From PVT to allocation uncertainty

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Introduction

Some of the work presented is based on work performed in

Join Industry Project

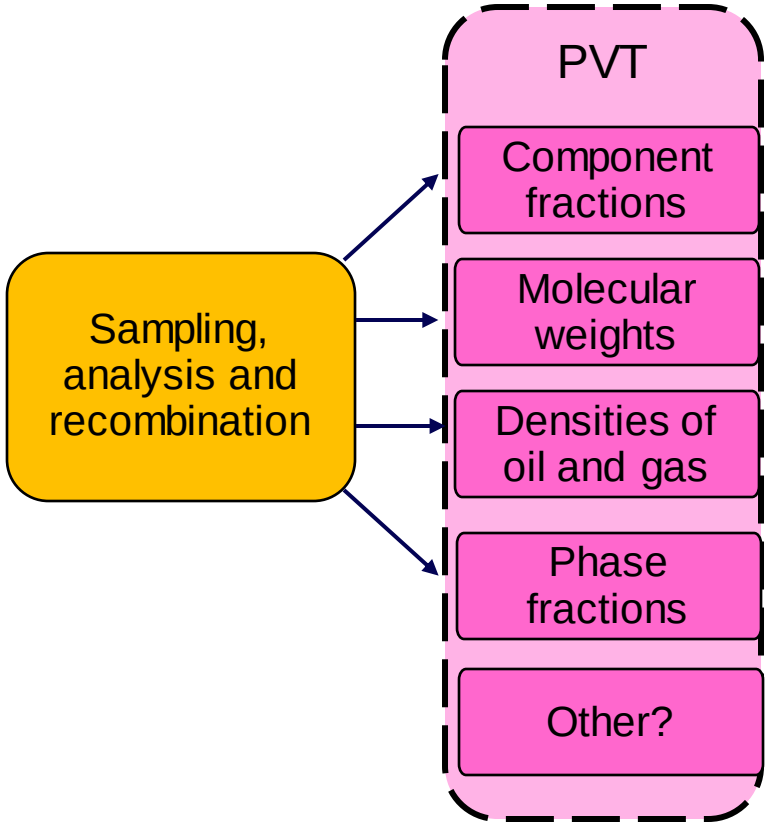
Participants: Wintershall Dea, Lundin Energy, DNO and NORCE

Goal: Foundation for Best practice for Allocation uncertainty and Risk-Cost-Benefit calculations

This presentation

How PVT and its uncertainties propagates through the measurement and allocation system

What do we mean by «PVT»?



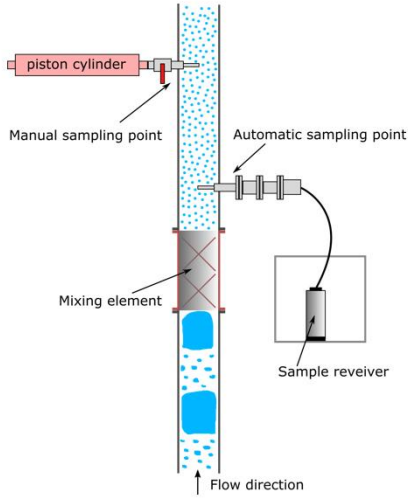
PVT is short for **p**ressure, **v**olume and **t**emperature.

Within the oil and gas industry terms such as PVT data, PVT analysis or PVT model are used in relation to **how the properties of a fluid are characterized as function of pressure and temperature.**

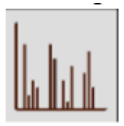
What are the sources of uncertainties in PVT?

Sampling of separated oil and gas at inlet or test separator, or multiphase sampling.

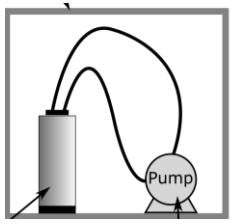
Sampling
Spatial representativity
Temporal representativity

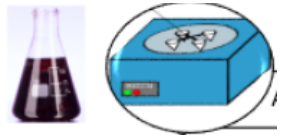


Gas
Online Gas Chromatograph



Oil
Sampling handling
Storage
Subsampling
Transport
Laboratory analysis





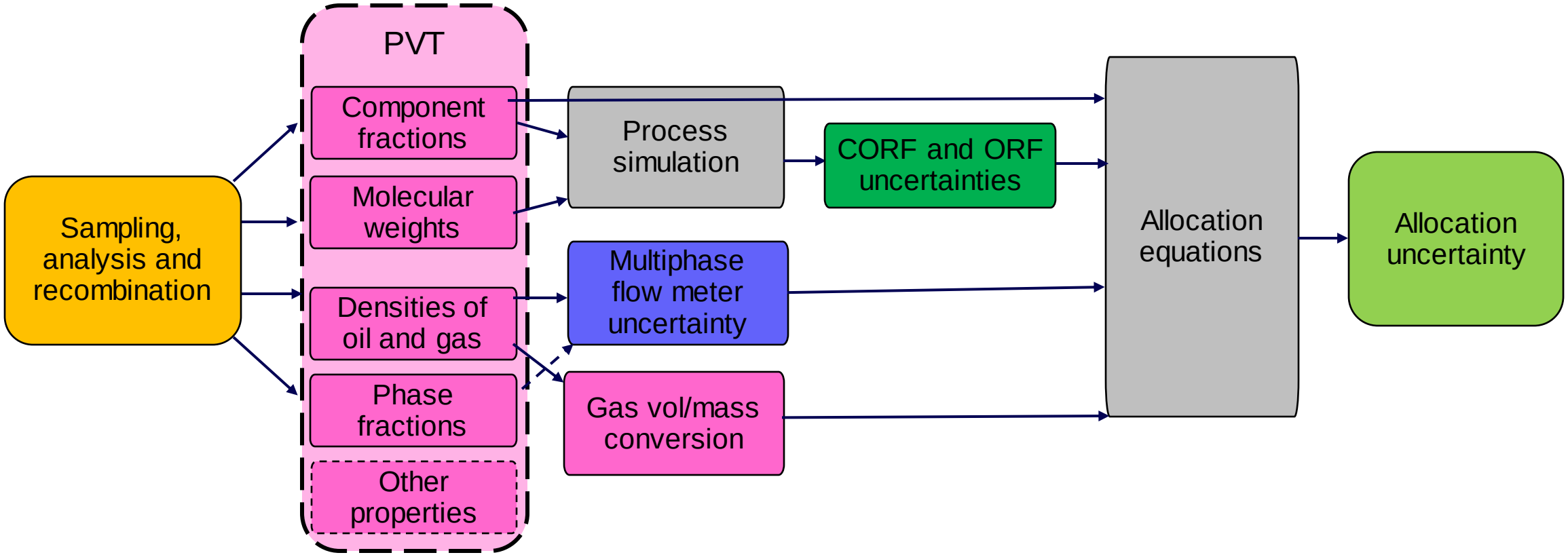
Recombination

Some illustrations from NFOGM online course Fiscal metering of petroleum liquids

More details in the NFOGM Fagdag presentations:
O. Øiestad, 2023, H. Nilsen, 2023 and C. Nilsson, 2021

