Setting the Standard for Automation™

LPG measurements by Suncor & GWI – *Control You Can Measure*:

A Novel Configuration for Near-Infrared Analysis of LPG Composition and Quality Control in a Refinery Setting.

Shashi Mistry, Nate Peters, Dian Wang, Suncor Energy
Susan J. Foulk, Terry R. Todd Guided Wave, Inc.

Standards
Certification
Education & Training
Publishing
Conferences & Exhibits

Presenter- Debra Hall

- Debra Hall was appointed VP Sales & Marketing, Analytical Products, Americas of Advanced Holdings in May 2015.

- Debra has over 20 years of experience in Process Industrial Analyzer Sales Management worldwide for the Chemical Industry in gas and liquid measurement solutions. With a Bachelor's Degree in Electrical Engineering from New Jersey Institute of Technology she helps companies improve their processes both from a technical and economical standpoint.

Overview

- Background
  - Terminology
  - Measurement locations
- NIR review
- Hardware
- Data review
- Performance

Background

- Suncor Edmonton Refinery
  - Processes 142,000 barrels of oil/day
  - Extensive NIR installation onsite
  - Improved production and blending capabilities[1].

- Guided Wave, Inc.
  - Designs and manufactures NIR and UV/Vis spectrometers
  - Photometers, probes, and fiber optics for process installations.

1. Real-time Optimization of a Gasoline Run-down Header Blending Operation. Shashi Mistry, Craig Mangan, Jim Eshpeter, Suncor Energy, Edmonton, Canada. Sanjay Sharma, Honeywell International, Houston, Texas.

Terminology

- LPG
  - Liquefied petroleum gas; Primarily propane and butane
  - Produced during oil refining or extracted during the natural gas production process
- LNG
  - natural gas cooled to a liquid state; primarily of methane (typ 90%+).
  - May also contain propane, ethane, and other heavier hydrocarbons
  - The composition of natural gas from can vary slightly from locations.
- Hydrocracker (HCU)
  - A petroleum refining process that upgrades heavier fractions to more valuable products (LPG, naptha, diesel,kerosene, etc)
  - Removes hetero-atoms such as S, N, etc and adds hydrogen to the cracked hydrocarbon molecules.

Background

- Composition analysis of LPG is typically carried out by gas chromatography (GC).
- LPG - need to control the purity of both Butane and Propane for the export market as well as to stabilize the process unit.
- The LPG analyses must work for the entire operating range of the HCU.
- The goal is to measure the concentrations of the C1-C4 alkanes in liquid phase.

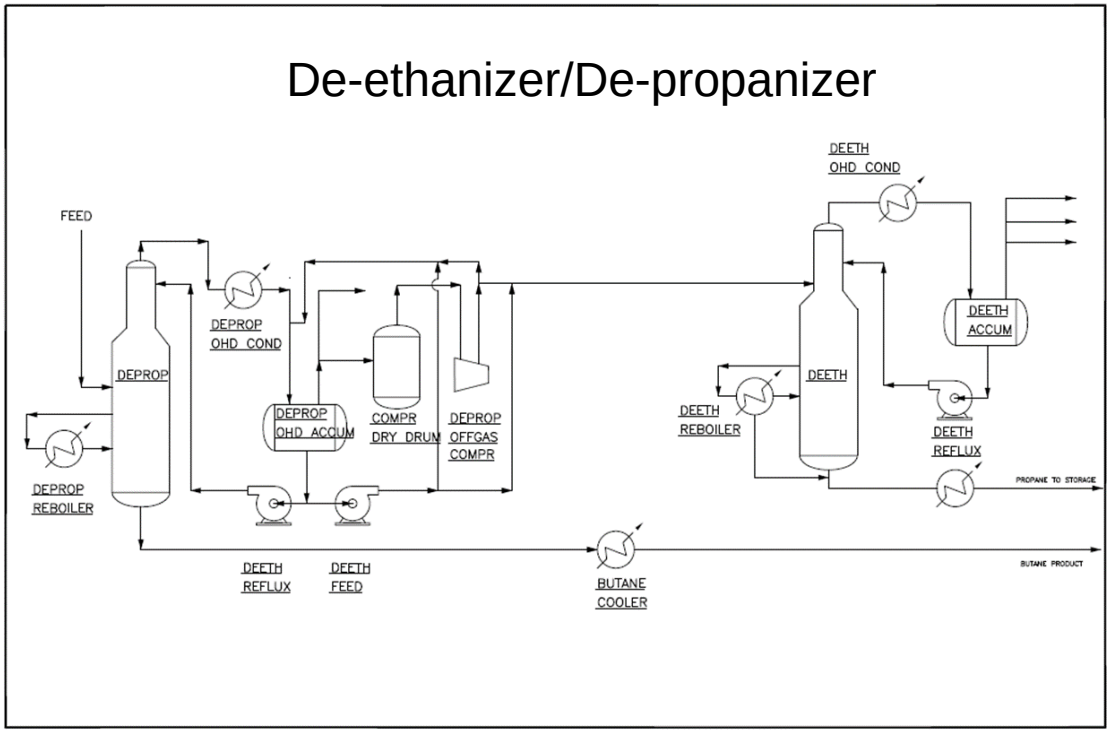
Measurement Locations

A multi-channel Near-Infrared analyzer was installed on the Hydrocracker fractionation unit (HCU) on following columns:

1. Main fractionator unit (Naphtha) ; NIR Analyzer
2. Main fractionator unit (light distillate) ; NIR Analyzer
3. Main fractionator unit (Heavy distillate) ; NIR Analyzer
4. De-propanizer bottoms stream (Butane analysis) ; GC
5. De-ethanizer bottoms stream (Propane analysis) ; GC

Measurement Locations

- GCs installed for Analysis of Butane and Propane streams.
- Suncor shifted to NIR technology for these LPG measurements.
- Due to the need to improve on quality, uptime and to reduce analyzer maintenance costs



NIR Review

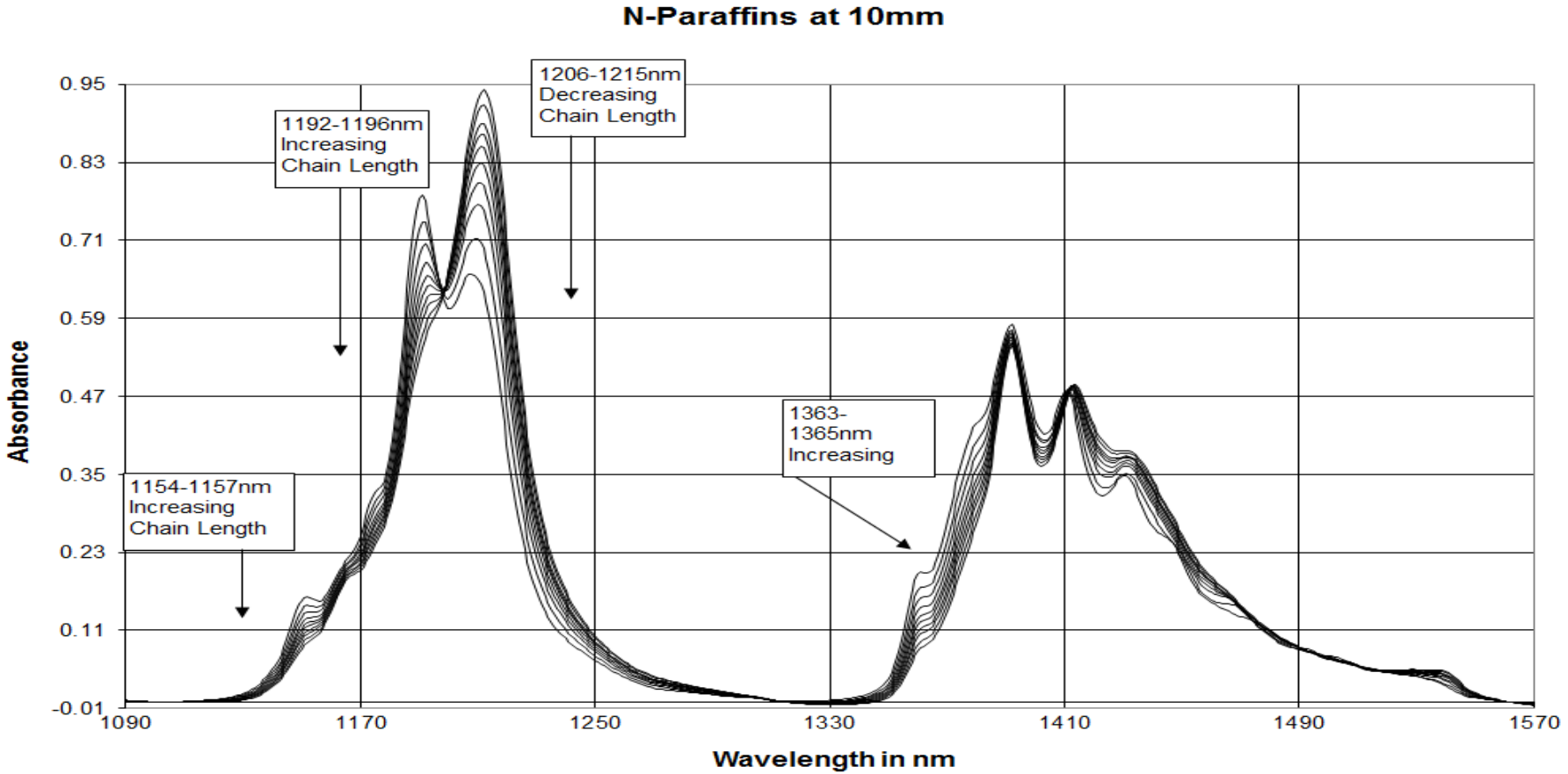
- Suncor intends to economically optimize the HCU using the NIR measurements on all streams.
- An HCU multi-variable controller is incorporated for QC using five NIR measurement points.
- NIR allows Suncor to achieve speed of quality control at a much reduced cost over the long term.

