Hadron Spectroscopy with a low-mass composite scalar in the sextet model

Chik Him (Ricky) Wong

Lattice Higgs Collaboration (LatHC):

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Outline

- Review: Sextet model as Composite Higgs candidate
- Hadron Spectroscopy on Extended Dataset
  - Simulation Details
  - Higgs Impostor: Light M_{f_0}
  - LHC reachable resonances : $M_{a_0}, M_{\rho}, M_{a_1}$
  - Lightest Baryon: M_N
- Conclusion

Review: Sextet model as Composite Higgs candidate

- Goal: Look for a Composite Higgs model:
  An infrared fixed point almost exists + Confining
  $\Rightarrow$ models at the edge of conformal window
- After Higgs boson discovery : Light 0^{++} Higgs + reproduce detected phenomenology
- Predicts any observed new resonances
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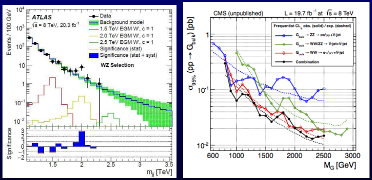

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- Focus of this talk: $SU(3)$ $N_f = 2$ Sextet(Two-index symmetric) Model

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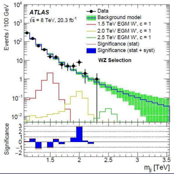

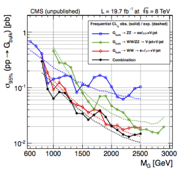

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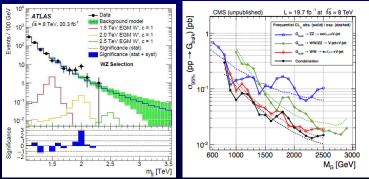

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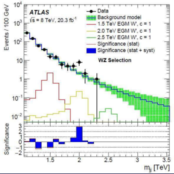

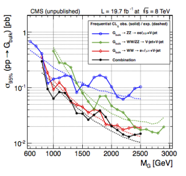

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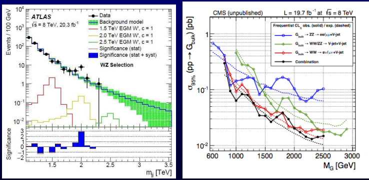

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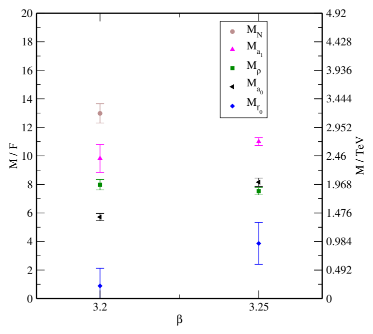

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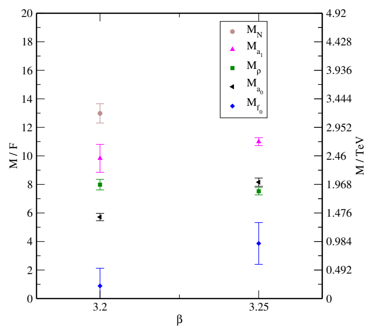

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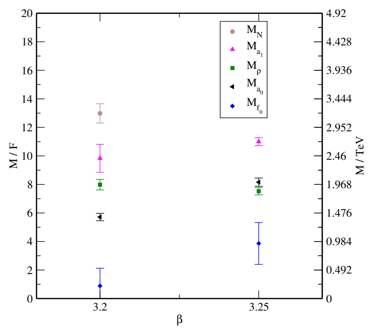

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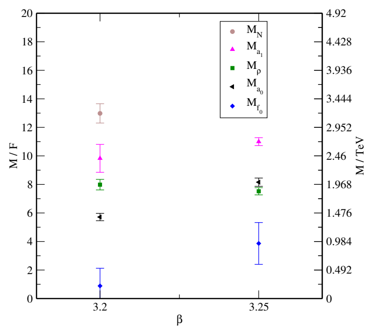

