Timely Verification at Large-scale Gas Centrifuge Enrichment Plants

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What do ongoing trends in gas centrifuge enrichment technology mean for IAEA safeguards?

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What can the IAEA do to keep pace with these trends?

BACKGROUND

WHERE ARE THE GOALPOSTS?

Comprehensive Safeguards Agreements (NNWS), Voluntary Offer Agreements (NWS)

HSP

<u>Hexapartite Safeguards Project (1980–1983)</u>

- Goals: Detect diversion of declared material AND facility misuse
- Traditional item-based safeguards measures
- Limited Frequency Unannounced Access (LFUA) to cascade halls

Continuous enrichment monitoring (1995), environmental sampling (1996), AP (1997–)

RMA

<u>Revised Model Approach (2006)</u>

- Additional goal: Detect excess LEU production using undeclared material
- Short-notice random inspections (SNRIs) to feed/withdrawal areas to verify that only declared material is fed

WHAT HAS CHANGED SINCE 2006?

<u>Pre-Fukushima: Construction of new GCEPs, Expansion of existing ones</u>

- New plants: URENCO USA (4.7 MSWU), Georges-Besse II (7.5 MSWU)
- Expansions: Gronau UTA II (2.4 MSWU), Almelo expansion (1.8 MSWU)

<u>Post-Fukushima: 60 MSWU supply glut accumulates</u>

- This LEU is somewhere… not necessarily in UF_6, however.

Bottom line: More capacity per site, More LEU in storage

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What might an HEU production scenario look like at a modern commercial GCEP?

SIMULATING A MISUSE SCENARIO

SMITH, LEBRUN & LABELLA, JNMM 2013:

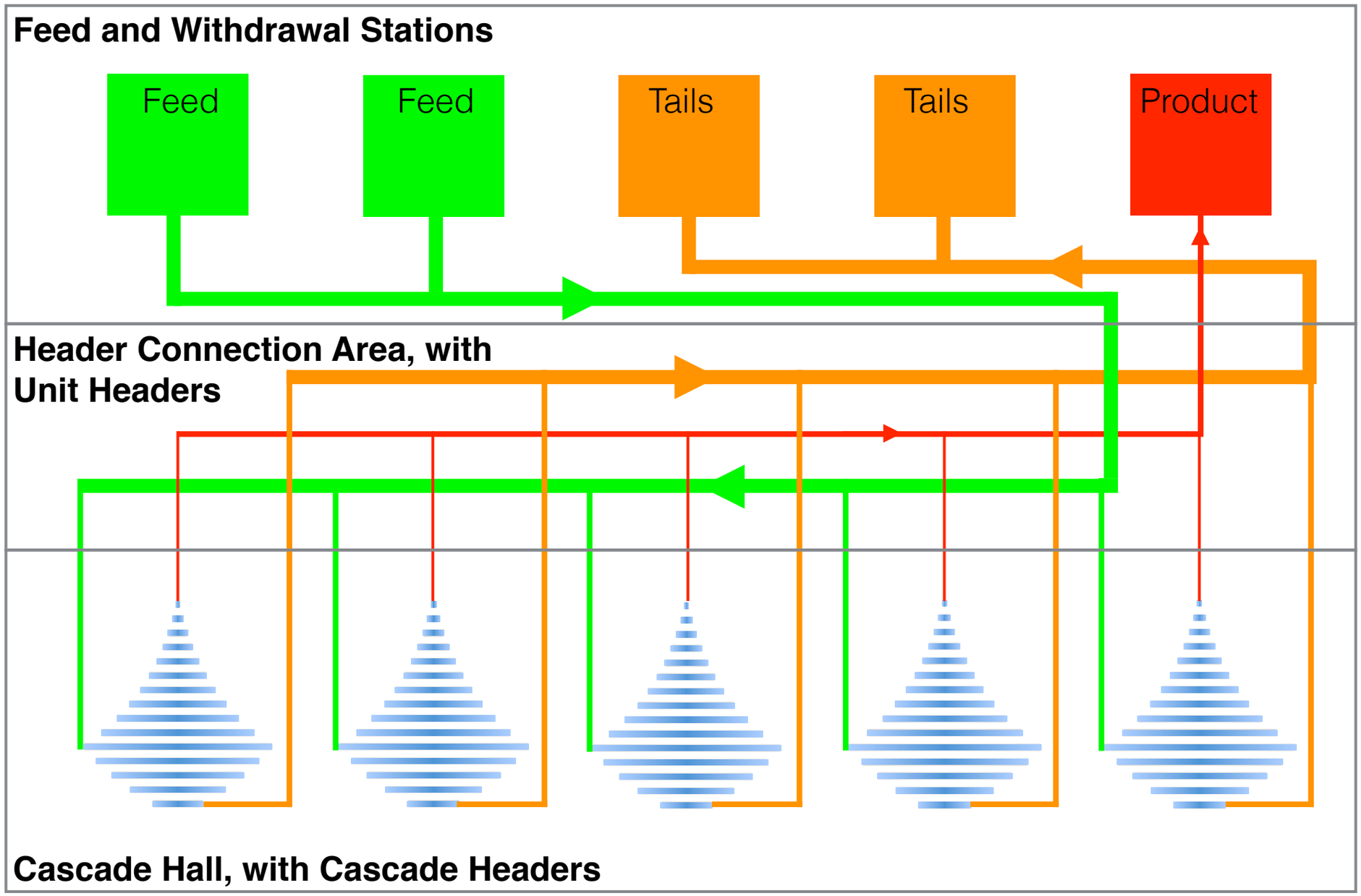
	#	tSWU/year
GCEP	1	4000
Units/GCEP	8	500
Cascades/Unit	10	50

