UNIVERSIDAD SAN SEBASTIAN

Air Pollution, Transport and Health Effects

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Overview

- Background
- Description of the project
- Methodology
- Transport, air quality and health data
- Discussion

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Evolution of Santiago's transport system

Pre 1980
- State system
- Regulation of tariffs, routes and frequencies
- State involvement in the operation

Between 1980 and 1990
- Free market
- Better frequencies and coverage
- Steep tariff increase
- Uncontrolled increase of the fleet
- Congestion and pollution

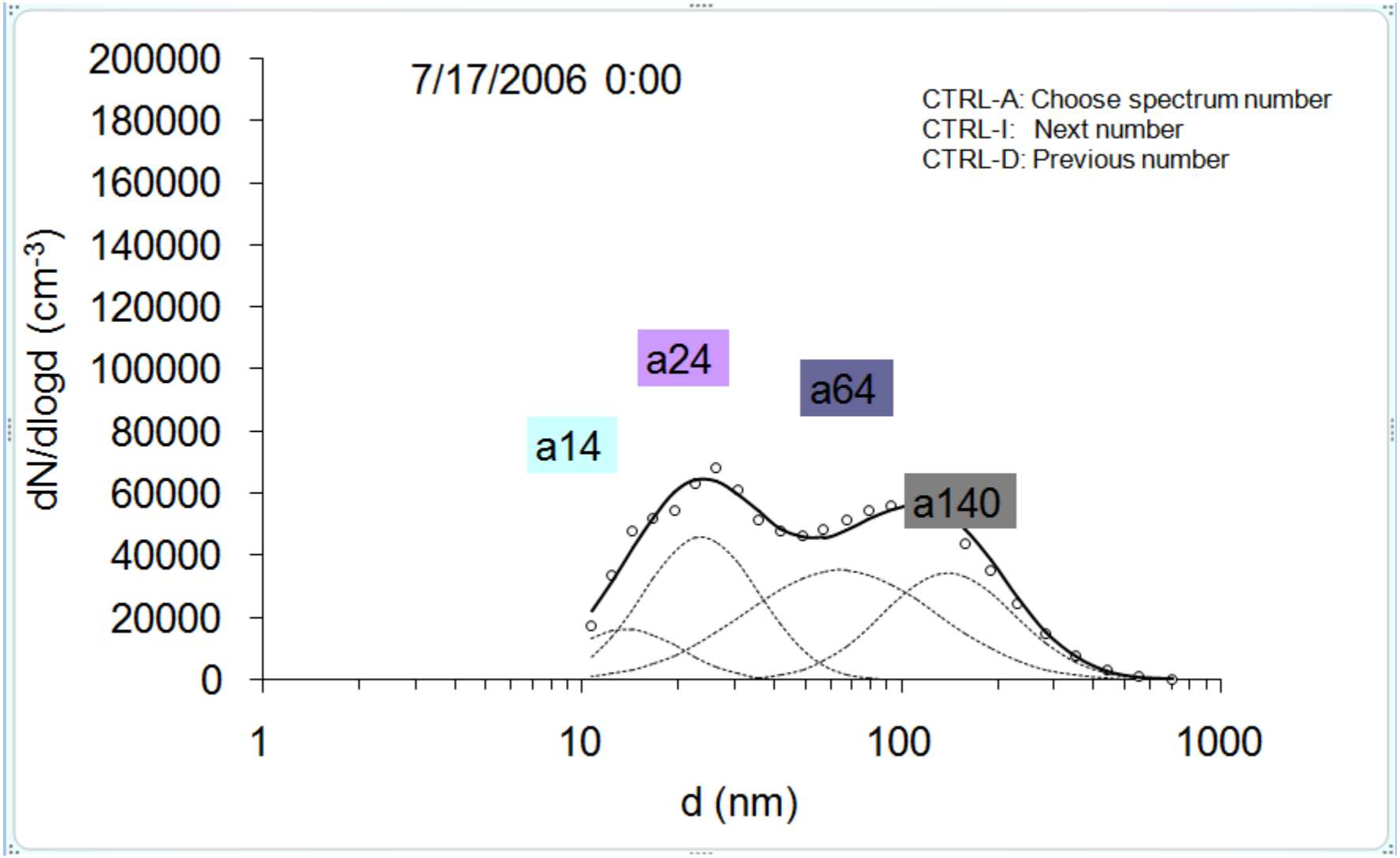
Between 1991 and 2003
- Regulated market
- Multiple tenders of routes
- Regulated area: interior of Vespucio ring
- Fleet renovation
- Tariff fixed in the tender process

Year 2004
- Regulated by Ministerial Resolution (the majority) and tender (Metrobus)
- More than 3000 bus owners grouped in 120 organizations
- Regulated area: all Gran Santiago
- 323 transport services
- 7000 buses

