FLOMEKO2019

Performance of Water Flow Velocity Calibration Facility

Heming Hu
huhm@nim.ac.cn
中国计量科学研究院
National Institute of Metrology, China

2019-6-27, Lisbon

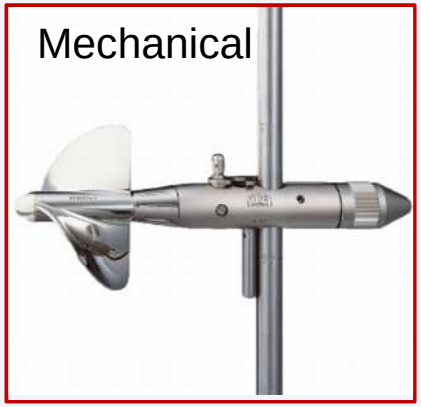
Application of current meters

- Methodology to calibrate current meter
- NIM small tow tank and initial test
- Conclusions and future work

Commonly used current meters

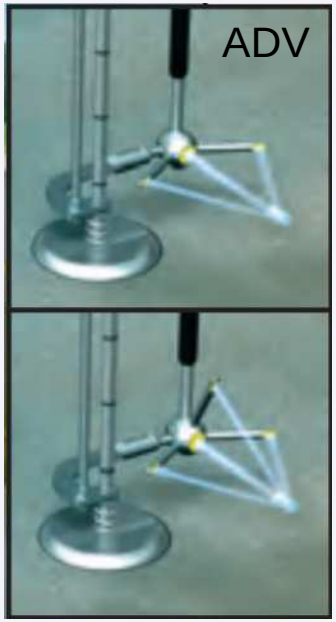
- Mechanical meter
- Acoustic meter (ATT / ADV / ADCP)
- Magnetic meter
- Radar sensor
- Pitot-tube / PIV / LDV

Mechanical

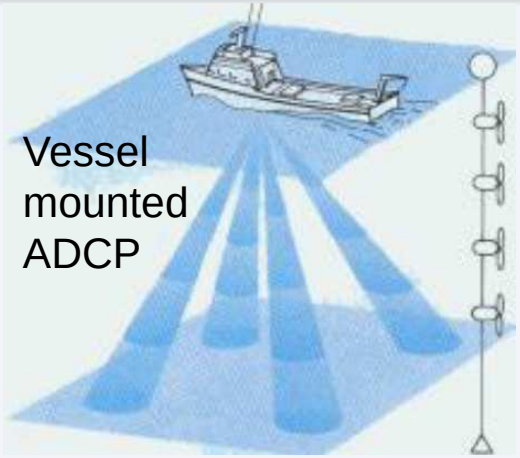


Magnetic

ADV



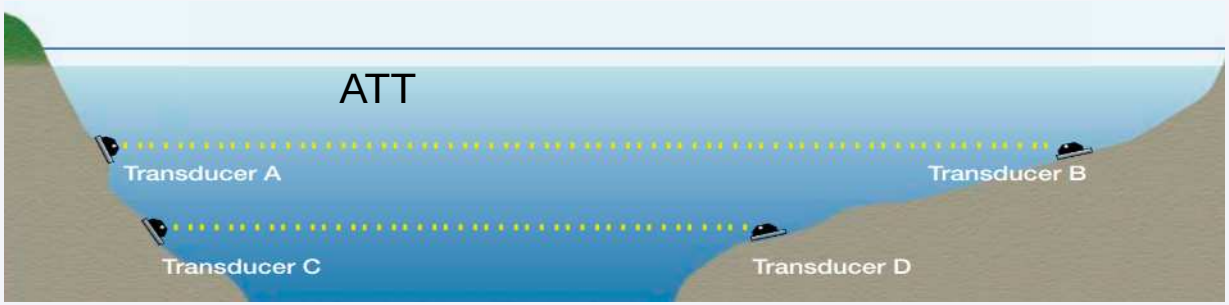
Vessel mounted ADCP



Fixed ADCP

Radar

ATT



Velocity-area method to calibrate flowrate onsite

- Velocity-area method：velocity sampling → flow rate calculation
- Methodology to calculate averaged velocity by limited points of sampling velocities

Large pipe:

- ultrasonic transit time sensor

Open channel

- Mechanical
- Doppler

Outline

- Application of current meters

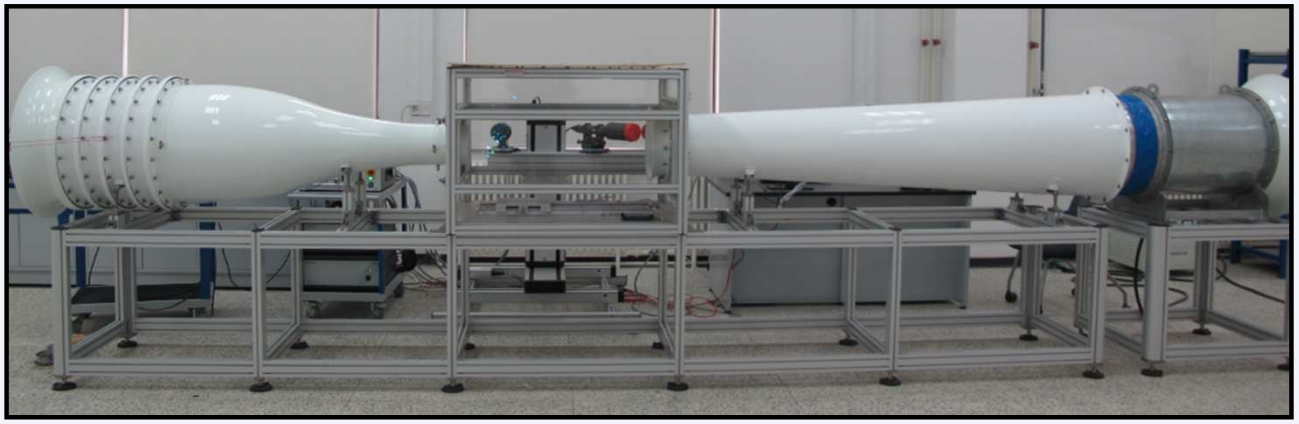
- **Methodology to calibrate current meter**

