muEDM: BVR: simulation

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Simulation overview

- We split the simulation into 3 groups:

G4Beamline

- Determine the muons arriving at the experiment, rates, momentum, polarisation, etc
- Storage efficiency, from injection to stable orbit

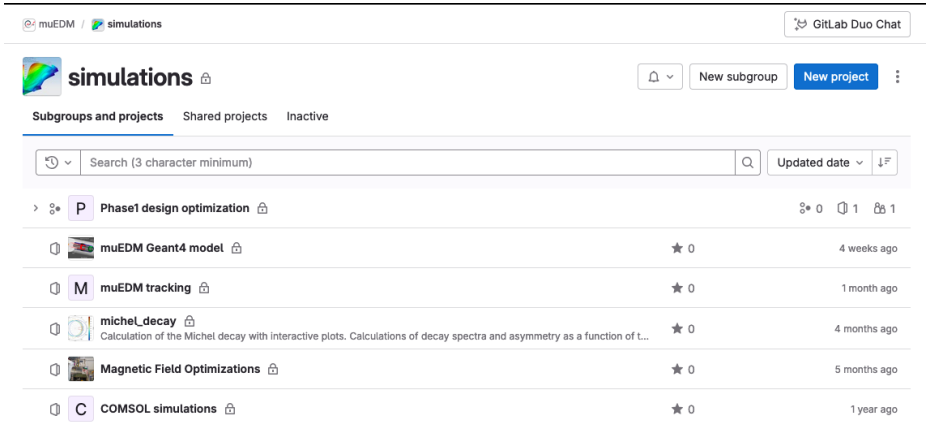
GEANT

- GEANT based models of the detectors and support structures
- Simulate interactions of incident particles, mimic detector response

Fields

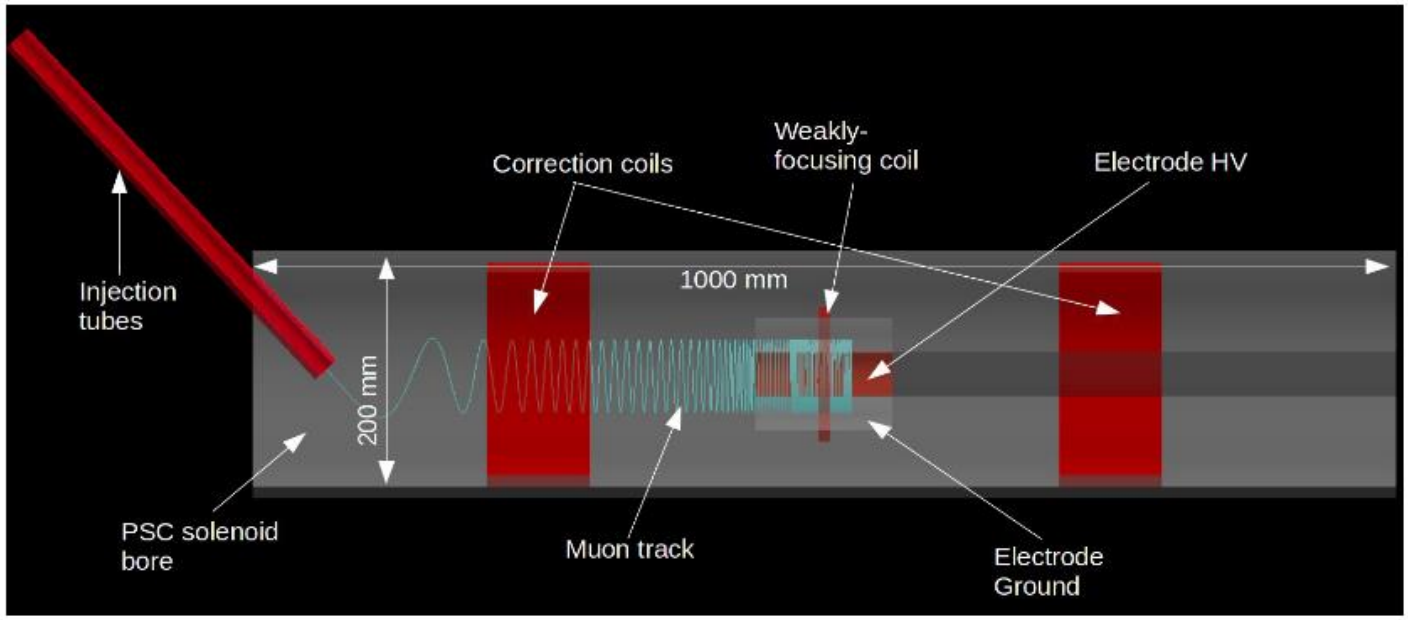
- OPERA/COMSOL/ANSYS models of the magnetic fields used to store muons
- Time dependent fields, impacting stored muons/decay positrons etc.

