Adding a Neutron Detector to HADES: First Geant3 Simulations

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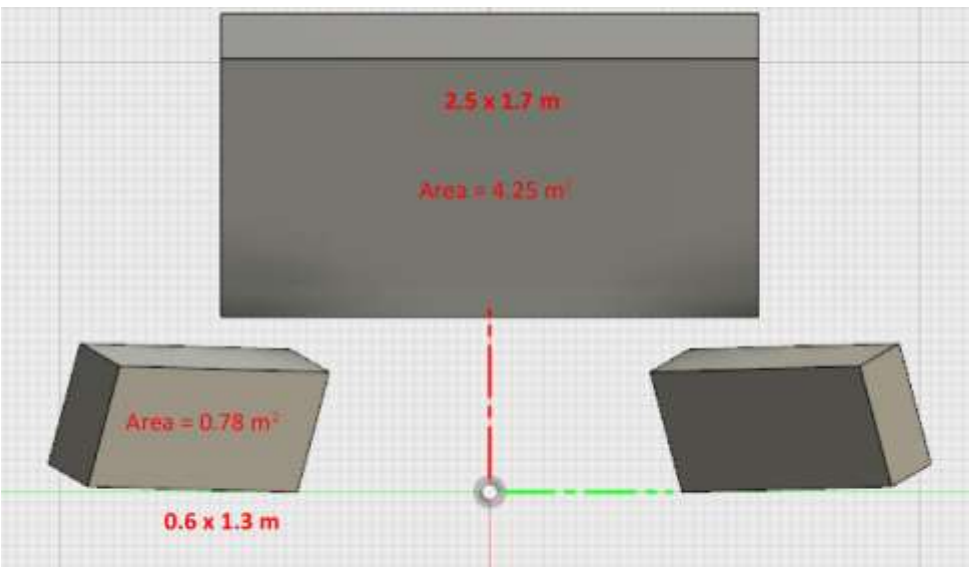
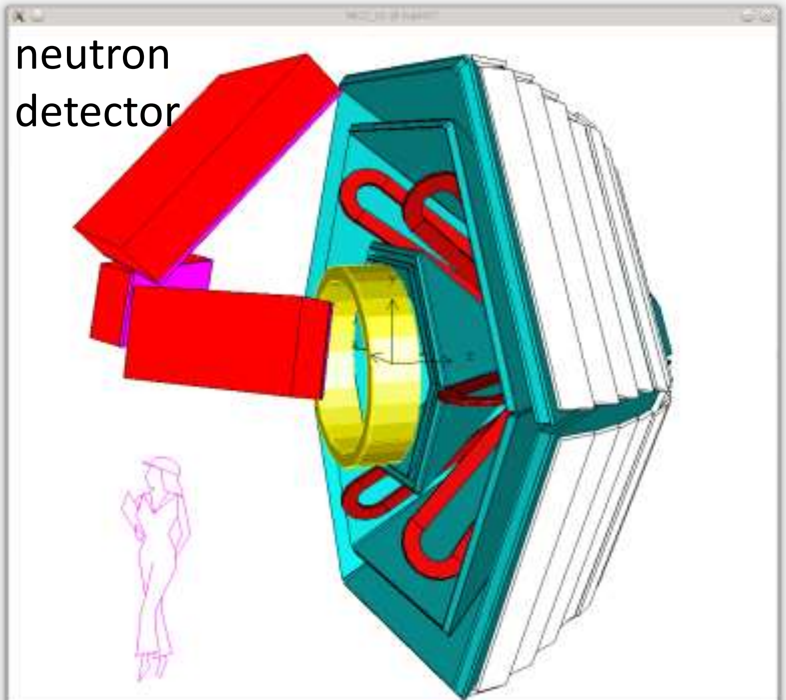


Design based on plastic scintillators
by G. Laskaris & J. Pietraszko

- **Implementation in HGeant**
  - geometry
  - materials
  - hit definition
- **Neutron hit analysis**
  - acceptance
  - efficiency
  - resolution
  - n rescattering

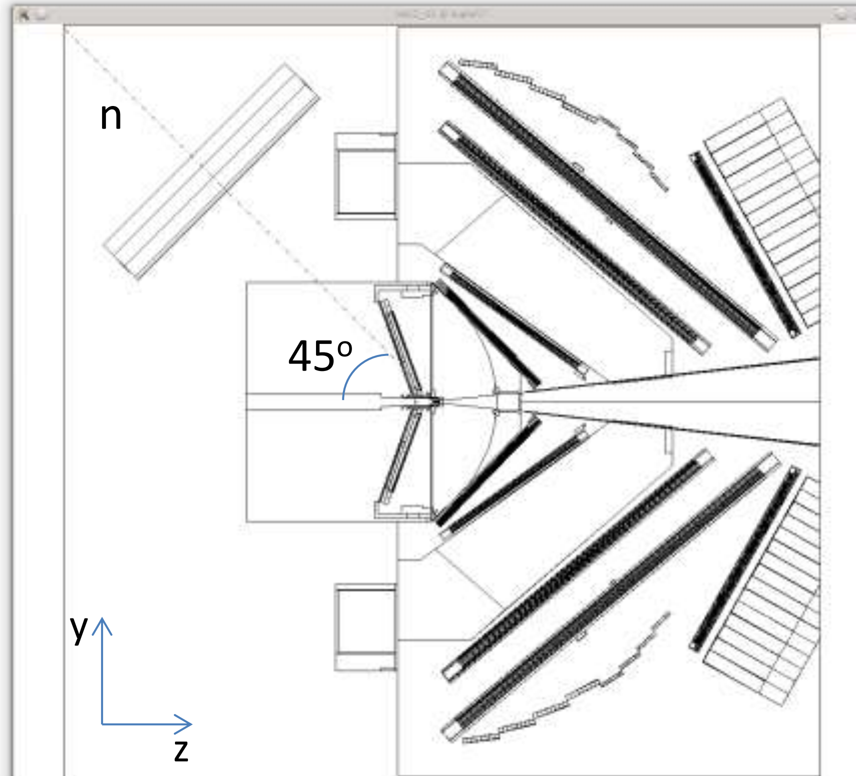
Geometry in HGeant

(based on Ilse‘s FWDET implementation)



