Physical and Optical Properties of Black Carbon from Biomass Burning

Allison C. Aiken, Manvendra Dubey, Shang Liu*, Kyle Gorkowski⁺
Earth Systems Observations (EES-14)
Los Alamos National Laboratory, NM, *now at CU, ⁺now at CMU

Gavin McMeeking, Paul DeMott, Ezra Levin, Sonia Kreidenweis**
Colorado State University, Fort Collins, CO
**now at Droplet Measurement Technologies, Boulder, CO

Claudio Mazzoleni, Swarup China, Noopur Sharma
Michigan Tech. University

Chris Cappa UC-Davis
Nga Lee Ng, Lu Xu Ga. Tech.
Leah Williams, Doug Worsnop Aerodyne, Billerica, MA

FLAME-IV Team led by Sonia Kreidenweis (CSU), Allen Robinson (CMU), and Bob Yokelson (U. Montana)

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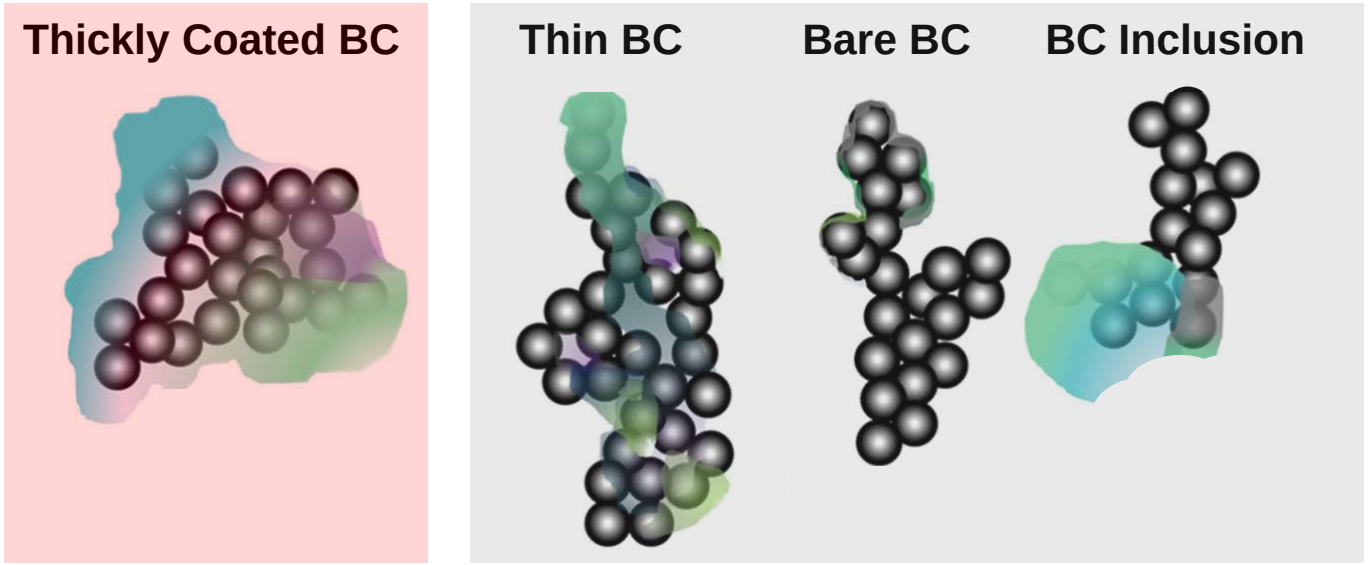
Climatic Effects of BC from Biomass Burning

- **2nd most important factor in global warming** (Bond et al., 2013) **& most uncertain!**
- **~50% of BC is from Wildfires/BB, ~0.6 W/m^2, reduced by presence of OC**

Questions: What is the morphology of BC from Wildfires?

Does it result in enhanced BC absorption?

- **3-4 Types of BC from SEM Images during Las Conchas**
  (China et al., Nature Communications, 2013)



