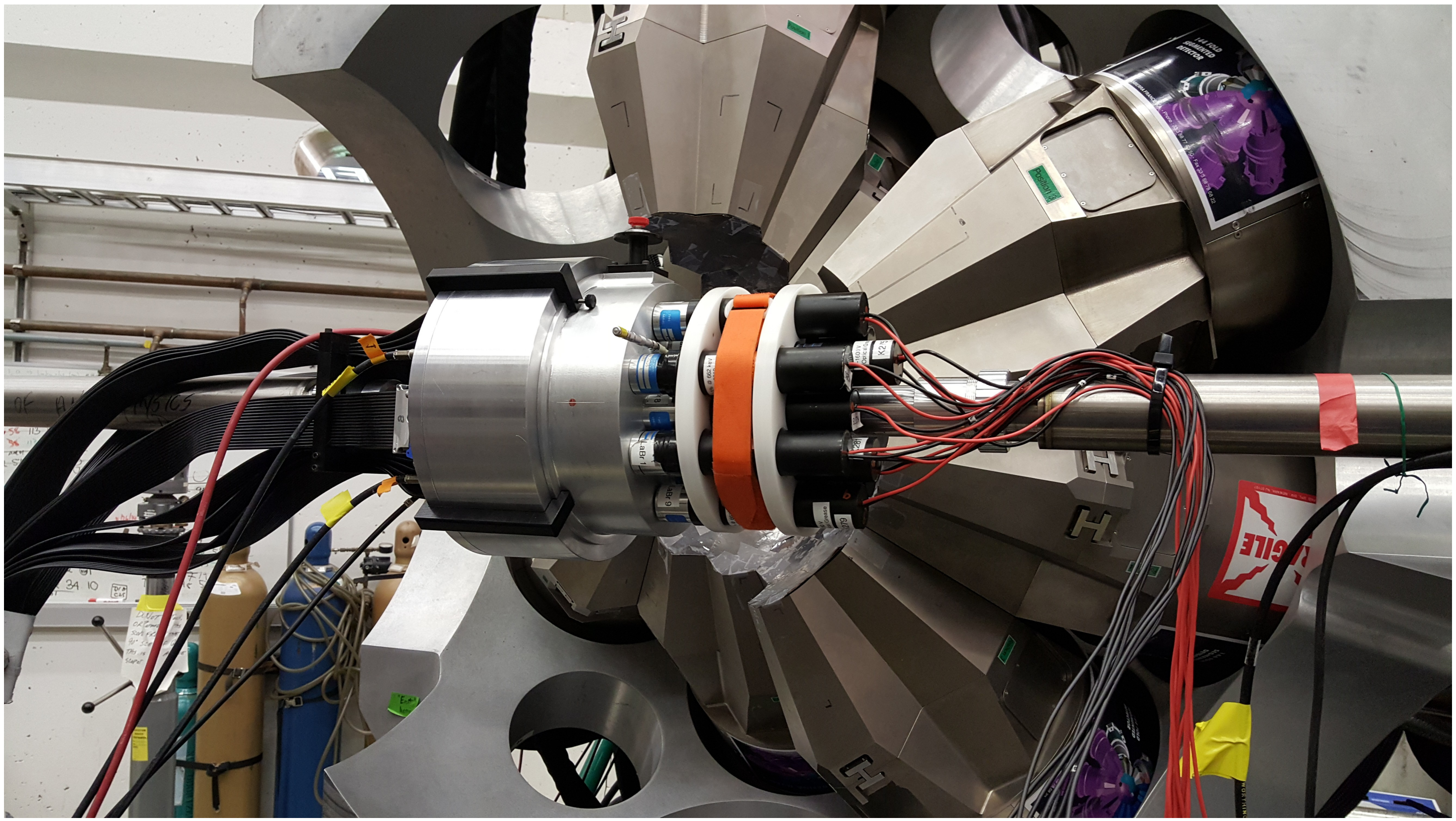
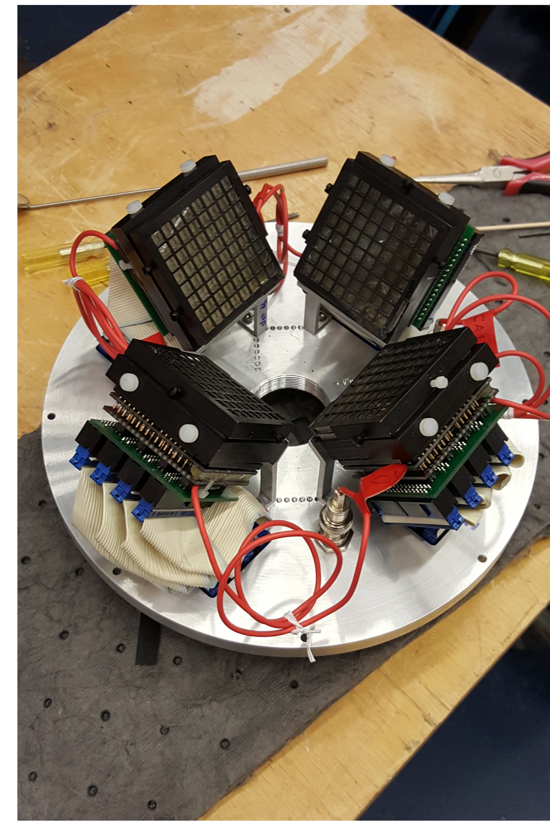
Nuclear Level Density and Gamma Strength from Quasi-Continuum Lifetimes with GRETINA





Leo Kirsch
Oslo 5/10/17

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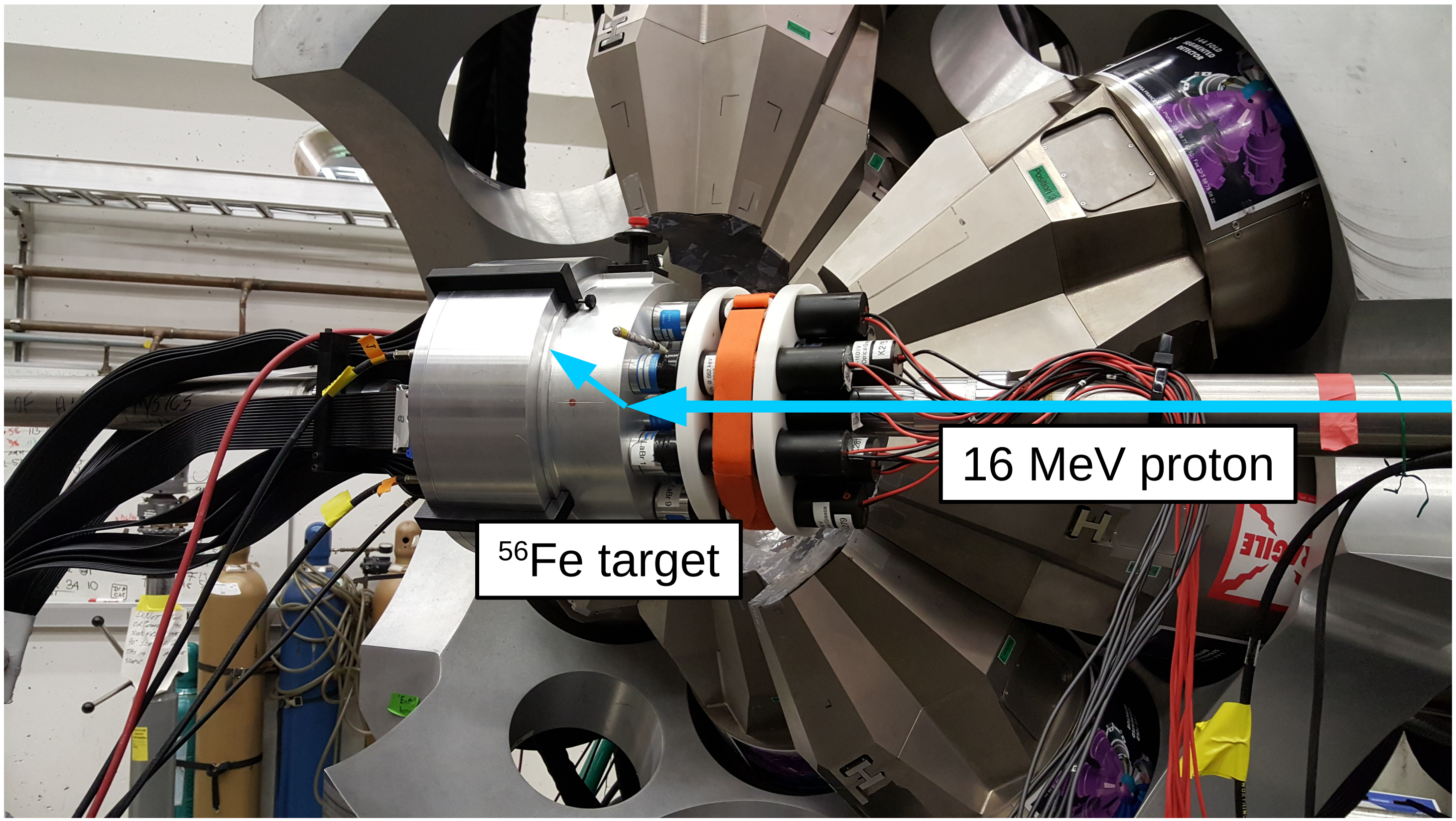

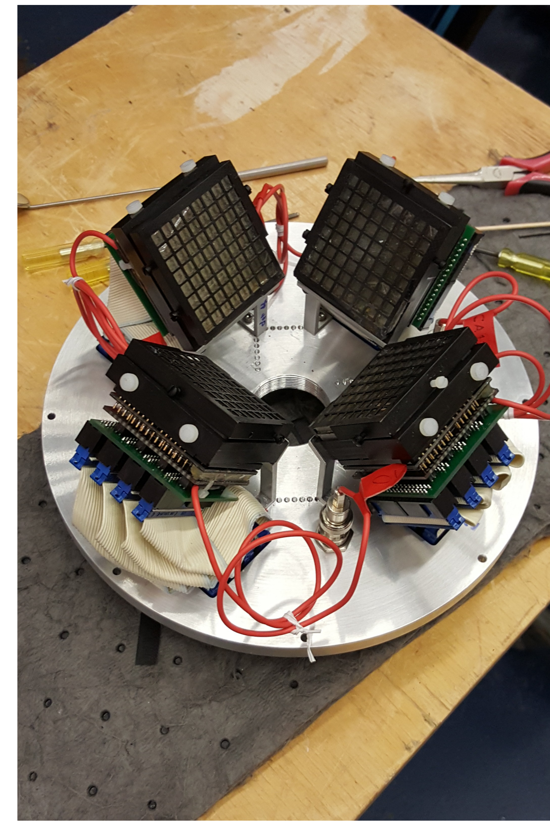

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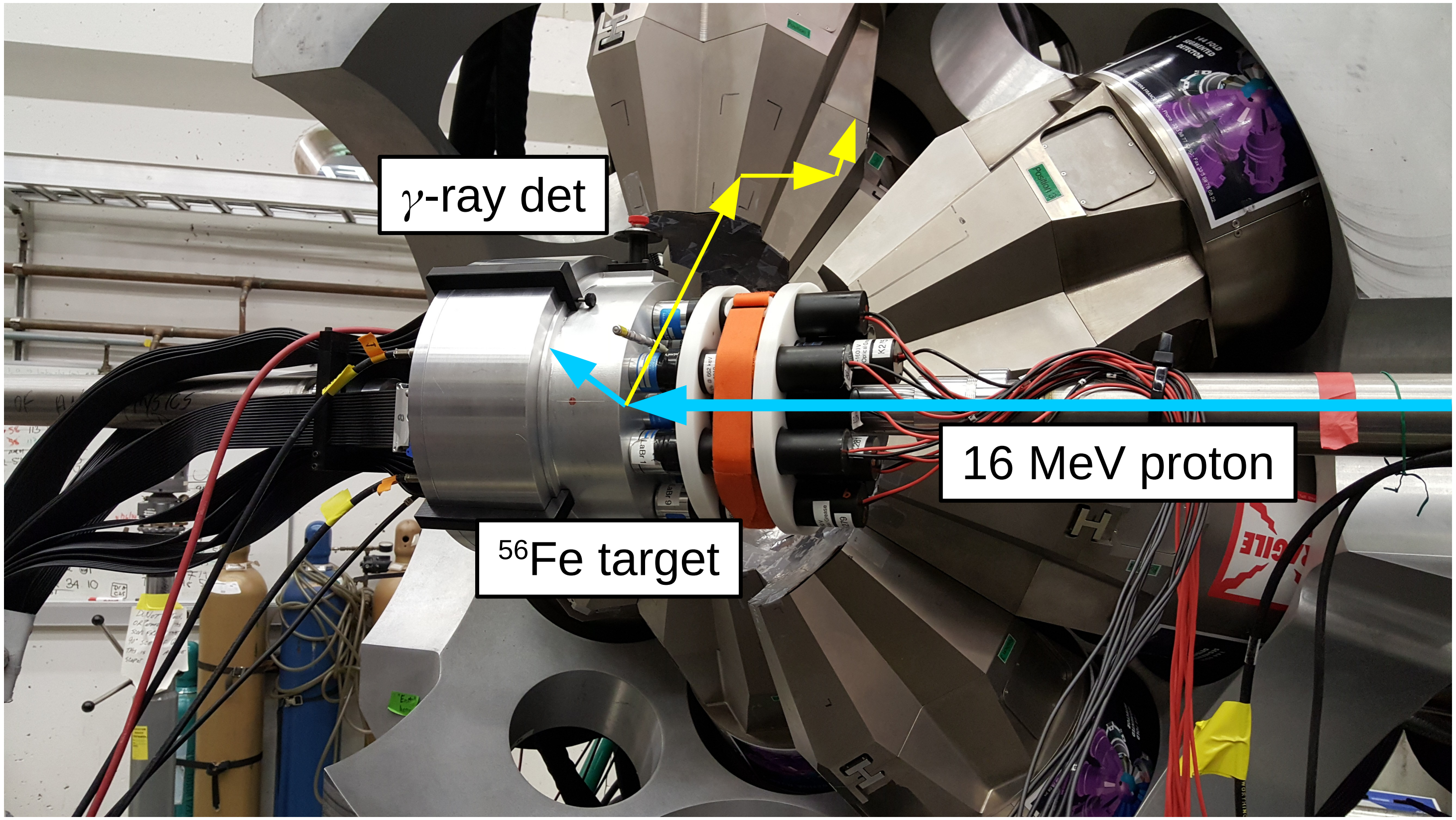

