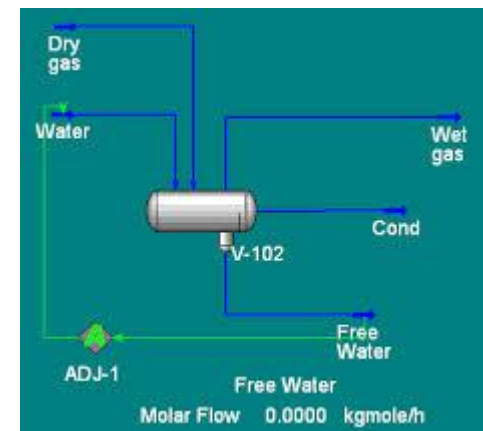


UNCERTAINTY CONTRIBUTION FROM PROCESS SIMULATIONS FOR ALLOCATION SYSTEMS

Phil Stockton
Accord Energy Solutions



This is what I'm going to talk about

11:35

16th September 2012

The Telegraph

HOME NEWS WORLD SPORT FINANCE COMMENT BLOGS CULTURE TRAVEL LIFE FASHI
Politics | Obits | Education | **Earth** | Science | Defence | Health | Scotland | Royal | Celebrities
Earth News | **Environment** | Climate Change | Wildlife | Outdoors | Picture Galleries | Earth Vi

HOME » E

Just 1

Overfish



THE SUNDAY TIMES

Only 100 adult cod in N Sea

ed.

Most wrong number ever reported?



ICES – International
Council for the Exploration
of the Sea

Half a billion total!

21 million adult

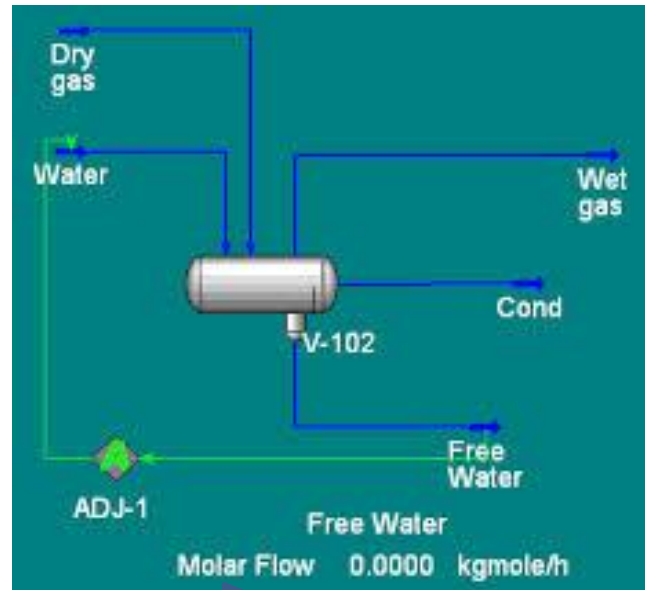
100 over the age of 12



Uncertainty of a simulation

M

&



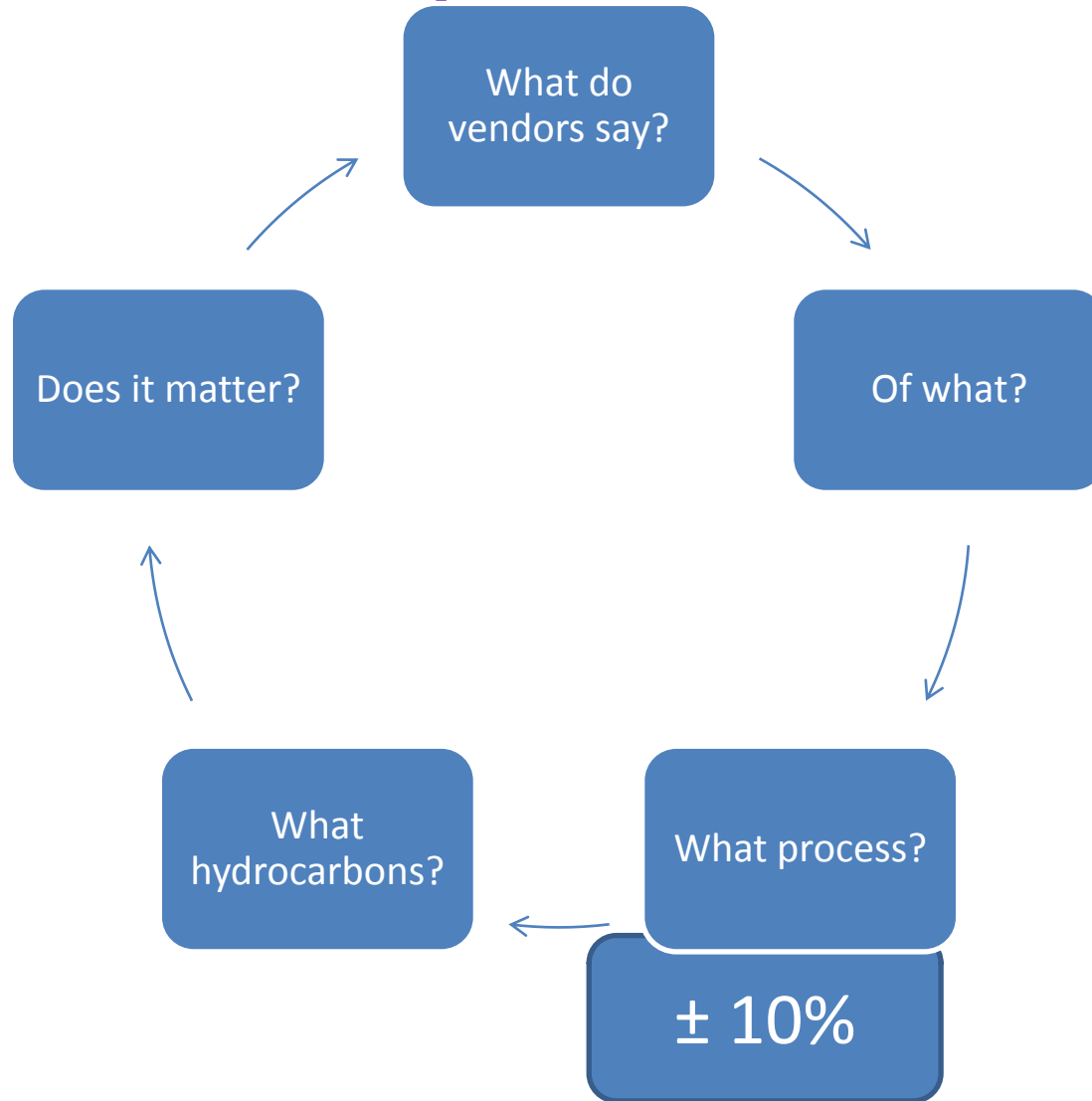
= Answer

$\pm 1\%$

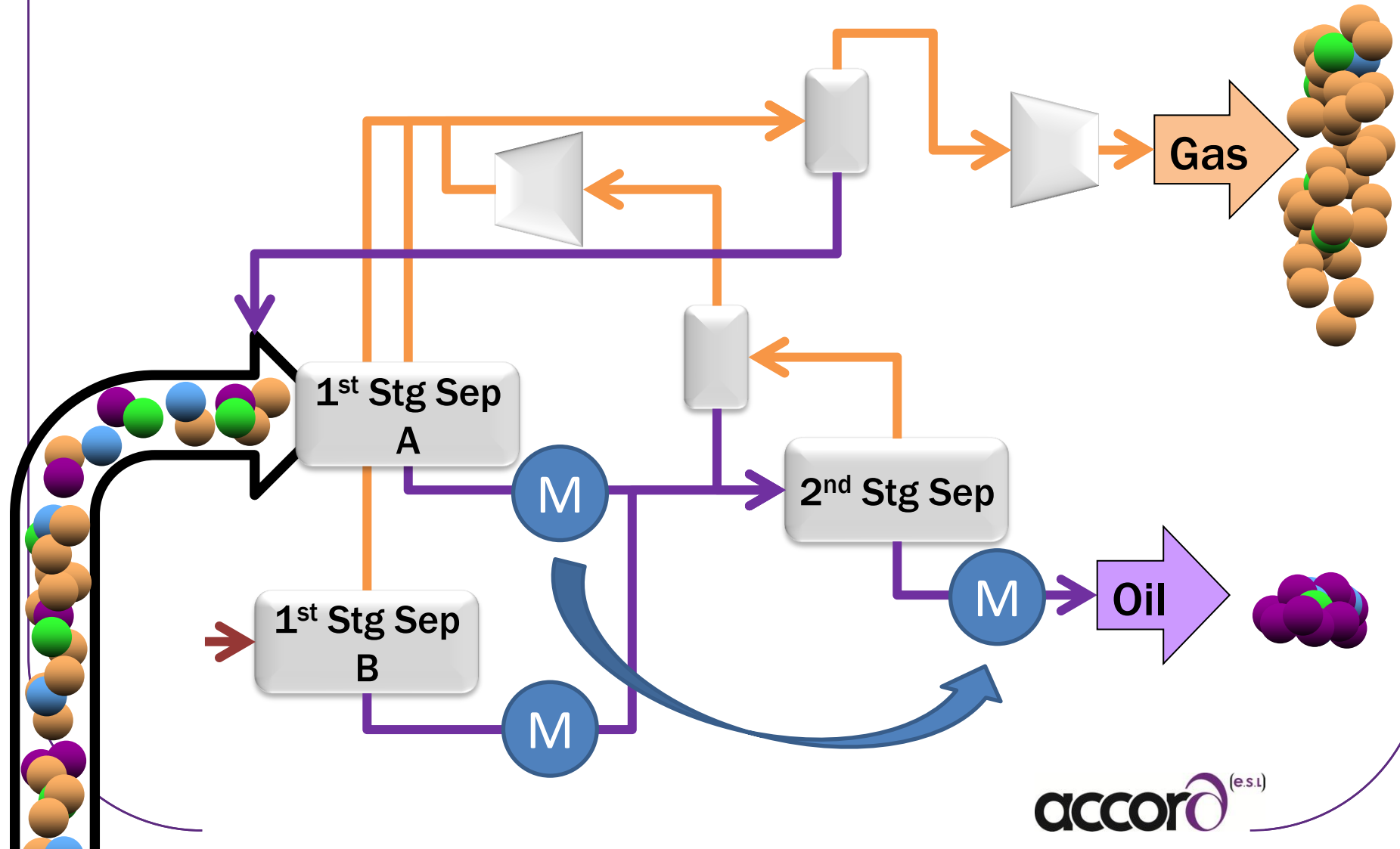
$\pm ?\%$

$\pm 10\%$

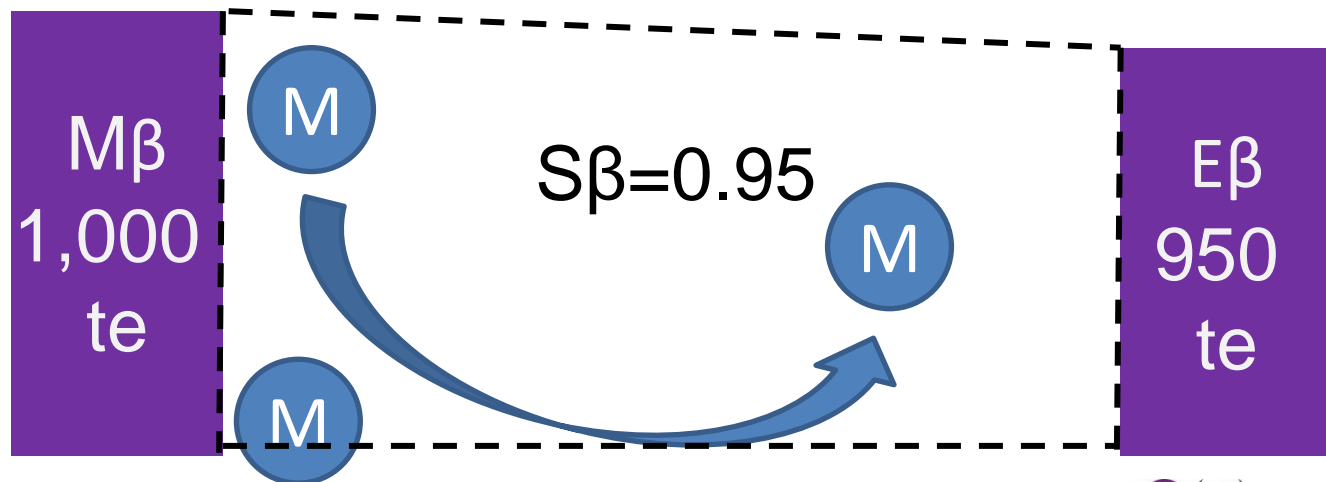
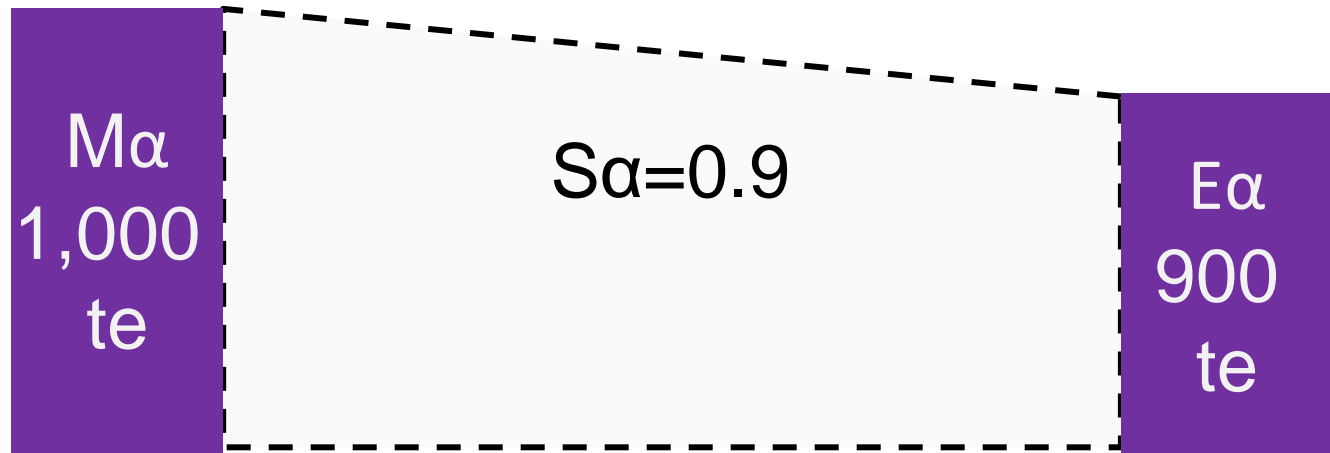
Uncertainty of a simulation



