Setting the Standard for Automation™

What is Turbidity?

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Standards
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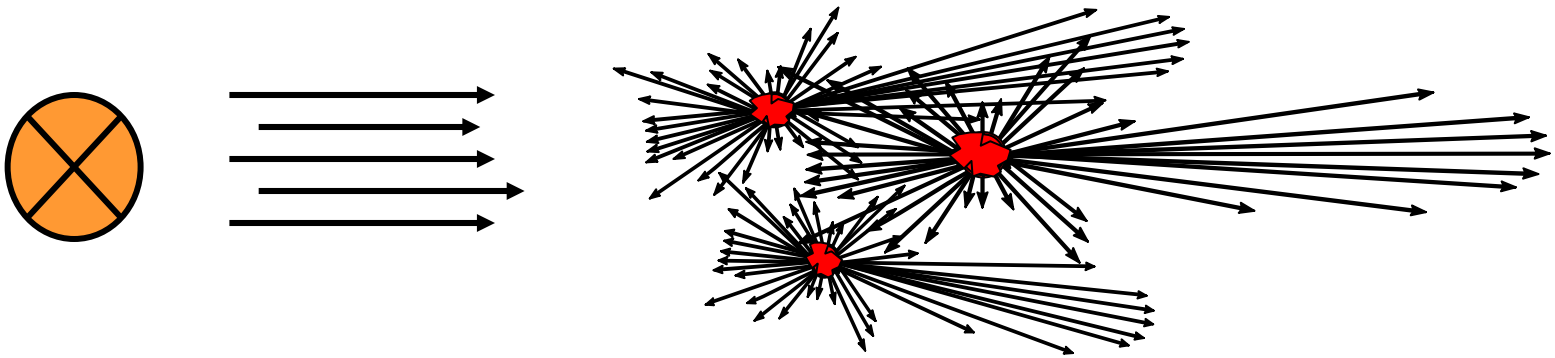
Objectives

- Understand what Turbidity is
- Investigate the various methods of measurement
- Compare those measurements
- Calibration and how it relates.

Definition

What is Turbidity ?

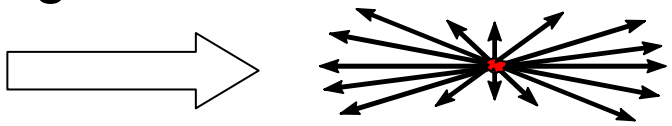
Turbidity is the phenomen where by a specific portion of a light beam passing through a liquid medium is deflected from undissolved particles.



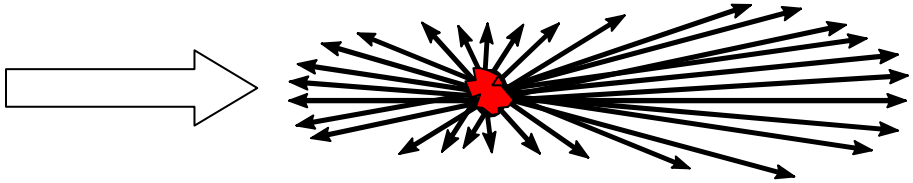
Scattered Light

The deflection is a function of the size and shape of the particles

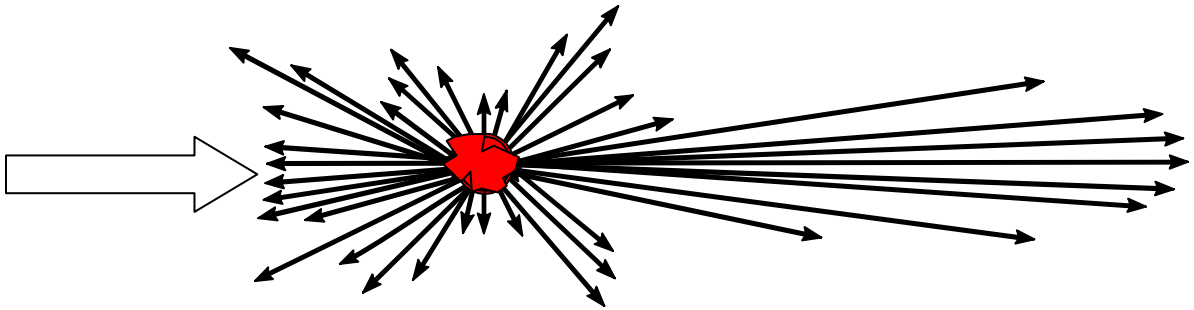
Incident Lightbeam



Size: Smaller Than 1/10 the Wavelength of Light
Description: Symmetric



Size: Approximately 1/4 the Wavelength of Light
Description: Scattering Concentrated in Forward Direction



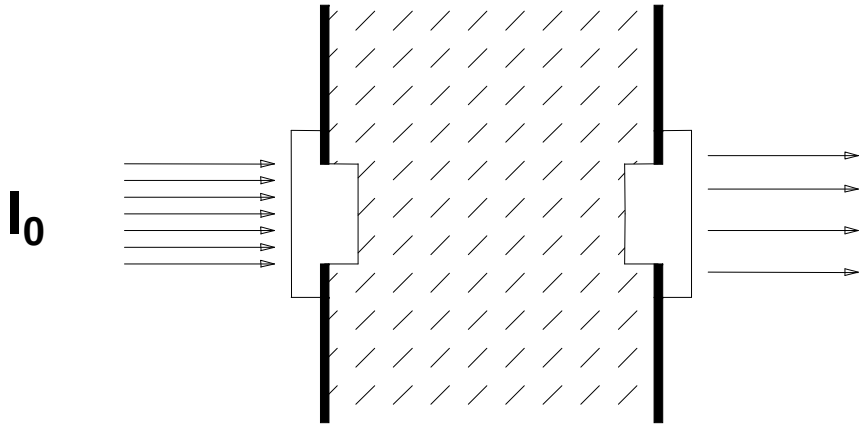
Size: Larger Than the Wavelength of Light
Description: Extreme Concentration of Scattering in Forward Direction; Development of Maxima and Minima of Scattering Intensity at Wider Angles

Absorbance vs. Scattered Light

Absorbance of light:

(Concentration)

