1. Tracking Small-Fine-Calibration

2. Monte Carlo Fine Tuning

3. Measurement of the Likelihood efficiency

Paolo Beltrame
for $\pi\pi\gamma$ group
Phi decay meeting 30.05.07

1. Tracking Small-Fine-Calibration

Methods

1. **Collinear events** ⇒ expected vs observed momentum quantities

   High $M_{\pi\pi}^2$ region

2. **π^0 Mass** ⇒ $\pi^+\pi^-\pi^0$ Missing Mass

   Low $M_{\pi\pi}^2$ region

Collinear events DATA "sample"

- **2002**: Venanzoni's CLB `prod2ntu-`ntuples (for collinear events),
  standard `stentu-`ntuples (for Trackmass)
- **2006**: standard `stentu-`ntuples (abundance of collinear events)
- Müller's DATA run quality applied (**2002** DATA only) and new `ppgtag`
- Condition on first hit: $\rho_{\text{First Hit}} < 50$ cm
- Condition on PCA: $\rho_{PCA} < 8$ cm, $|z_{PCA}| < 12$ cm
  (selecting, for **2002**, tracks from DTFS with the same ID of tracks making the vertex)
- Condition on vertex: $\rho_{vtz} < 12$ cm, $|z_{vtx}| < 7$ cm
- Cut on spiraling tracks
- `.and.` of the Likelihood
- Tracks in the angular region $50° < \theta < 130°$

Collinear event selection

$M_{\pi\pi}^2 > 0.95$ GeV^2

no prompt photon detected

$$\Delta\phi_{CM} = \pi - |\phi^+_{CM} - \phi^-_{CM}| < 0.5°$$

$$\Delta\theta_{CM} = \pi - |\theta^+_{CM} + \theta^-_{CM}| < 0.5°$$

$$\Delta p_{CM} = |p_{CM}^+| - |p_{CM}^-| < 5 \text{ MeV}$$

πππ events "sample"

- **2002**: standard 3π`stream-`ntuples
- **2006**: Venanzoni's πππ MC 2006 `prod2ntu-`ntuples
- Müller's DATA run quality applied (**2002** DATA only)
- Condition on first hit: $\rho_{\text{First Hit}} < 50$ cm
- Condition on PCA: $\rho_{PCA} < 8$ cm, $|z_{PCA}| < 12$ cm

  (selecting, for **2006**, tracks from DTFS with the same ID of tracks making the vertex)
- Condition on vertex: $\rho_{vtz} < 12$ cm, $|z_{vtx}| < 7$ cm
- Cut on spiraling tracks
- `.and.` of the Likelihood
- Tracks in the angular region $50° < \theta < 130°$

πππ event selection

$0 < \chi^2 < 50$

$\sqrt{s}$

2002 DATA

$\sqrt{s} \rightarrow \sqrt{s}$ (no 150 KeV correction)

2006 DATA

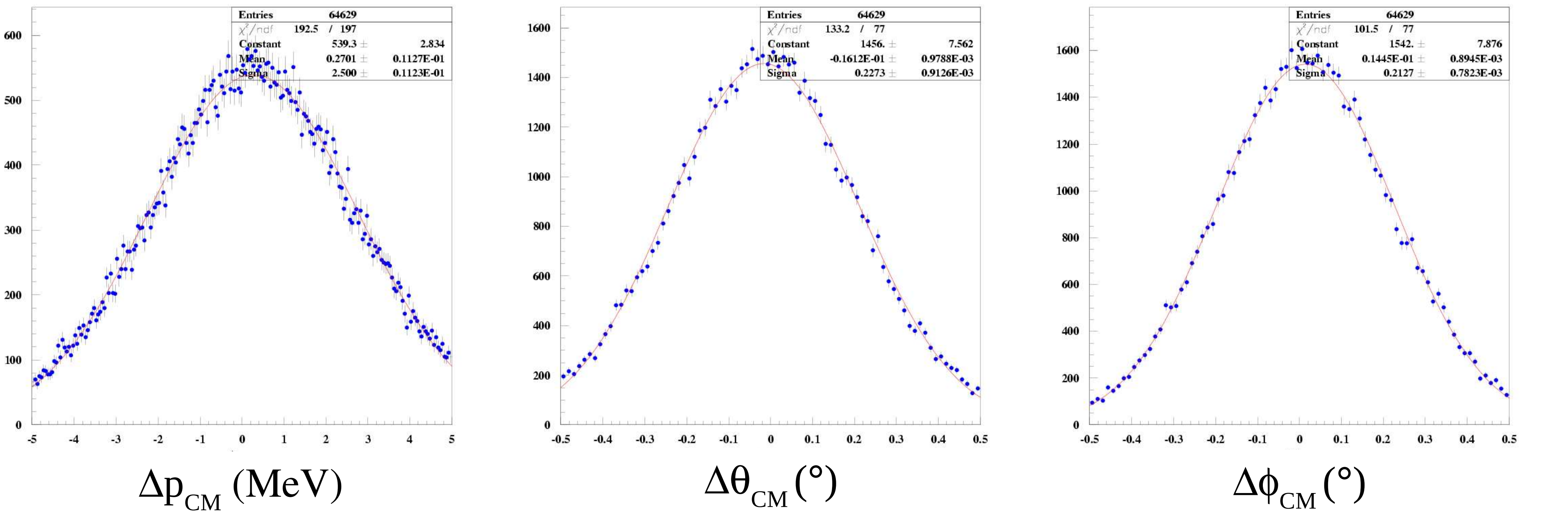
2006: $\sqrt{s} \rightarrow \sqrt{s}$ **–240KeV** (Müller's ϕ-lineshape fit)

DATA 2002

Collinear Events

in the CM system

DATA 2002



Mean value of the gaussian fits

Δp_{CM} **= (0.270 ± 0.011) MeV**

$\Delta\theta_{CM} = (-0.0161 \pm 0.0098)°$

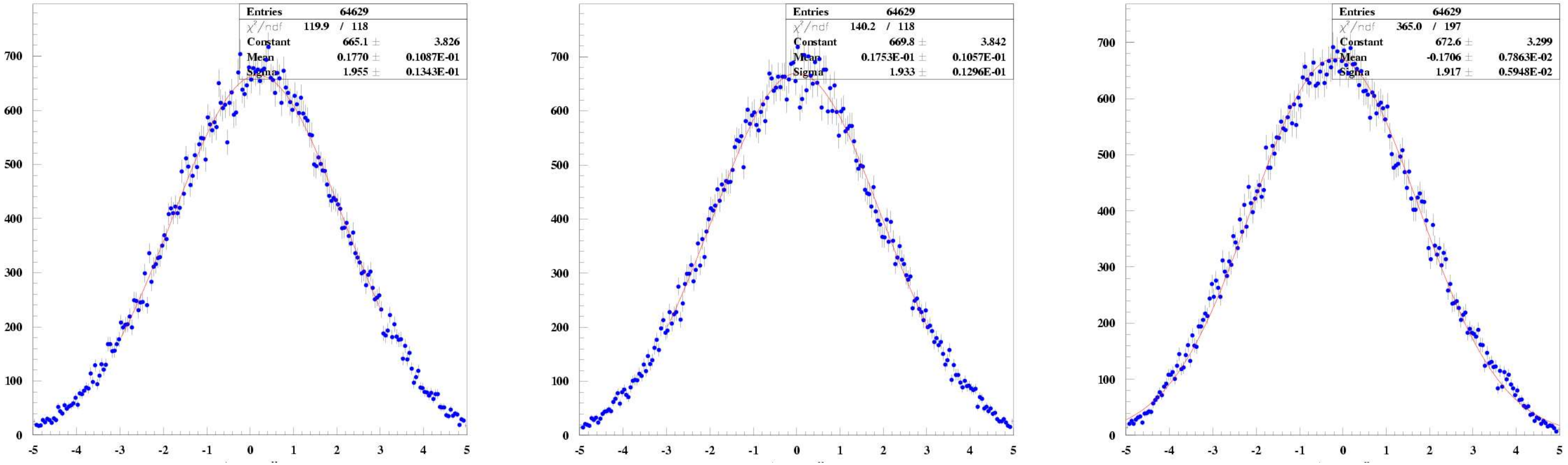
$\Delta\phi_{CM} = (0.0145 \pm 0.0009)°$

Hint of tiny miscalibration?

DATA 2002
Collinear Events
in the CM system

$p_i^+{}_{CM} - p_i^-{}_{CM} = \Delta p_{i\,CM}$

DATA 2002



Δpx_{CM} (MeV) Δpy_{CM} (MeV) Δpz_{CM} (MeV)

Mean value of the gaussian fits

$\Delta p_{x\,CM}$ = (0.177 ± 0.011) MeV Hint of tiny miscalibration?

$\Delta p_{y\,CM}$ = (0.018 ± 0.011) MeV

$\Delta p_{z\,CM}$ = (-0.171 ± 0.008) MeV Hint of tiny miscalibration?

Expected vs Observed quantities for collinear events

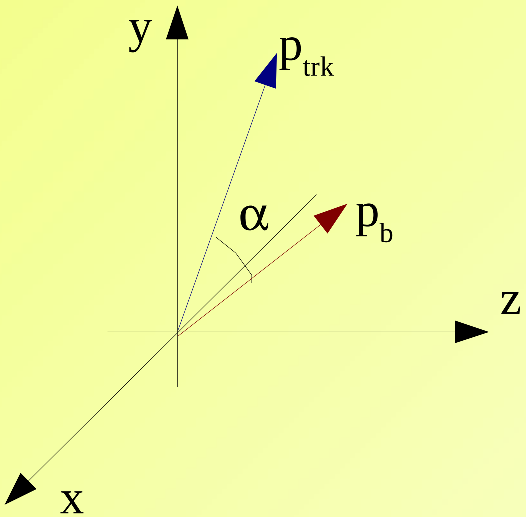
1. Expected and observed **momentum** **ee → ππ hypothesis**

$$\sqrt{(\sqrt{s}/2)^2 - m_\pi^2} = |\vec{p}_{CM}|$$

CM system

positive track (-0.260 ± 0.014) MeV

2. Expected and observed **track-boost angle** **ee → ππ hypothesis** ($|M_{trk} - m_\pi| < 20$ MeV)



$$\cos(\alpha) = E_b \cdot E_{trk} - \frac{S}{2} = \vec{p}_b \cdot \vec{p}_{trk}$$

Expected — Observed

LAB system

E_b: Total energy from the beams

p_b: boost

positive track (-2.66 ± 0.007) °

Momentum SFC

steps

0. z component fixed
1. agreement between expected and observed values: Δp and $\Delta\alpha$
2. check the effect on:
   - 2002 ⇒ missing mass for $\pi\pi\pi$ DATA events
     ⇒ Trackmass for $\pi\pi\gamma$ DATA events
   - 2006 ⇒ Trackmass for $\pi\pi\gamma$ DATA

- Trackmass value to obtain ⇒ MC `kine`

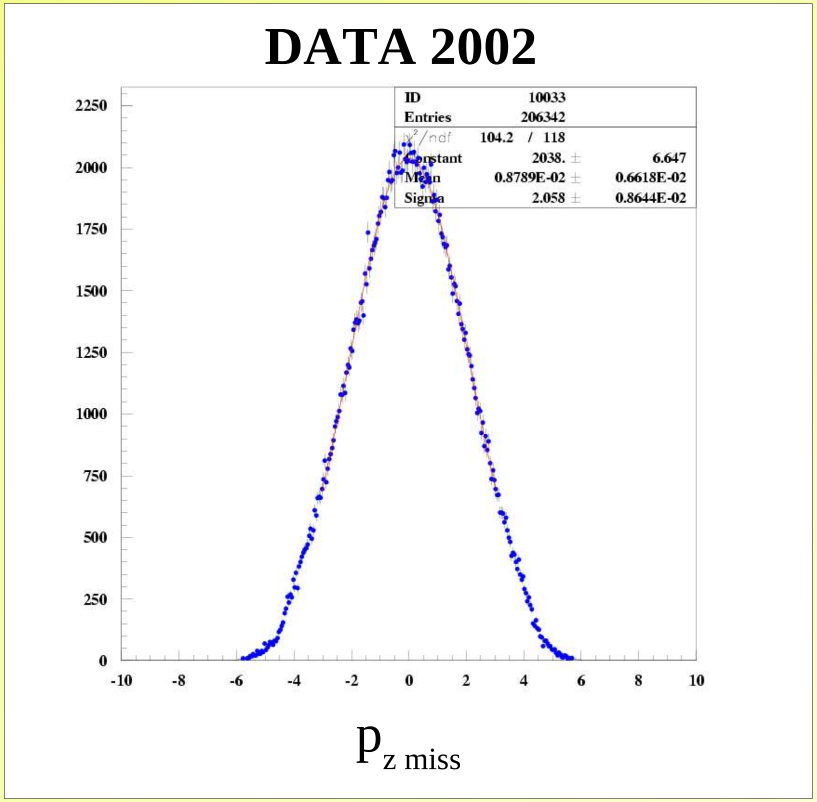
3. go back to 1. and see *“di nascosto l'effetto che fa”*
4. reach a compromise

2002

- $\sqrt{s} \rightarrow \sqrt{s}$ (as it is from the bank: no 150 KeV correction)
- Corrections on momenta :

positive $p_z \rightarrow p_z + |p_z| \cdot 5 \cdot 10^{-4}$, $p_{x,y} \rightarrow p_{x,y} \cdot (1 - 7 \cdot 10^{-4})$

negative $p_z \rightarrow p_z + |p_z| \cdot 4 \cdot 10^{-4}$, $p_{x,y} \rightarrow p_{x,y} \cdot (1 - 2 \cdot 10^{-4})$



