NATIONAL NUCLEAR LABORATORY

# NNL-CEIDEN meeting

## Reprocessing & Recycle R&D at NNL

# Requirements for advanced reprocessing

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Optimise recycling processes so the option to close the fuel cycle by ~2050 is competitive with other spent fuel management options

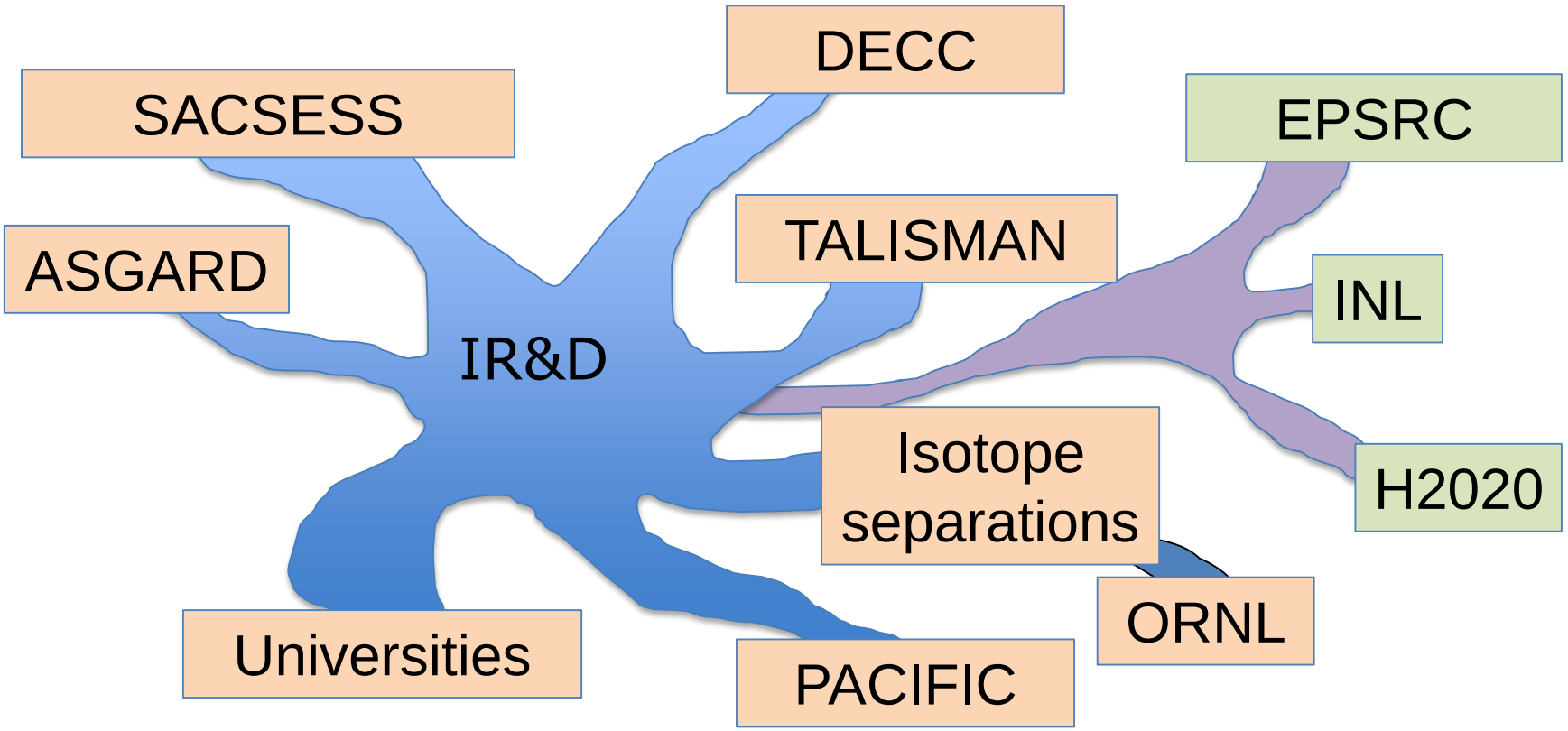
- Reduced costs
- Reduced wastes
- Reduced environmental impact
- Enhanced process safety
- Enhanced proliferation resistance / safeguards
- Enhanced public acceptability
- Flexibility to process wider range of fuel types
- Integrated with fuel fabrication and waste management