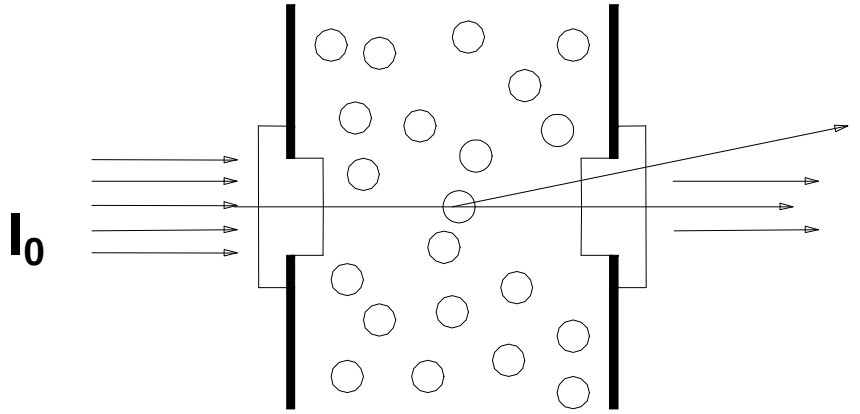
Dissolved Solids



Scattering of light:

(Turbidity)

Particulate and Solids



Scattered Light - What are Particles ?

Particles may be anything creating heterogeneous surfaces:

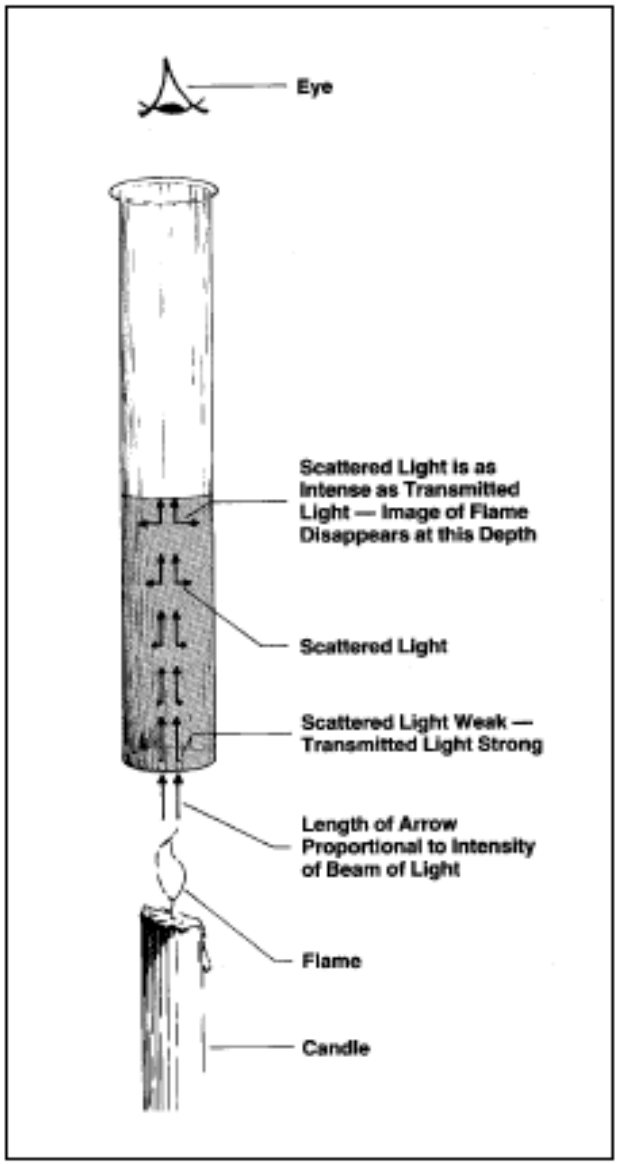
- solids in liquids (suspension)
- oil in water / water in oil (emulsion)
- gas bubbles (foam)
- dust in air (smoke)
- droplets in air (fog, aerosol)

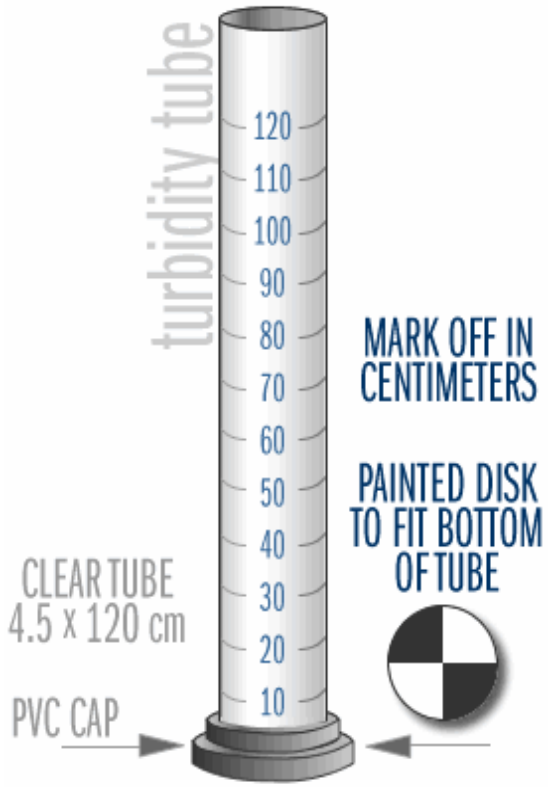
Scattered Light

The diffusion of light caused by undissolved particles in the medium to a lesser or greater degree of the deflection depends on:

- the type of the particles (absorbance)
- the size of particles
- the concentration (the number of particles)
- the type and shape of particles
- the wavelength of the light
- the angle of measurement

