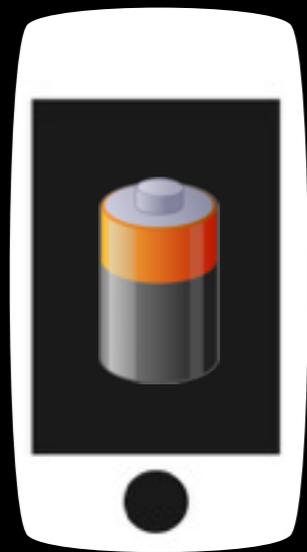


Cellular base station PHY measurement

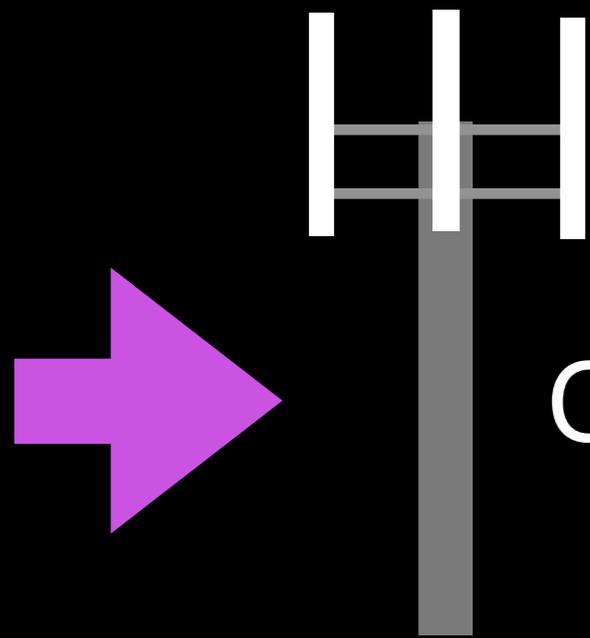
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Smartphone power measurement

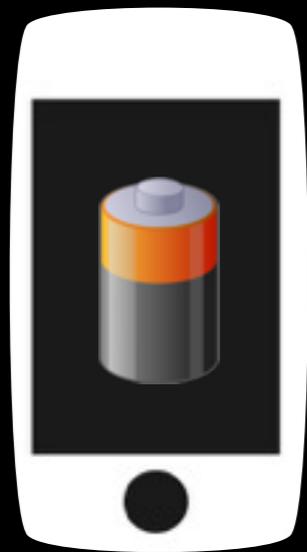
**Aaron Schulman**

Stanford University



Cellular base station PHY measurement

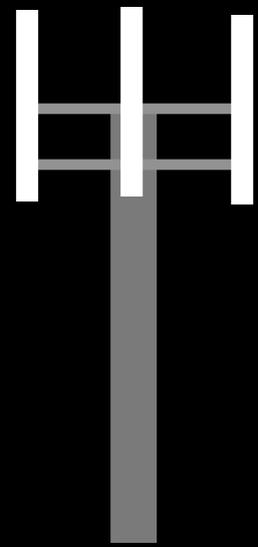
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Smartphone power measurement

**Aaron Schulman**

Stanford University



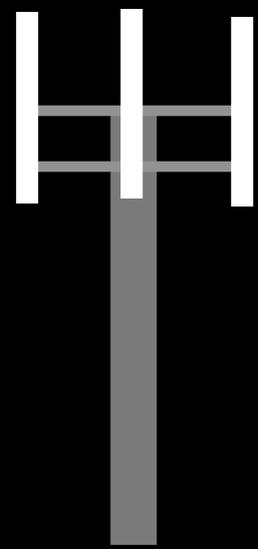
# Why measure the PHY of cellular base stations?

**To quantify the pervasiveness of PHY faults:**

How often are frames dropped due to inter-cell interference?

**To identify and adapt to challenging PHY environments:**

Can we observe high delay spread and adjust to compensate?



