X17 Beam Energy Discussion

Chao, Rafo, and Tyler

Proposal compared to the current schedule

Proposal

Energy	PAC Days
2.2 GeV (@50nA)	20
3.3 GeV (@100nA)	30

Current Schedule

Energy	PAC Days
2.2 GeV	15.5
4.4 GeV	24.5

Background Generation

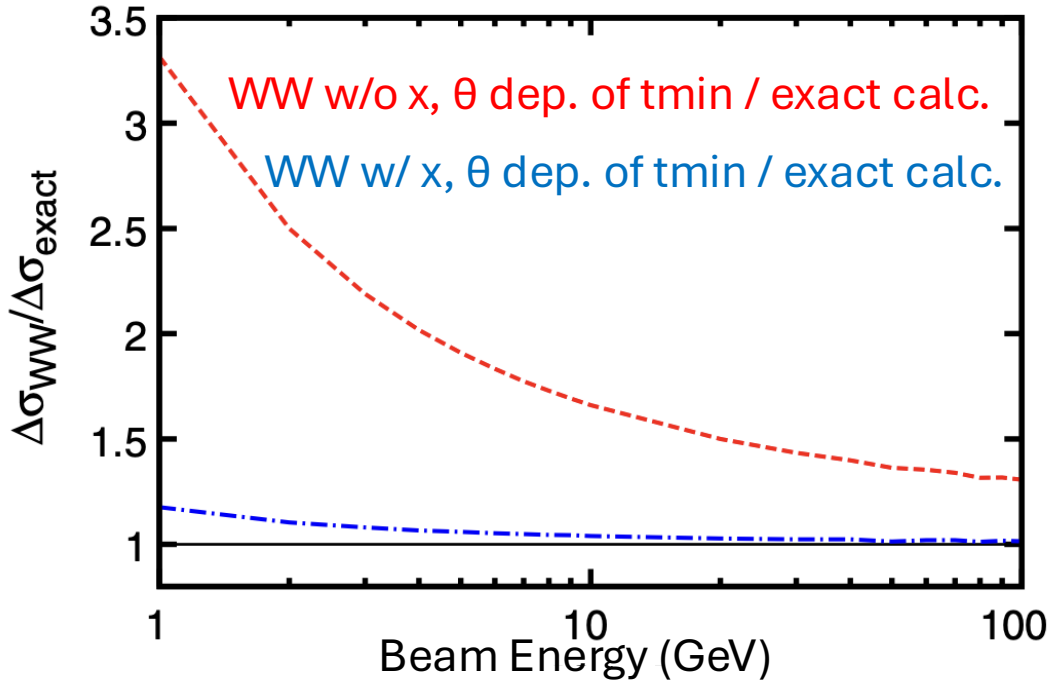
- For the *proposal*, we used Geant4 for all processes except Bethe-Heitler and then used MadGraph (5?) for Bethe-Heitler
- For the current studies, the backgrounds are generated using MadGraph5
  - The processes generated are Bethe-Heitler, Radiative Tridents, Wide Angle Bremsstrahlung, and corresponding interference terms
  - The procedure for generating the background has been benchmarked against HPS data on tape
- 10 Million events for each beam energy