Some History - Jackson Candle Turbidity Scale





Scattered Light - Formazine Standard

Formazine = $C_2H_4N_2$

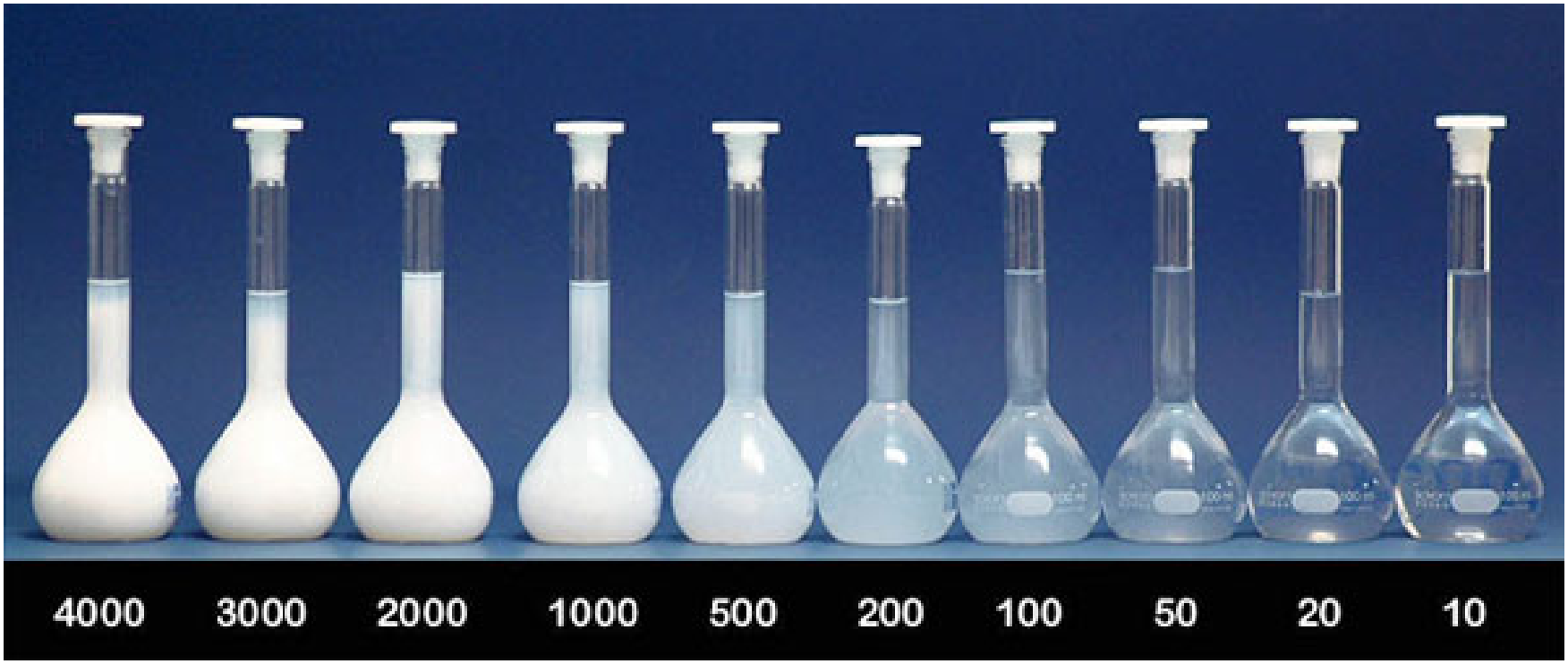
ingredients: Hexamethylentetramine + Hydrazinsulfate

standard-formazin-solution = 4000 FNU

1 FNU = 1 FTU = 1 NTU = 1 TU/F = 0,25 EBC

FNU = formazine nephelometric unit
FTU = formazine turbidity unit
NTU = nephelometric turbidity unit
TU/F= turbidity units formazin
EBC = European Brewery Convention

What does Turbidity look like?



