KLOE preliminary results for $\Gamma(K \to e\nu)/\Gamma(K \to \mu\nu)$

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for the KLOE collaboration

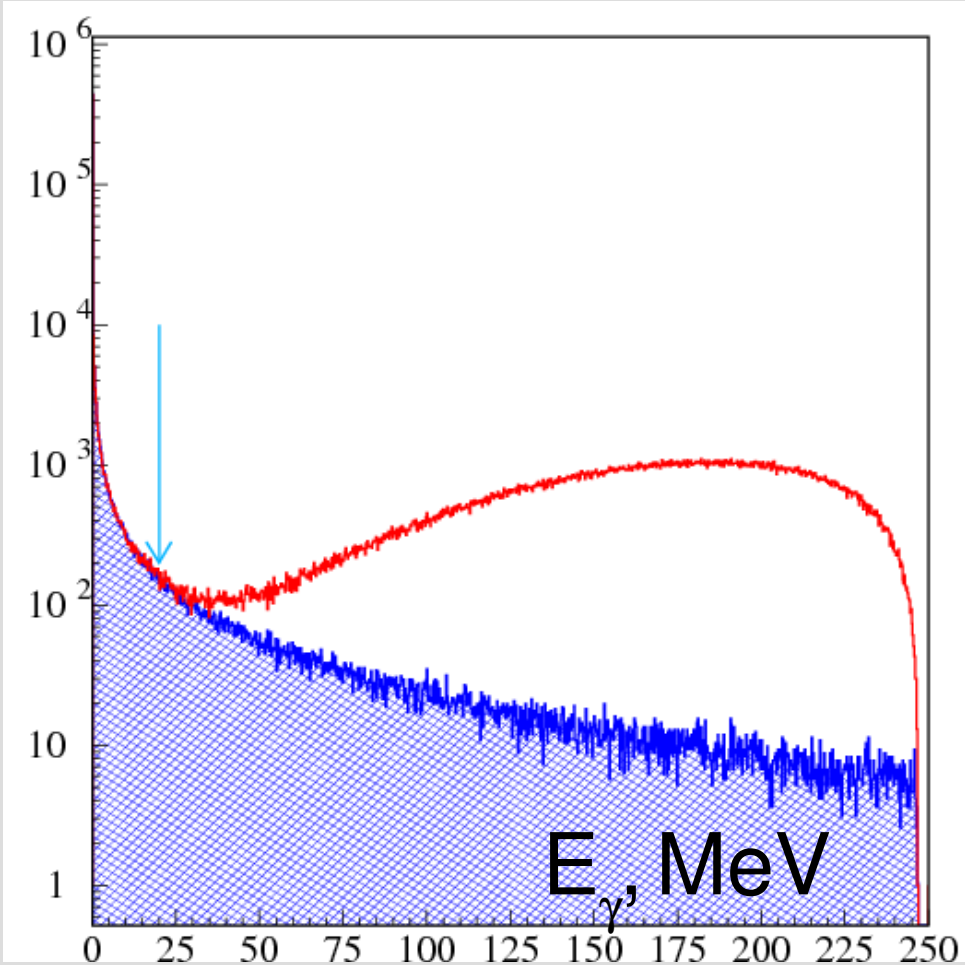
- Motivation
- Selection
  - Kinematic cuts
  - Particle identification using EmC
- Counting
- Conclusion

Motivations

- Test of lepton universality in SM helicity suppressed decays
- High sensitivity to “new physics”:
  - SM prediction is very precise, 0.04%, see Finkemeier, PLB387(1996)
  - Deviations up to few% could appear in MSSM with LFV, see Masiero, Paradisi, Petronzio PRD74(2006)
- Accuracy at KLOE can reach 1% level

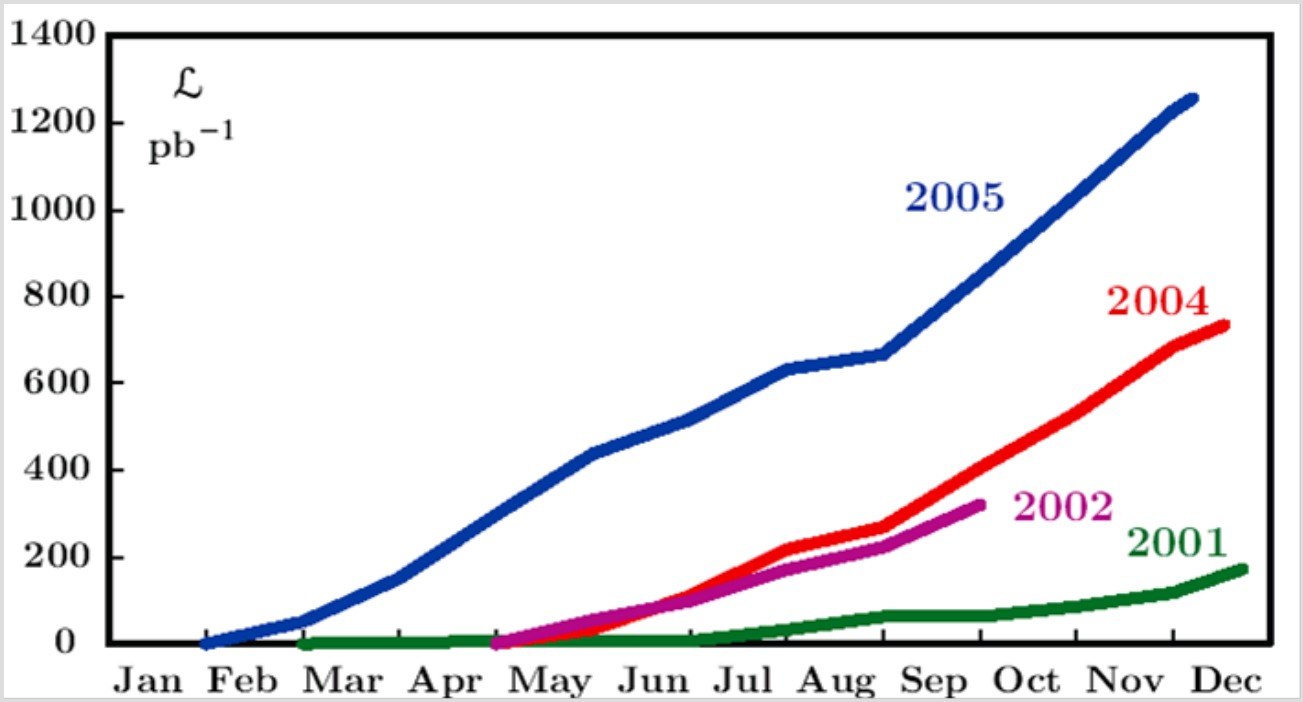
Signal definition

- Radiative corrections: IB + DE terms in MC generator
- Signal: $K \to e\nu(\gamma)$, $E_\gamma < 20$ MeV
- DE is negligible in this range
- SM prediction made in terms of IB process only (unobservable)
  - After counting, correct for $\varepsilon_{IB} = 0.9528(5)$ to compare with SM



Data sample

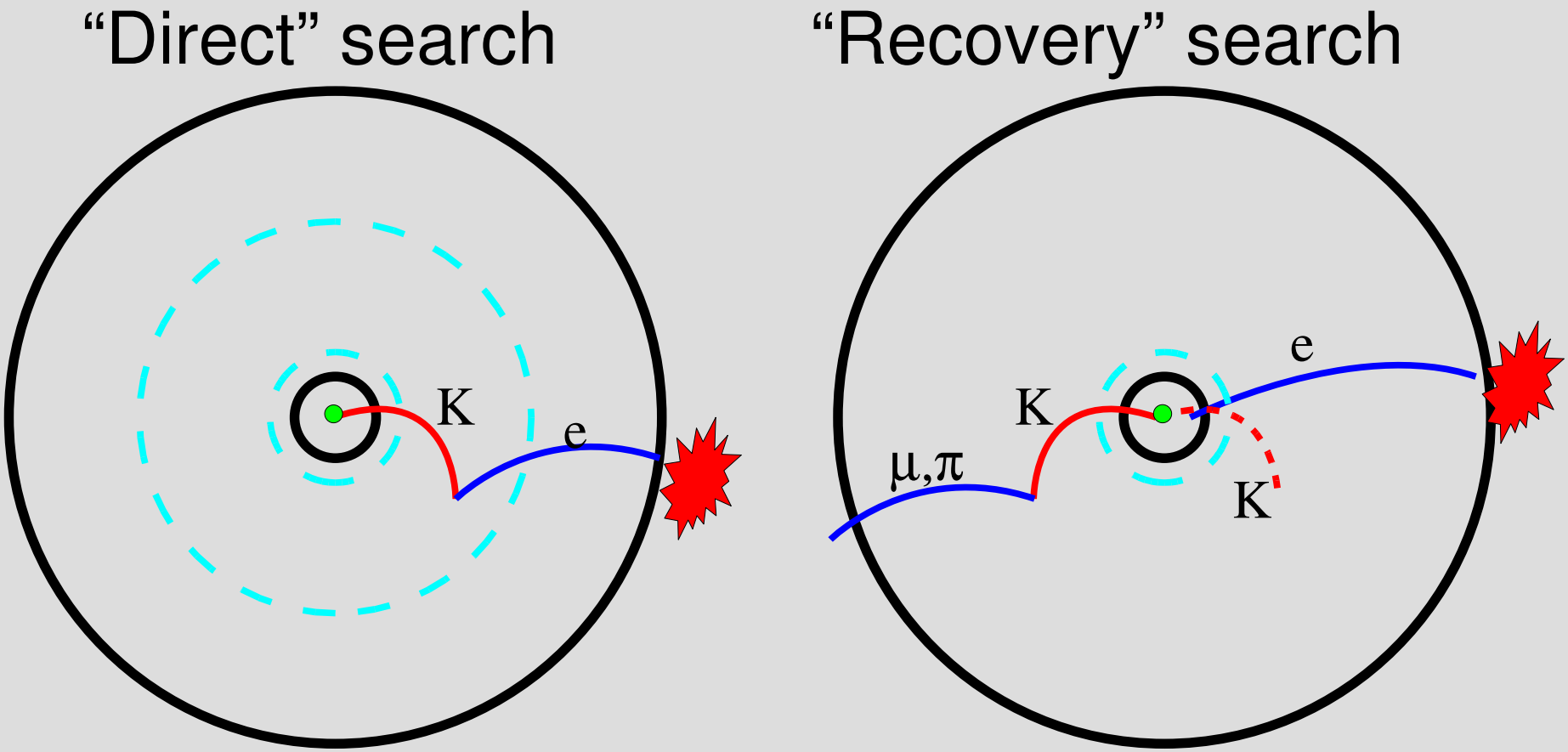
- Total integrated luminosity at ϕ–peak is ~ 2.3 fb^{-1}
- Analyzed luminosity is ~1.7 fb^{-1}
- MC set produced on a run-by-run basis (2001+2002+2005), ~1 fb^{-1}
  - Background - 1:1
  - Signal - 100:1



