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Introduction

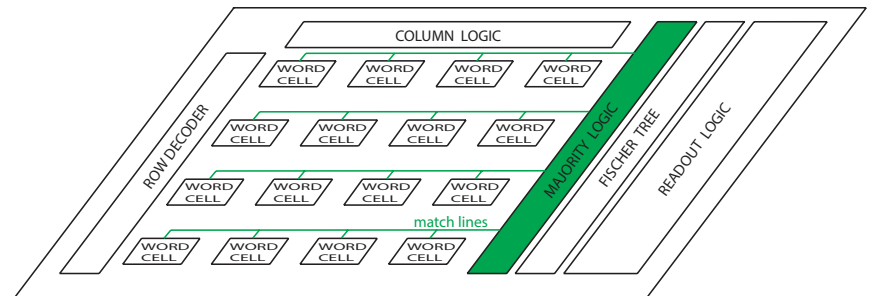
High Energy Physics trend:

- Higher luminosity to produce rare events results in very high hit rate.
- Increasing number of channels.

Tracking Challenge:

- Fast pattern recognition to identify useful traces.

LHC solution based on Associative Memories (AM):
pattern matching exploiting parallelism to the full.



Planar-AM Architecture.

The Idea/Concept

Planar AM Limitations:

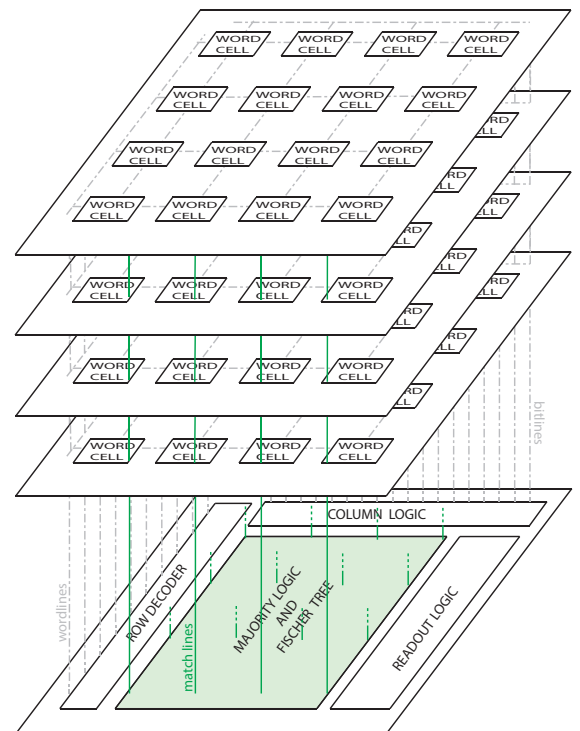
- Limited pattern density: limited number of comparison per chip.
- Limited performance: long paths to propagate matches along a single road.
- Significant die area used for memory controller and readout logic.

A new 3D stacking approach:

- Multiple conventional 2D dies stacked to create a 3D IC.
- Cell arrays stacked on logic-only die
- Through Silicon Via (TSV) technology allows for electrical connections among dies.
- TSV approach already used in industry: **very high chance of success.**

The proposed 3D stacking architecture:

- Maximize the pattern density:
 - Much higher integration.
 - Each array die is dedicated to store patterns.
 - Separate optimization of memory array and logic.
- Increase performance and reduced power density:
 - Reduced path length (greater impact on **match lines**).
- Much less number of AMs reduce complexity at system level:
 - Reduced PCB design complexity.
 - Reduced overall system dimension and costs.



Proposed 3D-AM Architecture.

Immediate Goal:

- Proof-of-concept device
- 2 cell arrays layers
- 3D cell array density: +33%
- Up to 2x increase in density

Ultimate Goal: 8 cell arrays layers.

Potential Industrial Impact

Impact in typical pattern matching applications other than high energy physics:



- **Computer aided diagnosis:**
 - EEG
 - Mammography
- **Bioinformatics:**
 - DNA sequence analysis



- **Engineering:**
 - Image analysis.
 - Data analytics.
- **Military:**
 - Automatic target recognition.

