Simulations for the Target Recoil Tracker at the R^3B experiment

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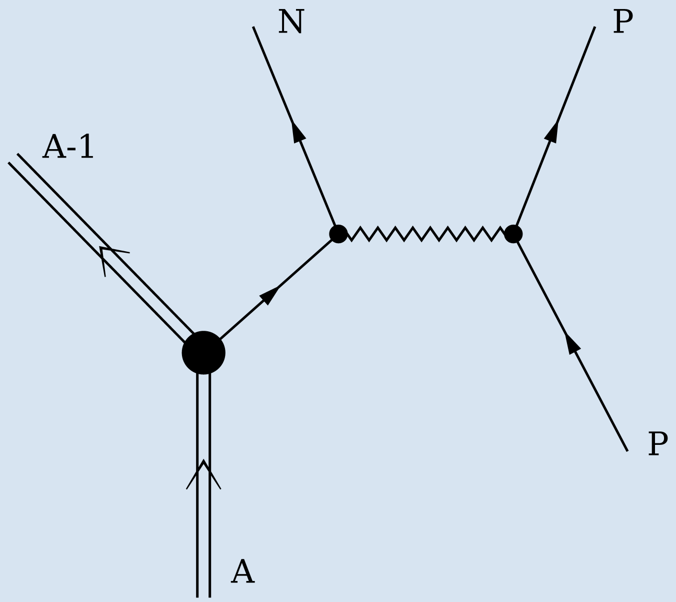
16.05.25

Quasi-free scattering



The impulse approximation:

- At high beam energies (100-1000 MeV/A), de Broglie wavelength of incident proton is less than avg. internucleon separation ⇒ strongly localized interaction
