Dielectron measurements in Bi+Bi collisions at 9.2GeV with MPD

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MPD collaboration

Outline

1、Dataset

2、eID cut, efficiency and purity

3、Rejections of e^+e^- pairs from PCM and Dalitz decay

4、$M_{e^+e^-}$ distribution, S/B and $S/\sqrt{B}$ ratios

5、Comparison with previous results by Sudhir

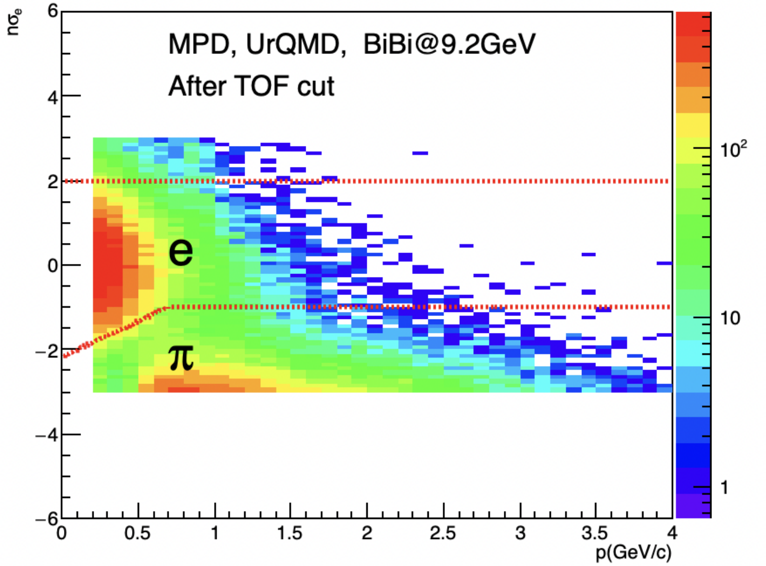
6、Summary

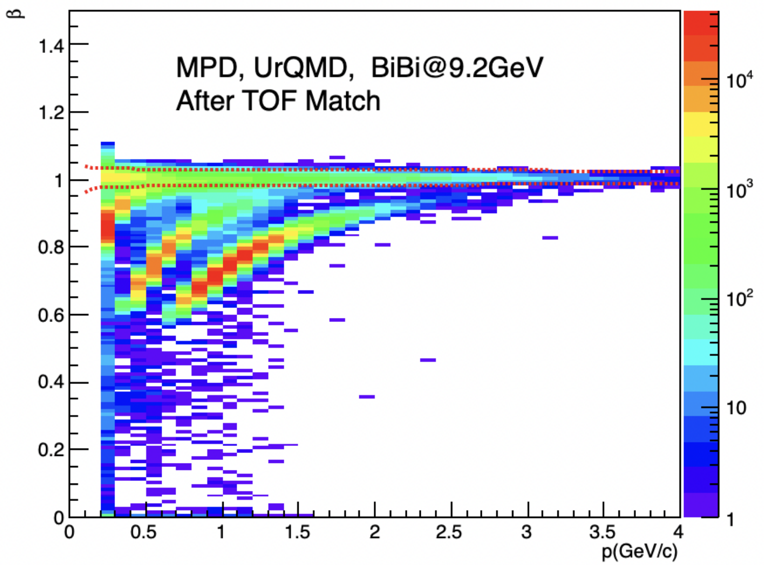
Dataset & strategy

- Data Production: Request 34, 15M events (latest dielectron production)
- Collision system: Bi+Bi @9.2GeV, UrQMD
- Use weights (e^+e^- mass, parent ID) for each electron to reweight UrQMD to PHSD

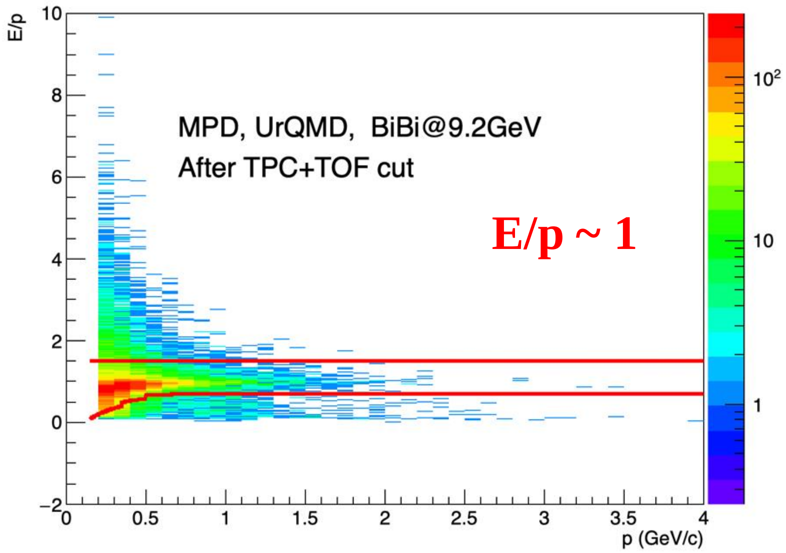
- Analyze method: classical analysis based on linear cuts and selections (no ML)
  - optimization of e-reconstruction and e-ID
  - rejection of pairs from PCM and Dalitz
  - accumulate invariant mass Mee distribution (FG)
  - estimate combinatorial background with LS-pairs or event mixing (BG)
  - Build (FG-BG) distributions and estimate S/B and signal significance