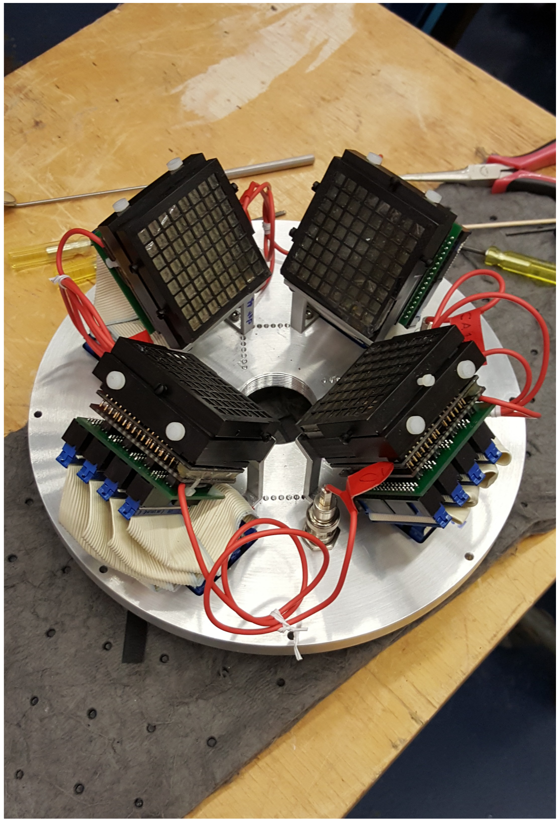

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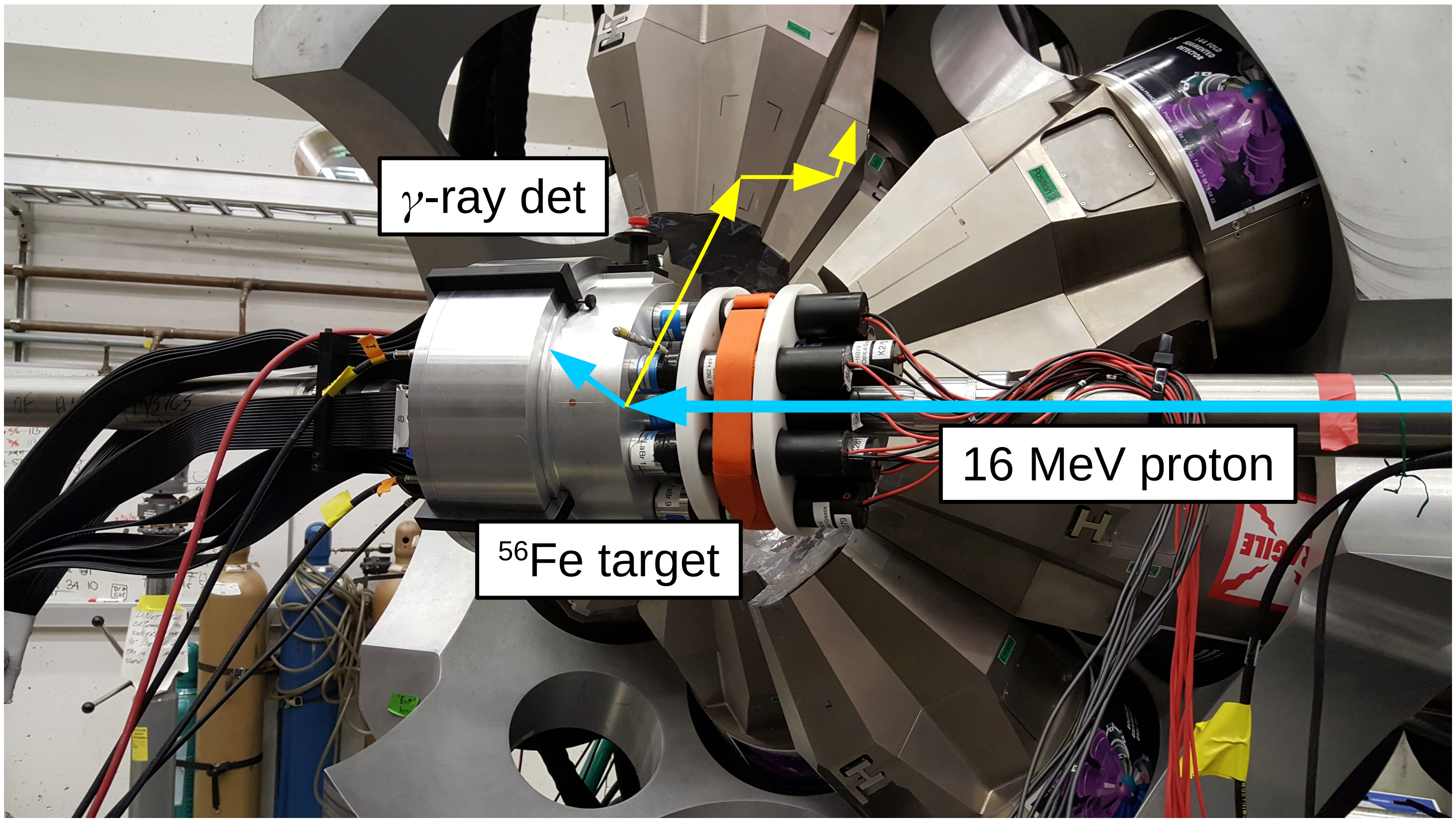

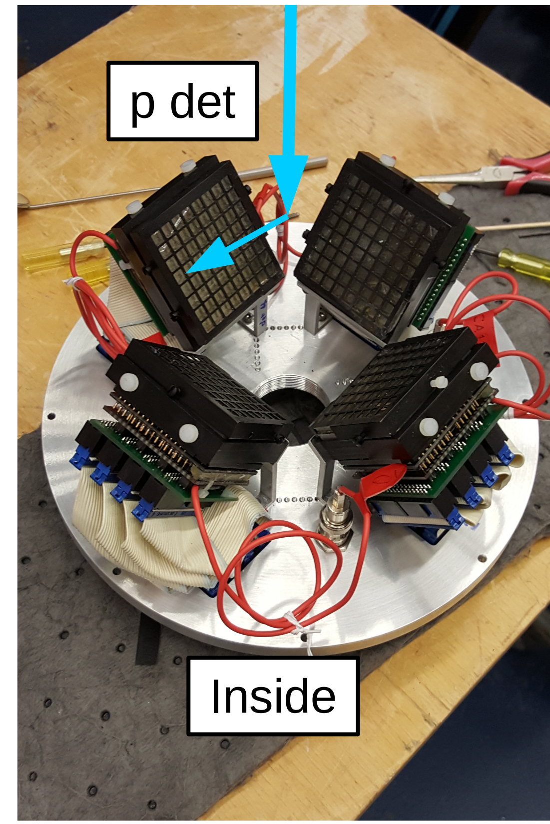

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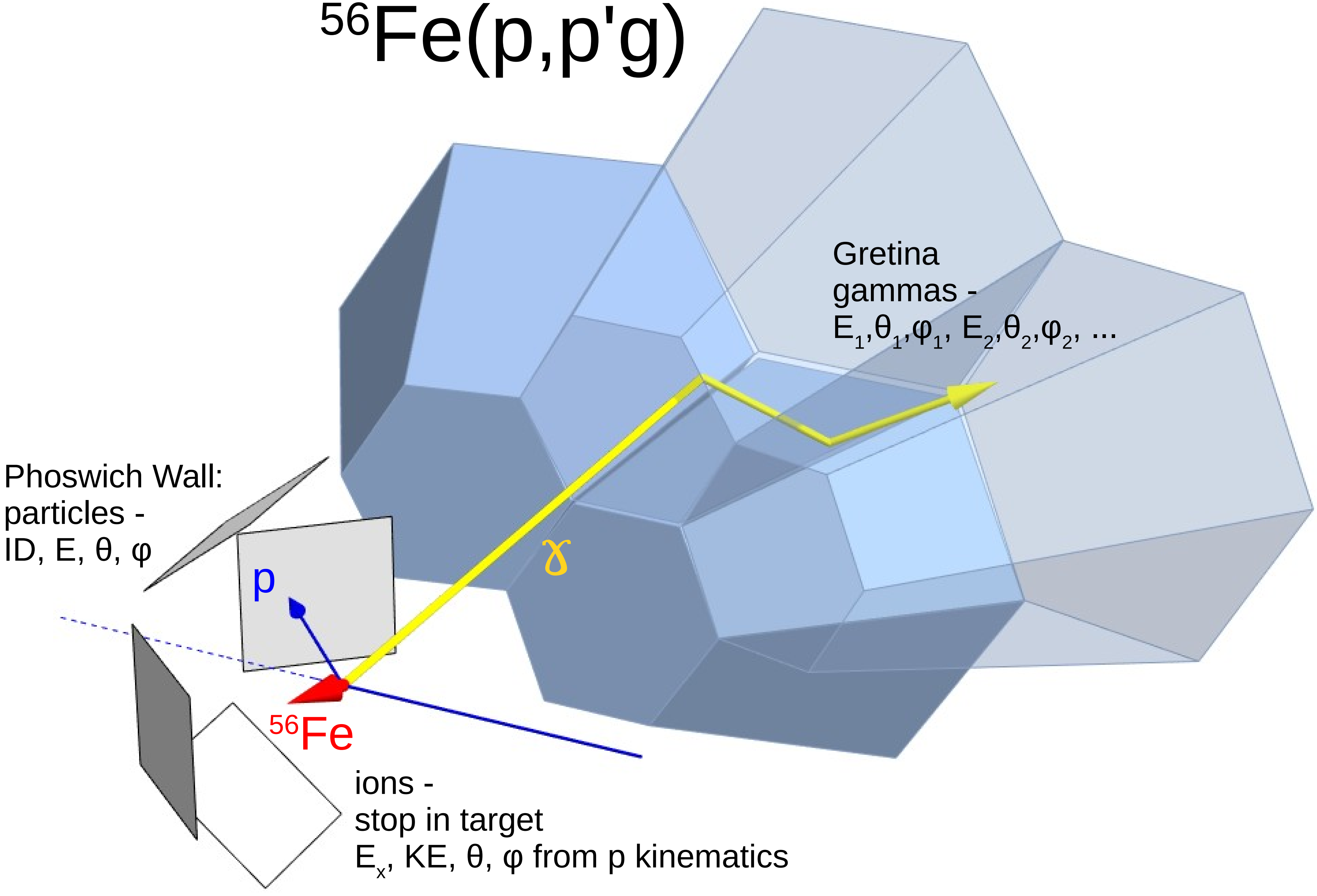
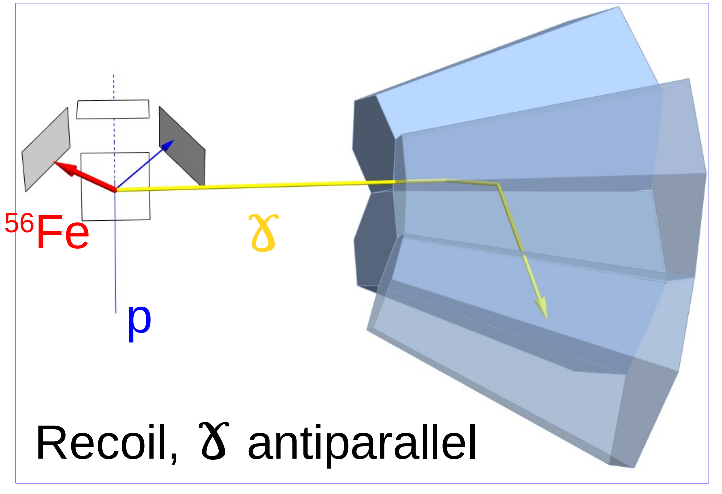
^{56}Fe(p,p'g)

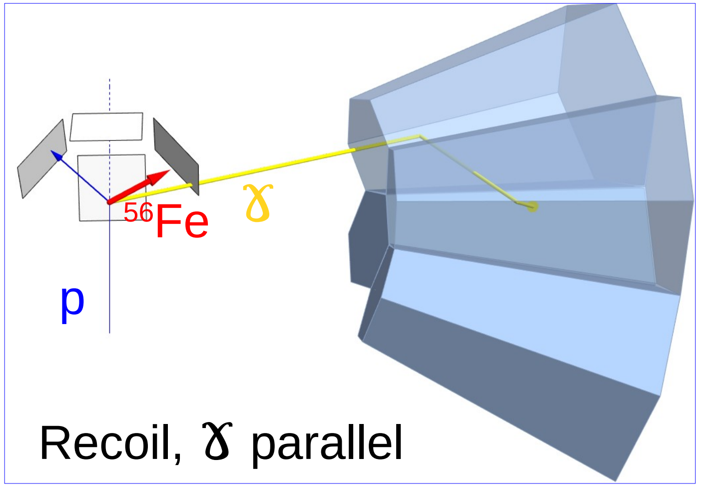


Gretina
gammas -
E1,θ1,φ1, E2,θ2,φ2, ...
γ
Phoswich Wall:
particles -
ID, E, θ, φ
p
56Fe
ions -
stop in target
Ex, KE, θ, φ from p kinematics

Doppler Shift Review:

$$E_{\gamma,\ observed} = E_{\gamma,\ source}(1 + v \cos \Theta / c)$$





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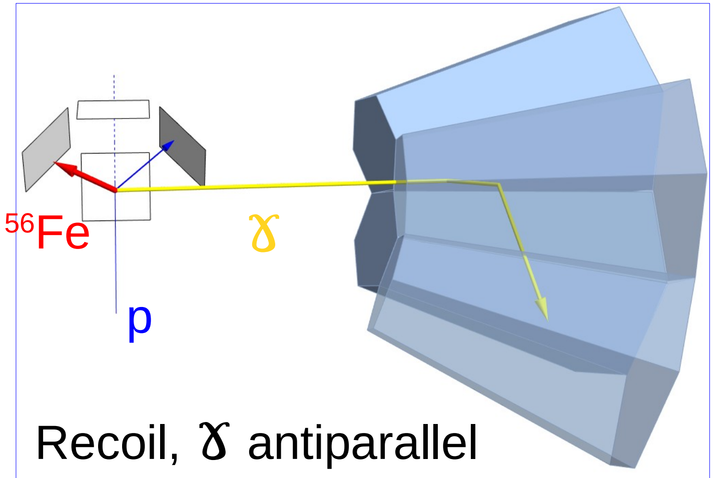
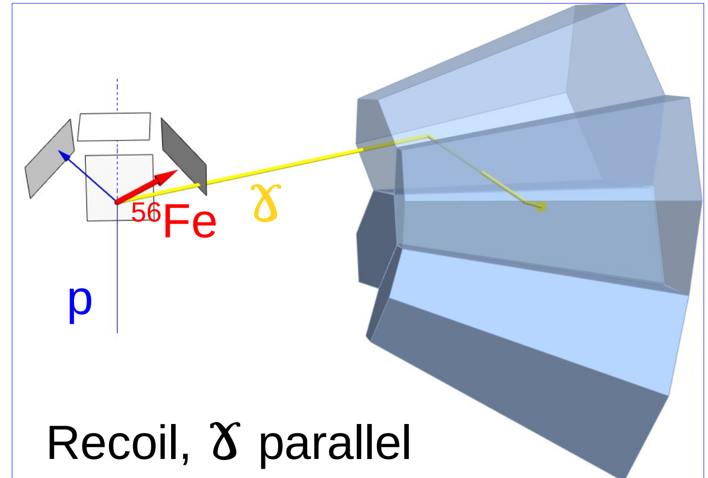
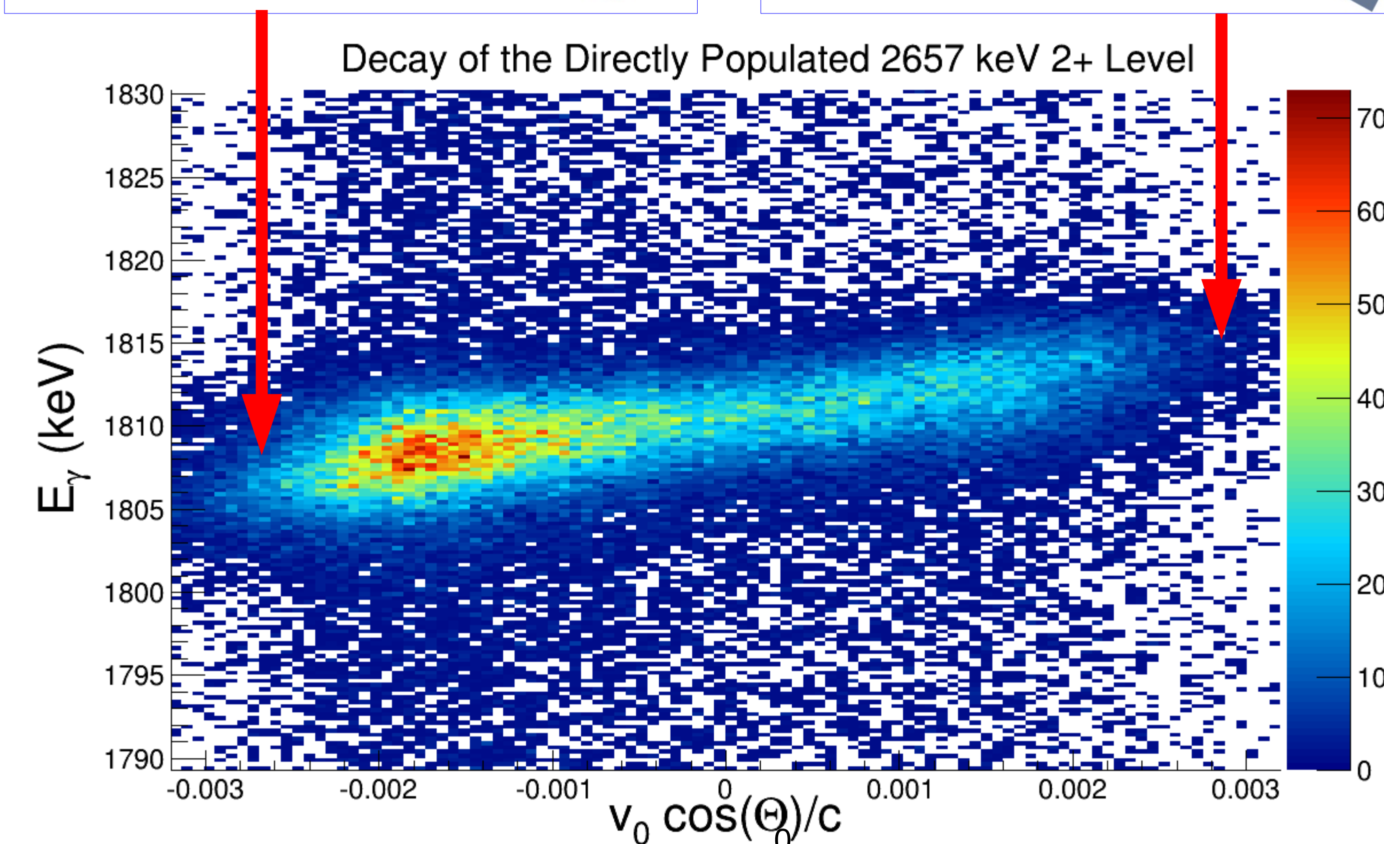