- Influence of spectator nucleons minimal ⇒ “quasi”-free process
- Residual (A-1) nucleon gives valuable info about knocked out proton: internal momentum, separation energy

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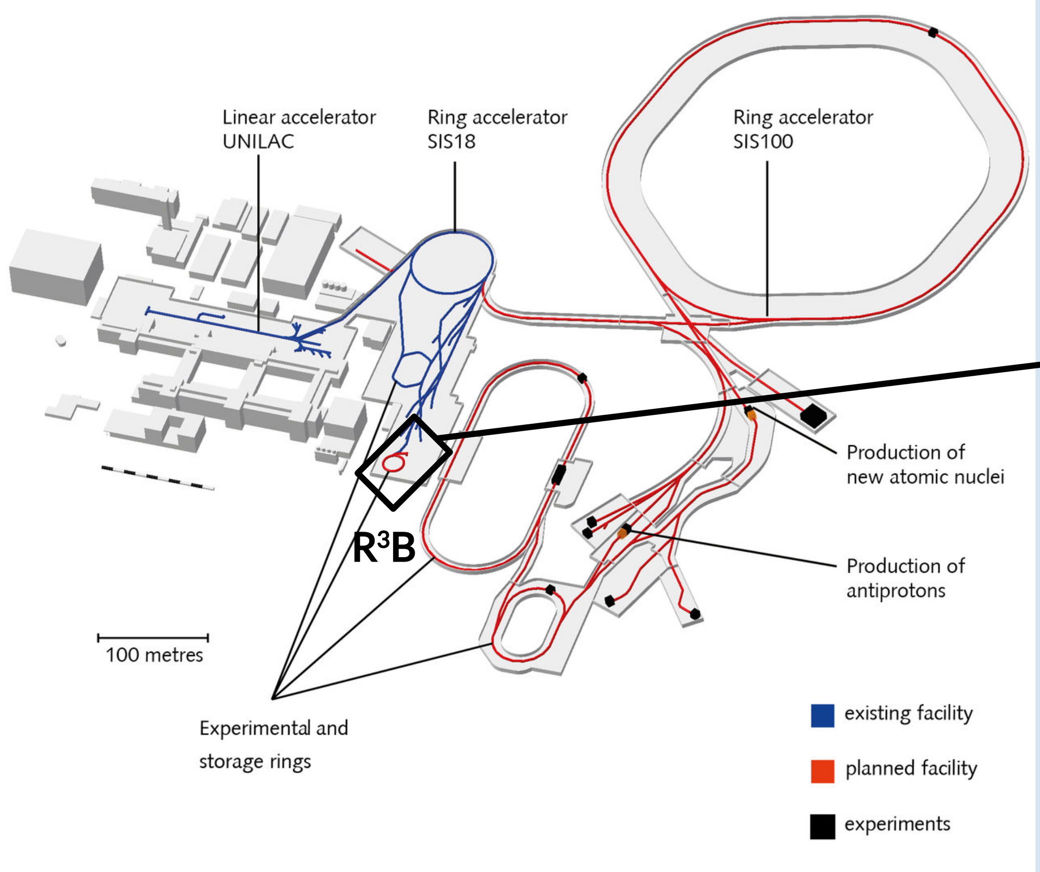
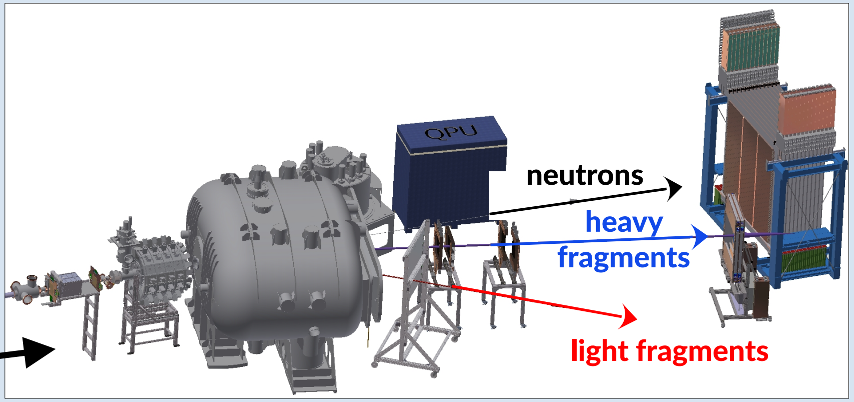
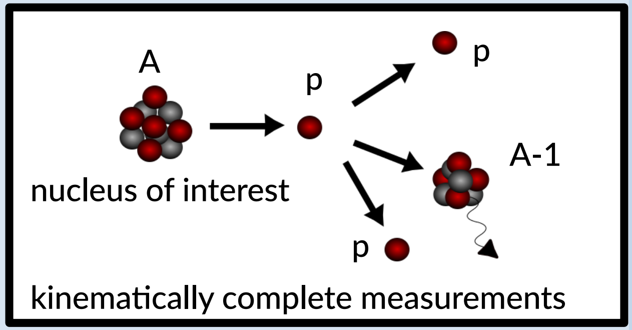
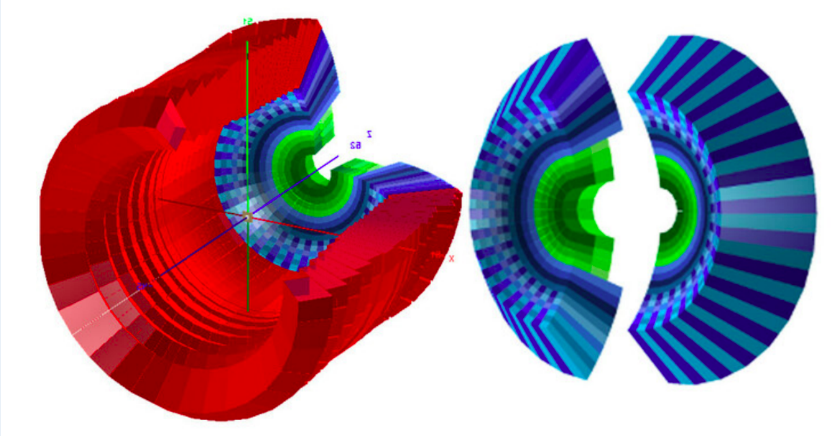
Overview : R^3B and CALIFA



