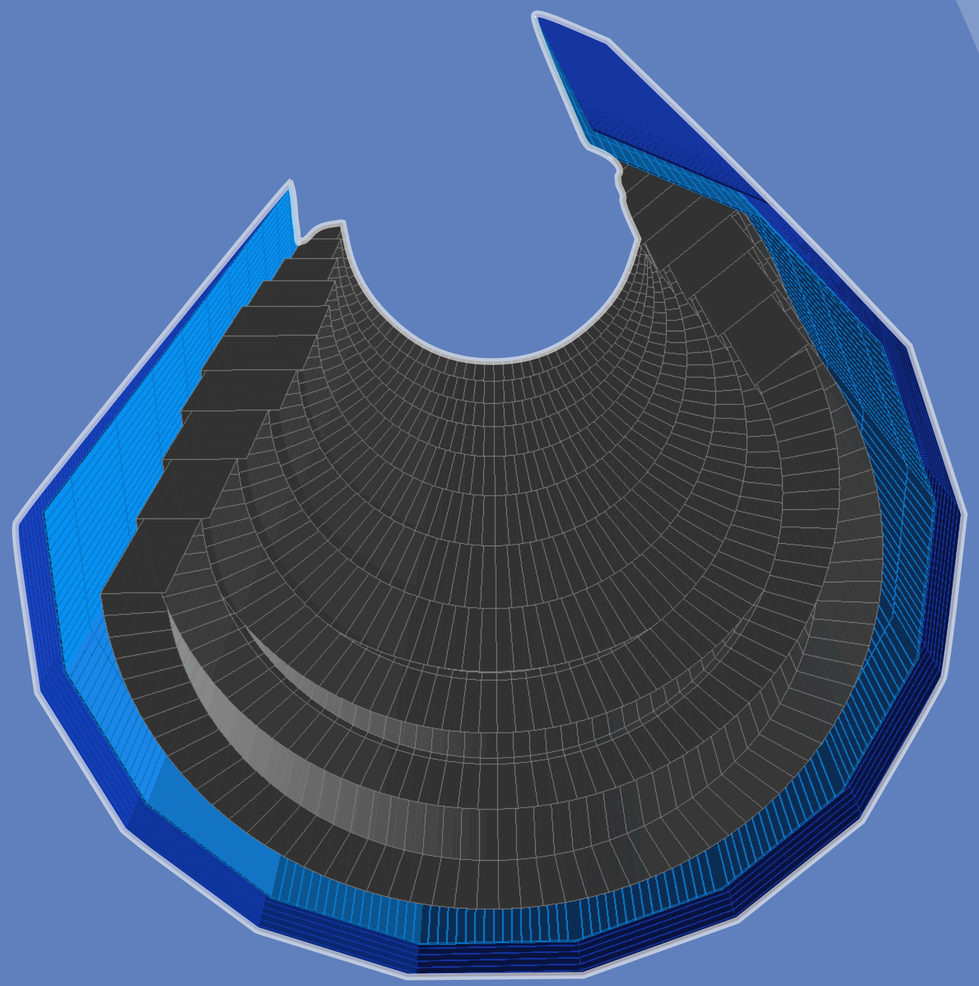


Status of MC simulations for the MID

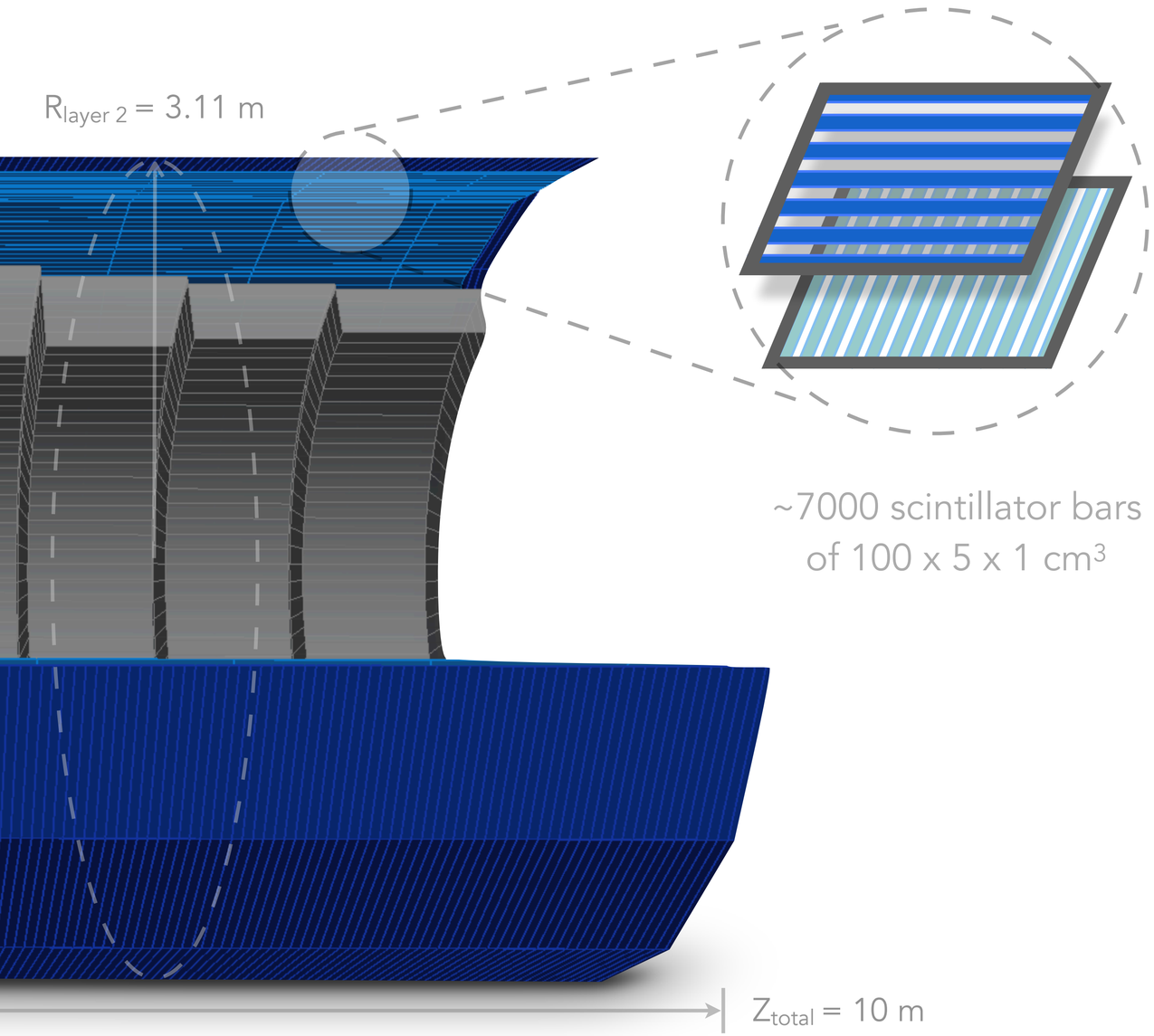
Jesús Eduardo Muñoz Méndez

ALICE Mexico MID meeting
15 Apr, 2026

Instituto de Ciencias Nucleares UNAM

ALICE

MID (plastic scintillator option)



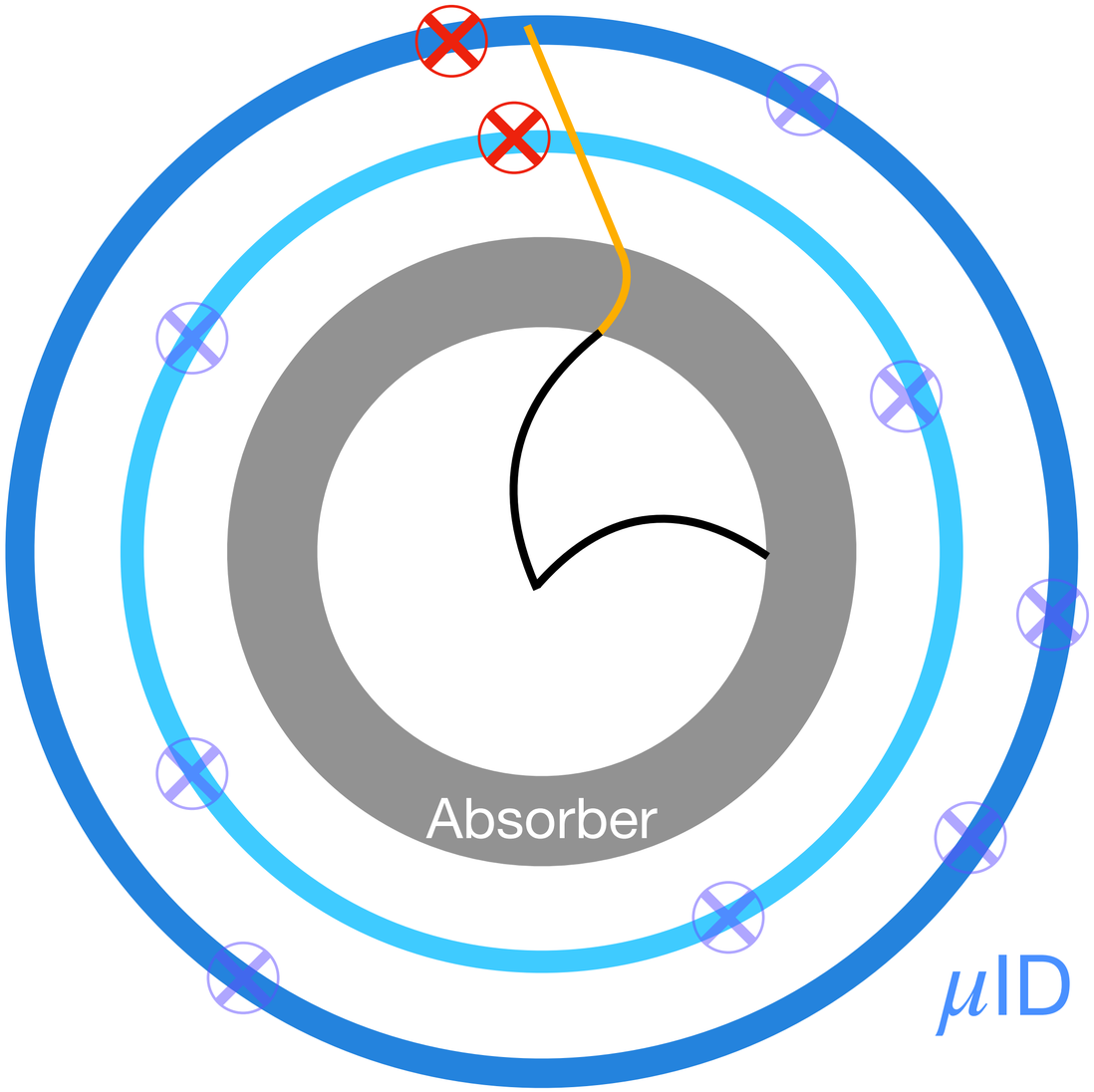
Baseline option:

Plastic scintillator bars equipped with wave-length shifting fibers and SiPM

- **simplicity** (no need of gas mixture)
- **excellent timing resolution** (ns)
- **good performance on light-yield output** (around 40 photoelectrons)

