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Gas Centrifuge Enrichment Plant Safeguards System Modeling

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Disclaimer

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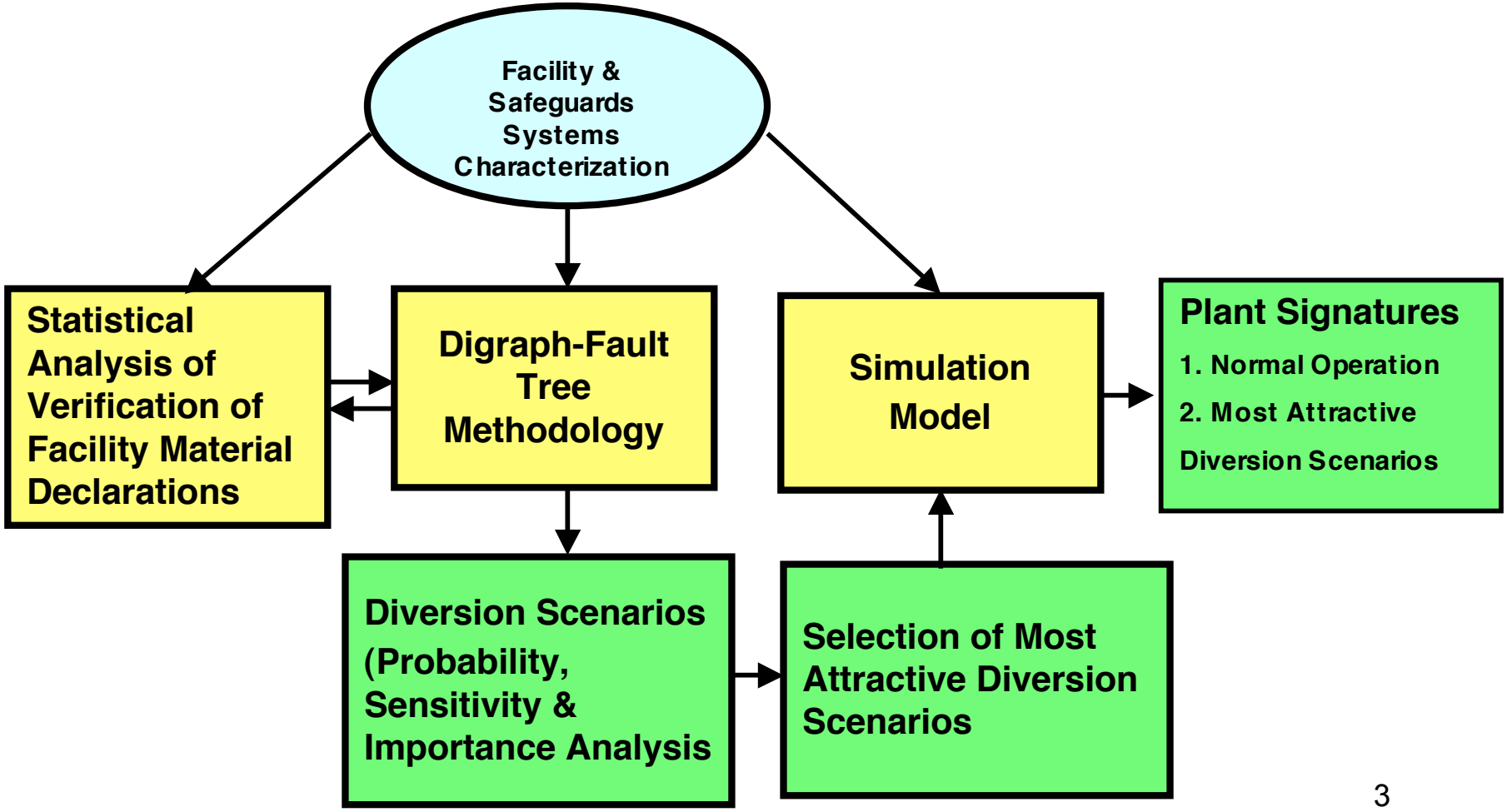
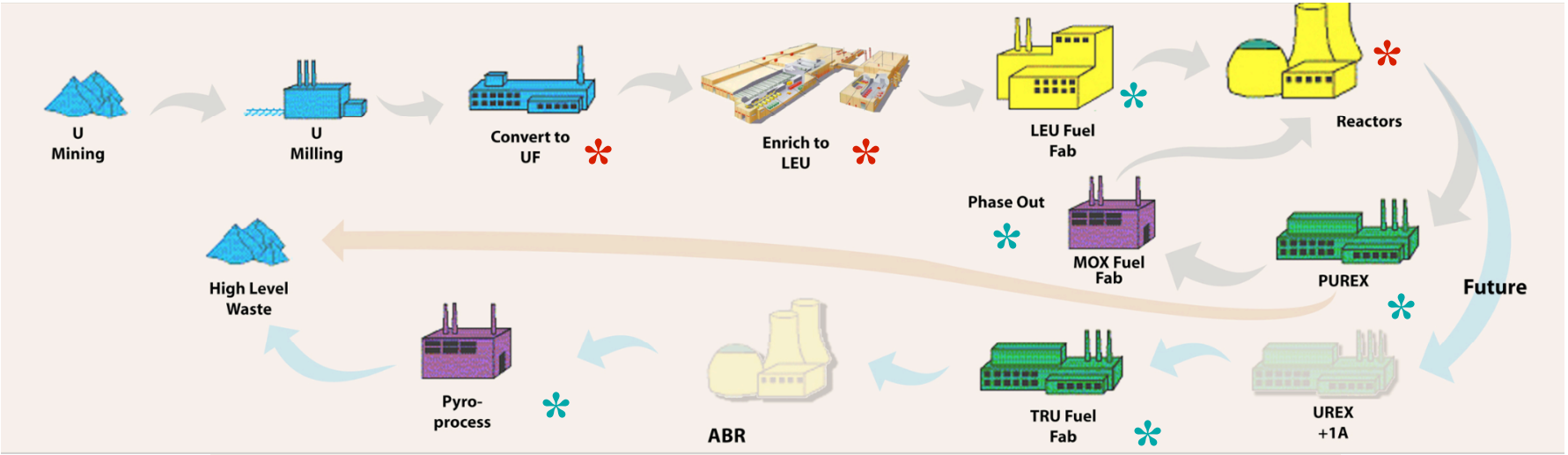
Overview

