# AI Revolution in Making

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**I do not represent Fermilab and/or US DOE.**

# Message

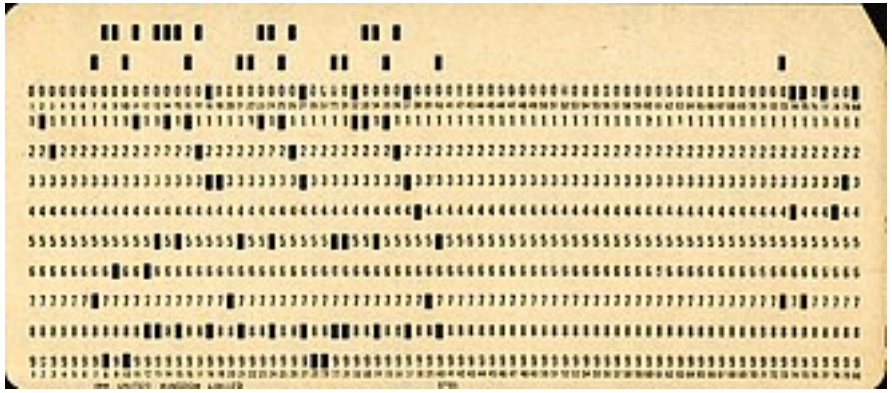
"इस देश के लिए कुछ करो“

- My Dad

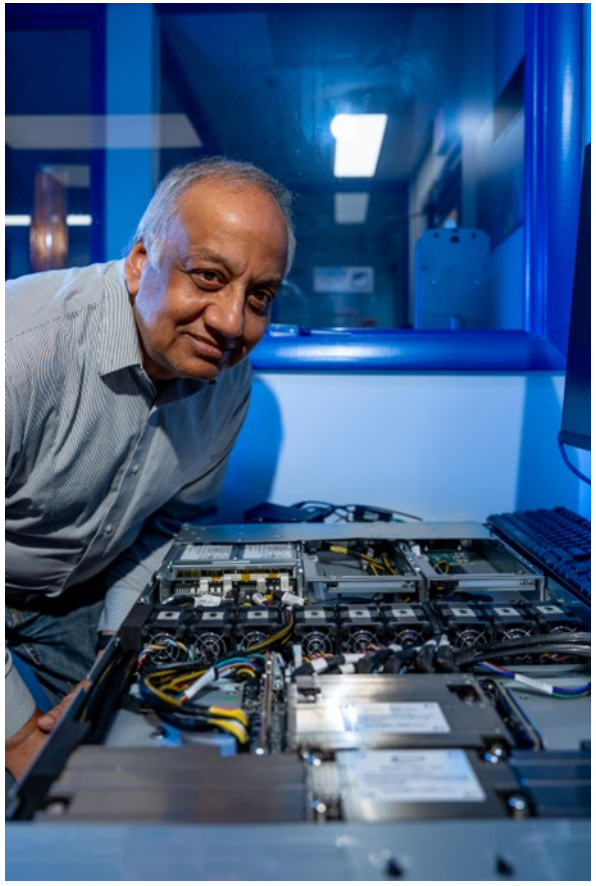
- (India 2003)

I am very thankful to the US and Indian Government, University and Scientific Establishments in both countries and around the world for making this message a reality.

# Evolution in a Generation

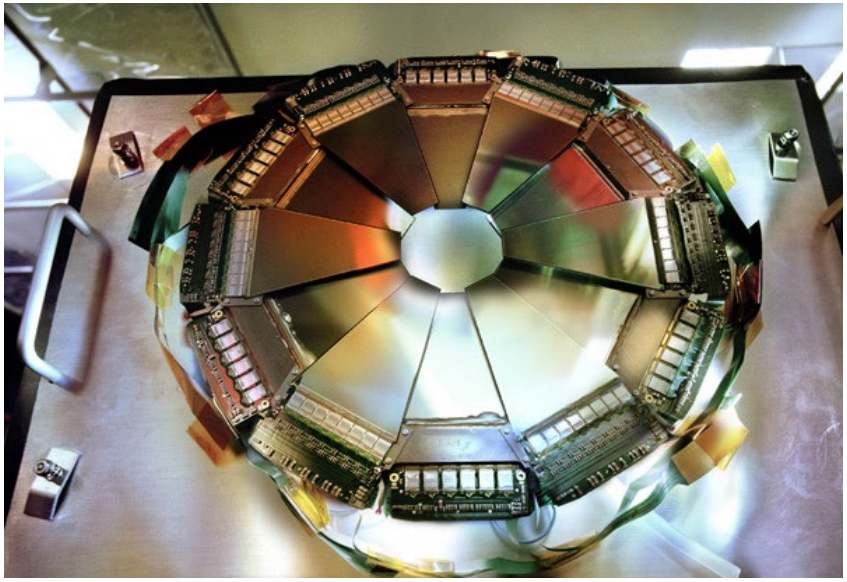


1980s Computer Punch card, One line of code, 80 Characters (Meson Experiment Los Alamos National Lab



