# Low mass dielectrons with ALICE 3

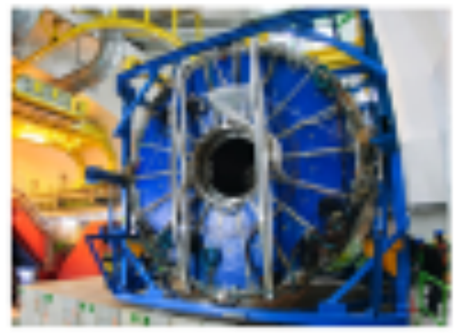
Raphaelle Bailhache

Goethe-Universitaet Frankfurt am Main, Germany

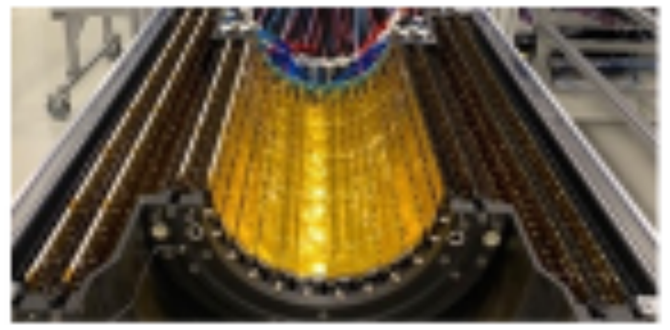
# ALICE now

Right now: preparing for **Run 3**

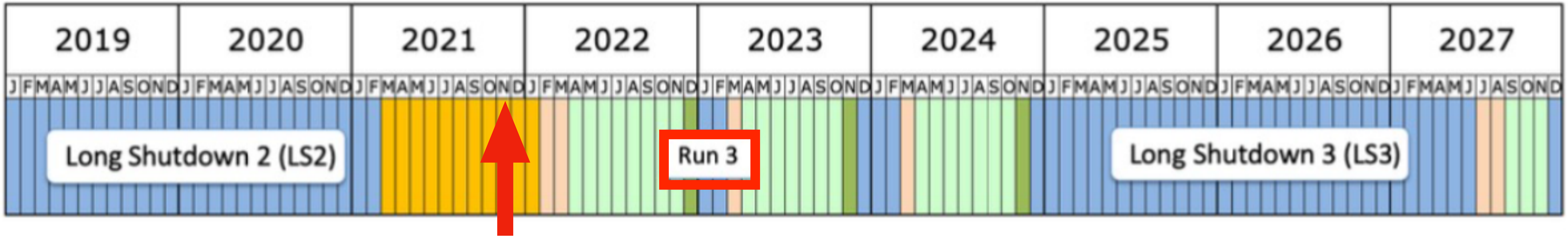
**GEM TPC**



**ITS 2**



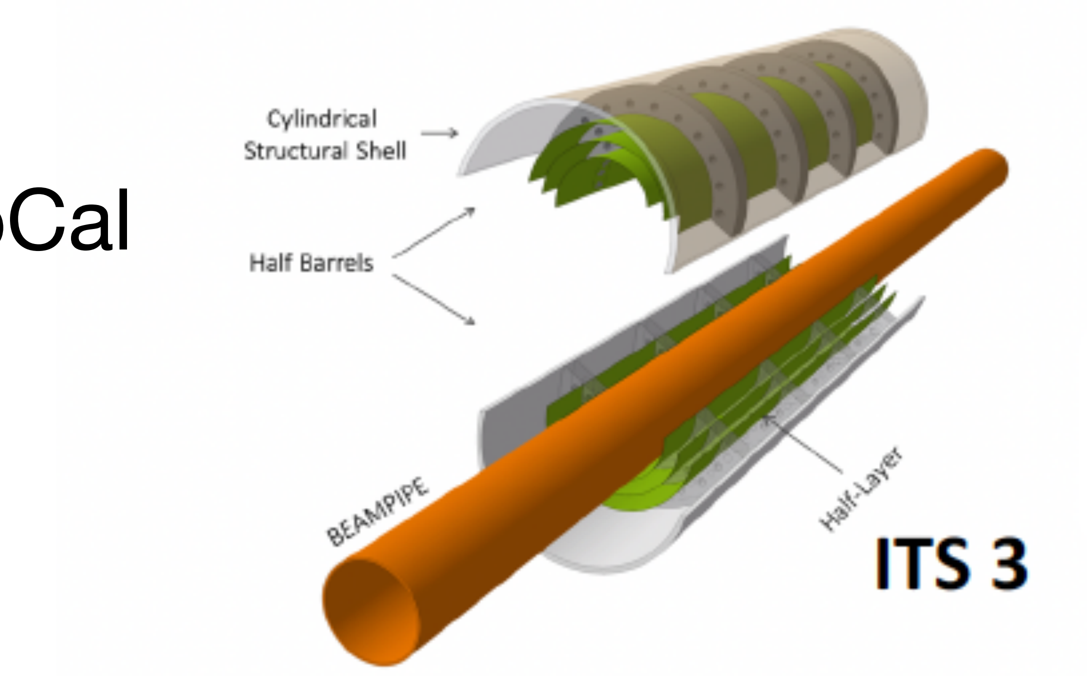
**O2**

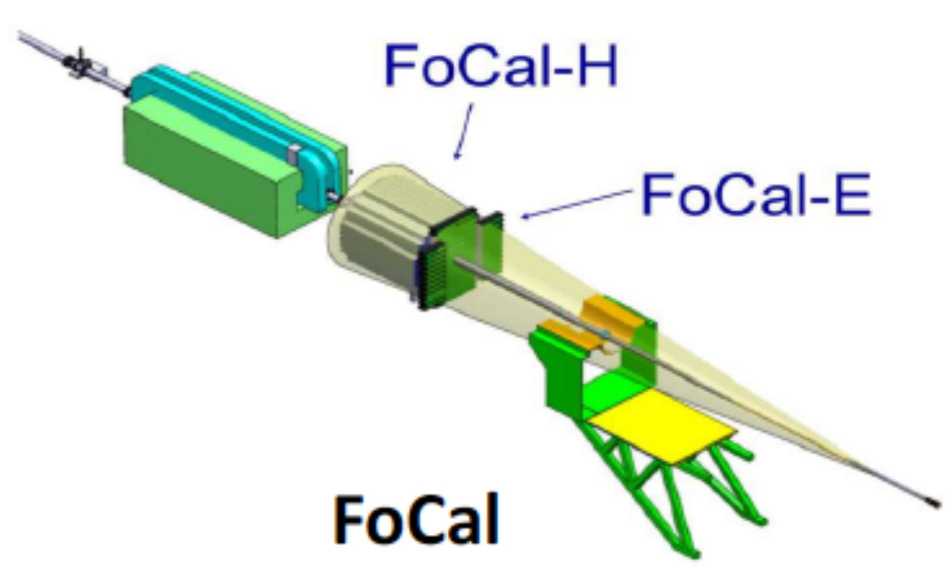



Shutdown/Technical stop
Protons physics
Ions
Commissioning with beam
Hardware commissioning/magnet training

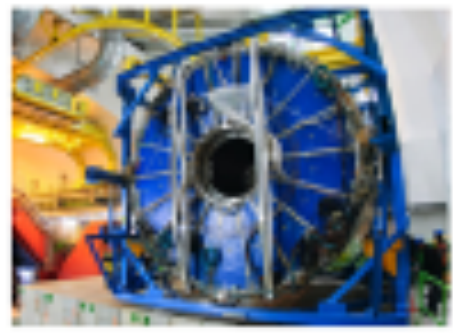
# ALICE tomorrow

Long Shutdown 3: preparation for **Run 4**, installation of ITS3 and FoCal

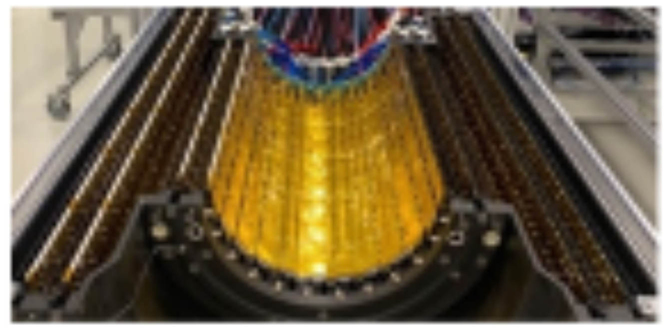


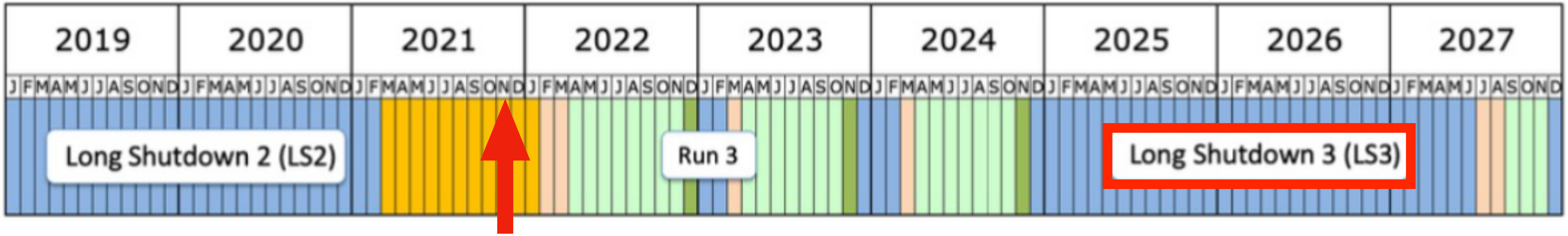

GEM TPC



ITS 2

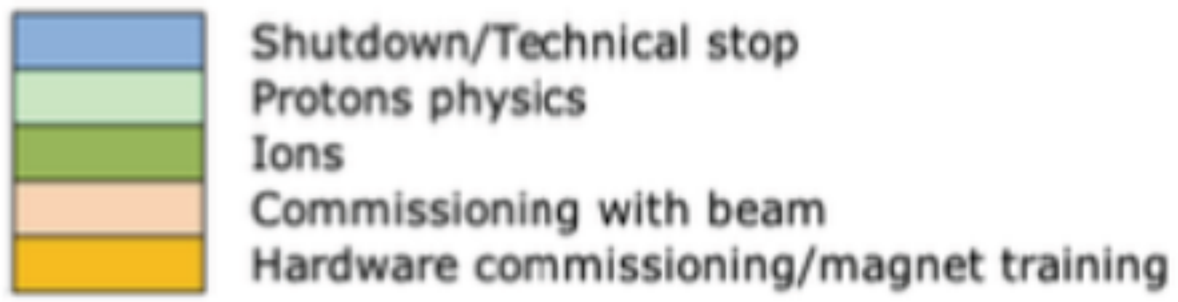


O2

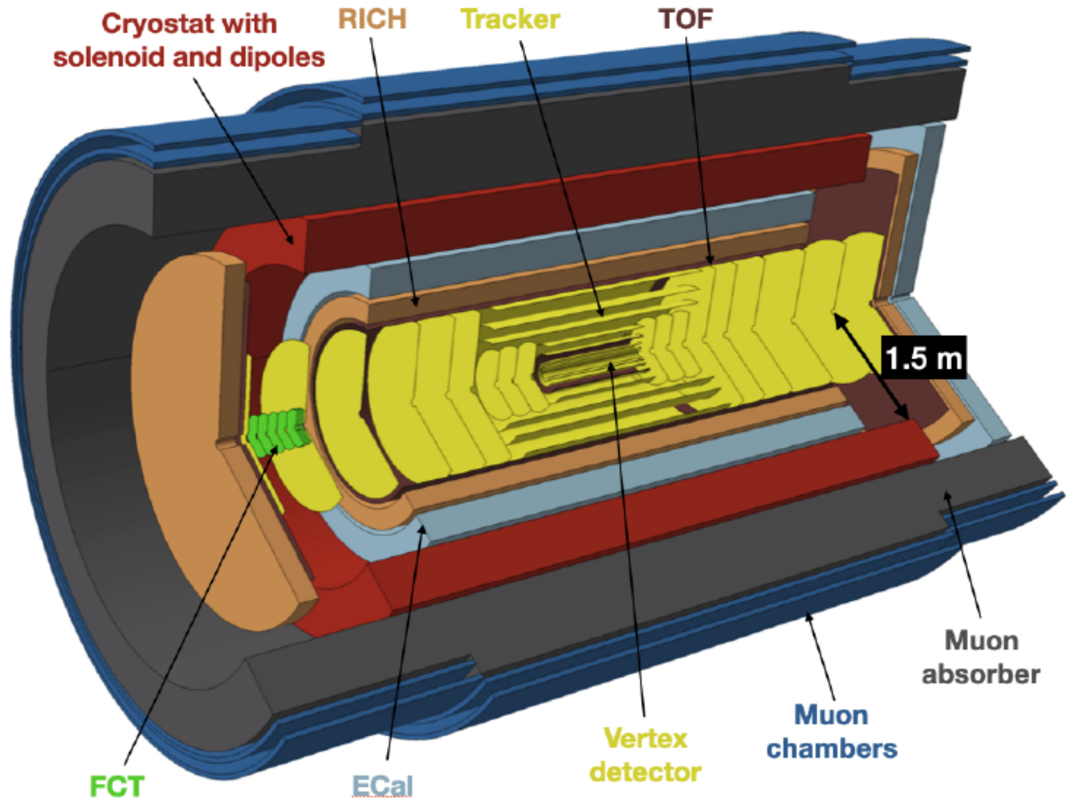



### Heavy-ion physics goals of Run 3 + 4:

- **Early temperature of the medium created in heavy-ion collisions with dileptons**
- High-precision heavy flavour measurements: parton energy loss, hadronisation



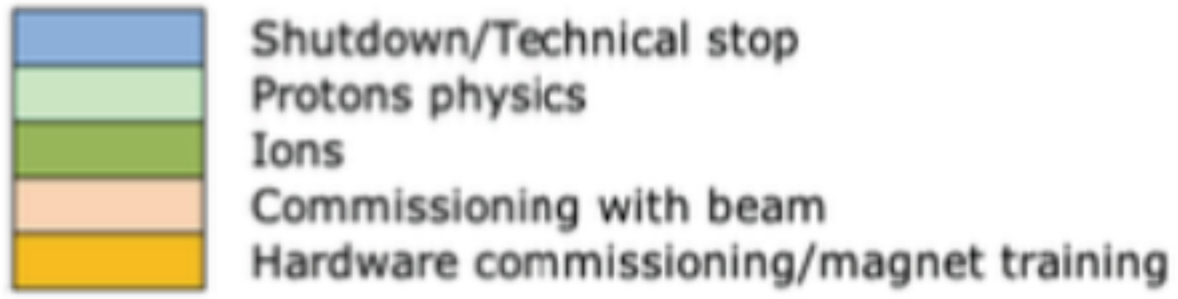
# ALICE 3 after tomorrow




Long Shutdown 4:  installation of ALICE 3 for **Run 5**


**Beyond 2030: qualitative steps in detector performance and luminosity**

- **Precision differential measurements of dileptons**
- **(Ultra-soft) real and virtual photon production**
- Deconfinement and coalescence with multi-charmed baryons
- Heavy-flavour probes of the QGP



# Temperature measurements

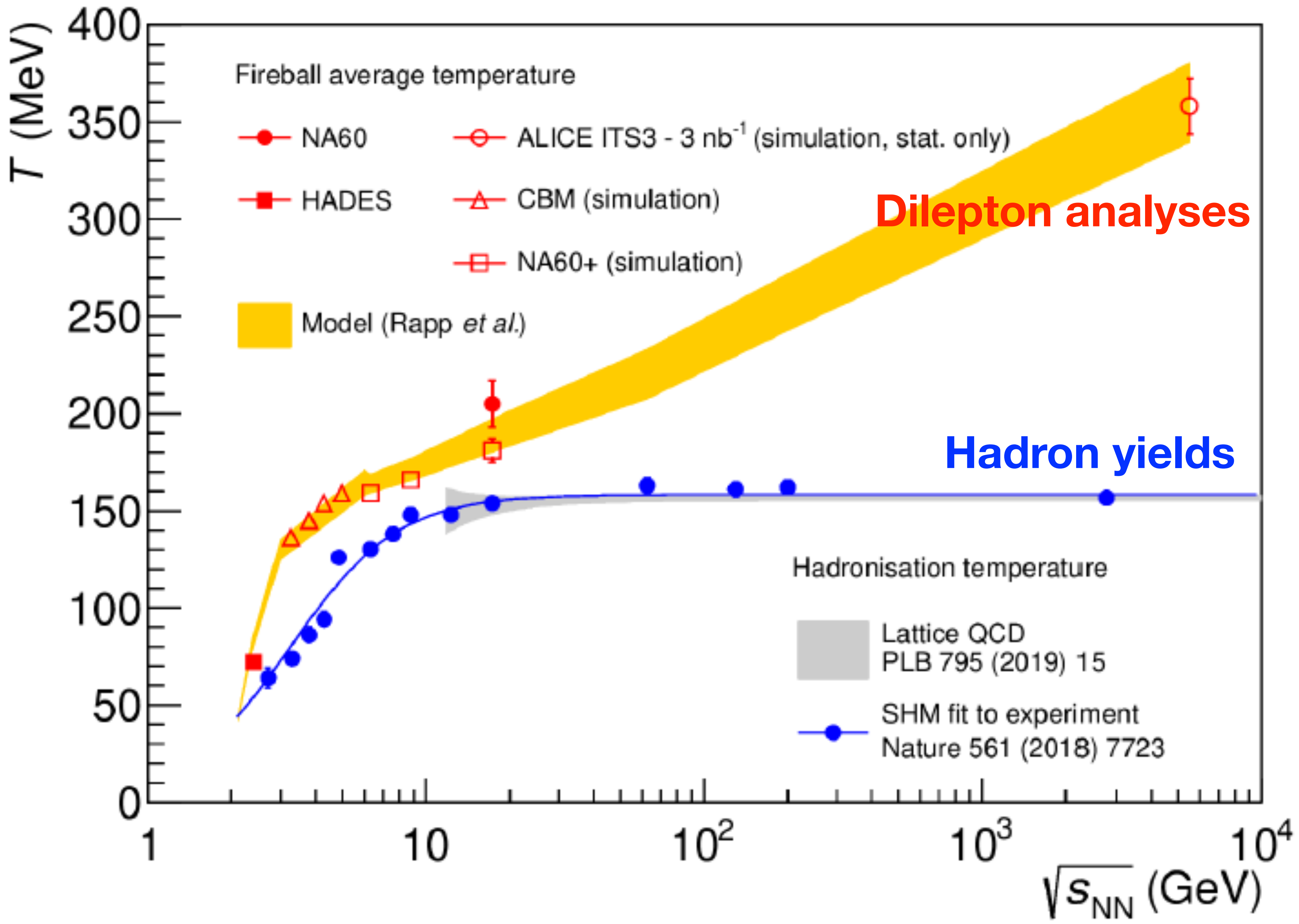
**Dileptons:**

- Slope of the $m_{ee}$ spectrum in $1.1 < m_{ee} \leq 2$ GeV/$c^2$
  → Early-time temperature without radial flow effect

- **Precise differential measurements of *T* with ALICE 3**

**Real photons:**

- $p_T$ spectrum of direct photons
  → **Time-average temperature affected by radial flow effect**
  (Complementary to virtual photon measurements)



# Elliptic flow measurements

$\gamma/\gamma^*$ **elliptic flow sensitive to bulk & shear viscosity**
and **initial anisotropies** not accessible with hadronic probes

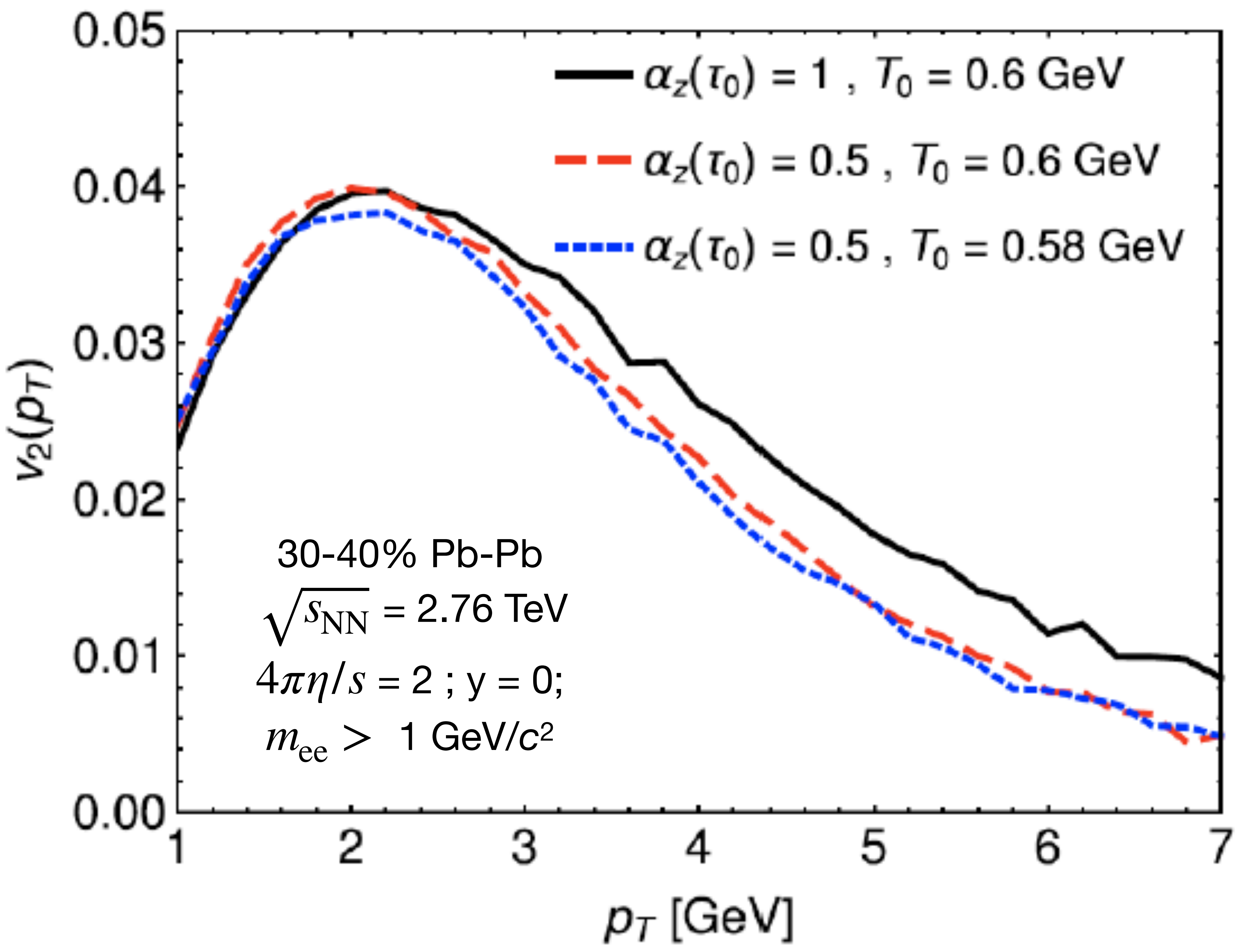
**Dielectrons:**

- **Probe $v_2$ as function of time from low to high $m_{ee}$ (and $p_{T,ee}$)**
  **→ Sensitivity limited with ALICE 2**

**Real photons:**

- $v_2$ integrated over time
  **→ Puzzle at RHIC, large uncertainties at the LHC with Run 2 data**

Predictions for elliptic flow of dielectrons




B.S. Kasmaei and M. Strickland, PRD 99 (2019) 3, 043015

# Chiral-symmetry restoration


Chirality conserved in QCD
Symmetry breaking → 95% of the visible mass in the universe

