PELLENC ST

PET SORTING FOR CIRCULARITY: Solutions and perspectives

PETCORE SORTING WEBINAR

ANTOINE BOURELY, CHIEF SCIENTIFIC OFFICER, MARCH 19, 2024

PELLENC ST IN A NUTSHELL

- **Manufacturer of optical sorters**
- **Leader in France, Japan, Australia,…**
- **International** reach
- **Independent** company
- Main customers:
  - Material Recovery Facilities
  - Plastic recyclers
  - Textile sorters / recyclers

- **A mid-cap company!**

2001
YEAR FOUNDED

260
EMPLOYEES

2500
Machines in operation worldwide

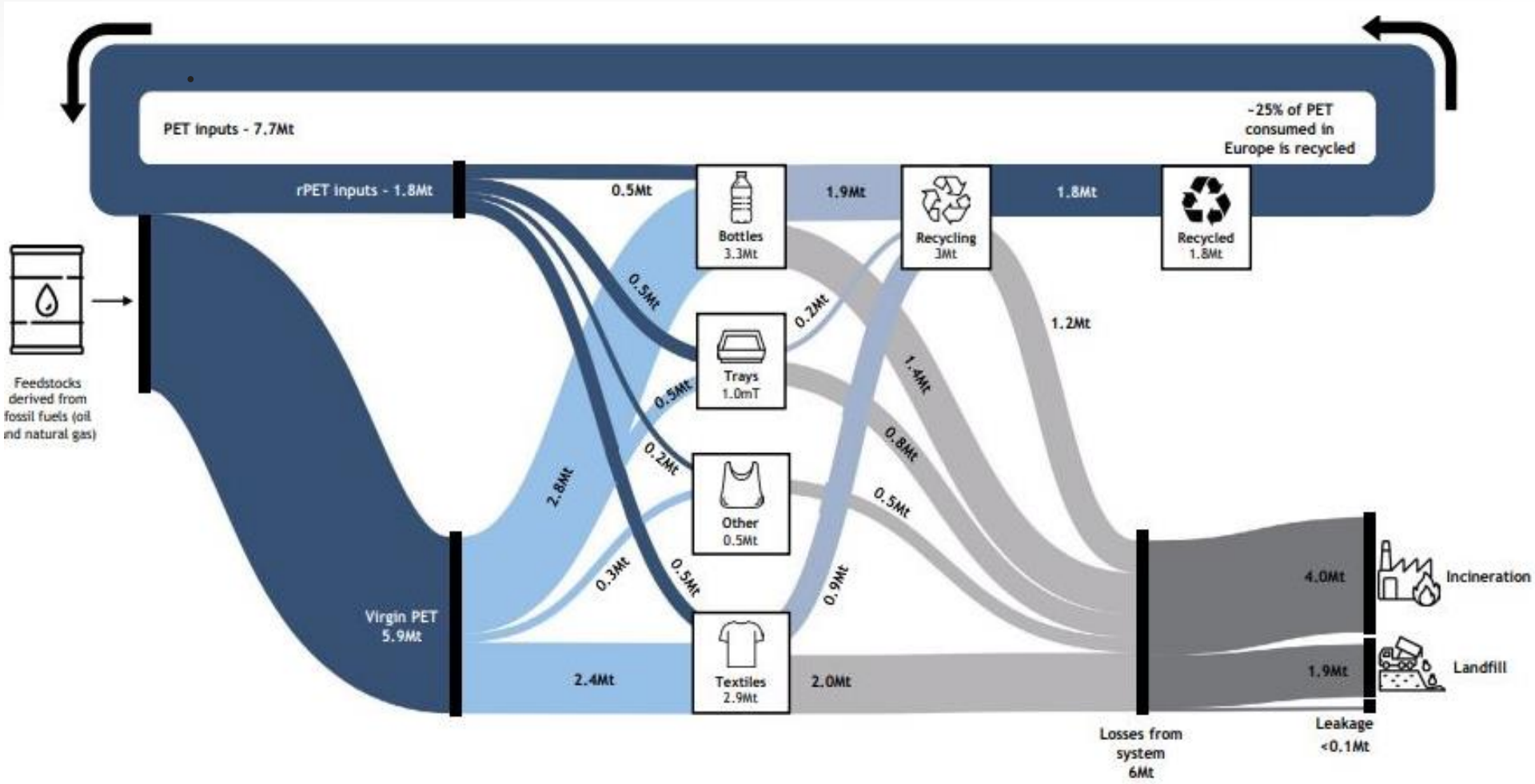
15%
AVERAGE ANNUAL GROWTH FOR 6 YEARS

85
MILLION EUROS 2023 TURNOVER

MEMBER OF THE **ACCÉLÉRATEUR PME [SME ACCELERATOR] PROGRAMME**

bpifrance

PET Circularity: situation in 2020 in Europe



Source: SystemIQ, Eunomia, Zero Waste Europe, Bryan, Garnier & Co IRIS

Comments:

- **Circularity = 25%**
- Bottle rPET also used for trays & textiles
- **Trays** poorly collected (20%), little recycled
- **Textile** recycling mainly post-industrial

How Can PET Sorting Help Circularity

Status on Circularity: only clear food bottles and some white opaque bottles

Sorting with NIR/VIS spectroscopy to separate:

- Monolayer trays from bottles (Bottle to Bottle recycling)
- Mono/multi layer trays (tray to tray recycling)
- Food grade white opaque bottles (create circularity)
- Refine color sorting: clear vs light blue, opaque vs transparent
- Detect fully sleeved bottles

Sorting combining NIR/VIS with AI or Watermarks to separate:

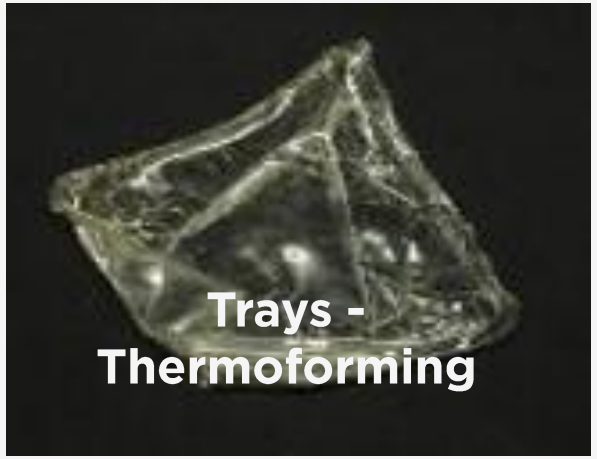
- Food grade bottle streams (for countries without DRS)
- Non-food grade bottle streams for non-food brands
- Food grade trays/thermoforms from other trays

Separating Monolayer Trays from Bottles

- **BtoB Recycling: key to avoid lowering quality of rPET bottles** (Trays make rPET bottles brittle)

- **Differences**: same chemical composition but use a different process:
  - trays are thermoformed
  - bottles are injected and blow-molded

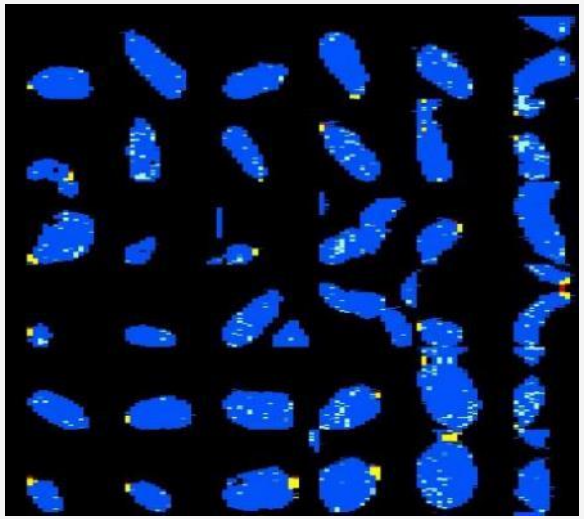
- **Sorting challenge :** the spectral difference is very small



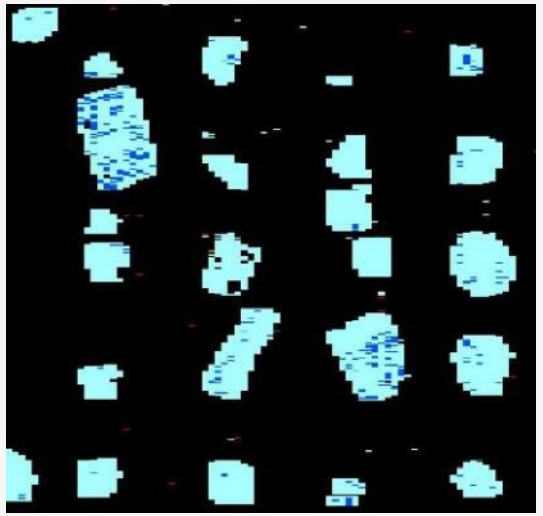
Sorting Bottles and Trays With NIR

NIR images

(pixel data before filtering)



