

---

# **Air pollution from ships - Measurements**

**Dr. Axel Friedrich**  
**Germany**

# What is the problem?

- Sulfur content of fuel for marine sea ships can be about 3,500 times as high as on shore (cars, trucks)
- Sulfur content of fuel for marine sea ships on average it is 2,700 times higher
- From 2020 sulfur content will be limited
- To 0.5 %, in ECA and EU harbors: S- max 0.1 %
- Toxic emissions:
  1. Particulate Matter (PM) and
  2. Black Carbon (BC)
  3. Sulfur Dioxides ( $\text{SO}_2$ )
  4. Poly Aromatic Hydrocarbons (PAH)
  5. Heavy Metal Oxides
  6. Nitrogen Oxides ( $\text{NO}_x$ )



## Problem: BlackCarbon(1)

- results from the incomplete burning of fossil fuels and biomass
- component of PM
- shortens life expectancy
- causes respiratory and cardiovascular diseases
- can cause lung-cancer



🔍 Calle Scuola, Venedig, Italien



Calle Scuola

Google







# Black Carbon Measurements

## microAeth<sup>®</sup> / AE51



### Measurement Principle

Real-time analysis by measuring the rate of change in absorption of transmitted light due to continuous collection of aerosol deposit on filter. Measurement at 880 nm interpreted as concentration of Black Carbon ('BC').

### Measurement Range

0-1 mg BC/m<sup>3</sup>, filter life time dependent on concentration and flow rate setting:

avg. 5 µg BC/m<sup>3</sup> for 24 hours @ 100 ml/min

avg. 100 µg BC/m<sup>3</sup> for 3 hours @ 50 ml/min

avg. 1 mg BC/m<sup>3</sup> for 15 minutes @ 50 ml/min

### Measurement Resolution

0.001 µg BC/m<sup>3</sup>

### Measurement Precision

±0.1 µg BC/m<sup>3</sup>, 1 min avg., 150 ml/min flow rate

### Measurement Timebase (User setting)

1, 10, 30, 60, or 300 seconds



# Ultrafine Particle

## P-TRAK™ ULTRAFINE PARTICLE COUNTERS (CPC)

### Model 8525

- + Counts ultrafine particles less than 1 micron diameter in real time
- + Tracks particles to the source
- + Portable, battery operated
- + Data logs to document results



Model 8525

### SPECIFICATIONS

#### P-TRAK ULTRAFINE PARTICLE COUNTER MODELS 8525

##### Concentration Range

0 to  $5 \times 10^5$  particles/cm<sup>3</sup>

##### Particle Size Range

0.02 to 1 micrometer

##### Temperature Range

Operation

32 to 100°F (0 to 38°C)

Storage

-40 to 160°F (-40 to 70°C)

##### Flow Rate

Sample

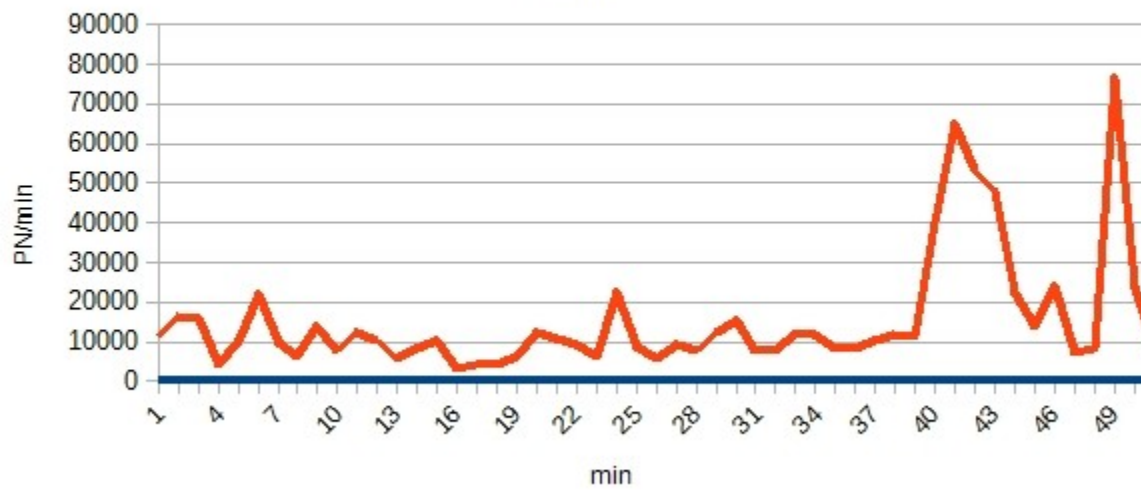
100 cm<sup>3</sup>/min

Total

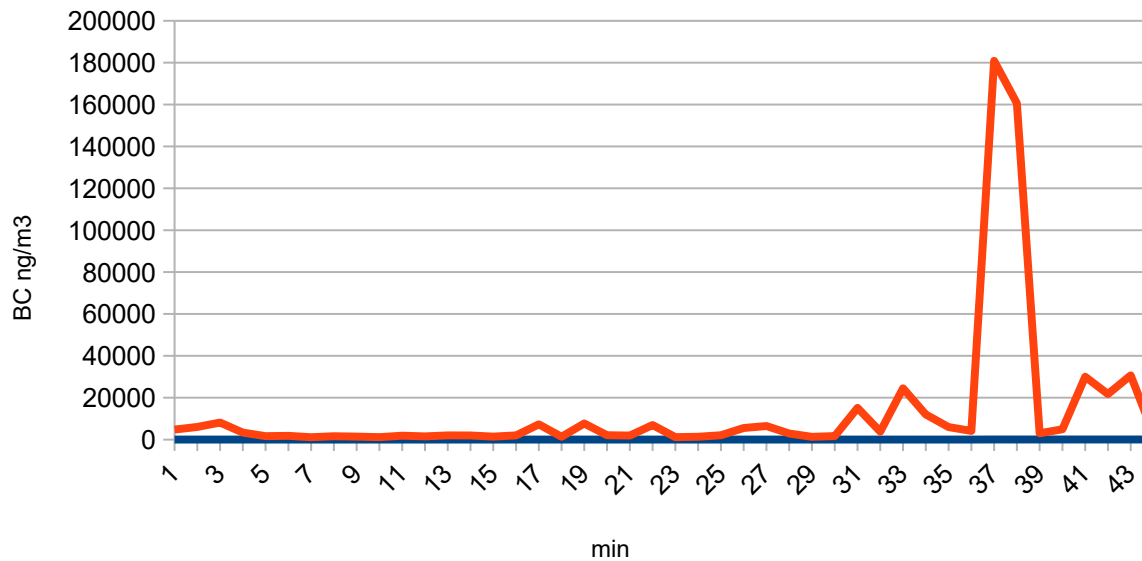
700 cm<sup>3</sup>/min (nominal)

