

ThermoFisher
S C I E N T I F I C

The world leader in serving science

ON-line Slag and Iron Analysis using an automated cost effective WD-XRF instrument

Steinfurt 2 march 2009

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ARL OPTIM'X: Unique Wavelength Dispersive XRF

WD-XRF
SmartGonio™
Flexible, versatile,
elemental analysis

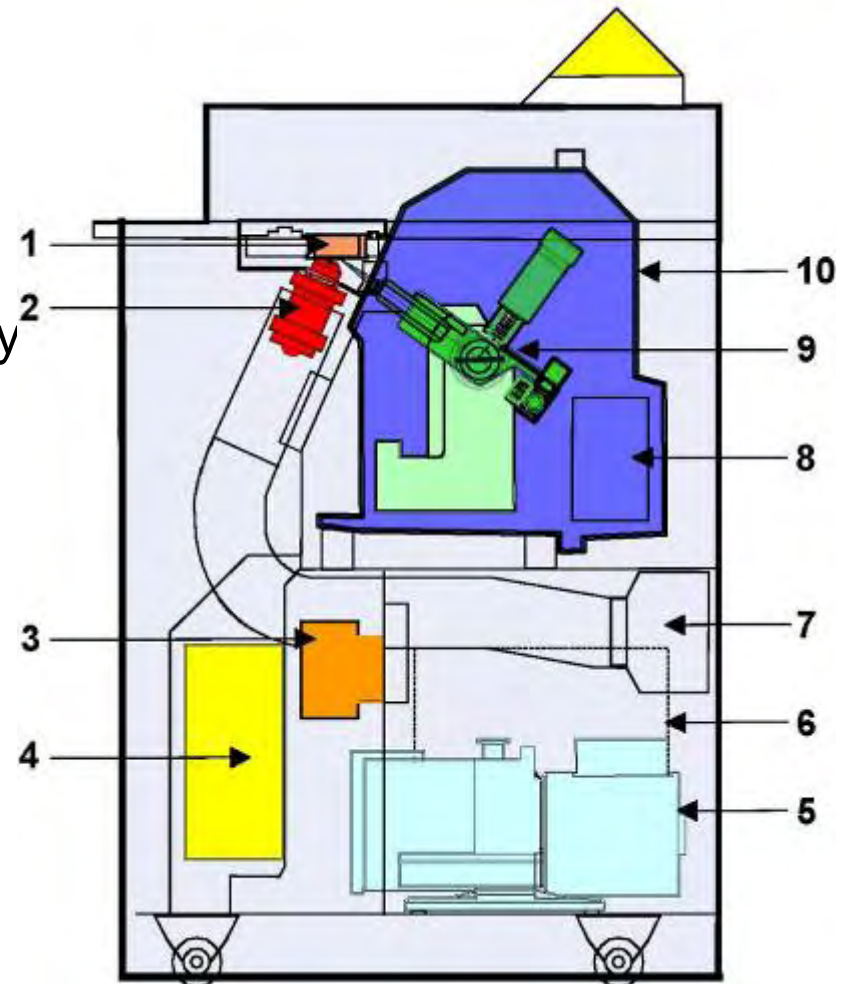
WD-XRF
Multichromators™
Rapid, dedicated
routine analysis



ARL OPTIM'X

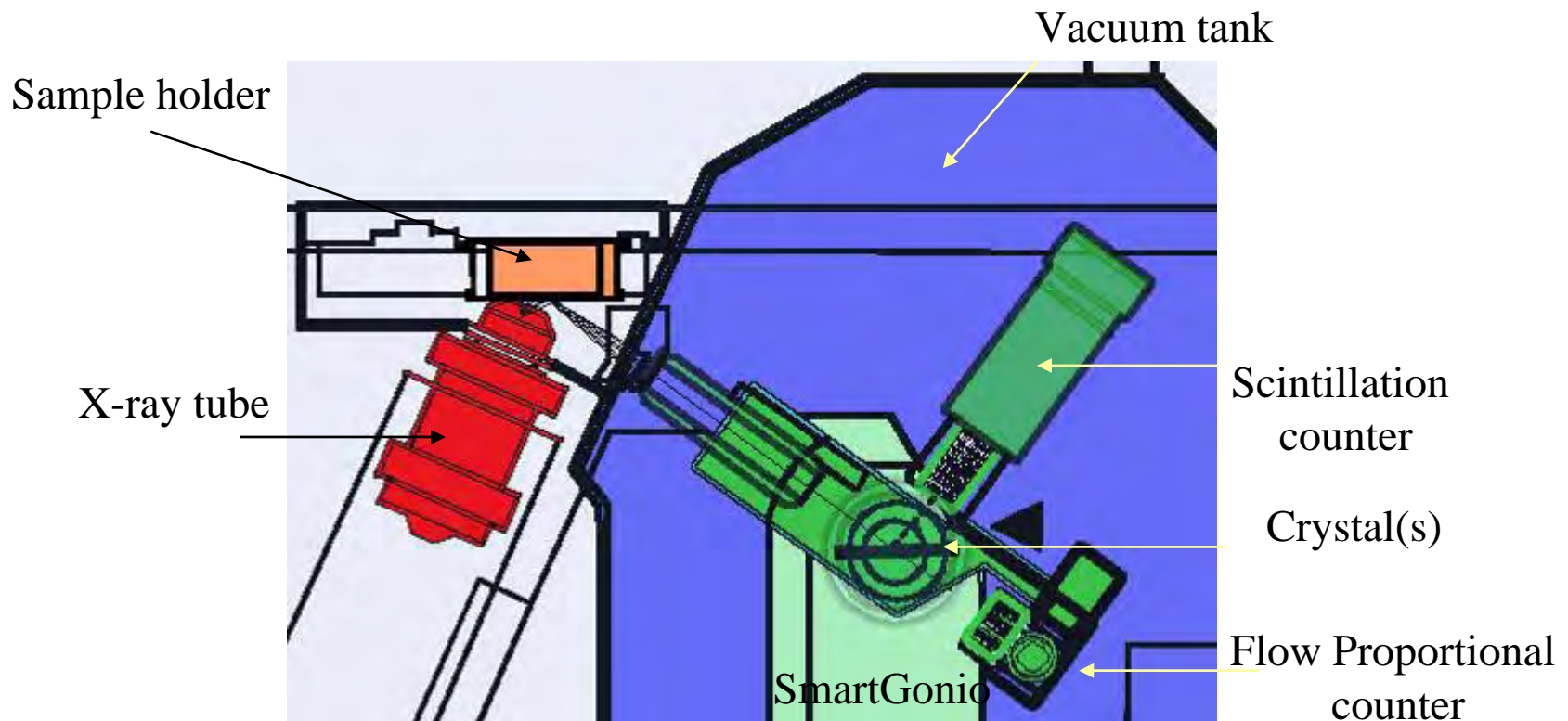
■ Side view

- 1 Sample
- 2 X-ray Tube
- 3 High voltage Power Supply
- 4 Low voltage power supply
- 5 Vacuum Pump
- 6 Electronic Rack
- 7 X-ray Tube cooling
- 8 Carte XMI
- 9 SmartGonio™
- 10 Vacuum tank



Close coupling

- Unique mini X-ray tube (50W - air cooled)
- SmartGonio ; 2 detectors, 3 crystals
- Multichromators; up to 8 fixed channels



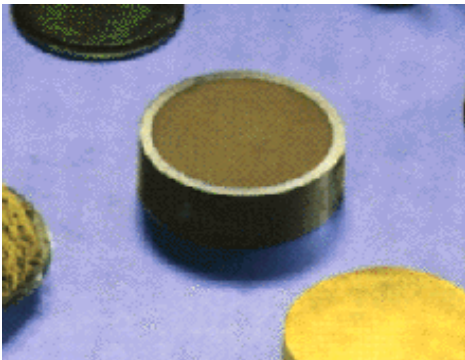
Sample holders

- Cassettes for solid samples (in manual mode)
 - Max. height 20mm - max. diameter 52 mm
 - 29 mm opening diameter



Analysis in a blast furnace process with ARL Optim'X

- Elemental analysis of
 - Slags as pressed pellets
 - Slags as directly cast slags
 - Hot metal



Slags analysis with low power WDXRF

Pressed pellets – typical ranges and accuracy

Elements/ Oxides	Analytical device	Calibration ranges	SEE (%)
Fe₂O₃	SmartGonio™	1.6% - 34%	0.27
Al₂O₃	SmartGonio™	1% - 52%	0.19
MgO	Fixed	3.1% - 12.2%	0.22
P₂O₅	SmartGonio™	0.021% - 0.9%	0.012
S	SmartGonio™	0.035% - 0.21%	0.007
SiO₂	SmartGonio™	4.2% - 16.3%	0.22
CaO	SmartGonio™	30% - 58%	0.33
MnO	SmartGonio™	1.5% - 4.9%	0.027

