ALICE

Simulation
&
Performance tools for ALICE 3

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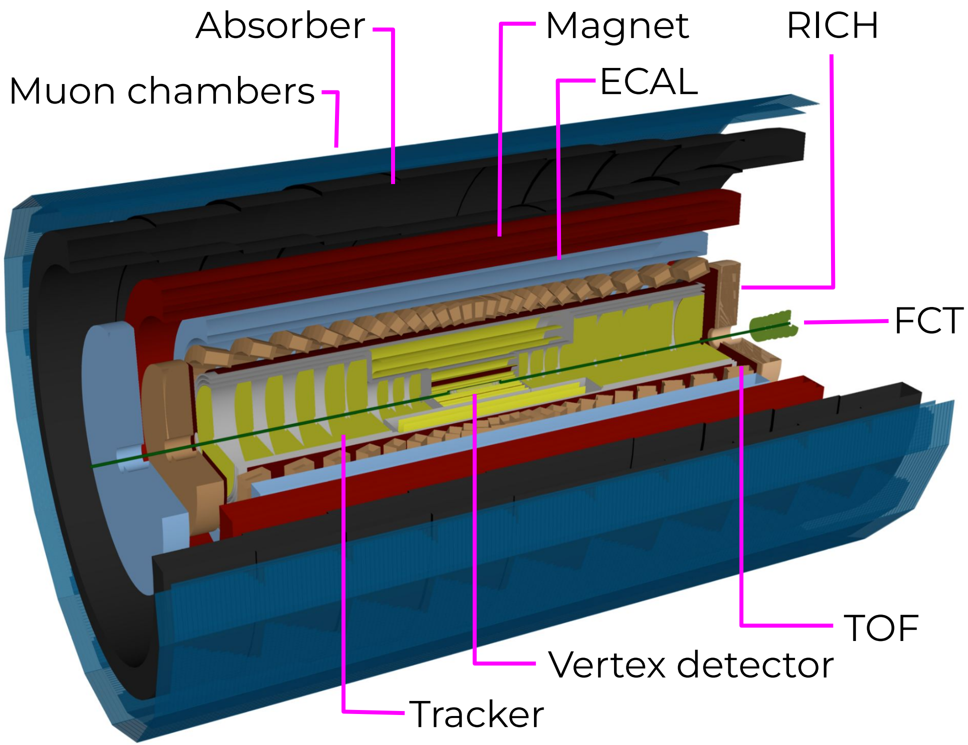
ALICE 3 - A short overview of the physics program

- High-precision beauty measurements
- $D\bar{D}$ azimuthal correlations
- Multi-charm baryons, P-wave quarkonia, exotic hadrons
- QGP thermal radiation
- Chiral symmetry restoration
- Fluctuations of conserved charges

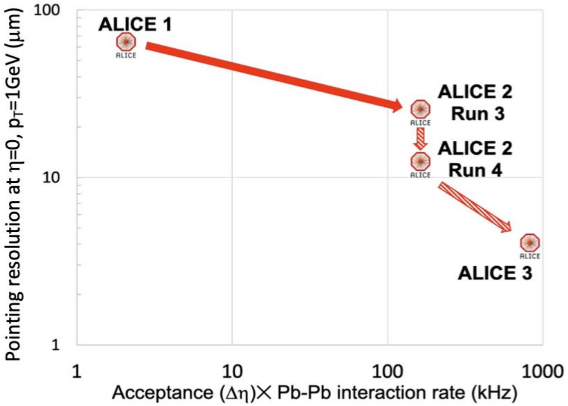
For more information, see the Letter of Intent https://arxiv.org/pdf/2211.02491.pdf

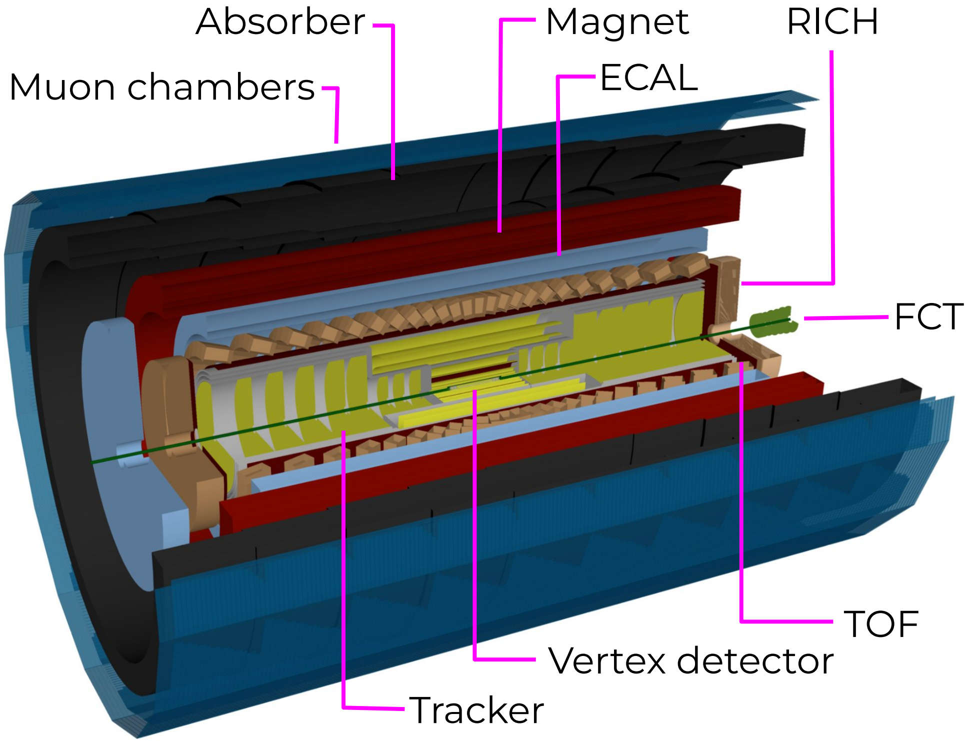


ALICE 3 - A short overview of the detector concept

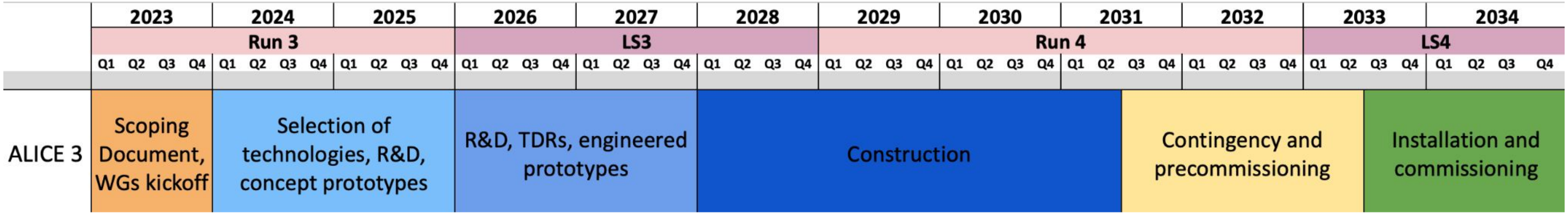
➡ **Novel and innovative detector concept**

