

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

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Duke Quantum Center, Duke University

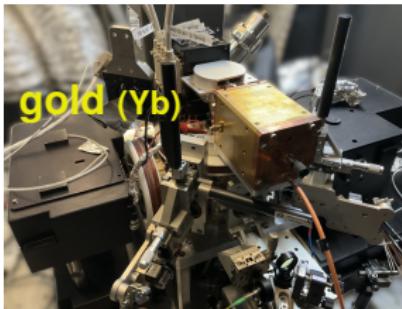
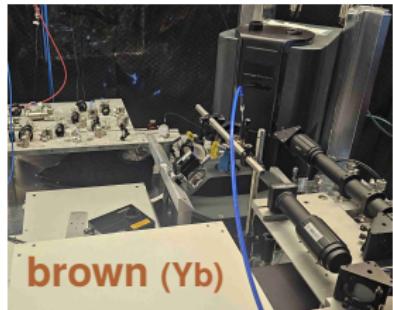
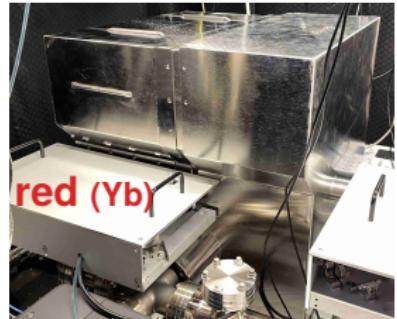
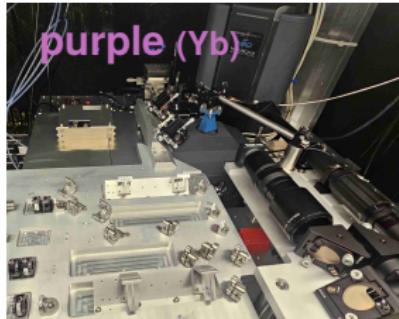
June 19, 2025



arXiv:2504.12544



Duke Quantum Center (DQC)

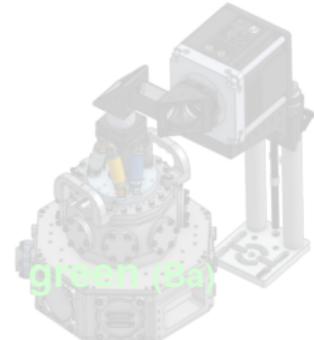
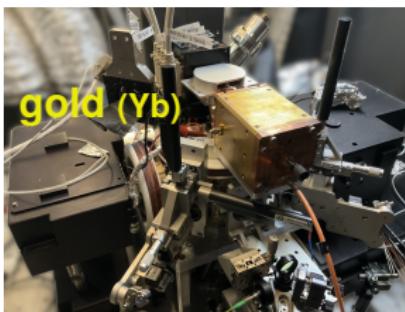
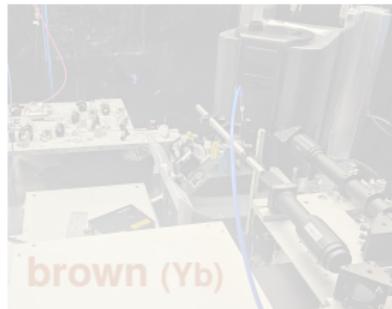