ARL Optim'X – 50W – Rh anode

SEE= standard error of estimate is an average estimation of accuracy

Slags analysis with low power WDXRF

Pressed pellets – Precision test

Element /Oxide	Analytical device	Counting time	Slag 491		Slag 82	
			<i>Average concentration %</i>	<i>Typical Std.Dev. %</i>	<i>Average concentration %</i>	<i>Typical Std.Dev. %</i>
Al₂O₃	SmartGonio	20 s	38.52	0.028	1.16	0.02
CaO	SmartGonio	20 s	46.49	0.055	35.57	0.035
Fe	SmartGonio	20 s	2.51	0.01	32.7	0.04
MnO	SmartGonio	20 s	1.69	0.006	2.17	0.007
MgO	Fixed channel	Fixed	6.25	0.02	7.21	0.04
P₂O₅	SmartGonio	20 s	0.0332	0.0036	0.476	0.01
S	SmartGonio	20 s	0.069	0.0018	0.061	0.001
SiO₂	SmartGonio	20 s	5.99	0.03	6.92	0.028

ARL Optim'X - 50W – Rh anode tube – 10 repeats

ARL Optim'X: Excellent long term reproducibility

1 analysis every 4 hours over 36 hours

Counting time Time of analysis	CaO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	K ₂ O	Na ₂ O	SO ₃	P ₂ O ₅	TiO ₂	MnO
	30s PET	40s PET	20s PET	10s PET	30s AX06	6s PET	10s AX06	20s PET	10s PET	10s PET	10s PET
28.11.2008 15:00	63.78	20.23	5.15	2.90	1.90	0.915	0.192	3.26	0.214	0.227	0.126
28.11.2008 19:00	63.83	20.29	5.15	2.90	1.86	0.913	0.205	3.27	0.246	0.241	0.121
28.11.2008 23:00	63.81	20.27	5.17	2.90	1.85	0.905	0.193	3.28	0.262	0.222	0.121
29.11.2008 03:00	63.86	20.29	5.15	2.89	1.90	0.919	0.210	3.24	0.258	0.226	0.125
29.11.2008 07:00	63.88	20.26	5.15	2.88	1.87	0.907	0.196	3.28	0.247	0.227	0.121
29.11.2008 11:00	63.79	20.28	5.16	2.89	1.86	0.920	0.203	3.26	0.260	0.223	0.122
29.11.2008 15:00	63.81	20.23	5.16	2.89	1.85	0.928	0.199	3.25	0.245	0.229	0.117
29.11.2008 19:00	63.82	20.26	5.15	2.91	1.89	0.928	0.191	3.28	0.272	0.233	0.122
29.11.2008 23:00	63.82	20.28	5.15	2.91	1.86	0.924	0.198	3.27	0.244	0.227	0.126
30.11.2008 03:00	63.86	20.25	5.13	2.89	1.86	0.914	0.199	3.27	0.253	0.234	0.119
Average	63.83	20.26	5.15	2.89	1.87	0.92	0.20	3.27	0.25	0.23	0.122
St. dev. (1 sigma)	0.032	0.022	0.010	0.009	0.019	0.008	0.006	0.014	0.016	0.006	0.003

- Same pressed pellet analyzed every 4 hours over 36 hours
- No drift correction
- Analysis time per run for 11 elements/oxides: 3 minutes 16s

Analysis of slags

- Elemental analysis of slag using XRF
 - As pressed pellets
 - As directly cast slags
 - using specially designed probes or moulds for sample taking



Analysis of slags

Preparation as directly cast slag

Elements/ Oxides	Analytical device	Calibration ranges	SEE (%)
Al₂O₃	SmartGonio™	5% - 12%	0.074%
MgO	SmartGonio™	2.4% - 9%	0.14%
SiO₂	SmartGonio™	34% - 38%	0.23%
CaO	SmartGonio™	32% - 47%	0.24%
Cr₂O₃	SmartGonio™	1.6% - 7.8%	0.16%

ARL Optim'X – 50W – Rh anode tube
SEE= standard error of estimate

Analysis of slags

Preparation as directly cast slag

- Precision test on the same sample using two different counting times

Element/ Oxide	Analytical device	<i>Average concentration %</i>	Counting time	<i>Std.Dev. %</i>	Counting time	<i>Std.Dev. %</i>
Al₂O₃	SmartGonio™	9.74	20 s	0.034	40 s	0.027
CaO	SmartGonio™	44.1	20 s	0.034	40 s	0.033
Cr₂O₃	SmartGonio™	4.59	20 s	0.018	40 s	0.017
MgO	SmartGonio™	3.17	20 s	0.018	40 s	0.013
SiO₂	SmartGonio™	36.2	20 s	0.041	40 s	0.026
Total counting time			100s		200s	

ARL Optim'X – 50W – Rh anode tube

Conclusion about slag analysis

- Sample preparation is slowly evolving towards directly cast slags
 - speeds up the analysis
 - avoids grinding and pressing
- Low power WD-XRF can do reliable and easy determination of elemental content in slags
- Light elements like Fluorine can also be analyzed satisfactorily with such instruments.

Irons analysis with ARL Optim'X WDXRF

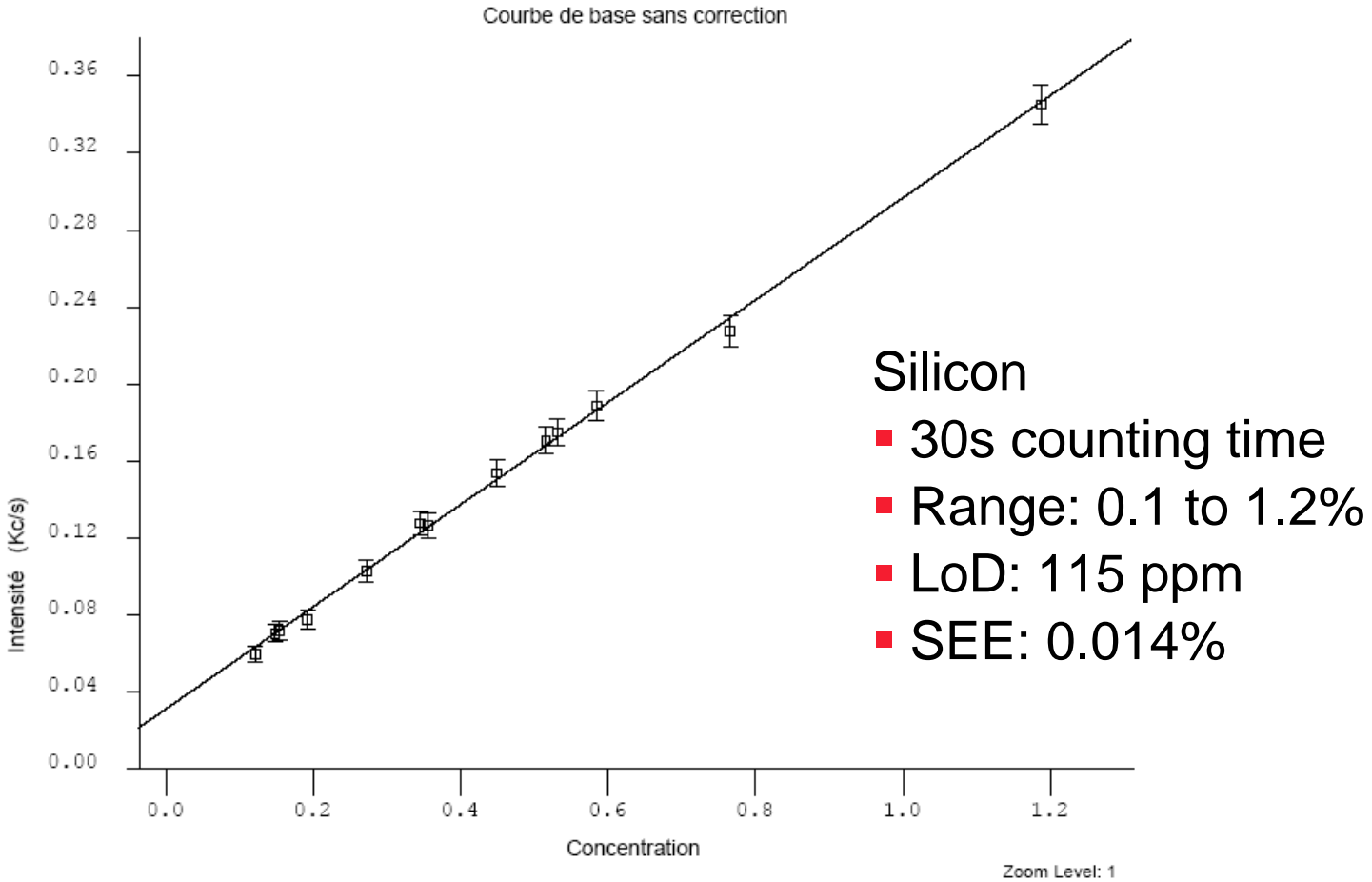
Analysis of hot metal during desulfurisation process

- Analysis of Si, Mn, S, Zn, P and Ti
- Total analysis time for 6 elements : 2 min 40s
- 50W – Rh anode X-ray tube



