Genetic Algorithm-Driven IBIS-AMI Optimization for Robust 200G SerDes Design

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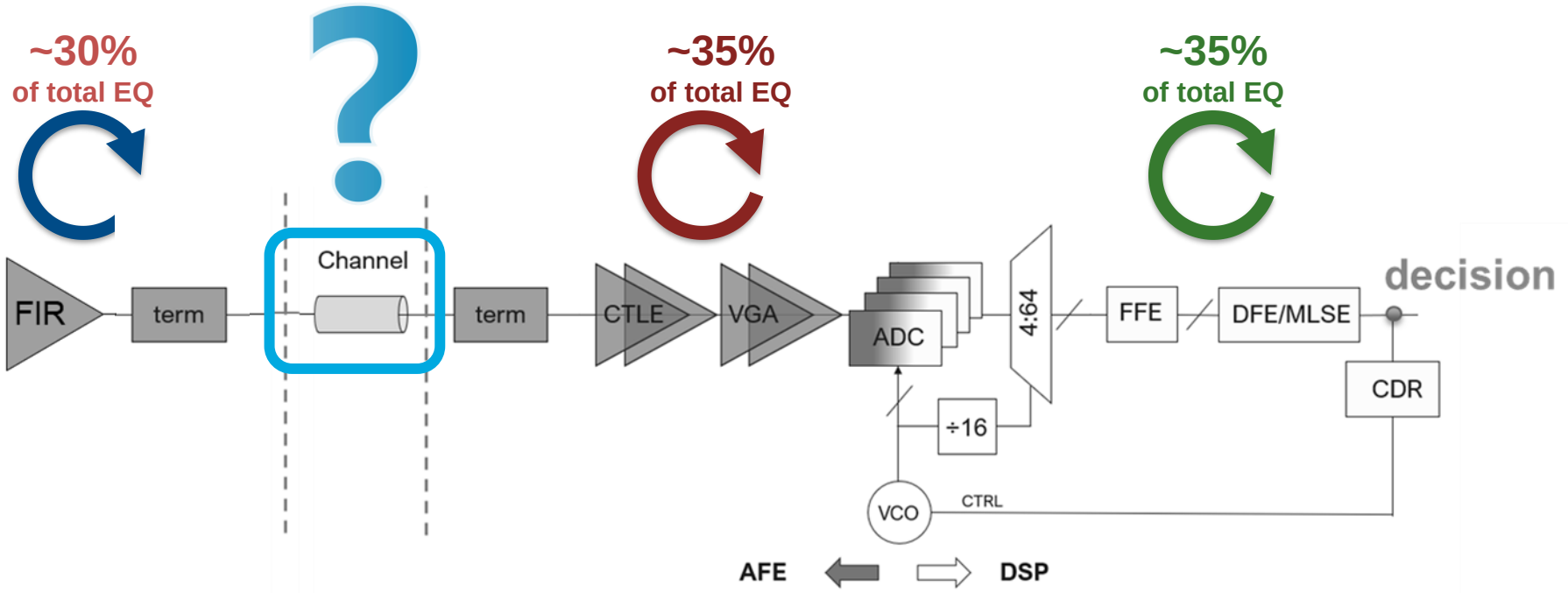
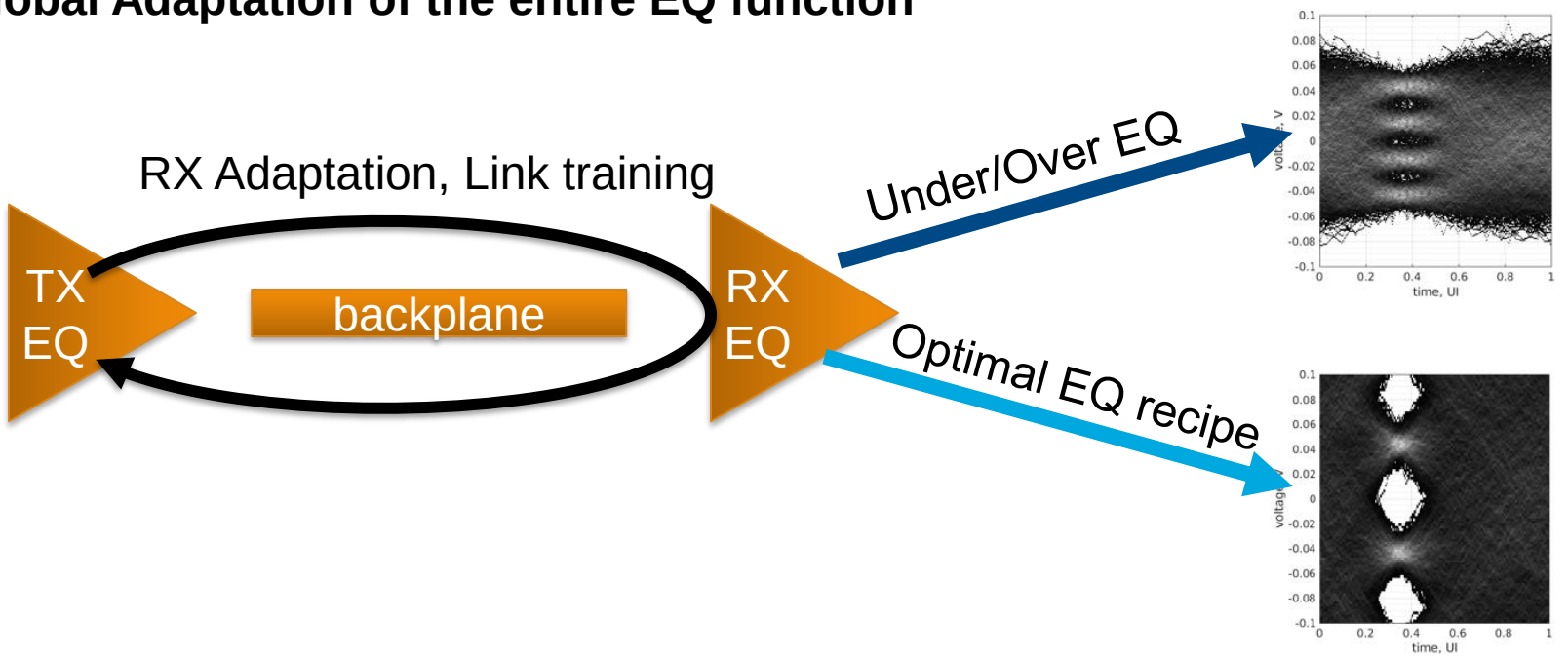
DesignCon IBIS Summit
Santa Clara, CA
January 31, 2025