Duke Quantum Center (DQC) — Gold System

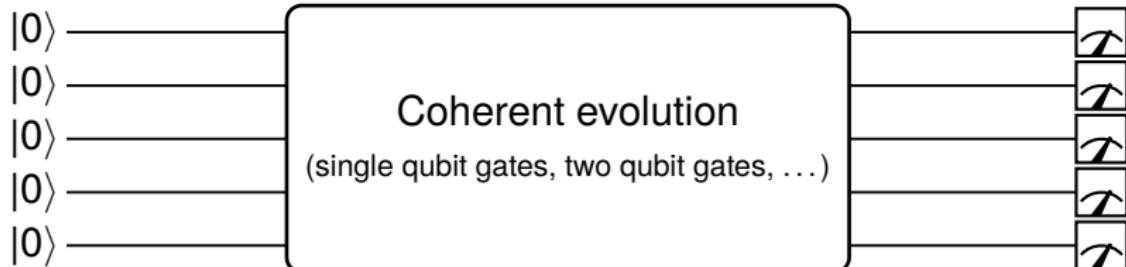


Current status

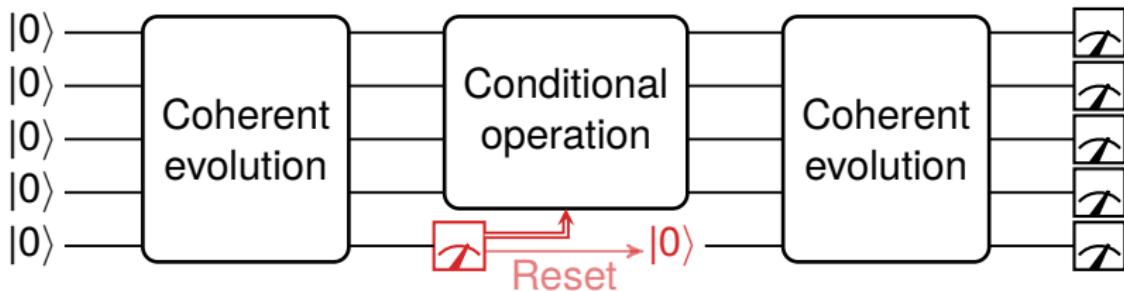
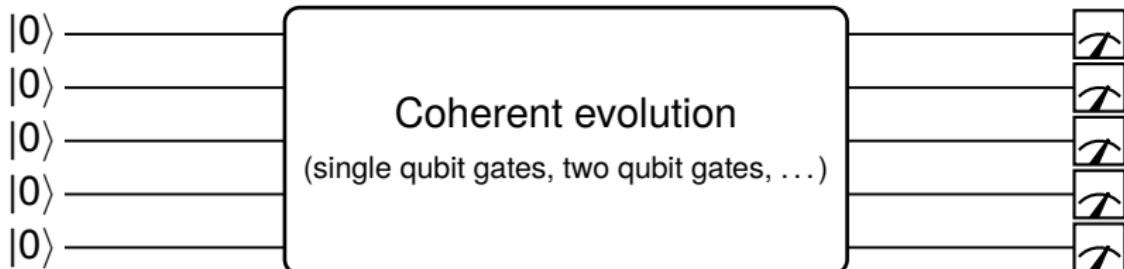
- SPAM: 99.7%
- 1q gate: $\geq 99\%$
- 2q gate: $\geq 98\%$



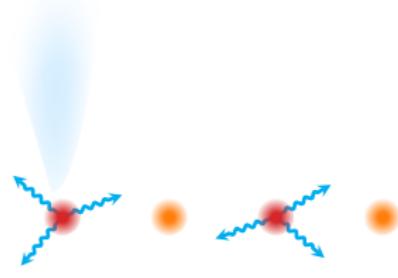
Mid-circuit measurement and reset (MCMR)



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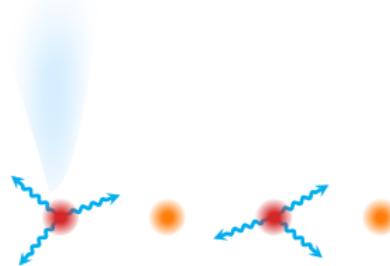


Mid-circuit measurement and reset (MCMR)



Aux Data Aux Data

Mid-circuit measurement and reset (MCMR)



MCMR in ions

- Shuttling

Nature Physics 19, 1 (2023)

- Multi-species

Science 309, 749 (2005)

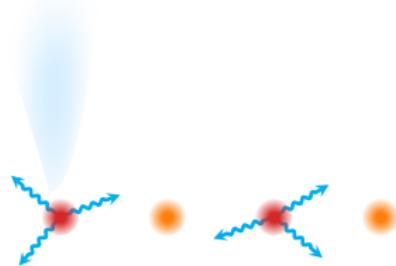
- Metastable states

omg-architecture

PRX 13, 041035 (2023)

