Investigation of the Chiral Magnetic Effect using Event Shape Engineering at $\sqrt{s_{NN}}$ = 5.02 TeV Pb-Pb

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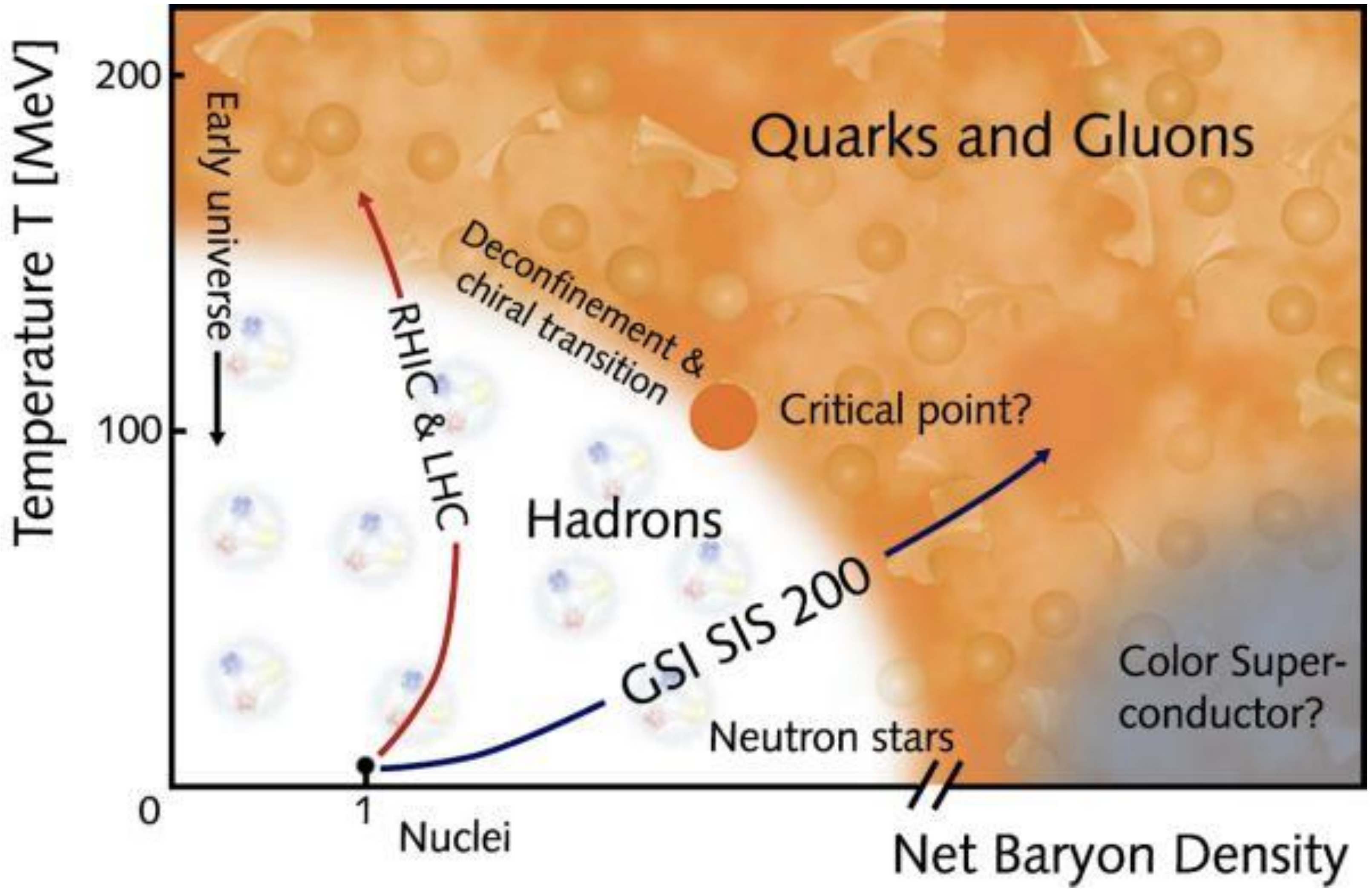
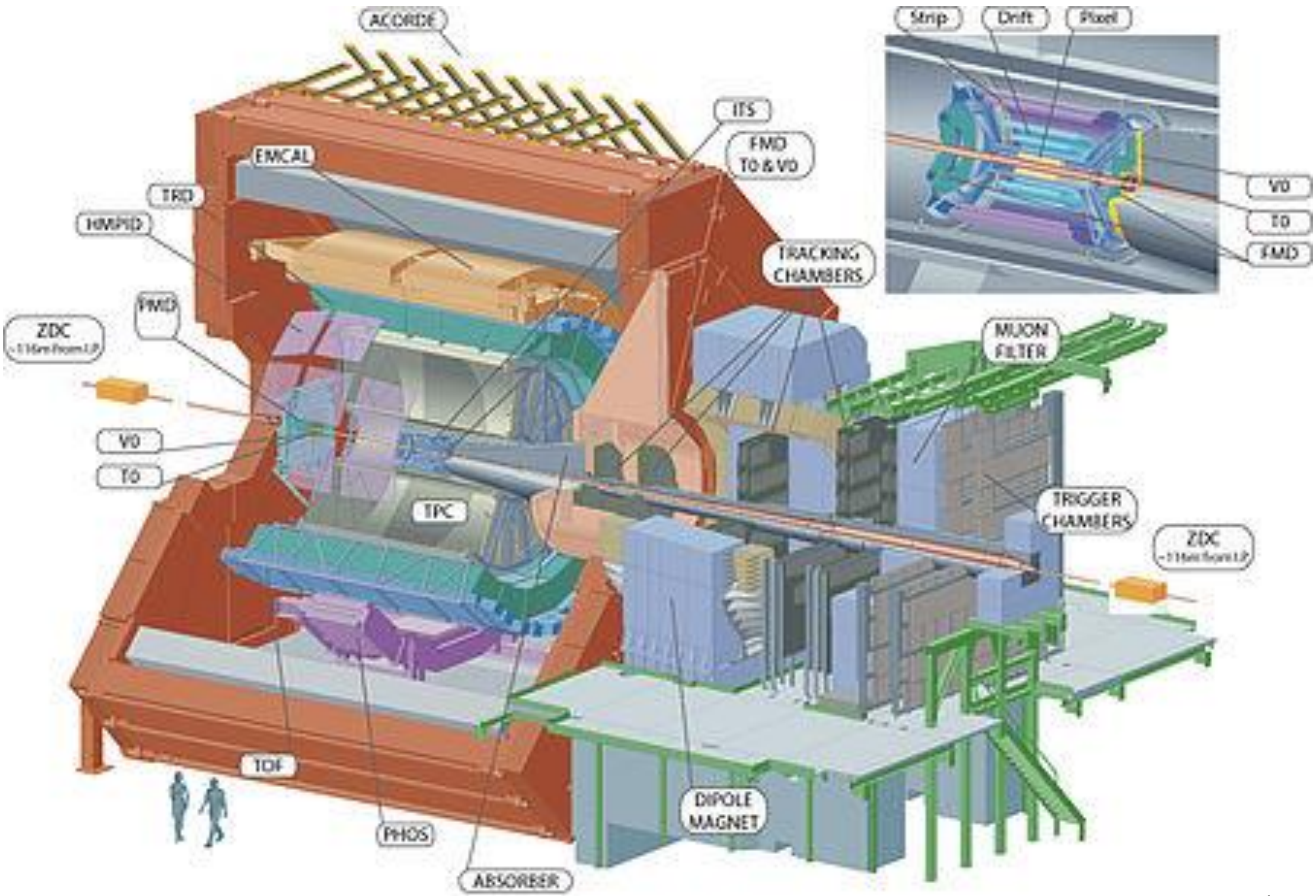
- Physics Background
- Experimental Approach
- Event Shape Engineering (ESE)
- CGC-KLN Model
- Connecting Data and Model
- Summary & Outlook

