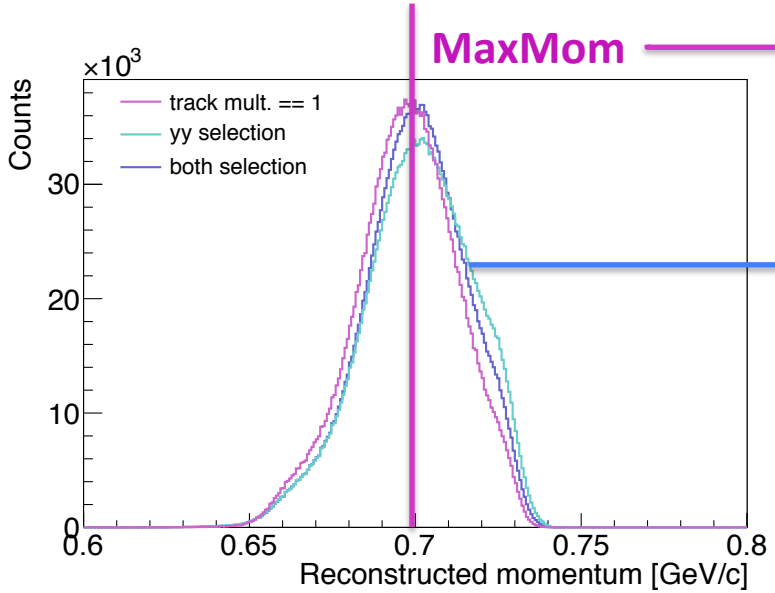
# Selection of the Momentum




→ Extracted for each run from reference sample (track mult == 1)

→ Beamtime: Finetuning beamline (magnet) settings

→ DST: first momentum (per event) == selected momentum

**SELECTION METHOD:**

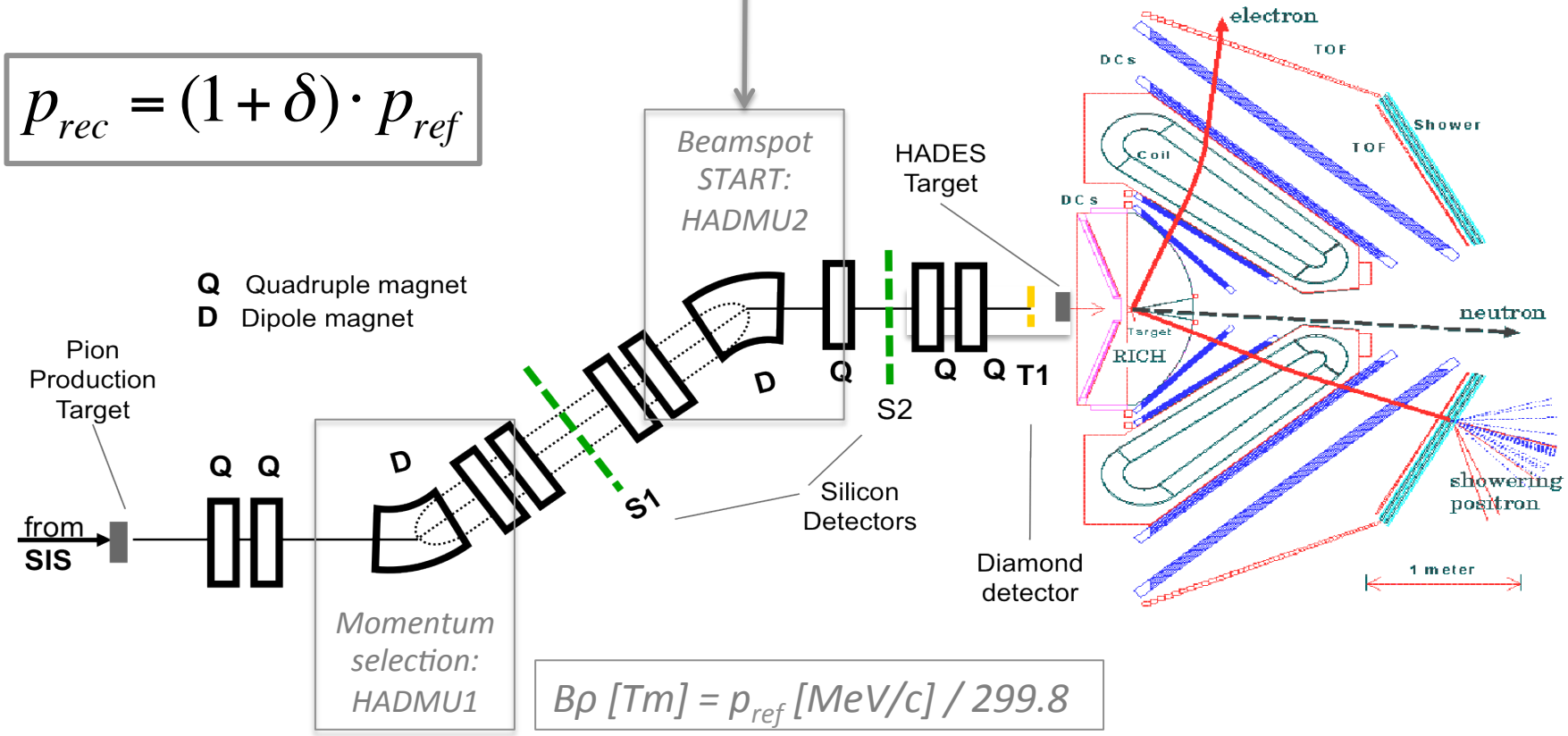
$$dis_{both} = \sqrt{100000\left(\frac{-4.2\cdot y_{NE5} + y_{HADES} - 1}{\sqrt{(4.2)^2+1}}\right)^2 + \left(MaxMom - \mathrm{Re}\,cMom\right)^2} \rightarrow Min$$

YY CORRELATION

# Selection of the Momentum

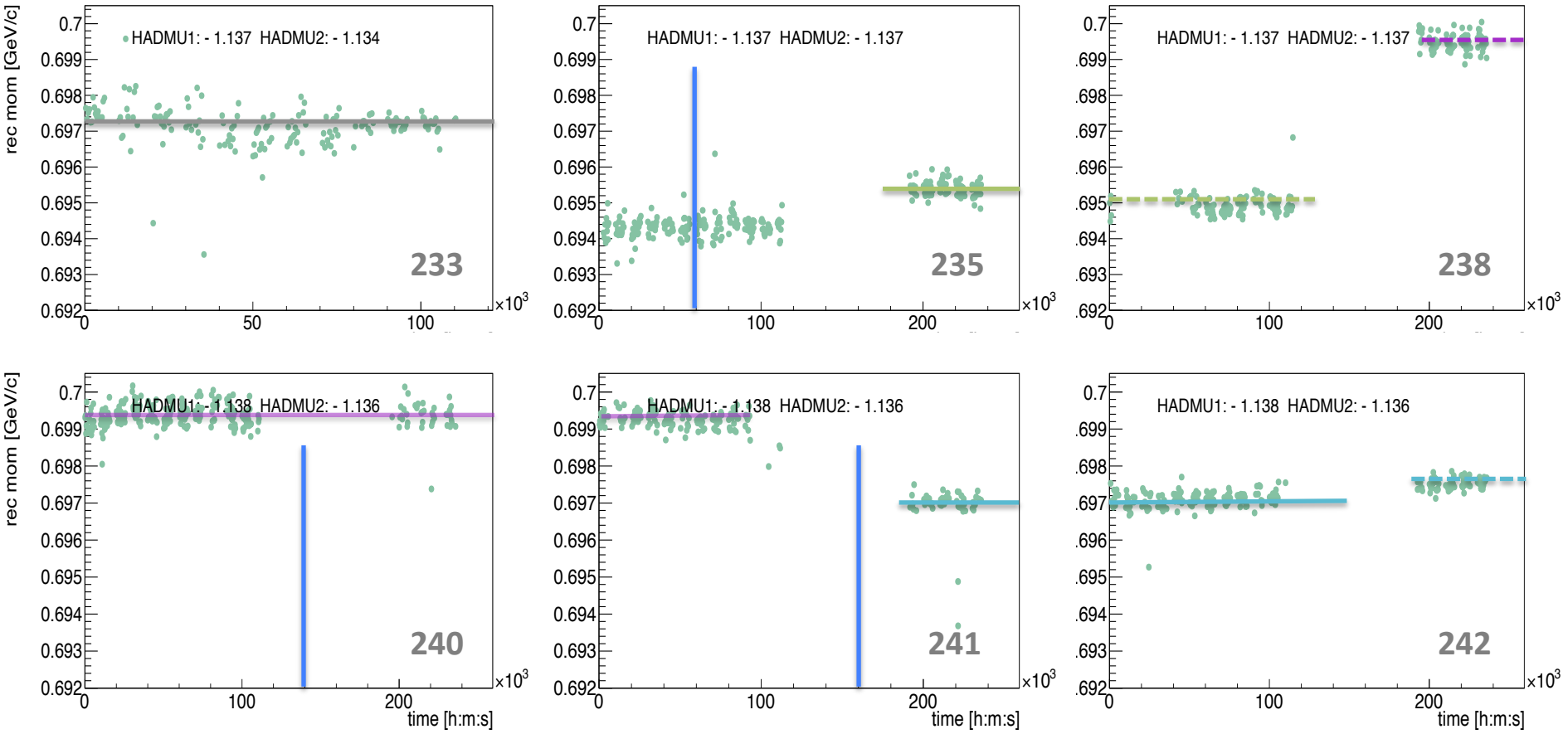
Finetuned during the second beam time

$$p_{rec} = (1+\delta) \cdot p_{ref}$$




$Bp\ [Tm] = p_{ref}\ [MeV/c] / 299.8$

# MaxMom for each Run (0.690 GeV/c, PE)




HADMU1: - 1.137 HADMU2: - 1.134

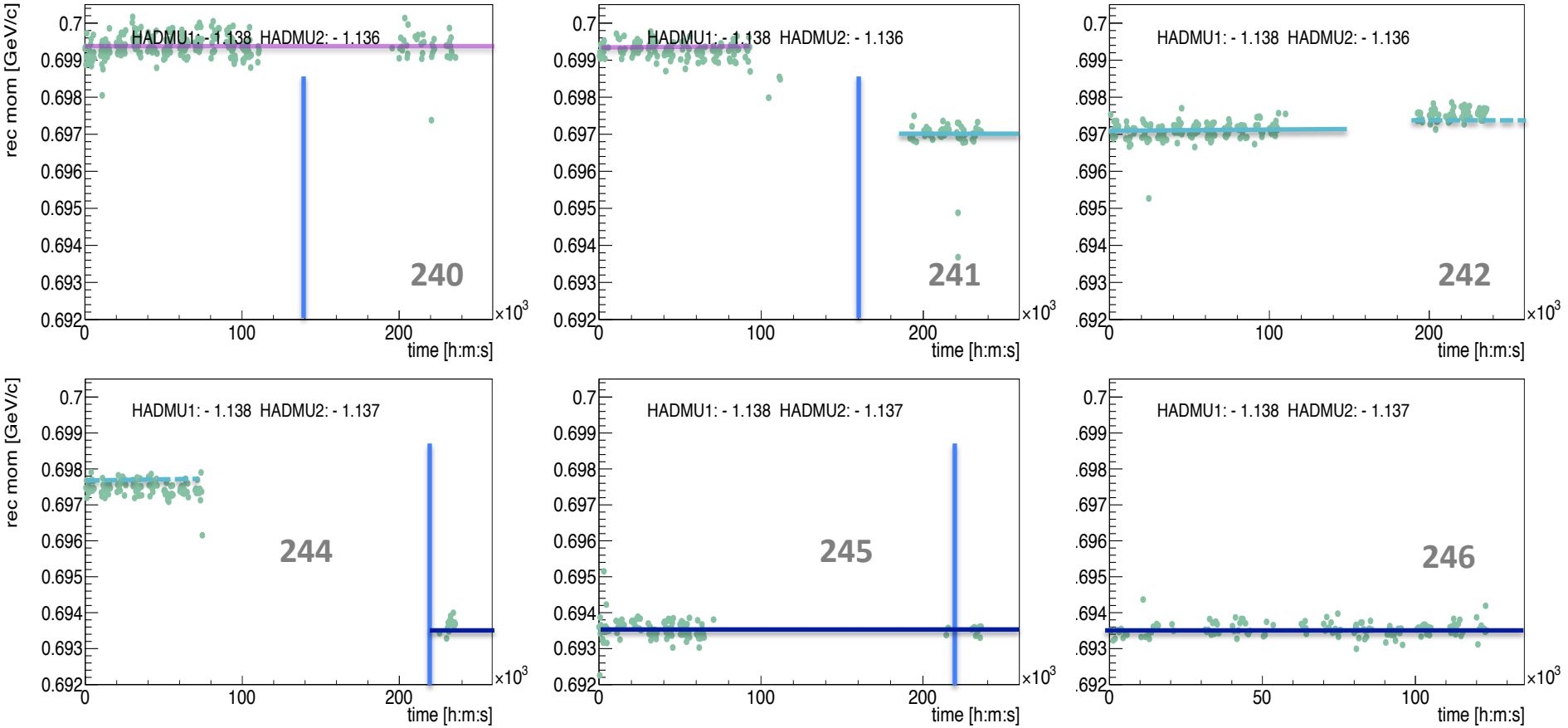
HADMU1: - 1.138 HADMU2: - 1.136

HADMU1: - 1.137 HADMU2: - 1.137

HADMU1: ? HADMU2: ?

HADMU1: - 1.138 HADMU2: -1.137

# MaxMom for each Run (0.690 GeV/c, PE)




HADMU1: - 1.137 HADMU2: - 1.134

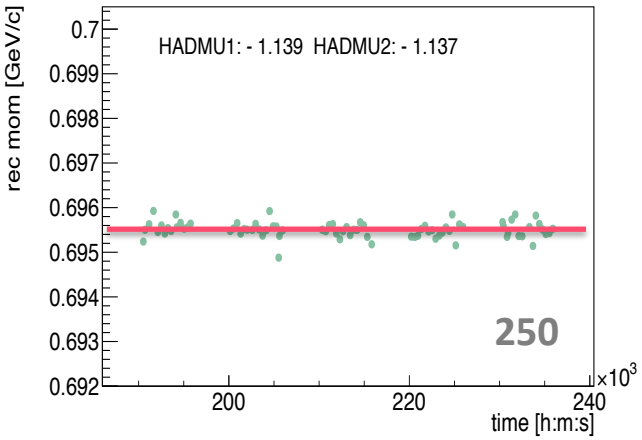
HADMU1: - 1.138 HADMU2: - 1.136

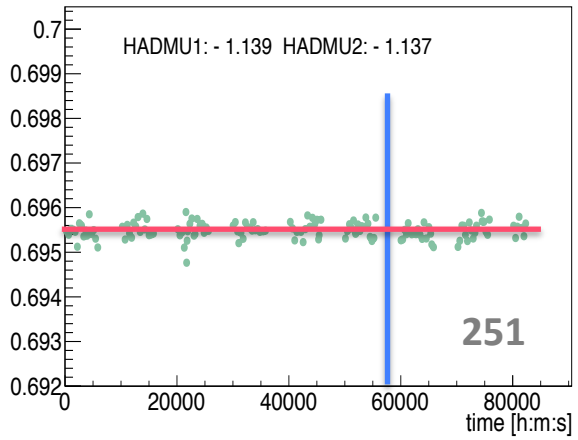
HADMU1: - 1.137 HADMU2: - 1.137

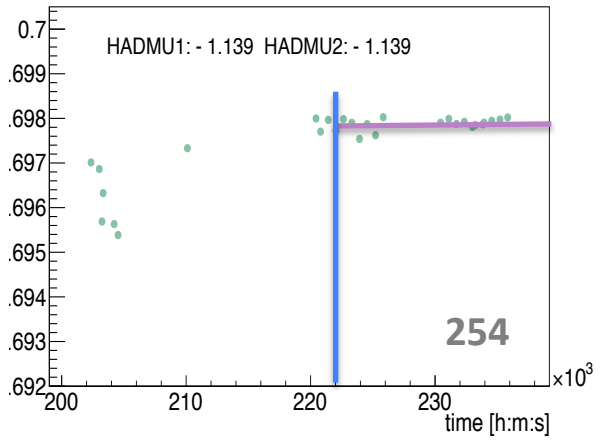
HADMU1: ? HADMU2: ?