## Particle Number Venice

Av. min

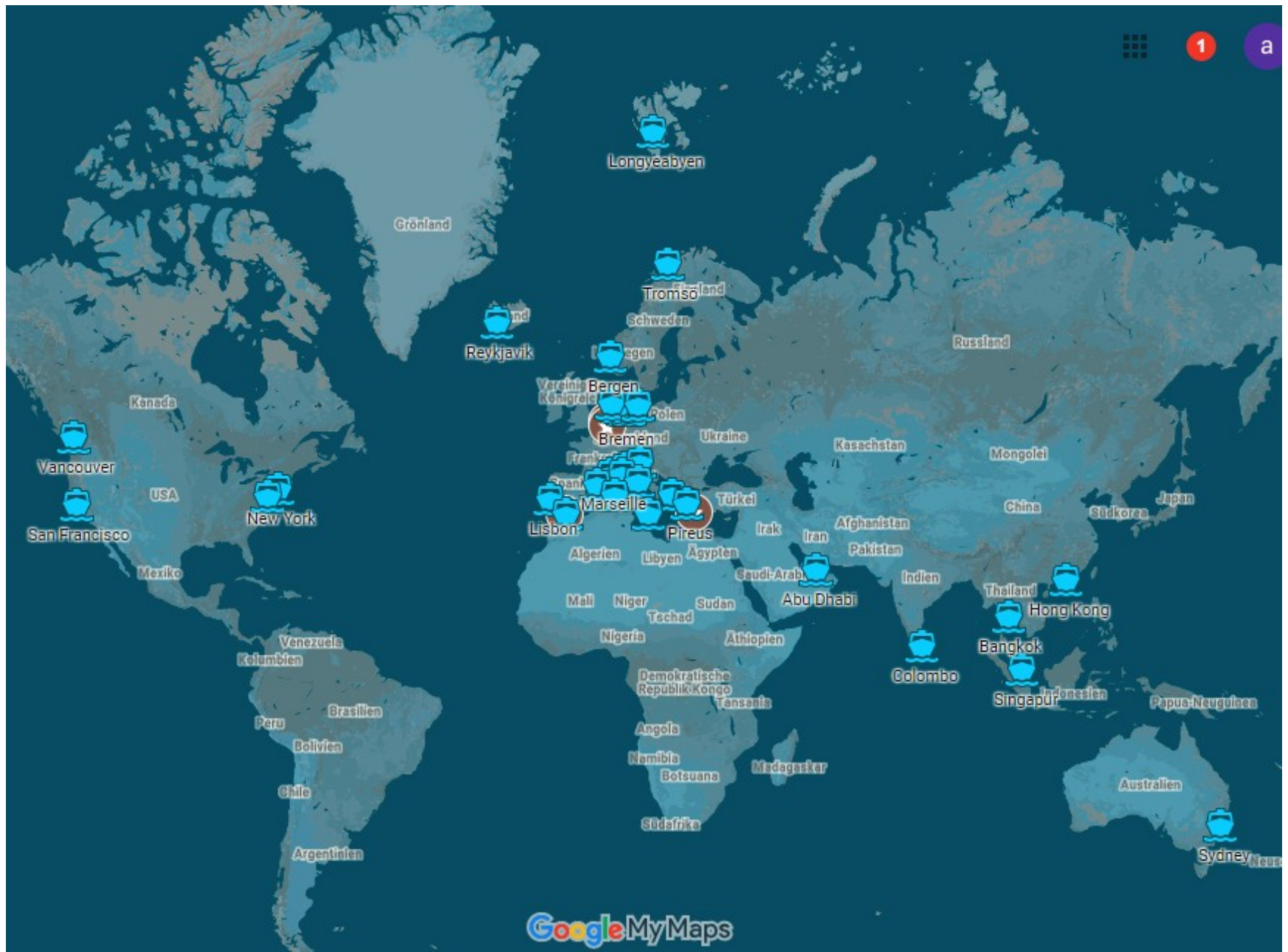


BC units = ng/m<sup>3</sup>





# Measurements in Ports and on Cruise Ships

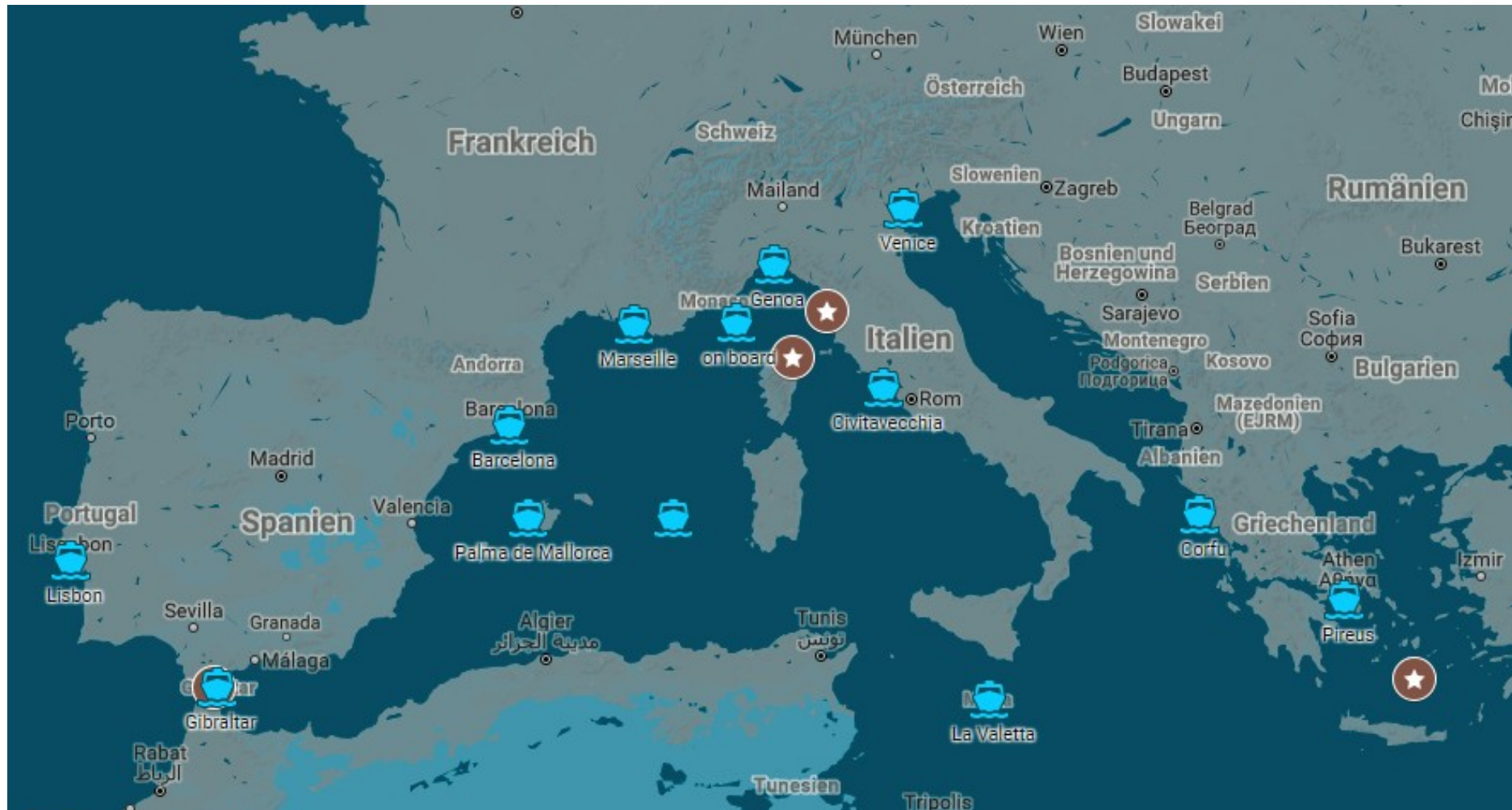


