2nd Workshop on Black Carbon
- Instrument Testing and Measurement Protocol
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Current BC testing efforts in Japan

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BC study at NMRI

Goal

- To establish the measurement and evaluation methods of BC for marine diesel engines
- To determine the correction factors to evaluate BC values obtained by various BC measurement methods

Procedure

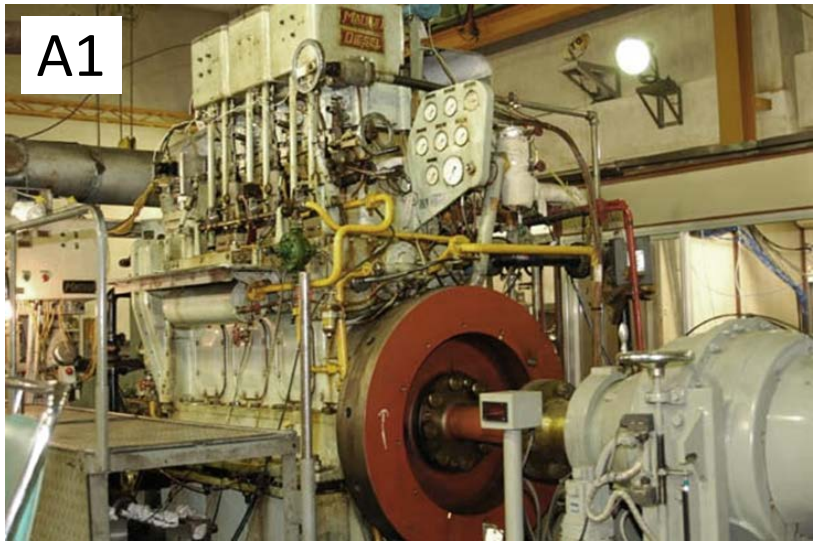
- To evaluate measurement and sampling methods for marine diesel engines
- To specify the influence factors on BC measurement

BC measurement : Engines for lab testing

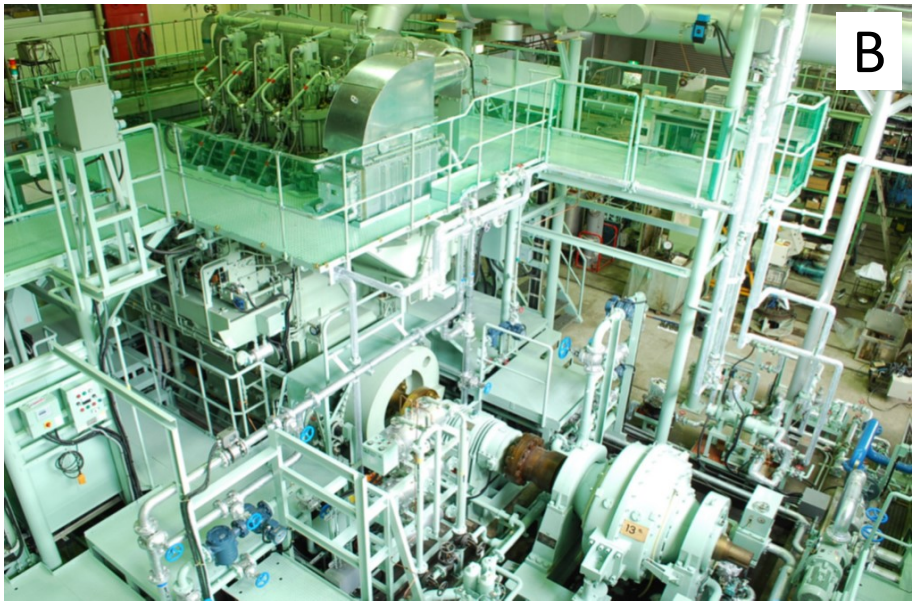
Engine	A1	A2	B
Type	4 stroke Middle speed		2 stroke Low speed
N. of cylinders	3	6	3
Cylinder bore	230mm	190mm	330mm
Piston stroke	380mm	260mm	1050mm
Rated power max.	257 kW	750 kW	1275 kW
Speed max.	420 rpm	1000 rpm	162 rpm
Fuel injection control	Mechanical	Electronic	Electronic
Fuel	HFO(2.6%S) MDO(0.6%S) LS MDO(0.08%S)	MDO(0.6%S) LS MDO(0.08%S)	HFO(2.5%S) LS MDO(0.085%S)
	NMRI		Tokyo Univ. of Marine Sci. & Tech.