- **2 main instruments (direct/online): SP2 (BC) and PASS-3 (Absorption)**

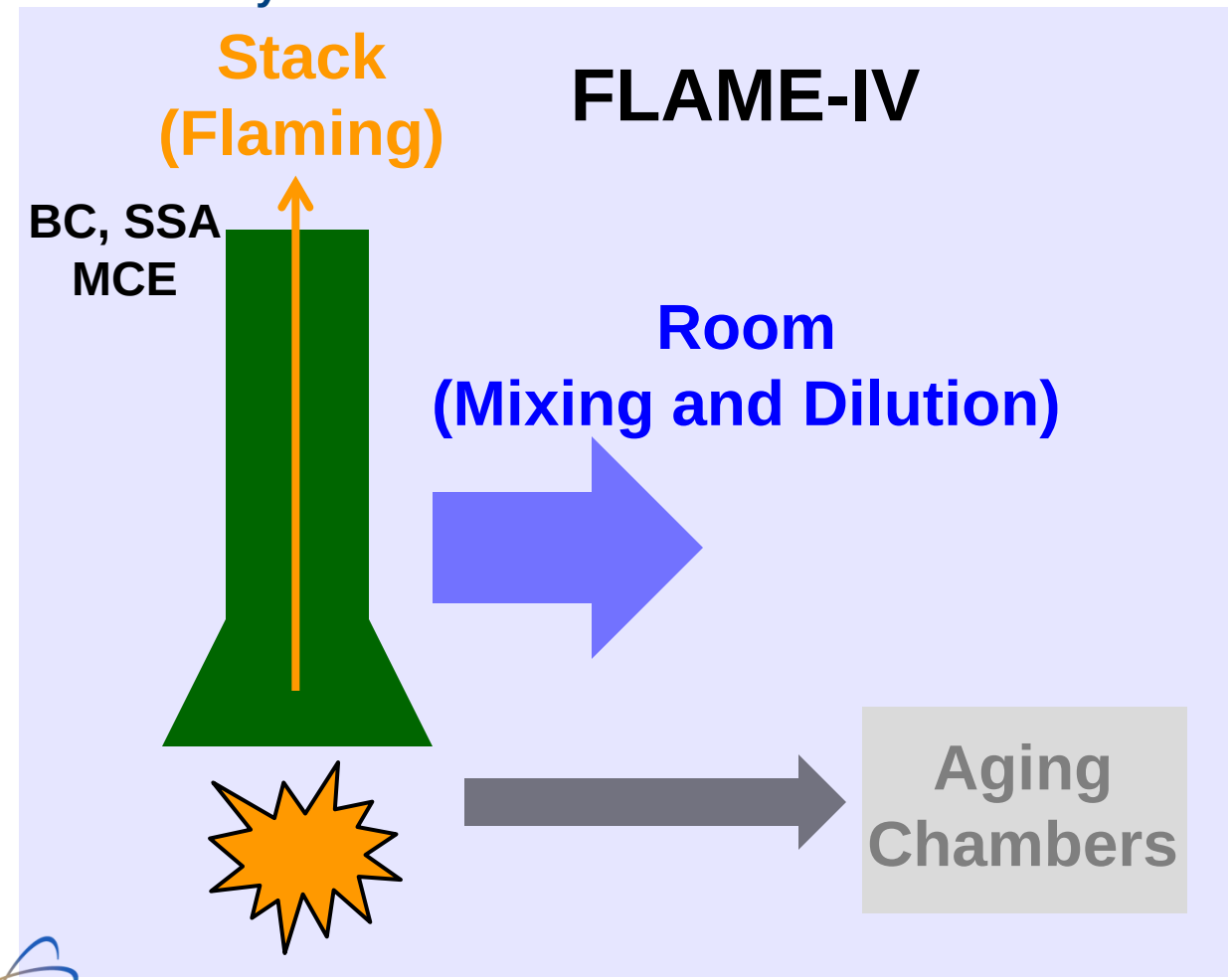
BC Coatings and Enhancements – Detling/ClearfLo

- **Winter measurements – wood burning from heating and diesel emissions from the region and continental Europe**
- **S. Liu, A.C. Aiken, K. Gorkowski, M. Dubey et al., in prep.**

Biomass Burning Aging Studies – Bridging the Gap

Bottom Up — Parameterizations — Top Down

τ (NO_x/NO_y)