- NIM small tow tank and initial test

- Conclusions and future work

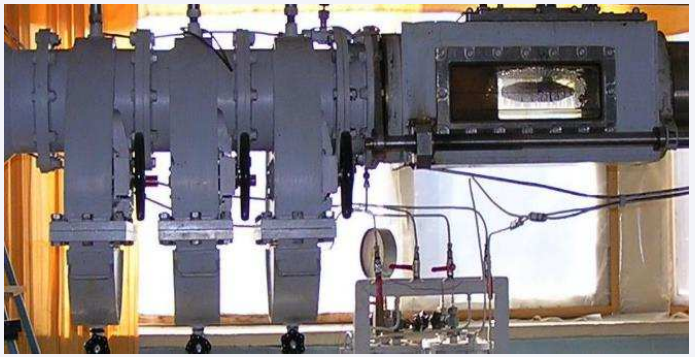
Methodology: flow velocity calibration facilities

NIM low wind speed facility (tow speed)

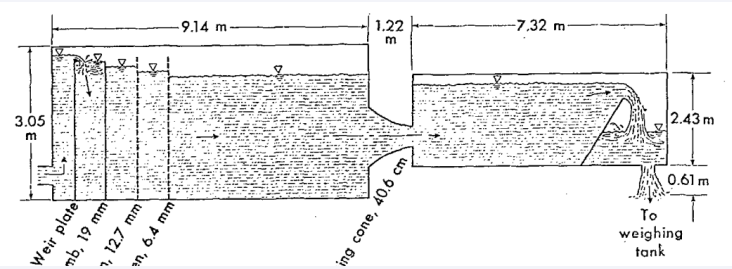


NIM wind tunnel (LDV as standard)

METAS tow tank (tow speed)



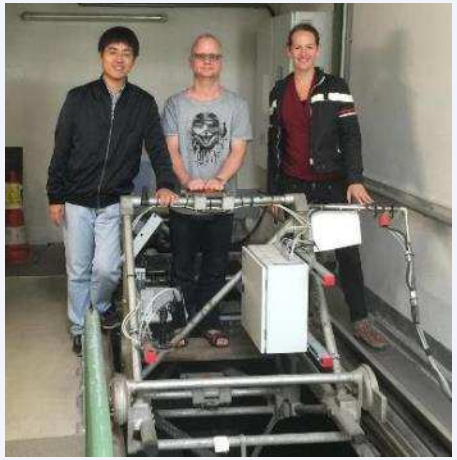
VNIIM water tunnel (pitot-tube)



USGS Submerged jet tank (pitot-tube)

Tow tank facilities in the world

Organization	dimension（m）	Speed (m/s)	Driven method	remarks
USGS, US	24.4×1.2×1.2	0.03~0.91	/	Acoustic test
	137×3.7×3.7	0.015~5.5	wheel-driven	/
METAS, Swiss	140×4×2.4	0.02~10.0	wheel-driven	uncertainty：0.04%+2mm/s
BAW-IWB, Austria	40×2.25×2.0	0.02~3.4	Tow at one end	Uncertainty: 2mm/s
NIWA, New Zealand	50×1.85×1.75	()~3.3	wheel-driven	/
OTT, Germany	50×2.9×2.1	0.05~10.0	Tow at one end	/



BAW-IWB

OTT

USGS

METAS

NIWA

Tow tank facilities in China

Chongqing, (50×1.7×1.7) m

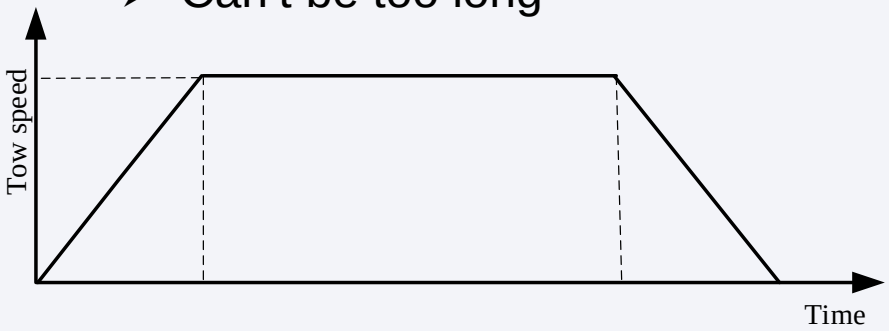
Weifang, (100×2.5×2) m

Nanjing, (135×3×3) m

Shanghai

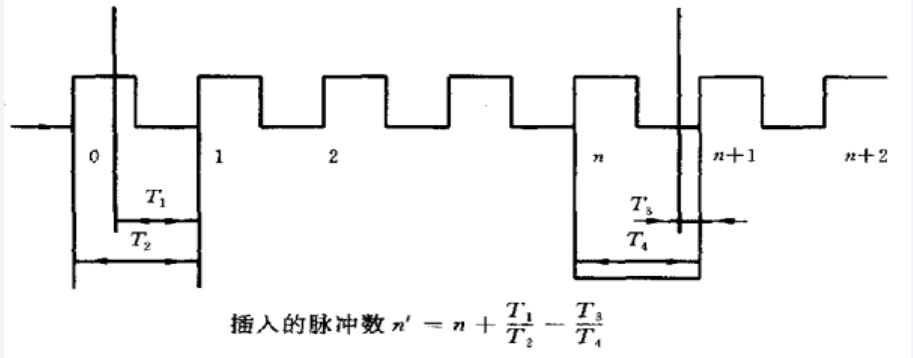
Driving method of tow tank

- Wheel-driven cart
  - Motor on cart, slide wire
  - Heavy cart to keep stable running
  - Suitable to long enough tank
- Tow cart
  - Motor at one end, simple wire connection
  - Higher acceleration and deceleration
  - Higher maximum speed or longer test time period for same tank length
  - Can’t be too long



