Round 2:
Standard parallelism.

Can we ?

What this presentation is or is not ?

Outline

`std::simd`

Abstraction for vectorization

Parallel Algorithms

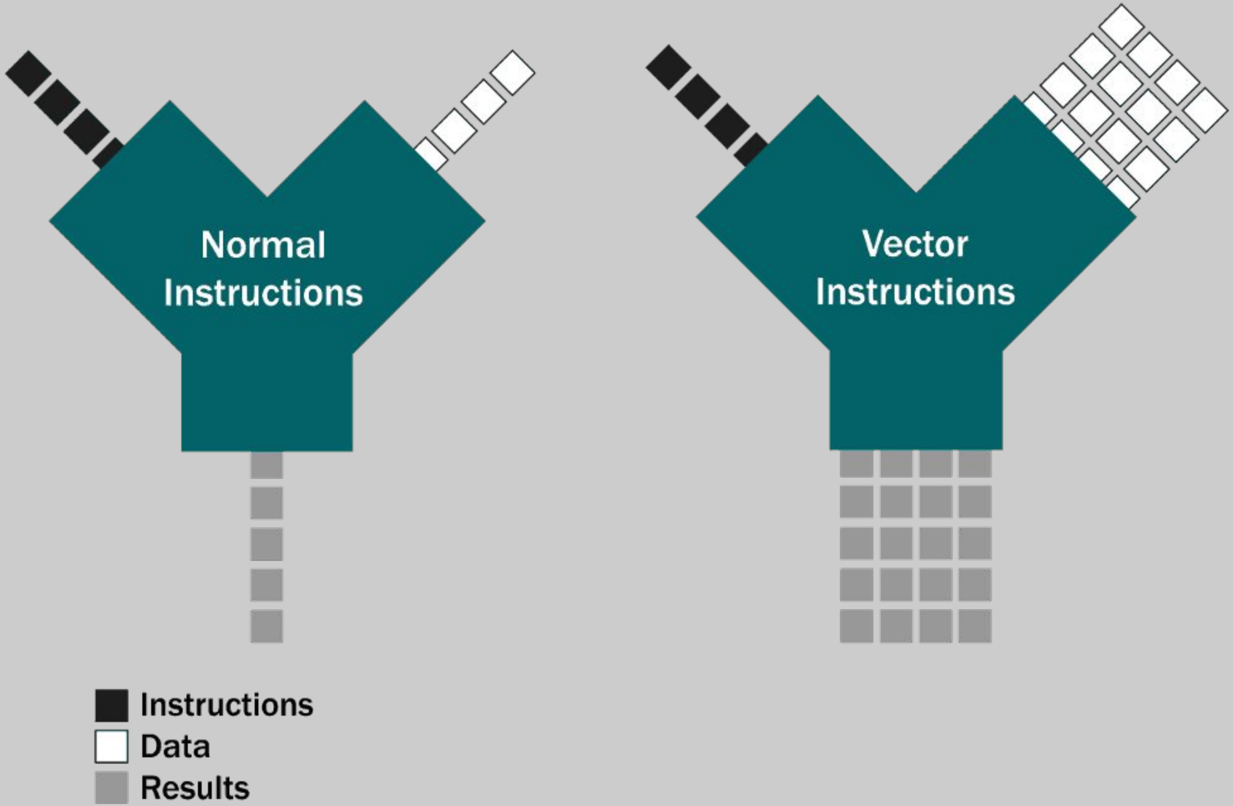
First step towards standard support for parallelism

`std::execution`

Going further with design opportunities

SIMD abstractions

Quick Reminder



`std::simd` in C++26... maybe...

Why ?

Performance !

But how ?

By hand, with intrinsics... maybe no.

Let the compiler do it ! Ok but... maybe no.

First step

So, can I write SIMD code like scalar code ?

```
[…]
const __m256 a = _mm256_loadu_ps( p1 );
const __m256 b = _mm256_loadu_ps( p2 );
__m256 res = _mm256_add_ps( a, b);
[…]
```

`std::simd` in C++26… maybe…

Developers libraries

- Yes, we can ease this process with third party libraries.
- There is history here.
- Eve (boost.simd), xsimd, etc…

Should the standard jump in the train ?