Physics Background

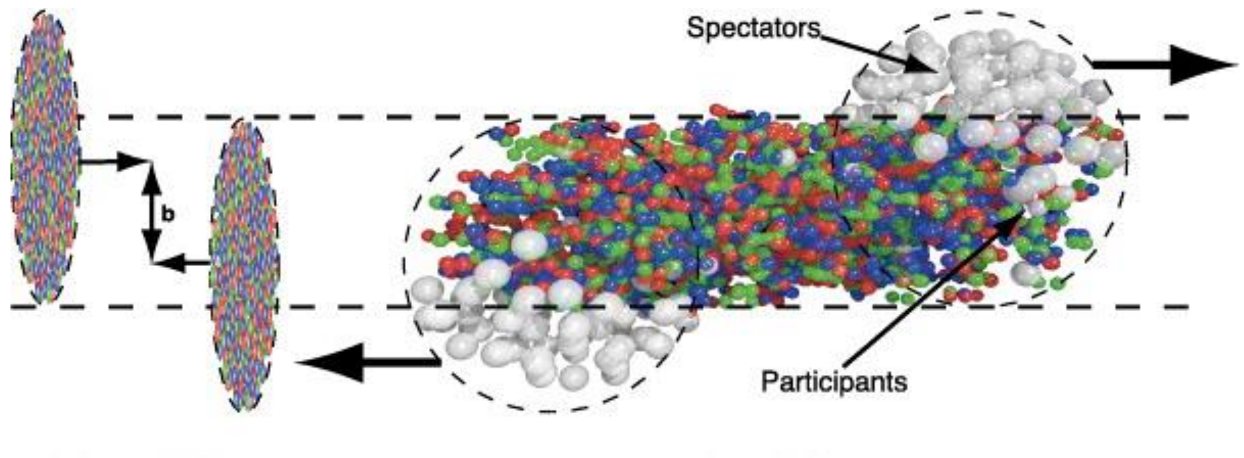


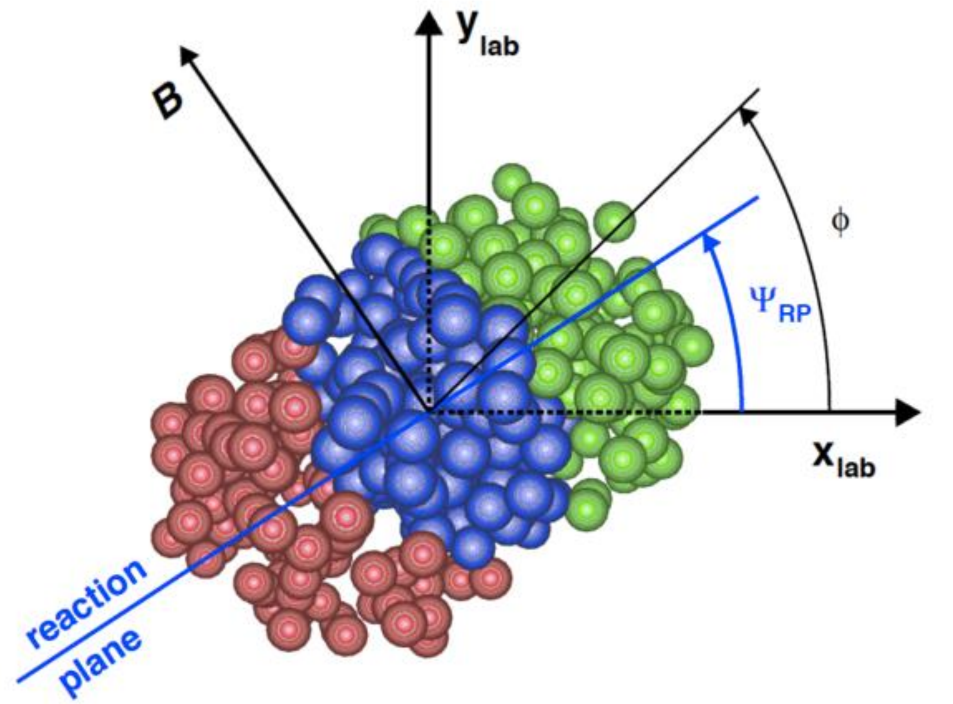
- Quantum Chromodynamics (QCD) predicts at high temperature a new phase of matter, Quark Gluon Plasma (QGP), a deconfined system of quarks and gluons.
  - QGP is expected to be present in the early universe in the first milliseconds.

A Large Ion Collider Experiment



