



# NorthStar Progress Towards Domestic Mo99 Production

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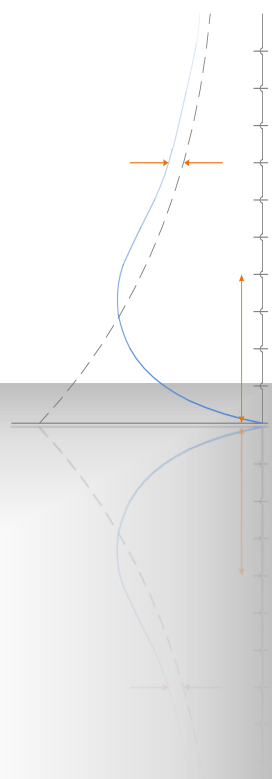
**Mo-99 2015 TOPICAL MEETING ON  
MOLYBDENUM-99 TECHNOLOGICAL DEVELOPMENT**

**August 31-September 3, 2015**

**Boston, MA**

# Topics

- Production Pathways Summary
- Status Update
  - ✓ Neutron Capture Readiness
  - ✓ RadioGenix™ FDA status
- Summary & Discussion

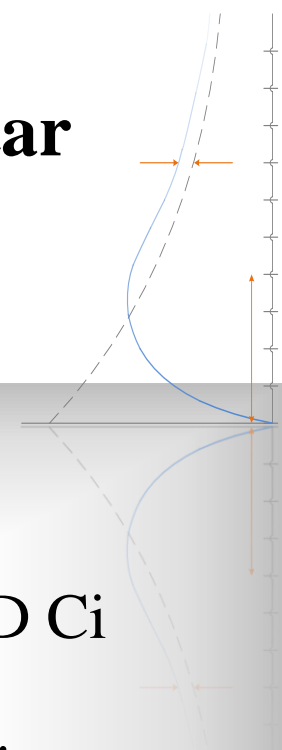


# Mo99 Production Pathways at NorthStar

- **Near Term Solution – Neutron Capture**
  - Missouri University Research Reactor
    - ✓ Neutron capture using either natural or enriched Mo targets
- **Long Term Solution – Photon Capture**
  - NorthStar's LINAC methodology for the production of Molybdenum-99
- It is expected that this solution will eventually be able to produce 50+% of the US requirement
- Once up and running both solutions will be used to supply not only the US market but also ROW.
  - *These two approaches require NorthStar's RadioGenix™ technology in order to guarantee success*

# Background on Mo99 Production at NorthStar Neutron Capture

- NorthStar has been active in this option since 2009
  - MURR originally produced Mo99 with nat-Mo
- NorthStar/MURR capable of producing up to 3,000+ 6D Ci per week
  - One target set per week (100 6D Ci – 3,000+ 6D Ci Mo99; nat or enriched Mo dependent) processed,
  - Steady weekly production
  - Dedicated shipping to client pharmacies
  - Ground return of spent Mo99 solutions/source vessels for recovery and recycle

