

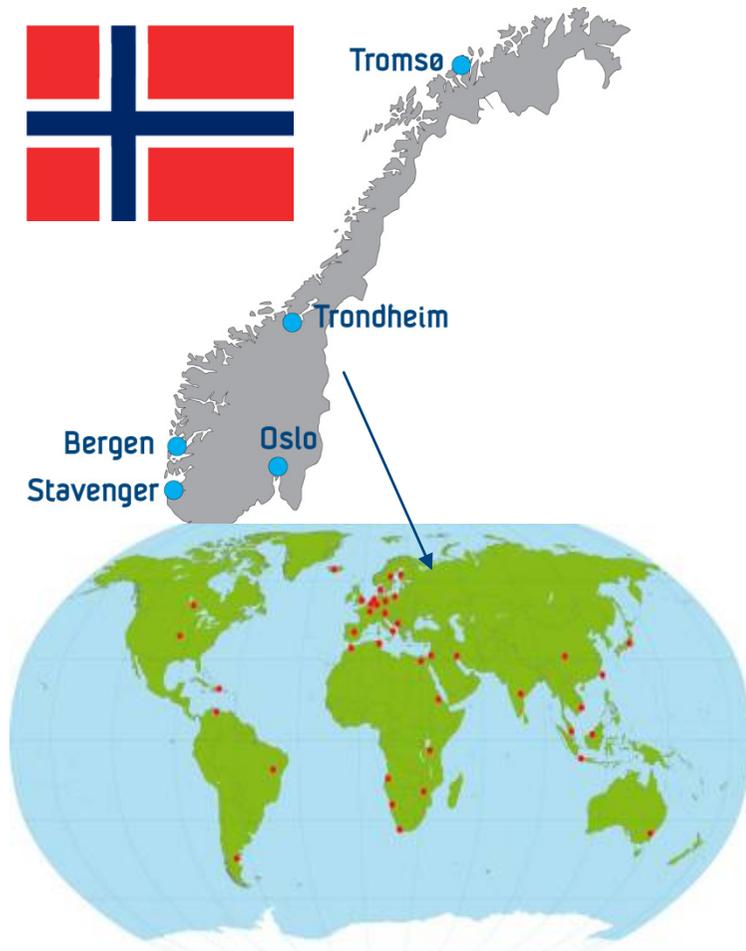
Commercial Refrigeration Applications

# Italian supermarkets: R744 multi-ejector enhanced parallel compression system

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# SINTEF - A contract research organization based in Trondheim, Oslo, Bergen, Stavanger and Tromsø

- SINTEF is one of the largest independent research organisations in Europe.



## Social perspective

SINTEF wishes to contribute to the creation of value and to a society in healthy sustainable development.

## Business concept

SINTEF sell research-based knowledge and related services to Norwegian and international clients.

## Fundamental values

Honesty, Generosity, Courage and Unity

SINTEF has 2145 employees, 1600 situated in Trondheim and 430 in Oslo.



## MULTIJET (2013-2017)

Application of an innovative expansion work recovery system with multiple ejectors for energy performance improvement in the R744 refrigeration installations for supermarkets

### Direct Objectives

- Test campaigns for **two supermarkets** (Trondheim and in Italy)