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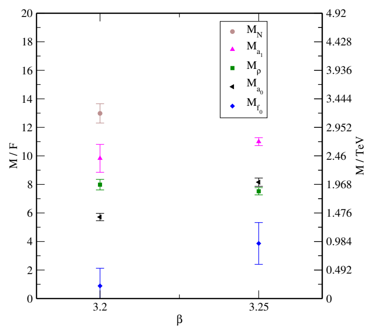

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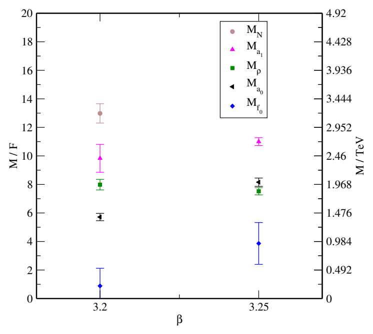

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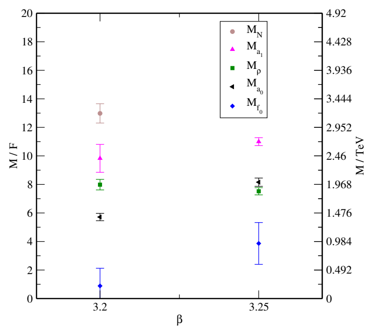

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Hadron Spectroscopy on Extended Dataset - Simulation Details

- Action: Tree-level Symanzik-Improved gauge action with Staggered $N_f = 2$ Sextet SU(3) fermions
- RHMC algorithm with multiple time scales and Omelyan integrator
- $\beta \equiv 6/g^2 = 3.20$, 3.25 and 3.30, which is in the weak coupling regime
- Lattices available:($\sim 2000 - 9000$ Trajectories each)

β	L	T	m	β	L	T	m
3.20	56	96	$0.001-0.002$	3.25	64	96	0.001
	48	96	$0.001-0.004$		56	96	$0.001-0.002$
	40	80	$0.002-0.004$		48	96	$0.001-0.004$
	32	64	$0.003-0.008$		40	80	$0.002-0.004$
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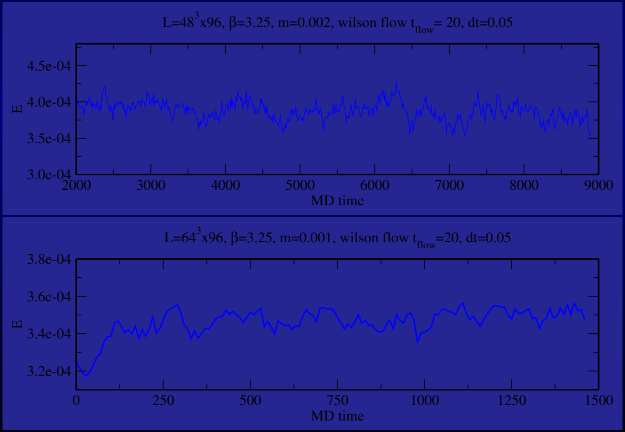

