DARKLIGHT 1c

DarkLight 1c at ARIEL/TRIUMF

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RBRC
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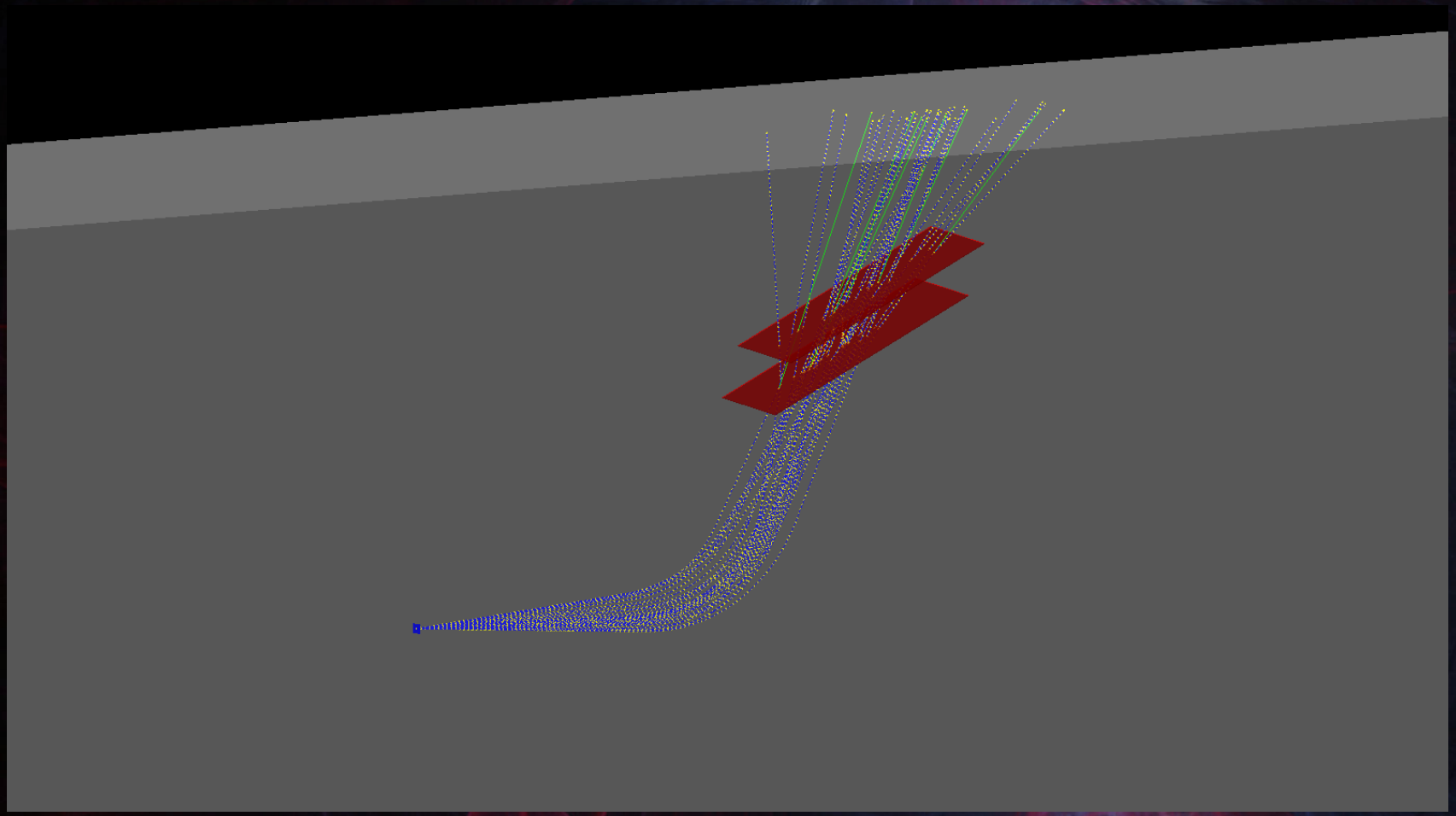
