Developments in the MSRR SSL

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Introduction

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What is the MSRR?

- **Molten Salt Research Reactor**
- **Up to 1MWth**
- **FliNaK salts**

Image sources: https://acu.edu/research/next-lab/

What is the SSL?

- Scientific Surveillance Layer
- Part of I&C
- NOT safety critical

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SSL Survey

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SSL Survey Motivation

- **What quantities to measure?**

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- What quantities to measure?
- Form follows function – what sensors are needed to acquire those quantities?
- Where should these sensors be located?

SSL Survey Methods

- **Survey sent out to heads of working groups A-G, then further disseminated.**
- **Input allowed for quantities, proposed locations, and rationale.**

SSL Survey Results

- 11 responses, mostly from I&C
- Mass flow rate, salt temperature, pump status...

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Online Void Fraction Monitoring

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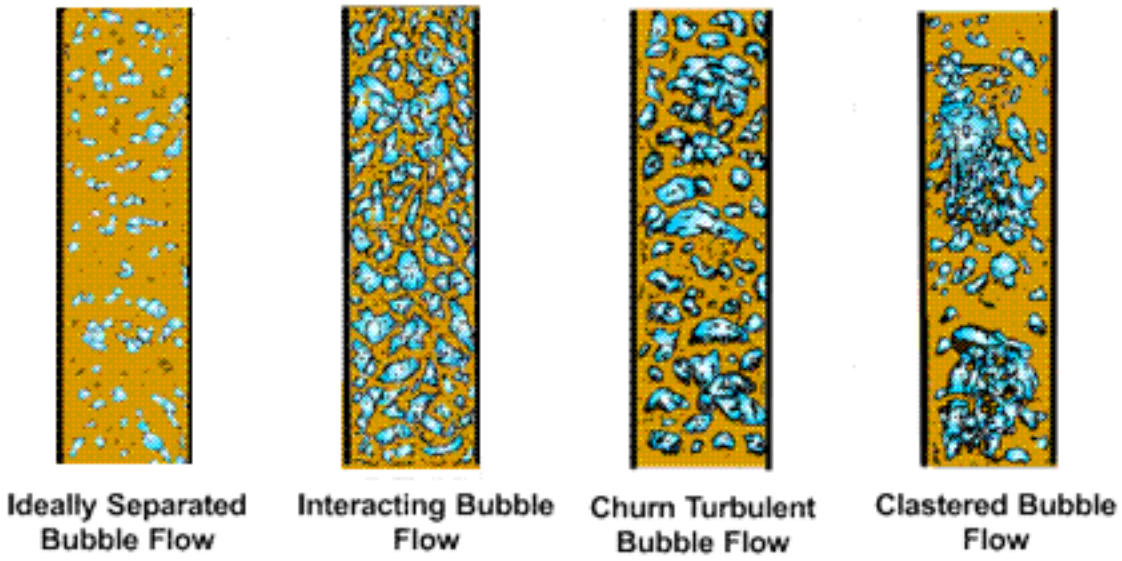
What is Void Fraction?