Measurement of cart speed

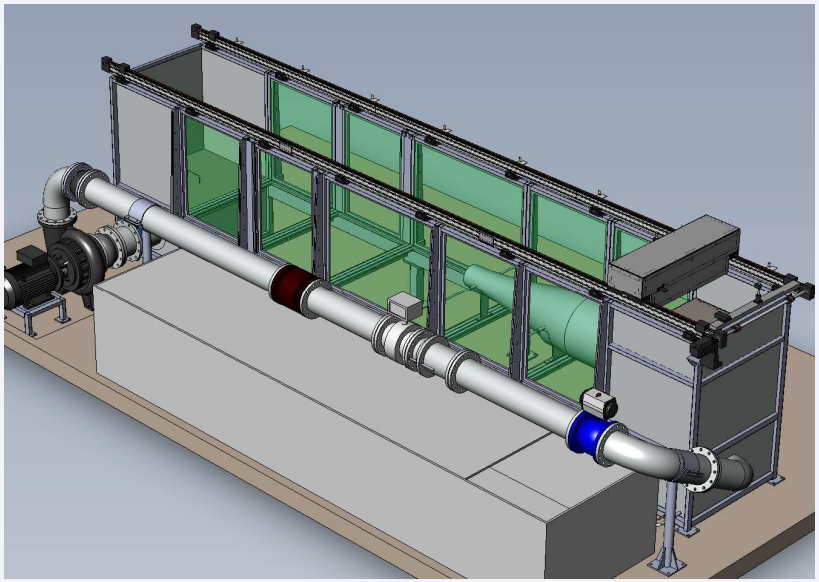
- Speedometer, wheel with encoder，need to be calibrated dynamically
- Triggers with known distances and pulse timer
  - Multi triggers & single photoelectric switch（METAS, BAW）
  - Two triggers & multi photoelectric switch （OTT）
- Synchronization of tow speed & velocimetry
  - decimal part of pulse number

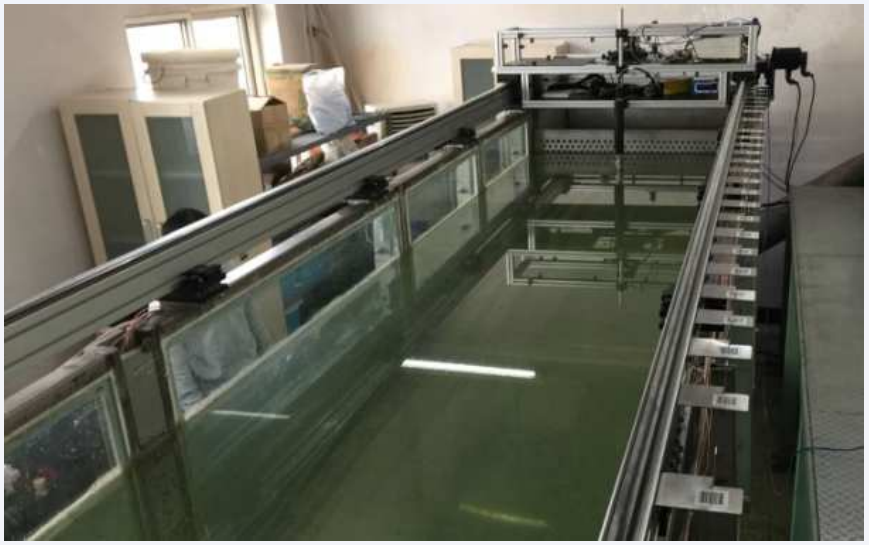


Outline

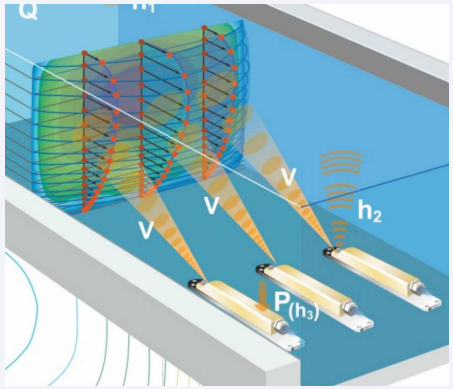
- Application of current meters
- Methodology to calibrate current meter
- **NIM small tow tank and initial test**
- Conclusions and future work

NIM small tank: 8m*1.2m*1.2m

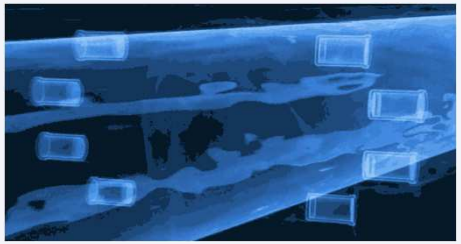




- Calibration of current meter
  - Mechanical propeller, magnetic, doppler, transit-time, …
  - Tow method
  - Dynamic method with LDV as standard

