Status of Large photon polar Angle Analyses

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for the Mainz $\pi\pi\gamma$ group

Outlook

LA 2002

- Where were we last time?
- Changes: unfolding and LO-/NLO- FSR (unshifting)
- Pion Form Factor extraction

PoP

- Overview on all the further steps of the analysis:
    - background subtraction
    - efficiencies
    - unfolding and unshifting
- Pion Form Factor

Status of Large Angle 2002

LA 2002 Analysis flow

$\pi\pi\gamma(\gamma)$ spectrum
Background free, corrected by FILFO and Likelihood efficiencies

Unfolding (D'Agostini)
$s_{\pi REC} \rightarrow s_{\pi KINE}$

Correction by Global efficiency from MC "true"
$s_{\pi KINE}$ (all cuts)/ $s_{\pi KINE}$ (no cuts)

DT/MC efficiency corrections
Tracking, Trigger, Vertex

Unshifting (D'Agostini)
$s_{\pi} \rightarrow s_{\gamma*}$

Normalization to Luminosity

Division by Radiator function

Undressing for FSR

f_0+$\rho\pi\gamma$ correction
Phokhara6.1 stand alone
a'la Olga

$|F_{\pi}|^2$

Where were we?

Last referee meeting (9.05.2008) conclusion

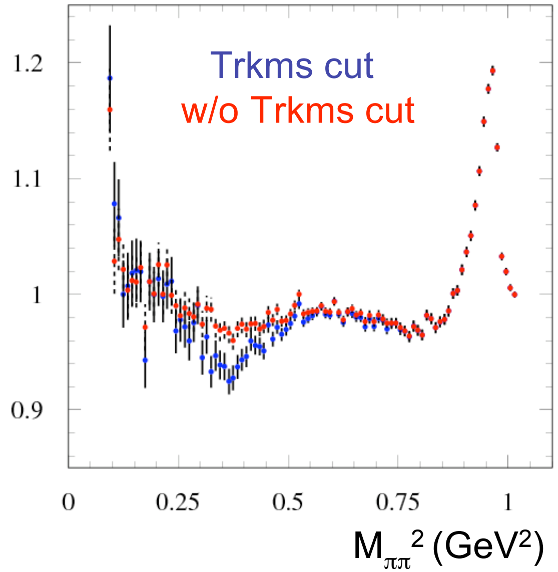
(Memo LA2002 circulating among the referees)

- Systematic error on $|F_\pi|$
  (w/o f_0 & $\rho\pi\gamma$ contribution)

0.4 GeV²	0.6 GeV²	0.85 GeV²
0.8%	0.6%	1.0%

- Scalar background: insertion of the latest $f_0+\rho\pi\gamma$ model (Achasov) together with the best radiative correction description, `PHOKHARA6.1` (Olga Shekhovtsova)

(ISR+sQED+f_0+$\rho\pi\gamma$) / (ISR+sQED)



Where were we?

- *FSR-NLO* (*unshifting*) and *unfolding* corrections
  using matrix (D'Agostini) instead of bin by bin
  (as it is in SMA 2002)

- Extended measurement down to 0.3 GeV^2 (previosusly it was at 0.5 GeV^2)

- Theoretical error on FSR still under discussion

Unfolding, Unshifting and Global Efficiency

Previously: Global efficiency, bin-by-bin unfolding, bin-by-bin unshifting
In one step (PHOKHARA5Ω)

$$\frac{dN/ds_{\pi}^{rec}\ \text{(all cuts)}}{dN/ds_{\gamma^*}\ \text{(no cuts)}}$$

Now: unfolding a'la D'Agostini (Bayes), Global efficiency, unshifting a'la D'Agostini (Bayes)
Three steps a'la PoP (PHOKHARA5Ω)

$$dN/ds_{\pi}^{REC}\ (\text{all cut } rec) \Downarrow dN/ds_{\pi}^{KINE}\ (\text{all cuts } rec)$$

unfolding

$$\frac{dN/ds_{\pi}^{KINE}\ (\text{all cuts } rec)}{dN/ds_{\pi}^{KINE}\ \text{(no cuts)}}$$

global efficiency

$$dN/ds_{\pi}^{KINE}\ \text{(no cuts)} \Downarrow dN/ds_{\gamma^*}^{KINE}\ \text{(no cuts)}$$

unshifting

Unfolding

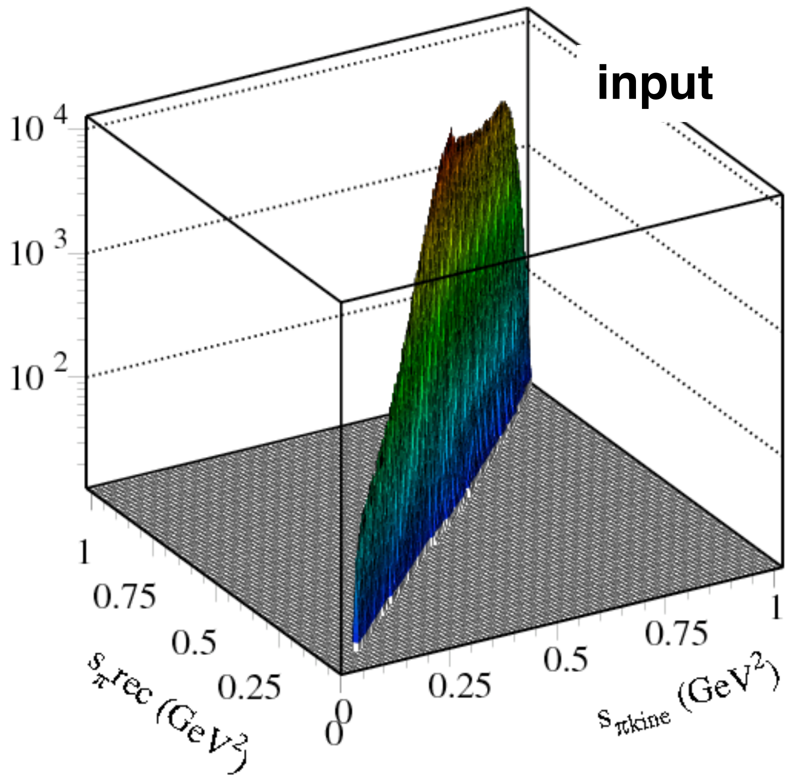
PHOKHARA5Ω

dN / ds_{π}^{REC} (all cut rec)

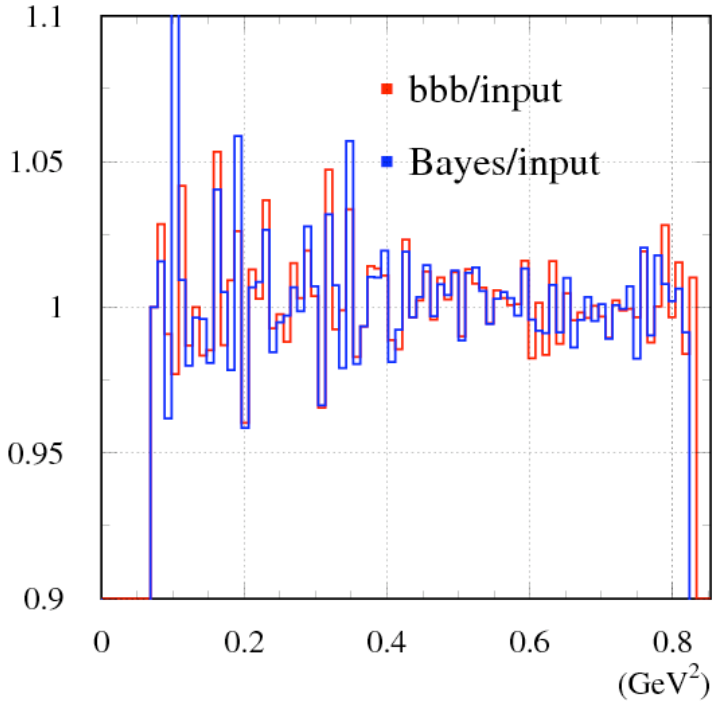
$\Downarrow$

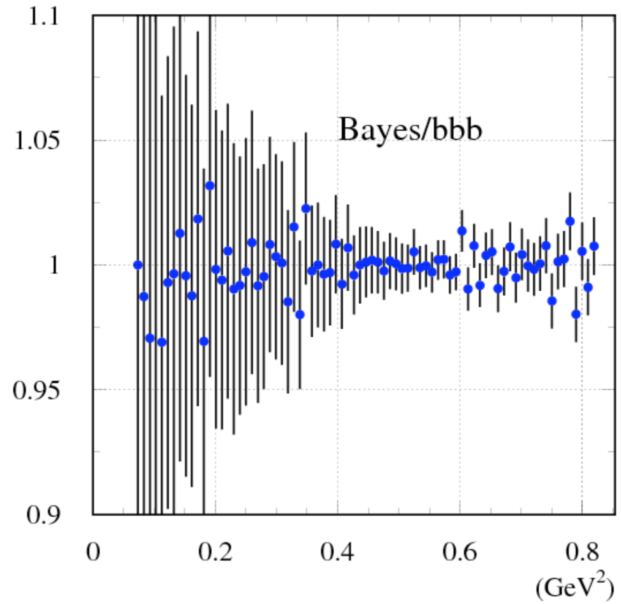
dN / ds_{π}^{KINE} (all cuts rec)

