

AUTO-ID LABS



Keeping TABS on Things:

**Field Intelligence using RFID Tag Antenna-Based
Sensors**

**Presented by Isaac Ehrenberg
MIT Auto-ID Labs**

- **Motivation**
- **UHF RFID tag antenna-based sensing**
- **A temperature threshold sensor**
- **A fluid level sensor**
- **Conclusions**

Pervasive sensing would improve *savings* and *safety* in multiple applications



>\$3



KSW semi-passive RFID
temperature logger



O(\$100)

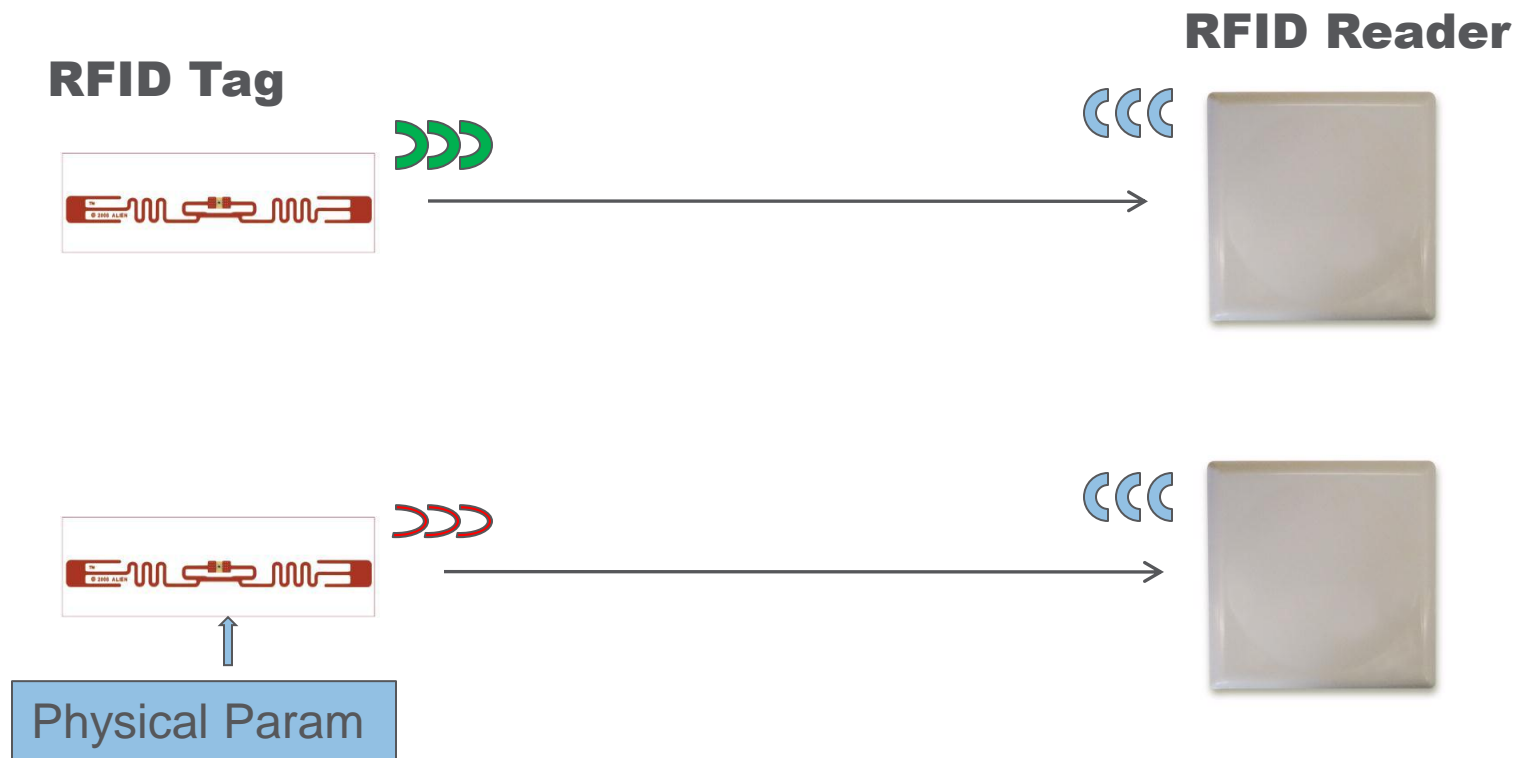


SG-Link wireless strain sensor

Why RFID?

- Proven track record of pervasive deployment
- Low cost RFID tag manufacturing
- Standardized reader-tag communication
- Free adoption in RFID-enabled processes

Question: How to add sensing functionality at low-cost?



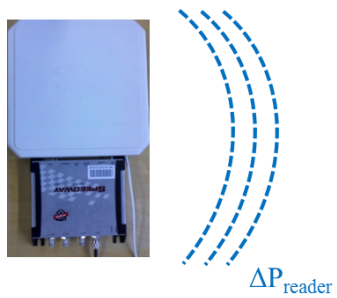
- **Reader-Tag signal parameters for sensing**
 - Amplitude Modifying (AM) TABS
 - Frequency Modifying (FM) TABS
- **Low-cost, non-electric memory**



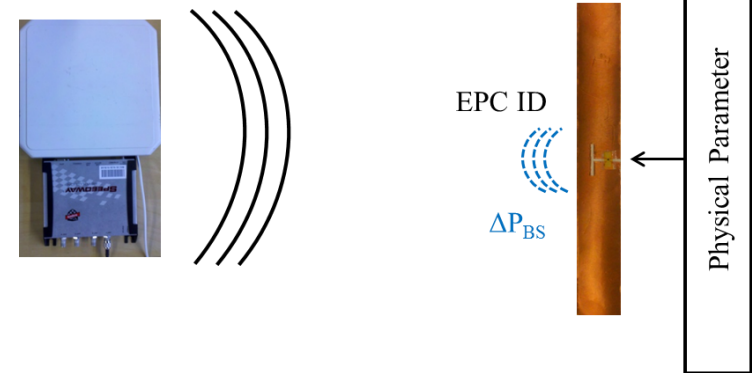
Reader-Tag Signal Parameters for Sensing



