JÜLICH
FORSCHUNGSZENTRUM

Simulation of Wall-Corrosion of High-Energy-Discharge Lamps

3. June 2009 | Sarah Fischer

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- High – Energy – Discharge – Lamps
- Construction of a Lamp – Burner
- The formation of aluminum iodide
- The transport cycle
- Scheme of the transport program
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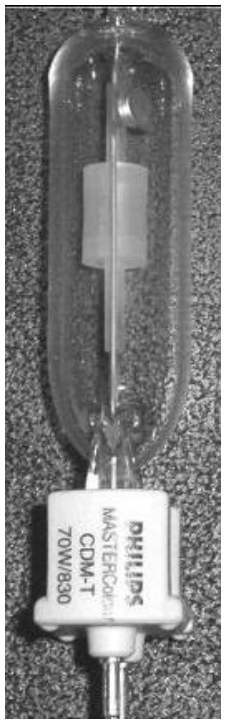
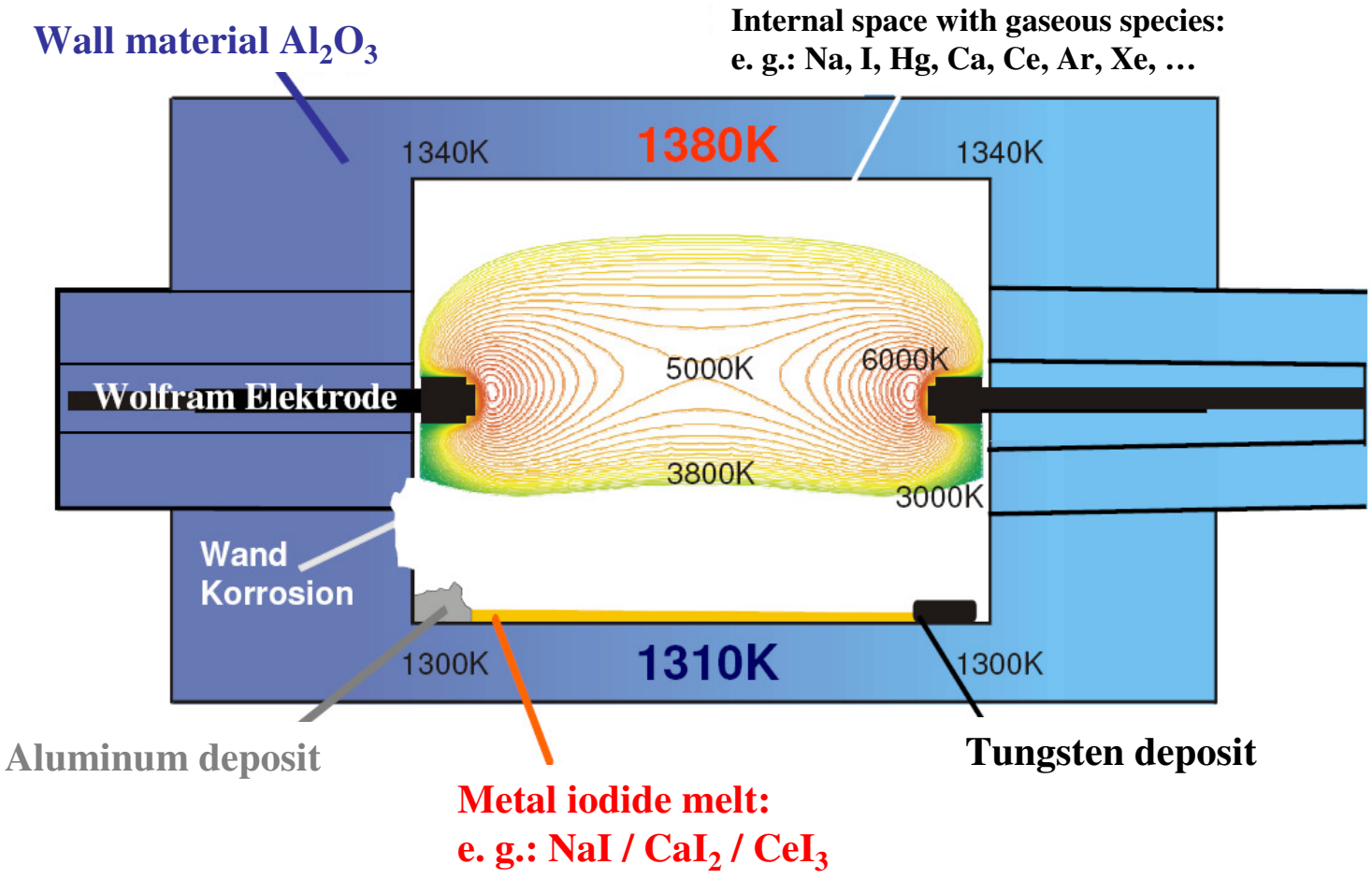
- Comparison between experiments and calculations
- Summary