Two approaches:
- bin by bin
- Bayesian approach (D'Agostini)



Unfolding





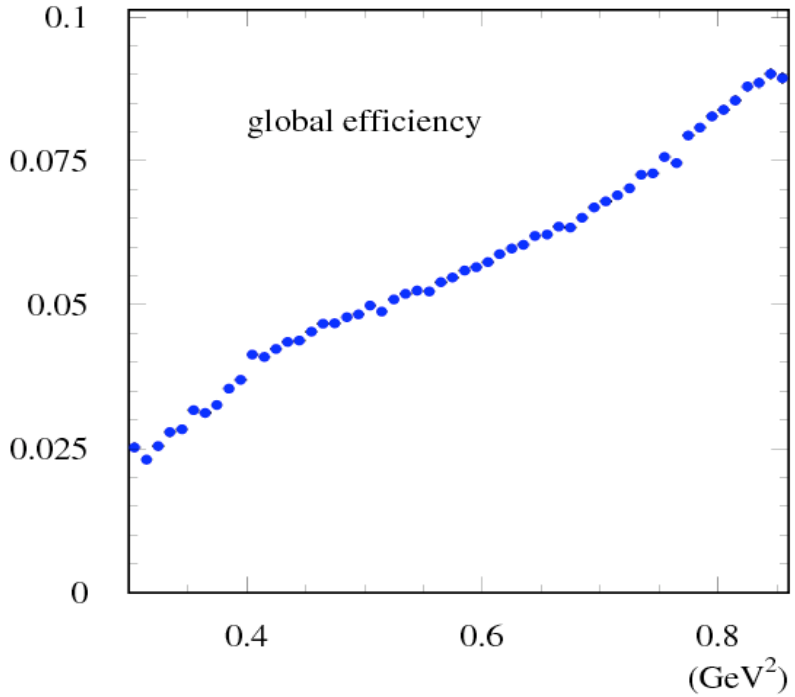
- Spectrum not deformed by unfolding
- Agreement between the two approaches
- **More statistics needed**

Global efficiency

Analysis cuts

- $\rho_{PCA} < 8$ cm, $|z|_{PCA} < 12$ cm, $\rho_{FirstHit} < 50$ cm
- $\rho_{VTX} < 8$ cm, $|z|_{VTX} < 12$ cm
- $50° < \theta_{\pi,\gamma} < 130°$
- `.and.` of π-e likelihood function
- $\chi^2_{\pi\pi\pi} > 200$
- $M_{trk}(s_\pi)$
- $\Omega_{p_{miss}\text{-}\gamma}(s_\pi)$

$$\frac{dN/ds_\pi^{KINE}(\text{all cuts } rec)}{dN/ds_\pi^{KINE}(\text{no cuts})}$$



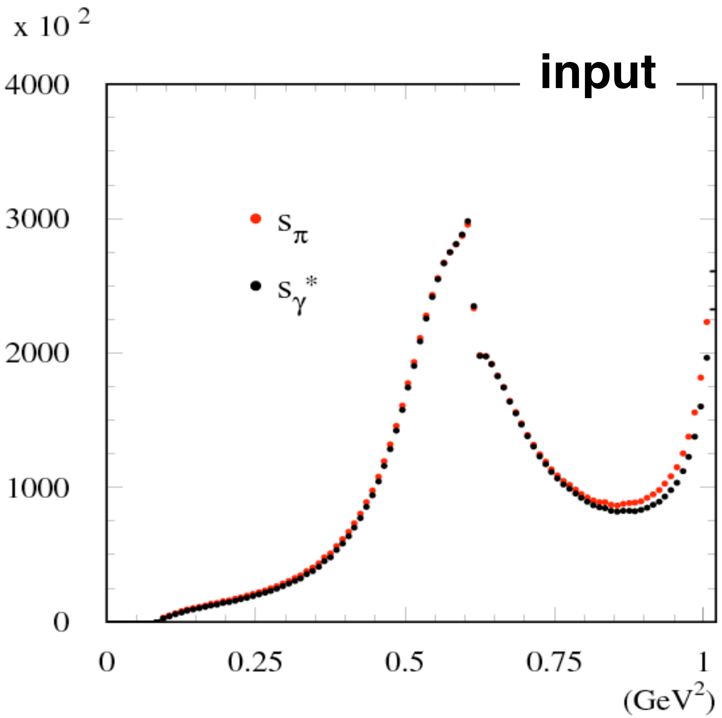
LO-/NLO- FSR correction (unshifting)

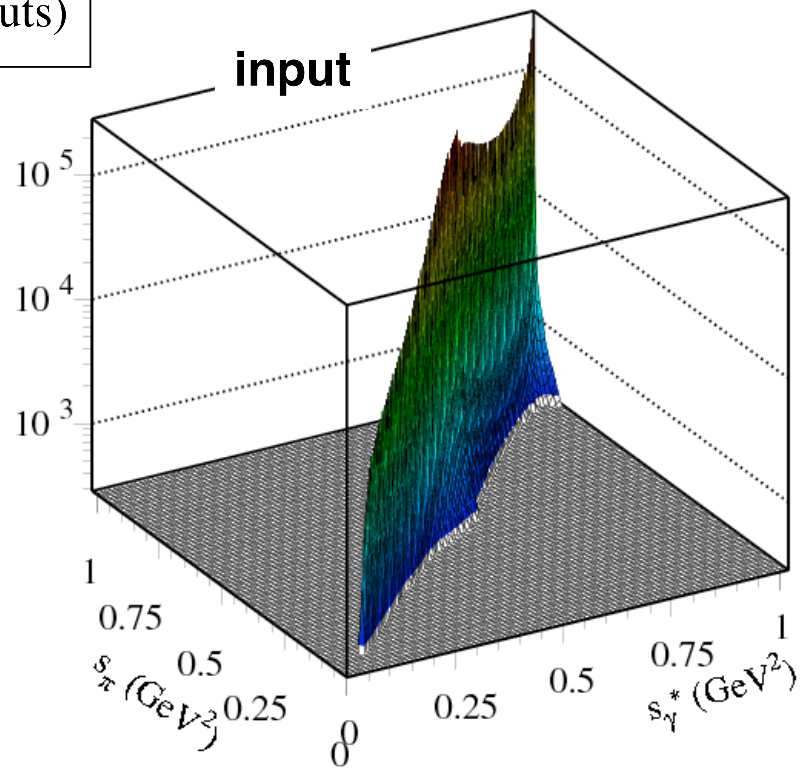
PHOKHARA5Ω

$$dN / ds_{\pi}^{KINE} \text{ (no cuts)}$$

$$\Downarrow$$

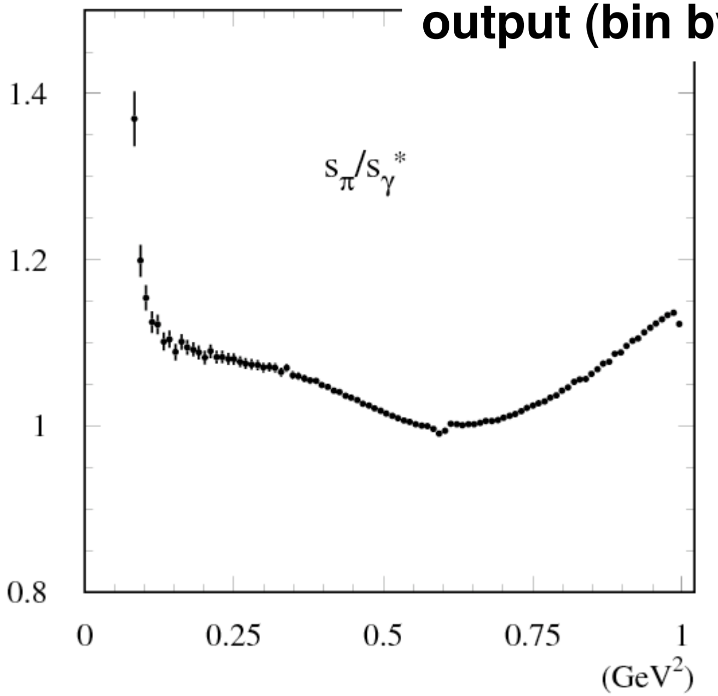
$$dN / ds_{\gamma^*}^{KINE} \text{ (no cuts)}$$

