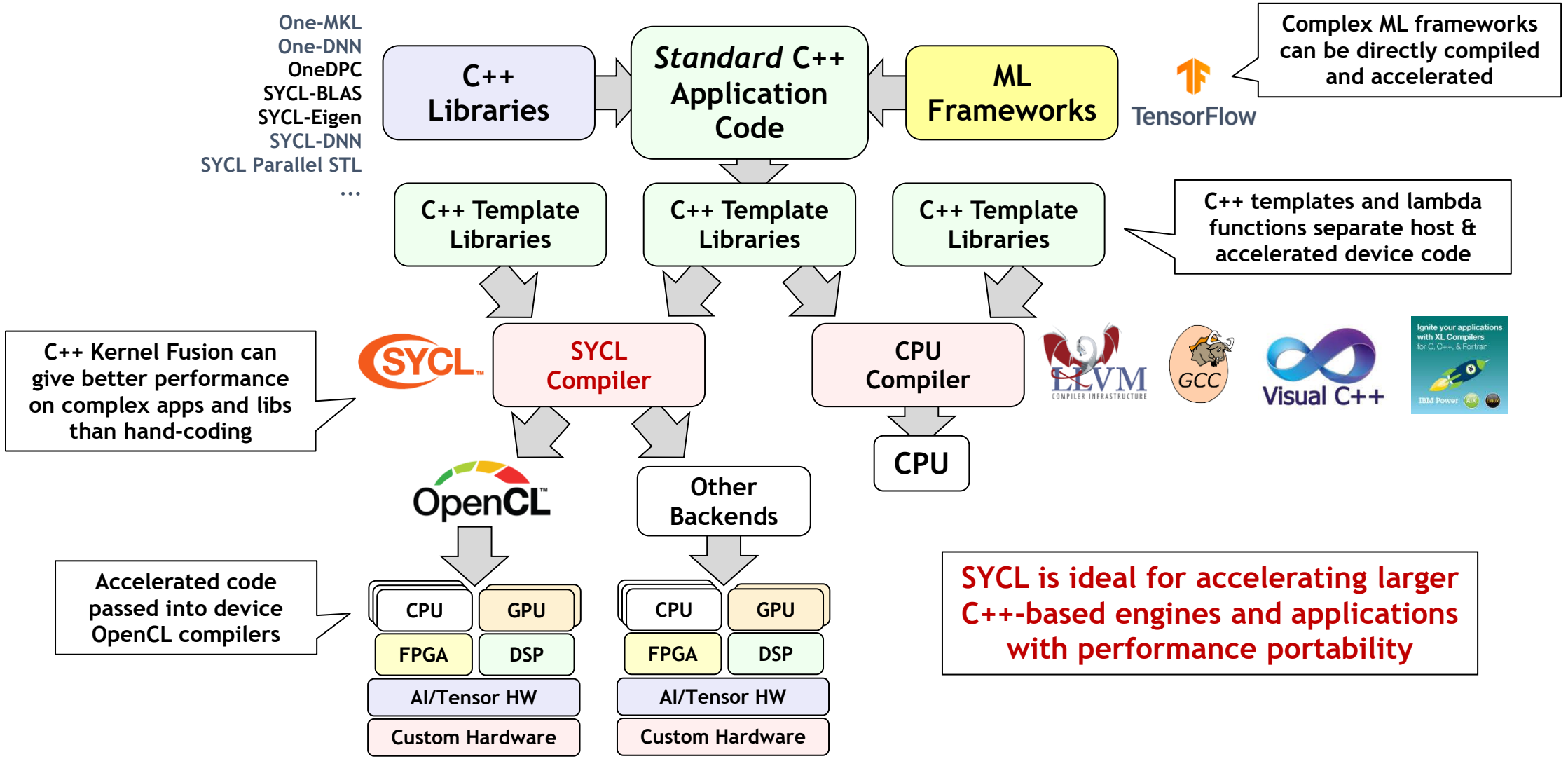
SYCL Academy

SYCL 2020 and the future

Michael WOng

Acknowledgements:
SYCL WG
Rod Burns

SYCL Single Source C++ Parallel Programming



SYCL 2020 is here!

Open Standard for Single Source C++ Parallel Heterogeneous Programming

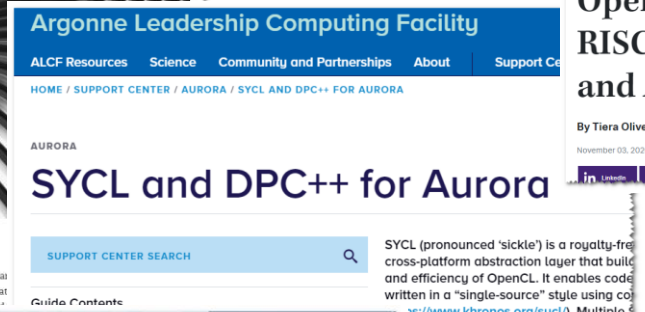
SYCL 2020 is released after 3 years of intense work
Significant adoption in Embedded, Desktop and HPC markets
Improved programmability, smaller code size, faster performance
Based on C++17, backwards compatible with SYCL 1.2.1
Simplify porting of standard C++ applications to SYCL
Closer alignment and integration with ISO C++
Multiple Backend acceleration and API independent