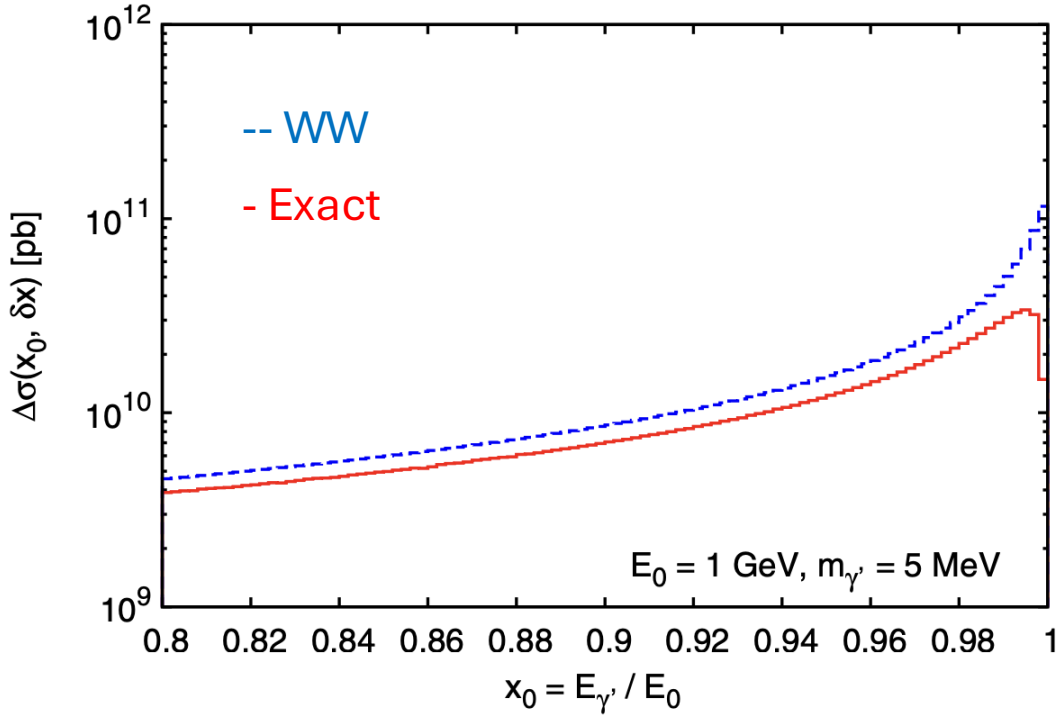
Signal Generation

- MadGraph5 used to generate ~50k signal events for each beam energy and mass setting
  - Masses studied are 10, 17, 25, 35, and 55 MeV.
- MadGraph5 solves for the amplitude of the process, leading to a more accurate distribution than the Weizacker Williams approximation used last time this was discussed

Signal Cross Section

- MG5 signal is more realistic, but absolute scale is far from benchmarks in literature
- Using the WW for integrated cross section to set the scale
- My WW implementation has x, θ dependence of tmin
- Realistic distribution broadens high x peak -> more acceptance!





Figures from: T. Beranek and M. Vanderhaeghen, Study of the discovery potential for hidden photon emission at future electron scattering fixed-target experiments Phys. Rev. D **89** https://doi.org/10.1103/PhysRevD.89.055006

Simulation

- All events passed through Geant4 geometry of X17 setup
- Uses virtual detector with real resolutions to smear
- Fixed 85% efficiency applied to be conservative

Signal Acceptance

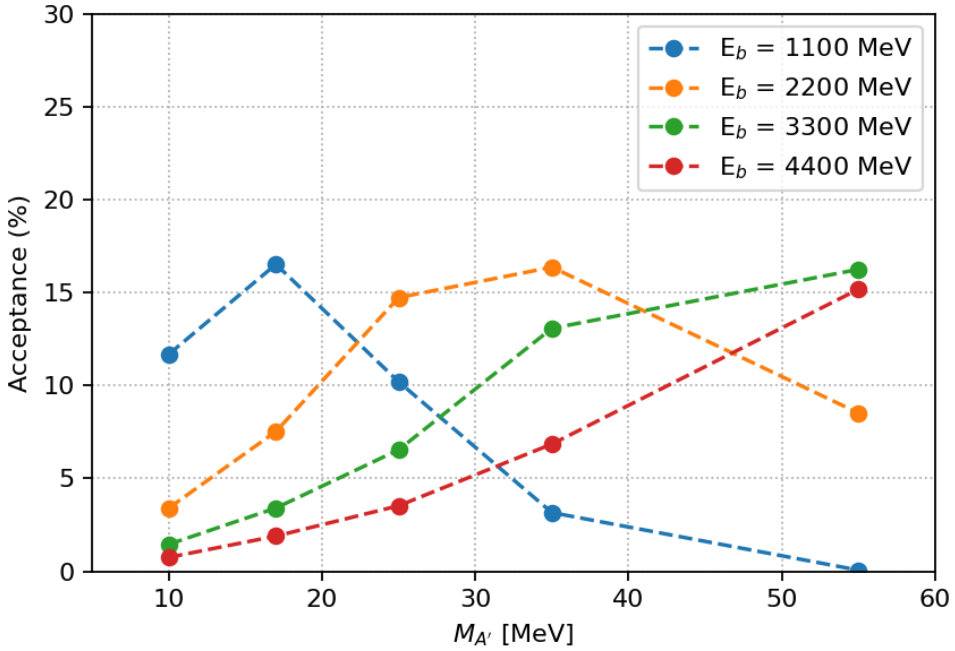
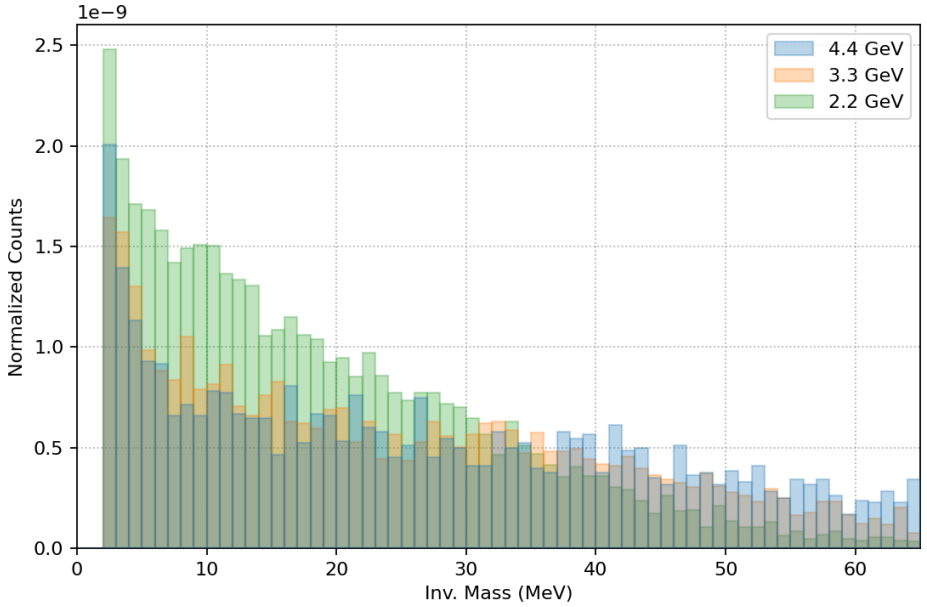


