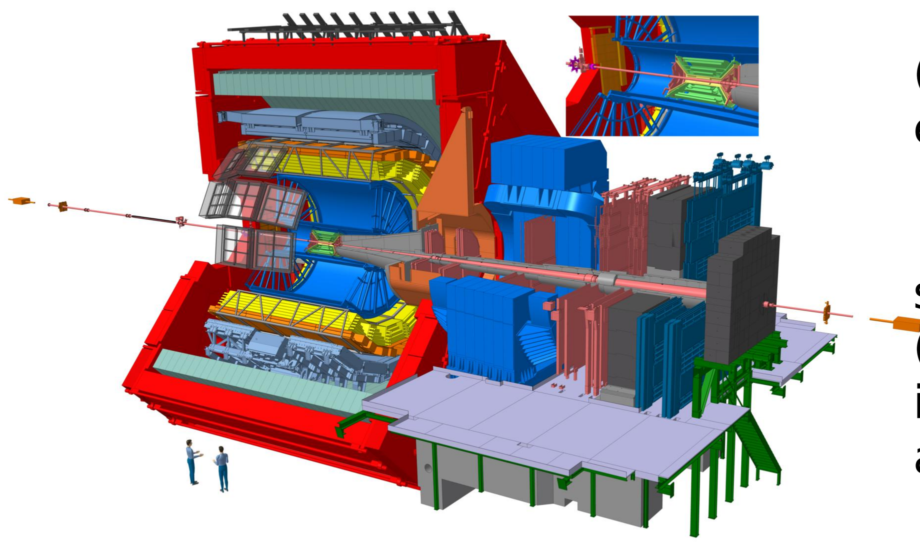
Measurement of electrons from heavy-flavour hadron decays in proton-proton collisions with ALICE at the LHC

Sudhir Pandurang Rode*[1] (for the ALICE collaboration)
1. Discipline of Physics, School of Basic Sciences, Indian Institute of Technology Indore, Indore 453552, India.
*Corresponding author. E-mail: sudhir.pandurang.rode@cern.ch

1. Physics Motivation

- Heavy quarks (charm and beauty) are produced in the early stages of the collision due to their large masses and therefore, they witness the full evolution of the hot and dense Quantum ChromoDynamics (QCD) medium created in heavy-ion collisions.
- Measurements of open charm and beauty hadron production in proton-proton (pp) collisions
  - Test the perturbative QCD predictions in the LHC energy domain.
  - provide the required reference for the measurements in nuclear collisions.
- A significant contribution of electrons from semielectronic decays (branching ratio of the order of 10% [1]) of heavy-flavour hadrons to the inclusive electron spectrum.

2. ALICE experiment

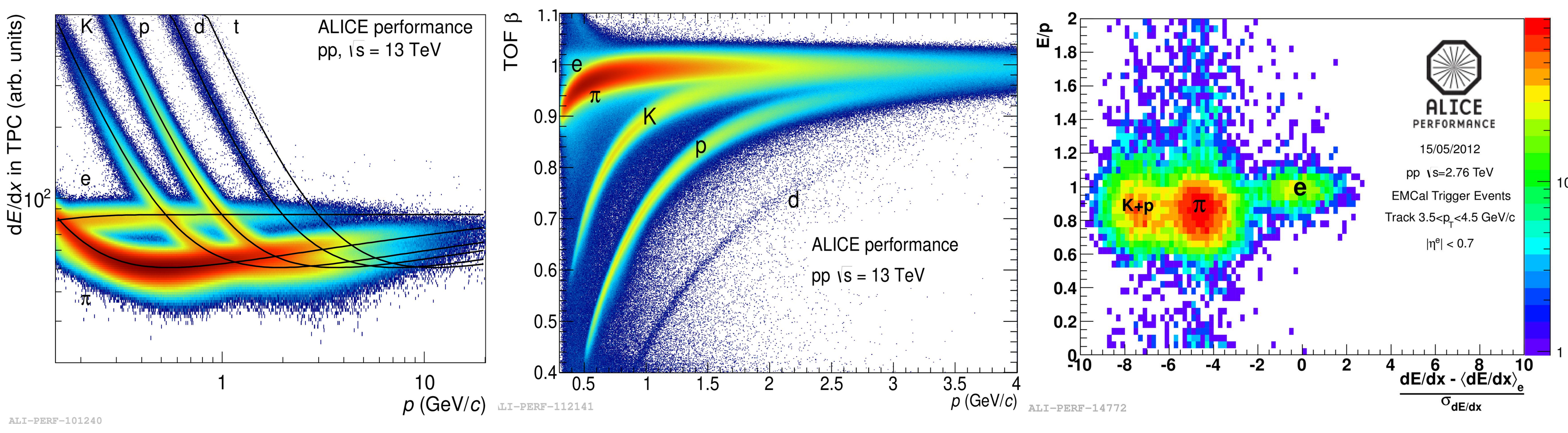


- A Large Ion Collider Experiment (ALICE) is one of the four main experiments at the LHC.
- The main goal of ALICE is the study of Quark-Gluon Plasma (QGP), a state of the strongly-interacting matter in which quarks and gluons are deconfined.