SerDes Design



Adaption

Global Adaptation of the entire EQ function



Adaption on hardware

Asynchronous (Blind)

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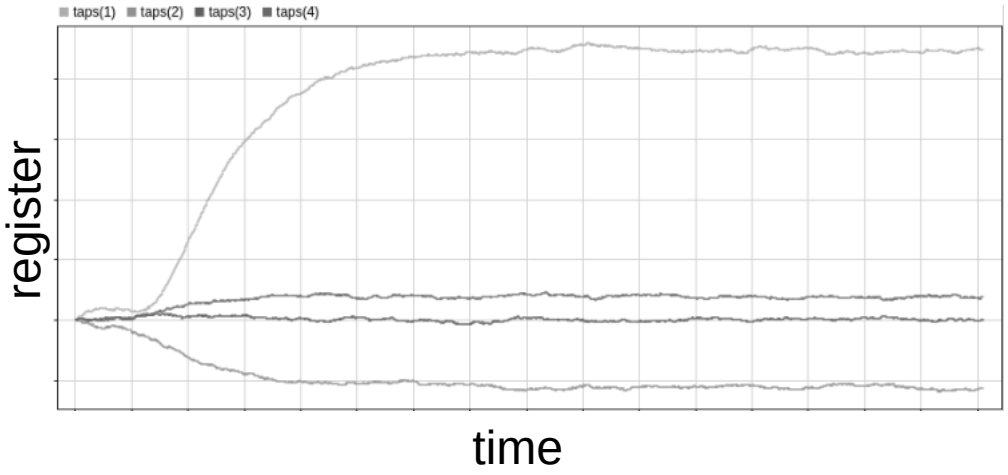
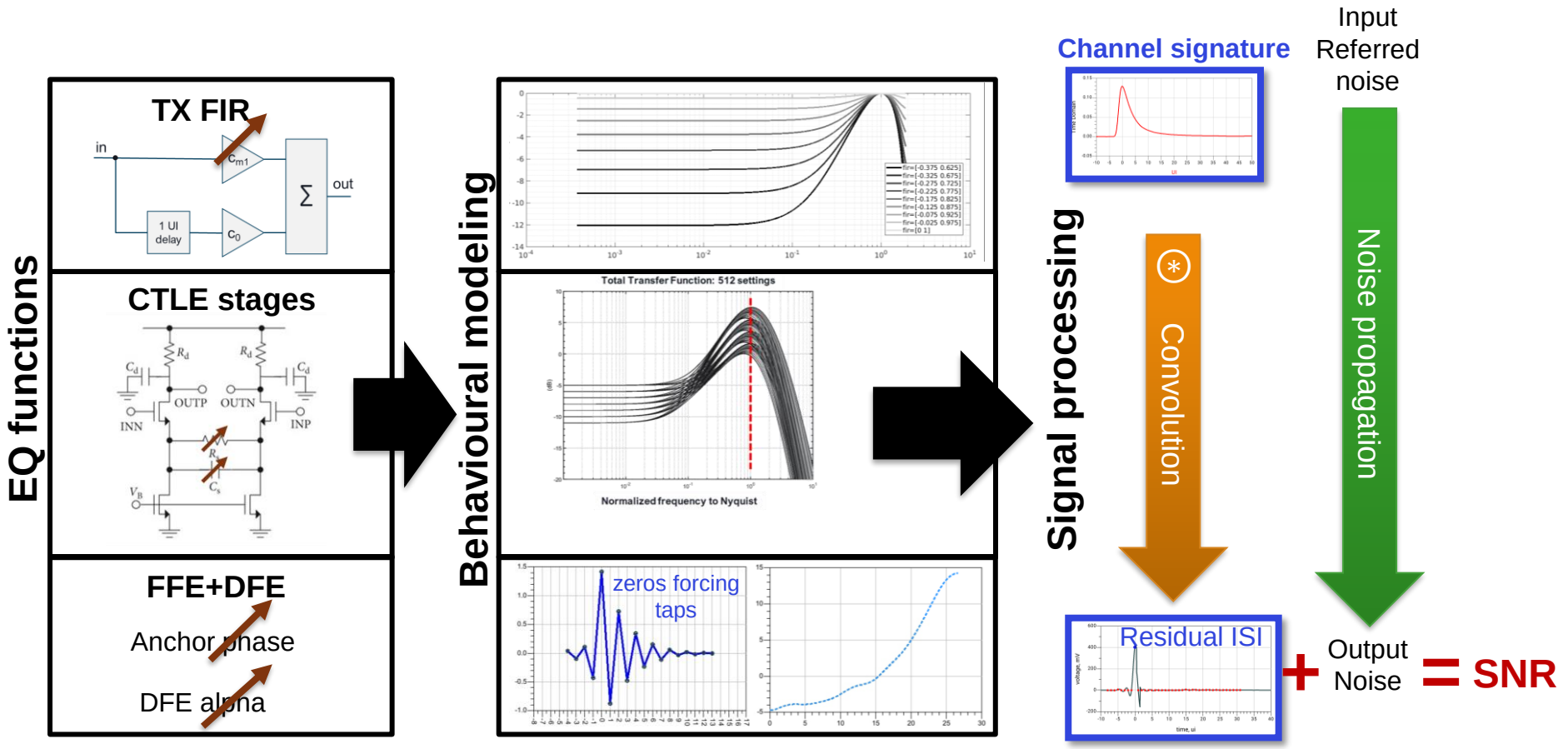
Synchronous