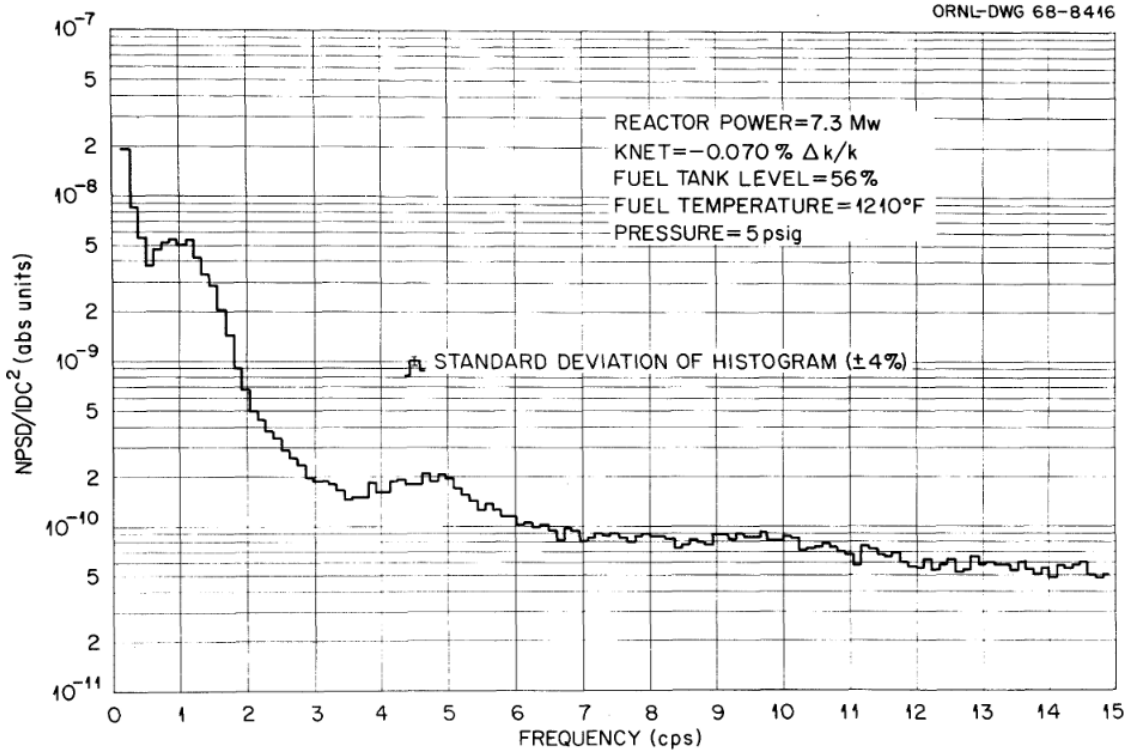
- % of loop volume occupied by gas
- Composed of helium, fission products
- Critical to quantifying Xe-135 poisoning/reactivity!



https://www.thermopedia.com/content/8/

Previous Work at the MSRE

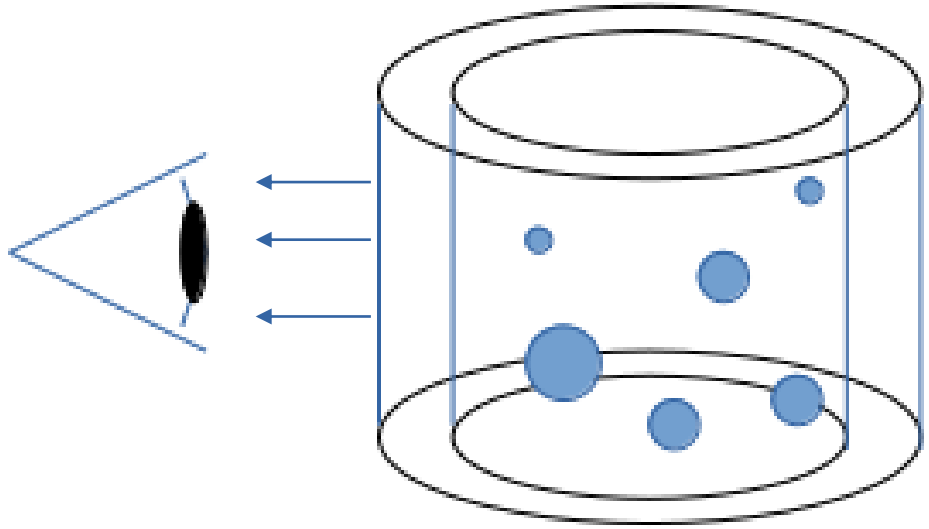
- Neutron noise analysis (ORNL-TM-2315)
- Pressure modulation analysis (ORNL-TM-2318)
- Some densitometry (ORNL-TM-2987)



