HERMES北大组工作进展

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Part I Physics Analysis:

- Nuclear DVCS

Part II Techniques:

- Target Magnet Correction
- Artificial Neural Network on TOF

Part I   Physics Analysis

Nuclear DVCS

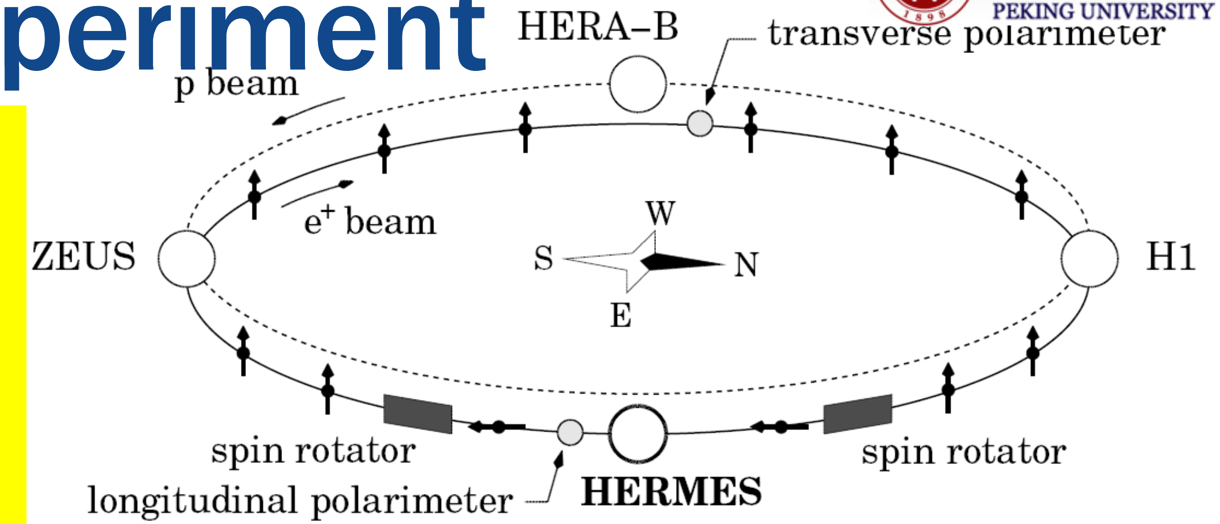
16th International Workshop on Deep Inelastic Scattering and QCD (DIS 2008)
Apr 7 - 11, 2008 ……….
London, UK

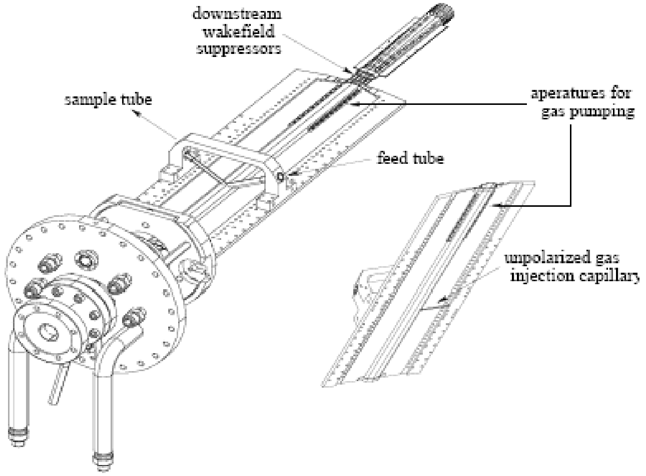
- HERMES Experiment
- Motivation
- Released Results Talked by Hongxue in DIS2008

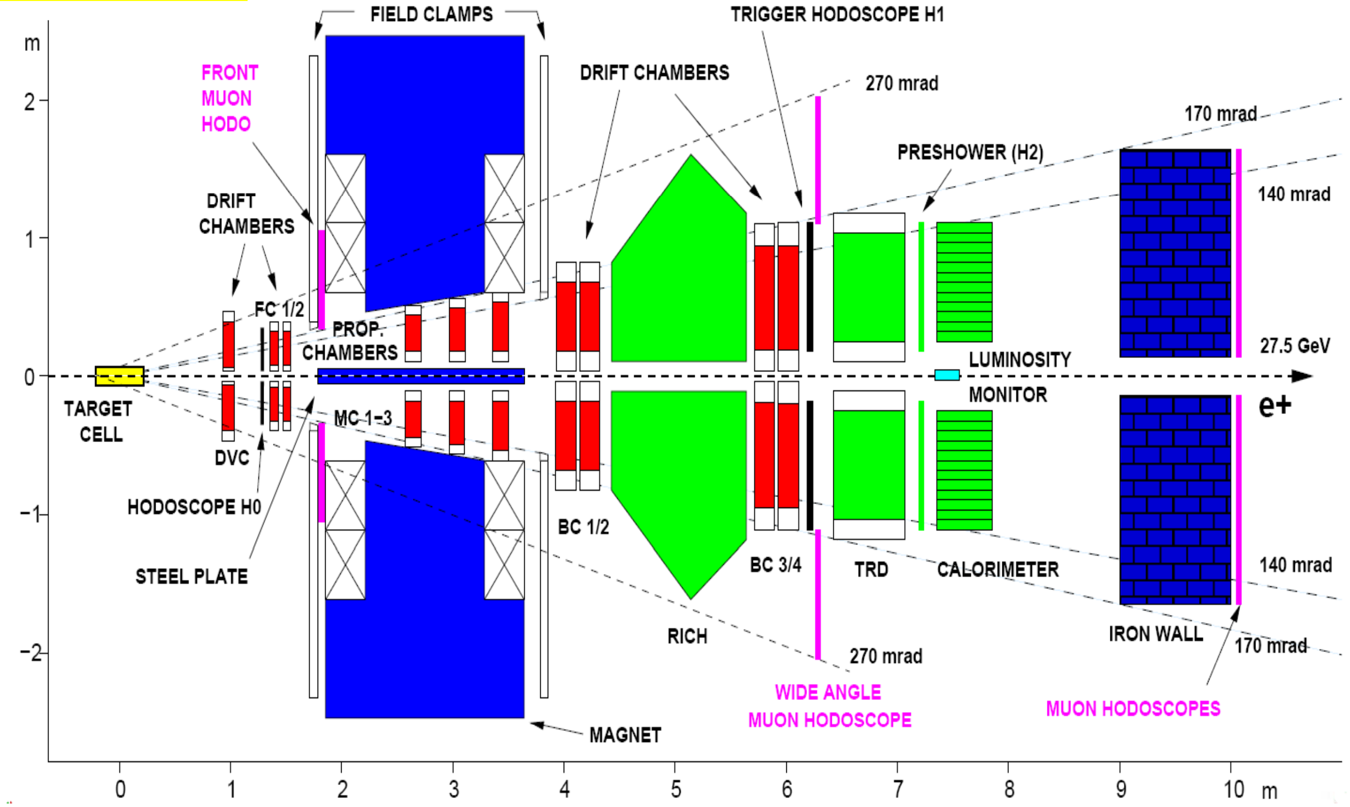
HERMES Experiment

HERA Beam:
- 27.6GeV e^+ and e^-
- <P>≈35-55%

Gas Targets:
- pol. and unpol.
- H, D, He, N, Ne, Kr, Xe







The Spin Structure of the Nucleon

- Nucleon Spin: $\frac{1}{2} = \underbrace{\frac{1}{2}\overbrace{(\Delta u + \Delta d + \Delta s)}^{\Delta\Sigma} + L_q}_{J_q} + \underbrace{\Delta G + L_g}_{J_g}$