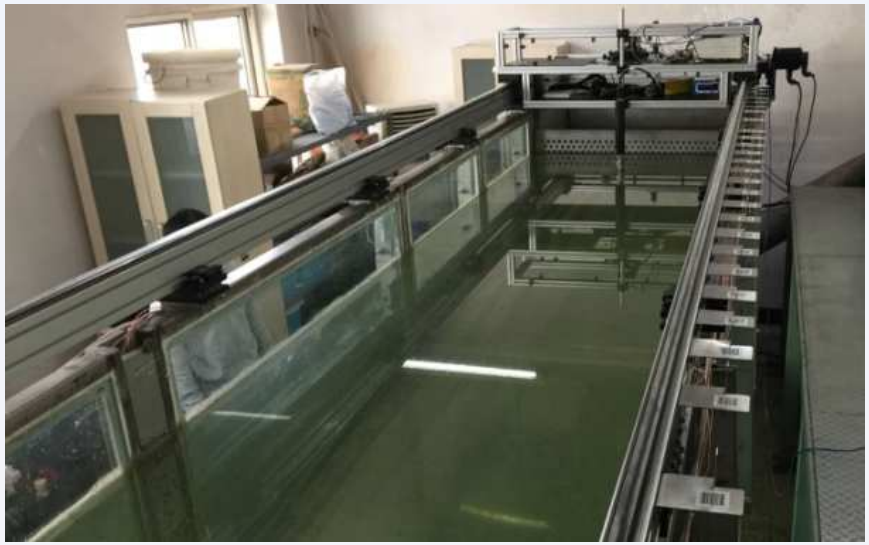


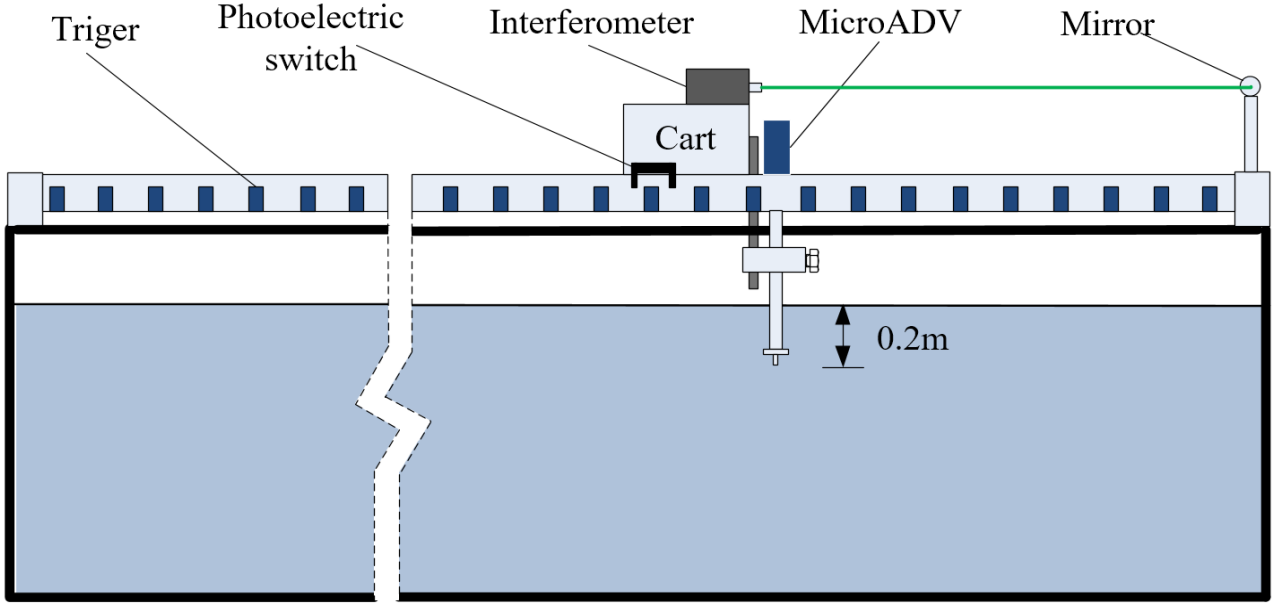
- Test of open channel flow meter
  - doppler
  - transit-time

