Ecological impact of a sapphire watch cover

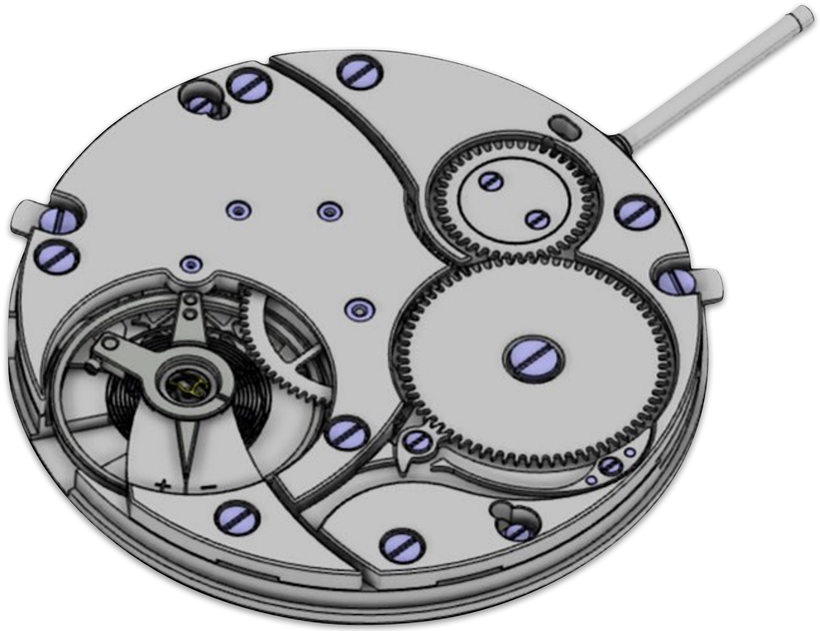
Analysis in 3 parts:

1. Impact of sapphire *vs* other parts
2. Analysis of sapphire production environmental footprint
3. How to reduce the footprint ?

Sapphire

vs

other parts



Definition

Total energy = **Embodied energy** + **Manufacturing energy**

Embodied energy

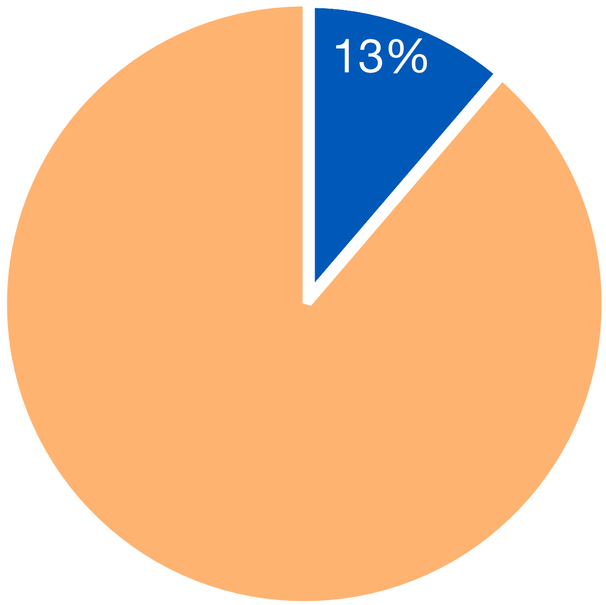
energy required to produce the raw material

Manufacturing energy

energy to process raw material into final product shape

Literature data [1]

Total energy



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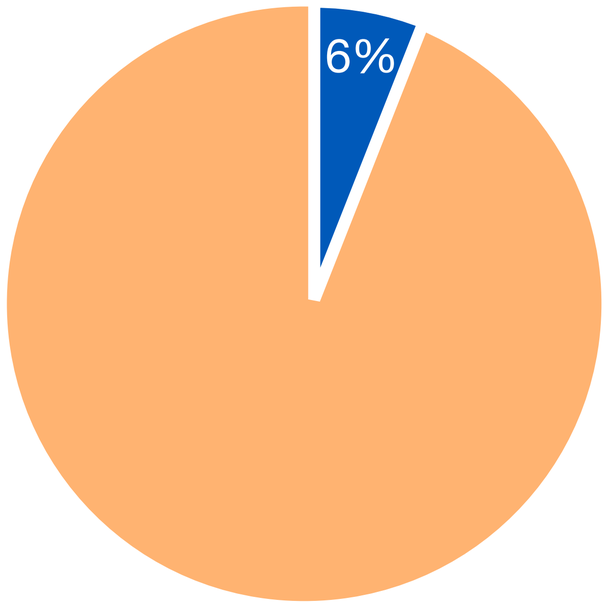
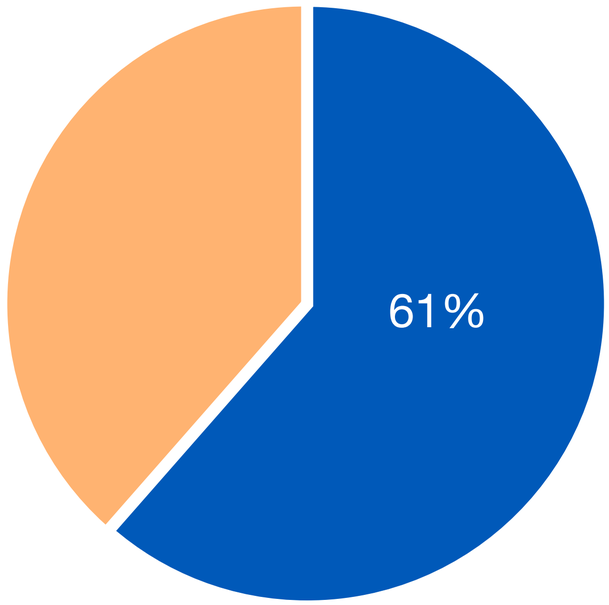
Embodied energy