**Chiral symmetry restored at high *T*:**

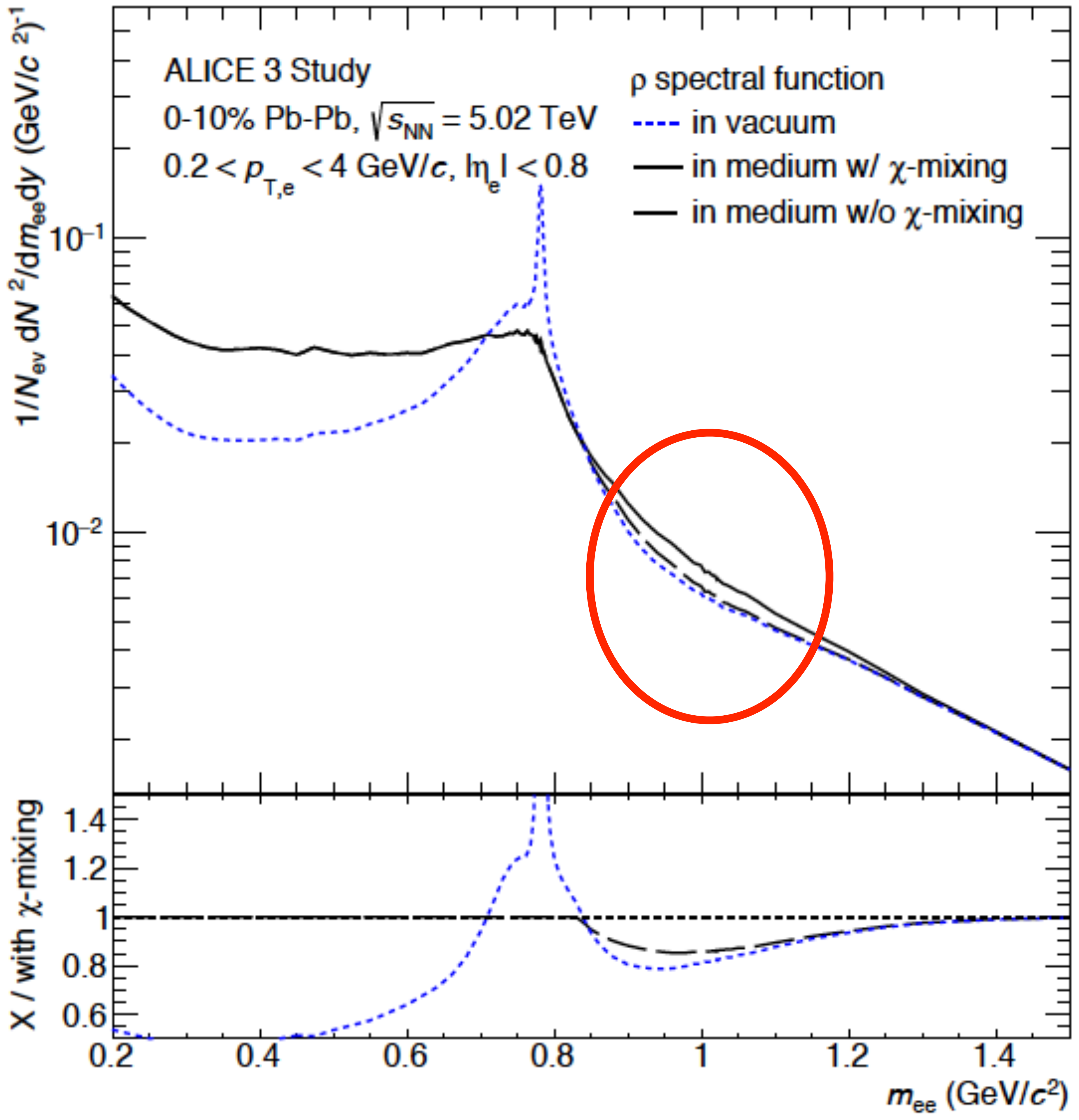
- Chiral partners ($\rho$ and $a_1$ mesons) get similar masses and mix
- Accessible via $\rho \to e^+e^-$
- Broader $\rho$ spectral function predicted and observed at lower energies [1]

- **Predictions for $\rho$ - $a_1$ chiral mixing:**
  - Affects thermal $e^+e^-$ spectrum around $m_{ee}$ = 1 GeV/$c^2$
  - Better understand chiral-symmetry restoration mechanisms

→ **Sensitivity not reached with ALICE 2**

[1] CERES/NA45, PRL 91 (2003) 042301, NA60 PRL 96 (2006) 162302

Thermal dielectron spectrum
for different $\rho$ spectral function




R. Rapp, Adv. High Energy Phys. 2013 (2013) 148253
P.M Hohler and R. Rapp, Phys. Lett. B 731 (2014) 103
R. Rapp private communication

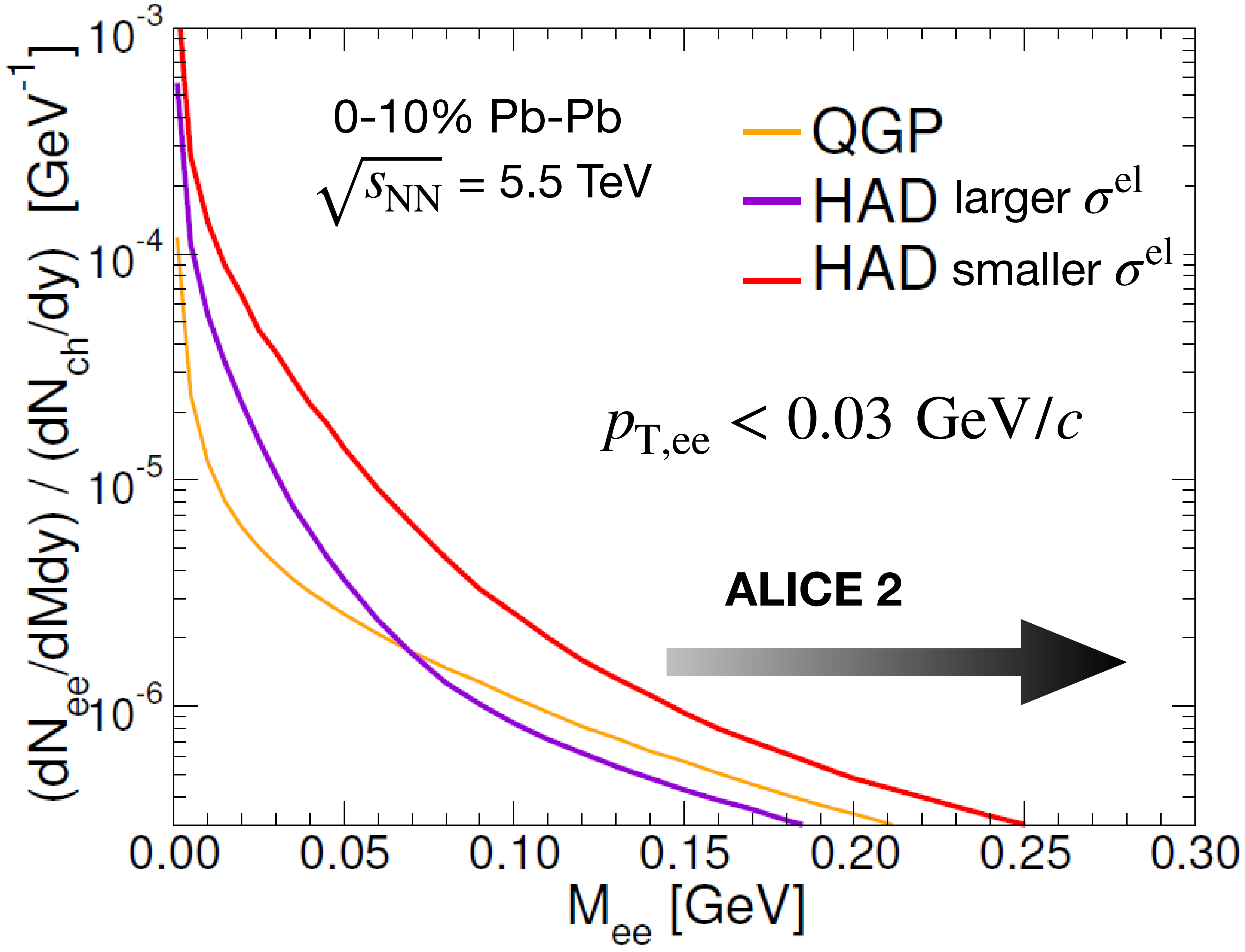
# Electric conductivity of the medium

$$\lim_{p_T \to 0} \frac{dN_{\gamma,\gamma^*}}{p_T dp_T} = \sigma^{el}$$

Fundamental transport properties of the medium not known
Related to thermal $\gamma/\gamma^*$ spectrum at very low $p_T$ and $m_{ee}$

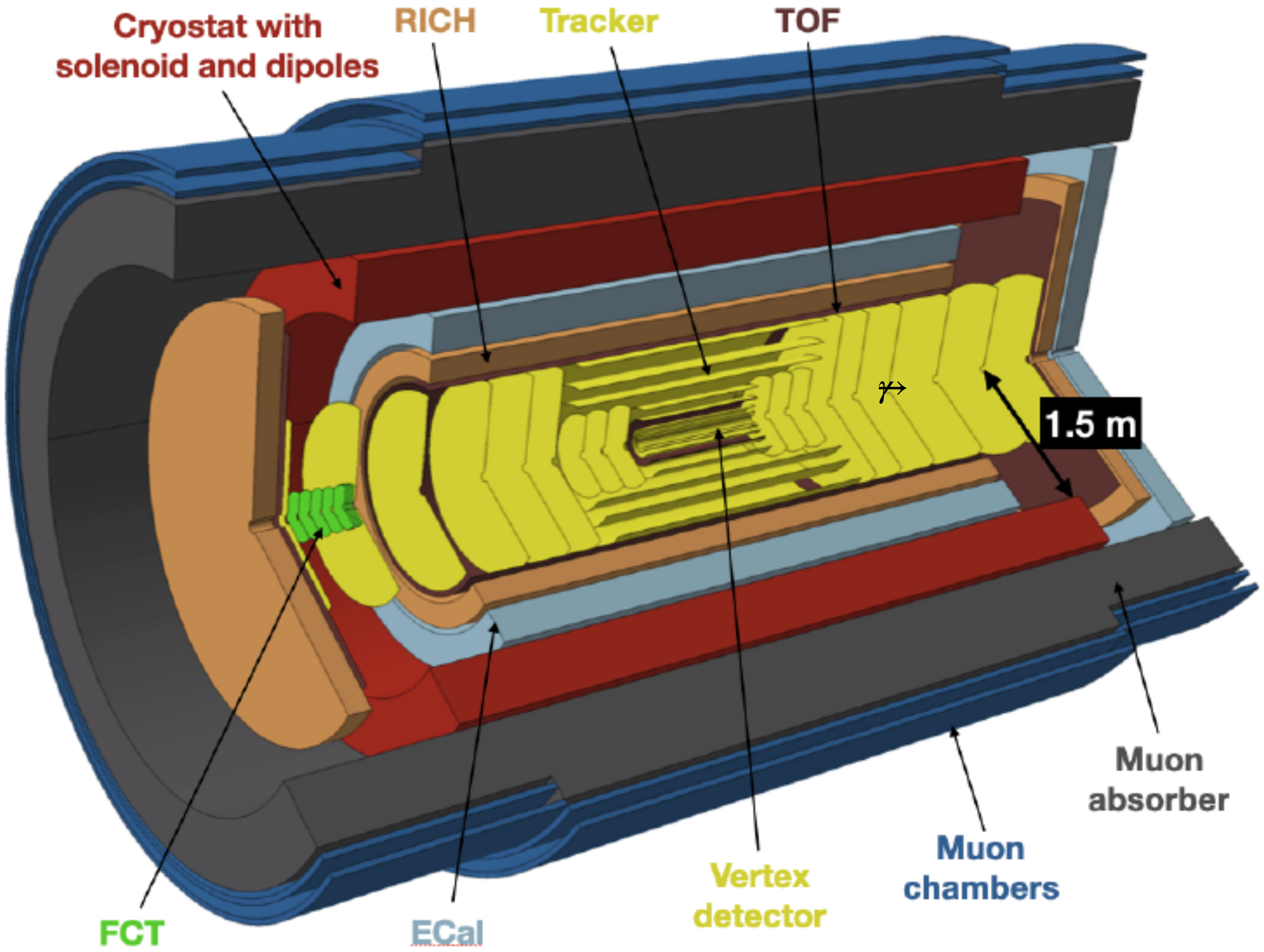
- **Dielectrons:**
  - **Width of the thermal $e^+e^-$ spectrum** at low $p_{T,ee}$
  - **At the boundary of ALICE 2 acceptance**
- **Real photons:**
  - **Direct $\gamma$ yield at very low $p_T$ via photon interferometry (HBT)**
    No need of subtracting huge $\gamma$ decay background
    WA98, Phys. Rev. Lett. 93 (2004) 022301
  - **Need large statistics and low $p_T$ coverage (ALICE 3)**

Thermal dielectron at very low $m_{ee}$ and $p_{T,ee}$



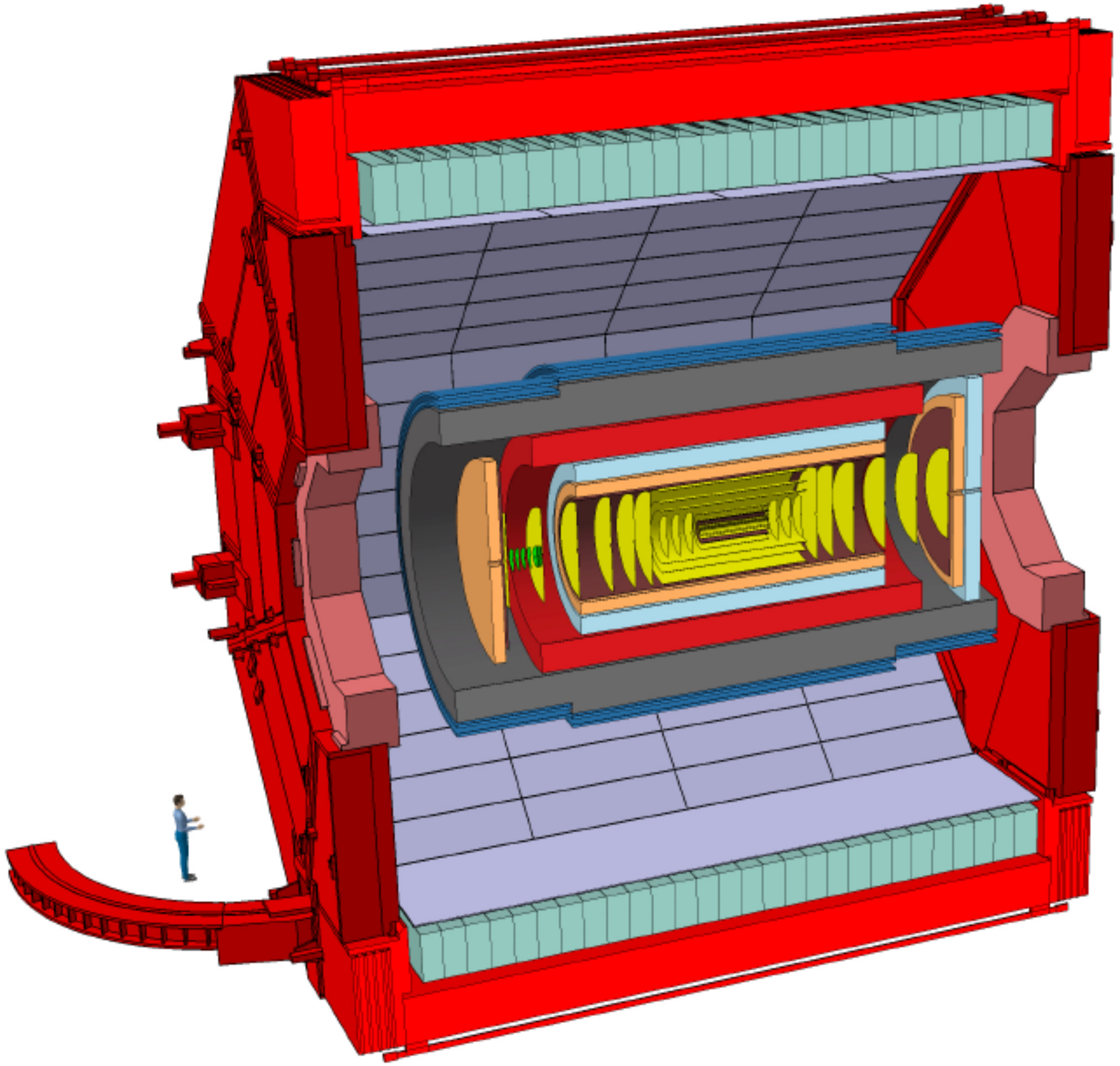

R. Rapp, EMMI Workshop Sept 13, 2021
ALICE 3 Workshop Oct 19, 2021

# Detector overview



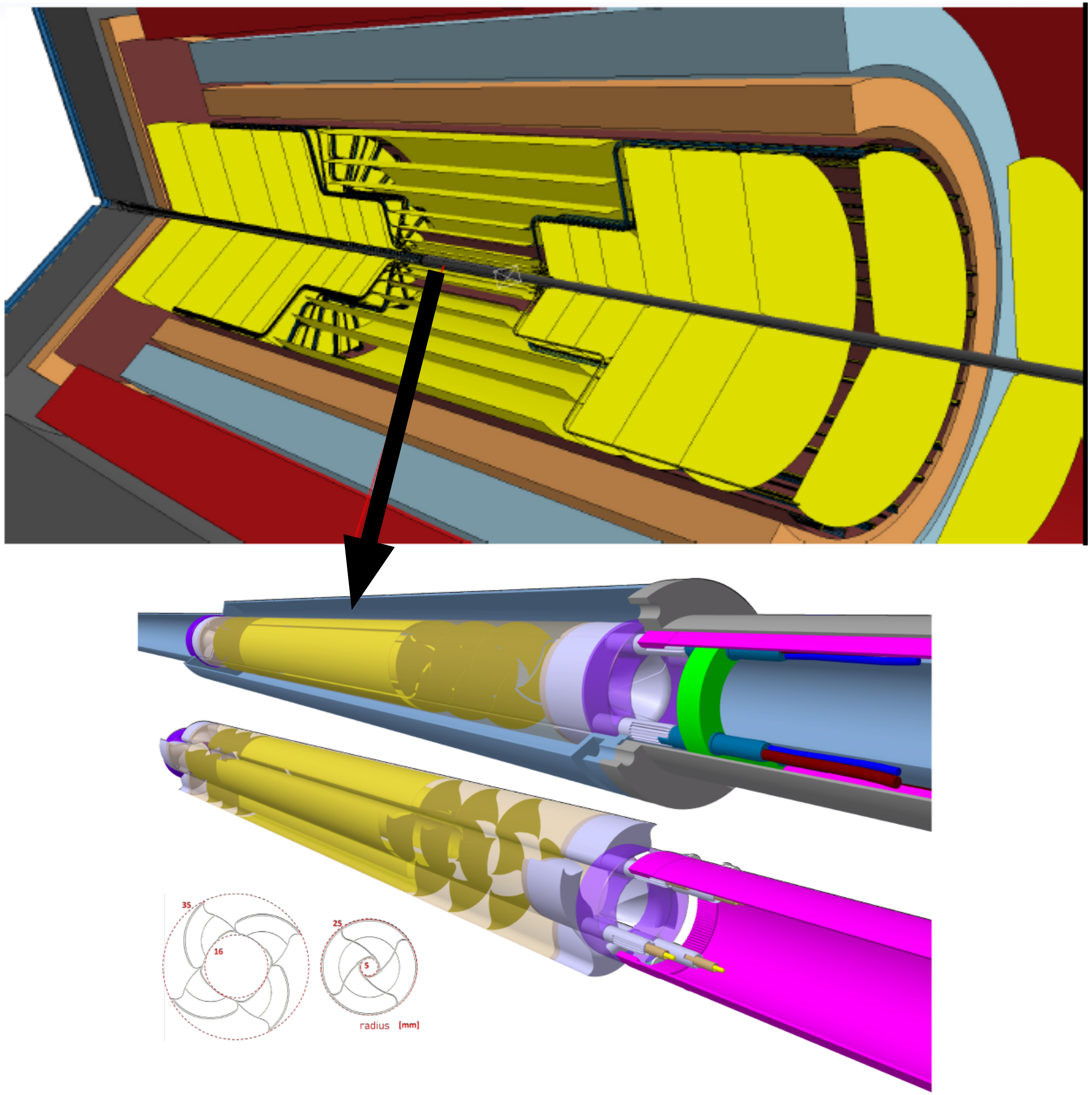

- **Cover -4 < $\eta$ < 4 rapidity range**
- All-silicon tracker in **super-conducting magnets**
- Particle identification: **TOF**, **RICH**, **ECAL**, **MUON**
- Ultra-soft photons with **Forward Converter Tracker**
- Fast read-out and online processing

# Detector overview



Could be installed in ALICE L3

# Trackers




- **At mid-rapidity:** 11 layers
- **At forward- and backward-rapidity:** 2x12 discs
- **Vertex detector (3 first layers):**
  - Retractable IRIS tracker in secondary vacuum
  - **First layer at mid-rapidity at $r$ = 5 mm** (ITS3 18mm)

**Compared to ALICE Run 4:**

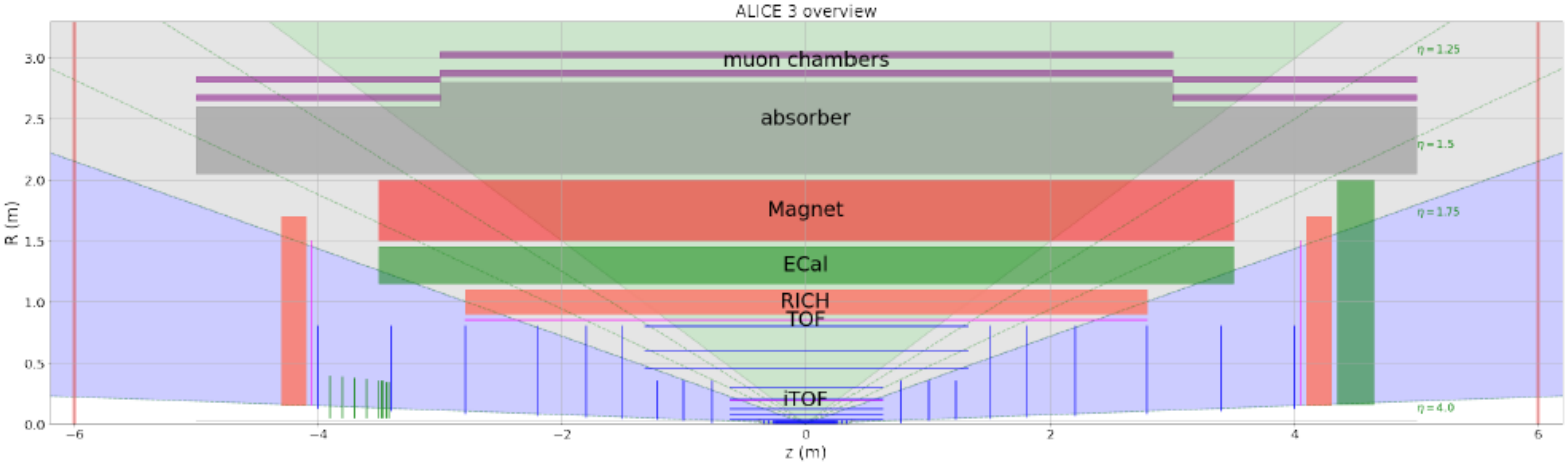
**→ Combinatoric background from conversion $e^{\pm}$ / 2.**

**→ Better rejection of heavy-flavour background**

# Electron identification

- **Cover a large rapidity range**

- **At mid-rapidity:**
    - Inner TOF at 20 cm: low momentum **down to $p_T$ = 15 MeV/$c$ for $B$ = 0.5 T** (ALICE: 75 MeV/$c$ for $B$ = 0.2 T)
    - Outer TOF and RICH at about 1m: intermediate momentum ($p$ < 2 GeV/$c$)
    - ECAL detector: larger $p$

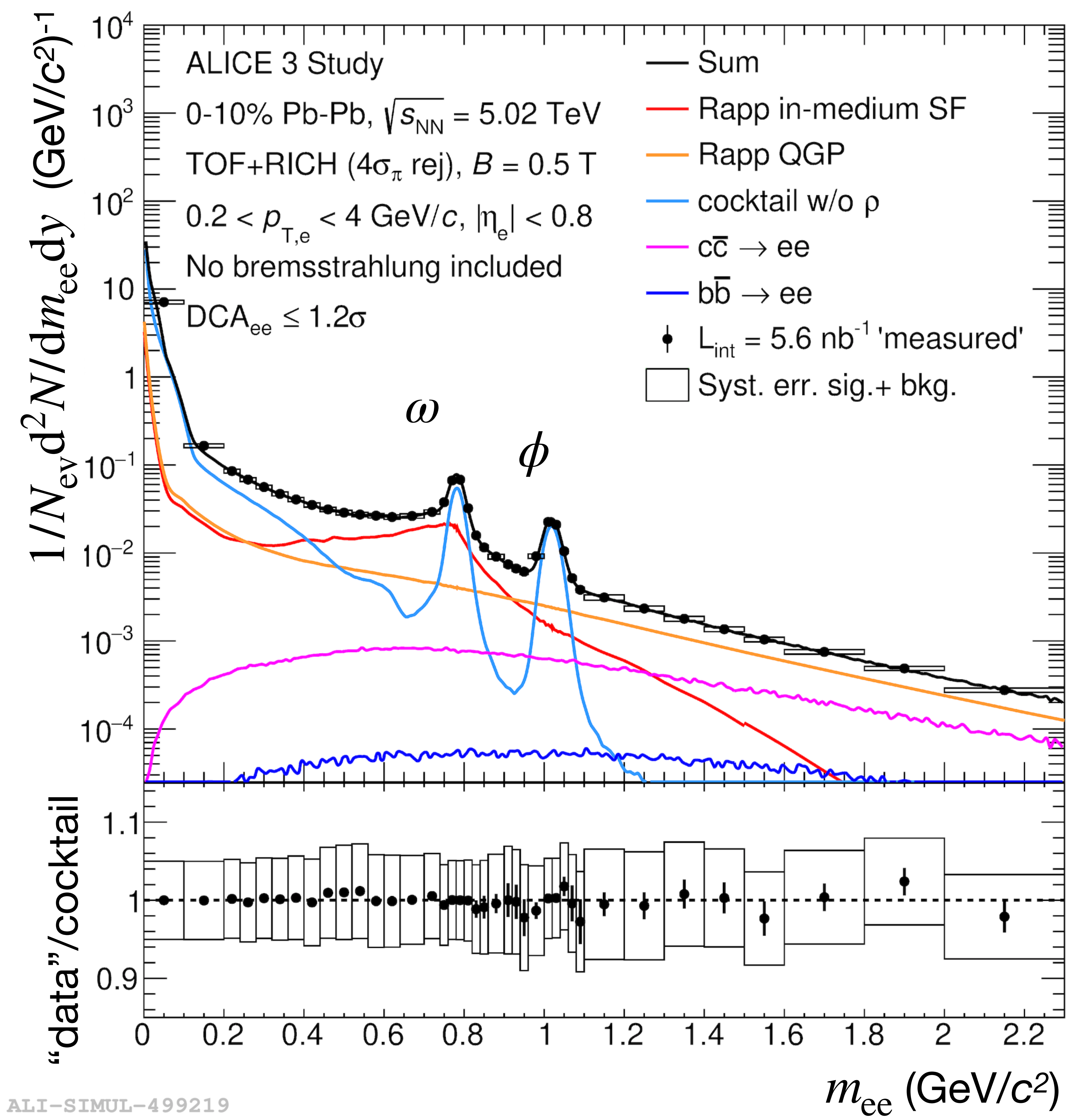


# Dielectron raw spectrum

- **Simulated raw $e^+e^-$ spectrum in 0-10% central Pb-Pb collisions for one month running using outer TOF + RICH**