3d view

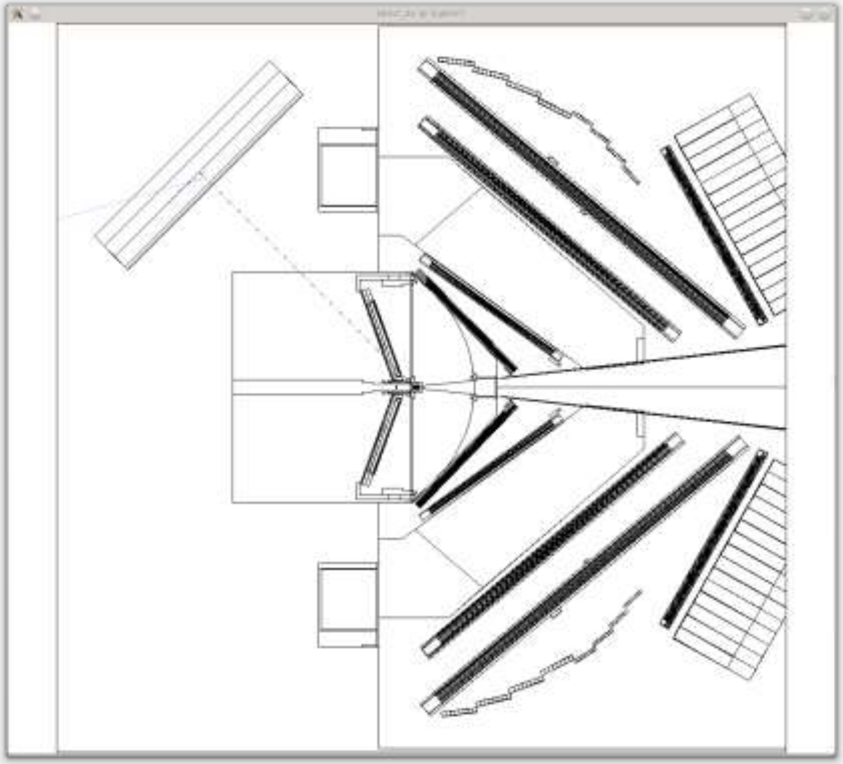
3 layers + charged-particle veto



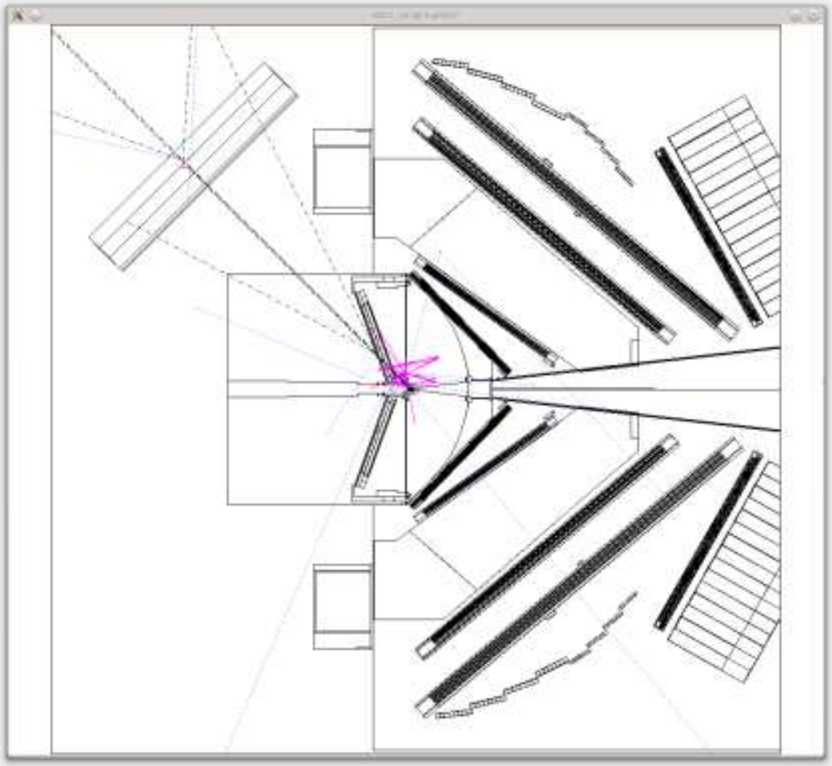
cut: y-z plane at x=0

Neutron hits in HGeant

Geant3 run with GCalor hadronic interaction code



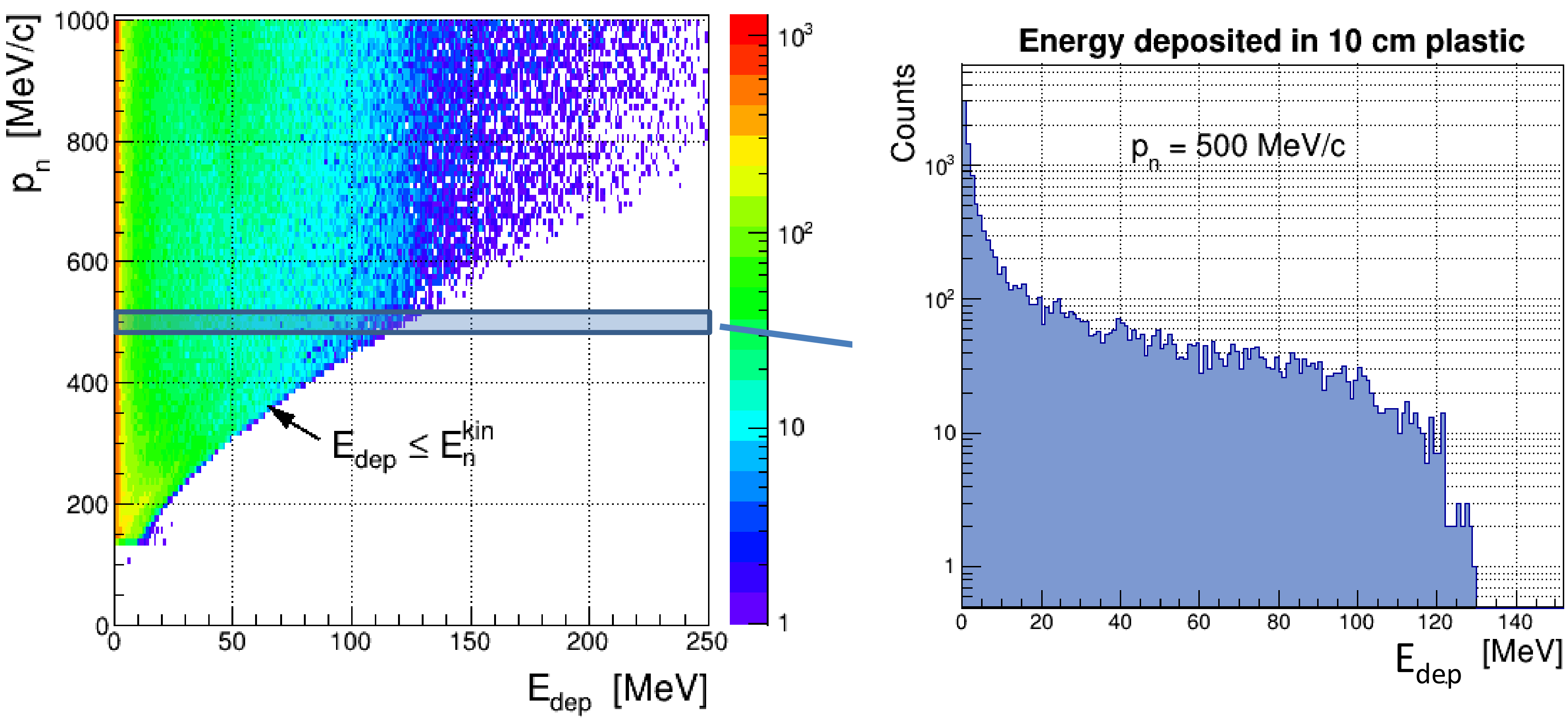
clean neutron hit



neutron rescattering in RICH backplane