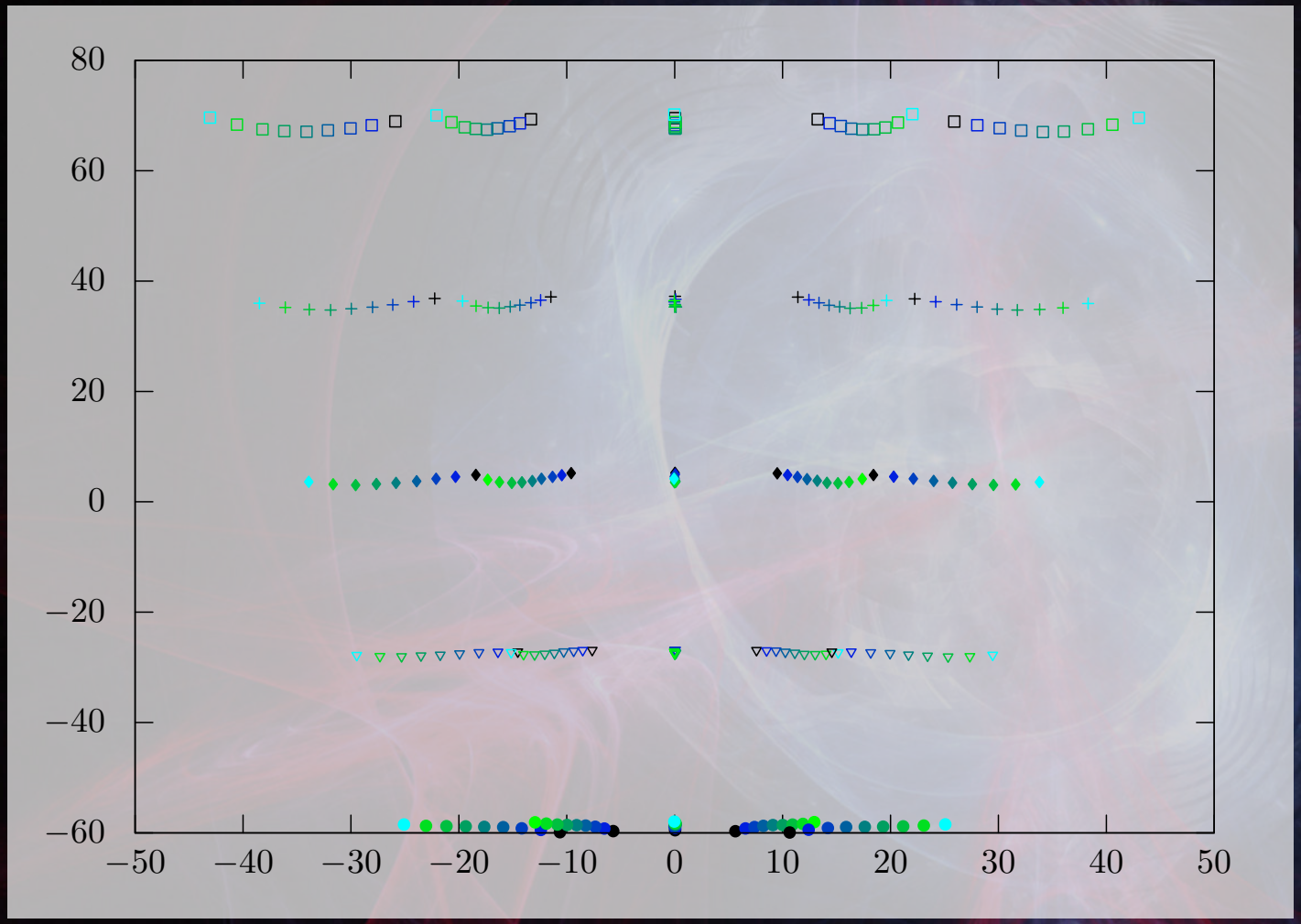
Magnetic field implemented in GEANT4



Thanks to Xiaqing, Bobby, Ernie, Chris

Focal plane image



Symbol↔momentum. Color↔out-of-plane angle.