- Different contributions:
  - Light-flavour hadron decays
  - Thermal radiations (signal):
    - **from hadron gas**
    - **from QGP**
  - Heavy-flavour hadron decays ($c\bar{c}$, $b\bar{b}$) suppressed using DCA to primary vertex

Simulated $e^+e^-$ raw spectrum with uncertainties




**Thermal radiations dominate**

**for $m_{ee} \geq$ 0.4 up to $m_{ee} \geq$ 2.3 GeV/$c^2$**

ALICE 2 Run 4: heavy-flavour dominant for $m_{ee} \geq$ 1.5 GeV/$c^2$

# Dielectron excess

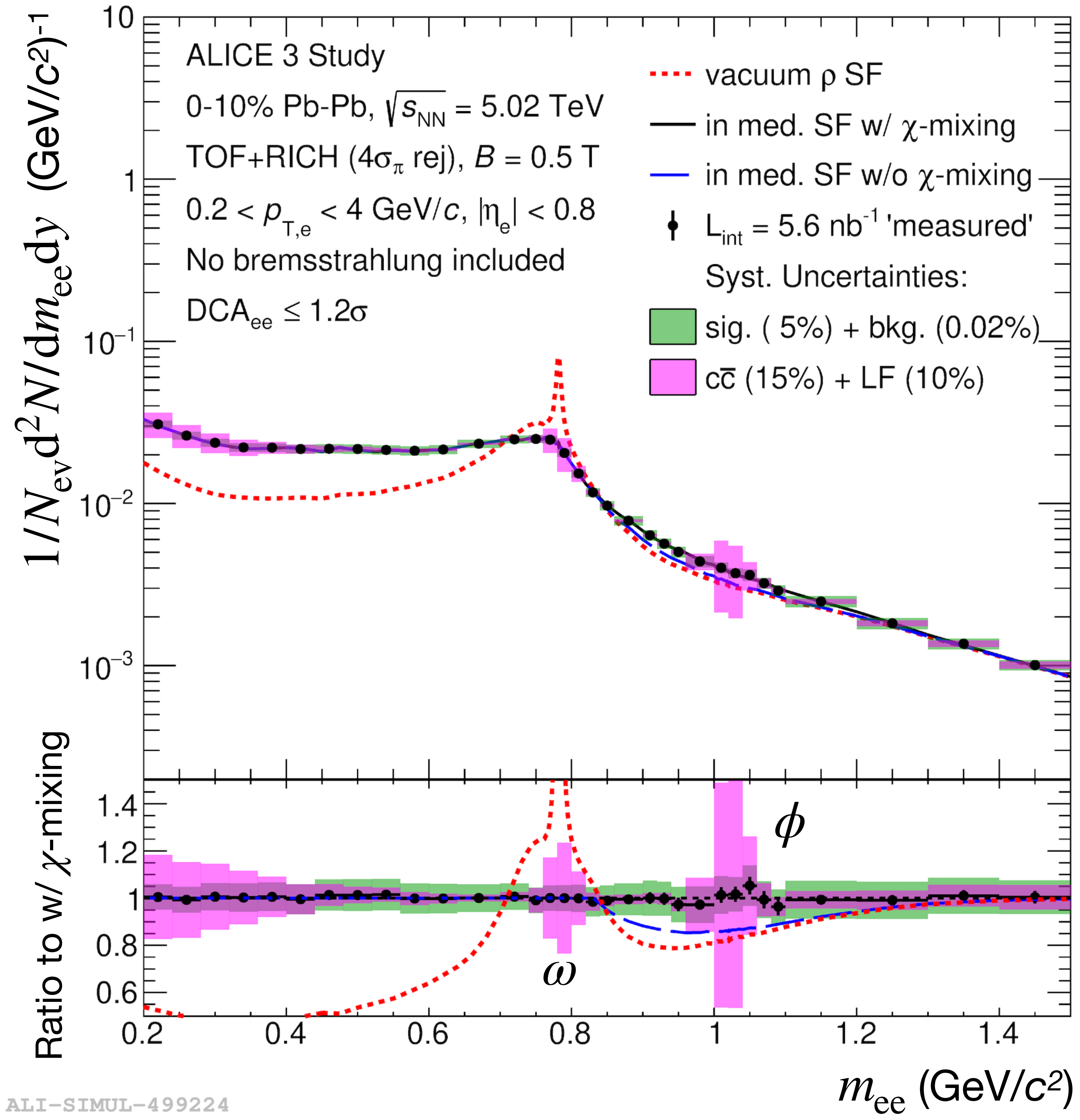
## Chiral symmetry restoration

- **Simulated excess = thermal radiation $e^+e^-$ spectrum**
  after subtraction of light- and heavy-flavour background

- Comparison with different $\rho$ spectral functions (SF):
  - Vacuum SF
  - In medium SF w/o $\rho$-$a_1$ chiral mixing
  - In medium SF w/ $\rho$-$a_1$ chiral mixing

**Expect be sensitive to $\rho$-$a_1$ chiral mixing with ALICE 3**

Excess $e^+e^-$ raw spectrum with uncertainties

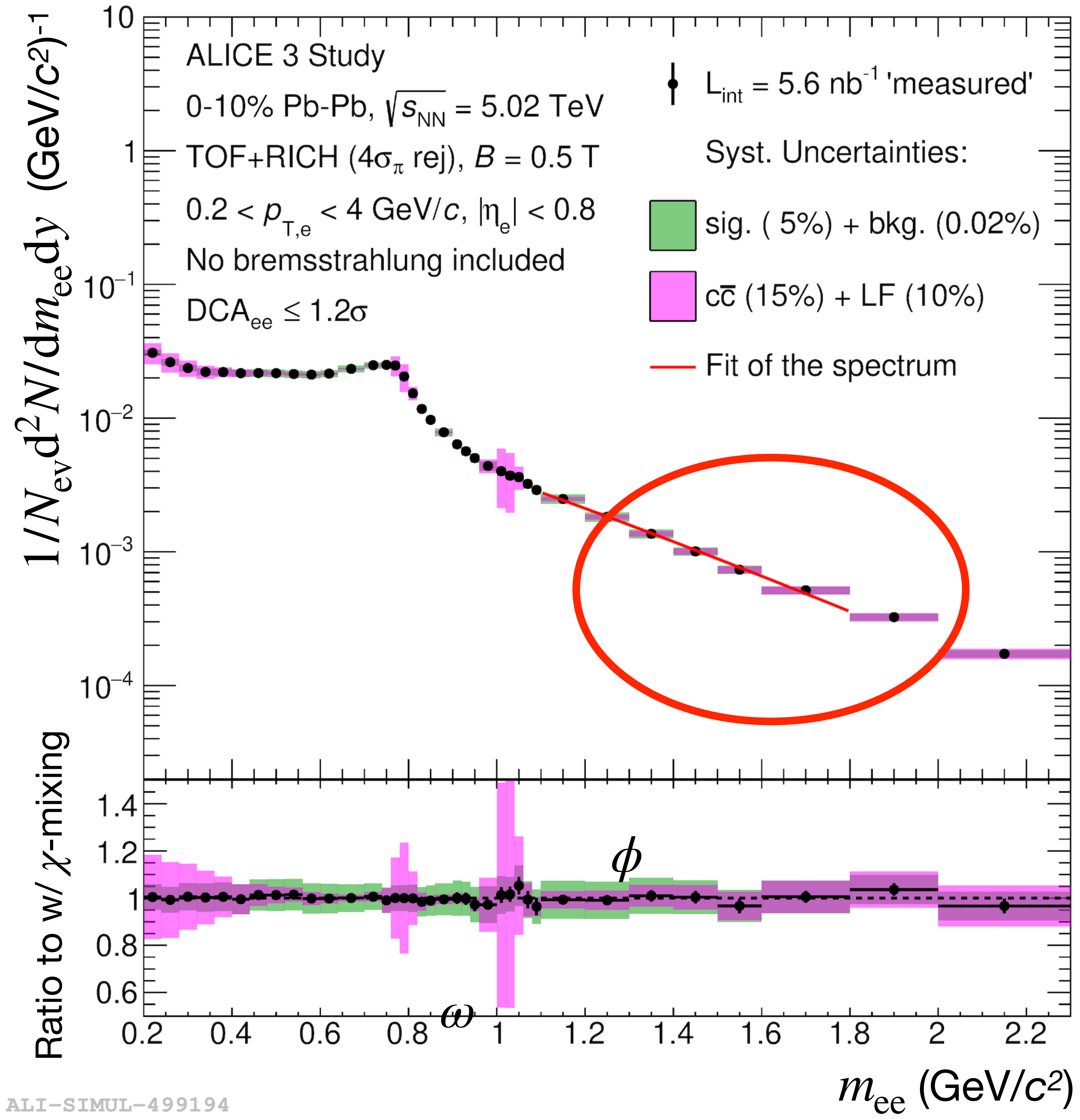



R. Rapp, Adv. High Energy Phys. 2013 (2013) 148253
P.M Hohler and R. Rapp, Phys. Lett. B 731 (2014) 103
R. Rapp private communication

# Dielectron excess
## Early-time temperature

- **Extract early-time $T$ of the medium** from the $m_{ee}$ excess spectrum: $dN/dm_{ee} \sim \exp(-m_{ee}/T)$
- Differential measurements of $T$ possible with ALICE 3
  Larger $p_{T,ee} \rightarrow$ earlier emission

Excess $e^+e^-$ raw spectrum with uncertainties

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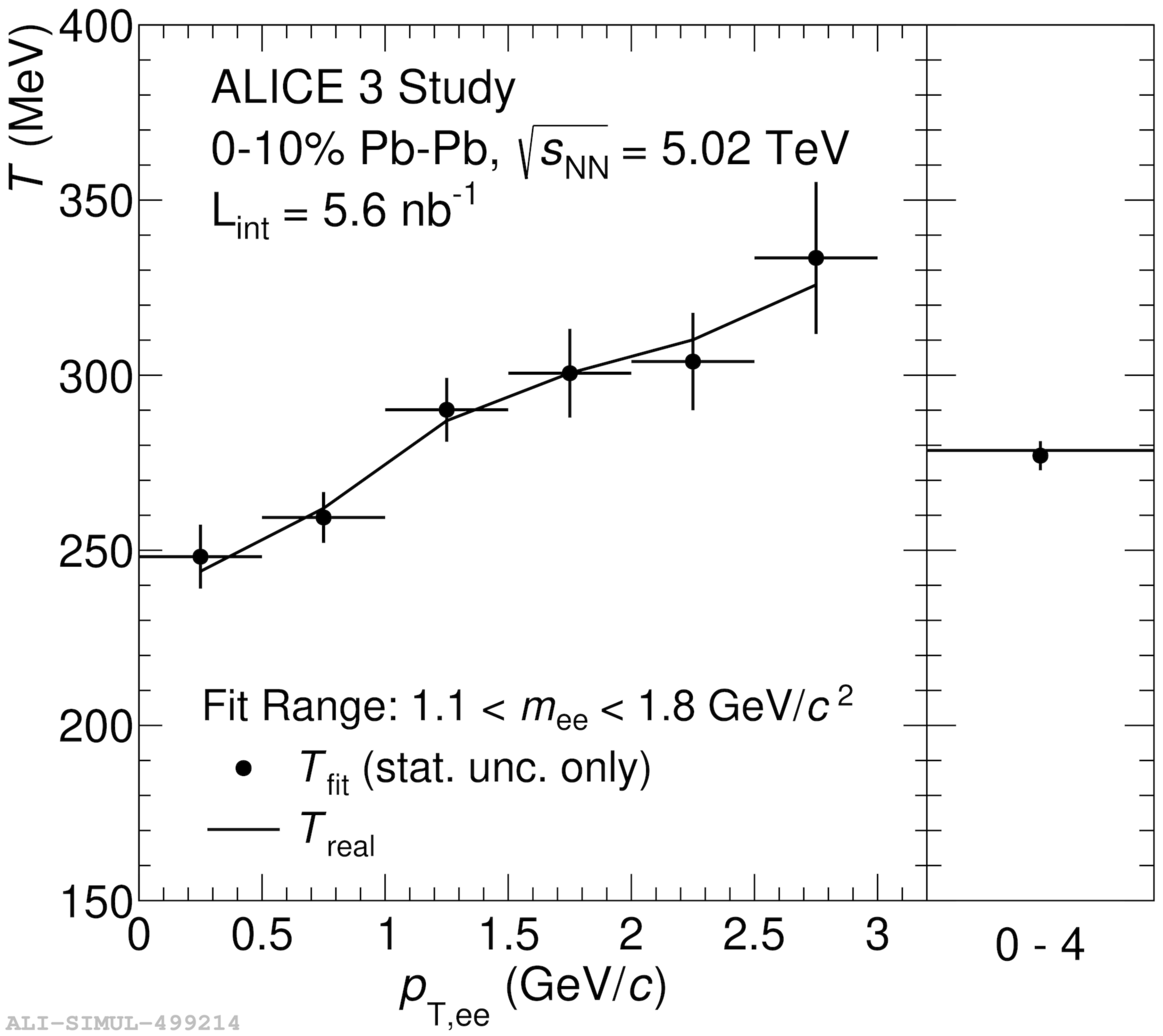
- Extract early-time $T$ of the medium from the $m_{ee}$ excess spectrum: $dN/dm_{ee} \sim \exp(-m_{ee}/T)$

- **Differential measurements of $T$ possible with ALICE 3**
  As a function of $p_{T,ee}$ or in different $m_{ee}$ ranges (under studies)

**Complementary measurement planned with real direct photons**

Extracted temperature




**Statistical errors ≈ 1.5% for $0 < p_{T,ee} < 4$ GeV/c**

ALICE 2 Run 4: 4% from previous studies

# Dielectron elliptic flow

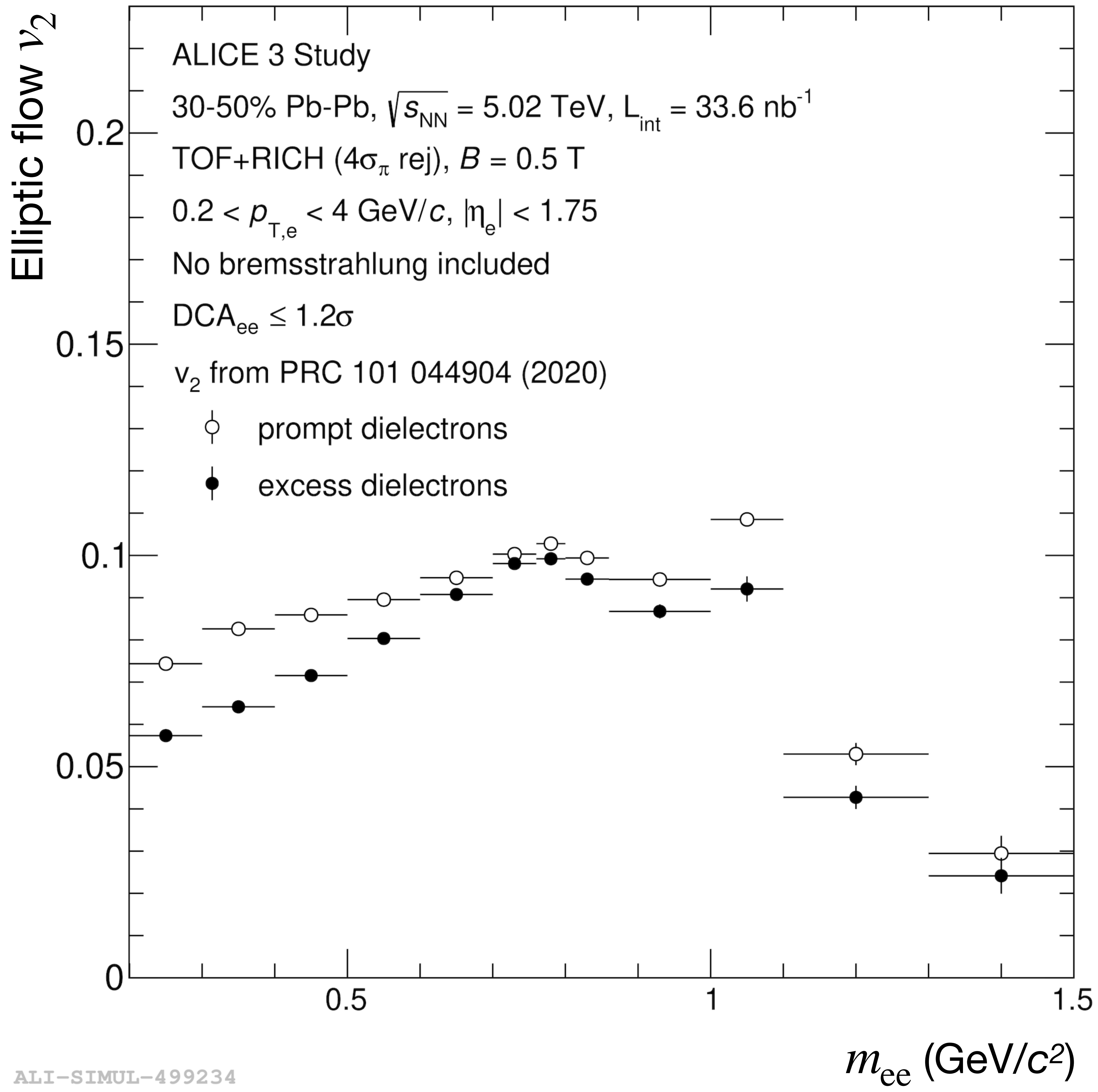
$$v_2^{\text{prompt}} = \frac{\pi}{4} \frac{1}{R_2} \frac{N^{\text{INP}} - N^{\text{OOP}}}{N^{\text{INP}} + N^{\text{OOP}}}$$

$N^{\text{INP}}, N^{\text{OOP}}$: prompt $e^+e^-$ yields in- and out-of-plane
$R_2$ : resolution of the reconstructed event plane

**Expected $v_2$ for all (prompt) and excess $e^+e^-$ in 30-50% Pb-Pb collisions**

- **Statistical uncertainty** for **6 years of data taking**
- $v_2(p_{T,ee}, m_{ee})$ **studies statistically possible with ALICE 3**

Dielectron $v_2$ in 30-50% central Pb-Pb collisions




ECal detector under study for higher in $p_{T,ee}/m_{ee}$
Access to pre-hydrodynamic phase

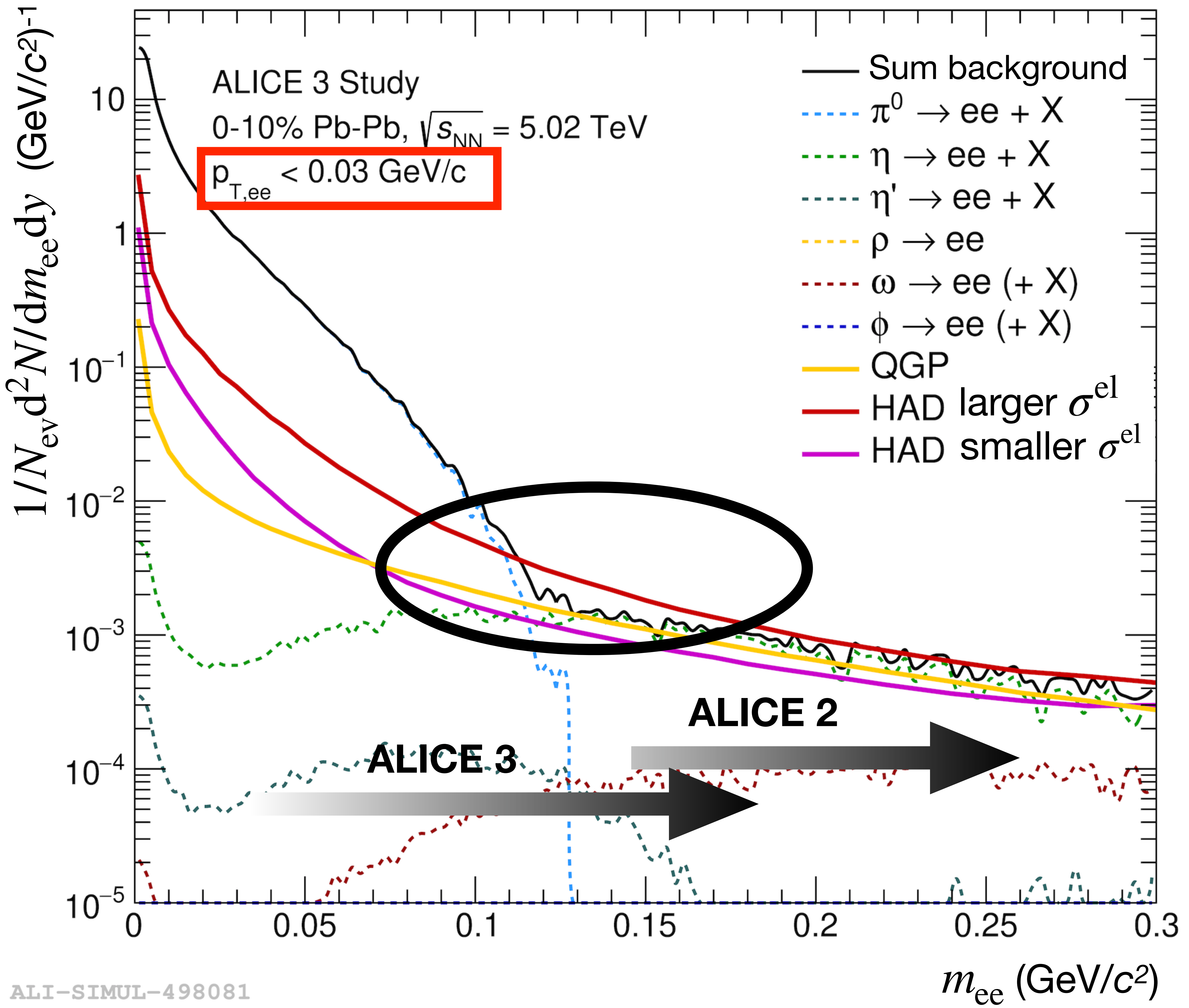
G. Vujanovic et al. PRC 101 (2020) 044904

# Electric conductivity

**Dielectrons at very low $p_{T,ee}$ and $m_{ee}$:**

- **Room for possible measurements above $m_{\pi^0}$**
  **→ Need to go lower in $p_{T,e}$ than ALICE (inner TOF in ALICE 3)**
- measurements of $\pi^0, \eta$ mesons crucial at very low $p_T$
- $\gamma\gamma \rightarrow e^+e^-$ background under investigation

0-10% central Pb-Pb
**No** single $p_T$ cut on electrons

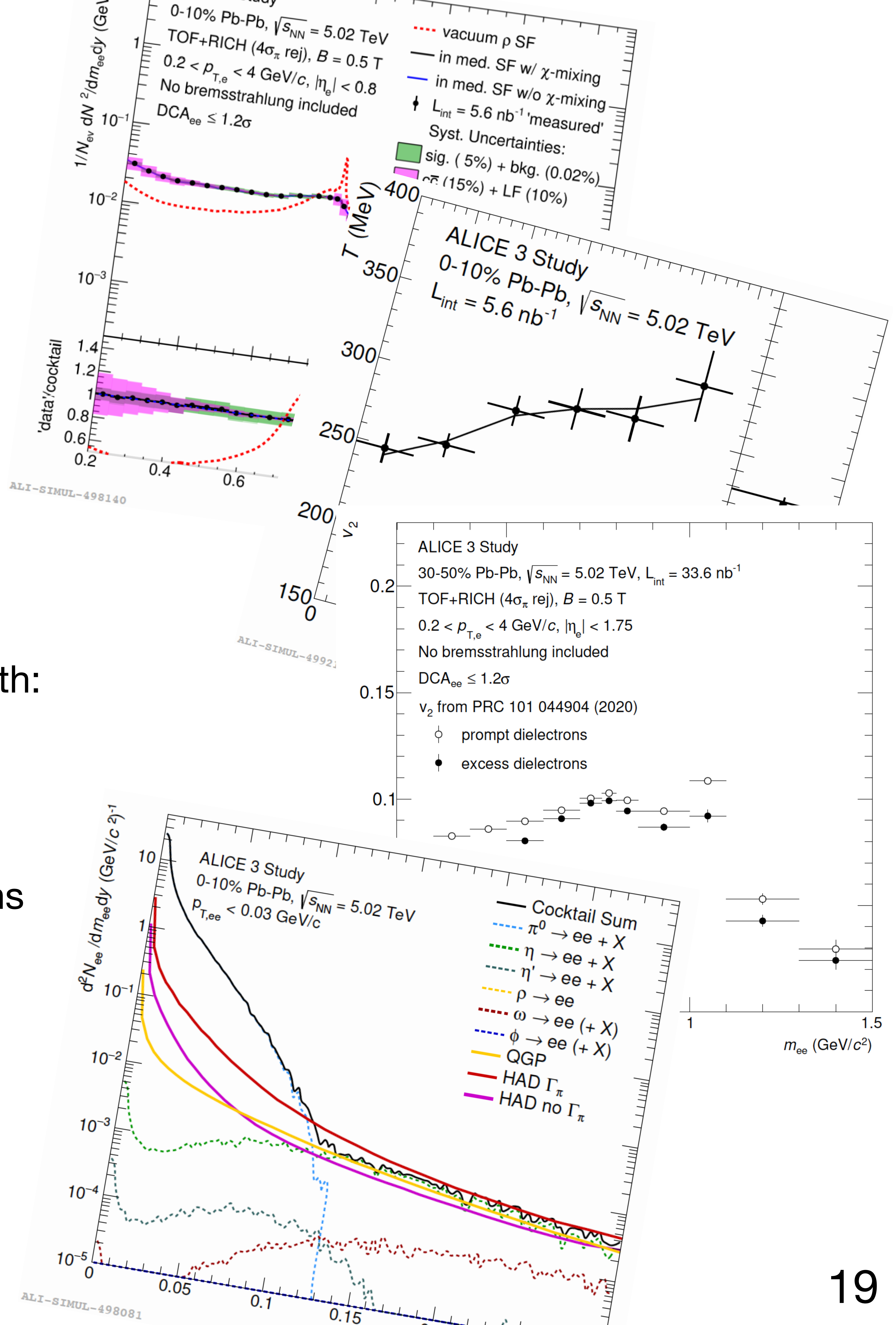



R. Rapp, EMMI RRTF Sept 13, 2021
ALICE 3 Workshop Oct 19, 2021

# Summary

**Beyond Run 3/4 we would need ALICE 3 to:**

- Identify the chiral mixing between $\rho$ and $a_1$ mesons
- Access to the dynamics of the very early stages of the heavy-ion collision with: Elliptic flow measurements as a function of $m_{\mathrm{ee}}$ and $p_{\mathrm{T,ee}}$
- Explore $\mathrm{e}^{+}\mathrm{e}^{-}$ spectrum at very low $m_{\mathrm{ee}}$ and $p_{\mathrm{T,ee}}$ (electric conductivity…)
  - Measure super soft dielectrons as a complementary probe to soft photons