Experimental Approach





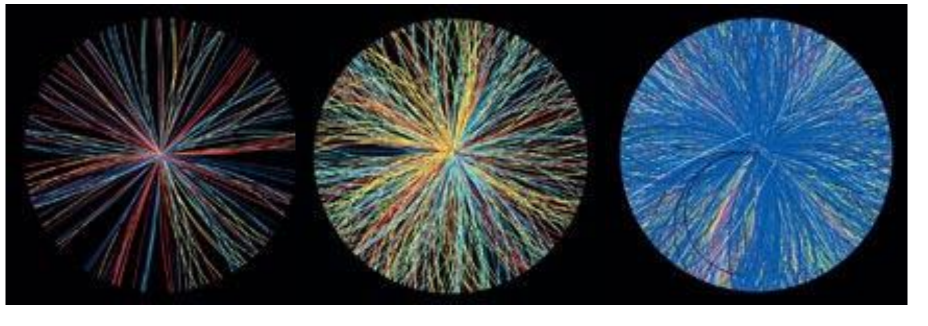
Impact Parameter b

- Normal to the beam direction
- Estimated from the multiplicity of the event → **centrality**

Reaction Plane Ψ_{RP}

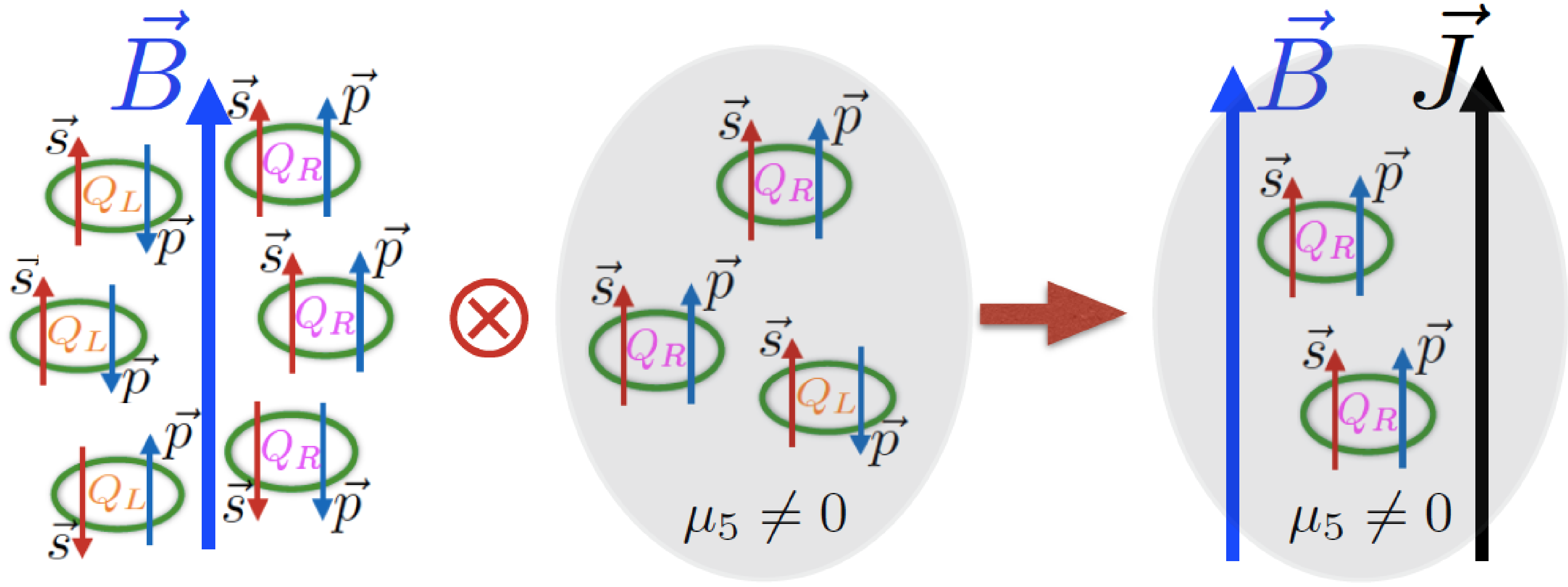
- Due to fluctuations of event shapes, use symmetry plane Ψ_n to investigate the collision