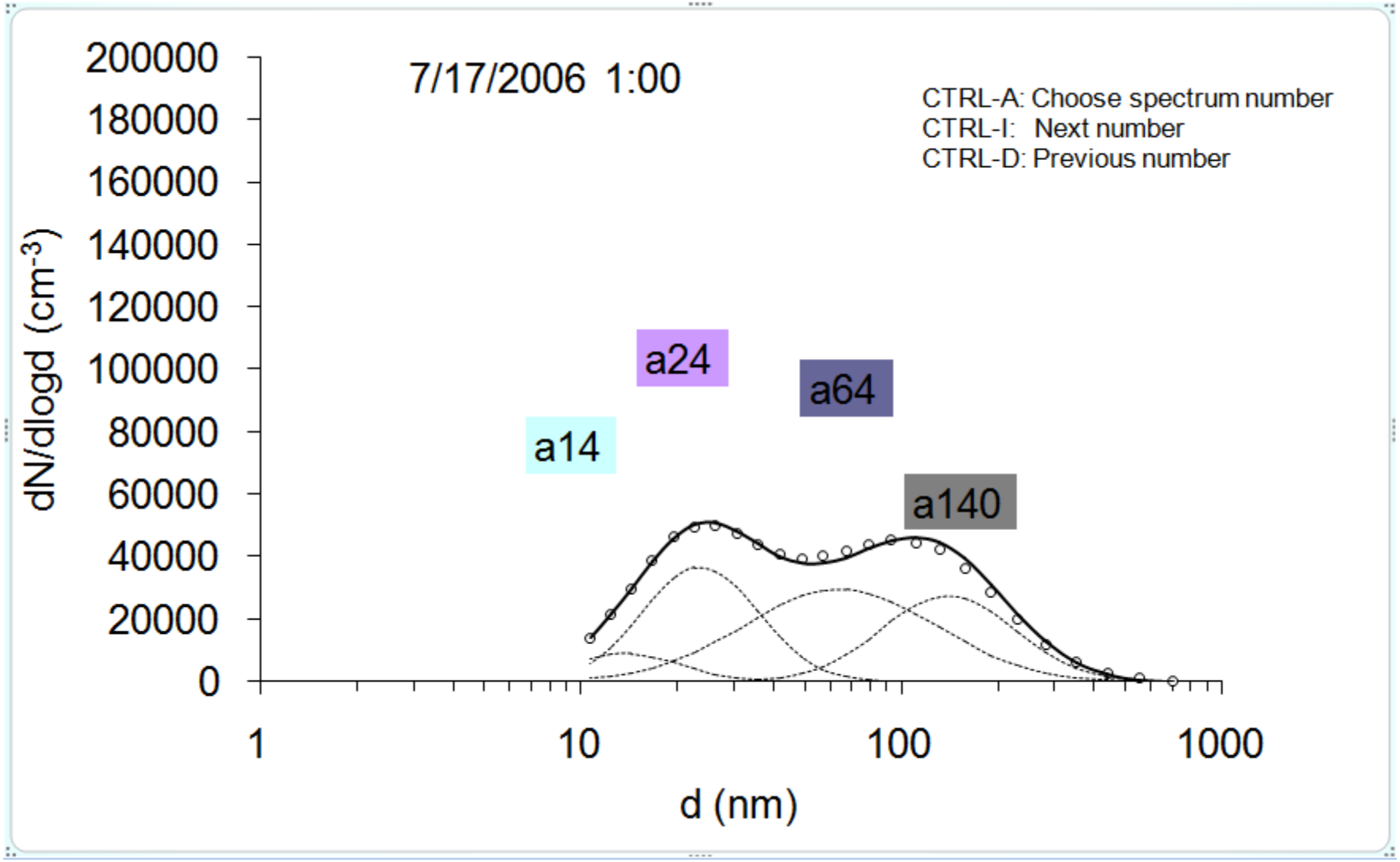
Pollution reduction objectives

- The Atmospheric Pollution Reduction and Prevention Plan for Santiago (PPDA) established the PM10 and NOx emissions reduction goals for public transport
- New emissions standard for new buses (Euro III, october 2000)
- Modification of opacity standard for Euro I and Euro II buses (30 % reduction).
- Filters implementation for Euro III buses

Monday 17/7/06 – Alameda Street



Source: Estudios Transantiago - Centro Mario Molina, Chile



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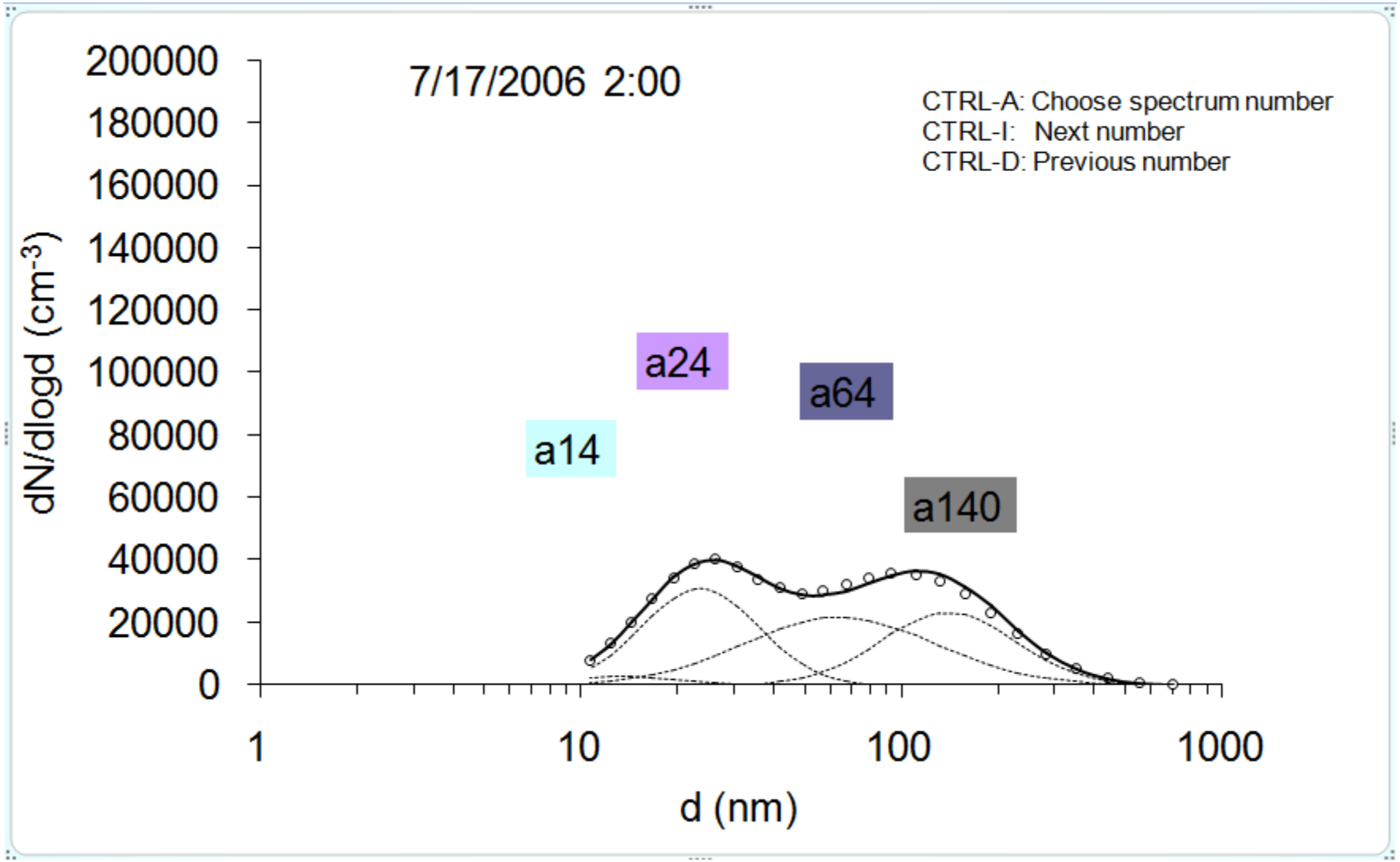

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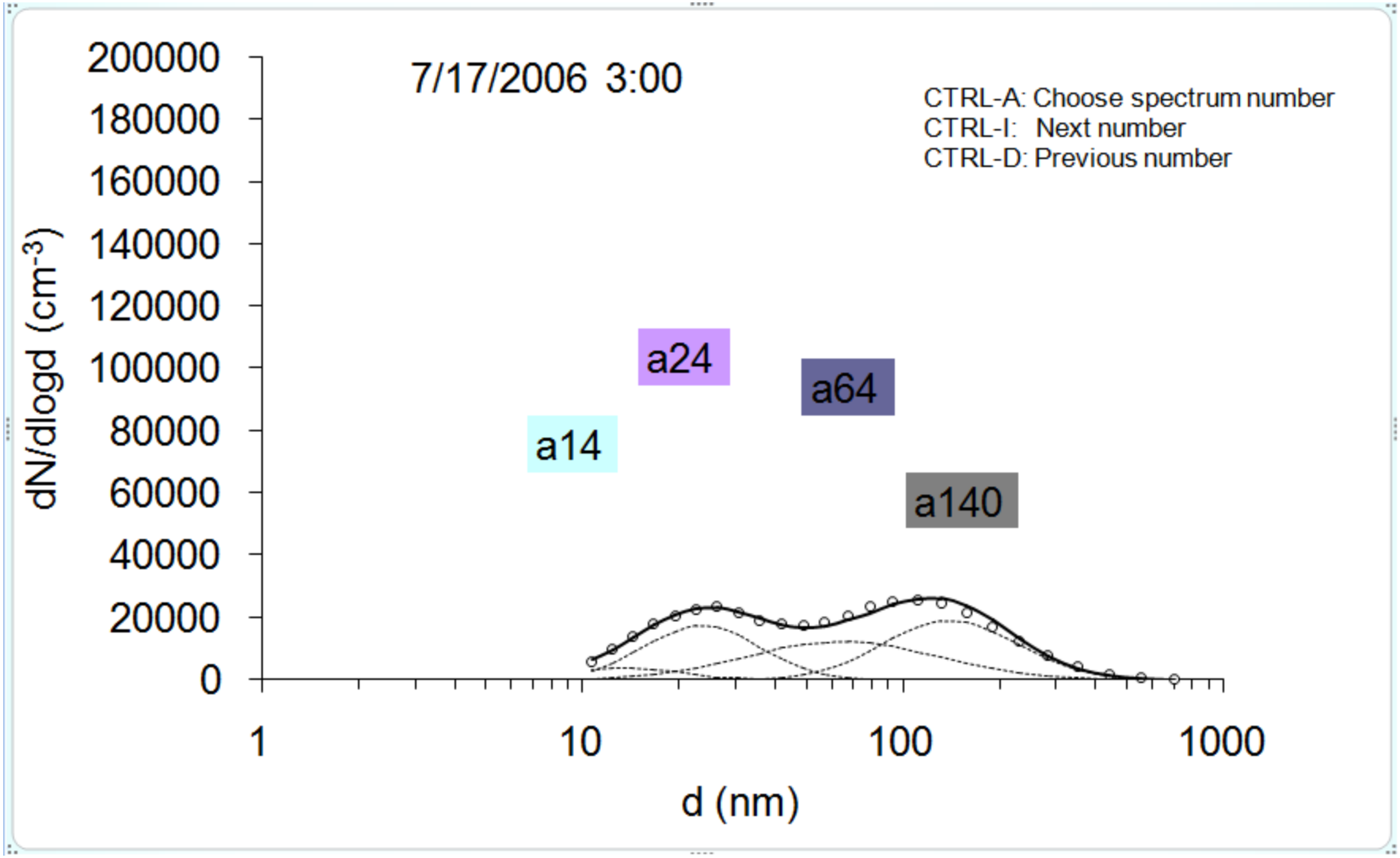

