INTRODUCTION TO ARBOR
What's new and demonstration

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arbor

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WHAT IS ARBOR?

Arbor is a library for implementing performance portable network simulations of multi-compartment neuron models.

- Simulate large networks of morphologically-detailed, spiking neurons
- Library: you control your program/workflow. Interoperable.
- Portable: scientific description is separate from execution instructions. E.g. run one scientific description on laptop CPU, GPU cluster or future hardware.
- *Performance* portable: add optimized backends for new computer architectures. Currently supported:
  - Distributed parallelism using MPI
  - CUDA backend for NVIDIA and AMD GPUs
  - Vectorized backends for x86-64 (KNL, AVX, AVX2) and Arm64 (NEON, SVE) intrinsics
- Executes on all HPC systems in the HBP (and outside).

WHO IS ARBOR?

Repo: `github.com/arbor-sim/arbor`, website: `arbor-sim.org`

- Latest release: v0.6
- 48 Github forks, 69 Github stars
- 1400+ commits to main branch
- loc: C++: 157k, Python: 13k, reStructuredText: 21k
- 26 contributors, from 9+ institutions

Core contributors

- Ben Cumming, Nora Abi Akar, Fabian Bösch, Simon Frasch, Lukas Drescher
- Anne Küsters, Thorsten Hater, Brent Huisman

CSCS
Centro Svizzero di Calcolo Scientifico
Swiss National Supercomputing Centre

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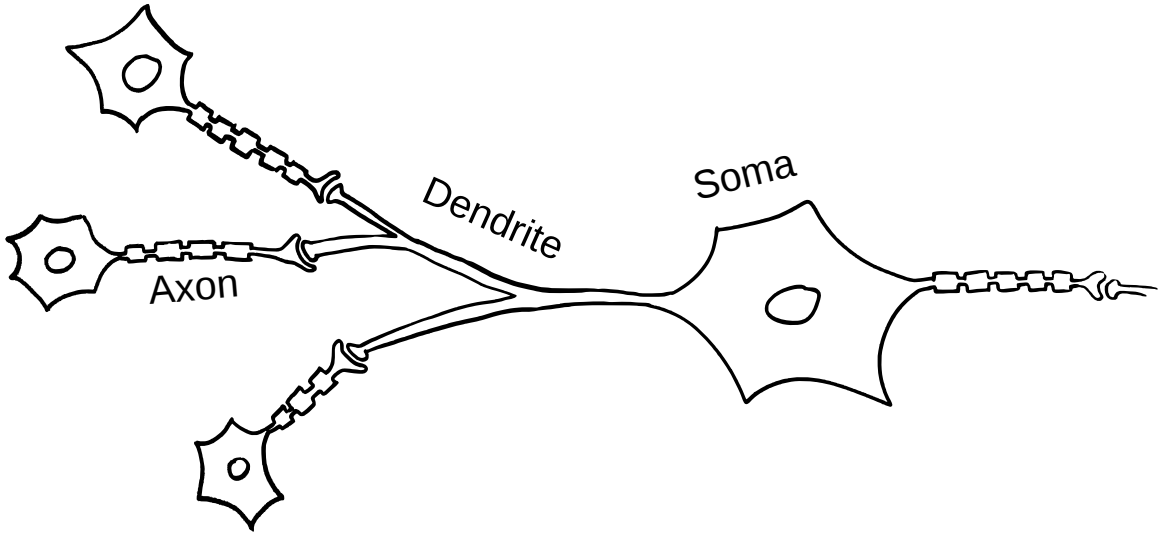
Modeling

Neuron



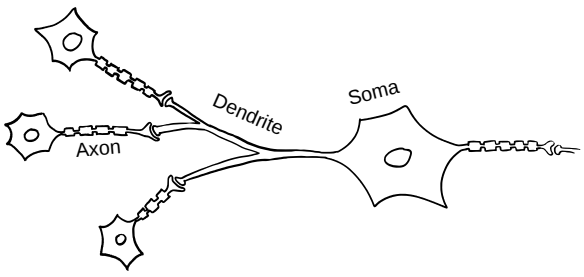
[1]

