Detector specifications and performance studies

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Outline:

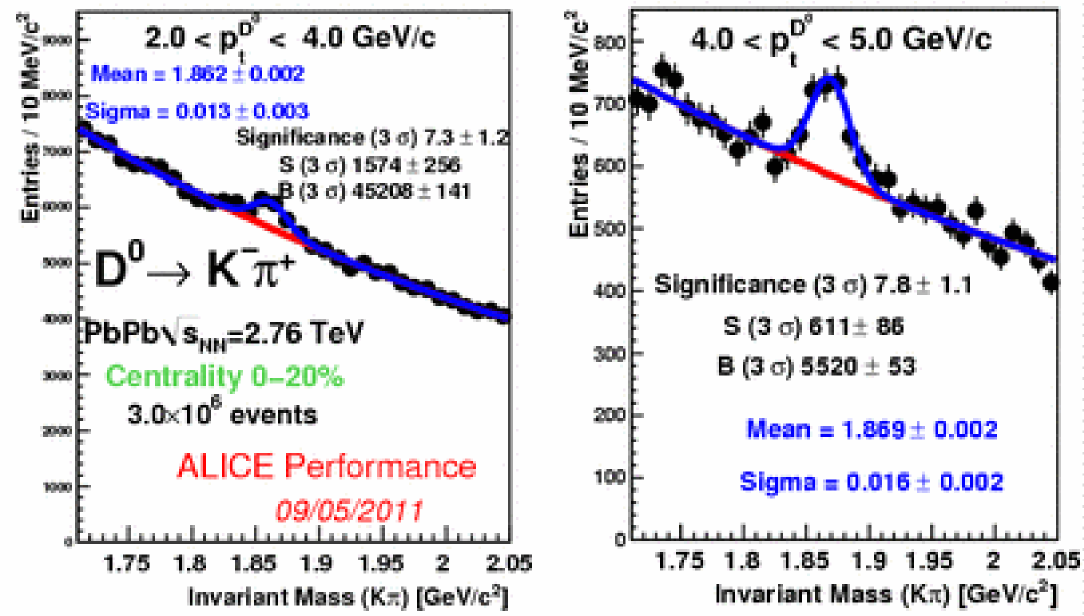
- introduction
- available tools to estimate the physics performance of the upgrade
- PID studies
- considerations on occupancy & radiation load

Introduction

- I’m not going to cover all the topics under study within this wg
- I will give an overview of the methods developed so far to simulate the physics performances of the upgraded ITS detector
- I will also shortly present the ongoing studies to assess the relevance of PID capabilities for an upgraded ITS

Introduction

- Why should we need PID capabilities from ITS ?
  - In present analysis we rely on TPC+TOF PID, and this is very important for the study of low p_T charmed hadrons



Introduction

- PID capabilities paired to high standalone tracking performances (operated at a L2 trigger) might reveal to be the key combination for a 2^{nd} generation detector

- High standalone tracking efficiency would open the possibility to a level 2 **(latency 100μs)** trigger based on topological identification of open heavy flavour hadrons

How to simulate the detector performances ?

1. fast estimation tool

   → S. Rosseger, next talk, (input to 3 & 4)
2. slow simulation integrated within AliRoot
   - standard "event generator + transport code + reconstruction code" procedure
3. hybrid approach
   - use the existing MC simulations and improve the track parameters "on the fly" based on the expected improved performances of the upgraded ITS
4. pure MC smearing
   - only event generator + smearing of the track parameters according to parameterized response of TPC+$ITS_{upgrade}$ detectors

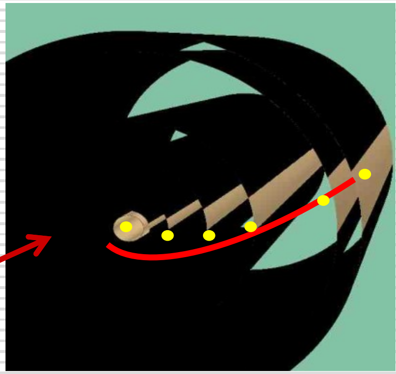
Tools: what can they provide ?

1. fast estimation tool (→ S. Rosseger talk)
   - Impact parameter resolution and momentum resolution
   - tracking efficiency estimate
2. Slow Monte Carlo simulation
   - Simulated events as in the standard Aliroot framework (ESD,AOD)
3. Hybrid approach (→ M. Mager talk)
   - Improvements in Significance and S/B for existing analyses ($D^0 \rightarrow K\pi$, $\Lambda_c \rightarrow pK\pi$, $B \rightarrow J/\psi + X$)
4. pure MC smearing
   - fast way to study more exotic channels (e.g. exclusive Beauty)

A. Mastroserio, C.Terrevoli

Slow MC simulation

- Goal: replace in AliRoot the actual ITS “module” with a new one ($ITS_{upgrade}$) which has very flexible layout configuration
- From a configuration file (Config.C) one can set:
  - n. of layers
  - radii of the layers
  - material budgets
  - layer segmentation into modules (new)
  - module segmentations (i.e. spatial resolution)
  - *new beam pipe*