$p_{z\ miss}$ = (0.01 ± 0.007) MeV

Other variables of collinear events also good → peaked at zero

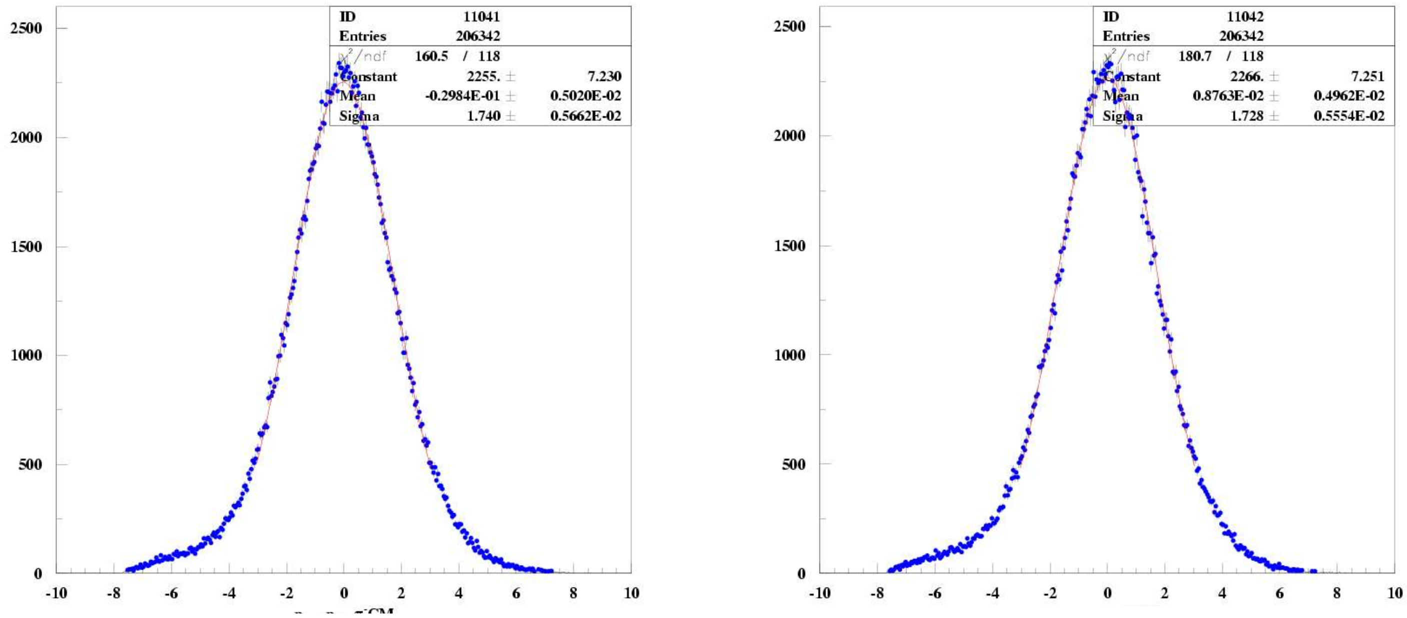
Expected vs Observed quantities for collinear events (2002)

1. Expected and observed **momentum ee → ππ hypothesis**

$$\sqrt{(\sqrt{s}/2)^2 - m_\pi^2} = |\vec{p}_{CM}|$$

CM System

DATA 2002



$p_{exp} - p^{+}_{obs}$ (MeV) $\qquad$ $p_{exp} - p^{-}_{obs}$ (MeV)

(-0.030 ± 0.005) MeV $\qquad$ **(-0.009 ± 0.005) MeV**

2. Expected and observed **track-boost angle ee → ππ hypothesis** ($|M_{trk} - m_\pi| < 20$ MeV)

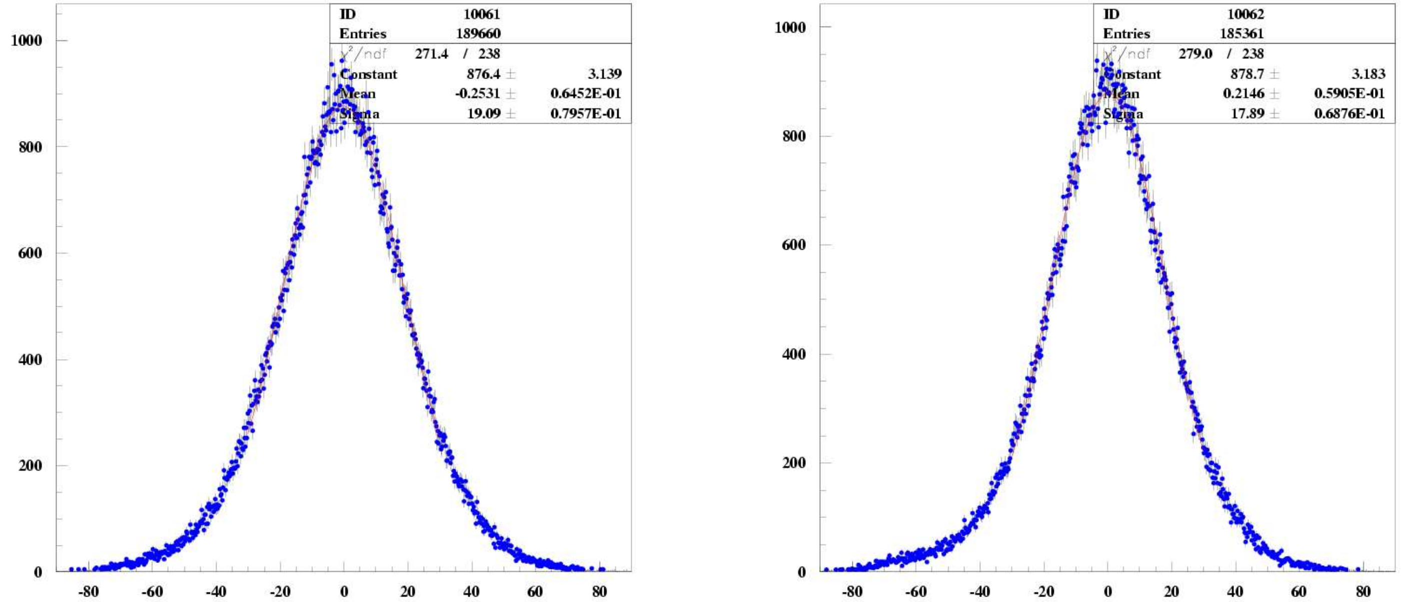
$$\cos(\alpha) = \underbrace{E_b \cdot E_{trk} - \frac{S}{2}}_{\text{Expected}} = \underbrace{\vec{p}_b \cdot \vec{p}_{trk}}_{\text{Observed}}$$

E_b: Total energy from the beams

p_b: boost

LAB System

DATA 2002



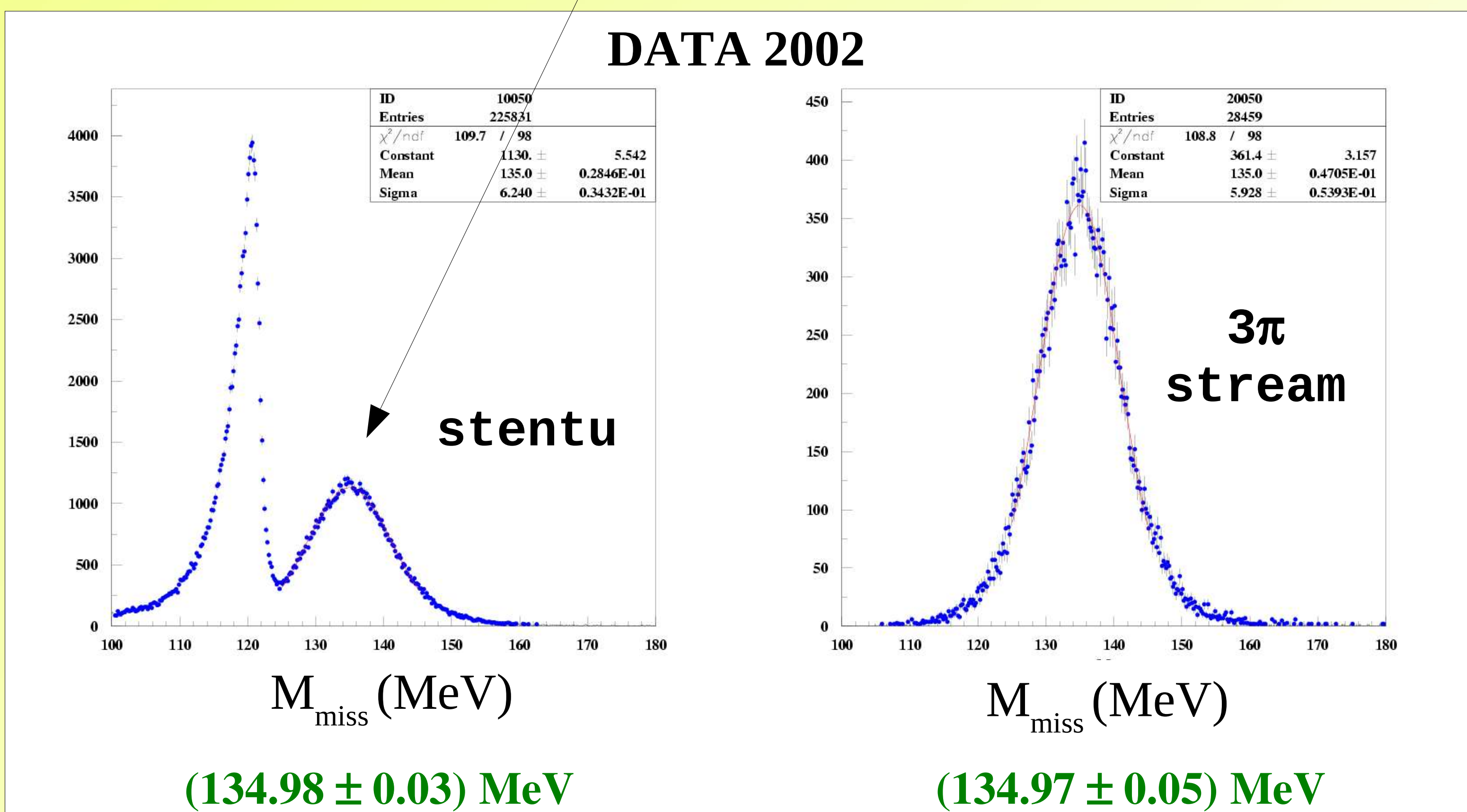
$\alpha_{exp} - \alpha^{+}_{obs}$ (°) $\alpha_{exp} - \alpha^{-}_{obs}$ (°)

(-0.25 ± 0.06)° **(0.21 ± 0.06)°**

Looking at physical quantities (DATA 2002): $\pi^+\pi^-\pi^0$

- **√s from the bank**
- **Momentum corrections (*from collinear events*)**
- Condition on first hit, on PCA and vertex
- Cut on spiraling tracks
- `.and.` of the Likelihood
- Tracks at Large Angle
- **χ**

Fit range: 125–145 MeV



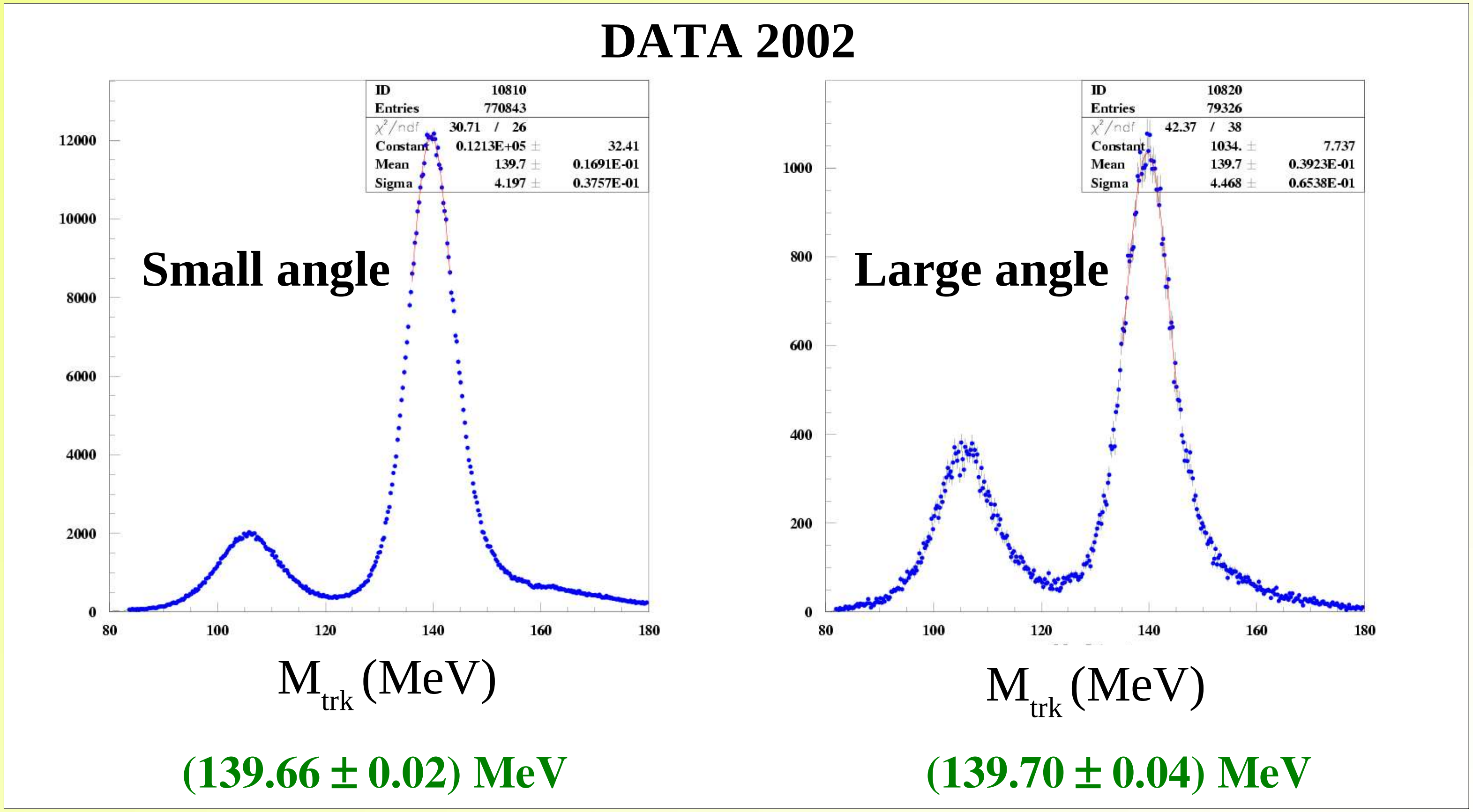
Without *SFC*

M_{miss} = 134.2 MeV

Looking at physical quantities (DATA 2002): <u>TRACKMASS</u>

- **$\sqrt{s}$ from the bank**
- **Momentum corrections (*from collinear events*)**
- Condition on first hit, on PCA and vertex
- Cut on spiraling tracks
- `.and.` of the Likelihood
- Tracks at Large Angle