- Formazin Turbidity Standards - NTU

Scattered Light - Comparability

A lot of suppliers with different sensors

hard to compare

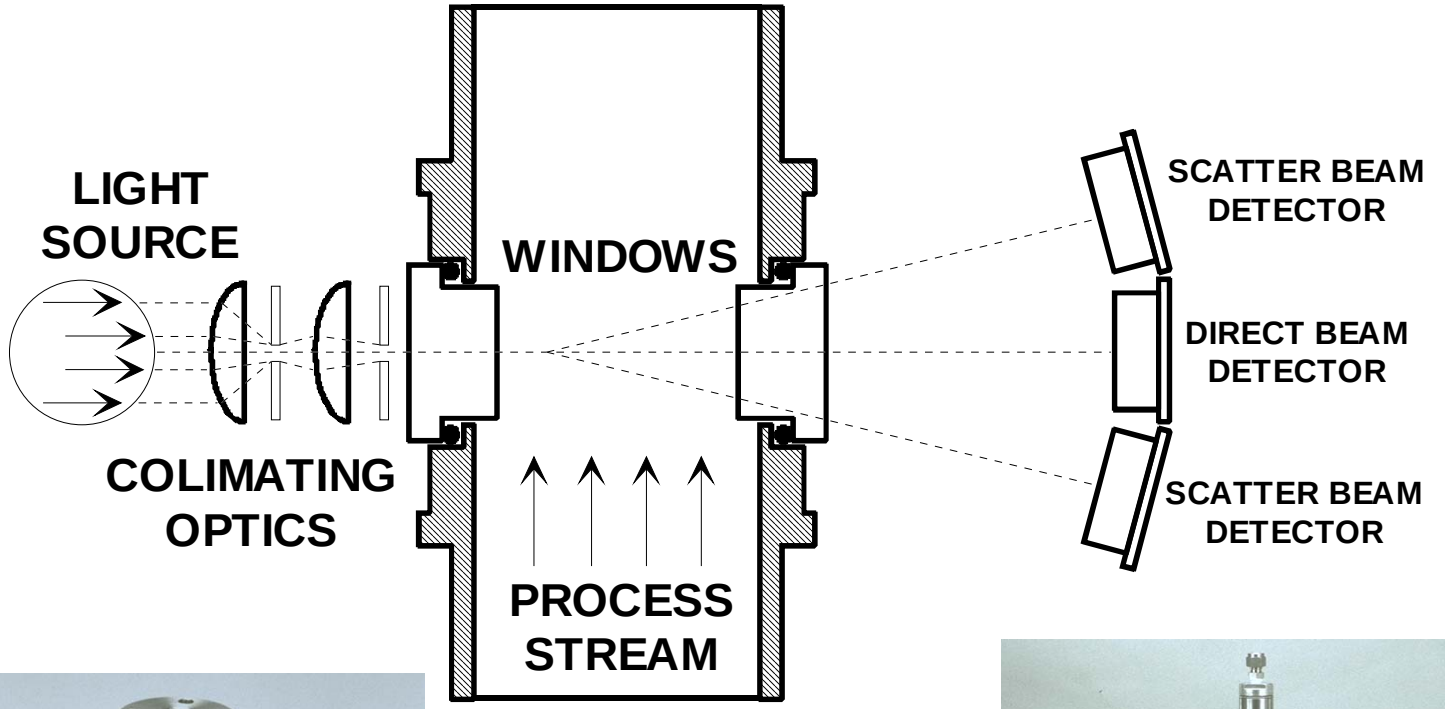
Forward Scattered light

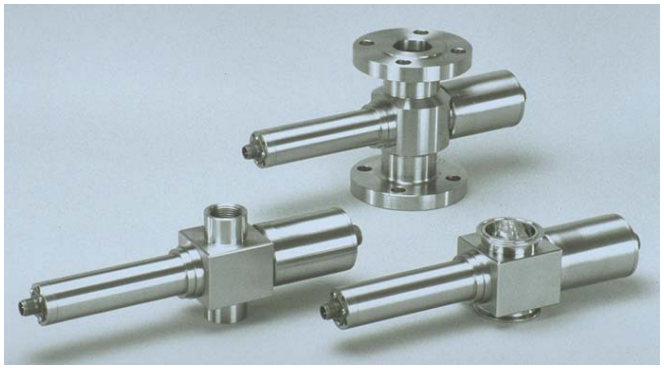
180° Direct light (Absorbance)