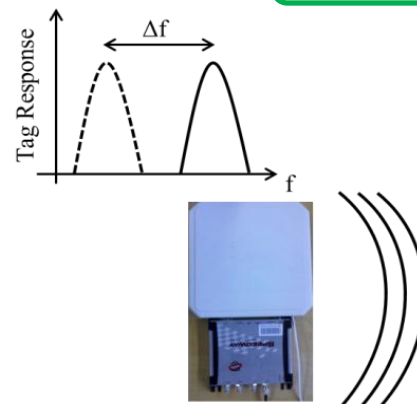
AM TABS: Reader Power



AM TABS: Tag Backscatter



FM TABS

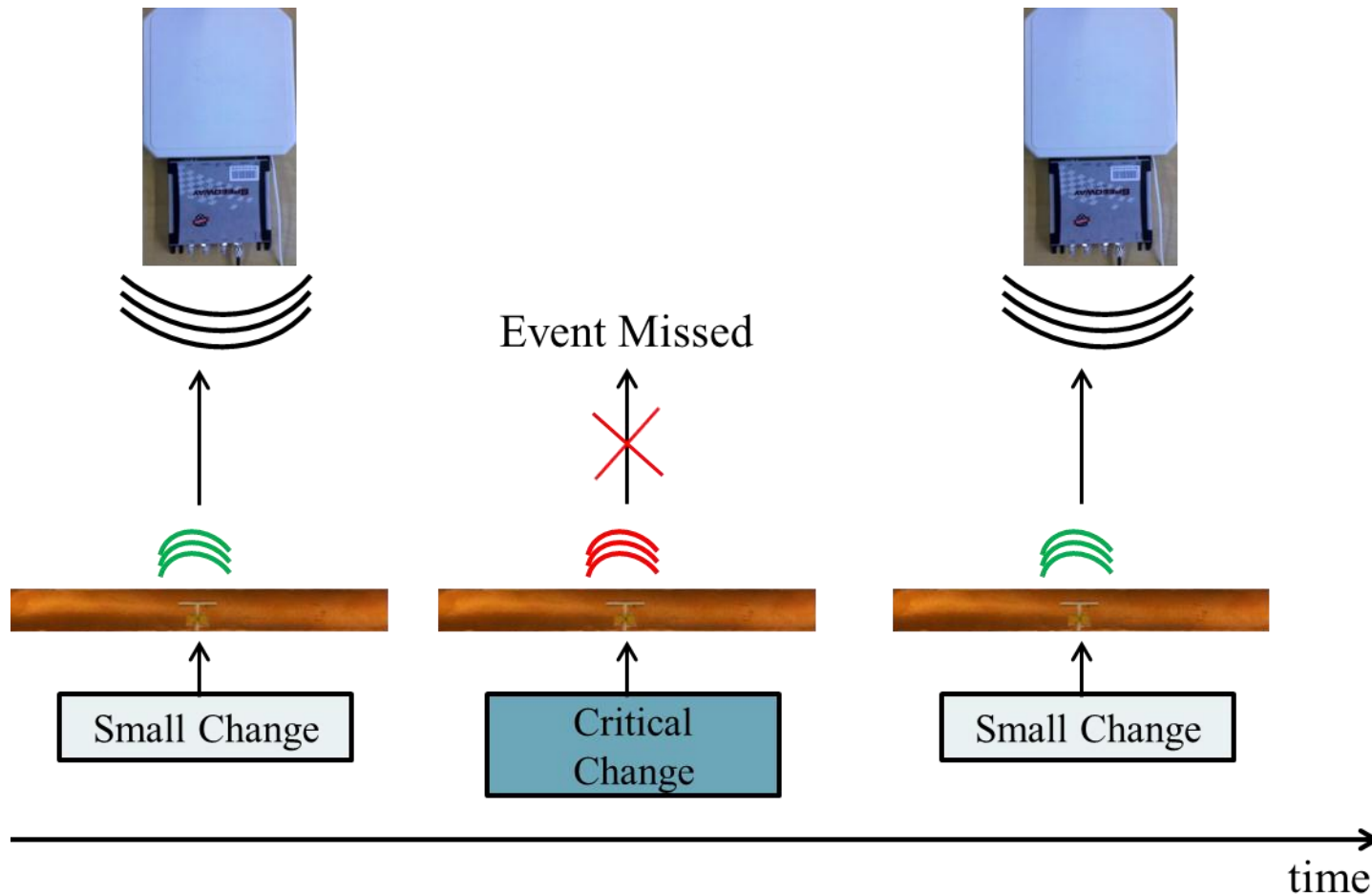




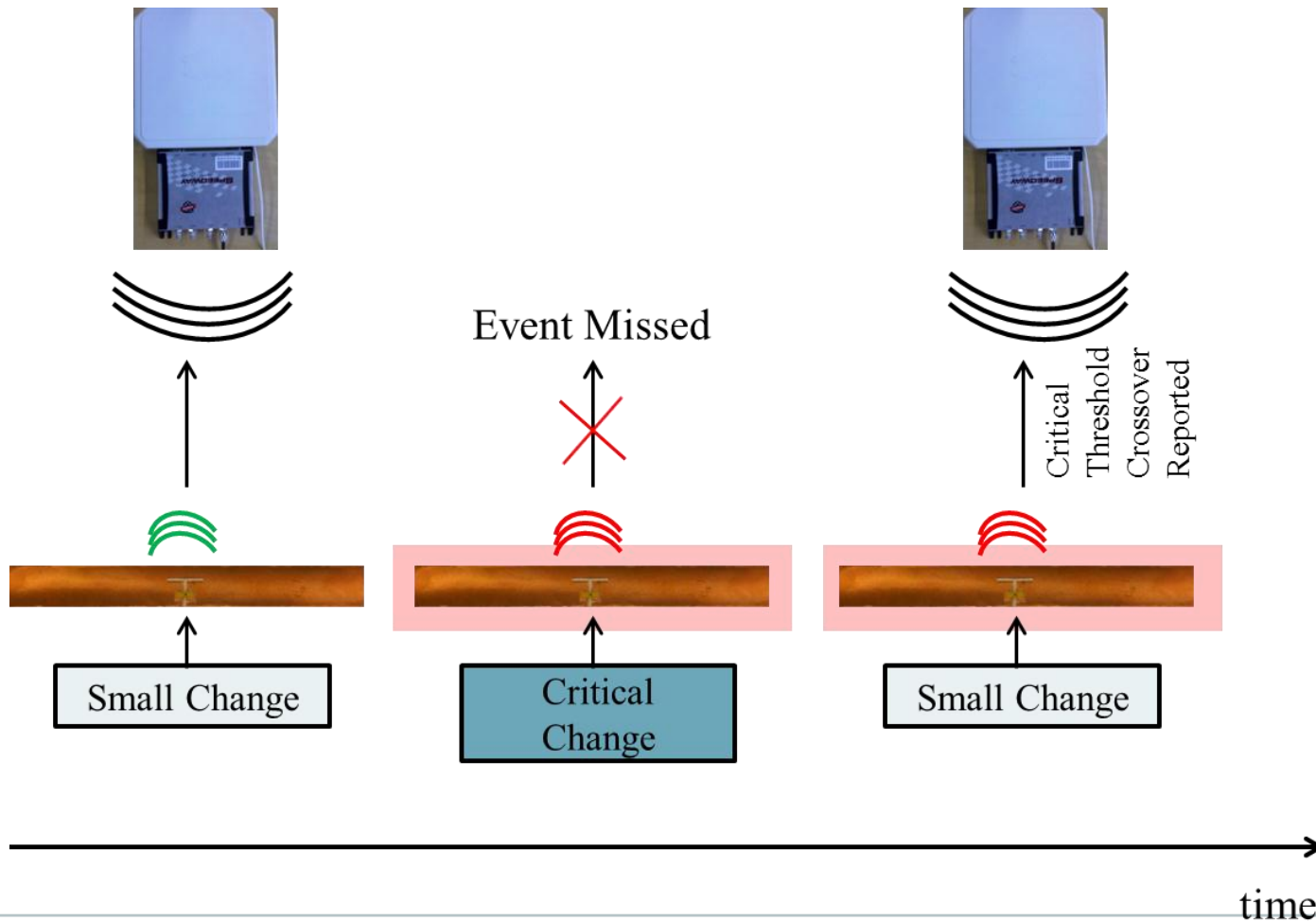
Low-Cost, Non-Electric Memory



Passive RFID tags can't record events when unpowered



Non-electric memory – permanent change to antenna