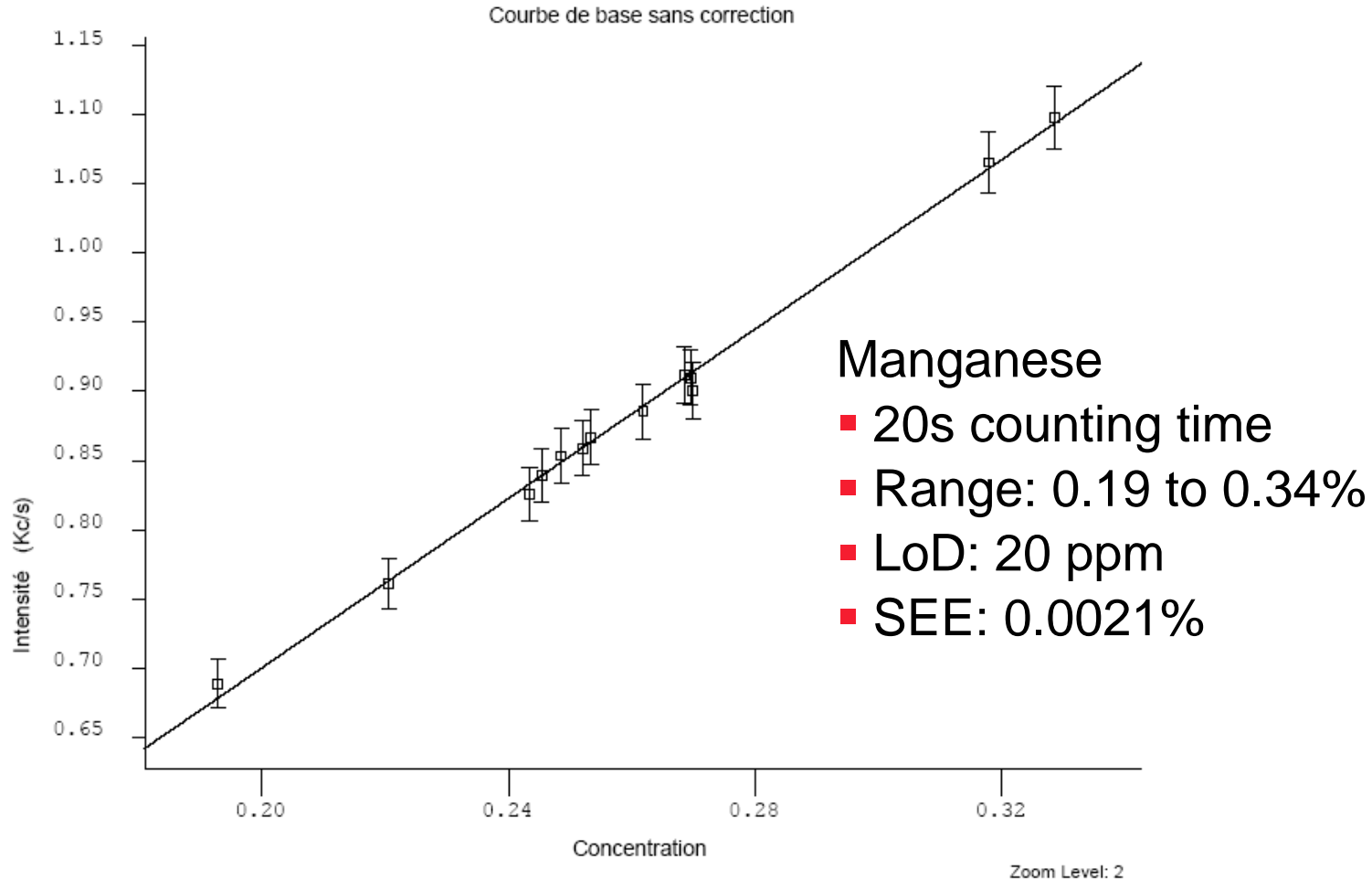
Irons analysis – WDXRF low power

Analyte: SiKa_Cl LDD (30 s): 115.1 ppm BEC: 0.117 % Q: 0.266 (Kc/s)/% SEE: 0.0136