Marine diesel engines

NMRI



Tokyo Univ. of Marine Sci. & Tech.



Measurement methods for lab testing

> Methods discussed at IMO

- FSN / Filter Smoke Meter
- Multi-Angle Absorption Photometry (MAAP)
- Photo Acoustic Spectrometry (PAS)
- Thermal Optical Analysis (TOA)
- Laser Induced Incandescence (LII)*

> Other measurements

- PM gravimetric analysis (PM)
- Light extinction and scattering method / Laser Smoke Meter (LSM)

* LII equipment was not available in this study.

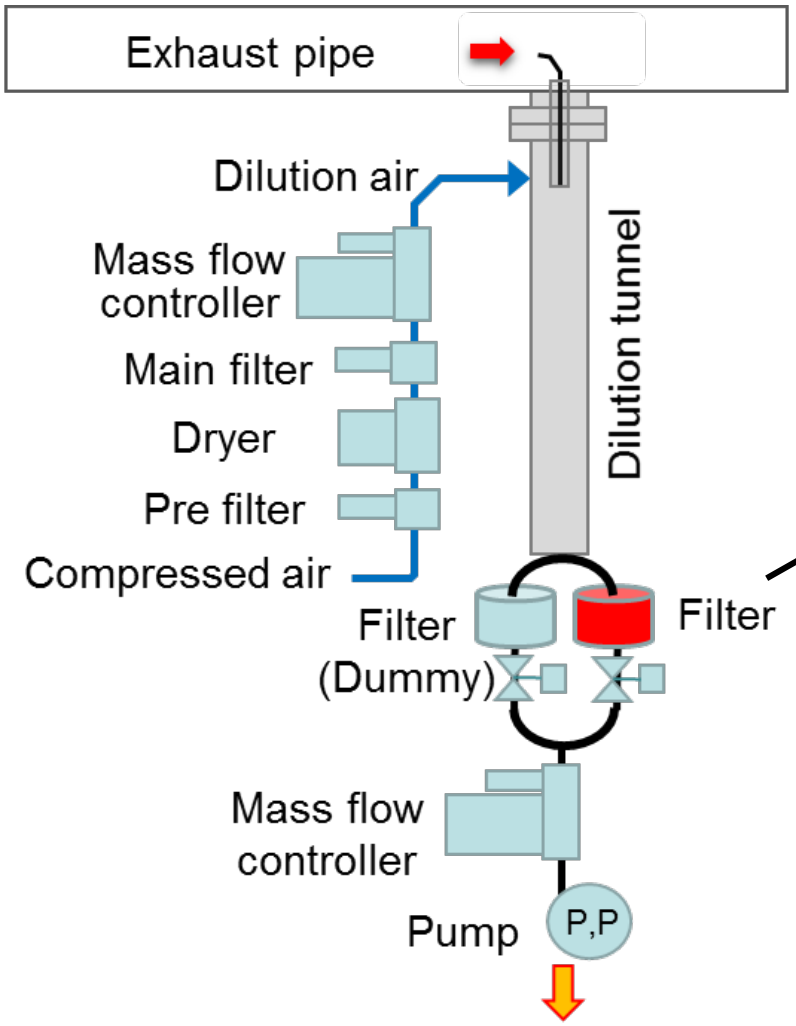
Instruments for lab testing

Method	Instrument	Measurement conditions		
		Dilution ratio	Heating option	
FSN	415S AVL	------	Sampling line: 70°C Measurement unit: 70°C	Auto-range presampling
MAAP	MAAP 5012 Thermo Scientific	External diluter MD-9E 1000 - 3000	Dilution unit: 150°C	
PAS	MSS 483 AVL	4 – 8	Dilution cell: 120°C Sampling line: 65°C Measurement cell: 52°C	
TOA	Model-5 Sunset Laboratory			TOR, TOT NIOSH, IMPROVE
PM	ISO 8178-1:1996	Dilution tunnel 7 – 26		
LSM	LEX-635s* Tsukasa Sokken	------	Sampling line: 120°C Measurement cell: 120°C	

*SAE International Paper #:2014-01-1580, 2014-04-01.

