INL/MIS-24-77307-Revision-0

MSTEC: Molten Salt Thermophysical Examination Capability

April 2024

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Idaho National Laboratory

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NRIC National Reactor Innovation Center

MSTEC

Molten Salt Thermophysical Examination Capability

Toni Karlsson (PI/TPOC), Carson Stronks and Steve Warmann (PM's)

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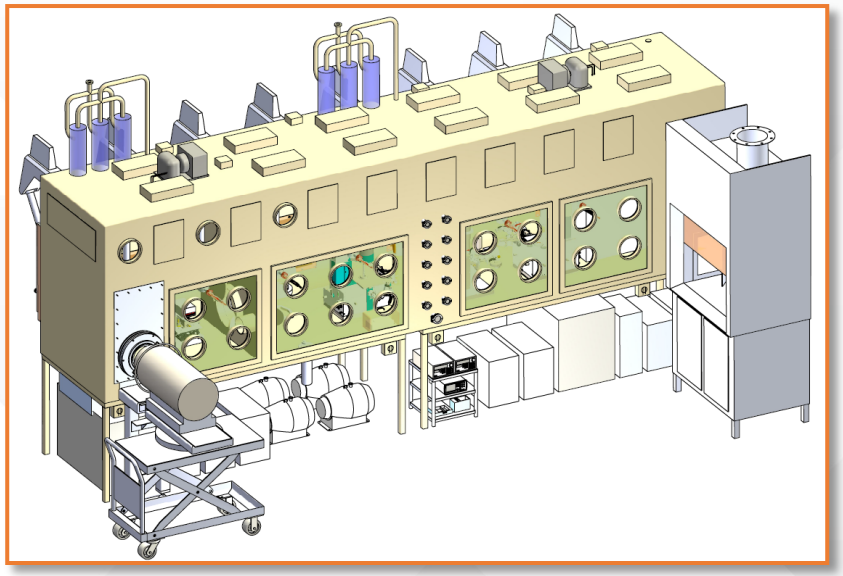
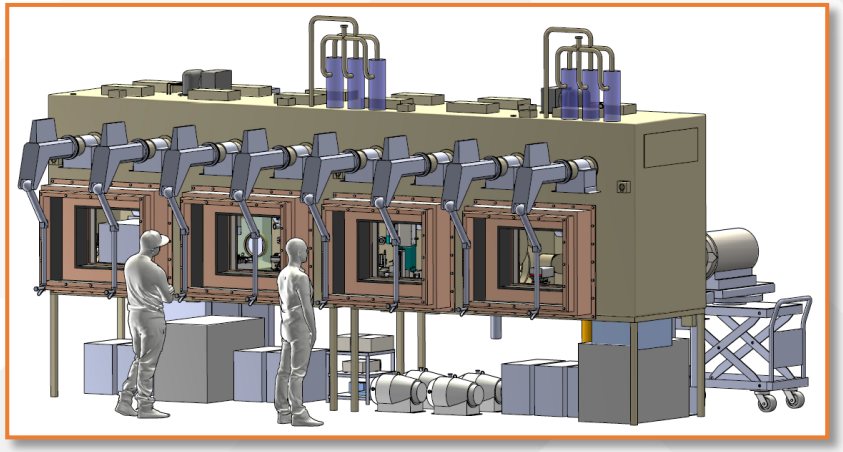
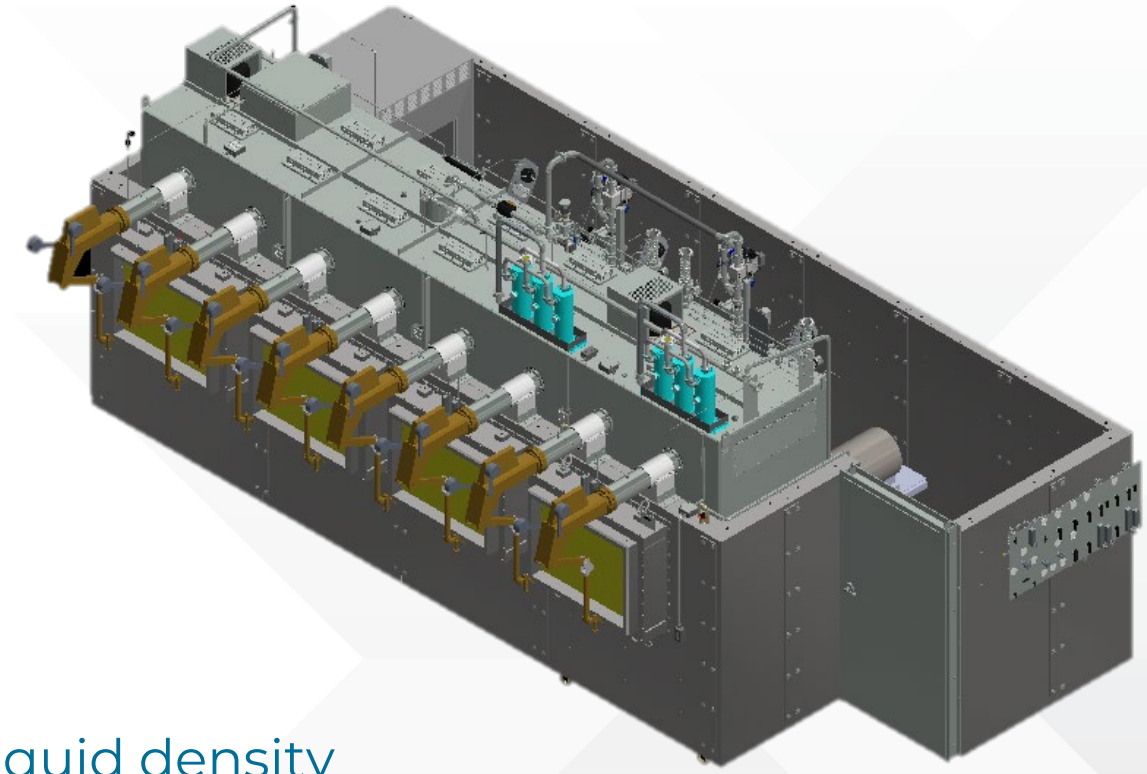
Overview