Event selection - 1

- "Direct" search, **without tagging (x4 statistics):**
  - Search for kink inside drift chamber
  - Track quality for K and secondary tracks, vtx quality
- "Recovery" search (additional 40% of statistics):
  - Tag $K^{+,-}$ with 2-body or track dE/dx
  - Search for decays of $K^{-,+}$ before DC
- For Ke2: PID technique based on EmC info
- Signal counting based on kinematics and PID
- **Preliminary result based on "direct" method**

Event selection - 2



Kaon momentum is measured with 1% resolution,
close kinematics to get M_{lep}

Ratio definition

$$R = \frac{N_{e2}}{N_{\mu 2}} \left[C^{TRG} \right] \left[C^{TRK} \frac{\varepsilon^{TRK}_{\mu 2}}{\varepsilon^{TRK}_{e2}} \right] \left[\frac{1}{C^{PID} \varepsilon^{PID}_{e2}} \right] \frac{1}{\varepsilon^{IB}_{e2}}$$

$C^{TRG} = \dfrac{\varepsilon^{TRG}_{\mu 2}}{\varepsilon^{TRG}_{e2}}$ Trigger efficiencies from data

ε^{TRK}_{i} Tracking efficiency from MC

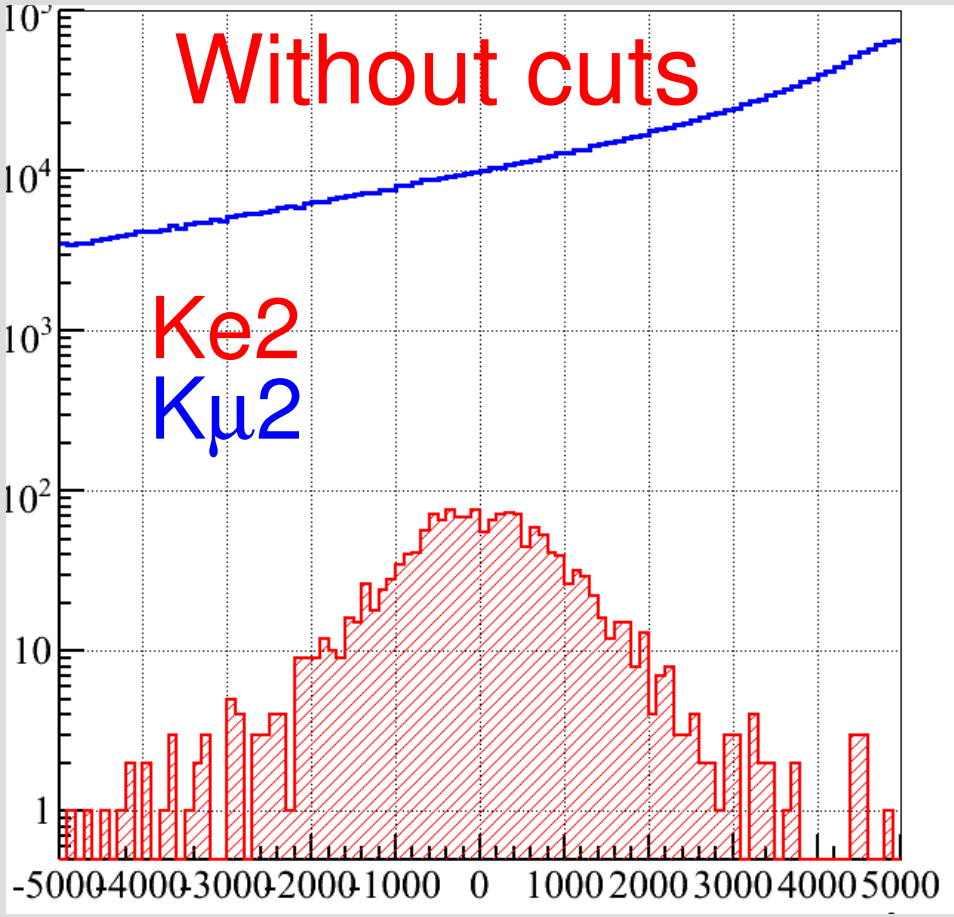
C^{TRK} Correction from data

ε^{PID}_{e2} PID efficiency from MC

C^{PID} Correction from data

Track+Vtx quality cuts

- Require:
  - $\chi^2_K < 6.6$
  - $\chi^2_e < 7$
  - $\chi^2_{vertex} < 3$
  - $\Delta M^2_{lep} < 2000$ (MeV/c²)²
- Quality cut suppress ~×10 Kμ2 resolution tails in signal region



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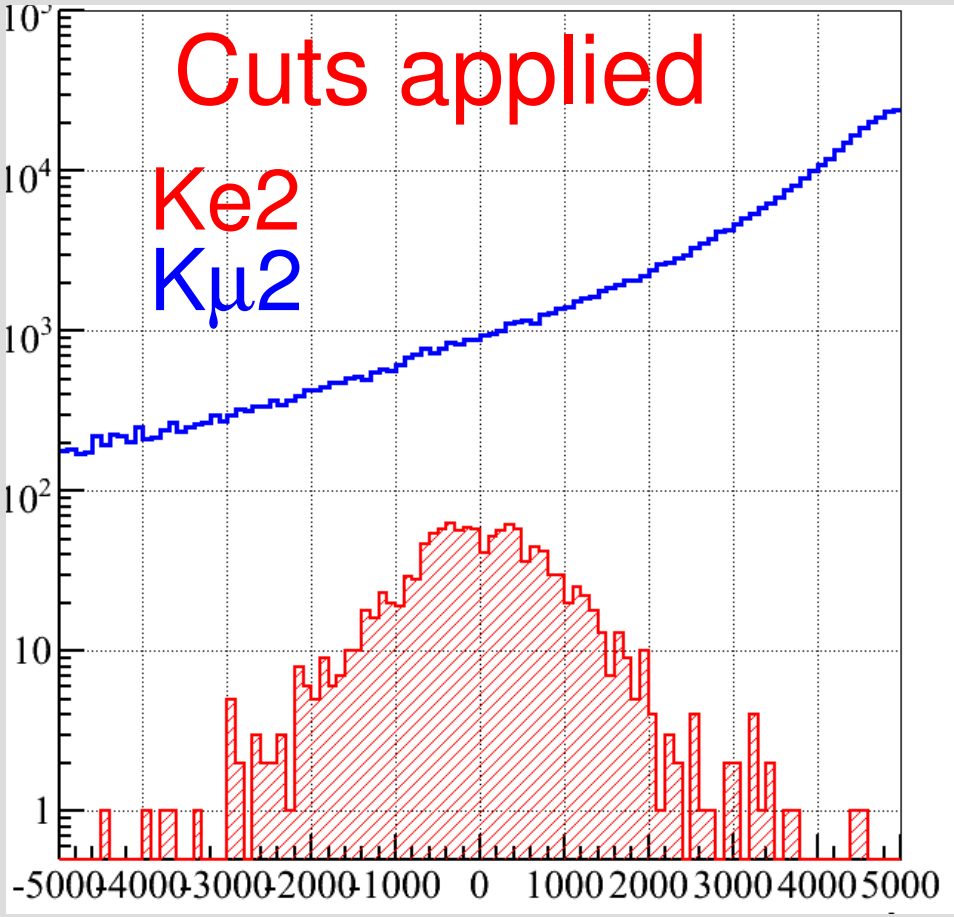
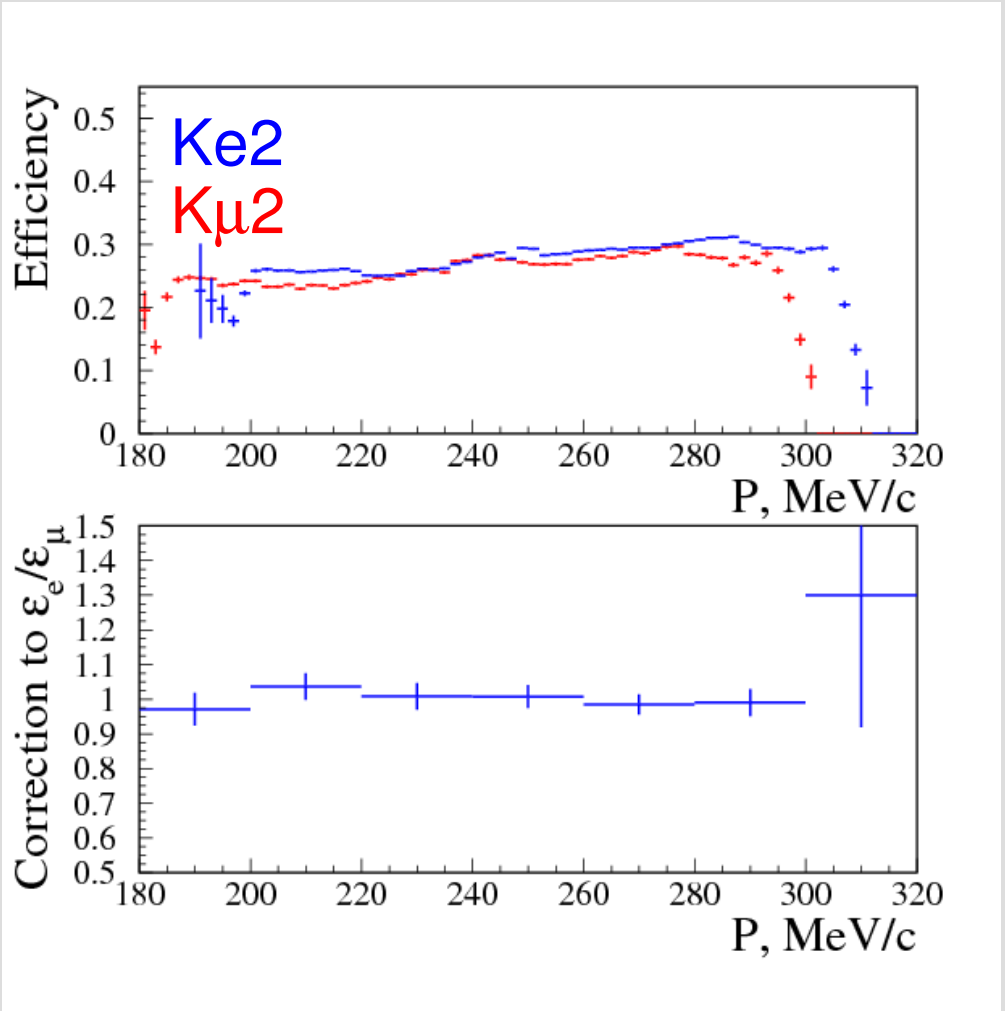


