Progress of NIM's Smoke Stack Simulator and Field Measurement in Power Plants

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01 Background

02 Smokestack Simulator of NIM China

03 Field Calibration System

04 Field Tests

05 Future Works

Need for Stack Gas Flowrate Measurement

- **Industry plant efficiency test**
- **Air pollution emission monitoring**
  - Chinese Environmental Protection Agency has clear demand for accurate flue gas flowrate measurement
- **Carbon trading**
  - In 2013, China has carried out pilot carbon trading in 7 provinces, and extended to the national carbon trading market in 2017
  - In 2013 NDRC issued first 10 industry sectors greenhouse gas emission accounting methods and reporting guidelines

Measurement and Calibration Scheme

- **Industry plant efficiency test**
  - S type pitot tube point by point measurement
  - Wind tunnel calibration at 0 pitch and 0 yaw angle
- **Air pollution emission monitoring**
  - On site velocity comparison using S type pitot tube.
  - Wind tunnel calibration at 0 pitch and 0 yaw angle
- **Carbon trading**
  - Fuel based calculation method

Overall Research Plan

- **Stack flowrate calibration**
  - Build calibration facilities to calibrate standard 3D pitot tubes in different flow conditions
  - Study the pitot tube integration method
  - Field calibration system
- **Stack ultrasonic flowmeter calibration**
  - Dry calibration
  - Real flow velocity calibration
- **Field tests**

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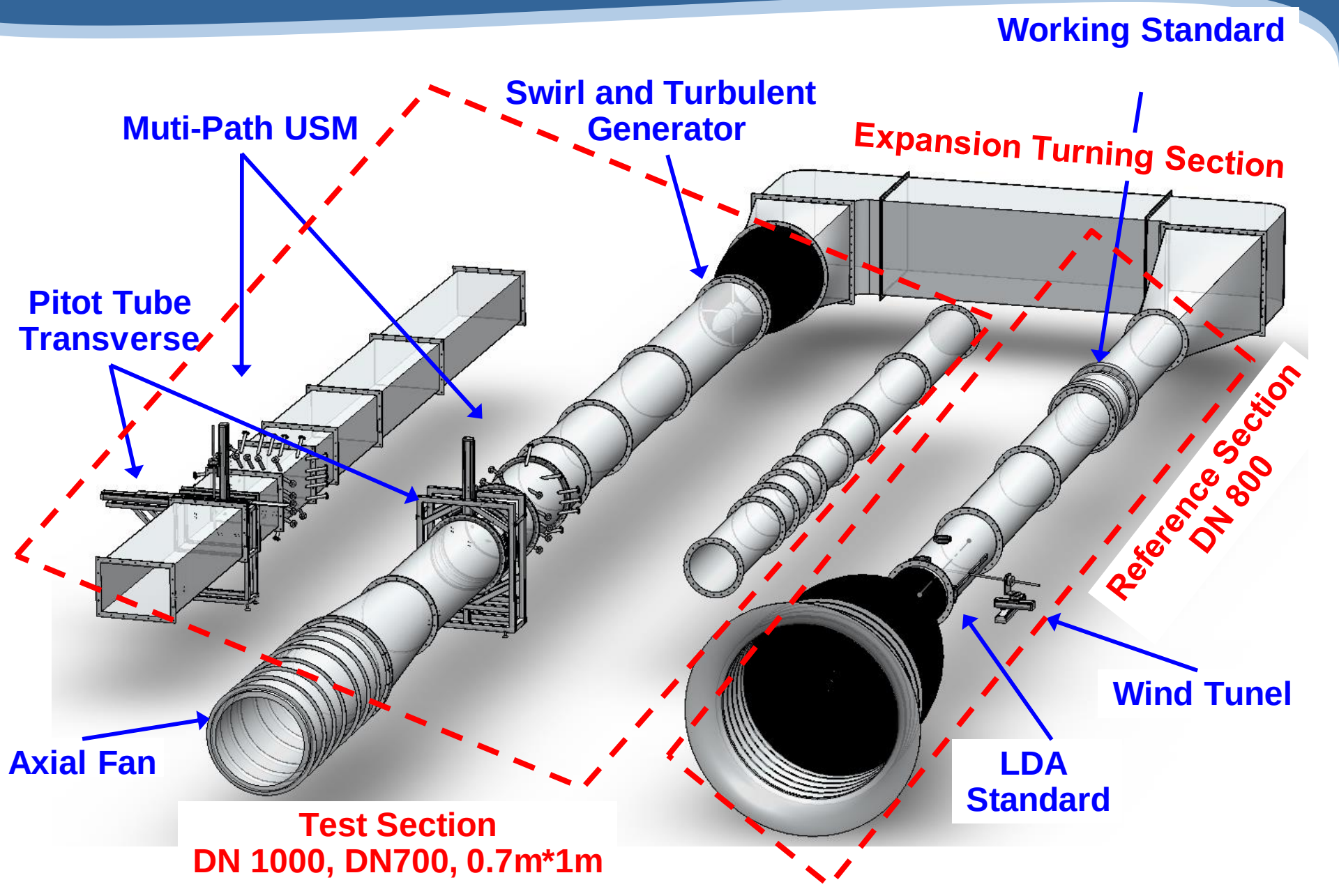
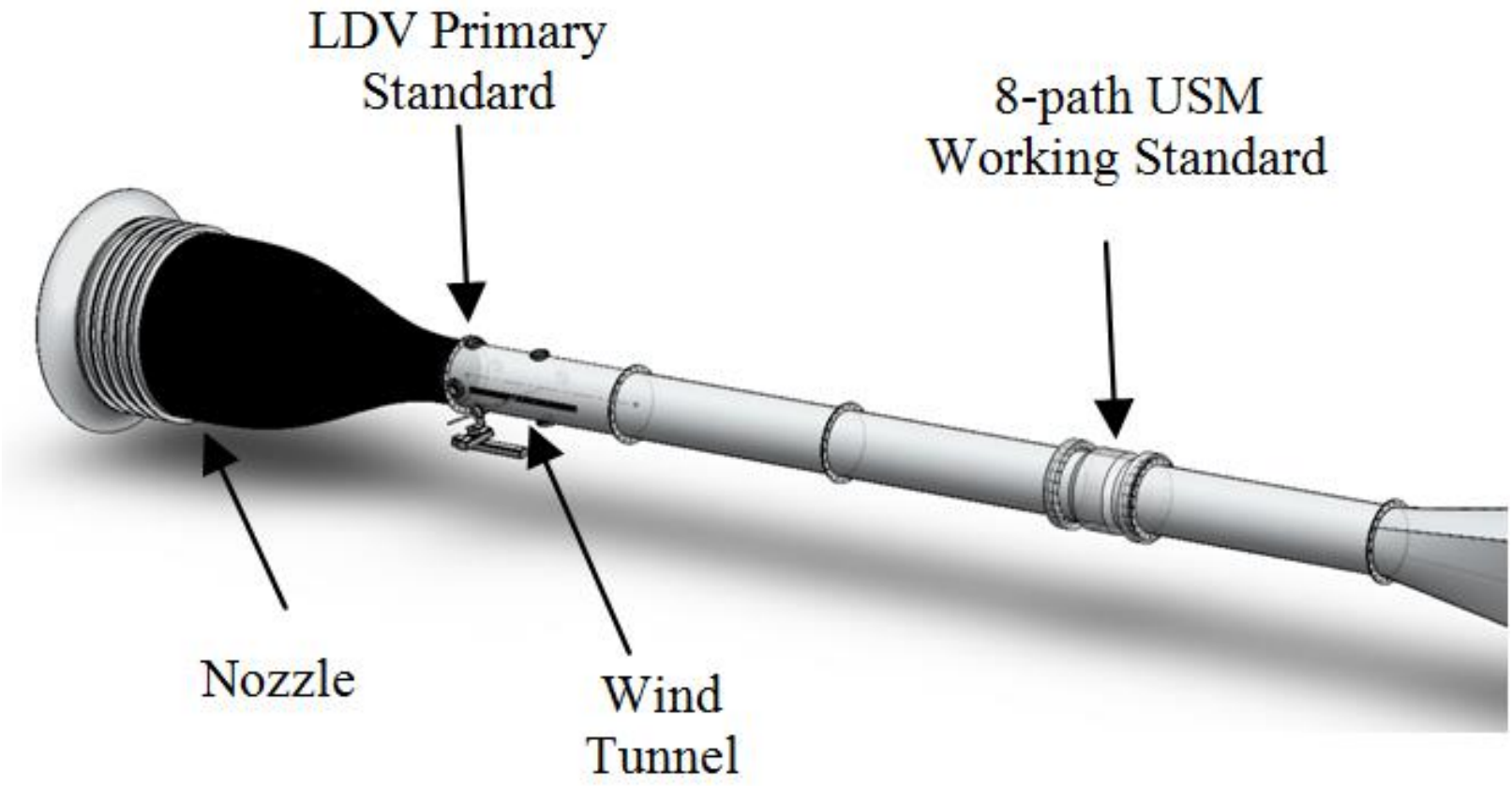
Smoke Stack Simulator of NIM