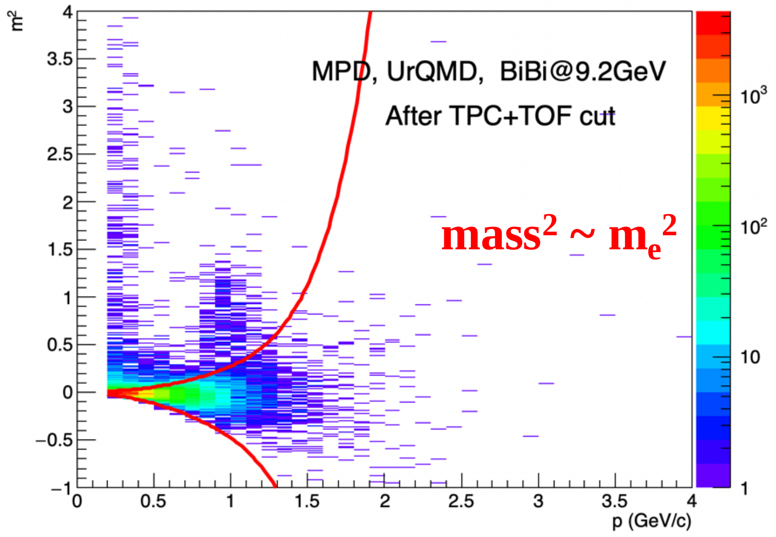
Track selection and TPC+TOF+ECAL e-ID cuts





ECal Match cut: $\sqrt{\frac{(dphi - meanphi)^2}{widthphi^2} + \frac{(dz - meanz)^2}{widthz^2}} < 2.0$





event cut:

$|z_vertex| < 80$cm → 11M in total

Track cut:

nhit_mpd ≥39;
$|\eta| \leq 1$;
|dca_sigma| ≤ 2.5;
$p_T \geq 0.2$ GeV/c;
matched to TOF (3σ in d*phi*, 2σ in d*zed*);

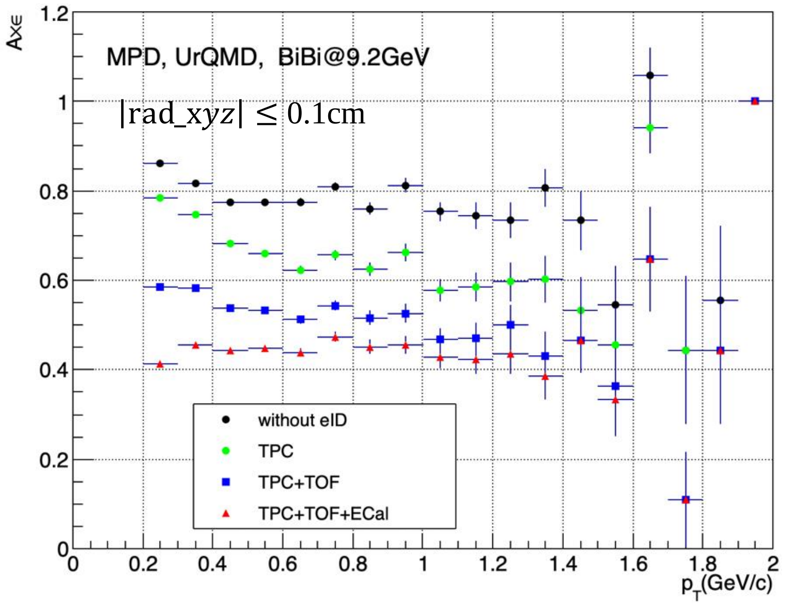
TPC e-ID

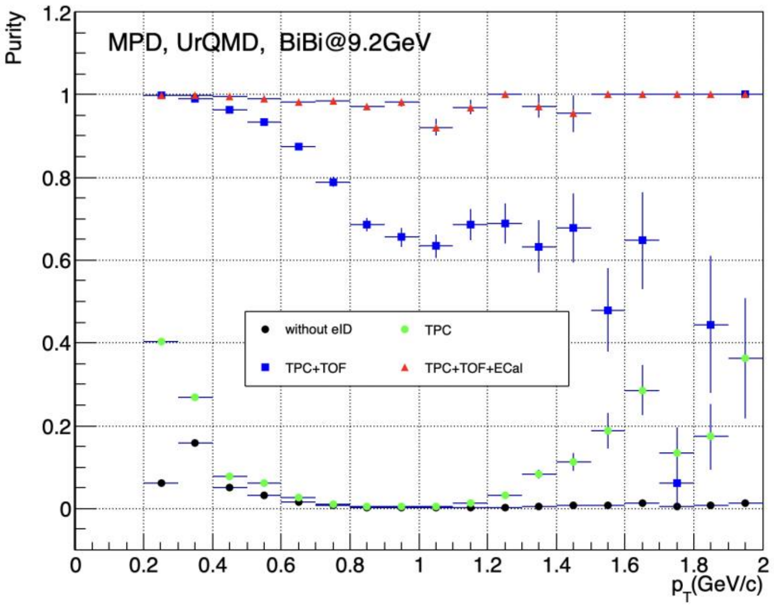
$|n\sigma_\pi| > 2$
if p<0.7 GeV/c
$(1.67\times p - 2.167) \leq n\sigma_e < 2$
if p ≥ 0.7GeV/c
$-1 \leq n\sigma_e < 2$

