

# Mid-circuit measurement and reset using *omg* architecture in trapped-ion quantum computing systems

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Crystal Noel, Christopher R Monroe, Alexander Kozhanov

Monroe Group/Duke Quantum Center

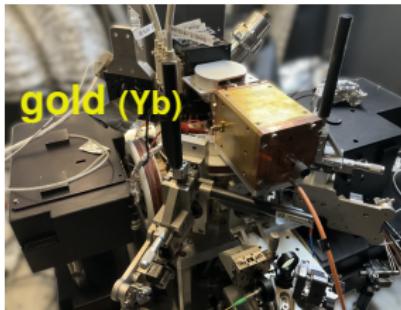
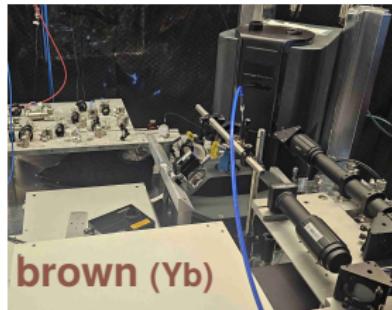
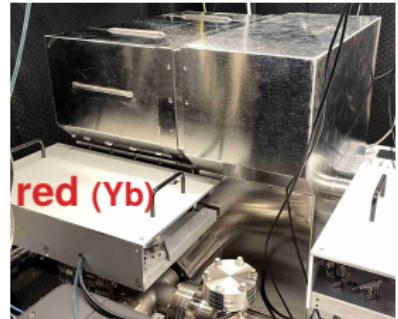
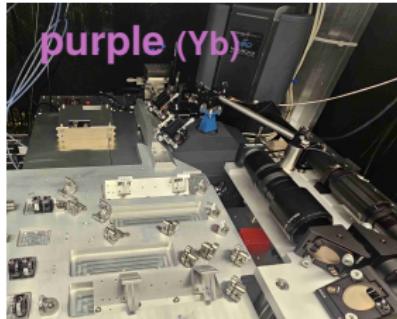
June 19, 2025



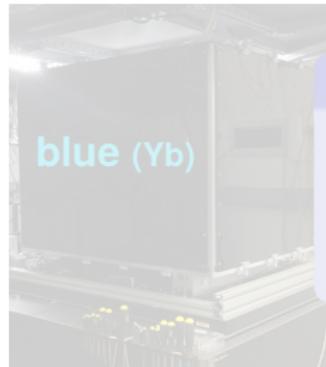
arXiv:2504.12544



# Duke Quantum Center

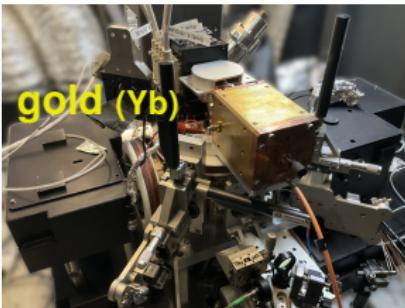
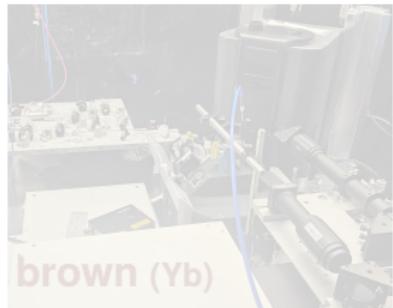