R^3B: Reactions with Radioactive Beams







CALorimeter for the **I**n **F**light detection of γ rays and light charged p**A**rticles

Inverse QFS as a probe for:

- Short range NN correlations
- Deformation of asymmetric nuclei
- In-medium effects: clusterization of nuclei
- and so on...

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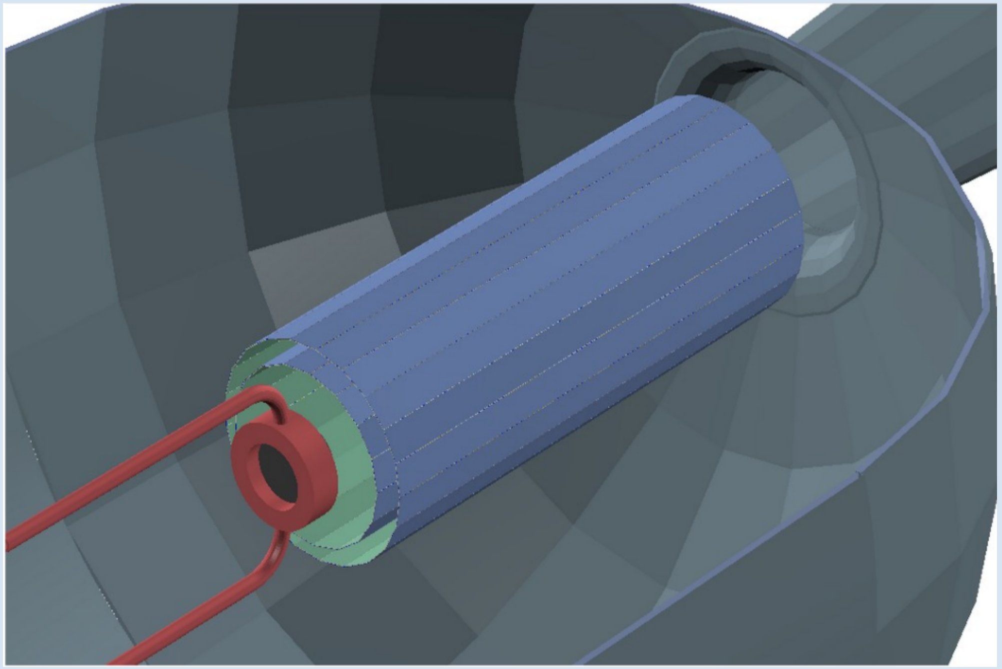
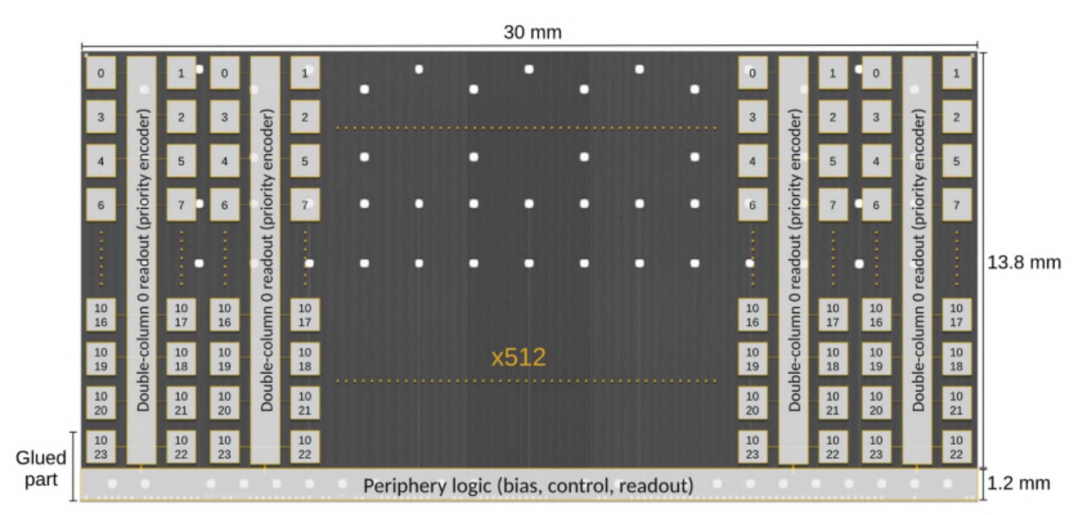
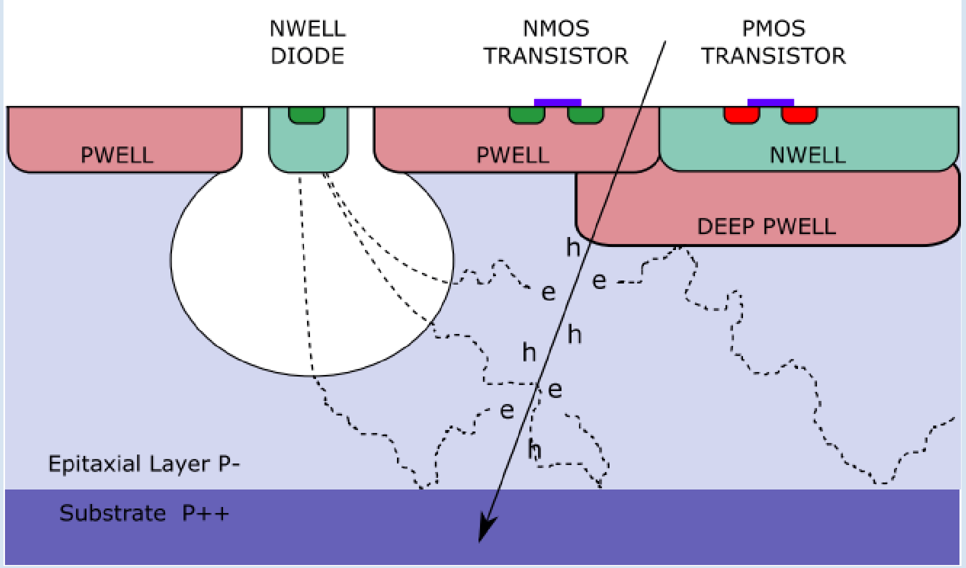
Target Recoil Tracker







- A precise reaction vertex reconstruction + kinetic energy measurement in CALIFA, provides 4-momenta of light charged particles
- Helps identify missing mass in a (p,2p) reaction
- Ideal choice: adopt the ALPIDE MAPS sensor
  → small pixel size (sub 10 μm res.), high efficiency for MIPs, etc.