Figure from Chao

- Calculated with 2 inner PbWO4 layers covered
- Uses MG5 produced signals

- Note improvement over last time we discussed this:
  - Realistic distribution is in our acceptance more
  - Bug in my acceptance code

Background Distribution

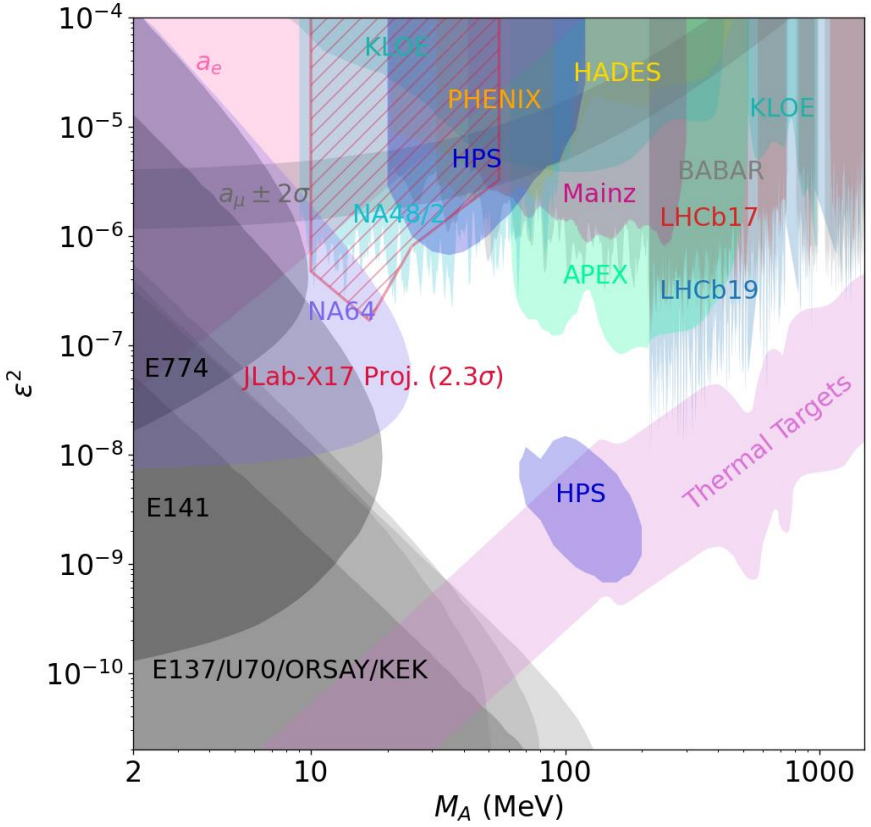


- 4.4 GeV represents half the beam time of 2.2 GeV
- Beam time of sample
  - 2.2 GeV: 16.2 seconds
  - 3.3 GeV: 22.3 seconds
  - 4.4 GeV: 32.7 seconds