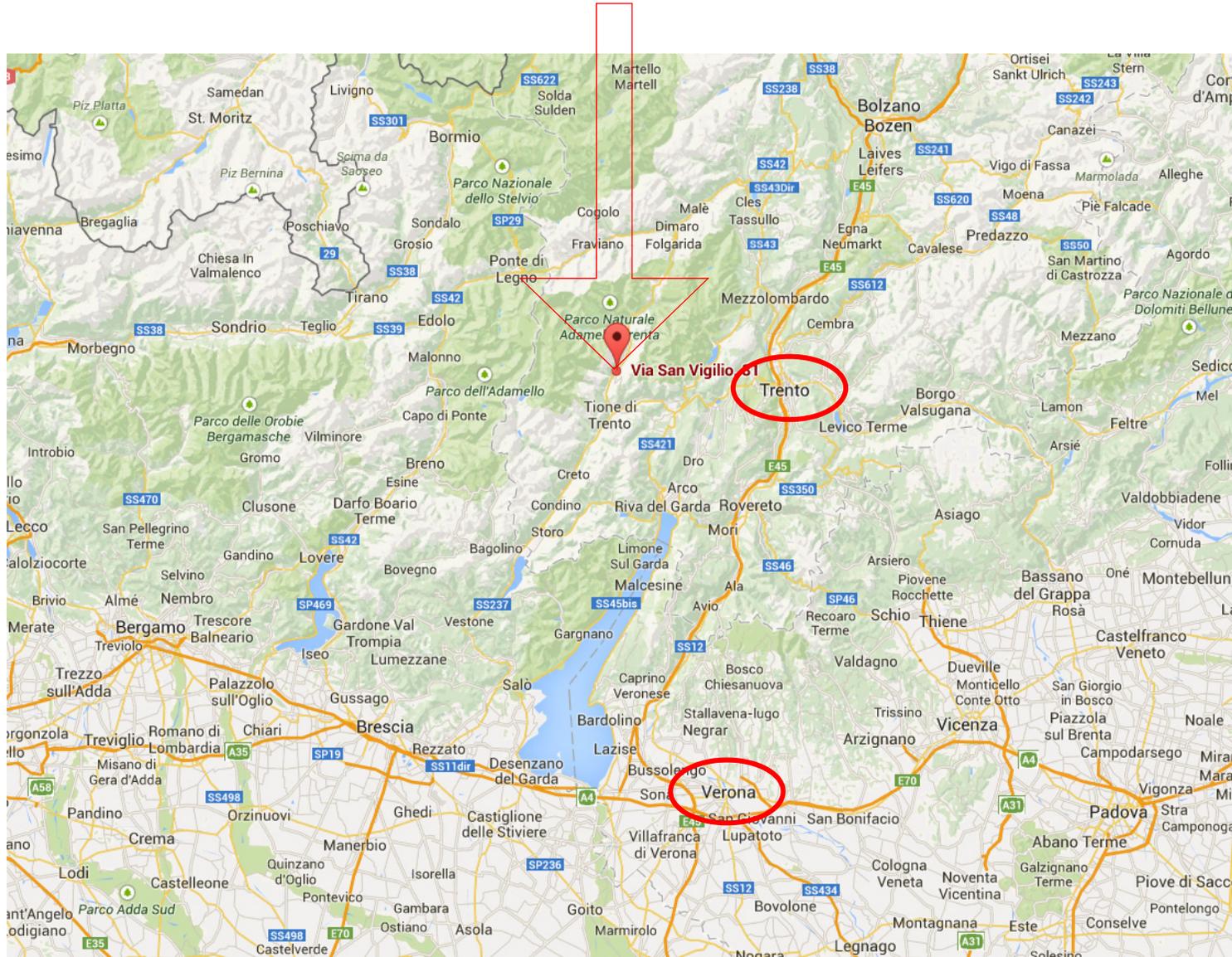
### Long-term aspects

- Making the ejector-equipped CO<sub>2</sub> refrigeration systems thermodynamically, operationally, and economically competitive with the HFC systems over the whole range of operating conditions (high  $t_{amb}$ ).