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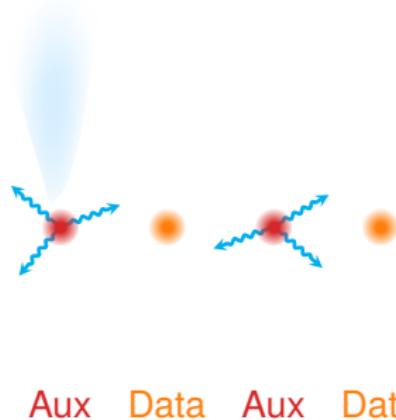
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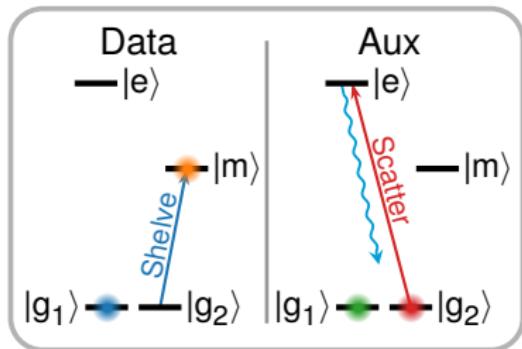
- Metastable states

omg-architecture

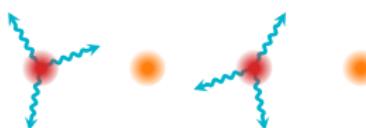
PRX 13, 041035 (2023)

- Yb⁺: D_{3/2} (50 ms), D_{5/2} (7 ms), F_{7/2} (>1 yr)
- Ba⁺: D_{3/2} (20 s), D_{5/2} (30 s)
- Sr⁺: D_{3/2} (0.4 s), D_{5/2} (0.4 s)
- ...

MCMR with metastable state — shelving method

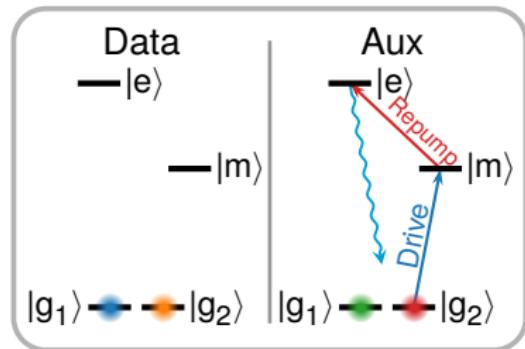


Individual Shelf



Aux Data Aux Data

MCMR with metastable state — hands-off method

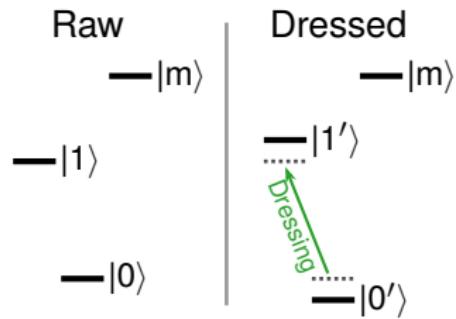


Individual Drive

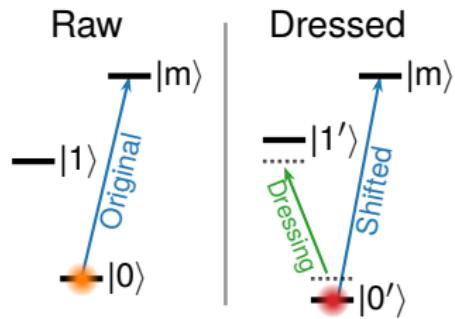


Aux Data Aux Data

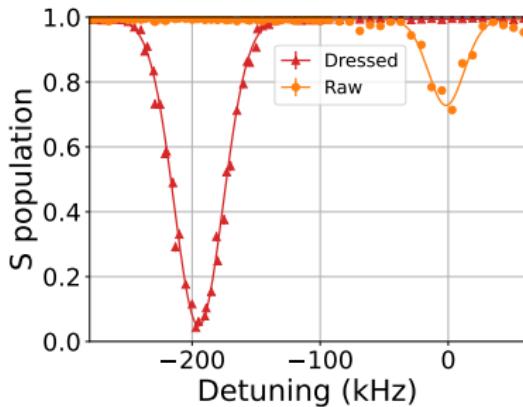
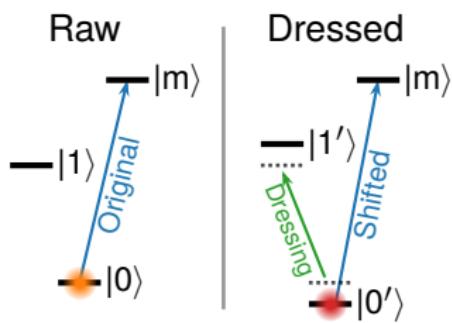
Individual control of metastable state — dressing