TOF e-ID

$|\sigma_\beta| < 2$

Efficiency and purity of e





$$A\times \epsilon = \frac{\text{e after cut}}{\text{mc\_e\_matchtoTPC}}$$

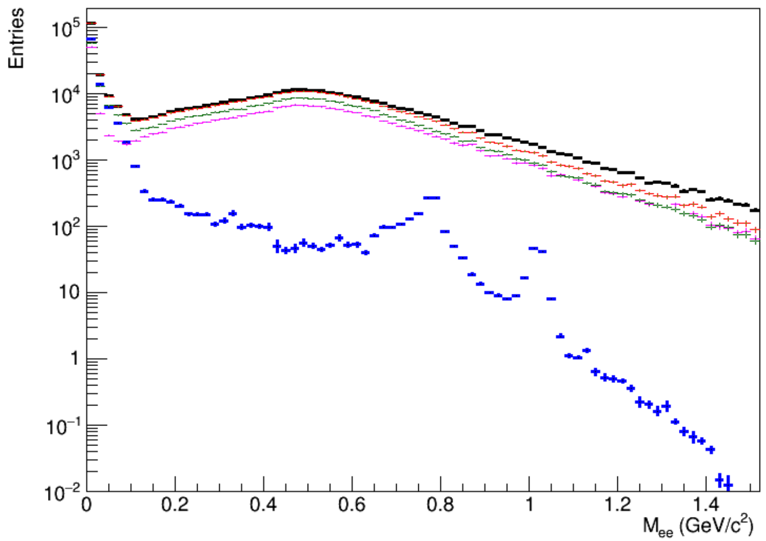
$$\text{Purity} = \frac{\text{all e after cut}}{\text{all particle after cut}}$$

The ECal becomes efficient at $p_T > 0.6$-0.8 GeV/c

Main background

TPC+TOF cut for e+/e-

$$M_{e+e-} = \sqrt{(E_{e^+} + E_{e^-})^2 - (\boldsymbol{p}_{e^+} + \boldsymbol{p}_{e^-})^2}$$



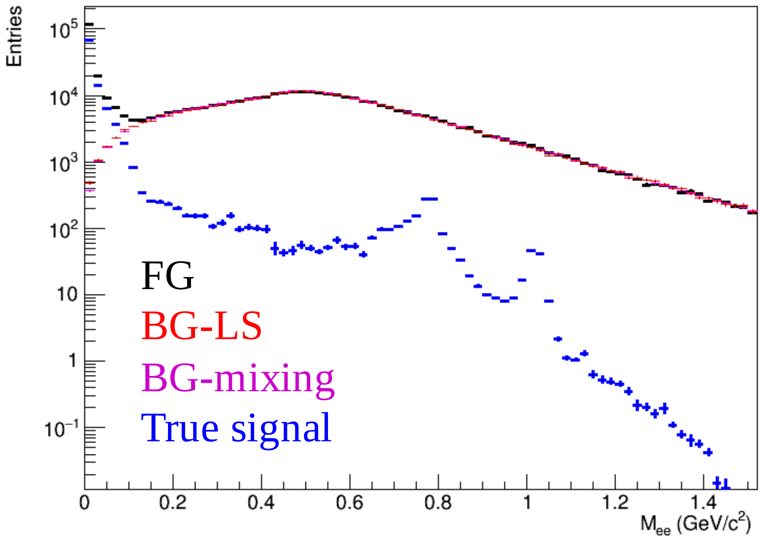
FG
True e+e-
Conversion
Dalitz
True signal