Clear bottles



Clear monolayer trays

Sorting mode	Bottles ejected	Trays ejected
Mode#1: eject bottles (1 step)	92 - 94%	< 5%
Mode #2: eject trays (1 step)	< 6%	95%

Separate Multilayer vs Monolayer Trays

This separation is key for tray-to-tray recycling:

- **Sorting task:** obtain a clean monolayer stream
- **Sorting process:** 1 step
  eject multilayer trays and contaminants

- **Results using NIR only:** (validated @ Wellman France 2021)

Final purity on monolayer trays	**91.6%**
Final loss of monolayer trays	**2.4%**

Multilayer stream

Monolayer stream

A Circular Success Story

How to recycle white Opaque PET Stream

- Opaque PET contains TiO_2
- No recycling outlet in 2017

Recycling strategy (CITEO 2021):

=> A circular loop created

- Use the fact that most food grade bottles contain a black carbon layer
- NIR advanced settings to:
  - separate opaque vs transparent
  - separate opaque food (carbon layer) vs. opaque non-food

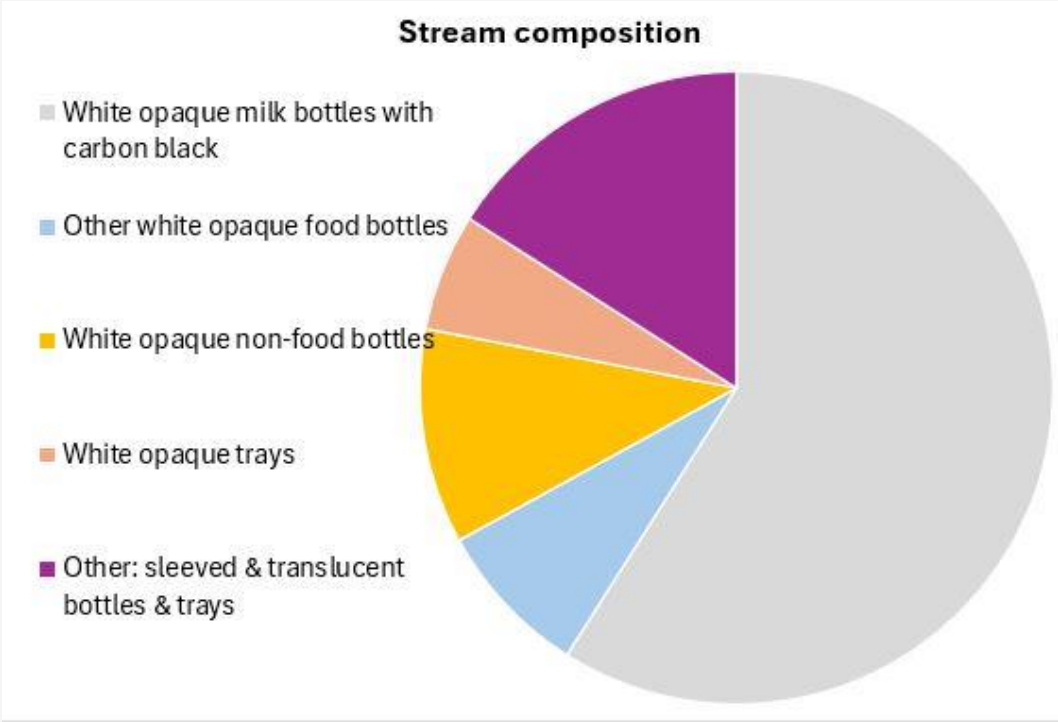
Food White Opaque PET Stream: Industrial Sorting Result

Sorting task & Process (1 step):

Extract white opaque food bottles with carbon black

Sorting Result:

- **Purity of food white opaque stream :** **98.7%**
- Recovery of bottles with carbon black: 95%
- Final recovery of food bottles: 85%



Impact: grey color after recycling

Fine Color Sorting: Light Blue vs Clear

Sorting task: separate light blue vs clear PET (required in Italy and Belgium)

