MHG2000 Generator for $e^+e^- \to$ Hadrons

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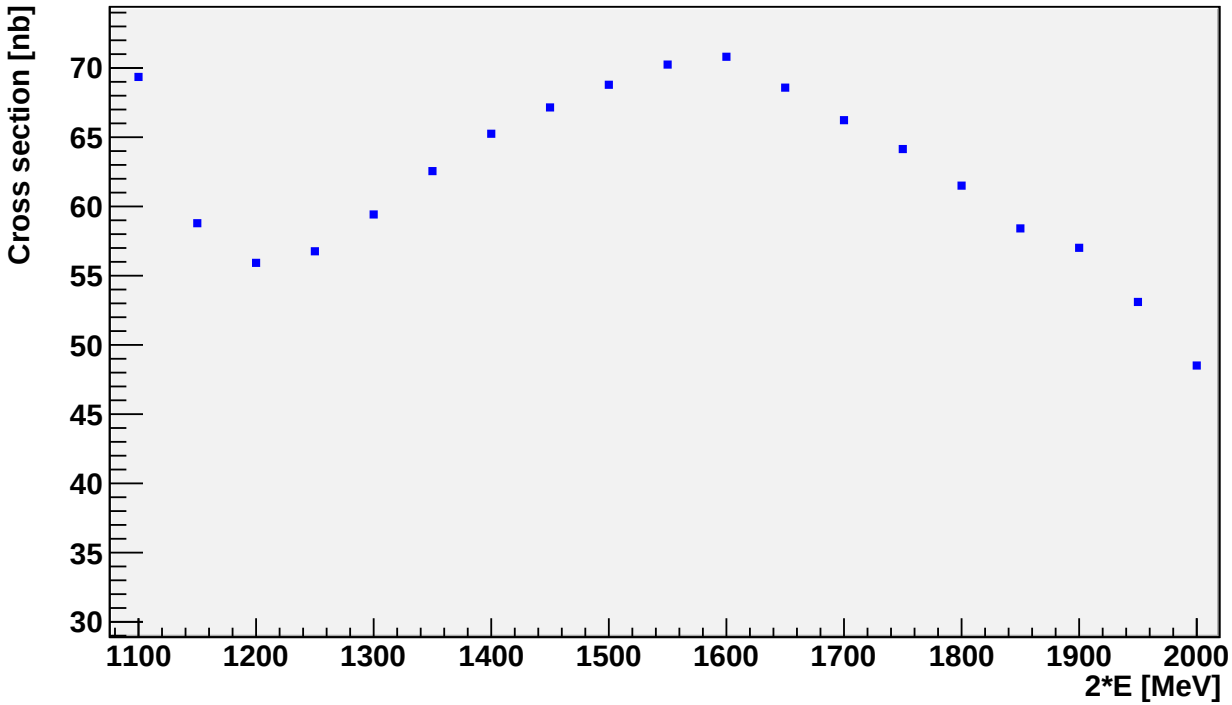
General

