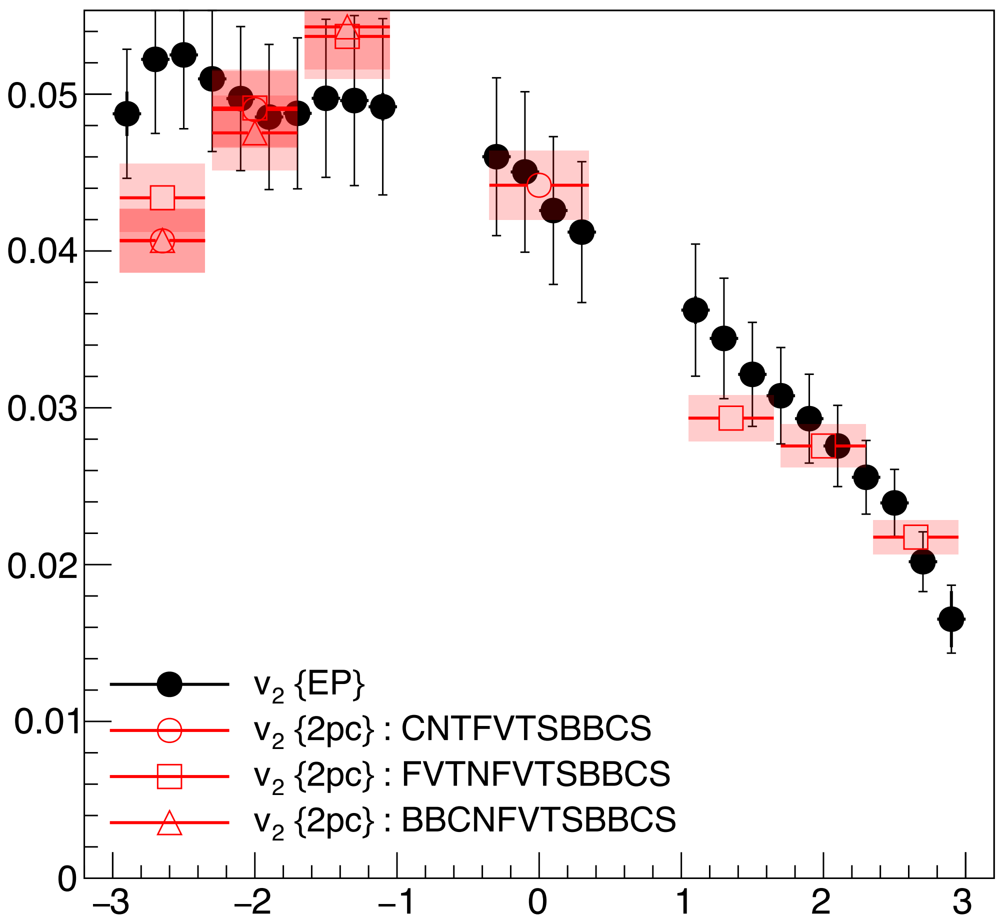
# d+Au analysis status update

Seyoung Han

# d+Au 200GeV
# published $v_2$ vs. rapidity reproduced




10% systematic uncertainty included reproduced results.

Results reproduced in a fair range.

# 2pc with 3sub combinations

1. Get the fitting function

$$F(\Delta\phi) = N_0(1 + \sum_{n=1}^{3} 2C_n \cos(n\Delta\phi))$$

2. $c_n$ include 2 $v_n$ parameters : $C_n = v_n^a * v_n^b = C_n^{ab}$

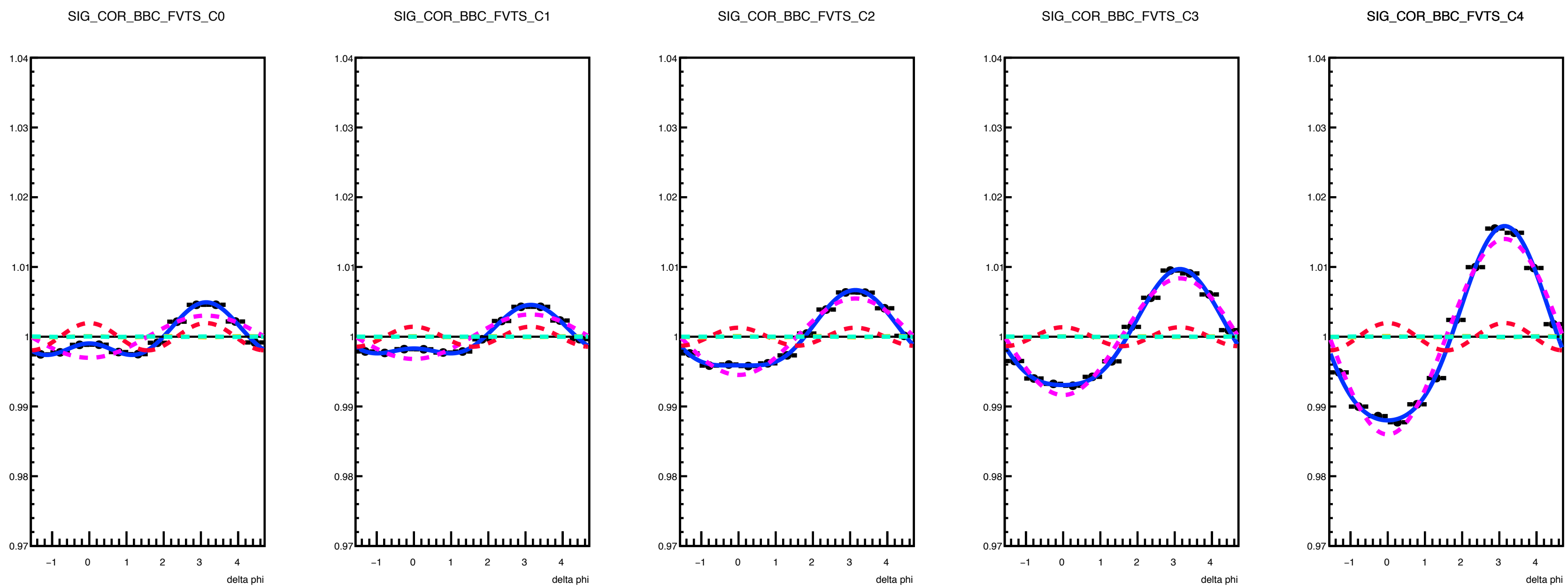
3. To calculate $v_n$, need 3 sub combinations

$$C_n^{ab} = v_n^a * v_n^b$$
$$C_n^{bc} = v_n^b * v_n^c$$
$$C_n^{ac} = v_n^a * v_n^c$$

$$v_n^a = \sqrt{\frac{C_n^{ab} C_n^{ac}}{C_n^{bc}}}$$

Ex ) a=BBCs, b=CNT
a=FVTXn, b=FVTXs ..

# 2pc fitting function : Fourier expansion



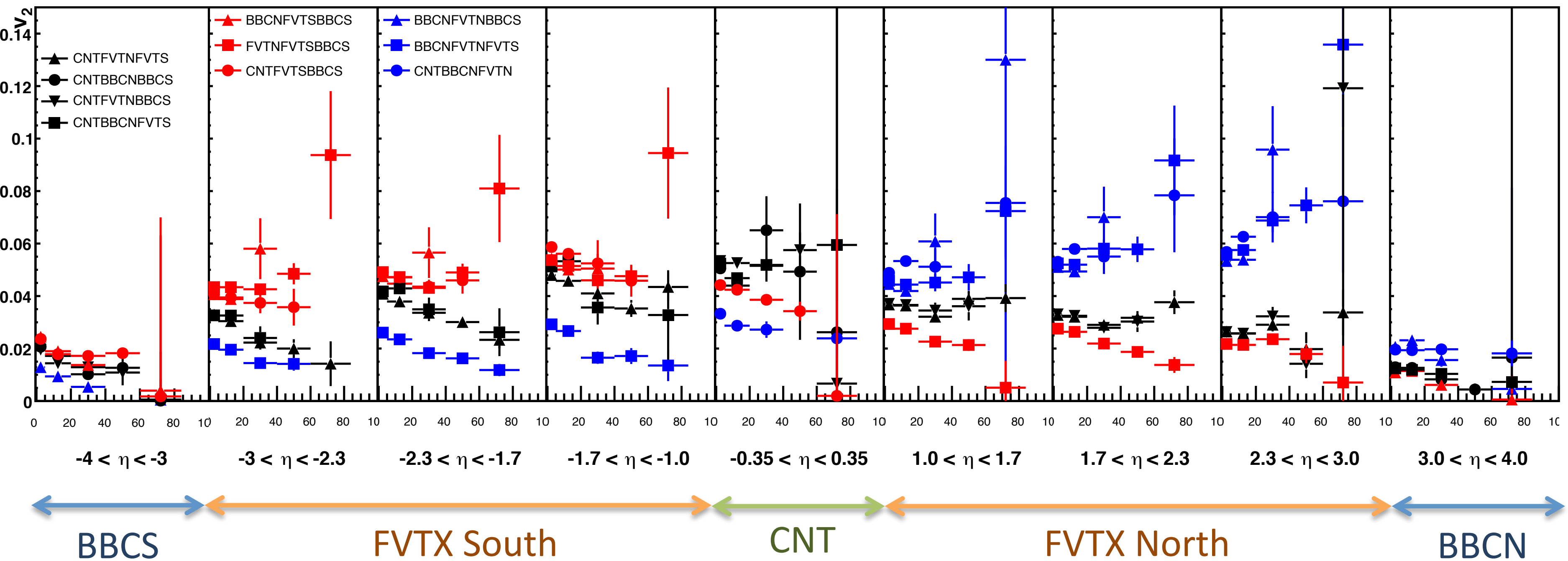

**Central** → **Peripheral**

Near-side area shows size of $c_2$(Red dashed line), which is getting smaller while it goes to the peripheral collisions.

Central & peripheral decided by BBC South charge sum.

# d+Au 200GeV
# $v_2\{2pc\}$ vs. centrality

Cent -> Peri




Black : Mid + **Forward + Backward** → Could have Δη between two particles large enough