- Compact and lightweight all-silicon tracker
- Retractable vertex detector
- Extensive particle identification
- Large acceptance
- Superconducting magnet system
- Continuous read-out and online processing





ALICE 3 - Timeline



- **2023-25:** Scoping Document, selection of technologies, small-scale prototypes (~25% of R&D funds)
- **2026-27:** Large-scale engineered prototypes (~75% of R&D funds) → TDRs and MoUs
- **2028-30:** Construction and testing
- **2031-32:** Contingency and pre-commissioning
- **2033-34:** Preparation of cavern, installation
- **2035-** : Data taking

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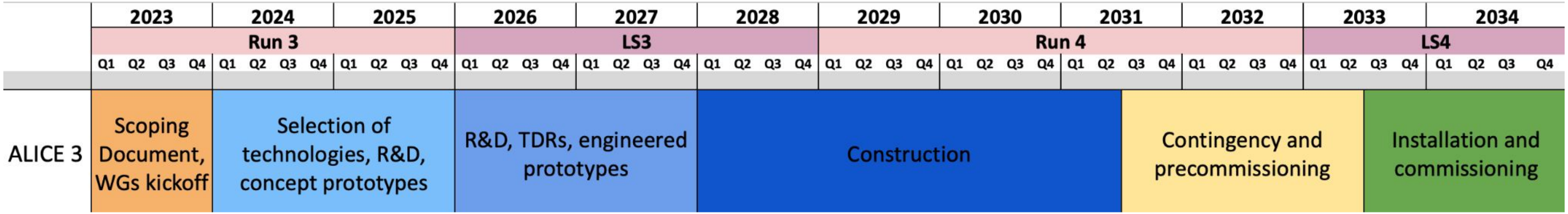

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Simulation is a big and important part of this!

Why we need simulations?

- Guarantee the **success** of the **physics program** upon considered layouts options

- **Estimate** the **impact** of **variations** on **experimental setups**
    - **Layouts**: geometries, materials
    - **Magnetic field**: intensity, maps
    - Project on **resources** and **cost estimations**

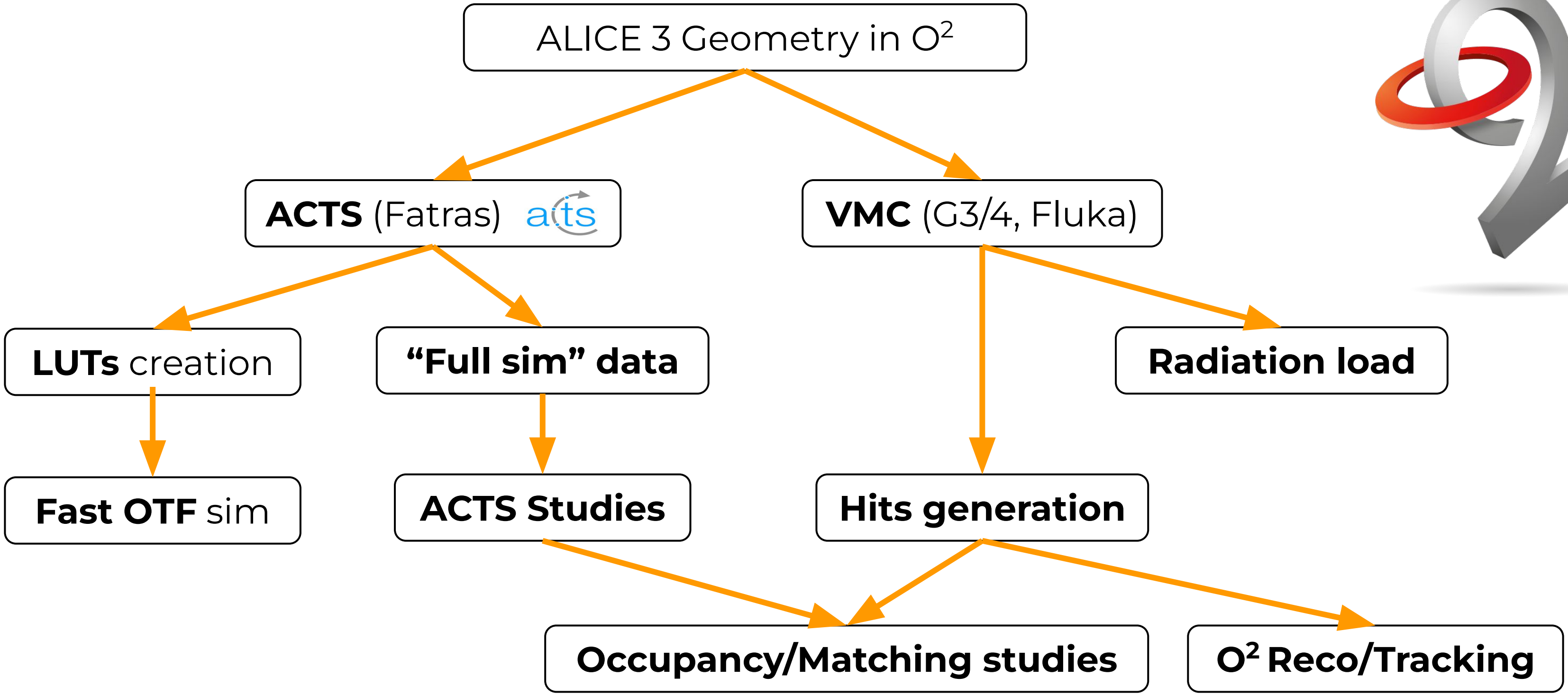
- **Ongoing: studies** focusing on **specific scoping topics** in parallel
    - Studying the **interplay** of **options** or **features**

