Review of TRDI’s Solutions to Moving Bottom

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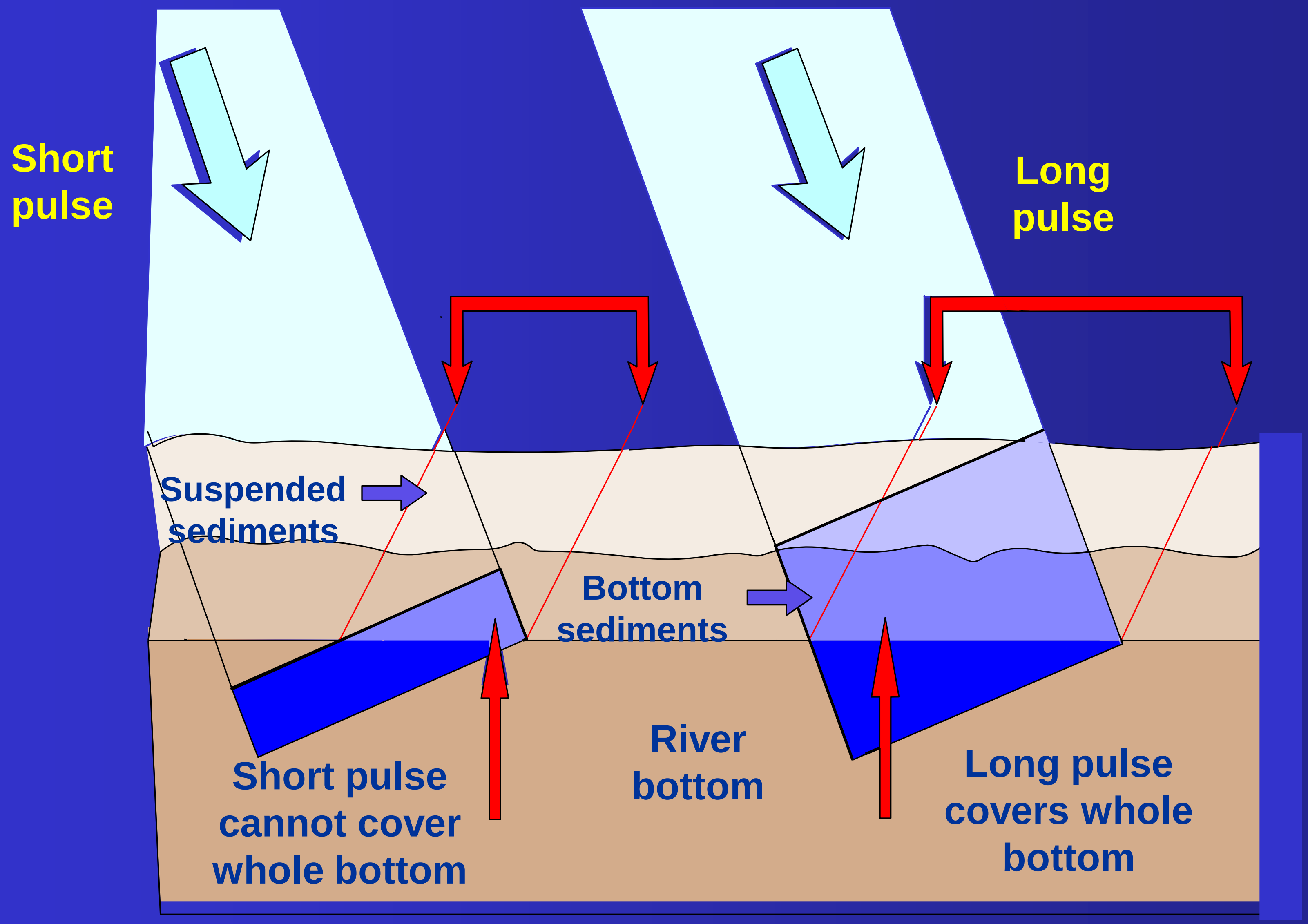
Bottom Tracking Pulses



Bottom Tracking Echo Include

1. Echo from bottom (solids)

2. Echo from bed-load transport (real moving bottom)

3. Near bottom suspended sediments (internally called water bias)

Solutions to Moving Bottom

1. GPS
2. Stationary ADCP method (or called section by section method)
3. Loop method
4. Use low frequency ADCP

1. GPS

Pros

- No bottom tracking needed
- Q measurement track independent

Cons

- GPS cost
- Subject to errors due to:
  - Compass
  - Magnetic variation
  - DGPS Quality
- GPS may not be available at some sites due to near by structures

ADCP-GPS Integration

RiverRay： GPS directly connect to ADCP

- Simple integration on the float
- GPS data are included in the PD0 data file
- GPS data and ADCP data are sychronized well

