# Contribution of Solid Fuel Burning to $PM_{2.5}$ in Residential Areas of Ireland

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# Dublin Smog 1980s

The New York Times

## Dublin Journal; Fair Is City but Foul Is Air When Smog Creeps In

By SHEILA RULE, Special to the New York Times
Published: January 18, 1989

The smog creeps menacingly through doors and windows here. It attacks throats and lungs. It sometimes invades Dublin to such a degree that night appears to fall by midday.

*Ballyfermot, Thursday 24 November 1988, 4pm*

Tony Gavin

*Dublin city centre, Friday 25 November 1988, 2pm*

# Ban on Bituminous Coal in Dublin

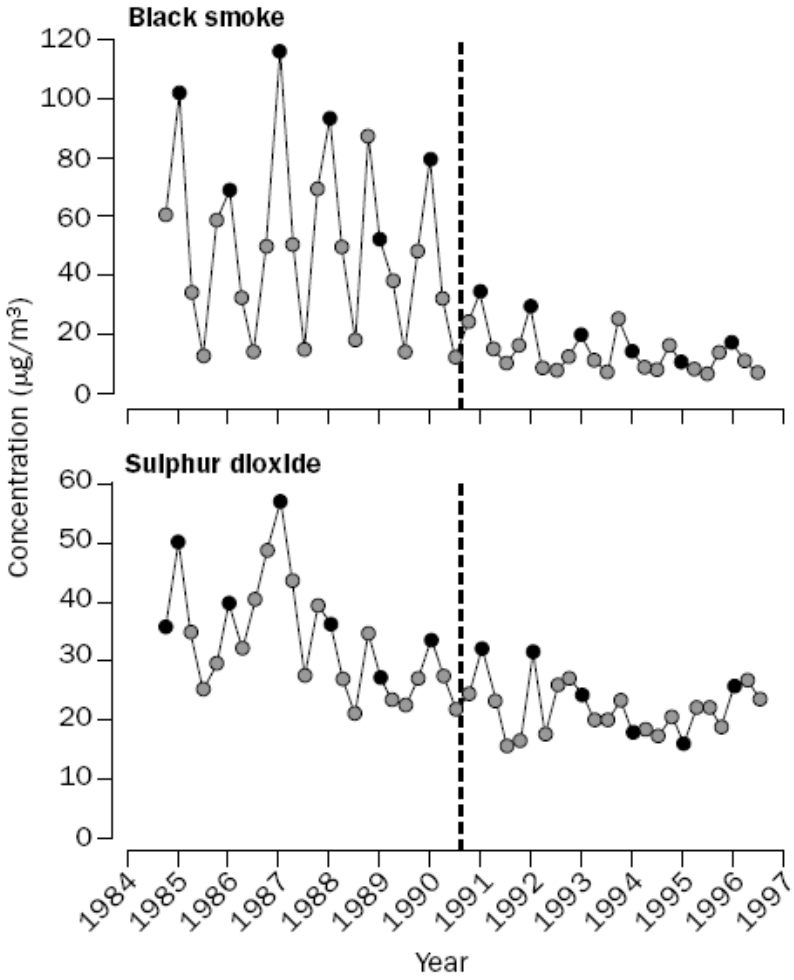



Figure 1: **Seasonal mean black smoke (upper) and sulphur dioxide (lower) concentrations, September 1984–96**
Vertical line shows date sale of coal was banned in Dublin County Borough. Black circles represent winter data.

1st September 1990

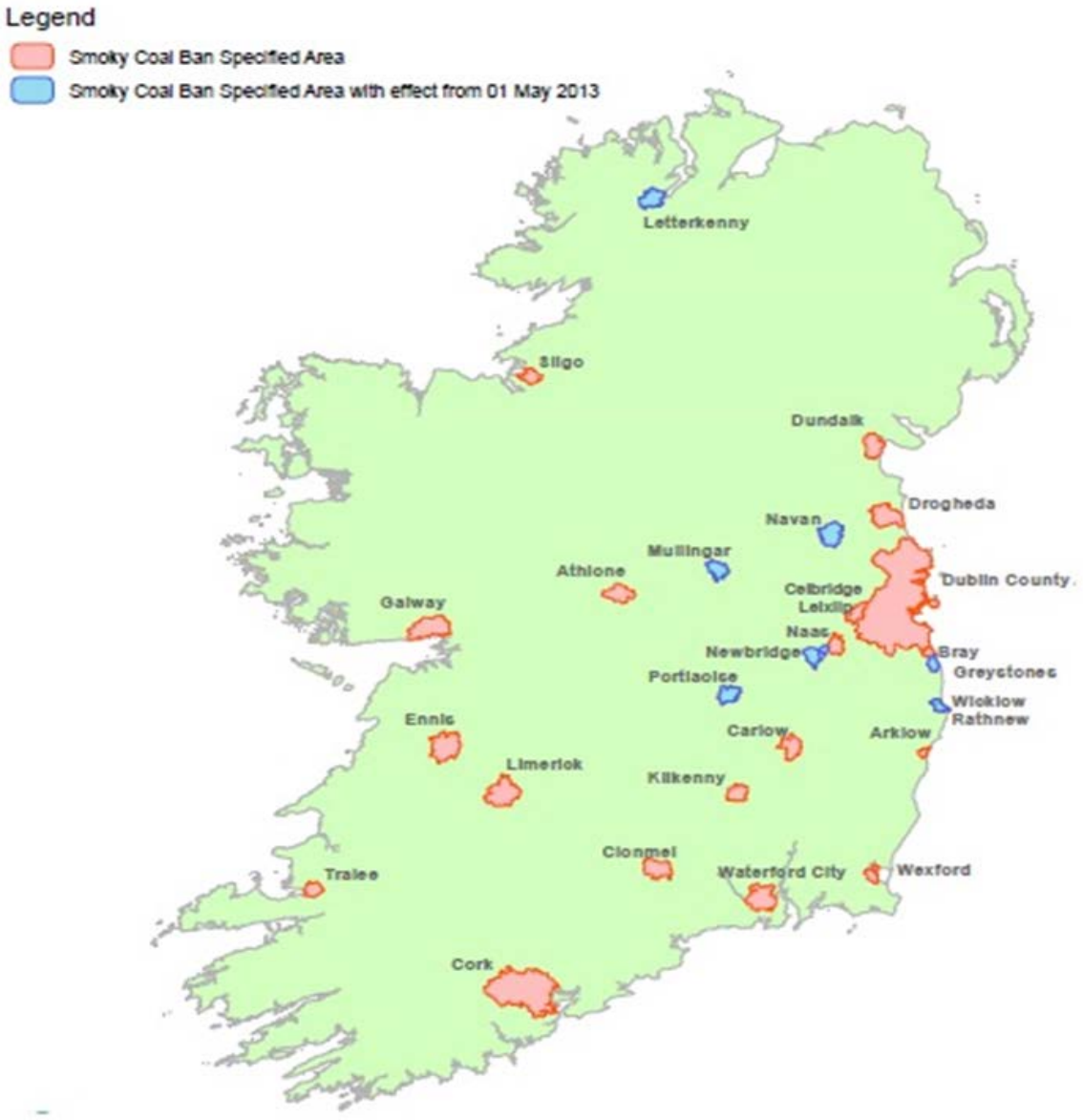
70% reduction in black smoke

34% reduction in sulphur dioxide

On average per year:
116 fewer respiratory deaths
243 fewer cardiovascular deaths

Clancy et al., Lancet 2002

# Extent of Bituminous Coal Ban 2015

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# WE'RE CALLING FOR CLEAN AIR FOR ALL

04 DEC 2014 By THE ASTHMA SOCIETY OF IRELAND




**Urgent action is needed to ensure clean air for all, not just for some**

**25 years on …. Estimated that 9,000 lives saved since Dublin smoky coal ban in 1990 - but thousands more are lost each year throughout the country**

# A Hot Topic!

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## Phil Hogan: I want smoky coal to be banned within the next 3 years

Smoky coal is already banned in 27 towns and cities around the country, but now the Minister for the Environment says he wants to see it nationwide.



MINISTER FOR THE Environment Phil Hogan has said he wants to see a ban on smoky coal throughout the country within the next 3 years.

Image: Sasko Lazarov/Photocall Ireland

Smoky coal was banned in seven more towns around the country – Greystones, Letterkenny, Mullingar, Navan, Newbridge, Portlaoise and Wicklow – on 1 May, bringing to 27 the total number of towns and cities which have already banned the fuel.

The government has brought in a number of measures to discourage people from using fossil fuels, including a carbon tax on solid fuels which began last Wednesday.

Phil Hogan pointed to research which found that the smoky coal ban resulted in up to 350 fewer deaths every winter since being introduced in Dublin in 1990. The ban was in response to severe episodes of winter smog which resulted from the widespread use of smoky coal.

"The health benefits in areas where the ban is already in place are well documented and an all-Ireland ban is the next phase I anticipate in this area," he said. "The burning of solid fuel for residential heating makes a disproportionate contribution to air pollution".

> The ban has clearly been effective in reducing air pollution with proven benefits for human health and our environment and has led to improved quality of life in cities and towns where the ban applies.

> I am convinced of the health benefits from an all Ireland ban on smoky coal and these benefits should be extended to all citizens through such a ban.

He made the comments as he announced a major new study which will measure air pollution caused by people burning solid fuel – such as coal and peat briquettes – in their homes.

The study, which is a joint piece of research between Northern Ireland and the Republic, will look at possible policy options to reduce pollution from solid fuel as well as the potential environmental and human health benefits.

"North-South cooperation in this area provides an opportunity to further improve air quality for the citizens of this island both North and South," Phil Hogan said.