Sampling for TOA and PM

- ISO 8178-1:1996



Gravimetric analysis
weighted before and after sampling

1. PTFE coated glass fibre filter (TX40HI-20-WW, Pall)
2. Tissuequartz filter (2500 QAT-UP, Pall)

2. TX
3. QAT
4. TX

TOA (OC/EC analysis TOR/TOT)
measured by both IMPROVE & NIOSH protocols

Partial flow dilution tunnel
connected directly to the exhaust pipe

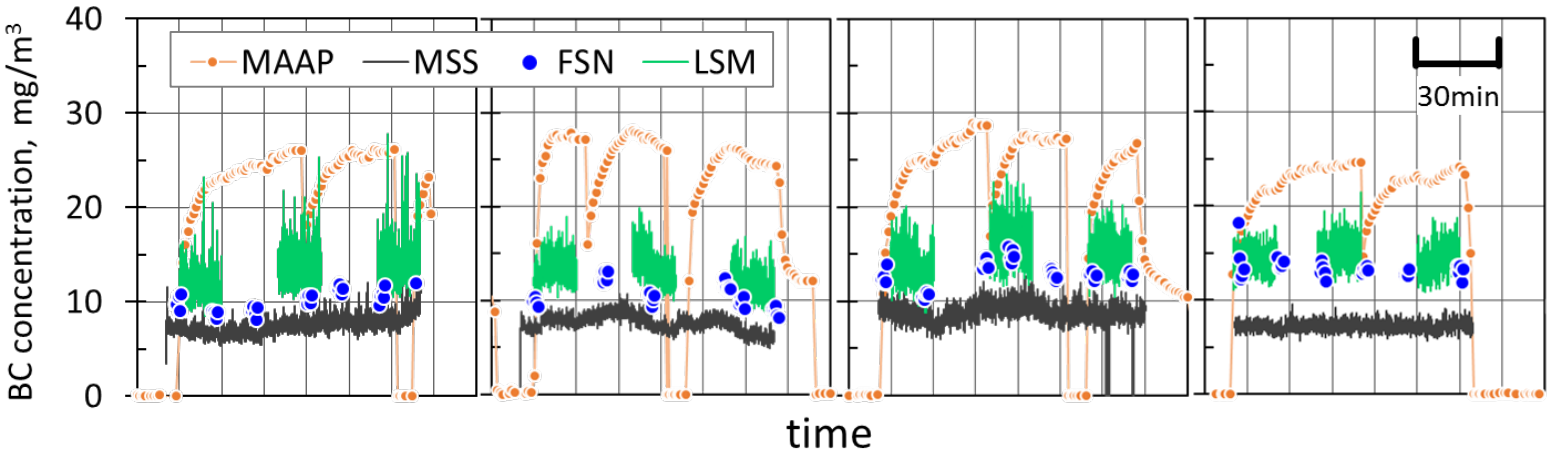
Results of BC measurements for lab testing