+

Manufacturing energy

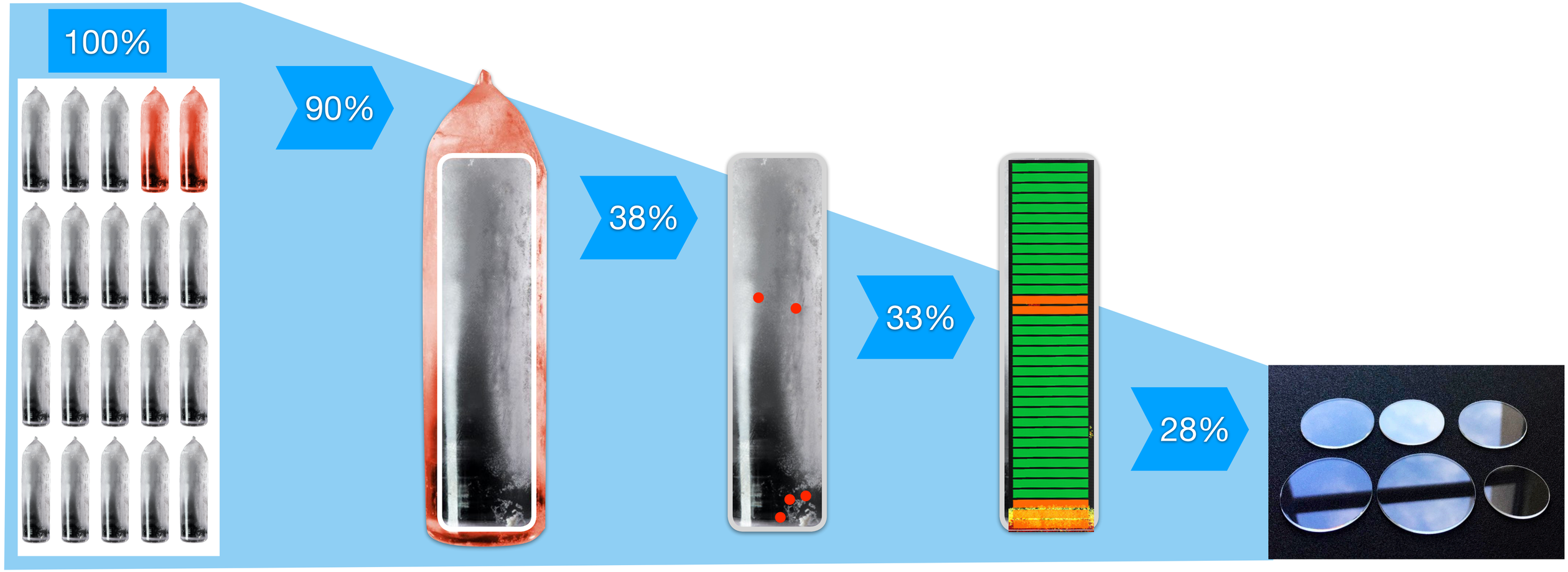


- Sapphire cover
- All other parts

Sapphire cover represents <10% of the watch weight but 61% of its manufacturing energy.