Low Multiplicity
Large b
Peripheral Collisions



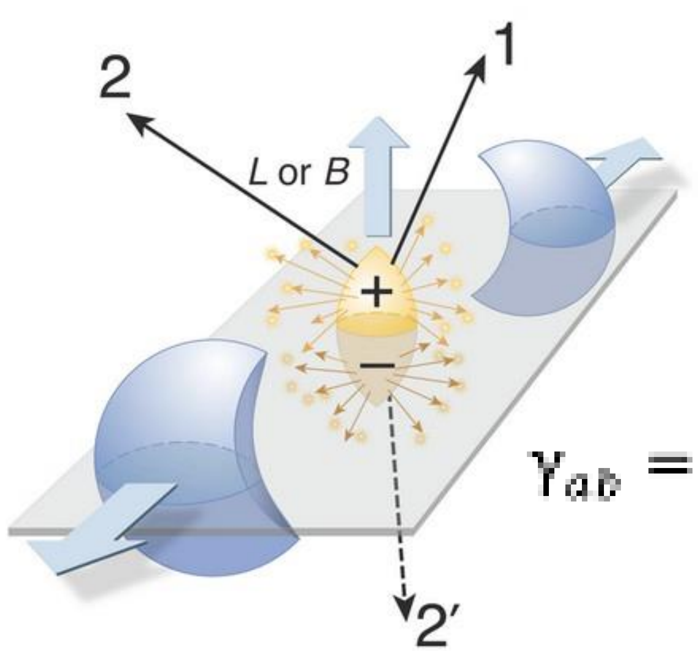
High Multiplicity
Small b
Central Collisions

Chiral Magnetic Effect (CME)



Kharzeev, D.E. et al. Prog.Part.Nucl.Phys. 88 (2016) 1-28 arXiv:1511.04050 [hep-ph]

- An electric current will be induced in chiral domains along the B field in the heavy ion collisions (B ~ 10^{15} T).
- Experimental evidence: Charge Separation along the magnetic field.



3-particle correlator

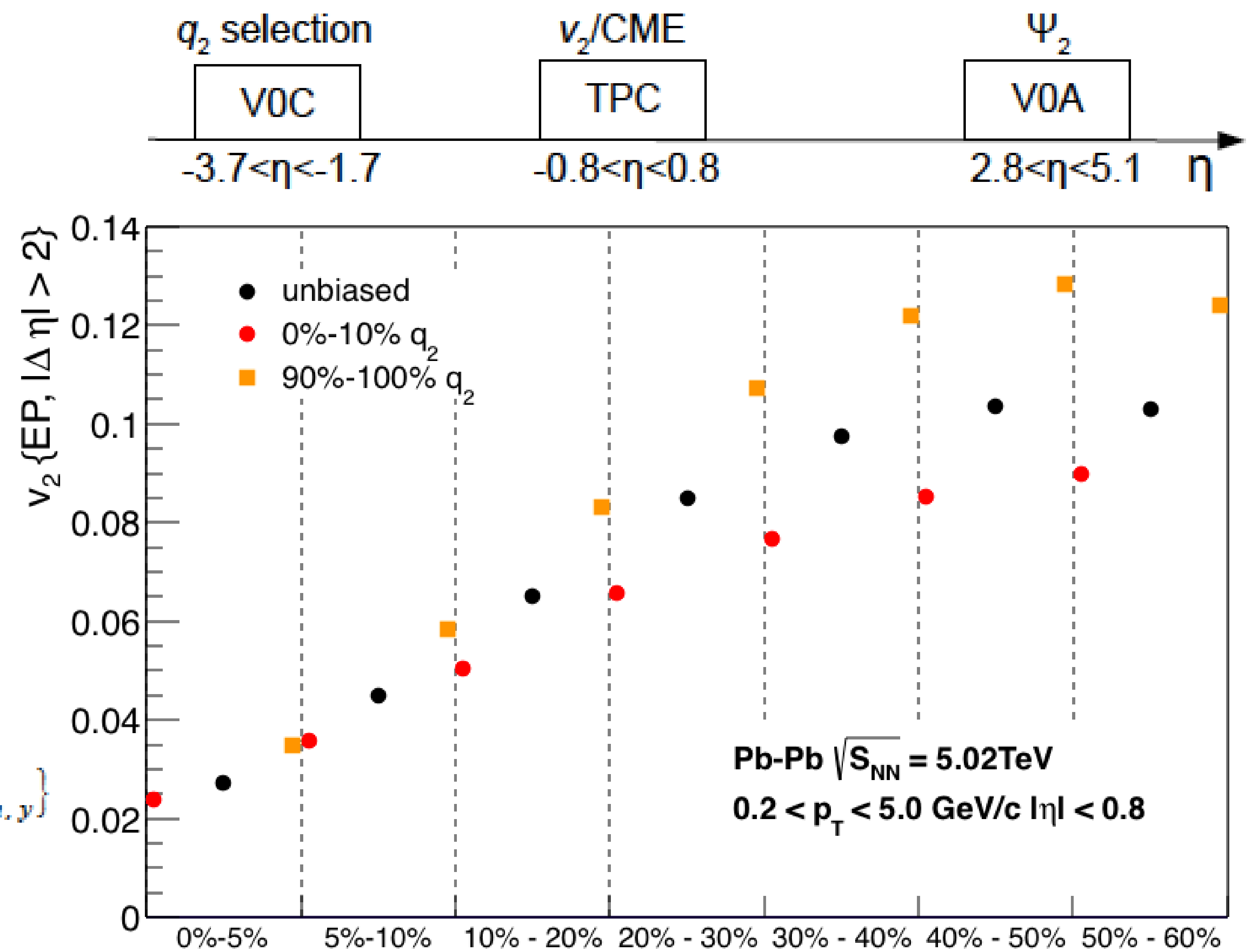
$$\gamma_{ab} = \langle\cos(\varphi_a + \varphi_b - 2\Psi_2)\rangle \approx -\langle a_{1,a}a_{1,b}\rangle + Bkg_{in-plane} - Bkg_{out-plane}$$