- Technical Description – a shielded modular hotcell with an inert argon atmosphere, housing characterization equipment for determining thermophysical and thermochemical properties of high temperature liquids not limited to but focusing on irradiated fuel salts
- Location – MFC, FCF, rm 35
- Compatible Materials:
  - Chloride, fluoride salts
  - Fresh fuel salts and irradiated fuel salts
  - Pyrophoric material - U, Pu metal
  - Gases – H_2, HCl, Cl_2, HF, F_2, NF_3
  - Beryllium containing salts
  - Many others





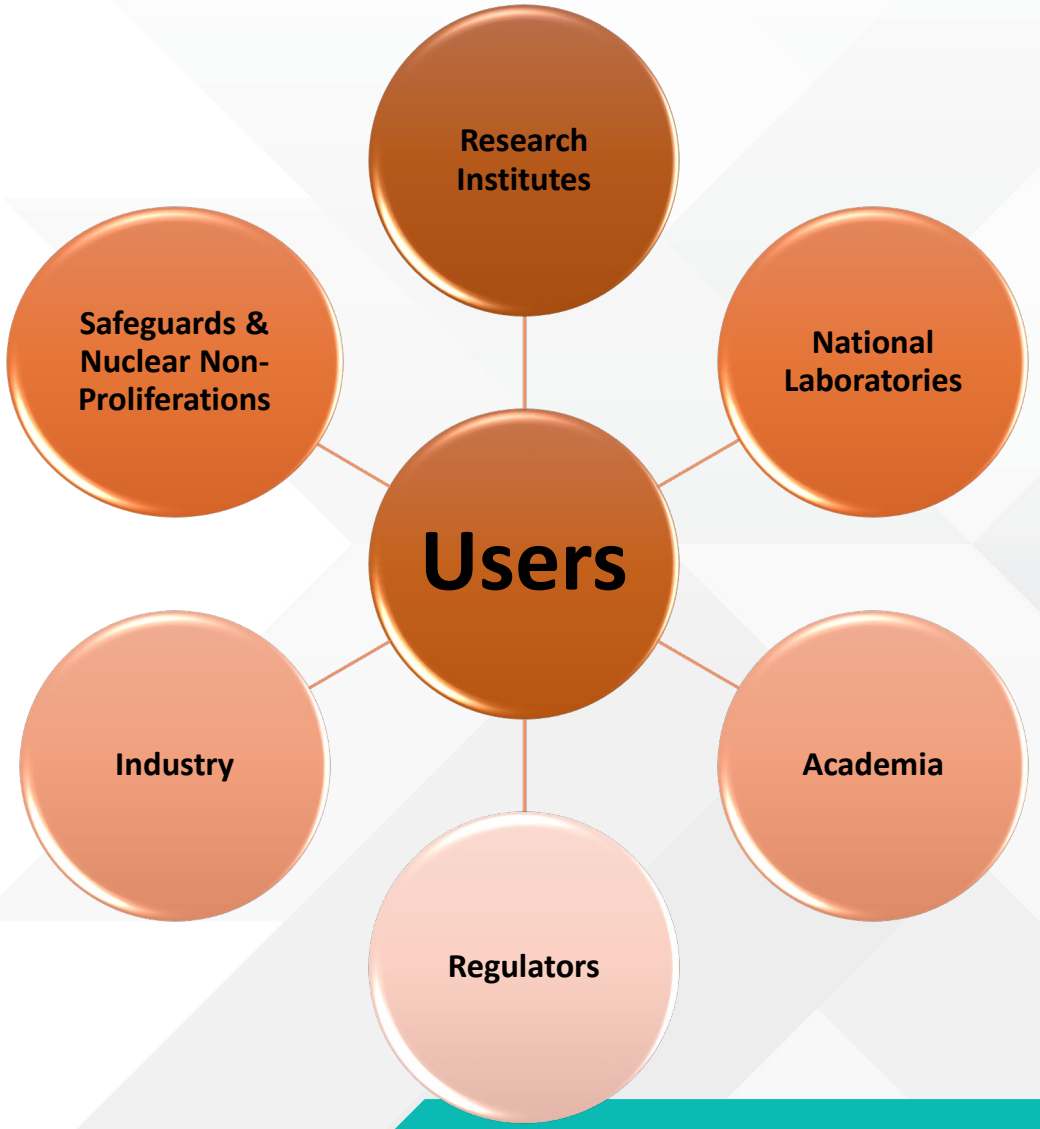
Overview



- Modular hot cell
  - Shielded on one side
  - Glove ports on the other side
- Instrumentation (≥ 1000°C)
  - Rheometer – viscosity
  - Densitometer/pycnometer – solid and liquid density
  - STA – invariant and transition temps, weight loss
  - DSC – specific heat capacity
  - Well furnace – corrosion, salt synthesis, electrochemistry
  - Versatile experimental space

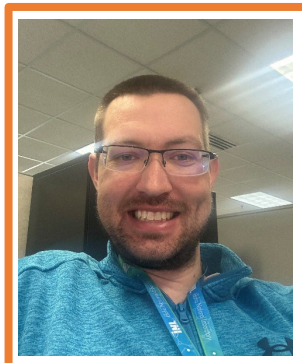
Overview

- Purpose/objective – Provide users with characterization equipment, infrastructure, and technical staff necessary to produce critical data needed to design, demonstrate, license, and operate an MSR.