Smoke Stack Simulator of NIM

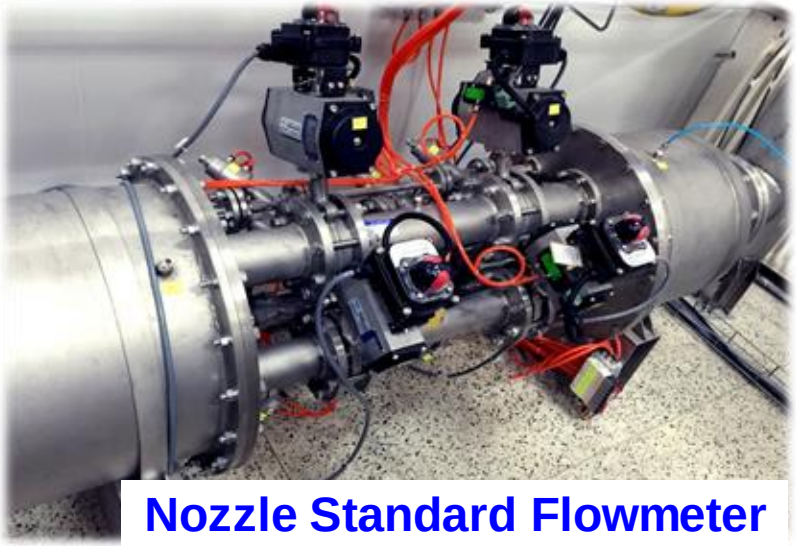
Reference Section & Wind Tunnel



- Velocity range of wind tunel: 0.5~70m/s
- Turbulence intensity: 0.75%@50m/s

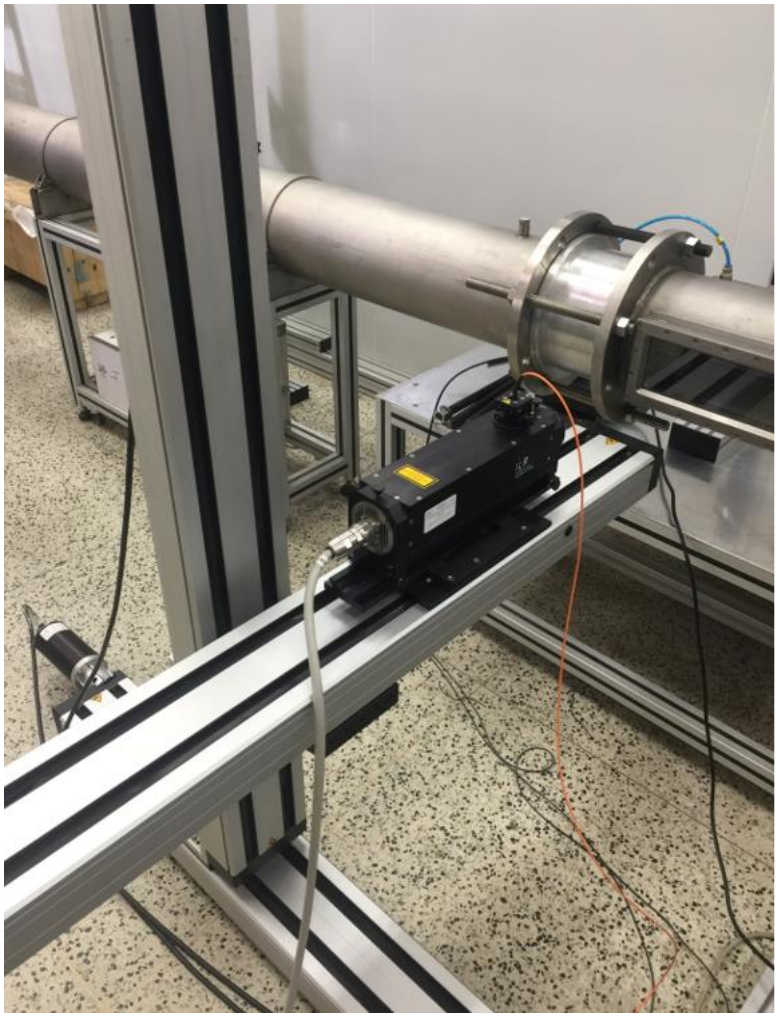
NIM's Dual LDA Flowrate Standard

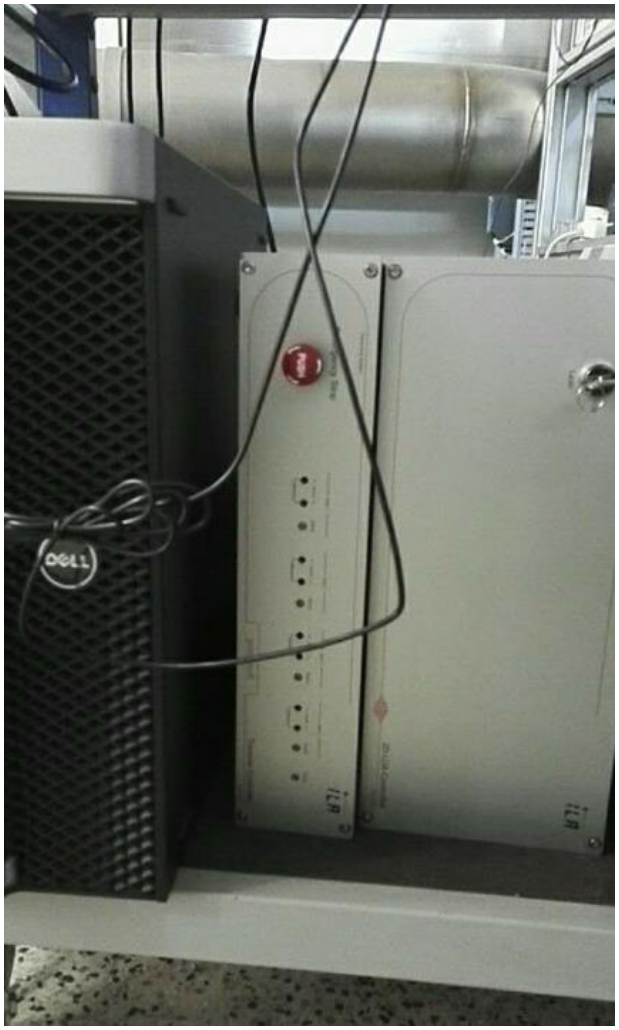
NIM's Dual LDA Flowrate Standard



NIM's Dual LDA Flowrate Standard

- Boundary layer LDV



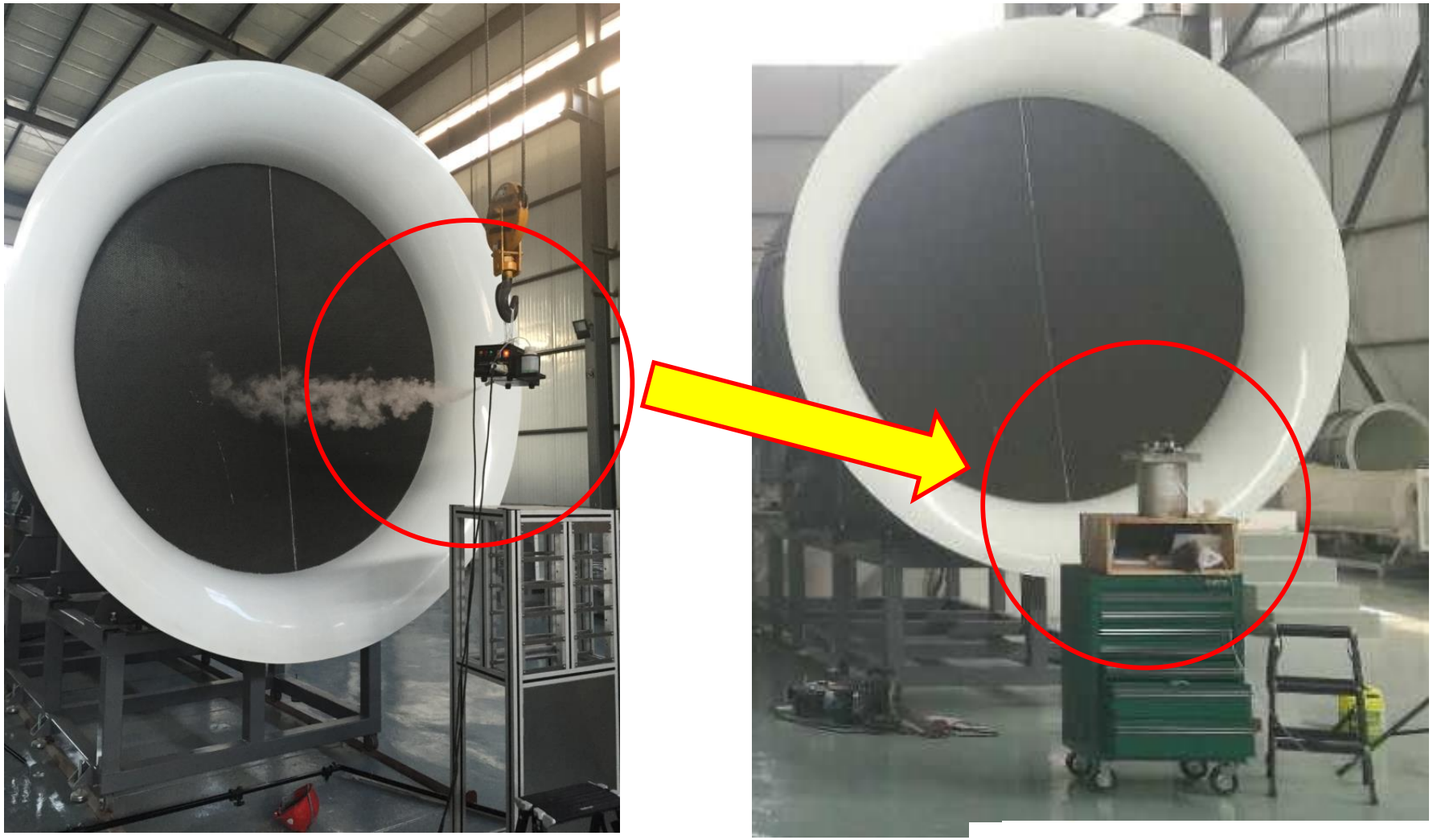


Reference Section & Wind Tunnel

- LDV primary standard of SMSS

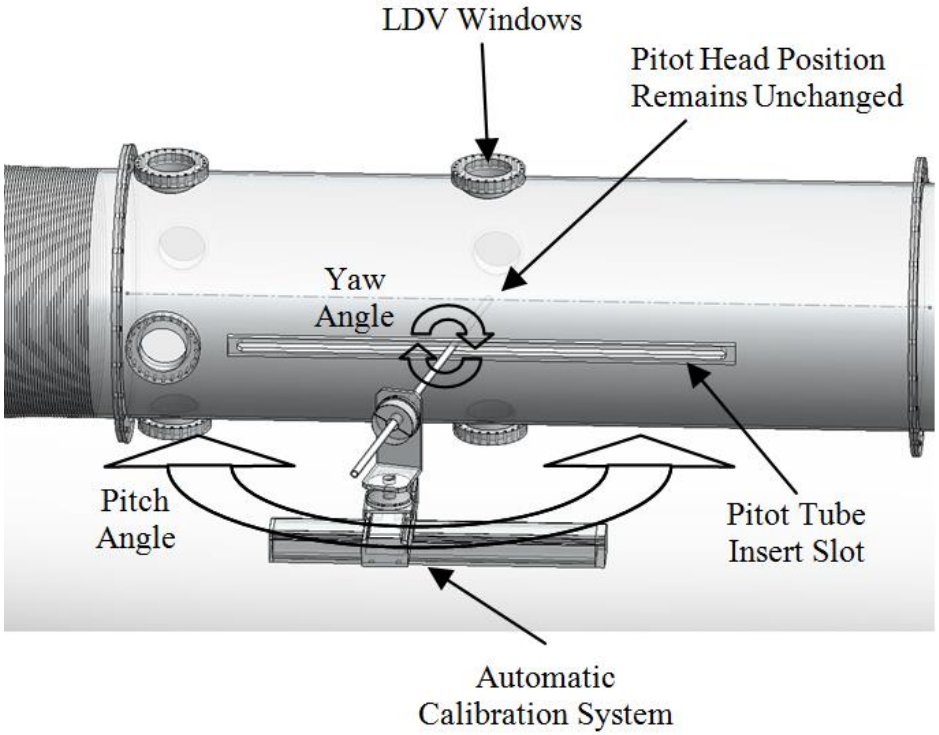
Reference Section & Wind Tunnel

- LDV seeding

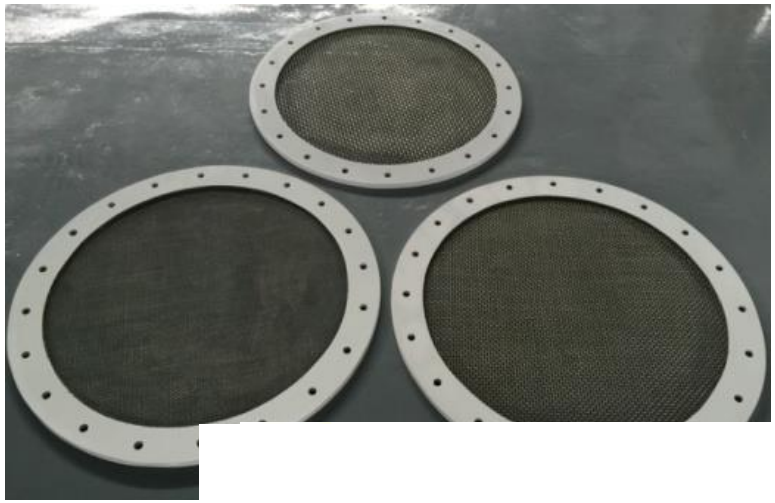


Reference Section & Wind Tunnel

Wind tunnel



PIV



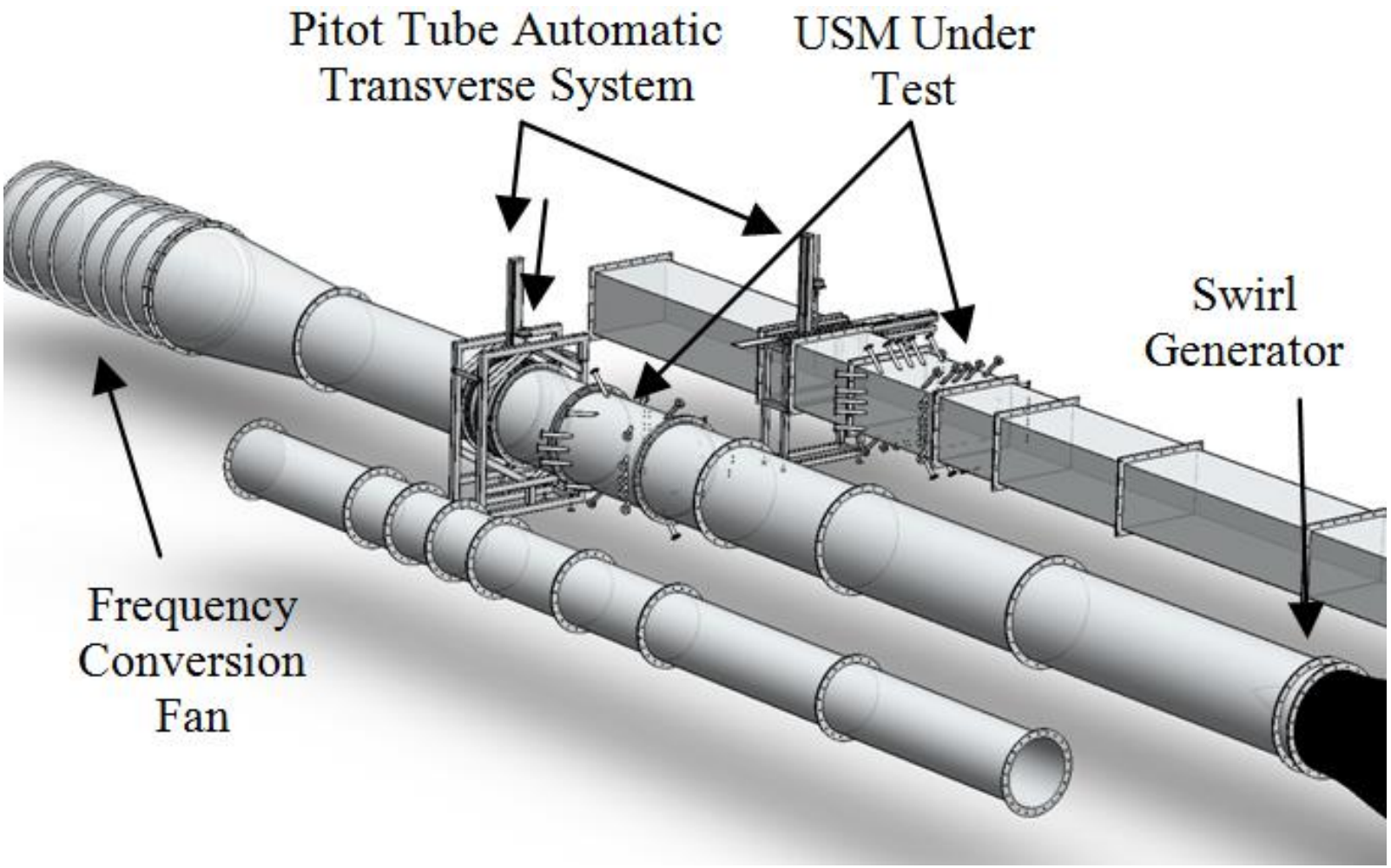
Reference Section & Wind Tunnel

- 8-path USM working standard

Reference Section & Wind Tunnel

- USM lost signal
- Electromagnetic interference

Test Section

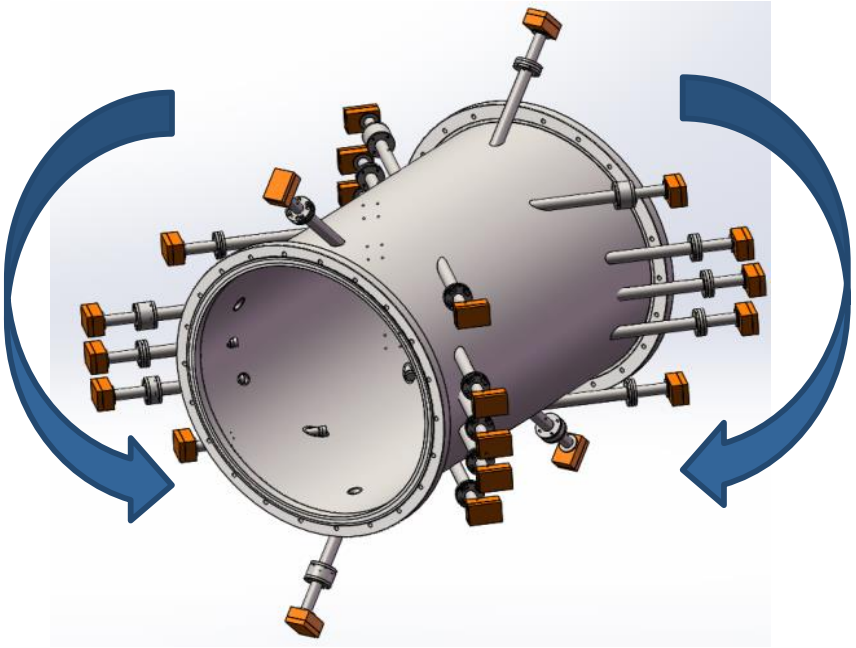


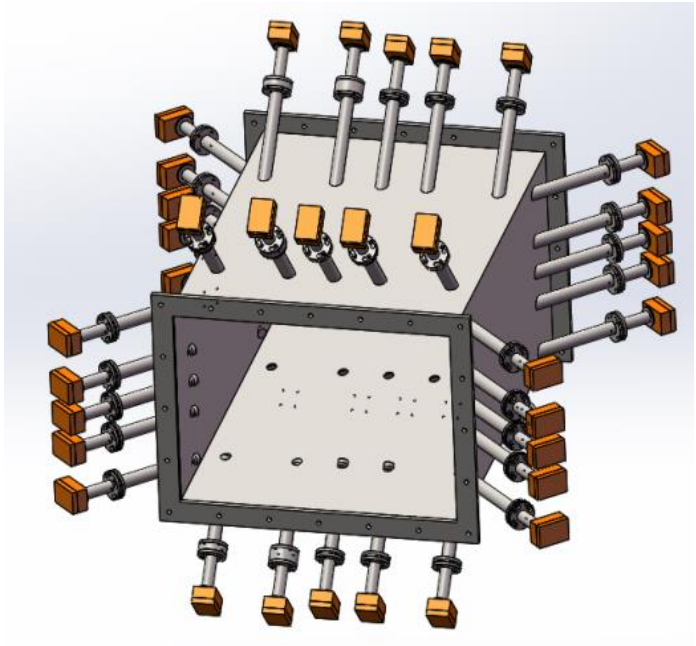
