ASBESTOS DETECTION

The challenges and impact of the new European directive on laboratory practices

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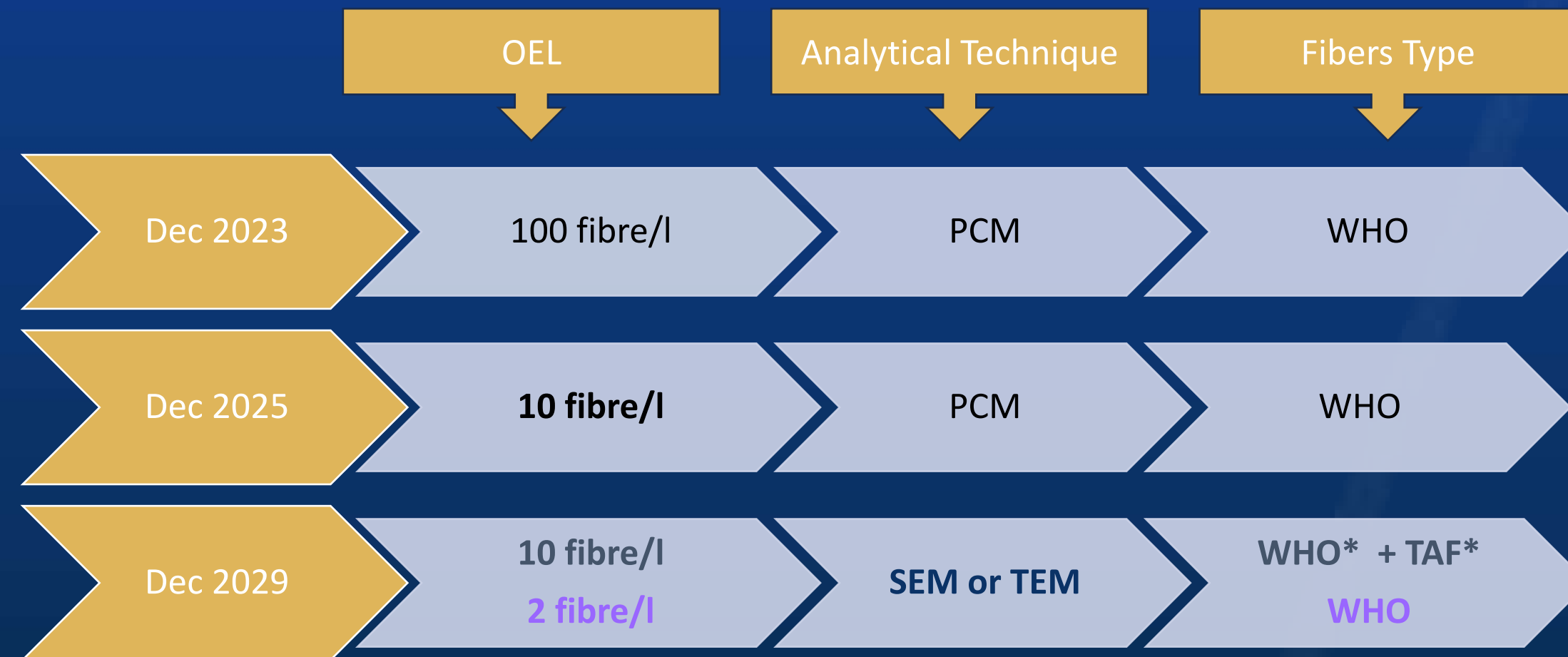
SUMMARY

- Introduction

- Current practices

- New directive impacts

- Conclusion

INTRODUCTION

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MAIN EVOLUTION OF THE DIRECTIVE

	OEL	Analytical Technique	Fibers Type
Dec 2023	100 fibre/l	PCM	WHO
Dec 2025	**10 fibre/l**	PCM	WHO
Dec 2029	10 fibre/l / 2 fibre/l	**SEM or TEM**	**WHO* + TAF*** / WHO

In addition : Focus on worplaces and exposure assessment →Personal monitoring

* WHO fibers : 0,2 µm < Ø < 3µm
* Thin Fibers : 0,02 µm < Ø < 0,2 µm

CURRENT PRACTICES

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Regulation

- OELs differ between countries
- Fibers to consider can be different (WHO fibers, TAF fibers, …)

Sampling

- Static or Personal sampling is used
- Flowrate is adapted to OEL and type of measurement (static, personal)
- Duration is adapted to dust concentration (filter has to be readable)

Analysis

- Analytical Methods can differ (PCM, SEM, TEM)
- Magnification depends on the analytical techniques (PCM, SEM, TEM) and type of fibers to consider

CURRENT PRACTICES

PCM : Example of Asbestos Analysis in UK and Australia

	Personal measurement - UK	Personal measurement - Australia
Standard	HSG 248	NOHSC:3003
Air volume	Flowrate : 1-4 l/min Volume : 120 -> 240 l	Flowrate : 1-4 l/min Volume : 500 -> 1000 l
Sampling time	1-4 hours	1-8 hours
Detection Limit	10 fibre/l	10 fibre/l
Sample analysis	1. Fibre morphology	
Minimum fiber size to be observed	Magnification X 400 -> Minimum Fiber size : 0,2 µm	
Examined area	$1 - 1.5$ mm^2 -> (200 fields)	$1 - 1.5$ mm^2 -> (100 fields)
Time analysis	15 min depending on filter loading	10 min depending on filter loading

CURRENT PRACTICES

SEM : Example of Asbestos Analysis in Germany

	Static measurement	Personal measurement
Standard	VDI 3492	BGI/GUV-I 505-46
Air volume	Flowrate : $2 * \frac{l}{cm^2 * min}$: 2 to 3 L/min Volume : $1800 - 3600L$	Flowrate : $0,24 - 0,3 \frac{l}{cm^2 * min}$: 1 to 1,5 L/min Volume : $300 - 1000L$
Sampling time	4-8h	2-3h
Detection Limit	0,3 fiber /l	$15\ fiber/\ L$ Depending $on\ Air\ volume$
Sample analysis	1. Fiber morphology 2. Chemical composition (EDX), for example Element Ratio Mg/Si>1 3. Or Comparison with reference spectra	
Minimum fiber size to be observed	Magnification about x2000-x2500 -> Minimum Fiber size : 0,2 µm	
Examined area	$min.\ 1\ mm^2$ -> (100 fields)	$min.\ 0,15\ mm^2$
Time analysis	20 min –2 hours depending loading filter	