O^2 - The Online/Offline ALICE software

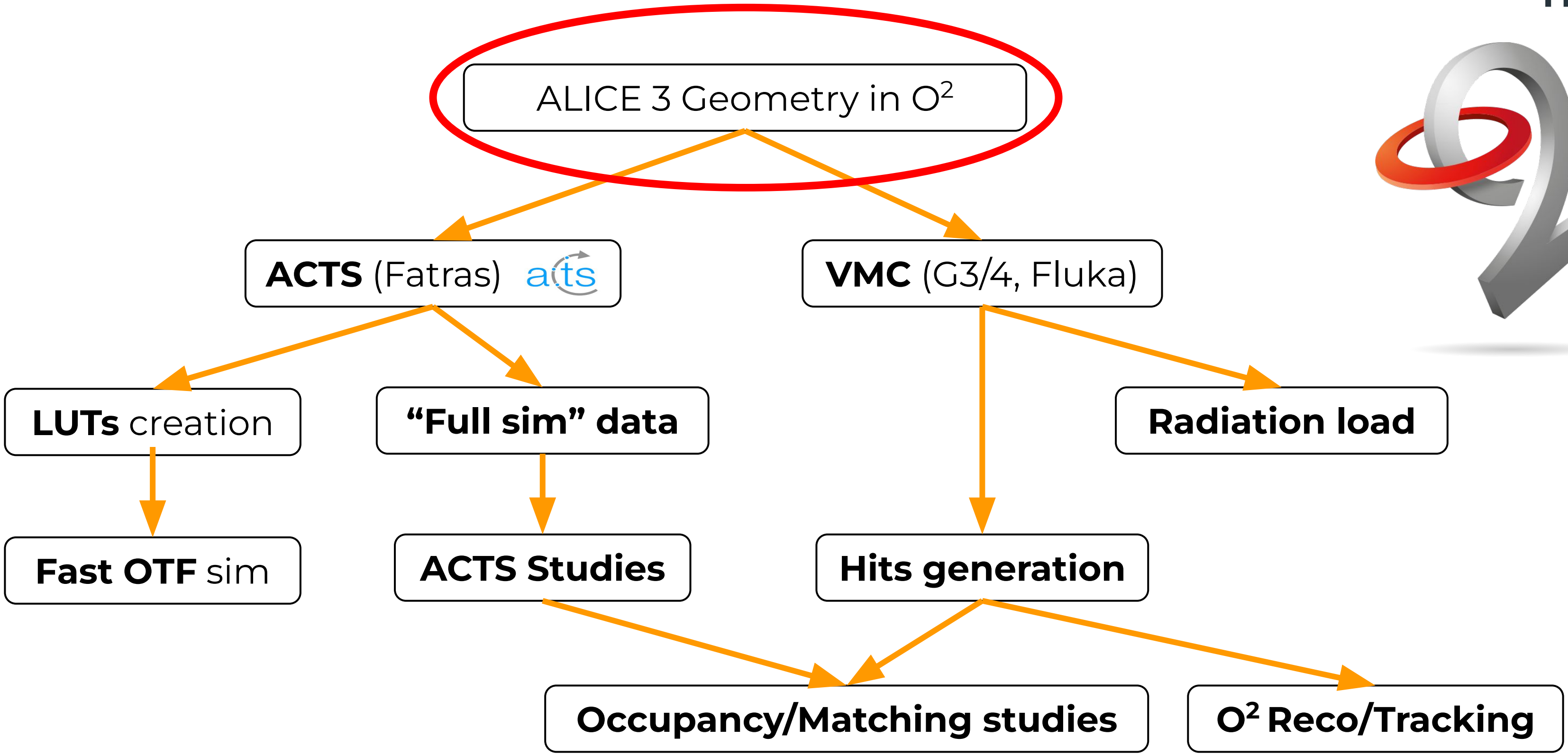
O^2 contains the code for **reconstruction**, **calibration** and **simulation** for the ALICE experiment at CERN for Run 3 & 4 and in particular for **ALICE 3** for **Run 5+6**.

Arxiv: https://arxiv.org/abs/2402.01205
Github: https://github.com/AliceO2Group/AliceO2/tree/dev

