

Young Scientists Symposium

The ATLAS Fast Track Trigger

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Feb. 16, 2016

What is the **Fast TrackK** Trigger?

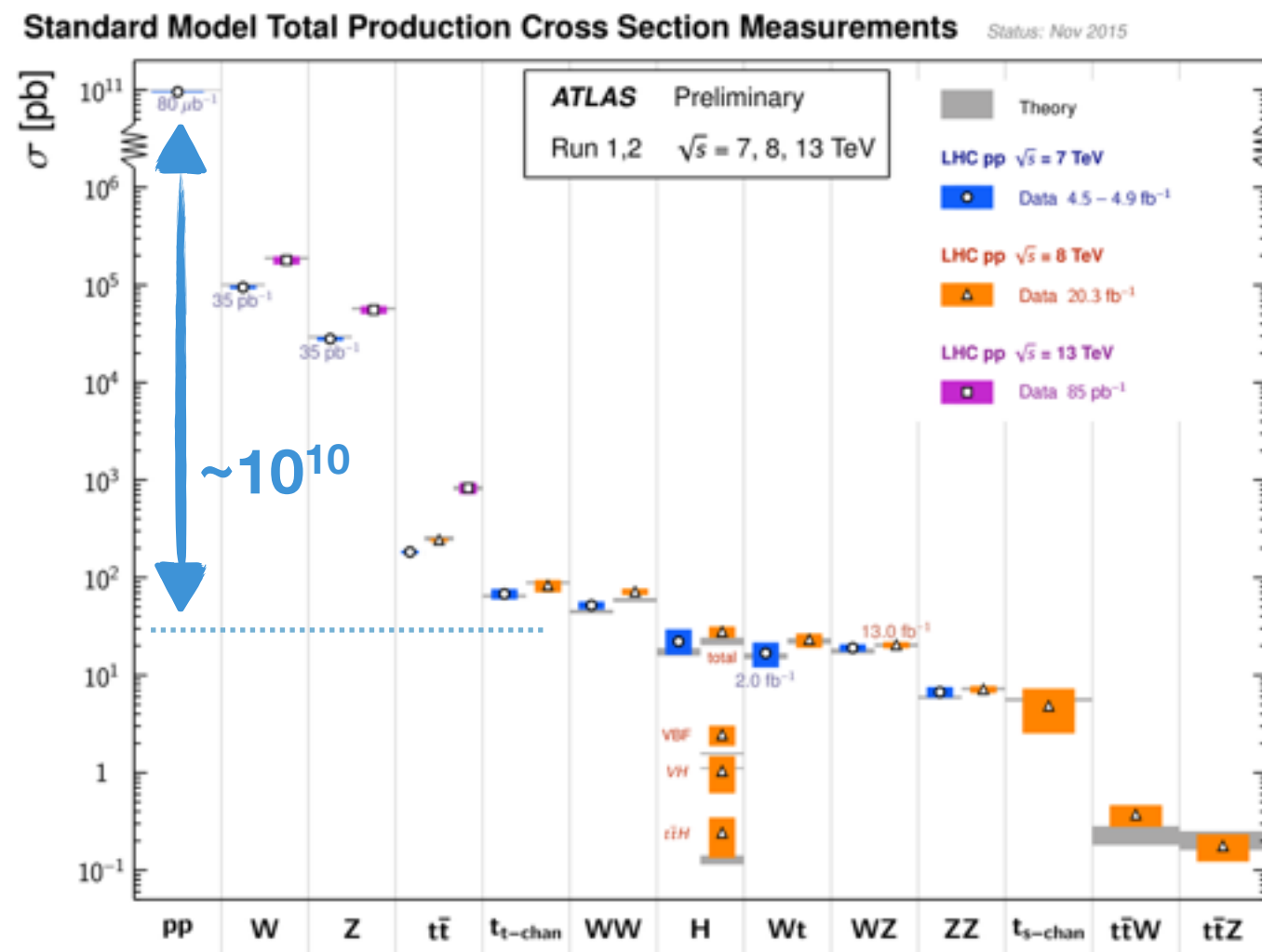
FTK is a hardware upgrade to the ATLAS trigger system that will be used to reconstruct particle tracks at an event rate of 100 KHz

Outline...

1. Motivation
2. Design
3. Performance
4. Timeline & Future

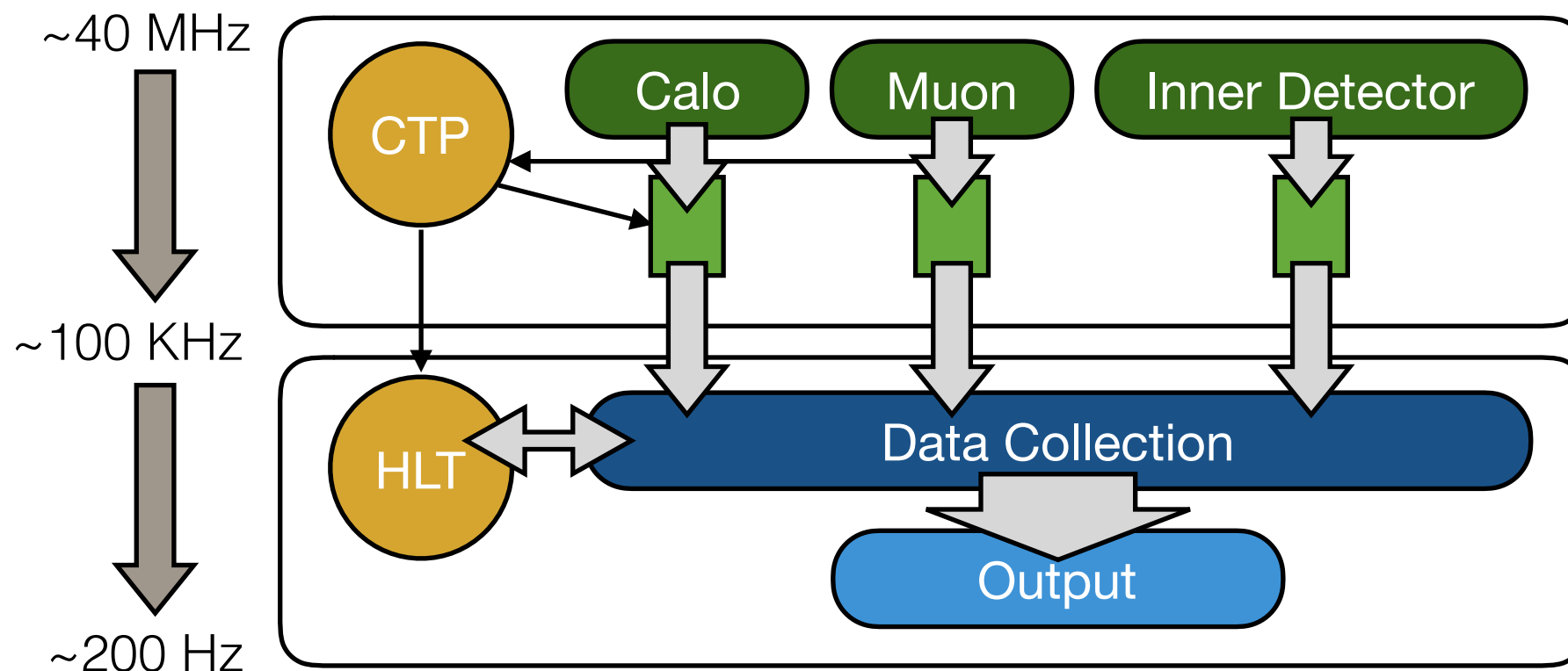
Why FTK?

- * The LHC is designed to create 40M collisions per second
- * Each event O(1 MB)
- * Saving every event would mean...
 - * ~1 library of congress per second
 - * ~2500 Wikipedias per second



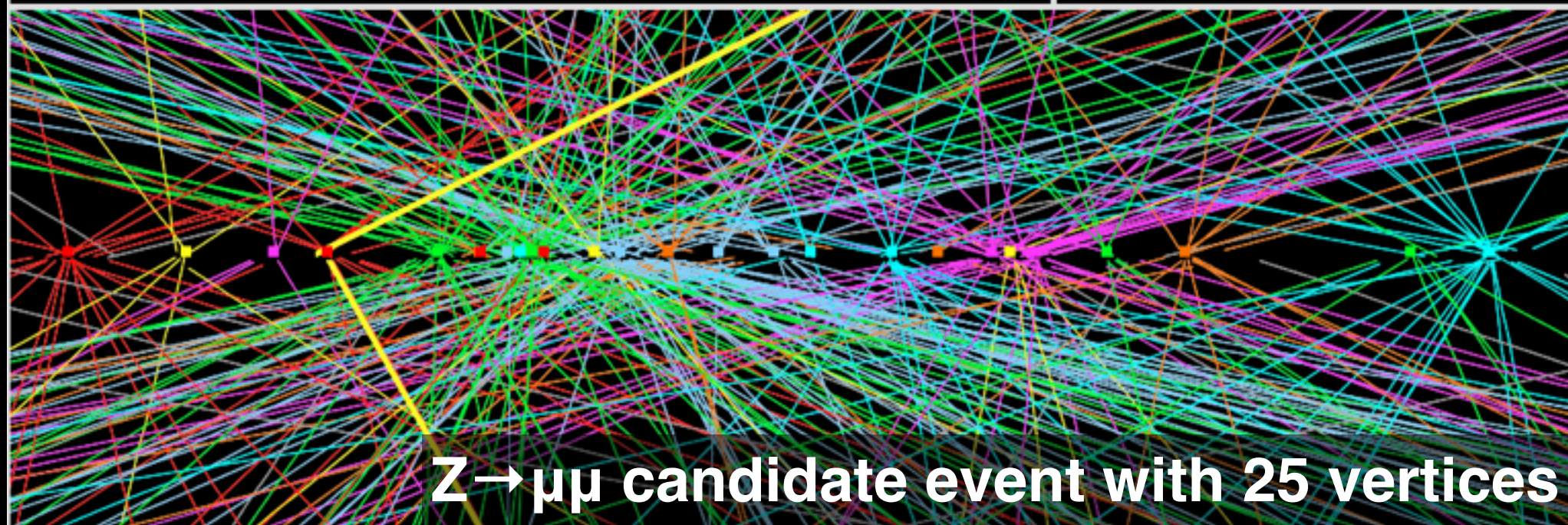
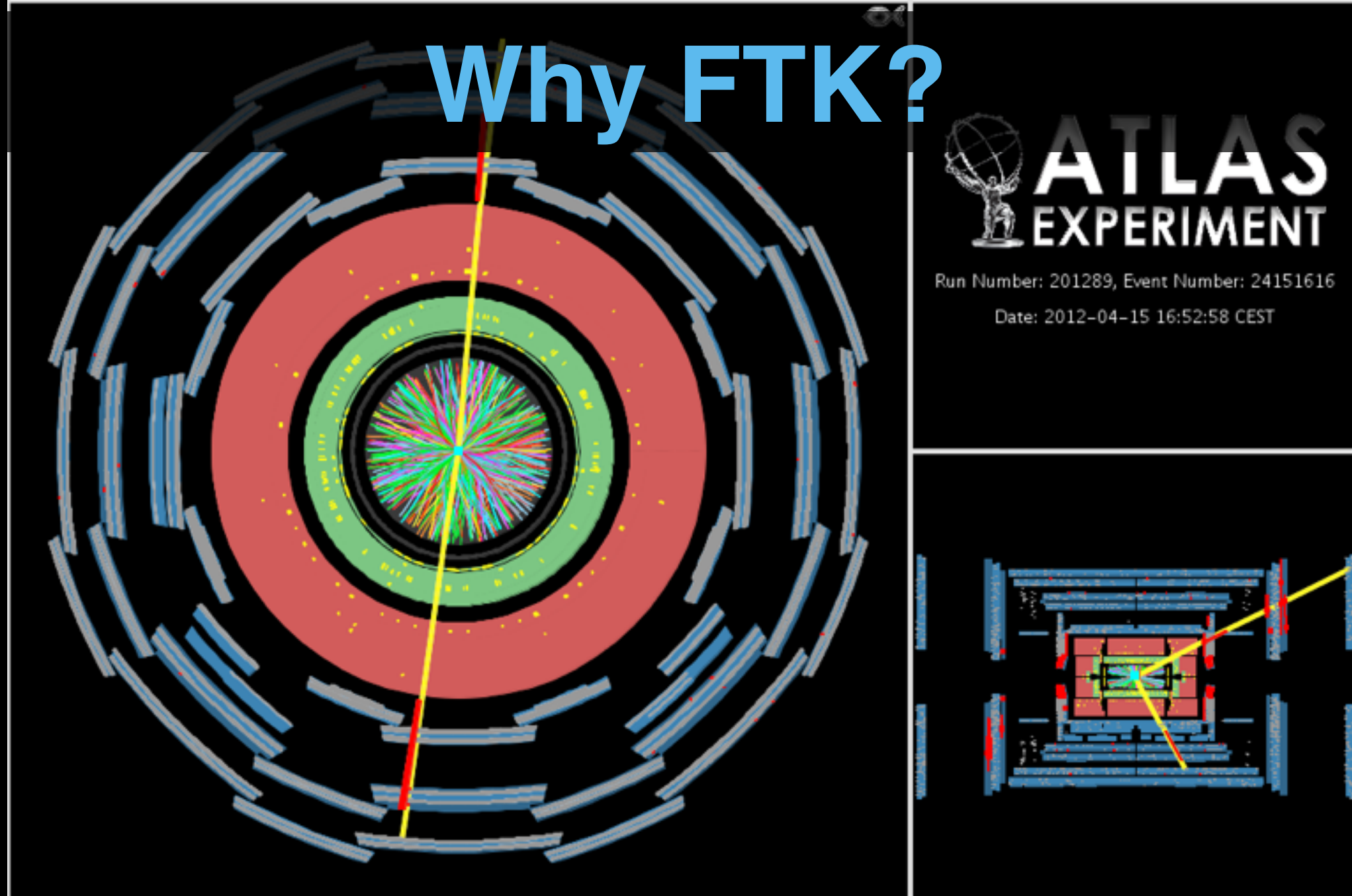
Why FTK?