[1] David Weber, HE-Arc “Case study of the ecological impact of a typical mechanical Swiss watch”, May 2022 Link

Calculating real embodied energy of sapphire



-10%
of grown carrots are scrapped

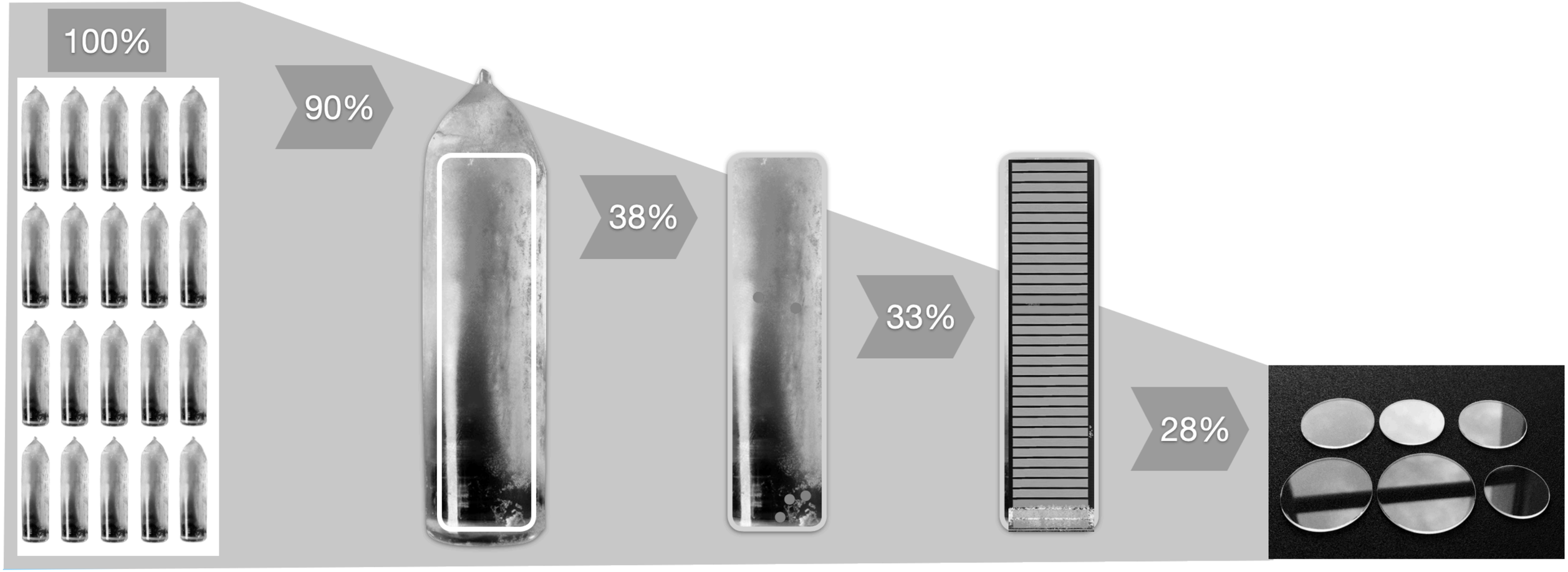
-58%
cut head & bottom, grind the sides

-13%
core volume defective

-14%
slicing & polishing

Combined yield is 28% ±3 ppt

Calculating real embodied energy of sapphire



Scrapping factor

Form factor

Yield of cores

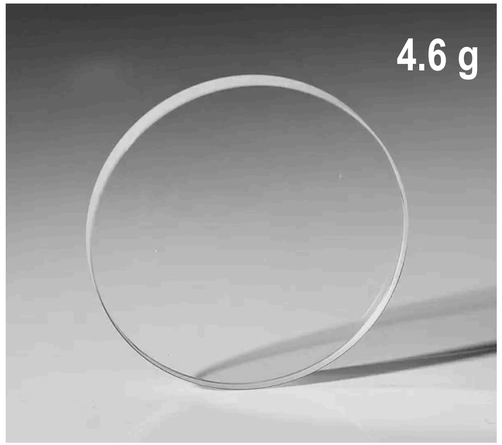
Slicing yield

Combined yield

28%

average sapphire yield in watch industry

Calculating real embodied energy of sapphire



Flat requires growing ~16g of Verneuil sapphire

~8 kWh	**1 kg CO_2** @ CH average 89g/kWh	**4 kg CO_2** @ World average 475g/kWh

Dome requires growing ~73g of Verneuil sapphire

~36 kWh	**3 kg CO_2** @ CH average 89g/kWh	**17 kg CO_2** @ World average 475g/kWh