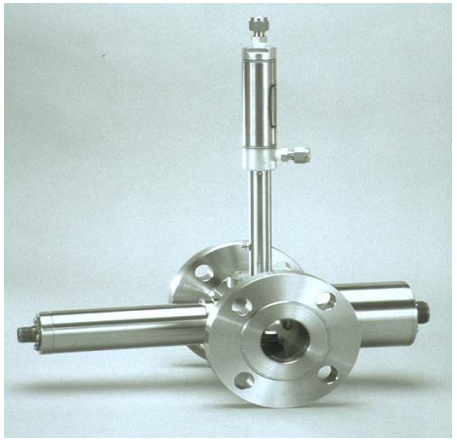
90°-Scattering

Back Scatter

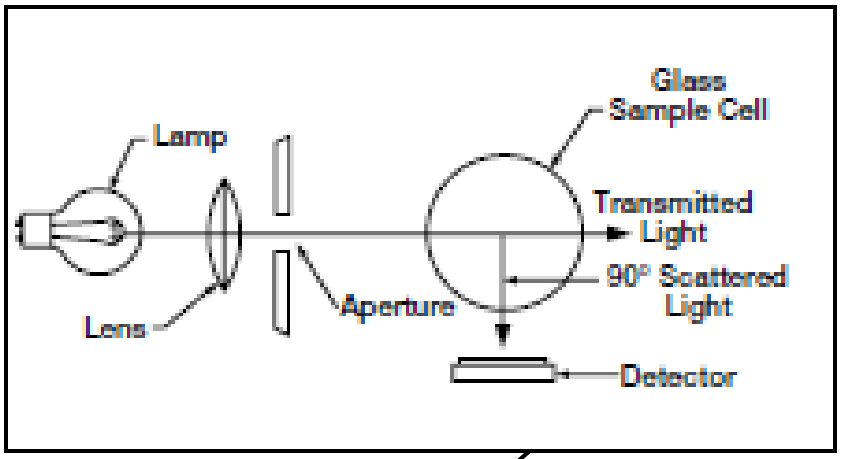
Dual Beam Forward Scattered Light



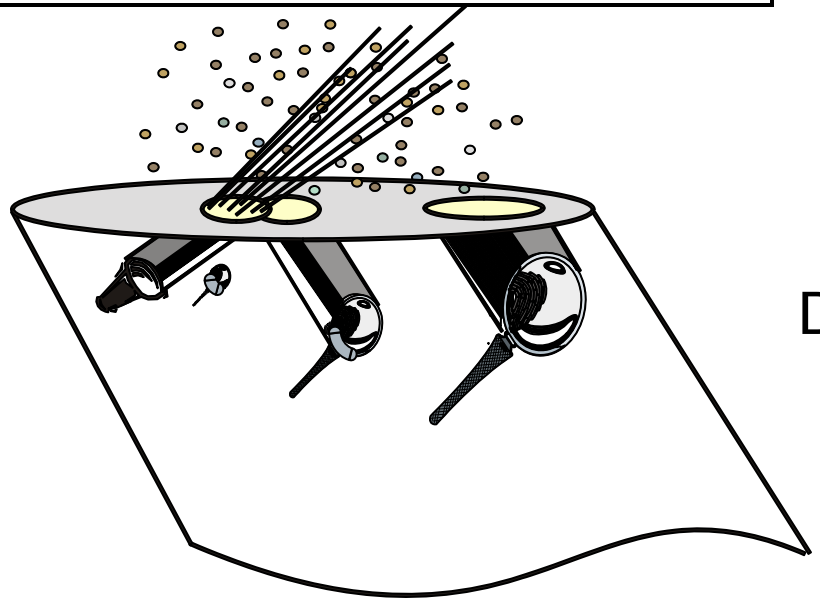




90 degree Scatter- Nepholometry

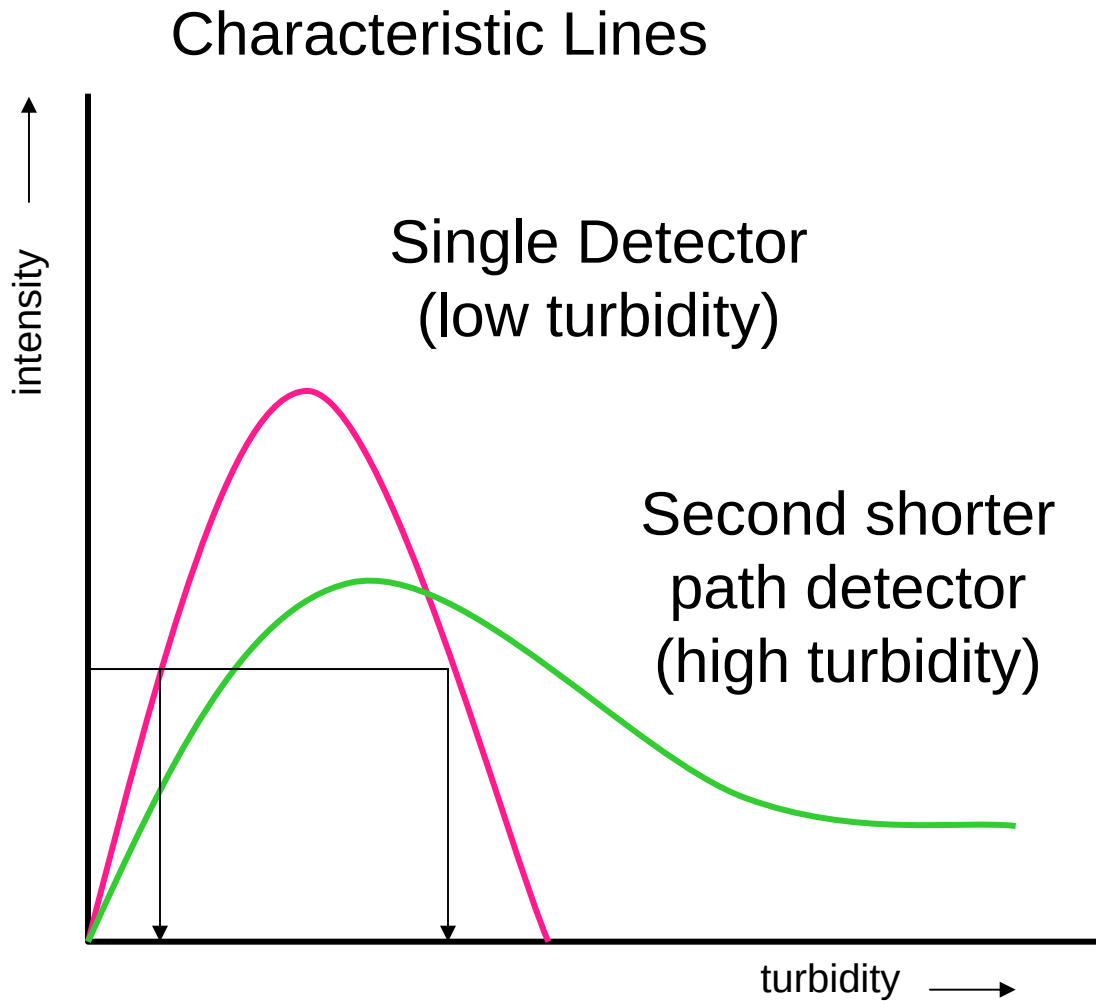


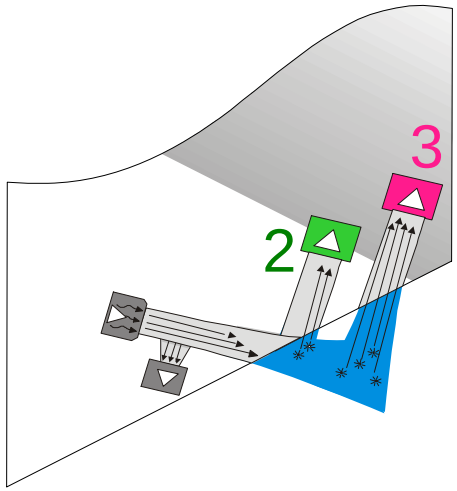
Single Detector Nepholometry