1st GH200 (Thanks to NVIDA and Super Micro Collaboration) (DUNE Experiment Fermilab)

# Early Implantation



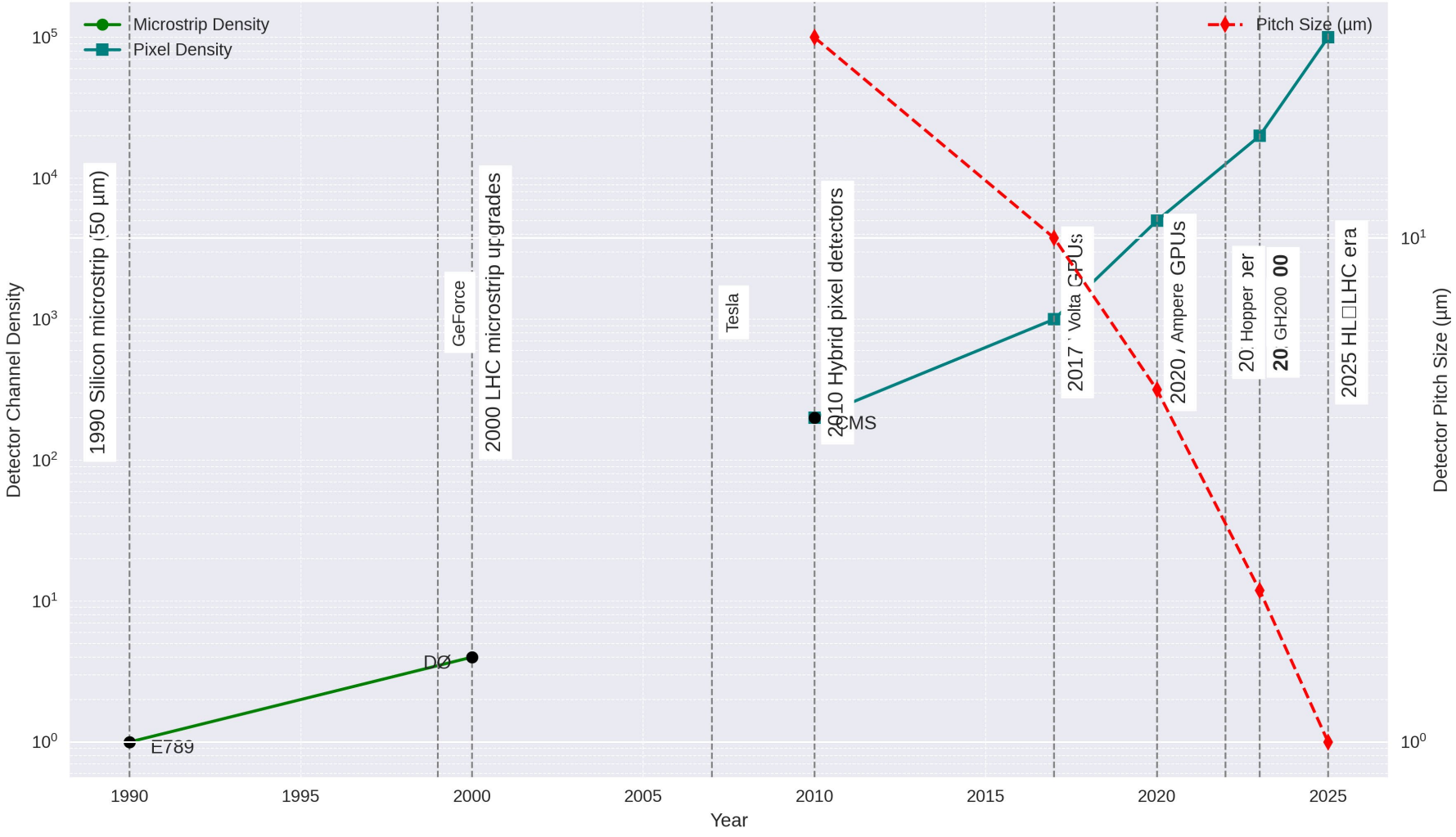
Silicon strip disk for the Dzero: “Neural Network Implementation” for top and bottom quark physics (2000)

