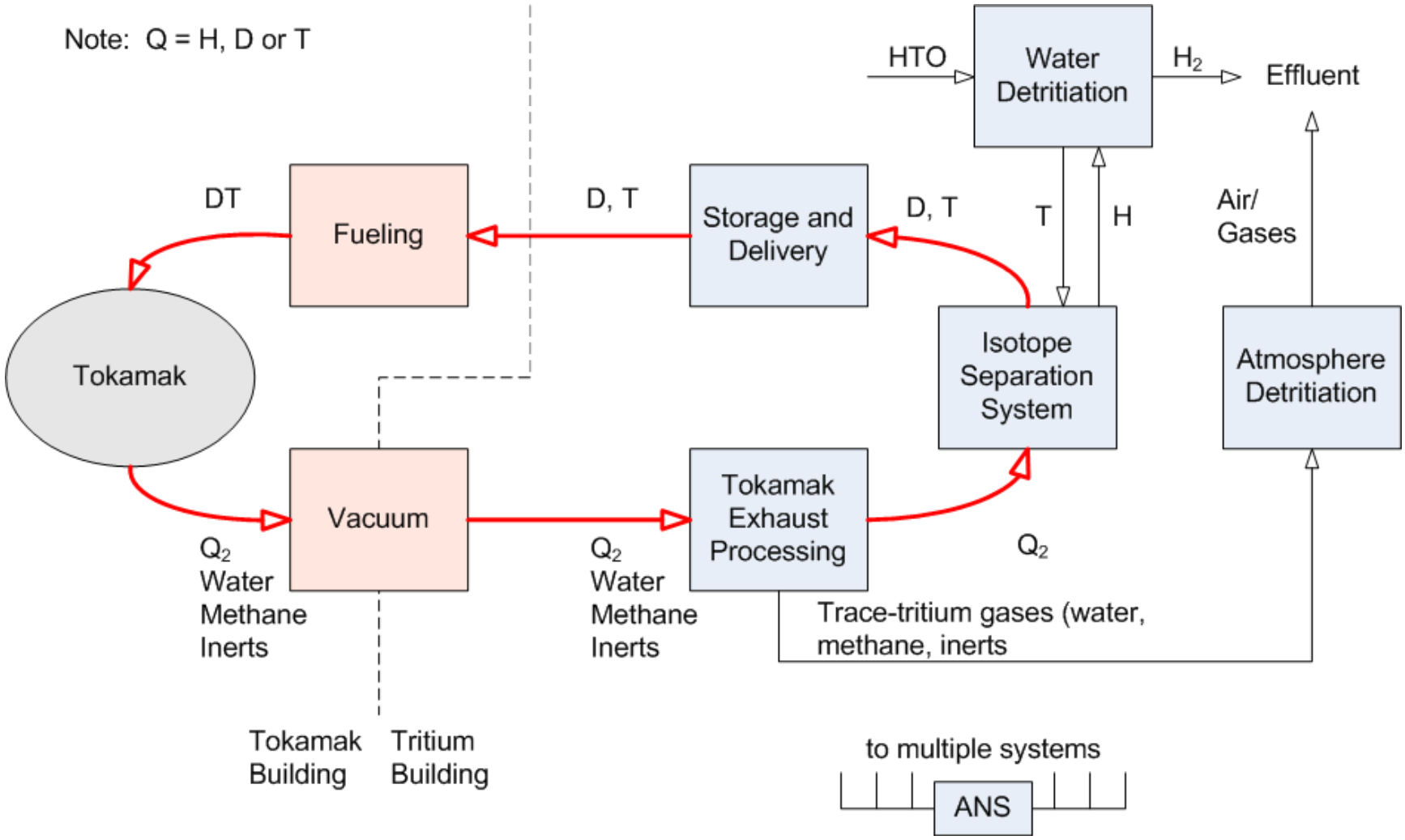
ITER Fuel Cycle Paths To DT

Scott Willms (US) and Manfred Glugla (IO)

ITER Fuel Cycle Integrated Product Team

February 17, 2010

Simplified view of ITER Fuel Cycle



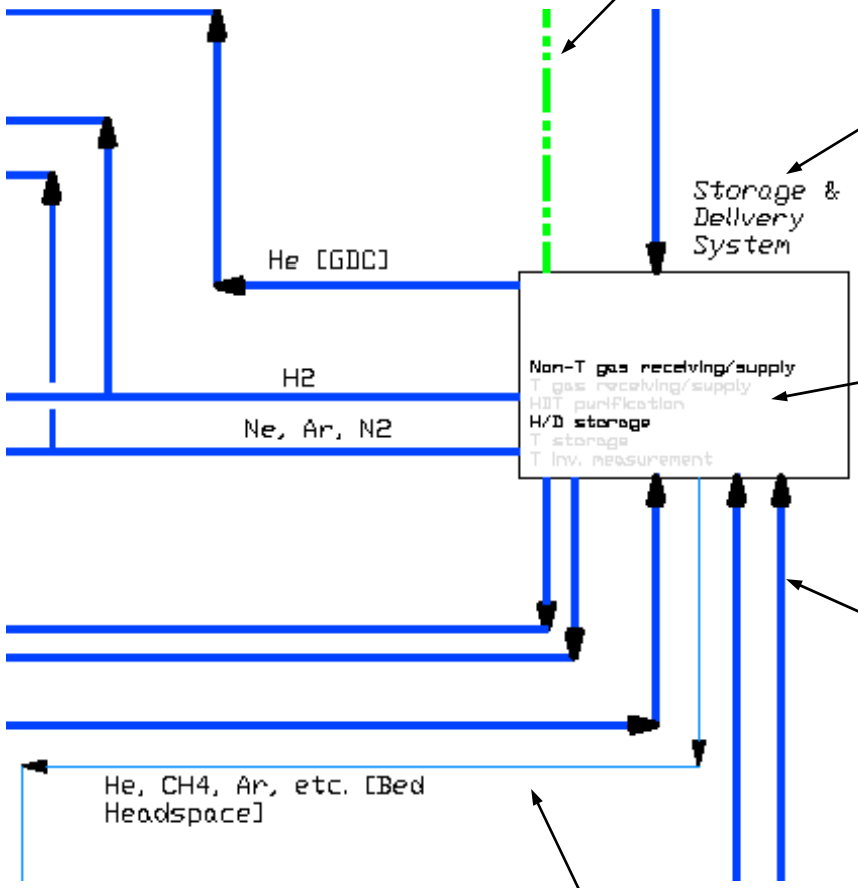
“Scenario 1” Impacts

- All ITER Fuel Cycle systems were to be fully ready at “first plasma” (2018). This schedule was revised to the “Scenario 1” sequence with “first plasma” in 2019, but full DT beginning in 2026
  - This results in four (rather than one) key endpoints for the ITER Fuel Cycle
- A Fuel Cycle Integrated Project Team (FC-IPT) Task Force was established in July 2009 to
  - Analyze the Fuel Cycle requirements in HH, DD, Trace T and DT
  - Consider technology solutions to meet requirements
  - Consider non-tritium and tritium compatible solutions
  - Consider staging/scheduling to meet requirements
  - Develop strategies for Fuel Cycle systems testing and commissioning
- Task Force led by Scott Willms (LANL (US), FC IPT deputy leader)