Event Shape Engineering (ESE)

Small q_2 Large q_2

Flow vector → q-distributions

$$Q_{n,x}=\sum_i \cos(n\varphi_i) \qquad Q_{n,y}=\sum_i \sin(n\varphi_i) \quad \rightarrow \quad Q_n=\{Q_{n,x}, iQ_{n,y}\} \qquad q_n=|Q_n|/\sqrt{M}$$

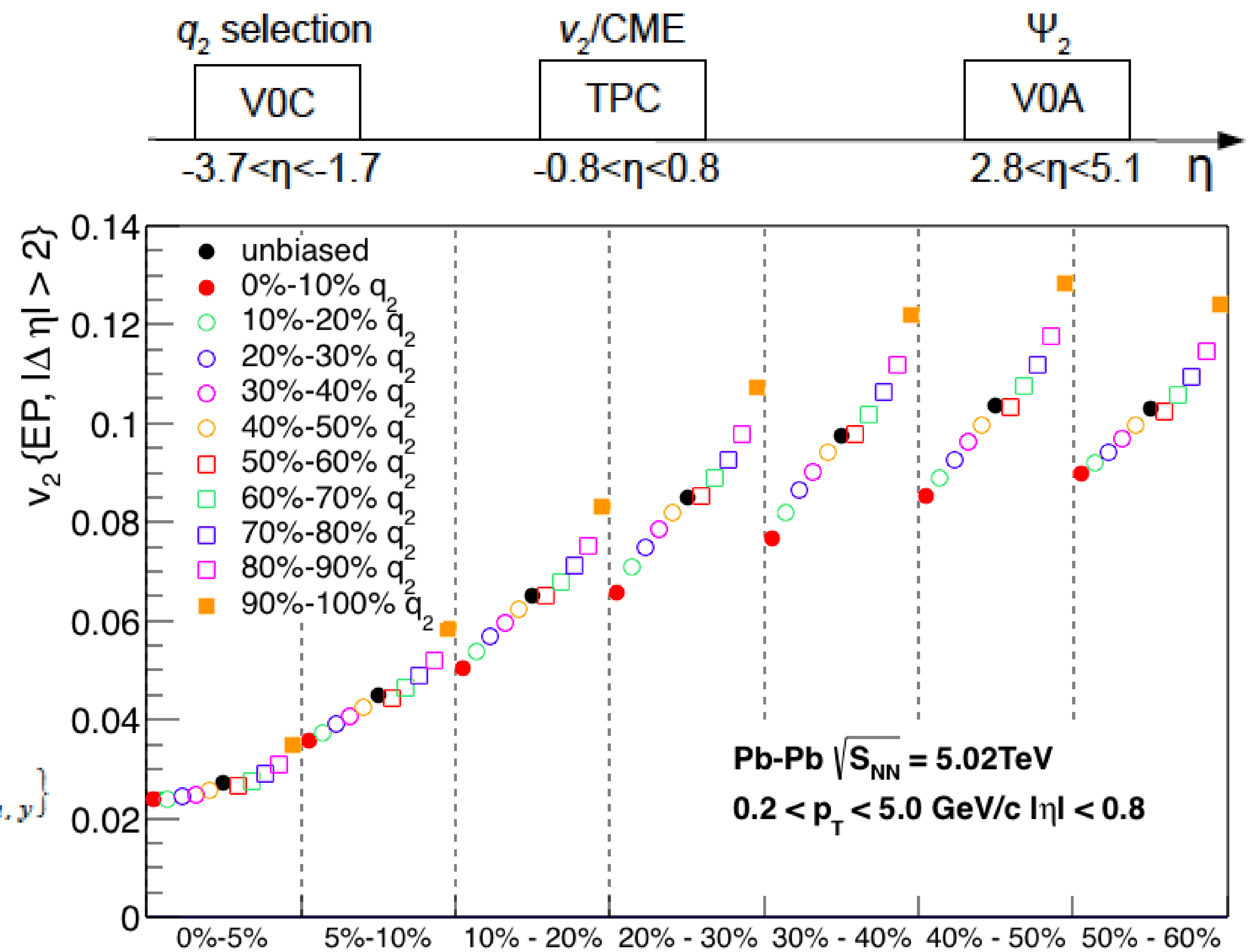


- **Event Shape Selection**
  - Using q_2 to select different geometry
  - Using v_2 to quantify event anisotropy

$$v_2 = \langle \cos[2(\phi_i - \Psi_2)] \rangle$$

Event Shape Engineering (ESE)