Test Section

- Contraction section and swirl generator

Test Section

- **USM under test**
  - **Circular: 8-path (OWICS) + dual cross diametric path**
  - **Rectangular: 8-path (OWIRS) +dual cross diametric path**



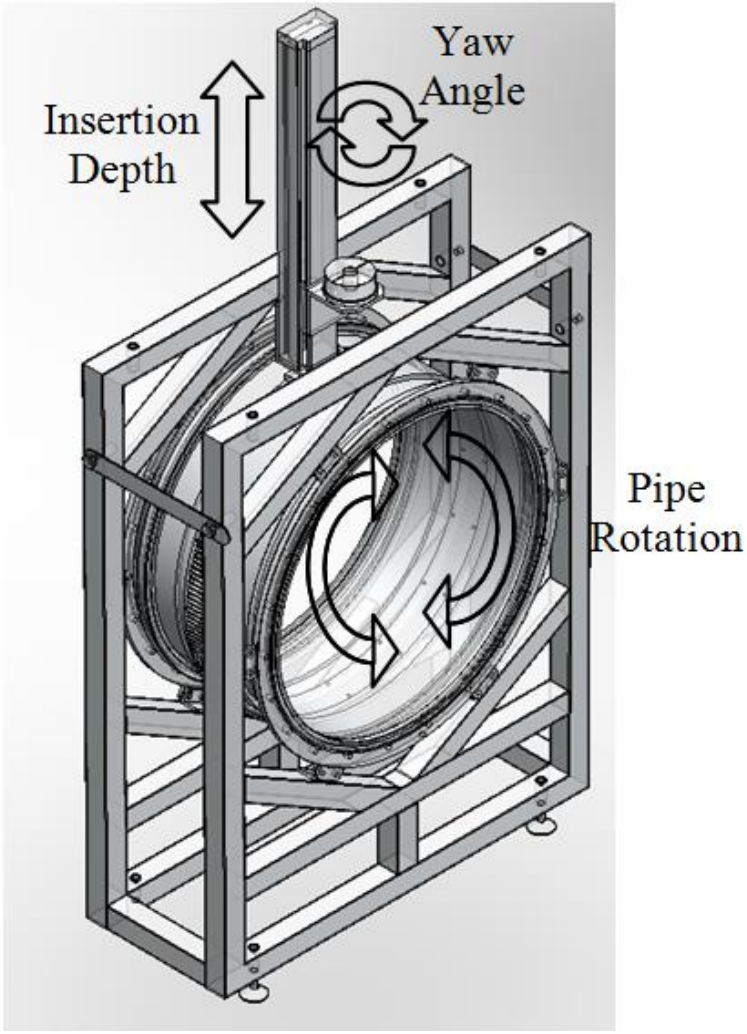


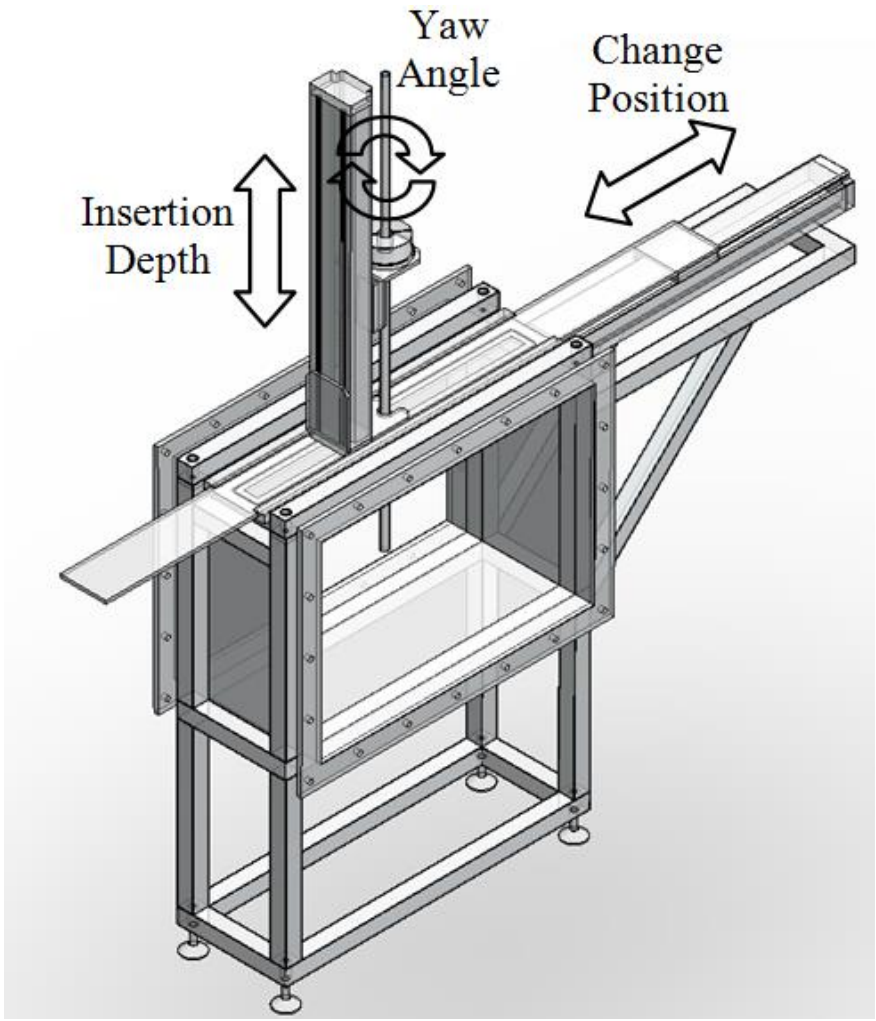
Test Section

- USM under test

Test Section

- Pitot tube automatic transverse system





Test Section

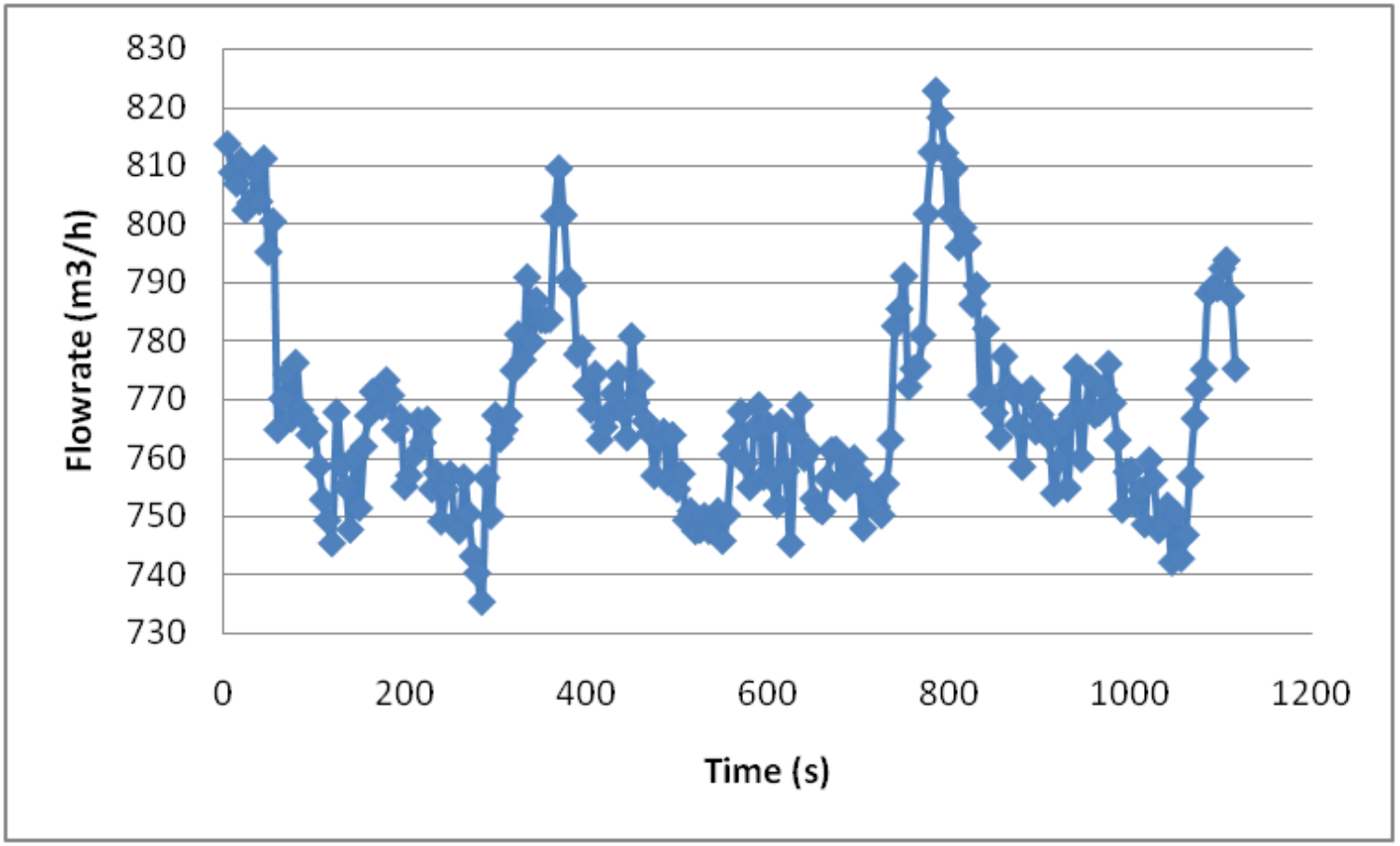
- Pitot tube automatic transverse system

Test Section

- Fans

Test Data

- Flow stability



Test Data

LDV calibrate USM

Set flowrate (m^3/h)	750	1700	3500	8500	17000	32000	50000	80000
Velocity in the Center of the pipe (m/s)	0.5	1	2	5	10	20	30	50
LDV flowrate (Nm^3/h)	755.467	1684.68	3494.48	8496.88	17375.7	32617.2	50932.2	84476.6
USM flowrate (Nm^3/h)	745.971	1681.39	3517.49	8588.96	17542.3	32830.1	51358.4	84381.5
Indication error	**1.26%**	**0.19%**	**-0.66%**	**-1.08%**	**-0.96%**	**-0.65%**	**-0.84%**	**0.11%**