Hoch – Energie – Entladungslampen

Corrosion effects in the lamp burner limit the life time

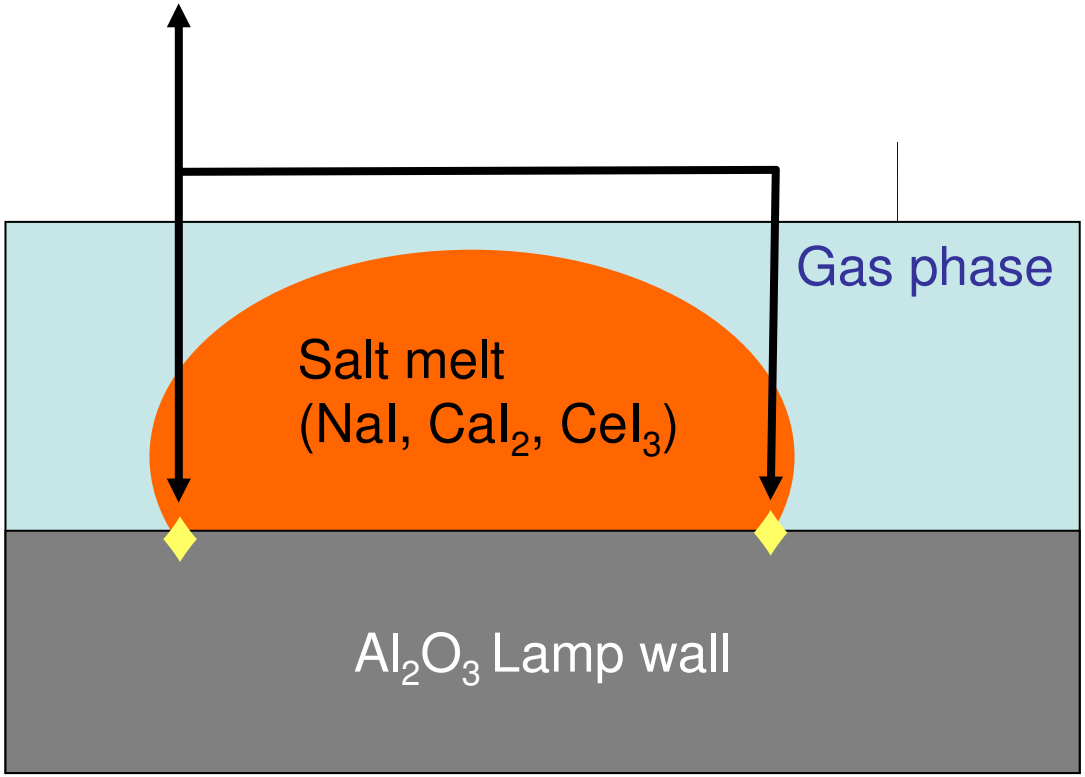