Red : Mid + **Backward + Backward**

Forward + **Backward + Backward**

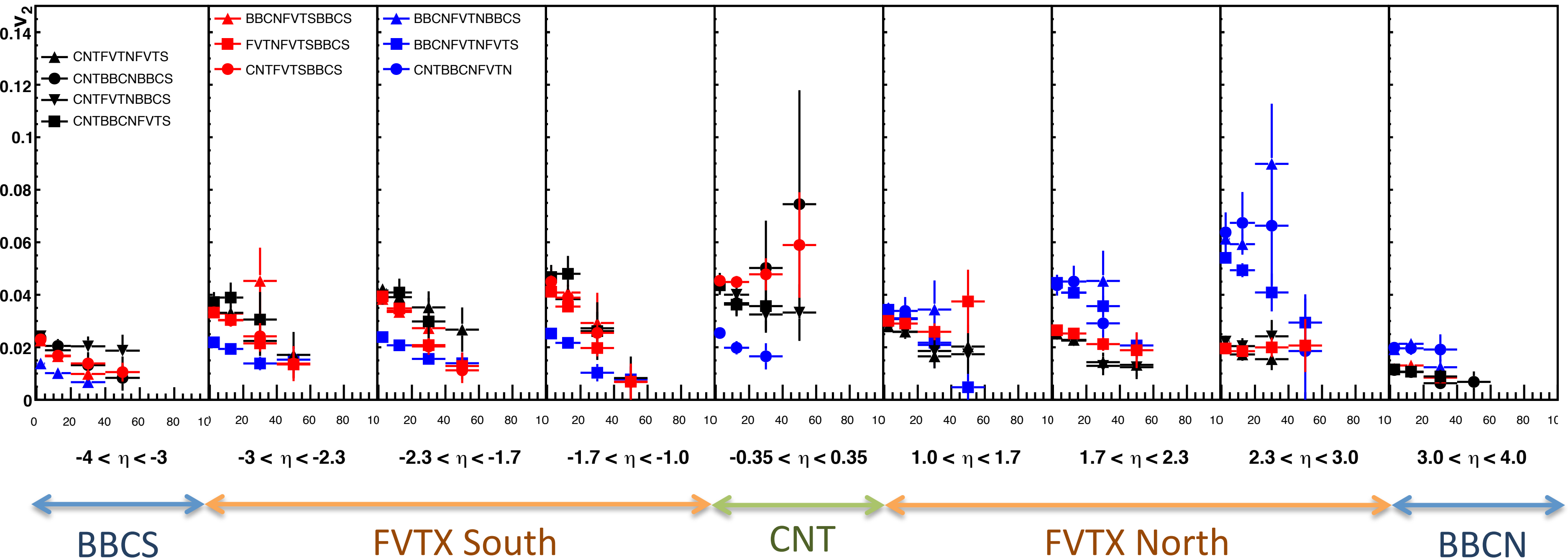
Blue : Mid + **Forward + Forward**

Backward + **Forward + Forward**

} Small Δη but different detector combinations

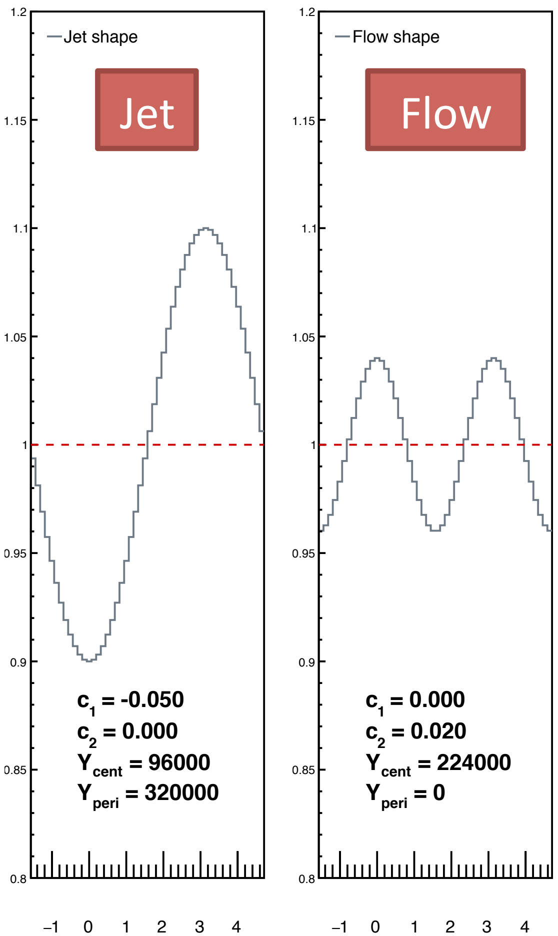
# d+Au 200GeV
# $v_2$\{Ref\} vs. centrality

Cent -> Peri




Even if we apply reference fit method, 3sub effect does not disappeared.
Why?

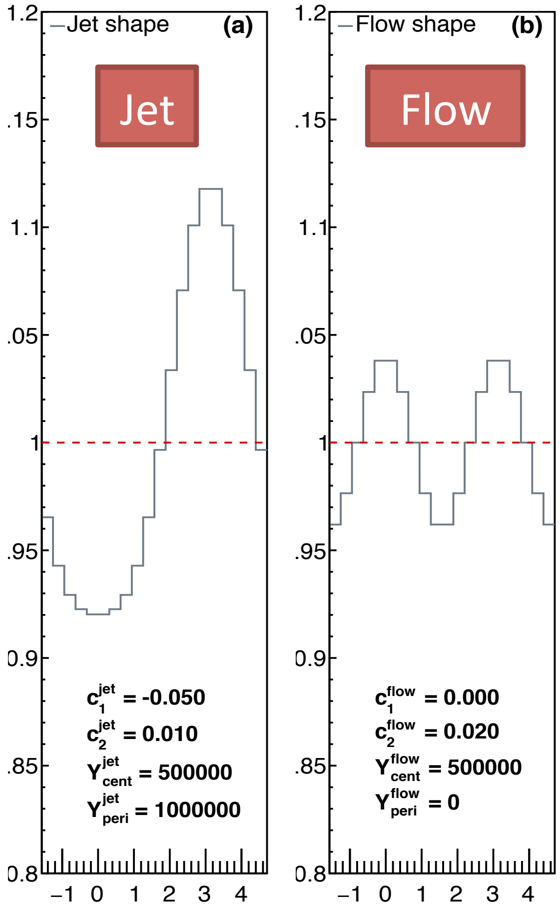
# Limitation of reference fit method




1st case

If **the jet only has c1 component** while **the flow only has c2**, reference fit will perfectly work.

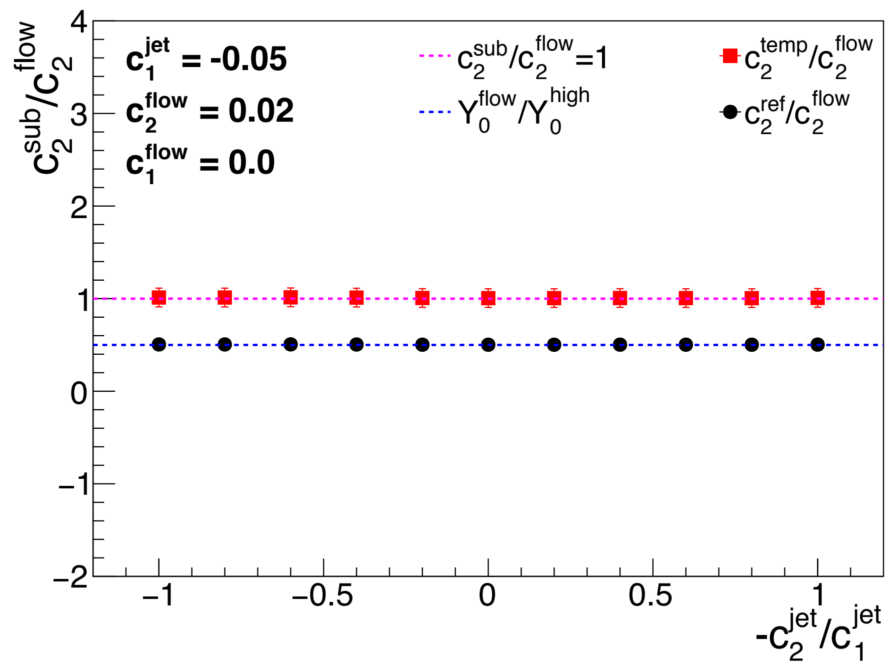
# Limitation of reference fit method



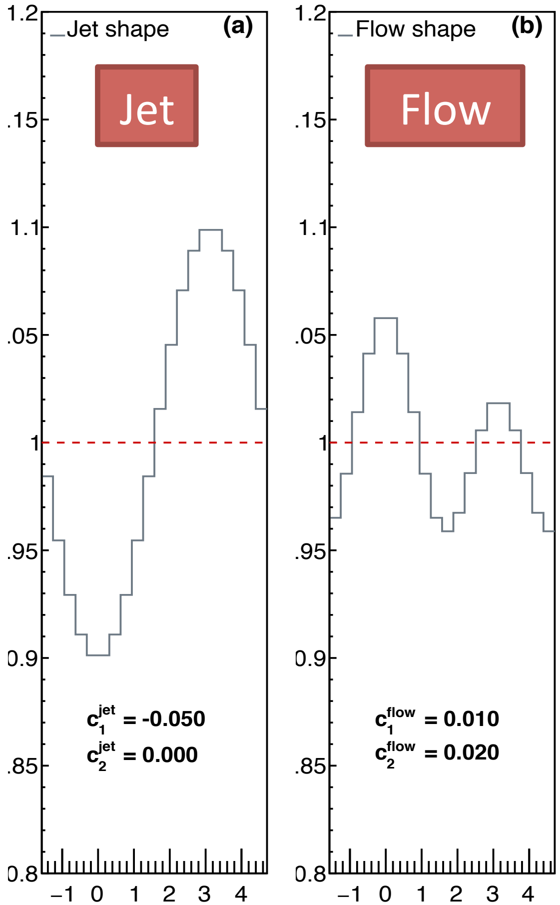

**2nd case**

If **the jet only has c1 component** while **the flow only has c2**, reference fit will perfectly work.

And if **the jet has c1 and c2 component** while **the flow only has c2**, reference fit will give stable results = yield flow / total yield



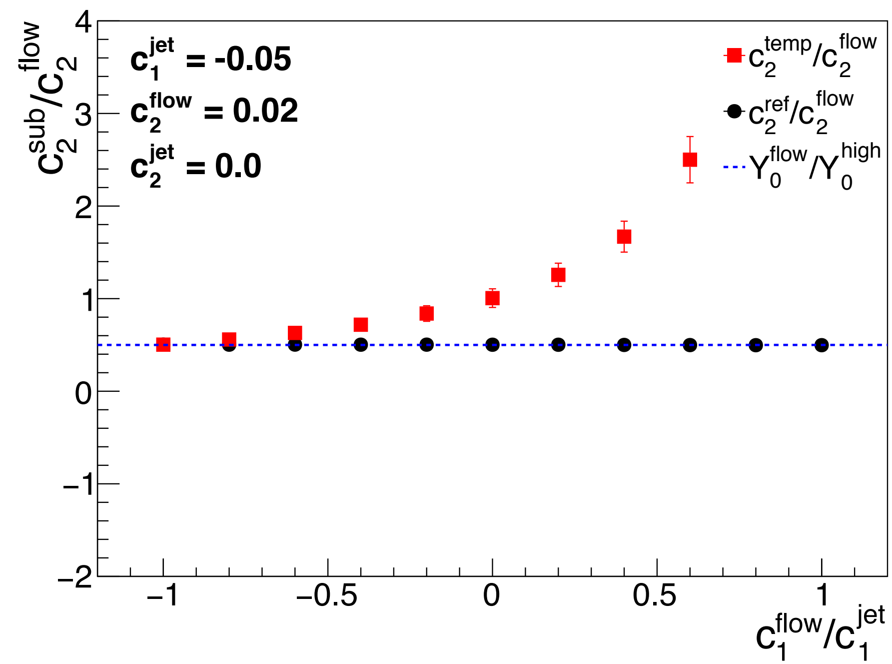
# Limitation of reference fit method



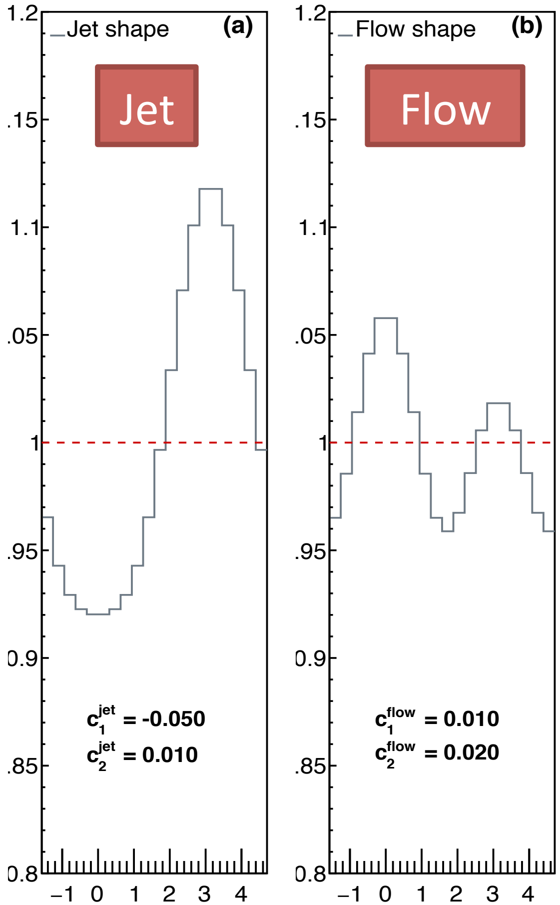

**3$^{rd}$ case**

If **the jet only has c1 component** while **the flow only has c2**, reference fit will perfectly work.

