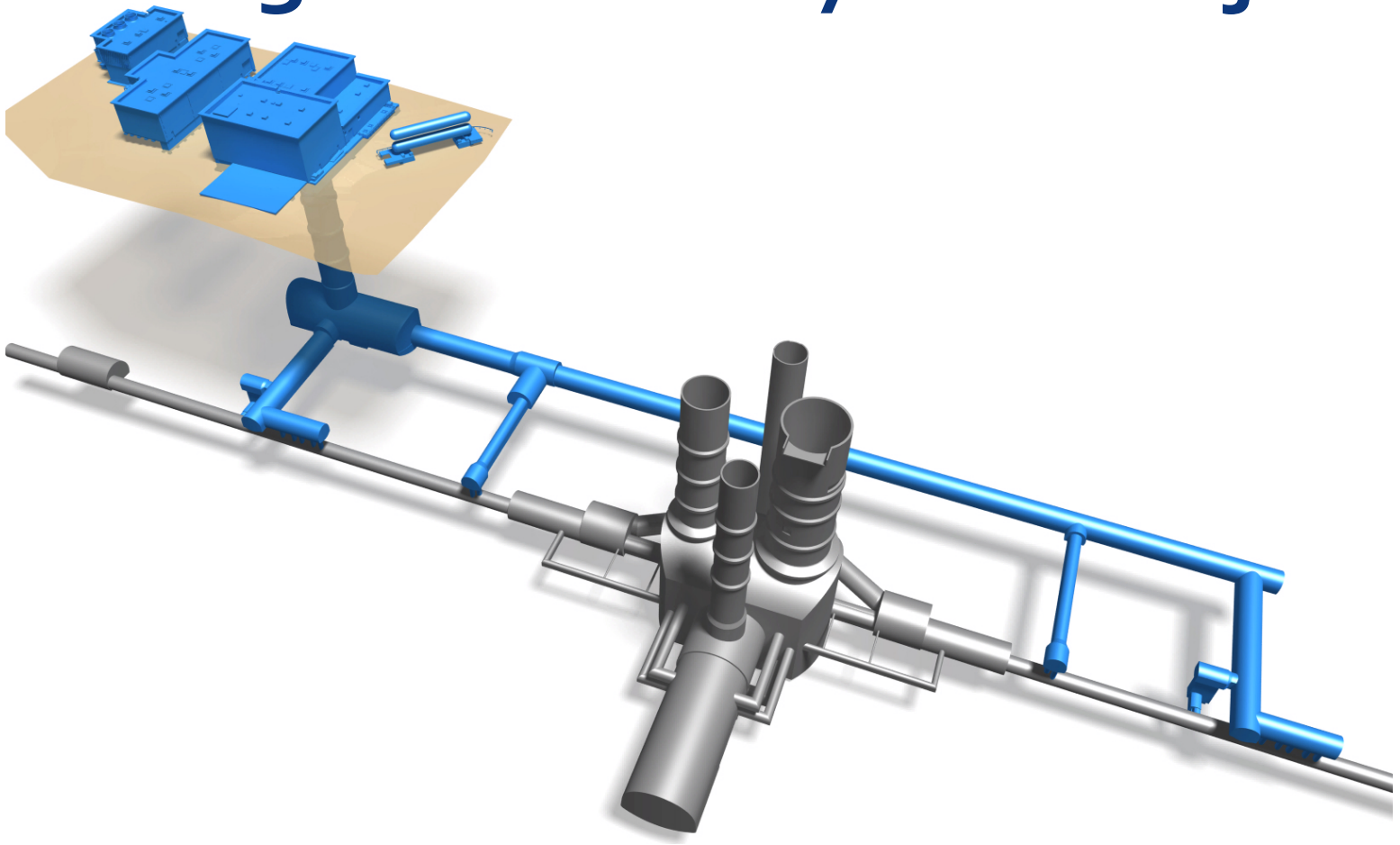
CERN - CO_2 primary cooling project for Inner Detector cooling of ATLAS and CMS Experiments