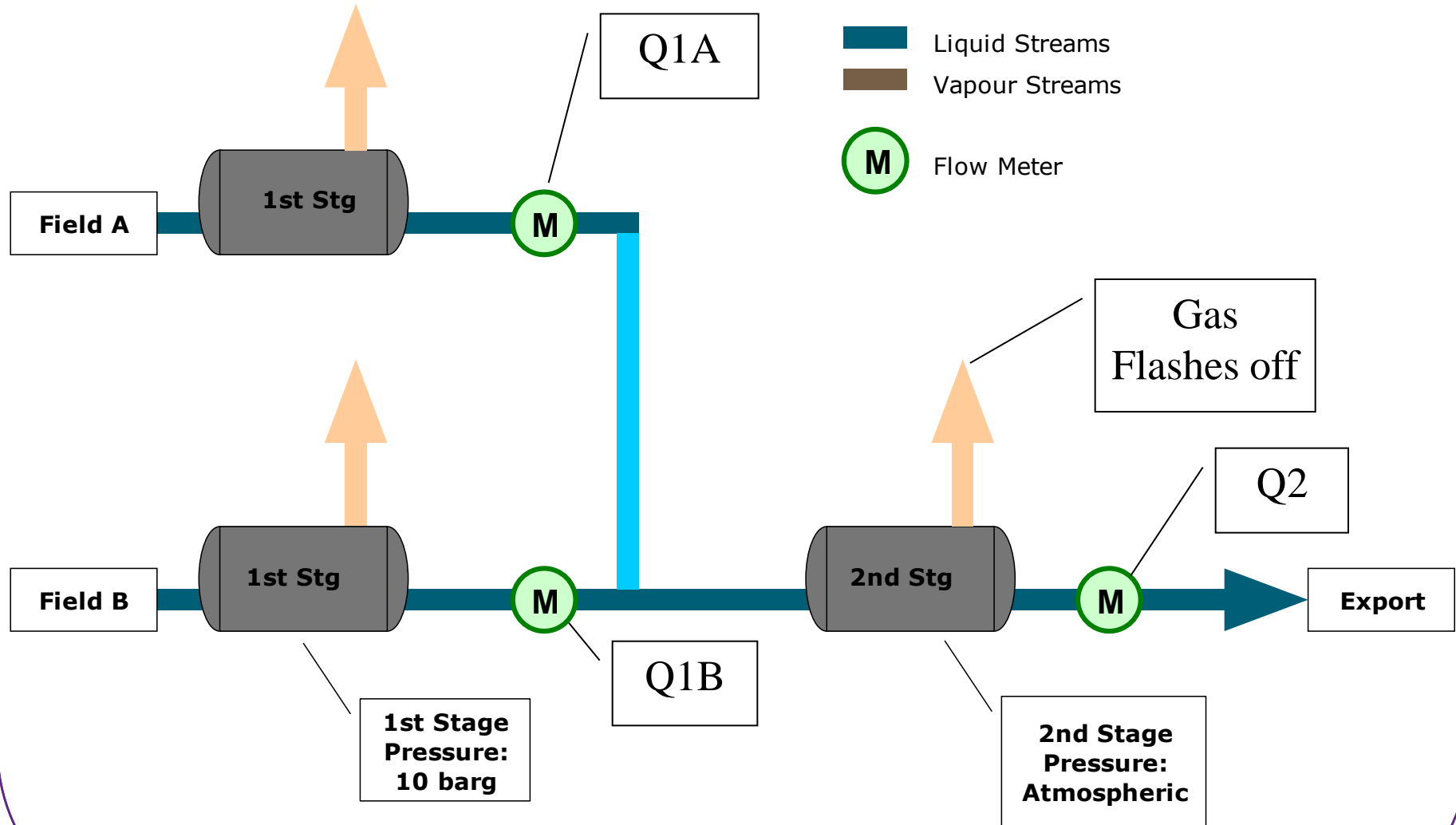
What Can A Simulation Tell Us?



