# What's New in PartialResponseMaximumLikelihood Channels

- Meet Data Rate Challenge (within power and cost constraints)
  - circuit - advanced, CMOS-only design
  - algorithm - symbol-detecting architecture

- Improving SNR performance
  - trellis-coded PR
  - extended PR

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What is PRML?

- shape and sample signal
- match samples with most likely ideal sequence
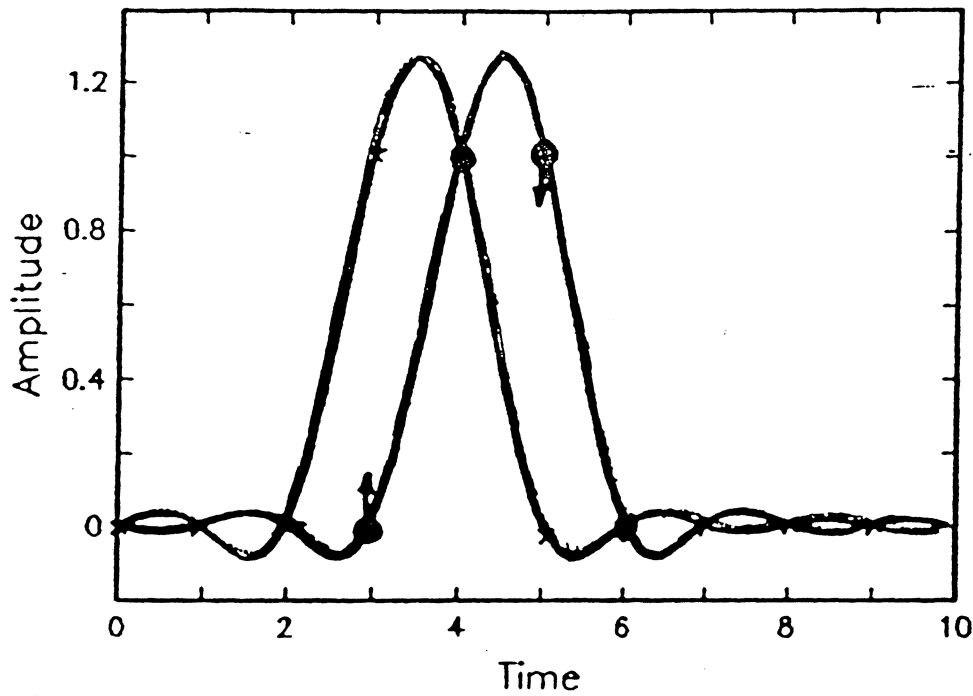
Compared to peak detection:
- control of interference
    - → slower clock for given data rate
- better noise immunity — *factor of 2*
    - → higher density