- as a consequence of such a flexibility the geometry has to stay simple (→ cylinder)

A. Mastroserio, C.Terrevoli

Slow MC simulation

- The implementation of this flexible geometry was *per sè* an easy task, but the adaptation of the ALICE reconstruction code to the new flexible geometry is not
- status of reconstruction with $ITS_{upgrade}$
  - clusterization ✔
  - stand-alone ITS reconstruction
    - track finding
      - pp ✔
      - PbPb to be optimized
    - track fitting ✔
  - combined TPC+$ITS_{upgrade}$ to be done

Option which can be implemented in the tracking: ideal (from MC truth) pattern recognition → *the tracking efficiency has to be evaluated differently*

M.Mager, A.Rossi, S.Moretto,C. Terrevoli

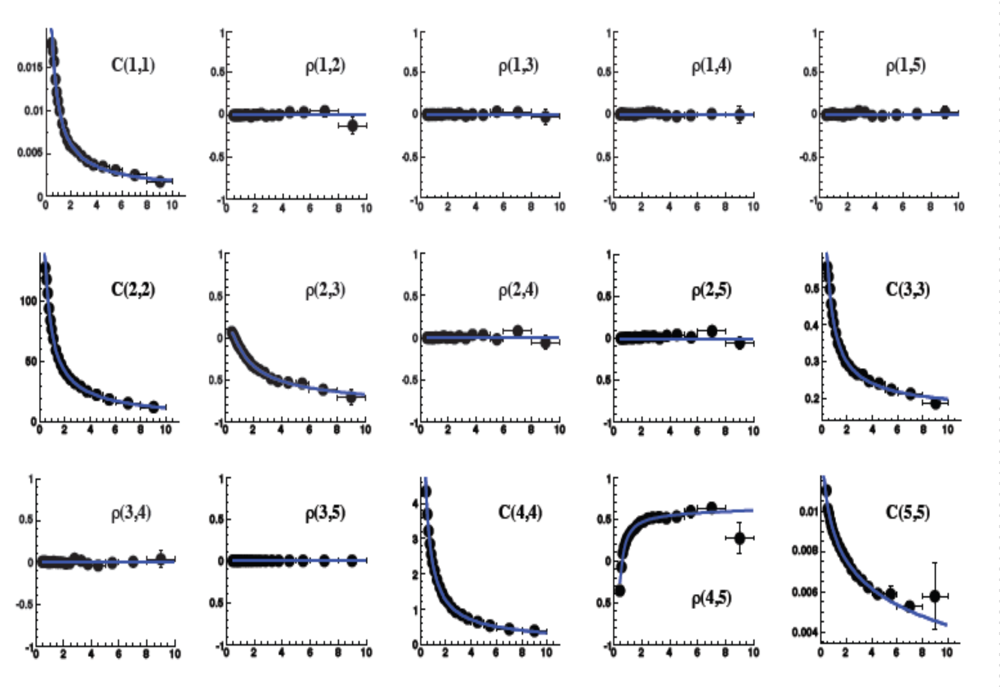
Hybrid approach (M. Mager talk)

- Input:
  1. Analysis Object Data (AOD) where the hadronic charm decay candidates are stored, from existing MC simulations
  2. track I.P. and transverse momentum resolution vs. p_T (for different particle species) expected for the $ITS_{upgrade}$
- Method:
  - candidate by candidate (for Sig. and Back.), the parameters of the decay tracks are improved (from input 2), preserving the correlations in the covariance matrix of the track
  - a new candidate is built with the improved tracks
  - kinematical and topological cuts are applied to the candidates
  - invariant mass analysis (as for data with actual detector)
- Output:
  - S, S/B and Significance for a given L_{int} as compared to the corresponding values with present ITS

C. Terrevoli

Pure MC smearing

- Input:
  - track I.P. and transverse momentum resolution vs. p_T (for different particle species) expected for the $ITS_{upgrade}$
  - other elements of the covariance matrix which describes a tracks from a parameterization of the present tracking system