# Why measure the PHY of cellular base stations?

**To quantify the pervasiveness of PHY faults:**

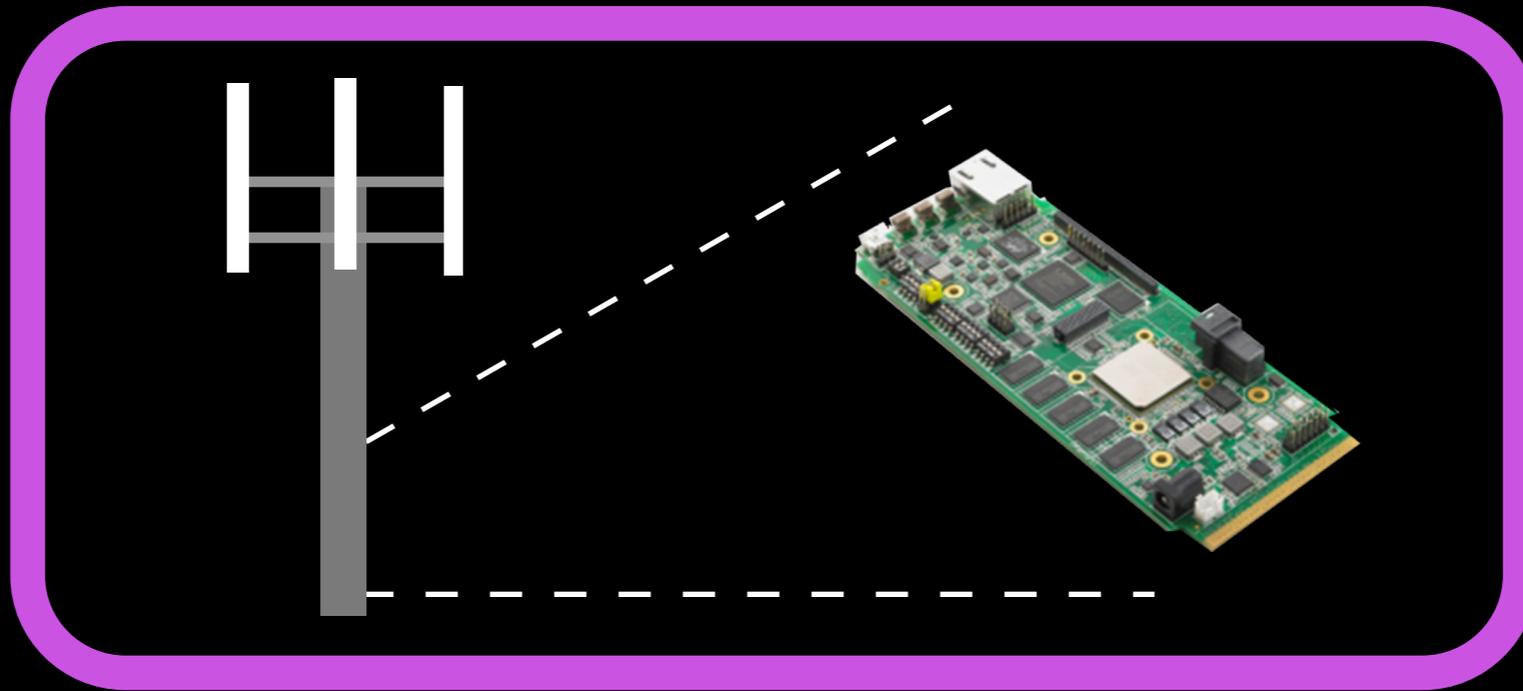
How often are frames dropped due to inter-cell interference?

**To identify and adapt to challenging PHY environments:**

Can we observe high delay spread and adjust to compensate?