IBM PRML History

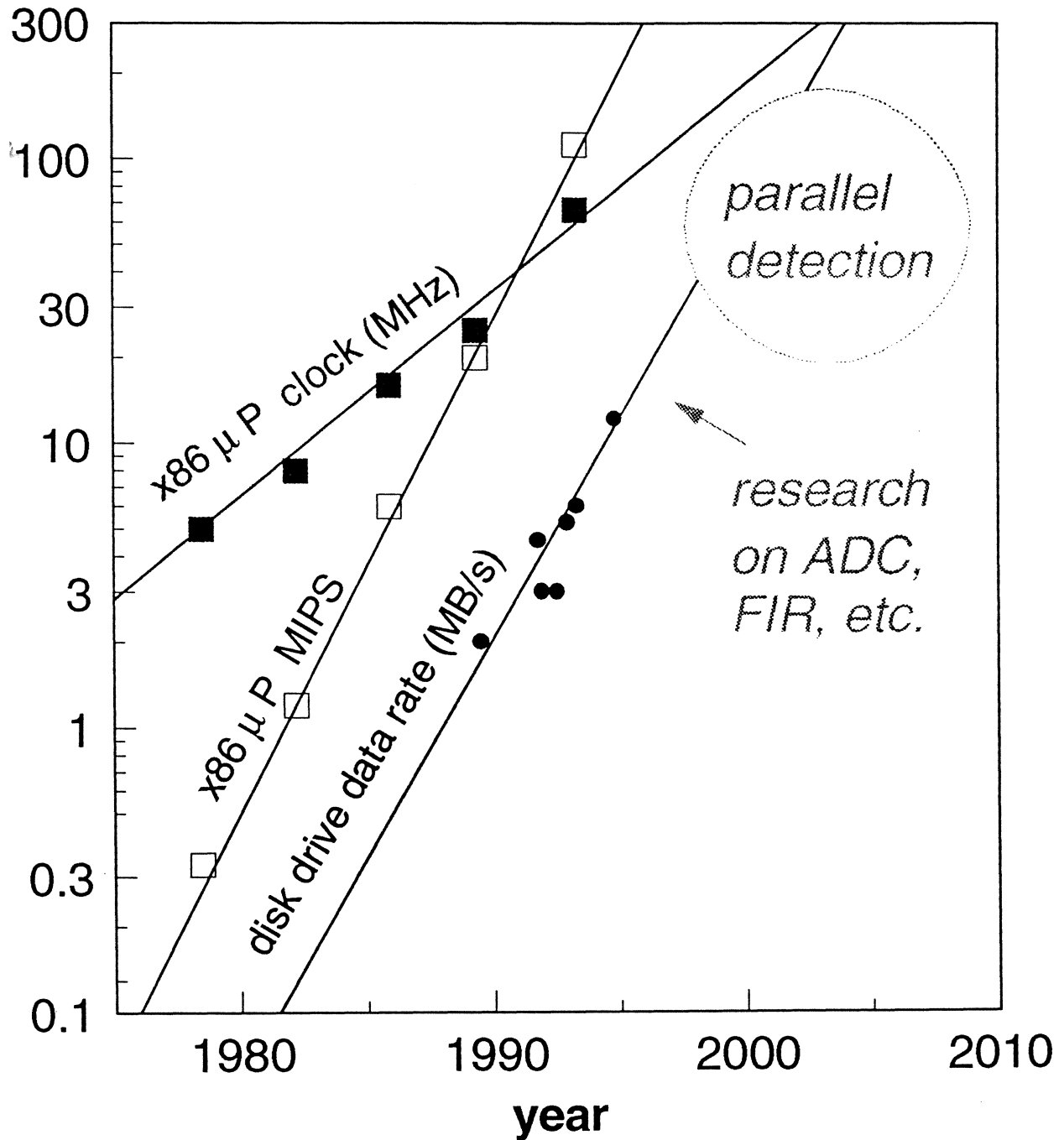- invented by H. Kobayashi & D.T. Tang, IBM, in 1970

year shipped in product	linear density (kbpi)	data rate (MB/sec)
1990	33	3.0
1992	69	5.2
1994	121	12.7