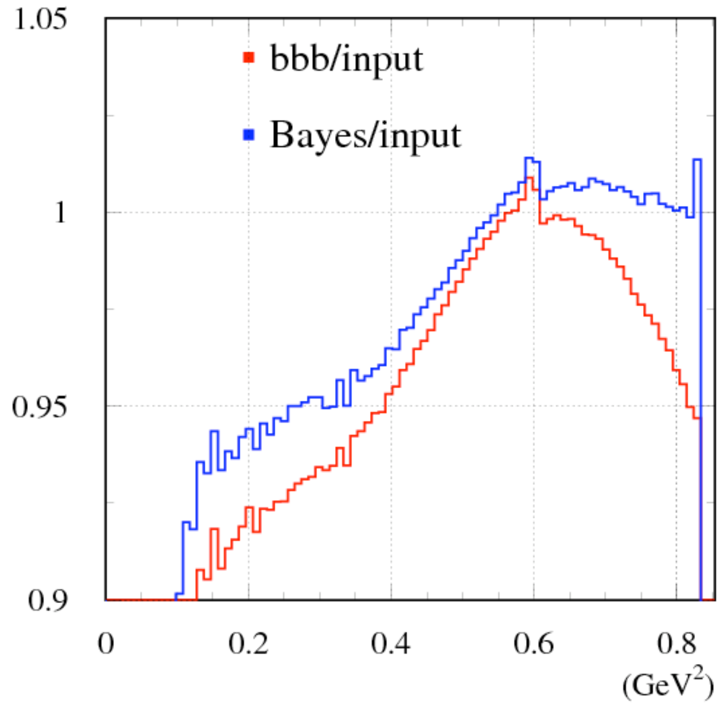




LO-/NLO- FSR correction (unshifting)

output (bin by bin)





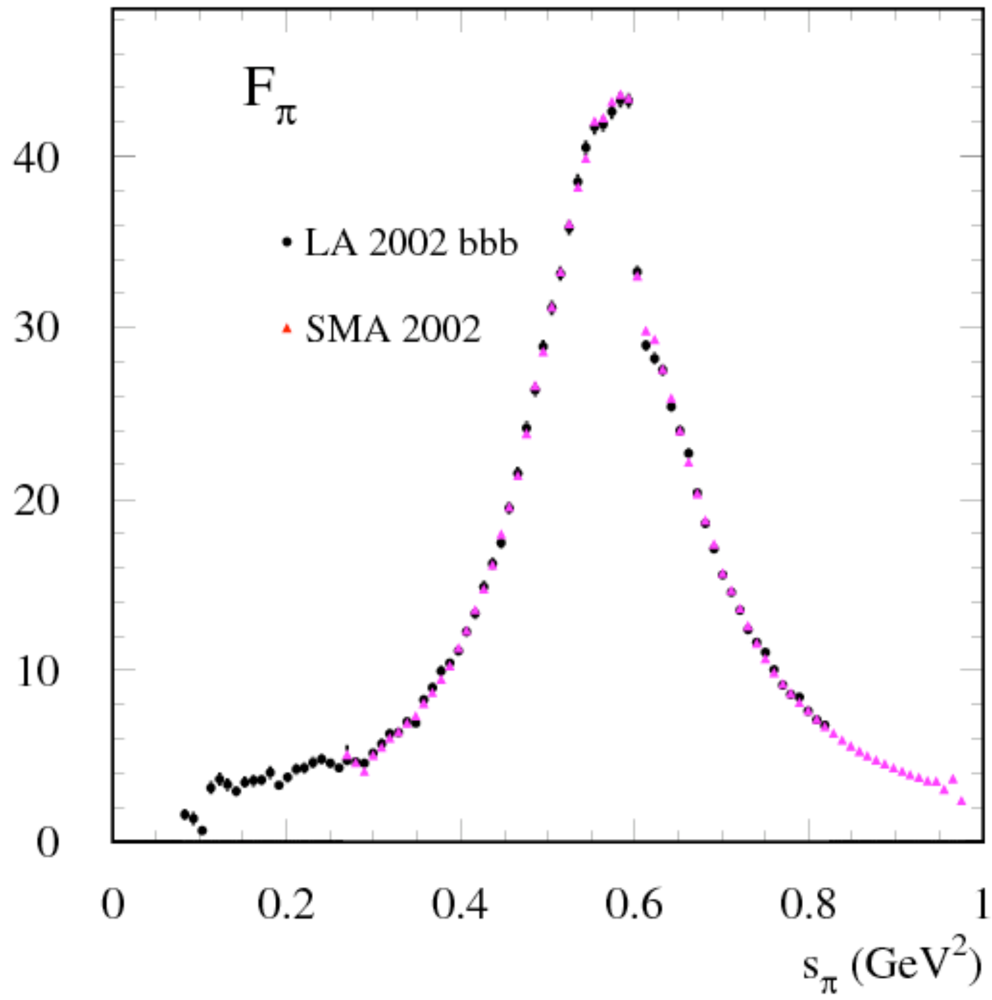
- Up to 5% disagreement between the two approaches

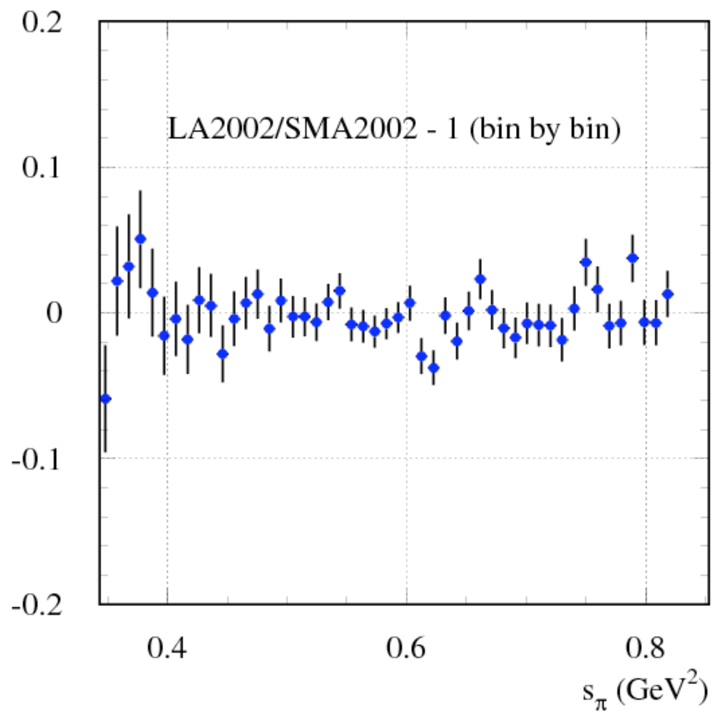
This directly affects F_π

⇒ **Must be understood**

Pion Form Factor

Bin by bin unshifting





Excellent agreement between LA2002 and SMA2002

Status of
Large Angle
2006

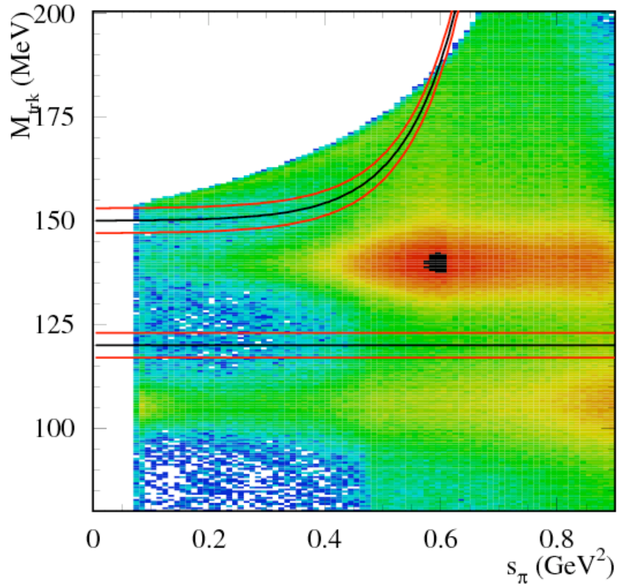
PoP

Background rejection

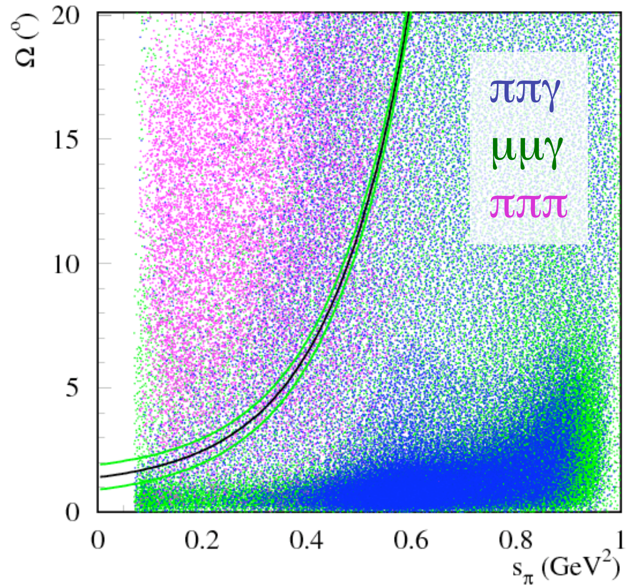
Analysis cuts

- $\rho_{PCA} < 8$ cm,
  $|z|_{PCA} < 12$ cm
- $\rho_{FirstHit} < 50$ cm
- **no vertex**
- $50° < \theta_{\pi,\gamma} < 130°$
- $|p| > 200$ MeV/c
- `.or.` of π-e likelihood
- **no** $\chi^2_{\pi\pi\pi}$
- $M_{trk}(s_\pi)$
- $\Omega_{p_{miss}\text{-}\gamma}(s_\pi)$