	Absorber	MID layer 1	MID layer 2
Inner radius (m)	2.20	3.01	3.11
Outer radius (m)	2.90	3.02	3.12
Total length (m)	10	10	10.5
No. of sectors in z	9	10	10
No. of sectors in φ	1	16	16
Scintillator bar length (cm)	–	99.8	123.5
Scintillator bar width (cm)	–	5.0	5.0
Scintillator bar thickness (cm)	–	1.0	1.0

Muon tagging

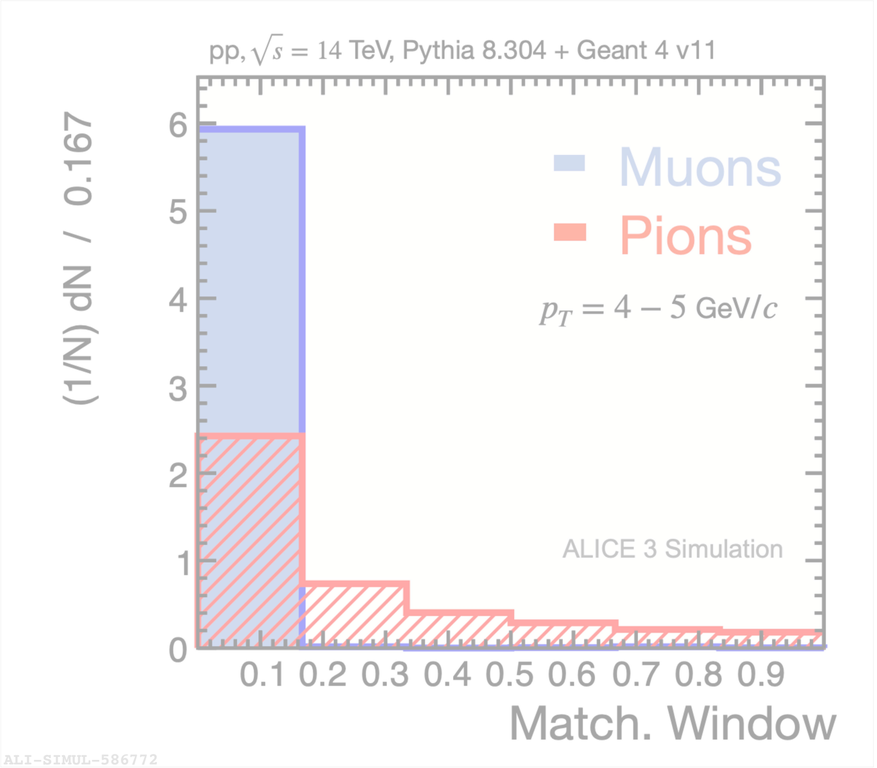


- Muon tagging is done by matching **activated bars** in the MID with tracks from the tracker
- All primary tracks are extrapolated to the MID
- Selection criteria are obtained via **boosted decision trees (BDT)**

BDT training

How to pick a set of variables for the training of the BDT?

- Momentum before the absorber
- **Matching window ($\Delta\eta$, $\Delta\phi$)**
- Number of bars activated around the extrapolation
- Highest **energy deposition** in the activated bars around to the extrapolation
- **Arrival time**



$$\mathrm{MW} = \sqrt{\Delta\eta^2 + \Delta\varphi^2} = \sqrt{(\eta^{\mathrm{extr.}} - \eta^{\mathrm{bar}})^2 + (\varphi^{\mathrm{extr.}} - \varphi^{\mathrm{bar}})^2}$$

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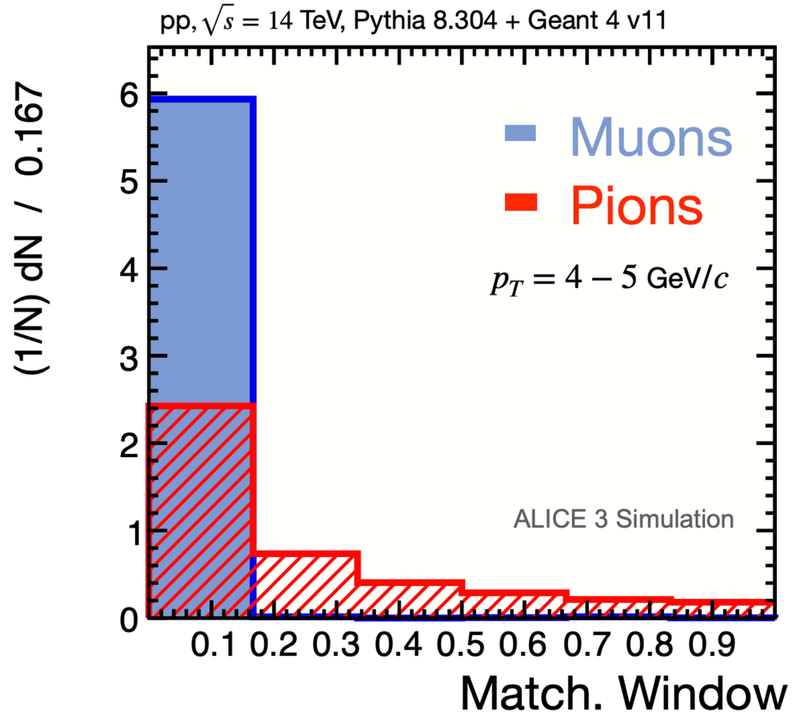

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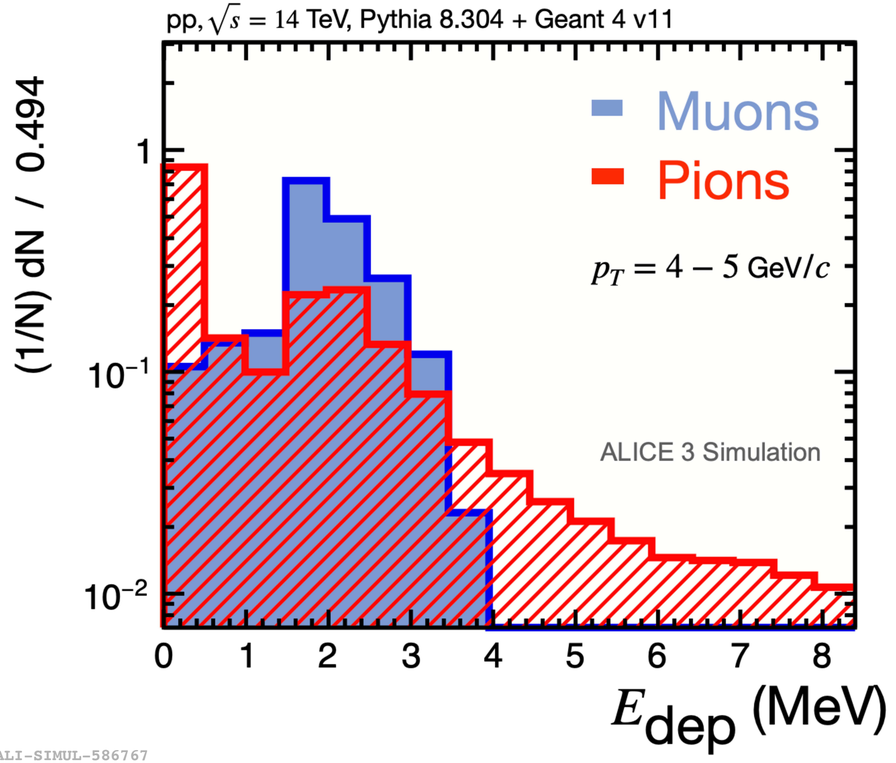

ALI-SIMUL-586767

BDT training

How to pick a set of variables for the training of the BDT?

