Low noise 2.56 GHz PLL with LC- and Ring-oscillator (LJPLL)

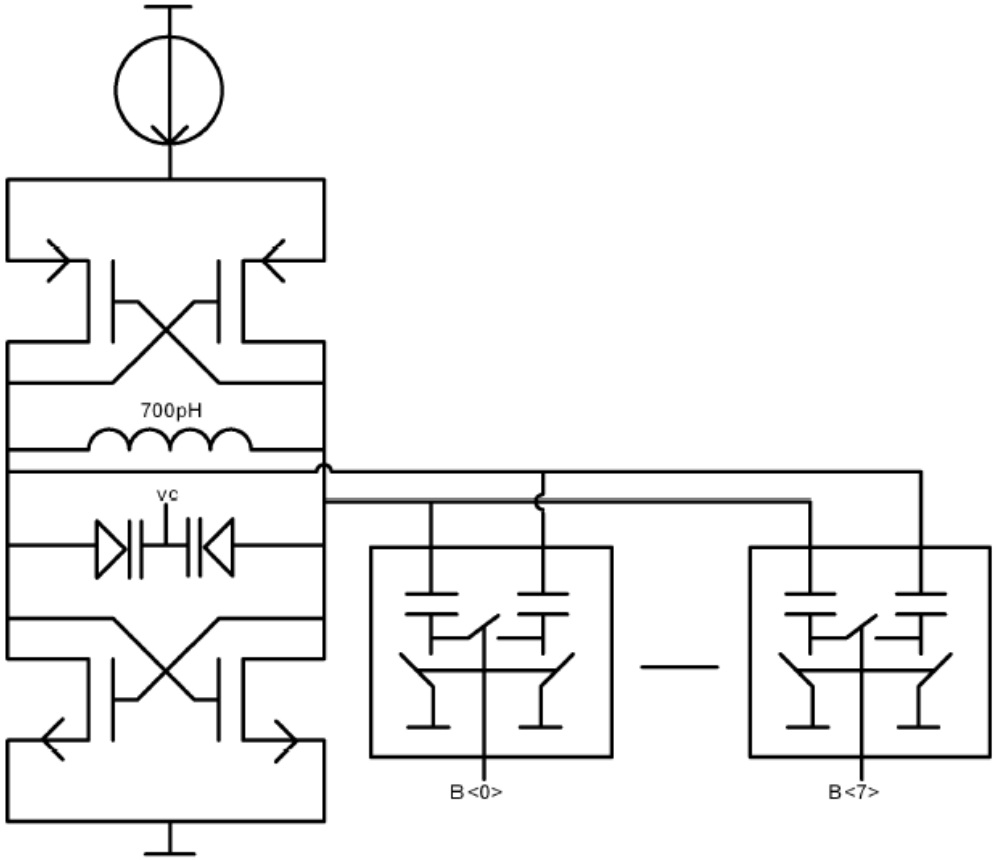
Comparison and radiation effects confirmed with TPA laser tests

Introduction
Our questions

- Ring oscillator or LC-tank oscillator?
- How sensitive is an LC-tank for SEUs?
- What is the PLL cross section?

Introduction

LC-oscillator



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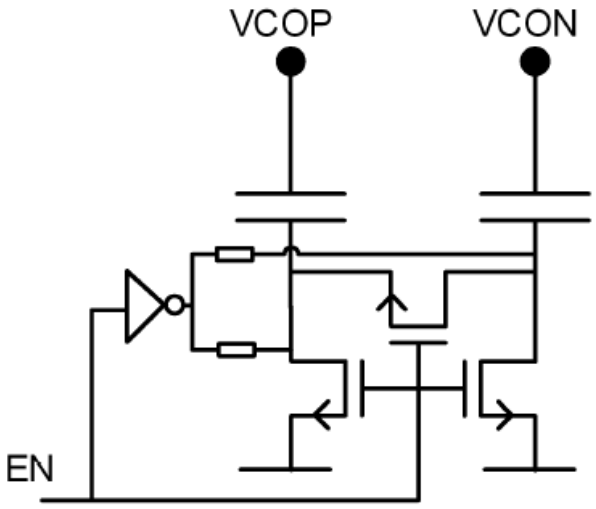