$M_{trk}(s_\pi) \pm \delta_{Mtrk} \approx 1\sigma$



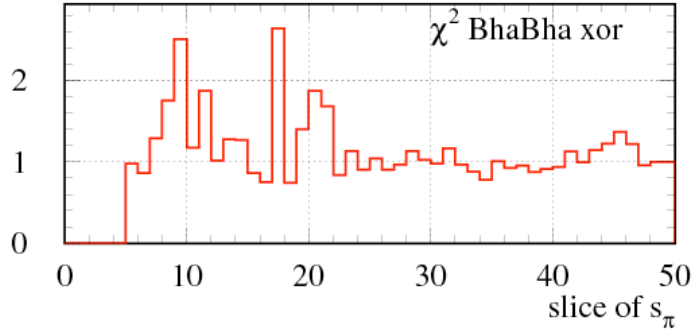
$\Omega_{p_{miss}\text{-}\gamma}(s_\pi) \pm \delta_\Omega \approx 1\sigma$



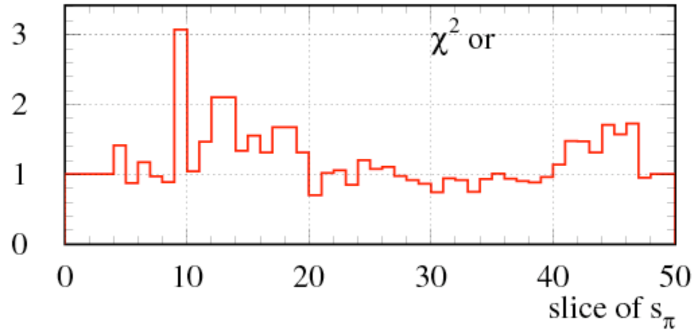
Background subtraction

Fitting procedure applied to M_{trk} shapes in slices of s_π

1. **.XOR. to get eeγ amount**



2. **.OR. to get $\mu\mu\gamma$ and $\pi\pi\pi$ amount**

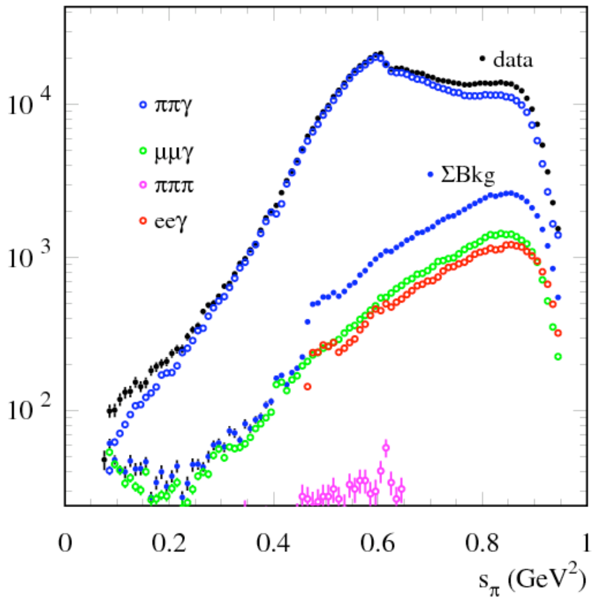


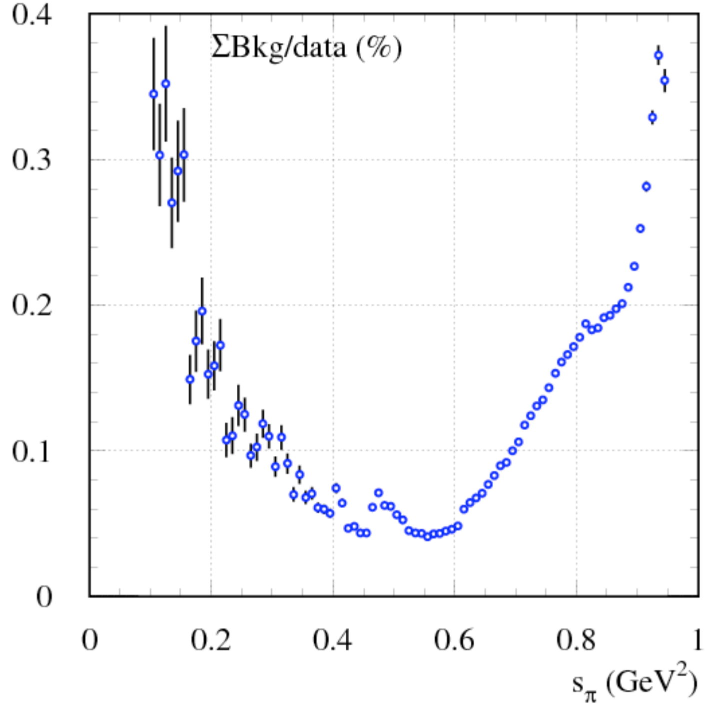
Spectrum and Background

Analysis cuts

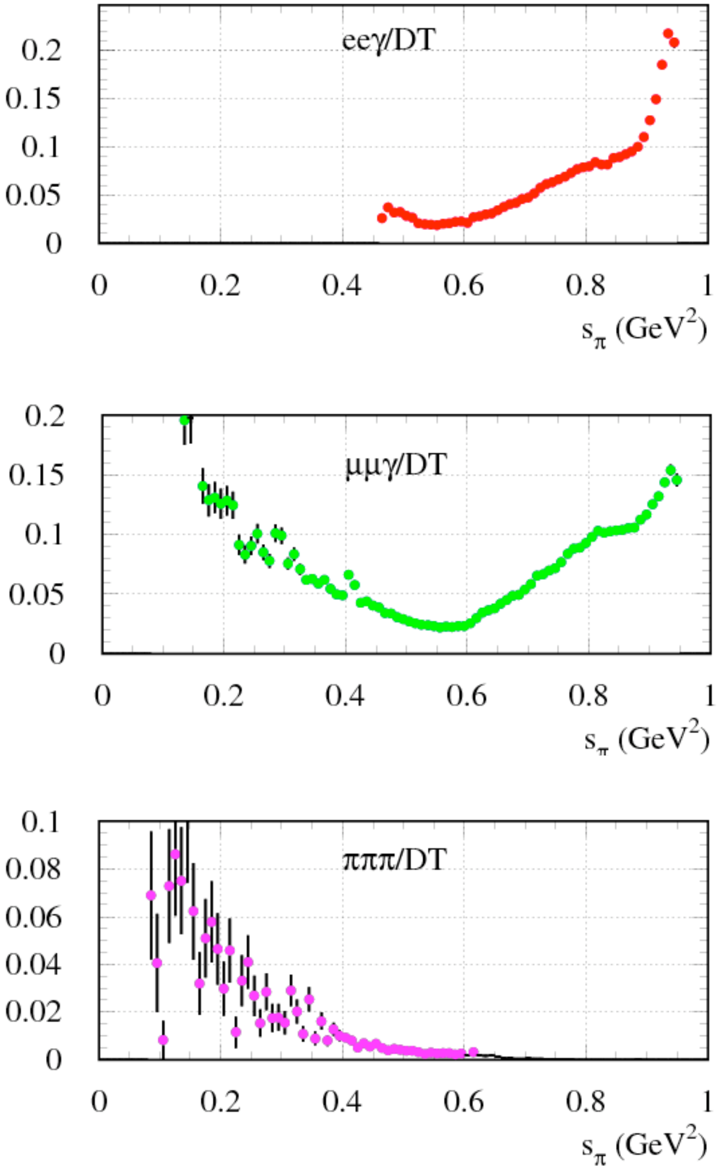
- $\rho_{PCA} < 8$ cm,
  $|z|_{PCA} < 12$ cm
- $\rho_{FirstHit} < 50$ cm
- **no vertex**
- $50° < \theta_{\pi,\gamma} < 130°$
- $|p| > 200$ MeV/c
- `.or.` of π-e likelihood
- **no** $\chi^2_{\pi\pi\pi}$
- $M_{trk}(s_\pi)$
- $\Omega_{p_{miss}\text{-}\gamma}(s_\pi)$

Background subtraction





Spectrum and Background



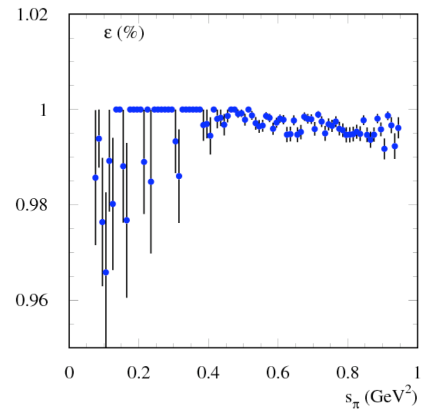
Further checks to be done for eeγ at low s_π

