Micro-Power Wireless

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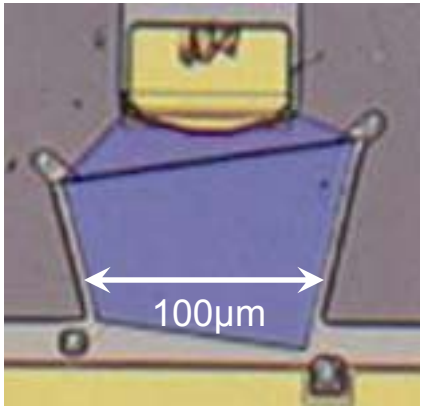
"Reactive radios" represent a new paradigm in wireless transceivers:

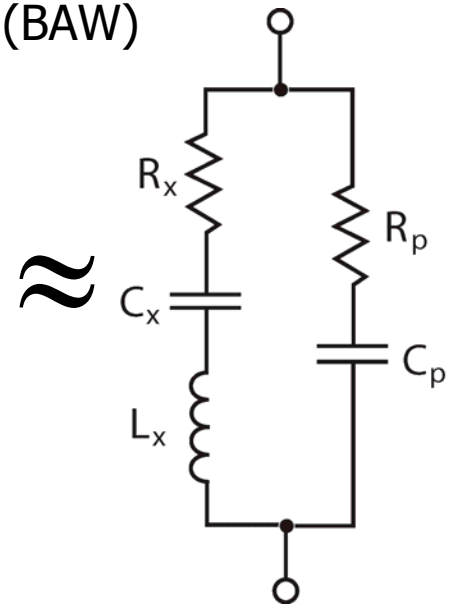
- Low power
- Low cost
- Low duty-cycle

RF-MEMS

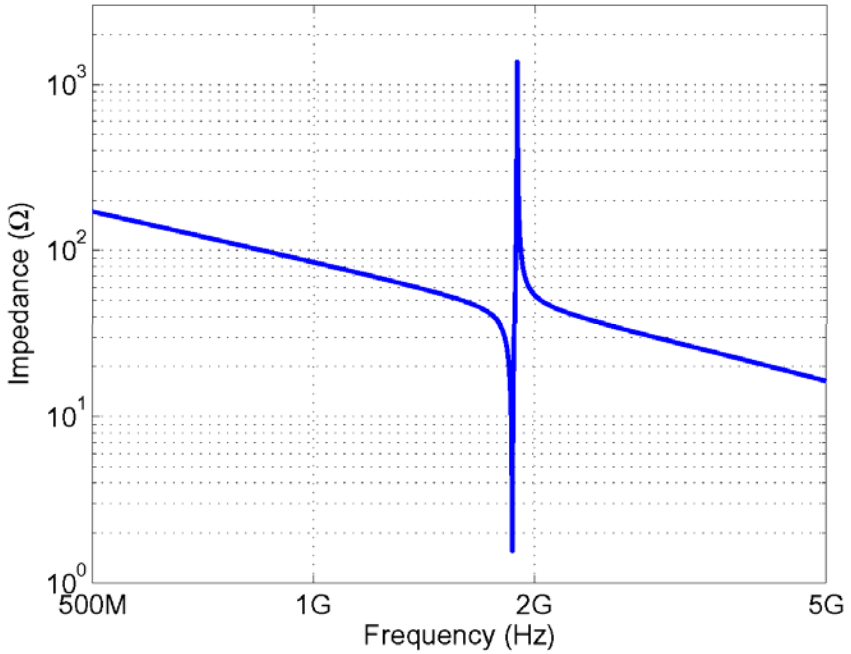
Agilent 1.9 GHz FBAR (BAW)