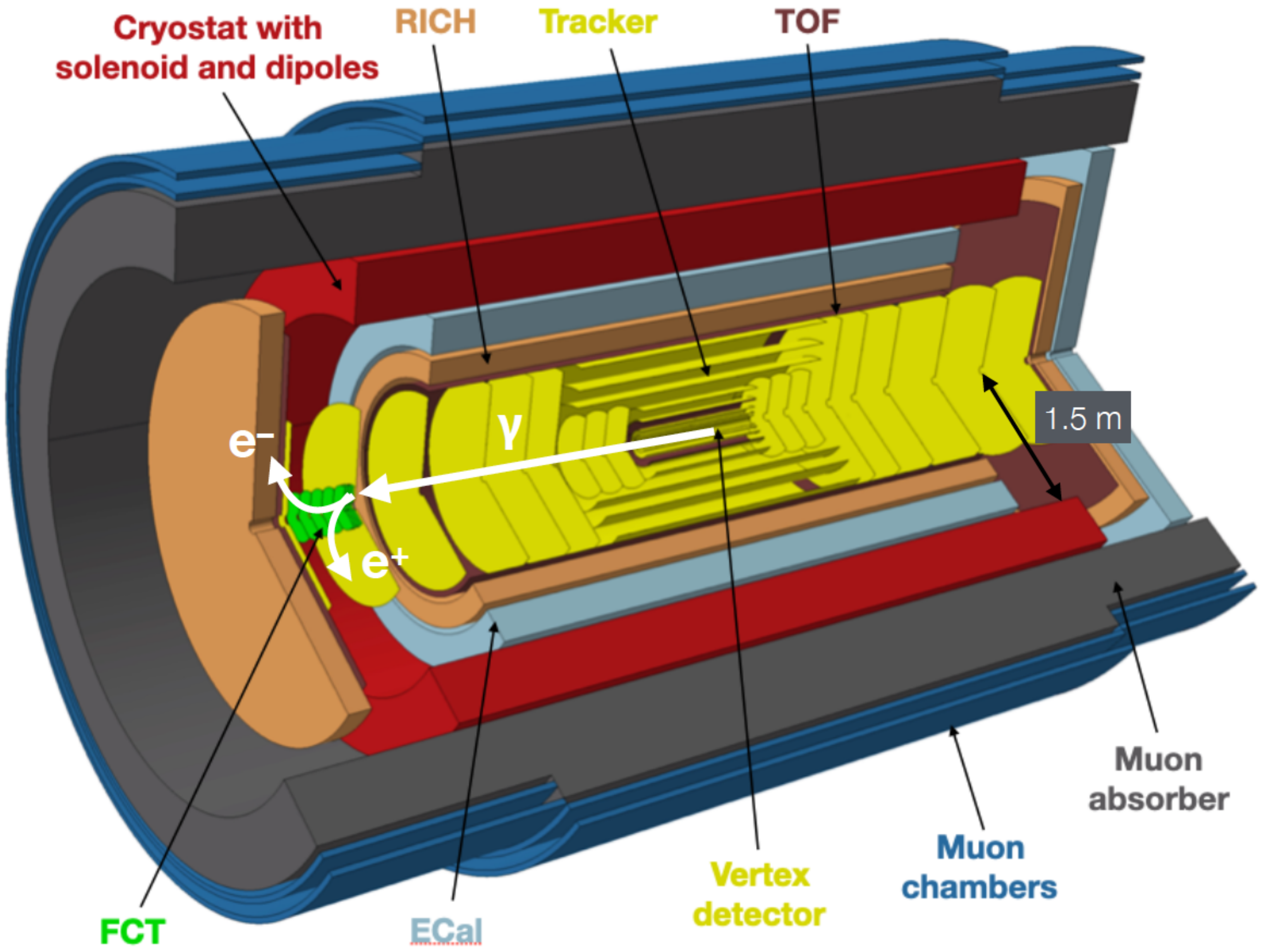


# More

- Measurement of real photons with ALICE 3:
  - Via $\gamma$ conversion and calorimeters
  - **Forward Converter Tracking at $3 < \eta < 4$**
  
  $\rightarrow$ **Very low $p_{\mathrm{T}}$ photons**

- Large rapidity coverage of ALICE 3:
  Very soft $\gamma, \gamma^*$ at forward rapidity

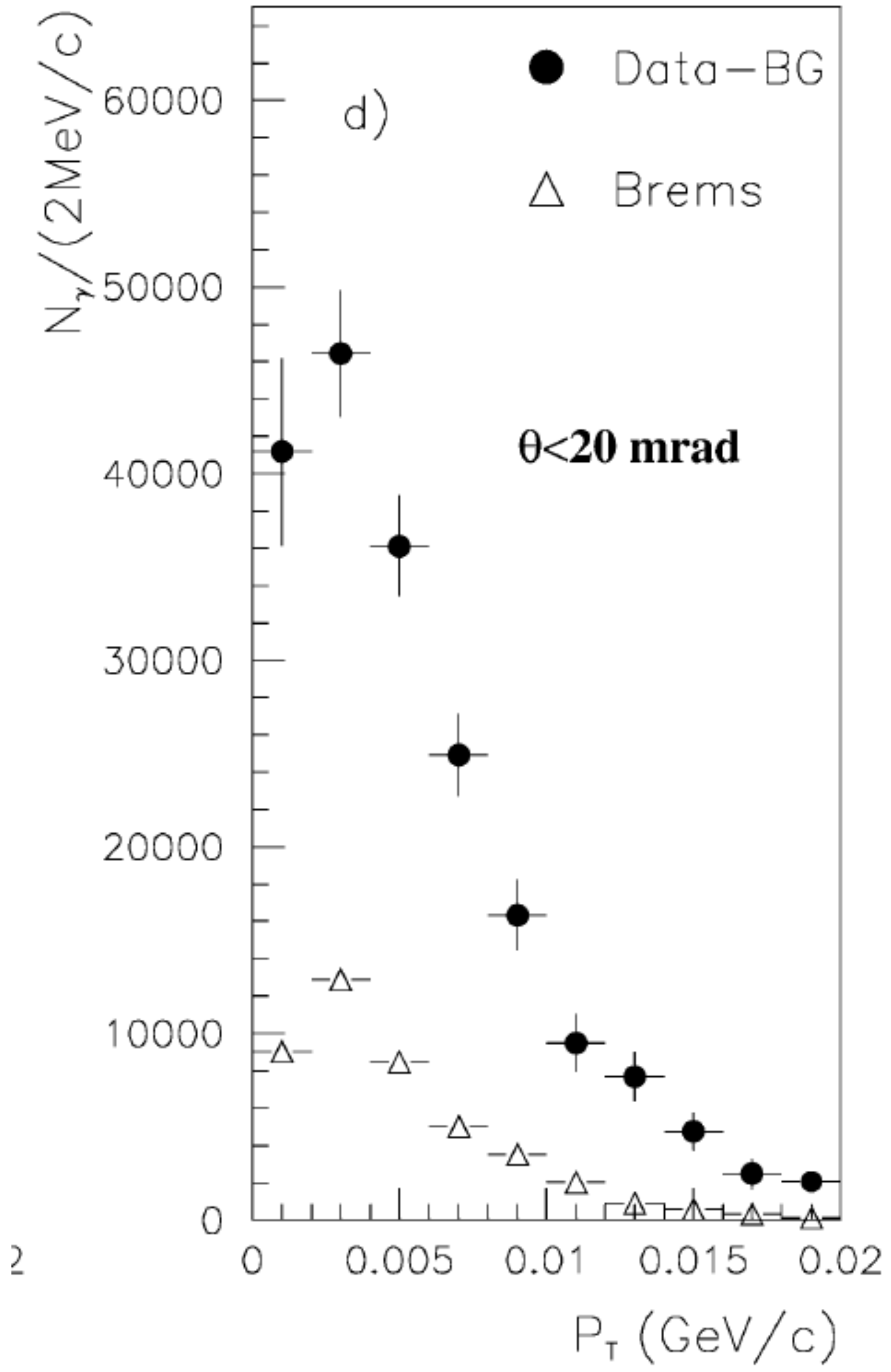
- ALICE 3 Letter Of Intent in preparation



# Back-up

# Non-QGP physics

WA102 at CERN SPS: Photon production in pp collisions at 450 GeV/*c*



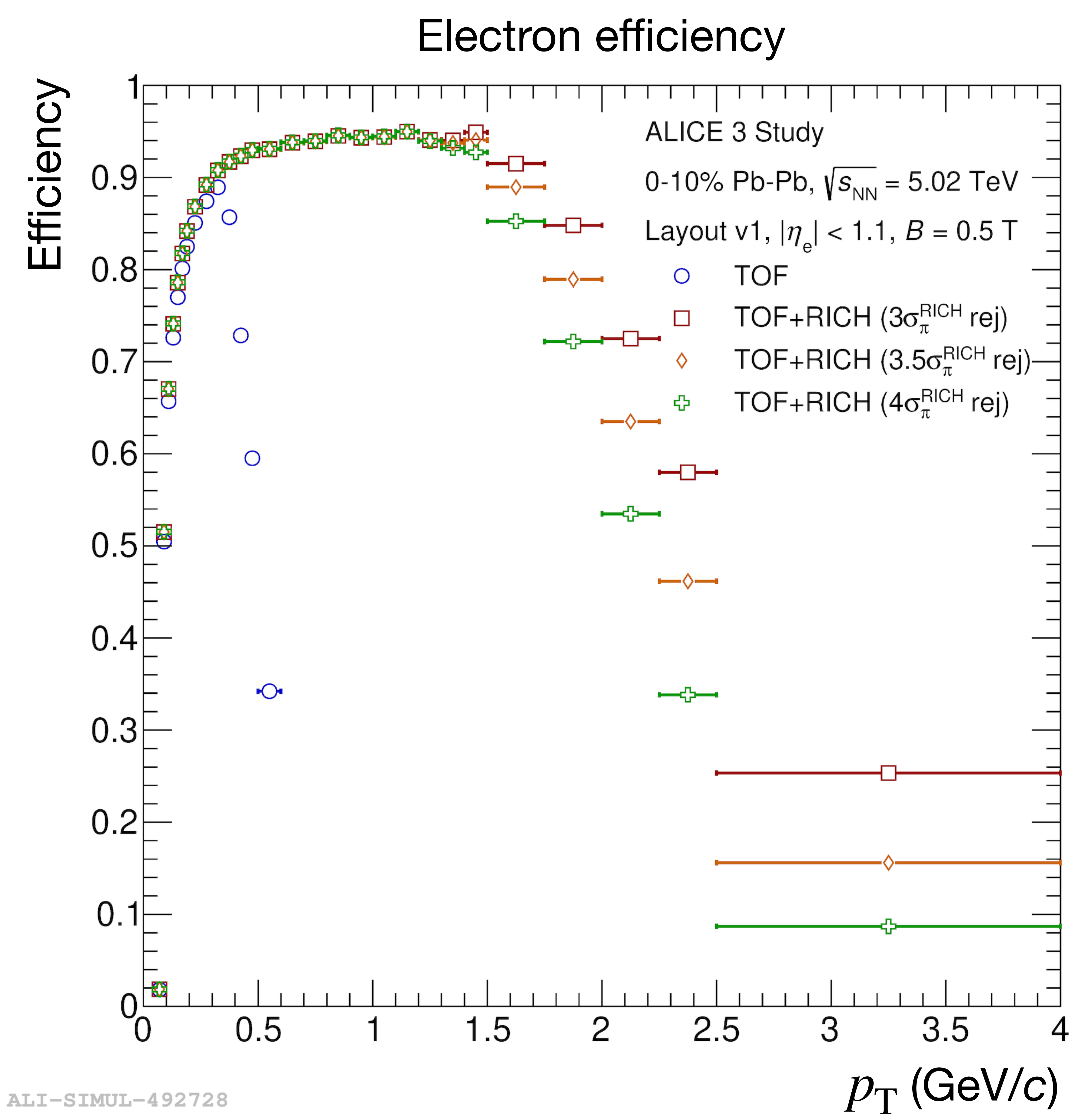

Belogianni et al., Phys. Lett. B548, 129 (2002)

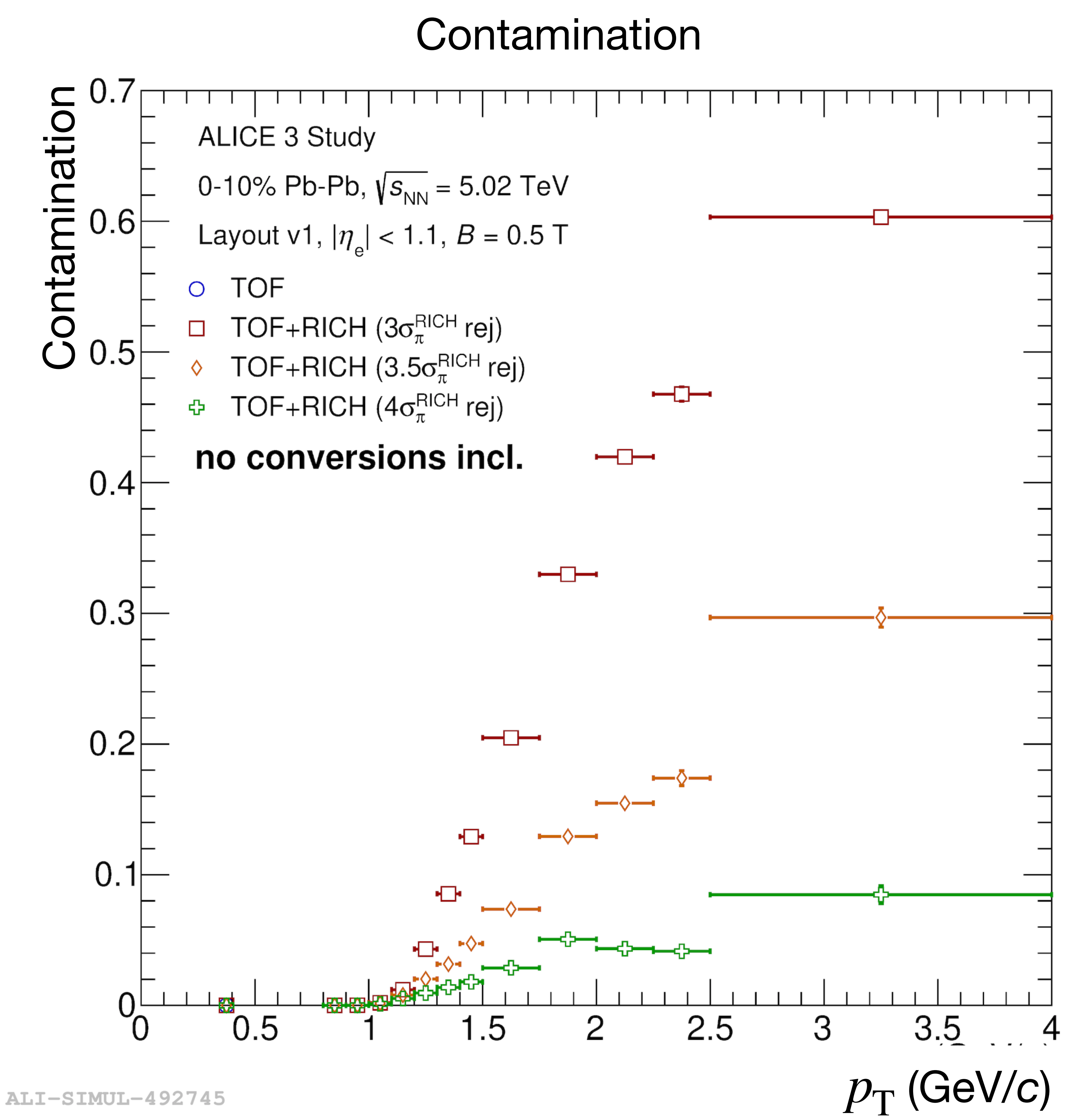
- **Ultra-soft photons:**
  - At very low $p_T$, $\gamma$ produced via inner bremsstrahlung
    → Cross section computable without model- and process-dependence (Low-theorem)
  - Very low $p_T$ means: $\gamma$ wavelength exceeds dimension of any hadronic or nuclear system
    → Easier to reach in small systems (pp collisions)
  - Previous measurements: excess of soft photon in association with hadrons

  **ALICE 3: test Low-theorem in pp collisions**

- **Others:**
  - Nuclei: search for super-nuclei (light-nuclei with c)….
  - Interaction potentials between charmed baryons and nucleons via femtoscopic correlation
  - Beyond Standard Model studies (axion-like particles…)

# Electron efficiency and purity at mid-rapidity




- $e^{\pm}$ identified with **outer TOF and RICH (1m)**
- TOF alone limited to narrow $p_T$ region
- TOF+RICH achieve **high efficiency** with negligible contamination up to 2 GeV/$c$

**Green scenario in the next slides**

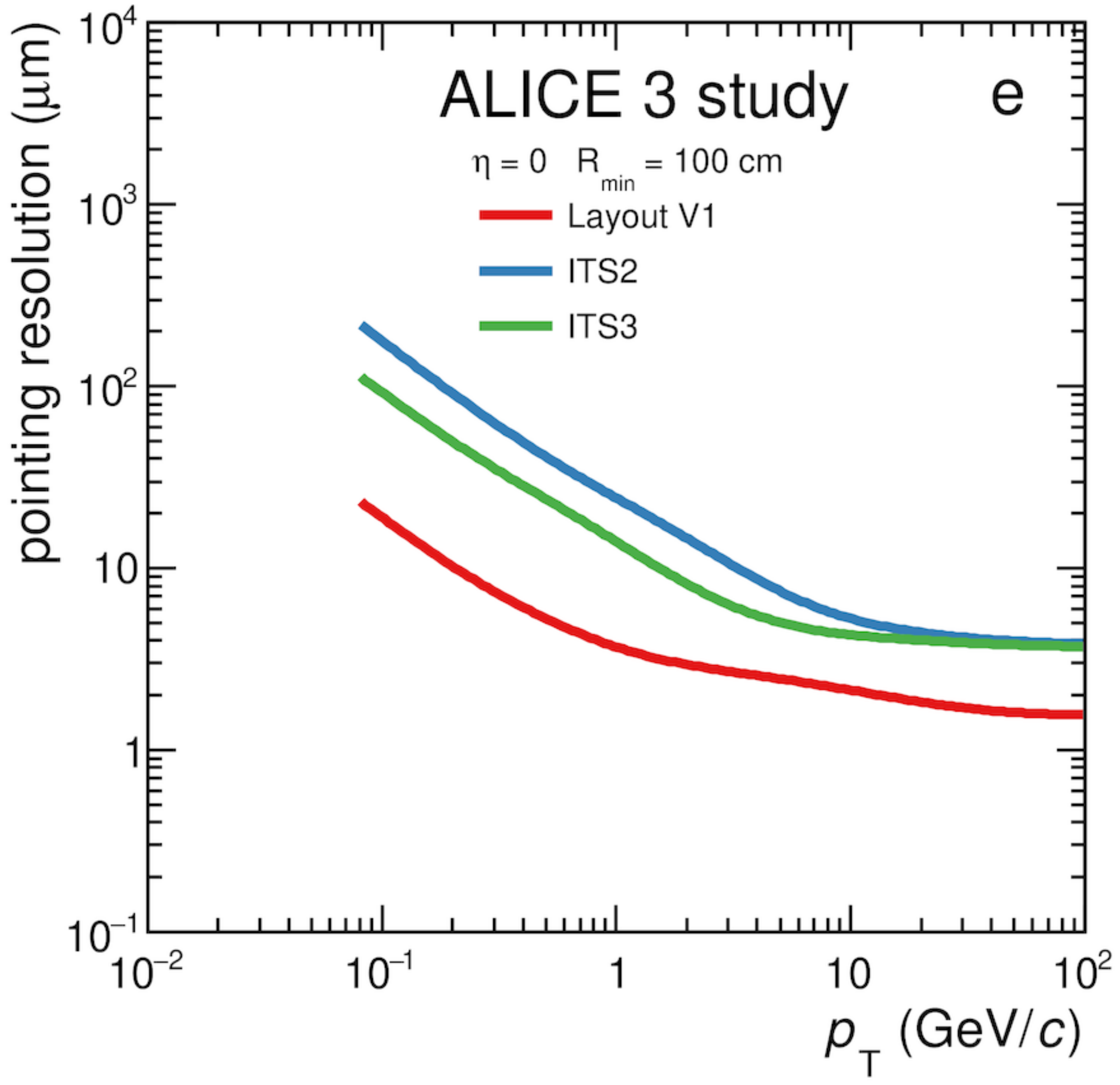
# Tracker performance at mid-rapidity

**Very good pointing resolution:**

- Pointing resolution for $p_{T,e}$ = 0.1 GeV/$c$ in transverse plane:
  - About 200 m for ITS2 (Run 3)
  - About 100 m for ITS3 (Run 4)
  - About 20 m for ALICE 3
- Similar pointing resolution in the longitudinal plane

→ Help to reconstruct or reject heavy-flavour

Pointing resolution for electrons




ALI-SIMUL-491681

# Luminosity projections

- Ongoing discussions with machine groups to establish projections for 2030s
- Current assumptions for physics projections:

| | levelling | limited by machine | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | pp | O-O | Ar-Ar | Ca-Ca | Kr-Kr | In-In | Xe-Xe | Pb-Pb |
| $\langle L_{AA} \rangle$ ($cm^{-2}$ $s^{-1}$) | $3.0 \cdot 10^{32}$ | $9.5 \cdot 10^{29}$ | $2.0 \cdot 10^{29}$ | $1.9 \cdot 10^{29}$ | $5.0 \cdot 10^{28}$ | $2.3 \cdot 10^{28}$ | $1.6 \cdot 10^{28}$ | $3.3 \cdot 10^{27}$ |
| $\langle L_{NN} \rangle$ ($cm^{-2}$ $s^{-1}$) | $3.0 \cdot 10^{32}$ | $2.4 \cdot 10^{32}$ | $3.3 \cdot 10^{32}$ | $3.0 \cdot 10^{32}$ | $3.0 \cdot 10^{32}$ | $3.0 \cdot 10^{32}$ | $2.6 \cdot 10^{32}$ | $1.4 \cdot 10^{32}$ |
| $\mathscr{L}_{AA}$ ($nb^{-1}$ / month) | $5.1 \cdot 10^{5}$ | $1.6 \cdot 10^{3}$ | $3.4 \cdot 10^{2}$ | $3.1 \cdot 10^{2}$ | $8.4 \cdot 10^{1}$ | $3.9 \cdot 10^{1}$ | $2.6 \cdot 10^{1}$ | $5.6 \cdot 10^{0}$ |
| $\mathscr{L}_{NN}$ ($pb^{-1}$ / month) | 505 | 409 | 550 | 500 | 510 | 512 | 434 | 242 |

- **Total luminosity increase 2-10 x wrt to Run 3 + 4**, depending on collision system
  (Larger increase for lighter collision system)
  Run 3 + 4: 13 $nb^{-1}$ Pb-Pb, 200 $pb^{-1}$ pp