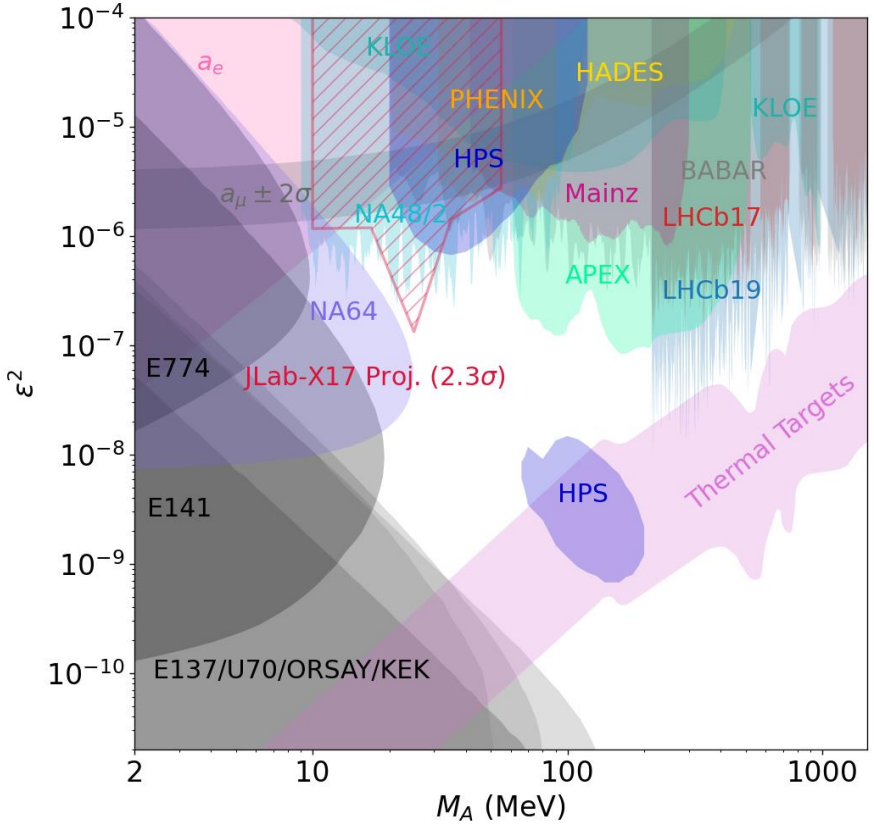
Figure from Chao

Reach – All 40 days at single energy, 2 layers covered, 100 nA

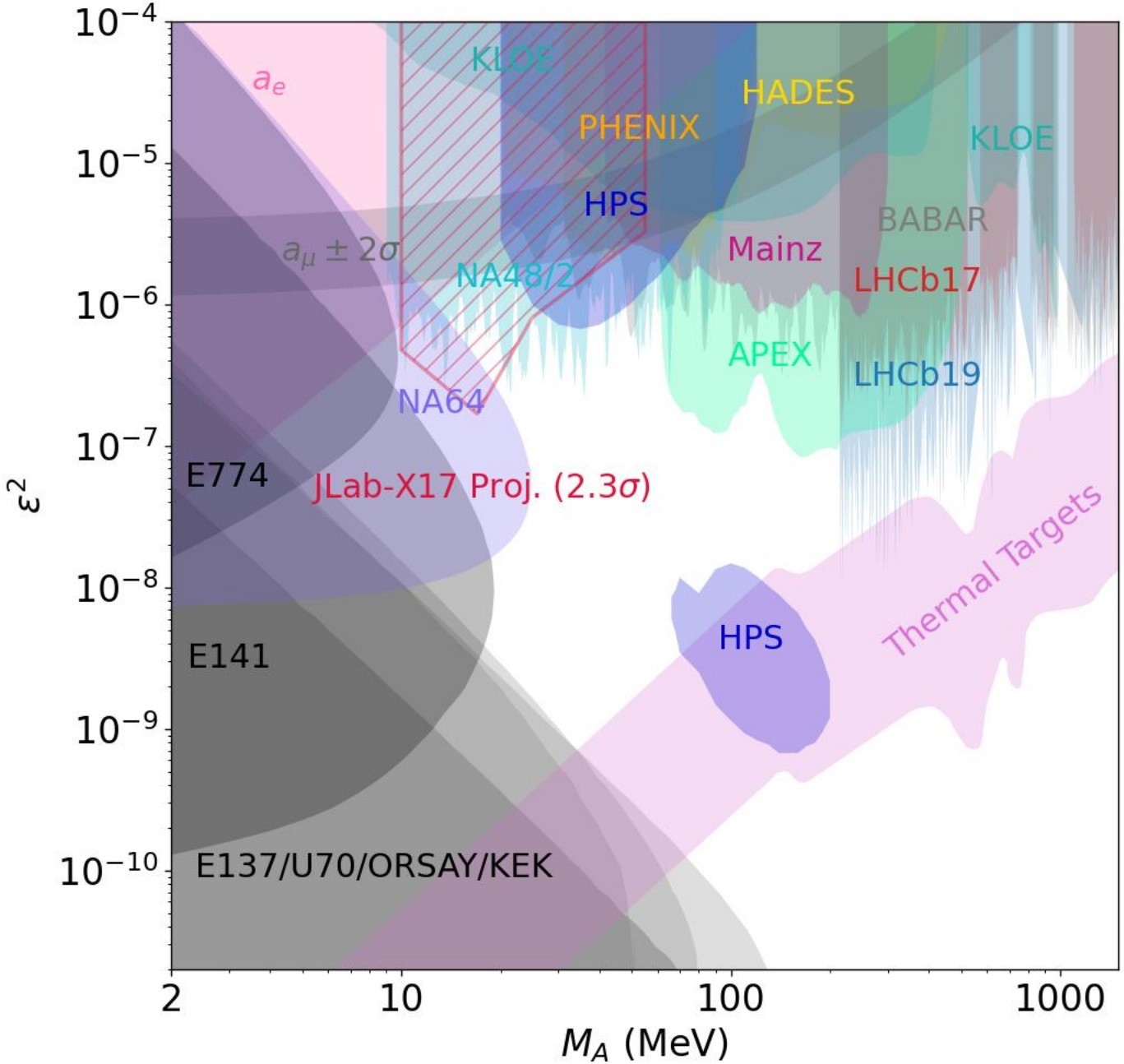
2.2 GeV



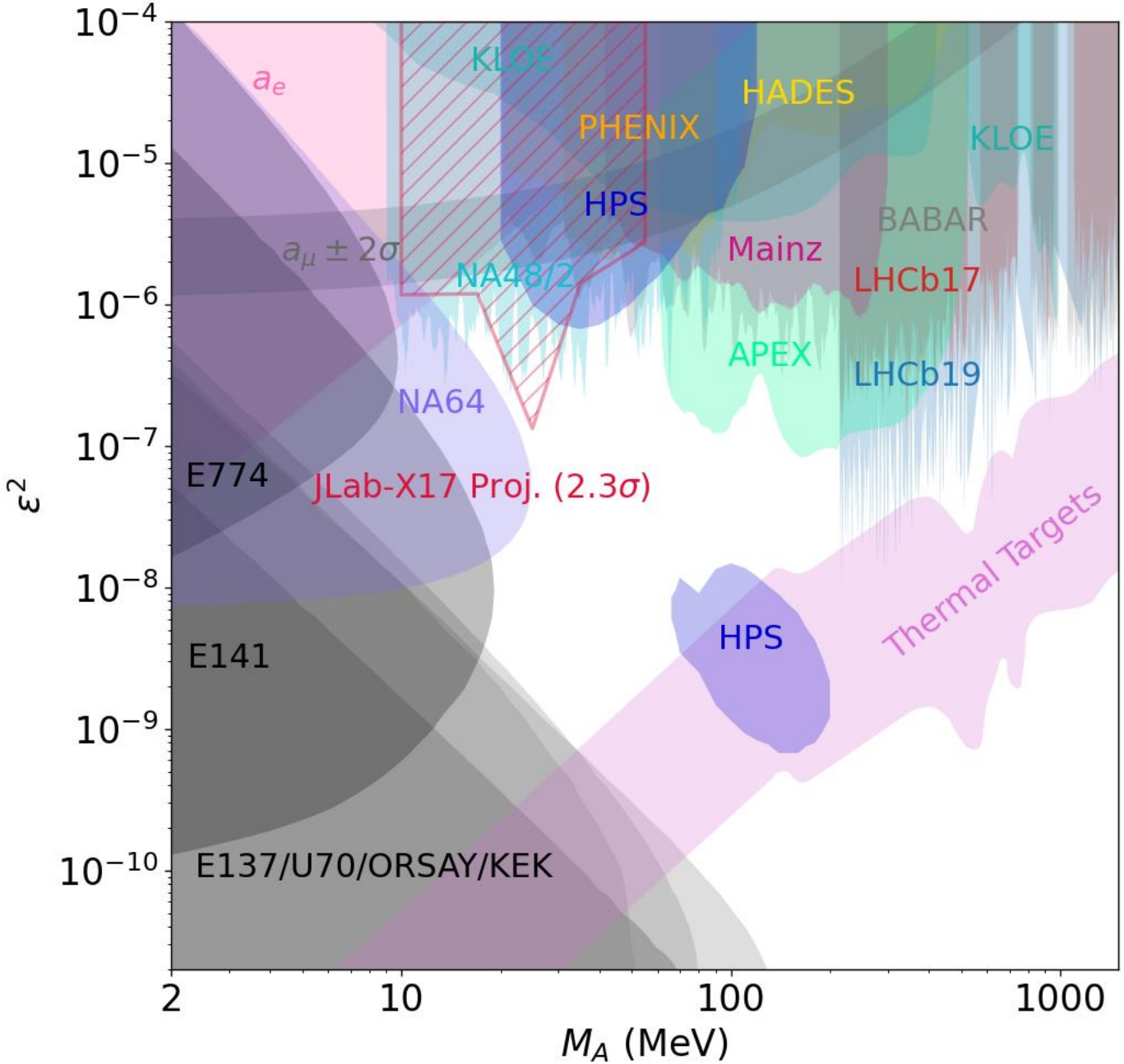
4.4 GeV



2.2 GeV