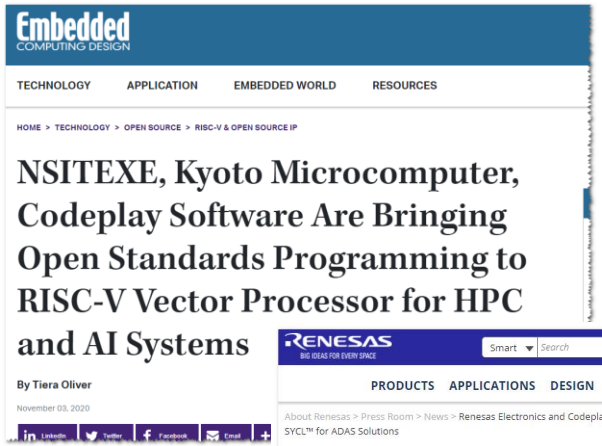
SYCL 2020 increases expressiveness and simplicity
for modern C++ heterogeneous programming

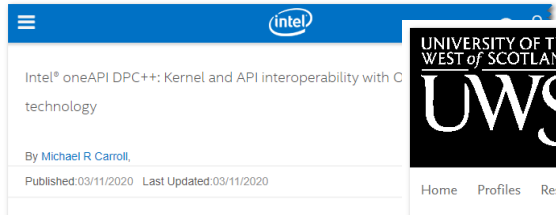
KHRONOS GROUP

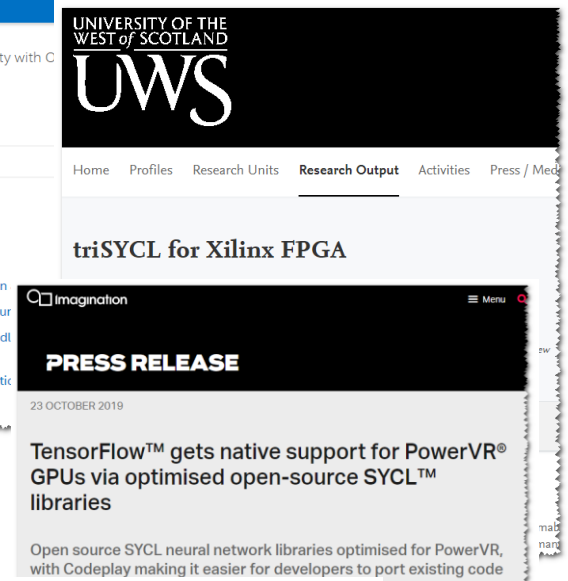
SYCL Academy

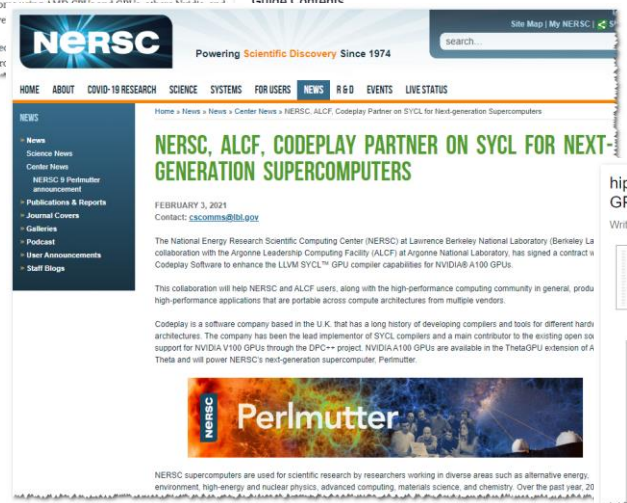
SYCL 2020 Industry Momentum

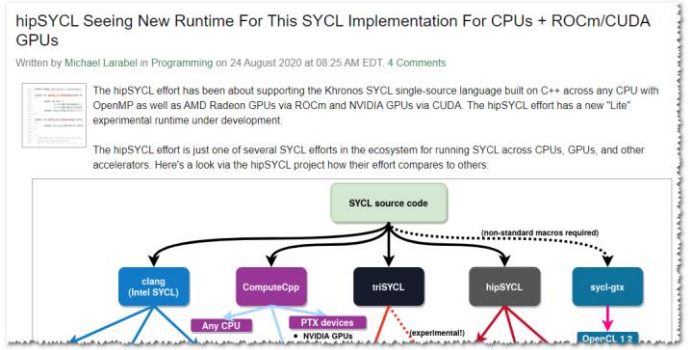












Argonne and Oak Ridge National Laboratories Award Codeplay® Software to Further Strengthen SYCL™ Support Extending the Open Standard Software for AMD GPUs

17 June 2021

LEMONT, IL, and OAK RIDGE, TN, and EDINBURGH, UK, June 17, 2021 - Argonne National Laboratory (ANL) in collaboration with Oak Ridge National Laboratory (ORNL), has awarded Codeplay a contract implementing the oneAPI DPC++ compiler, an implementation of

