Case Studies of Particle Imaging Technology for Differentiating Particles in Produced Water

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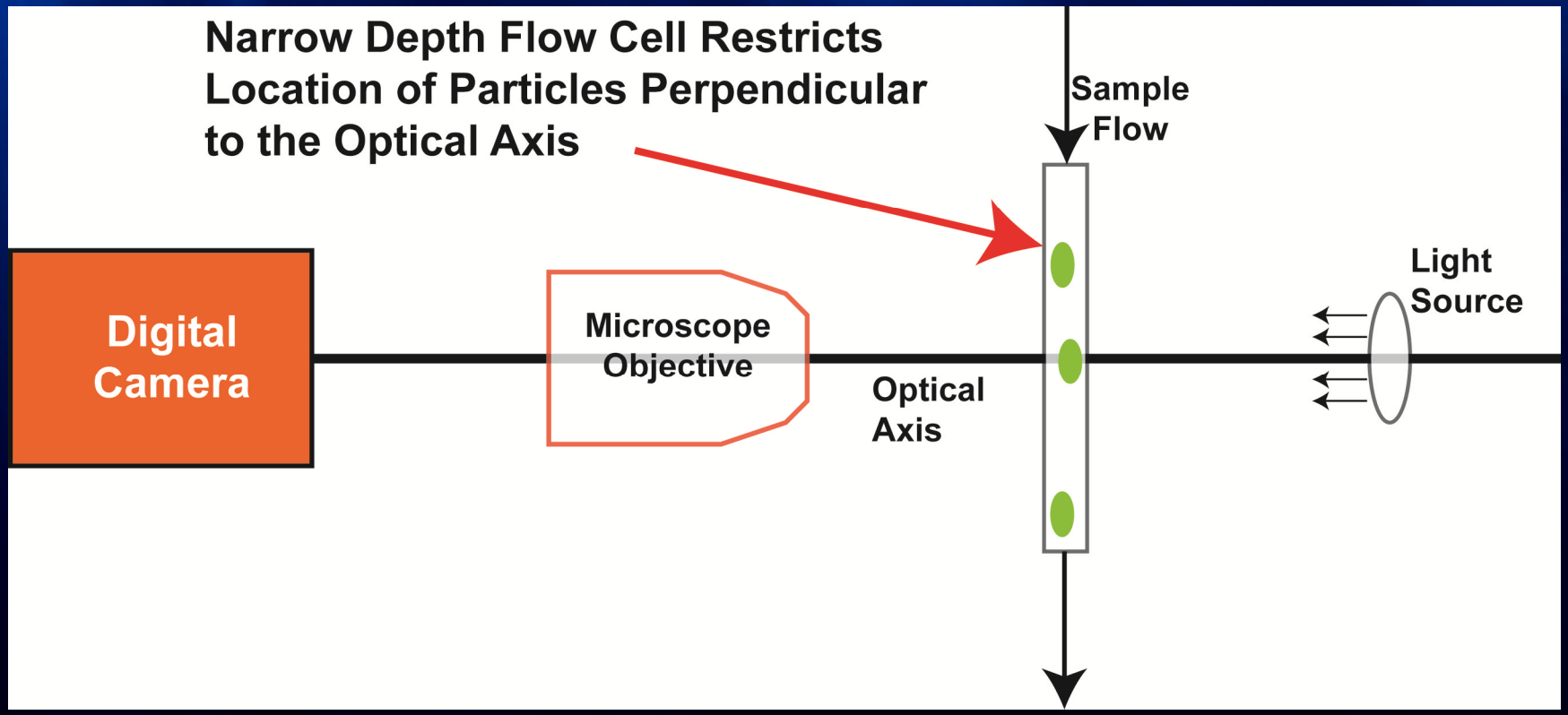
Outline

- What is Dynamic Imaging Particle Analysis?
- Examples of Particle Imaging for Calculating Oil and Solids in Produced Water.
- Limitations and Best Cases for Using Particle Imaging in Produced Water
- Questions

What is Dynamic Imaging Particle Analysis?

- **“Automated Microscopy”**
- **Sample is Moved Through Optical Path “Dynamically” & Imaged in Real-Time**
- **Large Number of Measurements/Particle Enables Differentiation by Shape**
- **“Shape Filters” Automatically “Bin” Particles Into Different Types**
- **High Quantity of Particles Measured Yields Higher Statistical Confidence**

How It Works
Flow Cell View



FlowCam® Overview

- Collects size, shape, and count data upwards of 50 particles/frame at 20 frames/second (~60,000 particle/min)
- Allows query and examination of individual particle microscopic images and associated morphology
- Wide particle size range of 5µm-2mm
- Low sample volume (usually a few ml)
- Total Magnification from 20x to 200x