Types of SEM's	W-Hairpin cathode	LaB6	TFE
Resolution	50nm	30nm	0,6nm
Average device costs	180.000-200.000€	250.000€	300.000-400.000€

CURRENT PRACTICES

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TEM : Example of Asbestos Analysis in France

	Personal measurement
Standard	NFX 43-269 // NFX 43-050
Air volume	Flowrate : 3 L/min Volume : 700 -> 1400 l
Sampling time	4-8h
Detection Limit	3 fiber /l (AS = 1 fiber/l)
Sample analysis	1. Fiber morphology 2. Chemical composition -> Comparison with reference spectra 3. Cristalline structure -> Diffraction pattern
Minimum fiber size to be observed	Magnification X 10000 -> Minimum Fiber size : 0,02 µm
Examined area	0,15 % of the sampling filter or field number to reach analytical sensitivity 100 - > 300 fields
Time Analysis	1 to 3 hours depending of loading filter and sampling volume

TEM	W cathode or LaB6 Cathod
Resolution	0,1 nm
Average device costs	~ 400.000€

Magnification of 10 000 is linked to analysis of Thin fibers .
Human eyes can detect an object only if its size is over 0,05 mm. To see a fiber with a size of 20 nm, the magnification has to X 10 000

CURRENT PRACTICES

SYNTHESIS

	PCM (UK, Australia)	SEM (Germany, Italy)	TEM (France)
Sample Collection			
Flowrate (L/min)	1-4	1-4	3
Sample duration (hours)	1-4 1-8	3-8 4-8	4 -8
Sample volume (L)	120-240 500-1000	300-1000 480-1000	700 - 1400
Sample Analysis			
Fibre type	WHO	WHO	WHO + TAF
Magnification	X 400	X 2000	X 10 000
Fibre identification	No	Yes	Yes
Number of fields	200 100	100-150	100-150
Detection limit (f/L)	10	5	3

CURRENT PRACTICES

SYNTHESIS

|	PCM UK, Australia	PCM UK, Australia	PCM UK, Australia
Sample Collection			
Flowrate (L/min)	1 - 4	1 - 4	3
Sample Duration (h)	1 - 4 / 1-8	3 – 8 / 4 - 8	4 -8
Sample Volume (l)	120 – 240/ 500 - 1000	300 – 1000 / 480 - 1000	700 - 1400
Sample Analysis			
Fibre type	WHO	WHO	WHO + TAF
Magnification	X 400	X 2000	X 10 000
Fibre Identification	No	Yes	Yes
Number of fields	200 / 100	100 - 150	100 - 150
Detection Limit	10	5	3