Provides high accuracy frequency reference or high Q filtering



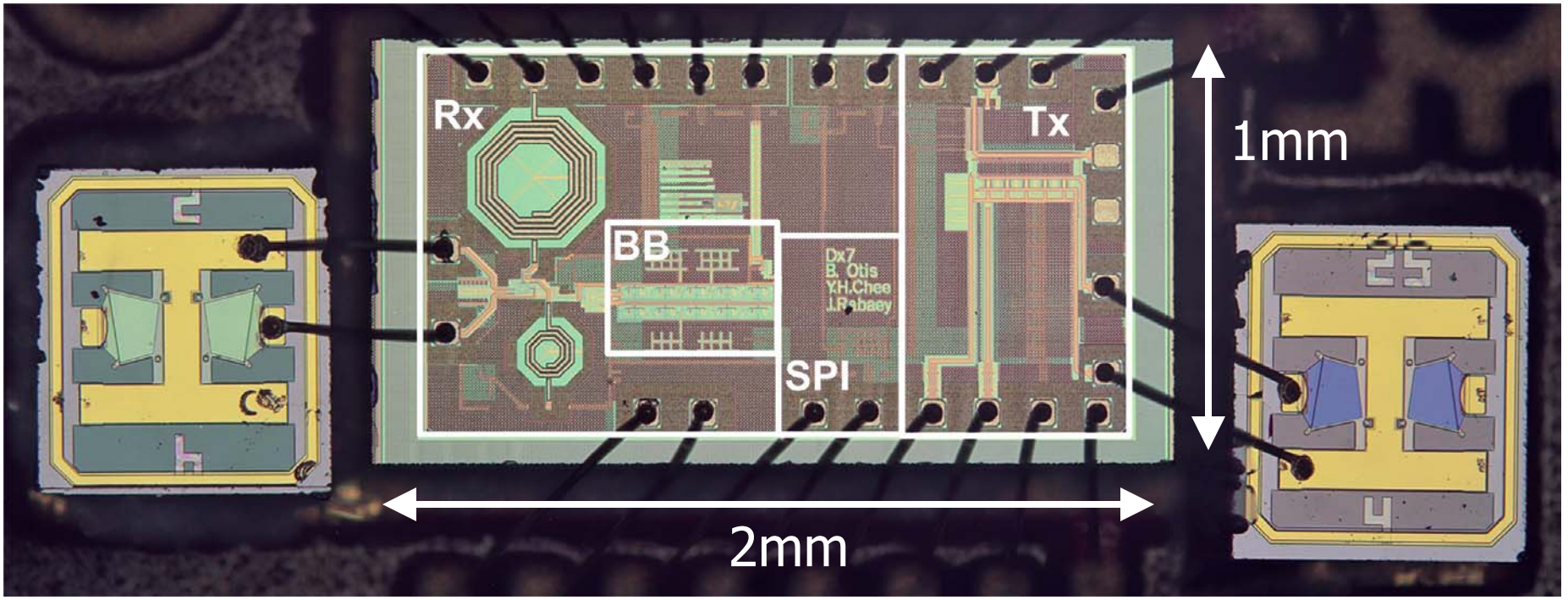
Simulated FBAR impedance response



MEMS can replace traditional external components (like crystals) for highly integrated transceivers:

- Reduction in implementation size
- Cost reduction

Fully Integrated 1mm^3 Rx/Tx



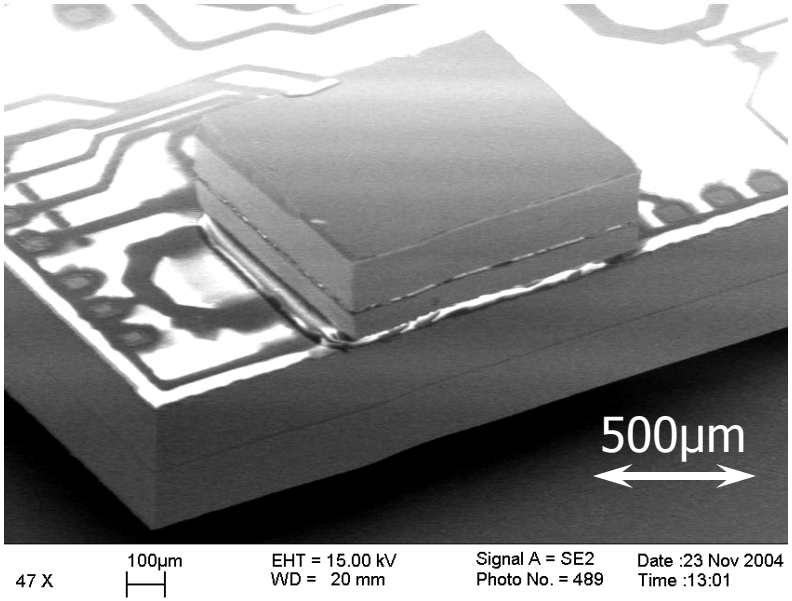
Presented at ISSCC 2005

- No external components (inductors, crystals, capacitors)
- 0.13µm CMOS
- Very small implementation volume