RiverRay or Rio Grande： Integration through WinRiver II

- Independent GPS data file
- Use GPS time set ADCP clock

RiverRay with a GPS

GPS Models Offered by TRDI

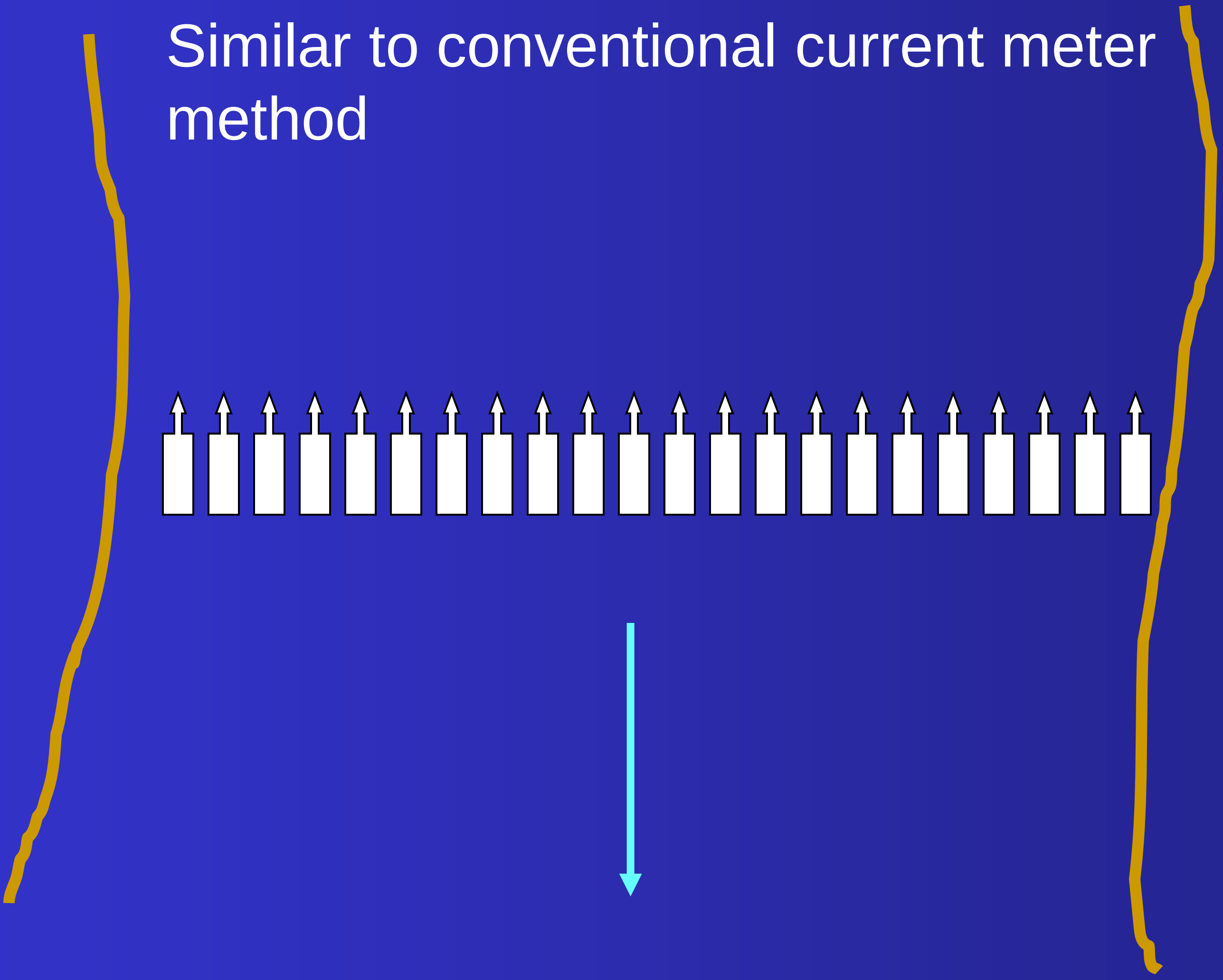
- Hemisphere A101 Smart Antenna DGPS
- Hemisphere A101-RTK DGPS System
- Hemisphere R120 DGPS
- Hemisphere S320 Smart Antenna DGPS
- Hemisphere S320-RTK GPS System

Note 1：Special cable and mounting hardware are required

Note 2：See Hemisphere website：http://www.hemispheregps.com/ for GPS specifications

2. Stationary ADCP Method

Similar to conventional current meter method



Applications：Under Ice, Moving Bottom

Stationary ADCP Method

Pros

- Similar to current meter method
- SxS Pro software
- Software cost only
- Reliable and accurate

Cons

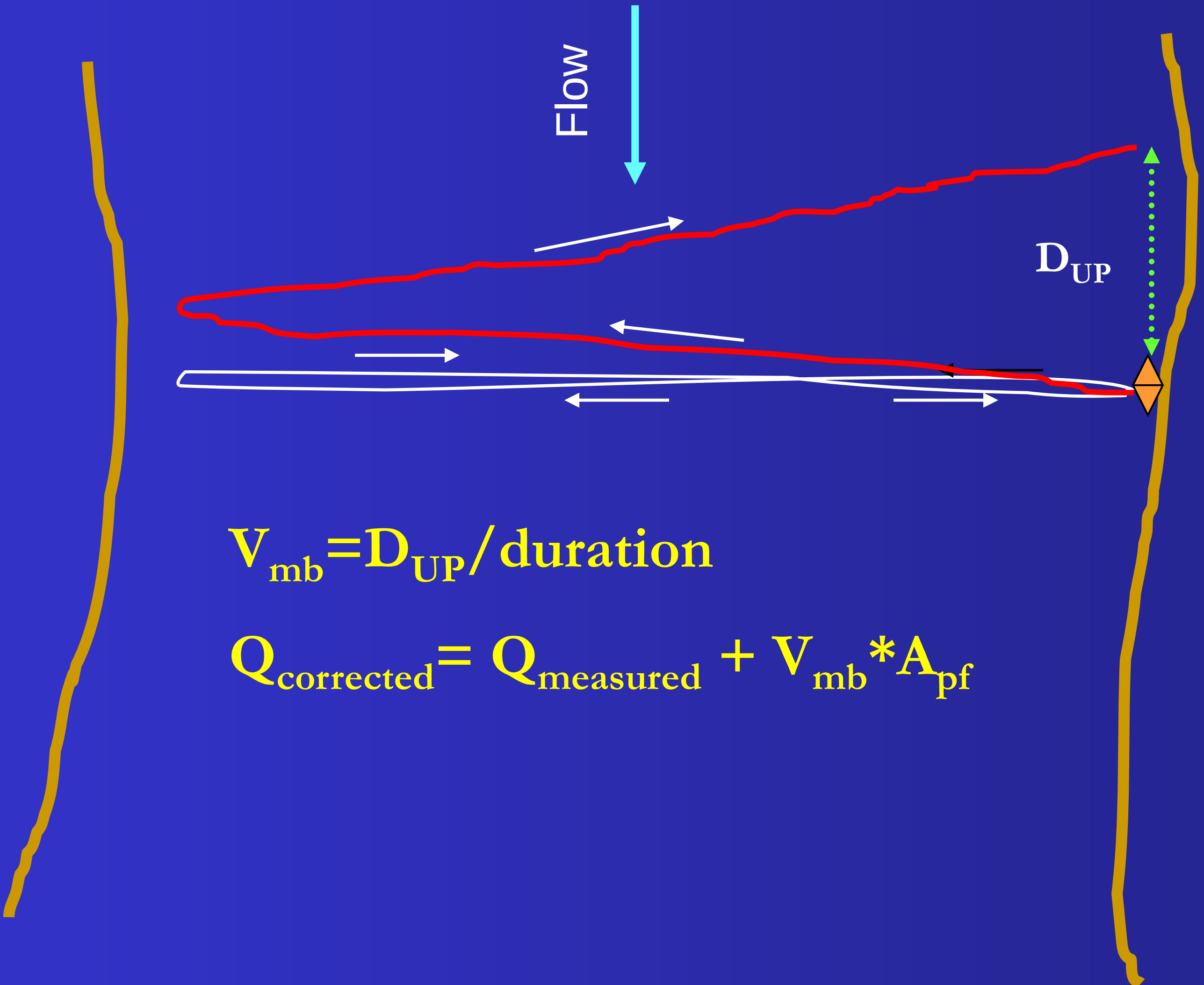
- Manual positioning
- Flow direction correction may required
- Keep ADCP from moving (use a tag line)
- Take a little bit longer time than moving-boat method

