



# How rare gases challenge us and allow us to open a new gate on Big Science

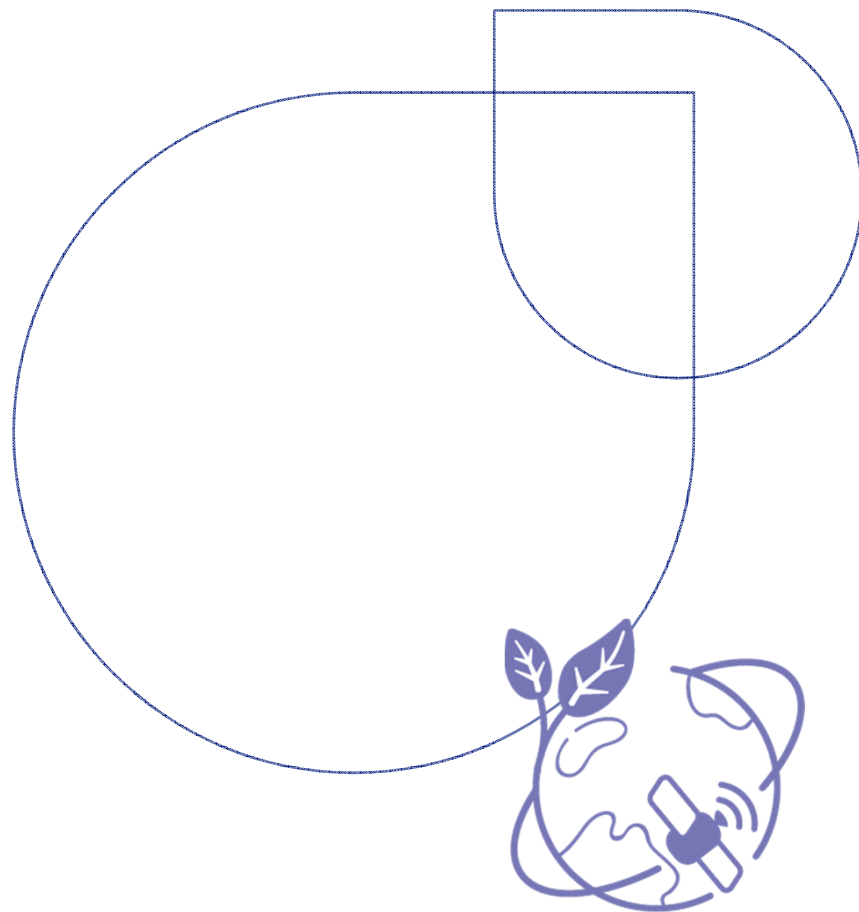
*Rare Gases: a challenge for Science and  
Industry*

Global Markets & Technologies

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Coimbra University - Portugal

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## Speakers' presentation



**Luc GAFFET**

*Global Market & Technologies -  
Big Science Market Director*



**Amandine Marc**

*Global Market & Technologies -  
Global Rare Gases Business  
Developer*

# Agenda



1. Air Liquide in brief
2. Key facts about Xenon
3. Argon for Big Science
4. Isotope sourcing: recent example of He3 debottlenecking
5. Take away
6. Q&A

# 01

## Air Liquide in brief

A world leader in gases, technologies, and services for...



## INDUSTRY

**Cleaner and sustainable solutions for a wide range of industrial processes of our customers:** energy, metals, food, chemicals, automotive, pharmaceuticals, etc.



