Oil Flow Rate Analysis

Deepwater Horizons Accident

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Introduction

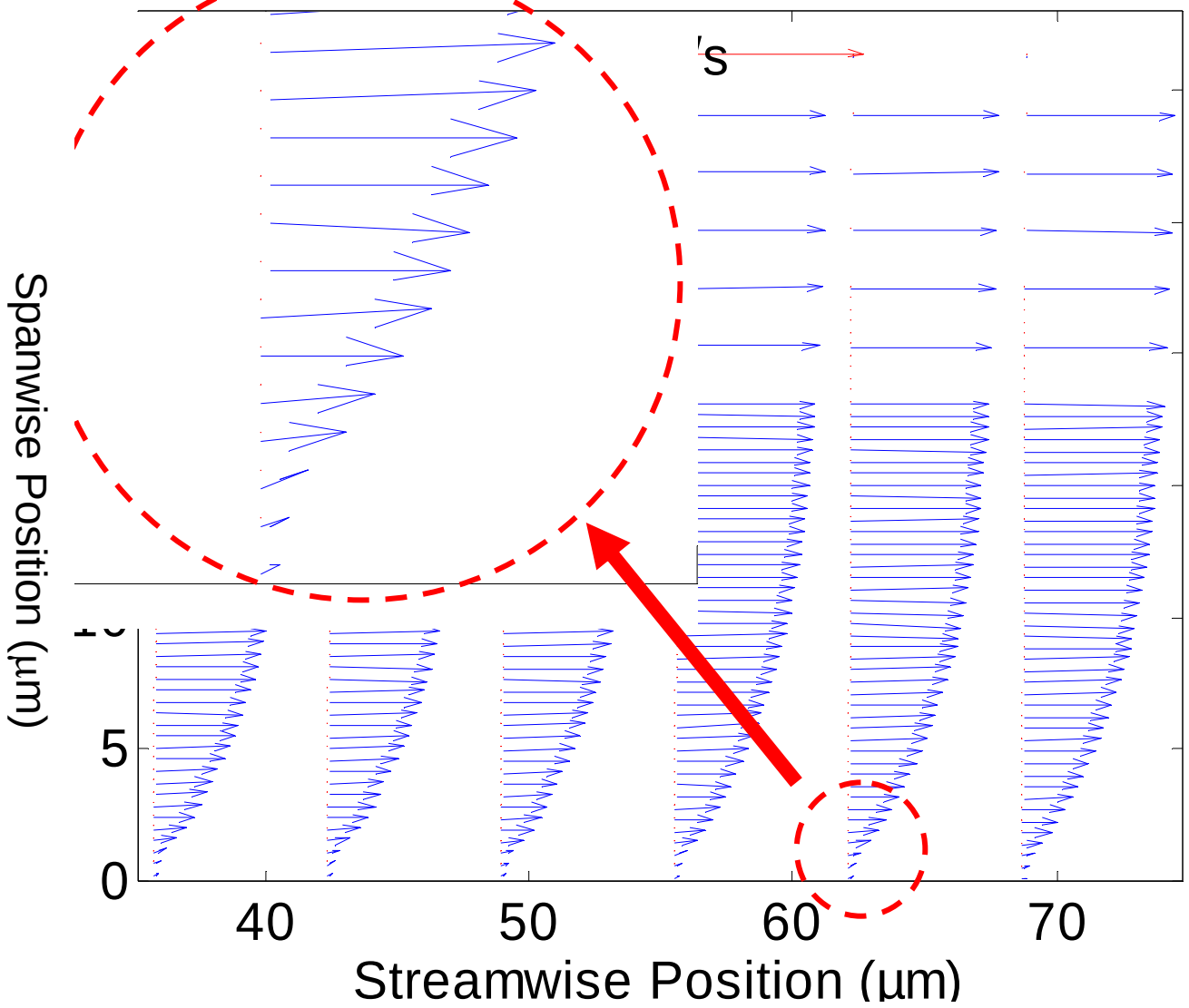
- My background
  - "wrote the book" on optical flow measurement
  - 18 years experience in flow measurement using image analysis
  - No petroleum industry involvement
- My involvement with this emergency
  - On May 13 Michael Harris of NPR informed me of BP's video release showing oil release
  - Analyzed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