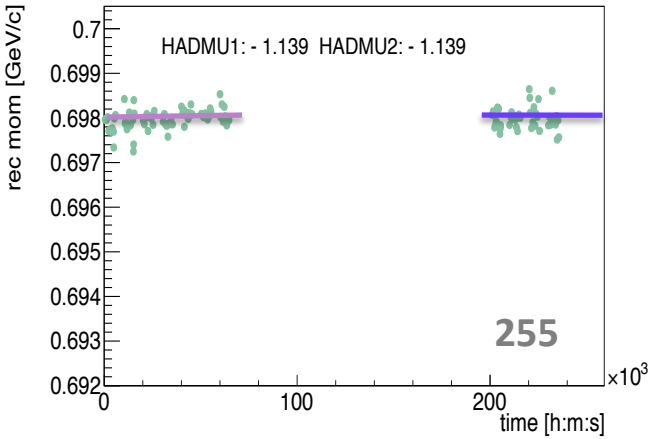
HADMU1: - 1.138 HADMU2: -1.137

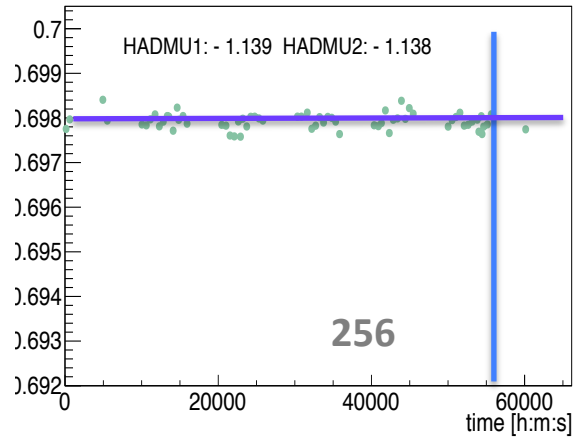
# MaxMom for each Run (0.690 GeV/c, C)




HADMU1: -1.139 HADMU2: -1.137

HADMU1: -1.139 HADMU2: -1.139

HADMU1: -1.139 HADMU2: -1.138

HADMU1: - 1.137 HADMU2: - 1.134

HADMU1: - 1.138 HADMU2: - 1.136

HADMU1: - 1.137 HADMU2: - 1.137

HADMU1: ? HADMU2: ?

HADMU1: - 1.138 HADMU2: -1.137

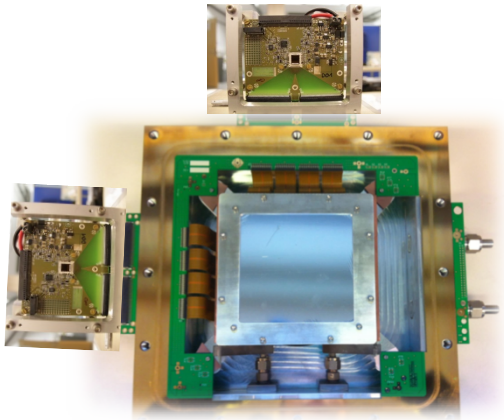
# MaxMom summary of 0.690 GeV/c

| | BEAMLINE SETTINGS | AVERAGE MAXMOM |
|---|---|---|
| PE | HADMU1: - 1.137 HADMU2: - 1.134 | ~ 0.698 GeV/c |
| | HADMU1: - 1.137 HADMU2: - 1.137 | ~ 0.695 GeV/c |
| | HADMU1: - 1.138 HADMU2: - 1.136 | ~ 0.6995 GeV/c |
| | HADMU1: ? HADMU2: ? | ~ 0.6971 GeV/c |
| | HADMU1: - 1.138 HADMU2: -1.137 | ~ 0.6935 GeV/c |
| C | HADMU1: -1.139 HADMU2: -1.137 | ~ 0.6955 GeV/c |
| | HADMU1: -1.139 HADMU2: -1.139 | ~ 0.698 GeV/c |
| | HADMU1: -1.139 HADMU2: -1.138 | ~ 0.698 GeV/c |

→ **Different settings for PE and C data** → **Change of transmission**

# Calibration: Elastic Scattering

Polyethylene target ($H_4C_2$): $\pi^- + p \longrightarrow \pi^- + p$

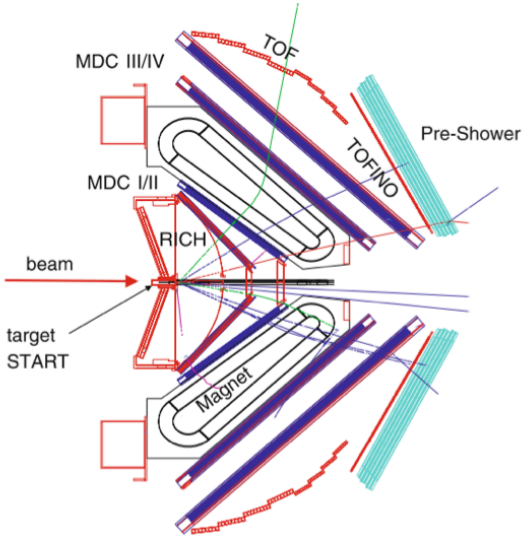


INITIAL STATE $\pi^- + p$ → FINAL STATE $\pi^- + p$

$\sqrt{s}$ = $M_{\pi\text{-}p}$

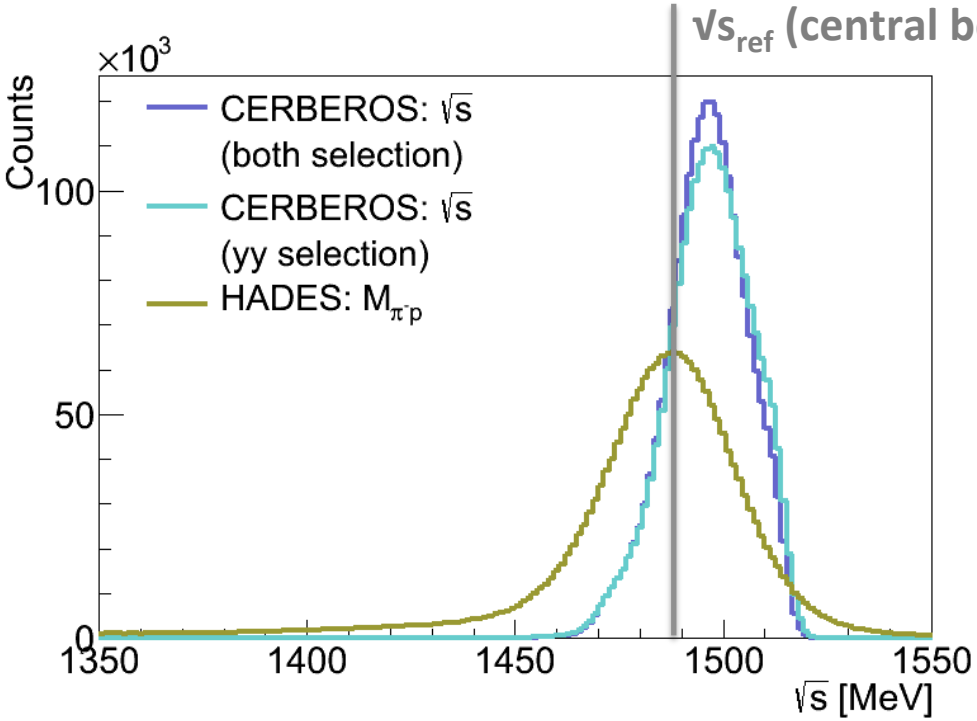
CERBEROS = HADES

ELASTIC SCATTERING



# Reminder: Comparison $M_{\pi\text{-}p}$ and $\sqrt{s}$

CENTRAL BEAM MOMENTUM: 0.690 GeV/c




| | 0.690 GeV/c |
|---|---|
| $\sqrt{s_{ref}}$ [GeV] | 1.489 |
| $\sqrt{s_{rec}}$ [GeV] | 1.497 |
| $M_{\pi\text{-}p}$ [GeV] | 1.488 |
| $\Delta(\sqrt{s_{ref}}\text{-}\sqrt{s_{rec}})$ [MeV] | 8 |
| $\Delta(\sqrt{s_{rec}}\text{-}M_{\pi\text{-}p})$ [MeV] | 9 ( 5 / 3 ) |

MaxMom

Mean

dE/dx

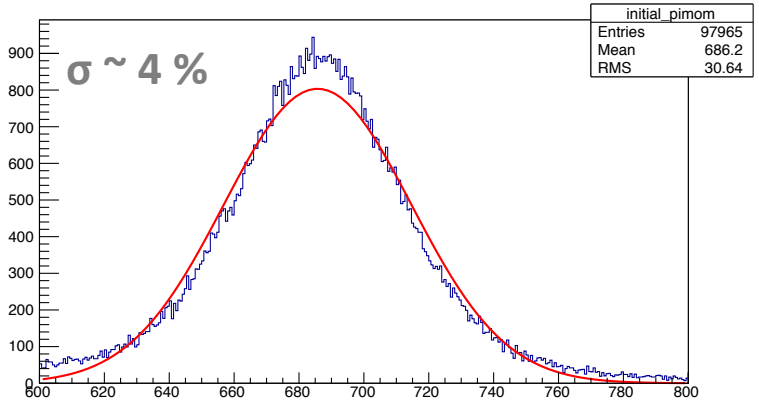
GEANT4

NIST

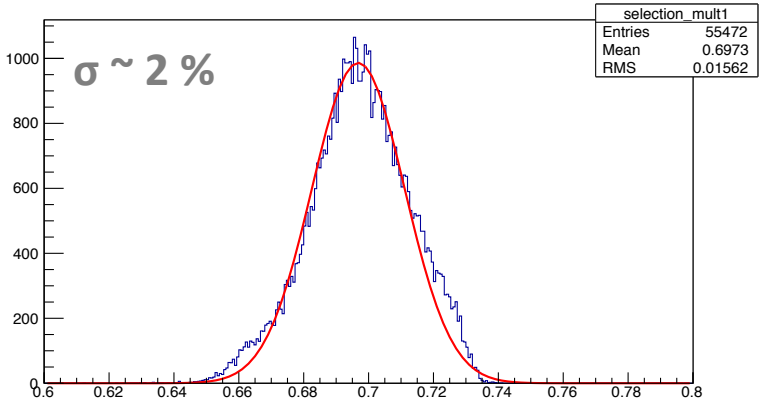
# Resolution Comparison

CENTRAL BEAM MOMENTUM: 0.690 GeV/c

**HADES**




**PION TRACKER**



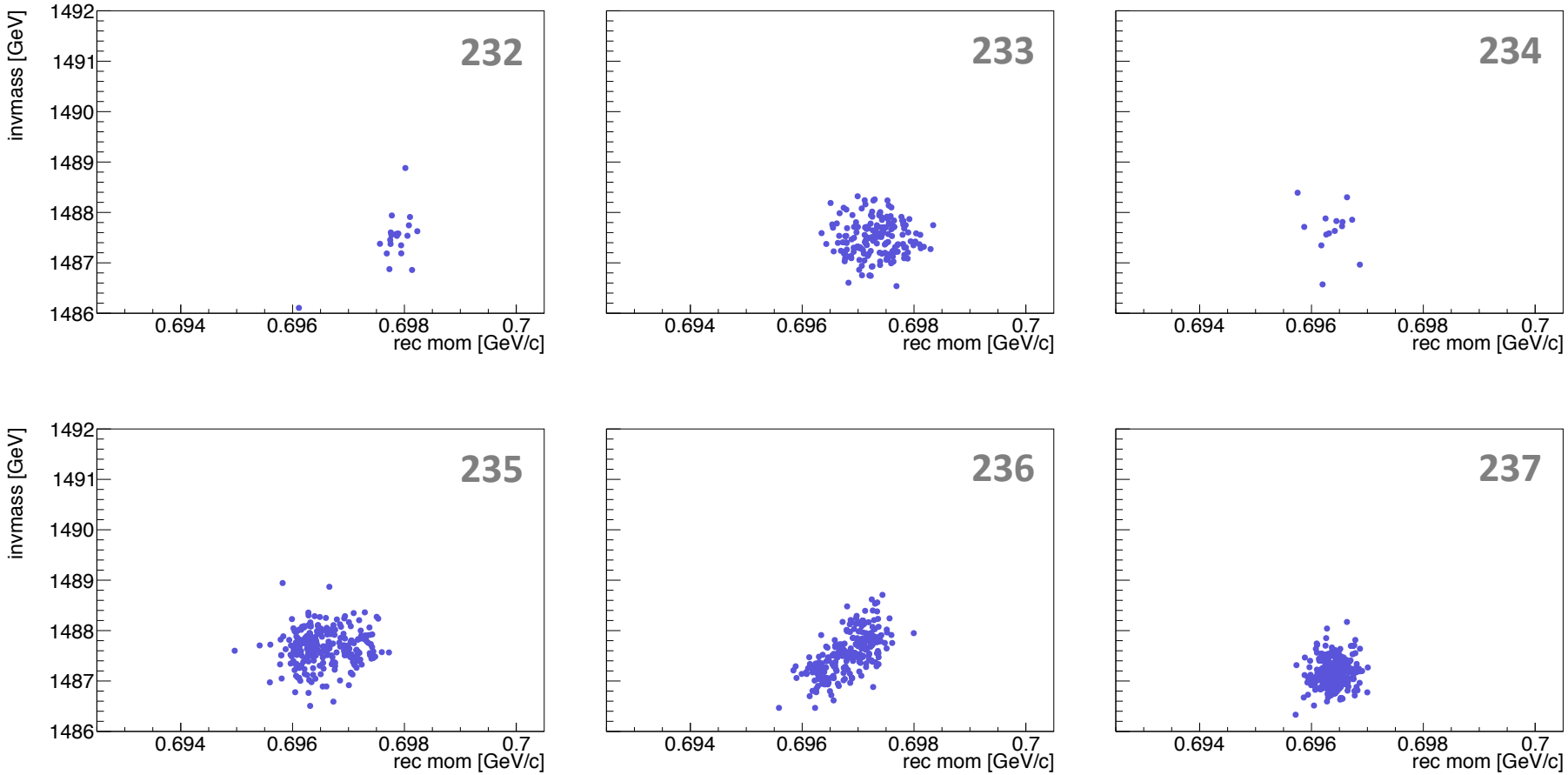

→ $\sigma_{PT} < \sigma_{HADES}$: intrinsic resolution of pion tracker much better (0.5 ‰)

→ HADES is not able to resolve MaxMom of the pion tracker

→ **MeanMom** is used instead of MaxMom to check the stability of InvMass

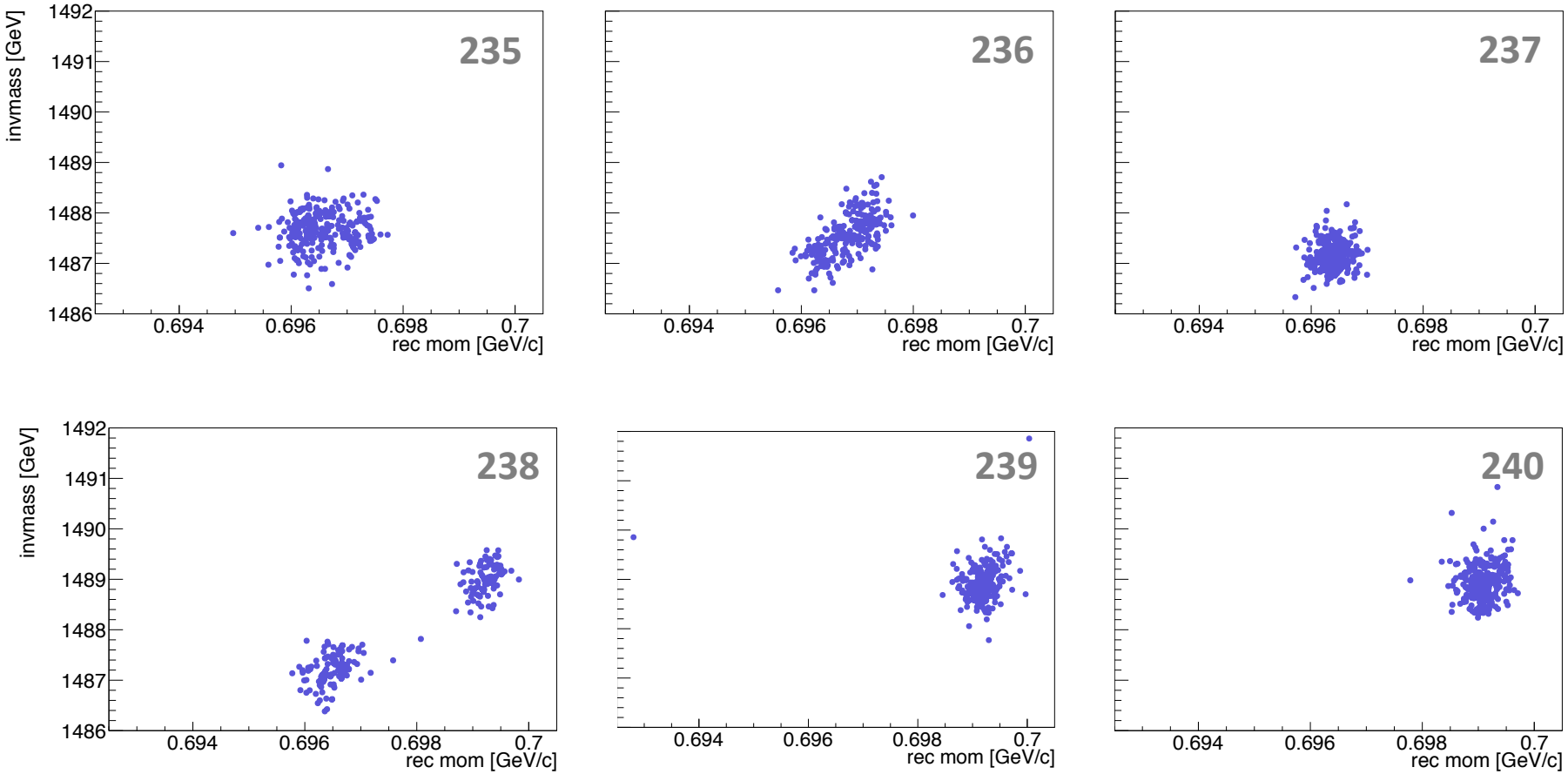
# InvMass vs. MeanMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)