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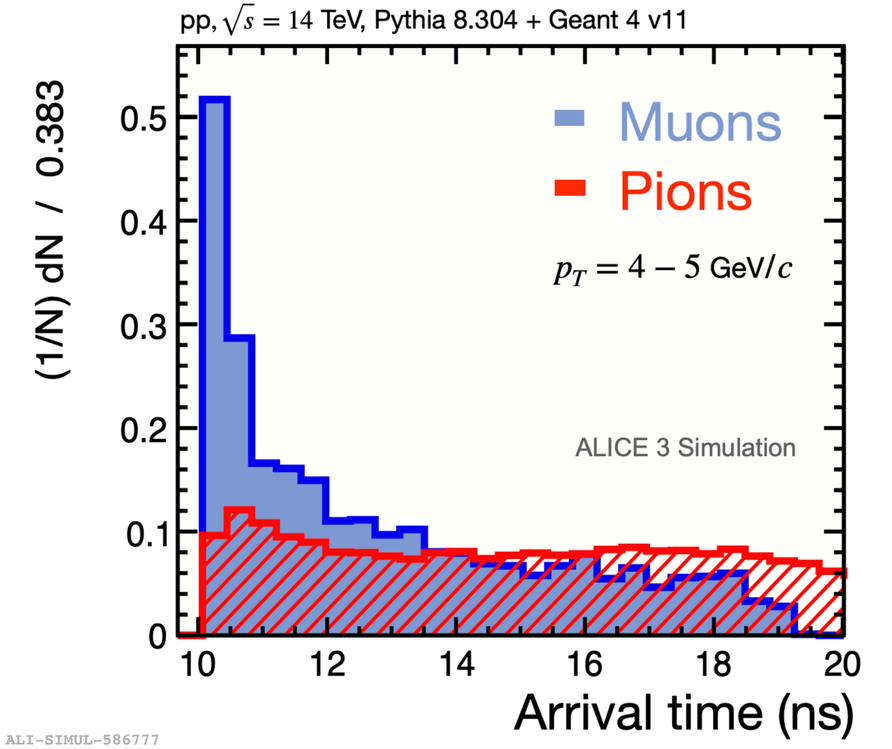
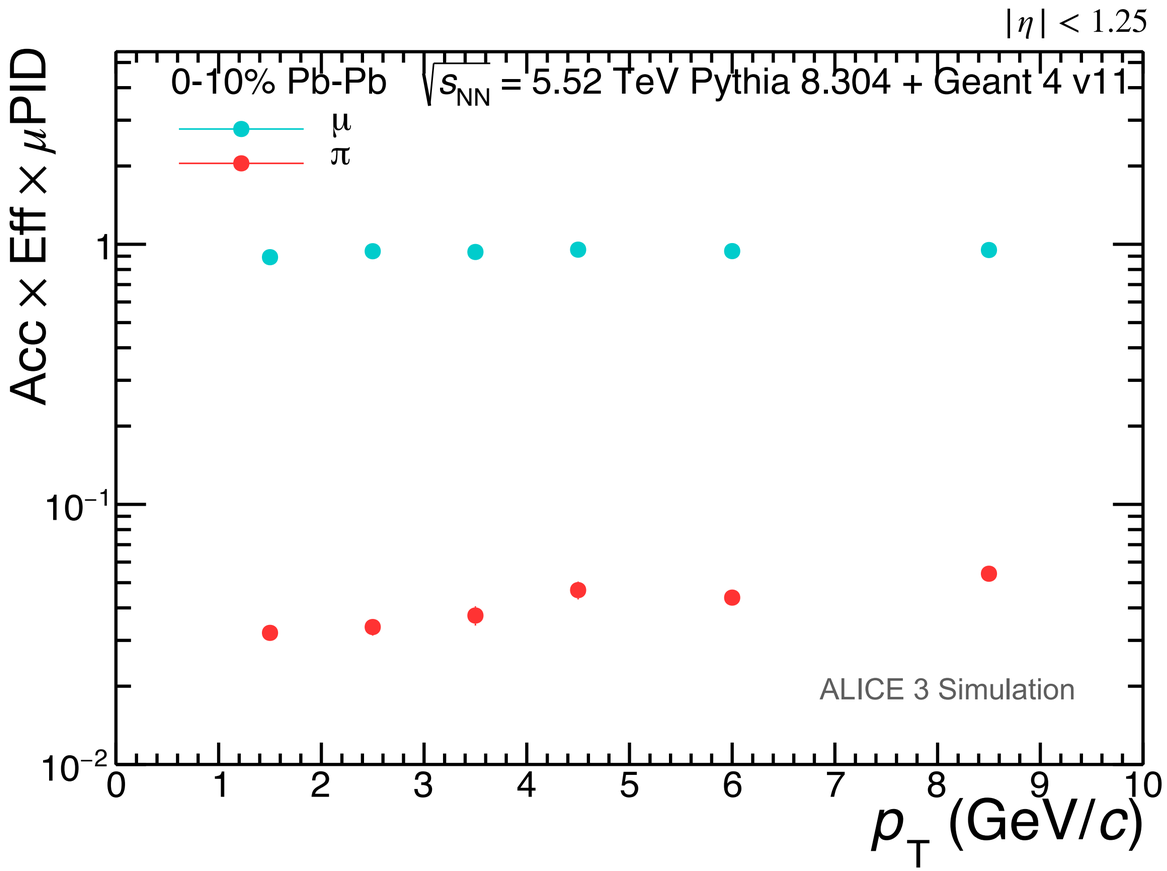
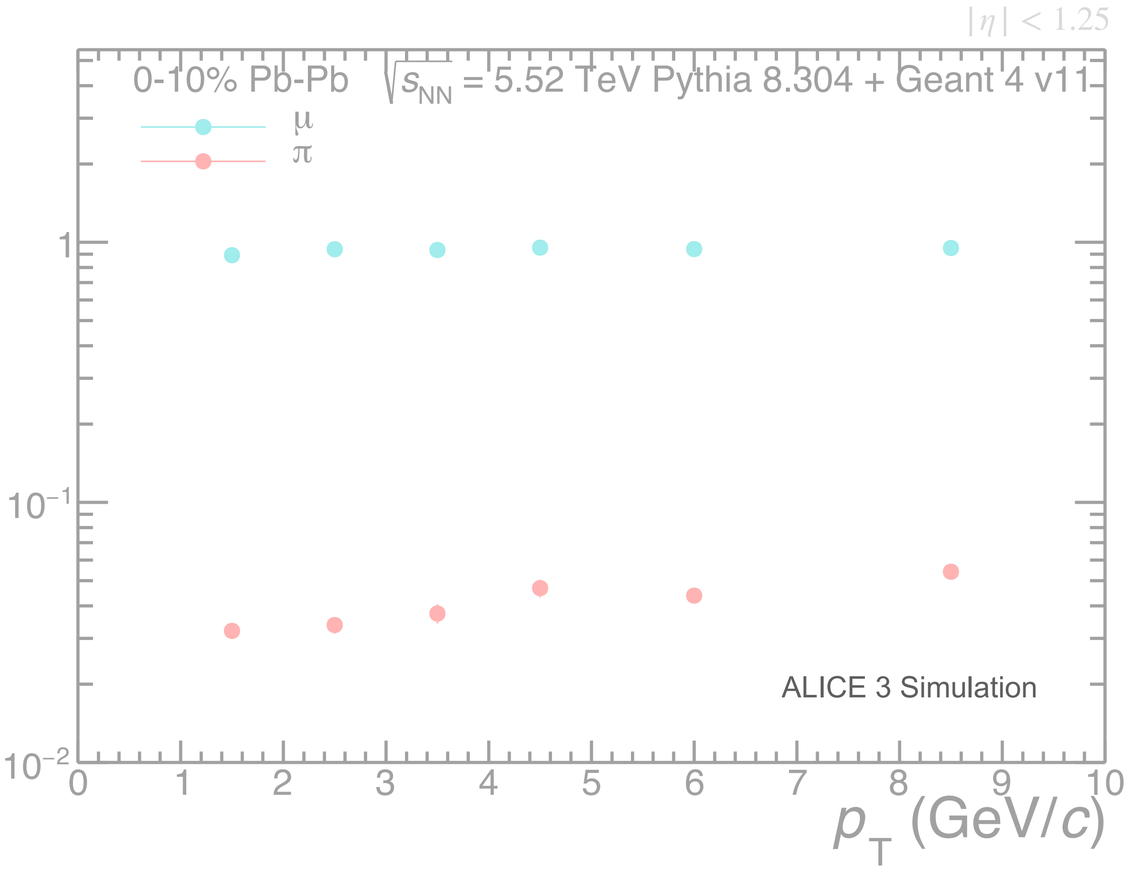


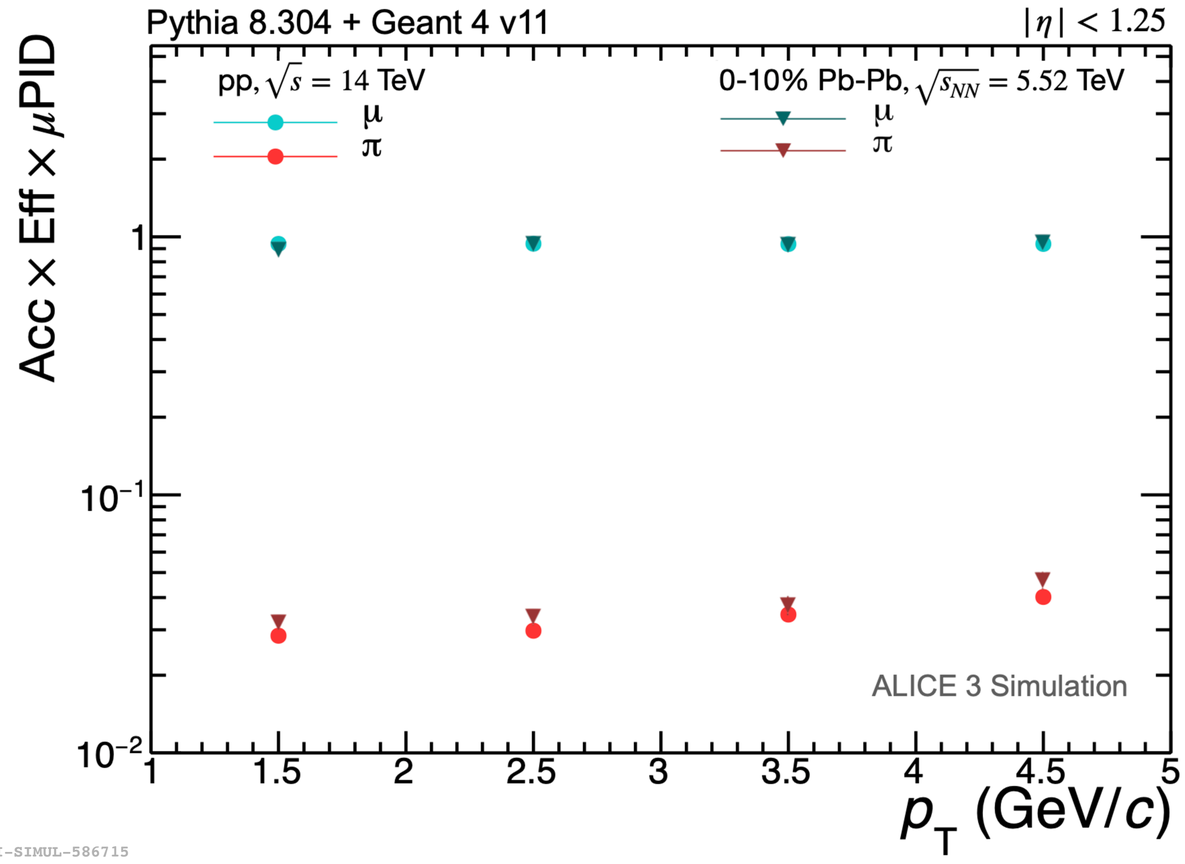
Pb-Pb and pp performance



- Muon efficiency around 94% for $p_{\mathrm{T}} > 1.5$ GeV/c
- Pion rejection at the level of 3-5%