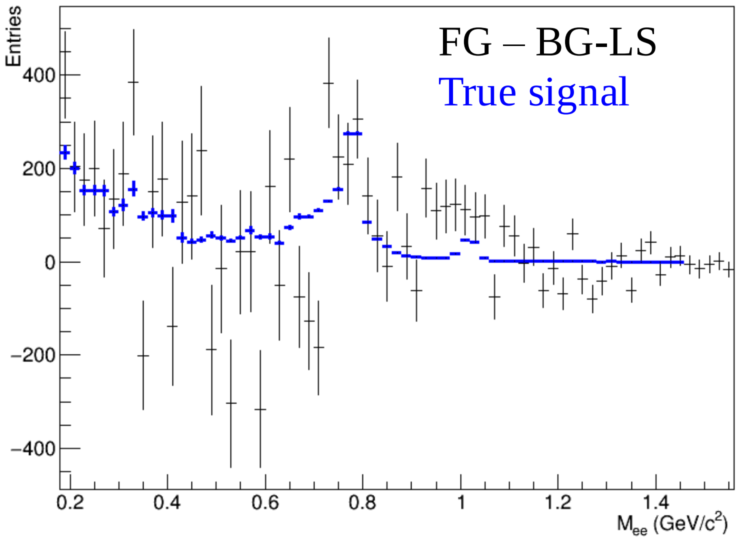
- Most of M_{ee} distribution is build of true e^+e^- pairs, some hadronic contamination at M_{ee} > 0.6 GeV/c^2
- Signal-to-background ratio is miserable due to huge combinatorial background
- Most of combinatorial background are from pairs:
  - ✓ where at least one electron is from π^0 Dalitz decay,
  - ✓ where at least one electron is from photon conversion
- Tagging and rejection of electrons from PCM and Dalitz may improve S/B

$M_{e^+e^-}$ distribution

TPC+TOF cut for e+/e-

$$M_{e+e-} = \sqrt{(E_{e^+} + E_{e^-})^2 - (\boldsymbol{p}_{e^+} + \boldsymbol{p}_{e^-})^2}$$



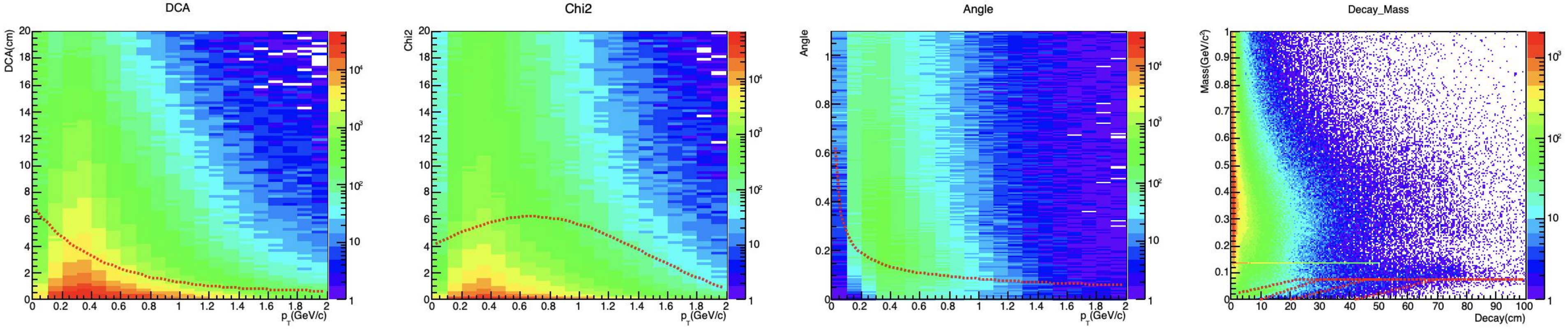



```
 S/B (0.2-1.5 GeV/c2) 0.0118605
===============================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 4.36974; S = 1912.91 BG = 191636
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 5.43012; S = 1542.1 BG = 80650.6
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 1.29382; S = 237.513 BG = 33700.1
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 6.58875; S = 3660.2 BG = 308605
===============================
```

- Although the electron purity is high, the mass integrated S/B is only 1.2%
- Signal significance is 6.6 σ

Tagging *e* from PCM

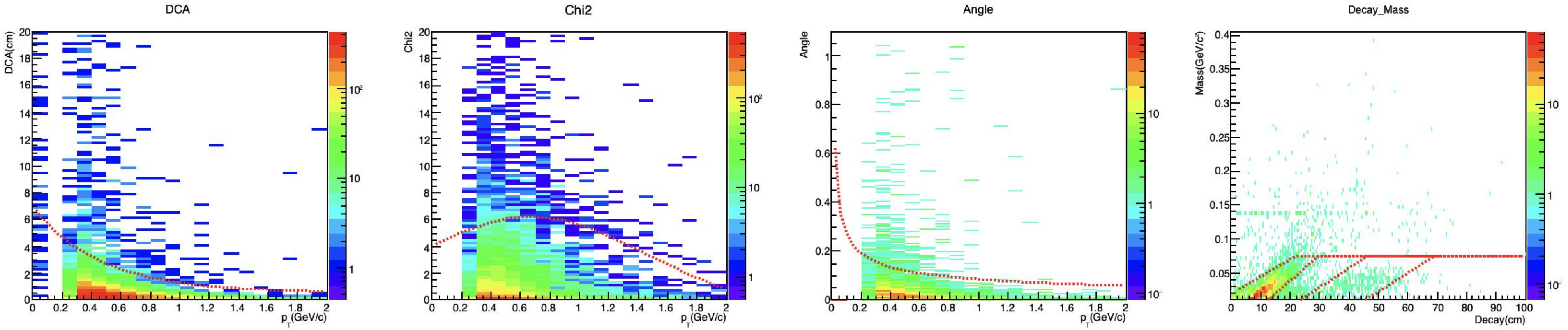
- Combine tightly identified electrons (slide 4) with loosely reconstructed & identified oppositely charged electrons