FlowCAM Models

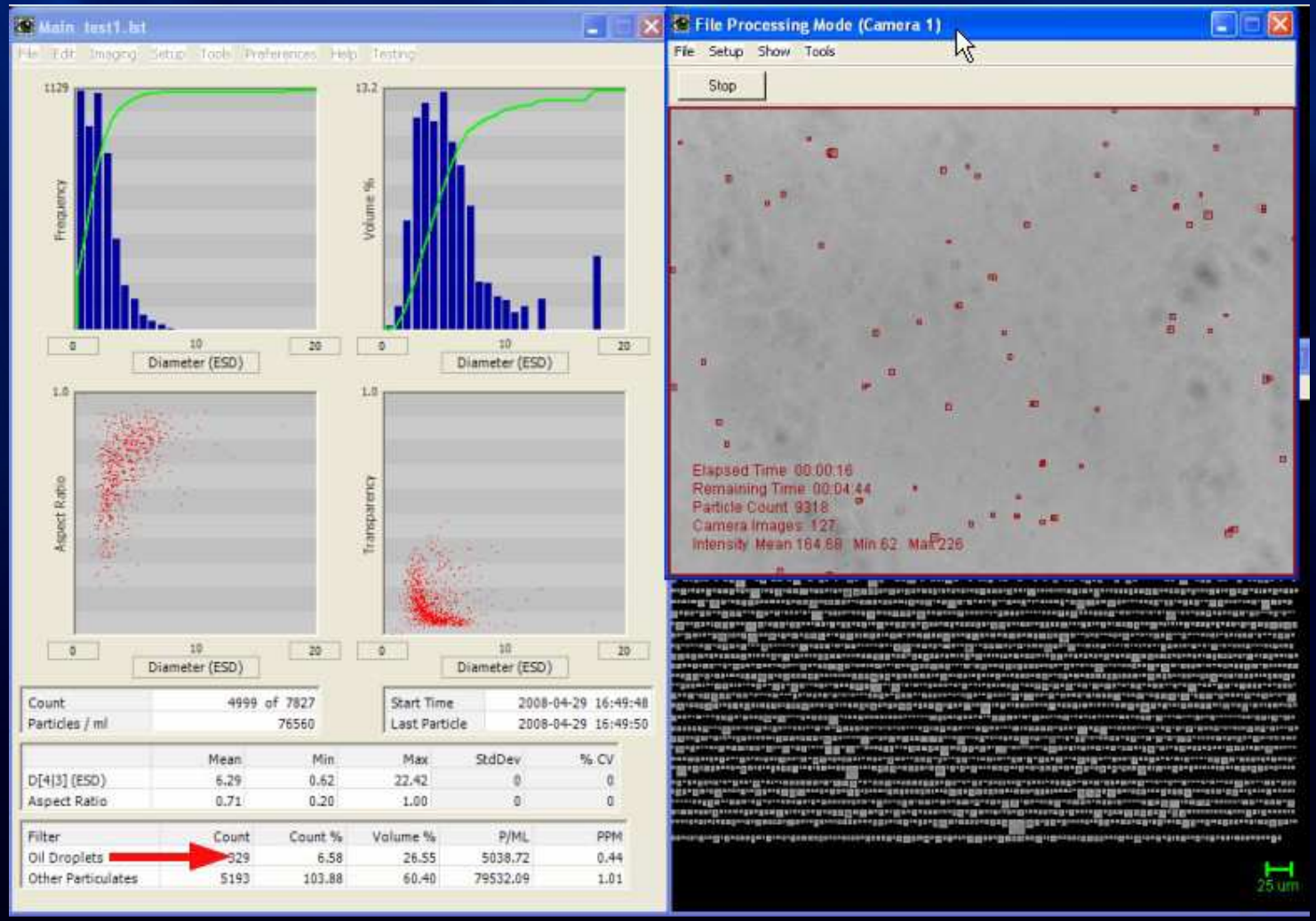
Benchtop

Portable

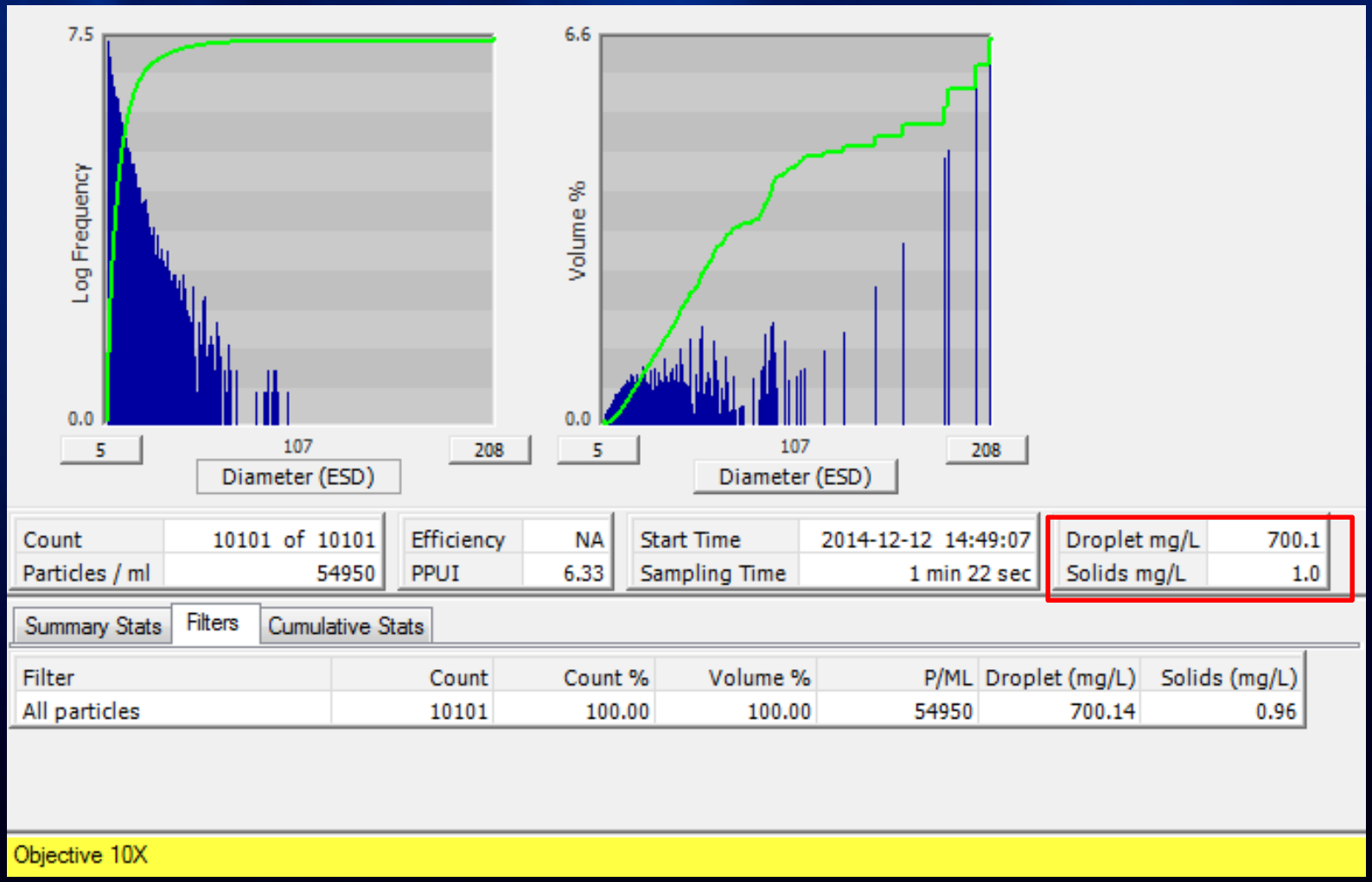
FLUID IMAGING TECHNOLOGIES FlowCAM

How It Works