- Yes it has, some work has been done in the Parallelism TS v2

Now targeting C++26

`std::simd` in C++26… maybe…

A data parallel type, defined as a class template of type **`T`**.

- Width of a given simd instantiation is a constant expression, determined by the template parameters.
  - **`std::simd<T>`**
    - Arithmetic operators, comparisons, masking abilities, ABI compatibility concerns, small amount of simd aware algorithms …

Intrinsics wrappers or more?

- Will **`std::simd`** be on par with developer libraries ?
- Is this a problem if …

We can go further with this ?

- Parallel execution policies and constrained algorithms.

Parallel algorithms

Standard algorithms

Works sequentially on iterators.

```
std::transform( std::begin(my_container), std::end(my_container)
              , [](auto e){ return std::cos(e); })
```

Great, standard sequential code…

But can I have a free parallel version of my code ?

Standard parallel algorithms

Yes, since C++17 and parallel policies.

```
std::transform( std::execution::par
                , std::begin(my_container), std::end(my_container)
                , [](auto e){ return std::cos(e); })
```

Different execution policies available

`std::execution::seq` -> *op in the calling thread, indeterminately sequenced*

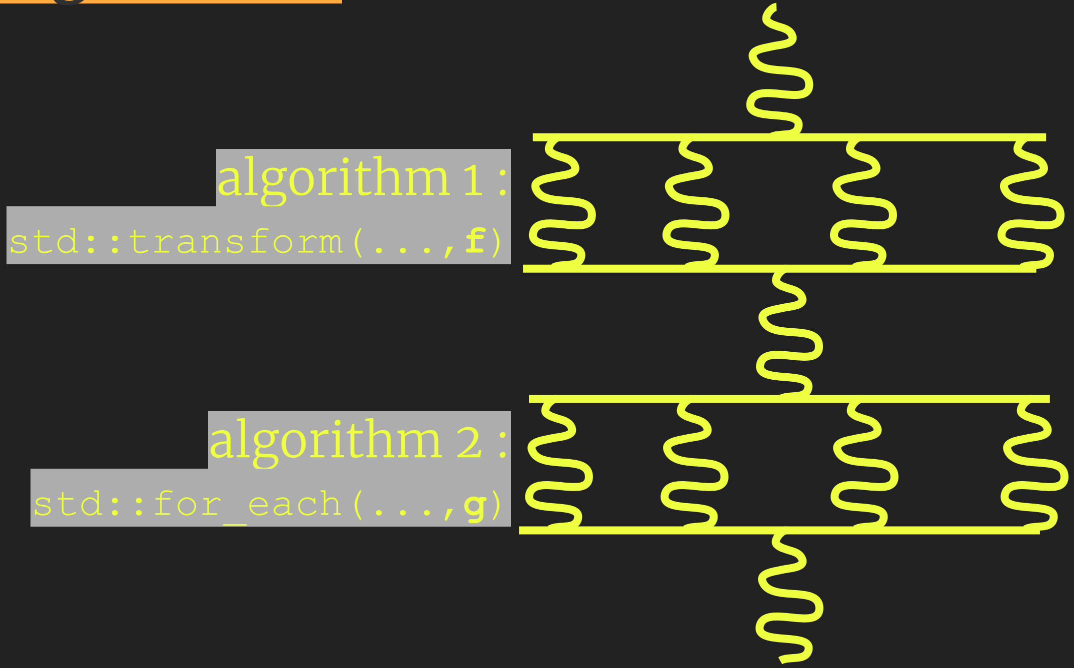
`std::execution::unseq` -> *op in the calling thread, unsequenced*

`std::execution::par` -> *potentially in multiple threads, indeterminately sequenced within each threads*

`std::execution::par_unseq` -> *potentially in multiple threads, unsequenced*

Standard parallel algorithms

Fork and join.