# Air Pollution Measurements in European Waters



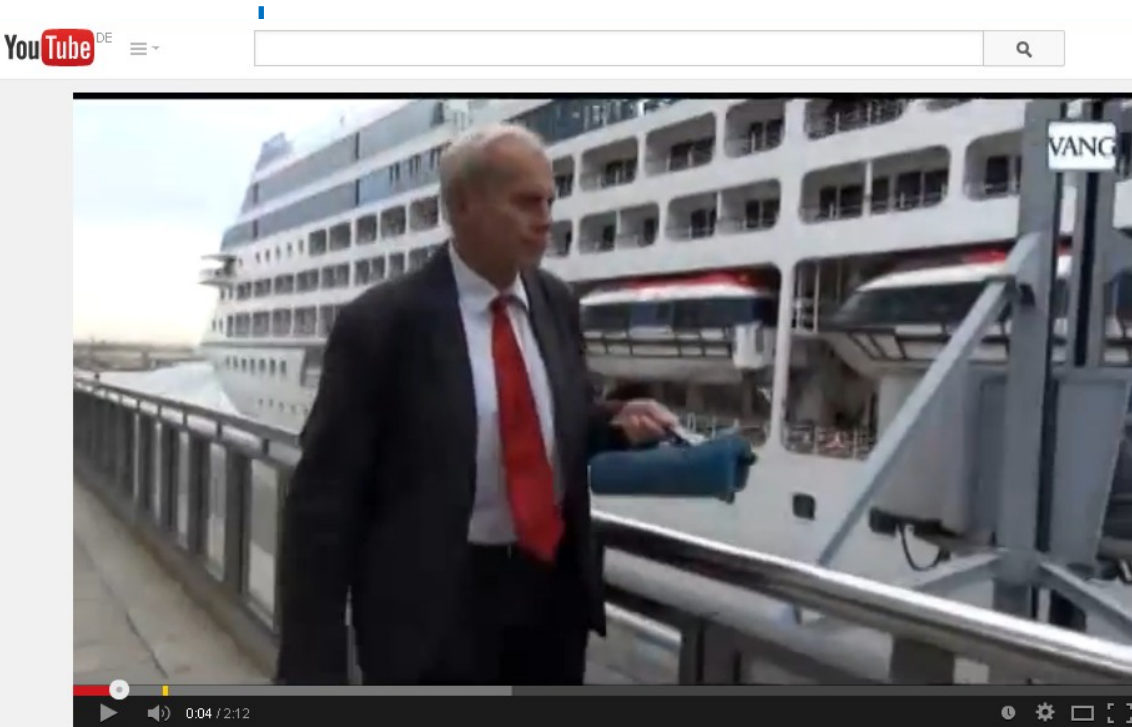


# Measurements in the Mediterranean Sea



# Cruise ships

Activities in Venice (Italy), Bergen (Norway) and Barcelona (Spain) and many harbor cities with very



