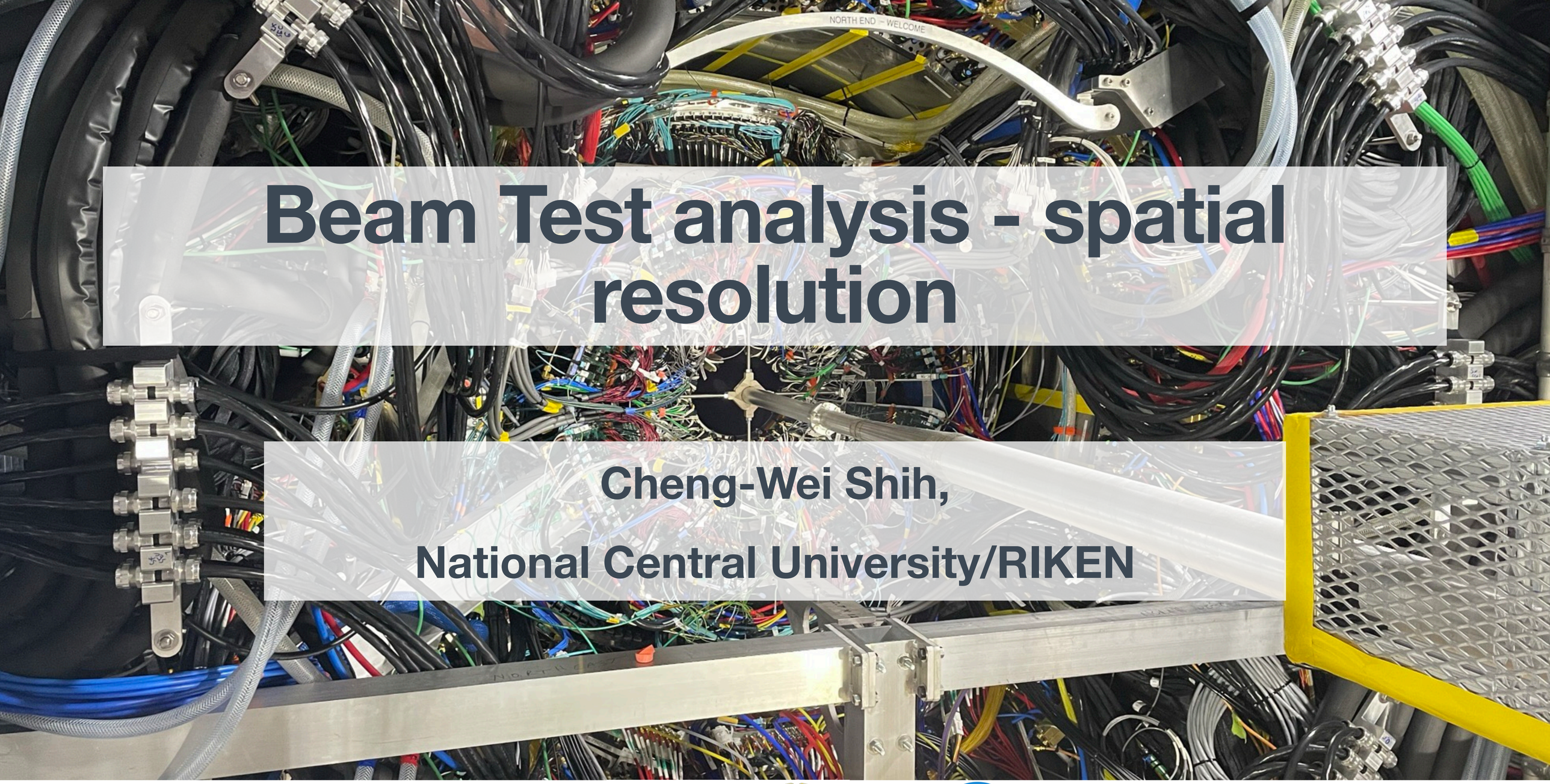


Beam Test analysis - spatial resolution

Cheng-Wei Shih,

National Central University/RIKEN

Aug 1st, 2025
INTT meeting

sPHENIX INTT sPHENIX 國立中央大學 National Central University RIKEN

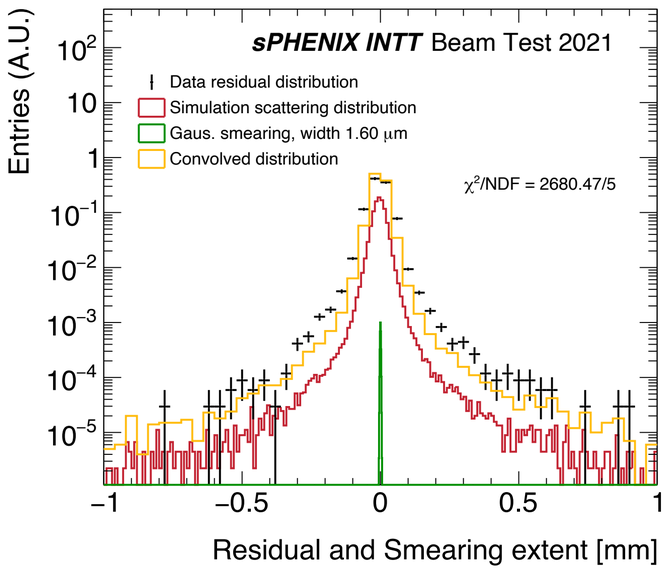
INTT hit spatial resolution

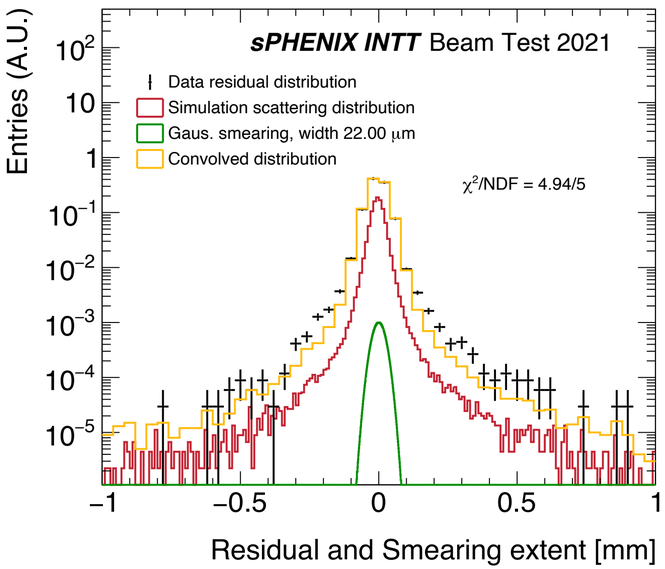
- Expected binary INTT hit spatial resolution = $78\ \mu\mathrm{m}/\sqrt{12} = 22.52\ \mu\mathrm{m}$
- The measured residual distribution = the convolution of
  - Residual distribution of multiple Coulomb scattering distribution σ_{MS}
  - Spatial resolution of the reconstructed track σ_{track} (L0-L2 interpolation)
  - Spatial resolution of the device under test (DUT) σ_{Ladder} (ladder L1)
- $\sigma^2_{\mathrm{measured}} = \sigma^2_{\mathrm{MS}} + \sigma^2_{\mathrm{track}} + \sigma^2_{\mathrm{Ladder}}$
  - This is not a mathematical expression, but more like a concept, as the residual distributions are not a Gaussian distribution