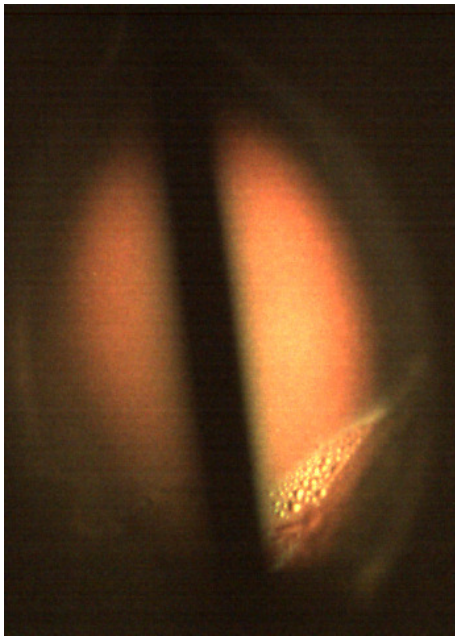
The lamp burner



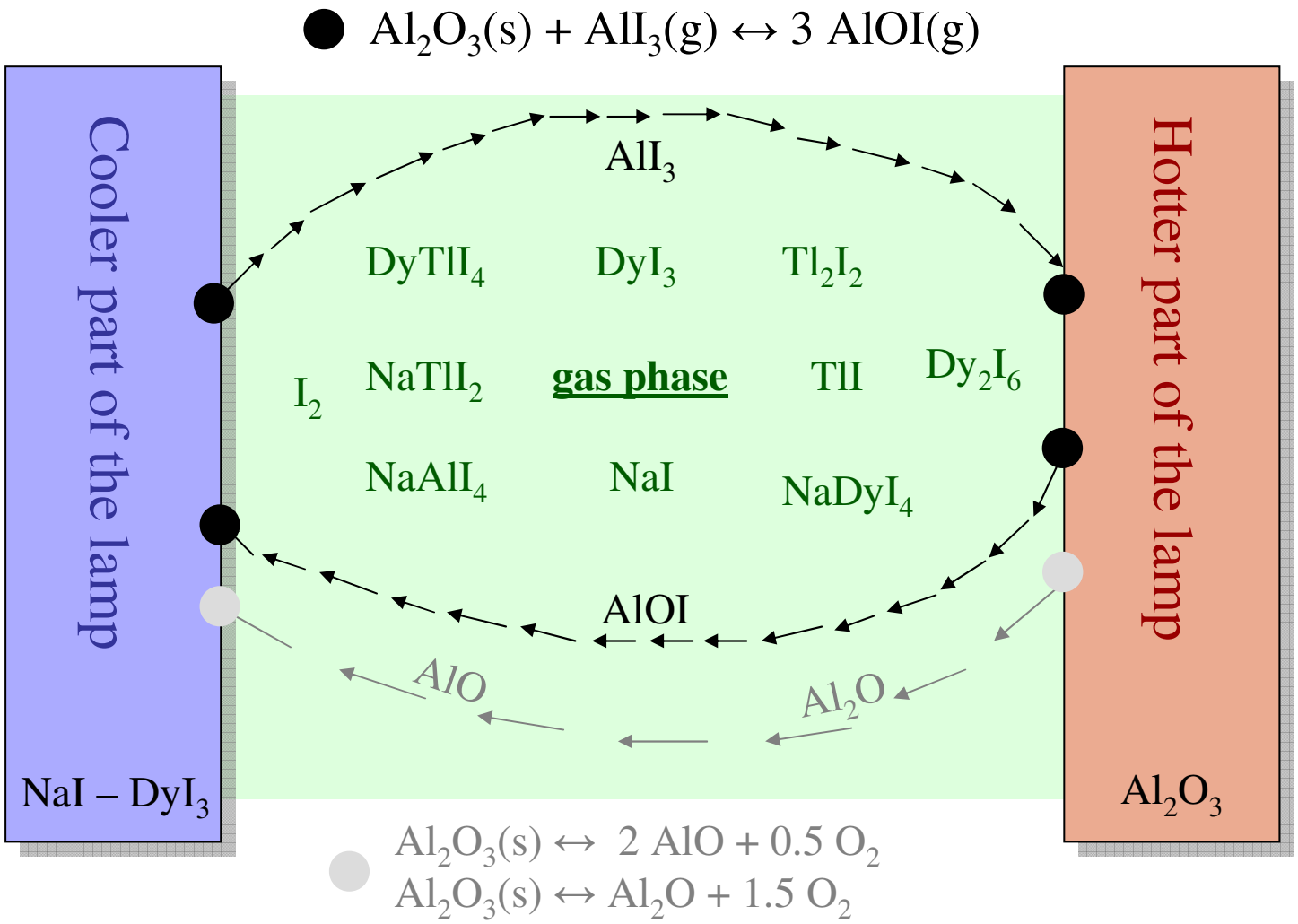
The formation of aluminum iodide

$$Al_2O_3(s) + CeI_3(l) \leftrightarrow