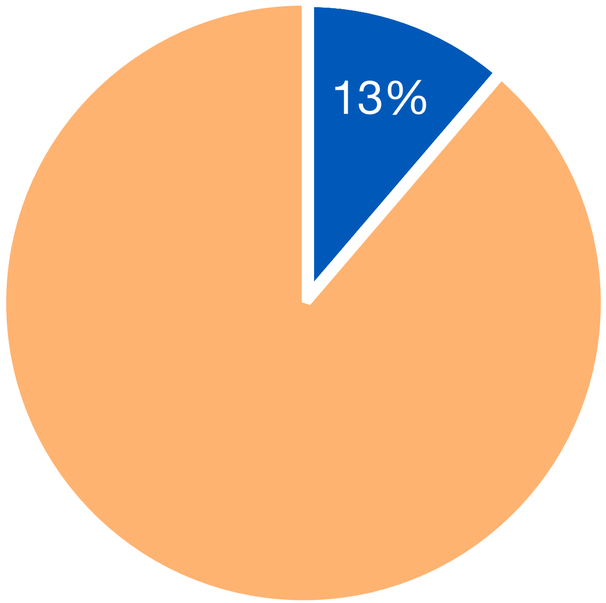
Real embodied energy of sapphire - by growth methods

	Energy for raw material kJ/g	Scrapping factor %	Form factor yield %	Yield of cores %	Slicing yield %	Combined yield %	Energy for final product kJ/g
Current growth methods with manual quality control							
Verneuil	1’800	10	42	87	85.1	28	6’431
Kyropoulos	923	4	34	95	85.1	26	3’498
HEM	360	5	45	90	85.1	33	1’099
Averages	**1’028**	**6**	**40**	**91**	**85.1**	**29**	**3’676**

➜ Effective embedded energy is ~3’600 KJ/g

Revised data taking into account sapphire yield

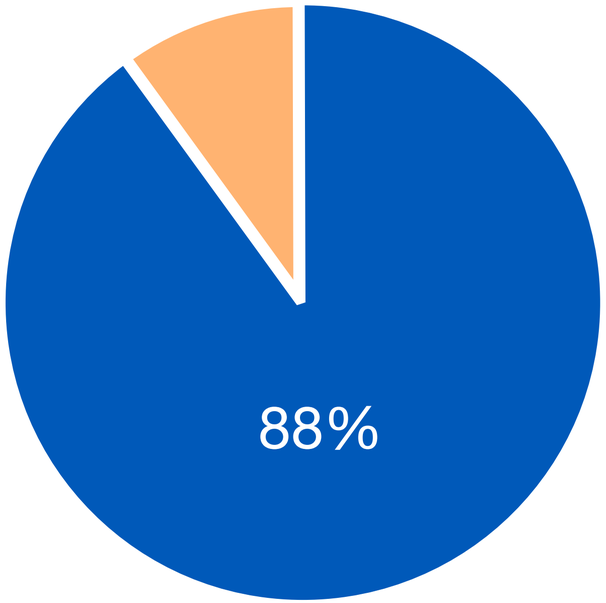
Literature data
for watch with DOMED
sapphire cover



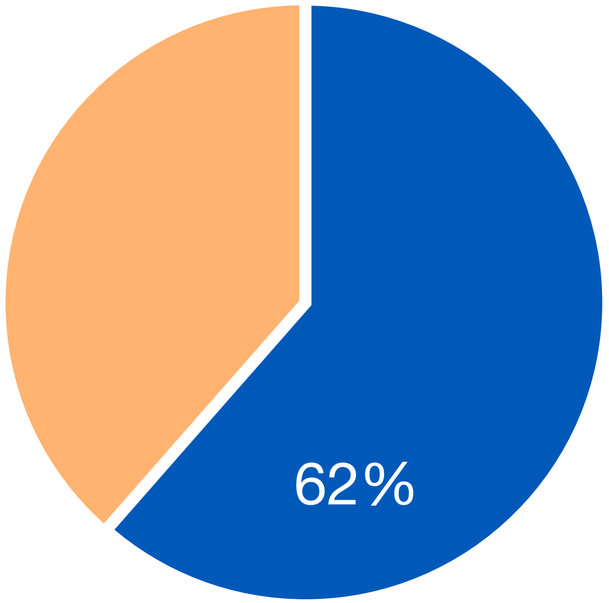
7 times more energy

Revised analysis, accounting for sapphire production yield

for DOMED cover



for FLAT cover



Sapphire cover
All other parts

*Assuming a Verneuil sapphire growth method

Reducing the watch industry footprint,

implies improving, first of all,

the sapphire processing.