- Present a tool/methodology that can be used to perform systems analysis for evaluation of nuclear safeguards effectiveness
  - LLNL Integrated Safeguards System Analysis Tool - LISSAT
  - Nuclear Fuel Cycle
- Discuss LISSAT components
- Present example for a generic enrichment facility
- Present recent results
- Summarize potential use and application of LISSAT

LLNL Integrated Safeguards System Analysis Tool (LISSAT)



Current & Potential use of LISSAT in Nuclear Fuel Cycle Safeguards



* Current use of LISSAT * Potential use of LISSAT → Material Tracking Potential use of LISSAT

LISSAT Components

- **Directed Graph (Digraph)/fault tree analysis**
  - **Provides a *structured systematic approach to incorporate all root causes for each diversion scenario* including operator misdeclarations**
  - **Help *quantify the change in the probability of detection of diversion* due to the introduction or use of:**
    - **Material accounting, surveillance cameras, detectors…**
    - **New safeguards measures/tools**
    - **New technology**
    - **Changes in plant designs**

Probability of Diversion Taking into Account Safeguards Implementation

	Current Safeguards		Added Safeguard Measure	
Scenario Description	Without Any Safeguards measures	With Current Safeguards Practice	Without Any Safeguards measures	With surveillance cameras, detectors…
Diversion scenario 1	1.0	**Probability of diversion**	1.0	**Reduction in Probability of diversion**

LISSAT Components

- **Simulation**
  - **Help *identify plant signatures* (normal versus abnormal) that might assist IAEA inspectors as indicators of diversion.**
  - **Help *identify the ideal location* of detectors, measurement sensors, surveillance cameras…**

LISSAT Helps Identify the Ideal Placement of Detectors & Monitors

	Material Measurement Points			
Diversion Scenario	**Measurement point 1**	**Measurement point 2**	**Measurement point 3**	**Ideal location Measurement point 4**
Diversion Scenario 1	Normal	Normal	Normal	**Low**