## HEALTH

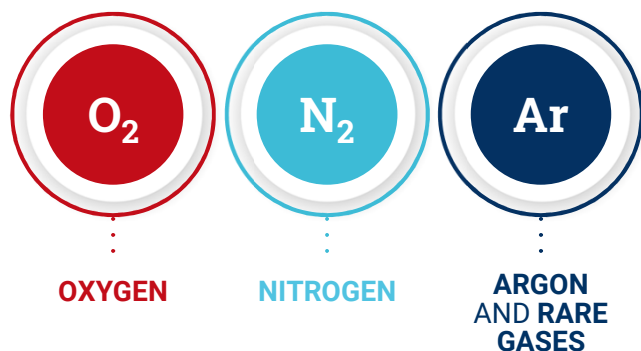
**Patients at home  
Hospitals  
Specialty ingredients**



## Our scientific territory: Essential small molecules

Oxygen, nitrogen and hydrogen are essential small molecules. They embody Air Liquide's scientific territory and have been at the core of the company's activities since its creation in 1902.

Separating the components of **air**  
to take advantage of their properties



Producing molecules from the  
**natural resources** of the planet



## 2021 Key Figures



**~66,400**  
EMPLOYEES



PRESENT IN  
**75** COUNTRIES



MORE THAN  
**3.8** MILLION  
CUSTOMERS &  
PATIENTS



REVENUE  
**€23.3bn**



NET PROFIT  
(GROUP SHARE)  
**€2.6bn**



INVESTMENT  
DECISIONS  
**€3.6bn**

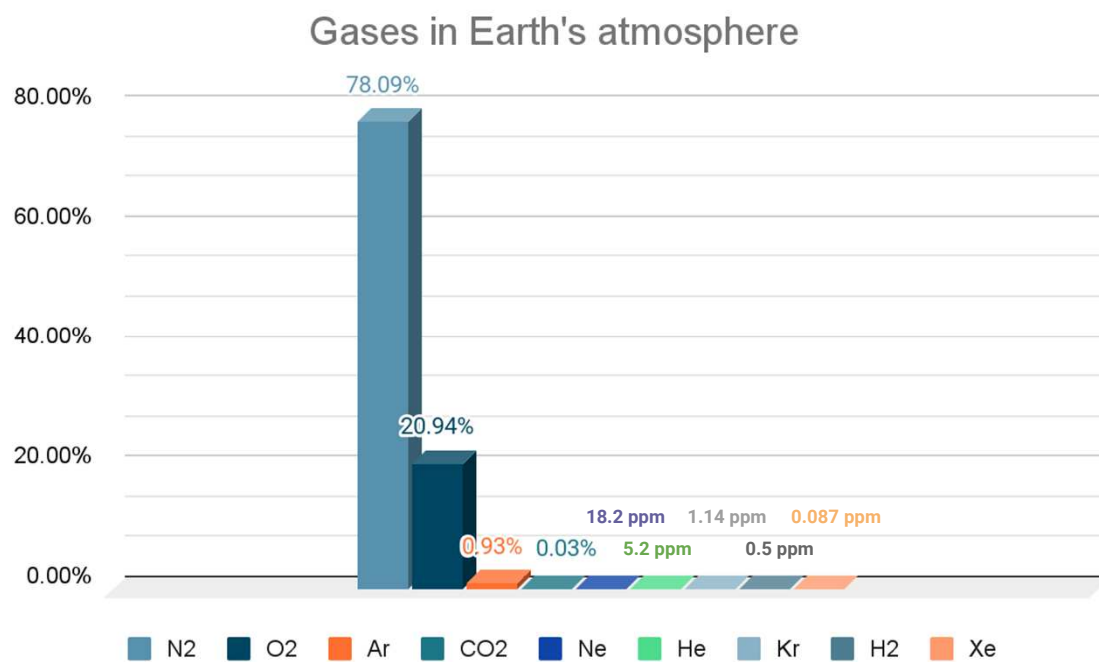
# 02

## Key facts about Xenon



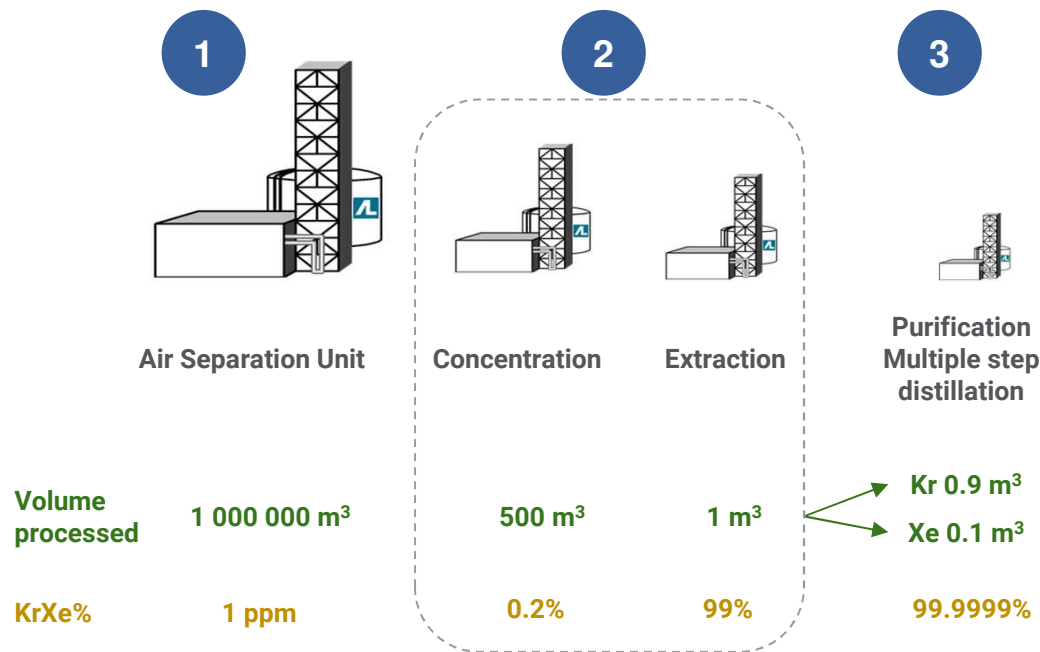
## Xenon in the Earth's atmosphere

Xenon is obtained from air, where it is present in extremely small amounts.



Gaz	Abundance
N2	78,09 %
O2	20,94 %
Ar	0,93 %
CO2	350 ppm
Ne	18,2 ppm
He	5,2 ppm
Kr	1,14 ppm
H2	0,5 ppm
Xe	0,087 ppm

## Kr and Xe extraction from the air requires multiple steps



### Key facts:

- Only very large air separation units (ASUs) can justify extraction of Kr and Xe
- Even large ASUs can only produce a small amount of Kr and Xe
- Increasing Kr/Xe capacity requires investments in very large ASUs which are Kr/Xe ready

⇒ Production of Kr and Xe is managed globally in order to maximize reliability of supply

## How is the Xe market evolving?

- Electronics demand for both molecules is meant to continue until 2030
- Space demand for both molecules is booming due to recent Space developments and private investment.
- Long term supply can be affected by:
  - Geopolitical context (Russia? China?)
  - Energetic transition in some supplying countries may have a long-term impact on the krXe production

**> Such demand provoked a shortage situation that is meant to continue over the next few years despite the different investments made by industrial players.**

## Key facts about Xenon market

- Xenon is a byproduct of oxygen with limited availability.
- Market is driven by the Electronics and the Space industry that are consuming significant volumes year after year.
- Xenon market has been in severe shortage for more than 2 years creating a strong competition between end markets.
- Main players plan and secure their volumes in advance (~5 years).