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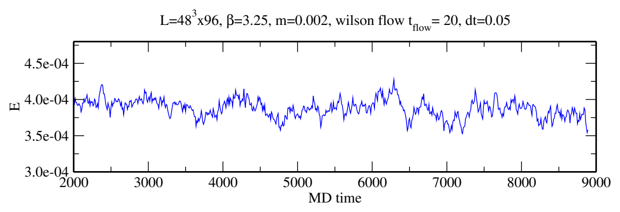
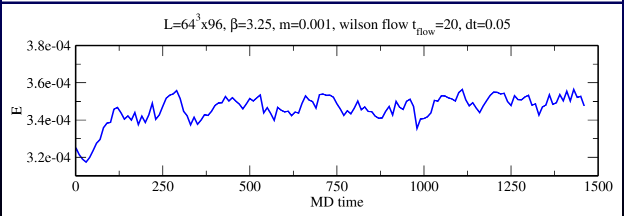
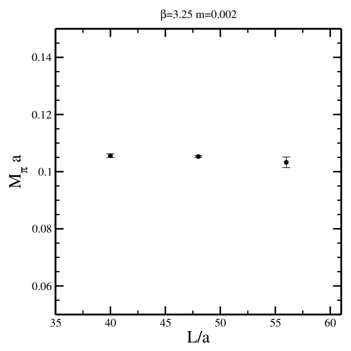
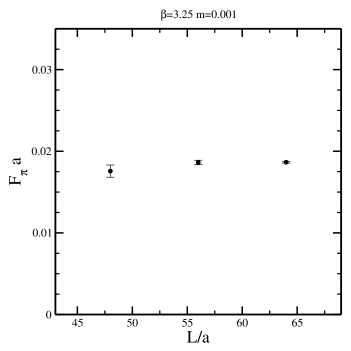




Hadron Spectroscopy on Extended Dataset - Finite Size Scaling

- Volume Dependence is mild





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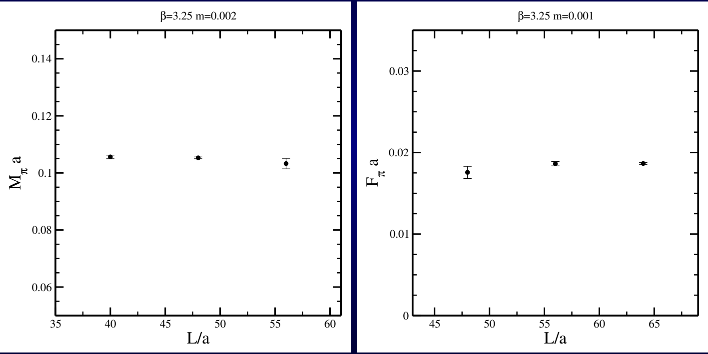

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Hadron Spectroscopy on Extended Dataset - M_π

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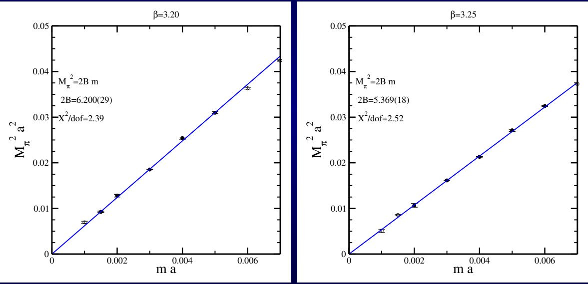

- Consistent with χPT

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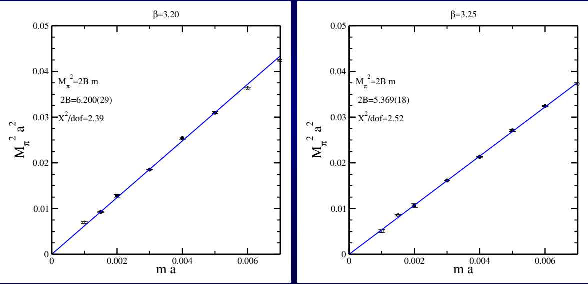

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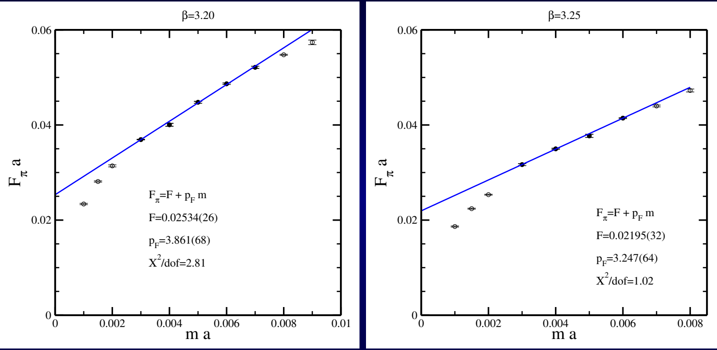
Hadron Spectroscopy on Extended Dataset - F_π