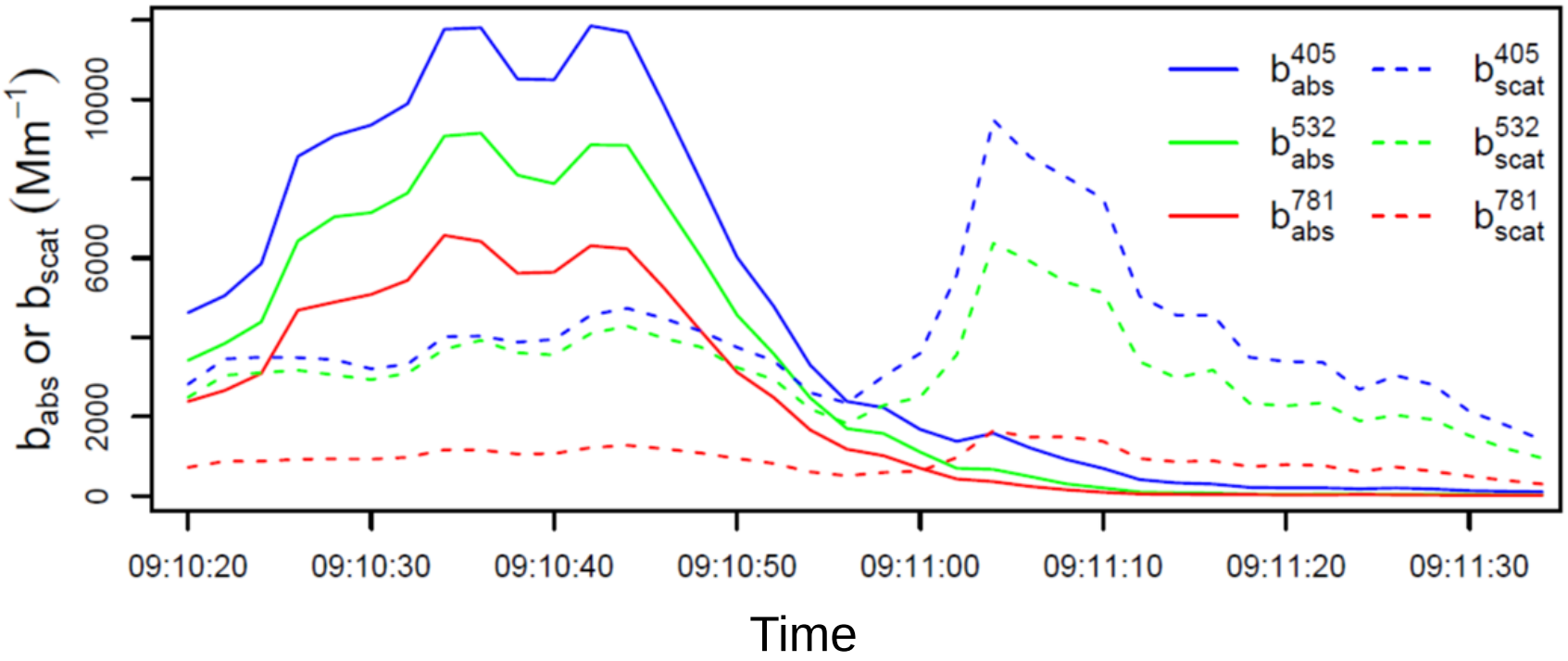


Ambient Wildfires

Las Conchas (1-3 hrs) 2011

Whitewater Baldy (9-20 hrs) 2012

FLAME-IV Fresh Stack Experiment



- **Fresh stack emissions: Burn proceeds from flaming → smoldering**
- **Characterized by MCE**