- Maintain, share and document the code on a git repository, hosted at PSI
- Accounts for internal and external users available

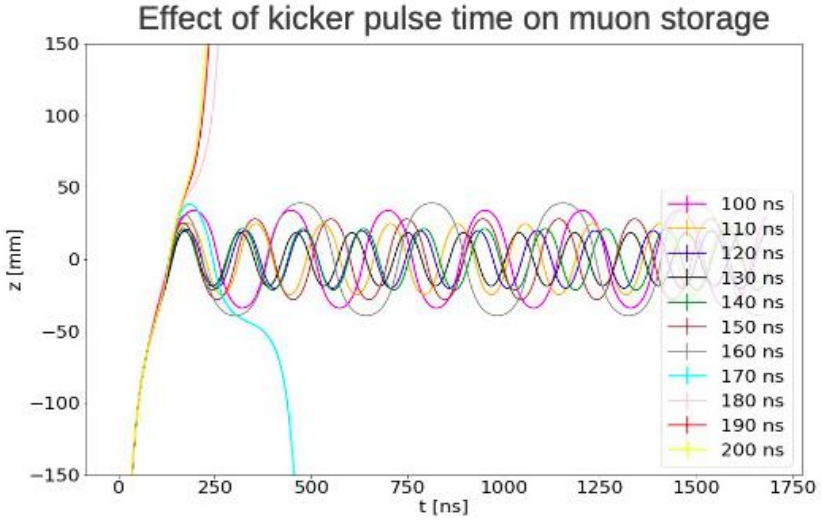


Beamline

courtesy of Ritwika Chakraborty

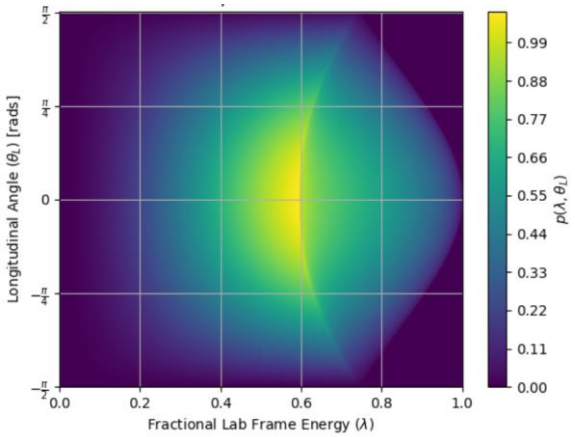


- Study injection efficiency as kicked pulse time changes
- Tweak time of pulsed field and observe effect on number of stored muons
- Output distribution of stored muons

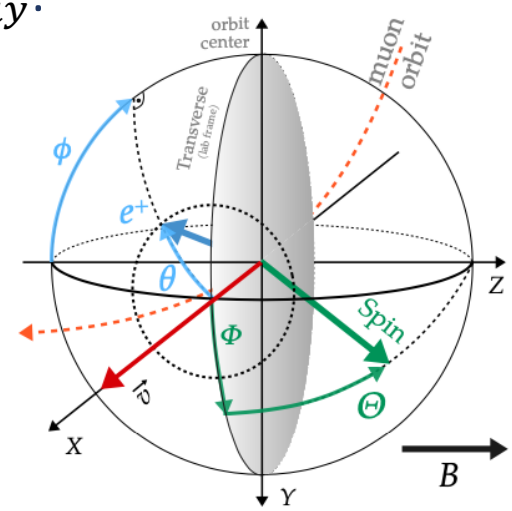


GEANT - Muon decay in simulation

- Propagate injected muons through inputted magnetic and electric fields
- Generate decay positrons based on time of decay t_{decay}:



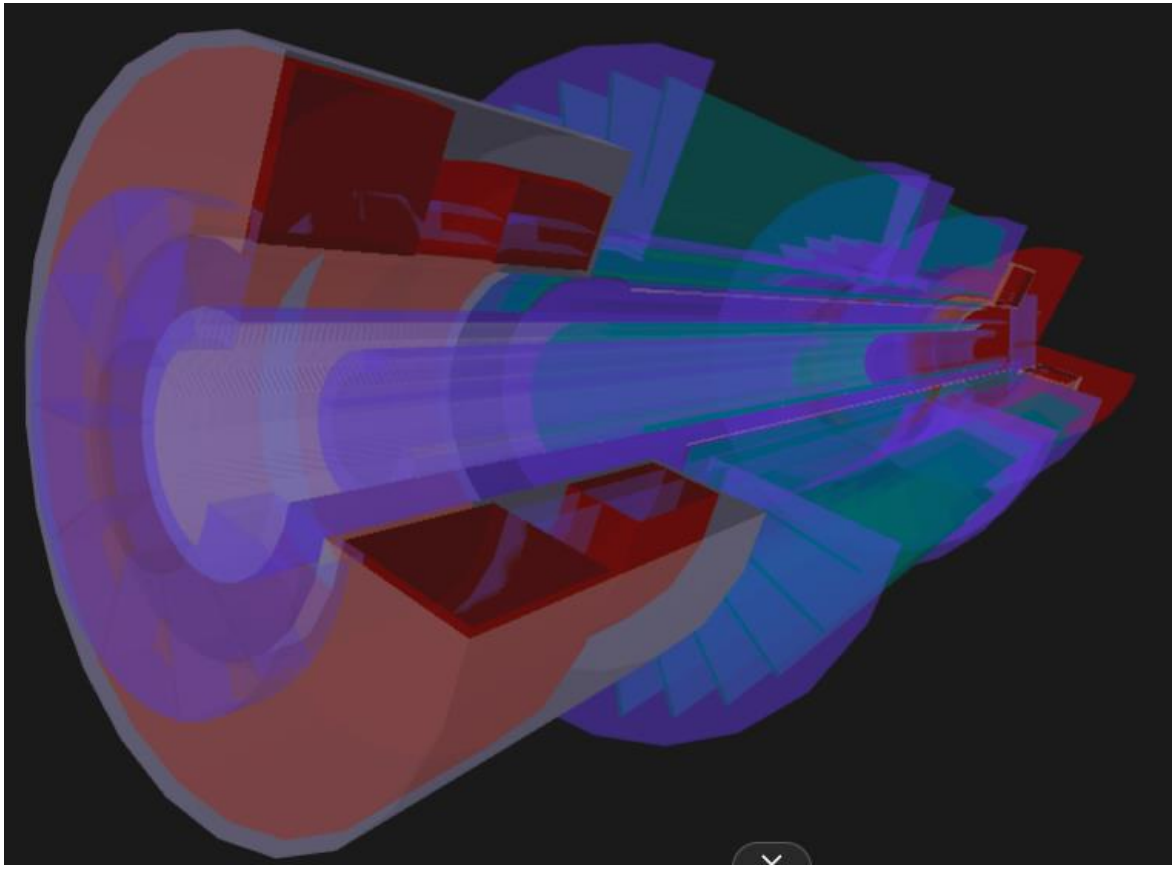
- Need muon momentum, position, and spin orientation at t_{decay}
- Randomly draw positron properties based on these



- Can choose to simulate muon **with** or **without a muon EDM**
- This alters polarisation orientation at given time, and thus effects distribution of decay positrons – **observable signal**
- Propagate decay positron through materials, recording the information as it passes through different detectors

Detector placement

- Detectors are placed into GEANT based on steerable input files
- Shown here is a slice through the detectors in the GEANT simulation



- Beampipe
- Correction Coils
- Triggers
- E-field Anode/Cathode
- Positron tracker (petals + cylinder)