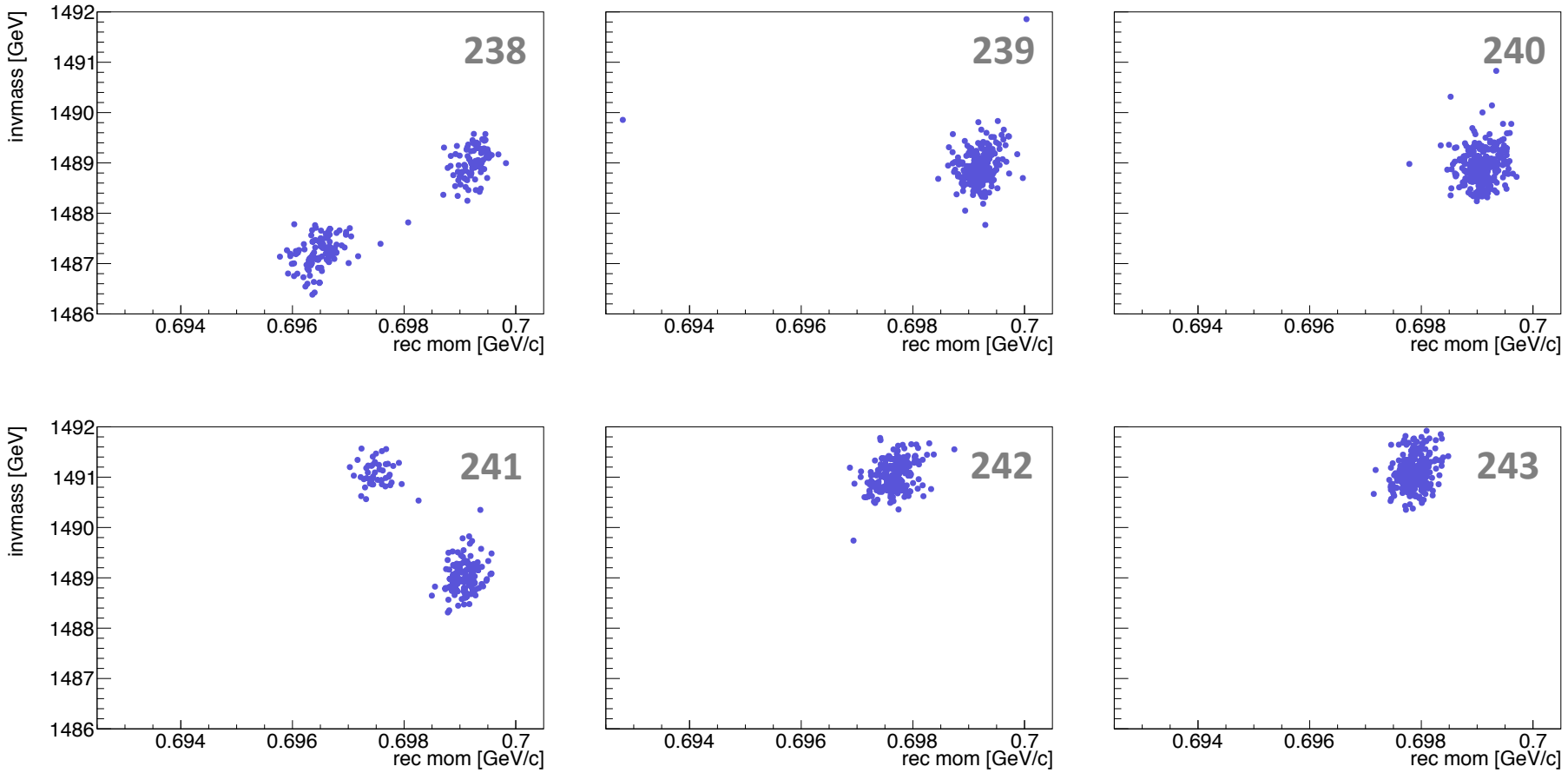
# InvMass vs. MeanMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)



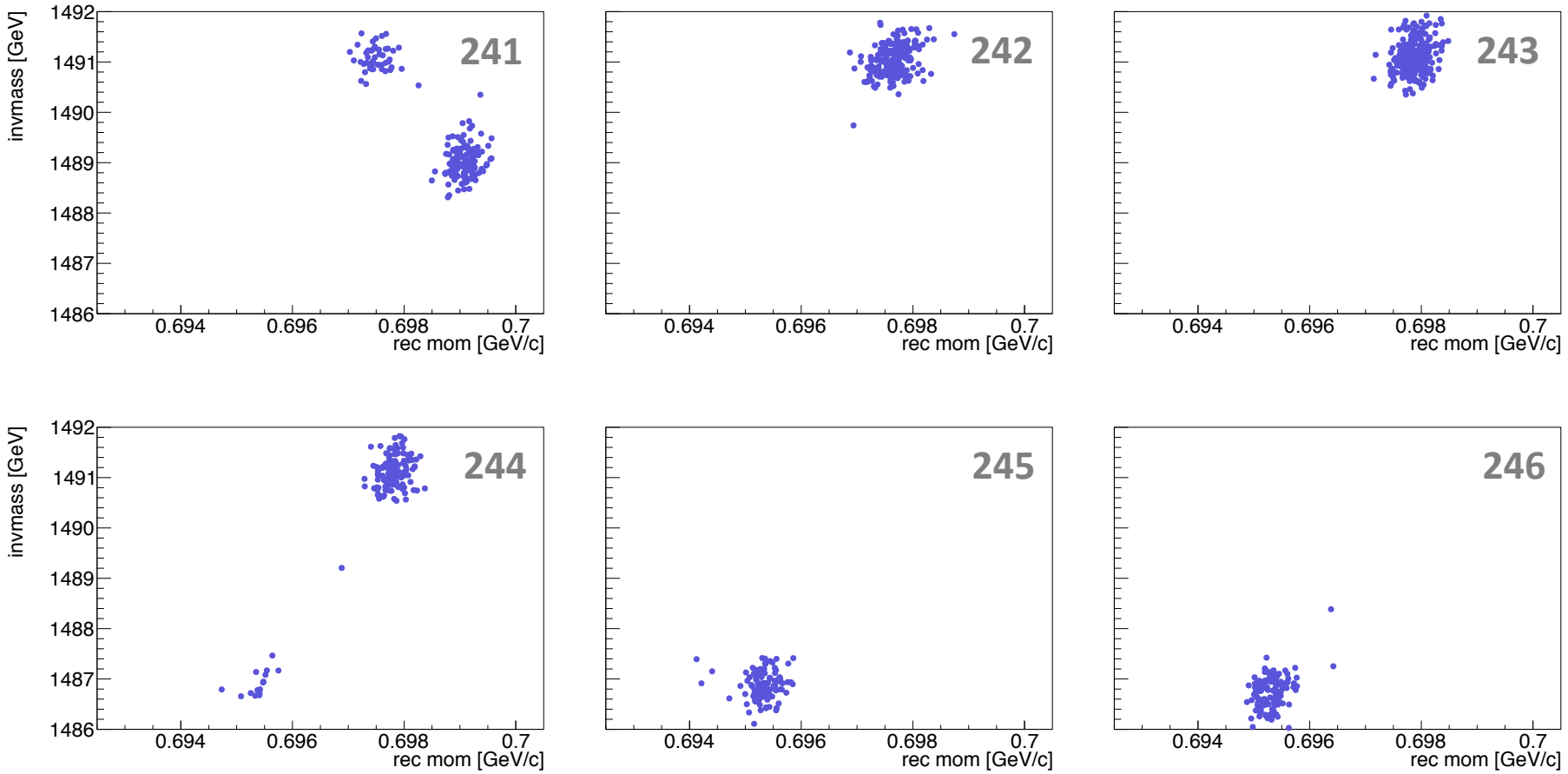
# InvMass vs. MeanMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)

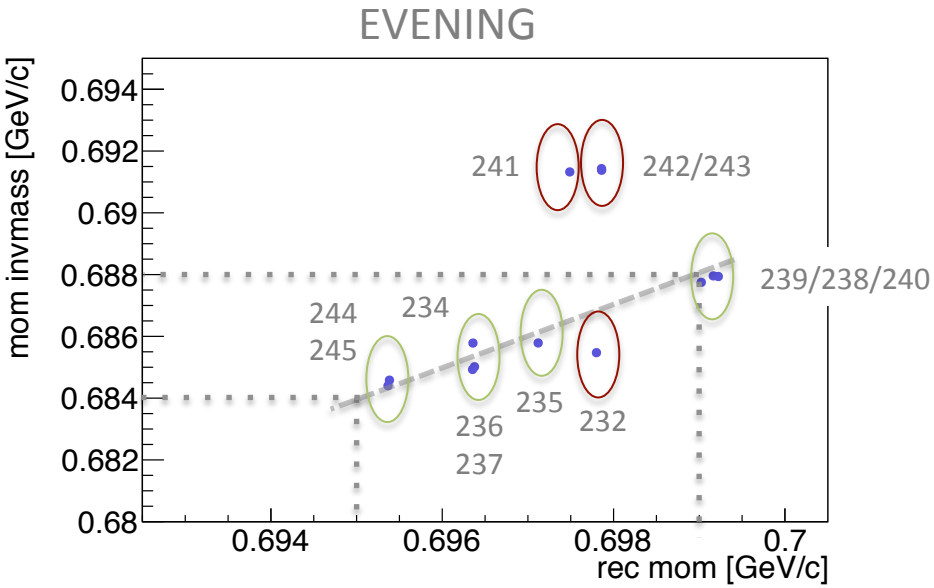


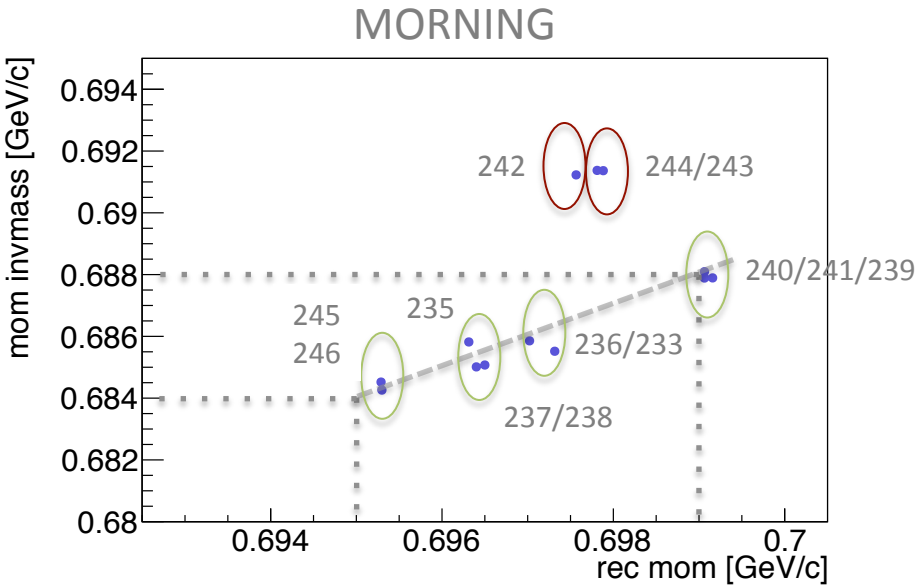
# InvMass vs. MeanMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)



# Summary of 0.690 GeV/c (PE)

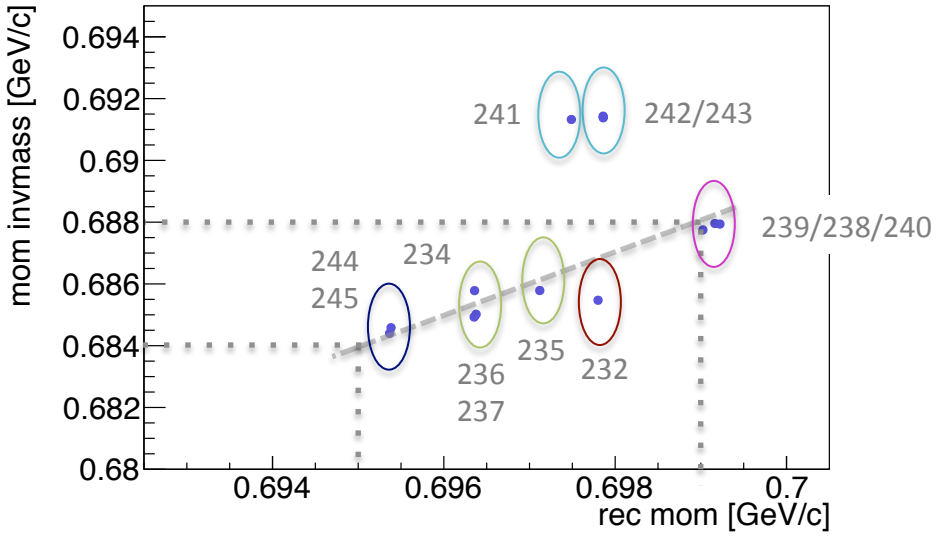


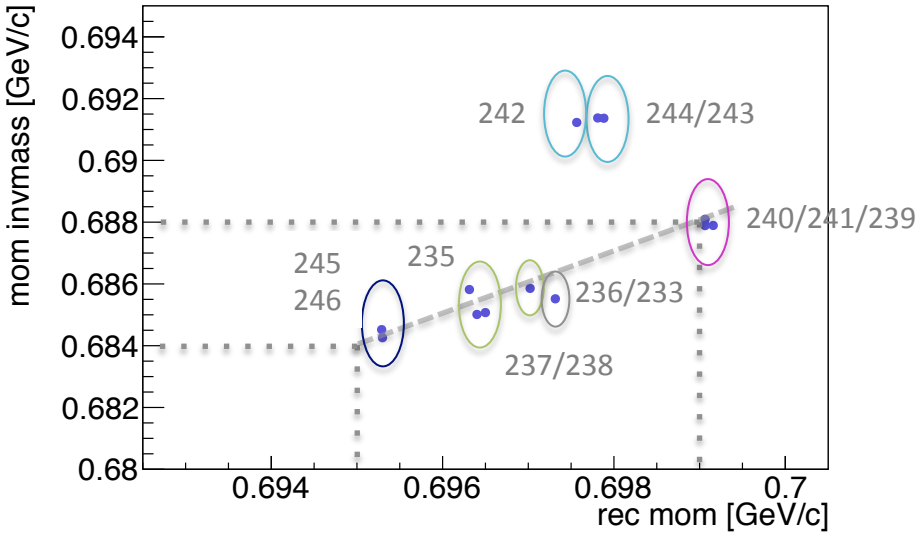

- For some days a linear dependence is visible: $Shift_{av}$ = 11 MeV/c
- Part of this offset correspondes due to the dE/dx: **GEANT4**: 4 MeV/c & **NIST**: 7 MeV/c
- Larger/smaller shifts due to different impact positions ($x_0$,$y_0$) of the primary beam on the production target

# Summary of 0.690 GeV/c (PE)

EVENING




MORNING



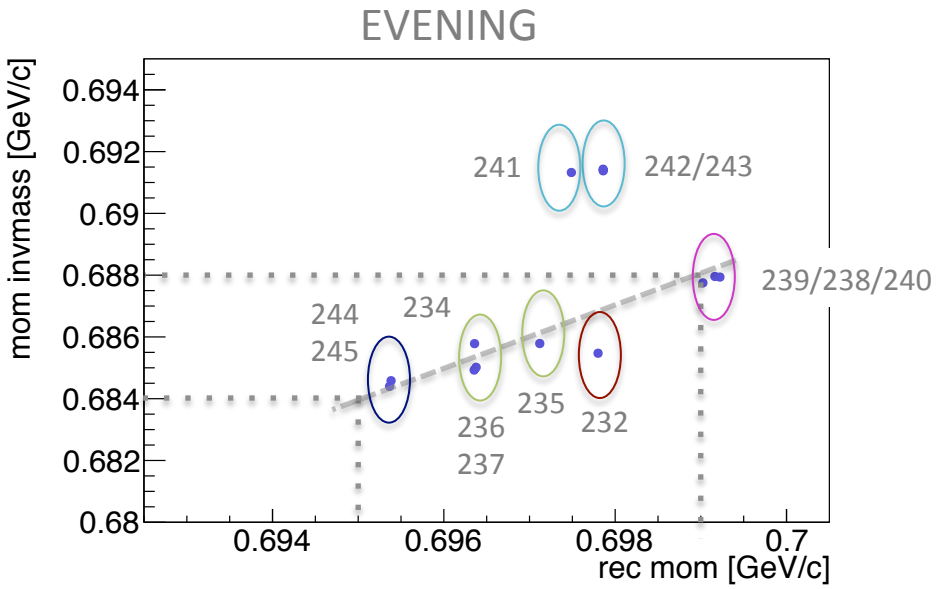

**PE**

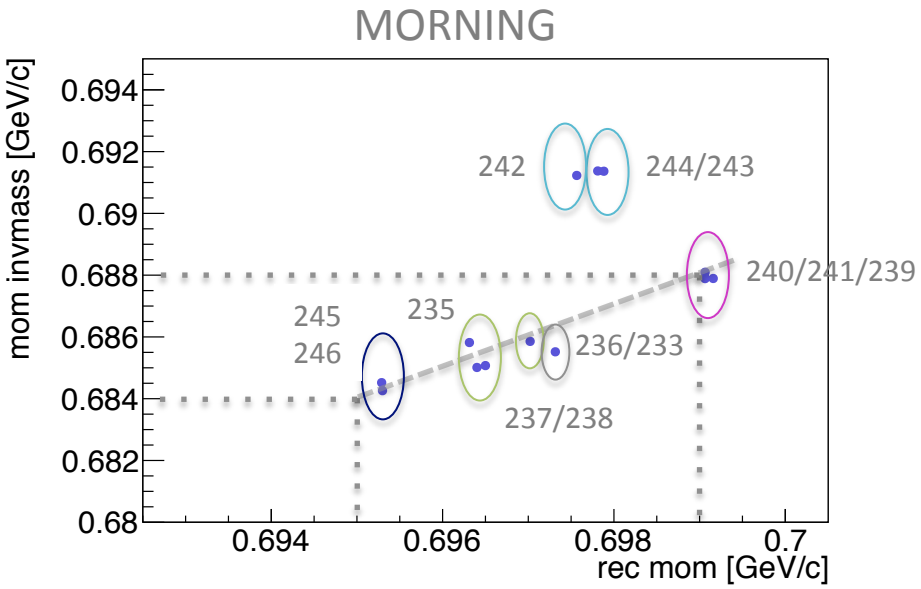
- HADMU1: - 1.137 HADMU2: - 1.134
- HADMU1: - 1.137 HADMU2: - 1.137
- HADMU1: - 1.138 HADMU2: - 1.136
- HADMU1: - 1.138 HADMU2: -1.137
- HADMU1: ? HADMU2: ?