Estimate shrinkage

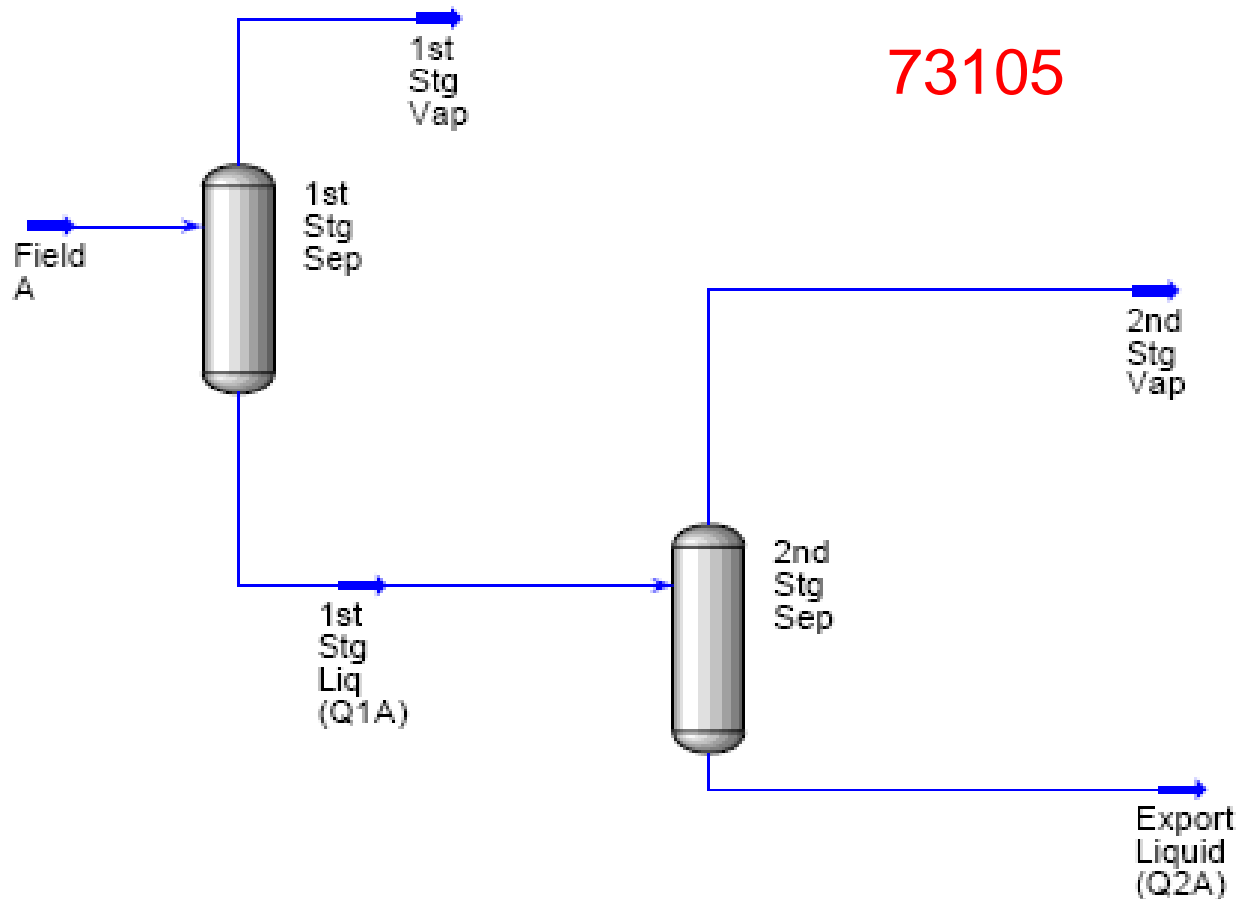


Calculate a shrinkage factor



Need to understand how A and B's hydrocarbons behave individually

Calculate Field A shrinkage factor



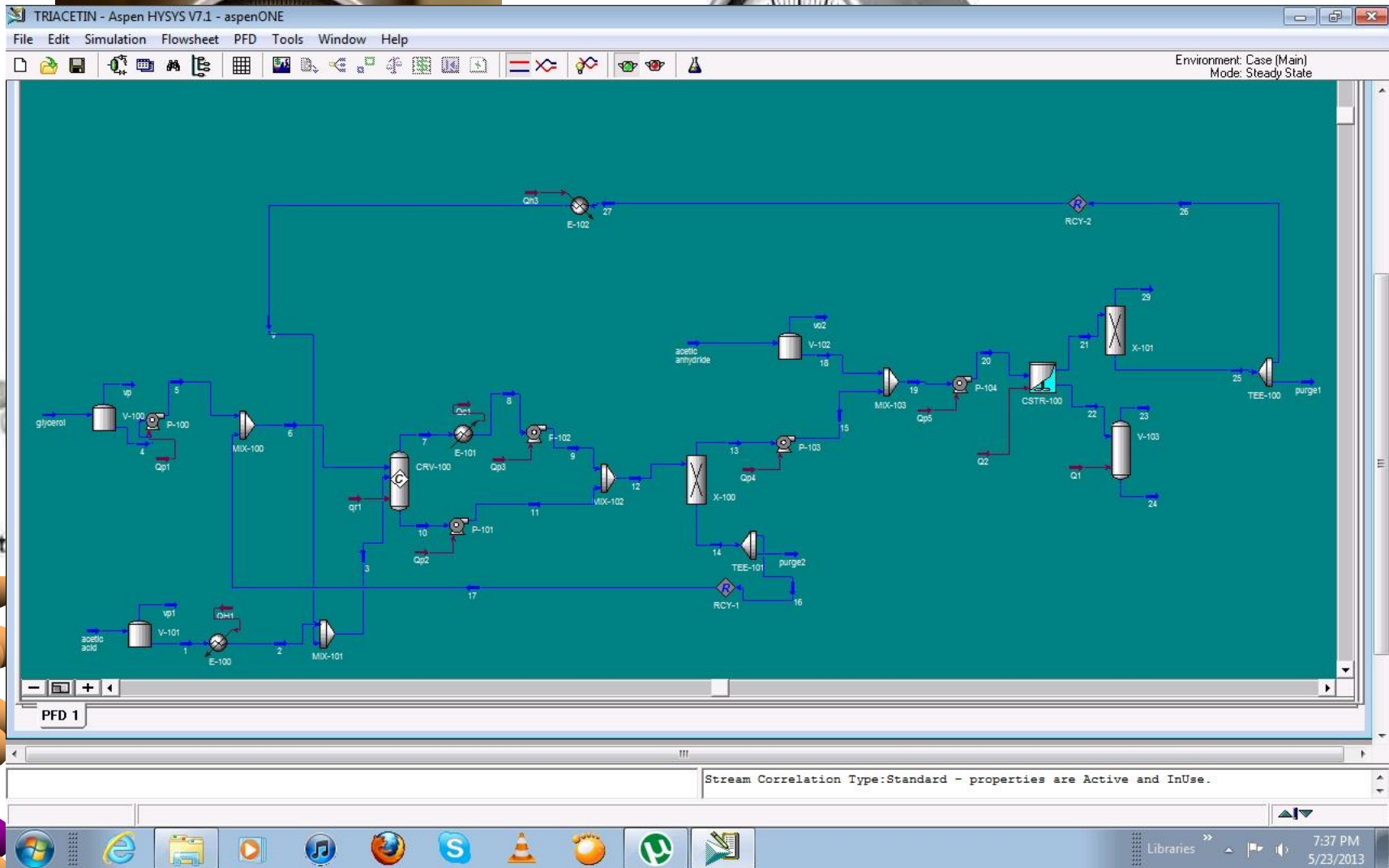
73105

$$S_A = \frac{\text{---}}{\text{---}} =$$

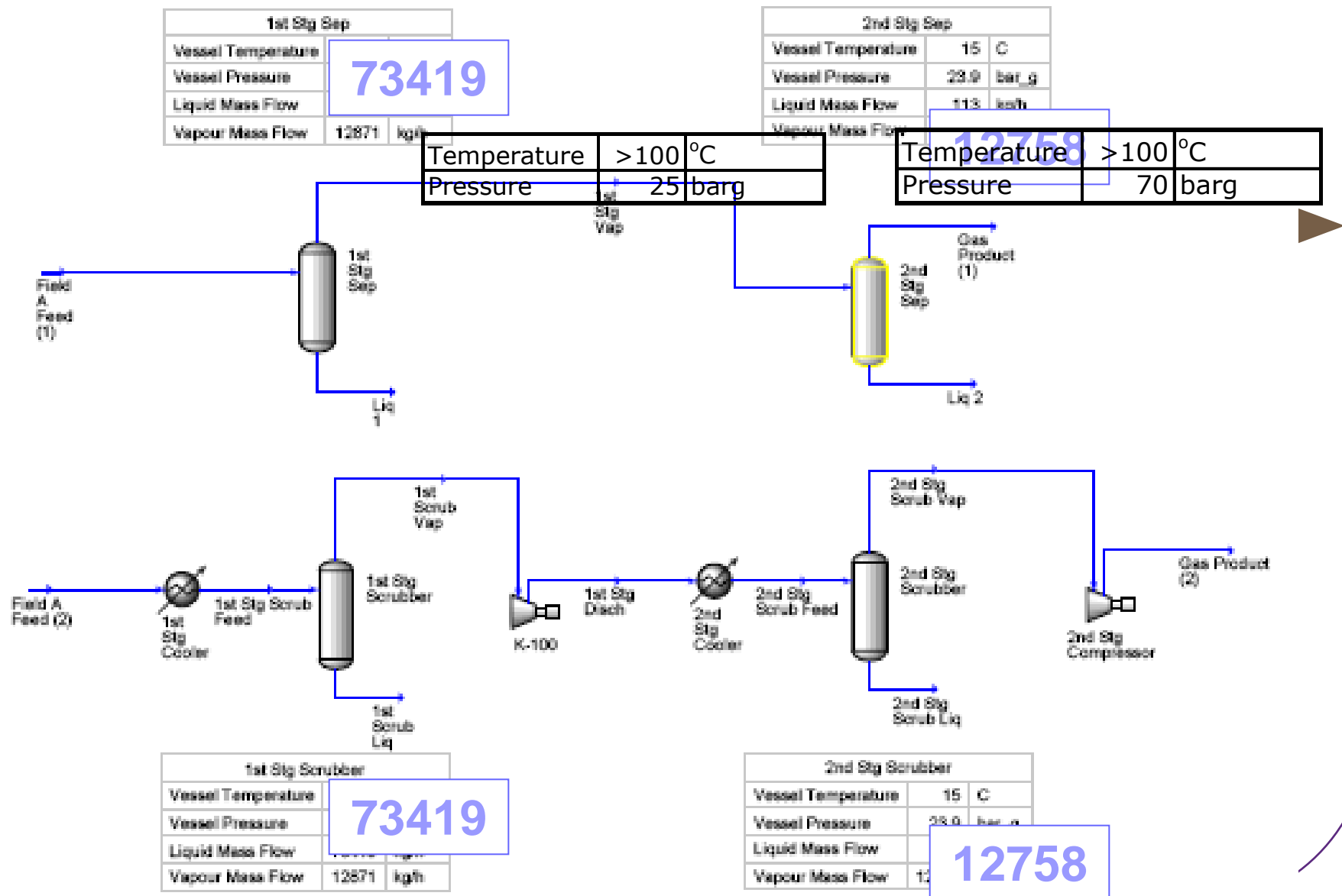
0.9769

70759