Los cruceros también contaminan el aire de Barcelona

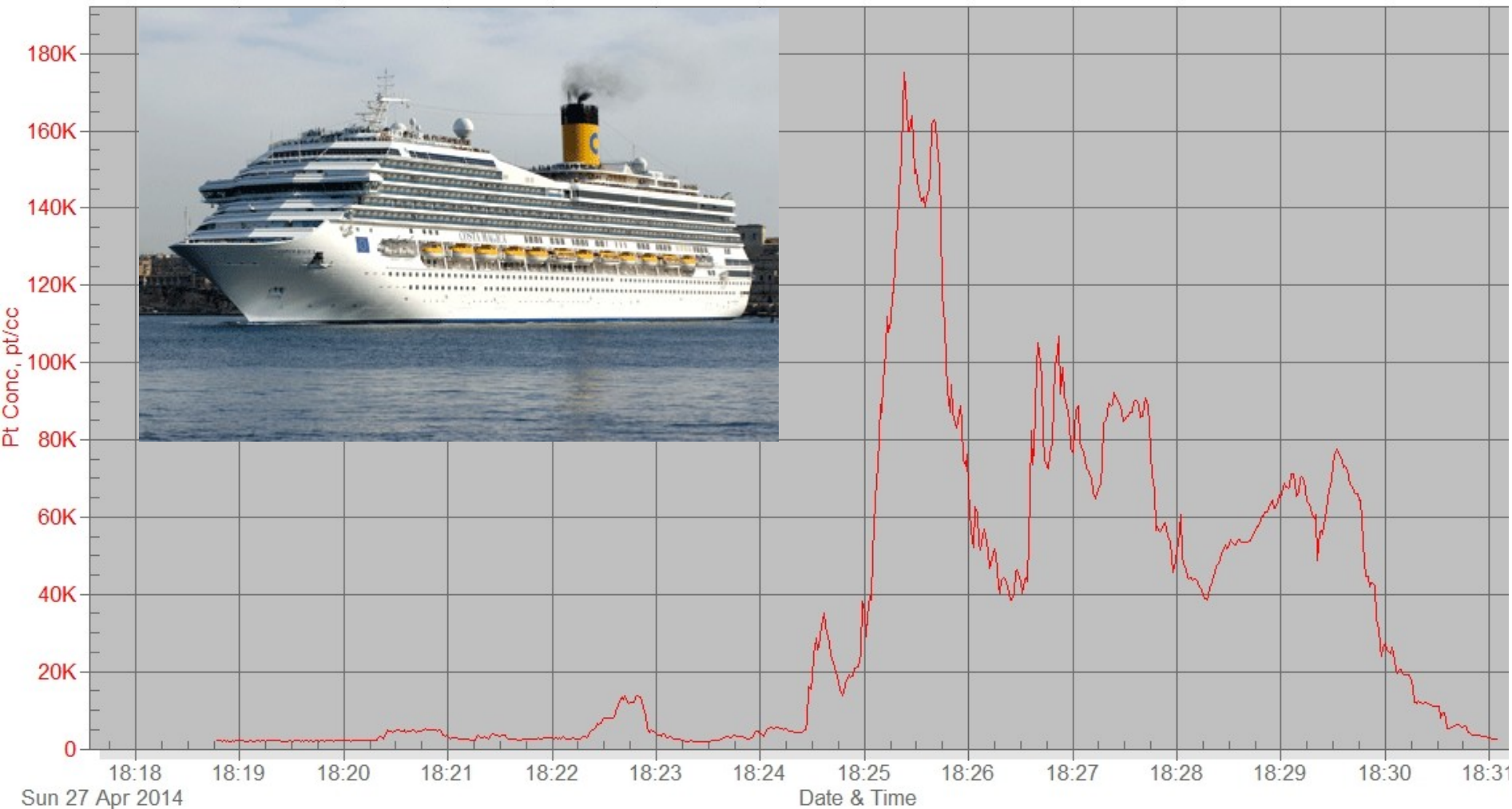




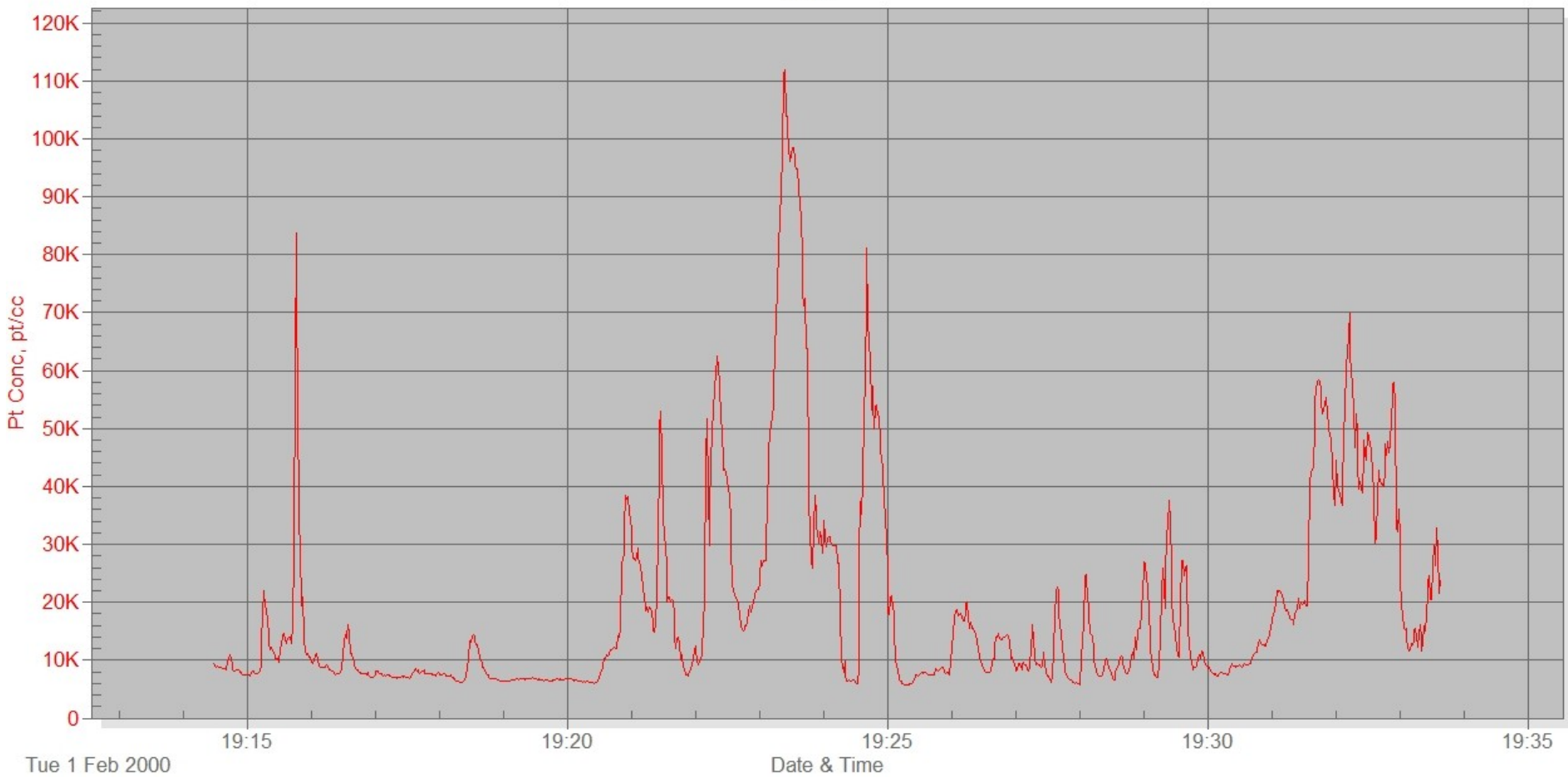
# Particle Number Measurements

# Cruise ship emissions: Peanuts?

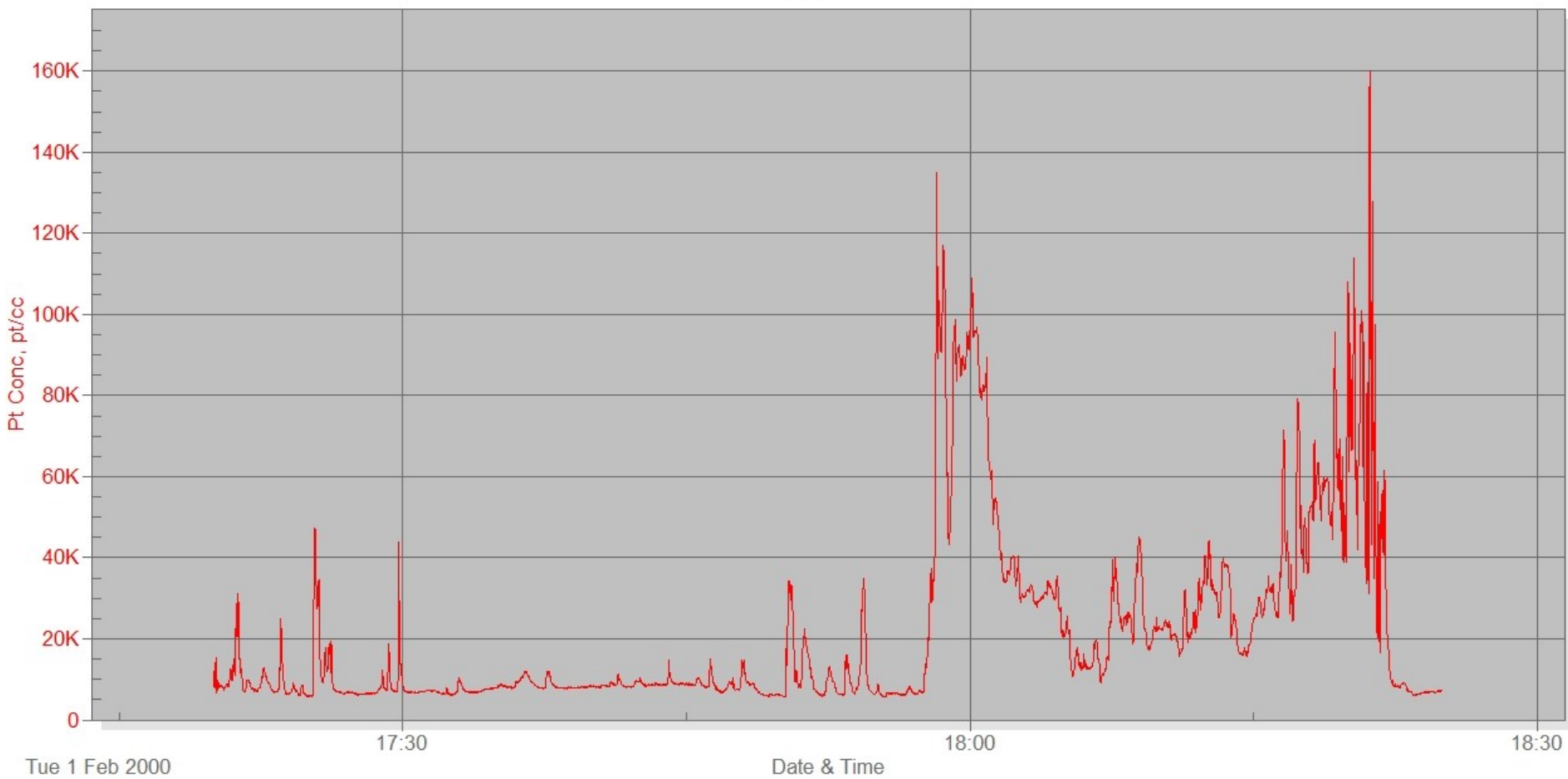