# Duke Quantum Center — Gold System

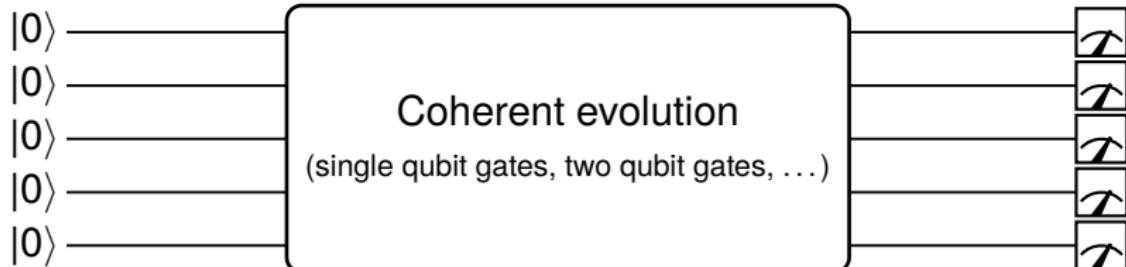


## Current status

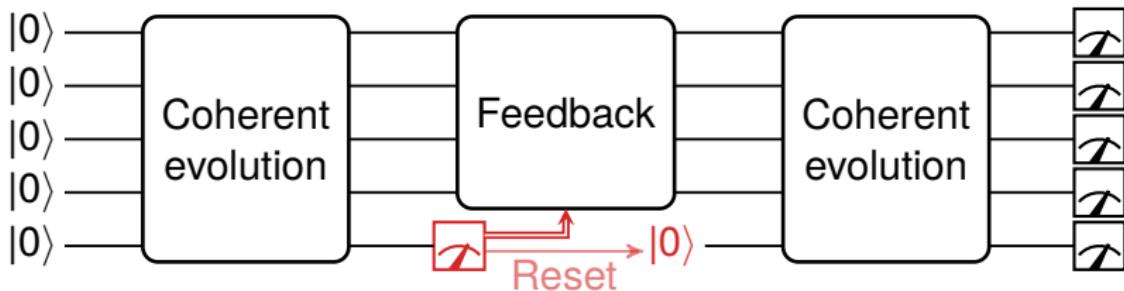
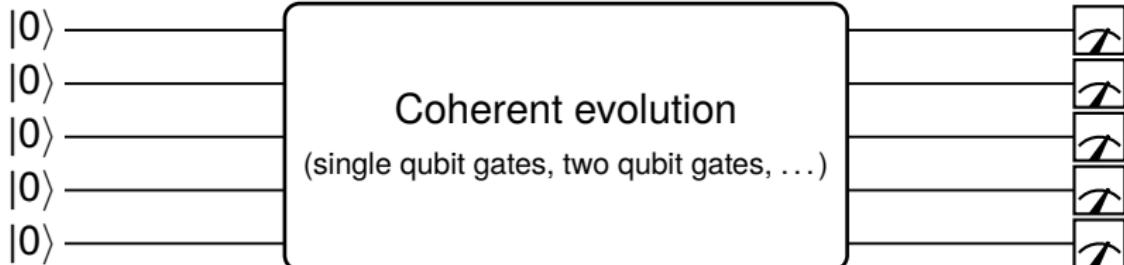
- SPAM: 99.7%
- 1q gate:  $\geq 99\%$
- 2q gate:  $\geq 98\%$



## Mid-circuit measurement and reset (MCMR)



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# Mid-circuit measurement and reset (MCMR)

## MCMR in ions

- Shuttling
- Multi-species
- Metastable states  
*omg-architecture*



Aux Data Aux Data

# Mid-circuit measurement and reset (MCMR)

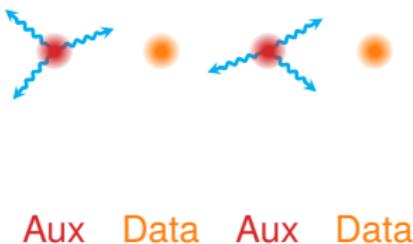
## MCMR in ions

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Aux Data Aux Data

# Mid-circuit measurement and reset (MCMR)

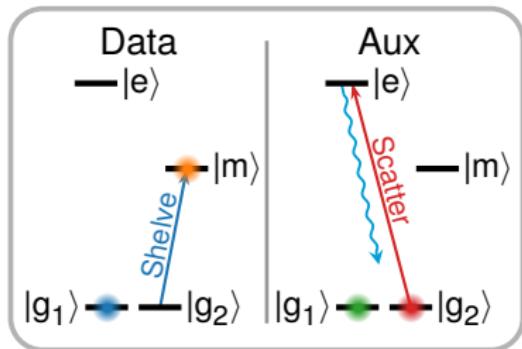


## MCMR in ions

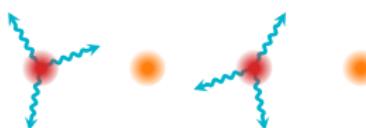
- Shuttling
  - Multi-species
  - Metastable states
- omg-architecture*

- Yb<sup>+</sup>: D<sub>3/2</sub> (50 ms), D<sub>5/2</sub> (7 ms), F<sub>7/2</sub> (>1 yr)
- Ba<sup>+</sup>: D<sub>3/2</sub> (20 s), D<sub>5/2</sub> (30 s)
- Sr<sup>+</sup>: D<sub>3/2</sub> (0.4 s), D<sub>5/2</sub> (0.4 s)
- ...