**Read: Bad news for fossil fuels: cost of coal and briquettes to rise today >**

http://www.thejournal.ie/smoky-coal-ban-ireland-pollution-phil-hogan-897056-May2013/

# Solid Fuels for Residential Heating in Ireland

Bituminous (Smoky) Coal

“Smokeless” Coal

Wood

Sod Peat (Turf)

Peat Briquettes

ucc
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

epa
Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

# Source Apportionment of Particulate Matter in Urban and Rural Residential Areas of Ireland (SAPPHIRE)

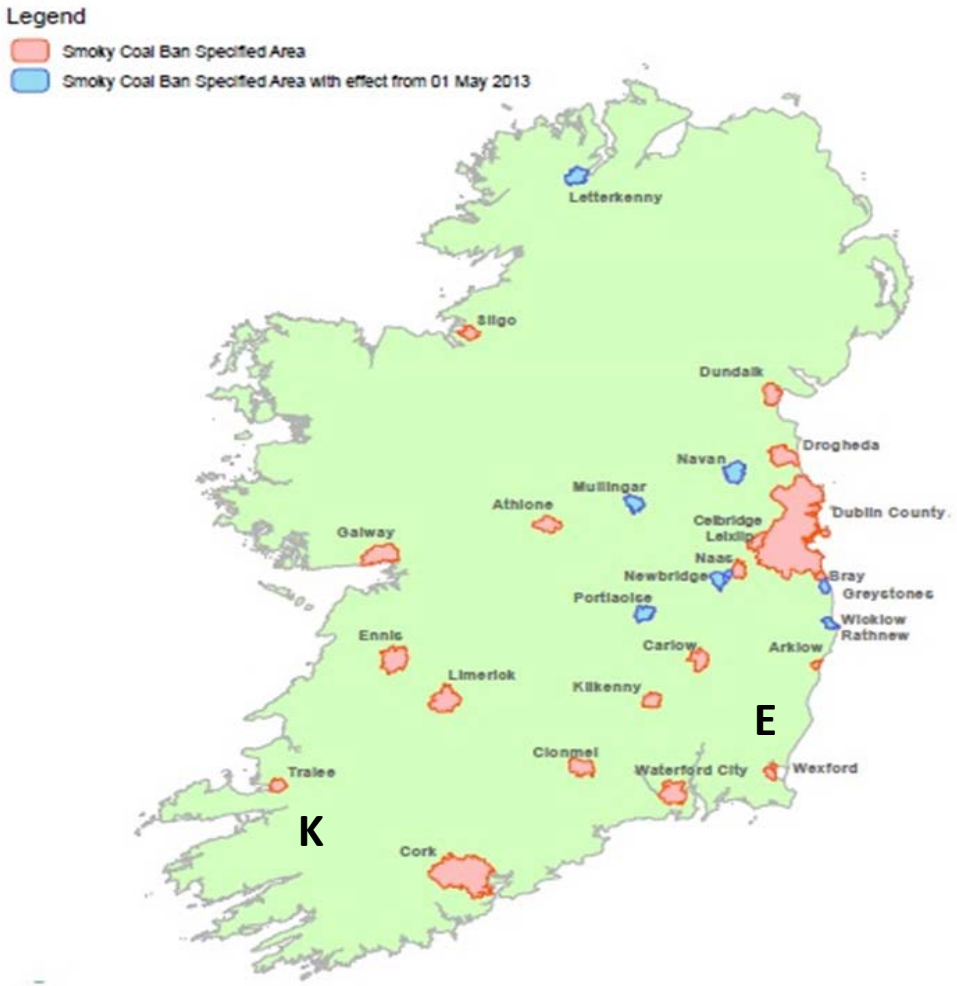
**1 April 2014 – 31 March 2016**

http://www.ucc.ie/en/crac/research/sapphire/

Centre for Research into Atmospheric Chemistry
CRAC

ERI
ENVIRONMENTAL RESEARCH INSTITUTE
UNIVERSITY COLLEGE CORK

# Monitoring Locations



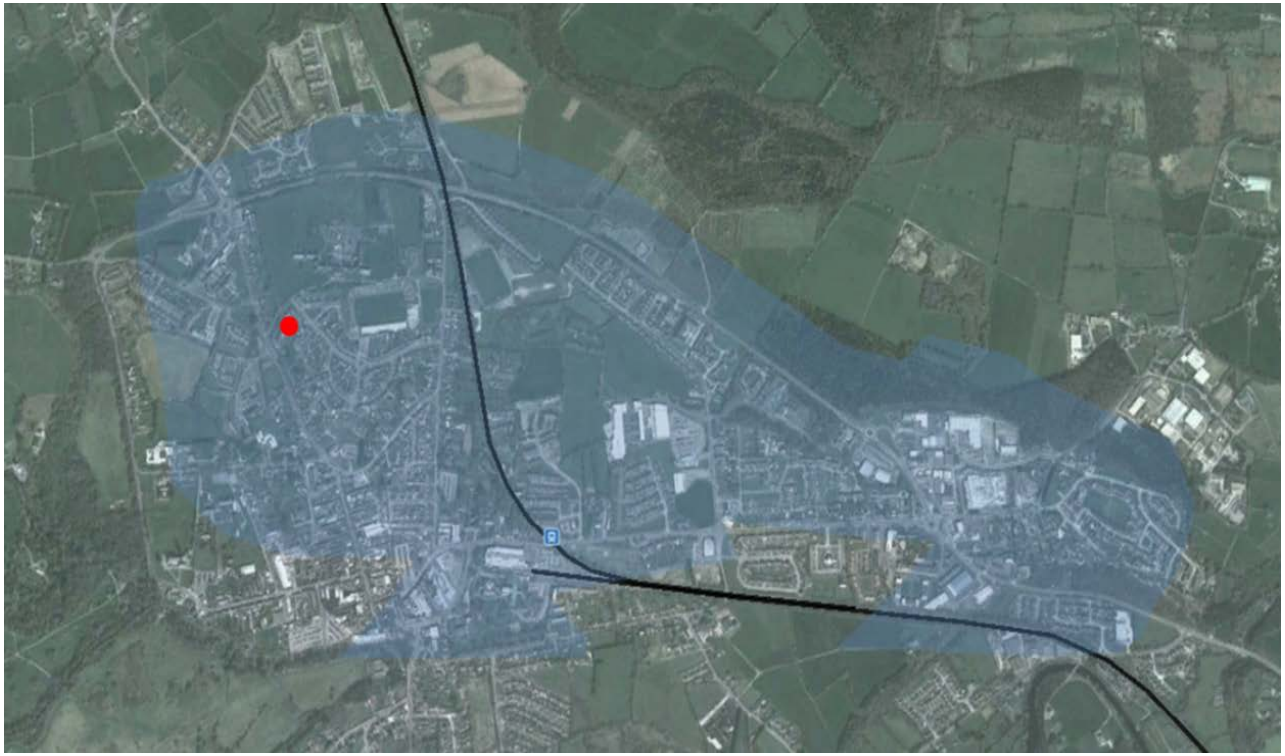

- Outside the Smoky Coal Ban Area (pop. < 15,000)
- No natural gas supply
- High usage of solid fuels (coal, peat/turf & wood)

- **Killarney, Co. Kerry (Nov & Dec 2014)**
- **Enniscorthy, Co. Wexford (Jan & Feb 2015)**

# Monitoring Location: Killarney


# Monitoring Location: Killarney

- Site is located on the western side of the town, in the grounds of the Community Hospital in a residential area



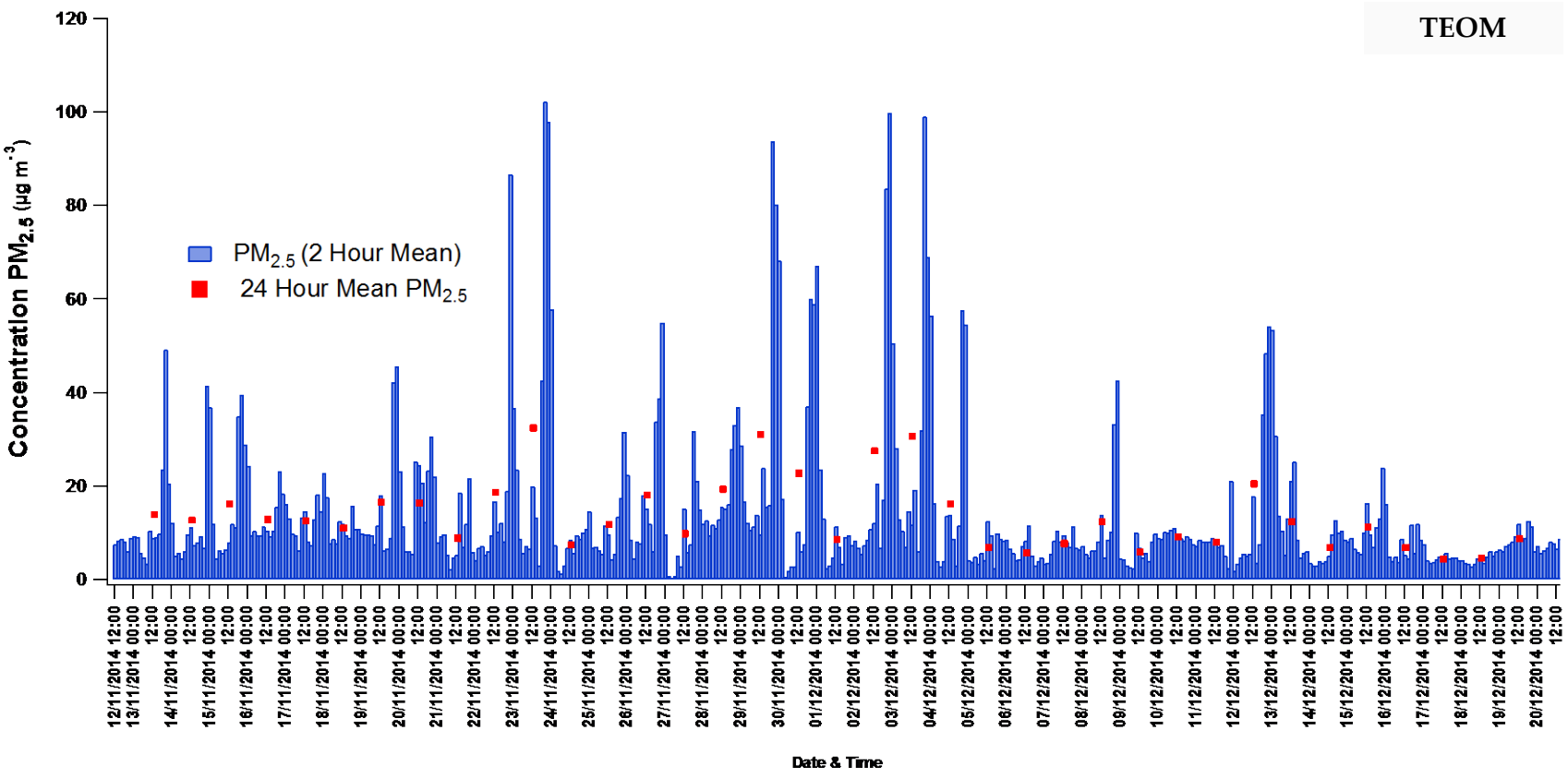
# Monitoring Location: Killarney

- Site is located on the western side of the town, in the grounds of the Community Hospital in a residential area

