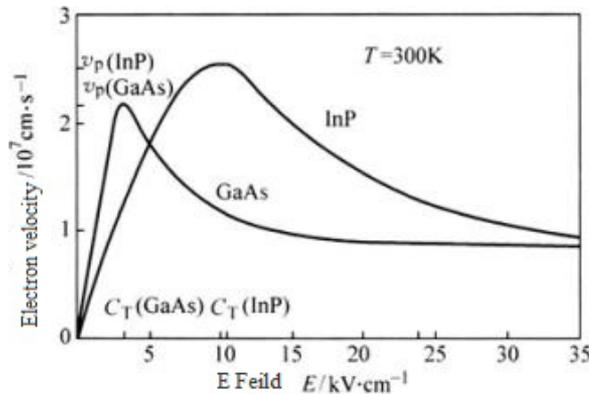


Security Check

# To Get *Higher* $f_{max}$



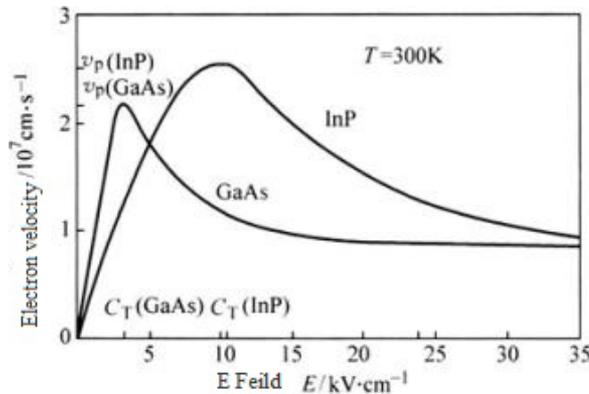
# Why *Indium Phosphide*



✓ *Higher electron velocity*

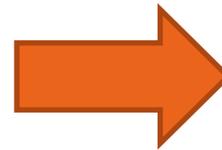
	<b>InP/InGaAs</b>	Si/SiGe	Superiority
Collector electron velocity	<b>2.5E7 cm/s</b>	1E7 cm/s	Smaller $\tau_c$ Larger $J_{kirk}$
Base electron diffusion velocity	<b>40 cm<sup>2</sup>/s</b>	4 cm <sup>2</sup> /s	Smaller $\tau_b$
Base sheet resistance	<b>500-800 Ohm</b>	5000 Ohm	Smaller $R_{bb}$

# Why *Indium Phosphide*



✓ *Higher electron velocity*

✓ *Smaller transit time*

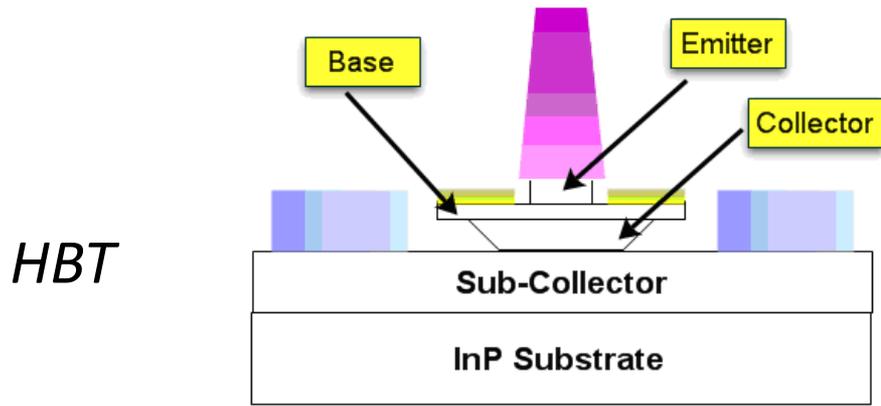


*InP is Better !*

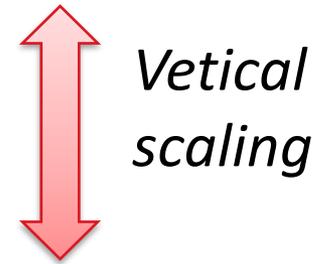
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# Reduce *Transit time*

