D-meson production in Pb-Pb collisions with ALICE at the LHC

Stefano Trogolo on behalf of the **ALICE Collaboration**

Università degli Studi di Padova - INFN Padova

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Heavy flavours in the QGP

- Heavy flavours (i.e. c and b quarks) are mainly produced in *hard-scattering process* on short time scale (~ 0.02—0.1 fm/*c*) in the early stage of the collision
- They probe the full evolution of the QGP created in ultra-relativistic heavy-ion collisions, interacting with its constituents

D-meson reconstruction

$D^0 \to K^-\pi^+$ (BR = 3.89%) $\quad D^{*+} \to D^0(\to K^-\pi^+)\pi^+$ (BR = 67.7% × 3.93%)

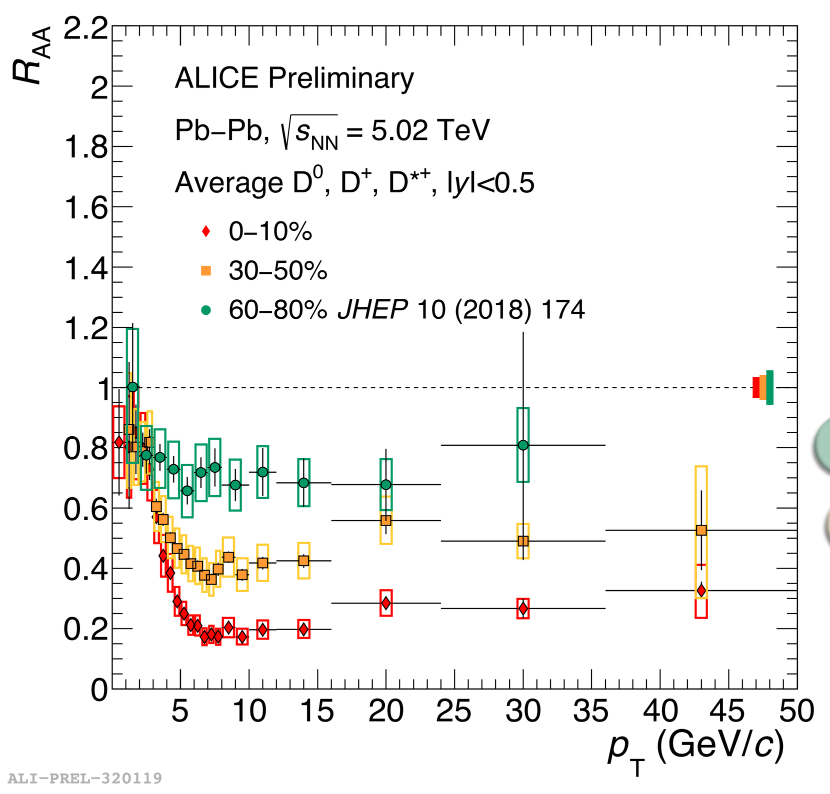
$D^+ \to K^-\pi^+\pi^+$ (BR = 9.46%) $\quad D_s^+ \to \phi(\to K^+K^-)\pi^+$ (BR = 2.27%)

- Reconstruction of decay vertices displaced ~100 microns from primary vertex combining pairs/ triplets of tracks
- Particle identification (PID) of decay tracks and geometrical selection of displaced decay-vertex topology
  → **NEW: D^0** for **p_T < 1 GeV/*c*** (0-10%) selected w/o vertexing and by exploiting only the PID capabilities
- Efficiency correction with Monte Carlo simulations using HIJING [1] events enriched with PYTHIA [2] $c\bar{c}$ and $b\bar{b}$ pairs. Beauty feed-down subtraction based on FONLL [3] calculations
- **NEW: D_s^+**-signal extraction optimized with supervised Machine Learning techniques for **p_T < 3 GeV/*c*** (both centrality classes), for **p_T > 36 GeV/*c*** (0-10%) and for **p_T > 24 GeV/*c*** (30-50%)

Nuclear modification factor

$$R_{AA} = \frac{1}{\langle T_{AA} \rangle} \frac{dN_{AA}/dp_T}{d\sigma_{pp}/dp_T}$$