And in the GFMW proceedings:
Skålvik, A. M., Bjørk, R. N., Alakbarova, S., Haukalid, K., Folgerø, K., (2023). *Measurement Uncertainty of Non-Stabilized Oil Sample Compositional Analysis Evaluated Using Monte Carlo Methodology*, Global Flow Measurement Workshop, Tønsberg, Norway

PVT uncertainty propagate through the measurement and allocation system

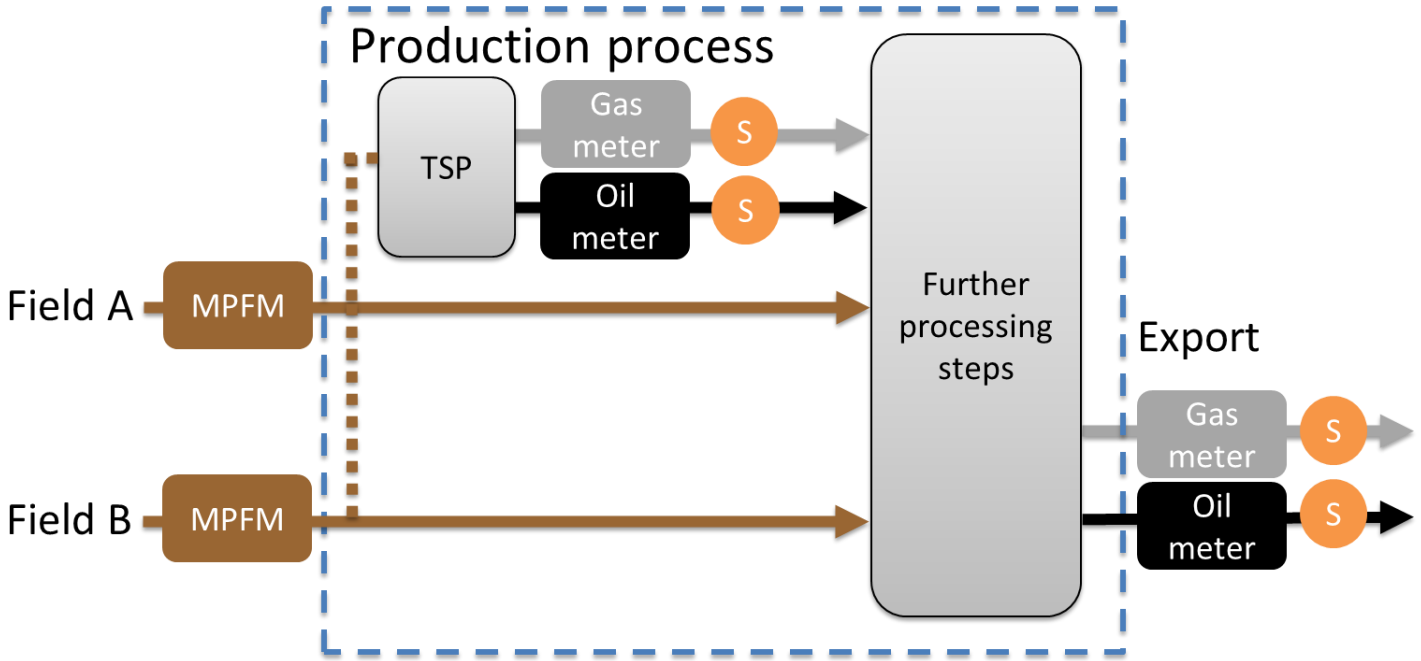


…etc!

PVT → … → Allocation uncertainty

How do PVT uncertainties affect **allocation** uncertainty?

Example – pro rata two fields



$$m_{oil}^{A} = ORF^{A} \cdot m_{HC}^{A}$$

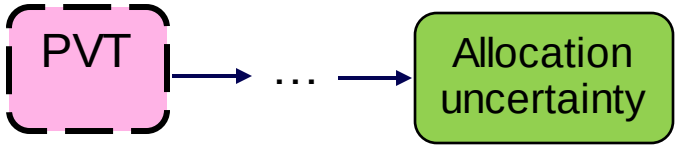
$$m_{oil}^{A,all} = m_{oil}^{export} \cdot \frac{m_{oil}^{A}}{m_{oil}^{A} + m_{oil}^{B}}$$

$$= m_{oil}^{export} \cdot \frac{ORF^{A} \cdot m_{HC}^{A}}{ORF^{A} \cdot m_{HC}^{A} + ORF^{B} \cdot m_{HC}^{B}}$$

$$m_{oil,i}^{A} = CORF^{A} \cdot C_{HC,i}^{A} \cdot m_{HC}^{A}$$

$$m_{oil,i}^{A,all} = m_{oil,i}^{export} \cdot \frac{m_{oil,i}^{A}}{m_{oil,i}^{A} + m_{oil,i}^{B}}$$

$$= m_{oil,i}^{export} \cdot \frac{CORF^{A} \cdot C_{HC,i}^{A} \cdot m_{HC}^{A}}{CORF^{A} \cdot C_{HC,i}^{A} \cdot m_{HC}^{A} + CORF^{B} \cdot C_{HC,i}^{B} \cdot m_{HC}^{B}}$$



How do PVT uncertainties affect **allocation** uncertainty?