✓ *Transit time reduction is easier for HBT*



HBT

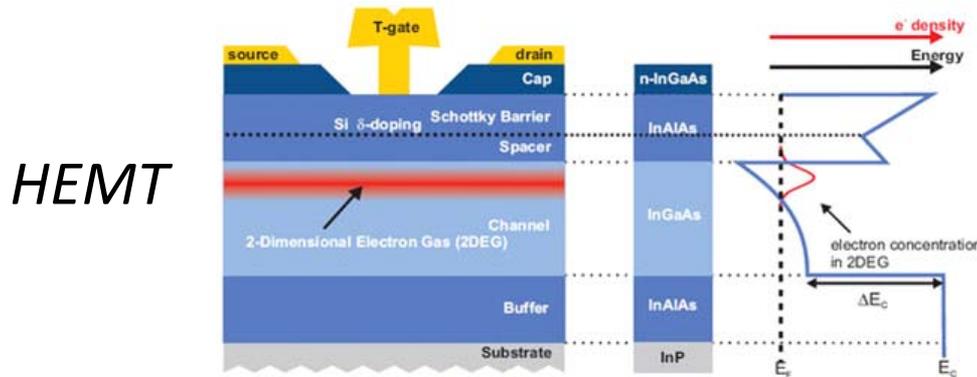


*Easy !*

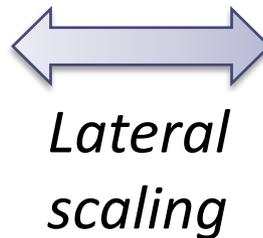
*Thinner Epi layer*

Compare

*Electron transition direction*



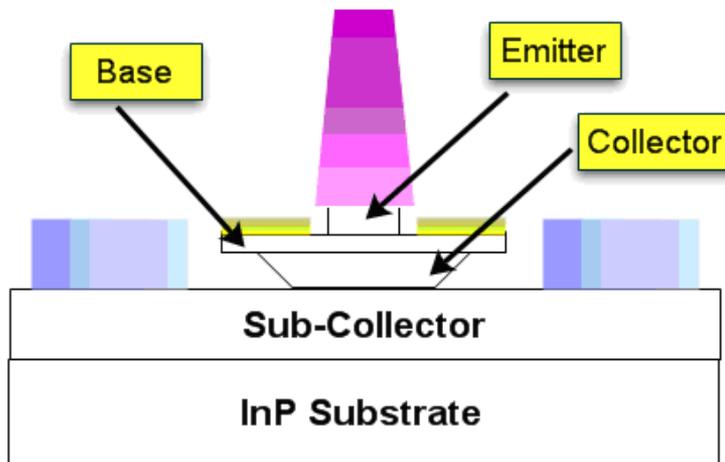
HEMT



*Hard !*

*Narrower gate width*

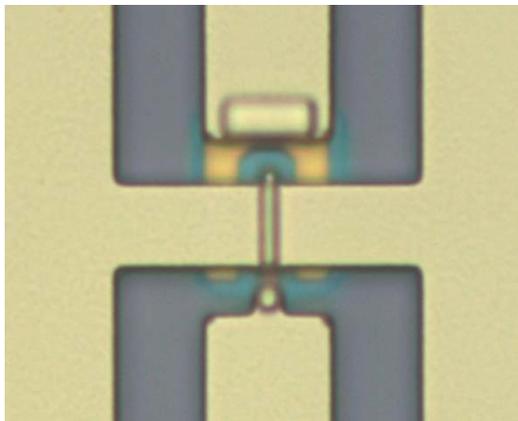
# Reduce *RC* delay



To half *RC* delay, we need:

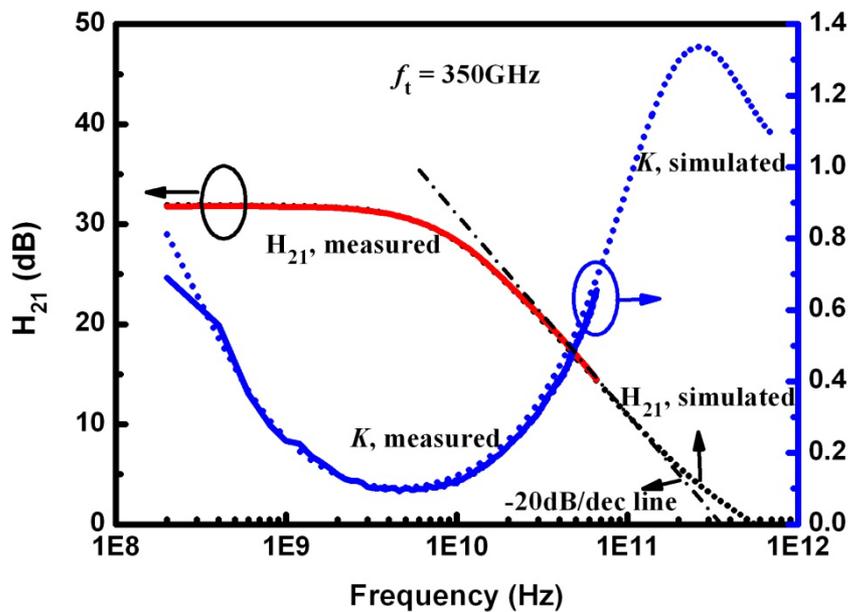
Parameter	Scaling
Emitter width	1/4
Contact resistivity	1/4
Current density	4
Collector thickness	1/2
Base thickness	1/1.4



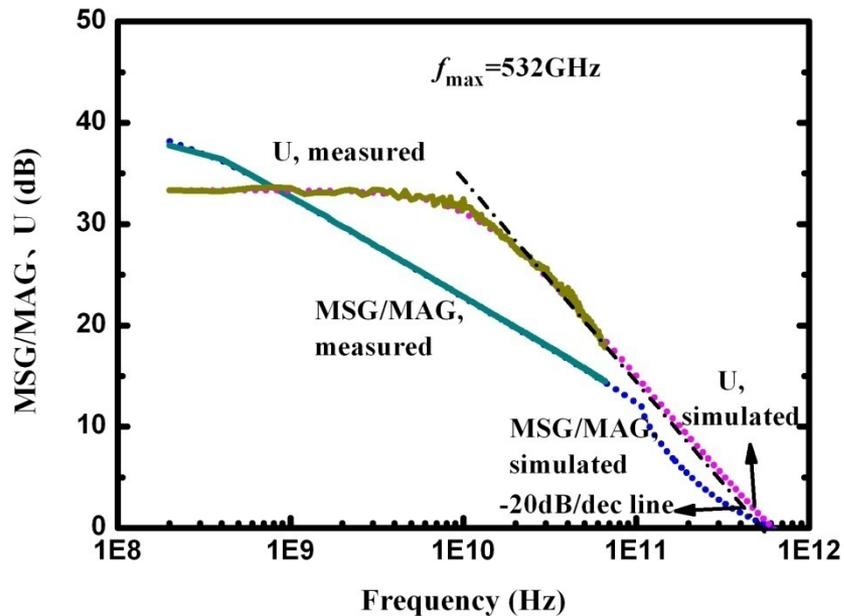


✓ NEDI 0.5 $\mu\text{m}$  HBT technology,  
peak performance :