  - Provide reliable data sets on properties including viscosity, density, heat capacity, thermal conductivity, melt temperature, vapor pressure, redox chemistry, and salt purification methods
  - Offers versatile space for users to setup one-of-a-kind experiments and to perform small-scale exotic salt fabrication



MSTEC Project Overview

Core INL Team Members



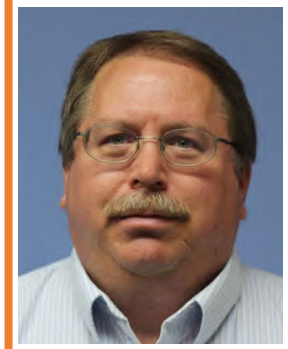
Carson Stronks
Lead PM

Stephen Warmann
PM

Toni Karlsson
Lead Scientist

Adam Butikofer
Lead Design Eng.

Dale Whalquist
Design Eng.



Mark Borland
Glovebox SME

Evan Lovel
Lead Electrical Eng.

Barbara Houck
Lead Nuc. Safety

Numerous other individuals contribute to the success of MSTEC

Subcontracts

- Applied Engineering Services – Engineering support design, construction, ventilation
- DR & Sons Construction – Phase II MSTEC Installation
- Extract Technologies (Walker Barrier) – Glovebox and shielding (complete)
- Wälischmiller Engineering GMBH – Manipulators (complete)
- Amentum – Nuclear safety (complete)
- C&H Construction – Phase I Construction - D&D and Facility Modifications (complete)