C. Terrevoli

Pure MC smearing

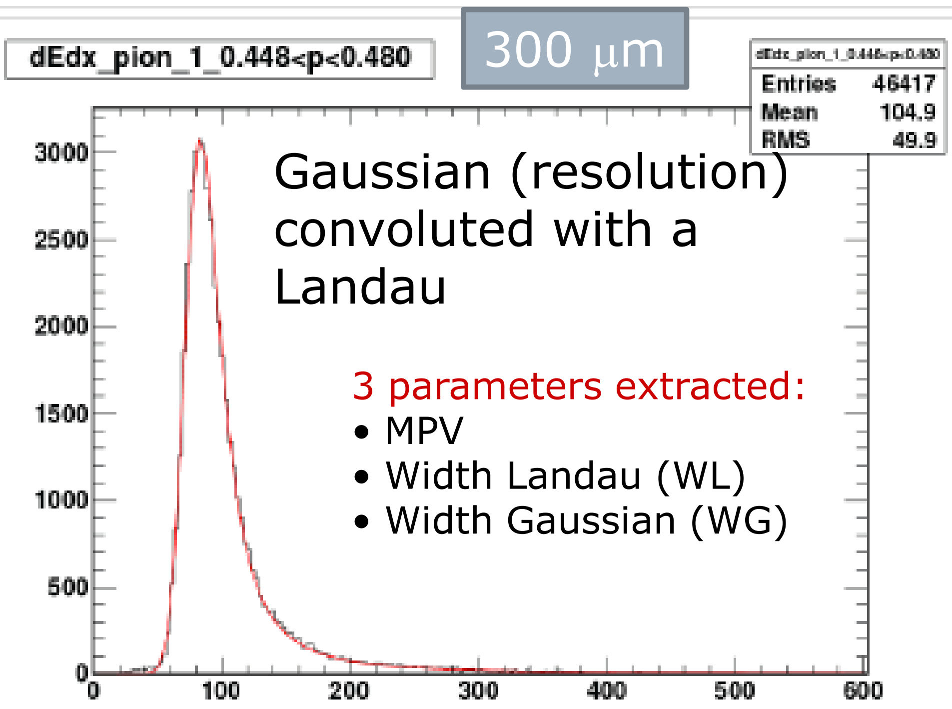
- Input:
  - track I.P. and transverse momentum resolution vs. p_T (for different particle species) expected for the $ITS_{upgrade}$
  - other elements of the covariance matrix which describes a tracks from a parameterization of the present tracking system

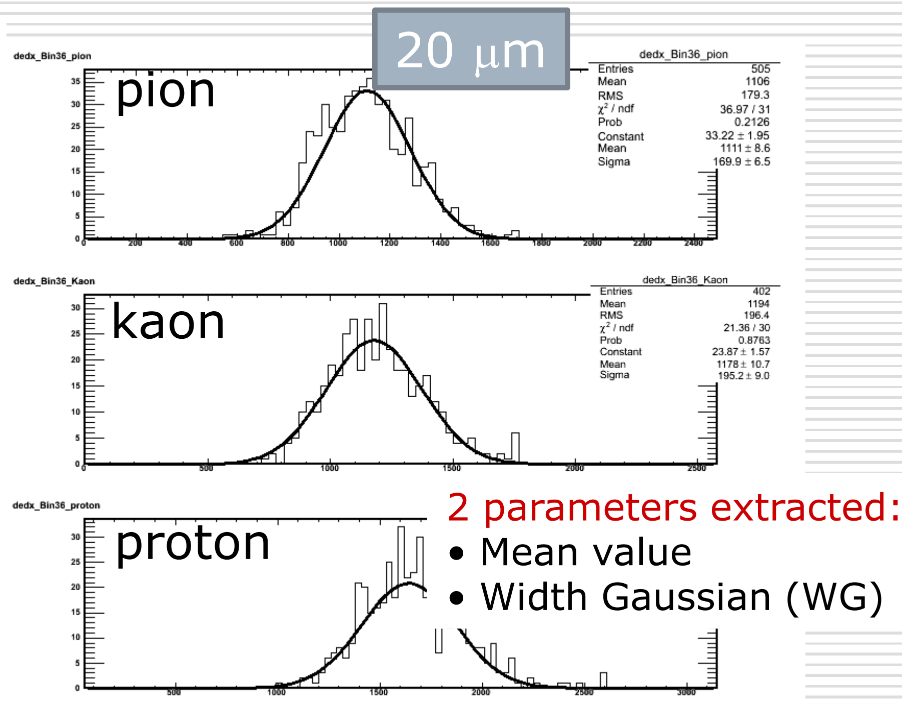
- Method:
  - particles from event generator are “smeared” according to this parameterized response of the covariance matrix and to the input IP and p_T resolutions
  - candidates are built from these tracks
  - physics analysis on these candidates to estimate S, S/N and Significance for different channels

S.Bufalino, S.Piano, F.Prino

PID studies

- two approaches developed, providing consistent results: 1) Fast simulation, 2) transport code
  1. Fast simulation: a parameterization of the dE/dx is used. Given a particle, in each layer the energy loss is extracted randomly from such a parameterization