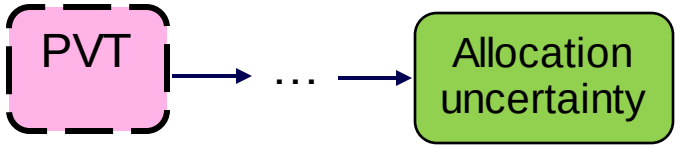
When allocation by total oil mass:

$$m_{oil}^{A,all} = m_{oil}^{export} \cdot \frac{ORF^A \cdot m_{HC}^A}{ORF^A \cdot m_{HC}^A + ORF^B \cdot m_{HC}^B}$$

$$\left(\frac{u\left(m_{oil}^{A,all}\right)}{m_{oil}^{A,all}}\right)^2 = \left(\frac{u\left(m_{oil}^{export}\right)}{m_{oil}^{export}}\right)^2 + \left(\frac{m_{oil}^B}{m_{oil}^A + m_{oil}^B}\right)^2 \left[\left(\frac{u\left(m_{oil}^A\right)}{m_{oil}^A}\right)^2 + \left(\frac{u\left(m_{oil}^B\right)}{m_{oil}^B}\right)^2\right]$$

$$\left(\frac{u\left(m_{oil}^{A,all}\right)}{m_{oil}^{A,all}}\right)^2 = \left(\frac{u\left(m_{oil}^{export}\right)}{m_{oil}^{export}}\right)^2 + \left(\frac{ORF^B \cdot m_{HC}^B}{ORF^A \cdot m_{HC}^A + ORF^B \cdot m_{HC}^B}\right)^2 \left[\left(\frac{u(ORF^A)}{ORF^A}\right)^2 + \left(\frac{u\left(m_{HC}^A\right)}{m_{HC}^A}\right)^2 + \left(\frac{u(ORF^B)}{ORF^B}\right)^2 + \left(\frac{u\left(m_{HC}^B\right)}{m_{HC}^B}\right)^2\right]$$

+ correlations



How do PVT uncertainties affect **allocation** uncertainty?

When allocation by component:

$$m_{oil,i}^{A,all} = m_{oil,i}^{export} \cdot \frac{CORF^{A} \cdot C_{HC,i}^{A} \cdot m_{HC}^{A}}{CORF^{A} \cdot C_{HC,i}^{A} \cdot m_{HC}^{A} + CORF^{B} \cdot C_{HC,i}^{B} \cdot m_{HC}^{B}}$$

$$\left(\frac{u\left(m_{oil,i}^{A,all}\right)}{m_{oil,i}^{A,all}}\right)^2$$

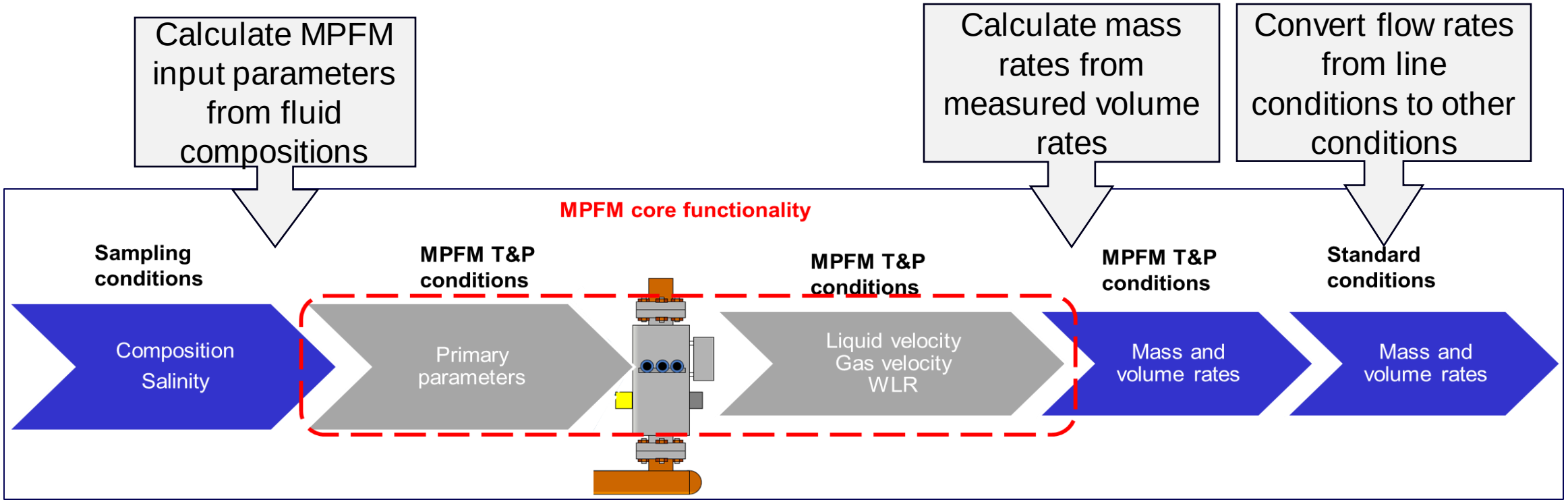
$$= \left(\frac{u\left(m_{oil,i}^{export}\right)}{m_{oil,i}^{export}}\right)^2$$

$$+ \left(\frac{ORF^{B} \cdot m_{HC}^{B} \cdot C_{HC,i}^{B}}{ORF^{A} \cdot m_{HC}^{A} \cdot C_{HC,i}^{A} + ORF^{B} \cdot m_{HC}^{B} \cdot C_{HC,i}^{B}}\right)^2 \left[\left(\frac{u(ORF^{A})}{ORF^{A}}\right)^2 + \left(\frac{u\left(m_{HC}^{A}\right)}{m_{HC}^{A}}\right)^2 + \left(\frac{u\left(C_{HC,i}^{A}\right)}{C_{HC,i}^{A}}\right)^2 + \left(\frac{u(ORF^{B})}{ORF^{B}}\right)^2 + \left(\frac{u\left(m_{HC}^{B}\right)}{m_{HC}^{B}}\right)^2 + \left(\frac{u\left(C_{HC,i}^{B}\right)}{C_{HC,i}^{B}}\right)^2\right]$$

+ correlations

PVT → MPFM uncertainty

How does uncertainty in PVT affect the multiphase flow meter uncertainty?

