

CTBT: SCIENCE AND TECHNOLOGY

2017 CONFERENCE

Enhancements to the CTBTO IDC radionuclide processing pipeline for particulate samples achieving significant improvement of automatic products

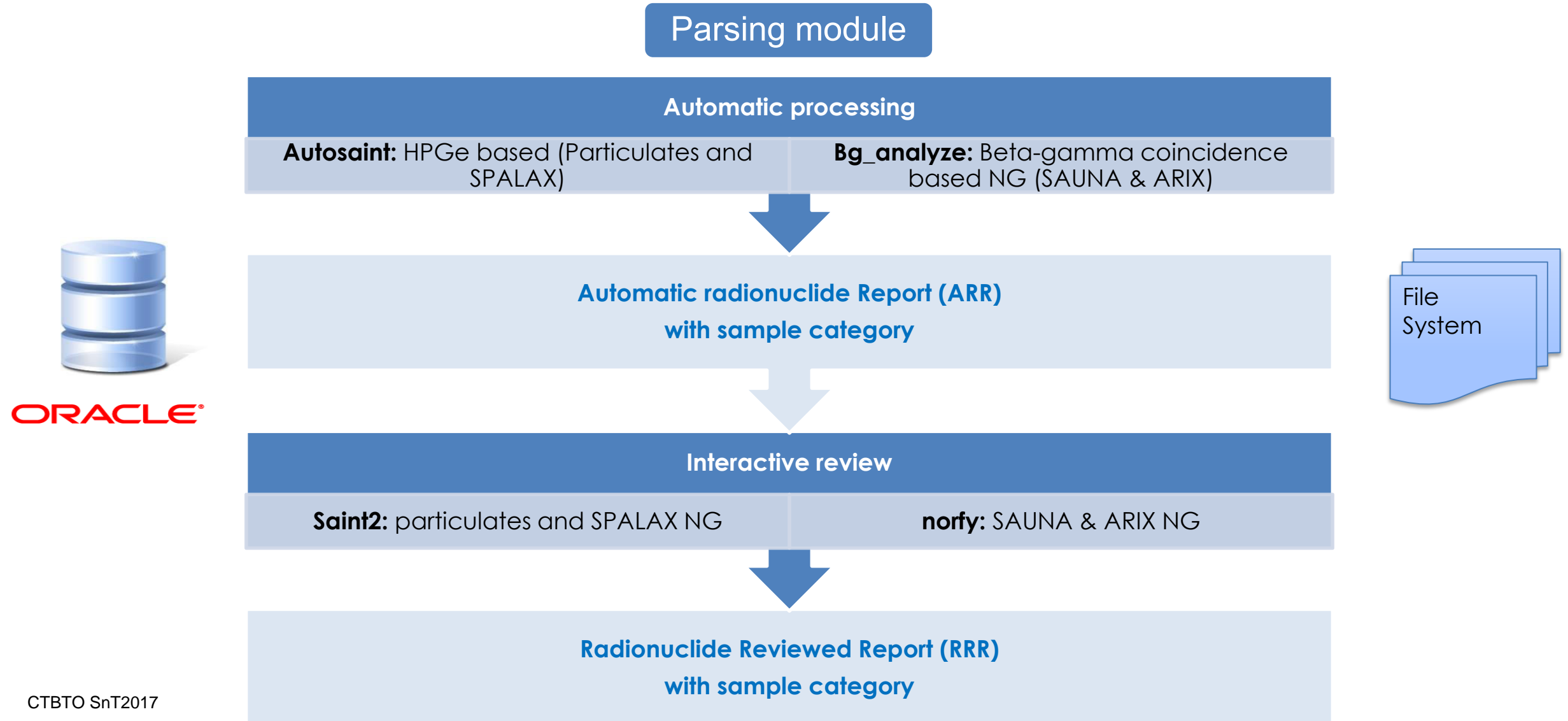
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IDC radionuclide processing pipeline