Facility & Safeguards Systems Characterization

- Generic Facility Design Based on:
  - URENCO Plant Layout
  - ORNL Input (Capacity, Flow Rates)
  - Medium sized generic enrichment plant
  - 500 MTSWU per year
  - There are 6 autoclaves
  - Cylinders are shipped to autoclaves- one cylinder every 3 days
  - One cylinder holds 7602 Kg U
  - Flow into cascade hall is 102.6 Kg/hr
  - There are 50 cascades
  - There are 250 centrifuge per cascade

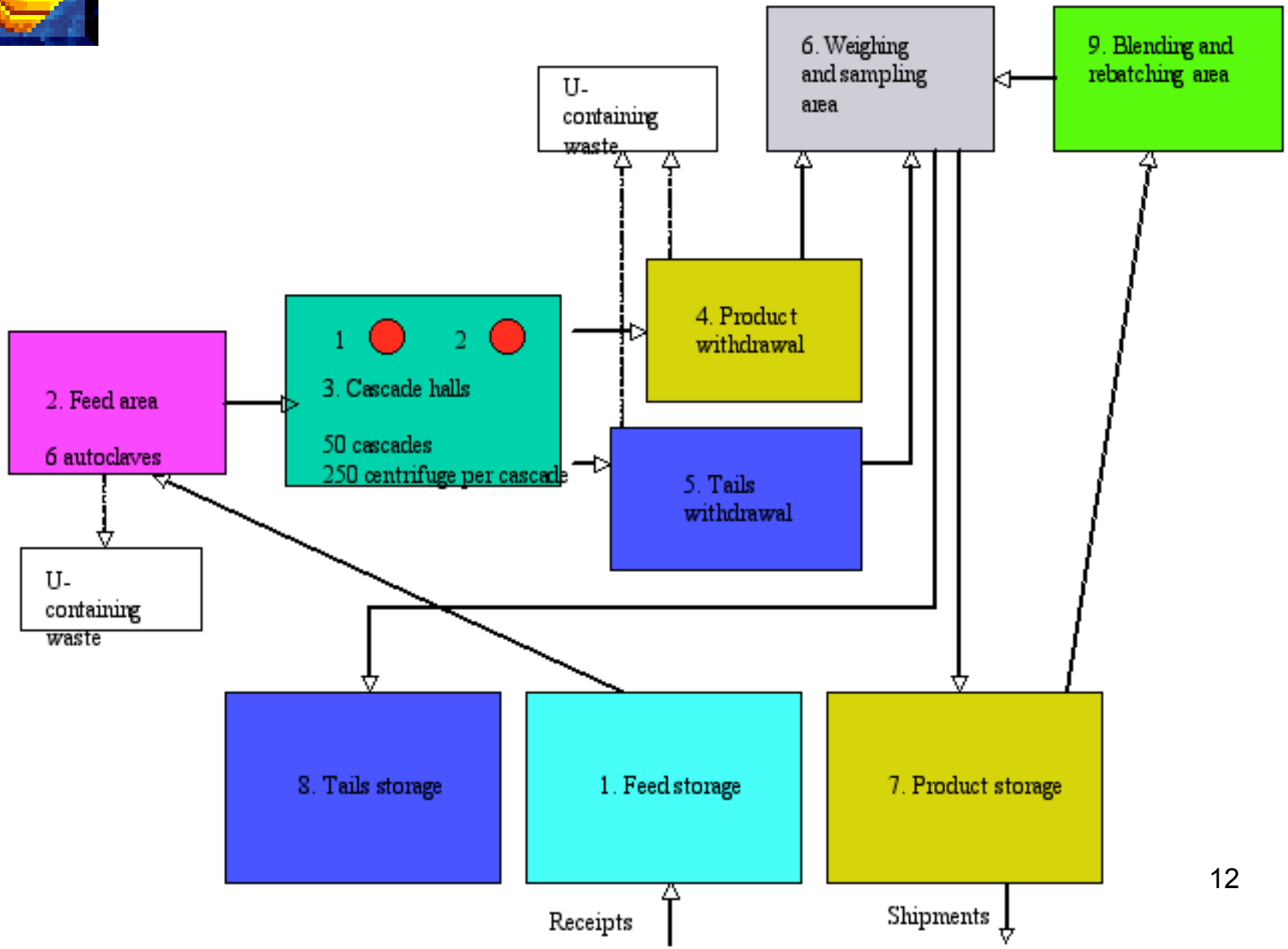
Facility Simulation Model

- We used Extend (v.6), a simulation software, to develop a simulation model for a generic enrichment facility
- Extend is a graphical, interactive, general-purpose simulation program for both discrete event and continuous modeling
- Allow manipulation of circumstances
- Illuminates signatures to identify anomalies
- These anomalies can be fed-back into the fault tree analysis