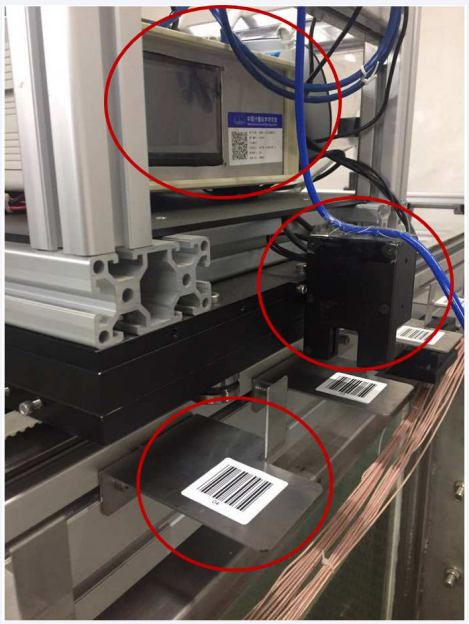


Cart speed measurement system

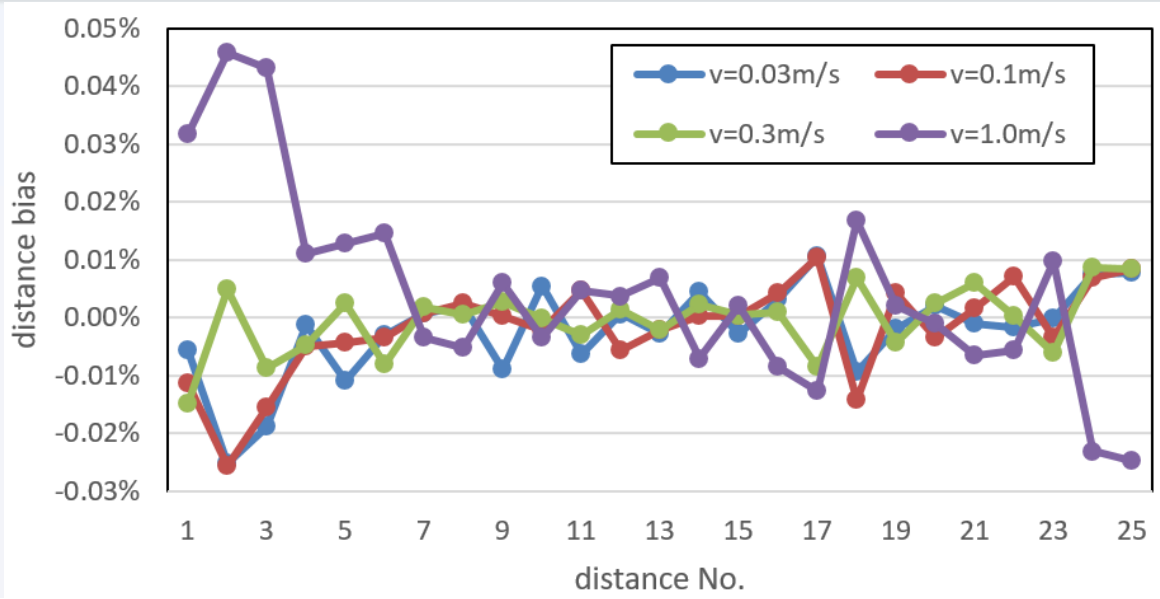
- Triggers with known distances and pulse timer
- Distances of triggers
  - ~300mm * 24
  - Calibrated by Interferometer, 30um
- Pulse timer, 10us

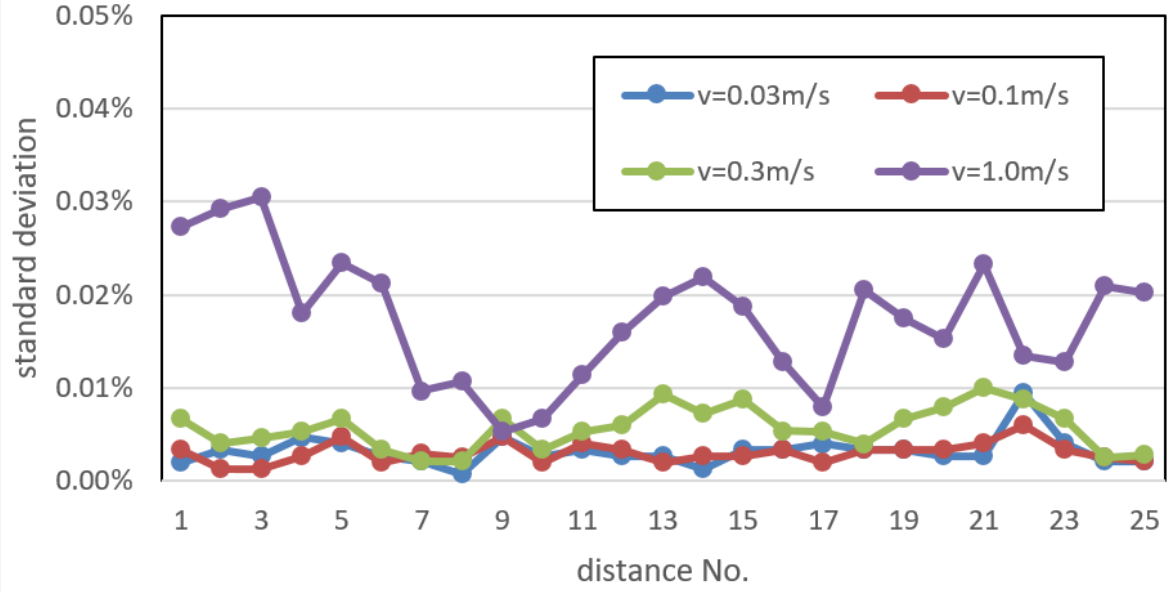






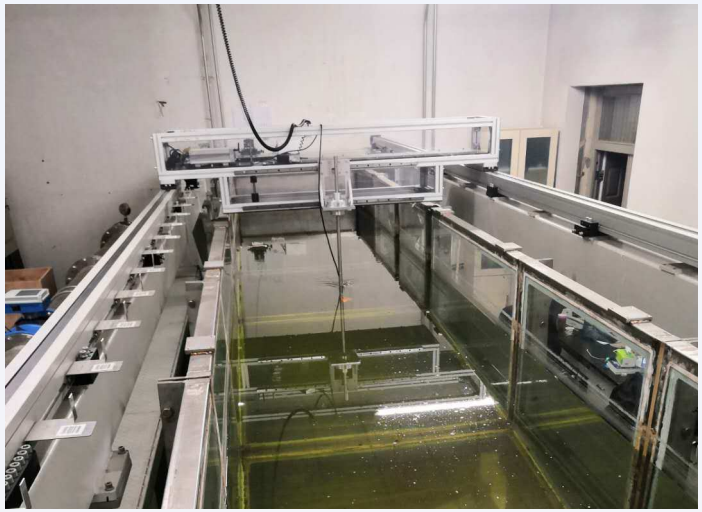
Interval calibration of triggers at different speeds