## Multijet – pilot supermarket SPIAZZO (TN), ITALY



# Near Trento / Verona



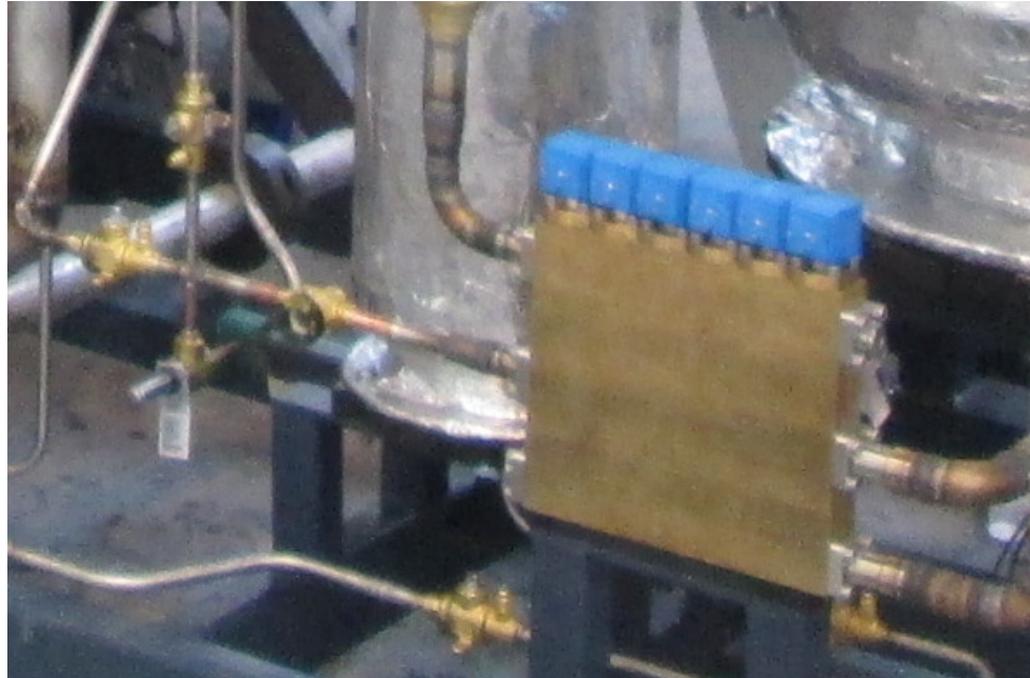
# Multi-Ejector Rack



*Photo: Enex srl [www.enex.it](http://www.enex.it)*

# Multi-Ejector block

- Compact design,  
made in cooperation  
with Danfoss
- Six fixed geometry nozzles
- 6-100 kW cooling capacity