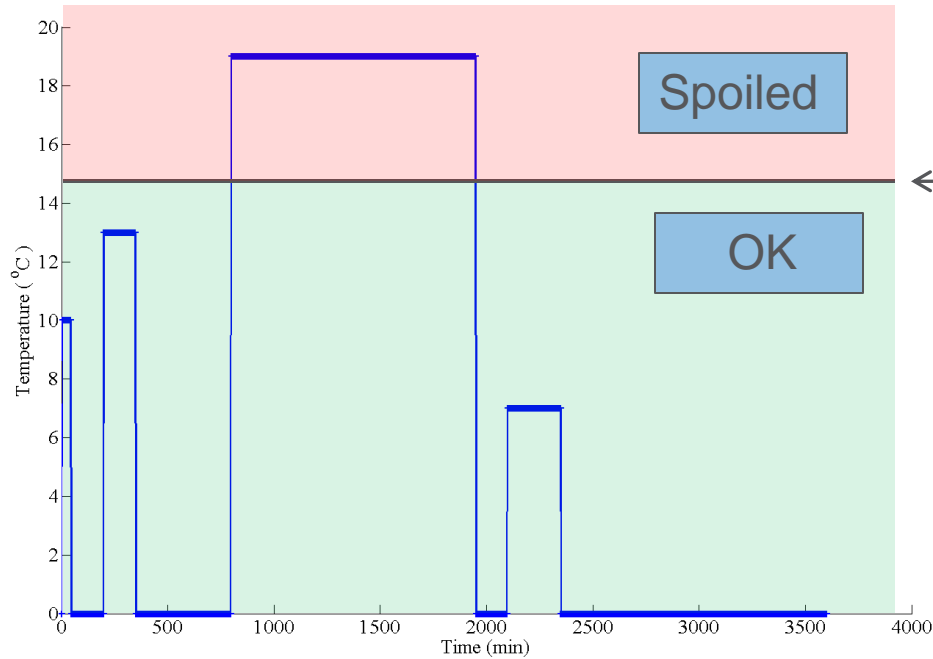
- **Temperature threshold sensor**
 - **AM TABS**
 - **Non-electric memory**
- **Fluid Level Sensor**
 - **FM TABS**



- **30% perishables damaged in cold chain**
- **Large-scale temperature, humidity, shock sensing**
- **Ideally - item level deployment!**