And if **the jet only has c1 component** while **the flow has c2 and c1**, reference fit will give better work than template fit method.



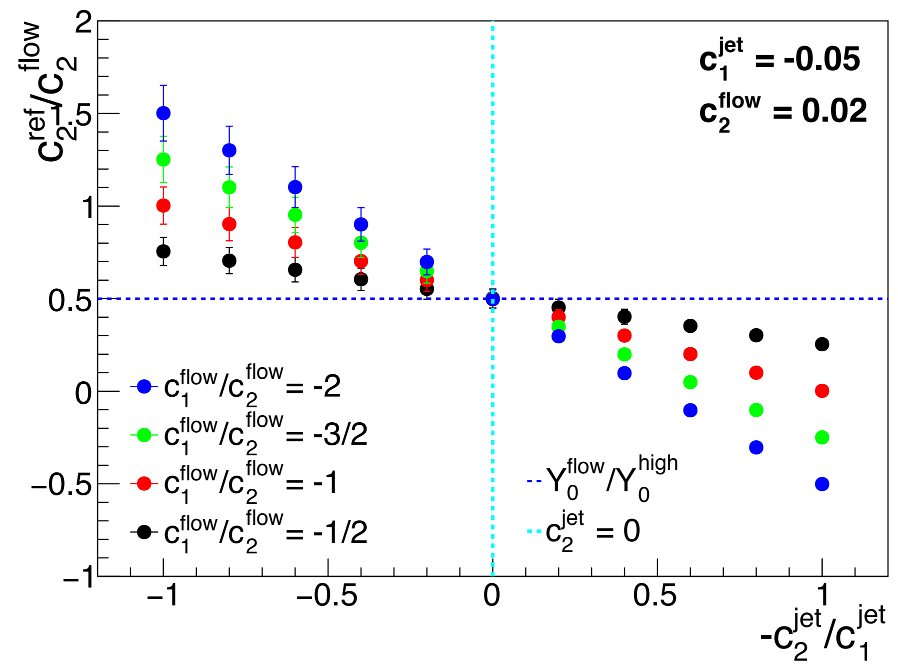
# Limitation of reference fit method




**4th case**

If **the jet only has c1 component** while **the flow only has c2**, reference fit will perfectly work.

But if **the jet and flow have c1 and c2 at the same time**, the results are not converge into the one value.

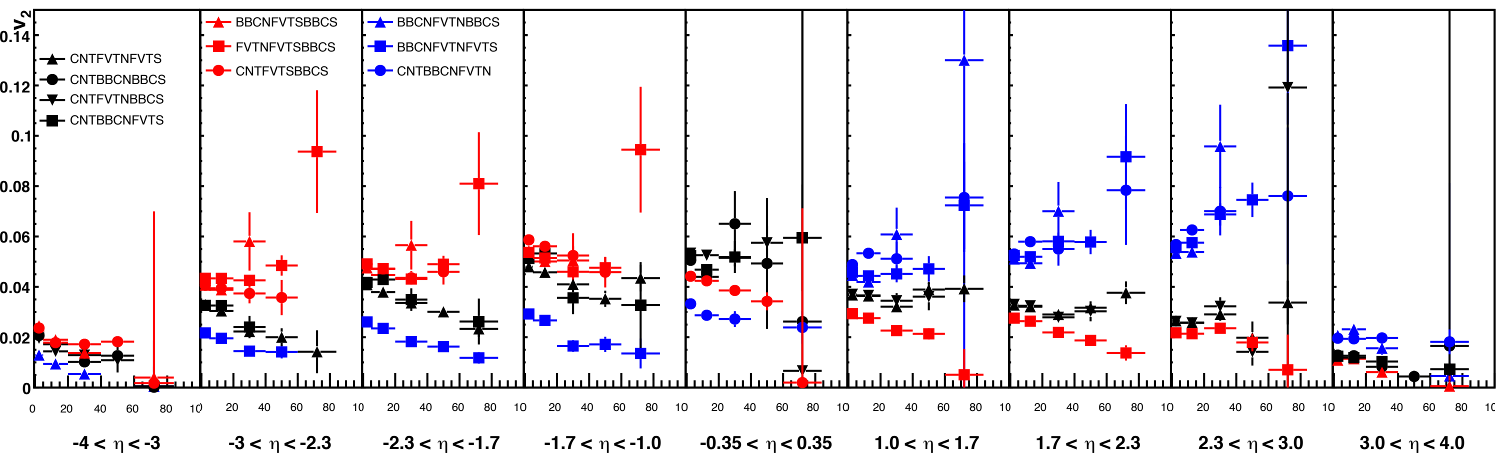


# Limitation of reference fit method

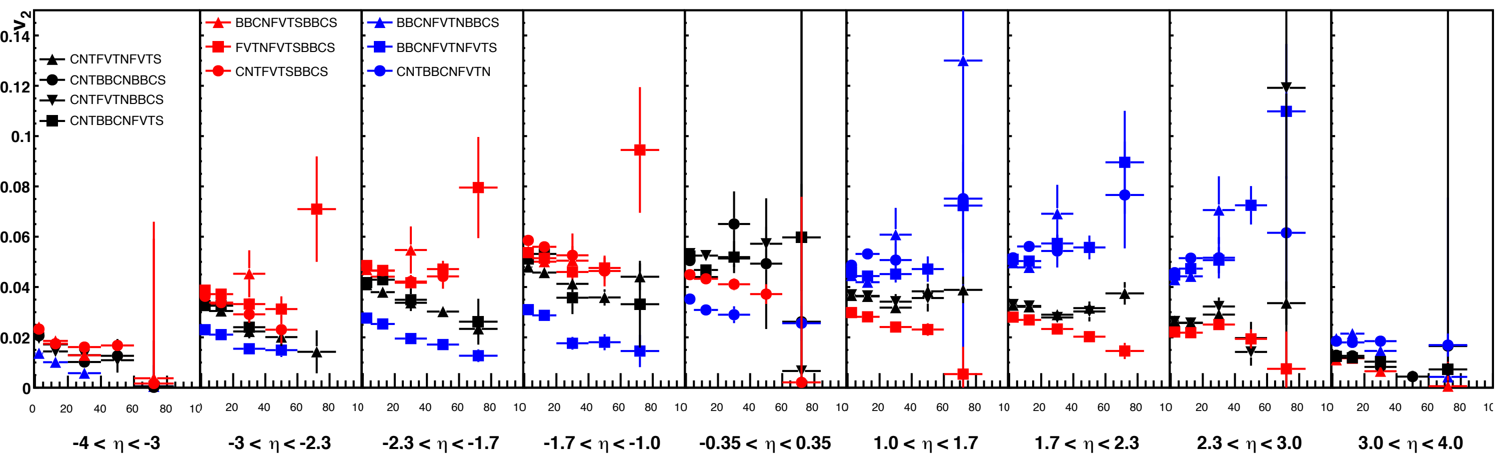
- The reference fit method fails when
  - the $c_1^{flow}$ is not zero, with $c_2^{jet}$ is not zero (4th case)
  - We know the $c_1^{flow}$ will not zero, even if we do not know the exact shape of the flow.
- So the home work will be **remove $c_2^{jet}$** (to make 3rd case)