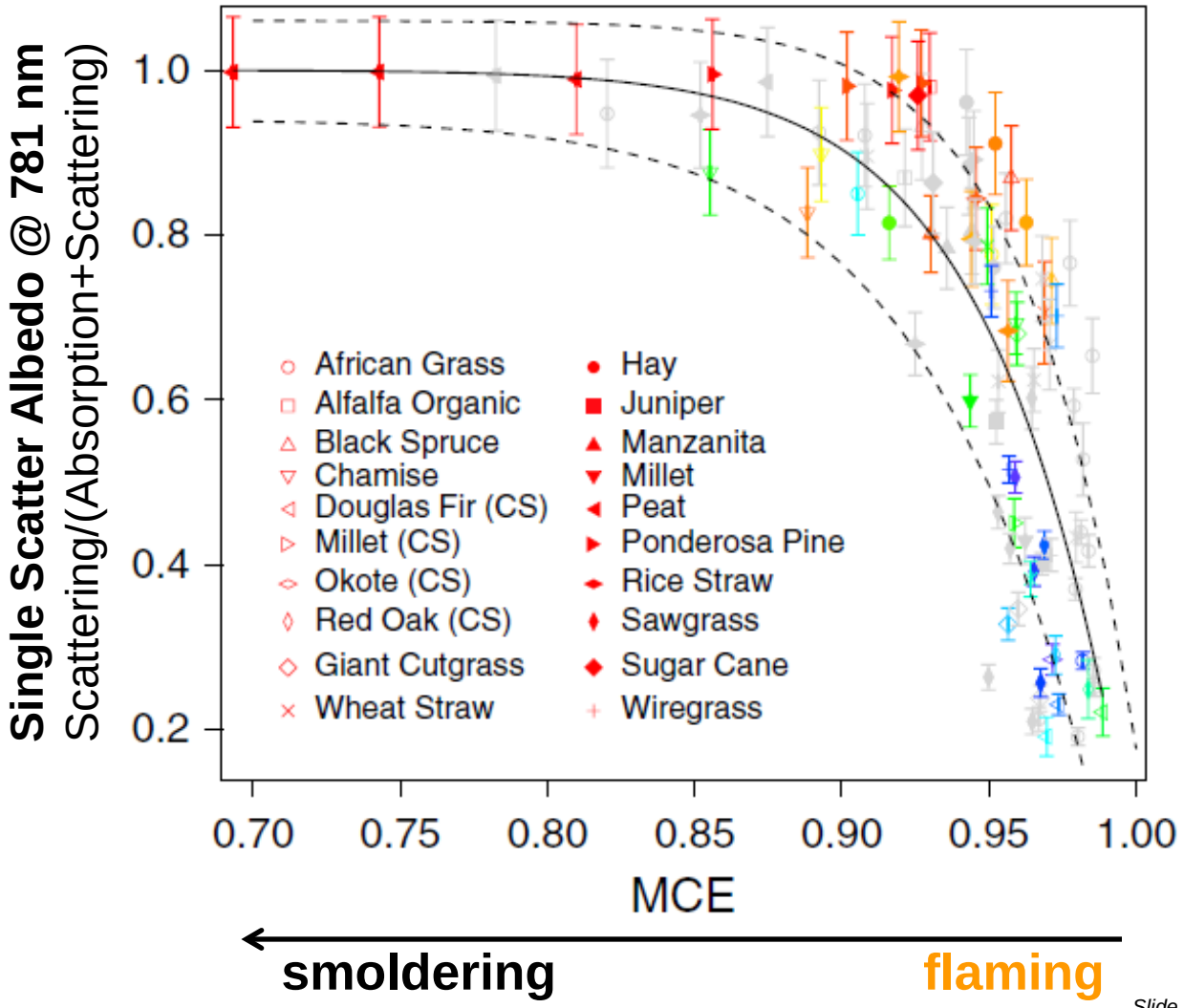
MCE = Modified Combustion Efficiency

$$\frac{\Delta CO_2}{(\Delta CO + \Delta CO_2)}$$

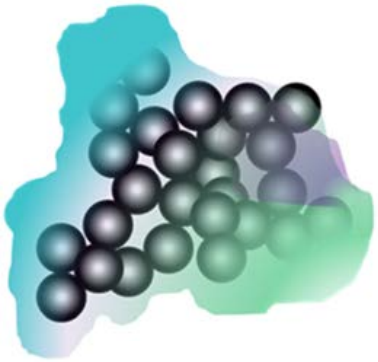
SSA Parameterized by Fire-Integrated MCE

- **FLAME-IV Lab data**