# MCMR with metastable state — shelving method

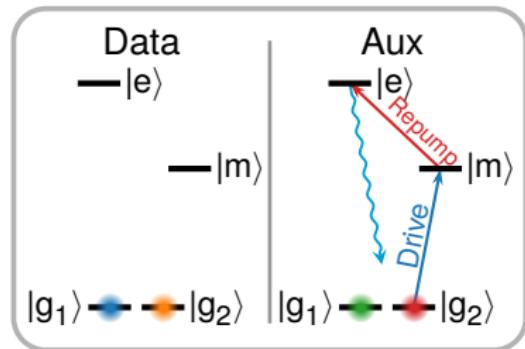


Individual Shelf



Aux Data Aux Data

# MCMR with metastable state — hands-off method

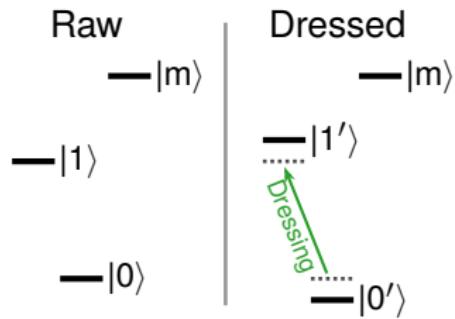


Individual Drive

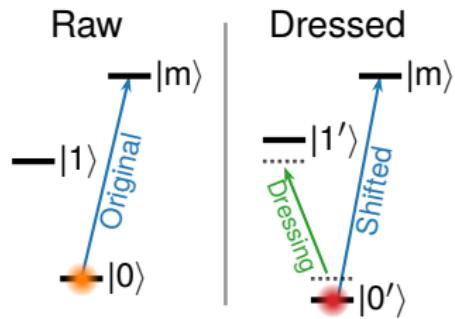


Aux    Data    Aux    Data

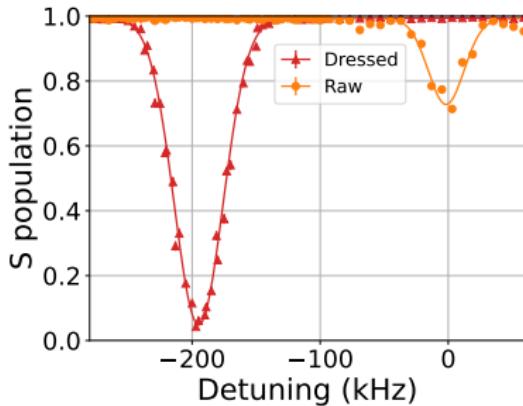
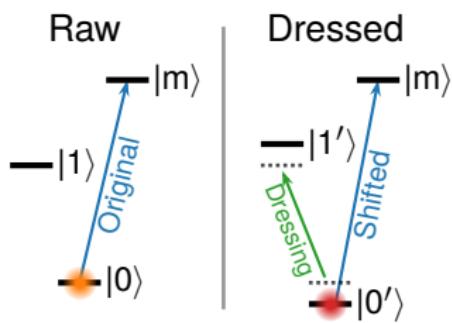
# Individual control of metastable state — dressing



# Individual control of metastable state — dressing

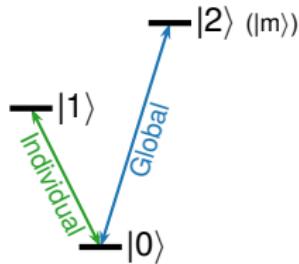


# Individual control of metastable state — dressing



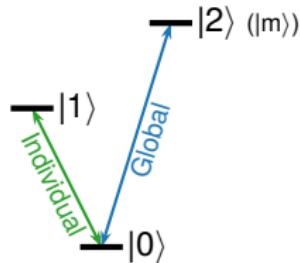
# Individual control of metastable state

