# MRAM Applications – Pros/Cons

- **Panel Discussion**   Chair: Satoru Araki

- **Goal:** Discuss upcoming MRAM Applications in Two Axes: Market and Performance

- **Panelists:**
  - Mark Webb, President MKW Ventures
  - Andy Walker, VP Product, Spin Memory
  - Daniel Worlege, Distinguished RSM, IBM Research
  - Terry Torng, Co-Funder, GyrFalcon
  - Tetsuo Endo, Prof. Tohoku
  - Rizwan Ahmed, VP Marketing, Everspin
  - Jean-Pierre Nozieres, CEO, Antaios

- **Two Domains:**
  - Market segments – NVM / Unified / SRAM / AI / Auto, etc
  - Performance axis – Retention / Endurance / Cost / Scalability

Performance Axis

Market Segment
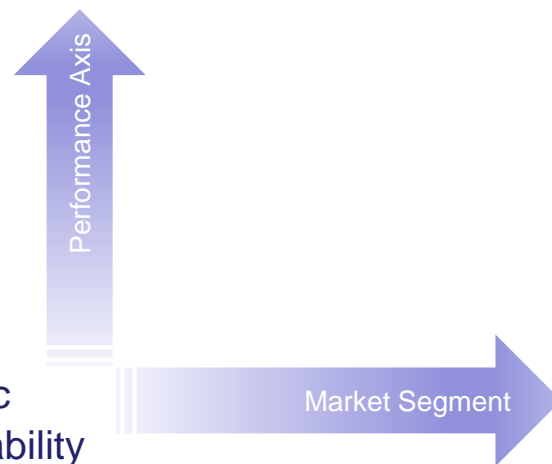
2019 MRAM Markets and Applications

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MRAM Future and Challenges

- MRAM technology is here today
  - We know what it is and what the challenges are
  - Cost, Performance, Density, Endurance, SOC integration, etc
- In past year, we have updates on multiple fronts
  - Existing companies announced 1Gbit parts, updated us on revenue and growth
  - Multiple Companies presented embedded MRAM technologies
    - IEDM/ISSCC Papers were popular. Embedded is an option to choose
  - New technologies and models and optimization
- No need to speculate on what is coming

A Tale of Two Markets

- Embedded: MRAM is ideal for market (revenue not measurable)
  - Potential to replace NOR, SRAM, DRAM applications
  - Ability to integrate (metal stacks), density (Mbit), performance (DRAM) match embedded needs well
  - Endurance work needed for full RAM replacement
  - Looks like Embedded "Universal Memory"… Why isn't it here already?
- Discrete: Targets and Market growth uncertain (Rev <$100M today)
  - Target applications requires specific density, speed, with NVM requirement.
  - Small markets exist, but they are vulnerable to attack on all sides.
  - No measurable NAND replacement market (Too small, expensive)
  - Performance/cost/density ratio not on track to match DRAM
  - Needs to dominate Niche or have "Killer App"

Revenue Projections for MRAM

- In 2018 we predicted >$900M in Revenue by 2024
  - This will not happen
  - 2018/2019 did not breakout like we hoped/expected

	MRAM Revenue Baseline	Notes/required milestone
2020	$115M	1Gb selling for revenue in 2020, DRAM-Like performance. Multiple IP sources for foundries
2022	$217M	Multiple foundries and 1+ Memory company in volume
2024	$429M	2+ memory companies in volume

Included discrete chips (may be stacked) and revenue from licensing
Does not include embedded memory (no revenue model)

What is Needed to meet Revenue by 2024 (Forecast=$429M)

- <u>ALL MRAM</u>: Volume production in applications in 2020
  - These are required to allow people to commit the technology to <u>significant</u> products.

- <u>Embedded:</u> Multiple foundry support with multiple applications
  - MRAM penetration into market is measureable in 2020
  - MRAM becoming chosen technology in 2022 designs

- <u>Discrete</u>: Meet aggressive endurance goals, Cell size Goals, Density roadmaps and Cost
  - To have any penetration into larger markets, confidence needs to increase in delivering specs.
  - MRAM is unique enough to not allow easy "backup plans", so high confidence is needed

- More details on MRAM vs other memories in my memory update on Tuesday
- Mark Webb, www.mkwventures.com