→ *PROCESS SIMPLIFICATION / INTENSIFICATION / INNOVATION*

# NNL R&D interests

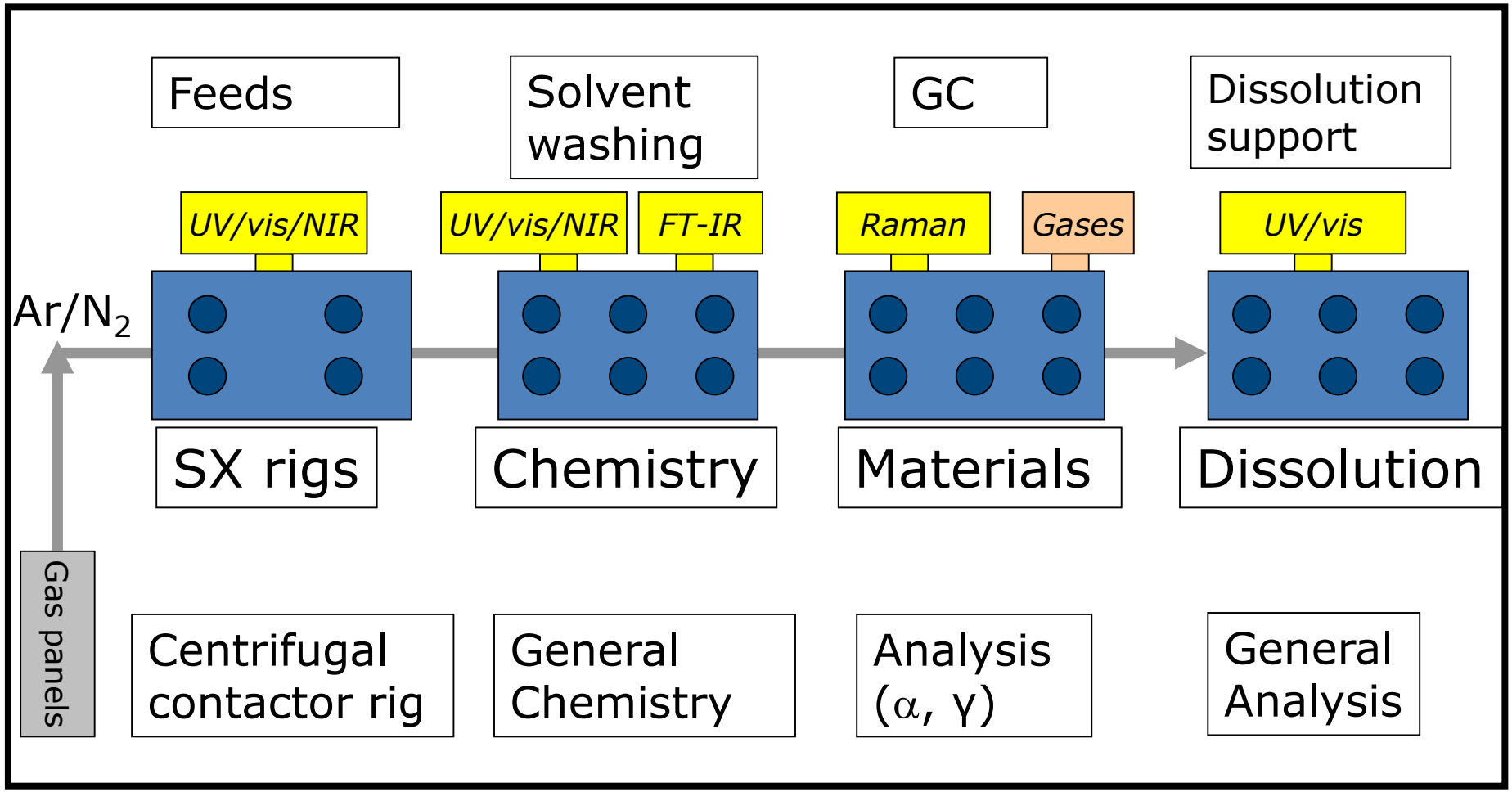
- Dissolution of SNF
  - ★High Pu content fuels
  - ★Non-oxide fuels (ASGARD)
- Advanced PUREX process
  - ★Aimed at thermal UOX/MOX fuels
- GANEX process
  - ★Aimed at GenIV FR fuels (SACSESS)
- Product finishing
  - ★Oxalate co-conversion or other routes
- Cross-cutting capabilities
  - ★Modelling & simulation
  - ★Radiation chemistry
  - ★Engineering & process design
  - ★Safety studies