- **Parameterization for models to determine SSA from MCE**
- **Whitewater Baldy falls within the lab results**

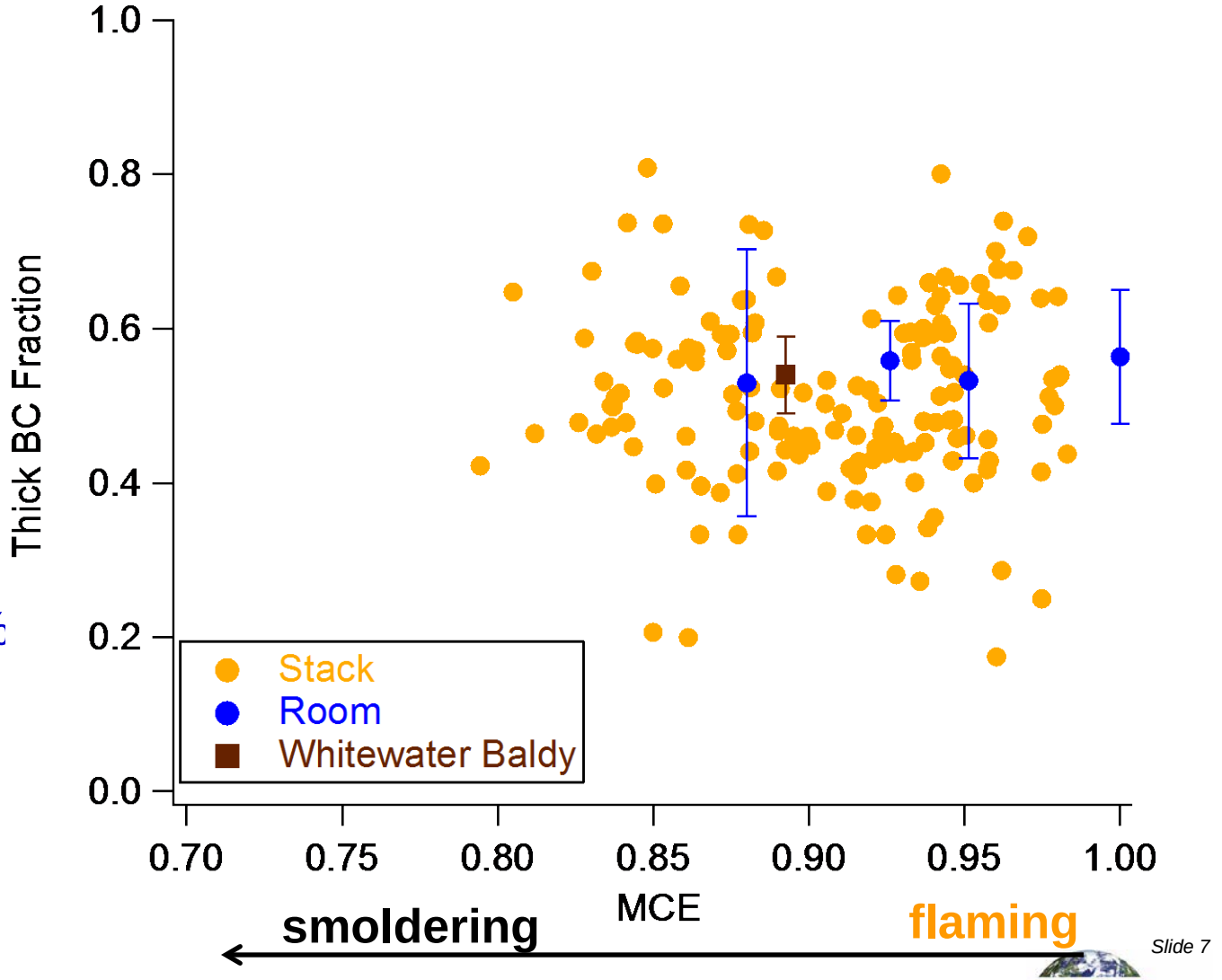
S. Liu, A.C. Aiken, C. Arata, M. Dubey et al., 2014, GRL, 41, 742-748.