SxS Pro Software Features

- Support both mean-section method and mid-section method
- Built-in uncertainty analysis model for measurement quality evaluation and control
- Support various velocity profile models
- User-friendly interface
- Applicable to TRDI's three river ADCP models: "Rio Grande", "RiverRay", and "StreamPro"

SxS Pro Demonstration

3. Loop Method



$$V_{mb} = D_{UP}/\text{duration}$$

$$Q_{corrected} = Q_{measured} + V_{mb} * A_{pf}$$

Loop Method

Pros

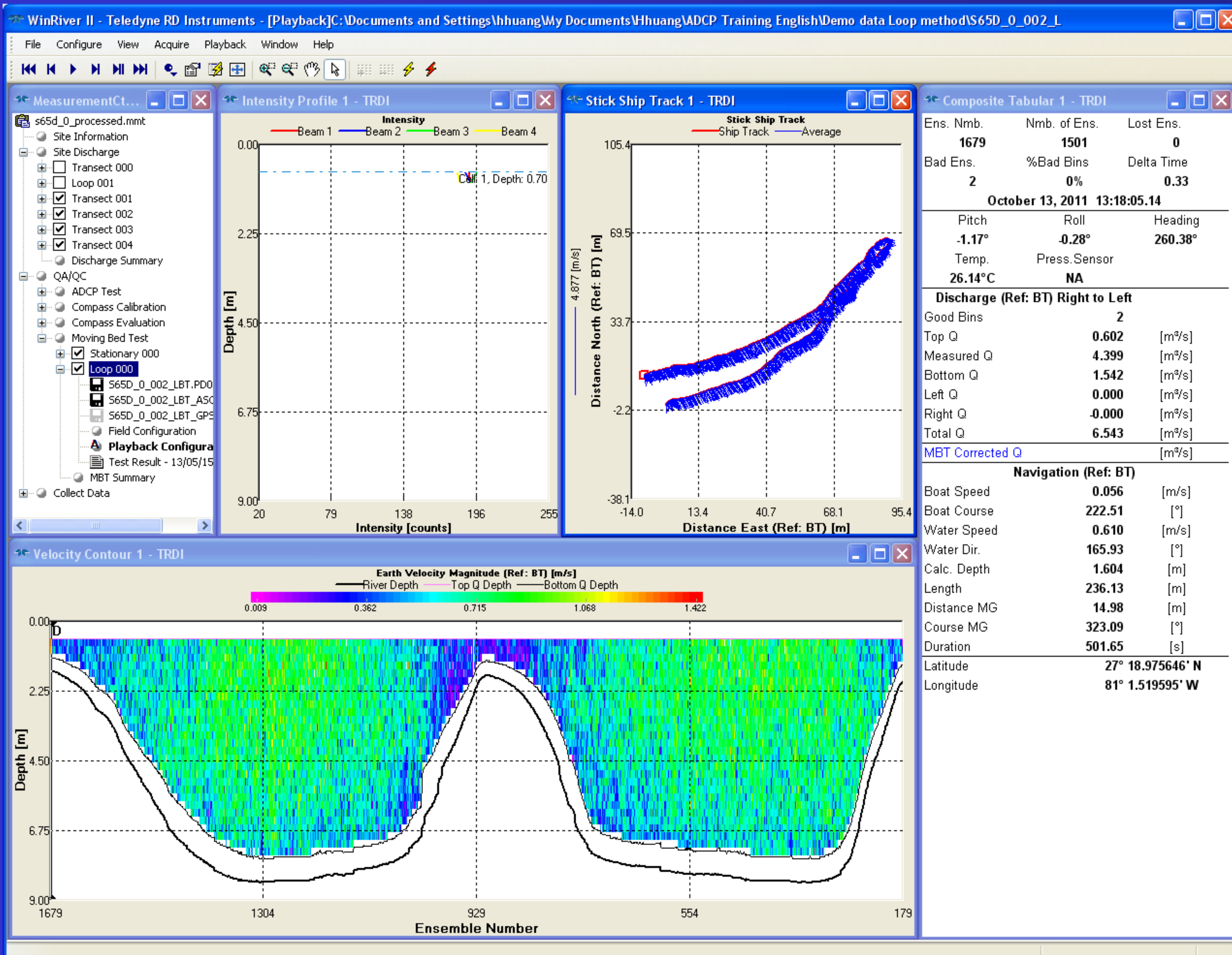
- Easy to use
- Built-in WinRiver II
- No additional cost

Cons

- Start and end points must be the same
- Compass must be calibrated
- Bottom tracking must work (no data loss)
- Steady boat speed

Reference:
Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport
David S. Mueller and Chad R. Wagner, *Journal of Hydraulic Engineering, December 2007. http://il.water.usgs.gov/adcp/*