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Simulations: simple (p,p) scattering

- Simulation without any target dimensions or detector geometry
- Provide initial 4 momenta to beam, target
- In the CM frame, calculate t_{min} and t_{max} using known relations:

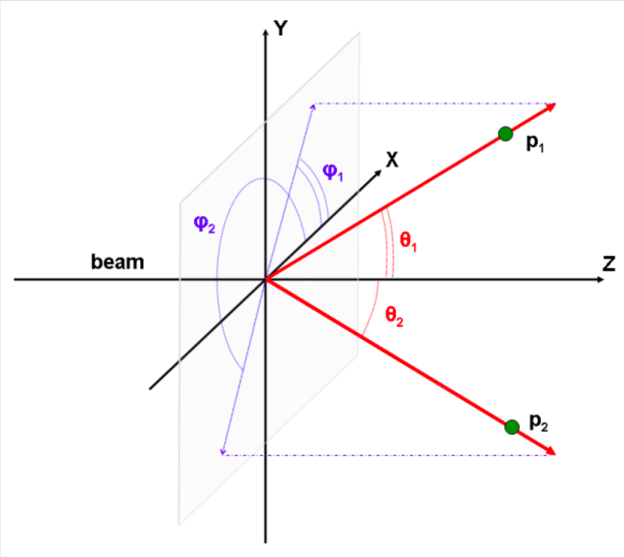
$$t = (p_1 - p_3)^2 = -2|\vec{p}|^2(1 - \cos\theta_{CM})$$

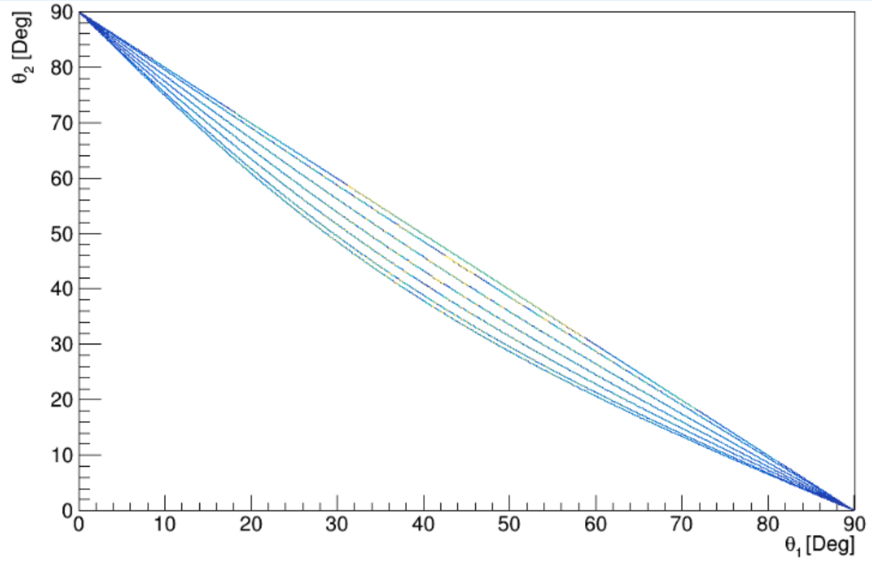
$$-1 \leq \cos\theta_{CM} \leq 1 \Rightarrow -4|\vec{p}|^2 \leq t \leq 0$$

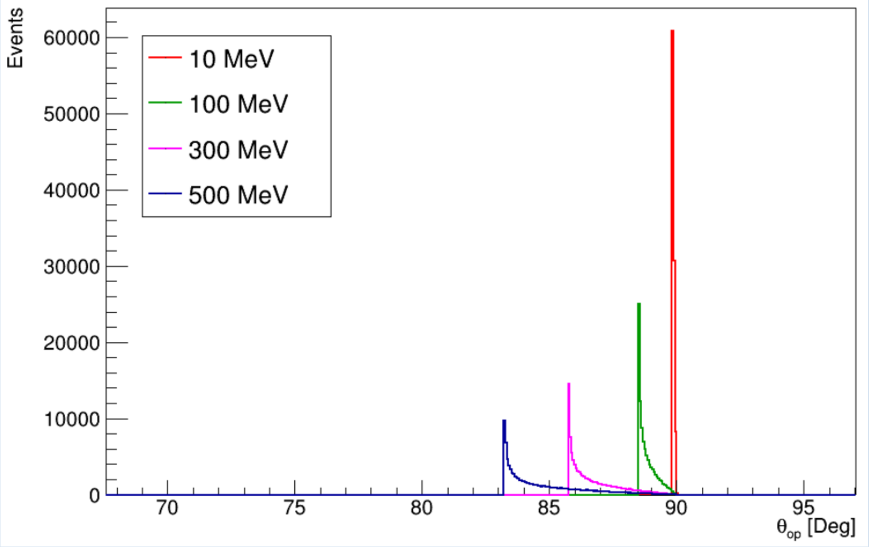
- Sample t randomly from a parametrized pp cross section:

$$d\sigma/dt = e^{Bt}\,;\, B = f(p_{lab})$$

- Obtain θ_1 and θ_2, perform Lorentz transformations back to lab frame $\rightarrow$ θ_{1L} and θ_{2L}