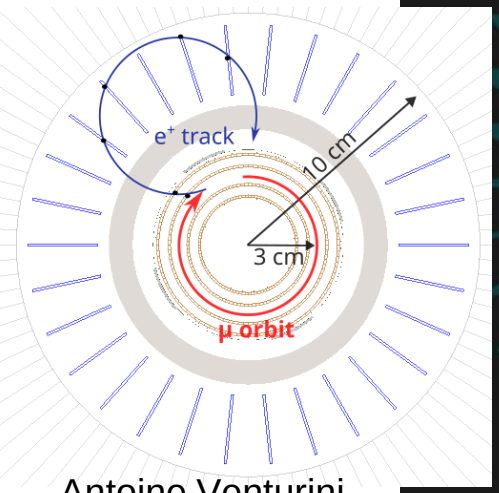
Complete support structures + readout to be added

Detector response and reconstruction

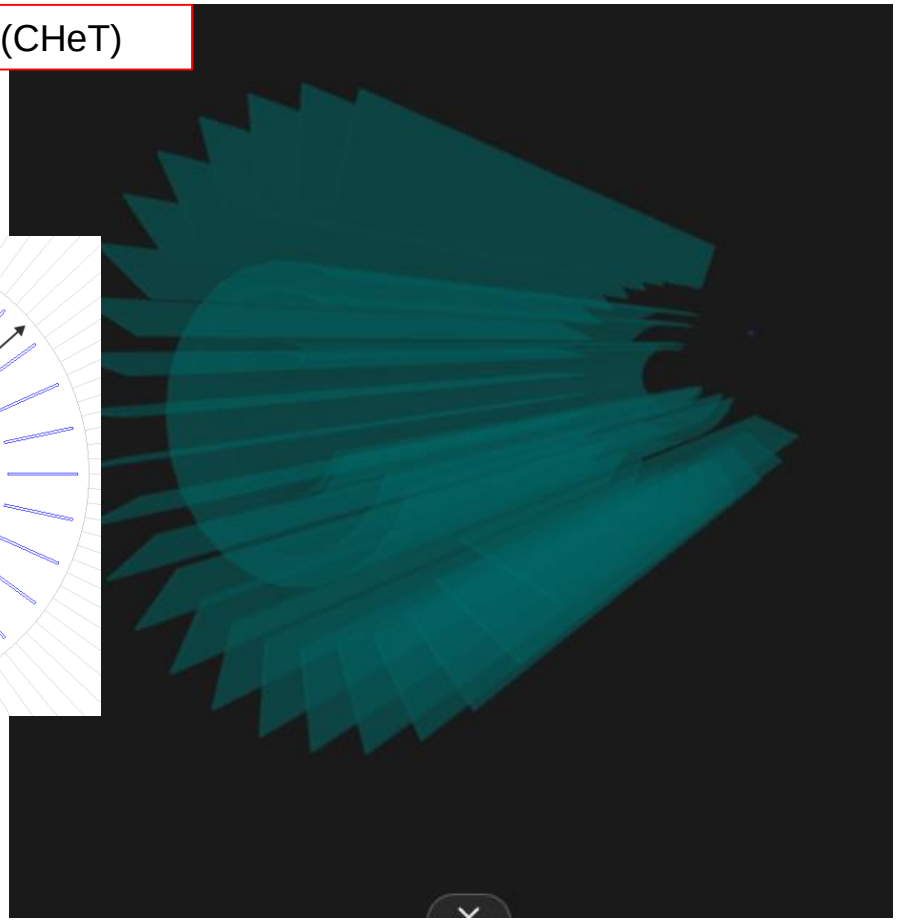
- Set which detectors are ‘sensitive’ – record the true positions and momenta
- Multiple scattering is taken into account within GEANT

Turn on and off for systematic studies!

Positron Tracker (CHeT)