Loop method example:　Loop 000

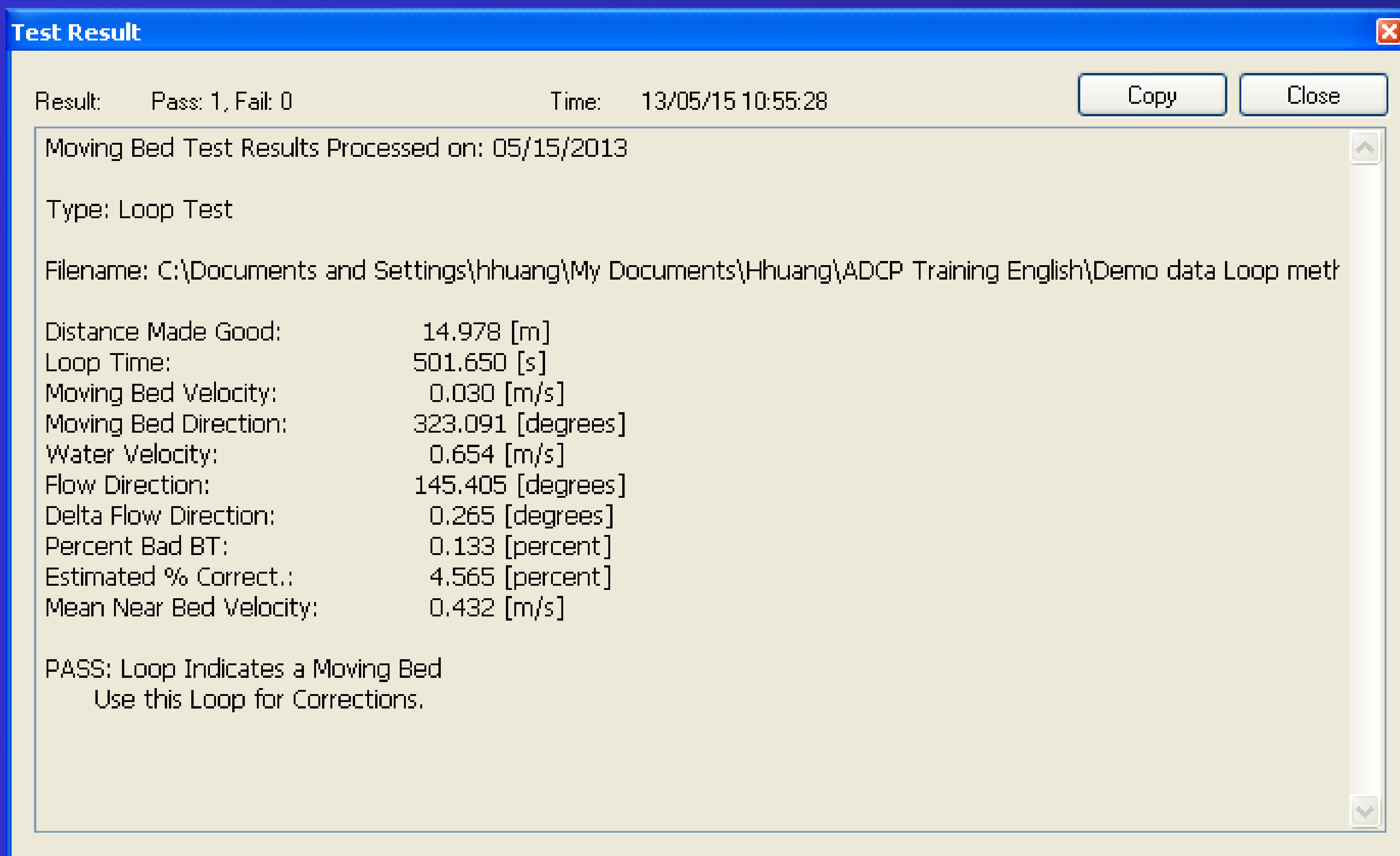


Loop 000 Summary report

Duration： 501.65s

Distance made good: 14.978m

V_{mb}=0.03m/s



Corrections using Loop 000 results

- TRDI

Selected MB Tests

MB Test	Used in Correction	Distance US/MG m	Duration s	MB Vel m/s	MB Dir °	Water Vel m/s	Flow Dir °	Diff in Flow Dir °	Average Depth m	% Bad Bottom Track	Potential MB Error %
Loop 000	**YES**	**14.978**	**501.65**	**0.030**	**323.09**	**0.654**	**145.41**	**0.27**		**0.13**	**4.56**
Loop 001	**NO**	**6.322**	**545.91**	**0.012**	**345.46**	**0.652**	**100.43**	**1.67**		**0.12**	**1.78**
Stat. 000	**NO**	**27.581**	**621.13**	**0.044**	**296.32**	**0.793**			**8.40**	**0.05**	**5.59**

Applied Corrections

Transect ID	Bottom-Track Discharge m³/s	MB Corrected Discharge m³/s	Correction Difference %	Correction Type	Average MB Velocity m/s
001	**508.284**	**535.750**	**5.40**	**Distributed**	**0.030**
002	**509.796**	**536.643**	**5.27**	**Distributed**	**0.030**
003	**506.863**	**532.495**	**5.06**	**Distributed**	**0.030**
004	**515.434**	**540.962**	**4.95**	**Distributed**	**0.030**
平均	**510.094**	**536.462**	**5.17**	**Distributed**	**0.030**