Sorting Challenge: rPET is clear, but with a greyish shade

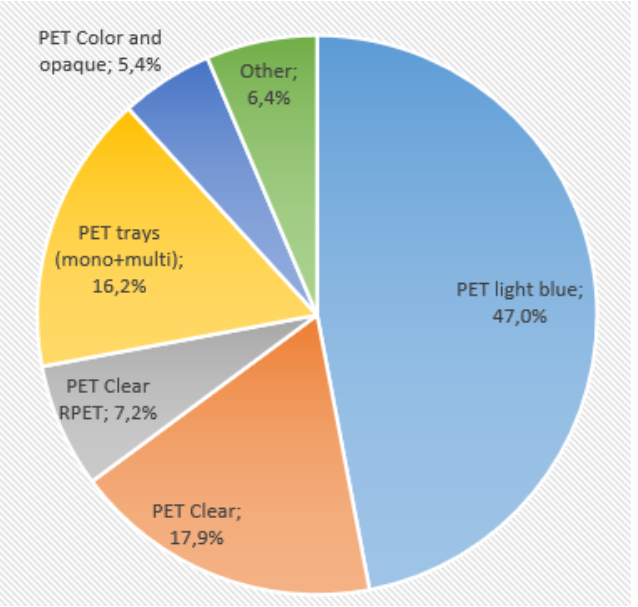
Process (1 step):

- Extract light blue bottles from mixed PET
- Throughput: 7.5 tph on 2800 mm width

Sorting result:

- Efficiency on light blue: 94%
- Purity on light blue: 94%

Light blue rPET clear



Fine Color Sorting: Opaque vs Transparent

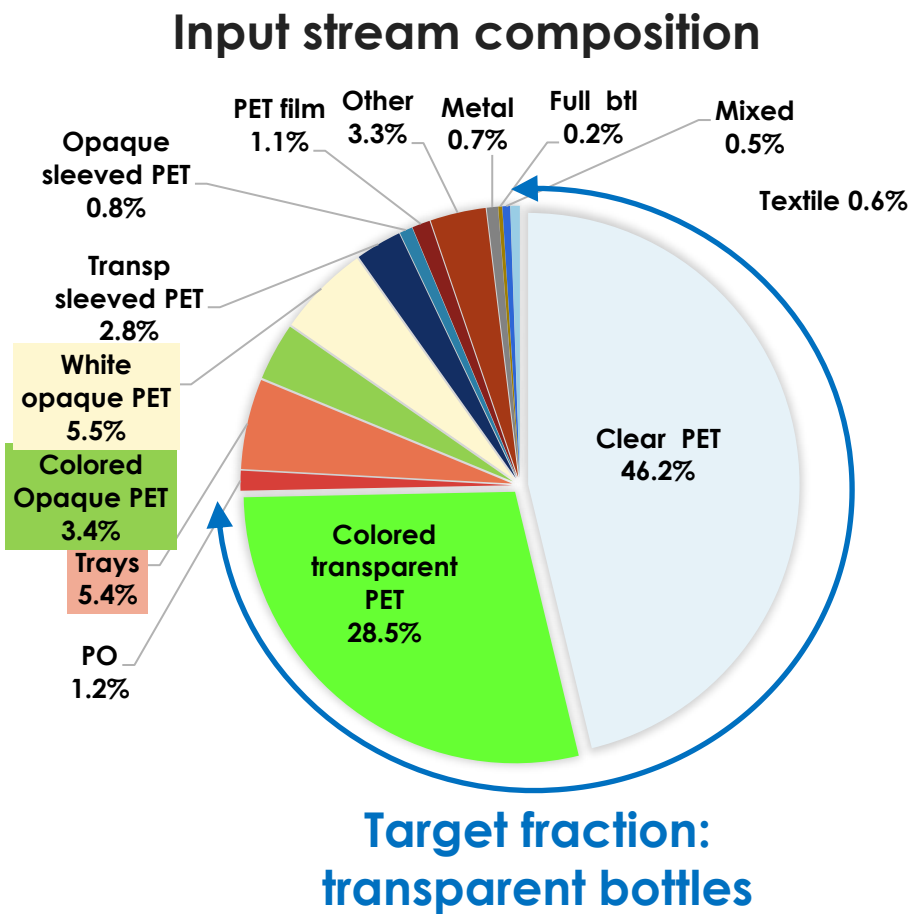
Sorting task: remove **trays & opaque bottles** (white or colored) from transparent bottle streams

Process (3 steps + recovery):

- Step1: extract transparent bottles (clear & col.)
- Steps 2 & 3: remove opaque bottles
- Recovery: recover transparent bottles from losses