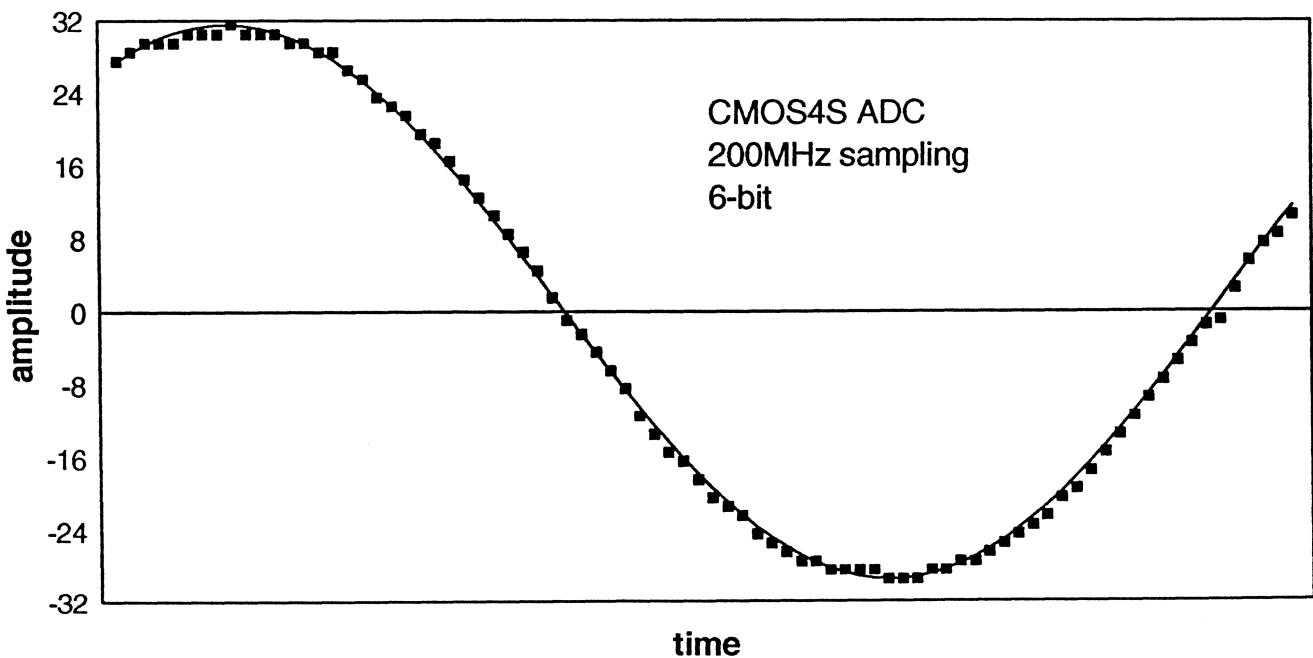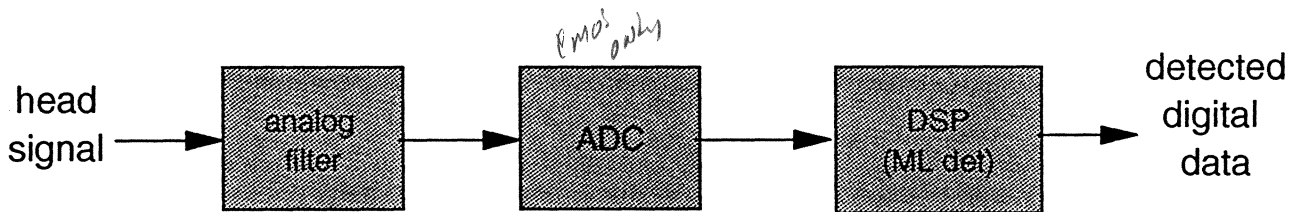- now working on 4th generation channel
- extensive integration know-how