# Current projects & internal R&D



# PuMA Laboratory

# NNL PuMA laboratory (Plutonium & Minor Actinides)




**GBs are inerted ($N_2$ or Ar)**

# $PuO_2$ & MOx pellet & powder dissolutions

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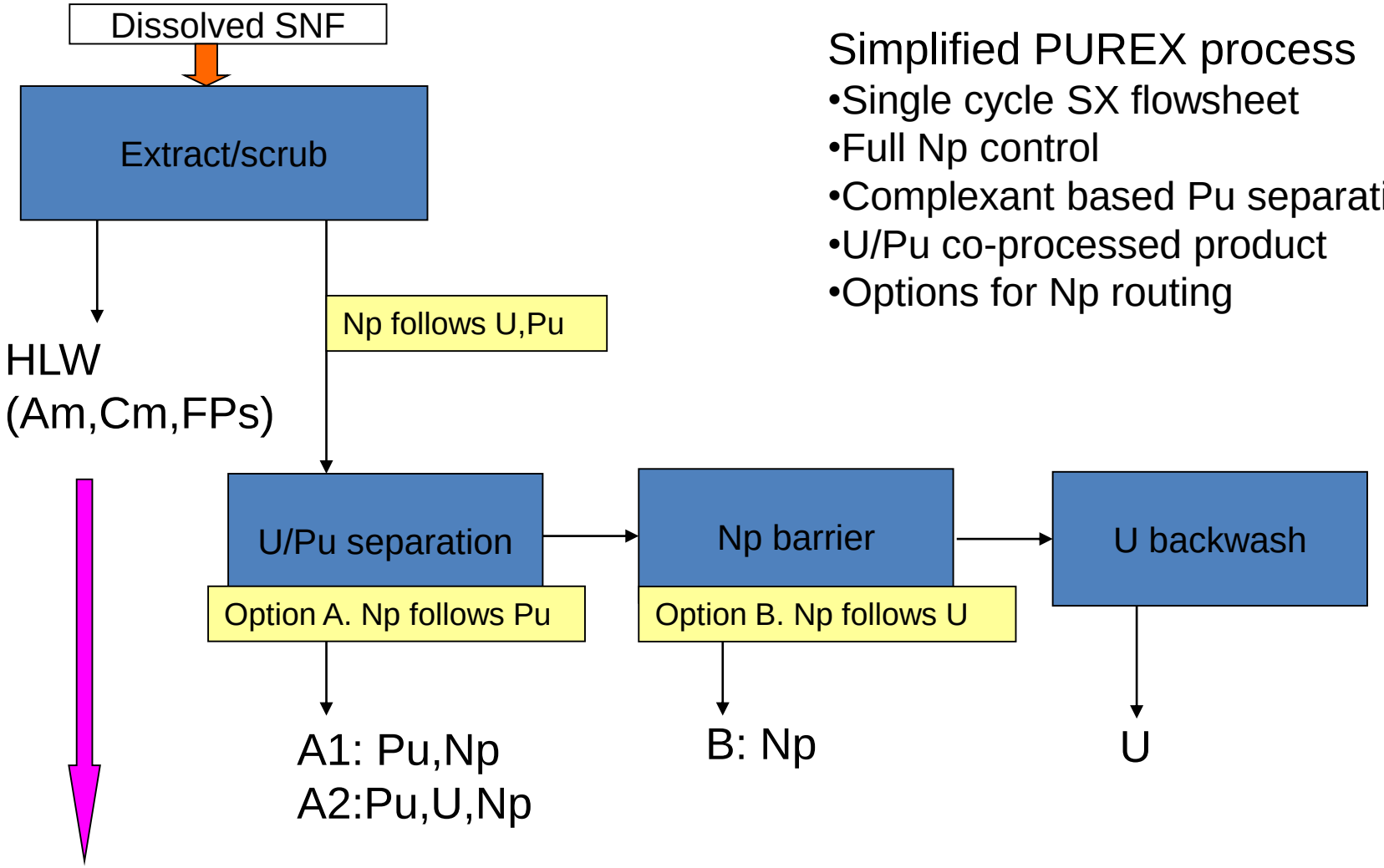
- Direct dissolution
- Ag(II) catalysed dissolution – also for organics destruction
- Mechanistic and modelling studies
- Carbides (U only at present)

The University of Manchester

# Advanced PUREX process



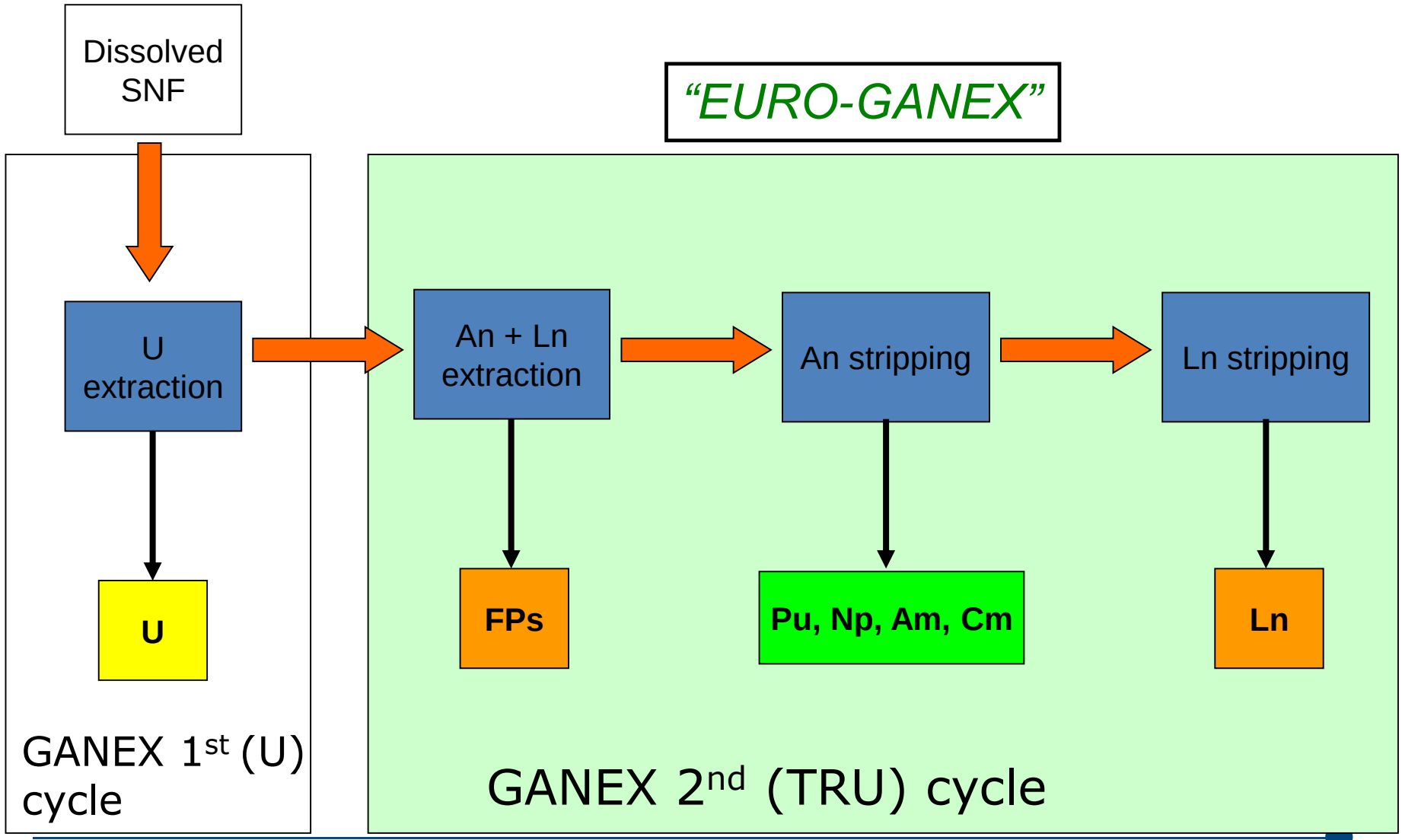

Simplified PUREX process

- Single cycle SX flowsheet
- Full Np control
- Complexant based Pu separation
- U/Pu co-processed product
- Options for Np routing