Costa\_Magica  
S\_Elena



MSC Preziosa  
Venice



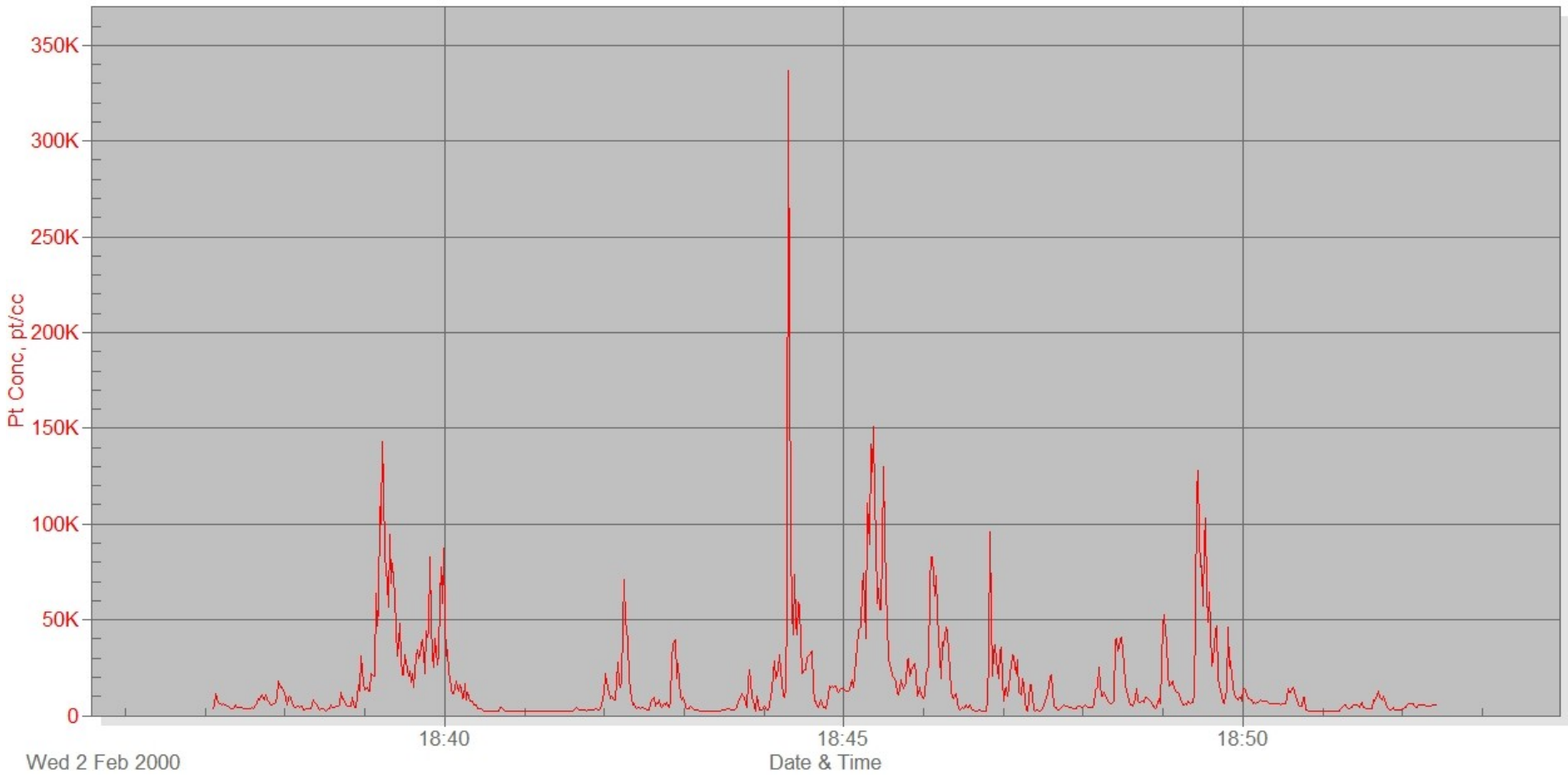
NSL\_Noordam  
Venice1



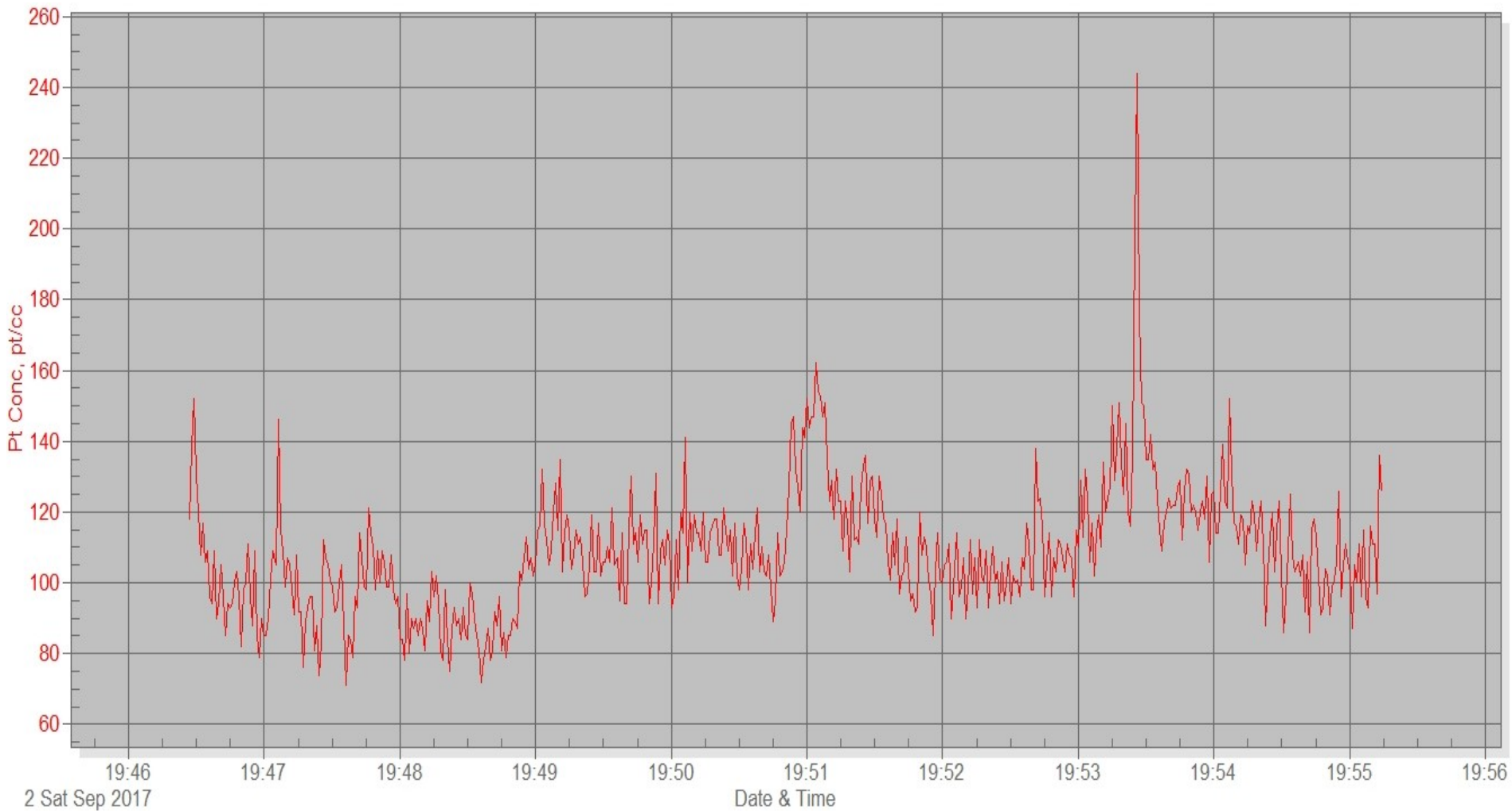


# Vaporetto\_Trip

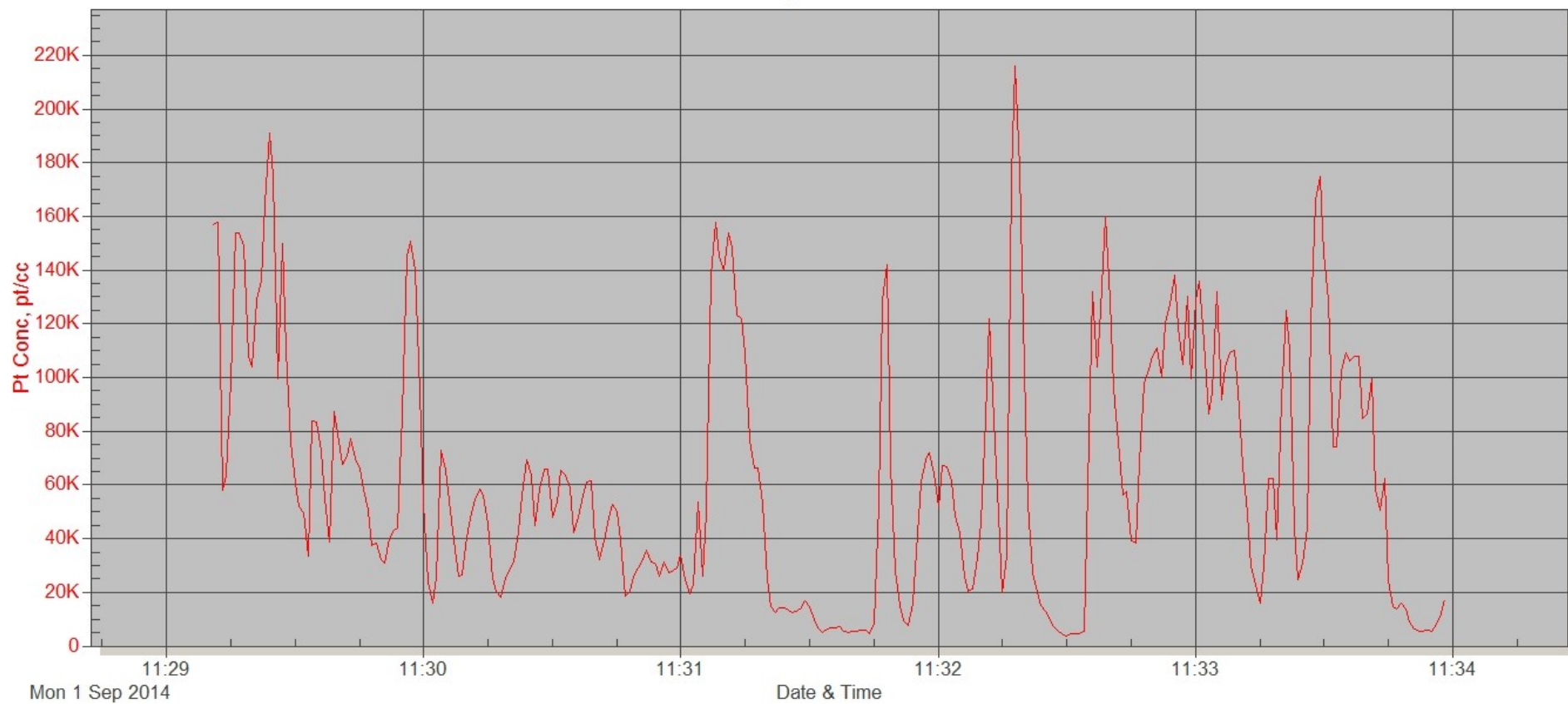
Sub Title

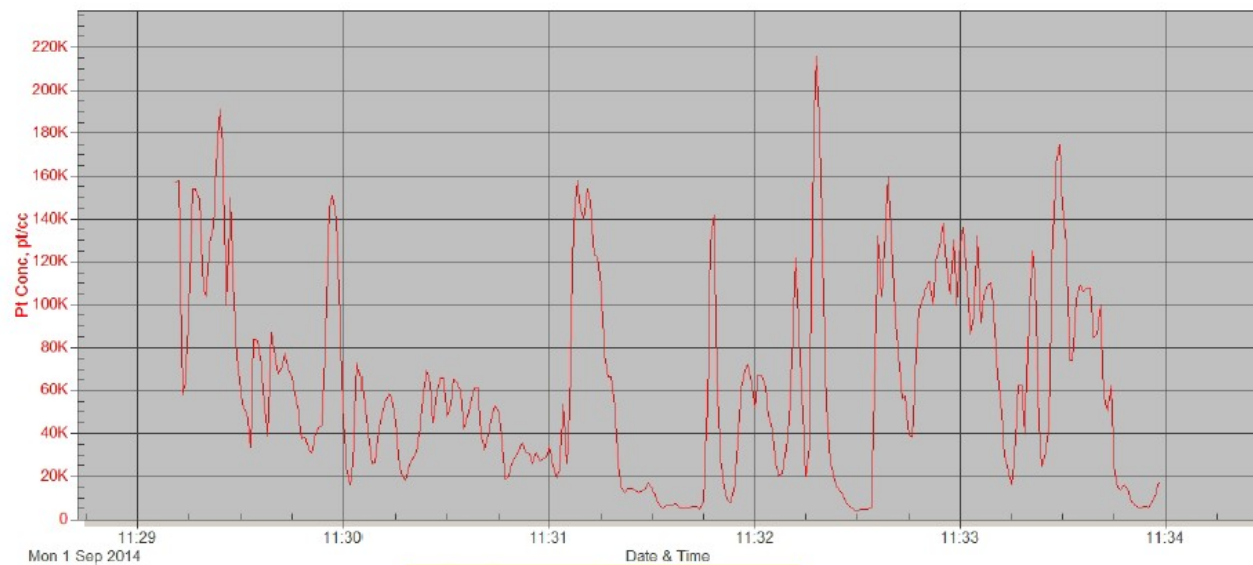