Fuel Cycle Outline (functional) Drawings

- Functional drawings for HH, DD, Trace T and DT have been drafted
  - Drawings include all Fuel Cycle packages
  - Highest-level process drivers identified
  - Highest-level process interfaces defined
  - Lines are labeled with
    - Major fluid composition (gases)
    - Hydrogen isotope content
    - Stream properties or uses
  - More detail given in Process Flow Diagrams
- Technology options (value engineering) for HH, DD, Trace T and DT have been identified

Drawing Features



Green used for “additional scope” packages

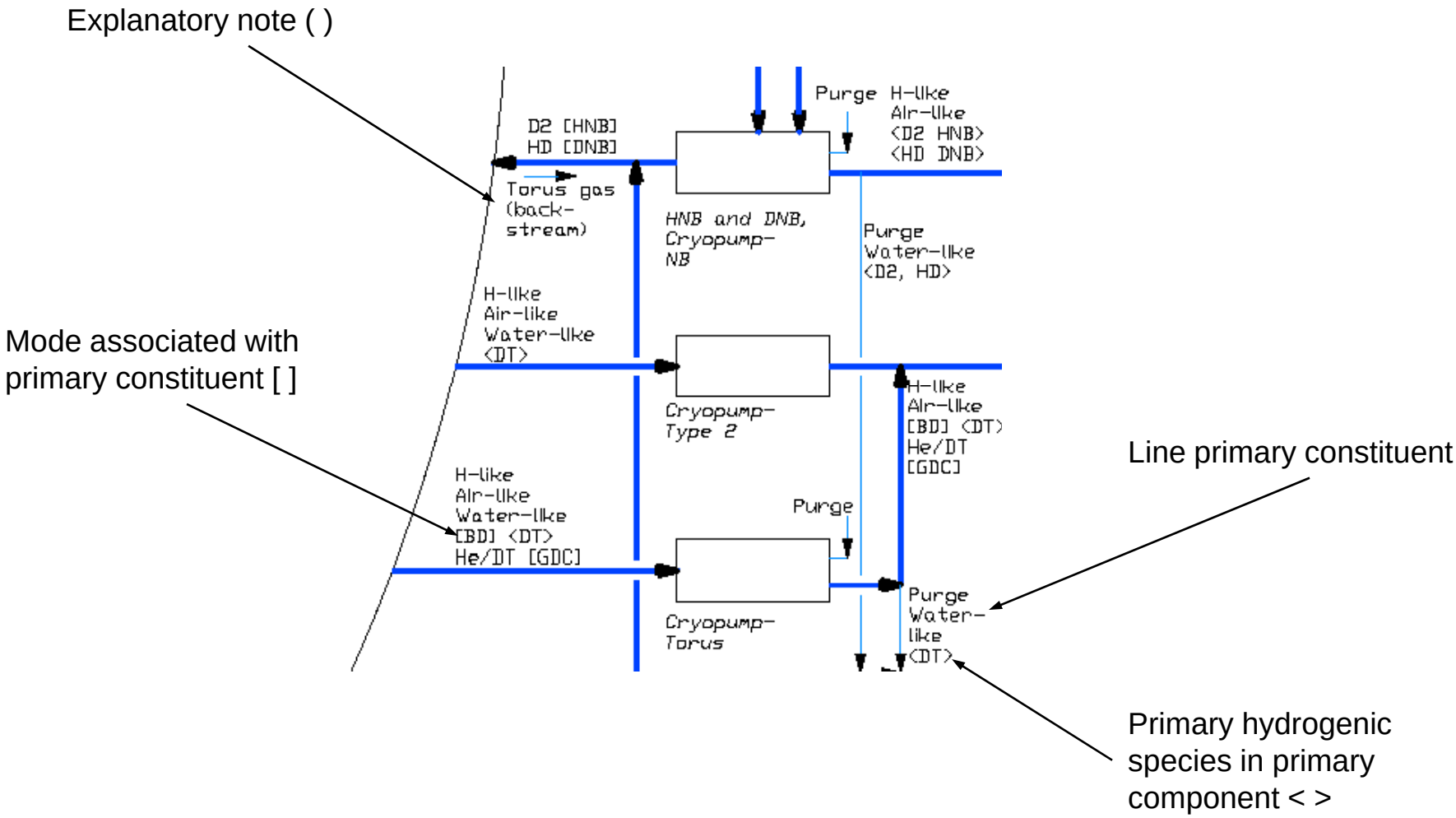
All Fuel Cycle packages shown

Primary functions (greyed functions not needed at phase shown)