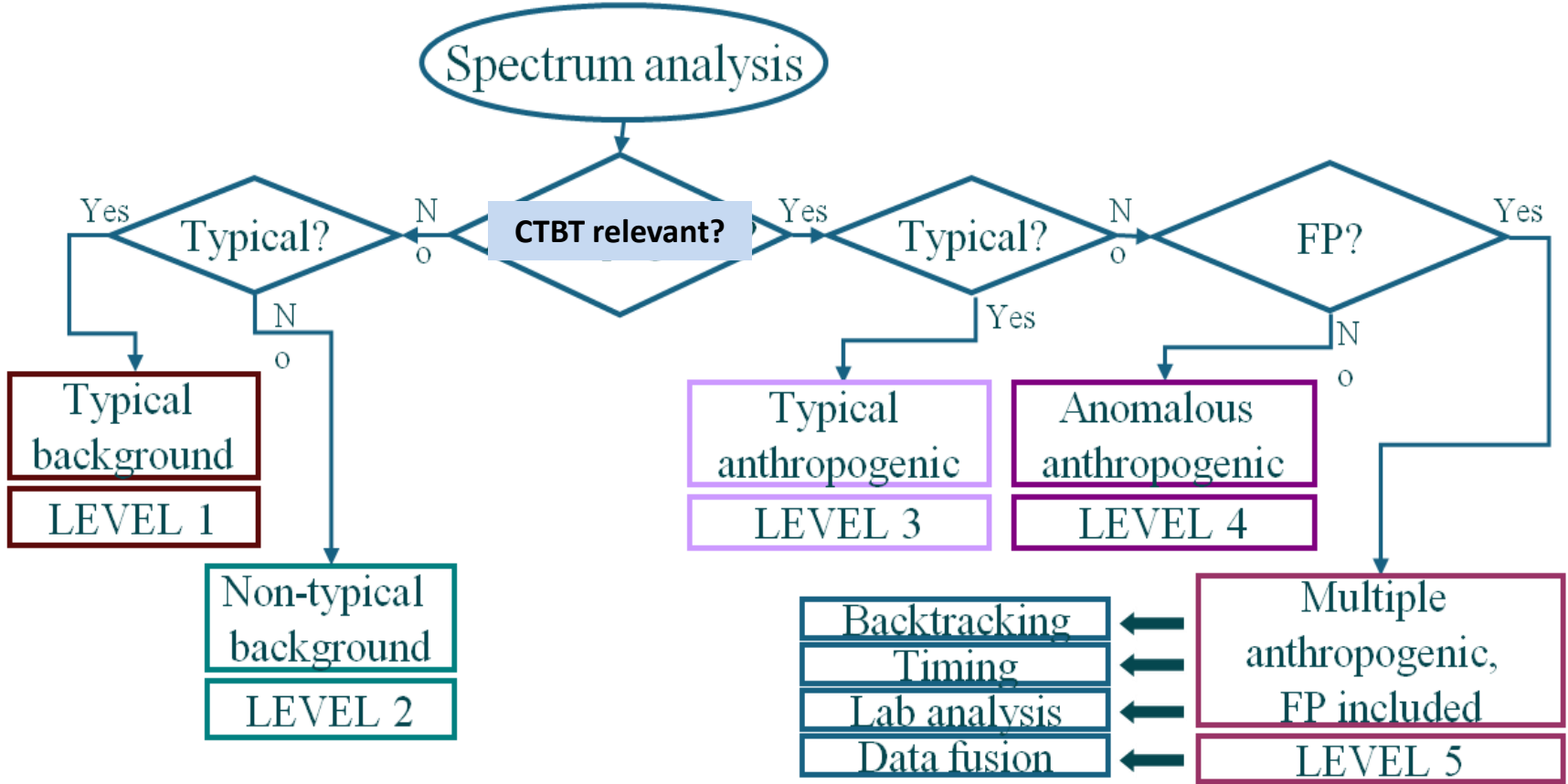


Categorization scheme of particulates samples



83 nuclides in the list of relevant particulate radionuclides:

AG-106M	EU-152	RB-84	U-237
AG-108M	EU-152M	RB-86	W-187
AG-110M	EU-155	RH-102	Y-88
AG-111	EU-156	RH-105	Y-91
AS-74	EU-157	RU-103	Y-93
AS-76	FE-59	RU-106	ZN-65
AU-196	GA-72	SB-120	ZN-69M
AU-196M	I-130	SB-122	ZR-89
AU-198	I-131	SB-124	ZR-95
BA-133	I-133	SB-125	ZR-97
BA-140	I-135	SB-126	
CD-115	IR-190	SB-127	
CD-115M	IR-192	SB-128	
CE-141	K-42	SC-46	
CE-143	LA-140	SC-47	
CE-144	MN-54	SM-153	
CO-57	MO-99	SM-156	
CO-58	NA-24	SN-125	
CO-60	NB-95	SR-91	
CR-51	ND-147	TC-99M	
CS-132	NP-239	TE-129M	
CS-134	PB-203	TE-131M	
CS-136	PD-112	TE-132	
CS-137	PM-149	TM-168	
	PM-151		



▪ **Level 5:** The sample contains multiple relevant nuclides at anomalously high concentrations, out of which at least one is a fission product.

Objectives



Revisiting IDC radionuclide software algorithms, Jan 2015 – Jan 2017

- **Priority in previous years:** enhancing the quality of reviewed results
- **New focus:** enhancing the quality of automatic results



Improve the consistency of automatic processing results

Reduce the work load on Analysts in interactive mode

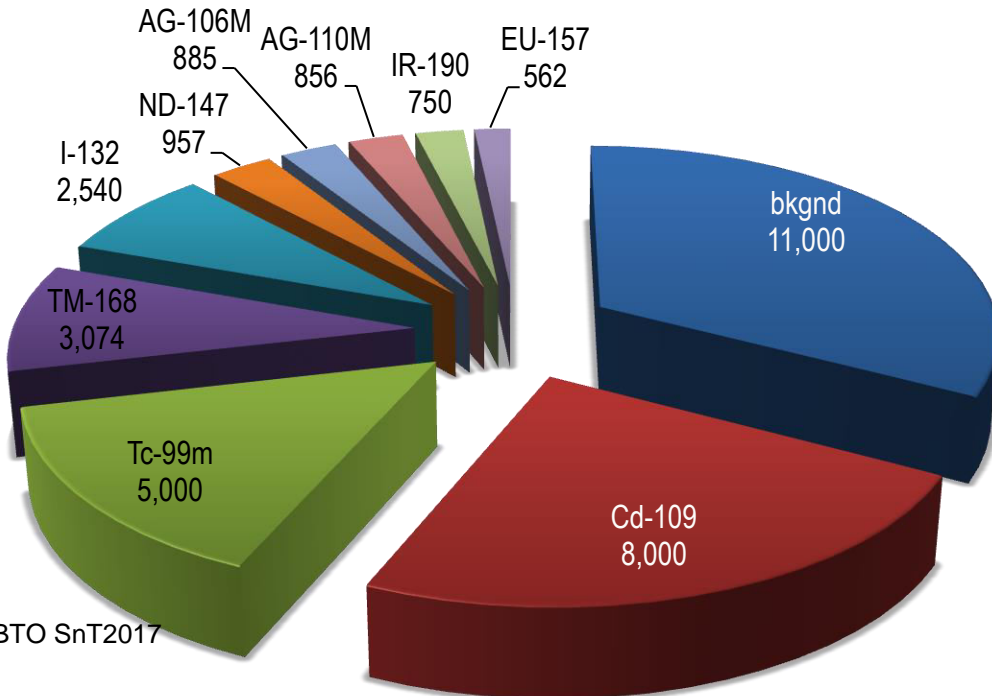


Enhancement areas

Within 2015/2016 IDC development efforts, areas have been identified for further improvement in order to enhance the quality of automatic processing results of particulate samples and increase the analysts effectiveness in interactive mode.

Retrospective analysis based on year 2014 (20 000 samples):

- 11 000 false peaks
- 33 500 false positives (nuclides)
- CTBT relevant nuclides in background



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Defined software solutions:

- Automatic handling of false peaks
- Optimizing the key lines of anthropogenic nuclides
- Automating the discrimination tool between Tc-99m and Ge-75m
- Implementing a background subtraction module in automatic mode
- Updating nuclear data of natural nuclides in the IDC library
- Optimizing baseline parameters in automatic mode.