# Instrumentation

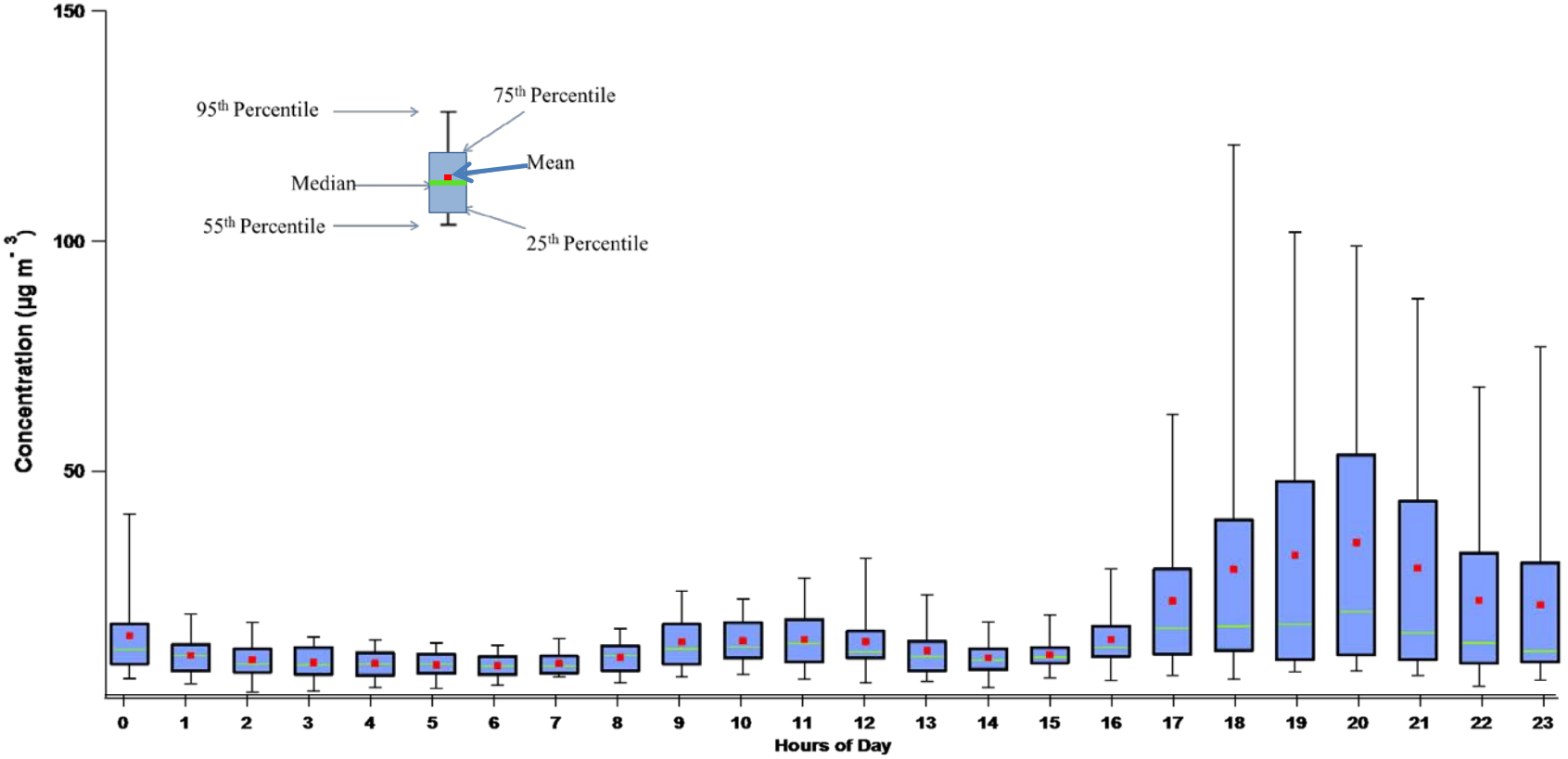
| Instrument | Parameter(s) measured | Temporal resolution |
|---|---|---|
| **Aerosol time-of-flight mass spectrometer (TSI model 3800)** | Single particle size and chemical composition (100-3000 nm) | 1 min |
| **Scanning mobility particle sizer (TSI model 3081)** | Particle number concentration (10-800 nm) | 3 min |
| **Optical Particle Sizer (TSI model 3330)** | Particle number concentration (300-10000 nm) | 3 min |
| **TEOM (Thermo Electron model RP 1400a)** | $PM_{2.5}$ mass concentration | 30 min |
| **Thermal-optical carbon analyser (Sunset Inc. model 3rd generation)** | Elemental and organic carbon mass concentrations | 2 hr |
| **7-Wavelength Aethalometer (Model AE33, Magee Scientific)** | Black Carbon concentration | 1 min |
| **High volume sampler (Digitel model DHA 80)** | Collection of particulate matter ($PM_{2.5}$) | 6 hr |
| **$NO_x$ analyser (Teledyne T200)** | NO and $NO_x$ mixing ratio | 1 min |
| **$O_3$ analyser (Teledyne T400)** | $O_3$ mixing ratio | 1 min |
| **Weather station (Casella 'Nomad')** | Wind speed, wind direction, relative humidity, air temperature, rainfall, pressure, solar irradiation | 5 min |