The detectors used in this analysis are:
1) Inner Tracking System (ITS): vertex reconstruction and tracking
2) Time Projection Chamber (TPC): tracking and particle identification
3) Time Of Flight (TOF): particle identification
4) Electromagnetic Calorimeter (EMCal): particle identification and trigger
5) V0: trigger

3. Electrons from heavy-flavour hadron decays (HFE)

(1) Electron identification:



- Specific energy loss of particles in the TPC ($-1\sigma <$ dE/dx - <dE/dx>$|_e < 3\sigma$) and background from kaons and protons at low p_T is suppressed using TOF ($|t - t_e| < 3\sigma$).
- Energy deposited in the EMCal / track momentum ($E/p \sim 1$).

(2) Subtraction of background electrons:

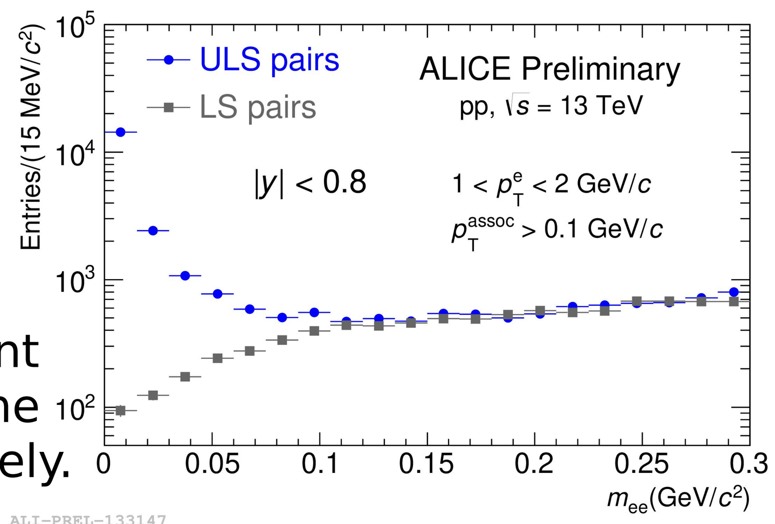
- Electrons from Dalitz decays and photon conversions are the important background sources.
- After the subtraction of hadron contamination ($h(p_T)$) from inclusive yield ($N_{Inc}(p_T)$), photonic background ($N_{Photonic}(p_T)$) is estimated using Photonic-electron tagging method and corrected for the tagging efficiency ($\varepsilon_{tagging}$).
- Raw yield of heavy-flavour decay electrons ($N_{HFe}(p_T)$) is obtained by,

$$N_{HFe}(p_T) = N_{Inc}(p_T) - h(p_T) - N_{Photonic}(p_T)$$

and $$N_{photonic} = \frac{N_{ULS} - N_{LS}}{\varepsilon_{tagging}}$$

with $$\varepsilon_{tagging} = \frac{N_{found}}{N_{photonic}}$$

where, N_{ULS} and N_{LS} are the number of unlike and like-sign pairs with an invariant mass smaller than the requirement on the pair mass ($m_{ee} < 0.14$ GeV/c^2), respectively.

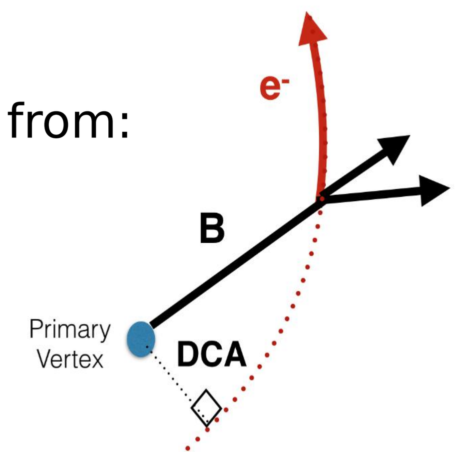


- Raw yield is corrected for the acceptance, reconstruction and electron identification efficiencies to obtain the fully corrected spectrum.