**C**

- HADMU1: -1.139 HADMU2: -1.137
- HADMU1: -1.139 HADMU2: -1.139
- HADMU1: -1.139 HADMU2: -1.138

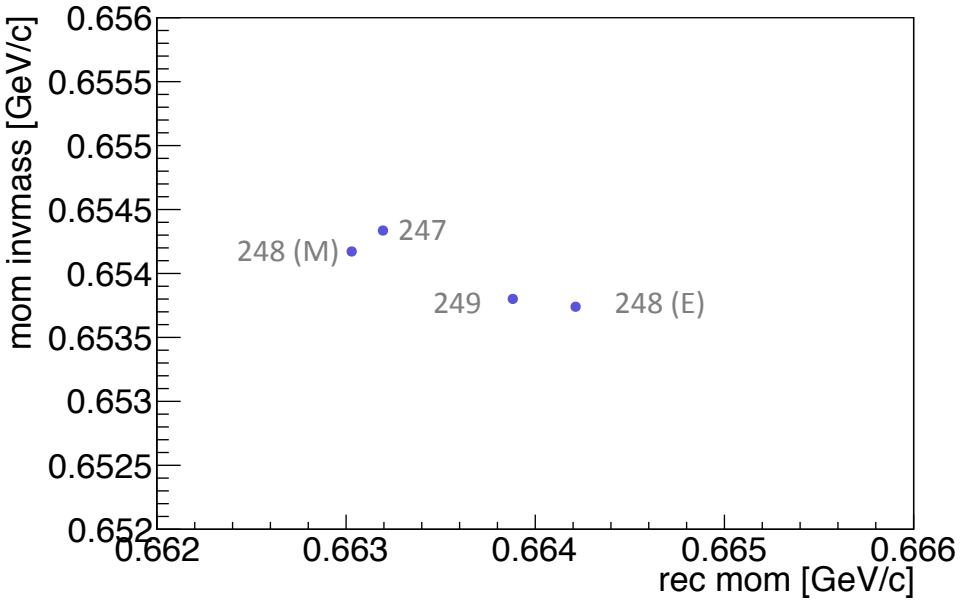
# Summary of 0.690 GeV/c (PE)



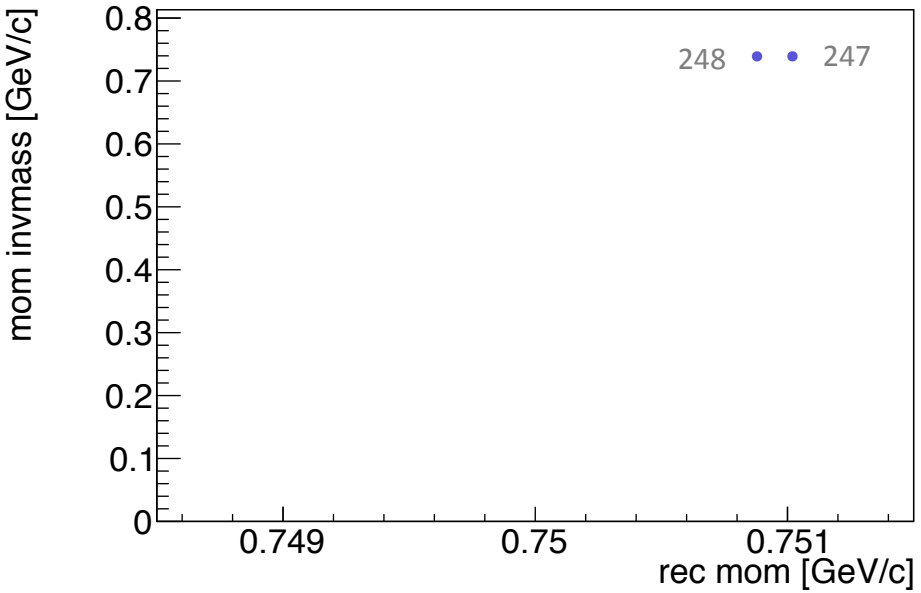

- → **Correction only for PE data: Δ(mom invmass - rec mom)**
- → **No correction possible for C data:**
  - → Different impact positions ($x_0$,$y_0$) of the primary beam on the production target
  - → Different beamline settings

# Summary of 0.656 GeV/c (PE)



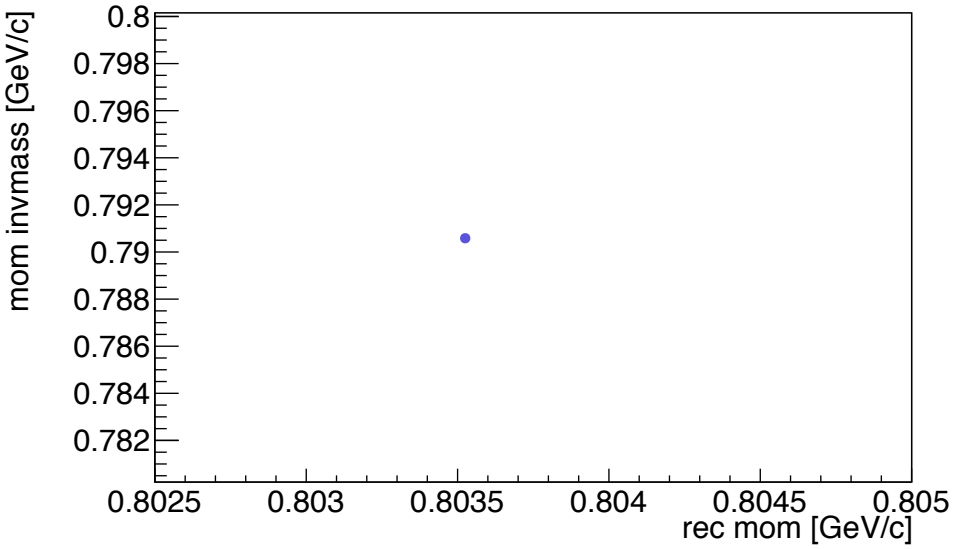

- → **Correction only for PE data: Δ(mom invmass - rec mom)**
- → **No correction possible for C data:**
  - → Different impact positions ($x_0$,$y_0$) of the primary beam on the production target
  - → Different beamline settings

# Summary of 0.748 GeV/c (PE)




- **Correction only for PE data: Δ(mom invmass - rec mom)**
- **No correction possible for C data:**
  - Different impact positions ($x_0$,$y_0$) of the primary beam on the production target
  - Different beamline settings

# Summary of 0.800 GeV/c (PE)




- **Correction only for PE data: Δ(mom invmass - rec mom)**
- **No correction possible for C data:**
  - Different impact positions ($x_0$,$y_0$) of the primary beam on the production target
  - Different beamline settings

# Summary & Outlook

**Momentum Selection & Calibration:**

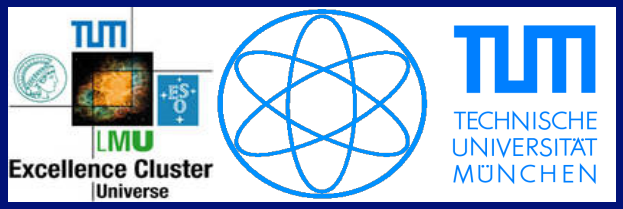
➔ **Selection** based on MaxMom of reference sample for each run

- ➔ **DST: first momentum (per event) == selected momentum**

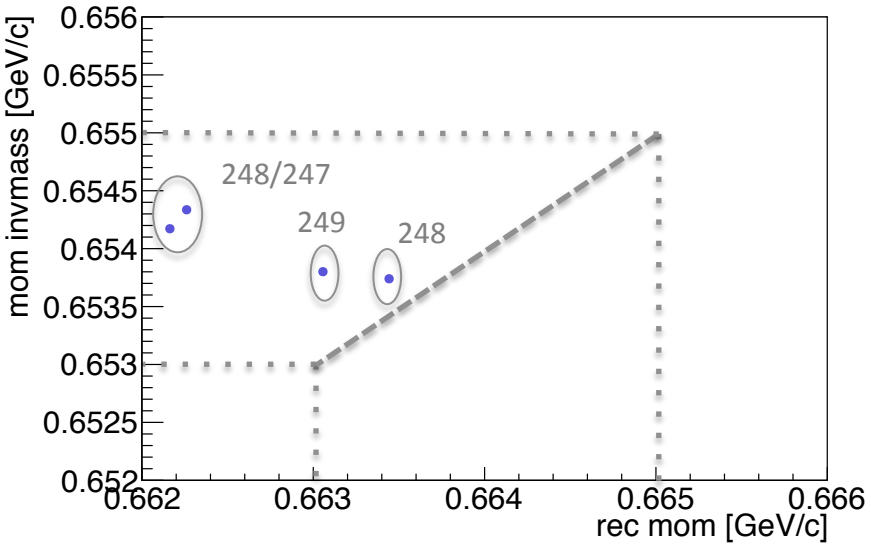
➔ **Calibration:**

- ➔ **No linear correlation between mean mom($M_{\pi\text{-}p,HADES,av}$) & mean mom($PT_{av}$)**
- ➔ **Correction only for PE data:**
  - ➔ **$\Delta$(mom($M_{\pi\text{-}p,HADES,av}$) - mom($PT_{av}$))**
- ➔ **No correction possible for C data:**
  - ➔ Different beamline seetings (HADMU1 & HADMU2)
  - ➔ Different impact positions ($x_0$,$y_0$) of the primary beam on the production target

# BACKUP


LMU
Excellence Cluster
Universe
TECHNISCHE
UNIVERSITÄT
MÜNCHEN

# Summary of 0.656 GeV/c (PE)

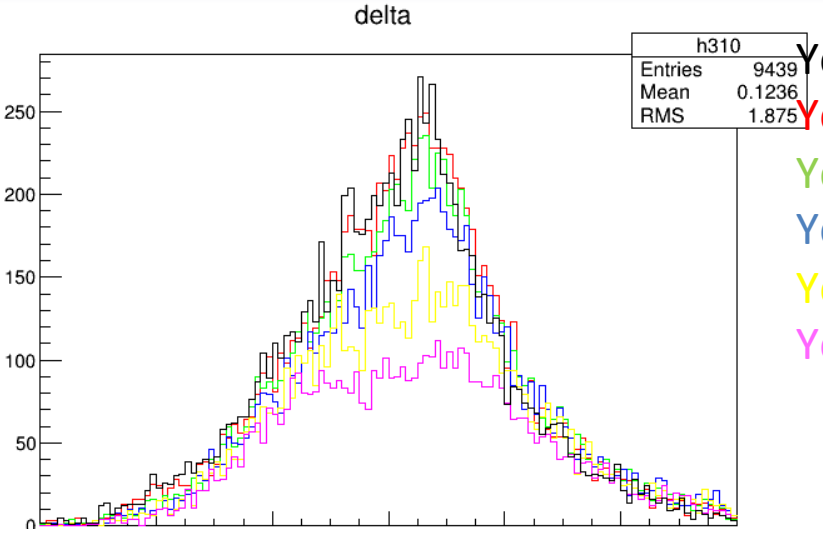



→ No linear dependence is visible

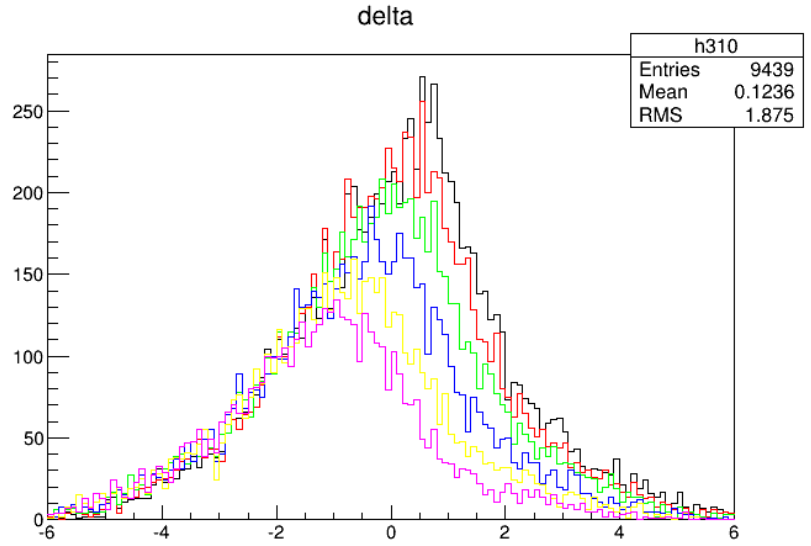
→ Correction according to InvMass

# Summary & Outlook

δ (%)




Yc=0.
Yc=+0.2 mm
Yc=+0.4 mm
Yc=+0.6 mm
Yc=+0.8 mm
Yc=+1 mm



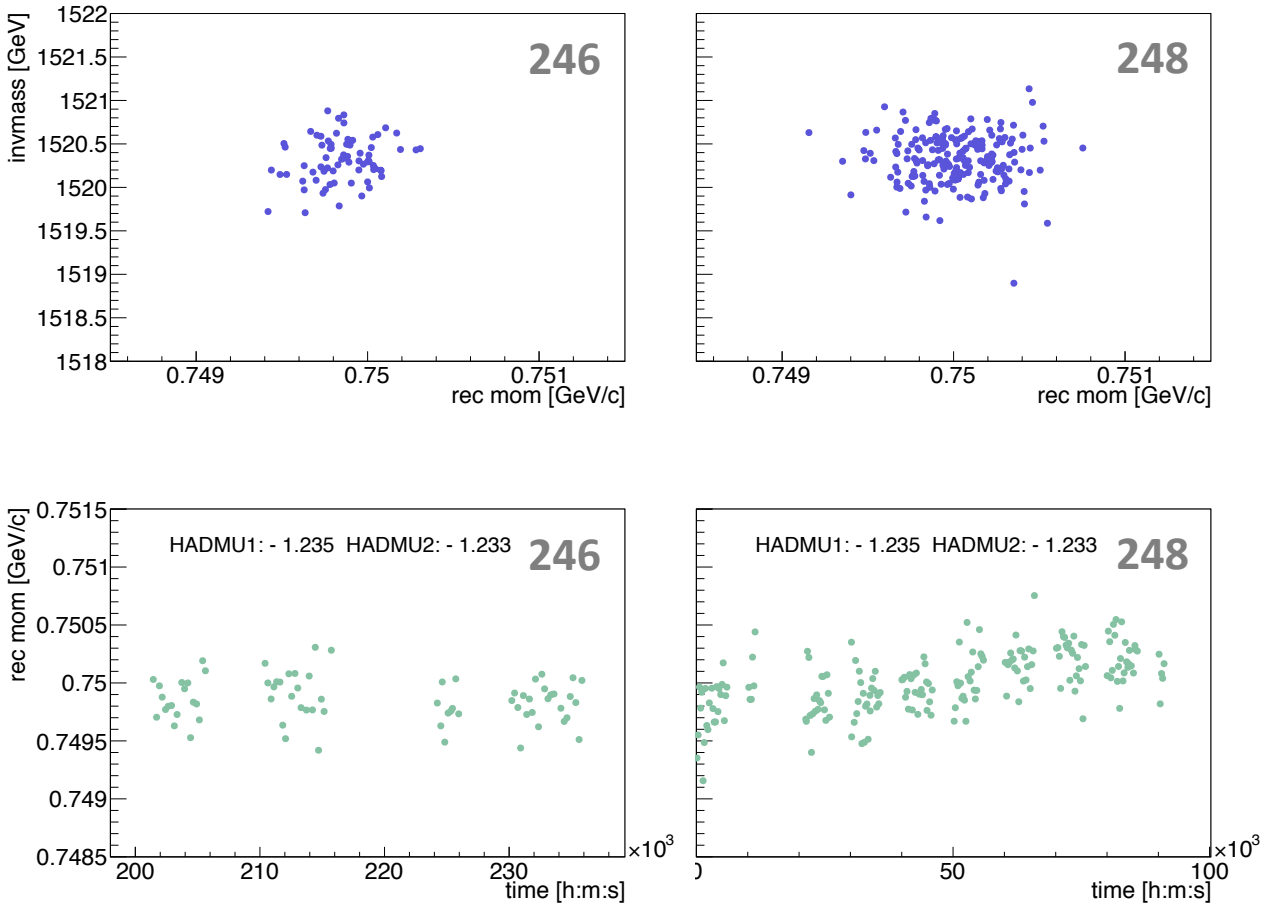

Yc=0.
Yc=-0.2 mm
Yc=-0.4 mm
Yc=-0.6 mm
Yc=-0.8 mm
Yc=-1 mm

Relatively small effect up to 0.6 mm
Most probable value not affected,
mean value slightly shifted downwards