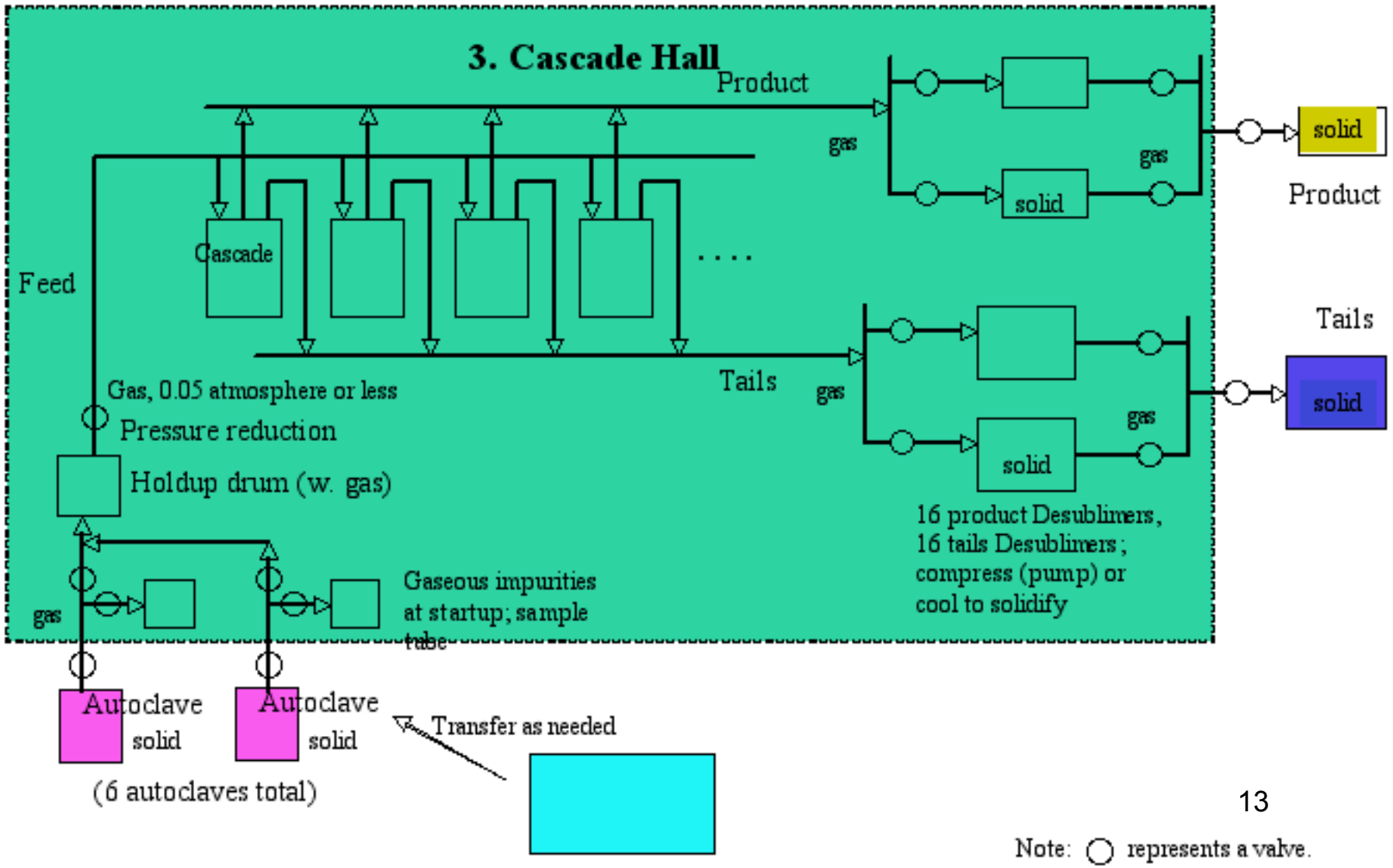
Simulation Model Assumptions

- Gaseous impurities losses 0.3%
- Modeled for one calendar year
- Diversion of LEU Product by skimming inside the cascade hall
- Digraph/Fault tree & Statistical Analysis were not performed