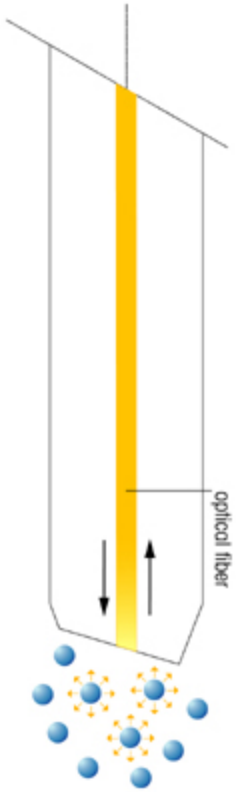
Dual Detector Nepholometry

One and Two Detector 90 degree Measurement





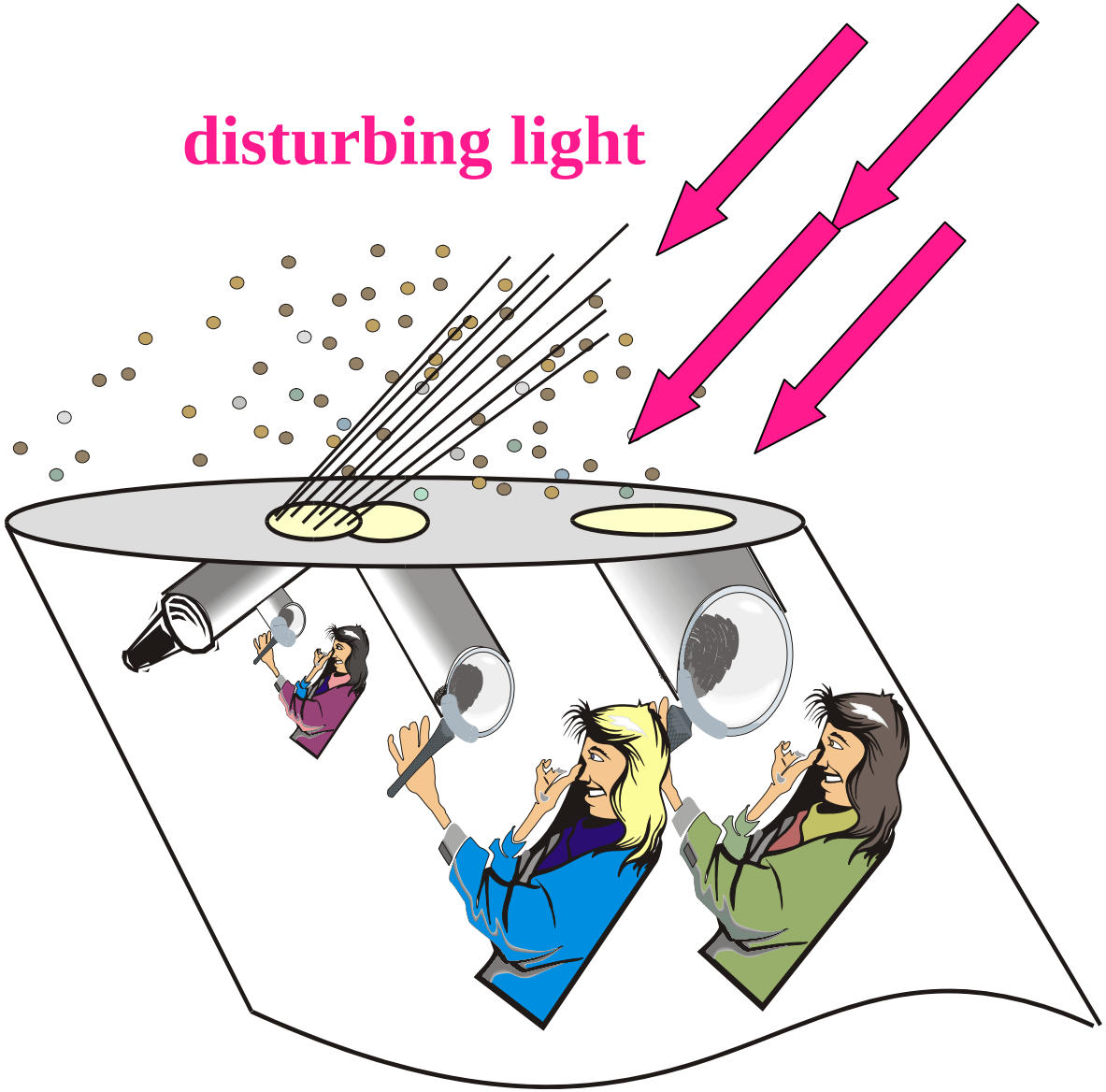
Backscatter Measurement



High Turbidity Systems – 4000 FTU

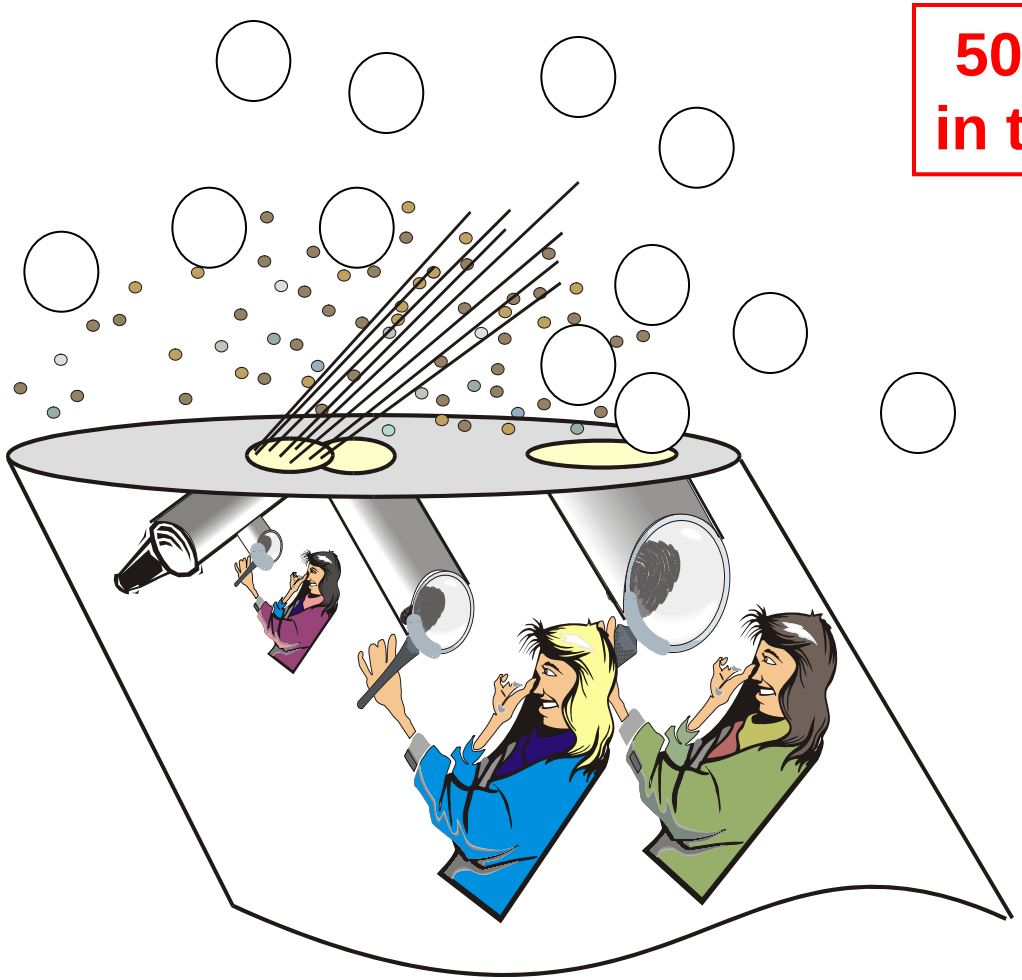
Typically probe systems

Disturbing Light Effects



- daylight
- other light
- heat sources (IR)