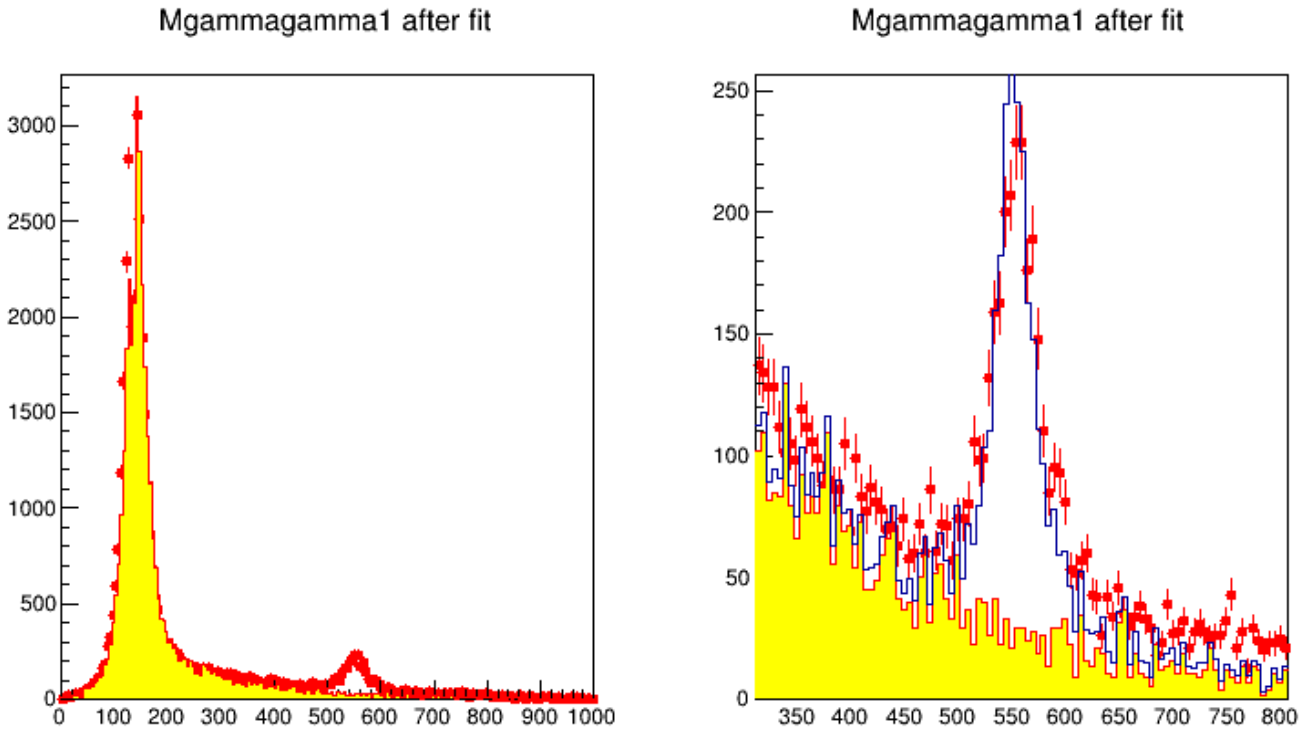
- MHG2000 - MultiHadronic Generator for VEPP2000
- In collaboration with Alexander Korobov and Korneliy Todyshev
- It is a data-driven generator based on the bulk of measured exclusive σ's:
  2-body $(\pi^+\pi^-,\ K^+K^-,\ K^0_SK^0_L,\ p\bar{p},\ n\bar{n},\ \pi^0(\eta)\gamma),\ n(\pi^+\pi^-)m(K\bar{K})(\eta)$
- Energy dependence of σ_i is approximated, $\sigma_{\rm tot} = \Sigma\sigma_i$,
  a final state number i is sampled with a weight of $\sigma_i/\sigma_{\rm tot}$
- An event is sampled with one ISR photon: $d^3\sigma/d\Omega_\gamma dE_\gamma \propto f(E_\gamma, cos\theta_\gamma)$
- Currently more than 30 different final states
- Matrix elements are added whenever possible,
  output compared to PHOKHARA for N=3,4

MHG2000 - Total Cross Section Above 1.1 GeV



We estimate the current accuracy of $\sigma_{\rm tot}$ as $(5-7)\%$ (missing modes)