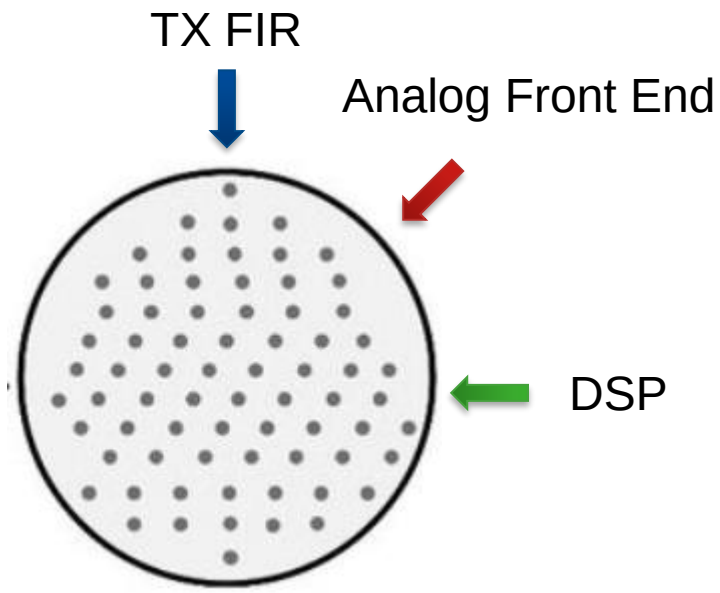


Requires 10/100s Millions of symbols

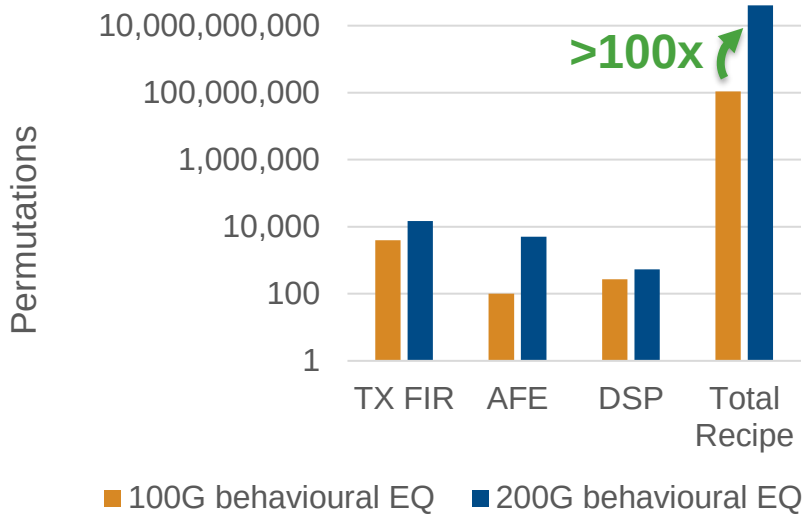
Adaption in models



SerDes transceiver search space



Each dot represent a “**recipe**” = set of EQ register settings



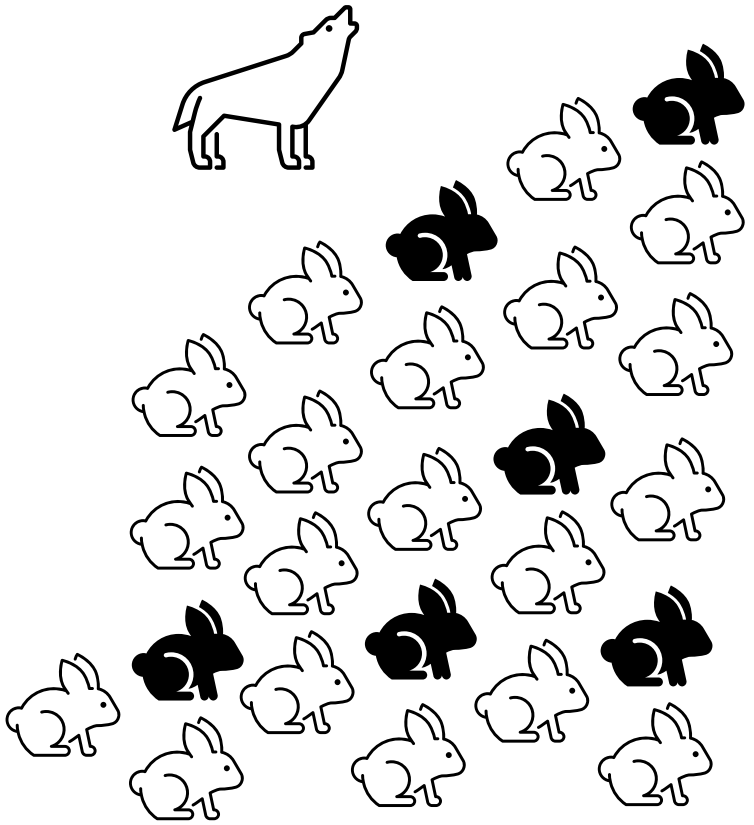
Cannot pass runtime to the user, how to efficiently search for optimal EQ with 200G behavioural modeling ???

Options to optimize

- Many options:
  - Brute Force
    - Run everything
  - Random Search
    - Shot in the dark
  - Hybrid Search
    - Course to fine
  - Genetic Algorithm
    - Mimic principle of evolution

Genetic Algorithm