**Remove near-side jet effect is the key for the reference fit makes work!**

# d+Au 200GeV
# $v_2\{2pc\}$ vs. centrality

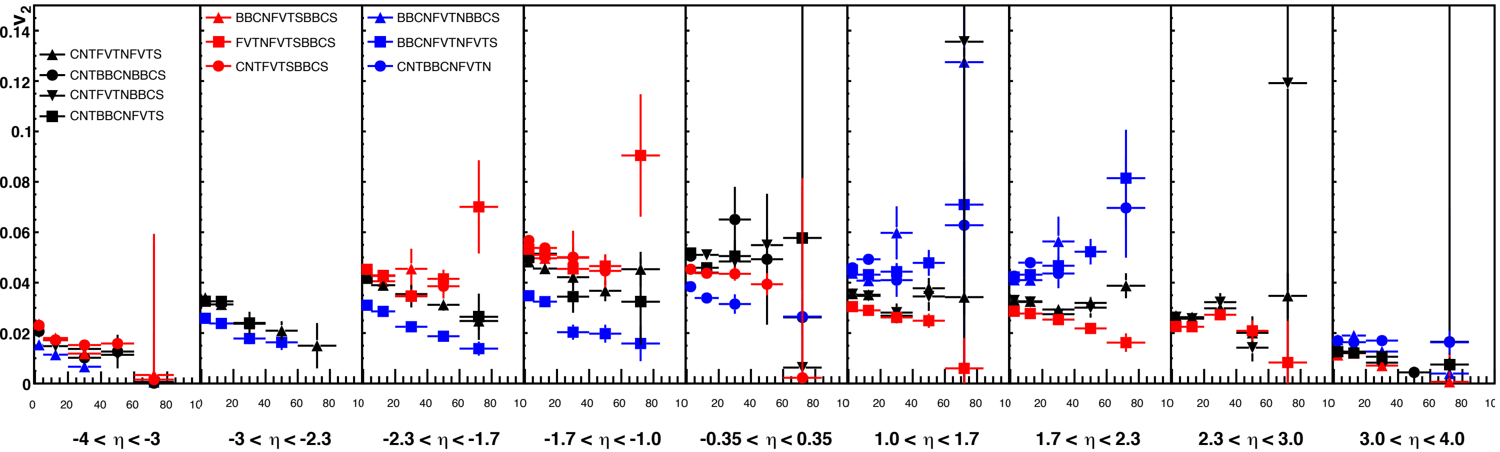



w/o Δη

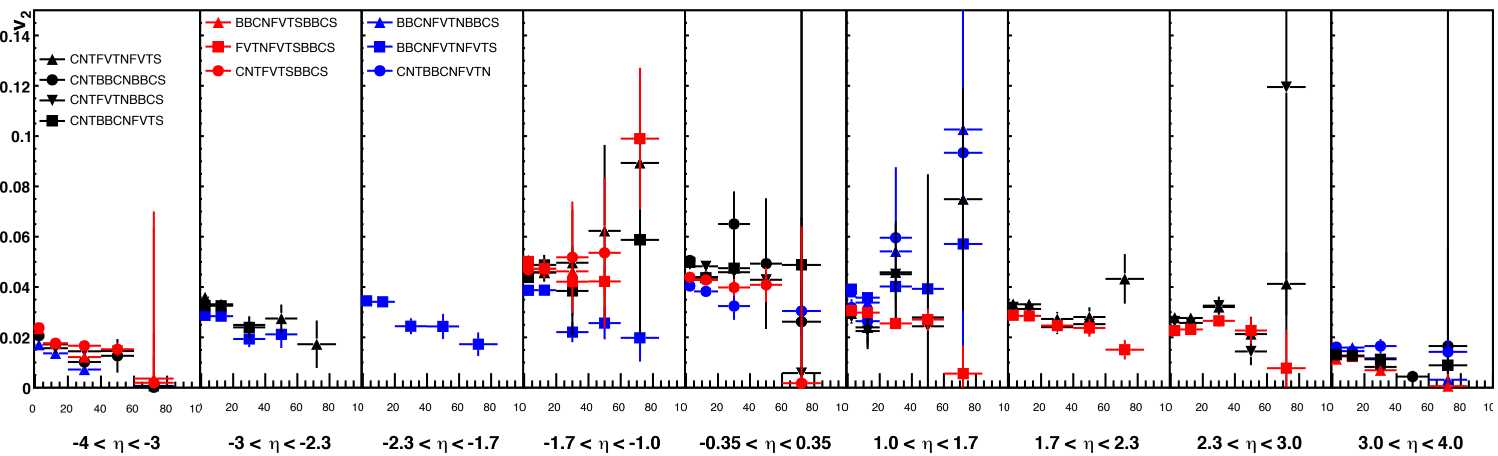



Δη>1.0

# d+Au 200GeV
# $v_2$\{2pc\} vs. centrality

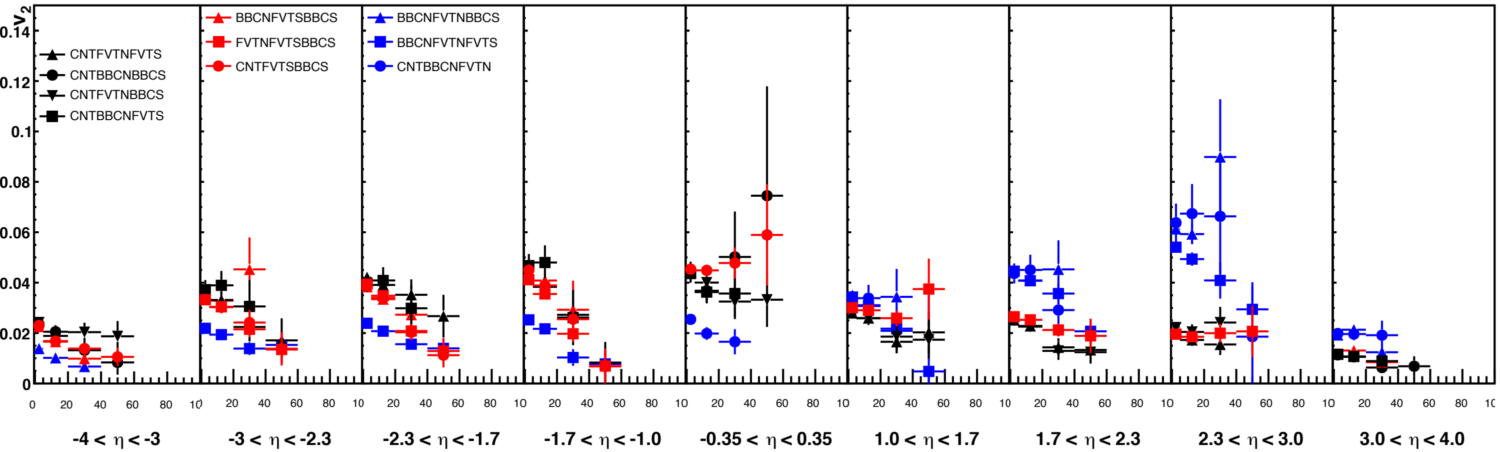



Δη>1.5

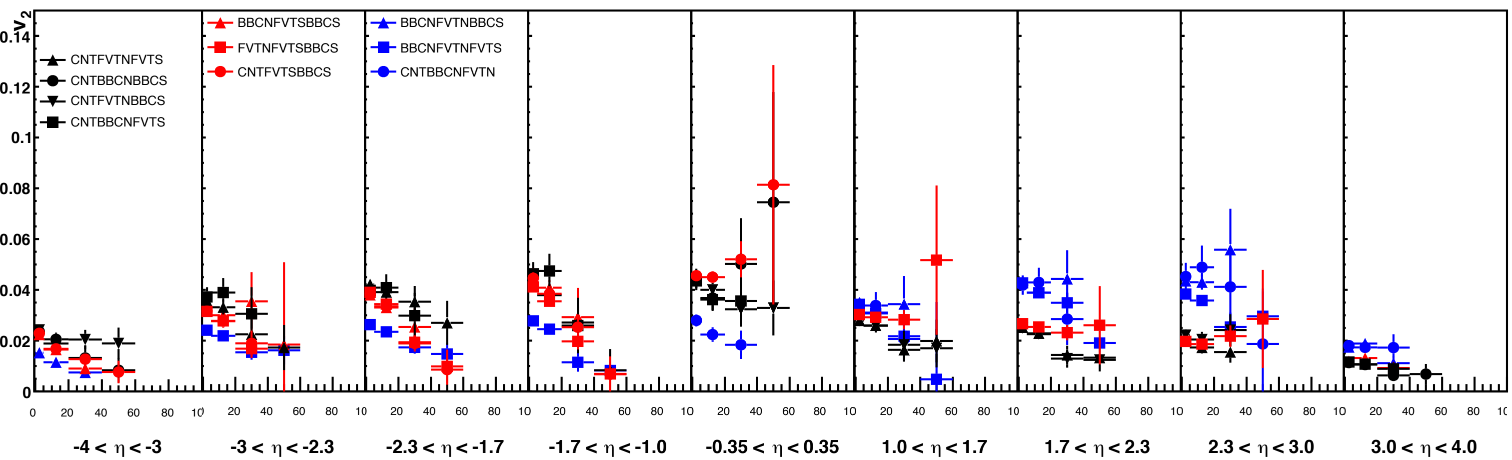



Δη>2.0

# d+Au 200GeV
# $v_2$\{ref\} vs. centrality

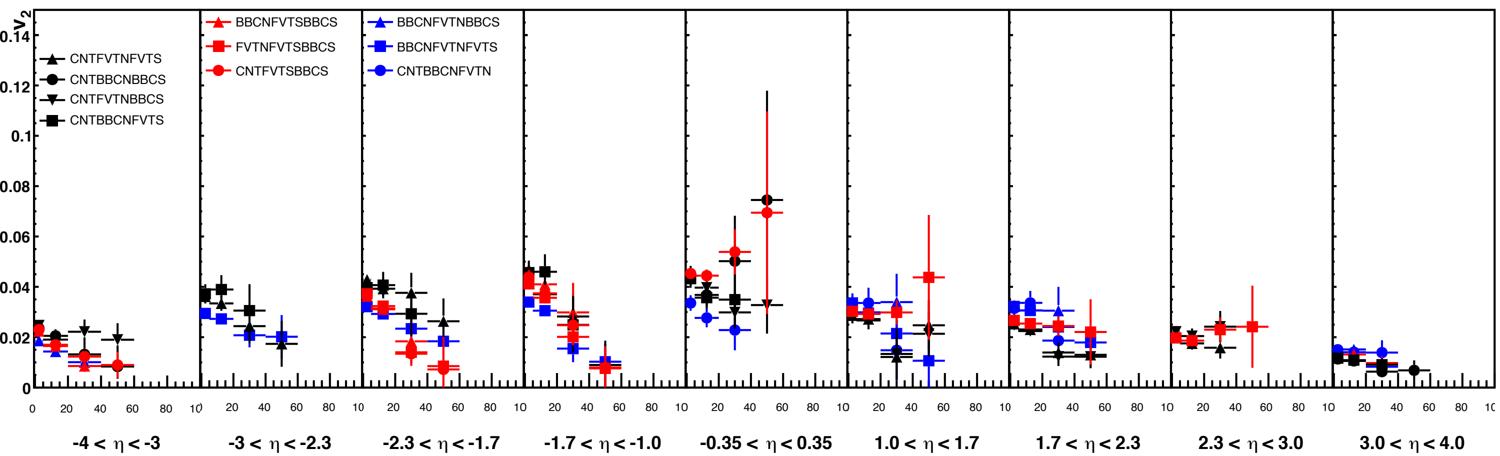



w/o Δη

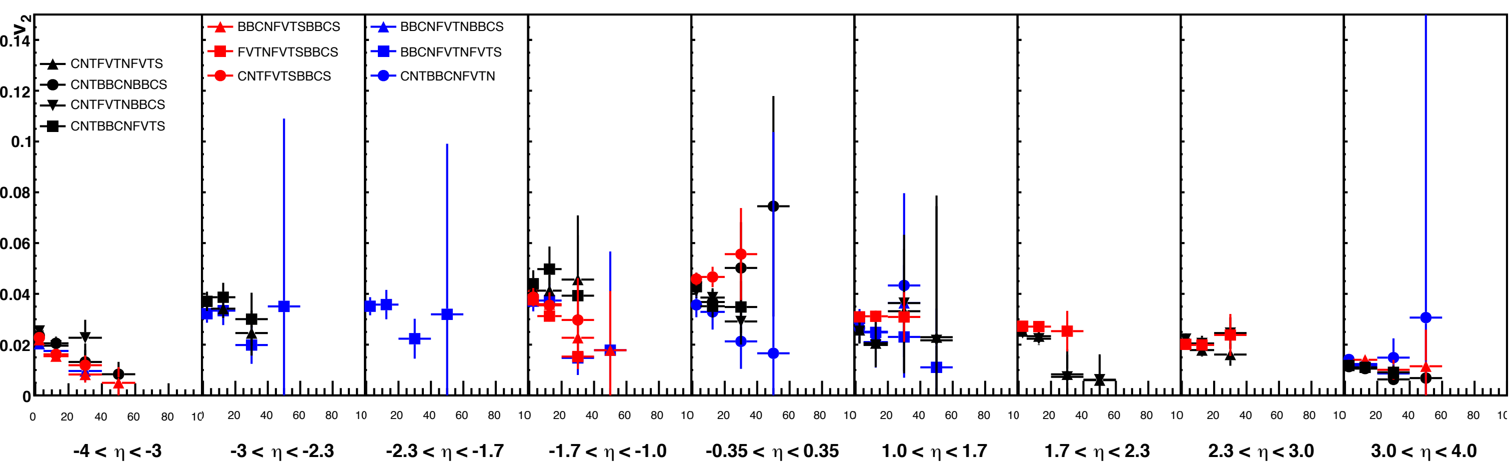



Δη>1.0

# d+Au 200GeV
# $v_2$\{ref\} vs. centrality




Δη>1.5




Δη>2.0

# Summary

- After applying Δη cut (~1.5) to the two particle correlation method, we found the **3sub combination effects** goes away.
- The reference fit method gives better agreement & centrality dependence after using Δη cut.

# BACKUP

# revisit; Mathematical derivation

$$Y^{temp}(\Delta\phi) = FY^{Low}(\Delta\phi) + Y^{Ridge}(\Delta\phi)$$

$$Y^{Ridge}(\Delta\phi) = Y^{High}(\Delta\phi) - FY^{Low}(\Delta\phi)$$

$$= (Y_0^{High} - FY_0^{Low}) + 2\sum_n (Y_0^{High} c_n^{High} - FY_0^{Low} c_n^{Low}) \cos(n\Delta\phi)$$

$$= (Y_0^{High} - FY_0^{Low}) \left\{ 1 + 2\sum_n \frac{Y_0^{High} c_n^{High} - FY_0^{Low} c_n^{Low}}{Y_0^{High} - FY_0^{Low}} \cos(n\Delta\phi) \right\}$$

$$= Y_0^{Ridge} \left\{ 1 + 2\sum_n \frac{Y_0^{High} c_n^{High} - FY_0^{Low} c_n^{Low}}{Y_0^{Ridge}} \cos(n\Delta\phi) \right\}$$

**Reference fit method**

$$c_n^{ref} = \frac{Y_0^{High} c_n^{High} - FY_0^{Low} c_n^{Low}}{Y_0^{High}}$$

**Template fit method**

$$c_n^{temp} = \frac{Y_0^{High} c_n^{High} - FY_0^{Low} c_n^{Low}}{Y_0^{Ridge}}$$

# Reference fit and template fit in correlation functions

$$C^{high}(\Delta\phi) = 1 + 2\,\Sigma h_n \cos(n\Delta\phi)$$
$$C^{low}(\Delta\phi) = 1 + 2\,\Sigma l_n \cos(n\Delta\phi)$$
$$C^{ref}(\Delta\phi) = 1 + 2\,\Sigma c_n^{ref} \cos(n\Delta\phi)$$
$$C^{temp}(\Delta\phi) = 1 + 2\,\Sigma c_n^{temp} \cos(n\Delta\phi)$$