Further assumed here:

- 1000 Centrifuges/Cascade: 50 kgSWU/yr
- 11 enriching stages, 4 stripping stages
- Max enrichment = 5%
- 10 g U/centrifuge
- Separation factor γ = R'/R" = 1.44

VISUALIZING A MISUSE SCENARIO

A NOTIONAL (5-CASCADE) PRODUCTION UNIT:



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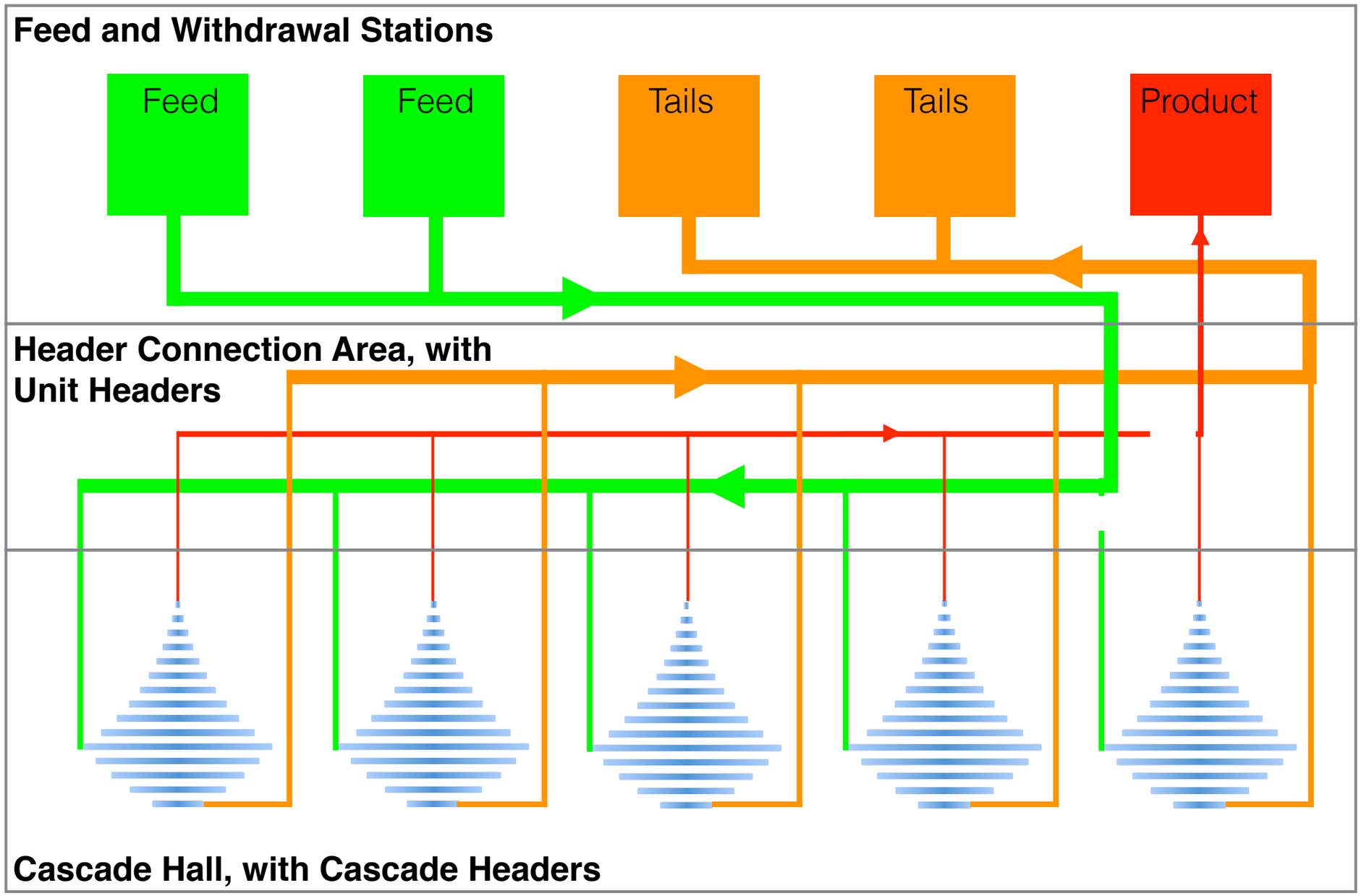