To inform the design and deployment of future standards

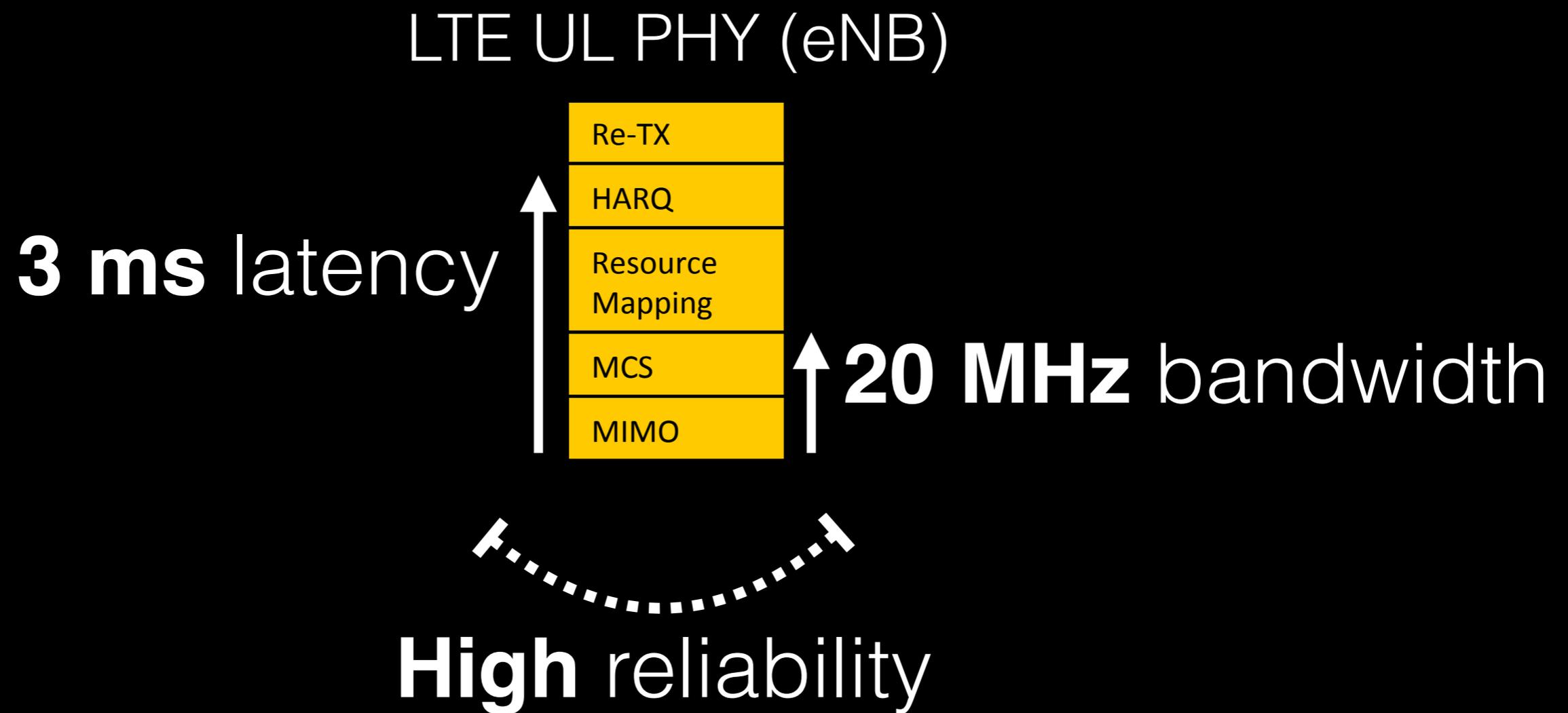
# An Opportunity! Programmable DSPs



## Example: TI 6678

- 8 DSP cores @ 1GHz ← ANSI C
- 4 ARM cores @ 1GHz
- Many co-processors

**Cellular requirements** make it challenging to add new measurements

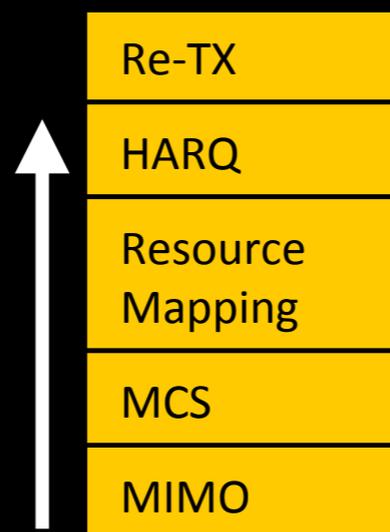




**Low DSP clock rates** make it challenging to add new measurements

### LTE UL PHY (eNB)

**3 ms** latency  
~2,000 cycles  
per byte

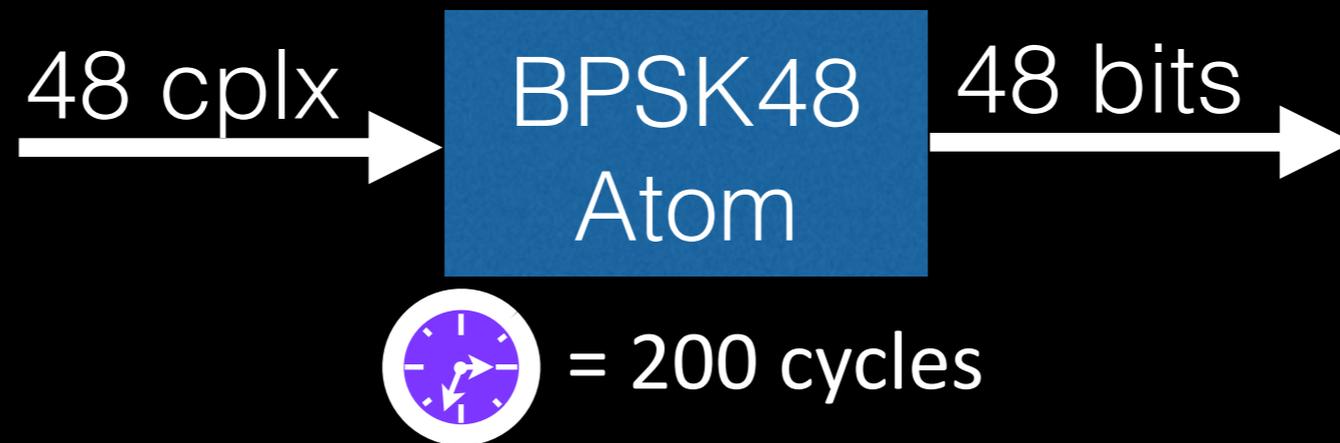


**20 MHz** bandwidth  
25 cycles per sample

**High** reliability  
Can not exceed cycle budget

# Atom

Composable processing block that requires fixed processing resources