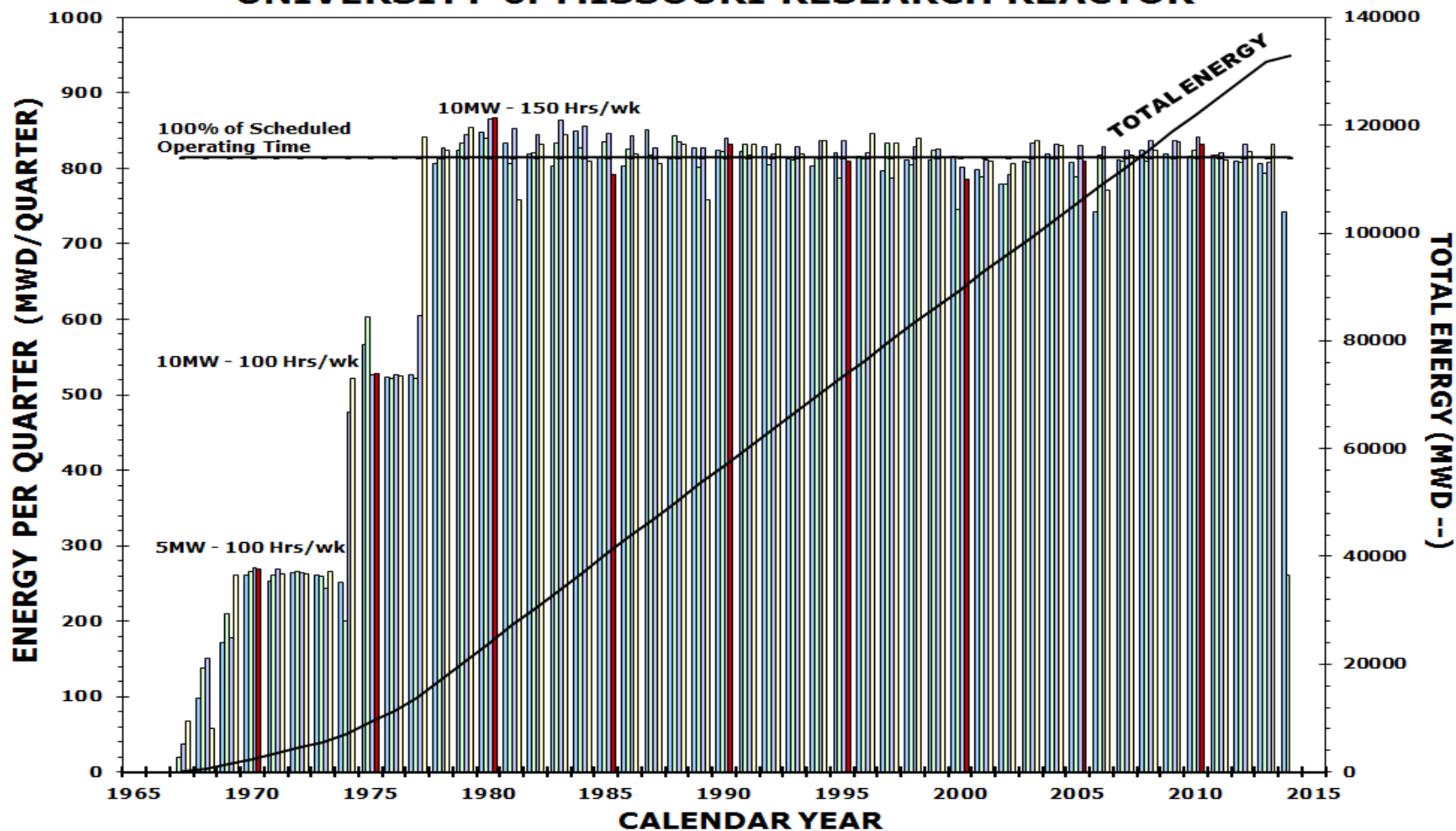


# Background on Mo99 Production at NorthStar Neutron Capture

- MURR has outstanding operational record,
- MURR/NorthStar production agreement announced March 1<sup>st</sup>, 2011
  - Batch size scale-up under review
- Production upon FDA approval,
- Supported by NNSA Cooperative Agreement, and
- No licensing issues.

# Background on Mo99 Production at NorthStar Neutron Capture

## OPERATING EXPERIENCE UNIVERSITY of MISSOURI RESEARCH REACTOR



# Status Update

## Neutron Capture

- MURR has filed the scale-up DMF with the FDA on July 2, 2013
  - Original DMF filed in September 2012
- NorthStar in process of completing setup of the Mo99 dispensing line at MURR
  - Physical install complete
  - Validation hot runs scheduled for completion 3QTR15
  - Dispensing Line (covered under drug substance section of Amendment to NDA) submitted as part of Final Amendment to NDA 4QTR15
  - Inspection ready 4QTR15
- Certification of NorthStar's Type A shipping system completed in 4QTR13

## ***NorthStar Successful Integrated Production Run***

- Announced May 5, 2015 that we successfully completed a full scale production run of 100 6D Ci that included:
  - Target preparation
  - Target irradiation
  - Mo99 extraction/preparation
  - Transfer to dispensing line
  - Fill NorthStar Type A shipping vessels
  - Ship overnight with receipt at facility within 8 hours