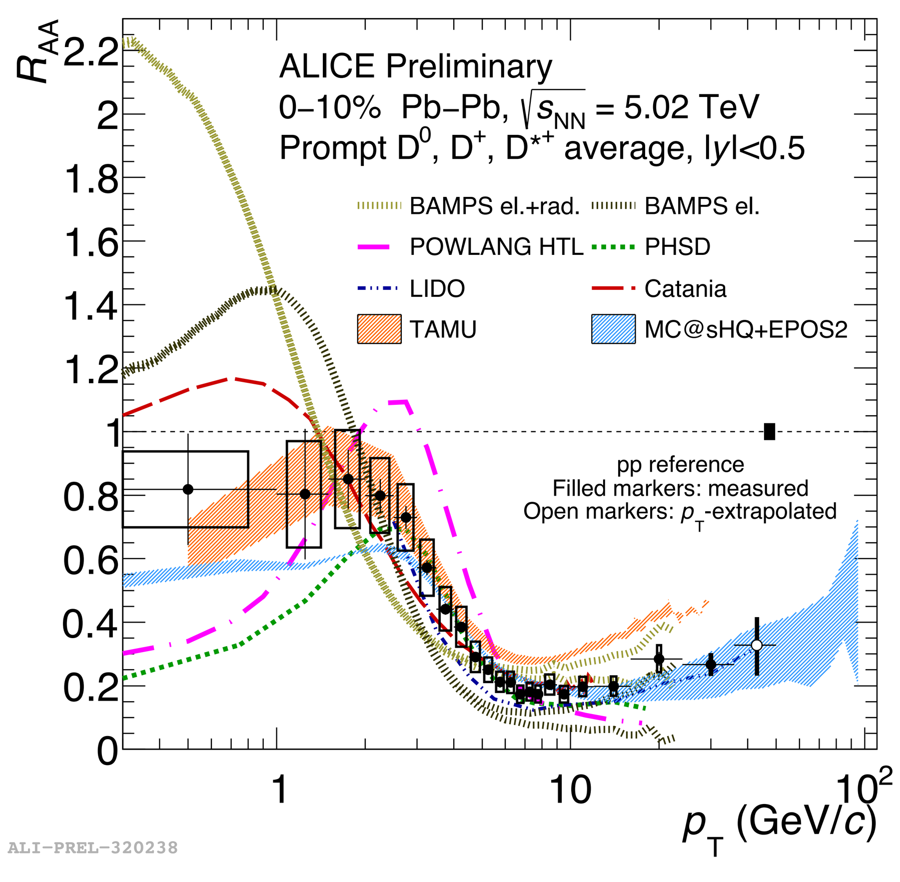
- $\langle T_{AA} \rangle$ is the average nuclear overlap function, proportional to the number of binary nucleon-nucleon collisions
- $d\sigma_{pp}/dp_T$ is the D-mesons cross section measured in pp collisions at $\sqrt{s}$ = 5 TeV
- It provides information about the of energy loss in the QGP which can occur via:
  - inelastic process (gluon radiation) [4]