Measurement Details

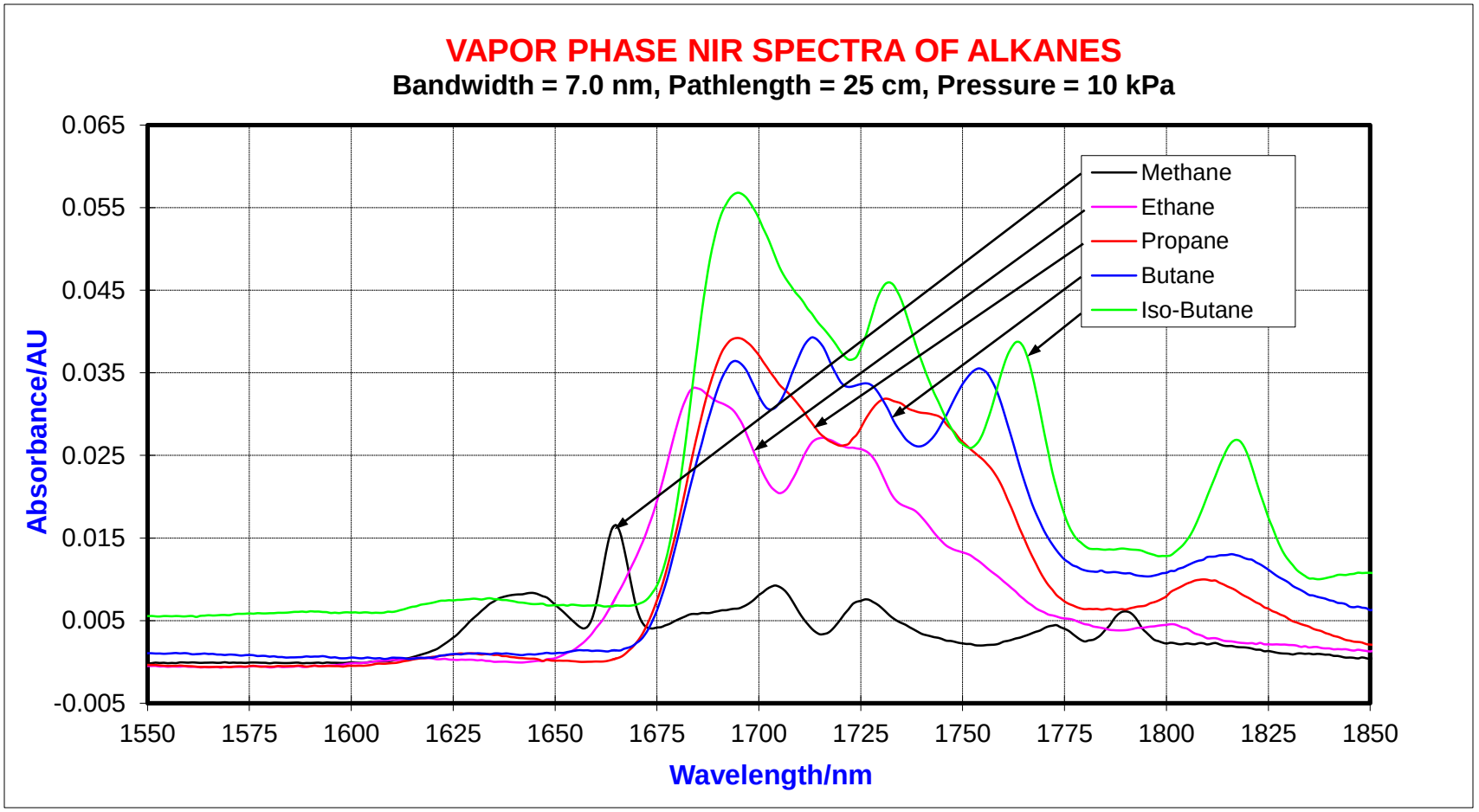
- NIR Spectroscopy
  - Powerful measurement technology for either gas or liquid phase samples
  - Allows for remote placement of sample interface via fiber optics
  - Multiple property predictions (HC's,vapor pressure, 90% distillation,etc).
  - Rapid Analysis of sample streams
  - Instantly reveals plant upsets/product quality drop-off, etc
- Liquid phase measurements
  - Short pathlengths, easy to clean and maintain
- Gas phase measurements
  - Long pathlengths required to achieve low detection limits
  - Probes more costly, more difficult to clean

