Momentum reconstruction and proton/pion identification using water-target ECC in the NINJA experiment

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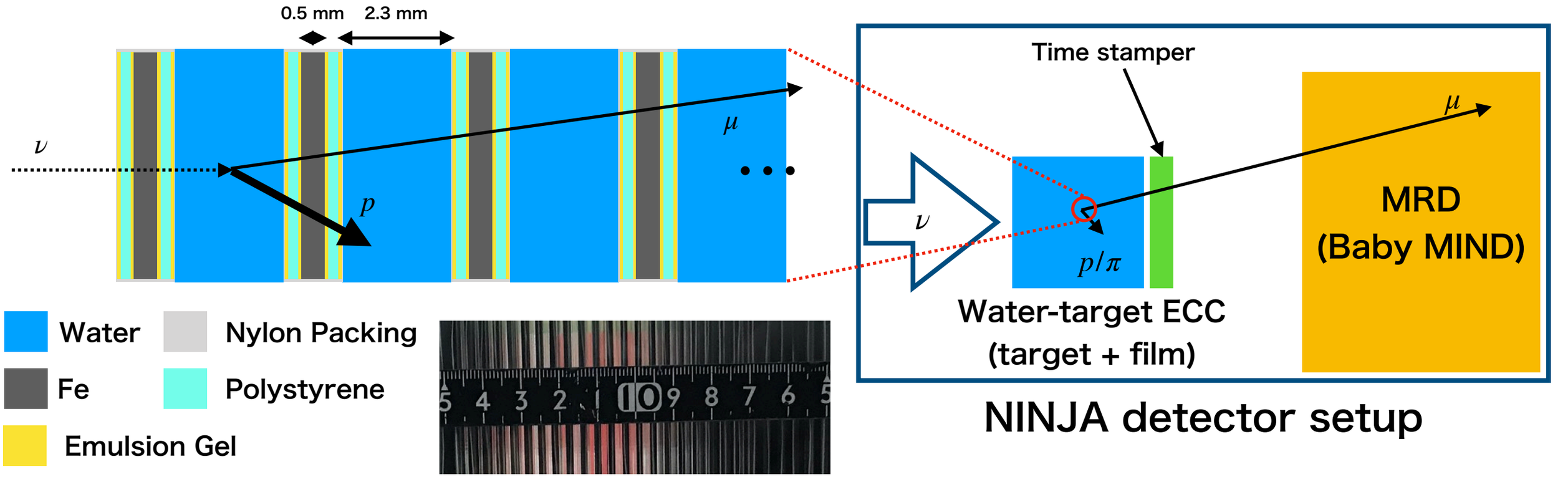
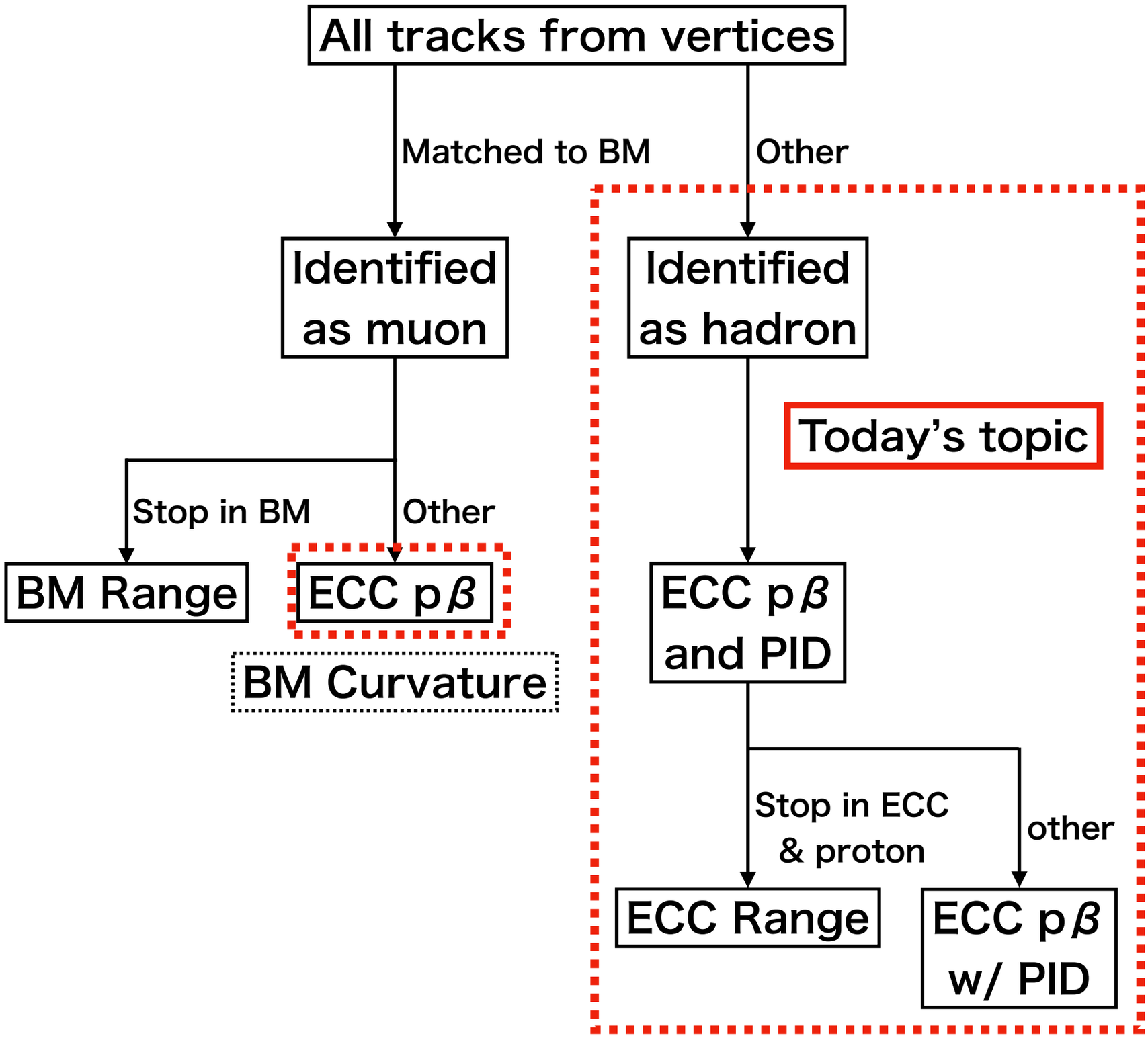
NINJA physics run