**Reference fit method**

$$C^{ref}(\Delta\phi) = C^{high}(\Delta\phi) - [a*C^{low}(\Delta\phi) + b] + 1$$
$$= C^{high}(\Delta\phi) - (1-b)[C^{low}(\Delta\phi) - 1]$$

$$\therefore c_n^{ref} = h_n - (1-b)*l_n$$

$a+b = 1$

$a^{temp} = a^{ref}$

b = normalization factor

**Template fit method**

$$C^{high}(\Delta\phi) = a*C^{low}(\Delta\phi) + b*C^{temp}(\Delta\phi)$$
$$= (1-b)*C^{low}(\Delta\phi) + b*C^{temp}(\Delta\phi)$$

$$C^{temp}(\Delta\phi)$$
$$= (1/b)\{ C^{high}(\Delta\phi) - (1-b)*C^{low}(\Delta\phi) \}$$

$$\therefore c_n^{temp} = (1/b)\{ h_n - (1-b)*l_n\}$$

b = Level of flow

$$c_n^{ref} / c_n^{temp} = b$$

# c1 scaling method

$c_1^{sub} = 0$

$( c_1^{ref} = c_1^{temp} = 0 )$

**Reference fit method**

$c_1^{ref} = h_1 - (1-b)*l_1 = h_1 - a*l_1 = 0$

$a = h_1/l_1 = c_1^{high}/c_1^{low}$

$\therefore c_n^{ref} = h_n - a*l_n$

$= h_n - (h_1/l_1) * l_n$

**=> c1 scaling method!**

**Template fit method**

$c_1^{temp} = (1/b)\{ h_1 - (1-b)*l_1 \} = 0$

$a = 1-b = h_1/l_1 = c_1^{high}/c_1^{low}$

$\therefore c_n^{temp} = (1/b)\{ h_n - a*l_n \}$

$= (1/b)\{ h_n - (h_1/l_1)*l_n \}$

# c1 scaling method

$c_1^{sub} = 0$

$( c_1^{ref} = c_1^{temp} = 0 )$

**Reference fit method**

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$\therefore c_n^{ref} = h_n - a*l_n$

$= h_n - (h_1/l_1) * l_n$

**=> c1 scaling method!**

c1 scaling method
= one of the Reference fit method

**Template fit method**

$c_1^{temp} = (1/b)\{ h_1 - (1-b)*l_1 \} = 0$

$a = 1-b = h_1/l_1 = c_1^{high}/c_1^{low}$

$\therefore c_n^{temp} = (1/b)\{ h_n - a*l_n \}$

$= (1/b)\{ h_n - (h_1/l_1)*l_n \}$

# Toy Monte-Carlo Simulation

- $Y^{High}(\Delta\varphi)$ subtracts $Y^{Low}(\Delta\varphi)$
- Only deal with c1 and c2
- $Y_0^{flow} : Y_0^{jet} = 1:1$
- $Y_0^{High} = Y_0^{flow} + Y_0^{jet}$
- $Y_0^{Low} = 2Y_0^{jet}$

| Flow | Jet |
|---|---|
| $c1^{flow} + c2^{flow}$ | $c1^{jet} + c2^{jet}$ |

| | Flow | | Jet | |
|---|---|---|---|---|
| case 1 | | $c2^{flow}$ | $c1^{jet}$ | |
| case 2 | $c1^{flow}$ | $c2^{flow}$ | $c1^{jet}$ | |
| case 3 | | $c2^{flow}$ | $c1^{jet}$ | $c2^{jet}$ |
| case 4 | $c1^{flow}$ | $c2^{flow}$ | $c1^{jet}$ | $c2^{jet}$ |

# Toy Monte-Carlo Simulation

- $Y^{High}(\Delta\varphi)$ subtracts $Y^{Low}(\Delta\varphi)$
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| Flow | Jet |
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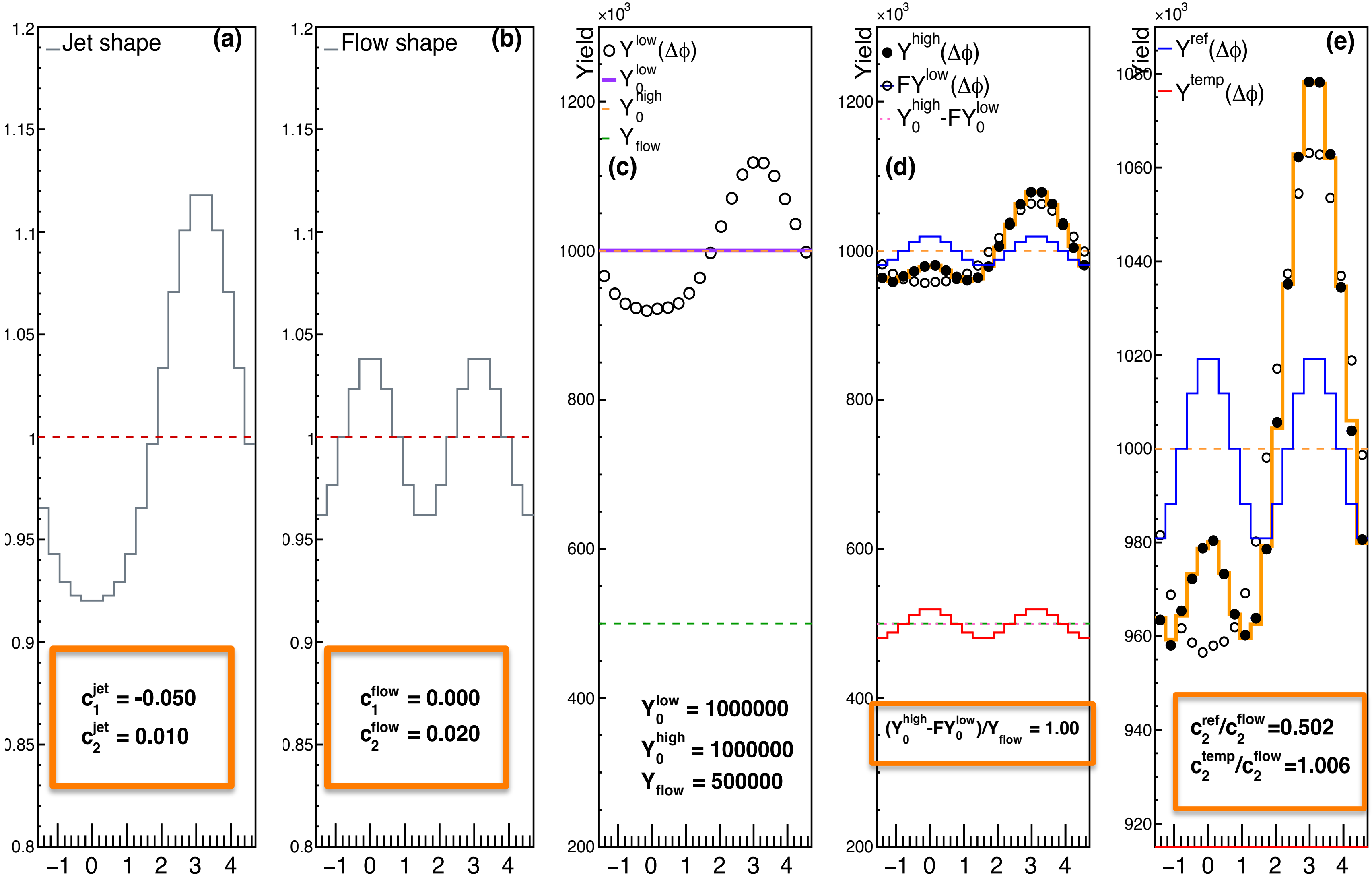
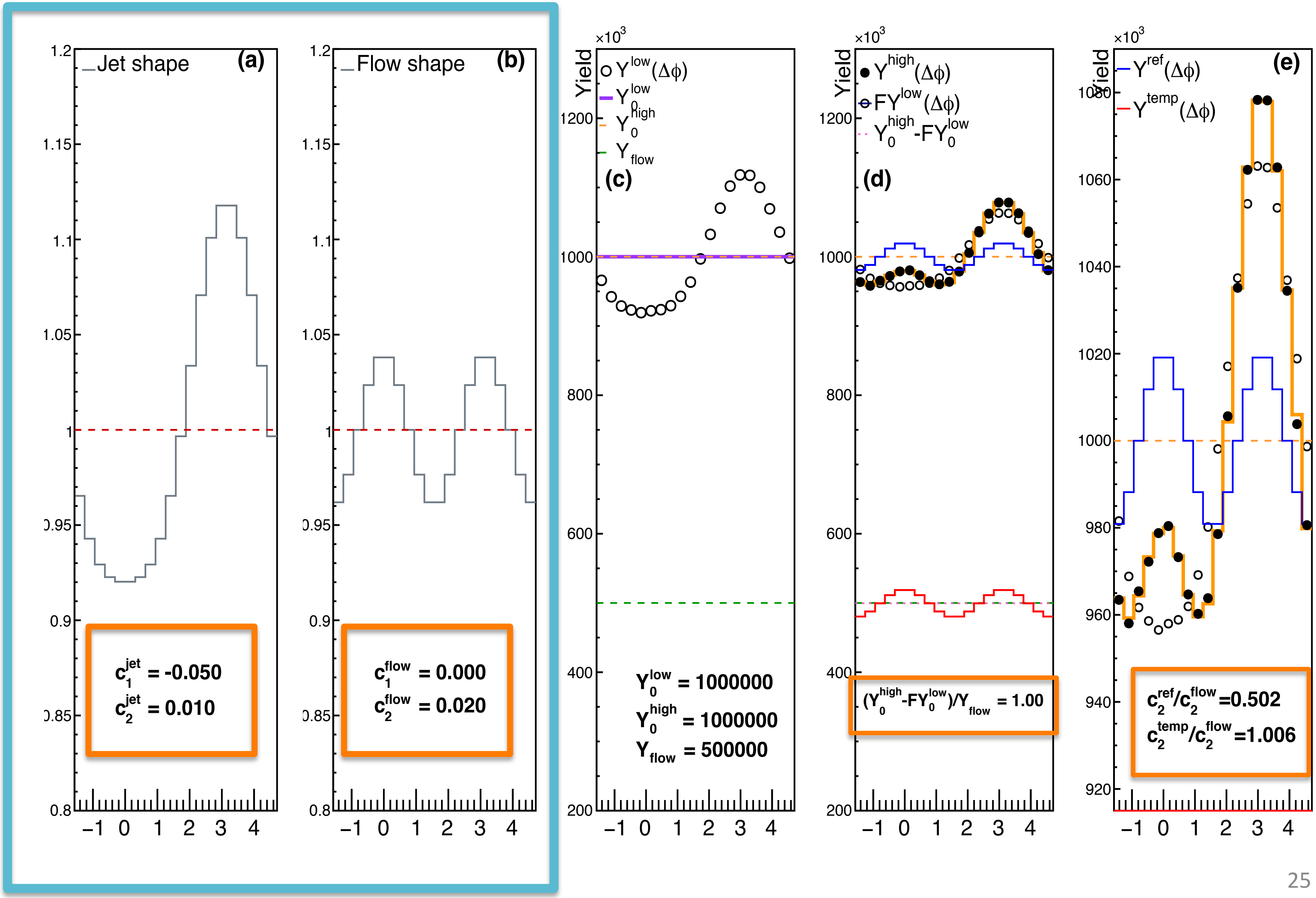
| | Flow | | Jet | |
|---|---|---|---|---|
| case 1 | | $c2^{flow}$ | $c1^{jet}$ | |
| case 2 | $c1^{flow}$ | $c2^{flow}$ | $c1^{jet}$ | |
| case 3 | | $c2^{flow}$ | $c1^{jet}$ | $c2^{jet}$ |
| case 4 | $c1^{flow}$ | $c2^{flow}$ | $c1^{jet}$ | $c2^{jet}$ |