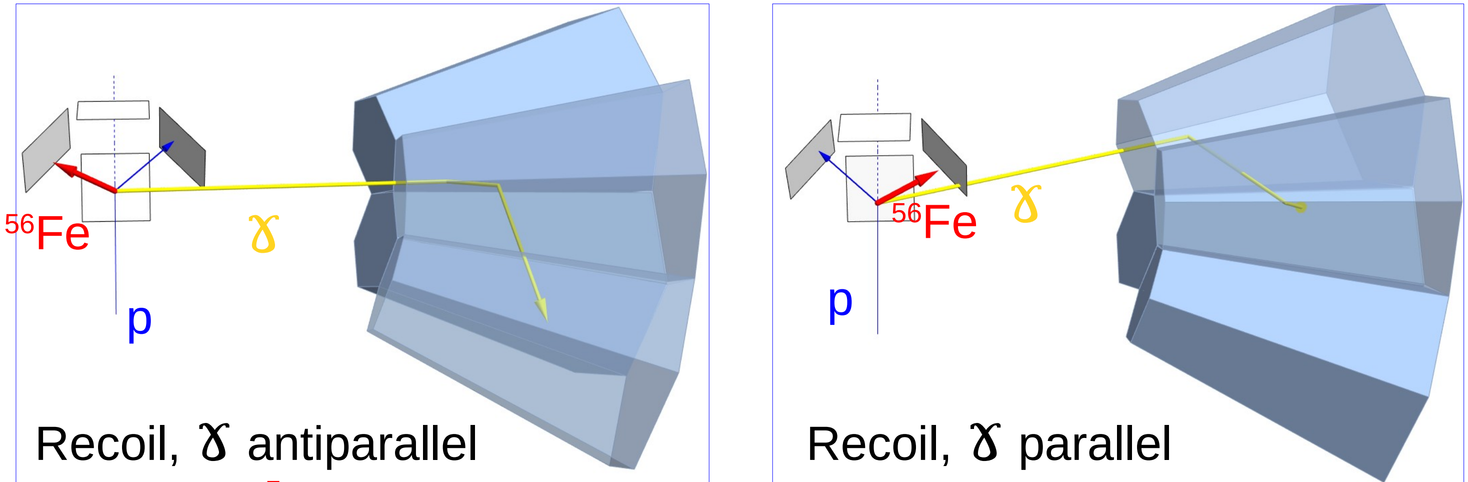


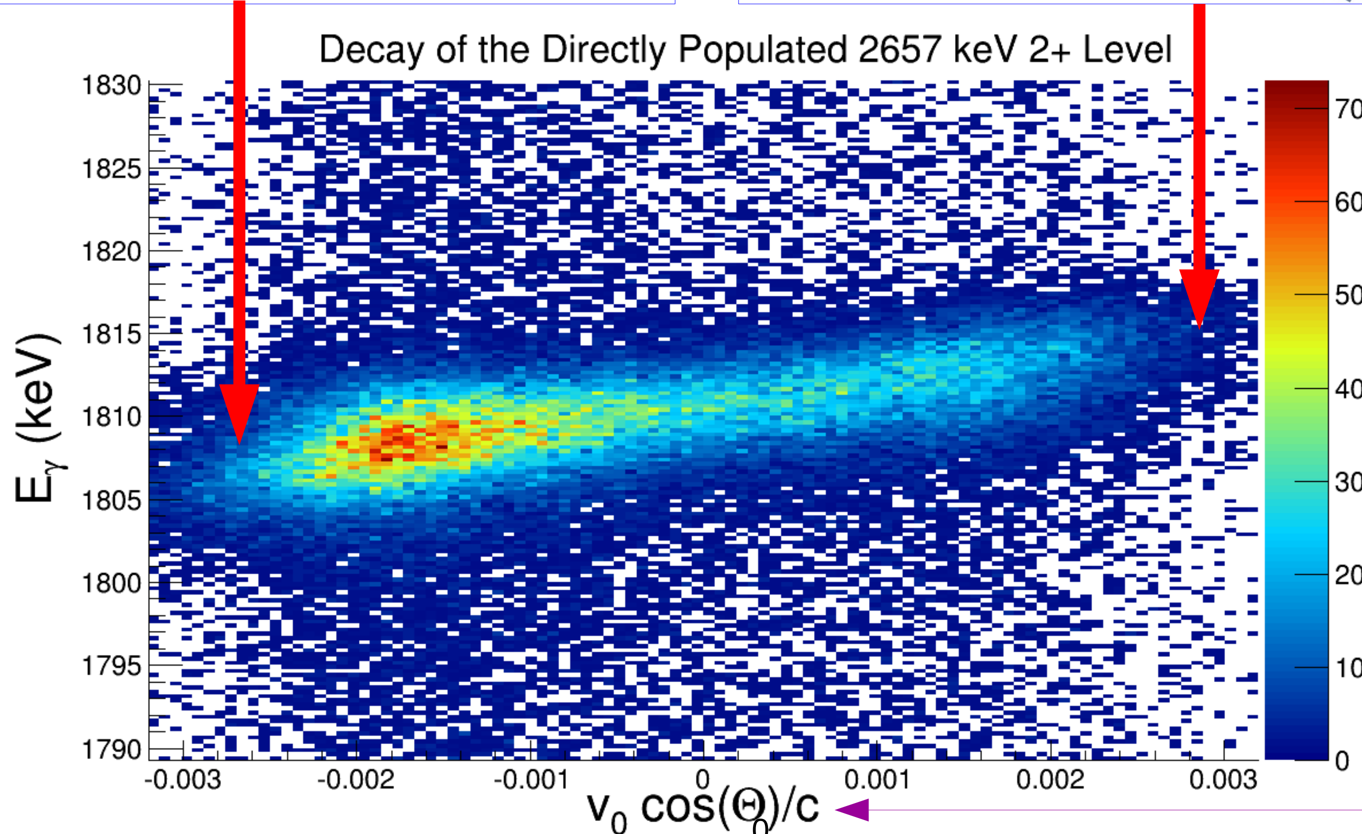
Doppler Shift Review:

$$E_{\gamma,\ \text{observed}} = E_{\gamma,\ \text{source}}(1 + v \cos \Theta / c)$$