- * Solution: ATLAS has a multi-level trigger system designed to quickly identify events with useful physics

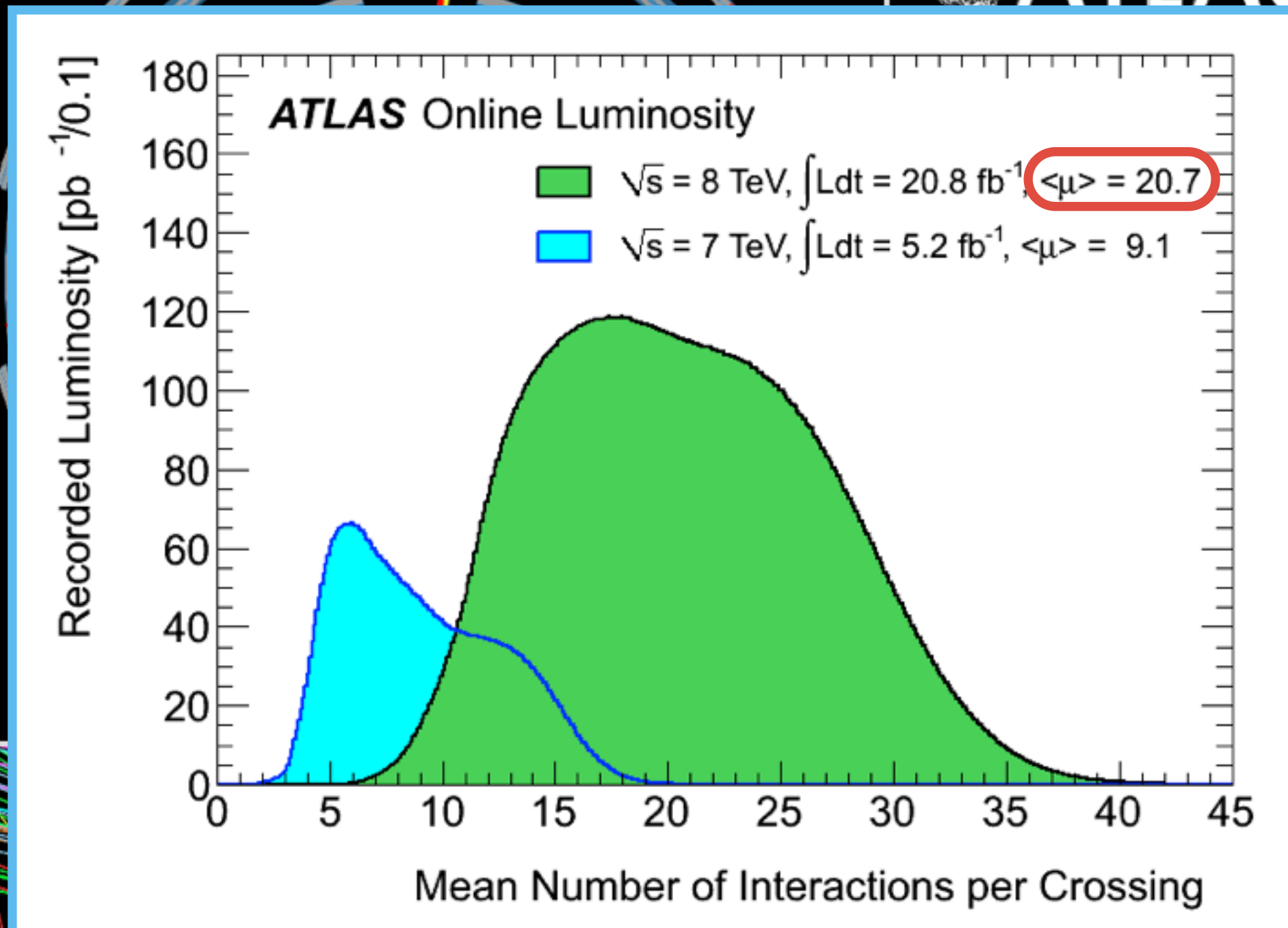


- * Reconstructing charged particle tracks in the trigger is very important... but challenging and slow

Why FTK?

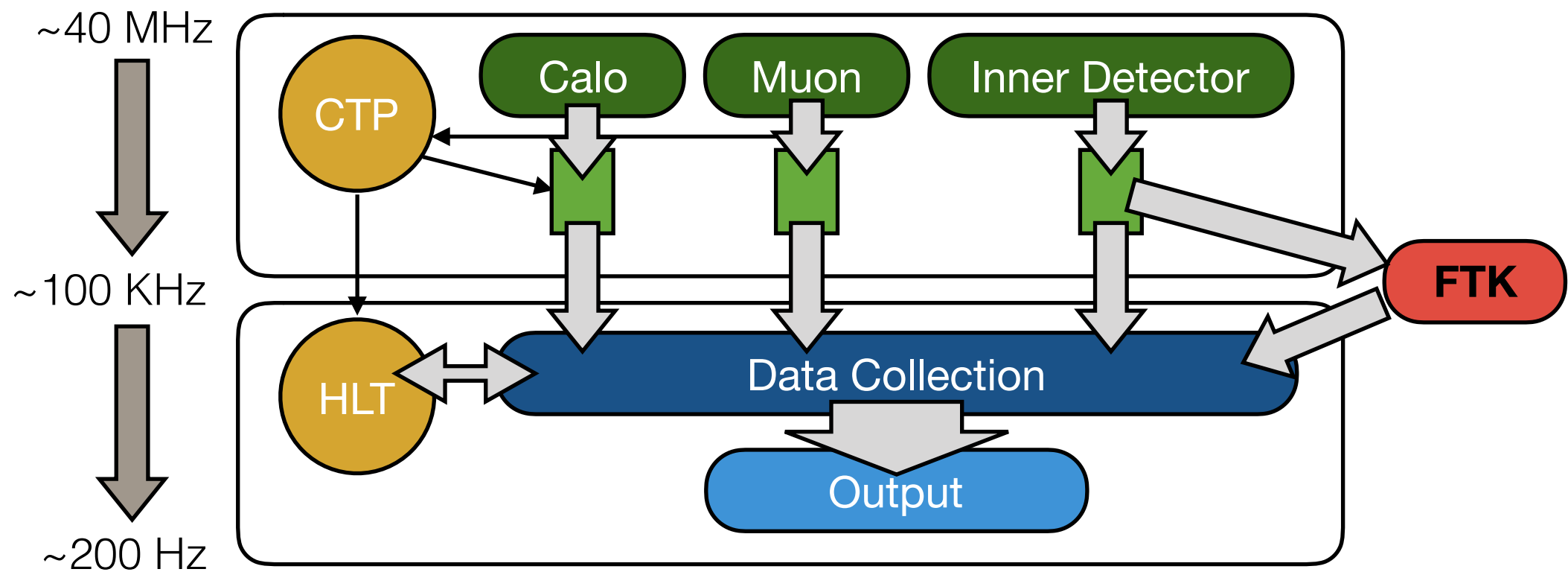


Why FTK?



$Z \rightarrow \mu\mu$ candidate event with 25 vertices

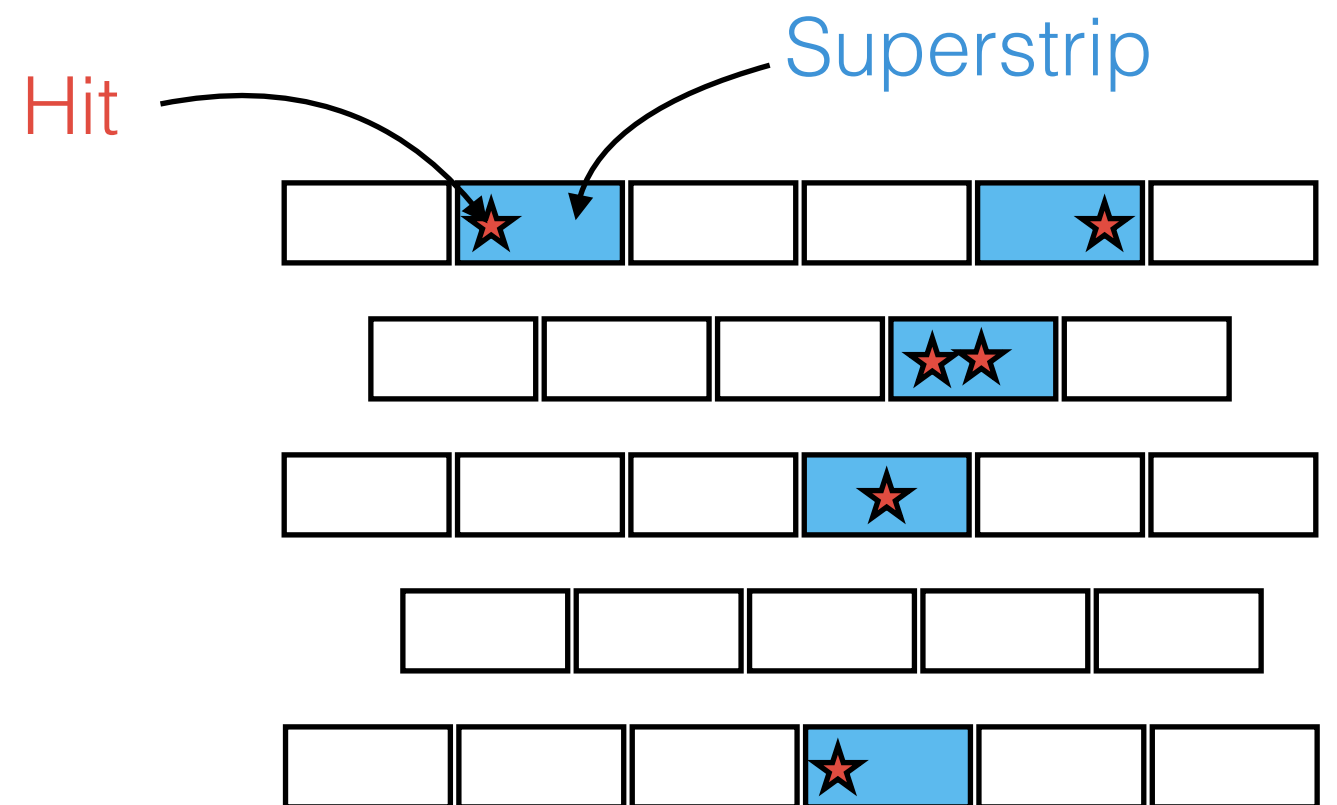
What is FTK?



- * Global track reconstruction at 100 KHz
- * Passes (p_T , η , ϕ , d_0 , z_0 , hits, χ^2) to HLT
- * Frees up resources for more complicated HLT decisions
- * b-tagging, τ 's, track-MET

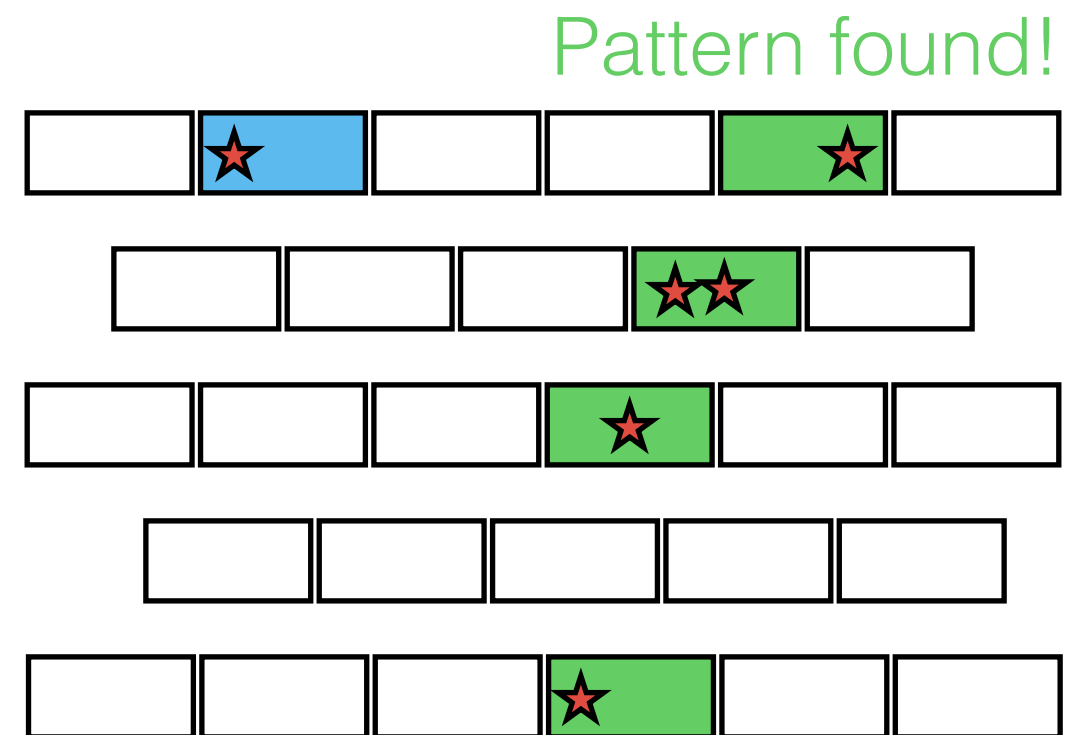
How does it work?