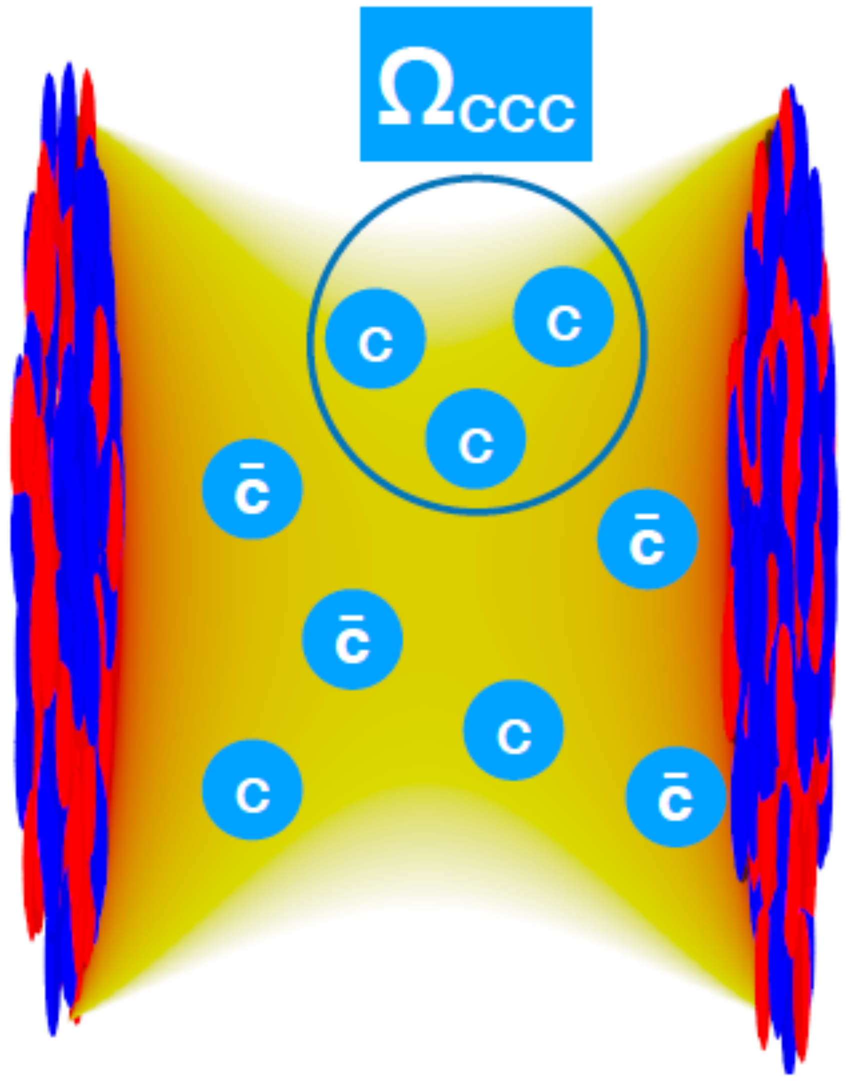
# Deconfinement and hadronisation

- **In proton-proton:** hadronisation via string fragmentation
- **In QGP:** coalescence/thermal production contributions
- **Multi-charm baryons:**
  - Charm quark produced in initial hard scattering
  - Multi-charm baryons: produced mostly via coalescence

→ Large enhancement in AA (large $\sigma_{c\bar{c}}$)

→ Sensitive to the equilibrium properties of charm in the QGP

**ALICE: charmed baryons, ALICE 3: multi-charm baryons**



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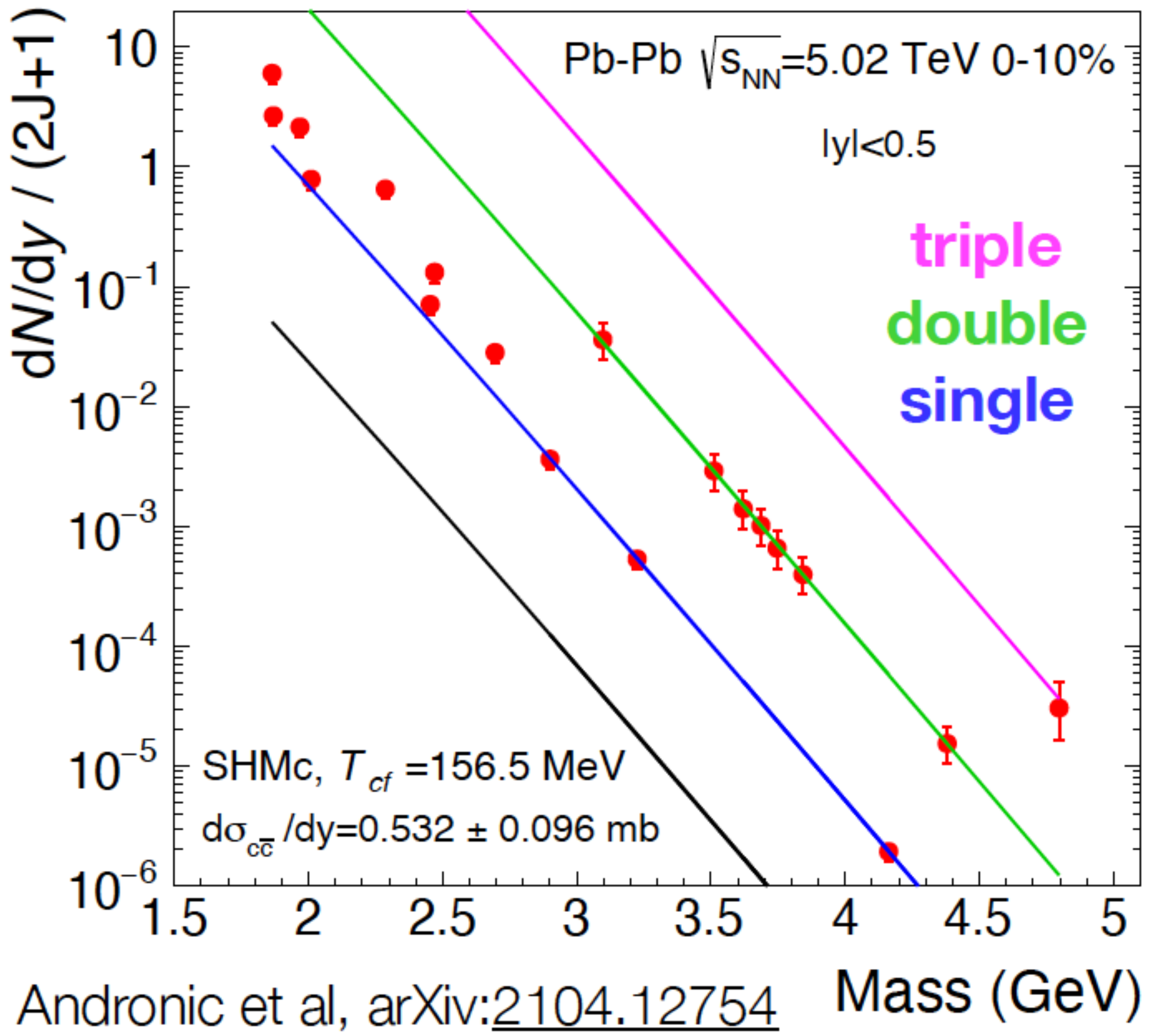
SHM predictions
**u,d,s only particles in black**
**and (multi-)charm states in red**




Andronic et al, arXiv:2104.12754

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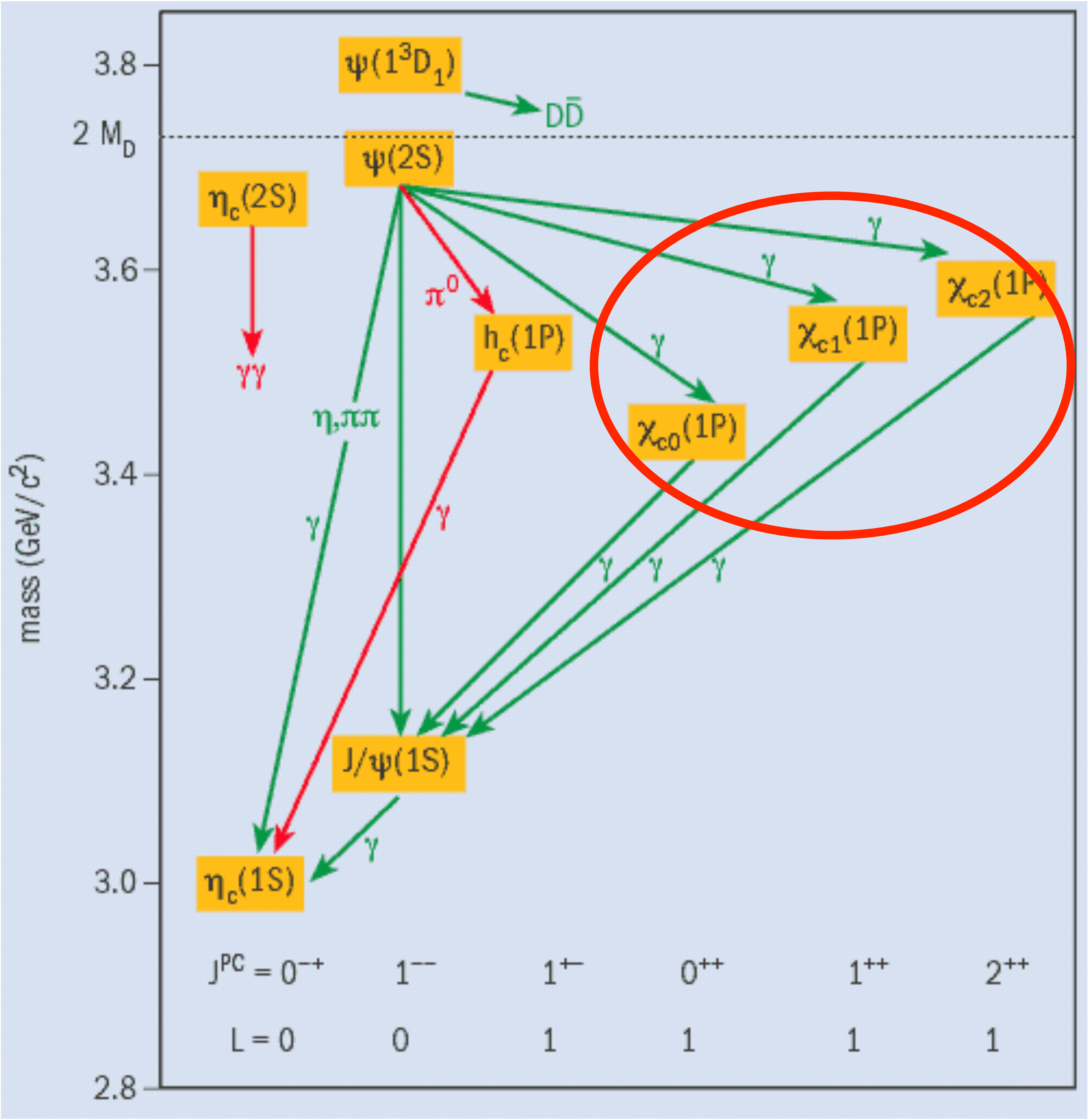
  - **ALICE: charmed baryons, ALICE 3: multi-charm baryons**
- **Quarkonium measurements beyond S-wave States:**
  - Measurements currently limited to S-wave states: $J/\Psi, \Psi(2S), \Upsilon(nS)$
  - $\chi_c, \chi_b$ **states with ALICE 3 down to $p_T$ = 0**

Charmonium states



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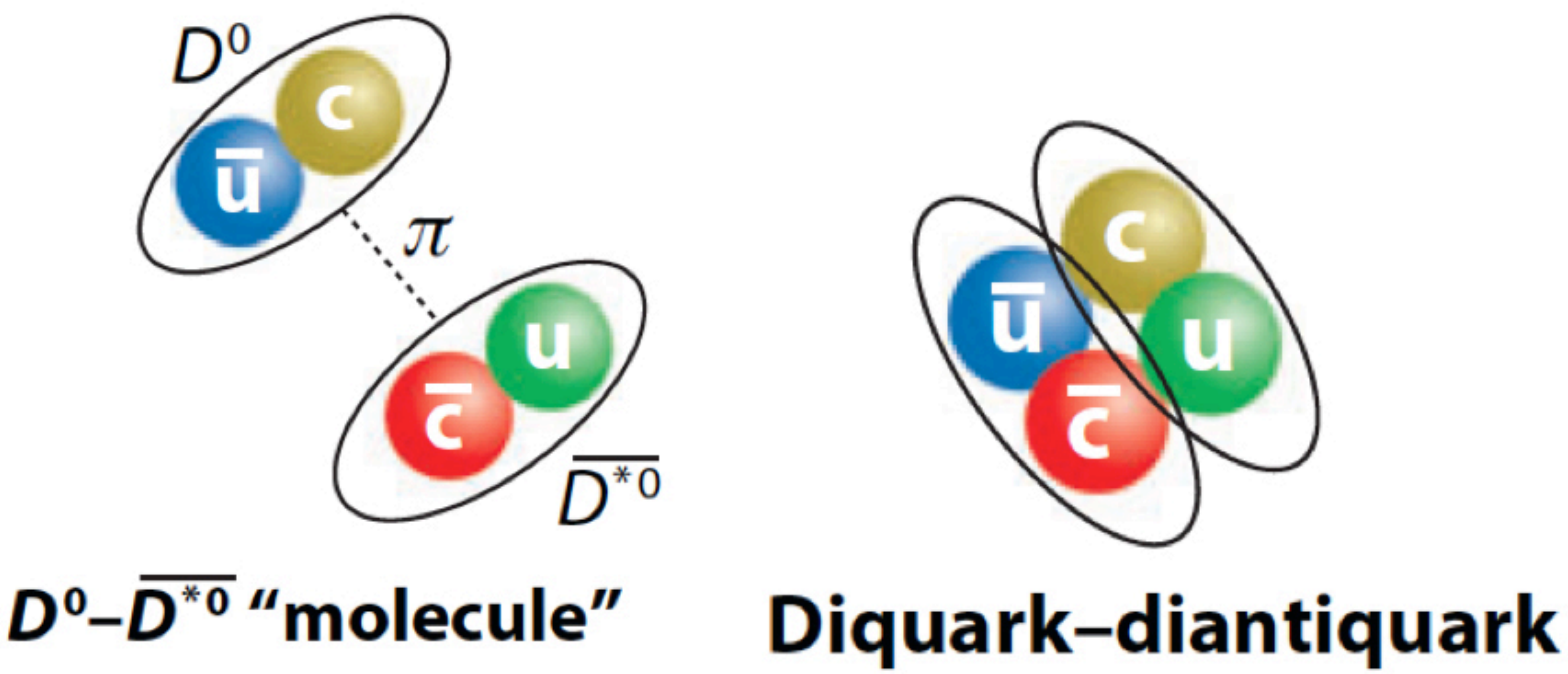
- **Heavy-flavour exotica:**
  - X(3872) discovered in 2003: nature not clear
    **Measurement down to low-$p_T$ with ALICE 3**
  - **Many other states** expected but not yet discovered

Possible nature of X(3872) state

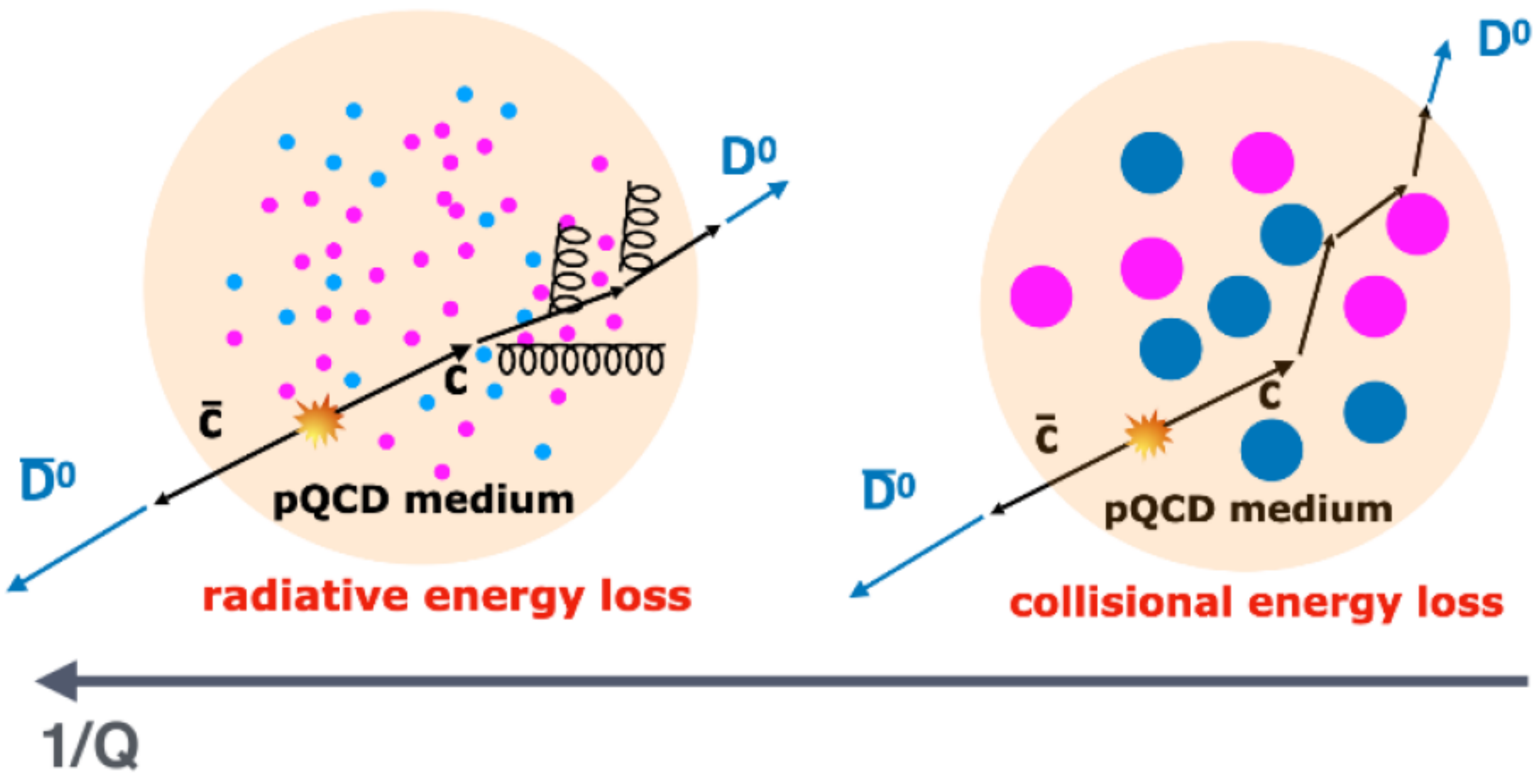


# Heavy-flavour probes of the QGP

- **Parton-medium interactions via heavy-flavour correlations**
  - $\Delta\eta, \Delta\varphi$ correlation of heavy-quark pairs:
    - radiative energy loss (small broadening)
    - collisional energy loss (larger broadening)
    - "thermalization" (randomization)

  **ALICE 3: $\mathrm{D\bar{D}}$ correlation over wide rapidity range**

$D^0\bar{D}^0$ correlation

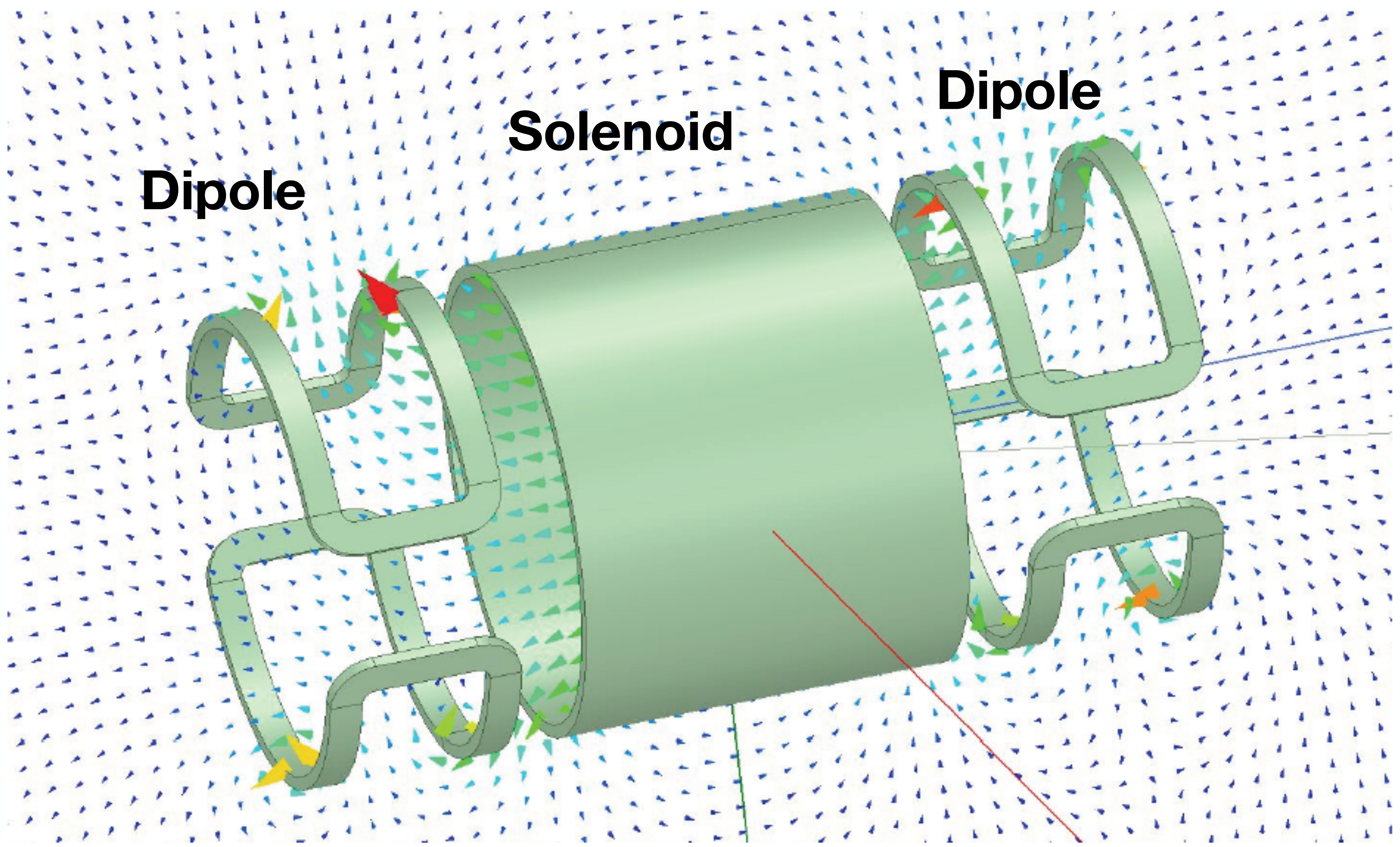



- **Energy loss and approach to thermalization:**
  - Photon-HF jet correlation:

    **ALICE 3: down to low $p_T$ over wide rapidity range**
  - Heavy-flavour baryon flow (including beauty):

    **ALICE 3: $\Lambda_c, \Lambda_b$ $v_2$ down to low $p_T$**
  - Heavy-flavour jet substructure….

# Superconducting magnets

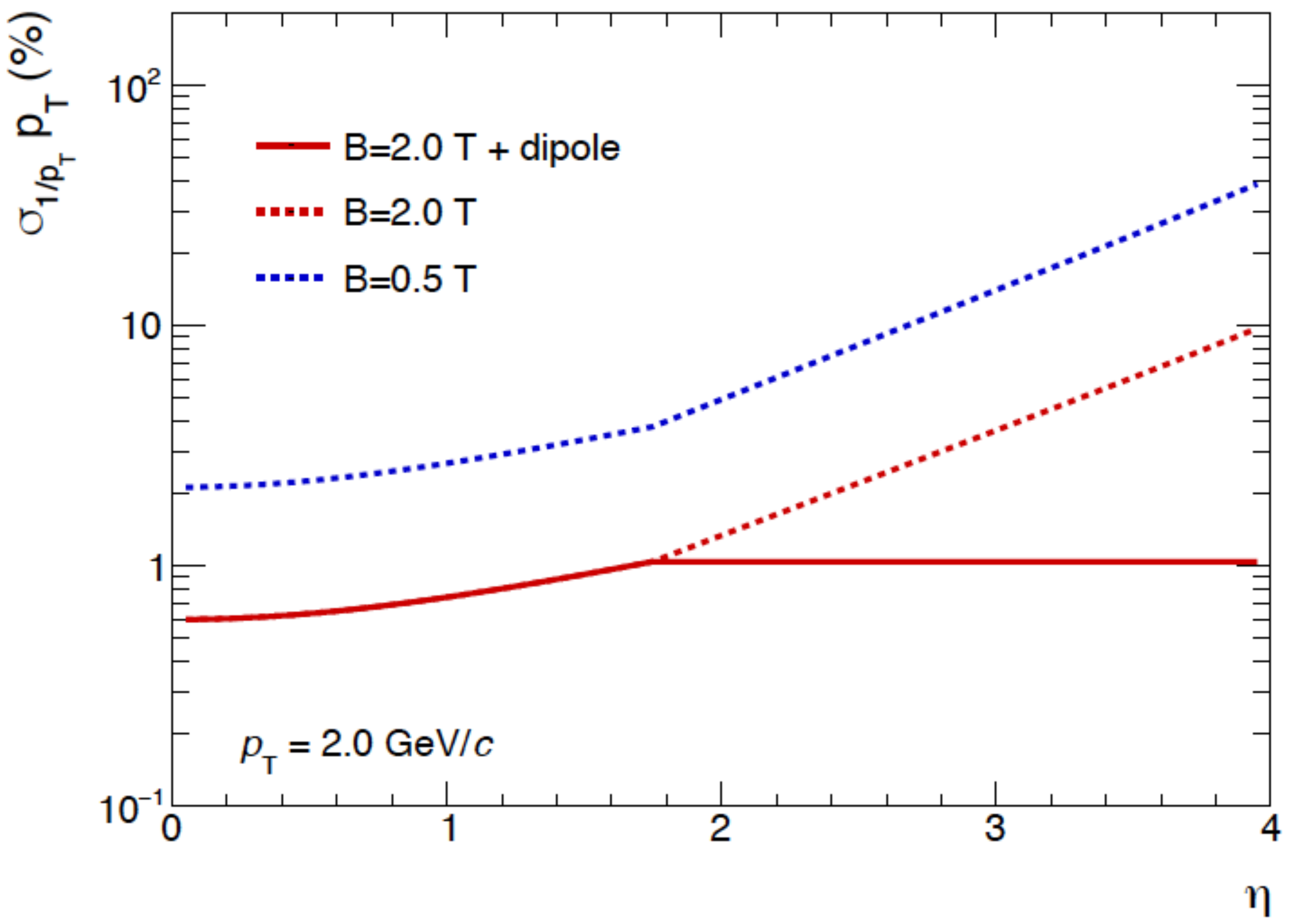



- **One large cryostat: 7m long**
  - Solenoidal field in the centre
  - Dipole components forward/backward