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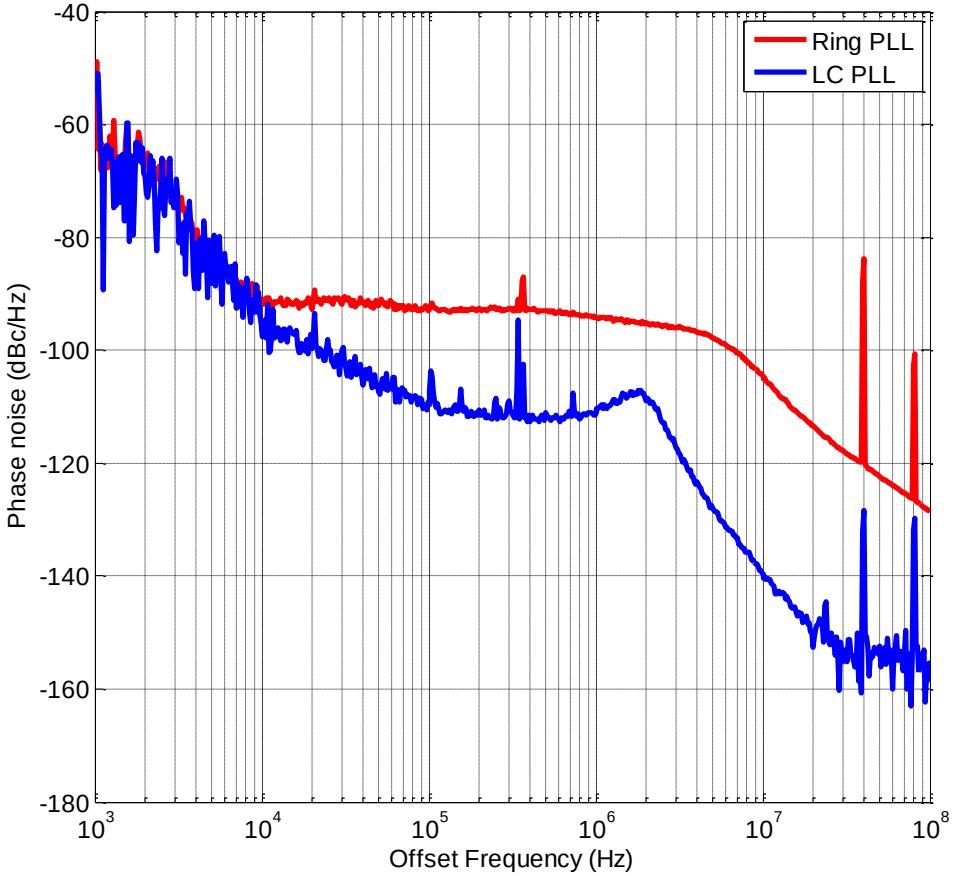
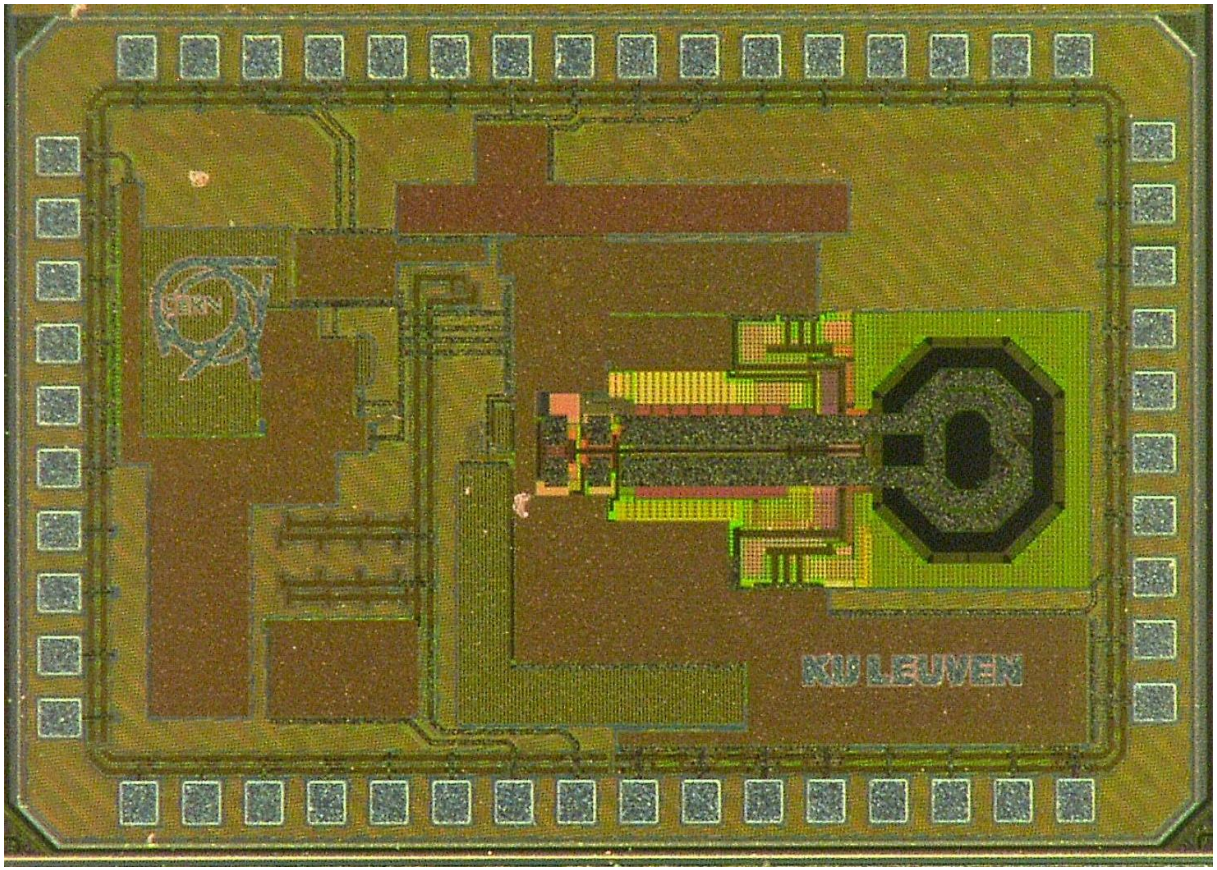
Introduction
Noise