Design Requirement: Detect Threshold Crossover



Binary Threshold Sensing

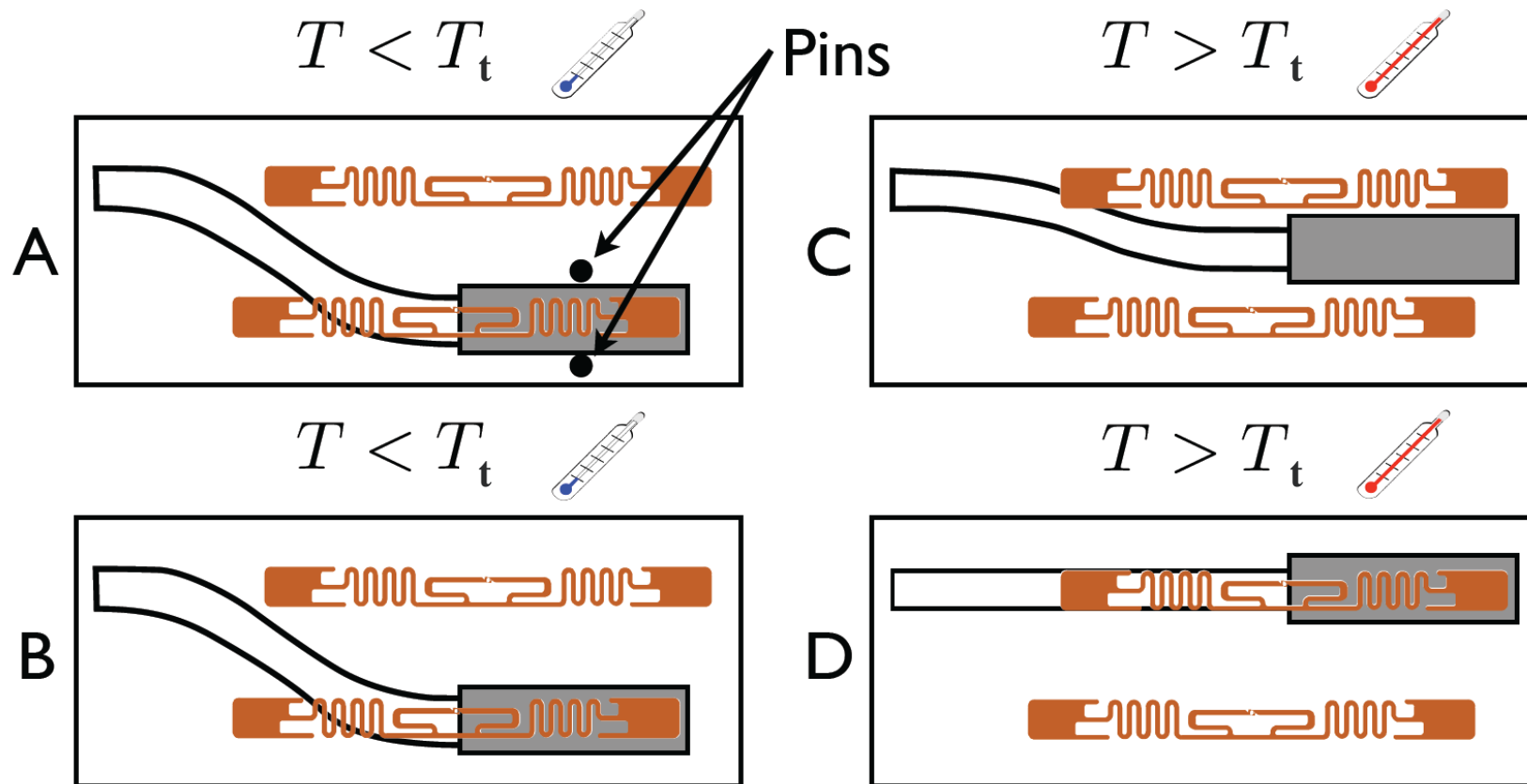


Sensor

Ok

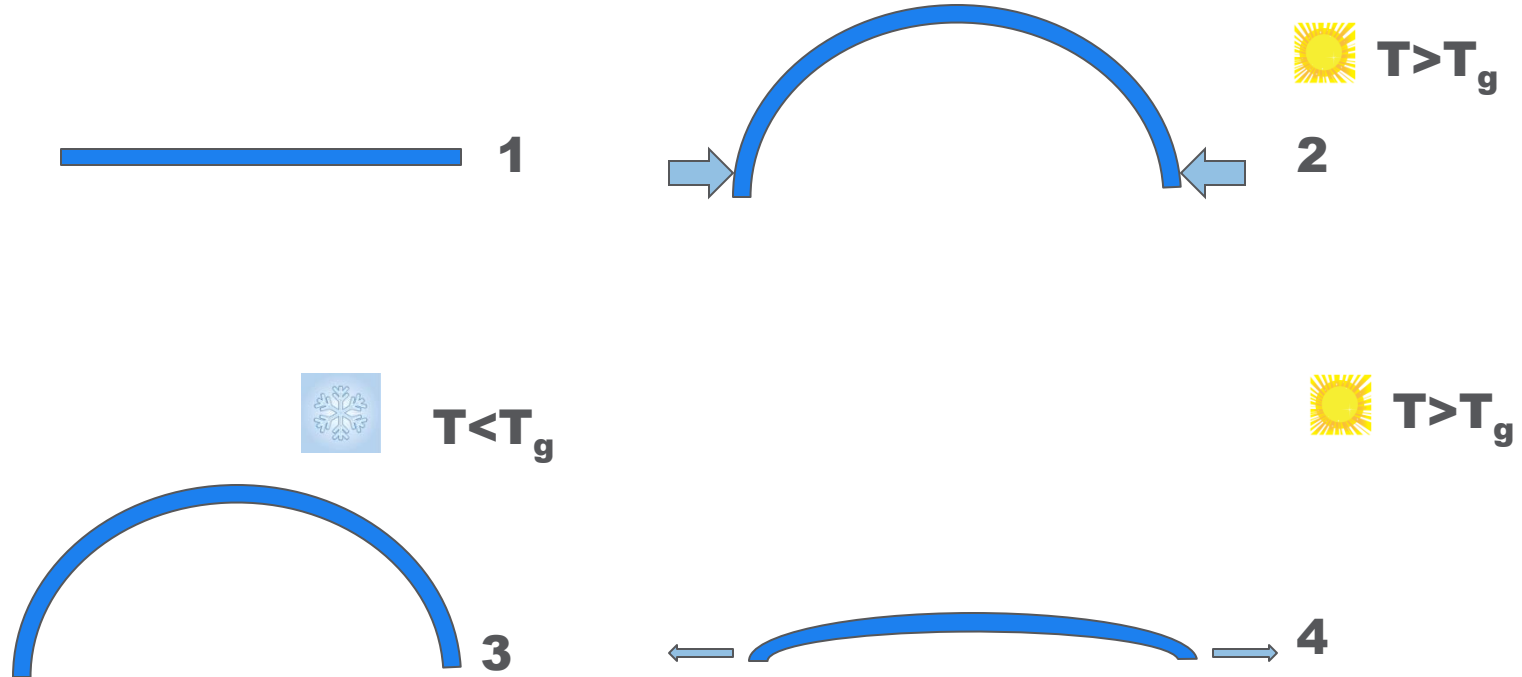