Track+Vtx efficiency

- Common to Ke2 (signal) and Kμ2 (normalization) almost cancel out in ratio
- Correct the efficiency dependence on **P** using Kμ2 control sample

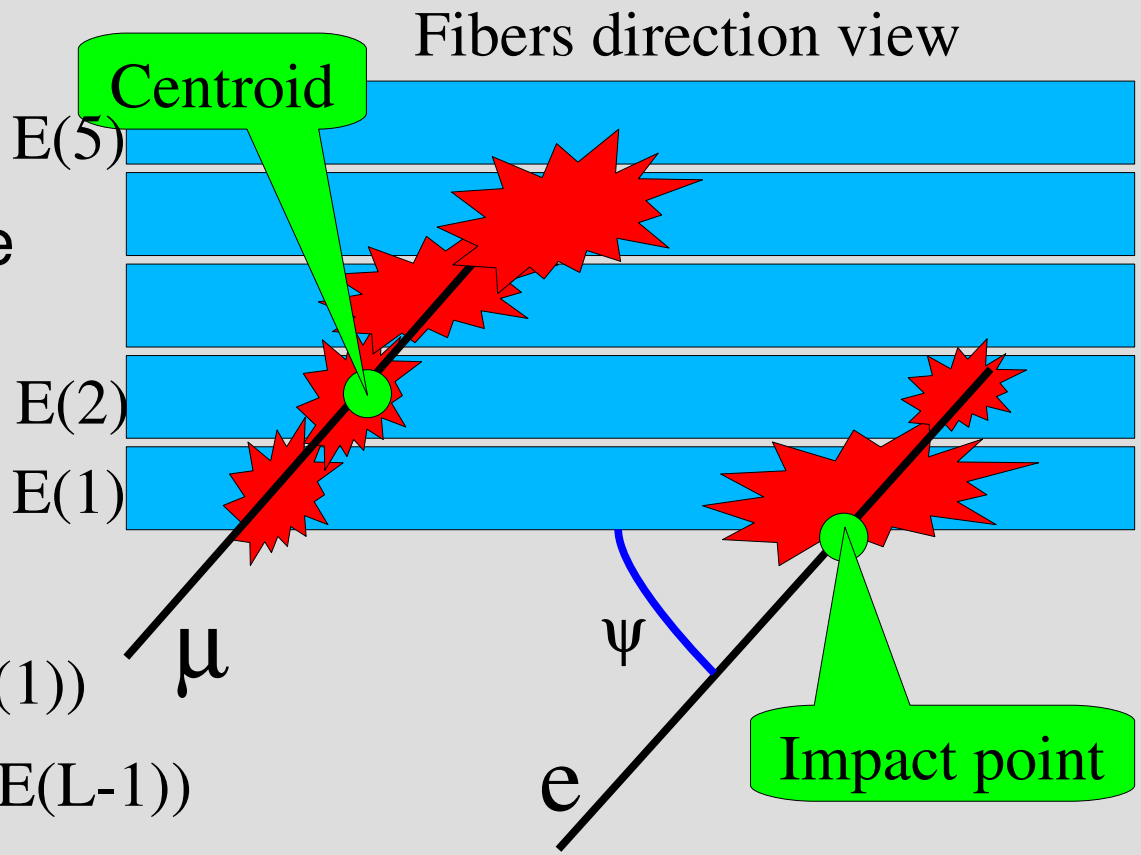
  C^{TRK} **= 0.994(9)**

  (only 10 pb^{-1} used)



PID in calorimeter

- PID exploits granularity of KLOE calorimeter building shower profile along particle path



Variables used:

$A_F = (E(2)-E(1))/(E(2)+E(1))$

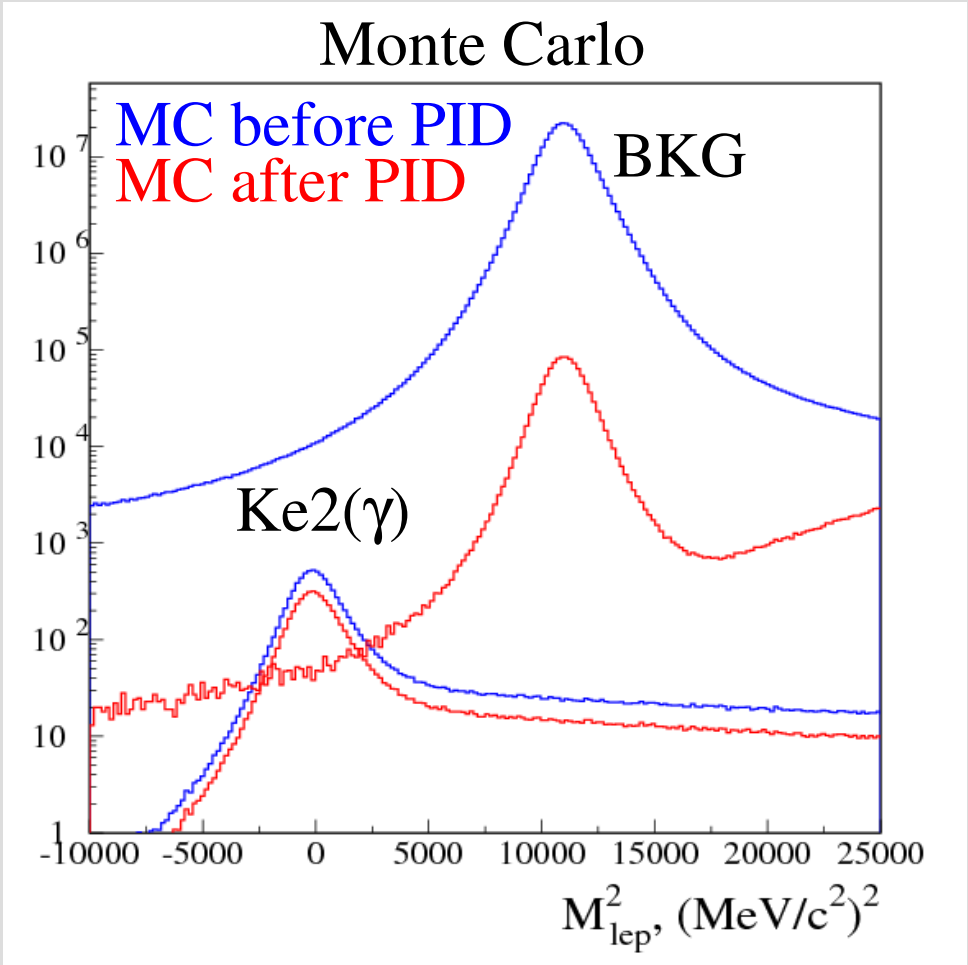
$A_L=(E(L)-E(L-1))/(E(L)+E(L-1))$

$E^2_{RMS} = \Sigma_{i=1..N}(E(i)-\langle E\rangle)^2/N$

Centroid position, E/P

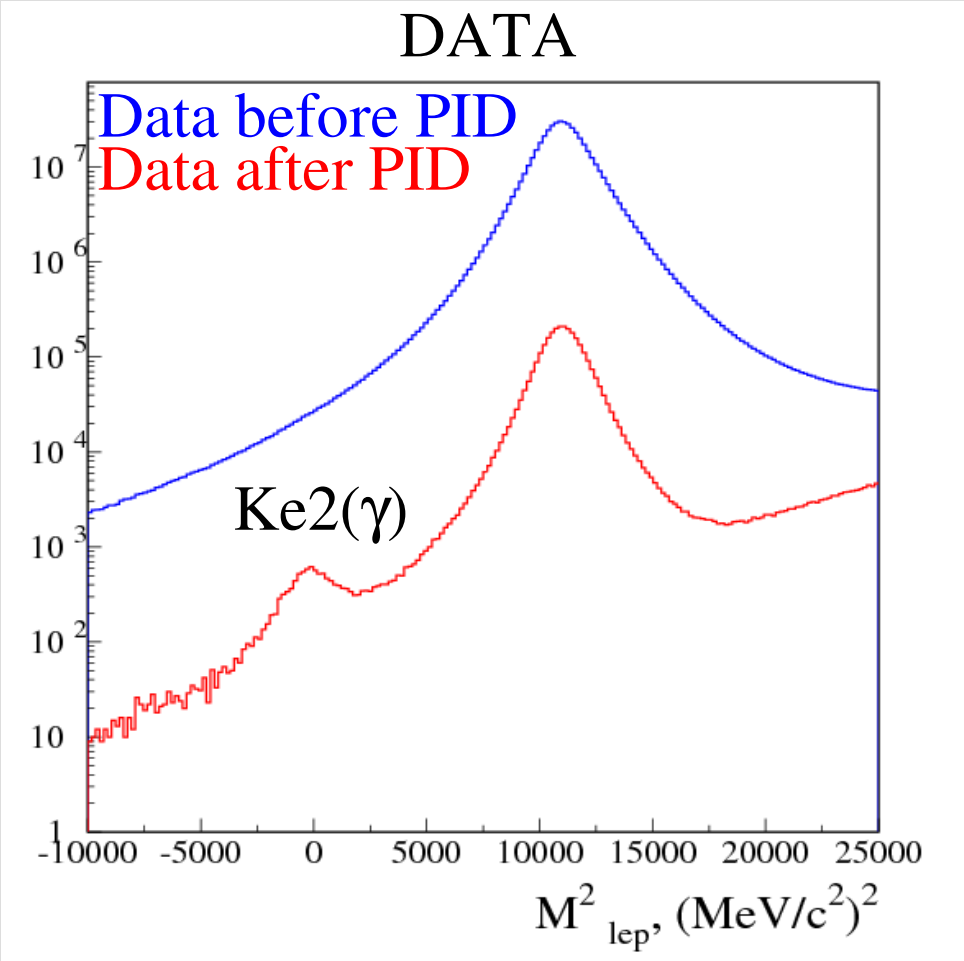
PID selection

- Electromagnetic shower pattern:
  - A_F<0, E(3)<45 MeV, E_{MAX}>70 MeV, L_{MAX}<12 cm
- Muon rejection:
  - E_{RMS} as fit variable
  - A_L<-0.85