# $PM_{2.5}$ mass concentration



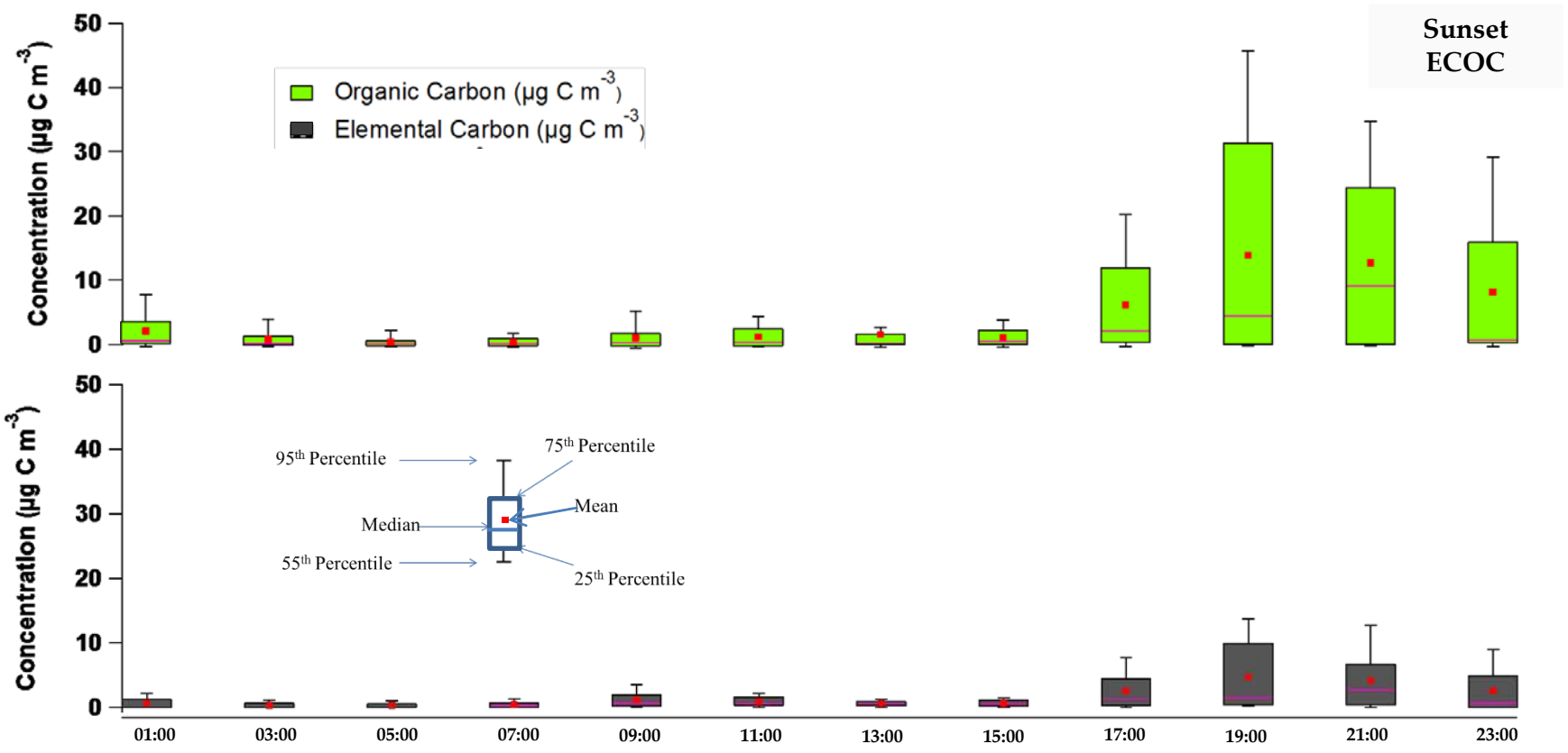

- $PM_{2.5}$ up to 10 times higher during evening hours

# $PM_{2.5}$ mass concentration



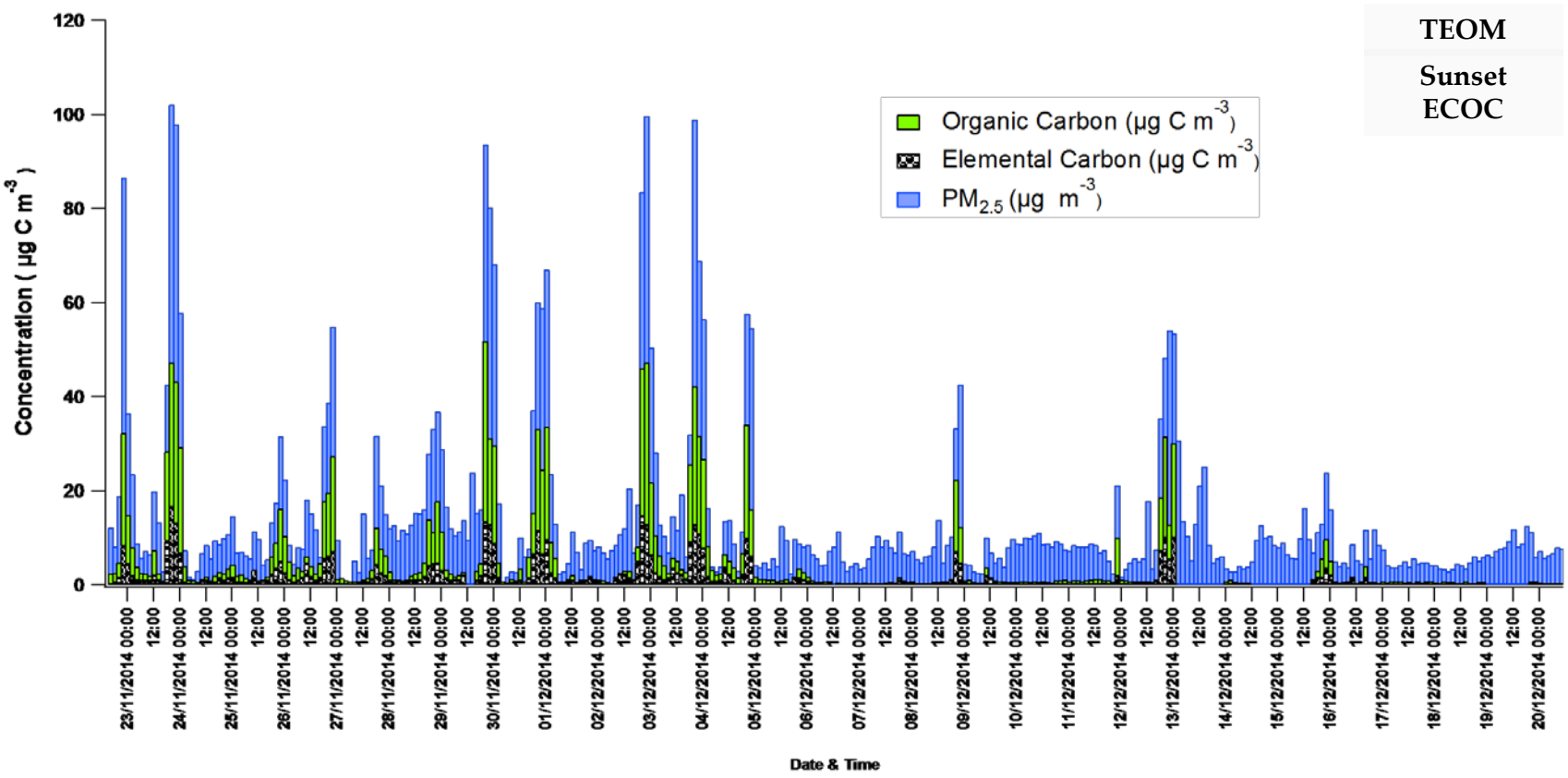

- Strong diurnal pattern

# Elemental and Organic Carbon (EC/OC)



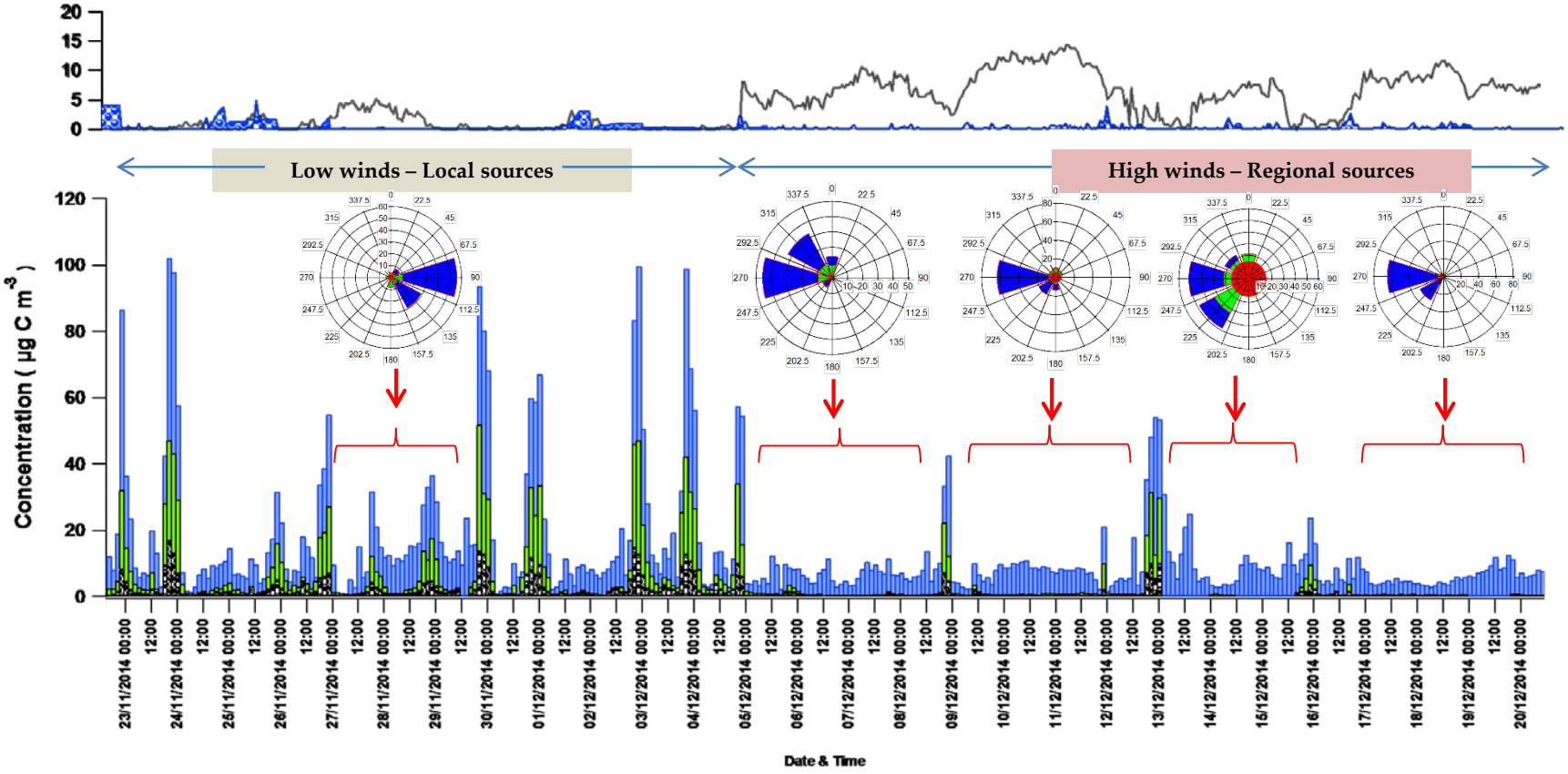

- Strong diurnal pattern

# Elemental and Organic Carbon (EC/OC)




- Majority of $PM_{2.5}$ during night-time pollution events is carbonaceous aerosol

# Influence of Meteorology




- Low wind speed – local emissions dominate
- High wind speed – regional sources dominate