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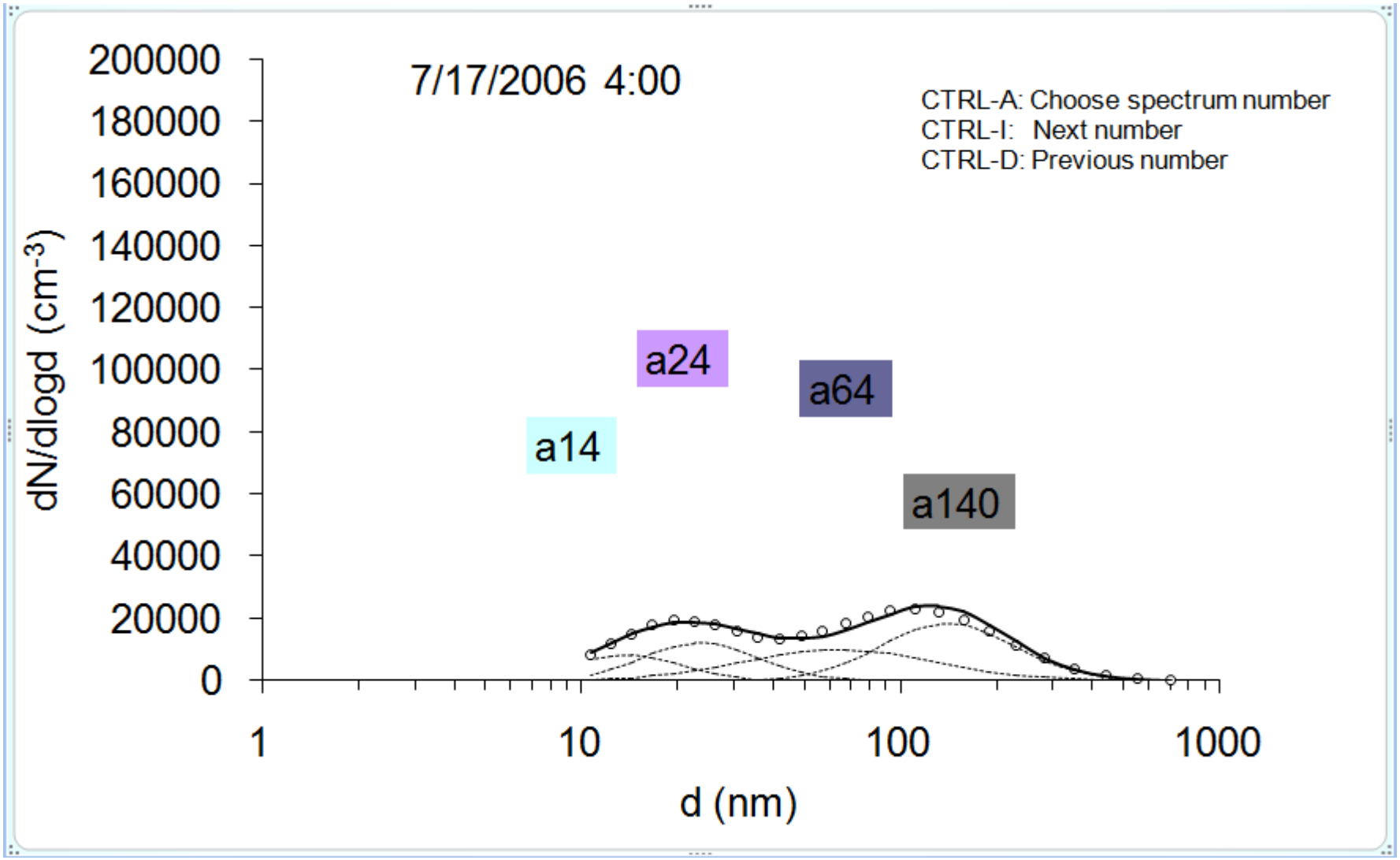