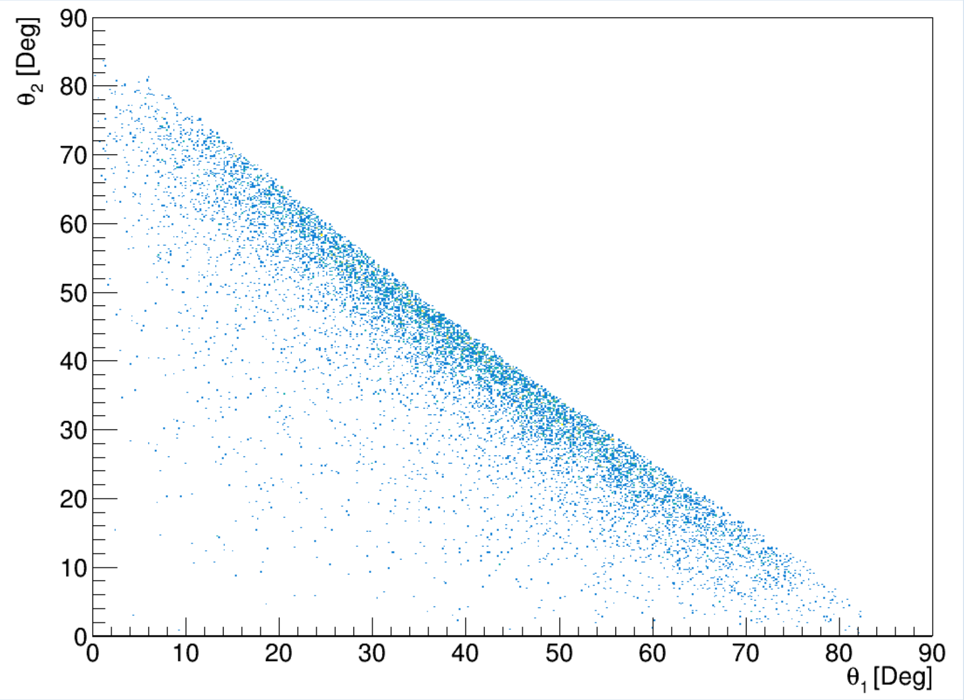


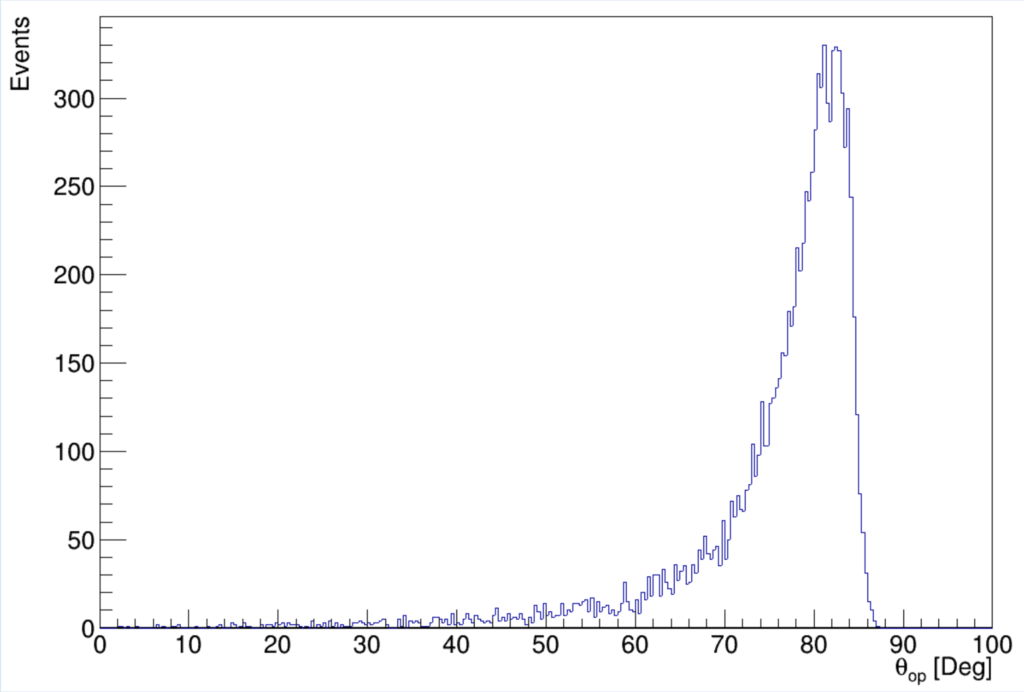




Non trivial case: d(p,2p)n scattering

- Defined an LH_2 target (1.5 cm)
- p_F = 116 MeV/c given to the deuteron beam with E_{beam} = 400 MeV/A
- Beam profile smeared in (x,y) directions as Gaussian, with σ = 0.5 mm, uniform distribution in z over target length
- Tracks propagated through the target using GEANT4 Engine