Spoiled

→ Design requirement: Low-cost, Non-electric Memory



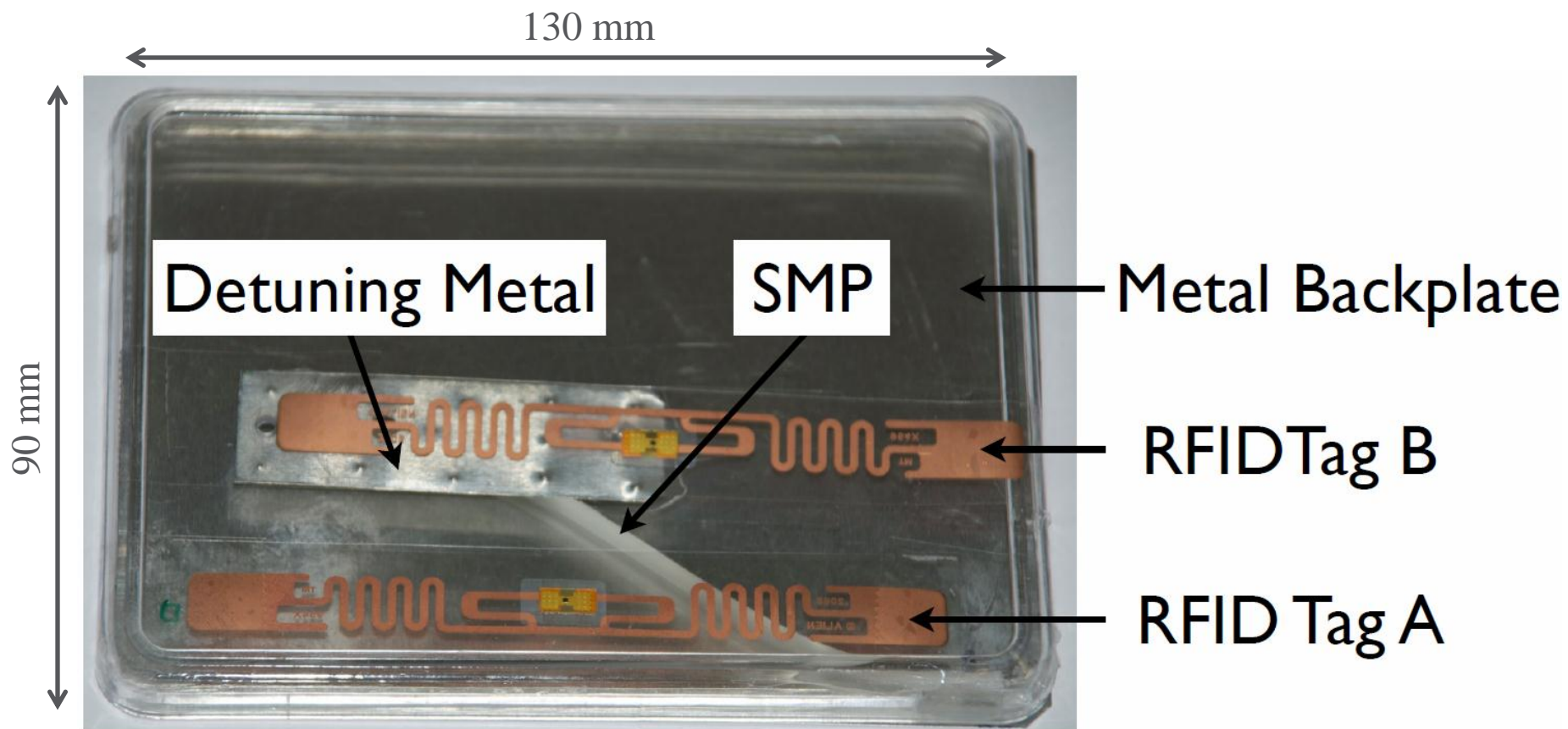
- **SMP glass transition temperature [Safranski 2008]:**