Typical Liquid Alkanes NIR Spectra

Pentane through Hexadecane



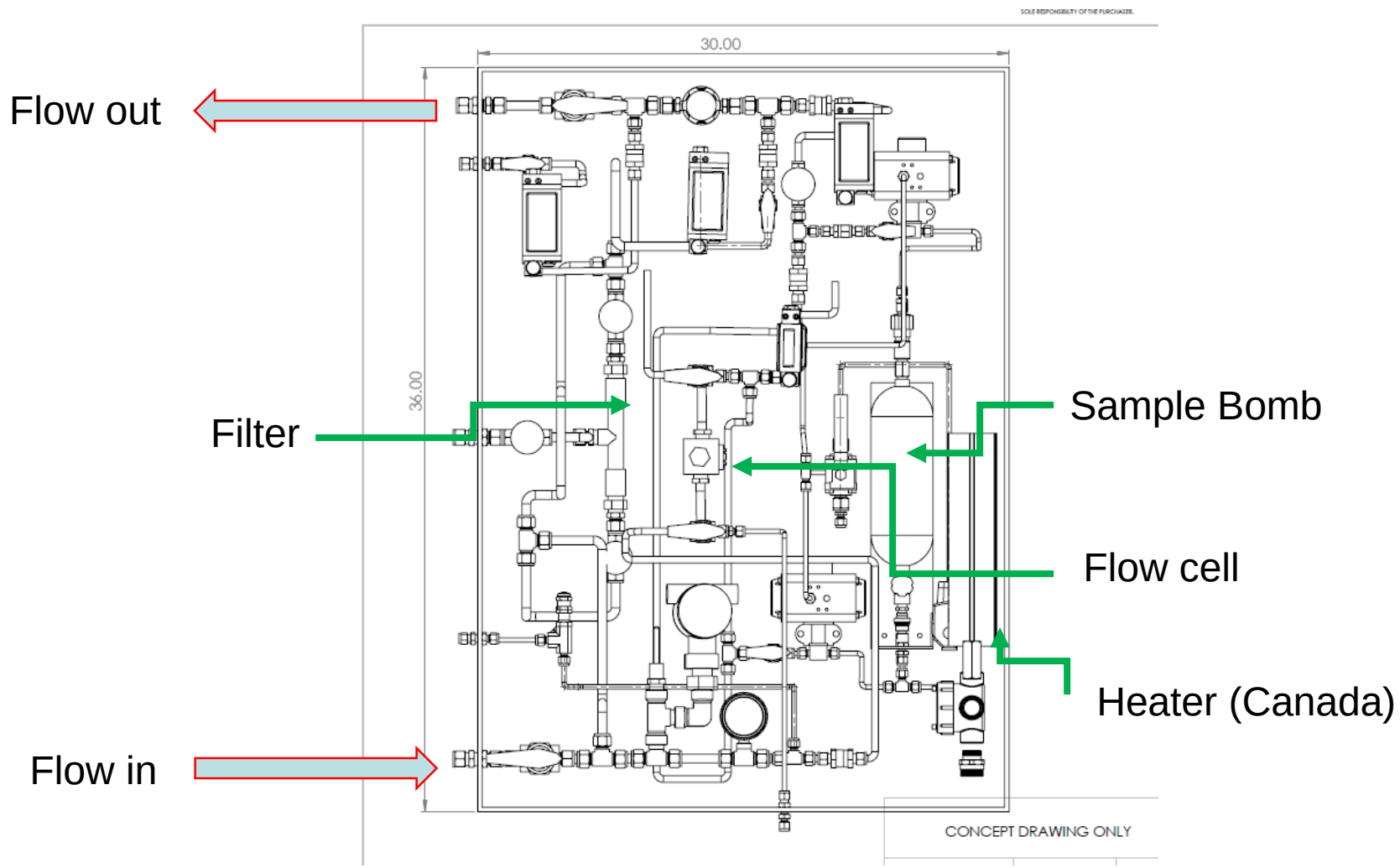
Short Chain Alkanes – Gas Phase NIR Spectra



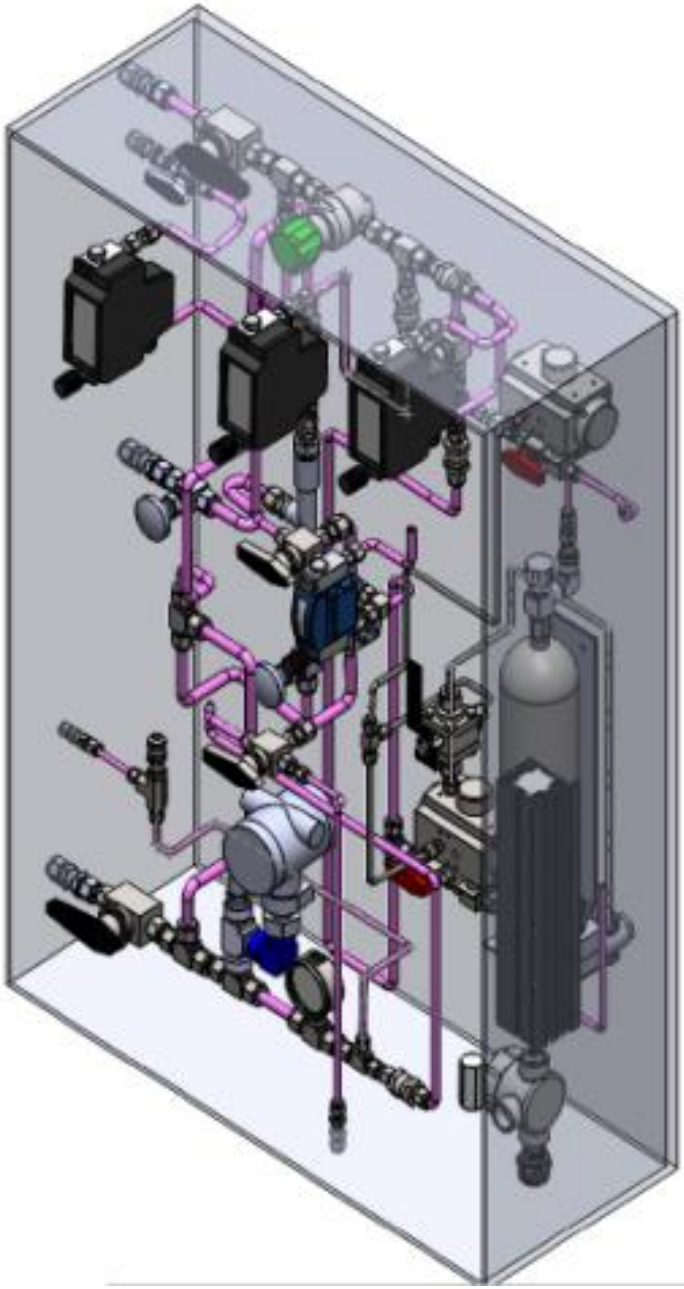
Measurement Hardware & Software

- Guided Wave M412 xNIR Spectrometer
- 10 mm multi-purpose flow cell on each stream (CRN certified - 500psi at 200°C [392°F])
- Sample conditioning / collection system
- Single strand fiber optics between flow cell and M412 analyzer
- Guided Wave Class-PA process monitoring software
- Unscrambler® multivariate models

