The ENUBET beamline

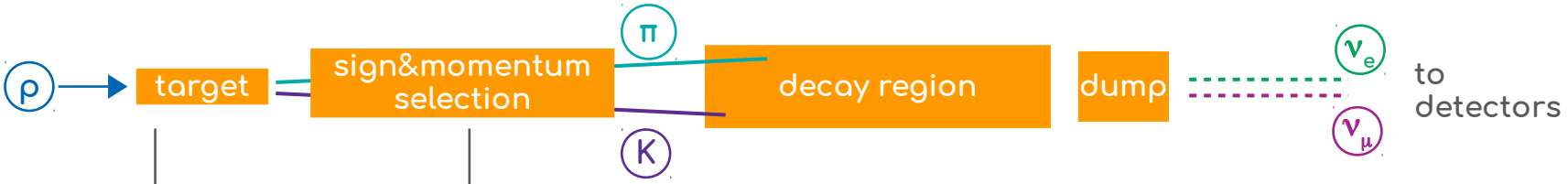
XIX International Workshop
on Neutrino Telescopes

18-26 February 2021
Online

Claudia Caterina Delogu
University of Padova & INFN
on behalf of the ENUBET Collaboration

This project has received funding from the
European Research Council (ERC)
under the European Union's Horizon 2020 research and
innovation programme (grant agreement N. 681647)

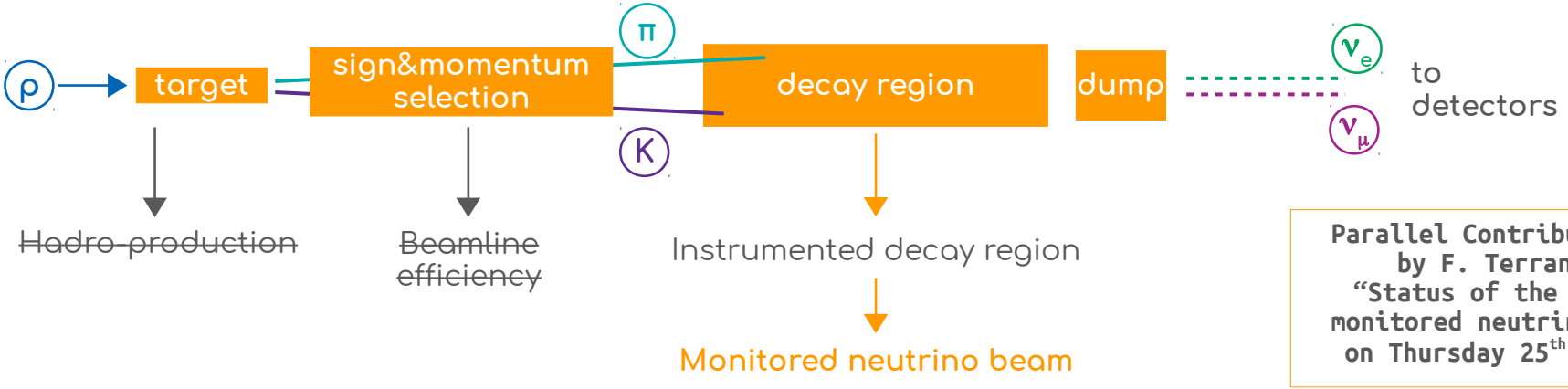
NP06/ENUBET: Enhanced NeUtrino BEams from kaon Tagging



→ O(10%) flux uncertainty

This project has received funding from the
European Research Council (ERC)
under the European Union's Horizon 2020 research and
innovation programme (grant agreement N. 681647)

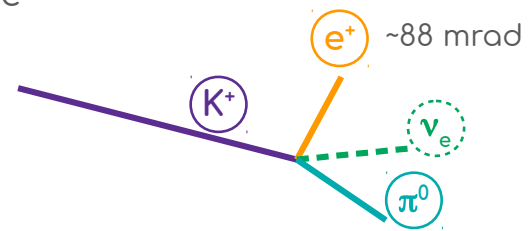
NP06/ENUBET: Enhanced NeUtrino BEams from kaon Tagging

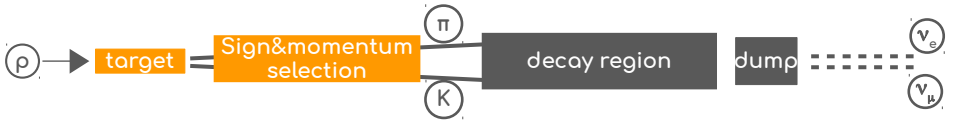


Parallel Contributed Talk by F. Terranova "Status of the ENUBET monitored neutrino beam" on Thursday 25th, 10:20

Novel ν_e source from $K^+ \rightarrow e^+ \pi^0 \nu_e$ decays, lepton production at large angles is monitored at single particle level by calorimetric techniques, I.e. tagging the e^+ in an instrumented decay pipe