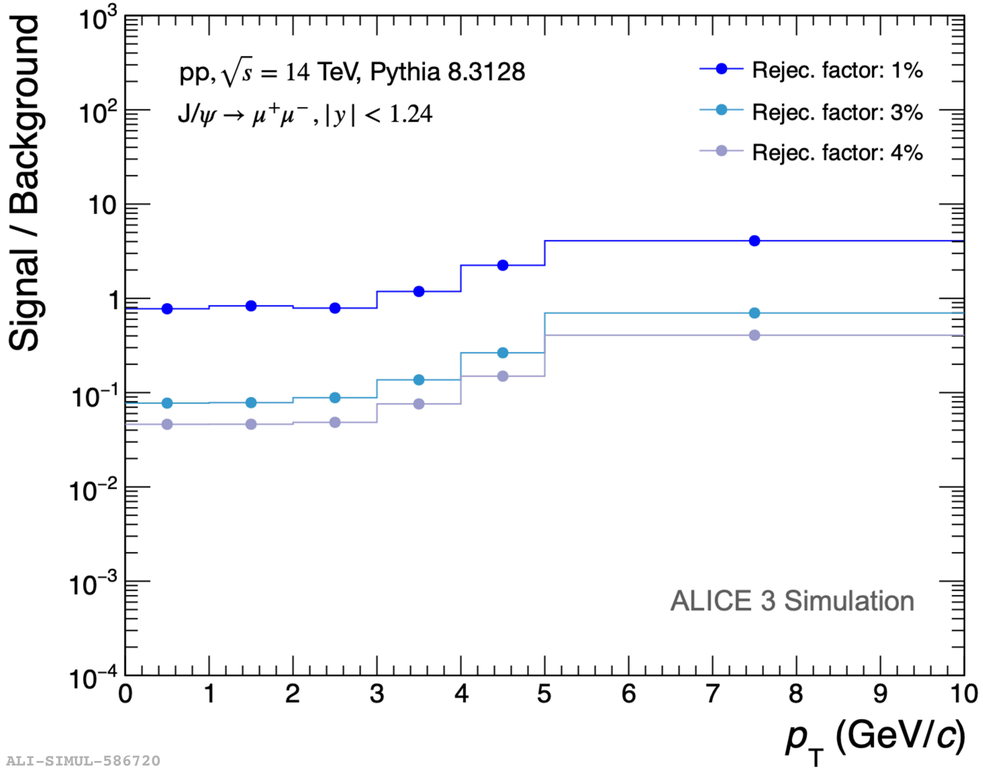
Pb-Pb and pp performance





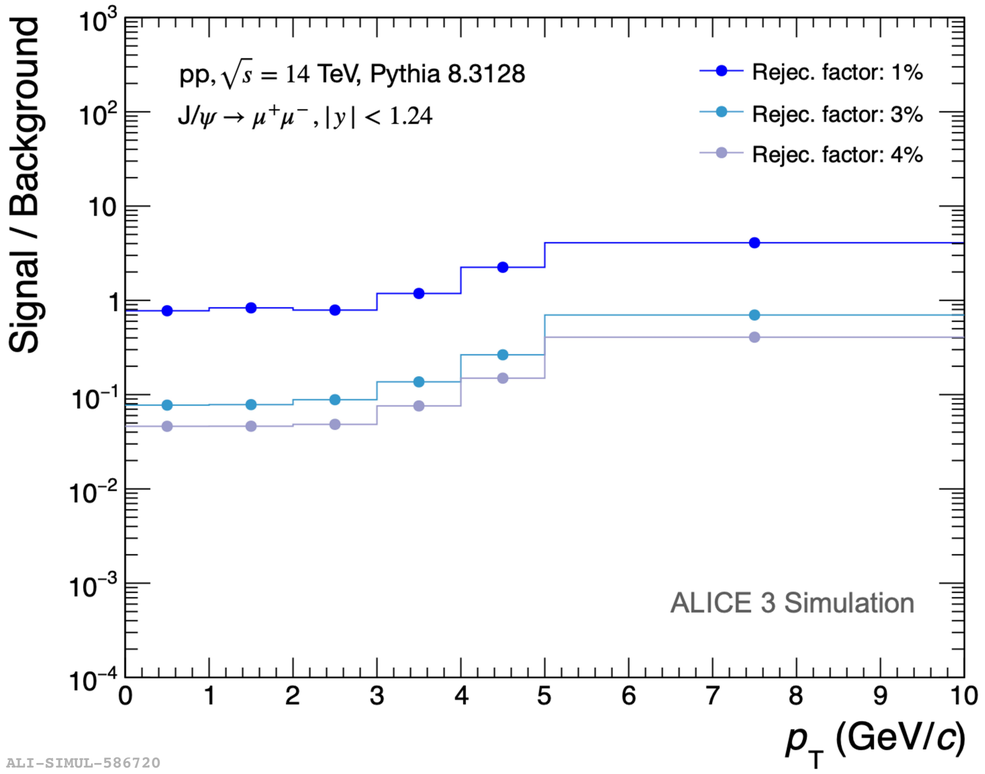
- Slightly above to the the pion rejection factor obtained in **pp simulations**

J/ψ reconstruction (pp collisions)



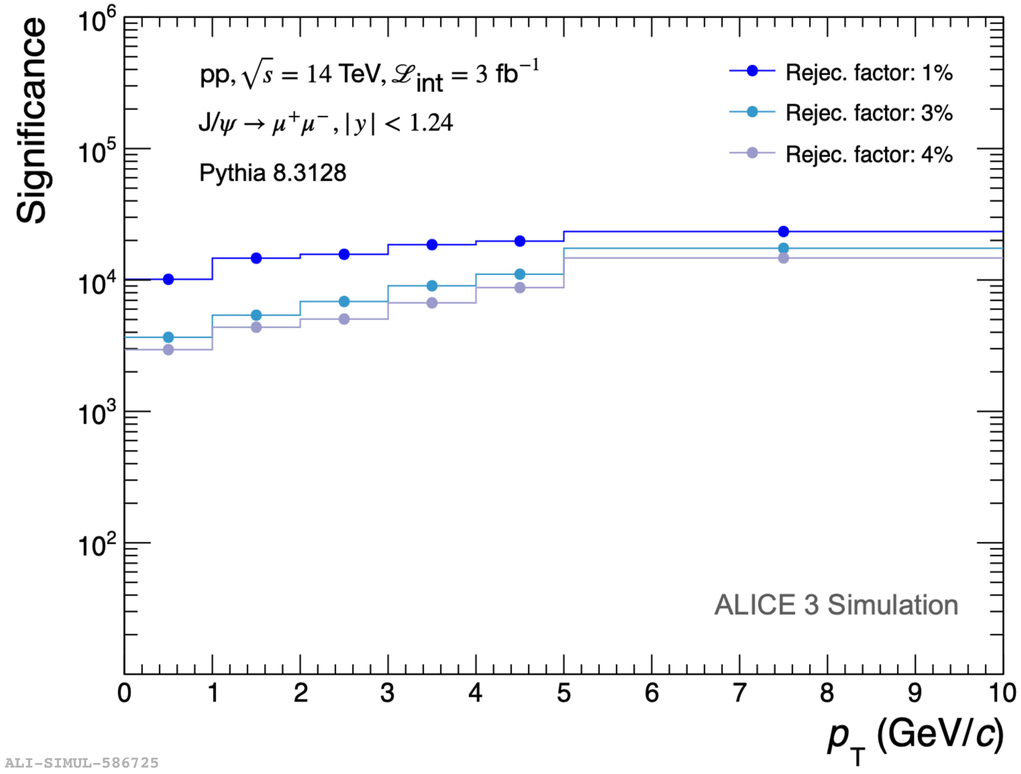
Even though the signal-to-background ratio varies with the **pion rejection factors**…

J/ψ reconstruction (pp collisions)



ALI-SIMUL-586720

Even though the signal-to-background ratio varies with the **pion rejection factors**…

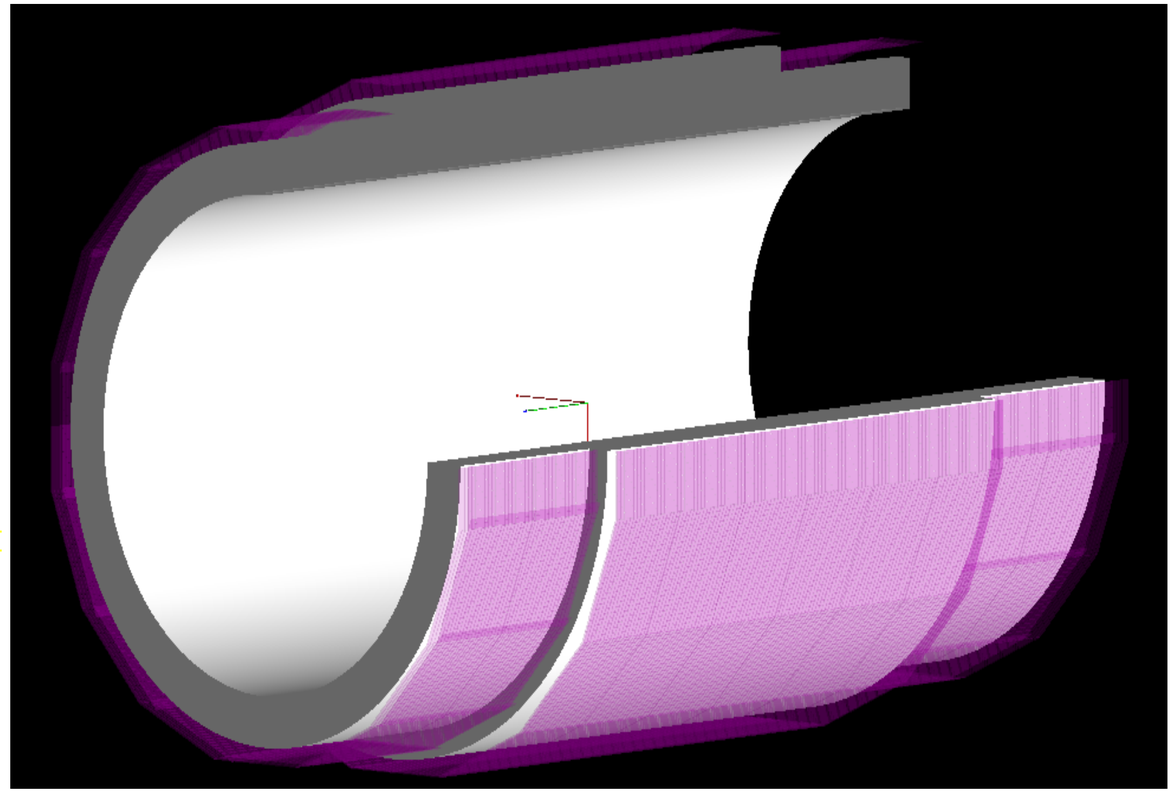


ALI-SIMUL-586725

…the **significance is less affected**, ensuring reliable detection of the signal across different conditions

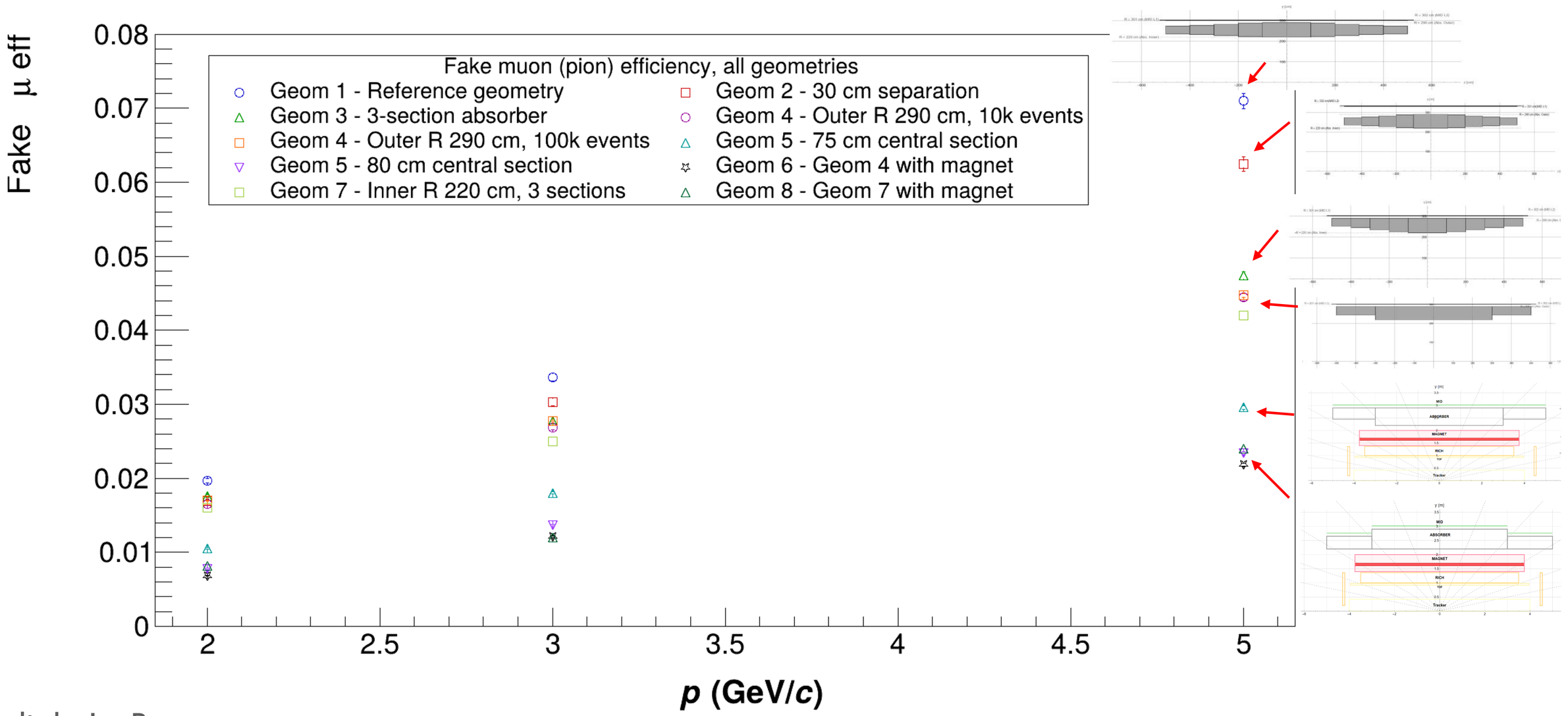
Geometry optimization studies

- 2nd Geometry – 40 cm between MID chambers and absorber
- 3rd Geometry – Fixed outer radius 290cm
- 4th Geometry – Fixed outer radius 290 cm but only 3 sectors along the z axis
- 5th Geometry – 4th Geometry + Central section increase (75 & 80cm)
- 6th Geometry – 4th Geometry + Magnet
- 7th Geometry – Fixed inner radius 220 cm with 3 sectors and bars evenly spaced
- 8th Geometry – 7th Geometry + Magnet