B. Otis, Y.H. Chee

Transceiver Performance

Technology	0.13µm CMOS
Die area	(1x2)mm^2
P_{rx}	380µA (1V)
P_{tx} (OOK)	1.05mW
$P_{out,tx}$	480µW
Data rate	10kbps



Combination of submicron CMOS and micromechanical resonators yields:

- Very low power
- 1mm^3 transceiver form factor

B. Otis, Y.H. Chee

Reducing Power Even Further

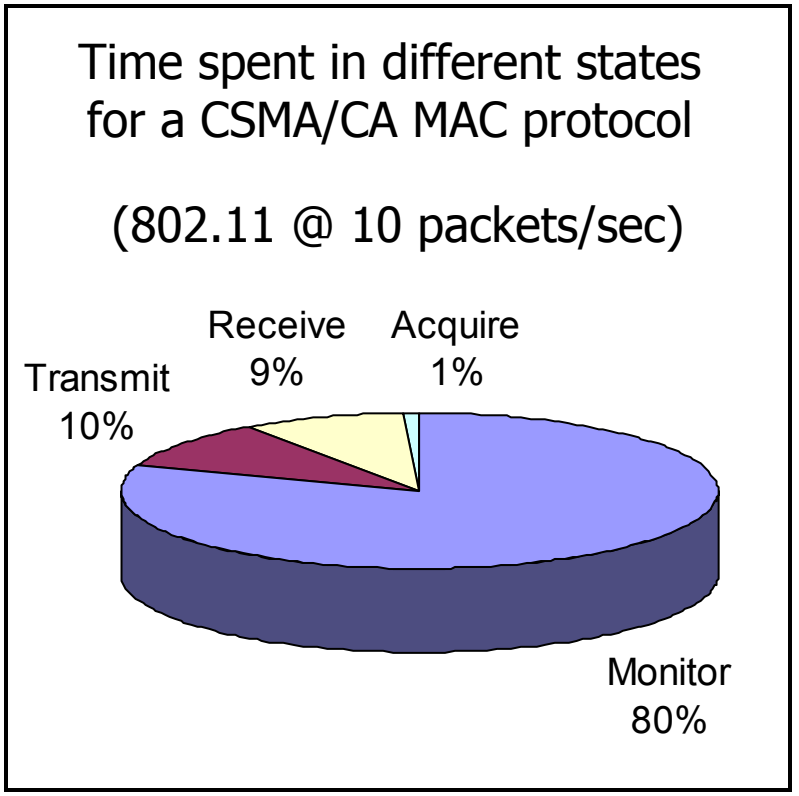
Key Characteristics of Sensor Networks:

- Low packet traffic rates
- Short packets (< 200 bits)

Monitor power dominant:

- Reduce monitor power through heavy duty cycling

➢ *Reactive radio with automatic wakeup*

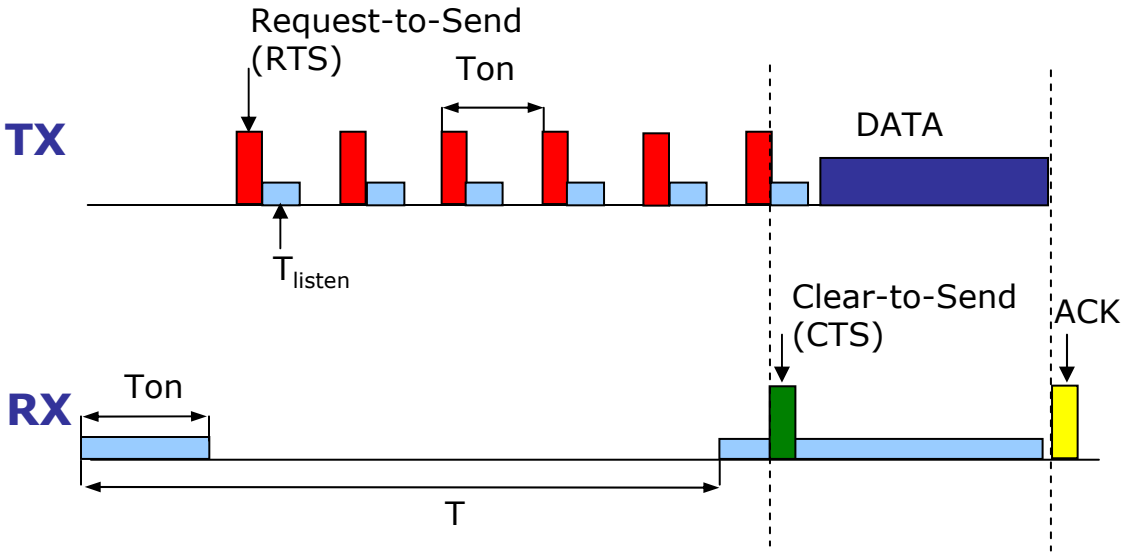


Adapted from: Lin Ph.D. 2005

Synchronization in Duty-cycled Systems

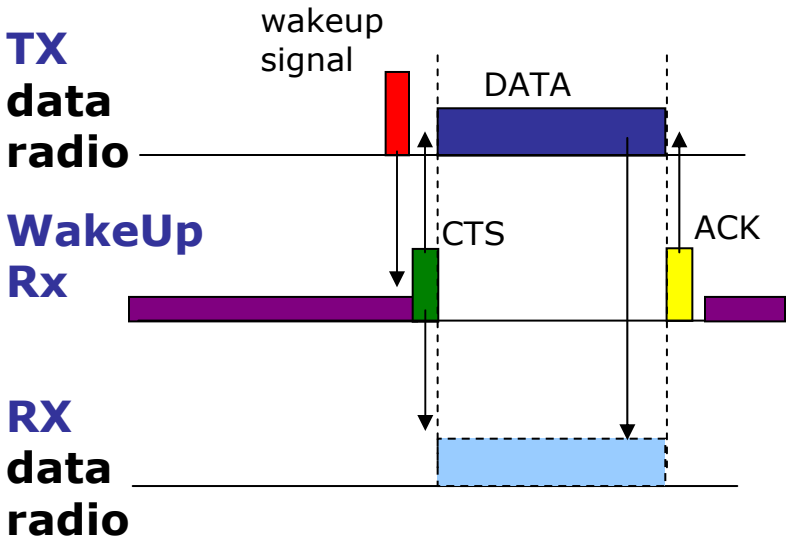
Pseudo-asynchronous:

- Tx node beacons while the Rx node periodically monitors the channel
- Rx channel monitoring power and Tx beaconing power is significant



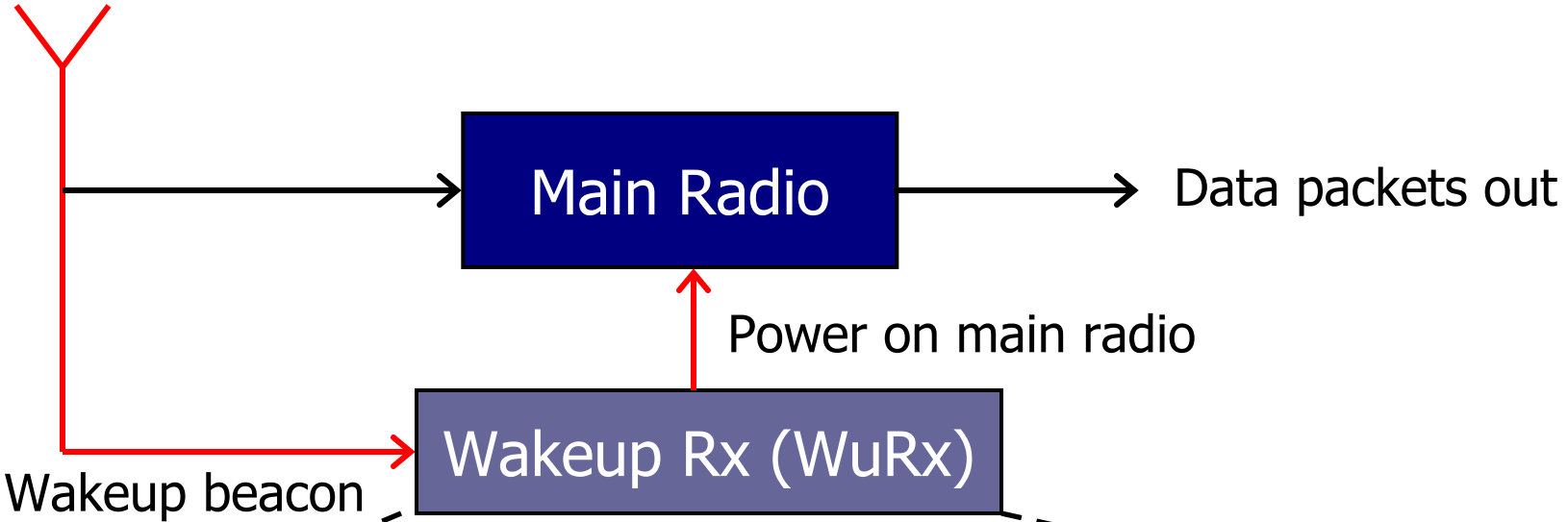
Asynchronous ("Reactive"):

