Feasibility Studies for an Inclusive R-Measurement using ISR with BESIII

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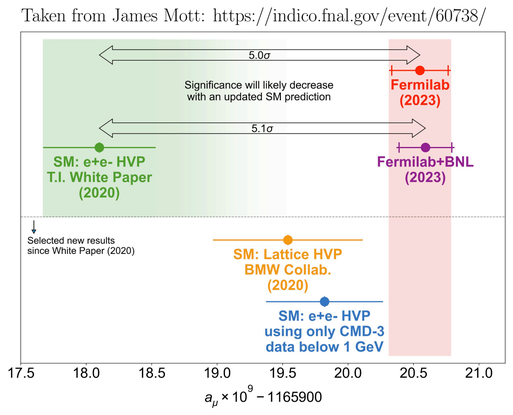
Anomalous Magnetic Moment of the Muon

- Deviation from $g = 2$: $a_\mu = \frac{(g-2)_\mu}{2}$
- Discrepancy of $5.1\,\sigma$ between
  - Experimental World Average [1, 2, 3] and
  - Standard Model (SM) prediction of Muon $g-2$ Theory Initiative [4]
- Uncertainties dominated by hadronic contributions
- Additional discrepancies between
  - Dispersive approach using e^+e^- and
  - Lattice QCD evaluation

  and within e^+e^- cross section measurements

Taken from James Mott: https://indico.fnal.gov/event/60738/

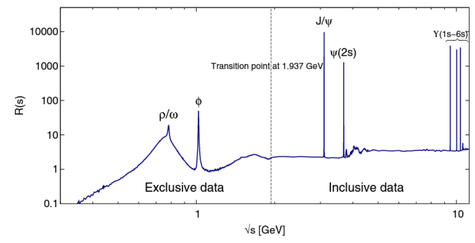


Hadronic R Value

Ratio of Born cross sections:

$$R \equiv \frac{\sigma^0(e^+e^- \to \gamma^* \to \text{hadrons})}{\sigma^0(e^+e^- \to \gamma^* \to \mu^+\mu^-)}$$

Taken from [5]



Measurements:

- Exclusive:
  Sum of individual channels with low multiplicities at lower energies
- Inclusive:
  Used at higher energies due to high multiplicities

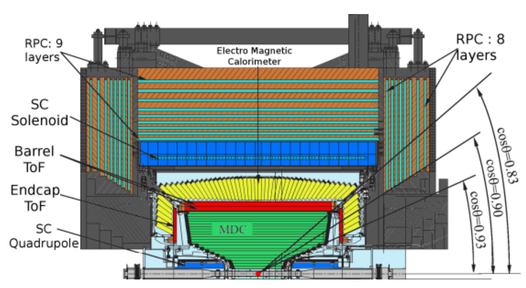
Techniques:

- Scans:
  Individual measurements at fixed energies
- Initial state radiation (ISR):
  One measurement over a continuous range of energies

BESIII Experiment

Symmetric e^+e^- experiment at the BEPCII accelerator at IHEP, Beijing, China [6]

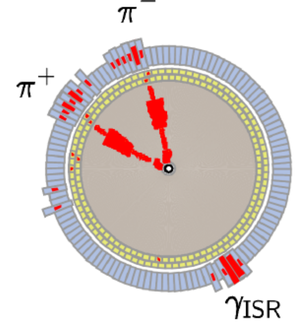
- $\sqrt{s}$ range: 2.0 GeV to 5.0 GeV
- Design luminosity of $10^{33}\,\text{cm}^{-2}\,\text{s}^{-1}$ reached
- Solid angle coverage: 93 %
- World's largest τ-charm data sets in e^+e^- annihilation