Spec mapping

- Momentum $p \leftrightarrow$ dispersive focal plane direction x
- In-plane angle $\Phi \leftrightarrow$ non-dispersive focal plane direction y (and dx)
- out-of-plane angle $\Theta \leftrightarrow$ dispersive focal plane slope dx

Mass effects

- dx measured via two GEMs. First GEM essentially destroys information
  - out-of plane from $\pm 0.043^\circ$ to $\pm 2.7^\circ$
  - This also affects extraction of in-plane angle: $\pm 0.068^\circ$ to $\pm 0.133^\circ$
  - The latter could be rescued with a better optic
- Target mass for 10 (1) um tantalum for large-angle spec:
  - out-of-plane: 2.8° (2.7)
  - in-plane: 0.878° (0.290)

Interestingly, symmetric angle config is slightly worse!

What does that mean for the reconstructed mass?

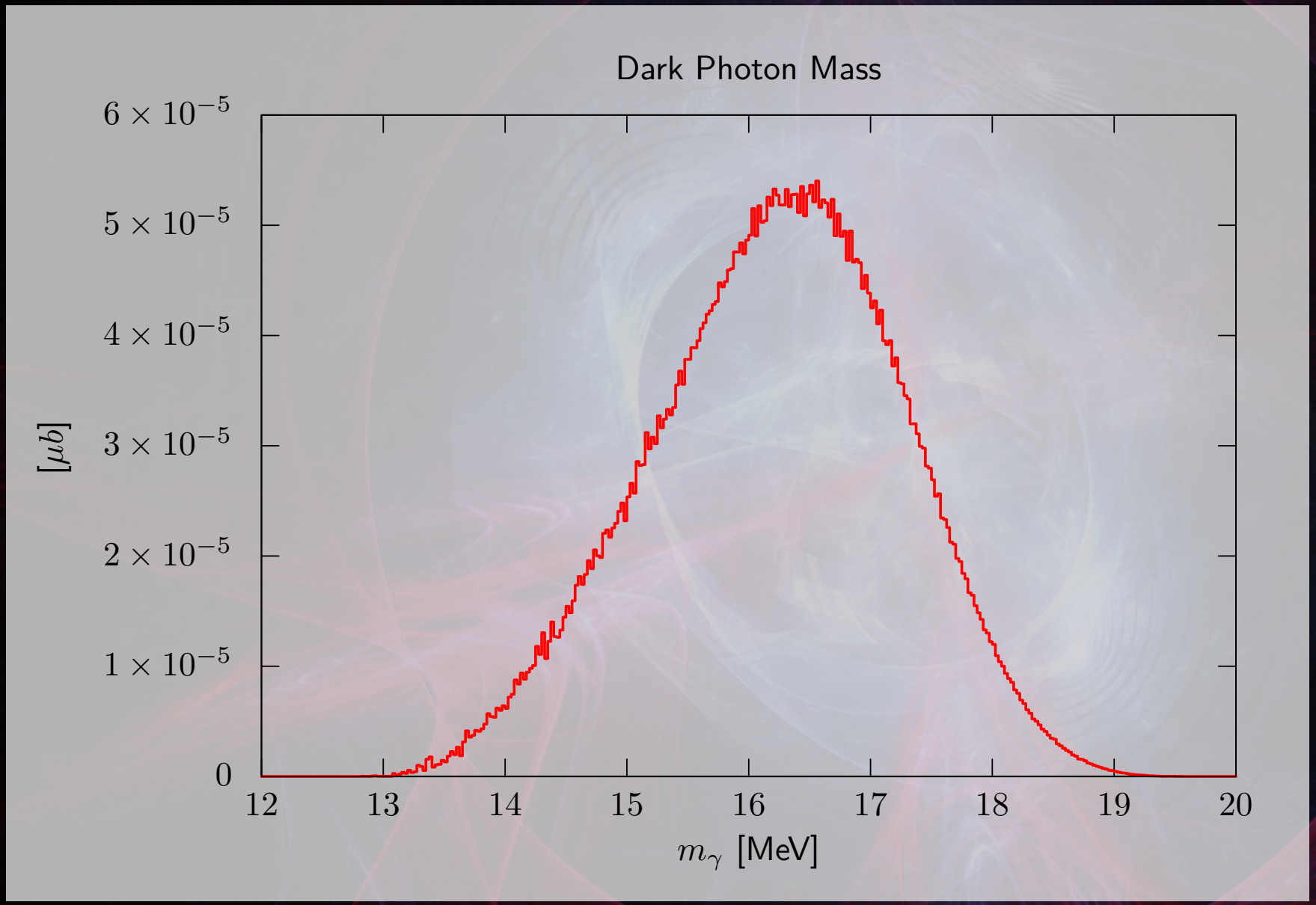
- To get all correlations right, I propagated both arms through GEANT4, and reconstructed the mass
- Only 1 um target.
- At 45 MeV, we get about 130 keV resolution
- At 32 MeV, we get about 110 keV resolution
- 10 um is so wide that it's worthless.
- We could forgo the second GEM plane.