$\Delta\Sigma \approx 20-35\%$ measured in DIS

HERMES : $\Delta\Sigma \approx 0.3$

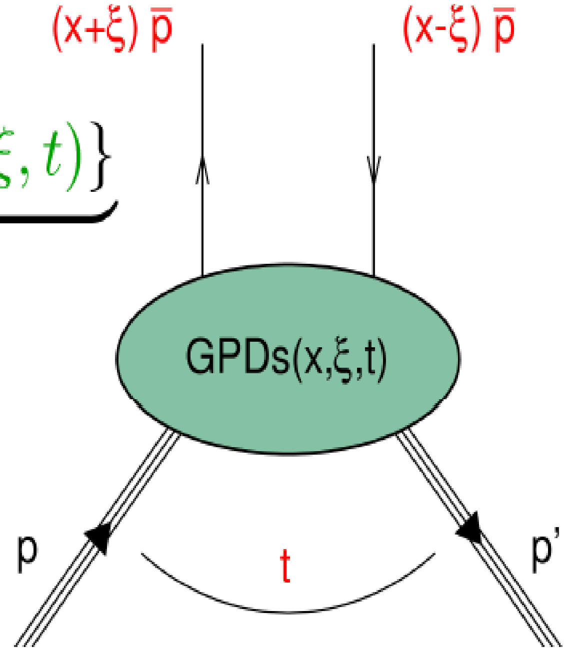
ΔG first Measurements

L_q, L_g unknown

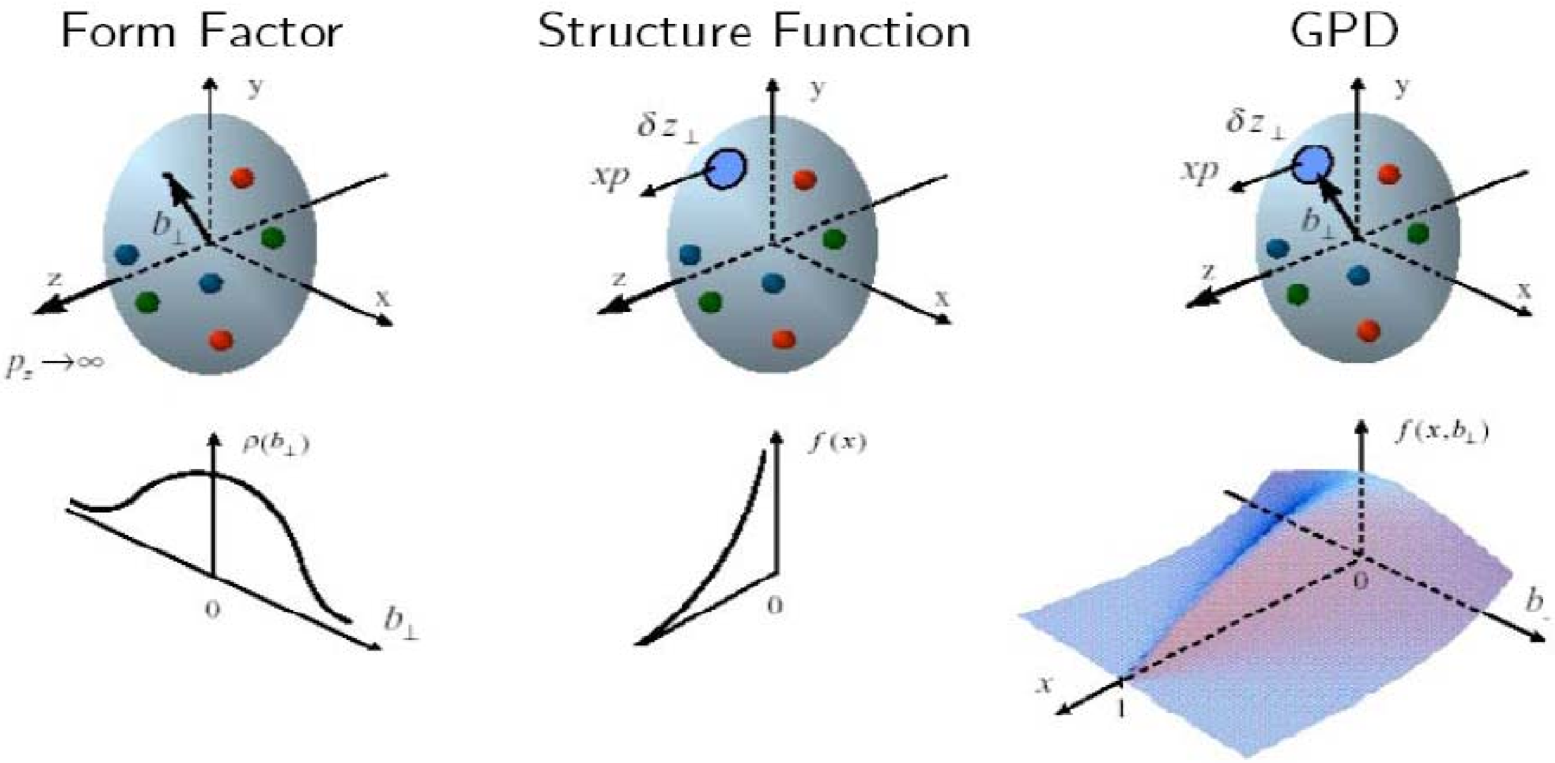
Ji Sum Rule - **Ji, PRL 78 (1997) 610**

➡ $J_{q,g} = \lim_{t\to 0}\int_{-1}^{1} dx\, x \underbrace{\{H_{q,g}(x,\xi,t) + E_{q,g}(x,\xi,t)\}}_{\text{GPDs}}$

$(x \pm \xi)$	parton logitudinal momentum fractions
ξ	fraction of the momentum transfer
t	invariant momentum transfer to the nucleon



FF , PDF and GPD



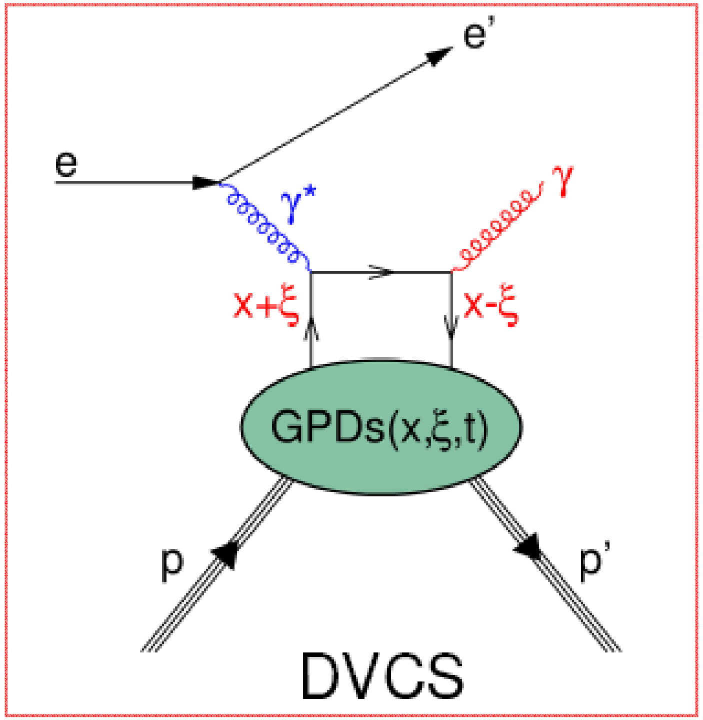
Form Factors ⟶
Transverse Position
⟵Elastics Scattering

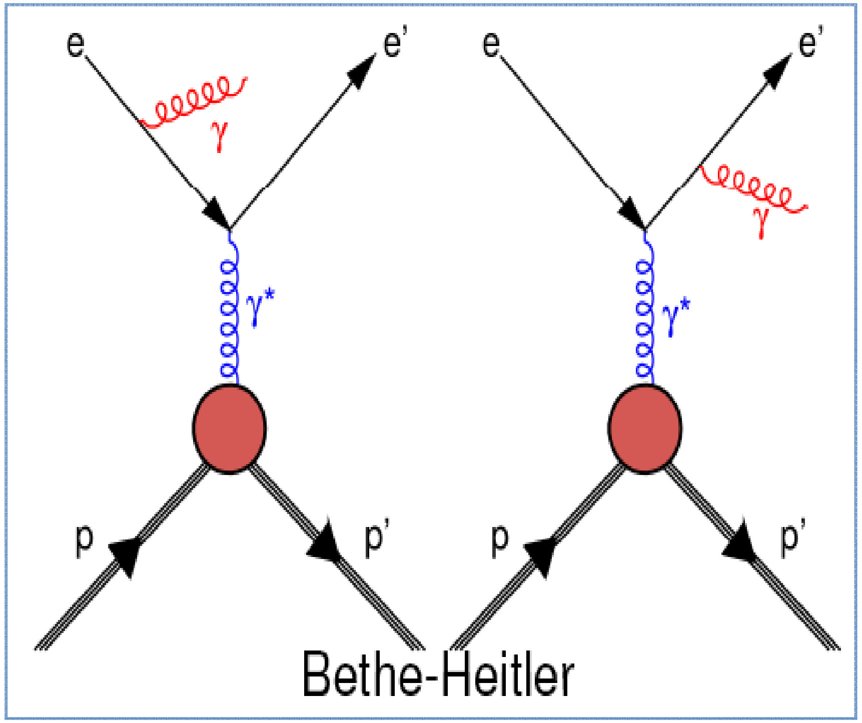
Parton Distribution
Functions: ⟶
Longitudinal
Momentum Distribution
⟵ DIS

Generalized Parton
Distribution: ⟶
Access to Transverse
Position and
Longitudinal
Momentum Distribution
⟵ DVCS

What is DVCS

(Deeply Virtual Compton Scattering)