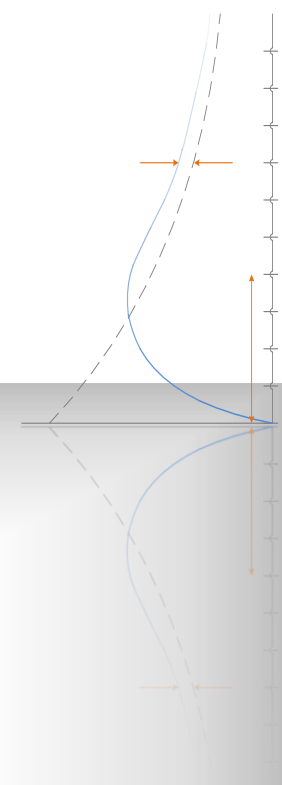
***Mount and run RGX successfully to produce Tc99m***

***Successfully compounded several molecules***

***All microbiology and sterility data favorable***

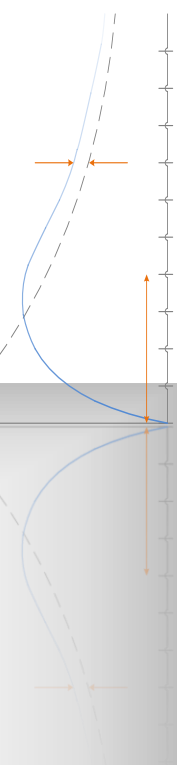
***Successful completion and validation critical to FDA approval***

***Has been repeated numerous times since***

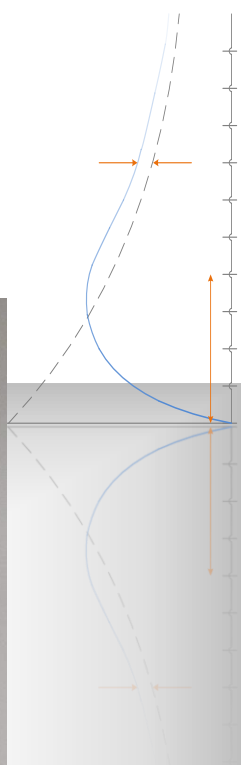




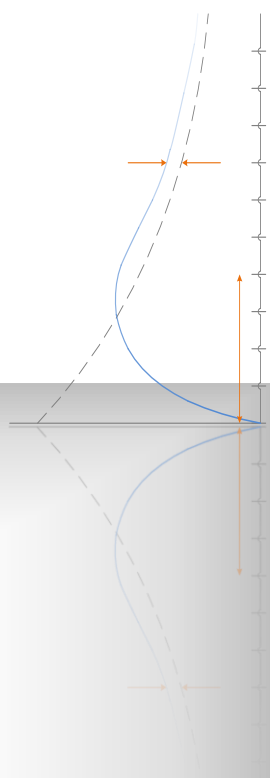
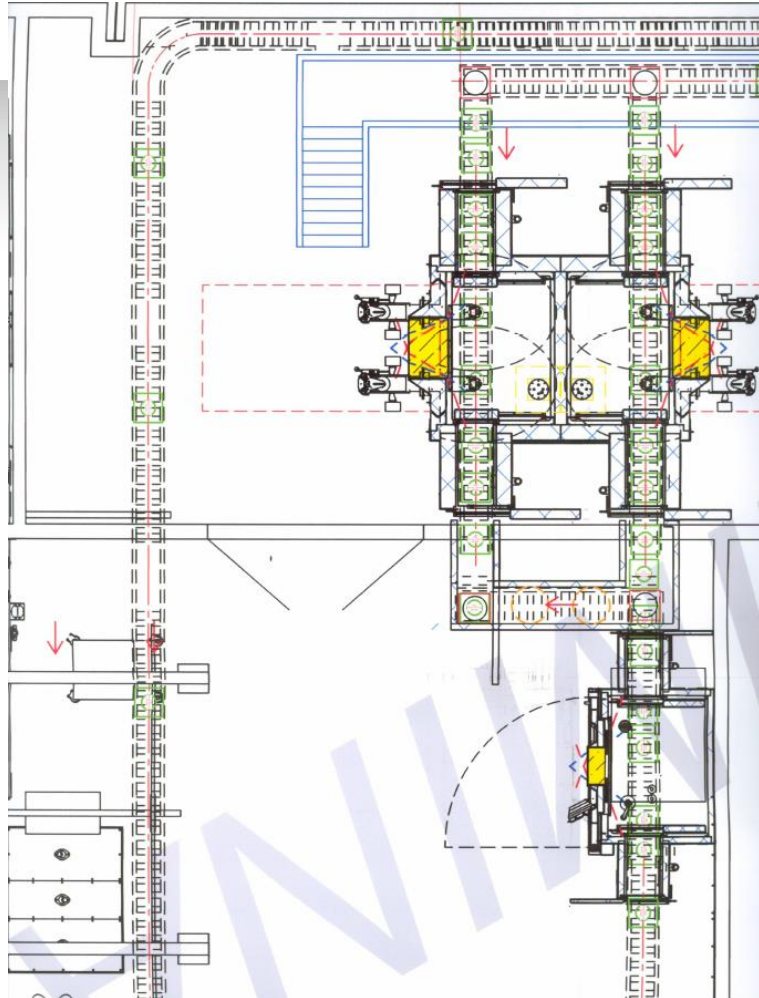
# Status Update Neutron Capture



