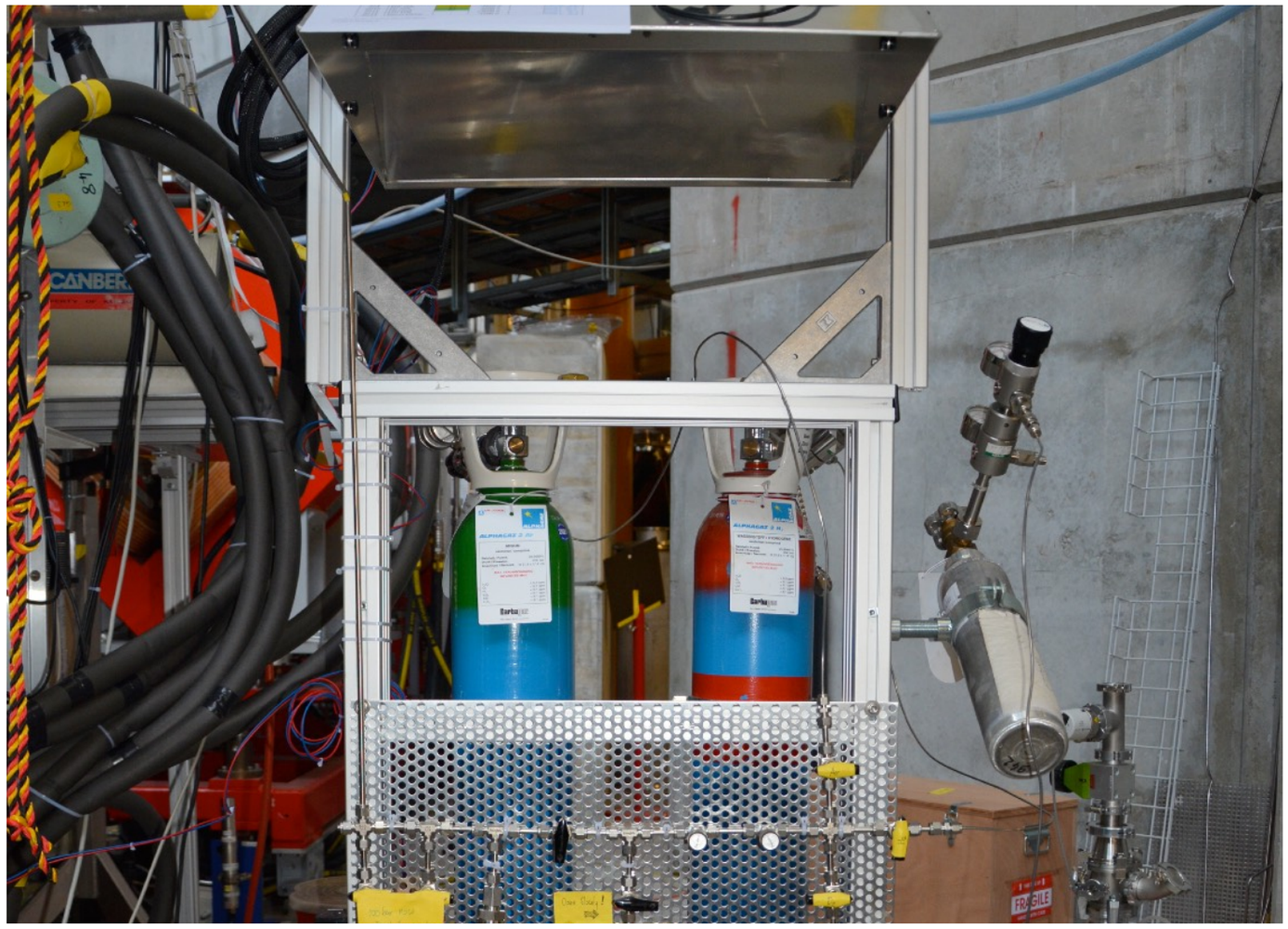
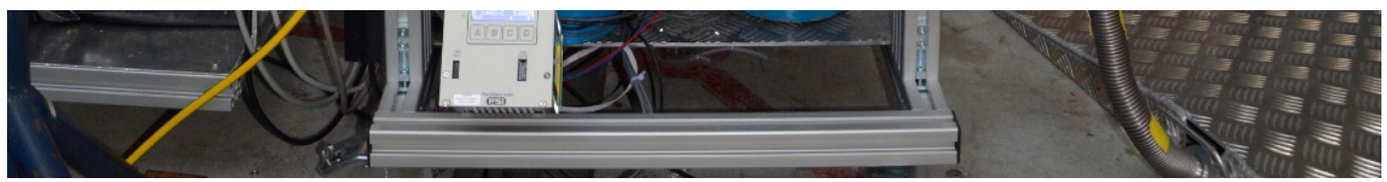