Example of MHG2000 - $\eta\pi^+\pi^-\pi^0$

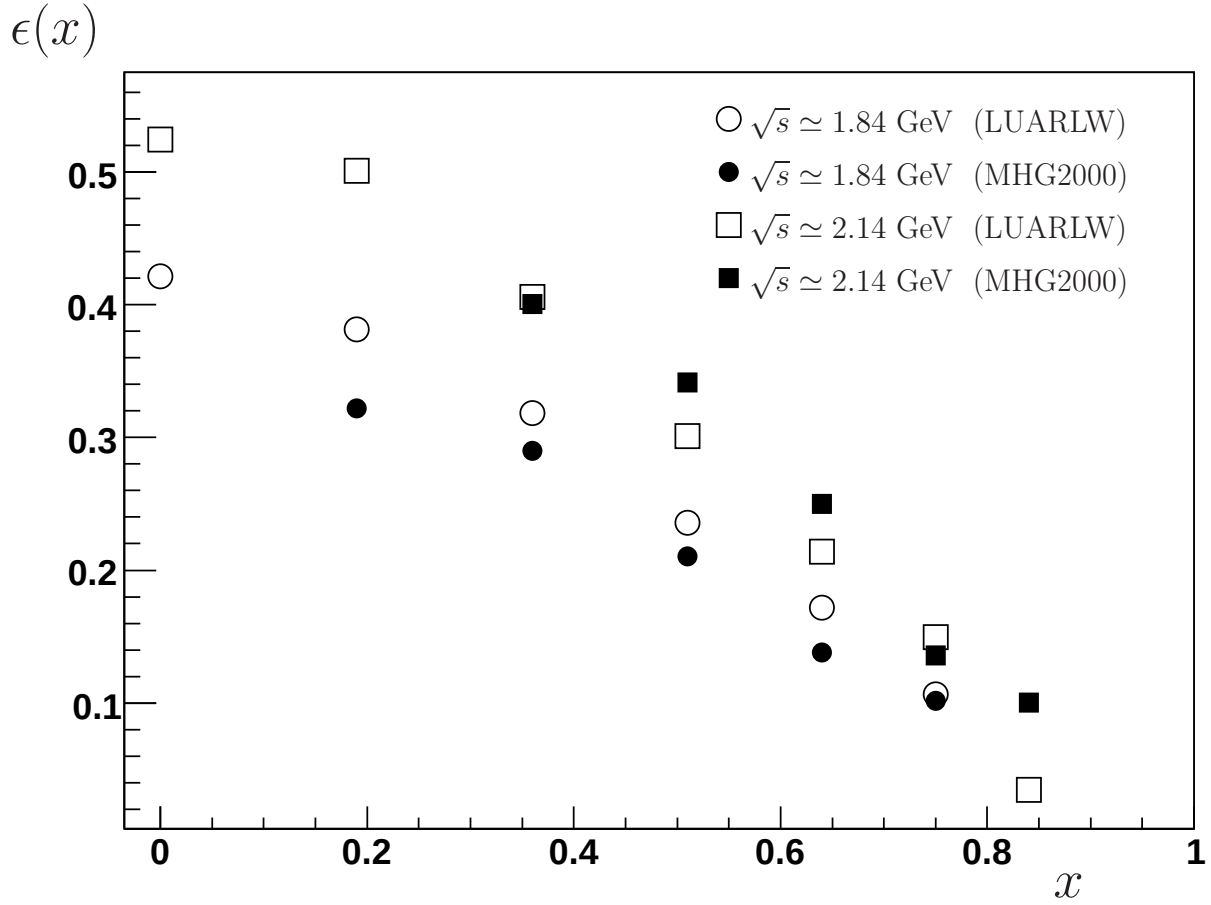


Background shape is OK, some modes with π^0's missing

MHG2000 Generator for R Measurement at KEDR

- KEDR performed two measurements of R from 1.84 to 3.72 GeV:
  V.V. Anashin et al., Phys. Lett. B753 (2016) 533 (7 points, 3.12-3.72 GeV)
  V.V. Anashin et al., Phys. Lett. B770 (2017) 174 (13 points, 1.84-3.05 GeV)
- They use LUARLW and JETSET 7.4 for efficiency calculations,
  input parameters tuned by comparing ~ 20 parameters with data
- To calculate radiative corrections MHG2000 is used
- Tuning and therefore final accuracy is limited by
  low statistics currently collected at KEDR:
  $\sim 13 \times 10^3$ below and $\sim 18 \times 10^3$ above the J/ψ
- The achieved accuracy is $< 3.9\%$ with systematics $< 2.4\%$ below the J/ψ
  and better than 3.3% with a systematic uncertainty $< 2.1\%$ above the J/ψ