ORNL-TM-2315, pg. 11

Online Void Fraction Monitoring

- **Gamma densitometry external source: hazardous, needs shielding, maintenance, replacing**
- **Rather, utilize *existing salt spectrum* as source!**
- **Only requires installation of gamma detector(s).**



Theory

- $A_{sp,\,salt}$ and $A_{sp,\,void}$ specific activity
- P^{void}, P^{salt} self-att'n. & inv. square factor
- α void fraction
- $\text{Counts} \propto \alpha \left(A_{sp}^{\text{void}}(E) \cdot P^{\text{void}(E)} - A_{sp}^{\text{salt}}(E) \cdot P^{\text{salt}}(E) \right) + A_{sp}^{\text{salt}}(E) \cdot P^{\text{salt}}(E)$
- Set energy to E_0 not found in the void ($A_{sp,\,void} = 0$)
- $\text{Counts} \propto (1-\alpha) A_{sp}^{\text{salt}}(E_0) \cdot P^{\text{salt}}(E_0)$

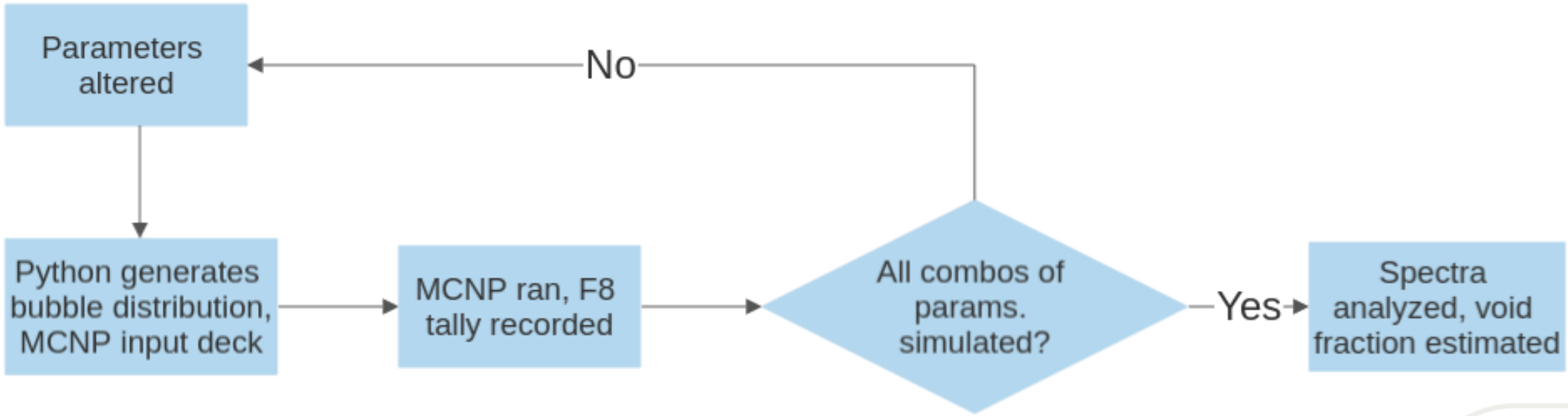
$$\alpha \propto 1 - \frac{\text{Counts}}{A_{sp}^{\text{salt}}(E_0) \cdot P^{\text{salt}}(E_0)}$$

P-constants

- Depend on *spatial arrangement of void and salt.*
- Assuming bubbles small & uniformly distributed, can estimate P.
- Does this assumption provide valid results?

