Brief update on the dielectron analysis using Pluto and UrQMD

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Outline

- Pluto is one possibility for various di-electron sources, i.e., Signal.
- Pluto: simulate different M_{ee} contributions: not full event $\rightarrow$ to be scaled with multiplicities and BR afterwards.
- UrQMD is used to mimic the background.

Inputs to Pluto

Energy is distributed according to,

$$\frac{\mathrm{dN}}{\mathrm{dE}} \propto \mathrm{p} \times \mathrm{E} \times \mathrm{e}^{(-\mathrm{E}/\mathrm{T})} \textbf{ OR } \frac{\mathrm{dN}}{\mathrm{dE}} \propto \sqrt{\mathrm{p}} \times \mathrm{E} \times \mathrm{e}^{(-\mathrm{E}/\mathrm{T})} \textbf{ OR } \frac{\mathrm{dN}}{\mathrm{dE}} \propto \mathrm{p}^3 \times \mathrm{E} \times \mathrm{e}^{(-\mathrm{E}/\mathrm{T})}$$

and Angular distribution is sampled as,

$$\frac{dN}{d\Omega} \propto 1 + A_2 \cos^2 \theta^{\mathrm{c.m.}} + A_4 \cos^4 \theta^{\mathrm{c.m.}}$$

Masses are fixed in case of stable particles and sampled using Breit Weigner distribution with **mass-dependent** width in case of resonances (see slide 16 for equations for widths).

Azimuthal angle, ϕ is uniformly distributed. Rest of the kinematic variables are obtained using these distributions.

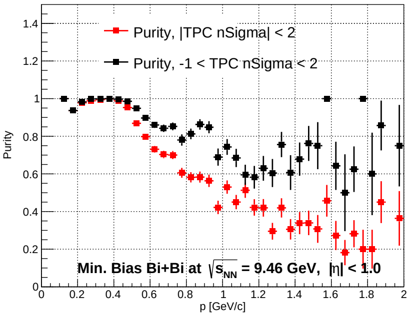
At the moment, input parameters for Pluto:

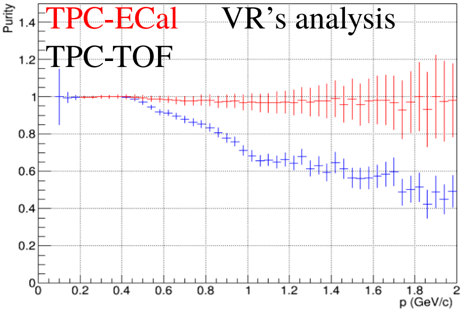
$\Rightarrow$ T_π = 0.10 GeV, T_η = 0.14 GeV, $\mathrm{T}_{\omega,\rho}$ = 0.16 GeV, T_ϕ = 0.19 GeV

Ingredients:

- **Statistics:**
  - **UrQMD:** 61K (Min. Bias Bi–Bi@ 9.46 GeV).
  - **Pluto:**
    - $\phi \rightarrow e^+e^-$: 1.4M.
    - $\omega \rightarrow e^+e^-$: 1.9M.
    - $\omega \rightarrow \pi^0 e^+e^-$: 1.5M.
    - $\pi^0 \rightarrow \gamma e^+e^-$: 1.6M.
    - $\eta \rightarrow \gamma e^+e^-$: 2M.
    - $\rho^0 \rightarrow e^+e^-$: 1.7M.
- SR: Track and PID selection with TPC–TOF.
  - $|V_z| < 50$ cm.
  - $p_T > 100$ MeV/c, $|\eta| < 1.0$ for tracks.
  - nHits > 39, $|DCA_{x,y,z}| < 2\sigma$.
  - -1 < $n\sigma^e_{TPC} < 2$, $|n\sigma^e_{TOF}| < 2$.
  - $|n\sigma^\pi_{TPC}| > 2$ (pion veto), TOF-matching $< 2\sigma$.