Data Channel

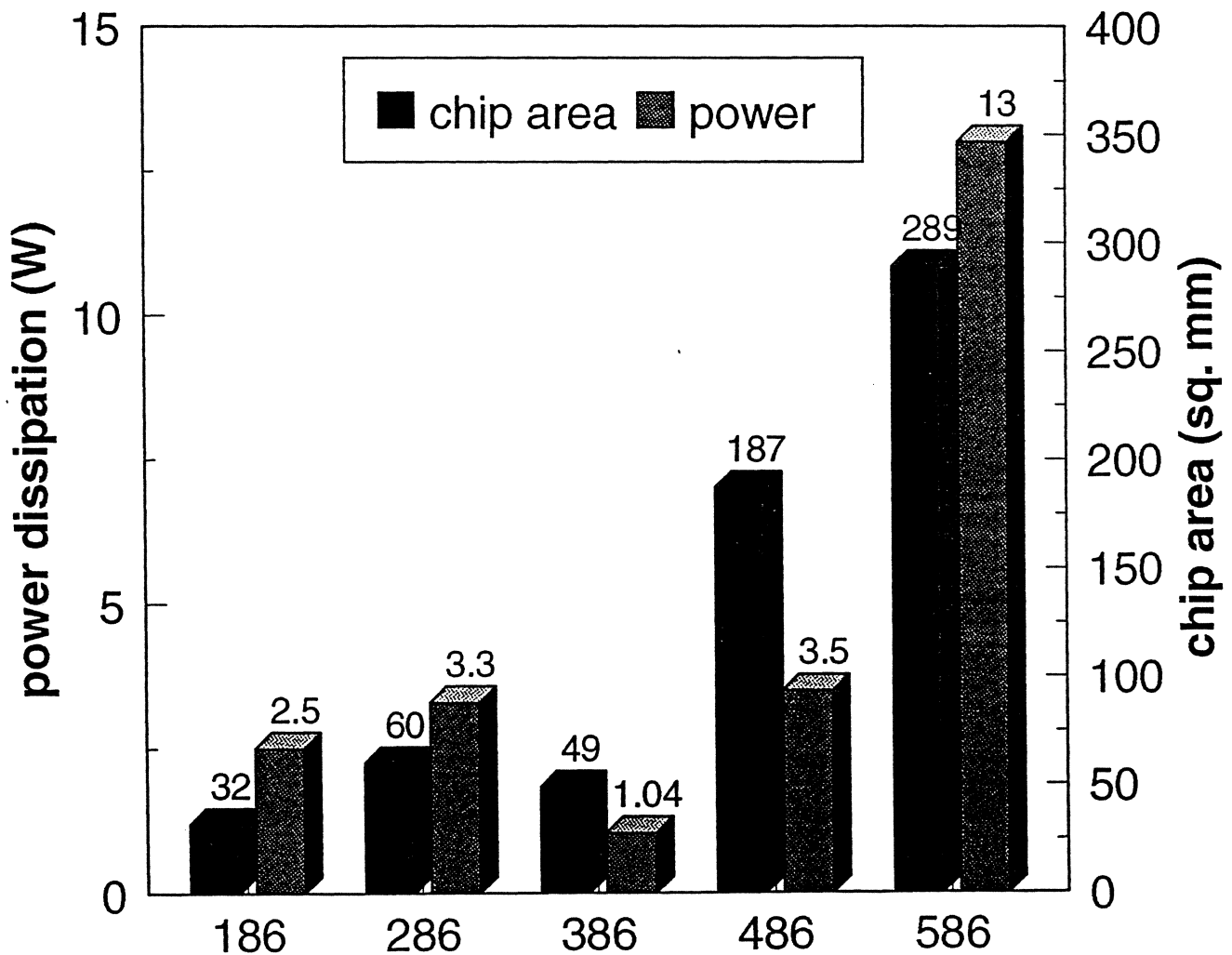Data Rate Challenge:

Data Rate = (linear density) x (velocity)

Custom-Designed, CMOS-only ADC for PRML Channel

technology	BiFET4S	CMOS4S	CMOS5X
lithography	0.8um	0.8um	0.5um
# masks (3LM)	26	19	17
design style	standard cell	full custom	full custom
speed	12MB/s	20MB/s	30MB/s
power	210mW	100mW	60mW

head signal → | analog filter | → | ADC | → | DSP (ML det) | → detected digital data