- Ring : 4.6 ps RMS jitter
- LC: 400 fs RMS jitter

For noise, we really want an LC-tank ☺



Introduction



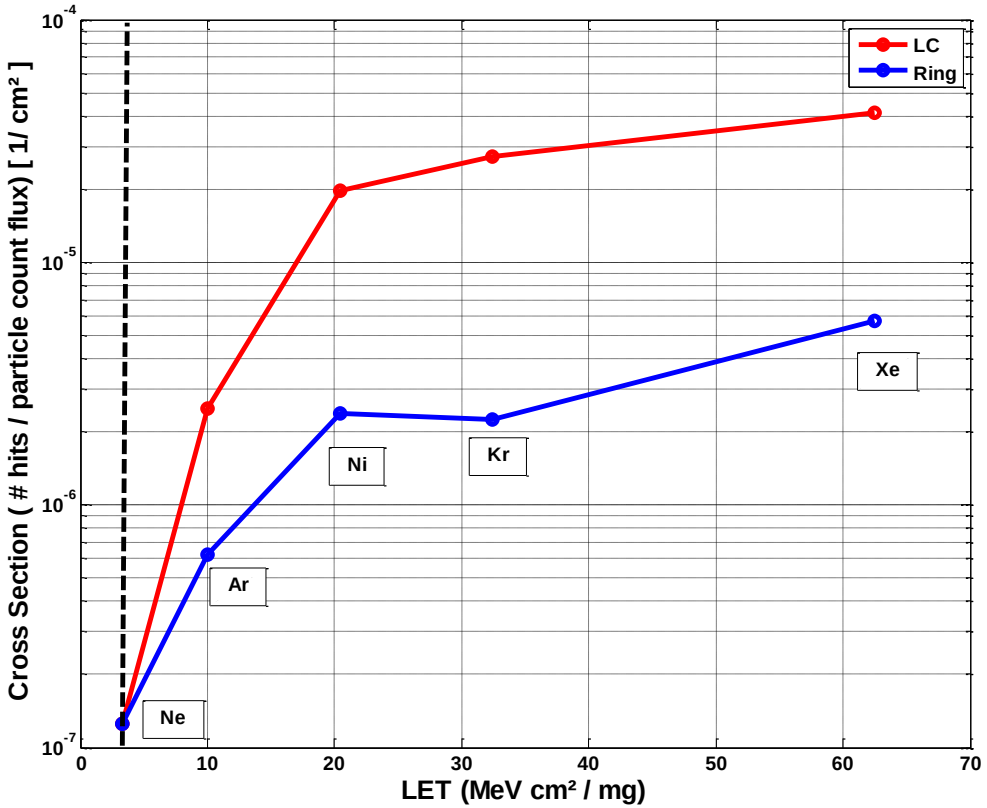
Introduction

	LC	RING
Tuning range	Moderate	High
Phase noise/Jitter	Low	Moderate
Design	High	Medium
Area	Large	Small
TID tolerance (100Mrad)	3%	3%
TID tolerance (600Mrad)	6%	30%

For TID, we also want an LC-tank ☺, so let's focus on the LC oscillator

Single event tests

- Upset = recorded phase jump in the PLL



Single event tests
What do we see?