- Rx node monitors the channel continuously with low power CSR
- Overall network power savings possible, also latency reduced significantly



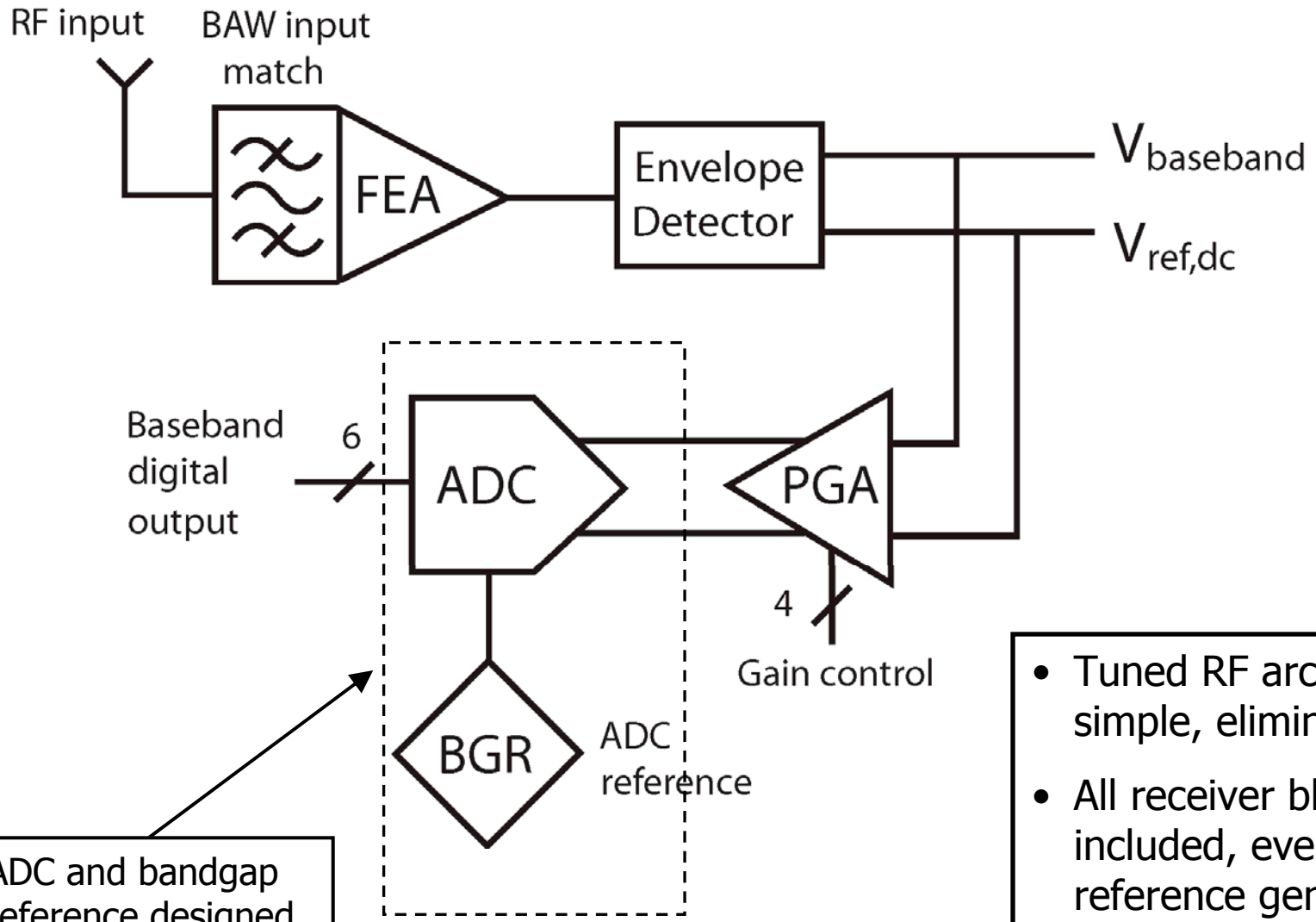
Ref [2]: E. Lin, Ph.D. thesis, 2005.