- DVCS: a γ^* is absorbed and a real γ is produced in hard exclusion reaction by nucleon with the recoiling nucleon being in ground state $l(k)+N(p)\rightarrow l'(k')+N'(p')+\gamma(q')$
- DVCS Final State is indistinguishable from the Bethe-Heitler (BH)

Why Nuclear DVCS

- Done for H & D but not yet Heavier Nuclear Targets
- A good opportunity to understand the effect of nuclear medium on structure of nucleon

Different Unpol. Targets in HERMES:
H2, He-4, N2, Neon, Krypton and Xenon
gas injected into target cell

DVCS ⇔ σ ⇔ Asymmetries

- The same final state in DVCS and Bethe-Heitler ⇒interference

$$\sigma \propto |\mathcal{T}_{\rm BH}|^2 + |\mathcal{T}_{\rm DVCS}|^2 + \underbrace{(\mathcal{T}_{\rm BH}\mathcal{T}^*_{\rm DVCS} + \mathcal{T}^*_{\rm BH}\mathcal{T}_{\rm DVCS})}_{\mathcal{I}}$$

- At HERMES, $\mathcal{T}_{\rm BH} \gg \mathcal{T}_{\rm DVCS} \Rightarrow \mathcal{T}_{\rm DVCS}$ can be accessed through $\mathcal{I}$: both its amplitude and phase
- For longitudinal polarized beam with beam polarization P_b and charge e_l, and unpolarized target, the cross section can be factorized as

$$\sigma_{LU} = \sigma^0_{UU}(\phi)\left[1 + e_l\ A_C(\phi) + P_b\ A^{DVCS}_{LU}(\phi) + e_l\ P_b\ A^{\mathcal{I}}_{LU}(\phi)\right]$$

σ^0_{UU}: neither dependent on beam charge nor beam polarization

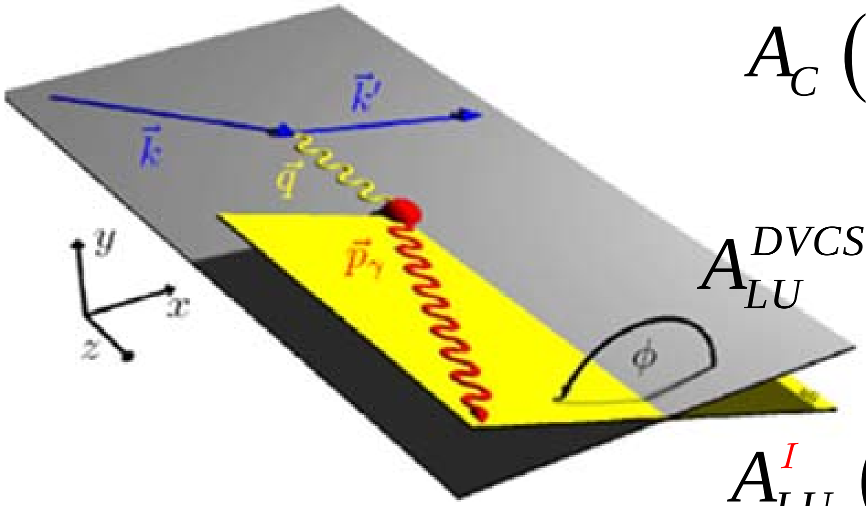
A_C : the traditional Beam Charge Asymmetry $\Rightarrow c^{\mathcal{I}}_{0/1/2,unp}$

A^{DVCS}_{LU}: only dependent on beam polarization $P_b \Rightarrow s^{DVCS}_{1,unp}$

$A^{\mathcal{I}}_{LU}$: dependent on P_b and beam charge $\Rightarrow s^{\mathcal{I}}_{1/2,unp}$

How to Measure Asymmetries?

- Combined analysis method for H/Kr/Xe since e^+ and e^- beams available:



$$A_C(\phi) = \frac{\sigma^{+\rightarrow} - \sigma^{-\rightarrow} + \sigma^{+\leftarrow} - \sigma^{-\leftarrow}}{\sigma^{+\rightarrow} + \sigma^{-\rightarrow} + \sigma^{+\leftarrow} + \sigma^{-\leftarrow}}$$

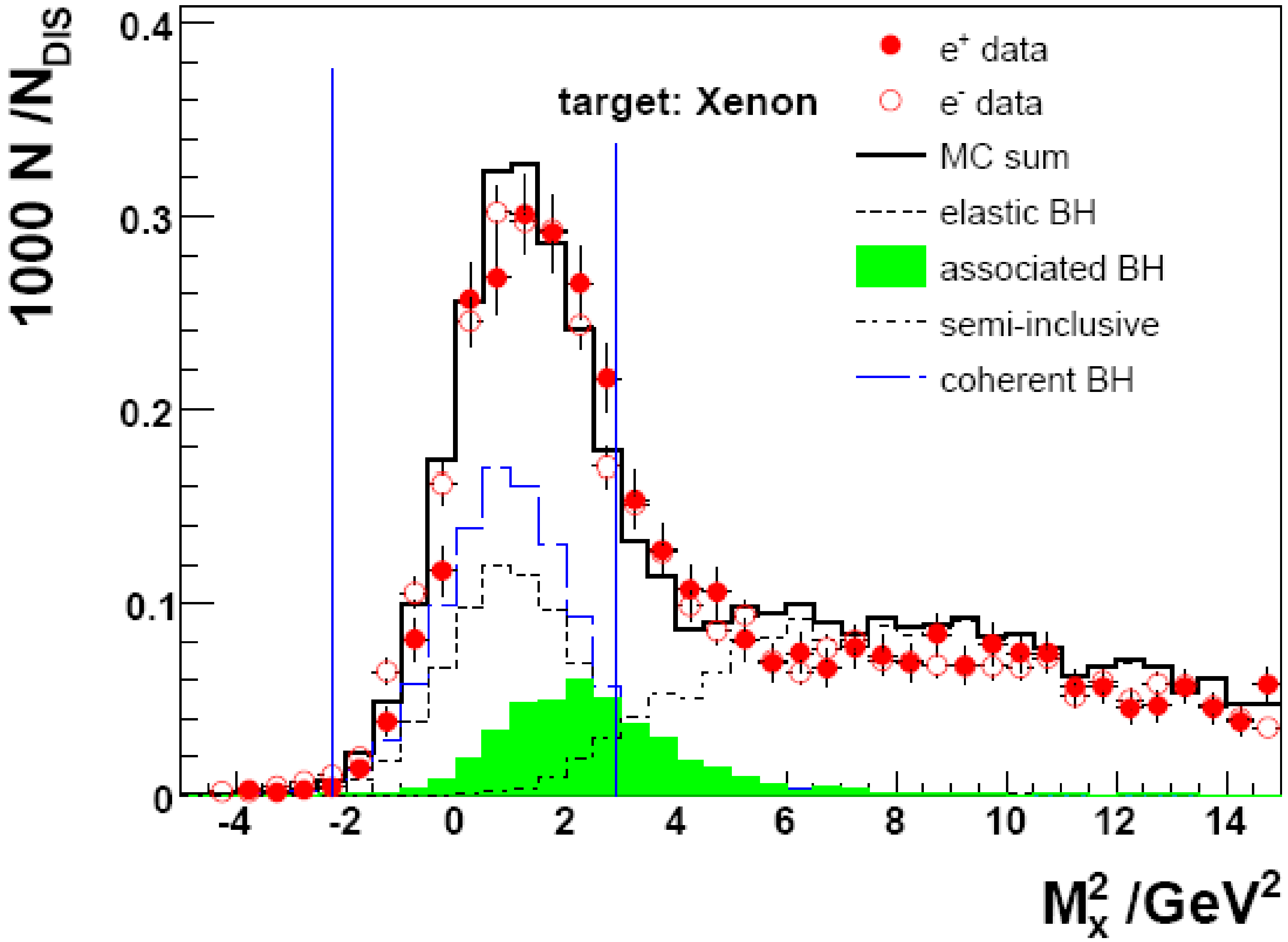
$$A_{LU}^{DVCS}(\phi) = \frac{\sigma^{+\rightarrow} + \sigma^{-\rightarrow} - \sigma^{+\leftarrow} - \sigma^{-\leftarrow}}{\sigma^{+\rightarrow} + \sigma^{-\rightarrow} + \sigma^{+\leftarrow} + \sigma^{-\leftarrow}}$$

$$A_{LU}^{I}(\phi) = \frac{\sigma^{+\rightarrow} - \sigma^{-\rightarrow} - \sigma^{+\leftarrow} + \sigma^{-\leftarrow}}{\sigma^{+\rightarrow} + \sigma^{-\rightarrow} + \sigma^{+\leftarrow} + \sigma^{-\leftarrow}}$$