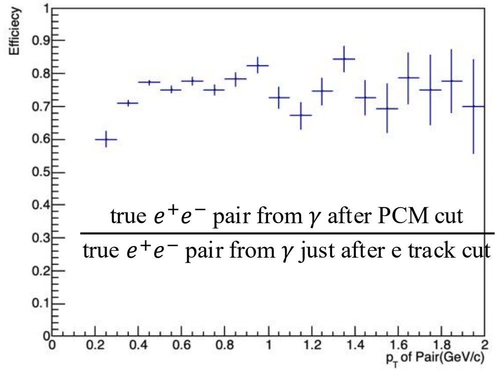
Loose e-selections:

- ✓ p_T > 50 MeV/c
- ✓ nhits > 10
- ✓ |η| < 2.5
- ✓ TPC 2σ eID or

(TPC 2σ && TOF 2σ) eID if matched to TOF



true e^+e^- pair from γ just after e track cut

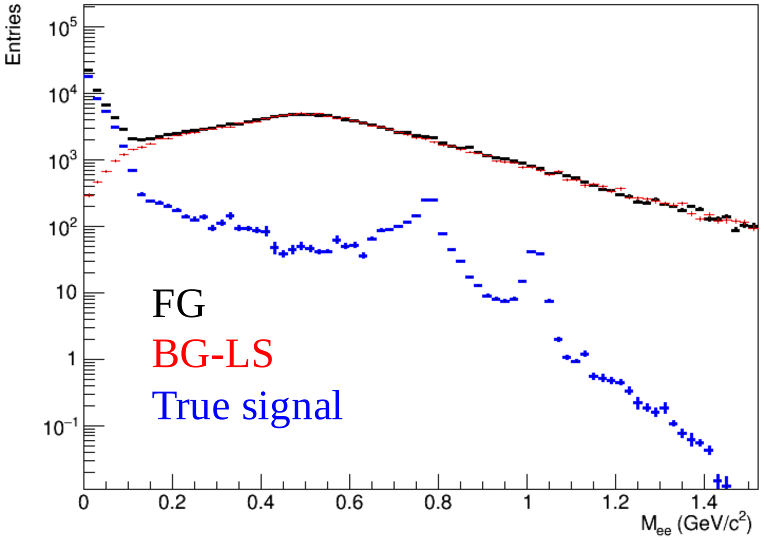


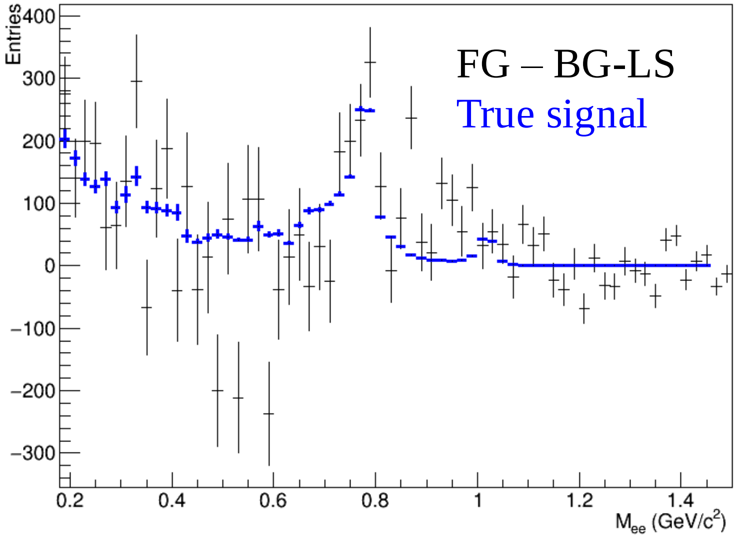
~ 80% of pairs from the PCM are selected for tagging with the applied cuts

$M_{e^+e^-}$ distribution after PCM tagging

TPC+TOF cut for e+/e-

$$M_{e+e-} = \sqrt{(E_{e^+} + E_{e^-})^2 - (\boldsymbol{p}_{e^+} + \boldsymbol{p}_{e^-})^2}$$






```
 S/B (0.2-1.5 GeV/c2) 0.0244392
===============================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 5.94993; S = 1705.94 BG = 82206.2
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 7.4507; S = 1403.71 BG = 35494.7
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 1.72344; S = 216.878 BG = 15835.8
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 8.9767; S = 3297.21 BG = 134915
===============================
```

- S/B: 1.2% → 2.4%; Signal significance 6.6 σ → 9.0 σ
- A very noticible improvement !!!