## Individual qudit control

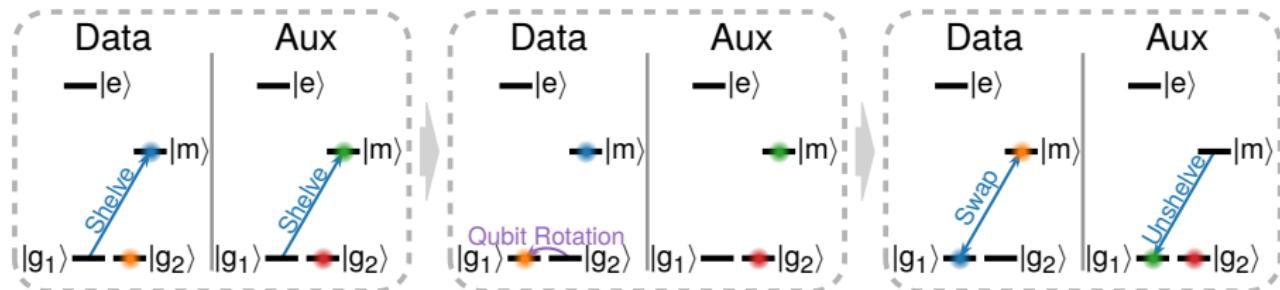


# Individual control of metastable state — qubit rotation

## Individual qudit control

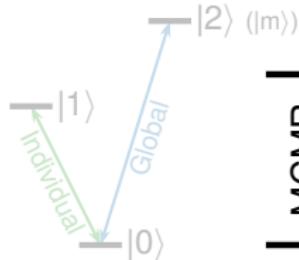


## Example Sequence



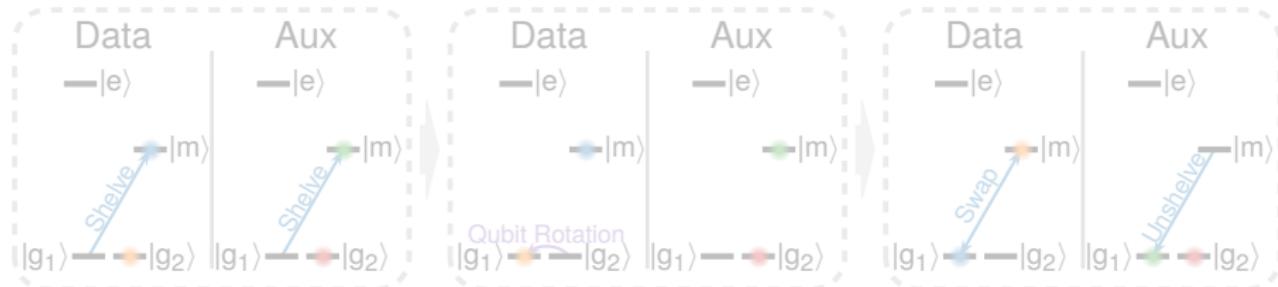
# Individual control of metastable state