- Single-BSA analysis for ^{4}He/N/Ne since only e^+ beam available:

$$A_{LU}(\phi) = \frac{\sigma^{+\rightarrow} - \sigma^{+\leftarrow}}{\sigma^{+\rightarrow} + \sigma^{+\leftarrow}}$$

M_x^2 distribution and exclusive sample selecting



Coherent/incoherent separation

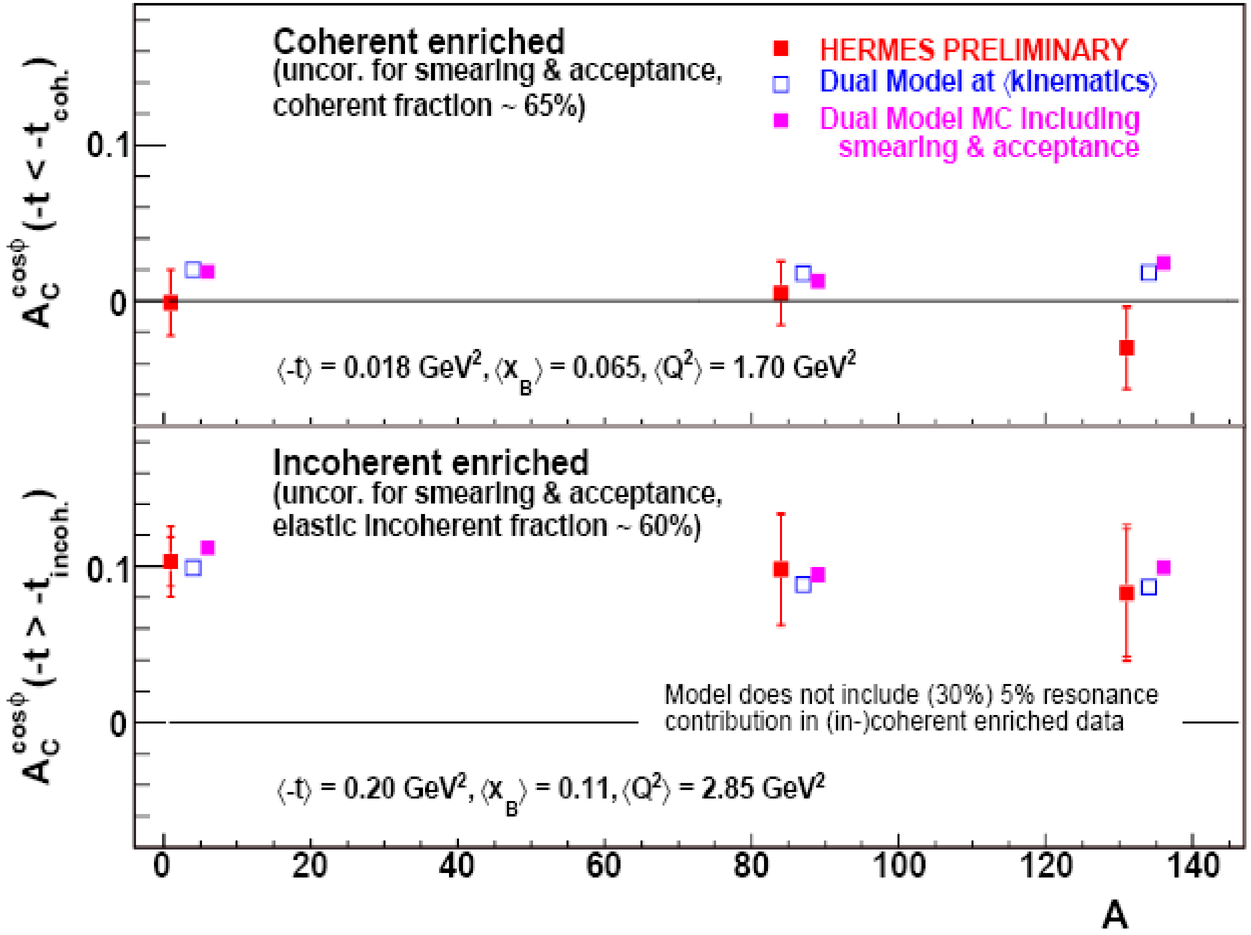
- nuclear DVCS involves 2 contributions:
  1. Coherent process: nuclear target stays intact
  2. Incoherent process: nuclear target breaks up, the γ is emitted by a particular proton or neutron
- Separate coherent/incoherent part by a t cutoff value
- Given the t dependence of the asymmetries $\Rightarrow$ to get the same $\langle t \rangle$ for all the targets $\Rightarrow$ differences for $\langle x_B \rangle$, $\langle Q^2 \rangle$ are also quite small

Target	t cutoff	estimated %elas. coh. incoh. (by MC)	$\langle t \rangle$ (RMS)	$\langle x_B \rangle$ (RMS)	$\langle Q^2 \rangle$ (RMS)
H	$-t < -t_{coh.}$	–	-0.018(0.008)	0.070(0.023)	1.81(0.75)
	$-t > -t_{incoh.}$	–	-0.200(0.120)	0.109(0.059)	2.89(1.62)
Kr	$-t < -t_{coh.}$	70	-0.018(0.015)	0.064(0.023)	1.63(0.68)
	$-t > -t_{incoh.}$	58	-0.200(0.125)	0.108(0.058)	2.84(1.61)
Xenon	$-t < -t_{coh.}$	66	-0.018(0.017)	0.062(0.023)	1.60(0.66)
	$-t > -t_{incoh.}$	56	-0.200(0.126)	0.107(0.058)	2.86(1.63)

t is the target squared 4-momentum transfer:

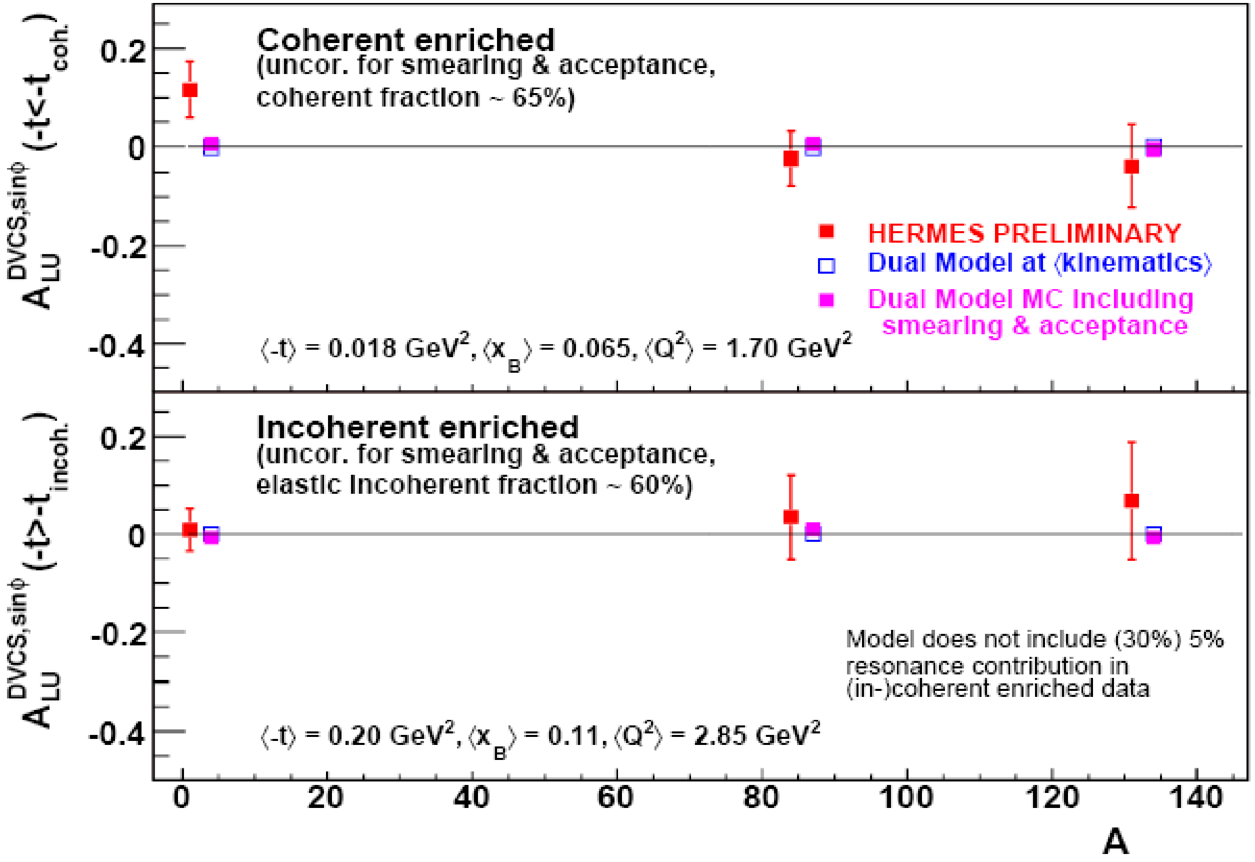
$$t \equiv (p' - p)^2 \overset{\text{lab}}{=} -Q^2 - 2E_\gamma(\nu - \sqrt{\nu^2 + Q^2}\cos\theta_{\gamma\gamma*})$$