2002 $\pi\pi\gamma$ MC kine
M_{trk} = 139.67 MeV



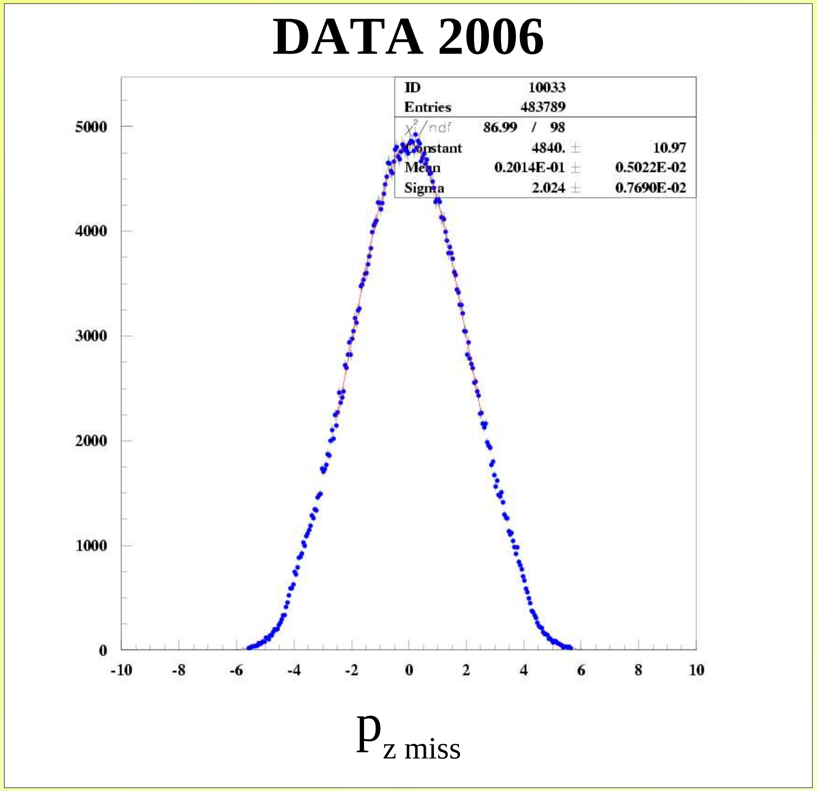
Without *SFC*
M_{trk} = 139.5 MeV

2006

- $\sqrt{s} \rightarrow \sqrt{s}$ -240KeV (Müller's ϕ-lineshape fit)
- Corrections on momenta :

  positive $p_z \rightarrow p_z + |p_z| \cdot 6 \cdot 10^{-4}$, $p_{x,y} \rightarrow p_{x,y} \cdot (1 - 4 \cdot 10^{-4})$

  negative $p_z \rightarrow p_z + |p_z| \cdot 5 \cdot 10^{-4}$, $p_{x,y} \rightarrow p_{x,y} \cdot (1 + 3 \cdot 10^{-4})$



$p_{z\ miss}$ = (0.020 ± 0.005) MeV

Other variables of collinear events also good ⟶ peaked at zero

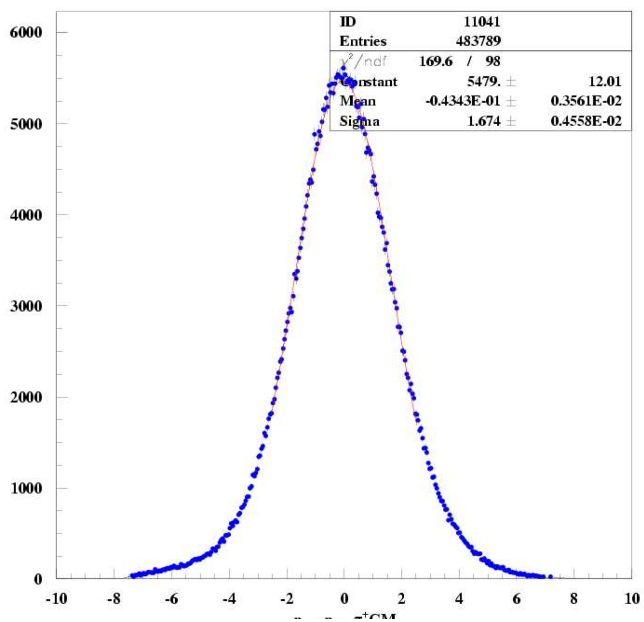
Expected vs Observed quantities for collinear events (2006)

1. Expected and observed **momentum ee → ππ hypothesis**

$$\sqrt{(\sqrt{s}/2)^2 - m_\pi^2} = |\vec{p}_{CM}|$$

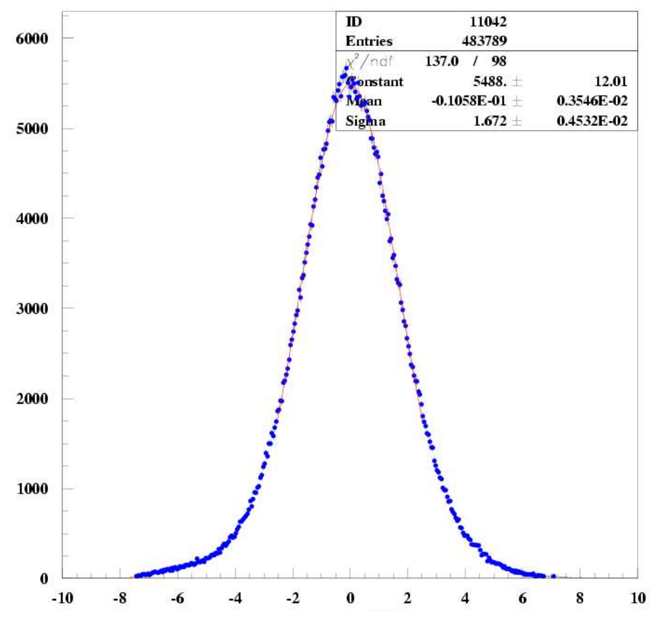
CM System

DATA 2006



$p_{exp} - p^{+}_{obs}$ (MeV)

(-0.043 ± 0.004) MeV



$p_{exp} - p^{-}_{obs}$ (MeV)

(-0.011 ± 0.004) MeV

2. Expected and observed **track-boost angle ee → ππ hypothesis** ($|M_{trk} - m_\pi| < 20$ MeV)

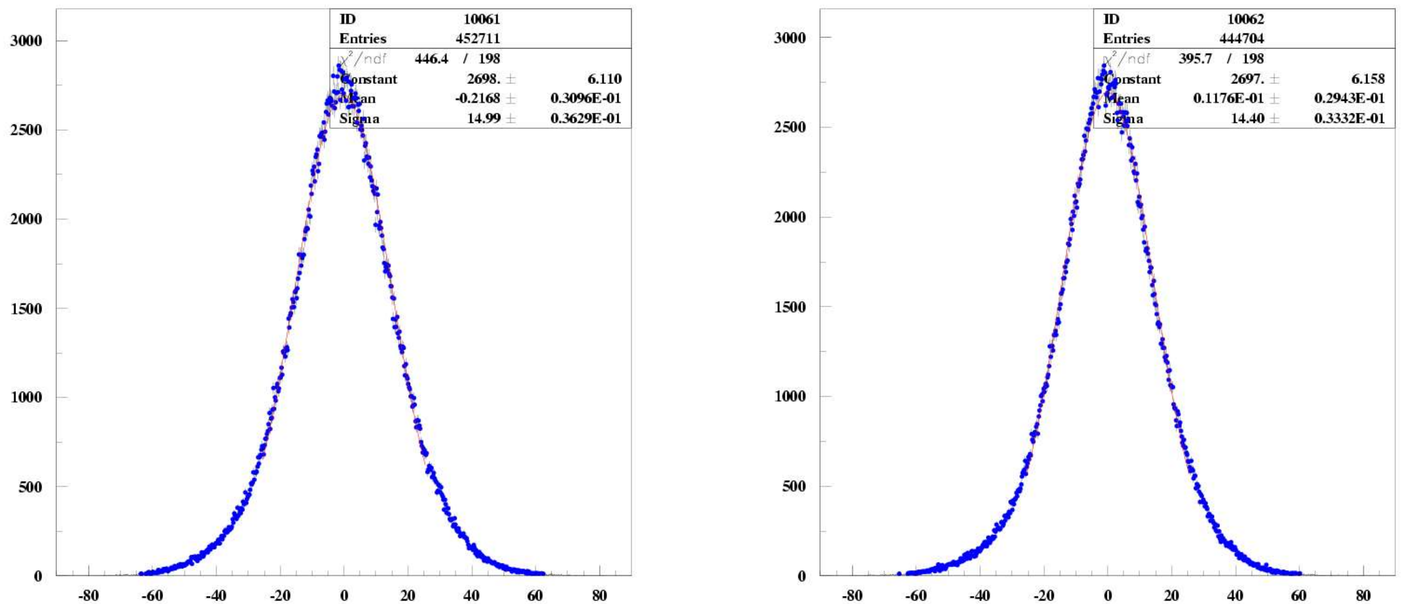
$$\cos(\alpha) = \underbrace{E_b \cdot E_{trk} - \frac{S}{2}}_{\text{Expected}} = \underbrace{\vec{p}_b \cdot \vec{p}_{trk}}_{\text{Observed}}$$

E_b: Total energy from the beams

p_b: boost

LAB System

DATA 2006



$\alpha_{exp} - \alpha^{+}_{obs}$ (°) — **(-0.21 ± 0.03)°**

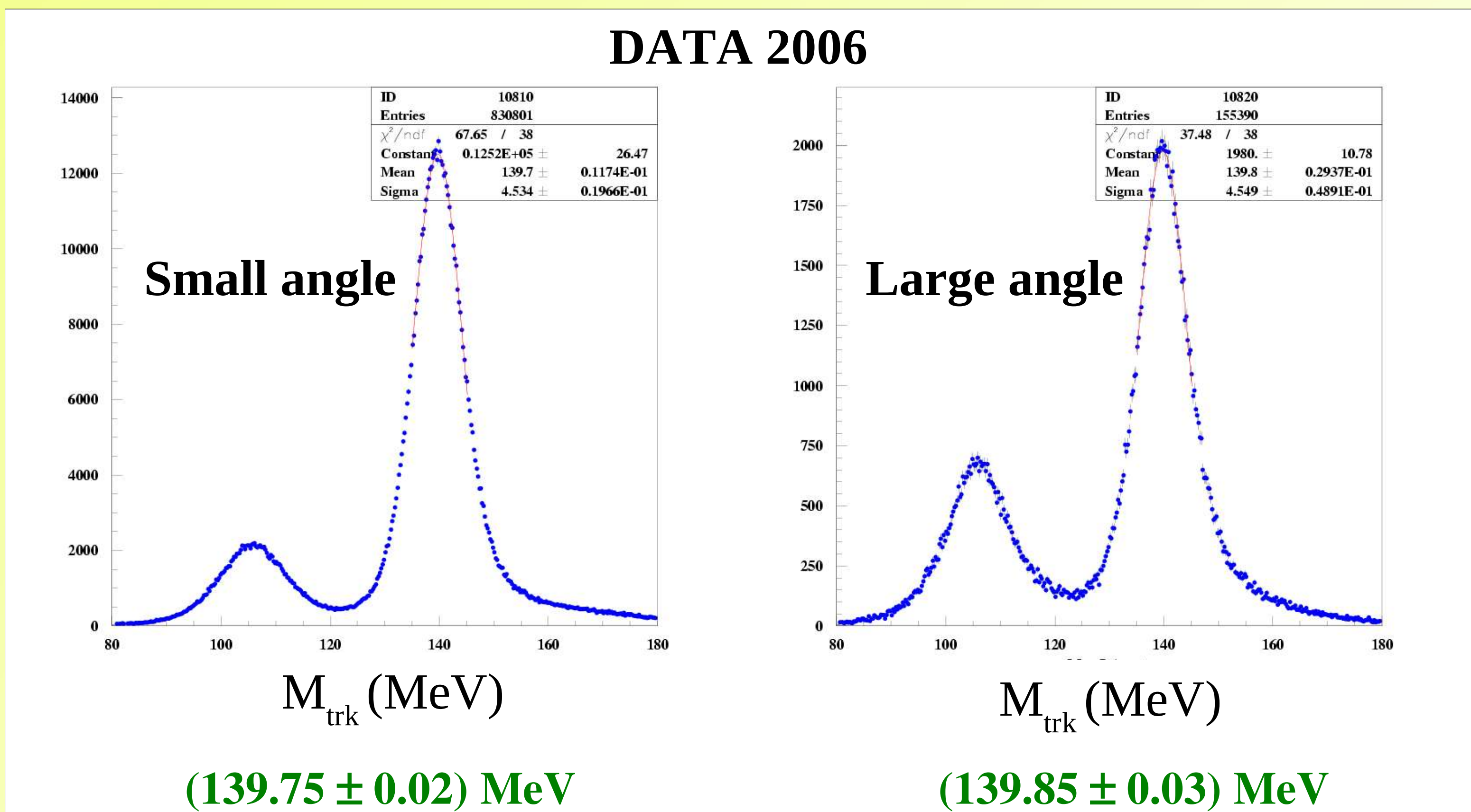
$\alpha_{exp} - \alpha^{-}_{obs}$ (°) — **(0.01 ± 0.03)°**

Looking at physical quantities (DATA 2006): TRACKMASS

- **$\sqrt{s}$ correction**
- **Momentum corrections (*from collinear events*)**
- Condition on first hit, on PCA and vertex
- Cut on spiraling tracks
- `.and.` of the Likelihood
- Tracks at Large Angle

2006 $\pi\pi\gamma$ MC kine

M_{trk} = 139.86 MeV



Without *SFC*

M_{trk} = 140.2 MeV

A “practical” summary

- Momentum *Small Fine Calibrations* for DATA 2002 and 2006 in usable status
(... trying to correct as less as you can)

- DATA 2002

1- no **√s** correction

2- **boost** has not been touched

3- **momenta**:

- corrections: $(1 \pm O(10^{-4}))$ with respect to the momentum ⟶ 0 - ~100 KeV
(seldom ~200KeV)
  - bigger for the positive tracks

- DATA 2006

1- **√s** corrected according to the ϕ-lineshape fit

2- **boost** has not been touched

3- **momenta**:

- corrections: $(1 \pm O(10^{-4}))$ with respect to the momentum ⟶ 0 - ~100 KeV
- symmetric for both tracks, apart the same shift on z component

- Comparison with Monte Carlo and MC fine tuning (if needed) in progress... next slides

2. Monte Carlo Fine Tuning

Standard procedure ⇒ take DATA as they are and tune the MC on them

TRYING A DIFFERENT APPROACH WITH MORE TOOLS

1. DATA → "Small Fine Calibration": $DATA_{SFC}$
2. MC *As It Is*
   → 2.1 *Bini-Valeriani's Corrections* MC_{BV}
   → 2.2 *(2)007's Corrections* MC_{007}

DATA-MC comparisons in the different configurations

DATA & MC sample

- **DATA 2002**: `stentu-`ntuples
- **Monte Carlo 2002**:
  - → **official $\pi\pi\gamma$, $\mu\mu\gamma$, $\pi\pi\pi$** (BhaBha negligible with "`.and.` of the Likelihood")

Some selection cuts

- Condition on first hit: $\rho_{First\ Hit} < 50$ cm
- Condition on PCA: $\rho_{PCA} < 8$ cm, $|z_{PCA}| < 12$ cm
- Condition on vertex: $\rho_{vtz} < 12$ cm, $|z_{vtx}| < 7$ cm
- Cut on spiraling tracks
- `.and.` of the Likelihood
- Tracks in the angular region $50° < \theta < 130°$
- $0° < \theta_{\Sigma} < 15°$ or $165° < \theta_{\Sigma} < 180°$

DATA SFC effect (M_{trk} vs θ_π)

- **Monte Carlo 2002**: **ππγ, μμγ, πππ**
- No corrections applied
- Small angle angular cuts