Major improvements



Optimizing the key lines of 7 major nuclides (*Ag-106m, Ag-110m, Eu-157, Ir-190, Nd-147, Tm-168, I-132*)

- Jan. – June 2015 in IDC Operations
- Dec. 2015 in NDC-in-a-Box, 1.0



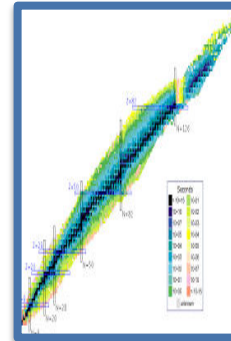
Automatic handling of false peaks

- Feb. 2015 in IDC Operations
- Dec. 2015 in NDC-in-a-Box, 1.0



Automating the discrimination tool between Tc-99m and Ge-75m

- July 2015 in IDC Operations
- Dec. 2015 in NDC-in-a-Box, 1.0



Updating nuclear data for Pb-212F (Pb-212, Bi-212, Tl-208), Cd-109 and Pb-214

- Late June 2016 in IDC Operations
- Apr. 2017 in NDC-in-a-Box, 2.0



Implementation of automatic background subtraction module

- Nov. 2016: in IDC Operations
- Apr. 2017 in NDC-in-a-Box, 2.0



Optimizing spectrum baseline configuration

- Jan. 2017 in IDC Operations
- Apr. 2017 in NDC-in-a-Box, 2.0

Optimizing the key lines of 7 nuclides

Old key lines

Radionuclide	Energy,keV	Intensity,%	Interference issues
EU-157	49.96 @NDC-in-a-Box	2.06	Too low parameters
	63.93 @IDC pipeline	23.00	Th-234
ND-147	91.11	27.90	Th-234, U-235
AG-110M	657.76	94.60	Pb-212F
TM-168	198.24	52.60	Ge-71m
IR-190	186.68	52.00	U-235, Ra-226
AG-106M	511.85	88.00	Annihilation
I-132	667.72	98.70	Pb-212F

Old key lines were defined at energies that show potential interferences with natural radionuclides in the filter sample and/or from the detector background.

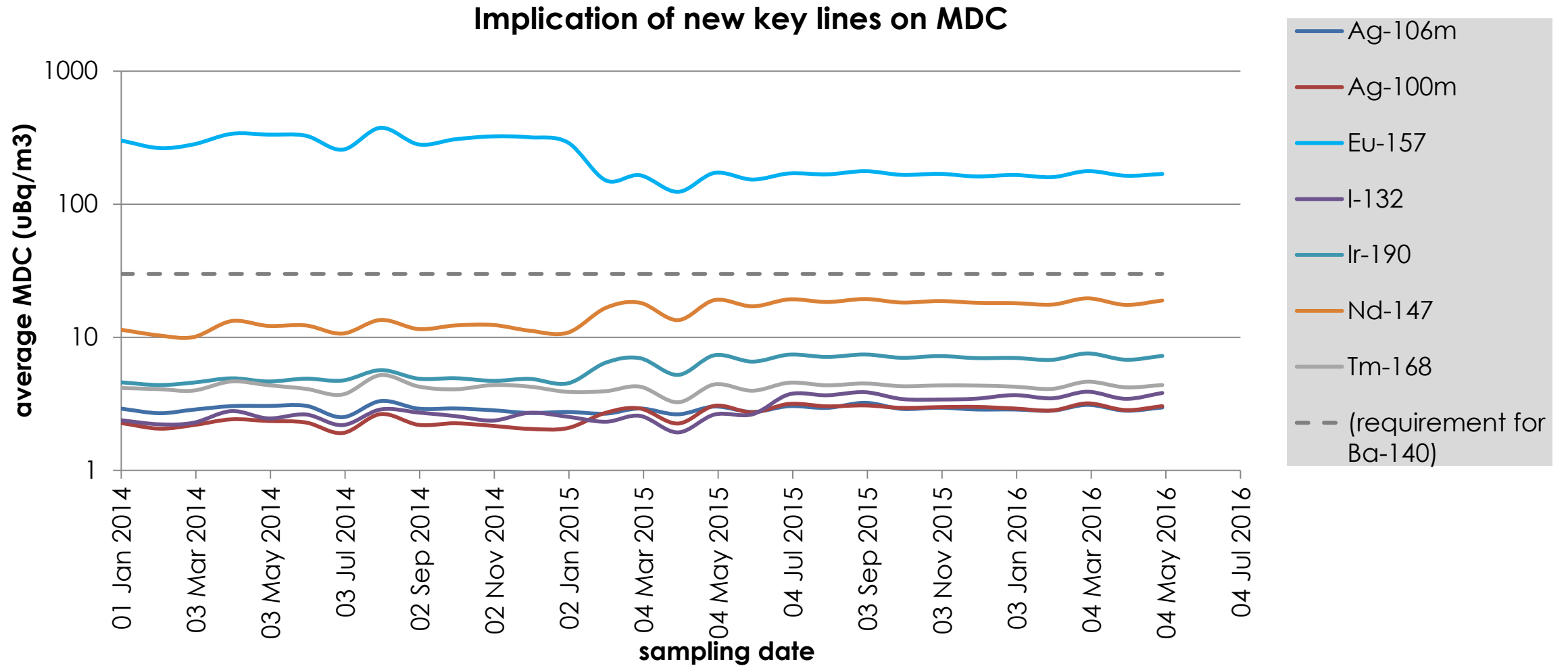
In order to boost radionuclide the screening in automatic processing mode, a new set of optimized key energy lines is defined for these 7 radionuclides. *Implication on MDC is also considered in the choice.*

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New key lines

Radionuclide	Energy, keV	Intensity, %
EU-157	370.51	11.00
ND-147	531.02	13.10
AG-110M	884.69	72.70
TM-168	815.99	49.00
IR-190	518.55	34.00
AG-106M	450.98	28.20
I-132	772.60	75.60

Optimizing the key lines of 7 nuclides



Discrimination tool of Tc-99m vs. Ge-75m

Specificity of the case !

- Tc-99m, one of the 83 CTBT-relevant nuclides, has a gamma energy line at 140.51 keV.
- Ge-75m, produced by interaction of neutrons from cosmic radiation with the germanium crystal of the detector itself, has a gamma peak at 139.68 keV.