# Single Particle Mass Spectrometry

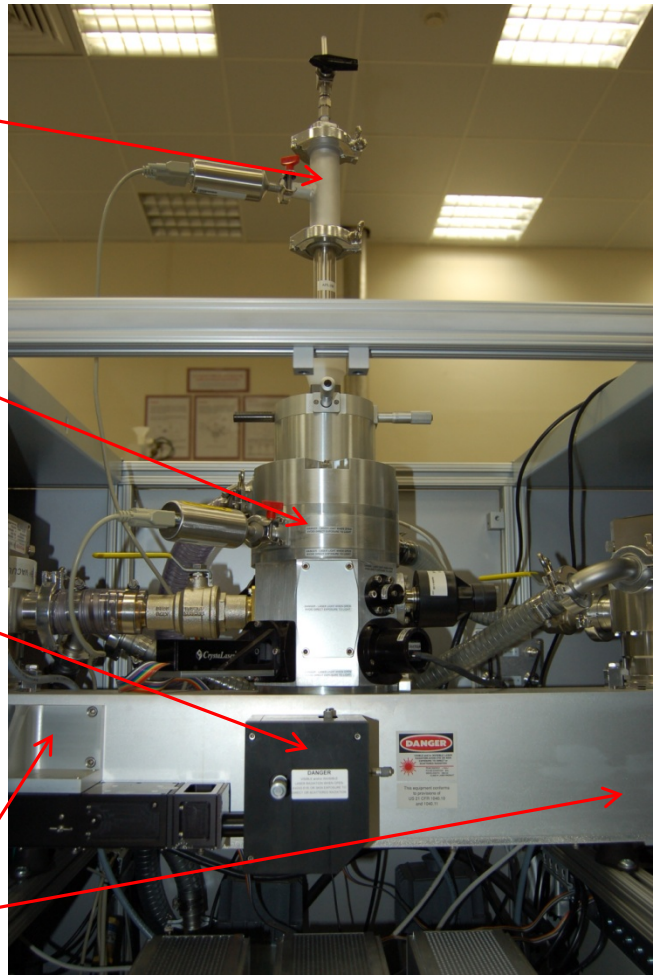
What is ATOFMS?
Aerosol
Time-Of-Flight
Mass
Spectrometry

Aerodynamic lens (transmission of particles in range 100-3000 nm)

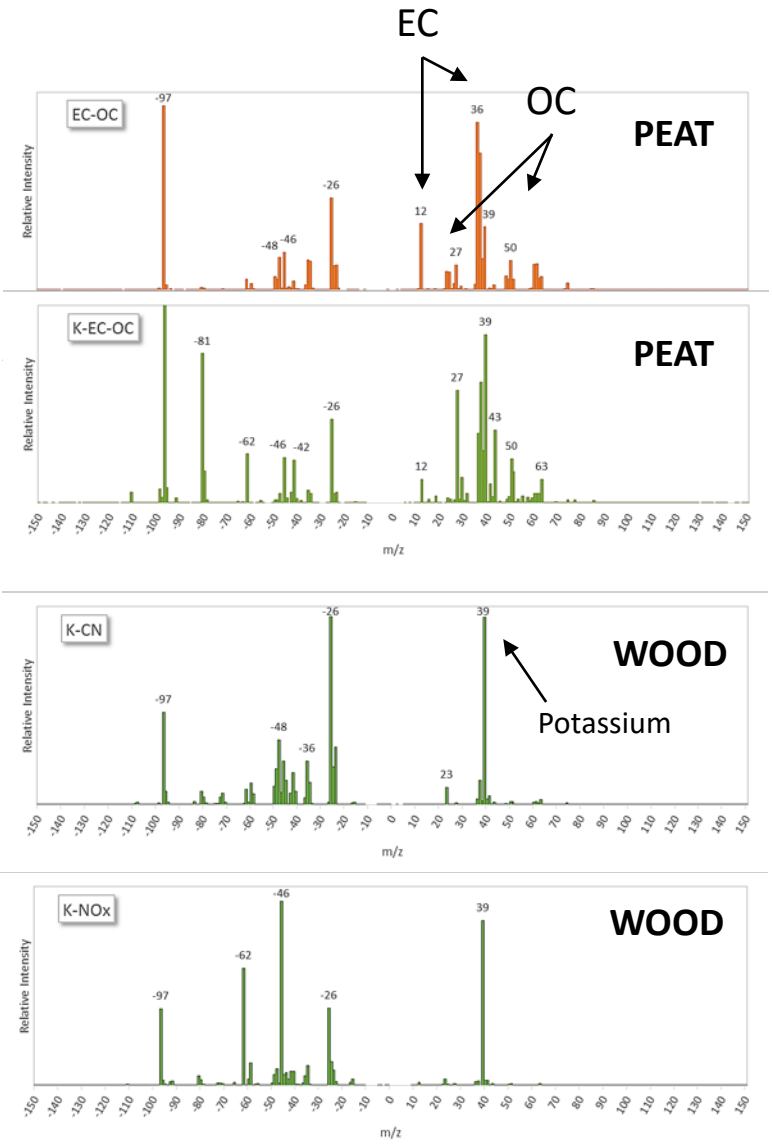
Sizing Region (2 sizing lasers 532 nm)

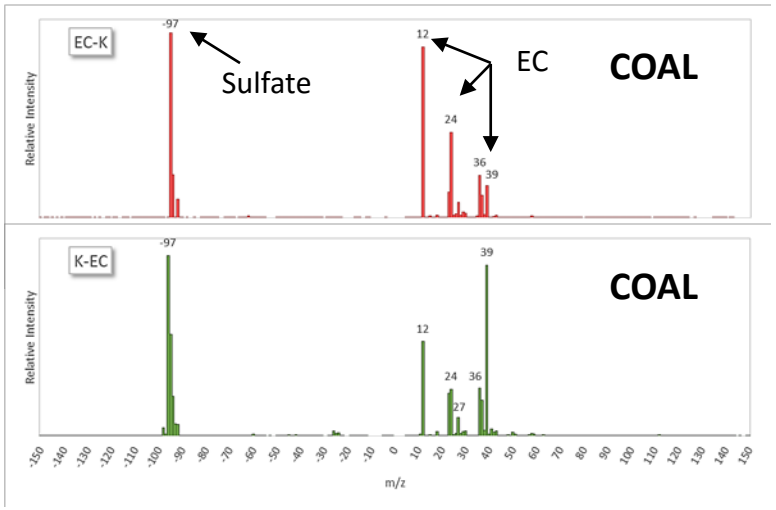
Ionization laser (266 nm)