Major interfaces

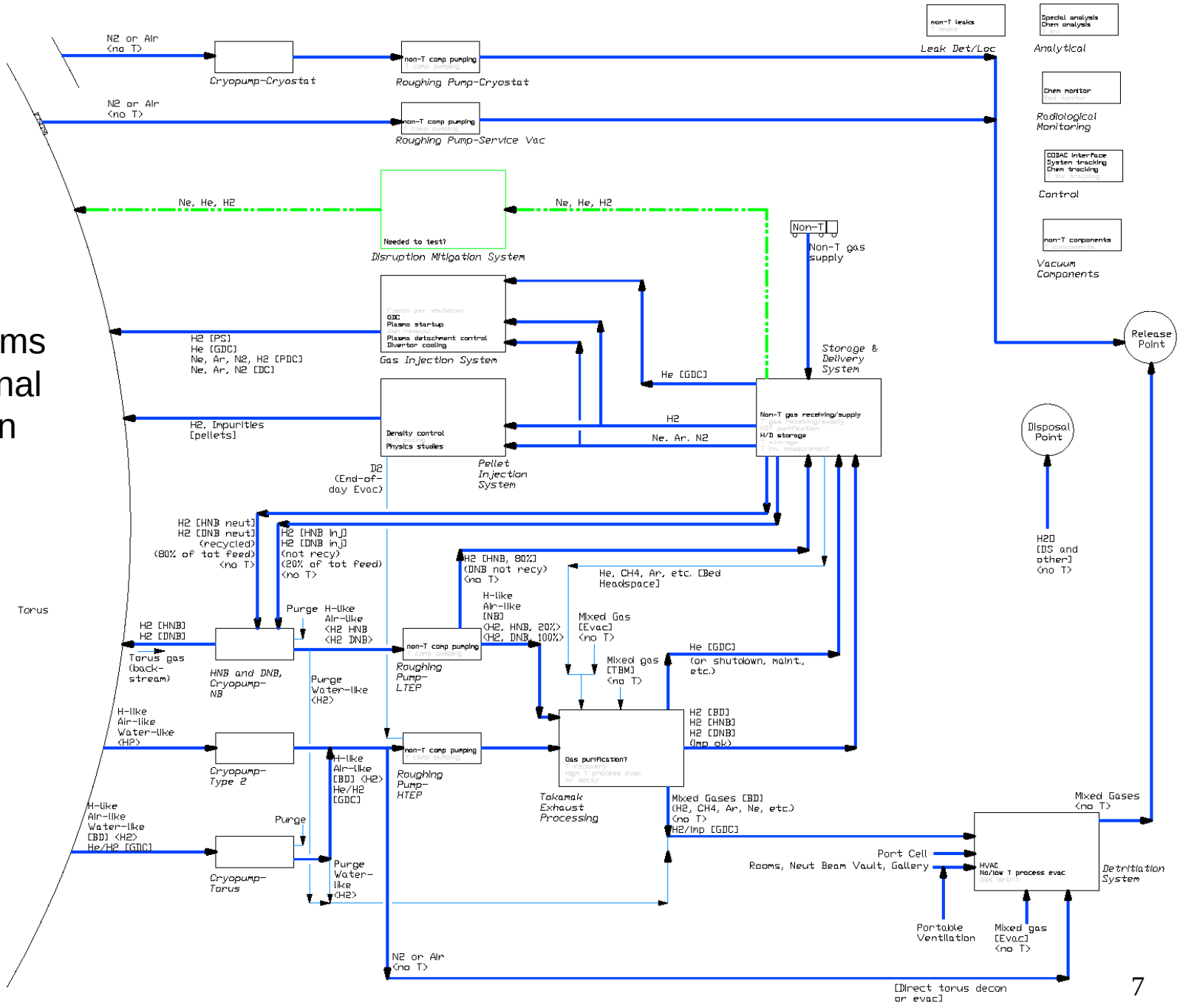
Less used lines shown lighter

Drawing features - line descriptions



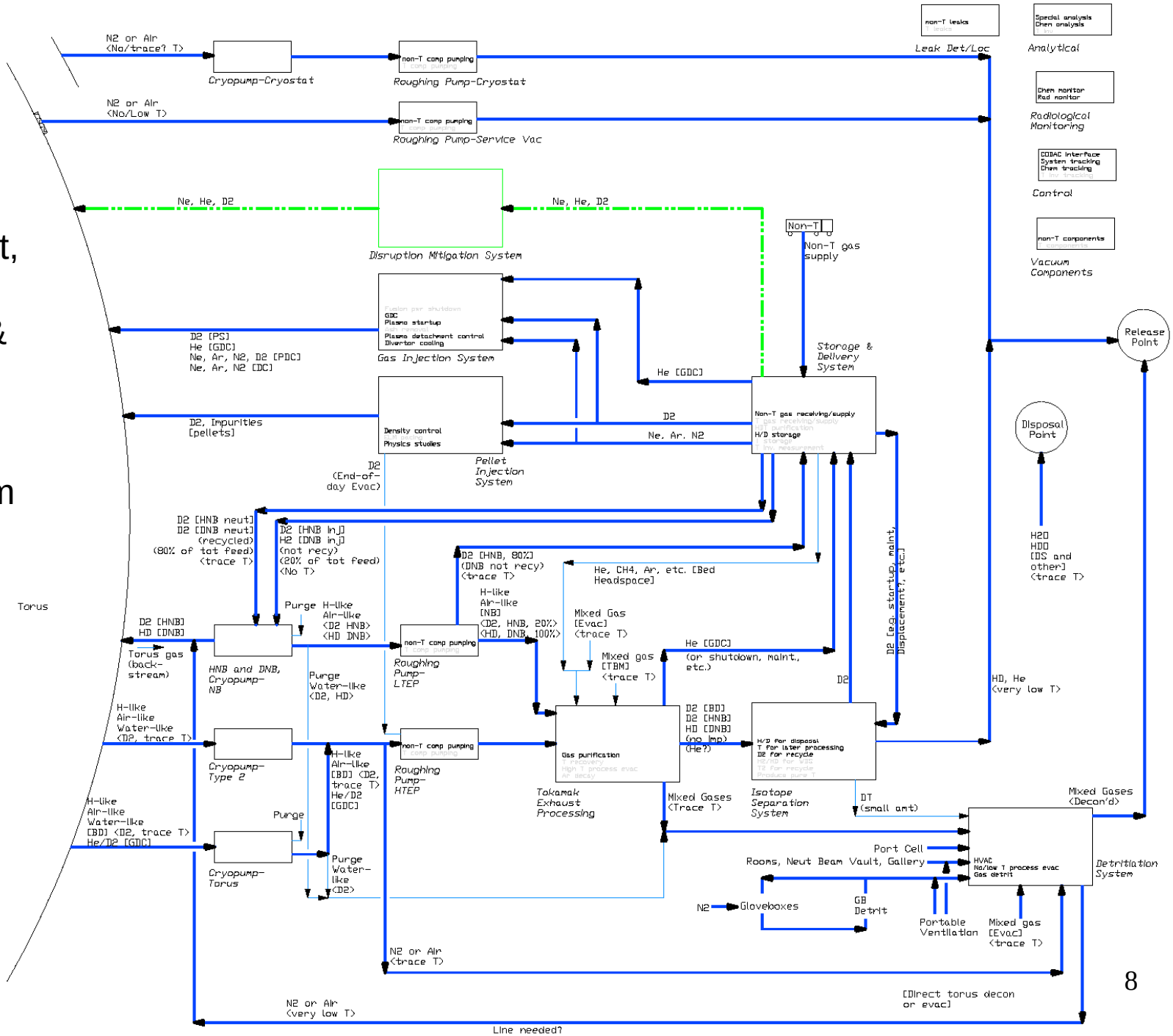
HH

- HVAC
- Some systems already in final configuration (e.g. cryopumps)
- Hydrogen recycle?