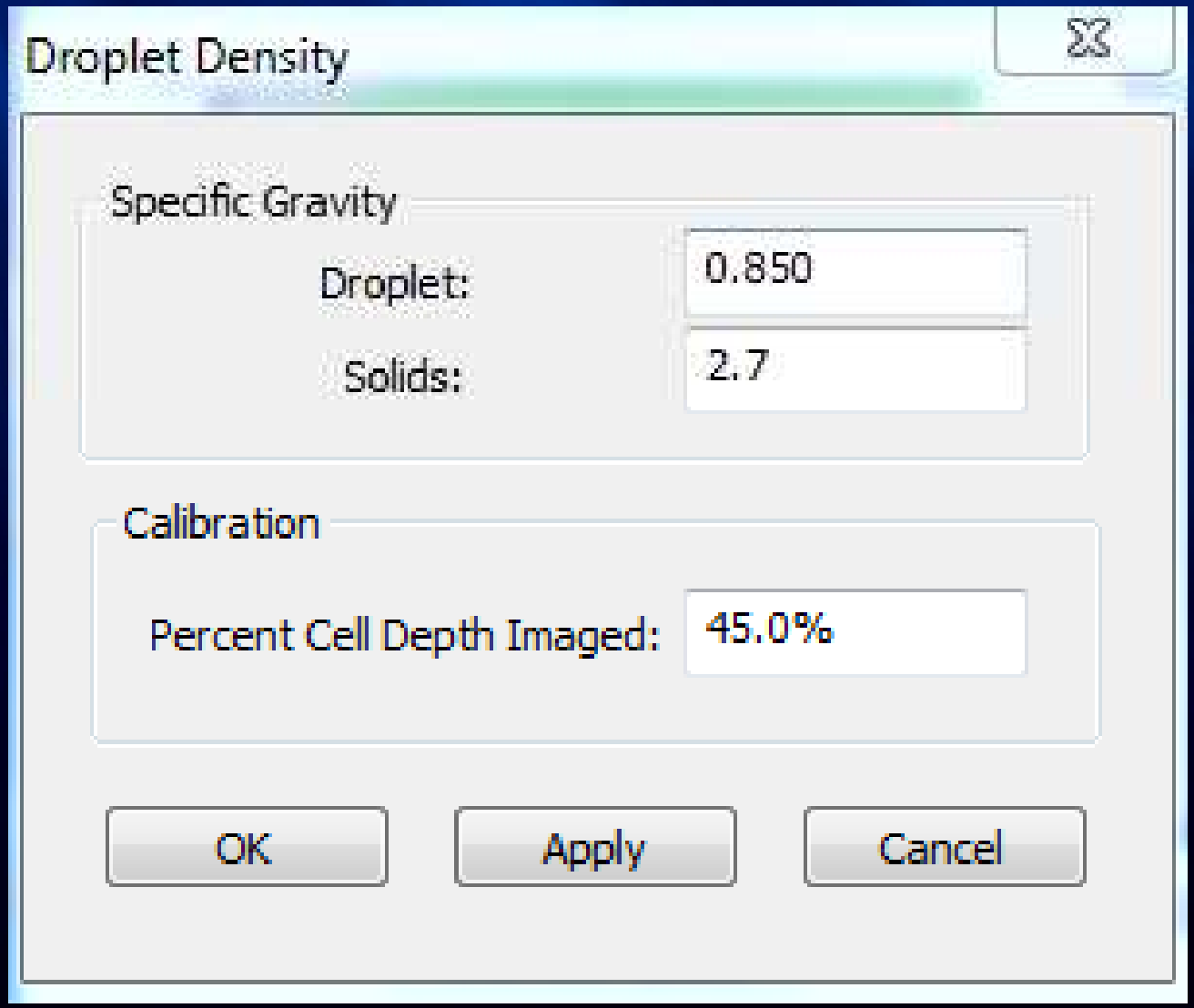
Imaging Mode



Ideal Case
Just Oil in Water

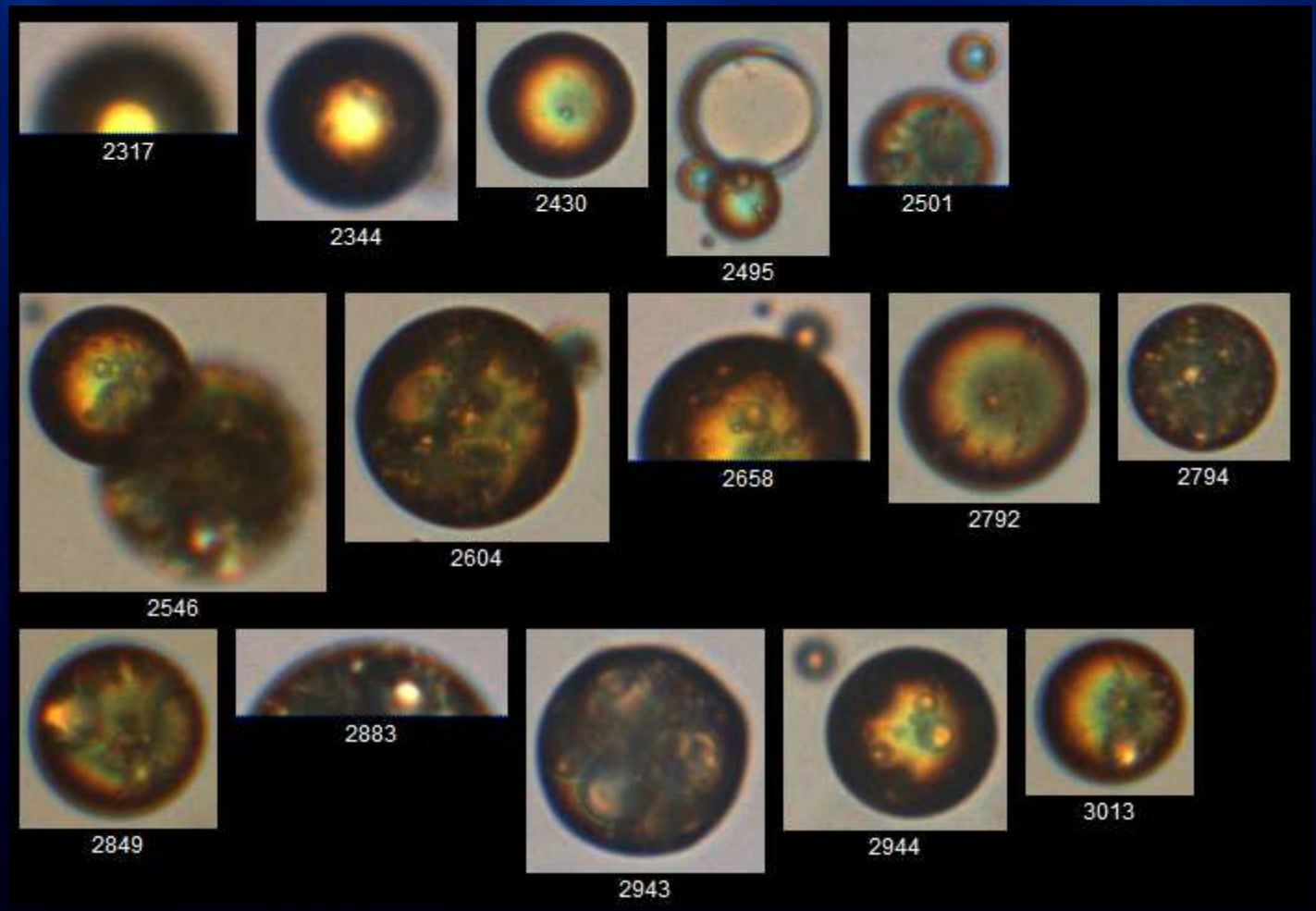


Set Droplet & Solids Densities



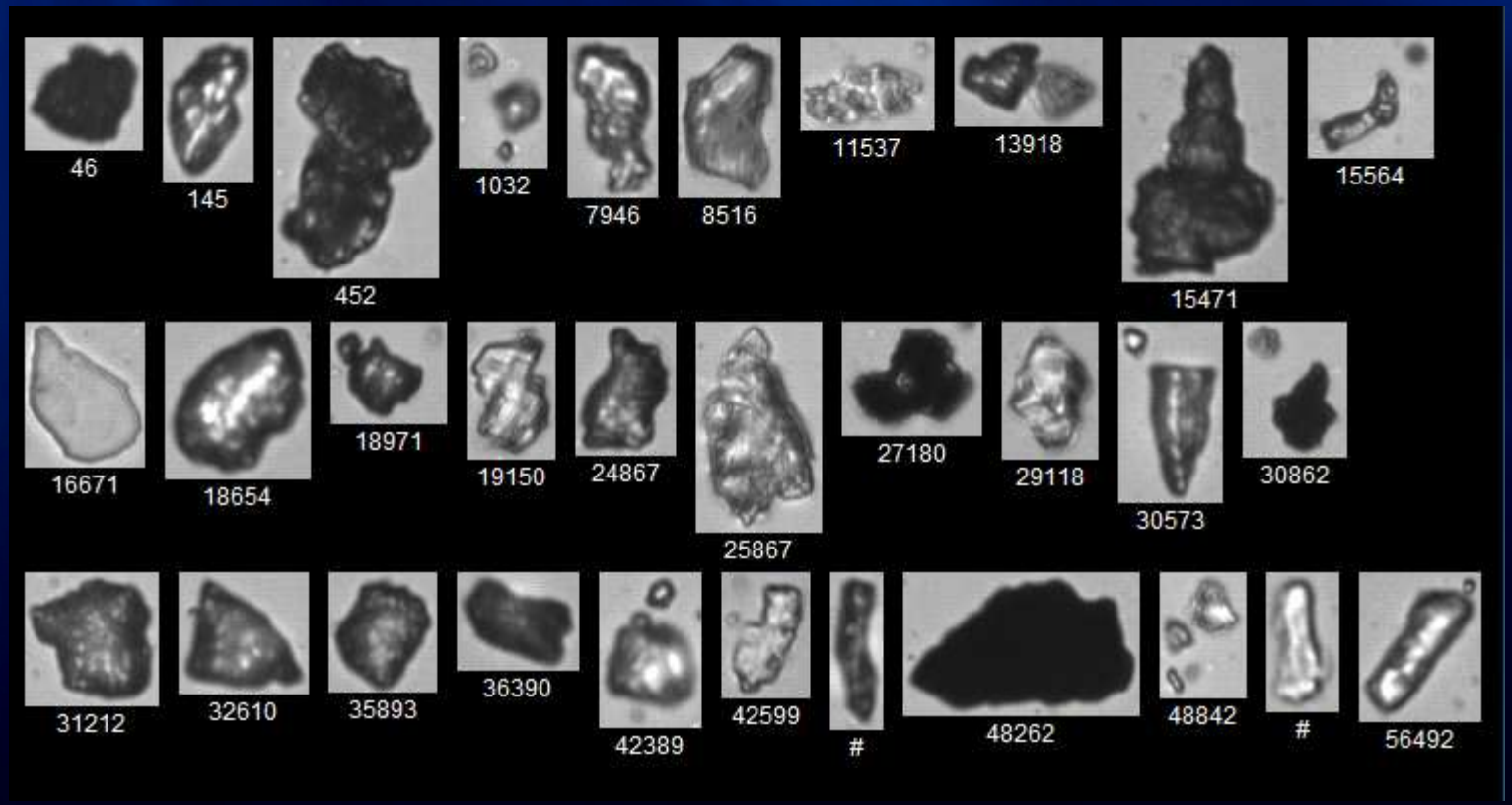
Ideal Case

Only Oil Droplets in Water

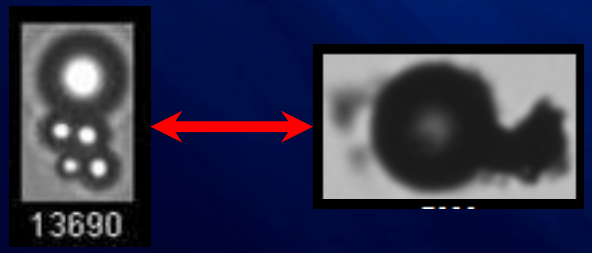


Real Case Has Solids

Need to Handle Solids Too



But What About Agglomerated Oil Droplets?