Reactive Radio with WuRx



- Reactive radio improves network latency and can reduce network power consumption
- WuRx must be very low power compared to main data radio » 50μW

WuRx Architecture Overview



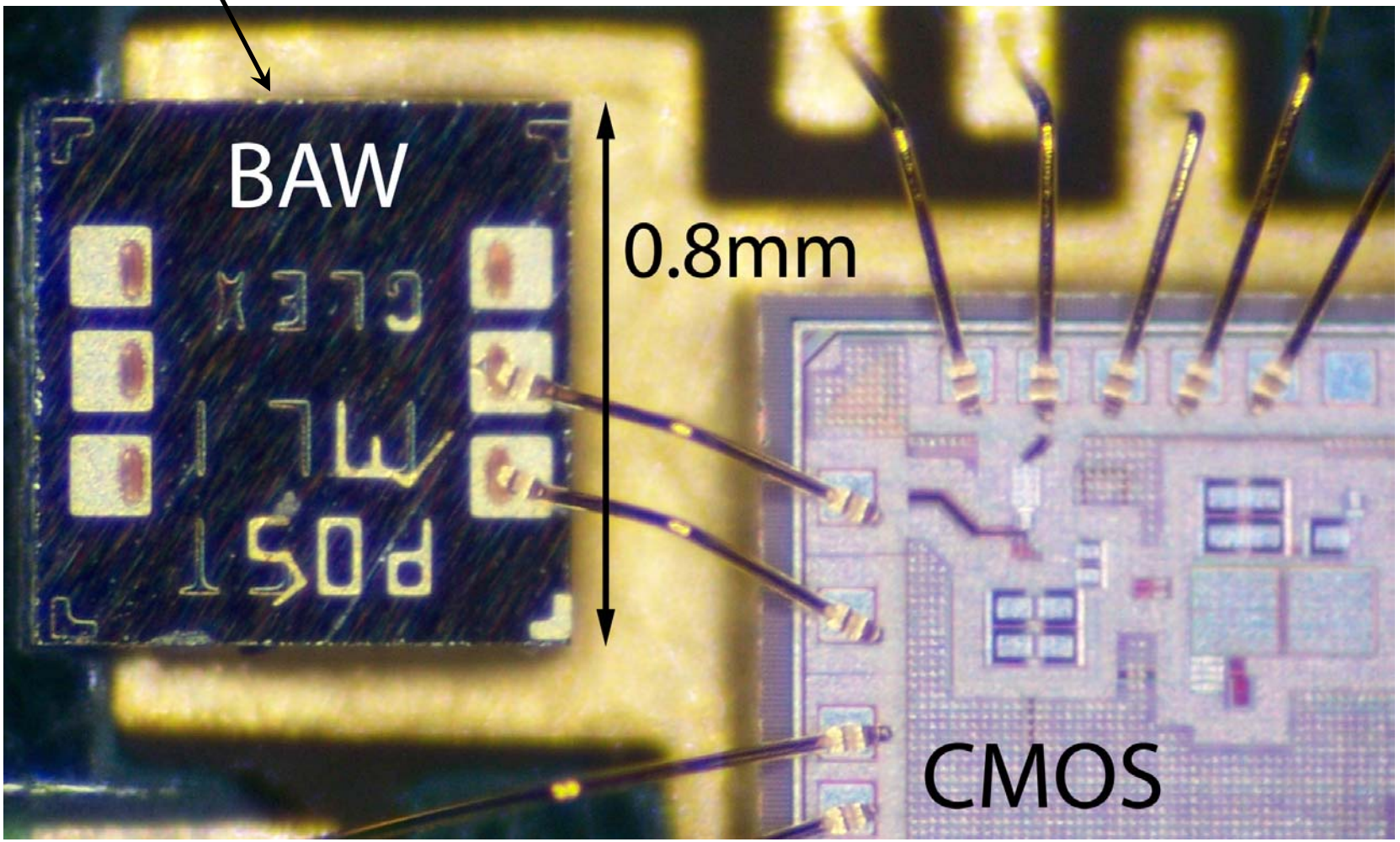
ADC and bandgap reference designed by S. Gambini