- Genetic Algorithms (GAs) are optimization techniques inspired by the process of **natural selection**
- They are used to find approximate solutions to complex problems by mimicking biological evolution
- **Key Components:**
  - **Population:** A set of potential solutions.
  - **Chromosomes:** Representation of a solution.
  - **Genes:** Elements of a chromosome.
  - **Fitness Function:** Evaluates how good a solution is.
  - **Selection, Crossover, Mutation:** Mechanisms to evolve solutions.



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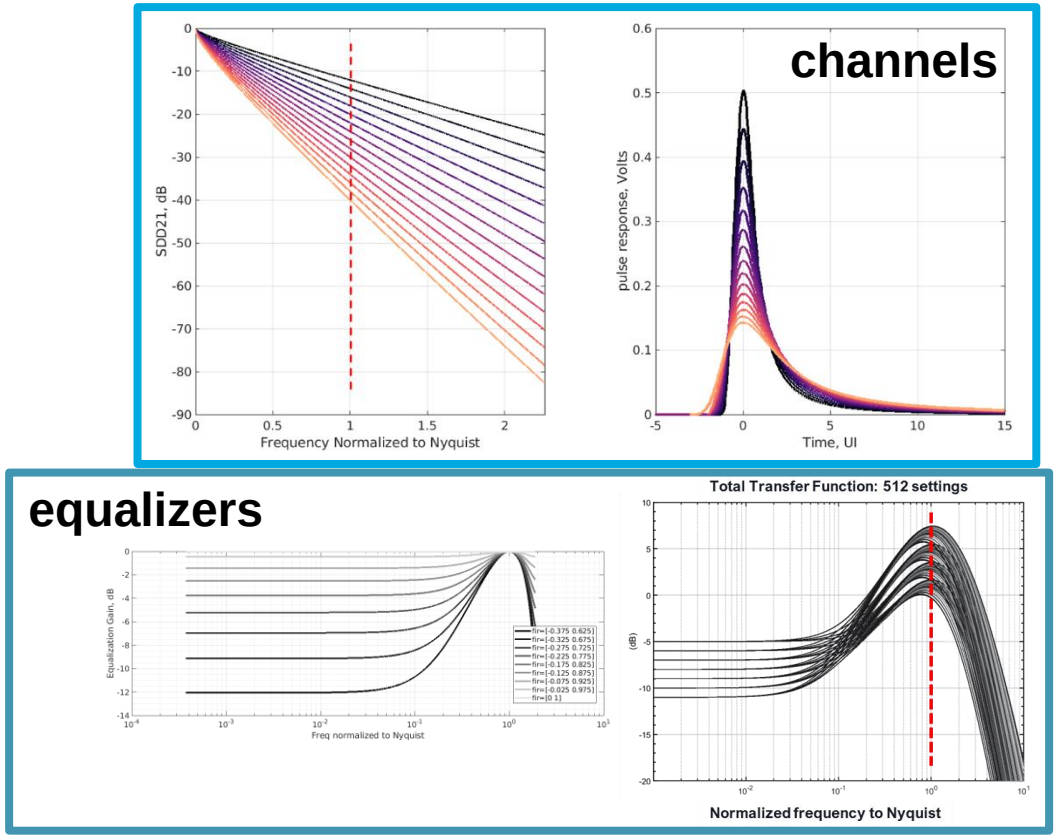
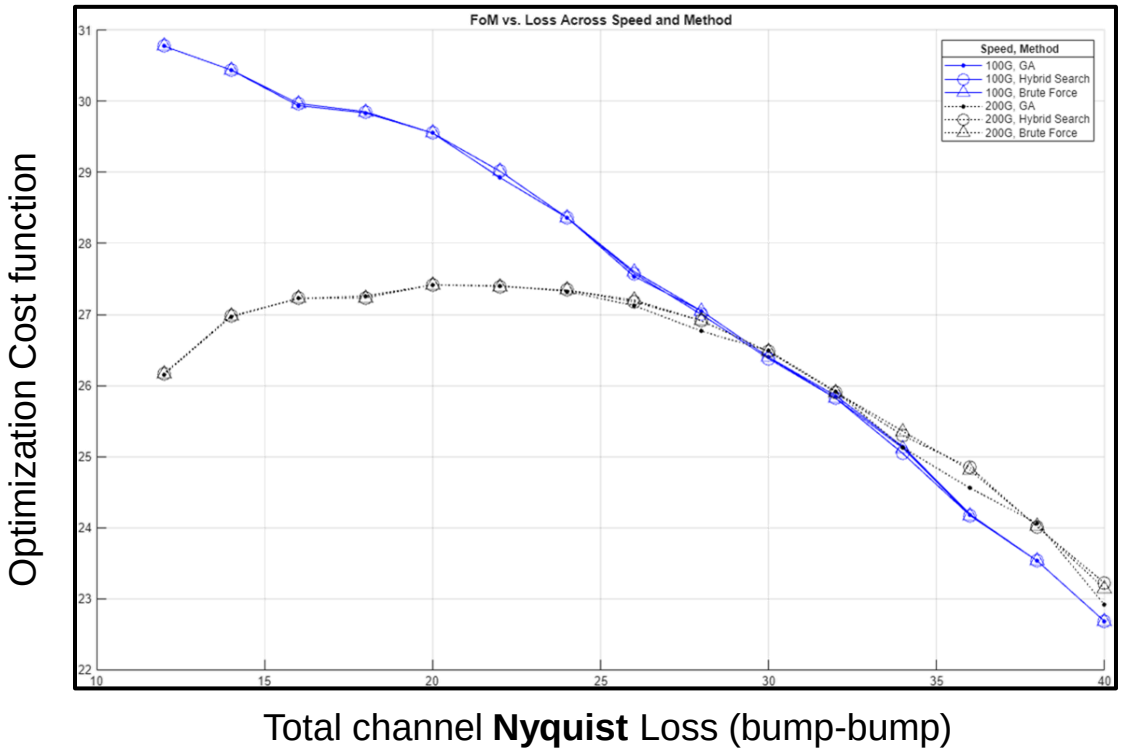
Optimization benchmark setup