# Clean Air Spitsbergen

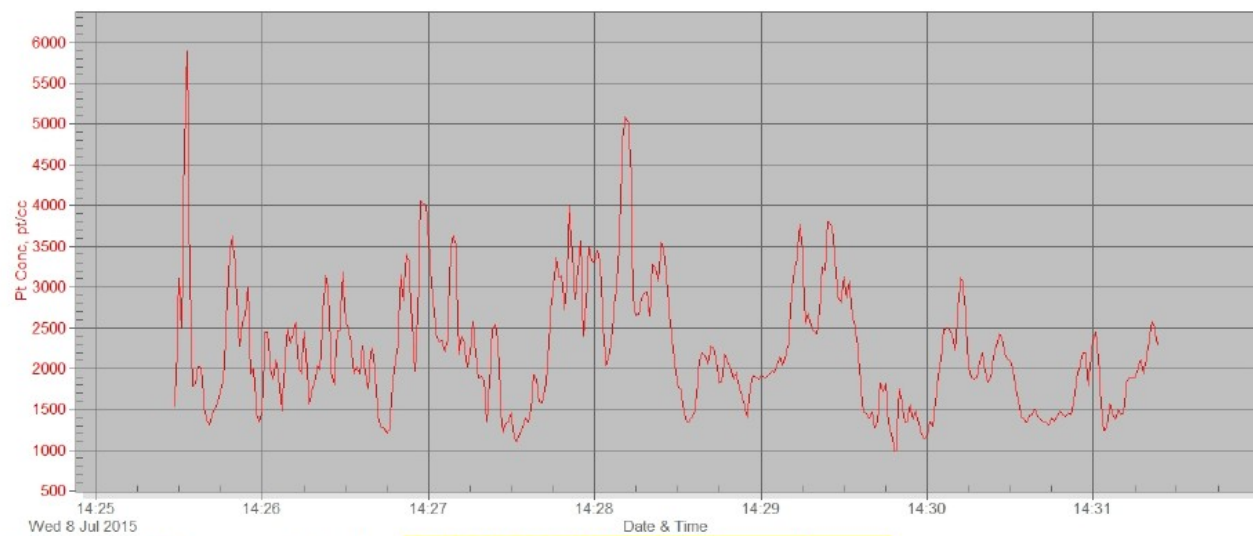


BMBF Heincke  
Bergen Port





Graph 1: UFP concentration 09/01/2015 Heincke, Bergen



Graph 2: UFP concentration 08/07/2015 Heincke, Bremerhaven