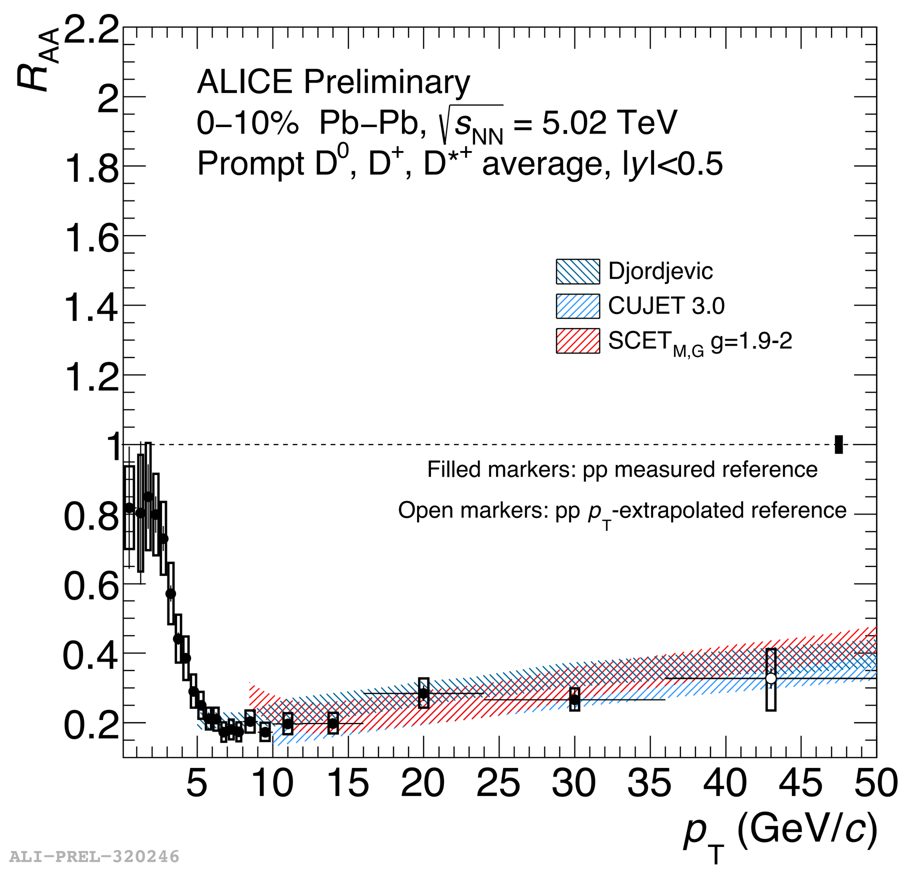


- Prompt D R_{AA} in Pb-Pb collisions in three different centrality classes
- R_{AA}(60-80%) > R_{AA}(30-50%) > R_{AA}(0-10%) → suppression factor up to a factor 5 observed in the 10% most central Pb-Pb collisions for p_T > 5 GeV/*c*
- The suppression increases from peripheral (60-80%) [6] to central (0-10%) Pb-Pb collisions

Comparison with theoretical models

- Heavy-quark transport in medium with realistic evolution can fairly describe the data for p_T < 10 GeV/*c* [7-13]
  → interplay of collisional energy loss, radial flow, hadronisation via recombination
  → good description for both central and semi-central collisions

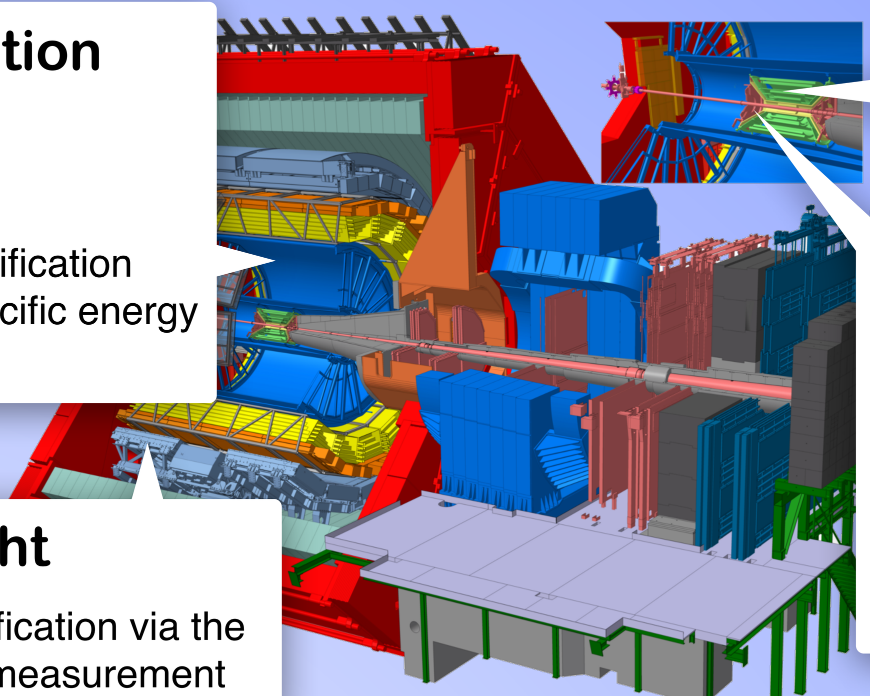




- Models based on pQCD [14-16] provide a good description of the data for p_T >10 GeV/*c*
  → radiative energy loss dominant effect
  → agreement in 0-10% centrality class, while a small tension in 30-50%