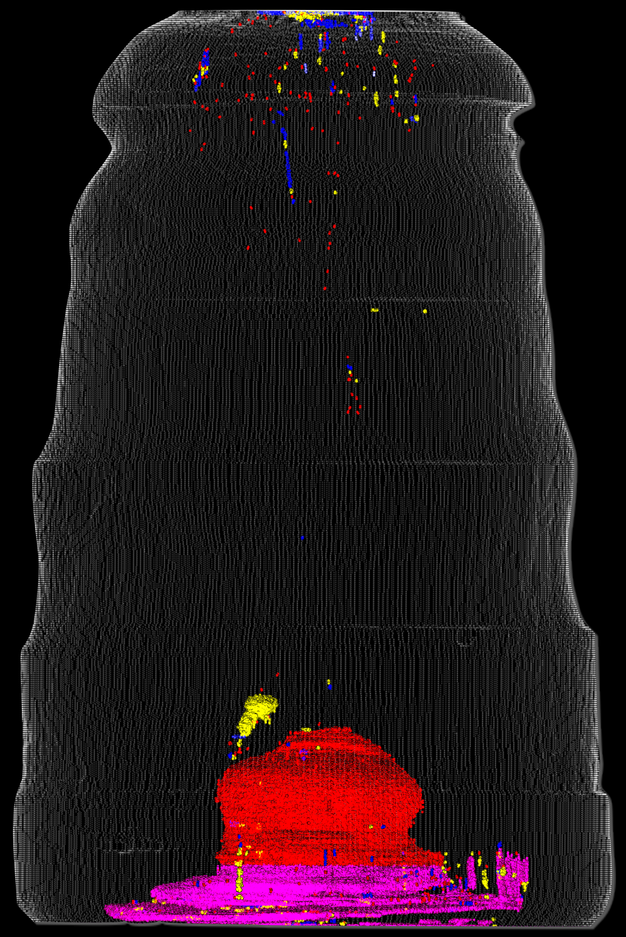
How can we process sapphire smarter?

Adopt Industry 4.0 approach:

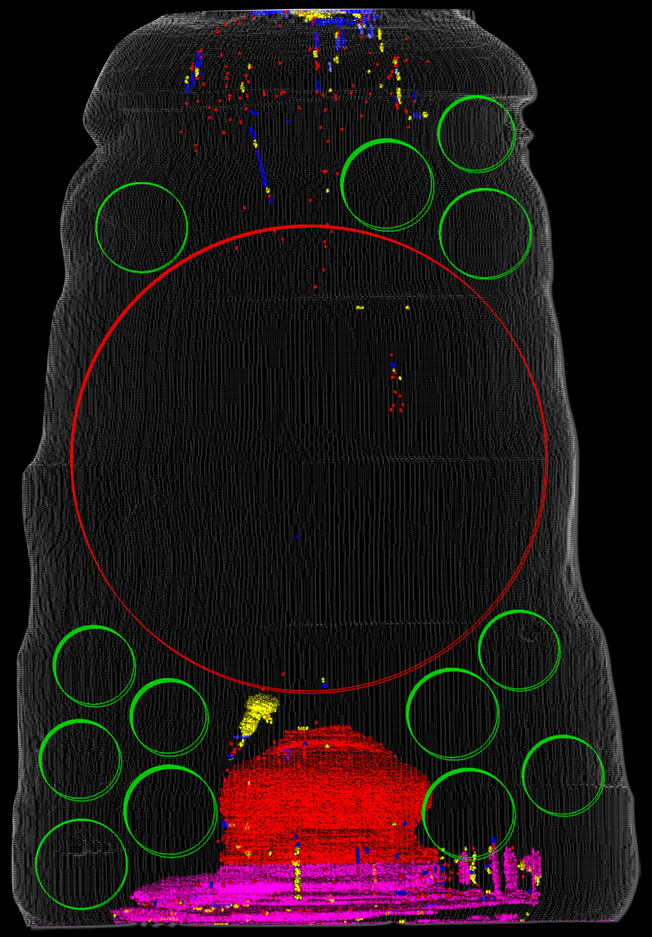
- Digital Quality control
- Coring optimisation
- Wafering optimisation
- Dome orientation