- * Divide detector layers into coarse resolution “superstrips”
- * 8 layers used for initial fit



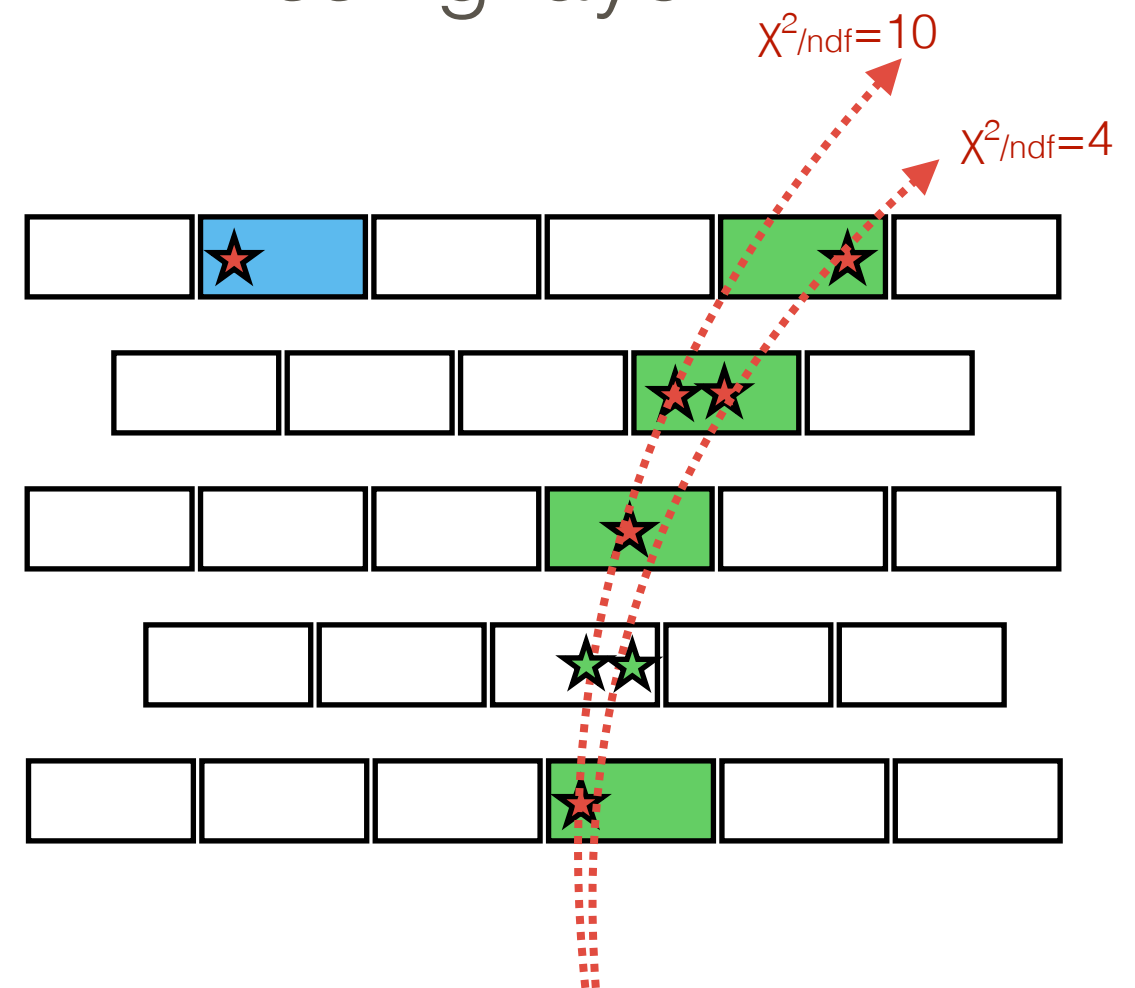
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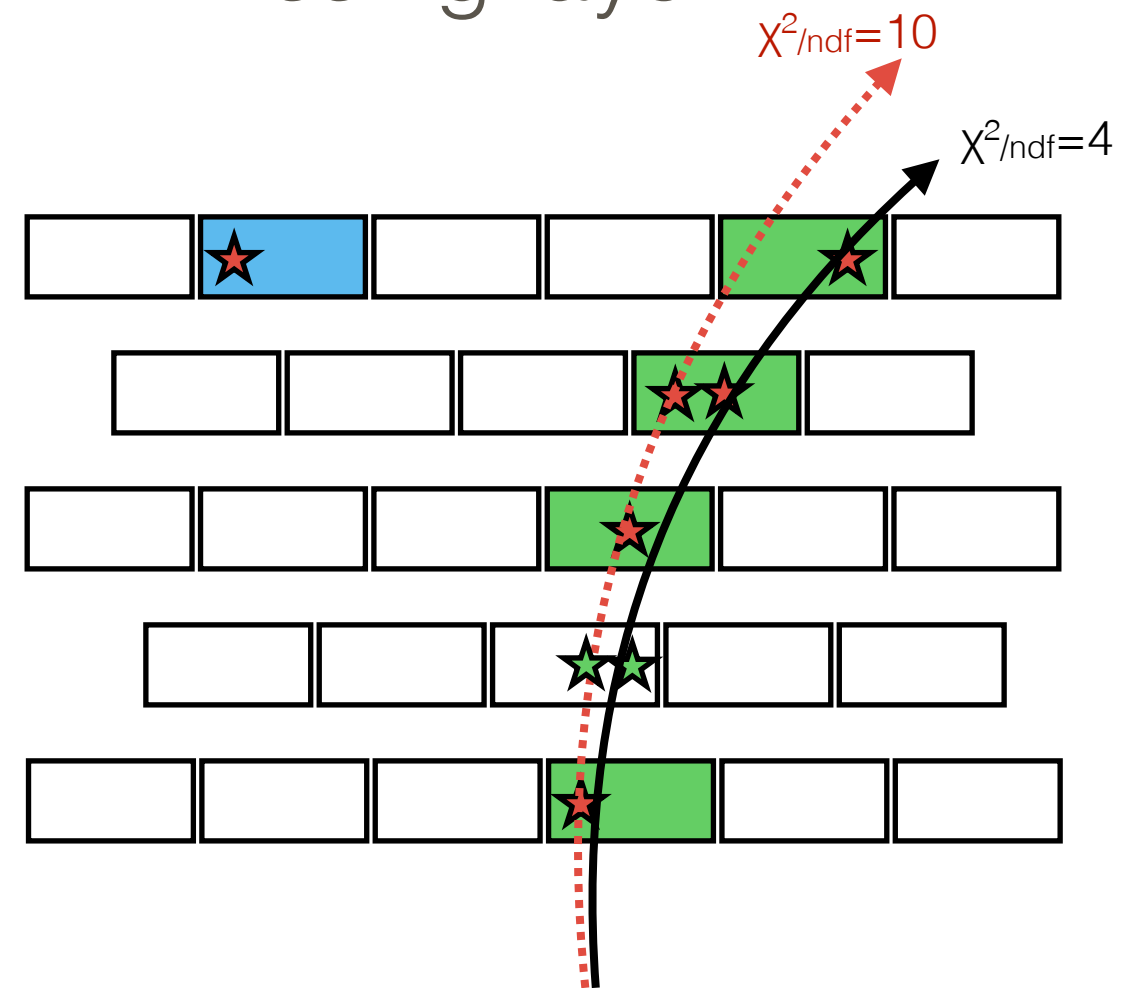
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- * Compute χ^2 with full resolution hits using fast linear approx
 - * “Guess” missing hits



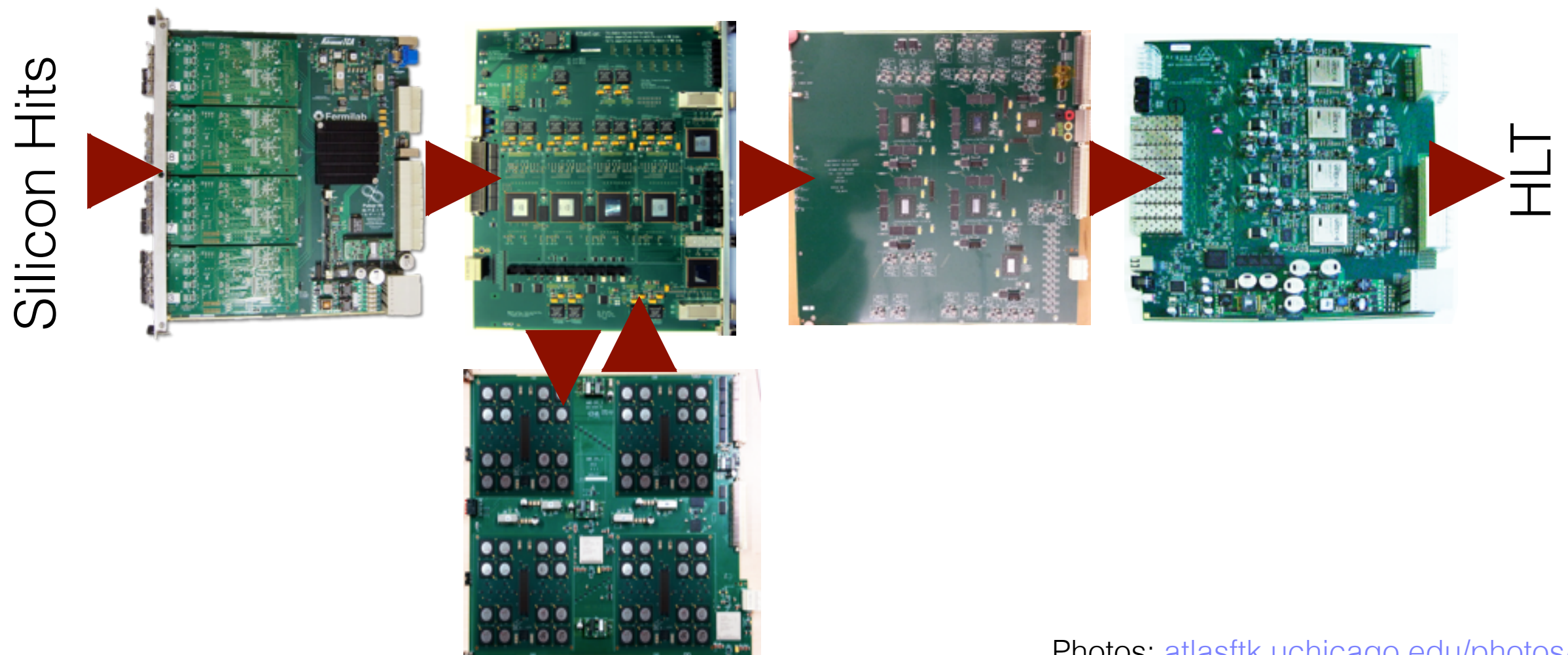
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- * Tracks with good χ^2 are extrapolated to 3 additional layers, track parameters computed with linear approx



Hardware Design

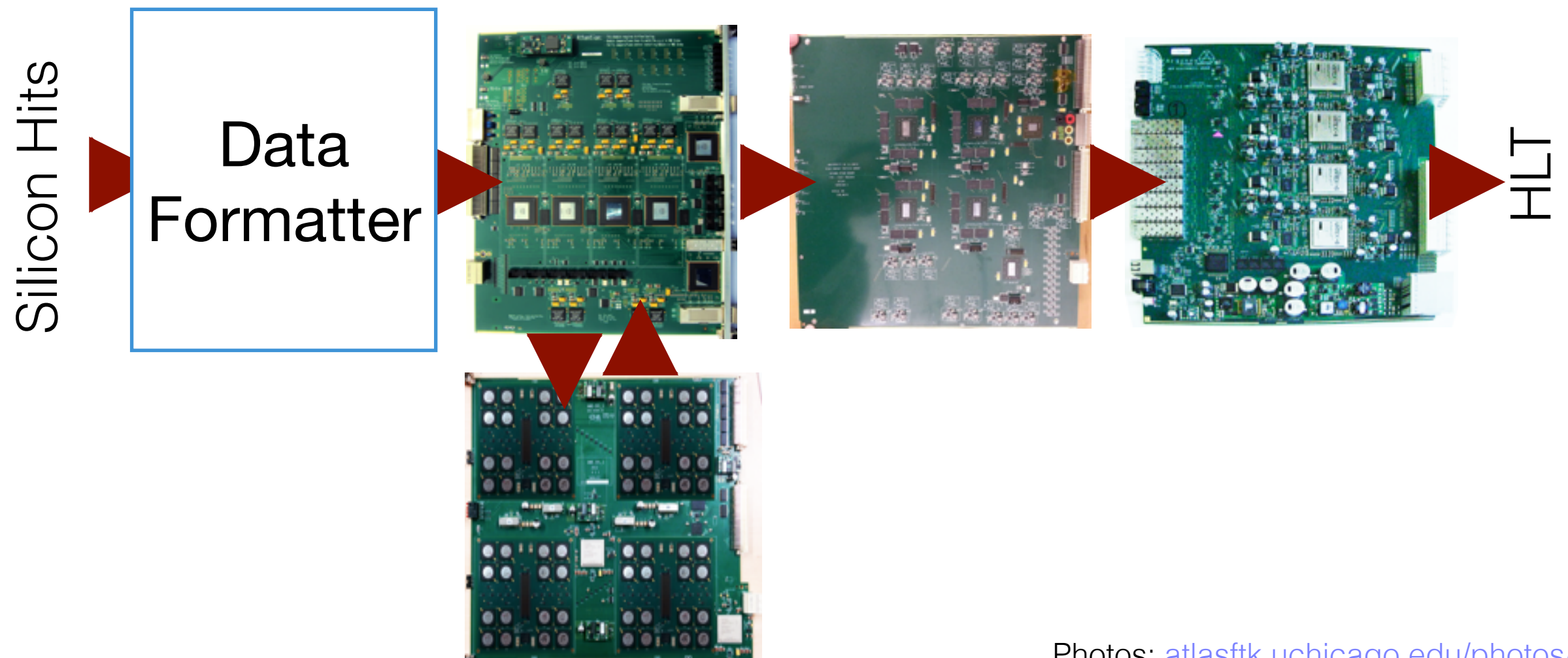
- * 64 parallel pipelines each handling hits from different slices of the detector