The issue: energy discrimination between Ge-75m and Tc-99m only applies if the peaks are large enough which allow centroid determination with low uncertainty.

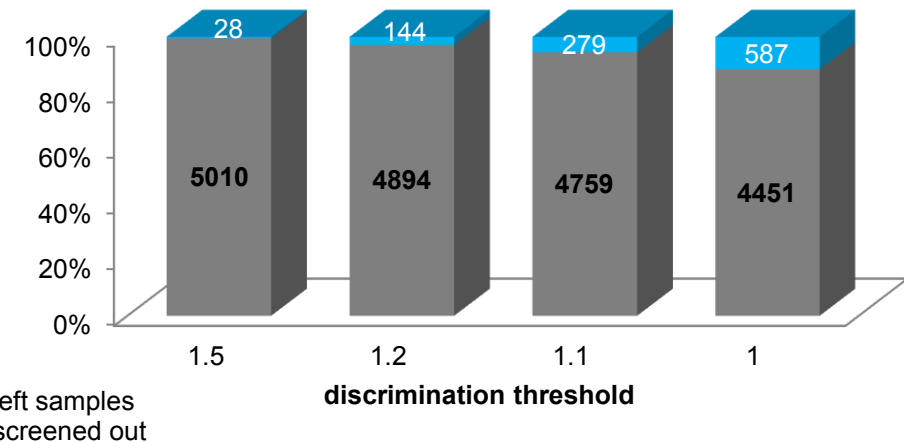
Automated algorithm

Basis: peak area ratio 140keV:198keV (Ge-75m to Ge-71m).
The presence of a peak at 198 keV with a ratio around 1 compared to 140 keV means the peak around 140 keV is due to Ge-75m.

The absence of a peak at 198 keV or a ratio 140:198 considerably larger than 1 indicates the possible presence of Tc-99m.

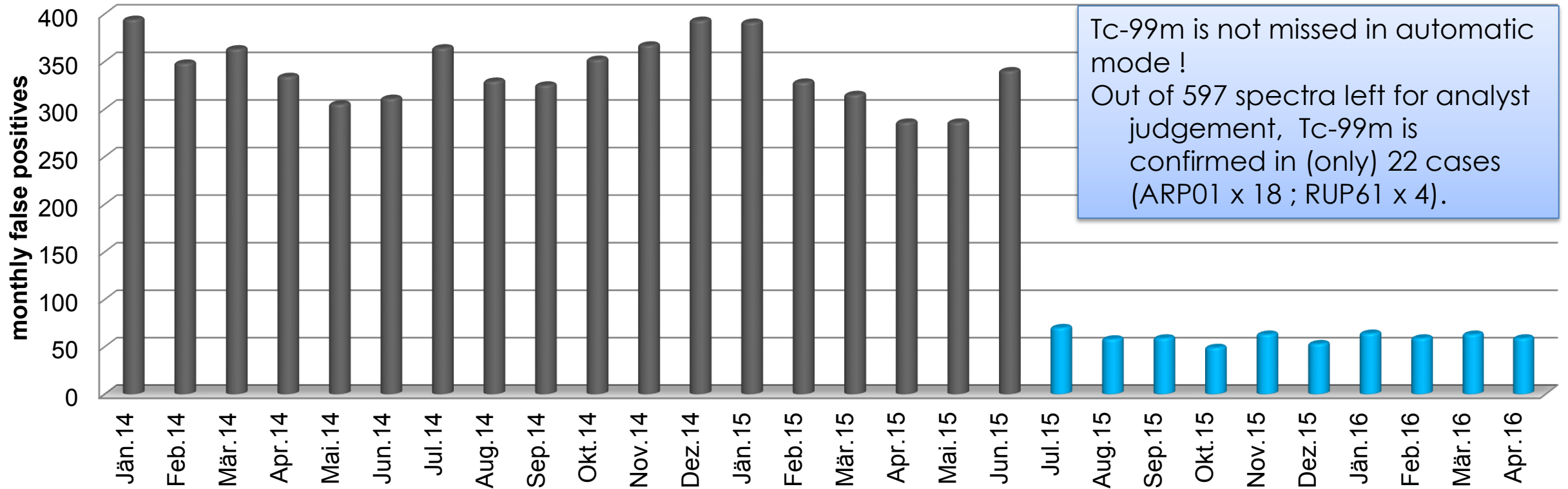
Optimum threshold of 1.1 is adopted for the discrimination peak ratio.

- Efficient automatic screening-out;
- Safe margin for actual detections;



Achieved enhancements

Reduction of false positives of Tc-99m in automatic mode (after implementation of automated discrimination tool)

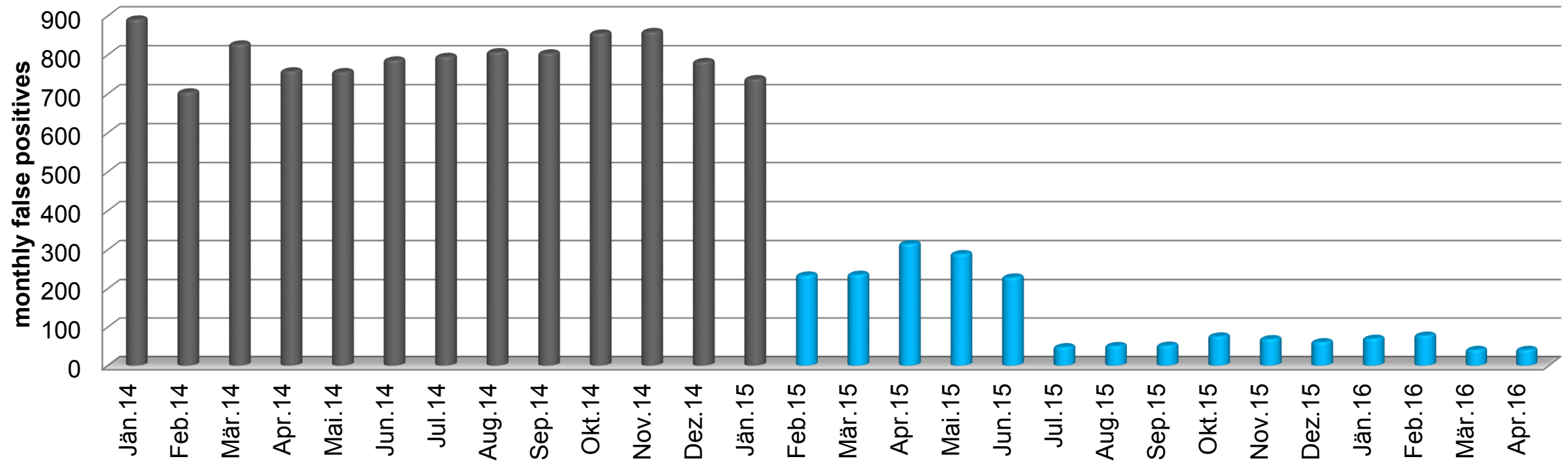


Reduction factor ~ 85%

- These are actual results in IDC Operations
- Same improvement is achievable in the NDC-in-a-Box