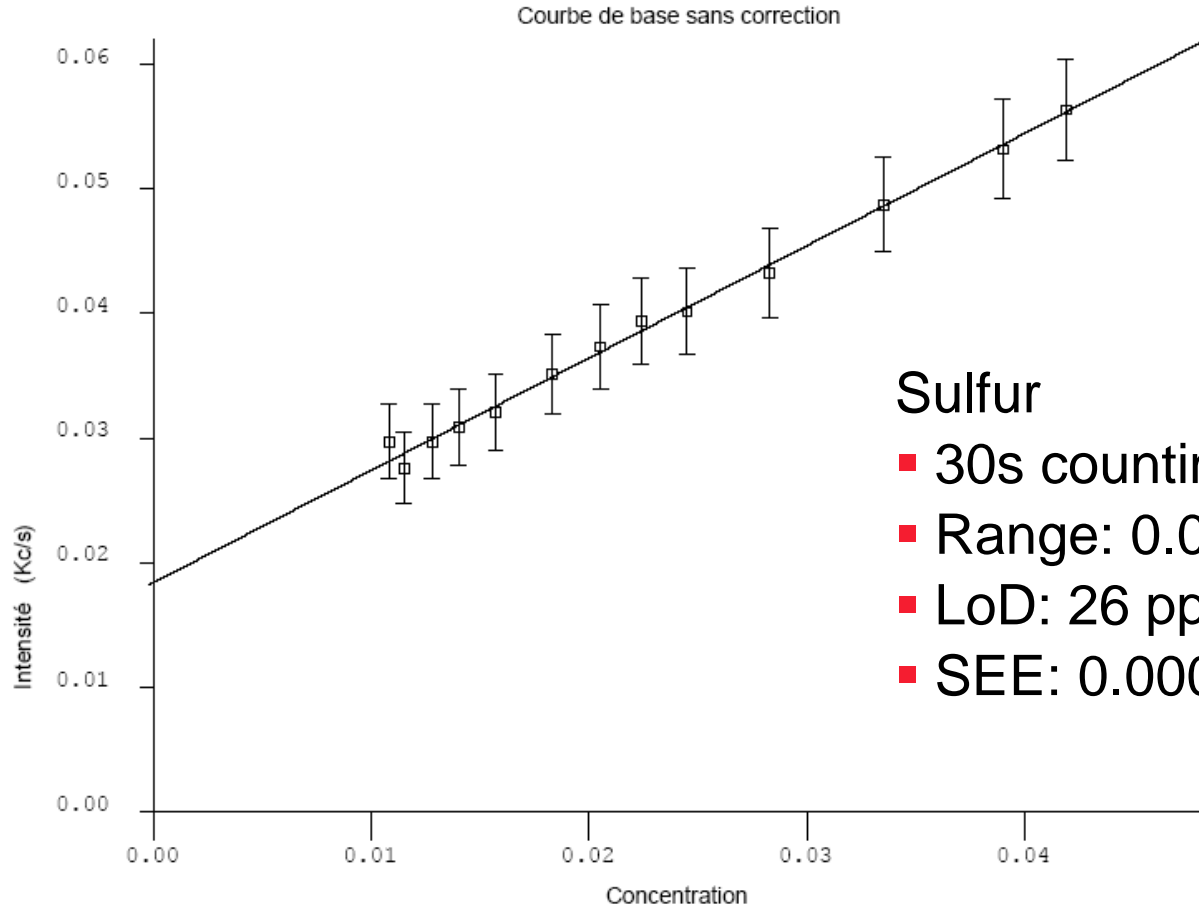
Irons analysis – WDXRF low power

Analyte: MnKa_CI LDD (20 s): 20.4 ppm BEC: 0.028 % Q: 3.064 (Kc/s)/% SEE: 0.0021



Irons analysis – WDXRF low power

Analyte: S Ka_Cl LDD (30 s): 26.1 ppm BEC: 0.020 % Q: 0.901 (Kc/s)/% SEE: 0.0008

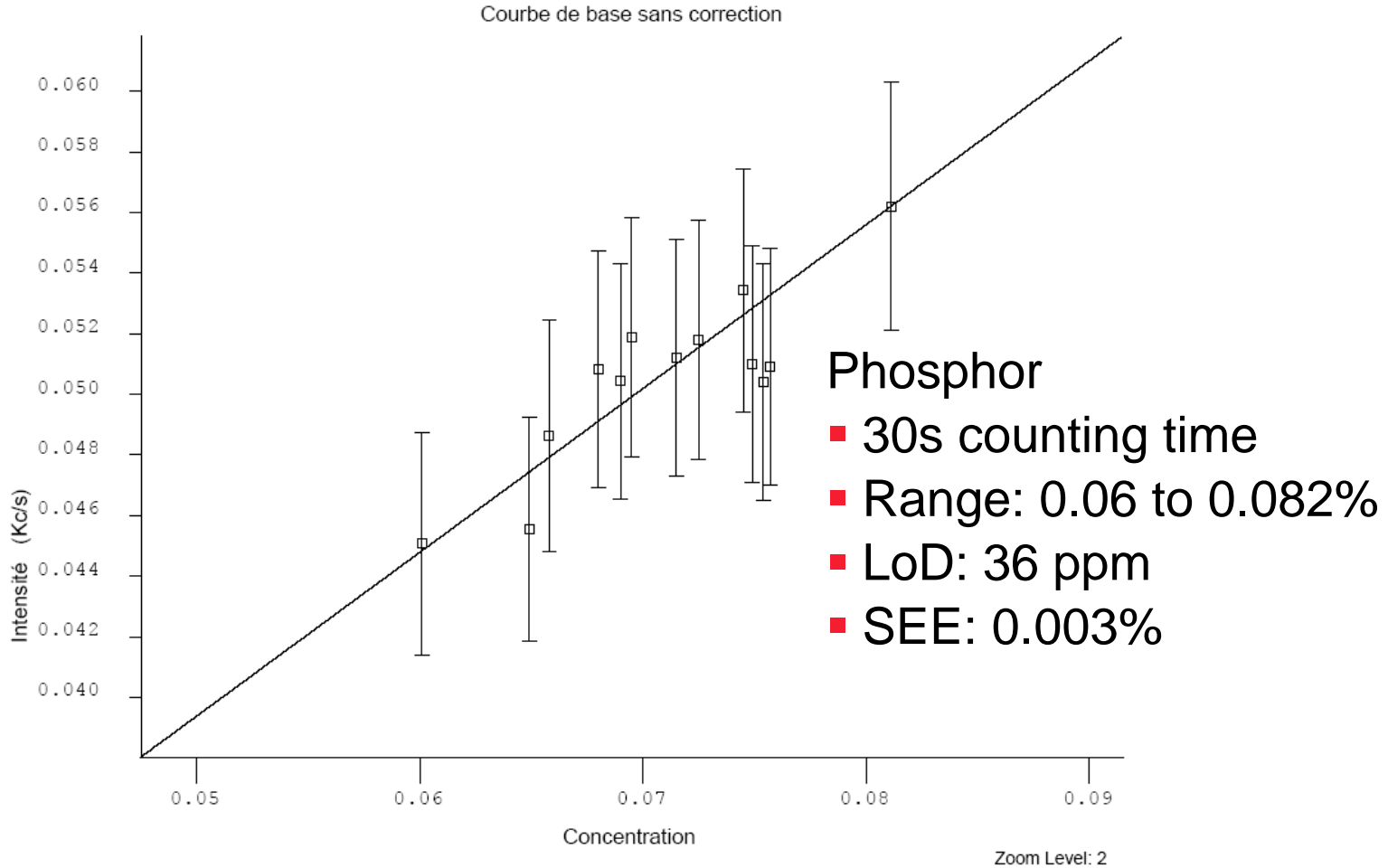


Sulfur

- 30s counting time
- Range: 0.01 to 0.042%
- LoD: 26 ppm
- SEE: 0.0008%

Irons analysis – WDXRF low power

Analyte: P Ka_Cl LDD (30 s): 35.6 ppm BEC: 0.023 % Q: 0.541 (Kc/s)/% SEE: 0.0030



automation of ARL Optim'X SMS Omega

- Automatic Analysis
 - Automatic preparation of samples
 - Fused beads or pressed pellets
 - Conveyed on transport belt
 - Loaded automatically in instrument



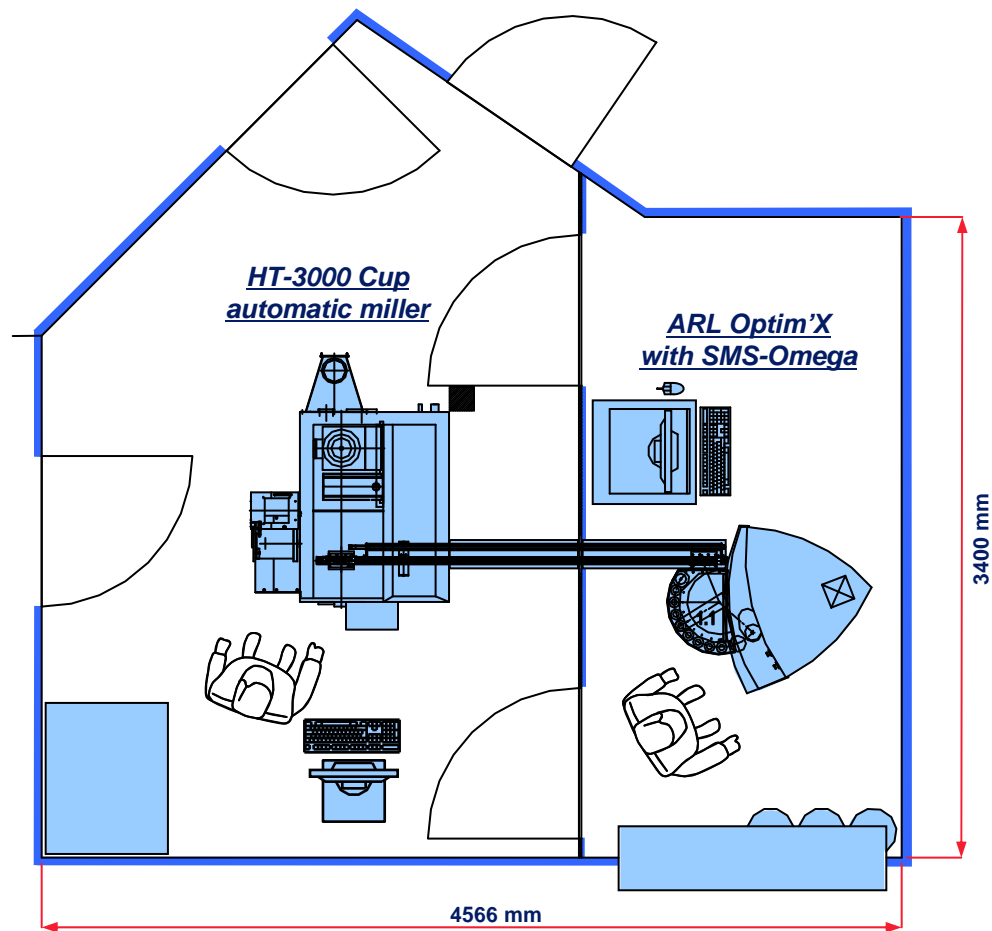
Automation of ARL Optim'X SMS Omega

- Automatic Analysis
 - Automatic preparation of samples
 - Fused beads or pressed pellets
 - Conveyed on transport belt
 - Loaded automatically in instrument
 - Pumped down and analysed
 - Results transmitted to relevant computers
 - Management of samples after analysis
 - Fused beads are stored
 - Pressed pellets are returned to prep machine
- Other samples can be loaded manually
- Automatic SPC (statistical process control)
 - Automatic analysis of control samples

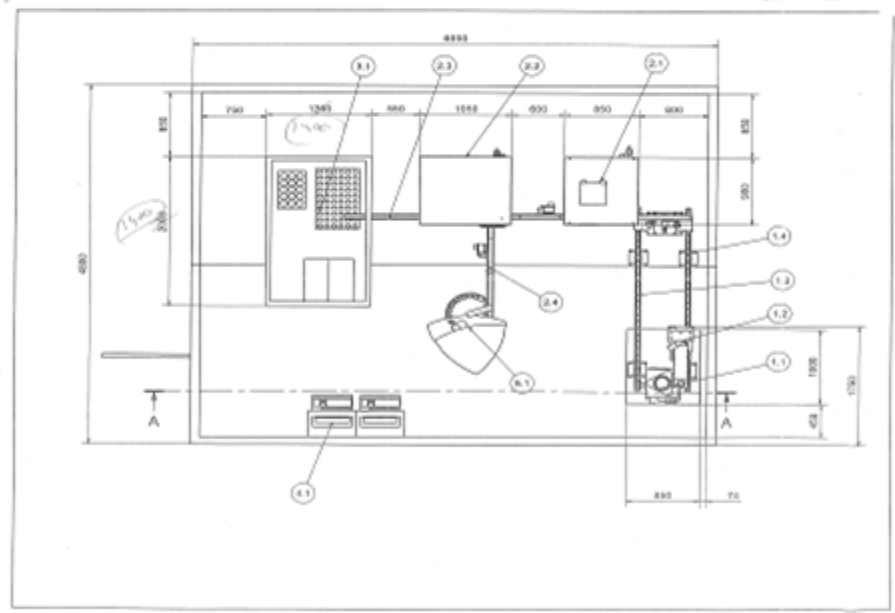
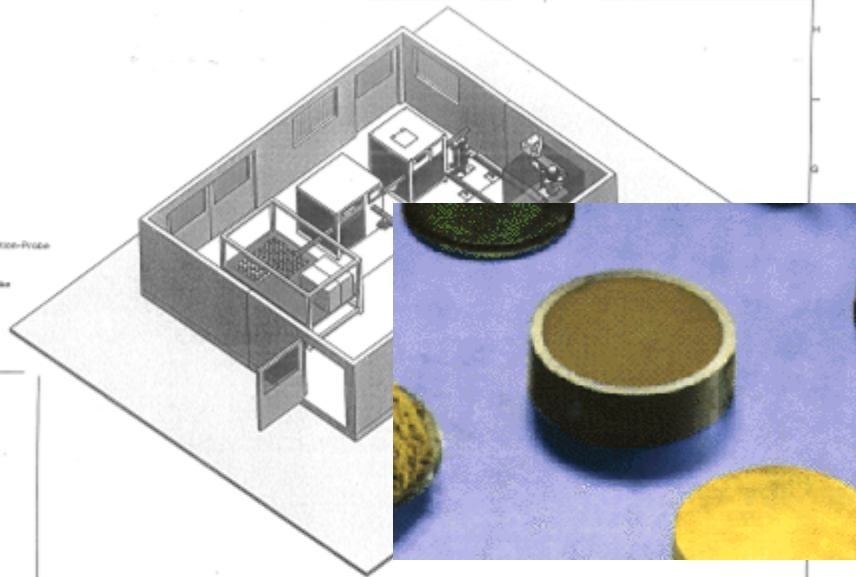
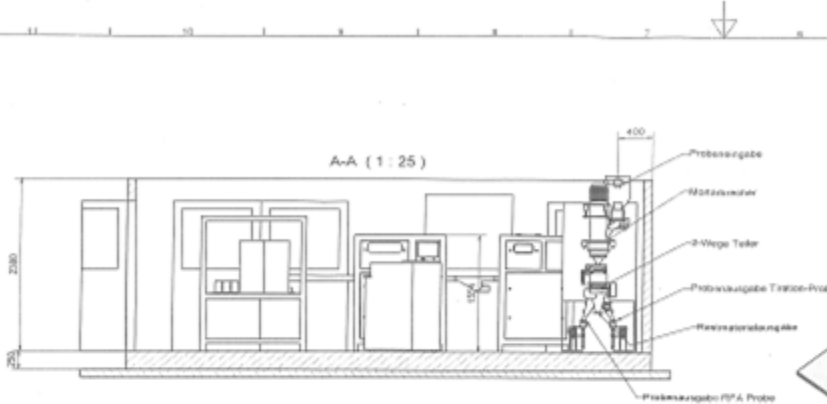