- NINJA = **N**eutrino **I**nteraction research with **N**uclear emulsion and **J**-PARC **A**ccelerator
- Measurement of low-momentum hadron kinematics from the neutrino-water interactions



NINJA detector setup

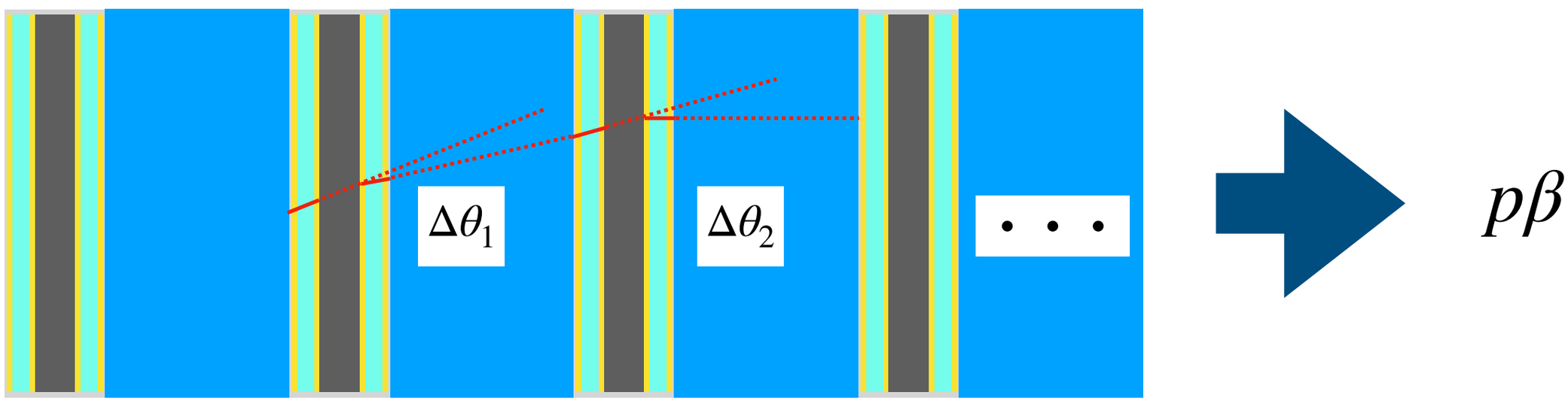
Analysis flow by water-target ECC



Reconstruction by scatterings

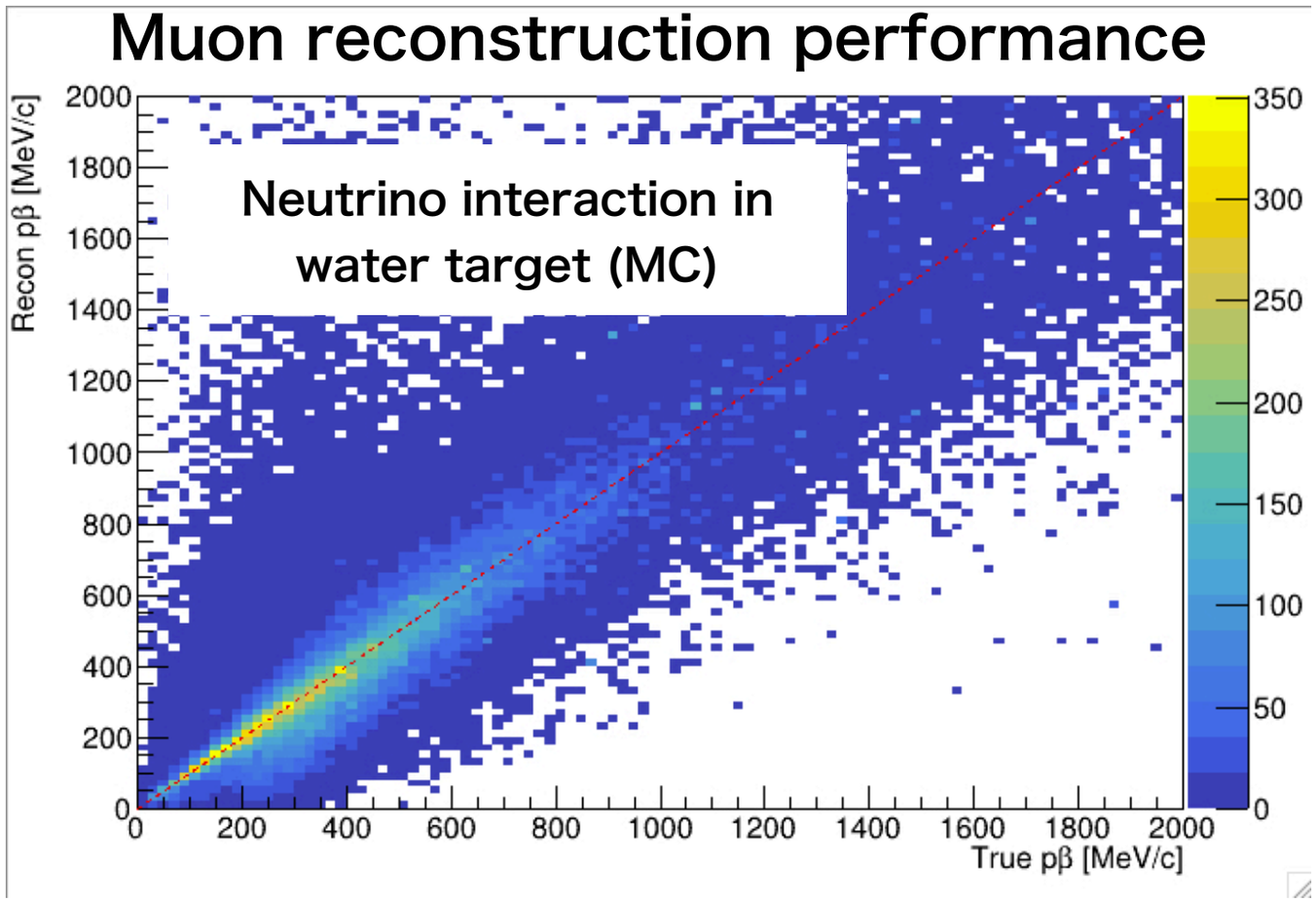
- The momentum of a charged particle can be reconstructed from the deviation of angle differences by multiple Coulomb scatterings.
- Good angle resolution allows us this calculation.