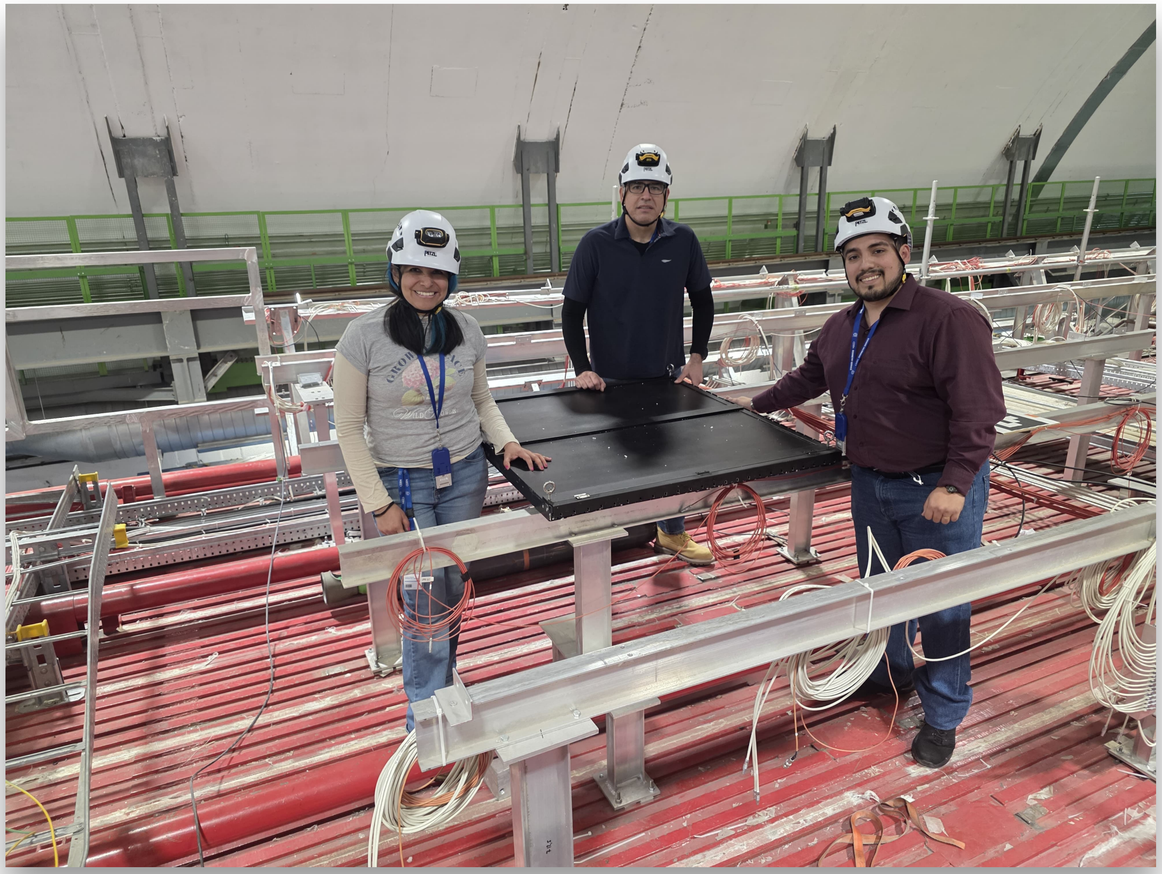
Results by Ian Perez

Geometry optimization studies



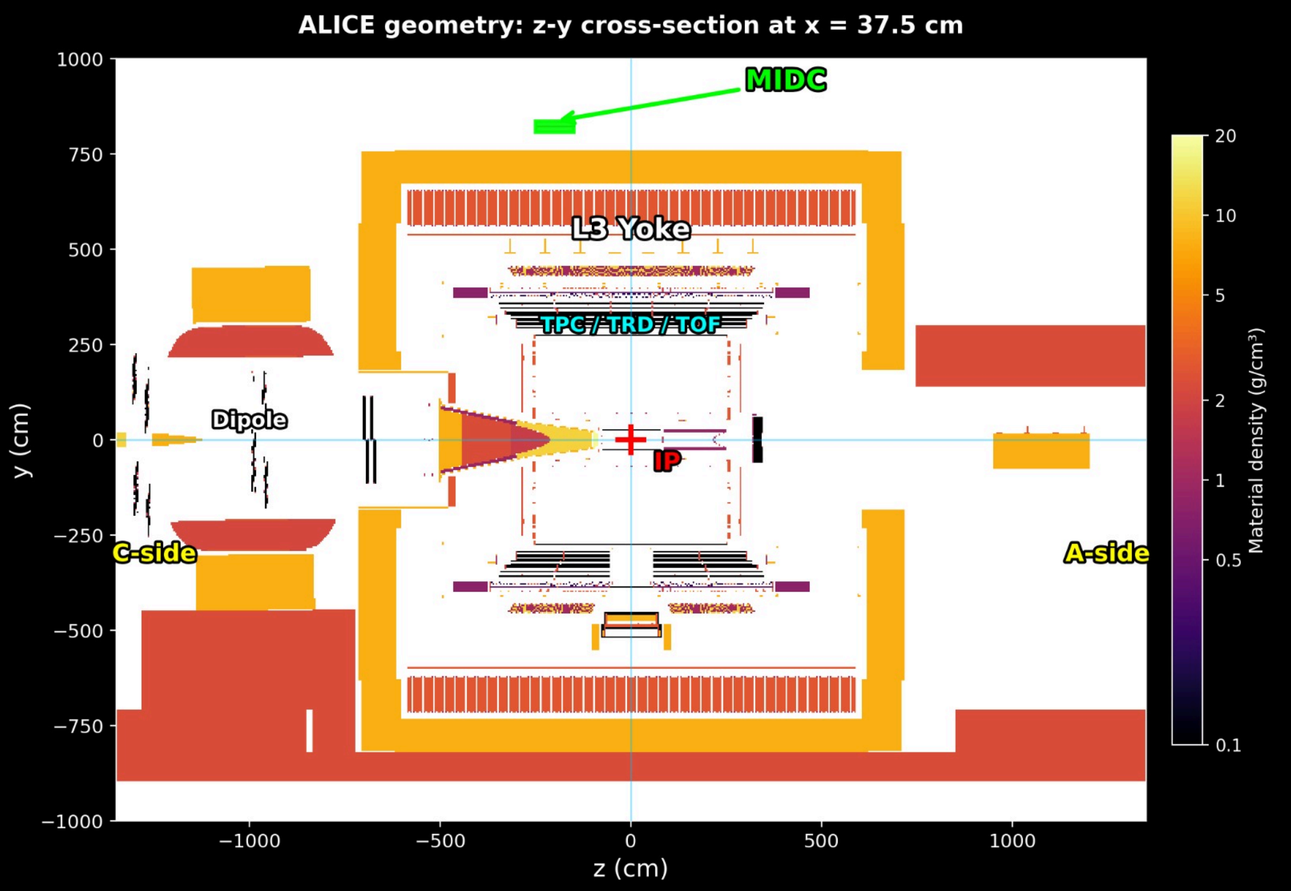
Results by Ian Perez

Test beam simulations



- Simulations of the MID prototype inside ALICE cavern are on their way
- A sensitive detector inside the current O^2 implementation of ALICE 2 has been added