Positive and negative time-of-flight mass spectrometers



# Mass Spectra: Solid Fuel Combustion



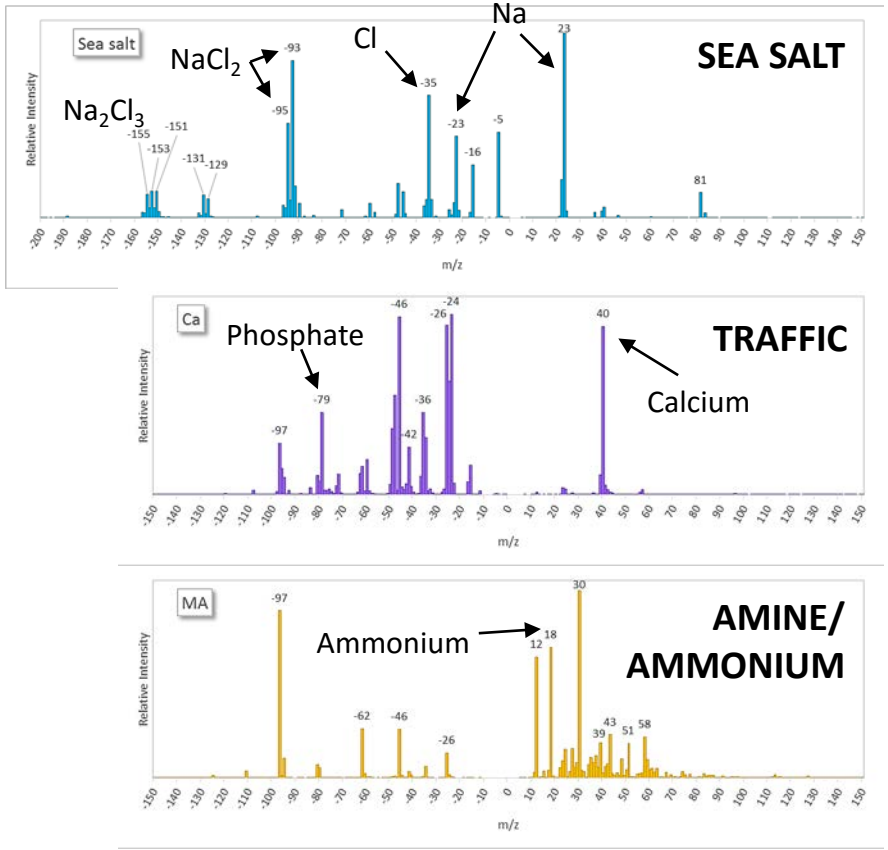

Assigned on the basis of combustion experiments

**COAL** → EC & some potassium, sulfate dominates negative spectra

**PEAT** → EC & OC fragments, some potassium

**WOOD** → Potassium dominates positive spectra

# Mass Spectra: Other Particle Types

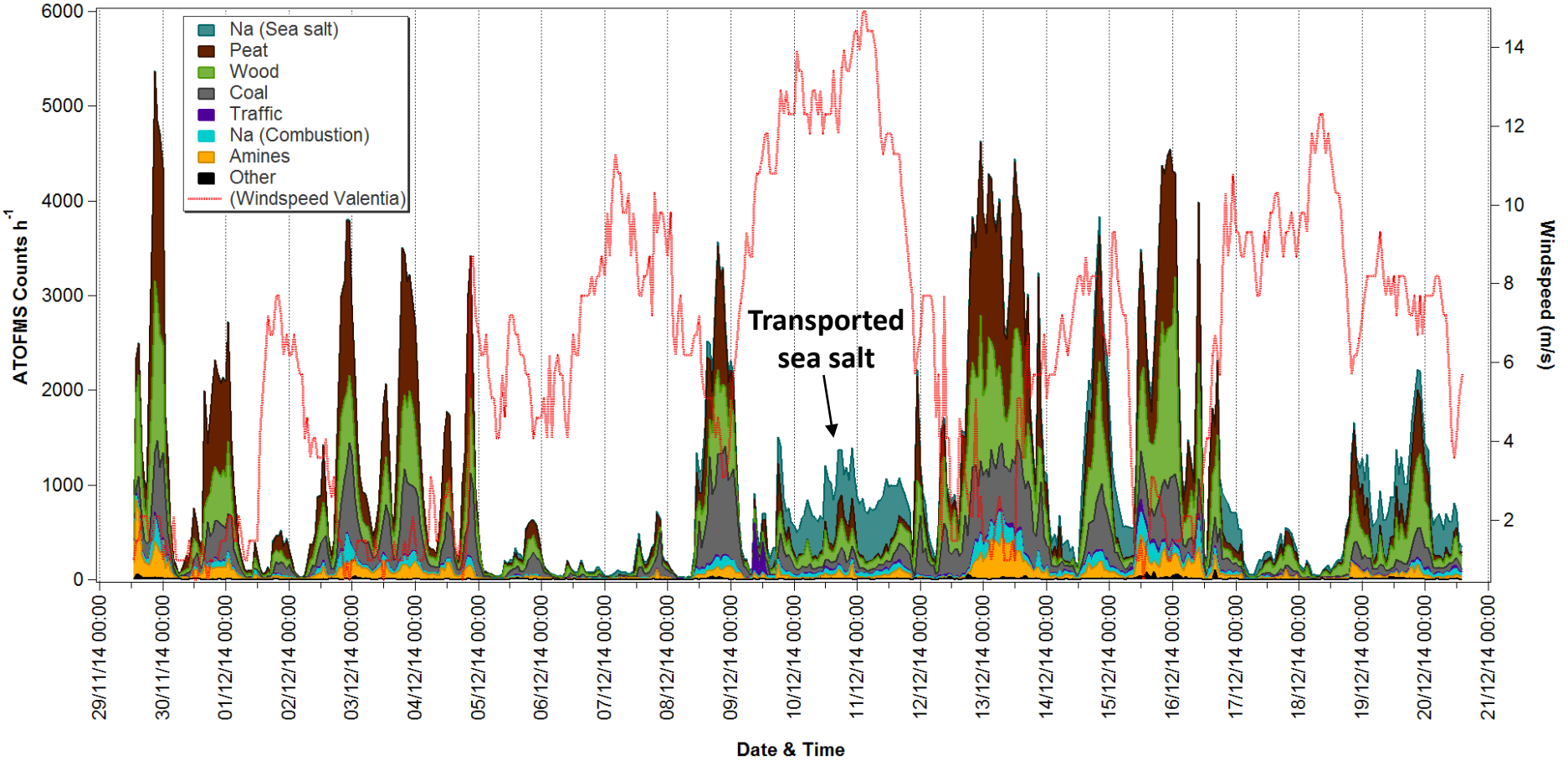



Sea salt characteristics:
→ sodium & chloride peaks, *no EC*

Traffic characteristics:
→ calcium & phosphate (lubricating oil), some EC

Ammonium/amine characteristics:
→ ammonium, trimethylamine, OC, large sulfate peak in negative spectra

# ATOFMS Particle Number

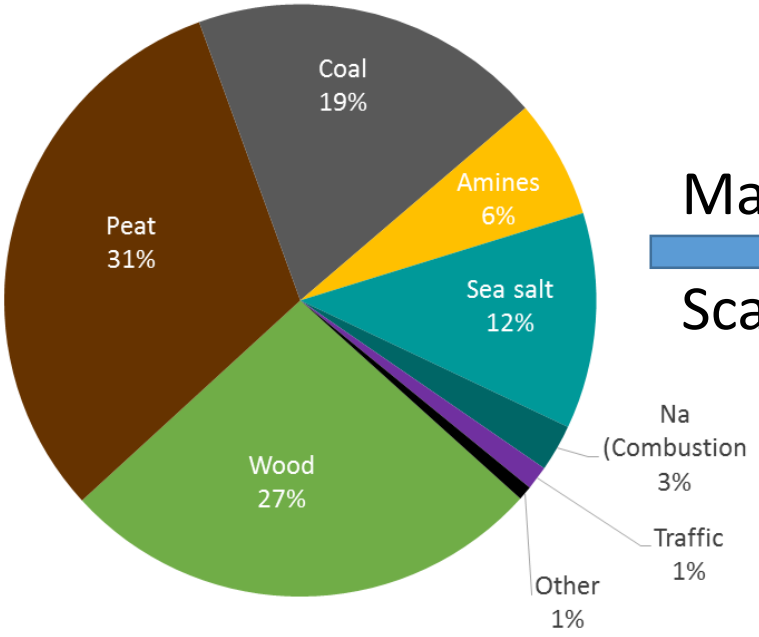



- Each source category made up of several particle types

# ATOFMS: Source Contribution to $PM_{2.5}$

## Particles from solid fuel burning 80% of $PM_{2.5}$

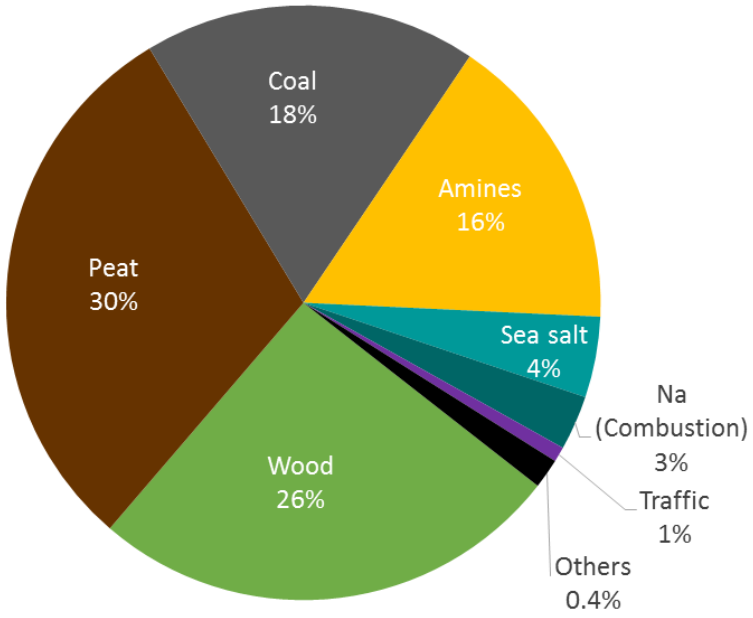
SAPPHIRE Killarney:
ATOFMS Composition
Particle Numbers




Mass
Scaling

## Particles from solid fuel burning 77% of $PM_{2.5}$

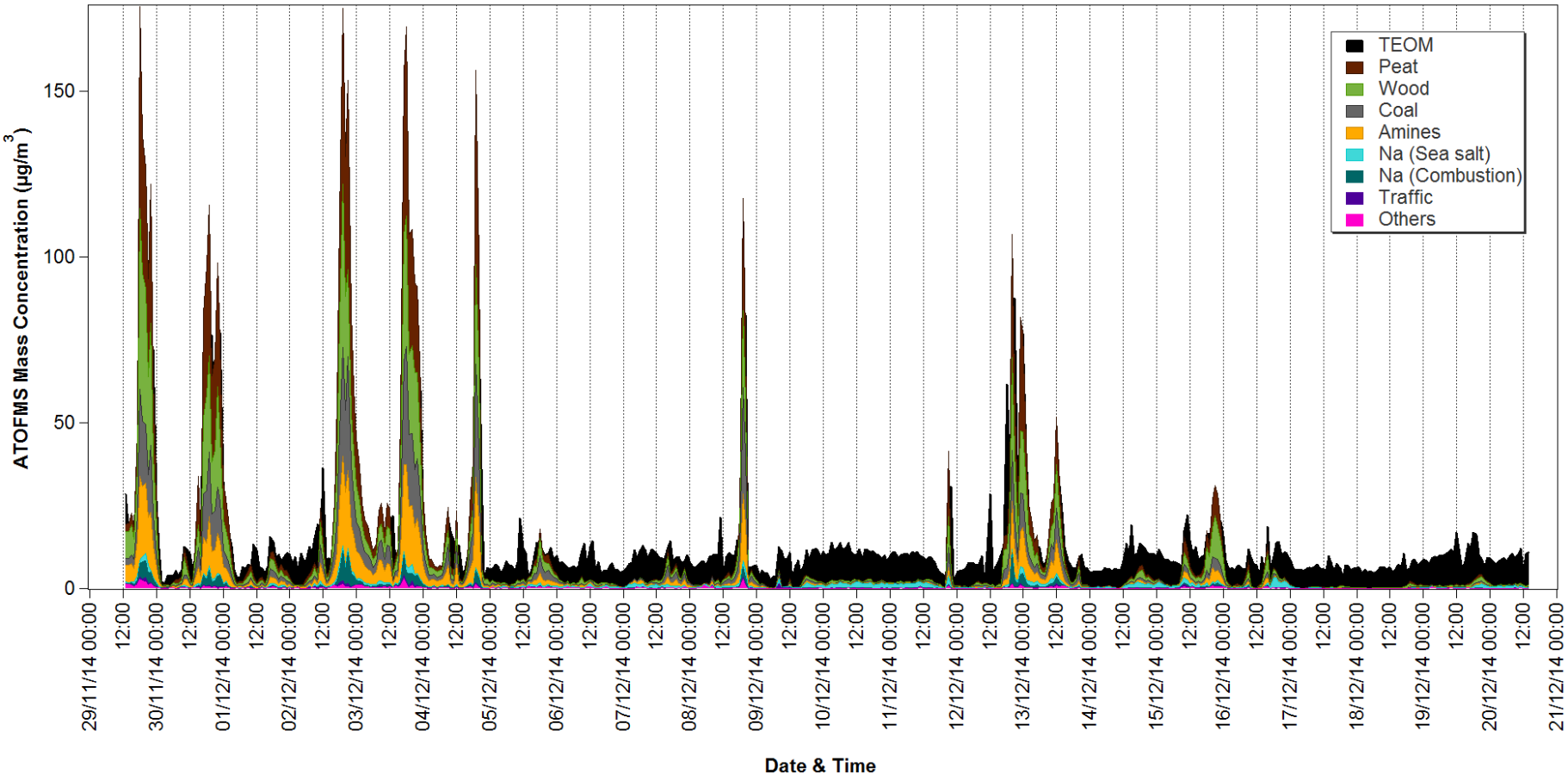
SAPPHIRE Killarney:
ATOFMS Composition
Mass Concentration