- Above T_g – polymer is flexible
- Below T_g – polymer is rigid



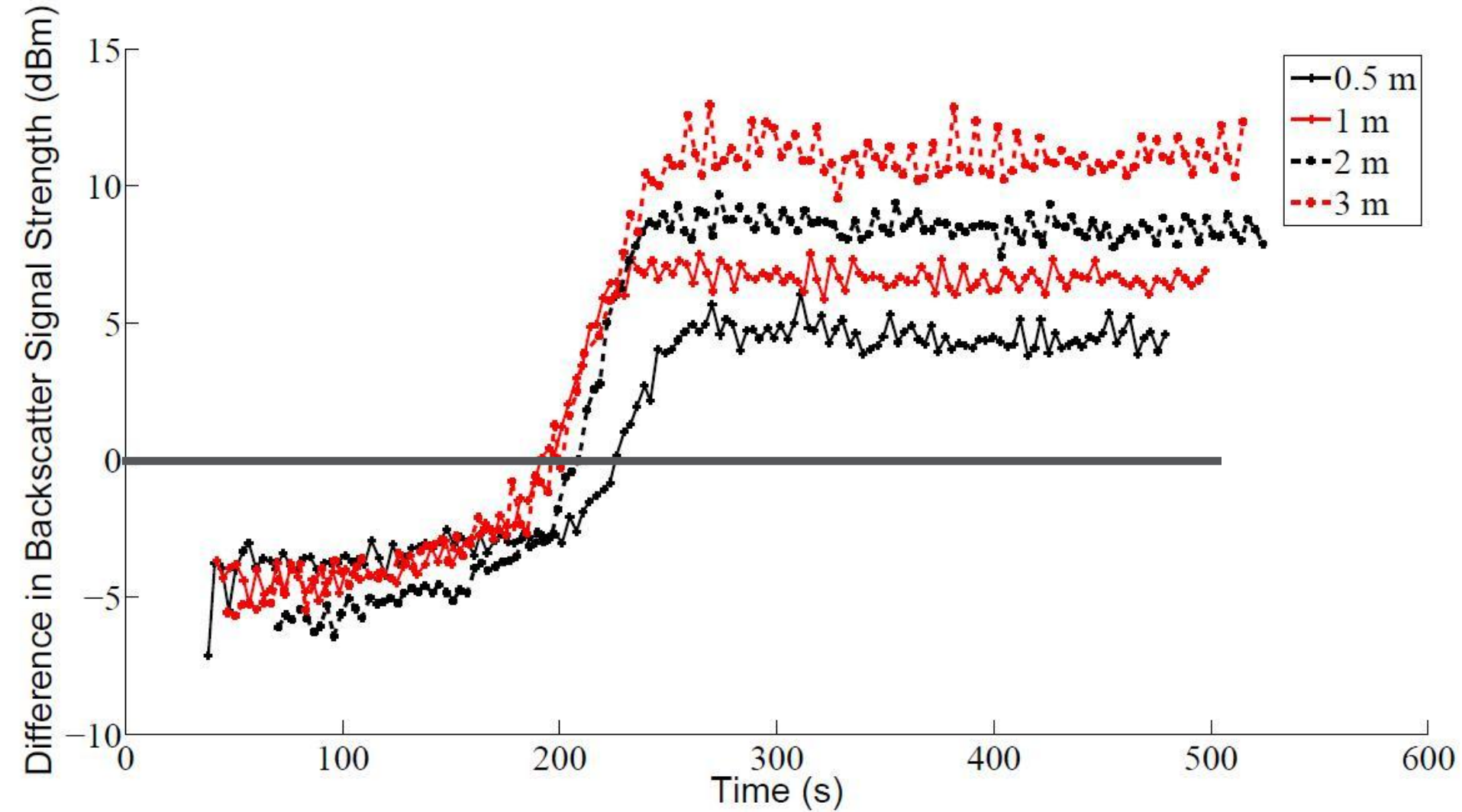


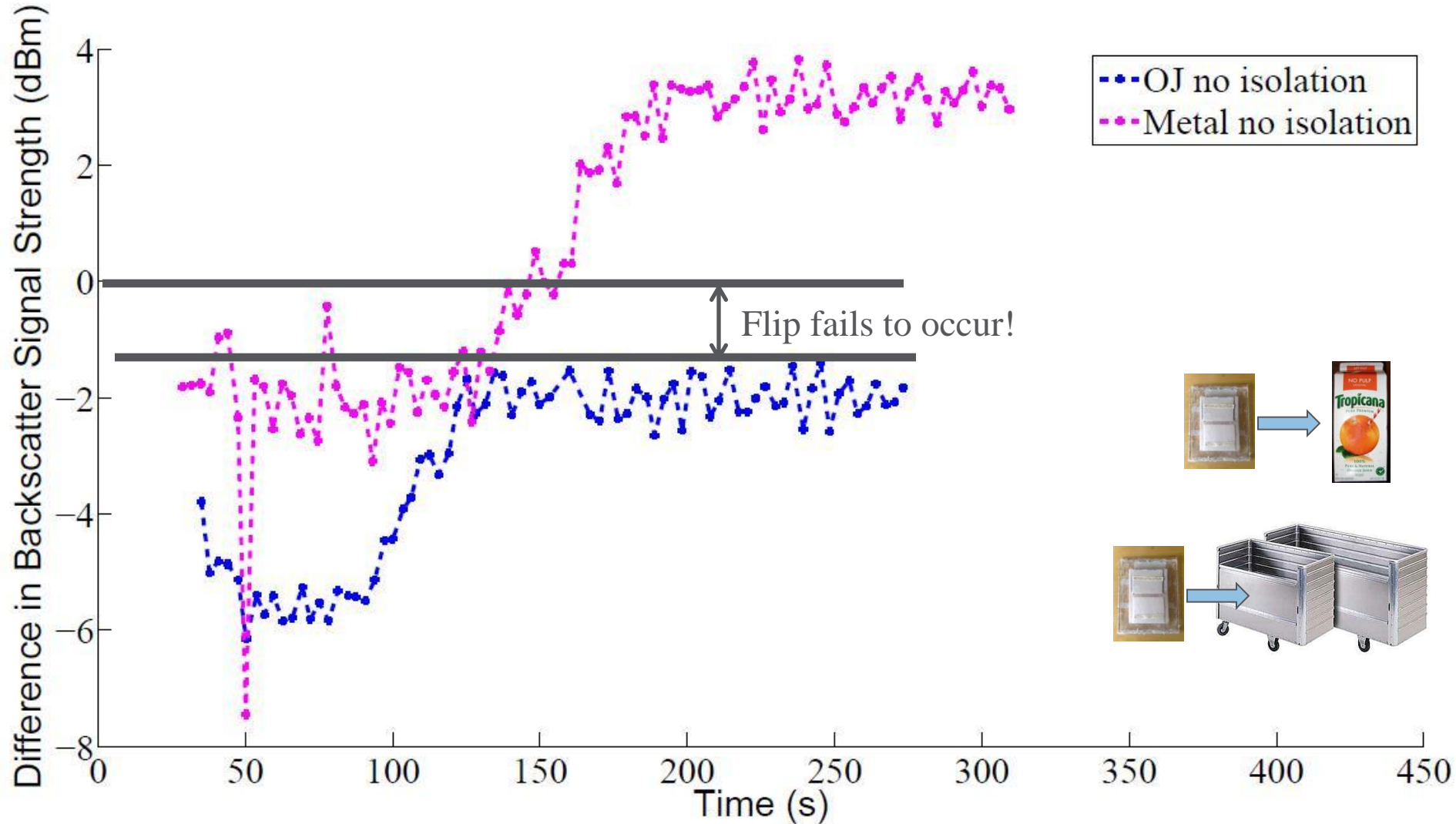
Temperature Threshold Sensor Prototype





Results





- **Advantage**
 - Low-cost design
 - Good read range
 - Performance agnostic of material of deployment