Generic Enrichment Facility Block Diagram



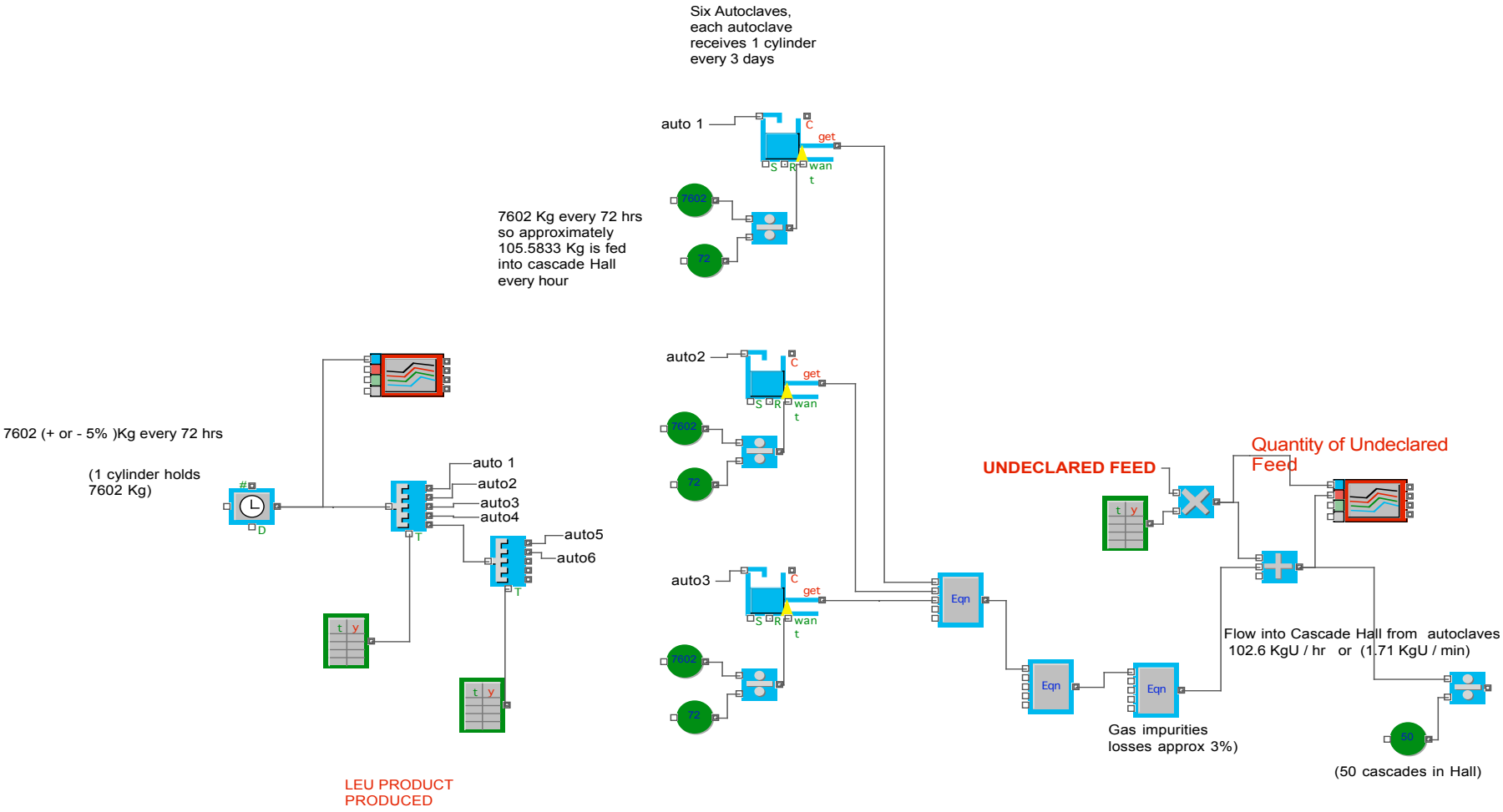