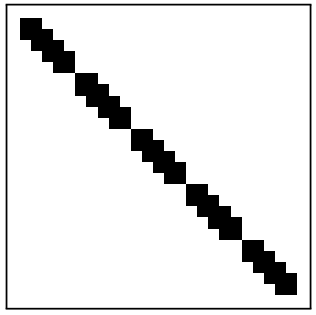
- Dendrite: 1D electric flux on tree structure
- Soma: Emits spikes if the voltage rises over a threshold
- Axon: The output for the spike signal modeled by a time delay

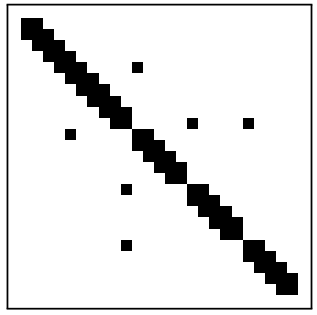
1D flux with varying properties in a tree structure

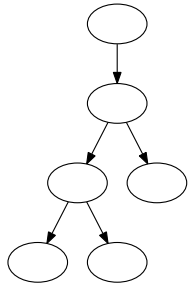
Modeling [2]

Discretization









- Each branch: subdivide each branch →tridiagonal matrix
- With branching: almost tridiagonal →Hines matrix

Which Solver?

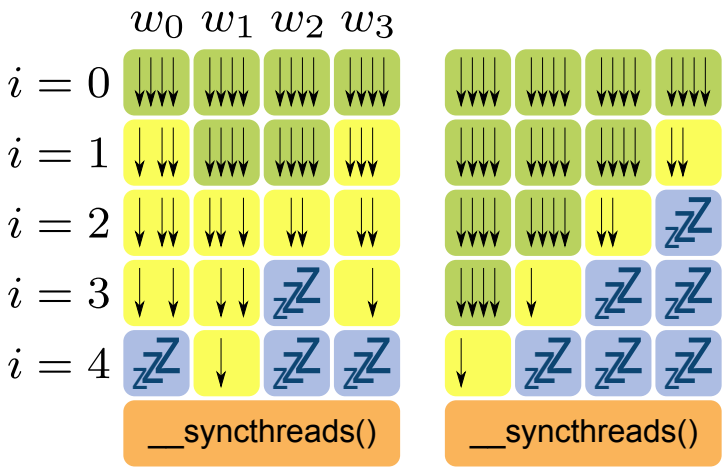
- Tridiagonal matrix: Thomas algorithm
- Hines matrix: tree solver, starting at the leaves

We've got Hines matrices and know how to solve them, let's make it fast!

GPU Recap

Many Threads, grouped in blocks. Good for parallelization:

- enough threads and blocks
- latency hiding, memory access
- low divergence
- independent tasks