CURRENT PRACTICES

SYNTHESIS

PCM

SEM

TEM
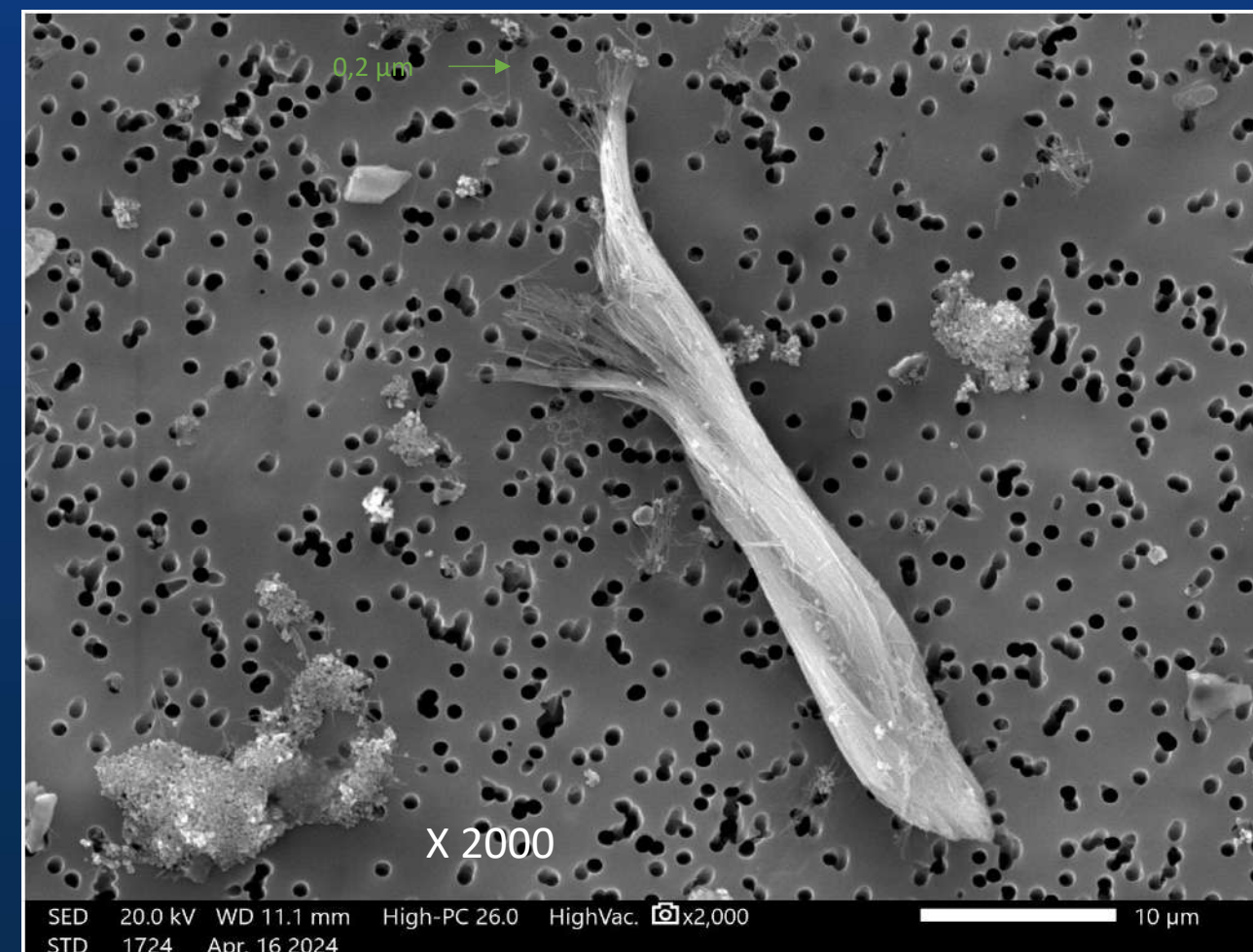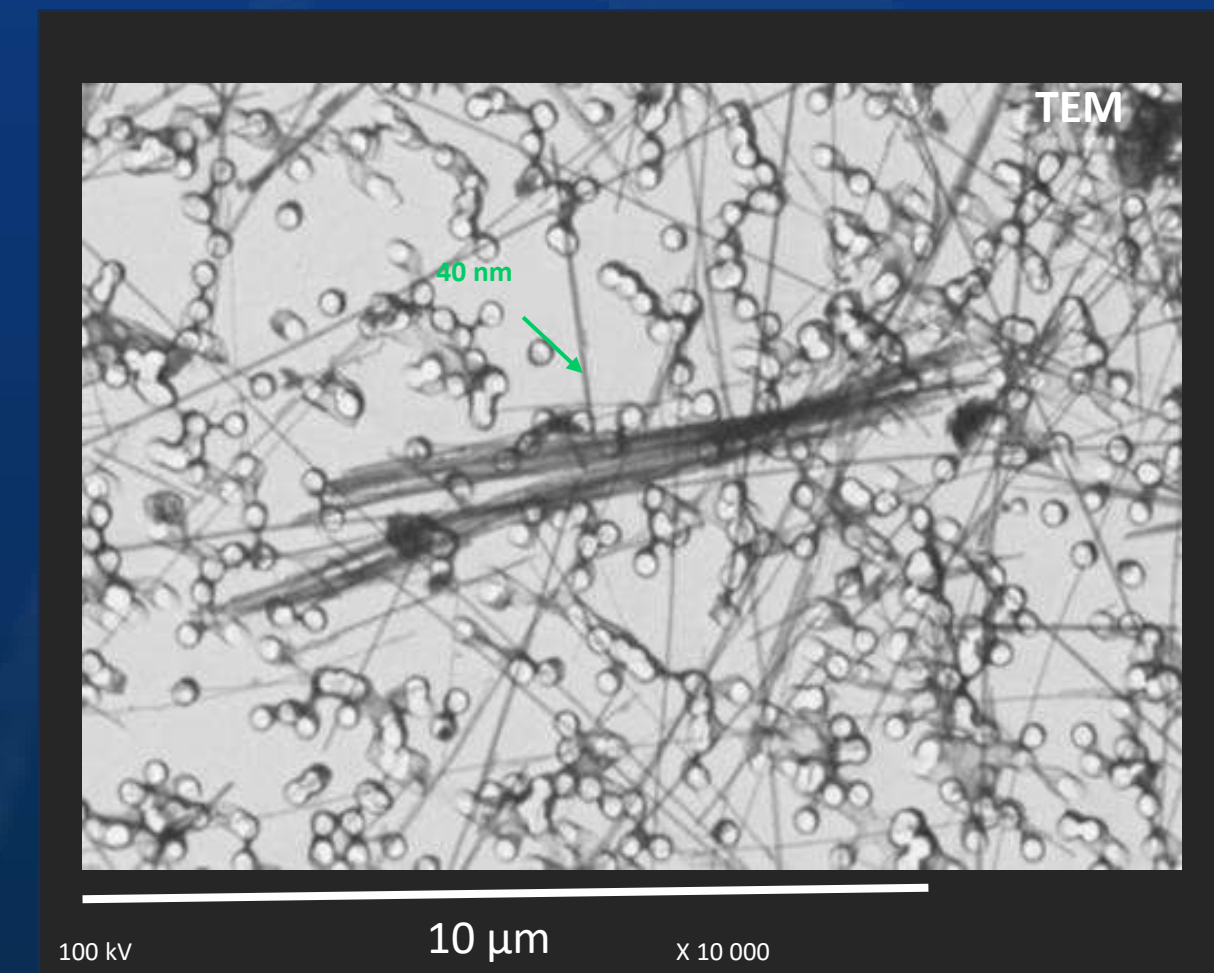
EVALUATION METHODOLOGY

1. Requirement

- Occupational exposure limit : OEL
- Analytical sensivity
- Range of fibres to count [0 – 100]