- **Magnetic field can be changed**
  (Running scenarios under discussion)

- **Good momentum resolution over large $\eta$ range**

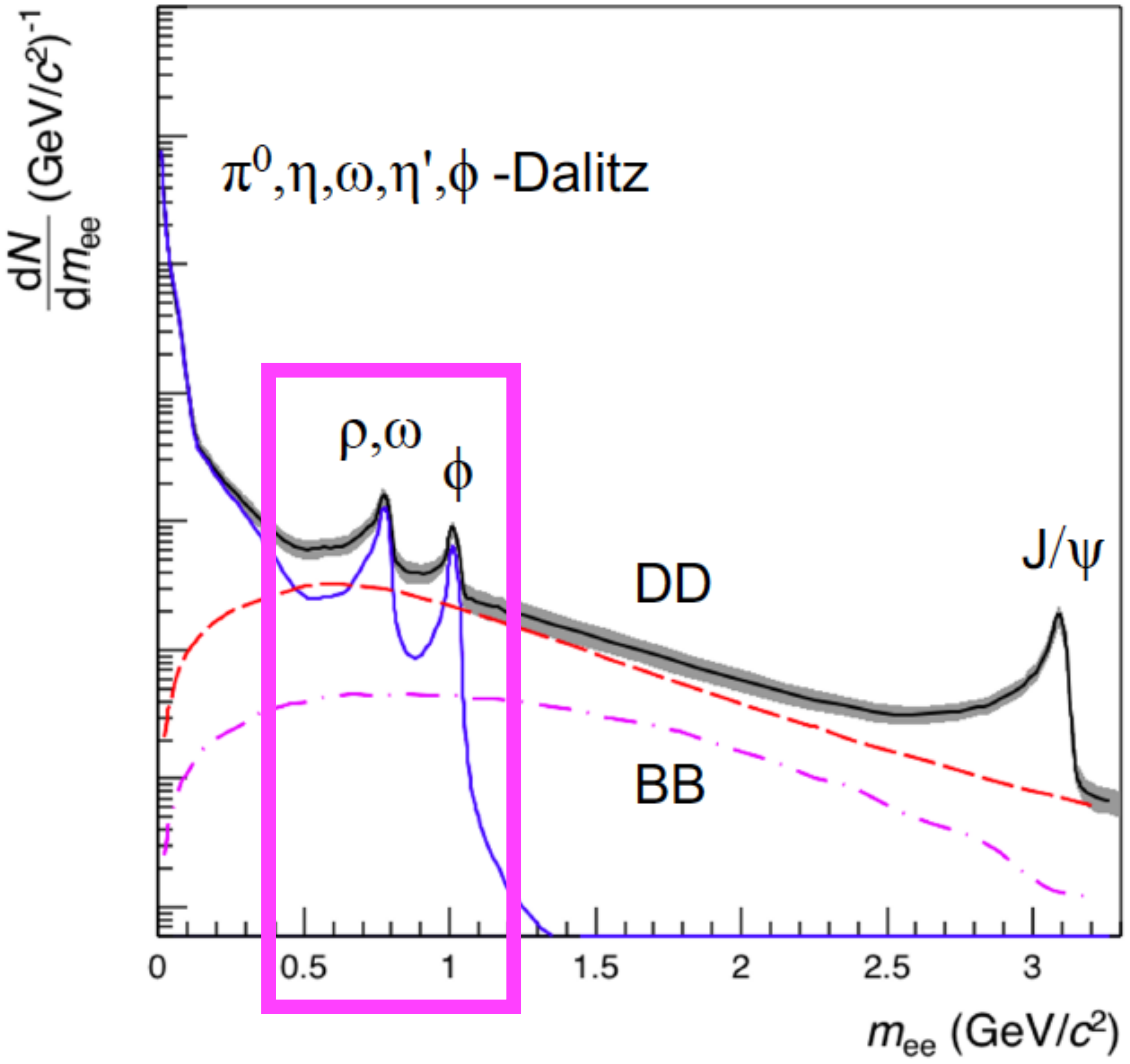
Momentum resolution versus $\eta$



# Differential measurements of $e^+e^-$

Dileptons produced at all stages of the heavy-ion collision: larger $m_{ee} \rightarrow e^+e^-$ emitted earlier

- **Hadron gas:** modification of the $\rho$ spectral function (chiral symmetry restoration)
- **Quark-Gluon-Plasma:** thermal radiations from the QGP
- **Pre-equilibrium/pre-hydrodynamic phase:** radiations from the medium before hydrodynamic phase



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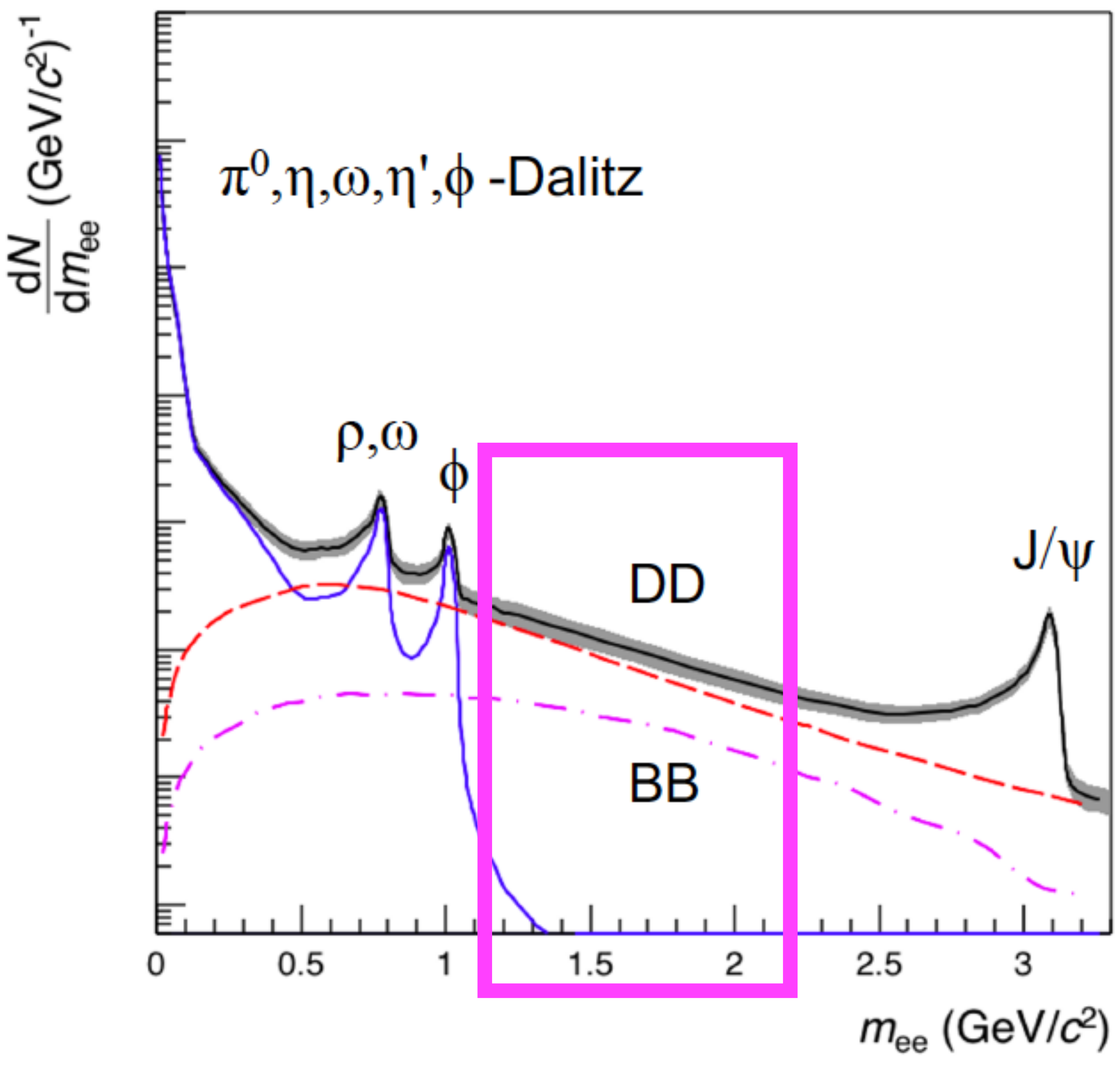

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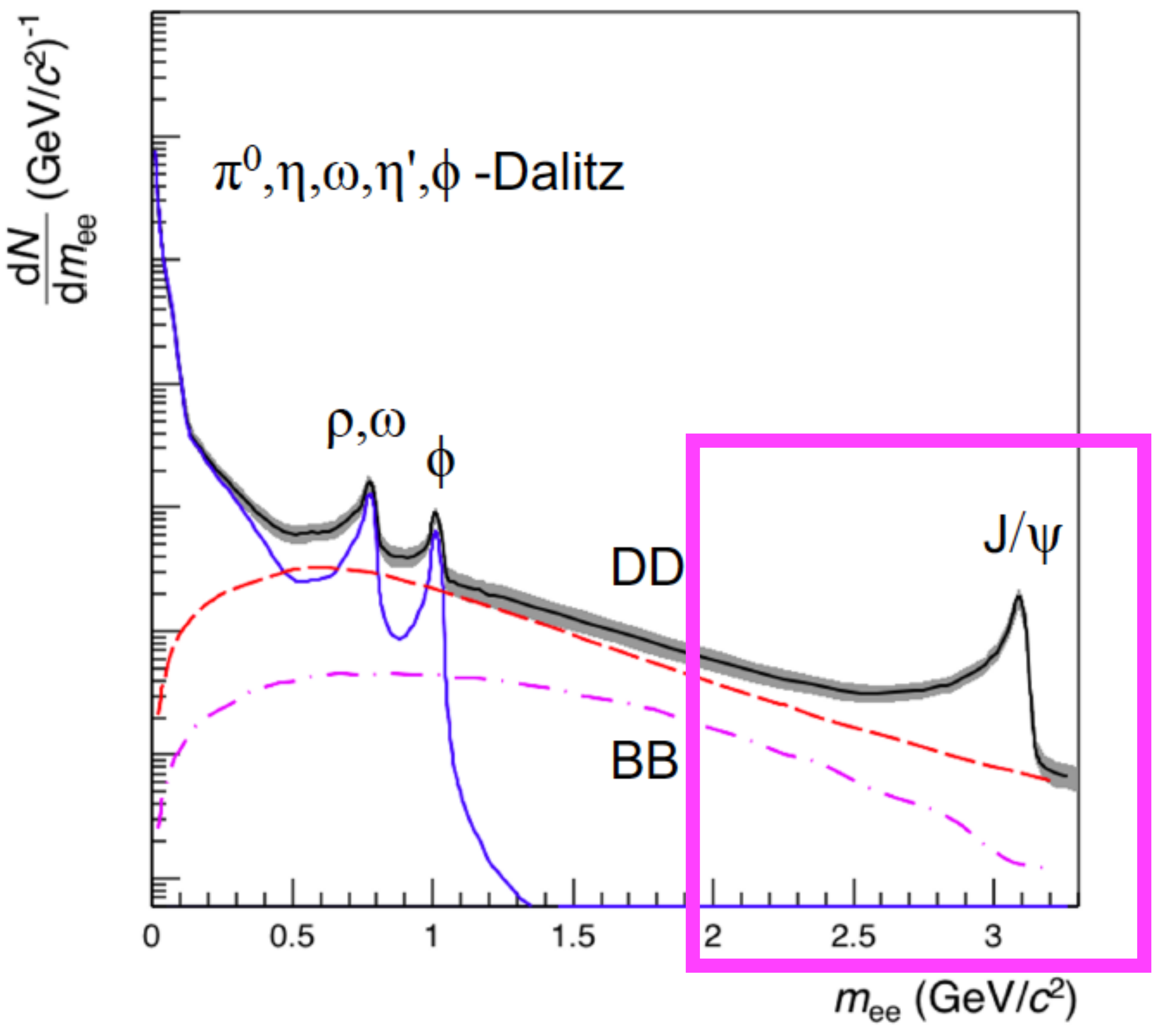


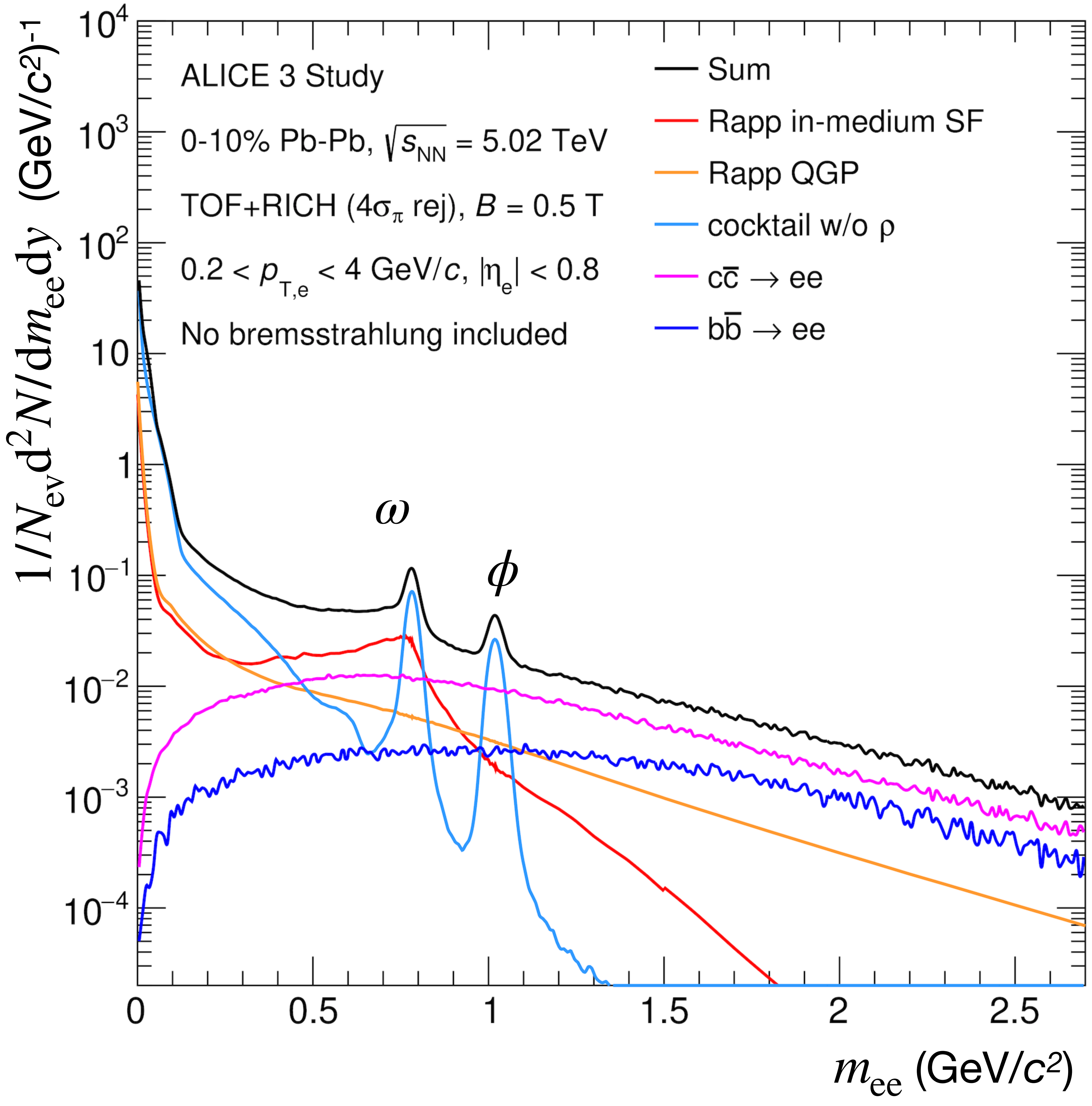
# Sources of correlated dielectrons

- 0-10% central Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

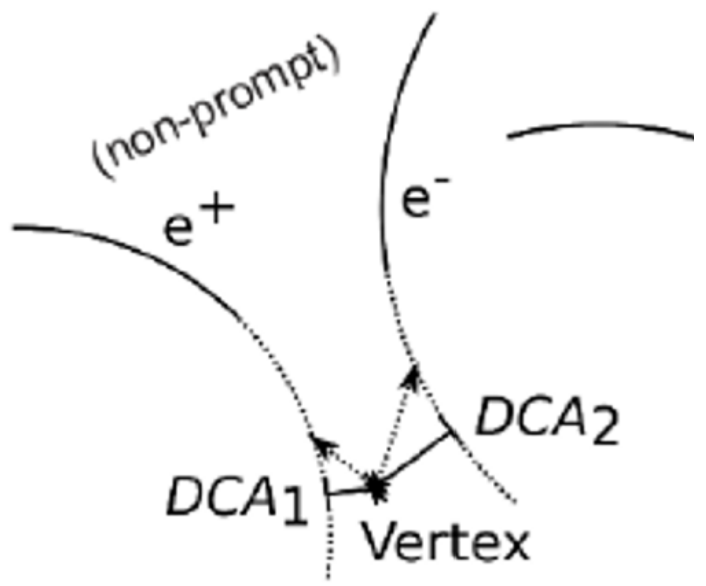
- Thermal radiation signal (R.Rapp):
  - **from hadron gas**
  - **from the QGP**

- Hadronic cocktail calculations based on Run 2 data
  - **long-lived light-flavour hadron decays**
  - Heavy-flavour hadron decays based on pp measurements with EPS09 cold-nuclear matter effects:
    - **open-charm**
    - **open-beauty**

Correlated dielectron raw spectrum



# Suppress correlated heavy-flavour background

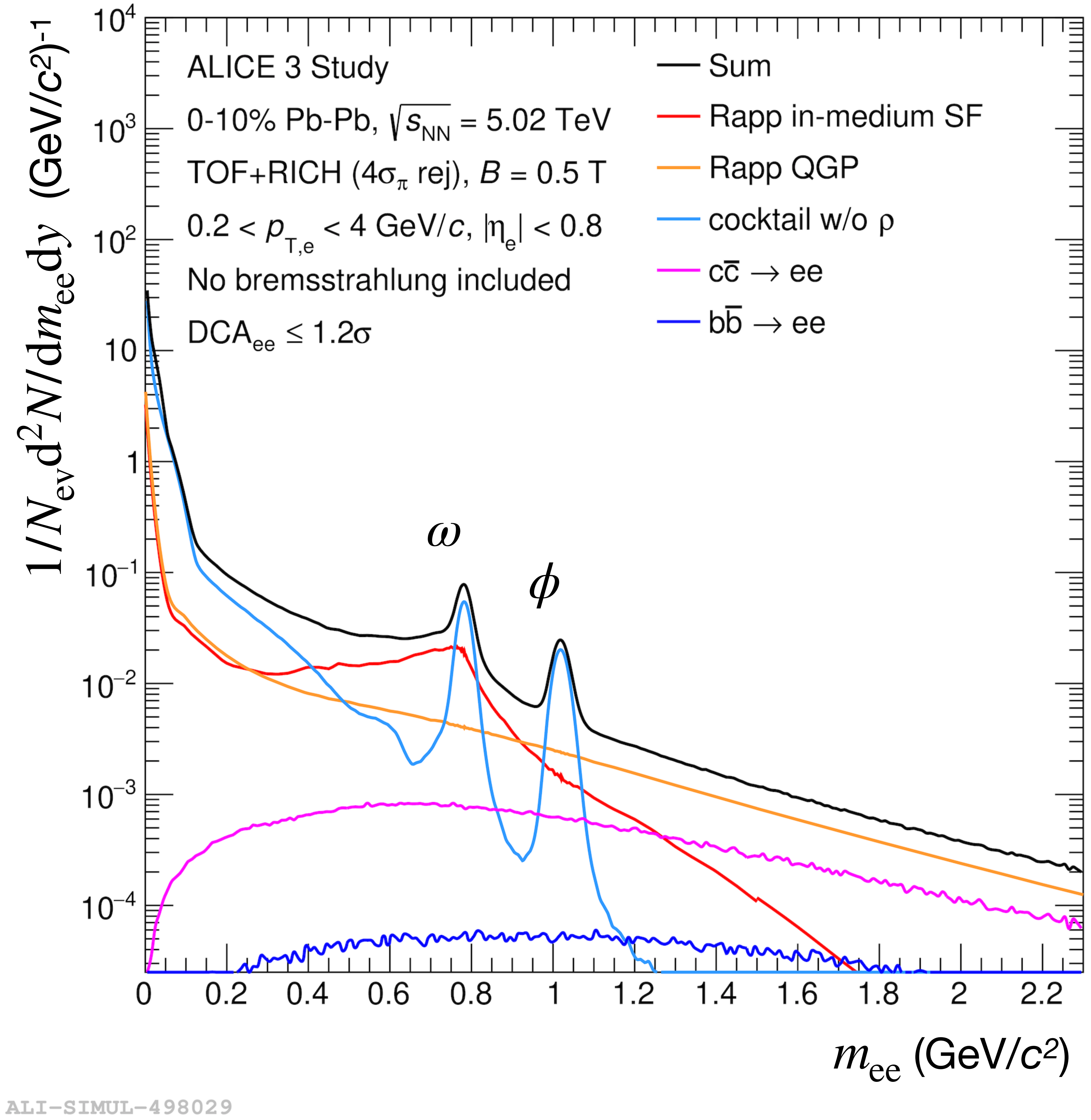



- Suppress heavy-flavour contributions with:

$$DCA_{ee} = \sqrt{\frac{(DCA_{xy,1}/\sigma_{xy,1})^2 + (DCA_{xy,2}/\sigma_{xy,2})^2}{2.}} \rightarrow DCA_{ee}(\mathrm{prompt}) < DCA_{ee}(\mathrm{heavy-flavour})$$

- With ALICE 3 and a maximum cut on $DCA_{ee}$ at $1.2\sigma$:
  - **Keep 73% of signal/prompt** $e^+e^-$
  - **Reject:**
    - **94%of** $c\bar{c} \rightarrow e^+e^-$
    - **98% of** $b\bar{b} \rightarrow e^+e^-$
- **With ITS2 (ITS3)** for the same rejection factor for $c\bar{c} \rightarrow e^+e^-$ **keep only about 17%(30%) of signal/prompt** $e^+e^-$