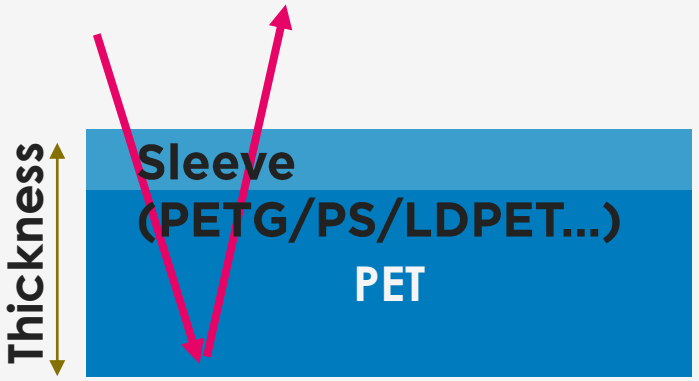
Sorting Result:

- Transparent PET purity: **99.4%**
- Transparent losses: **< 2%**
- PET Opaque & tray purity: **91%**



Full Sleeved PET

Widespread to avoid glue): 14 % of bottles



Sorting task:

- recognize the product as a sleeved bottle
  → OK: NIR signal goes through the sleeve
- Sort the product towards the clear PET stream:
  → Not OK: color under sleeve not visible

Sorting Results:

- PE, PP, LDPET, PS, PVC detectable as sleeve + bottle
  → downcycled to colored stream
- PETG (thin layer) confused with opaque PET
  → downcycled to opaque stream

Food vs non-food PET

Digital Watermarks and Artificial Intelligence

What Are Digital Watermarks (DW)

The marker is a high-resolution pattern (150 dpi) that can be:

- **Printed** (2D) or **Moulded** (3D)all around packaging
- Causes **no recycling issues** (natural elimination during recycling), **unlike chemical tracers**
- Wide encoding capability (like a QR code)

Challenges:

- Expensive equipment for sorting (lightings, computers, cameras…)
- Licensing fees
- International standardisation needed
- Data governance

Printed version (2D)

Looks Like This

Performs Like This

Moulded Version (3D)

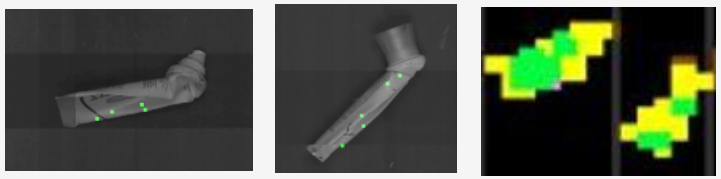
Images courtesy of P&G / Digimarc/ Logoplaste

DW & NIR: A Necessary Combination

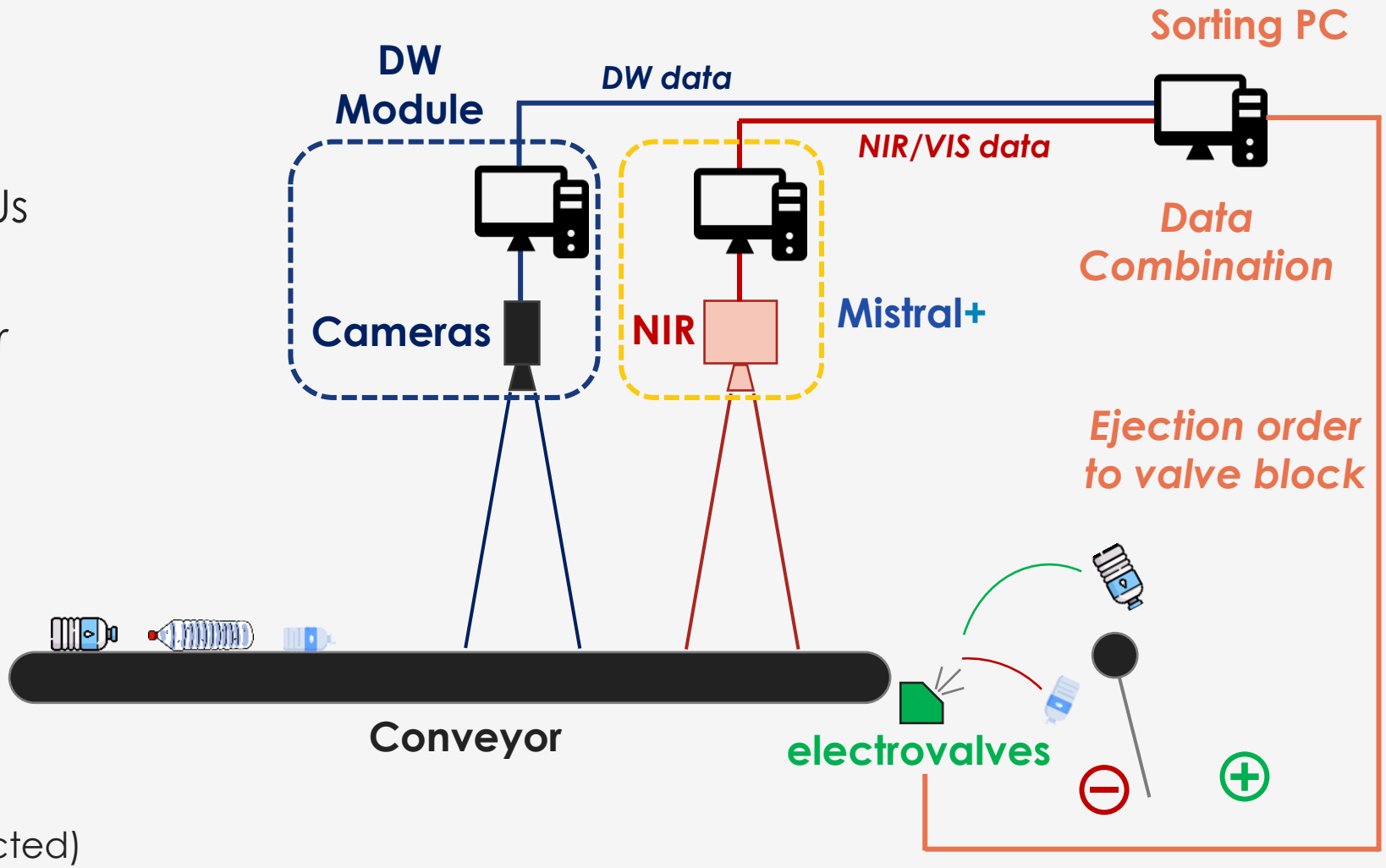
Why combine?