- **DATA 2002**
- Without and with ***Small Fine calibrations***
- Small angle angular cuts

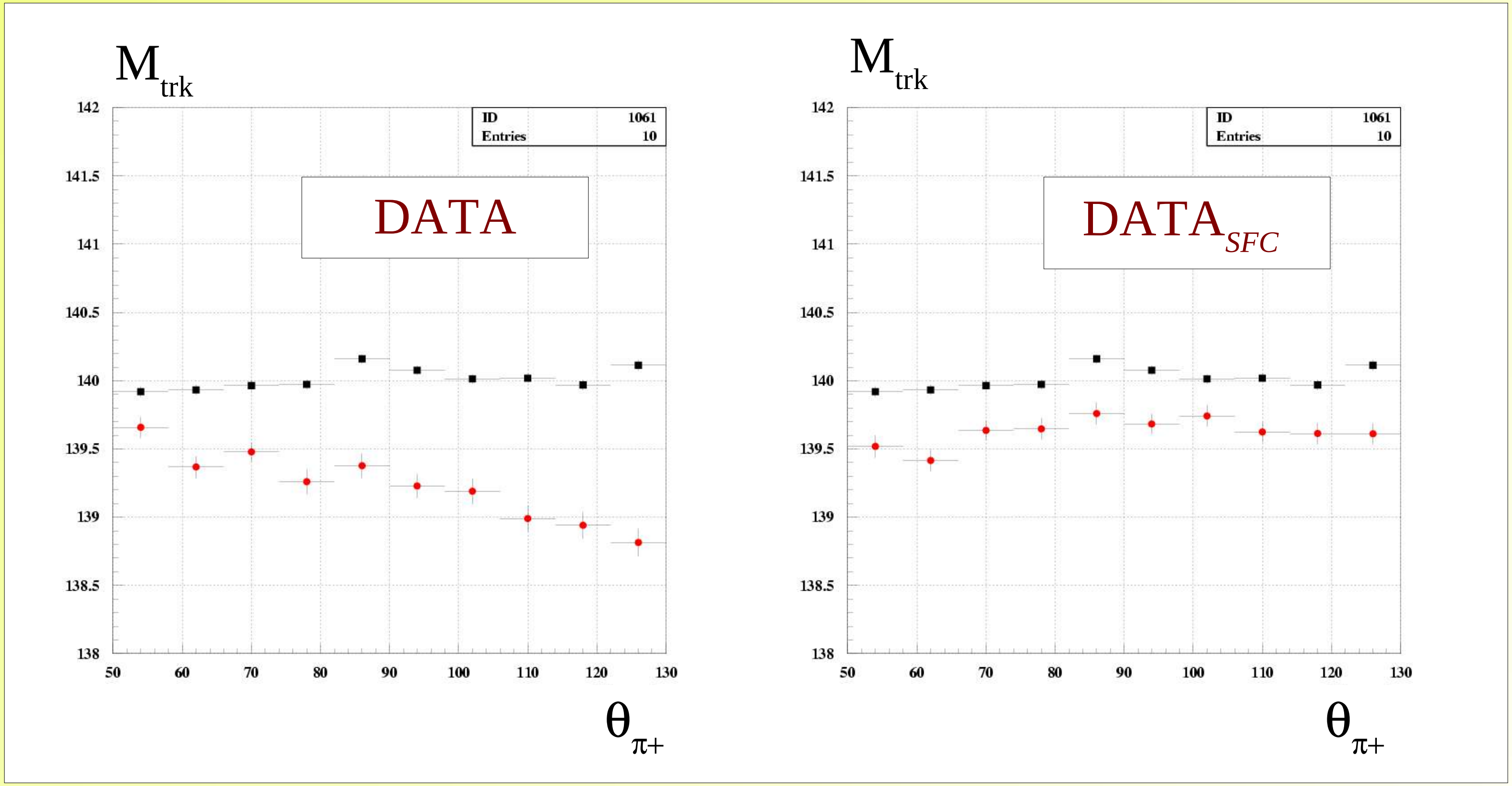
DATA *Small Fine Calibrations*

positive $p_z \rightarrow p_z + |p_z| \cdot 5 \cdot 10^{-4}$, $p_{x,y} \rightarrow p_{x,y} \cdot (1 - 7 \cdot 10^{-4})$

negative $p_z \rightarrow p_z + |p_z| \cdot 4 \cdot 10^{-4}$, $p_{x,y} \rightarrow p_{x,y} \cdot (1 - 2 \cdot 10^{-4})$

MCs 2002

DATA 2002



DATA SFC effect (M_{trk} vs $M_{\pi\pi}^2$)

- **Monte Carlo 2002**: **ππγ, μμγ, πππ**
- No corrections applied
- Small angle angular cuts

- **DATA 2002**
- Without and with
  Small Fine calibrations
- Small angle angular cuts

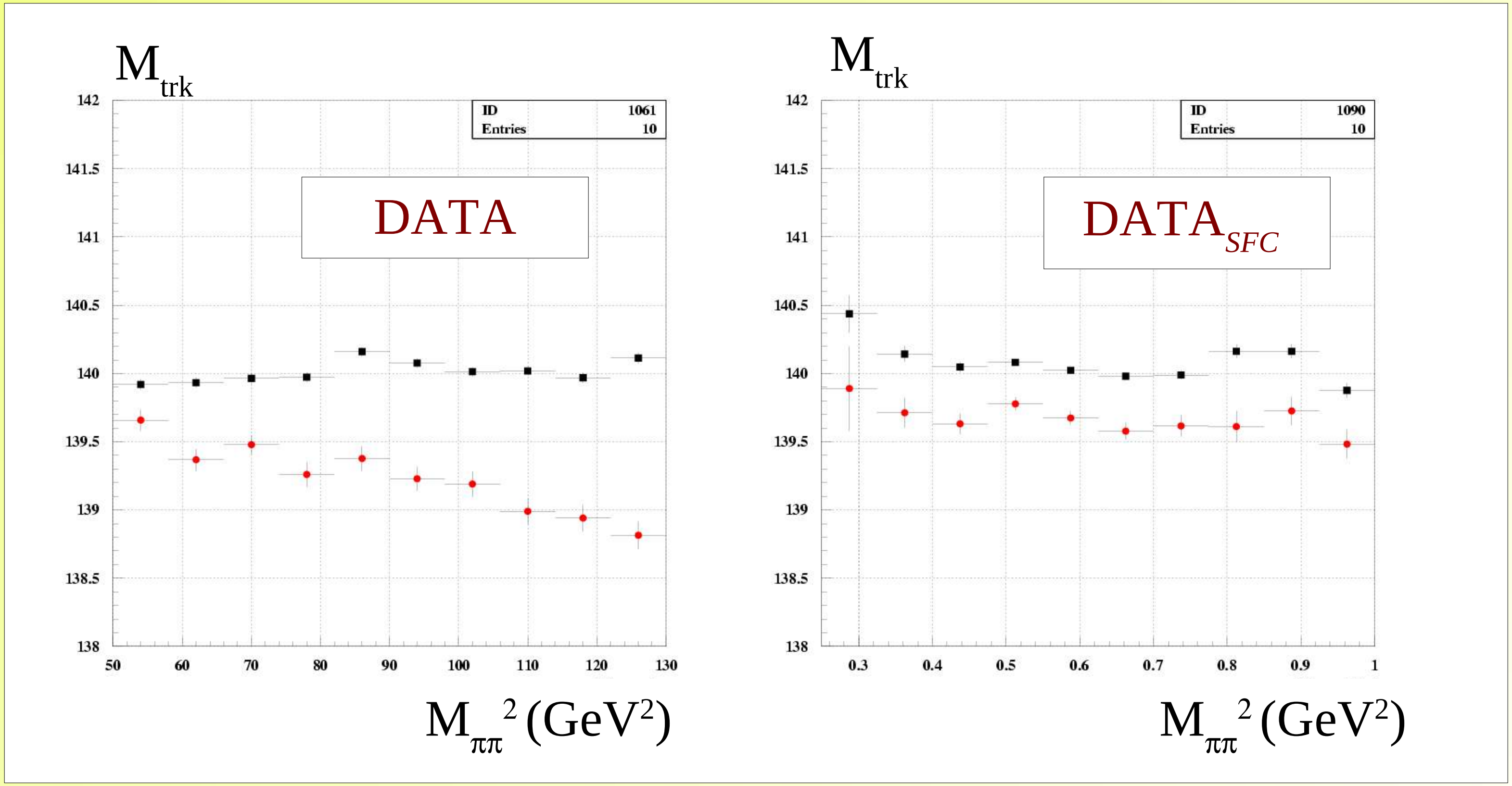
DATA *Small Fine Calibrations*

positive $p_z \to p_z + |p_z| \cdot 5 \cdot 10^{-4}$, $p_{x,y} \to p_{x,y} \cdot (1 - 7 \cdot 10^{-4})$

negative $p_z \to p_z + |p_z| \cdot 4 \cdot 10^{-4}$, $p_{x,y} \to p_{x,y} \cdot (1 - 2 \cdot 10^{-4})$

MCs 2002

DATA 2002



MC_{BV} & MC_{007} effects (M_{trk} vs θ_π)

- **Monte Carlo 2002**: **ππγ, μμγ, πππ**
- ***BV*** or ***007***
- Small angle angular cuts

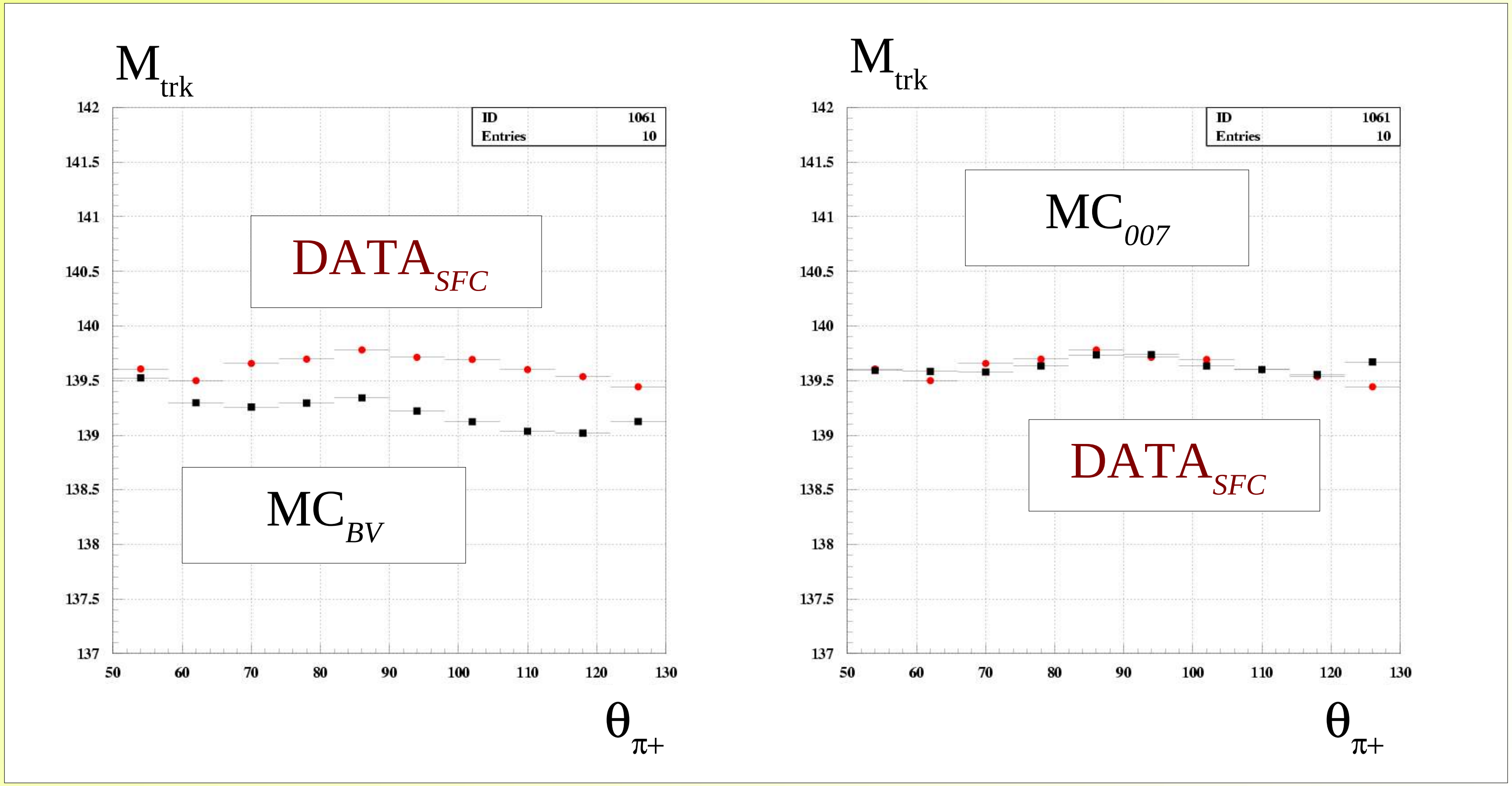
- **DATA 2002**
- ***Small Fine calibrations***
- Small angle angular cuts

MC (2)007 Tuning

- Small correction on momenta: p → p (1+ $O(10^{-4})$)
- Small smearing in three different $M_{\pi\pi}^2$ regions

MCs 2002

DATA 2002



MC_{BV} & MC_{007} effects (M_{trk} vs $M_{\pi\pi}^2$)

- **Monte Carlo 2002**: **ππγ, μμγ, πππ**
- ***BV*** or ***007***
- Small angle angular cuts