$$\theta_0 = \frac{13.6\ \mathrm{MeV}}{p\beta c}\sqrt{\frac{x}{X_0}}\left[1 + 0.038 \ln\left(\frac{x}{X_0}\right)\right]$$

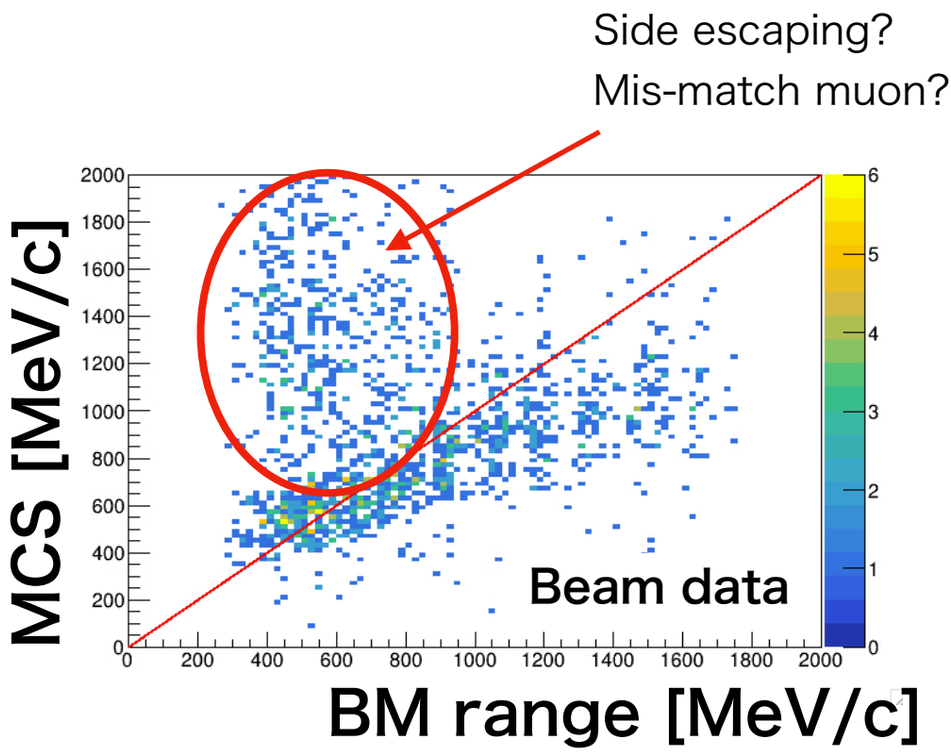


Reconstruction by scatterings

- Performance is evaluated by the MC simulation.
- # of films and angle dependences are checked and the accuracy can be 10% for the best cases.