Purity

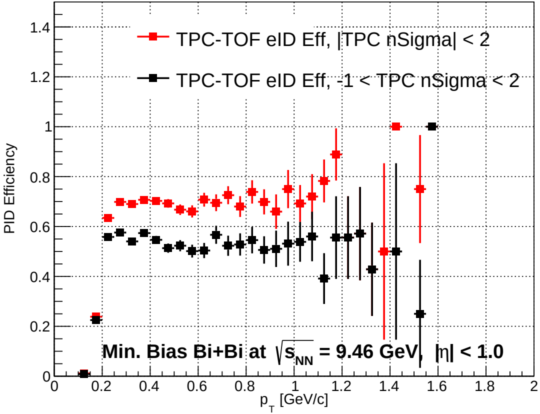




- Obtained using UrQMD with TPC-TOF only.
- $-1 < n\sigma^{e}_{TPC} < 2$: High purity.
- $-2 < n\sigma^{e}_{TPC} < 2$: Low purity.

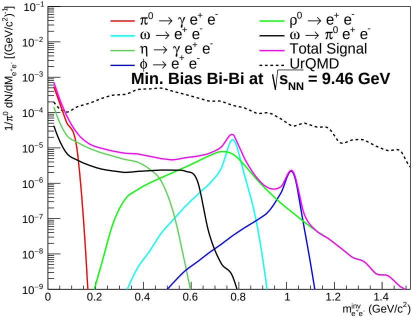
- More contamination in SR compared to VR with same TPC PID cut.
- However, similar purity with tighter TPC cut in SR.

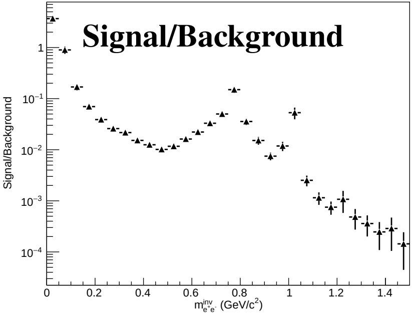
PID Efficiency



- TPC-TOF PID efficiency.
- **Denominator:** nHits > 39, $p_T > 100$ MeV/c, $|\eta| < 1.0$, $|DCA_{x,y,z}| < 2\sigma$, Prod. Radius < 2 cm.
- **Numerator:** Additional cuts: $-1 < n\sigma^{e}_{TPC} < 2$, $|n\sigma^{e}_{TOF}| < 2$, $|n\sigma^{\pi}_{TPC}| > 2$ (pion veto), TOF-matching $< 2\sigma$.
- $-1 < n\sigma^{e}_{TPC} < 2$: Low efficiency.
- $-2 < n\sigma^{e}_{TPC} < 2$: High efficiency.

Invariant Mass spectra: Min. Bias Bi–Bi@ 9.46 GeV.





- Multiplicities of different dielectron sources is taken from UrQMD (Thanks to Victor).
- ϕ: 0.4, ω: 12.5.
- π^0: 117, η: 8.7.
- ρ^0: 36.7.

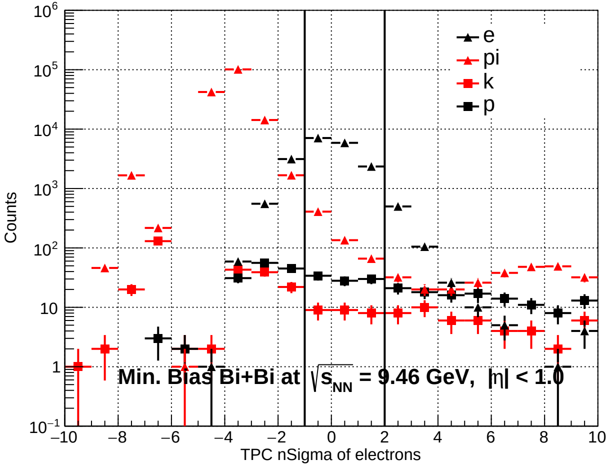
- S/B = 0.02439 ($0.2 < m^{inv}_{e^+e^-} < 1.5$ GeV/c^2) → similar order as Victor's analysis (S/B ∼ 0.025).
- Not quite apple-to-apple comparison, since ECal info is not used.