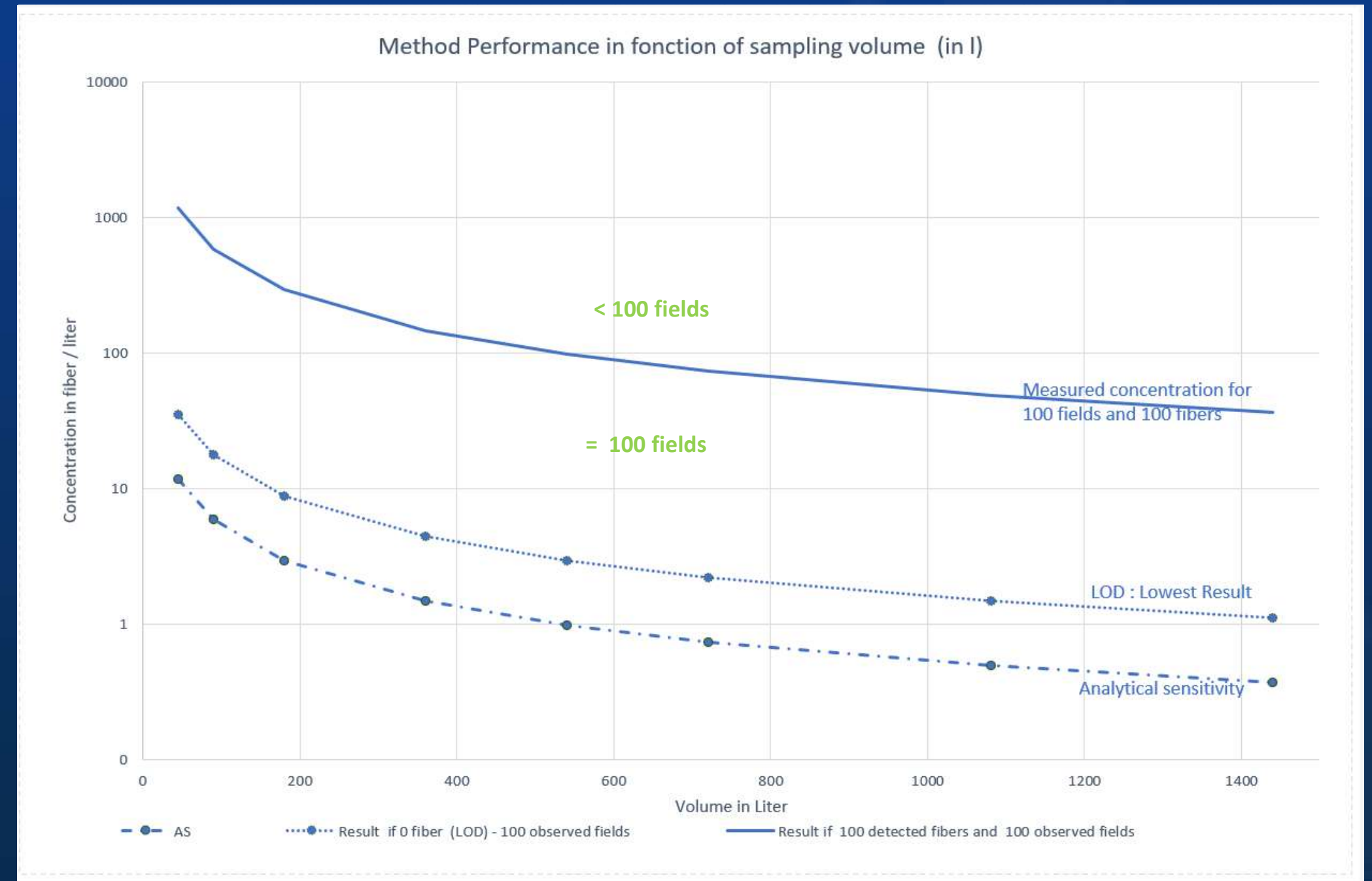Method Performance in fonction of sampling volume (in l)
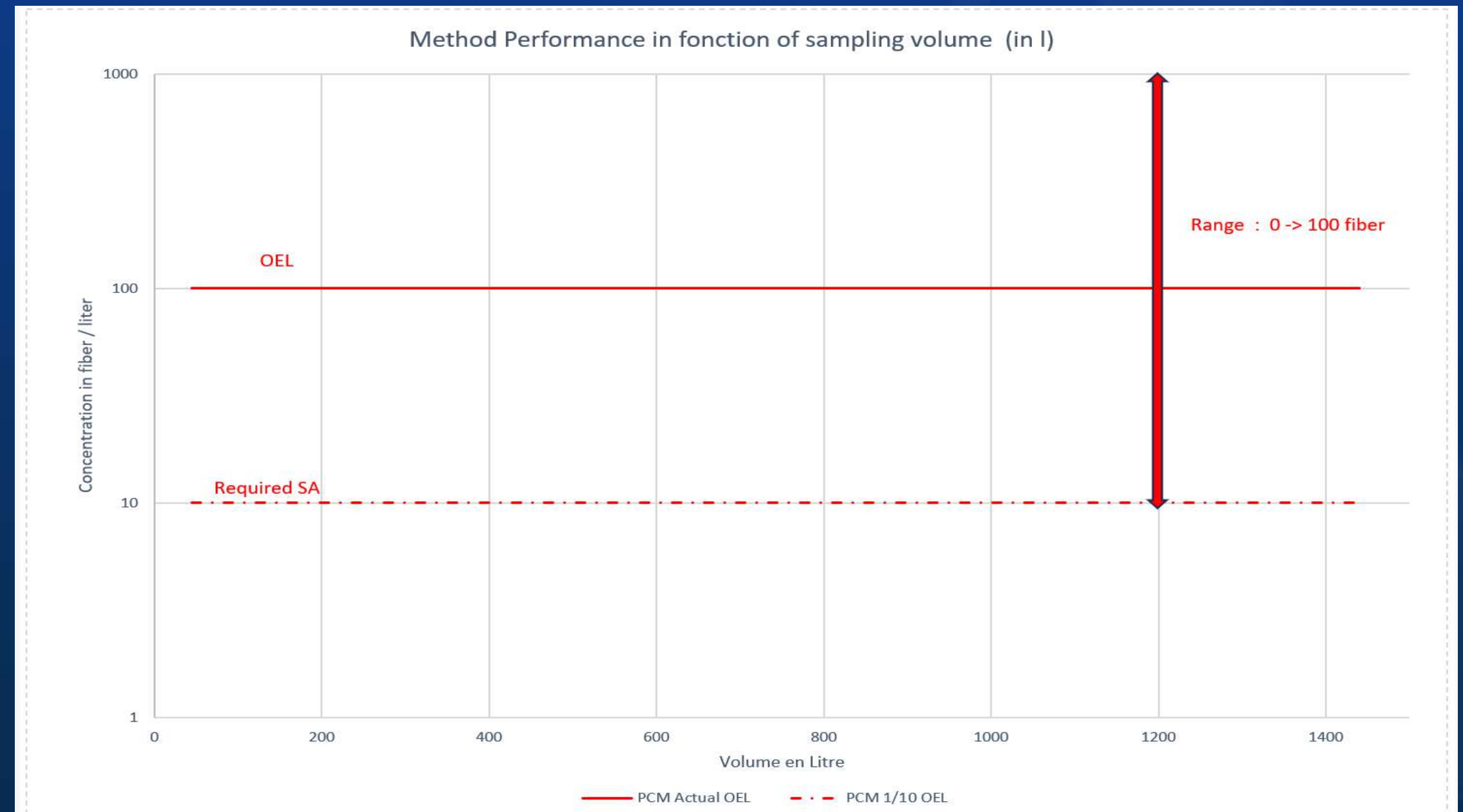
Methods must demonstrate the compliance of the result with the OEL
The analytical sensitivity (1 detected fiber during analysis) has to be at least 1/10 OEL