CeAlO_3(s) + AlI_3(g)$$

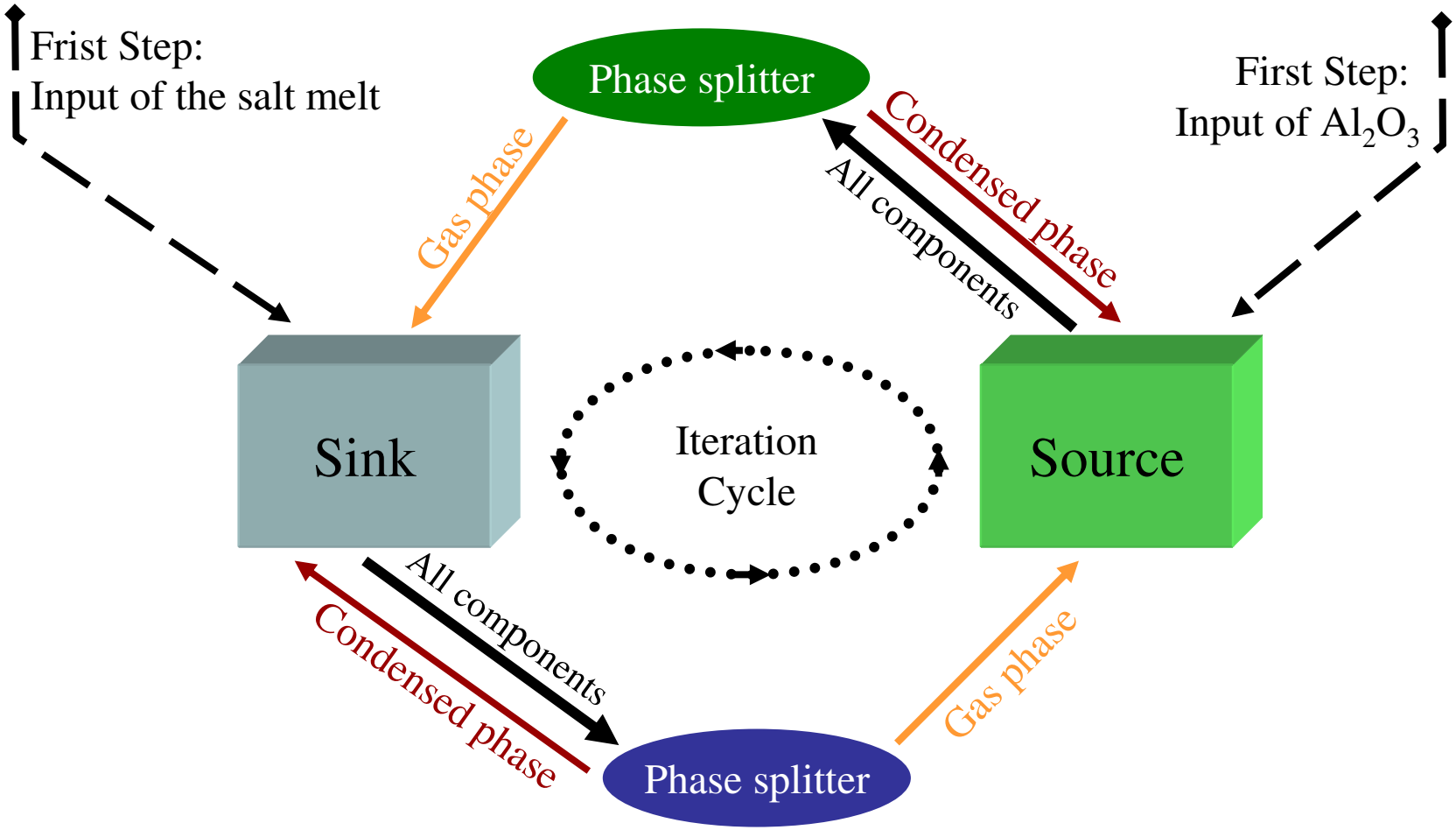




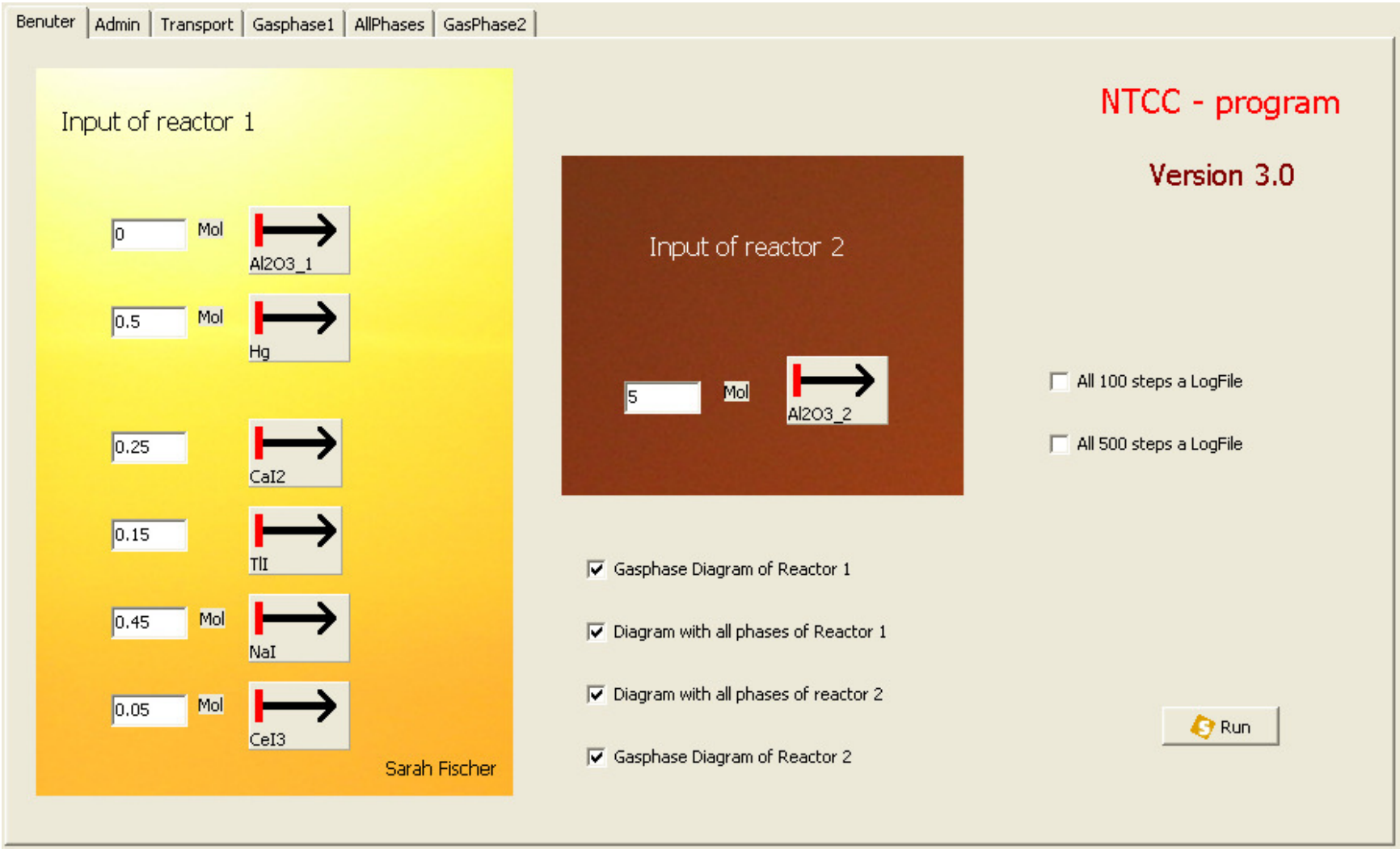
The transport - cycle