Individual control of metastable state — dressing

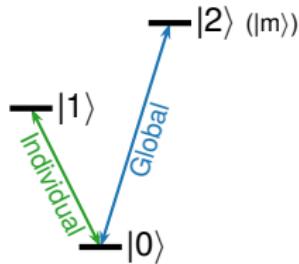


Individual control of metastable state — dressing



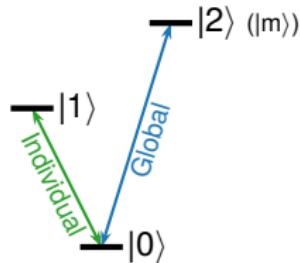
Individual control of metastable state

Individual qudit control

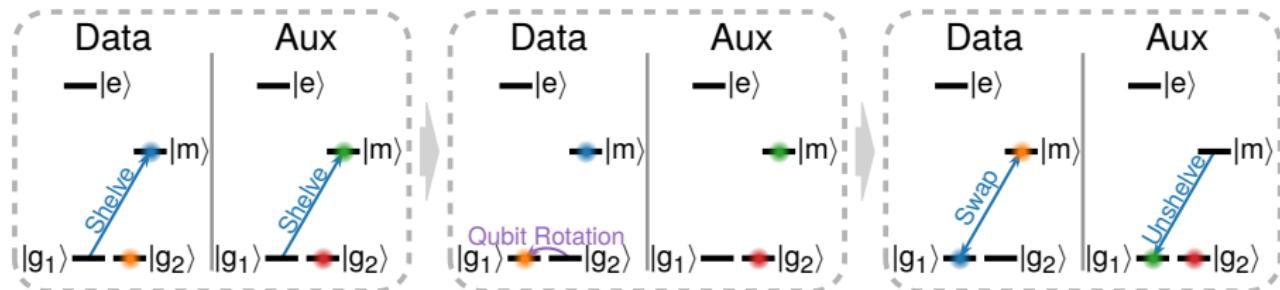


Individual control of metastable state — qubit rotation

Individual qudit control

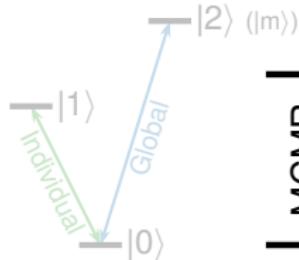