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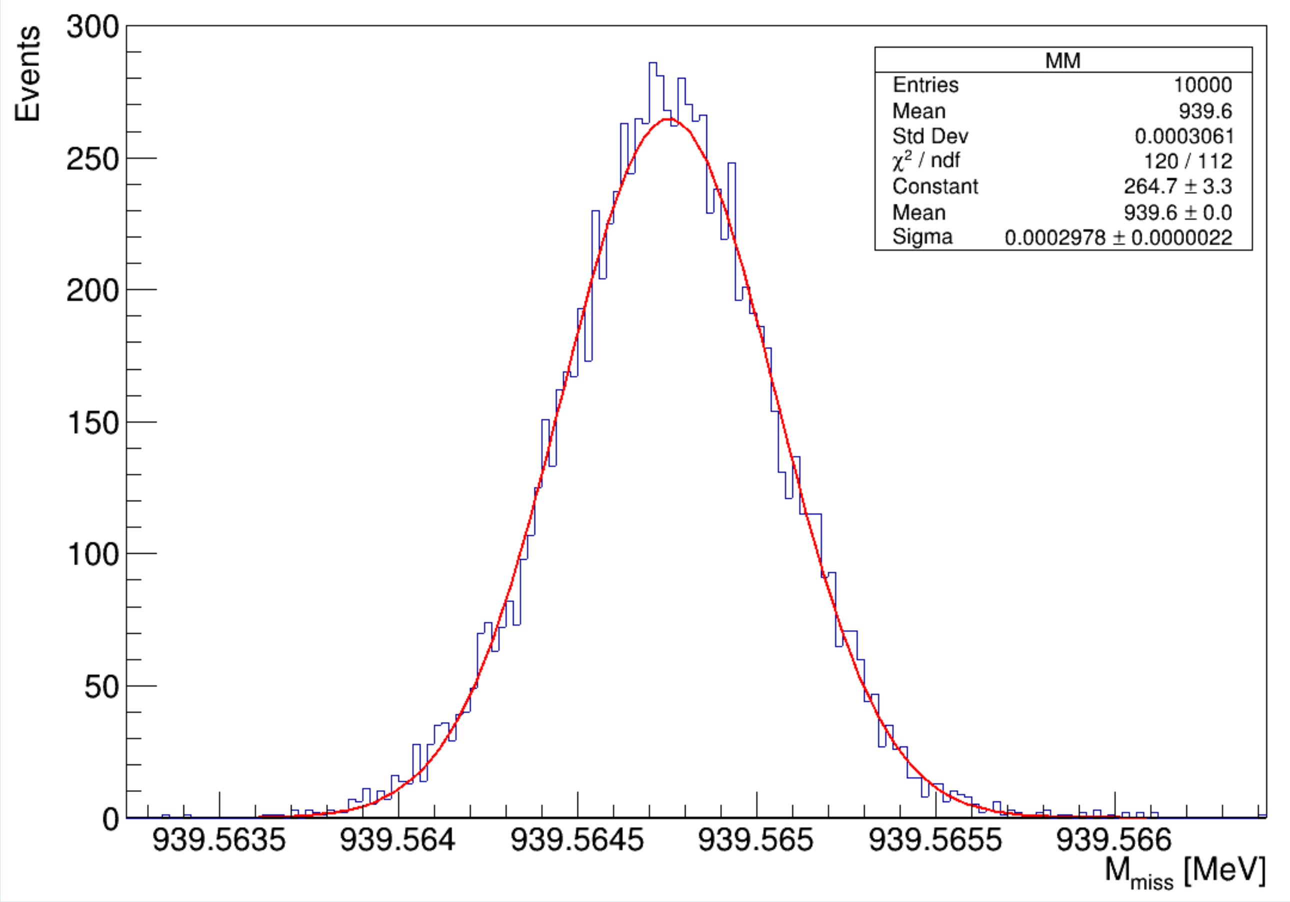
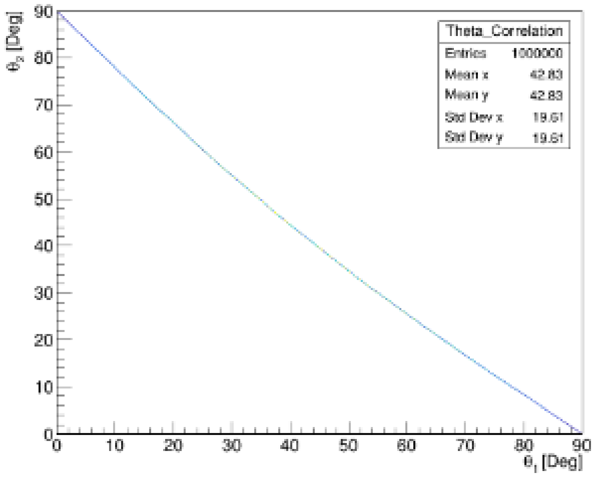