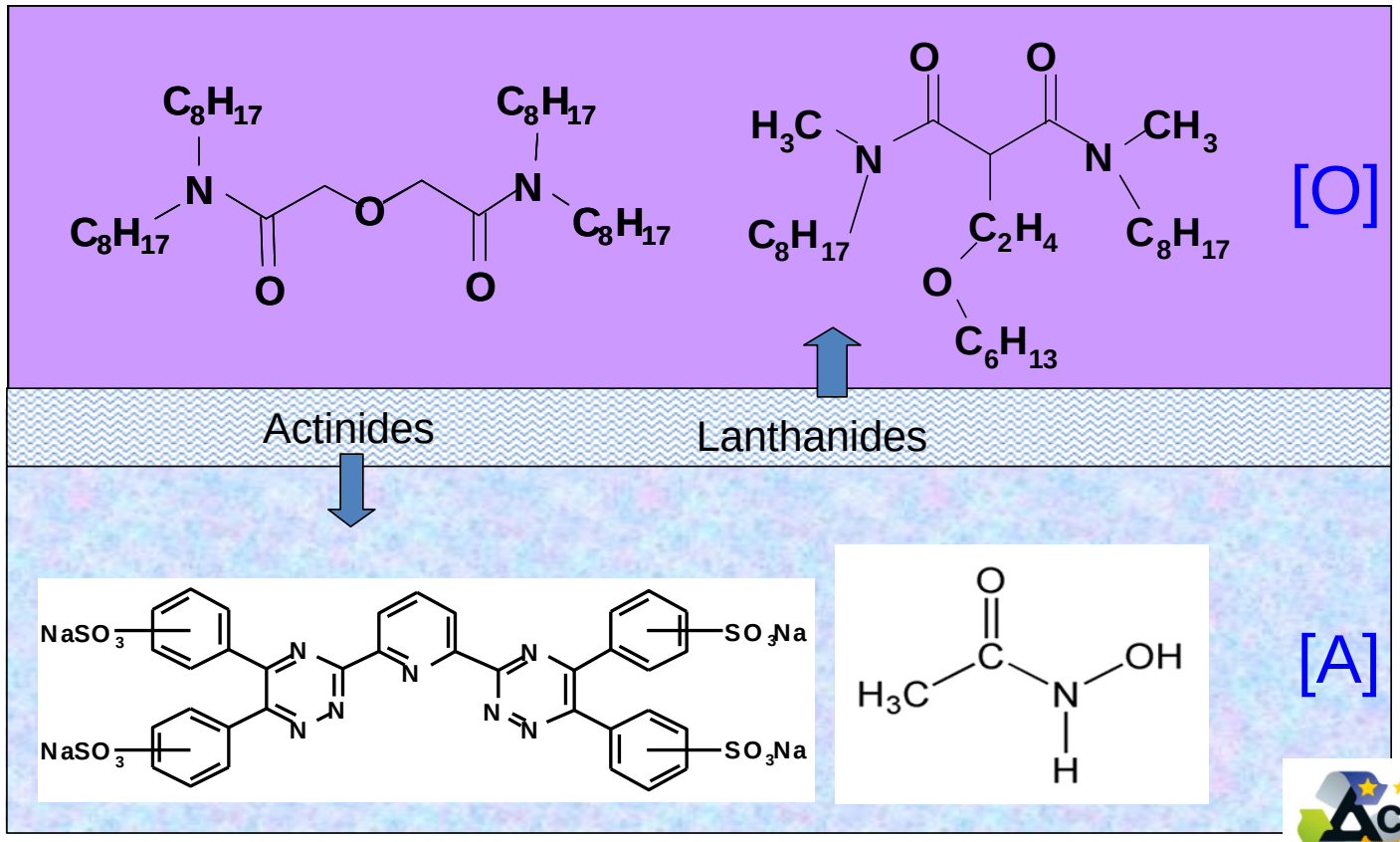
Minor actinide (Am,Cm) separations require additional SX cycles on HLW

=>i-SANEX vs EXAm

# GANEX Concept



# Basis of separation



# EURO-GANEX testing at NNL & ITU

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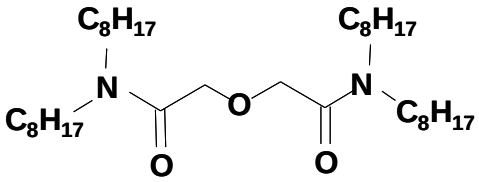
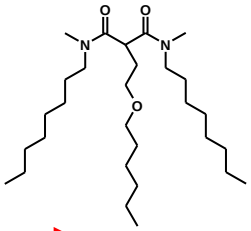


Solvent Feed

Actinides Lanthanides

1 Extract 12

13 Scrub 16

FPs

Active feed
5.9 M $HNO_3$ + 0.055 M CDTA
SF solution (10 g/L Pu)