- $\sigma^2_{\mathrm{track}} = \mathrm{k} \cdot \sigma^2_{\mathrm{plane}}, \mathrm{k} = \dfrac{\sum_{\mathrm{i}}^{\mathrm{N}} \mathrm{z}_{\mathrm{i}}^2}{\mathrm{N}\sum_{\mathrm{i}}^{\mathrm{N}} \mathrm{z}_{\mathrm{i}}^2 - (\sum_{\mathrm{i}}^{\mathrm{N}} \mathrm{z}_{\mathrm{i}})^2}$, where z_i is the plan location in the beam direction
  - Assuming the layers used for the track reconstruction have the same spatial resolution
  - If the track layers are symmetrically distributed on both sides of the DUT → k = 1/N
  - For the case of INTT telescope, $\sigma^2_{\mathrm{track}} = \frac{1}{2}\sigma^2_{\mathrm{plane}} = \frac{1}{2}\sigma^2_{\mathrm{Ladder}}$ (track layers are identical to the DUT. And layers are placed symmetrically)

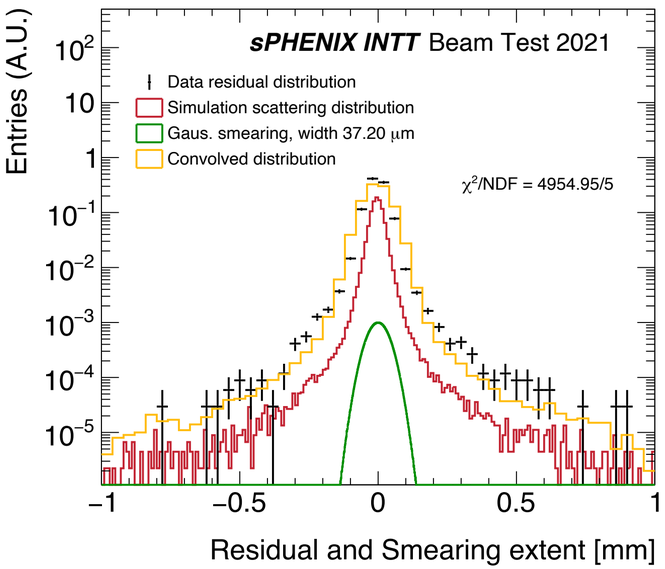
- **For the INTT beam test, the measured residual distribution = convolution of pure scattering distribution (σ_{MS}) and a Gaussian distribution (σ_{track}+σ_{Ladder}) with the Gaussian width of $\frac{3}{2}\sigma^2_{\mathrm{Ladder}}$**