Fermilab Main Injector: Foundation of “Digital Twin” automation (2000)

# Evolution of Particle detector and AI (GPU):

- **Silicon Detectors Pushed Semiconductor Technology Forward**
  - Microstrip detectors (50–100 μm) drove early CMOS precision and yield
  - Pixel detectors (25 → 10 → 5 → 2 → 1 μm) required:
    - Smaller feature sizes, Higher interconnect density, 3D stacking, TSVs, stitched sensors
  - These same advances later enabled high-density GPU cores and HBM memory
- **GPU Evolution Enabled the Pixel Era**
  - GPUs became massively parallel just as pixel detectors exploded in channel count
  - Memory bandwidth jumped from **GB/s → TB/s**
  - Compute per watt improved by orders of magnitude
  - Enabled real-time tracking, AI-based triggers, and large-scale reconstruction

# Evolution of Technology



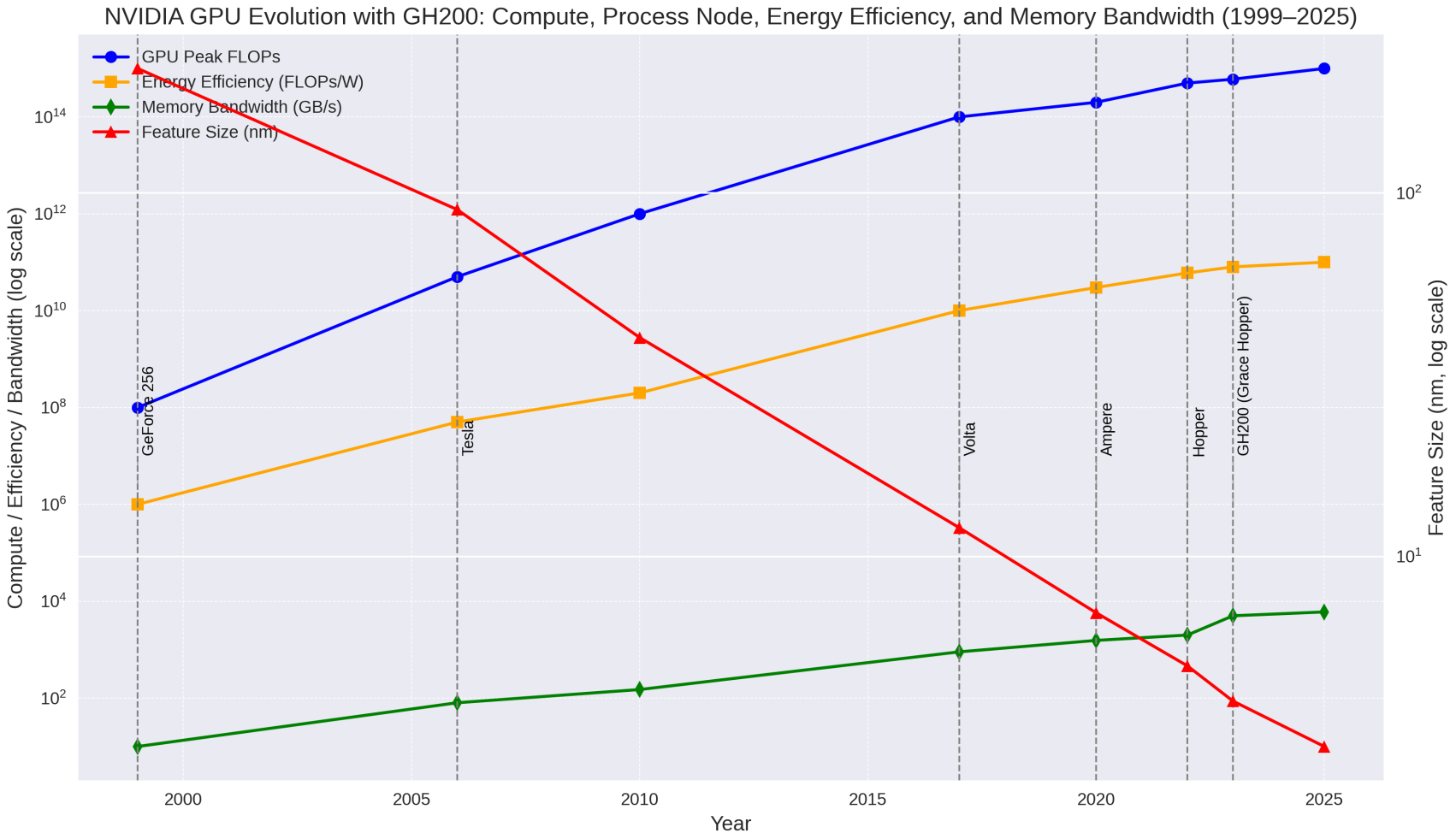
# Evolution of AI (1990-2025…)