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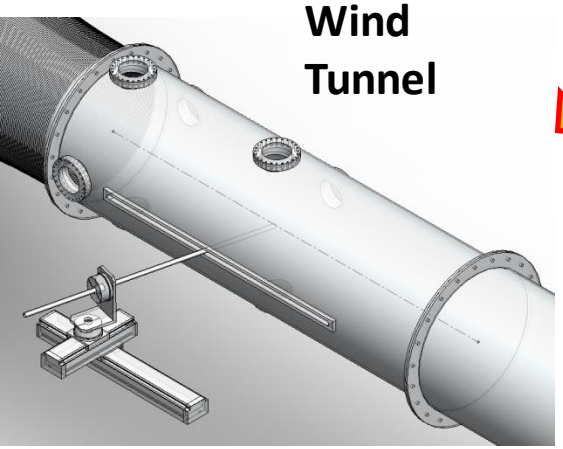
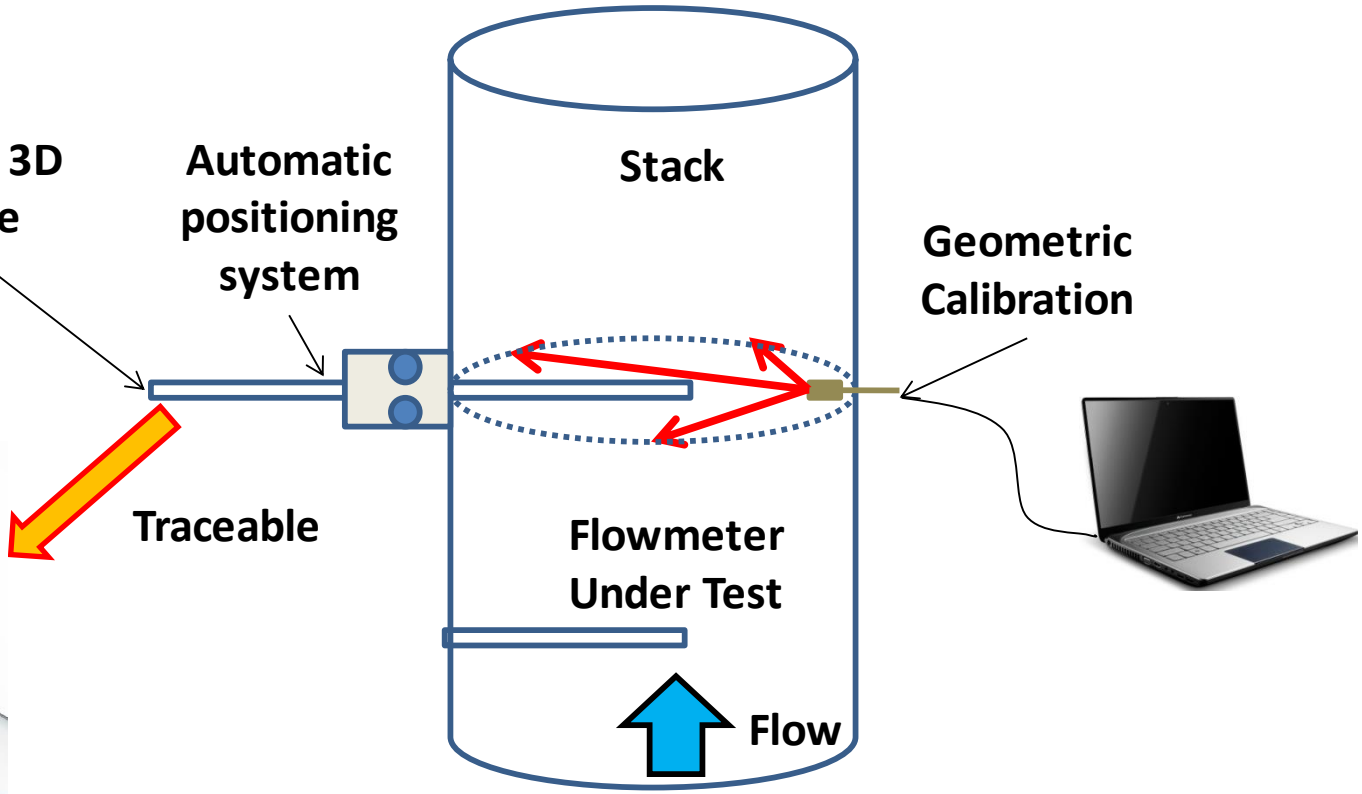
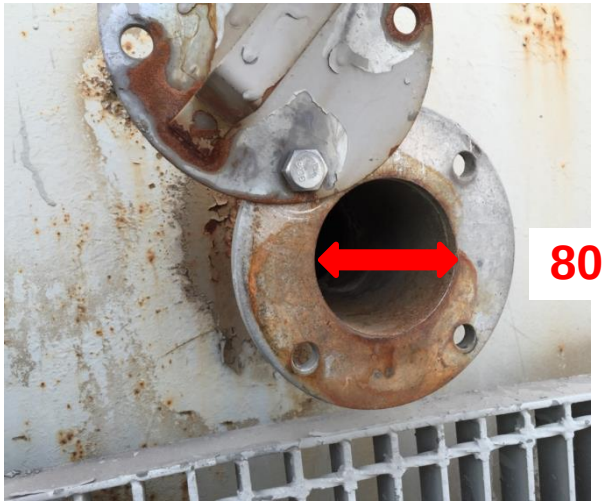
Field Calibration System



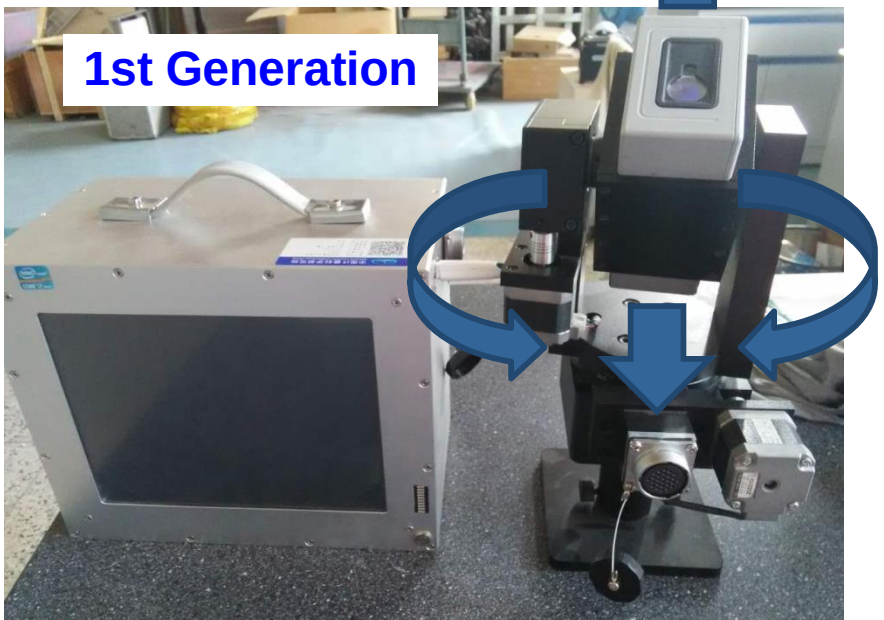


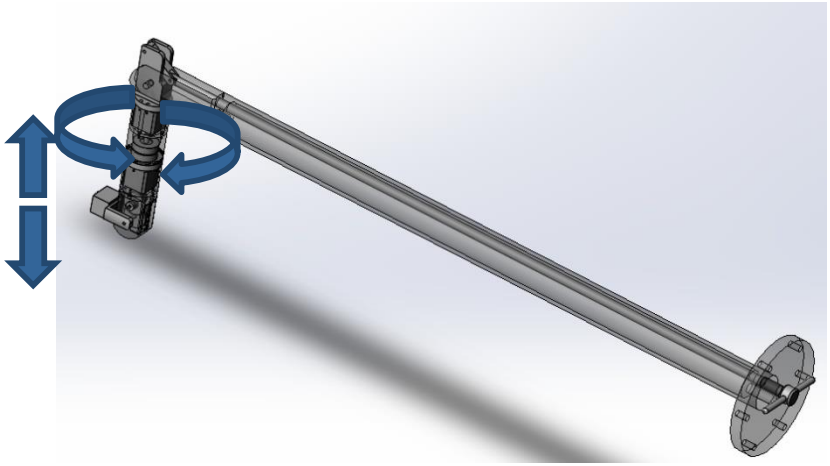
Field Calibration System

- Geometric calibration device



2nd Generation





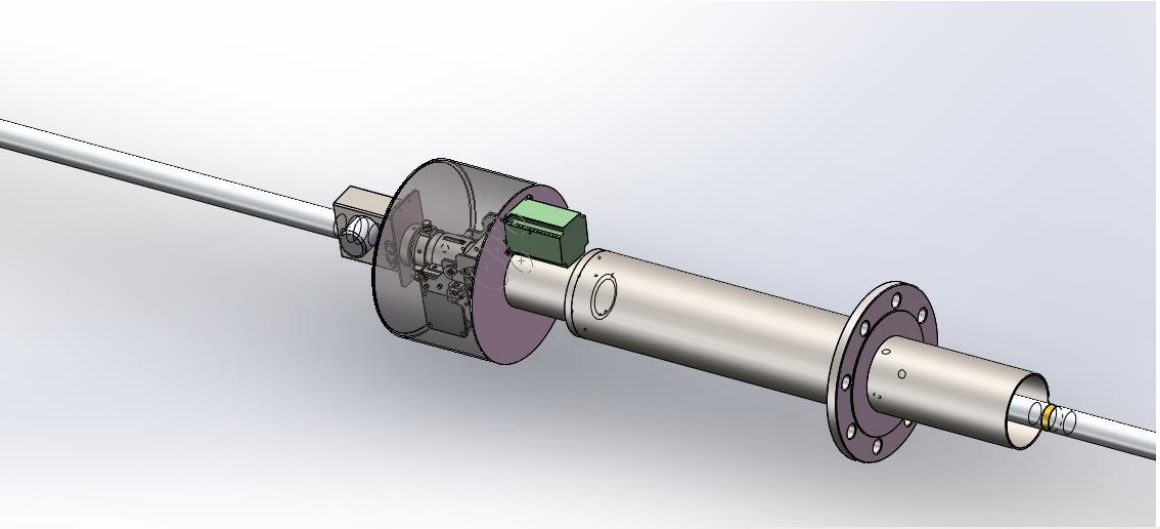
Field Calibration System

- Geometric calibration device

2nd Generation

Field Calibration System

- **Automatic pitot tube positioning system**



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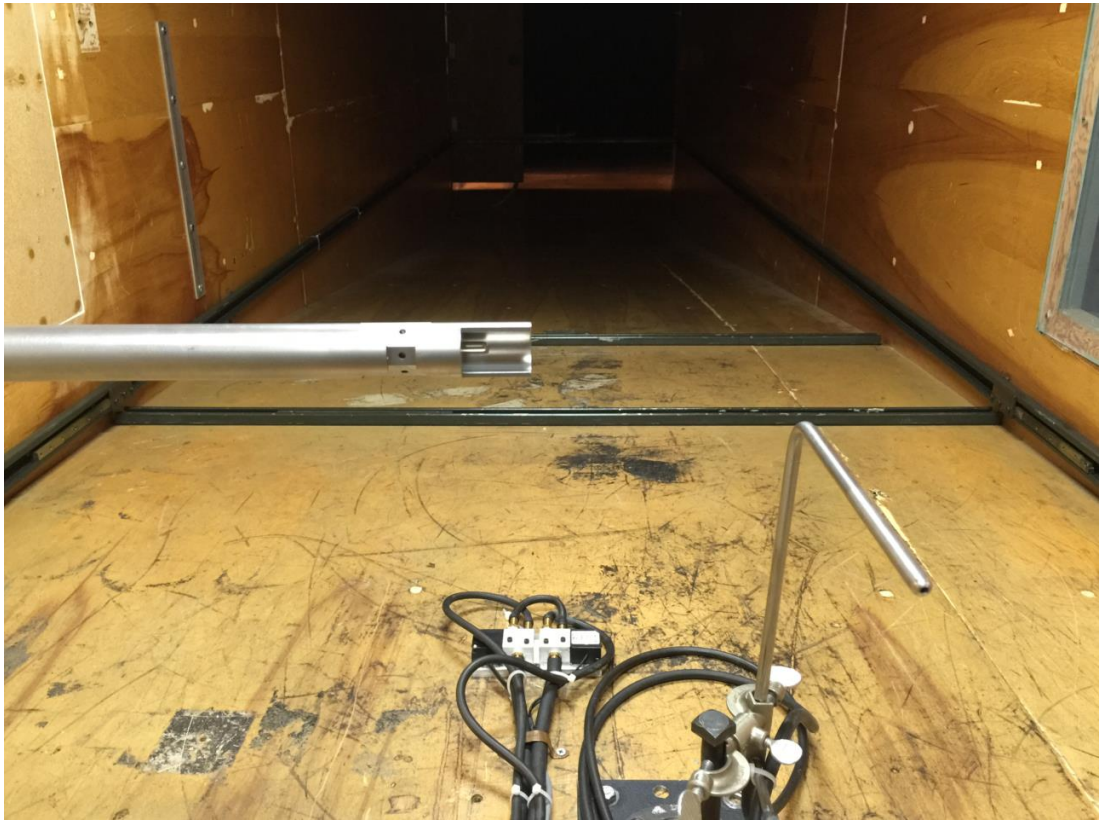
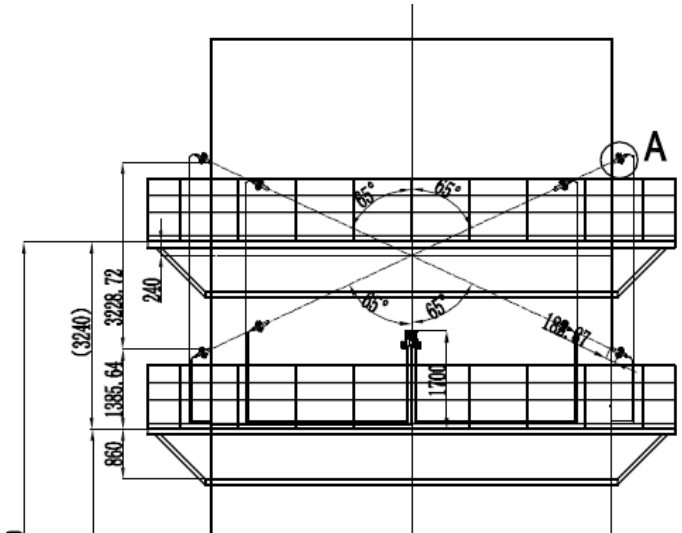
Field Tests