## Particle Numbers

## Particle Mass

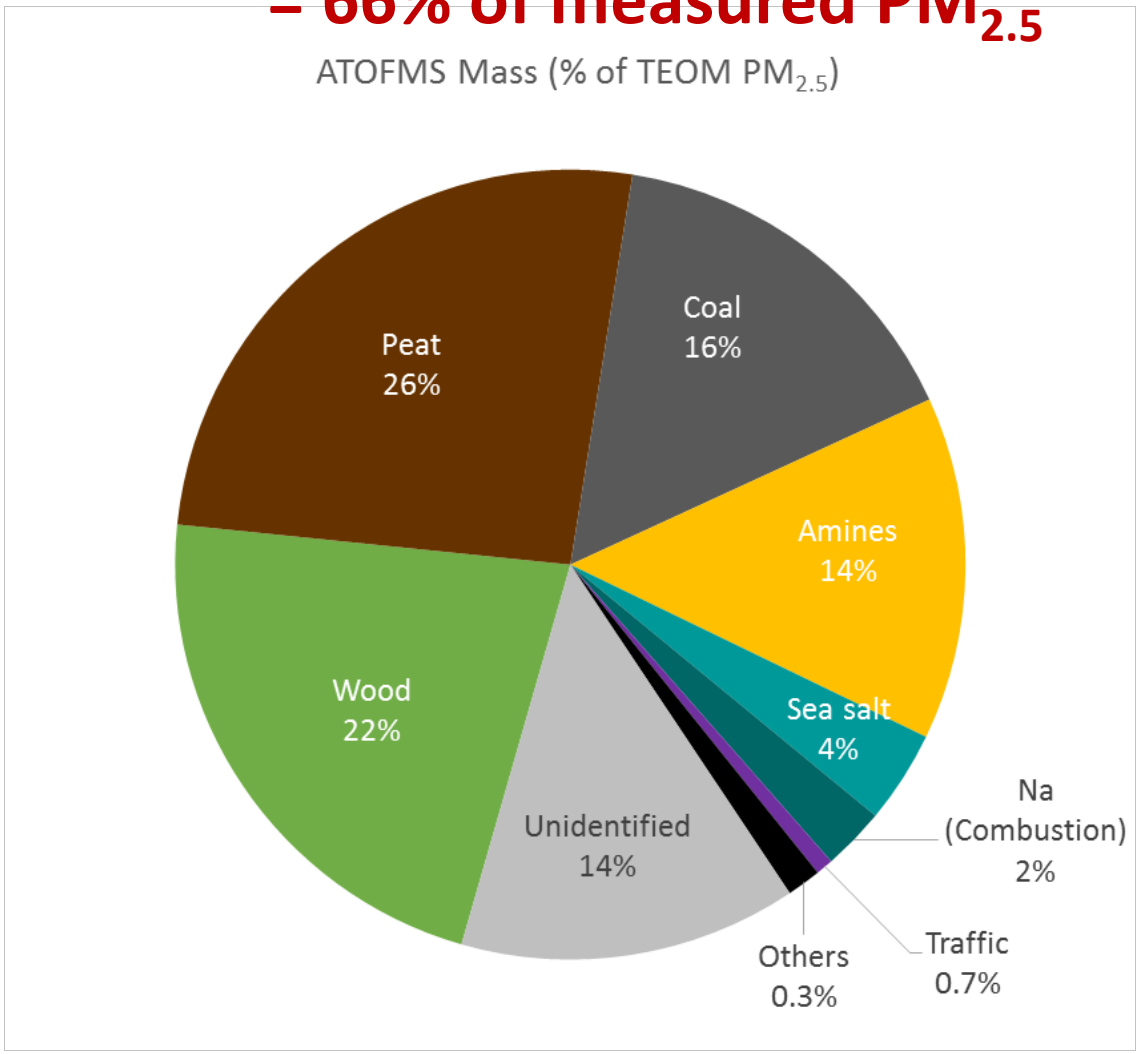
# ATOFMS Particle Mass vs TEOM




- Missing mass due to regional sources – organic aerosol, ammonium sulfate?

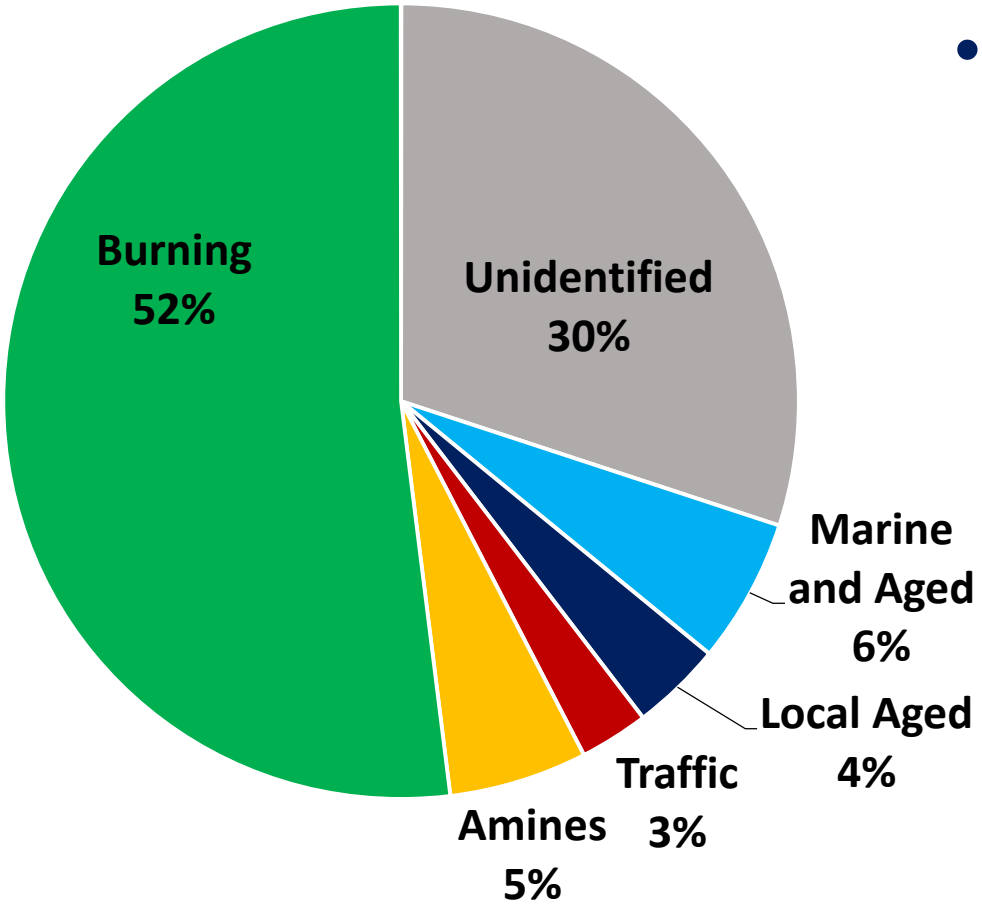
# Source contributions (% of TEOM $PM_{2.5}$)