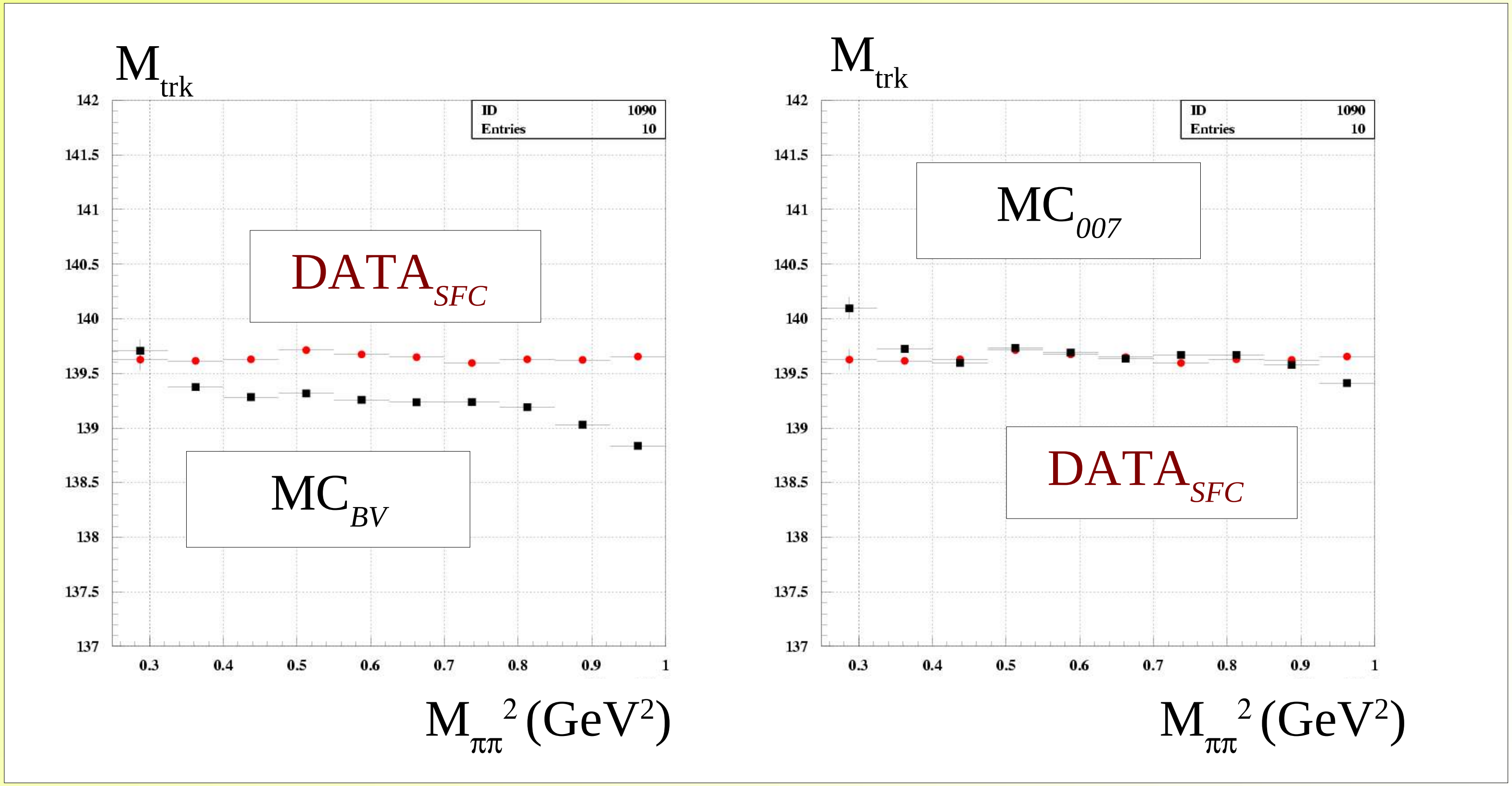
- **DATA 2002**
- ***Small Fine calibrations***
- Small angle angular cuts

MC (2)007 Tuning

- Small correction on momenta: p → p (1+ $O(10^{-4})$)
- Small smearing in three different $M_{\pi\pi}^2$ regions

MCs 2002

DATA 2002



MC_{BV} & MC_{007} effects (Widths vs $M_{\pi\pi}^2$)

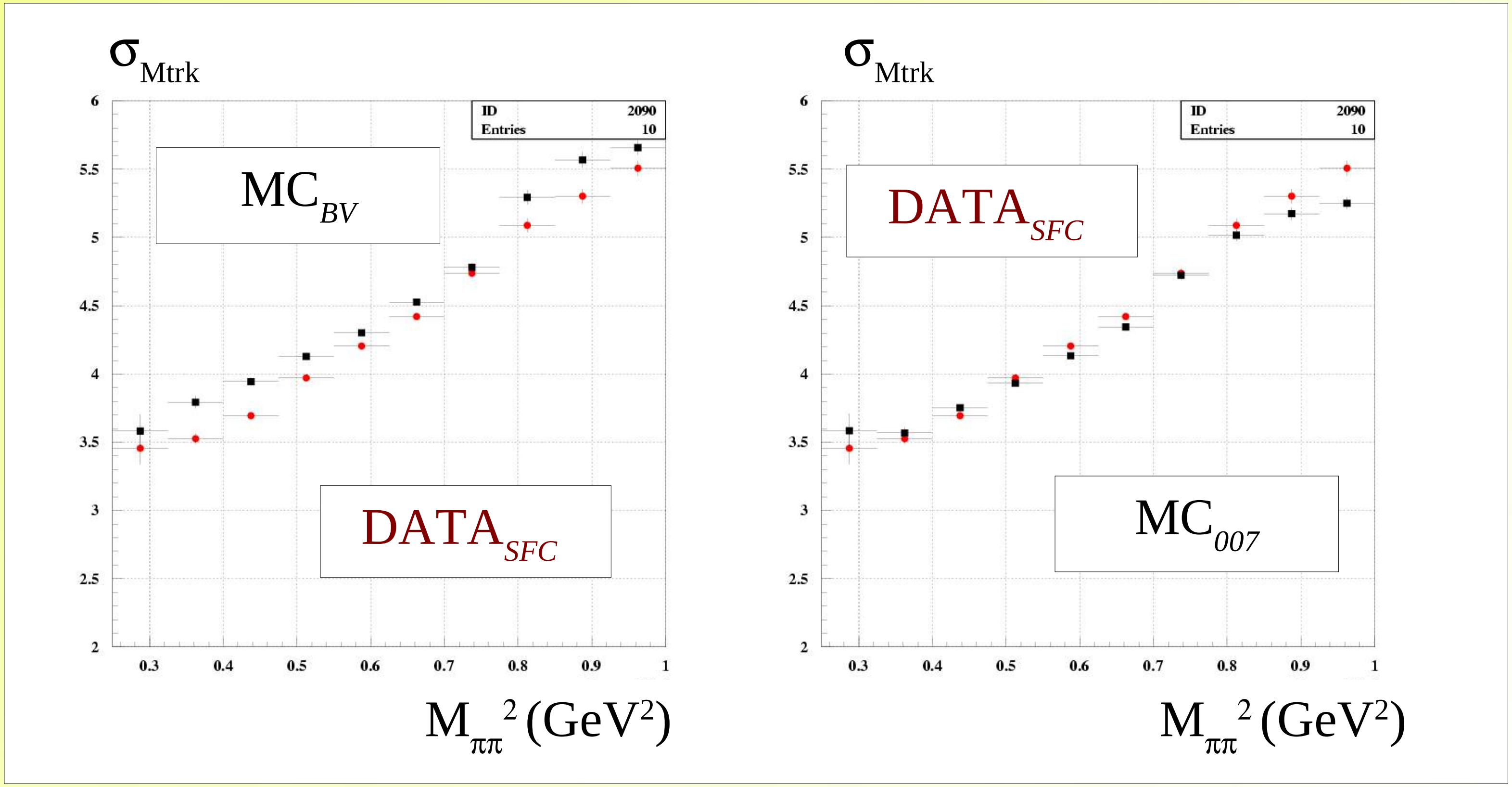
- **Monte Carlo 2002: ππγ, μμγ, πππ**
- ***BV*** or ***007***
- Small angle angular cuts

- **DATA 2002**
- ***Small Fine calibrations***
- Small angle angular cuts

MC (2)007 Tuning

- Small correction on momenta: p → p (1+ $O(10^{-4})$)
- Small smearing in three different $M_{\pi\pi}^2$ regions

MCs 2002
DATA 2002



A second "practical" summary

DATA & MC 2002

- **Small Fine Calibration** procedures seems to give a better DATA – MC agreement
- **Tuning on MC** seems to be much simpler than the 2001-2002 one
    - ⇒ mean value physical variables comparison → only small shift on MC value needed
    - ⇒ widths of physical variables comparison → bit smaller (with respect to BV) smearing on MC needed

STATUS

- Study dedicated on 2002 Small Angle selection
- Maybe small further development on DATA Small Fine Calibration and MC 2002 Tunning
    - ⇒ However **ready to be used**

... TO BE DONE

- Further check on the effect on some physical quantities: Ω for Large Angle, θ_{Σ}, $M_{\pi\pi}^2$ spectrum...
- Study for 2002 Large Angle and 2006

3. Measurement of the Likelihood efficiency

- Already performed in B. Valeriani's PhD thesis
- Needed for Large Angle (`.and.` configuration) with high precision
- Obtained directly from DATA

Two control samples

$\pi^+\pi^-\pi^0$

- kinematic fit $\chi^2 < 30$

- $M_{\pi\pi}{}^2 < 0.5$ GeV^2

- $M_{trk} > 130$ MeV

limited at high momenta

Large momentum region overlap

$\pi^+\pi^-\gamma$

- $|M_{trk} - m_\pi| < 2.5$ MeV

- logrl(π^+) > 2 for testing π^-

- logrl(π^-) > 2 for testing π^+

limited at low momenta

Strategy

- **Very clean sample of π tracks**
- Likelihood requires **DCH track associated with EMC cluster** (track velocity one of the input): **`newextratom`** assiciation: *TRASSOC*

a) TWO KIND OF EFFICIENCIES

1. Intrinsic likelihood efficiency:

$$\varepsilon_{intr} = \frac{\texttt{logrl>0|TRASSOC=.true.}}{\texttt{any logrl|TRASSOC=.true.}}$$

2. Intrinsic likelihood efficiency + TRASSOC efficiency:

$$\varepsilon_{trassoc} = \frac{\texttt{logrl>0|TRASSOC=.true.}}{\texttt{any logrl|(TRASSOC=.true.} \cup \texttt{TRASSOC=.true.)}}$$

b)TWO STEPS

1. Efficiency in bins of momentum and polar angle

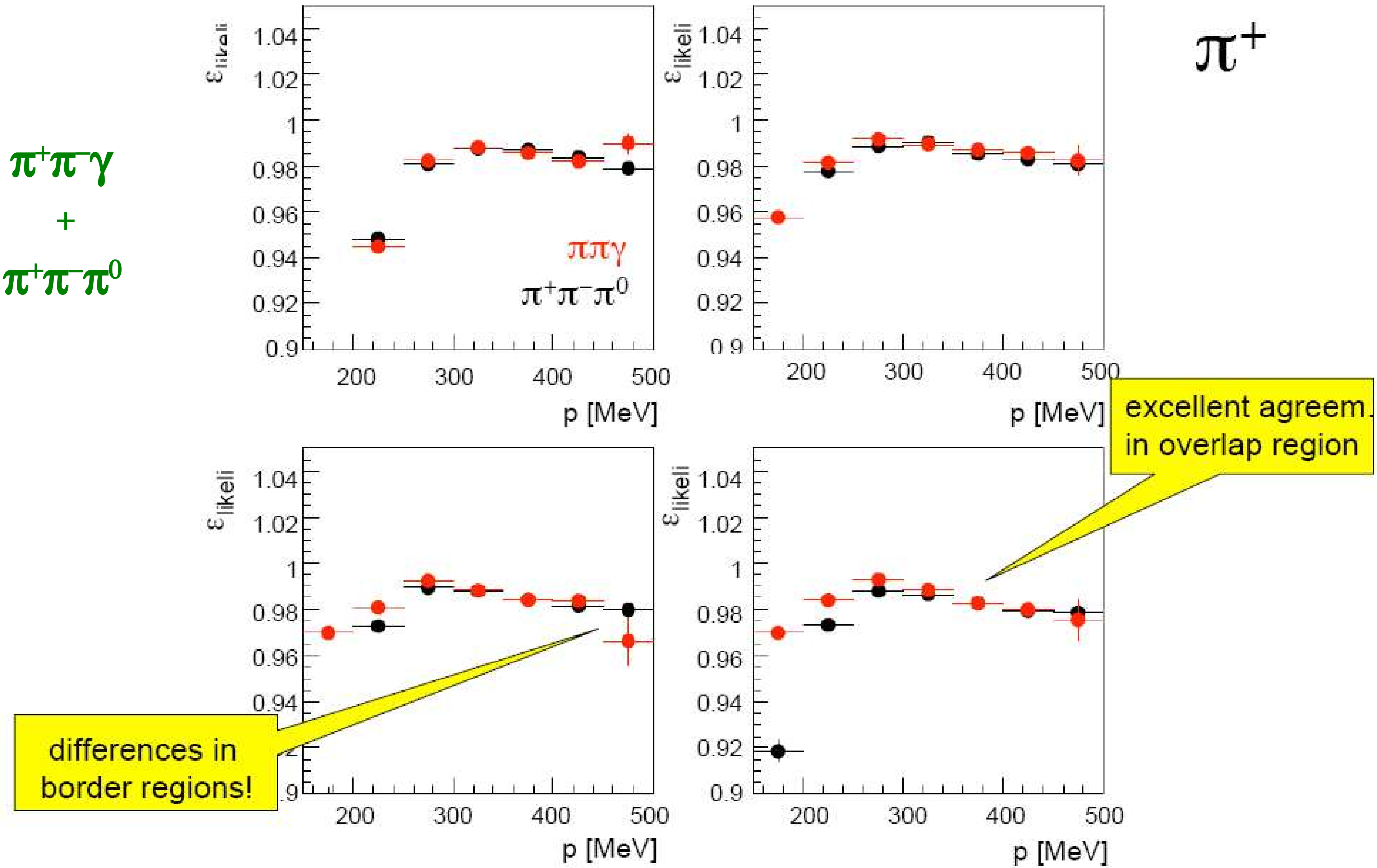
2. $\pi\pi\gamma$ MC → efficiency as function of $M_{\pi\pi}^2$