Small q2 Large q2



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CME with ESE

3-particle correlator

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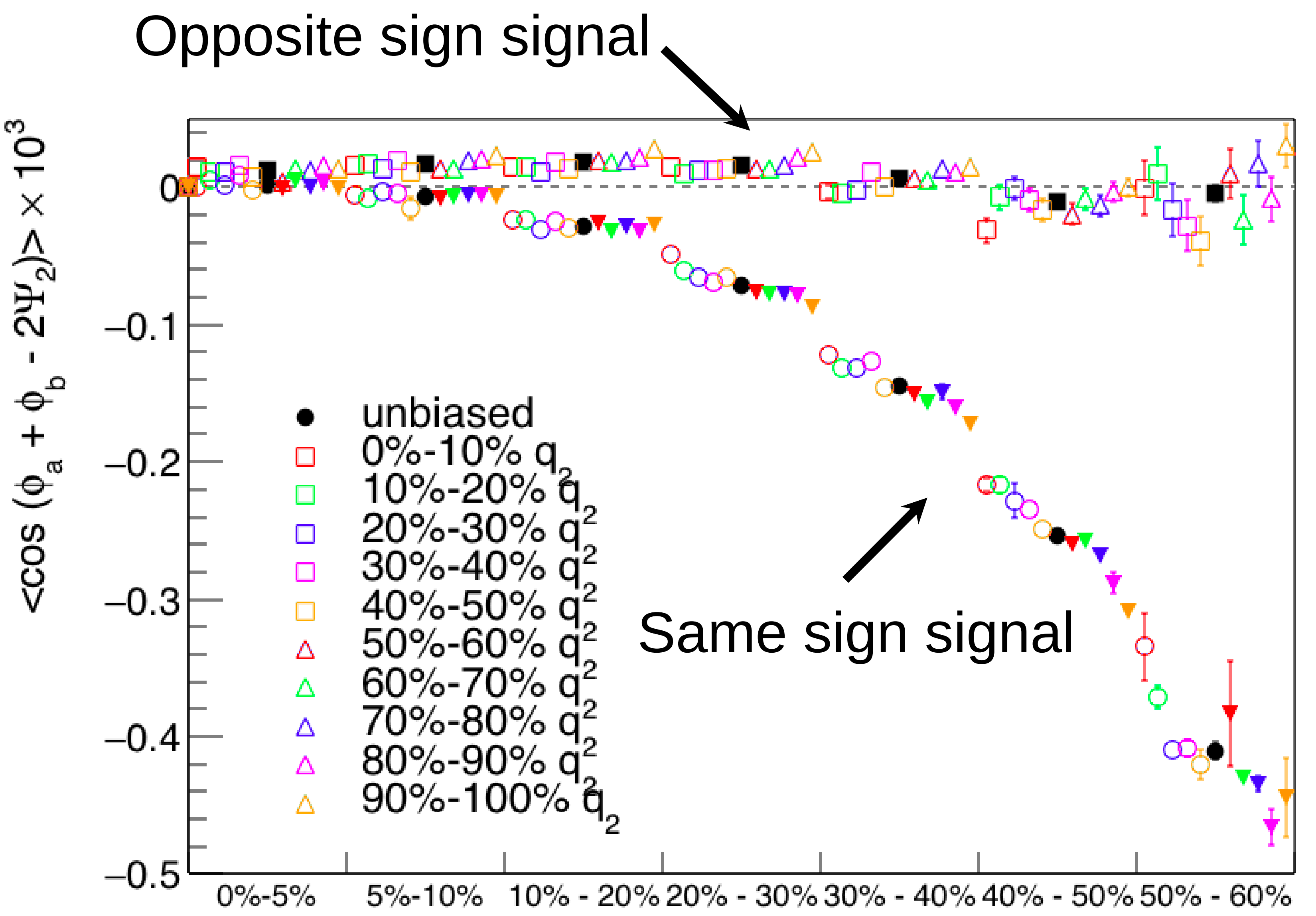
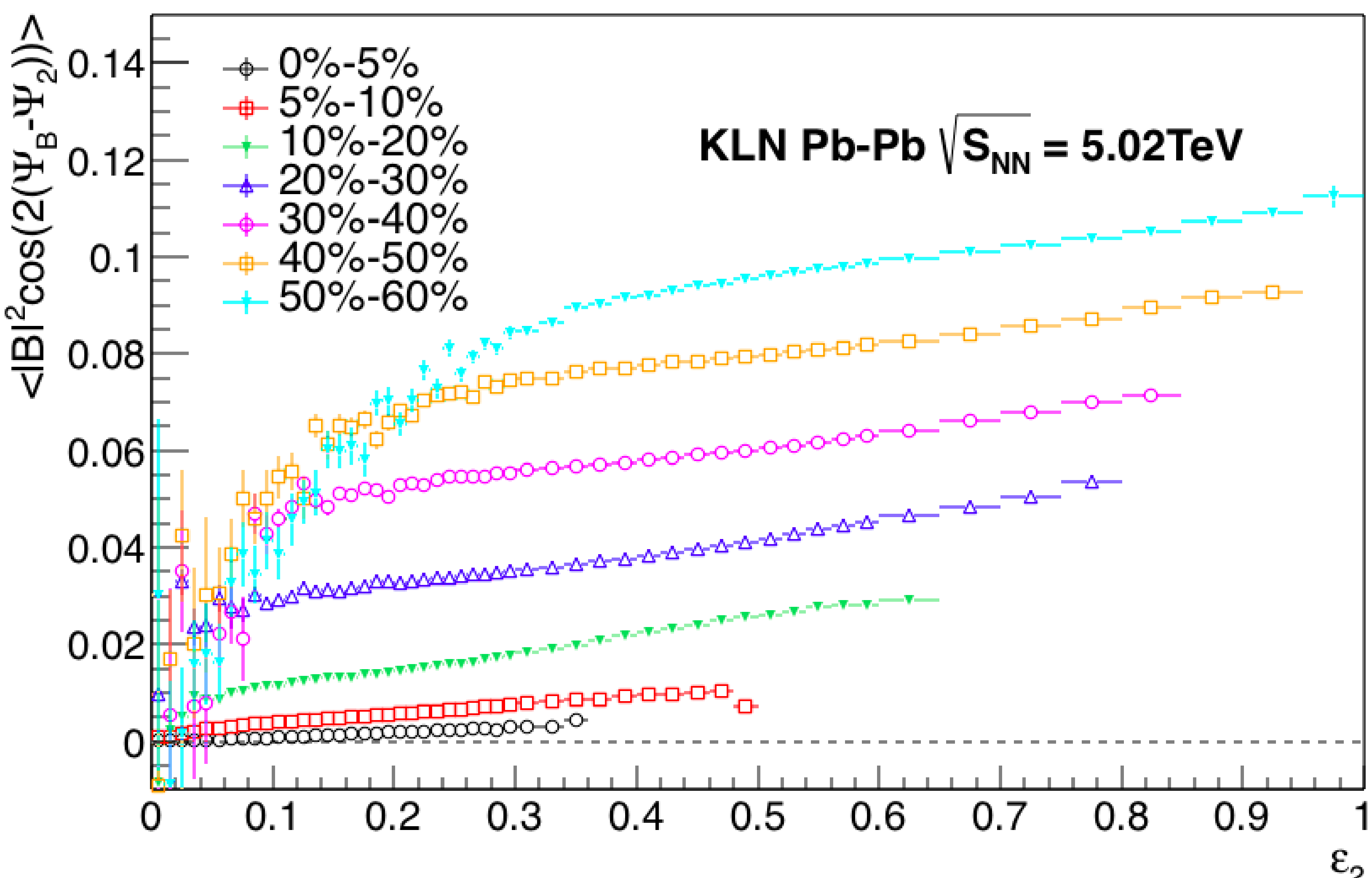