Thickly-coated BC Fraction

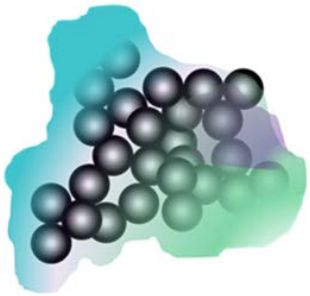


- **FLAME-IV: 51.6%**
  - Fresh 48.4%
  - Well-mixed 54.7%
- **Whitewater Baldy: 54%**

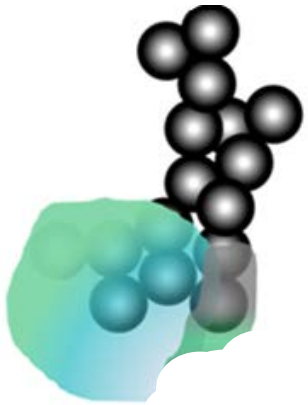


Coated BC to BC Core Ratio decreases with increasing MCE

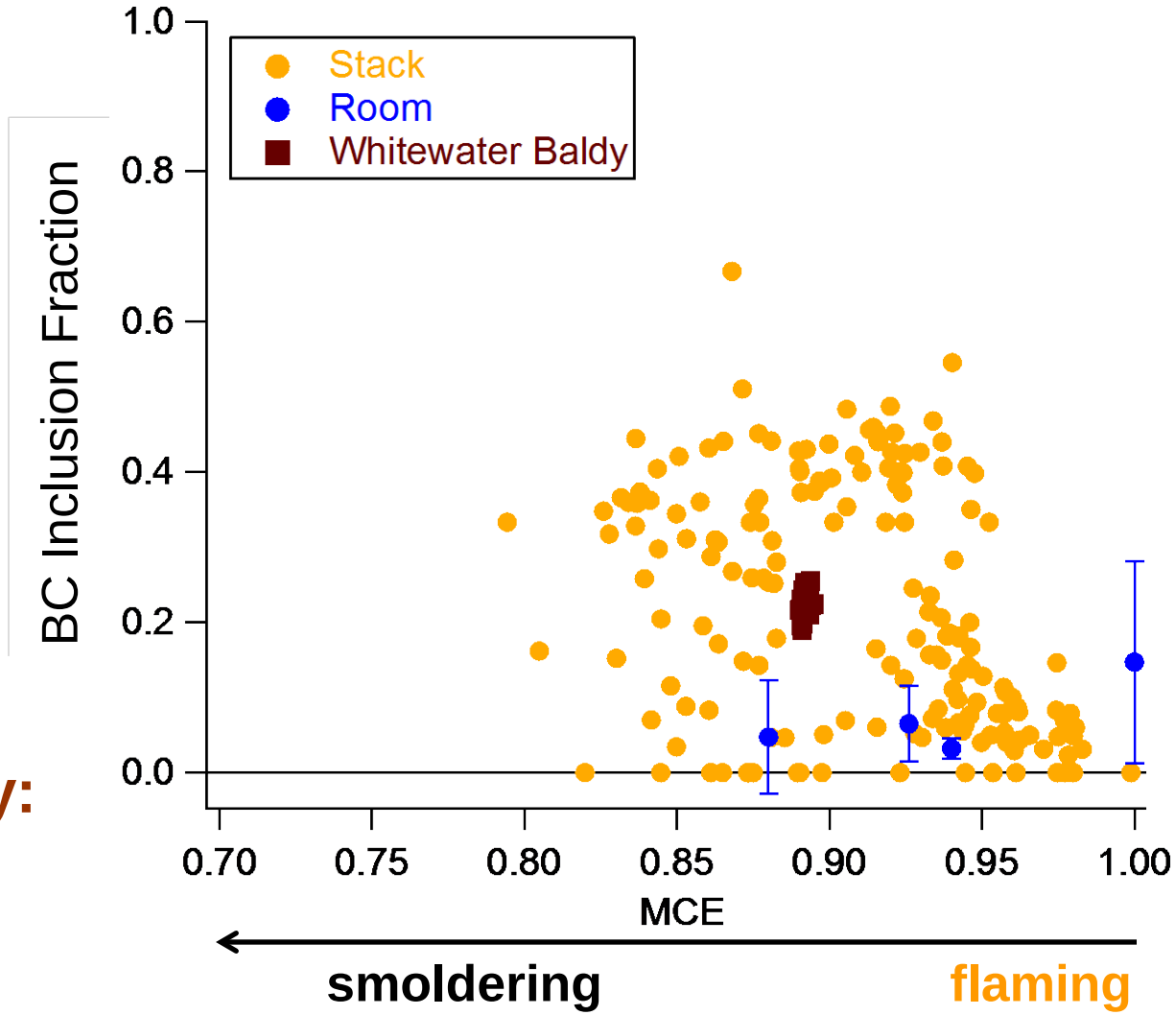
- **Thickly Coated BC Fraction**
- **Fresh**
  - Ratio decreases with increasing MCE
- **Well-Mixed**
  - More uniform values
  - Lower ratio due to larger cores and/or thinner coatings
  - short-term “ageing” a.k.a. mixing and dilution (likely evaporation of higher volatility species) and/or more coagulated BC