Preliminary Results: Beam Charge Asymmetry $A_C^{\cos\phi}$



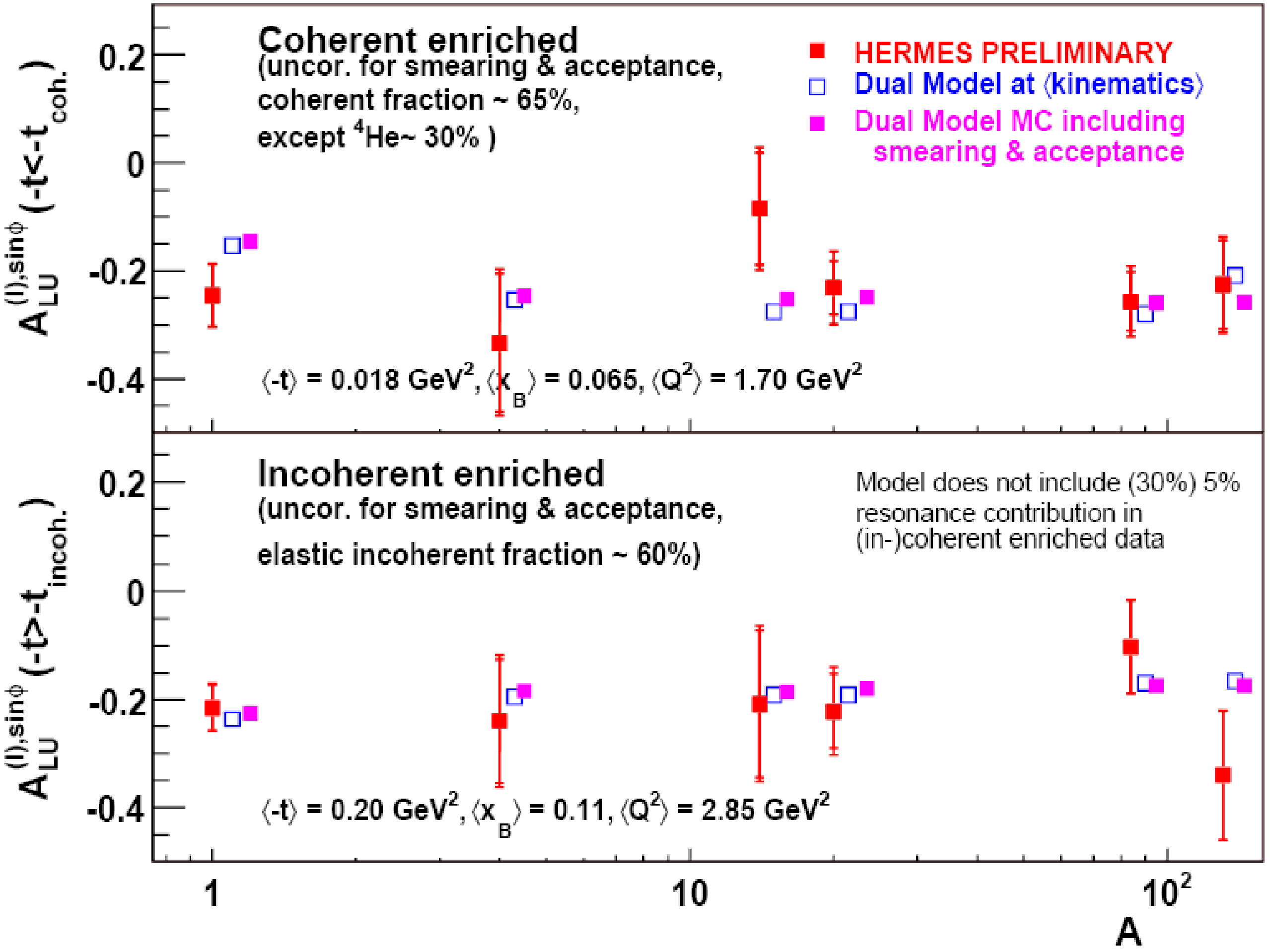
- The measured $A_C^{\cos\phi}$(shown as red points) in coherent enriched part is quite small

DVCS Term of Beam Spin Asymmetry: $A_{LU}^{DVCS,\sin\phi}$



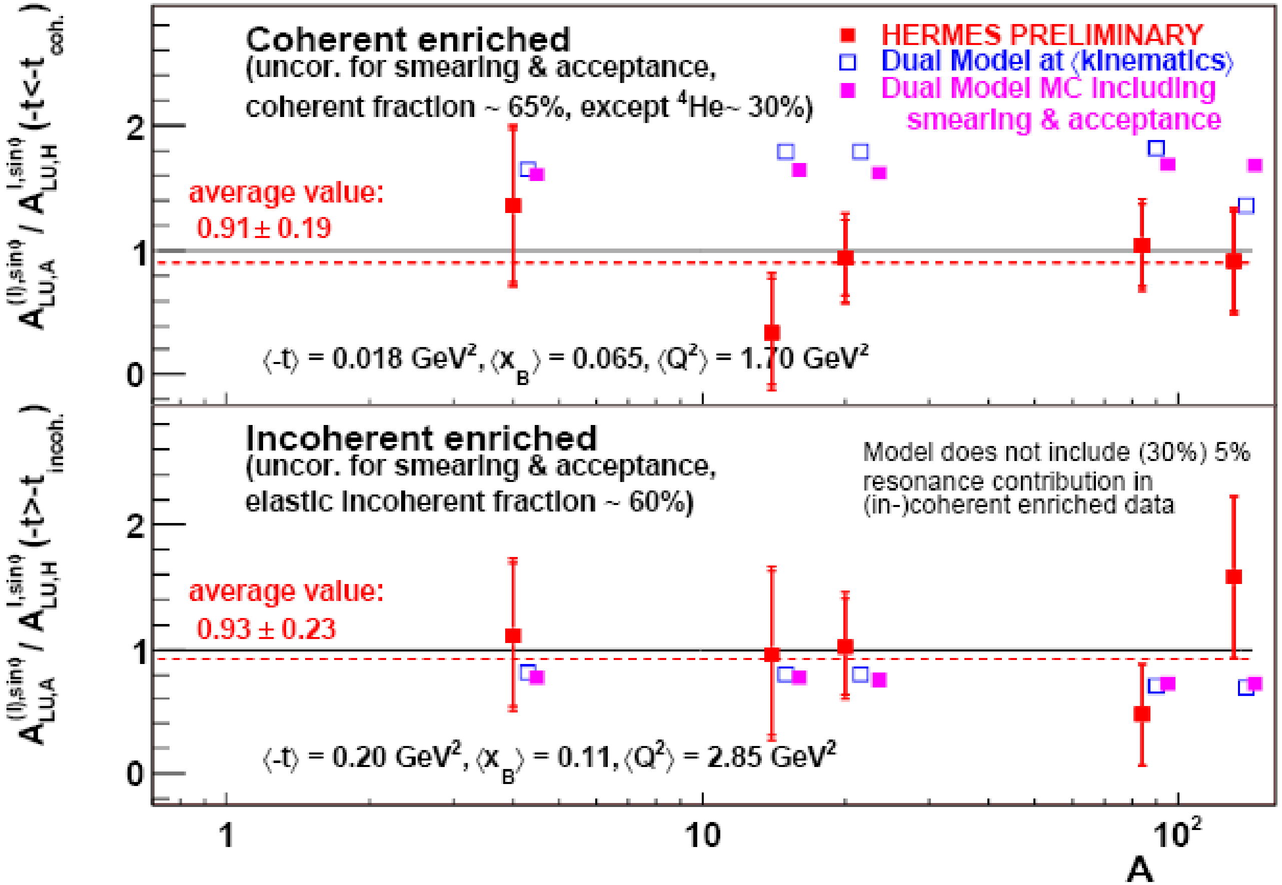
- The measured $A_{LU}^{DVCS,\sin\phi}$ are comparable with zero, except for the coherent enriched Hydrogen