Sample Collection



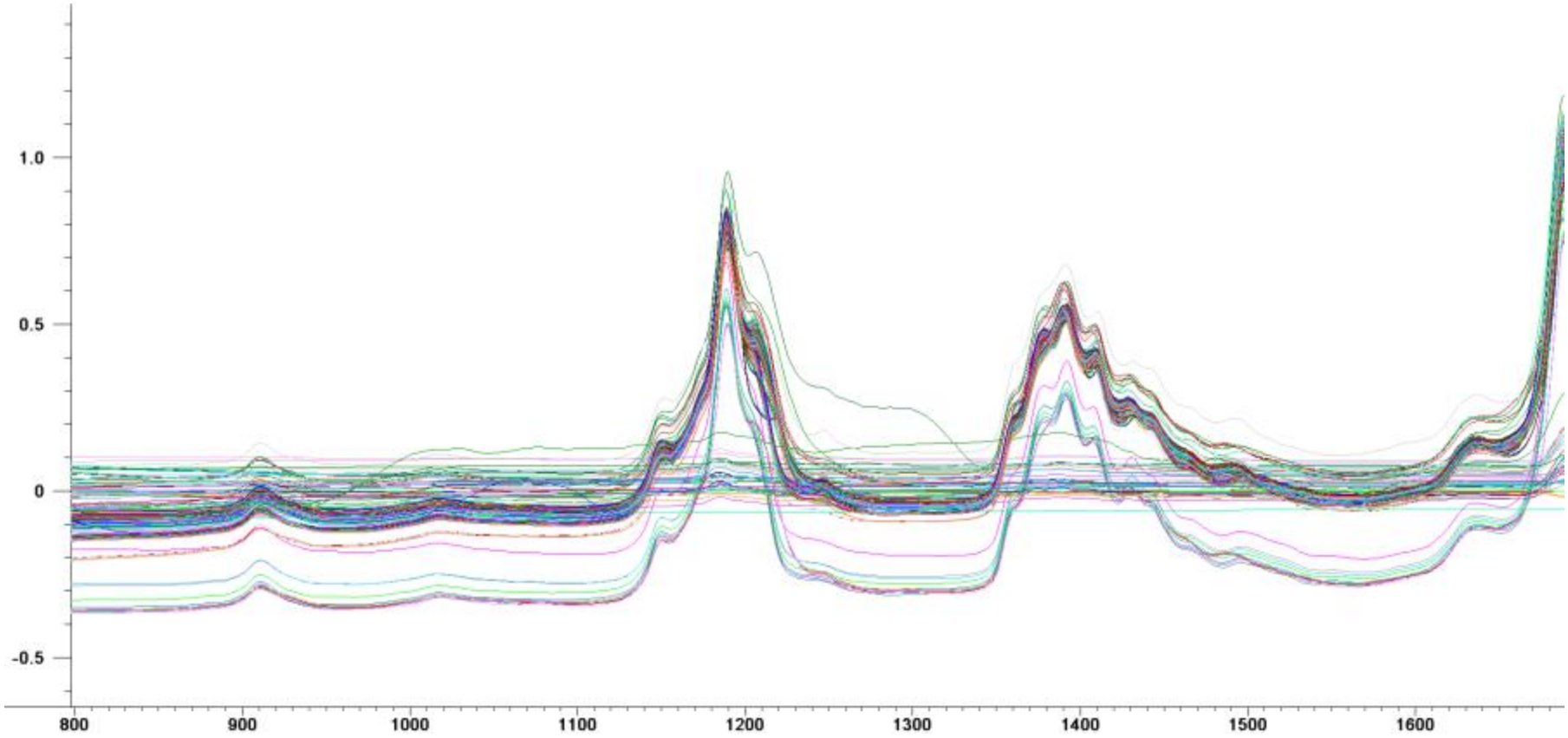
Sample Collection



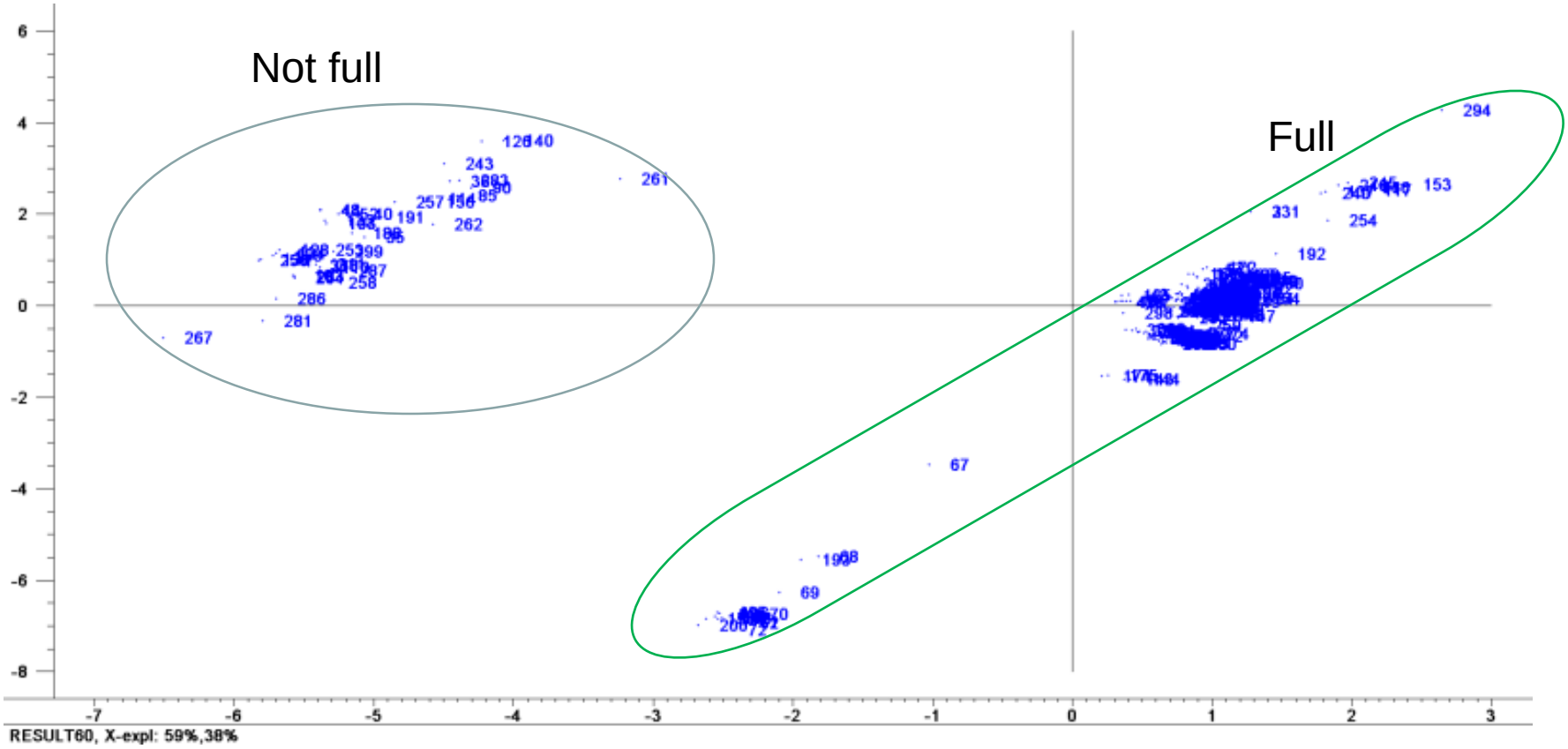
NIR Measurement

- Conditions
  - 10 mm pathlength
  - Temperature depends on stream
  - Pressure is sufficient to maintain liquid state
  - 4 co-adds
  - Range 800-1700 nm
- Challenges
  - Cell not full (mixed gas / liquid)