Intrinsic likelihood efficiency ε_{intr}

$\pi^+\pi^-\gamma$

$+$

$\pi^+\pi^-\pi^0$

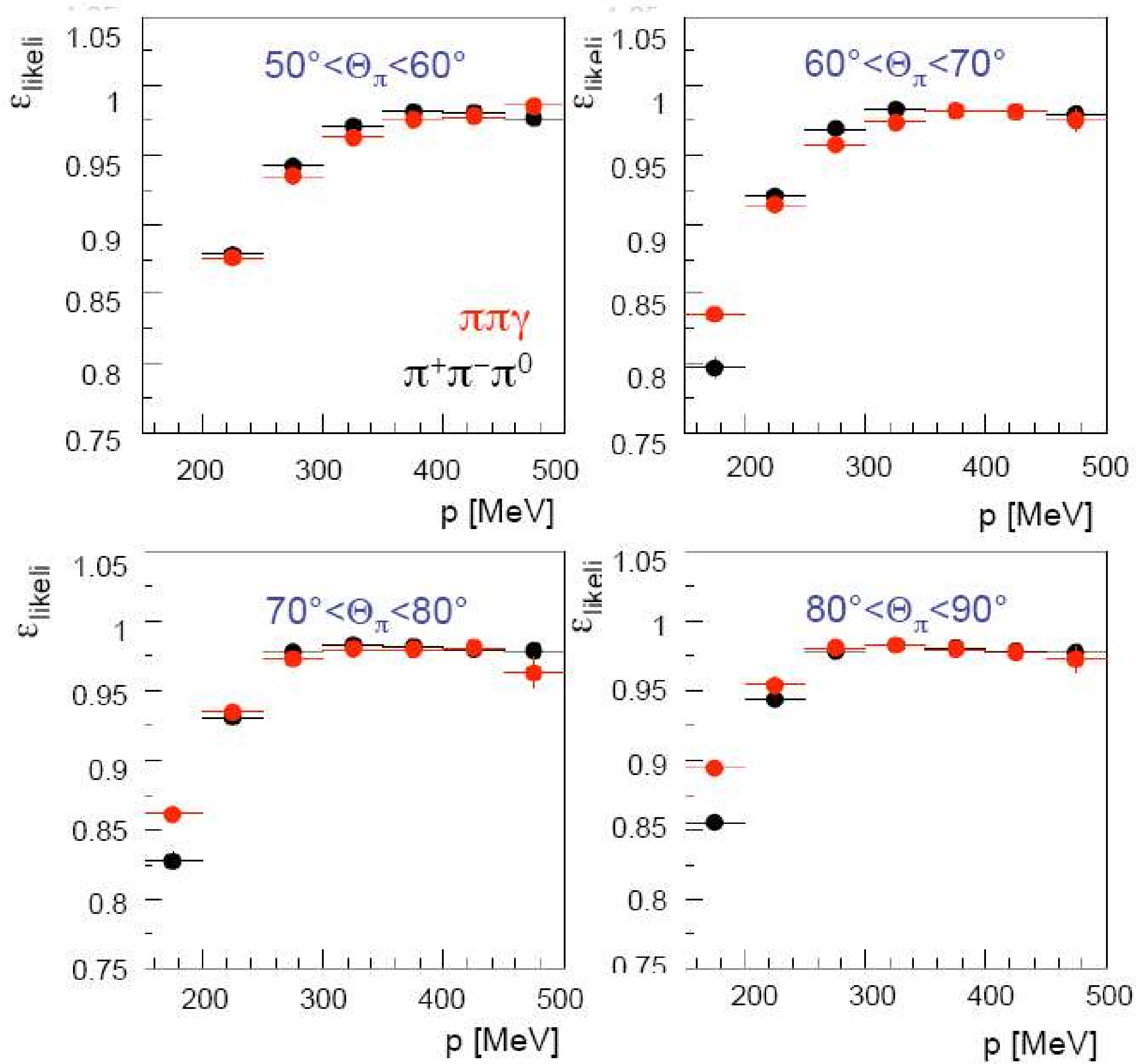


Intrinsic likelihood + TRASSOC efficiency $\varepsilon_{trassoc}$

$\pi^+\pi^-\gamma$

+

$\pi^+\pi^-\pi^0$



π^+

Likelihood efficiency as function of $M_{\pi\pi}^2$

- Likelihood efficiency table merging ππγ and πππ samples:

πππ → p < 350 MeV and ππγ → p > 350 MeV

- MC ππγ, all the selection applied but *logrl*

- Look for each event at p_i and θ_i of π^+ and π^-

- Take the corresponding likelihood efficiencies elik(±,p_i,θ_i)

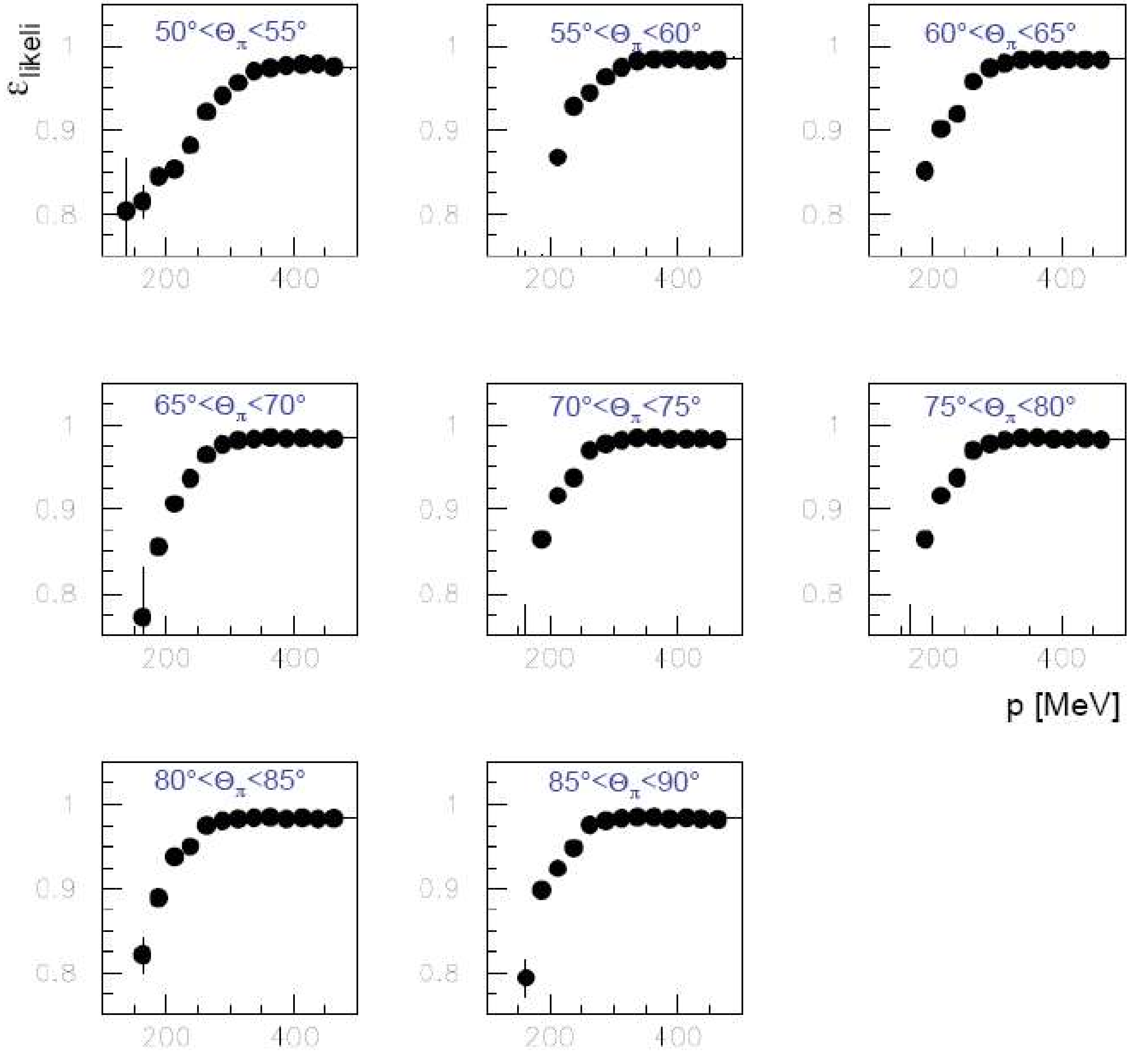
- Generate 10^3 events with current kinematic taking into account the appropriate likelihood efficiency tables

⇒ Store the likelihood efficiency as a function of $M_{\pi\pi}^2$

To increase the precision: finer binning

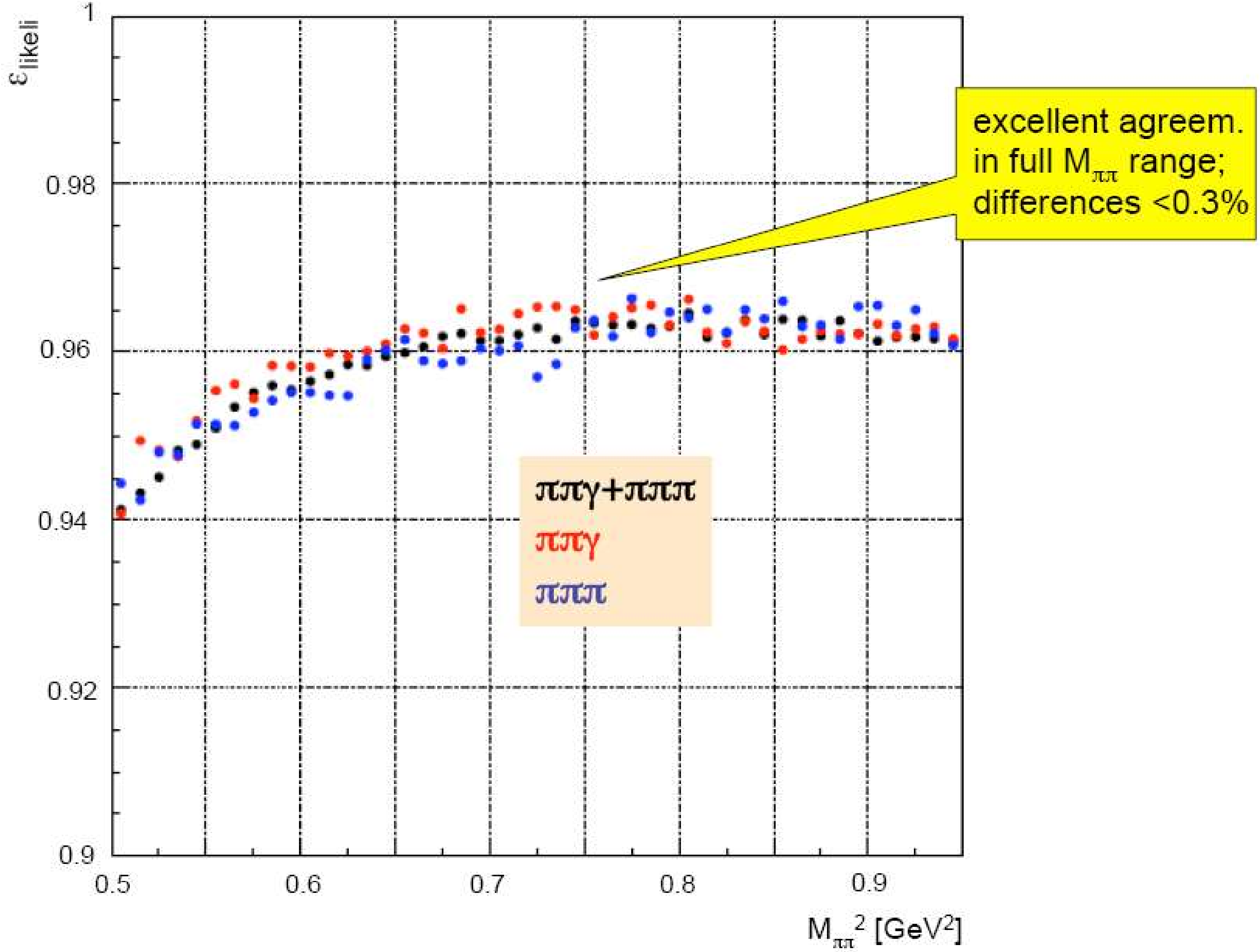
→ 8 bins in polar angle [50°-130°]: bin width 5°

→ 16 bins in momentum [100 MeV-500 MeV]: bin width 25 MeV



ε_{likeli}
50°<Θπ<55°
55°<Θπ<60°
60°<Θπ<65°
65°<Θπ<70°
70°<Θπ<75°
75°<Θπ<80°
80°<Θπ<85°
85°<Θπ<90°
1
0.9
0.8
200
400
p [MeV]

Intrinsic likelihood + TRASSOC efficiency $\varepsilon_{trassoc}$



Systematic studies

Check BhaBha residual contamination

$\pi\pi\gamma$

- Enlarge $|M_{trk} - m_\pi| < 2.5$ MeV $\rightarrow$ $|M_{trk} - m_\pi| < 5$ MeV
- Hemisphere where e^- (e^+) contamination reduced

  $\theta(\pi^+) > 90°$ for testing π^+

  $\theta(\pi^-) < 90°$ for testing π^-

$\pi\pi\pi$

- Change systematically χ^2 cut: $\chi^2 < 15$, $\chi^2 < 45$
- Require second track to be identified as a pion

  logrl(π^+) > 2 for testing π^-

  logrl(π^-) > 2 for testing π^+

Result stable within 0.2% precision

Conclusion for Likelihood efficiency & Outlook

- Likelihood efficiency and Track To Cluster association measured for 2002 DATA

$\pi\pi\pi$ for low momenta and $\pi\pi\gamma$ for high momenta

- Large Angle Analysis (. and . configuration) up to 6% of inefficiency

- Excellent agreement between the two control samples

- Systematic for the efficiency 0.2%

- Efficiency as function of $M_{\pi\pi}^2$: deviation from B. Valeriani's for $M_{\pi\pi}^2 < 0.6$ GeV^2 up to 2% difference

- Still do be checked: Check the dependence of the efficiency on the initial Pion Form Factor in MC signal

Near future plan for Large Angle Analysis (2002 DATA)

- Background subtraction of irreducible f_0(980) contribution

- FEVA code
- Fit to Charge Asymmetry using FEVA
- Common fit to Mass Spectrum and Charge Asymmetry

(Debora and Graziano)

- Fit procedure for reducible background contribution

- Detailed study on tracking calibration and MC tuning

- Dedicated fine tuning for MC 2002 at Large Angle

GOALS

- New value for the Pion Form Factor for EPS

- f_0(980) contribution improvement
- other small refinements (for instance bkg.)