Tagging *e* from Dalitz

- Combine tightly identified electrons (slide 4) with loosely reconstructed & identified oppositely charged electrons

Loose e-selections:

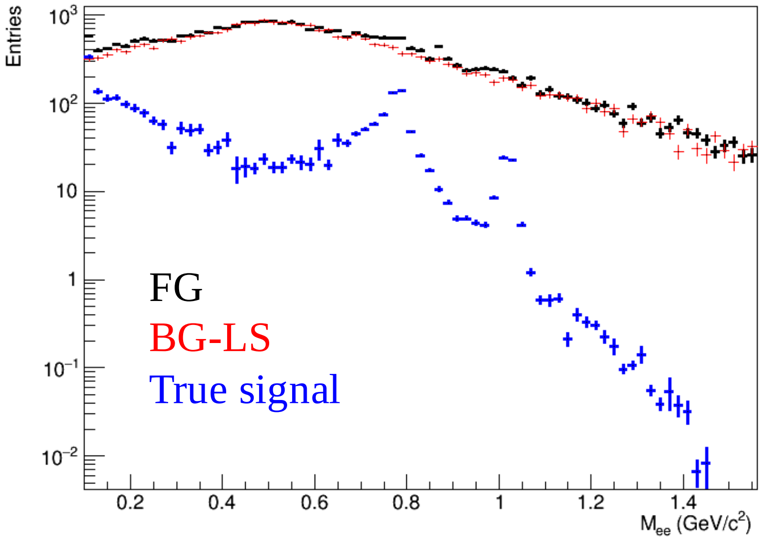
✓ $p_T > 50$ MeV/c
✓ nhits > 10
✓ $|\eta| < 2.5$
✓ TPC 2σ eID or
(TPC 2σ && TOF 2σ)
eID if matched to TOF

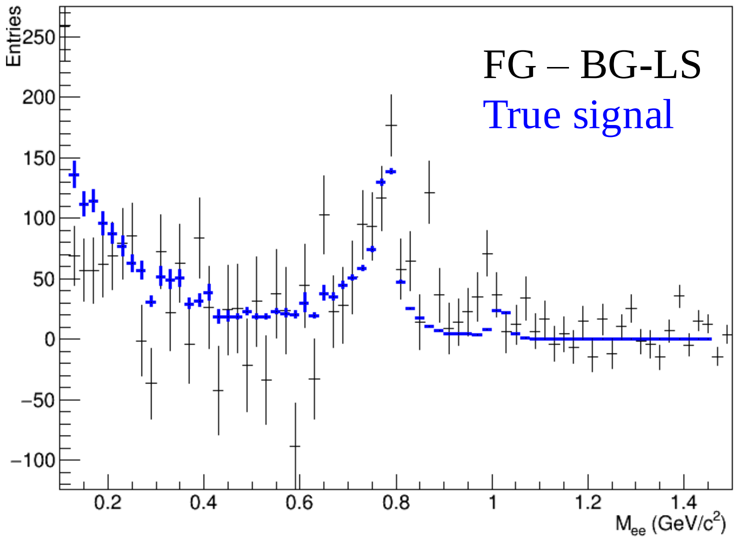
✓ DCA < 5σ -- NEW – subject of optimization
✓ Mee < 0.1 GeV/c^2 – NEW – subject of optimization

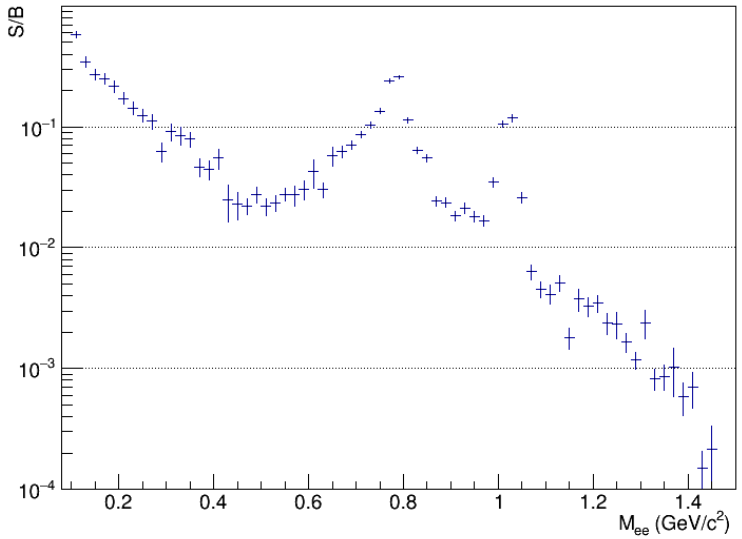
$M_{e^+e^-}$ distribution after PCM and Dalitz tagging

TPC+TOF cut for e+/e-

$$M_{e+e-} = \sqrt{(E_{e^+} + E_{e^-})^2 - (\boldsymbol{p}_{e^+} + \boldsymbol{p}_{e^-})^2}$$








```
 S/B (0.2-1.5 GeV/c2) 0.0622429
================================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 6.40842; S = 745.148 BG = 13520.2
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 8.40359; S = 708.388 BG = 7105.8
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 1.89845; S = 116.563 BG = 3769.84
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 9.83515; S = 1554.08 BG = 24968
================================
```