10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
ε^2
2
10
100
1000
M_A (MeV)
a_e
KLOE
PHENIX
HADES
KLOE
HPS
BABAR
$a_\mu \pm 2\sigma$
Mainz
NA48/2
LHCb17
APEX
LHCb19
NA64
E774
JLab-X17 Proj. (2.3σ)
Thermal Targets
HPS
E141
E137/U70/ORSAY/KEK

4.4 GeV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Significance to Resolve X17 Anomaly ($\varepsilon^2 = 4.9e\text{-}7$)

Days at Energy	Significance at 2.2 GeV	Significance at 4.4 GeV
40	14.5	2.0
25	11.4	1.6
15	8.9	1.2

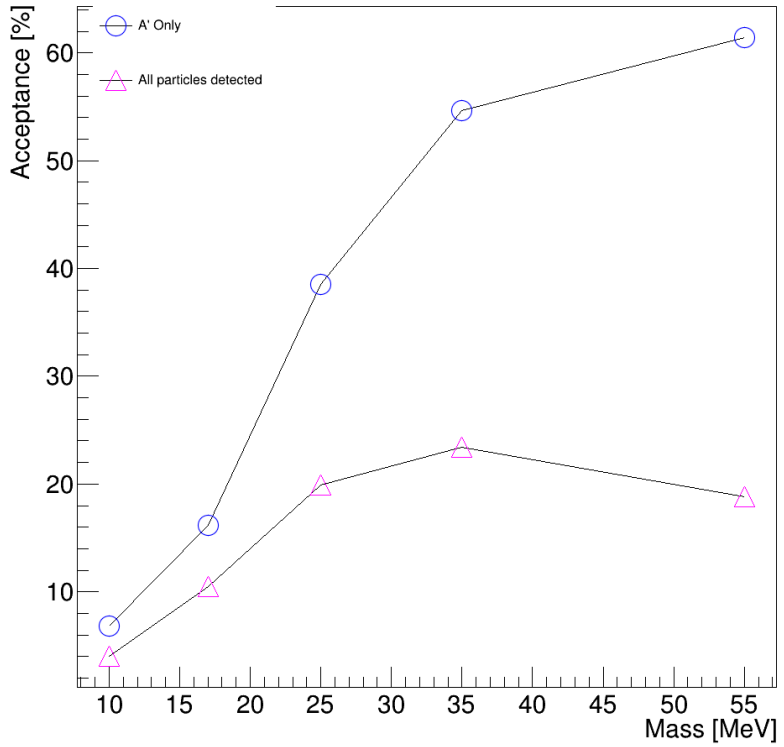
Looks Promising!