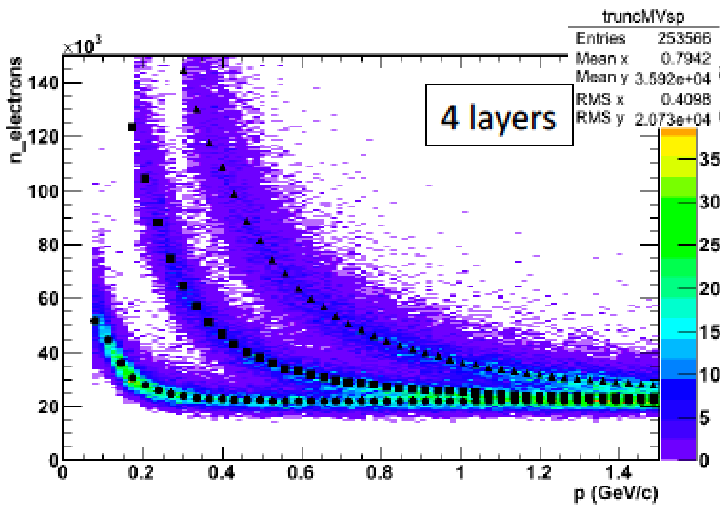


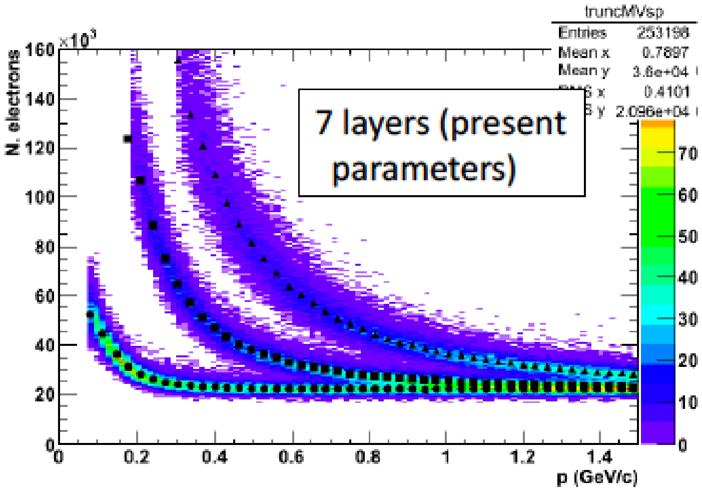


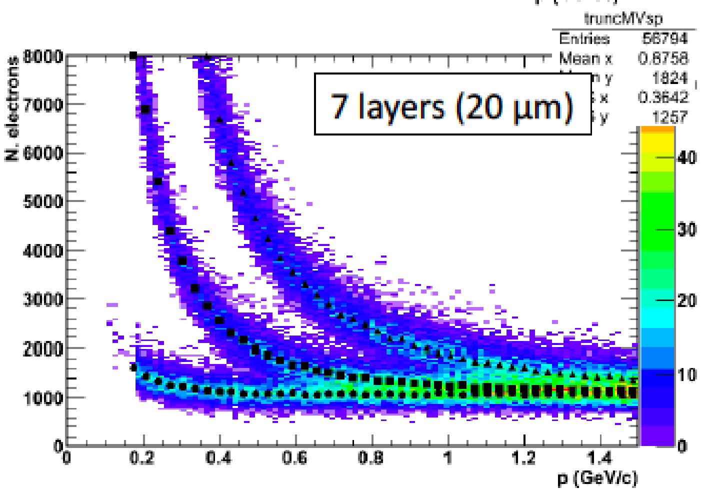
PID studies

S.Bufalino, S.Piano, F.Prino

Truncated mean







Abundances = 1/3 for π^+, K^+, p

