Improving Reach at ~GeV (High) A' Masses

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New Light Weakly Coupled Particle Session
CSS Conference
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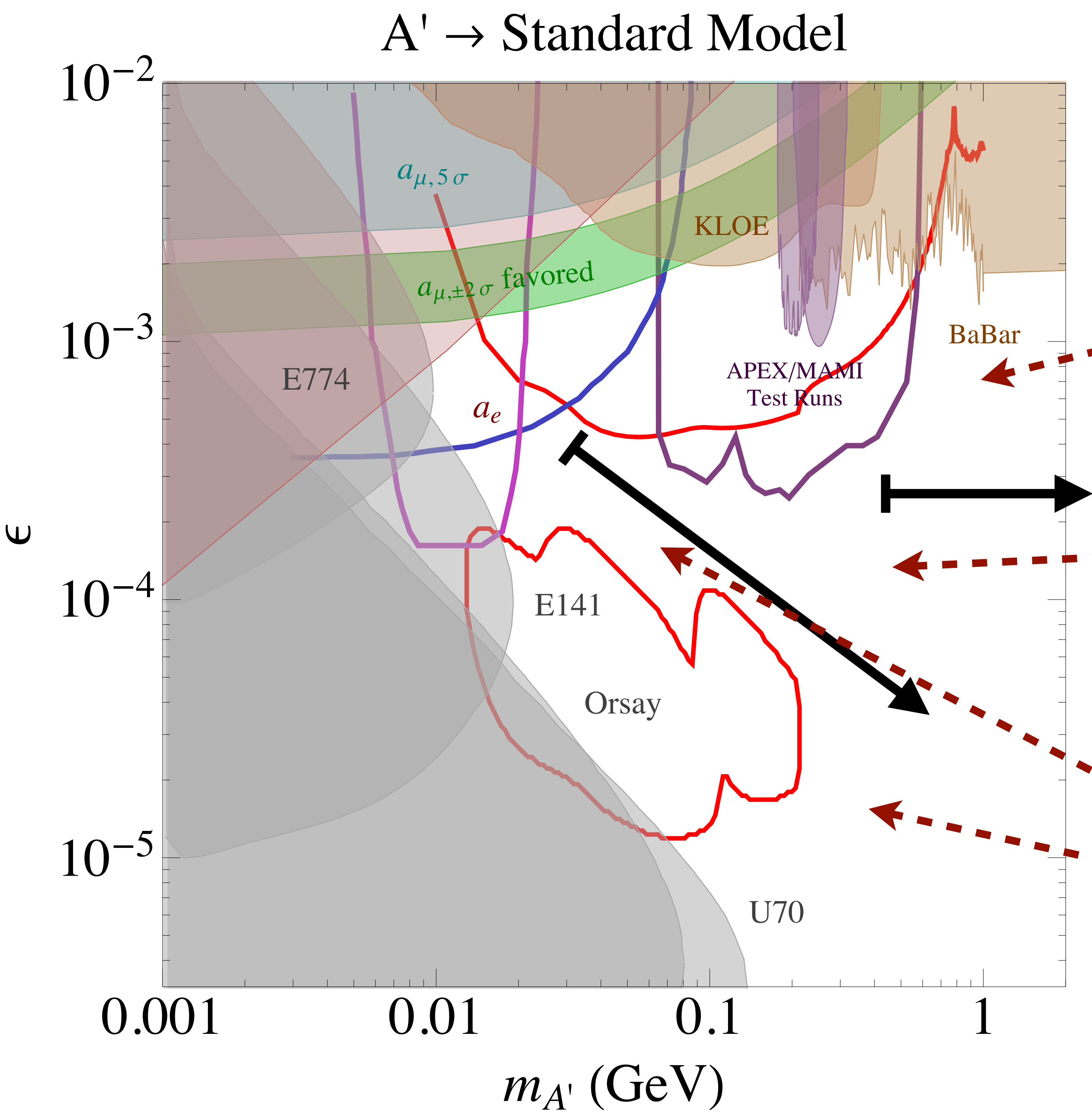
Directions for Improvement?

