

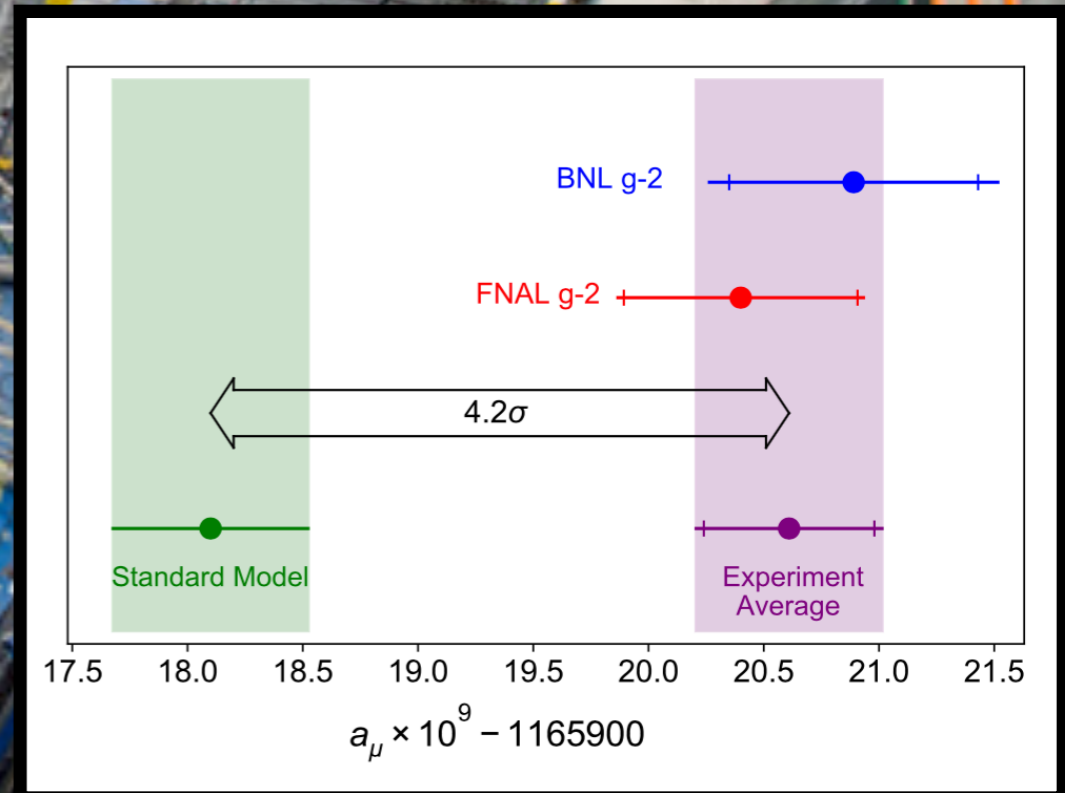
Searching for Dark Forces at ARIEL

Ross Corliss

for the  Collaboration

Muon g-2 Anomaly

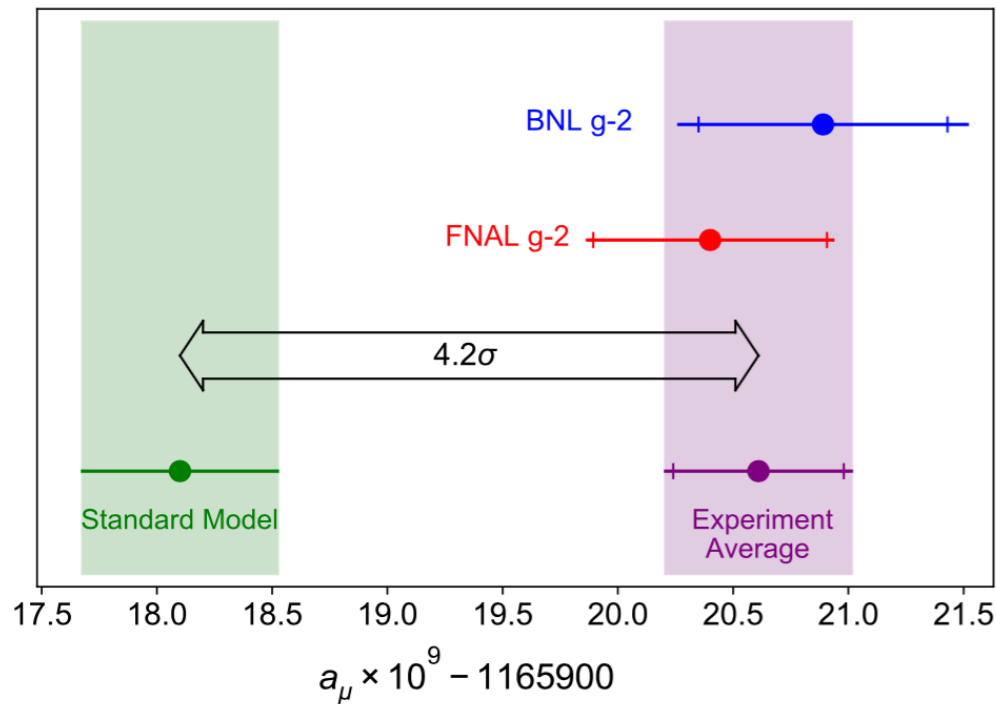
- FNAL result agrees with previous E821
- Large deviation from SM prediction!