Summary

- Pluto is used as input for dielectrons and UrQMD as source of background.
- Decent purity using TPC-TOF: with tigher TPC cut
- Similar S/B ratio as VR analysis, though ECal information is not used in this analysis.

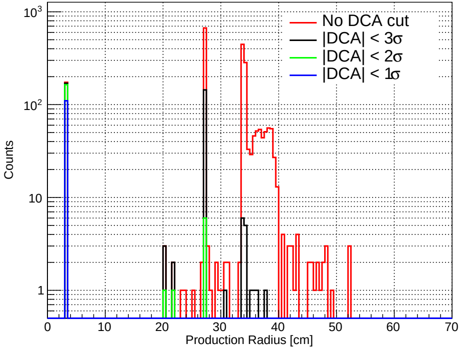
BACK-UP

TPC nSigma

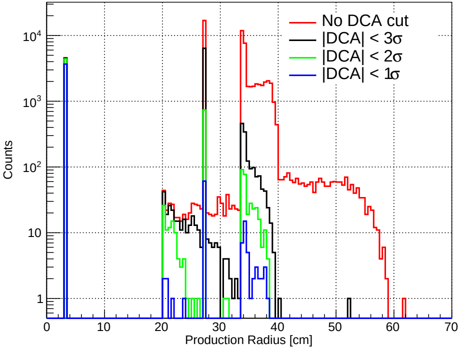


Counts
TPC nSigma of electrons
e
pi
k
p
Min. Bias Bi+Bi at $\sqrt{s_{NN}}$ = 9.46 GeV, |η| < 1.0
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
−10
−8
−6
−4
−2
0
2
4
6
8
10