SYCL support growing from Embedded Systems through Desktops to Supercomputers

https://www.alcf.anl.gov/support-center/aurora/sycl-and-dpc-aurora
https://www.embeddedcomputing.com/technology/open-source/risc-v-open-source-ip/nsitexe-kyoto-microcomputer-and-codeplay-software-are-bringing-open-standards-programming-to-risc-v-vector-processor-for-hpc-and-ai-systems
https://www.nextplatform.com/2021/02/03/can-sycl-slice-into-broader-supercomputing/
https://www.phoronix.com/scan.php?page=news_item&px=hipSYCL-New-Lite-Runtime
https://software.intel.com/content/www/us/en/develop/articles/interoperability-dpcpp-sycl-opencl.html
https://www.renesas.com/br/en/about/press-room/renesas-electronics-and-codeplay-collaborate-opencl-and-sycl-adas-solutions
https://www.nersc.gov/news-publications/nersc-news/nersc-center-news/2021/nersc-alcf-codeplay-partner-on-sycl-for-next-generation-supercomputers/
https://research-portal.uws.ac.uk/en/publications/trisycl-for-xilinx-fpga
https://www.imaginationtech.com/news/press-release/tensorflow-gets-native-support-for-powervr-gpus-via-optimised-open-source-sycl-libraries/

SYCL 2020 Major Features

- Unified Shared Memory (USM)
  - Code with pointers can work naturally without buffers or accessors
  - Simplifies porting from most code (e.g. CUDA, C++)
- Parallel Reductions
  - Added built-in reduction operation to avoid boilerplate code and achieve maximum performance on hardware with built-in reduction operation acceleration.
- Work group and subgroup algorithms
  - Efficient parallel operations between work items
- Class template argument deduction (CTAD) and template deduction guides
  - Simplified class template instantiation
- Simplified use of Accessors with a built-in reduction operation
  - Reduces boilerplate code and streamlines the use of C++ software design patterns
- Expanded interoperability
  - Efficient acceleration by diverse backend acceleration APIs
- SYCL atomic operations are now more closely aligned to standard C++ atomics
  - Enhances parallel programming freedom

Parallel Industry Initiatives

C++11

C++14

C++17

C++20

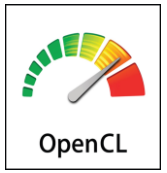
C++23

SYCL 1.2
C++11 Single source programming

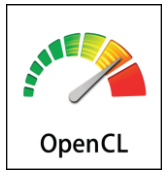
SYCL 1.2.1
C++11 Single source programming

SYCL 2020
C++17 Single source programming
Many backend options

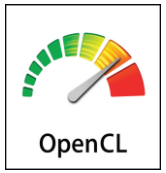
SYCL 202X
C++20 Single source programming
Many backend options