*Photo: Enex srl [www.enex.it](http://www.enex.it)*



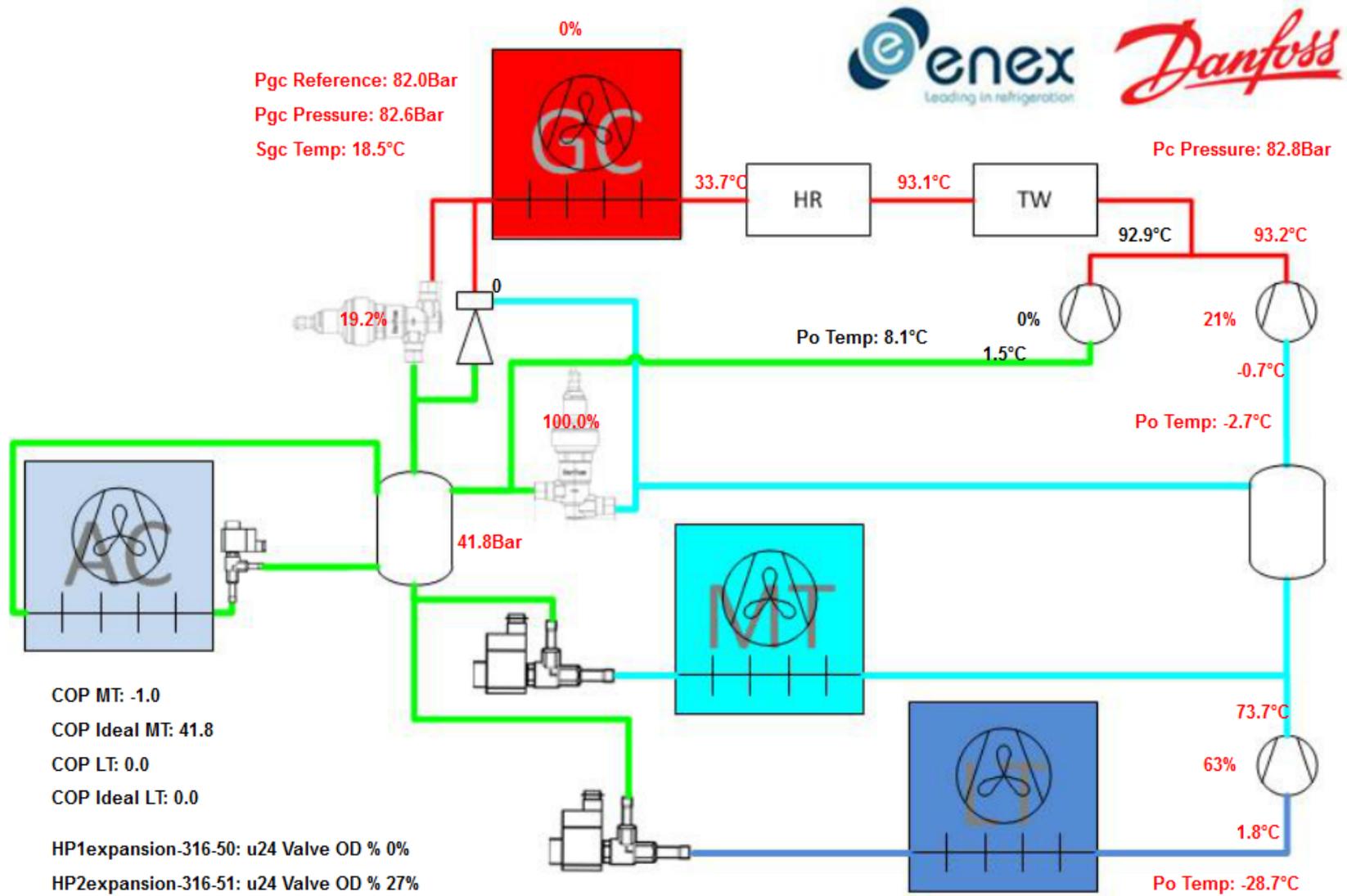
6+12+6+12+25+50

# System configuration (Simplified)

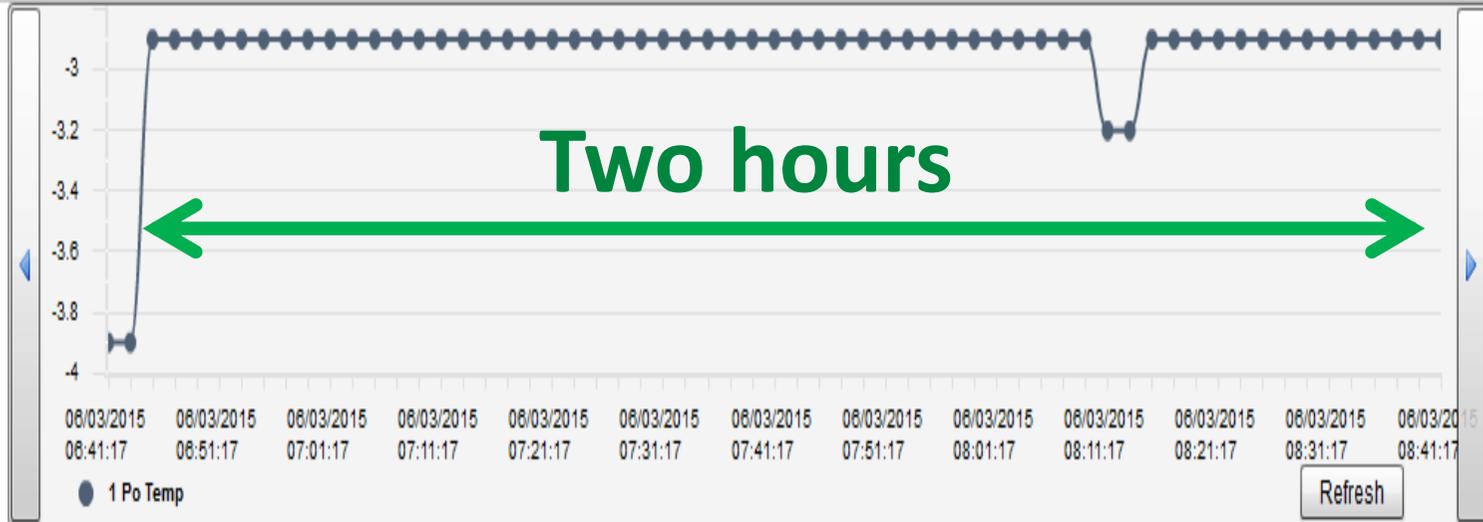