- To allow mixed sorting of marked & unmarked SKUs
- To detect full object area, for dirty, partially marked or damaged packaging

Example on difficult objects



Green: DW and NIR detected
Yellow: NIR detected (No DW detected)



Industrial Sorting Test with DW

Place: Wellman Indorama, Verdun
Time: Jan-Feb 2023

Input stream:

DW marked products mixed with waste, sorted in MRFs, prepared in bales

Process : 2 steps

eject marked non-food bottles

Industrial conditions: 3 m/s, 4 tph

Input bales: 20% DW

distorted bottles

Sorting Results:

400.000 bottles ejected

95 % Efficiency = 95% non-food bottles ejected

(88% in first step)

Industrial Sorting Test with AI

Place: Wellman Indorama, Verdun
Time: March-Oct 2023

Input stream:

Natural PET stream from MRFs
Average non-food PET in input : 8%

Process : 1 step

eject non-food bottles, at 4 tph, 3 m/s
AI algorithms designed by Pellenc ST team
Extensive database built: 100.000 images
Challenging differences, especially without labels

Food Non-food

Sorting result:

54% non-food ejected / 6 % downcycling food to non-food
Final non-food content ≈ 4%,complies with specs

How does AI compare to Watermarks?

Who	Input : NF share	Output: NF share	Eject	Efficiency (%)	Downcycled F to NF (%)
Polyperception	13%	<5%	F	67.5%	32.5%
Pellenc ST (with AI)	8%	< 5%	NF	54%	6%
Pellenc ST & Digimarc (with DW)	20%	1%	NF	95%	< 2 %

Major learnings:

AI sorting works: **AI achieves customer specifications today**

tradeoff: **significant downcycling** of food grade into non-food grade

DW sorting performance is far above AI:

when available, it will raise quality and reduce losses

For trays, food vs non-food sorting also proven in Copenhagen (Holy Grail 2.0 phase 2)

Takeaway: What Can We Achieve?

Sorting task	NIR/VIS	NIR/VIS + AI	NIR/VIS + DW
Trays vs bottles	YES	YES	YES
Mono vs multilayer trays	YES	YES	YES
Food grade white opaque bottles	YES	YES	YES
Fine color sorting	YES	YES	YES
Opaque vs transparent colored bottles	YES	YES	YES
Sleeved bottles	YES, with downcycling	maybe	YES
Clear food grade bottle stream	NO	YES, with downcycling	YES
Create non-food grade bottle stream	NO		YES
Food grade trays vs non-food grade	NO	maybe	YES

Caveat: With AI: consider costs of database updates

With DW: consider costs of hardware and licenses & wait for standardized solution

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PARTENAIRE
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Restons connectés !

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