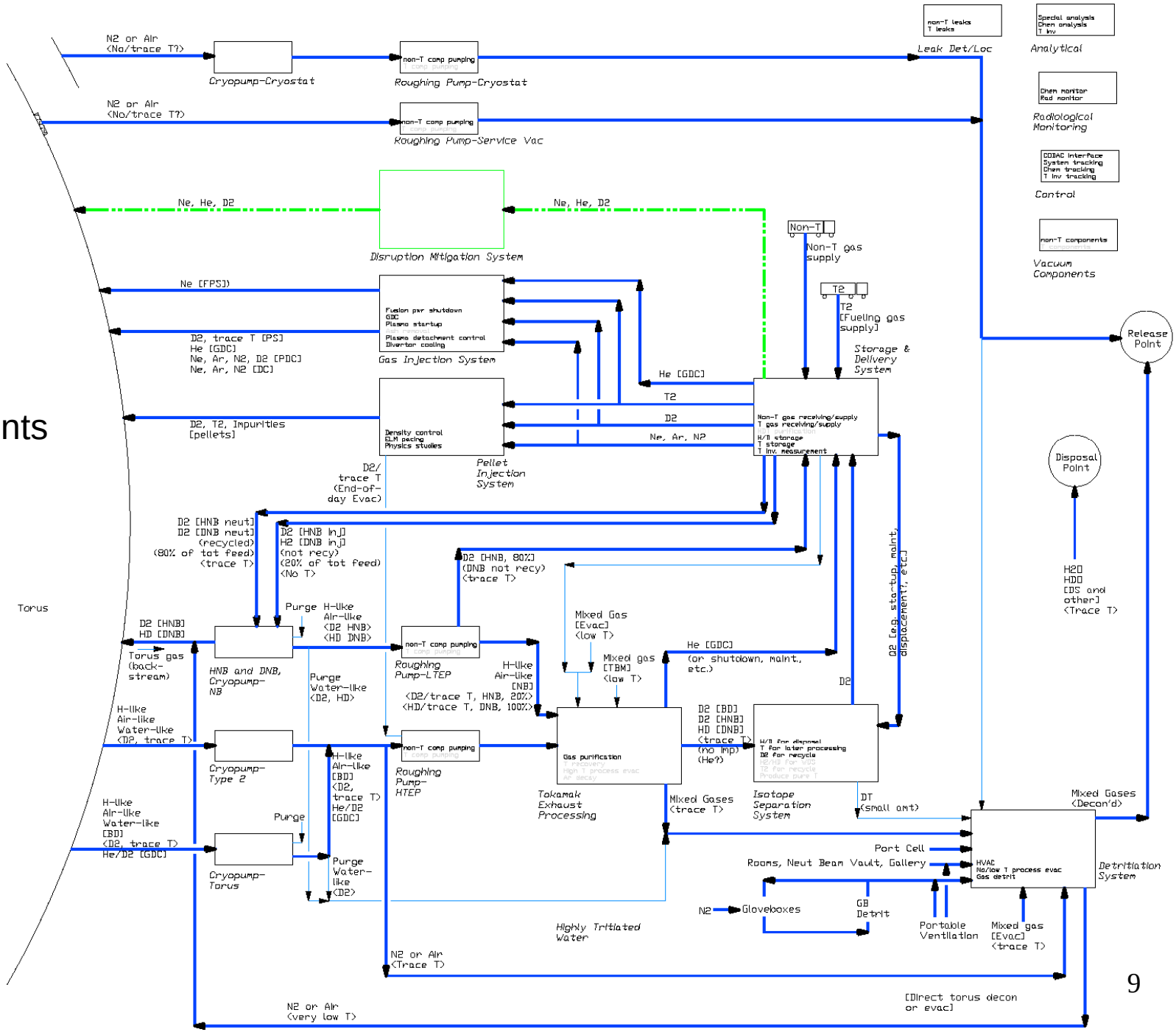
DD

- Confinement, Radiological Monitoring & detritiation
- Tritium removal from D_2



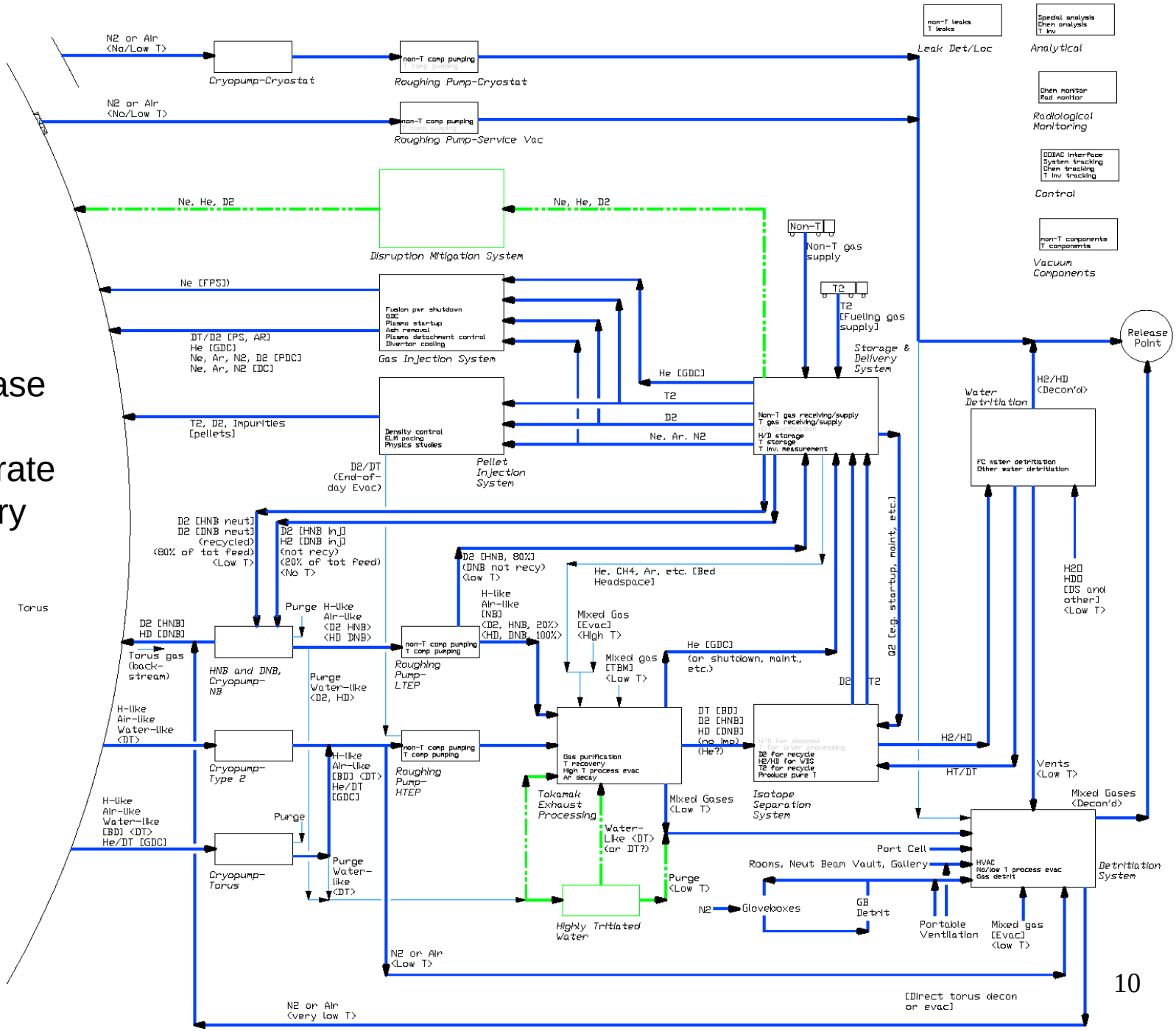
Trace T

- External T supply
- T inventory measurements



DT

- Full tritium capability
- Major increase in tritium processing rate and inventory