algorithm 1 :
`std::transform(...,`**`f`**`)`

algorithm 2 :
`std::for_each(...,`**`g`**`)`

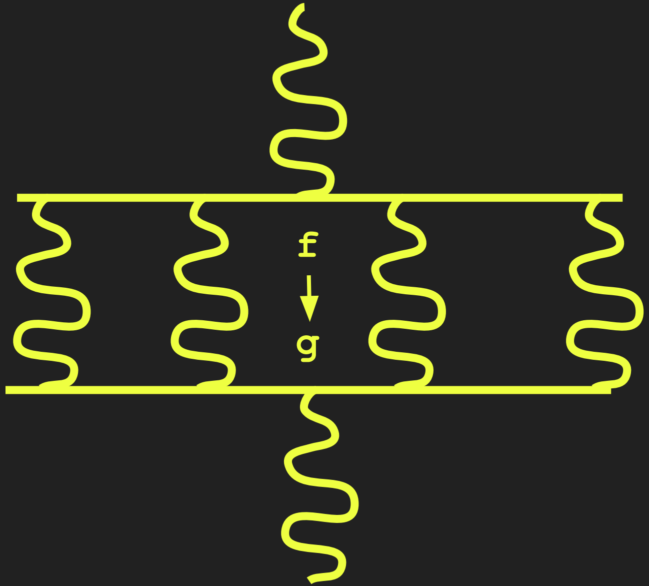
Pretty cool but,

what about merging two steps ?

Standard parallel algorithms

Yes, we can go further with the laziness of range adaptors from C++20.

```
std::vector x{...};
auto v = std::views::transform(x, f);
std::for_each(std::begin(v), std::end(v), g);
```



Standard parallel algorithms

Now, what are we missing?

- Unlock the fork and join model
- Get rid of possible latencies
- Say where things should execute

So, what do we need?

- A model for asynchrony
- A way to attach work to a computing resource

`std::execution` : Senders and Receivers

`std::execution` : Senders and Receivers

The standard answers the previous concerns with :

Senders and Receivers

Targeting C++26

Reference implementation available from NVIDIA.

`std::execution` : Senders and Receivers

```cpp
namespace ex = std::execution;
// retrieve a scheduler
ex::scheduler auto sch = thread_pool.scheduler();
// start chain of work
ex::sender auto begin = ex::schedule(sch);
// compose work on top of the first sender,
// return a new sender that will complete on the same execution context
ex::sender auto hi = ex::then(begin, [](){ return 13; });
// adding more work here
ex::sender auto add = ex::then(hi, [](int a){ return a + 42; });
// we finally wait for completion
auto [res] = std::this_thread::sync_wait(add).value();
```