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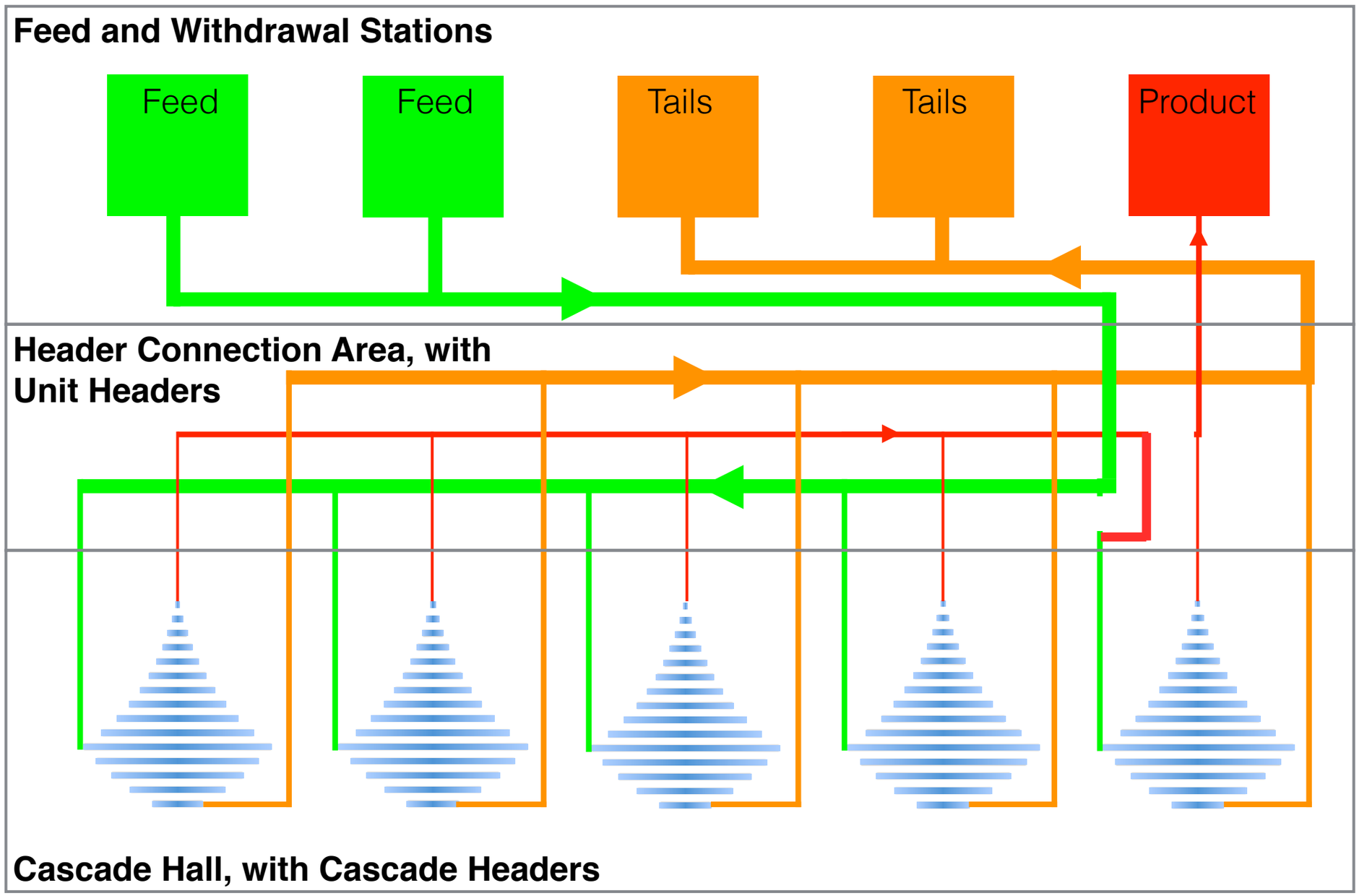