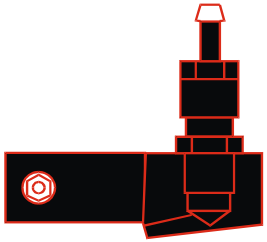
Main Disturbance: Gas Bubbles



50-80% of the mistakes in turbidity measurement

Many suppliers have a debubbler chamber associated with their installation

Sensor Cleaning Systems



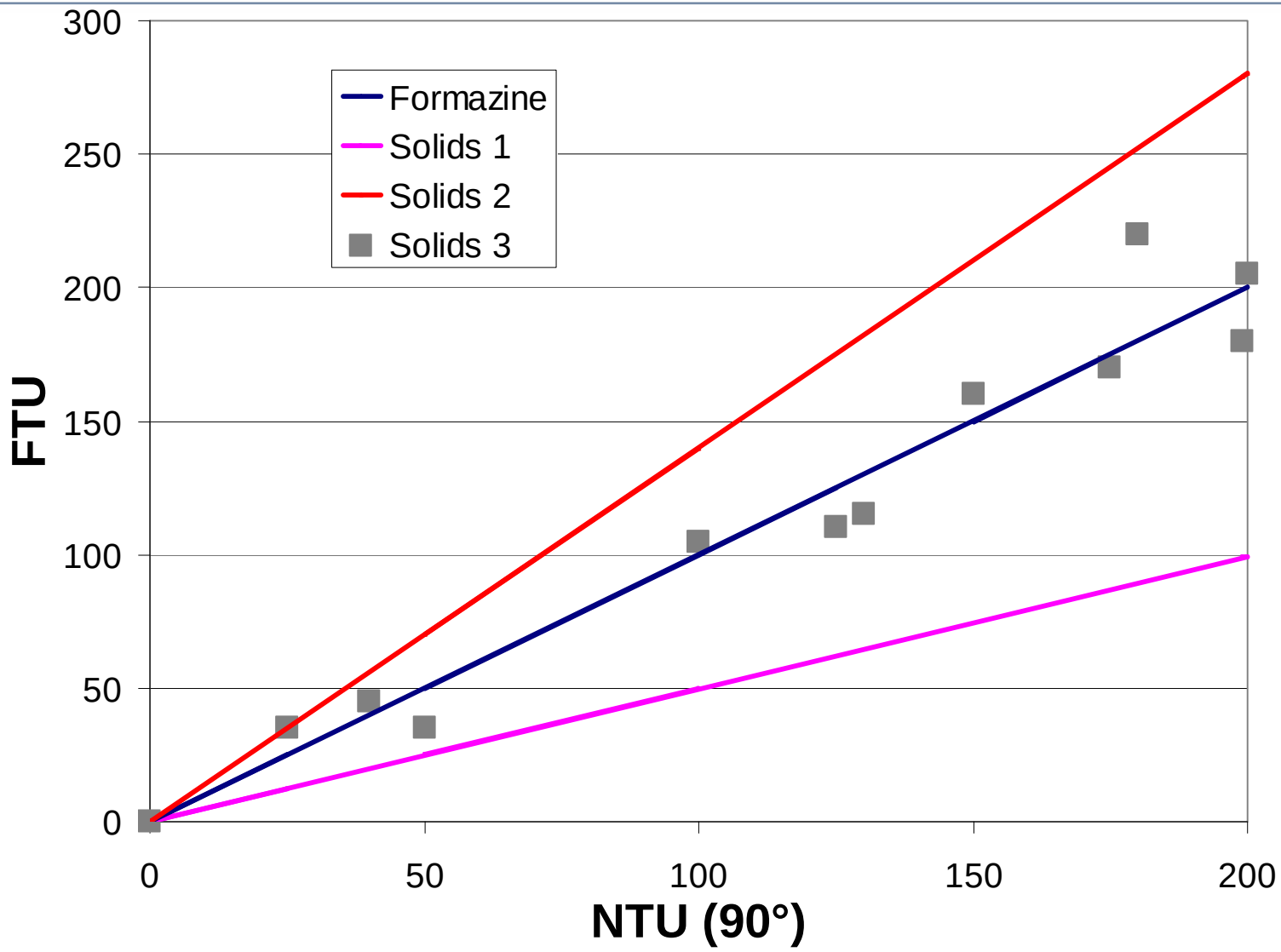
Spray head

- Wiper
- Spray cleaning

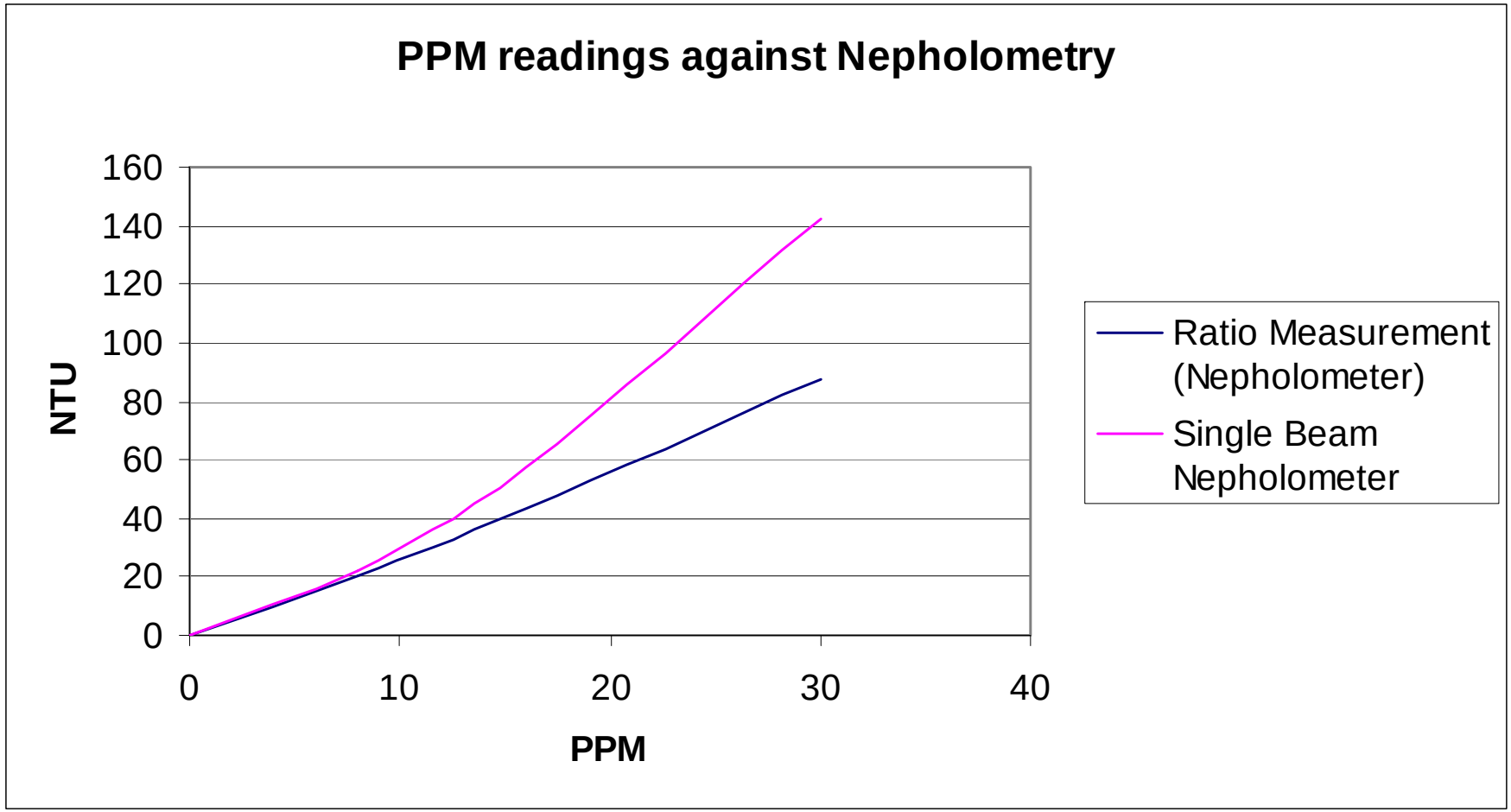
How does turbidity relate to Process?