1. Smart coring

Non-processed crystal



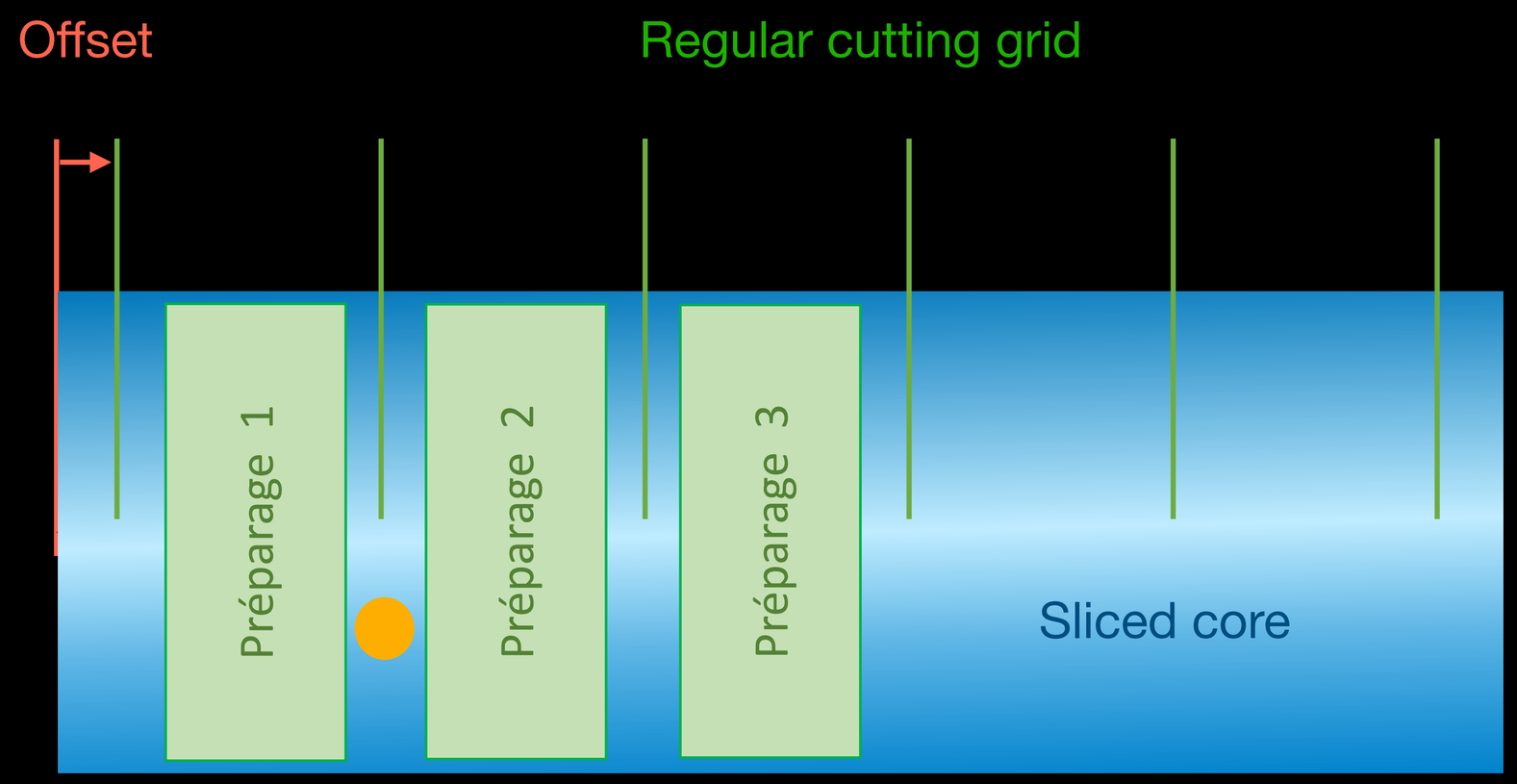
Digital twin



Coring optimised for max yield

2. Smart wafering™

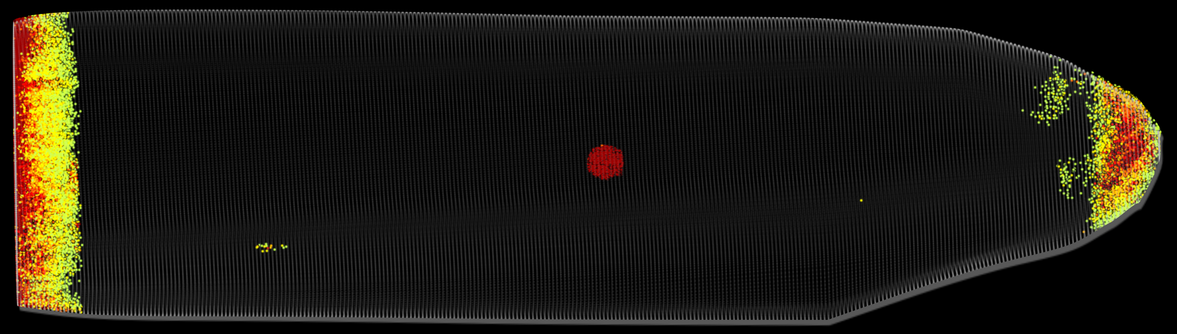
Pre-calculated core offset brings more defect-free préparages