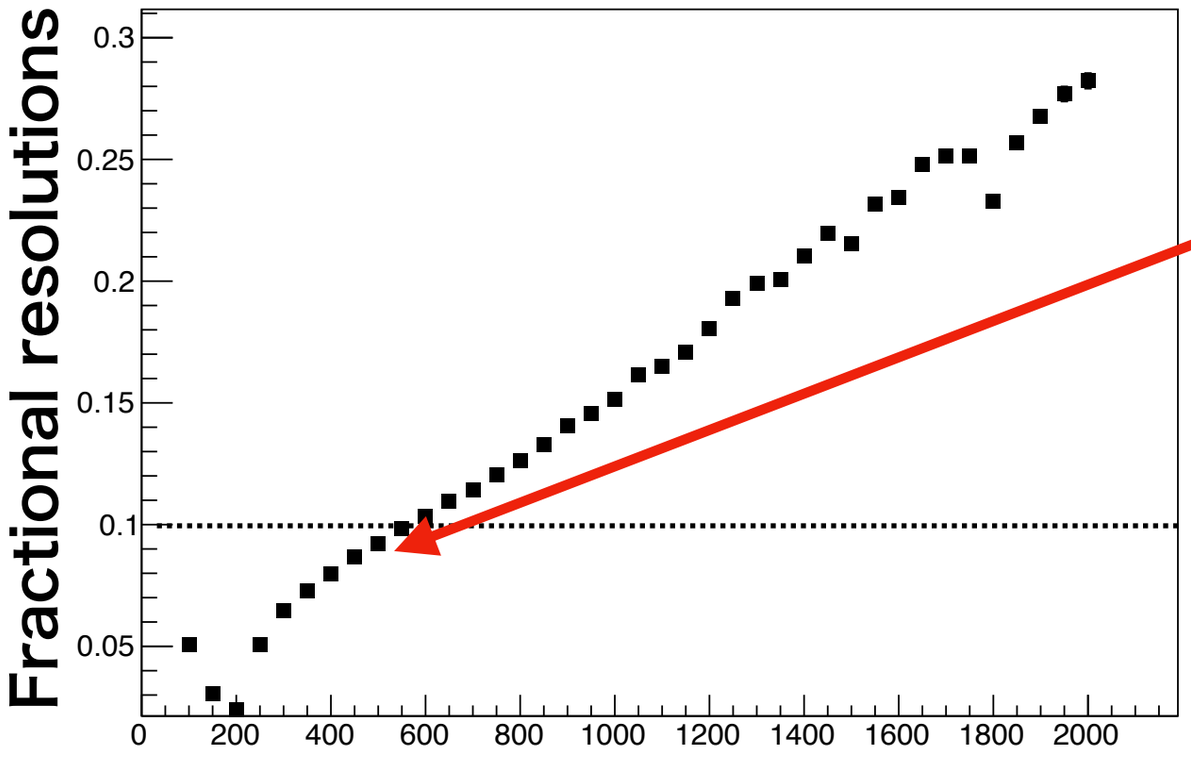
Validation with Baby MIND range data is ongoing