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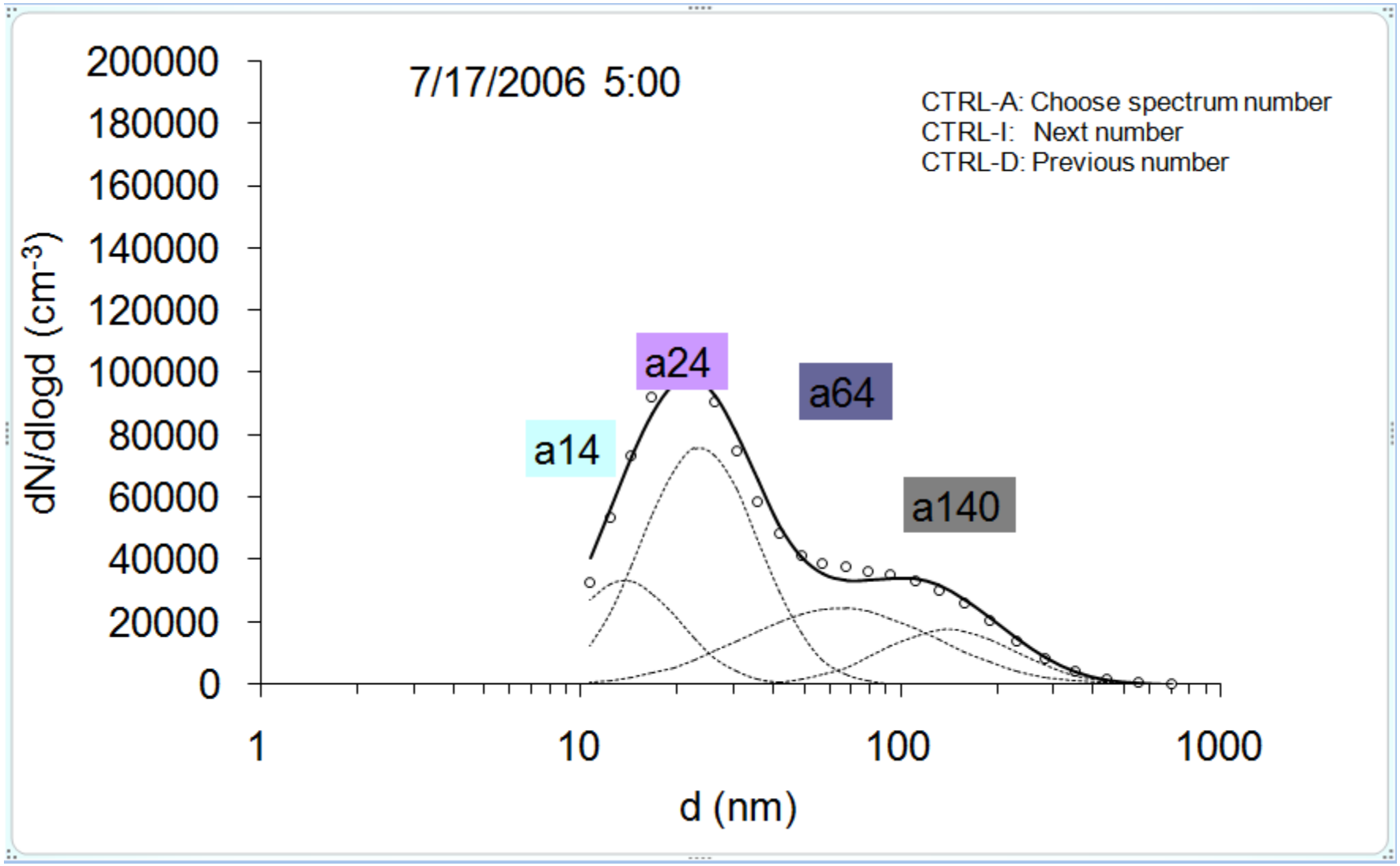

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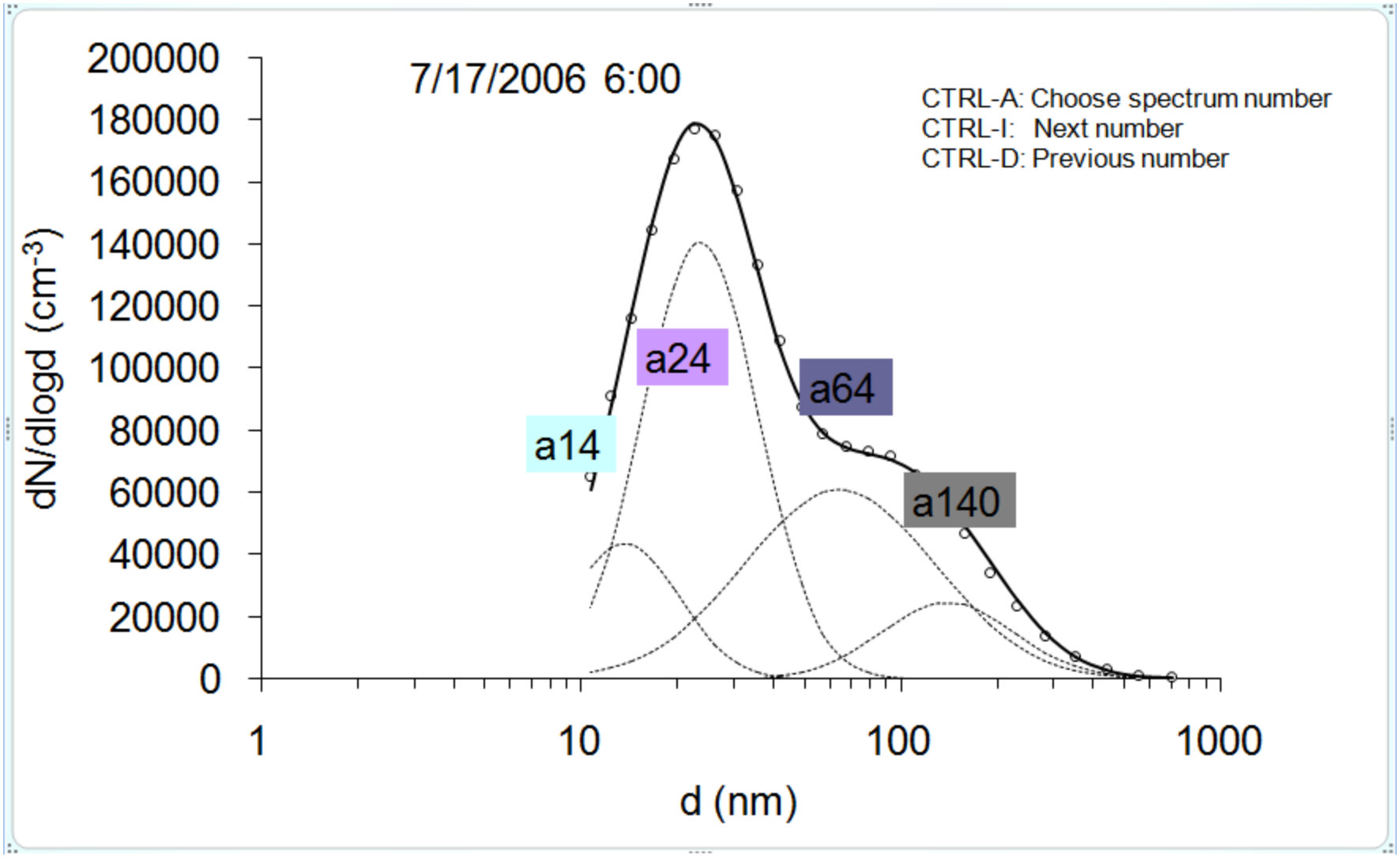