ARL Optim'X- SMS Omega Arcelor-Mittal Seraing (B)

- Two automated lines for blast furnace iron and slag analysis
- Automatic preparation and analysis of pig iron samples from blast furnace with cup wheel grinder and ARL SMS-Omega with ARL Optim'X
- Automatic analysis of vitrified and fused samples
- Manual analysis of pressed samples



OptimX SMS omega project Arcelor-Mittal Ougrée (B) in cooperation with Nucomat and Herzog



- 1.1: Mortarbrecher / Teiler
- 1.2: Probeneingabe
- 1.3: Linear-Transport RFA-Probe
- 1.4: Linear-Transport Nasschemische Probe

- 2.1: Automatische Mühle HP-M
- 2.2: Automatische Presse HP-PA
- 2.3: Transportband für Probenbecher
- 2.4: Transportband für Stahlringe zum RFA

- 3.1: Automatische Titration

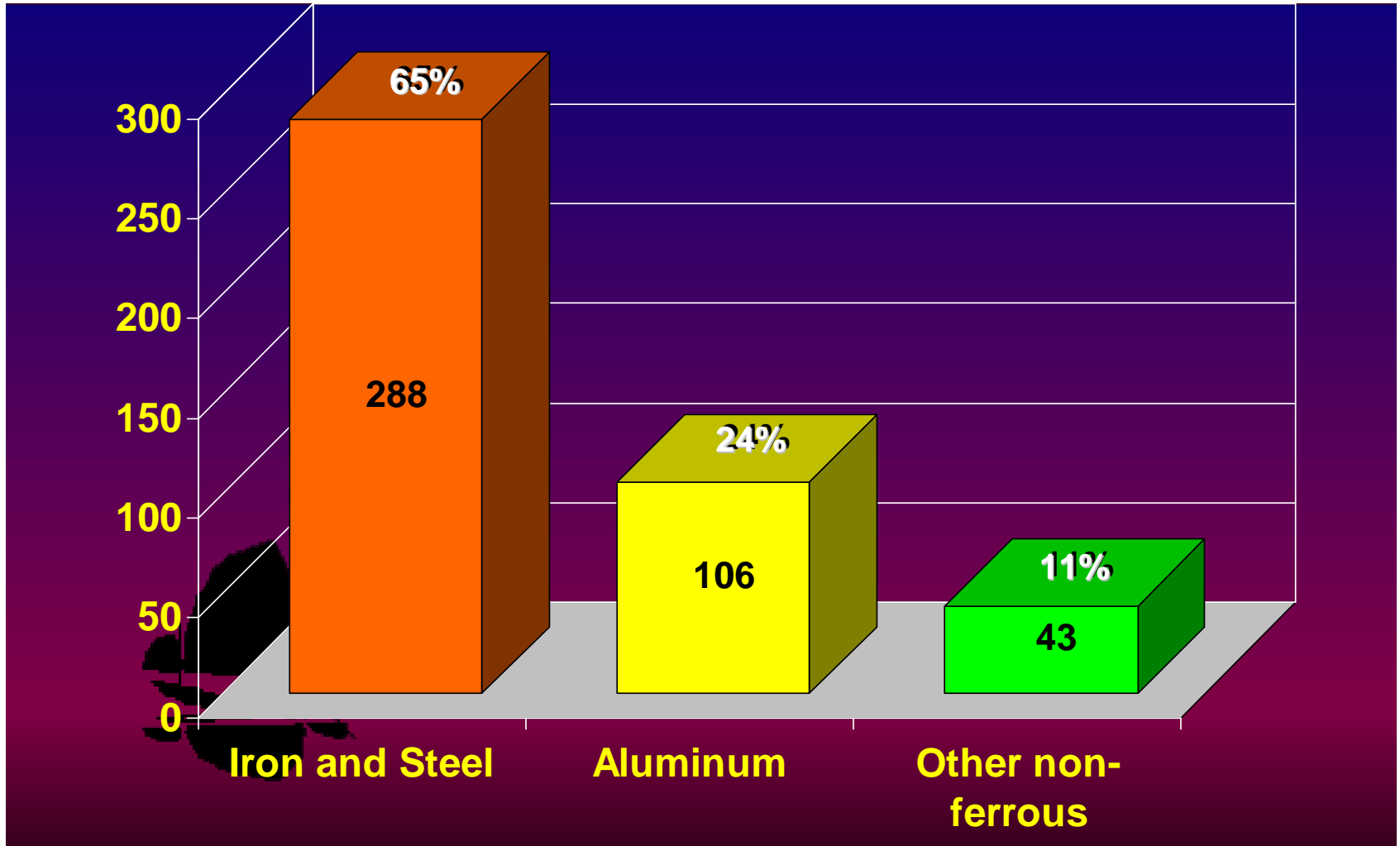
- 4.1: Prepmaster Kontroll PC

- 5.1: RFA

HERZOG	
Layout Cockerill Ougrée	
FE 0-0000-289004-9	
7/2011	

ARL automation in metals around the world

■ Iron and Steel ■ Aluminum ■ Other non-ferrous



A choice of automation solutions

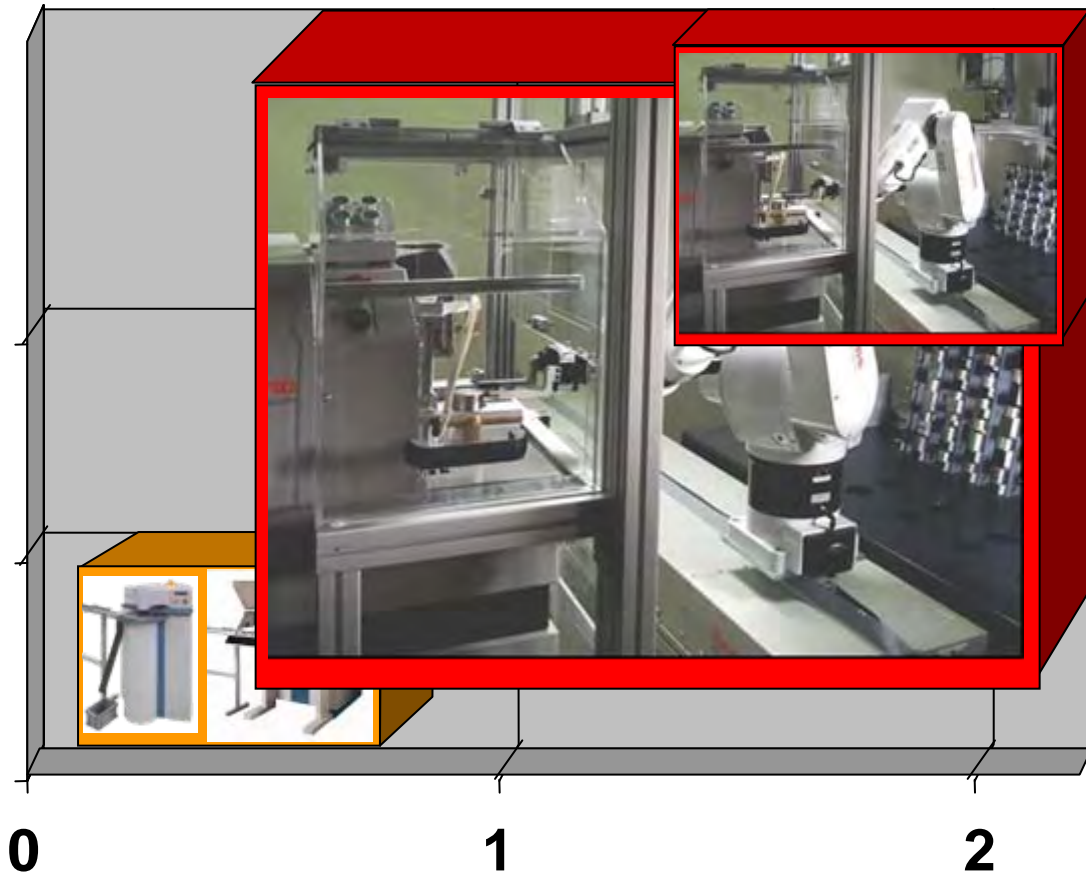
- From entry level to fully robotized systems with multiple instruments support