- LC
  - Just 1 direction of phase jumps
  - Phase jump amplitude varies from 0 – 4 ns
  - Amplitude decreases with LET
  - Not real phase jumps but frequency jumps
- Ring
  - Phase errors in both directions
  - Amplitude decreases with LET

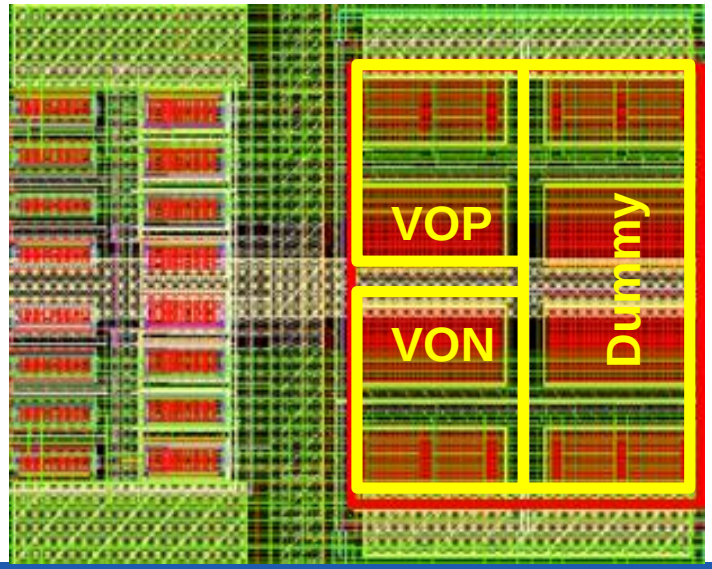
WHY???

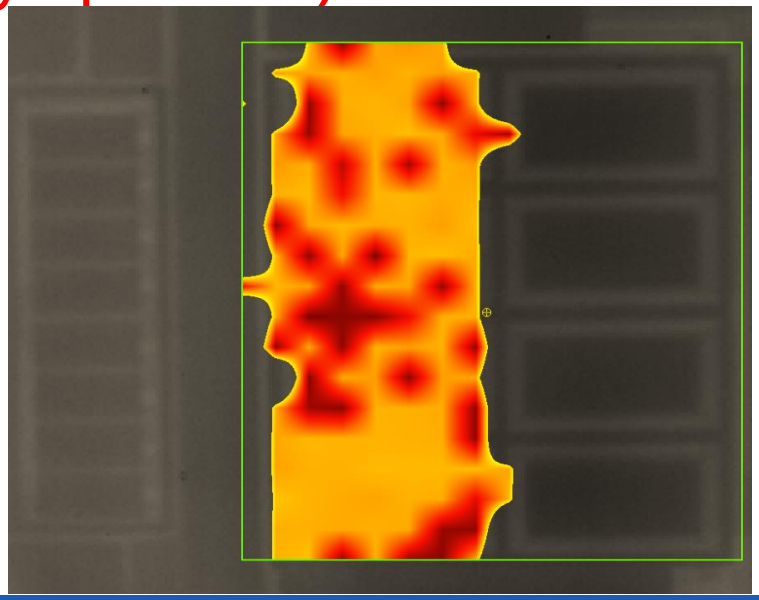
Single event tests
Laser tests

- Laser tests @ Montpellier
- 2 photon absorption laser to generate charge
- XY scan on the chip
- Scanned all blocks individually