Effect is larger
Most probable value shifted downwards
Slightly larger shift for the mean value

# InvMass vs. MaxMom for each Run

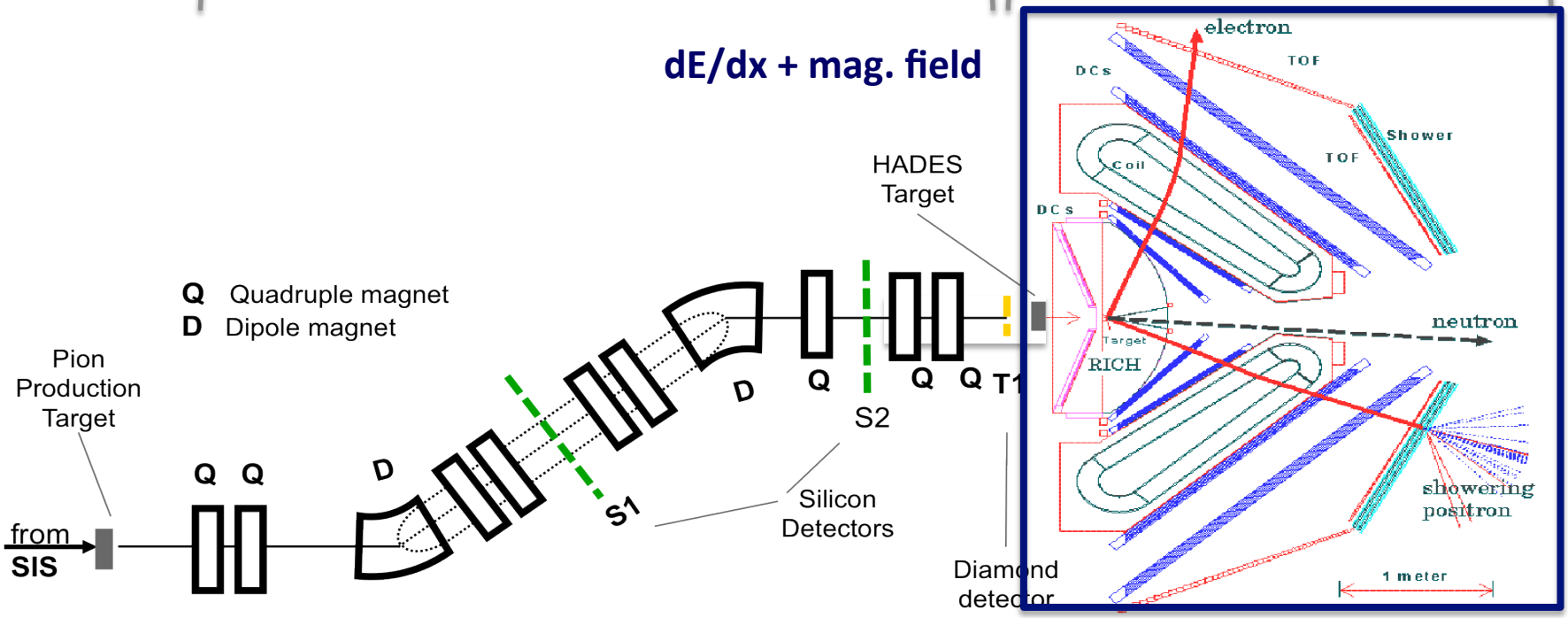
CENTRAL BEAM MOMENTUM: 0.748 GeV/c (PE)



# Comparison between $M_{\pi\text{-}p}$ and √s

| √s (tuned HADMU2 (START)): | ΔE | InvMass (dE/dx + mag. field corr.): |
|---|---|---|
| 1497 | 9 | 1488 |
| 1475 | 8 | 1467 |
| 1529 | 10 | 1519 |
| 1560 | 10 | 1550 |

**dE/dx + mag. field**

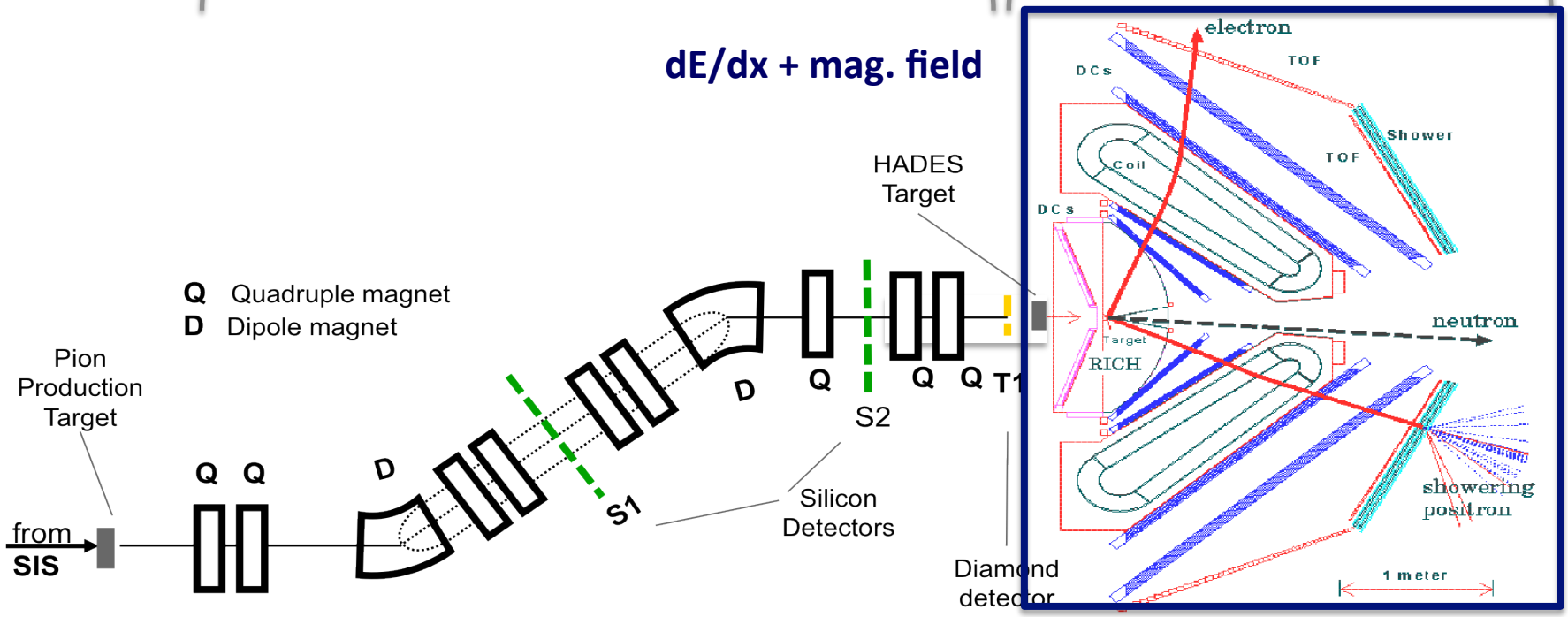


# Comparison between $p_\pi(M_{\pi\text{-}p})$ and $p_\pi(\sqrt{s})$

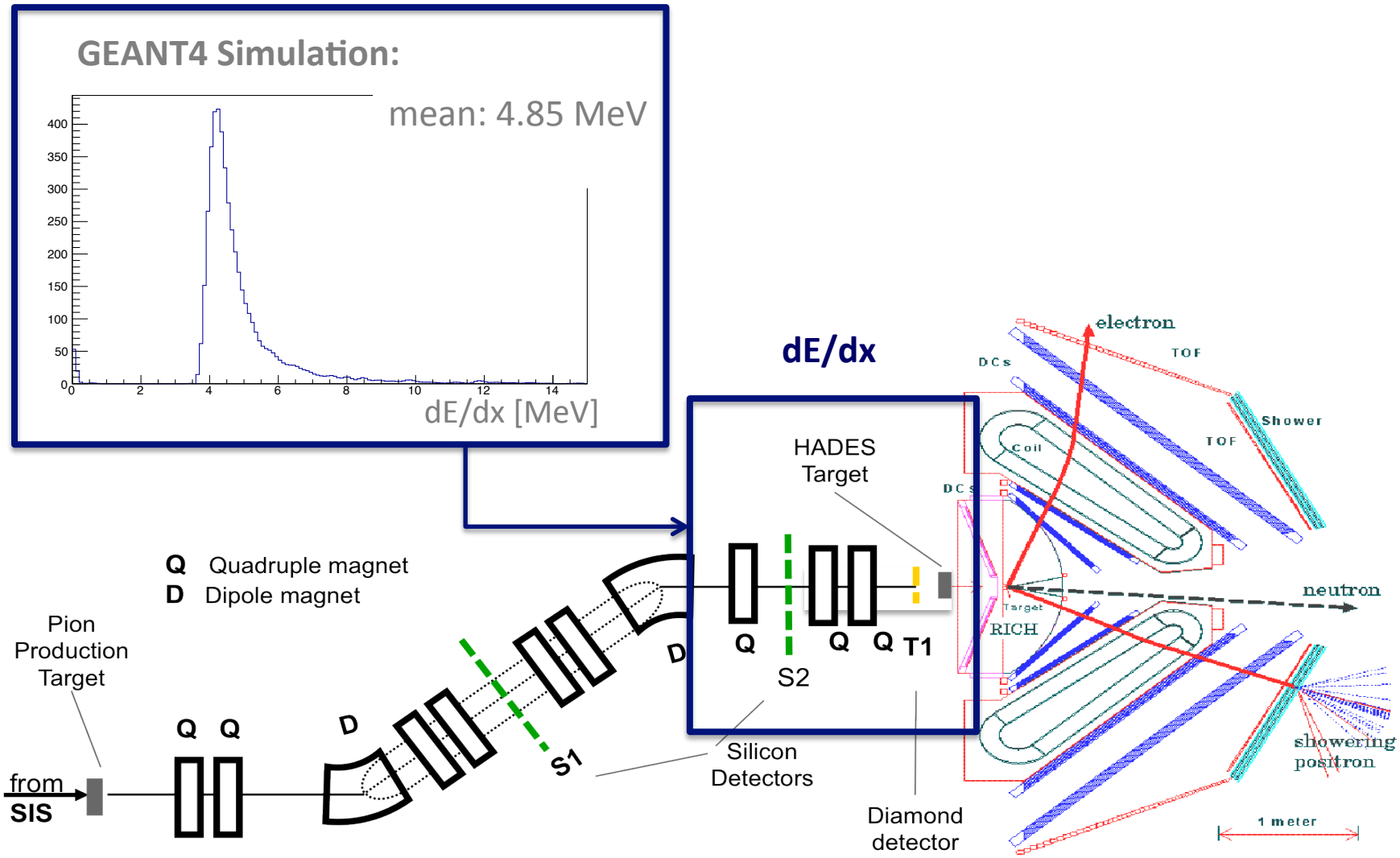
| $p_{ref}$: | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|
| 690.0 | 700.0 | 14 | 686.3 |
| 656.0 | 666.0 | 13 | 652.9 |
| 748.0 | 753.0 | 16 | 737.0 |
| 800.0 | 806.0 | 18 | 788.5 |

$$p_{rec} = (1+\delta)\cdot p_{ref}$$

**dE/dx + mag. field**

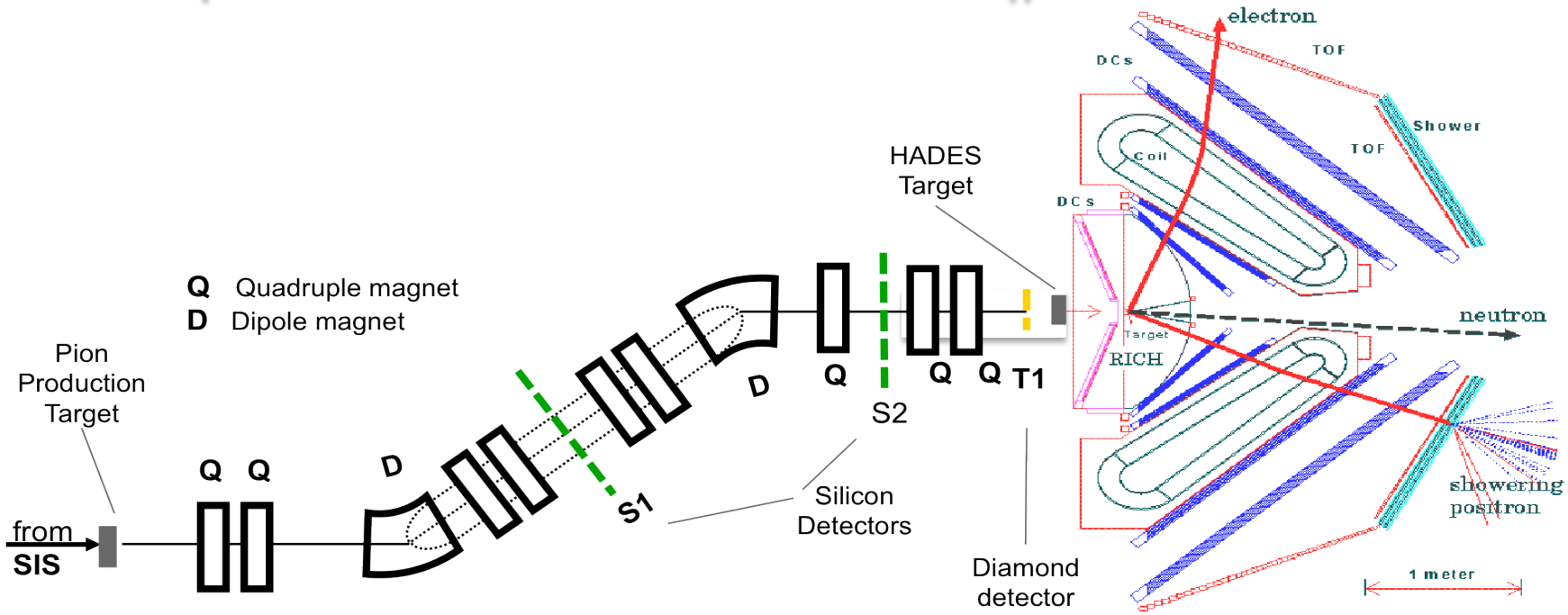


# Energy Loss along the Chicane



# Comparison between $M_{\pi\text{-}p}$ and √s

| | √s (tuned HADMU2 (START)): | ΔE | InvMass (dE/dx + mag. field corr.): |
|---|---|---|---|
| GEANT4 | 1494 | 6 | 1488 |
| | 1472 | 5 | 1467 |
| | 1526 | 7 | 1519 |
| | 1557 | 7 | 1550 |