Production Radius: Conversion electrons

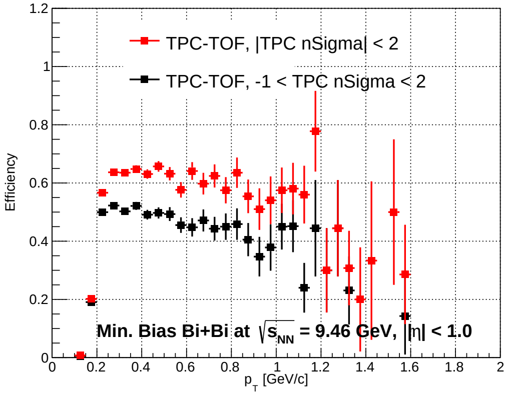


Pairs



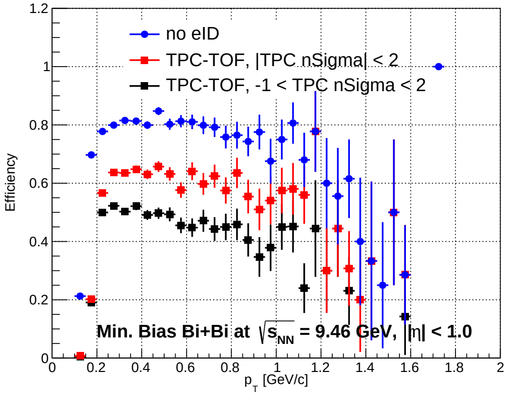
Single electron

Reconstruction efficiency



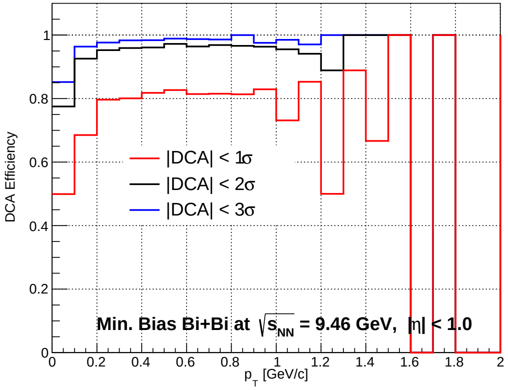
- Reconstruction efficiency.
- **Denominator:** $p_T > 100$ MeV/c, $|\eta| < 1.0$, Prod. Radius < 2 cm.
- **Numerator:** Additional cuts: nHits > 39, $|DCA_{x,y,z}| < 2\sigma$, $-1 < n\sigma^{e}_{TPC} < 2$, $|n\sigma^{e}_{TOF}| < 2$, $|n\sigma^{\pi}_{TPC}| > 2$ (pion veto), TOF-matching $< 2\sigma$.

Reconstruction efficiency

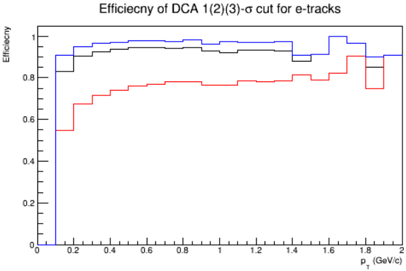


- Reconstruction efficiency.
- **Denominator:** $p_T > 100$ MeV/c, $|\eta| < 1.0$, Prod. Radius < 2 cm.
- **Numerator:** Additional cuts: nHits > 39, $|DCA_{x,y,z}| < 2\sigma$, $-1 < n\sigma^{e}_{TPC} < 2$, $|n\sigma^{e}_{TOF}| < 2$, $|n\sigma^{\pi}_{TPC}| > 2$ (pion veto), TOF-matching $< 2\sigma$.
- Track efficiency.
- **Denominator:** $p_T > 100$ MeV/c, $|\eta| < 1.0$, Prod. Radius < 2 cm.
- **Numerator:** Additional cuts: nHits > 39, $|DCA_{x,y,z}| < 2\sigma$, TOF-matching $< 2\sigma$.

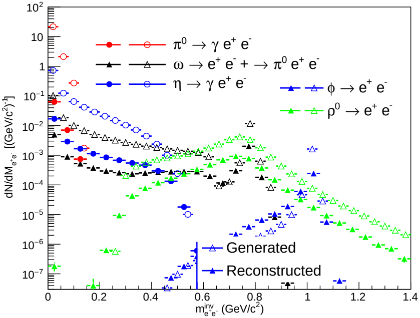
DCA efficiency

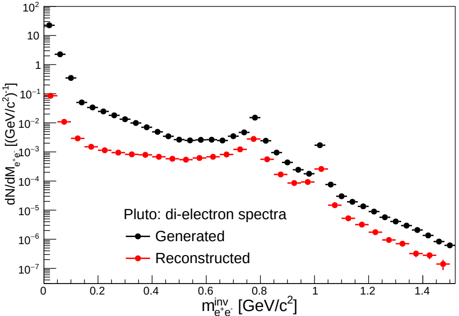


- DCA efficiency.
- **Denominator:** $p_T > 100$ MeV/c, $|\eta| < 1.0$, Prod. Radius < 2 cm, nHits > 39.
- **Numerator:** Additional cuts: $|DCA_{x,y,z}| <$ 1, 2, 3σ



Di-electron spectra: Generated and Reconstructed





Fraction of integrated reconstructed to generated yield:

- Pi0 $\to$ 0.00296215
- Eta: $\to$ 0.0244894
- WDalitz: $\to$ 0.0541358

- Rho: $\to$ 0.183078
- Phi: $\to$ 0.204956
- WDirect: $\to$ 0.204186

Similar fraction for two body decays

Inputs to Pluto

The mass dependence of the decay width of Dalitz decay of pseudo-scalar mesons, π^0 and η is,

$$\frac{d\Gamma^{k}(m)}{\Gamma^{A\rightarrow 2\gamma}dm} = \frac{4\alpha}{3\pi m}\sqrt{1-\frac{4m_e^2}{m^2}}\left(1+\frac{2m_e^2}{m^2}\right)\left(1-\frac{m^2}{m_A^2}\right)\left|F_A(m^2)\right|^2$$

and, for vector mesons, ω is,

$$\frac{d\Gamma^{k}(m)}{\Gamma^{A\rightarrow B\gamma}dm} = \frac{2\alpha}{3\pi m}\sqrt{1-\frac{4m_e^2}{m^2}}\left(\left(1+\frac{m^2}{m_A^2-m_B^2}\right)^2-\left(\frac{2m_A m}{m_A^2-m_B^2}\right)\right)^{\frac{3}{2}}\left|F_A(m^2)\right|^2$$

direct decay of vector mesons, ρ, ω and ϕ,

$$\Gamma^{V\rightarrow e^+e^-}(m) = \frac{c_V}{m^3}\sqrt{1-\frac{4m_e^2}{m^2}}\left(1+\frac{m_e^2}{m^2}\right)$$

where the the index V refers to one of ρ^0, ω and ϕ, and c_V is 3.079×10^{-6}, 0.287×10^{-6}, and 1.450×10^{-6} GeV^4 respectively

Thermal models

Following the usual Ansatz (see e.g. [8]) we use the relativistic form of the Breit Wigner distribution:

$$g(m) = A\frac{m^2\Gamma^{\text{tot}}(m)}{(M_{\text{R}}^2 - m^2)^2 + m^2(\Gamma^{\text{tot}}(m))^2} \tag{1}$$

where m denotes the running unstable mass, and M_{R} is the static pole mass of the resonance. The mass-dependent width depends on the partial widths:

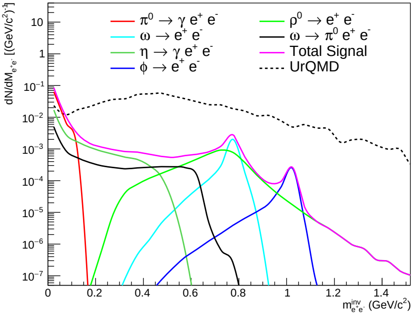
$$\Gamma^{\text{tot}}(m) = \sum_{\text{k}}^{N} \Gamma^{\text{k}}(m) \tag{2}$$

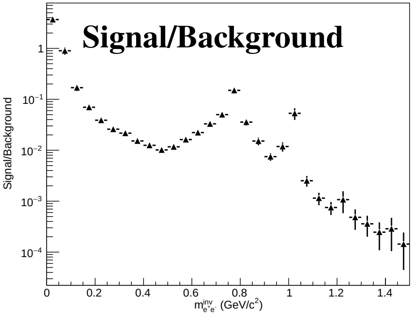
with N the number of decay modes. The factor A has been chosen such that the integral is statistically normalized ($\int dm\, g(m) = 1$).