- using eeγ MC
- enlarging the bins and the slices for the fit

FILFO and Likelihood efficiency

Filfo efficiency

Efficiency directly from DATA
Using downscaled events



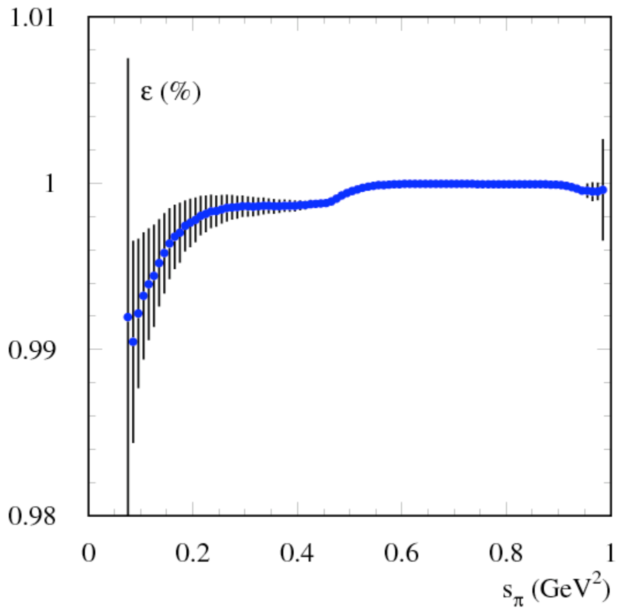
- fit the efficiency and correct the spectrum via the fit function

π-e likelihood with TCA efficiency (`.or.`)

Efficiency directly from DATA. Selecting ππγ events

- All the analysis selection

⇒ look for at least one track associated to a cluster and with $L_\pi/L_e > 0$



1. Efficiency in slices of θ as a function of p
2. Mapping of $\varepsilon(\pm,\theta,p)$ to get $\varepsilon(s_\pi)$

$$\varepsilon = 1 - (1- \varepsilon(+,\theta,p))(1- \varepsilon(-,\theta,p)) \rightarrow \varepsilon(s_\pi)$$

- cross check with MC

Unfolding

PHOKHARA5@1GeV

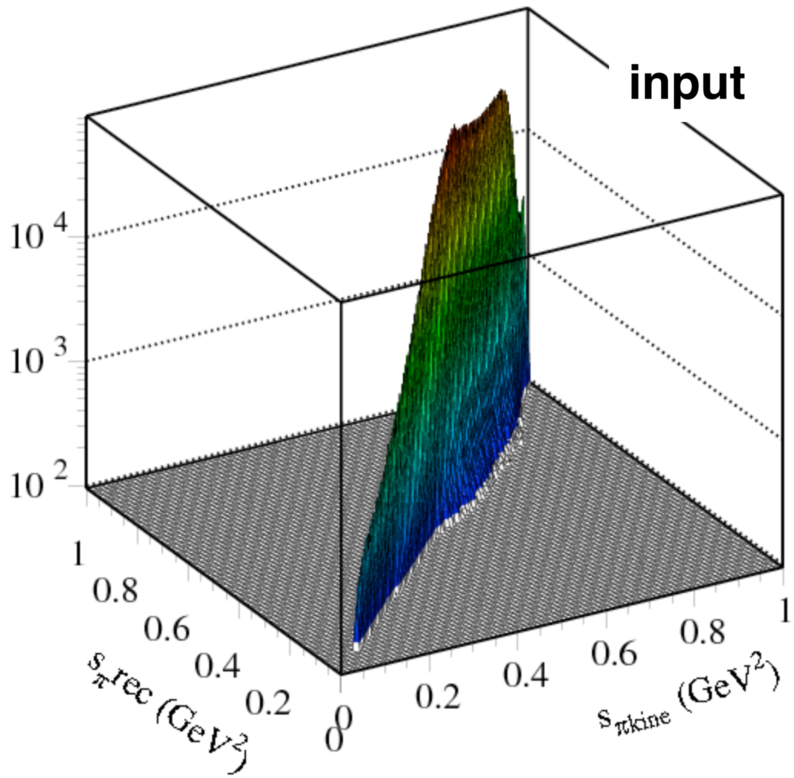
$$dN/ds_{\pi}^{REC} \text{ (all cut } rec)$$

$$\Downarrow$$

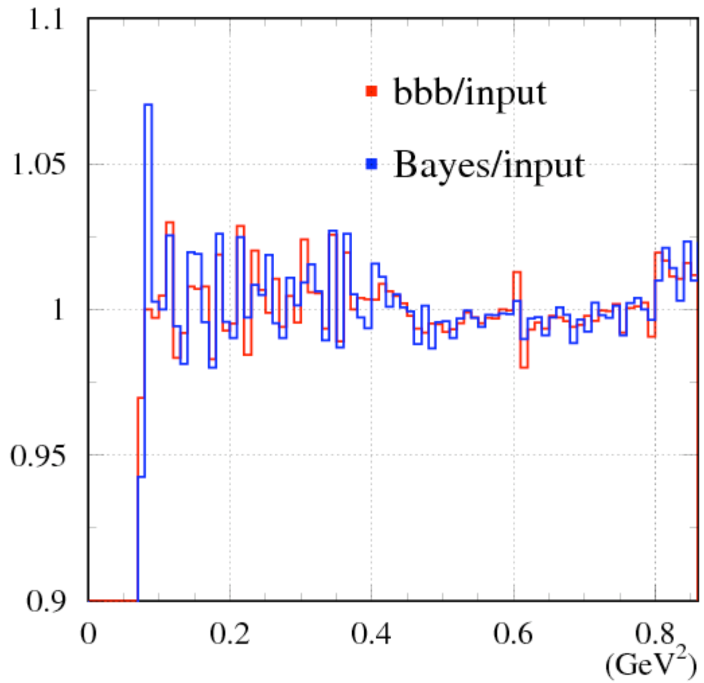
$$dN/ds_{\pi}^{KINE} \text{ (all cuts } rec)$$

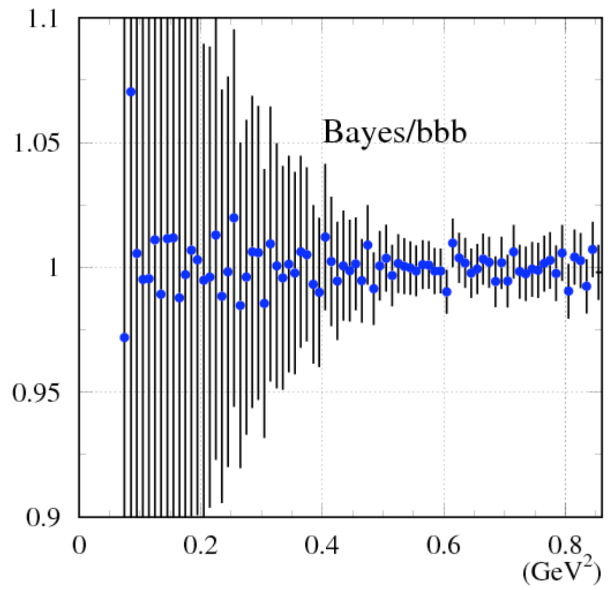
Two approaches:

- bin by bin
- Bayesian approach (D'Agostini)



Unfolding





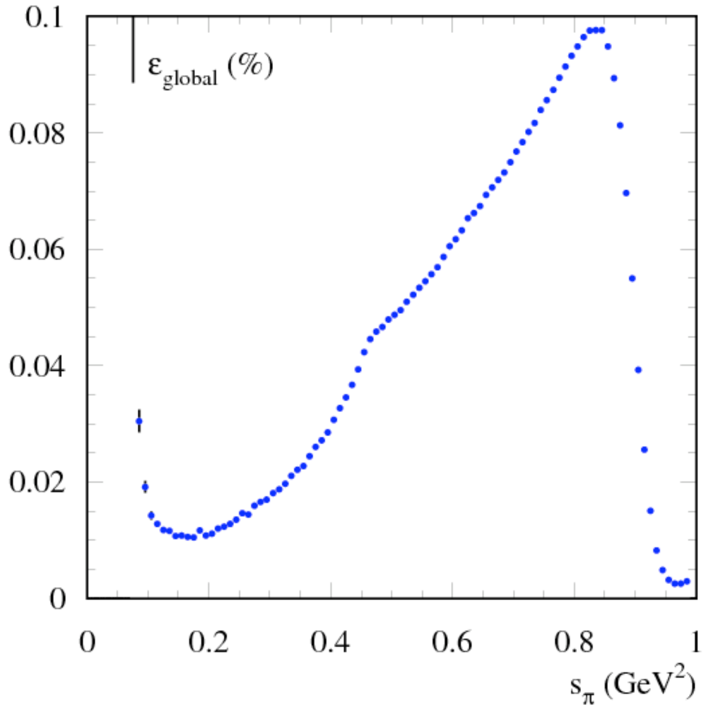
- Spectrum not deformed by unfolding
- Agreement between the two approaches