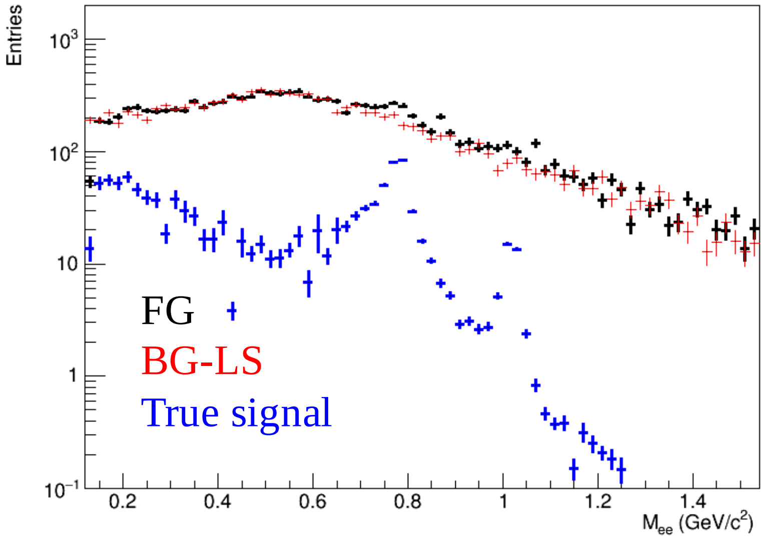
- S/B: 2.4% → 6.2%; Signal significance 6.6 σ → 9.8 σ
- A very noticible improvement !!!

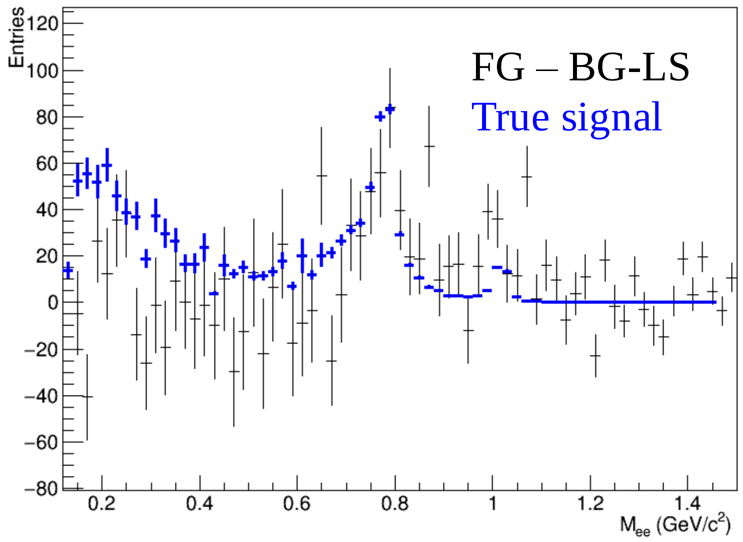
$M_{e^+e^-}$ distribution after PCM and Dalitz tagging

TPC+TOF cut for e+/e-

$$M_{e^+e^-} = \sqrt{(E_{e^+} + E_{e^-})^2 - (\boldsymbol{p}_{e^+} + \boldsymbol{p}_{e^-})^2}$$

Mconv = 0.135 MeV/c^2






```
 S/B (0.2-1.5 GeV/c2) 0.0871631
================================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 6.10404; S = 456.989 BG = 5605.02
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 7.72738; S = 433.148 BG = 3142.02
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 1.68356; S = 72.3828 BG = 1848.48
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 9.11366; S = 952.912 BG = 10932.5
================================
```

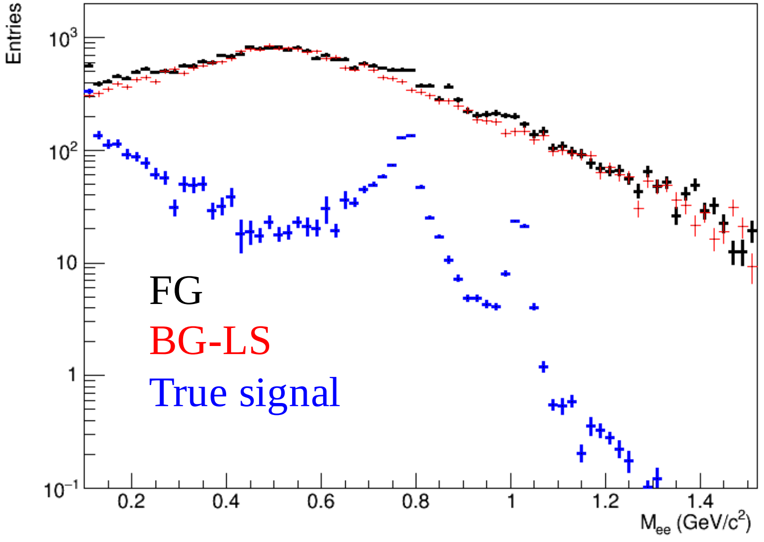
- S/B: 6.2% → 8.7%; Signal significance 9.8 σ → 9.1 σ
- Improvements in S/B in expense of statistical significance