4. Low Frequency ADCP

Pros

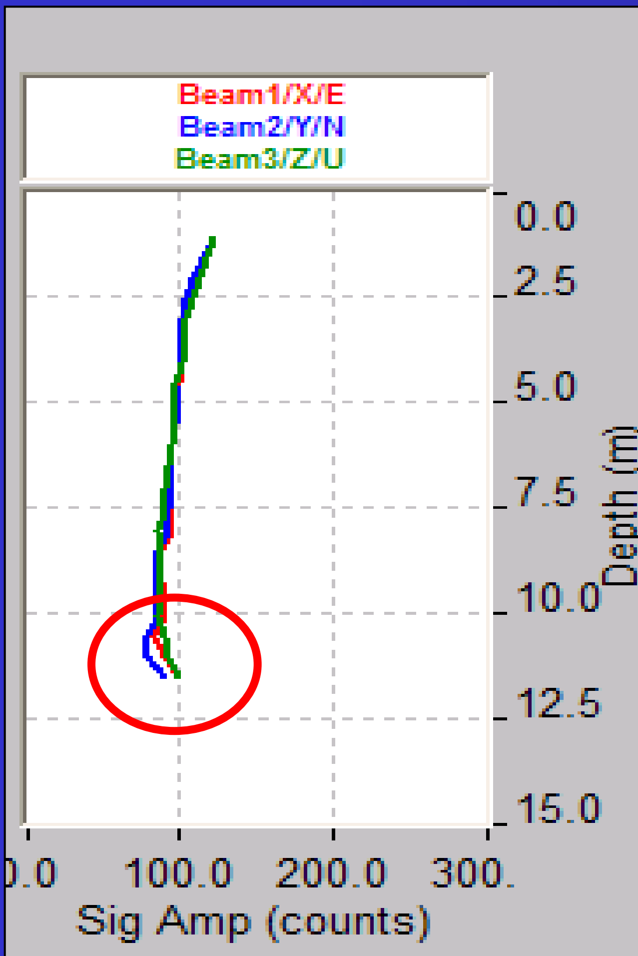
- More reliable bottom tracking
- less sensitive to solids concentration
- No additional cost
- Q measurement track independent