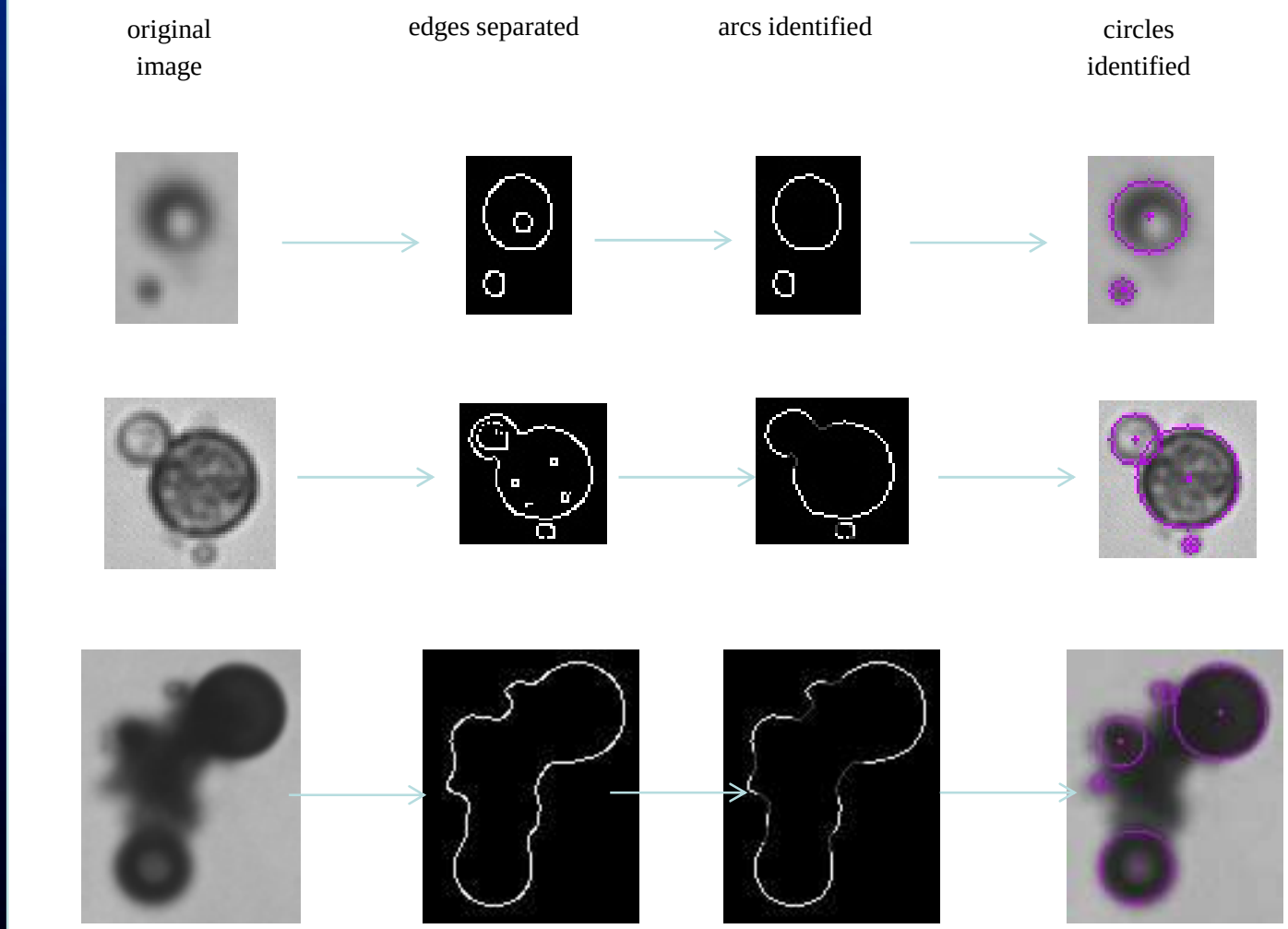


Oil Droplets Can Also Adhere to Solids or to Each Other

How to Handle Agglomerated Oil Droplets

- **Methodology Used:**
  1. **Detect Full Particle Image**
  2. **Detect Edges on Image**
  3. **Identify Circular Arcs**
  4. **Fit Circles to Arcs**
  5. **Calculate Spherical Volume of Each Circle**
  6. **Left over material is TSS**