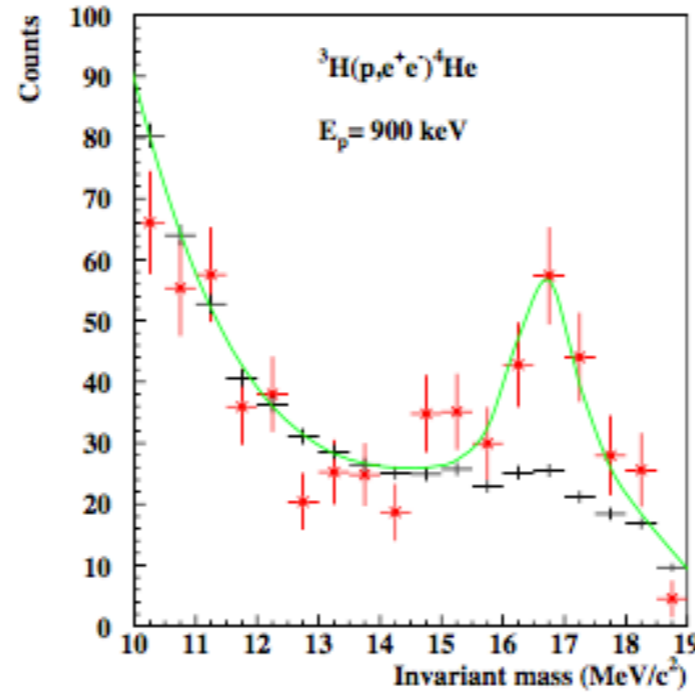
arxiv:2104.03281
PRL.126.141801 (2021)

Anomalies as New Interactions?

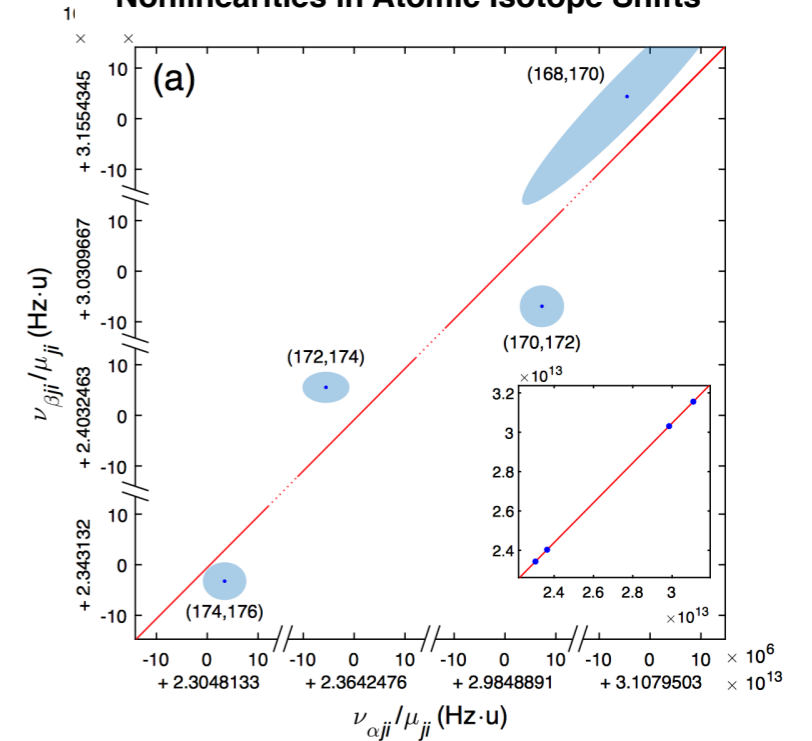
Muon g-2 Discrepancy



X17 in 4He and 8Be



Nonlinearities in Atomic Isotope Shifts



- Anomalies could be resolved with a new interaction:

- Kinetic Mixing: flavor-independent effective coupling:

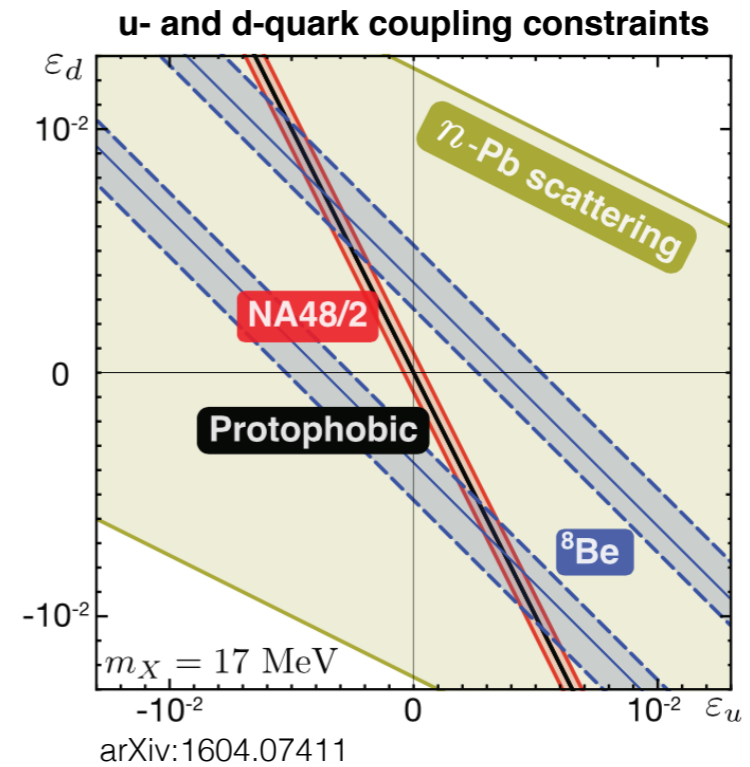
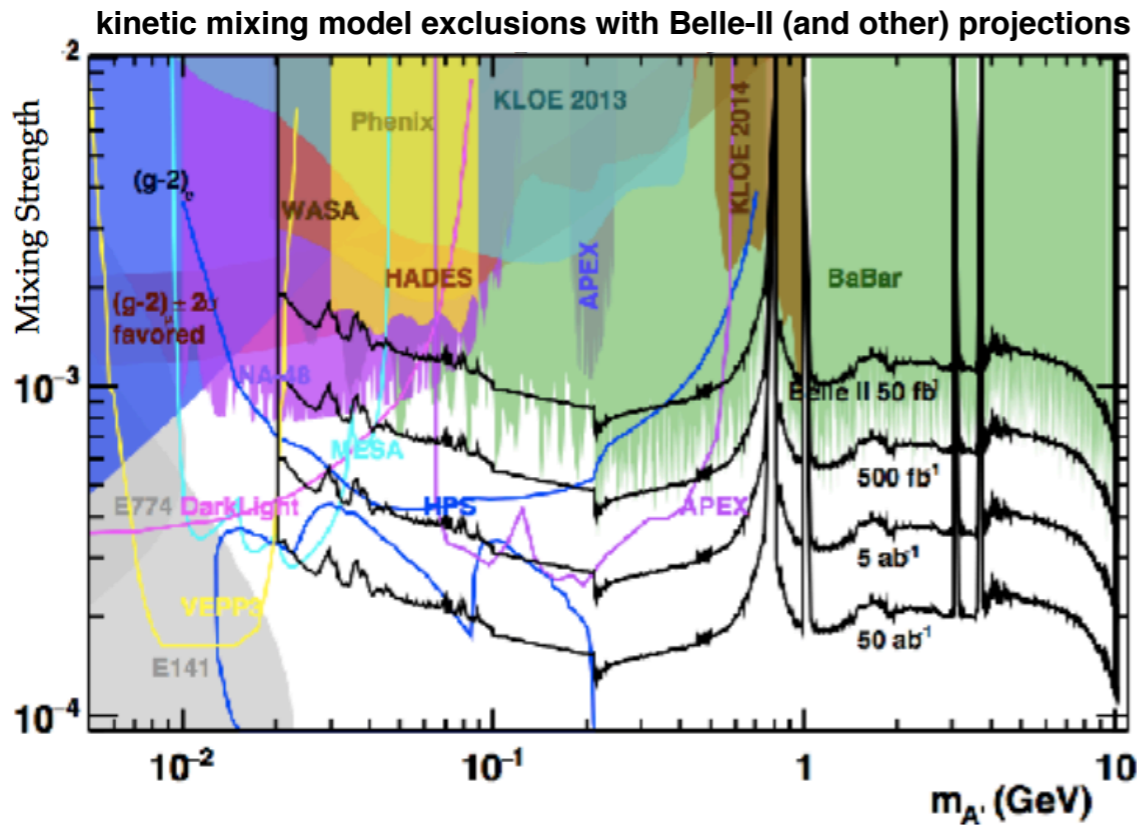
$$\frac{\epsilon}{2} F^{\mu\nu} F'_{\mu\nu}$$

- Generic new force could have flavor-dependent coupling:

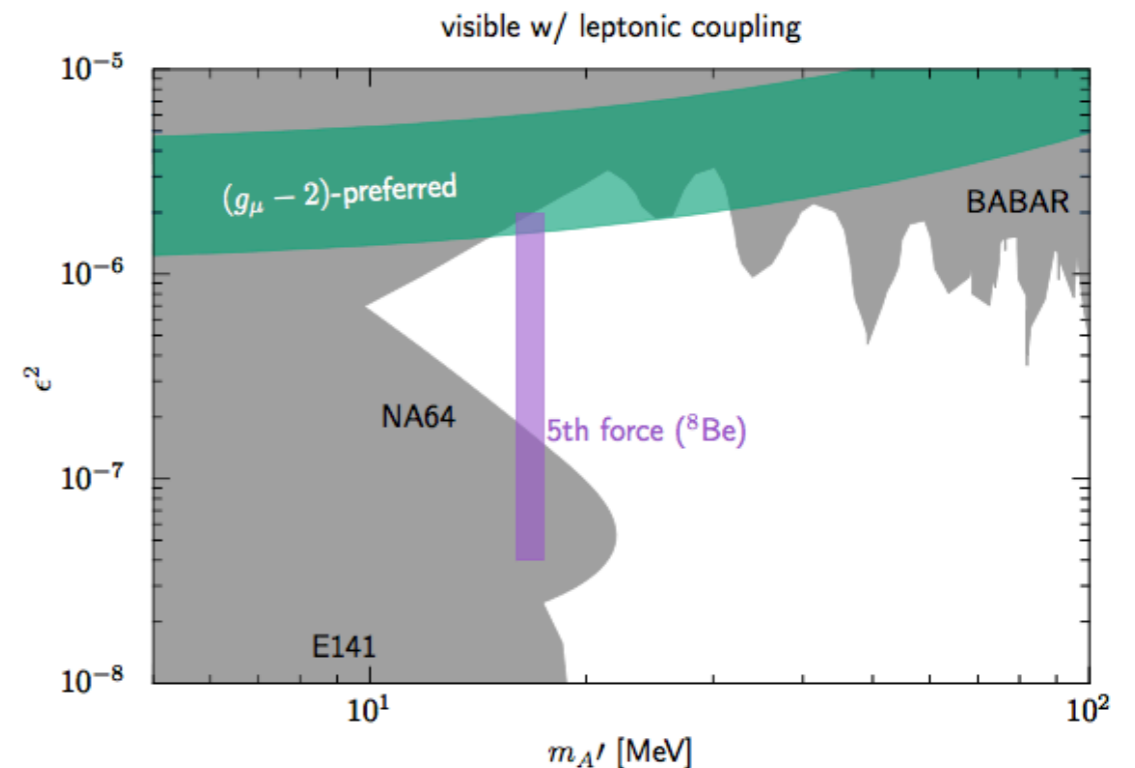
$$X^\mu (\sum_f e \epsilon_f \bar{f} \gamma_\mu f)$$