Correlated dielectron raw spectrum after $DCA_{ee}$ cut



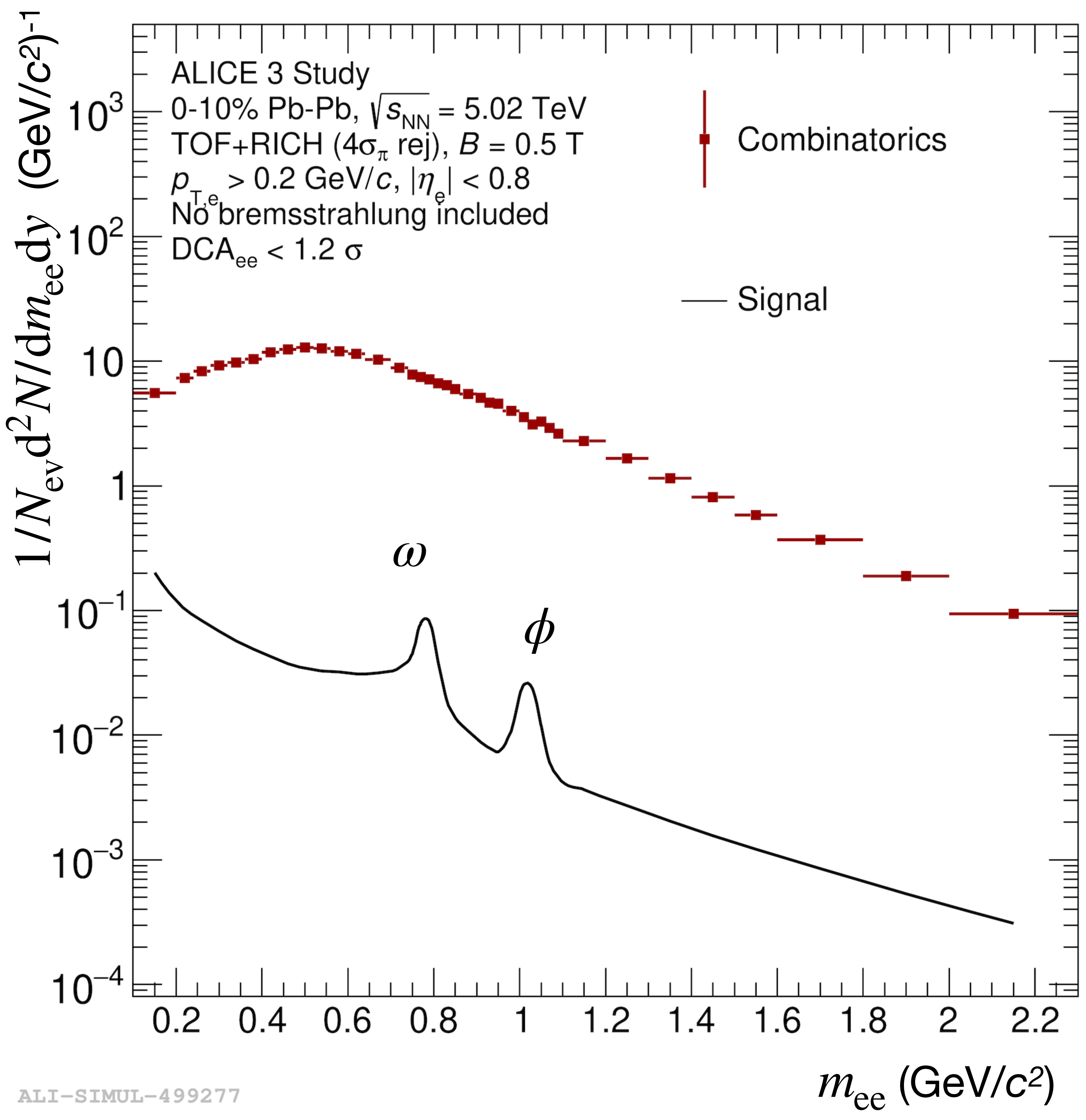

**Thermal radiations dominate the spectrum for $m_{ee} >$ 0.4 GeV/$c^2$ (outside of the $\omega$ and $\phi$ peaks)**

# Combinatoric background

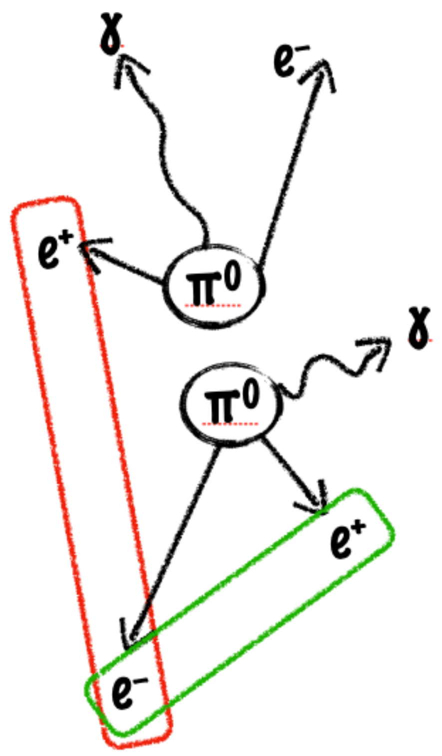
- **Correlated dielectron yield (*S*)** obtained in real data by:
  - Pairing all identified $e^-$ and $e^+$ from the same event
  - Subtracting the contribution from **combinatoric pairs (*B*)**

- **Combinatoric background** estimated with:
  - $e^-e^-$ and $e^+e^+$ pairs from the same event
  - PYTHIA 8 Angantyr event generator weighted to reproduce $\pi^\pm$ and $b, c \rightarrow e$ measurements

- **Statistical unc. of *S*** given by the significance ($\frac{S}{\sqrt{S+2B}}$)



# Suppress combinatoric background

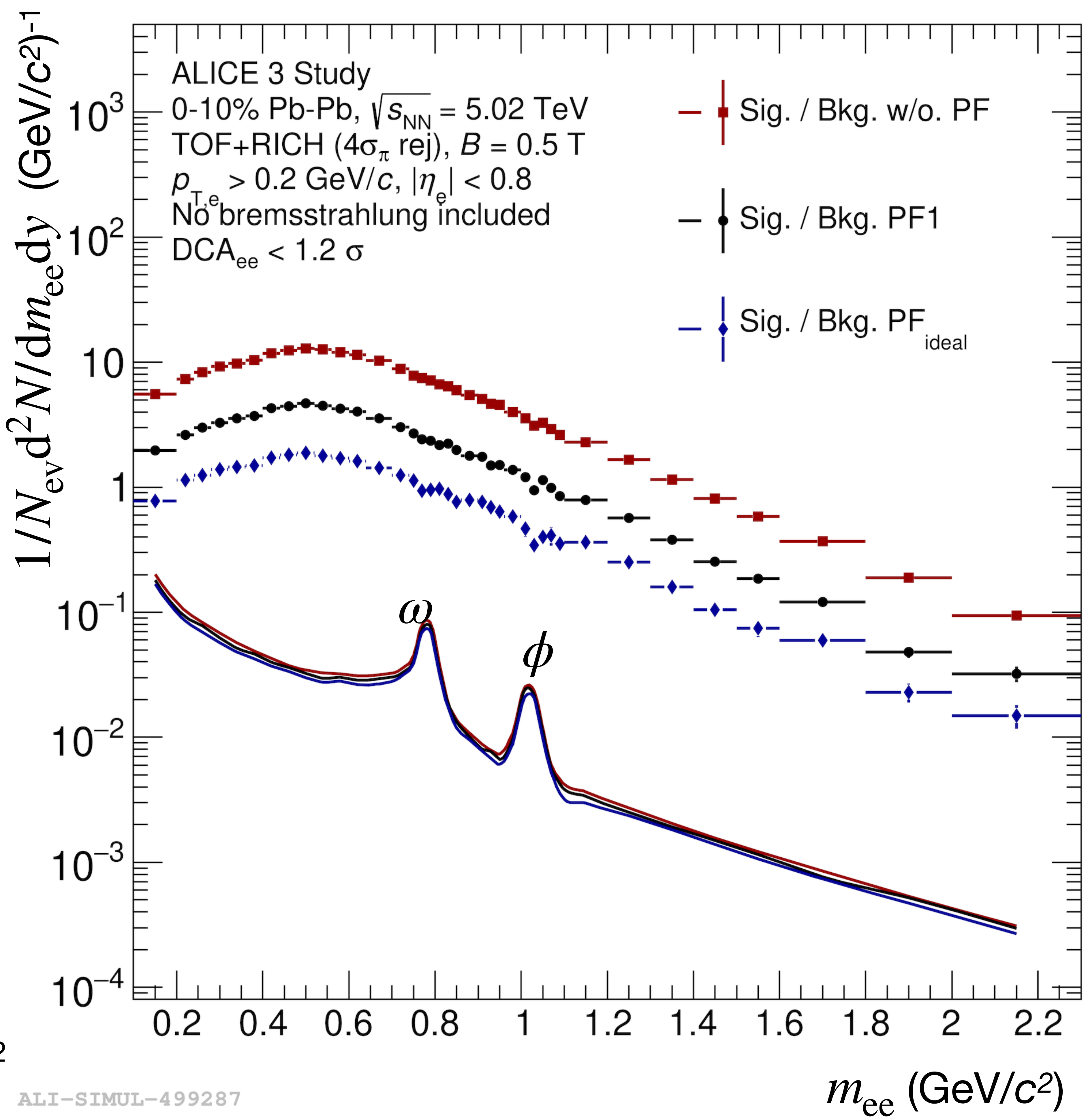



Signal

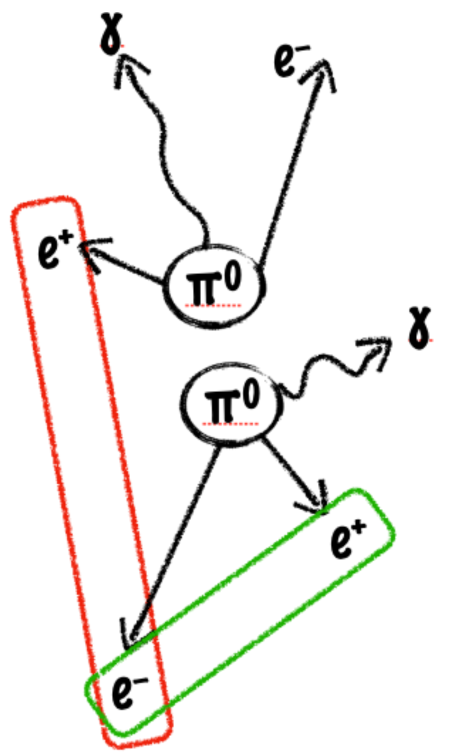
Combinatoric from two different $\pi^0$ decays

- Combinatoric background dominated by independent $\pi^0$ decays
- Can be reduced by pre-filtering the tracks:
  - searching for the partner $e^{\pm}$ of the Dalitz decay $\pi^0 \rightarrow \gamma e^+ e^-$:
    - **down to $p_T$ = 0.08 GeV/$c$ with oTOF+RICH (default)**
    - down to $p_T$ = 0.02 GeV/$c$ with MC PID
  - If one possible partner is found (small $m_{ee}$ and opening angle) $\rightarrow$ Reject the $e^{\pm}$ candidate from the analysis
- Low $p_T$ tracking and eID important to increase S/B and significance for $m_{ee} > 1.1$ GeV/$c^2$

Correlated dielectrons and combinatoric pairs



# Suppress combinatoric background

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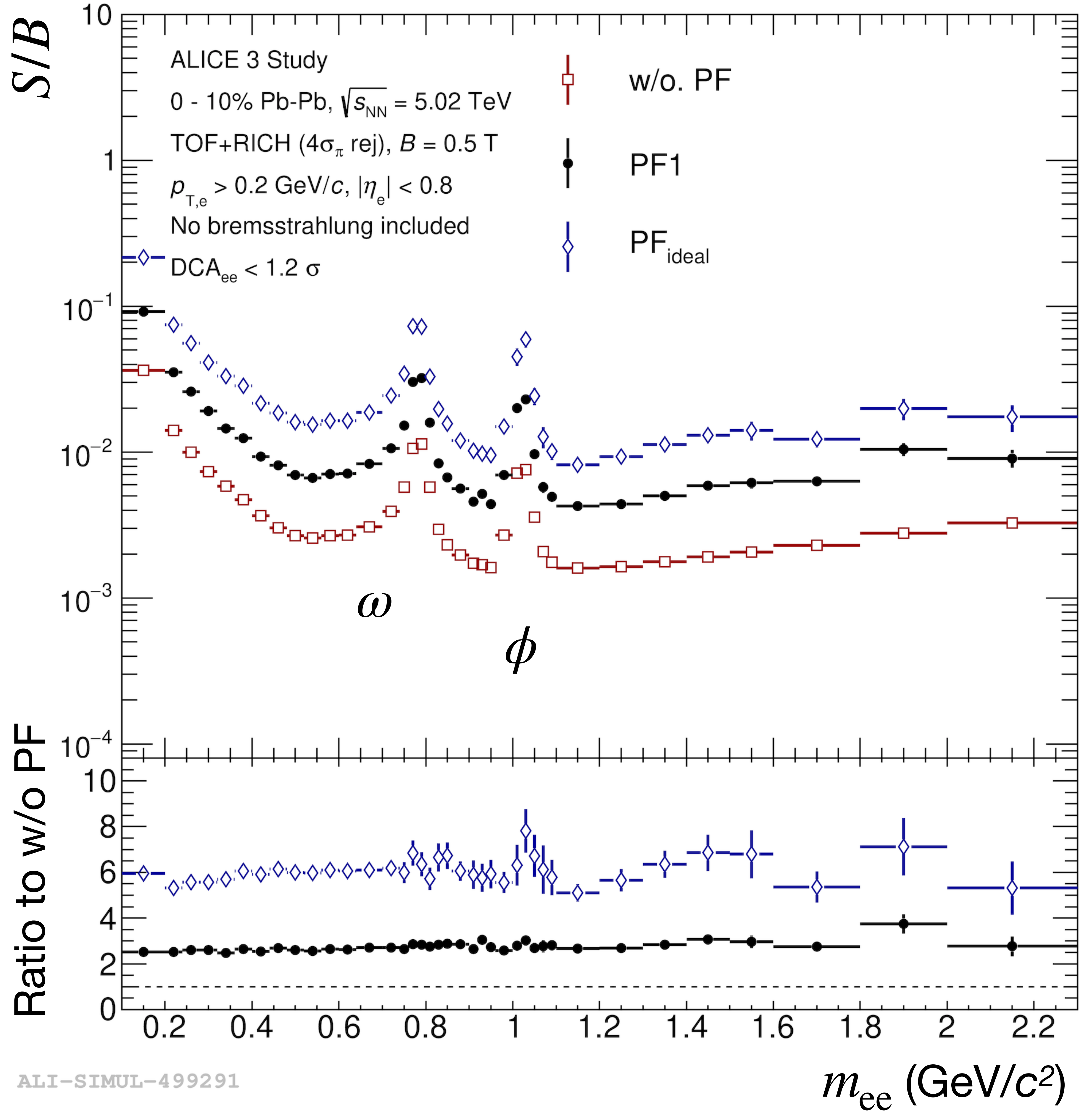
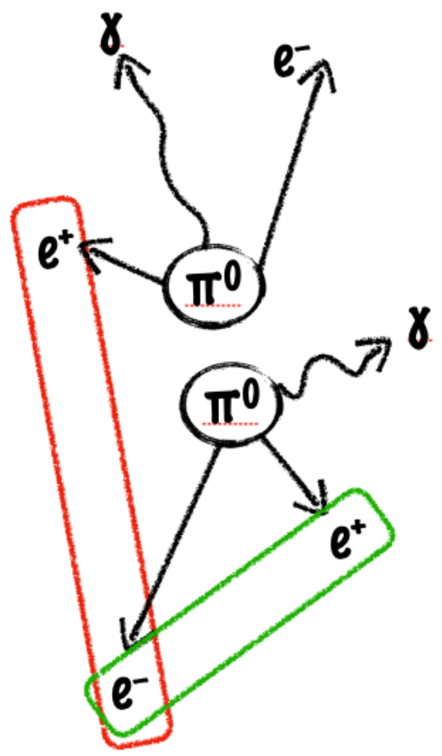
Signal over background




**S/B increased by a factor about 3 (default)**

# Suppress combinatoric background




Signal

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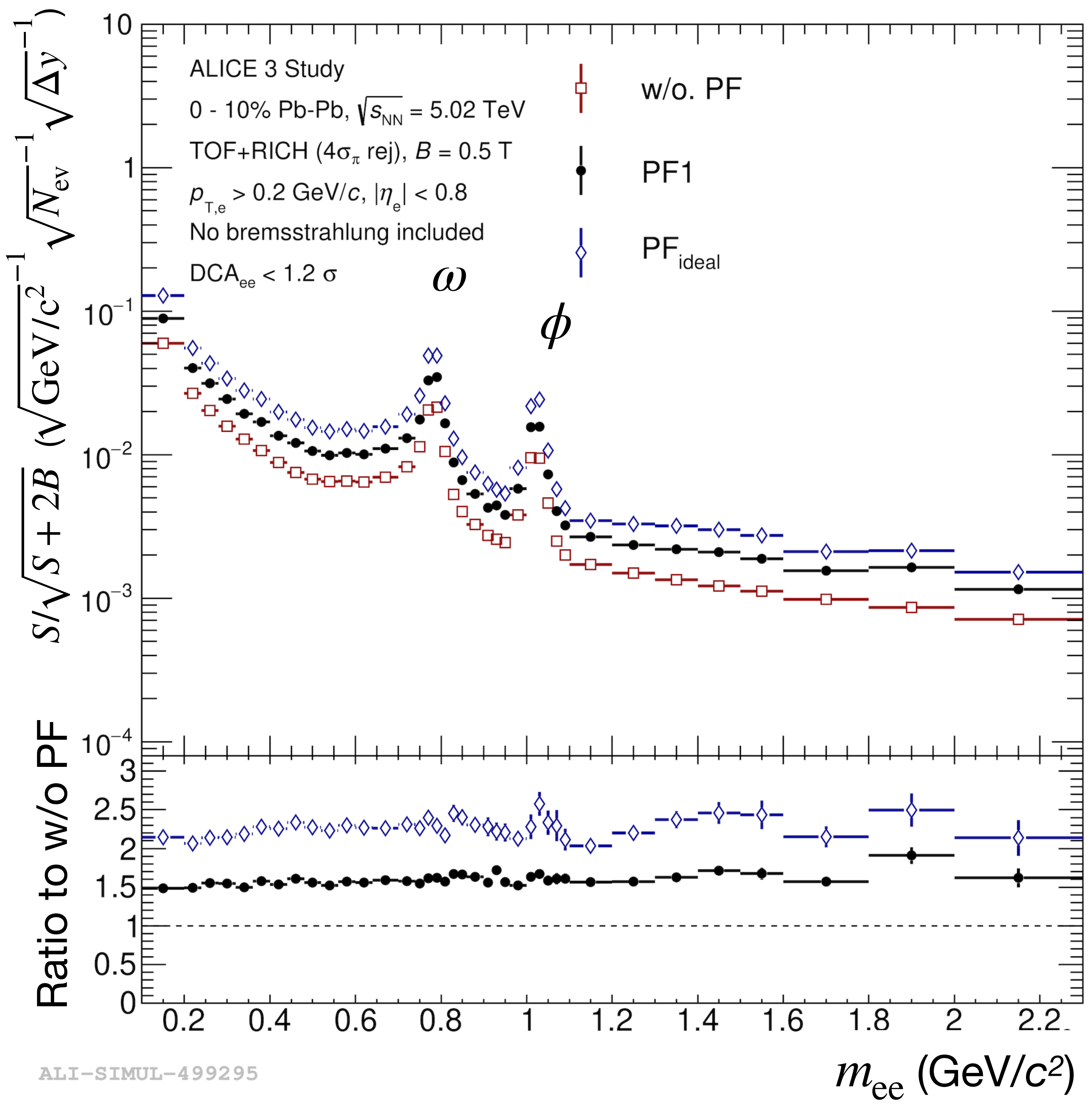
- Low $p_T$ tracking and eID important to increase S/B and significance for $m_{ee} > 1.1$ GeV/$c^2$

Significance

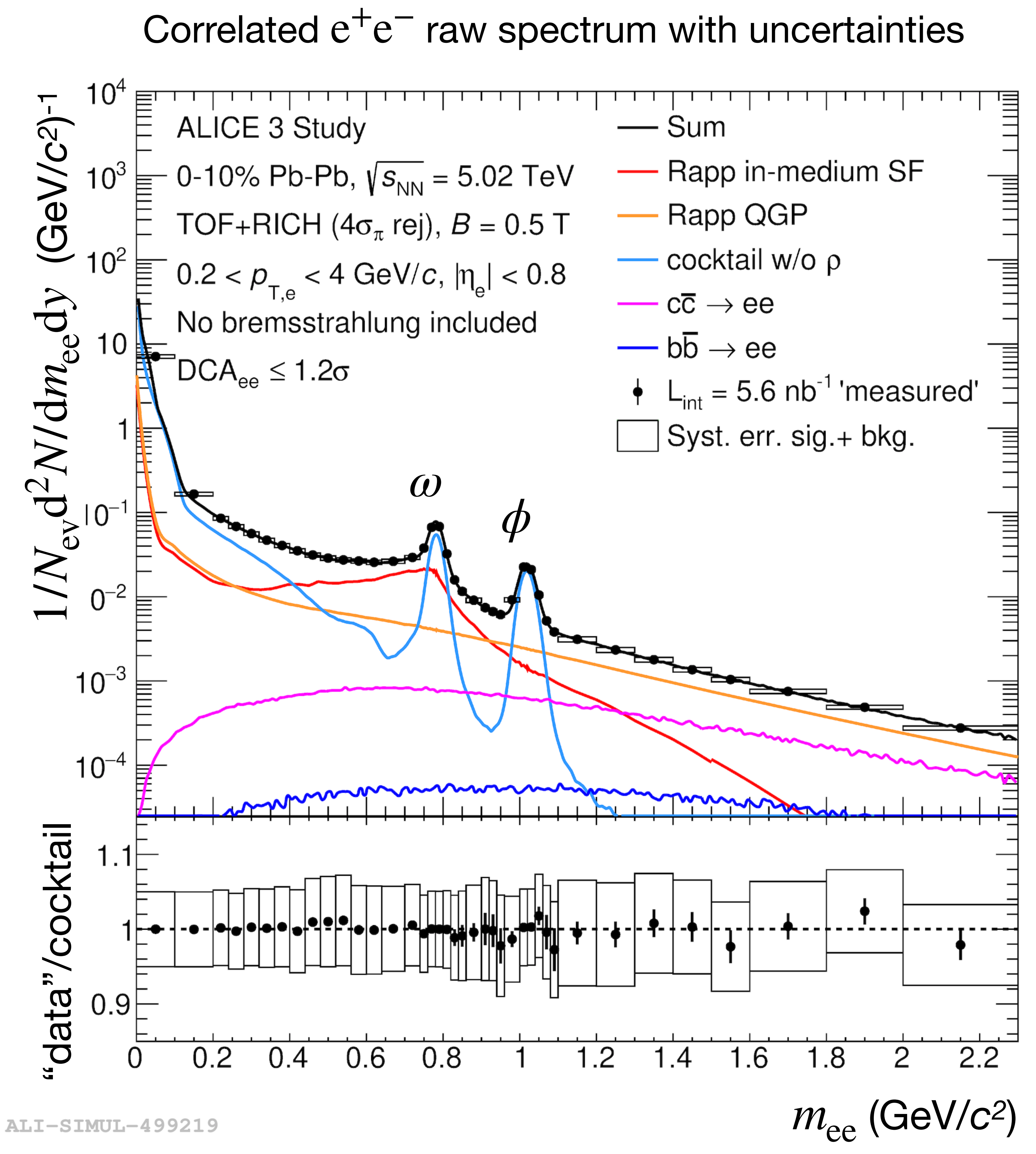



**Significance increased by a factor about 1.6 (default)**

# Dielectron measurement

- **Statistical uncertainties:**
  - Expected signal from sampling data according to the expected significance
  - Assume 5.6 $nb^{-1}$ integrated luminosity for one month running Pb-Pb

- **Systematic uncertainties assumed:**
  - 5% from tracking and PID on $e^+e^-$ yield
  - 0.02% on the background estimation *B*
    (Inspired from sys. unc. on *R* factor observed in Run 2 ALICE data)



# Dielectron elliptic flow

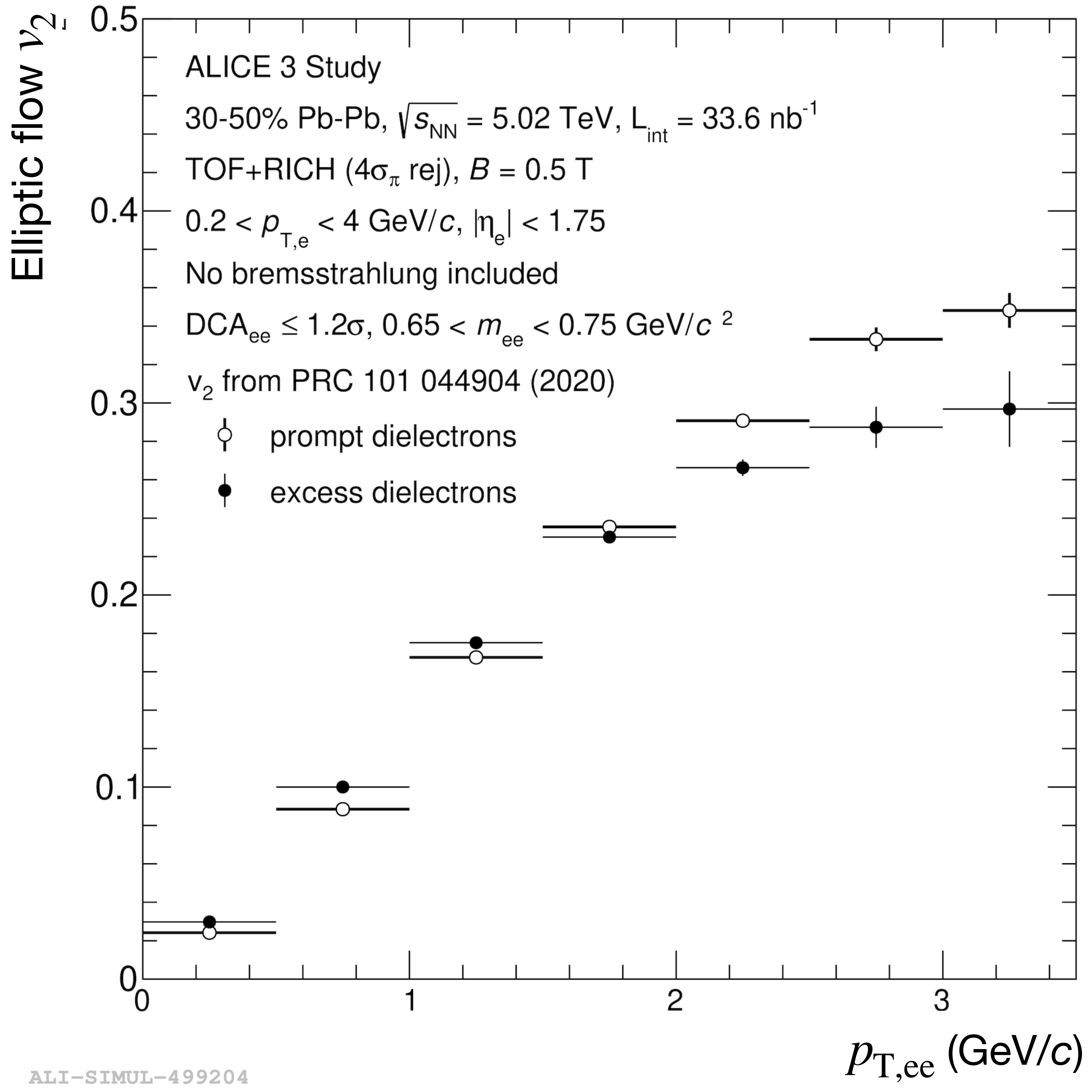
$$v_2^{\mathrm{prompt}} = \frac{\pi}{4}\frac{1}{R_2}\frac{N^{\mathrm{INP}} - N^{\mathrm{OOP}}}{N^{\mathrm{INP}} + N^{\mathrm{OOP}}}$$