Michele Battistin – on behalf of the Primary CO_2 Project team

6/2/2020

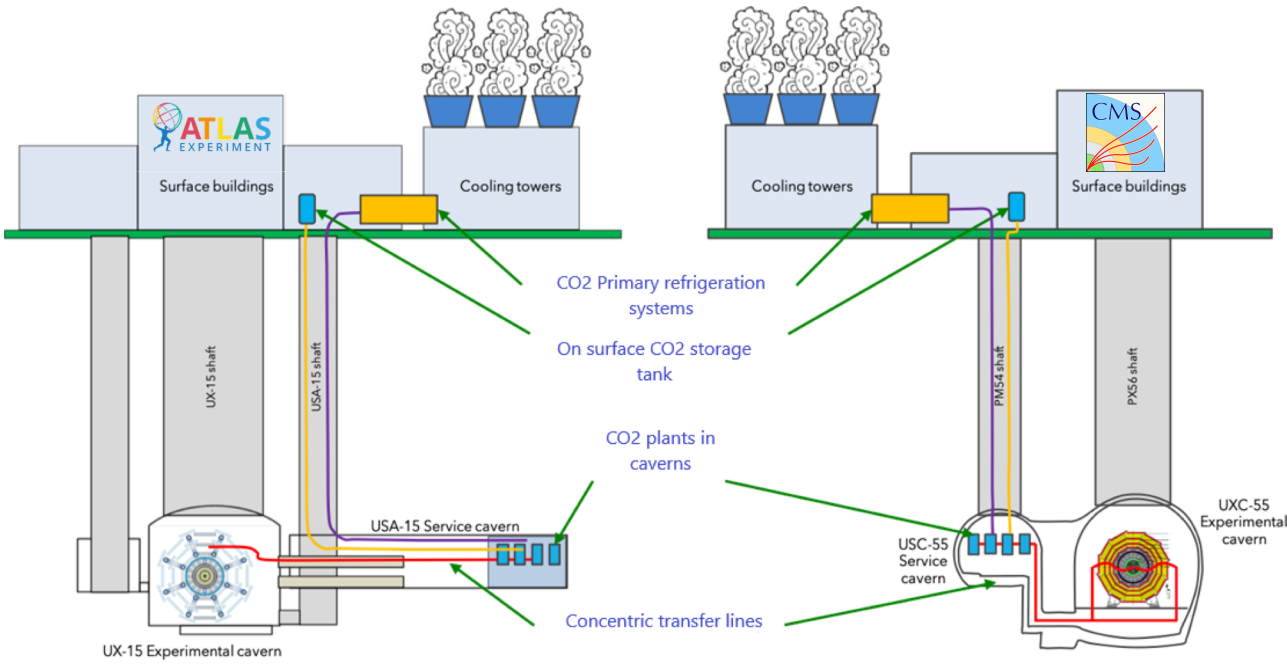
High Luminosity LHC Project



CERN project for CO_2 cooling

- **New Silicon Inner Detector** of the two largest CERN Experiments (ATLAS and CMS) will be installed in 2025: the new detectors will require higher cooling power (hundreds of kW) and lower controlled negative temperature;
- A new concept of **two stage transcritical CO_2** refrigeration system is R&D phase at CERN in collaboration with **NTNU** (Norwegian Institute of Technology – Trondheim);
- First **prototype** under construction (50 kW; -53°C);
- Four **future** systems to be realised in industry (50 kW; 50 kW; 300 kW; 600 kW @ -53°C): **Invitation to Tender** process in **2020.**

