Oil Flow Rate Analysis

Deepwater Horizons Accident

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Introduction

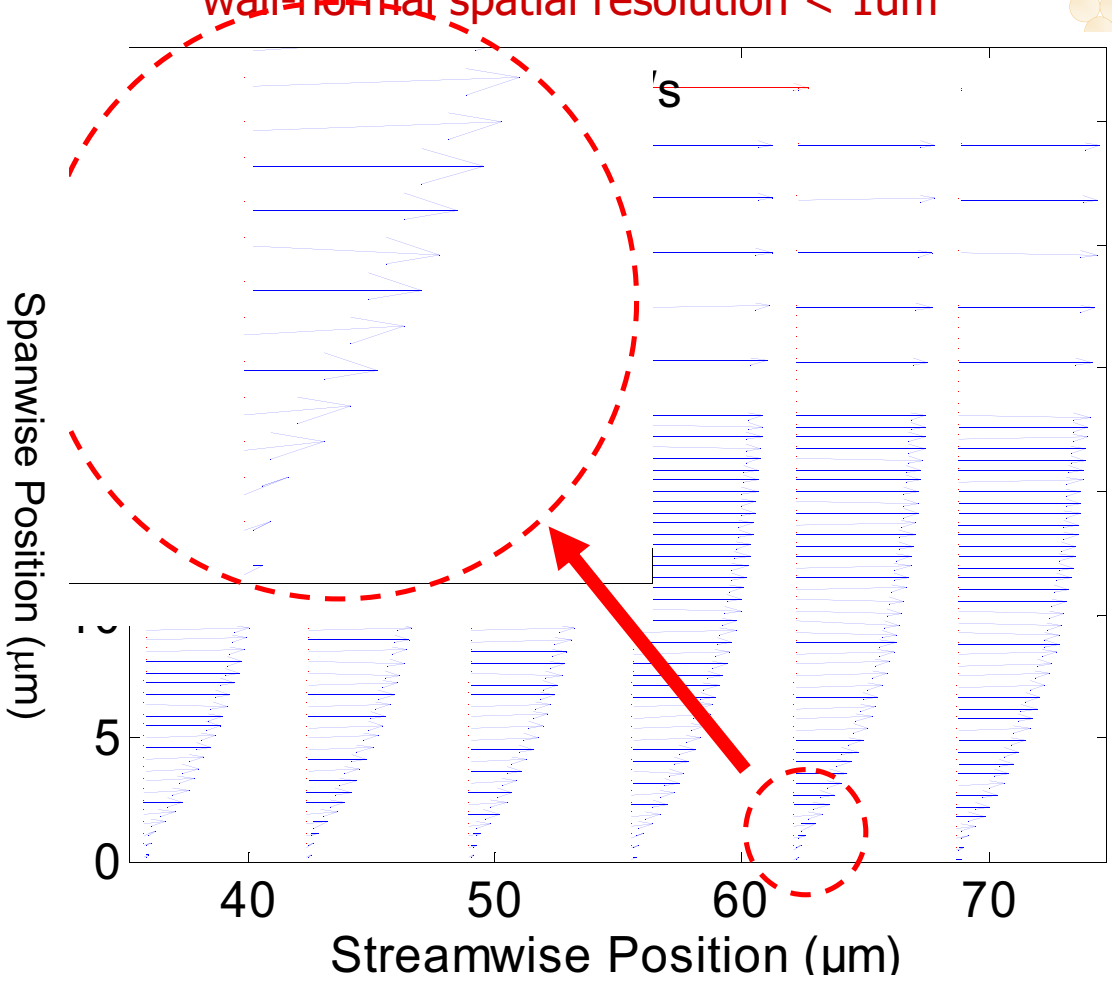
- My background
  - "wrote the book" on optical flow measurement
  - 18 years experience in flow measurement using image analysis
  - No petroleum industry involvement
- My involvement with this emergency
  - On May 13 Michael Harris of NPR informed me of BP's video release showing oil release
  - Analyzed video to compute magnitude of oil release

Flow Measurement

- Flows can be analyzed in a "stand off" manner using image analysis
- One technique called Particle Image Velocimetry (PIV)
  - 25 year history
  - Thousands of practitioners worldwide
- Particles carried by a transparent flow are tracked from frame to frame
  - Statistical methods
  - Accuracies as high as +/- 1%