OpenCL 1.2
OpenCL C Kernel Language



OpenCL 2.1
SPIR-V in Core



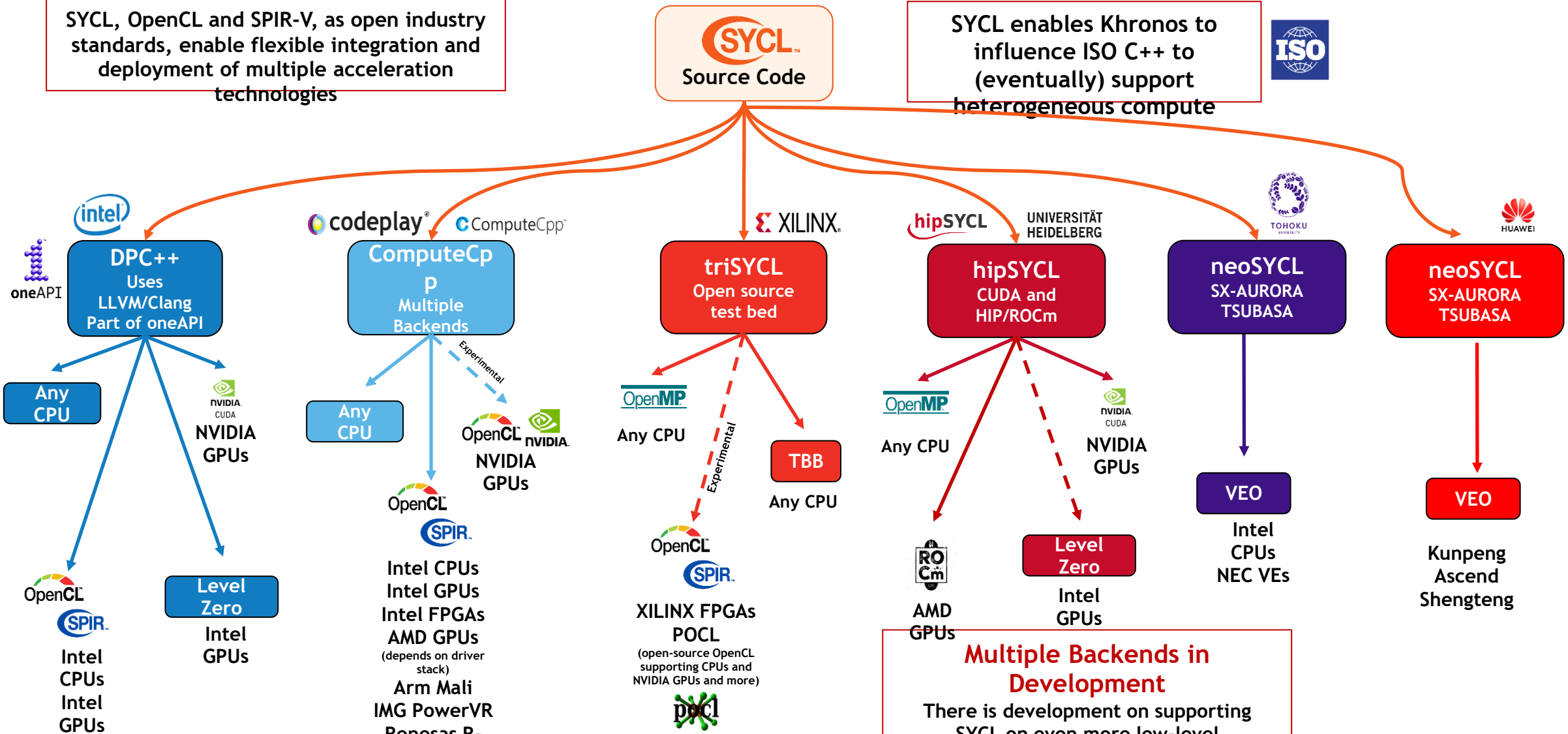
OpenCL 2.2

OpenCL 3.0

2011 **2015** **2017** **2020** **202X**

SYCL Implementations in Development

SYCL, OpenCL and SPIR-V, as open industry standards, enable flexible integration and deployment of multiple acceleration technologies



SYCL Ecosystem, Research and Benchmarks

Implementations

triSYCL

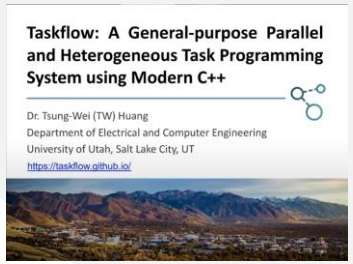
Celerity
High-level C++ for Accelerator Clusters

neoSYCL
SX-AURORA TSUBASA

ECP
EXASCALE COMPUTING PROJECT

kokkos

oneAPI



RAJA

ATLAS
EXPERIMENT

ComputeCpp

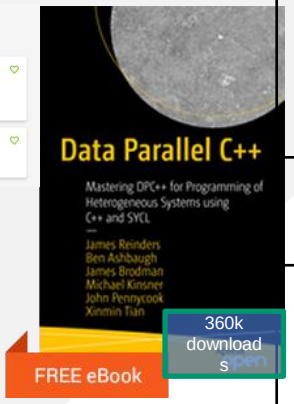
hipSYCL

GROMACS
FAST. FLEXIBLE. FREE.

alpaka

Benchmarks/Books

Direct Programming Benchmark



SYCL-Bench

Linear Algebra Libraries

Machine Learning Libraries and Parallel Acceleration Frameworks

BLAS	FFT	Math	RAND
SYCLBLAS oneMKL	oneMKL	oneMKL	oneMKL
SOLVER	**SPARSE**	**TENSOR**	**STL**
oneMKL	oneMKL	SYCL-DNN Eigen oneDNN TensorFlow	SYCL Parallel STL oneDPL