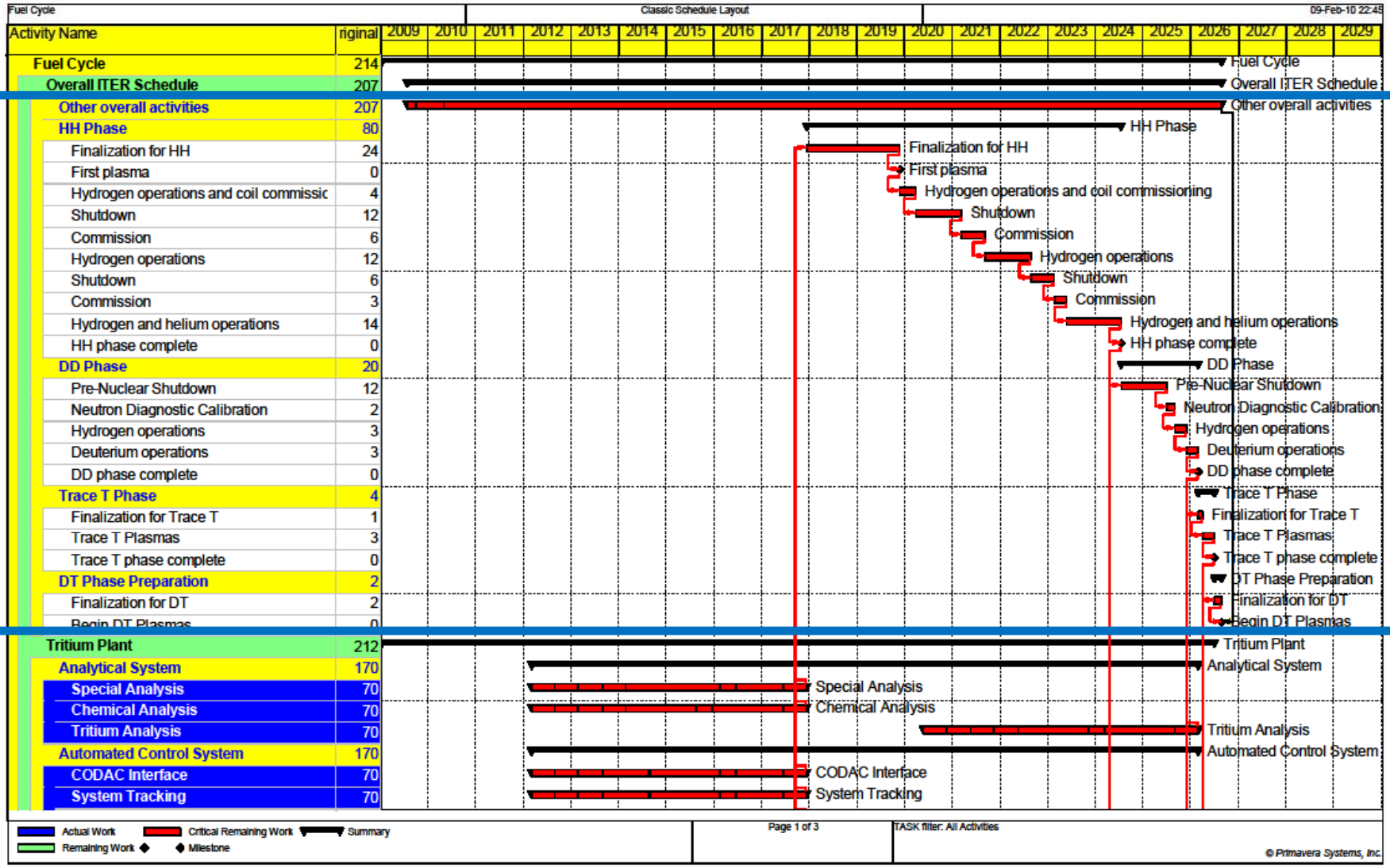
Key considerations on pathways to DT

- Fuel Cycle systems available in time to meet ITER requirements
- Increasing nuclear function
- Consider non-tritium/tritium compatibility needs (value engineering)
- No tritium operation prior to “pre-nuclear shutdown”
- Staged installation facilitates testing, integration, commissioning, training and debugging

FC “Scenario 1” Outline Schedule Development

- Start with ITER-wide schedule elements (e.g. first plasma and pre-nuclear shutdown)
- Include a “finalization period” prior to each ITER phase
  - Period for integration, debugging, commissioning and training
- Estimate the time needed to define, design, construct and install each system
  - Durations in this presentation are very rough estimates
  - Assumed that tasks start as late as reasonably practical
- At present, this is very much a “work in progress”