- Parameterized by coupling (ϵ_f) and mass

Direct Search Limits and Projections

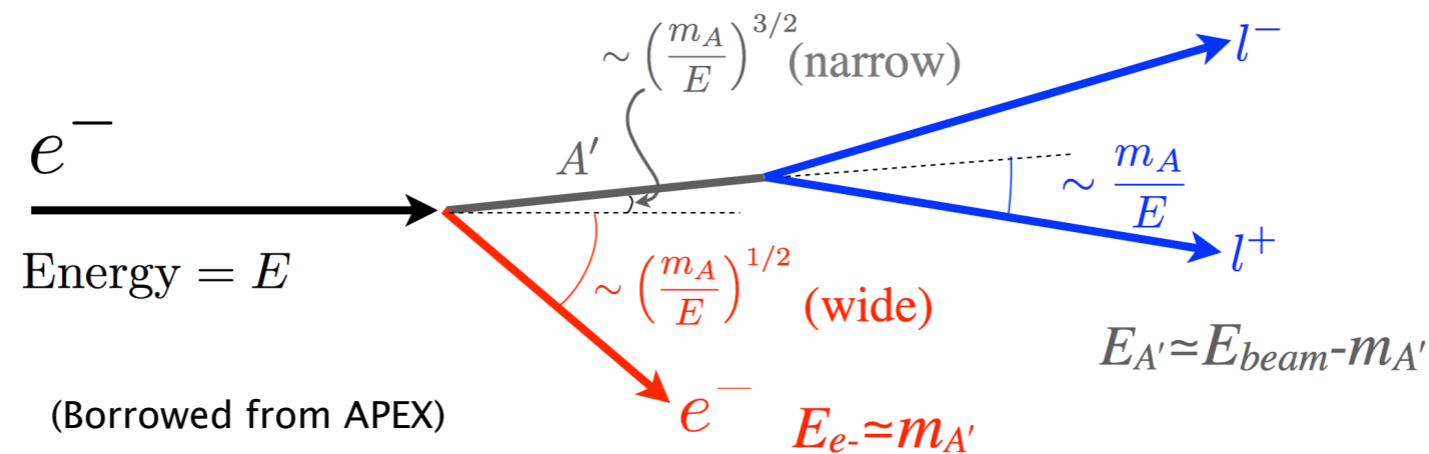


- Kinetic mixing disfavored by existing searches via hadronic production of A'
- Flavor-dependent couplings allows 'protophobic' solution
- **Purely leptonic production** key aspect of expanded search for this new particle
- X17 region can be reached with **low beam energy**



* $g-2$ preferred band does not include FNAL result

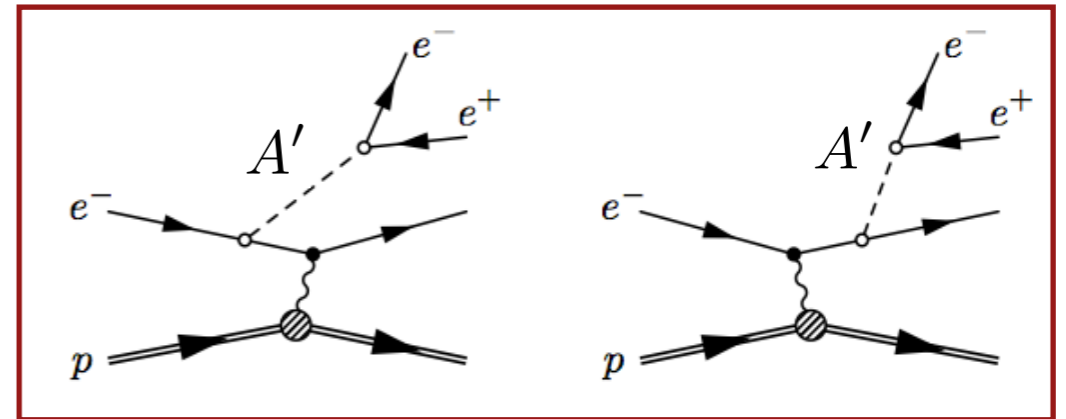
Searching at an e⁻ Accelerator



- Radiative production:

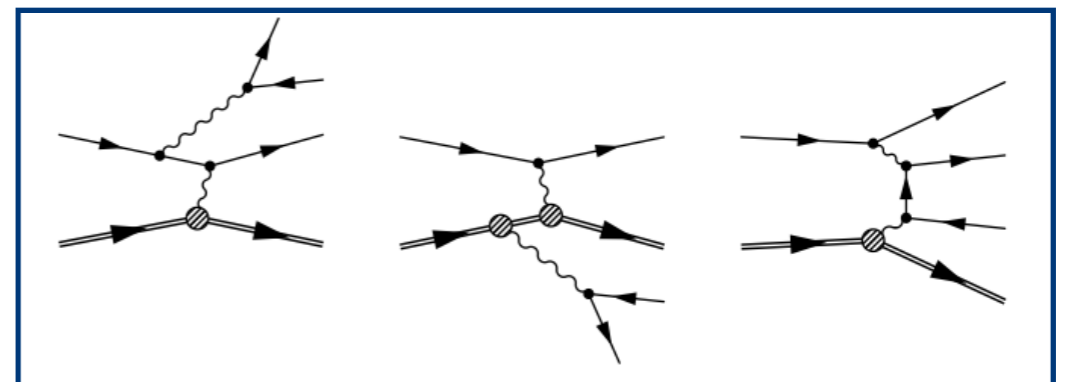
$$e^- + \text{Ta} \rightarrow e^- + \text{Ta} + A'$$

$$A' \rightarrow e^+ + e^-$$



- Irreducible QED background similar, but no mass peak:

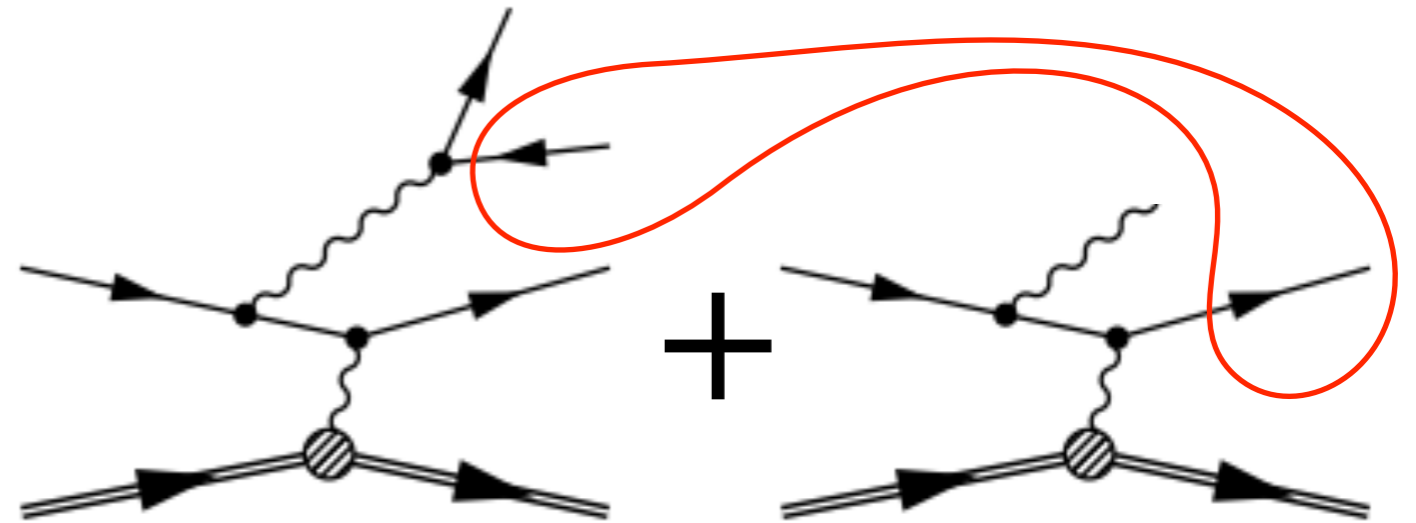
- $\text{FOM} \sim \frac{S}{\sqrt{B}}$



- Want to maximize integrated luminosity

Combinatoric Background

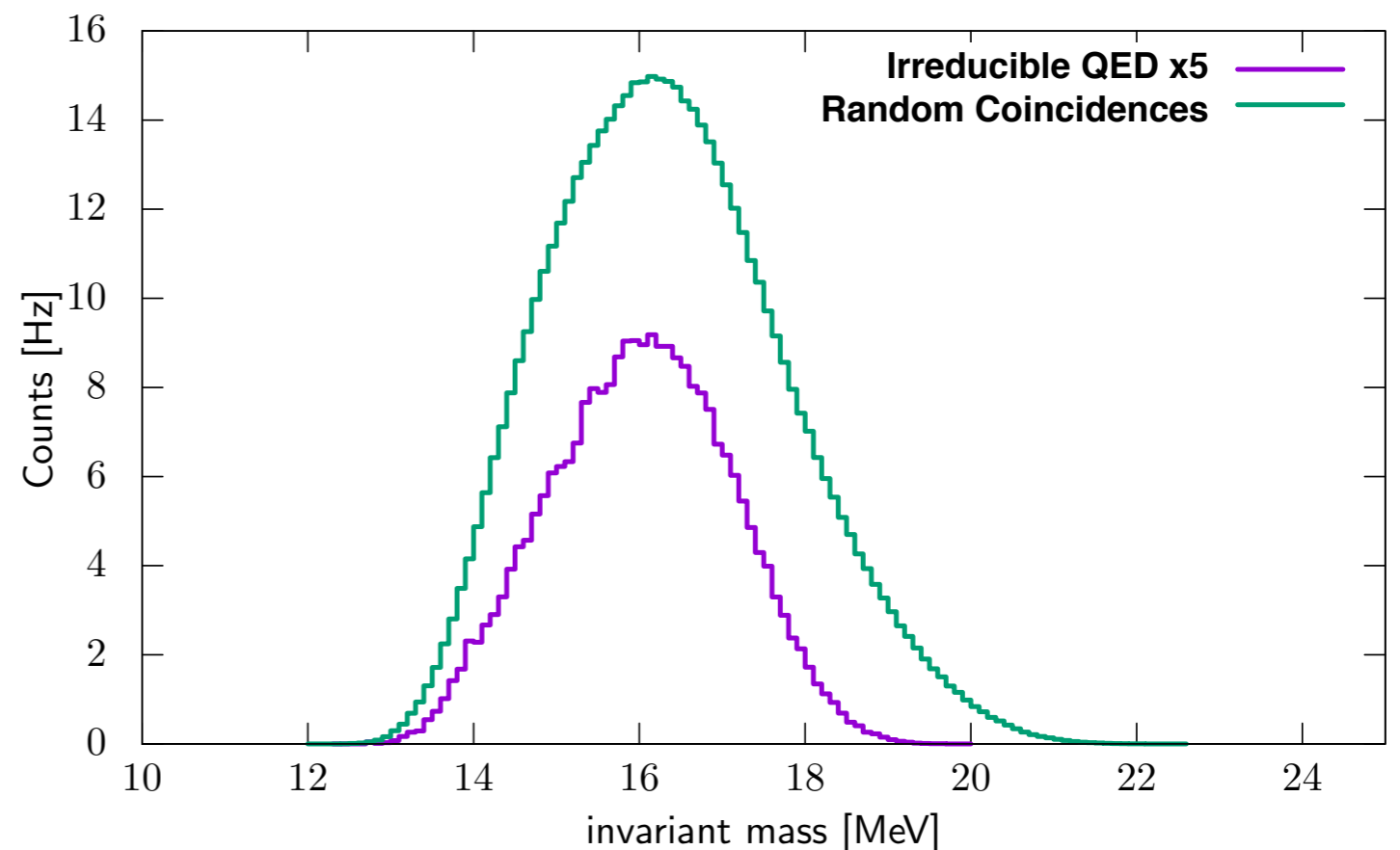
- Limited acceptance:
single e^+ far more likely
than complete e^+e^- pair
 \implies elastic e^- from
same bunch acts as
missing partner!