Working Group Members

STREAM HPC

Argonne NATIONAL LABORATORY

QUALCOMM

University of BRISTOL

arm

SYCL

codeplay

XILINX

universität innsbruck

AMD

intel

TOHOKU UNIVERSITY

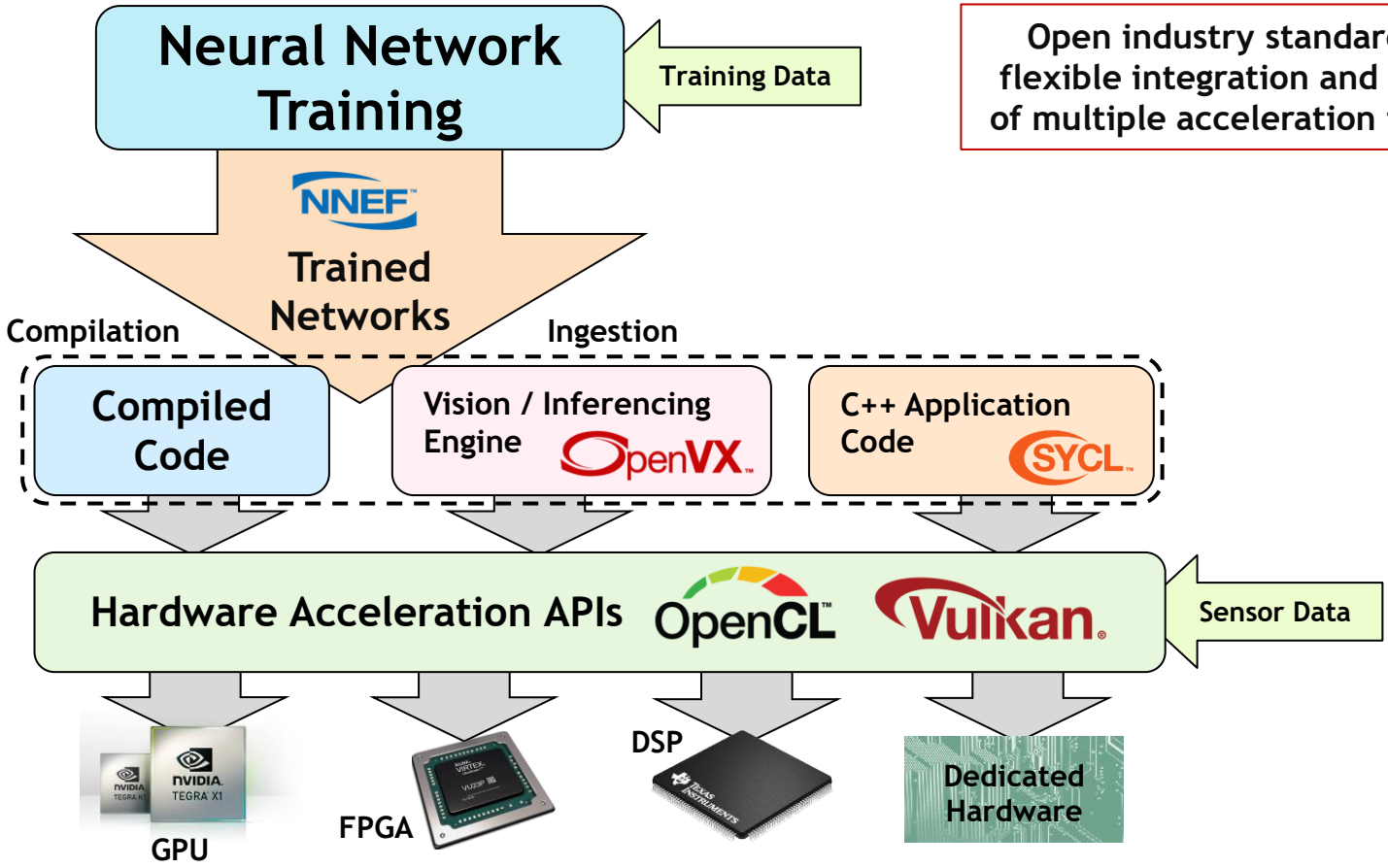
HIPPOCRATICA CIVITAS STUDIUM SALERNI

SYCL in Embedded Systems, Automotive, and AI

Networks trained on high-end desktop and cloud systems

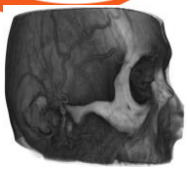
Applications link to compiled inferencing code or call vision/inferencing API

Diverse Embedded Hardware
Multi-core CPUs, GPUs
DSPs, FPGAs, Tensor Cores
* Vulkan only runs on GPUs



Open industry standards, enable flexible integration and deployment of multiple acceleration technologies

Safety Critical API Evolution



New Generation Safety Critical APIs for Graphics, Compute and Display

OpenCL and SYCL SC work will minimize API surface area , reduce ambiguity, UB, increase determinism

OpenCL

Rendering Compute Display

Industry Need
for GPU Acceleration APIs designed to ease system safety certification is increasing
ISO 26262 / ASIL-D