Detection Efficiency with ISR

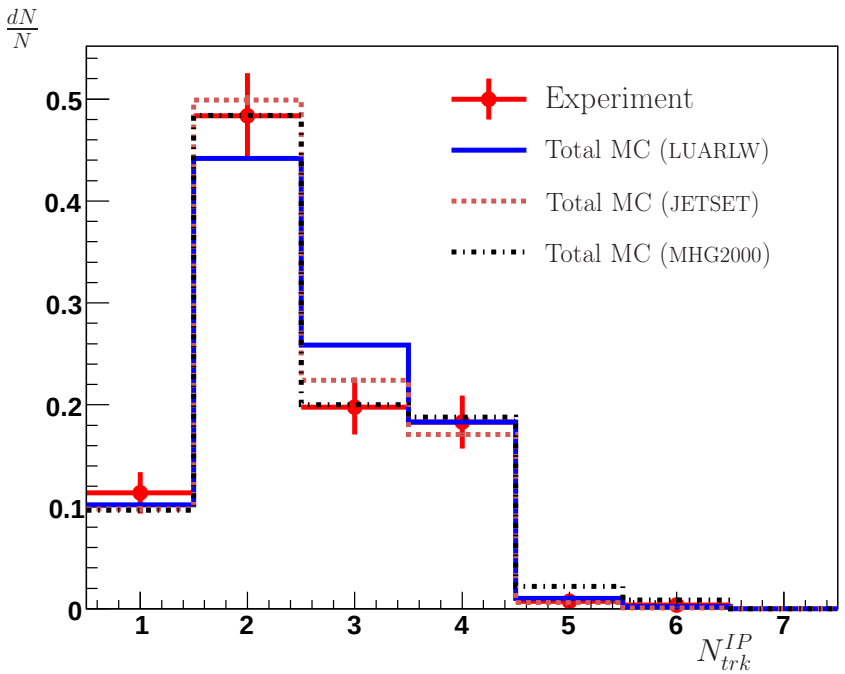


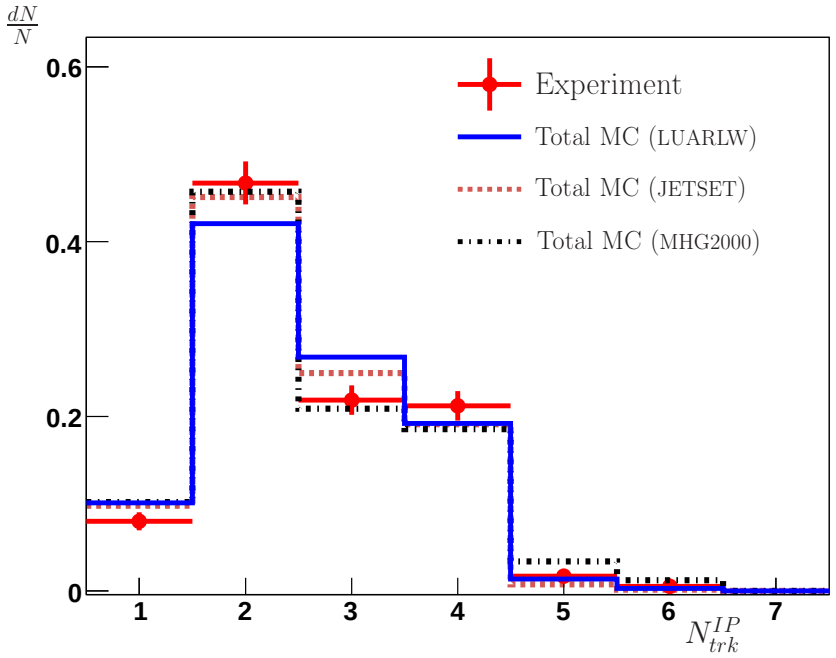
$x = E_\gamma/E$ - fraction of energy lost due to ISR, $s \to s(1-x)$

Detection Efficiency in R Measurement between 1.84 GeV and J/ψ

$\sqrt{s}$, GeV	$\varepsilon_{\text{LUARLW}}$,%	$\varepsilon_{\text{JETSET}}$,%	$\delta\varepsilon/\varepsilon$,%
1.84	42.2 ± 0.1	45.0 ± 0.1	-6.6 ± 0.3
1.94	47.2 ± 0.1	46.0 ± 0.1	-2.5 ± 0.3
2.14	52.5 ± 0.1	51.3 ± 0.1	-1.2 ± 0.3
2.64	68.2 ± 0.1	68.0 ± 0.1	-0.2 ± 0.2
3.05	72.4 ± 0.1	73.2 ± 0.1	$+1.1 \pm 0.2$

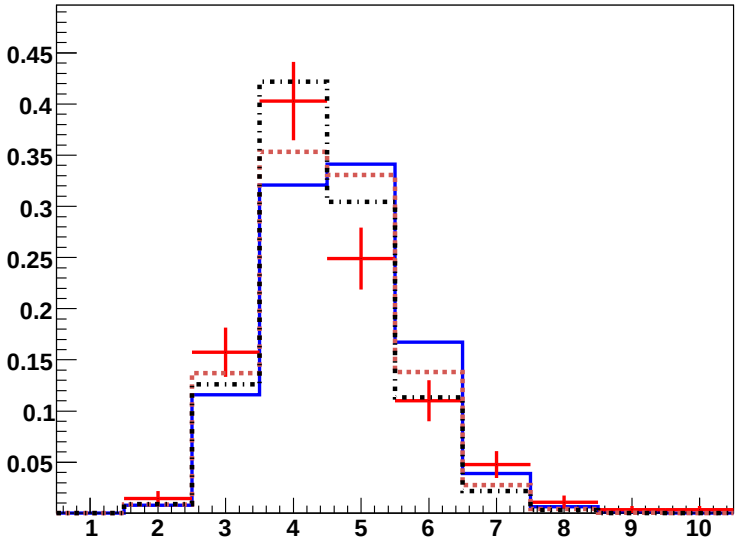
Comparison of 3 Generators – I (Number of Tracks)