- Speed sweep
  - 100G
  - 200G
- Channel sweep
  - Loss based model
  - 12dB-40dB at 2dB increment
- Genes
  - Tx FIR tap setting (reduced to 1 tap)
  - 2x CTLE configurations
  - Rx FFE taps
- Chromosomes possible
  - 200k @ 100G
  - 8mil @ 200G



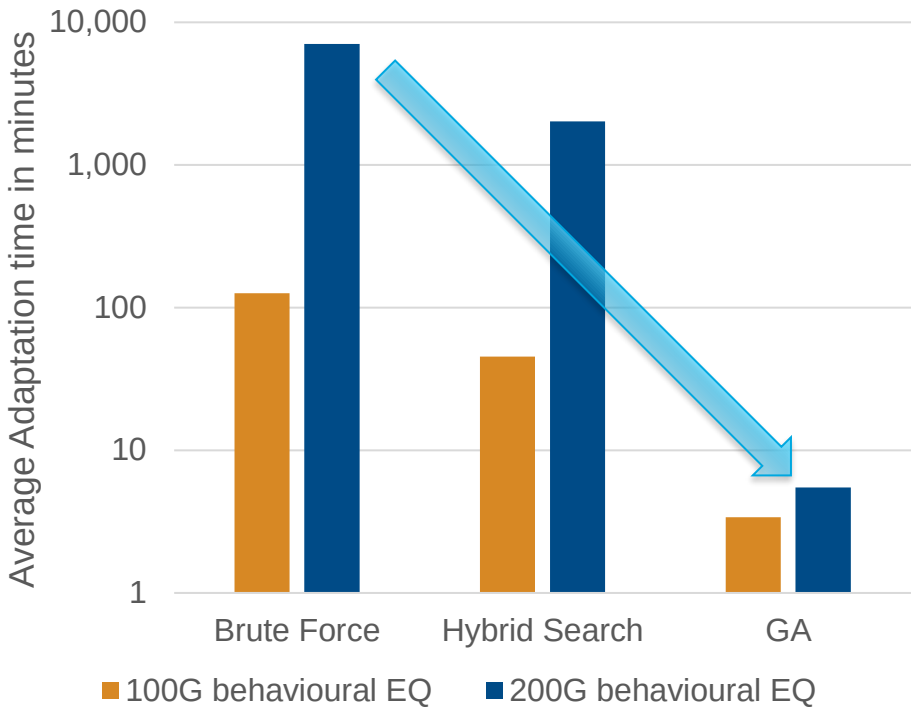
Optimization comparison

- Optimization methods produce near identical FoM results across loss
- Consistent for both **100G** and **200G**