Achieved enhancements

Reduction of false positives in automatic mode Ag-106m, Ag-110m, Eu-157, Ir-190, Nd-147, Tm-168, I-132 (after optimizing the key lines in the Radionuclide library)



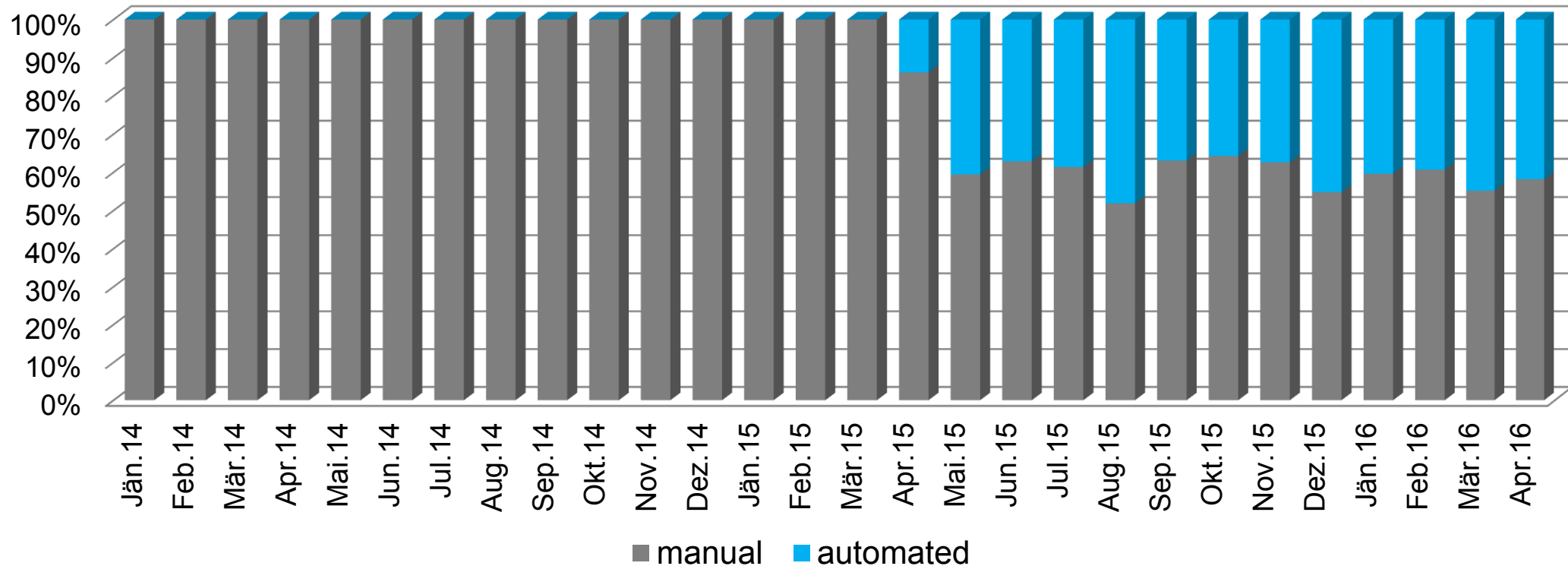
Reduction factor ~ 93%

- These are actual results in IDC Operations

- Same improvement is also achievable in the NDC-in-a-Box

Achieved enhancements

Automatically commented out false peaks (then endorsed by Analysts)