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Composable processing block that requires fixed processing resources



Entire base station PHY can be made of Atoms

We built a 54 Mbps 802.11a receiver entirely out of Atoms

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We built a 54 Mbps 802.11a receiver entirely out of Atoms

New measurements are just new Atoms

We added a delay spread measurement Atom

# Atom

Composable processing block that requires fixed processing resources



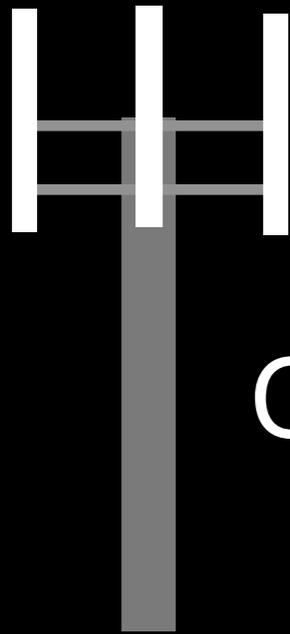
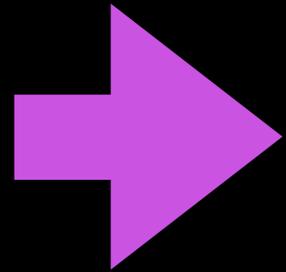
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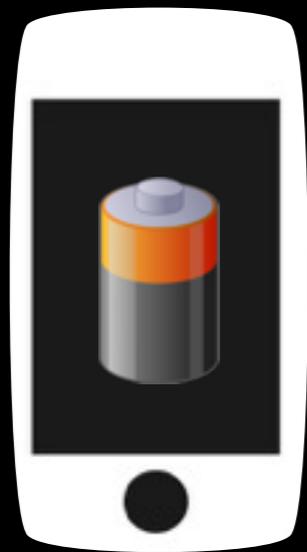
We added a delay spread measurement Atom