Microchannel Flow (x-z plane)

wall-normal spatial resolution < 1um



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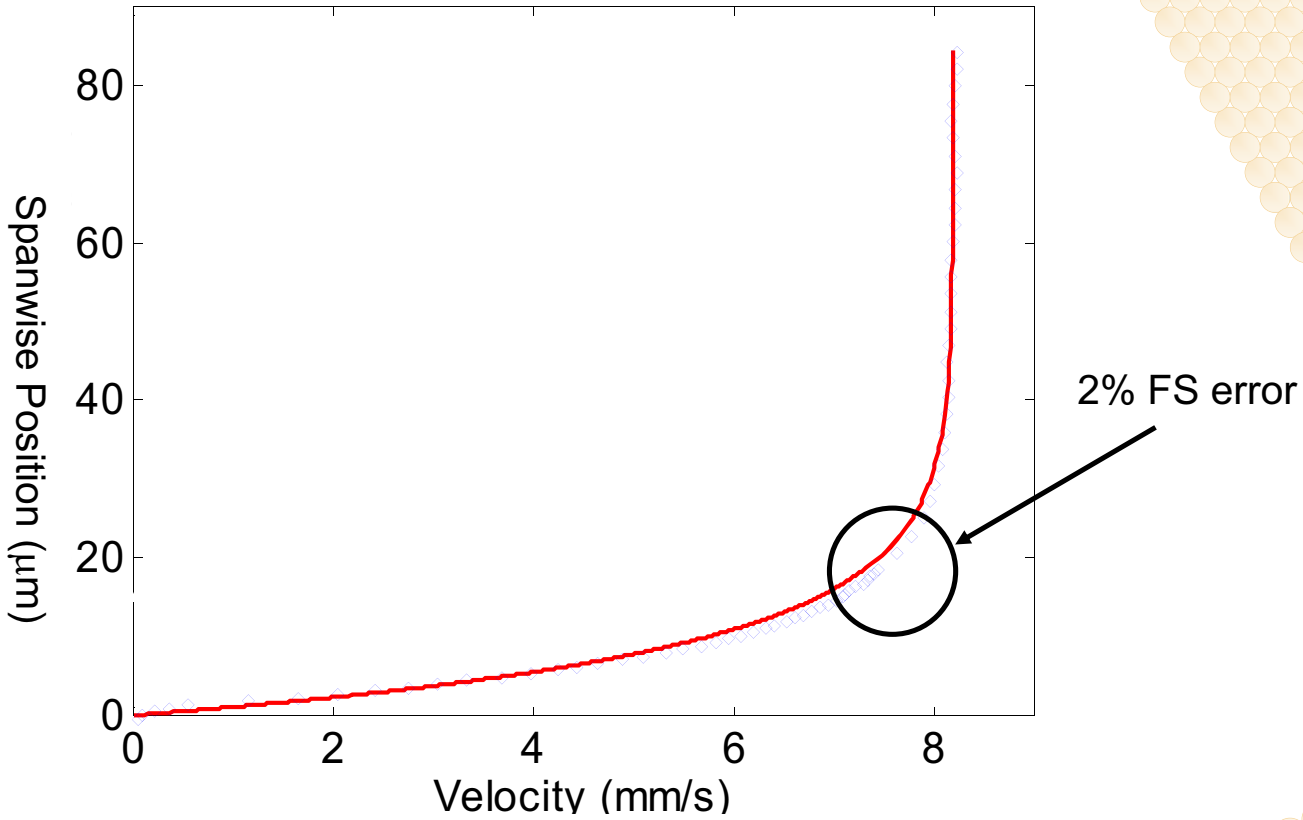
Streamwise Profile (x-z plane)

C.D. Meinhart, S.T. Wereley, and J.G. Santiago, “PIV Measurements of a Microchannel Flow,” Exp. Fluids, Vol. 27, No. 5, 414-419, (1999).



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Oil Leak Rate Prior to RITT

Based on video

"Crater_plume_gassing_11_may_2010_2333"

Manual Feature Tracking

Not rocket science—identify features in the image and see where they go as time elapses

Observed displacement: 11.7 pixels

Computer Analysis (PIV)

Calculated displacement: 10.2 pixels

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Convert to Barrels per Day

- Find average plume velocity

$$10.2\,\frac{pixels}{frame}\times\frac{1\,frame}{0.067\,sec}\times\frac{21in}{124pixels}=25.8\,\frac{in}{sec}$$

- Multiply by cross-sectional area to find volume flow rate

$$25.8\,\frac{in}{sec}\times\frac{\pi}{4}\times(20in)^2=8105\,\frac{in^3}{sec}$$

- Convert to barrels per day

$$8105\,\frac{in^3}{sec}\times\frac{60\times60\times24sec}{day}\times\frac{1gal}{231in^3}\times\frac{1bbl}{42gal}=72179\,\frac{bbl}{day}$$

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How does this agree with others?

- Surface analysis
  - BP: 5,000 bbl/day
  - MacDonald (FSU): 25,000 bbl/day
- Video analysis
  - Chang (UCB): 20,000-100,000 bbl/day
  - Crone (Columbia): 20,000-100,000 bbl/day
  - Wereley (Purdue): 56,000-84,000 bbl/day
- Comparison
  - All outsider estimates higher than BP's
  - Good overlap among outsider estimates

How can these results be improved?

- More transparency from BP!
  - Measurements, parameters, properties, etc.
- Better quality video
  - Existing videos are compressed screen captures
  - Better videos reduce exp uncertainty
- Long videos to assess Gas/Oil Ratio (GOR)
- BP should have large number of high-quality videos documenting disaster response

Leaks at kink on top of BOP

Manual tracking:
Kink oil flow rate:
25,000 bbl/day
35% of riser flow

1.2 in hole

Leak past RITT

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