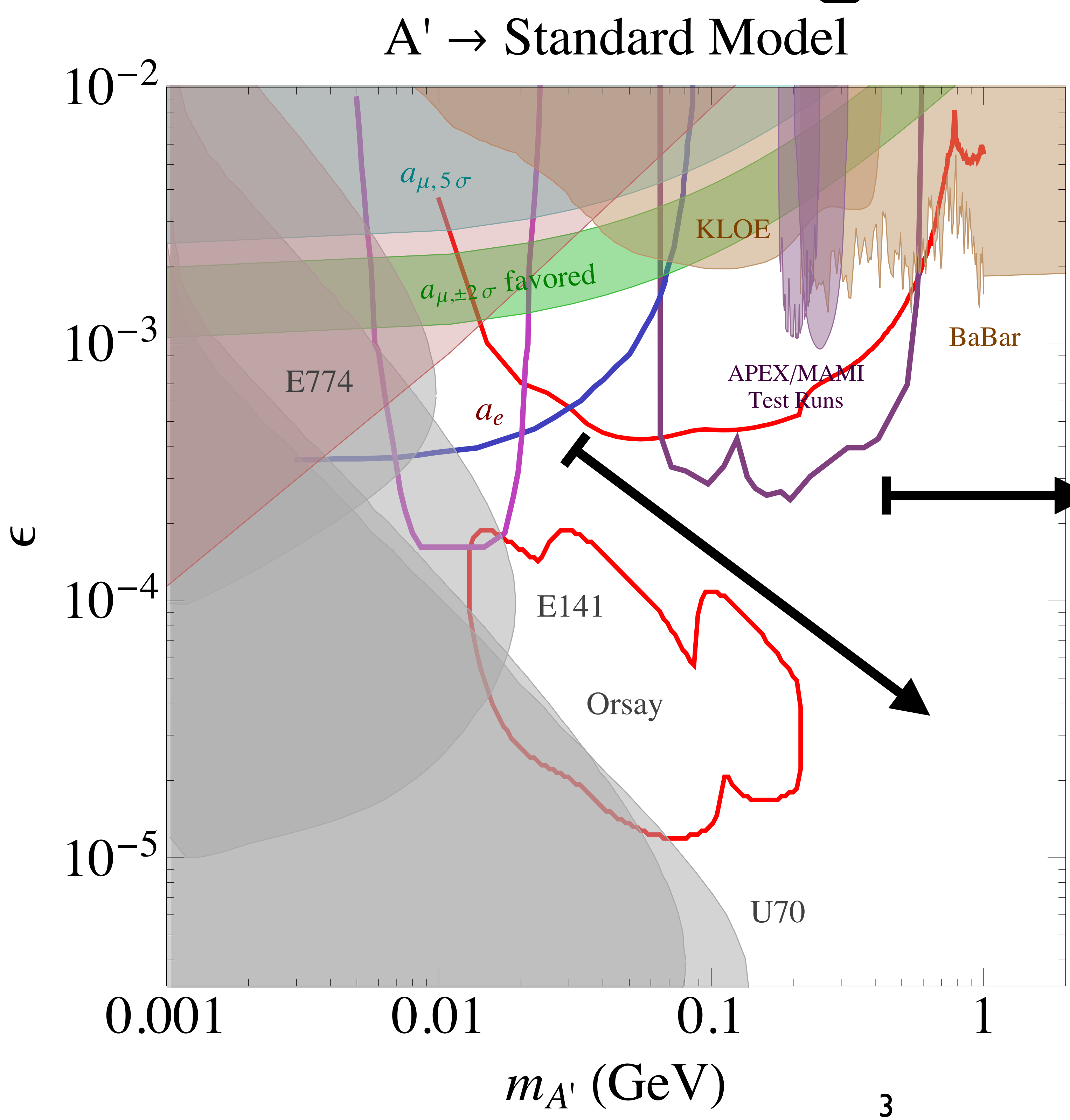


muons+pions acceptance

+ tolerance to high-current

Vertex precision (higher intensity?)