# Case 3



Jet shape
(a)
$c_1^{jet}$ = -0.050
$c_2^{jet}$ = 0.010
Flow shape
(b)
$c_1^{flow}$ = 0.000
$c_2^{flow}$ = 0.020
Yield
$Y^{low}(\Delta\phi)$
$Y_0^{low}$
$Y_0^{high}$
$Y_{flow}$
(c)
$Y_0^{low}$ = 1000000
$Y_0^{high}$ = 1000000
$Y_{flow}$ = 500000
$Y^{high}(\Delta\phi)$
$FY^{low}(\Delta\phi)$
$Y_0^{high}-FY_0^{low}$
(d)
$(Y_0^{high}-FY_0^{low})/Y_{flow}$ = 1.00
$Y^{ref}(\Delta\phi)$
$Y^{temp}(\Delta\phi)$
(e)
$c_2^{ref}/c_2^{flow}$ =0.502
$c_2^{temp}/c_2^{flow}$ =1.006

# Case 3



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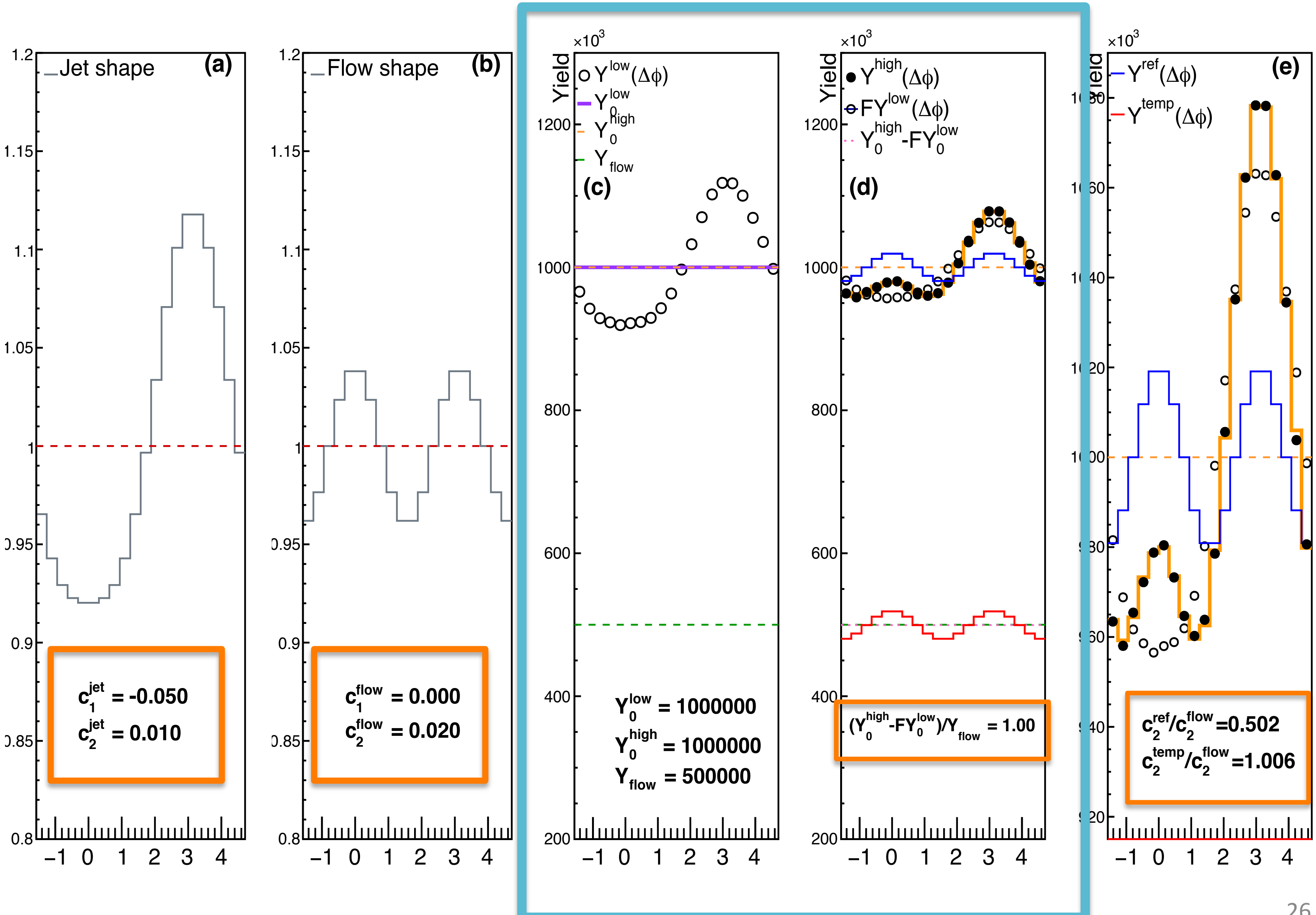
$c_2^{flow}$ = 0.020
Yield
$Y^{low}(\Delta\phi)$
$Y_0^{low}$
$Y_0^{high}$
$Y_{flow}$
(c)
$Y_0^{low}$ = 1000000
$Y_0^{high}$ = 1000000
$Y_{flow}$ = 500000
$Y^{high}(\Delta\phi)$
$FY^{low}(\Delta\phi)$
$Y_0^{high}-FY_0^{low}$
(d)
$(Y_0^{high}-FY_0^{low})/Y_{flow}$ = 1.00
$Y^{ref}(\Delta\phi)$
$Y^{temp}(\Delta\phi)$
(e)
$c_2^{ref}/c_2^{flow}$=0.502
$c_2^{temp}/c_2^{flow}$=1.006

# Case 3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$Y^{high}(\Delta\phi)$
$FY^{low}(\Delta\phi)$
$Y_0^{high}-FY_0^{low}$
(d)
$(Y_0^{high}-FY_0^{low})/Y_{flow}$ = 1.00
$Y^{ref}(\Delta\phi)$
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(e)
$c_2^{ref}/c_2^{flow}$ =0.502
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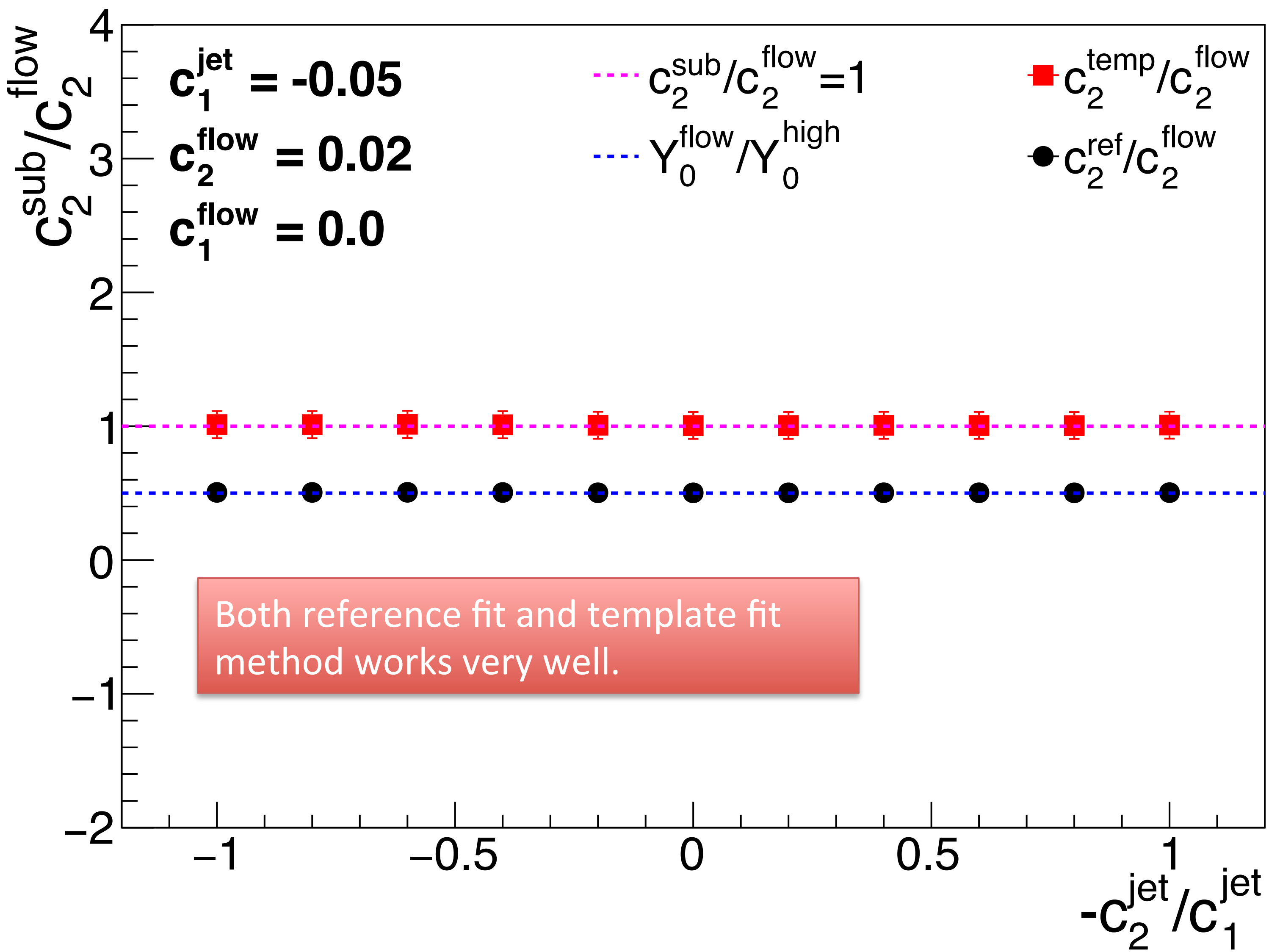
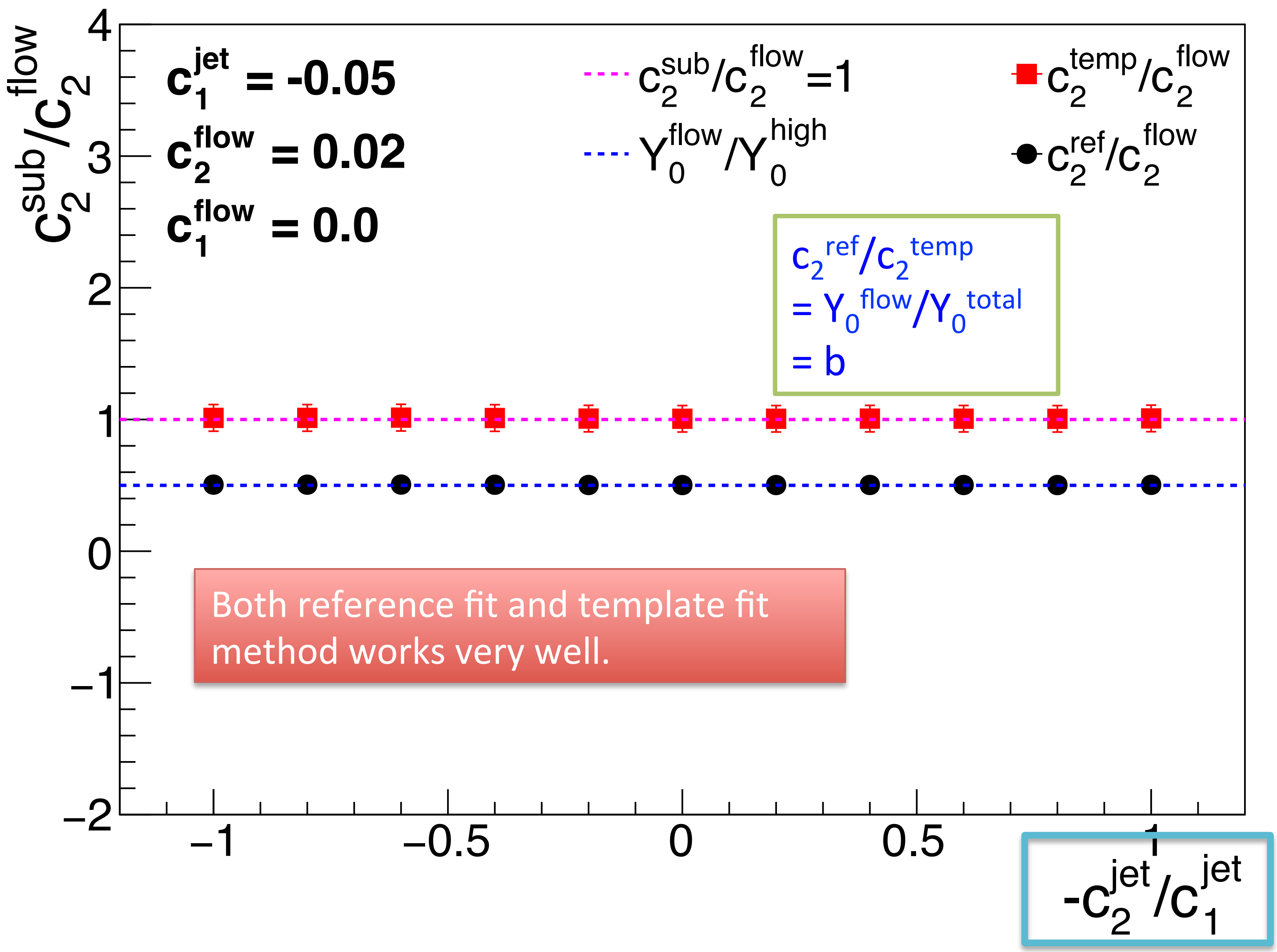
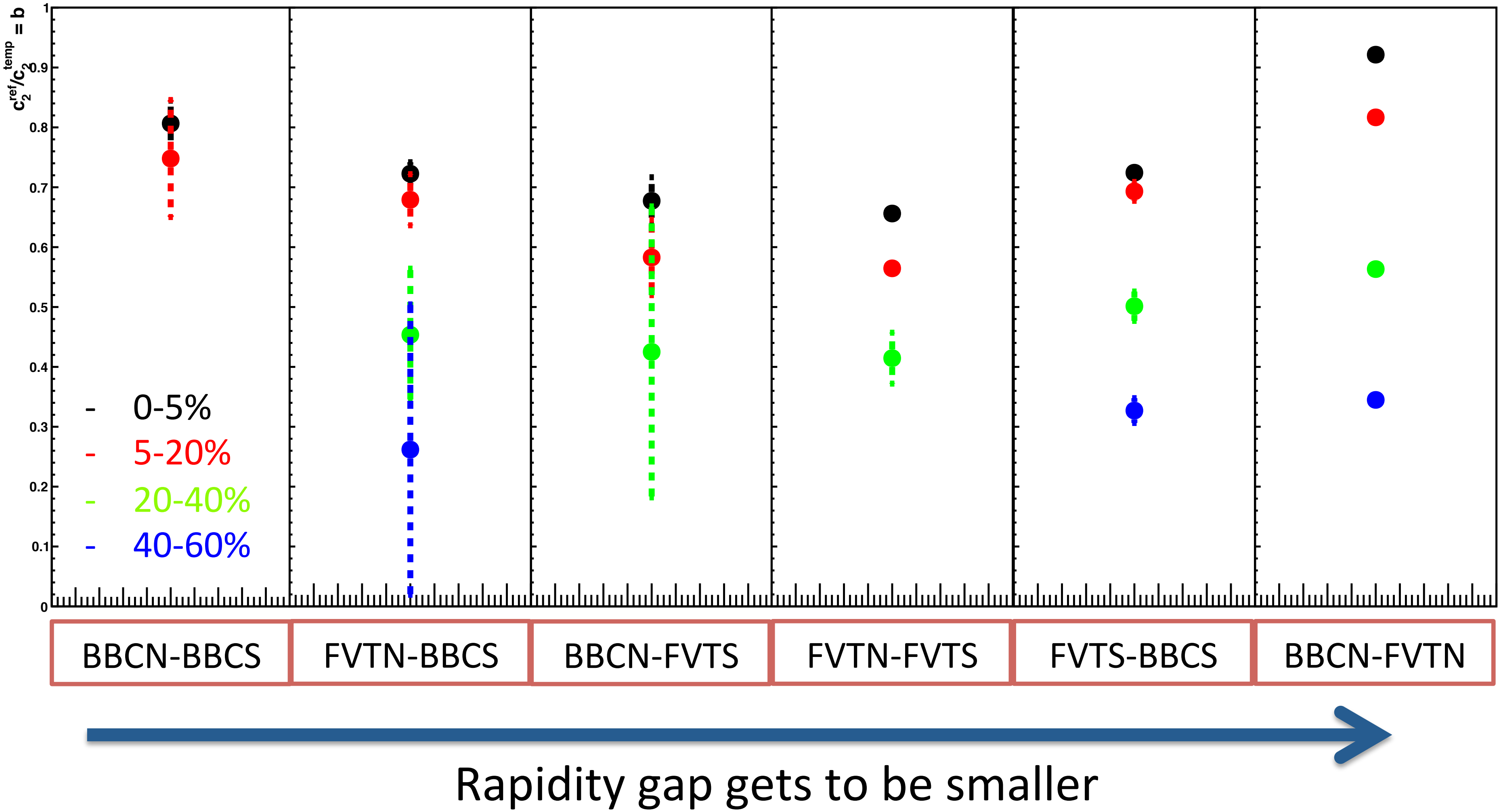