Aim of the project CO2 primary

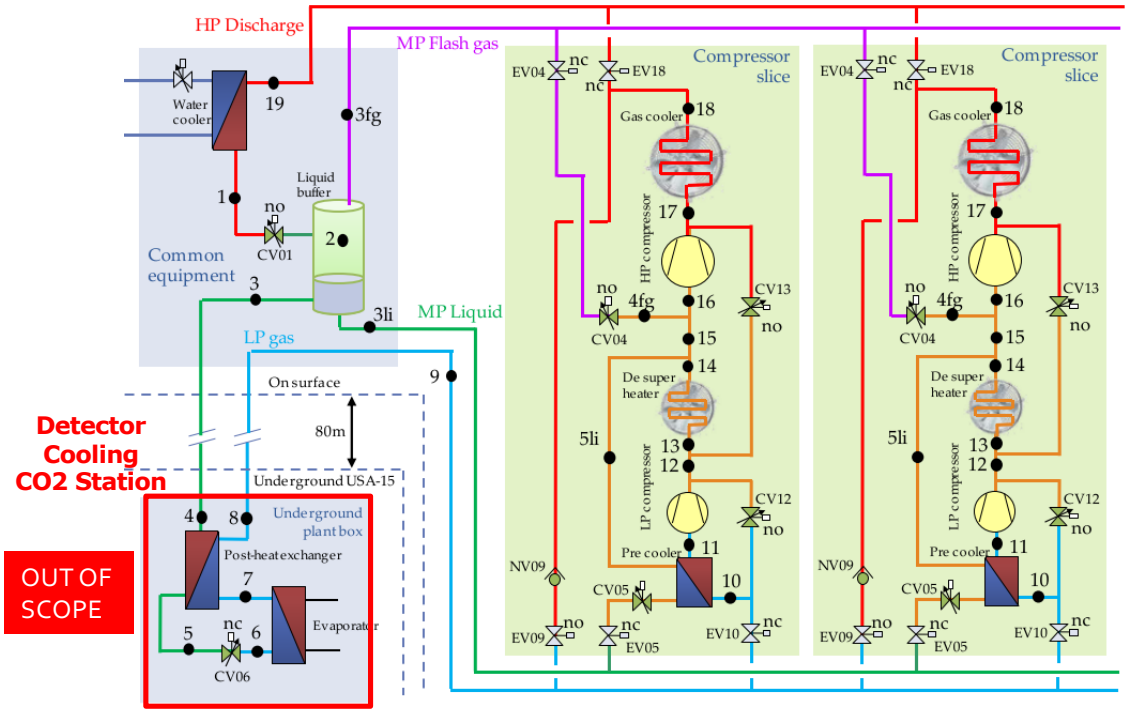


- A primary CO2 lubricated loop (yellow lines)
- A secondary CO2 oil free distribution loop (red lines)

Requirements:

- CO2 Refrigerant fluid (R744).
- Supply liquid CO2 below -45°C to detectors ➔ Evaporation temperature **@-53°C** in cavern at the CO2 plants.
- Cooling needs
  1. ATLAS **300 kW**
  2. CMS **600 kW**
- Supply of CO2 in cavern @ ambient temperature to **avoid insulation** of pipes.
- 24/364 Operation
- Reduced **Oil** carry over in cavern.