Test beam simulations



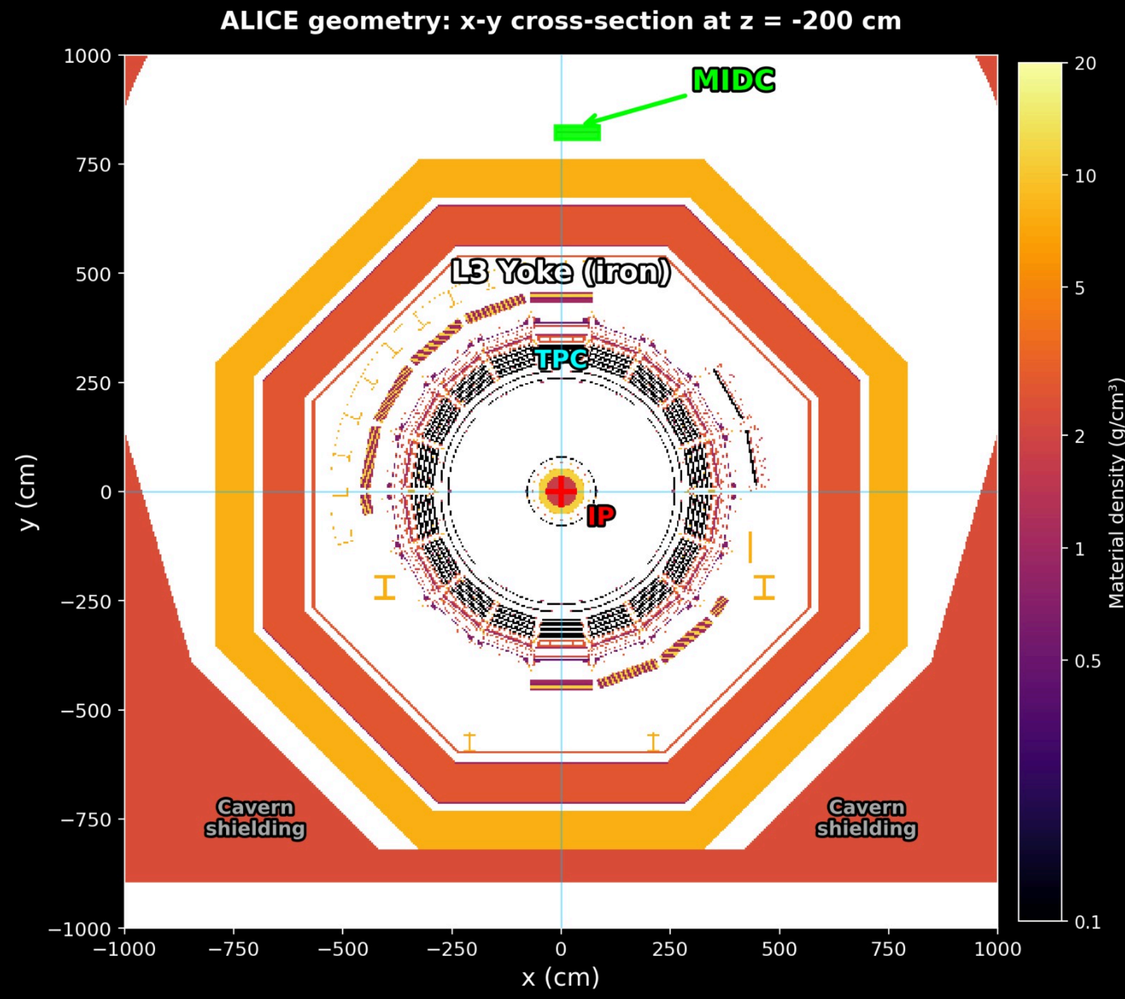
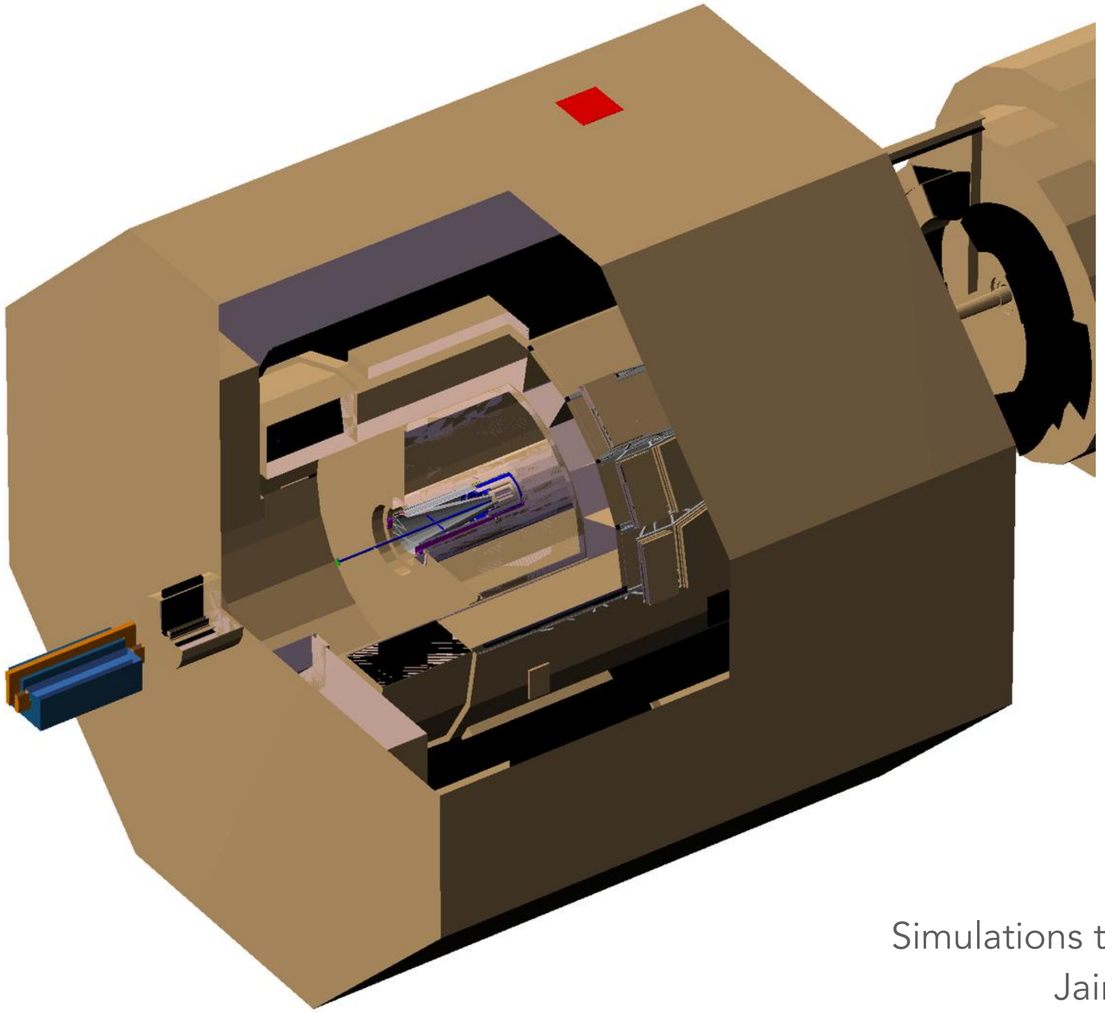
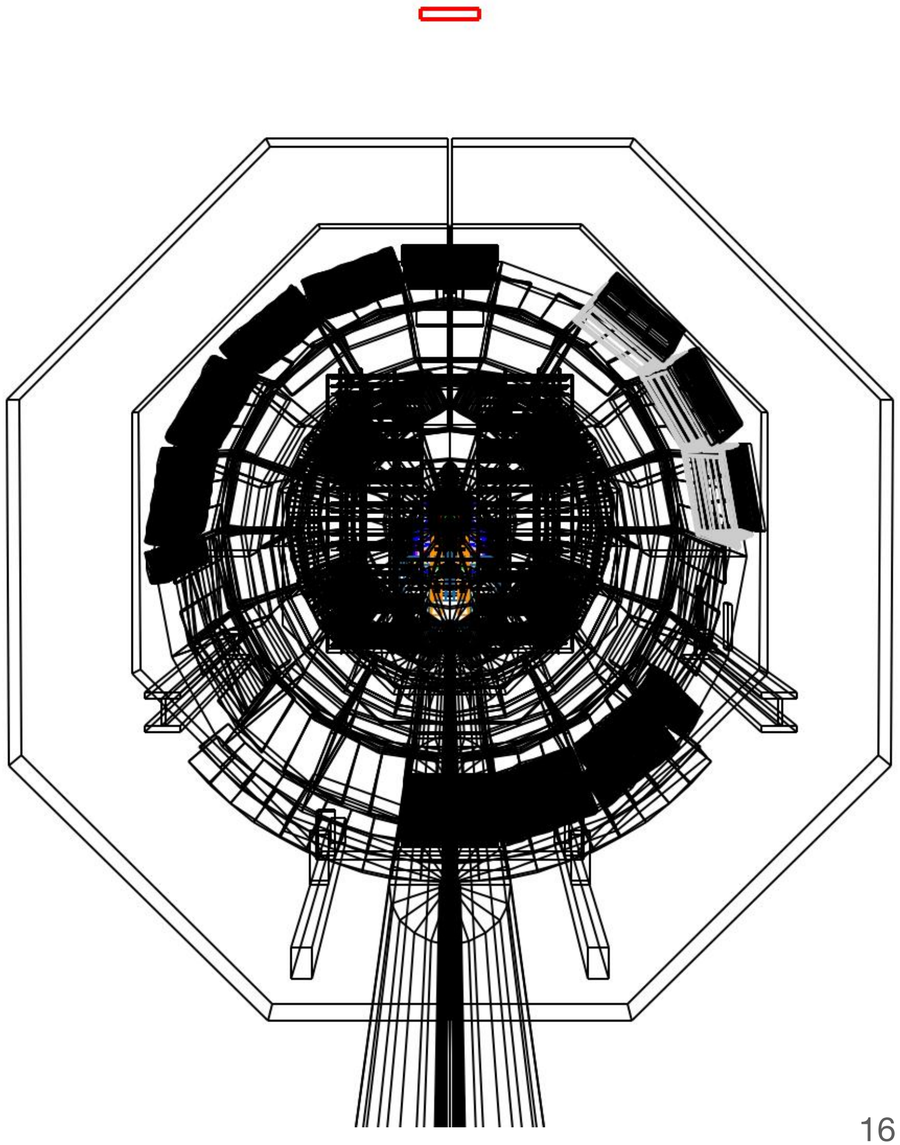


Figure by Oscar Jair Miranda Ibarra

Test beam simulations





Simulations to be performed by Oscar Jair Miranda Ibarra

Analysis note

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ALICE-ANA-2024-1585
April 17, 2025

Radiation load studies for the ALICE 3 detector

Jesús Muñoz, Antonio Ortiz

Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Mexico City, Mexico

Email: jmunozme@cern.ch

Abstract

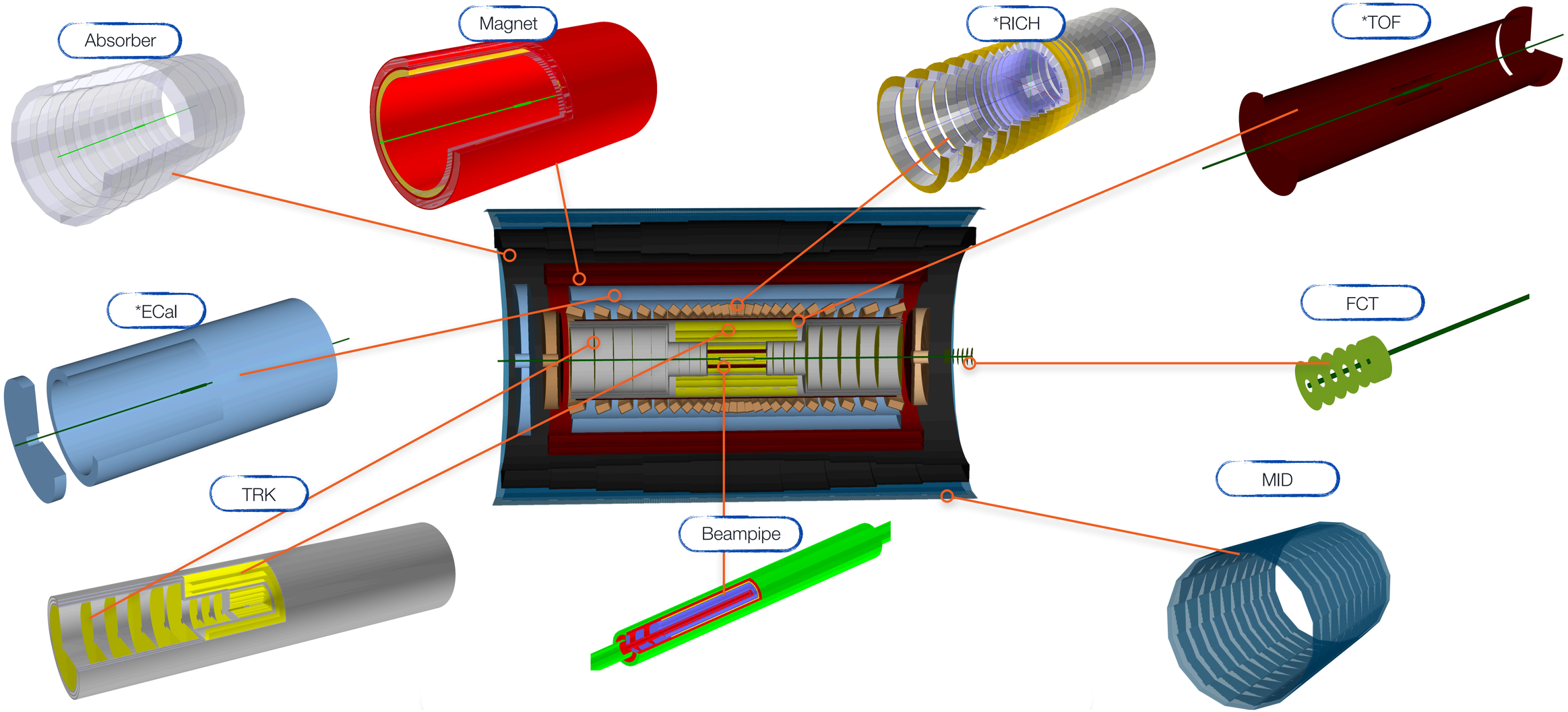
The study in this note addresses the expected radiation load for the proposed upgrade to the ALICE detector. In order to recreate the conditions foreseen in the Runs 5 and 6, PYTHIA 8 and FLUKA via the O^2 framework were employed as the event generator and particle transport of the simulations, respectively.