Photos: atlasftk.uchicago.edu/photos/

Hardware Design

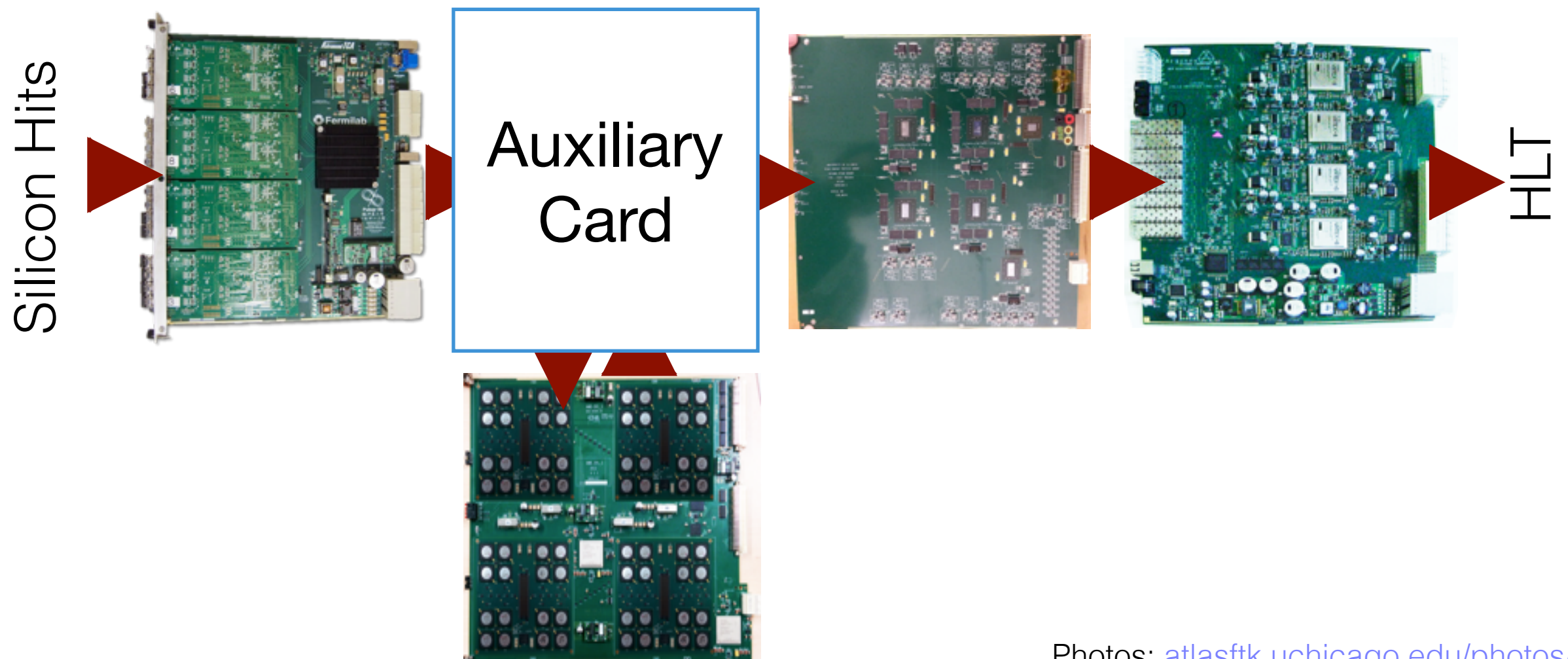
- * Clusters hit coordinates
- * Sends clusters to the proper stream



Photos: atlasftk.uchicago.edu/photos/

Hardware Design

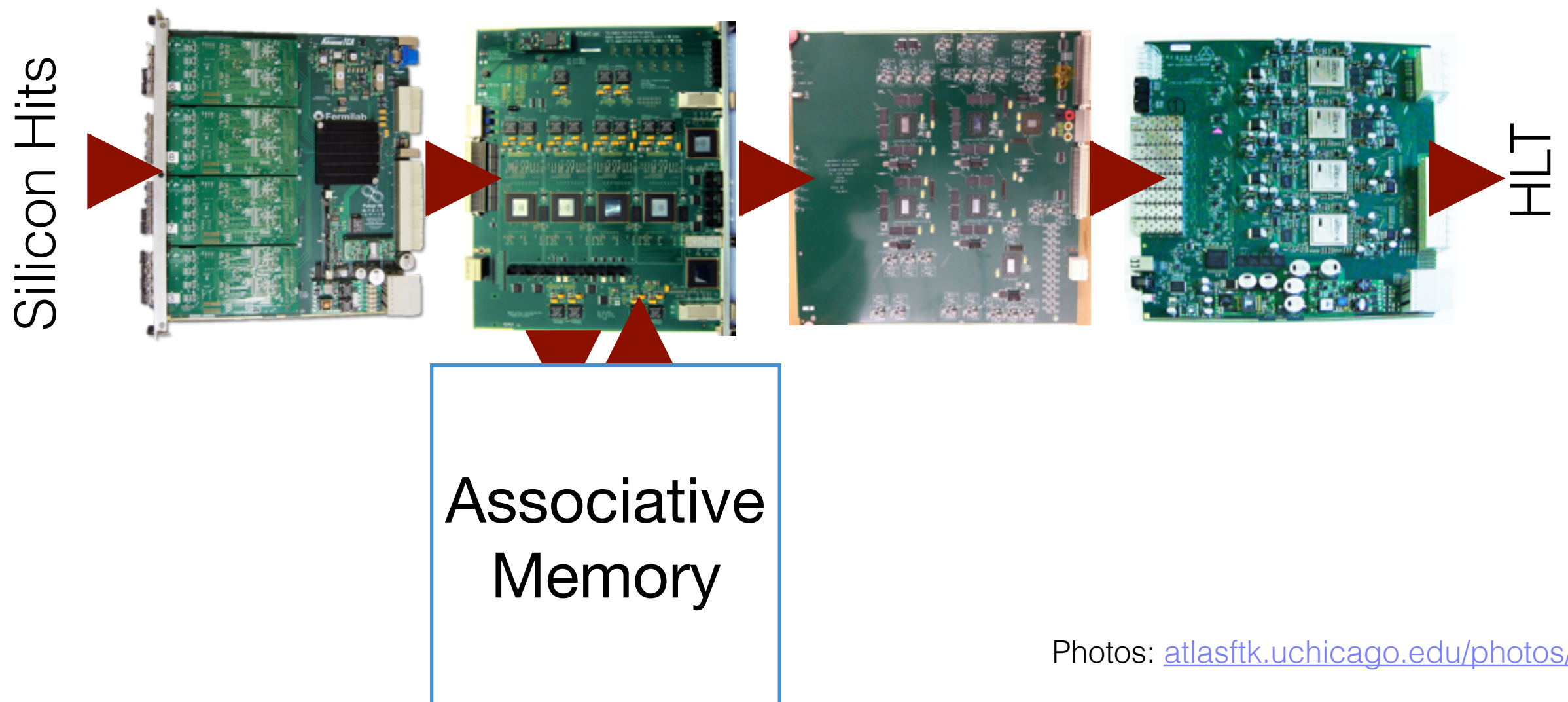
- * Organizes hits, sends superstrips to Associative memory for pattern matching



Photos: atlasftk.uchicago.edu/photos/

Hardware Design

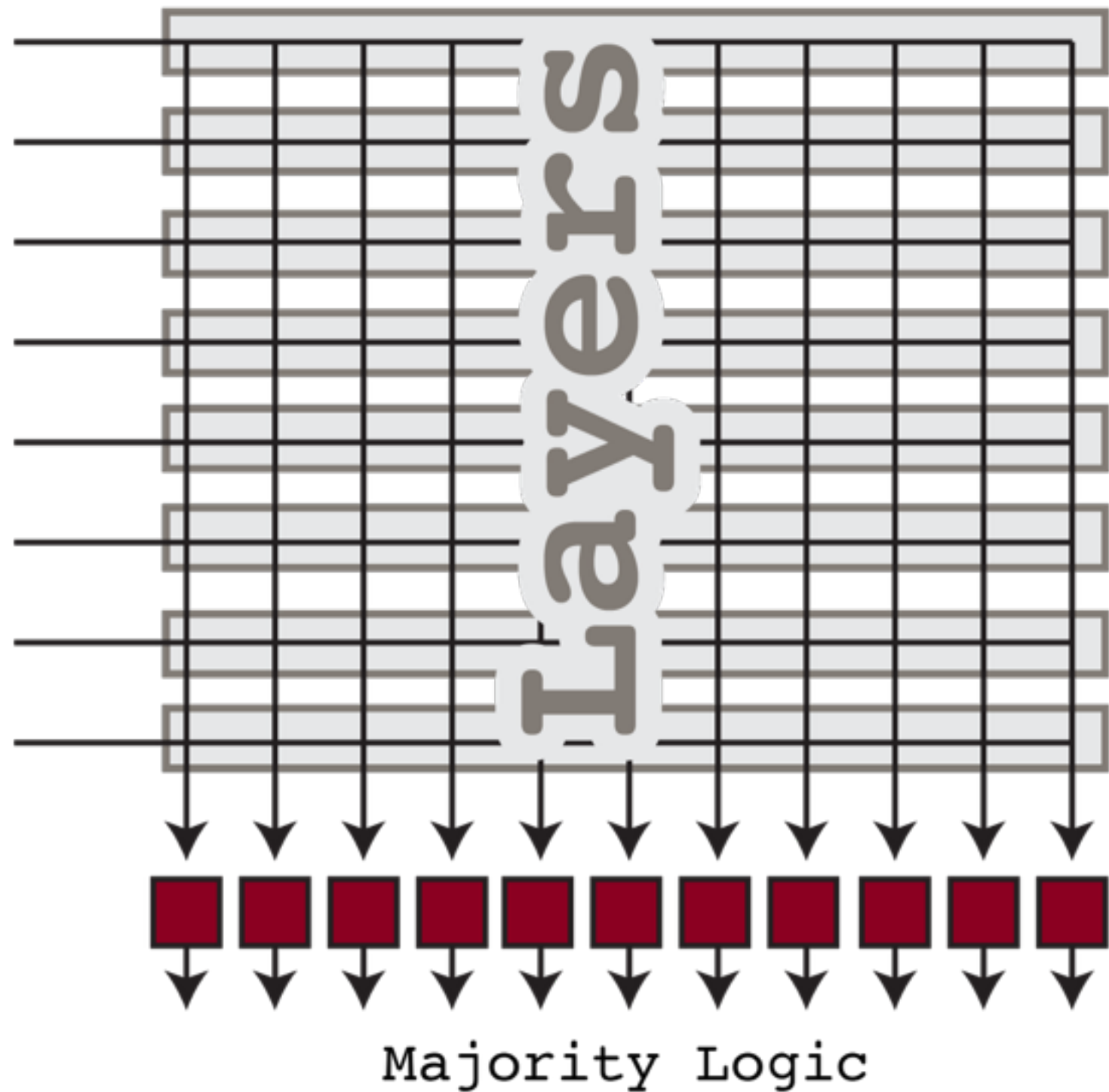
- * Core of the FTK system
- * Performs pattern matching simultaneously for all hits in the detector slice