Looked at four setups

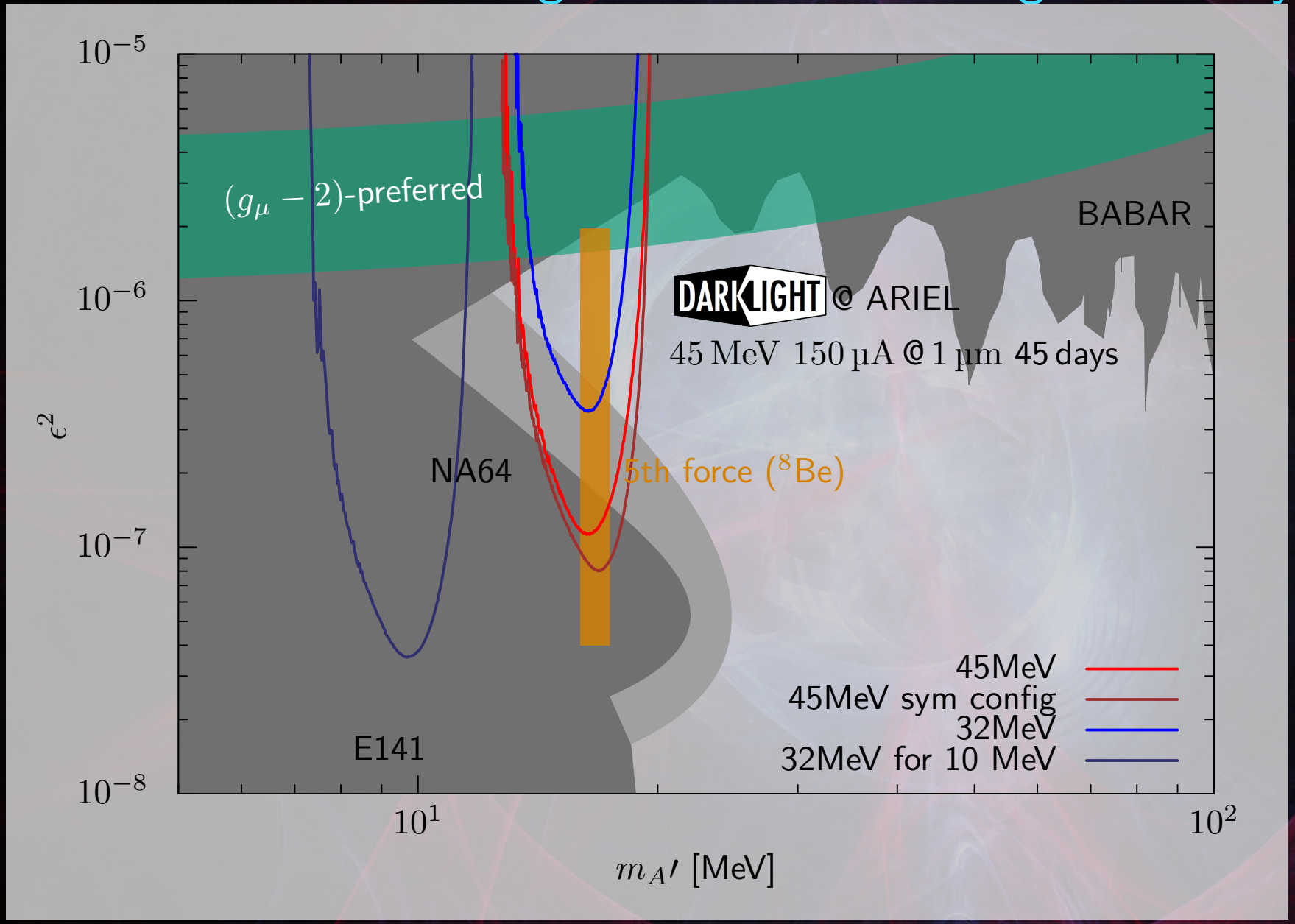
- 17@45: Search for the 17 MeV particle using 45 beam, asymmetric angles
- 17@45sym: Same, symmetric spectrometer angles
- 17@32: Search for 17 MeV at 32 MeV beam energy
- 10@32: Search at 10 MeV at 32 MeV beam energy