- Potential CME signal + flow-related background contributions
- γ_{ab} scales with q_2 in a given centrality bin: flow contributions

CGC-KLN Model

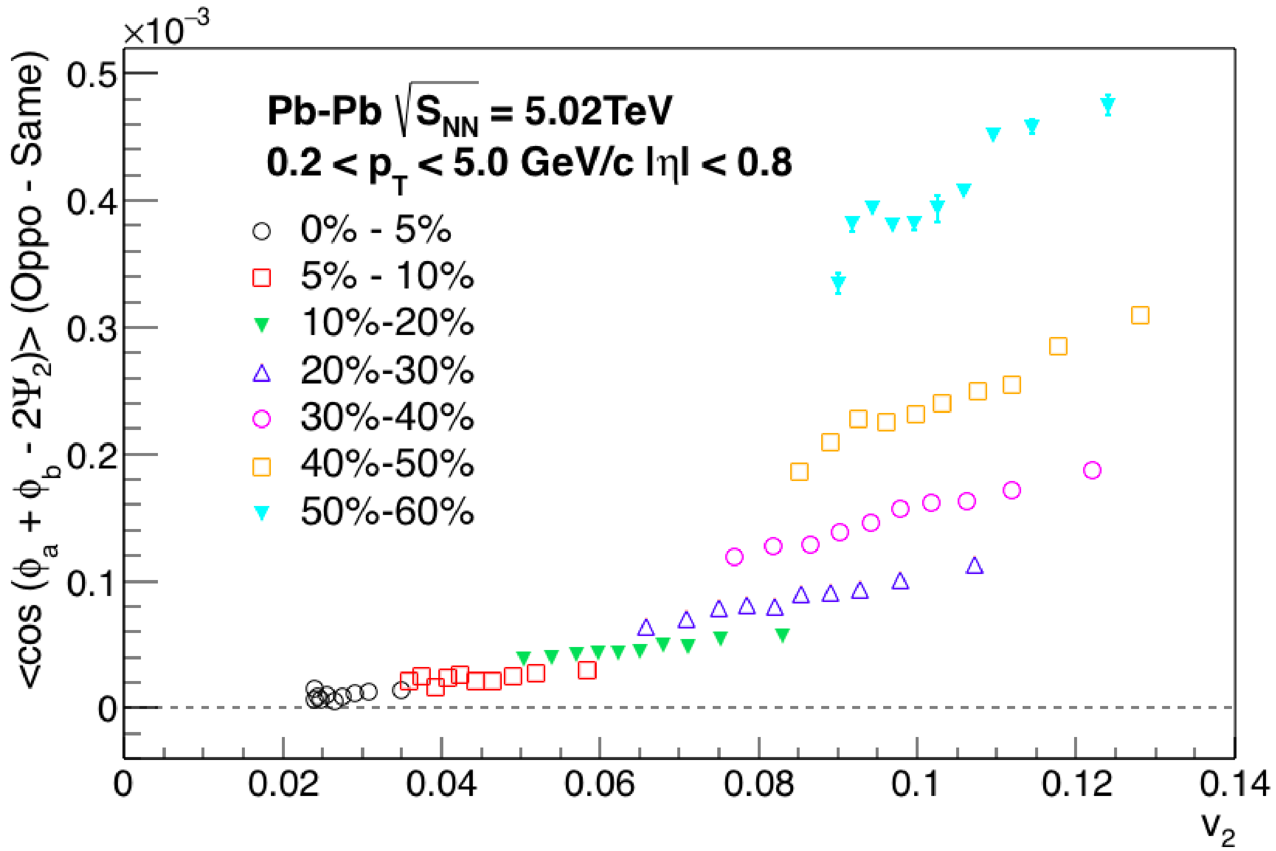
$$eB_s^{\pm}(\tau,\eta,\boldsymbol{x}_\perp) = \pm Z\alpha_{EM}\sinh(Y_0 \mp \eta)\int \mathrm{d}^2\boldsymbol{x}'_\perp \rho_\pm(\boldsymbol{x}'_\perp)[1-\theta_\mp(\boldsymbol{x}'_\perp)] \times \frac{(\boldsymbol{x}'_\perp - \boldsymbol{x}_\perp)\times \boldsymbol{e}_z}{[(\boldsymbol{x}'_\perp - \boldsymbol{x}_\perp)^2 + \tau^2\sinh(Y_0\mp\eta)^2]^{3/2}}$$