$$f_{max} = 532 \text{ GHz}$$

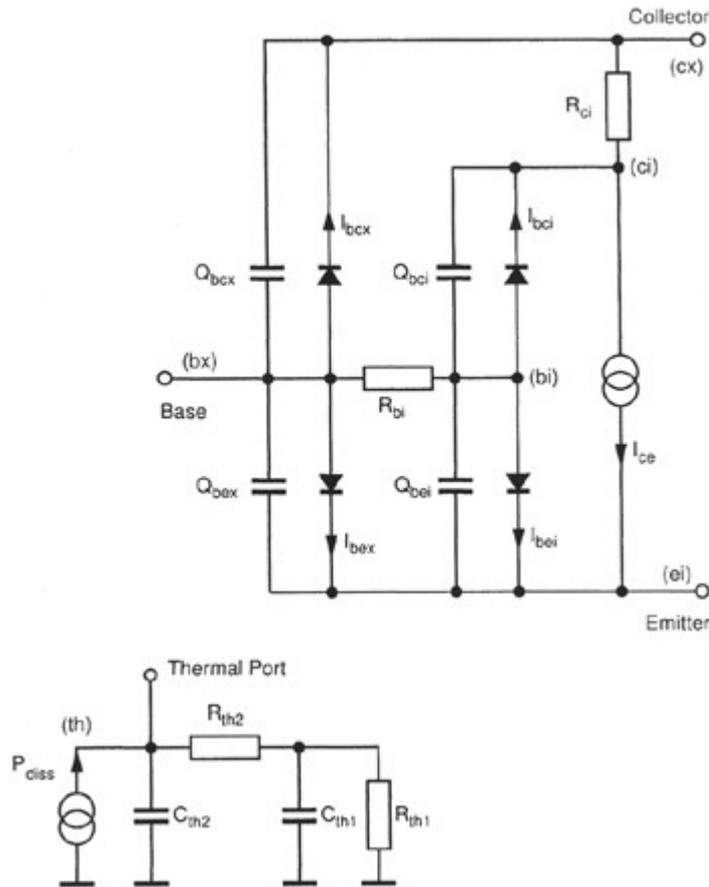


$$f_t = 350 \text{ GHz}$$



$$f_{max} = 532 \text{ GHz}$$

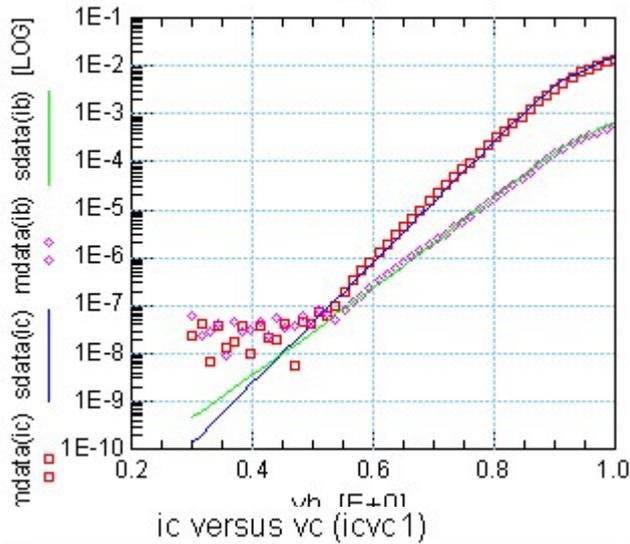
# Agilent HBT Model



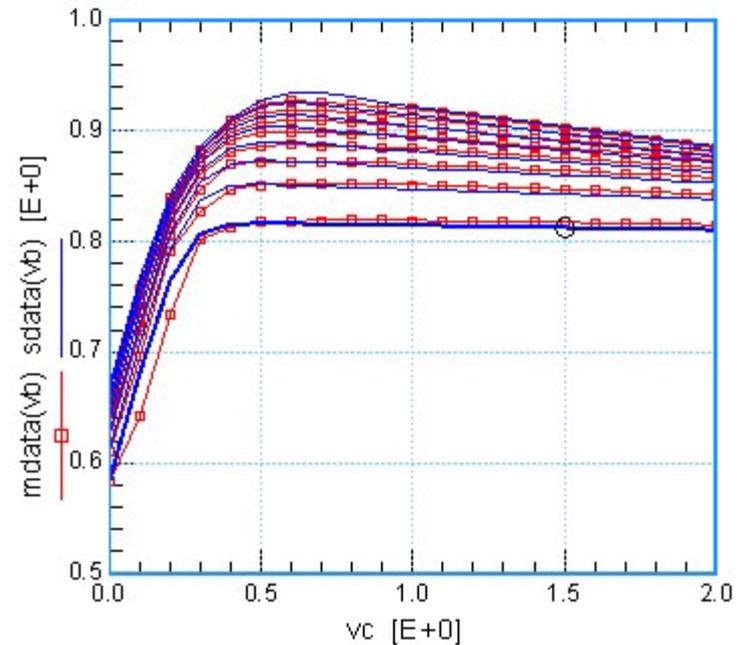
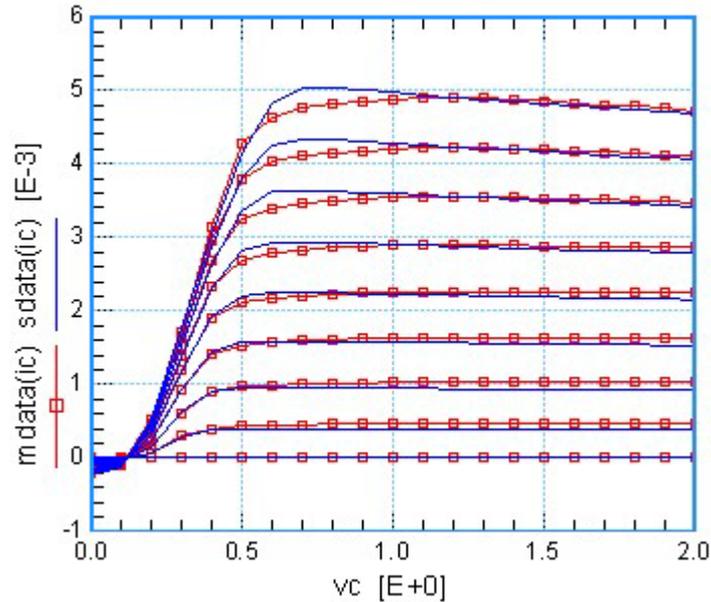