Fuel Cycle Scenario 1 Outline Schedule – Overall ITER schedule


Fuel Cycle
Classic Schedule Layout
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Activity Name
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2029
Fuel Cycle 214
Overall ITER Schedule 207
Other overall activities 207
HH Phase 80
Finalization for HH 24
First plasma 0
Hydrogen operations and coil commissic 4
Shutdown 12
Commission 6
Hydrogen operations 12
Shutdown 6
Commission 3
Hydrogen and helium operations 14
HH phase complete 0
DD Phase 20
Pre-Nuclear Shutdown 12
Neutron Diagnostic Calibration 2
Hydrogen operations 3
Deuterium operations 3
DD phase complete 0
Trace T Phase 4
Finalization for Trace T 1
Trace T Plasmas 3
Trace T phase complete 0
DT Phase Preparation 2
Finalization for DT 2
Begin DT Plasmas 0
Tritium Plant 212
Analytical System 170
Special Analysis 70
Chemical Analysis 70
Tritium Analysis 70
Automated Control System 170
CODAC Interface 70
System Tracking 70
Fuel Cycle
Overall ITER Schedule
Other overall activities
HH Phase
Finalization for HH
First plasma
Hydrogen operations and coil commissioning
Shutdown
Commission
Hydrogen operations
Shutdown
Commission
Hydrogen and helium operations
HH phase complete
DD Phase
Pre-Nuclear Shutdown
Neutron Diagnostic Calibration
Hydrogen operations
Deuterium operations
DD phase complete
Trace T Phase
Finalization for Trace T
Trace T Plasmas
Trace T phase complete
DT Phase Preparation
Finalization for DT
Begin DT Plasmas
Tritium Plant
Analytical System
Special Analysis
Chemical Analysis
Tritium Analysis
Automated Control System
CODAC Interface
System Tracking
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
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TASK filter: All Activities
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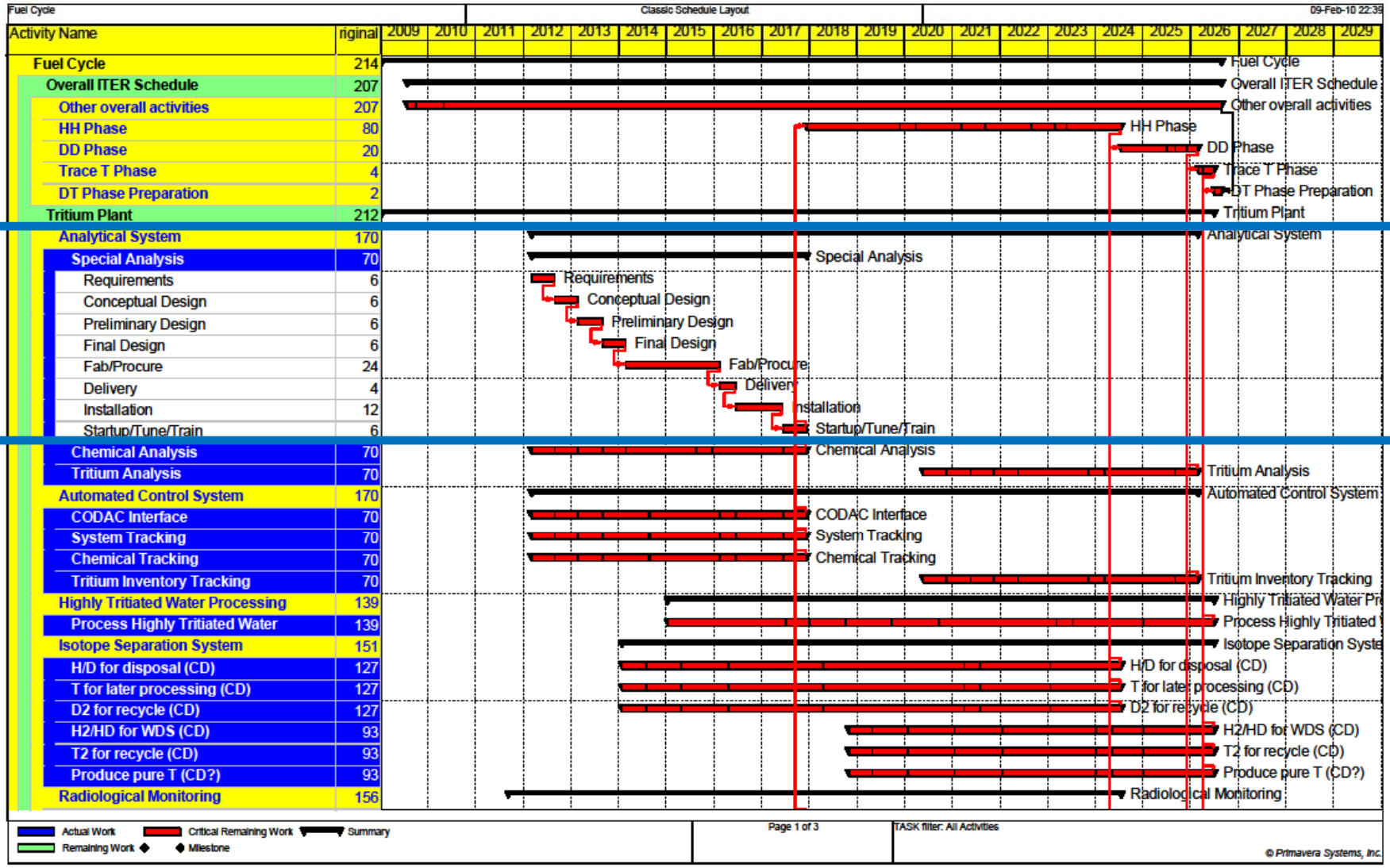