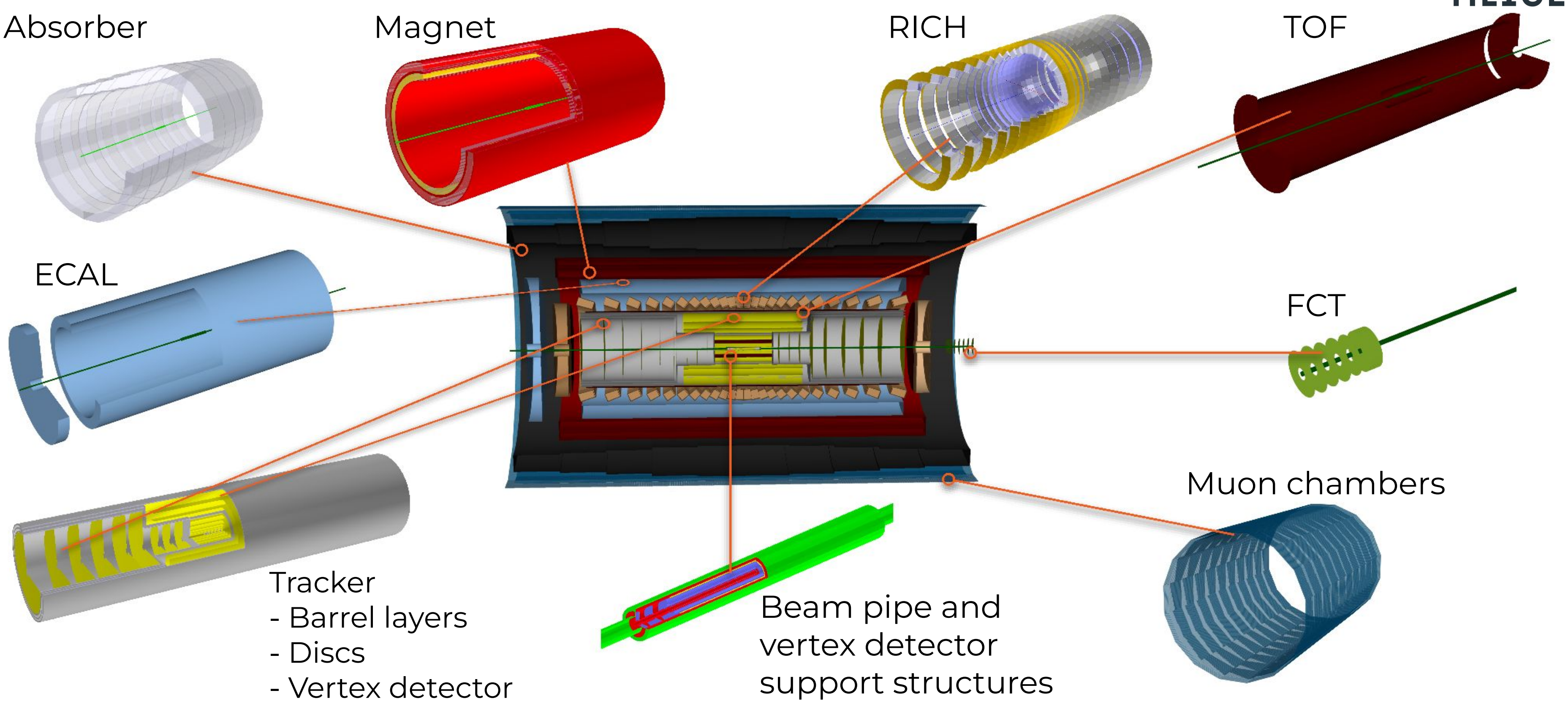
O^2 for ALICE 3



O^2 for ALICE 3



ALICE 3 Geometry in O^2



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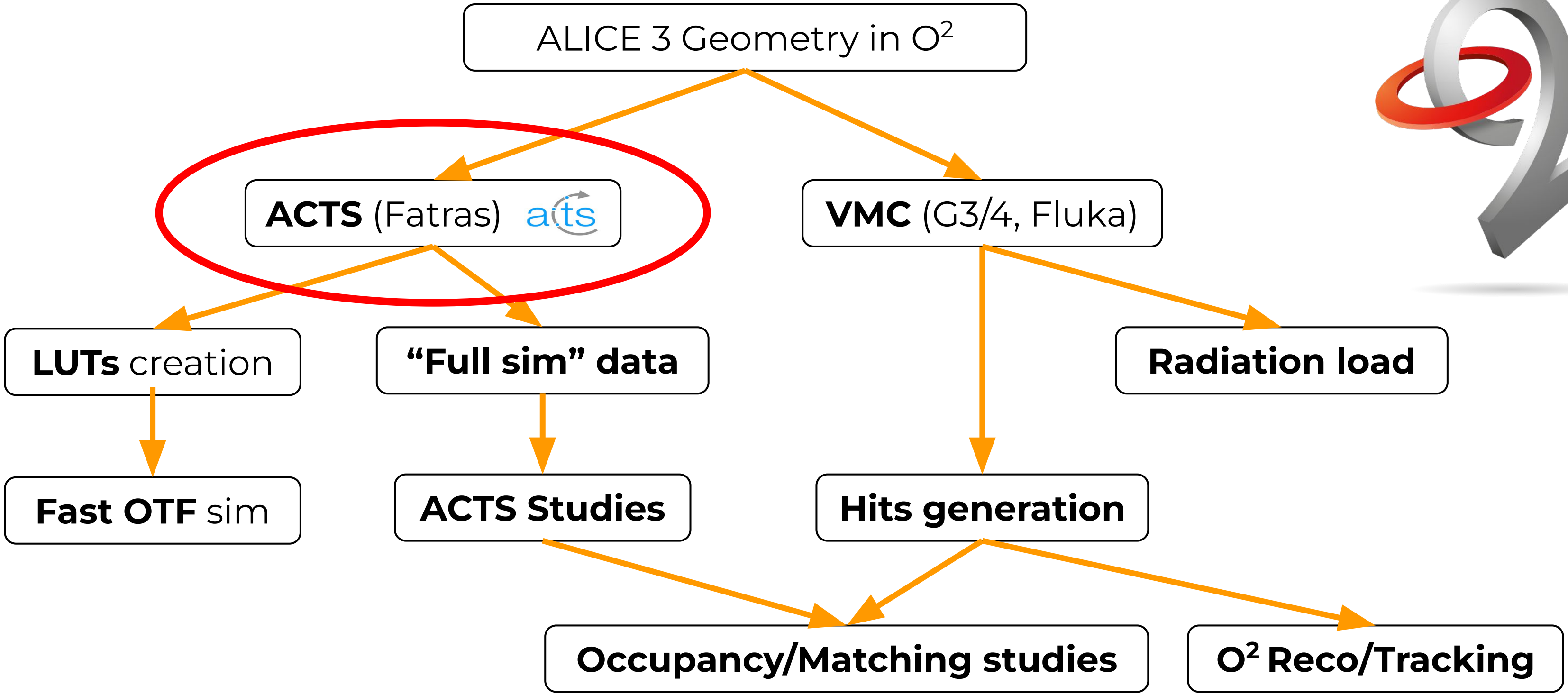
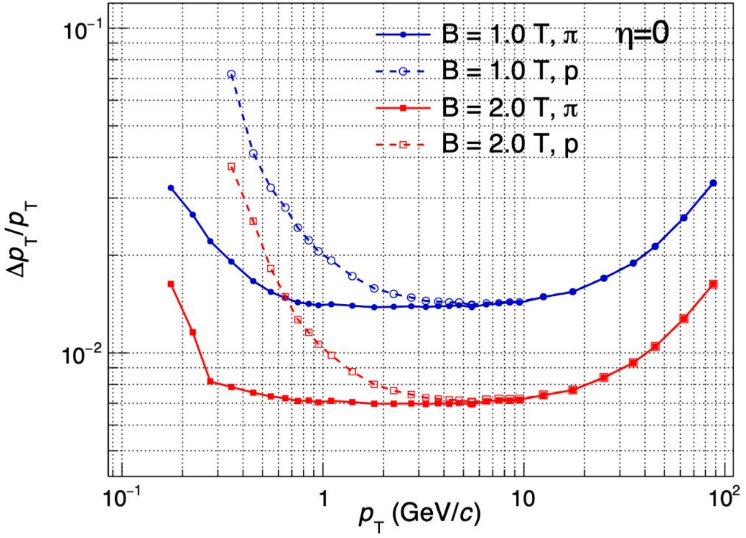


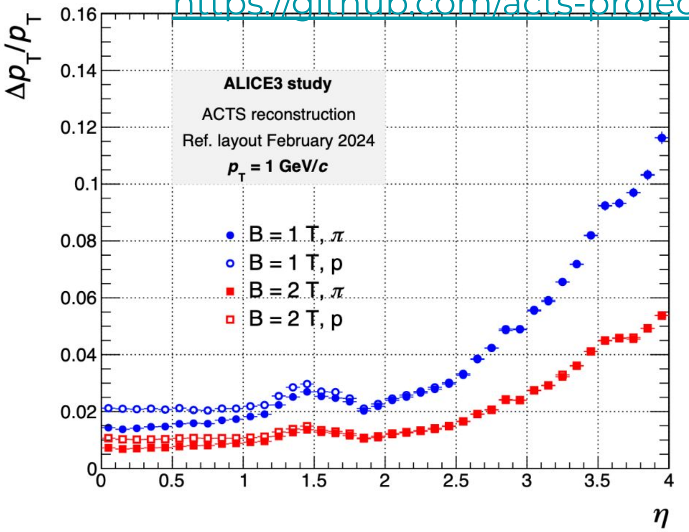
ACTS Studies for ALICE 3

ACTS: A Common Tracking Software Project

“Experiment-independent toolkit for (charged) particle track reconstruction in (high energy) physics experiments implemented in modern C++”

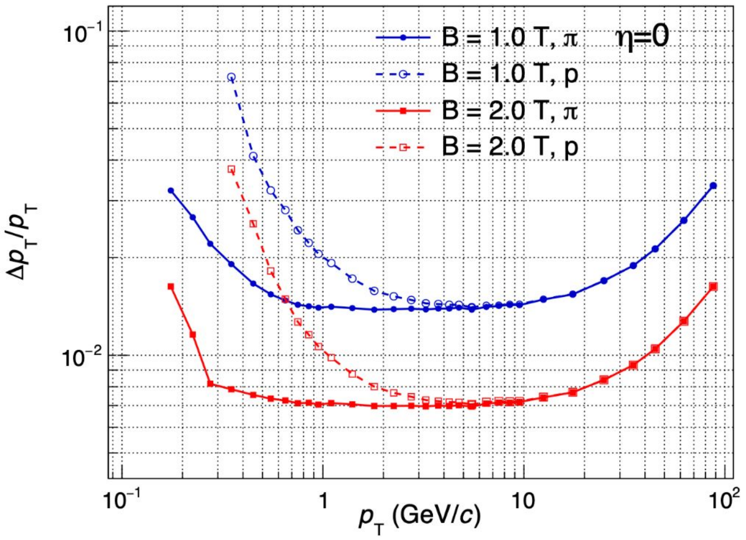
arXiv: https://arxiv.org/abs/2106.13593
Github: https://github.com/acts-project/acts

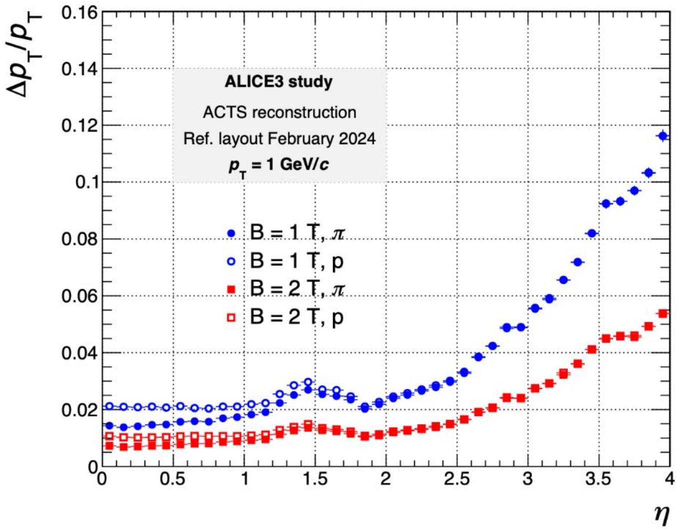




ACTS Studies for ALICE 3

Even with a reduced magnetic field of 1 T, the transverse momentum resolution is still acceptable for our physics goals.