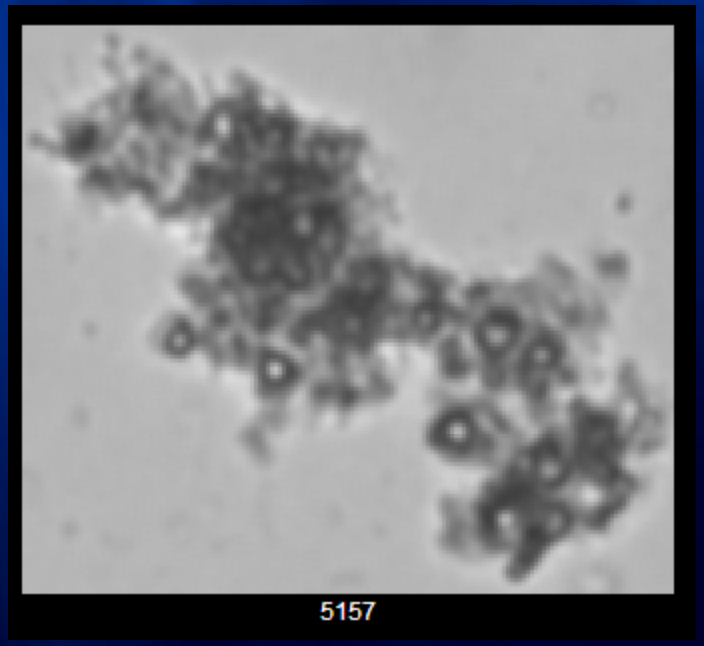
Example of Method



Example: Single Droplet

Sphere Complement	0.00
Sphere Count	1
Sphere Volume	4200.11

Example: Oil Agglomerate

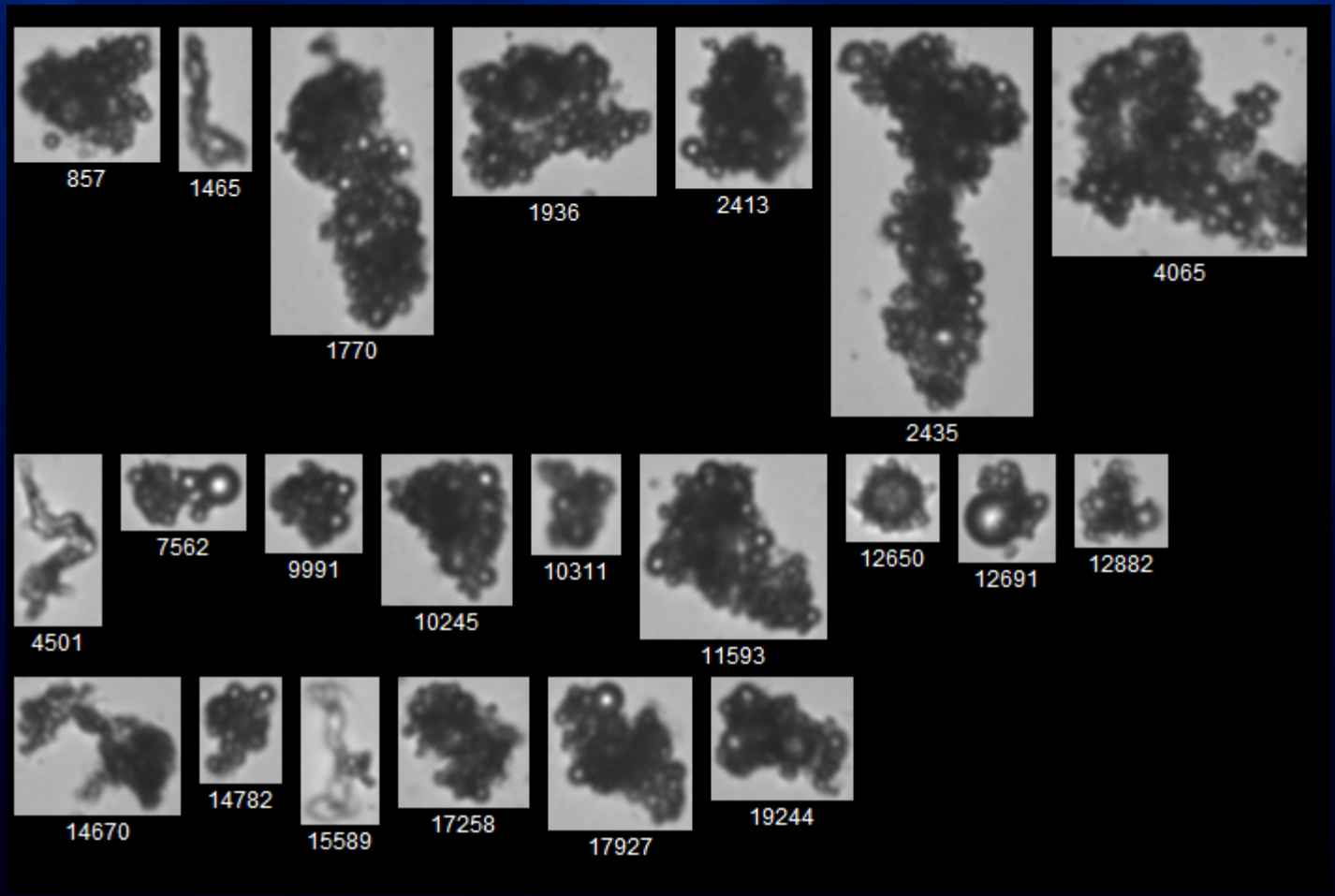


Sphere Complement	1196.47
Sphere Count	14
Sphere Volume	743.12

Texas A&M
Tishomingo Field Study

- Raw Water Feed
- Highly Agglomerated
- Average of Three Runs

Texas A&M
Tishomingo Field Study



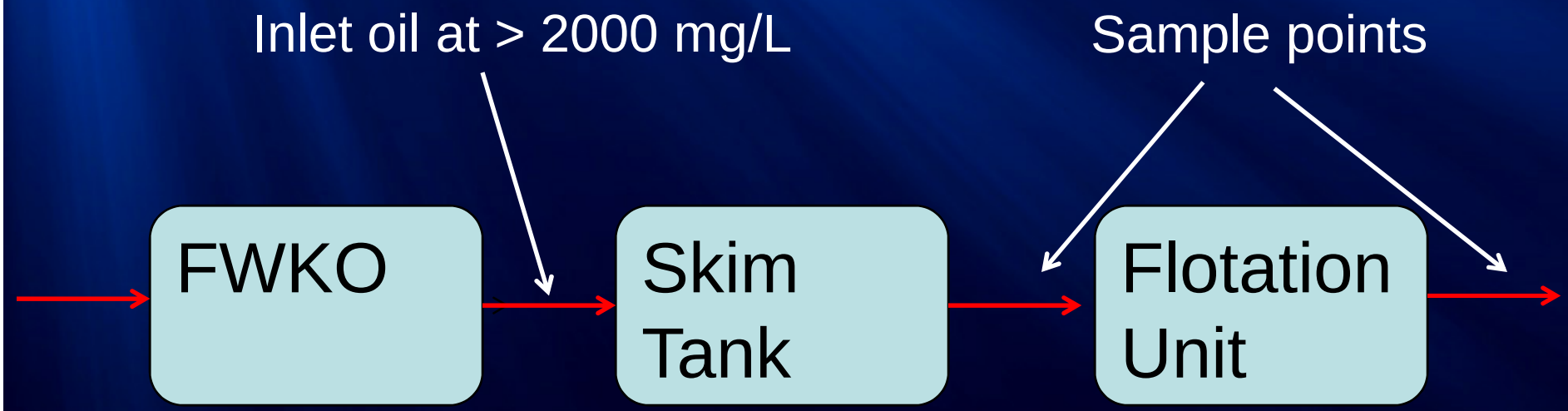
Texas A&M
Tishomingo Field Study

- FlowCAM
  - 25 mg/L oil
- Independent Lab Analysis
  - 35 mg/L oil

Canada
Heavy Oil Field Study

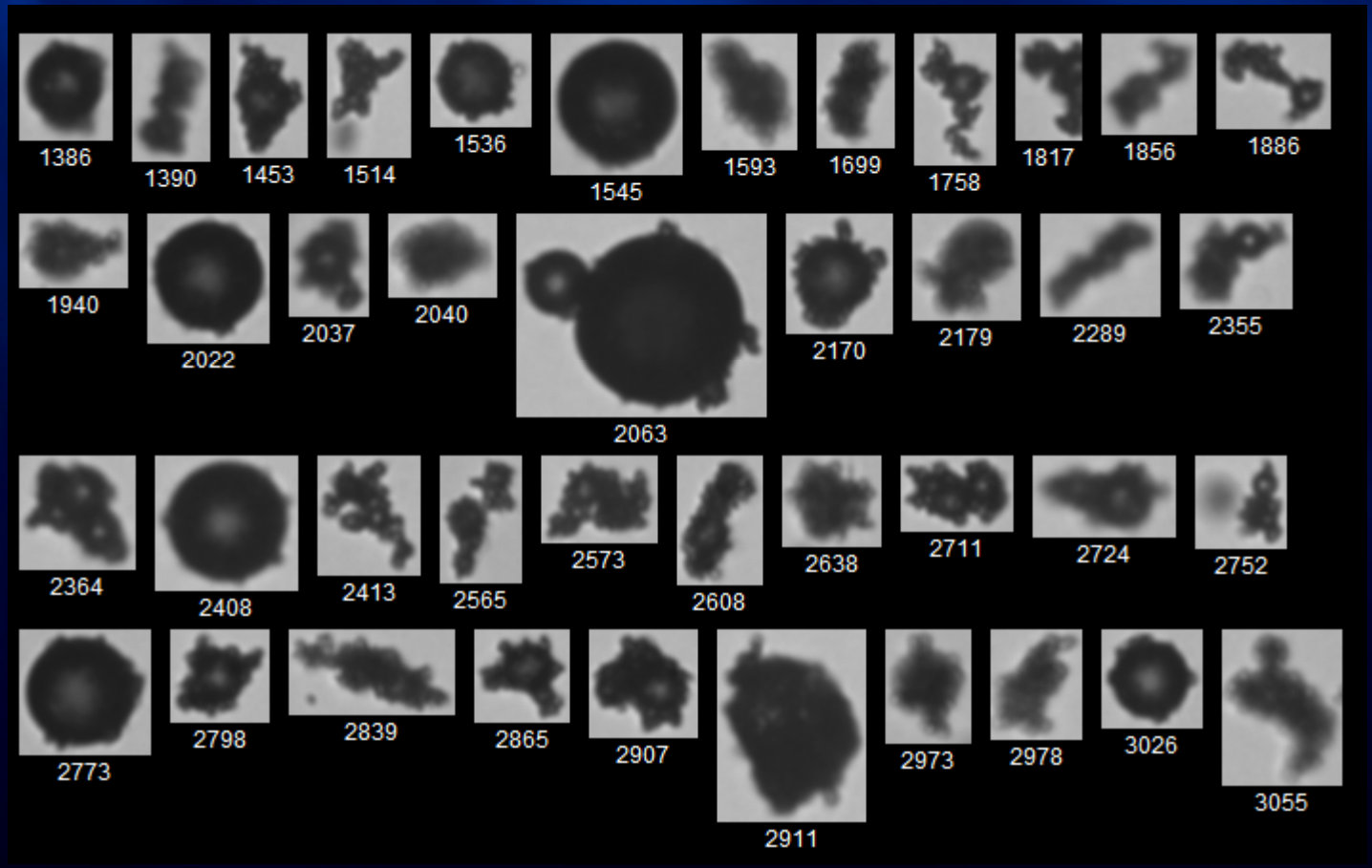
- Evaluated Thee Production Areas
- Highly Agglomerated
- Average of Three Runs
- Compared to UV Methods