$N^{\mathrm{INP}}, N^{\mathrm{OOP}}$: prompt $e^+e^-$ yields in- and out-of-plane

$R_2$ : resolution of the reconstructed event plane

**0.65 < $m_{ee}$ < 0.75 GeV/$c^2$**

Dielectron $v_2$ in 30-50% central Pb-Pb collisions




**Expected $v_2$ for all (prompt) and excess $e^+e^-$ in 30-50% Pb-Pb collisions**

- **Statistical uncertainty** for **6 years of data taking**
- $v_2(p_{T,ee}, m_{ee})$ **studies statistically possible with ALICE 3**

ECal detector under study for higher in $p_{T,ee}/m_{ee}$
Access to pre-hydrodynamic phase

G. Vujanovic et al. PRC 101 (2020) 044904

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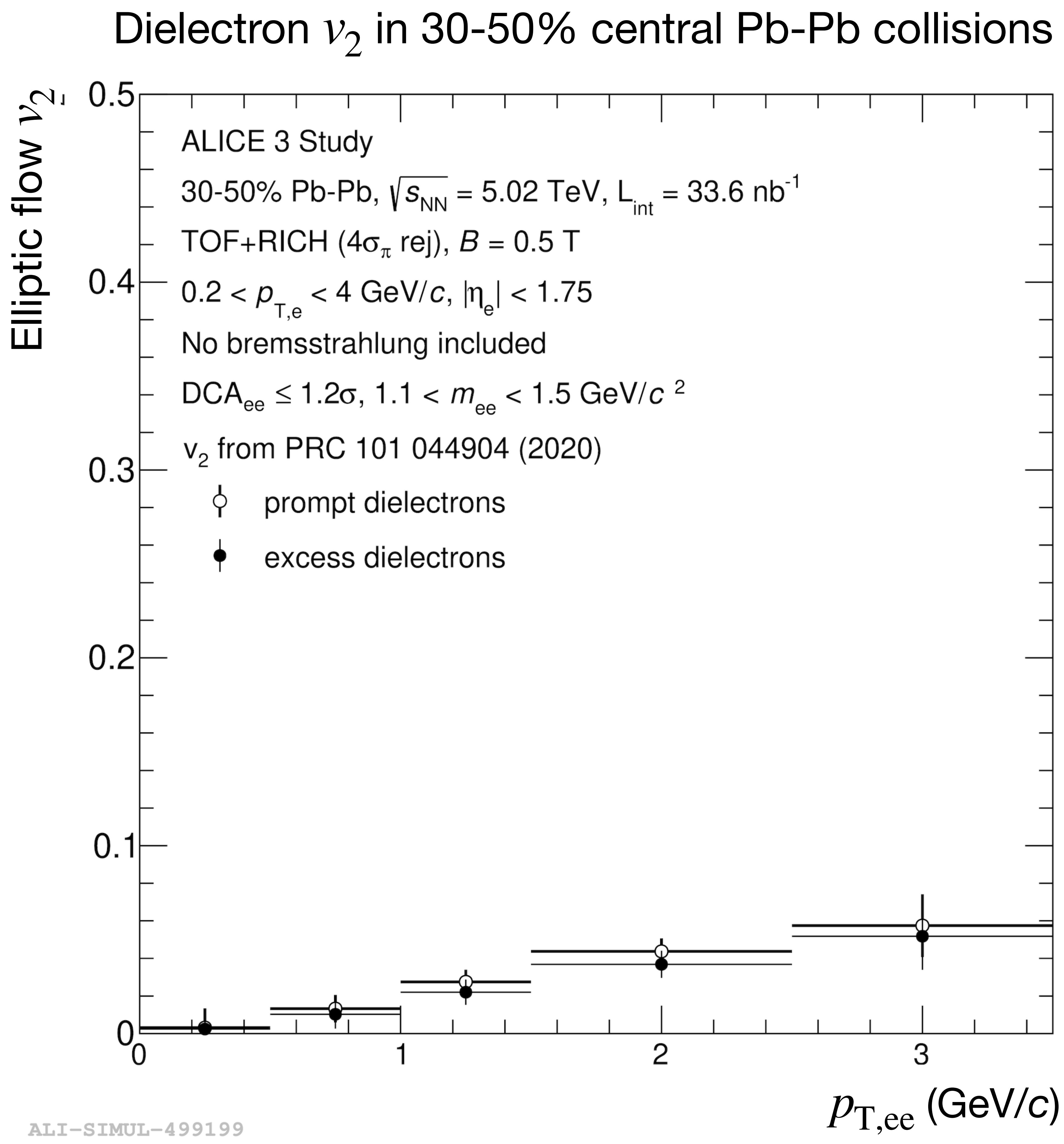
- **Statistical uncertainty** for **6 years of data taking**
- $v_2(p_{T,ee}, m_{ee})$ **studies statistically possible with ALICE 3**

**1.1 < $m_{ee}$ < 1.5 GeV/$c^2$**



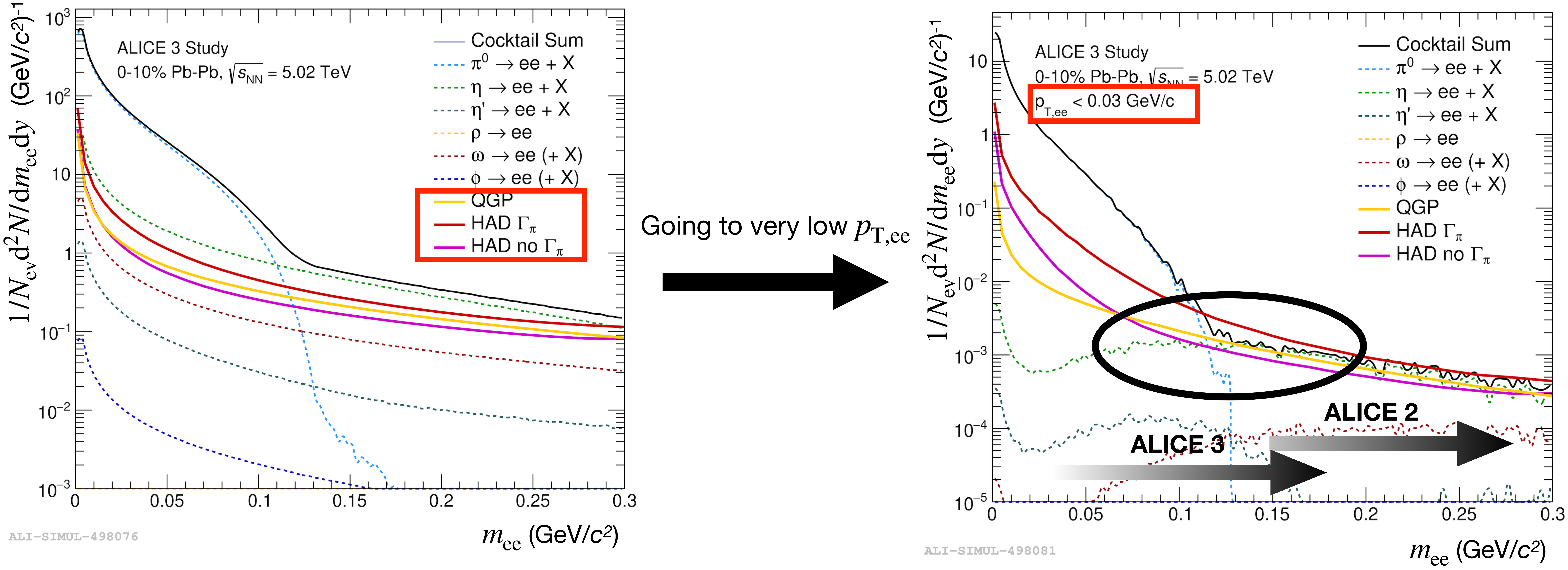

ECal detector under study for higher in $p_{T,ee}/m_{ee}$

Access to pre-hydrodynamic phase

G. Vujanovic et al. PRC 101 (2020) 044904

# Electric conductivity

Compare thermal dielectron yield at low $m_{ee}$ with cocktail of light-flavour hadron decays
**without** single $p_T$ cut on electrons




- Some room for possible measurements above $m_{\pi^0}$ for $p_{T,ee} < 0.03$ GeV/$c$: **measurements of $\pi^0, \eta$ mesons crucial at very low $p_T$**
- **Need to go lower in $p_{T,e}$ than ALICE 2**

# ALICE 3 soft-photon strategy

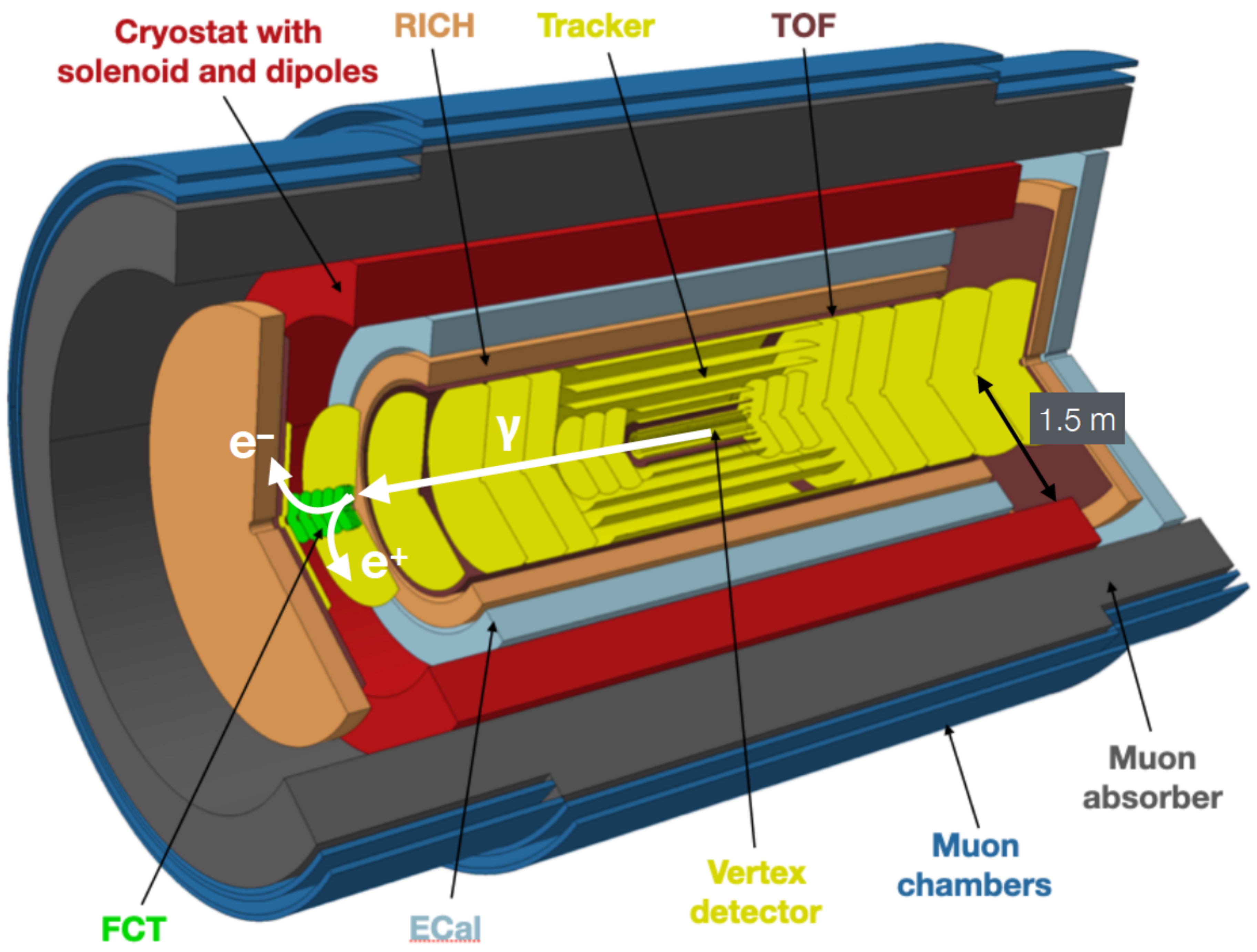
- **Reactions/Systems where to look:**
  - ***Clean* exclusive process** like $\mathrm{pp} \rightarrow \mathrm{pp}\pi^{+}\pi^{-}\gamma$
    - Precise calculations for $\mathrm{pp} \rightarrow \mathrm{pp}\pi^{+}\pi^{-}\gamma$ exist
  - **Inelastic (non-diffractive) pp collisions**
  - **Reactions/systems with higher charged particle multiplicities**

  → **Take advantage of the large rapidity coverage of ALICE 3:**
    - To select exclusive process
    - To measure charged particle multiplicity in more complicated reactions/systems

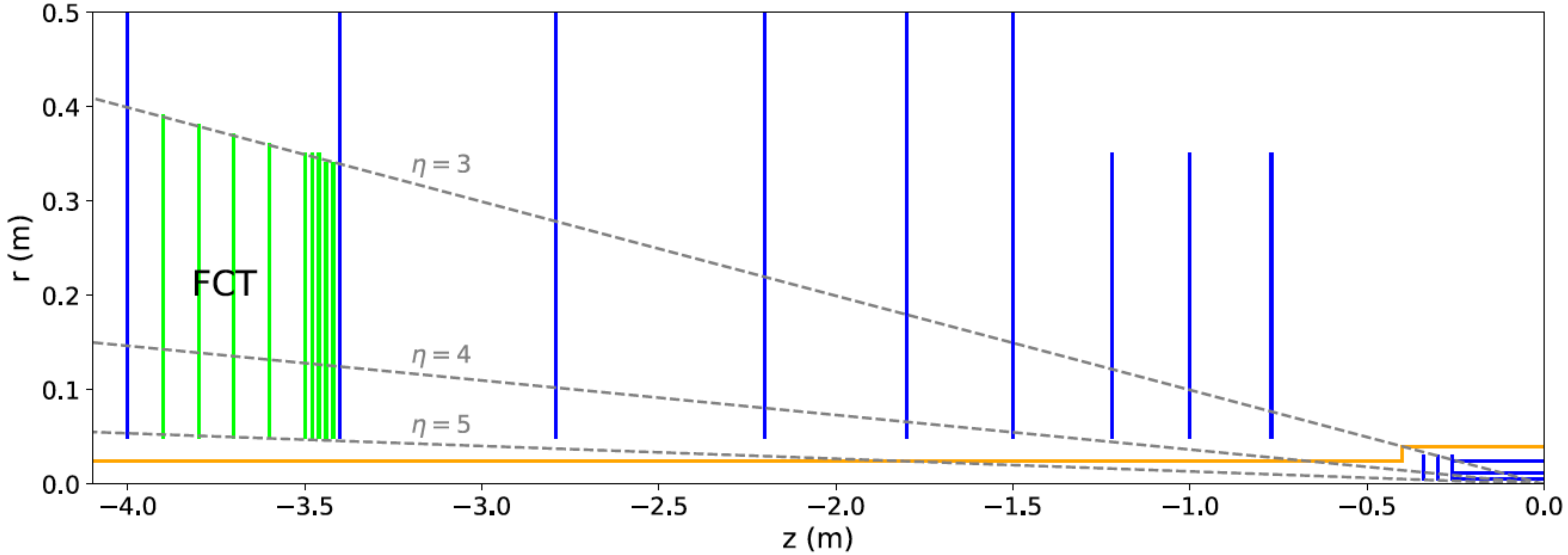
- **Rapidity where to measure:**
  - Need to measure $\gamma$ with $p_{T} \leq$ 5 MeV due to decay $\gamma$ background n
  - Low $E$ photon measurement possible down to $E \approx$ 50-100 MeV via conversion

  Gain a factor 10, 27 and 74 in $p_{\mathrm{T}}$ going to $\eta =$ 3, 4, 5 $(E/p_{\mathrm{T}} = cosh(\eta))$

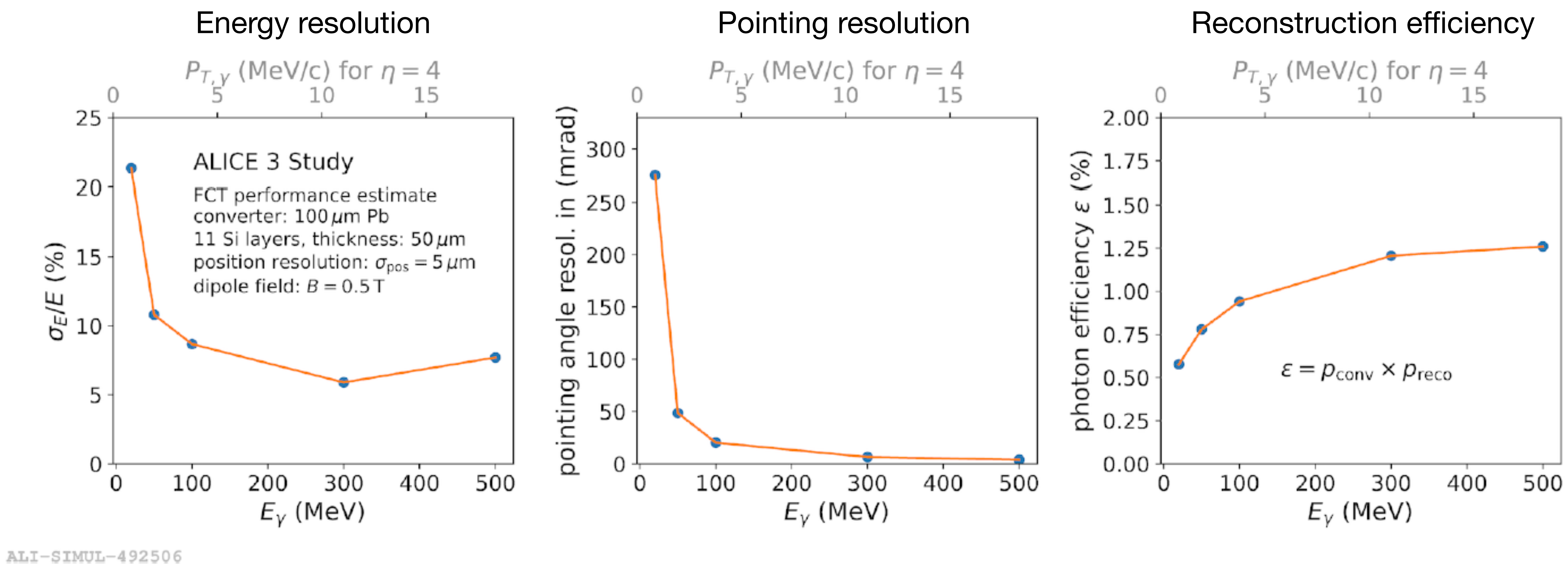
  → **Forward Conversion Tracker covering $3 \leq \eta \leq$ 5**



# Forward Conversion Tracker

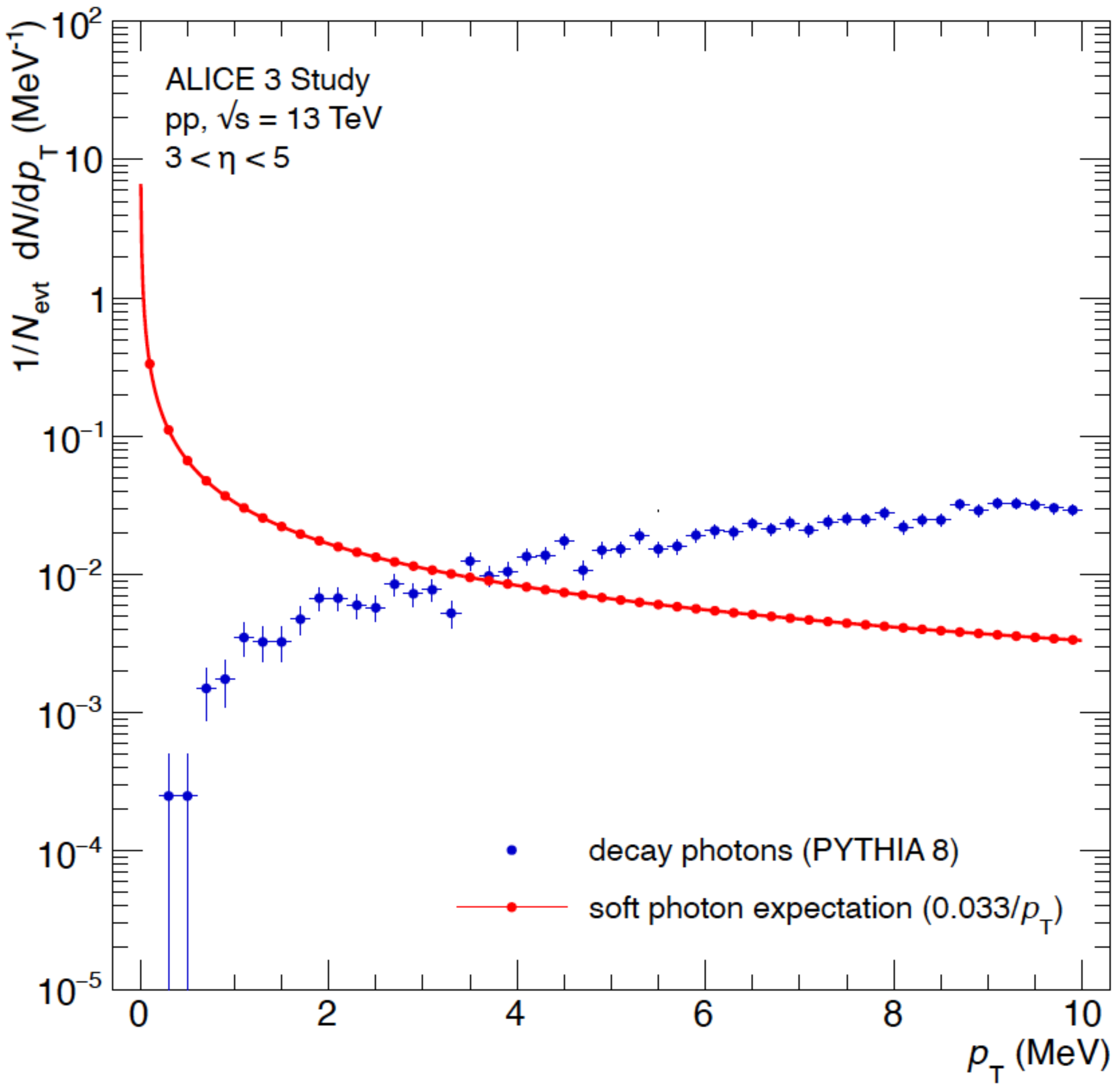



Can measure $\gamma$ down to $E_\gamma \approx$ 50 MeV $\rightarrow 1 \leq p_\mathrm{T} \leq$ **10 MeV accessible at forward rapidity:**

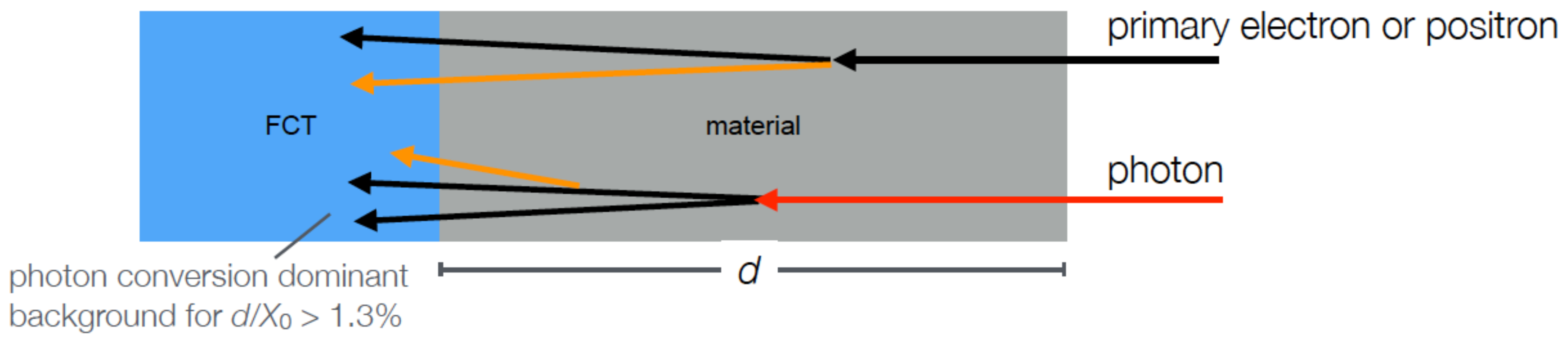


# Background

pp collisions at $\sqrt{s}$ = 13 TeV




- Signal: **Inner bremsstrahlung $\gamma$**
- Background:
  - **Decay photons** ($\pi^0 \rightarrow e^+e^-$)
  - **External bremsstrahlung (study on going):**




- Minimize material in front of FCT
  - Avoid crossing of the beam pipe at shallow angles ($d = d_{\perp} cosh\eta$)
  - To reach a measurement with 3$\sigma$ significance
    → Need to limit material in front of FCT to $\leq 14\%$ $X_0$ assuming 5% unc. on the background
- Develop strategy to reject events with $e^+/e^-$ in the $\eta$ range of the FCT

For an overview: see K. Reygers ALICE 3 Workshop 19.10.2021