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EVALUATION METHODOLOGY

2. Method performances

- **Analytical sensitivity** : Corresponds to one fiber detected during the analyse

- **Detection limit** = 3 * SA : Correspond to upper limit of the 95% confidence interval fof the concentration for zero detected fiber

- **Criteria to stop analysis currently**: either 100 fibers counted, either 100 fields scanned

Method Performance in fonction of sampling volume (in l)

< 100 fields

= 100 fields

Measured concentration for 100 fields and 100 fibers

LOD : Lowest Result

Analytical sensitivity

- • - AS ·····•····· Result if 0 fiber (LOD) - 100 observed fields ——— Result if 100 detected fibers and 100 observed fields

For High concentration: 100 fibers are counted before scanning 100 fields
For low concentration: less than 100 fibers are counted even if 100 fields are scanned

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EVALUATION METHODOLOGY

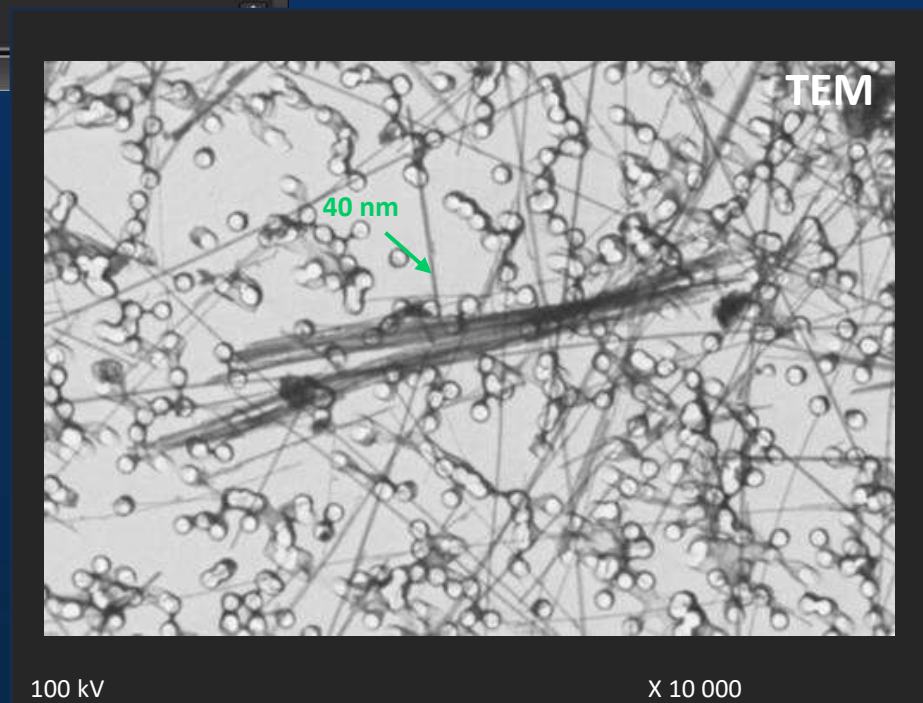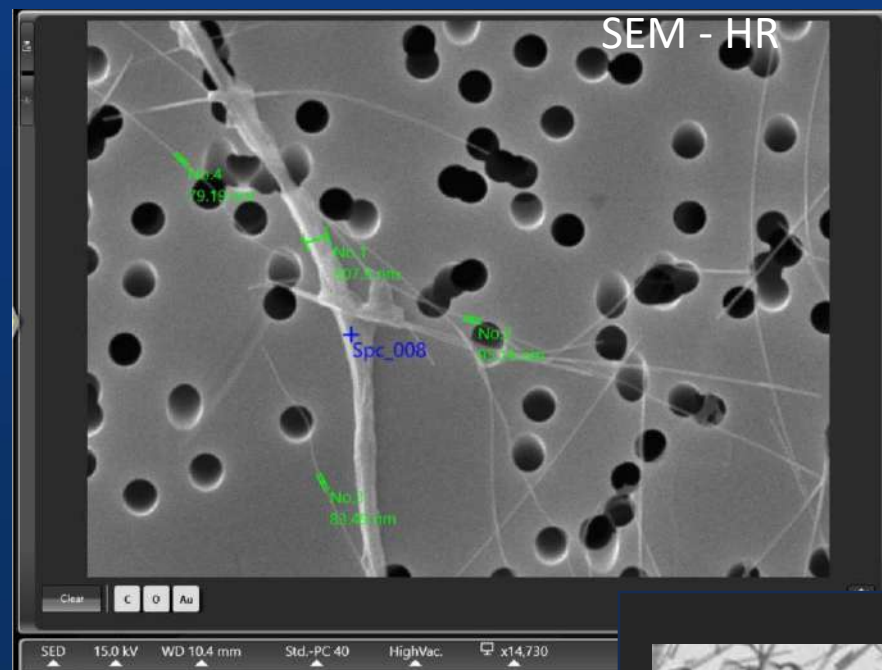## 3. Comparaison between requirements and performance criteria