| AI Era | New Capability | Physics | Medicine | Finance |
|---|---|---|---|---|
| Early NNs | Pattern recognition | Event classification | ECG/X-ray | Credit scoring |
| CNNs | Vision | Jet images | Radiology | OCR, fraud |
| Deep Learning | High-dimensional learning | Boosted jets | Cancer detection | Market modeling |
| Transformers | Language & sequences | Event modeling | EHR analysis | NLP for markets |
| GNNs | Relational reasoning | Tracking | Genomics | Fraud networks |
| Foundation Models | Generalization | Simulation | Multimodal diagnosis | Forecasting |
| Agentic AI | Decision-making | Autonomous experiments | Clinical copilots | Trading agents |

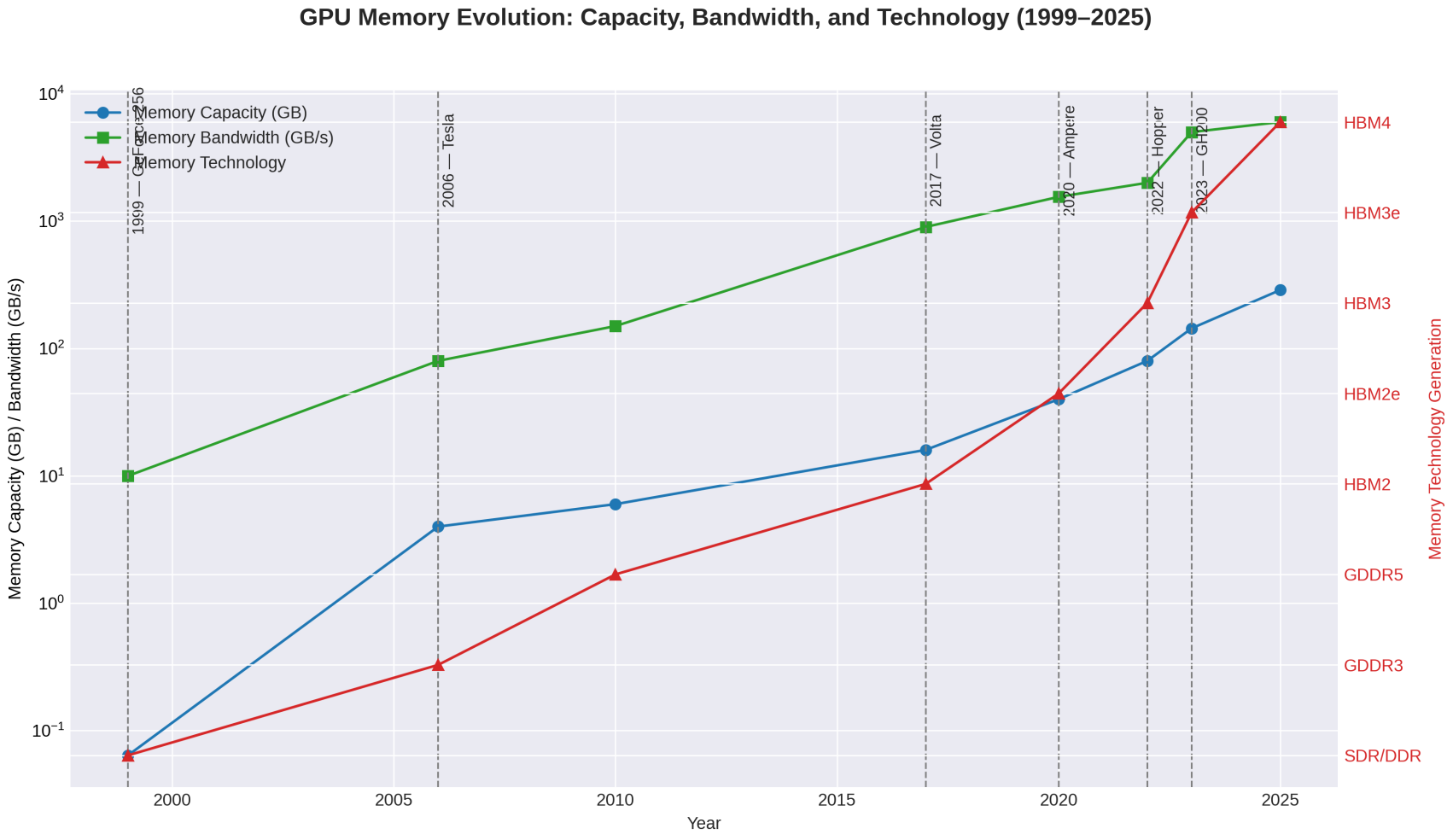
# Evolution of AI (1990-2025…)