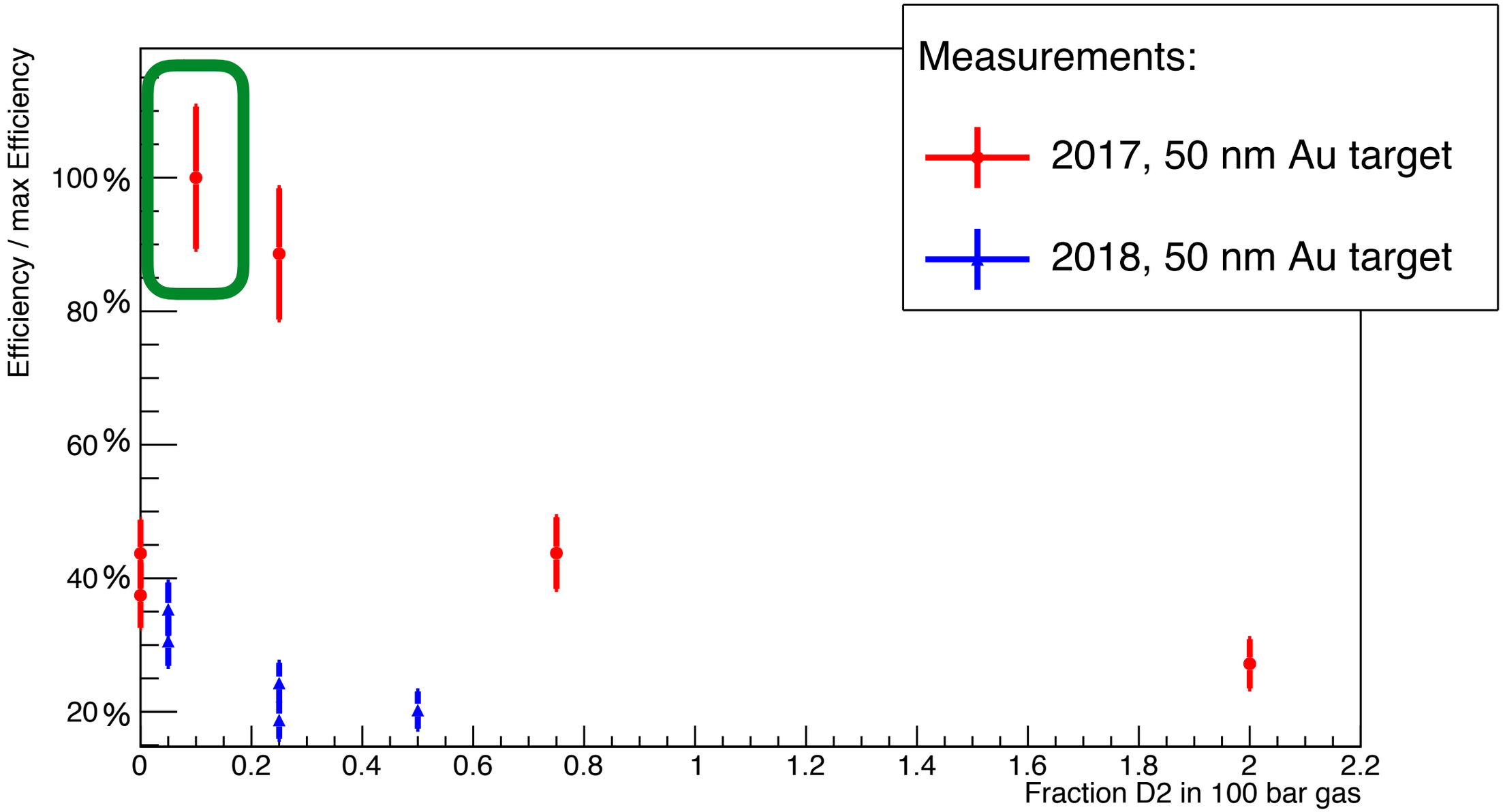
GAS SYSTEM FOR MUX

MUX COLLABORATION MEETING
18 JUNE 2019, JOHANNES GUTENBERG UNIVERSITY MAINZ

Alexander Albert Skawran



EFFICIENCY DEPENDENCY REGARDING GAS MIXTURE



- The muon transfer efficiency depends strongly on the mixture of H_2 and D_2 in the gas
- We have strong discrepancies in the results for 2017 and 2018
- A possible reason is that we had not a proper gas mixture

Valve

Gas bottle

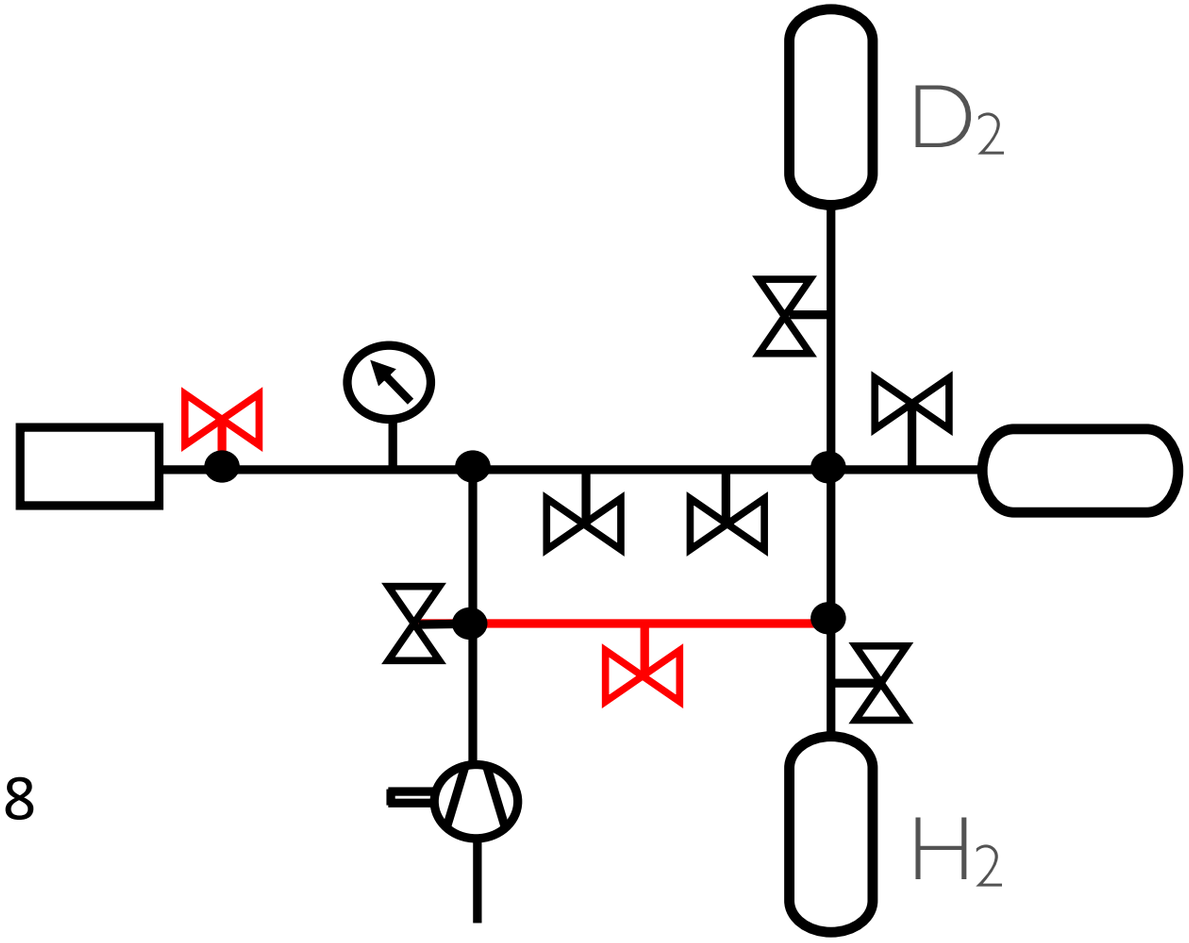
Gas cell

Vacuum pump

Barometer

Set up 2017/2018

Set up 2018



Mixing procedure:

1) Pump gas out
2) Flush gas pipes and gas cell 5 times with hydrogen
3) Fill the required amount of D2
4) Fill H2 up to a pressure of 100 bar

We assumed always that we can use the ideal gas law

Valve

Gas bottle

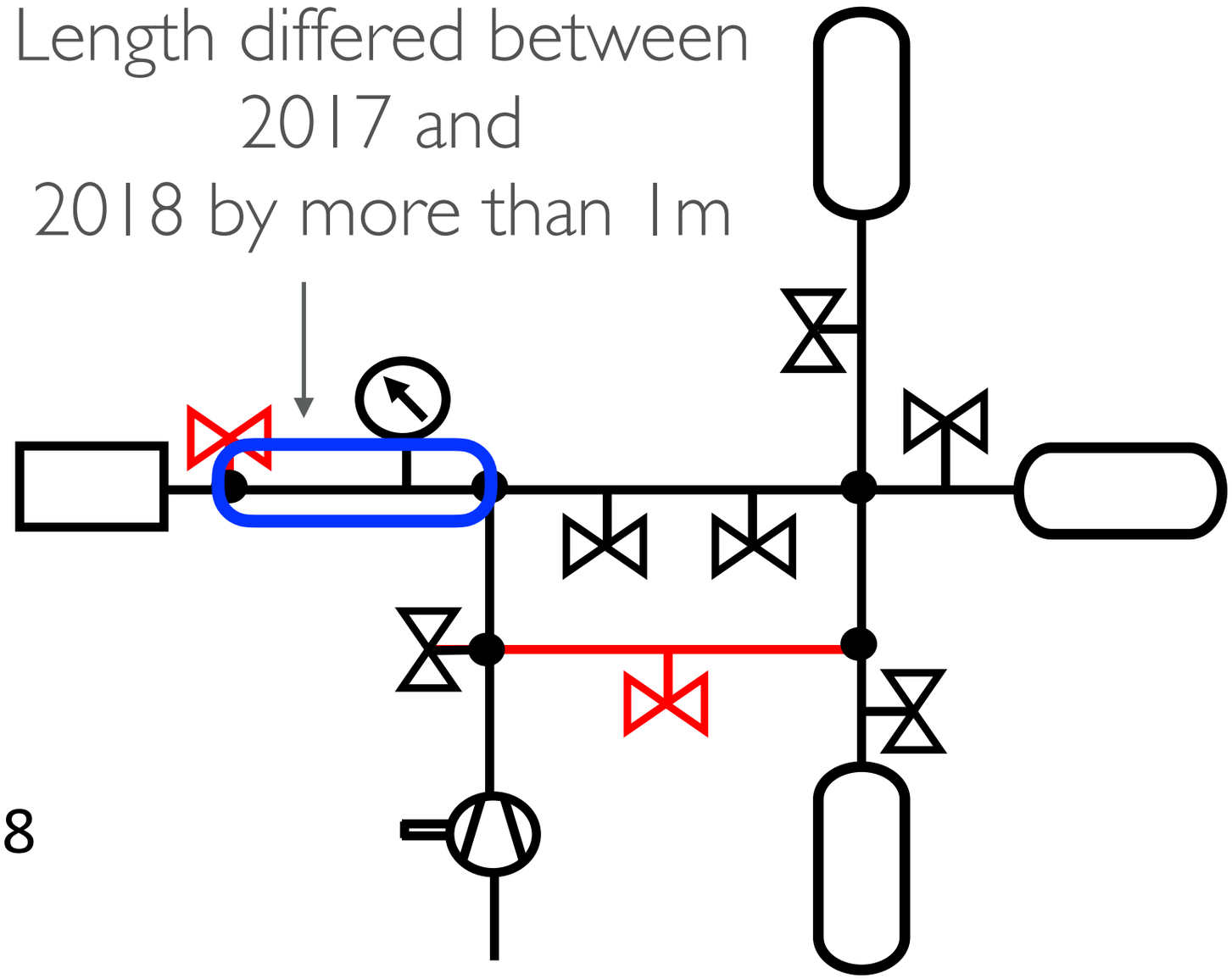
Gas cell

Vacuum pump

Barometer

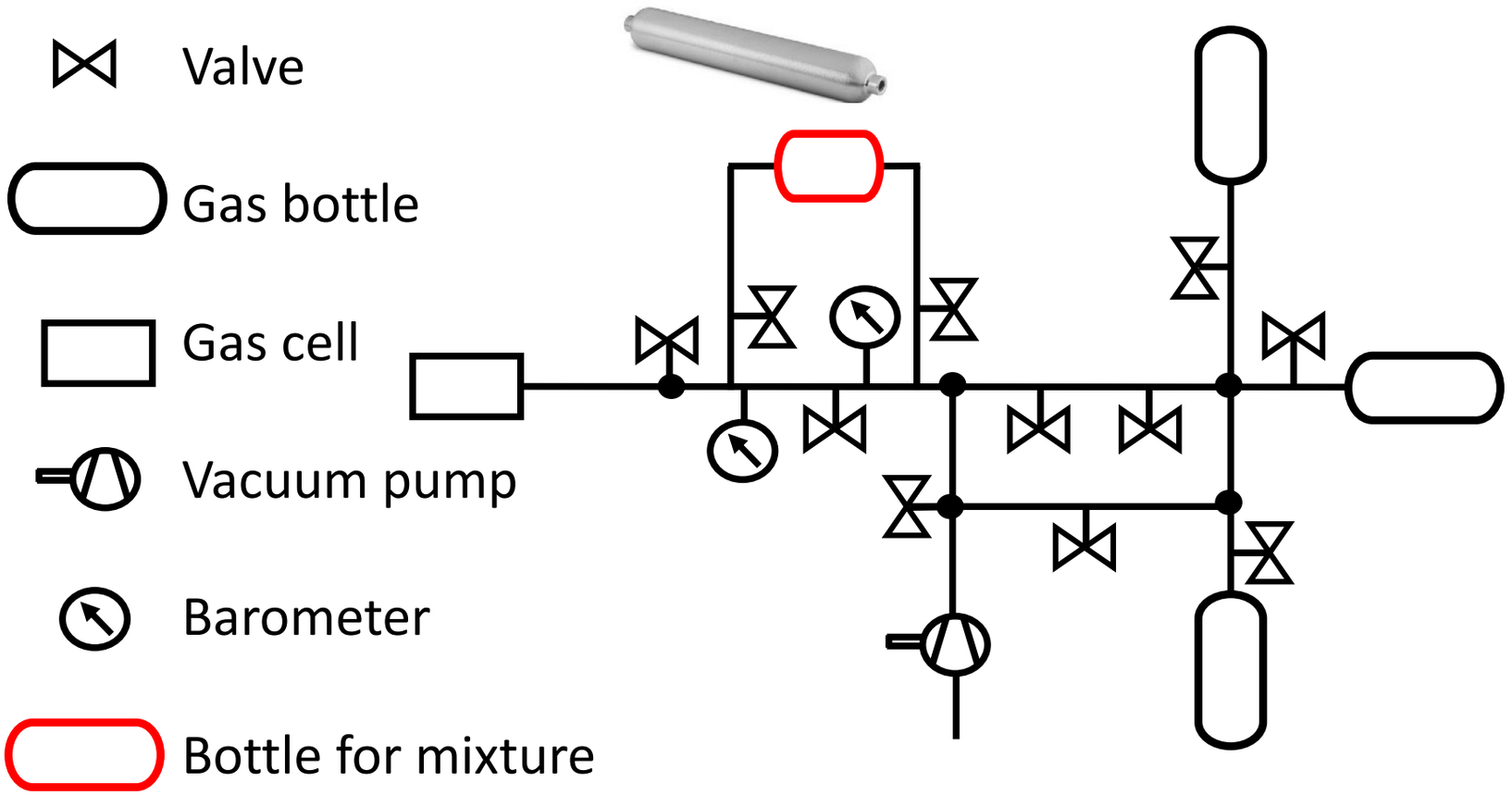
Set up 2017/2018

Set up 2018



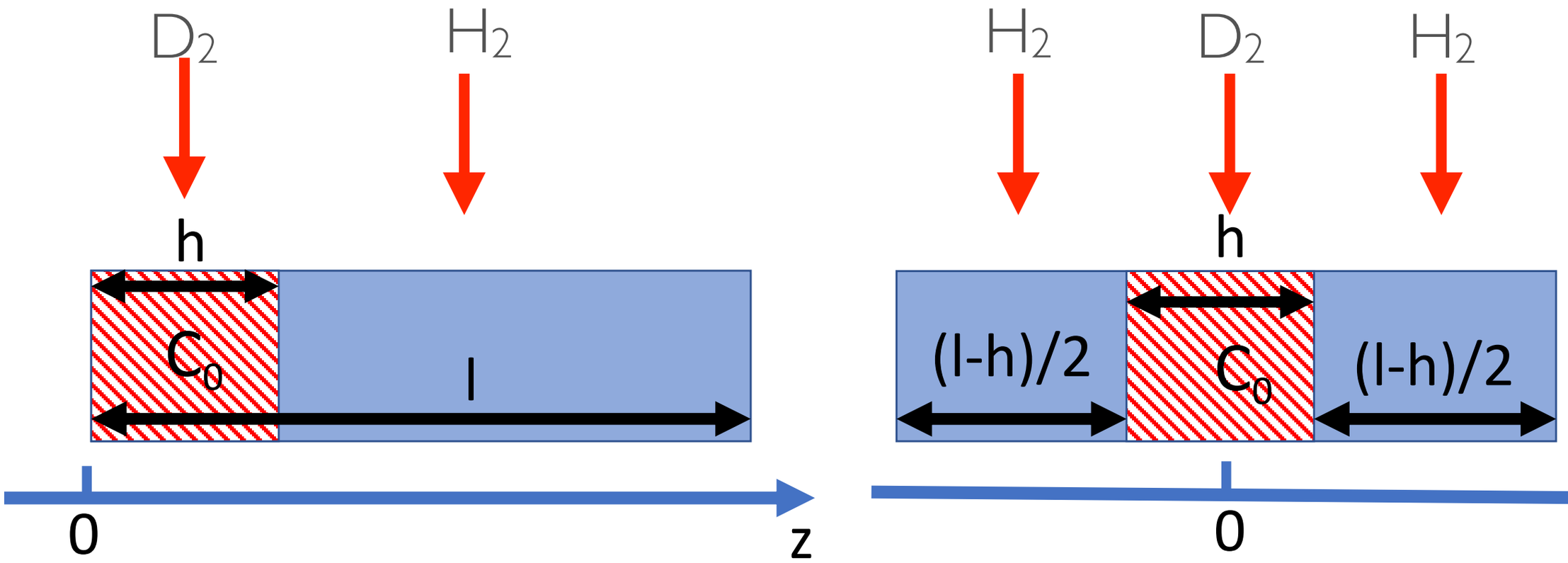
The main difference between the gas systems of 2017 and 2018 was the length of the gas pipe

IMPROVING MIXING



Our first plan was to premix the gas in a 0.5 l bottle to increase the quality of the gas mixture.

IMPROVING MIXING



Two possible initial conditions for gas mixing of D_2 and H_2 in a bottle

We have to be sure that the gas is well mixed
The worst case for mixing is that we have just mixing by diffusion