ν_e flux prediction = e^+ counting → O(1%) precision on the ν_e flux

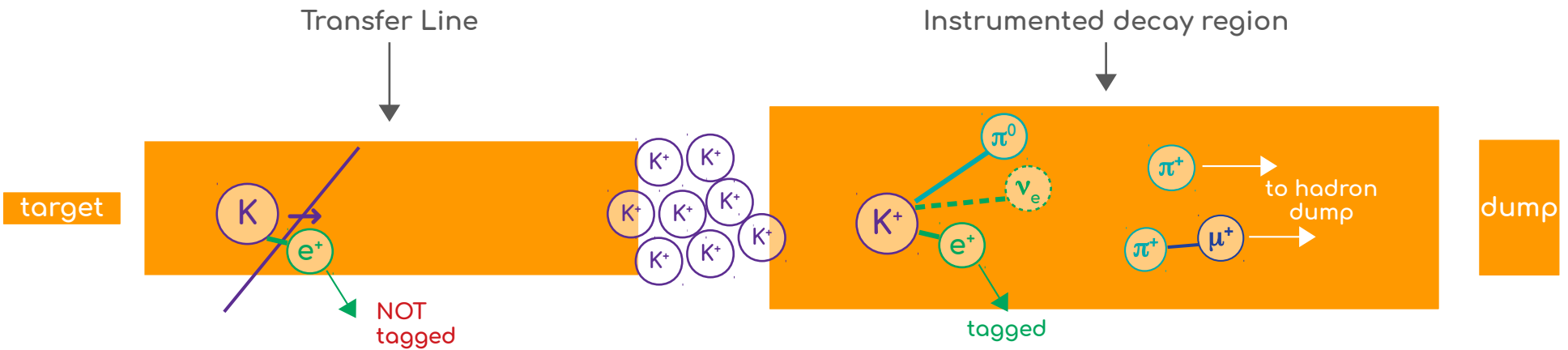


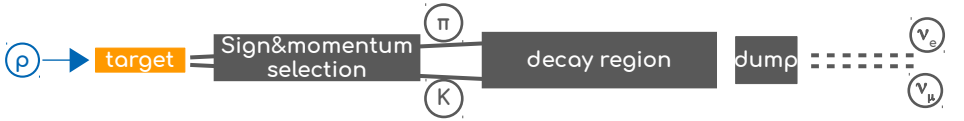


The Beamline

Requirements:

- Use of **conventional magnets** (normal-conducting, aperture < 30cm)
- Keep under control level of **background** transported to the tunnel: fine tuning of **shielding and collimators**
- **Small beam size**: non decaying particles should exit the decay pipe without hitting the walls
- **Maximize** number of **K^+ at tunnel entrance** (looking for $K^+ \rightarrow e^+ \pi^0 \nu_e$)
- Minimize total length of the transferline (~20 m) to **reduce kaon decay** in the **not instrumented region**





Proton driver & target

Fast extraction: pile-up rate not sutainable in the tagger (decay region)

Focusing:

- **Horn**: 2 ms pulse, 180 kA, 10 Hz during the flat top
- **Static** focusing system: a quadrupole triplet before the bending magnet

Proton extraction:

→ "burst mode" extraction tested during machine studies at the CERN-SPS

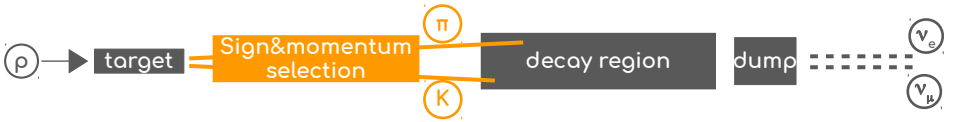
→ 2s slow extraction

Target: optimization of transverse dimensions, length and material (**FLUKA**)

→ analyze secondary particle productions with different primary energies (400, 120 and 30 GeV/c).

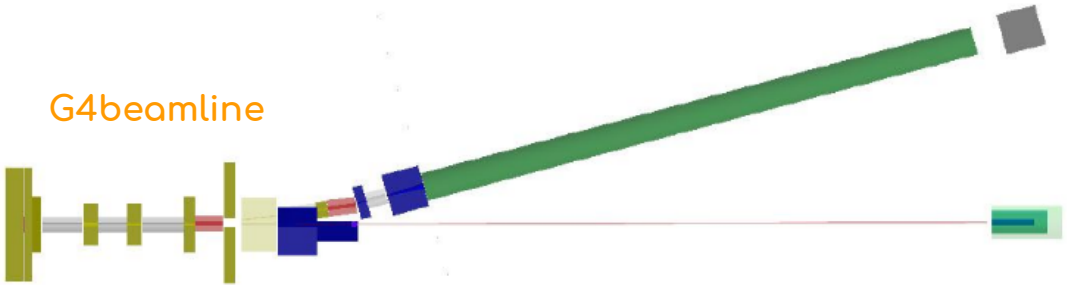
Best candidates: Beryllium, Carbon, Inconel.