| AI Era | Particle Physics | Accelerator Physics |
|---|---|---|
| Early NNs | Top-quark discovery, b-tagging | Basic beam diagnostics |
| CNNs | Jet images, calorimeter analysis | Beam-profile imaging |
| Deep Learning | Higgs, boosted jets, fast sim | Predictive maintenance, RL tuning |
| Transformers | Event modeling, PF, unfolding | Time-series control, quench prediction |
| GNNs | Tracking, event graphs | Lattice optimization, digital twins |
| Foundation Models | Simulation, anomaly detection | Autonomous control systems |
| Agentic AI | AI-driven experiments | Self-optimizing accelerators |

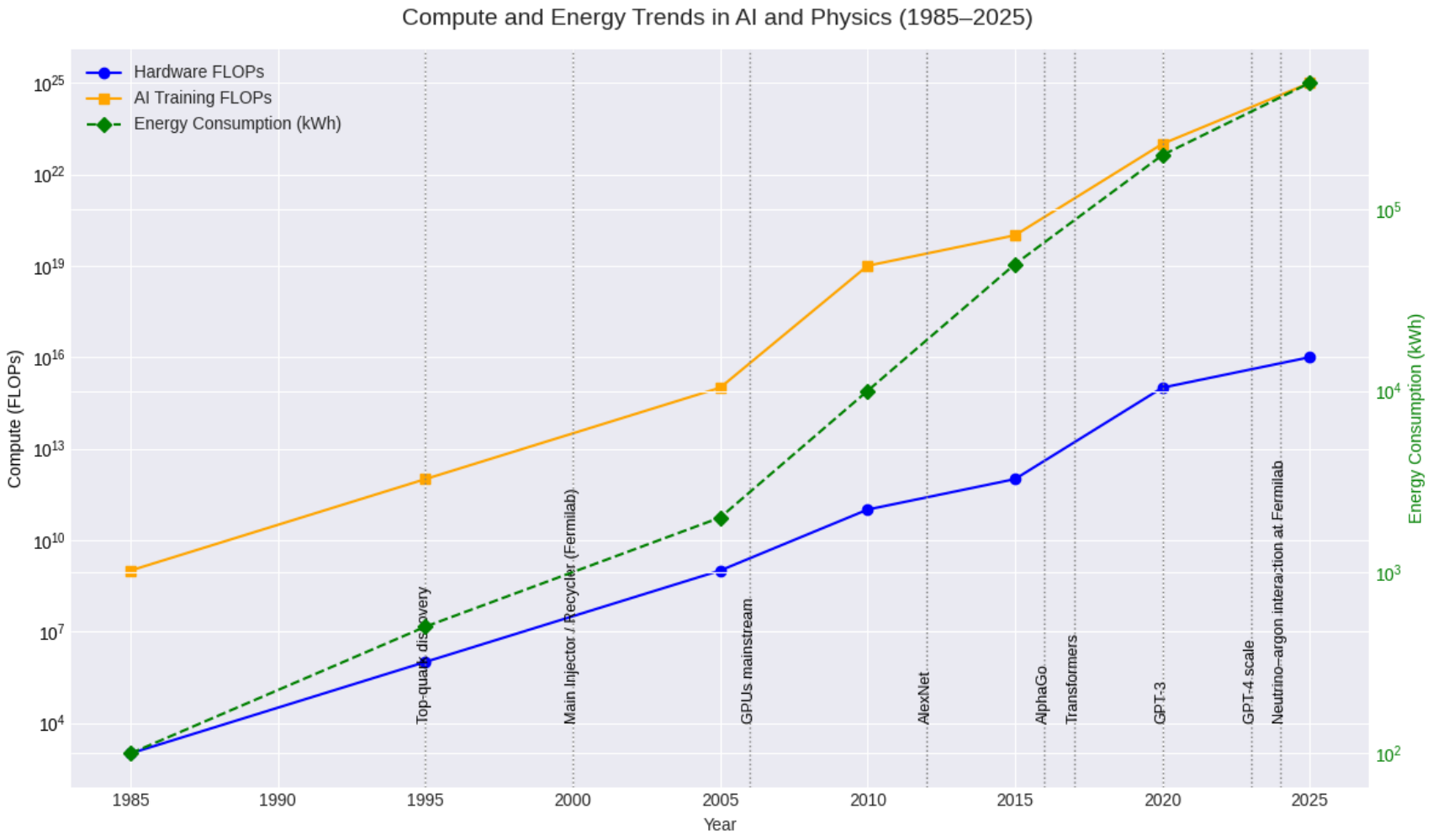
# Compute Power



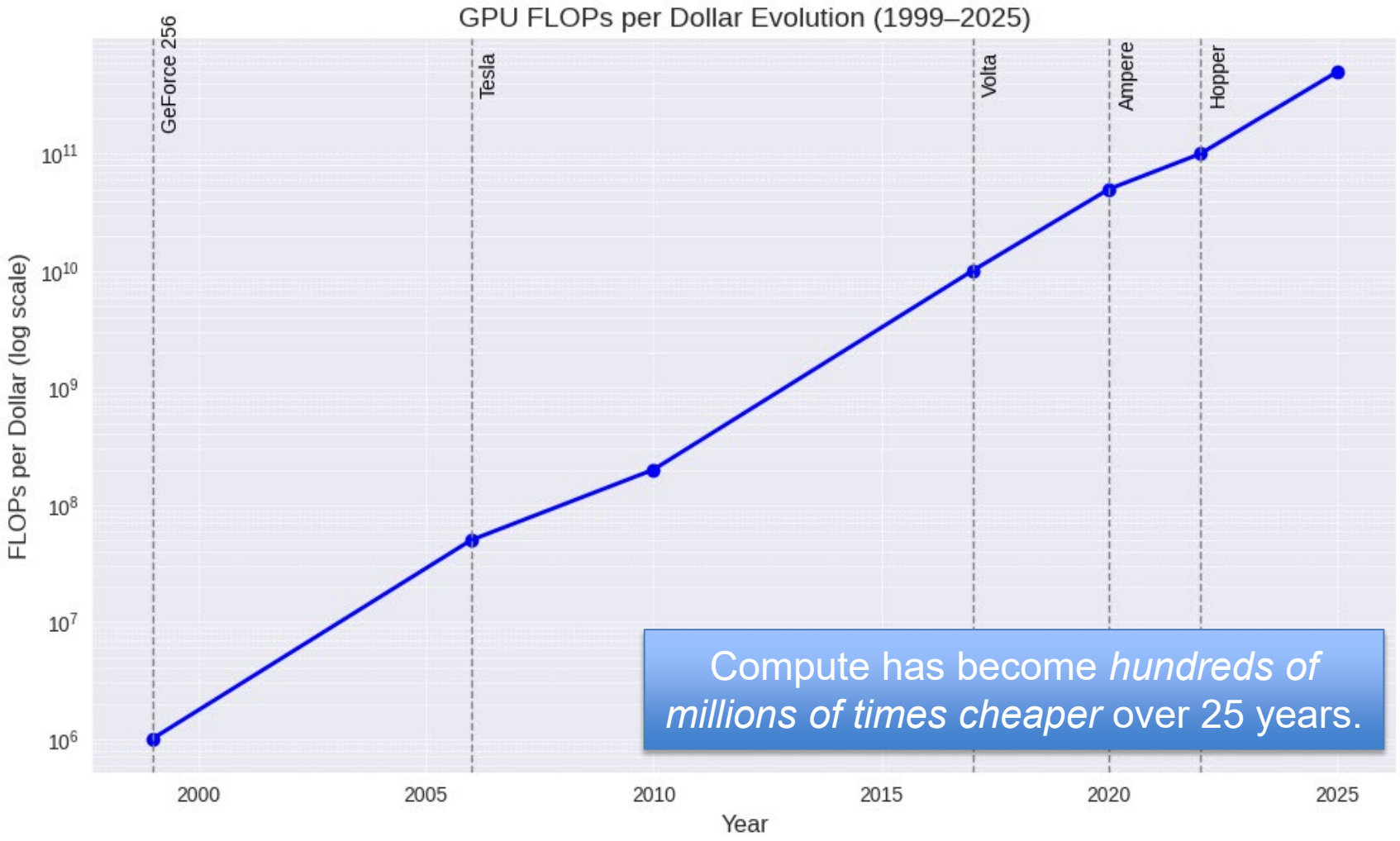