For 7 layers (20 μm): noise with gaussian smearing of 20 electrons

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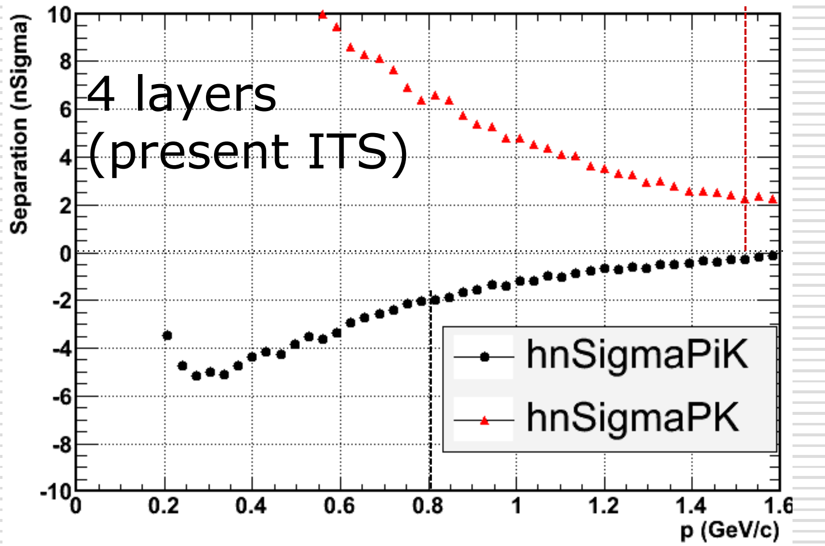
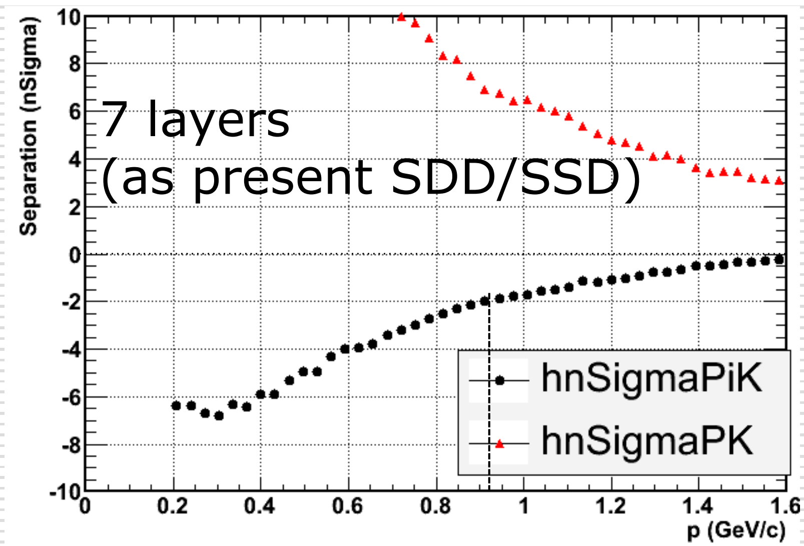
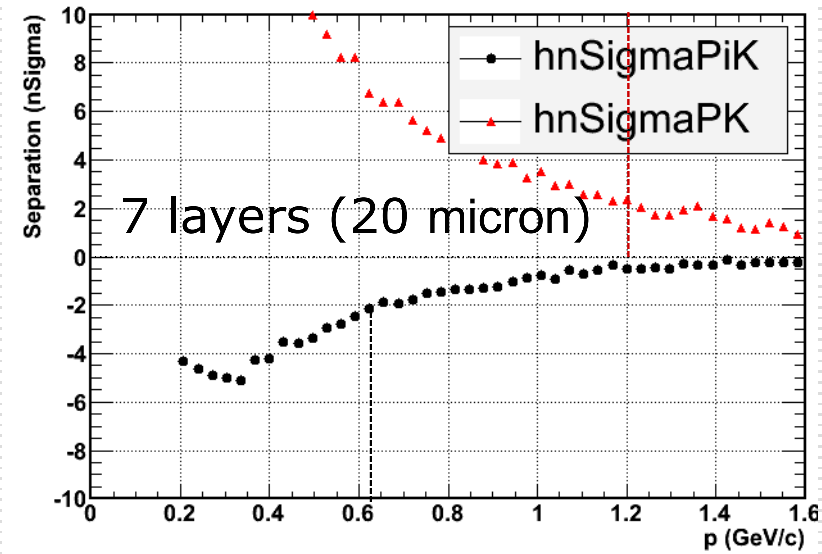
S.Bufalino, S.Piano, F.Prino