Emission

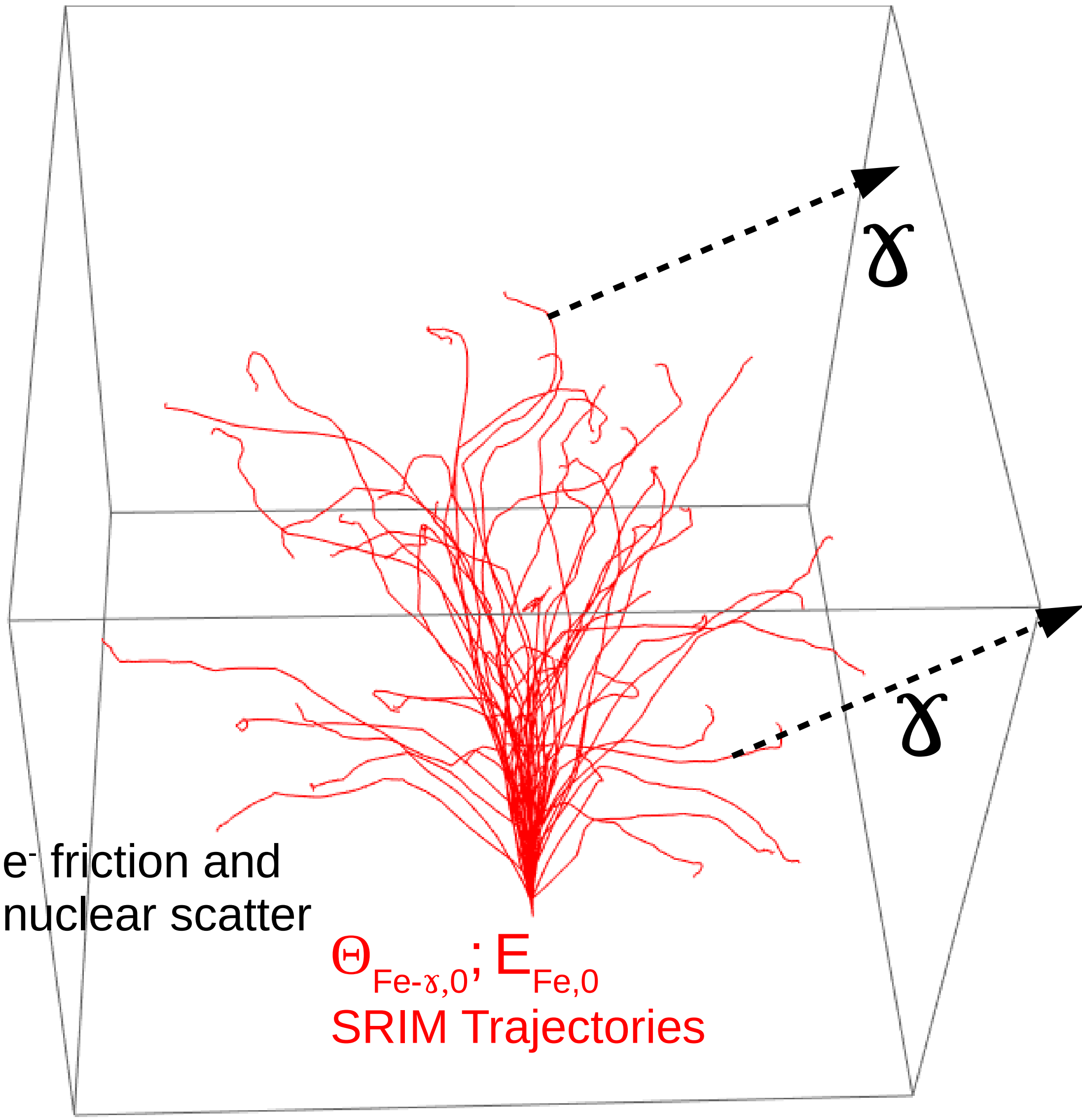
Depends on lifetime

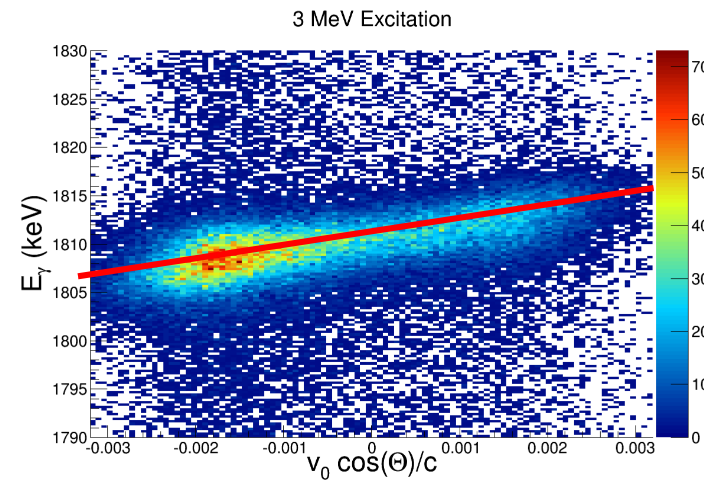




Initial

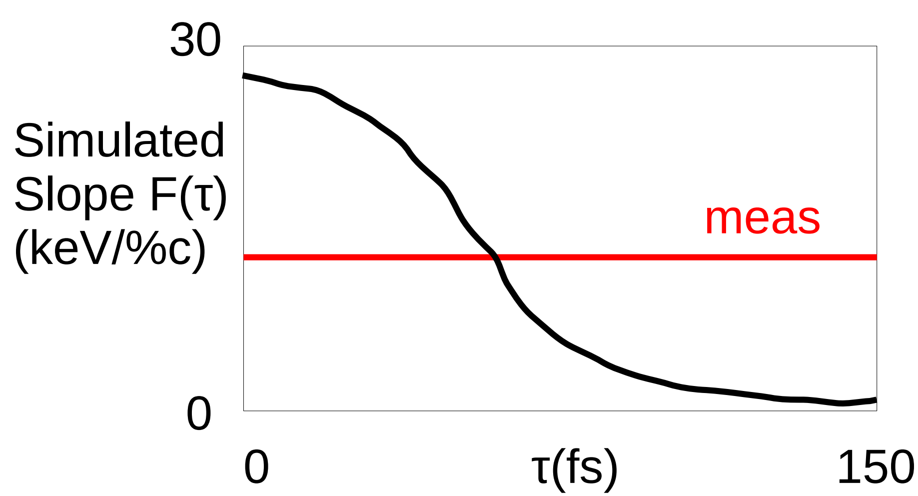
Monte-Carlo DSAM



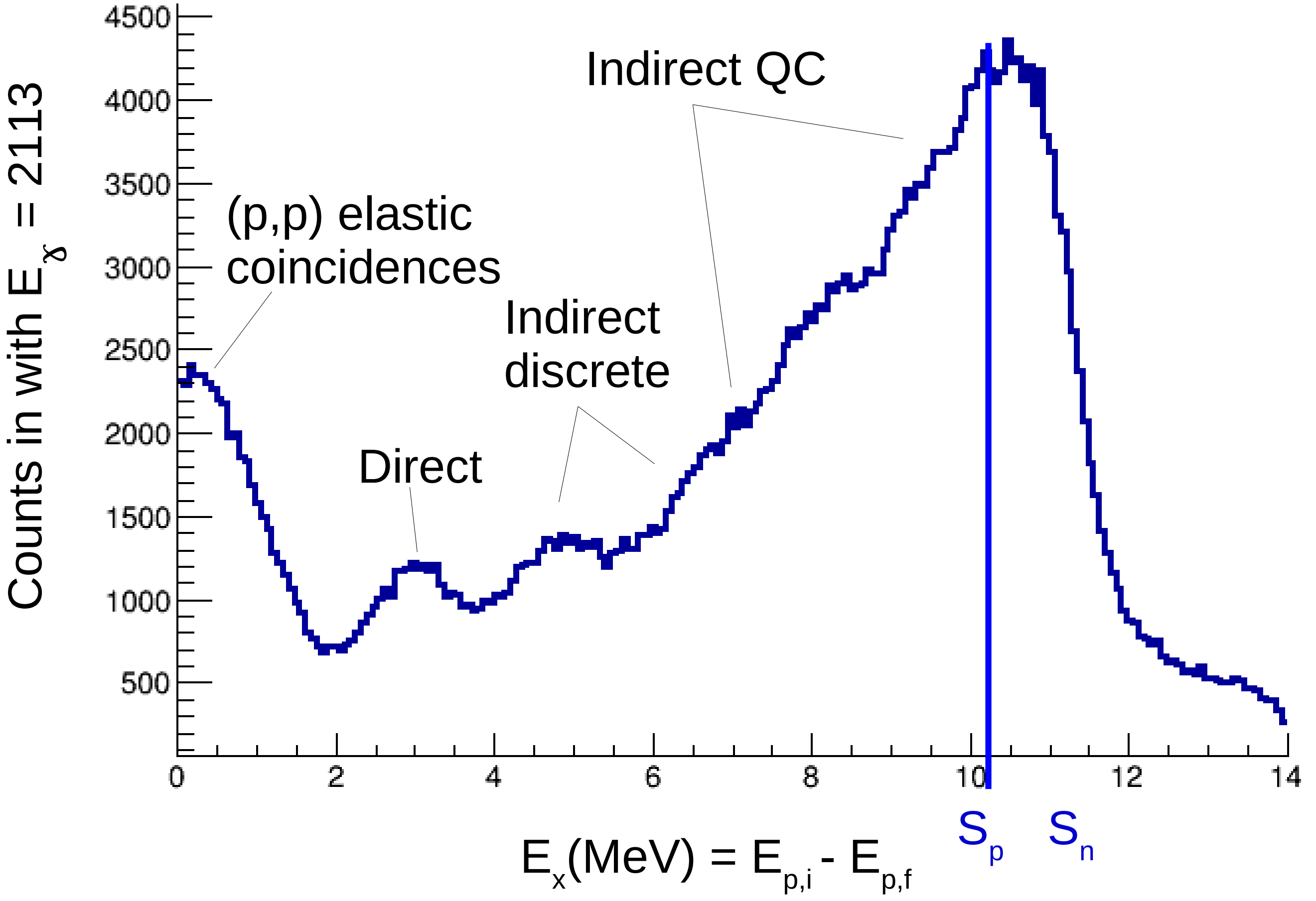


Directly populated events: $\Delta E_p = E_L$

Compare well with ENSDF



Excitation Cuts



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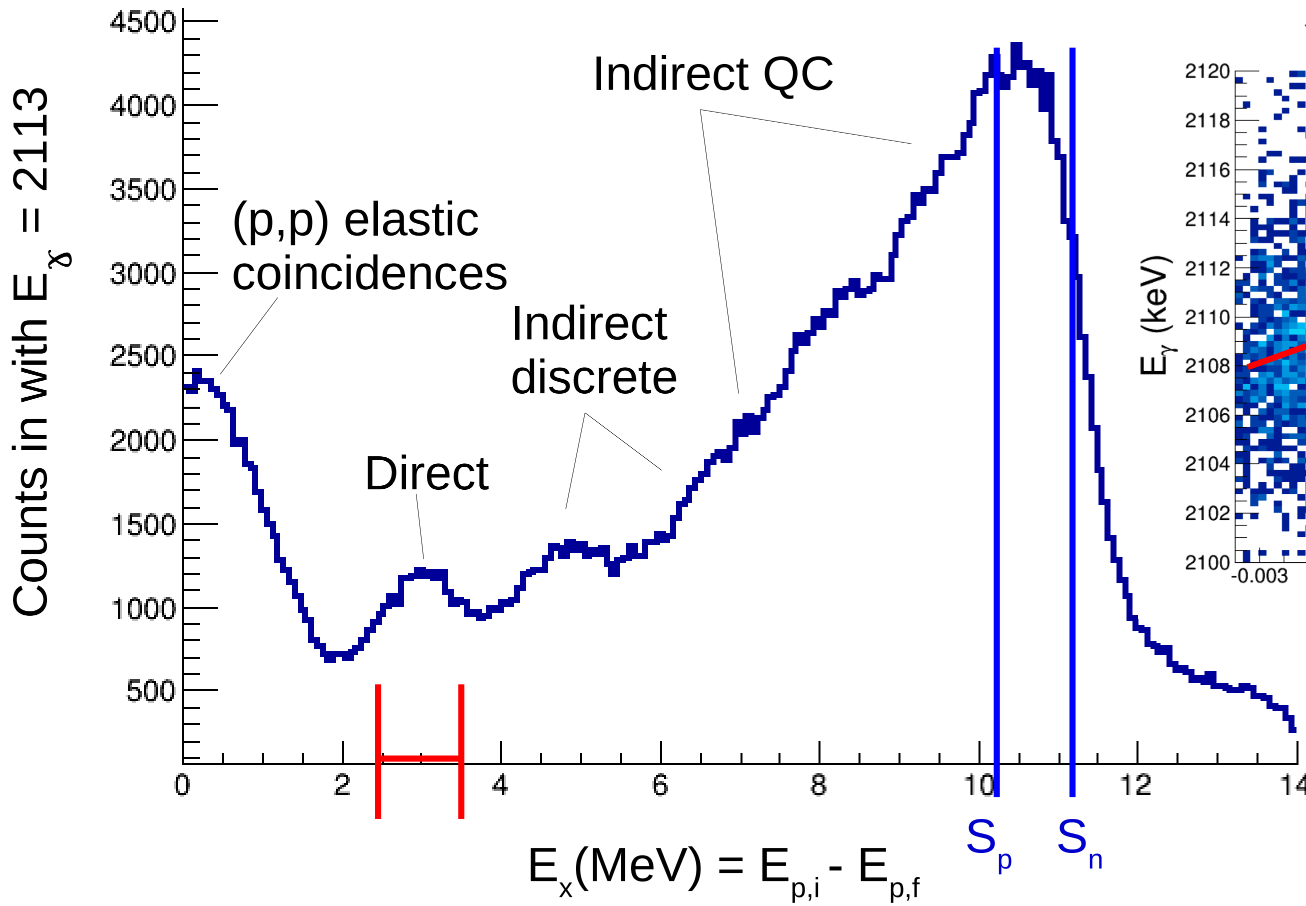

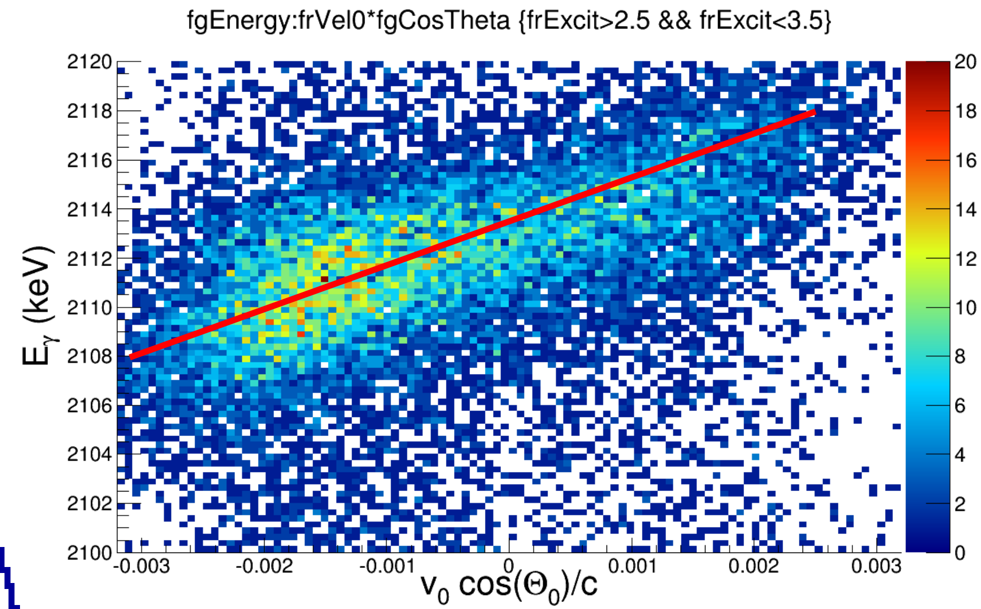

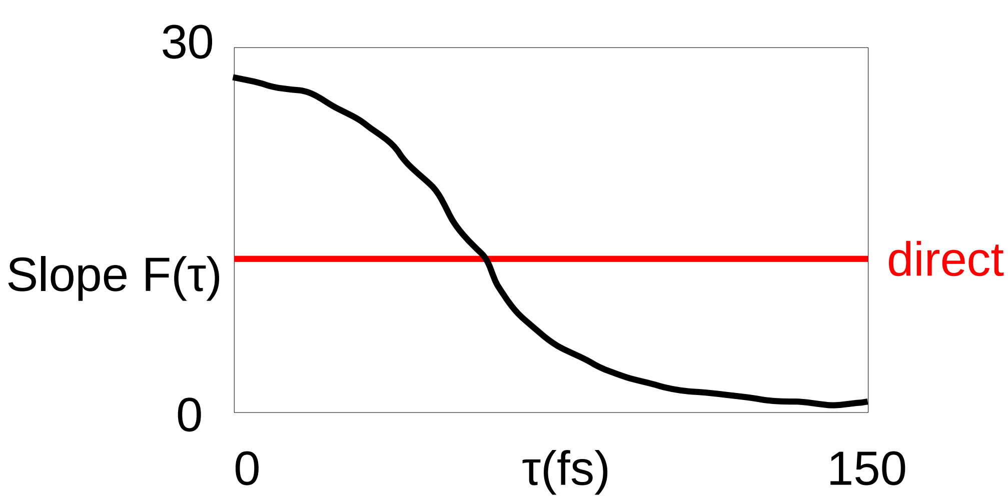

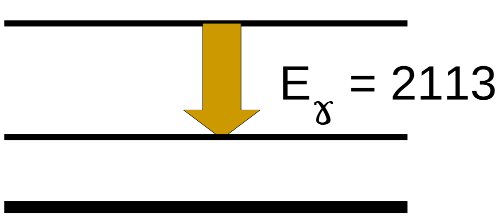

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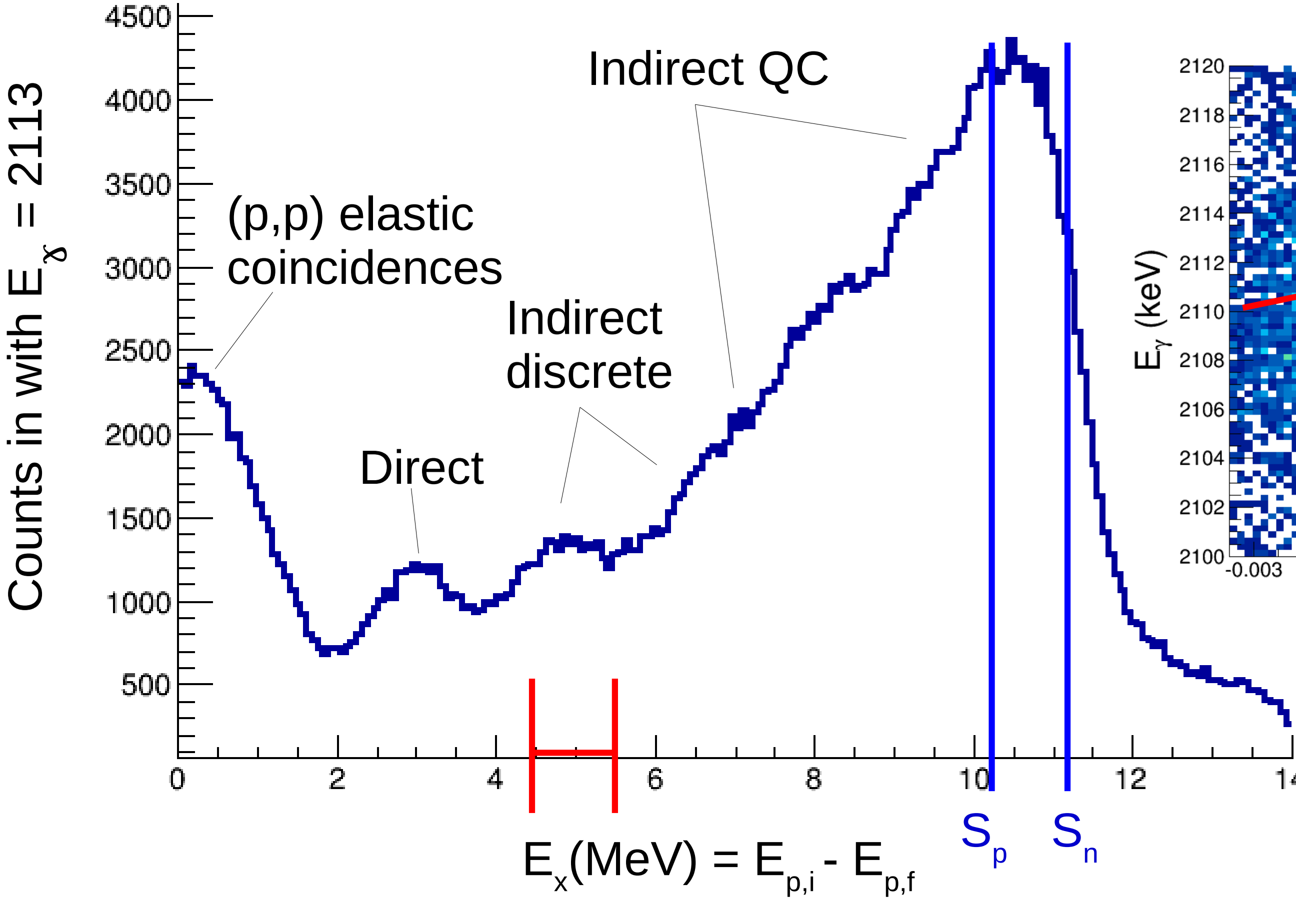