Milestones for FY24

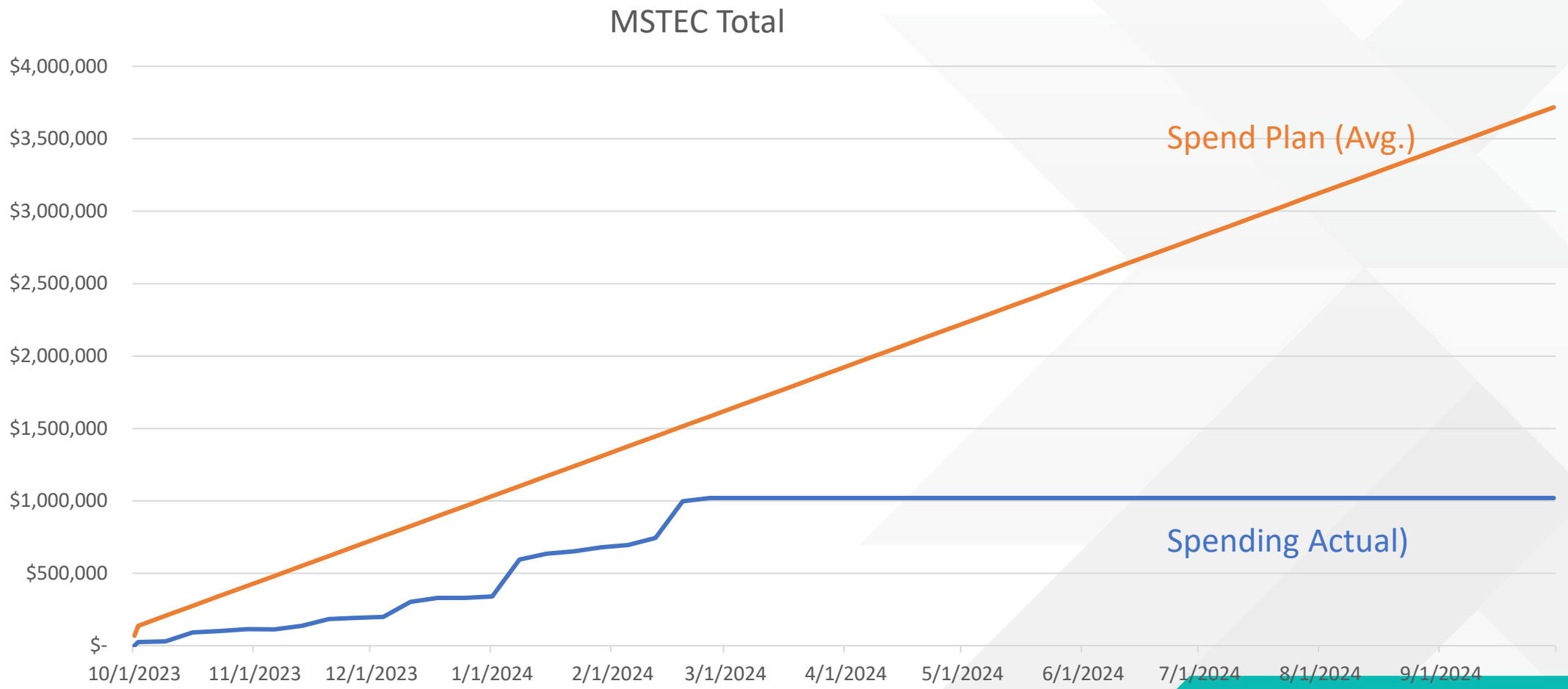
- M2, Milestone memo documenting in person support of the factory acceptance test in Wisconsin, 03/01/2024 (complete)
- M2, Milestone memo documenting beginning of instrument installation, 09/30/2024 (on schedule)
- M2, Milestone memo documenting initiation of acceptance testing of the newly installed MSTEC at FCF, 09/30/2024 (on schedule)

Funding Summary

- All major equipment procurements complete, except final milestone payment of shielded cell itself
  - $49k increase due to steel prices, accounted for in contingency
  - No other major cost increase
- Risks: Unfinished decontamination of room, construction in legacy nuclear facility, Safety Analysis Report (SAR) review pending, Structural upgrades
  - All Mitigated!

Year	Total Funding
2020	$ 1,782,072
2021	$ 3,033,919
2022	$ 3,475,481
2023	$ 2,496,810
2024	$ 3,928,171
2025	$ 900,000
Total	$ 15,616,453

FY24 Spending



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Accomplishments

FY20

- Kickoff, May 1st 2020
- Assembled a team of diverse and uniquely skilled people
- Procured characterization equipment
- Completed the design requirements for MSTEC
- Finished numerous INL engineering documents (source term and shielding calcs, floor loading analyses, south wall removal analysis, ventilation evaluation, installation logistics evaluation, etc.)