Cascade Hall Block Diagram



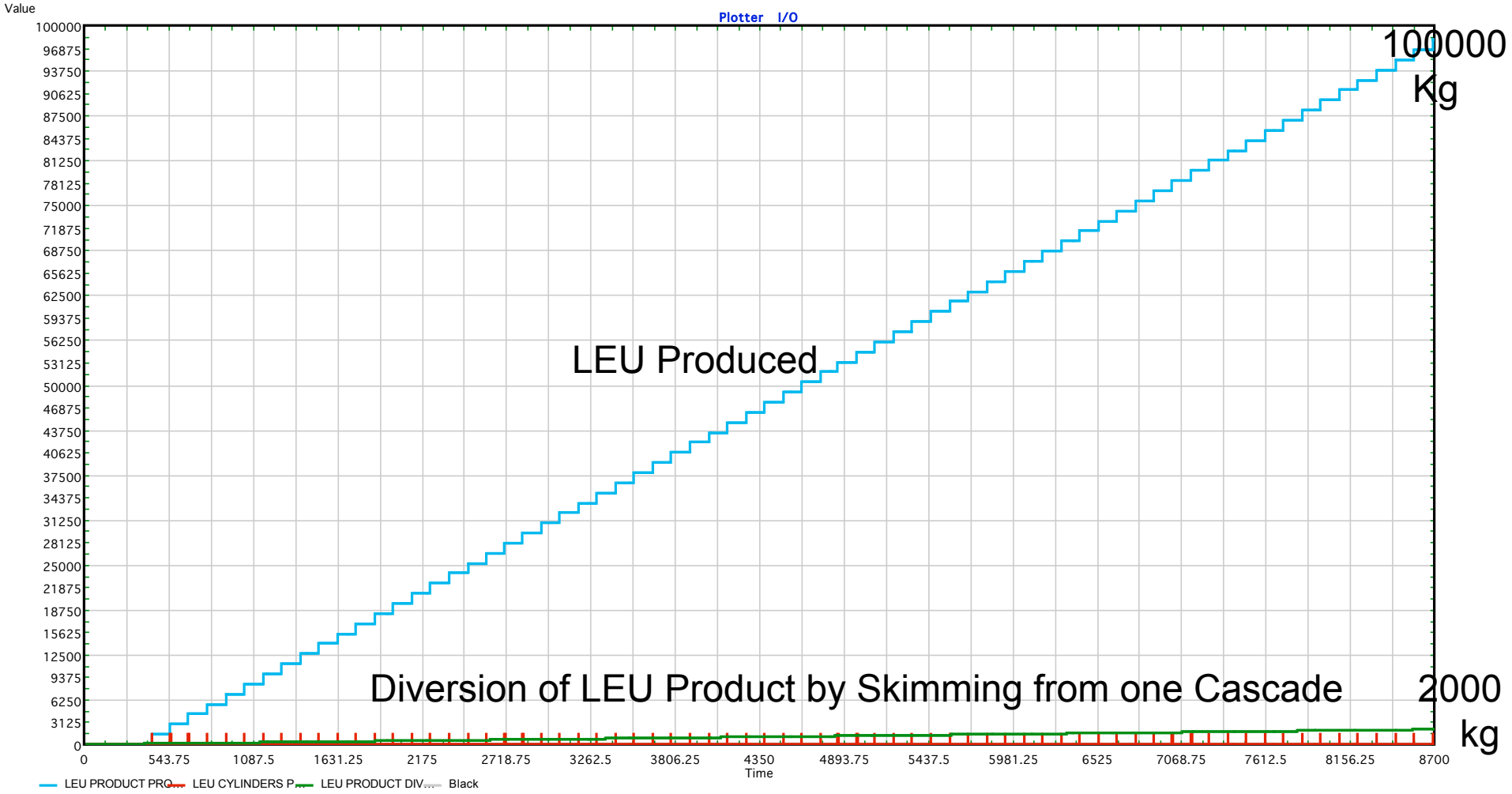
Note: ◯ represents a valve.