New measurements can be deployed on Atom-based base stations

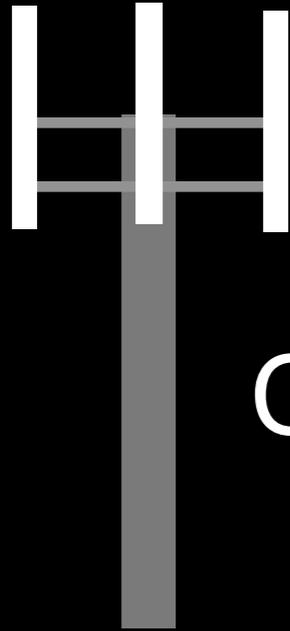


Cellular base station PHY measurement

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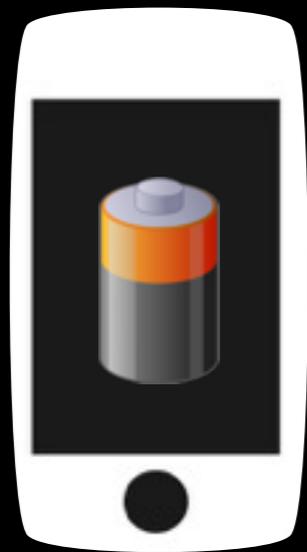
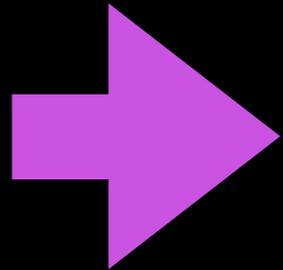


Smartphone power measurement



Cellular base station PHY measurement

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Smartphone power measurement



# Why measure smartphone power?

**To create models of energy consumption:**

Are apps using hardware inefficiently?

Do users use apps in a way that wastes energy?

**To inform developers about app energy consumption:**

Did a code change harm energy consumption?



# Why measure smartphone power?

## To create models of energy consumption:

Are apps using hardware inefficiently?

Do users use apps in a way that wastes energy?

## To inform developers about app energy consumption:

Did a code change harm energy consumption?

To find new ways to improve smartphone battery life

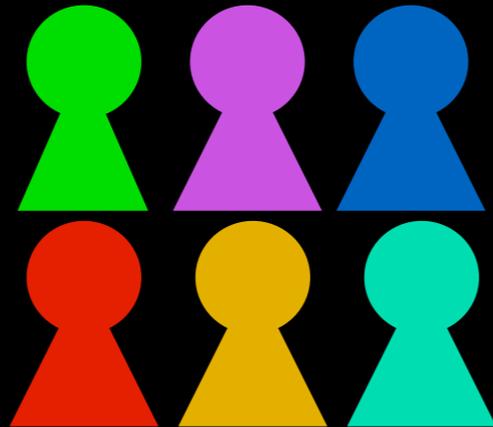


# Properties of an ideal smartphone power monitor

Passive



Scalable



Mobile



Universal



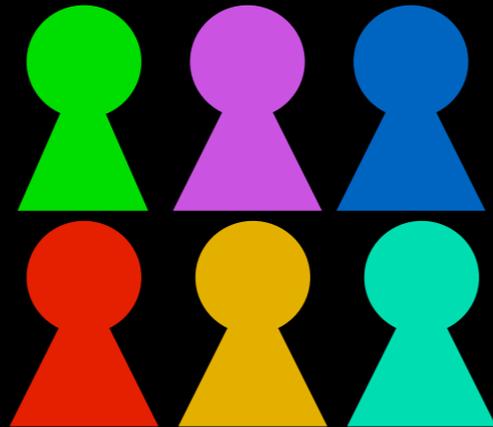


# Properties of an ideal smartphone power monitor

Passive



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No existing power monitor has all 5 properties