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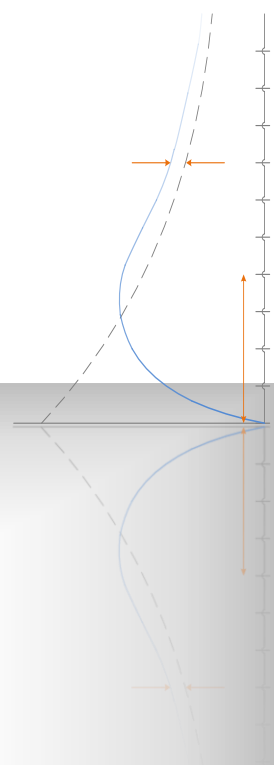


## *MURR NorthStar Dispensing Line #2*

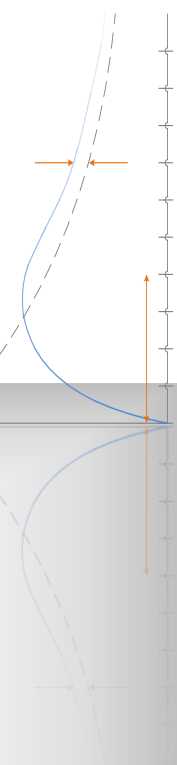
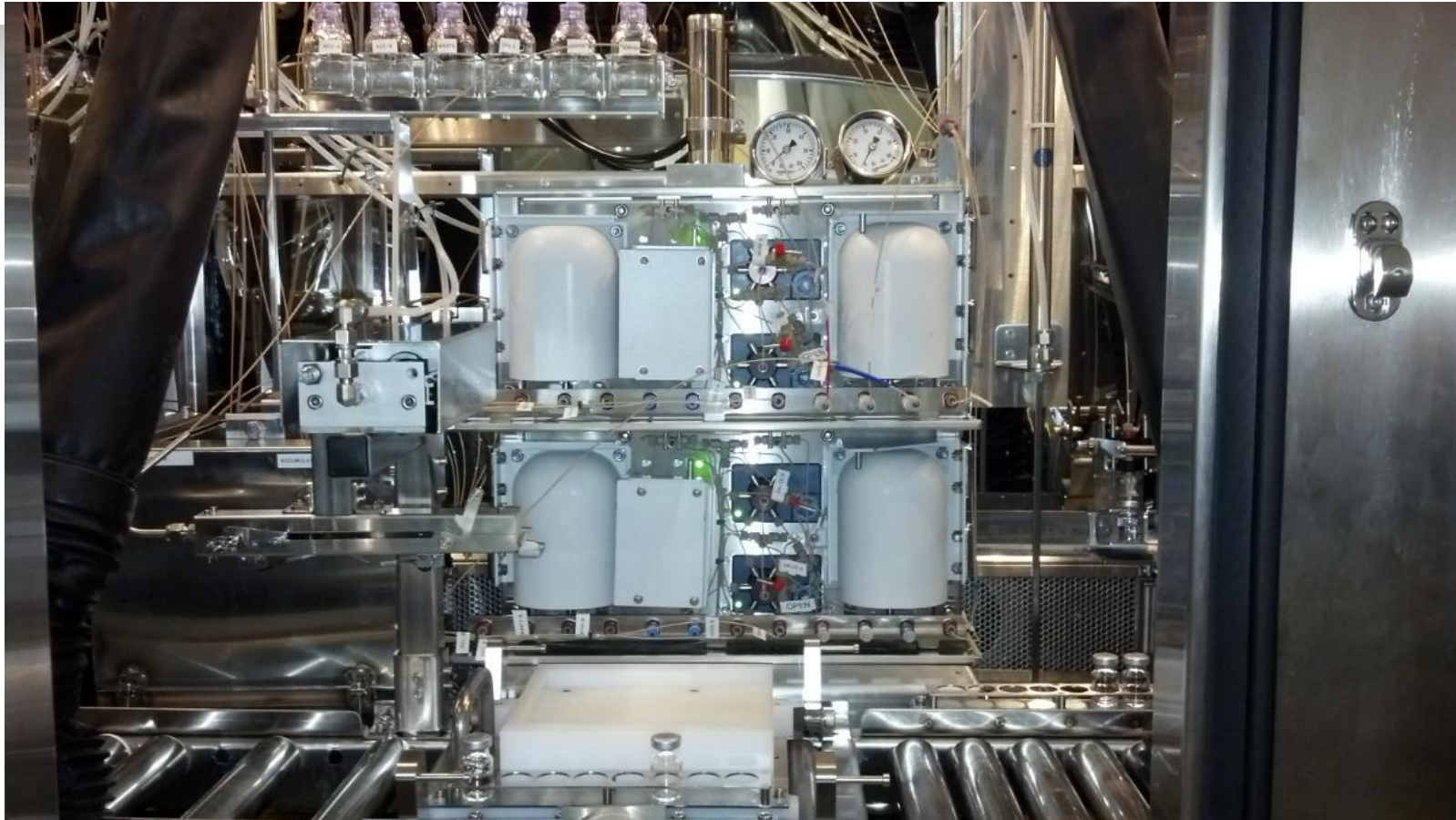