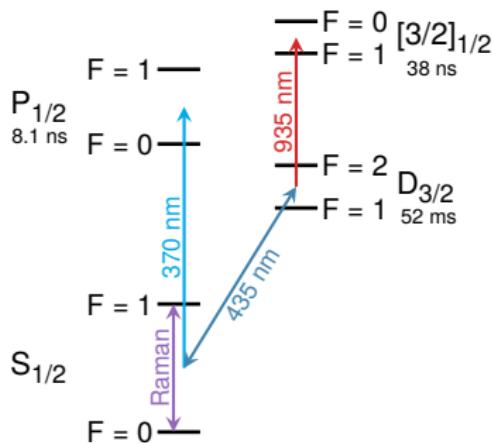
## Individual qudit control

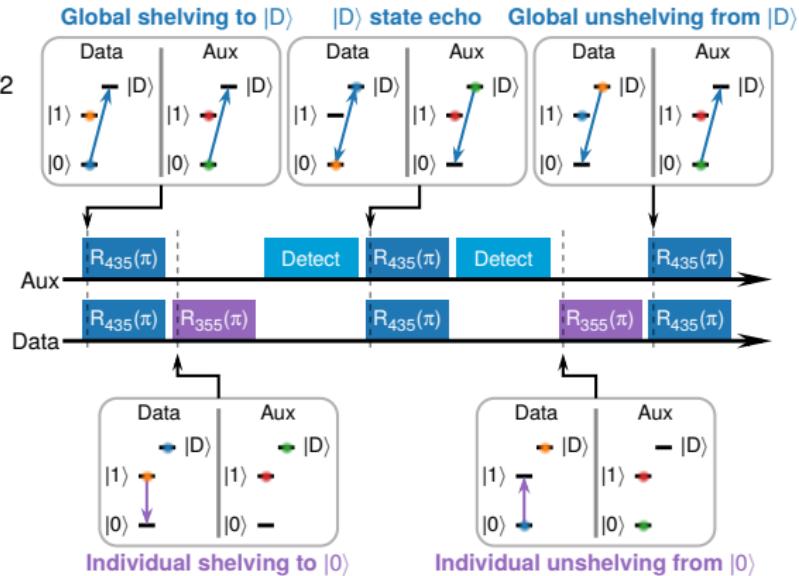
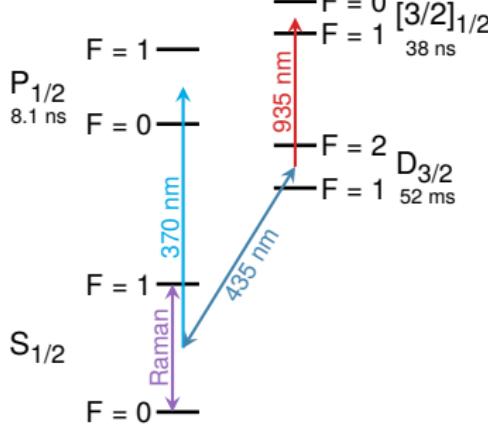


MCMR methods	Individual metastable control	
	Dressing	Qubit rotation
Shelving	✓	✓
Hands-off	✓	✗

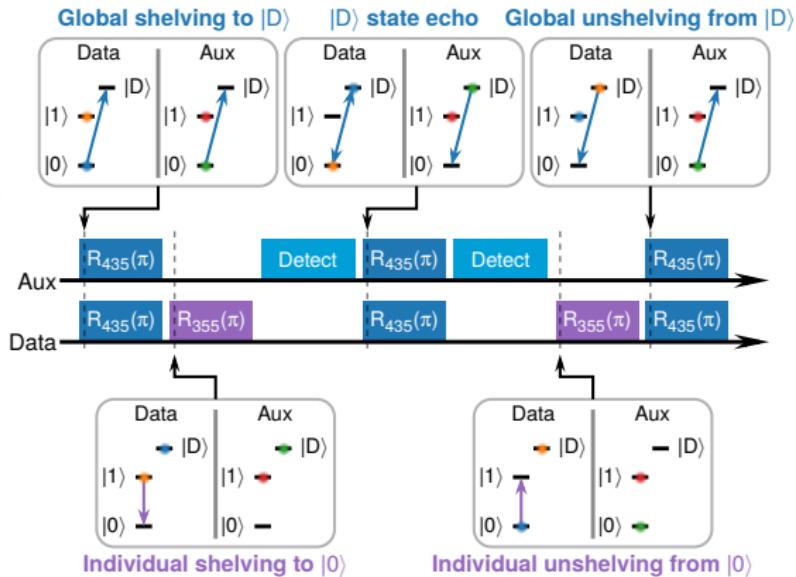
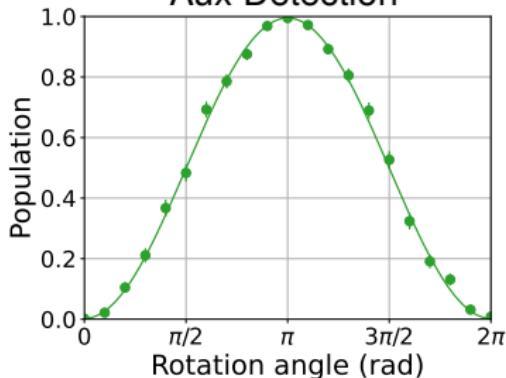
## Example Sequence