# 03

## Argon for Big Science

# Use case N°1 CERN Proto-DUNE

## CERN Neutrino platform: Proto-DUNE in Preveessin

### ■ CERN demand:

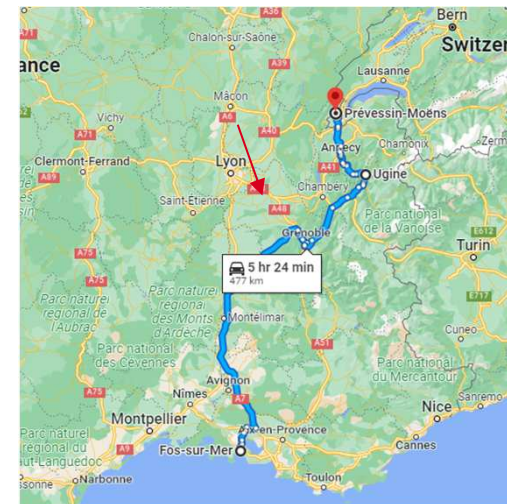
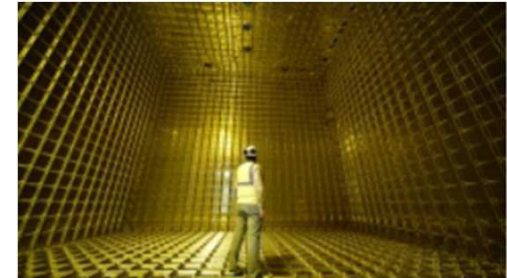
The CERN wanted to empty the cryostat containing the Argon and asked Air Liquide (AL) about how to vaporise 1,600 tons of LAr during summer 2020 (COVID lockdown).

### ■ Air Liquide Answer:

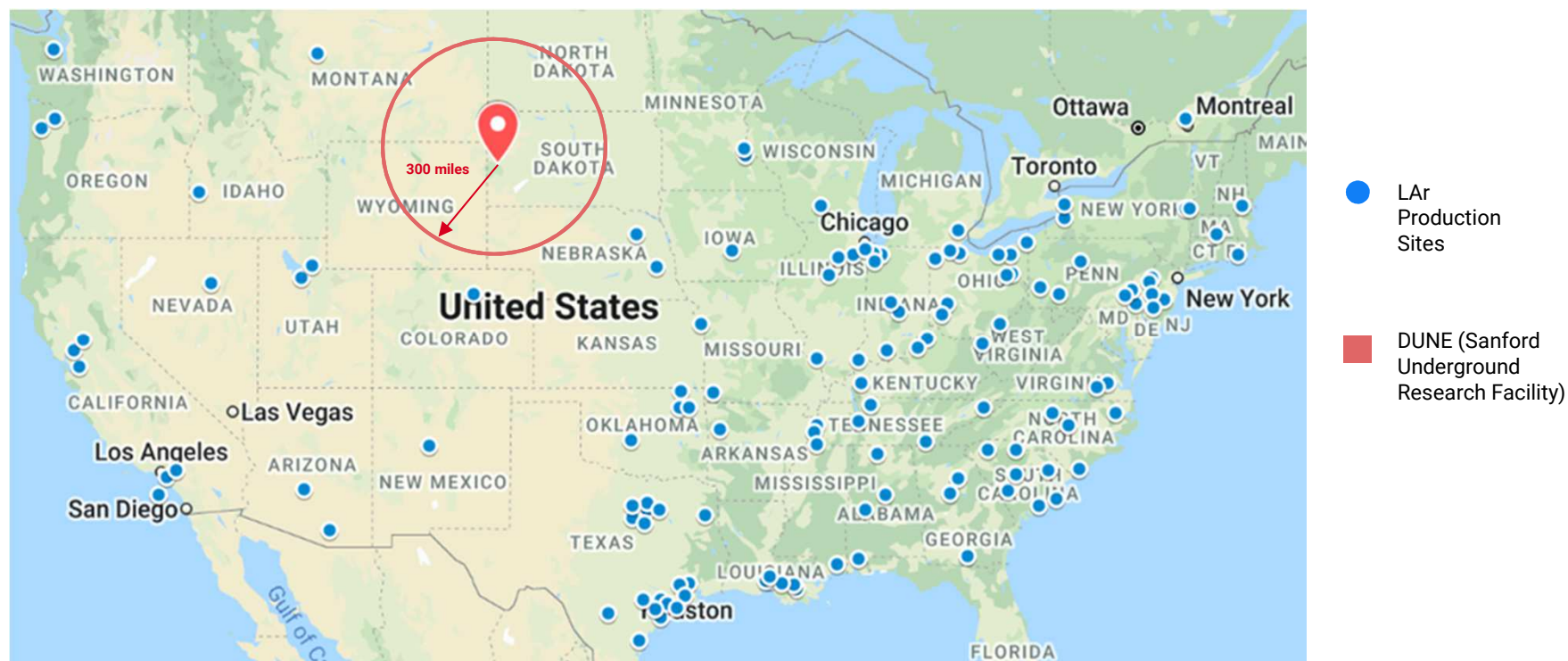
- 1) Such quantity is difficult to vaporise: you need to install and warm a swimming pool. It is noisy and expensive.
- 2) In terms of CO2 footprint and image, it's a nonsense to vaporise and loose the product.