UNECE WP.29

ISO 26262

ISO/PAS 21448

UL 4600

MISRA

SAE INTERNATIONAL

ISO/IEC JTC 1/SC 42
Artificial intelligence

RISC-V

SCSC FOR EVERYONE WORKING IN SYSTEM SAFETY WWW.SCSC.UK

ISO International Organization for Standardization

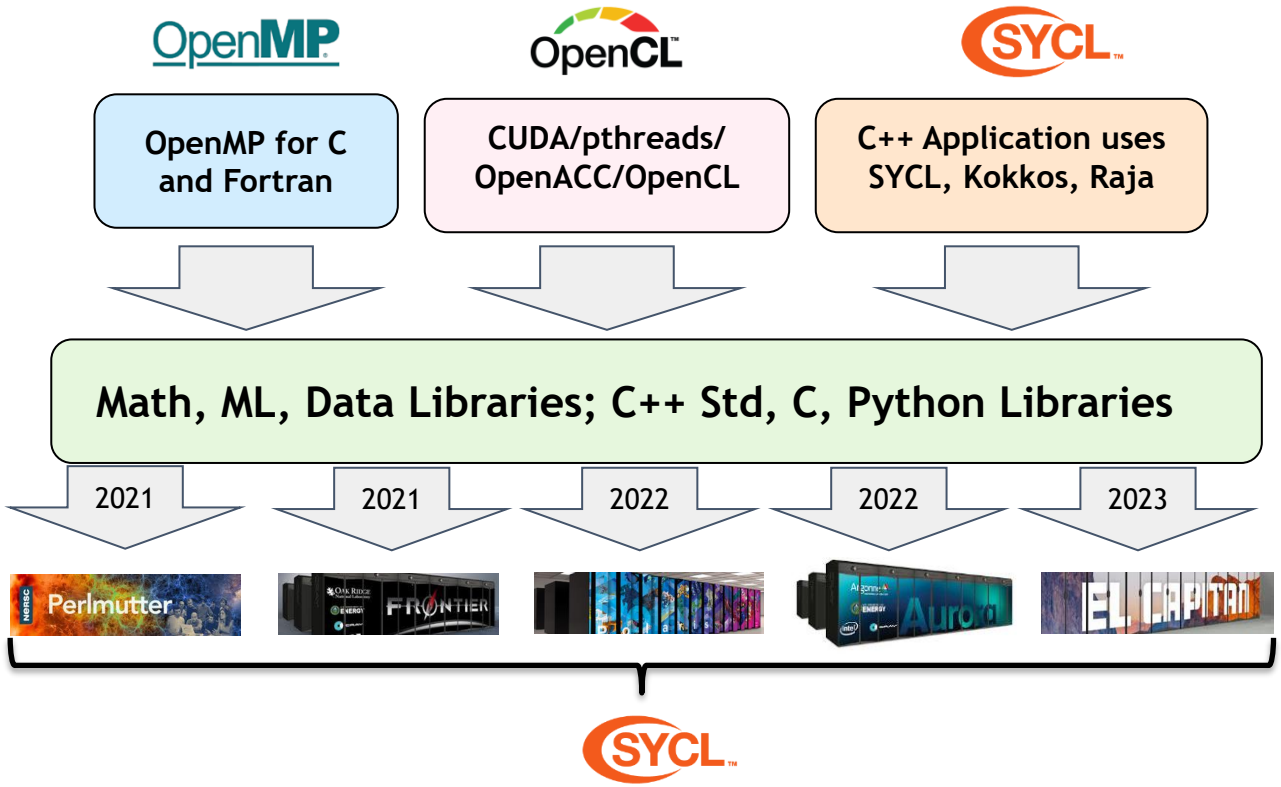
SYCL in HPC/Supercomputers

Simulation
HPC Languages
Solver Libraries, Parallel RT

Data
Productivity Languages
Big Data Stack, Stats Lib, Databases

Learning
Productivity Languages
Deep Learning, Linear Alg, ML

Three Pillars of Science Problem

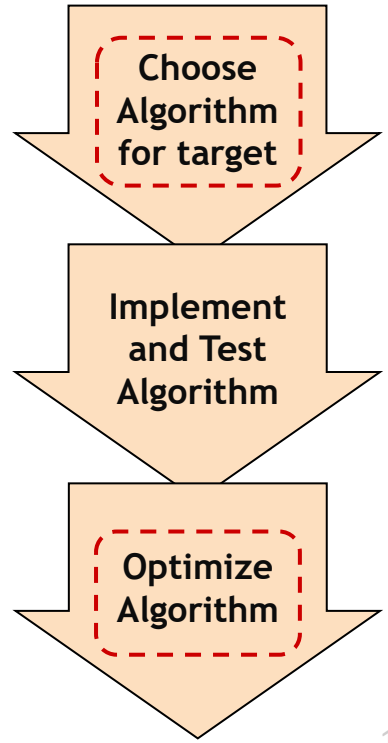


Need Languages that allow control of these Data Issues
Set Data affinity, Data Layout, Data movement, Data Locality, highly Parameterized Code and dynamically compose the algorithms (C++ templates, parallel STL, inlining and fusion, abstractions)

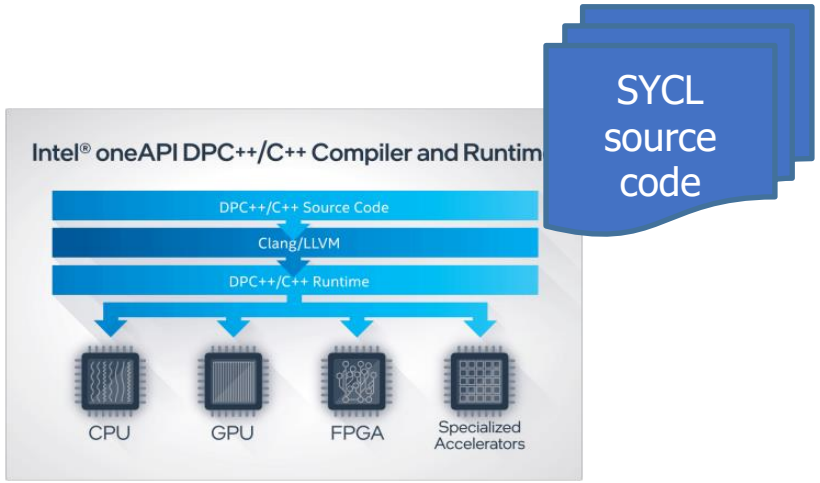
Libraries augment compiler optimizations for Performance Portable programs

Use open standards to run Performance Portable code on new generation, or different vendor's, hardware with compiler optimization, explicit parametrization and dynamically composed algorithm

Today's Supercomputing Development Workflow needs knowledge of system architecture and tools that control data