$c_1^{jet}$ = -0.05
$c_2^{flow}$ = 0.02
$c_1^{flow}$ = 0.0
$c_2^{sub}/c_2^{flow}=1$
$Y_0^{flow}/Y_0^{high}$
$c_2^{temp}/c_2^{flow}$
$c_2^{ref}/c_2^{flow}$
$c_2^{sub}/c_2^{flow}$
$-c_2^{jet}/c_1^{jet}$
Both reference fit and template fit method works very well.


$c_1^{jet}$ = -0.05
$c_2^{flow}$ = 0.02
$c_1^{flow}$ = 0.0
$c_2^{sub}/c_2^{flow}$=1
$Y_0^{flow}/Y_0^{high}$
$c_2^{temp}/c_2^{flow}$
$c_2^{ref}/c_2^{flow}$
$c_2^{ref}/c_2^{temp}$
$= Y_0^{flow}/Y_0^{total}$
= b
Both reference fit and template fit method works very well.
$c_2^{sub}/c_2^{flow}$
$-c_2^{jet}/c_1^{jet}$
4
3
2
1
0
−1
−2
−1
−0.5
0
0.5
1

# Calculated “b” in various combinations



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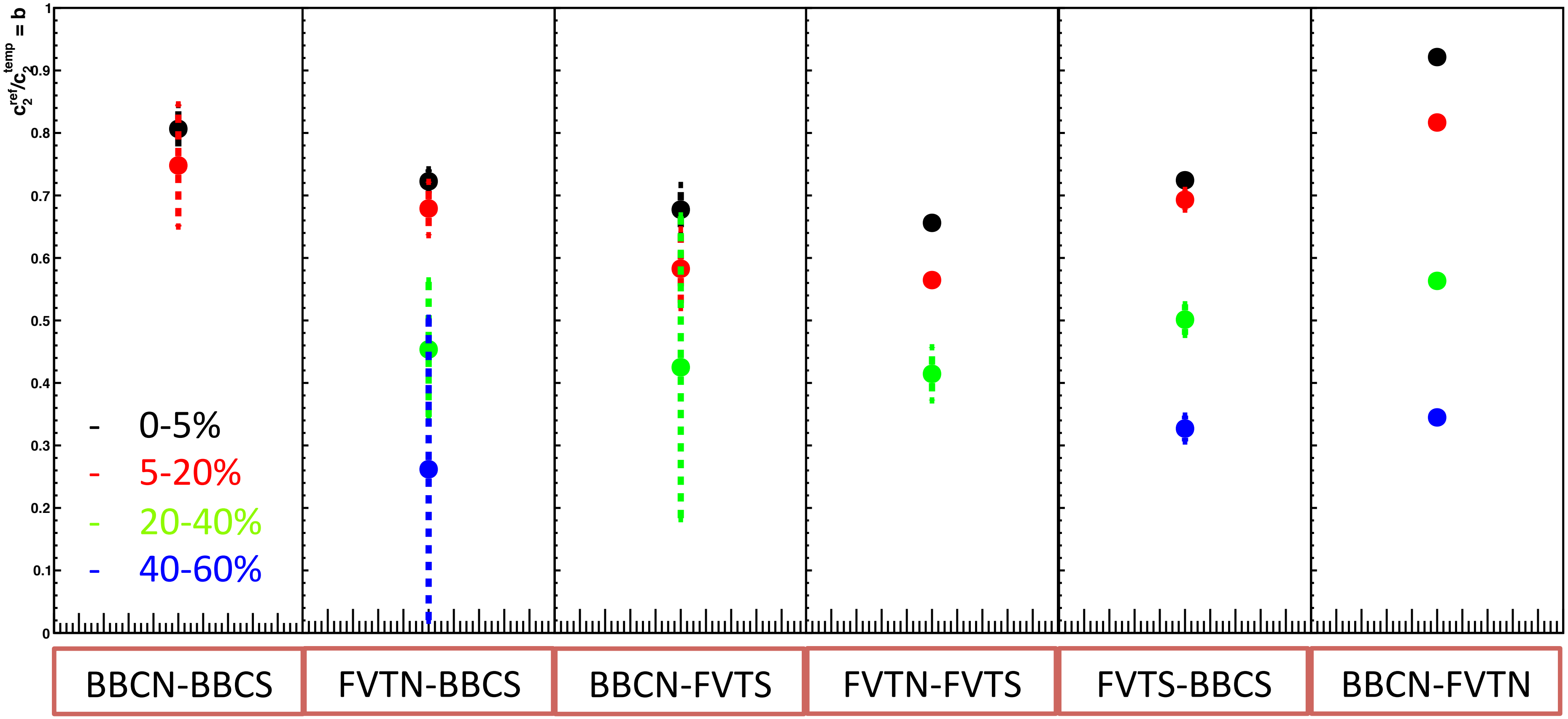