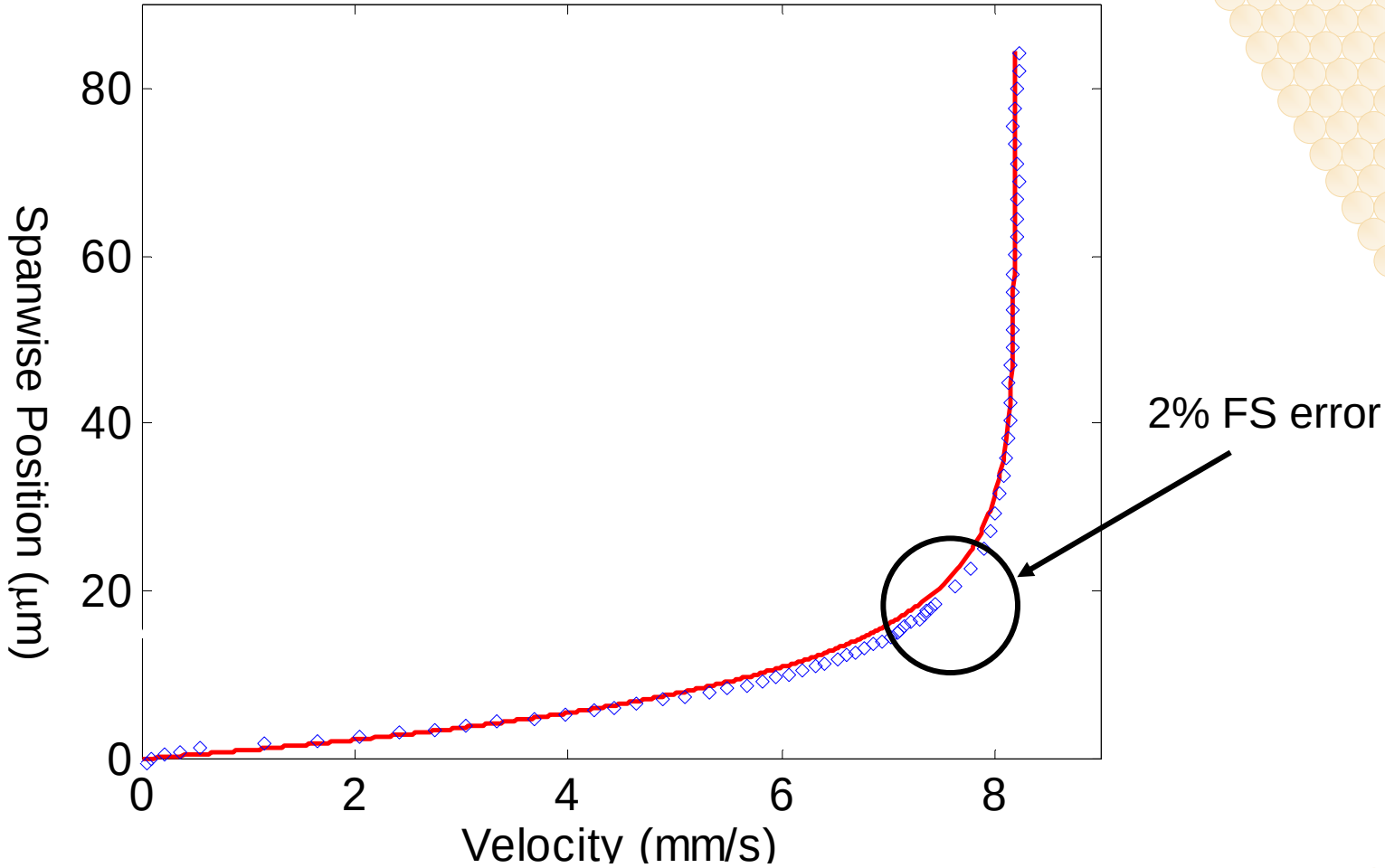
Microchannel Flow (x-z plane)

wall-normal spatial resolution < 1um



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).



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

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Leak past RITT

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