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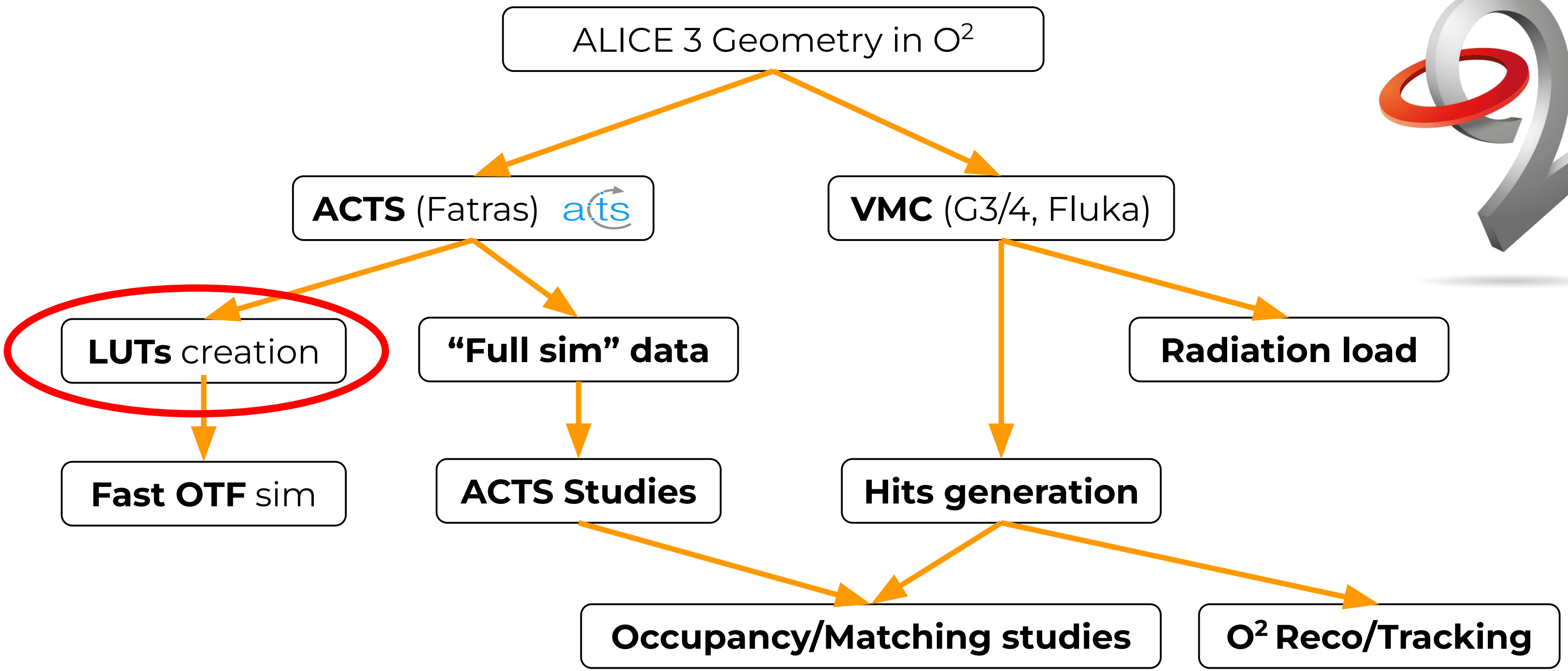


Look-Up Tables creation for Fast Simulations - example

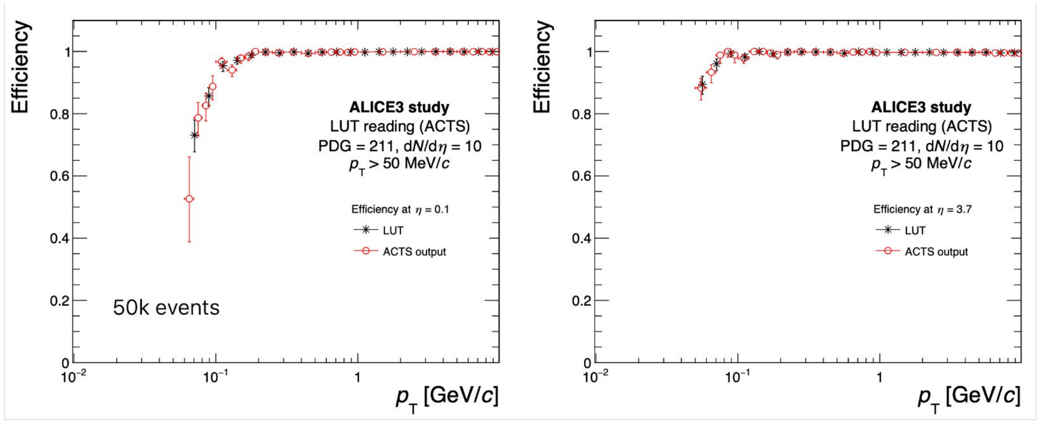
Look-Up Tables (LUTs) allow for fast simulations

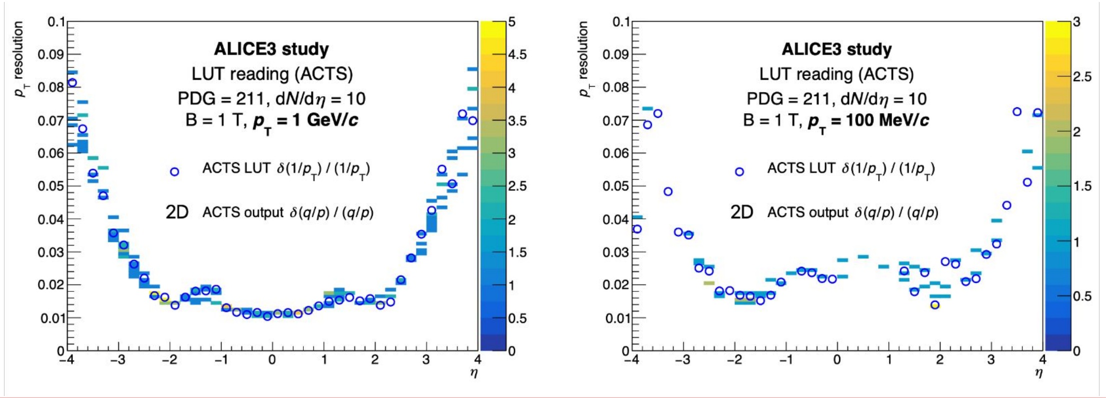
Efficiencies and p_T **resolution** for

$$\pi^{\pm}, \mathrm{K}^{\pm}, \mathrm{p}, \bar{\mathrm{p}}, \mu^{\pm}, \mathrm{e}^{\pm}$$