Why does everyone lose reach at high $m_{A'}$?



How do we improve high-mass sensitivity?

Can we go here with fixed-target?

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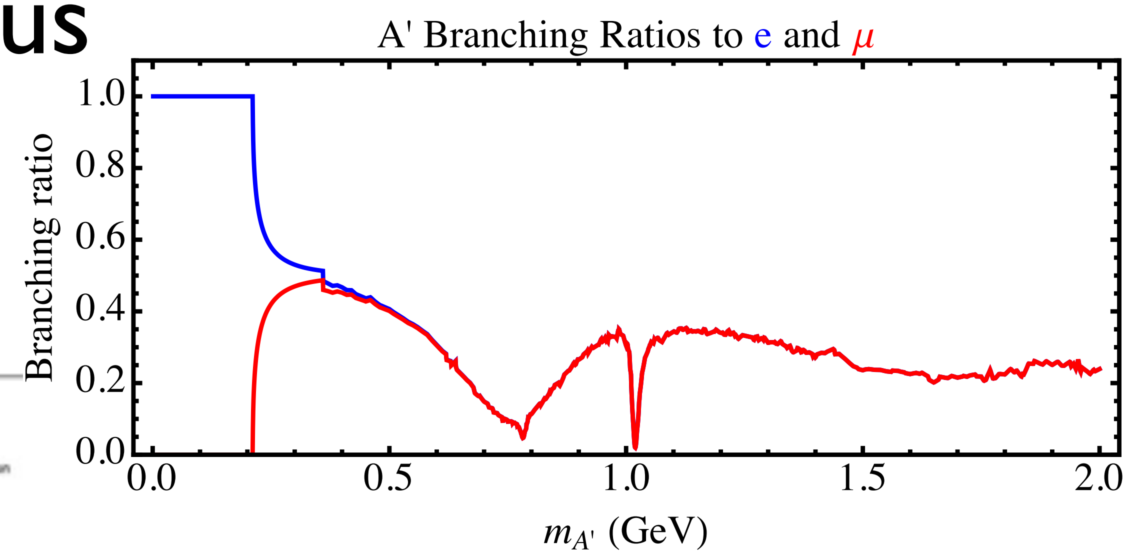
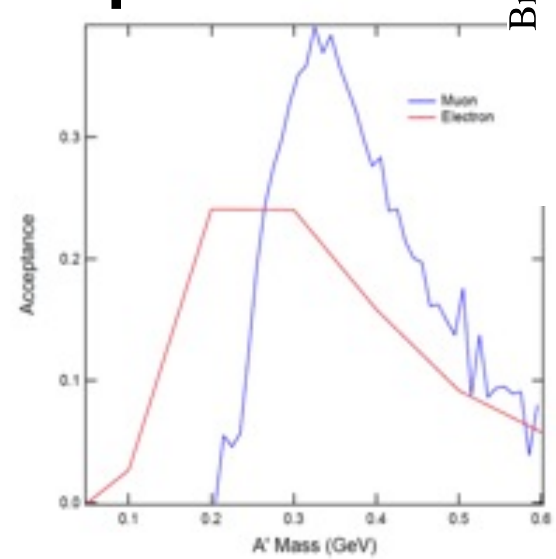
Why does everyone lose reach at high $m_{A'}$?