$$S \sim \mathcal{L} \quad \text{FOM} \sim \frac{S}{\sqrt{B}}$$

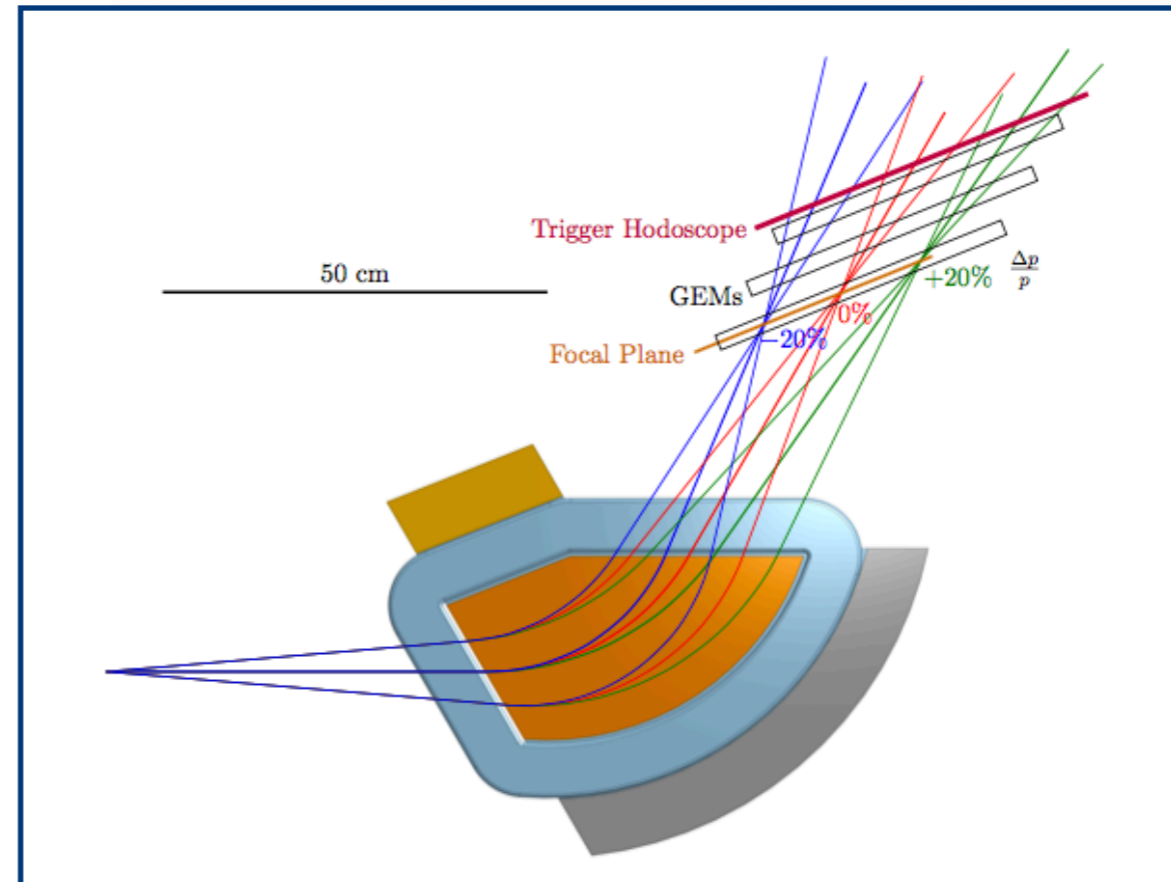
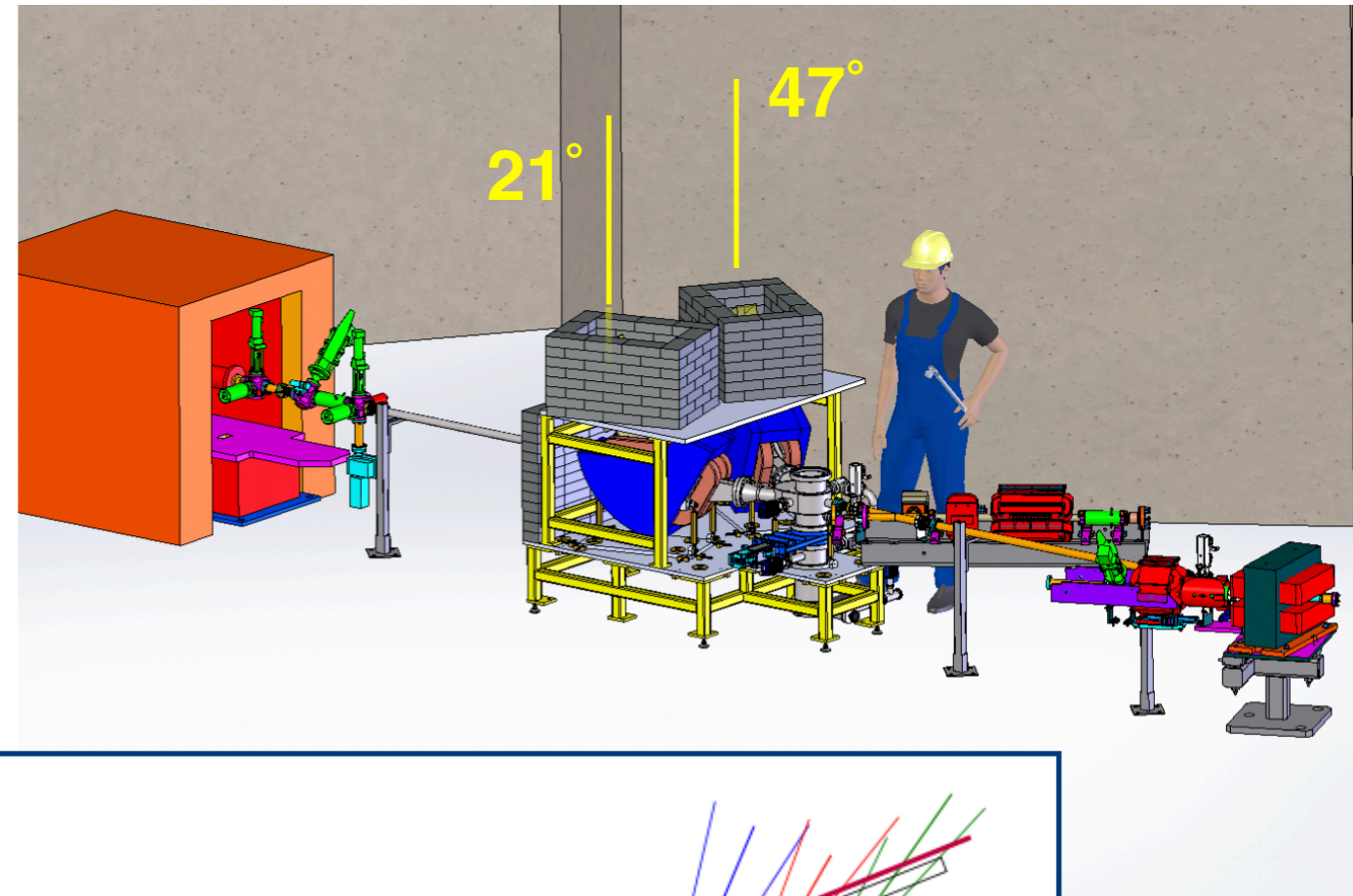
$$B \sim \mathcal{L}^2$$