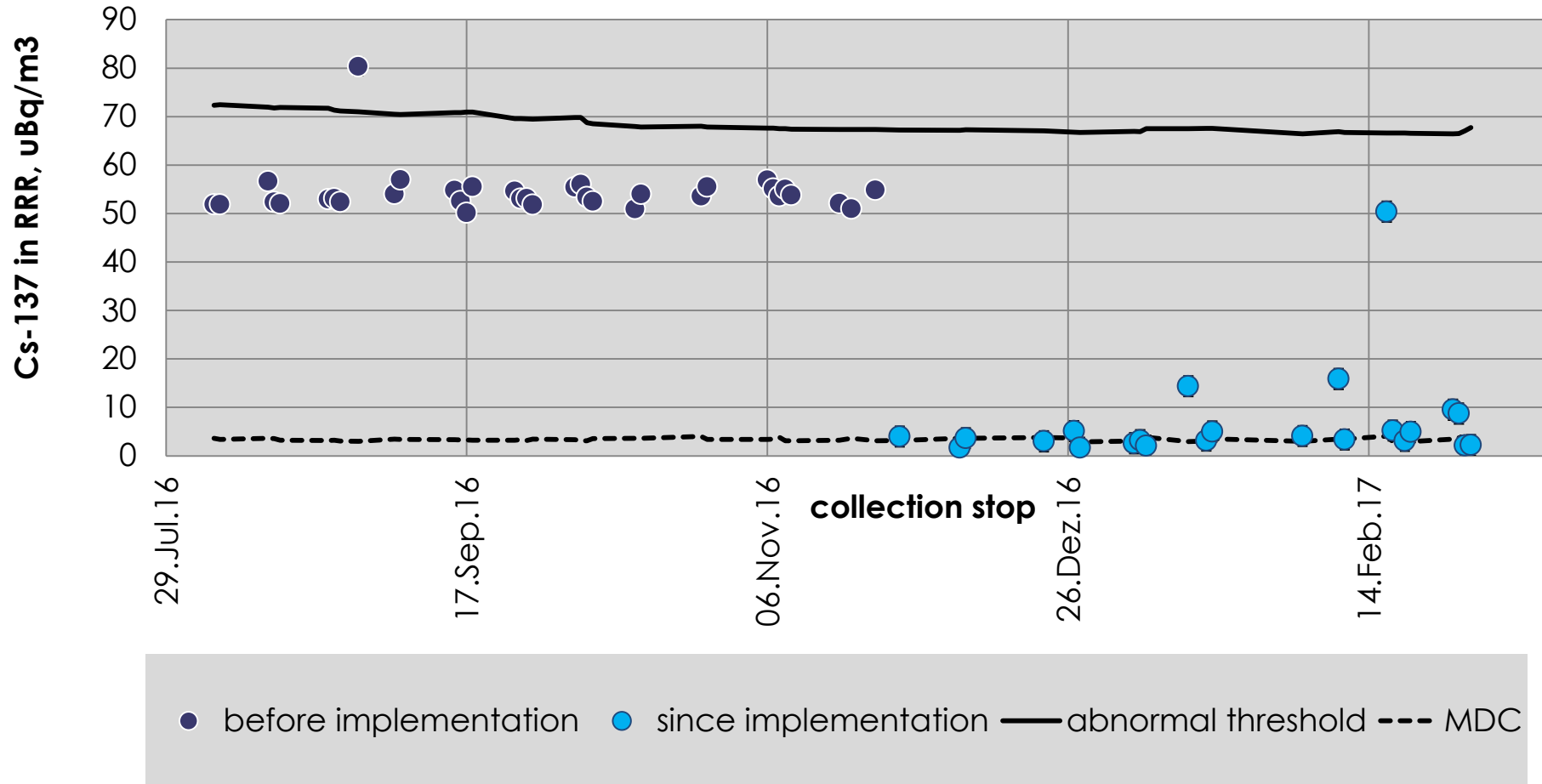
Reduction factor ~ 40-50%

- These are actual results in IDC Operations

- Same improvement is also expected in the new release of NDC-in-a-Box

Achieved enhancements

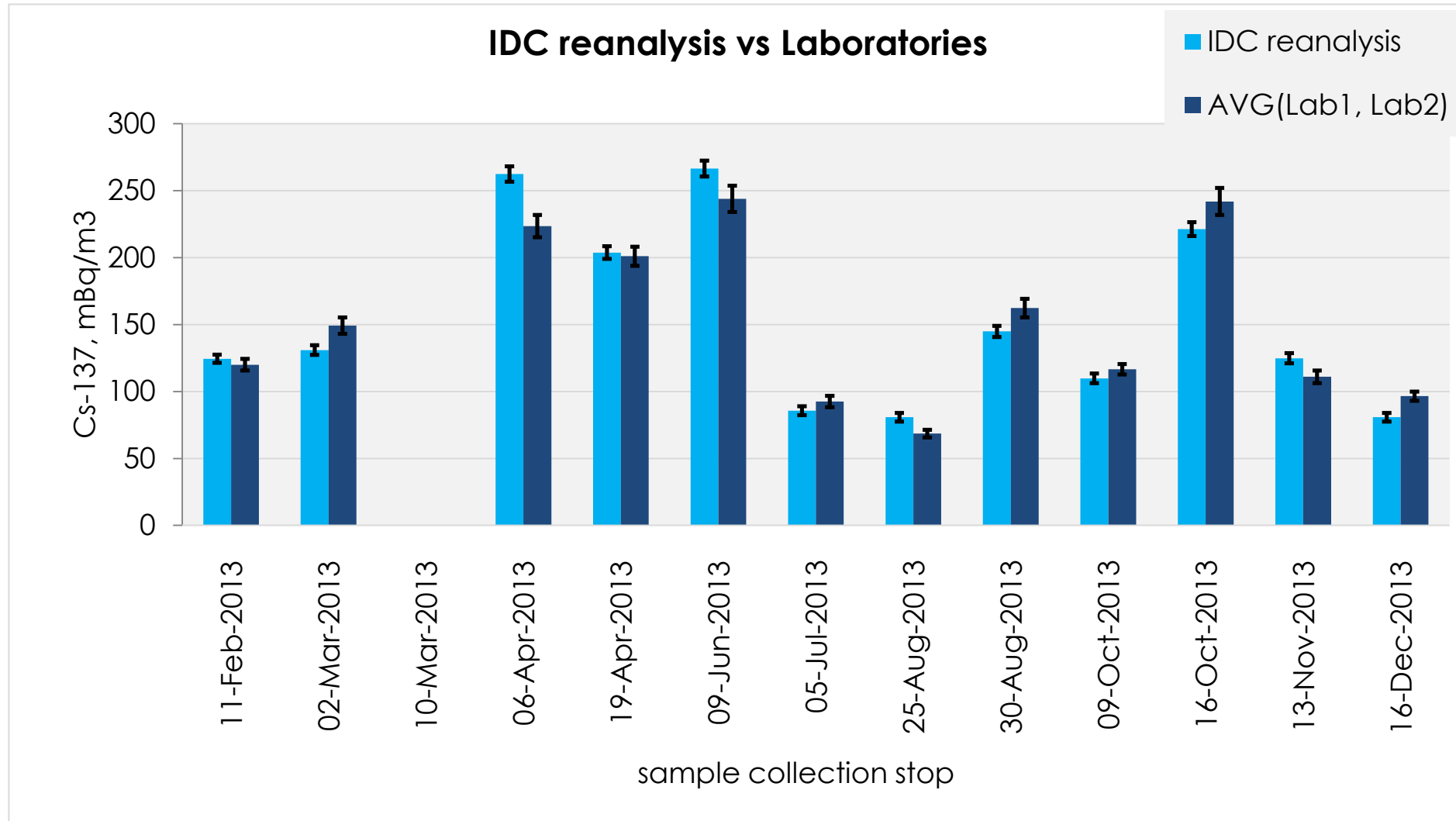
Implication of background subtraction on Cs-137 results at RN38



Higher consistency in activity results of Cs-137 (and Cs-134) is achieved since late Nov. 2016 as background contribution is automatically corrected for.