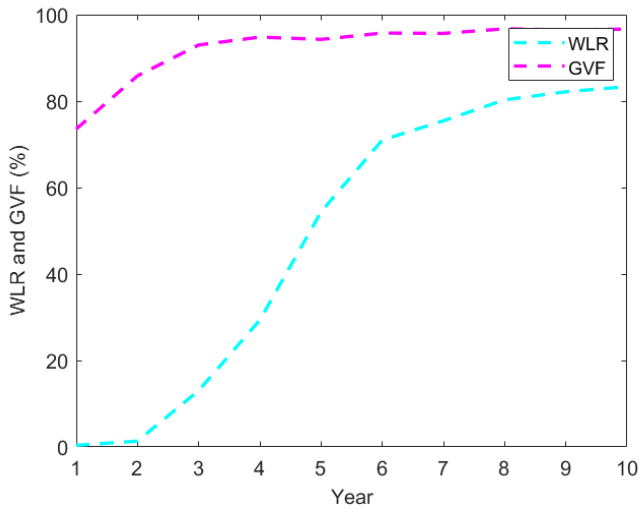


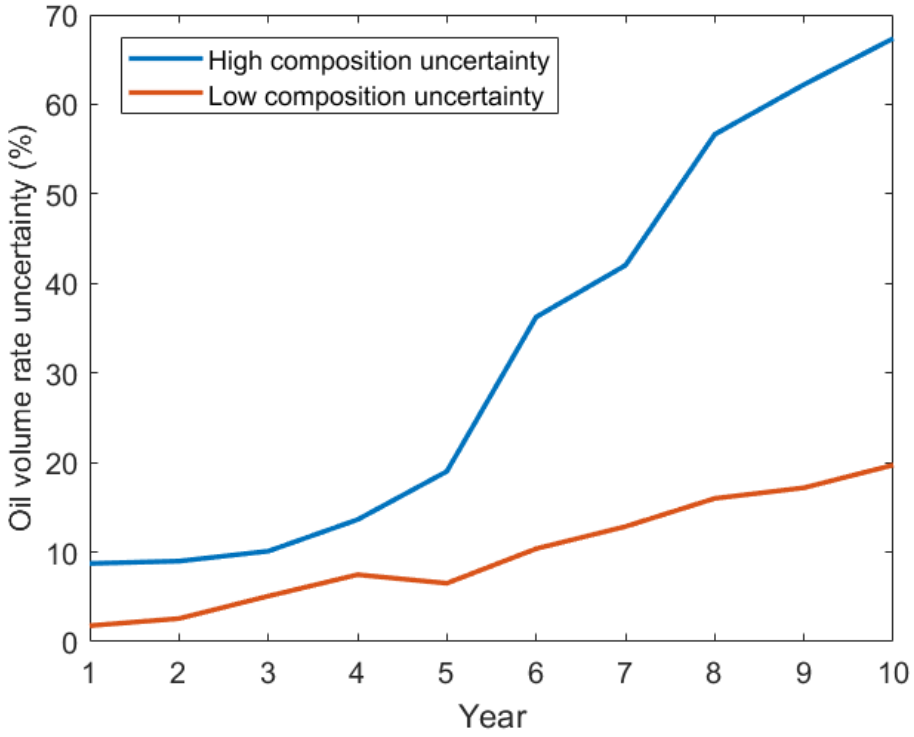
K Folgerø, J Kocbach, K Haukalid, A Hallanger, M B Holstad, E Åbro, A Faanes, A Erdal, "Subsea Multiphase Fluid Analyzer (MuFA) – A new concept to provide accurate fluid parameter input to multiphase flow meters," NSFMW 2019

E. Åbro, K. Folgerø, K. Gundersen "High Pressure Flow Loop Testing of the Multiphase Fluid Analyzer (MuFA) concept," GFMW 2023

PVT → MPFM uncertainty

How does uncertainty in PVT affect the multiphase flow meter uncertainty?





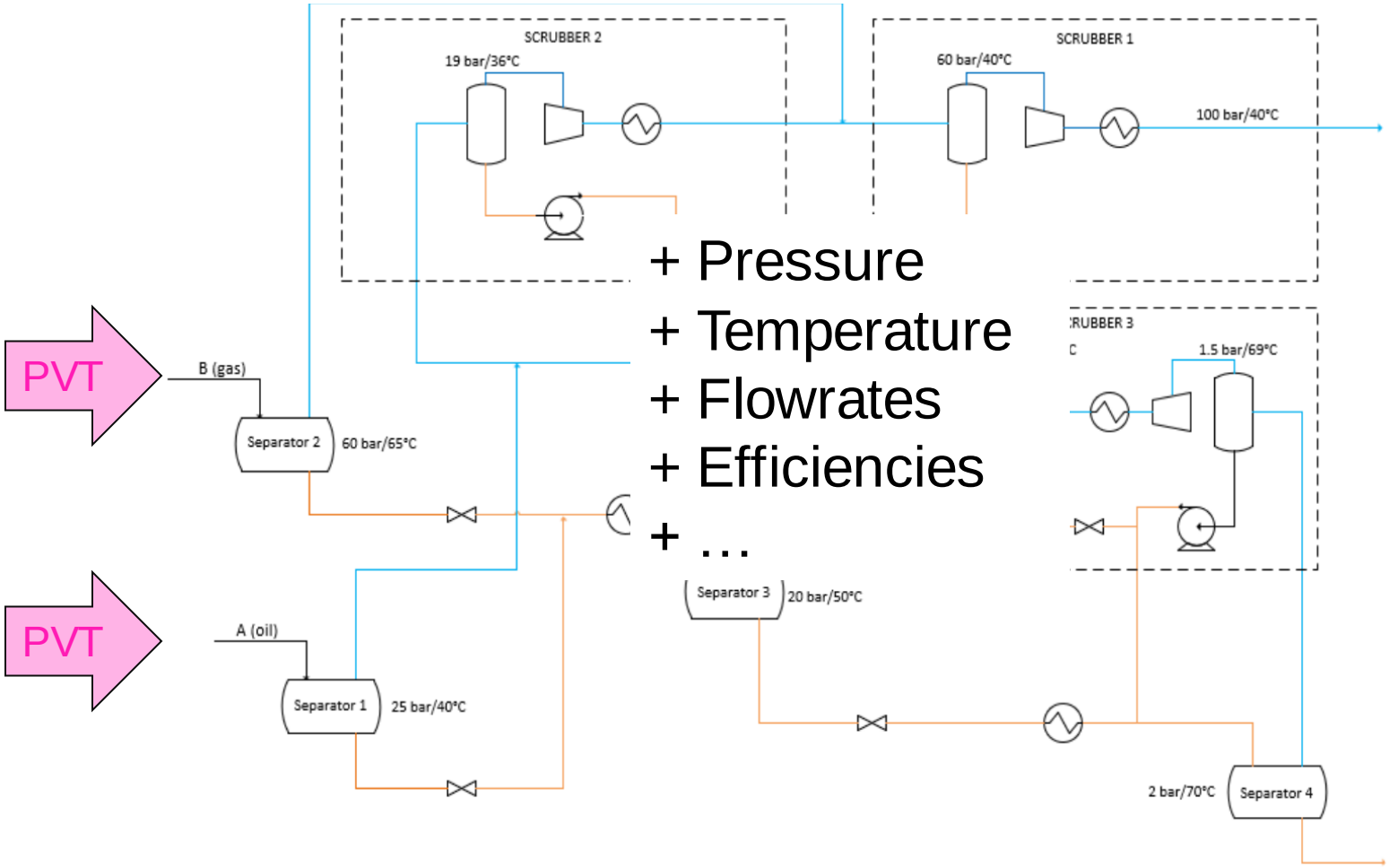
Blue line: Fluid parameters from PVT-calculations, giving 5 % uncertainty in oil and gas densities

Orange line: Reduction in uncertainties of fluid properties, among others 0.6 % and 3.8 % uncertainty in oil and gas densities