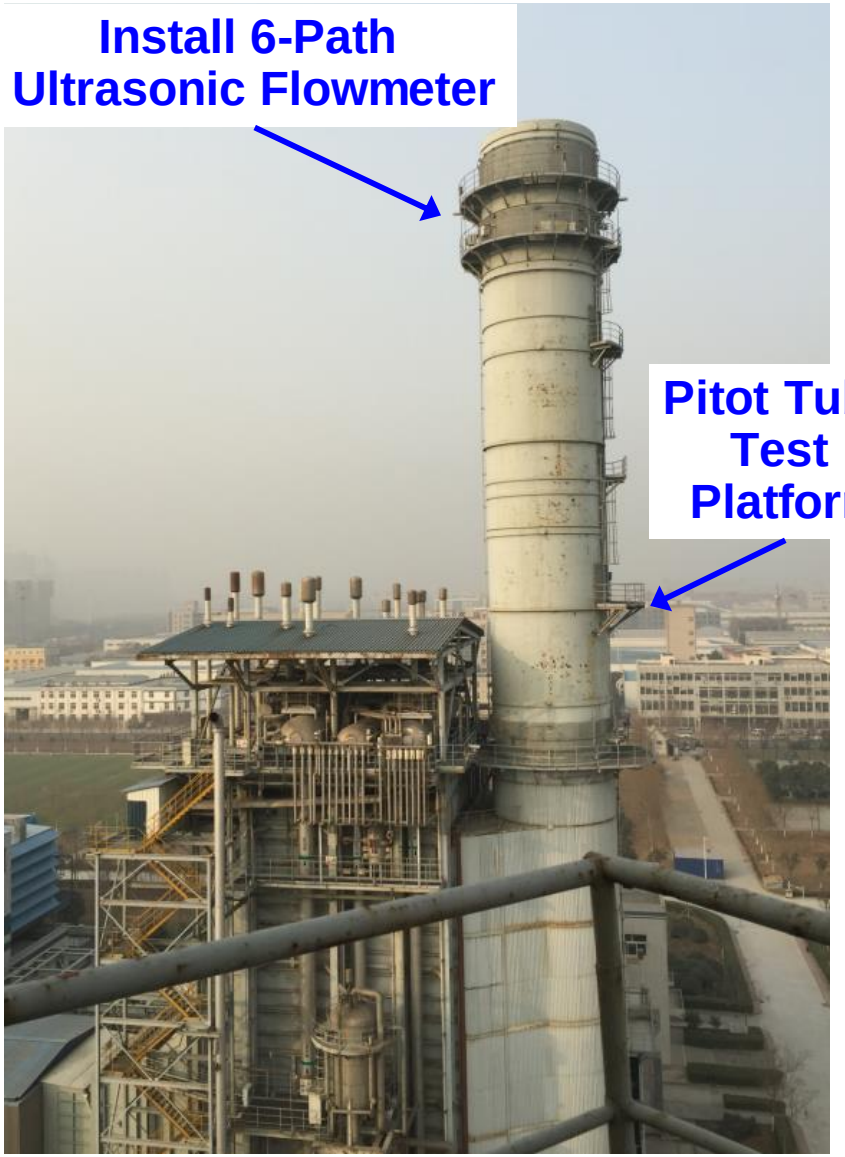
- Pitot tubes calibration in NIST wind tunnel