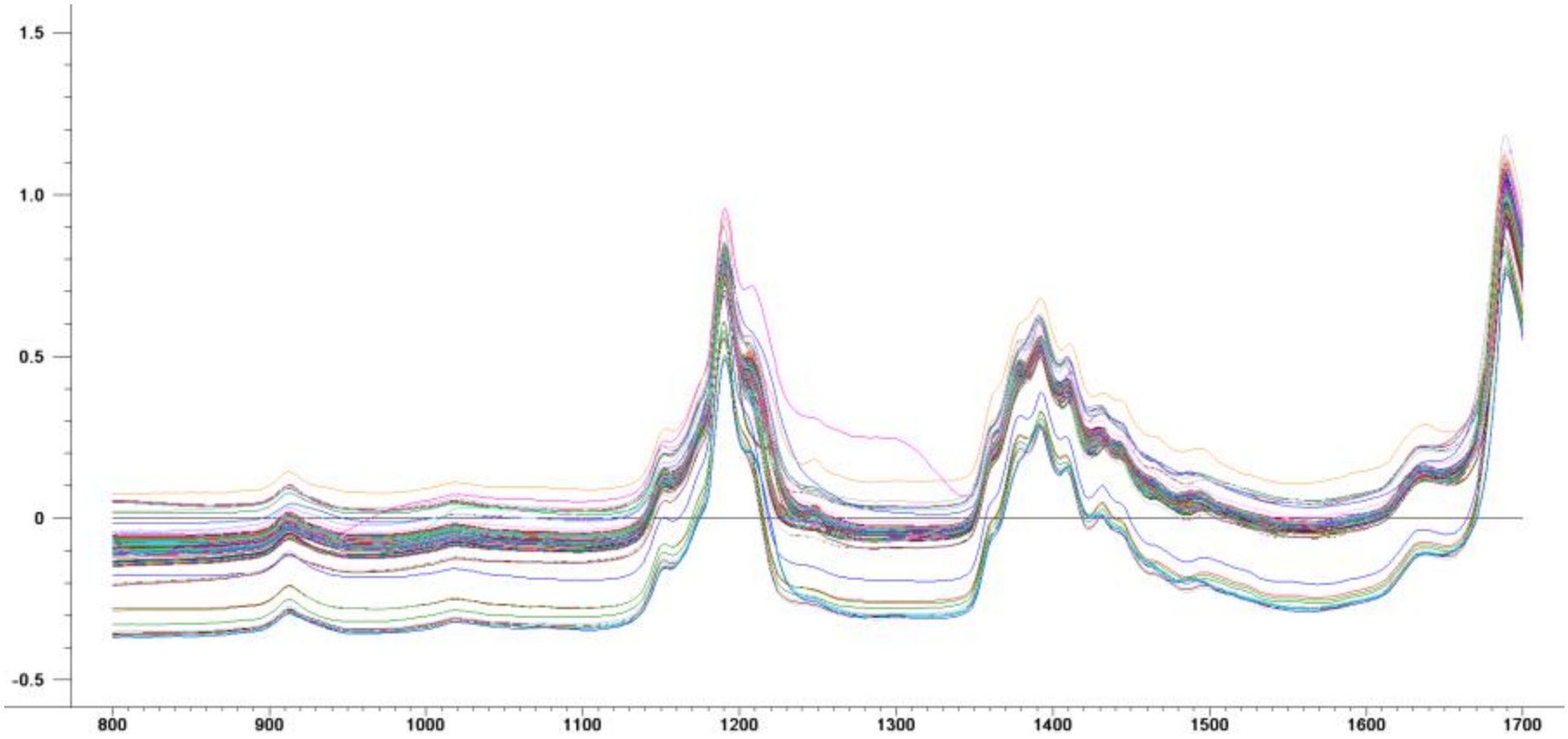
Raw Data



Segregate spectra when cell is not full



Full Cell Spectra – Propane / Butane line



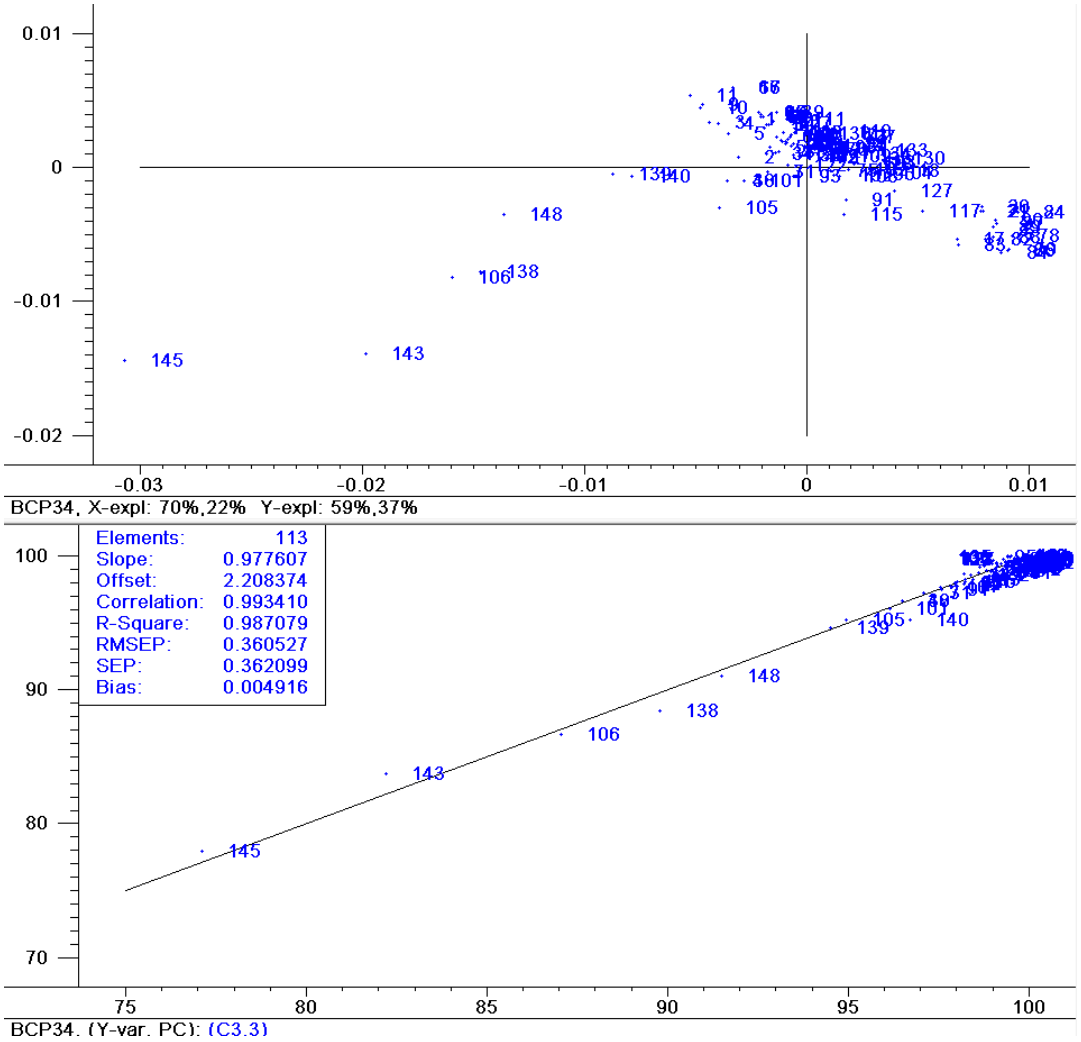
Models

- C2 (ethane) [for propane stream only]
- C3 (propane)
- iC4 (iso-butane)
- nC4 (normal butane)
- C5+ [for butane stream only]

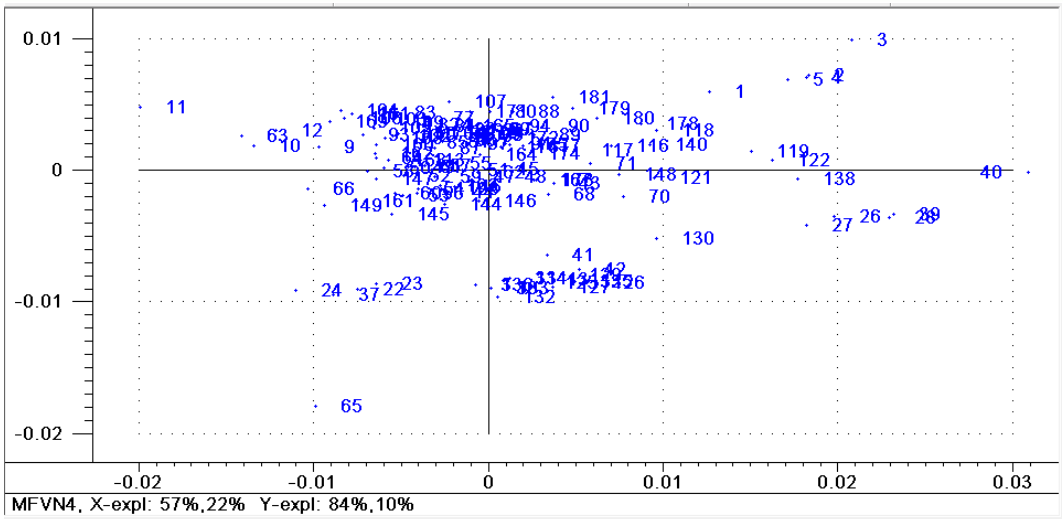
Modeling

- All models generated with the Unscrambler® software
- Pre-processing standardized at 1st deriviative
- All models are PLS-1
- Some parameters have a limited concentration range