Figure based on examples shown in E. Åbro, K. Folgerø, K. Gundersen "High Pressure Flow Loop Testing of the Multiphase Fluid Analyzer (MuFA) concept," GFMW 2023

PVT → Process simulation → CORF and ORF uncertainties

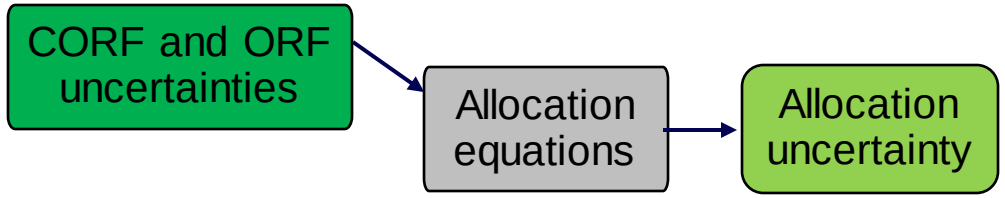
How does uncertainty in PVT affect the CORF and ORF uncertainties?



$$ORF^A = \frac{m_{oil}^A}{m_{HC}^A}$$

$$CORF^A = \frac{m_{oil,i}^A}{m_{HC,i}^A} = \frac{C_{oil,i}^A \cdot m_{oil}^A}{C_{HC,i}^A \cdot m_{HC}^A}$$

Figure from (and more details in): Folgerø, K., Haukalid, K., Skålvik, A. M., Helsør, T., Holstad, M. B., Syre, B., Maudal, K. Å., Johnsen, A., Westgaard, E. (2021). Influence of fluid compositions and process parameters on allocation uncertainties, North Sea Flow Measurement Workshop, Tønsberg, Norway



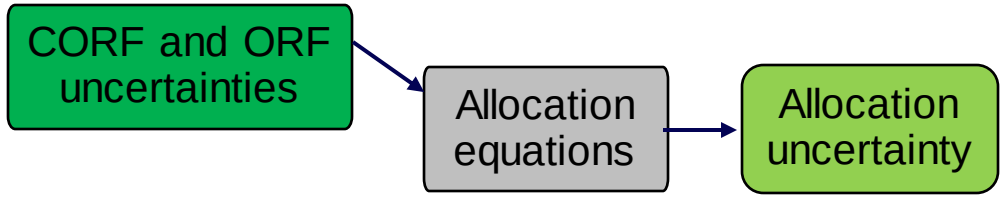
In what cases are CORF & ORF uncertainties dominating **allocation** uncertainties?

Example – pro rata two fields

- If ORF uncertainties are high compared to m_{HC} measurement uncertainties
  - For instance if m_{HC} is measured by an inlet separator
- If CORF uncertainties are high compared with m_{HC} and component uncertainties
  - For instance if high uncertainty in process variations between simulations

$$m_{oil}^{A,all} = m_{oil}^{export} \cdot \frac{ORF^A \cdot m_{HC}^A}{ORF^A \cdot m_{HC}^A + ORF^B \cdot m_{HC}^B}$$

$$m_{oil,i}^{A,all} = m_{oil,i}^{export} \cdot \frac{CORF^A \cdot C_{HC,i}^A \cdot m_{HC}^A}{CORF^A \cdot C_{HC,i}^A \cdot m_{HC}^A + CORF^B \cdot C_{HC,i}^B \cdot m_{HC}^B}$$



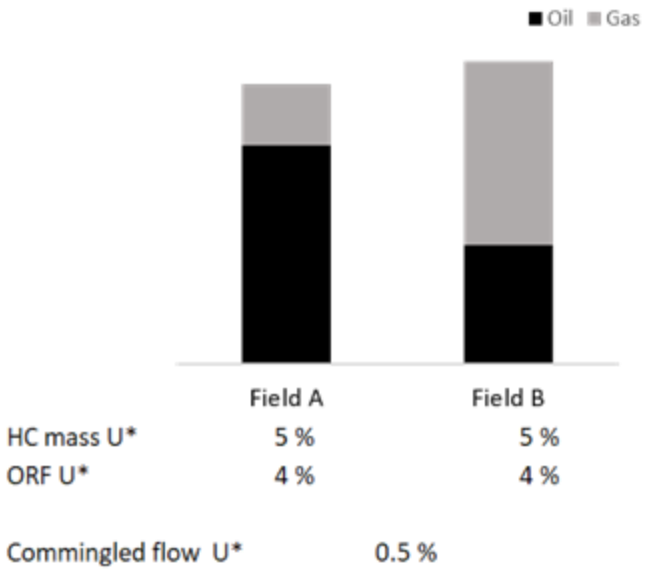
How do ORF uncertainties affect **allocation** uncertainties?

The following slides show examples with example numbers from

K Folgerø, K Haukalid, A. M. Skålvik, T. Helsør, M. B. Holstad, B. Syre, M. Å. Maudal, A. Johnsen, E. Westgaard Influence of fluid composition and process parameters on allocation uncertainties, 39th Int. North Sea Flow Measurement Workshop 2021. 22-25 October 2021

Correlations between uncertainties in HC mass and ORF/CORF,
as well composition uncertainties are not taken into account in the examples.

Total ORF



Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0,8 %	1,00	0,8 %	U*
Field A HC mass	5,0 %	0,35	1,8 %	U*
Field A ORF	4,0 %	0,35	1,4 %	U*
Field B oil mass	5,0 %	0,35	1,8 %	U*
Field B ORF	4,0 %	0,35	1,4 %	U*
Allocated HC mass			3,3 %	**U***
ORF relative contribution			61 %	

Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0,8 %	1,00	0,8 %	U*
Field A HC mass	5,0 %	0,65	3,2 %	U*
Field A ORF	4,0 %	0,65	2,6 %	U*
Field B oil mass	5,0 %	0,65	3,2 %	U*
Field B ORF	4,0 %	0,65	2,6 %	U*
Allocated HC mass			5,9 %	**U***
ORF relative contribution			62 %	

62 % - 94 % of allocation uncertainty caused by ORF uncertainty

(depending on field, by-difference or pro-rata, oil or gas)

C1

	Field A	Field B
HC mass U*	5 %	5 %
ORF U*	0.1 %	0.1 %

Commingled flow U* 0.7 %

Small to negligible effect on oil and gas relative uncertainties

Will depend on how low the CORF relative uncertainty is for C1

Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.79	4.0 %	U*
Field A ORF	0.1 %	0.79	0.1 %	U*
Field B oil mass	5.0 %	0.79	4.0 %	U*
Field B ORF	0.1 %	0.79	0.1 %	U*
Allocated HC mass			5.6 %	**U***
ORF relative contribution			2 %	

Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.21	1.1 %	U*
Field A ORF	0.1 %	0.21	0.0 %	U*
Field B oil mass	5.0 %	0.21	1.1 %	U*
Field B ORF	0.1 %	0.21	0.0 %	U*
Allocated HC mass			1.7 %	**U***
ORF relative contribution			2 %	

C10

	Field A	Field B
HC mass U*	5 %	5 %
ORF U*	0.1 %	0.1 %

Commingled flow U* 0.7 %

Small to negligible effect on oil relative uncertainty

High effect on gas relative uncertainty, but negligible in absolute terms

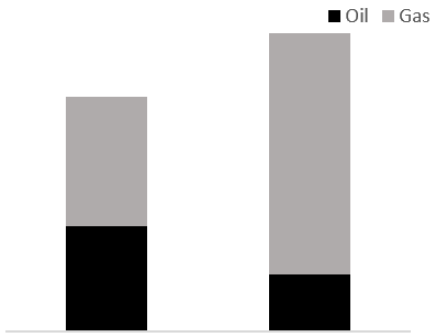
Will depend on how low the CORF relative uncertainty is for C10

Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.29	1.5 %	U*
Field A ORF	0.1 %	0.29	0.0 %	U*
Field B oil mass	5.0 %	0.29	1.5 %	U*
Field B ORF	0.1 %	0.29	0.0 %	U*
Allocated HC mass			2.2 %	**U***
ORF relative contribution			2 %	

Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.71	3.6 %	U*
Field A ORF	0.1 %	0.71	0.1 %	U*
Field B oil mass	5.0 %	0.71	3.6 %	U*
Field B ORF	0.1 %	0.71	0.1 %	U*
Allocated HC mass			5.1 %	**U***
ORF relative contribution			2 %	

nC4



	Field A	Field B
HC mass U*	5 %	5 %
ORF U*	16.7 %	5.3 %

Commingled flow U* 0.6 %

Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.35	1.7 %	U*
Field A ORF	16.7 %	0.35	5.8 %	U*
Field B oil mass	5.0 %	0.35	1.7 %	U*
Field B ORF	5.3 %	0.35	1.8 %	U*
Allocated HC mass			6.6 %	**U***
ORF relative contribution			92 %	

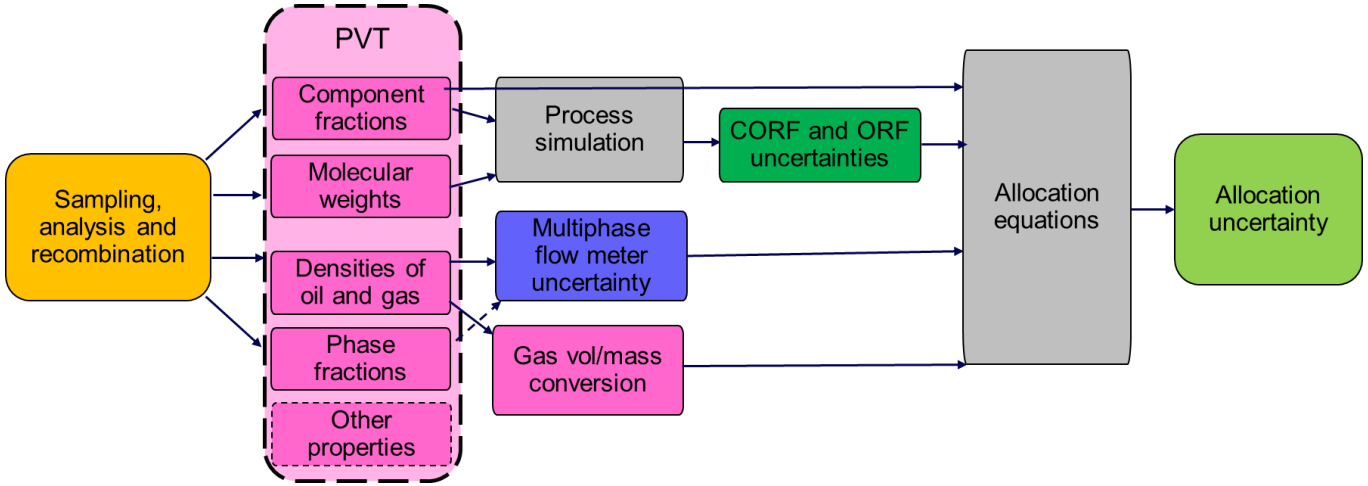
Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.65	3.3 %	U*
Field A ORF	16.7 %	0.65	10.8 %	U*
Field B oil mass	5.0 %	0.65	3.3 %	U*
Field B ORF	5.3 %	0.65	3.4 %	U*
Allocated HC mass			12.3 %	**U***
ORF relative contribution			93 %	

88 % - 96 % of allocation uncertainty caused by ORF uncertainty

(depending on field, by-difference or pro-rata, oil or gas)

From PVT to **allocation** uncertainty

- PVT affect allocation uncertainty
  - directly though mass fractions
  - as input to MPFM
  - as input to process simulations
  - and possibly more, depending on specific case
- Uncertainties related to PVT can be challenging to estimate
- In some cases the ORF/CORF uncertainties can be negligible and in other cases important
- **The devil is in the details**



Thank you! Any questions?

And please come and discuss with us in the breaks!



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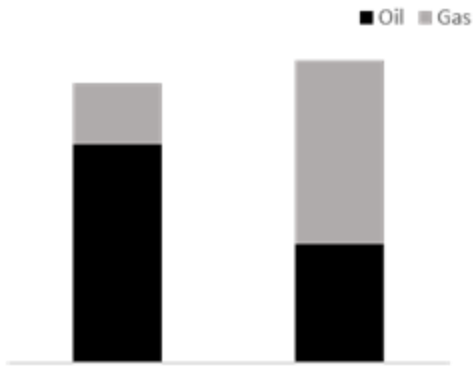
Appendix on How do ORF uncertainties affect **allocation** uncertainties?

The following slides show examples with example numbers from

K Folgerø, K Haukalid, A. M. Skålvik, T. Helsør, M. B. Holstad, B. Syre, M. Å. Maudal, A. Johnsen, E. Westgaard Influence of fluid composition and process parameters on allocation uncertainties, 39th Int. North Sea Flow Measurement Workshop 2021. 22-25 October 2021

Correlations between uncertainties in HC mass and ORF/CORF, as well composition uncertainties are not taken into account in the examples.