CMOS4S ADC
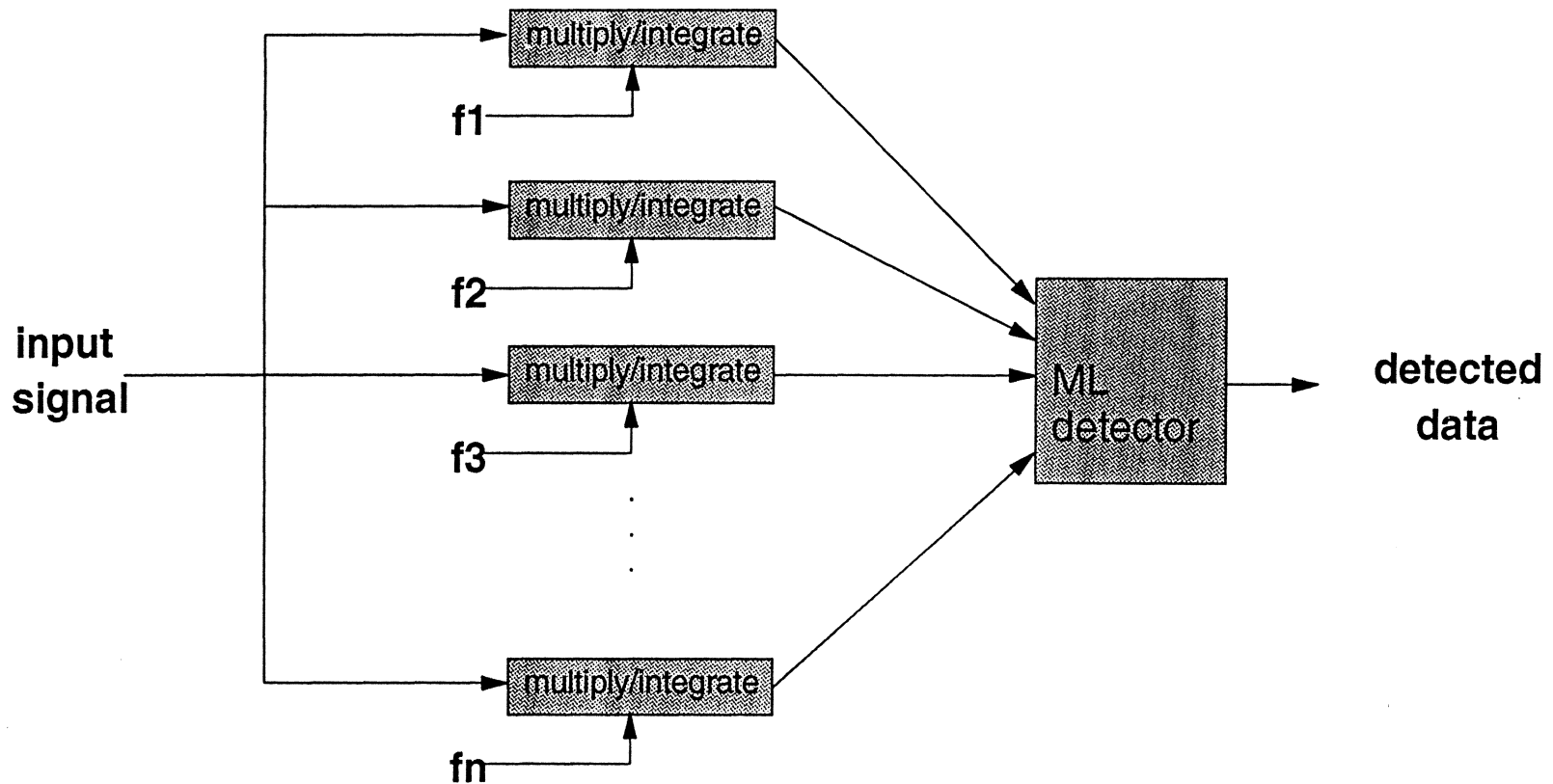200MHz sampling
6-bit

amplitude

time

Parallel Implementations