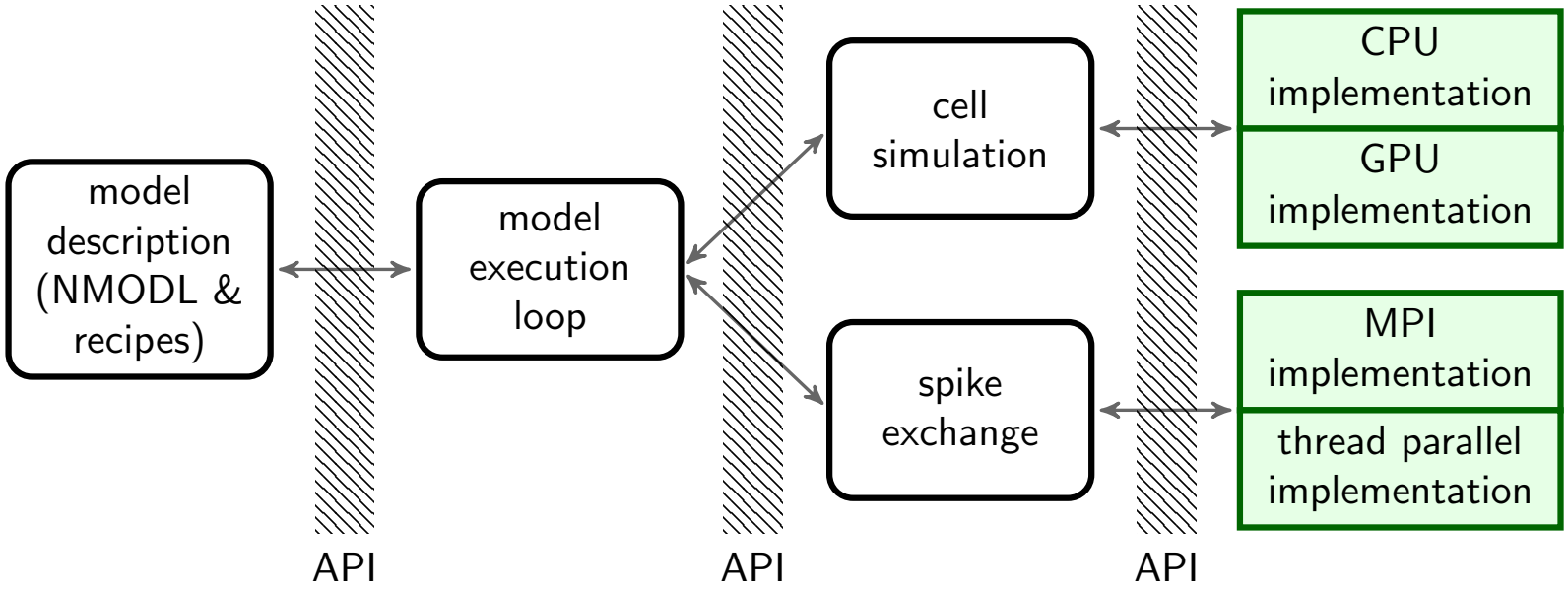


kernel

```
int count = counts[threadIdx.x];
for (int i = 0; i < count; ++i) {
    // smart stuff
}
__syncthreads();
```

ARBOR DESIGN

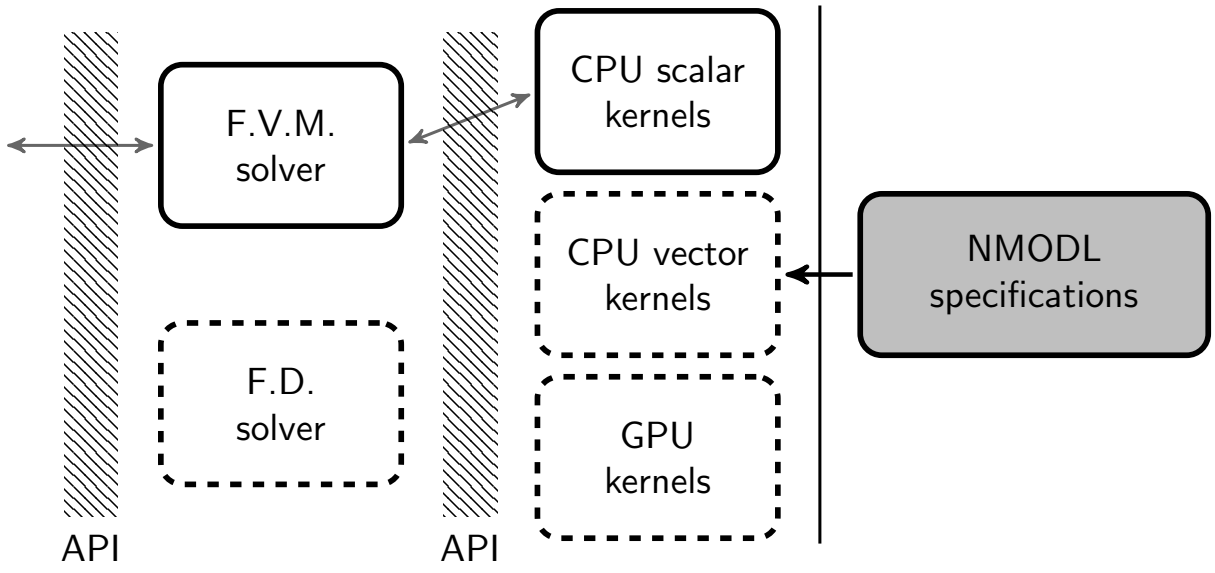
- Modular: components can be substituted according to internal API
- Internal API: ‘thin’ API; type parameterization allows components to determine low-overhead API data structures