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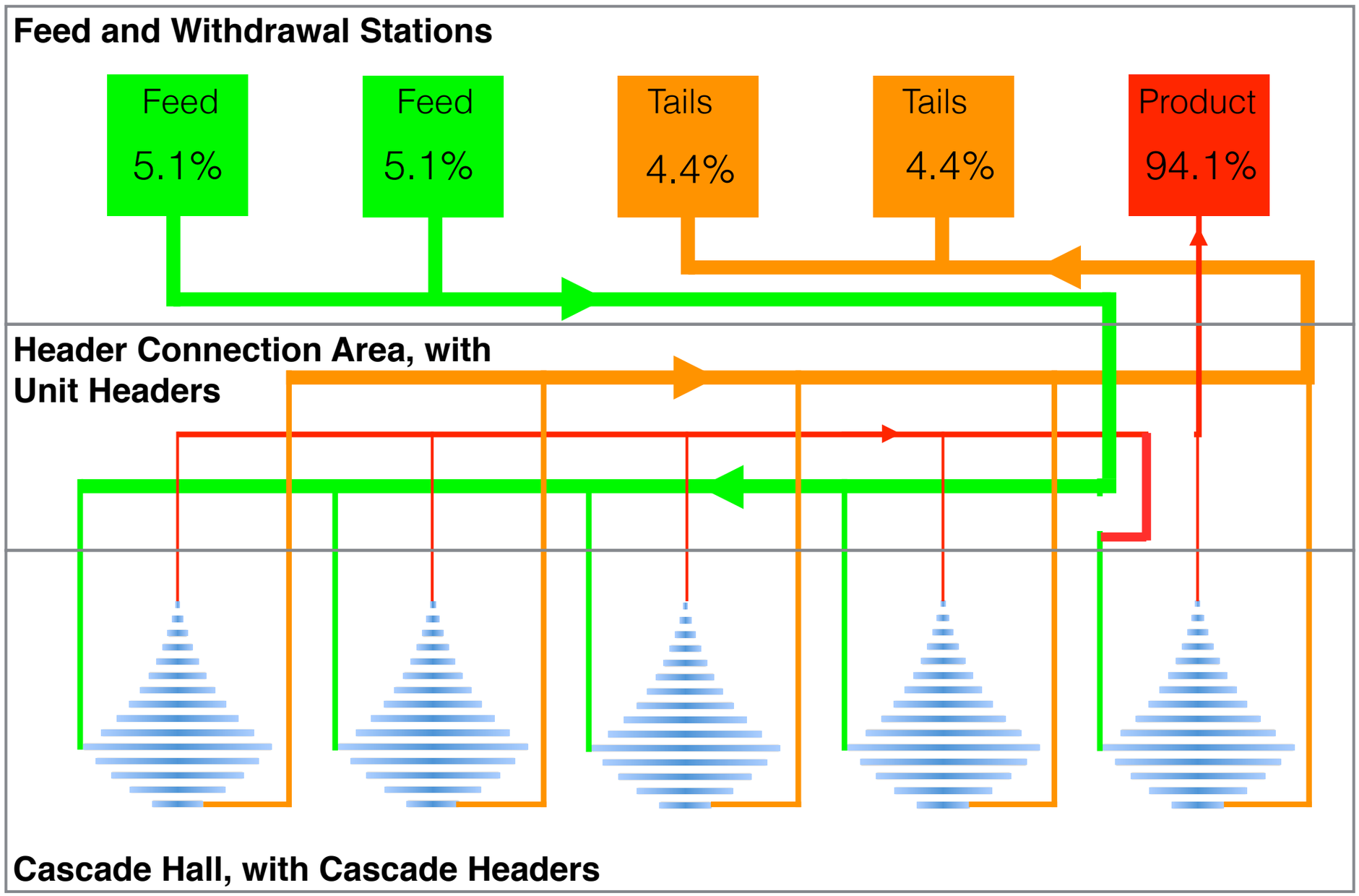


IS IT WORTH RESHAPING CASCADES?