Data set used in this analysis: $3\,\text{fb}^{-1}$ at 4.178 GeV

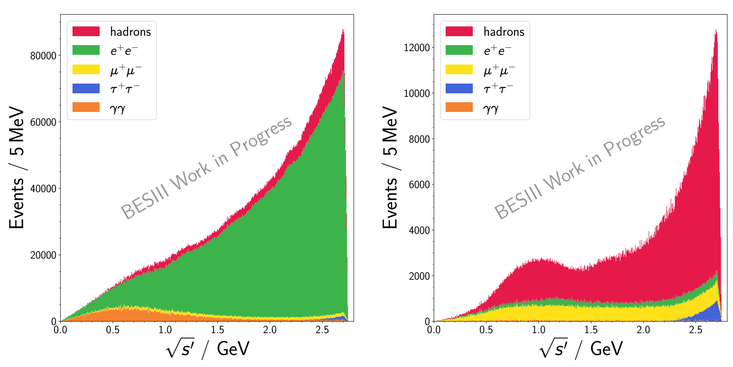
Analysis Strategy

- Detect ISR Photon in barrel part of EMC
- Require a charged track in MDC
- Dedicated cuts to suppress QED background from e^+e^- and $\gamma\gamma$
- Veto meson decays into photons
- Reconstruct mass of hadronic final state from recoil of ISR photon



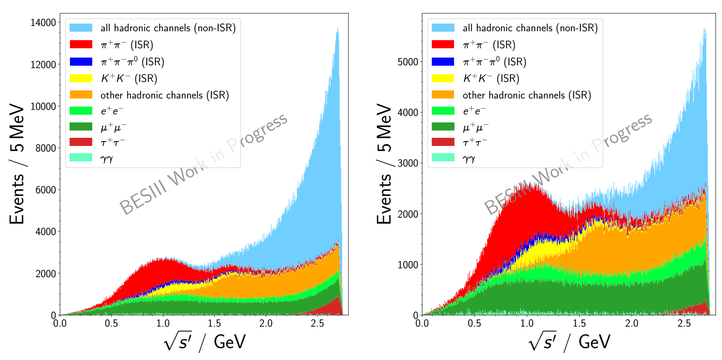
Electron Rejection

Use $\frac{dE}{dx}$ and ToF information to significantly suppress events containing electrons



Meson Veto

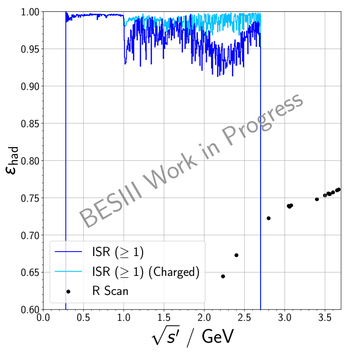
Veto decays of $\pi^0/\eta \to \gamma\gamma$



Hadronic Efficiency

Efficiency to detect at least 1 charged track in the MDC after detecting the ISR photon

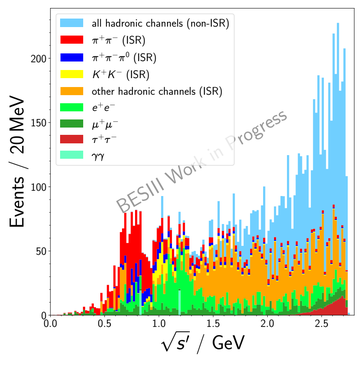
- Over 98 % across the whole mass range (for charged events)
- Higher compared to BESIII R-scan [7]



Photon Conversion

Alternative strategy:
Utilize e^+e^- pair created by ISR photon in the detector material

- Improved mass resolution compared to using the EMC
- However, very limited statistics
- New $20\,\text{fb}^{-1}$ data set at 3.773 GeV available soon



Summary

- New independent approach
- First inclusive measurement below 2 GeV

Advantages:

- Very high hadronic tagging efficiency
- Less reliant on description of hadronic simulation
- Single measurement from threshold
- Also able to measure fully neutral channels
- Independent of previous cross section and R measurements

Challenges:

- Background from radiative charmonia and high-energetic π^0/η decays
- Subtraction of QED background using high-precision MC generators
- Mass resolution limited by EMC
- Unfolding required to extract narrow resonances

References

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[6] M. Ablikim et al. Design and Construction of the BESIII Detector. *Nucl. Instrum. Meth. A*, 614:345–399, 2010.

[7] M. Ablikim et al. Measurement of the Cross Section for e^+e^- →Hadrons at Energies from 2.2324 to 3.6710 GeV. *Phys. Rev. Lett.*, 128(6):062004, 2022.

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