Neutron hits in 10 cm plastic

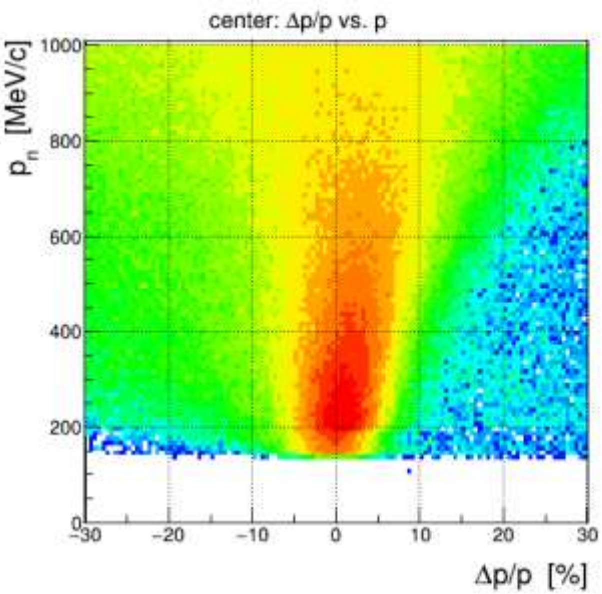
E deposited vs. neutron momentum

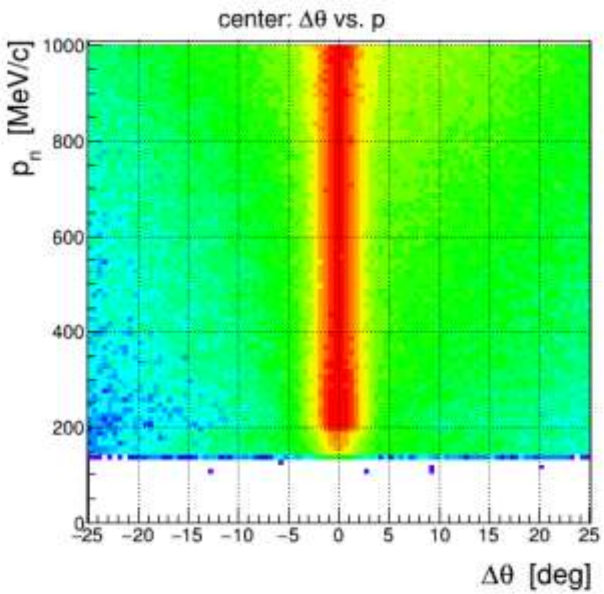


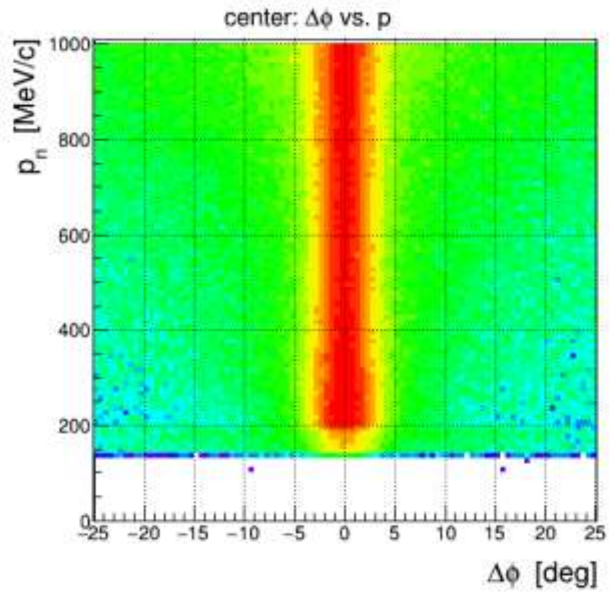
➔ threshold dependence of ε_n

Simulated neutron resolution

Simulated assuming: $\sigma_{TOF} = 0.5\, ns,\ \sigma_{x,y,z} = 50\, mm,\ \ \sigma_{vertex} = 10\, mm$