IN THIS CASE, PROBABLY NOT.

TRADEOFFS OF NO RESHAPING

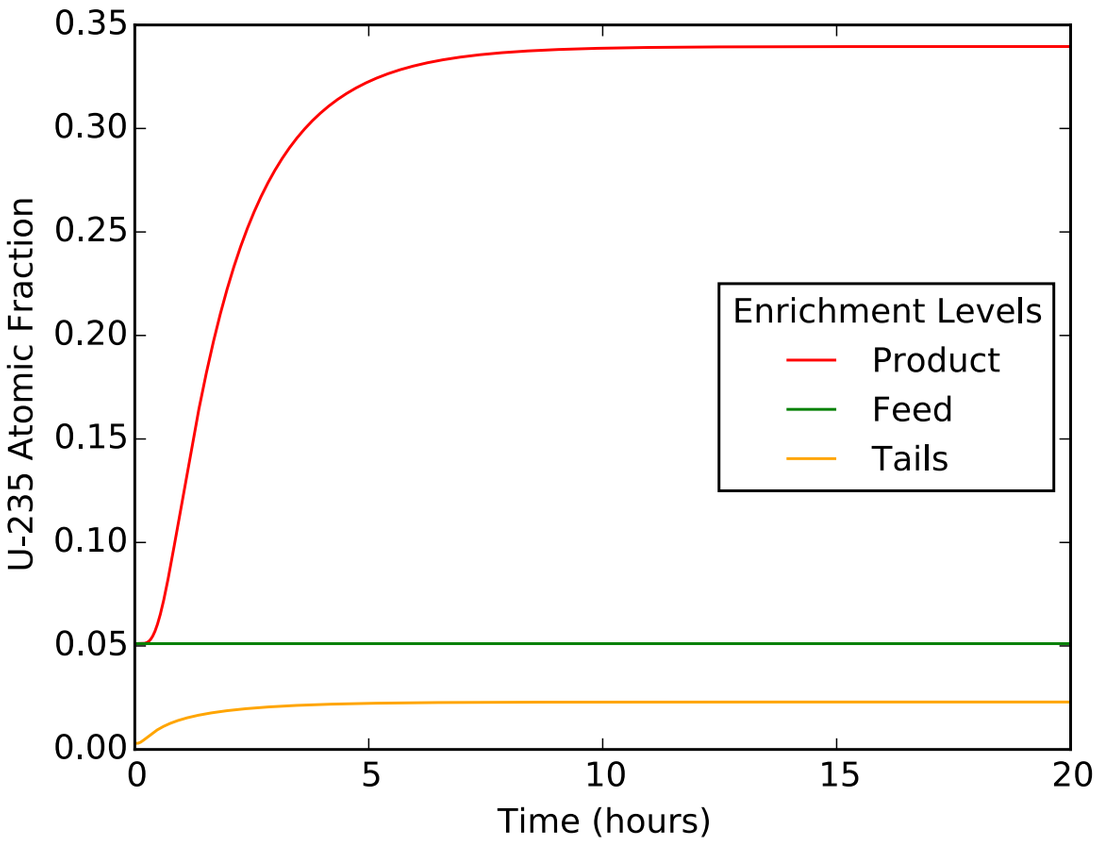
Pros: Expedient, Simple, Additional enrichment gain from off-normal stage cuts

Cons: Some loss of nominal SWU capacity

3 CASCADE GROUPS (2 IN MODIFIED UNIT)

	Feed Enrichment	Product Enrichment	Tails Enrichment	tSWU/year
Original	0.72%	5.11%	0.29%	50
Mid Group	5.11%	34.0%	2.29%	49.5
Top	34.0%	94.1%	28.1%	28.4

EQUILIBRATION IS QUICK.