0.5M $HNO_3$

Solvent Raffinate

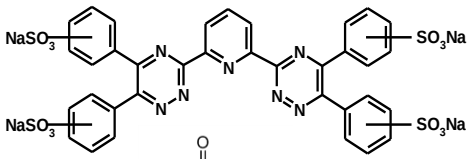
Loaded Solvent Feed

Solvent Feed

32 Ln Strip 29

23 22

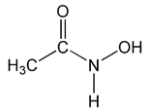
28 An Strip 17




0.01M $HNO_3$

Lanthanides

0.5M $HNO_3$
1M AHA
0.055M BTP



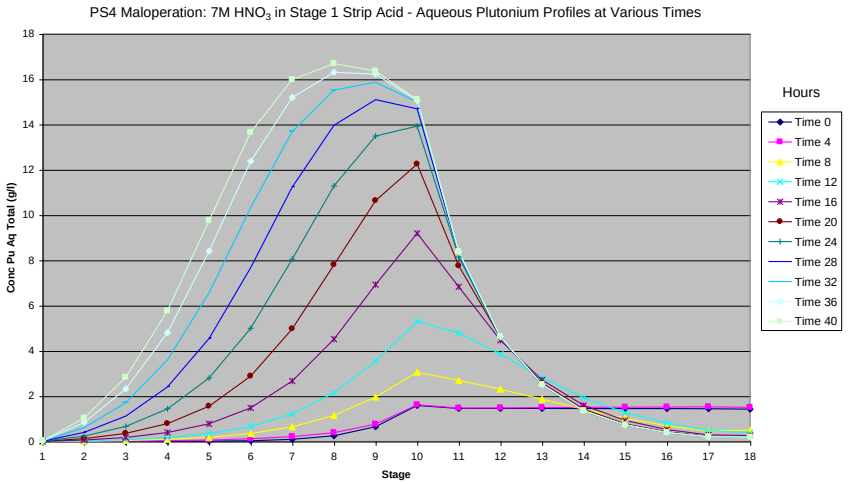

Pu, Np, Am, Cm

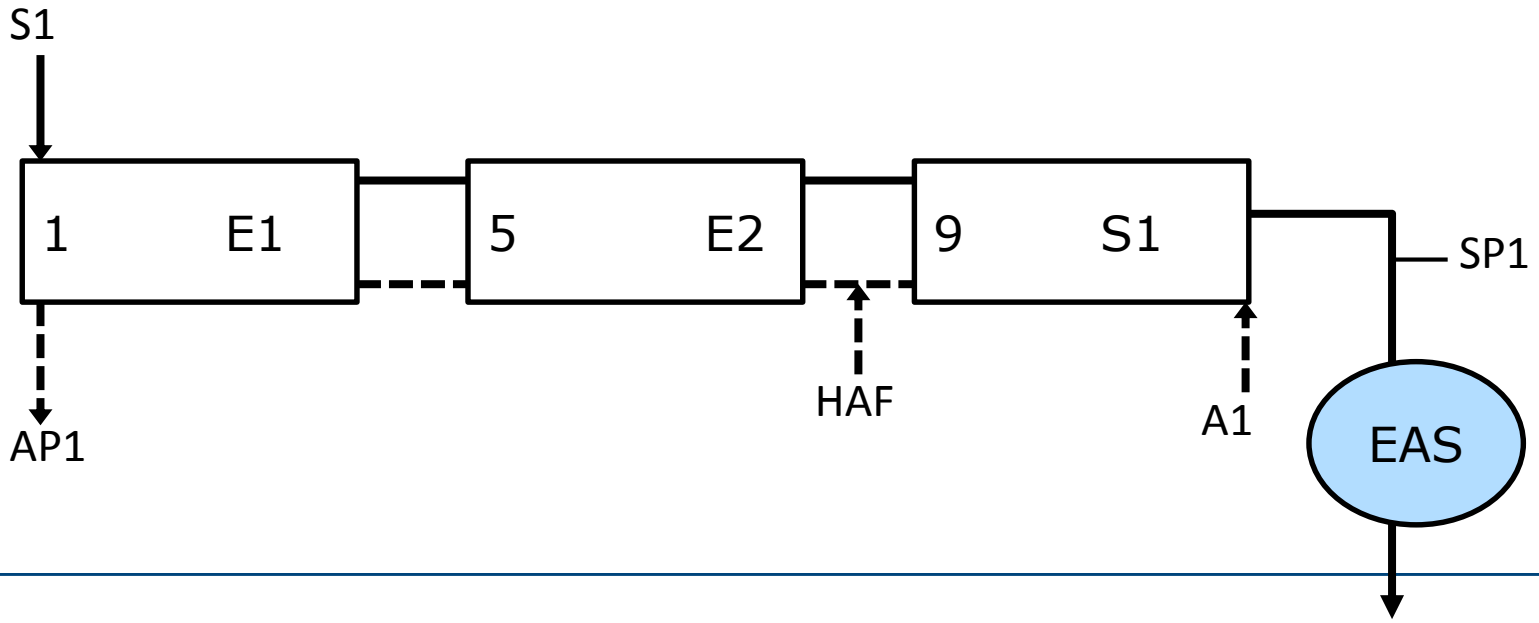
M. Carrott, et al, Solv. Extr. Ion Exch. 32(5), 447-467 (2014)

ACSEPT innovative solutions for sustainable nuclear energy

# Flowsheet maloperation

- Based on engineering design & safety review
- EURO-GANEX extract-scrub
- Loss of scrub acid
  - ★Actinide accumulation in contactor