Reporting rate of Cs-137: from 9 down to ~5 detections /month

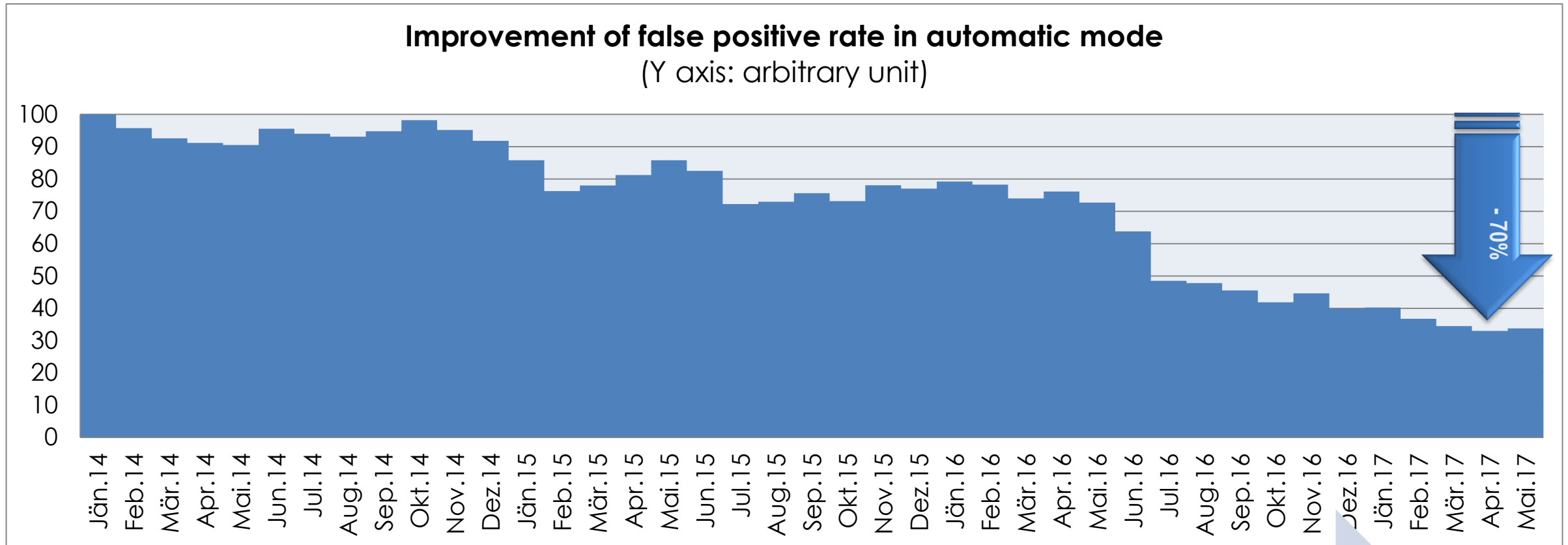
Achieved enhancements



Outcome:
IDC reanalysis results (with background subtraction) are very consistent with average results from certified IMS Laboratories.

Note: in order to “decouple” any disparity issue in the two half-samples, the average activity concentration results of the two reanalyzing Laboratories (Lab1+Lab2)/2 is considered in the comparison.

Overall impact on the quality of automatic results



Jan 2015: started optimizing key lines

Jul 2015: automated Tc-99m/Ge-75m discrimination

Jul 2016: Revisiting Pb-212 Family, Cd-109 and Pb-214

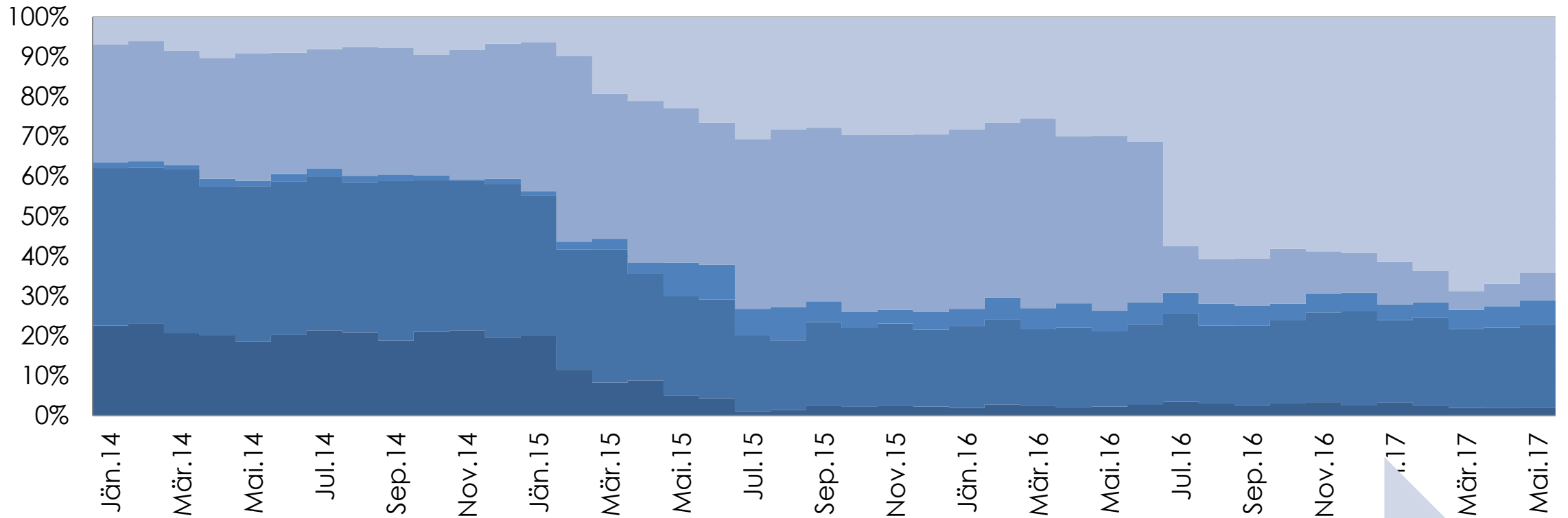
Dec 2016: automatic background subtraction