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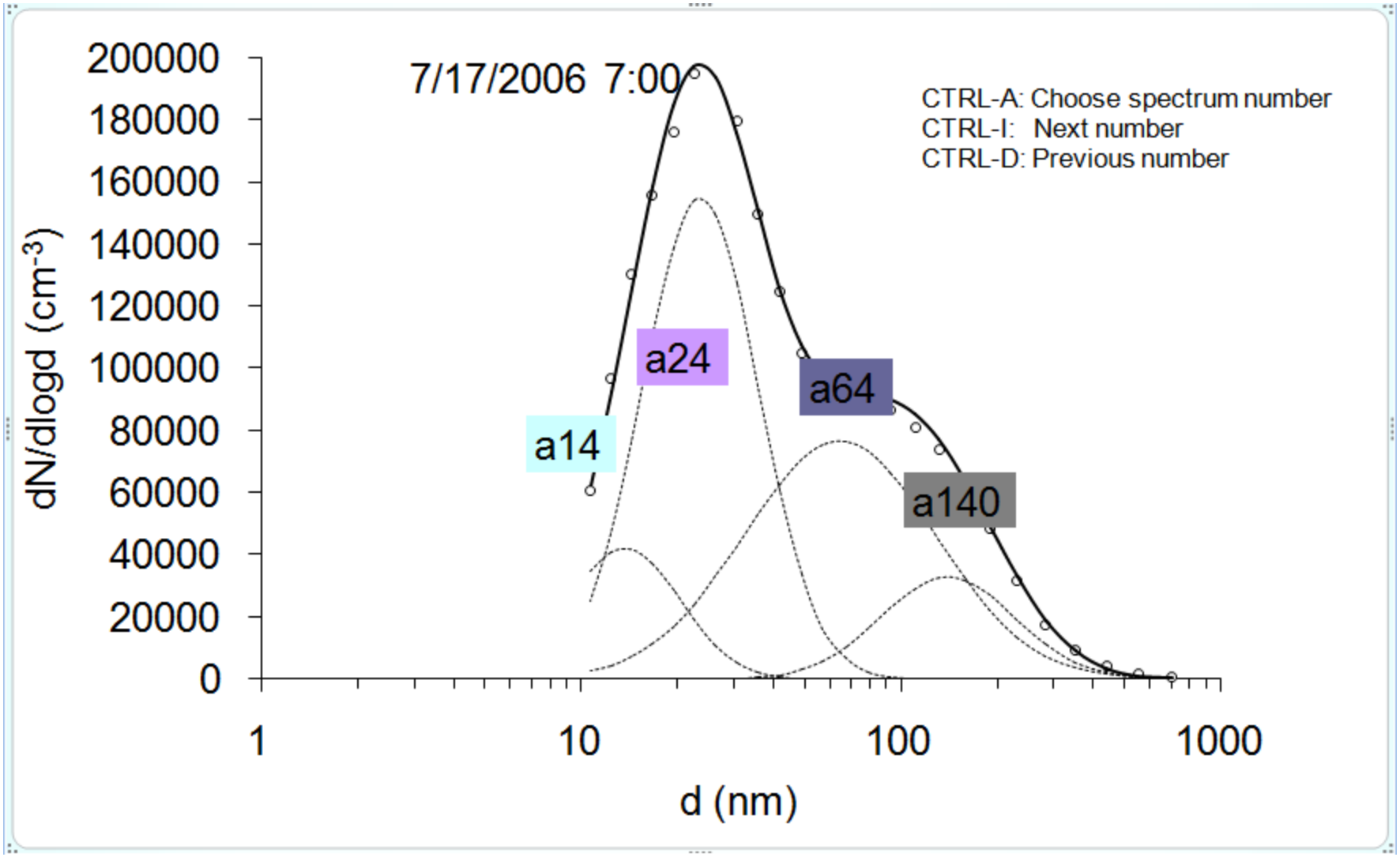

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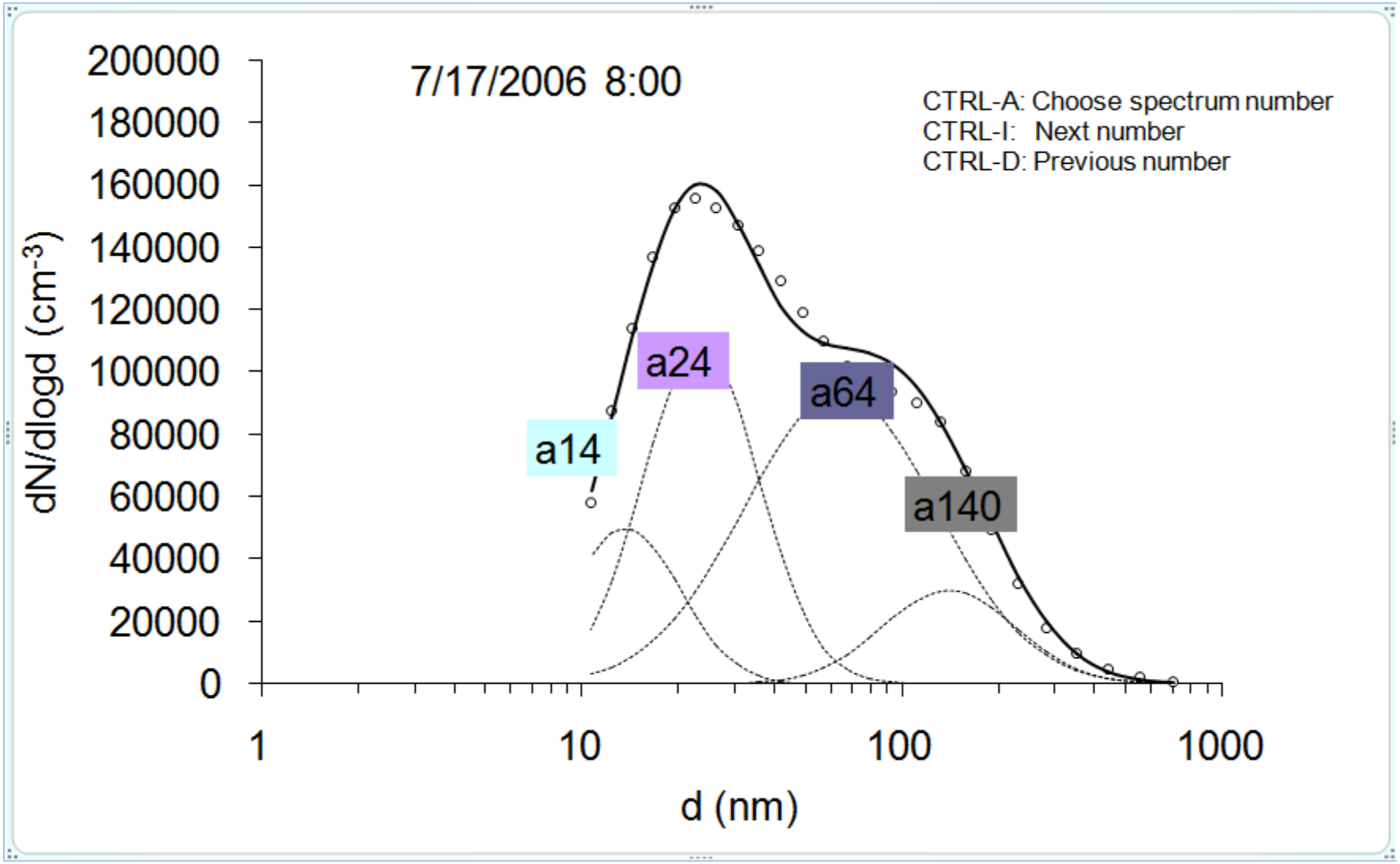