Concept and number of systems



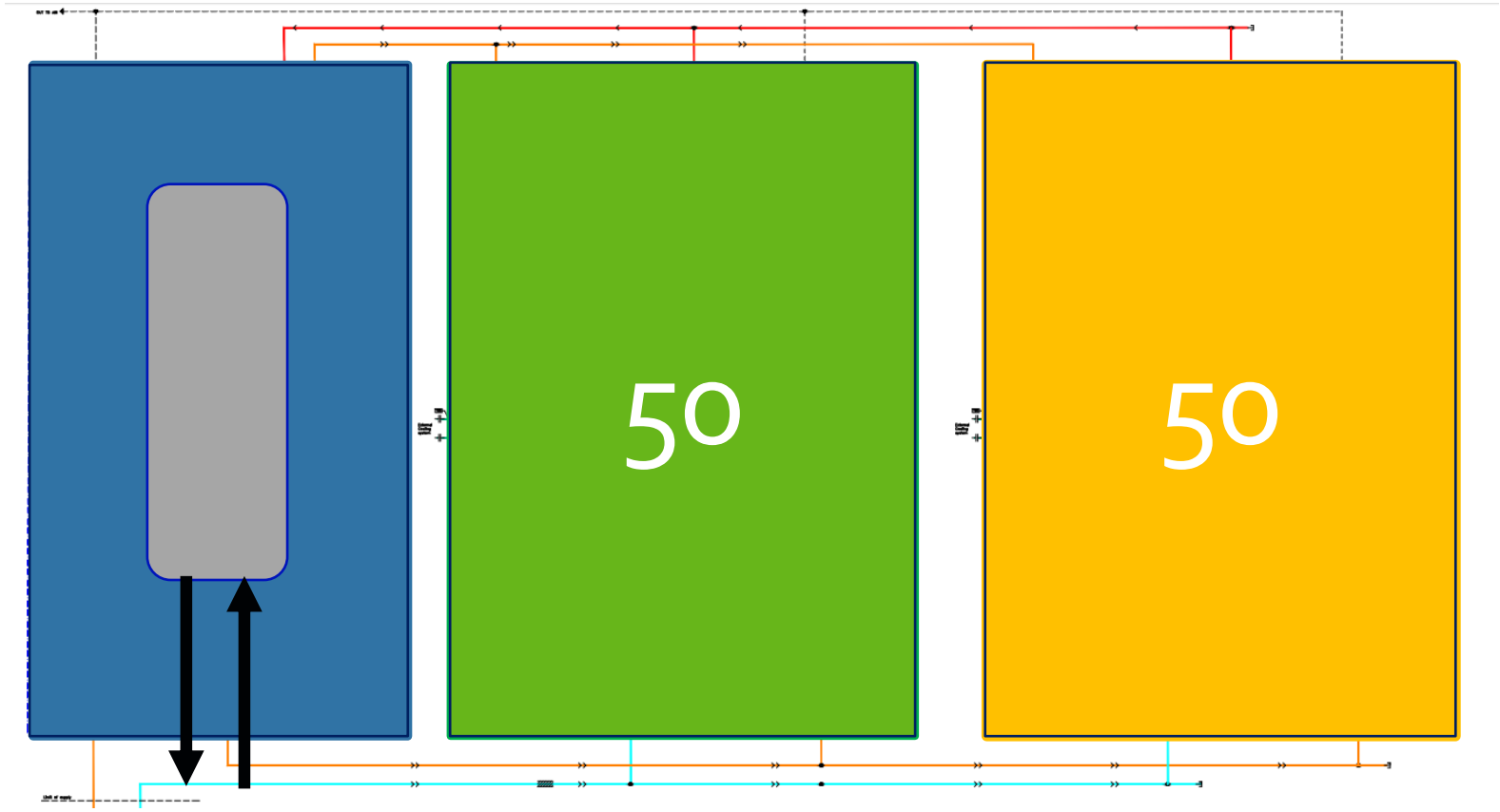
Simplified schematic of the first prototype unit of 100 kW cooling capacity.

Technical Solution:

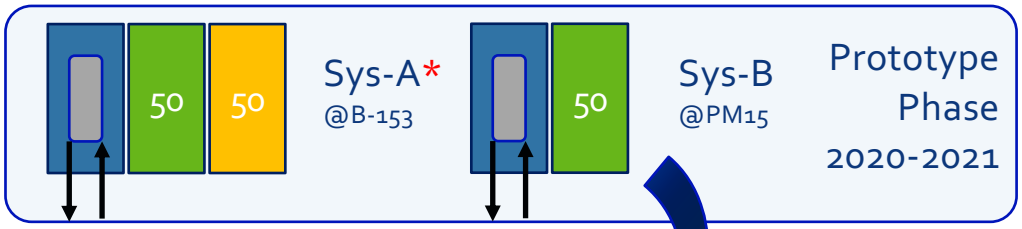
- Two stages CO2 **transcritical** compression circuit.
- Semi-hermetic reciprocating compressors.
- **Modular** approach based on :
  1. One common equipment slice
  2. Compressors slices with cooling capacity **between 50 to 75 kW**
- On each compressor slice only one compressor by stage (two compressors per slice).