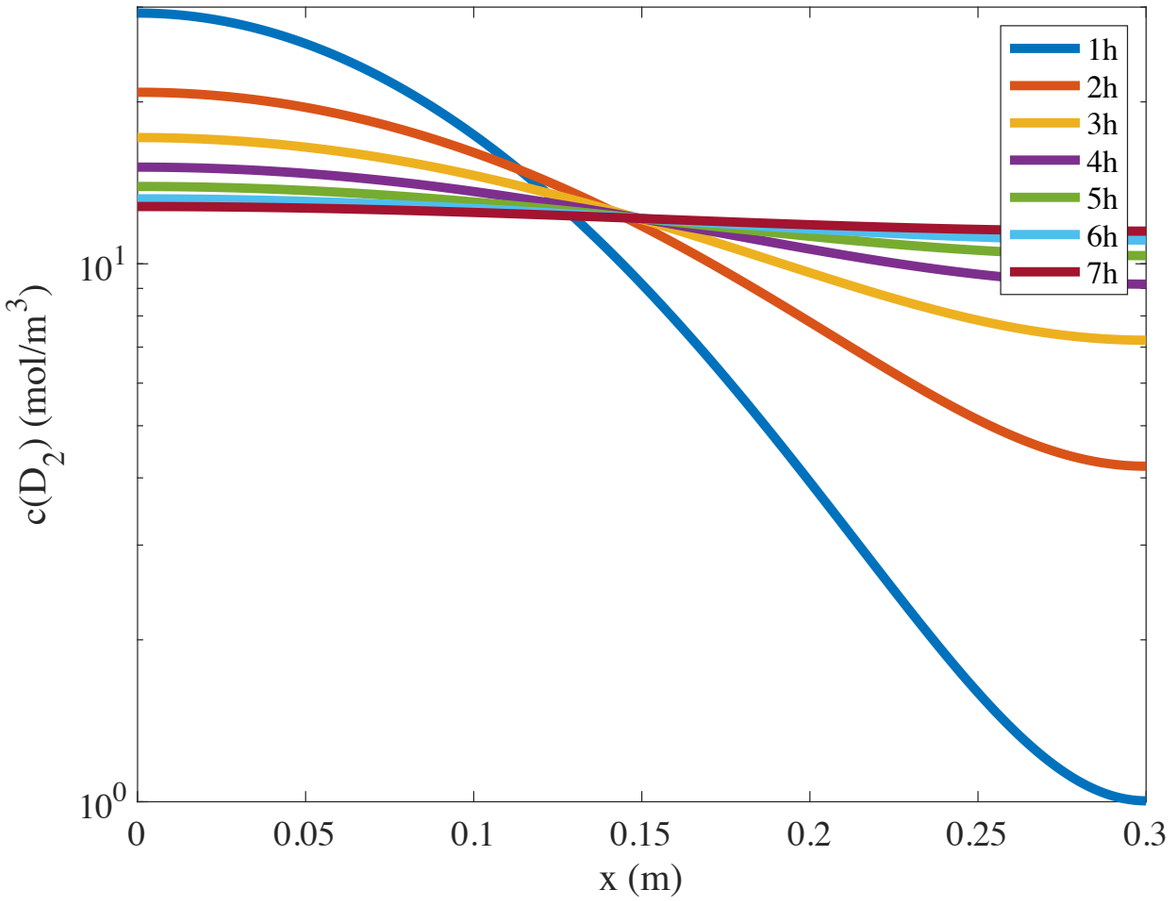
MIXING BY DIFFUSION CASE I

Fick's second law of diffusion

$$\frac{\partial c}{\partial t} = D\frac{\partial^2 c}{\partial z^2}$$

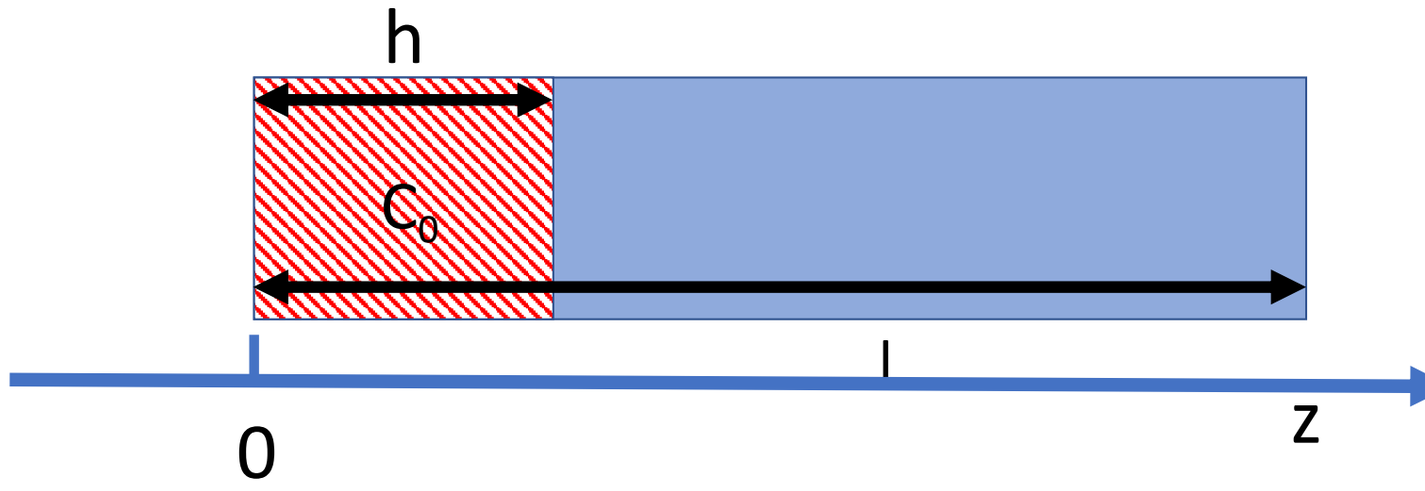
D=1.3 10^{-6} m^2/s

for D_2 in H_2 P = 100 Bar, T = 300K



Solution:

$$\mathrm{C} = \frac{1}{2}C_0 \sum_{n=-\infty}^{\infty} \left\{ erf\,\frac{h + 2nl - x}{2\sqrt{Dt}} + erf\,\frac{h - 2nl + x}{2\sqrt{Dt}} \right\}$$