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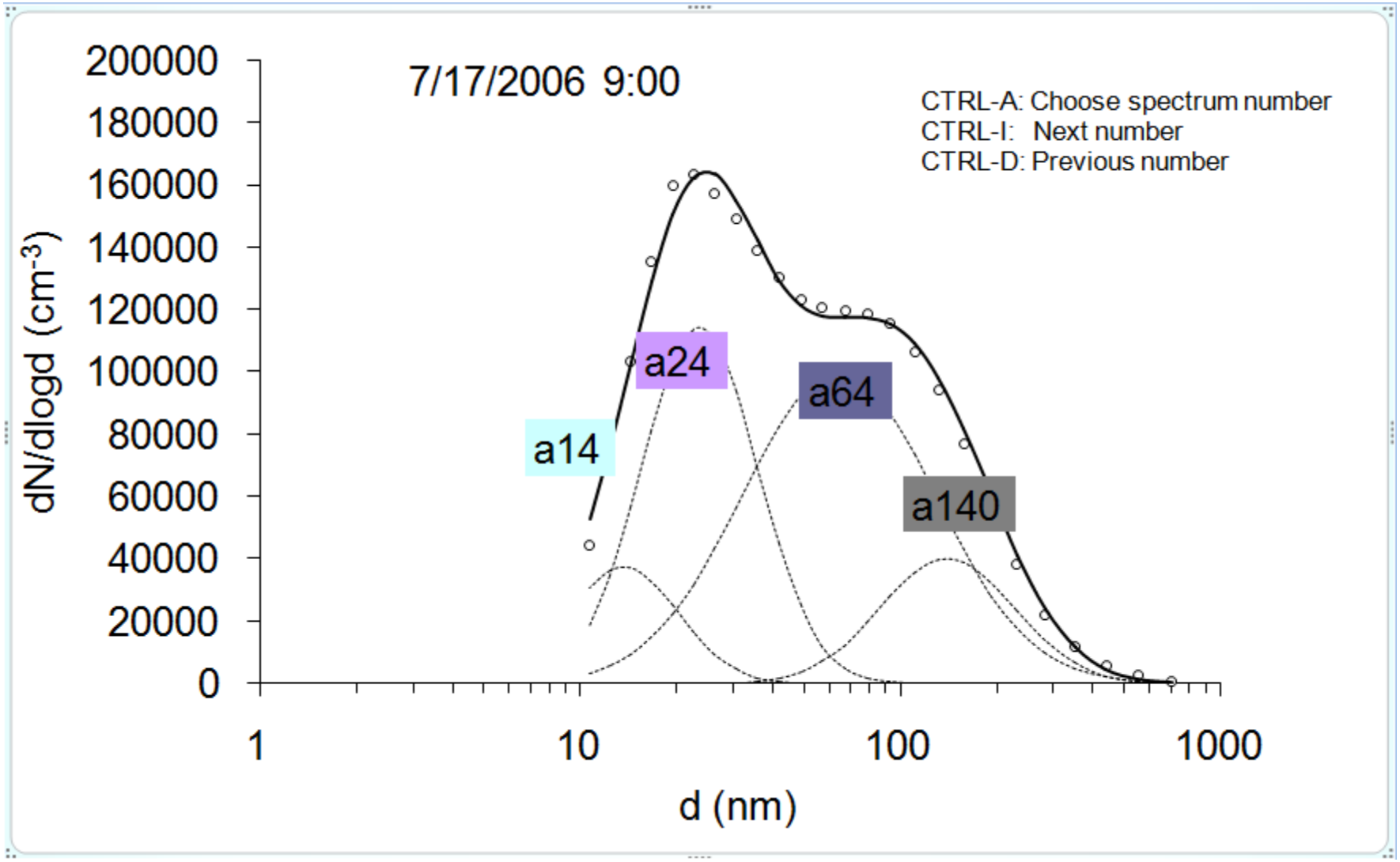

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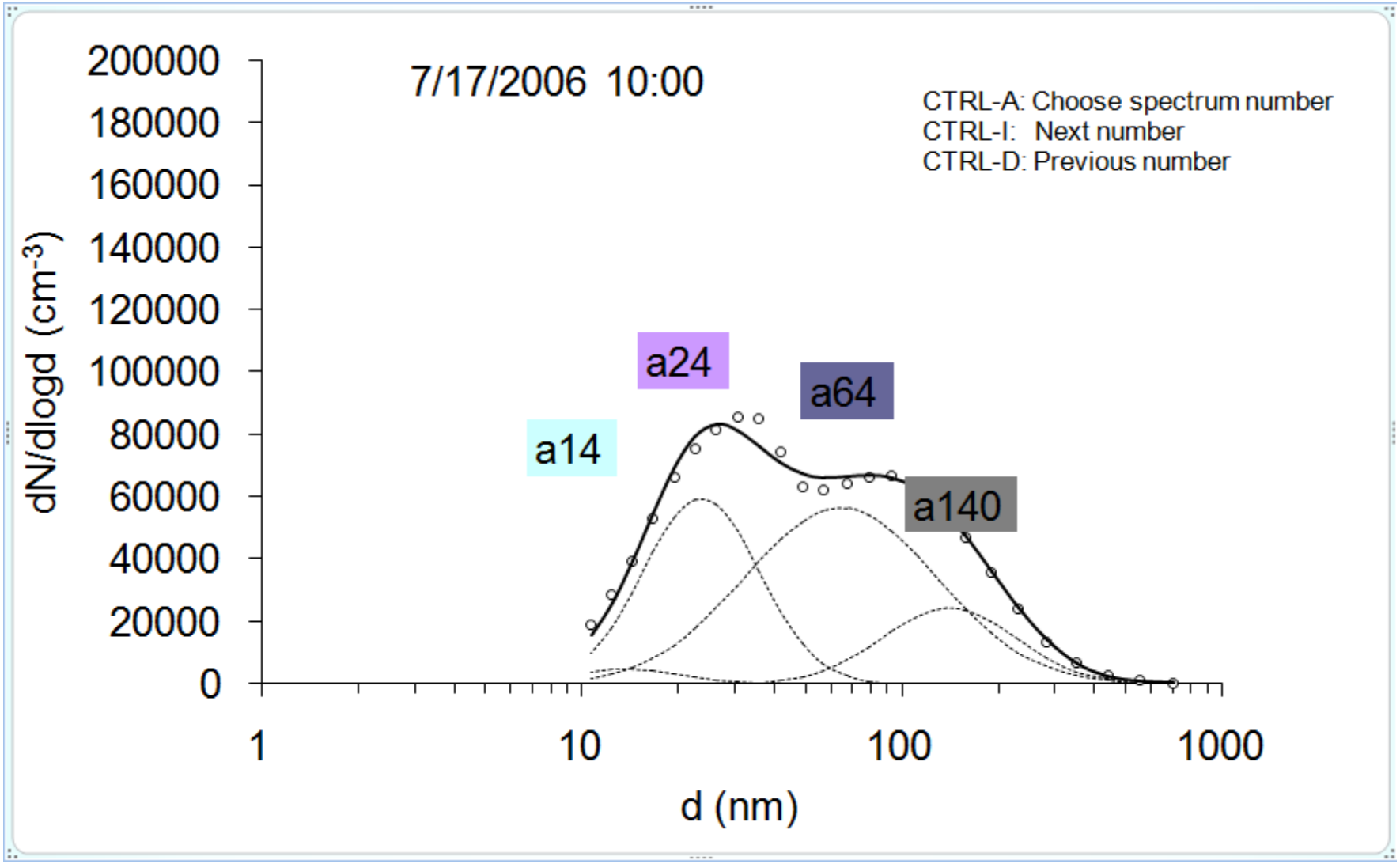