Thoughts

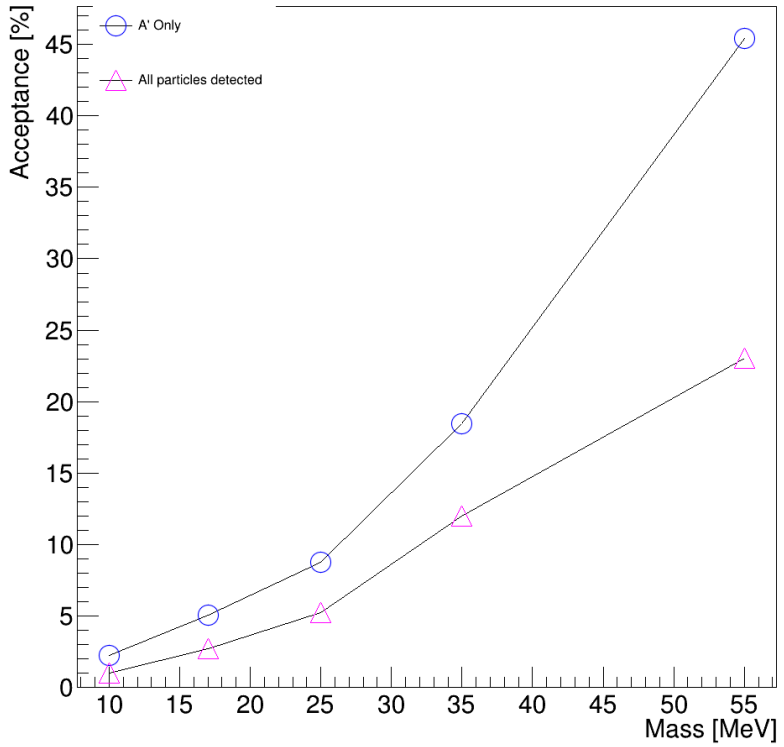
- Clearly, 2.2 GeV is the better option
  - With 4.4 GeV, using *ALL* 40 days, only one of the 5 masses has reach into un-excluded territory
  - (not shown in previous figures) Leaving only one layer cover does not meaningfully increase the reach of 4.4 GeV
- Needs done:
  - Calculation of exact cross section
    - *Almost* done, but didn't make it in time for this presentation
    - Study 2-cluster trigger rate and background
      - Greatly improves acceptance

Acceptance with 2 Clusters

2.2 GeV



4.4 GeV



Figures from Rafo

Radiation Hardness Test

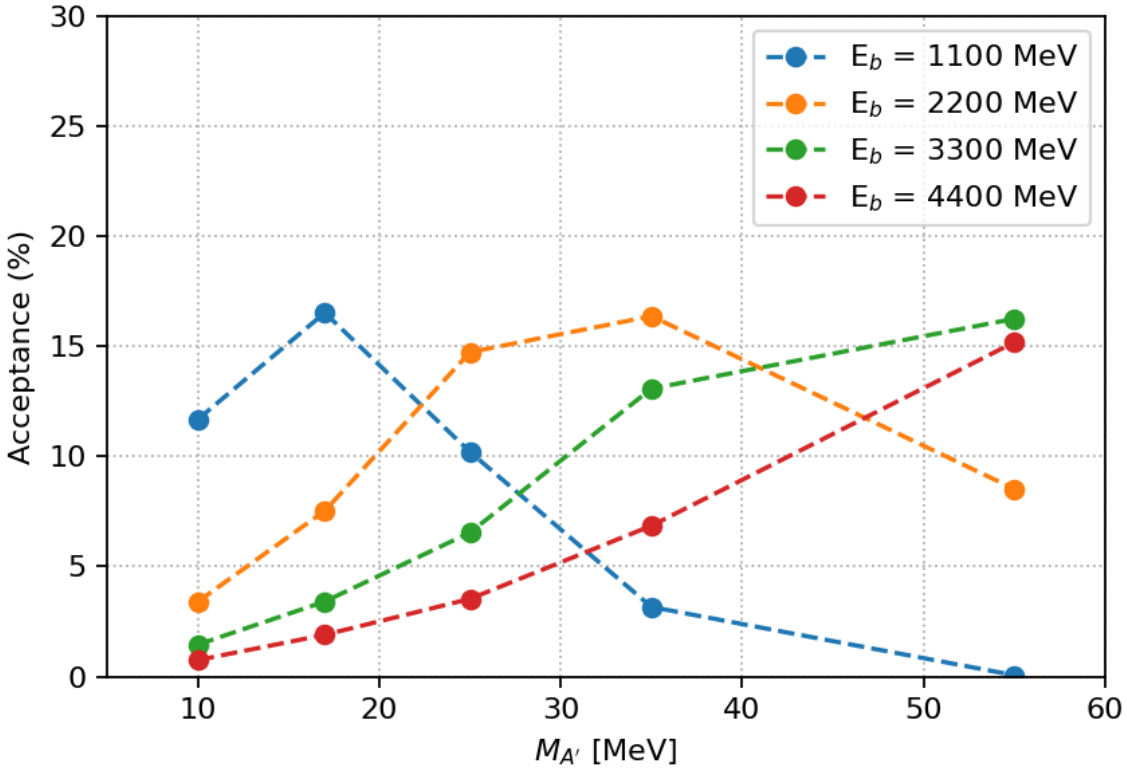
- Test at the beginning of X17 runs
  - Give enough time to recover for the PRad-II runs