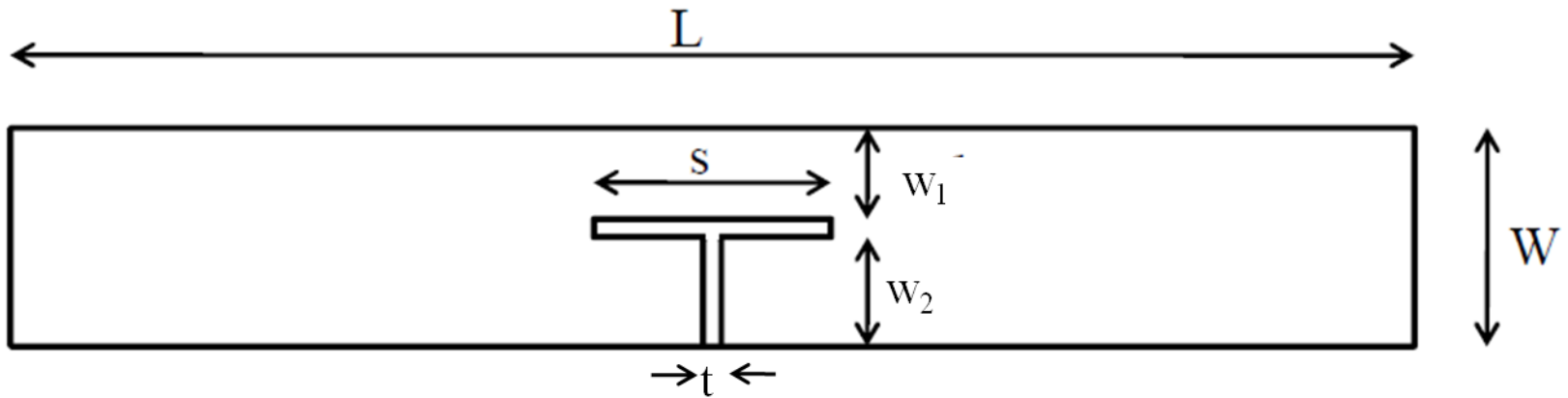
- **Disadvantage**
 - Requirement of reference tag

- **Size reduction?**
 - Frequency domain measurements

26 MHz in America

- **Detect state of a beverage glass**

- Completely full
- Completely empty

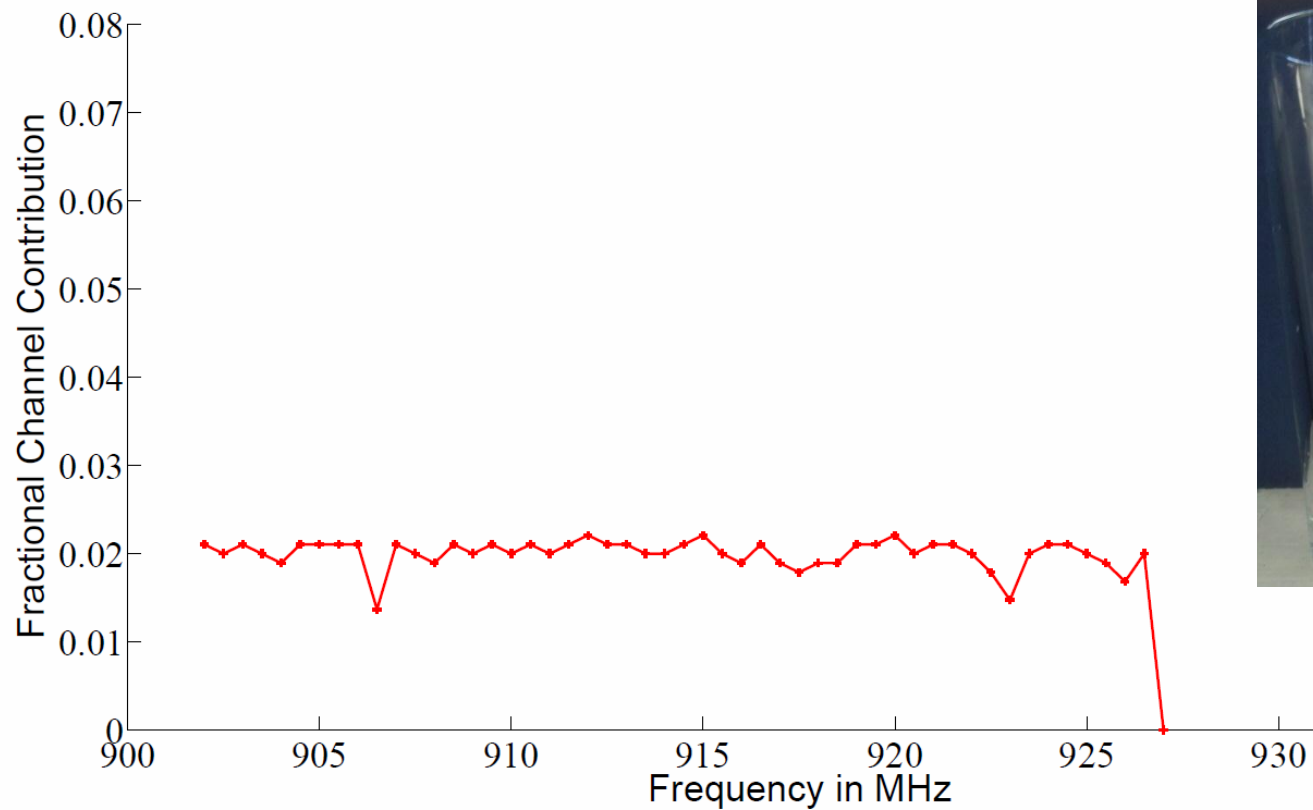


- Only 4 design parameters: (L, W, w_1, s)
- Design methodology (Deavours 2010)