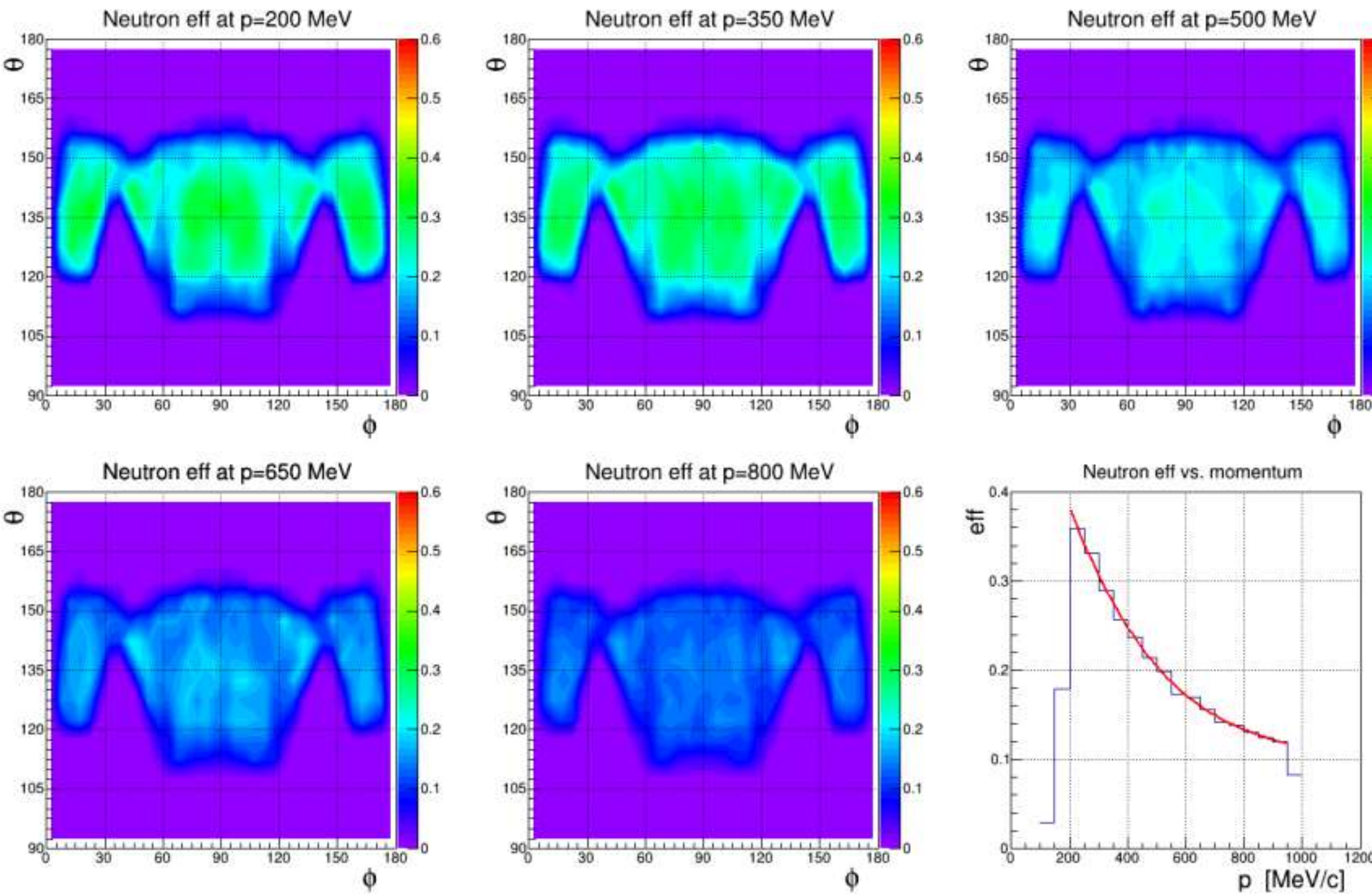




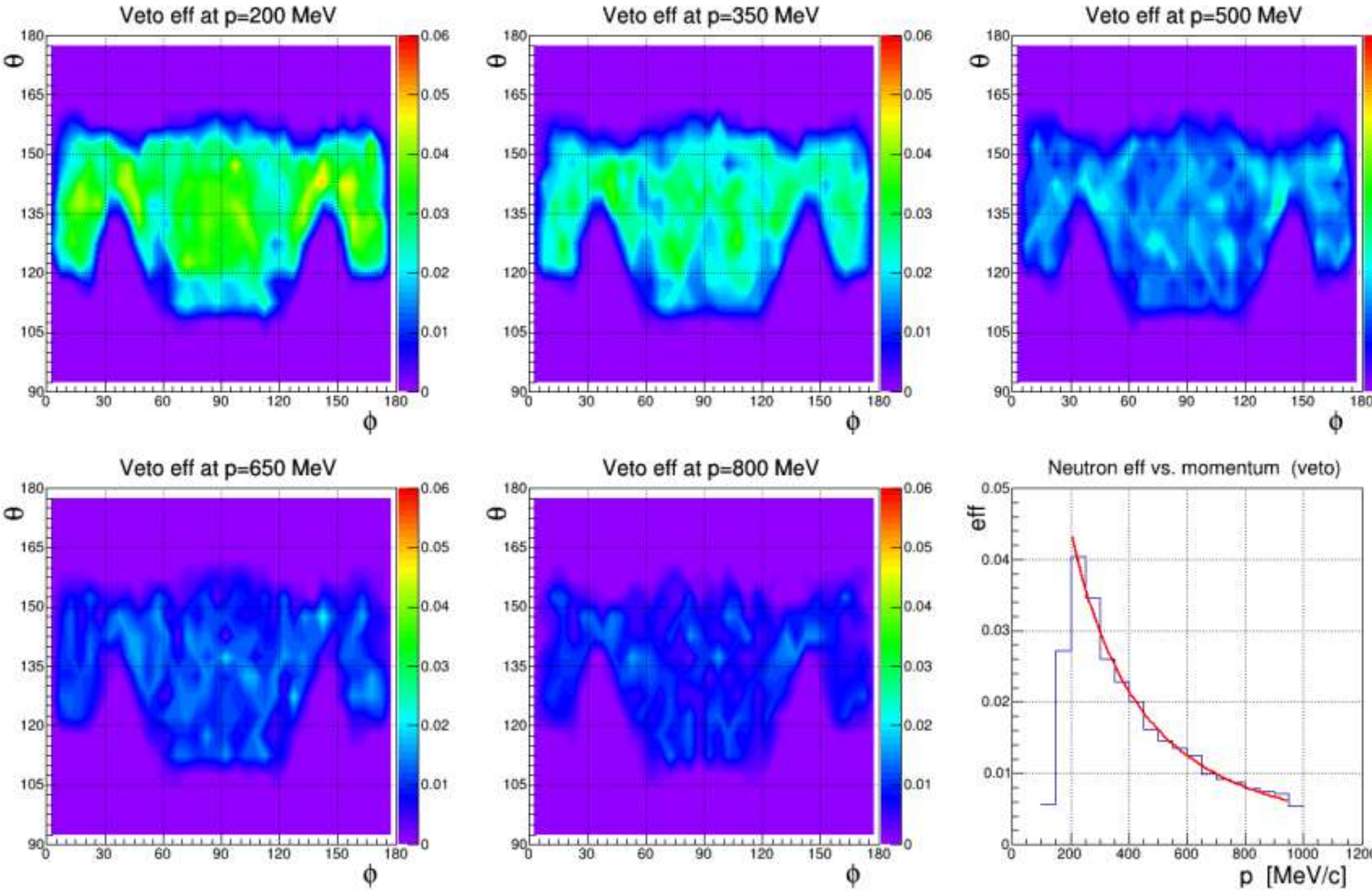
p resolution = 5% - 10%

angular resolution = 2^{o} - 3^{o}

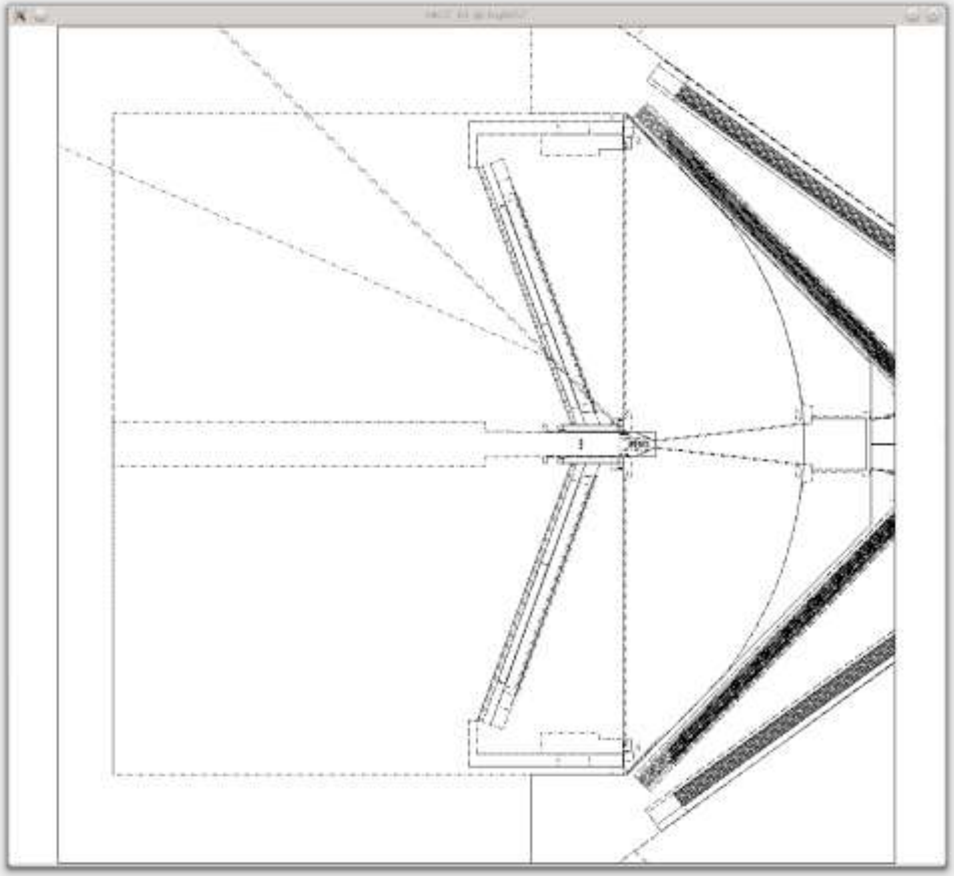
Neutron efficiencies (3x10 cm)



Veto neutron efficiencies (2 cm)