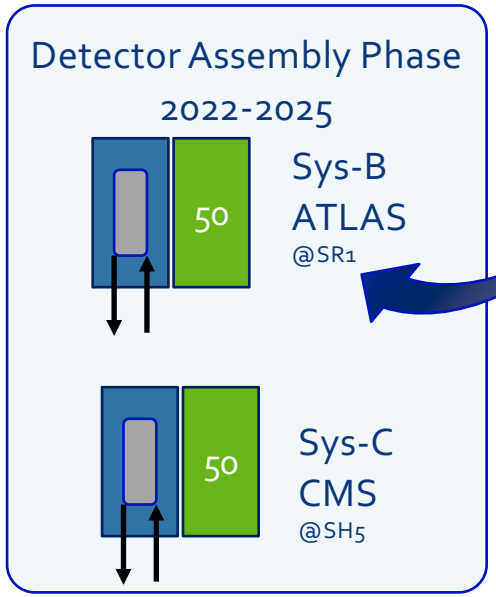
Secure operation and give possibility of hidden maintenance

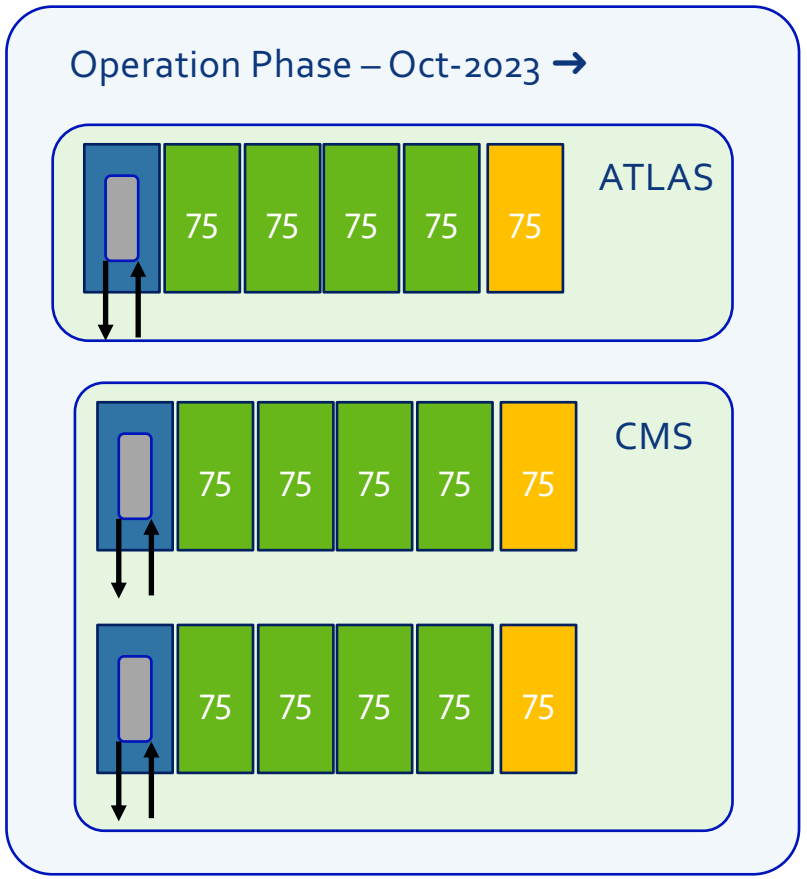
Detailed P&ID of System-A (under construction)



Modularity & units







* Under construction now

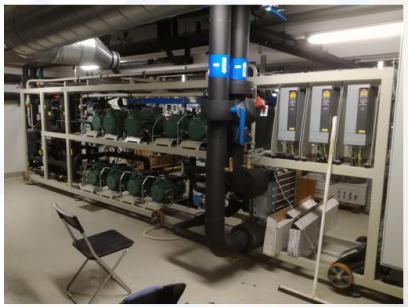
Example of similar system in NTNU

R744 (CO_2) primary prototyping

- All future primary projects have been placed in the same development program.
  - Primary for the DEMO 2PACL plant (System A)
    - 2x 50kW slices
    - Testing capacity control and swapping philosophy
    - Testing cold operation <-53'C
    - Possible to go sub-triple to compensate pressure drop losses
  - Vertical flow test set-up (System B)
    - One 50kW slice system
    - Using existing mini thermosiphon pipes (1" & 2") installed in the ATLAS shaft
    - Plant on surface, dummy load in USA15
    - System B will become primary for SR1 cooling
    - Dummy load initially used for system A commisioning
  - System for CMS surface testing (System C)
    - SR1 equivalent
- The 3 projects acts as prototypes to prepare for a smooth final system integration
- Tests in an existing set-up at NTNU showed the cold temperature feasibility
  - <-50'C R744 systems are being developed for the fishing industry.