5% → 34%

9 cascades

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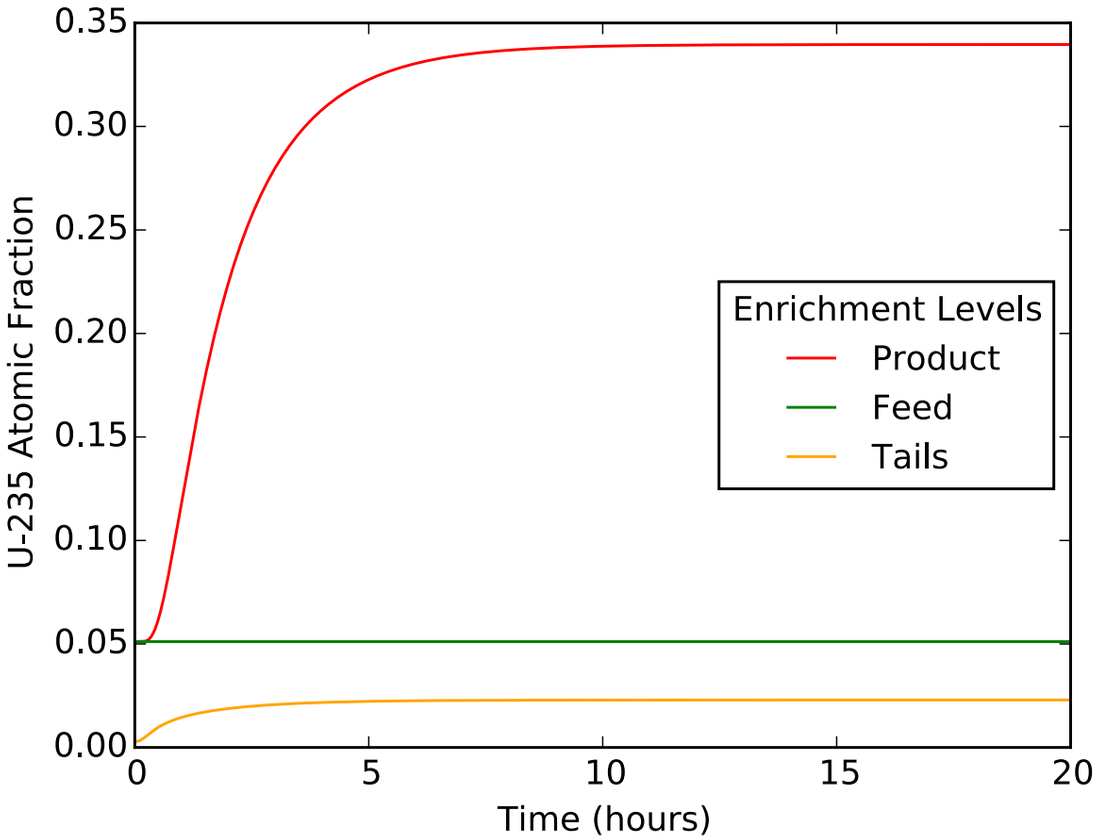