- Charge Asymmetry from *PoP* DATA

- testing the sQED for FSR impact for *OnPeak* DATA

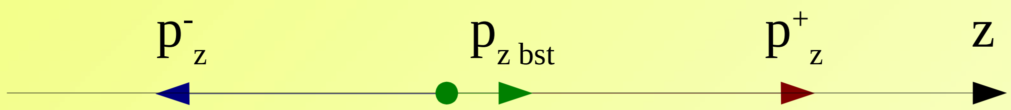
Backup

Let's try to have some geometrical thoughts

1. Assume that p^+_z is over estimated

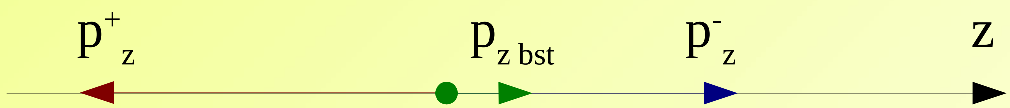
2. Two different condition ($\theta^+ < 90°$ and $\theta^+ > 90°$)

2.1 $\theta^+ < 90°$



$\Rightarrow \mathbf{p^+_z + p^-_z > p_{bst} \Rightarrow p_{miss}} = p_{bst} - (p^+_z + p^-_z) \mathbf{< 0}$

2.2 $\theta^+ > 90°$



$\Rightarrow \mathbf{p^+_z + p^-_z < p_{bst} \Rightarrow p_{miss}} = p_{bst} - (p^+_z + p^-_z) \mathbf{> 0}$

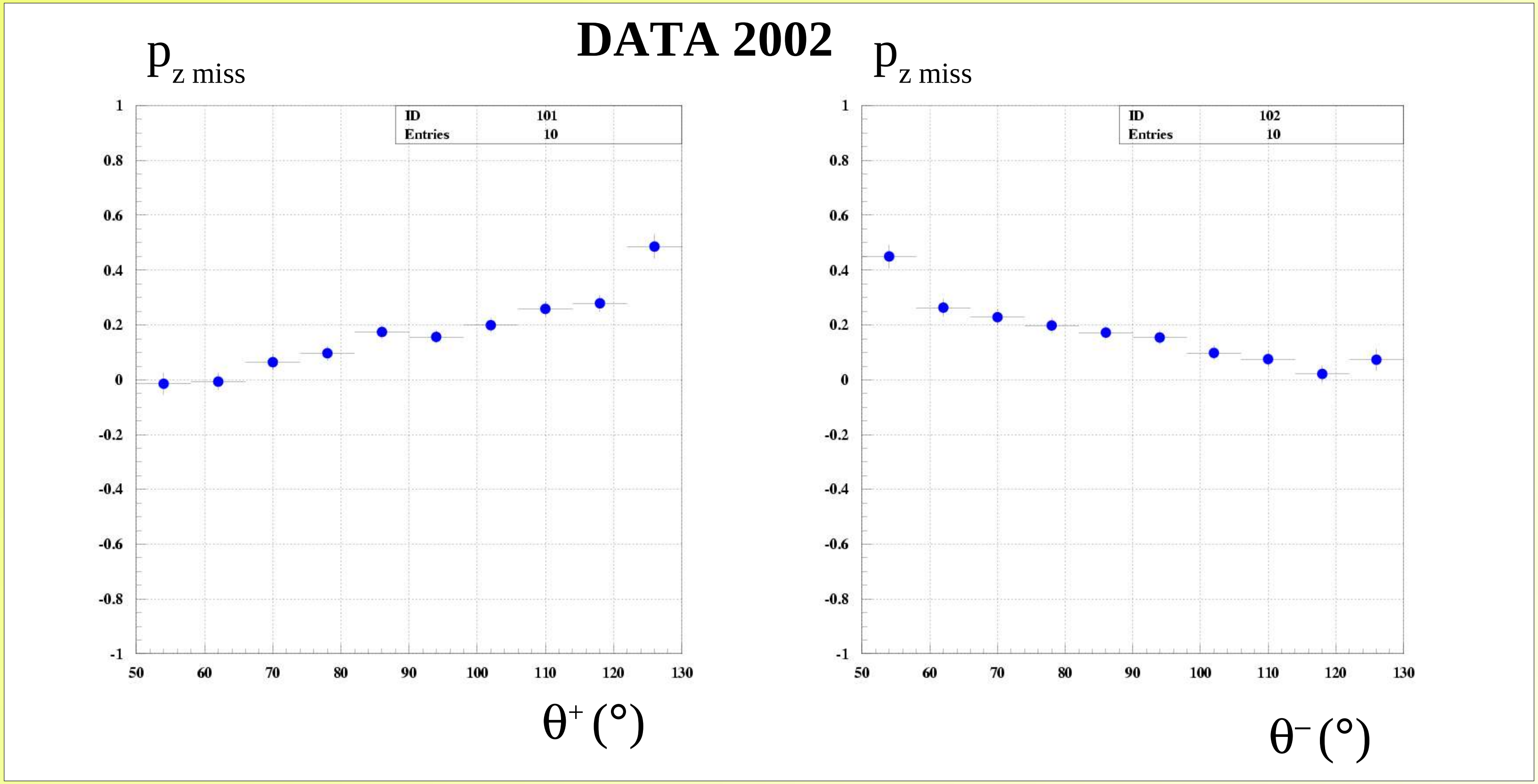
Look at the mean value of the Gaussian fit of the

$p_{z\,miss}$ vs θ distributions...

... mean value of the Gaussian fit of the $p_{z\,miss}$ vs θ distributions

DATA 2002 Collinear Events

in the LAB system

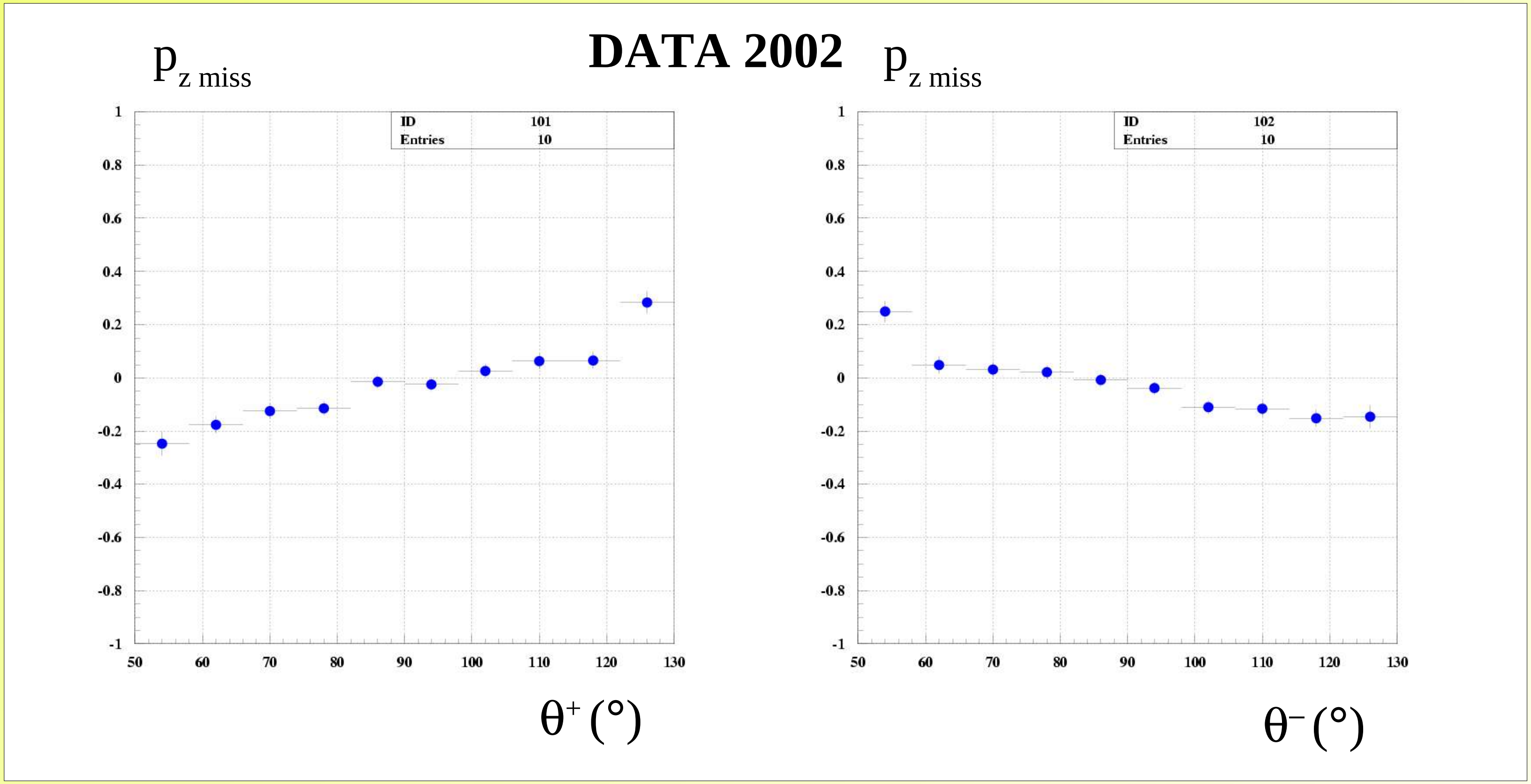


- $p_{z\,miss}$ trend as expected
- if perfect fine calibration $p_{z\,miss}(90°) = 0$.

But it is not ⇒ **hint for a systematic shift on the z component**

After small shift on the z component of momenta of p_z ($1 \pm O(10^{-4})$)

DATA 2002 Collinear Events in the LAB system



The code of (2)007 MC tuning

MOMENTUM

CORRECTION

⇒ M_{trk} mean value

```
*=============================================*
      SUBROUTINE PTUNE07(pxtra,pytra,pztra)
*=============================================*
*     2007 2nd version
      IMPLICIT NONE
      INCLUDE ?
      INCLUDE 'physqua.inc'
      INTEGER idh, ii
      REAL pxtra(2) ,pytra(2) ,pztra(2), pmod(2)
      if (QQ.lt.0.5) then
         do ii = 1, 2
            pxtra(ii) = pxtra(ii) * (1. + 3.8E-4)
            pytra(ii) = pytra(ii) * (1. + 3.8E-4)
            pztra(ii) = pztra(ii) * (1. + 3.8E-4)
         enddo
      elseif (QQ.ge.0.5.and.QQ.lt.0.8) then
         do ii = 1, 2
            pxtra(ii) = pxtra(ii) * (1. + 2.5E-4)
            pytra(ii) = pytra(ii) * (1. + 2.5E-4)
            pztra(ii) = pztra(ii) * (1. + 2.5E-4)
         enddo
      elseif (QQ.ge.0.8.and.QQ) then
         do ii = 1, 2
            pxtra(ii) = pxtra(ii) * (1. + 3.E-4)
            pytra(ii) = pytra(ii) * (1. + 3.E-4)
            pztra(ii) = pztra(ii) * (1. + 3.E-4)
         enddo
      endif
 999  continue
      RETURN
      END
*========*
```

MOMENTUM CORRECTION

⇒ M_{trk} width

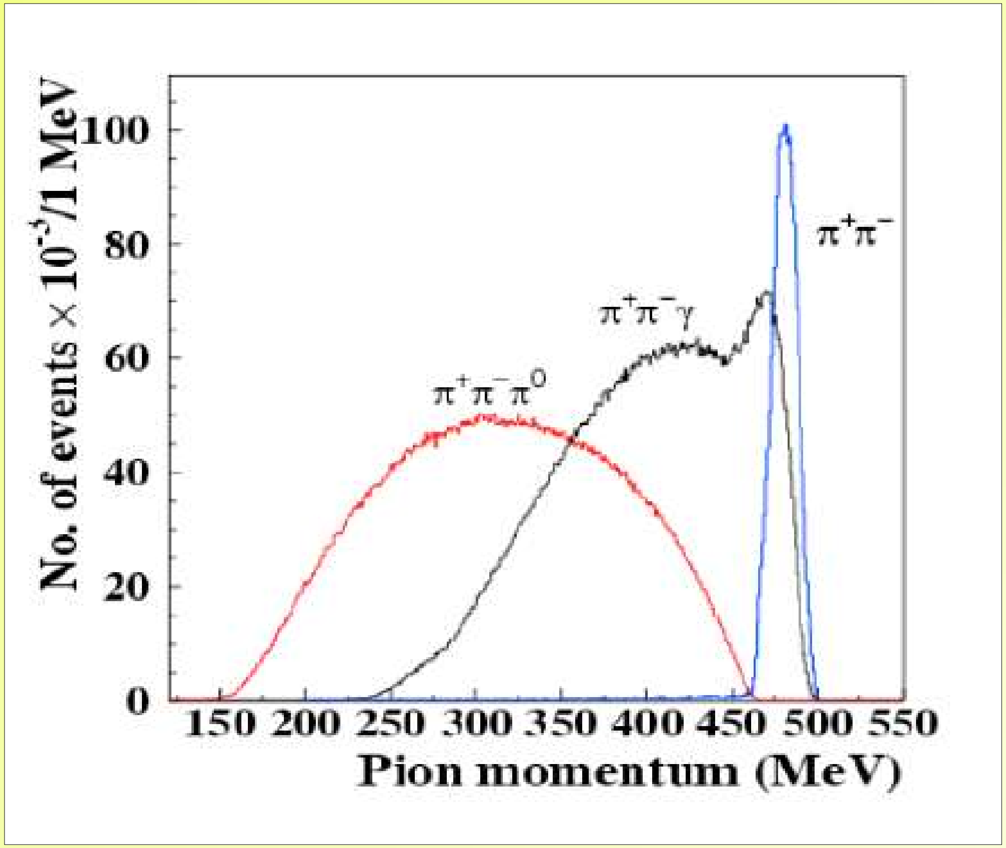
```
*==========================================*
      SUBROUTINE PSMEA07(pxtra,pytra,pztra)
*==========================================*
C     2007 2nd version smearing
      IMPLICIT NONE
      INCLUDE ?
      INCLUDE 'physqua.inc'
      INTEGER ii
      REAL ranlux, prescale, smear1, smear2
      REAL pxtra(2) ,pytra(2) ,pztra(2), gau(2)
      EXTERNAL ranlux
C     INIZIALIZATION
      call vzero(gau,2)
      if (QQ.lt.0.7) then
         call RNORMX(gau,2,RANLUX)
         call ranmar(prescale,1)
         if (prescale.lt.0.05) then
            smear1 = 1. - gau(1)*0.005
         else
            smear1 = 1. - gau(1)*0.0015
         endif
         call ranmar(prescale,1)
         if (prescale.lt.0.05) then
            smear2 = 1. - gau(2)*0.005
         else
            smear2 = 1. - gau(2)*0.0015
         endif
      else
         call RNORMX(gau,2,RANLUX)
         call ranmar(prescale,1)
         if (prescale.lt.0.05) then
            smear1 = 1. - gau(1)*0.007
         else
            smear1 = 1. - gau(1)*0.0018
         endif
         call ranmar(prescale,1)
         if (prescale.lt.0.05) then
            smear2 = 1. - gau(2)*0.007
         else
            smear2 = 1. - gau(2)*0.0018
         endif
      endif
C     Pi+
      PXTRA(1) = pxtra(1)*smear1
      PYTRA(1) = pytra(1)*smear1
      PZTRA(1) = pztra(1)*smear1
C     Pi-
      PXTRA(2) = pxtra(2)*smear2
      PYTRA(2) = pytra(2)*smear2
      PZTRA(2) = pztra(2)*smear2
      RETURN
      END
*========*
```