Extend for fluid detection

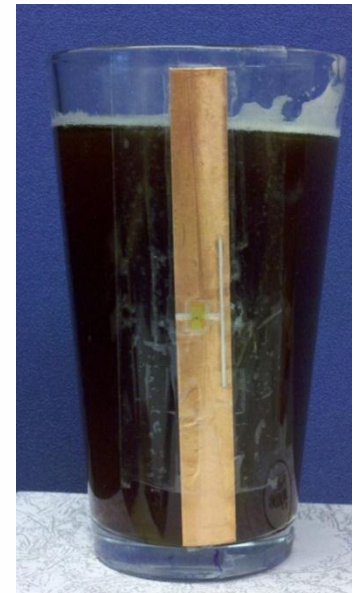
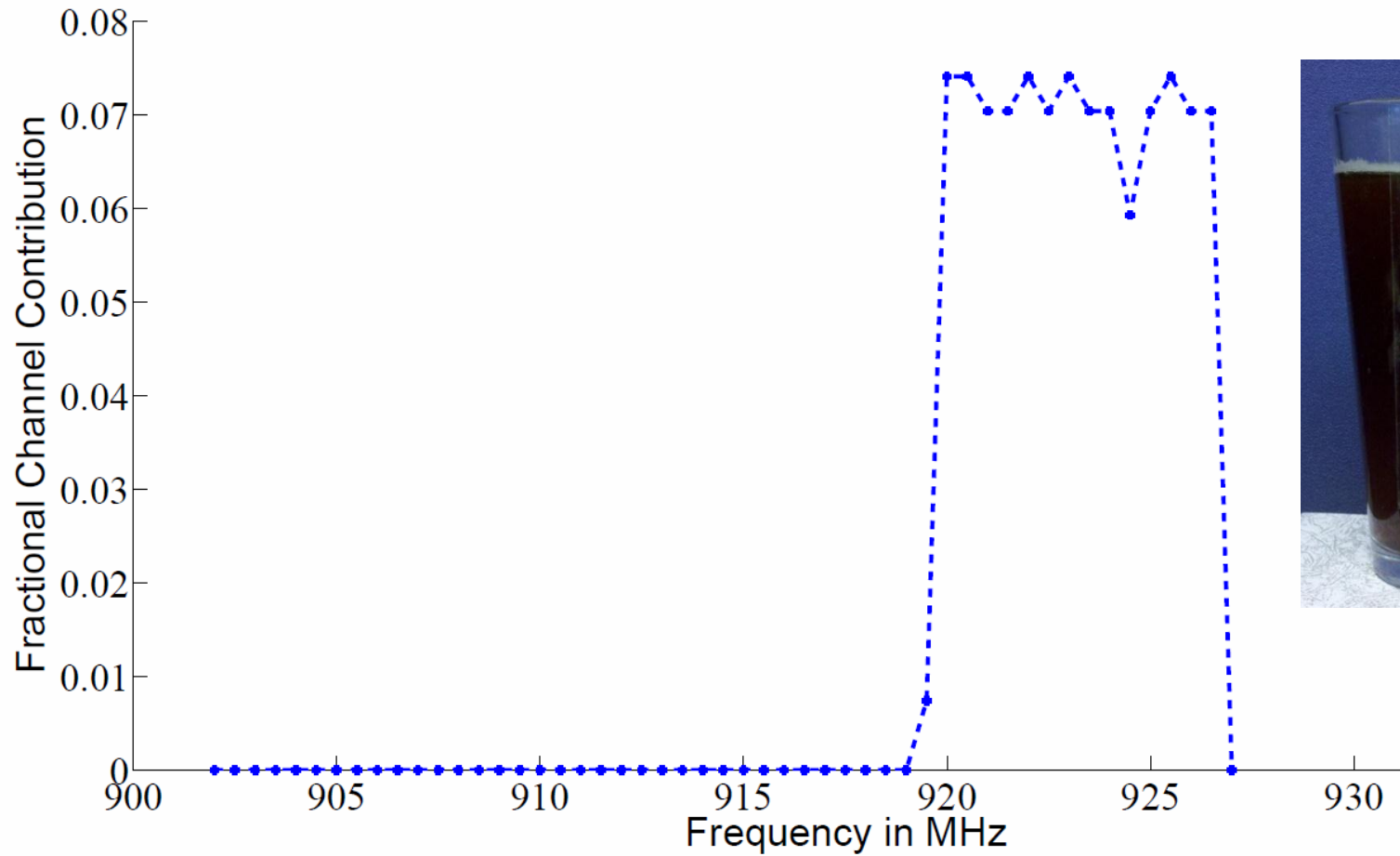


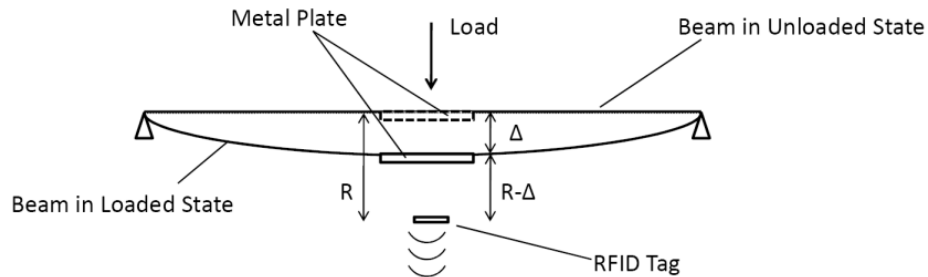
Fluid Sensor: Glass Empty





Fluid Sensor: Glass Full



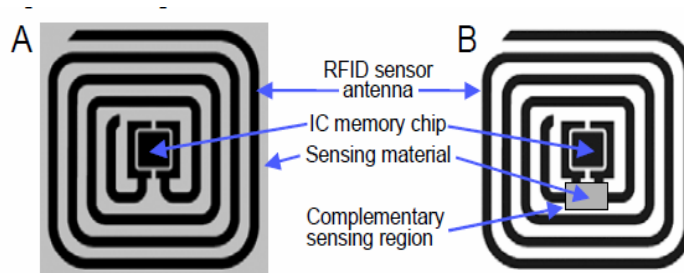


[2009]

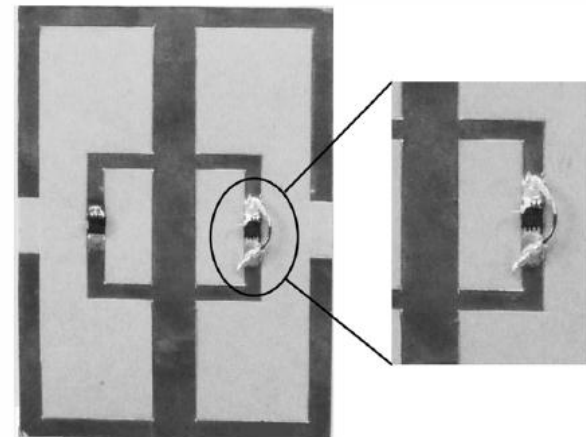
Blotting paper



[Siden 2007]



[Potyrailo 2010]



[Caizzone 2011]

- **2 Reader-Tag signal parameters for sensing**
- **Low-cost, non-electric memory**
- **Potential for RFID + smart materials research**
- **Motivational examples**



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