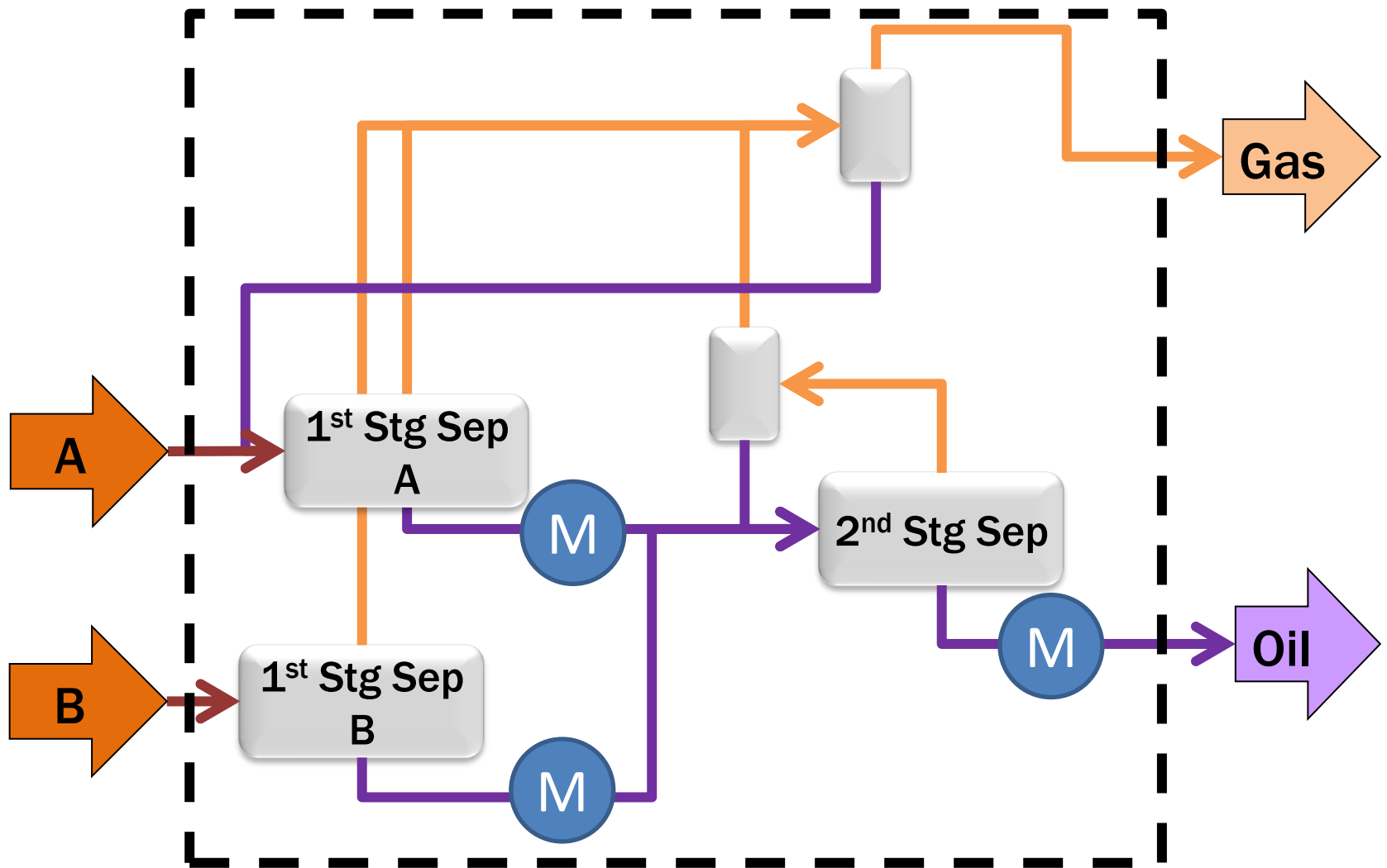
Sources of Uncertainty



Simplify the simulation

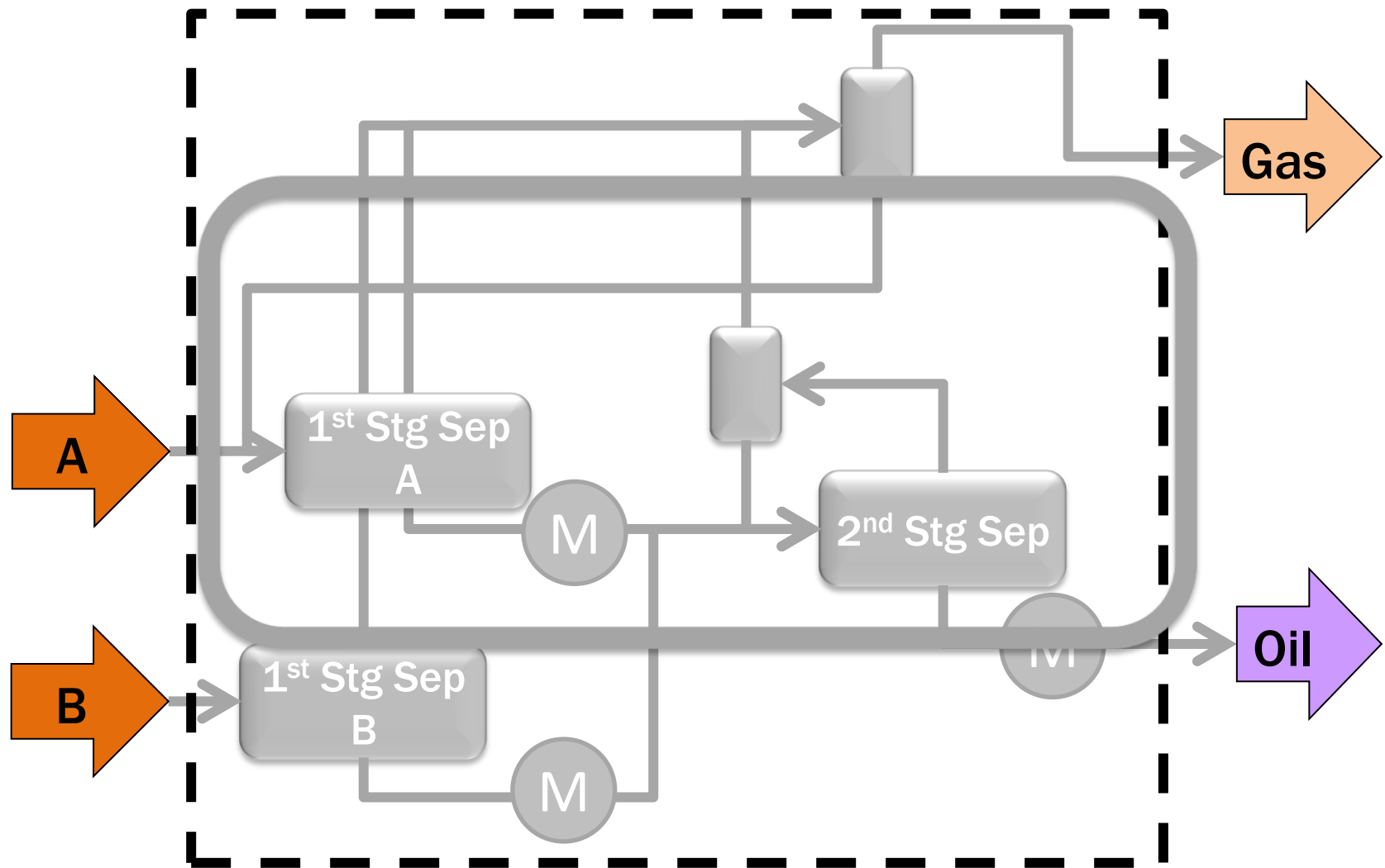


Mass Balance

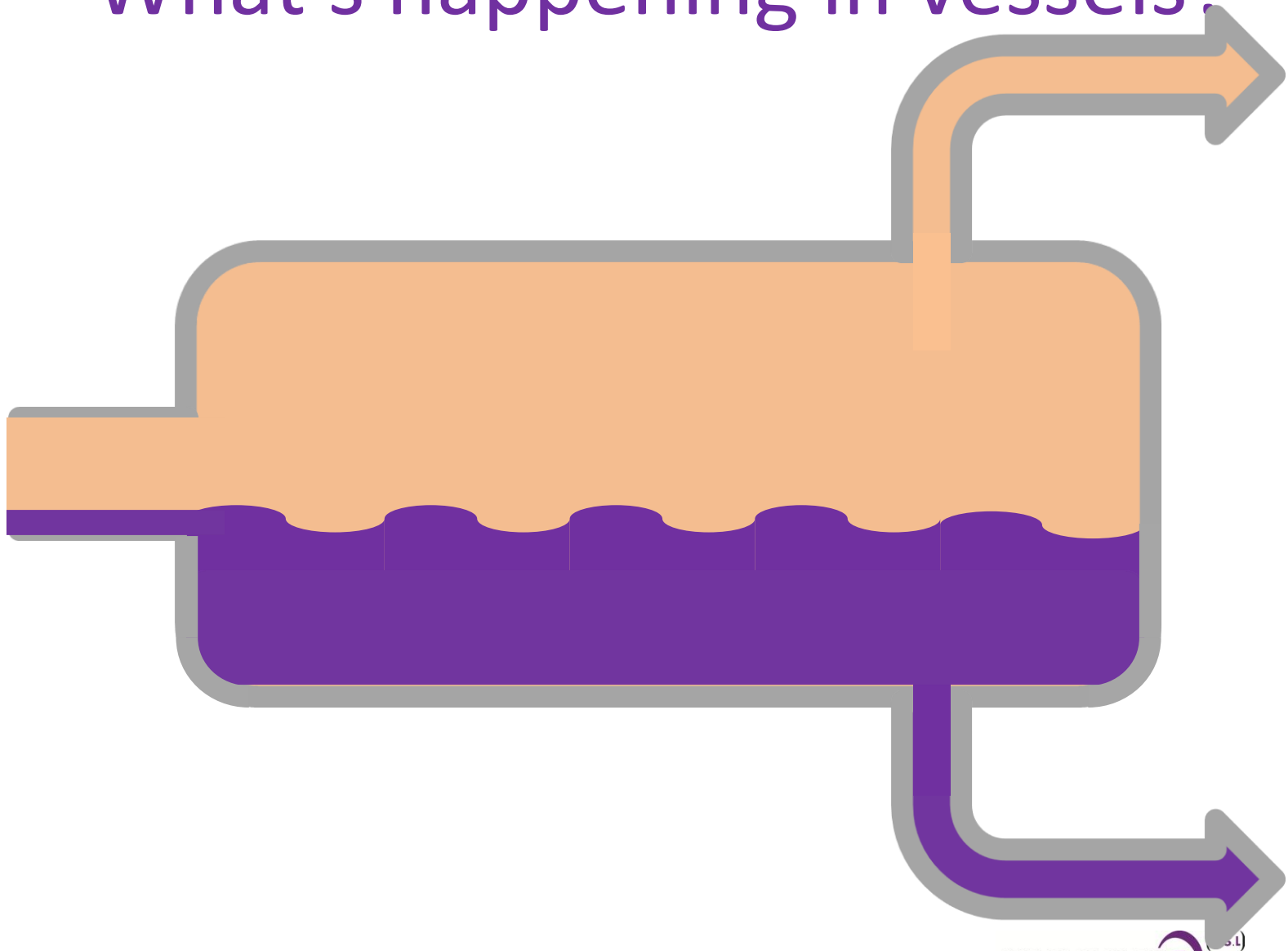




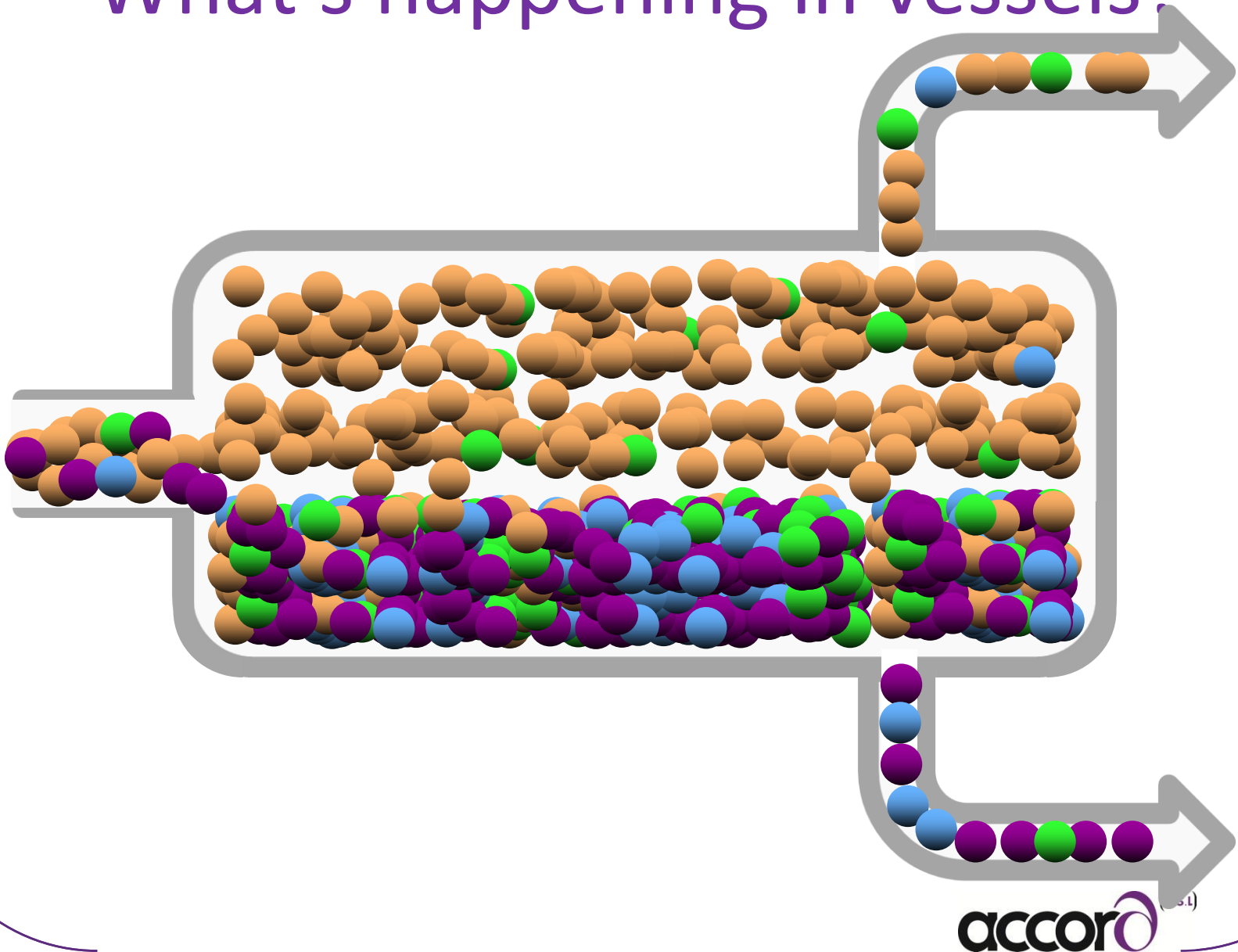
What's happening in vessels?

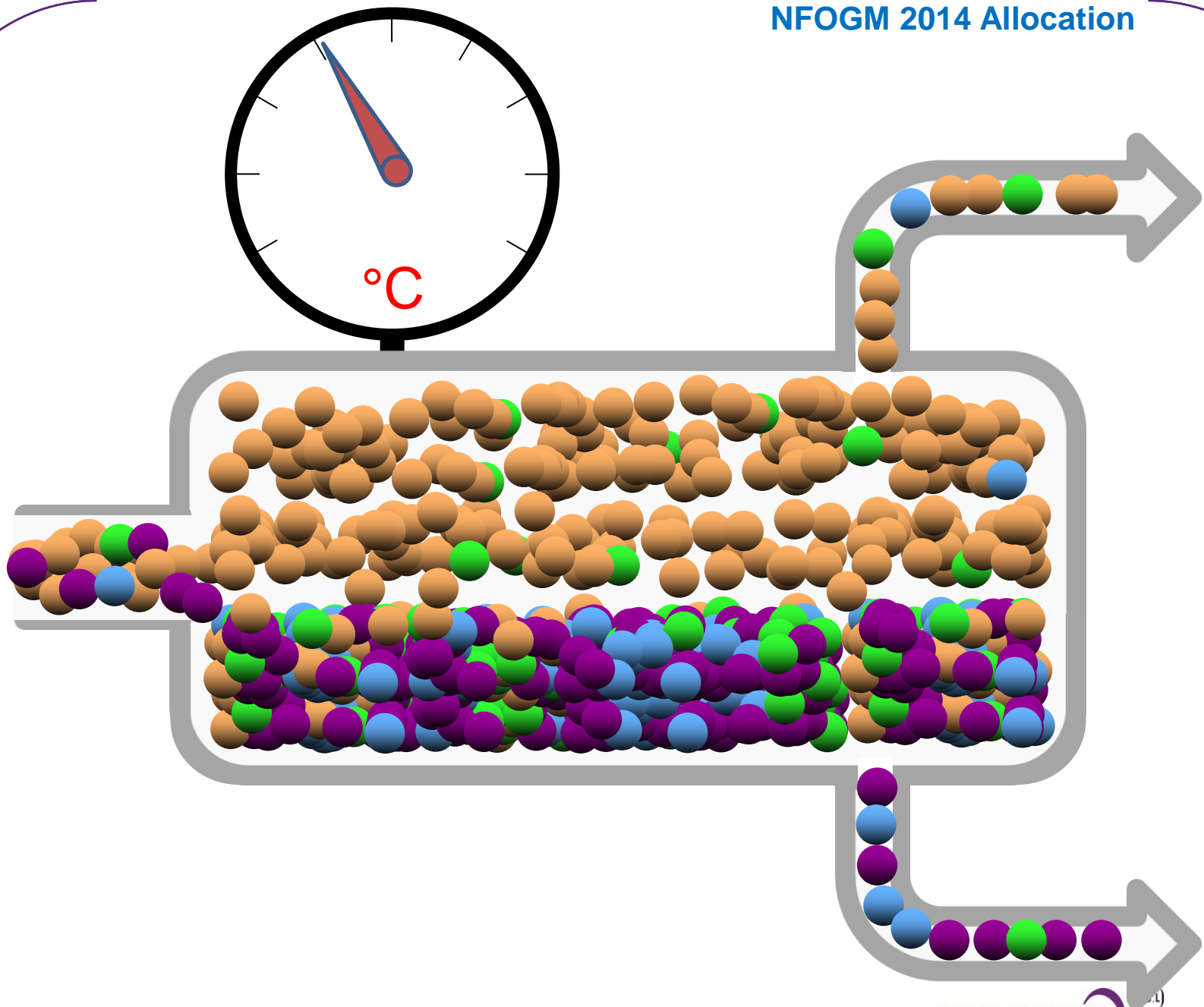


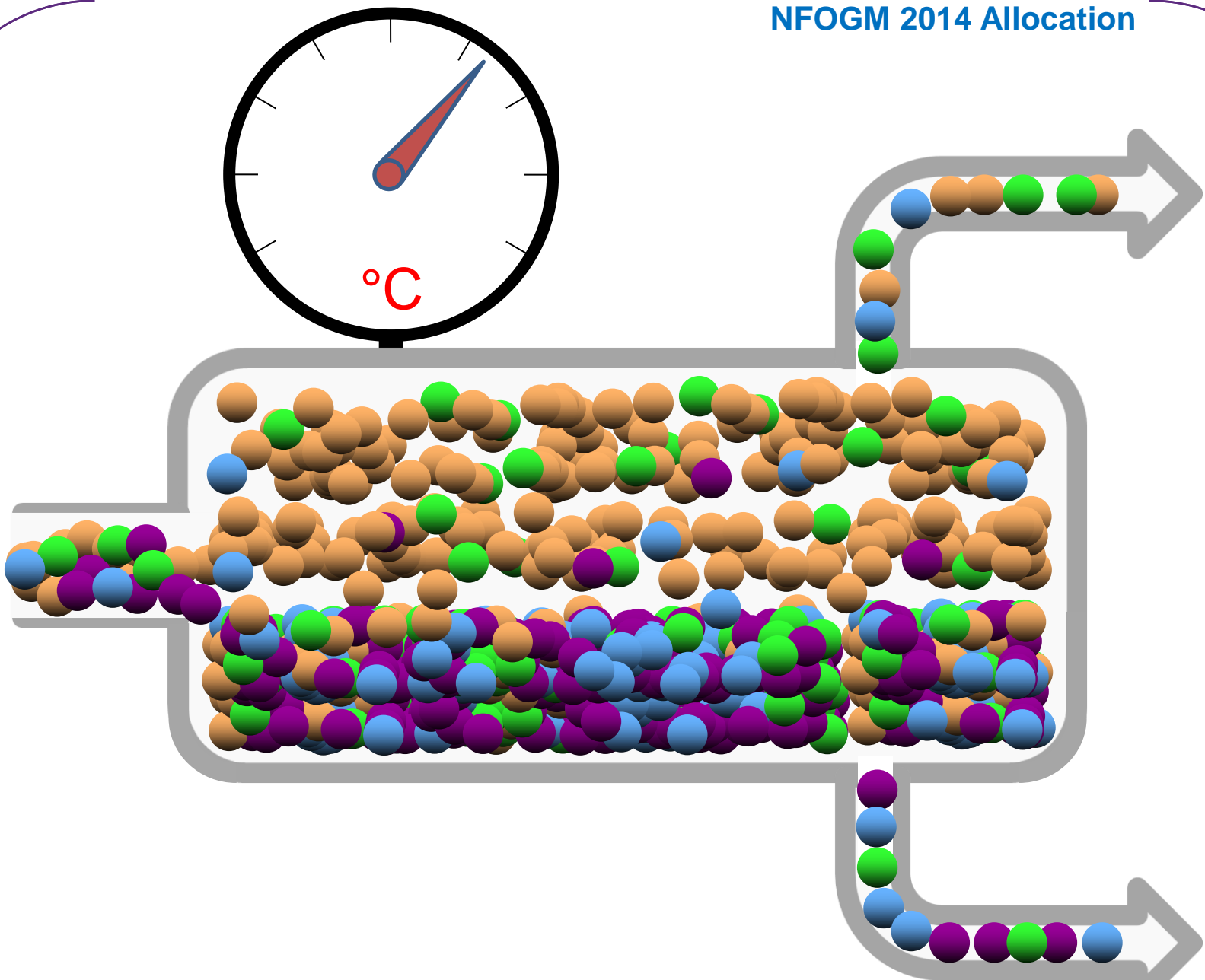
What's happening in vessels?