- $\sigma \sim 1/m_{A'}^2$ for point-like nucleus



- Falling B.R. for each species
- Acceptance cutoff



- Form factor

This is the biggest effect, and may be avoidable w/ low-Z target

Form factors at high A′ mass

A′ production cross-section: $\frac{d\sigma}{dx} \approx \frac{8\alpha^3\epsilon^2 x}{m_{A'}^2}\left(1 + \frac{x^2}{3(1-x)}\right) Z^2 \mathcal{L}og$
[BEST]

"Z² Log" is ~ integral of nuclear form factor over γ momenta

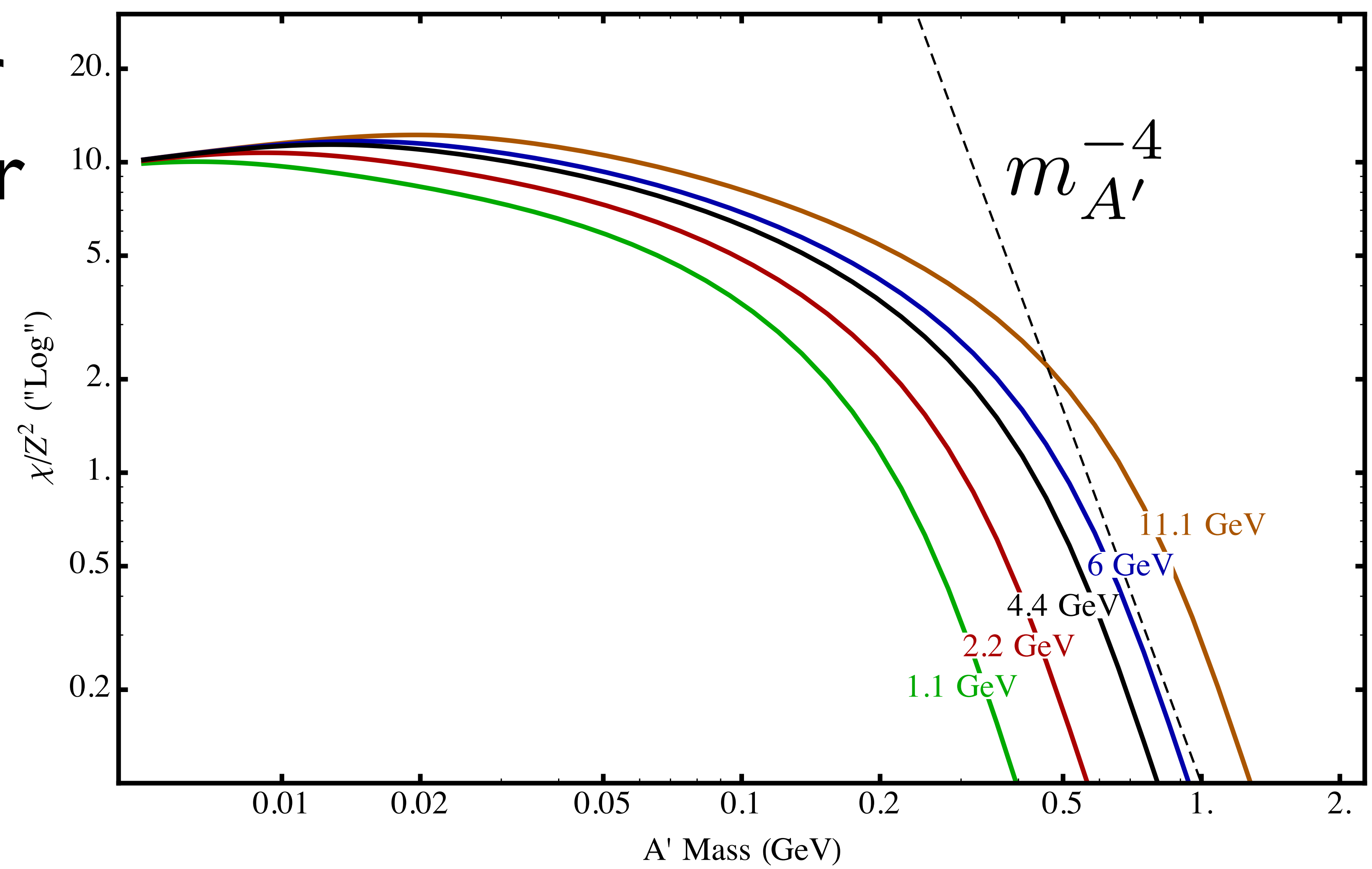
$$q \gtrsim q_{min} \equiv \frac{m_{A'}^2}{2E_{beam}}$$