PID studies: particle separations





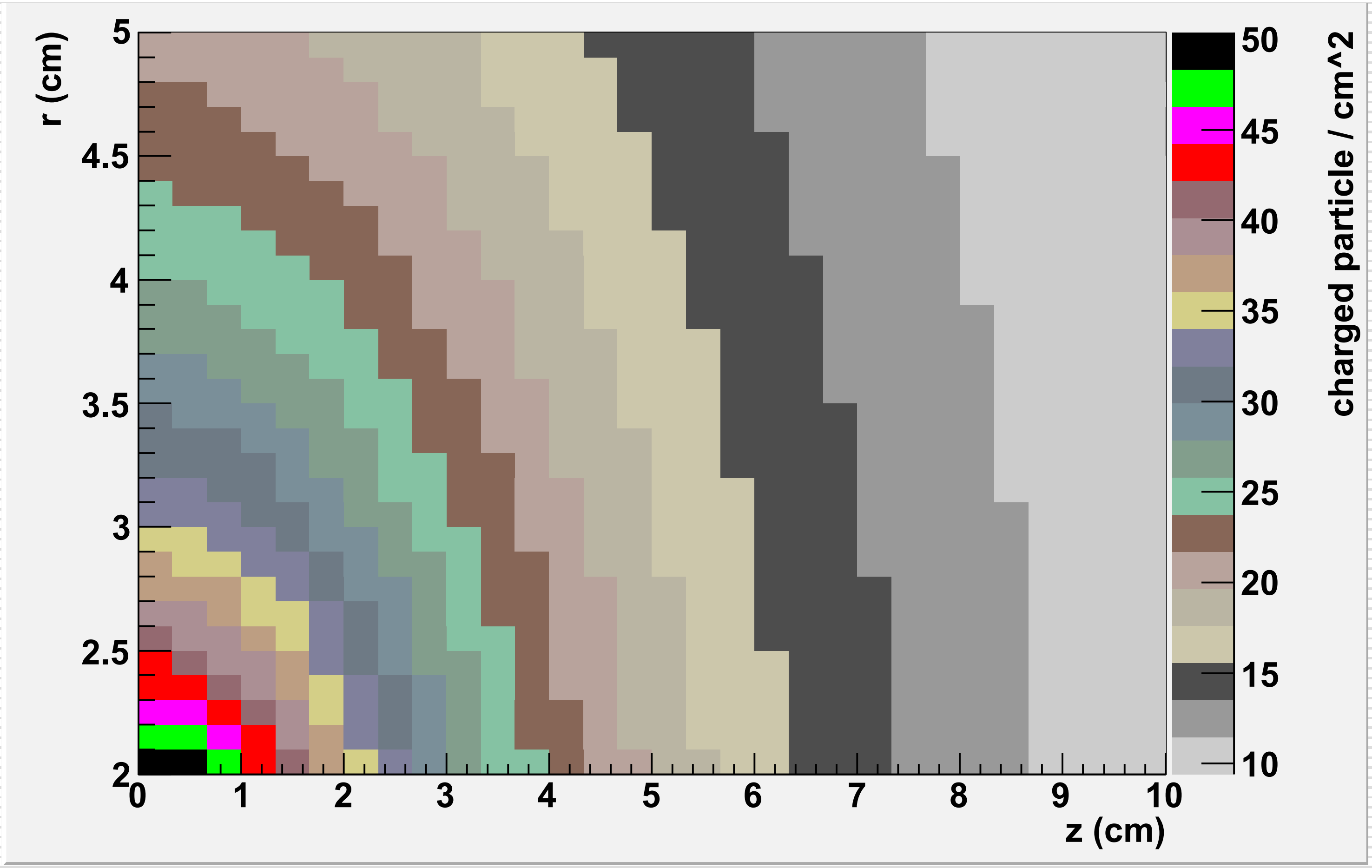


Actually much more was done, e.g. the simulation of a Time Over Threshold approach (à la ATLAS)

To be done: application to physics cases

Occupancy estimate

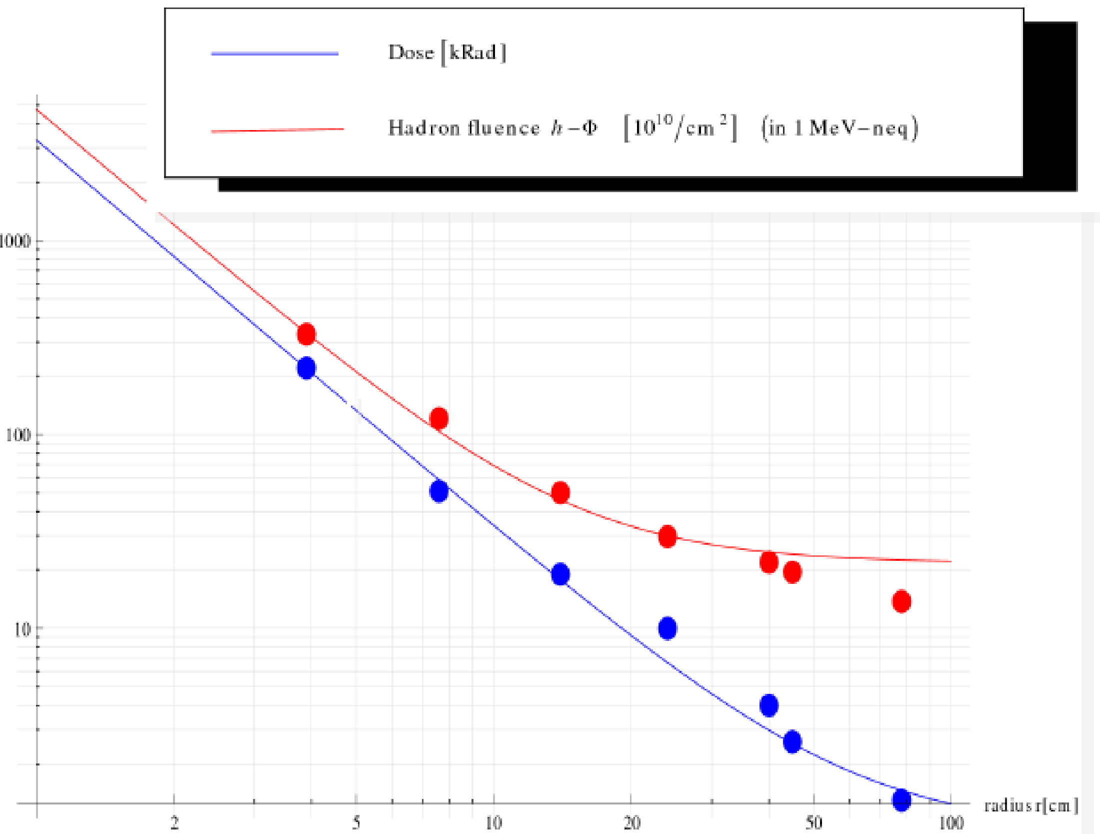
- Input: measured dN/dη(0-5%) = 1600, scaled to $\sqrt{s_{NN}}$=5.5 TeV
  → occupancy at z=0 and r=3.7 cm: **28 charged tracks / cm^2**



UPDATED Estimate on Doses and Hadron fluences

Data points for a "ALICE 10-years running scenario" (see backup slide)

Stefan Rossegger



Simple Fit (valid for ~ r<100cm):

$$Dose \approx \frac{3324}{r^2}[kRad]$$

$$h_\Phi \approx \frac{4731}{r^2} + 22[10^{10}/cm^2]$$

Radius [cm]	2.0	2.2	3.9
Dose [kRad]	830	680	220
h–Φ $[10^{10}/cm^2]$	1204	999	333
(old) NF $[10^{10}/cm^2]$	200	170	80