ALICE detectors

- Data sample used for the analysis
  → Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV **collected in 2018**
  → $\mathscr{L}_{int} \approx$ 114 μb^{-1} (0-10%) and $\mathscr{L}_{int} \approx$ 49 μb^{-1} (30-50%)



Inner Tracking System
- Tracking
- Reconstruction of primary and secondary (decay) vertices

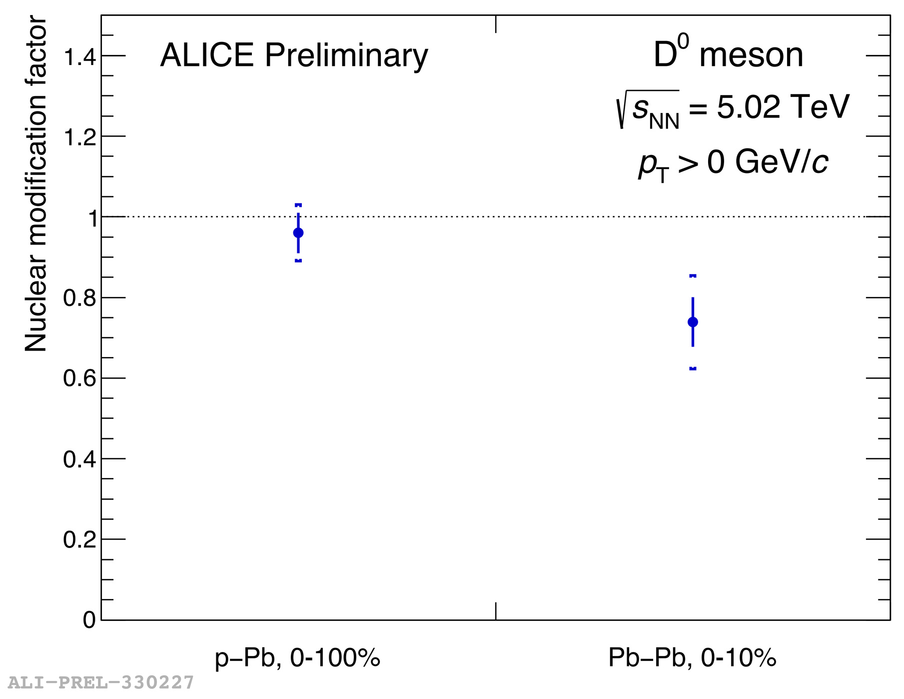
Time Projection Chamber
- Tracking
- Particle identification (PID) via specific energy loss

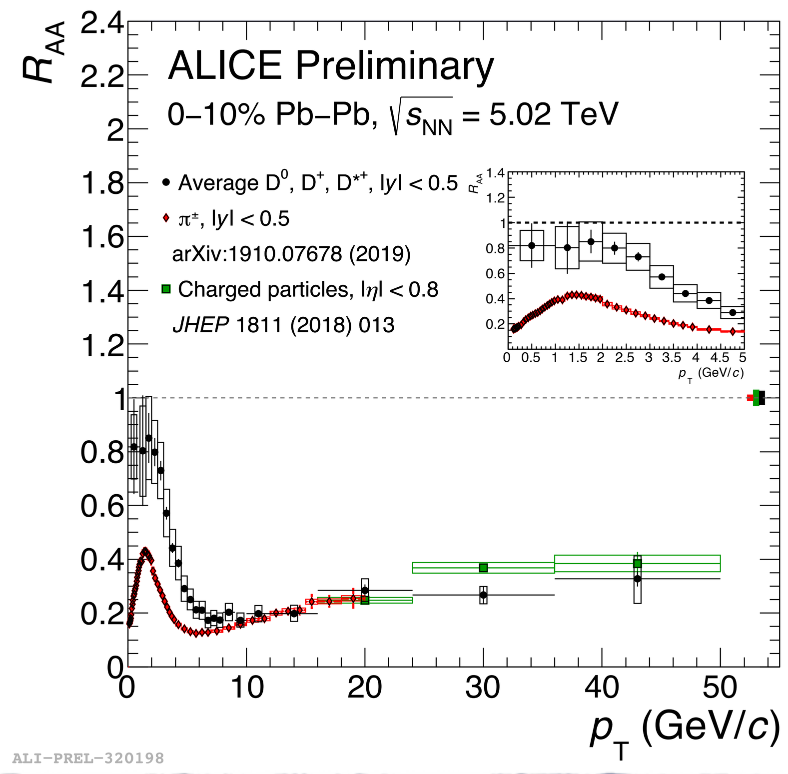
V0 detectors
- Trigger
- Centrality
- Event Plane determination (estimator of Reaction Plane)