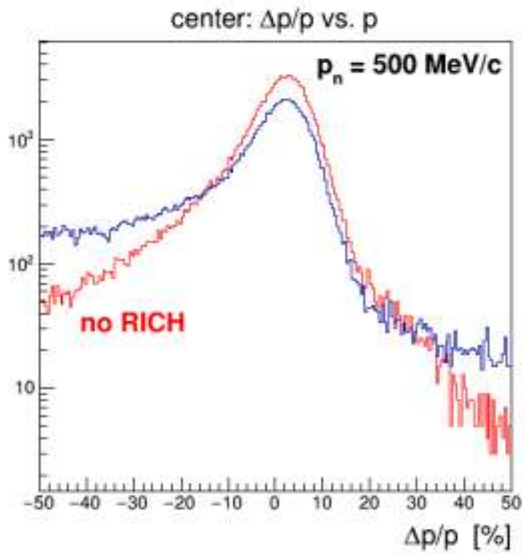
HADES RICH + target region

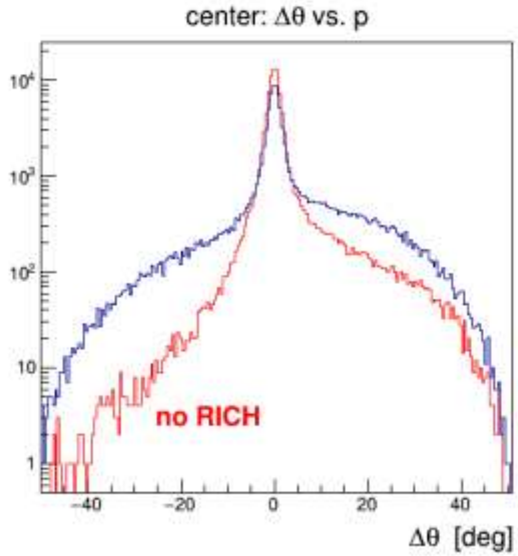


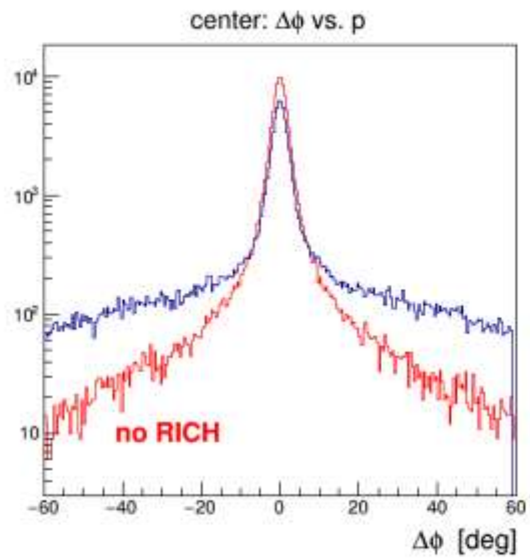
➔ Neutron rescattering by RICH material
(15% - 30% effect!)