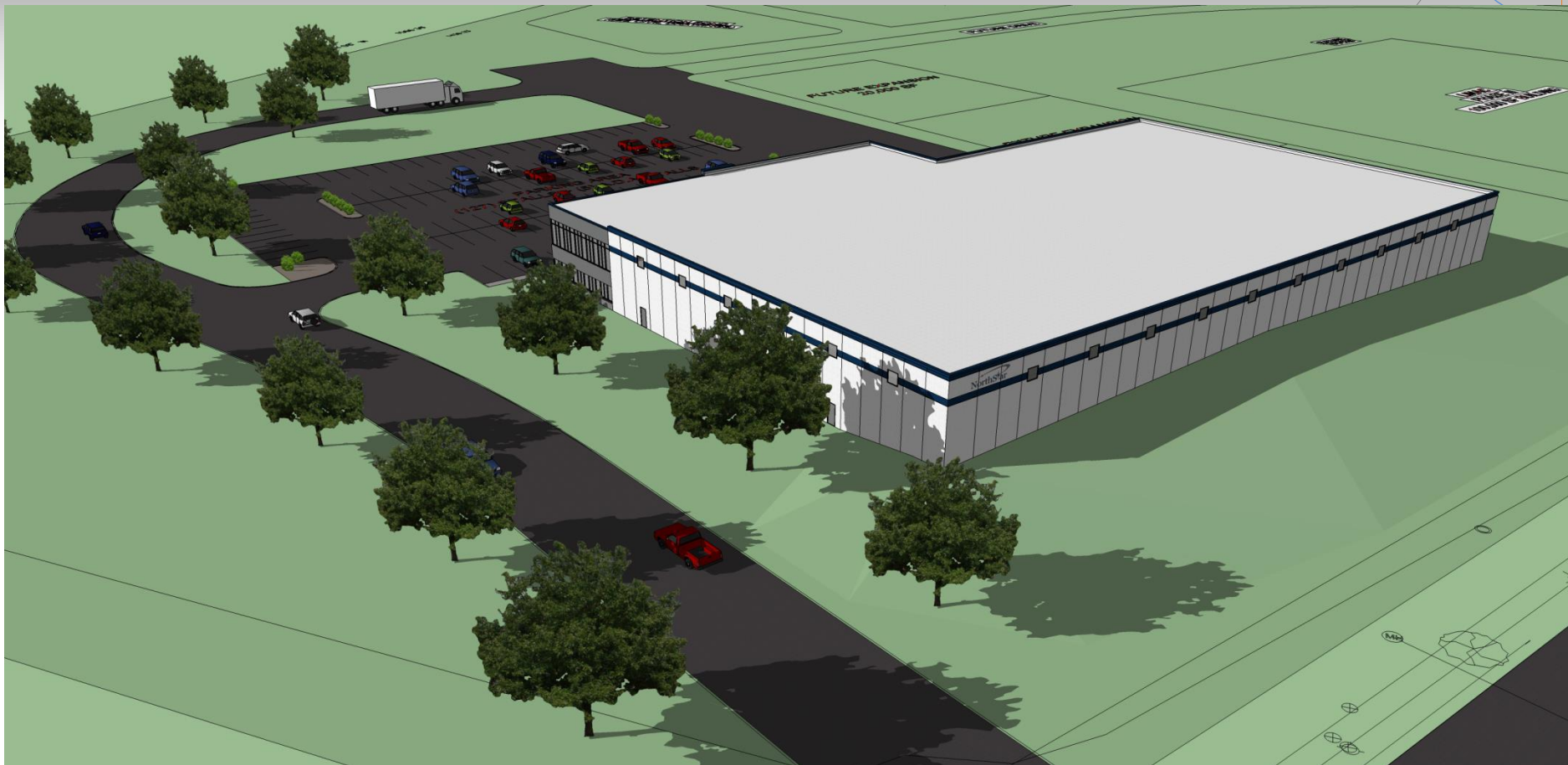
# Status Update Neutron Capture



# Status Update Neutron Capture



# Status Update Beloit Facility

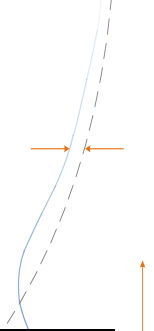




## New NorthStar Facility Occupancy May 2015



# New NorthStar Facility

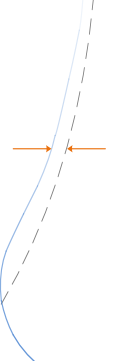




# New NorthStar Facility

- Additional 32,000 square foot facility was approved by the NorthStar Board of Managers this past Thursday, August 27<sup>th</sup>, 2015
- Financing for this addition has been approved!

# *RadioGenix™*



# *RadioGenix*<sup>TM</sup> FDA Timeline

- October 2010 NorthStar met with the FDA to outline a path to NDA submission
- MURR submitted DMF for production via neutron capture in September 2012
- NorthStar submitted *RadioGenix*<sup>TM</sup> (TechneGen) DMF in October 2012
- January 2013 NorthStar submitted its NDA
- NorthStar received its Complete Response letter from the FDA on November 4, 2013 outlining deficiencies primarily in two areas
  - Microbiological Control
  - User Manuals
- NorthStar met with the FDA on February 27, 2014 to gain clarity on the CR letter
  - NorthStar has submitted to FDA its revised Microbiological Test Plan (MTP) for comment;
  - Added ozone sterilization to the system and made other enhancements.
  - Met with the FDA July 2, 2014 to MTP; “.....appears to be a reasonable approach to addressing many of the microbiology concerns raised during the NDA review cycle.”  
“Very impressive!” “Congratulations!”
- Meeting with FDA on June 16<sup>th</sup> 2015 covering latest HFE results
- NorthStar now generating data to support Amendment to the NDA; to be submitted 4QTR15

# Summary

- All operations supporting NorthStar to be inspection ready by 4QTR15
- Neutron capture production upon FDA approval of NorthStar's NDA for the generating system
  - 100 6D Ci/wk at introduction w/high purity nat-Mo targets
  - Ramp to 750 6D Ci/wk within 6 months of start
  - Transition to eMo98 targets in 2016
    - ❖ Additional DMF and Supplement to NDA required
  - Production capability goal of up to 3,000 6D Ci by 4QTR16
- NorthStar will shortly announce a relationship with another irradiator who will provide production capability to provide production redundancy and outage reserve capacity (ORC)

# Summary

- Facility construction (Phase 1; 50,000 sqft) completed
  - Building to support initial ISO 8 manufacturing and administrative needs
  - Phase 2 (35,000 sqft) approved and completion is expected in 2QTR16
- RadioGenix FDA Amendment underway
  - Addresses concerns FDA raised in Complete Response Letter
  - To be submitted in 4Q2015 with approval and production to begin in the first half of 2016



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