- Open-up the 2nd layer of HyCal inner modules
  - Monitor its gain closely with the LMS system
  - Stop and cover them if the gain drops quickly (over 5% in a run)
  - Continue with gain monitoring if the gain drop is bearable (below 5% per run and less then 15% in total)

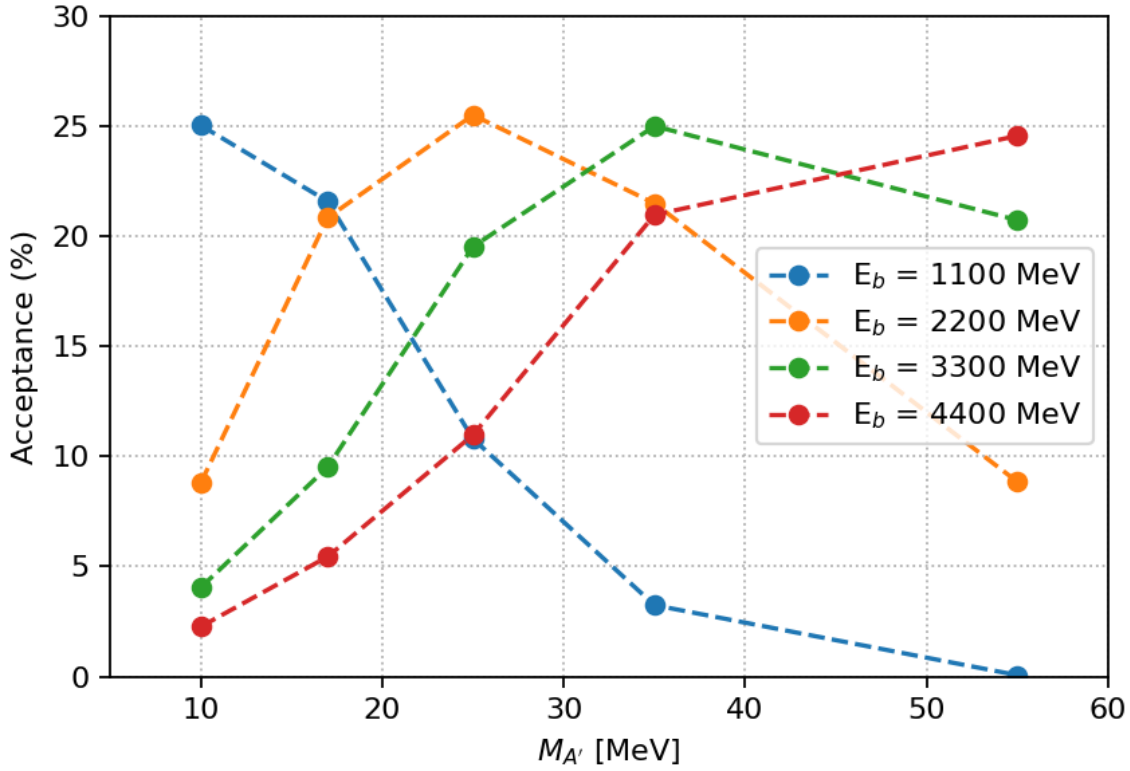
Slide from Chao

Acceptance Improvement

Cover 2nd Layer



Cover 1st Layer



Slide from Chao