2. Smart wafering™

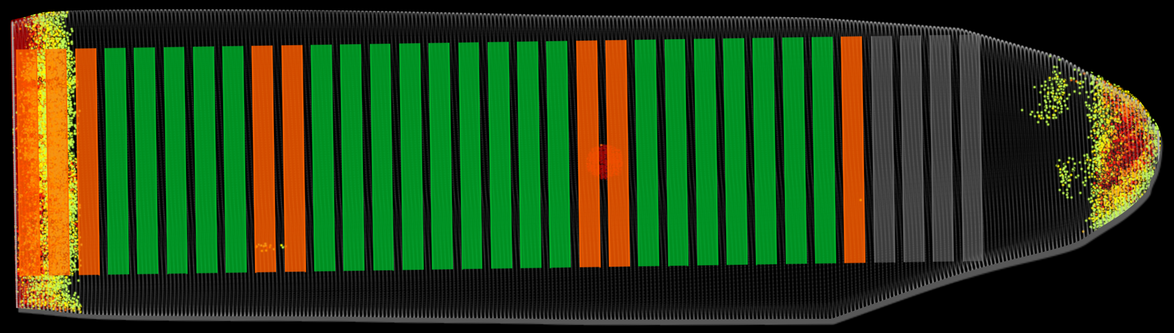
Core to slice for préparages

⌀ 23 mm, Th 2.0, Gap 1.0 mm



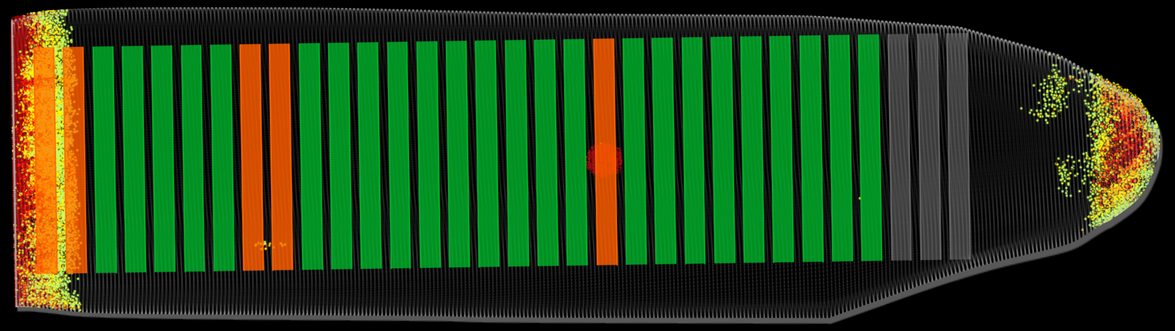
Traditional slicing

21 defect-free préparages



Smart slicing, offset 0.8 mm

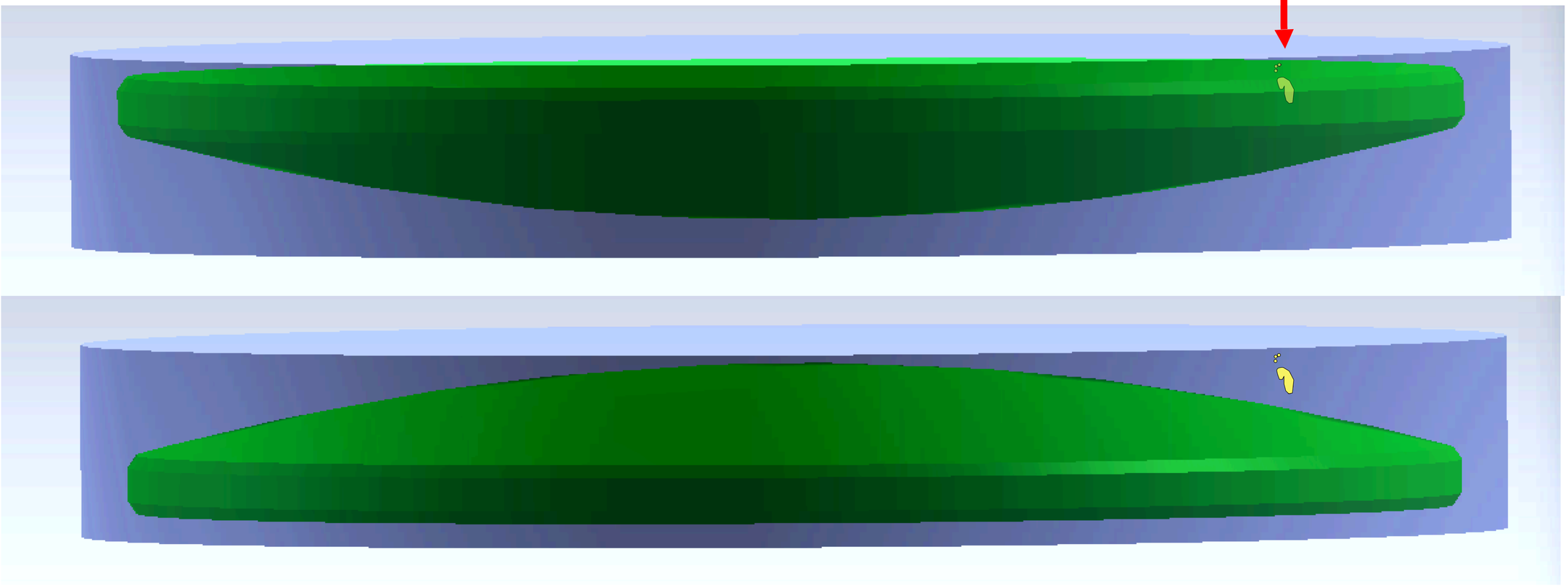
23 defect-free préparages



➜ + 2 préparages
+ 9.5% yield

3. Dome orientation

Avoiding material defects by flipping a domed piece



➜ +4.2% yield

Modelling the impact of introducing Digital Quality Control

	Energy for raw material kJ/g	Scrapping factor %	Form factor yield %	Yield of cores %	Slicing yield %	Combined yield %	Energy for final product kJ/g
Averages of 3 major growth methods controlled manually							
Averages	1’028	6	40	91	85.1	29	**3’676**
Impact of digital quality control (DQC)							
ppt	—	-1 ppt	+5 ppt	+2 ppt	+3 ppt		
Average including DQC		5	45	93	88	35	2’933

Impact of digital quality control at the scale of the Swiss watch industry (21 millions watch covers/year)