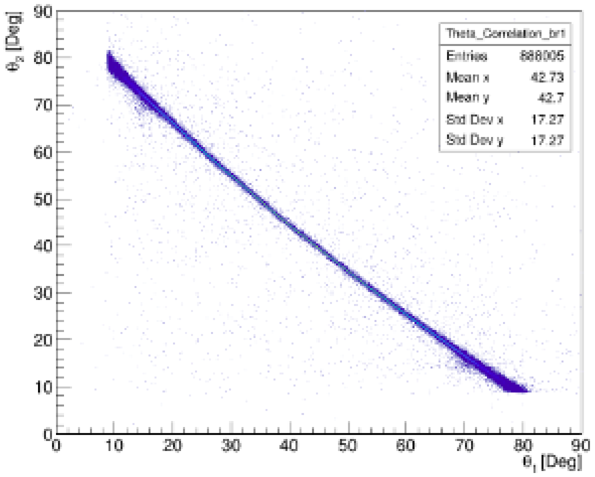
$$p_{miss} = p_{tgt} + p_{beam} - (p_1 + p_2)$$
$$= E_{ex} + m_{frag}$$

Here, just the neutron mass

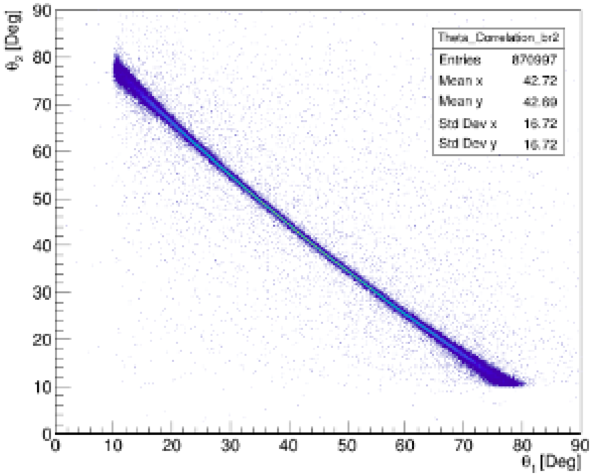
Back to (p,p) scattering (with TRT)



Without TRT

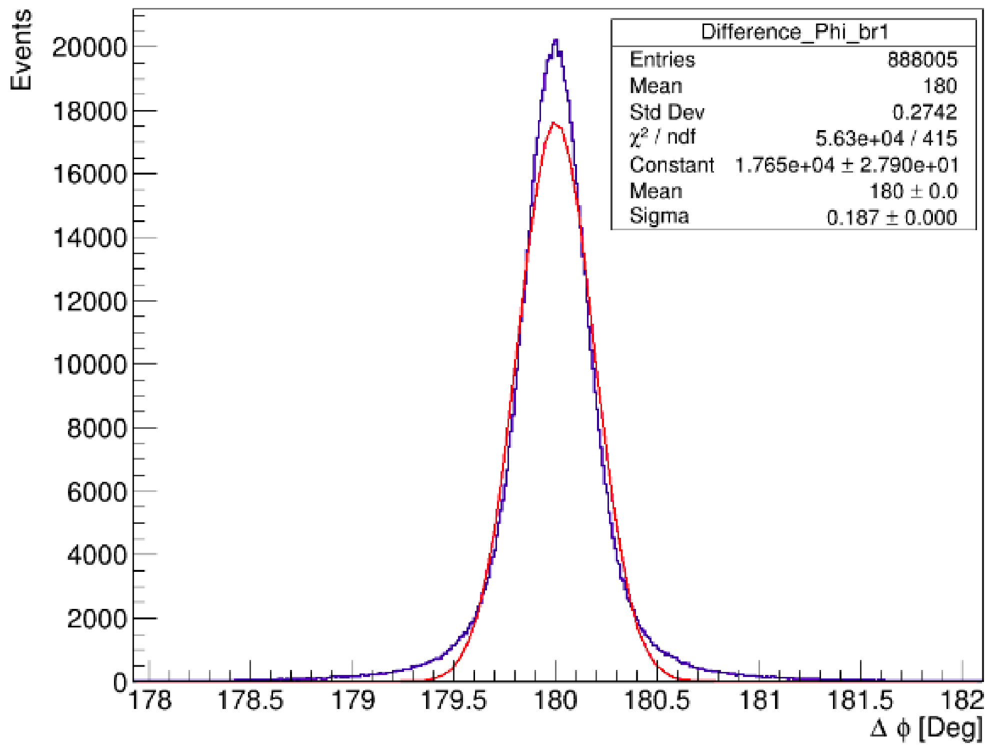


With TRT (inner barrel)