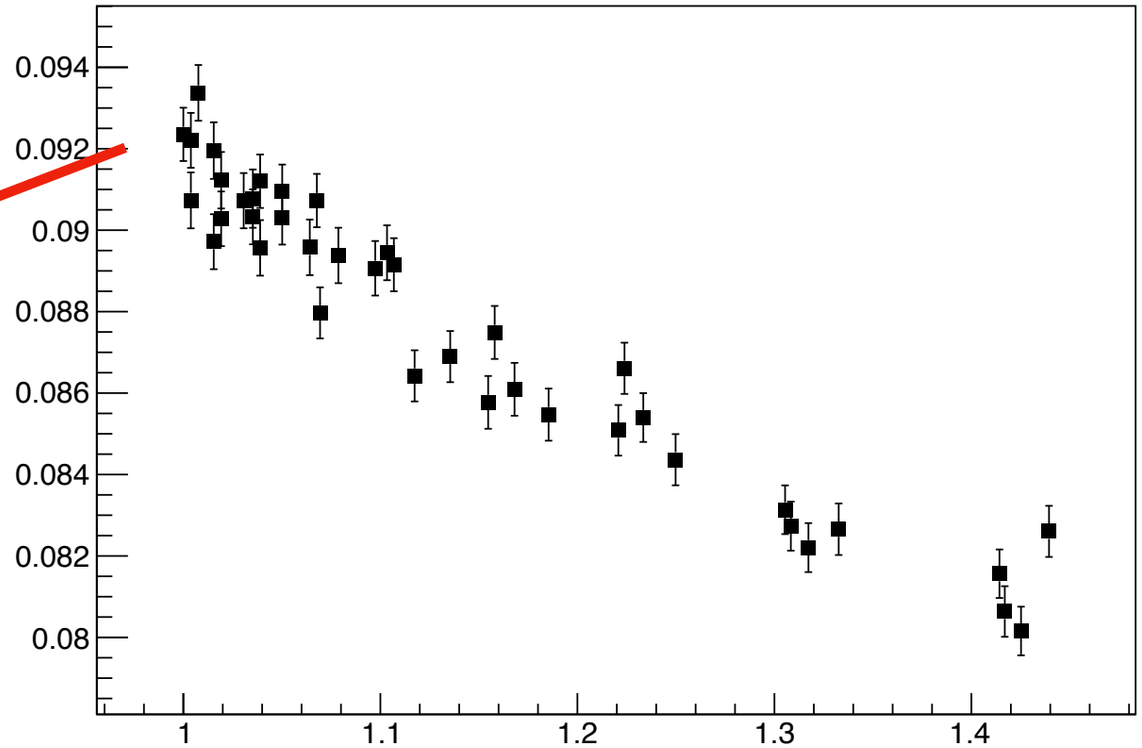
Reconstruction by scatterings

- Resolutions evaluated by particle gun MC

Momentum dependence



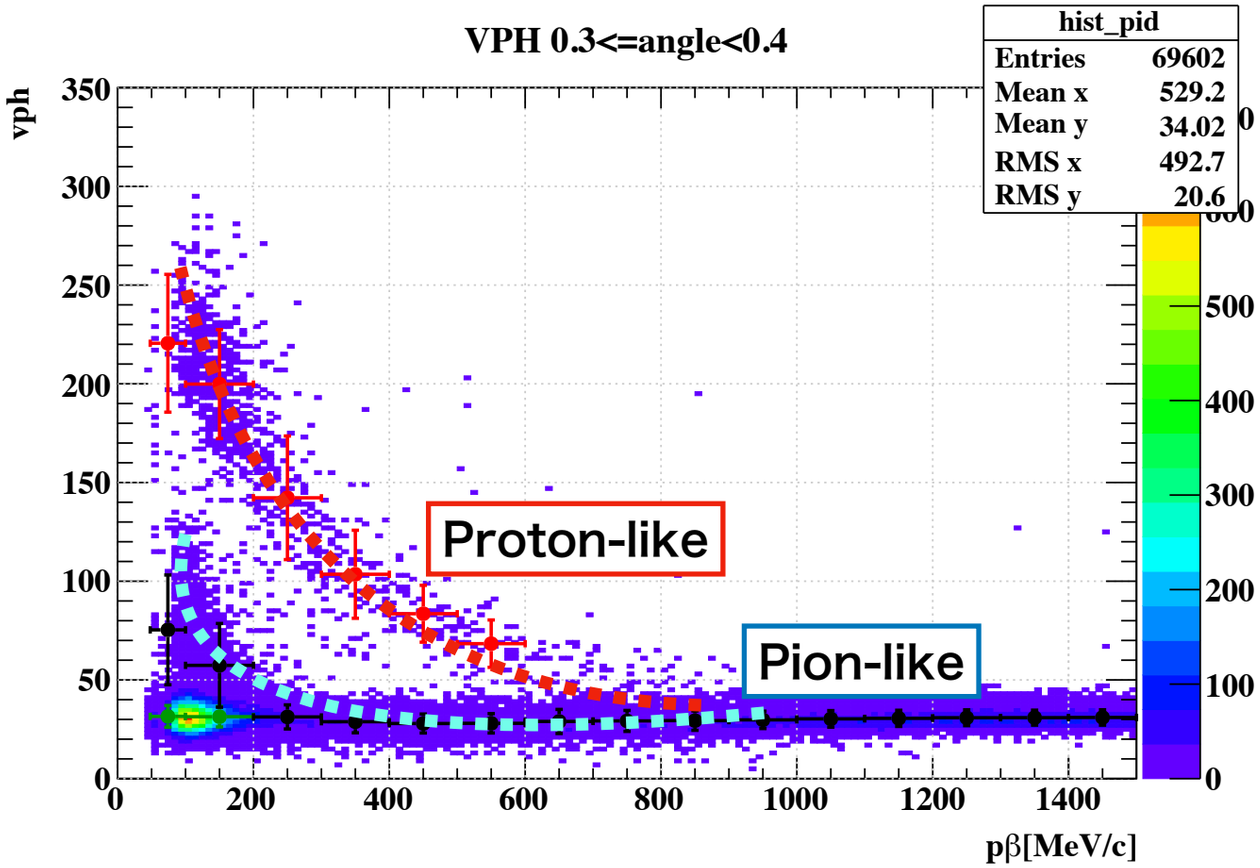
Angular dependence (500MeV/c)

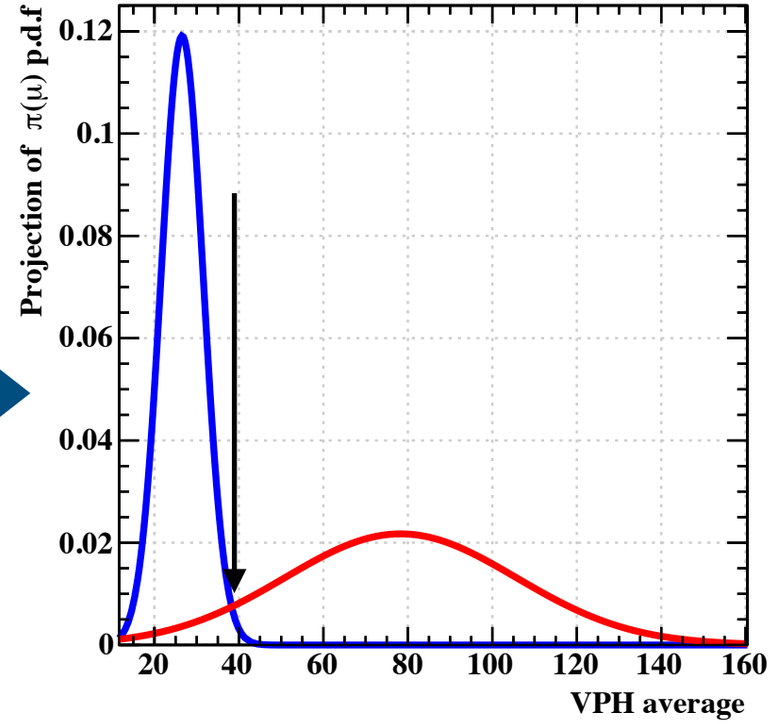


When the charged particle starts from the most upstream of the ECC, the resolution will be around 10%

Particle identification

- Particle identification is applied using the blackness of the track (VPH) and $p\beta$.
- Proton/pion PDF (gaussian) is obtained from the accumulated tracks.