### >>> Solution developed:

- AL proposed to have an on-site analysis of the Argon.
- AL purchased back the CERN inventory and used it to serve a side customer who was in need of Argon. Concretely, AL loaded the LAr at CERN and delivered the product to UGINE that is 86km from CERN (instead of supplying UGINE from Fos-sur-Mer, 400 km away).



## Use case N°2 DUNE project (forthcoming)



DUNE challenge: LAr sources versus Cryostats location

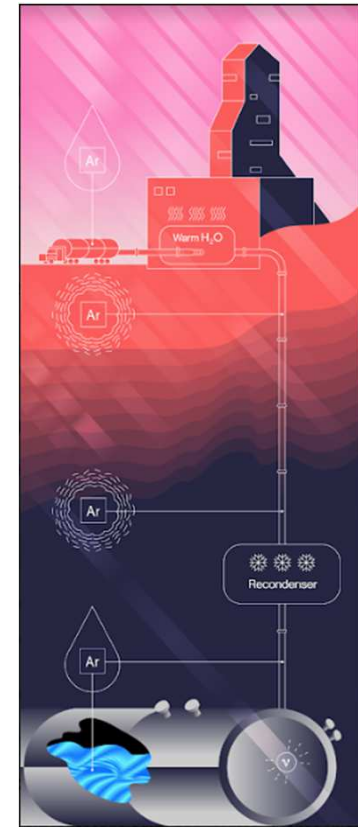
## Use case N°2 DUNE project (forthcoming)

**Question: How to supply 68,000 tons of LAr in South Dakota?**

### ■ Challenges for gas industry

- 1) Volume ~ 4,000 trucks (5,000 gallons per truck ~ 20 tons)
- 2) Distance from sourcing: logistic challenge, Hurricane storage capacity + train shipping?
- 3) Availability of the product, a large % of US total production

→ **Anticipation is key success factor**





# 04

## Isotope He3

## Use case N°3 Helium 3

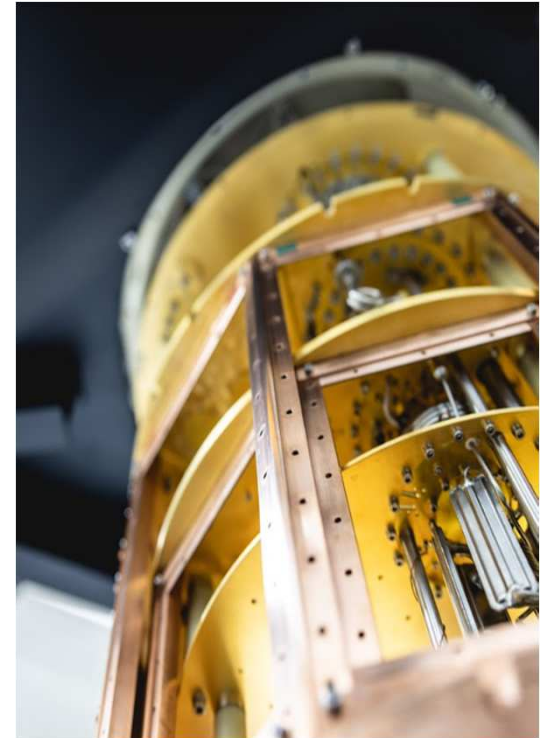
- **Increase of Solid State Qubit research**