are in these LUTs

These are used for the on-the-fly simulations





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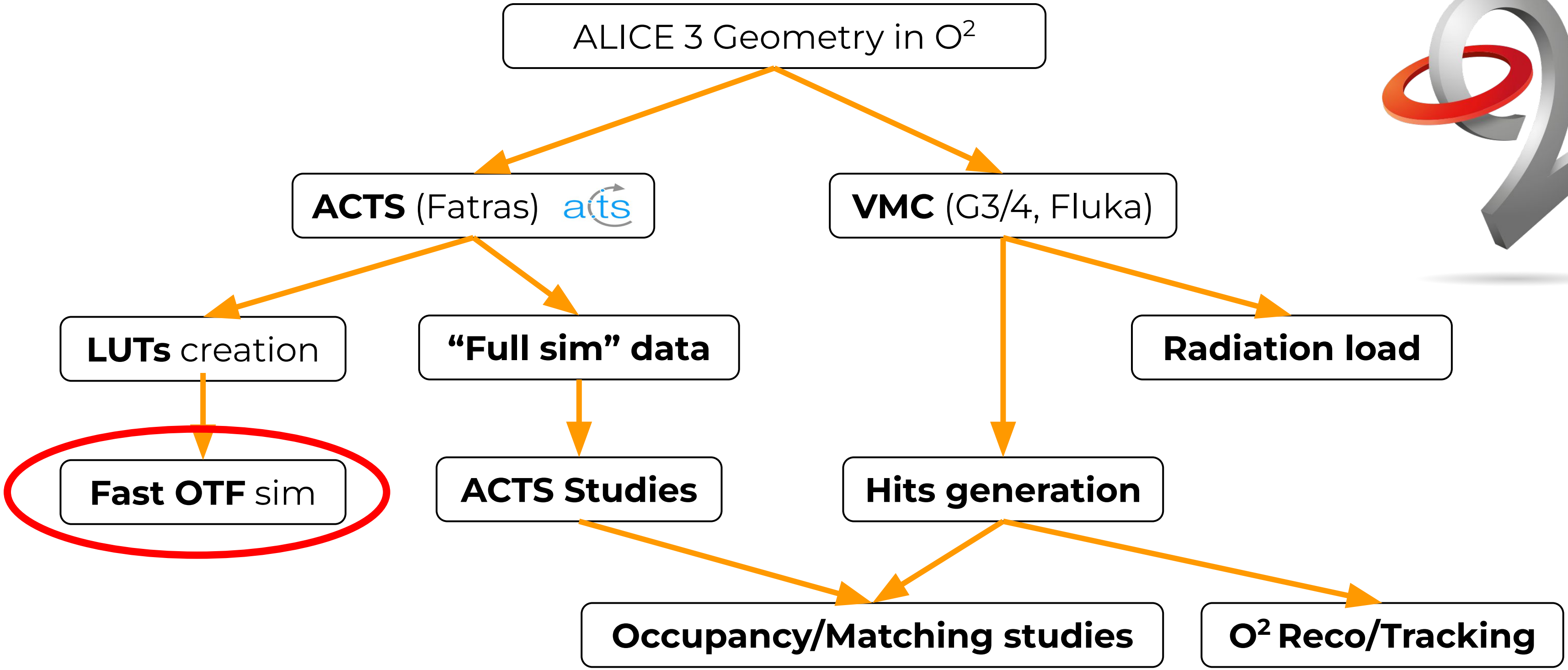


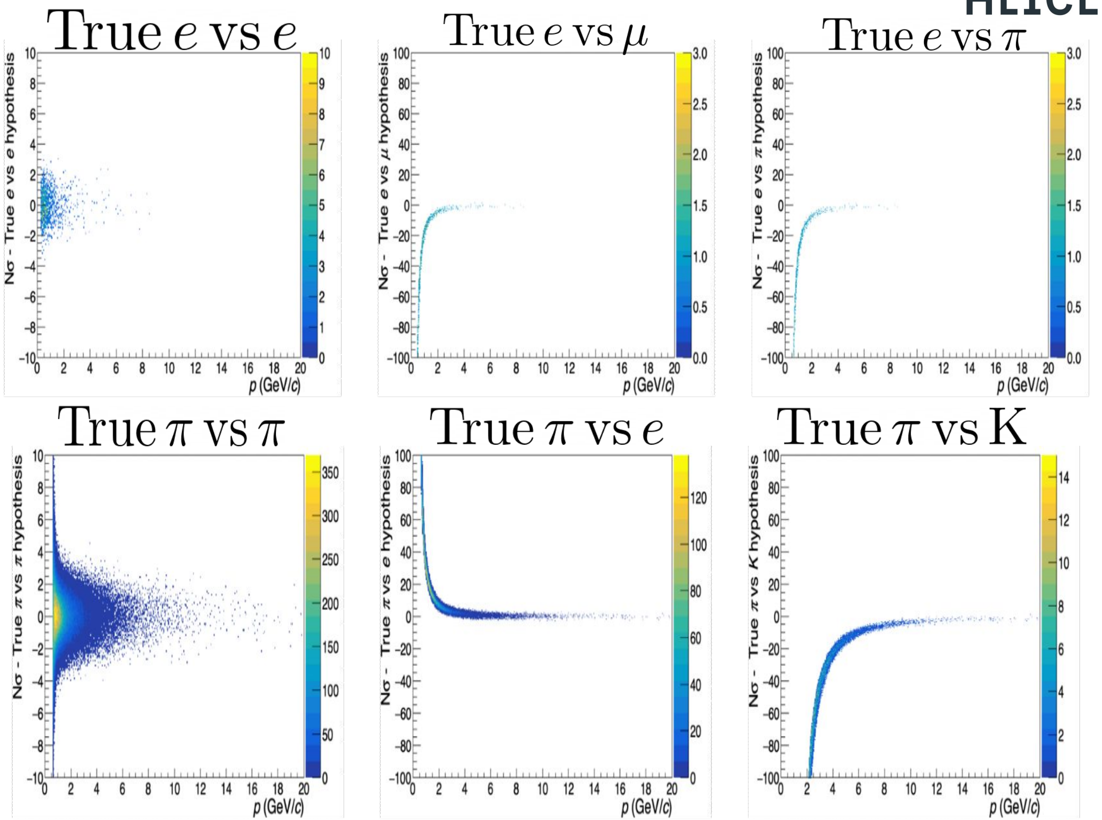
Fast On-The-Fly Simulations

These simulations are fast and lightweight, which allow for quick analyses if the layout of the geometry changes

Includes
- PID smearing for RICH
- Time response smearing for oTOF

Example: RICH N_σ separation for e⁻ and π

These On-The-Fly simulations allows for an increase in speed of at least 10x in comparison to full simulations