Simulated neutron resolution

Rescattering of neutron in RICH backplane

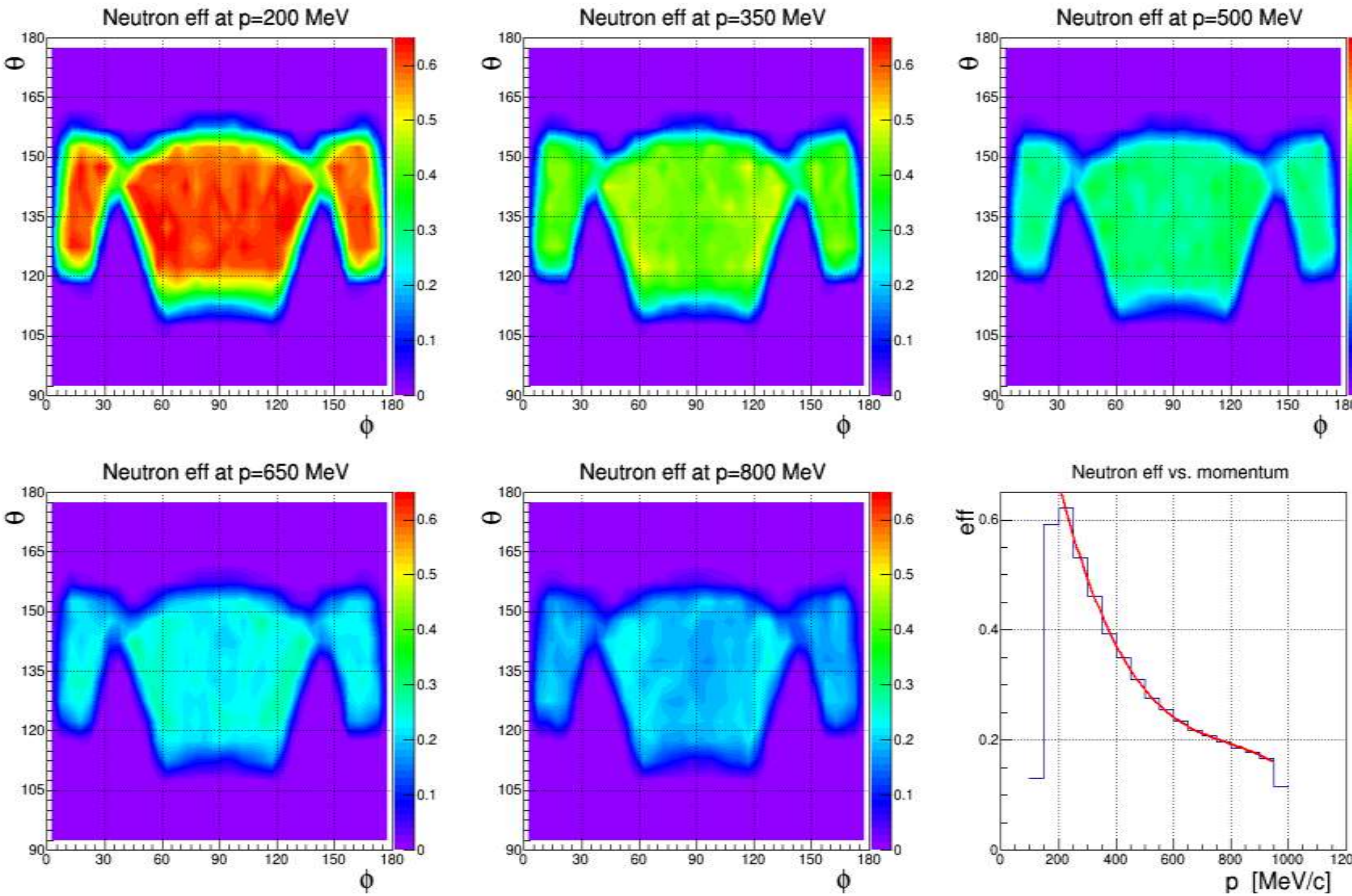




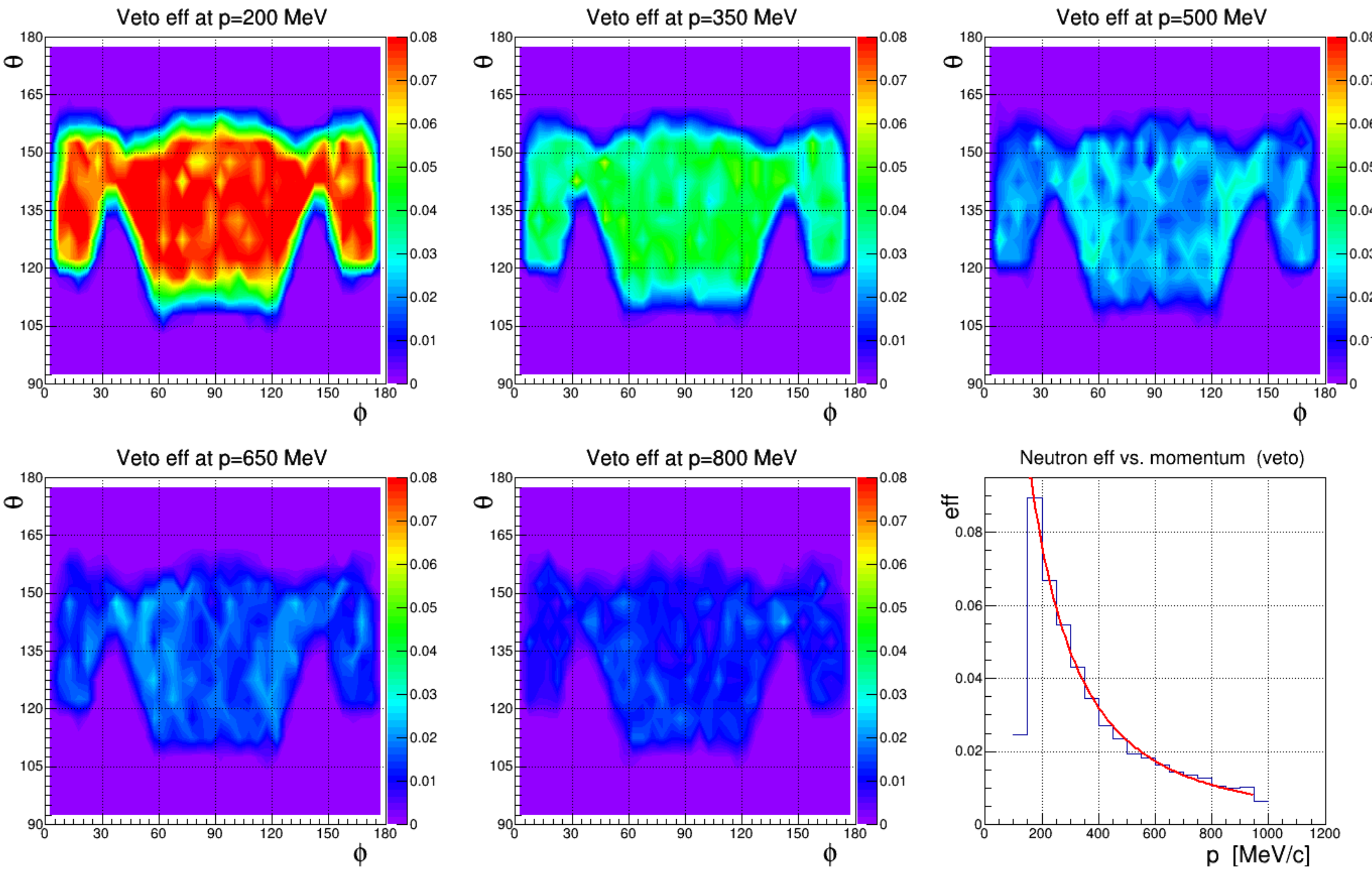


➔ much less tailing without RICH backplane !

Neutron efficiencies without RICH



Veto neutron efficiencies without RICH

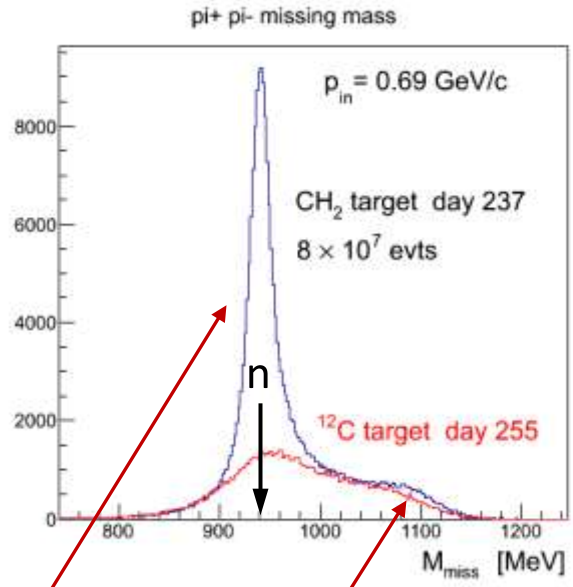


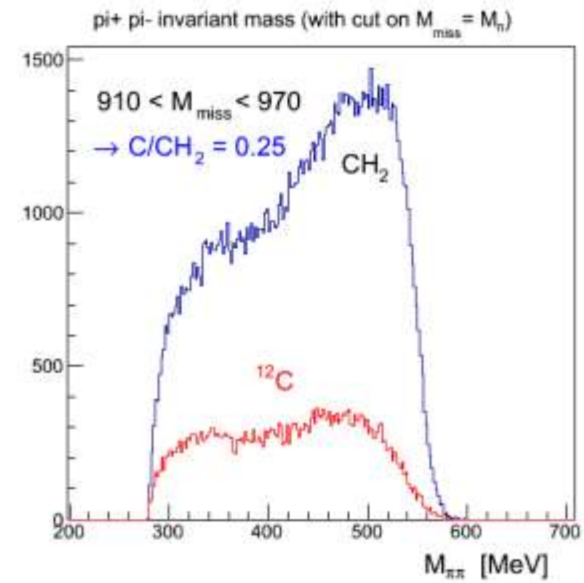
Simulation To-Do list

- Finalize neutron detector geometry
- Update RICH geometry (backplane, full material budget)
- Implement proper digitizer and hit finder
- Implement full event reconstruction (neutron + ch. part.)
- Full simulation of SRC events
- Realistic background from p+A events (transport codes)
- Get a signal/background estimate

Neutron efficiencies obtained with tagged neutrons from the $\pi^- + p \rightarrow n\,\pi^-\,\pi^+$ exclusive reaction

August 2014 run: 0.69 GeV/c $\pi^- + CH_2$, ≈$8 \cdot 10^8$ evts (≈1/3 on H_2)