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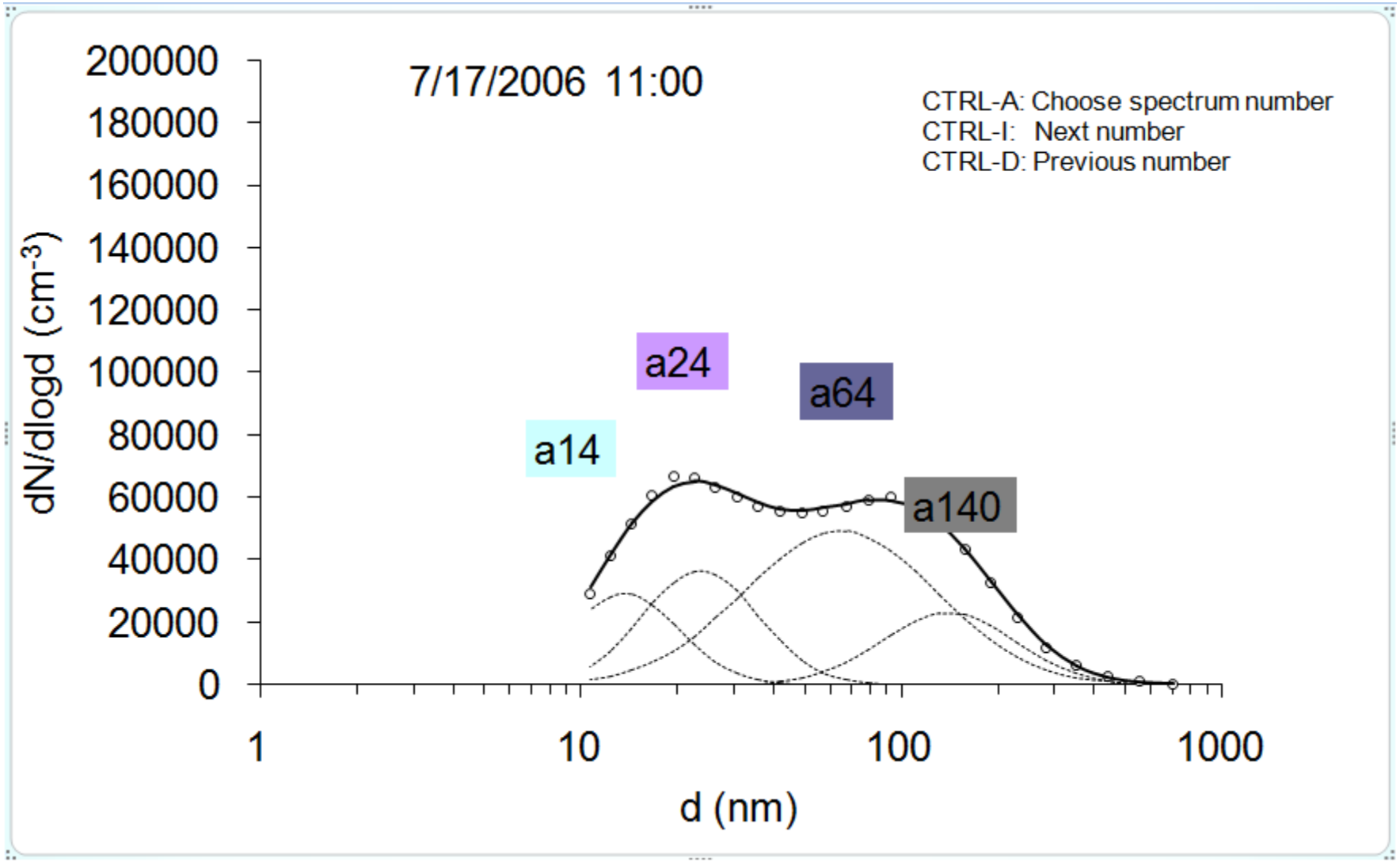

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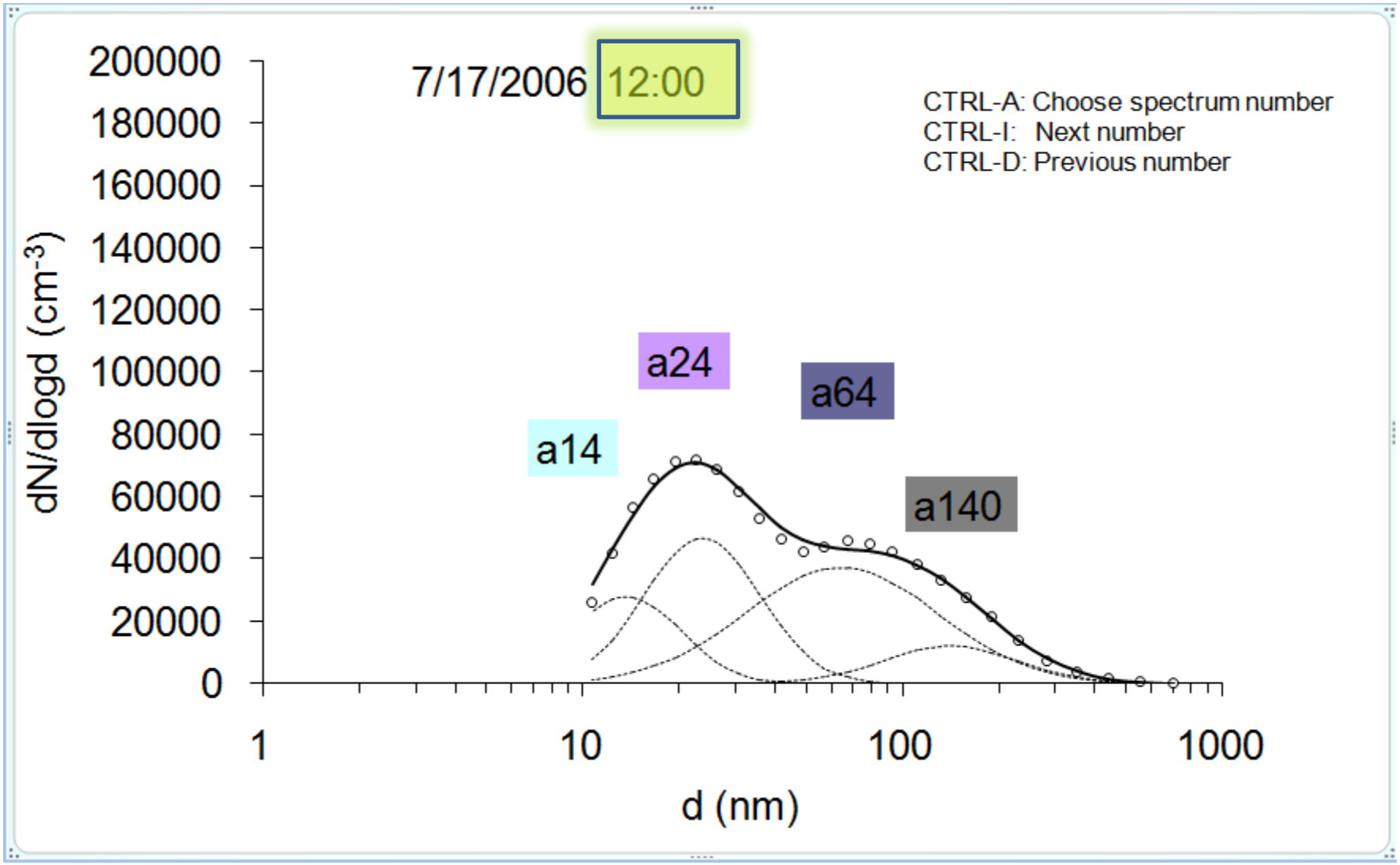