Cons

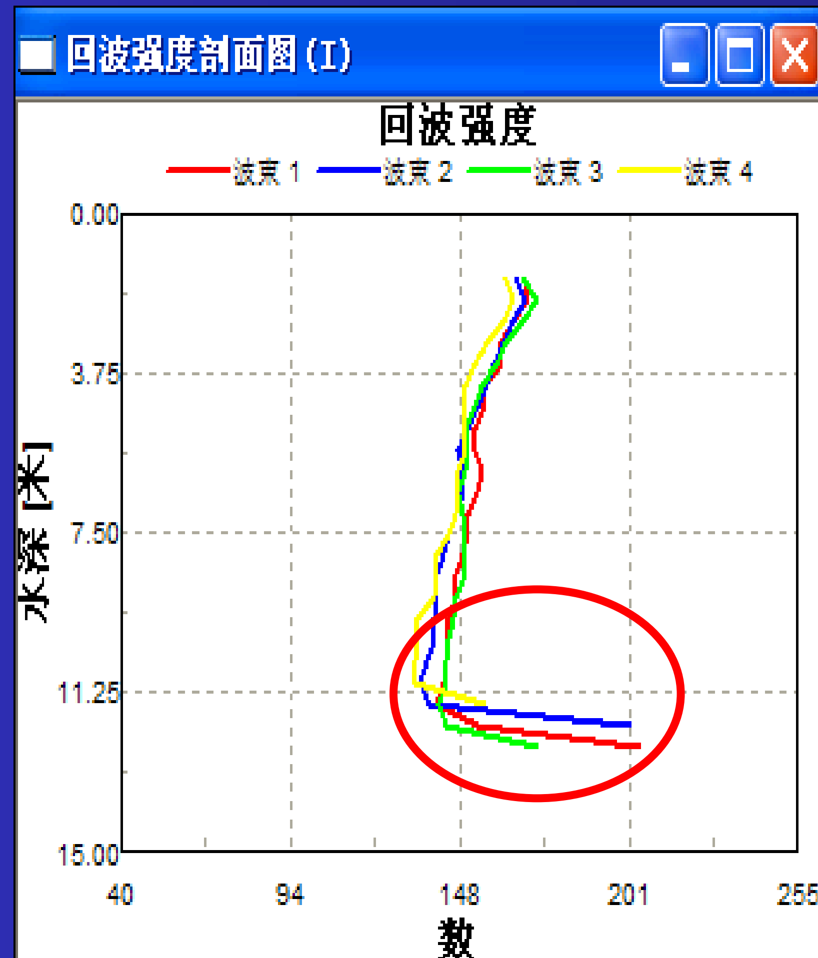
- Lower resolution and precision

Echo Intensity Comparison

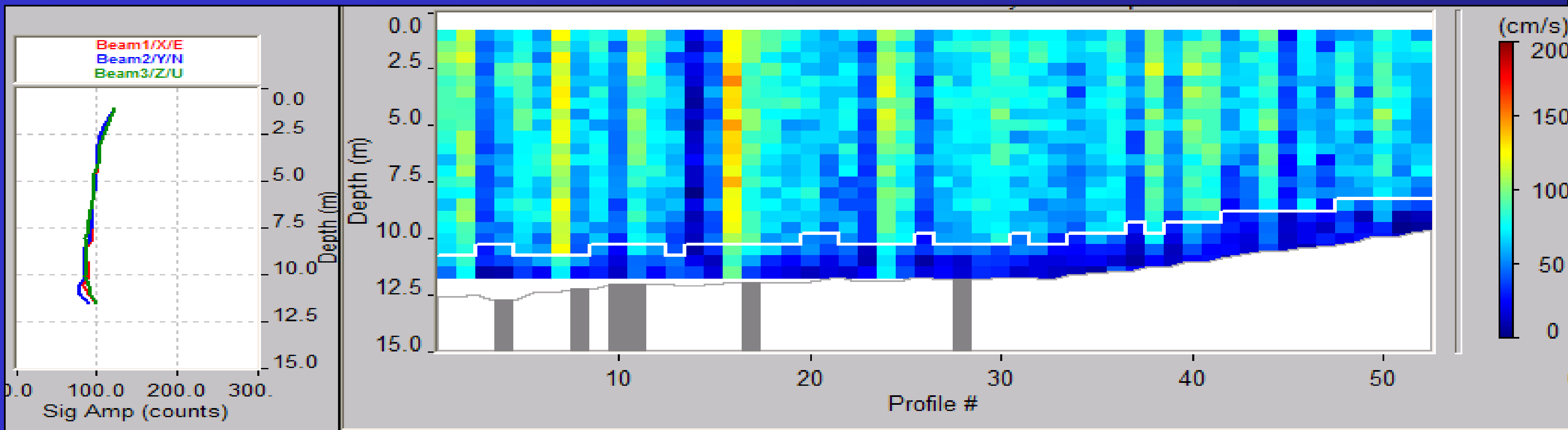
High frequency ADCP



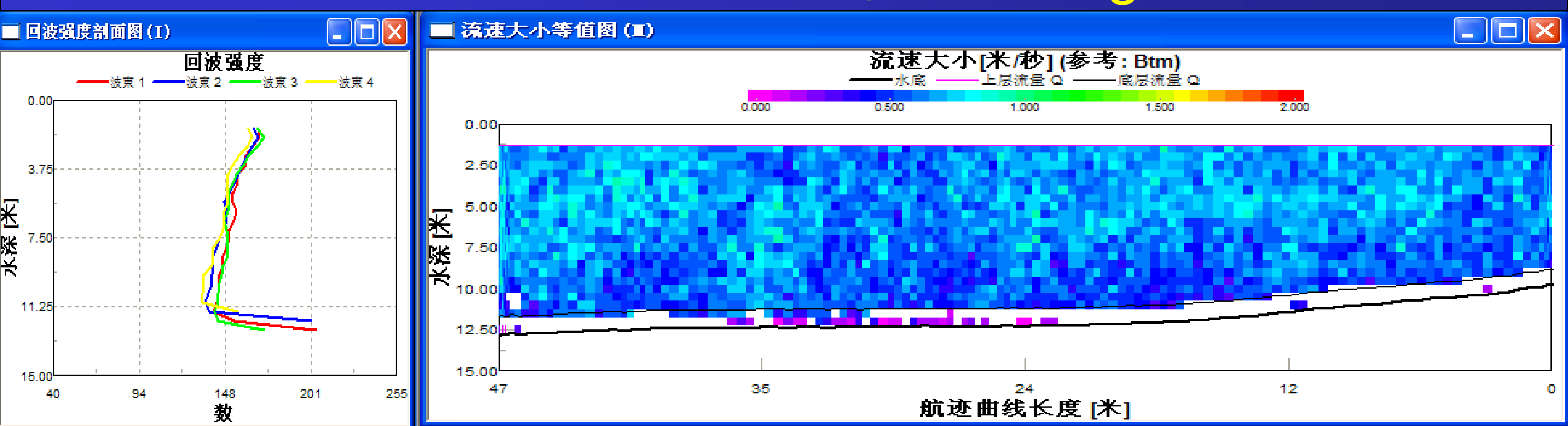
600 kHz ADCP



High frequency ADCP, losing bottom

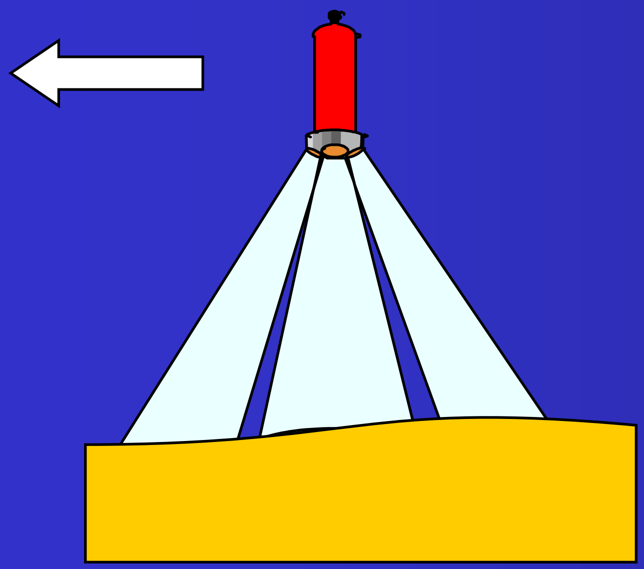


600 kHz ADCP, no losing bottom

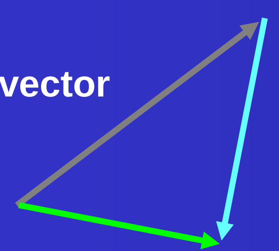


Thank you !