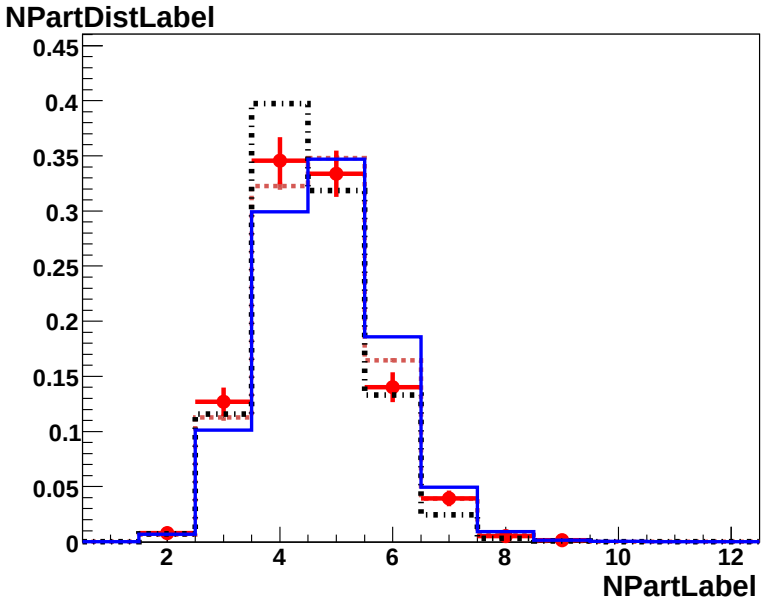




Fair agreement of MHG2000 with data at 1.84 and 1.94 GeV

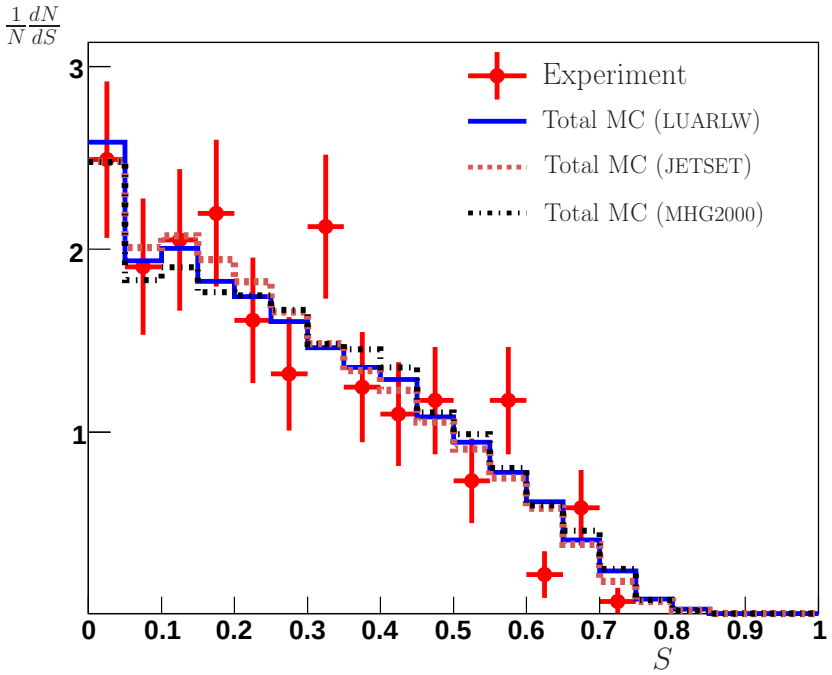
Comparison of 3 Generators – II (Number of Particles)