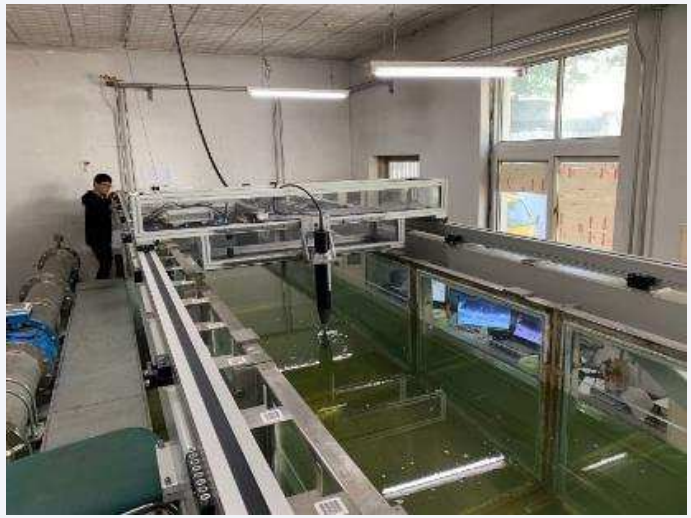
- Good repeatability at low speeds

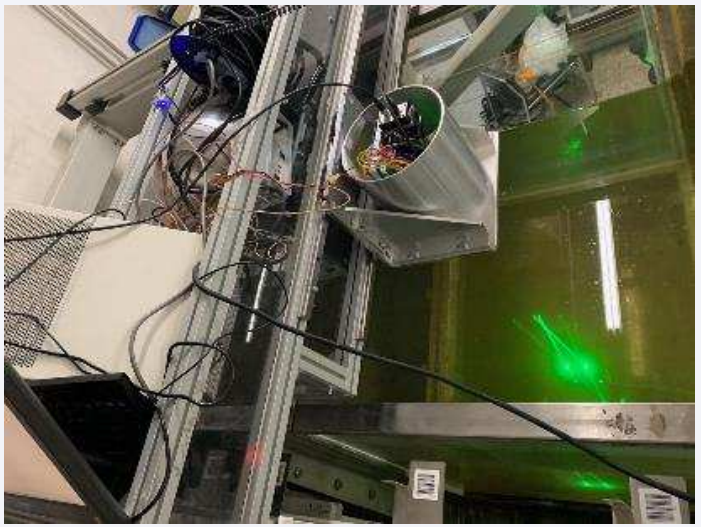
Different kind of current meters tested



Mechanical Current | Ultrasonic Doppler

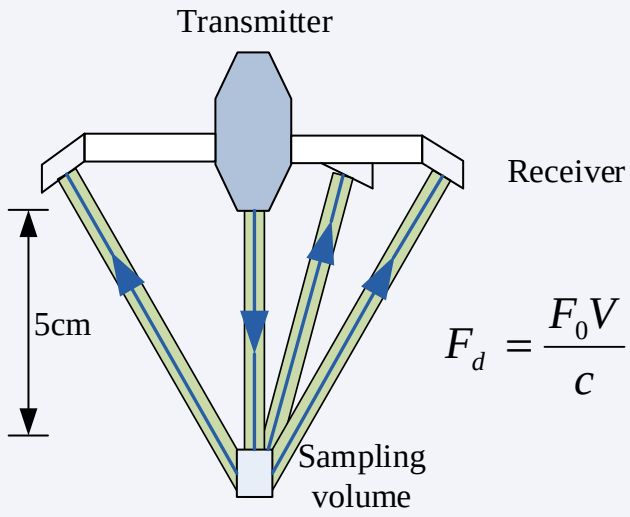
Ultrasonic Transit time | Laser Doppler



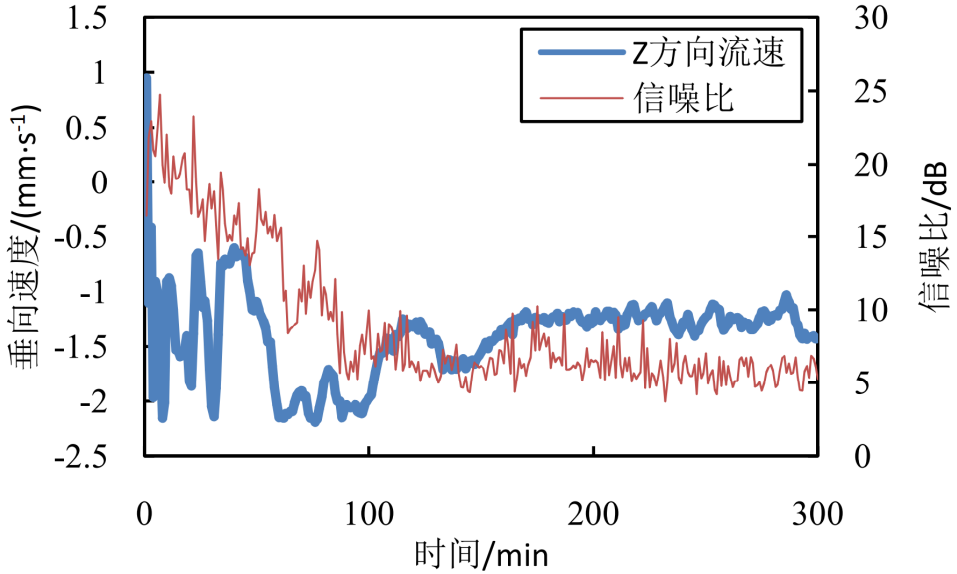


Sontek MicroADV

- Three-axis velocity measurement
- Sampling Rate: 0.1~50 Hz
- Sampling Volume: 0.09 cc
- Distance to Sampling Volume: 5 cm
- Resolution: 0.01 cm/s
- Programmed Velocity Range: 3/10/30/100/250 cm/s
- Accuracy: 1% of measured velocity, 0.25 cm/s
- Maximum Depth: 60 m
- Temperature Sensor: 0.1°C