# Memory Evolution



# Evolution of AI Technology



# Cost Effective



# Evolution of AI in the US

- AI gets smarter and more useful, fast: It will move beyond answering questions to helping complete tasks and make decisions.
- AI spreads across every industry: Businesses will use it to cut costs, speed up work, and improve customer service—not just as a “chatbot,” but inside core operations.
- Big boost to science and innovation: AI will accelerate drug discovery, improve climate and weather forecasting, and help design new materials and technologies.
- Jobs will change—not just disappear: Routine work will be automated, while new higher-skill roles grow (AI supervisors, workflow designers, quality and compliance roles).
- Stronger US rules and national strategy: Expect more standards on safety, privacy, and accountability—especially in healthcare, finance, and critical infrastructure.
- More AI in government and defense: Used for faster analysis, cybersecurity, logistics, and decision support—along with tighter oversight and security requirements.

# AI Evolution in India: From Coding → AI Delivery Hub

- Software writing shifts to “software directing”
  - IT services move up the value chain
  - Massive re-tooling of the workforce
  - India becomes a global hub for AI operations
- AI Built on India’s Digital Public Infrastructure
- AI for Public-Sector Transformation (Agriculture, Healthcare, Education, Transportation, Governance)

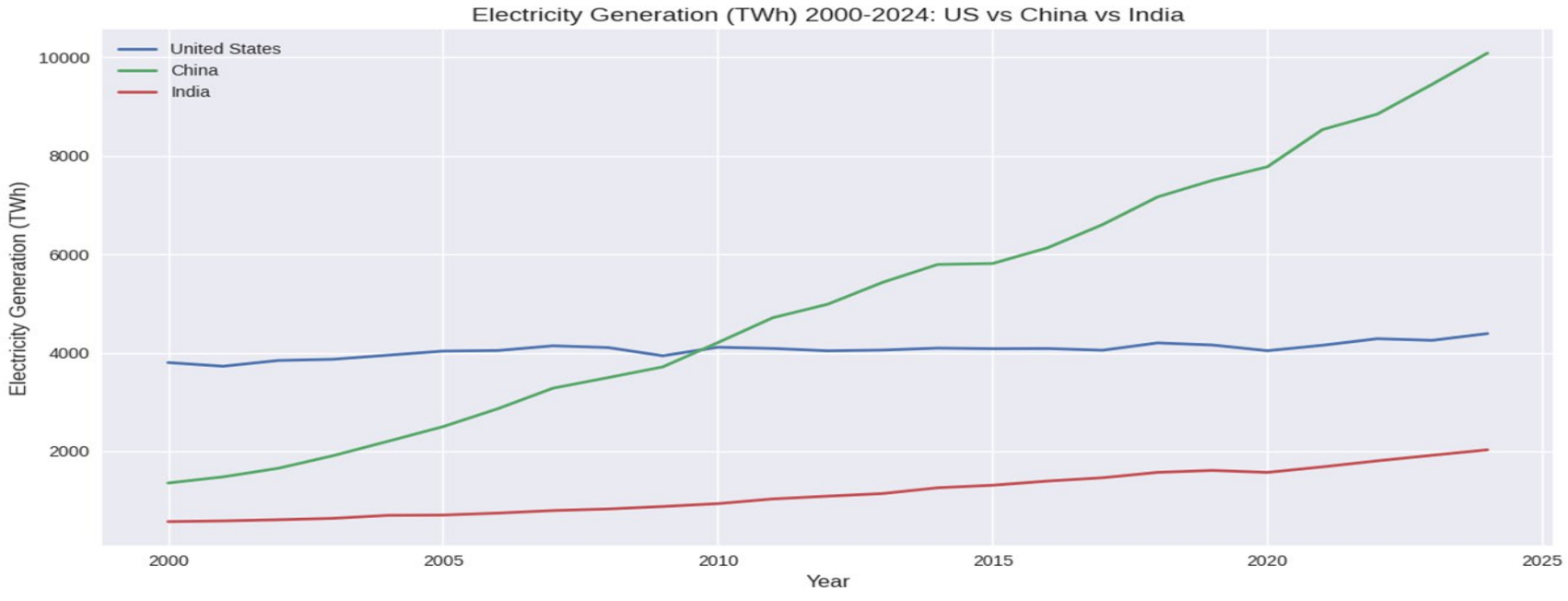
In my opinion India as a developing country must moved beyond the Human resource provider of the Western world.