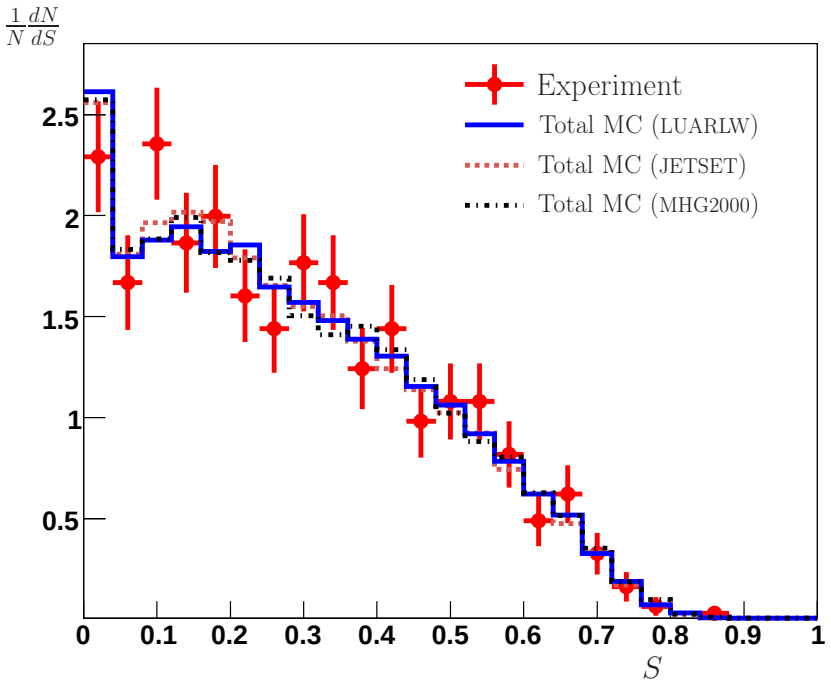




Fair agreement of MHG2000 with data at 1.84 and 1.94 GeV

Comparison of 3 Generators – III (Charged Sphericity)





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