Leading Beam Spin Asymmetry Amplitude: $A_{LU}^{(I),\sin\phi}$



- H/Kr/Xenon⇐combined analysis; He4/N/Neon ⇐ e^+ beam single-BSA fit

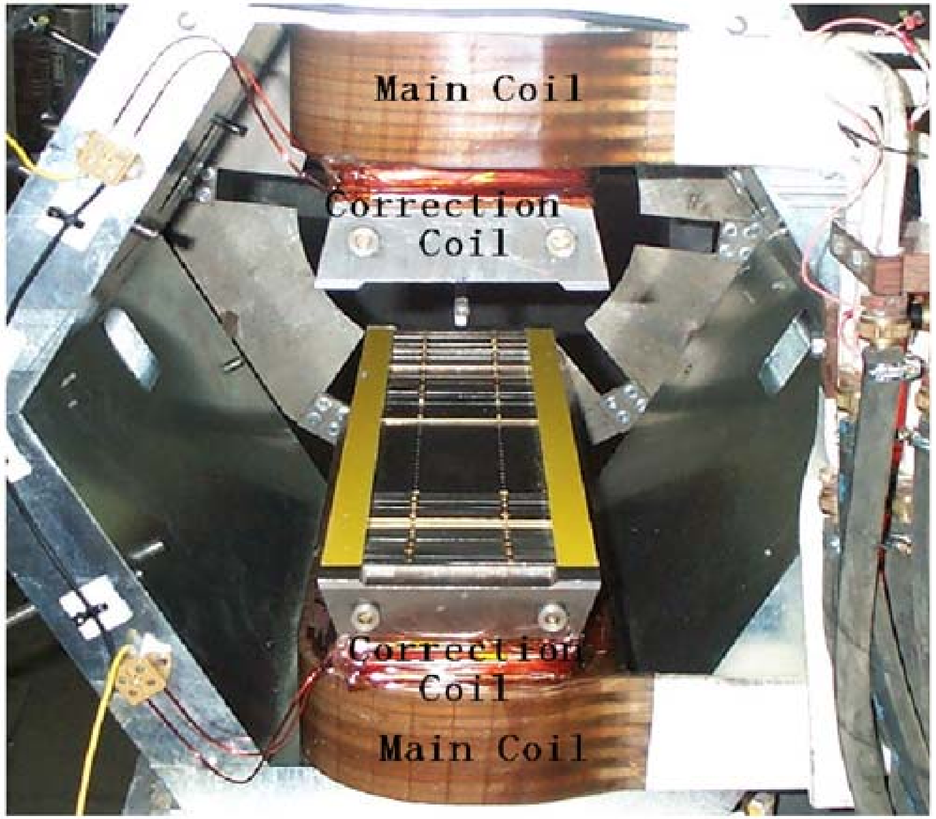
Ratio of Leading BSA Amplitude: $A_{LU,A}^{(I),\sin\phi}/A_{LU,H}^{I,\sin\phi}$



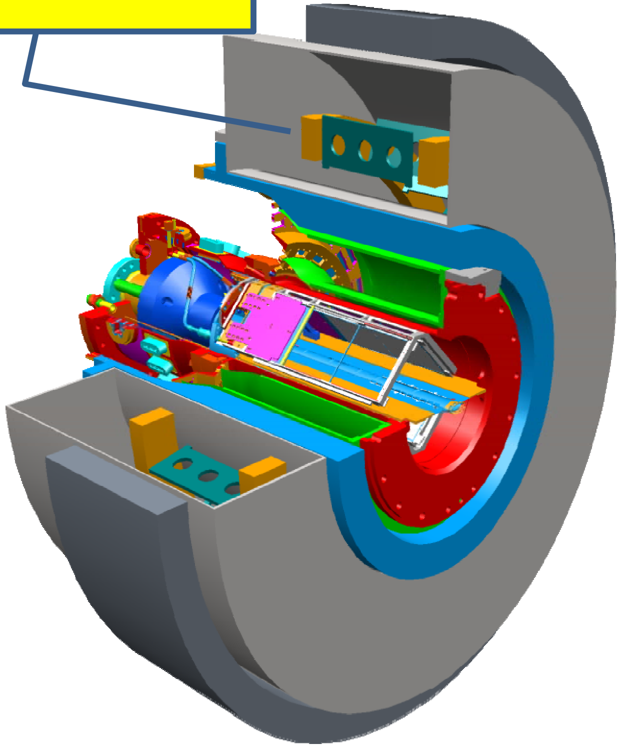
- The measured ratio of $A_{LU,A}^{(I),\sin\phi}/A_{LU,H}^{I,\sin\phi}$ is comparable with unity in both (in-)coherent enriched sample

Part II Techniques

—— Target Magnet Correction

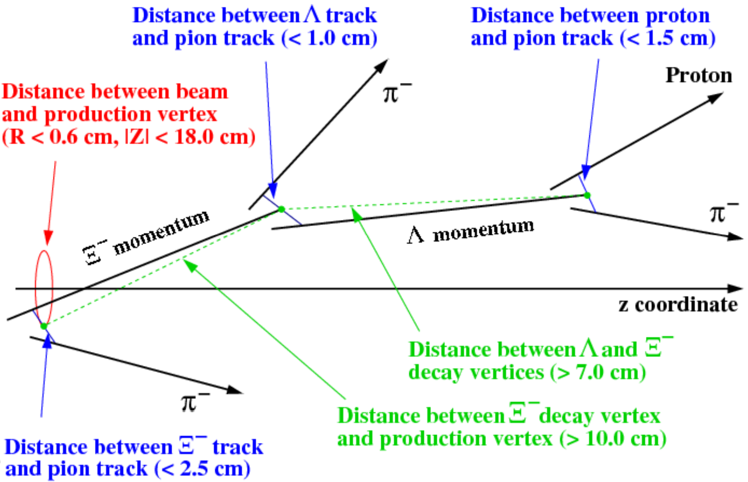


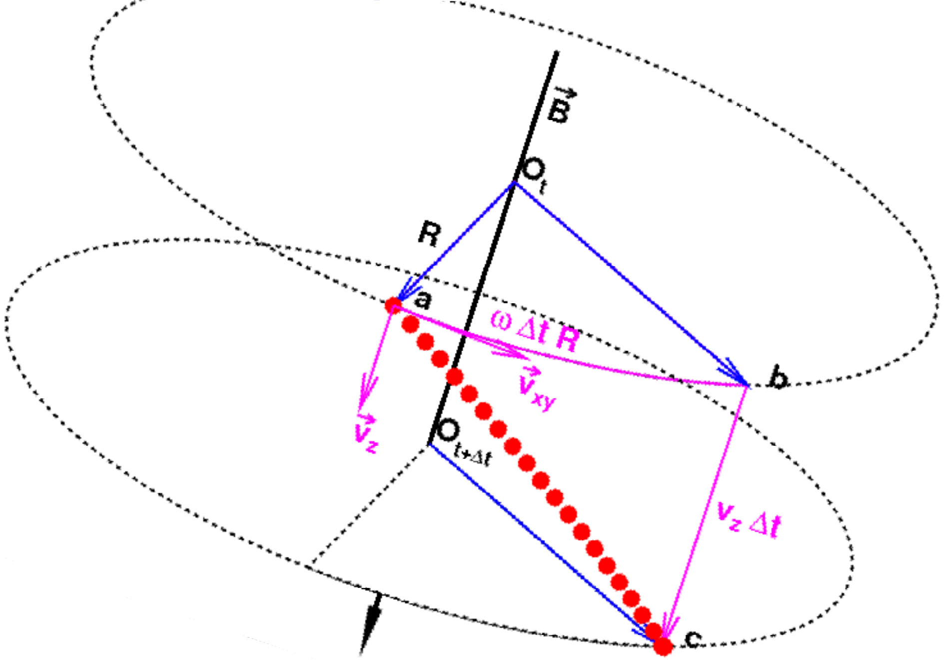
Transverse Target Magnet ~0.3T



1 Tesla Superconducting Solenoid on Recoil Detector

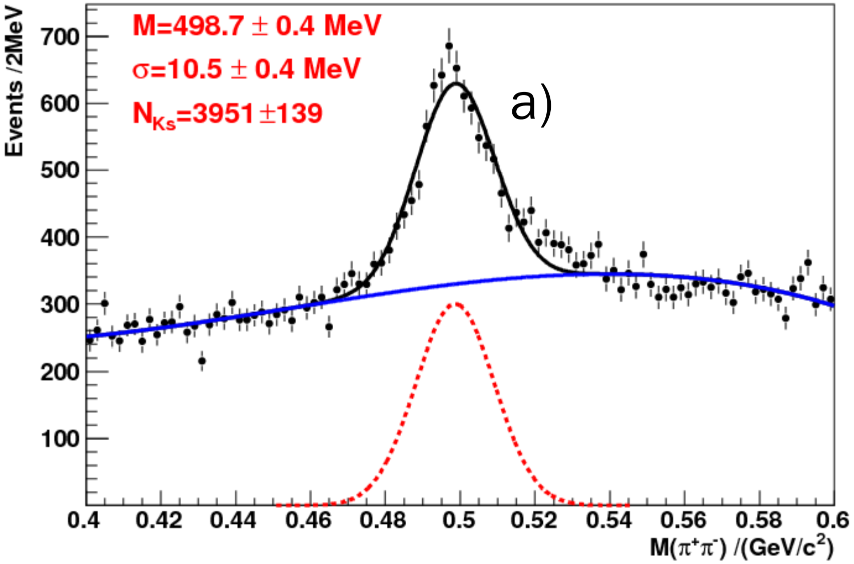
How SiguangTMC Work?