PID selection

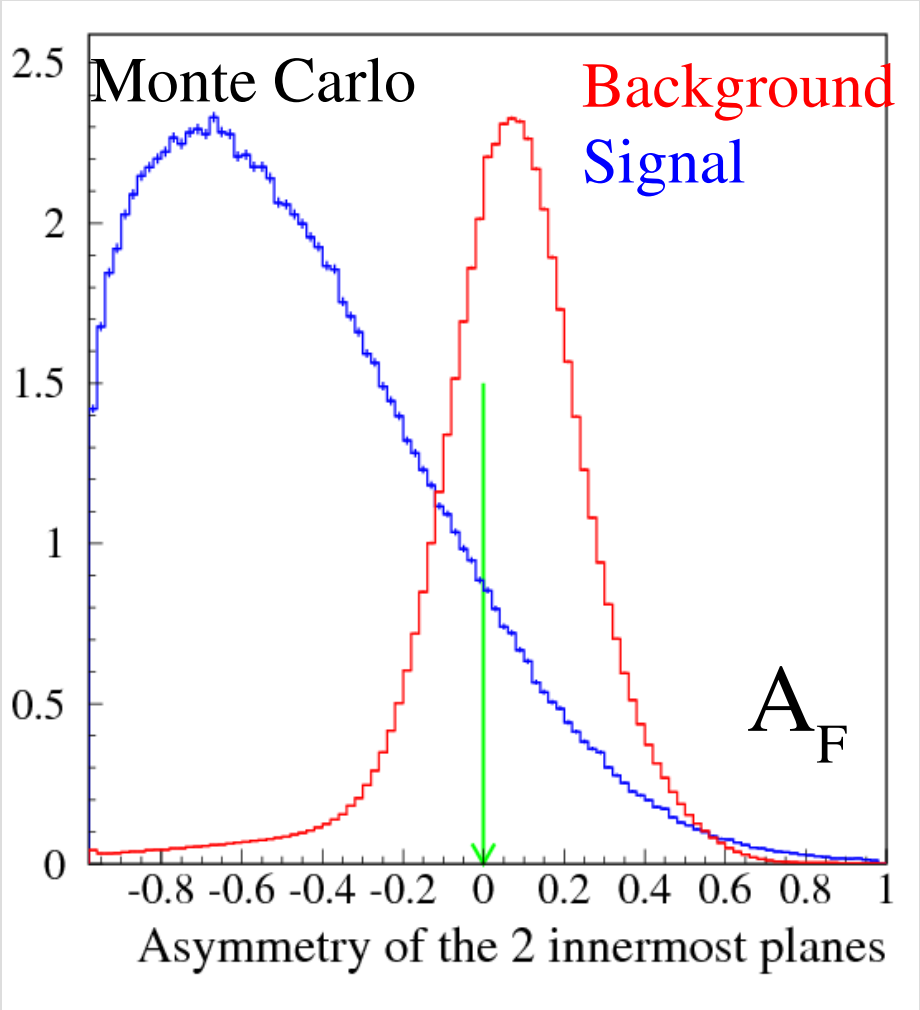
- Signal efficiency is 0.647(6)
- Background rejection is ~ 300

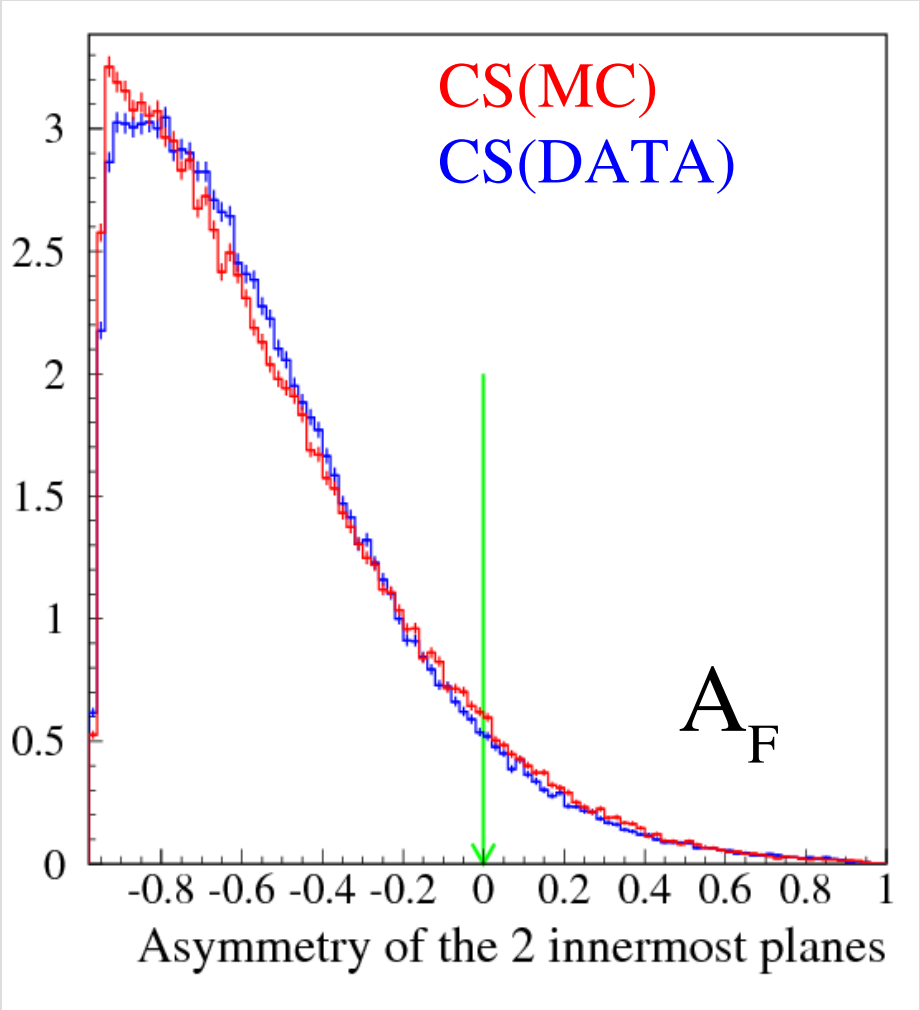


PID efficiency

- Use K_{e3} decay of K_L as a control sample (CS) for Track-to-Cluster Association and PID efficiencies (~same CS as in analysis of form factor slopes)
- CS purity reached ~ 99.7%, with:
  - ~200k events selected
  - 600 pb^{-1} used to evaluate efficiencies