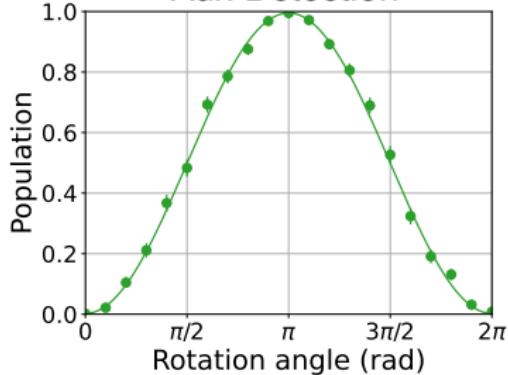




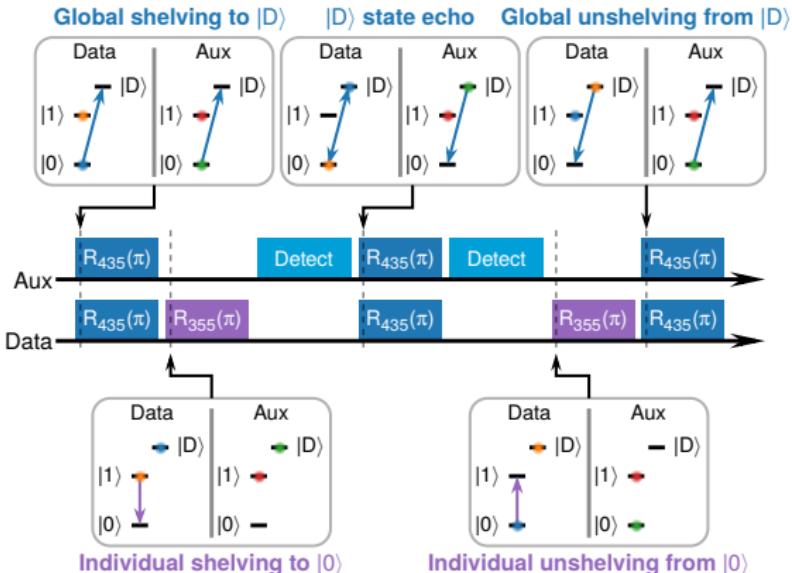
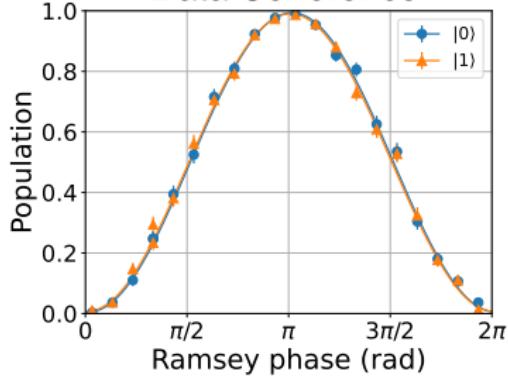
## Aux Detection