Photos: atlasftk.uchicago.edu/photos/

Associative Memory

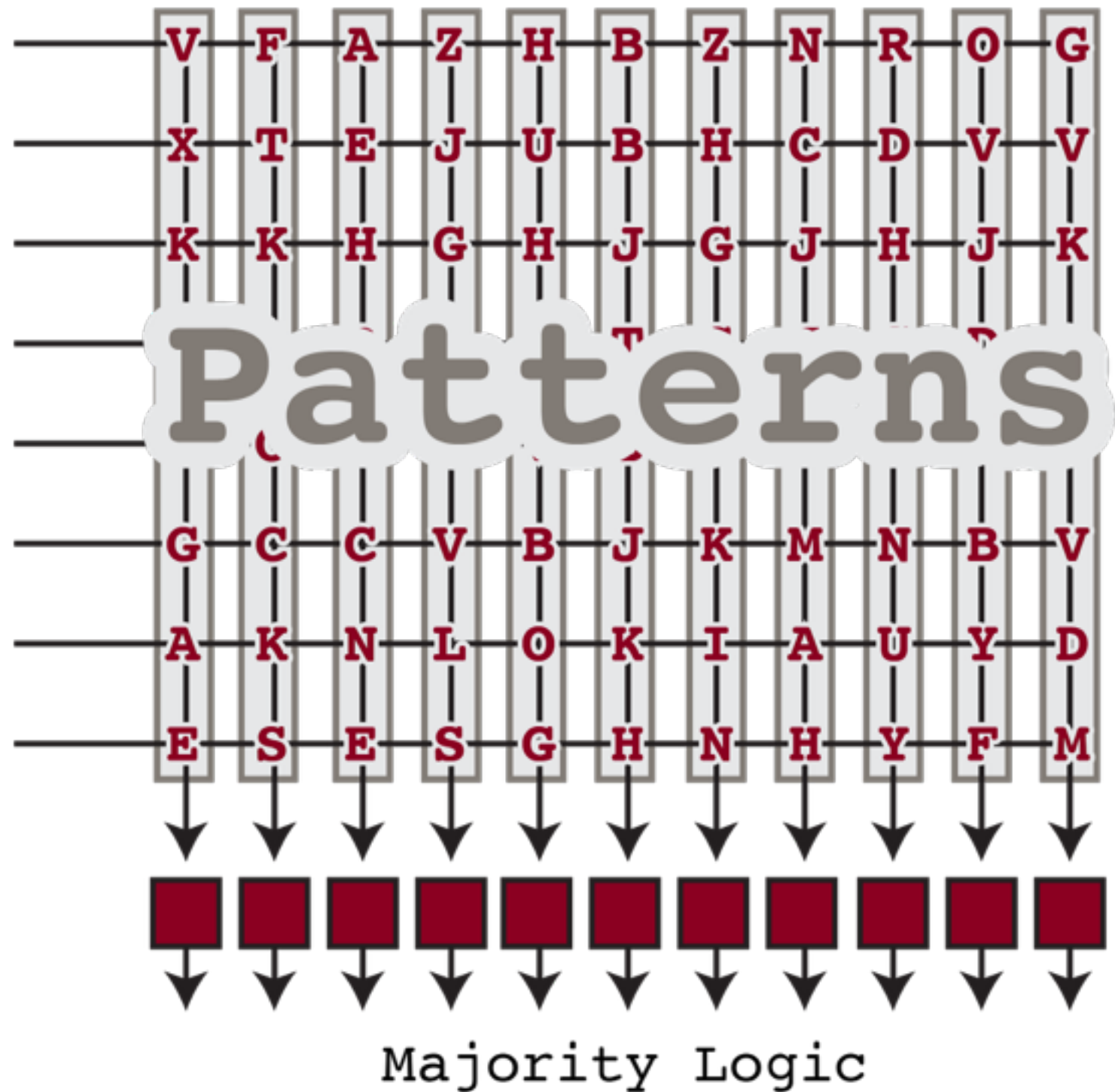
(Cartoon by Jamie Saxon)



Associative Memory

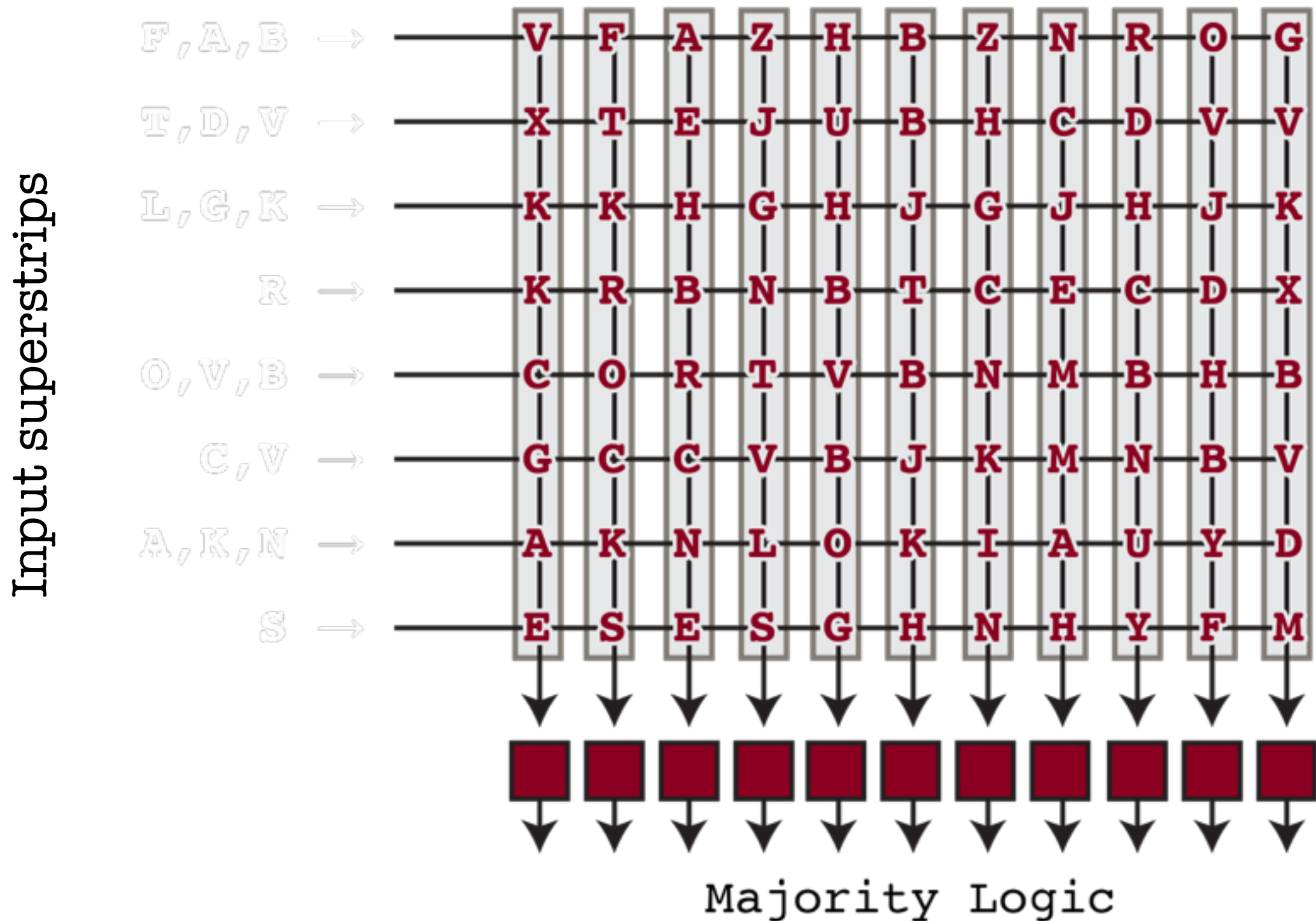
(Cartoon by Jamie Saxon)

Patterns are
generated using
clean, simulated
muon tracks
with $p_T > 1$ GeV



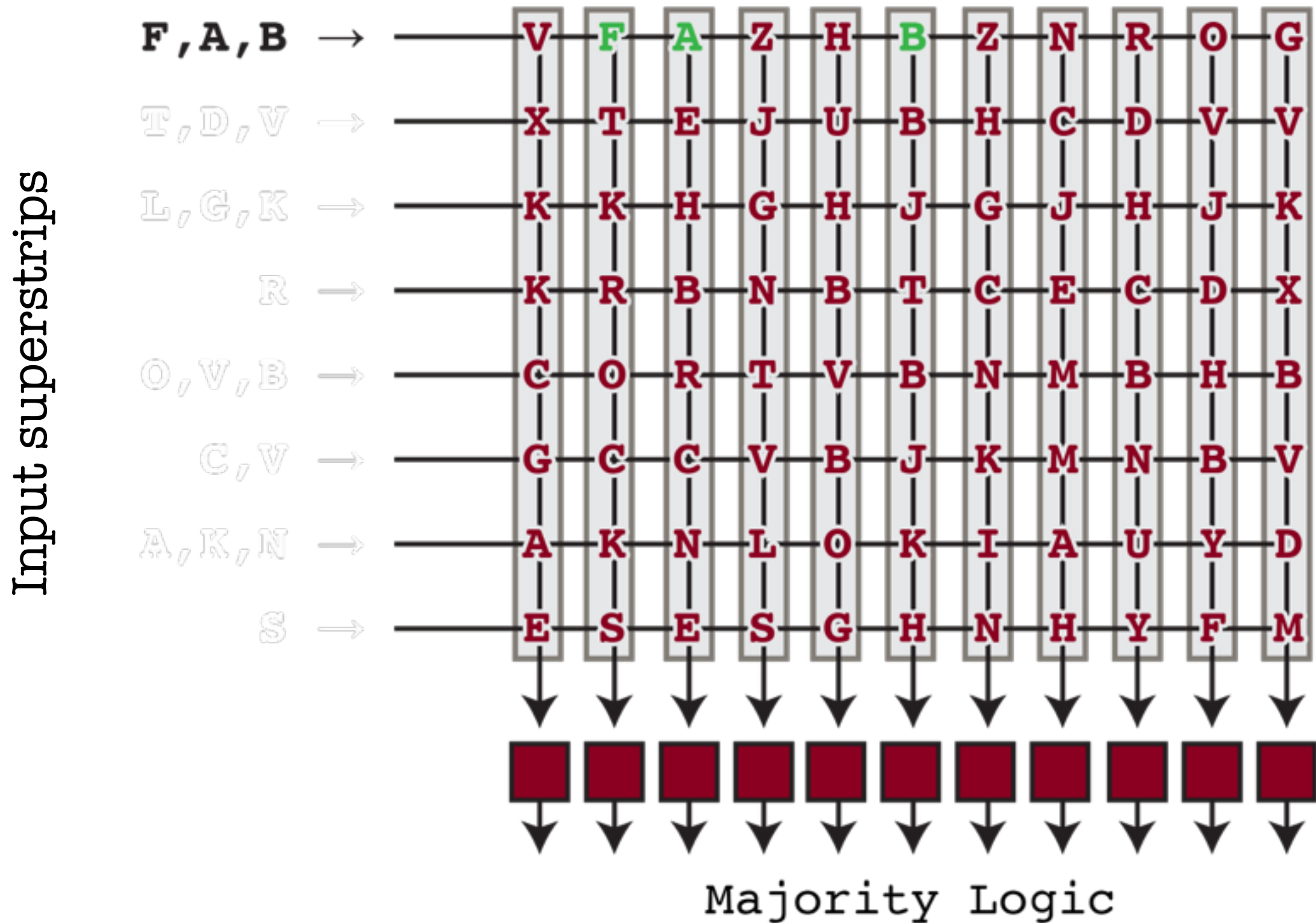
Associative Memory

(Cartoon by Jamie Saxon)