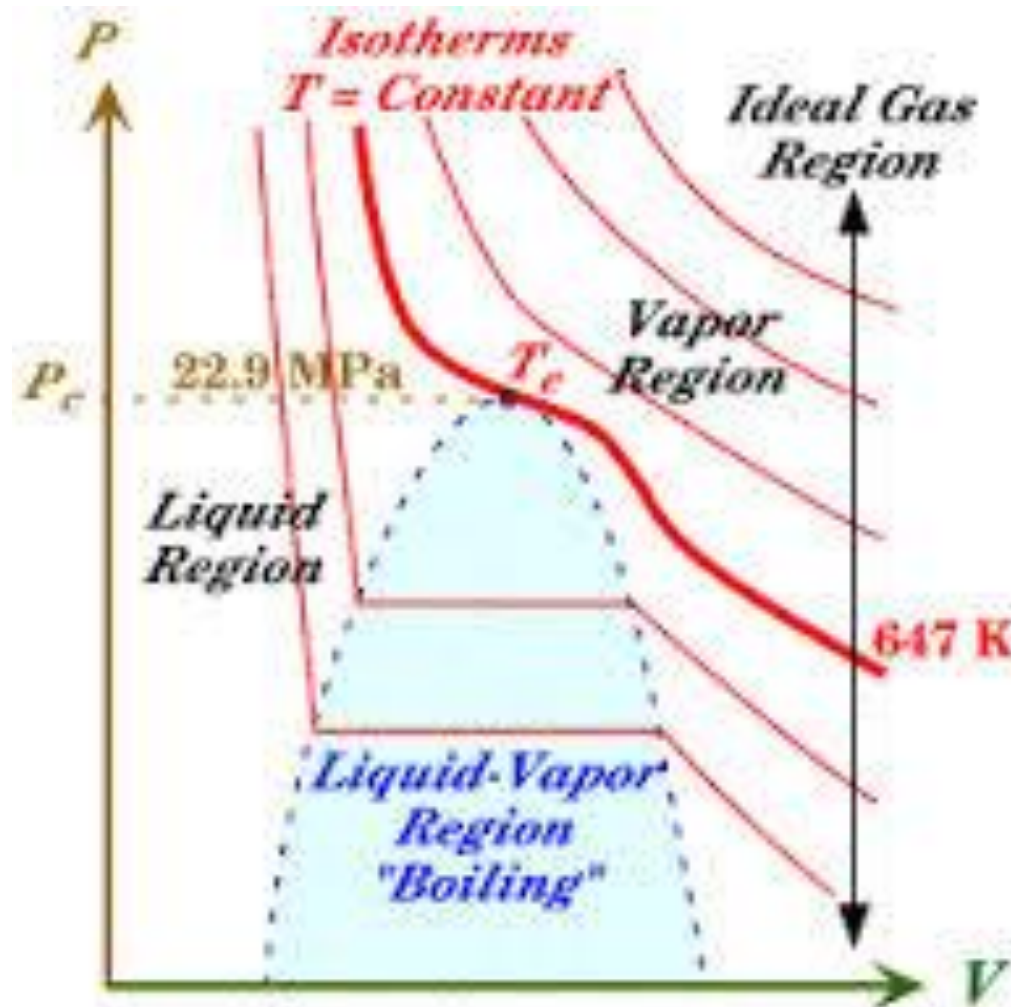
What's happening in vessels?







Equation of State



Equation of State

$$P = \frac{RT}{V_m - b} - \frac{a}{V_m^2 - 2V_m b - b^2}$$

$$a = \frac{R^2 T_c^2}{2.1870 P_c} \left(1 + k \left\{ 1 - T_r^{1/2} \right\} \right)^2 \quad \text{and} \quad b = \frac{R T_c}{12.8535 P_c}$$

$$Z = \frac{V_m}{V_m - b} - \frac{a}{RT V_m + 2RT b - (RT b^2 / V_m)}$$

$$k = 0.37464 + 1.54226\omega - 0.26922\omega^2$$

Peng Robinson

SRK – Soave Redlich Kwong

Equation of State

$$P = \frac{RT}{V_m - b} - \frac{a}{V_m^2 - 2V_m b - b^2}$$

$$a = \frac{R^2 T_c^2}{2.1870 P_c} \left(1 + k \left\{ 1 - T_r^{1/2} \right\} \right)^2 \quad \text{and} \quad b = \frac{R T_c}{12.8535 P_c}$$