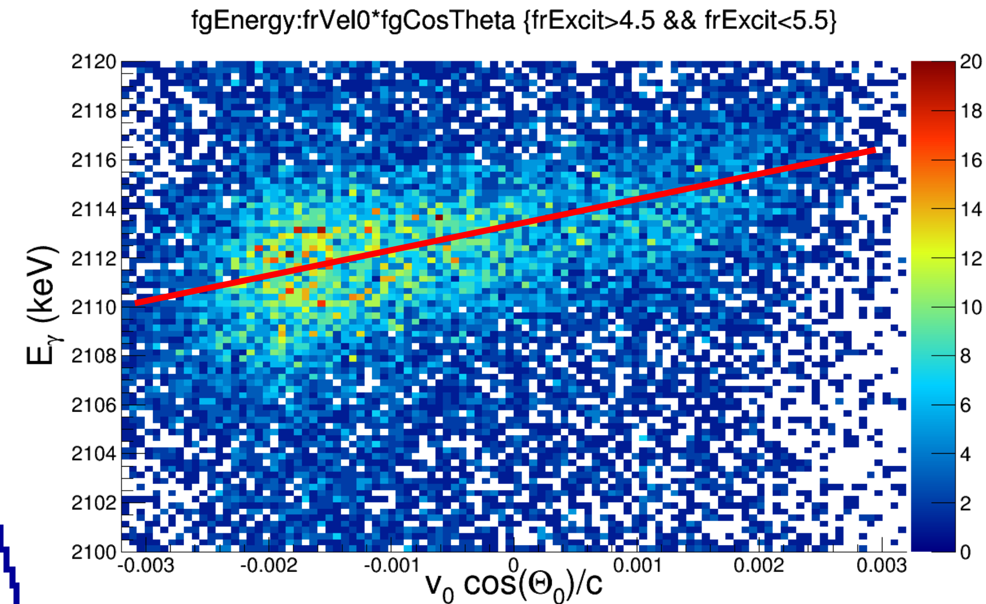

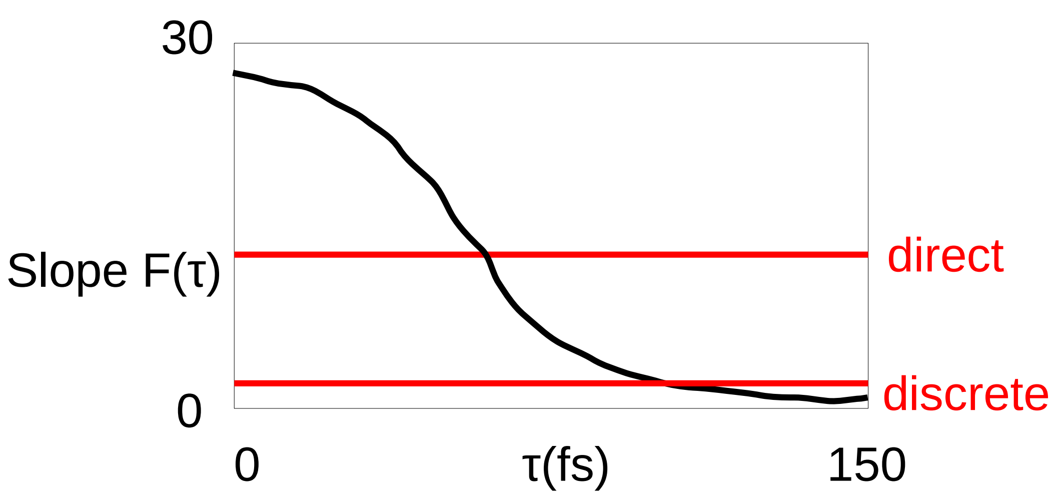

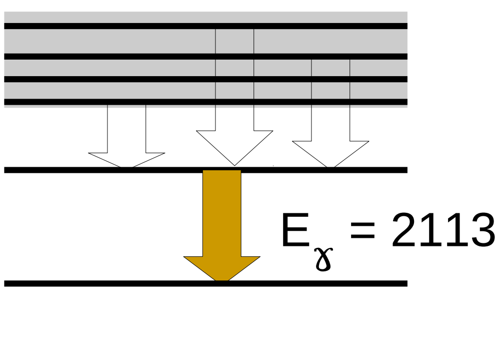

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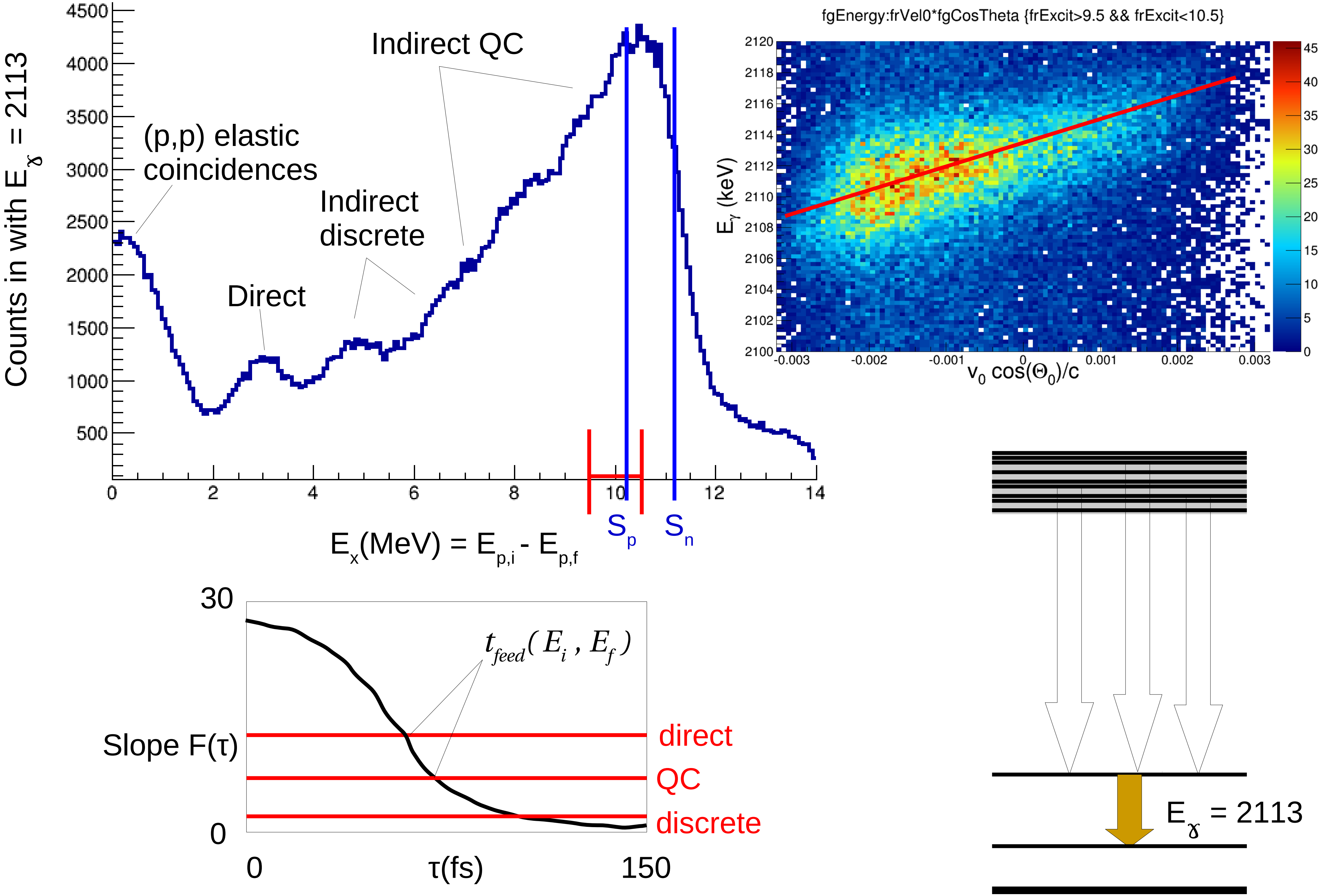
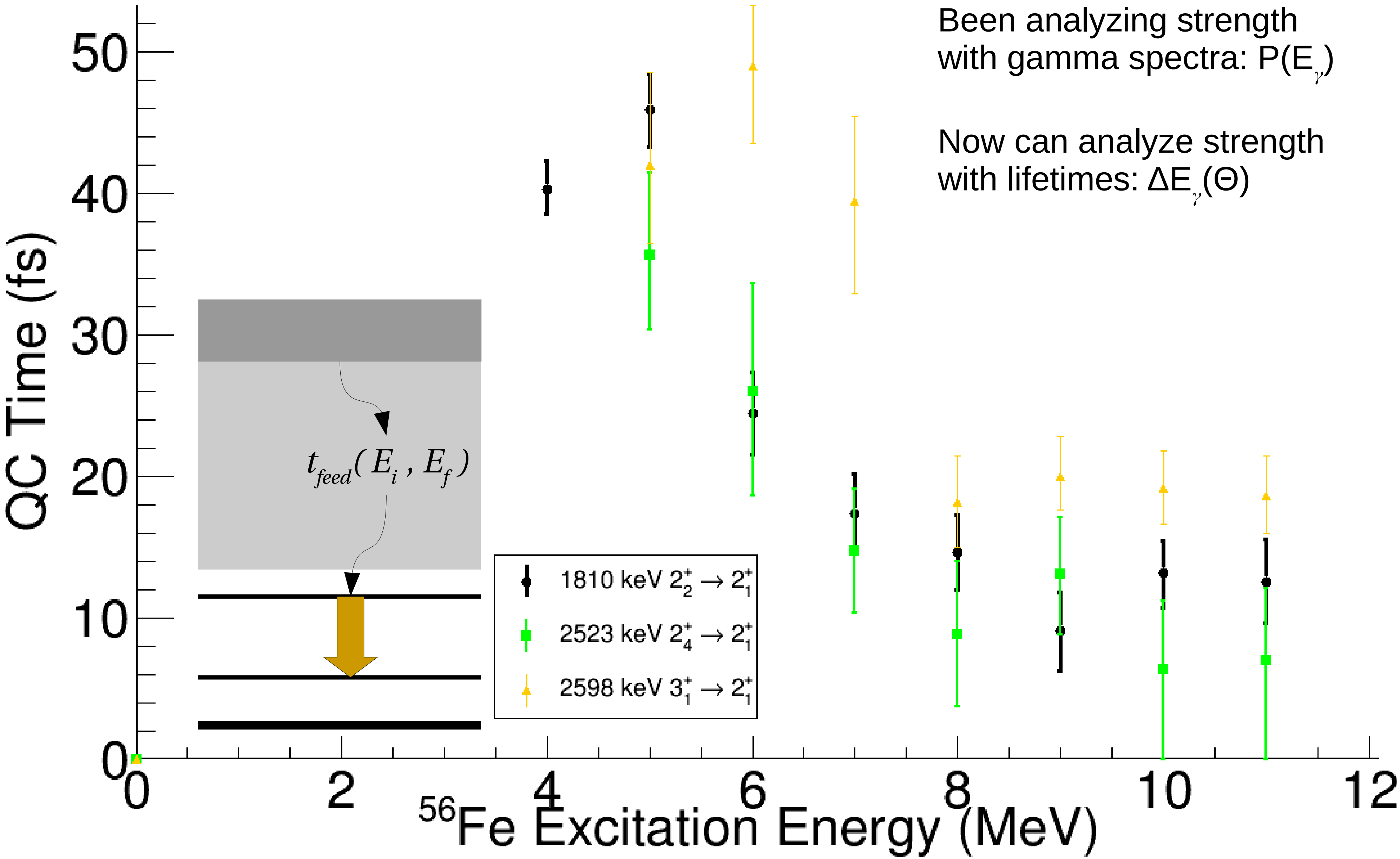


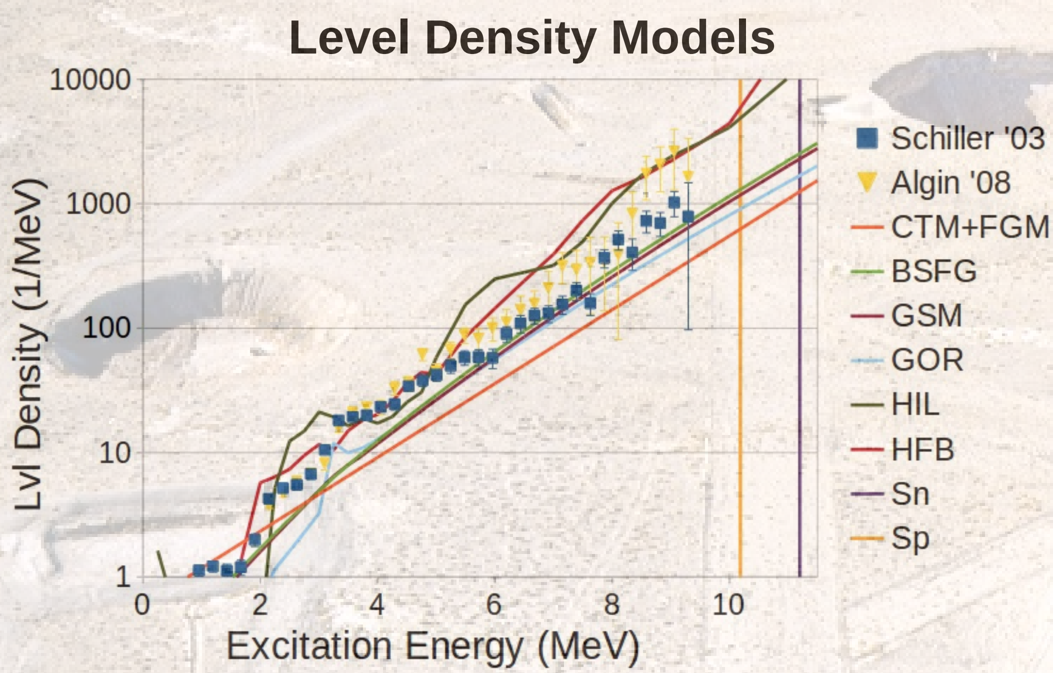
Feeding Time

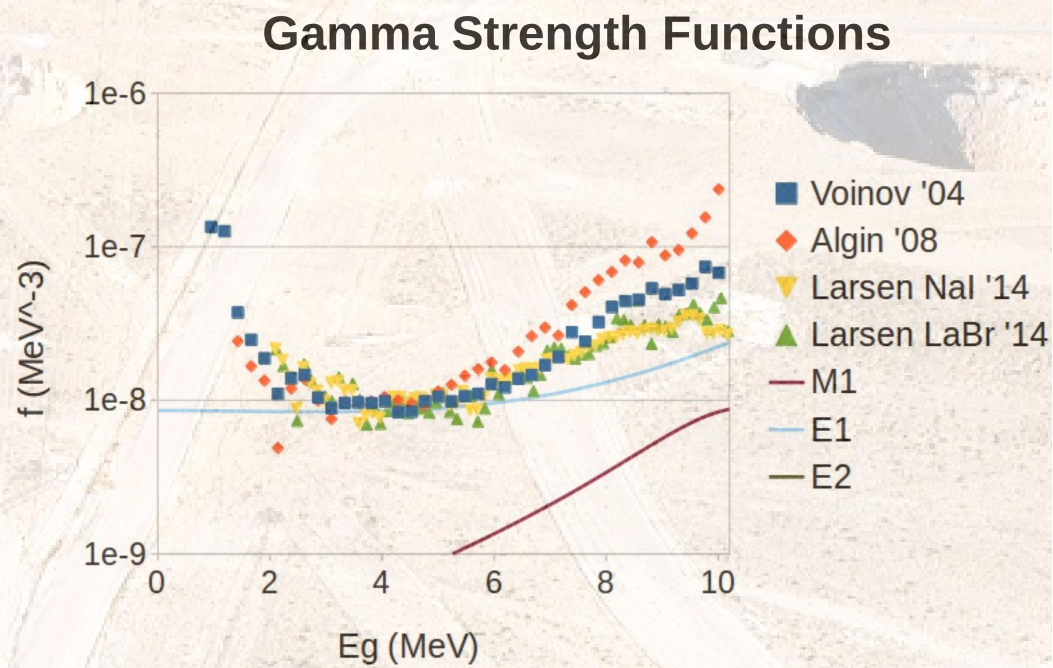


Been analyzing strength with gamma spectra: $P(E_\gamma)$

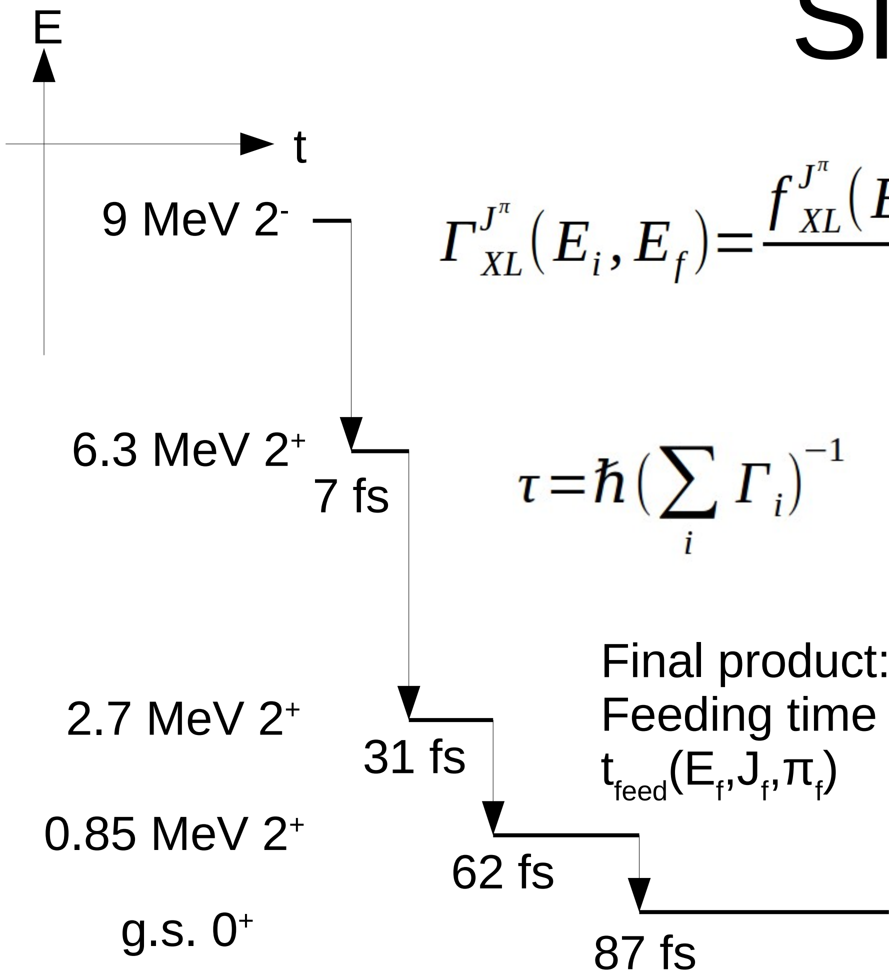
Now can analyze strength with lifetimes: $\Delta E_\gamma(\Theta)$