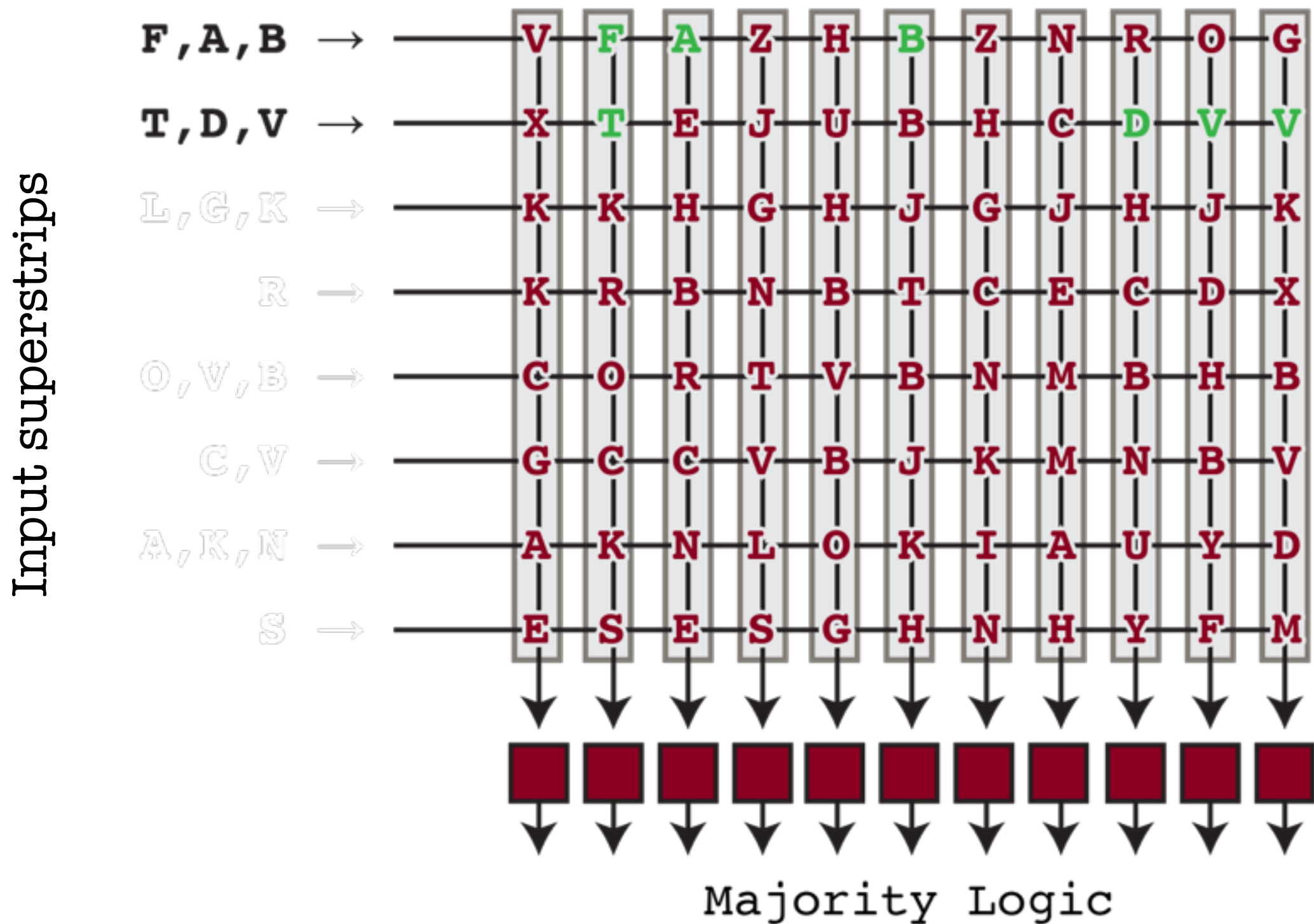
Associative Memory

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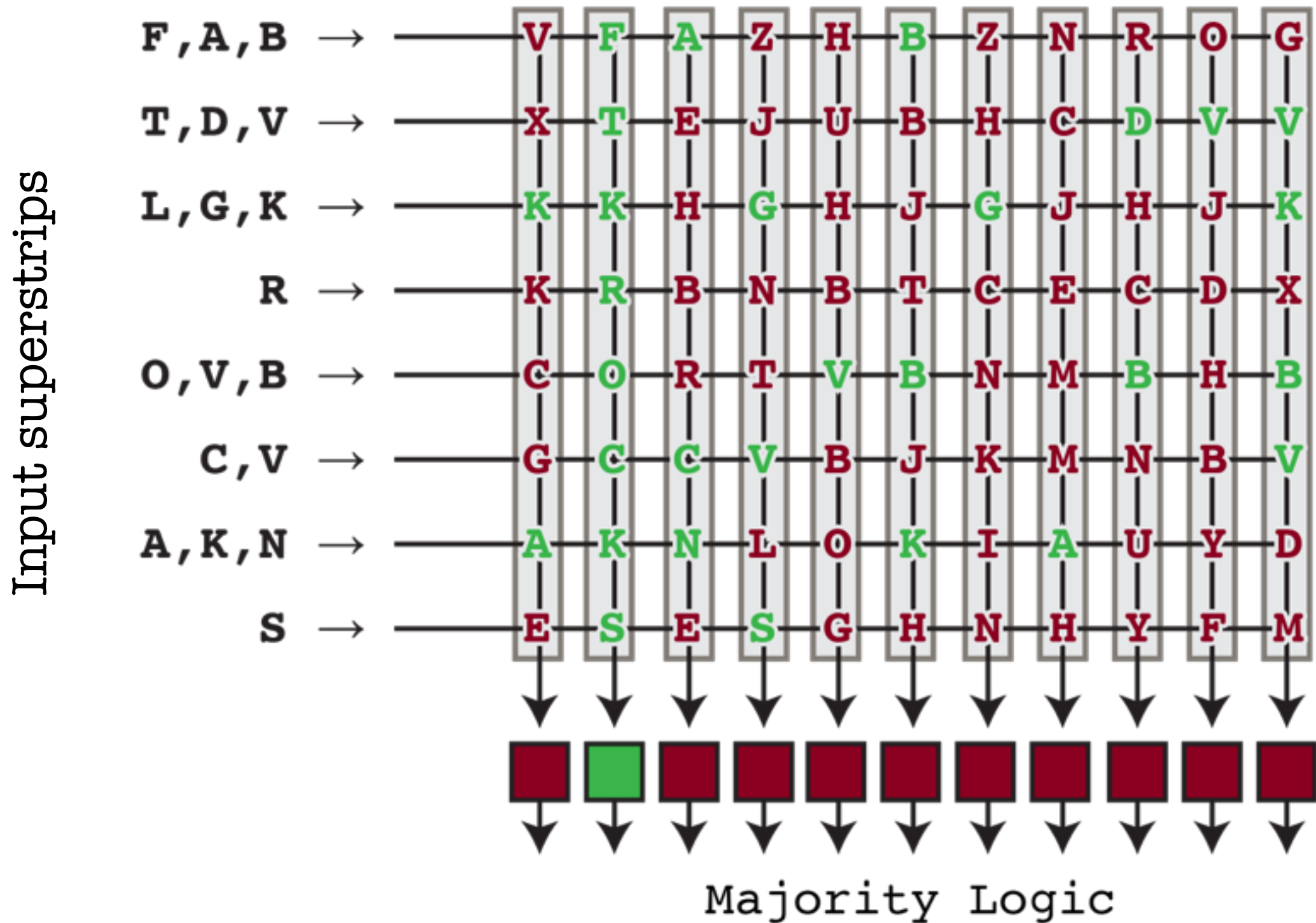
Associative Memory

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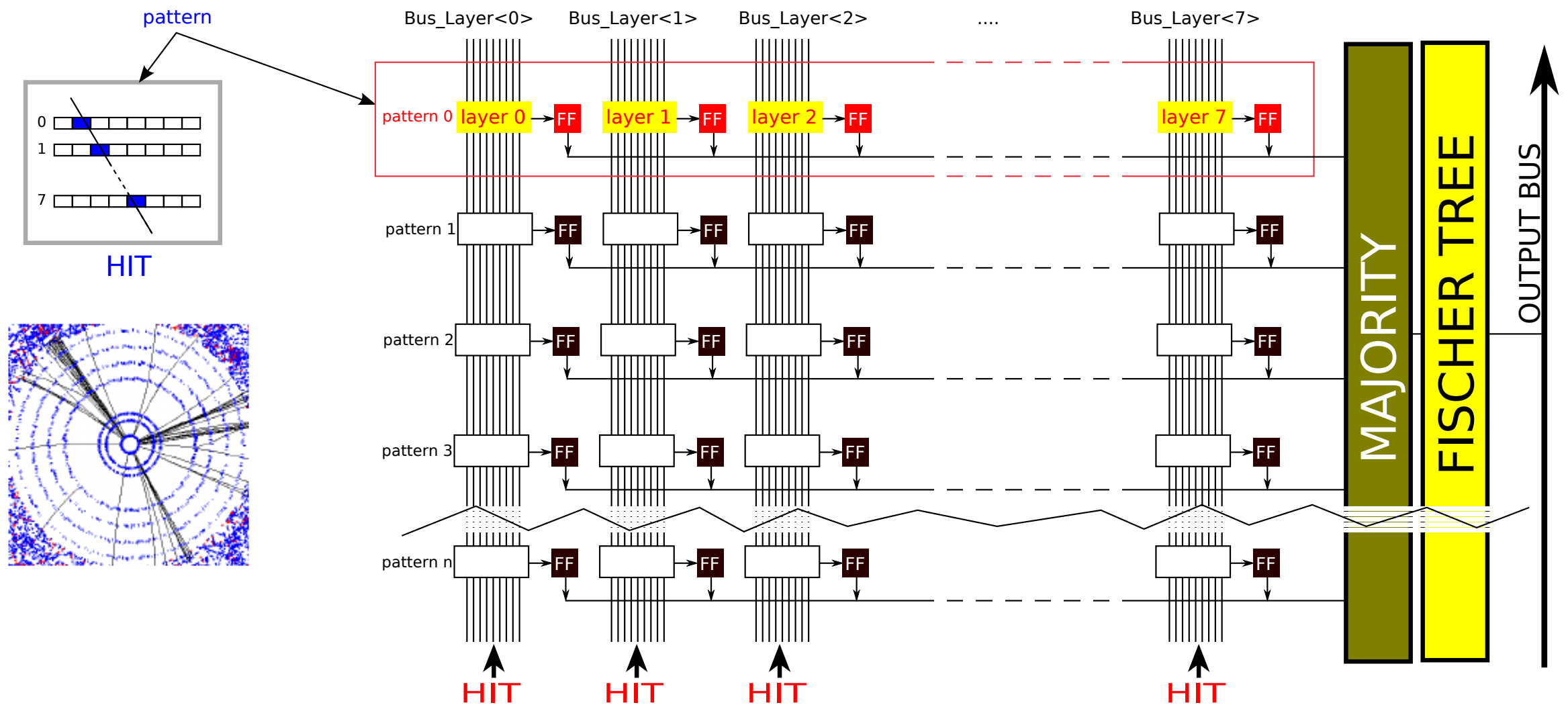
Associative Memory

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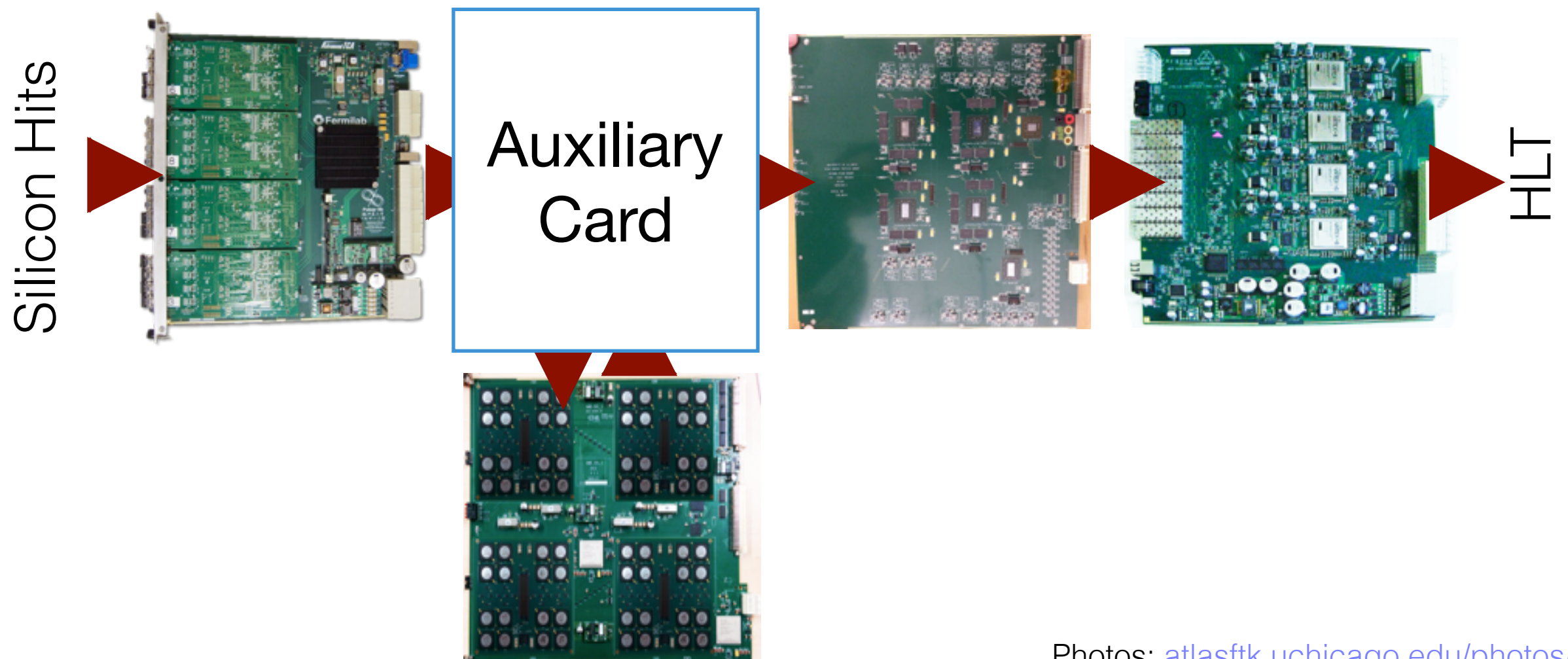
Associative Memory

A more realistic schematic...