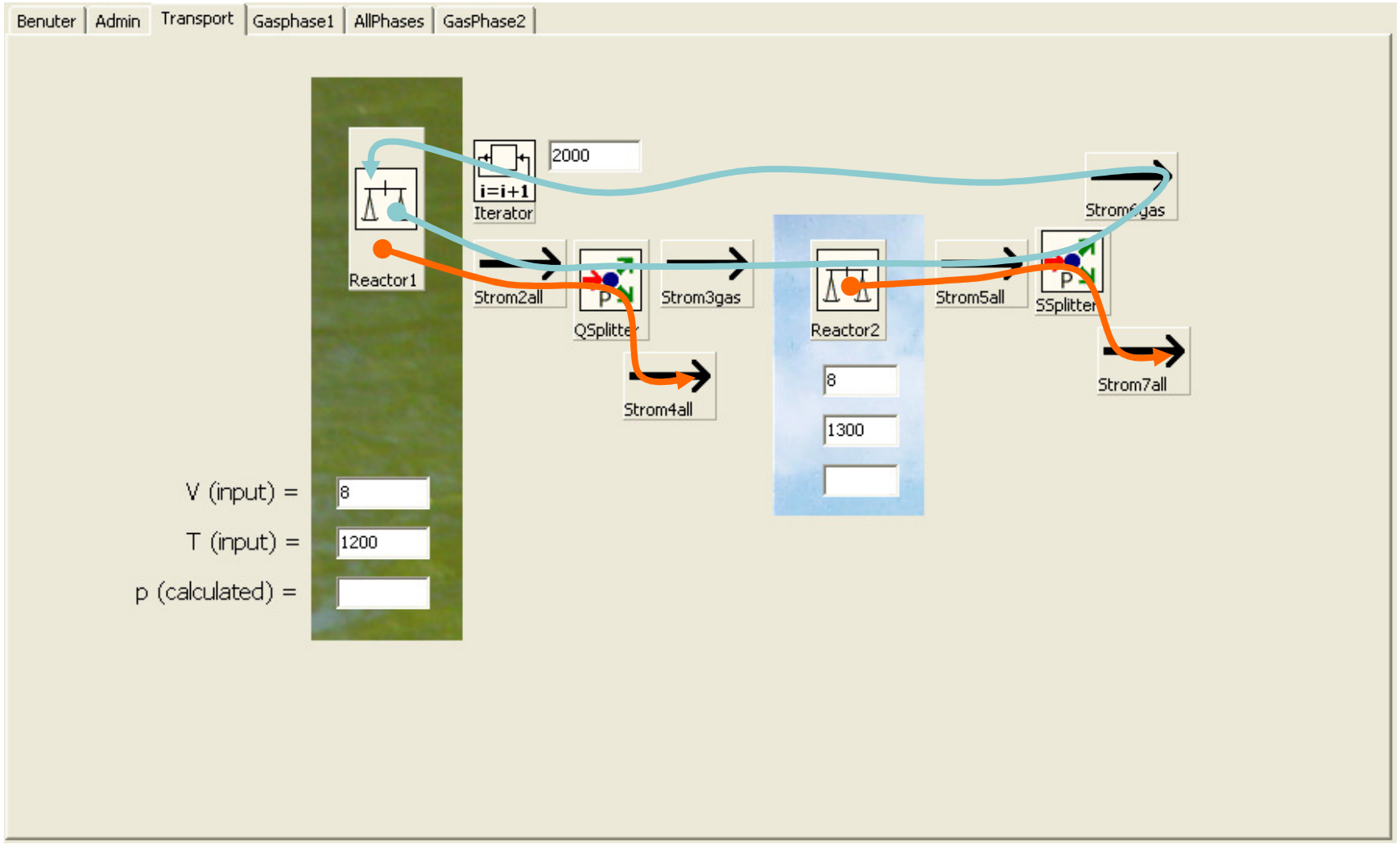
Scheme of the transport program



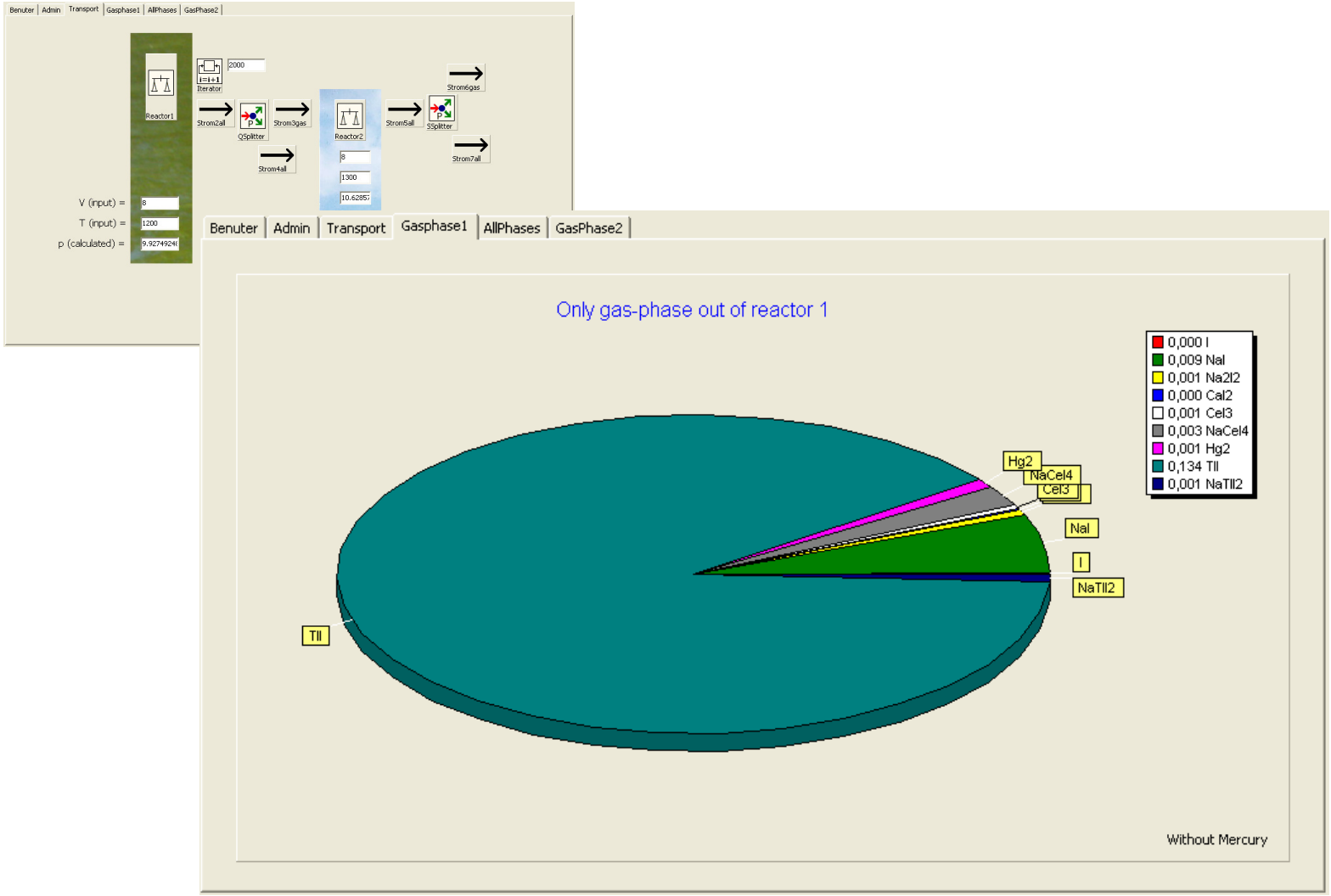
Input of the salt mixture and the Al_2O_3