Nuclear Testing Grounds





Simulation

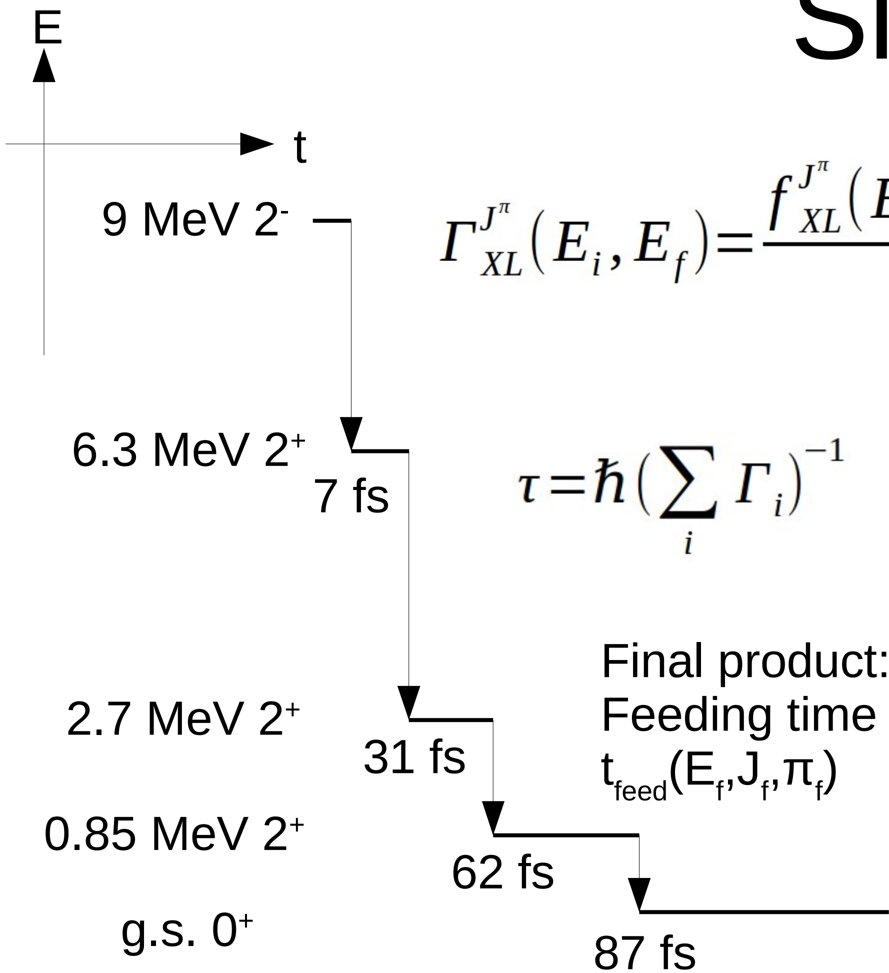


$$\Gamma_{XL}^{J^\pi}(E_i, E_f) = \frac{f_{XL}^{J^\pi}(E_i, E_f)(E_i - E_f)^{2L+1}}{\rho^{J^\pi}(E_i)}$$

$$\tau = \hbar \left(\sum_i \Gamma_i \right)^{-1}$$

Final product:
Feeding time distributions
$t_{feed}(E_f, J_f, \pi_f)$

Simulation



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Used DICEBOX[1]
But had trouble extending to different initial E,J,π
Suited to do (n,g)

New level energies, contents, widths

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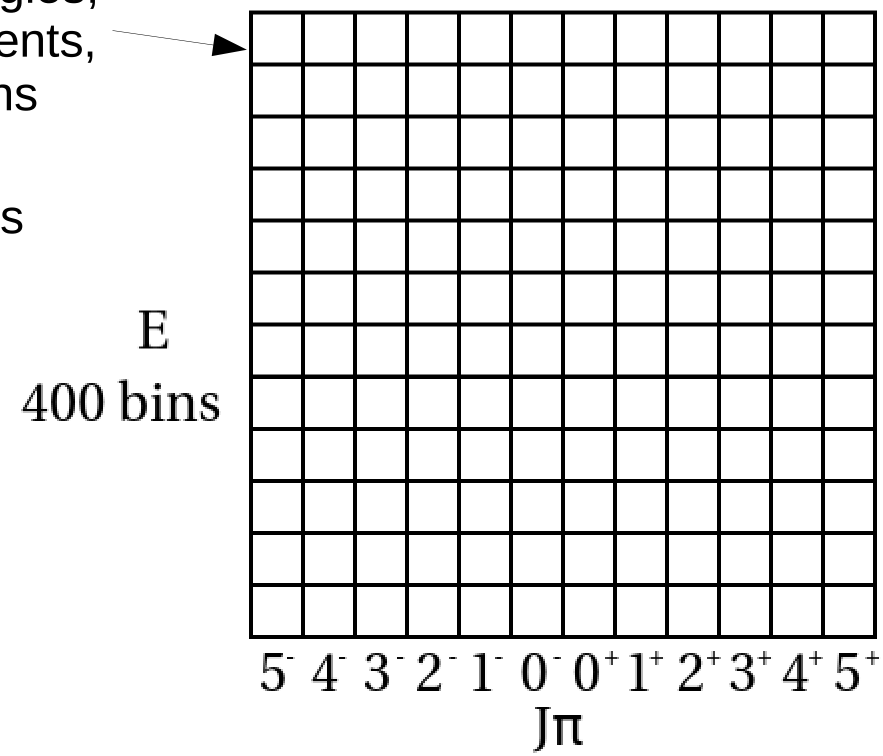
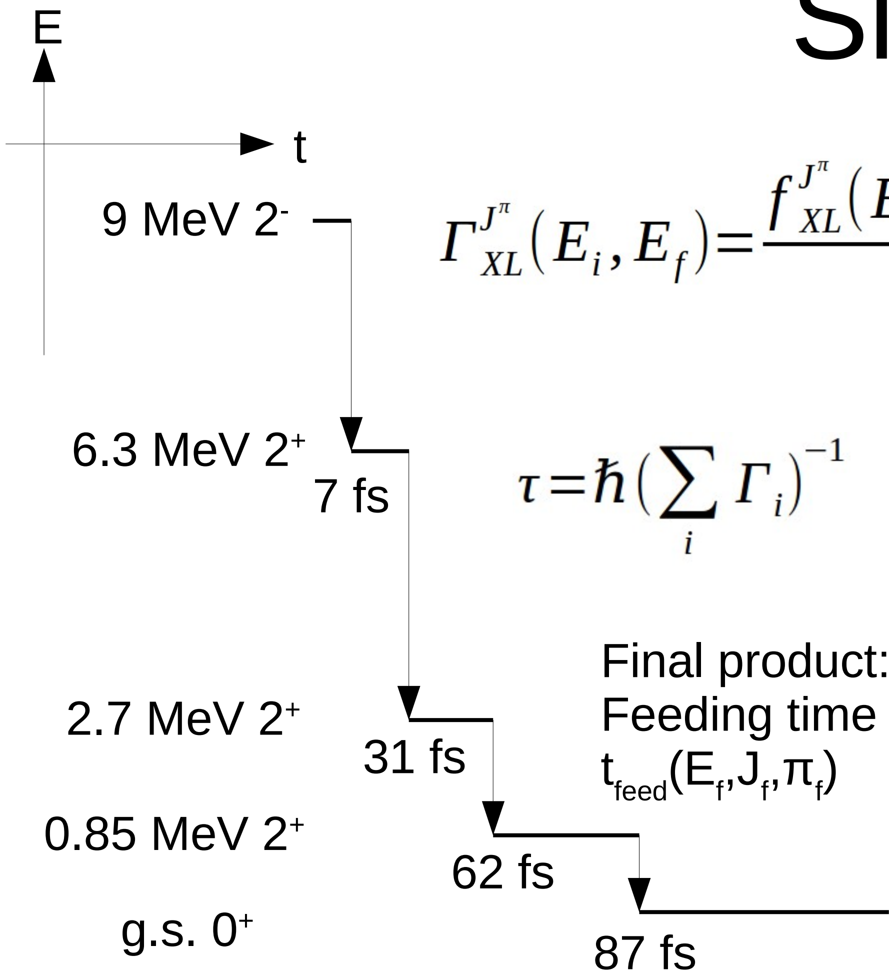


[1]F. Bečvář, NIM A 417, 2-3 (1998)

Simulation



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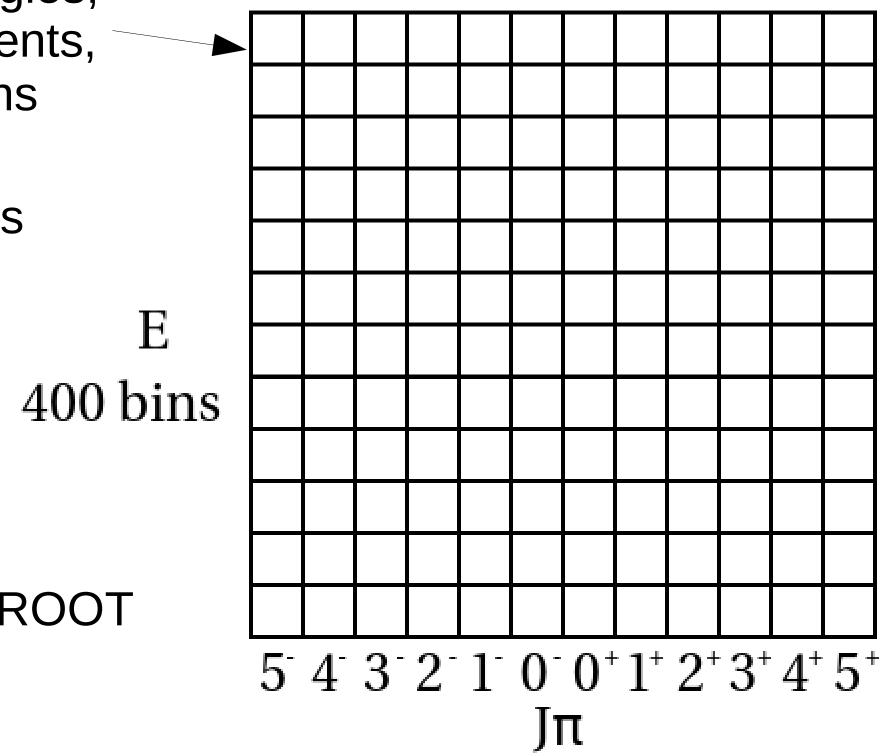

Final product:
Feeding time distributions
$t_{feed}(E_f, J_f, \pi_f)$

4500 lines FORTRAN → ~700-950 lines C++ / ROOT
Annotated well
Input energy, spin, parity distribution
Same built nucleus energies, contents, widths
Output many observables, including time

[1]F. Bečvář, NIM A 417, 2-3 (1998)

diCe.C

Simple Nuclear Parameters:

$$\rho_T^{\mathrm{tot}}(E_x) = \frac{1}{T}\exp\left(\frac{E_x - E_0}{T}\right)$$

$$P(\pi) = 1/2$$

$$R_F(E_x, J) = \frac{2J+1}{2\sigma^2}\exp\left[-\frac{(J+\frac{1}{2})^2}{2\sigma^2}\right]$$

Initial Excitations:
E = Gaussian, 11 +/- 0.2 MeV
J = Poisson, mean 2.2 ħ
P = Uniform +/-

Decay:
E1 = GLO; M1,E2 = std Lorentzian

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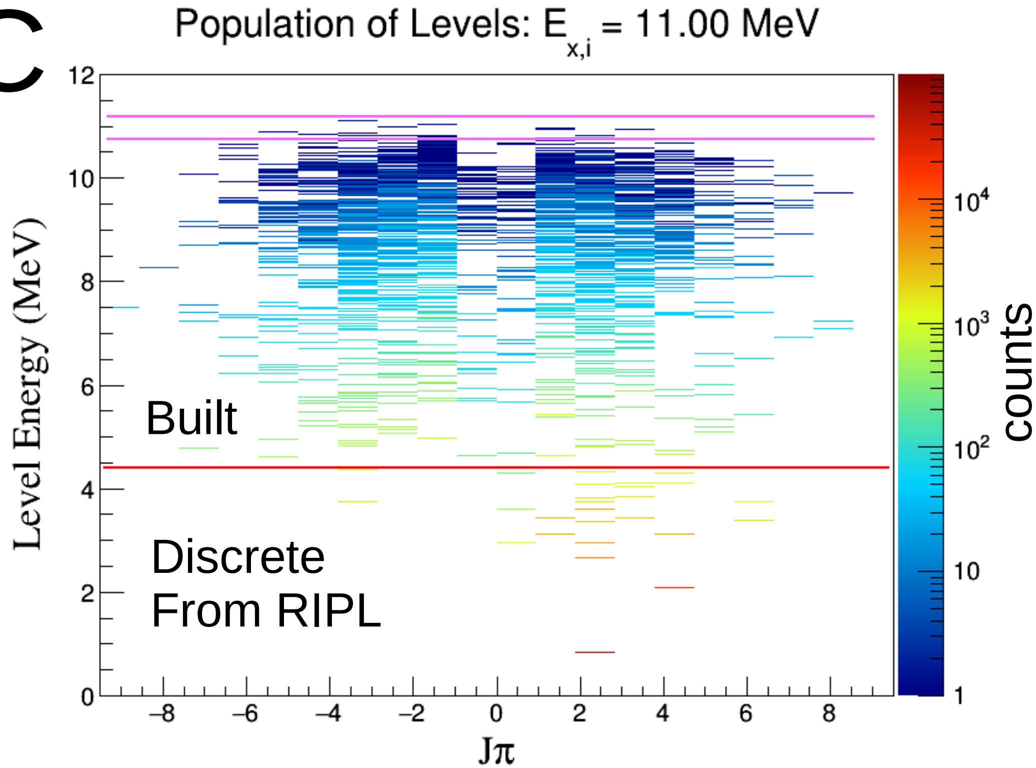

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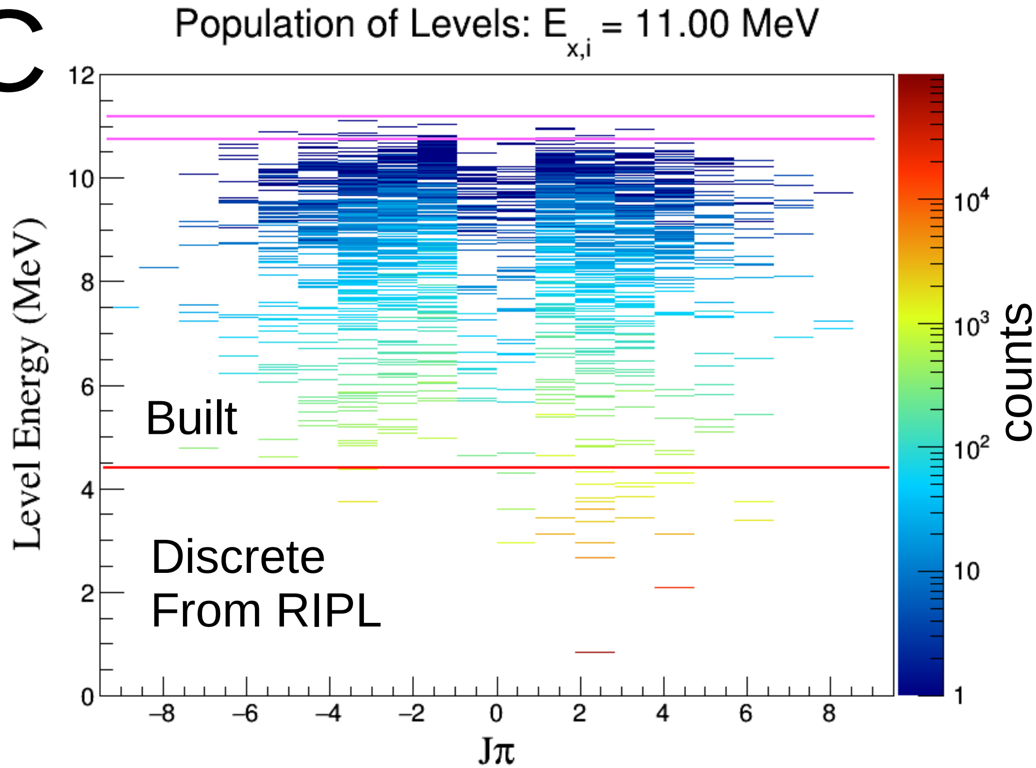