Hardware Design

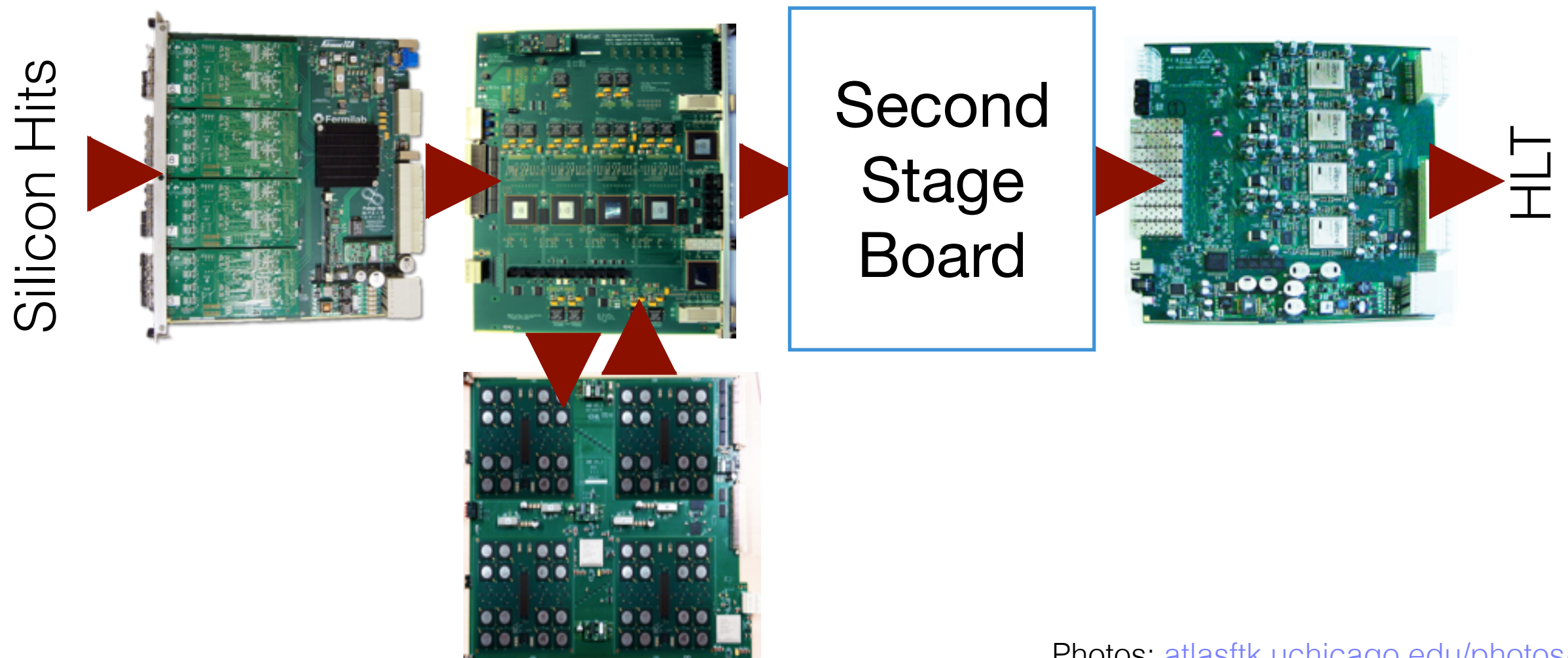
- * Receives matched patterns, computes χ^2 for each combination of full resolution hits in each pattern



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Hardware Design

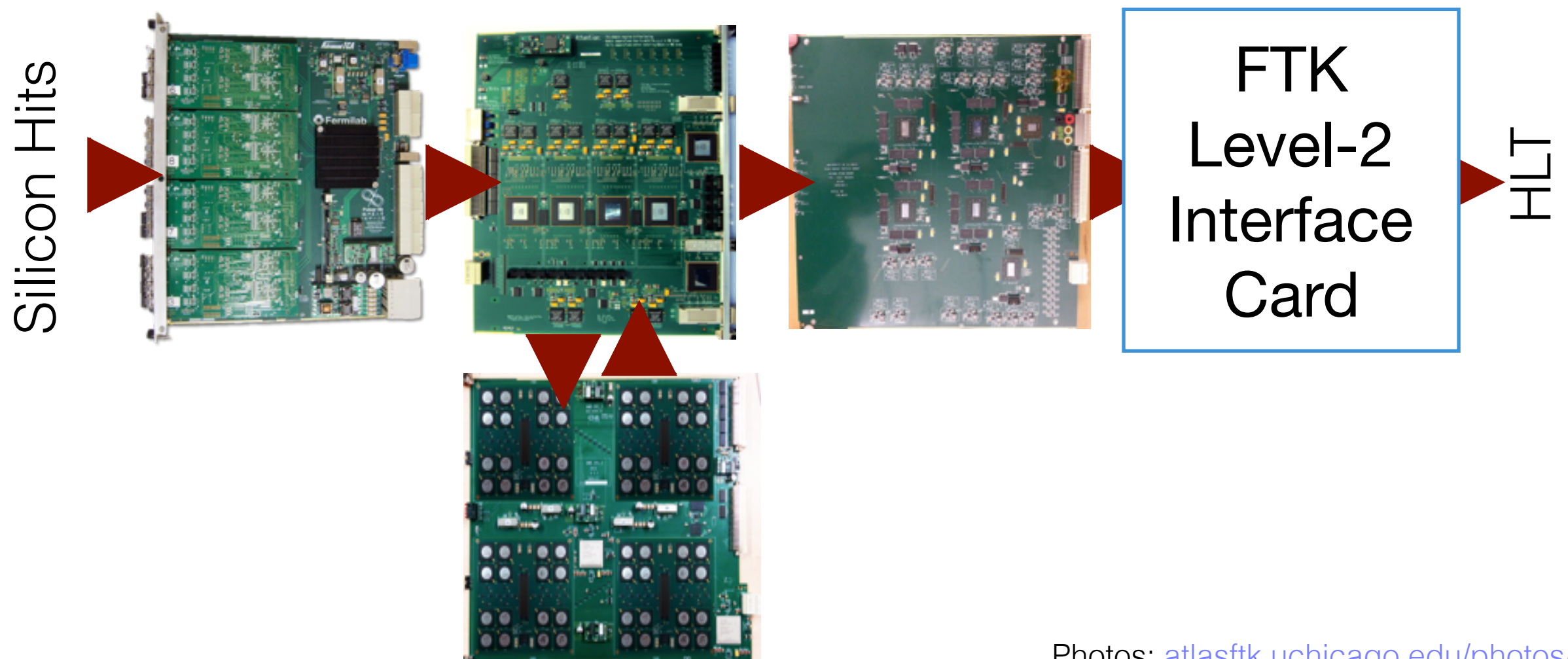
- * Extrapolates to additional layers
- * Computes helix parameters



Photos: atlasftk.uchicago.edu/photos/

Hardware Design

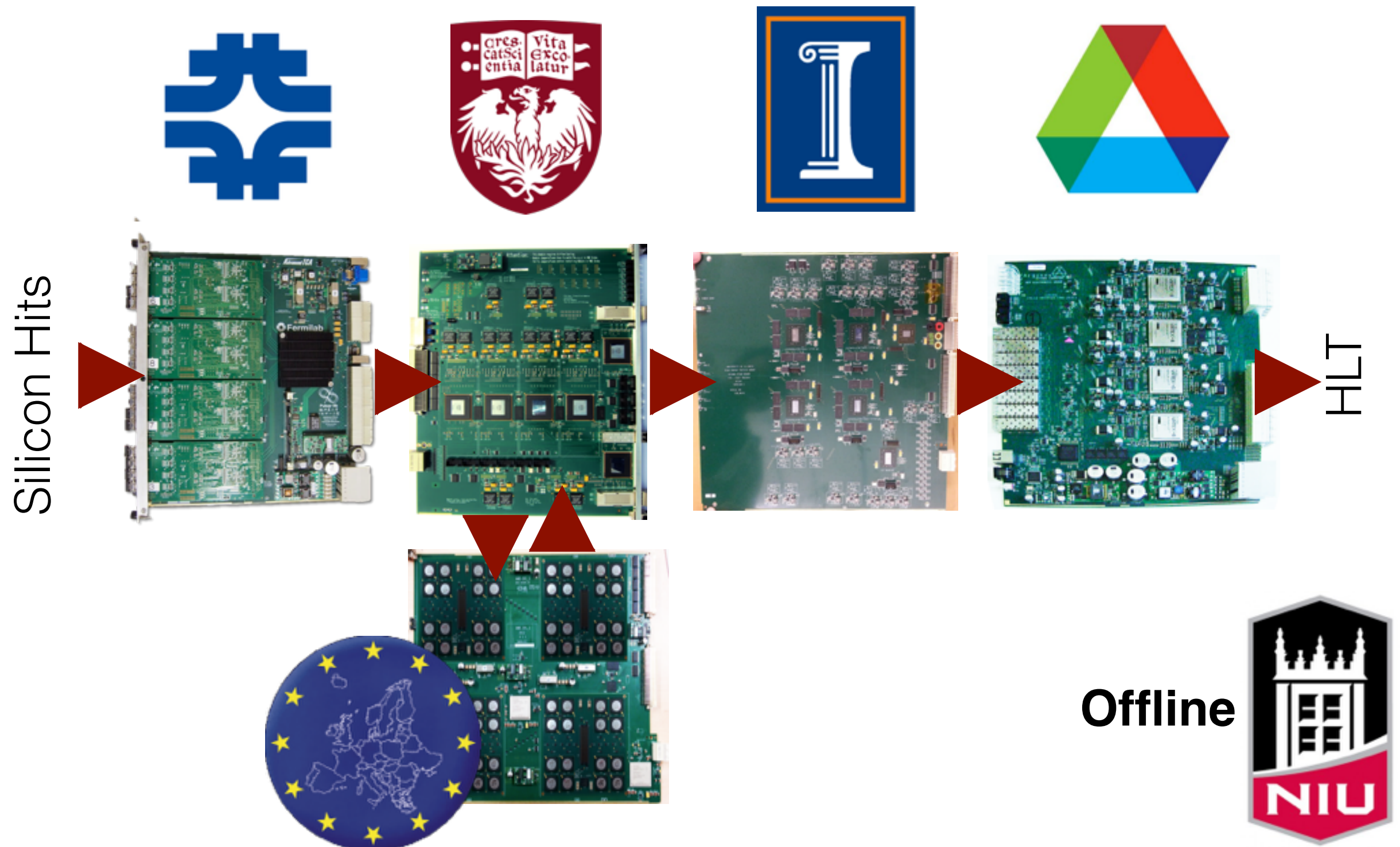
- * Restores global hit coordinates
- * Formats tracks for ATLAS HLT



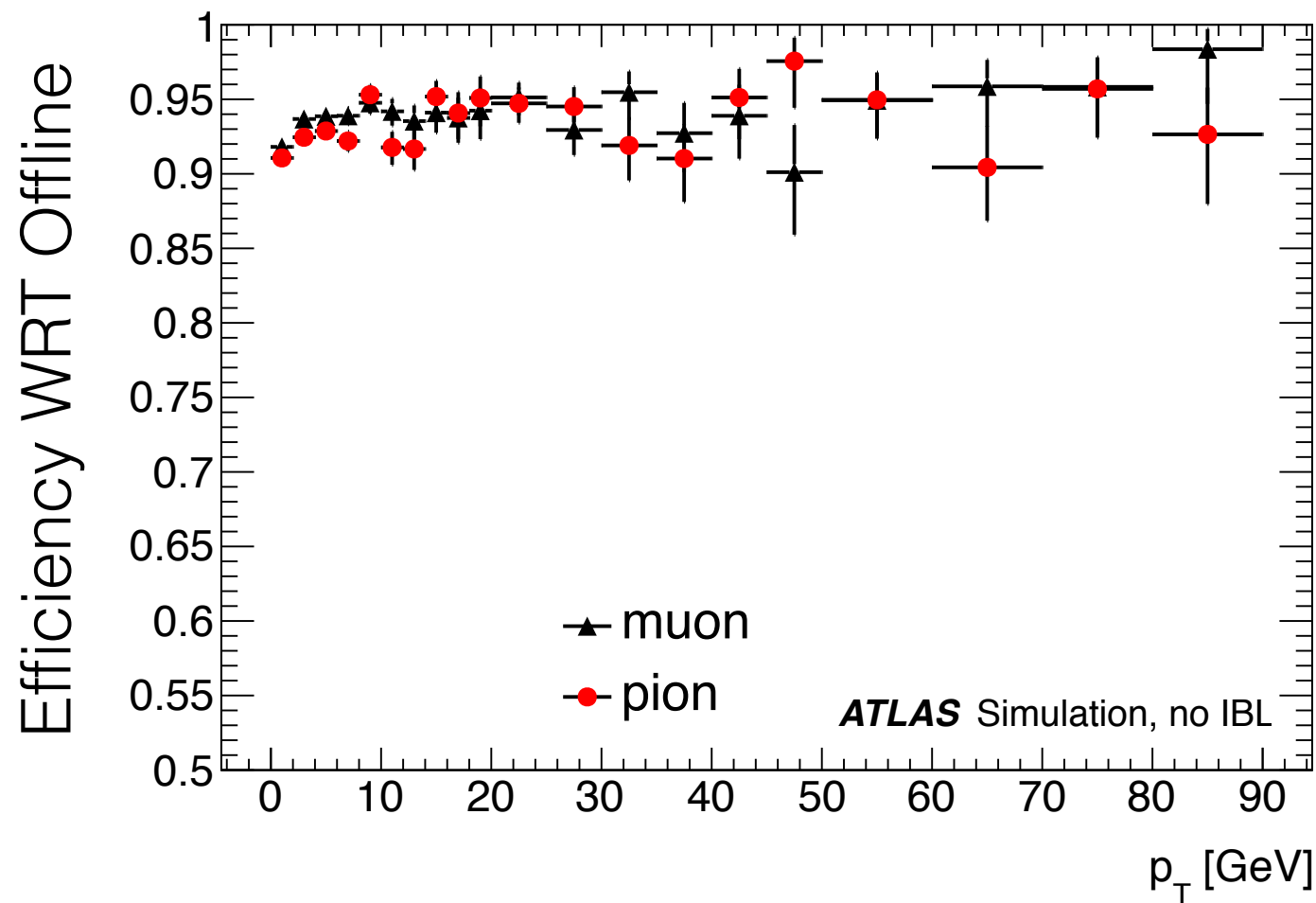
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Hardware Design