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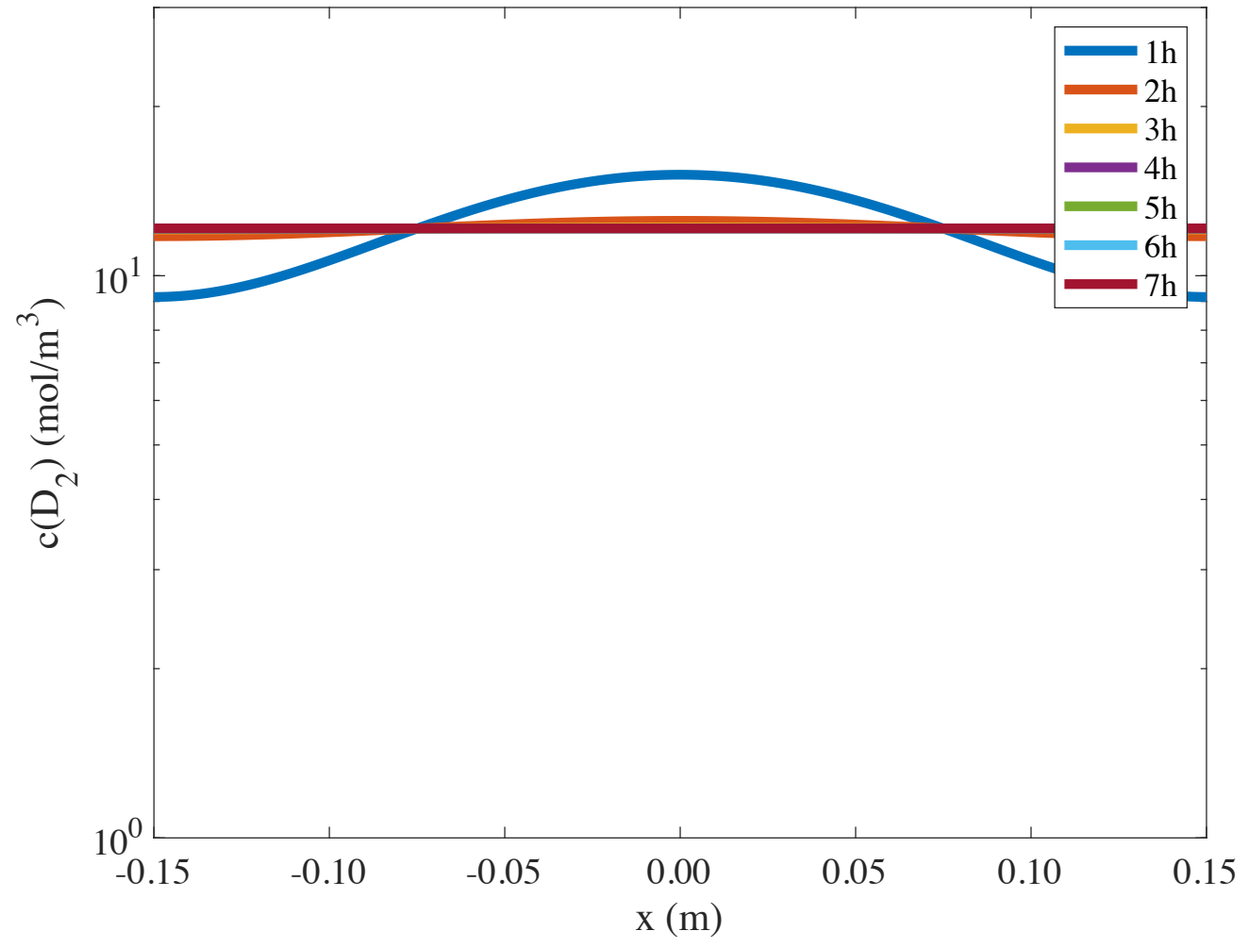
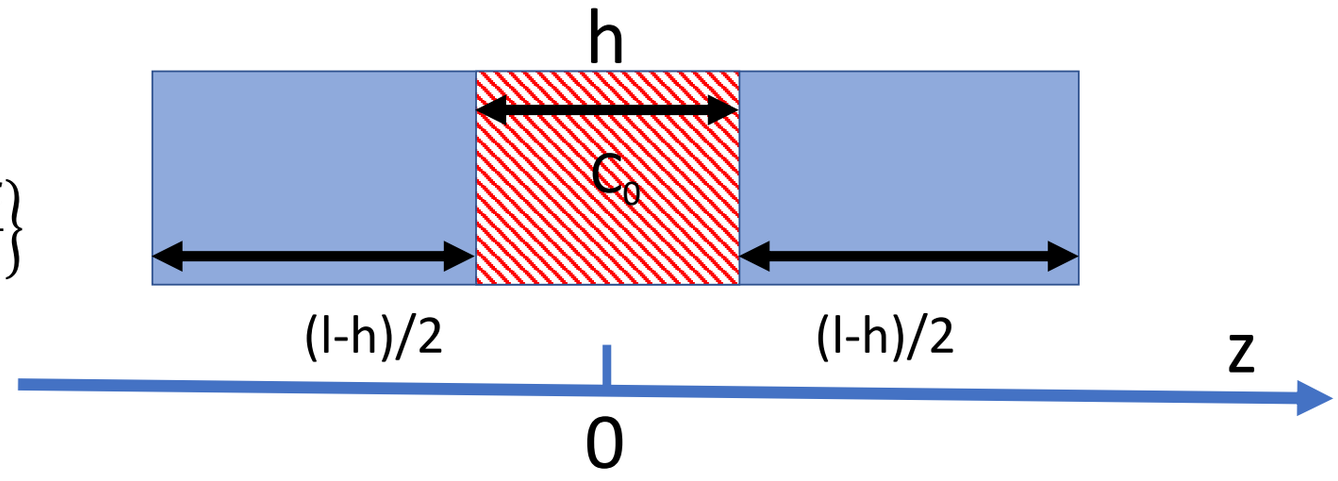
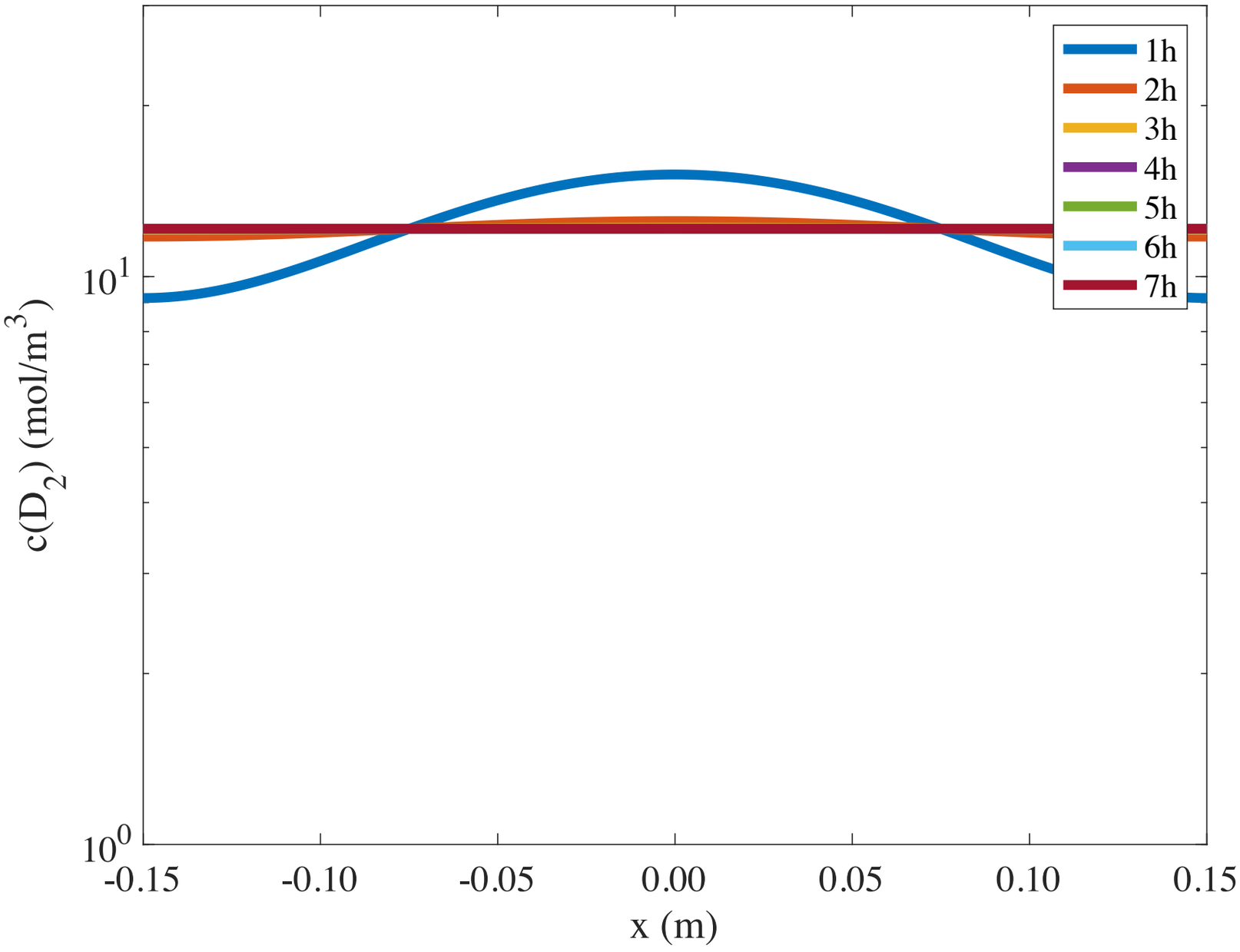