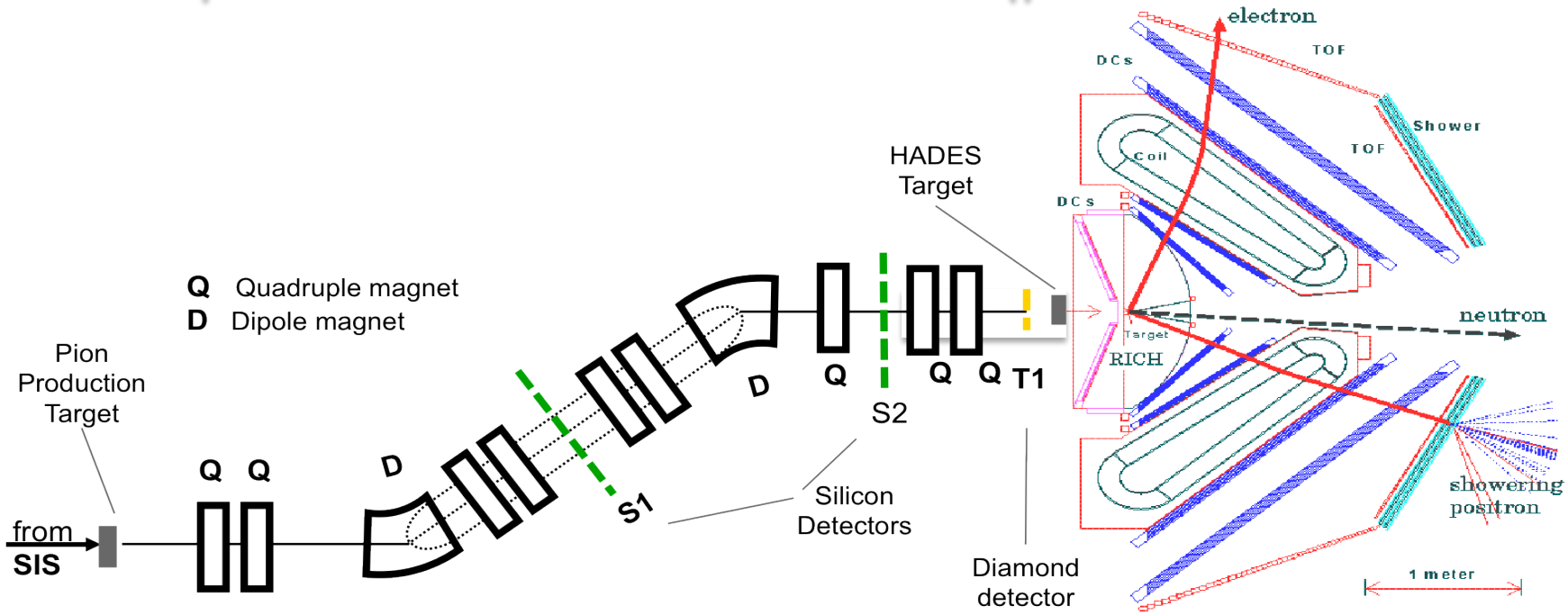


# Comparison between $p_\pi(M_{\pi\text{-}p})$ and $p_\pi(\sqrt{s})$

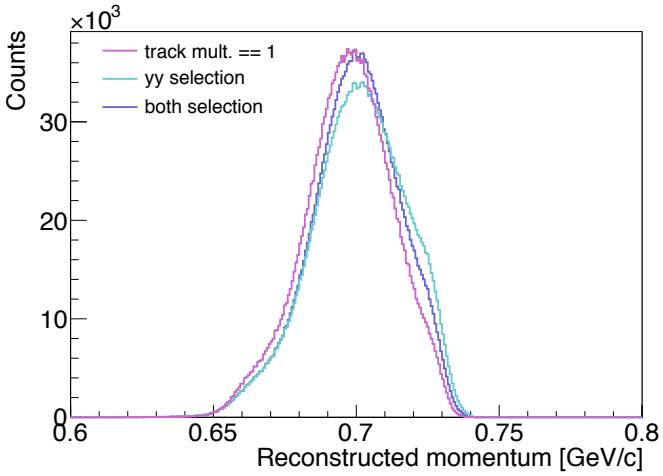
**GEANT4**

| $p_{ref}$: | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|
| 690.0 | 696.0 | 10 | 686.3 |
| 656.0 | 660.4 | 8 | 652.9 |
| 748.0 | 748.6 | 12 | 737.0 |
| 800.0 | 800.4 | 12 | 788.5 |

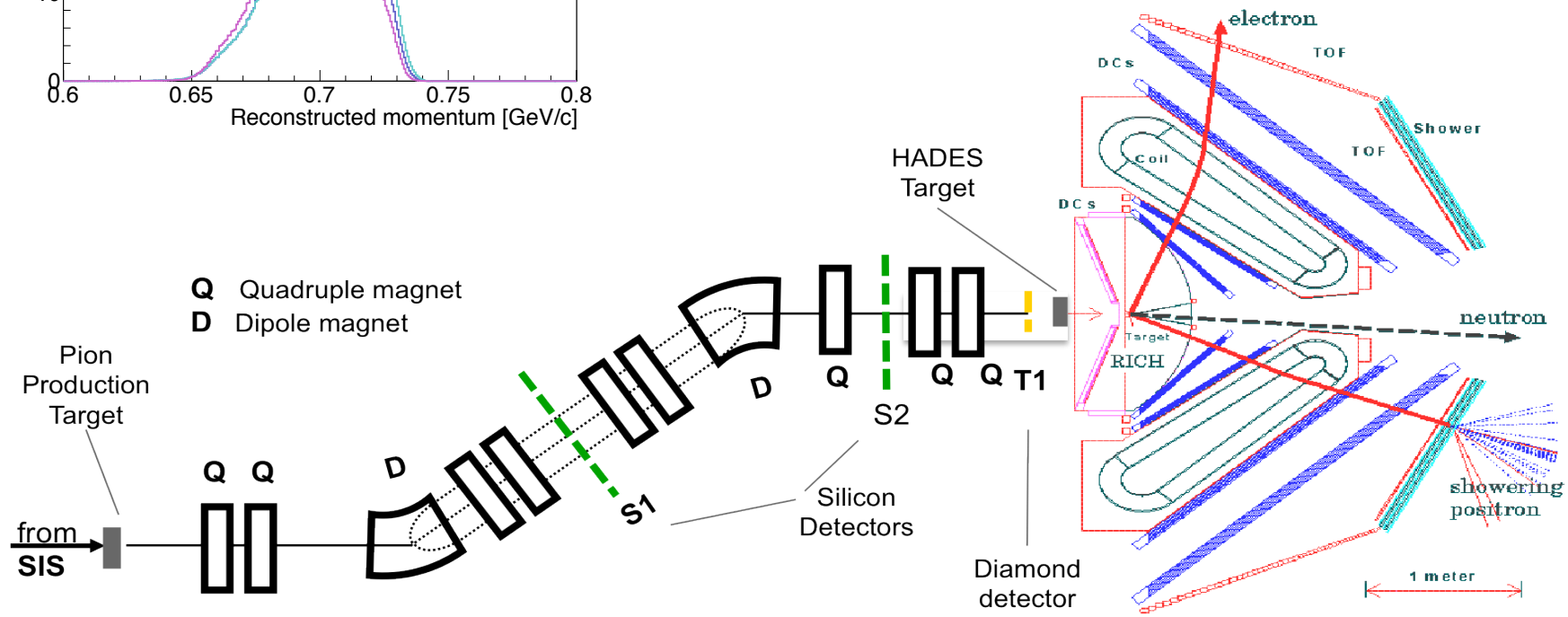
$$p_{rec} = (1+\delta)\cdot p_{ref}$$



# Momentum Shift Correction of √s

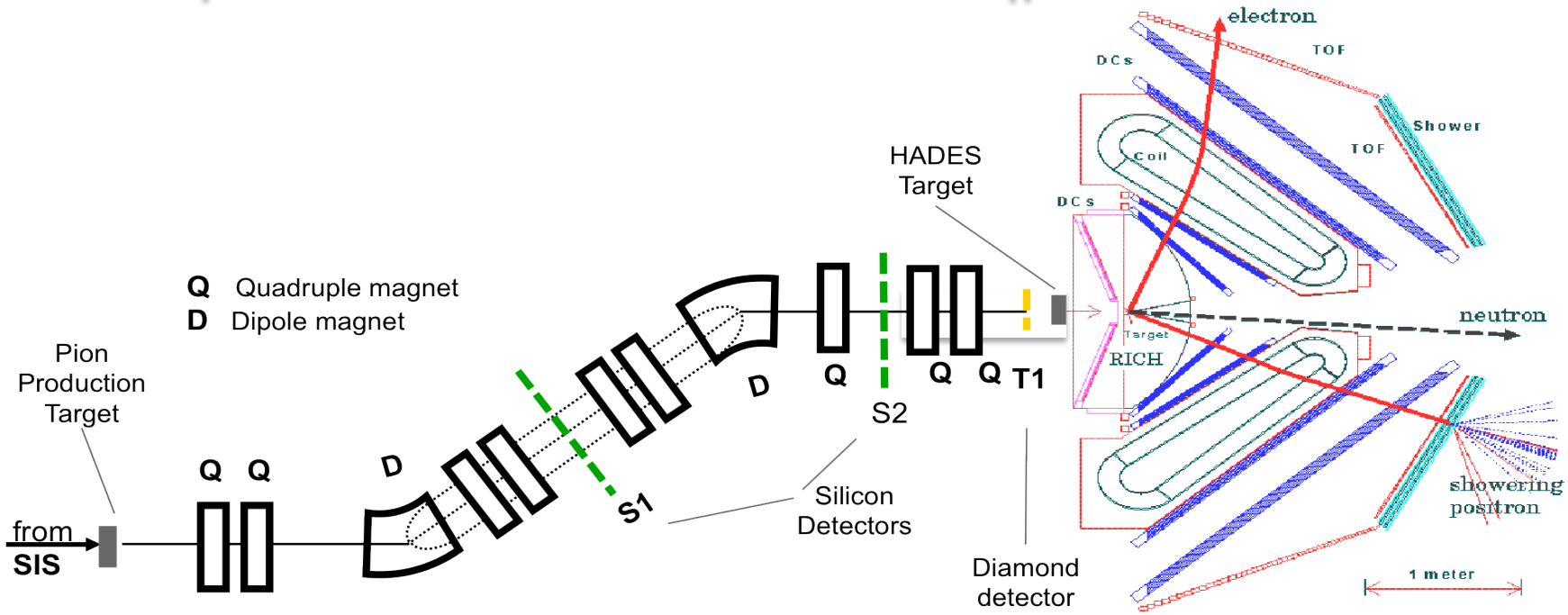



| RefValue | MaxValue (Mult1) | MaxValue (S2) |
|---|---|---|
| 690 | 698 | 700 |



# Comparison between $M_{\pi\text{-}p}$ and √s

| | √s (tuned HADMU2 (START)): | ΔE | InvMass (dE/dx + mag. field corr.): |
|---|---|---|---|
| GEANT4 | 1493 | 5 | 1488 |
| | 1471 | 4 | 1467 |
| | 1524 | 5 | 1519 |
| | 1556 | 6 | 1550 |



# Comparison between $p_\pi(M_{\pi\text{-}p})$ and $p_\pi(\sqrt{s})$

GEANT4

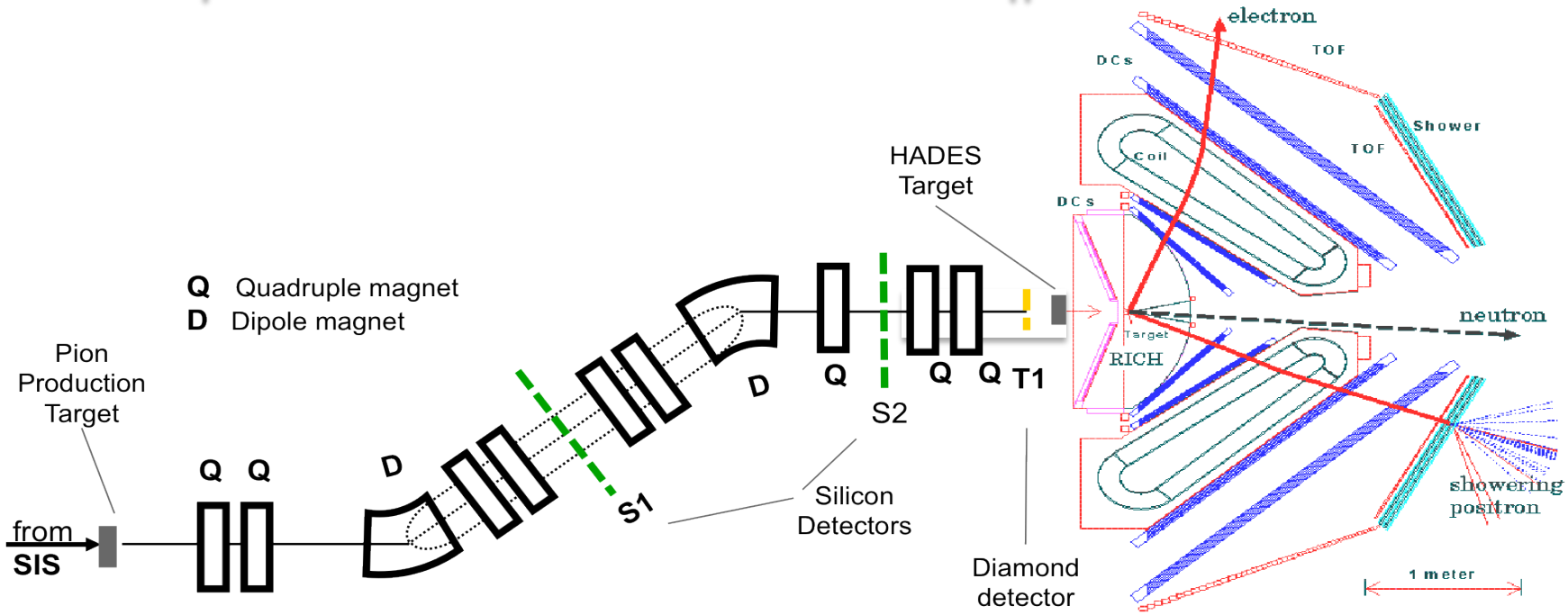
| $p_{ref}$: |
|---|
| 690.0 |
| 656.0 |
| 748.0 |
| 800.0 |

$$p_{rec} = (1+\delta)\cdot p_{ref}$$

| $p_\pi(\sqrt{s})$: |
|---|
| 694.0 |
| 658.4 |
| 745.6 |
| 798.4 |

| Δp |
|---|
| 8 |
| 6 |
| 9 |
| 11 |

| $p_\pi(M_{\pi\text{-}p})$ : |
|---|
| 686.3 |
| 652.9 |
| 737.0 |
| 788.5 |

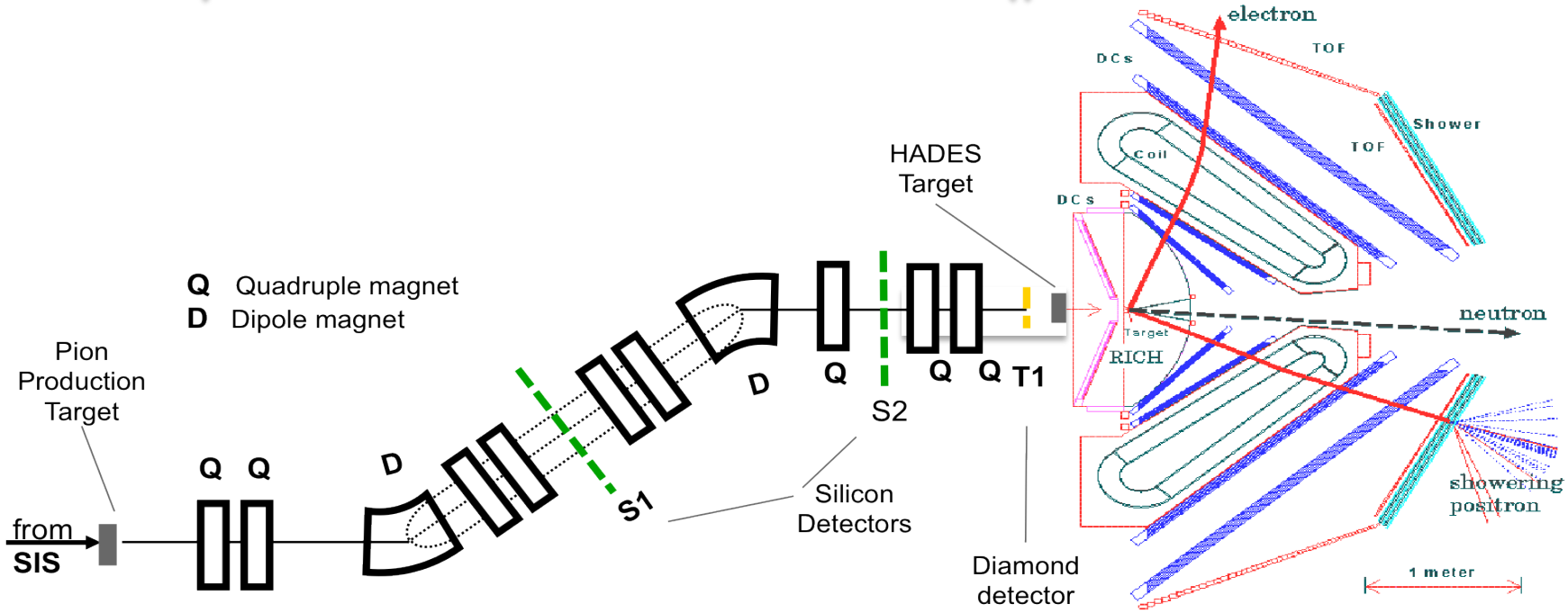


# Comparison between $p_\pi(M_{\pi\text{-}p})$ and $p_\pi(\sqrt{s})$

GEANT4

| $p_{ref}$: | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|
| 690.0 | 694.0 | 8 | 686.3 |
| 656.0 | 658.4 | 6 | 652.9 |
| 748.0 | 745.6 | 9 | 737.0 |
| 800.0 | 798.4 | 11 | 788.5 |