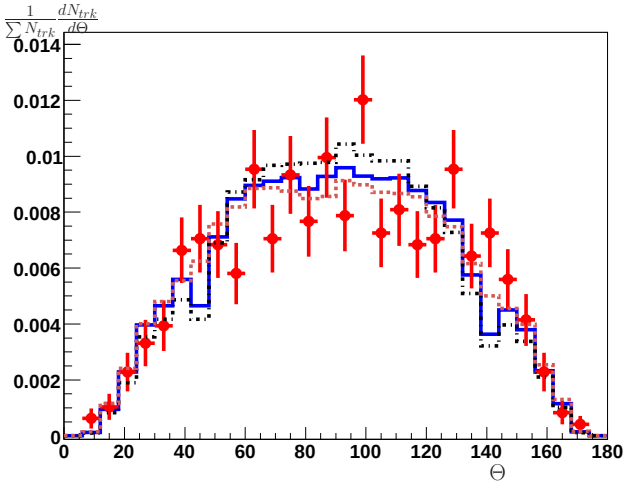
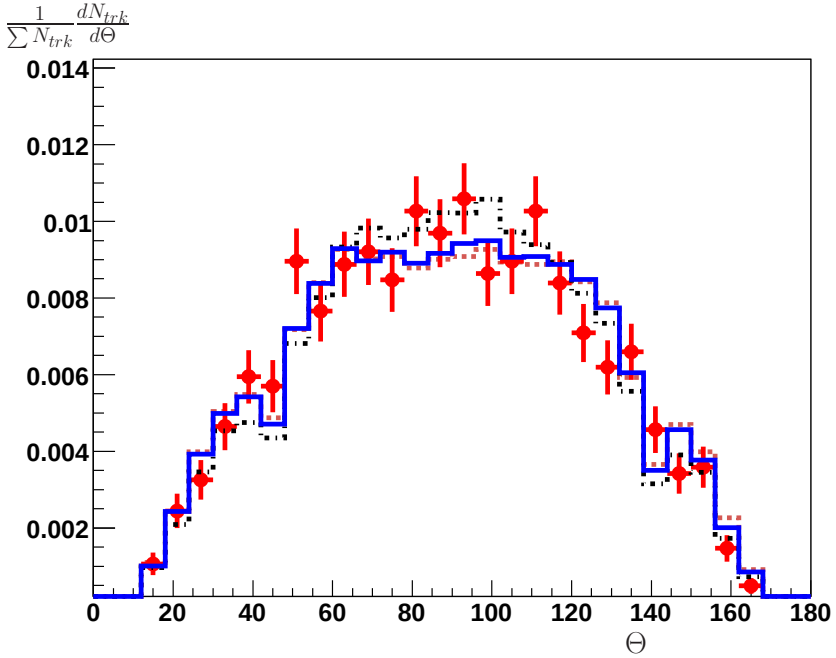
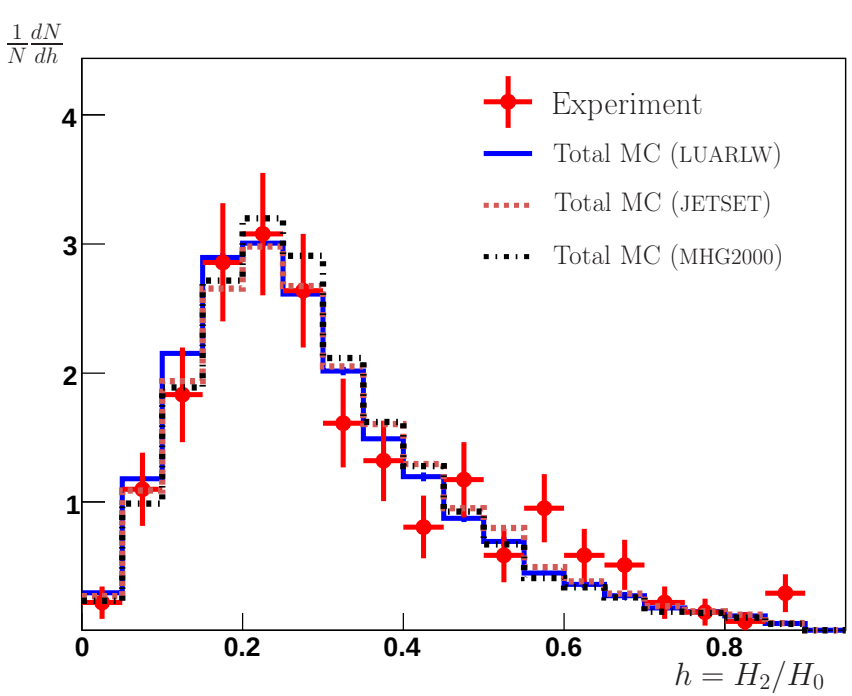
Comparison of 3 Generators – IV (Polar Angle)