Setup	Beam p MeV	central m_X MeV	e^+ p MeV	e^+ θ	e^- p MeV	e^- θ
17@45	45	17	28	16°	15	33.5°
17@45 sym	45	17	21	24°	21	24°
17@32	32	17	18.5	23°	11.5	49°
10@32	32	10	17	16.5°	13	22.5°

Acceptance


Dark Photon Mass
6×10^{-5}
5×10^{-5}
4×10^{-5}
3×10^{-5}
2×10^{-5}
1×10^{-5}
0
$[\mu b]$
12
13
14
15
16
17
18
19
20
m_γ [MeV]

Reach for 1000h, 1um target, irreducible background only



Background rates

Assuming 150uA on 1um tantalum or equivalent (see below)

Setup	irreducible	e^+	e^- rad	rnd coinc 1 ns window	trigger rate
17@45	30.5	47k	2M	93	123
17@45sym	17.6	16k	7.6M	121	139
17@32	2.5	20k	800k	16.3	18.8
10@32	191	78k	16M	1246	1.4k

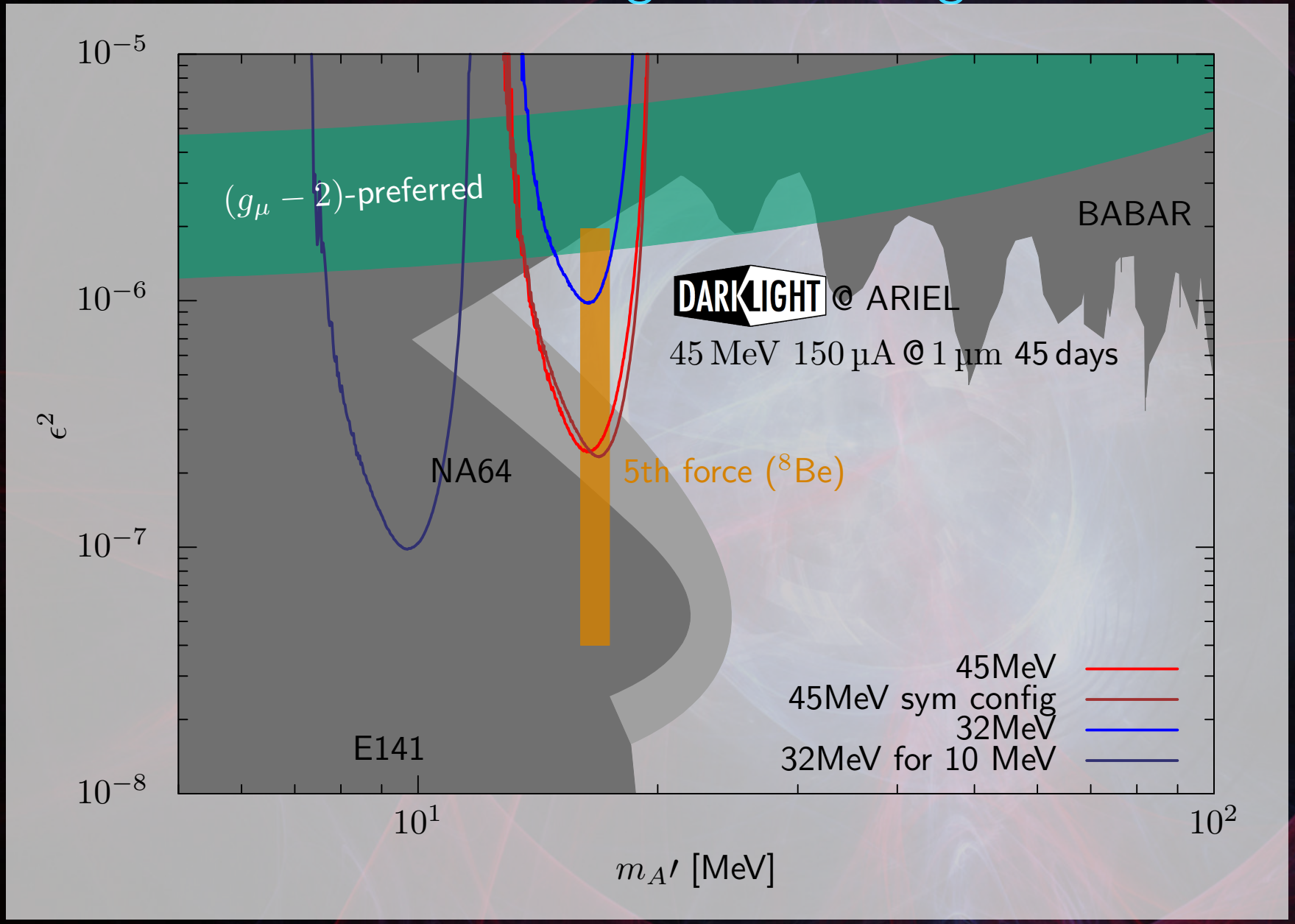
For now, I assume the same shape as the irreducible background.

Scaled by trigger rate/irr. rate

Comments

- Do not need to achieve 1ns res online – rates are low enough except for 10@32
- Reduce lumi for 10@32?
- Rates low enough that GEM readout ghosts not a problem.