Model – C3 / Propane stream



Model – nC4 / Butane stream

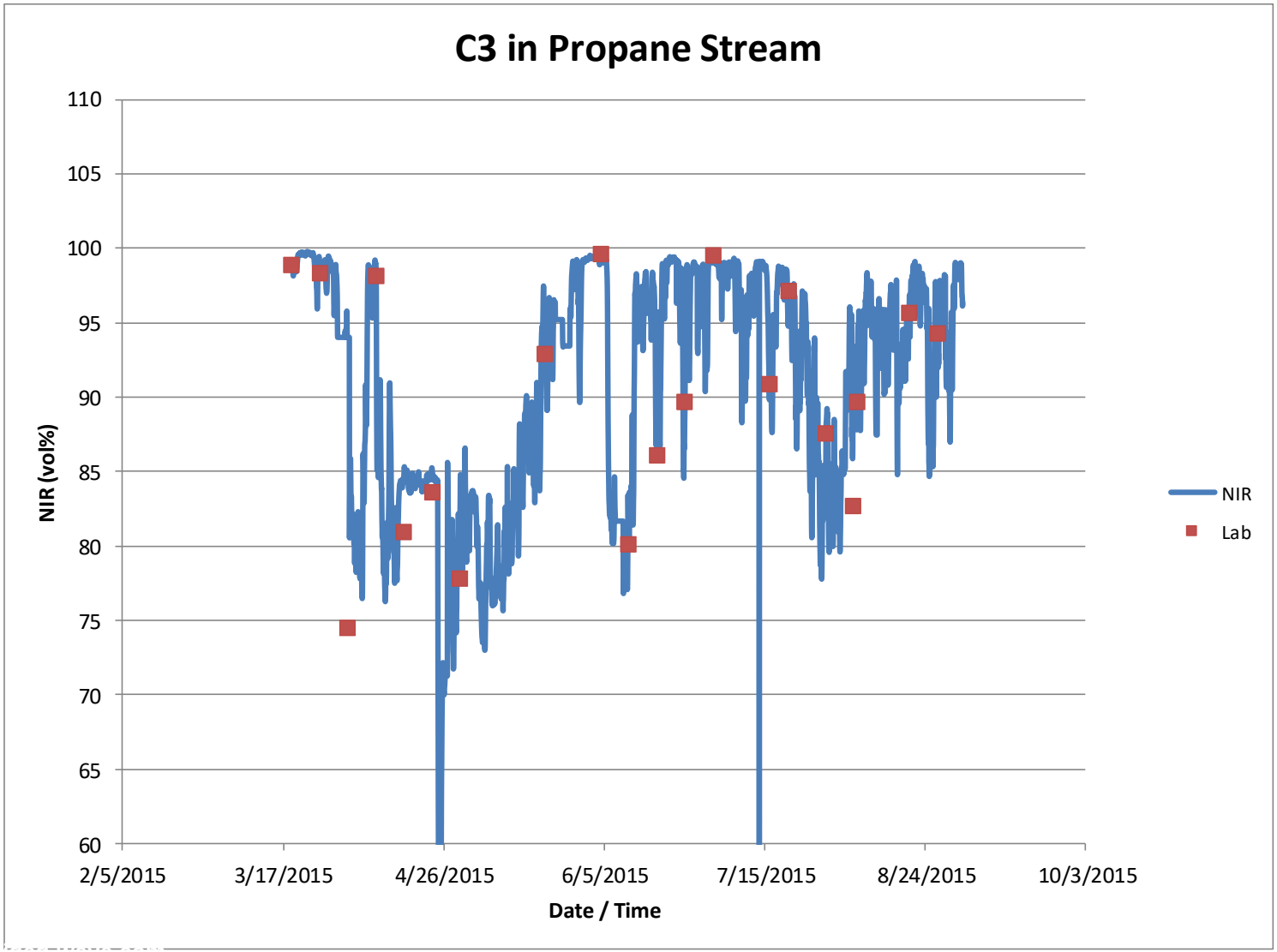


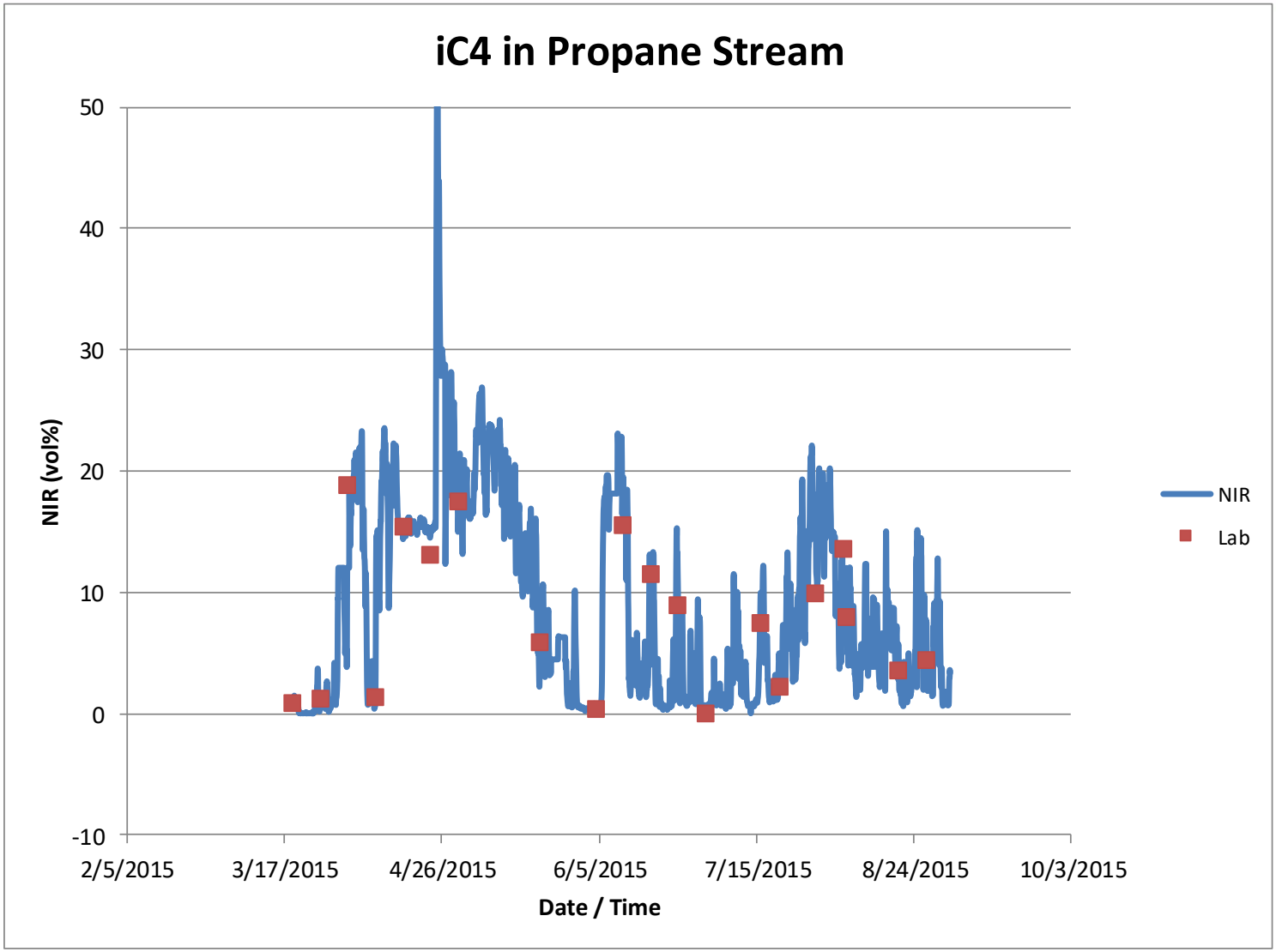
Models - Summary

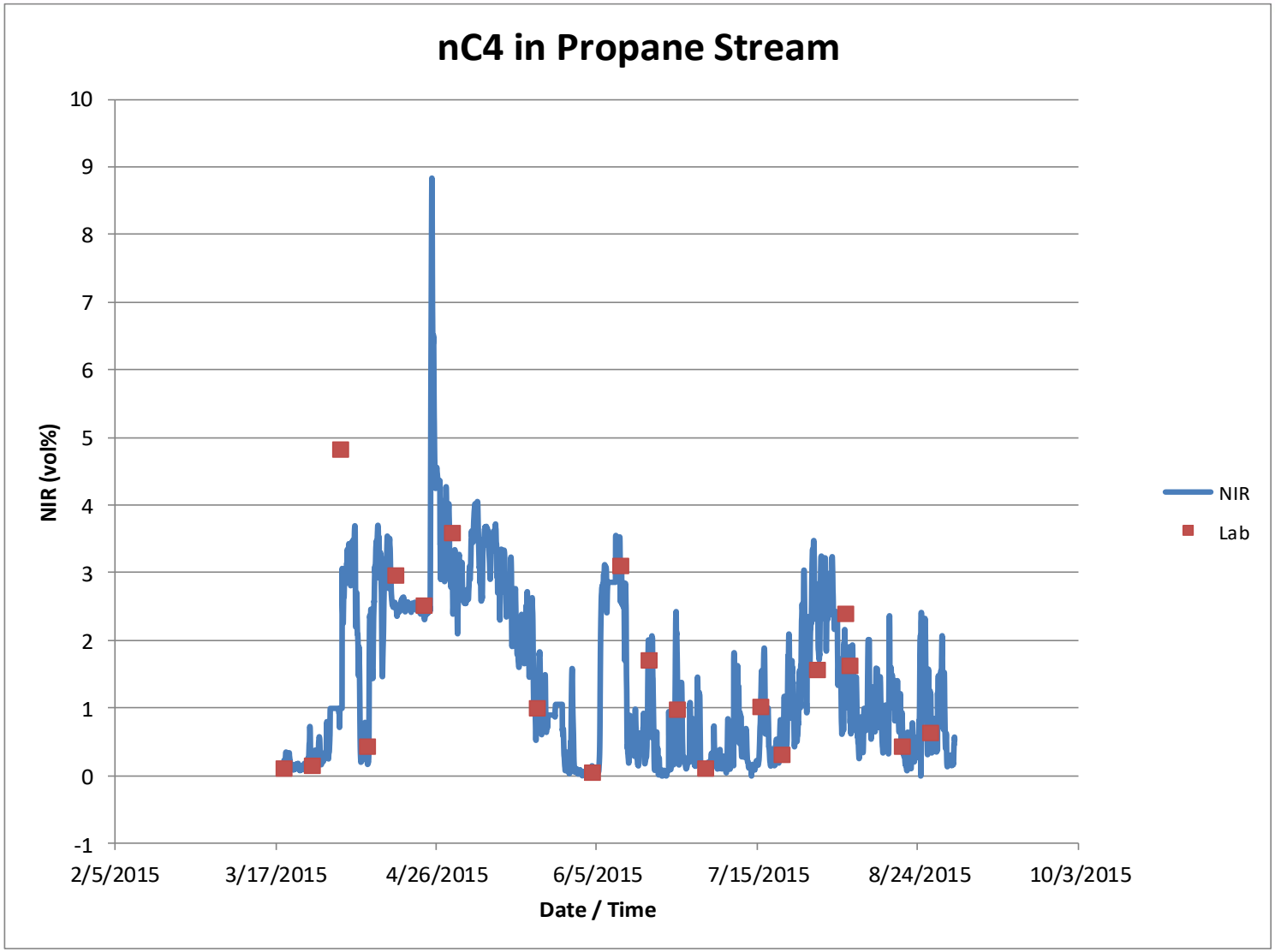
Stream	Parameter	Range (vol%)	#Samples	Principal Components	RMSEP
Propane	C2				
Propane	C3	77-99	113	3	0.36
Propane	iC4	0-22	120	3	0.40
Propane	nC4	0-3	117	2	0.15
Butane	C3	0-3.5	119	4	0.22
Butane	iC4	11-55	145	4	0.55
Butane	nC4	61-88	141	3	0.95
Butane	C5				