Example Sequence



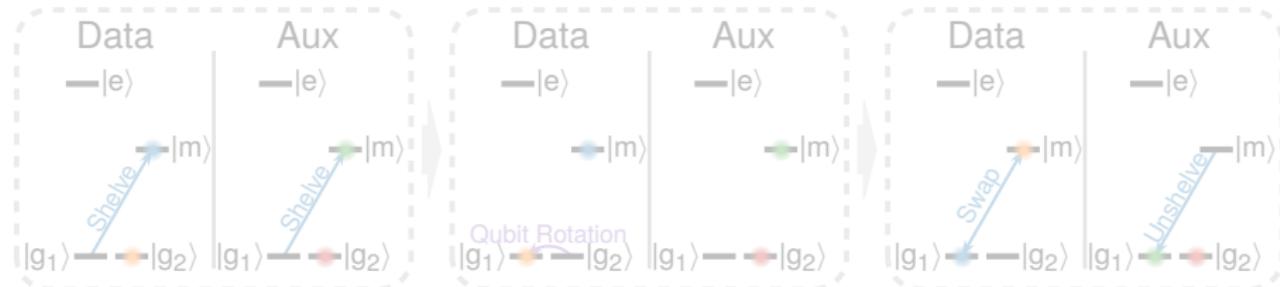
Individual control of metastable state

Individual qudit control

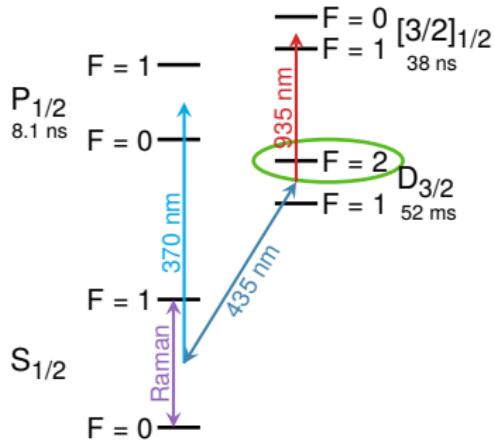


MCMR methods	Individual metastable control	
	Dressing	Qubit rotation
Shelving	✓	✓
Hands-off	✓	✗

Example Sequence



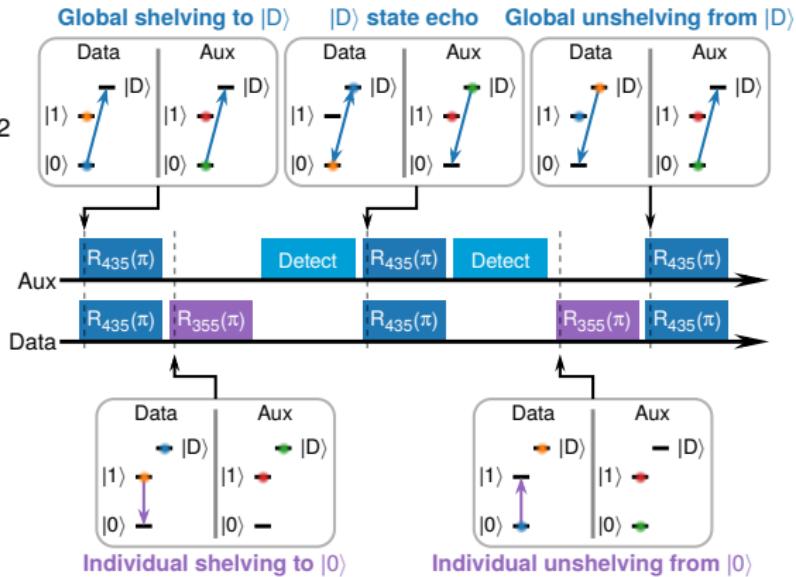
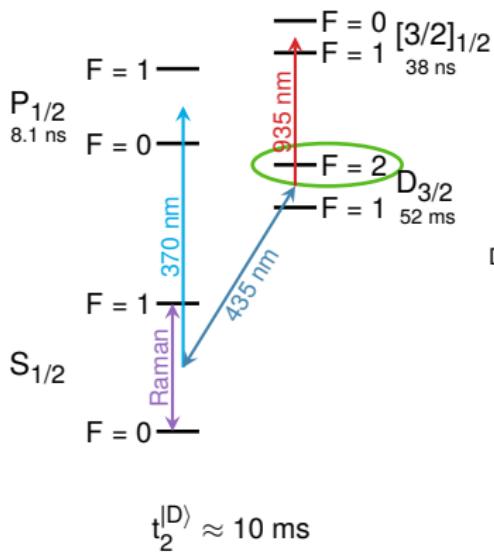
$^{171}\text{Yb}^+$ levels