# $HNO_3$ alpha radioysis: $H_2$ generation

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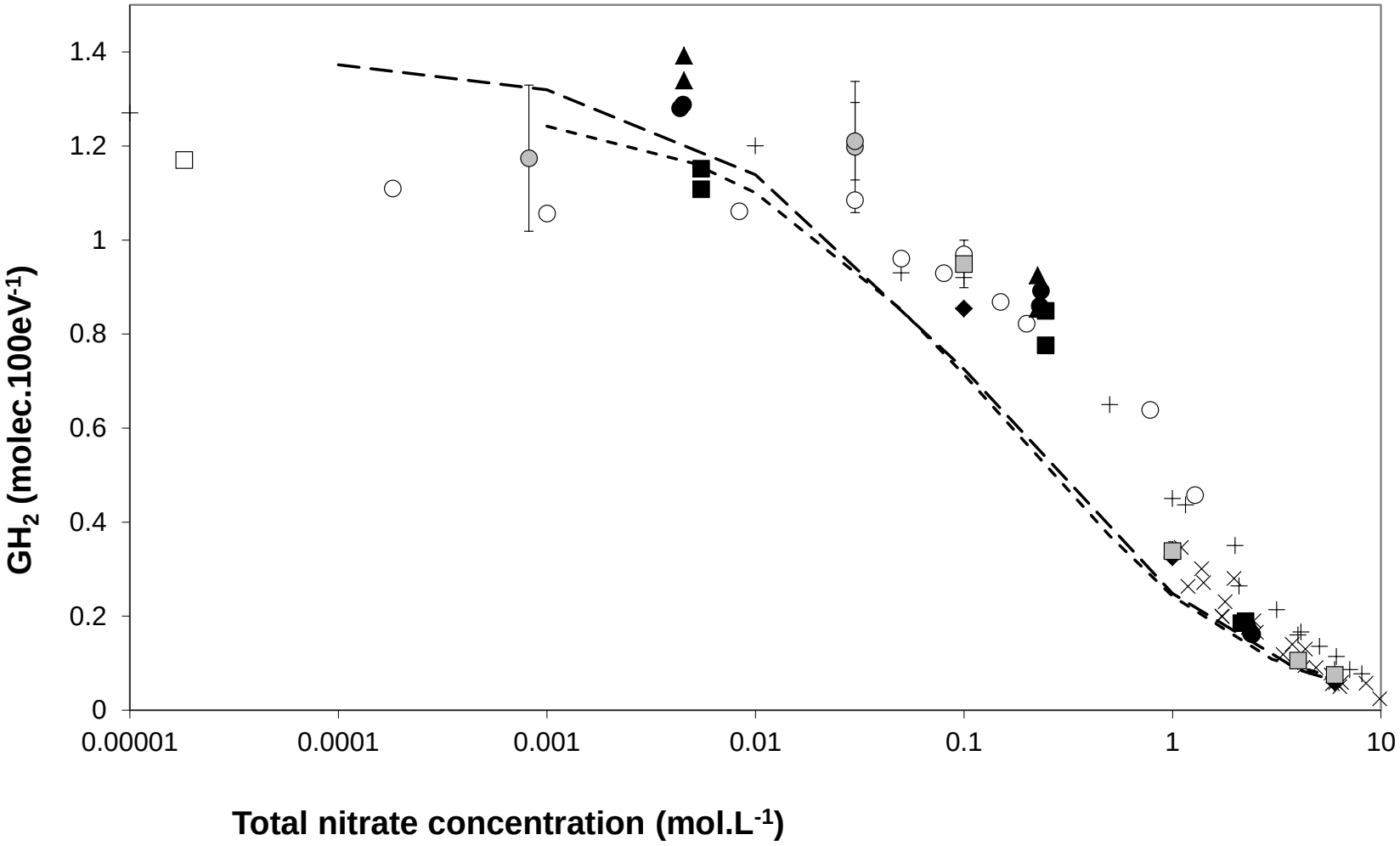
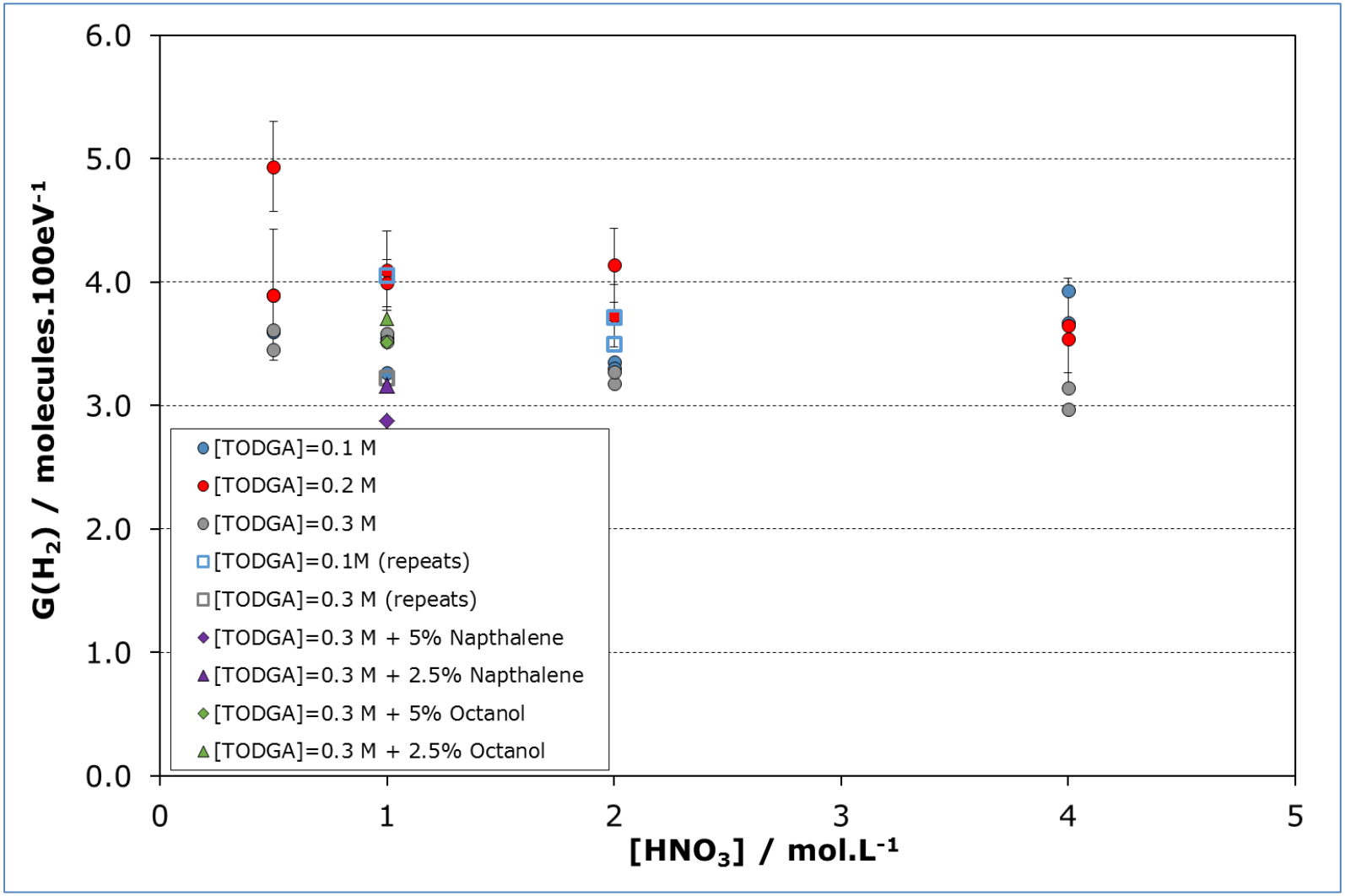