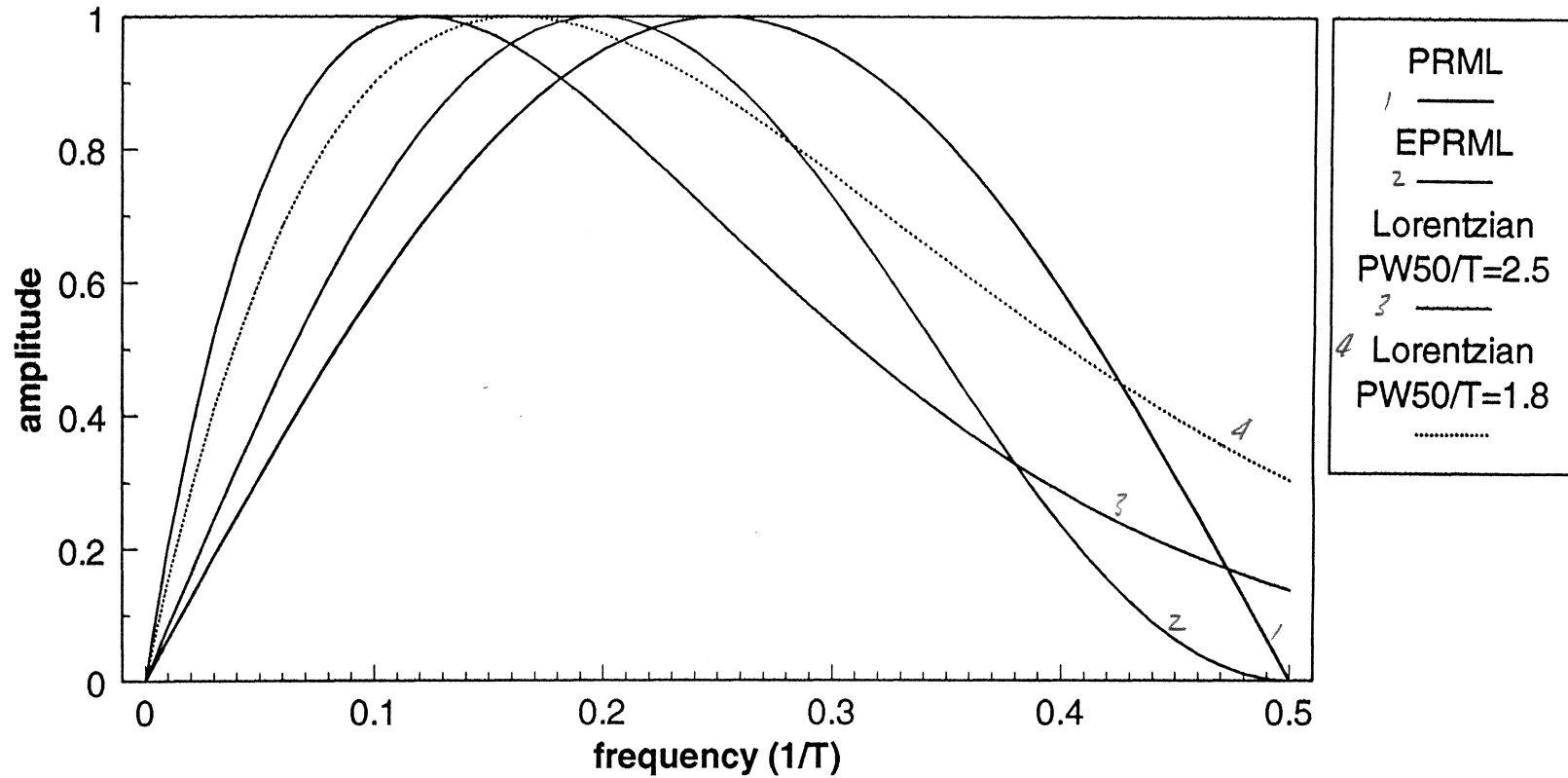- *uP approaches have costs not acceptable to disk channel*