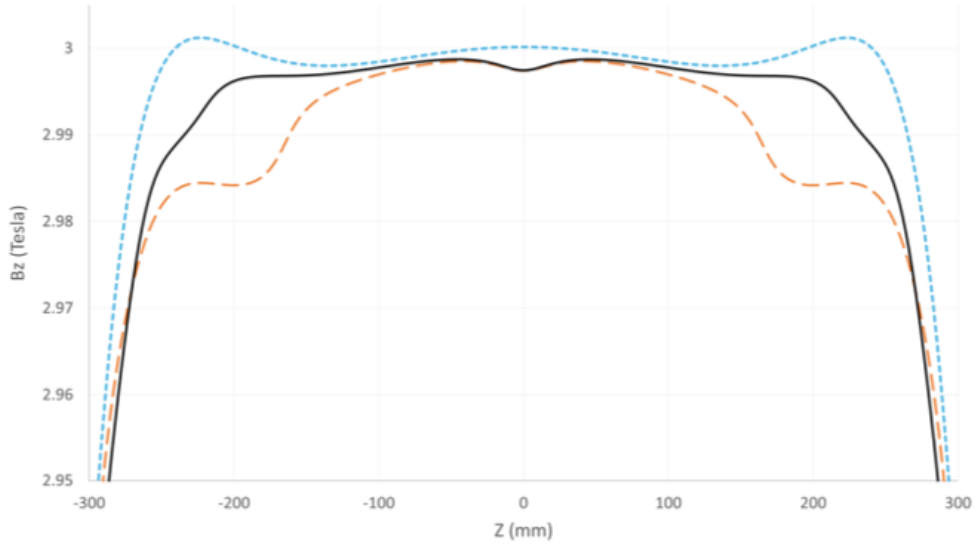
Antoine Venturini



- Determine response of detector to an incident particle
- Include efficiency/noise etc.
- Tuned to match data from test beams
- Based on the reconstructed hit positions, make tracks and estimate positron properties

Field: simulation

- Need to simulate the electric and magnetic field
- Magnetic field during storage:
  - Use OPERA based models and port into GEANT for charged particle propagation

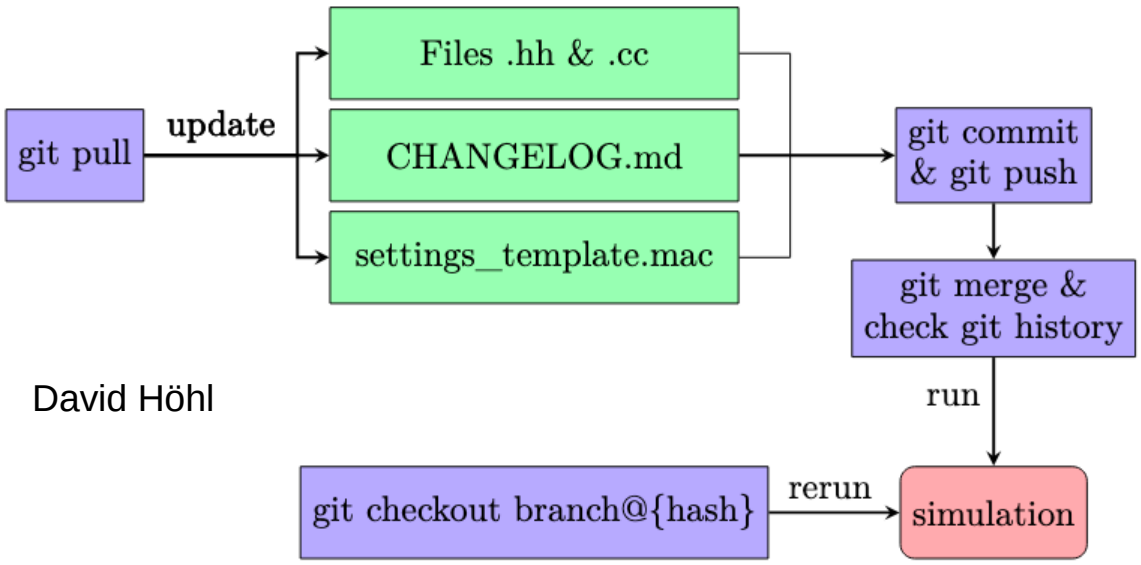


Alex Bainbridge

- Effect of the correction coils on the z component of the B-field, from OPERA
- Blue line shows simulated field without correction
- black is implemented in the main GEANT simulation – read in from file

Simulation: Organisation

- We have multiple people working on the simulation at the same time
- Maintain a ‘master’ branch as basis for all other branches
- Each analyser works on their own separate branch and merges into the master, documenting their changes



David Höhl

- High stats are often needed for each file
- More may need to be generated **at a later date**
- Store **Meta-data** with the output of the files
- Encapsulates status of repository when initially ran using ‘*git hash*’ – i.e. snapshot of the code