# Implementation India Context

- India has a great potential to leapfrog in AI Technology and take advantage of the changing global landscape. But …
- Technology know how
- Infrastructure
  - Electricity: (One Example)
    - US produces ~4 Terawatt-hours ( 10 times more electricity/person)
    - India produces ~2 Terawatt-hours
    - US is planning new power plant for every major data center.
- Reorient the vast younger generation
  - For software writer to software designer.
    - Software will be written by AI
- Protect Indian Data: India is a diverse country
    - US Technology giants have eye on the Indian data

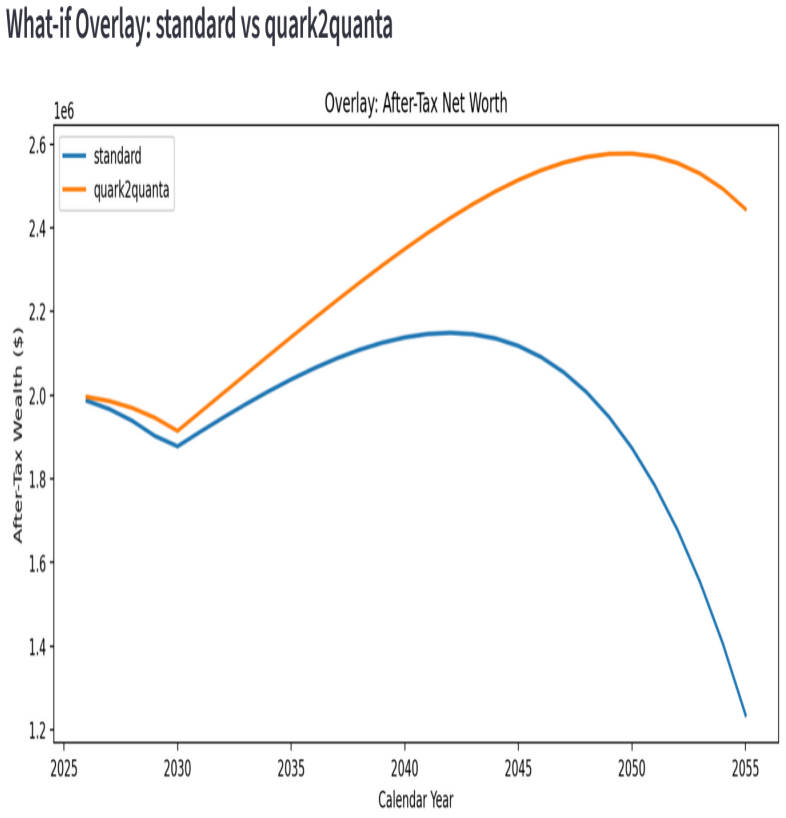
# India Electricity

- Rapid expansion of Data Center would require
  - Small Modular Reactor (SMR)
    - Joint Venture with US and Indian companies (including NTPC/NPCIL).
      - India government have been thinking about it



# Software will be written by AI

- The current model of multilayer approach for software development will end.
  - Almost all software will be written by AI
- India software hubs need to quickly adapt to this changing landscape.
- AI today can write, debug and document complex software.
- AI is getting excellent in Automation.




Retirement Modeling Fully written by AI

# Medical Science

- Next revolution of AI will come in Medical Science.
  - India has a lot to offer and benefit from it.
- India is a most diverse county in the world.
  - We have unique health issues hence
    - Heart Diseases
    - Chronic Obstructive Pulmonary Disease
    - Stroke
    - Diabetes
    - Cancer
  - Unique data set that western would like to have.
    - All modern drug research happens in the Developed world. India can change that.
- India should develop tools to collect secured data and analyze it with AI software

# Summary

- AI Revolution has just begun.
- Potential is very large,
  - Yet resources and infrastructure worldwide are very limited.
- Opportunities are unimaginable
  - We need to rethink and retrain
- Specific to India
  - Policymakers should bring realism and expertise
  - Infrastructure is India's biggest but solvable issue