Total ORF



	Field A	Field B
HC mass U*	5 %	5 %
ORF U*	4 %	4 %

Commingled flow U* 0.5 %

62 % - 94 % of allocation uncertainty caused by ORF uncertainty

(depending on field, by-difference or pro-rata, oil or gas)

Oil mass

Field B by-difference	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5,0 %	1,00	5,0 %	U*
Field A ORF	4,0 %	1,00	4,0 %	U*
Allocated oil mass			6,4 %	U*

ORF relative contribution 62 %

Field B by-difference	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0,8 %	2,85	2,1 %	U*
Field A HC mass	5,0 %	1,85	9,2 %	U*
Field A ORF	4,0 %	1,85	7,4 %	U*
Allocated oil mass			12,0 %	U*

ORF relative contribution 61 %

Gas mass

Field B by-difference	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5,0 %	1,00	5,0 %	U*
Field A ORF	4,0 %	-3,55	14,2 %	U*
Allocated gas mass			15,0 %	U*

ORF relative contribution 94 %

Field B by-difference	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0,8 %	1,33	1,0 %	U*
Field A HC mass	5,0 %	0,33	1,7 %	U*
Field A ORF	4,0 %	-1,18	4,7 %	U*
Allocated gas mass			5,1 %	U*

ORF relative contribution 92 %

Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0,8 %	1,00	0,8 %	U*
Field A HC mass	5,0 %	0,35	1,8 %	U*
Field A ORF	4,0 %	0,35	1,4 %	U*
Field B oil mass	5,0 %	0,35	1,8 %	U*
Field B ORF	4,0 %	0,35	1,4 %	U*
Allocated HC mass			3,3 %	U*

ORF relative contribution 61 %

Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0,8 %	1,00	0,8 %	U*
Field A HC mass	5,0 %	0,65	3,2 %	U*
Field A ORF	4,0 %	0,65	2,6 %	U*
Field B oil mass	5,0 %	0,65	3,2 %	U*
Field B ORF	4,0 %	0,65	2,6 %	U*
Allocated HC mass			5,9 %	U*

ORF relative contribution 62 %

Gas mass

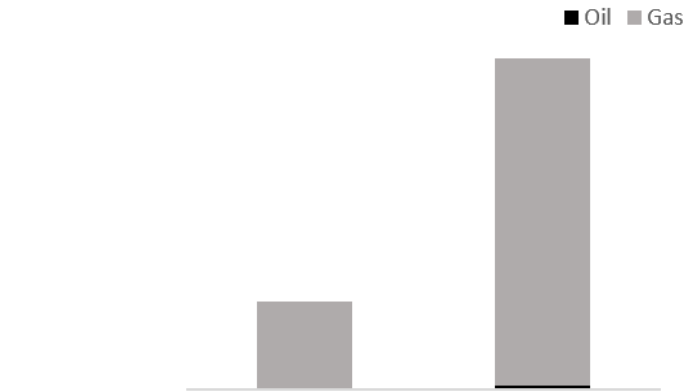
Pro rata	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0,75 %	1,00	0,8 %	U*
Field A HC mass	5,0 %	0,75	3,8 %	U*
Field A ORF	4,0 %	-2,66	10,6 %	U*
Field B oil mass	5,0 %	0,75	3,8 %	U*
Field B ORF	4,0 %	-0,48	1,9 %	U*
Allocated gas mass			12,1 %	U*

ORF relative contribution 90 %

Pro rata	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0,8 %	1,00	0,8 %	U*
Field A HC mass	5,0 %	0,25	1,2 %	U*
Field A ORF	4,0 %	-0,89	3,5 %	U*
Field B oil mass	5,0 %	0,25	1,2 %	U*
Field B ORF	4,0 %	-0,16	0,6 %	U*
Allocated gas mass			4,1 %	U*

ORF relative contribution 88 %

C1



	Field A	Field B
HC mass U*	5 %	5 %
ORF U*	0.1 %	0.1 %

Commingled flow U* 0.7 %

Small effect on oil relative uncertainty

Negligble effect on gas relative uncertainty

Will depend on how low the CORF relative uncertainty is for C1

Oil mass

Field B by-difference	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5.0 %	1.00	5.0 %	U*
Field A ORF	0.1 %	1.00	0.1 %	U*
Allocated oil mass			5.0 %	**U***

ORF relative contribution 2 %

Field B by-difference	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.27	0.9 %	U*
Field A HC mass	5.0 %	0.27	1.3 %	U*
Field A ORF	0.1 %	0.27	0.0 %	U*
Allocated oil mass			1.6 %	**U***

ORF relative contribution 2 %

Gas mass

Field B by-difference	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5.0 %	1.00	5.0 %	U*
Field A ORF	0.1 %	-0.01	0.0 %	U*
Allocated gas mass			5.0 %	**U***

ORF relative contribution 0 %

Field B by-difference	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.8 %	1.27	0.9 %	U*
Field A HC mass	5.0 %	0.27	1.3 %	U*
Field A ORF	0.1 %	0.00	0.0 %	U*
Allocated gas mass			1.6 %	**U***

ORF relative contribution 0 %

Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.79	4.0 %	U*
Field A ORF	0.1 %	0.79	0.1 %	U*
Field B oil mass	5.0 %	0.79	4.0 %	U*
Field B ORF	0.1 %	0.79	0.1 %	U*
Allocated HC mass			5.6 %	**U***

ORF relative contribution 2 %

Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.21	1.1 %	U*
Field A ORF	0.1 %	0.21	0.0 %	U*
Field B oil mass	5.0 %	0.21	1.1 %	U*
Field B ORF	0.1 %	0.21	0.0 %	U*
Allocated HC mass			1.7 %	**U***

ORF relative contribution 2 %

Gas mass

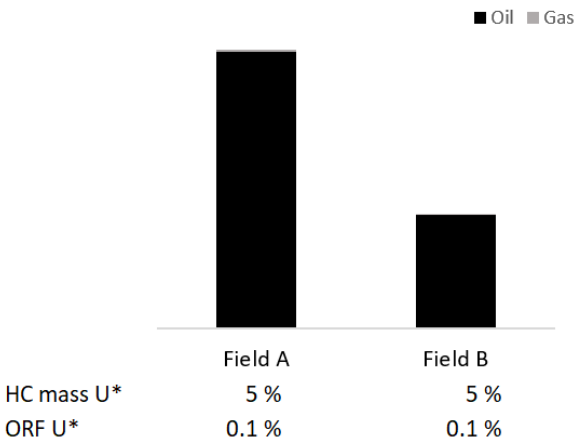
Pro rata	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.75 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.79	4.0 %	U*
Field A ORF	0.1 %	-0.01	0.0 %	U*
Field B oil mass	5.0 %	0.79	4.0 %	U*
Field B ORF	0.1 %	-0.01	0.0 %	U*
Allocated gas mass			5.6 %	**U***