Jan 2017: optimizing automatic baseline parameters

Overall impact on the quality of automatic results

Improvement of automatic categorization

Level 1 Level 2 Level 3 Level 4 Level 5



Jan 2015: started optimizing key lines

Jul 2015: automated Tc-99m/Ge-75m discrimination

Jul 2016: Revisiting Pb-212 Family, Cd-109 and Pb-214

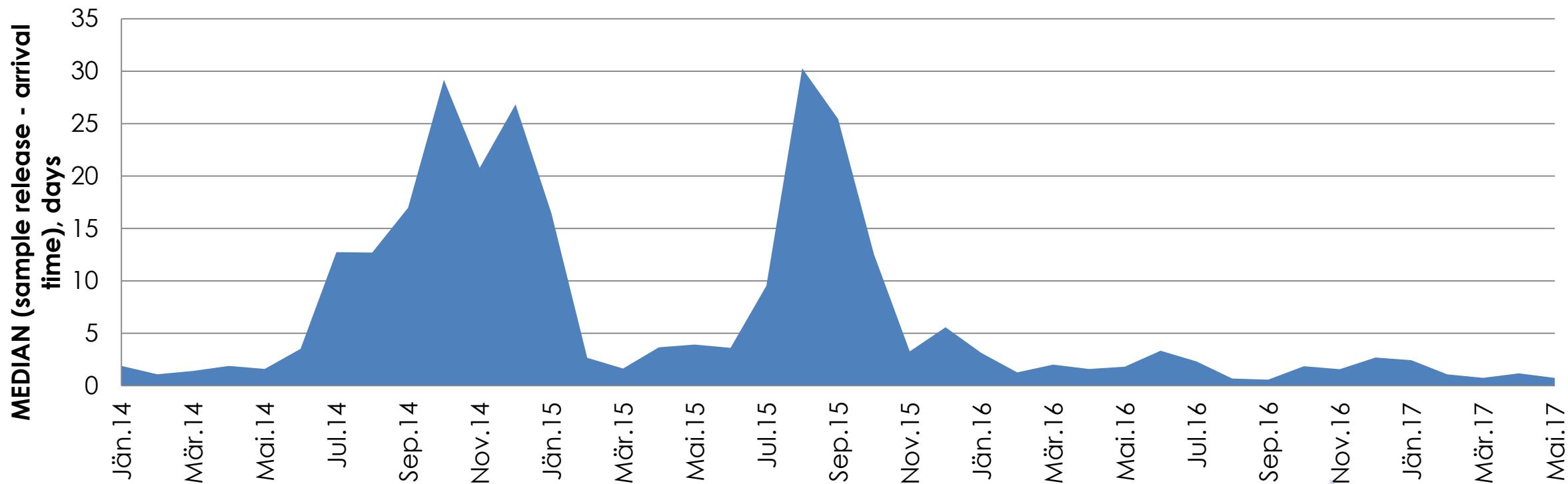
Dec 2016: automatic background subtraction

Jan 2017: optimizing automatic baseline parameters

Overall impact on the quality of automatic results



Improvement of IDC reviewed product (RRR) timeliness



2014/2015: High backlog over long period: *from summer holidays to winter break*

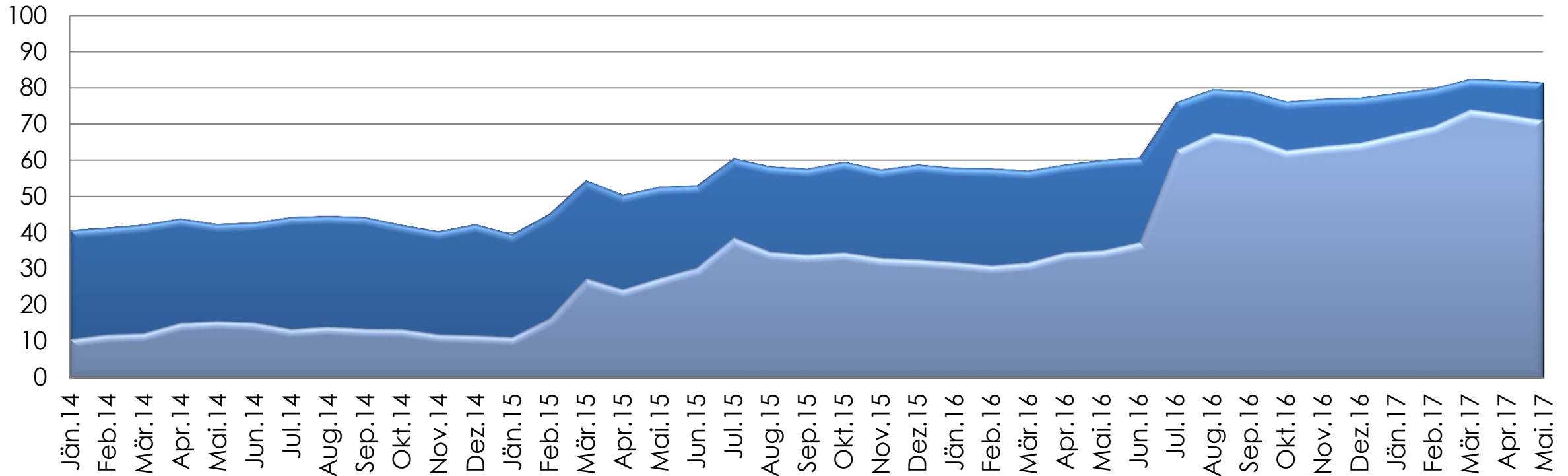
2015/2016: High backlog over short period: *mostly summer holidays*

2016/2017: No noticeable increase in backlog

Overall impact on the quality of automatic results

Consistency rate (%) of automatic vs. reviewed categorization results

■ particulates + Noble Gas ■ particulates



IDC Key Performance Indicators (PKI 2.6):

- **Overall improvement** (particulates and Noble Gas): **from 40 to 80%**
- **Achieved performance largely exceeds the target limit of 55% as set for 2016 and 2017.**

- Major improvements have been implemented in the Radionuclide software for particulates over Jan 2015 - Jan 2017.
- As confirmed by several (key) performance indicators, significant enhancements have been achieved in IDC Operations.
- Same software improvements have been implemented in the NDC-in-a-Box package (radionuclide release 1.1.0, December 2015 and 2.0, April 2017).

Impact:

- a) Improved quality of the automatic product (ARR);
- b) Lower work load on Analysts in interactive mode.

Thank you