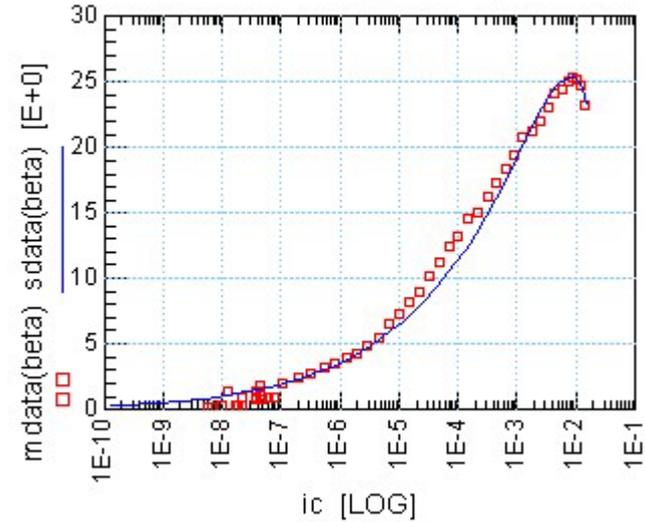
✓ Agilent HBT model was used for  $0.5\mu\text{m}$  InP/InGaAs DHBT modeling:

- ✓ More precise  $\beta$  model
- ✓ More precise  $T_c$  and  $T_{krk}$  model
- ✓ Partition of **BC junction** into intrinsic and extrinsic parts
- ✓ Self-heating