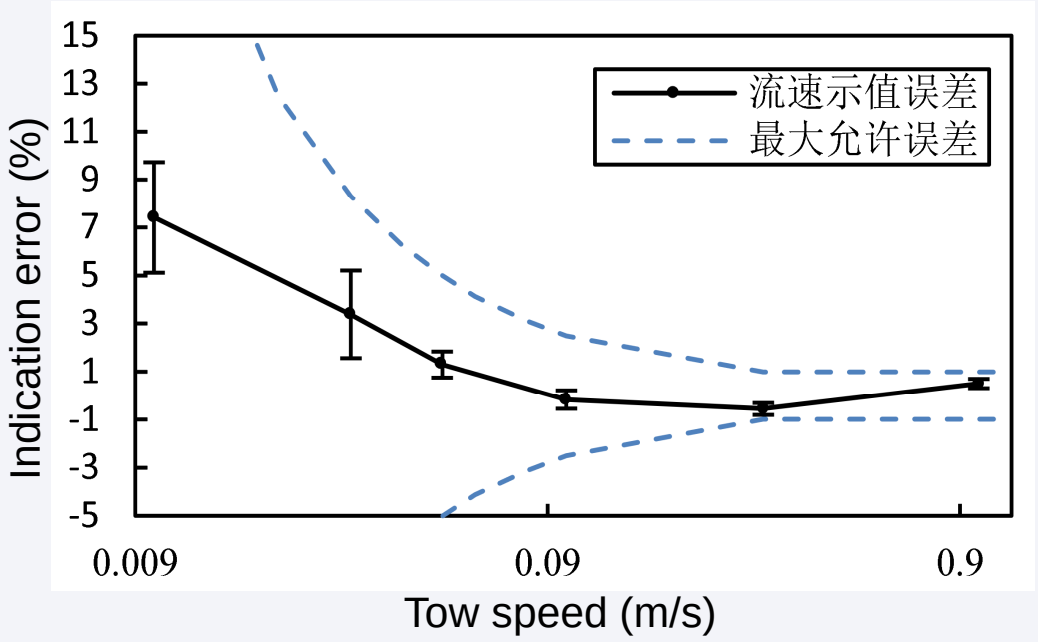


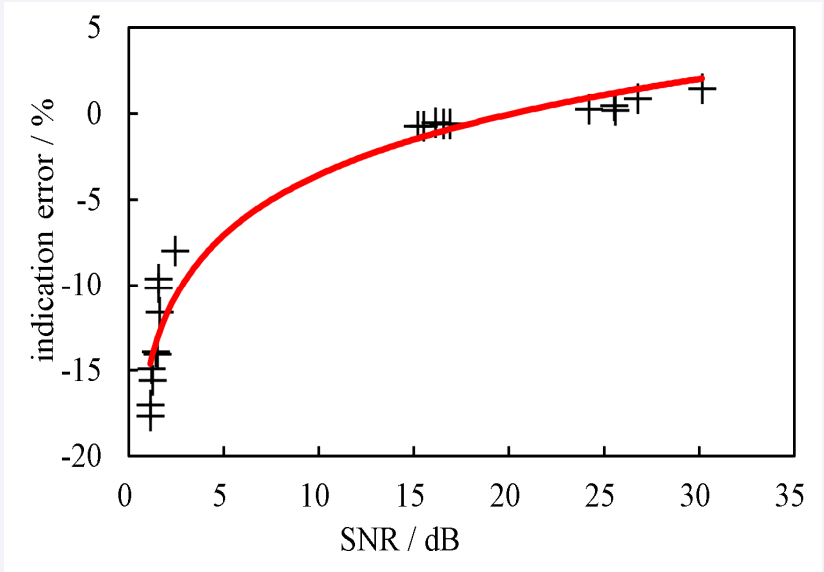
$$F_d = \frac{F_0 V}{c}$$



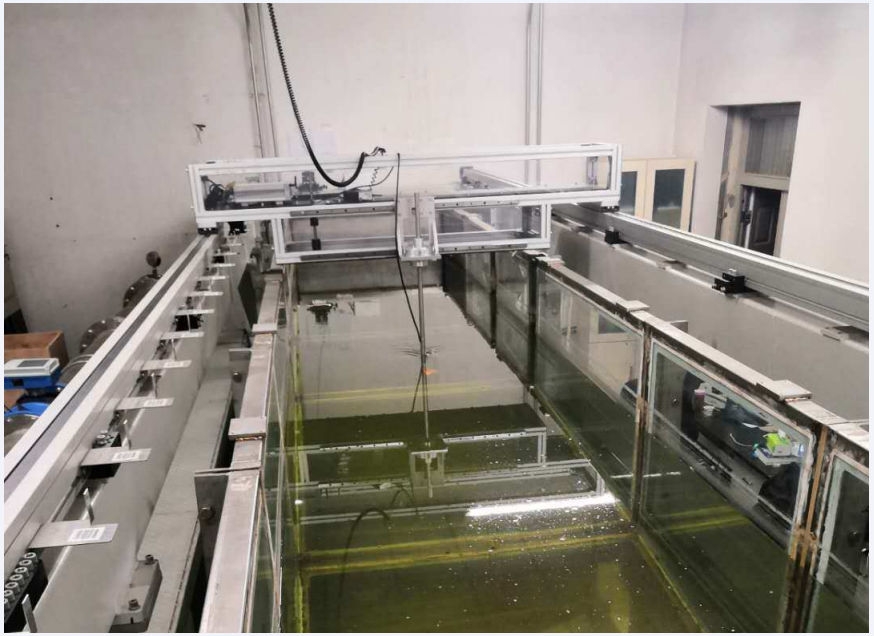
MicroADV test result

Nominal speed ($m \cdot s^{-1}$)	Indication error		Repeatability	
	Absolute ($mm \cdot s^{-1}$)	Relative (%)	Absolute ($mm \cdot s^{-1}$)	Relative (%)
0.01	0.8	7.4	0.3	2.3
0.03	1.1	3.4	0.6	1.8
0.05	0.7	1.3	0.3	0.5
0.1	-0.2	-0.2	0.4	0.4
0.3	-1.7	-0.6	0.7	0.2
1	5.1	0.5	2.0	0.2