Time-Of-Flight
- Particle identification via the time-of-flight measurement

Non-strange D-meson

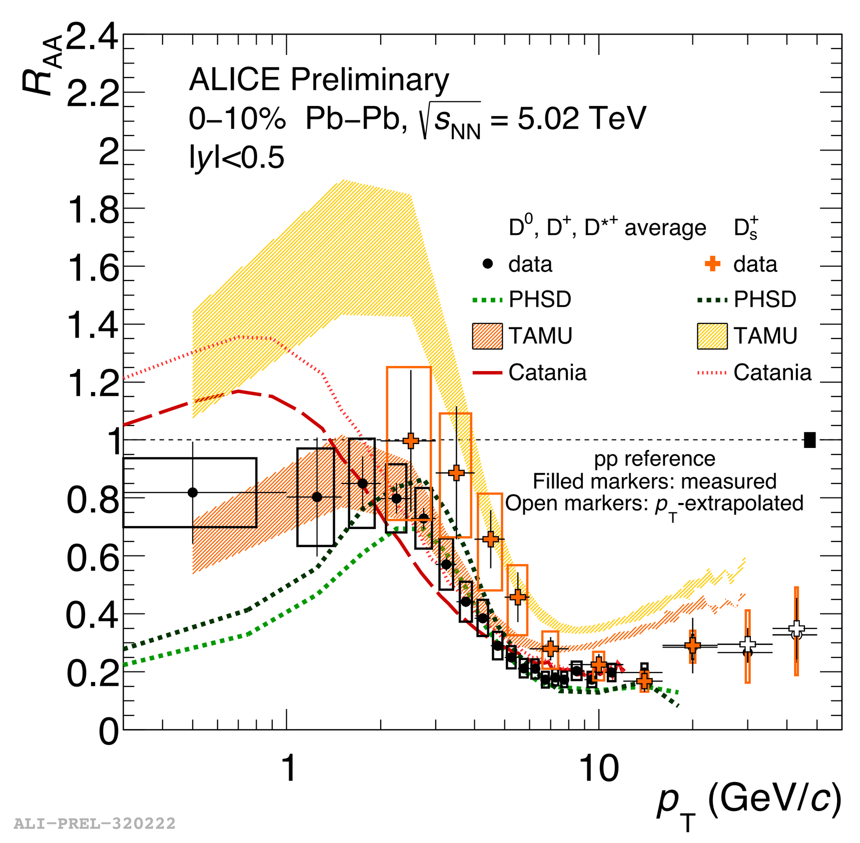
- R_{AA} of prompt D^0, D^+ and D^{*+} in the 0-10% and 30-50% centrality class of Pb-Pb collisions are in agreement within uncertainties
  - R_{AA} of prompt D^0 extended down to 0 GeV/*c* → compute D^0 R_{AA} **p_T-integrated**
- R_{AA} of prompt non-strange D mesons compared with those of charged particles and pions → difference observed for p_T < 8 GeV/*c* possibly due to an interplay of several factors:
  - **color-charge** and **quark-mass** dependence of the energy loss
  - **soft processes** contribution to the yields of light-flavor hadrons
  - different effects of **radial flow** and **hadronisation via recombination** on charm and light quarks