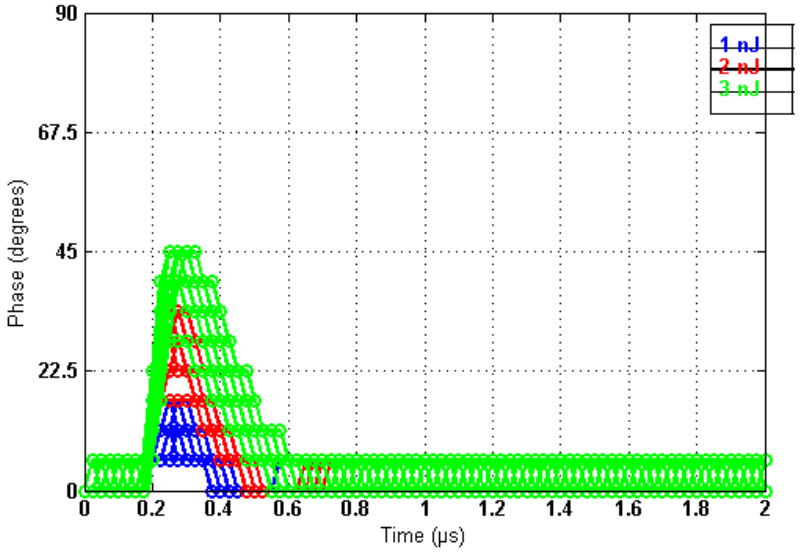
Single event tests
Laser tests – LC oscillator

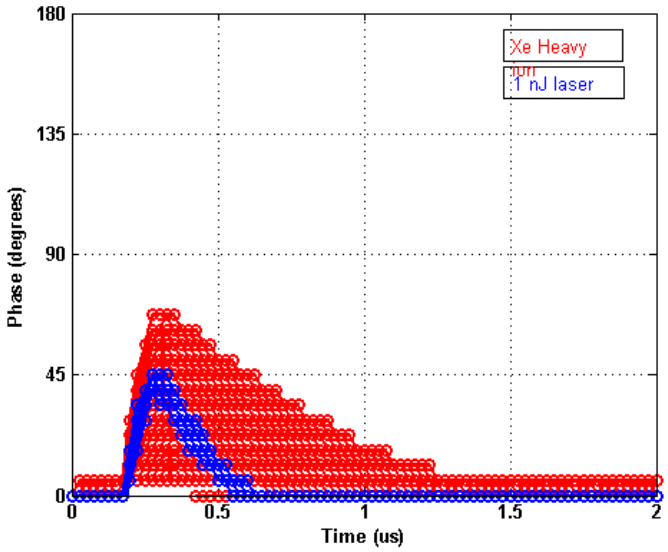
- No sensitive nodes at the VCO at 600 pj
- Increased energy to **1 nJ**
- Varactor showed similar results as Ion tests
  - Phase shape (always positive) and cross section



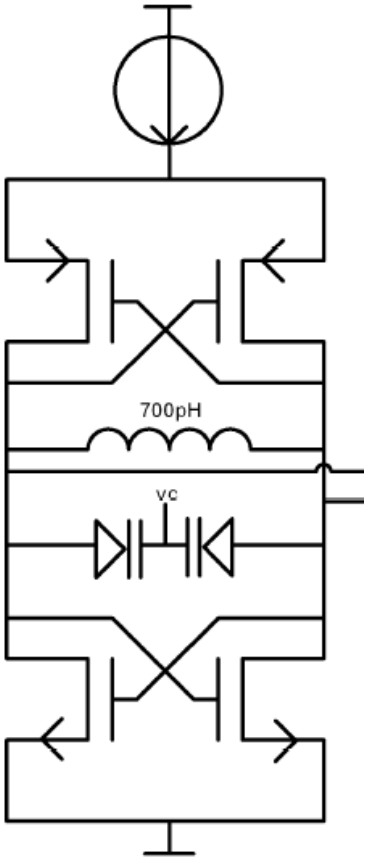


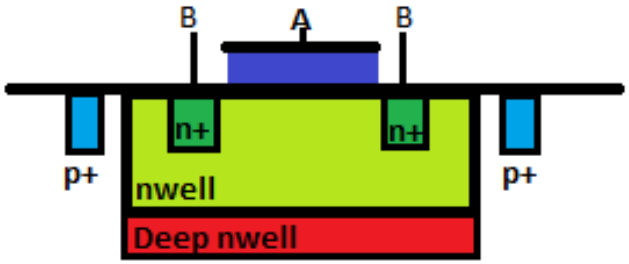
Single event tests
Laser tests – LC oscillator