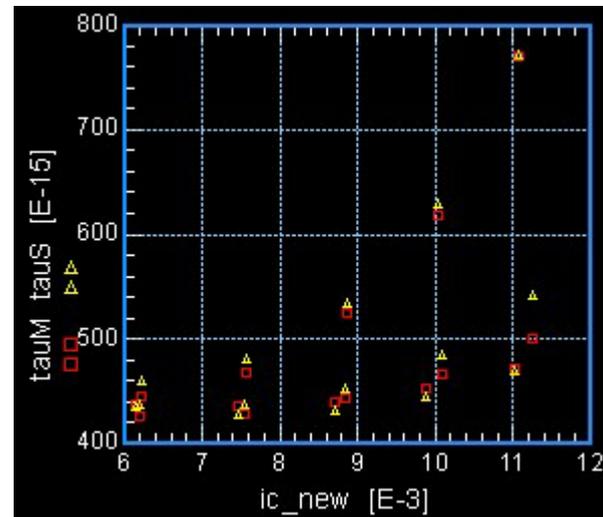
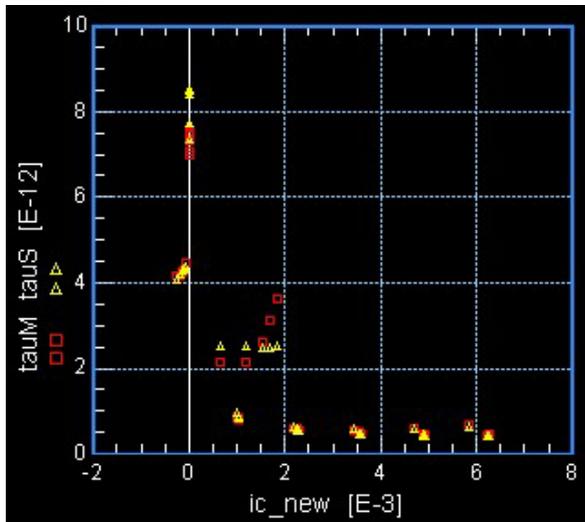
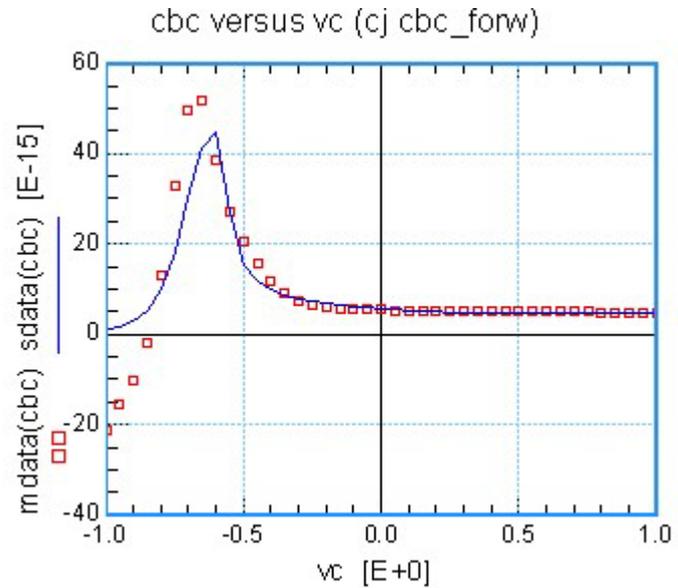
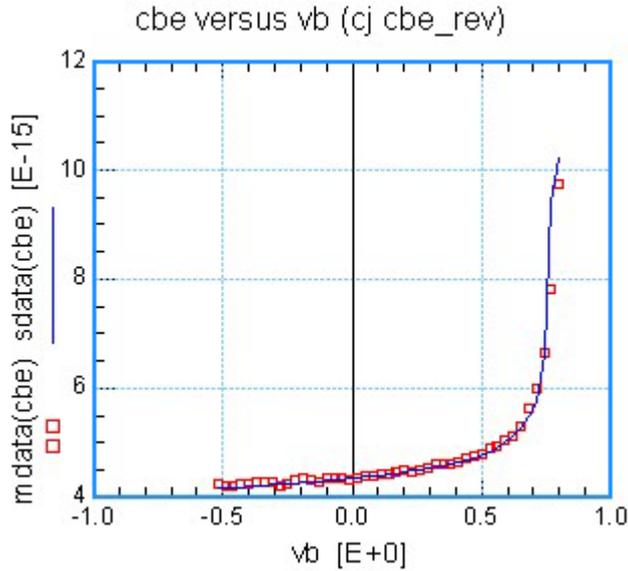
Gummel Plot (fgummel)