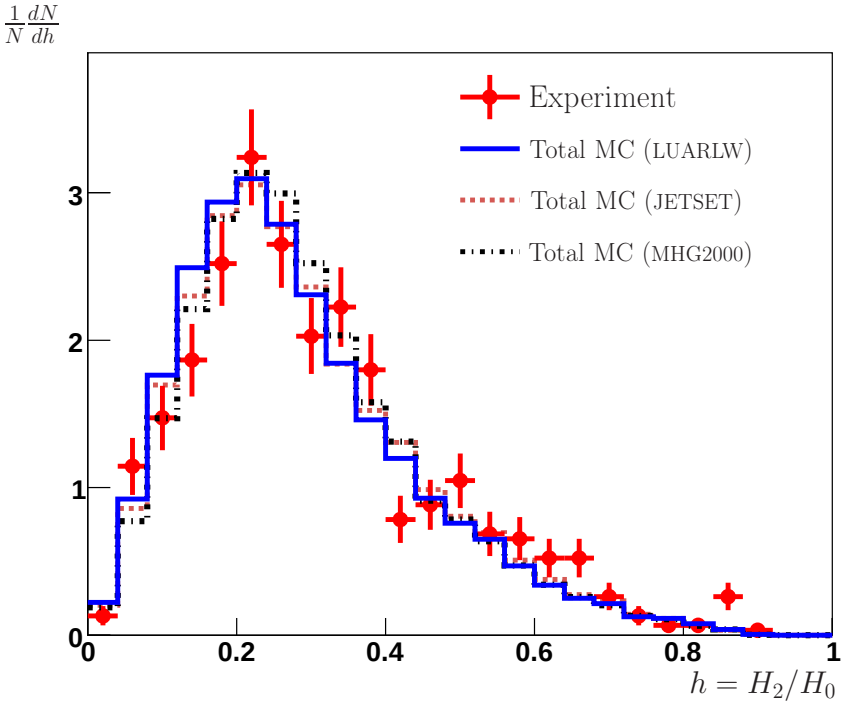




Fair agreement of MHG2000 with data at 1.84 and 1.94 GeV

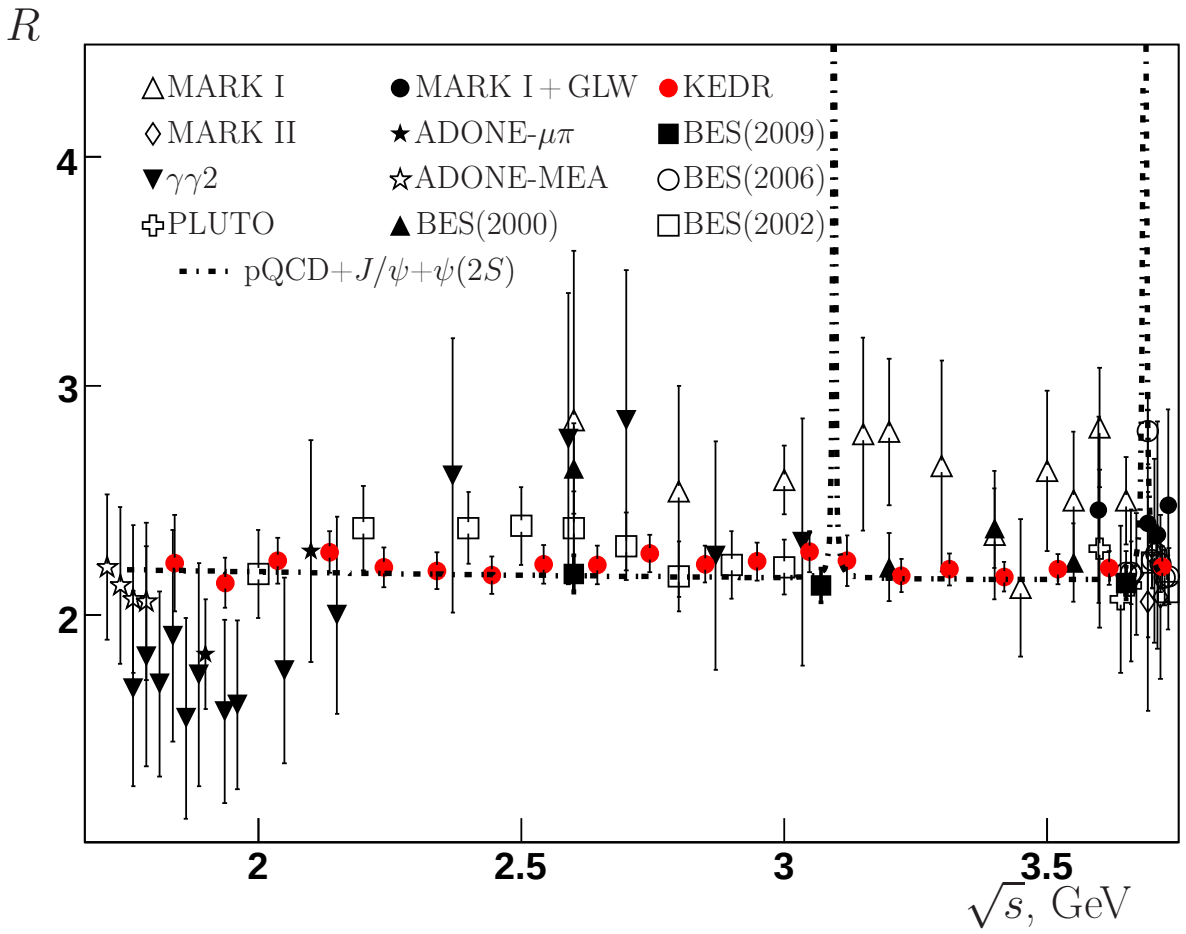
Comparison of 3 Generators – V (2nd Fox-Wolfram Moment)





Fair agreement of MHG2000 with data at 1.84 and 1.94 GeV

Results of R Measurement at KEDR



Good agreement with perturbative QCD with
detailed energy dependence from 1.84 to 3.72 GeV

Conclusions

- A data-driven generator of multihadronic final states MHG2000 is based on the measured cross sections at $\sqrt{s} < 2.4$ GeV
- MHG2000 is used to simulate background in experiments at VEPP-2000
- MHG2000 has been also used in R measurement at KEDR
- Its development is currently in progress: new modes and matrix elements added
- We started inclusive R measurement at CMD-3