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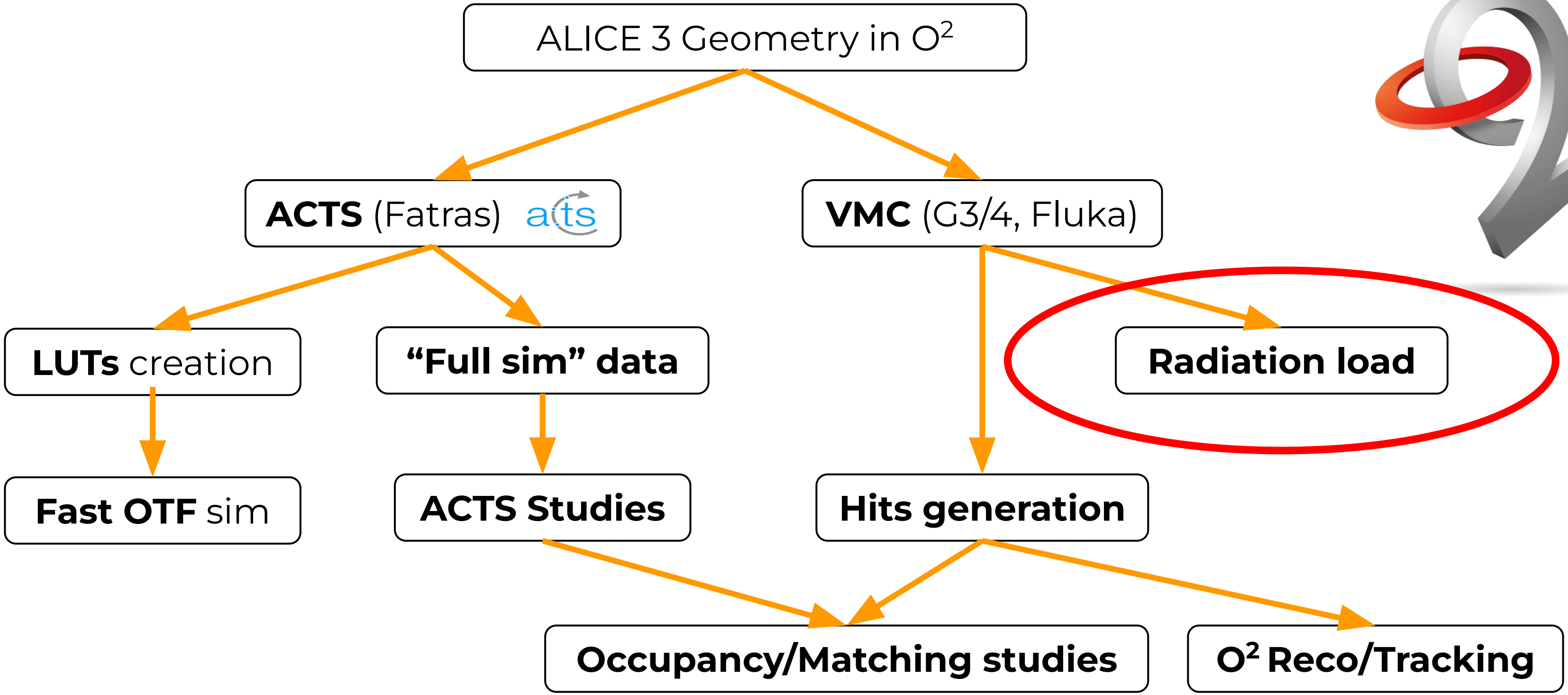
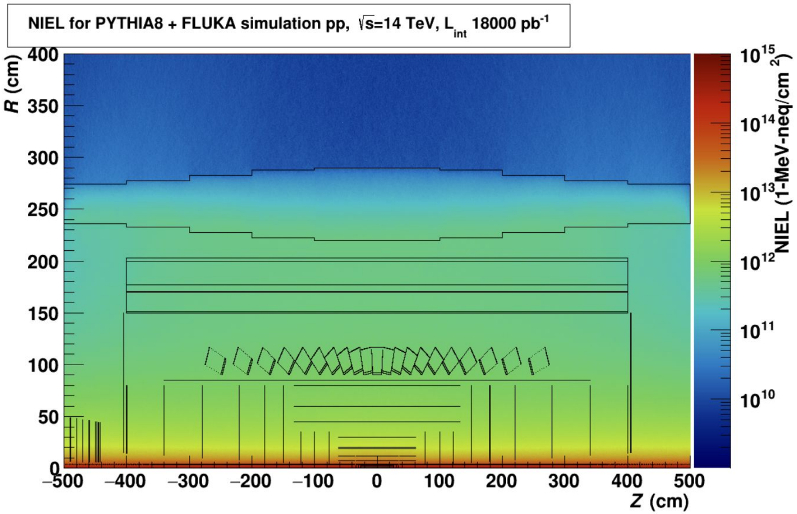


Radiation load studies with O² for ALICE 3

Non-Ionising Energy Loss obtained with PYTHIA 8 + Fluka simulations.

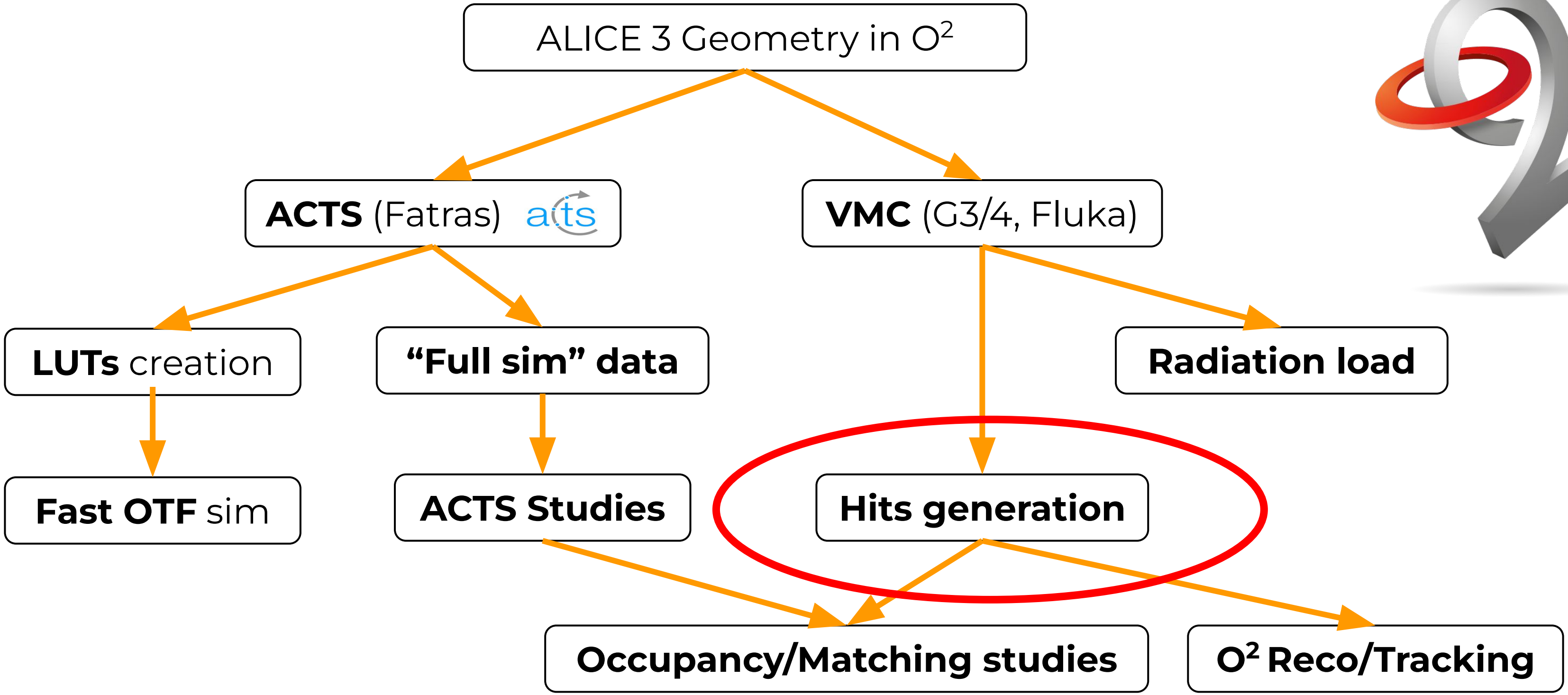
Corresponds to the pp integrated luminosity for Runs 5+6 $L_{\mathrm{int}} = 18\,\mathrm{fb}^{-1}$ and $B = 2\,\mathrm{T}$