$$t_2^{|\text{D}\rangle} \approx 10 \text{ ms}$$

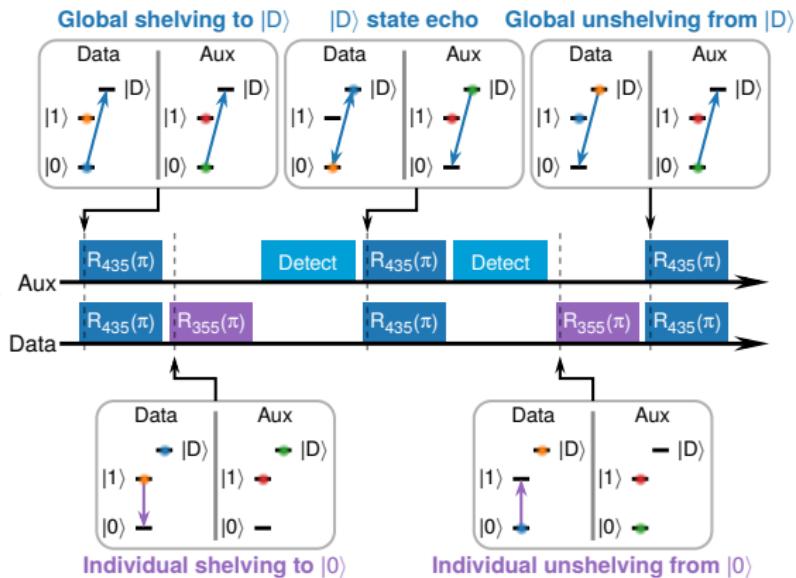
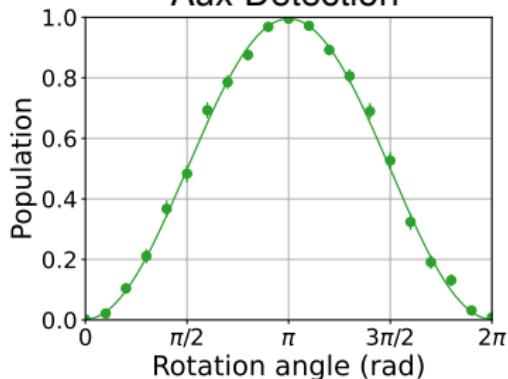
Mid-circuit measurement

$^{171}\text{Yb}^+$ levels



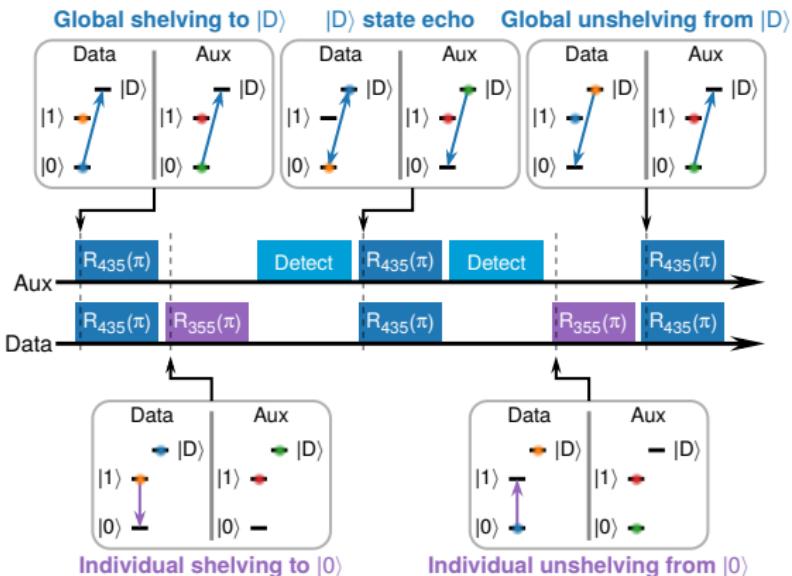
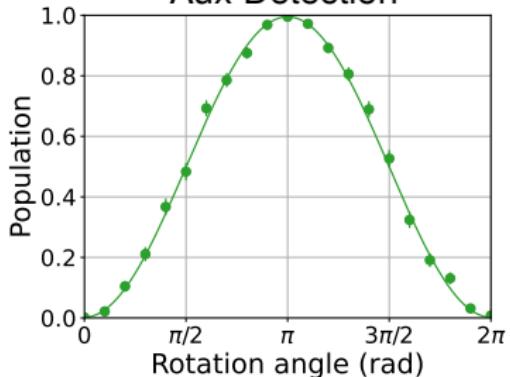
Mid-circuit measurement