- * Full system occupies 7 racks, capable of 250B fits/second



Performance



Resolution at 10 GeV	
p_T	0.5 GeV
η	0.0015
ϕ	0.001
d_0	0.06 mm
z_0	0.25 mm

- * > 90% efficiency w.r.t. offline & good resolution
- * E.g. **b-tagging**: p_T thresholds can be lowered by >20 GeV for triggers identifying events with 4 jets with 2 b-tags
- * E.g. **τ -tagging**: Factor of >2 improvement in QCD background rejection for same $ggH \rightarrow \tau_h \tau_h$ efficiency

Timeline & Future

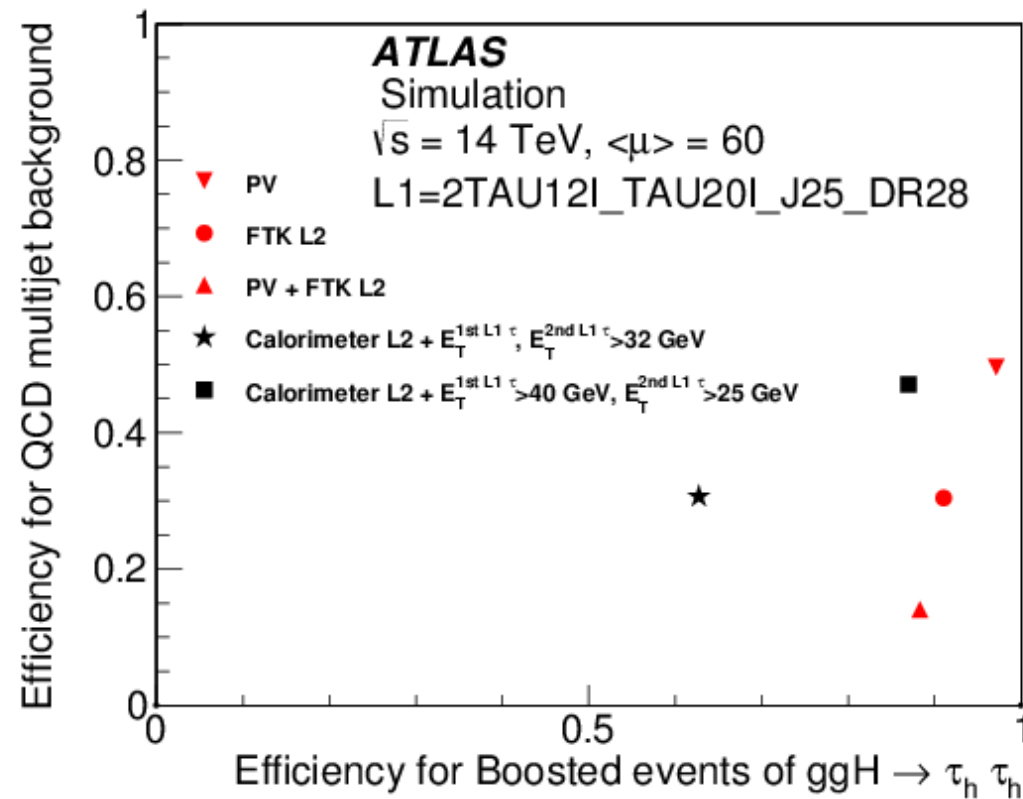
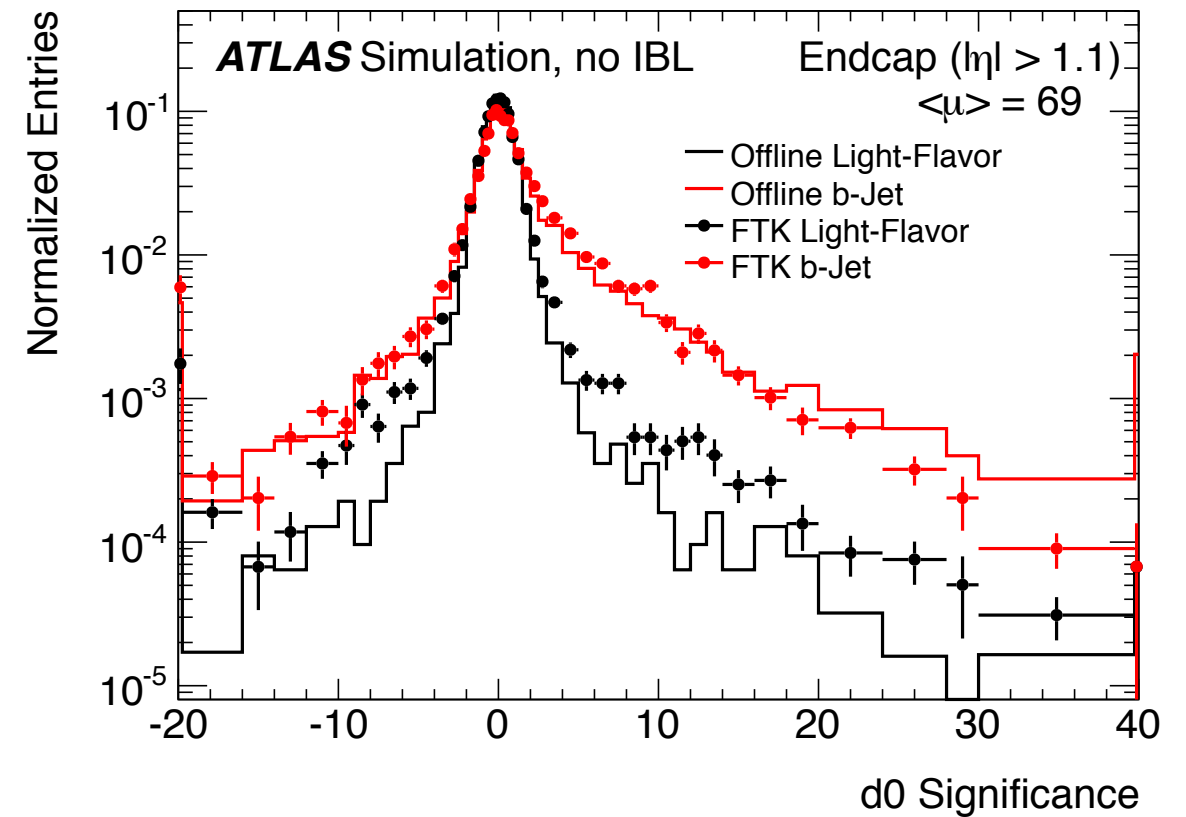
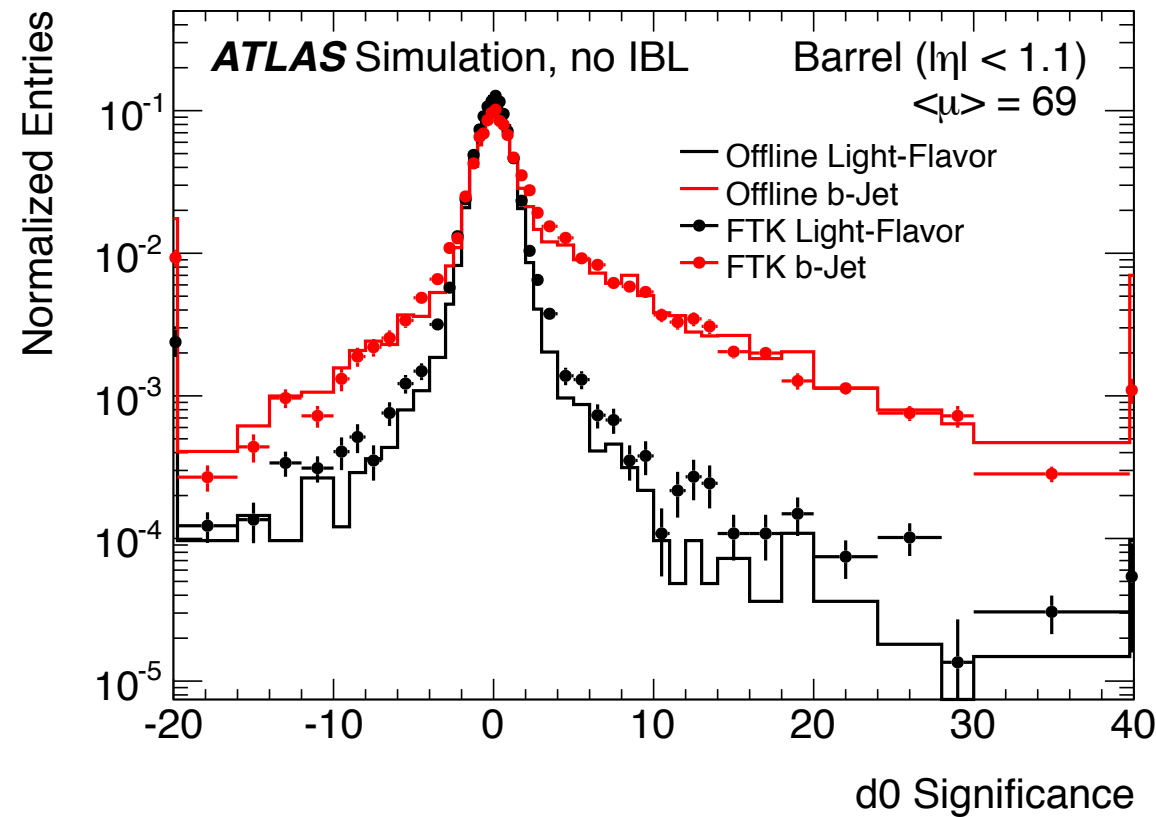
- * Installation & hardware testing ongoing
- * Initial installation will cover a slice of the detector, expected April 2016
- * Full barrel coverage in late 2016
- * Full detector (barrel+endcaps) in early 2017
- * Full design specs for handling higher luminosity in 2018
- * Future...
 - * Current system designed to operate until ~2022
 - * Phase-II inner detector changes & higher luminosity will require upgrades, under investigation
 - * Denser associative memory, more processing chips, etc...

Summary

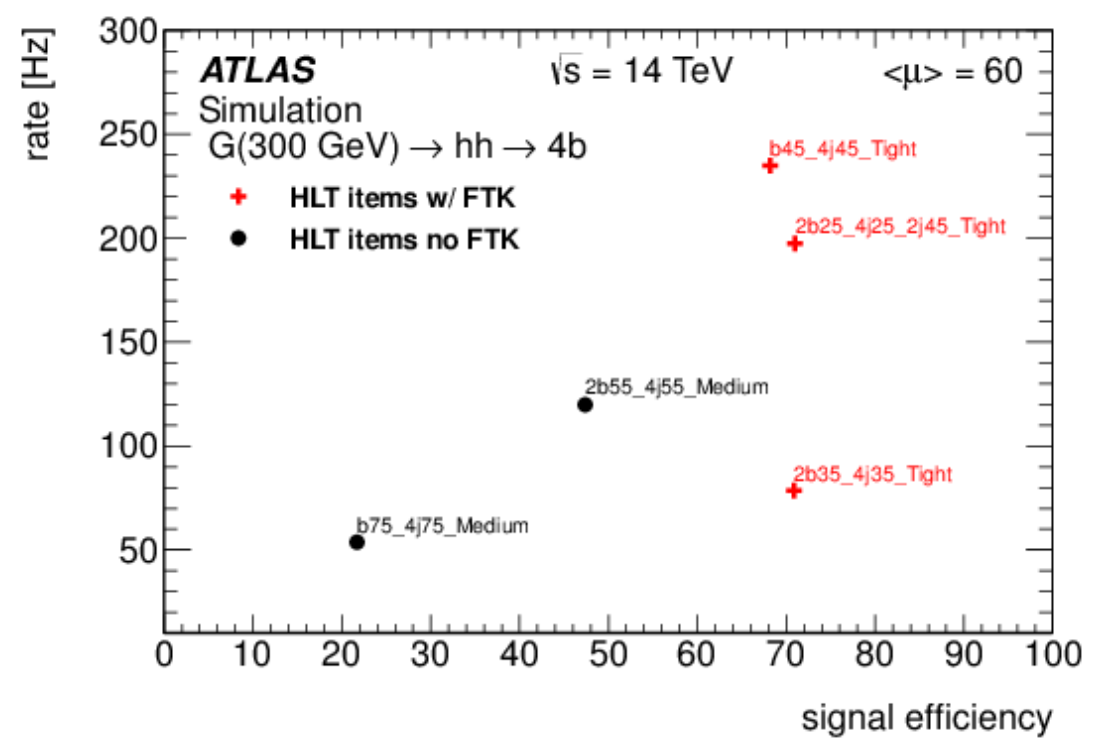
- * In ~1 year FTK will provide global tracking in the ATLAS trigger
- * Broad physics potential:
 - * Handling high pileup environments
 - * Allows lower trigger p_T thresholds
 - * Particularly for b's and τ 's!
- * Will be even more important in Phase-II

Bonus Slides

More Performance Plots



Tau Triggers



b-Jet Triggers

Schedule

	IM	DF	AUX	AMB	AMchip ver.	SSB	FLIC	Milestones	Expected
A	4	1	1*	1	05	1	1*	Included in TDAQ	In progress
B	32*	8*	1*	1	05	1	1*	Included in TDAQ	In progress
3rd	128	32	16	1	06	1	2	Included in TDAQ	4/2016
4th	128	32	16	16	06	8	2	Full barrel (mu=40)	7/2016
5th	128	32	32	32	06	8	2	Full detector (mu=40)	2/2017
Final	128	32	128	128	06	32	2	TDR Specs	2018 / Lumi driven

Goals: integration within ATLAS during winter shutdown
fully commission the system before AM06 are installed