Advanced Symbol (Multi-Bit) Detection Channel

- potential for very high data rate
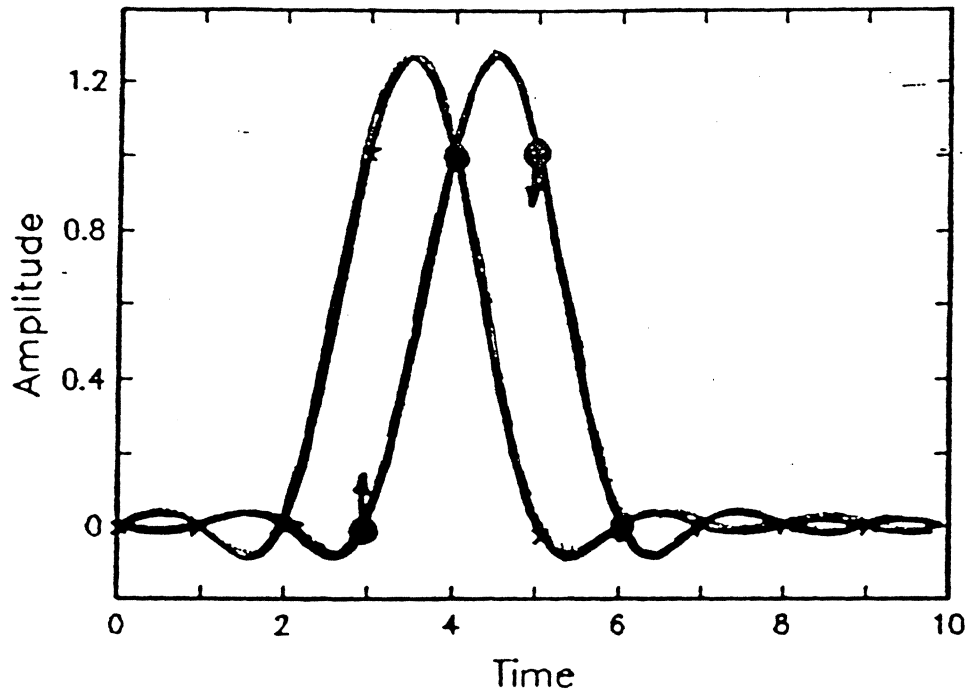- reduced circuit complexity
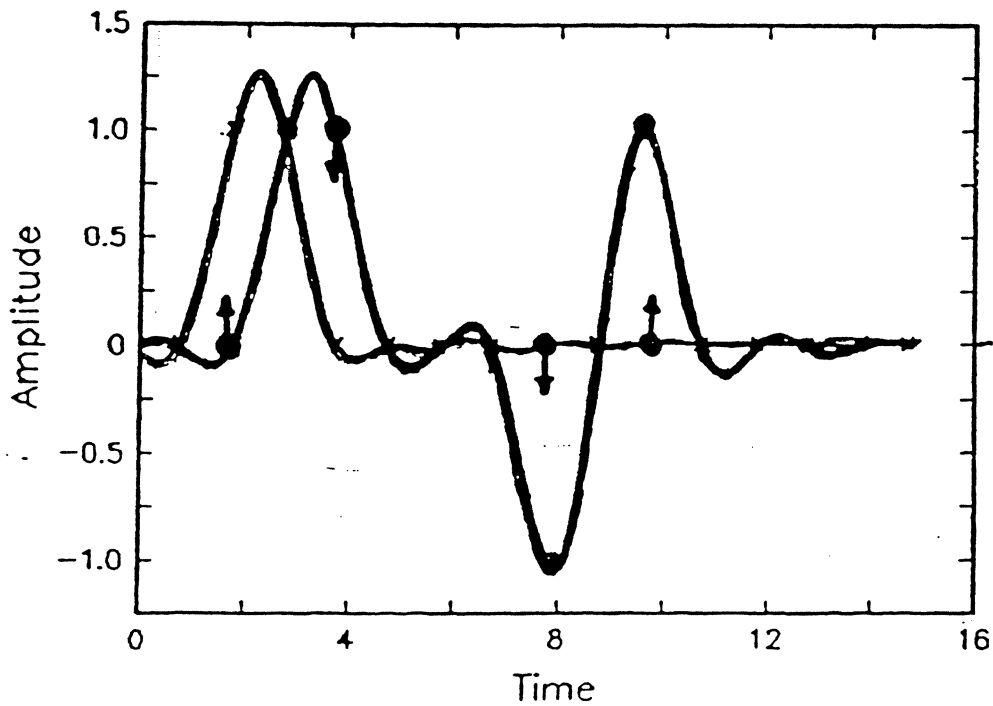
Extended PRML

- Better match to recording at higher densities than PRML
  - ~ 15% improvement in linear density
- 4X more complexity than PRML
  - IBM invention reduces complexity to 2X