Field Tests

- Natural gas power plant



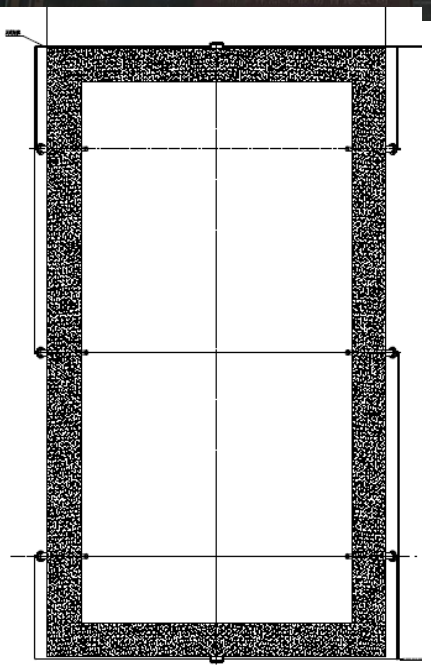


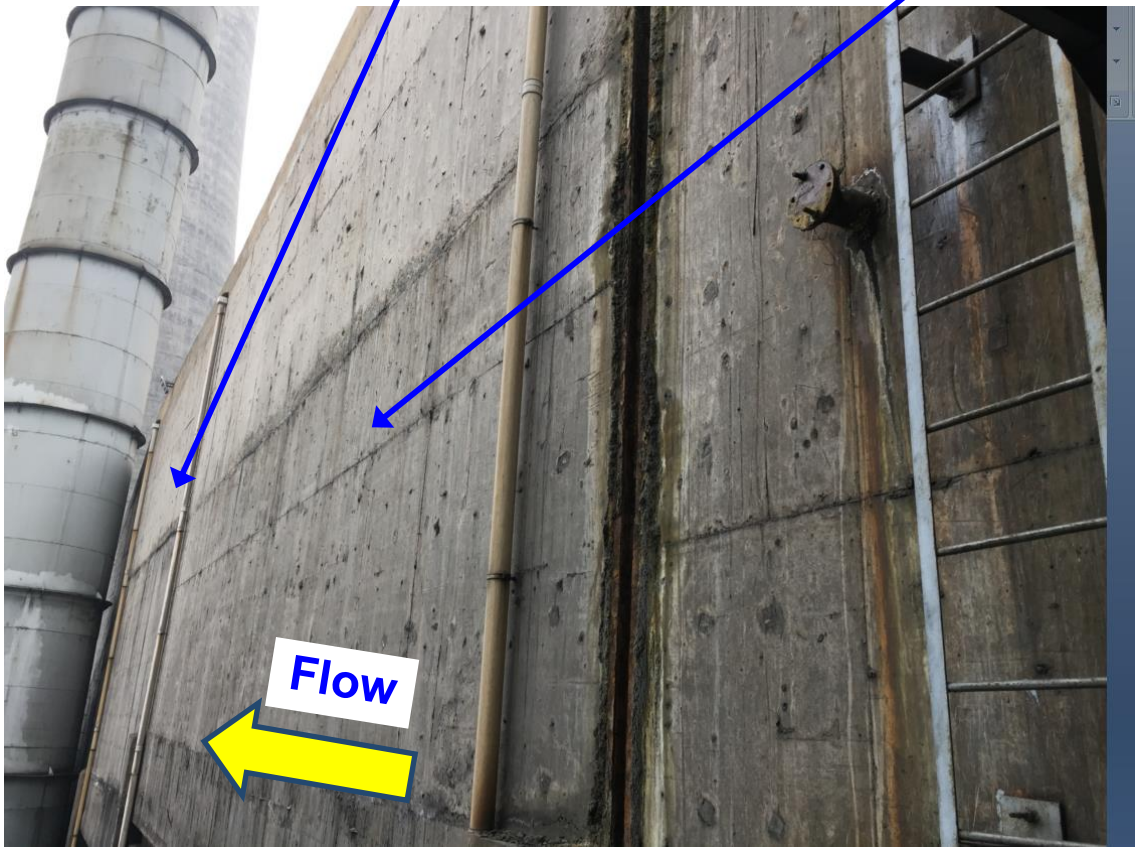
Field Tests

- Natural gas power plant

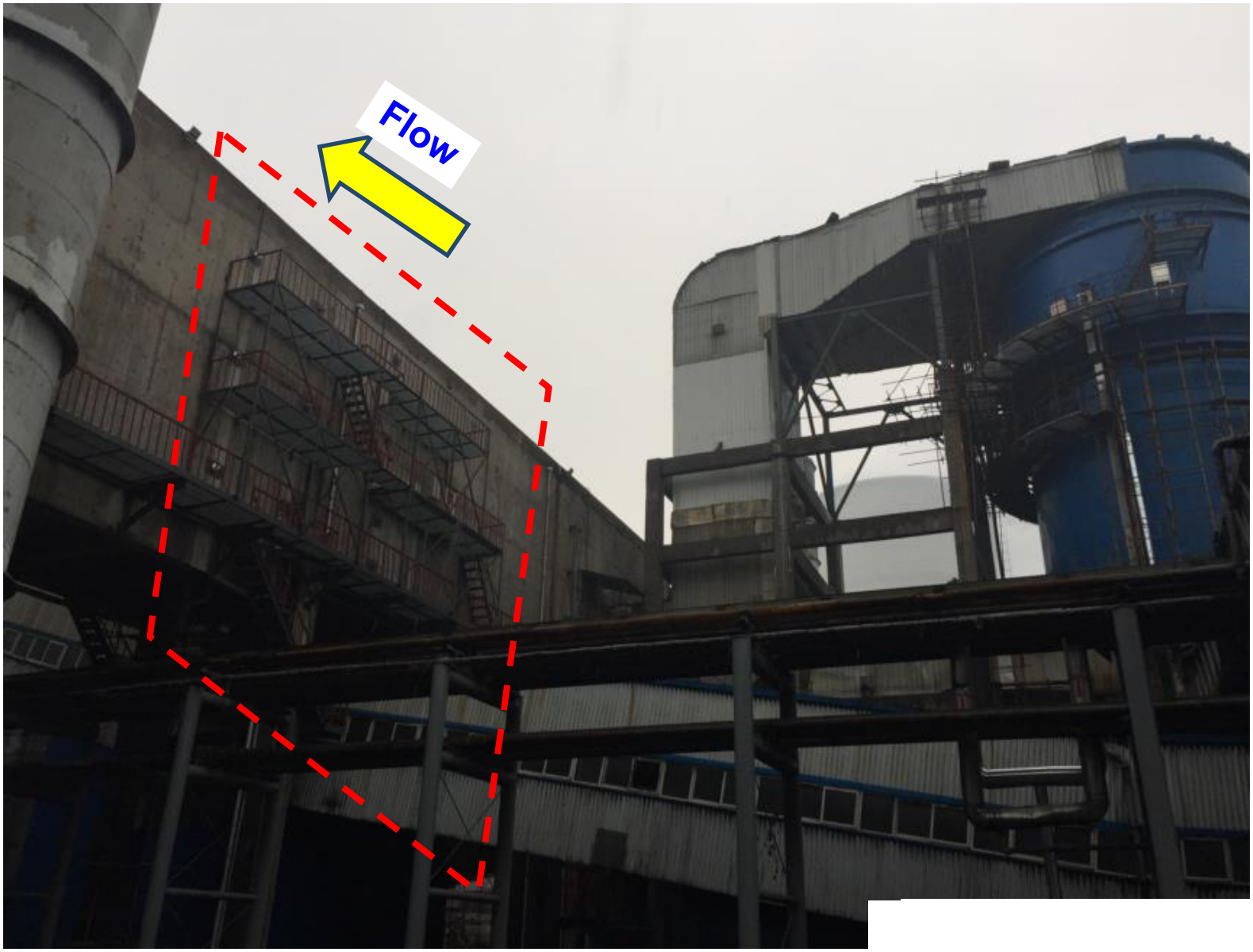
Field Tests

- Coal-fired power plant

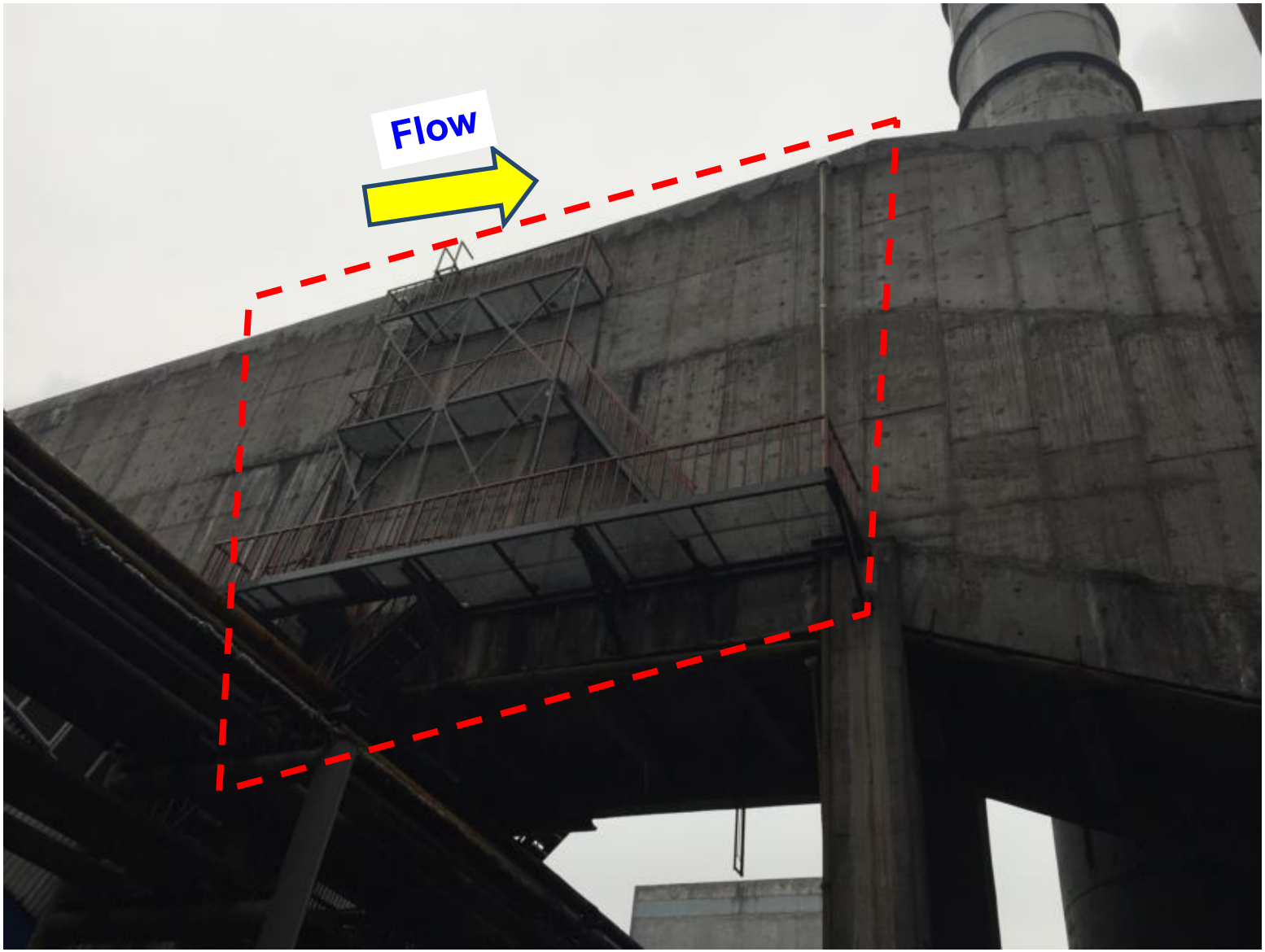




Field Tests



Field Tests



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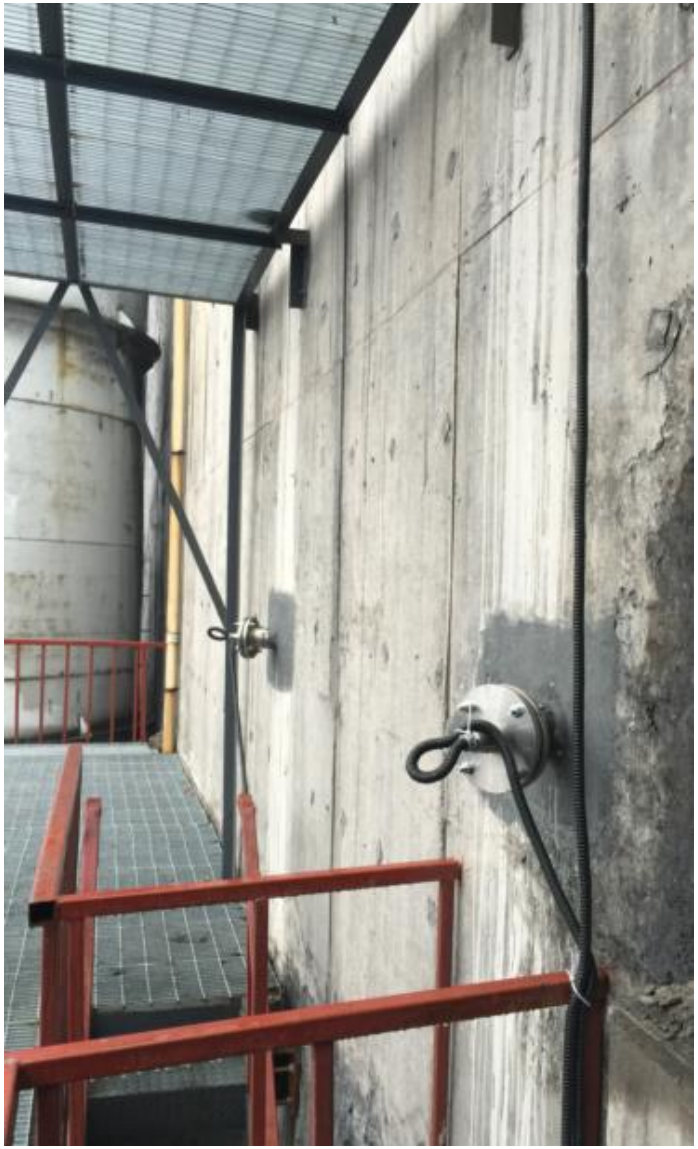
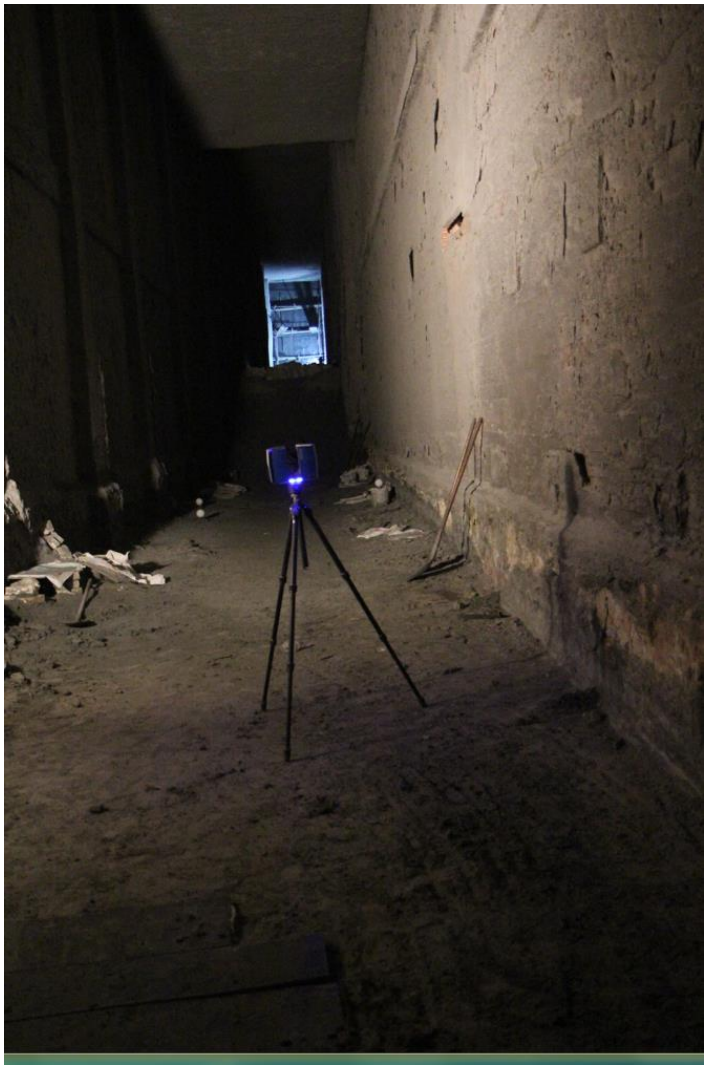
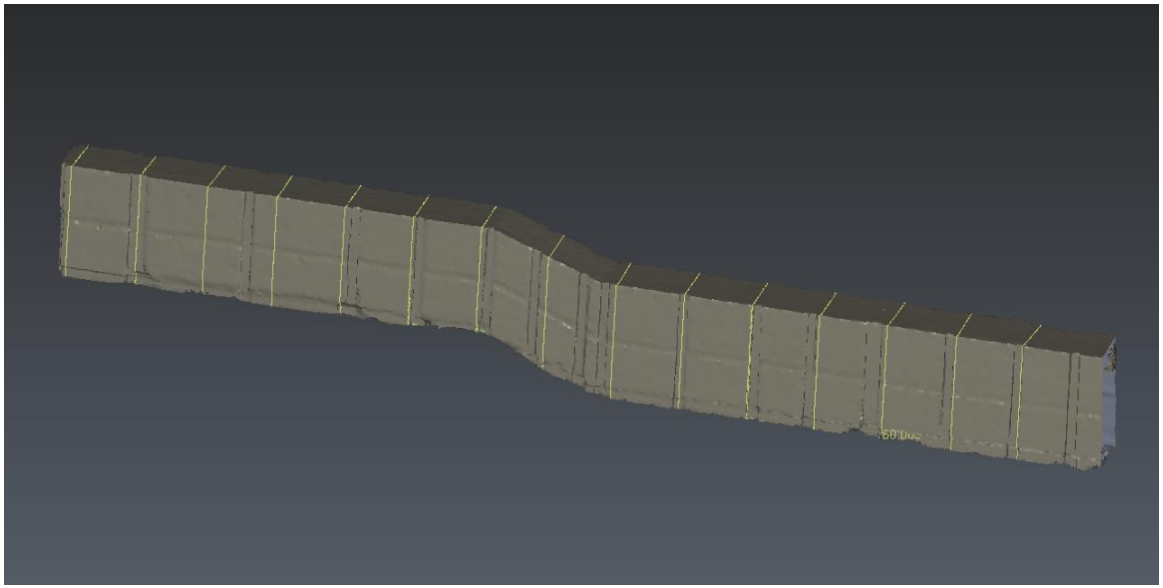