-52.2'C in a quick test

R744 test system in NTNU-Trondheim



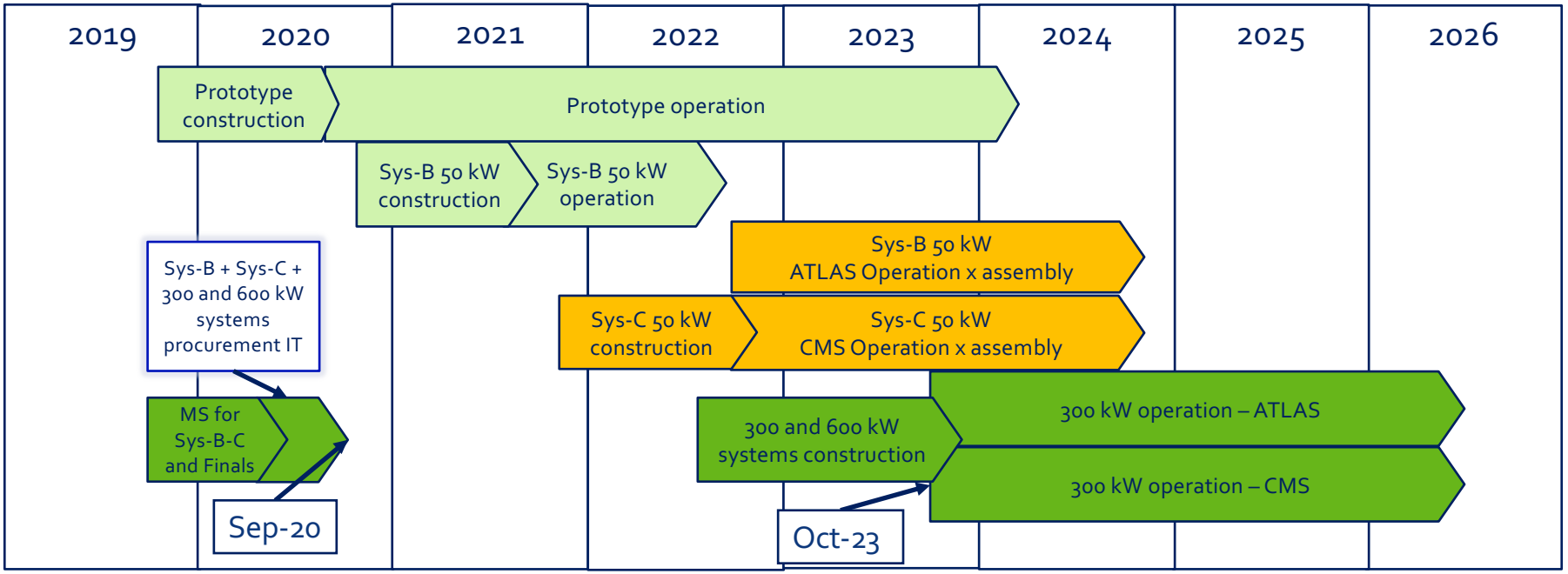
R744 refrigeration, a reborn technology

We use the term R744 for the primary, which is the refrigerant code for CO2, to distinguish both systems

18

Curtesy: Armin Hafner - NTNU

GENERAL SCHEDULE



Market Survey phase is opening: documents available on March 2020

CERN is looking for **competent companies** in this field.

Thank you for your attention

Any Question?

Credits: Anders Andersen, Stefanie Blust, Jerome Daguin, Martin Doubek, Dina Giakoumi, Armin Hafner, **Pierre Hanf**, Pierre Mondon, Angel Pardinas, Paolo Petagna, Hans Postema, **Bart Verlaat**.

Michele Battistin

CERN – EN/CV/PJ & CFD

CH-1211 Geneva 23

Tel +41.22.767.80.87

Mob +41.75.411.42.51

Michele.Battistin@cern.ch