Analysis note available

Current version (v3)

Contents

Status of the geometry in O^2



* Figures taken from M. Concas - ALICE 3 days, March 25-27, 2024

Status of the geometry in O^2

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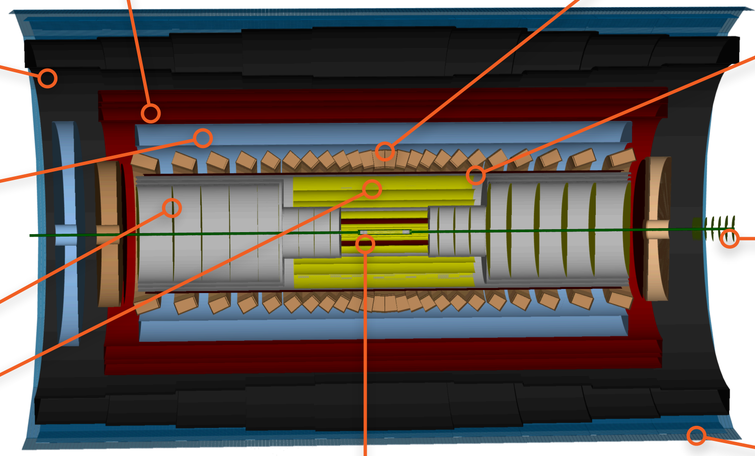
ALICE

Absorber
- Passive iron blocks
- Exposes the same thickness vs η

Magnet
- Passive cryostat filled with vacuum
- Cu/NbTi intermediate layer for the coils

***RICH**
- Projective geometry |η|<2
- Layout configurable via CLI

***TOF**
- Barrel and Fwd silicon layers
- Sensitive (produces hits)



***ECal**
- Barrel and forward
- For material budget

FCT
- Sensitive (produces hits)
- Layers can be interleaved with converter disks

TRK
- Sensitive barrel and fwd silicon layers
- Services for powering/data
- IRIS cold plate and vacuum vessel service

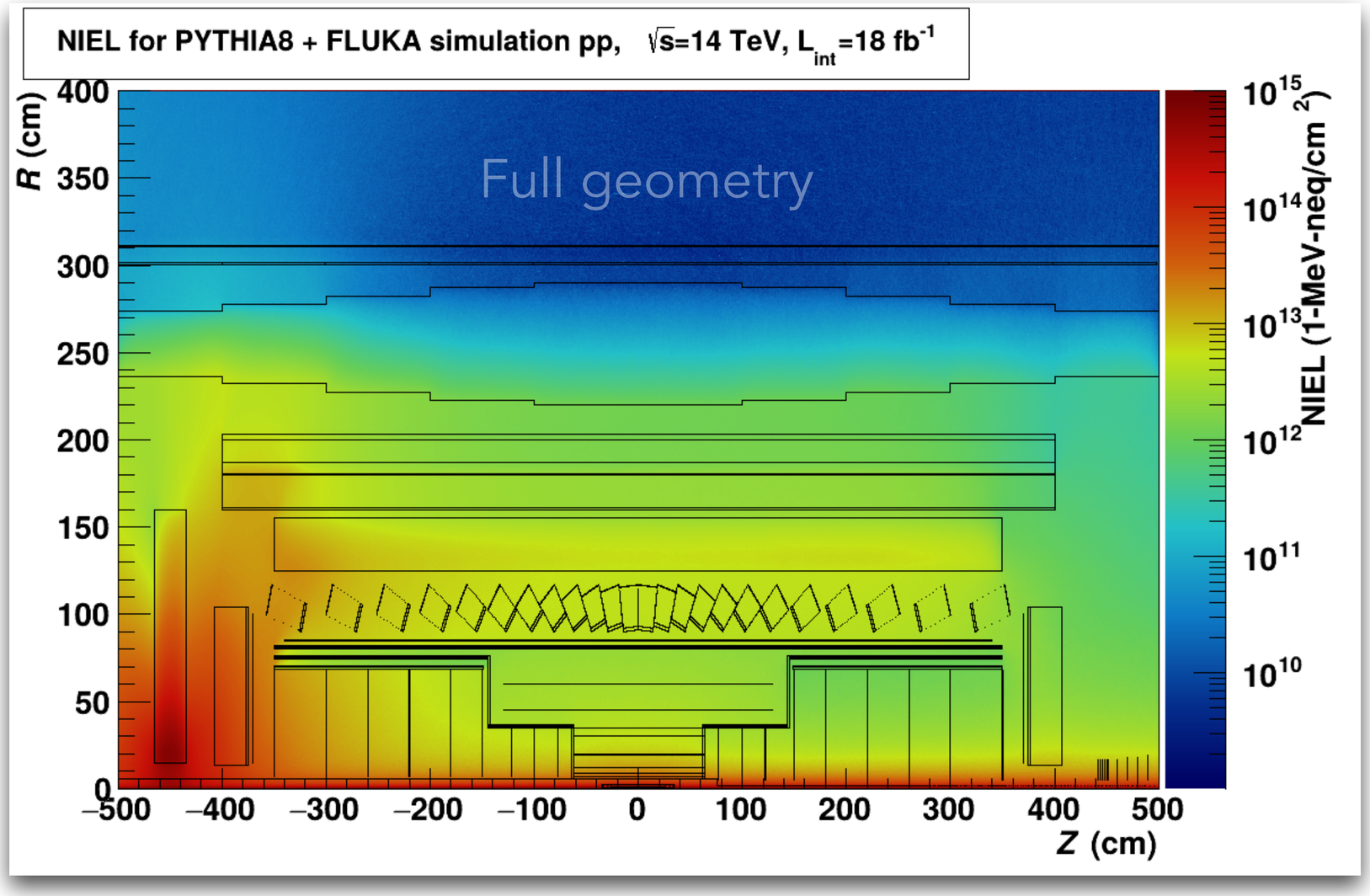
Beampipe
- Vacuum vessel to host IRIS

MID
- Polystyrene version
- Two layers with granular composition
- Modular structure: layer -> module -> bars