$$Z = \frac{V_m}{V_m - b} - \frac{a}{R T V_m + 2 R T b - (R T b^2 / V_m)}$$

$$k = 0.37464 + 1.54226 \omega - 0.26922 \omega^2$$

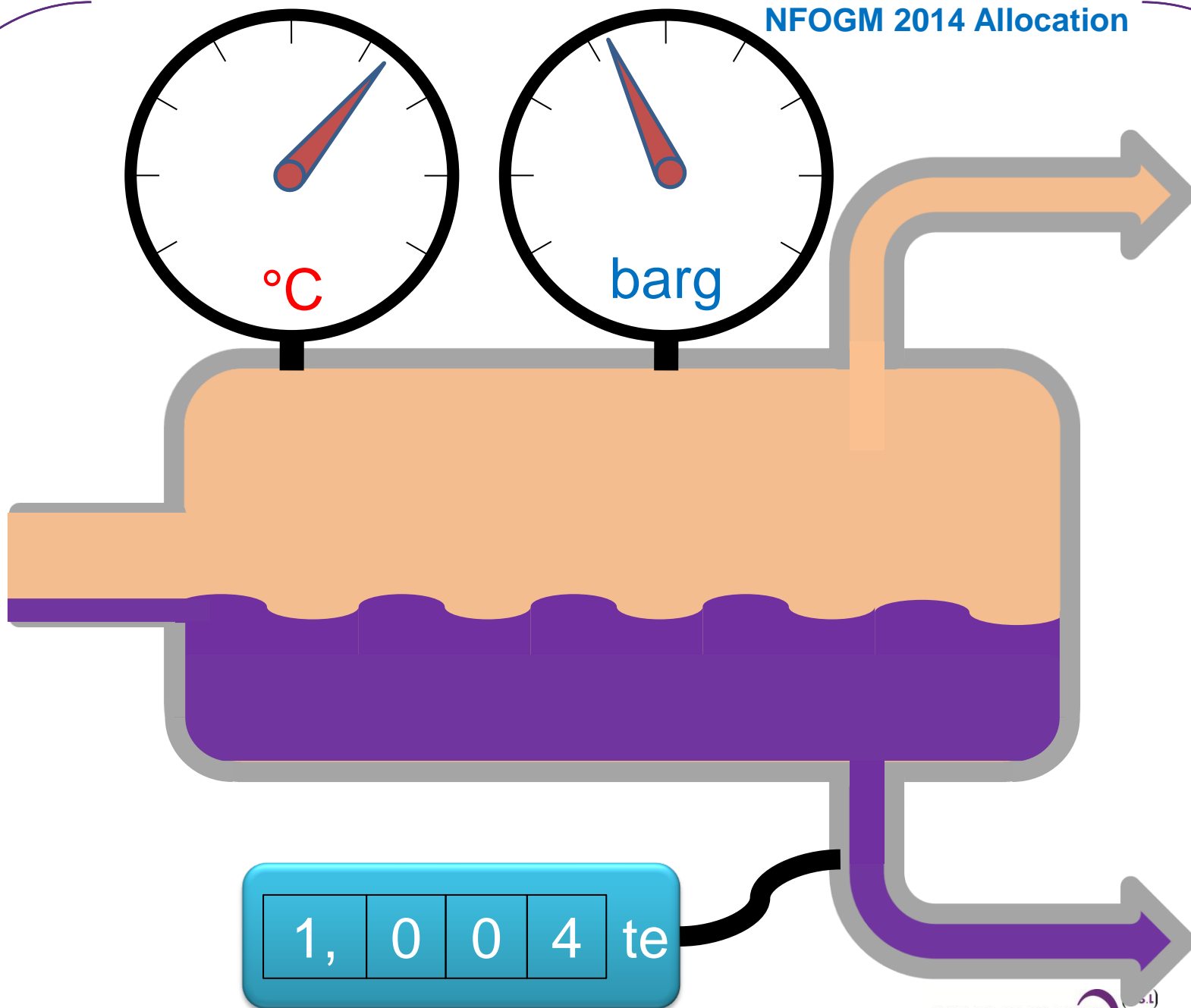
Peng Robinson

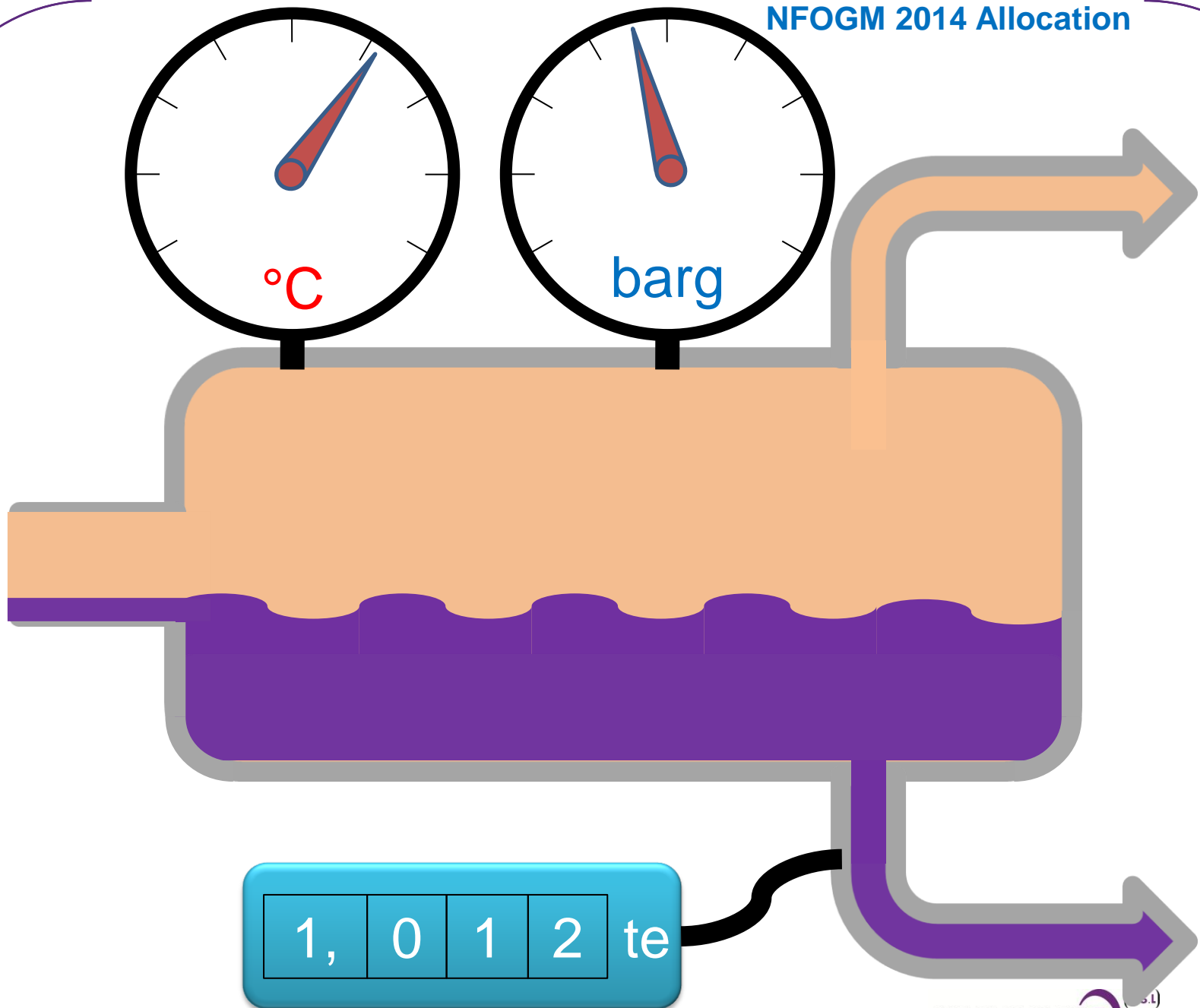
SRK – Soave Redlich Kwong

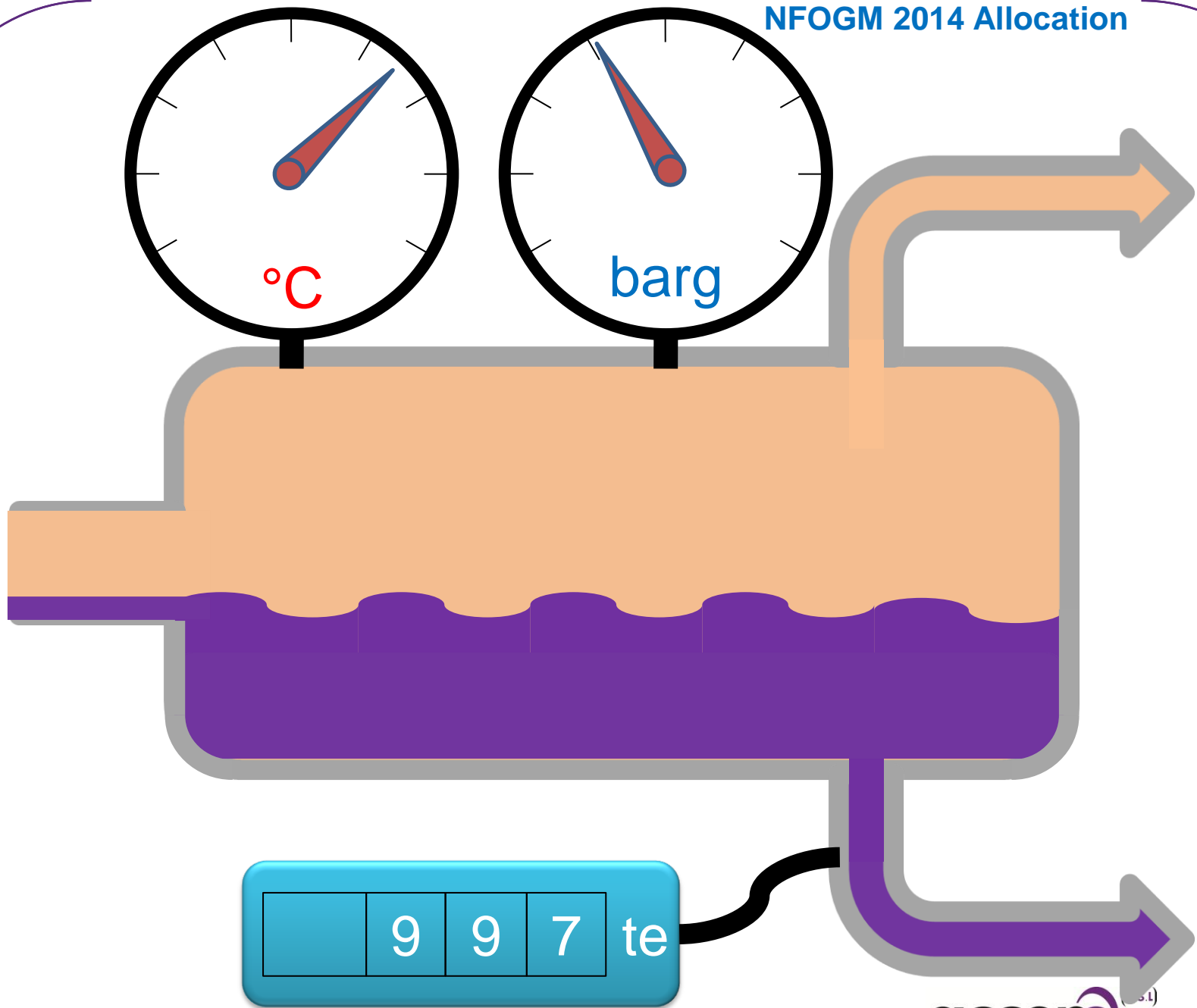
Equation of State

TABLE 1. *Values of Molecular Weight, T_c , P_c , Z_c , ω , α , and Sources of P-V-T Data for Selected Fluids*

Substance	M. Wt.	T_c (°R)	P_c (psia)	Z_c	ω	α	Sources of P-V-T Data
Argon	39.95	271.8	705.4	0.290	0	0	26
Krypton	83.80	377.2	196.9	0.291	0	0	27
Xenon	131.30	521.6	852.4	0.290	0	0	28
Methane	16.04	343.6	673.1	0.290	0.013	0	29, 30, 31, 32
Ethane	30.07	549.9	711.5	0.285	0.099	0	33, 34, 35
Propane	44.09	665.9	617.4	0.277	0.150	0	35, 36, 37, 38, 39, 40
Butane	58.12	765.4	550.6	0.274	0.201	0	34, 35, 39, 41, 42
Pentane	72.15	845.7	489.5	0.269	0.254	0	34, 39
Ethylene	28.05	509.0	739.8	0.270	0.087	0	34, 35, 43, 44
Benzene	78.11	1012.3	714.3	0.274	0.215	0	45, 46
Nitrogen	28.02	227.1	492.6	0.291	0.040	0	34, 47, 48, 49
Carbon monoxide	28.01	239.7	507.6	0.294	0.046	0	43, 50, 51
Carbon dioxide	44.01	547.6	1071.3	0.274	0.420	0	34
Hydrogen sulfide	34.08	672.4	1306.5	0.268	0.100	0	52, 53, 54
Propylene	42.08	657.0	667.5	0.274	0.142	0.002	55
Nitric oxide	30.01	323.9	946.9	0.251	0.577	-0.045	56
Nitrous oxide	44.02	557.4	1051.0	0.273	0.160	-0.003	57, 58
Sulfur dioxide	64.06	775.2	1142.9	0.268	0.252	0.006	59, 60
Methyl chloride	50.49	749.3	986.3	0.276	0.152	0.007	58, 61
Ethylene oxide	44.05	842.0	1043.4	0.255	0.207	0.012	62
Ammonia	17.03	730.2	1641.0	0.242	0.252	0.013	43, 63, 64









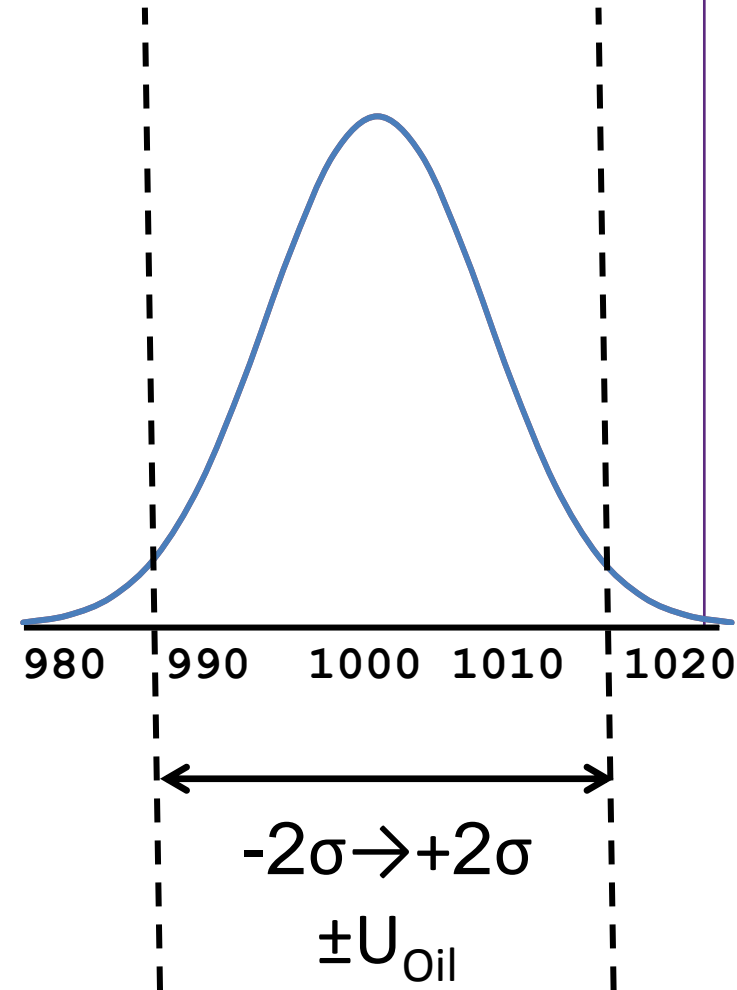
Monte Carlo

Iter	Temp (°C)	Pres (barg)	Oil (te)
	30±1%	40±1%	



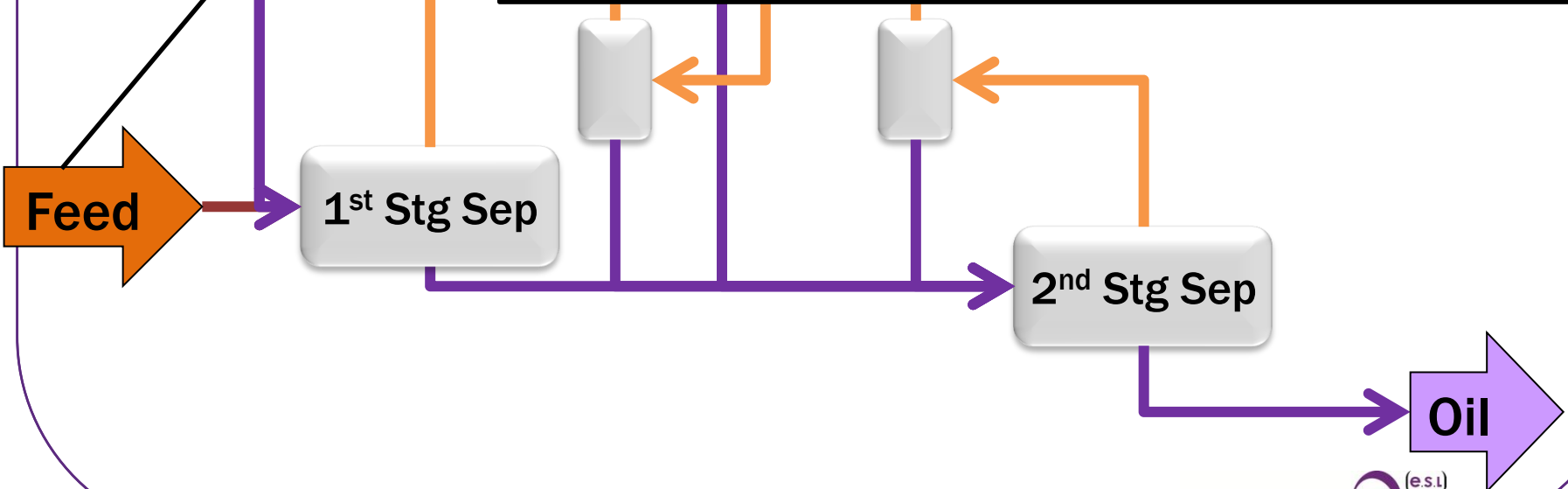
Monte Carlo

Iter	Temp (°C)	Pres (barg)	Oil (te)
	30±1%	40±1%	
1	29.8	40.2	1,010
2	30.1	40.5	990
3	30.2	39.8	985
4	29.9	38.9	1,005
5	30.3	40.0	1,020
:	:	:	:
10,000	30.1	40.1	1,015