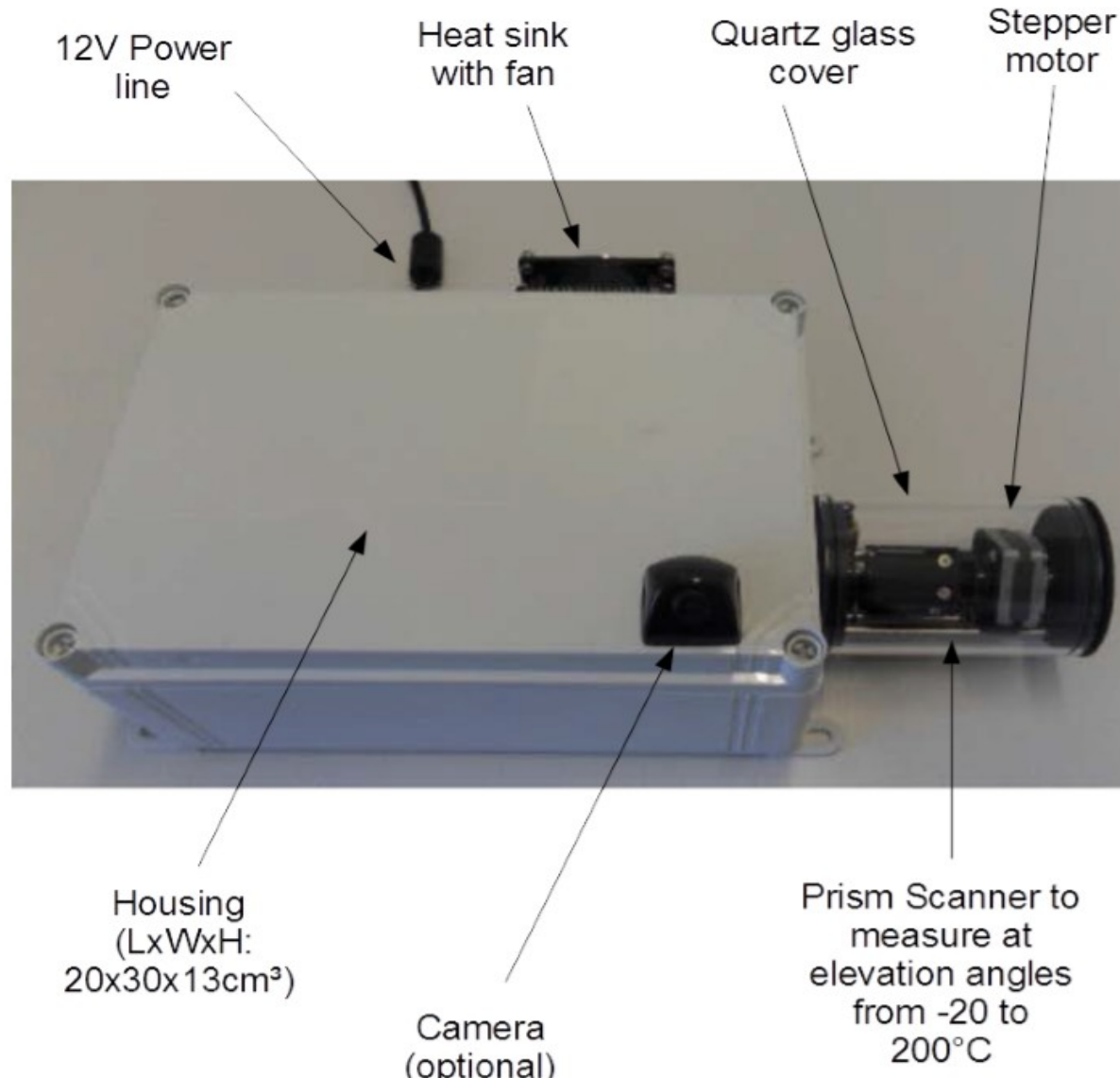


Particulate counter shows very low UFP concentration directly next to the smoke stack.

Foto:NABU/Diesener

As any other Regulation also an ECA in the Mediterranean Sea must be controlled