Global efficiency

Analysis cuts

- $\rho_{PCA} < 8$ cm,
  $|z|_{PCA} < 12$ cm
- $\rho_{FirstHit} < 50$ cm
- **no vertex**
- $50° < \theta_{\pi,\gamma} < 130°$
- $|p| > 200$ MeV/c
- `.or.` of π-e likelihood
- **no** $\chi^2_{\pi\pi\pi}$
- $M_{trk}(s_\pi)$
- $\Omega_{p_{miss}-\gamma}(s_\pi)$

$$\frac{dN/ds_\pi^{KINE}\,(\text{all cuts } rec)}{dN/ds_\pi^{KINE}\,(\text{no cuts})}$$



Tracking efficiency

Selecting $\pi\pi\gamma$ events

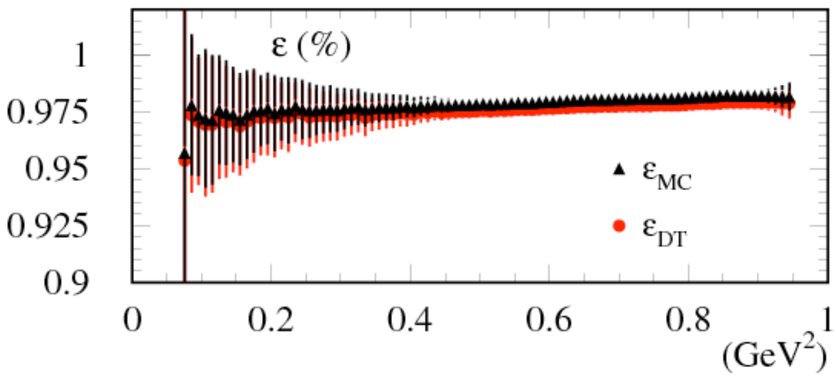
- Tagging Track

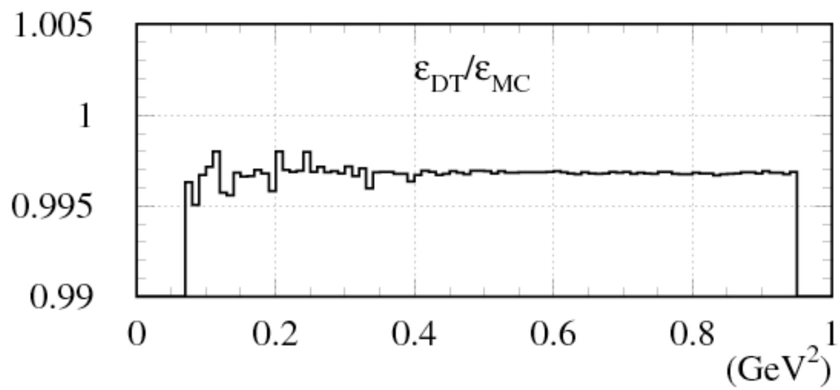
- Neutral prompt cluster

$\Rightarrow$ search for another track with opposite charge

ρ_{FH} < 50 cm, ρ_{PCA} < 8 cm and $|z_{PCA}|$ < 12 cm

1. Efficiency in slices of θ as a function of |p| for DATA and MC
2. DATA/MC correction obtained from fit of $\varepsilon(\pm,p)$ in slices of θ
3. Mapping of $\varepsilon(\pm,\theta,p)$ to get $\varepsilon(s_\pi)$





Bin by bin correction applied to the spectrum

Trigger efficiency

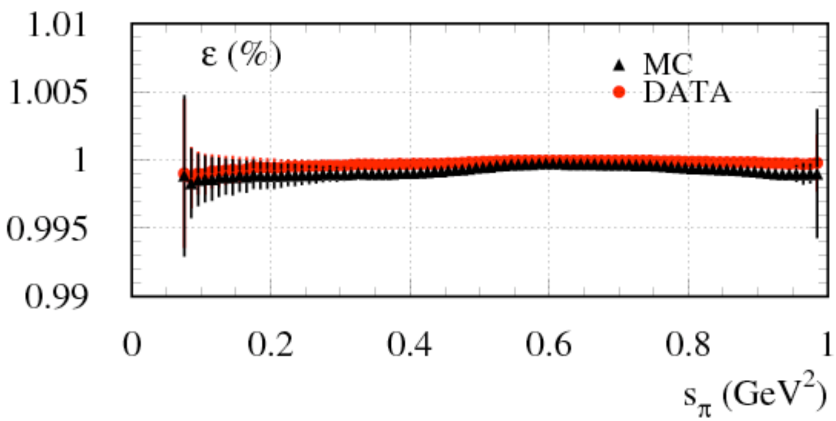
Selelecting $\pi\pi\gamma$ events

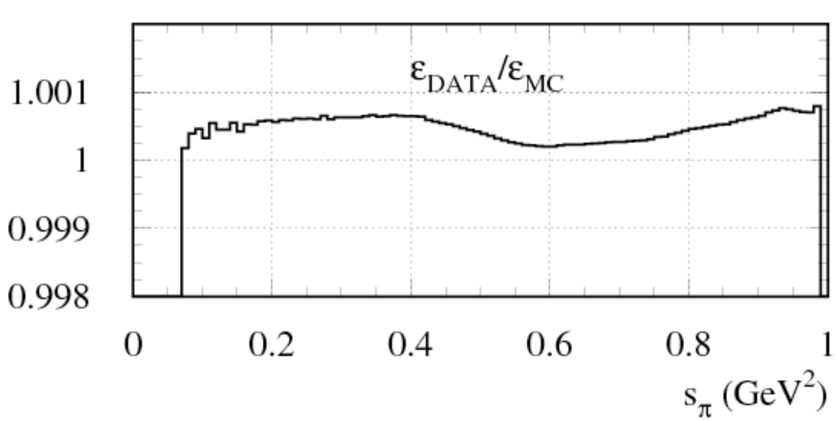
- All the analysis selection

1. Efficiency in slices of θ as a function of |p| for DATA and MC for a single particle to fire 0, 1 or 2 trigger sectors (P(0), P(1), P(2))
2. Mapping of $\varepsilon(\pm,\theta,p)$ to get $\varepsilon(s_\pi)$

Getting the inefficiency and fro that the efficiency

$\varepsilon = 1 - P^+(0)P^-(0)P^\gamma(0) - P^+(1)P^-(0)P^\gamma(0) - P^+(0)P^-(1)P^\gamma(0) - P^+(0)P^-(0)P^\gamma(1) \rightarrow \varepsilon(s_\pi)$





Bin by bin correction applied to the spectrum

LO-/NLO- FSR correction (unshifting)