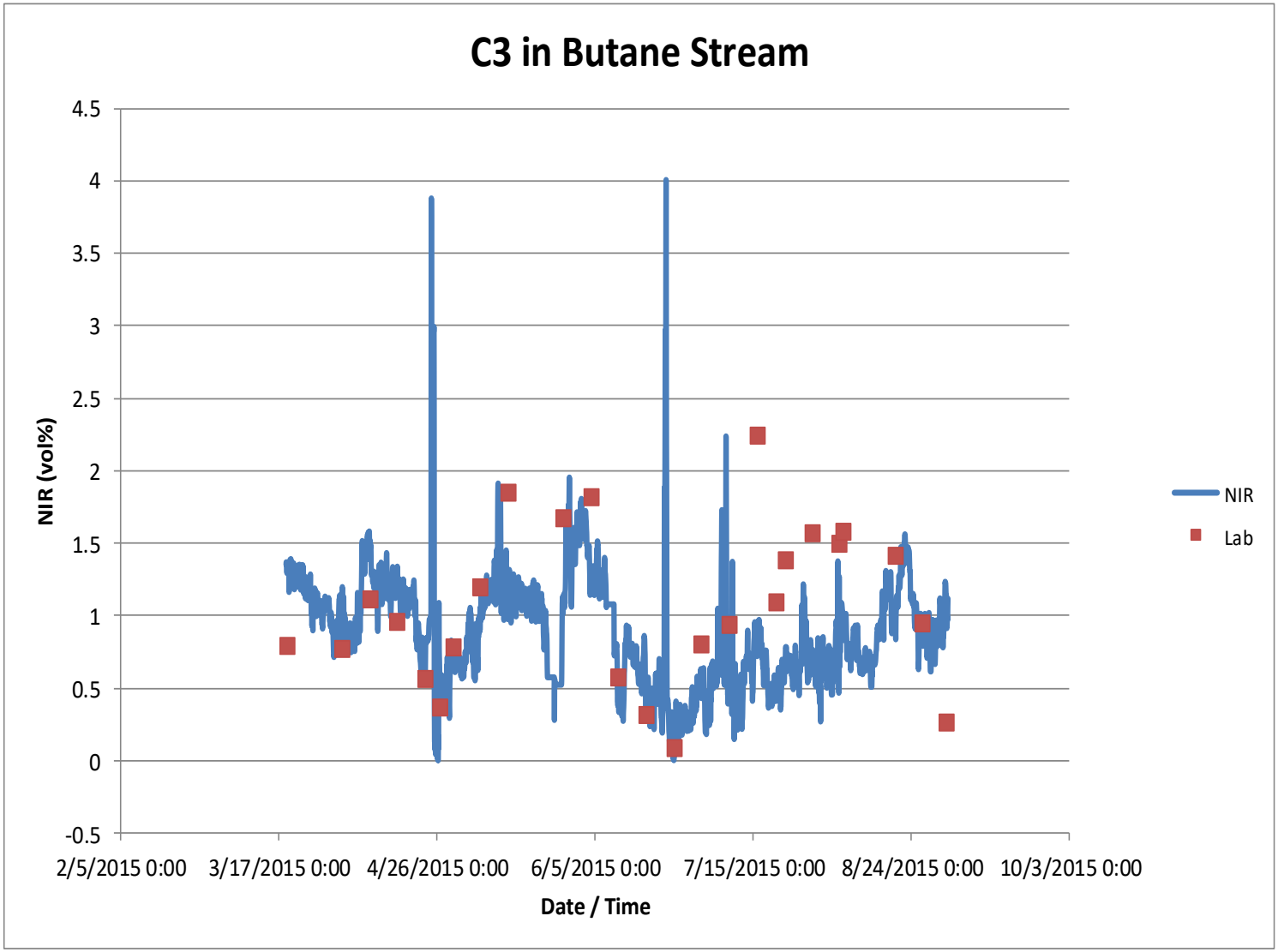
Results

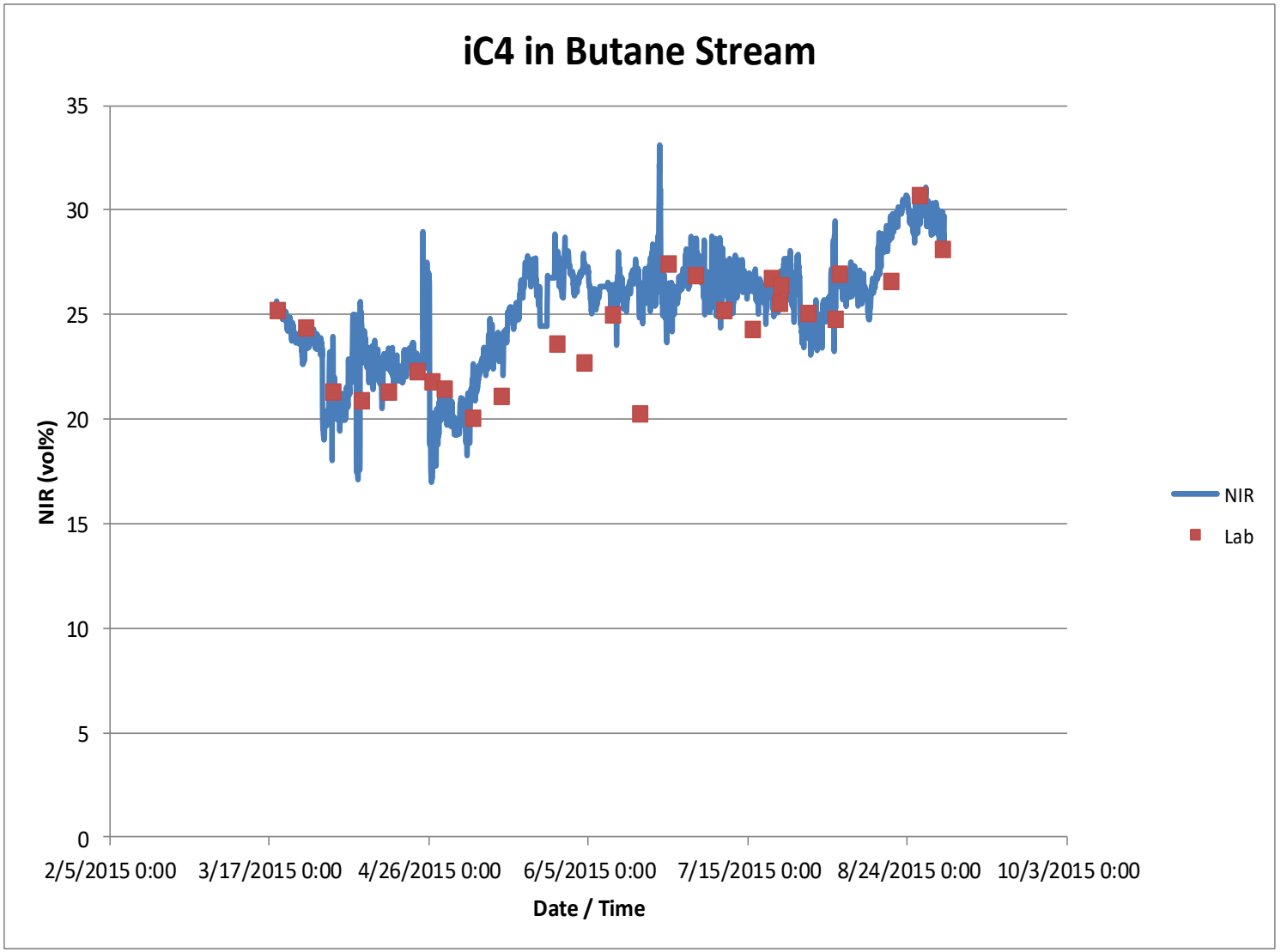
- The following slides are online trend charts from the NIR with lab values superimposed.
- The points are one hour apart
- Spikes – most likely due to bubble formation during measurement

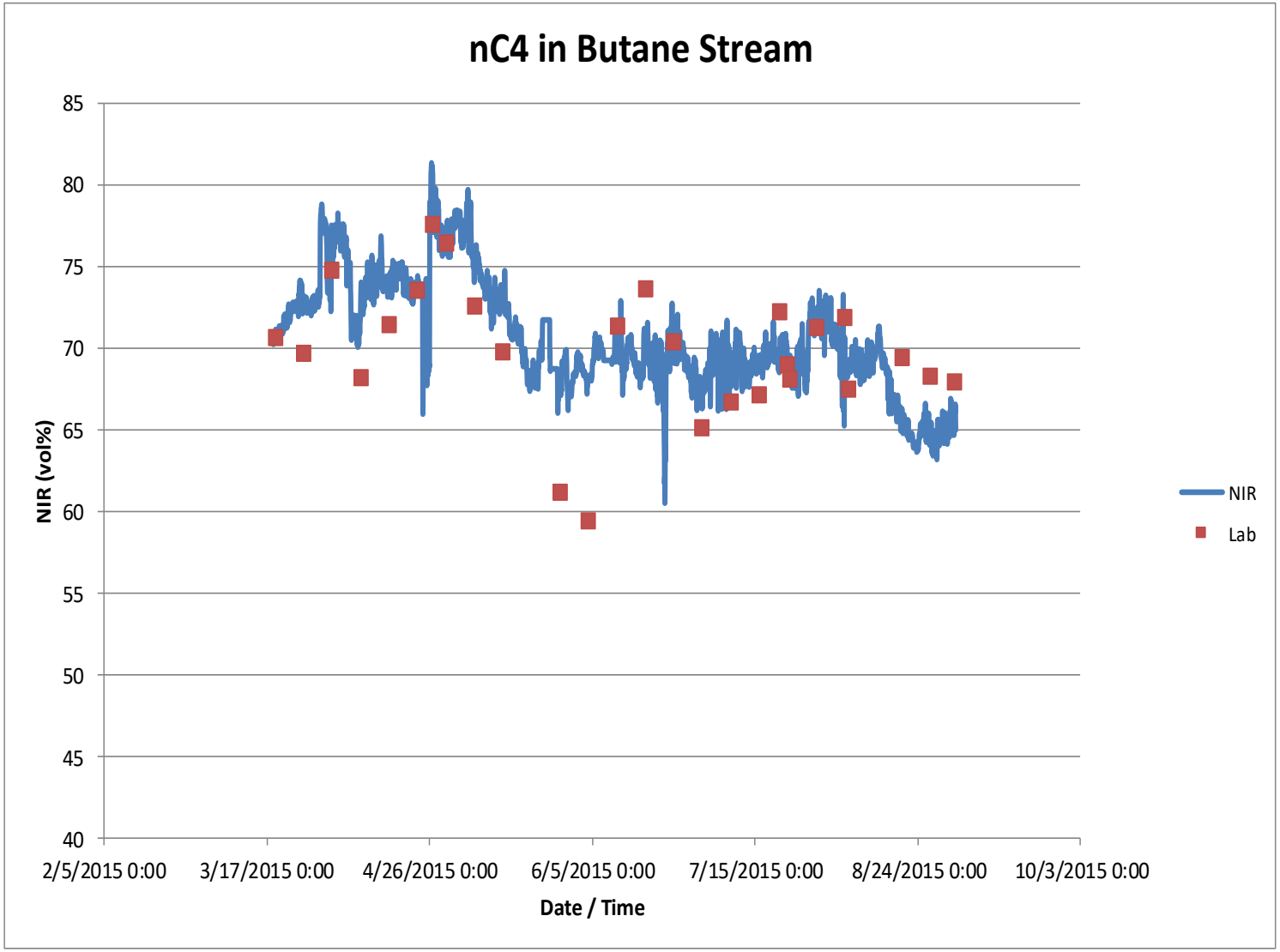

C3 in Propane Stream
110
105
100
95
90
85
80
75
70
65
60
NIR (vol%)
2/5/2015
3/17/2015
4/26/2015
6/5/2015
7/15/2015
8/24/2015
10/3/2015
Date / Time
NIR
Lab


iC4 in Propane Stream
50
40
30
20
10
0
-10
NIR (vol%)
2/5/2015
3/17/2015
4/26/2015
6/5/2015
7/15/2015
8/24/2015
10/3/2015
Date / Time
NIR
Lab


nC4 in Propane Stream
10
9
8
7
6
5
4
3
2
1
0
-1
NIR (vol%)
2/5/2015
3/17/2015
4/26/2015
6/5/2015
7/15/2015
8/24/2015
10/3/2015
Date / Time
NIR
Lab


C3 in Butane Stream
NIR (vol%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
2/5/2015 0:00
3/17/2015 0:00
4/26/2015 0:00
6/5/2015 0:00
7/15/2015 0:00
8/24/2015 0:00
10/3/2015 0:00
Date / Time
NIR
Lab


iC4 in Butane Stream
35
30
25
20
15
10
5
0
NIR (vol%)
2/5/2015 0:00
3/17/2015 0:00
4/26/2015 0:00
6/5/2015 0:00
7/15/2015 0:00
8/24/2015 0:00
10/3/2015 0:00
Date / Time
NIR
Lab


nC4 in Butane Stream
85
80
75
70
65
60
55
50
45
40
NIR (vol%)
2/5/2015 0:00
3/17/2015 0:00
4/26/2015 0:00
6/5/2015 0:00
7/15/2015 0:00
8/24/2015 0:00
10/3/2015 0:00
Date / Time
NIR
Lab

Conclusions

- NIR composition measurement of the LPG streams has allowed Suncor to achieve speed of quality control at a much reduced cost over GCs.
- For LPG analysis – Suncor was able to control the purity of both Butane and Propane for their export market as well as to stabilize the process unit.

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Questions?

For any questions, please contact us.

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