- Scale setting becomes challenging



- F_π at small fermion masses deviate from naive linear expectation $\Rightarrow$ More complicated fit forms needed
- Improved fit forms should :
  - Include chiral-log effects
  - Take the corrections from the light scalar into account
- New analysis strategies are being developed $\Rightarrow$ No chiral extrapolations will be attempted in this talk

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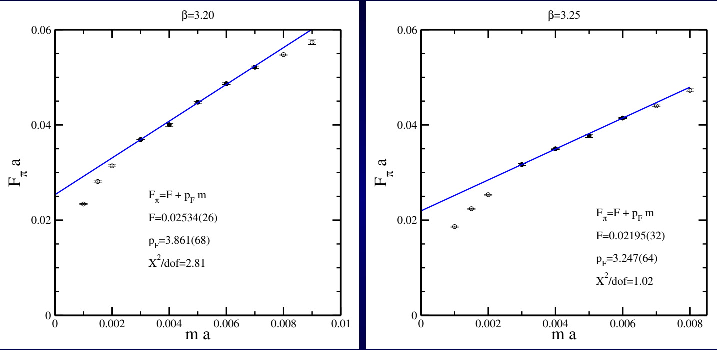

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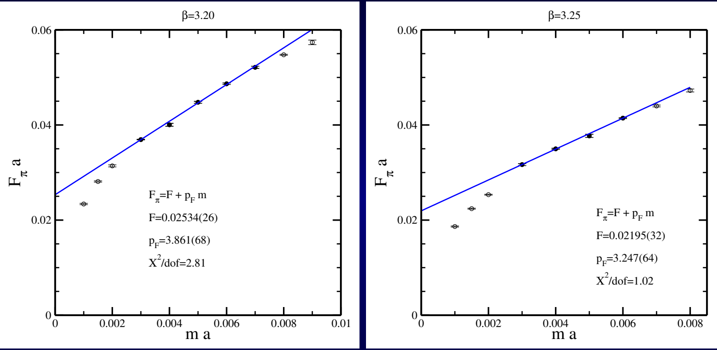

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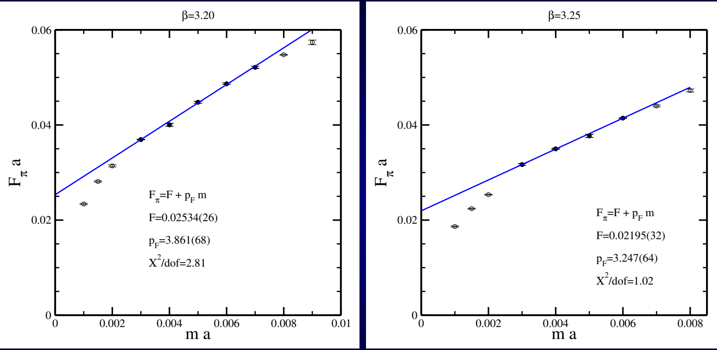

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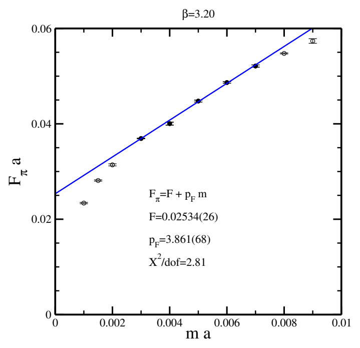