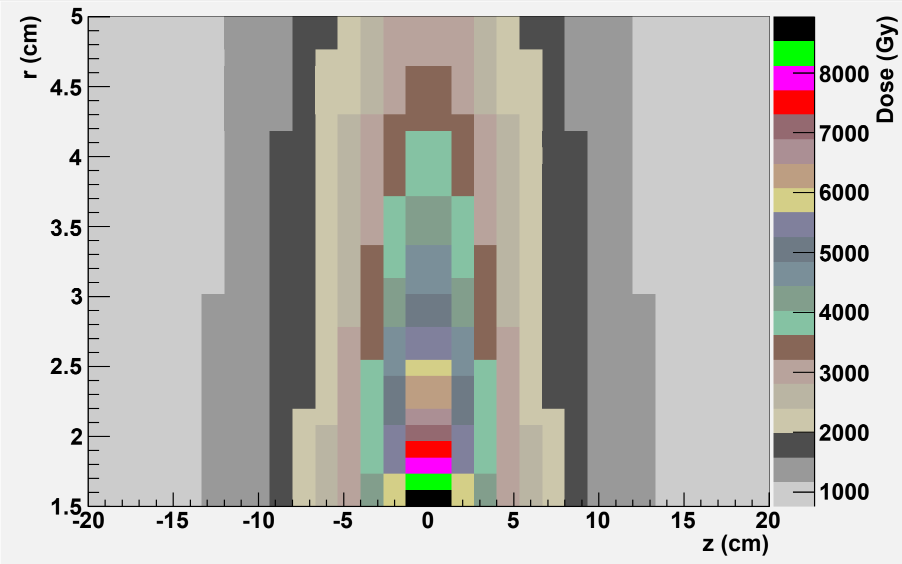
[1] ALICE-INT-2009-008, B.Pastircak et.al., "Radiation zoning calculations for ALICE experiment update", 2009

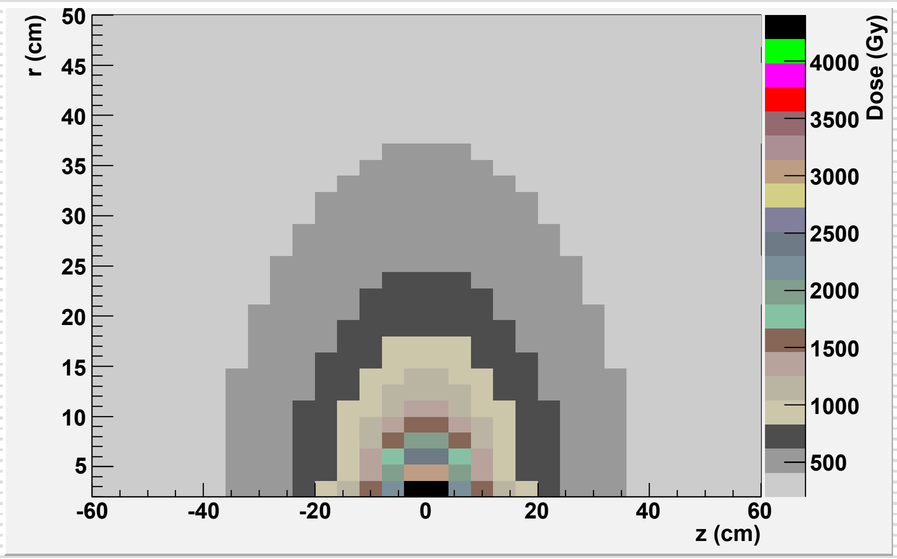
[redacted]

[redacted]

Dose distribution versus r and z

- In previous plot you have seen the average distribution over each ITS layer (and its extrapolation).
- One can obtain from that the z-r differential distributions (and in particular the maximum dose, at z=0, versus r)





- Previous dose estimates are still valid (pp dominates)
- We can simply extrapolate to smaller radius (the component from beam-beam interaction dominates the total dose)

Spare slides

Stefan Rossegger

Detector	SPD1	SPD2	SDD1	SDD2	SSD1	SSD2	TPC(in)	
Radius [cm]	3.9	7.6	14	24	40	45	78	(see [1], table 4)
Dose [kRad]	***220***	***51***	***19***	***10***	***4***	***2.6***	***1.3***	(see [1], table 4)
$NF_{[1]}$ [$10^{10}/cm^2$]	80	56	45	42	41	41	36	(see [1], table 4)
$NF_{[2]}$ [$10^{10}/cm^2$]	85	60	49	45	43	42	39	[2], Tab. 5
Scale ($NF_{[1]}$ to $NF_{[2]}$)	0.94	0.93	0.91	0.93	0.95	0.98	0.92	
h-Φ [$10^{10}/cm^2$] in 1MeV n-equ.	350	130	55	32	23	20	15	[2], Tab. 6
Rescaled h-Φ [$10^{10}/cm^2$] in 1MeV n-equ.	**328**	**121**	**50**	**30**	**22**	**19**	**14**	