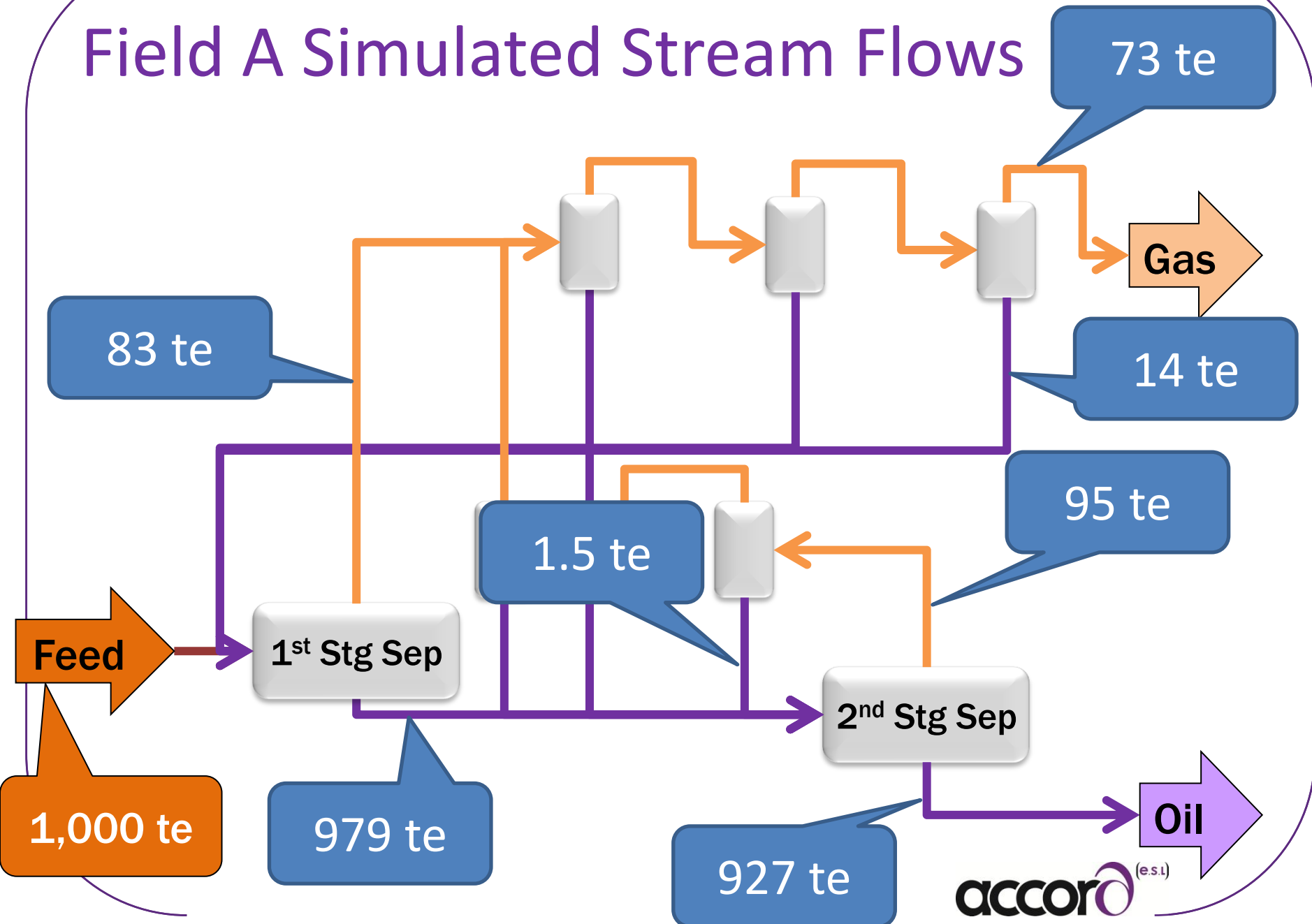




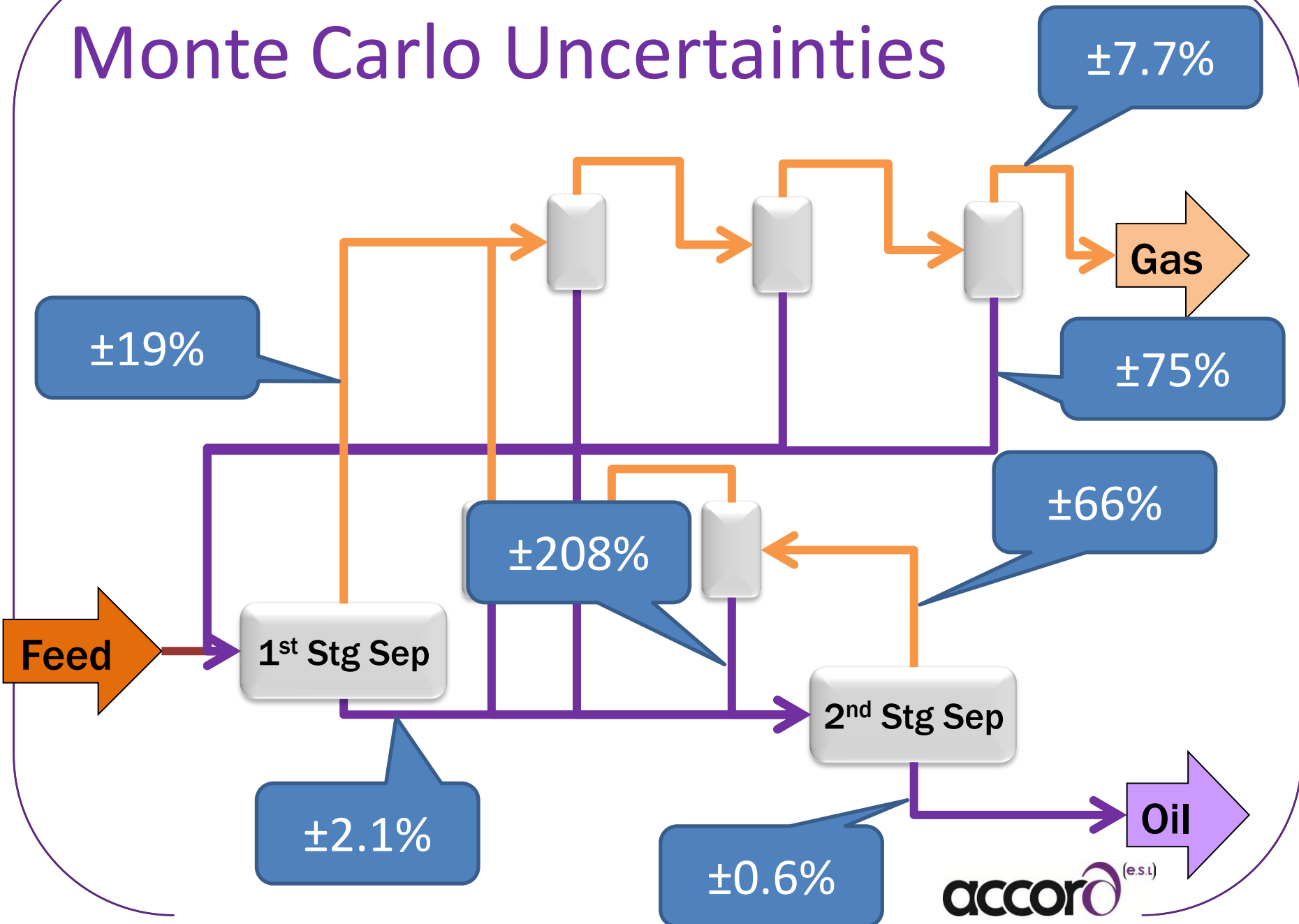
			MW kg/kmol	Tc K	Pc bara	ω	BIP
N ₂	0.0043	±10%					
CO ₂	0.0022	±10%					
C ₁	0.2282	±10%	16.043	190.97	46.380	0.01149	
C ₂	0.0404	±10%	(±0.2%)				
...							0.076
...							
C ₂₀₊	0.1190	±10%	300 (±5%)	800	14	0.7	