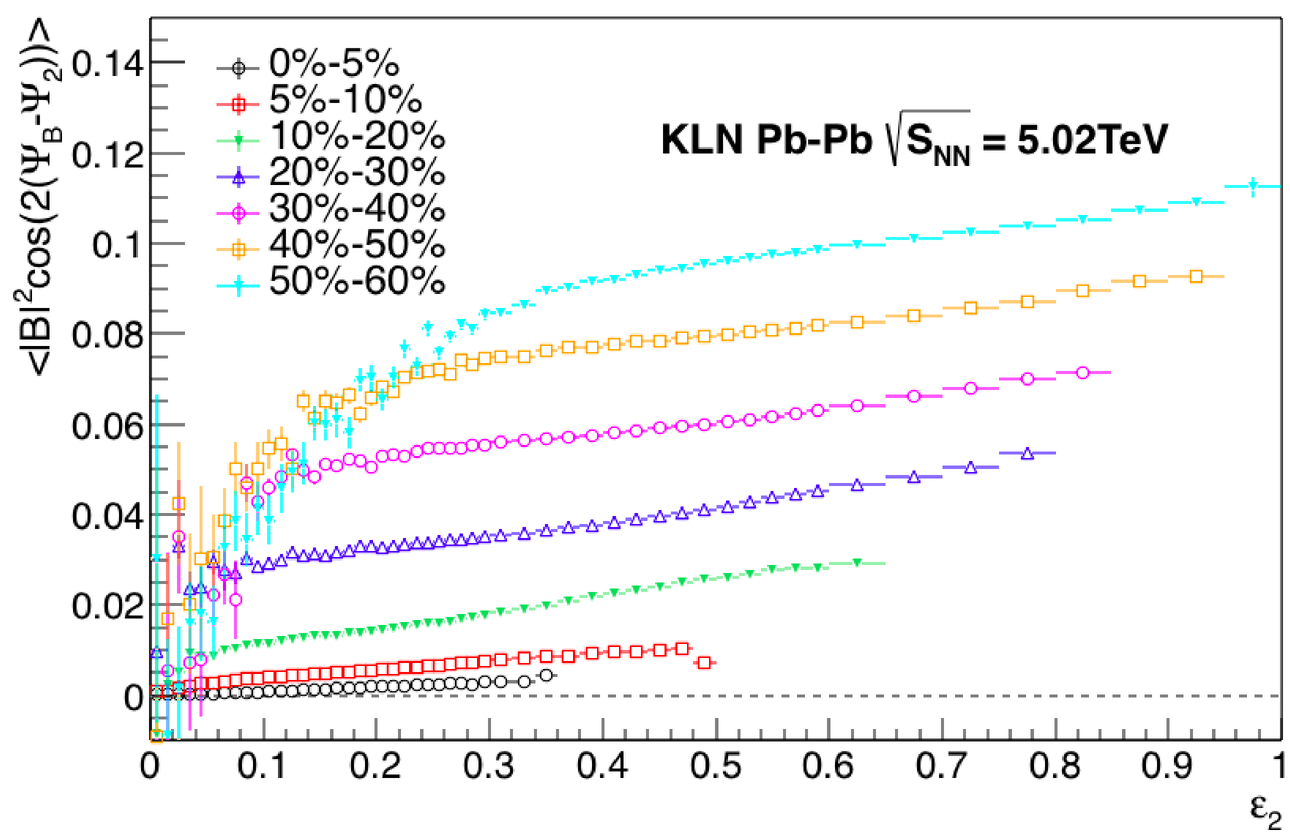


$$\varepsilon_2 = \frac{\langle y^2 - x^2\rangle}{\langle y^2 + x^2\rangle}$$

- Monte-Carlo simulation using the KLN Model to calculate the magnetic field using spectators
- To evaluate the dependence of the CME signal on different geometries
  - $\langle|B|^2\cos(2(\Psi_B-\Psi_2))\rangle$
- Using 2 million events, the proper time τ=0.1 fm

Connecting Data and Model





- Linear fit γ_{ab} (oppo - same) vs v_2 and $\langle|B|^2\cos(2(\Psi_B-\Psi_2))\rangle$ with ε_2
  - Fit function: $p_1(v_2)=p_0(1+ p_1(v_2-\langle v_2\rangle)/\langle v_2\rangle)$
- Fit with $f_{CME} * p_{1,MC} + (1-f_{CME}) * 1 = p_{1,data}$ to get the fraction of potential CME contributions

Summary & Outlook

- Use Event Shape Engineering (ESE) to select the event shape to study the flow-related contributions of Chiral Magnetic Effect
  - γ_{ab} (oppo-same) scales with v_2
  - From the Monte Carlo results using the CGC-KLN Model (Pure CME): CME contributions scale with v_2
- To-do
  - Check the error on the γ_{ab} (oppo-same) signal
  - Estimate the fraction of potential CME contributions by connecting the model and the data