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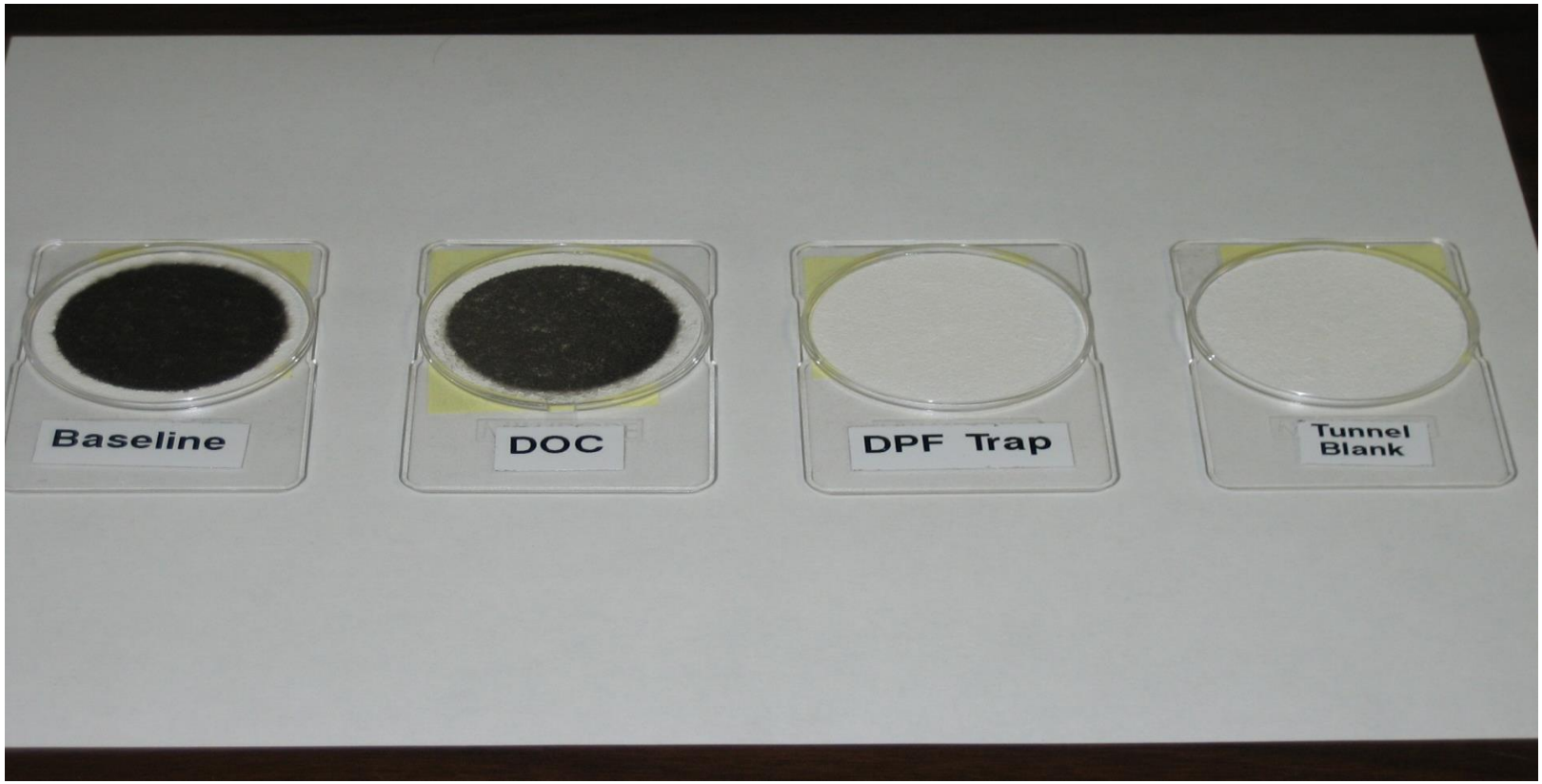
Why to study filters' implementation?



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Objectives

- To contribute towards understanding transportation effects on air quality
- To contribute towards understanding transportation effects on population health

Exhaust emissions and health

Carbon Monoxide (CO)	Results from incomplete combustion of fuel. CO reduces the ability of blood to carry oxygen and can cause headaches, respiratory problems and, at high concentrations, even death.
Oxides of Nitrogen (NO_x)	Produced in any combustion process, NOx emissions are oxidised in the atmosphere and contribute to acid rain. They also react with hydrocarbons to produce photochemical oxidants, which can harm plants and animals.
Sulphur Dioxide (SO_2)	Sulphur occurs naturally in the crude oil from which petrol and diesel are refined. It forms acids on combustion leading to acid rain and engine corrosion. It also contributes to the formation of ozone and of particulate matter. Sulphur can also adversely affect the performance of catalytic converters.
Hydrocarbons (HC)	HCs are emitted from vehicle exhausts as unburnt fuel and also through evaporation from the fuel tank, from the nozzle when you fill up and also at stages through the fuel supply chain. They react with NOx in sunlight to produce photochemical oxidants (including ozone), which irritate the eyes and throat.

Exhaust emissions and health

Benzene (C_6H_6)	Naturally occurring in small quantities (less than 2%) in petrol and diesel, Benzene is emitted from vehicle exhausts as unburnt fuel and also through evaporation from the fuel system. Benzene is toxic and carcinogenic. Long-term exposure has been linked with leukaemia.
Lead (Pb)	Lead accumulates in body systems and is known to interfere with the normal production of red blood cells. Following the introduction of unleaded petrol and withdrawal of leaded petrol lead is essentially eliminated as an exhaust product.
Particulates (PM)	Particulate matter is partly burned fuel associated mainly with diesel engines. PM_{10}s are very small particles that can pass deep into the lungs causing respiratory complaints.

Hypothesis

The main hypothesis is that the implementation of post combustion filters or a better technology improves significantly air quality resulting in a positive impact on public health.

Specific Goals

- To generate new data not available until today in Chile that could help to test the main hypothesis.
- To estimate the impact of several pollutants on a multivariate analysis that allows isolating the health effect resulting of the air filters´ implementation.
- To study the impact of implementing post combustion filters on both mortality and morbidity for the Metropolitan Region of Santiago.

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Methodology

- Population health and air quality

$$log\,E(y_{ij}(t)) = f_{1ij}(t;\,) + f_{2ij}(w(t);) + \beta_{ij}\, x_{ij}(t) + \delta_{ij}\, z_{ij}(t)$$

$y_{ij}(t)$ medical visits or mortality for day t, at location i in year j

$x_{ij}(t)$ air quality for day t, at location i in year j

$z_{ij}(t)$ public transport for day t, at location i in year j

Methodology

Transportation emissions

$$E_{ij}^{h} = N_{ij} d_j G_{ij} F_{i,} \ (g/km^2\ hour) \ ,$$

$N_{ij} d_j$ activity level per hour by bus type i and area j

E_{ij}^{h} pollutant emission by bus type i and area j

G_{ij} fuel consumption by bus type i $\left(\frac{l}{km}\right)$ in area j

$F_{i,}$ emission factor by pollutant, speed, and bus category

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Data

Population

Daily number of deaths and illness in Metropolitan Santiago:

- all non-accidental (ICD10<V*)
- cardiovascular (ICD-10 codes I00-I99)
- and respiratory (ICD-10 codes J00-J98)

Data

Traffic variables

- average speed and buses flow information calculated from traffic flow delivered, considering rush and non-rush hours
- the estimates emissions from public transport road traffic come from an emission factor with available information on bus mileage
- bus fleet composition by business unit
- activity level expansion factor by service.

Data

Air Pollution Data

- Ambient levels of hourly fine and coarse particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), ozone (O_3) and sulfur dioxide (SO_2).
- Locations represent areas of high population density, variety of land-use, and high traffic areas.

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Discussion

- This project could help assess if transport is appropriately targeted for reduction.

  For example, particulate matter is comprised of several physical and chemical characteristics with varying toxicity.

- Mitigation strategies that target a single or a limited number of pollutants may not yield expected proportionate improvements in population health if those mass reductions do not coincide with reductions in the most toxic components of particle phase pollution.

Thank you