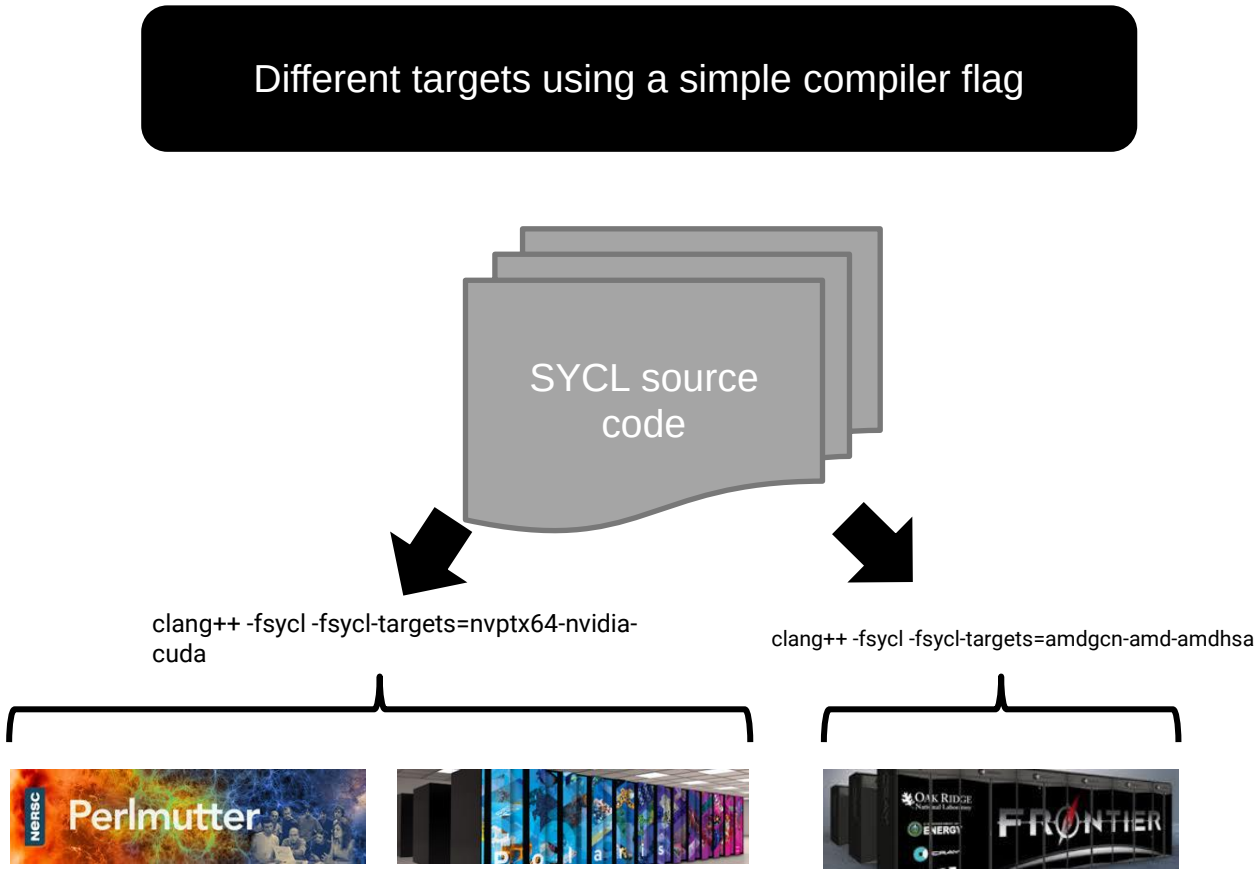
oneAPI and SYCL



- SYCL sits at the heart of oneAPI
- Provides an open standard interface for developers
- Defined by the industry

Nvidia and AMD Support in oneAPI

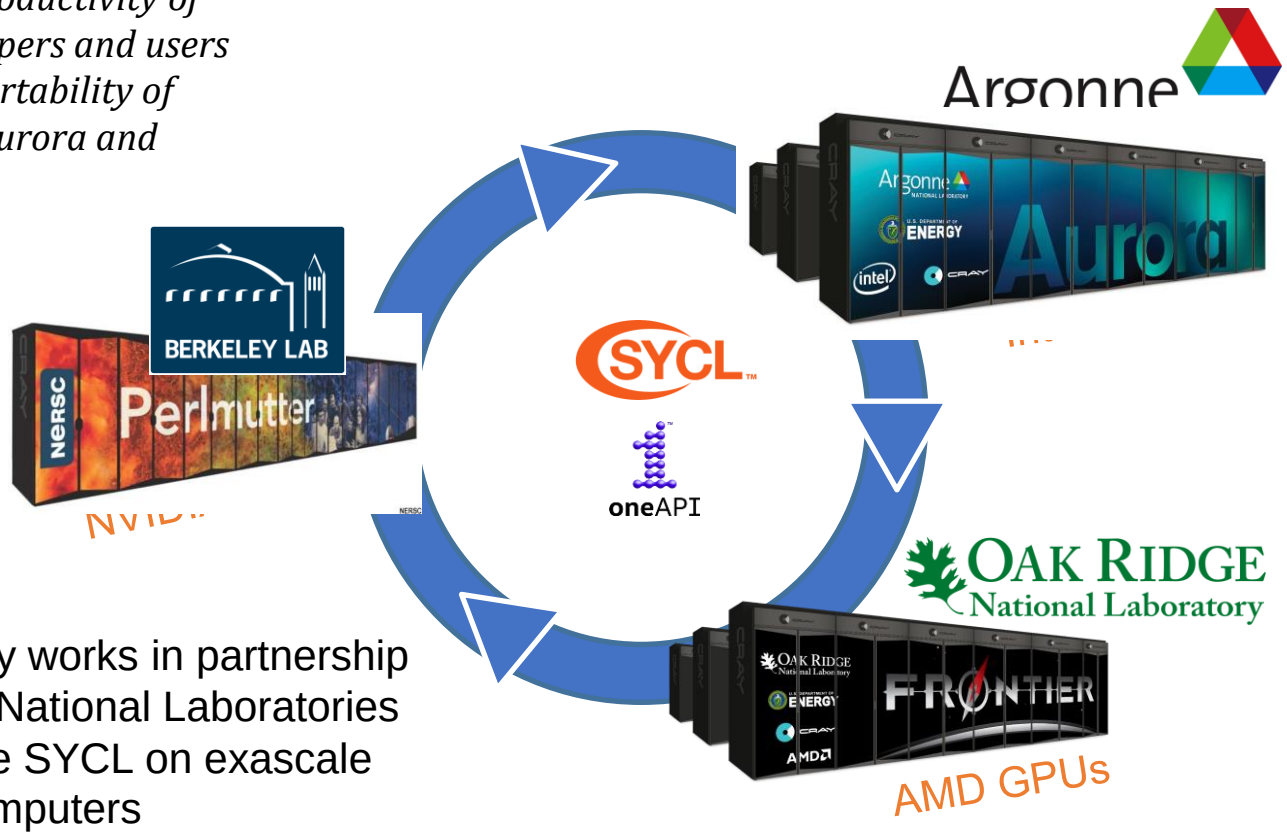
- Extending DPC++ to target Nvidia and AMD GPUs
- Supporting Perlmutter, Polaris and Frontier supercomputers
- Open source and available to everyone