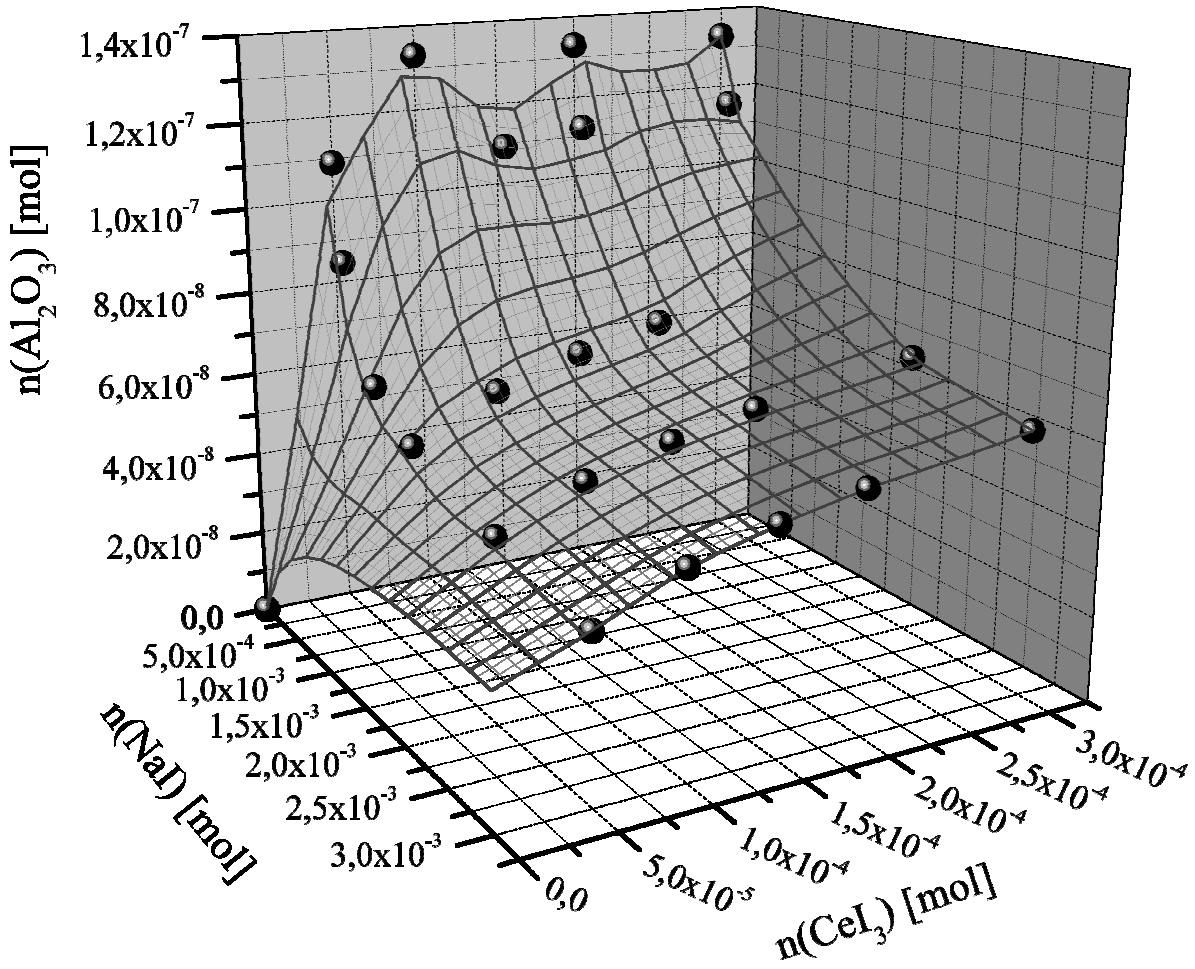
Equilibrium reactors



Amount of the gas phase components



Example: NaI – CeI_3 – Mixture



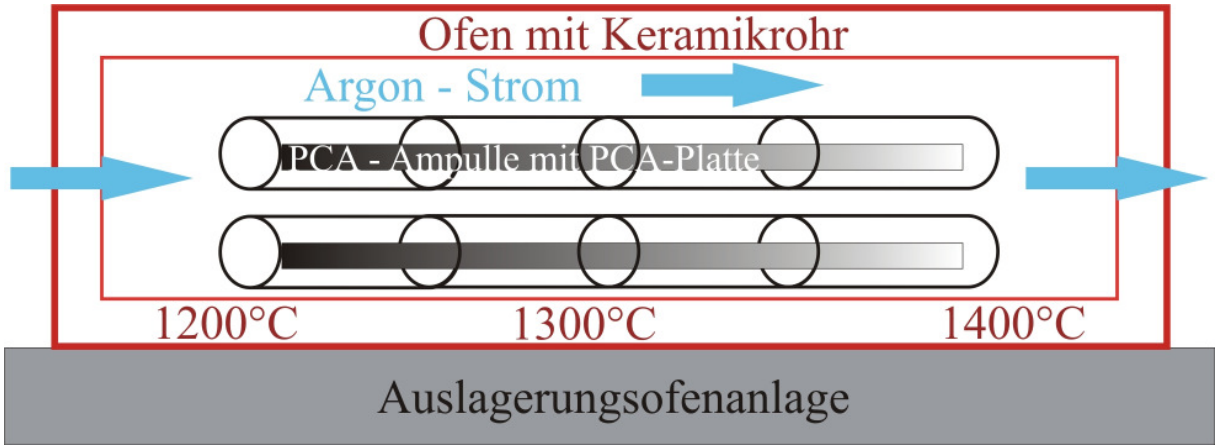
T_{Sink} = 1200 °C
T_{Source} = 1400 °C
V = 0,0285 dm³

Salt free annealing vessel

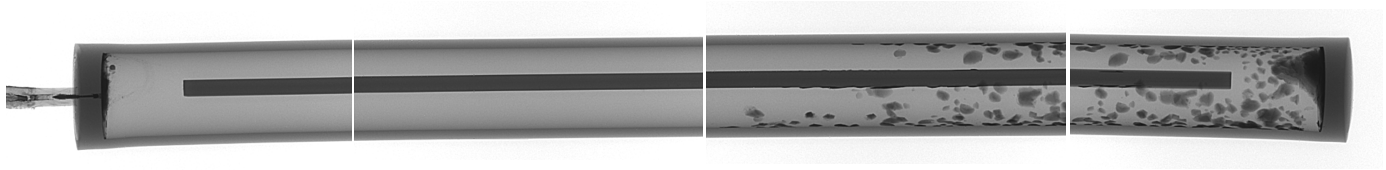
1400 °C 1200 °C

- Material: polycrystalline aluminum oxide (PCA)
- Metrics: Length 26cm; Diameter 1cm
- Closing: Platinum-Niobium-Conductor
- Atmosphere: Argon (Salt)
- Salt filling: 200mg