- Each process will have a specific turbidity signature
- Your process will have a different particulate size distribution to Formazin – so has to be correlated
- Standards only allow the instrument to be calibrated to the same condition
- Readings are TREND readings for your process
- If the particle size distribution changes, so does the reading!

Scattered Light - Comparability, Correlation

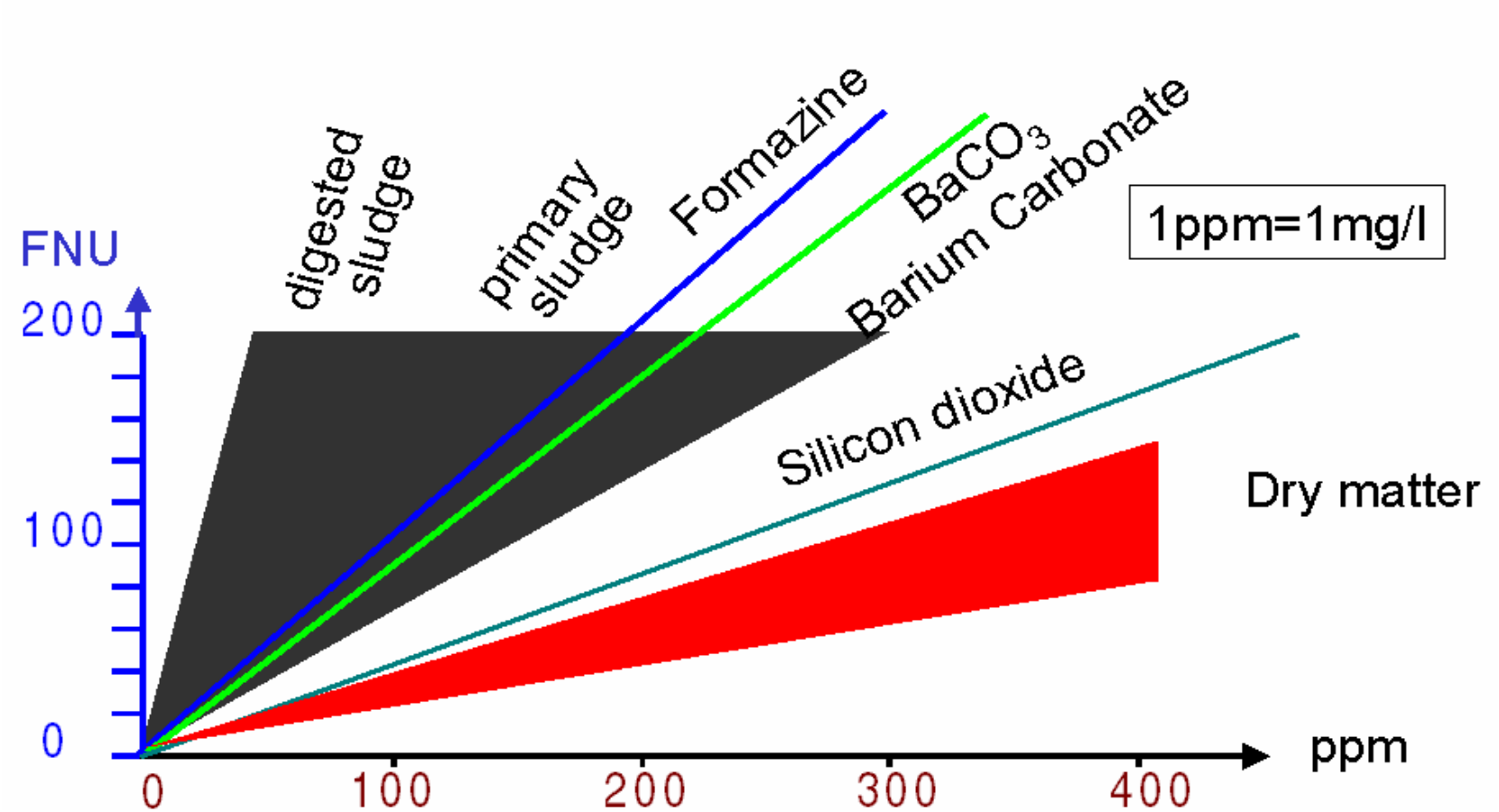


Scattered Light - Comparability, Correlation - again



Turbidity

Turbidity as Function of Concentration



Turbidity

Typical Values

Measured Sample	Measured Value
Waste Water	70-2000 NTU
Final outlet sewage treatment plant	4-20 NTU
Well Water	0.05 - 10 NTU
Potable water	0.05 - 1.5 NTU
Milk	> 4000 NTU
Orange juice	300 - 900 NTU
Primary sludge	6-3%(60 - 30 g/l)
Activated sludge	3-7 g/l
Recirculated sludge	6-8 g/l
Digested sludge	5-8%(50-80 g/l)

Turbidity - Examples of Applications

- Filter Control
- Centrifuge/Separator Control
- Biomass in fermenter
- Cell Growth
- Quality Control of final product
- Oil in water
- Water in oil
- Catalyst concentration
- Diesel in water
- Oil in condensate
- Leakage control heat exchanger
- Fat Content in milk
- Yeast dosage
- CIP return line
- Interphase detection
- Product recognition
- Water control, In- and Outlet
- Flocculant dosage
- Sludge concentration
- Pulp concentration
- Content of solids
- Dust in gases