Optimization Benchmark

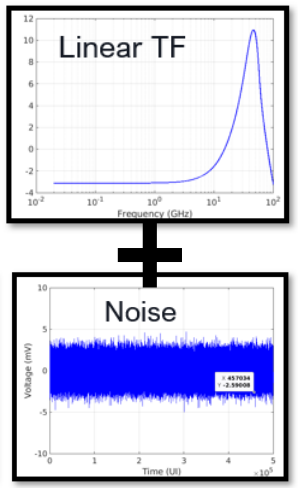
- 200G complexity significantly higher
- GA superior
  - Much faster across board
  - Does not scale with the equalizer complexity and runtime remains relatively constant for 100G and 200G



Speed	Method	Mean Run Time		Fitness Function Evaluations
100	GA	3.4	min	900
100	Hybrid Search	45.3	min	59,904
100	Brute Force	2.1	hours	199,680
200	GA	5.5	min	900
200	Hybrid Search	1.4	days	2,408,448
200	Brute Force	4.9	days	8,028,160

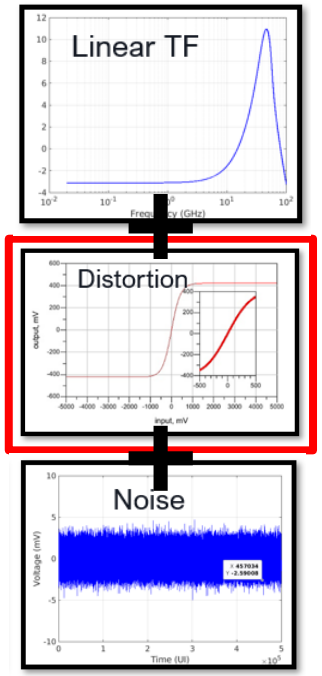
Future work

In the adaptation stage



Signal processing is different

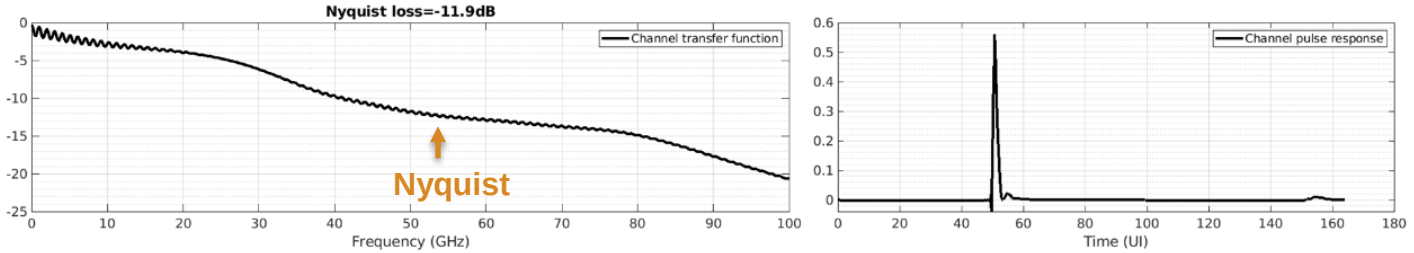
In the time-domain model



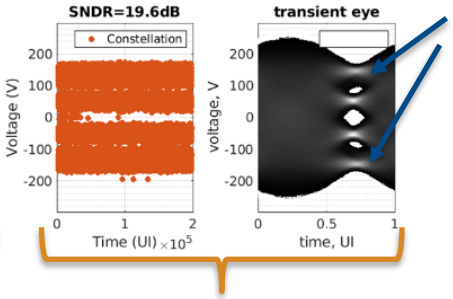
SNR (Signal-to-Noise Ratio)

SNDR (Signal-to-Noise and Distortion Ratio)