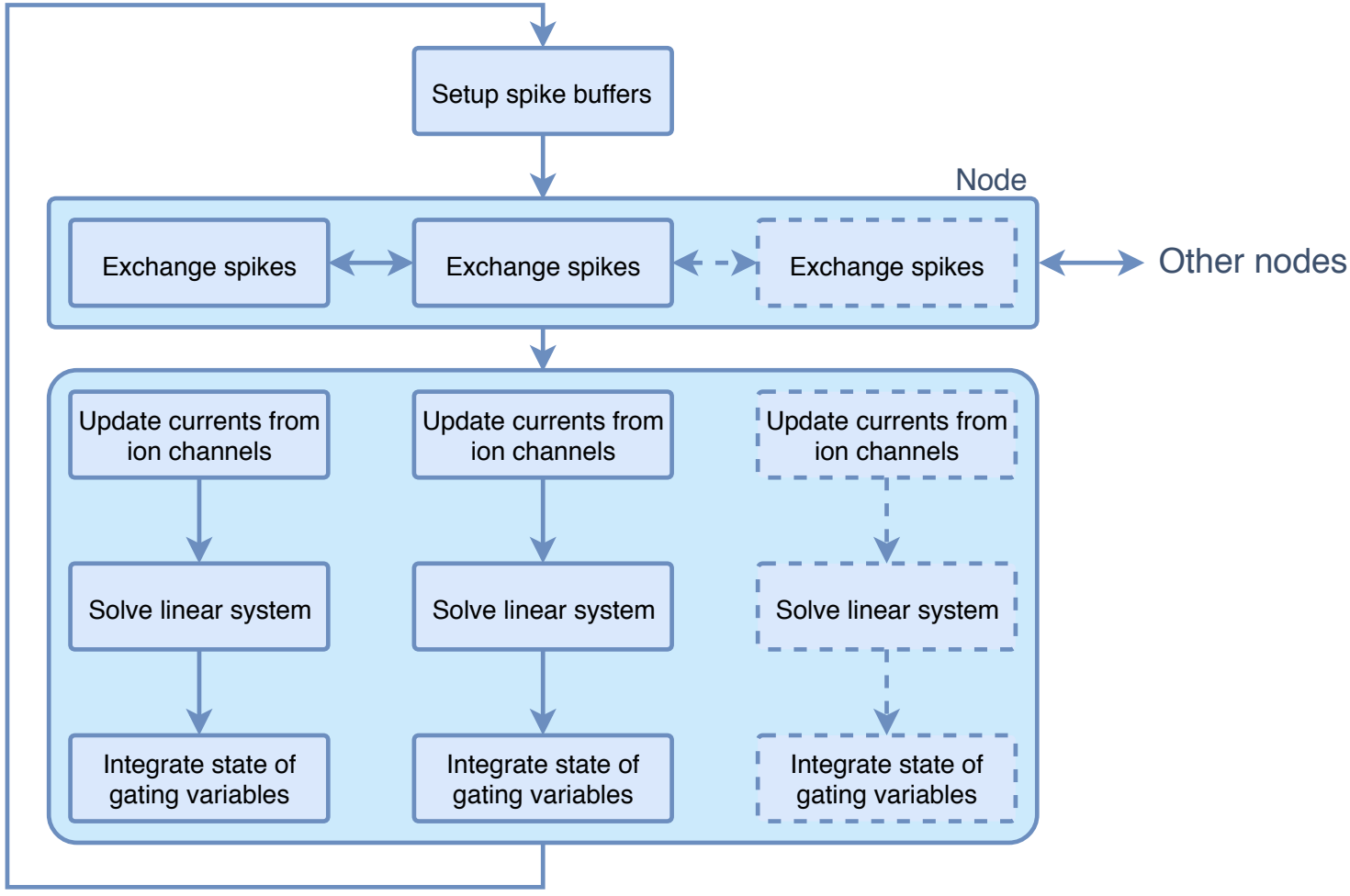
ARBOR BACKENDS

Cell simulation modules share computational backends for channel and synapse state evolution.

CPU-hosted finite volume cell simulation



CELL SIMULATION TIMELOOP



WRAP UP

Questions?

- Web: `arbor-sim.org`
- Docs: `docs.arbor-sim.org`
- Community: `github.com/arbor-sim/arbor/discussions`
- Chat: `gitter.im/arbor-sim/community`

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EBRAINS

Human Brain Project