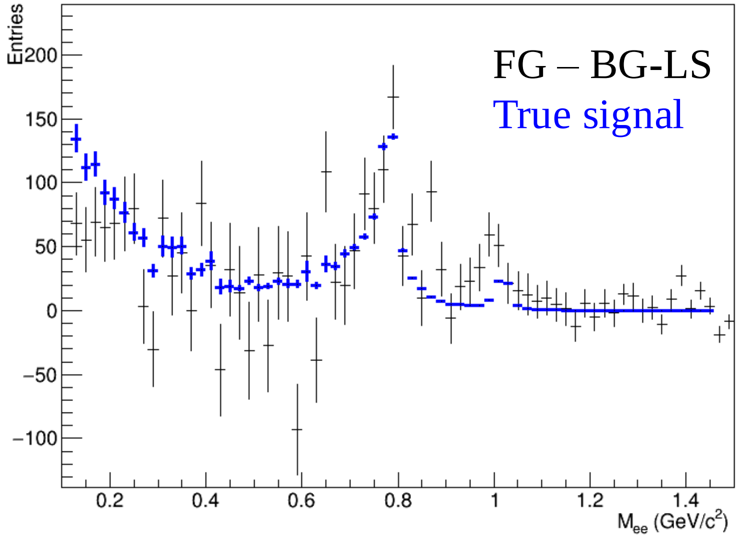
$M_{e^+e^-}$ distribution after PCM and Dalitz tagging

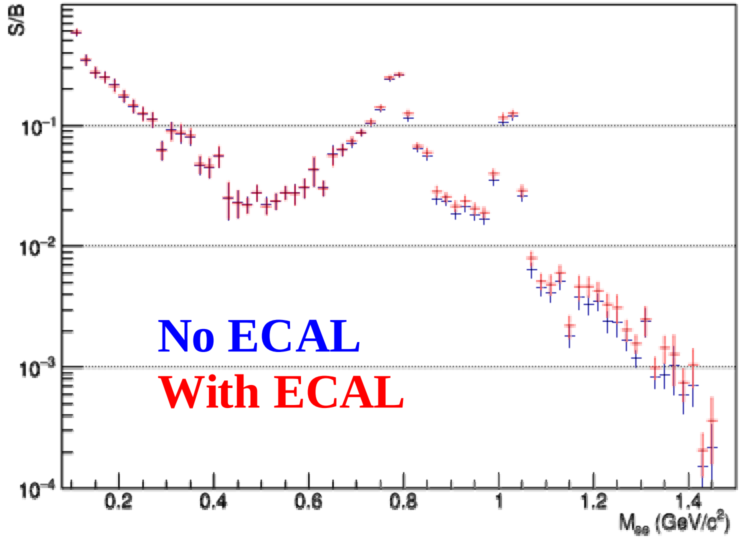
TPC+TOF cut for e+/e-

$$M_{e^+e^-} = \sqrt{(E_{e^+} + E_{e^-})^2 - (\boldsymbol{p}_{e^+} + \boldsymbol{p}_{e^-})^2}$$

ECAL e-ID at pT > 0.8 GeV/c








```
 S/B (0.2-1.5 GeV/c2) 0.0655446
==============================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 6.44846; S = 739.767 BG = 13160.7
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 8.49436; S = 697.668 BG = 6745.86
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 2.0094; S = 113.183 BG = 3172.68
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 10.0299; S = 1534.82 BG = 23416.4
==============================
```

- S/B: 6.2% → 6.6%; Signal significance 9.8 σ → 10 σ
- Improvements in signal with ECAL

Comparison with previous results by Sudhir

- Current results of this analysis (slide 13)

```
 S/B (0.2-1.5 GeV/c2) 0.0655446
===============================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 6.44846; S = 739.767 BG = 13160.7
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 8.49436; S = 697.668 BG = 6745.86
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 2.0094; S = 113.183 BG = 3172.68
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 10.0299; S = 1534.82 BG = 23416.4
===============================
```

- Results provided by Sudhir (thanks!)

Using 1D cuts for eID.

S/B (0.2-1.5 GeV/c) - 6.23%

Significance (S/sqrt(B))
LVM (0.2-0.6 GeV/c) - 4.33
omega (0.6-0.85 GeV/c) - 5.94
phi (0.85-1.2 GeV/c) - 1.36

Machine learning for eID.

S/B (0.2-1.5 GeV/c) - 6.23%

Significance (S/sqrt(B))
LVM (0.2-0.6 GeV/c) - 7.02
omega (0.6-0.85 GeV/c) - 8.61
phi (0.85-1.2 GeV/c) - 2.05

- Results are comparable with ML approach by Sudhir, but with much simpler and straight forward analysis
- Further optimization to be expected

Summary

1、The Invariant mass distributions for dielectron pairs were obtained

2、PCM and Dalitz tagging improve S/B and signal significance

3、The obtained results are comparable with those previously reported by Sudhir

Outlook

1、 Work on optimization of the single track and pair cuts

2、 Work with Sudhir to get even better results with all options combined

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Thanks!