Field Tests

Field Tests

- Coal-fired power plant – 3D laser scanner

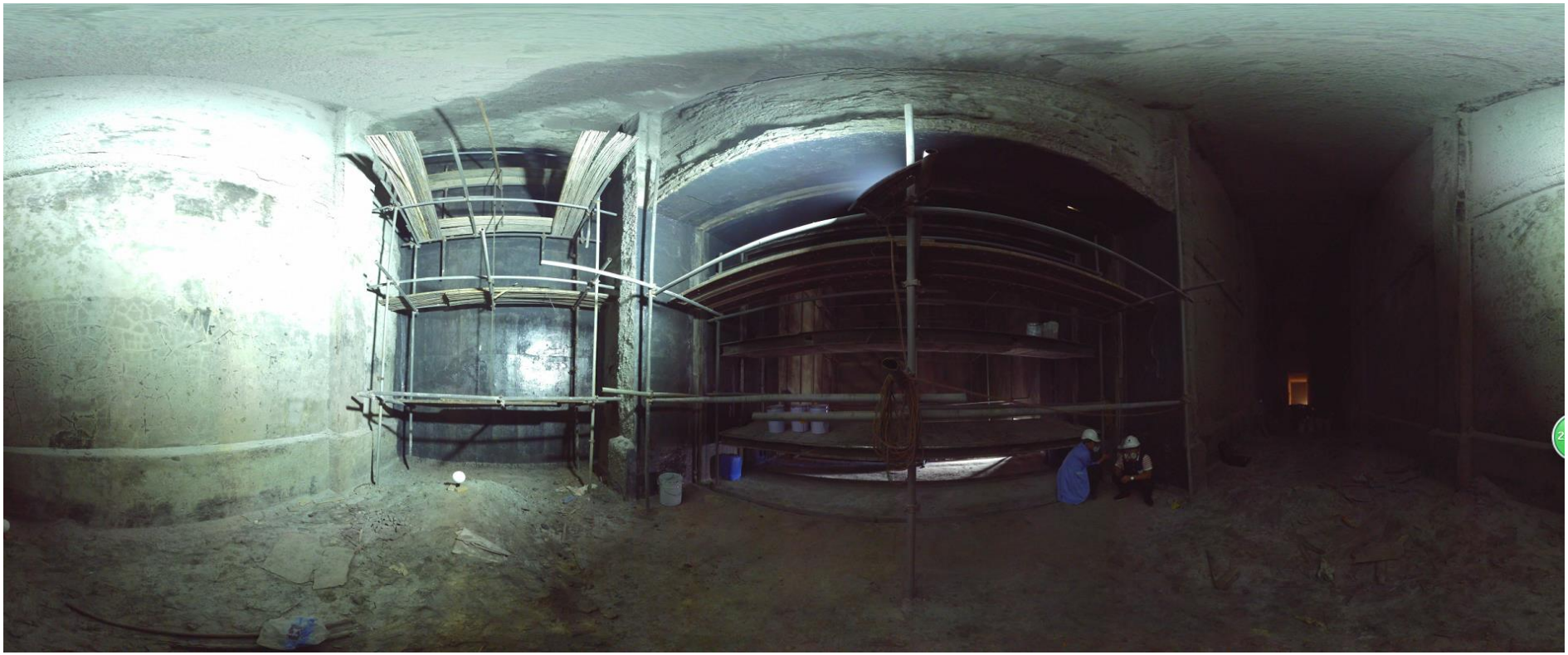




Comparison

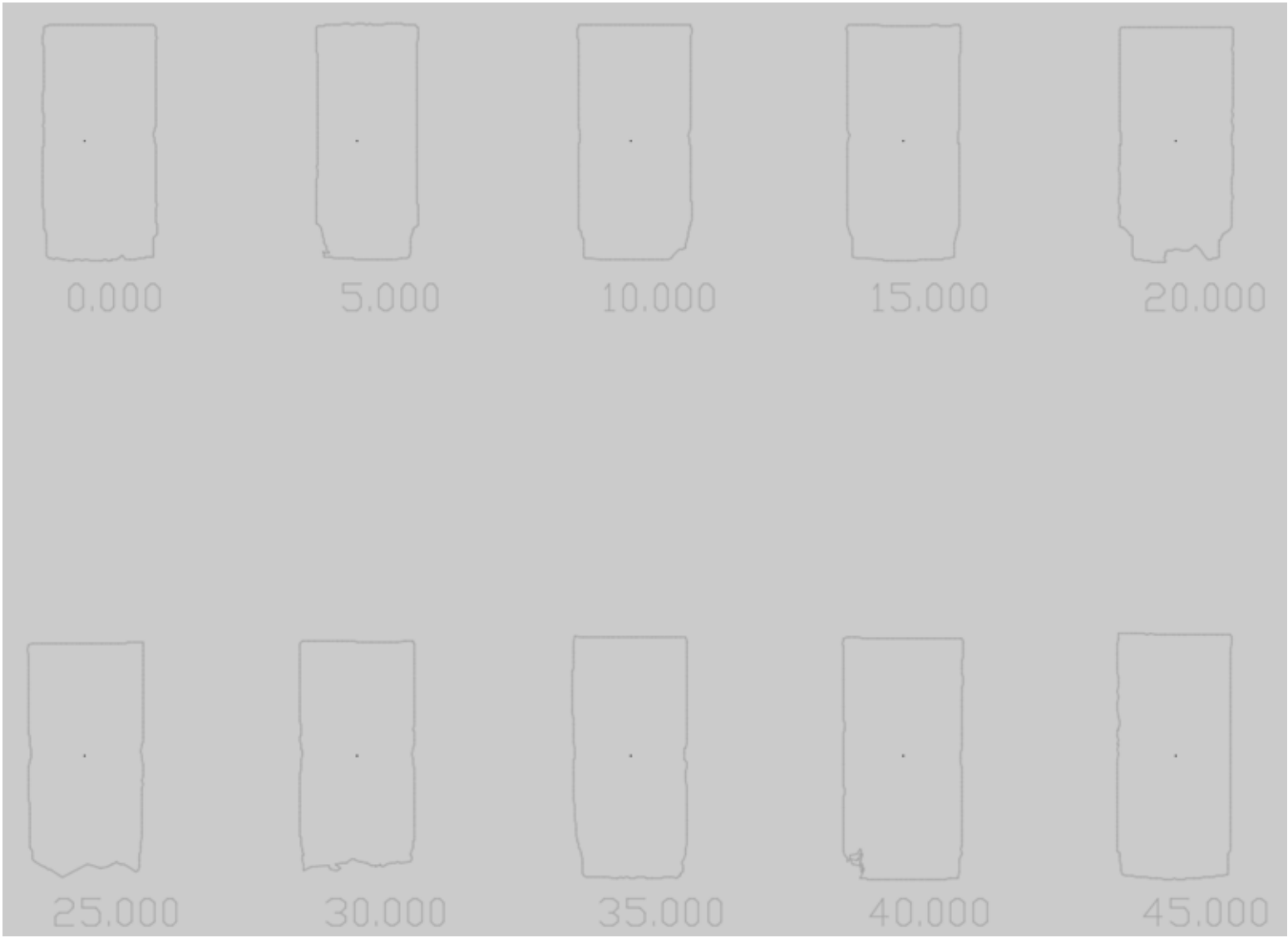
Field Tests

- Coal-fired power plant – 3D laser scanner



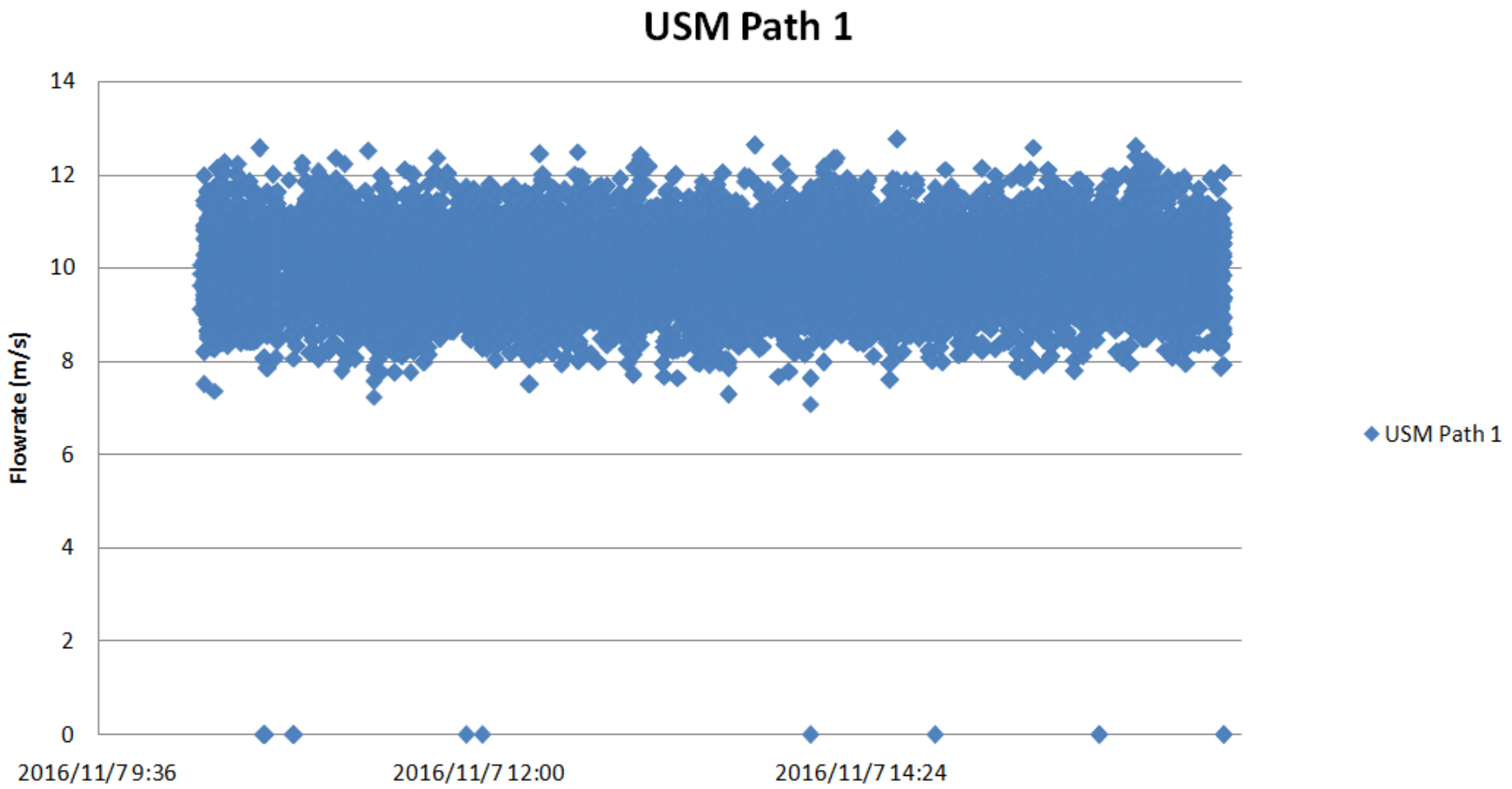
Field Tests

- Coal-fired power plant – 3D laser scanner



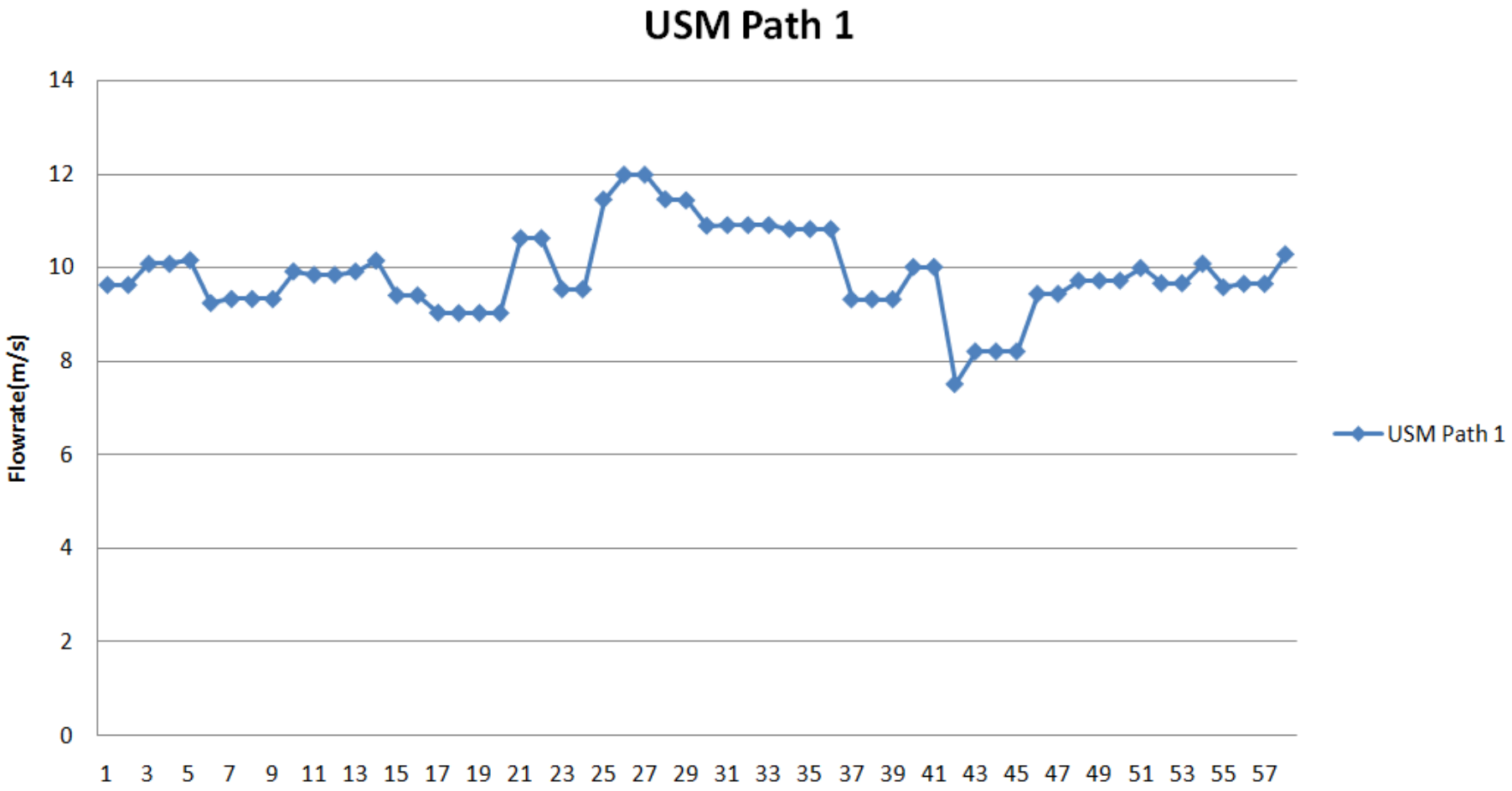
Field Tests

- Coal-fired power plant – Flowrate Measurement



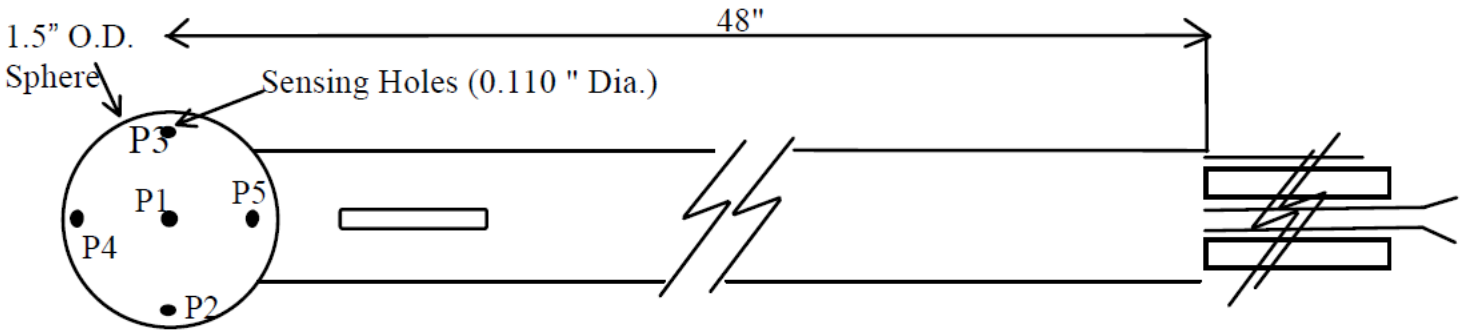
Field Tests

- Coal-fired power plant – Flowrate Measurement



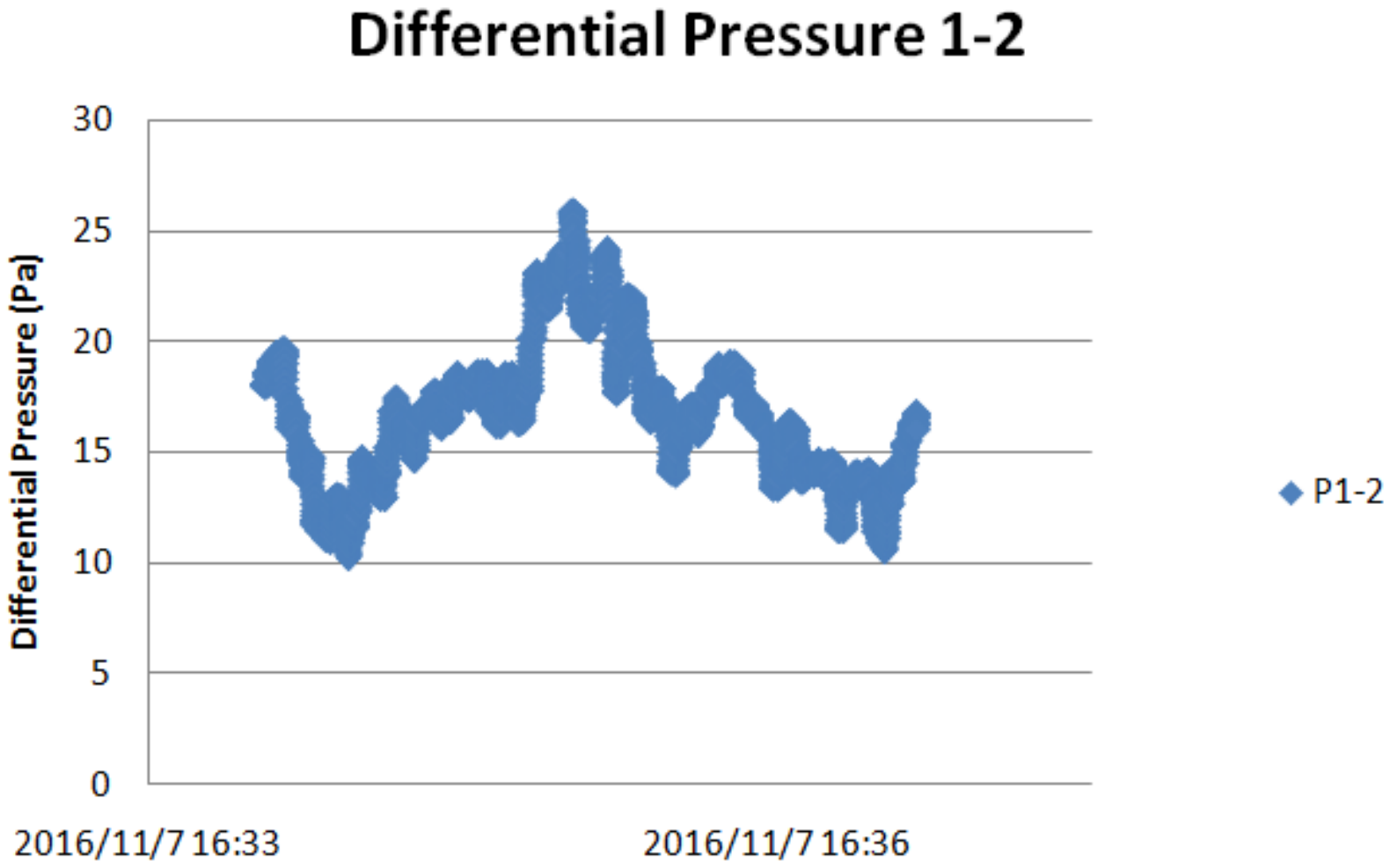
Field Tests

- Coal-fired power plant – Flowrate Measurement by pitot tube @ **10Hz**



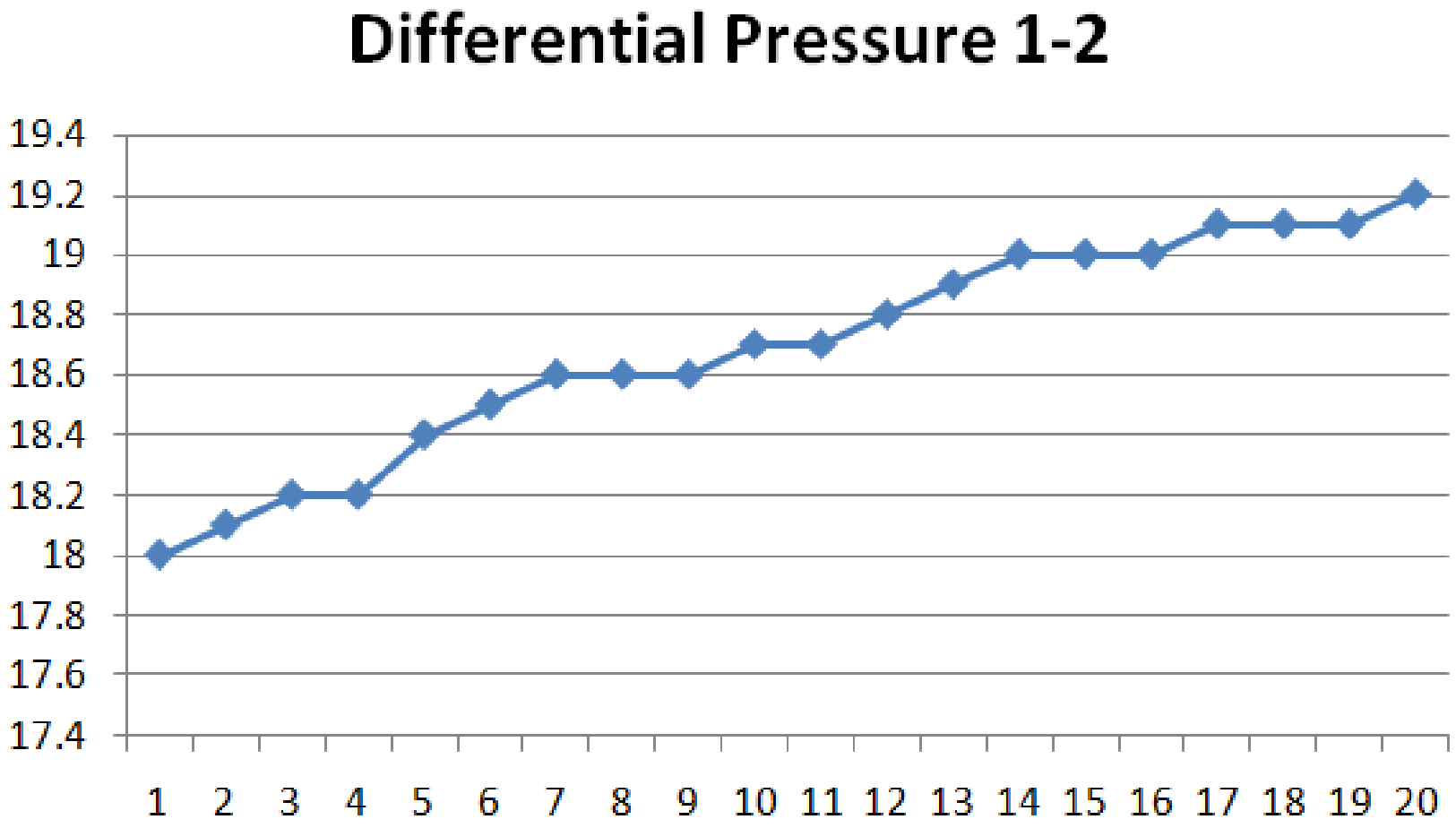
Field Tests