Solution:

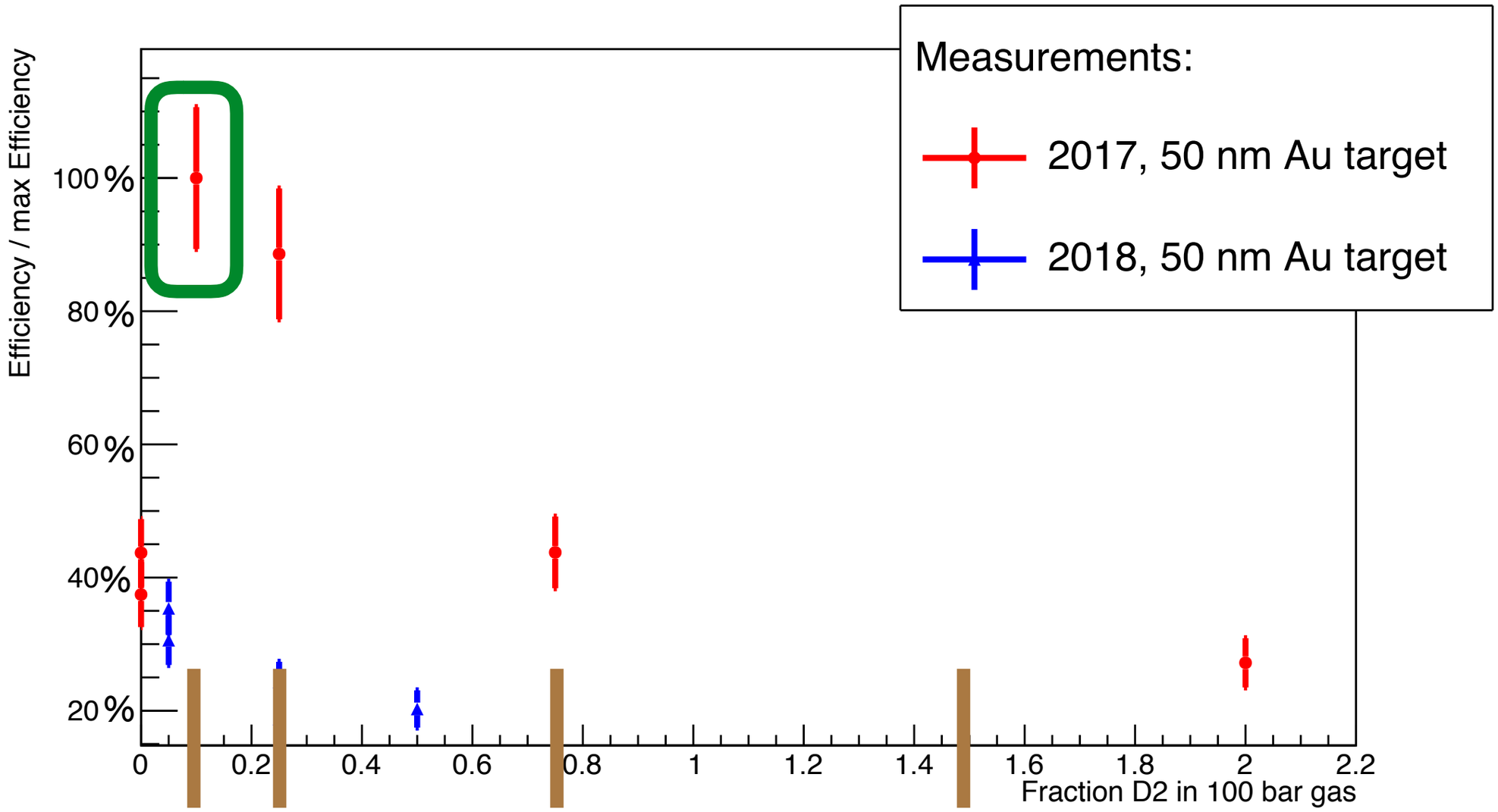
$$\mathrm{C} = C_0 \sum_{n=-\infty}^{\infty} \left\{ erf\frac{h/2 + 2nl - x}{2\sqrt{Dt}} + erf\frac{h/2 - 2nl + x}{2\sqrt{Dt}} \right\}$$