FY21

- Instrumentation
  - Integrated feedthroughs (cooling, electrical, gas) in interim glovebox
  - Setup rheometer, TMA, DSC, pycnometer, densitometer
  - Initiated testing equipment in non-rad lab
- Engineering
  - Held several design reviews for MSTEC (>40 people), finalized conceptual design
  - Issued manipulator and hot cell PO's
  - Put out to bid the RFP for construction work for FCF facility mods
- Nuclear Safety
  - Finalized major mod determination
  - Finalized Hazards Evaluation and accident scenarios
  - Reviewed safety design strategy (SDS)

FY22

- Instrumentation
  - Procedure development and demonstration of equipment on non-rad salts
  - Finalized electrical and feed through drawings
  - Finalized modifications needed for hot cell use
  - Developed a Concept of Operations
- Engineering
  - 100% design review with Walker Barrier
  - Engineering design review at INL
  - FAT test for manipulators
  - Decontamination & Initiate D&D of the sodium washroom
- Nuclear Safety
  - Finalize draft revision of SAR-403
  - Submitted and addressed comments from ISRC
  - Drafted DOE-ID submittal letter

Accomplishments

FY23

- Instrumentation
  - Setup and demonstrating well furnace and STA-skimmer
  - Developing MSTEC training and operator qualification plan
  - Writing glovebox and instrumentation operating procedures
- Nuclear Safety
  - SAR submitted to DOE-ID
  - INL Nuclear Safety address comments
  - Awaiting DOE approval of comment resolutions

- Engineering
  - Phase I construction complete in FCF
  - Structural inspections complete confirming no major structural upgrades (major risk mitigation)
  - Removal of south wall
  - Demo work complete
  - Roll-up door installed, outer wall extended, painted, crane removed, Ar lines routed, lighting upgraded
  - Walker Barrier major procurements and fabrication complete
  - Steel shield wall section fabrication, manipulator, and shielded glass fitting complete
  - Phase 2 construction contract for MSTEC installation awarded to DR Sons Construction

Accomplishments

FY24

- **Characterization**
  - Ensured operations of instruments on non-rad standard materials
  - Prepared equipment for transfer to MSTEC
  - Developed training plans and user qualifications
  - Developed operating procedures for glovebox and equipment
- **Engineering**
  - Received glovebox and all auxiliary equipment at INL, 82 tons
  - Repaired Crane
  - Installed MSTEC shielding
  - Installed mezzanine
  - Installed manipulators
- **Nuclear Safety**
  - Continue to work with DOE on SAR/TSR revision

Remaining Activities

- Major activities remaining
  - FY24
    - DOE review/approval of SAR/TSR revision
    - Construction contract, phase II, MSTEC installation
    - Installation of characterization equipment into MSTEC
  - FY25
    - FCF SAR/TSR implementation
    - MSTEC management self assessment
    - MSTEC contractor readiness assessment
    - MSTEC DOE readiness assessment and final commissioning

Securing future MSTEC work

Agreement	Description	Contract Value Related to Thermophysical Properties of MSR Fuel Salts
SPP with Seaborg Technologies of Denmark	5-year agreement to study thermophysical properties of unirradiated molten salt, irradiate molten salt in NRAD core, and measure thermophysical properties of irradiated salt in MSTEC.	$2,500,000
CRADA with Korean Atomic Energy Research Institute	5-year agreement to study thermophysical properties of unirradiated molten salt, irradiate molten salt in NRAD core, and measure thermophysical properties of irradiated salt in MSTEC.	$1,000,000
MCRE ARDP	2-year effort to measure thermophysical properties of unirradiated fuel salt.	~$1,500,000
MRTI Molten Salt Irradiation	3-year LDRD to irradiate molten salt fuel in the NRAD core and subsequent thermophysical property measurements on the irradiated salt. Serves as basis for KAERI and Seaborg irradiations.	$2,000,000
DOE MSR Campaign	Recurring annual scope to study thermophysical properties of plutonium-bearing MSR fuel salts.	$500,000
Safeguard & Nonproliferation Workshop	Meeting to gather the SMEs on molten salts from all DOE labs to discuss MSTEC utilization plans for Safeguarding and proliferation deterrence	$65,000
INL Internal Investment (NSUF)	Indirect funds provided to continue to mature INL scientist capability in measuring thermophysical properties of molten salts.	0.20 FTE
Total		**$7,600,000**

We would like to see this grow!

MSTEC Needs

Talent Pipeline & Scientist Development

- MSTEC thus far is a physical capability
- To be fully utilized, MSTEC needs to develop the human capability
  - Researcher
  - Instrument Scientists
  - Operators

Spreading the Word!

- We need your help!
  - Conferences & Publication (need funding)
  - Integration with other DOE campaigns, safeguards, industry
  - Making industry aware of the capabilities

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Questions ?

www.nric.inl.gov