https://www.codeplay.com/oneapiforcuda
Resources for AMD coming soon

SYCL Enables Supercomputers

"this work supports the productivity of scientific application developers and users through performance portability of applications between Aurora and Perlmutter."



Codeplay works in partnership with US National Laboratories to enable SYCL on exascale supercomputers

Enables a broad range of software frameworks and applications

SYCL Future Evolution

SYCL 2020 compared with SYCL 1.2.1

- Easier to integrate with C++17 (CTAD, Deduction Guides...)
- Less verbose, smaller code size, simplify patterns
- Backend independent
- Multiple object archives aka modules simplify interoperability
- Ease porting C++ applications to SYCL
- Enable capabilities to improve programmability
- Backwards compatible but minor API break based on user feedback

SYCL Future Roadmap (MAY CHANGE)

SYCL 2020

Over 40 Selected Features for SYCL 2020

Unified Shared Memory)
Parallel Reductions adds a built in reduction operation
Work-group and sub-group algorithms
Improvements to atomic operations
Class template argument deduction (CTAD) and deduction guides
Simplification of accessors
Expanded interoperability with different backends
Extension mechanism
Address spaces
Vector rework
Specialization Constants
...

Improving Software Ecosystem

Books, Tutorials, Tool, libraries, GitHub

Expanding Implementations

DPC++
ComputeCpp
triSYCL
hipSYCL
neoSYCL

Regular Maintenance Updates

Spec clarifications, formatting and bug fixes
https://www.khronos.org/registry/SYCL/

Repeat The Cycle every 1.5-3 years

NEXT

Conformance Tests

Working on Implementations

Future SYCL NEXT Proposals

...

Integration of successful Extensions plus new Core functionality

Converge SYCL with ISO C++ and continue to support OpenCL to deploy on more devices

CPU
GPU
FPGA
AI processors
Custom Processors

SYCL 2020 is here!

Open Standard for Single Source C++ Parallel Heterogeneous Programming

SYCL 2020 is released after 3 years of intense work
Significant adoption in Embedded, Desktop and HPC markets
Improved programmability, smaller code size, faster performance
Based on C++17, backwards compatible with SYCL 1.2.1
Simplify porting of standard C++ applications to SYCL
Closer alignment and integration with ISO C++
Multiple Backend acceleration and API independent

SYCL 2020 increases expressiveness and simplicity
for modern C++ heterogeneous programming

Enabling Industry Engagement

- SYCL working group values industry feedback
  - https://community.khronos.org/c/sycl
  - https://sycl.tech
- SYCL FAQ
  - https://www.khronos.org/blog/sycl-2020-what-do-you-need-to-know
- What features would you like in future SYCL versions?

- **Advisory Panel Chaired by Tom Deakin of U of Bristol**
- **Quarterly SYCL Advisory Panel**
- **Regular meetings to give feedback on roadmap and draft specifications**

Public contributions to Specification, Conformance Tests and software
https://github.com/KhronosGroup/SYCL-CTS
https://github.com/KhronosGroup/SYCL-Docs
https://github.com/KhronosGroup/SYCL-Shared
https://github.com/KhronosGroup/SYCL-Registry
https://github.com/KhronosGroup/SyclParallelSTL
https://github.com/intel/llvm

Invited Experts
https://www.khronos.org/advisors/

Khronos members
https://www.khronos.org/members/
https://www.khronos.org/registry/SYCL/

Open to all!
https://community.khronos.org/www.khr.io/slack
https://app.slack.com/client/TDMDFS87M/CE9UX4CHG
https://community.khronos.org/c/sycl/
https://stackoverflow.com/questions/tagged/sycl
https://www.reddit.com/r/sycl
https://github.com/codeplaysoftware/syclacademy
https://sycl.tech/