# BattOr - The ideal smartphone power monitor

Passive



Scalable



Mobile

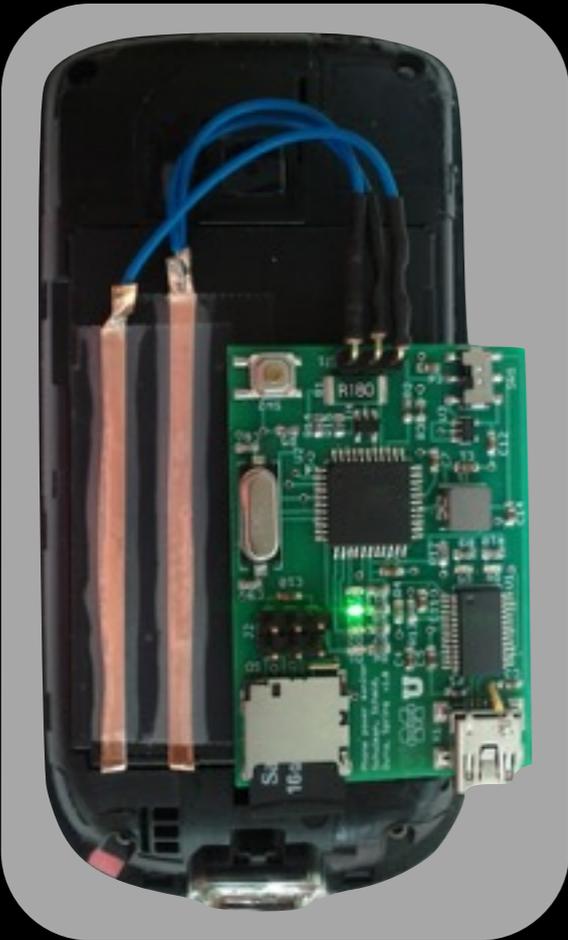


Universal

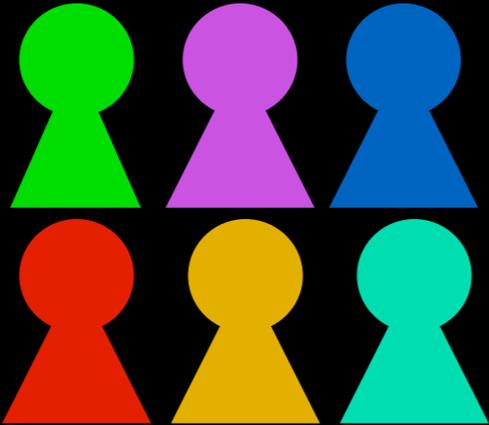


# BattOr - The ideal smartphone power monitor

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# BattOr - The ideal smartphone power monitor

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\$200  
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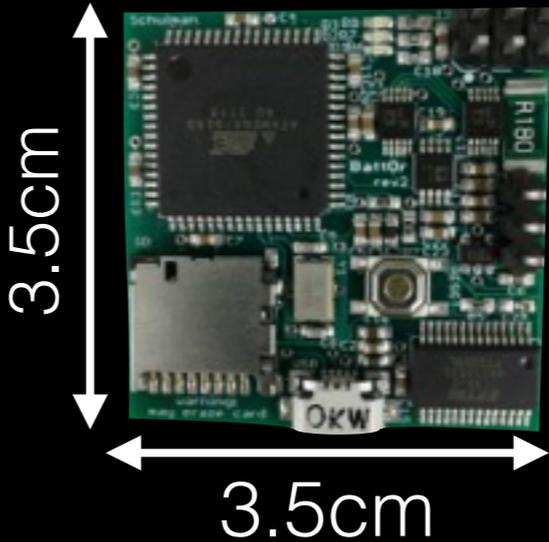
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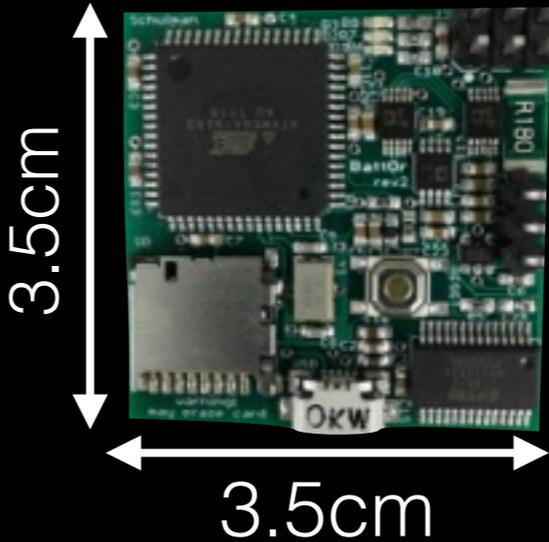
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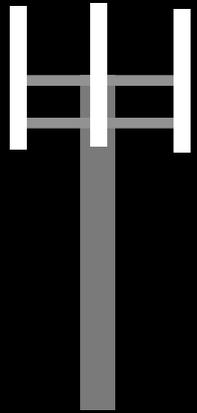
Universal



**\$200  
each**



# Conclusion



It is feasible to deploy new measurements on cellular base stations.



An ideal smartphone power monitor is obtainable.