Multiplicities from CBM dilepton group

Ebeam [AGeV]	s1/2 [AGeV]	F [AGeV1/2]	ymid -	muB [GeV]	Tchem [GeV]	Mπ0/Apart -	Mη/Apart -	Mρ0/Apart -	Mω/Apart -	Mφ/Apart -	Mη'/Apart -
1.0	2.309	0.443	0.679	0.802	0.055	0.042 fit	0.0003 exp	?	?	?	?
2.0	2.683	0.673	0.907	0.755	0.070	0.083 fit	0.0047 exp	?	?	?	?
3.0	3.010	0.841	1.059	0.718	0.080	0.126 fit	0.0014	0.00050	0.00019	0.00001	0.00001
4.0	3.305	0.976	1.175	0.688	0.088	0.168 fit	0.0029	0.0013	0.00057	0.00005	0.00003
6.0	3.827	1.186	1.348	0.640	0.100	0.244 fit	0.0089	0.0056	0.0029	0.00032	0.00019
8.0	4.287	1.350	1.475	0.603	0.109	0.312 fit	0.016	0.012	0.0068	0.0010	0.00054
10.0	4.701	1.485	1.577	0.573	0.115	0.374 fit	0.023	0.020	0.011	0.0019	0.0010
15.0	5.605	1.749	1.766	0.517	0.125	0.507 fit	0.039	0.039	0.023	0.0047	0.0023
20.0	6.382	1.950	1.902	0.477	0.132	0.618 fit	0.052	0.055	0.034	0.0075	0.0035
25.0	7.074	2.115	2.010	0.446	0.136	0.713 fit	0.064	0.069	0.044	0.010	0.0046
30.0	7.705	2.255	2.098	0.421	0.140	0.797 fit	0.074	0.081	0.052	0.012	0.0056
35.0	8.287	2.378	2.173	0.401	0.142	0.873 fit	0.084	0.092	0.060	0.014	0.0065
40.0	8.831	2.488	2.238	0.383	0.144	0.940 fit	0.092	0.101	0.067	0.016	0.0073
80.0	12.349	3.109	2.579	0.299	0.153	1.340 fit	0.144	0.156	0.111	0.027	0.012
158.0	17.258	3.813	2.916	0.229	0.159	1.770 fit	0.204	0.217	0.159	0.039	0.018

Invariant Mass spectra: Min. Bias Bi–Bi@ 9.46 GeV.





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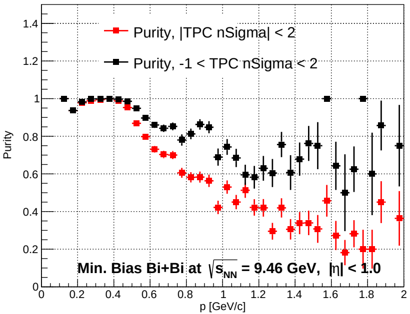
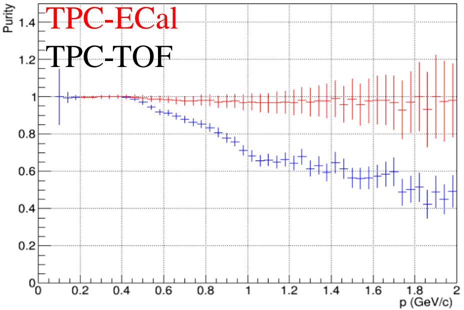
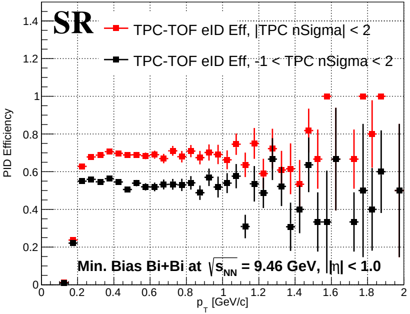
Purity

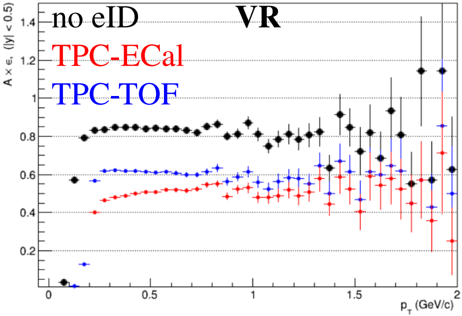




- Only TPC-TOF is used in SR analysis
- More contamination in SR compared to VR with same TPC PID cut.
- However, similar purity with tighter TPC cut in SR.

PID efficiency





- Similarly, high PID efficiency in SR compared to VR with same TPC PID cut.
- However, similar efficiency with tighter TPC cut in SR.