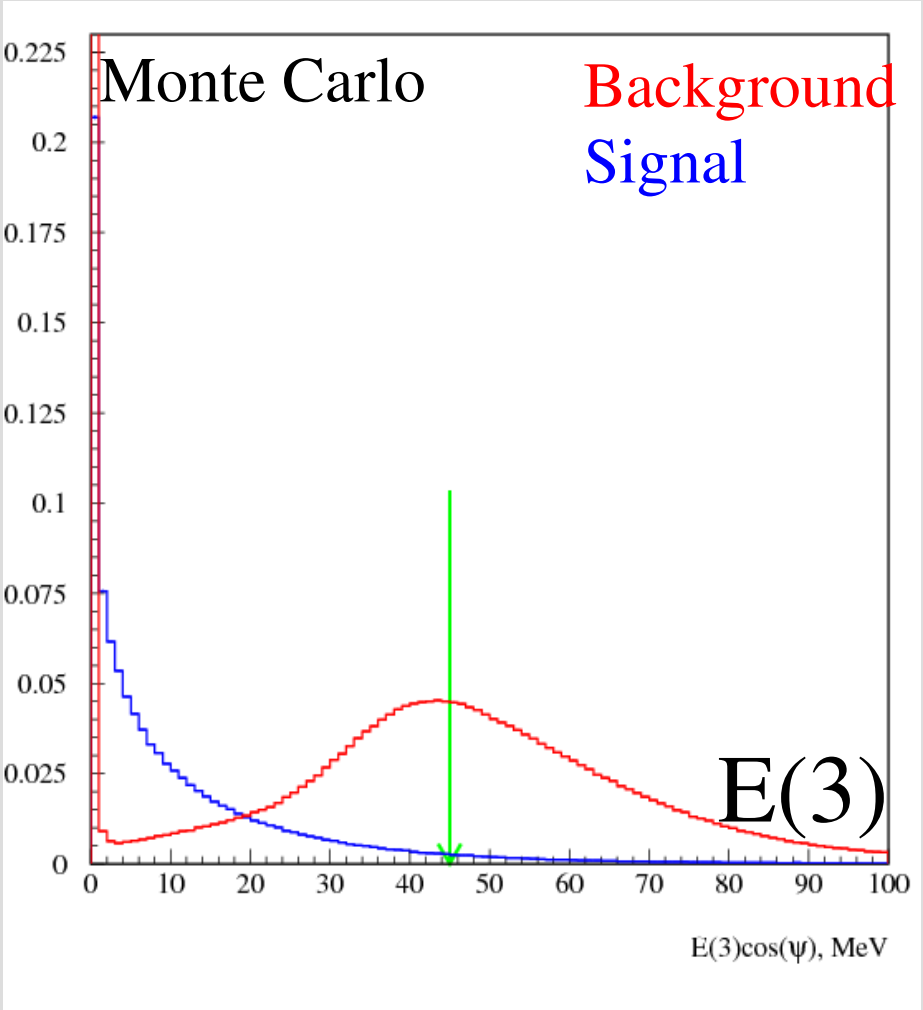
Check of PID variables - 1

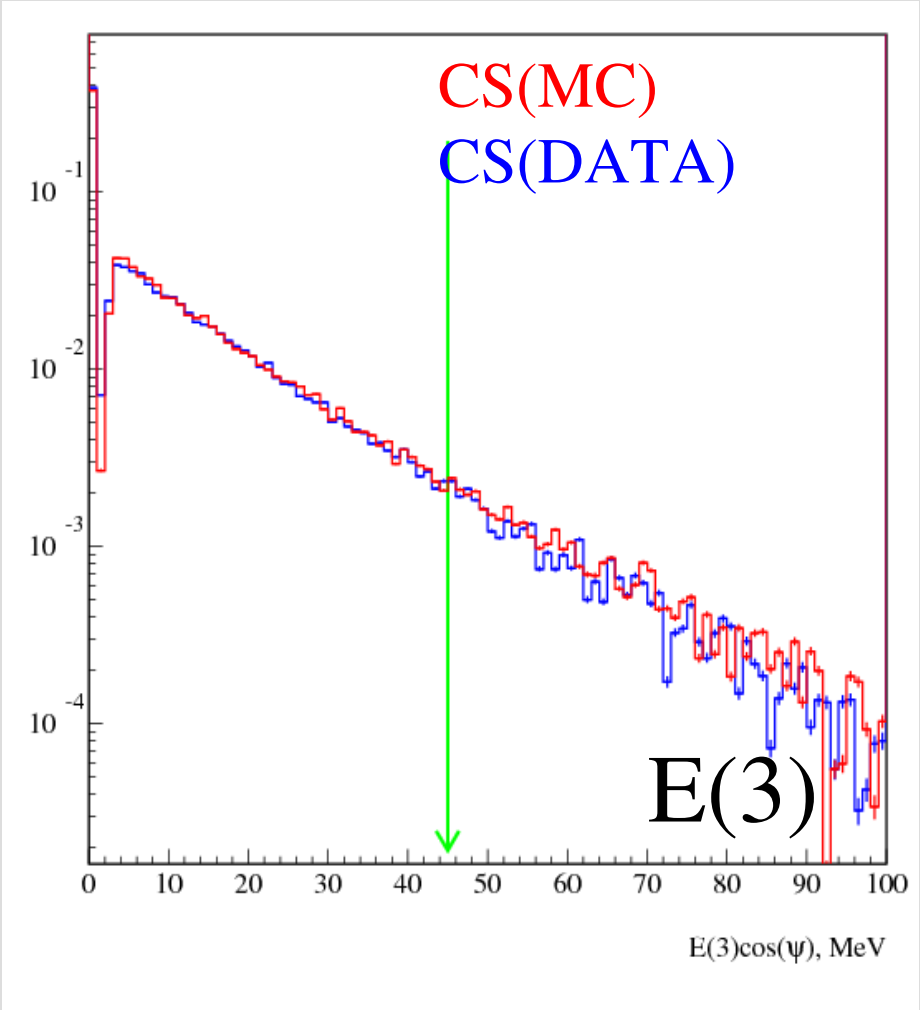




Asymmetry in energy deposition in the first two fired planes of calorimeter

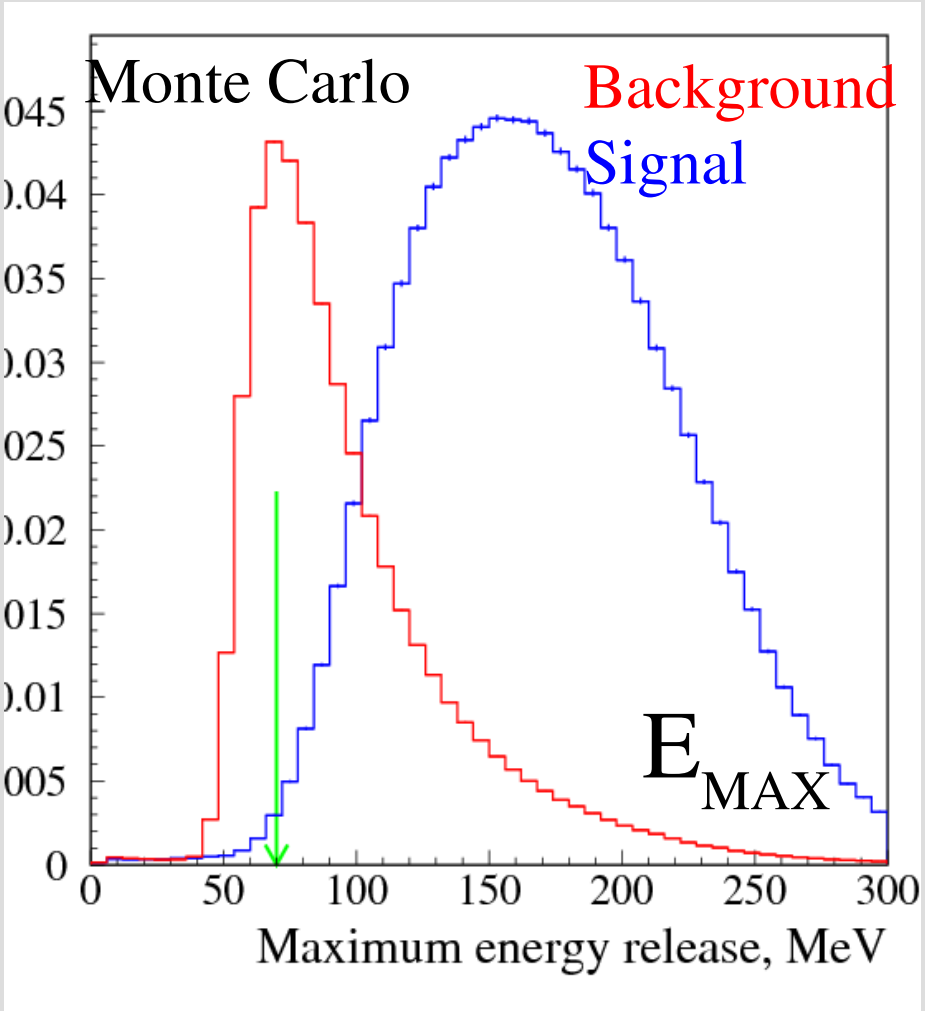
Check of PID variables - 2

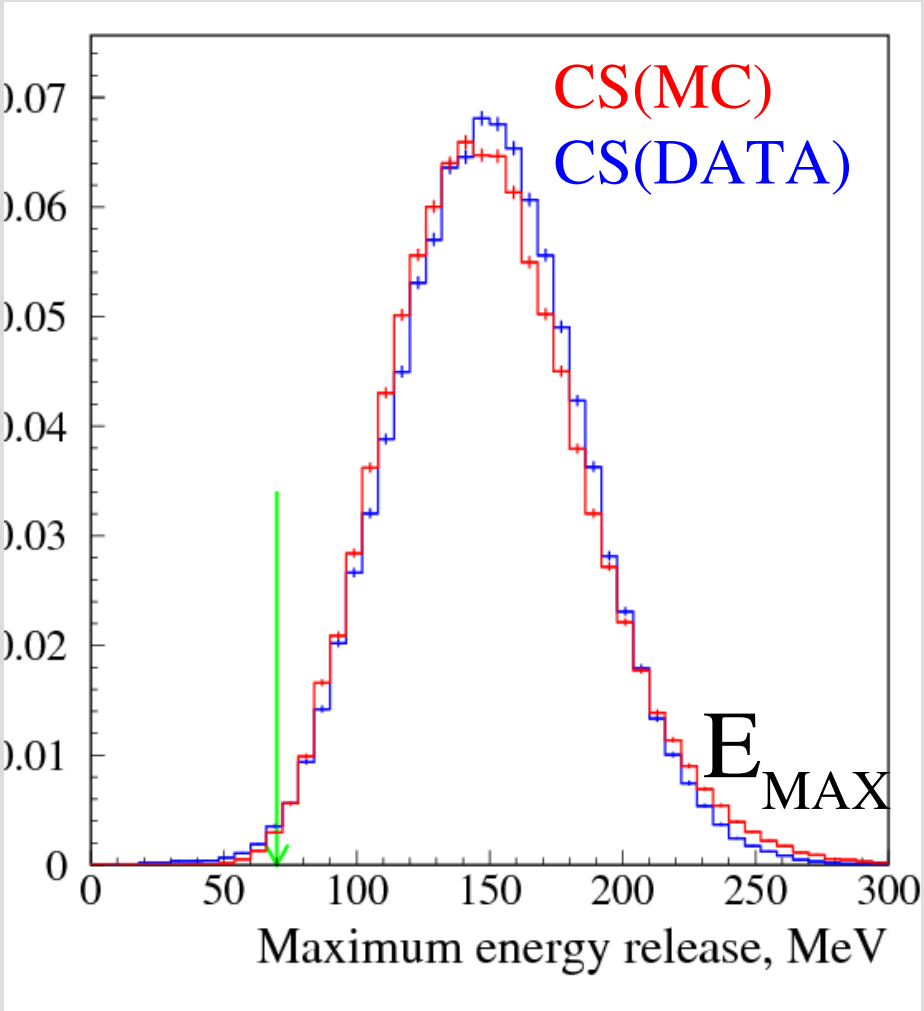




Normalized energy deposition in the third calorimeter plane

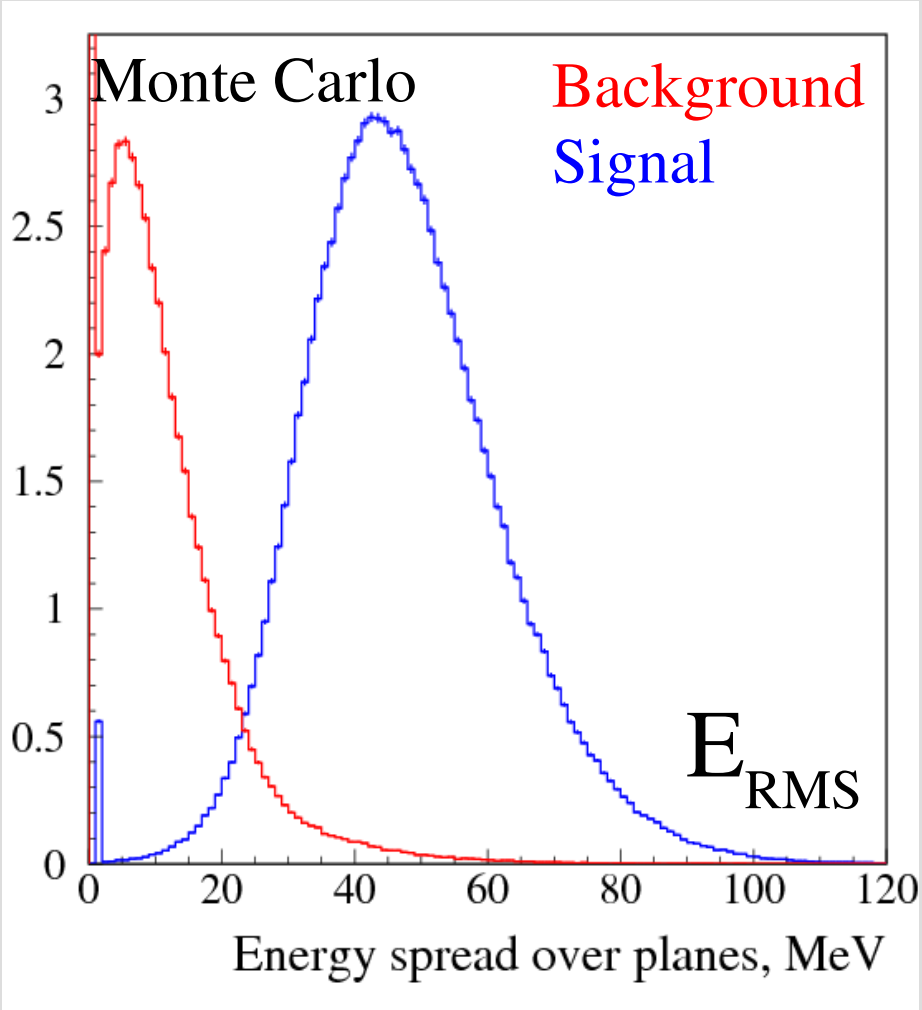
Check of PID variables - 3

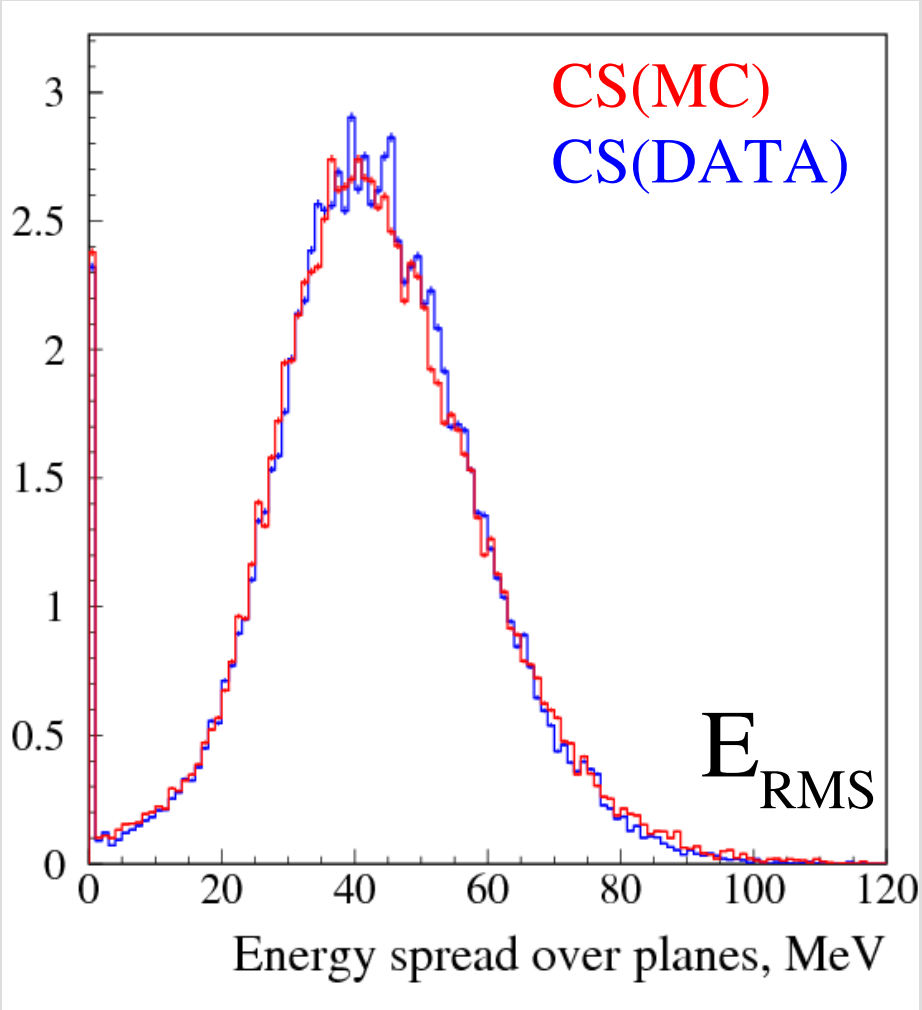




Maximum energy release in a calorimeter plane