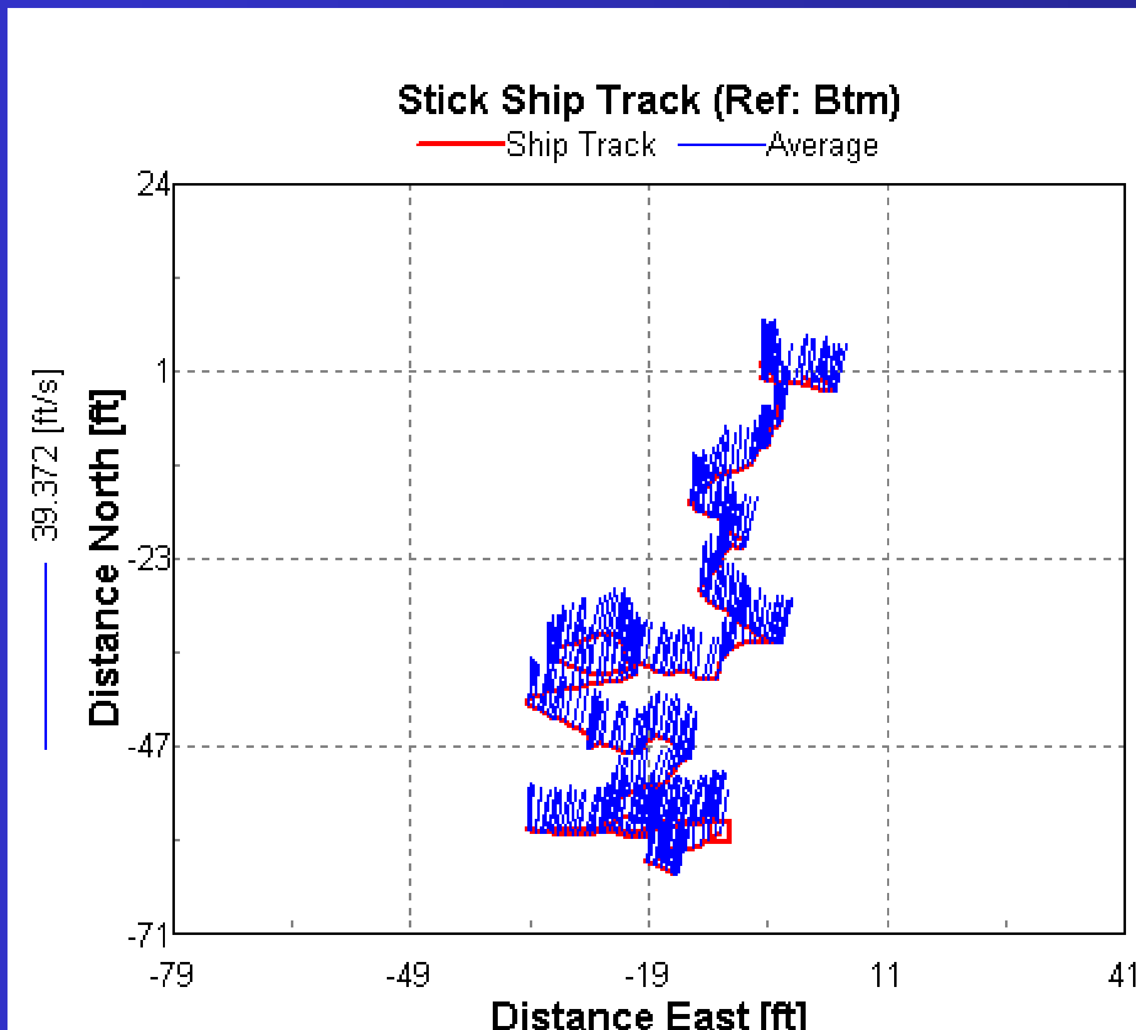
Bottom tracking



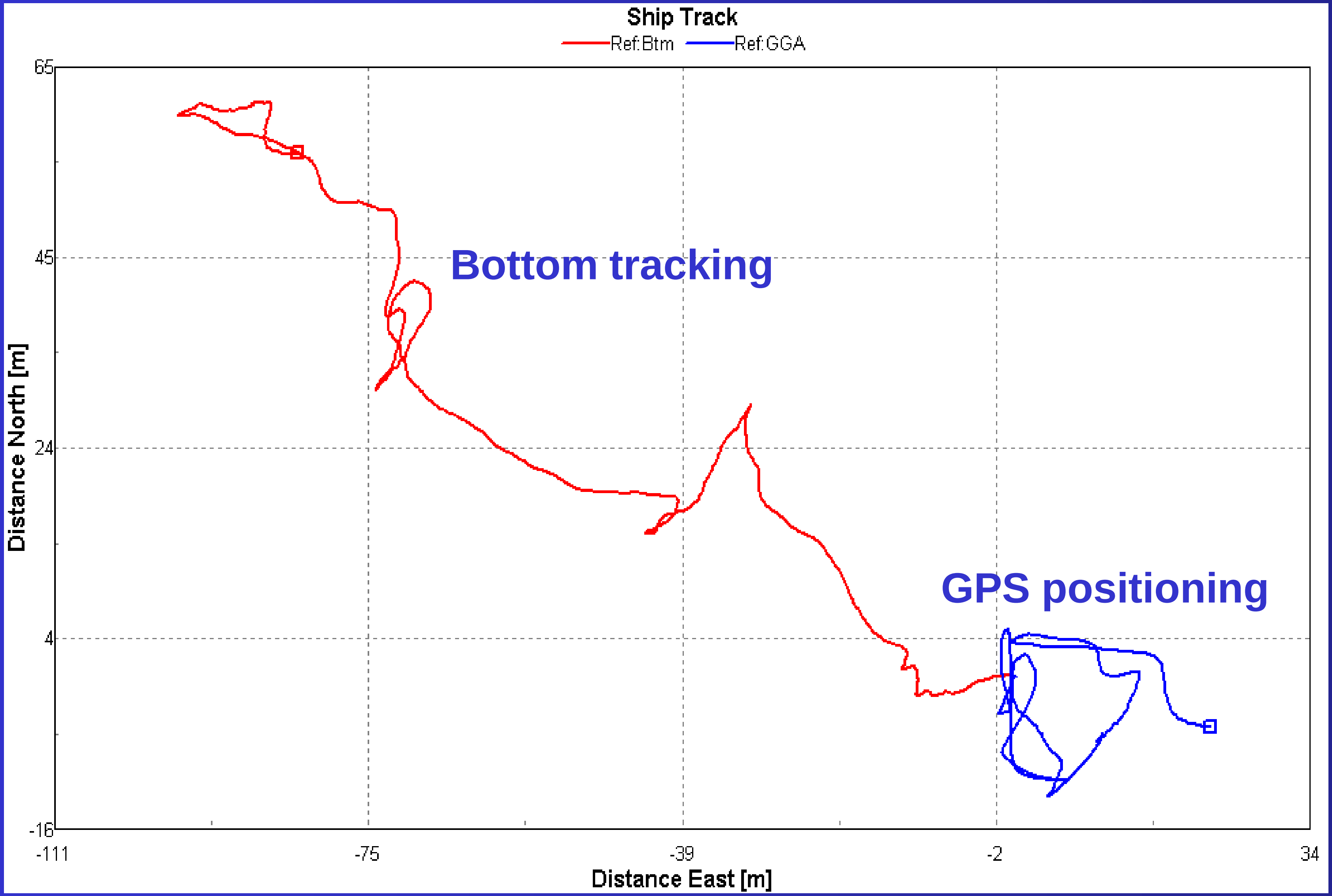
- Determined from Doppler shift of sound waves reflected from the streambed
- Used to determine boat speed and direction
- Used to compute the true water speed