→ ≈10^6 tagged neutrons could be prepared

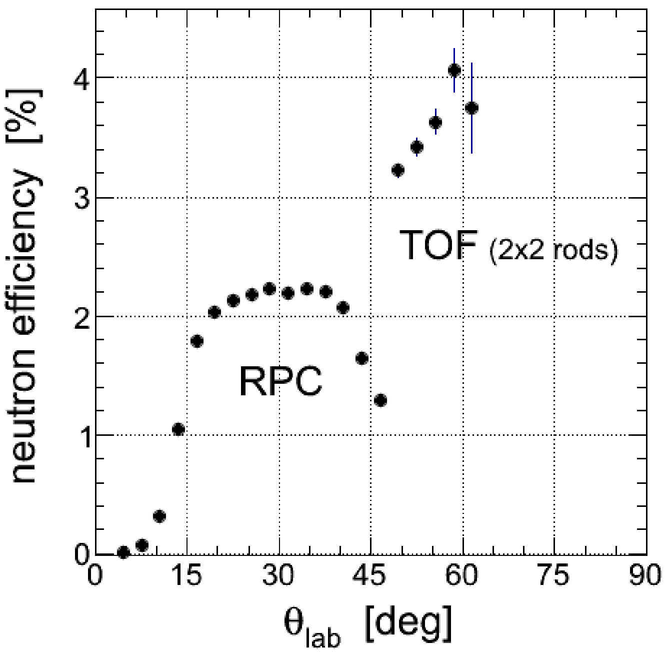
Width of <2%

$\pi^+\pi^-\pi^0$ final states

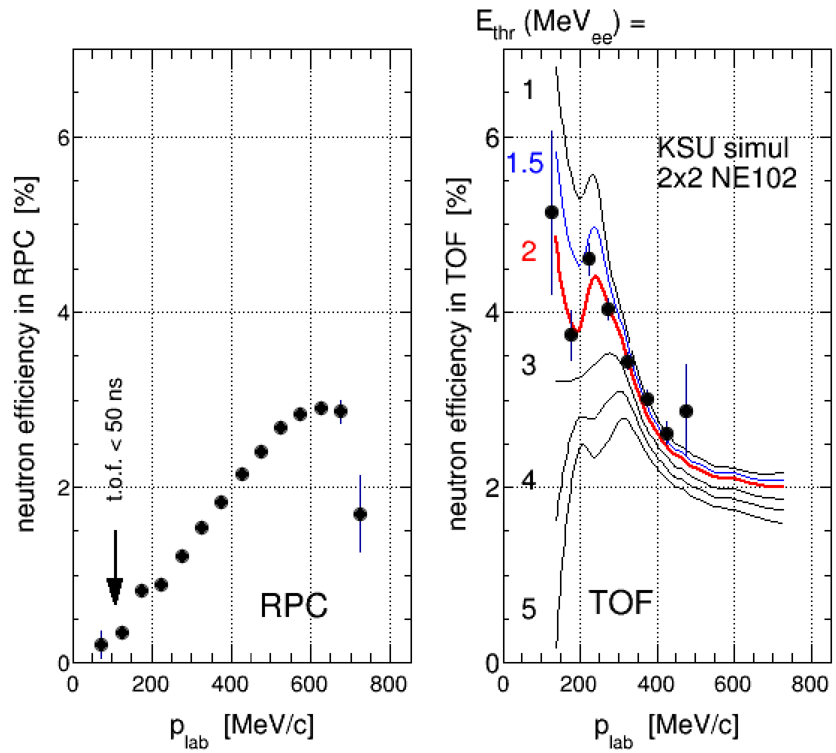
Neutron efficiencies of RPC & TOF

Comparison with full **KSU code** simulation:

Polar angle dependence



Momentum dependence



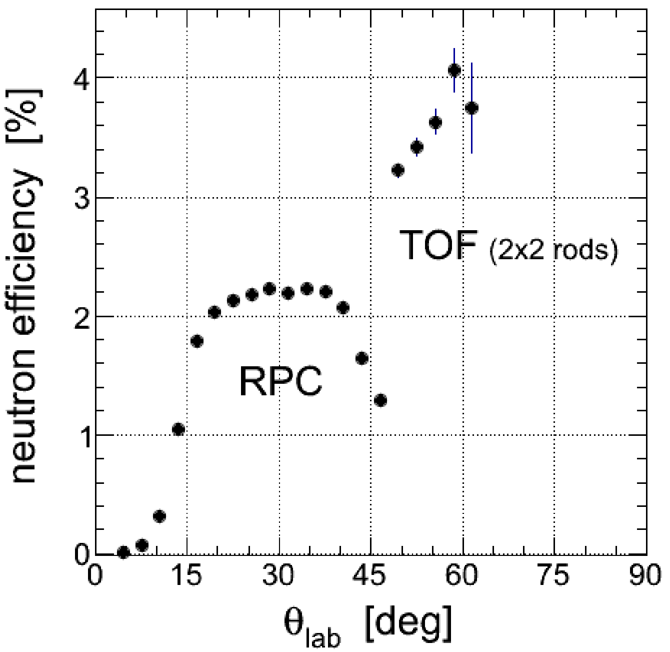
Reminder:
TOF has 2 & 3 cm rods (BC408)

KSU simul: Cecil et al. NIM 161 (1979)

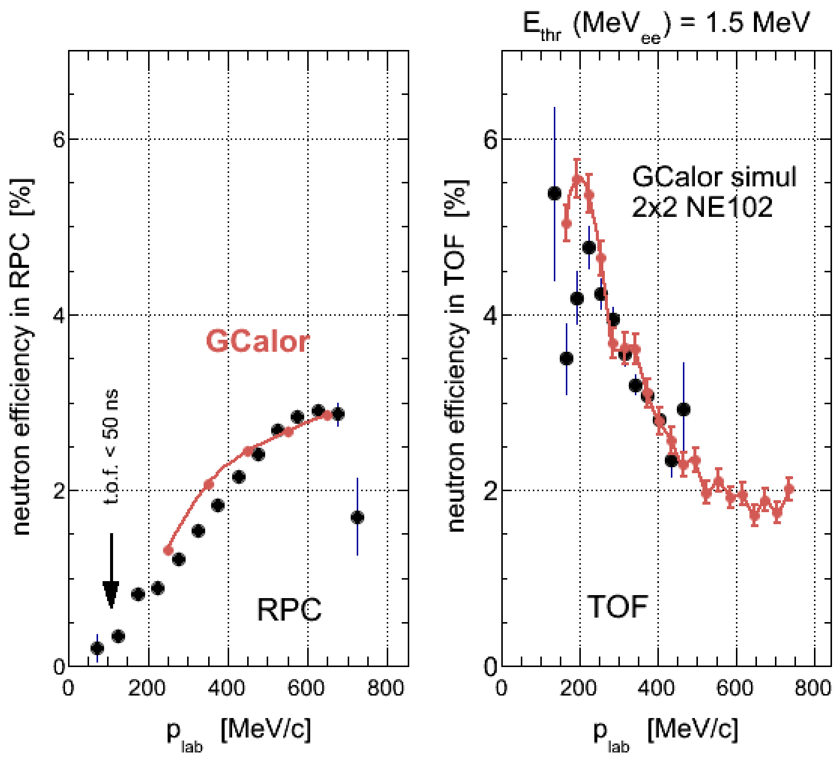
Neutron efficiencies of RPC & TOF

Comparison with full **HGeant/GCalor** simulation:

Polar angle dependence



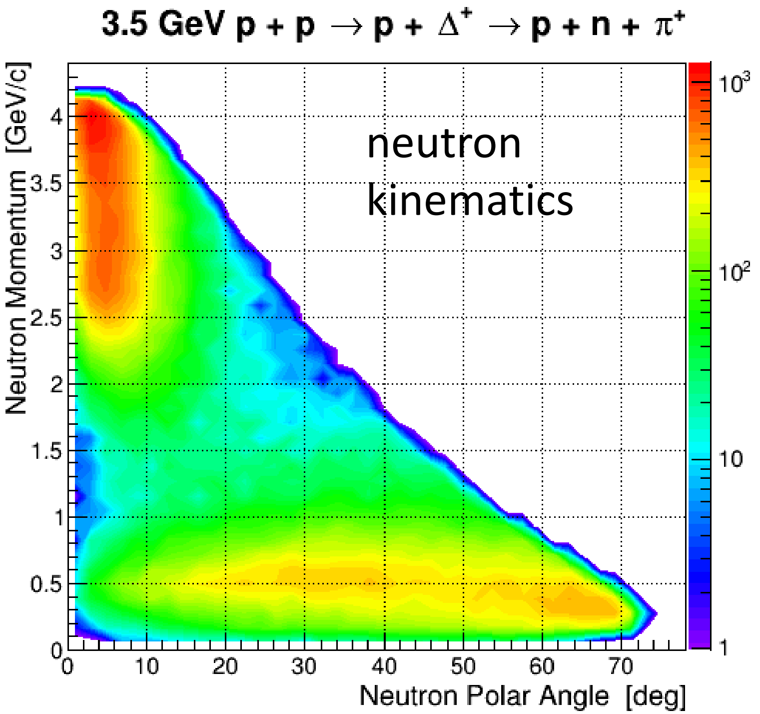
Momentum dependence

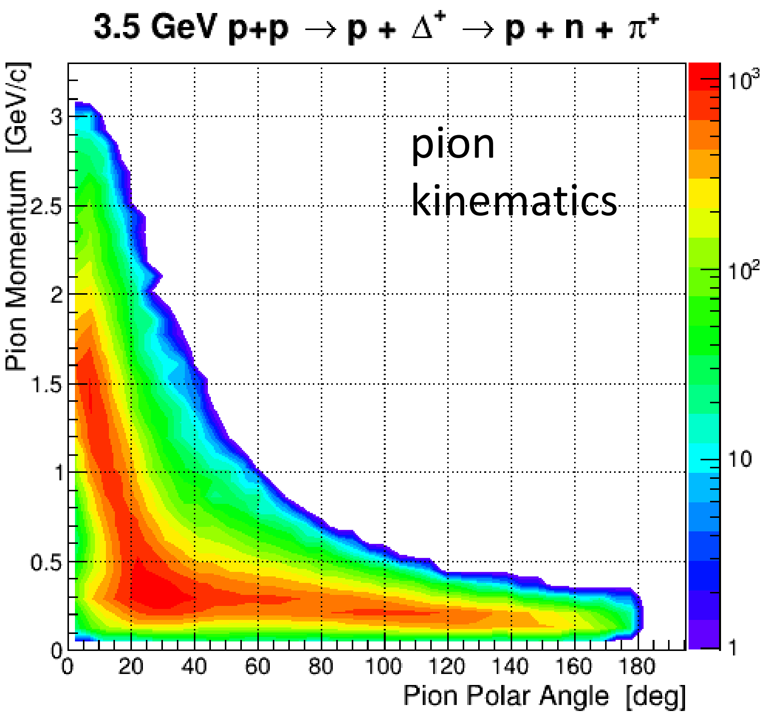


Reminder:
TOF has 2 & 3 cm rods (BC408)

Use exclusive $p + p \rightarrow p + n + \pi^+$ reaction to prepare tagged neutrons

Pluto simulation:

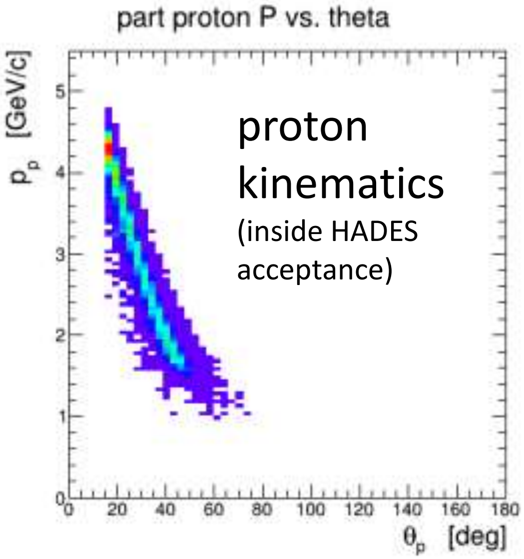


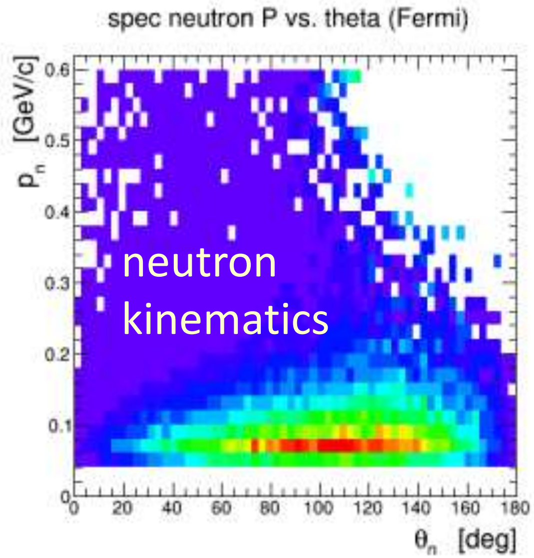


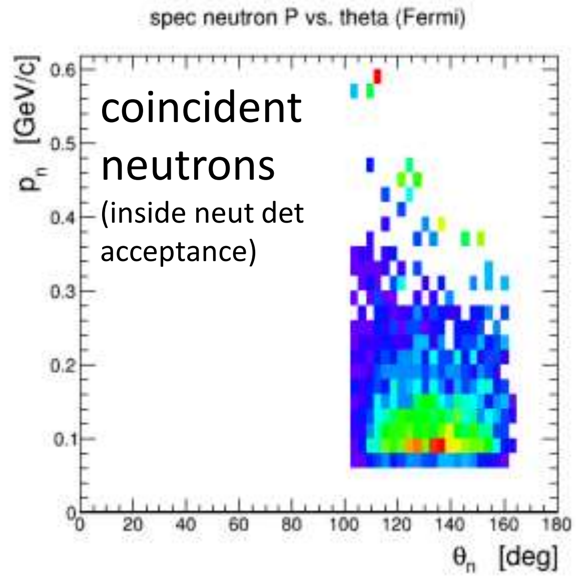
➔ reaction kinematics does not provide backwards running neutrons, but pions might still be useful to probe material budget

Use exclusive $p + d \rightarrow p + p + n$ reaction on deuterated polyethylene

Pluto simulation:

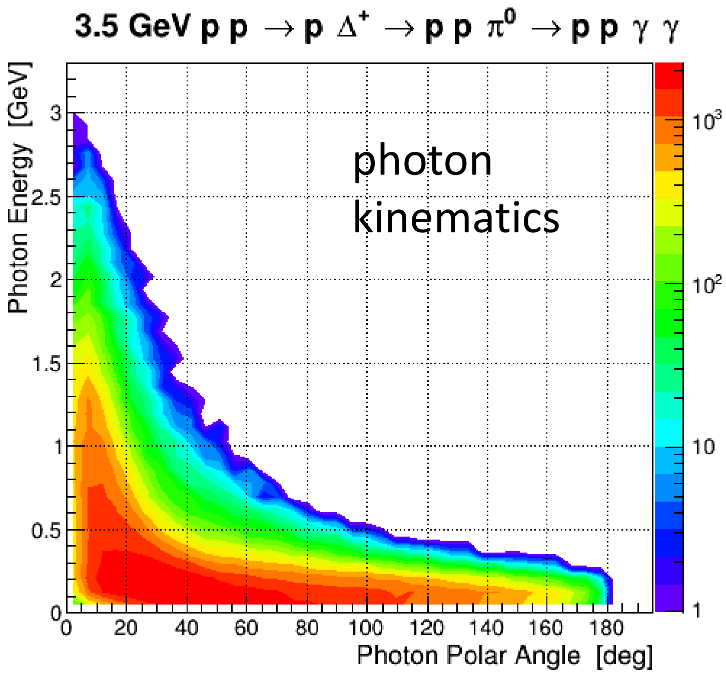






➔ reaction kinematics provides backwards running neutrons suitable for efficiency studies

Use exclusive $p + p \rightarrow p + p + \pi^0$ reaction to prepare photon source



➔ Photons are emitted into full solid angle