Check of PID variables - 4

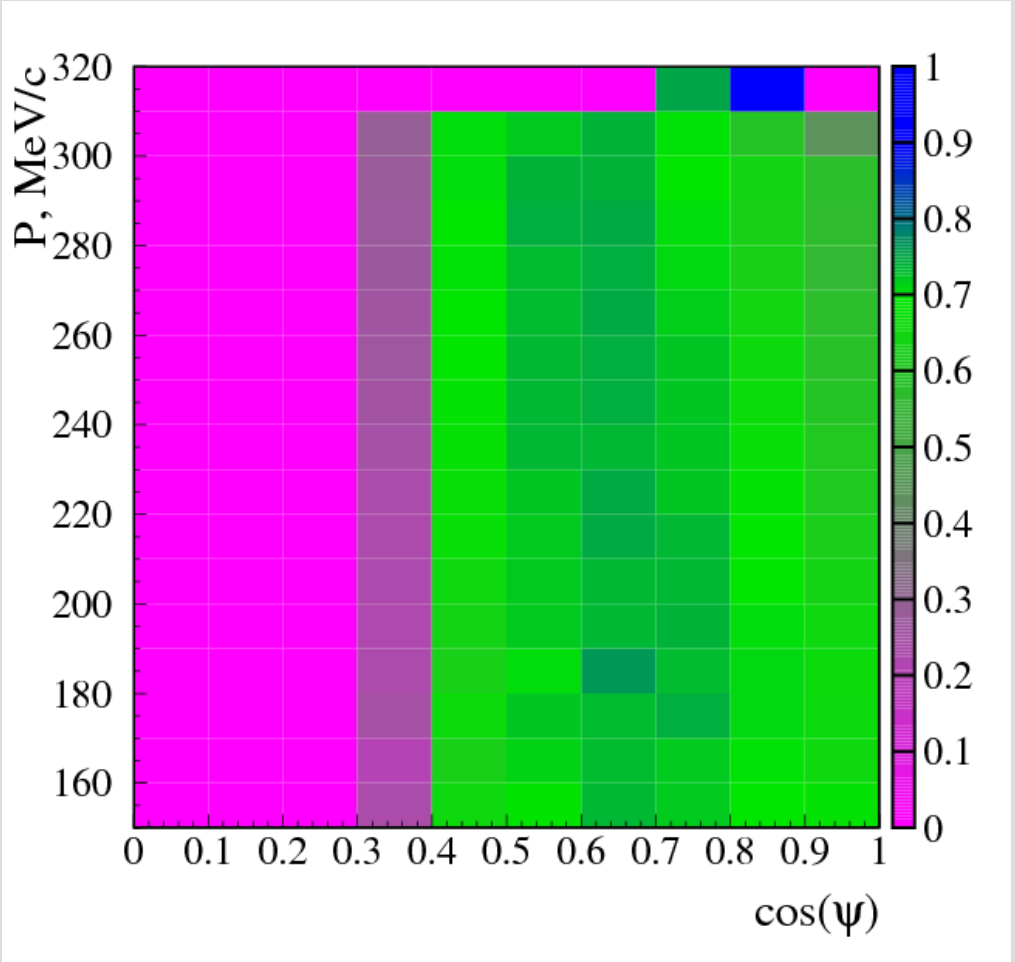




Energy spread over calorimeter planes

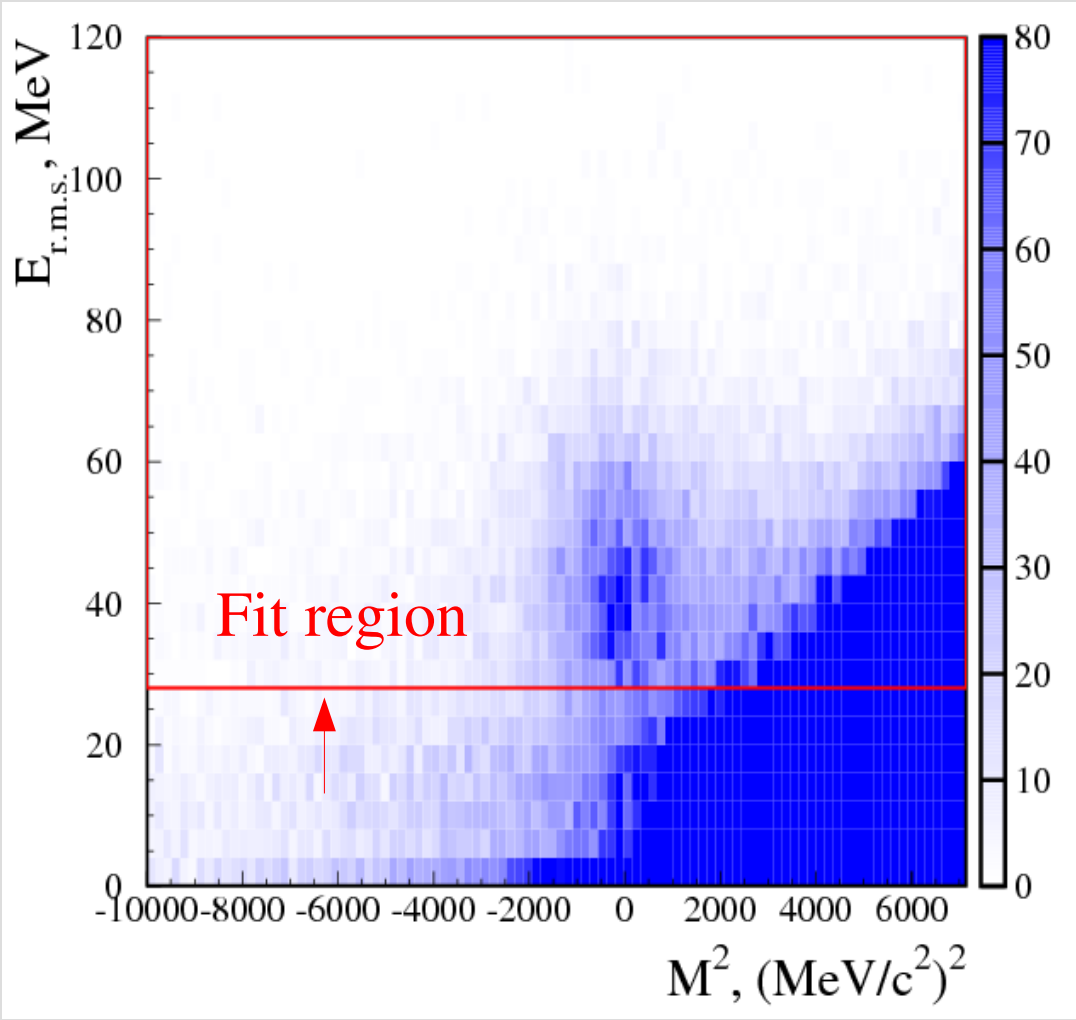
Efficiency of PID selection

- Correction evaluated from CS as function of impinging angle and momentum [cos(ψ) vs P] [barrel, end-cap]
- Result is C^{PID} = **1.009(9)(15)**
- Same CS used to evaluate cluster efficiency correction
- For regions which are not covered by CS systematic error conservatively evaluated as a total correction