Production Pads #1 & #2



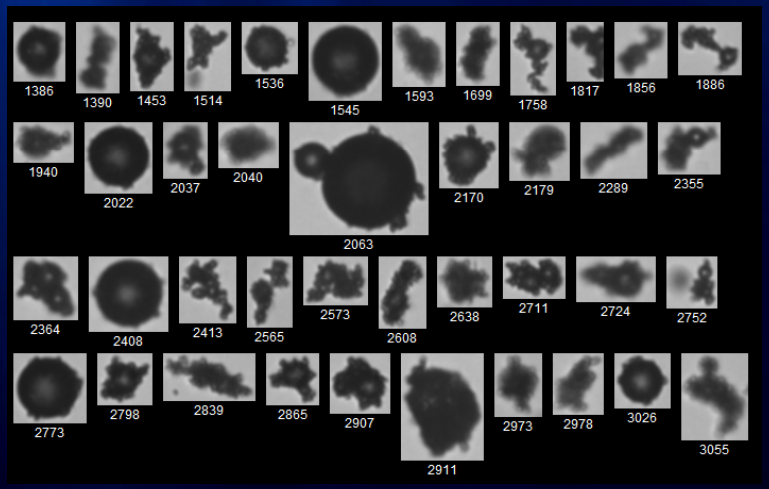
Production Pad #1

Skim Tank Outlet



37,000 p/ml

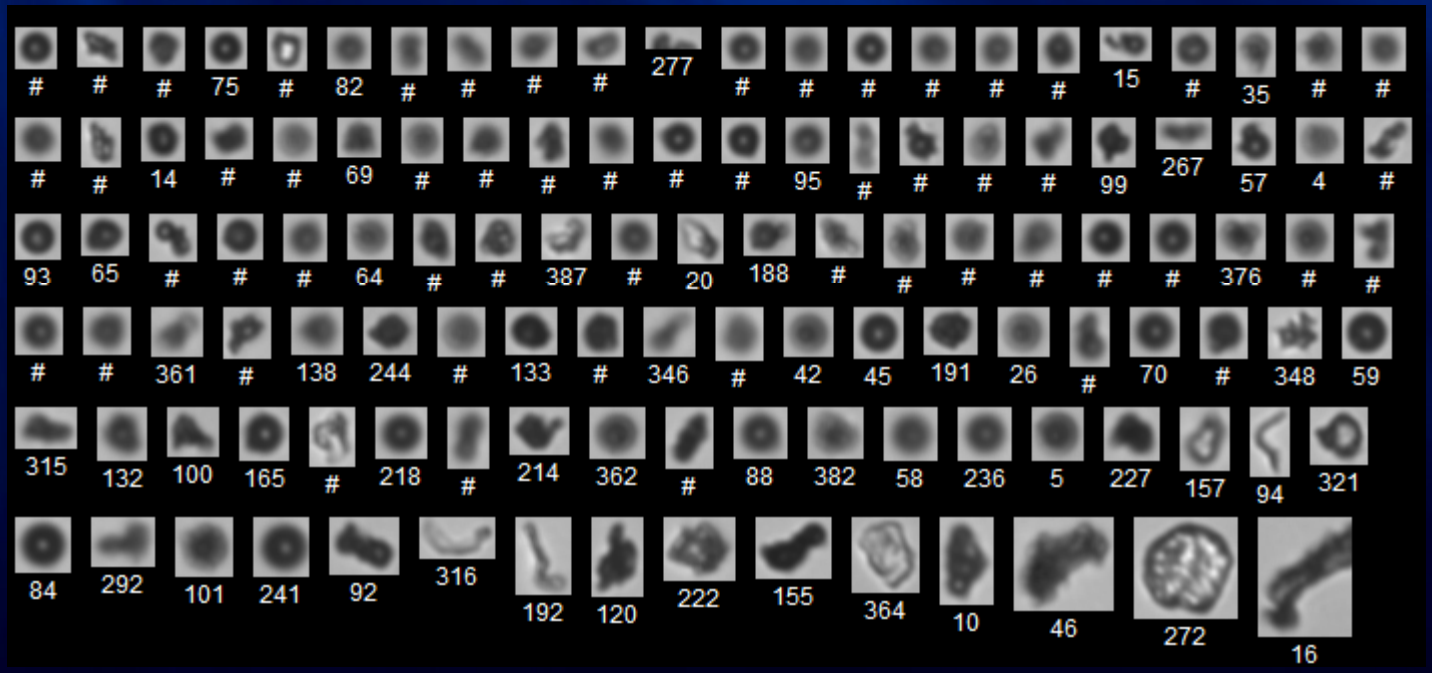
Production Pad #1
Skim Tank Outlet



- FlowCAM
  - Oil – 9 mg/L
- UV Oil
  - 20 mg/L

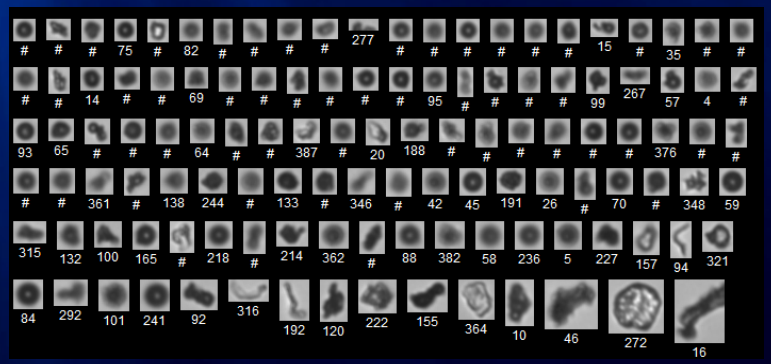
Production Pad #1

Flotation Unit Outlet



1,600 p/ml

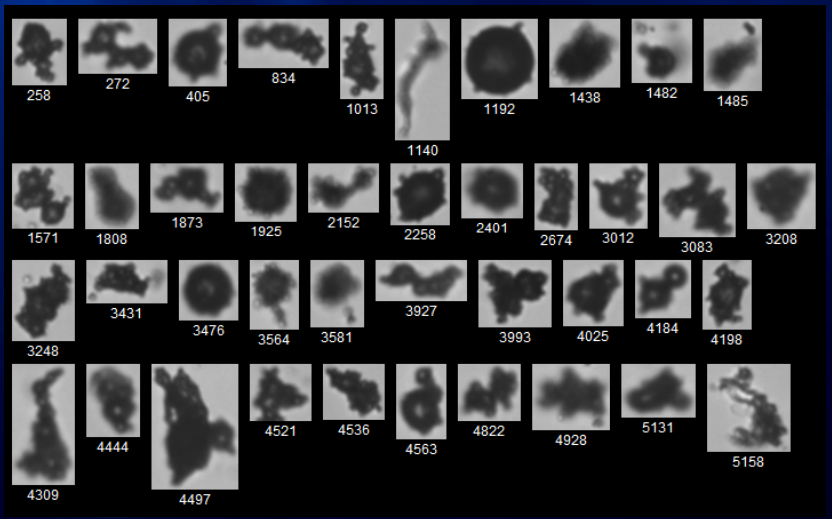
Production Pad #1
Flotation Unit Outlet



- FlowCAM
  - Oil – 0.6 mg/L
- UV Oil
  - 1.7 mg/L

Production Pad #2

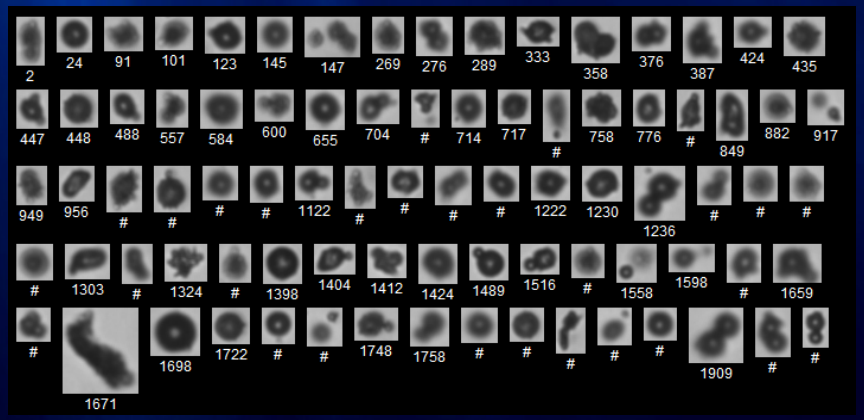
Skim Tank Outlet



- FlowCAM
  - Oil – 17 mg/L
- UV Oil
  - 7 mg/L

45,000 p/ml
15 um D50

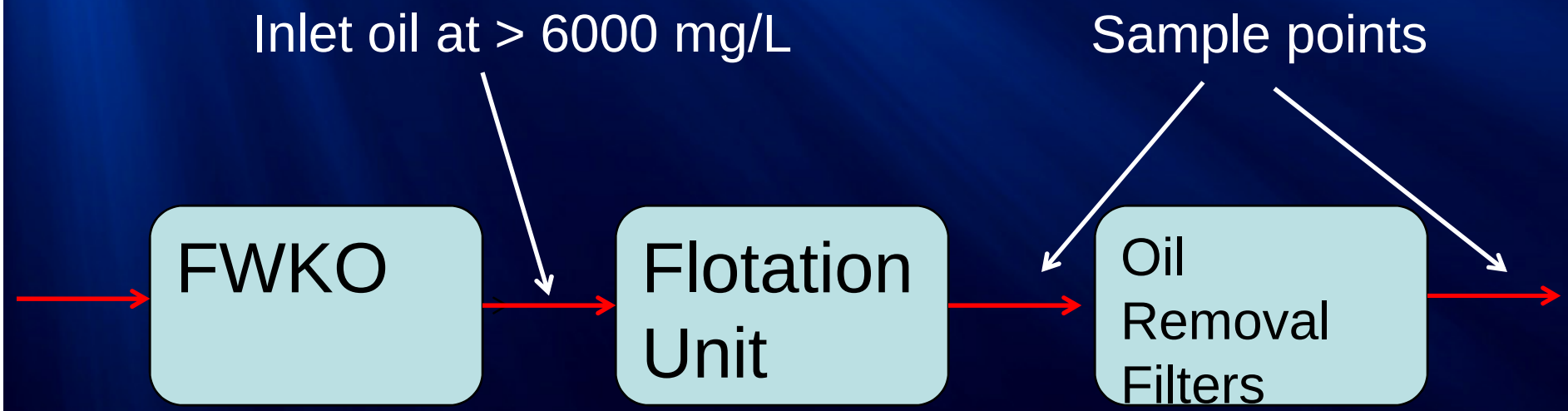
Production Pad #2
Flotation Unit Outlet



- FlowCAM
  - Oil – 3 mg/L
- UV Oil
  - 3.5 mg/L