A custom magnetic field can be implemented

* Figures taken from M. Concas - ALICE 3 days, March 25-27, 2024

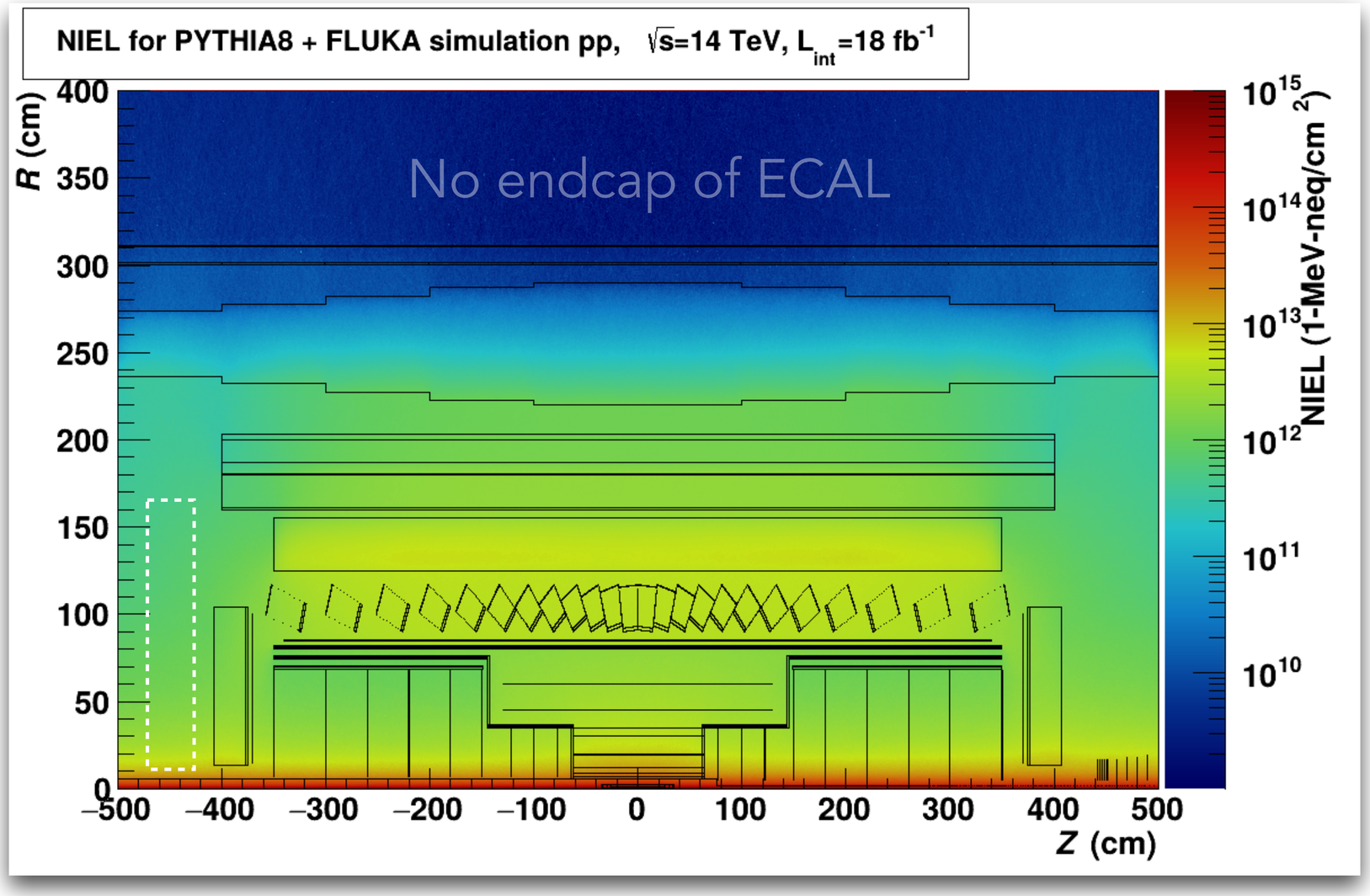
Layouts



pp and Pb-Pb simulations for different layouts

1. Full geometry
2. No endcap of ECAL
3. No ECAL (w/o radii reduction)
4. No ECAL (w radii reduction)

Layouts



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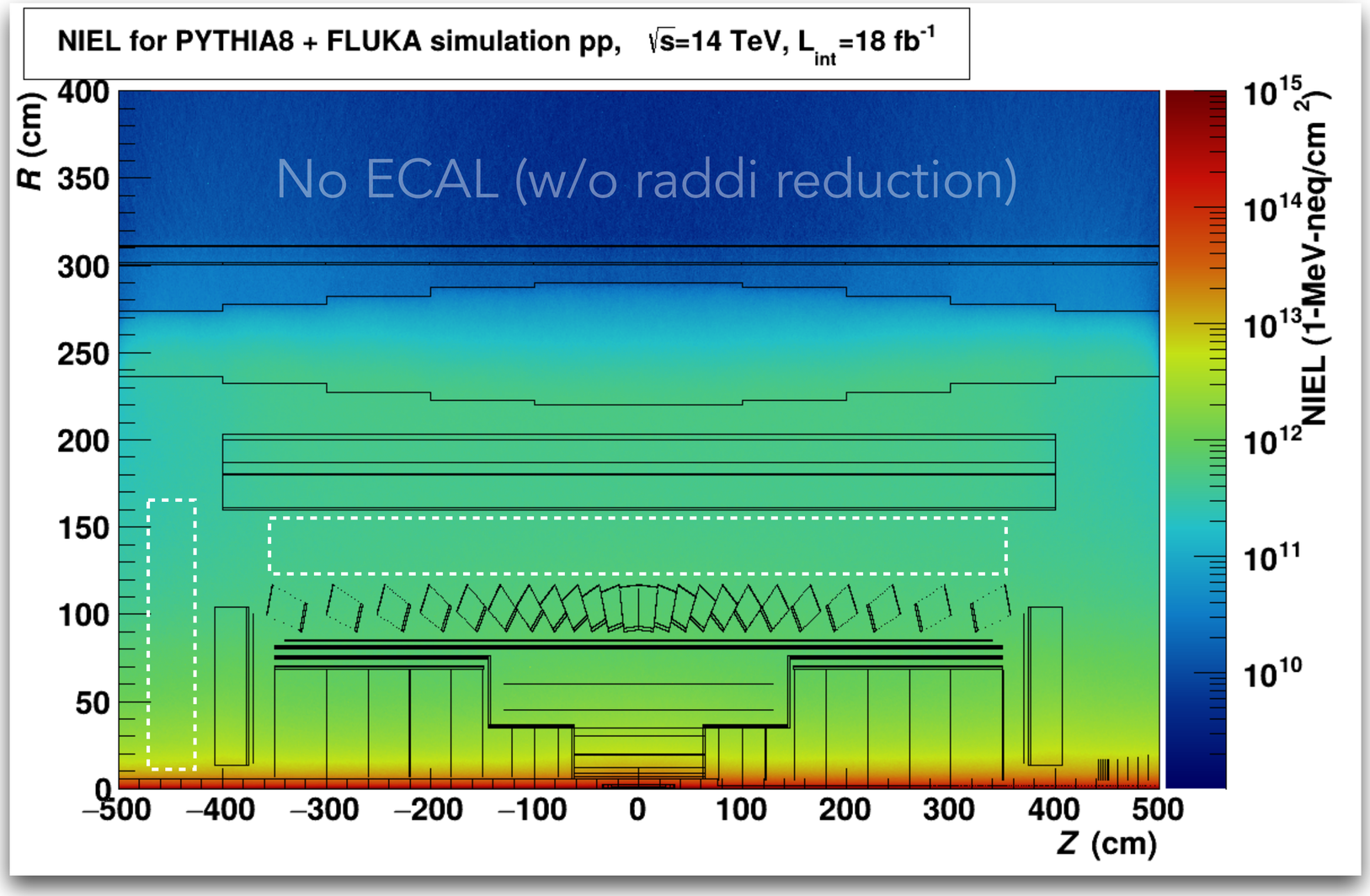

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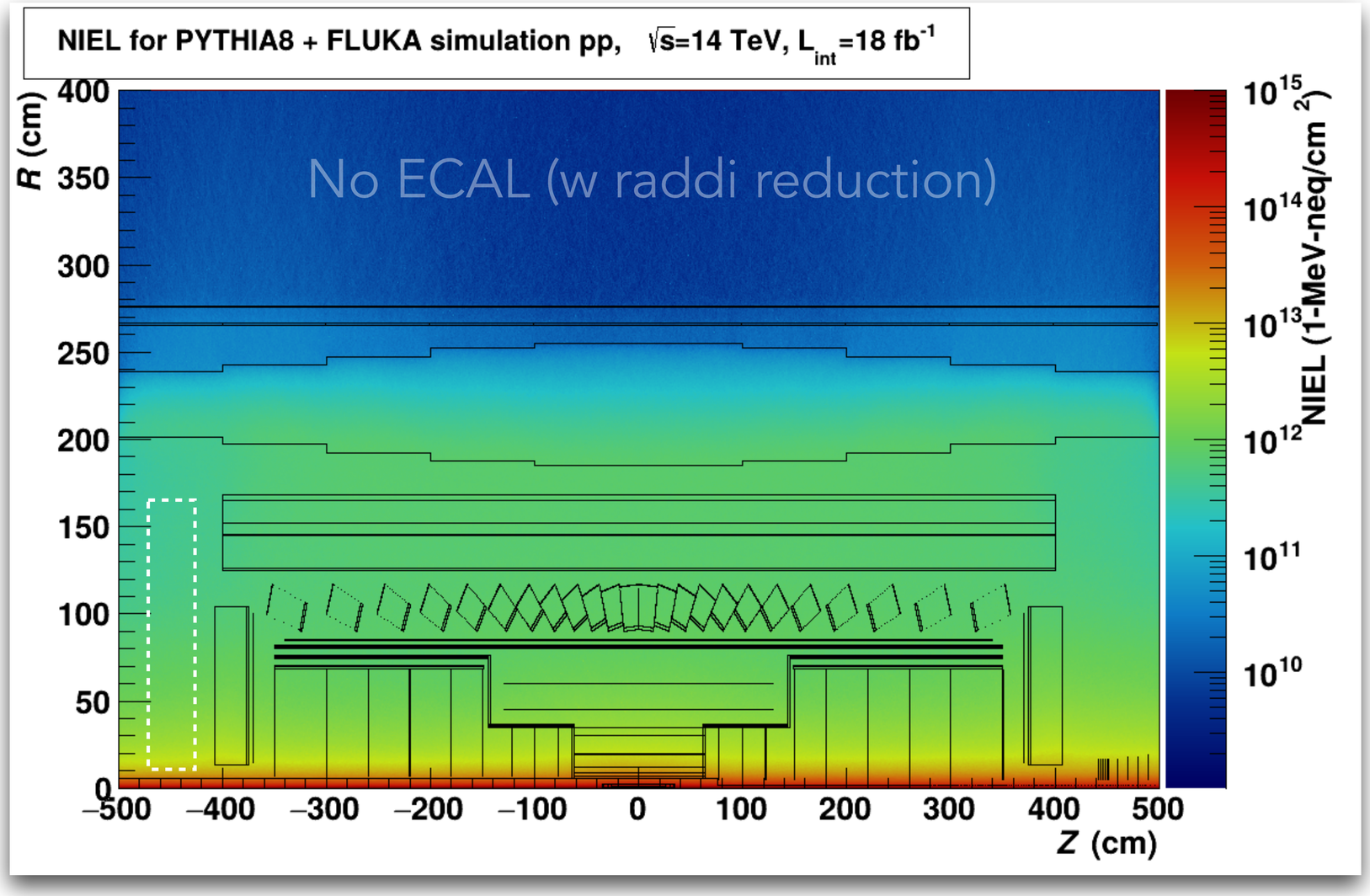

pp and Pb-Pb simulations for different layouts

1. Full geometry
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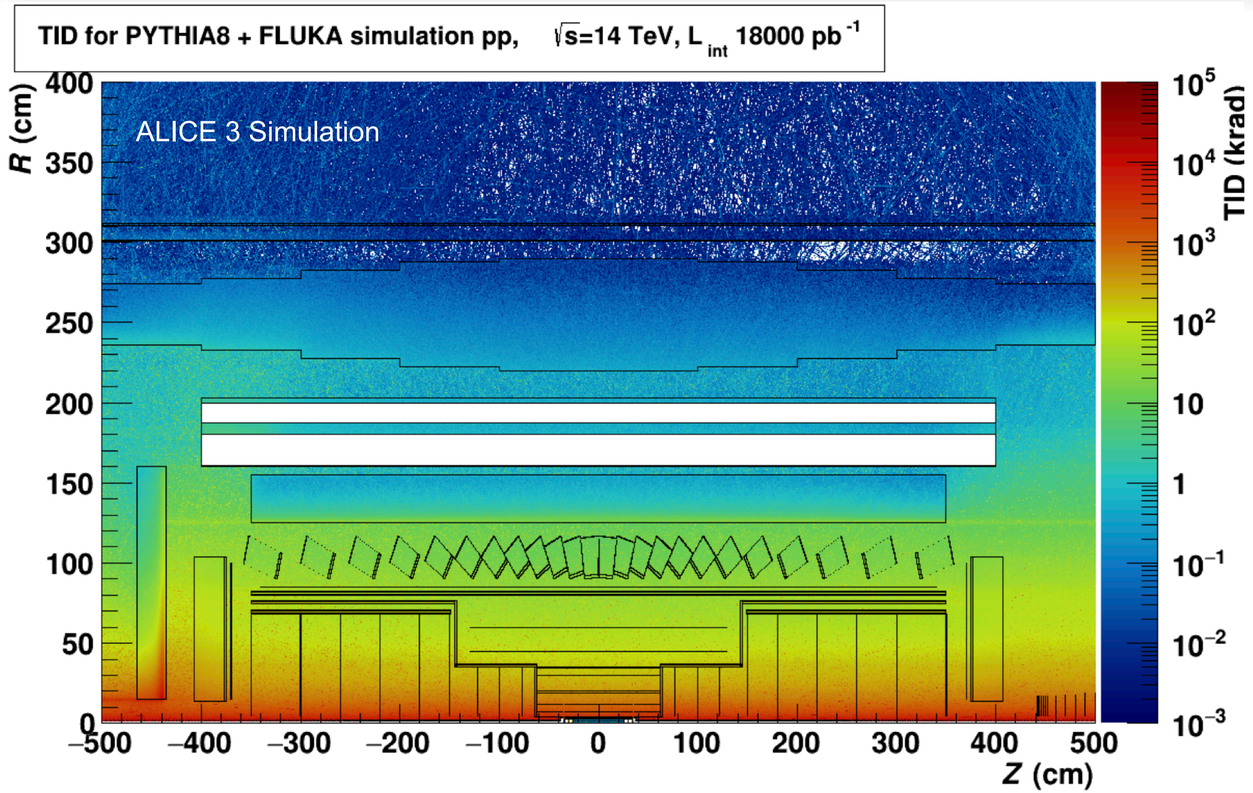
both average and maximum values for each subdetector region

Radiation load in the MID region



	pp	Pb-Pb
TID (rad)	54	0.94
NIEL (1 MeV neq/cm^2)	3.4 x 10^{10}	4.7 x 10^8

Table. *Radiation load in the MID* simulated with FLUKA for the Run 5+6 period

- **No significant decrease in light yield** due to the expected TID for baseline option scintillators [FERMILAB-PUB-05-344]
- **Our typical signals ~40 photoelectrons,** therefore single photoelectron detection with the SiPM is not required (impossible at 10^{11} MeV neq/ cm^2 at room temp.) [Nucl. Instrum. Meth. Phys. Res A, A 922 (2019)]

Summary

- **Simulations of the MID show a competitive performance in both pp and Pb-Pb simulations**
- **Significance results suggest that detecting reliable signals under varying pion rejection factors is plausible**
- **The expected radiation load does not represent a problem for plastic scintillators + SiPM**
- **Results from the test beam have confirmed muon candidate efficiency**

Scintillators represent an excellent candidate for the MID

(very simple, robust, cheap, excellent timing performance)

Thank you
for your attention!