- Tuned RF architecture simple, eliminates VCO
- All receiver blocks included, even reference generator

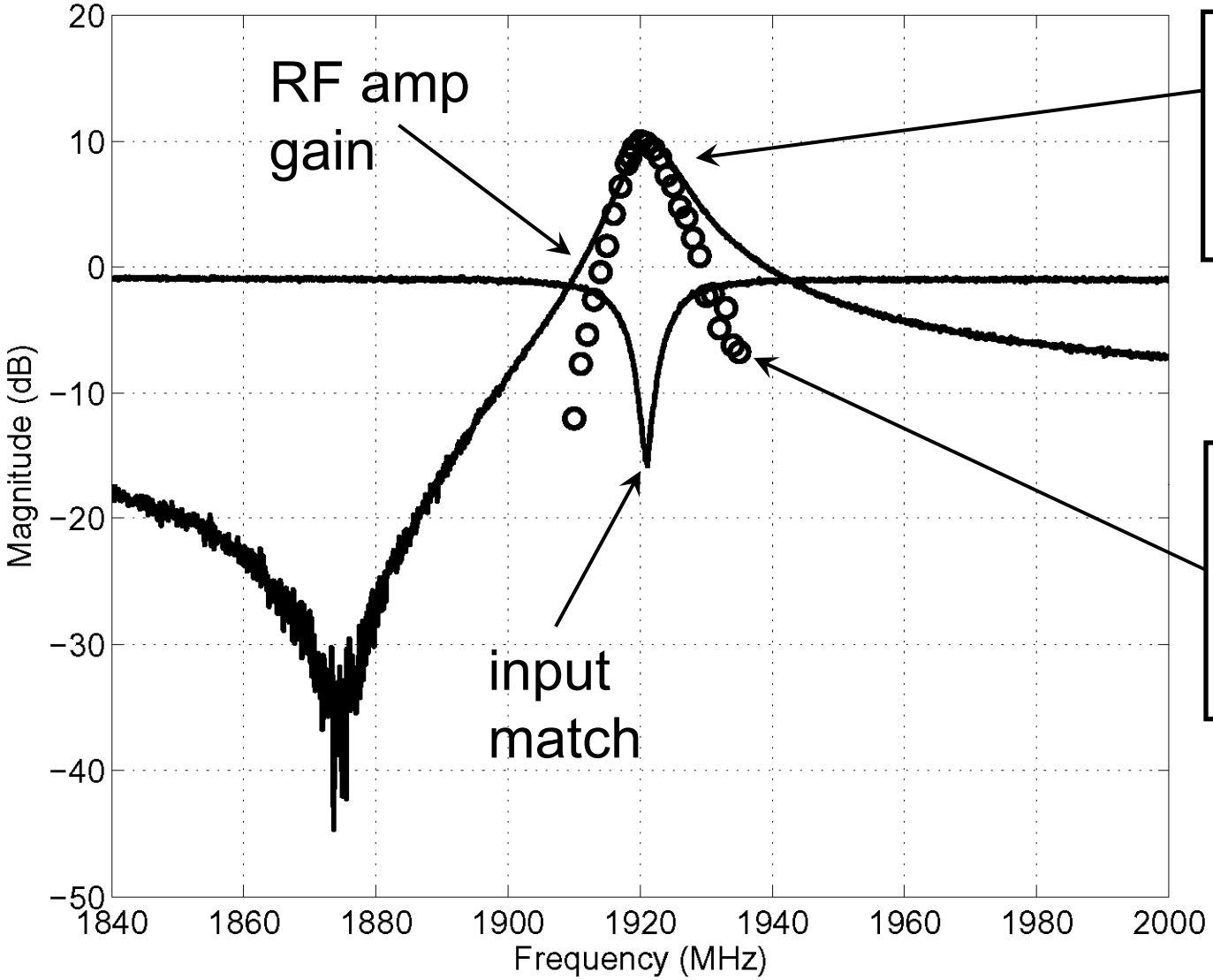
Silicon Prototype

BAW wirebonded directly to CMOS for prototyping

Fully integrated prototype in 90nm standard CMOS; no on-chip inductors



RF Frontend Measurements



BAW resonator enables sharp filtering against interferers

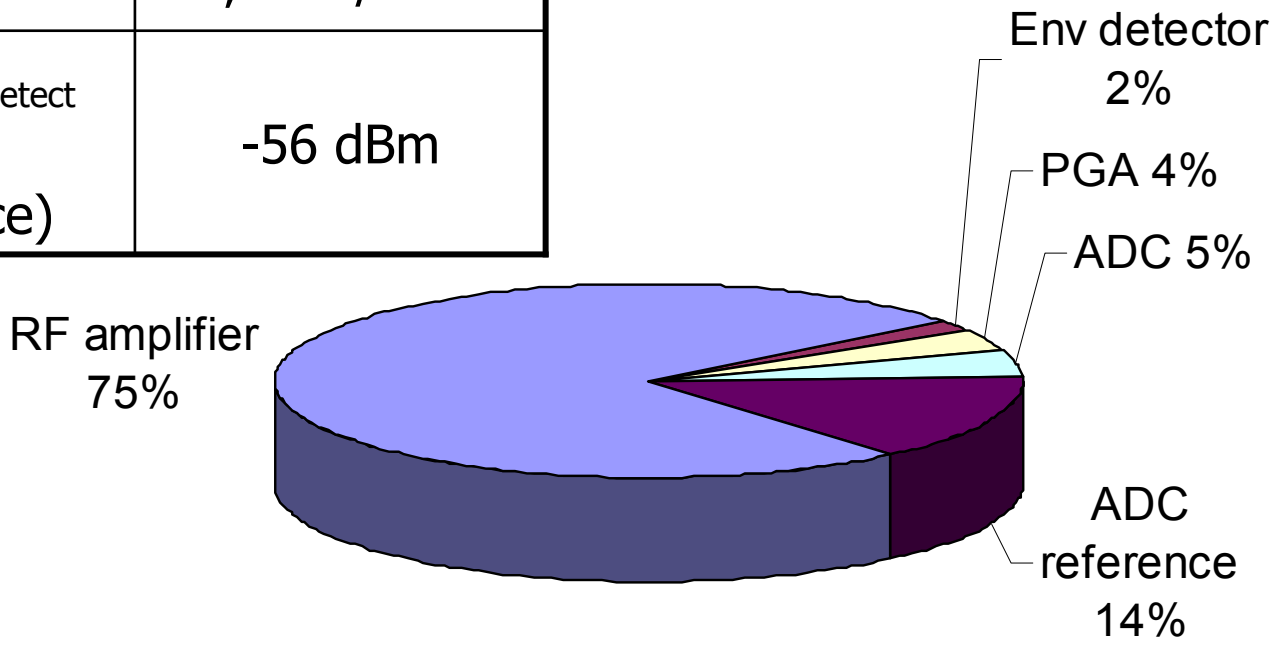
Normalized receiver gain to baseband

(RF BW=7MHz)

WuRx Performance Summary

Global supply voltage	0.5 V
Total power dissipation	65 µW
Nominal/Max datarates	40/100kbps
Overall Receiver -3dB BW	7 MHz
ADC performance	6b, 1MS/s max
Overall sensitivity for P_{detect} of 90% and 1 FA/sec (31-bit wakeup sequence)	-56 dBm

WuRx power consumption breakdown



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