Single event tests
Laser tests – LC oscillator

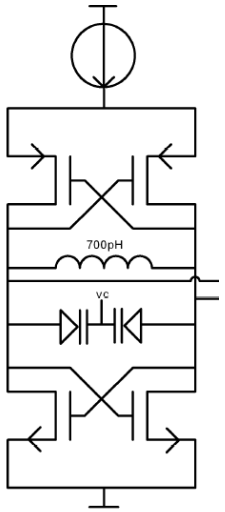


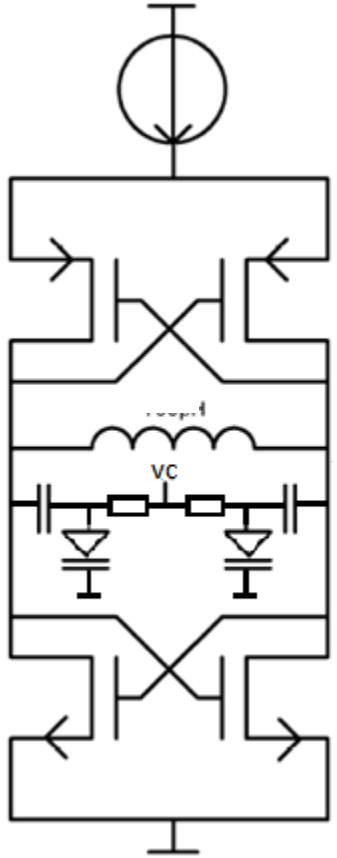


- 1 big nwell connected to Vc = big collection node
- 5.6 pF capacitor + 160 pF – 2 kOhm resistor
- **Can we have parasitic transistors that amplify the charge? Simulations showed that pC charges do NOT have this dramatic effect.**

Single event tests Improvements – LC

- Avoid big n-well
- Use of AC-coupled varactors
  - No collection node anymore
  - Cc ~ 10 x Cvar = 5 pF
  - Bottom plate capacitance! M3-M6
  - Decreased C, increased L (0.7 nH to 4 nH)





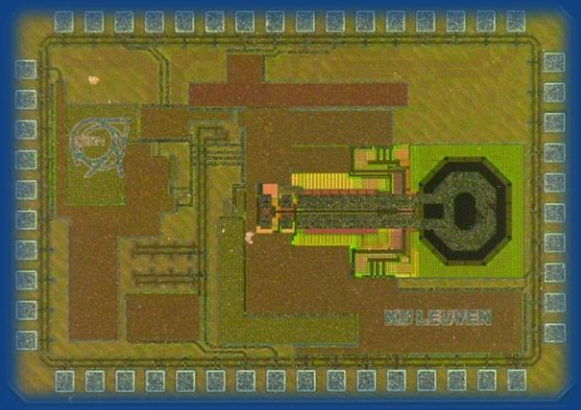
This SOLVED the problem

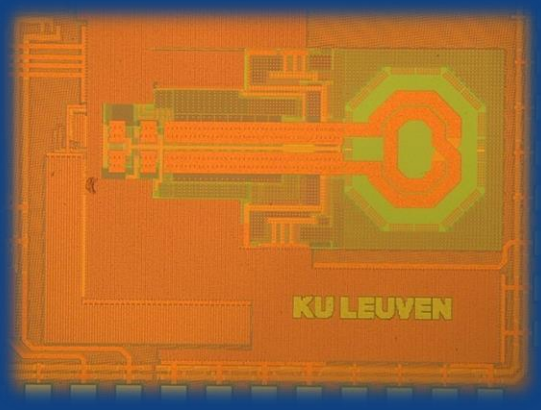
Final Conclusion

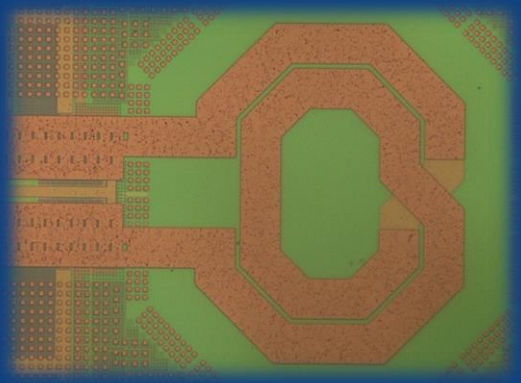
	LC	RING
Tuning range	Moderate	High
Phase noise/Jitter	Low	Moderate
Design	High	Medium
Area	Large	Small
TID tolerance	Good	Worse
SEU cross section	Larger	Smaller
After fix	Much smaller	Smaller, but limited by the bias circuit

Remaining question

- Why is the required energy so large to have the same effect as a heavy ion? (1-2 nJ)
- To have the same effect in simulation > 20 pC was required.
- Can a charge amplification occur somewhere?







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Thank You!

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