Low-loss channel issues



TX FIR	CTLE	RX FFE
Boost=2.5dB	Boost=7.5dB	Boost=2.5dB

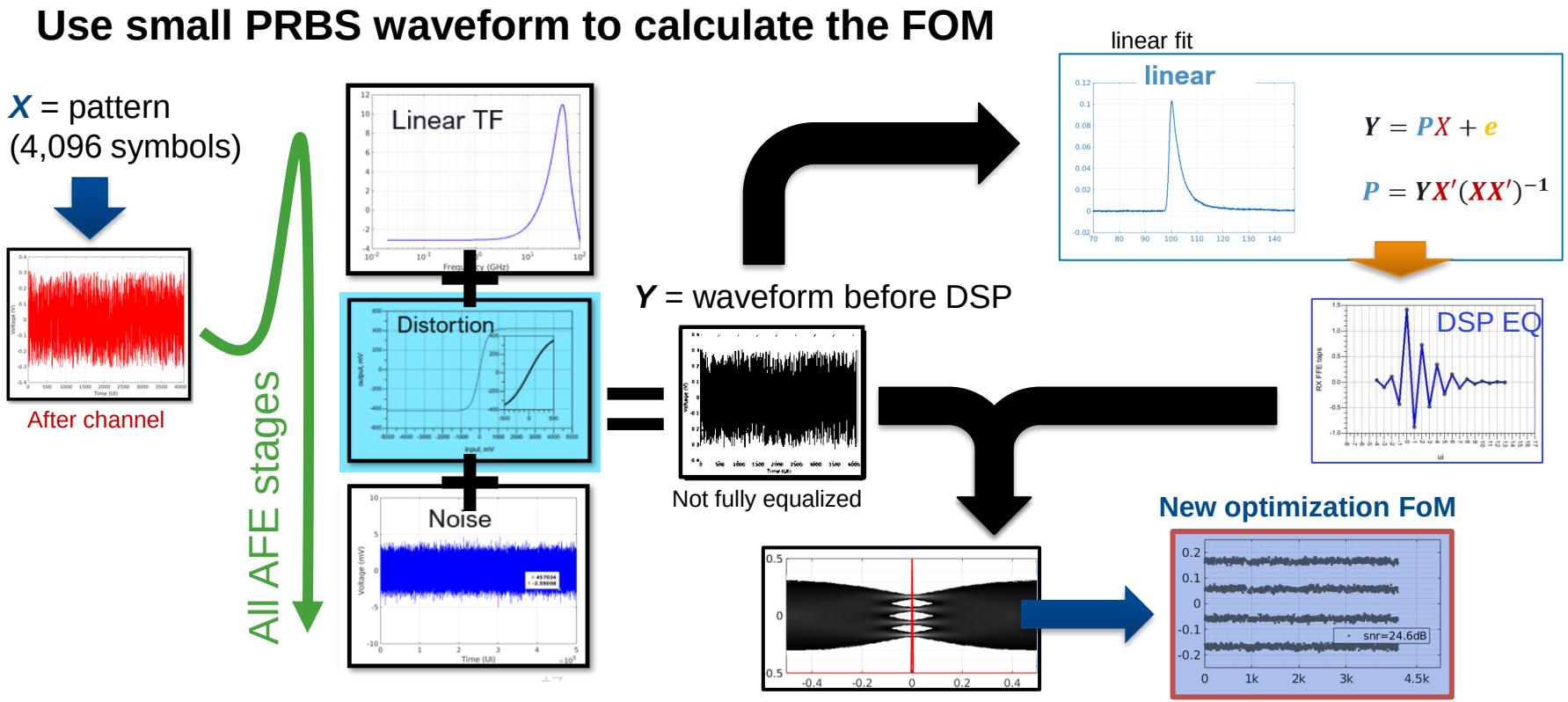


Adapted EQ recipe ignored non-linear aspect of the amplifiers and yields poor solution

Full 12dB ISI is cancelled

Poor time-domain performance

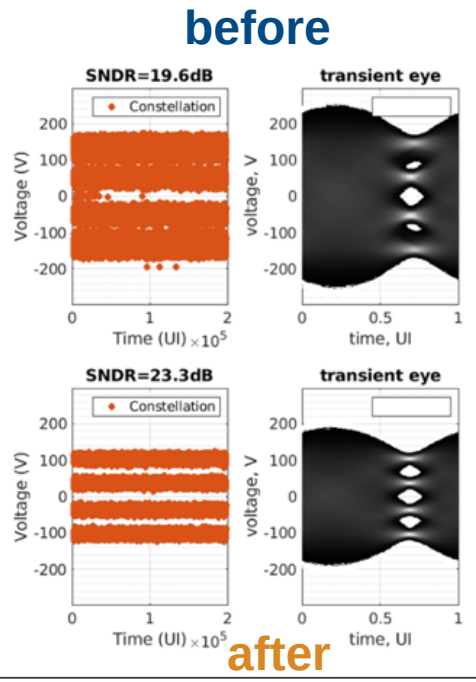
New cost function



Cost function comparison

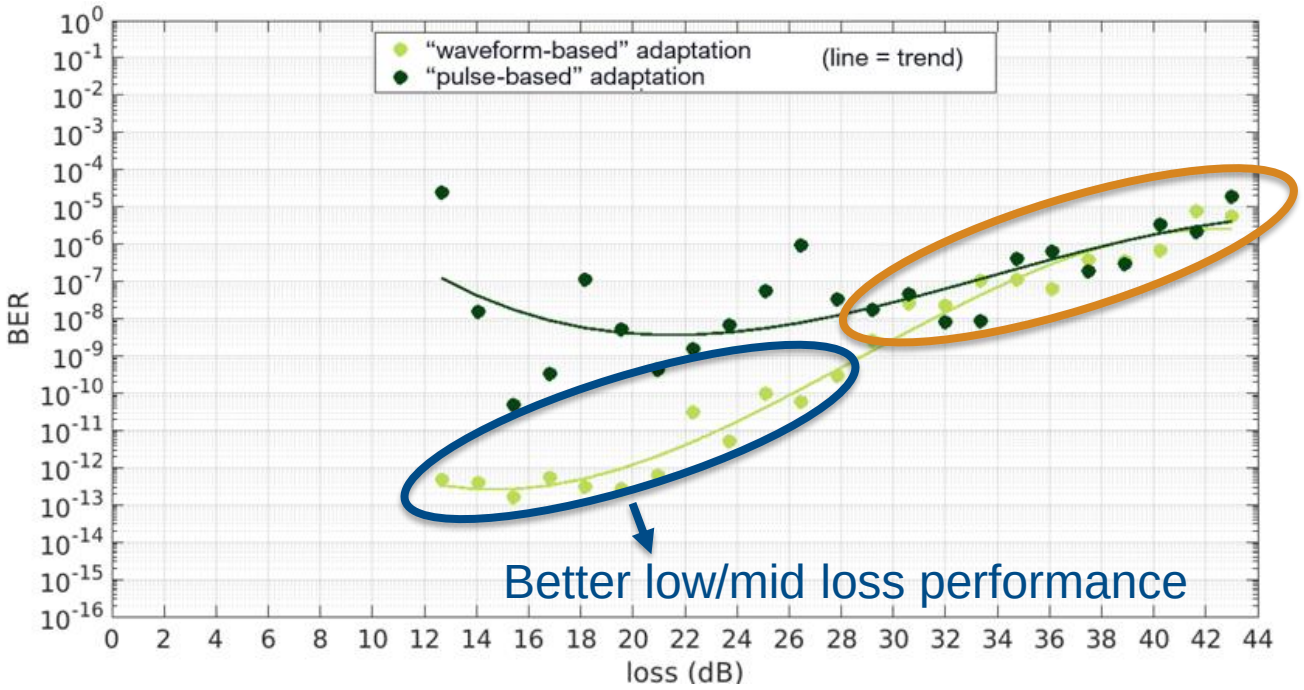
	TX FIR	CTLE	RX FFE
Pulse-based	Boost=2.5dB	Boost=7.5dB	Boost=2.5dB
Waveform-based	Boost=5.5dB	Boost=2.5dB	Boost=4.5dB