18,000 p/ml
8.4 um D50

Production Pad #3

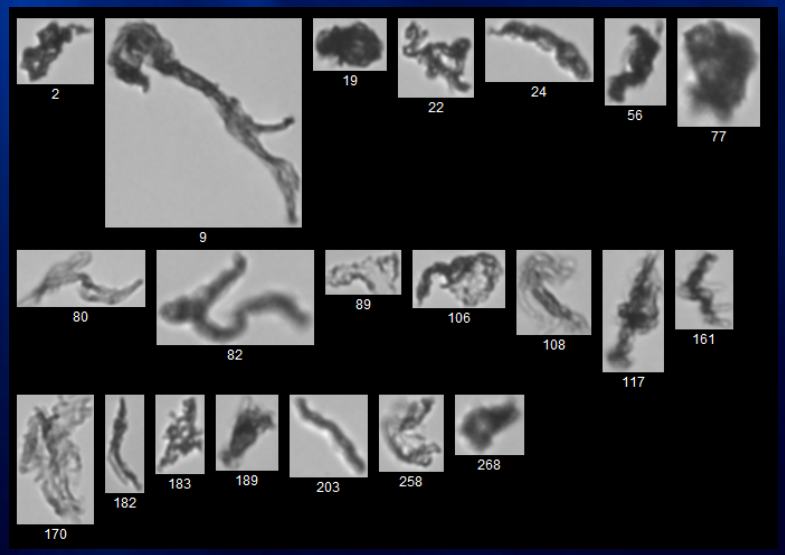


Production Pad #3
Flotation Unit Outlet

- FlowCAM
  - Oil – 1.5 mg/L
- UV Oil –
  - 5 mg/L

3,900 p/ml
40 um D50

Production Pad #3
Filter Unit Outlet



800 p/ml
40 um D50

- **FlowCAM**
  - **Oil – 0.6 mg/L**
- **UV Oil**
  - **5.6 mg/L**

Limitations of FlowCam Method

- Look at droplets down to 5 um
- Works best on suspended oil droplets rather than on globs of free oil where sample is not so saturated that oil droplets are clearly visible
- Can be used for oil in water or water in oil

Questions?

Thank You!

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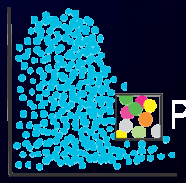

Particle Analysis with Vision©

FLUID IMAGING TECHNOLOGIES FlowCAM