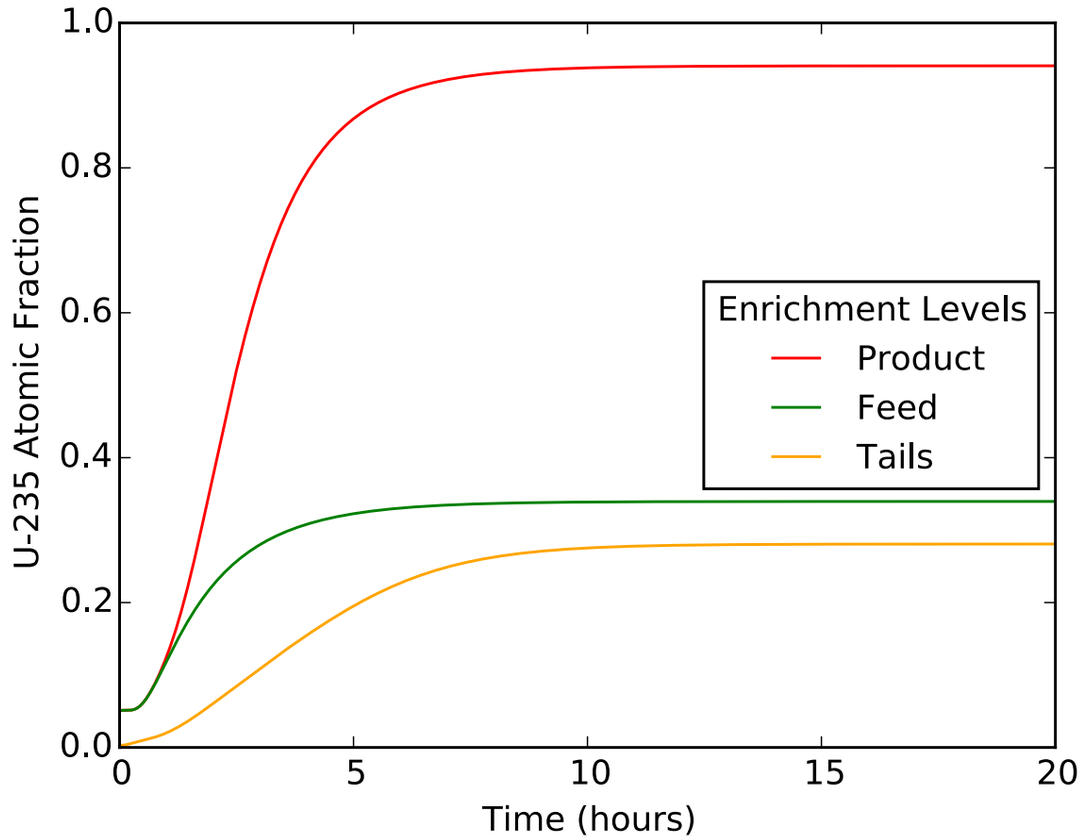

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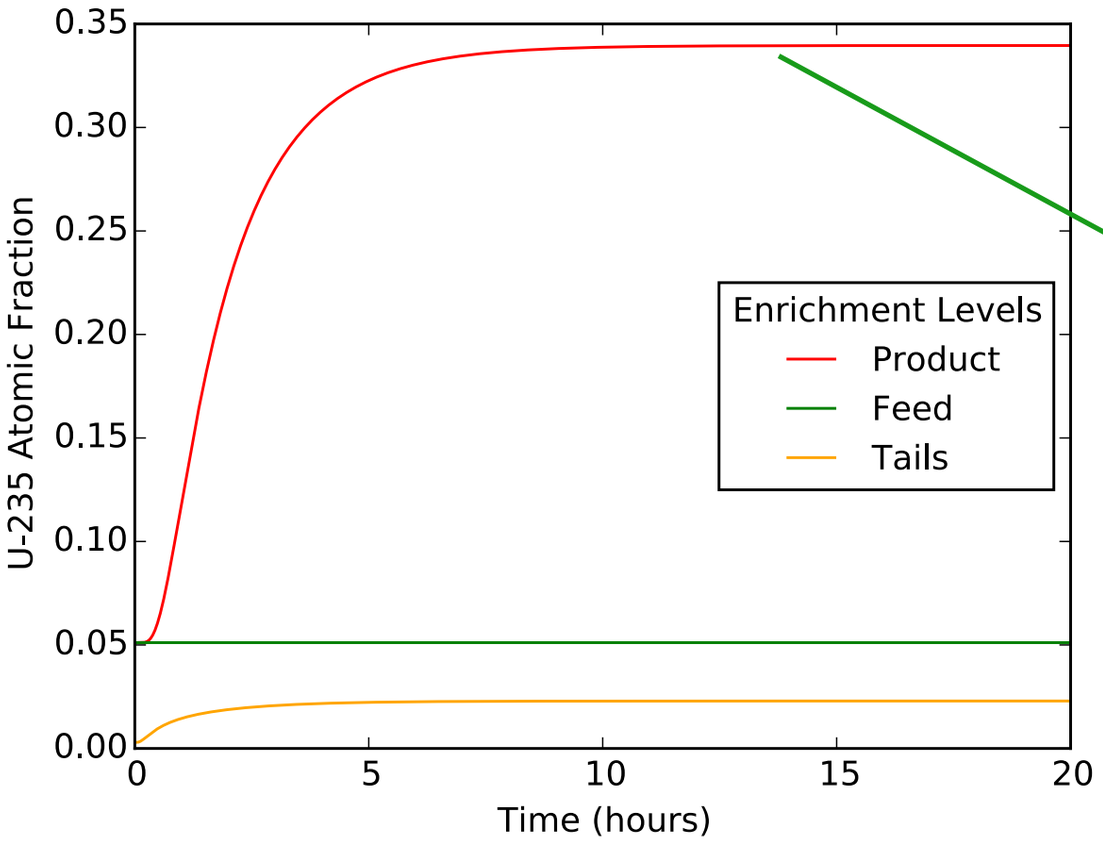