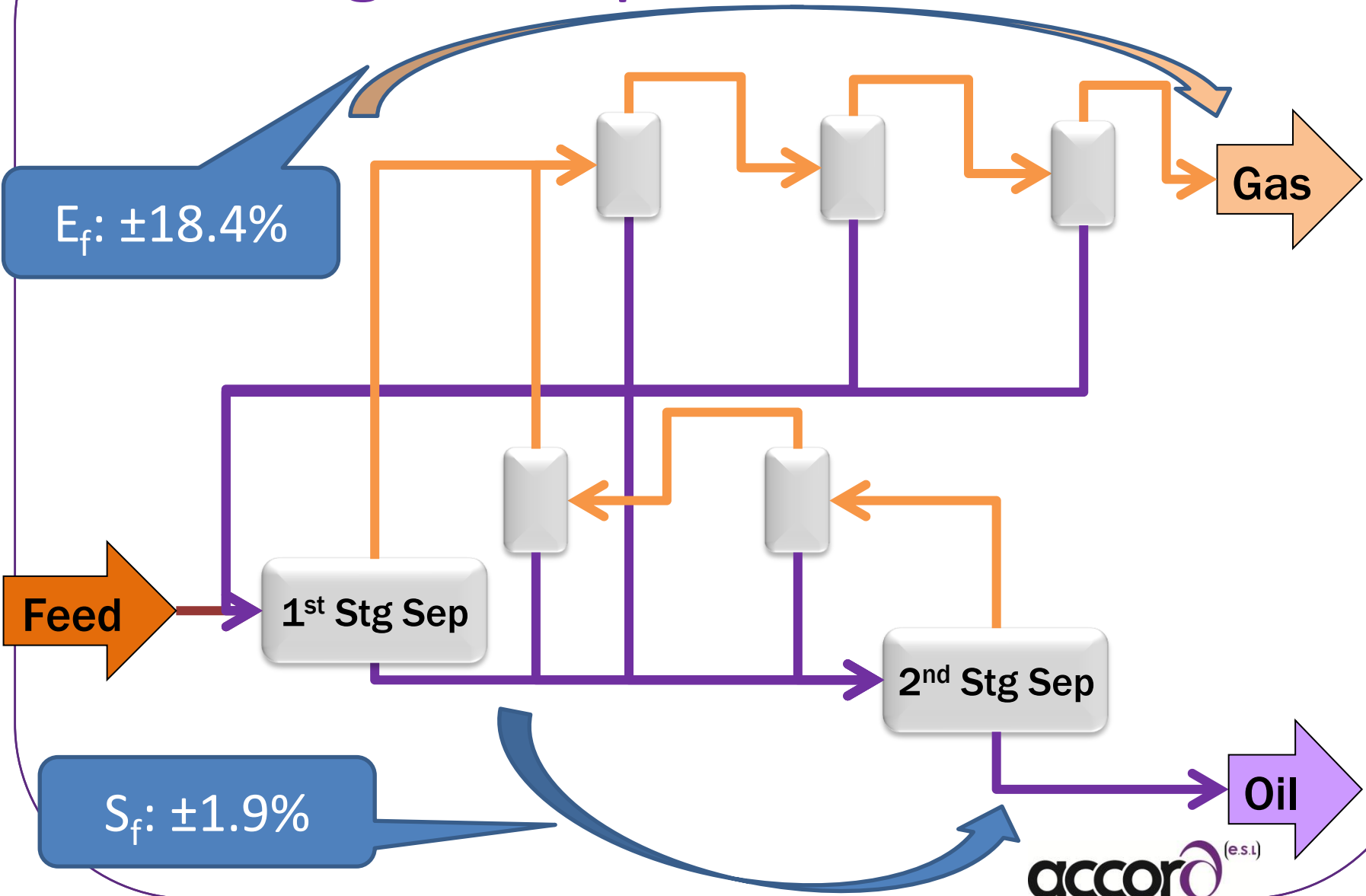
Field A Simulated Stream Flows



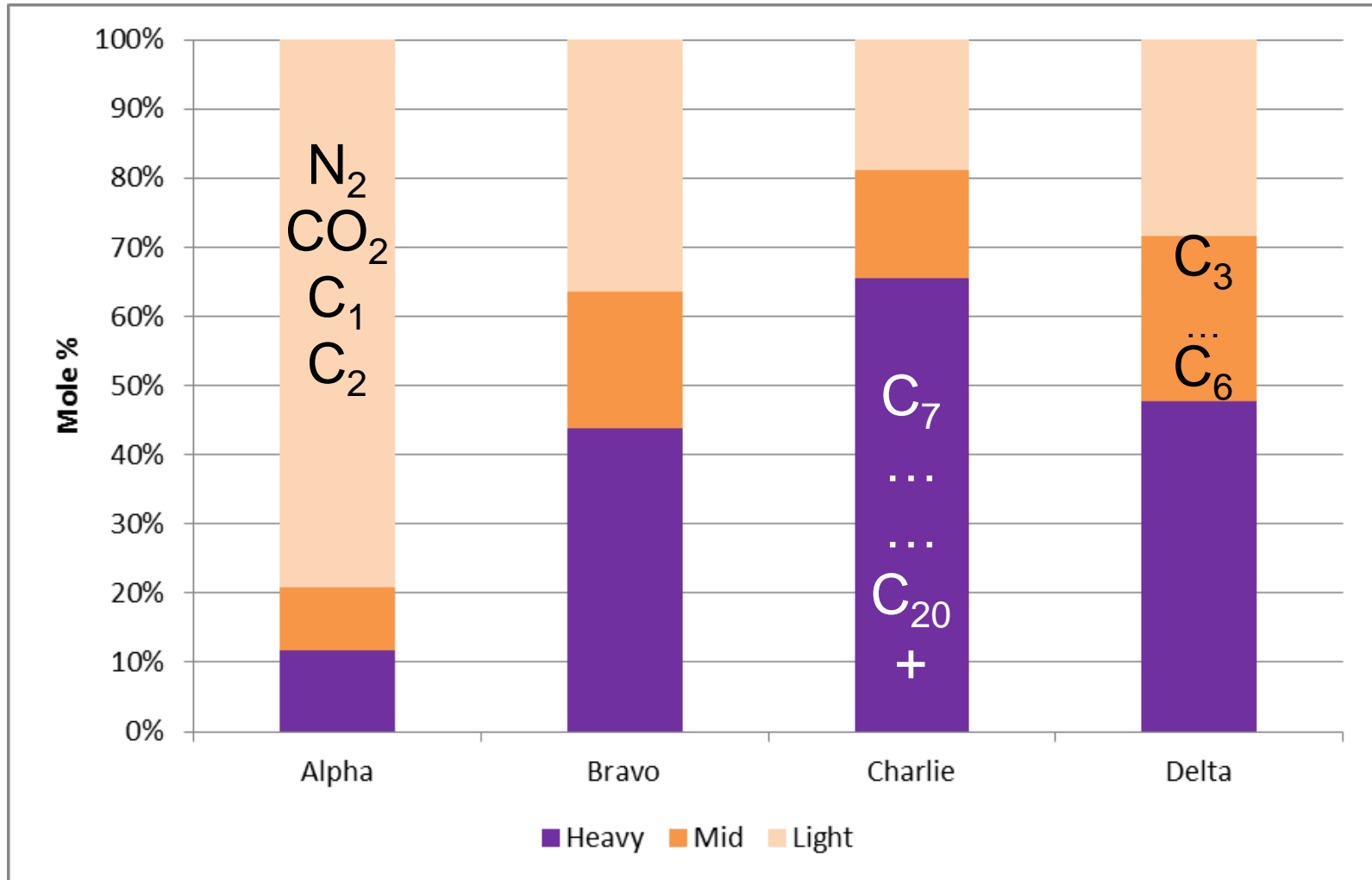
Monte Carlo Uncertainties



Shrinkage & Expansion Factors



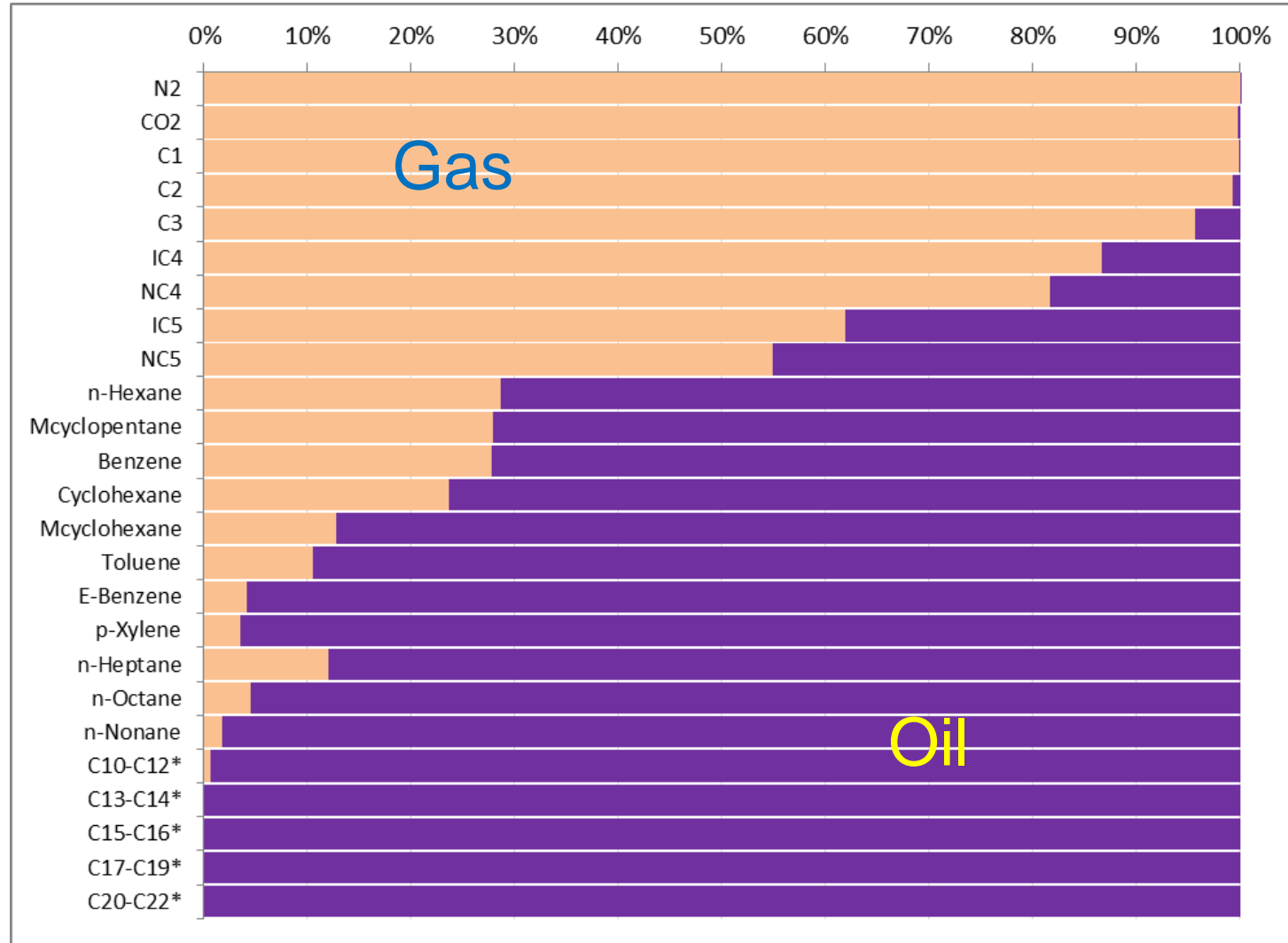
Four Fields – Different Compositions



Four Fields – Different Compositions

	Alpha	Bravo	Charlie	Delta
Oil S_f	0.982	0.947	0.948	0.947
Uncertainty ($\pm\%$)	0.4%	1.7%	1.9%	1.9%
Gas E_f	1.012	0.949	0.974	0.882
Uncertainty ($\pm\%$)	0.7%	17.8%	21.9%	18.4%

Component Split to Oil and Gas



Compositional Variation

$E_f: \pm 18.4\%$

Feed

$S_f:$

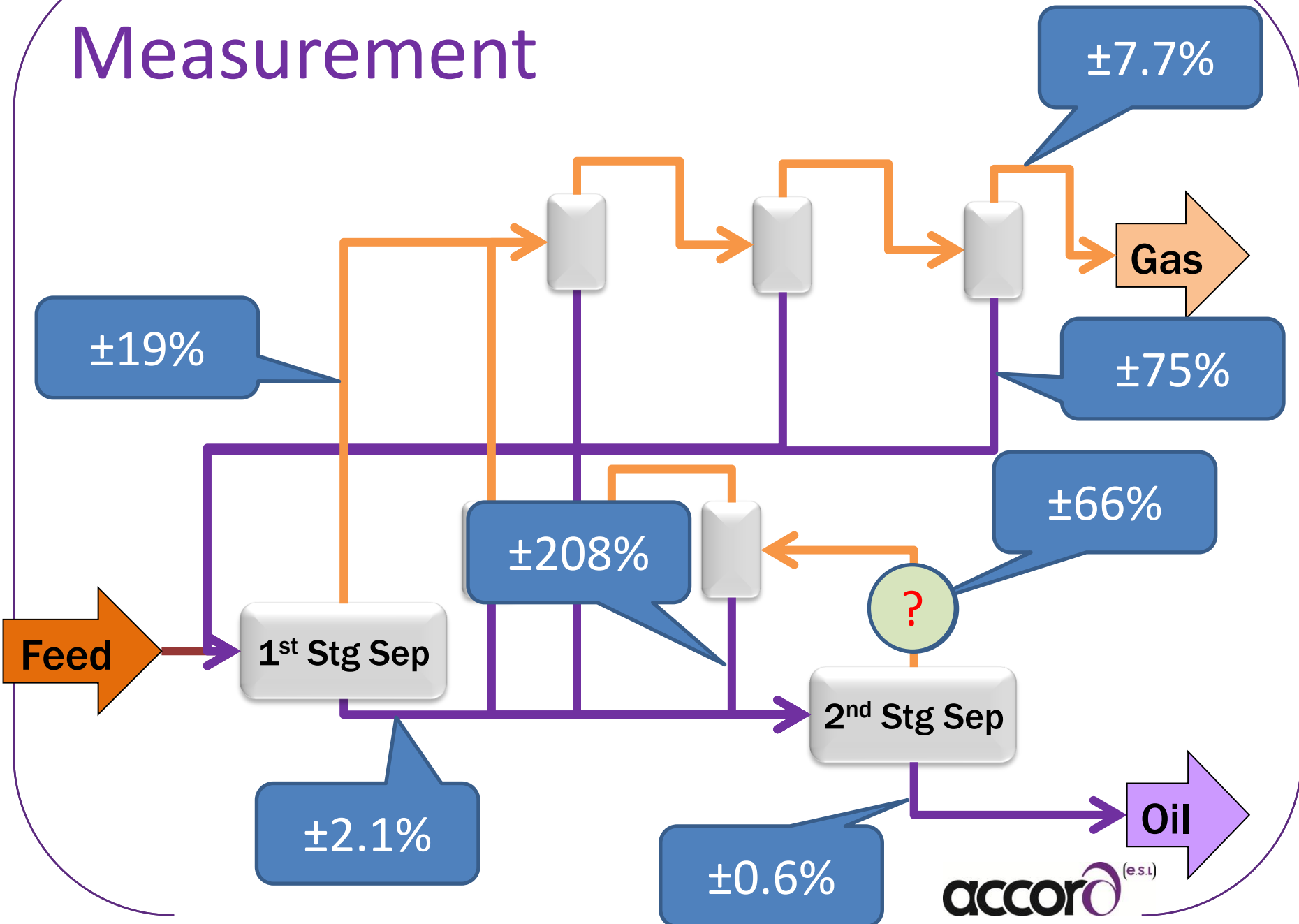


Oil

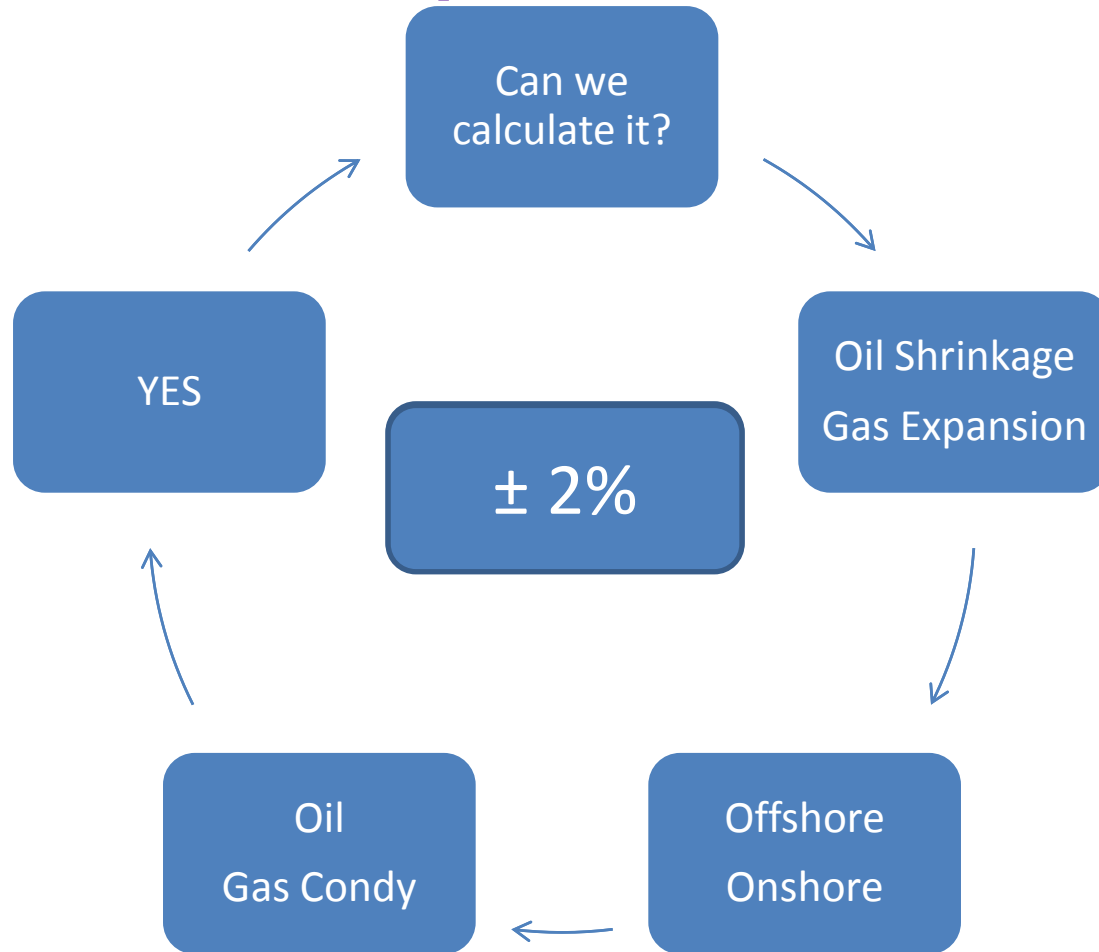
(e.s.)






pro

Measurement



Uncertainty of a simulation



Seed Rankings			Pts
1		Spain	1,513
2		Germany	1,311
3		Argentina	1,266
4		Colombia	1,178
5		Belgium	1,175
6		Uruguay	1,164
7		Switzerland	1,138
8		Netherlands	1,136
9		Italy	1,136
10		England	1,080

Ranking Points =
 $M \times I \times T \times C$

R=139.5



Indonesia



San Marino



Seed Rankings			Pts	W/O Friendlies			Pts
1		Spain	1,513		Spain	2,127	▲
2							12 ▲
3							02 ▼
4							27 ▼
5							52 ▲
6							41 ▲
7							90 ▼
8							77 ▲
9		Italy	1,136		Uruguay	1,471	▼
10		England	1,080		Switzerland	1,433	▼