ORF relative contribution 0 %

Pro rata	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.21	1.1 %	U*
Field A ORF	0.1 %	0.00	0.0 %	U*
Field B oil mass	5.0 %	0.21	1.1 %	U*
Field B ORF	0.1 %	0.00	0.0 %	U*
Allocated gas mass			1.7 %	**U***

ORF relative contribution 0 %

C10



Small effect on oil relative uncertainty

High effect on gas relative uncertainty, but negligible in absolute terms

Will depend on how low the CORF relative uncertainty is for C10

Oil mass

Field B by-difference	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5.0 %	1.00	5.0 %	U*
Field A ORF	0.1 %	1.00	0.1 %	U*
Allocated oil mass			5.0 %	**U***

ORF relative contribution 2 %

Field B by-difference	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	3.45	2.6 %	U*
Field A HC mass	5.0 %	2.45	12.2 %	U*
Field A ORF	0.1 %	2.45	0.2 %	U*
Allocated oil mass			12.5 %	**U***

ORF relative contribution 2 %

Gas mass

Field B by-difference	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5.0 %	1.00	5.0 %	U*
Field A ORF	0.1 %	-99.00	9.9 %	U*
Allocated gas mass			11.1 %	**U***

ORF relative contribution 89 %

Field B by-difference	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.8 %	3.45	2.6 %	U*
Field A HC mass	5.0 %	2.45	12.2 %	U*
Field A ORF	0.1 %	-242.38	24.2 %	U*
Allocated gas mass			27.3 %	**U***

ORF relative contribution 89 %

Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.29	1.5 %	U*
Field A ORF	0.1 %	0.29	0.0 %	U*
Field B oil mass	5.0 %	0.29	1.5 %	U*
Field B ORF	0.1 %	0.29	0.0 %	U*
Allocated HC mass			2.2 %	**U***

ORF relative contribution 2 %

Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.71	3.6 %	U*
Field A ORF	0.1 %	0.71	0.1 %	U*
Field B oil mass	5.0 %	0.71	3.6 %	U*
Field B ORF	0.1 %	0.71	0.1 %	U*
Allocated HC mass			5.1 %	**U***

ORF relative contribution 2 %

Gas mass

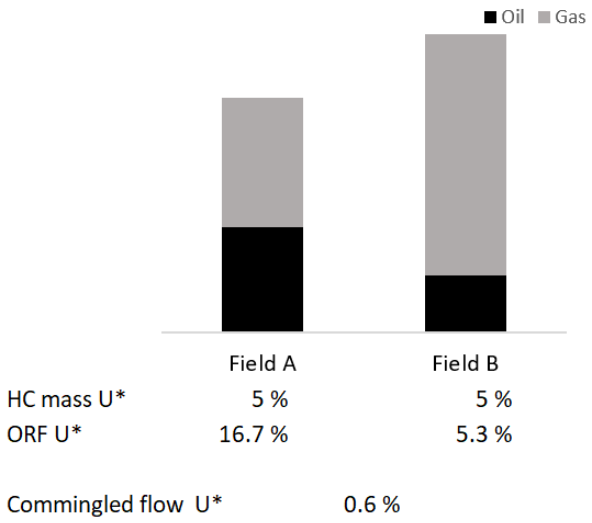
Pro rata	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.75 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.29	1.5 %	U*
Field A ORF	0.1 %	-28.71	2.9 %	U*
Field B oil mass	5.0 %	0.29	1.5 %	U*
Field B ORF	0.1 %	-28.71	2.9 %	U*
Allocated gas mass			4.6 %	**U***

ORF relative contribution 88 %

Pro rata	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.71	3.6 %	U*
Field A ORF	0.1 %	-70.29	7.0 %	U*
Field B oil mass	5.0 %	0.71	3.6 %	U*
Field B ORF	0.1 %	-70.29	7.0 %	U*
Allocated gas mass			11.2 %	**U***

ORF relative contribution 89 %

nC4



88 % - 96 % of allocation uncertainty caused by ORF uncertainty

(depending on field, by-difference or pro-rata, oil or gas)

Oil mass

Field B by-difference	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5.0 %	1.00	5.0 %	U*
Field A ORF	16.7 %	1.00	16.7 %	U*
Allocated oil mass			17.4 %	**U***

ORF relative contribution 96 %

Field B by-difference	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	2.86	2.1 %	U*
Field A HC mass	5.0 %	1.86	9.3 %	U*
Field A ORF	16.7 %	1.86	31.0 %	U*
Allocated oil mass			32.5 %	**U***

ORF relative contribution 96 %

Gas mass

Field B by-difference	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Field A HC mass	5.0 %	1.00	5.0 %	U*
Field A ORF	16.7 %	-0.82	13.6 %	U*
Allocated gas mass			14.5 %	**U***

ORF relative contribution 94 %

Field B by-difference	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.8 %	1.53	1.2 %	U*
Field A HC mass	5.0 %	0.53	2.7 %	U*
Field A ORF	16.7 %	-0.44	7.3 %	U*
Allocated gas mass			7.8 %	**U***

ORF relative contribution 93 %

Oil mass

Pro rata	Field A	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.35	1.7 %	U*
Field A ORF	16.7 %	0.35	5.8 %	U*
Field B oil mass	5.0 %	0.35	1.7 %	U*
Field B ORF	5.3 %	0.35	1.8 %	U*
Allocated HC mass			6.6 %	**U***

ORF relative contribution 92 %

Pro rata	Field B	Oil mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export oil mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.65	3.3 %	U*
Field A ORF	16.7 %	0.65	10.8 %	U*
Field B oil mass	5.0 %	0.65	3.3 %	U*
Field B ORF	5.3 %	0.65	3.4 %	U*
Allocated HC mass			12.3 %	**U***

ORF relative contribution 93 %

Gas mass

Pro rata	Field A	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.75 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.65	3.3 %	U*
Field A ORF	16.7 %	-0.53	8.9 %	U*
Field B oil mass	5.0 %	0.65	3.3 %	U*
Field B ORF	5.3 %	-0.15	0.8 %	U*
Allocated gas mass			10.1 %	**U***

ORF relative contribution 89 %

Pro rata	Field B	Gas mass		
	U*	Rel.sens.coeff	Rel. U. contr.	
Export gas mass	0.8 %	1.00	0.8 %	U*
Field A HC mass	5.0 %	0.35	1.7 %	U*
Field A ORF	16.7 %	-0.28	4.7 %	U*
Field B oil mass	5.0 %	0.35	1.7 %	U*
Field B ORF	5.3 %	-0.08	0.4 %	U*
Allocated gas mass			5.4 %	**U***

ORF relative contribution 88 %