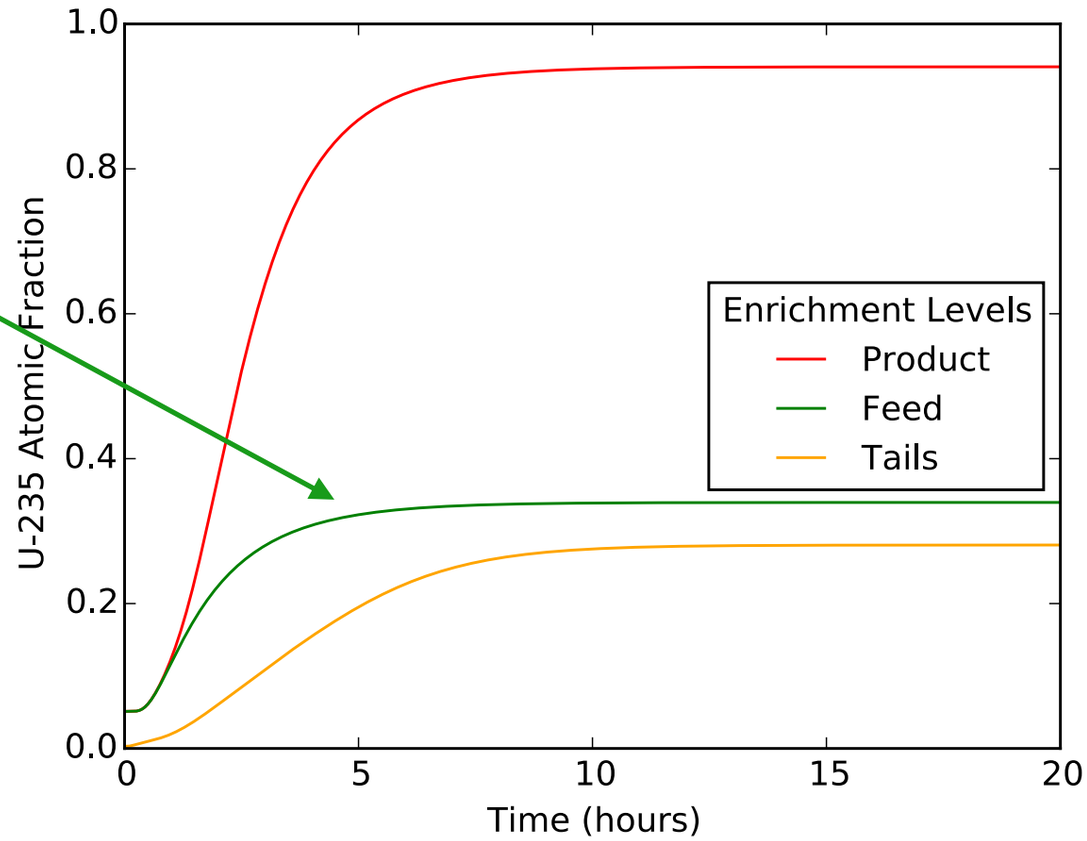

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34% → 94%

1 cascade

PRODUCTION RATE ESTIMATES

MODE 1:
No LEU sitting around

<u>While continuously producing LEU in unmodified units:</u>

- 1 modified unit: ~0.5 SQ/day
- 2 modified units: ~1.0 SQ/day

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<u>Modifying all 8 units and feeding them with on-hand LEU:</u>

- 10.8 SQ in 3 days
- With 2x tails recycling: 29 SQ in 7 days

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Time for a weekend breakout?

What measures can the IAEA apply to detect HEU production in a timely manner?

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Long-standing Measures

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Future Measures

- Unattended means for detecting piping reconfiguration in real time
- Unattended detection of hidden feed/withdrawal points

Detecting reconfiguration itself

UNATTENDED MEASURES FOR REAL-TIME RECONFIGURATION DETECTION

WITH INTERMITTENT DATA TRANSMISSION TO IAEA HQ

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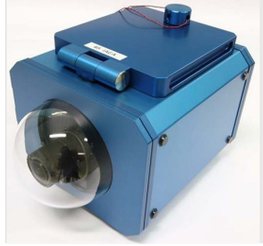

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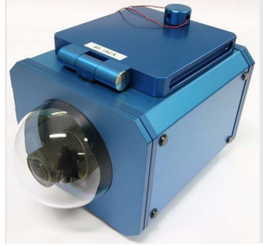

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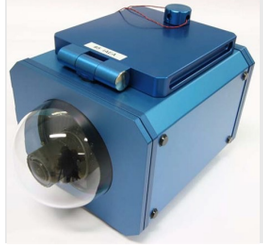

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Unattended NDA for detecting HEU presence in process areas

Detector arrays are expensive. How about a roving roomba detector?

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Potential synergies of new systems with operator needs should be exploited.

HF Detection -> Safety

Seals on sampling ports -> Insider threat mitigation

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IAEA
International Atomic Energy Agency

Potential Solutions:

- Unattended systems offer some improvements to detection timeliness for HEU production
- Unattended safeguards measures for detecting reconfiguration of piping and undeclared feed/withdrawal could pay further dividends.