Fuel Cycle Scenario 1 Outline Schedule – Generic detail for each fuel cycle element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Classic Schedule Layout
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Fuel Cycle 214
Overall ITER Schedule 207
Other overall activities 207
HH Phase 80
DD Phase 20
Trace T Phase 4
DT Phase Preparation 2
Tritium Plant 212
Analytical System 170
Special Analysis 70
Requirements 6
Conceptual Design 6
Preliminary Design 6
Final Design 6
Fab/Procure 24
Delivery 4
Installation 12
Startup/Tune/Train 6
Chemical Analysis 70
Tritium Analysis 70
Automated Control System 170
CODAC Interface 70
System Tracking 70
Chemical Tracking 70
Tritium Inventory Tracking 70
Highly Tritiated Water Processing 139
Process Highly Tritiated Water 139
Isotope Separation System 151
H/D for disposal (CD) 127
T for later processing (CD) 127
D2 for recycle (CD) 127
H2/HD for WDS (CD) 93
T2 for recycle (CD) 93
Produce pure T (CD?) 93
Radiological Monitoring 156
Fuel Cycle
Overall ITER Schedule
Other overall activities
HH Phase
DD Phase
Trace T Phase
DT Phase Preparation
Tritium Plant
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Special Analysis
Requirements
Conceptual Design
Preliminary Design
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Delivery
Installation
Startup/Tune/Train
Chemical Analysis
Tritium Analysis
Automated Control System
CODAC Interface
System Tracking
Chemical Tracking
Tritium Inventory Tracking
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Radiological Monitoring
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
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TASK filter: All Activities
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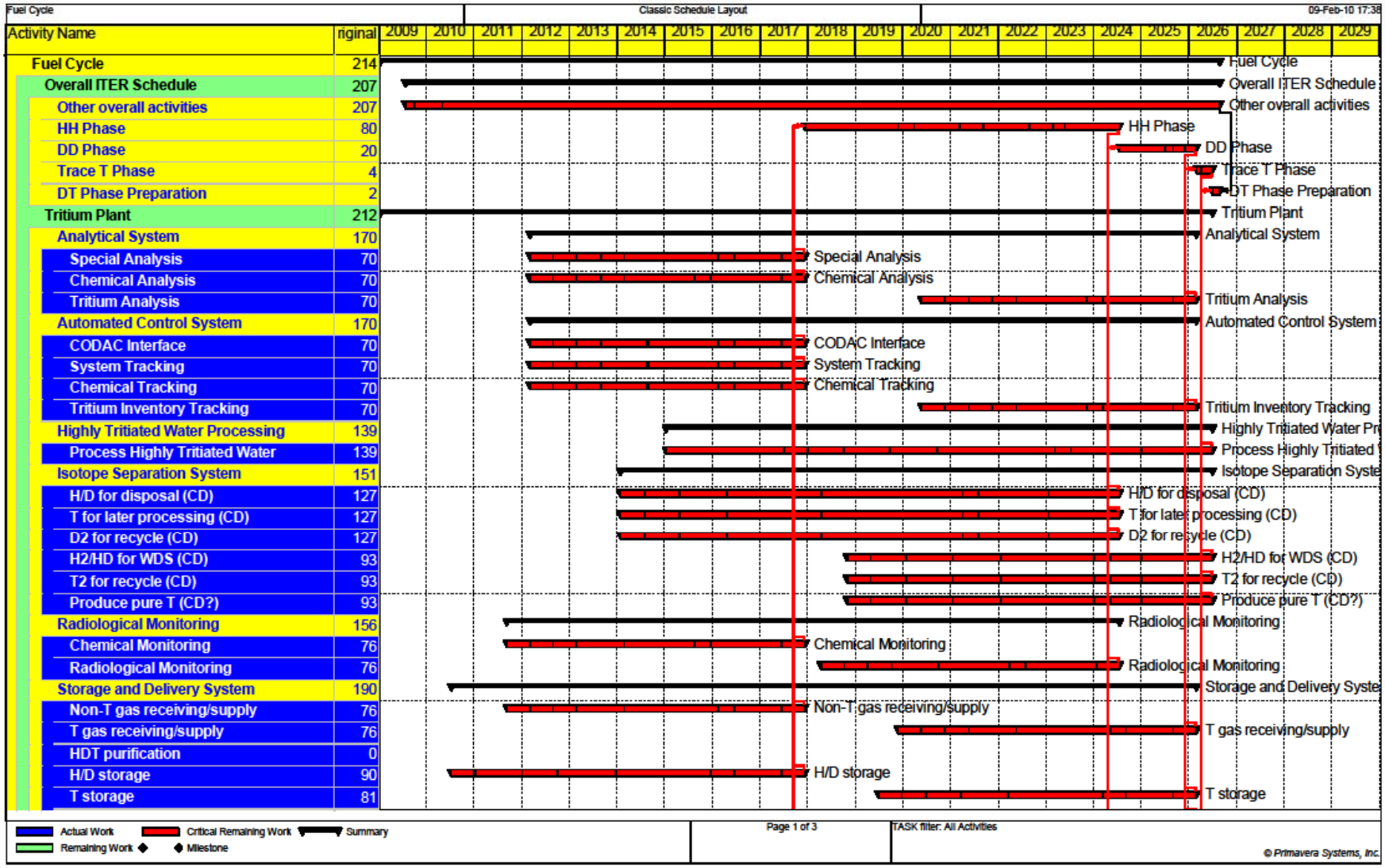
Fuel Cycle Scenario 1 Outline Schedule – Fuel cycle overview