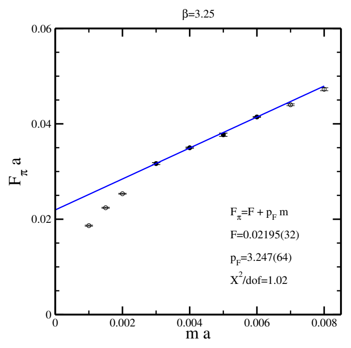

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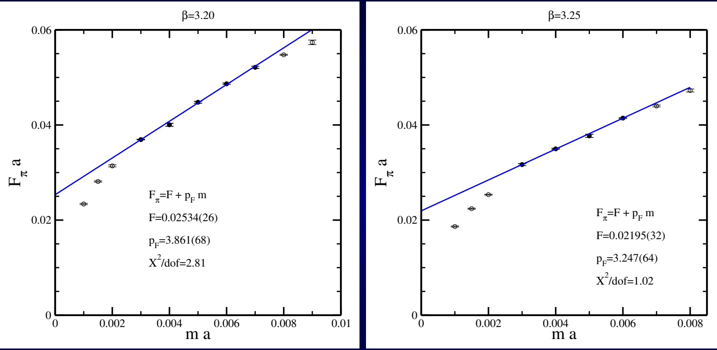

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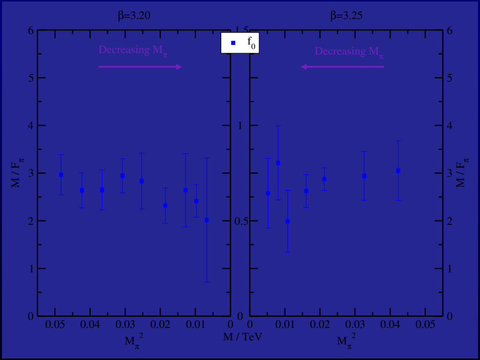
Hadron Spectroscopy on Extended Dataset - Light f_0 as Higgs Impostor

- Fermionic operator (f_0) is used
- Costly to compute the disconnected piece
  $\Rightarrow$ Stochastic estimation with Dilution improvement is used
- Typically Noisy
  $\Rightarrow$ Improvements such as Variational Method, Boosted operators and Faster inverters are planned



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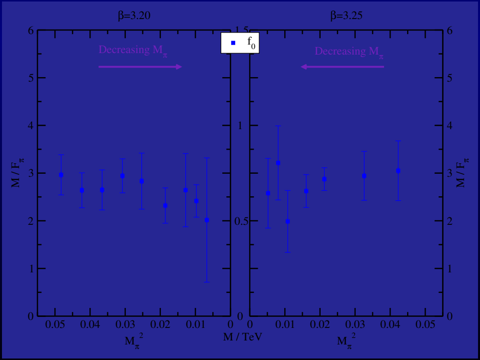

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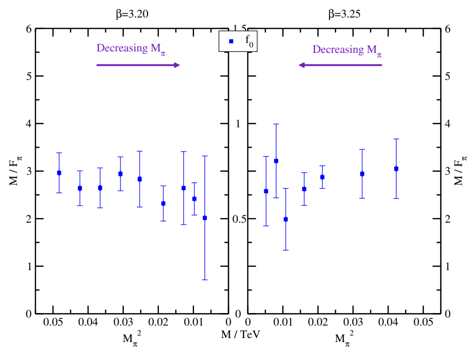

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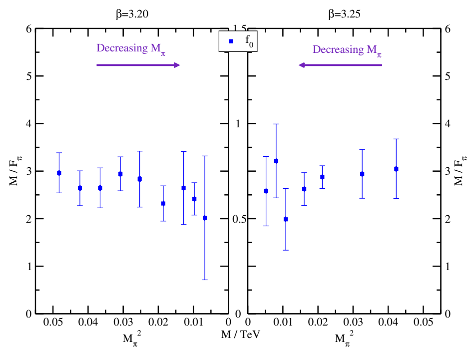

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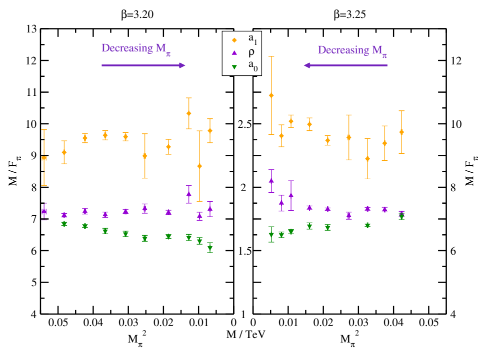
Hadron Spectroscopy on Extended Dataset - LHC-Reachable Resonance Candidates