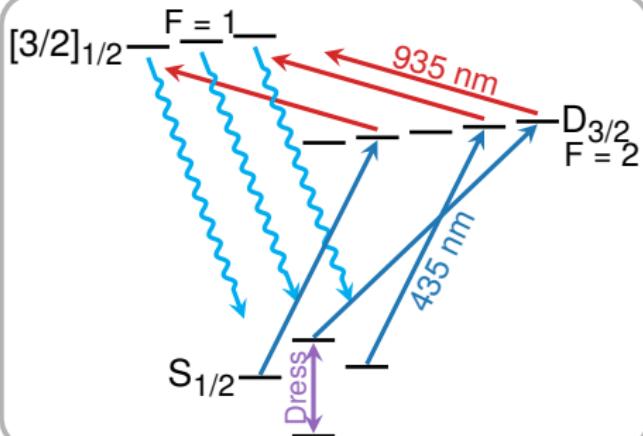


## Aux Detection

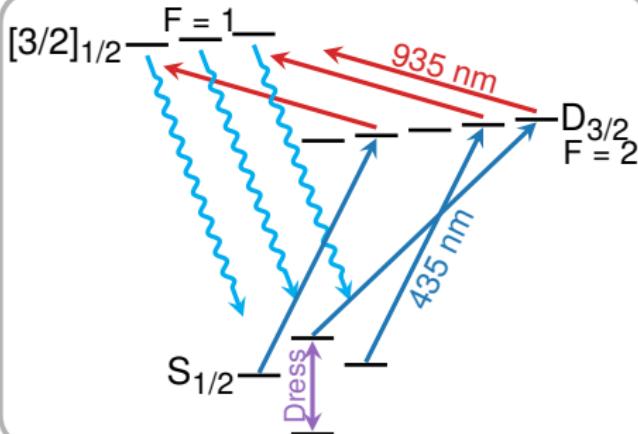
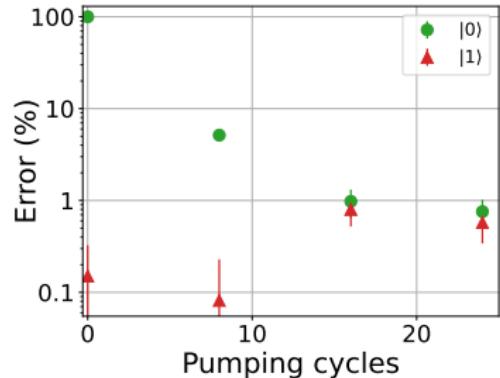


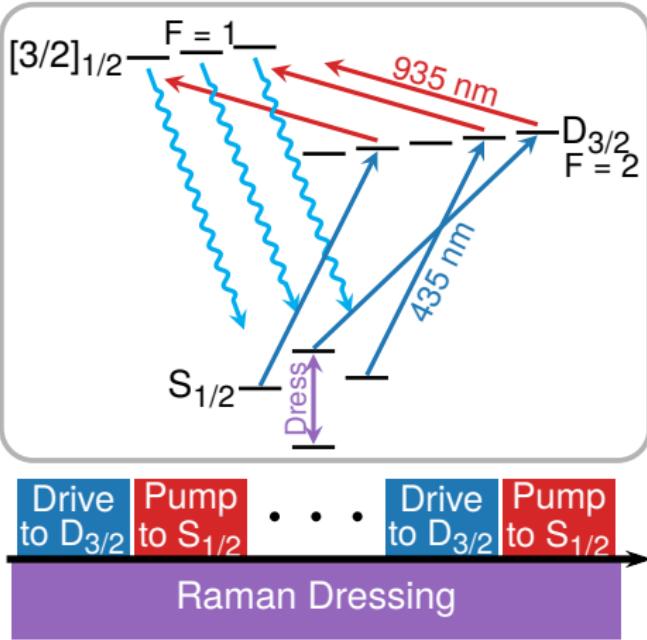
## Data Coherence



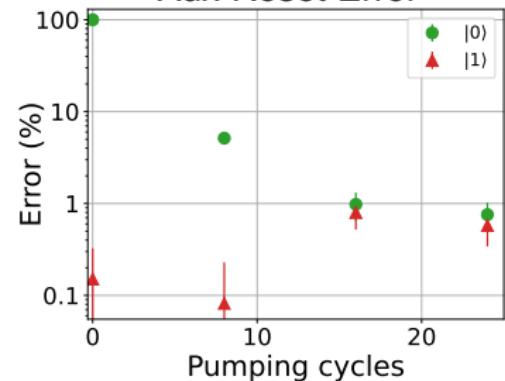


## Aux Reset Error

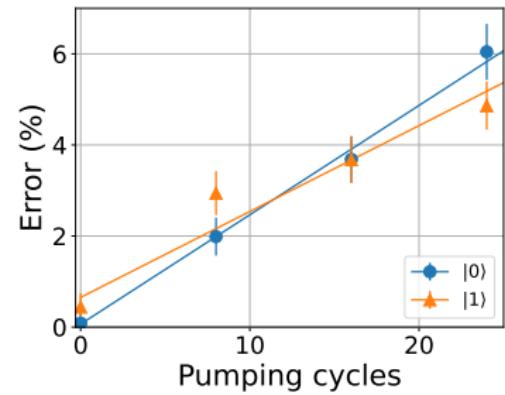




### Aux Reset Error



### Data Error





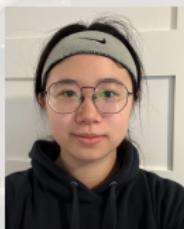
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**Yb result**  
arXiv:2504.12544



**Ba result**  
arXiv:2504.12538