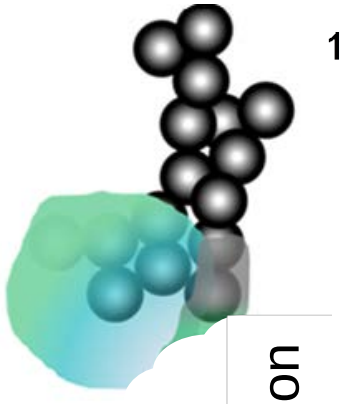
BC Inclusion Fraction

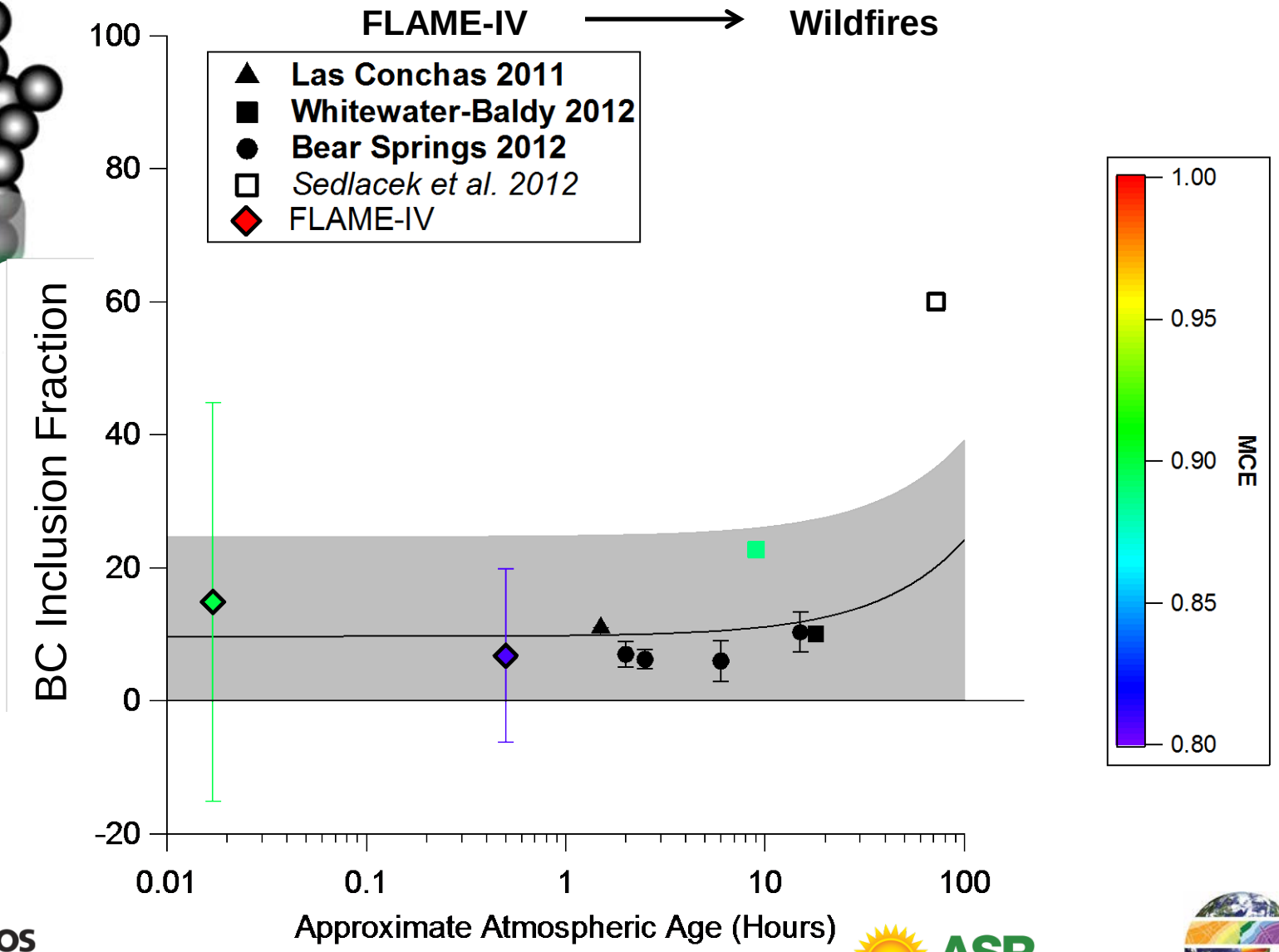


- **FLAME-IV: 8.3%**
  - Fresh14.9%
  - Well-mixed: 6.8%
- **Whitewater Baldy: 22.7%**