- Coal-fired power plant – Flowrate Measurement



Field Tests

- Coal-fired power plant – Flowrate Measurement



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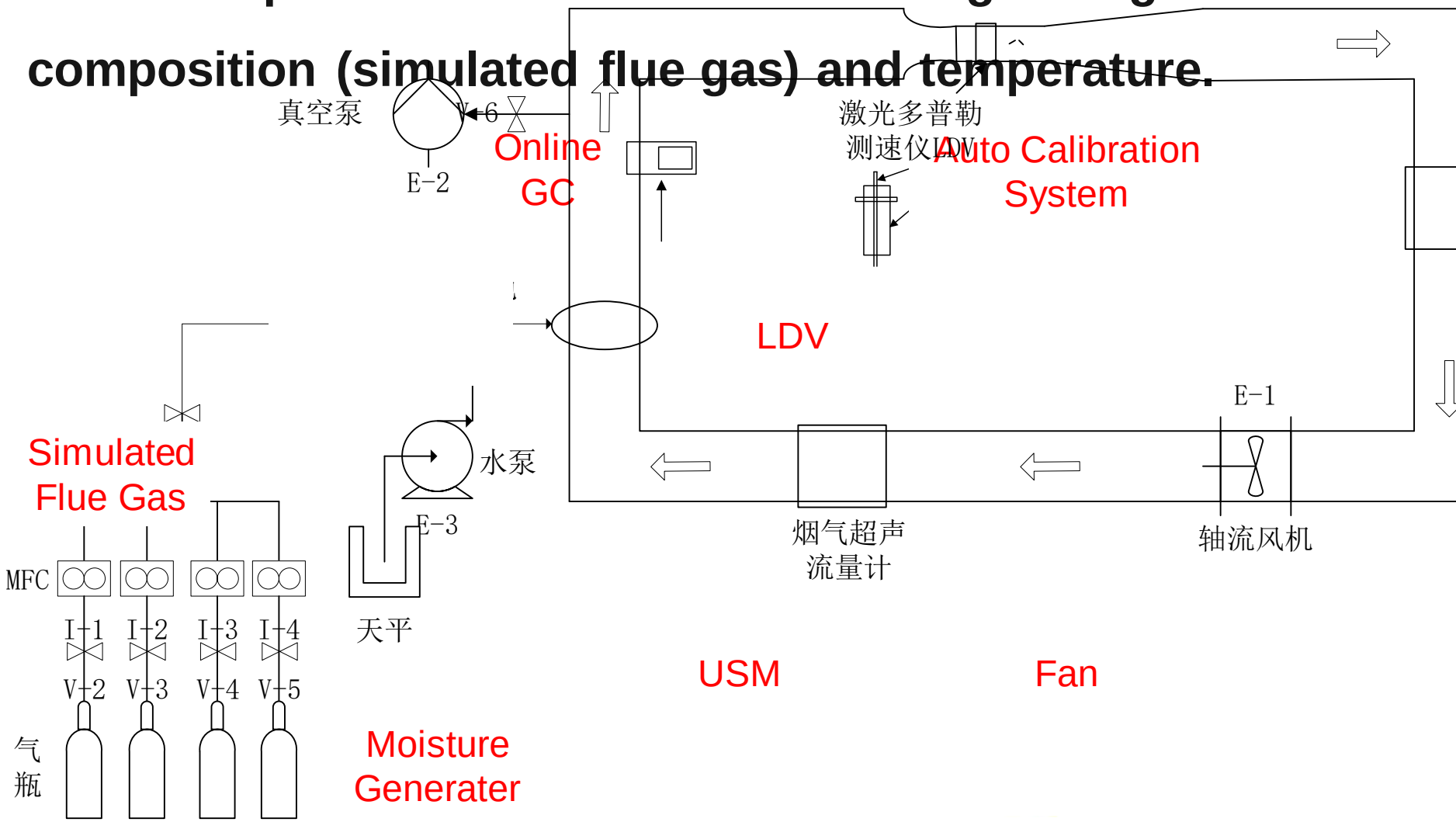
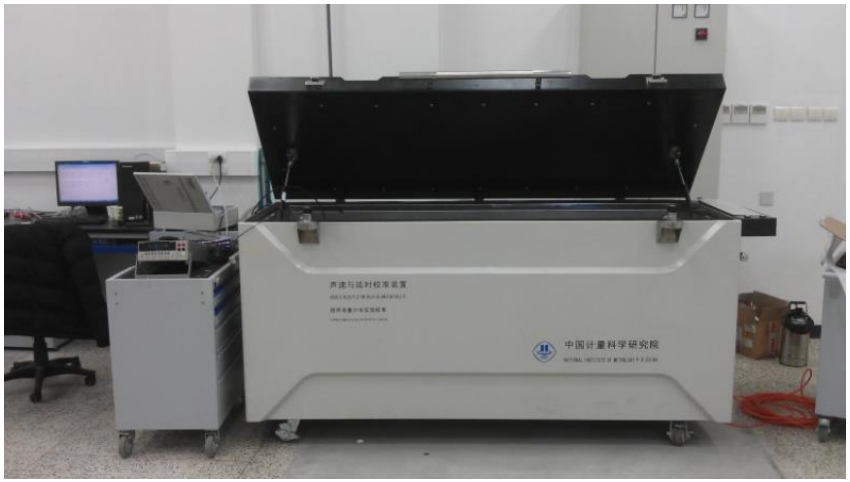
Future Work

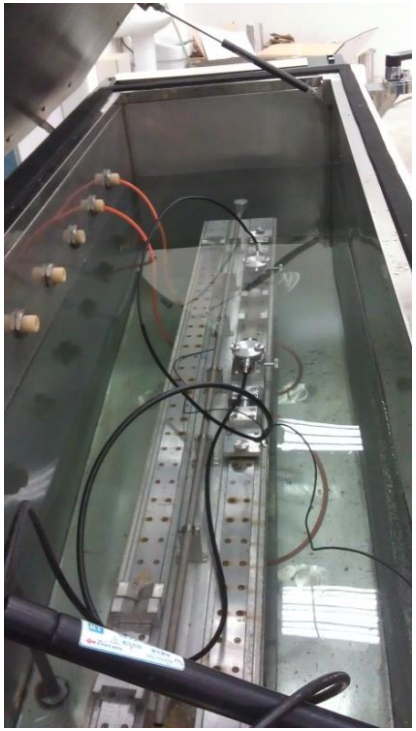
- Close loop wind tunnel which can change the gas composition (simulated flue gas) and temperature.



Future Work

- Dry calibration facility for flue gas USM





Future Work

- Other industry sectors (test 30 sites in 3 years)
  - Cement production
  - Glass production
  - Ceramic production
  - Chemical production
  - Non-ferrous metal production
  - Iron and steel production

Thank you for your attention

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