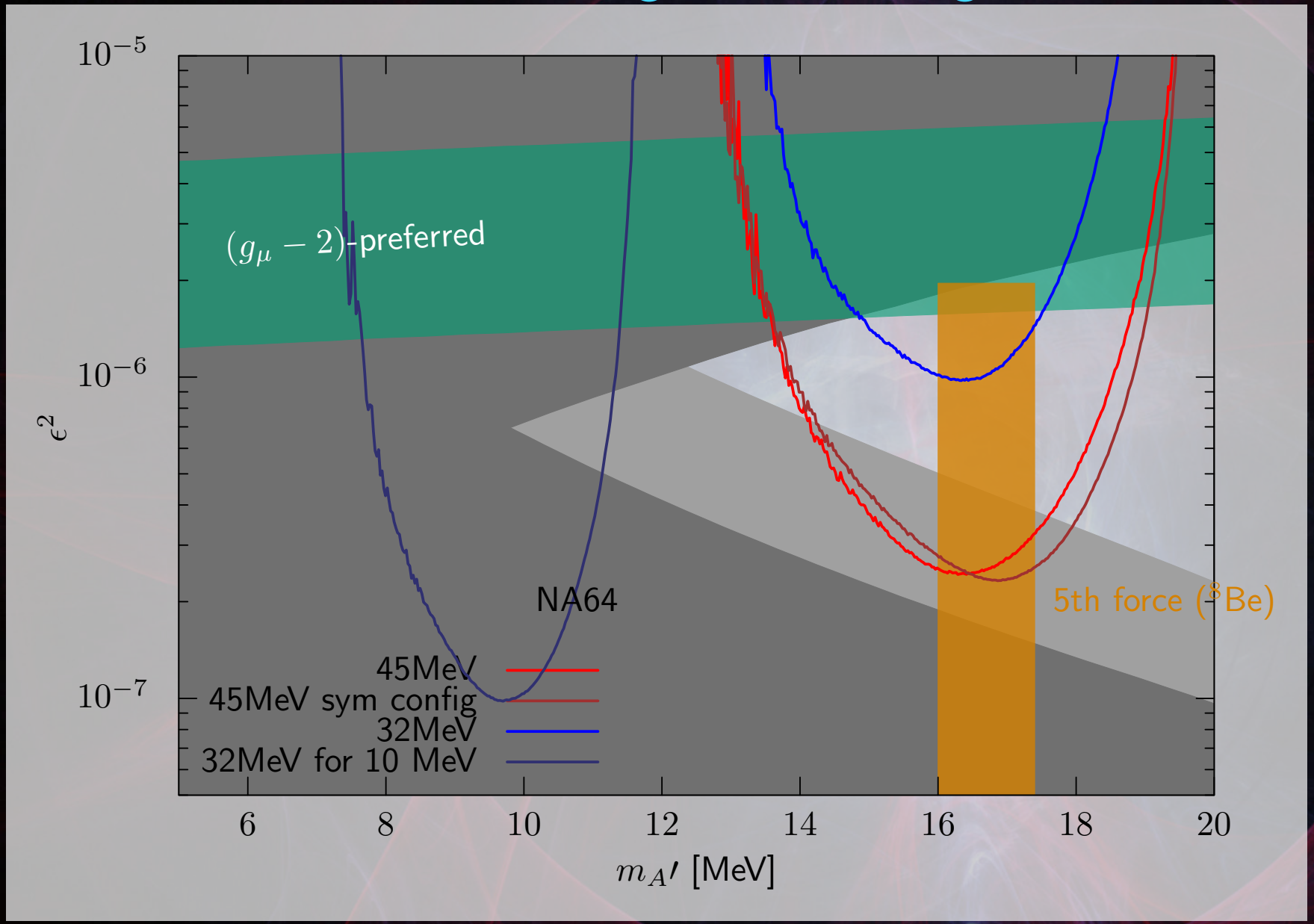
Reach for 1000h and 1um target, full background



32 MeV program

- 100 h at 1/10 of luminosity gives us coverage of the g-2 band
- Could also aim at 13 MeV. Estimate coverage of light gray area in O(1000 h)

Reach for 1000h and 1um target, full background



Alternative target material

Material	rel Z^2	rel. rad length	FOM
Ta	1	1	1
Au	1.17	0.816	0.96
Cu	0.158	3.5	0.55
C	0.0068	47.19	0.31
W	1.028	0.856	0.88
Si	0.037	22.9	0.84
Ti	0.091	8.7	0.79
Al	0.032	21.7	0.69
Hf	0.97	1.26	1.23
Zr	0.30	3.83	1.15
Ge	0.19	5.6	1.08