- Method AS < Required AS
- Lowest result < OEL

Method Performance in fonction of sampling volume (in l)
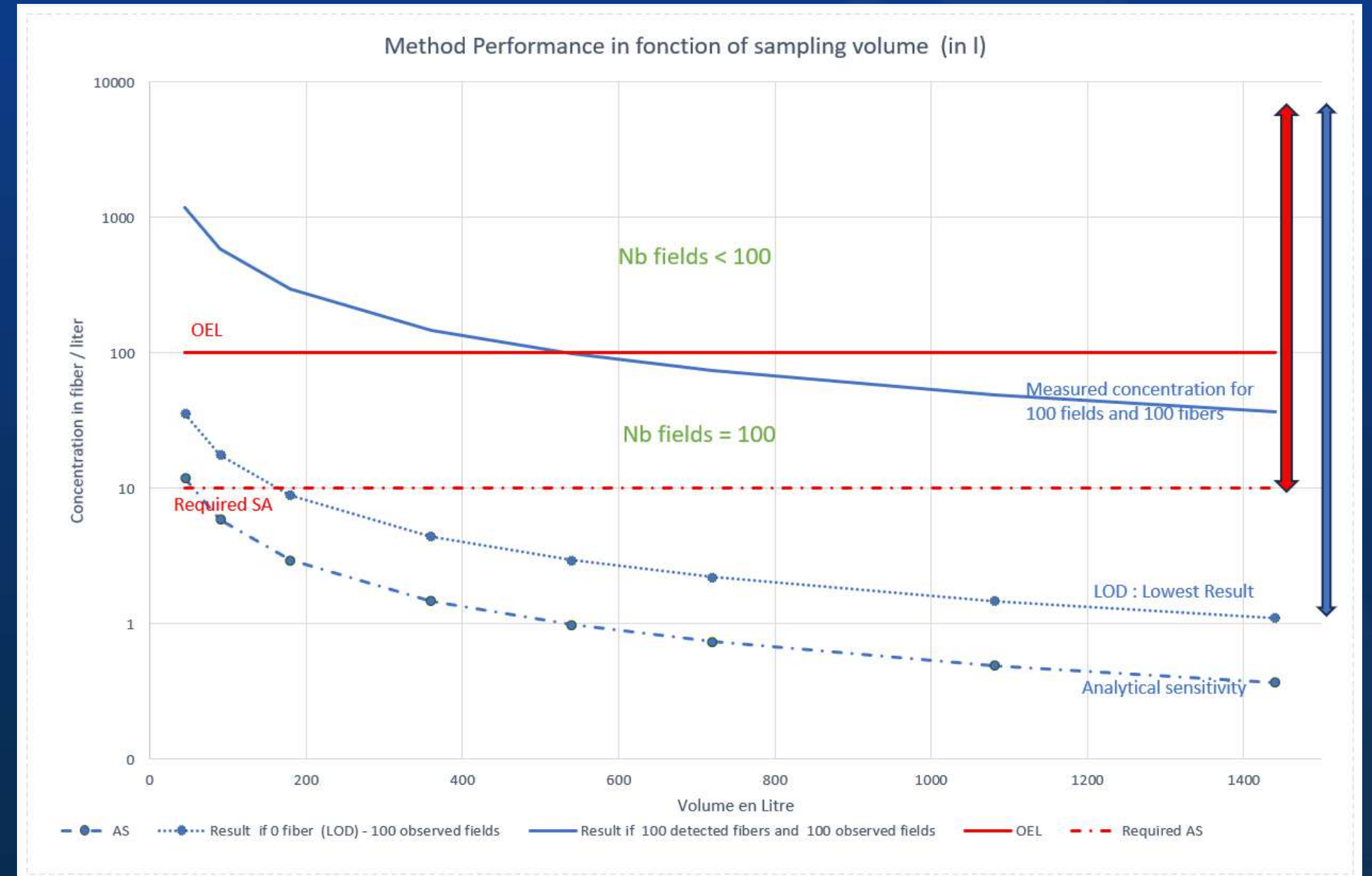
- Conclusion: To compare a result with an OEL of 100 fibers /liter,
- It is possible to sample from 50 to 1500 l and to observe a maximum of 100 fields

NEW DIRECTIVE IMPACTS

TRANSITION

SEM - HR

TEM

100 kV   X 10 000

Performance criteria

- **Technical performances** are defined by **analytical sensitivity** or detection limit

- **Economical performances** are lead by the **number of fields** to observe for the same volume

Other considerations

- **SEM High resolution** and **TEM** are able to detect and identify Thin fibers

  → **OEL of 10 fibers /liter** is usuable

- **SEM Low resolution** detect and identify only WHO fibers

  → **OEL of 2 fibers/liter** is usuable

- Note : The **blank filter** can contain a level of non identified structures higher to the OEL of 2 fibers /liter, which makes analysis impossibe in most of cases and **excludes PCM**
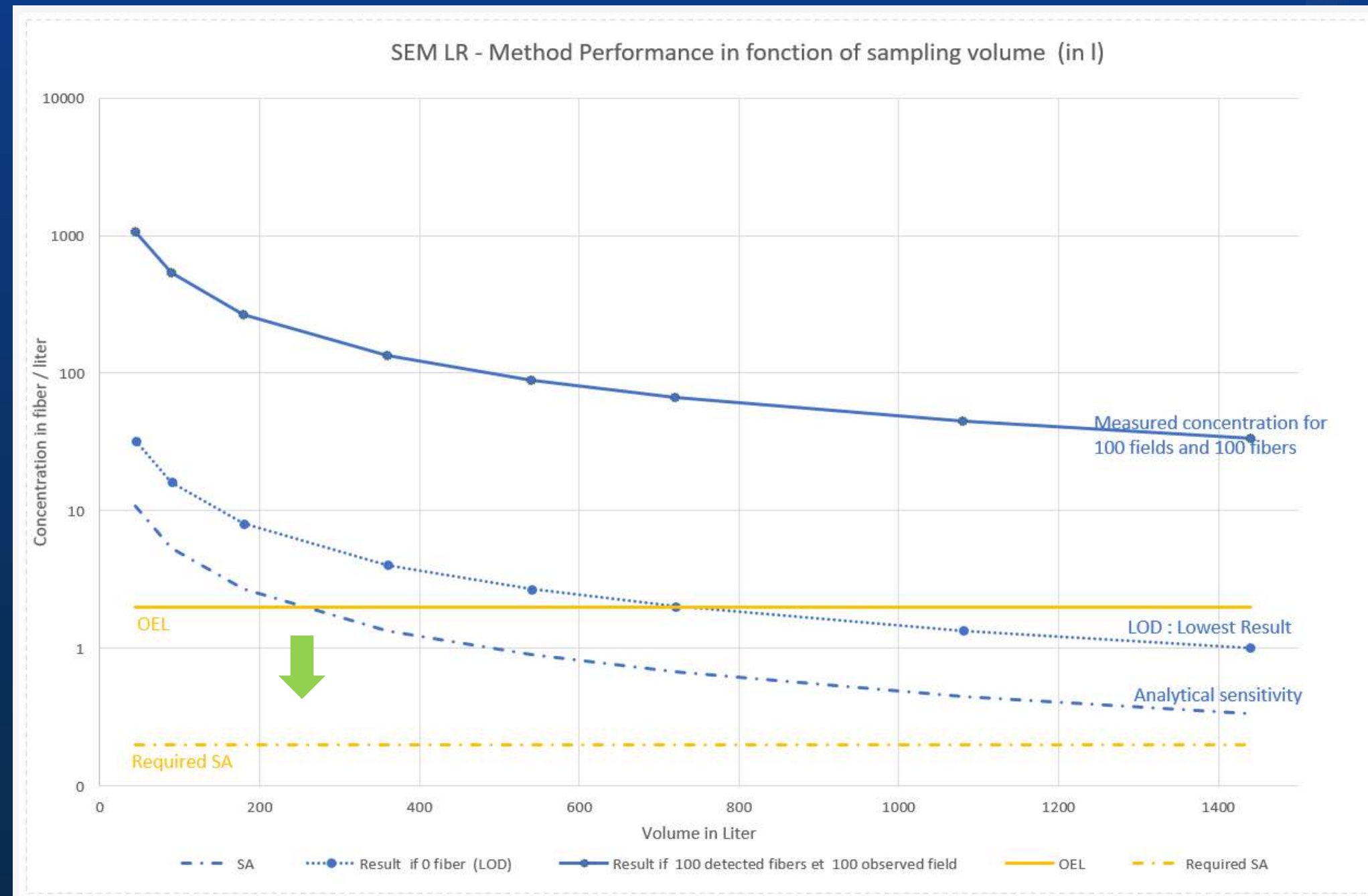
NEW DIRECTIVE IMPACTS