$$p_{rec} = (1+\delta)\cdot p_{ref}$$



# Comparison between $p_\pi(M_{\pi\text{-}p})$ and $p_\pi(\sqrt{s})$

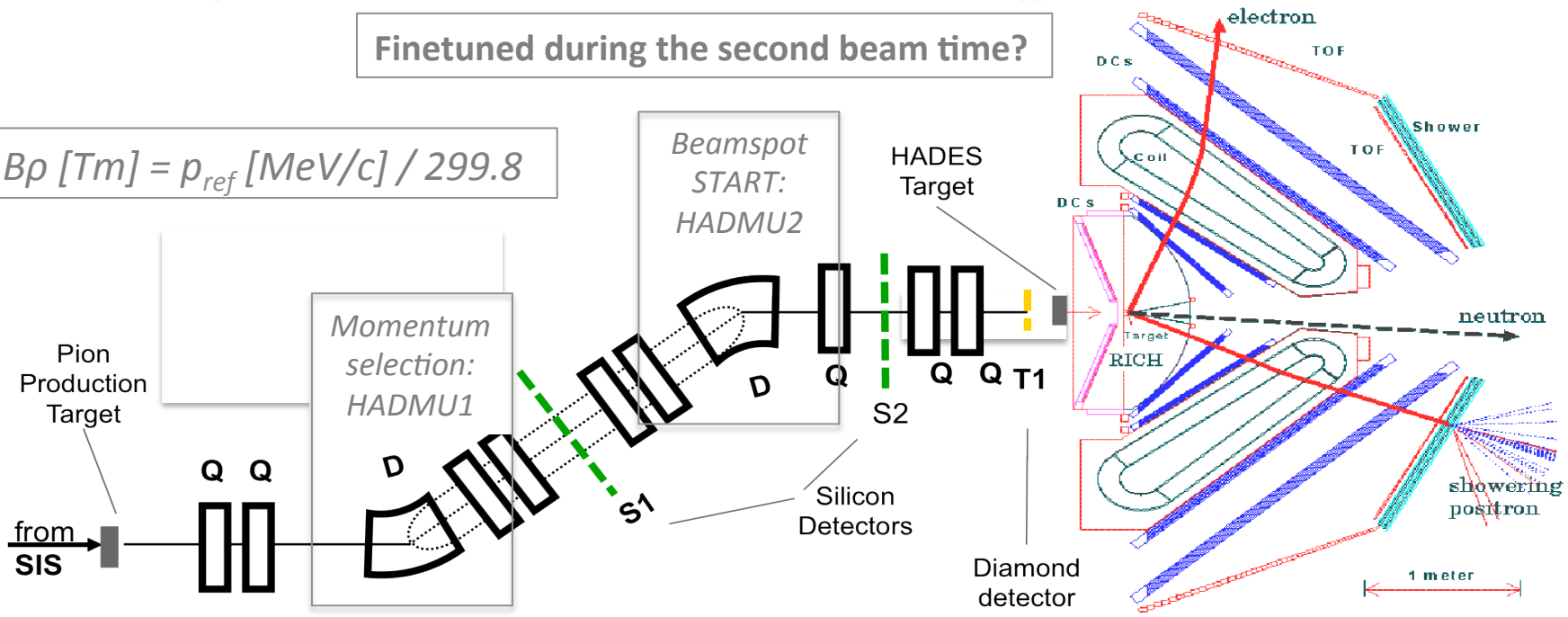
**GEANT4**

| $p_{ref}$: | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|
| 690.0 | 694.0 | 8 | 686.3 |
| 656.0 | 658.4 | 6 | 652.9 |
| 748.0 | 745.6 | 9 | 737.0 |
| 800.0 | 798.4 | 11 | 788.5 |

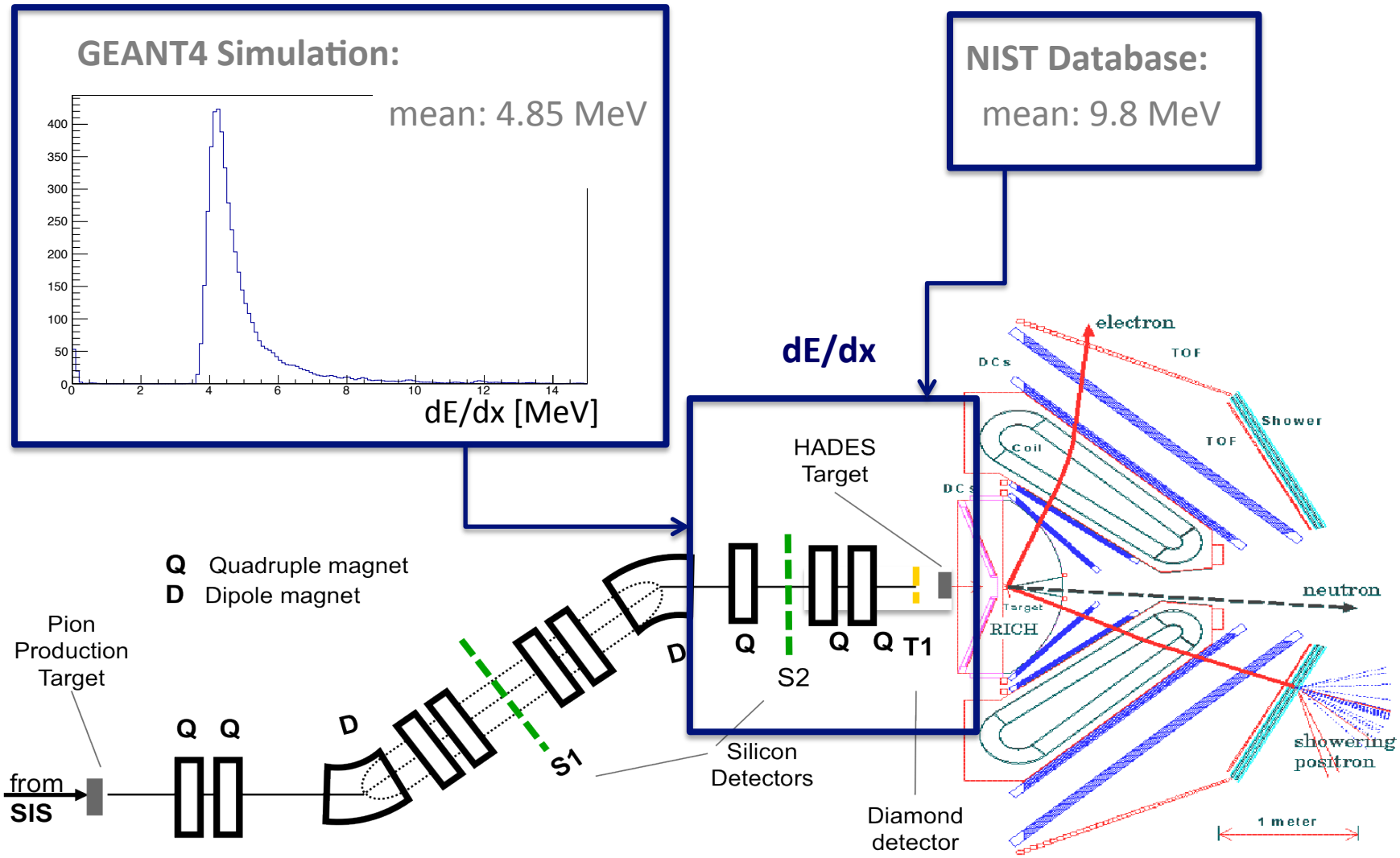
$$p_{rec} = (1+\delta)\cdot p_{ref}$$

**Finetuned during the second beam time?**

*Bρ [Tm] = $p_{ref}$ [MeV/c] / 299.8*



# Energy Loss along the Chicane



# Energy Loss Correction of √s

| | √s (tuned HADMU2 (START)): | ΔE | InvMass (dE/dx + mag. field corr.): |
|---|---|---|---|
| **GEANT4** | 1494 | 6 | 1488 |
| | 1472 | 5 | 1467 |
| | 1526 | 7 | 1519 |
| | 1557 | 7 | 1550 |
| **NIST** | 1492 | 4 | 1488 |
| | 1470 | 3 | 1467 |
| | 1524 | 5 | 1519 |
| | 1555 | 5 | 1550 |

# Comparison between $p_\pi(\sqrt{s})$ and $p_\pi(M_{\pi\text{-}p})$

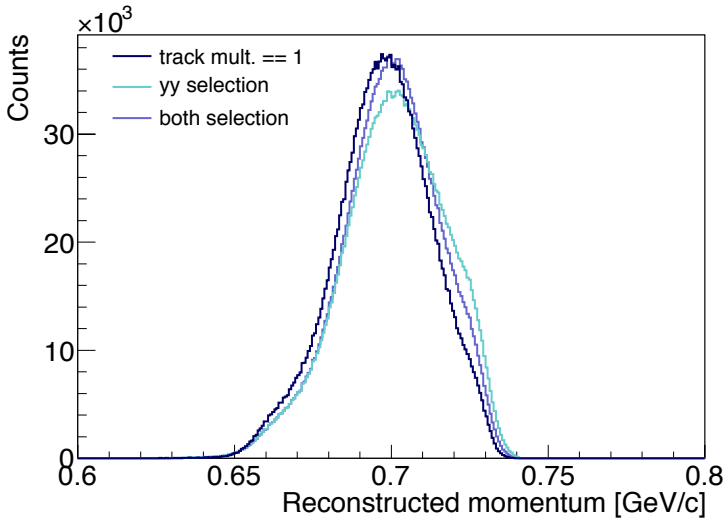
**GEANT4**

| $p_{ref}$: | $p_{rec} = (1+\delta)\cdot p_{ref}$ | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|---|
| 690.0 | | 696.0 | 10 | 686.3 |
| 656.0 | | 660.4 | 8 | 652.9 |
| 748.0 | | 748.6 | 12 | 737.0 |
| 800.0 | | 800.4 | 12 | 788.5 |

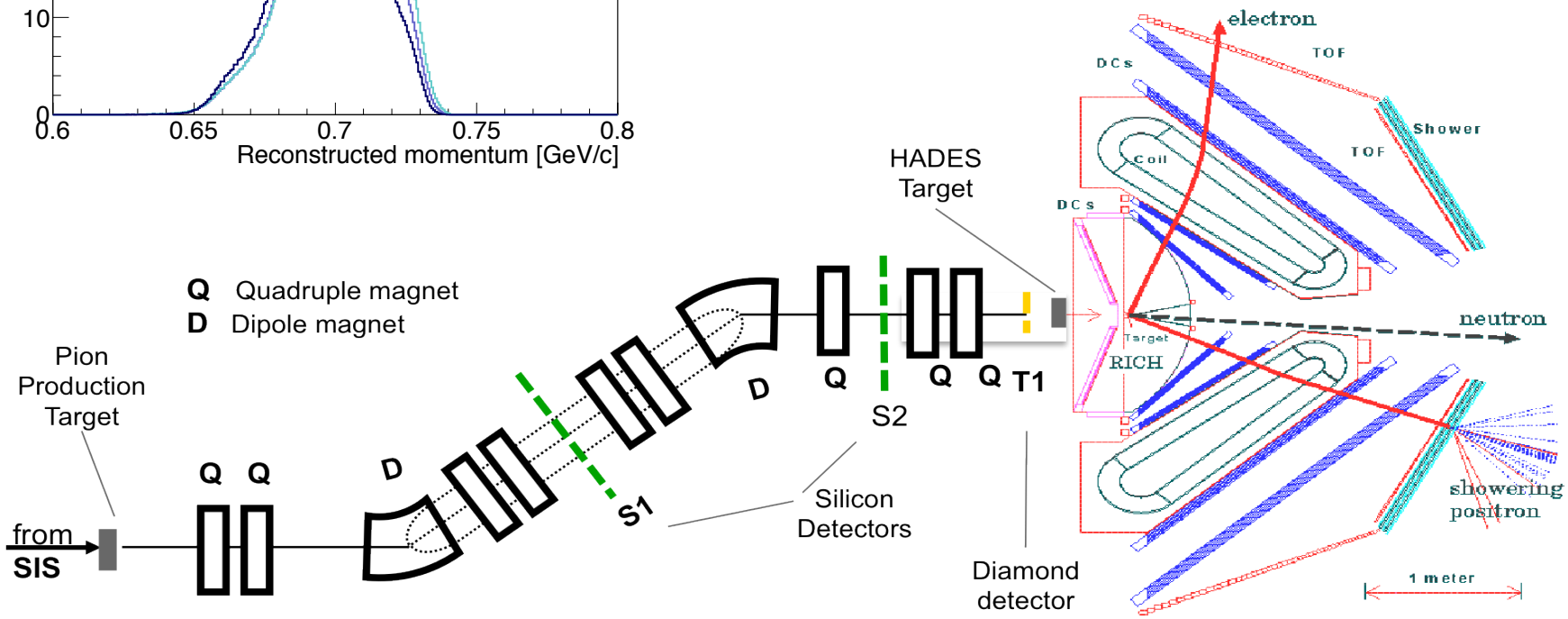
**NIST**

| $p_{ref}$: | $p_{rec} = (1+\delta)\cdot p_{ref}$ | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|---|
| 690.0 | | 693.3 | 7 | 686.3 |
| 656.0 | | 657.7 | 5 | 652.9 |
| 748.0 | | 745.9 | 9 | 737.0 |
| 800.0 | | 797.7 | 9 | 788.5 |

# Momentum Shift Correction of √s




| RefValue | MaxValue (Mult1) | MaxValue (S2) |
|---|---|---|
| 690 | 698 | 700 |



# Momentum Shift Correction of √s

| | √s (tuned HADMU2 (START)): | ΔE | InvMass (dE/dx + mag. field corr.): |
|---|---|---|---|
| **GEANT4** | 1493 | 5 | 1488 |
| | 1471 | 4 | 1467 |
| | 1524 | 5 | 1519 |
| | 1556 | 6 | 1550 |

| | √s (tuned HADMU2 (START)): | ΔE | InvMass (dE/dx + mag. field corr.): |
|---|---|---|---|
| **NIST** | 1491 | 3 | 1488 |
| | 1469 | 2 | 1467 |
| | 1523 | 4 | 1519 |
| | 1554 | 4 | 1550 |

# Comparison between $p_\pi(\sqrt{s})$ and $p_\pi(M_{\pi\text{-}p})$

**GEANT4**

| $p_{ref}$: | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|
| 690.0 | 694.0 | 8 | 686.3 |
| 656.0 | 658.4 | 6 | 652.9 |
| 748.0 | 745.6 | 9 | 737.0 |
| 800.0 | 798.4 | 11 | 788.5 |

$$p_{rec} = (1+\delta)\cdot p_{ref}$$

**NIST**

| $p_{ref}$: | $p_\pi(\sqrt{s})$: | Δp | $p_\pi(M_{\pi\text{-}p})$ : |
|---|---|---|---|
| 690.0 | 691.3 | 5 | 686.3 |
| 656.0 | 655.7 | 3 | 652.9 |
| 748.0 | 742.9 | 6 | 737.0 |
| 800.0 | 795.7 | 7 | 788.5 |

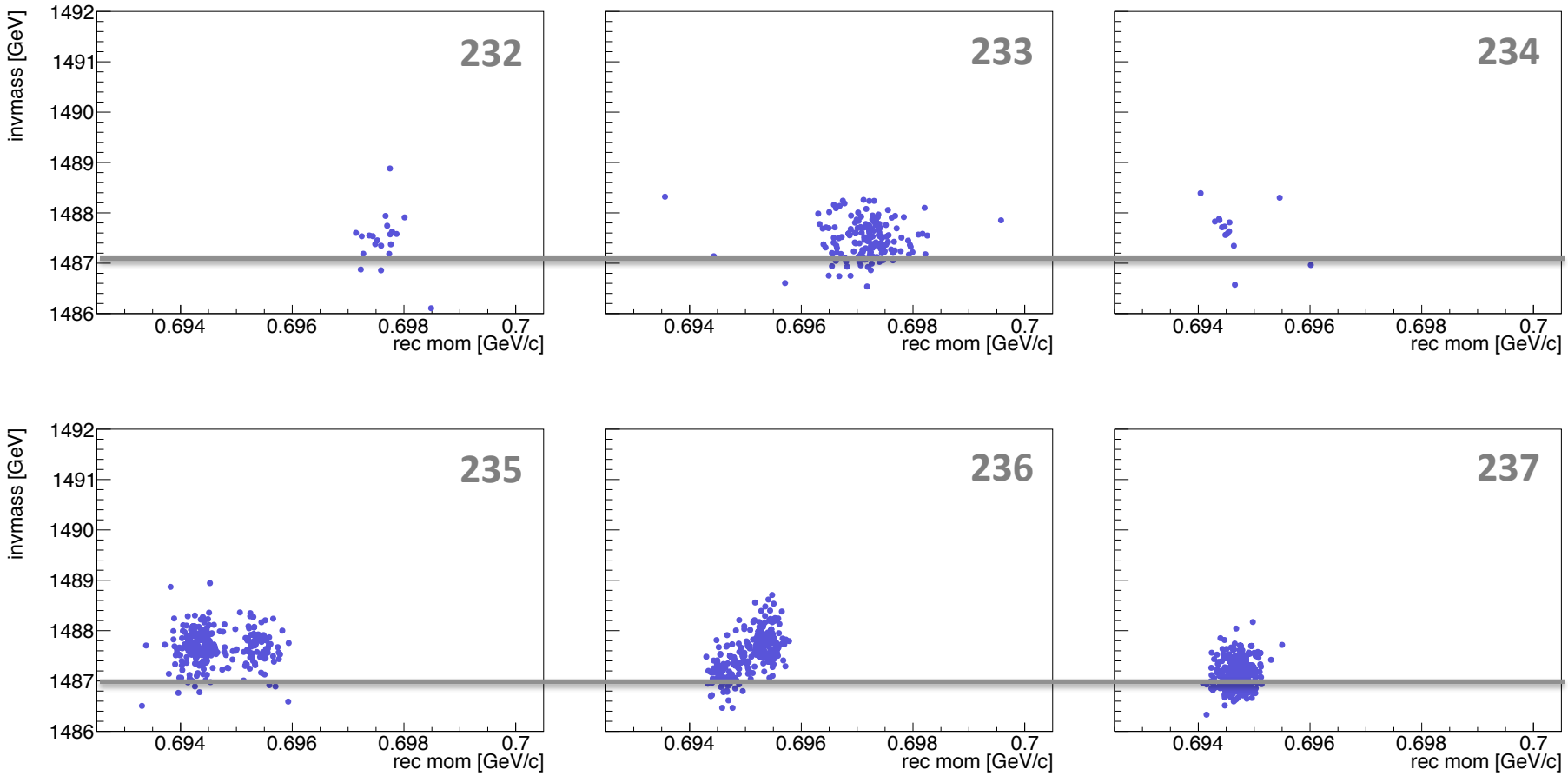
$$p_{rec} = (1+\delta)\cdot p_{ref}$$

→ In both cases part of the shift is remaining, most likely due to the finetuning of the magnets

→ Which dE/dx correction is more reliable?