MIXING BY DIFFUSION CASE 2



- In the worst case mixing can take several hours
- We cannot be sure when the gas is well mixed



- We considered to buy premixed gas mixtures to guarantee proper gas mixtures
- 4 x10 l bottles with a pressure of 150 bar; more than 50 fillings per bottle
- Total cost around 2000 CHF

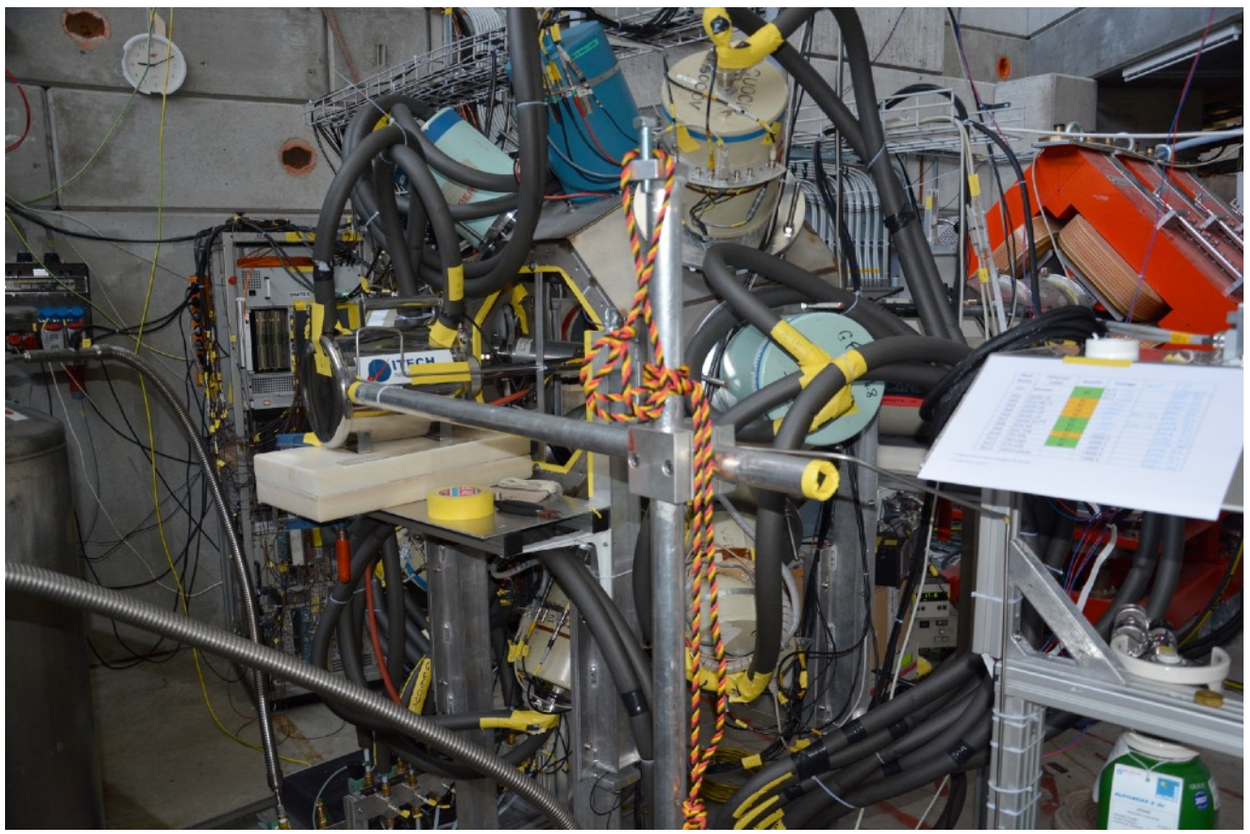
Relative fraction of D2 in gas	0.1%	0.25%	0.75%	1.5%

BACKUP SLIDES

Volume gas cell (2018):π*20mm*(15mm)^2 =1.42*10^{-5}m^3

Volume gas cell/Volume pipes = 1:4 (J.Nuber, 2018)

Total volume ≈ 7.1*10^{-5}m^3



Van de Waals equation

$$p = \frac{nRT}{V - nb} - \frac{n^2 a}{V^2}$$

	Kohäsionsdruck a in (kPa·dm^6)/mol = 10^{-3}·(Pa·m^6)/mol^2 = 10^{-3}·(J·m^3)/mol^2	…nen b in cm^3/mol = 10^{-6}·m^3/mol
Wasserstoff (H_2)[1]	24,7	26,6

Aufsteigend sortieren

R	8.314 4598(48)	J·K^{-1}·mol^{-1}

Ideal gas law

$$pV = nRT$$

Name					
MaxPressure (bar)	124	124	124	124	355
Volume ($cm^{3)}$	150	300	500	1000	150
Required Pressure (bar)	153	126	116	107.8	153
Required amount of substance H_2,D_2 (mol)	0.83	1.4	2.14	4.3	0.83
Price (CHF)	139	157	181	425	314

Total volume ≈ $7.1*10^{-5}m^3$

Can handle up to $10.5*10^{-5}m^3$

1	Price Elements							
2								
3	Name	Nr	Price	Amount	Sum			
4	Stainless Steel 304L maxPressure 124 bar 500ccm	304L-HDF4-500	180.75	1	180.75		Total Price	
5	Adapter 1/4" to 6mm	SS-6M0-1-4	9.2	2	18.4		1061.4	
6	Stainless Steel Quarter Turn Instrument Plug Valve, 1/4 in. Swagelok Tube Fitting, 1.6 Cv	SS-4P4T	78	5	390			
7	Stainless Steel Low Flow Metering Valve, 6 mm Swagelok Tube Fitting, Vernier Handle	SS-SS6MM-VH	197.3	1	197.3			
8	Stainless Steel High Flow Metering Valve, 6 mm Swagelok Tube Fitting, Vernier Handle	SS-6L-MM-MH	158.55	1	158.55			
9	tainless Steel Swagelok Tube Fitting, Union Tee, 6 mm Tube OD	SS-6M0-3	29.1	4	116.4			