Automation capabilities

High

Medium

Low



- **SMS-3000**
 - ❖ ARL 4460
 - ❖ ARL 9800 / 9900
- **SMS-2000**
 - ❖ ARL 3460 / 4460
 - ❖ ARL 9800 / 9900
- **SMS-2000 EL**
 - ❖ ARL 3460 / 4460
- **SMS-Ω & SMS-XY**
 - ❖ ARL 9800 / 9900
 - ❖ ARL Advant'X
 - ❖ ARL Optim'X

Enhanced ARL SMS-3000 version with an industry standard robot

Thermo Scientific F5



FANUC LR Mate 200iC

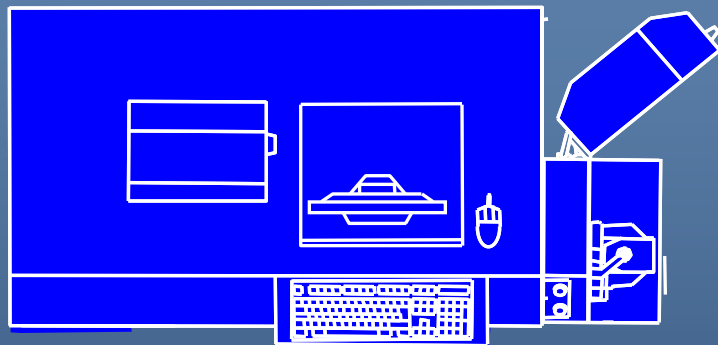


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Reach: 704 mm (635)
Payload: 5 Kg (3)
Repeatability: ± 0.02 mm (0.05)

Typical OES configuration

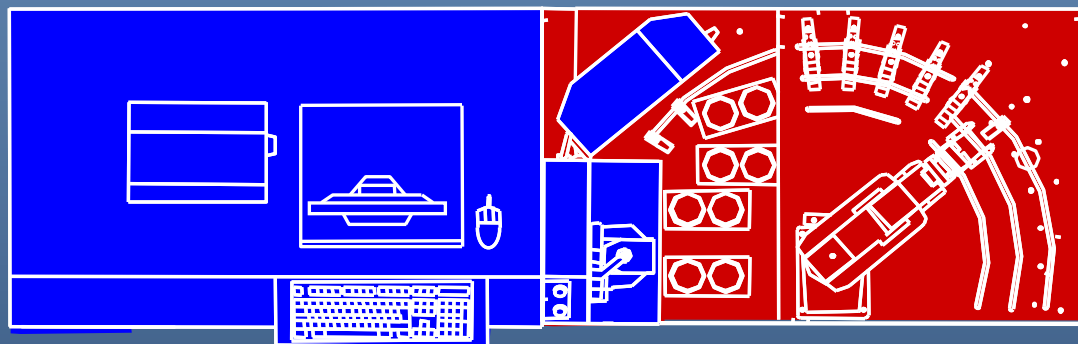
OE SPECTROMETER



Typical OES configuration - automated

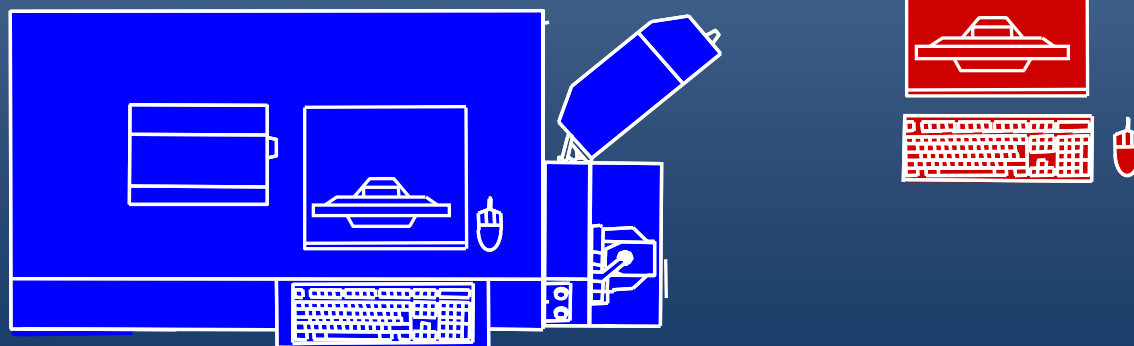
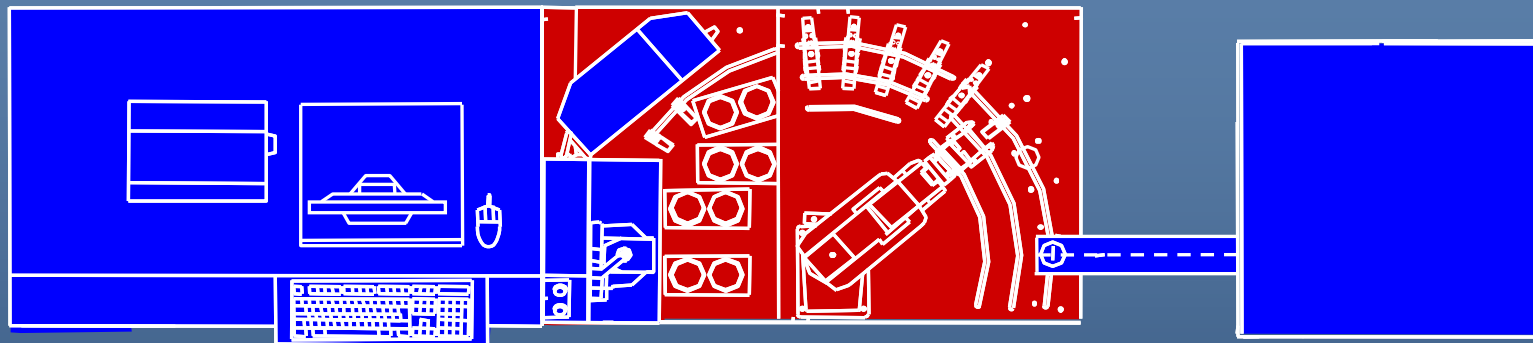
OE SPECTROMETER

AUTOMATION
SYSTEM



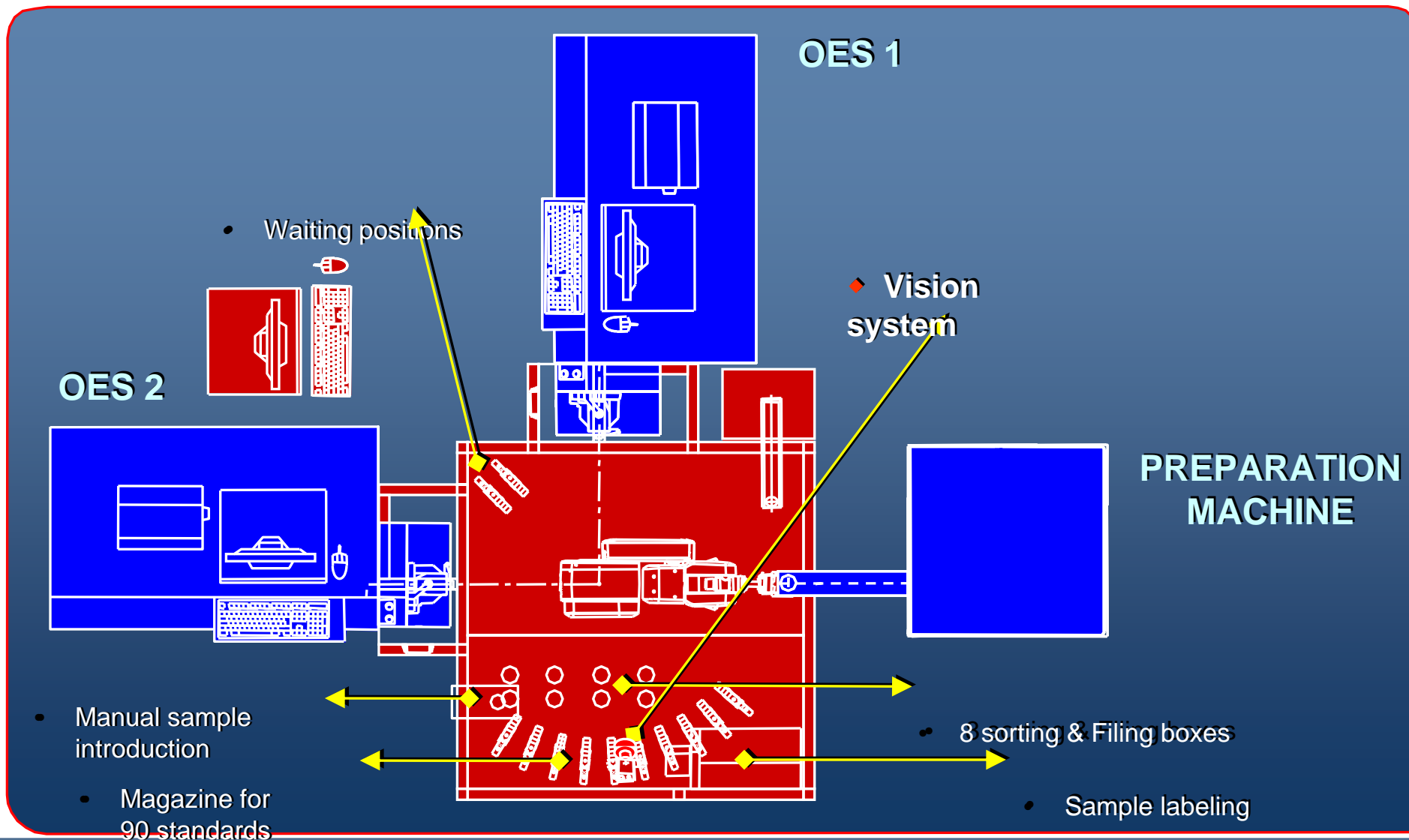
Typical OES configuration – automated & back up