MDO

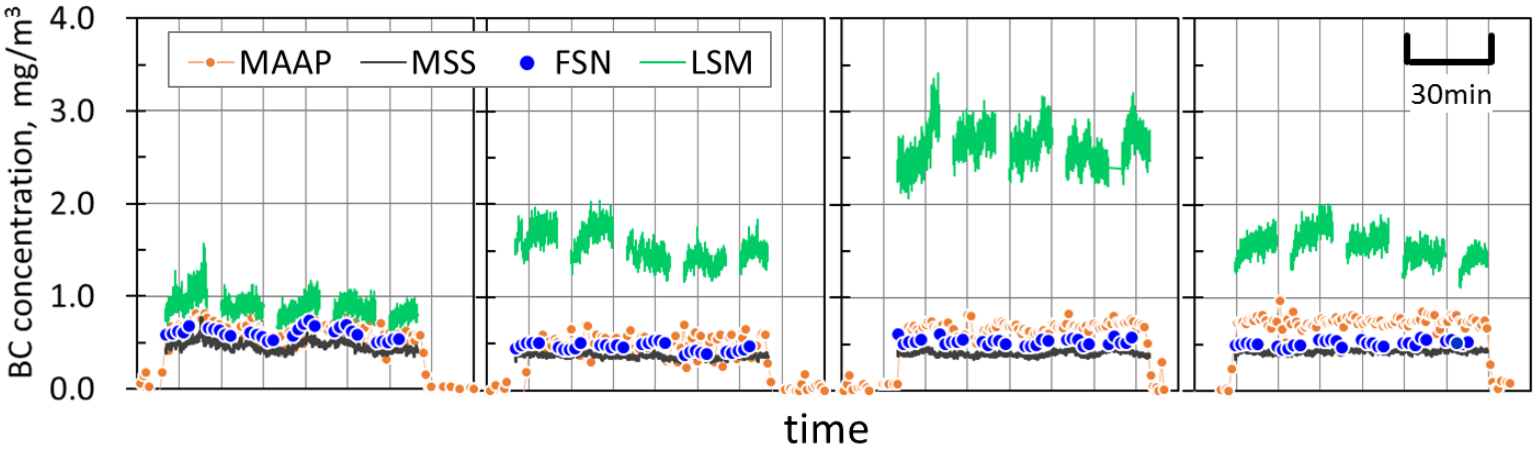
Engine load

25% 50% 75% 100%

A1
4 stroke



B
2 stroke

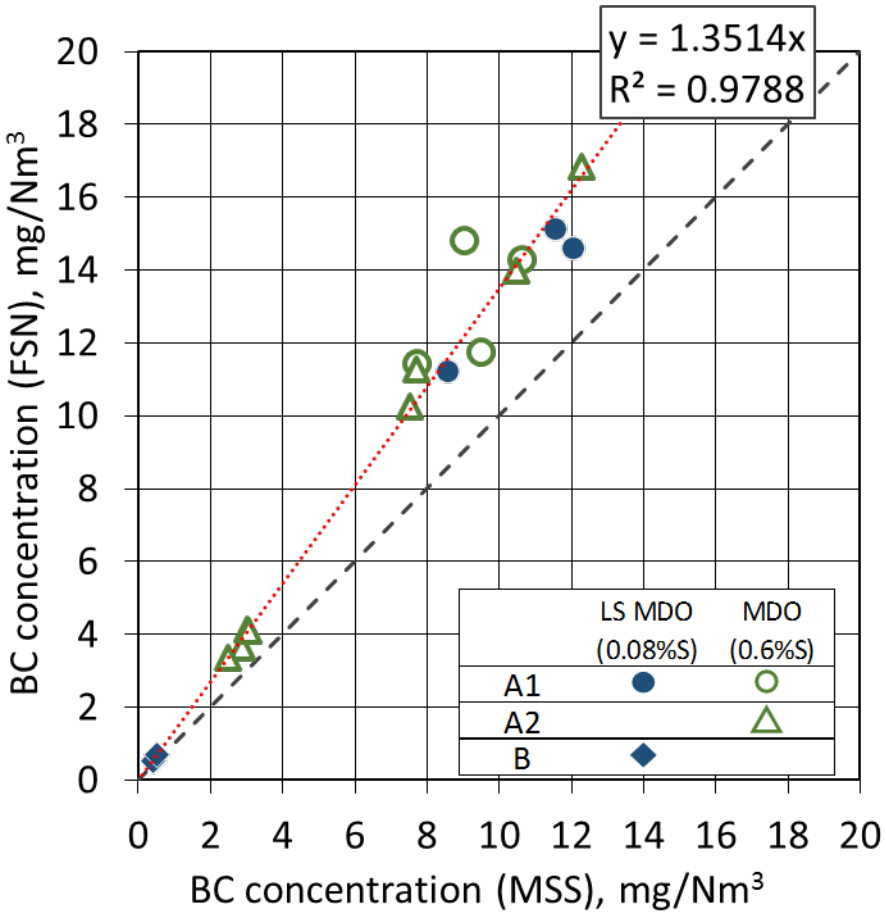


Note:

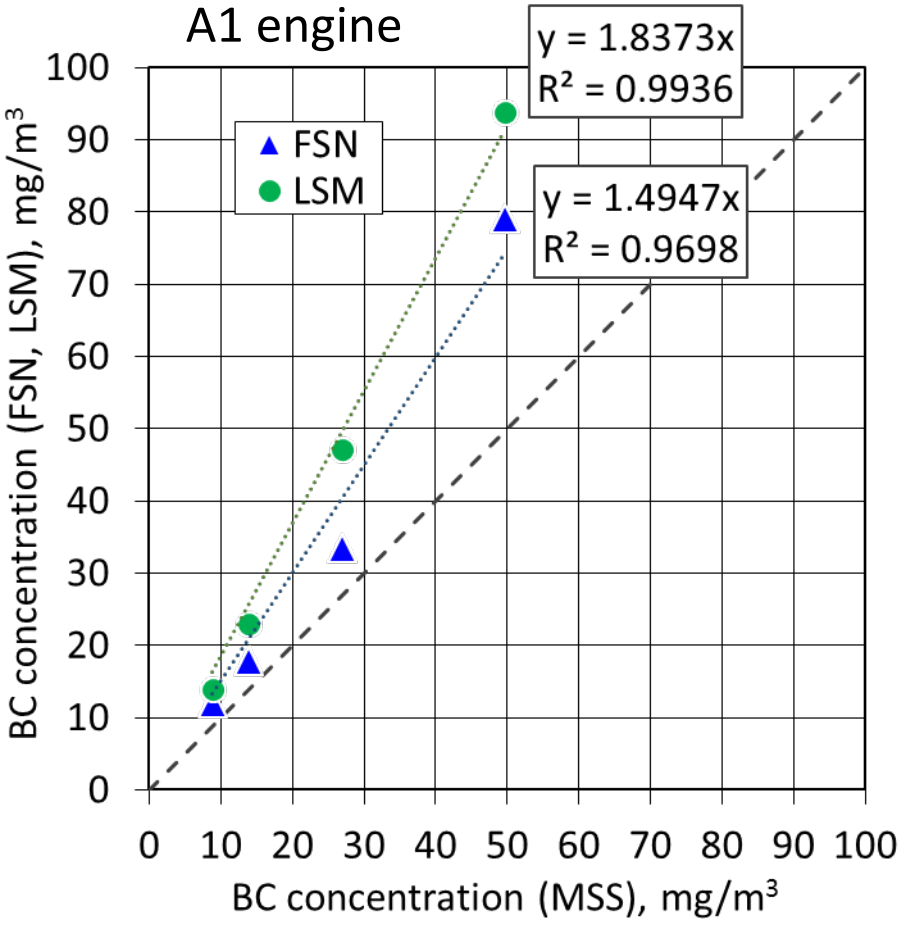
1) BC concentration values in these figures are “as-displayed” values on each instrument.

Relation between measurement methods

MDO



HFO



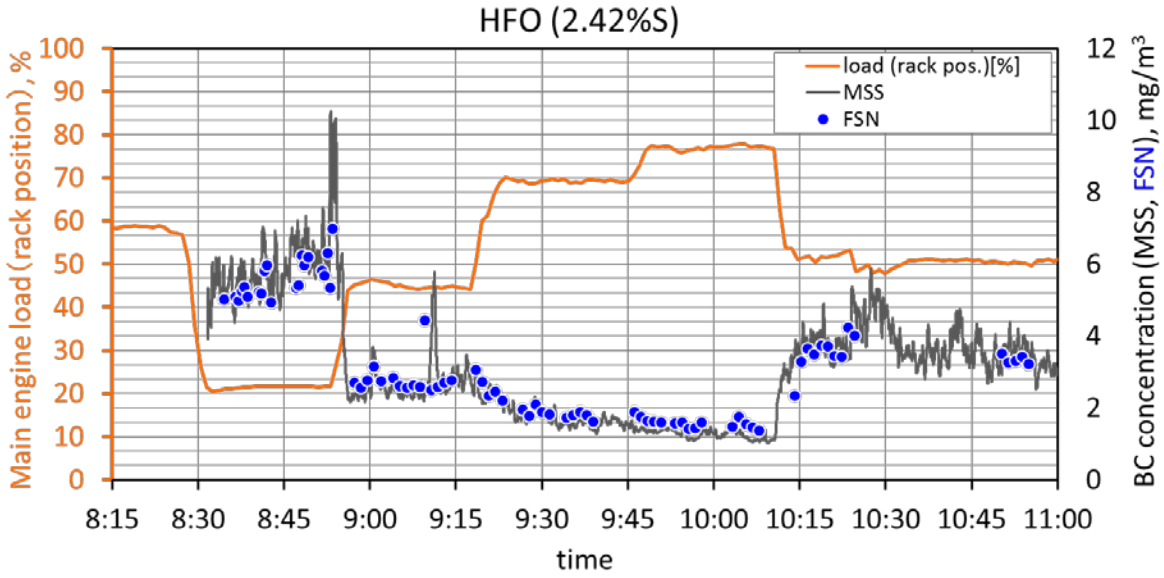
Note:

1) BC concentration value of MSS was corrected concerning particle losses due to thermophoresis inside the sampling line.
2) BC concentration unit: mg/Nm^3-wet (0^{o}C, 1 atm)

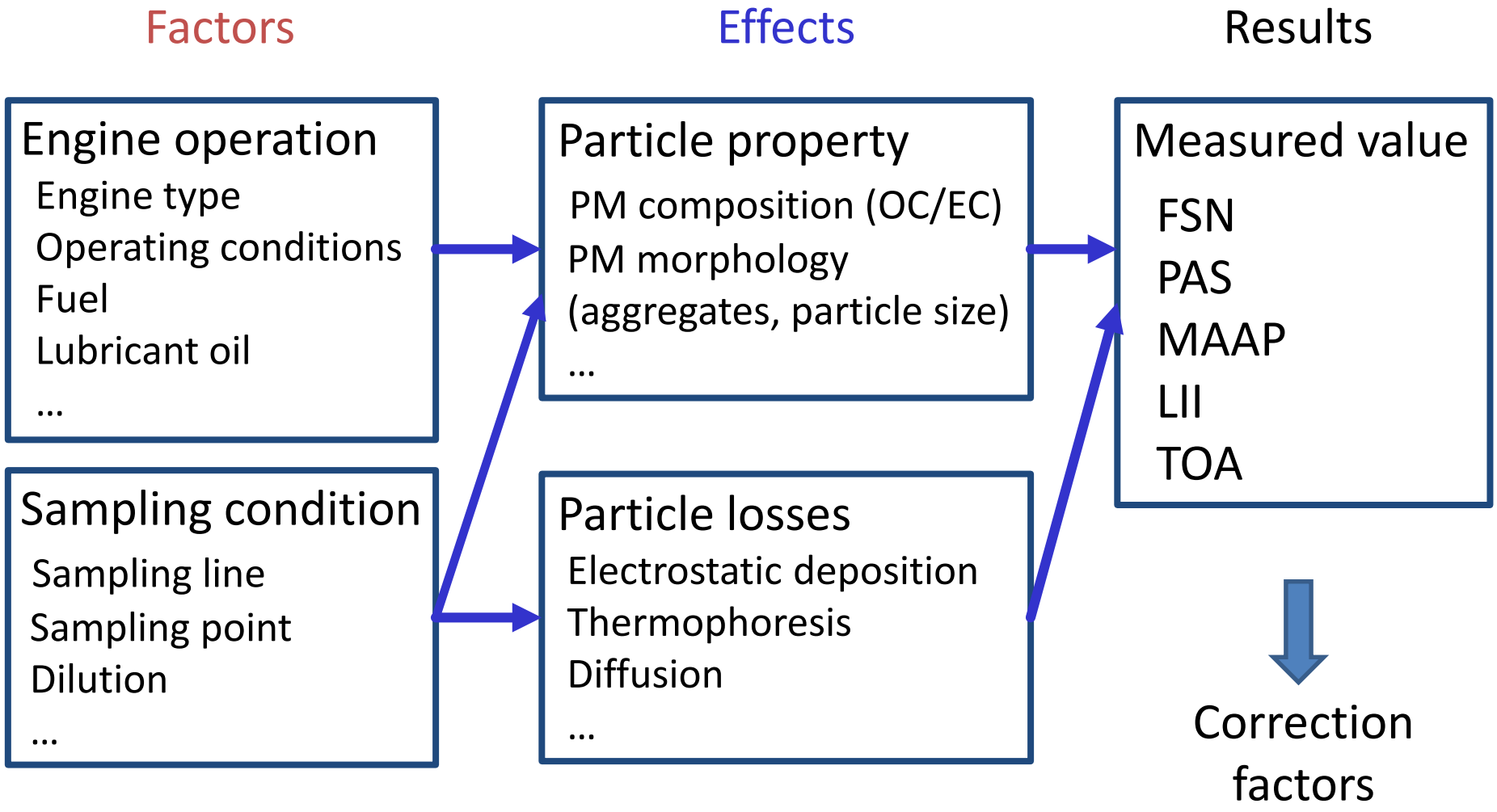
Onboard testing

Jan. 2014 FSN, LSM
Feb. 2015 FSN, MSS

ME : Low speed 2 stroke engine



Issues to be discussed



Future plans

Future plans:

1. The NMRI will conduct further experimental research on BC measurement.
2. LII method will be also tested in November of this year in the NMRI.

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