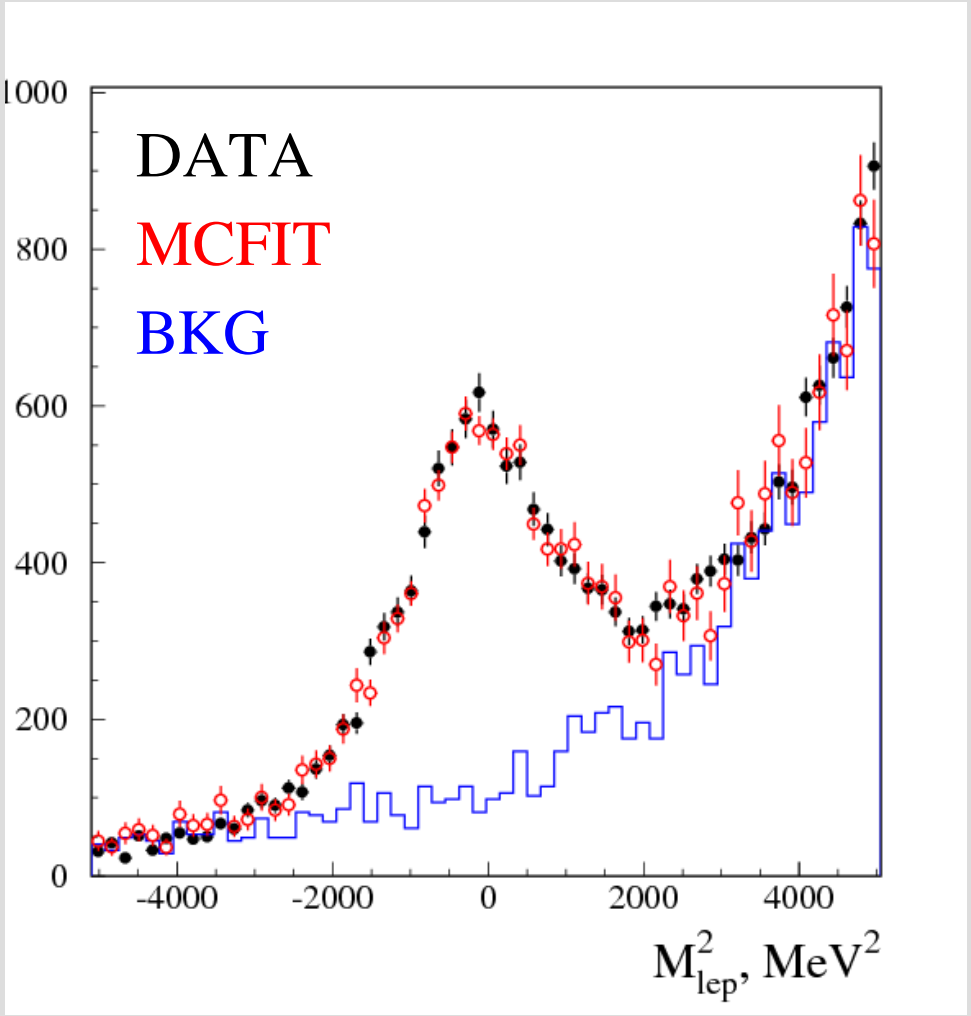


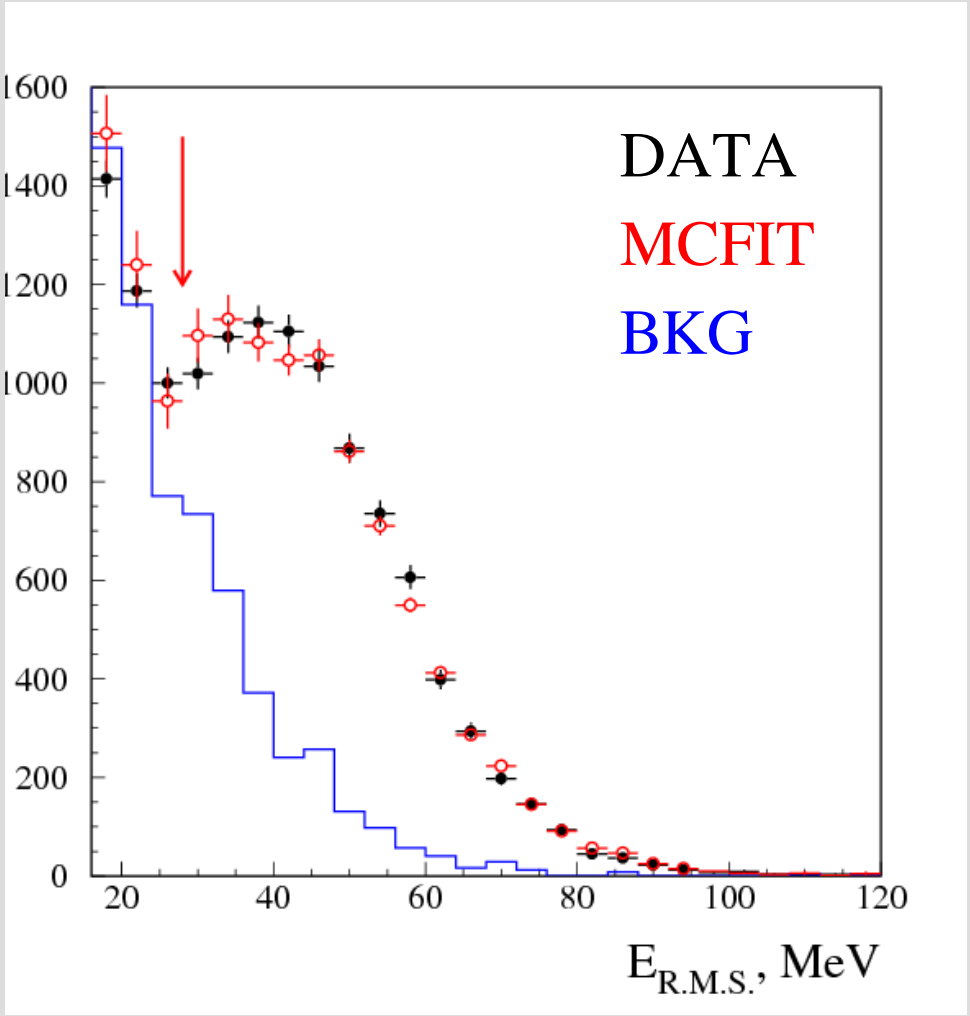
Signal event counting

- Fit data to the Monte Carlo E_{rms} vs M^2_{lep} distribution using log likelihood
- Fit quality is 434/291 n.d.f
- Count **8090(156)** events
- IB/DE fixed in the fit to the actual PDG value
  - Uncertainty evaluated by repeating the fit with different IB/DE ratio according to PDG error
  - Systematics ~ 0.3%