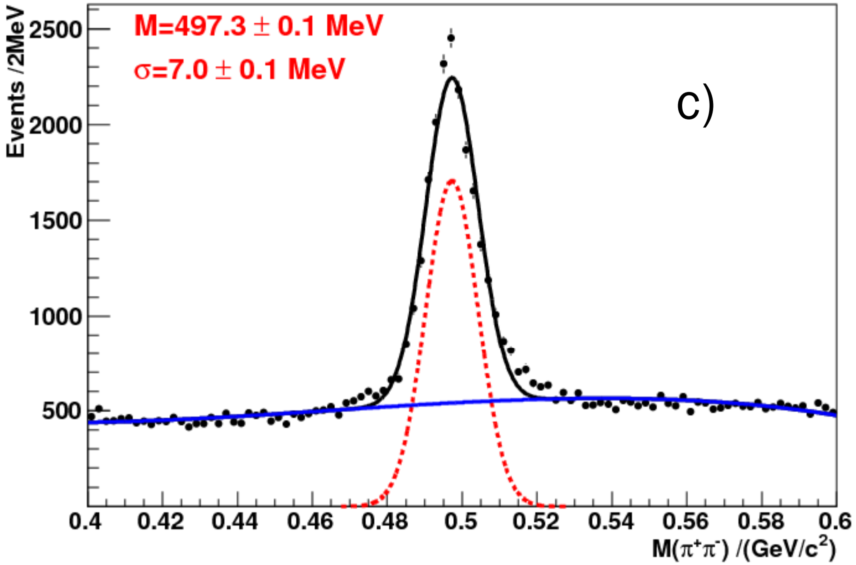


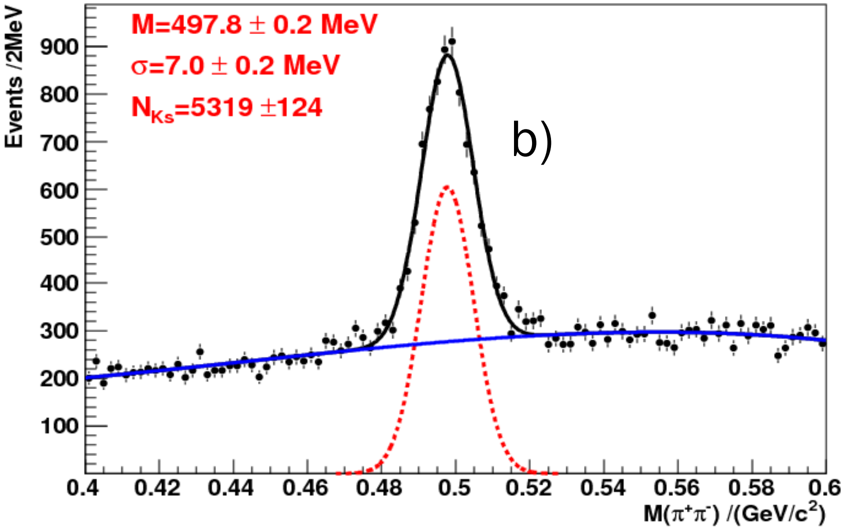


- Accurate Track Back inside Magnet Field:
  - Turn in $O_t$ab plane perpendicular to Mange Field along arc ab
  - Walk a straight line along bc parallel magnet Field
- Find nearest points from two curve tracks

Test TMC







a) Trans. Pol. No TMC

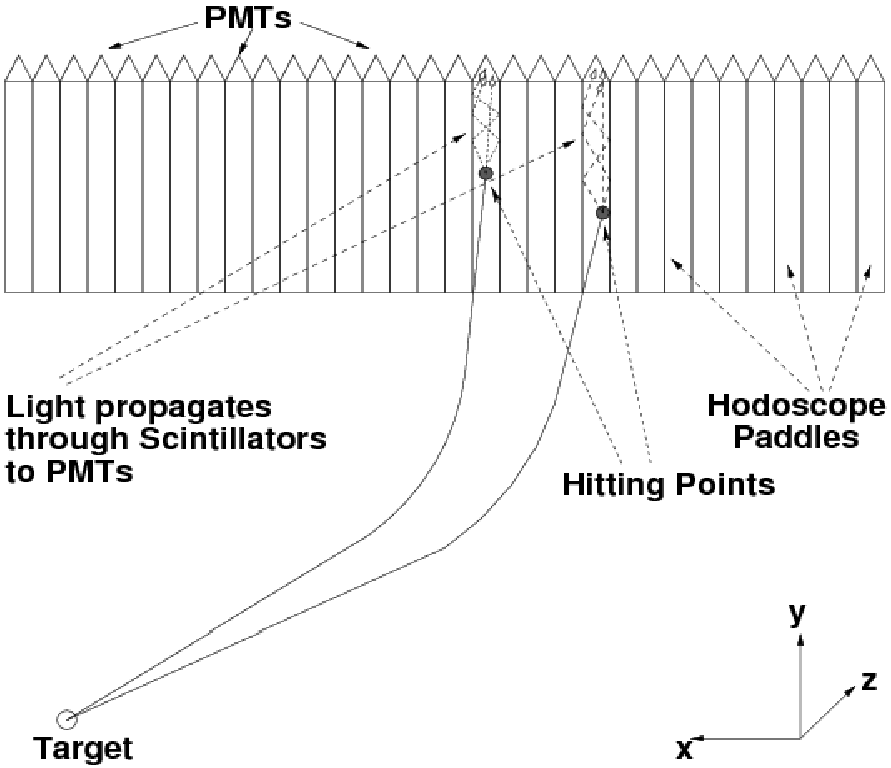
b) Trans. Pol. After TMC

c) Unpol. targets

TMC triggered re-measurement of HERMES Recoil Detector Field

Part II Techniques

——Artificial Neural Network(ANN) on TOF

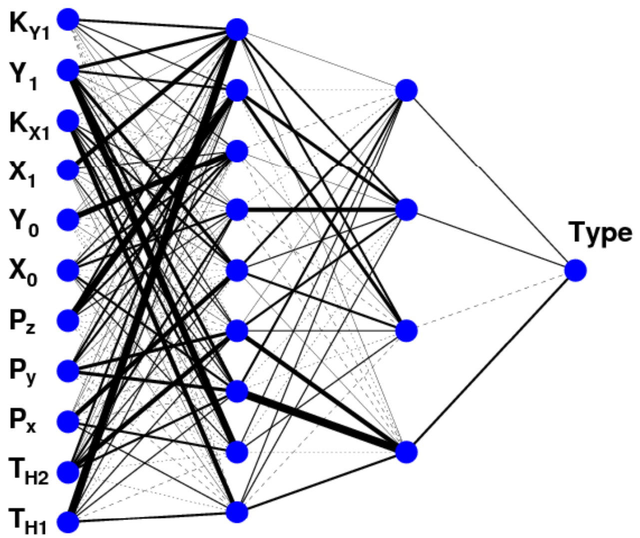


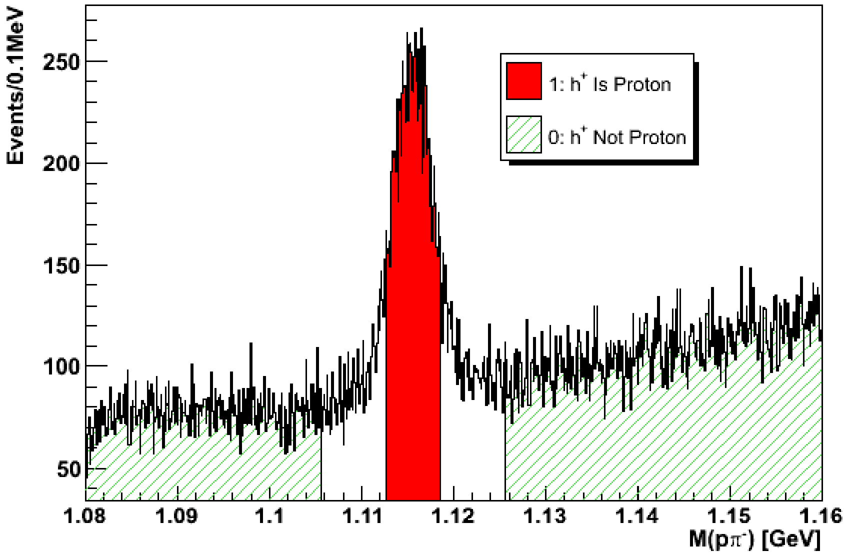
$$m^2 = p^2\left(\frac{1}{\beta^2} - 1\right)$$

Traditional Calibration Method:

- Cable length Correction
- Hit point to PMT Correction
- Difficult Magnet Bending Correction
- ....