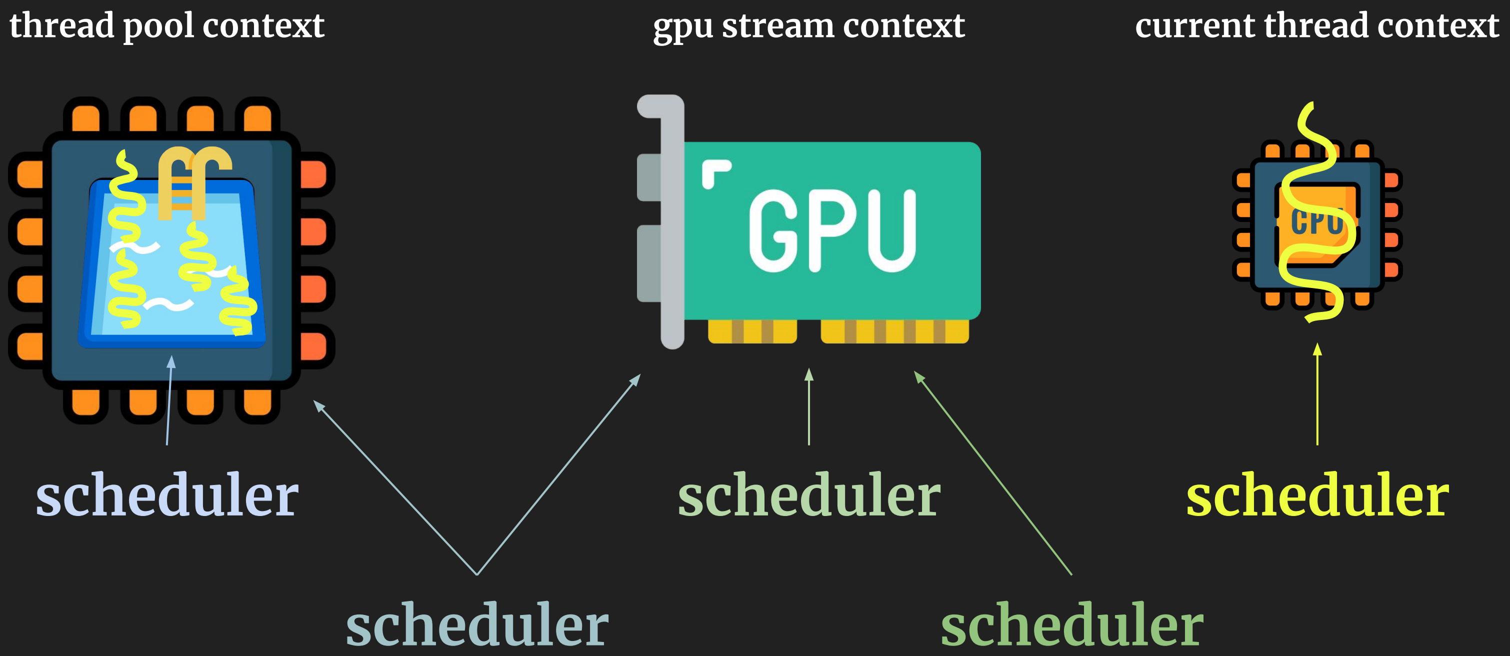
`std::execution` : Senders and Receivers

Schedulers are handles to execution contexts

Senders represent asynchronous work

Receivers process asynchronous signals

`std::execution` : Senders and Receivers



thread pool context

gpu stream context

current thread context

scheduler

scheduler

scheduler

scheduler

scheduler

`std::execution` : Senders and Receivers

Schedulers **produce** *senders*

that will produce work

on the *execution contexts* **attach to the** *schedulers***.**

Once we have a *sender***, we can compose work on it.**

`std::execution` : Senders and Receivers

We get senders with sender factories.

`schedule(), just(), transfer_just()...`

We compose work on senders with sender adaptors.

`then(), bulk(), on(), transfer(), split(), when_all(), ensure_started()...`

We start work by connecting sender graphs with sender consumers.

`sync_wait(), start_detached(), execute()`

`std::execution` : Senders and Receivers

Senders and Receivers are compatible with C++20 `std::coroutines`

Coroutines are stackless functions that can suspend execution to be resumed later.

Distributed memory support ?

It should, but not in a transparent way. (*Extensions ? Runtime support under the hood ?* *)

Error handling support

By design.

User facing design / Implementer facing design

Implementer side is open for adding support and extensions.(*)

Remember ? I never talked about receivers... :)

Let's wrap it up !

Quick reminder : `std::span` (20), `std::mdspan` (23), `std::blas` (26)

Parallel algorithms available since **c++17**.

Targeting c++26

`std::execution` :

- reference implementation available, NVIDIA
- designed to be composable and extended

`std::simd`

- work available in Parallelism TS v2 (gcc11, clang *in progress*)

Let’s wrap it up !

Concerns about :

- Is the scope of these works covering our needs ?
- If not, the c++ community may have already starts some works on the side of the standard. Round 3?
- What are your concerns/ideas ? Round 3 !

Going further : standard c++ ecosystem starts to be powerful right !?
Let’s see if we can make it even more…

To be continued...

...in round 3.

Any thoughts or questions ?