- ρ, a_0 and a_1



- In the range of 6 to 10 $F_\pi \Rightarrow$ Lowest states within reach of LHC
- Fun Fact:
  The observed excess in LHC as a walking techni-ρ candidate is at 2 TeV ($\approx 8F_\pi$)!
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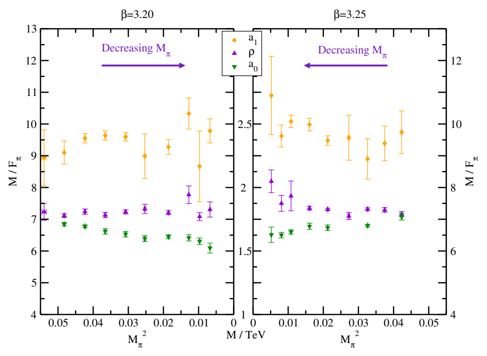

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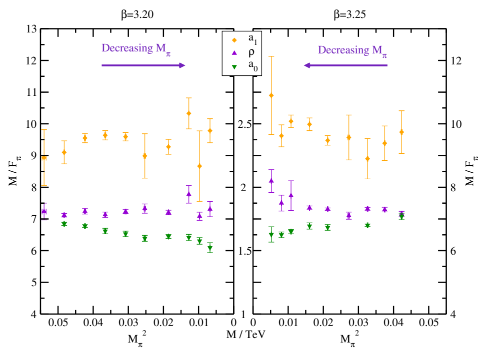

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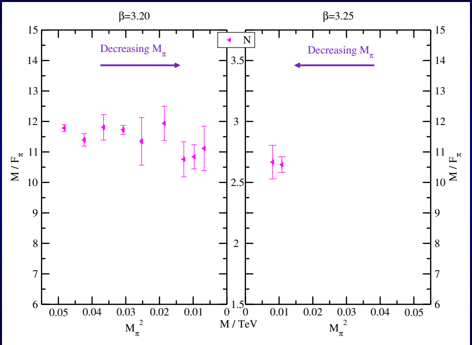
- The lightest baryon N is tricky to be constructed due to symmetric color structure $\Rightarrow$ Nonlocal operator required (Zoltan et al, PoS (LATTICE 2014) 270)



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  - Fractionally-Charged $\Leftarrow$ strictly constrained experimentally
  - Requires modification or extension of the model to possibly become Dark Matter candidates
- Interesting channel, whether Dark Matter candidate or not
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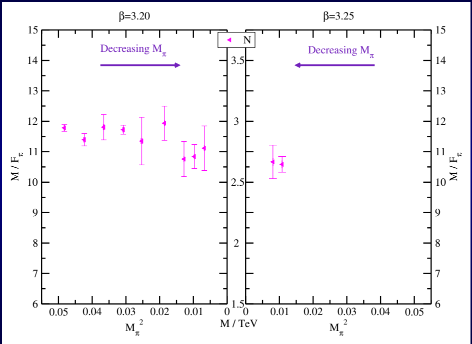

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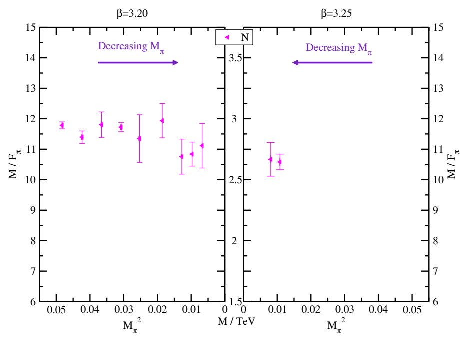