Feed Area Module in Extend

2. FEED AREA (SIX AUTOCLAVES)

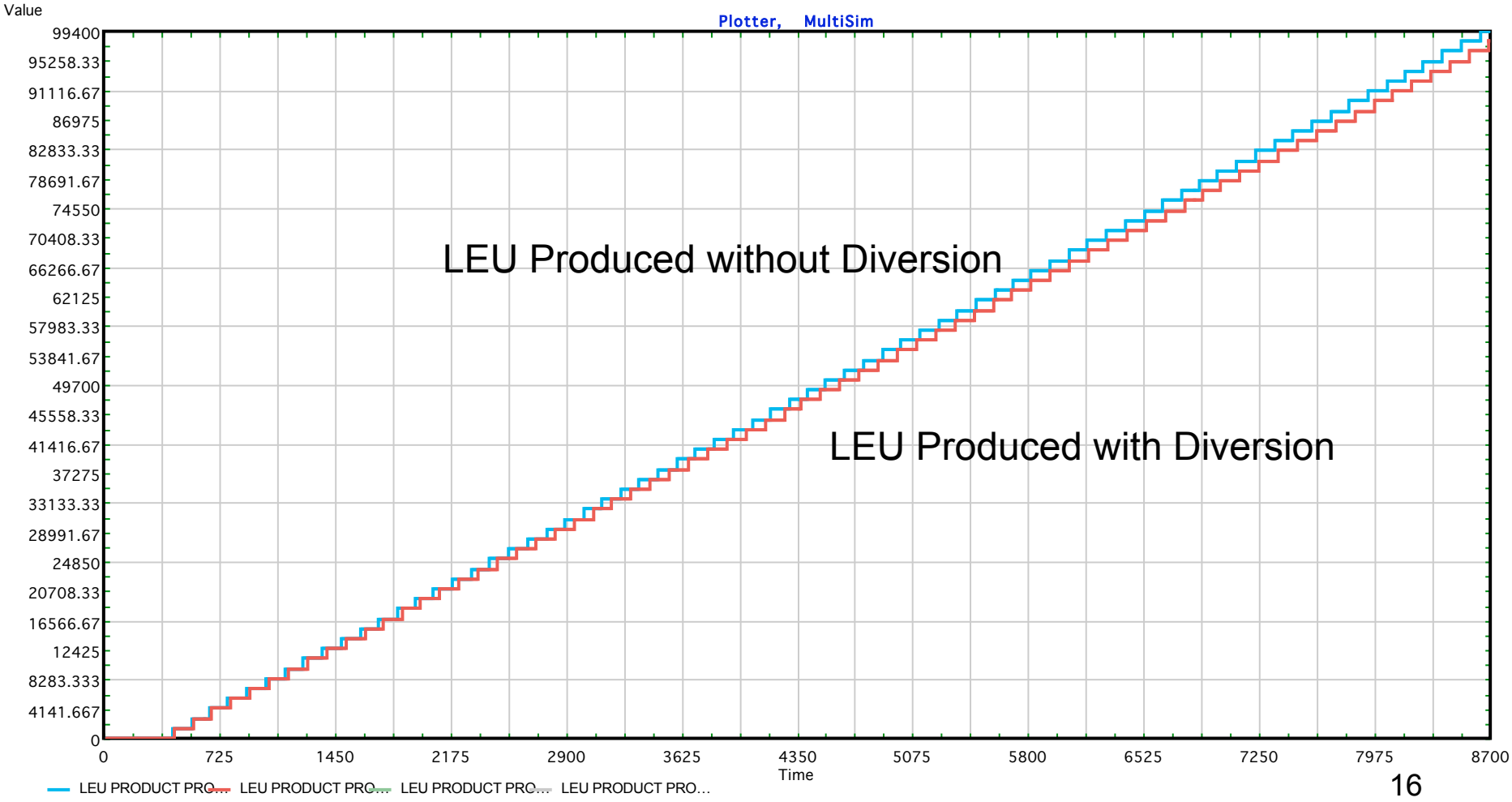


Simulated Total Production of LEU (100,000 kg) & Diversion of 2000 kg of LEU by Skimming from One Cascade Throughout the Year



TIME (Hrs)

Simulated Total Declared Production of LEU (100,000 kg) Under Normal Plant Operation Versus under Diversion of 2000 kg of LEU by Means of Skimming



TIME (Hrs)

Potential Use and Application of LISSAT

- To evaluate safeguards effectiveness of other facilities in the nuclear fuel cycle
  - Reactors
  - Fuel Fabrication Plants
  - Natural uranium conversion
  - Nuclear fuel reprocessing
- To evaluate safeguards for various proliferation resistant designs
- To evaluate current safeguards tools/methods/on-the-shelf tools to assess safeguards strategies beyond Hexapartite