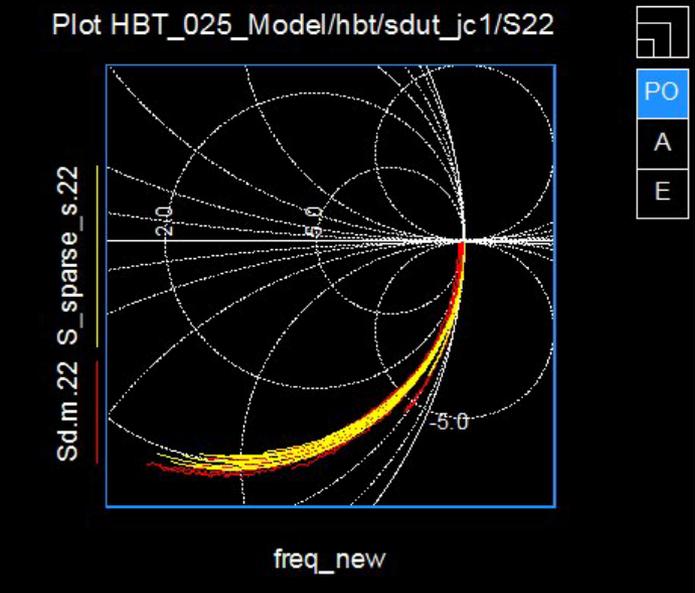
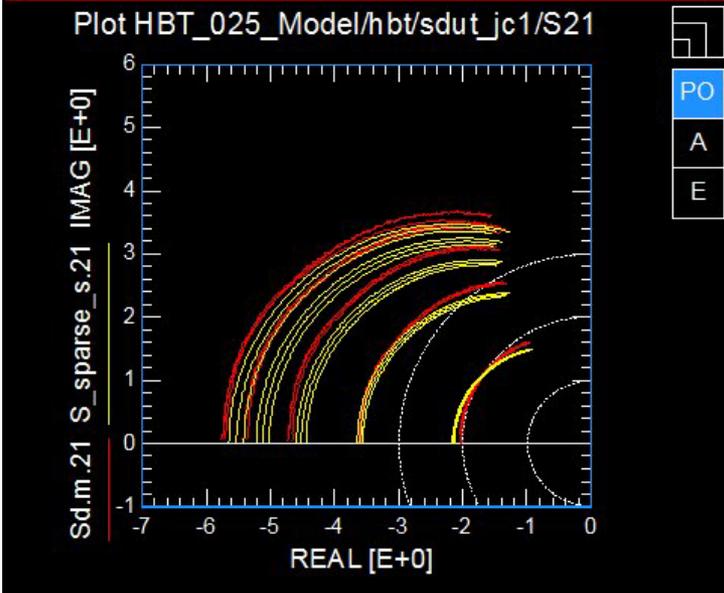
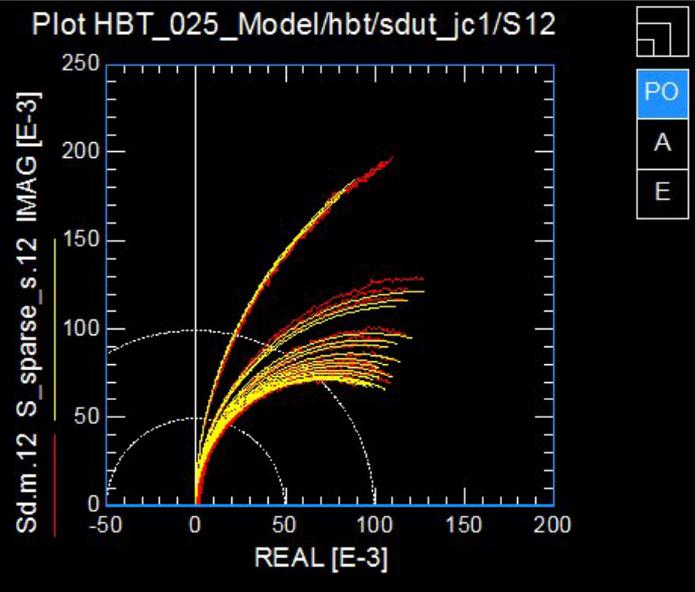
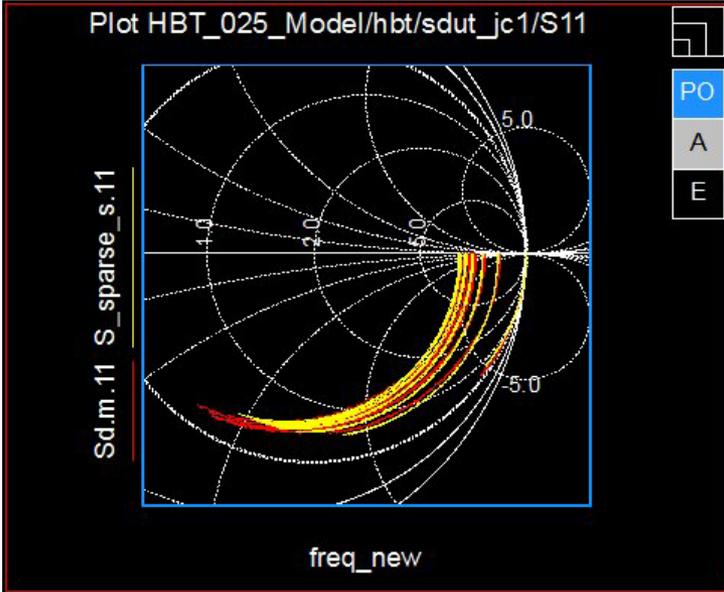
beta versus ic (fgummel)