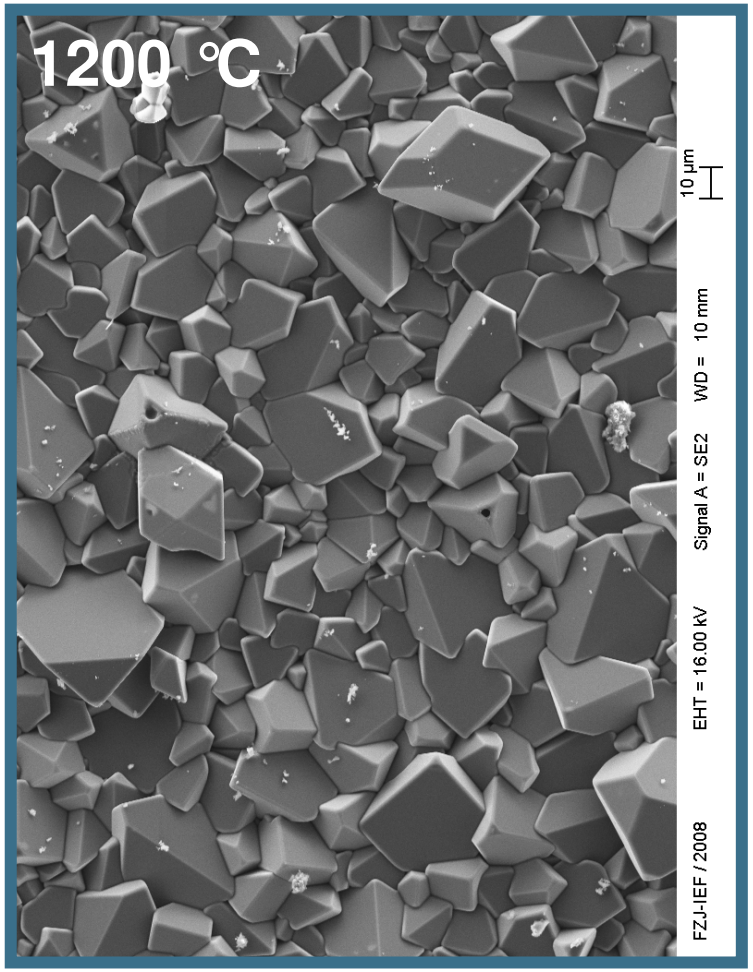
Scheme of the annealing furnace

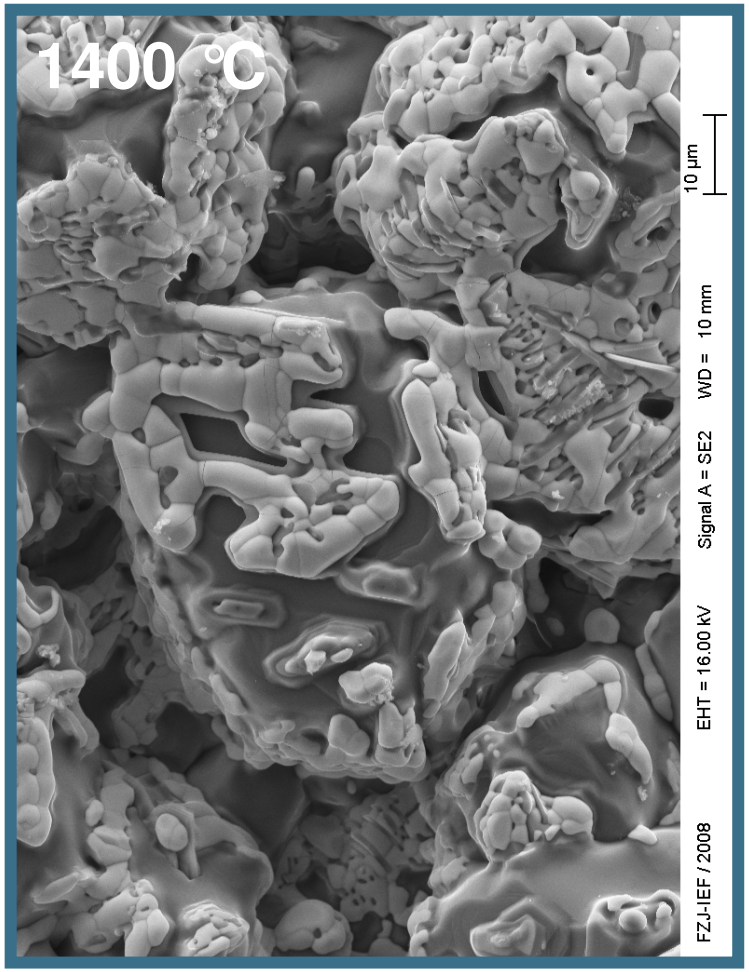


Destruction-free X-ray analysis of a annealing vessel with 47,5% NaI, 47,5% CaI_2 and 5% CeI_3:



SEM – Analysis with 90,48% CaI_2 and 9,52% CeI_3





Comparison between experiments and simulations

NaI – CaI_2 - Mixture

Composition NaI, CaI_2

75% NaI, 25% CaI_2 50% NaI, 50% CaI_2 25% NaI, 75% CaI_2

Simulation [mol Al_2O_3]: $1{,}22 \cdot 10^{-9}$ < $2{,}55 \cdot 10^{-9}$ < $7{,}16 \cdot 10^{-9}$

Experimental certification:  

→ Agreement for NaI – CaI_2 – Mixture

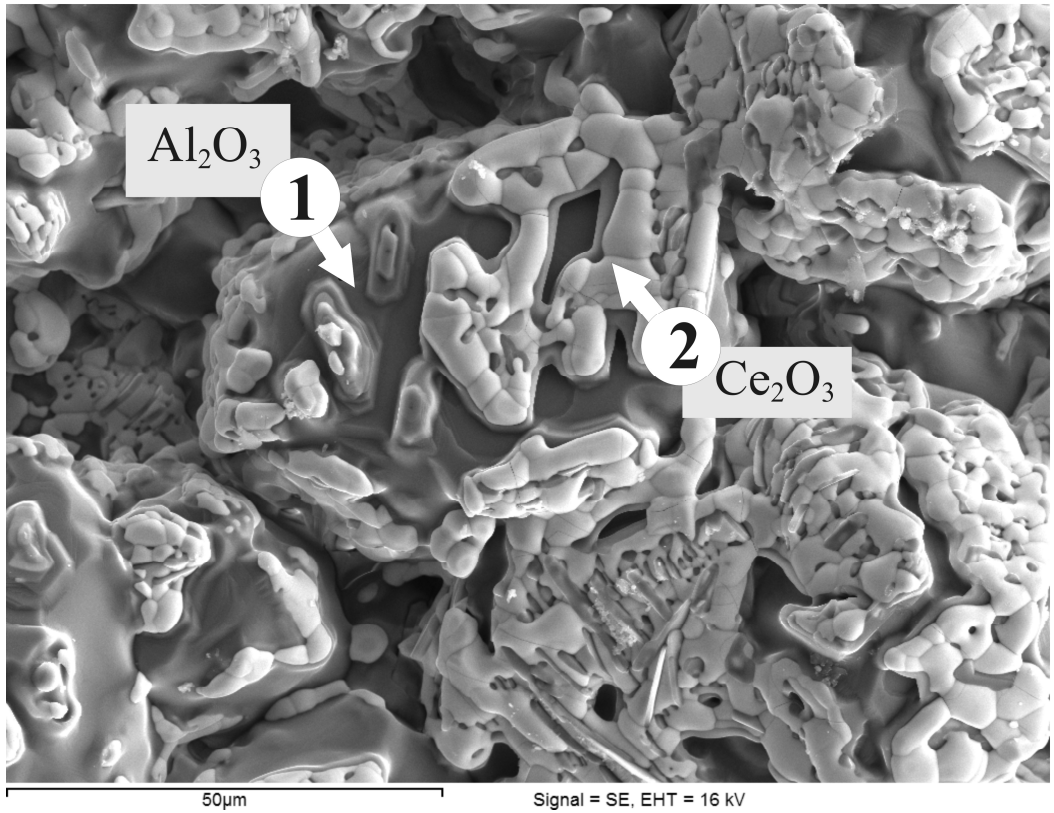
Comparison between experiments and simulations