Computational Validation

- **Ensemble of MCNP simulations with known α's, A_{sp}'s**
- **Obtain expected # counts**
- **Compared against theoretical estimate**
- **Multiple bubble arrangements per parameter combination**



Future Work

- Vary slice height, diameter, detector type
- Non-isotropic bubble distribution

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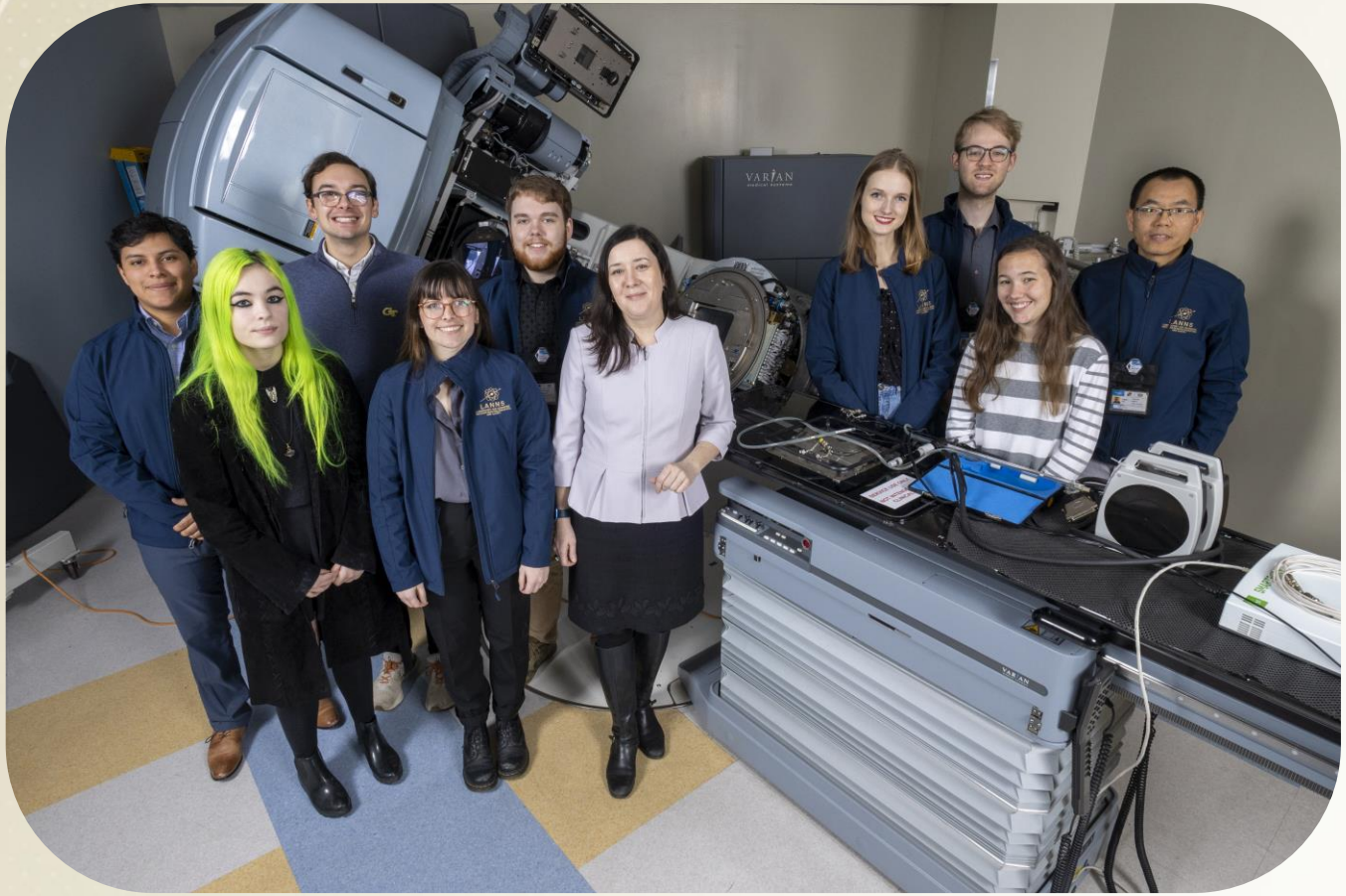
Thank you!



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