Coherence lost for

$$q > 0.4\ \mathrm{GeV} A^{-1/3}$$

$$m_{A'} \gtrsim \sqrt{\mathrm{GeV}\ E_{beam} A^{-1/3}}$$

Gold Integrated Form Factors



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What about Z-dependence?

- $\sigma_{A'\text{ (low mass)}}$ ~Z^2 Log
- $\sigma_{A'\text{ (high mass)}}$ ~Z scattering off nucle*ons* (i.e. Log ~1/Z)

but

- σ_{brem} ~ Z^2 Log ⇒ X_0 ~ $1/Z^2$

Yield per e⁻ per target thickness in r.l. $\frac{N_{A'}}{N_e T} \sim Log(m_{A'}) \frac{\alpha^3 \epsilon^2}{m_{A'}^2}$

is independent of Z for low $m_{A'}$ and ~1/Z for high $m_{A'}$.

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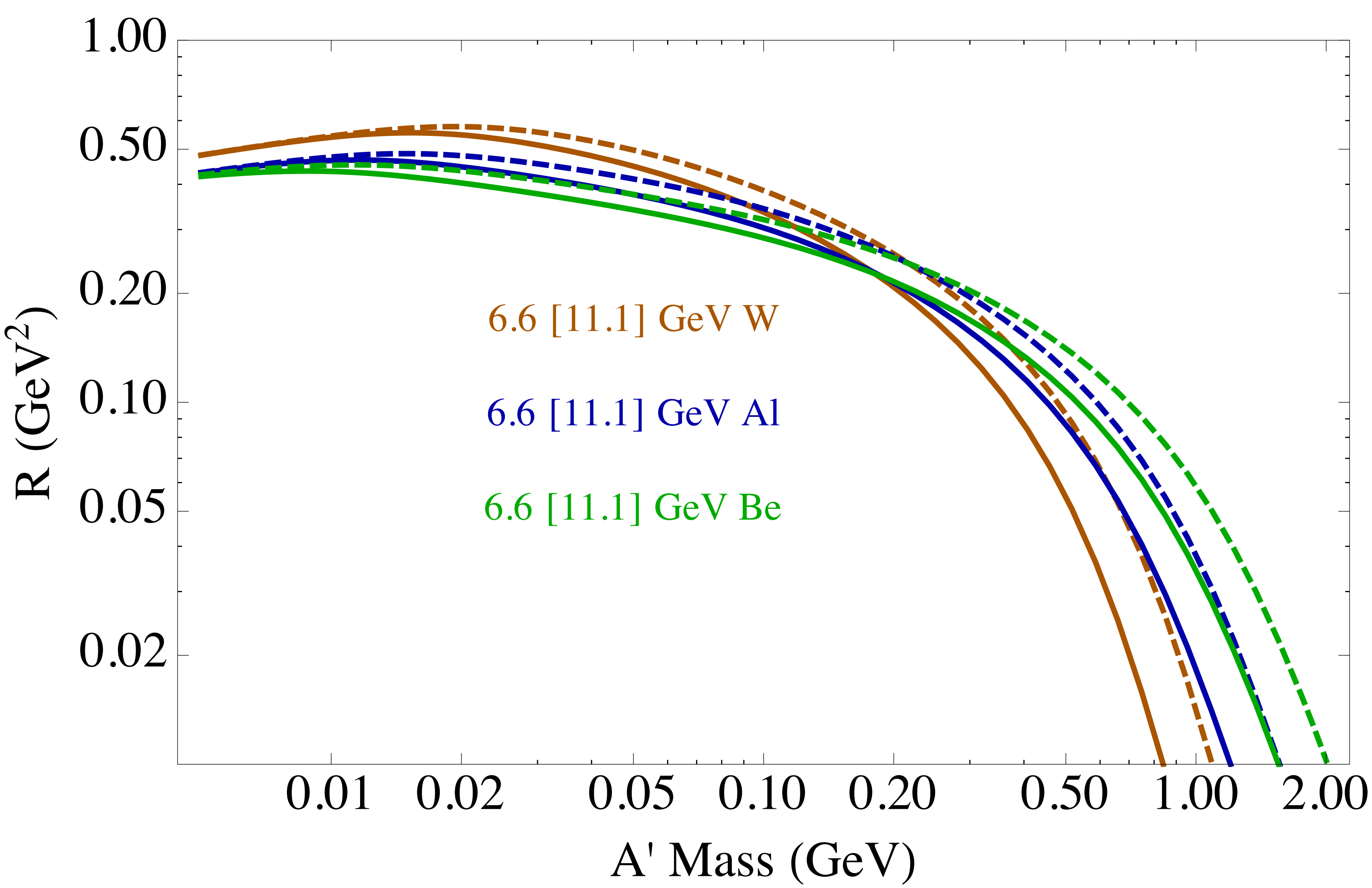
What about Z-dependence?