TEM and SEM – HR / OEL of 10 fiber/L
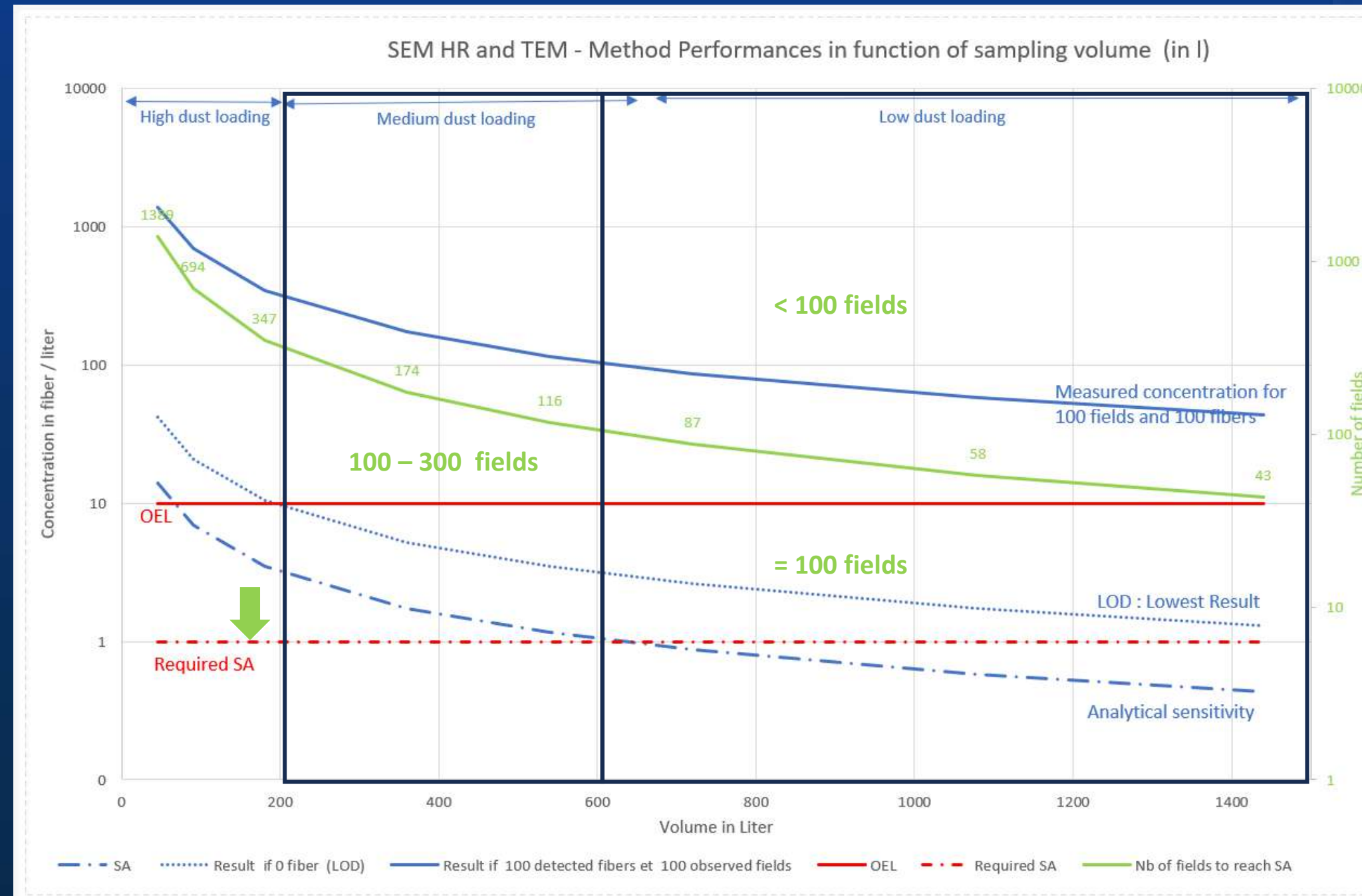
Analysis is possible with observation of at least 100 fields if volume is higher than 600 l
For places with dust loading that lead to a volume < 600 l -> Need to increase the number of fields to 300
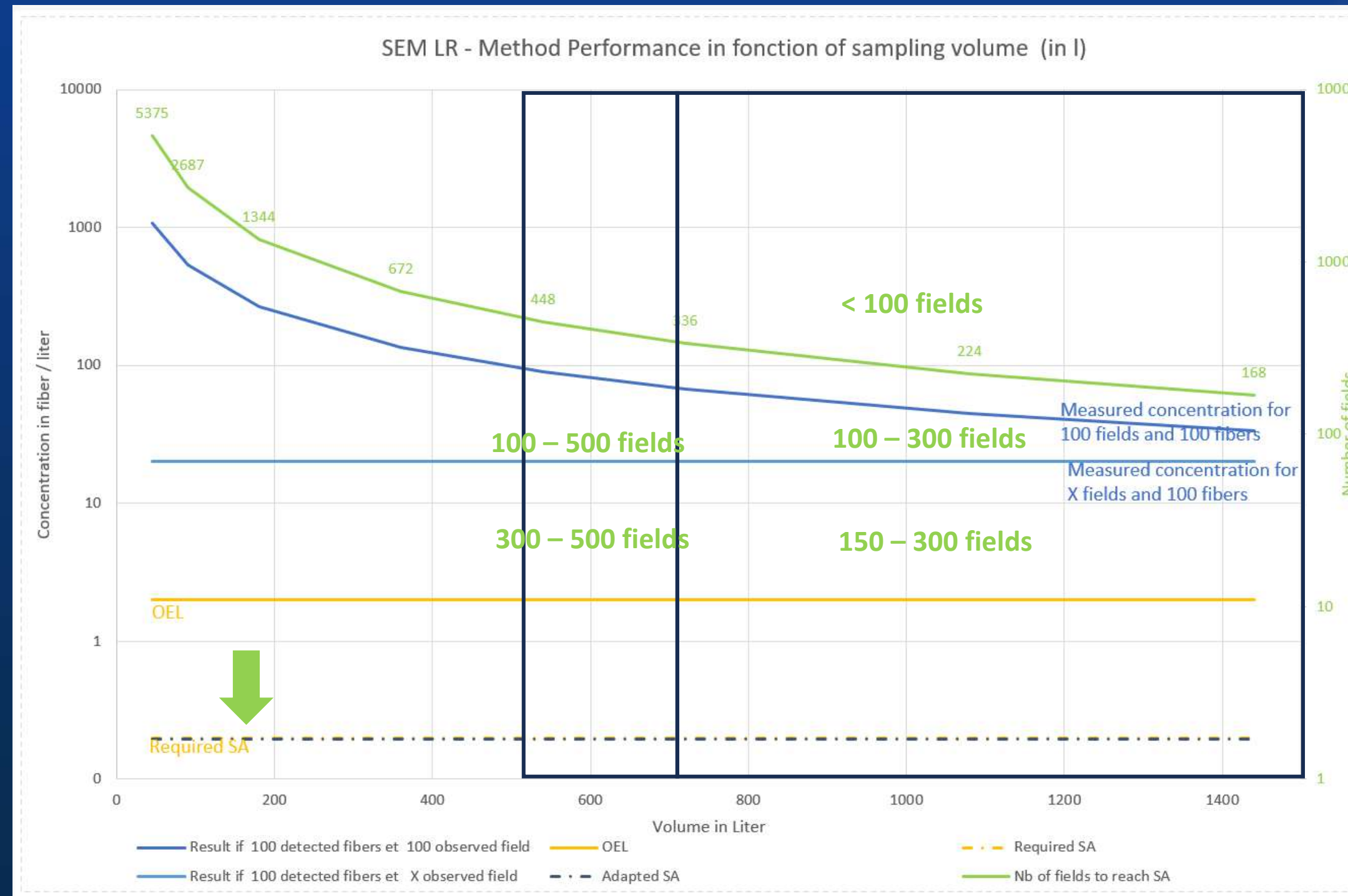
NEW DIRECTIVE IMPACTS