The six one-month heavy-ion runs have a negligible contribution.

These values are taken as reference for the subsystem design and R&D.

O^2 for ALICE 3



Forward Conversion Tracker in O^2

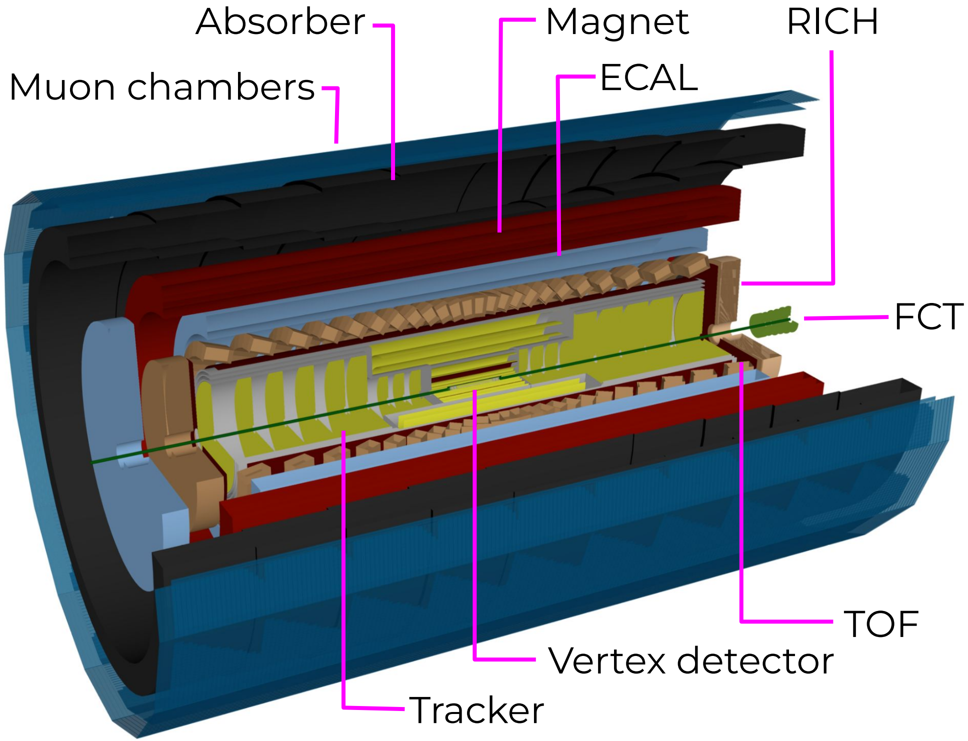
Low's theorem predicts the soft inner bremsstrahlung photon spectrum with a characteristic 1/E dependence

Most experiments in the past show an excess of a factor 4-8 above the photon spectrum predicted by Low's theorem

=> Soft photon puzzle

Forward Conversion Tracker aims to measure the soft photon spectrum via conversions to e+e-

p_T in the range of 1 to 10 MeV/c



Simulation studies of the FCT for ALICE 3 in O^2

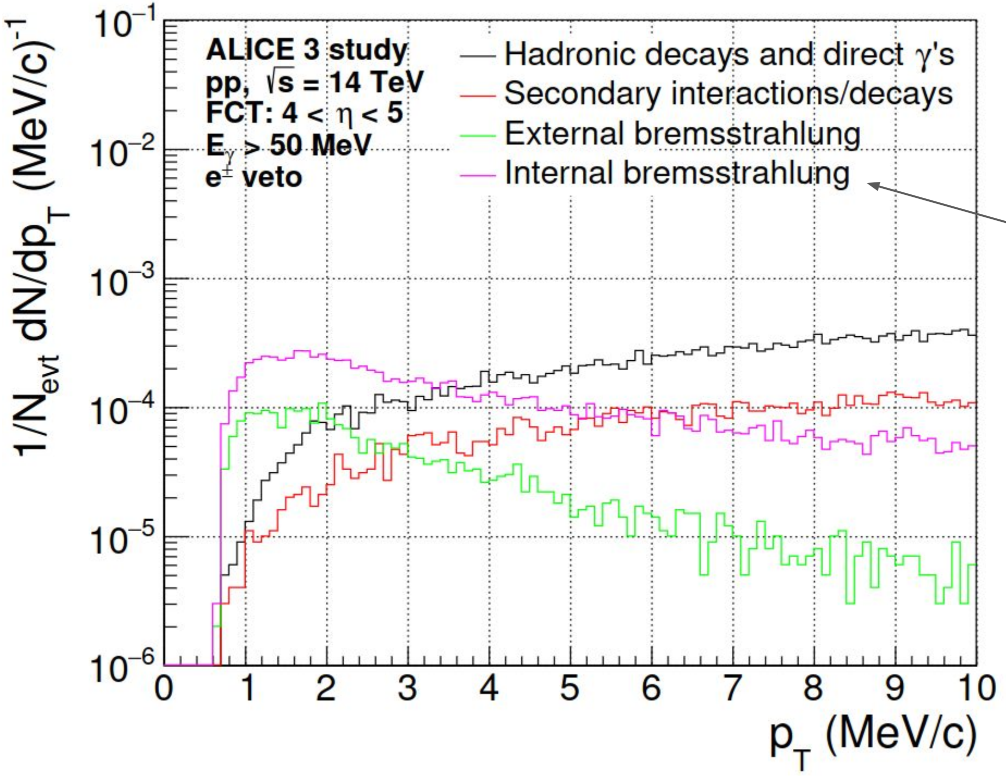
Detailed simulation within the O2 simulation framework with

- PYTHIA for background generation

- External signal generator for Low's theorem

- GEANT4 for particle propagation

Gives a promising signal / background ratio



Signal with $1/p_T$

Summary

The simulation and performance tools of ALICE 3 give us access to a wide range of studies and allow us to test our designs

ACTS studies allow us to investigate performance with changing layouts

On-the-fly simulations aided by the LUTs allow for fast analyses if e.g. the geometry changes

VMC simulation in O^2 is used for

- Radiation load studies
- Responses of tracking detectors (hits)