4. Electrons from beauty-hadron decays

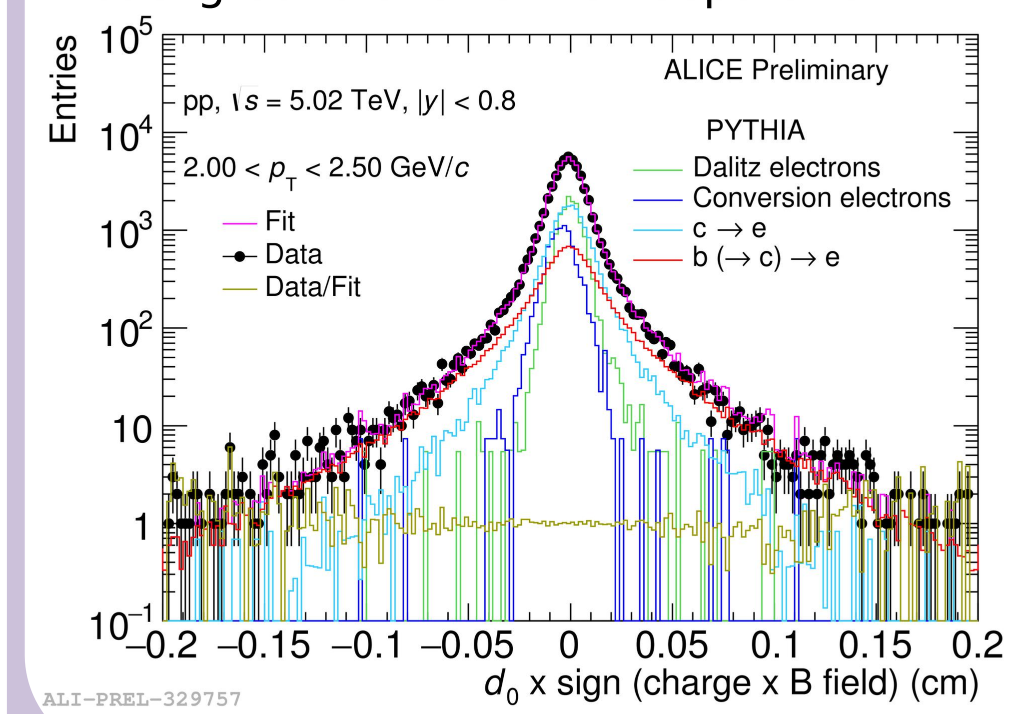
Inclusive sample contains contributions of electrons from:

1. Beauty-hadron semielectronic decays
2. Charm hadron semielectronic decays
3. Dalitz decays
4. Photon conversions



Separation of signal from the background

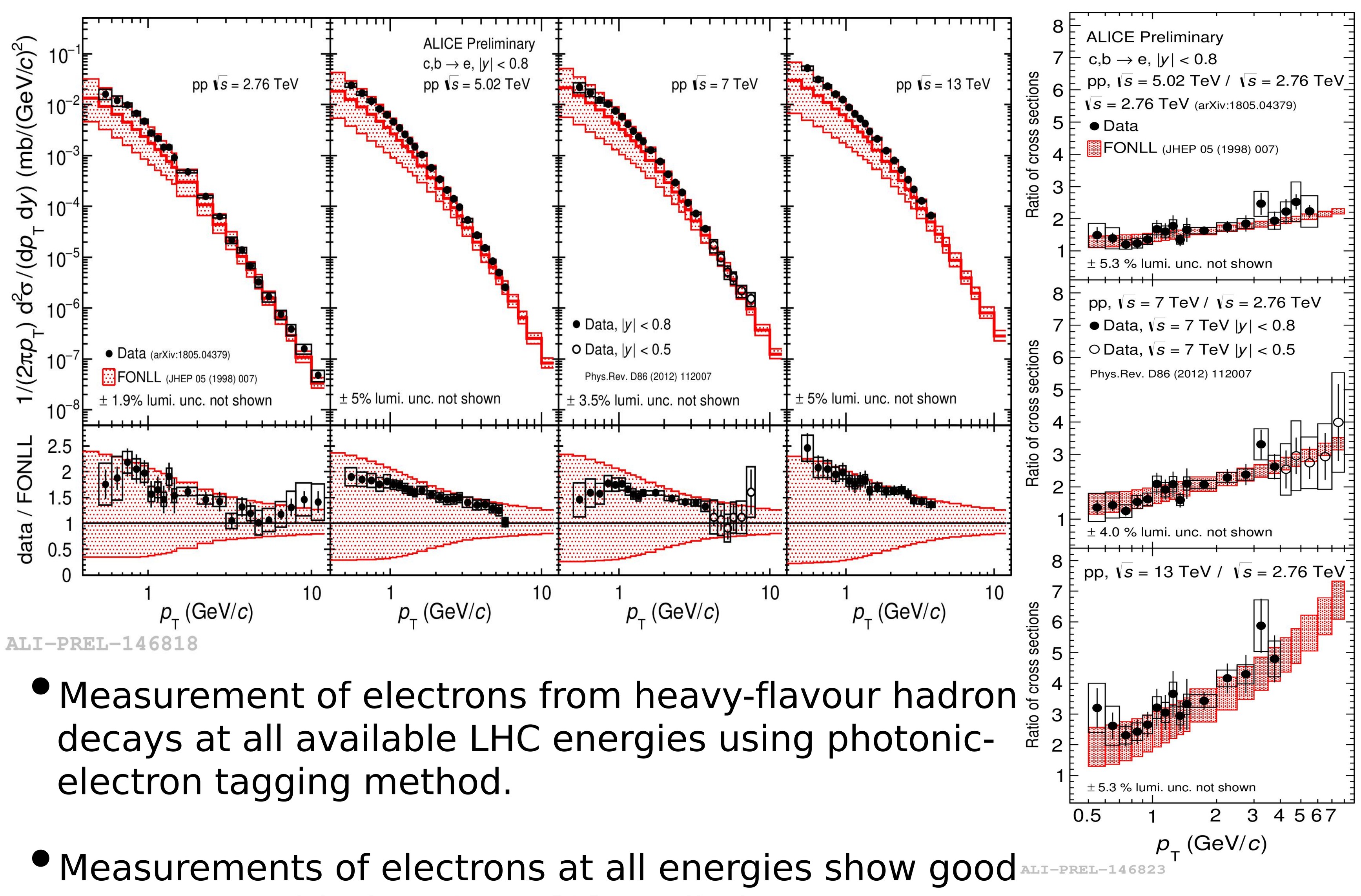
- Distribution of distance of closest approach (d_0) of the electrons to the primary vertex of electrons from different sources is obtained.
- Larger d_0 distribution of the signal electrons compared to the background allows their separation.



Distance of closest approach (DCA) template fit method:

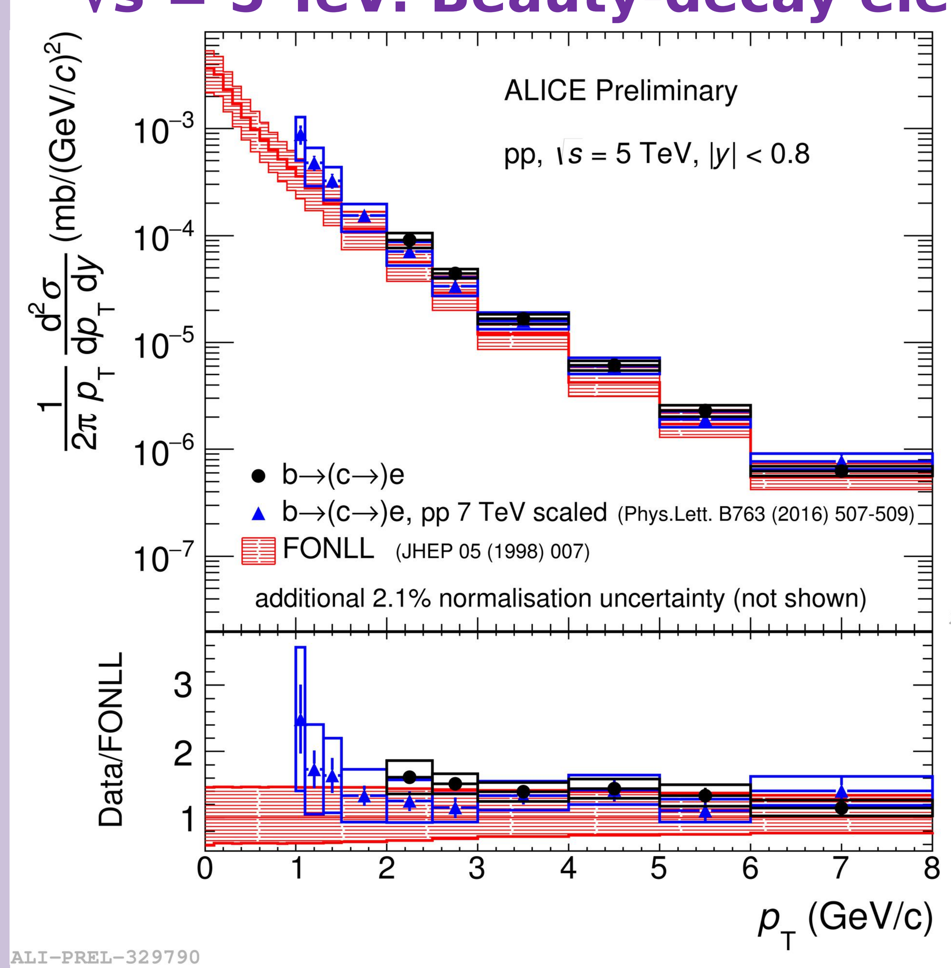
- d_0 distribution of inclusive electrons from the data is fitted.
- d_0 templates of electrons from different sources is obtained from the Monte Carlo simulations.
- Maximum likelihood approach takes into account the finite statistics of MC templates.