SEM LR /OEL of 10 fiber/L

- It's not possible to reach the SA required with 100 fields, regardless of the volume
- Application field is dedicated for the moment to high concentrations

SEM LR /OEL OF 2 FIBER /L

For a volume of 700 l, the AS is reachable between 100 and 300 fields to read
With significative analytical efforts, it could be possible to go to 500 fields and consider volumes until 500 l
Criteria to stop analysis has to be modified : 100 fibers or 100 fields or AS reached

SYNTHESIS

- For high concentration C > 100 fibers/liter :
  100 fibers or 100 fields is an adequate criteria whatever the method used

- For Low concentration
  - Volume has to be increased
  - Number of fields has to be increased

	SEM LR OEL = 2		SEM HR OEL = 10		TEM OEL = 10	
Volume in Liter	500-700	700 - 1500	200-600	600-1500	200-600	600-1500
Nb fields	300 - 500	150 - 300	100-300	< 100	100-300	< 100

Note : To have a significative projection of the effort to do, need to have the real expected concentration

CONCLUSION

- Current practices differ between countries

- New directive suggests limit value based on capabilities of the method used

- Future methods will be those with:
  - Personal sampling – some standards to be modified (eg VDI with flowrate of 8l/min)
  - OEL of 10 f/L – SEM high resolution or TEM – New standards has to be developed for Thin fibers
  - OEL of 2 f/L – SEM low resolution

- PCM will not be suitable – will need to move to electron microscopy

- Compromise between sampling and analysis to achieve required analytical sensitivity:
  - Optimal volume: 1000L
  - Optimal flowrate: limited by portable pump – 3-4 L/min to achieve volume
  - Optimal fields to read: 100-500 fields

- Price increases expected (investment, time to analyse)

- The increased workload can most likely only be handled with the help of automation, especially with an OEL of 2

FURTHER CONSIDERATIONS

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- Could PCM remain as a complementary technique to provide fast results in the field

- How to define the limit between SEM low resolution and SEM high resolution

- How to compare the results between different methods
  - Is the fibre count results similar between methods (proficiency testing)
  - Is the conclusion (compliance with the limit value) similar between methods

- Modification for clearance expected and the adoption of the same rules than personal sampling could occur

SPECIAL THANKS TO

Martine CHOUVET – France - ITGA (AFEL)

Johannes WEBER – Germany - TüV SüD

Matthew OWEN – Australia - IDENTIFIBRE (FAMANZ)

Günnar RIES – Germany-CRB Analyse Service GmbH

Jan VAN BOUWEL – Belgium - FEDASBEST

Bernard HERMANS – Belgium- FEDASBEST

Salvatore TRIPODI – Italy - INDAM

John RICHARDS – UK- Thames laboratories (ATAC)

Joel GUENIAT – Switzerland - Analysis Lab