AUTOMATED OES WITH SAMPLE PREPARATION

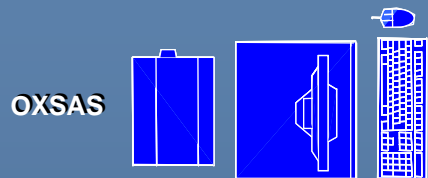


SECOND OES SPECTROMETER

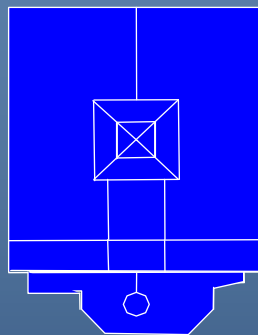
Twin automated OES with ARL SMS-3000



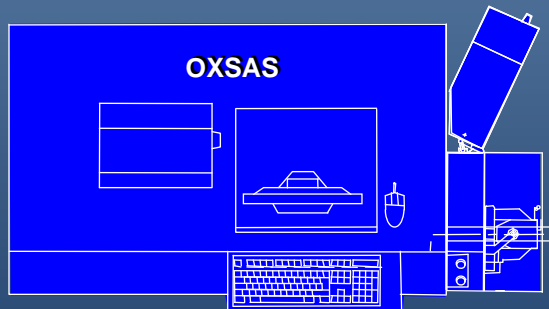
ARL SMS-3000 Combined XRF and OES analysis