Yield = (Particle Physics Factor) x (Nuclear Physics Factor)

WW effective photon cross-section ~ $1/m^2$

R=(eff. photon flux) x (column density)

$R = \chi X_0 N_0/A$ "A' production efficiency"



How much does lower Z buy you?

R[anything]/R[W] for same $m_{A'}$ & E_{beam}

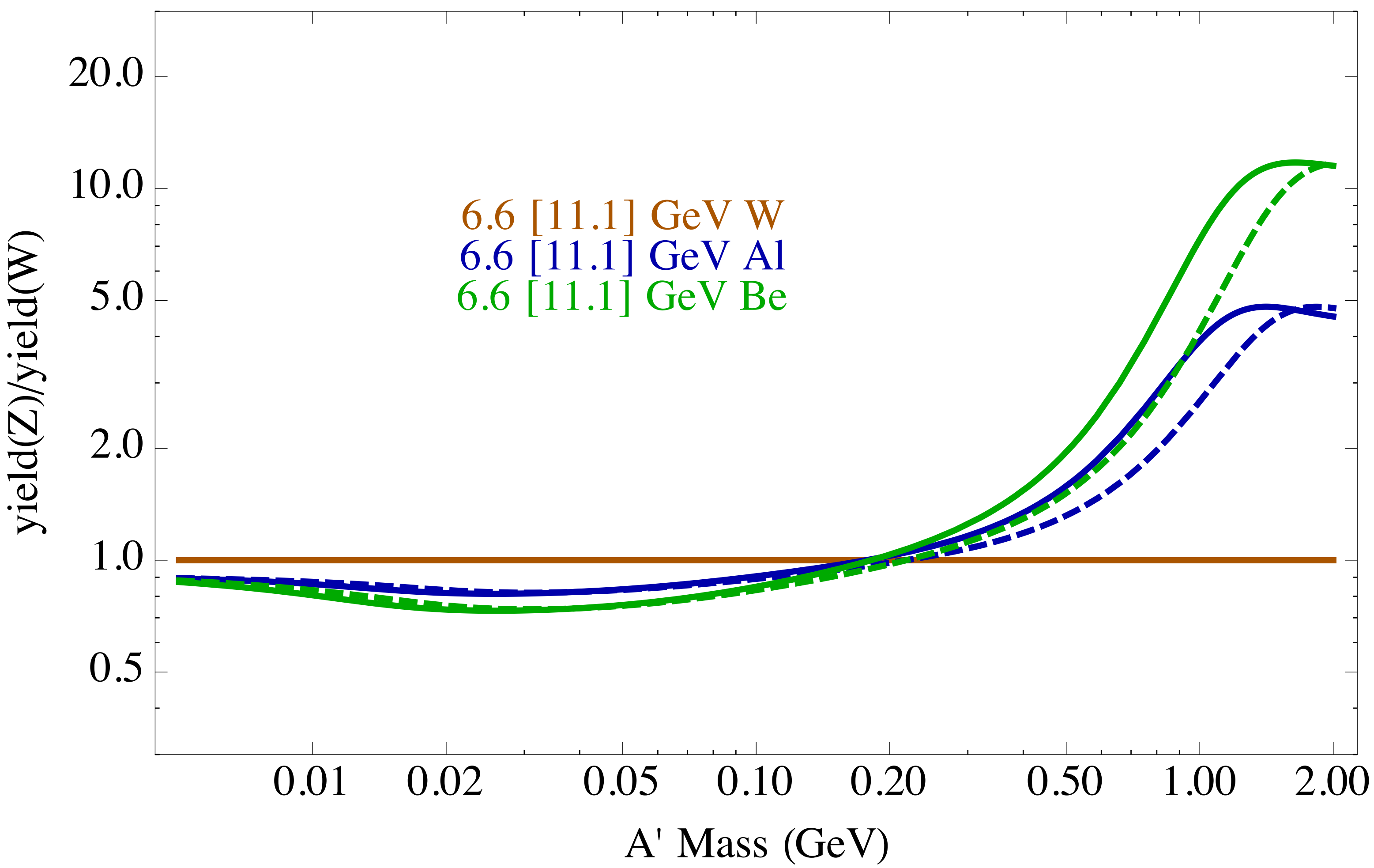
What about Z-dependence?