- $c_2^{jet}/c_1^{jet}$ = -0.0206176

- $c_2^{jet}/c_1^{jet}$ = 0.0333891

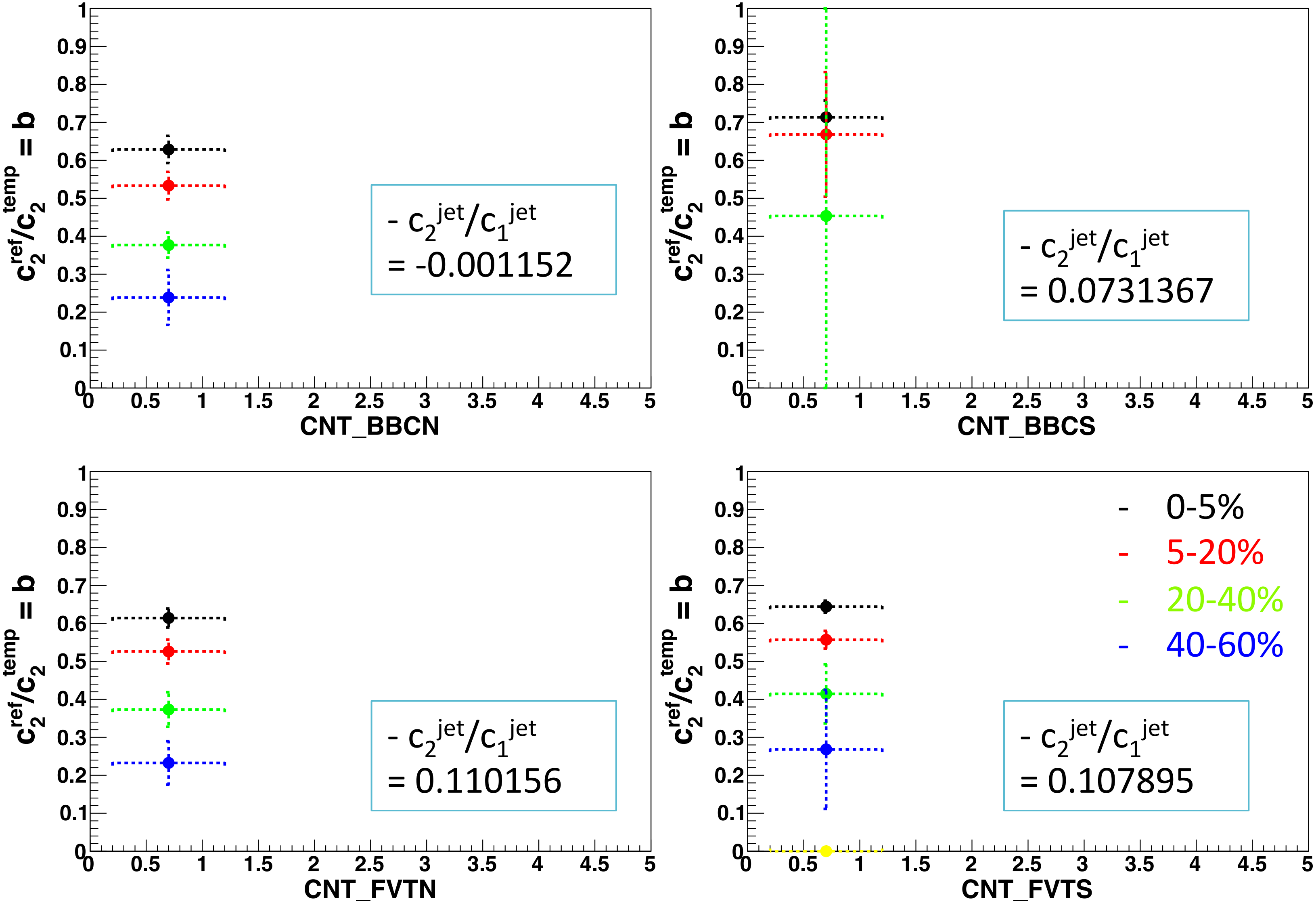
- $c_2^{jet}/c_1^{jet}$ = 0.0356002

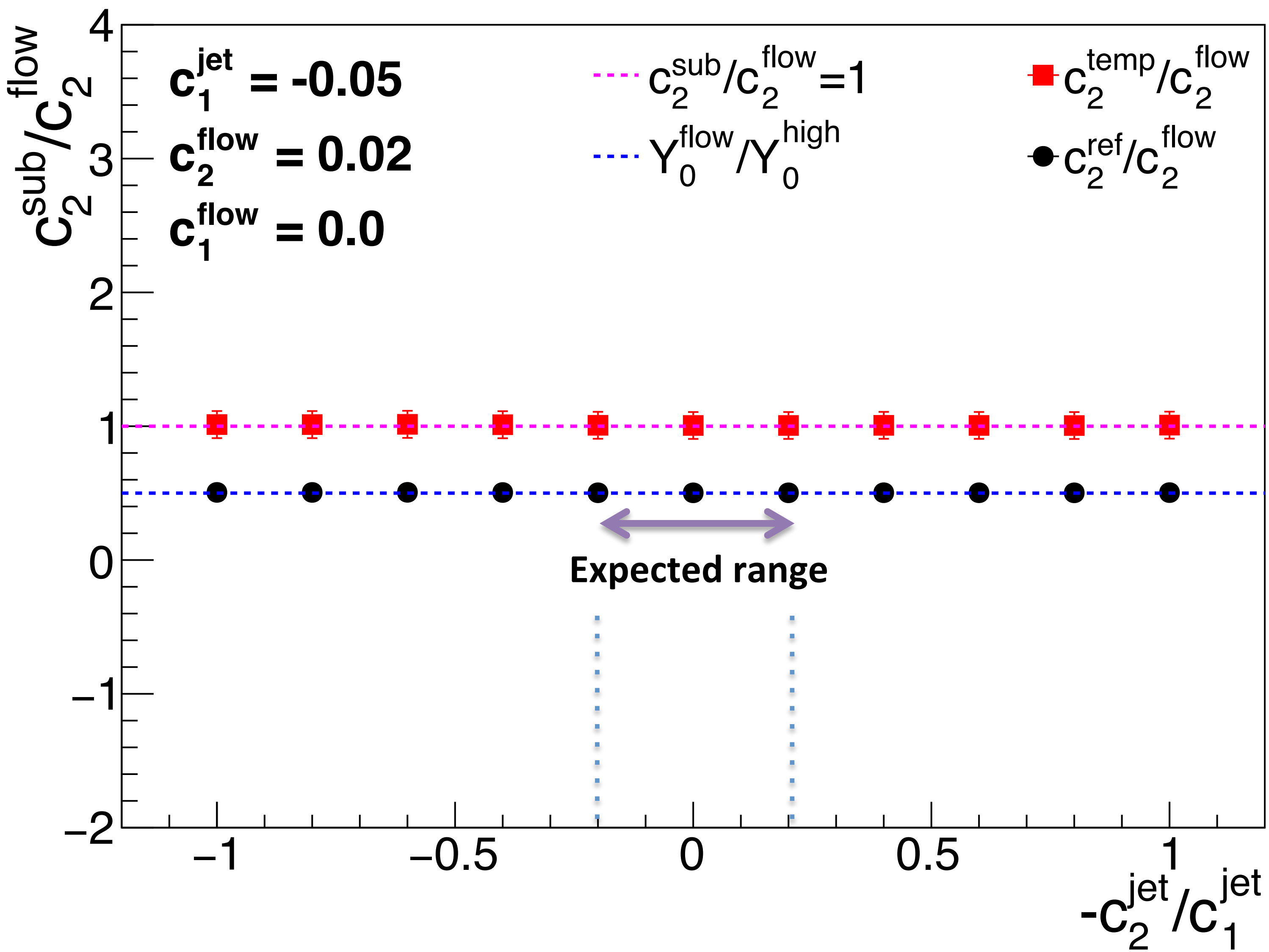
- $c_2^{jet}/c_1^{jet}$ = 0.0793924

- $c_2^{jet}/c_1^{jet}$ = 0.0896116

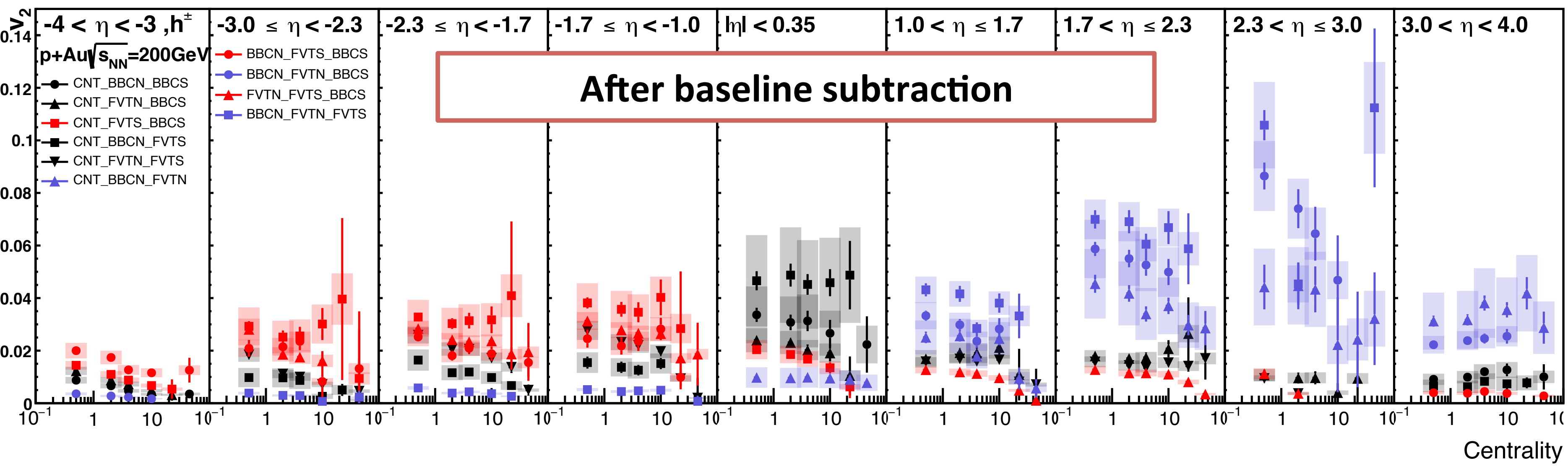
- $c_2^{jet}/c_1^{jet}$ = 0.119381

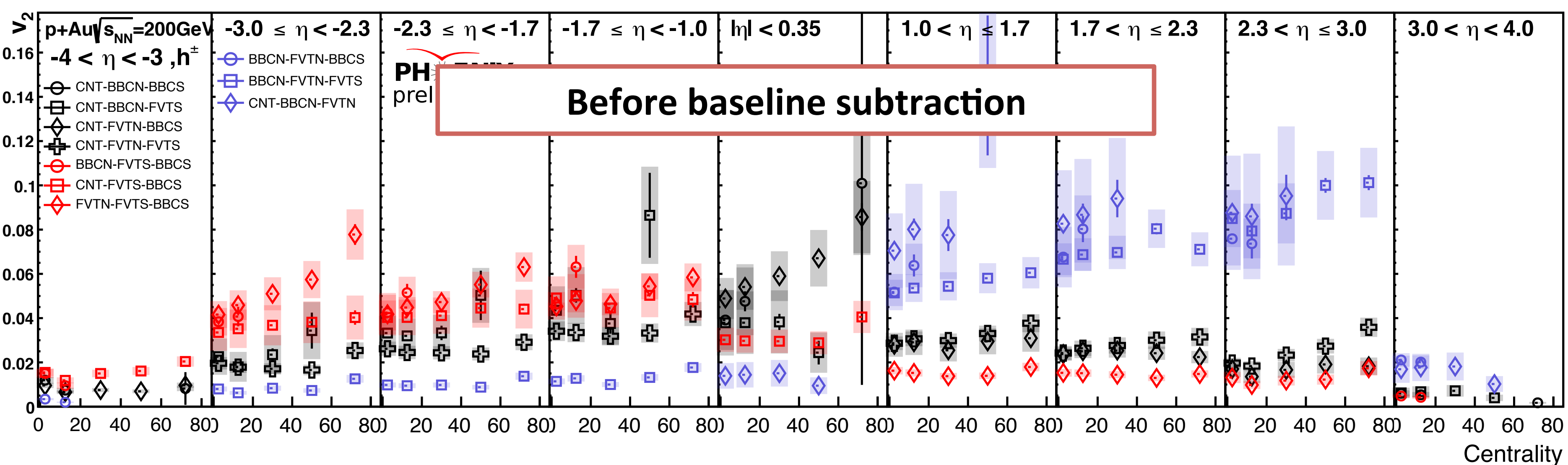
# Calculated "b" in various combinations




$c_1^{jet}$ = -0.05
$c_2^{flow}$ = 0.02
$c_1^{flow}$ = 0.0
$c_2^{sub}/c_2^{flow}$=1
$Y_0^{flow}/Y_0^{high}$
$c_2^{temp}/c_2^{flow}$
$c_2^{ref}/c_2^{flow}$
Expected range
$c_2^{sub}/c_2^{flow}$
$-c_2^{jet}/c_1^{jet}$
4
3
2
1
0
−1
−2
−1
−0.5
0
0.5
1

# $v_2$ as a function of rapidity : reference fit method



# Reference fit result; p+Au 200GeV

- We found expected range of the real data(p.14).
- Each $v_2$ at one rapidity area shows strong centrality dependence after we subtract with the reference fit method.
- The reference fit results describe majority of our data shows strong centrality dependence which can be the evidence of the QGP at the p+Au collisions, but cannot establish with quantifying discussions.