- At high \mathcal{L} , FOM scales
with wall clock, not \mathcal{L}



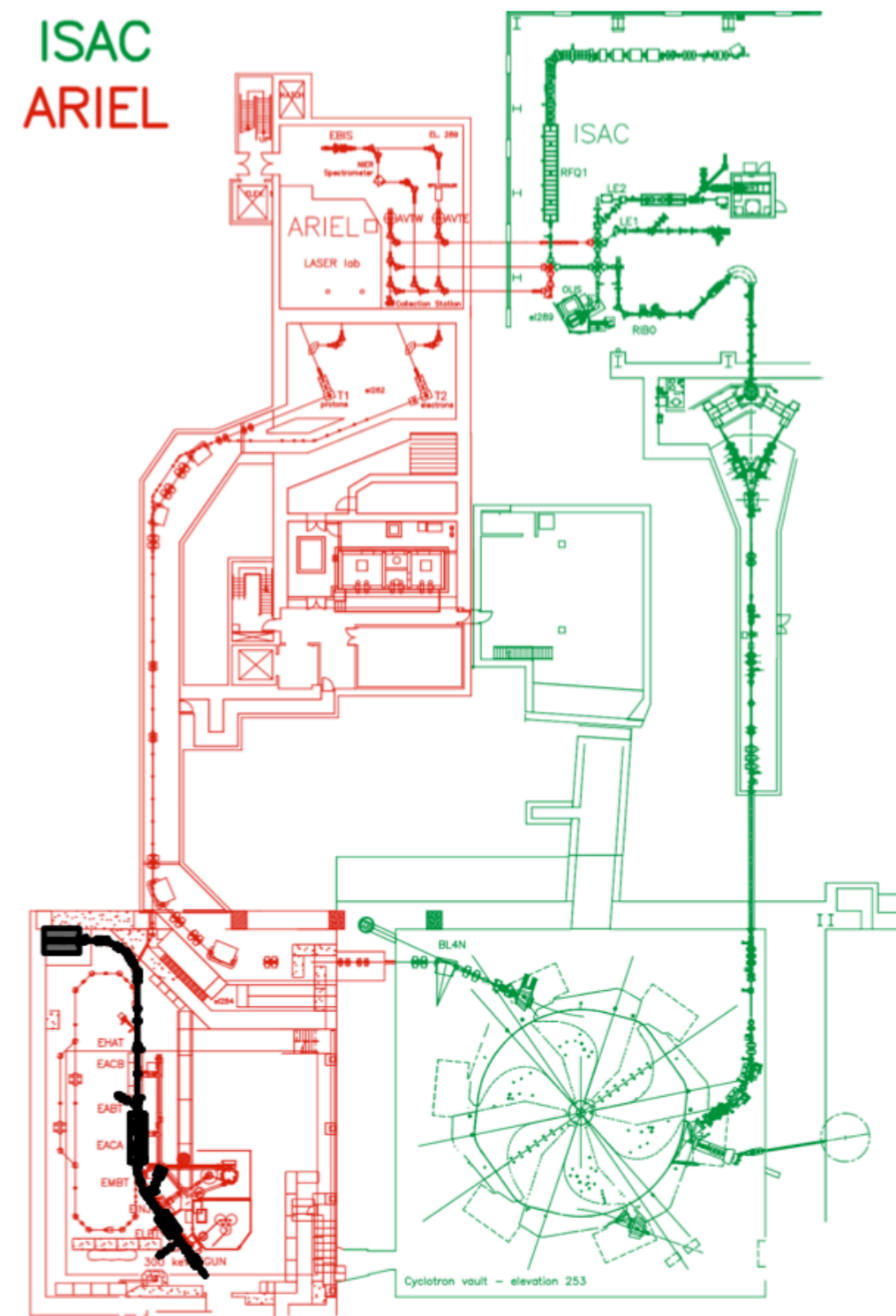
Detector Design

- Tantalum foil target
- Adjustable twin-arm spectrometer
- Asymmetric angle to optimize S/\sqrt{B} of e^+e^- against combinatorics
- GEM focal plane detectors w/ trigger hodoscopes
- Need high rate, low E electron beam