Control samples

$\pi^+\pi^-\pi^0$

- **kinematic fit $\chi^2 < 30$**
- **$M_{\pi\pi}{}^2 < 0.5$ GeV^2**
- **$M_{trk} > 130$ MeV**

limited at high momenta



$\pi^+\pi^-\gamma$

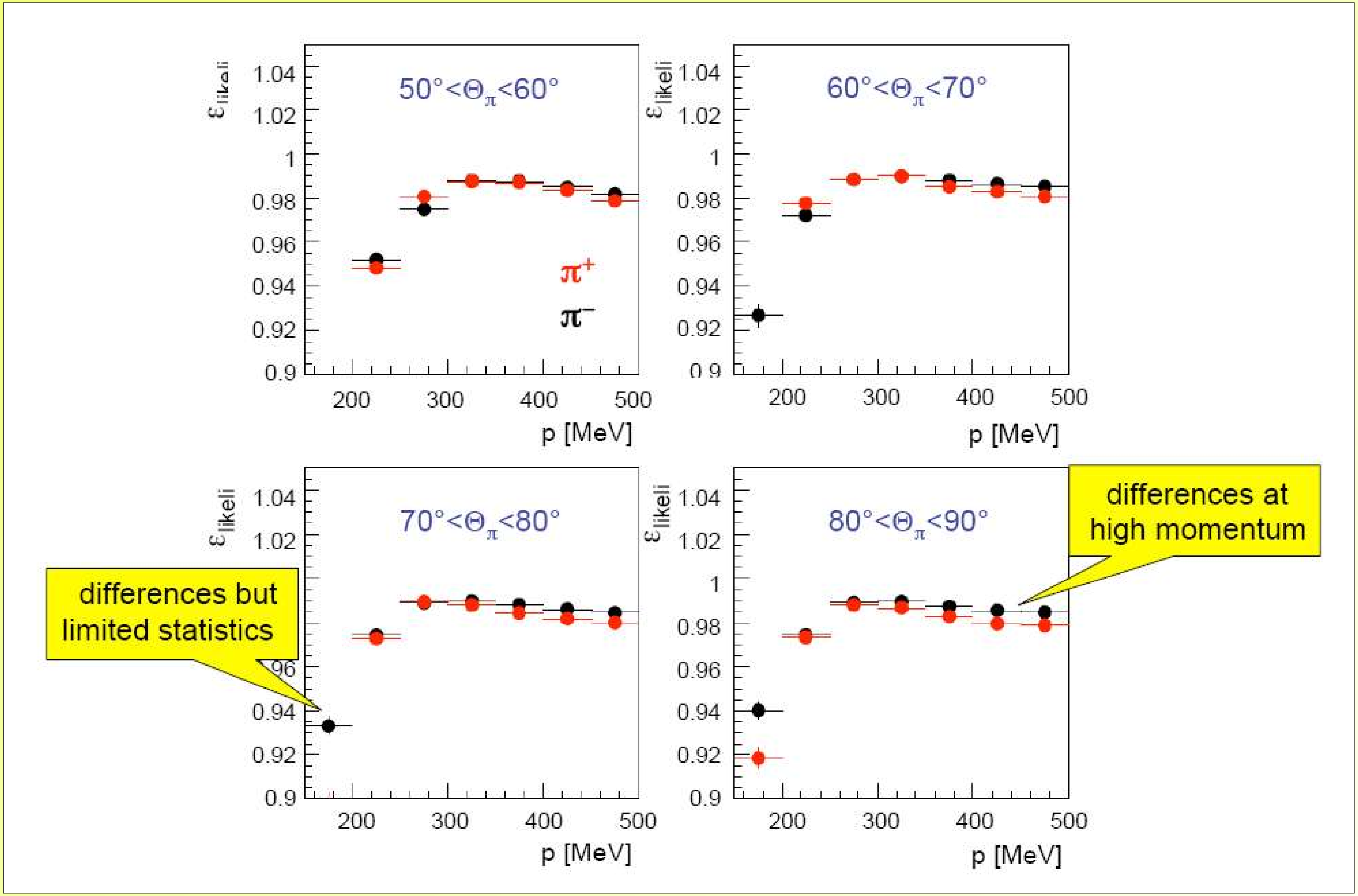
- **$| M_{trk} - m_\pi | < 2.5$ MeV**
- **logrl(π^+) > 2 for testing π^-**
- **logrl(π^-) > 2 for testing π^+**

limited at low momenta

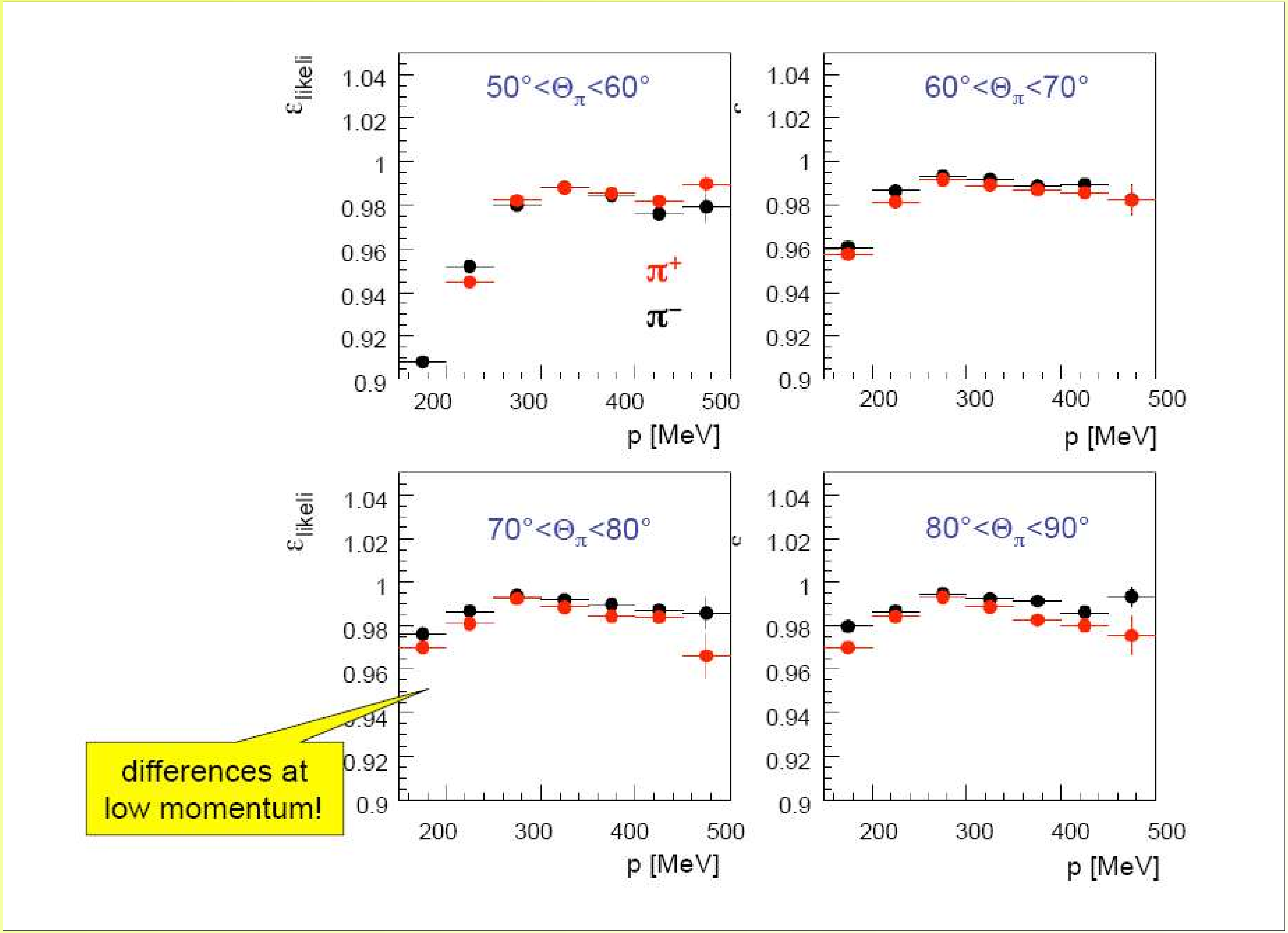
LARGE MOMENTUM REGION OVERLAP

Intrinsic likelihood efficiency ε_{intr}

$\pi^+\pi^-\gamma$ control sample

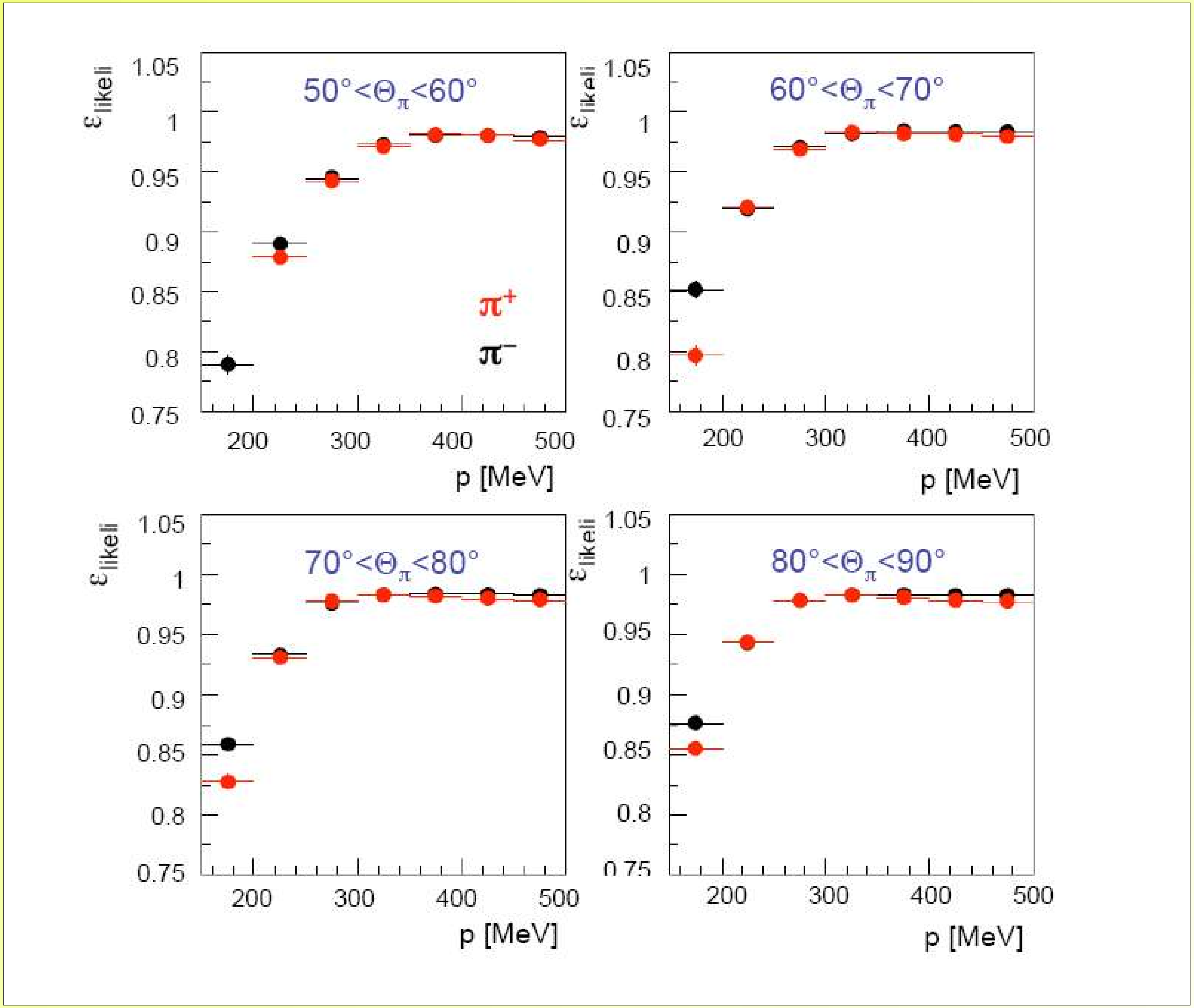


$\pi^+\pi^-\pi^0$ control sample

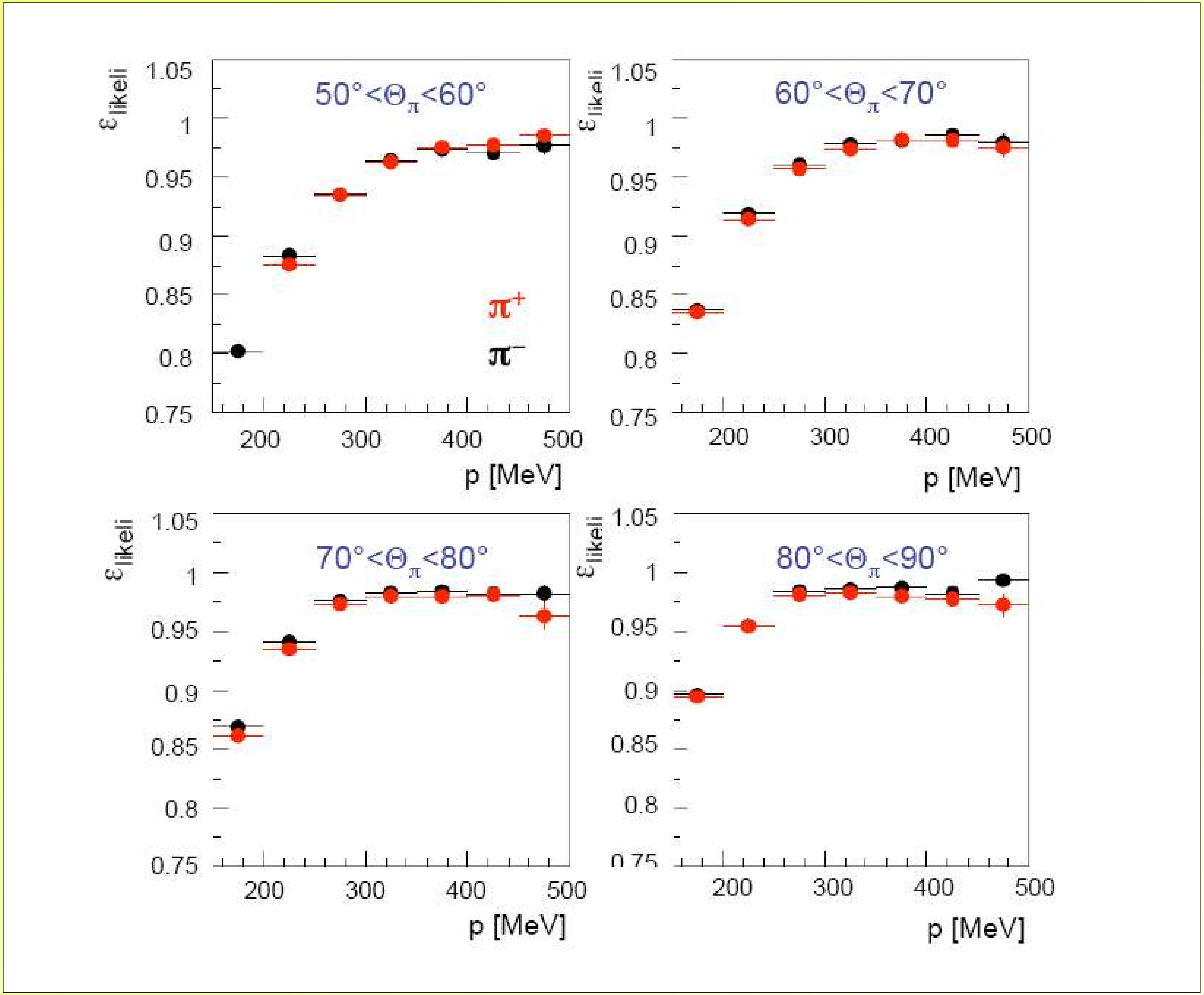


Intrinsic likelihood + TRASSOC efficiency $\varepsilon_{trassoc}$

$\pi^+\pi^-\gamma$ control sample



$\pi^+\pi^-\pi^0$ control sample



Comparison with B. Valeriani's intrinsic efficiency