Rescaled Hadron-Flux in 1MeV neutron-equivalent

[1] ALICE-INT-2009-008, B.Pastircak et.al., "Radiation zoning calculations for ALICE experiment update", 2009
https://edms.cern.ch/document/992721/1

[2] ALICE-INT-2004-017, A.Morsch et.al, "Radiation in ALICE Detectors and Electronics Racks",2004
https://edms.cern.ch/document/358706/1

ITSupgrade Geometry: Sectors

single sector →

20 sectors in this example

Each layer is constituted by n **cylindrical sectors**:

- the number of sectors is set in the Config
- possibility to switch between configurations:
  - a)cylinder without segmentation
  - b)cylinder made by n sectors
- the same number of sectors in each layer (→can be modified)
- each sector is made of silicon and copper
- no overlaps between volumes

Estimate on Doses and Neutron fluences

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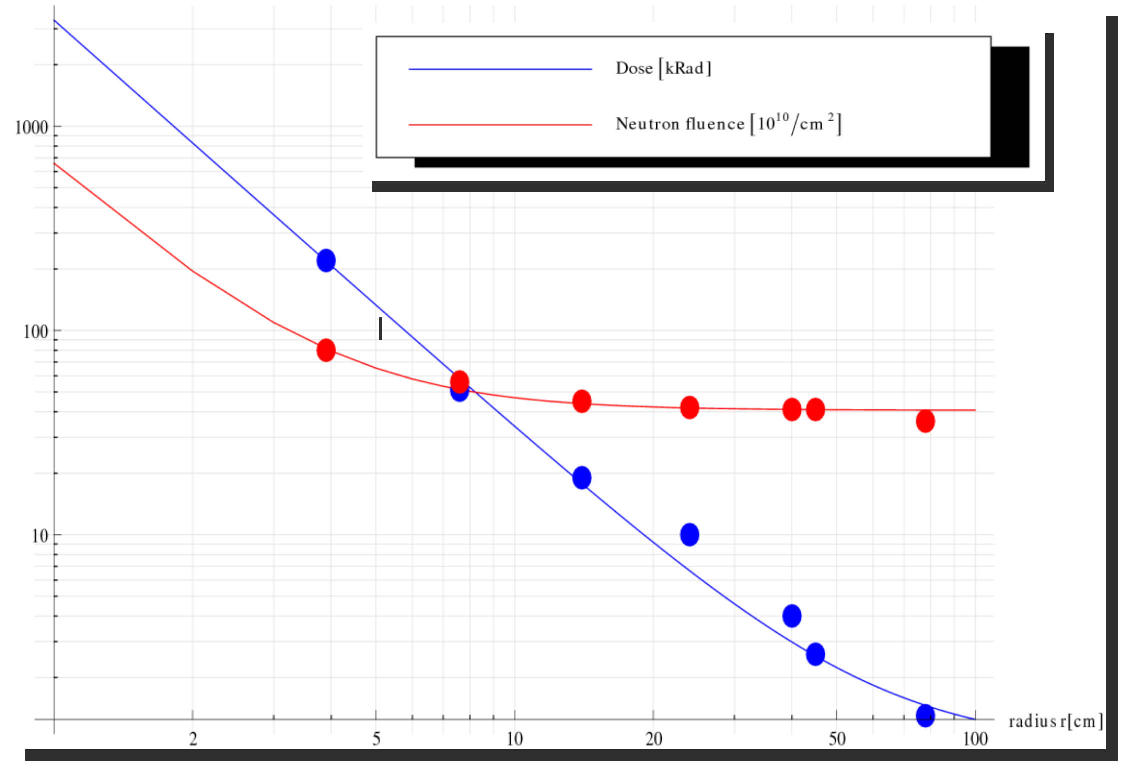

Stefan Rossegger

[redacted]

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Mandate of wg2 (1/2)

Define the detector specifications from physics requirements (WG2⇆ WG1)

Simulate the detector performance based on the detector design and implementation studies (WG1⇆ WG3-5)

- Study particle density and radiation load for the innermost layer
- Define detector specifications at mid rapidity
    - Number of layers and their geometry
    - Hermeticity, segmentation and alignment
    - Material budget
    - Detector efficiency, signal dynamic range and linearity
    - Event time resolution
    - Event readout time (Integration time for MIMOSA)
    - Definition of trigger algorithms and primitives

Mandate of wg2 (2/2)

- Study the possibility of extending the tracking at large rapidity (forward/backward) (in collaboration with muon-spectrometer upgrade group)
  - vetexing and tracking
  - PID
  - timing and triggering
- Simulate detector response and performance
- Several design options should be studied
  - A. present ITS + Pixel Layer0
  - B. Pixel Layer0 + replace SDD with a combination of Strip and Pixel layers
  - C. Replace entire ITS with a combination of Pixel and Strip detectors
  - D. C + extend acceptance to large rapidity
- Prepare the “Detector specifications and performance” chapter of the Technical Proposal