1 2

Refrigeration Plant

F



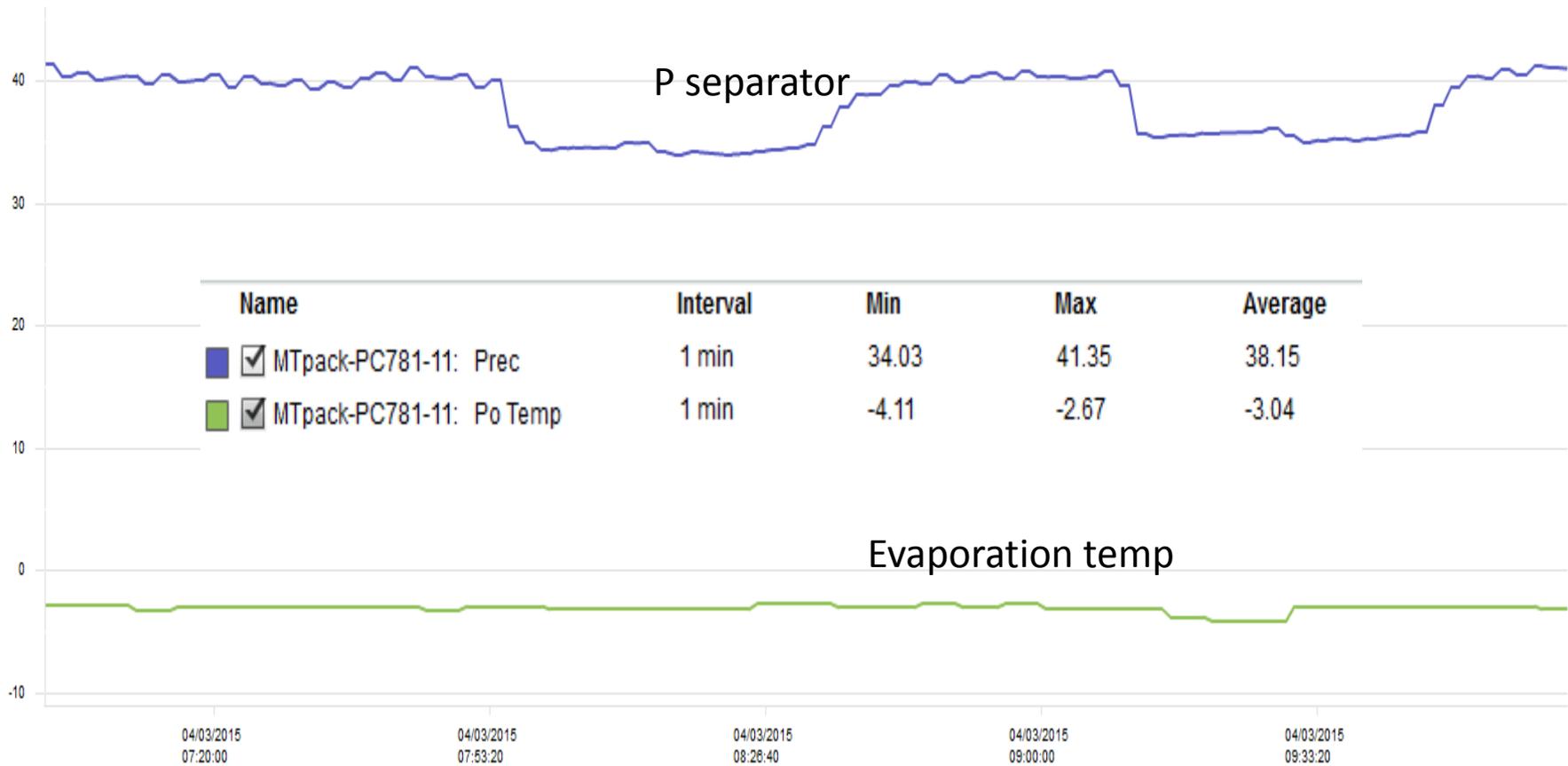
Status Running  
 Alarm  
 Address 11  
 Setpoint -3.0 °C  
 Current Value -2.6 °C  
 Model AK-PC781-044x