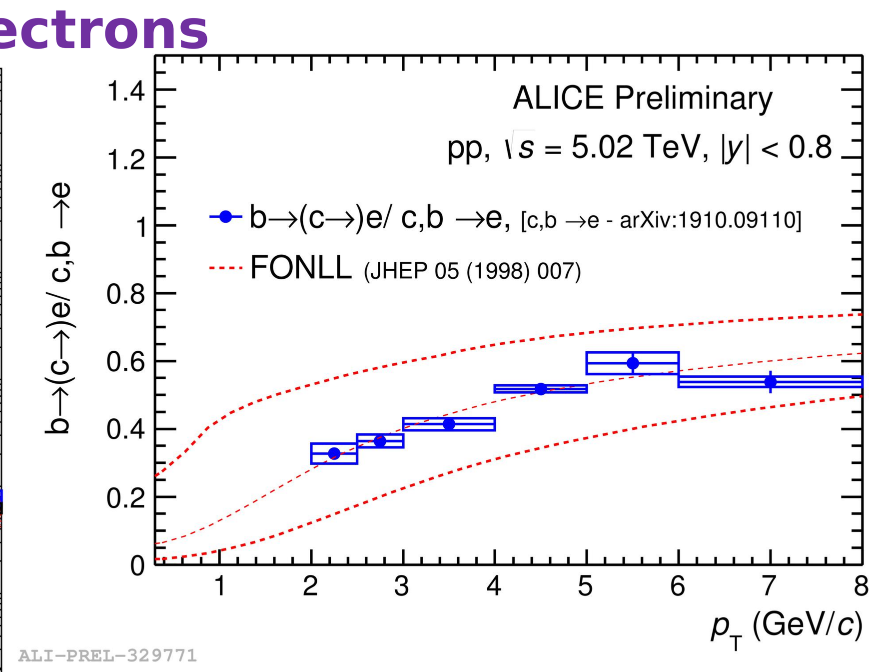
5. Results: Invariant cross-sections in pp collisions at different energies: Heavy-Flavour decay electrons



- Measurement of electrons from heavy-flavour hadron decays at all available LHC energies using photonic-electron tagging method.
- Measurements of electrons at all energies show good agreement with the FONLL [2] predictions.
- The ratios between cross-sections at the different energies further constrain predictions and provide more precise comparisons, since the uncertainties due to factorization scale are reduced.

6. Results: Invariant cross-sections in pp collisions at $\sqrt{s}$ = 5 TeV: Beauty-decay electrons





- The p_T-differential cross-section of electrons from beauty hadron decays is measured at $\sqrt{s}$ = 5 TeV using DCA template fit method ($2 < p_T < 8$ GeV/c) and is in agreement with the FONLL and scaled pp $\sqrt{s}$ = 7 TeV [3].
- These results provide a crucial reference for R_{AA} measurement in Pb-Pb collisions.
- Fraction of b->(c->)e to c, b->e [4] is also in agreement with the model prediction and beauty contribution becomes dominant beyond $p_T > 4$ GeV/c.

8. References:

[1] M. Tanabashi et al. (Particle Data Group), Phys. Rev. D 98, 030001 (2018).

[2] M. Cacciari, M. Greco and P. Nason, JHEP **9805**, 007, (1998).

[3] B. Abelev *et al.* [ALICE Collaboration], Phys.Lett. B763 (2016) 507-509.

[4] S. Acharya *et al.* [ALICE Collaboration], arXiv:1910.09110 [nucl-ex]..