- 1) Dilution refrigerators inventory increases by 250 units per year
- 2) He3 demand increases by 30% per year

- **Air Liquide issue: How to develop a strategy on Quantum Computing to become hardware of sub kelvin solution with limited volume of He3 ?**

**>>> Solution developed:**

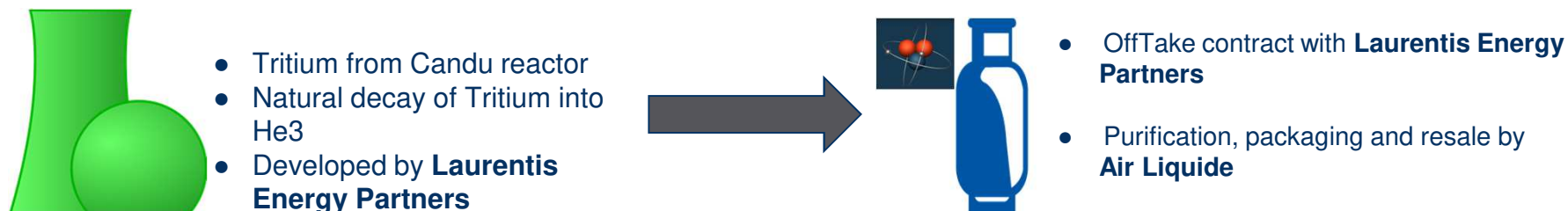
- Create a new source of Helium3 to anticipate the market growth



## Helium 3: from a strategic positioning to sourcing solution

Until **2021**, the He3 market was splitted into 2 main suppliers (USA, Russia) which production capacity was limited by the decay of tritium from nuclear weapons.

Driven by its ambition to support the Quantum segment development, Air Liquide entered into a long-term Agreement in **2022** with [Laurentis Energy Partners](#) to extract He3 from a Candu reactor located in Canada, creating the first non military Helium3 source.



# 05

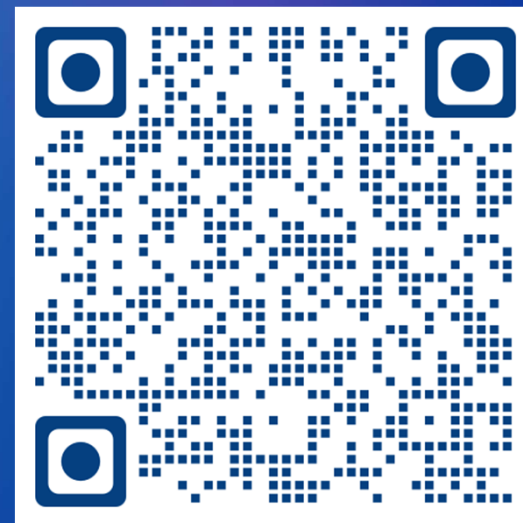
## — Take away

## Take away

- Big Science offers very interesting challenges for Gas activity in terms of technical specifications but also in terms of supply and logistics.
- It's for gas activity an inspiring domain, helping us push the frontier of our day to day business.
- But to succeed, a strong anticipation and customer dialogue is necessary to develop and optimize solutions in terms of cost and environmental footprint.

*For better understanding of needs, we invite you to answer to the attached google form*

06

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Q&A

## Speakers' presentation



**Luc GAFFET**

*Global Market & Technologies -  
Big Science Market Director*

[Luc.gaffet@airliquide.com](mailto:Luc.gaffet@airliquide.com)

**Tel: 00 33 (0) 6 19 77 06 80**



**Amandine Marc**

*Global Market & Technologies -  
Global Rare Gases Business  
Developer*

[Amandine.marc@airliquide.com](mailto:Amandine.marc@airliquide.com)

**Tel 00 33 (0) 7 88 19 33 01**



# Thank you