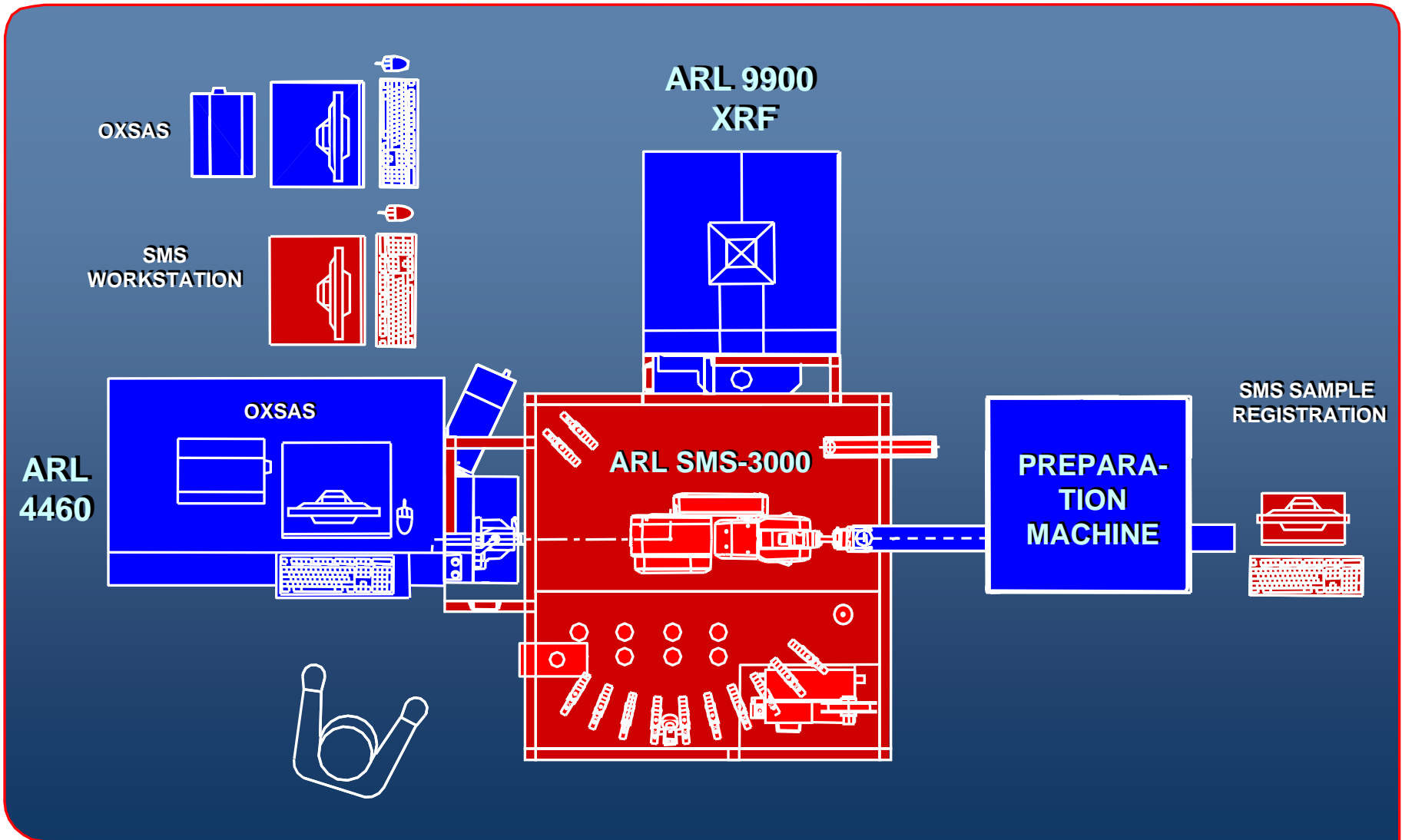
ARL 9900
XRF



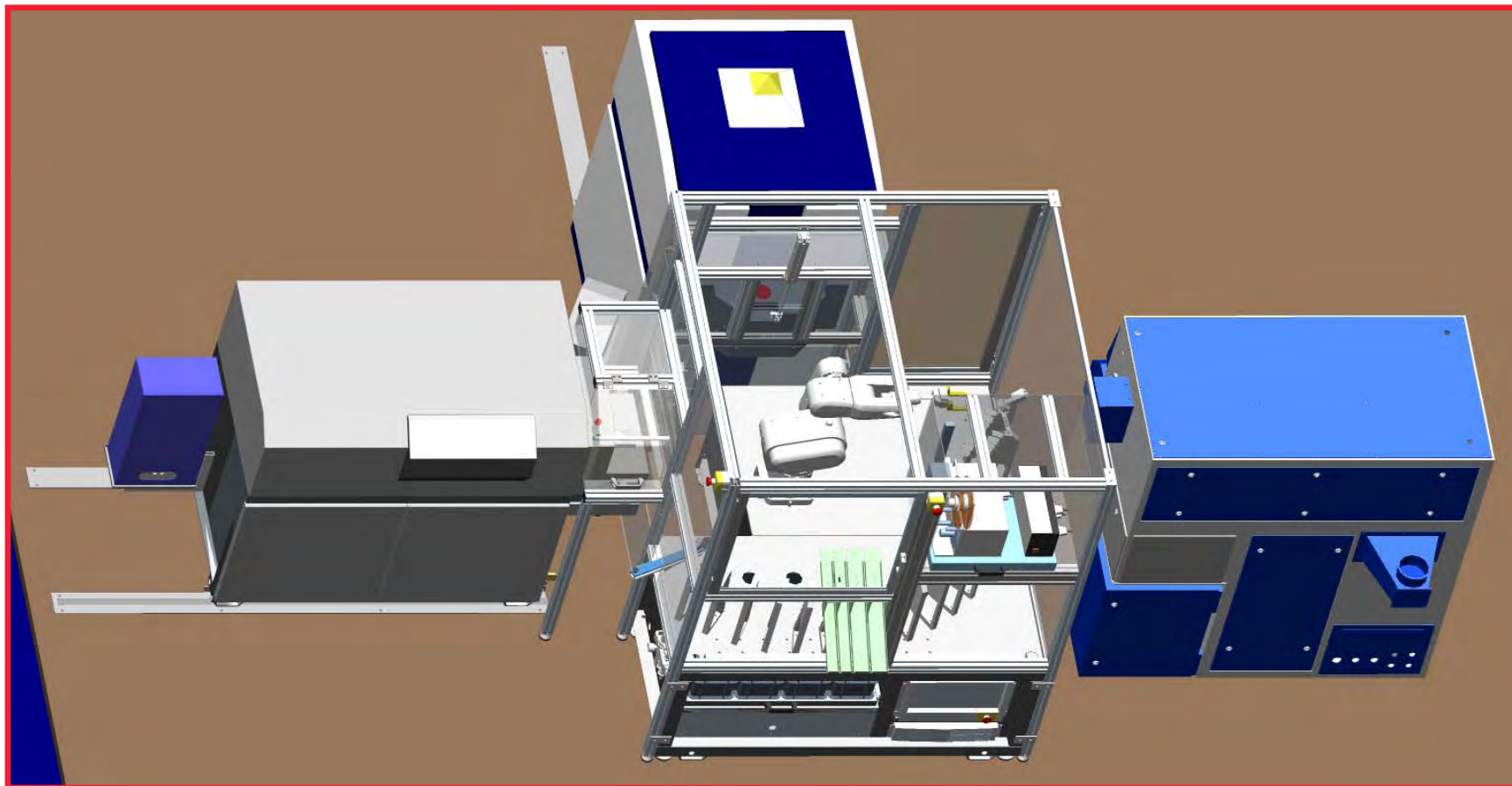
ARL
4460



ARL SMS-3000 Combined XRF and OES analysis

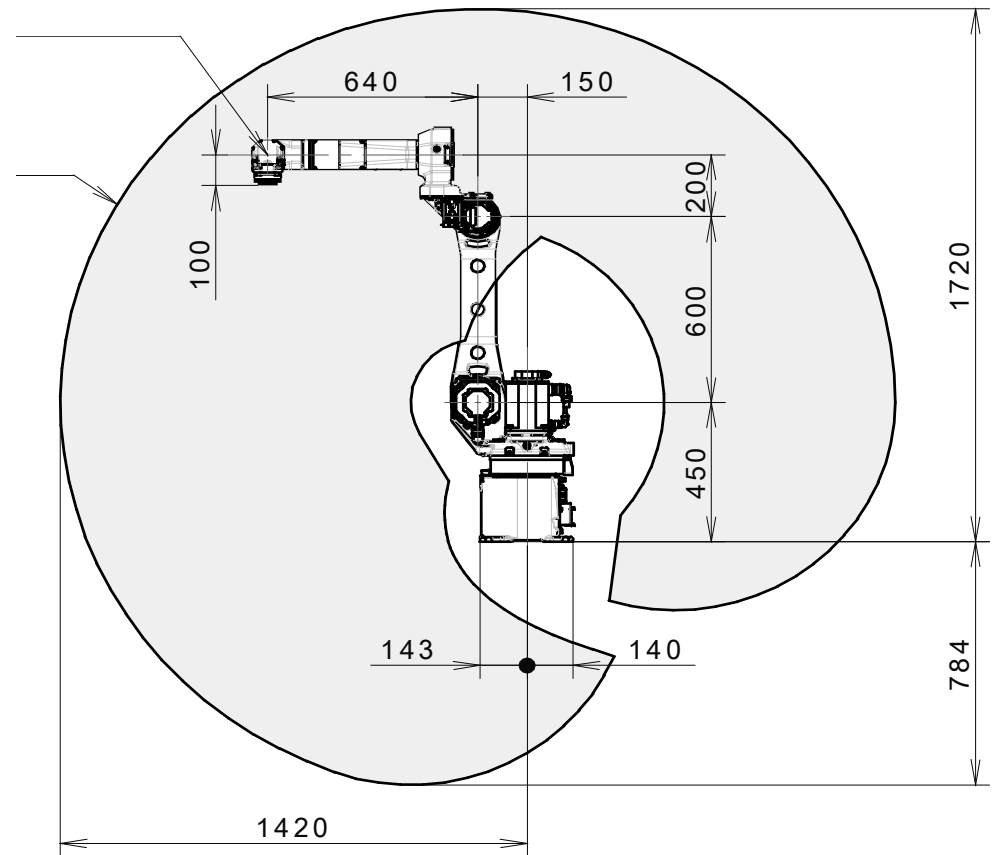


ARL SMS-3000 Combined XRF and OES analysis



The new ARL SMS-3500 robot

The FANUC M-10iA Robot

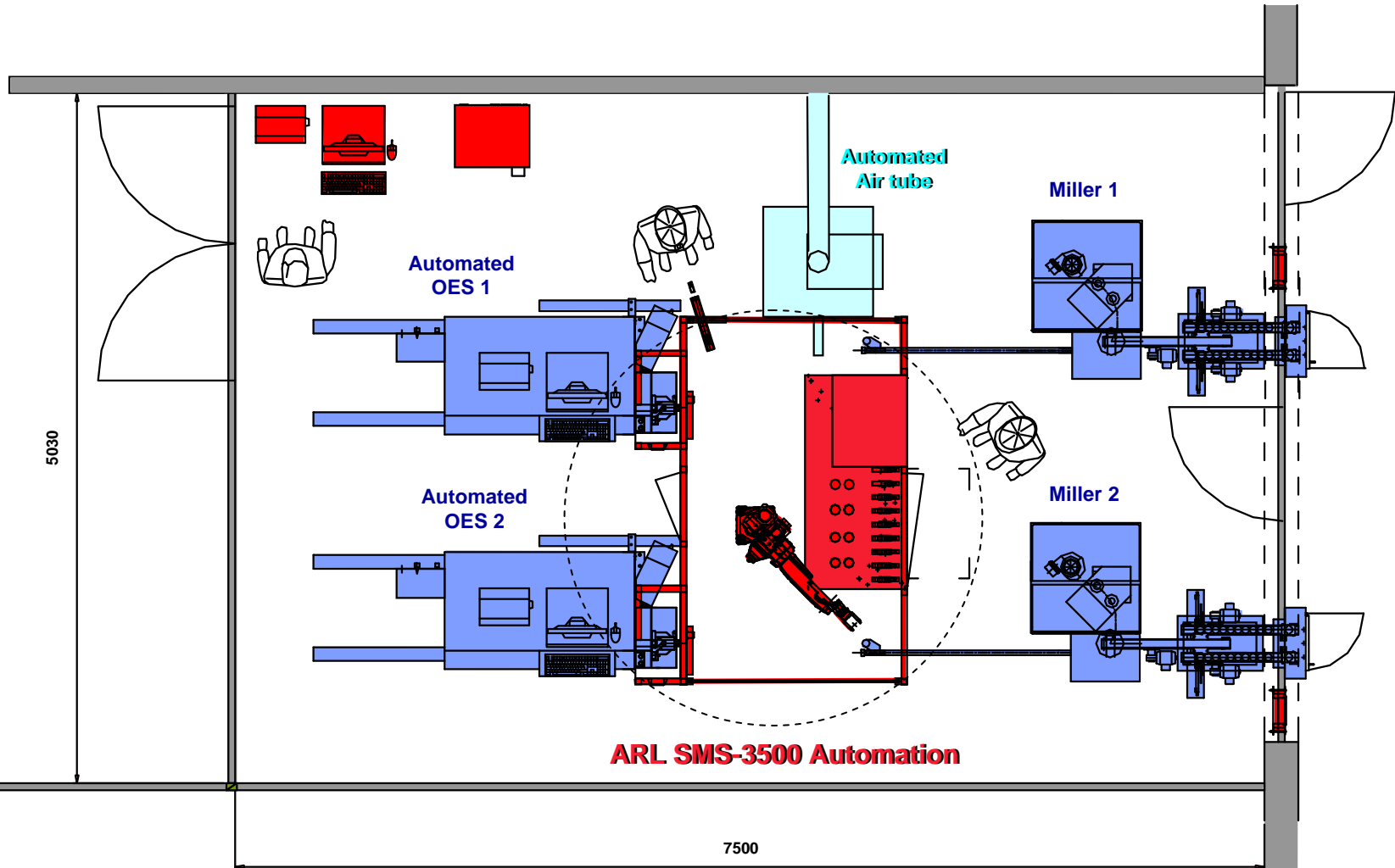


Reach: 1420 mm
Payload: 10 Kg
Repeatability: ± 0.08 mm

M-10iA Work Envelope

The Daimler AG project in Germany

- New ARL SMS-3500 version



Conclusion

- Reliable high-quality analysers are a must for lab automation
- Experience in implementing automation systems is important
- Thermo Fisher has a full product portfolio
- We provide automation solutions on customer's demand
- Systems designed with focus on your increase in productivity and reduction of operating costs in mind
- Outstanding reputation resulting in repeated orders from many customers
- Strong relation with local partners and experts is the key to success