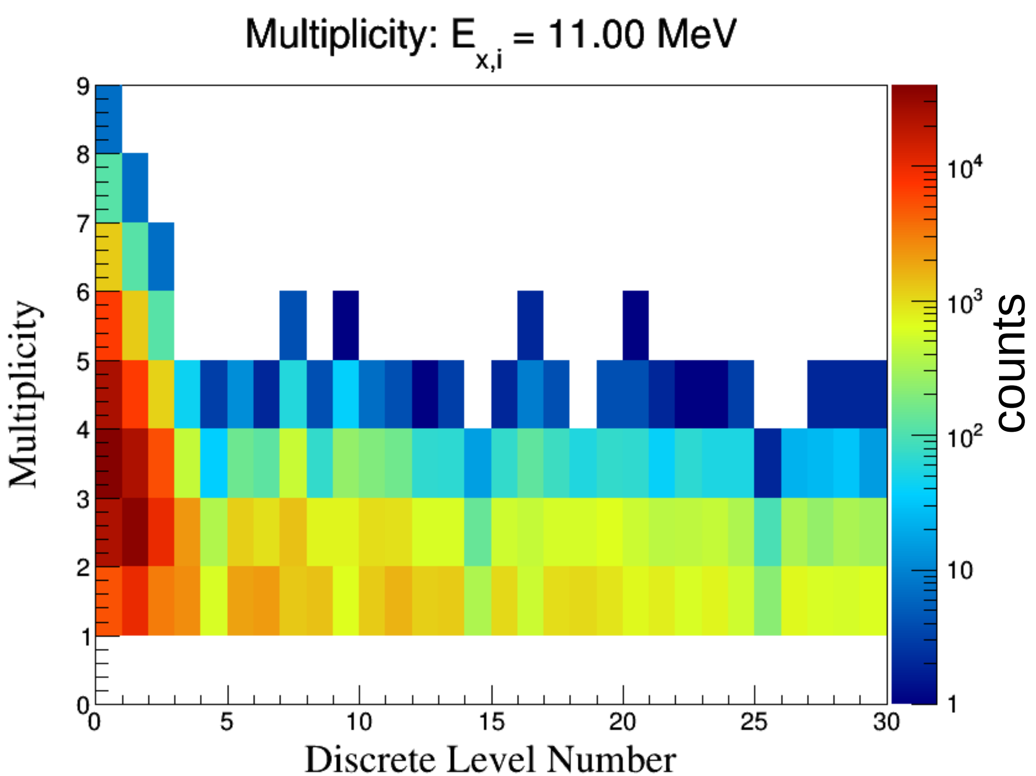

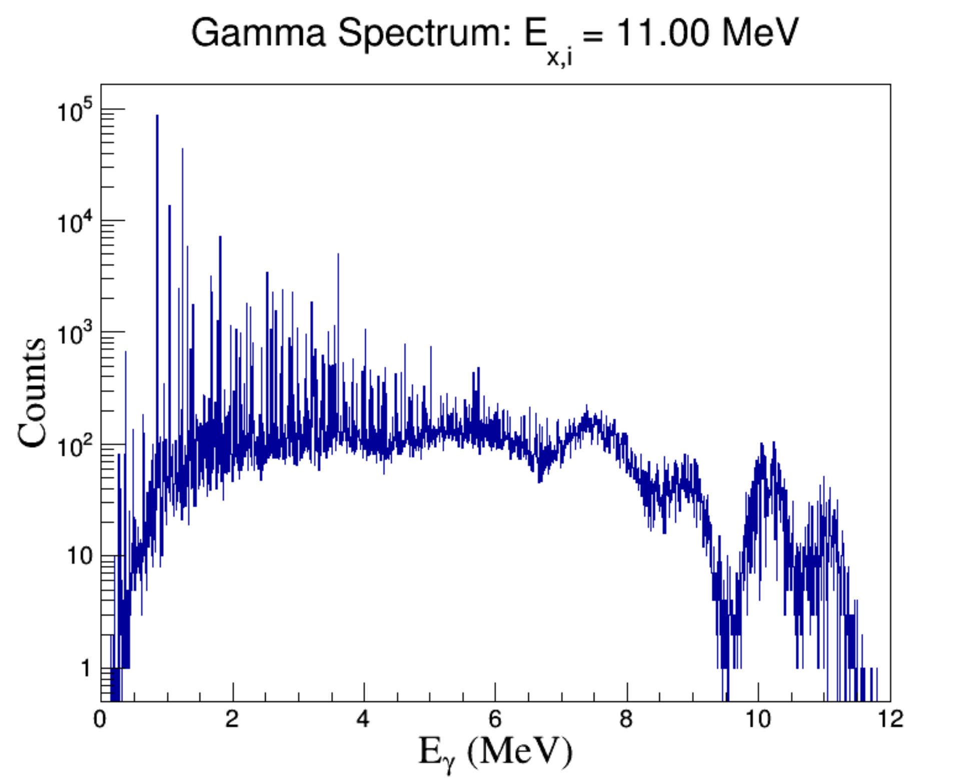

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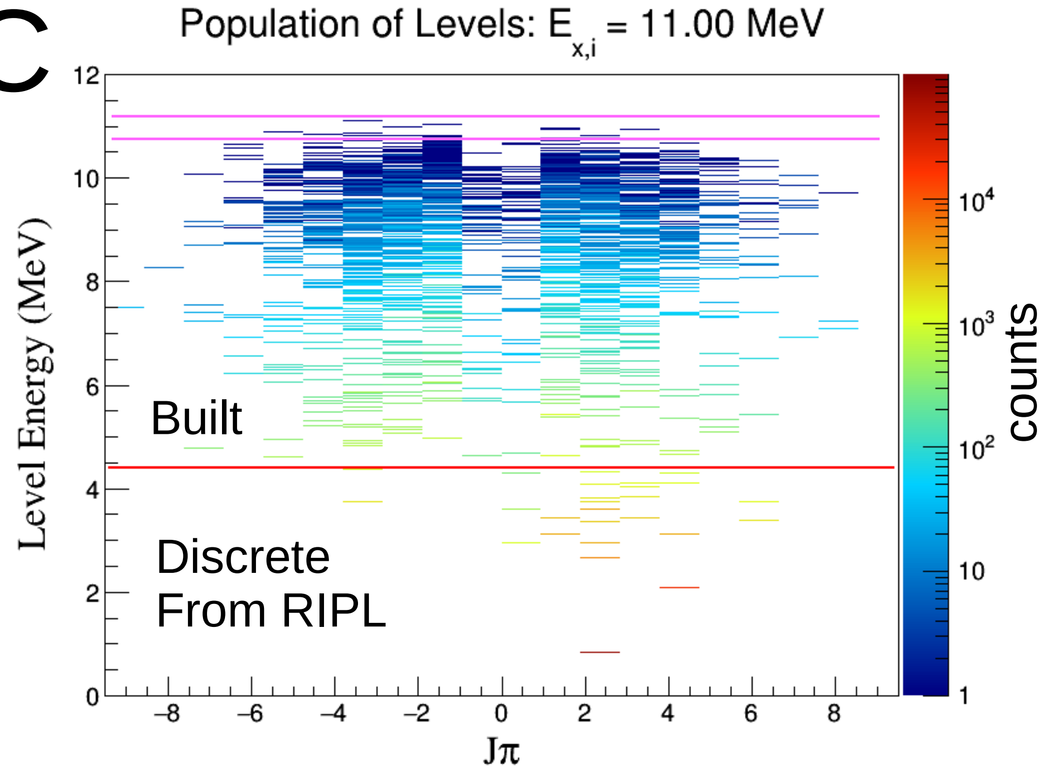