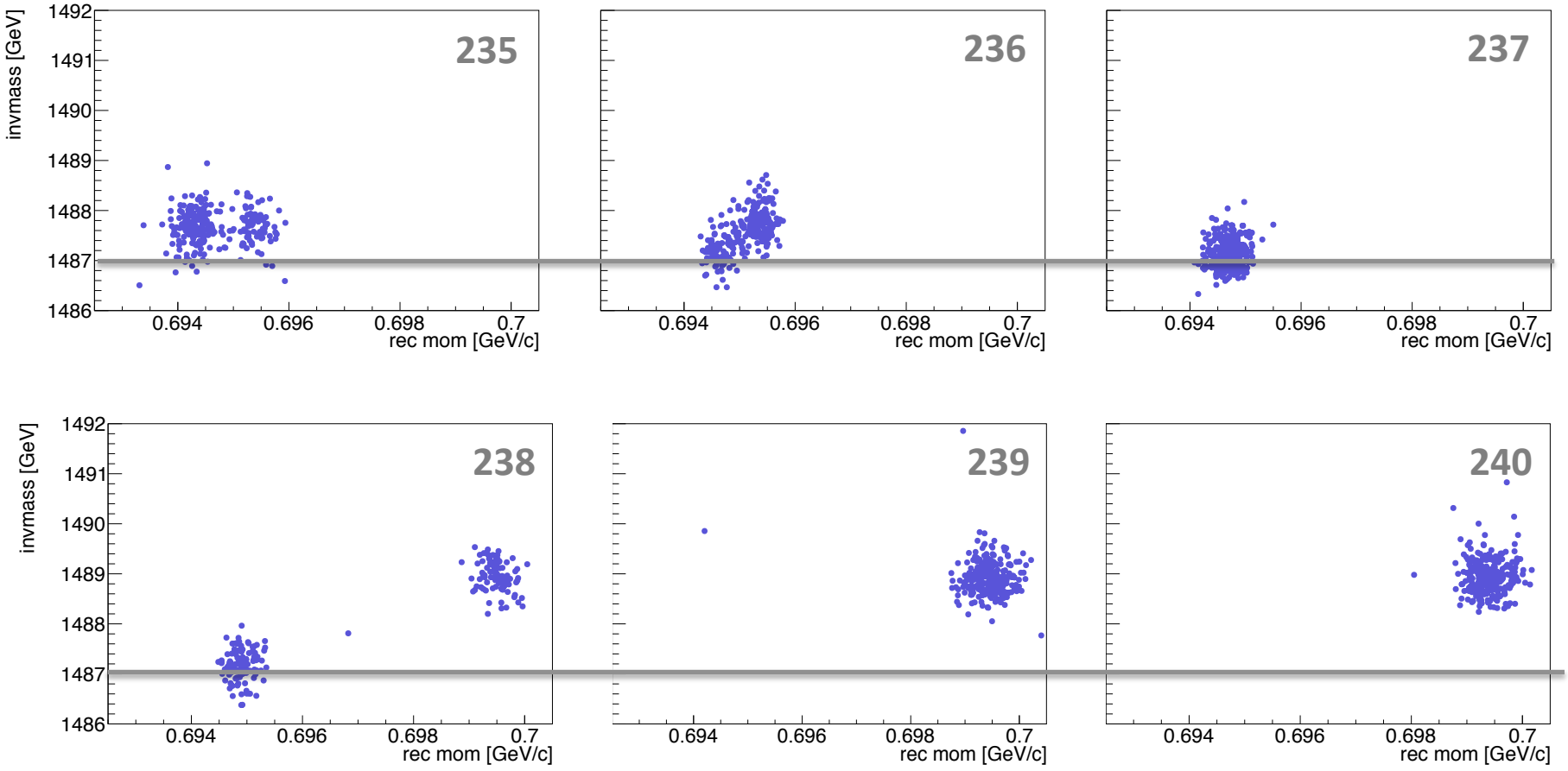
# InvMass vs. MaxMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)



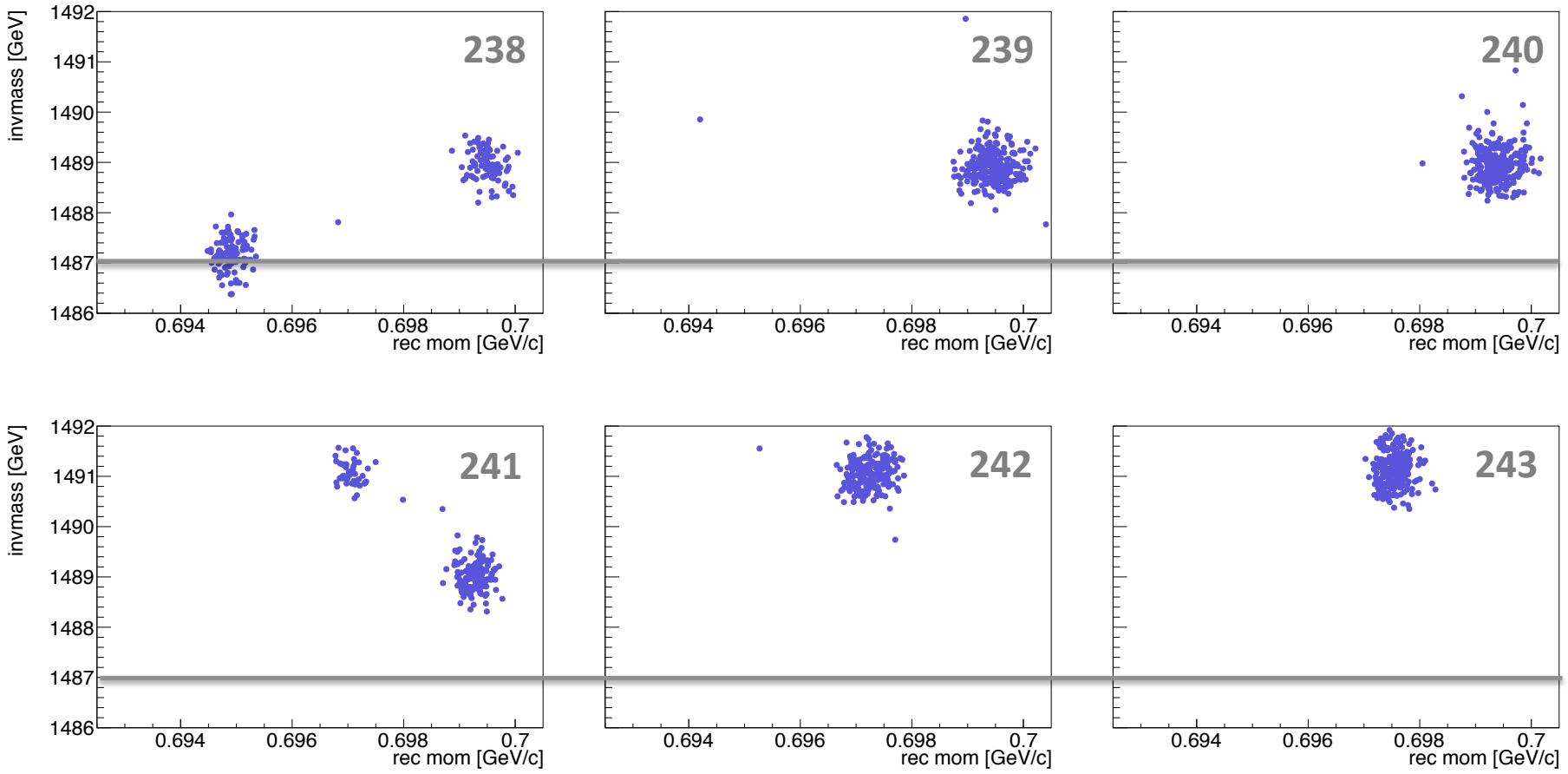
# InvMass vs. MaxMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)



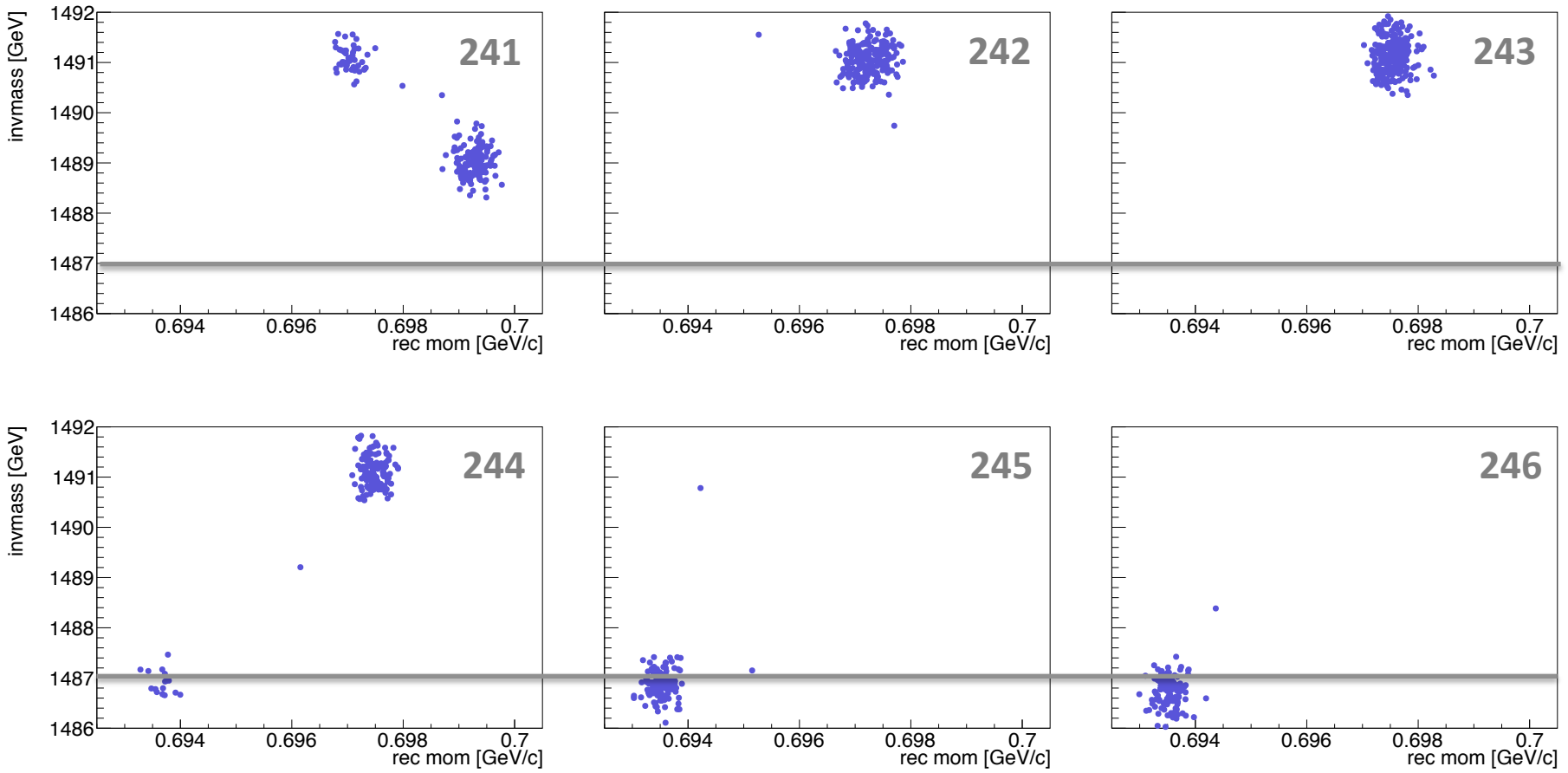
# InvMass vs. MaxMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)



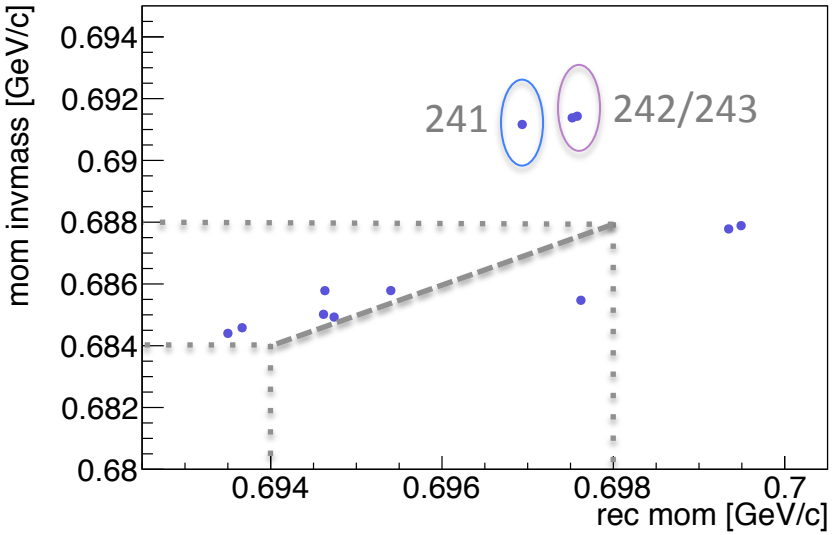
# InvMass vs. MaxMom for each Run

CENTRAL BEAM MOMENTUM: 0.690 GeV/c (PE)

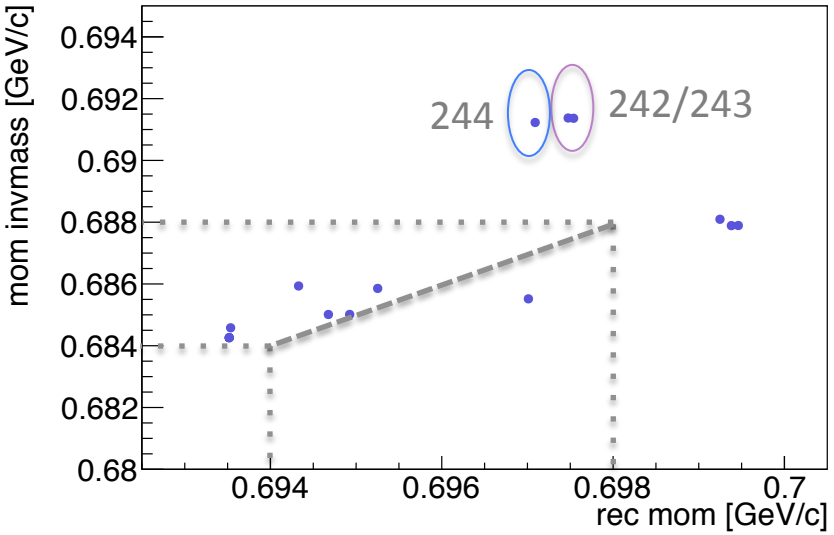


# Summary of 0.690 GeV/c (PE)

EVENING




MORNING




➔ **No linear dependence**