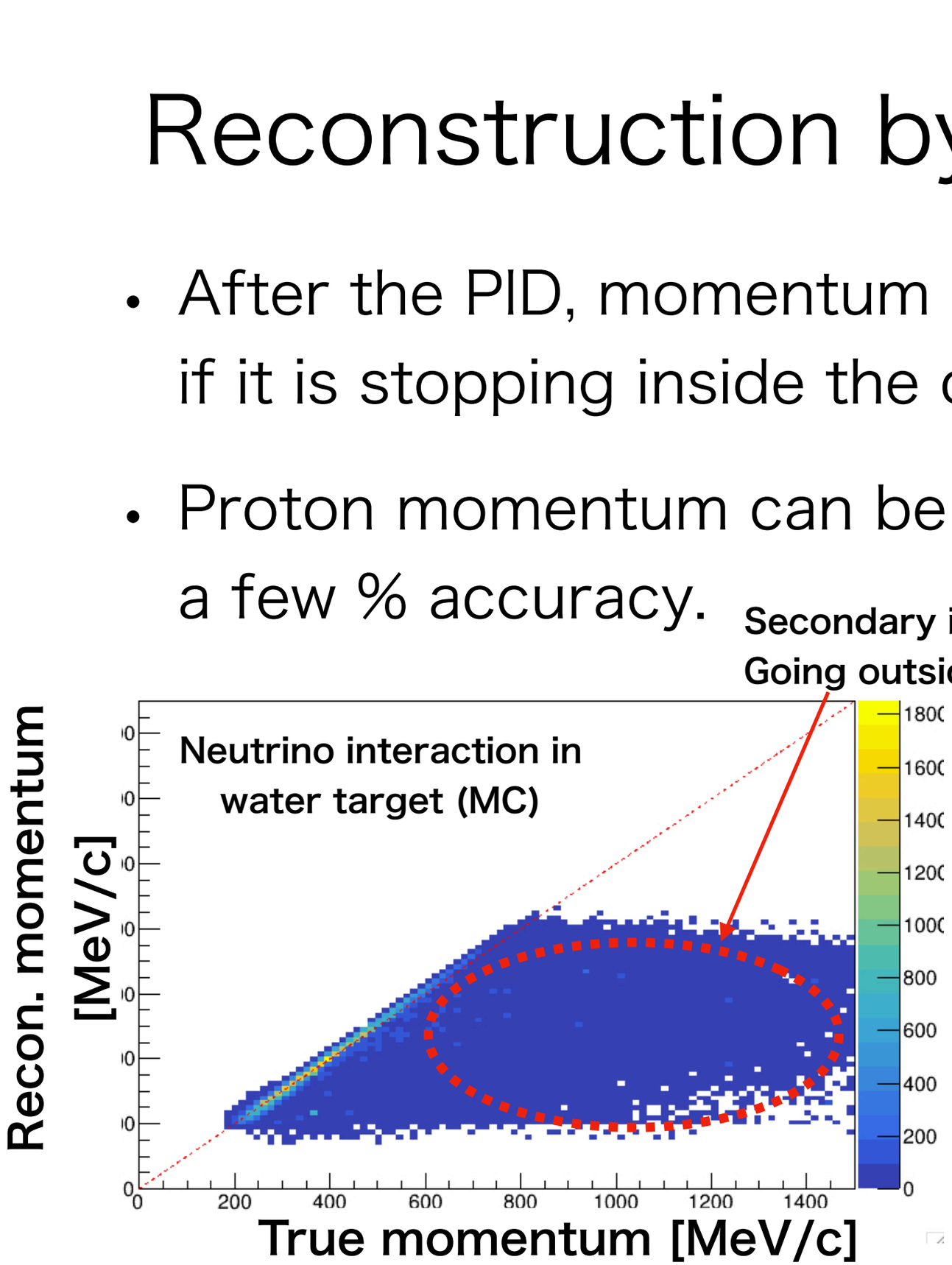




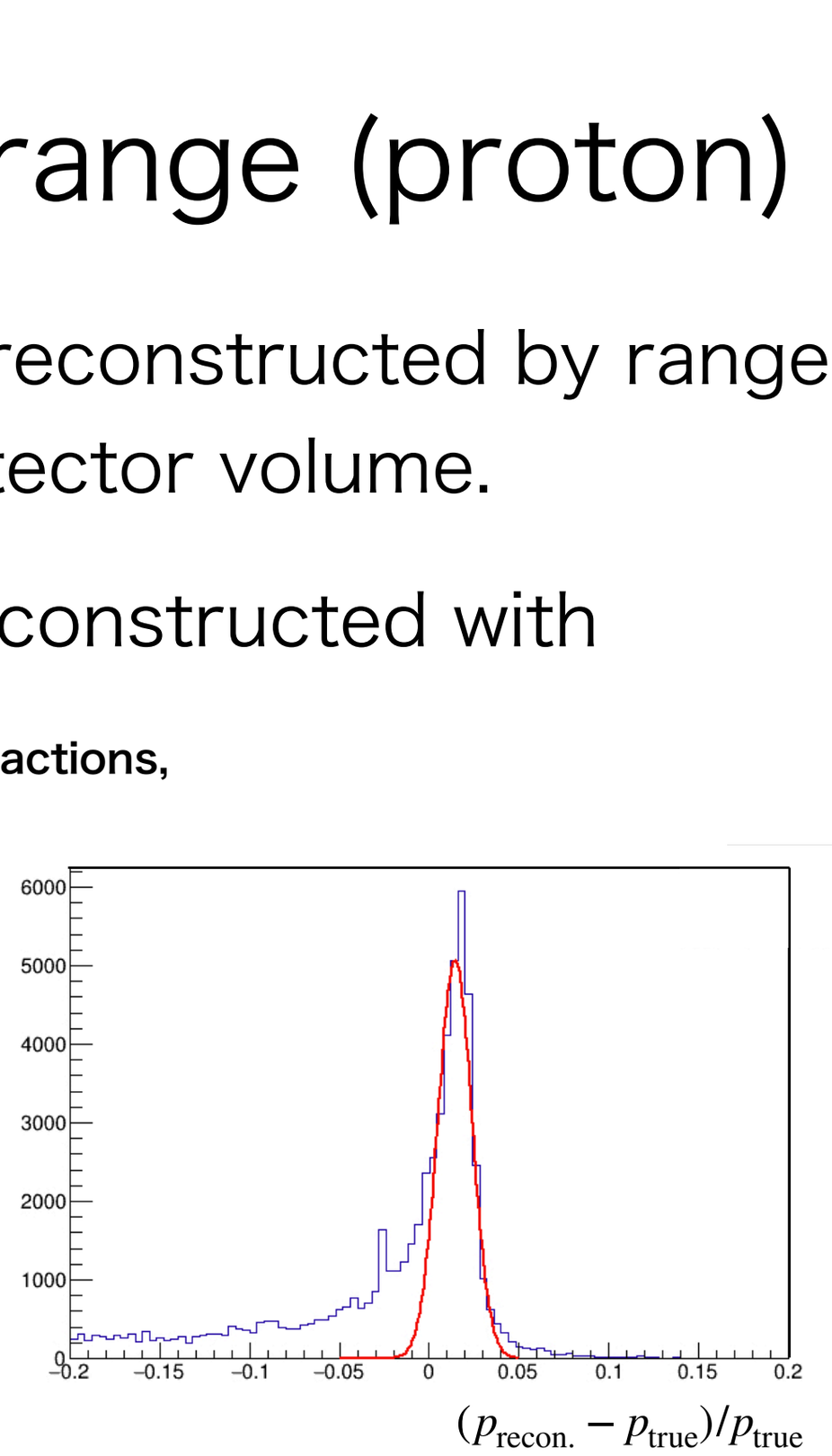
$$\frac{L_\pi}{L_\pi + L_p} = 0.5$$

Reconstruction by range (proton)

- After the PID, momentum is reconstructed by range if it is stopping inside the detector volume.
- Proton momentum can be reconstructed with a few % accuracy.