Same total ISI compensation



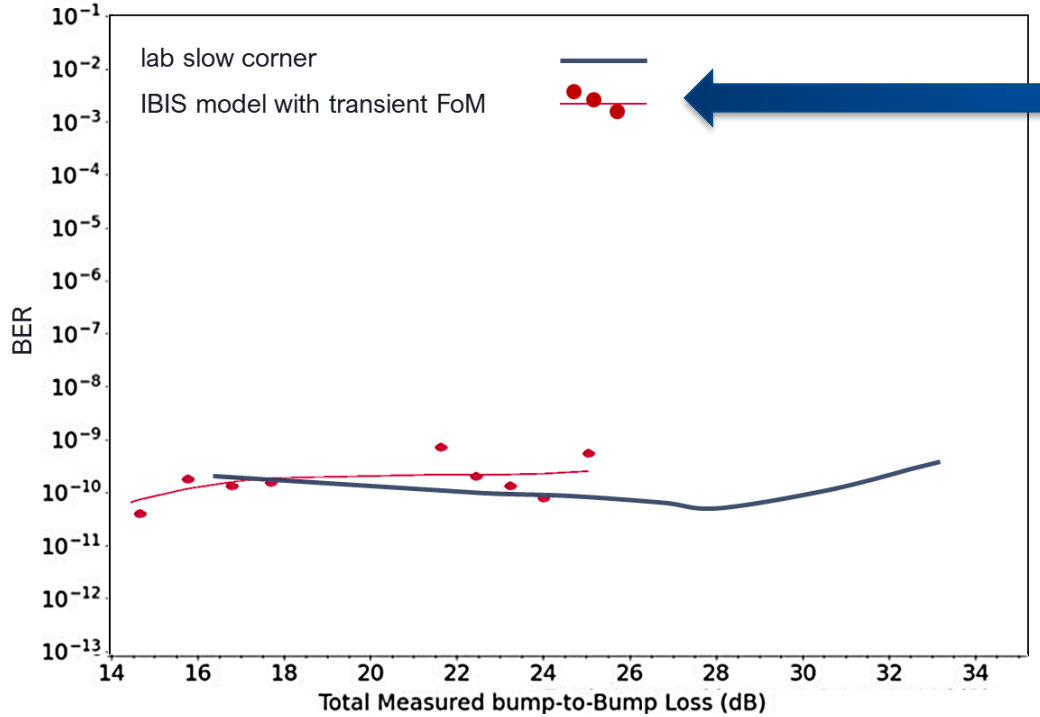
Waveform based adaptation provided an **EQ recipe** with the same ISI compensation while limiting the amplifiers non-linear distortion

New cost function results across loss

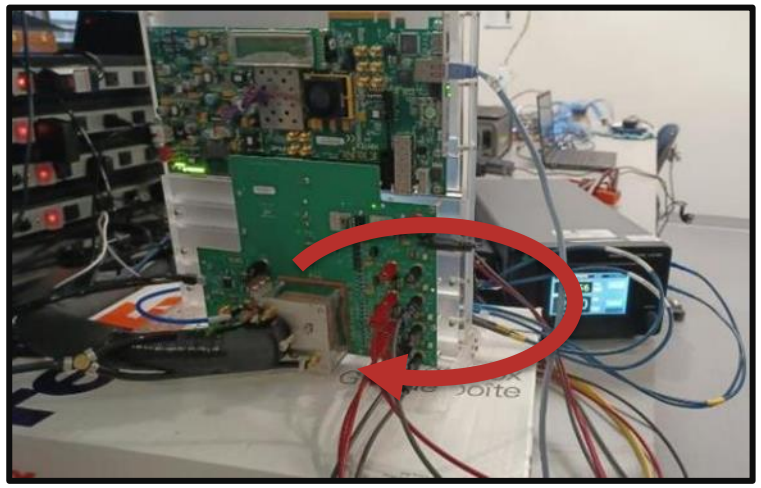


Same long reach adaptation/performance

Low loss lab comparison



new cost function



Loop back with lowest ISI traces

Thank you