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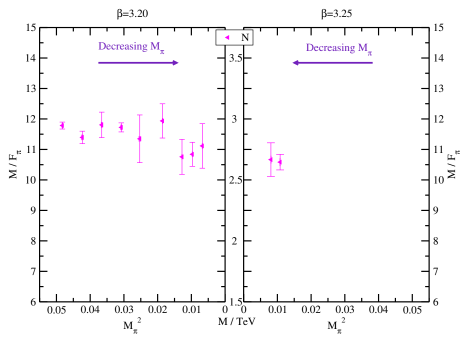

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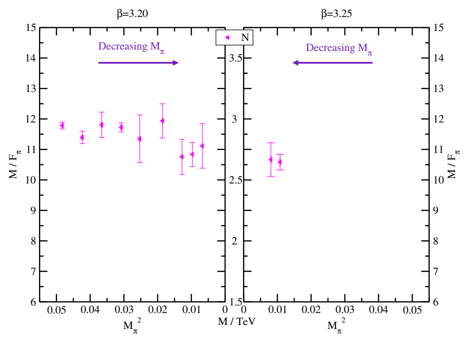

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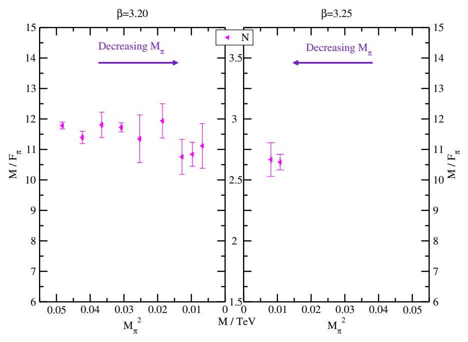

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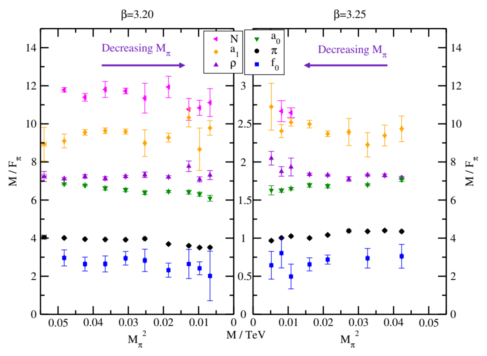

- It is observed that the ratios change slowly in the range of the data. Assuming similar ratios at the chiral limit and $F \equiv F_\pi(M_\pi \to 0) \sim 250$ GeV,

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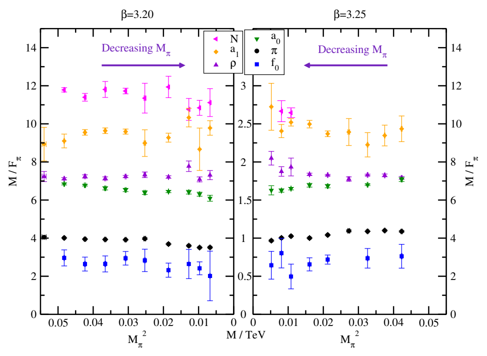

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  - Assuming mild dependence of mass ratios on fermion mass,
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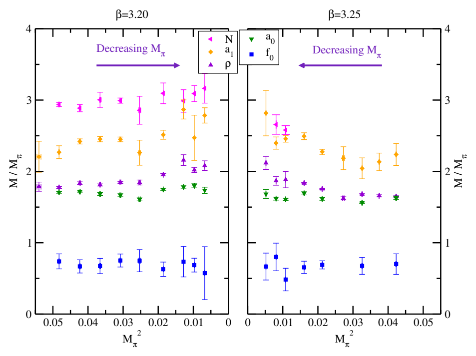
M/M_π vs M_π^2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β=3.25
Decreasing M_π
Decreasing M_π
N
a_1
ρ
a_0
f_0
M / M_π
M_π^2
0.05
0.04
0.03
0.02
0.01
0
1
2
3
4