# Remote Measurement of SO<sub>2</sub> and NO<sub>2</sub> by a MAXDOAS Instrument

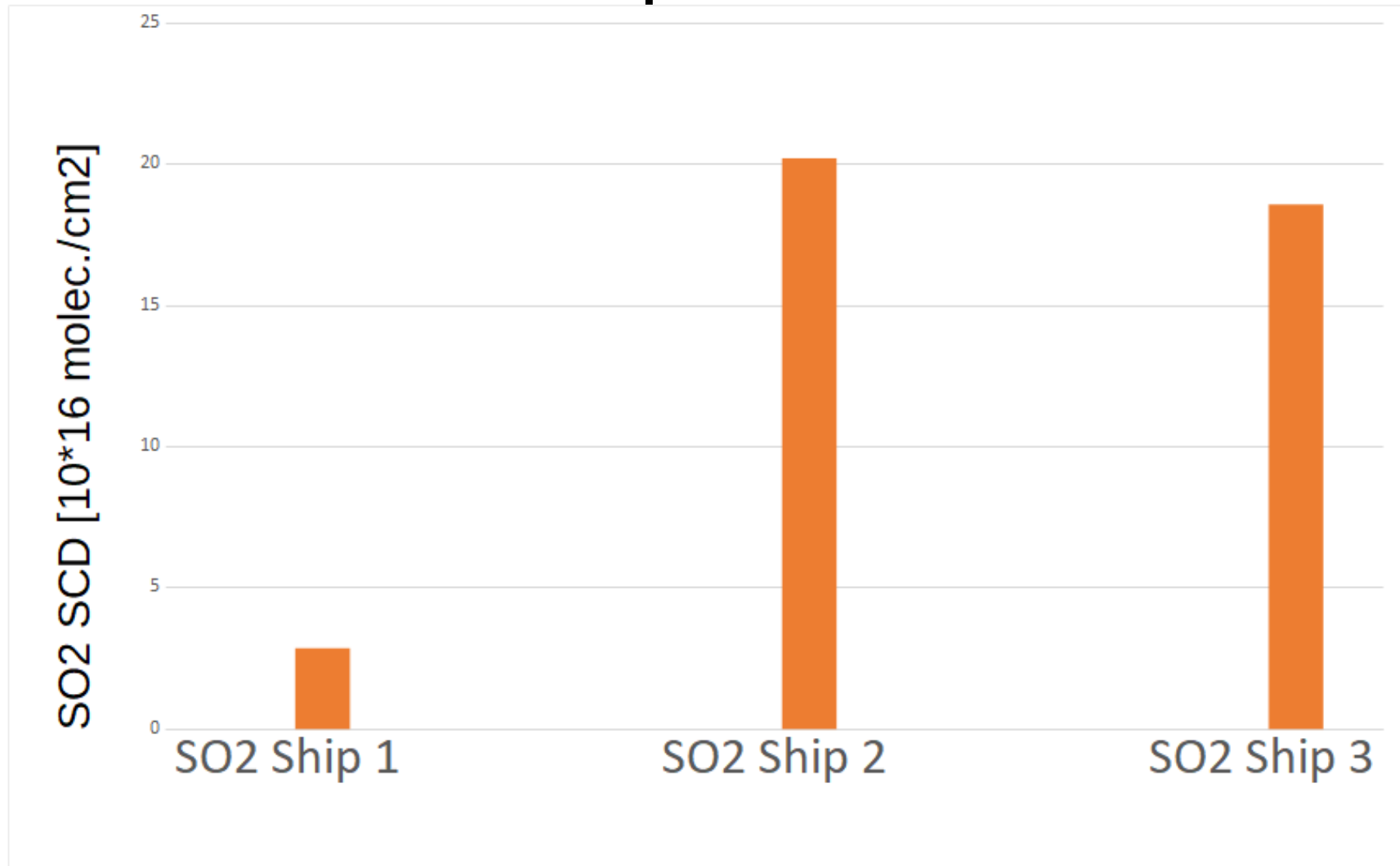


# Cruise Ship Terminal Funchal, Madeira





# SO<sub>2</sub> Concentrations in the Plume of Cruise Ships in Funchal



---

axel.friedrich.berlin@gmail.com