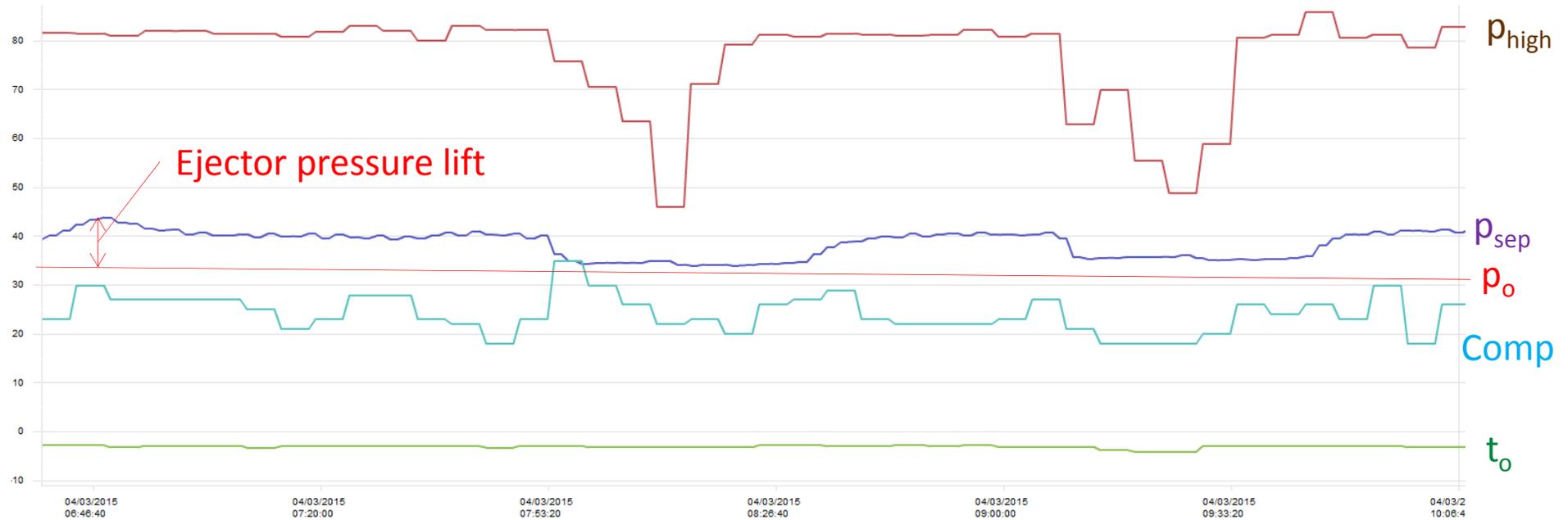
Po Temp	-2.6 °C
Comp Ctrl Ref	-3.0 °C
Compressor Cap %	27 %
Request Compr Cap%	28 %
Pc Pressure	83.4 Bar

Unit #0

Start: 06:59:37 04/03/2015 Stop: 10:03:37 04/03/2015



# 3.5 hours



Name	Interval	Min	Max	Average
<input checked="" type="checkbox"/> Mtpack-PC781-11: Prec	1 min	34.03	43.87	38.51
<input checked="" type="checkbox"/> Mtpack-PC781-11: Po Temp	1 min	-4.11	-2.67	-3.04
<input checked="" type="checkbox"/> Mtpack-PC781-11: Pc Pressure	1 min	46.05	85.82	76.98
<input type="checkbox"/> Mtpack-PC781-11: Pgc Pressure	1 min	42.04	85.29	76.66
<input checked="" type="checkbox"/> Mtpack-PC781-11: Compressor Cap ...	1 min	18	35	24.21

# Evolution of R744 Commercial Refrigeration

COP  
+ 10%

COP  
+ 10-20%

## R744 simple Booster (Baseline)

- Simple
- Many units in the market
- Flash gas bypass
- Low cost (below HFC in Scandinavia)
- COP baseline for moderate – cold ambient temp.

## Parallel Compression

- Advanced system
- Higher investment cost
- Flash gas (auxiliary) compression

## Ejector System

- Advanced system
- Flooded evaporators:
  - possible
  - simple (no pump)
- Pre-compression
- Higher load on Auxiliary compressors

# Ejector system ≠ Ejector system

## Classic Ejector

- High pressure control with needle in motive nozzle
  - High eff. at design point
- Part load operation challenges
  - Low motive flow rate and
  - Large mixing chamber
- Requires oil return strategy
- Ejector off (low pumping ability) – superheat operation of evaporators
- Discontinues operations

## Venturi type

- Part load challenges

## Liquid Ejector only

- Enables flooded evaporators all year
- Applicable for booster and parallel compression system
- Simple on/off control
- Requires low pressure accumulator

## Ejector supported parallel Compression

- Fixed nozzle ejectors: designed for pumping liquid and pre-compressing vapour (Multi-Ejector block)
- Enables flooded evaporators all year, requires low pressure accumulator
- Higher load on auxiliary compressors.
- Pressure lift can be adapted to provide efficient AC



# Summary & Outlook



- Commercial refrigeration is currently in an **innovative period**
- The so-called '**CO<sub>2</sub> equator**' has reached Africa!
- High system flexibility, efficiency, and performance can be achieved applying **smart ejector technology**
- Various ejector systems may enter the market depending on the **end-user demand** and **efficiency expectations**
- Cost- and energy efficient implementation of AC, etc. will open up for additional markets **outside EU**