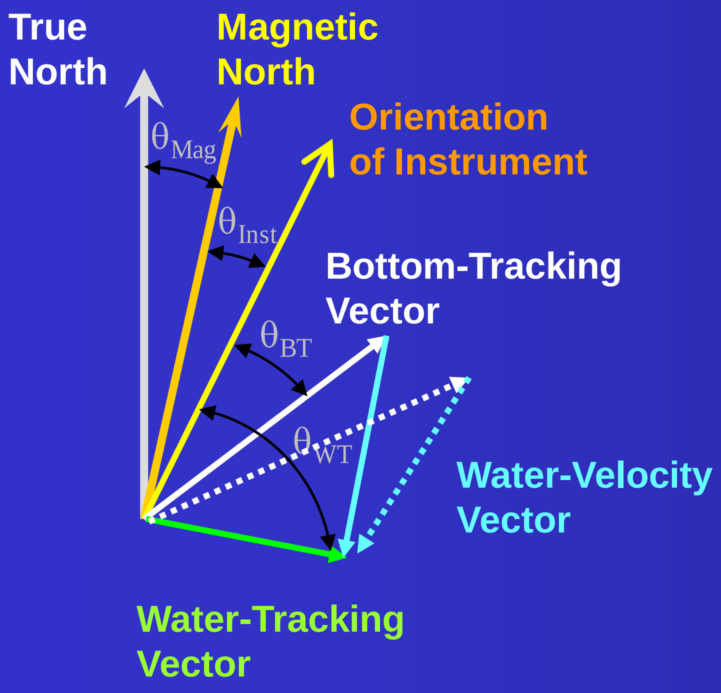
Moving Bottom Test 1: Stationary



Moving Bottom Test 2: Using GPS



Bias due to moving bottom



Negative bias:

- Water velocities are low
- Discharges are low

Uncertainty Model

Overall Uncertainty:

$$u_Q = \sqrt{u_A^2 + u_B^2}$$

Type A Uncertainty:

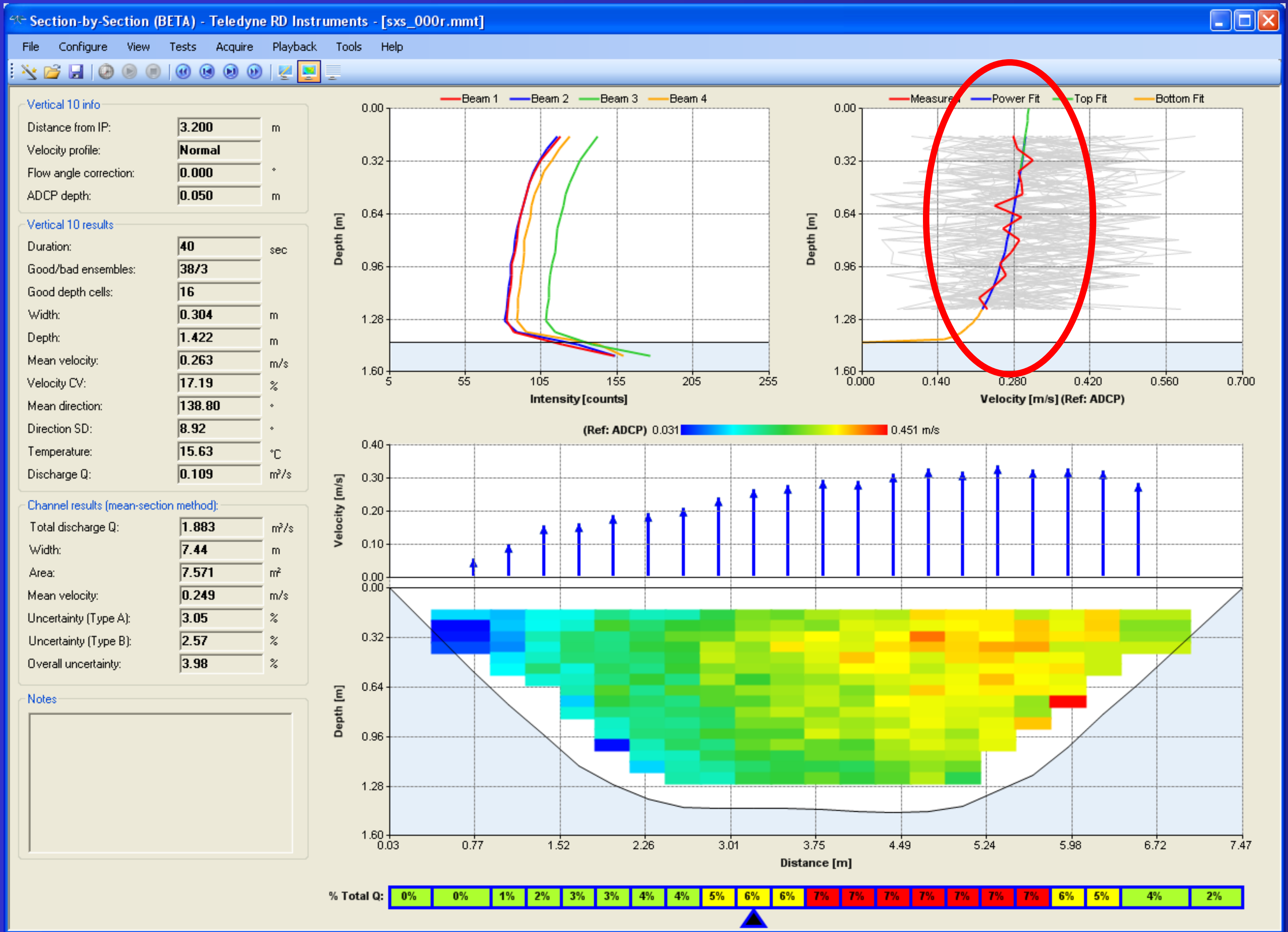
$$u_A = \frac{1}{Q}\sqrt{\sum_{i=1}^{m} \delta_{qi}^2 + 2\sum_{i=1}^{m-1} \delta_{qi}\, \delta_{qi+1}\, r_{i,i+1}}$$

Type B Uncertainty:

$$u_B = \sqrt{u_m^2 + u_{cal}^2 + \frac{u_b^2}{Q^2}\sum_{i=1}^{m} q_i^2}$$

Reference: Huang Hening (2012) “Uncertainty model for in situ quality control of stationary ADCP open-channel discharge measurement,” J. Hydraulic Engineering, ASCE, 138(1), 4-12

SxS Pro: Free Surface, Power Law Velocity Profile



SxS Pro: Under Ice Velocity Profile