Yield = (Particle Physics Factor) x (Nuclear Physics Factor)

WW effective photon cross-section ~ $1/m^2$

R=(eff. photon flux) x (column density)

Yield(Z)/Yield(W) [Dashed = 11.1 GeV]



R[X]/R[W] for same $m_{A'}$, E_{beam}.

At high mass:

C or Be buys up to factor of 12 over W (~ ratio of Z's)

Al buys up to factor of 5

Low-Z better for high mass

Practical Issues with low Z?

- $\sigma_{A'}$ (low mass) $\sim Z^2$ Log
- $\sigma_{A'}$ (high mass) $\sim Z$ scattering off nucle*ons* (i.e. Log ~1/Z)

- $\sigma_{brem} \sim Z^2$ Log $\Rightarrow$ $X_0 \sim 1/Z^2$

Yield per e⁻ per target thickness (in r.l.) $\frac{N_{A'}}{N_e T} \sim Log \frac{\alpha^3 \epsilon^2}{m_{A'}^2}$

is independent of Z for low $m_{A'}$, ~1/Z for high $m_{A'}$.

e^-/e^+ singles and e^+e^- pair are mainly from Coulomb & trident processes with $\sigma \sim Z^2$

$\Rightarrow$ yield per r.l. approximately indep. of Z

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- σ_{π} ~ A   ($\sigma_{\pi+\pi}$ ~ ??)

  Yield of pions per r.l. ~ A/Z^2

Switching to C, Be, (Al) would raise **pion** bkgs by factor of 10–15 (~5)

Summary & Discussion

- Low-Z target for 11 GeV beam (6 GeV?) may be advantageous
- Low Z may increase statistics x 5–10 for $m_{A'}$>0.5 GeV $\Rightarrow$ 2–3 in α'/α
  - Strategy will be limited by π backgrounds
- Need a better understanding of
  - pion contrib. to trigger, occupancy, etc. at 6, 11 GeV

    π^+e^- fraction of fixed-target trigger rate?
  - Sources & effects of $\pi^+\pi^-$ backgrounds
  - Gains vs. acceptance as function of mass
  - Engineering issues