Apply ANN on Raw Data of TOF





Parameters for trajectory, momentum and time information as inputs

Type = 1 for under peak region
Type = 0 for background region

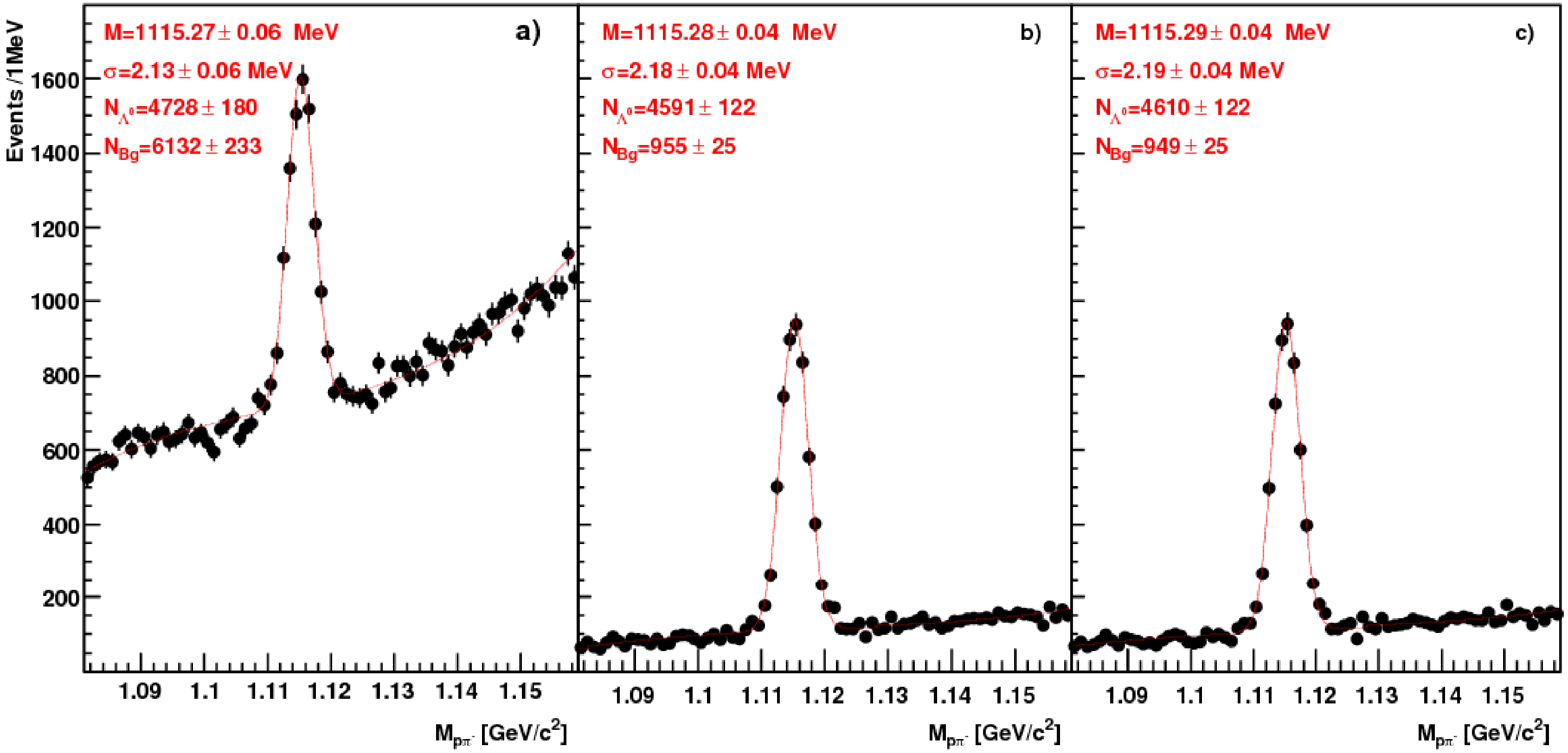
NO MC, ANN trained Directly with Experimental Raw Data!

Λ Peak Reconstructed with Proton

(a) Not been ID

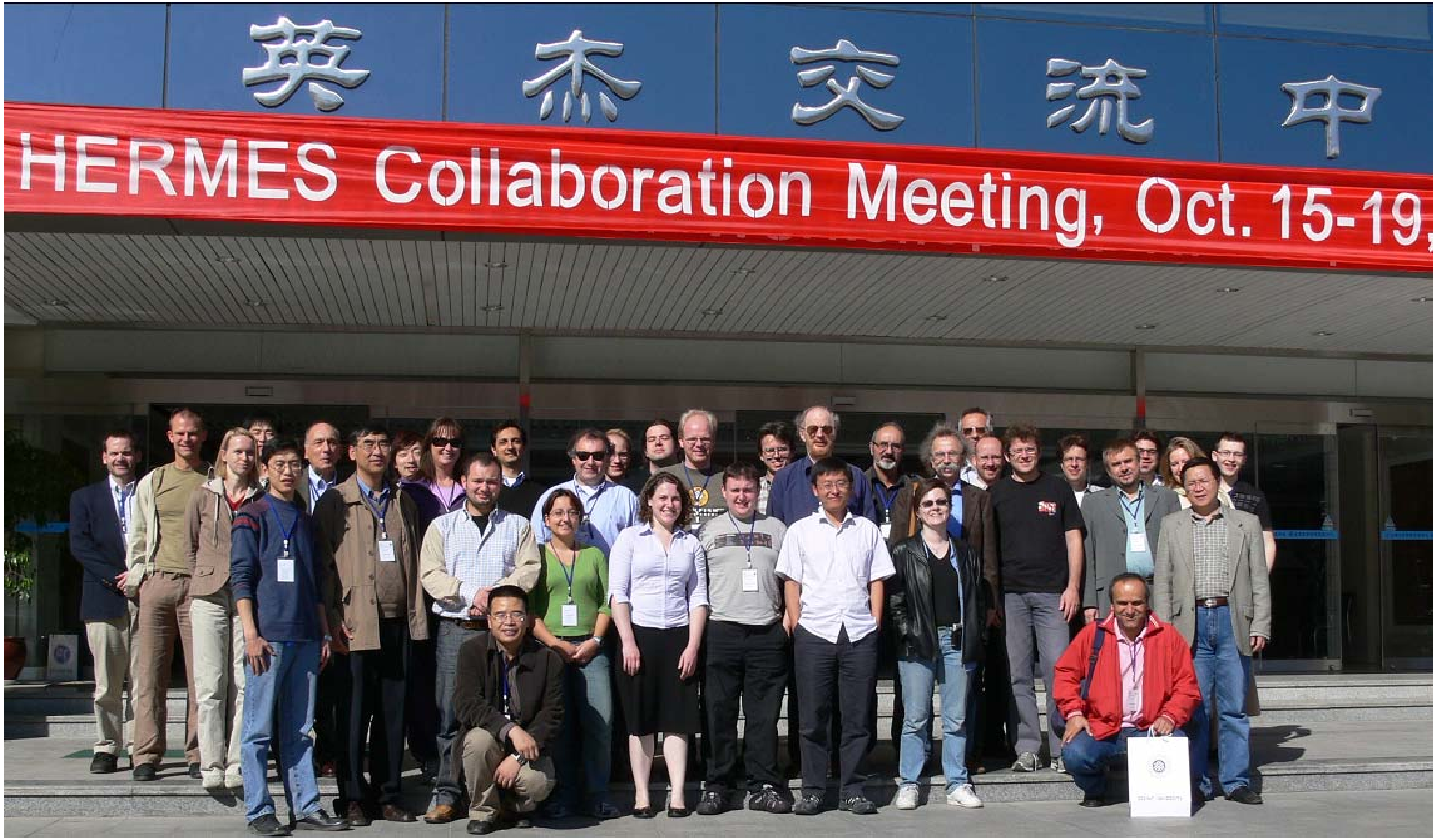
(b) ID by TOF (Traditional Calibration)

(c) ID by TOF (ANN Method)



HERMES Group Meeting in PKU

Oct. 15-19 2007



谢谢本次南京会议的组委会，辛苦了！

Summary

- Nuclear DVCS results released 3 weeks ago, pushed by Hongxue from PKU groups
- TMC: Fine for tracks reconstruction and triggered re-measurement of magnetic filed of recoil detector
- ANN on TOF: easily and can give same result as that of traditional method

Thank You