PHOKHARA5Ω @1GeV

$$dN / ds_{\pi}^{KINE} \text{ (no cuts)}$$

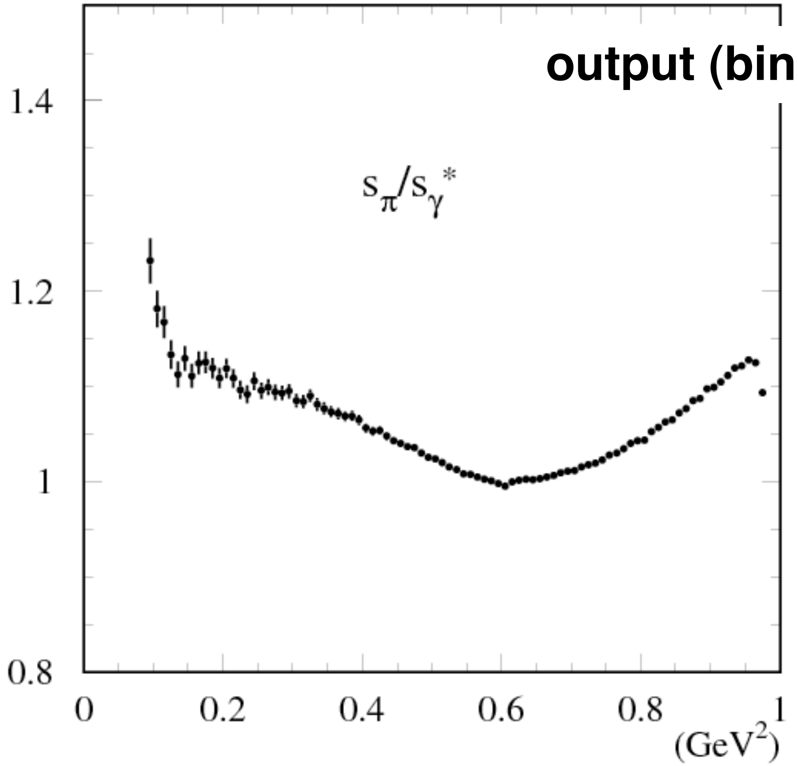
$$\Downarrow$$

$$dN / ds_{\gamma^*}^{KINE} \text{ (no cuts)}$$

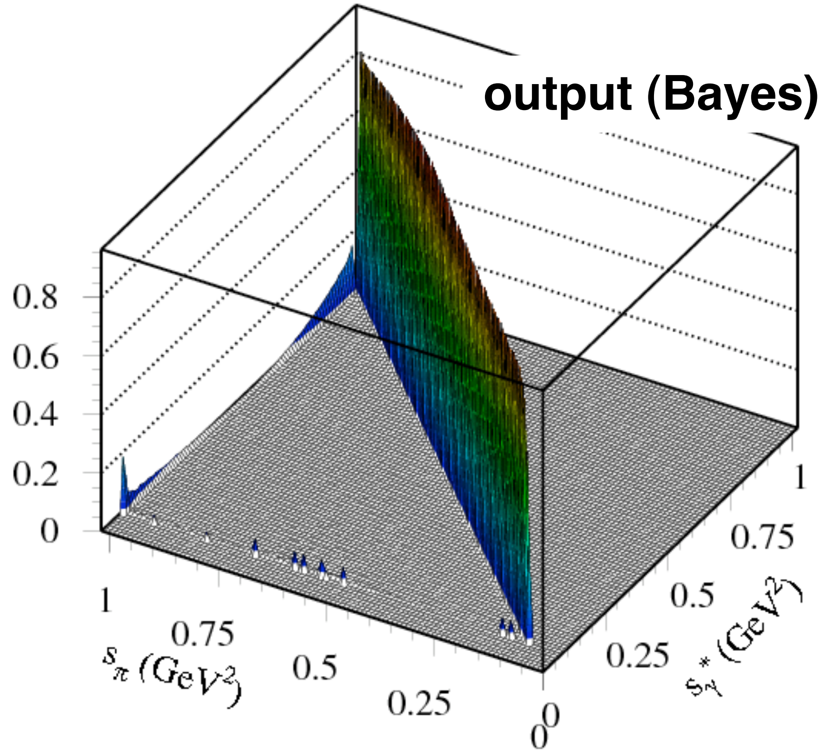
Two approaches:

- bin by bin
- Bayesian approach (D'Agostini)

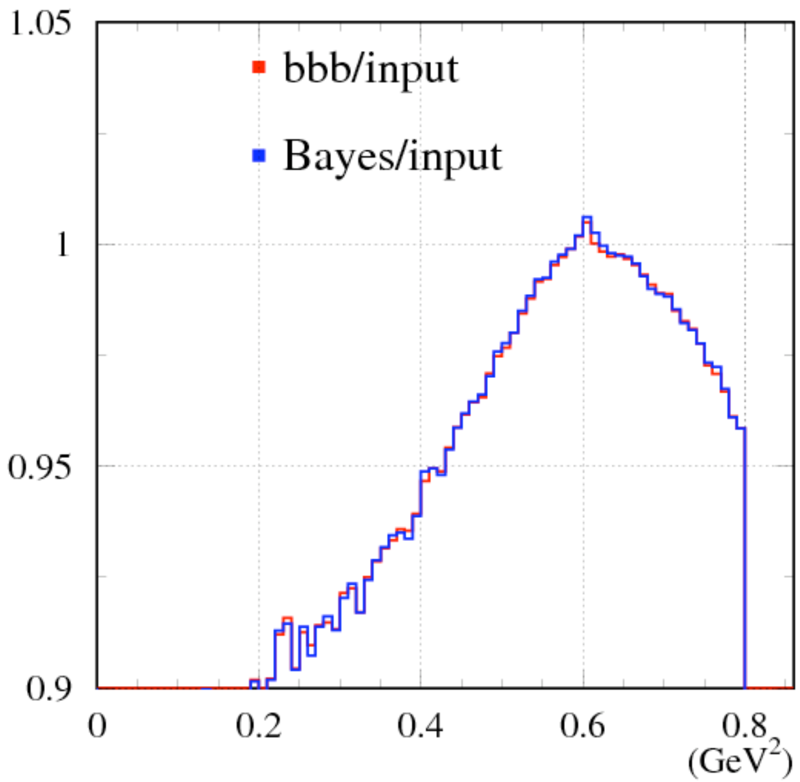
output (bin by bin)



output (Bayes)

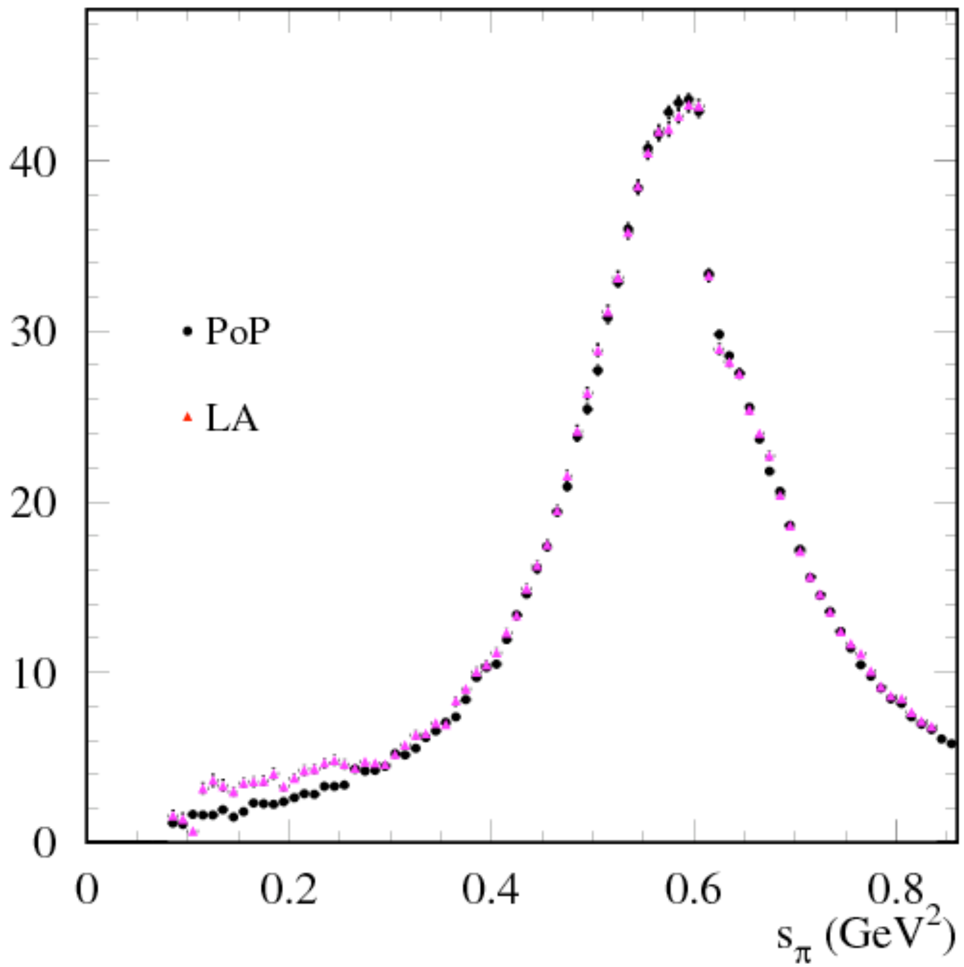


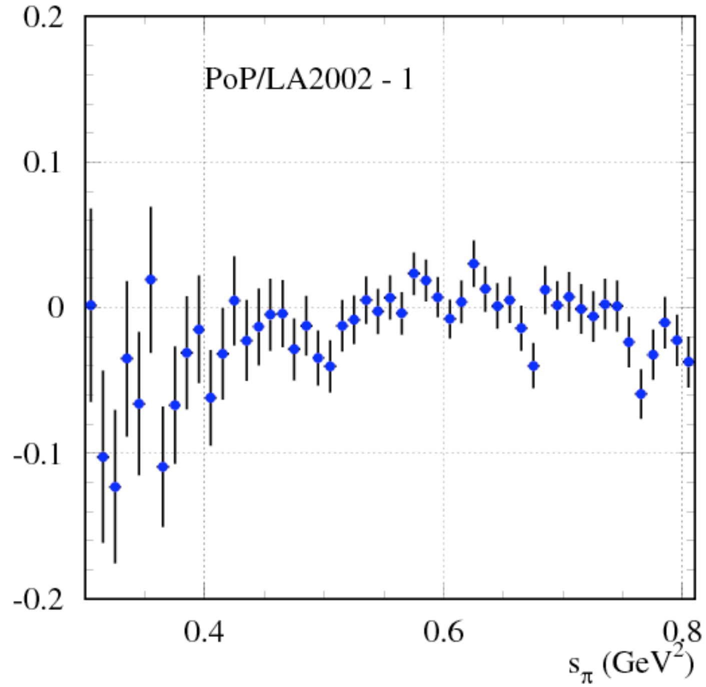
LO-/NLO- FSR correction (unshifting)