WHY IMPROVED PERFORMANCE WITH TCPR?
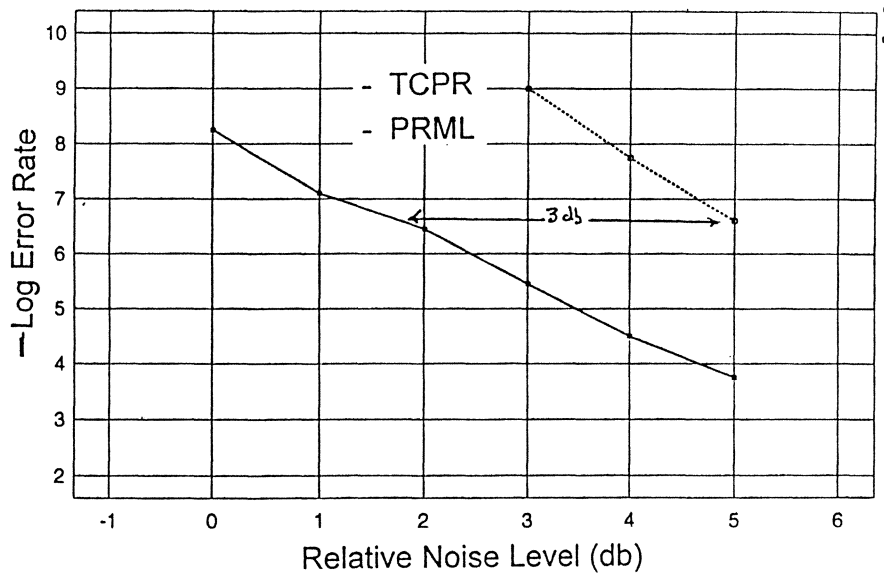
PRML Error Event

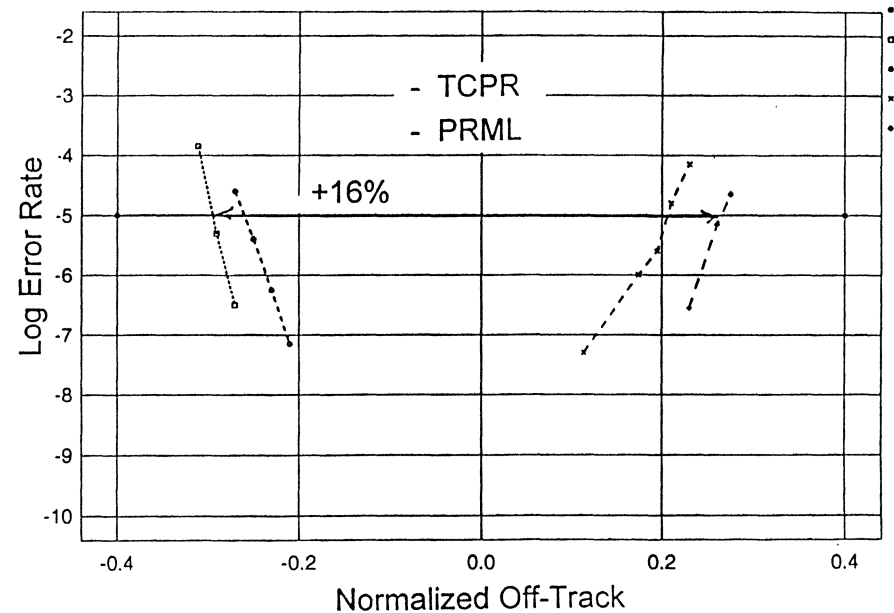## Trellis-Coded Partial Response Error Event

Trellis-Coded PRML

White Gaussian Noise Injection Test

PRML/TCPR Comparison

- similar complexity as EPRML
- can improve linear density or track density
- code rate is 8/10 (PRML: 8/9)

Channel Technology

- Combined data rate/power/cost challenge is substantial
- Need both algorithm and circuit advances
- IBM will continue to play a leading role in advancing this technology