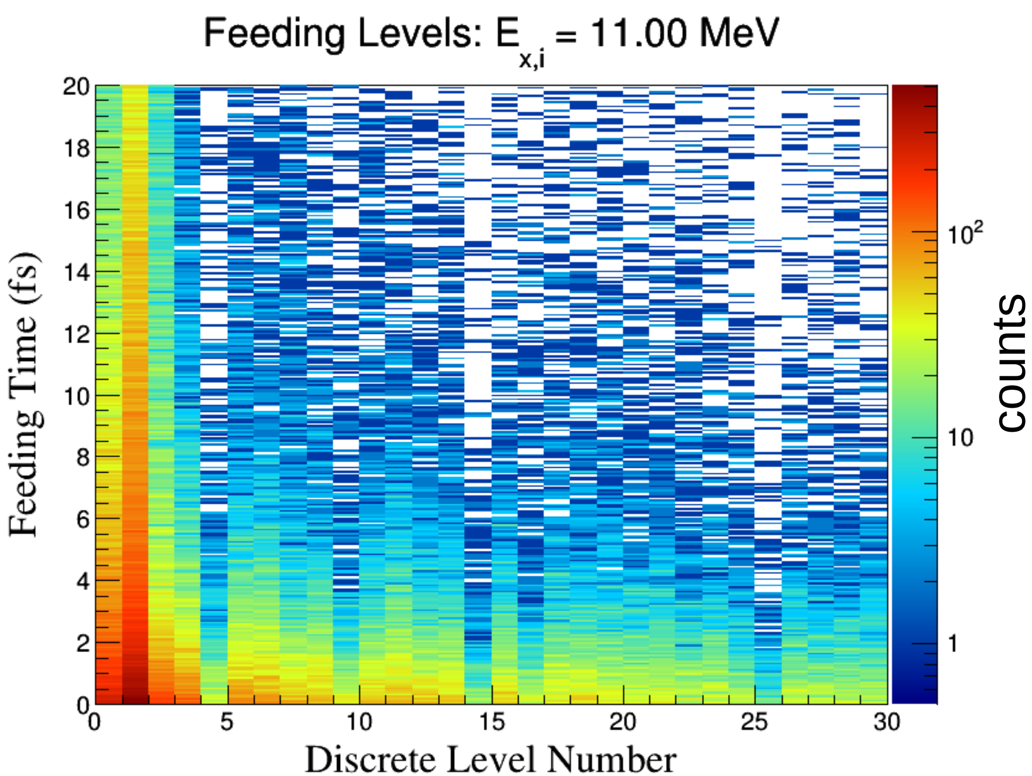

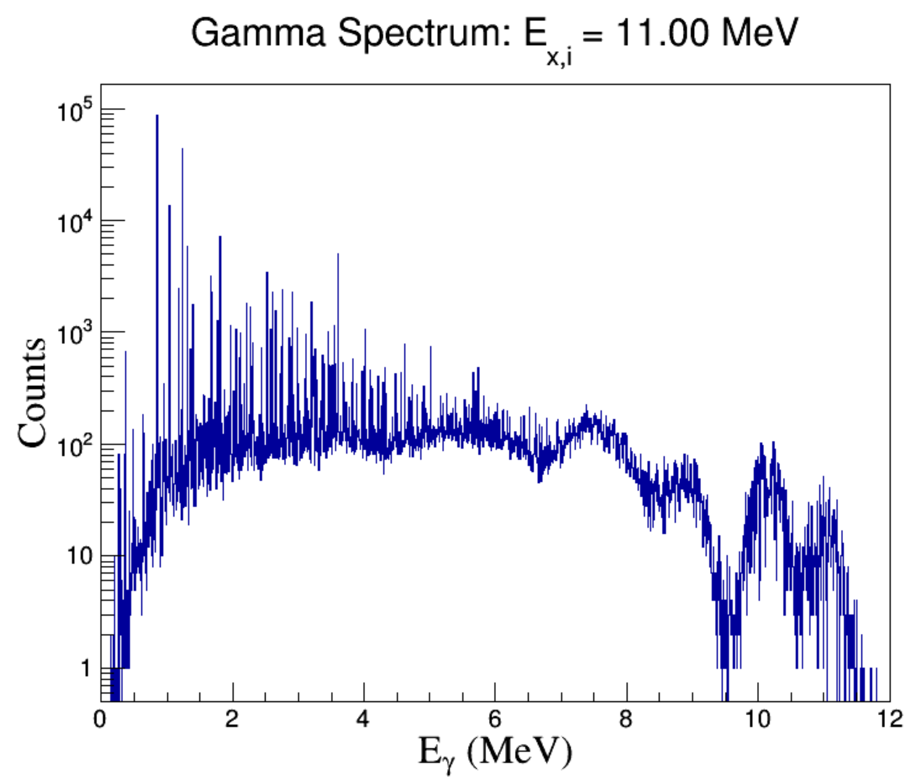

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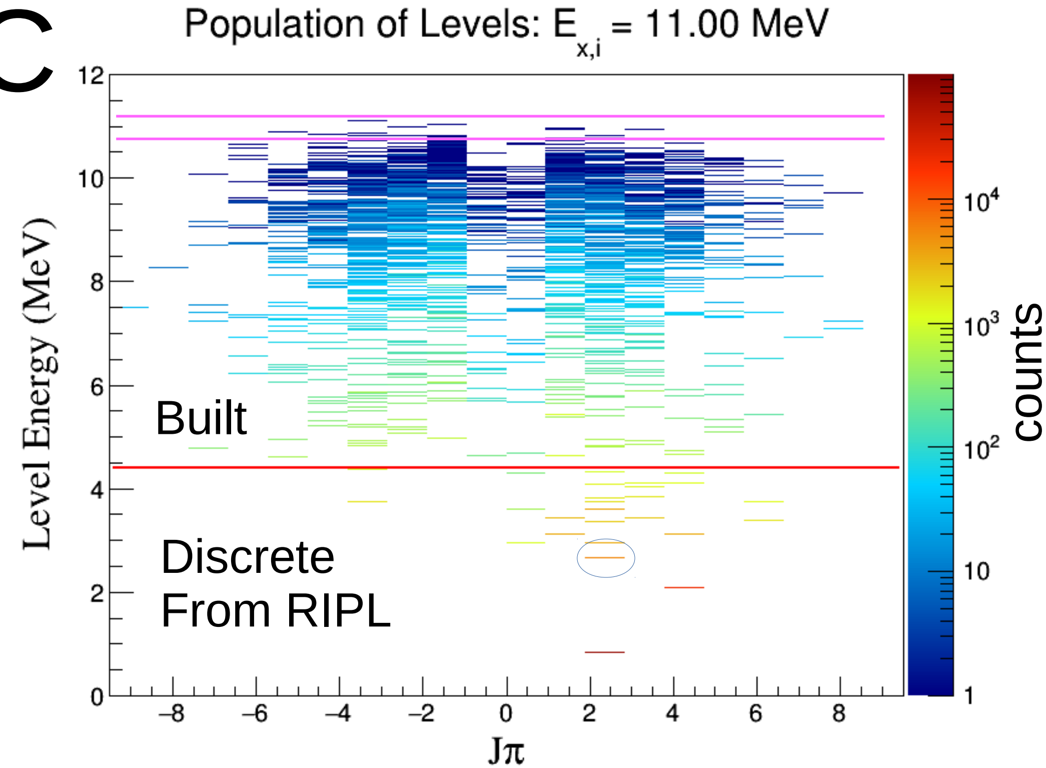
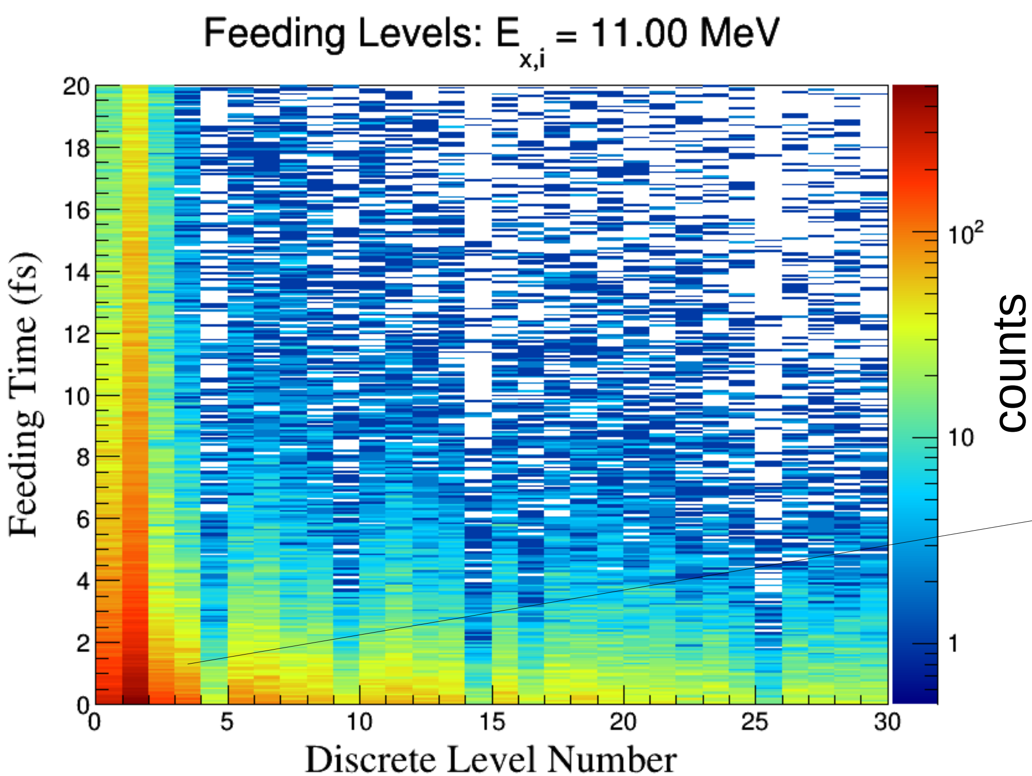
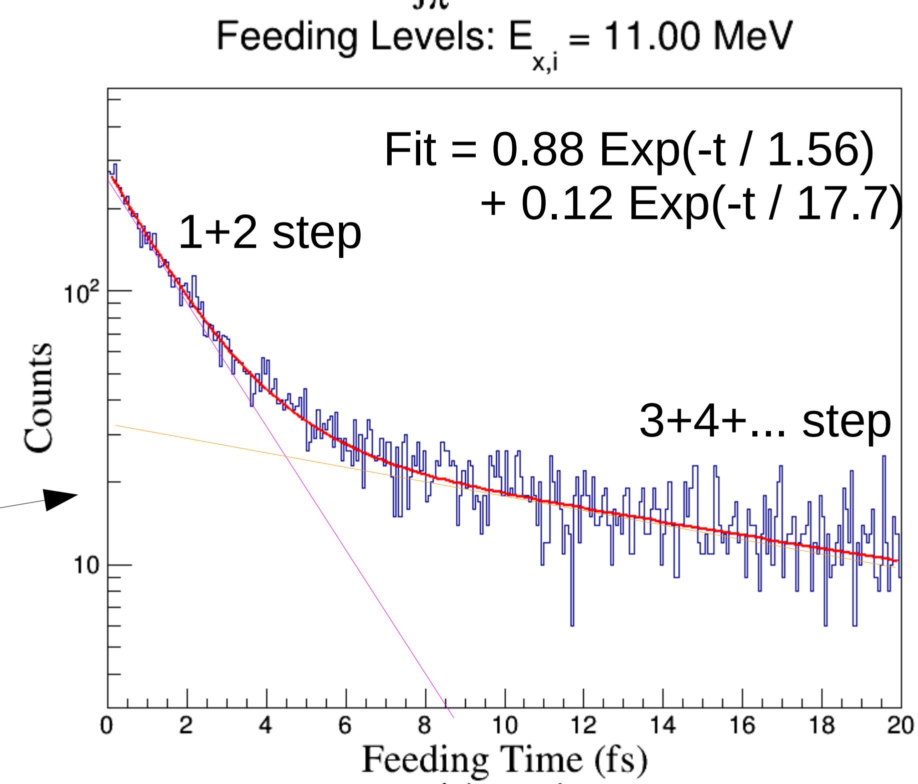
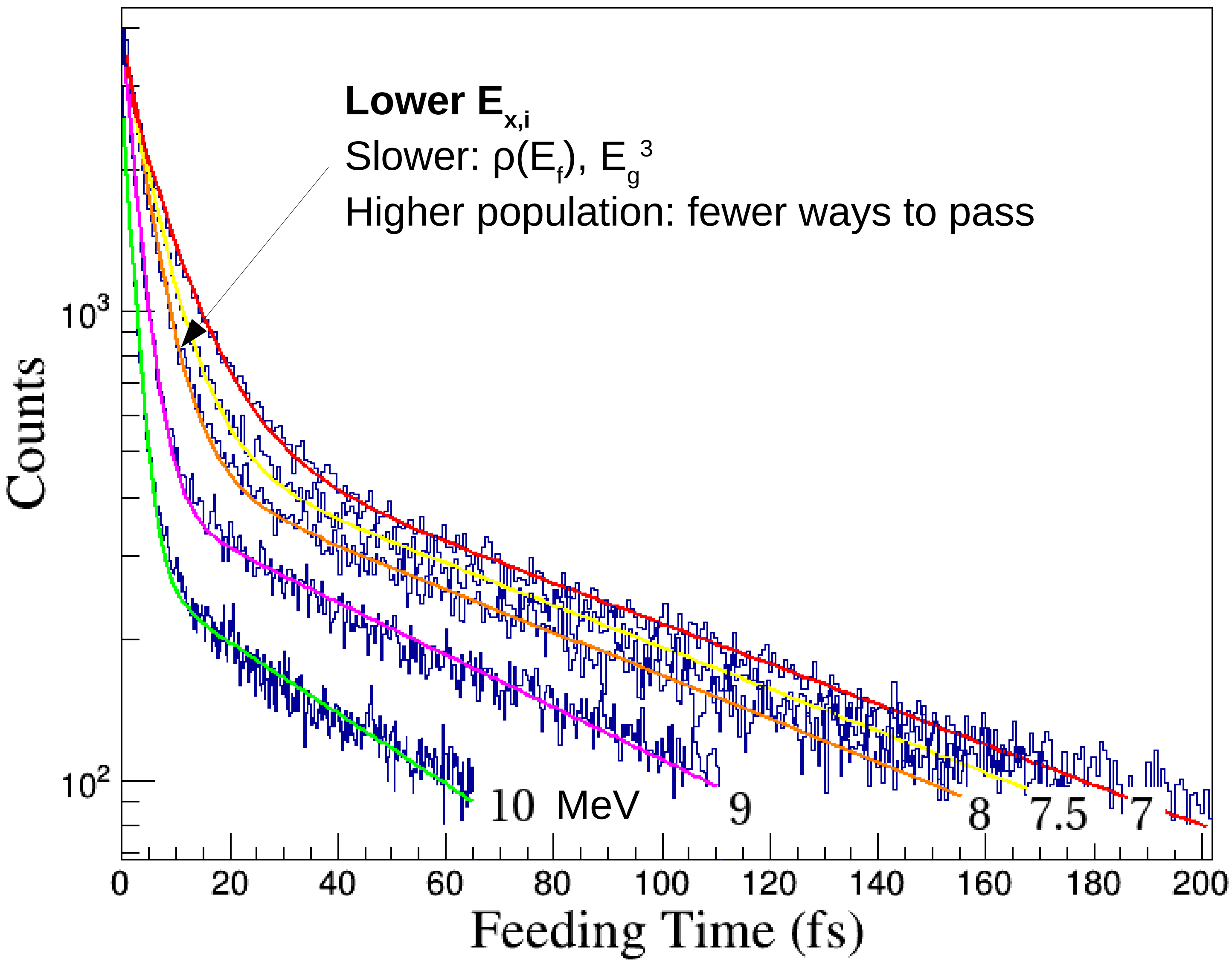
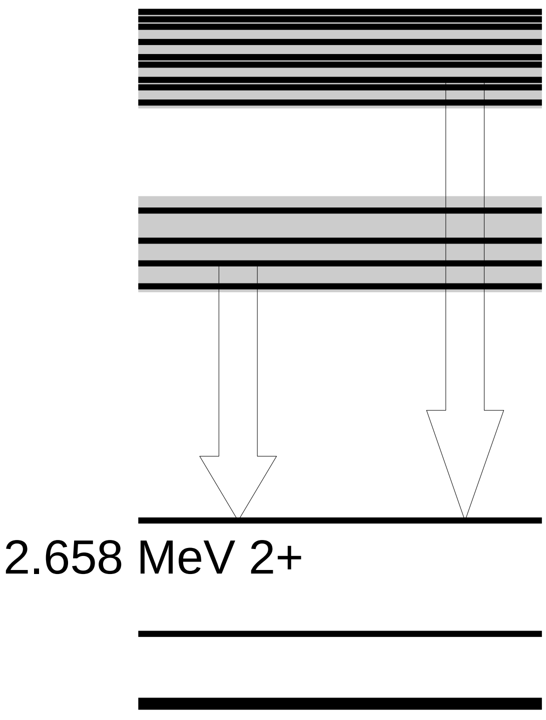




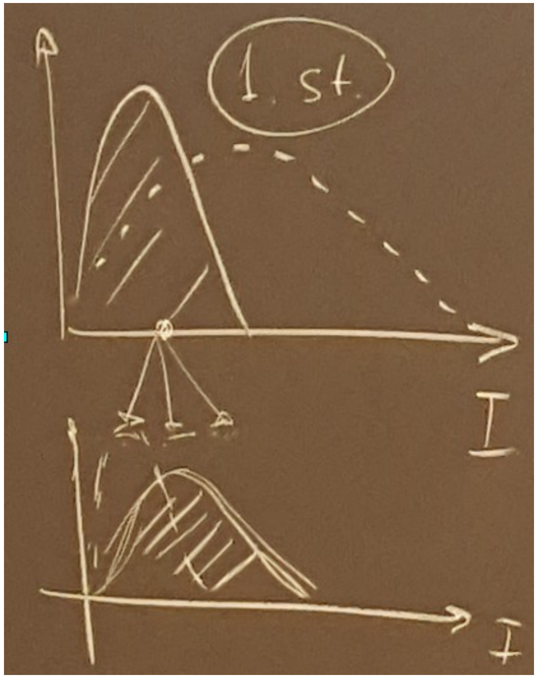


Starting Energy



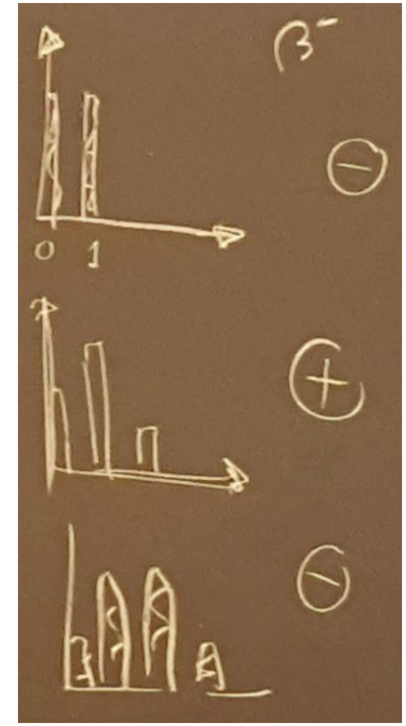


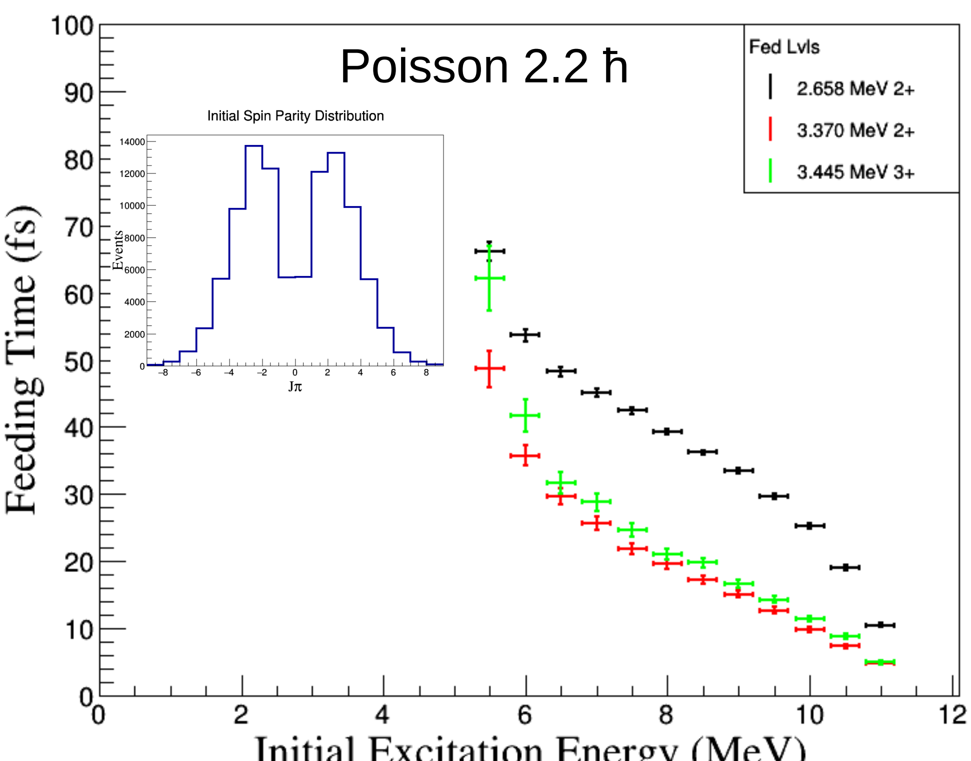
Initial Spin Dist

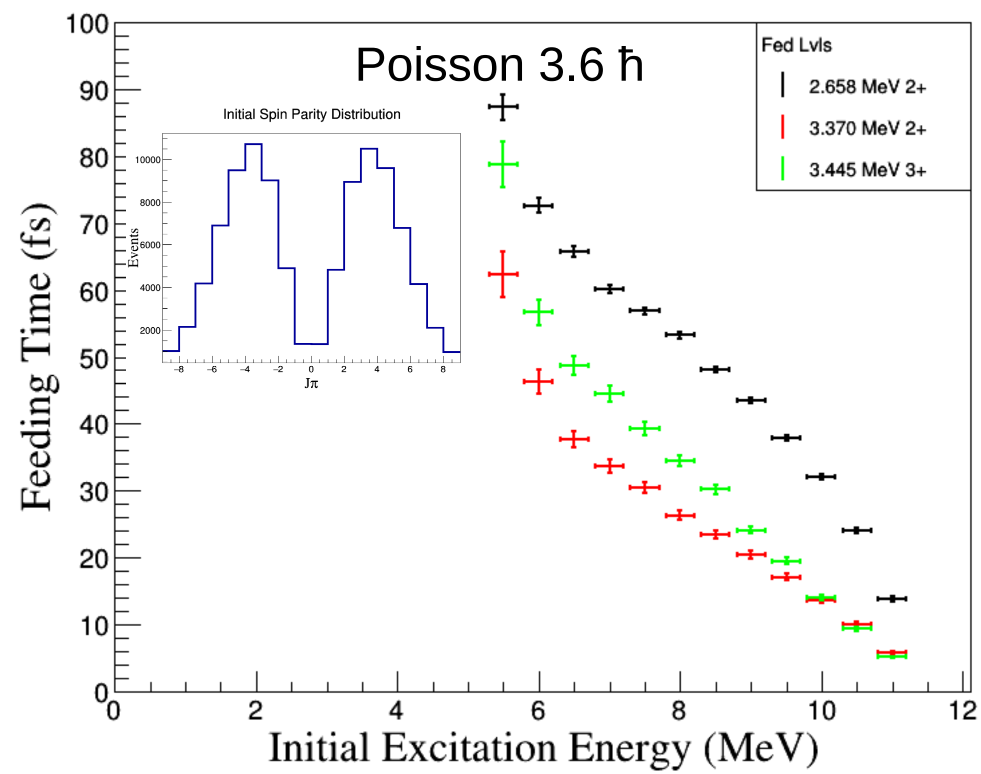


[2]T. Døssig, 6th Workshop on Nuclear Level Density and Gamma Strength, Oslo 2017

Still benchmarking
and tuning the feeding times







Thanks

- I.Y. Lee, A.O. Macchiavelli, C.M. Campbell, M. Cromaz, R.M. Clark, H.L. Crawford, P. Fallon, M.D. Jones and the rest of the GRETINA team
- L.A. Bernstein, Karl van Bibber

Benchmark In Progress

Initial state: ^{56}Fe, 7.0 MeV, 3+

Initial state: ^{186}Re, 6.0 MeV, 1+

Population of low lying levels

diCe

DICEBOX

Different random # methods
Magnitudes of the same order
Porter-Thomas Fluctuations of
same order:

PT: ν = 1
Violent dist

diCe might seem slower but:
1. DICEBOX is saving initial state widths
2. diCe presumes widths will need recalc every initial state
3. DICEBOX slows to same speed with this presumption

To Do

- Intricate strength and level density models
- Odd A nuclei
- Internal conversion
- More benchmarking