**Secondary interactions,
Going outside…**

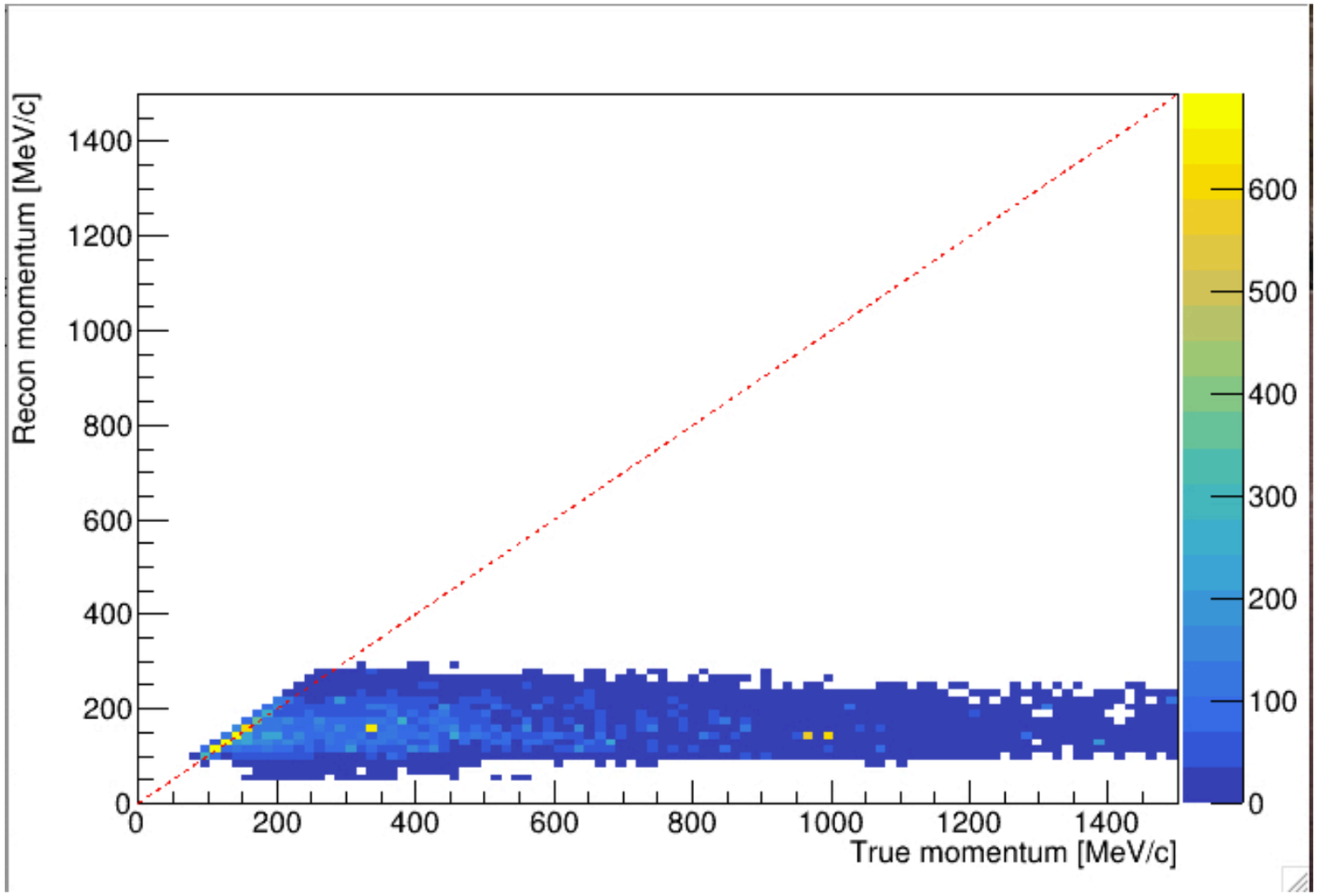


Bias : 1.4%, Sigma : 1%

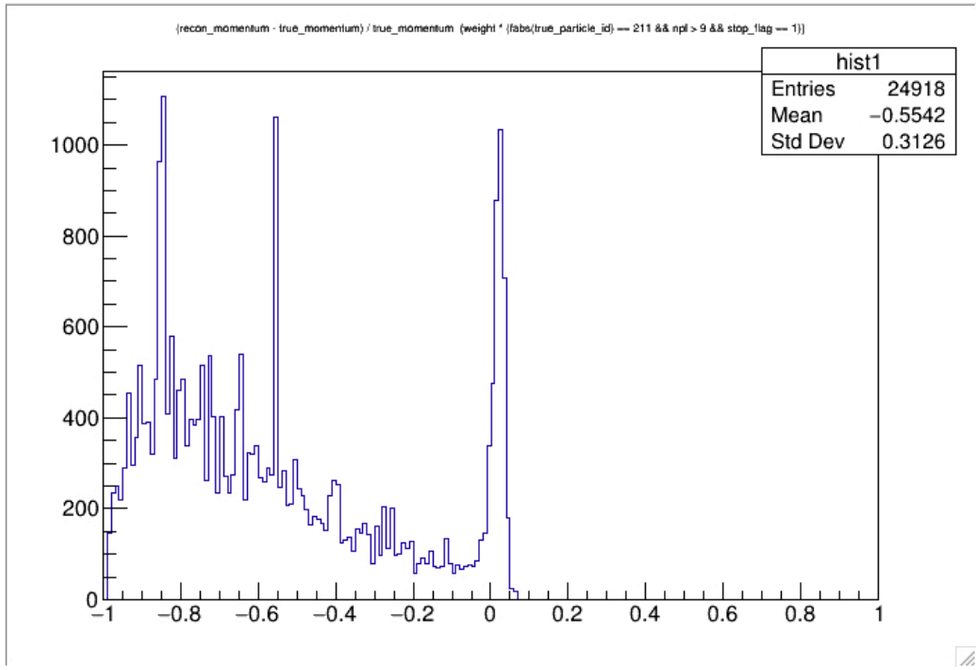
Summary

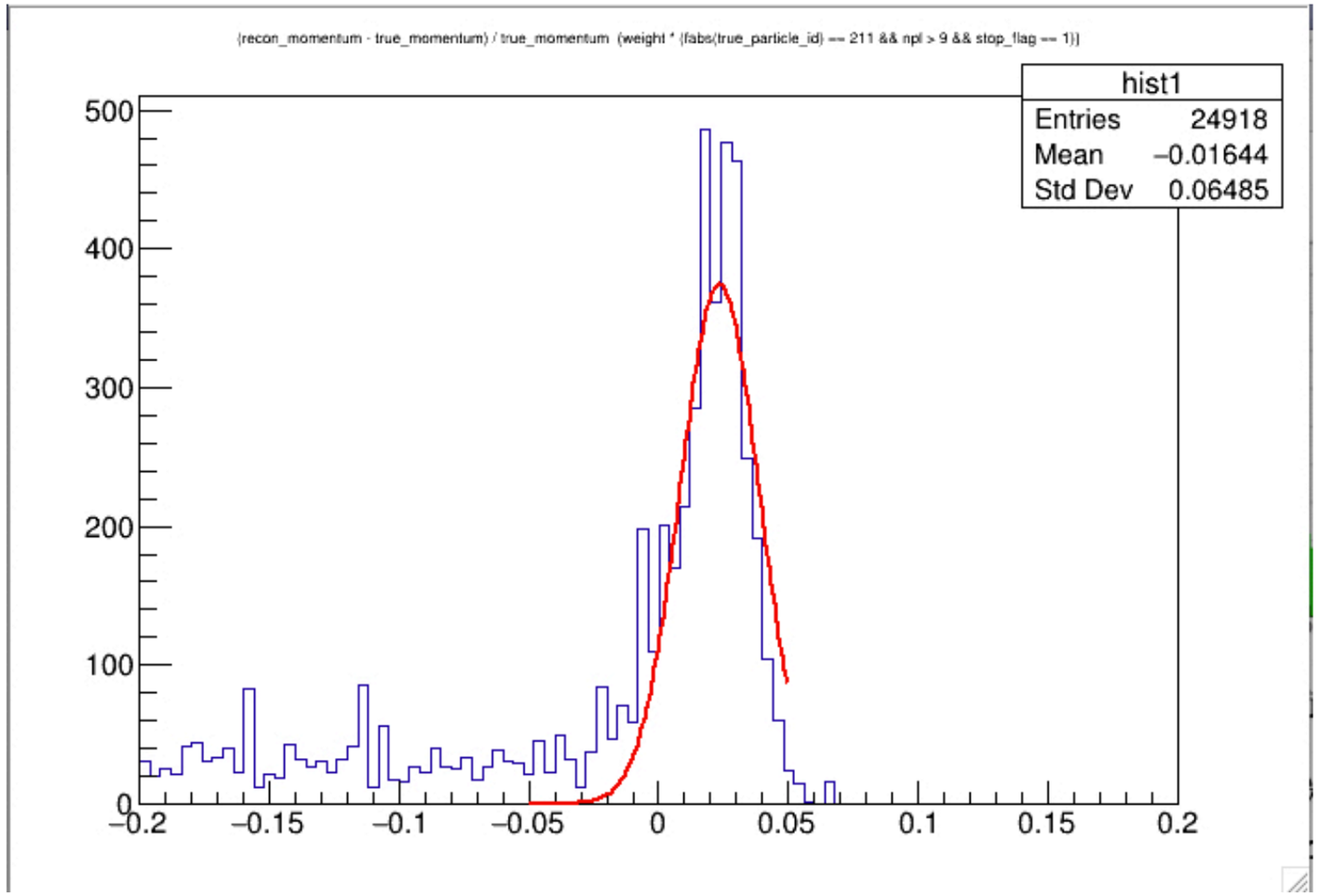
- NINJA experiment aims to measure neutrino-water interactions using nuclear emulsion detectors.
- Kinematics of hadrons can be reconstructed thanks to the high granularity and high sampling rate of the water-target ECC.
- protons (charged pions) down to 200 (100) MeV/c can be reconstructed.

Pion range


Recon momentum [MeV/c]
True momentum [MeV/c]
0
200
400
600
800
1000
1200
1400
100
300
500

Pion range





Bias : 2.3%, Sigma : 1.5%