Aux Detection

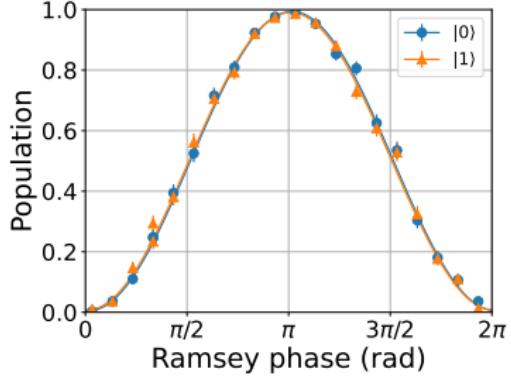


Mid-circuit measurement

Aux Detection



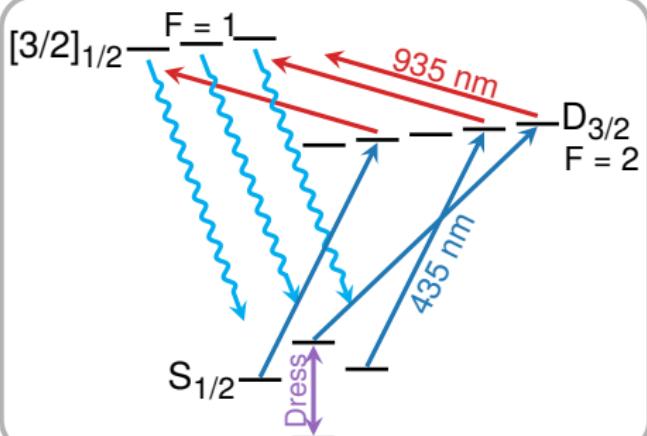
Data Coherence



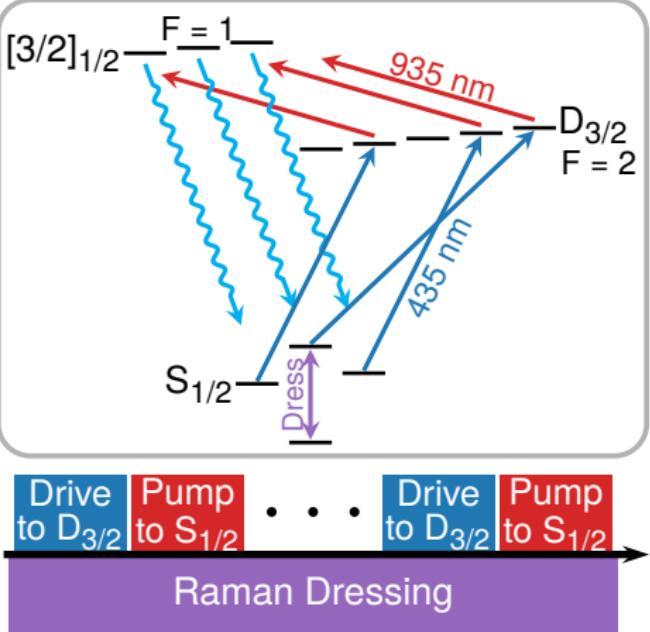
Dressing: 91.7(4)%

Qubit rotation: 98.5(5)%

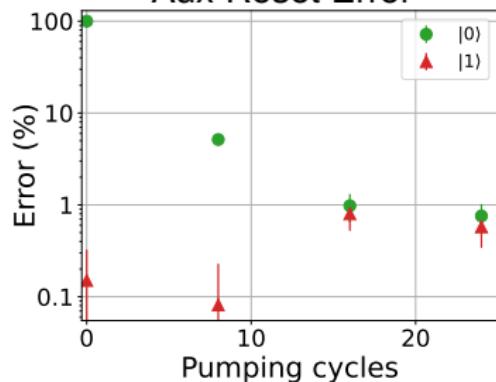
Mid-circuit reset



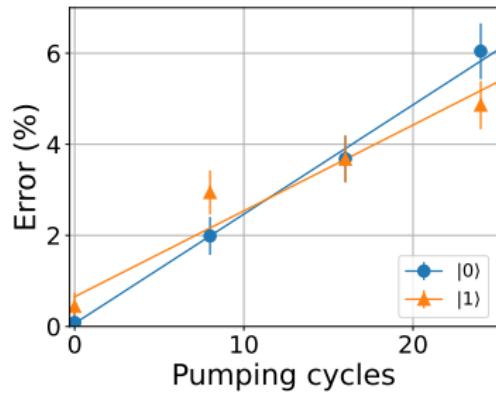
Mid-circuit reset



Aux Reset Error



Data Error





Christopher R Monroe



Alexander Kozhanov



Crystal Noel



Keqin Yan



Vivian Zhang



Debopriyo Biswas



Bahaa Harraz

Yb result
arXiv:2504.12544



Ba result
arXiv:2504.12538