Excellent agreement between the two methods

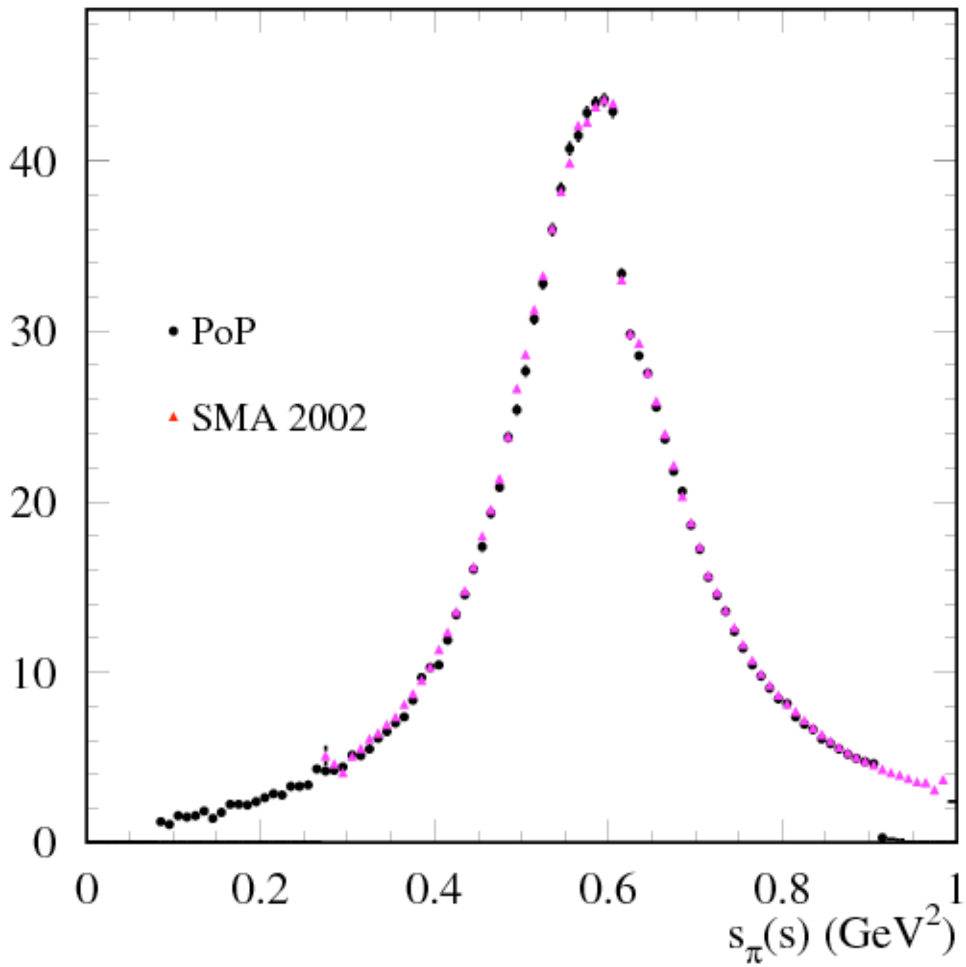
Pion Form Factor & comparisons

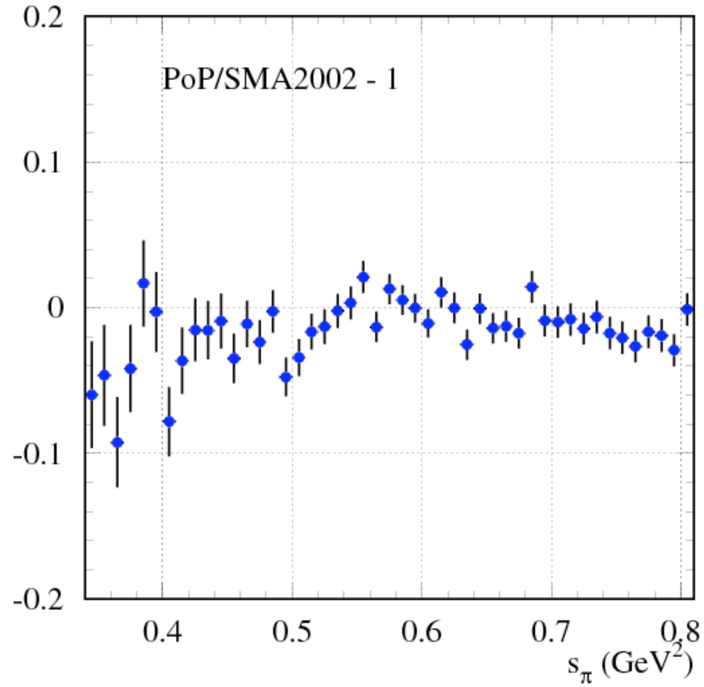




Discrepancies at low s_π region:
***f_0*+$\rho\pi\gamma$ contamination**
And small discrepancy at high s_π region

Pion Form Factor & comparisons





Nice agreement.
Trend at low s_π up to ~8%
Lower of ~1% above 0.7GeV²

Conclusion

LA2002

- **Questions from referees answered**

⇒ Unfolding and FSR a'la D'Agostini, like SMA2002, done

still to be understood **discrepancy between the two approaches for FSR**

- **Ready to go down to 0.3 GeV^2**
- Discussion ongoing about the treatment of the error on sQED approximation

PoP

- **All the main steps of the analysis done**

⇒ Analysis cuts, background rejection, efficiencies, unfolding and unshifting

- **Preliminary Pion Form Factor extracted**
- **Some other checks to be done**
- **Evaluation of systematics in progress**

Backup slides

PoP Analysis flow

Observed $\pi\pi\gamma(\gamma)$ spectrum
PCA variables

Background subtraction

Correction by efficiency taken from DATA
FILFO, Likelihood and TCA

Unfolding (D'Agostini)
$s_{\pi REC} \rightarrow s_{\pi KINE}$

Correction by Global efficiency
$s_{\pi KINE}$ (all cuts)/ $s_{\pi KINE}$ (no cuts)

DT/MC efficiency corrections
Tracking, Trigger, Photon

Unshifting (D'Agostini)
$s_{\pi} \rightarrow s_{\gamma *}$

Normalization to Luminosity

Division by Radiator function

Undressing for FSR

$|F_{\pi}|^2$

Unfolding & Unshifting

$$N_i^{true} = \sum_{j=1} P(N_i^{true} \mid N_j^{rec}) \cdot N_j^{rec}$$

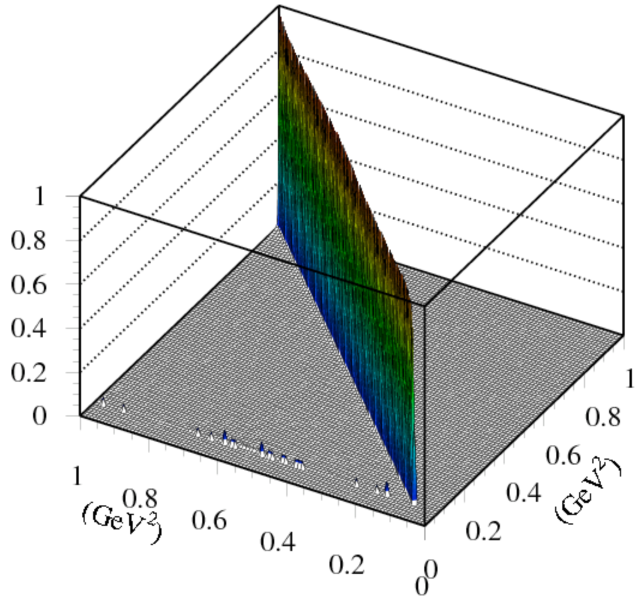
Two methods to get $P(N_j^{rec} \mid N_i^{true})$

1. $\sum_{i=1}^{n_{tue}} P(N_i^{true} \mid N_j^{rec}) = 1$ **bin by bin**

2. $P(N_i^{true} \mid N_j^{rec}) = \frac{P(N_j^{rec} \mid N_i^{true}) \cdot P_0(N_i^{true})}{\sum_{l=1}^{n_{true}} P(N_j^{rec} \mid N_i^{true}) \cdot P_0(N_i^{true})}$ **Bayes' theorem**

No cuts applied to unfold and to unshift
For unfolding only reconstruction required both in N_j^{rec} and N_i^{true}

Unshifting matrix for LA2002



a. $M_{trk}^{up}(s_{\pi}) = 150 + 3.5 \cdot 10^{-4} e^{11 \cdot s_{\pi}} \pm \delta_{Mtrk}$

b. $M_{trk}^{low} = 120 \pm \delta_{Mtrk}$

c. $\Omega(s_{\pi}) = 1 + 0.4 \cdot e^{6.5 \cdot s_{\pi}} \pm \delta_{\Omega}$

Trackmass resolution
$M_{trk}^{REC} - M_{trk}^{KINE}$
PoP