Mechanical Current meter test result

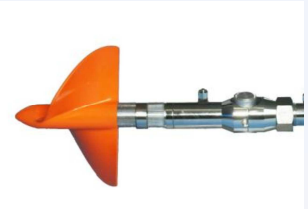


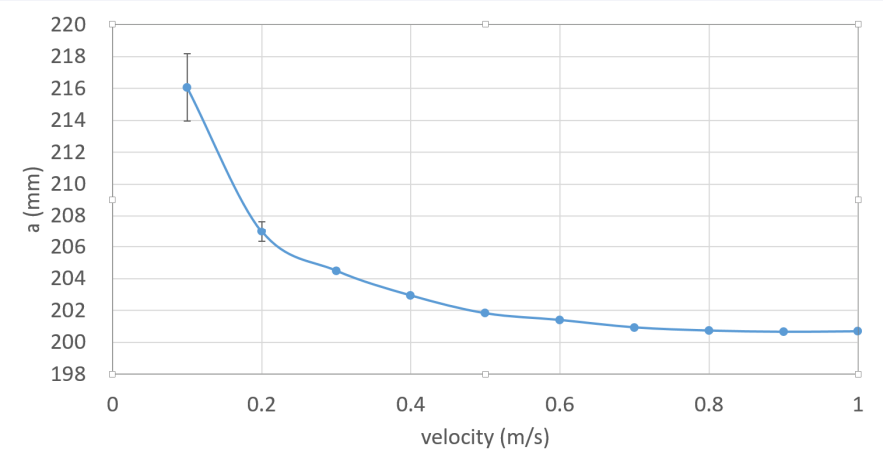
a(m) = v(m/s) / n(/s)

a: running distance per rotor turn

v: velocity

n: rotate speed





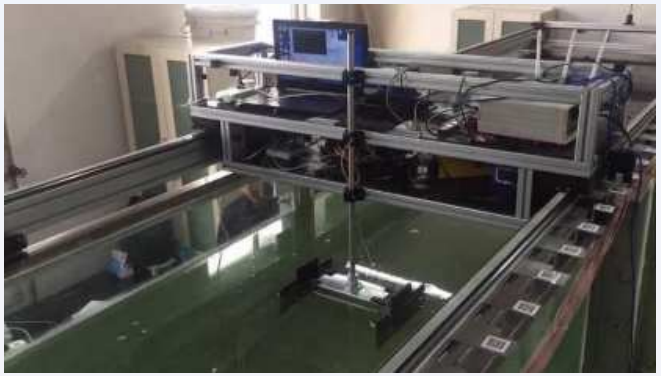
velocity (m/s)		1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
distance per rotor circle (mm)	average	200.68	200.65	200.73	200.93	201.39	201.82	202.94	204.49	206.99	216.06
	std	0.14	0.04	0.11	0.05	0.05	0.04	0.11	0.08	0.64	2.11
	relative std	0.07%	0.02%	0.06%	0.03%	0.02%	0.02%	0.05%	0.04%	0.31%	0.98%

Outline

- Application of current meters
- Methodology to calibrate current meter
- NIM small tow tank and initial test
- **Conclusions and future work**

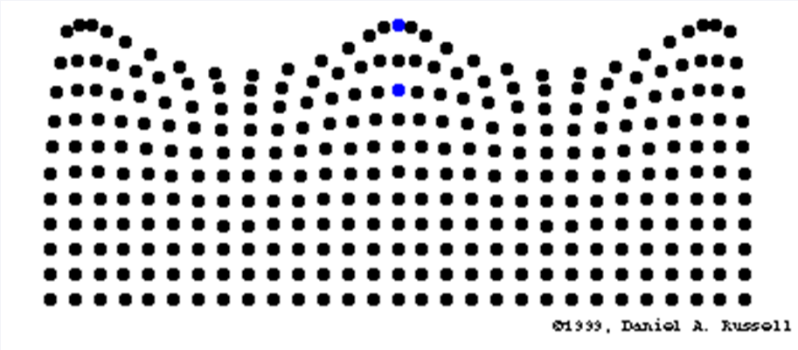
Conclusions and future work

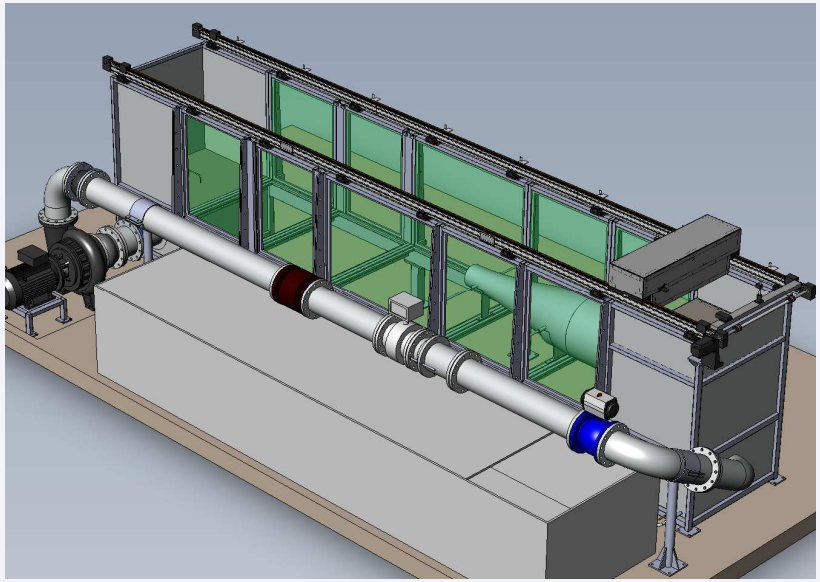
- NIM small tank facility
- Different current meters tested
  - Mechanical shows good repeatability (<0.1%)
  - ADV shows good performance at very low velocity



- Calibration for ATT Line averaged velocity
- Background flow observation for still water when towing
- Comparison among different tanks

- Submerged jet with LDV
  - Jet nozzle
  - Comparison with the two methods





Open channel flowrate measurement

- Pipe flowmeter as reference
- Transit-time transducers for open channel
- Open channel flow distribution and flowmeter test

Thanks for your attentions

Changping campus, NIM