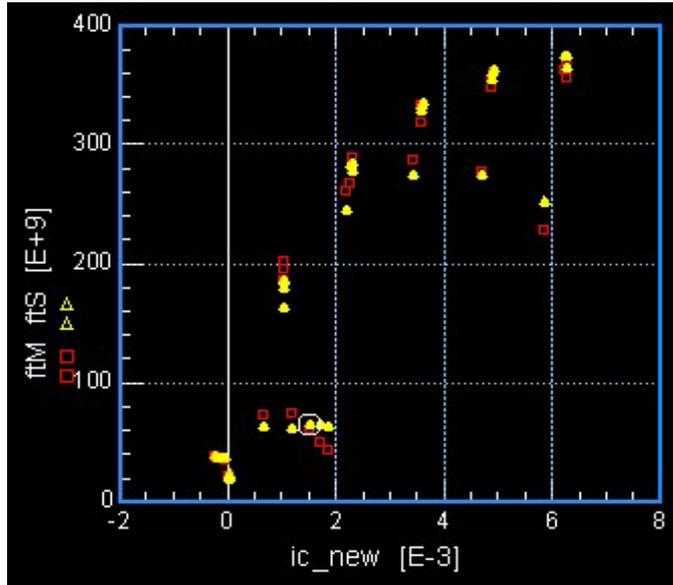
# $C_{be}$ , $C_{bc}$ , $\tau$ modeling



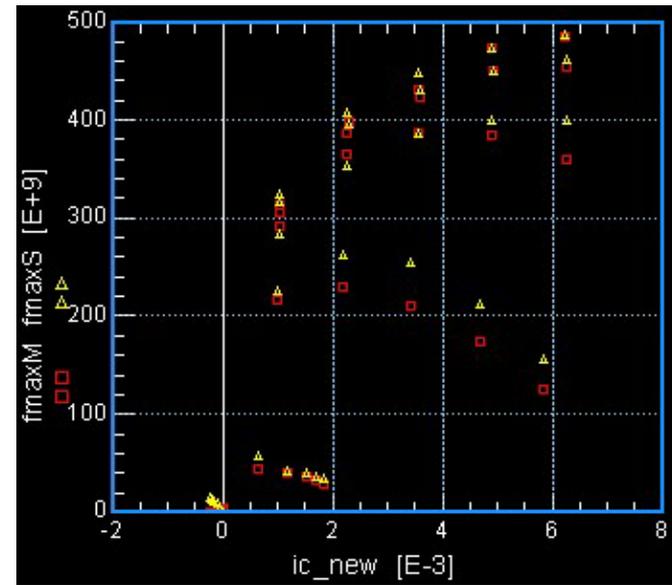
# S-parameter



# $f_t, f_{max}$ modeling



$$f_t = 370 \text{ GHz}$$



$$f_{max} = 493 \text{ GHz}$$



*Thank You !*