CaI_2 – CeI_3 - Mixture

	Composition CaI_2, CeI_3		
	90,48%, 9,52%		87,1%, 12,9%
Simulation [mol Al_2O_3]:	$5{,}08 \cdot 10^{-8}$	<	$5{,}58 \cdot 10^{-8}$
Experimental certification:		≈	

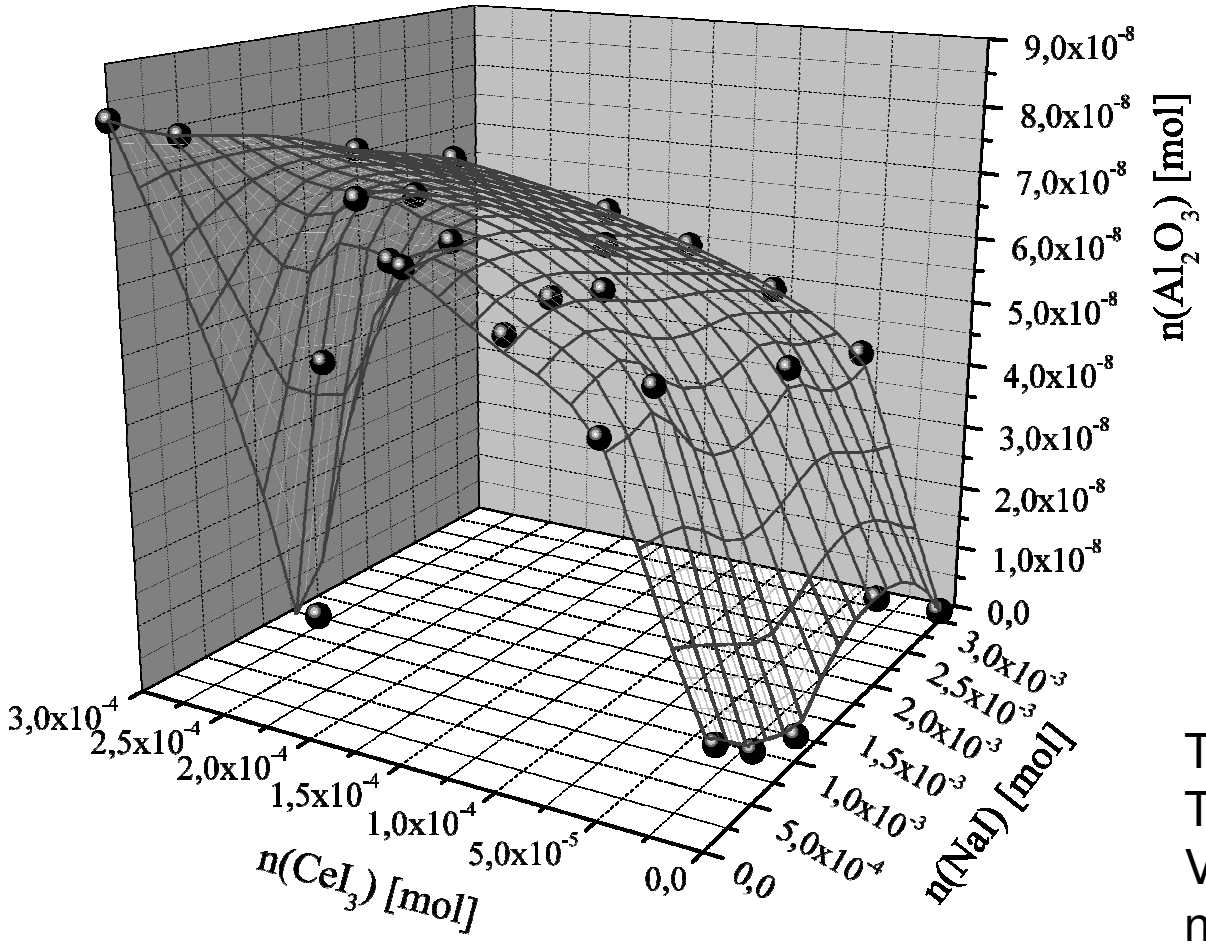
What causes this difference?

Formation of secondary phases



	Calculated Activity
$Al_2O_3\_ca(s)$	1.0000E+00
$CaI_2\_l(liq)$	9.4561E-01
$Al_2O_3\_cc(s2)$	4.9718E-01
$CaI_2\_ci(s)$	2.4571E-01
$CeOI\_ci(s)$	1.1649E-01
$CeI_3\_l(liq)$	5.4007E-02
$Al_2O_3\_l(liq)$	3.5536E-02
$CeAlO_3\_ci(s)$	2.0447E-02
$CeAl_{11}O_{18}\_ci(s)$	1.3446E-02
$CeI_3\_ci(s)$	1.1285E-02
$CeAlO_3\_l(liq)$	5.4999E-03
$Ce_2Al_2O_6\_ci(s)$	4.1199E-03
$CeAl_{11}O_{18}\_l(liq)$	3.4167E-03
$CaAl_4O_7\_ci(s)$	3.0990E-03
$CaAl_2O_4\_ci(s)$	7.1260E-04
$Al\_l(liq)$	6.7438E-04
$Al\_ci(s)$	4.0705E-04
$CaO\_ci(s)$	1.4573E-05
$AlI_3\_l(liq)$	2.7872E-06
$CeO_2\_ci(s)$	1.6025E-06
Al	9.3713E-07
$Ce_2O_3\_ci(s)$	6.0181E-07

Example: NaI – CaI_2 – CeI_3 – Mixture



T_{Sink} = 1200 °C
T_{Source} = 1400 °C
V = 0,0285 dm³
$n(CaI_2)$=0,0008mol

Summary

- Corrosion- and rearrangement – effects of the wall material limit the life time of High-Energy-Discharge-Lamps
- Cooperative Transport Model was programmed with SimuSage
- Simulations of the corrosion speed of lamp relevant salt mixtures
- Comparison of the experiments and simulations
- Next simulation step are ternary salt systems

Have you any questions?

Thanks for your attention.