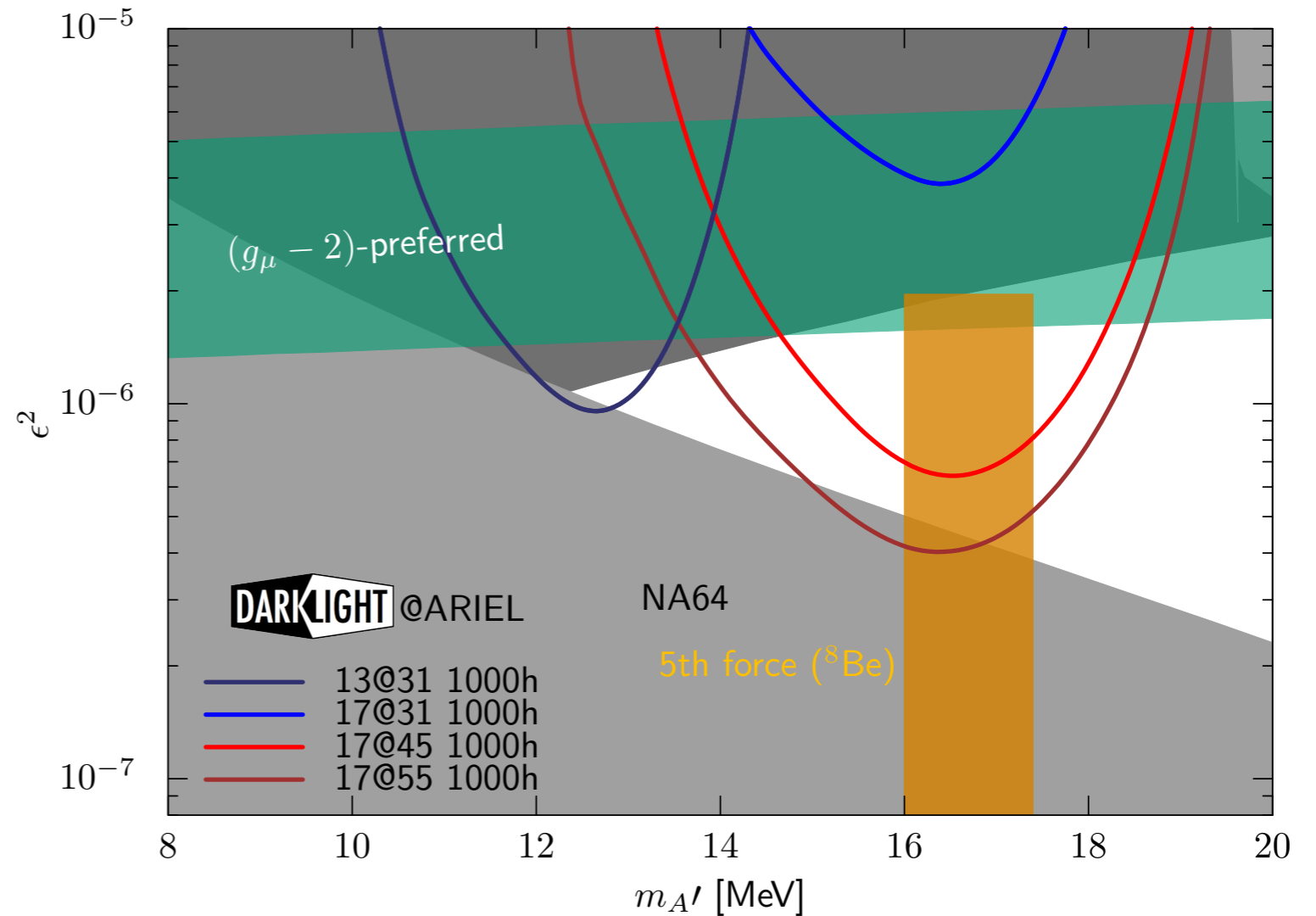
ARIEL

- Advanced Rare Isotope Lab being built at TRIUMF:
 - Nominal electron beam energy 50 MeV (optics designed for up to 75 MeV)
 - 650MHz gun, peak current up to 10 mA
- 31 MeV beam demonstrated, expect 10kW milestone in 2021.
- Later stages increase to 50+ MeV
- Proposal submitted to TRIUMF to operate detector in existing beamline



Projected Reach

- Current ARIEL config: commissioning and pilot searches @ 31 MeV
- With ARIEL upgrades: deeper search in X17 region possible



* $g-2$ preferred band does not include FNAL result

Outlook

- Several anomalies (including new $g-2$) are compatible with low-mass, nearly-protophobic force
- Can't probe effectively with pions
- Proposed search at ARIEL with asymmetric spectrometer pair, $O(1k)$ hour pilot search with upgrades possible
- On similar time scale, mixed-hadronic (LHCb etc) + pure-leptonic (this proposal) could provide complementary coverage of X17 region

The DarkLight Collaboration

R. Alarcon, R. Dipert, G. Randall
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