Fit projections





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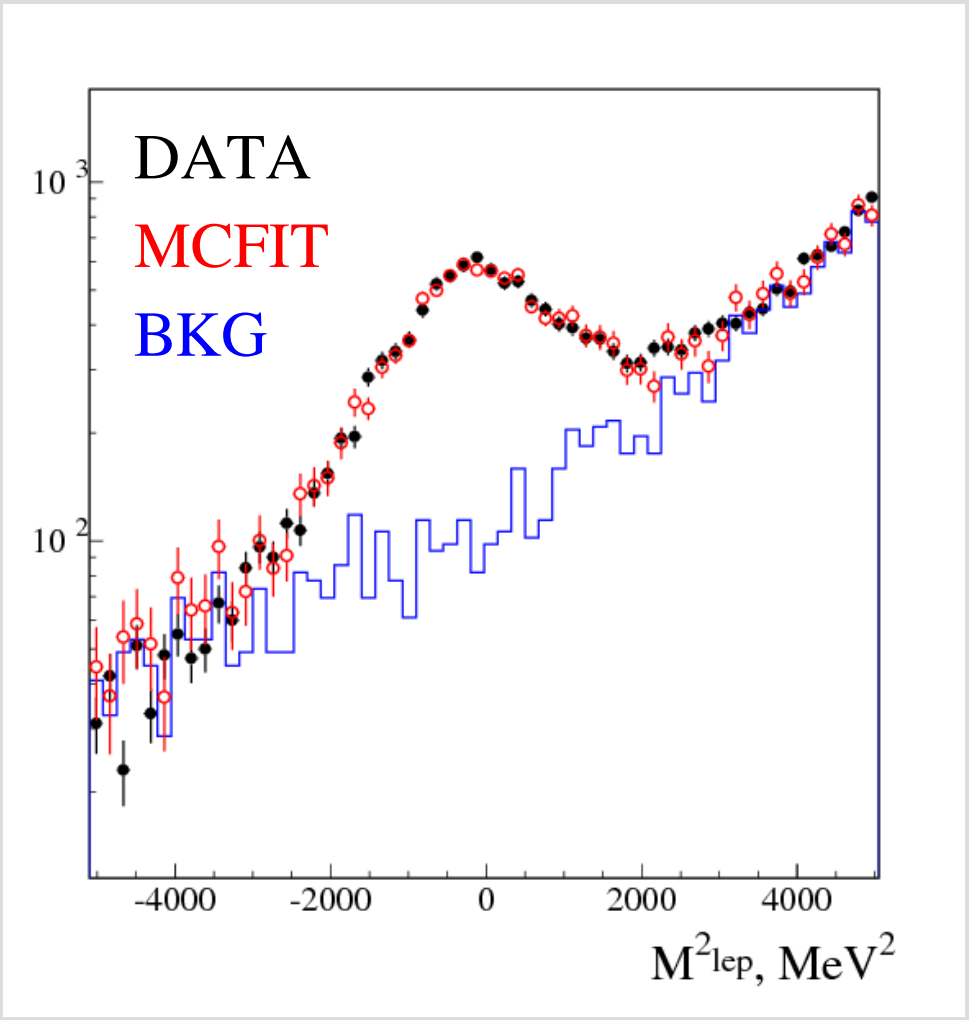
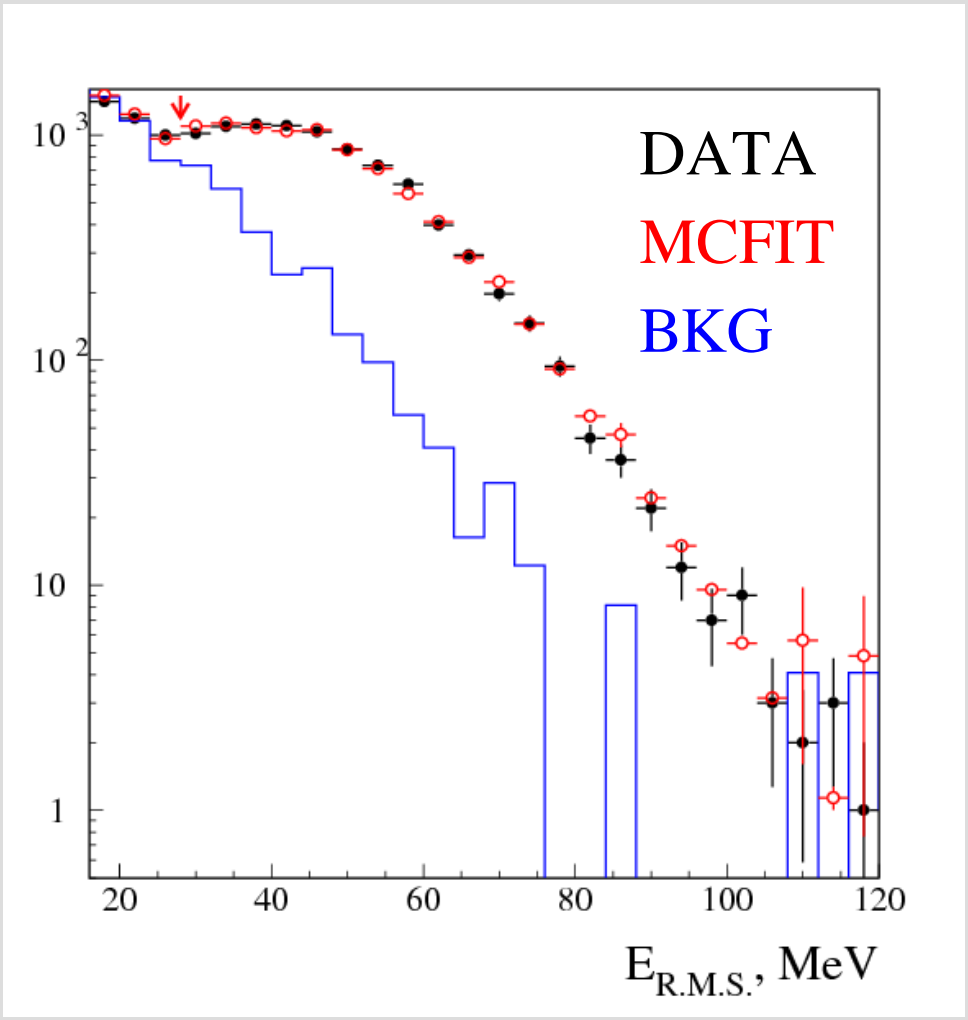
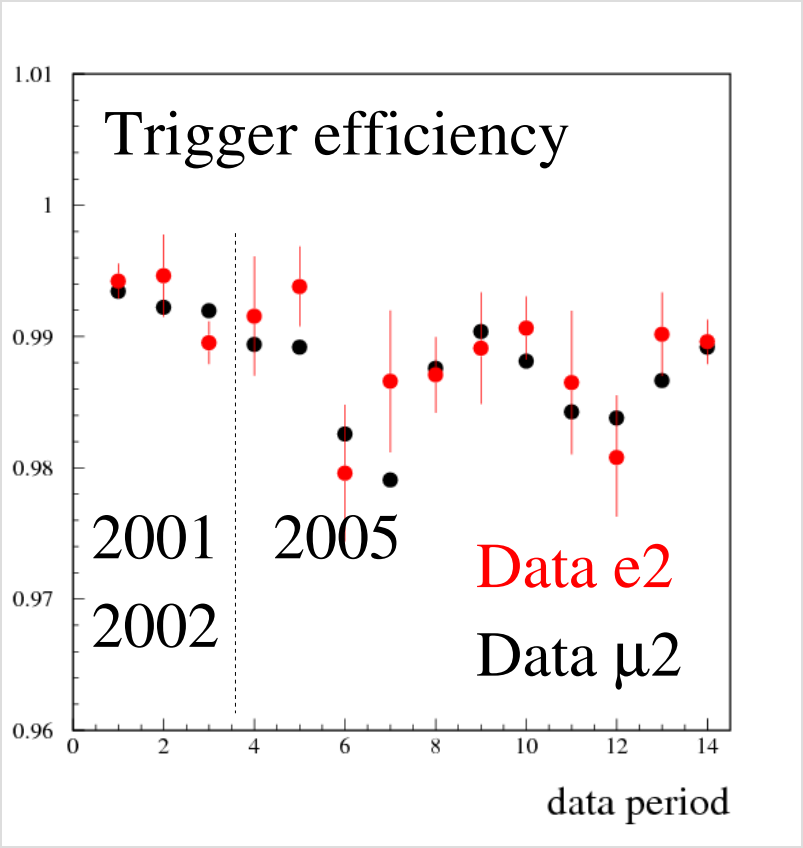




Trigger efficiency

- Trigger efficiency evaluated directly from data comparing DC and EMC triggers
- Correlation between two triggers from MC
- Correction evaluated as a function of data period
- Dependence on period at level of 1%
- $C^{TRG} = \varepsilon^{TRG}_{\mu}/\varepsilon^{TRG}_{e} =$ **0.998(9)(6)**



Preliminary result

- Number of $K_{\mu 2}$ events
  - $N_{k\mu 2}$ = **499251584±35403**
- Number of K_{e2}
  - N_{e2}= **8090±156**
-

Systematics(fractional):

– IB	0.0005
– IB/DE	0.003
– TRK+VTX	0.009
– PID	0.009±0.015
– TRG	0.006±0.004

$R = (2.55 \pm 0.05 \pm 0.05) \times 10^{-5}$

SM:$R=(2.472 \pm 0.001) \times 10^{-5}$

Comments on uncertainty: stat

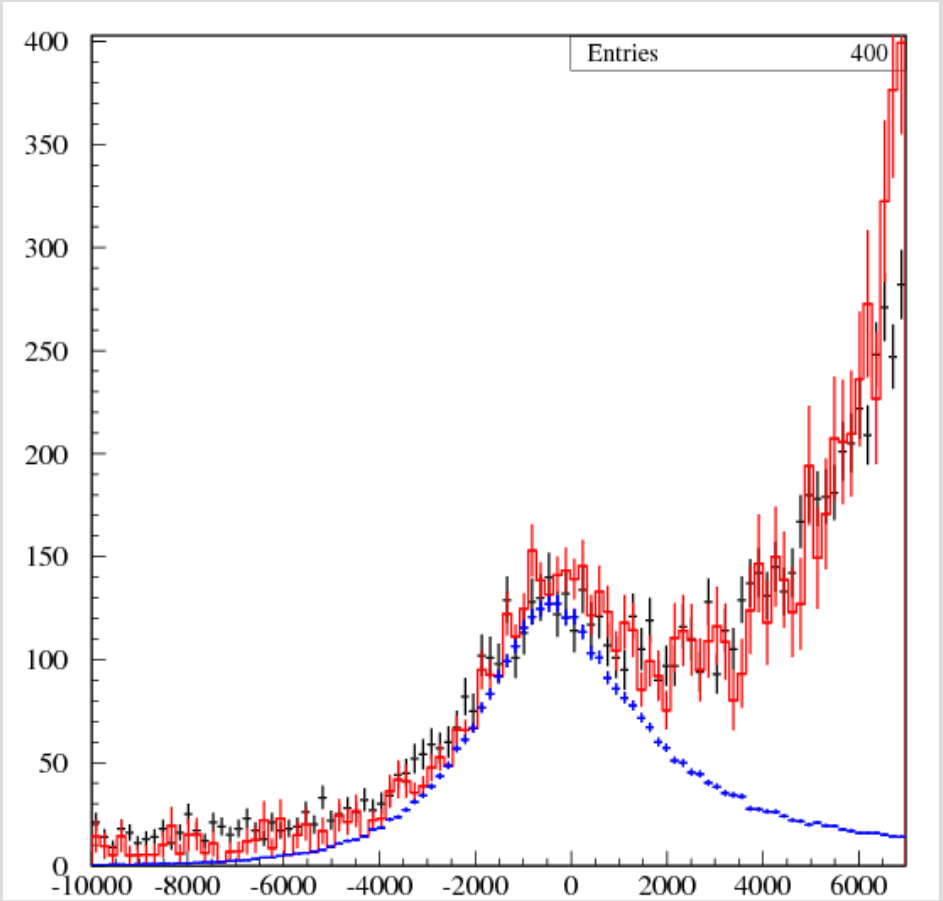
- Present statistical accuracy 1.9%
- Final statistics will be x1.3, counting >10k events
- Present stat error dominated by background:
  - Signal fluctuation 1.1%
  - MC statistics (1.4%)⊕ background fluctuation (0.7%)
- 1 fb^{-1} of additional MC statistics under production
- Cuts still have to be tuned, PID can be improved

Comments on uncertainty: syst

- Breakdown of present systematics:
  - TRK = stat + syst ... evaluated using only 10 pb^{-1}
    - Stat will be pushed down to < 0.5%
  - PID = stat + syst
    - Statistics of CS will be increased by a factor of 4
    - Systematics due to partial coverage of CS -> better tuning of PID method is needed
  - TRG = stat + syst
    - Dominated by data statistics of downscaled min. bias events
    - Have to study Data/MC agreement on reconstructed events

Signal from “recovery”

- Worse resolution on M_{lep} wrt direct, no K track can be used
- Improved PID by TOF, because of longer tracks + NN
- Number of selected events add 37% more statistics to direct search 3500 events



Conclusions

- Preliminary measurement of

  $\Gamma(K\to e\upsilon)/\Gamma(K\to\mu\upsilon)=(2.55\pm0.05\pm0.05)\times10^{-5}$

  at KLOE, based on 1.7 fb^{-1}
- 2% statistical and 2% systematic error was reached
- Recovery search has to be finalized
- About 1% accuracy goal can be reached
- Stay tuned...