# TODGA alpha radiolysis: $H_2$ generation



# Flowsheet modelling

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- gPROMS platform
  - ★Extraction algorithms
  - ★Chemical kinetics
  - ★Mass transfer model
  - ★Physical properties
- Validation
  - ★Single or 2-phase lab-scale experiments
  - ★Single stage contactor experiments
  - ★Flowsheet tests
  - ★Industrial data
- Add in radiolysis
- Explore use of SAFT

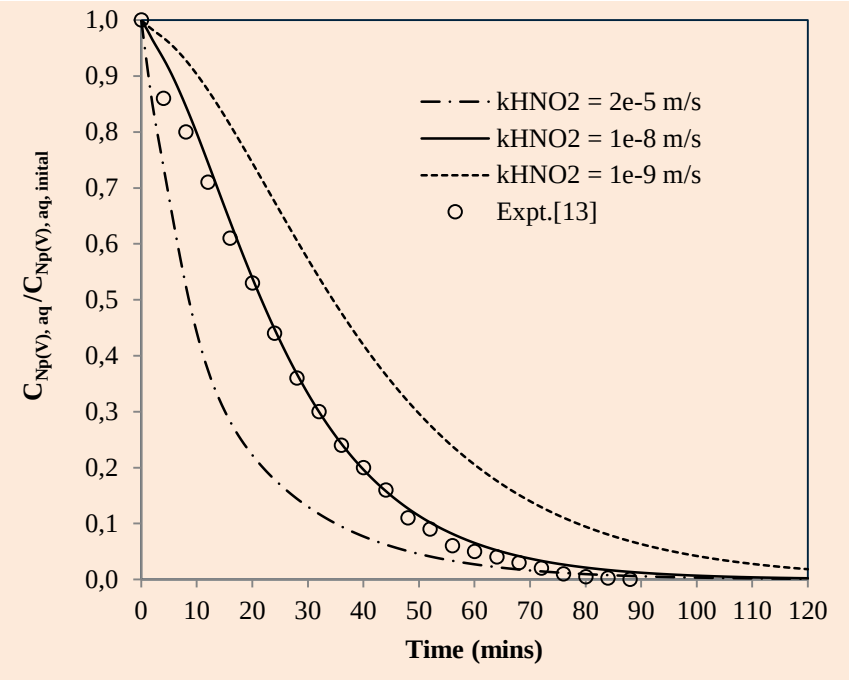
*Processes*:

PUREX

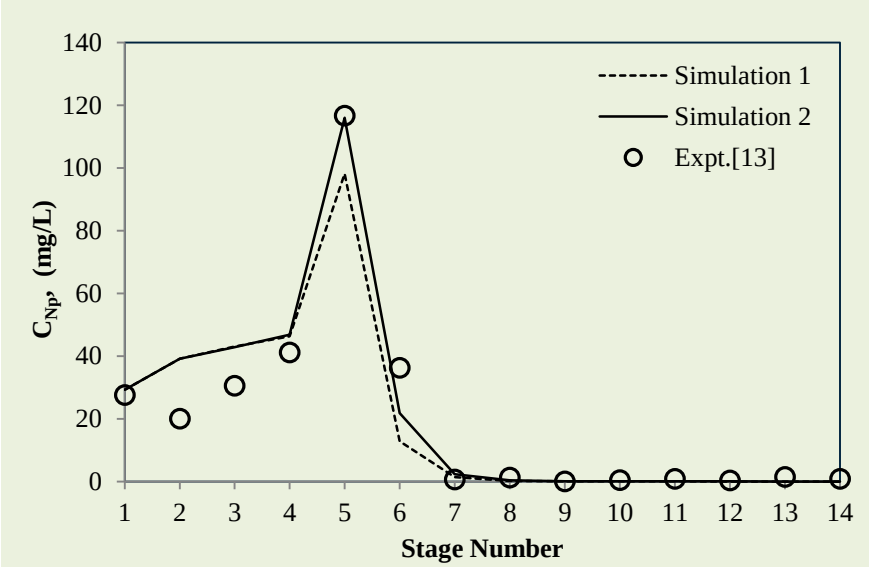
i-SANEX

EURO-GANEX

# Np extraction model (PUREX)

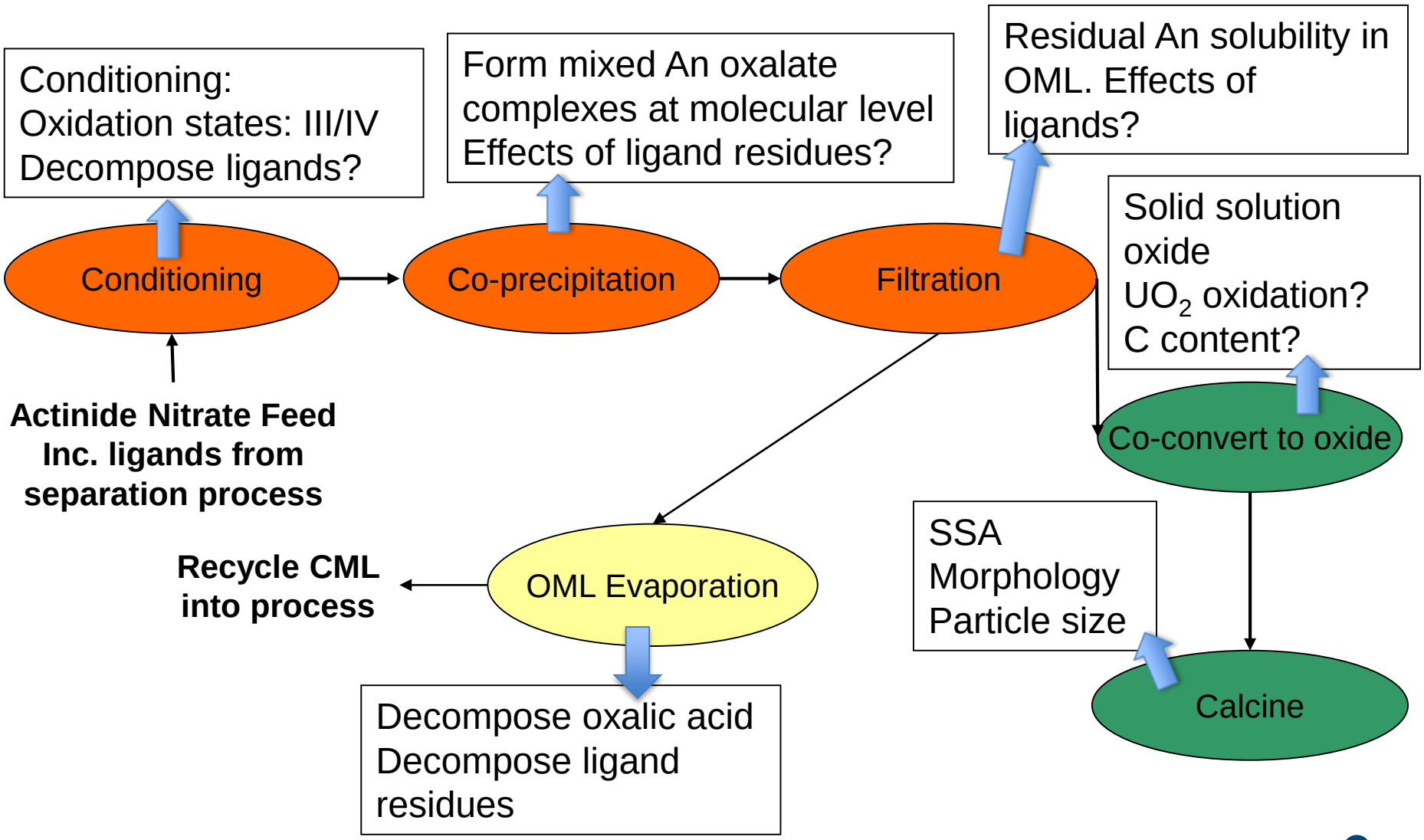



Single stage experiments




Flowsheet profiles

# Oxalate Conversion Process



# Summary

- Focused on R&D for Advanced Reprocessing:
  - ★Dissolution
  - ★Separations
  - ★Conversion
- Separation processes for Pu multi-recycling
  - ❖Advanced PUREX=>i-SANEX or EXAm
  - ❖GANEX-U=>EURO-GANEX
- Minor actinide process chemistry
  - ❖Neptunium
  - ❖Americium
- Cross cutting capabilities
  - ★Modelling & simulation
  - ★Radiation chemistry
  - ★Industrialisation