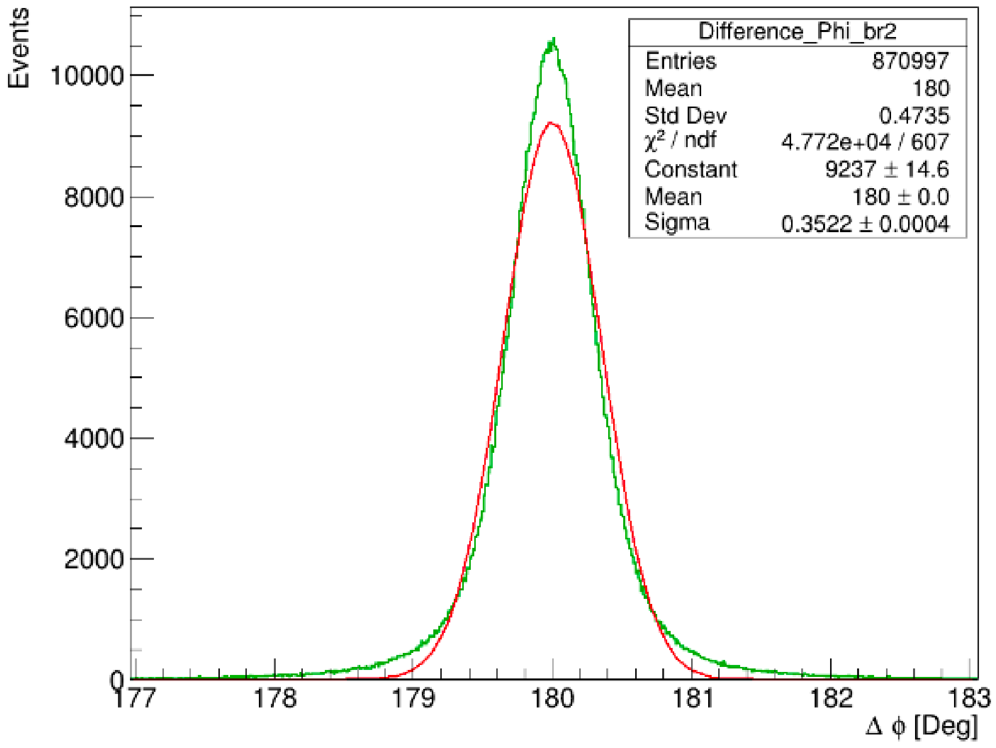


With TRT (outer barrel)

Back to (p,p) scattering (with TRT)



Gauss fit to $\Delta\phi$ distribution for inner barrel

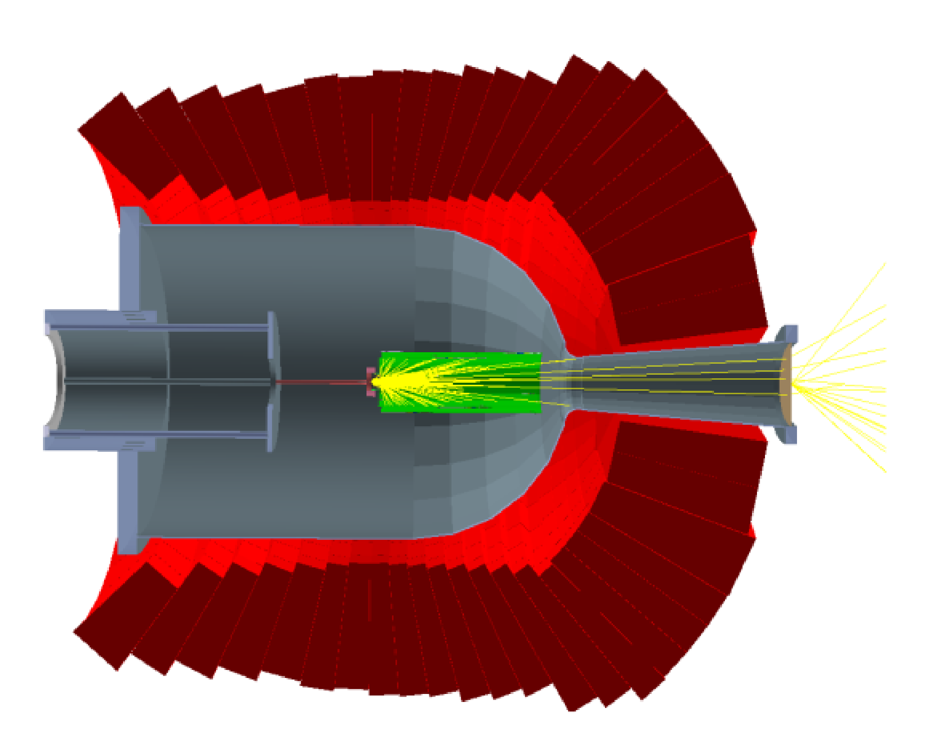


Gauss fit to $\Delta\phi$ distribution for outer barrel

Angular resolution for TRT : σ ~ 3 mrad

Outlook

- Simulations are still semi-realistic…
- Must include CALIFA calorimeter to get actual kinetic energies, as in experiment
- Apply an excitation energy in the simulation, Doppler correction to output excitation energy, to find this resolution
- Effect of background (delta electrons) in angular and vertex reconstruction not yet considered
- Future plan: an ideally thin, additional inner barrel (50 µm) to be used to improve track reconstruction



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Thank You !