Fuel Cycle
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D2 for recycle (CD) 127
H2/HD for WDS (CD) 93
T2 for recycle (CD) 93
Produce pure T (CD?) 93
Radiological Monitoring 156
Chemical Monitoring 76
Radiological Monitoring 76
Storage and Delivery System 190
Non-T gas receiving/supply 76
T gas receiving/supply 76
HDT purification 0
H/D storage 90
T storage 81
Actual Work
Remaining Work
Critical Remaining Work
Summary
Milestone
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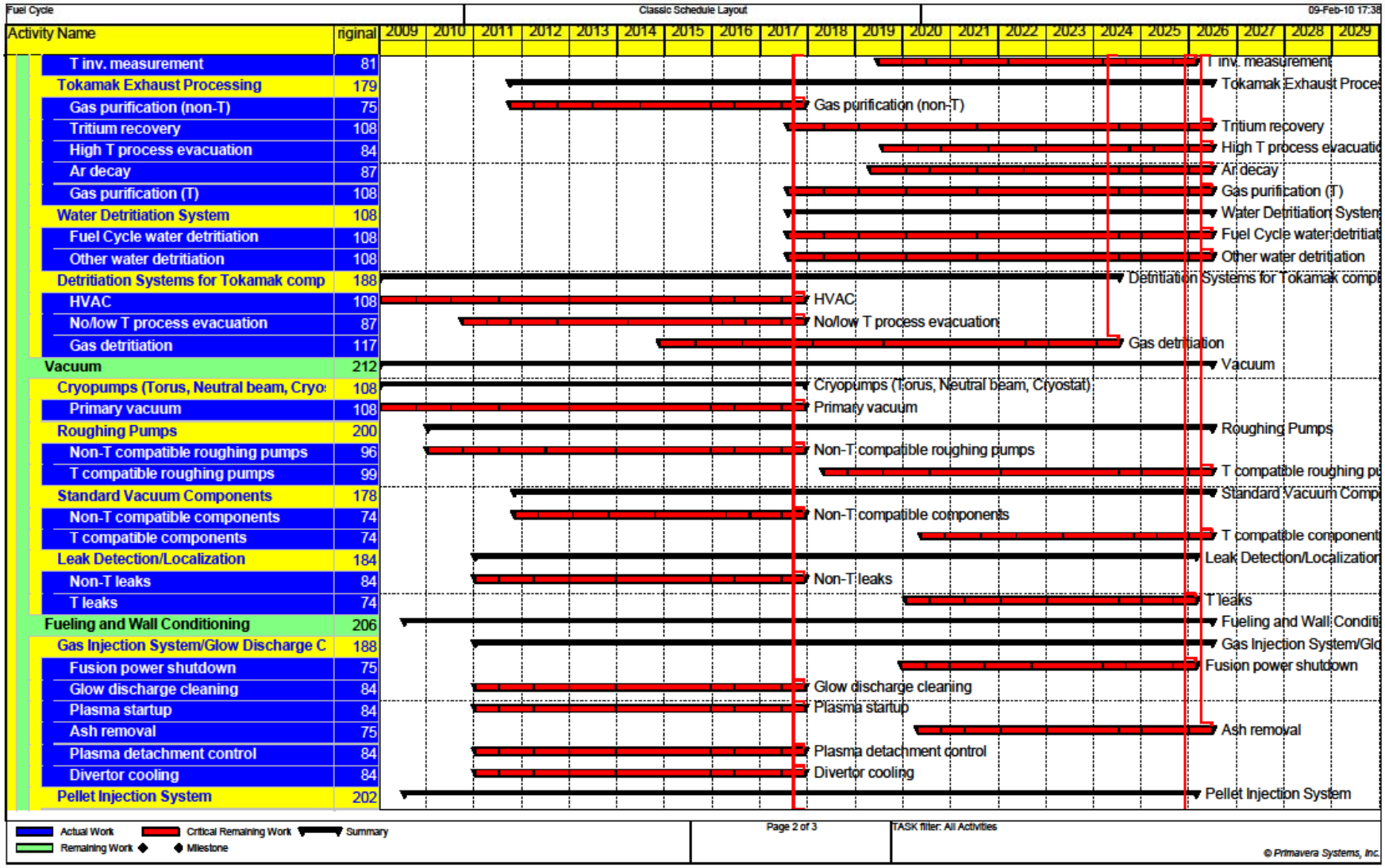
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T inv. measurement 81
Tokamak Exhaust Processing 179
Gas purification (non-T) 75
Tritium recovery 108
High T process evacuation 84
Ar decay 87
Gas purification (T) 108
Water Detritiation System 108
Fuel Cycle water detritiation 108
Other water detritiation 108
Detritiation Systems for Tokamak comp 188
HVAC 108
No/low T process evacuation 87
Gas detritiation 117
Vacuum 212
Cryopumps (Torus, Neutral beam, Cryo 108
Primary vacuum 108
Roughing Pumps 200
Non-T compatible roughing pumps 96
T compatible roughing pumps 99
Standard Vacuum Components 178
Non-T compatible components 74
T compatible components 74
Leak Detection/Localization 184
Non-T leaks 84
T leaks 74
Fueling and Wall Conditioning 206
Gas Injection System/Glow Discharge C 188
Fusion power shutdown 75
Glow discharge cleaning 84
Plasma startup 84
Ash removal 75
Plasma detachment control 84
Divertor cooling 84
Pellet Injection System 202
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Ar decay
Gas purification (T)
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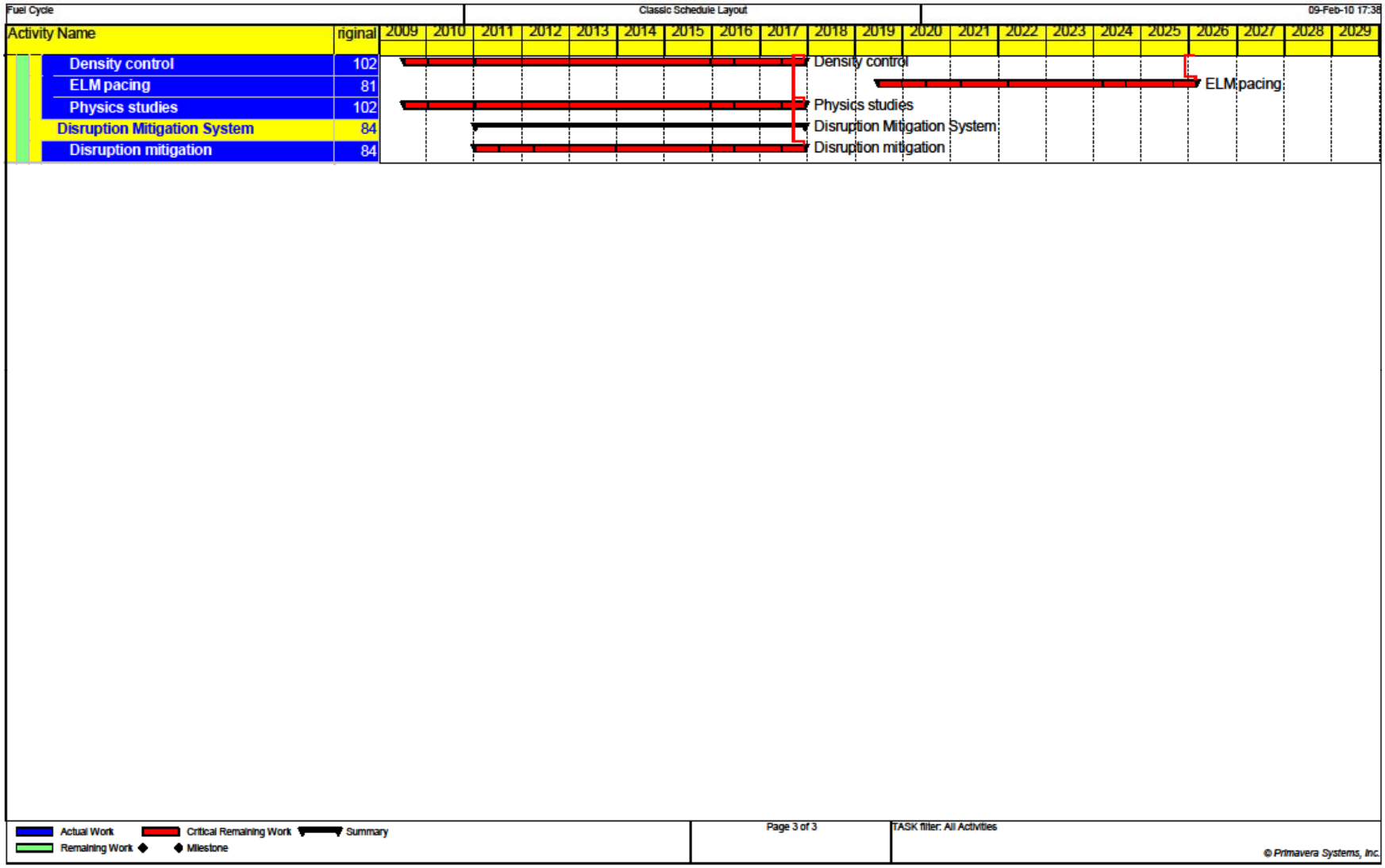
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Density control
102
ELM pacing
81
Physics studies
102
Disruption Mitigation System
84
Disruption mitigation
84
Density control
ELM pacing
Physics studies
Disruption Mitigation System
Disruption mitigation
Actual Work
Remaining Work
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Summary

- Scenario 1 has significant impacts on the overall ITER schedule
- The impacts of this on the ITER Fuel Cycle are being evaluated
  - Draft drawings, spreadsheet and schedules have established a high-level framework for evaluating impacts
  - These documents will form the basis for upcoming meetings and discussions. Results will be used to revise these documents.
  - Ultimately this exercise will help guide revisions to current ITER documents