INTT hit spatial resolution

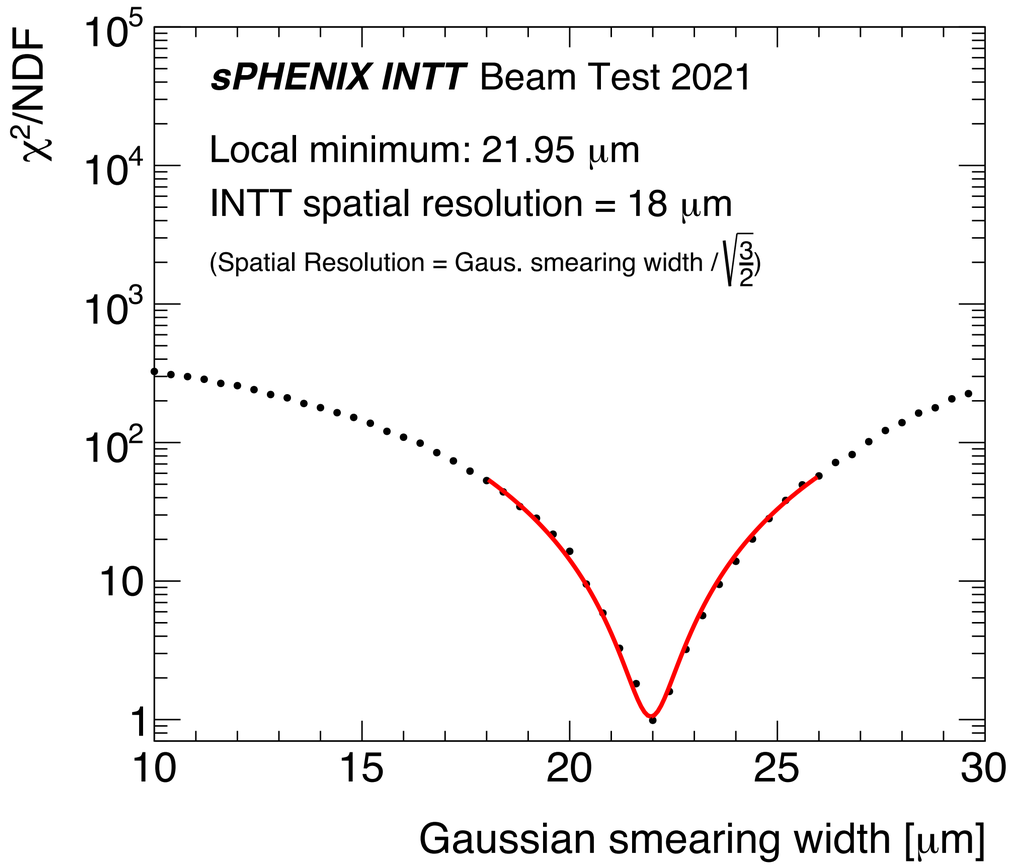
- **For the INTT beam test, the measured residual distribution = convolution of pure scattering distribution (σ_{MS}) and a Gaussian distribution (σ_{track}+σ_{Ladder}) with the Gaussian width of $\frac{3}{2}\sigma^2_{\text{Ladder}}$**
- Approach:
  - Prepare the residual distribution of multiple Coulomb scattering from simulation
  - Convolve the distribution with a Gaussian distribution with different width
  - Quantify the agreement between the data residual distribution and the convolved distribution by the chi-square test
  - σ_{Ladder} = width of the best matched Gaussian distribution / $\sqrt{3/2}$







INTT hit spatial resolution



Best matched Gaussian width (local minimum) = $\frac{3}{2}\sigma^2_{\text{Ladder}}$ → INTT spatial resolution of 18 μm is observed using beam test data

It is better than its binary spatial resolution (22.52 μm), attributed from the charged sharing, and the 3-bit adc of the FPHX chip

Reference

- https://link.springer.com/article/10.1007/s41365-024-01447-9