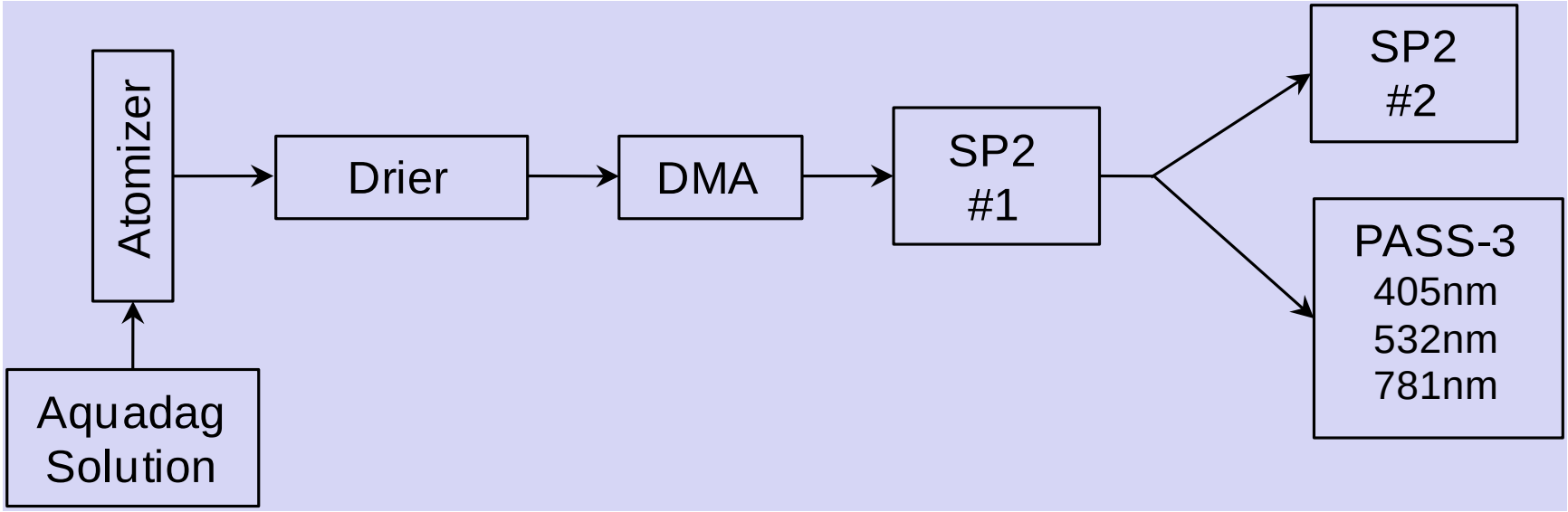


Understanding Coating/Particle Type vs Atmospheric Age





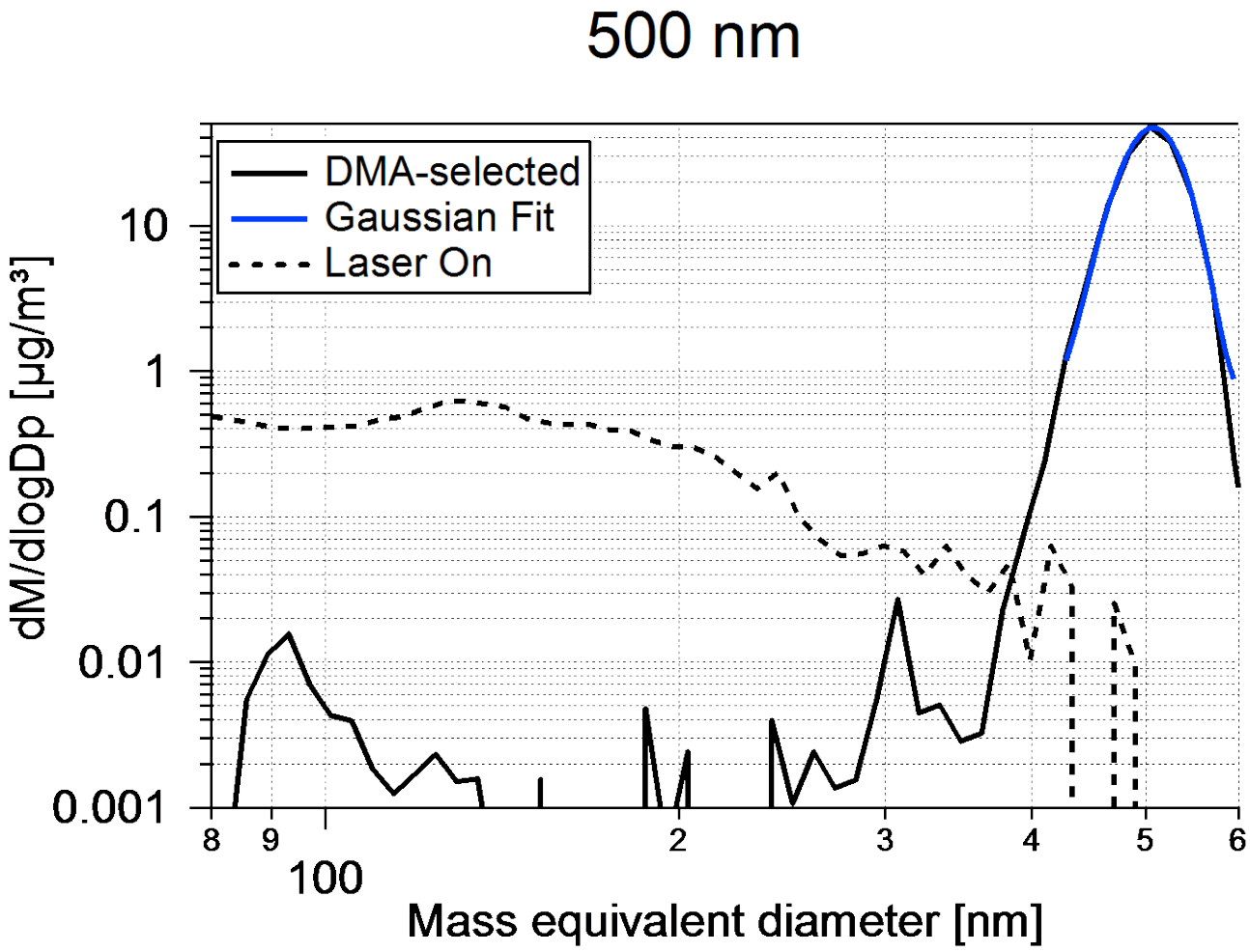
BC Removal Experimental Setup



- **Atomization of "classic" Aquadag (100 – 800 nm d_m)**
- **Standard drying and size selection with a DMA**
- **After LII in SP2 #1, the aerosol stream is sent to SP2 #2 and a PASS-3 for BC and optical characterization**
- **Aiken et al., in prep.**

BC Removal Results – Before and After

- **Original BC is mostly removed:**
  - < 10% total mass and
  - <1% original size range
- **"New" small BC present after removal of original BC**



Conclusions

- Black Carbon is ubiquitous yet due to complexity contains signatures of emission sources and aging/processing
- BC enhancement measured during ClearfLo
- Laboratory FLAME-IV – fresh to well-mixed BB BC
  - SSA parameterized as an inversely related function of MCE
  - Ratio of BC particle diameter to BC core is inversely related to MCE
  - Measured BC Inclusion particles
- Thickly coated BC represents ~50% (expected enhanced absorption)
- BC Removal Technique
  - ≥ 90% mass removed for particles >100 nm d_{me}
  - Potential to use for BC exclusion of mixed aerosol sampling to probe Brown Carbon
- Healthy BB signals at GoAMAZON from local sources, more expected

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