**Particles directly emitted from solid fuel combustion = 66% of measured $PM_{2.5}$**



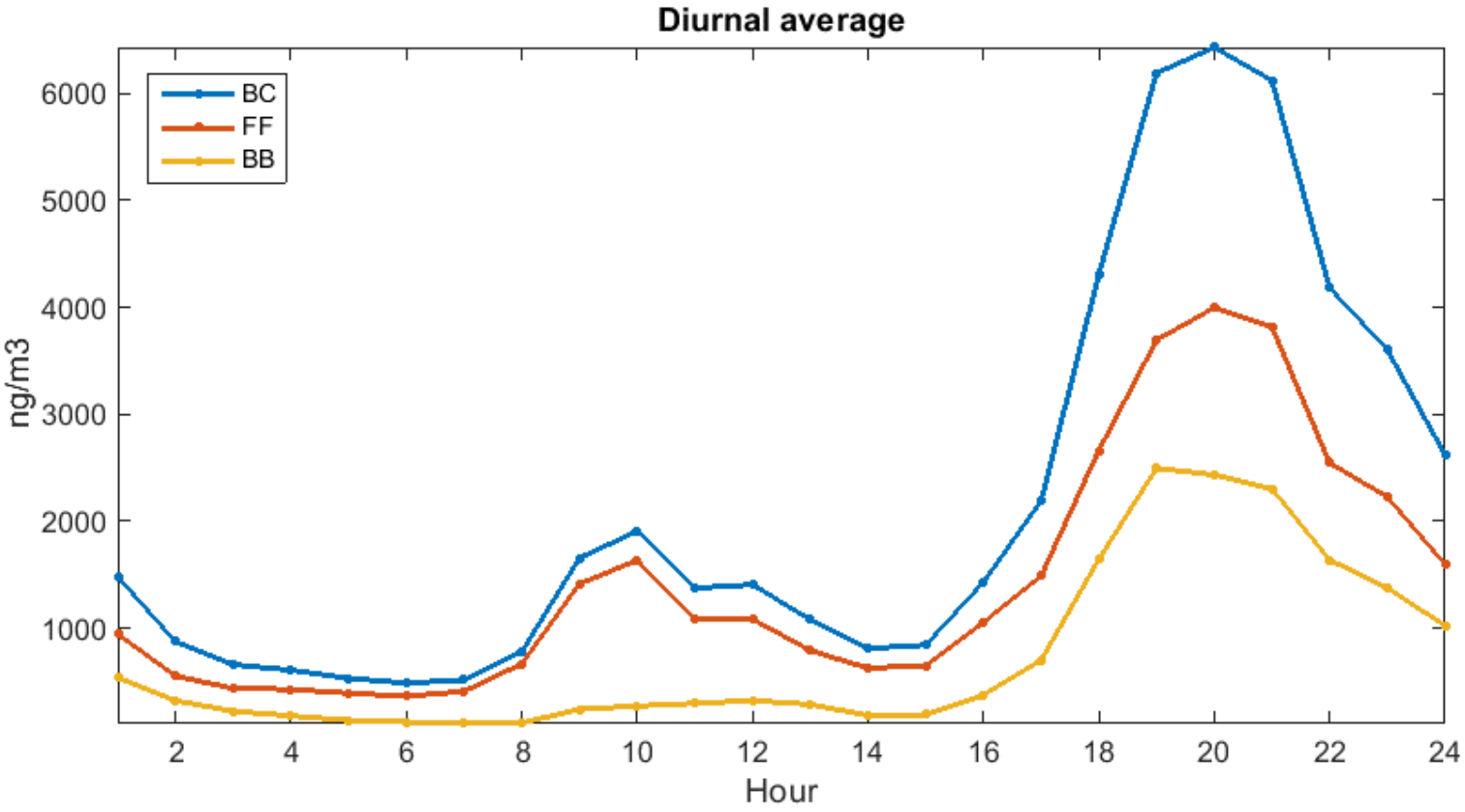
# Preliminary Source Apportionment

- **PMF ME-2 using ATOFMS particle classes, EC-OC, SMPS, OPS, NOx, Aethalometer**



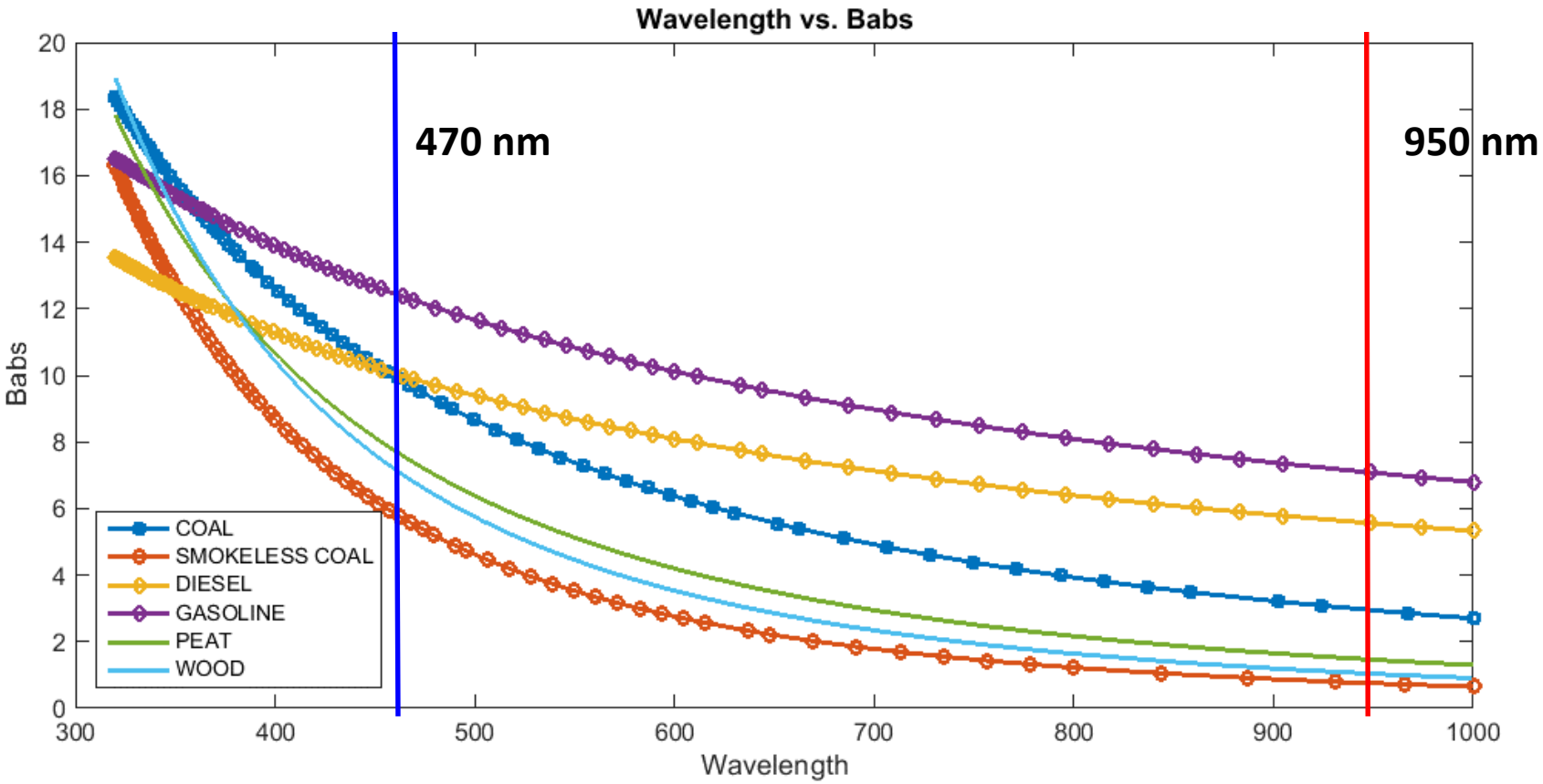

- **5 factors identified**
- **Primary emissions from solid fuel burning = 52% of $PM_{2.5}$ …….but no separation by fuel type**

# Aethalometer (AE-33)



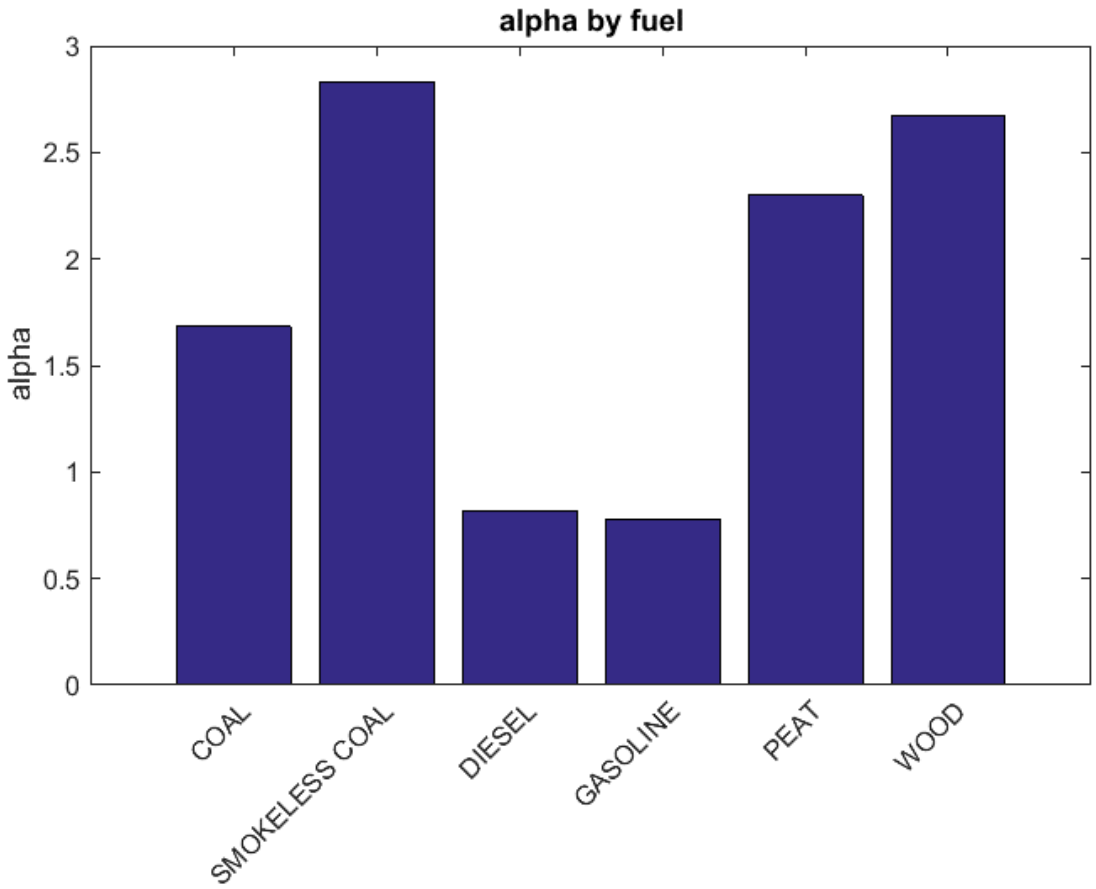

- Fossil fuel (FF) contribution higher than biomass burning (BB) at night!

# Fuel Burning Experiments




- Peat is very similar to wood → contributes to BB
- Coal has significant absorption across the wavelength range → contributes to FF

# Fuel Burning Experiments




- Derived alpha values are currently being used to develop our own model

# Summary and Perspectives

- Residential solid fuel burning contributes up to 60-70% of $PM_{2.5}$ in Killarney
- Similar results from Enniscorthy: also likely replicated in tens of small towns across Ireland.
- Peat, coal and wood all contribute: Extending the smoky coal ban may not deliver improvements in air quality
- ATOFMS can separate contributions from coal, peat and wood, but not easy to deploy on a routine basis.
- Aethalometer source apportionment model under development

# Acknowledgements

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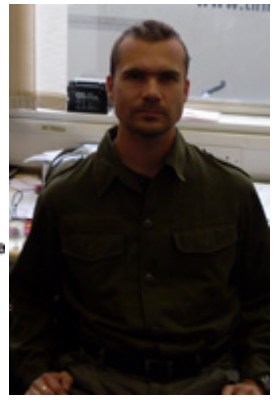

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