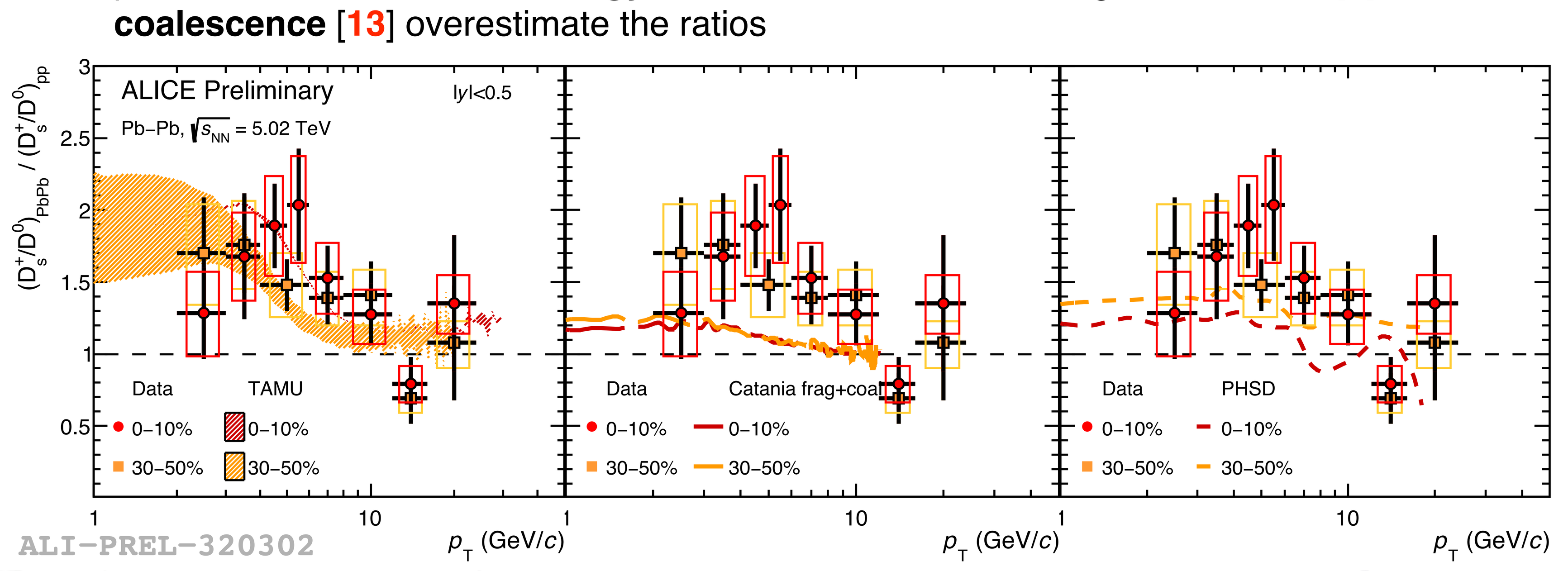




Charming strangeness

- The comparison between D_s^+ and non-strange D mesons allows to inquire possible modification of the hadronisation mechanism
- Hint of larger D_s^+-meson R_{AA} w.r.t. that of non-strange D mesons for p_T < 10 GeV/*c*
  → expected in case of hadronisation via coalescence due to the enhanced production of s quarks in the QGP
- The double ratio between D_s^+/D^0 in Pb-Pb and the one in pp shows a hint of strangeness enhancement:
  - ratios in 0-10% and 30-50% centrality classes are **in agreement**
  - models including interactions with only **collisional process** [7] fairly describe the trend
  - predictions based also on **energy loss** from medium-induced gluon radiation [8] or **coalescence** [13] overestimate the ratios





References

[1] PRD 44 (1991) 3501
[2] JHEP 0605 (2006) 026
[3] JHEP 9805 (1998) 007
[4] NPB 483 (1997) 291
[5] PRD 44 9 (1991) R2625
[6] JHEP 10 (2018) 174
[7] TAMU: PLB 735 (2014) 445
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[9] POWLANG: EPJC 75 (2015) 121
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[12] BAMPS: JPG 42 (2015) 115106
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[16] CUJET: JHEP 02, 169 (2016)