Reduction in embodied energy, assuming an average cover weight is 5 grams	7.8 E+10 kJ
Reduction in CO2, assuming a worldwide average conversion factor of 475g CO_2 per kWh	10’000 tons CO_2

Modelling the impact of introducing Digital Quality Control

10’000 cars

or

town of 2’300 population

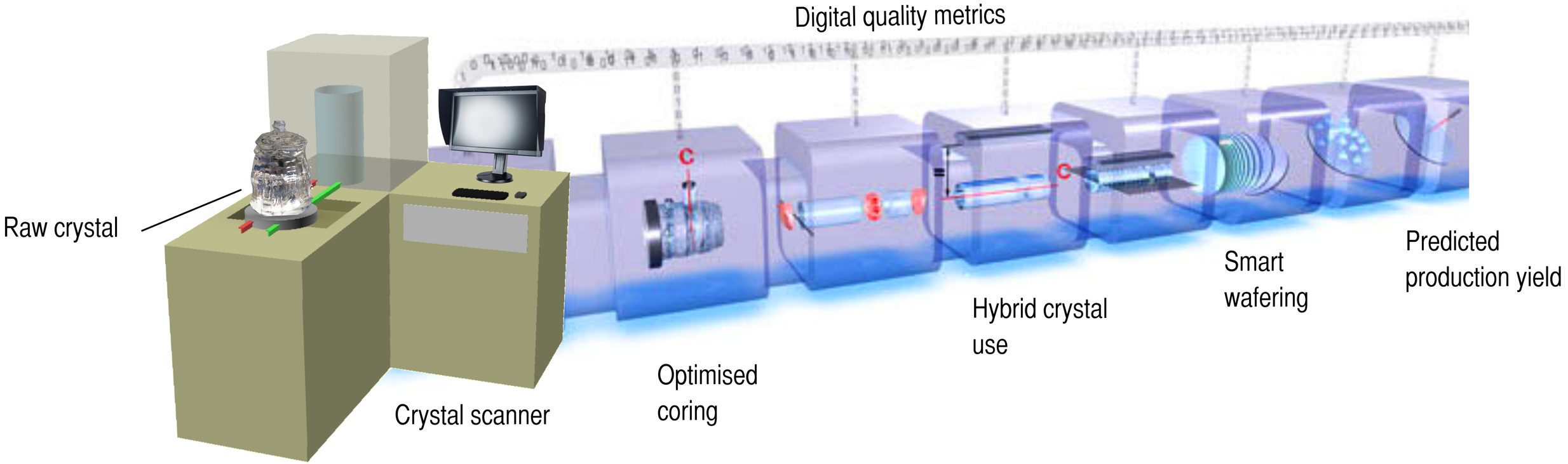
7.8 E+10 kJ

10’000 tons CO_2

Scientific Visual vision:

Produce Smarter to Impact Less

Produce Smarter to Impact Less



Scientific Visual supplies smart processing equipment

for Sapphire / Ruby, Spinel, CaF_2, LT/LN, Quartz, LBO, KTP

SapphiroScan™

for préparages

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for HEM and cores

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for X-large crystals

Contact

Frédéric Falise

+41 79 217 1210

frederic.falise@scientificvisual.ch

Scientific Visual

Automated
crystal inspection tools

Chemin du Closel 5

Renens VD 1020

Switzerland

www.scientificvisual.ch