Primary momentum: optimum particle production for kaons of 8.5 GeV, protons of 400 GeV/c

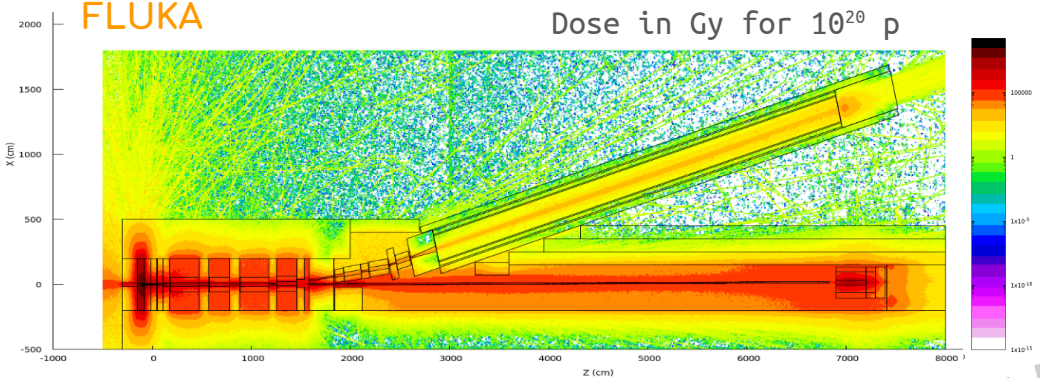


The Transfer Line

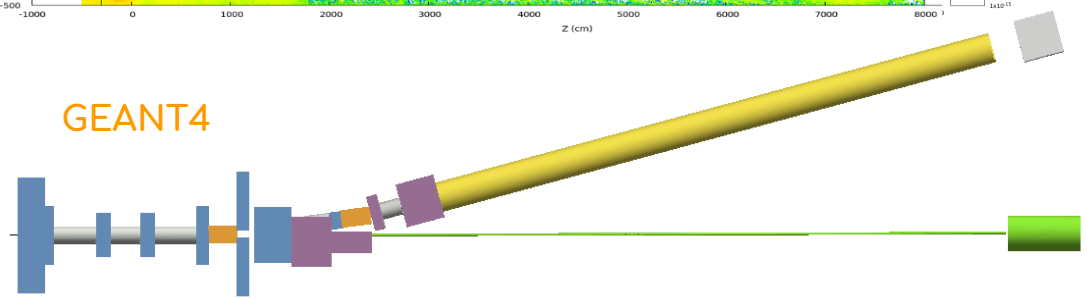
G4beamline



FLUKA



GEANT4



Static TL, top view

Reference momentum 8.5 GeV, 10% momentum bite

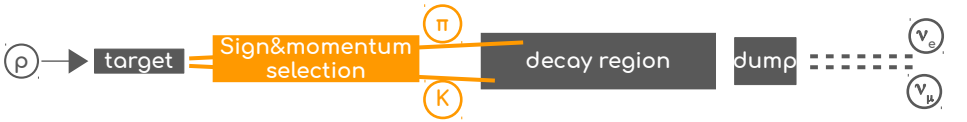
Focusing system: a quadrupole triplet before the bending magnets

One quadrupole triplet, two dipoles (14.8° bending)

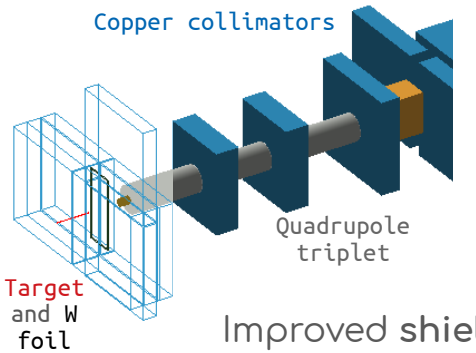
Optics optimized with **TRANSPORT**, particle transport and interaction: full simulation with **G4beamline**

FLUKA: assess doses in the tunnel area where instrumentation will be placed

GEANT4: systematic uncertainties on the neutrino flux

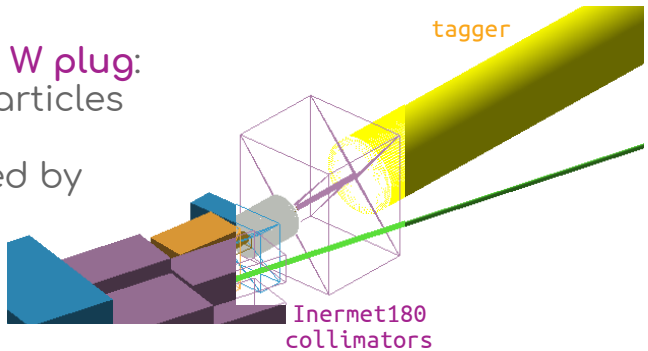


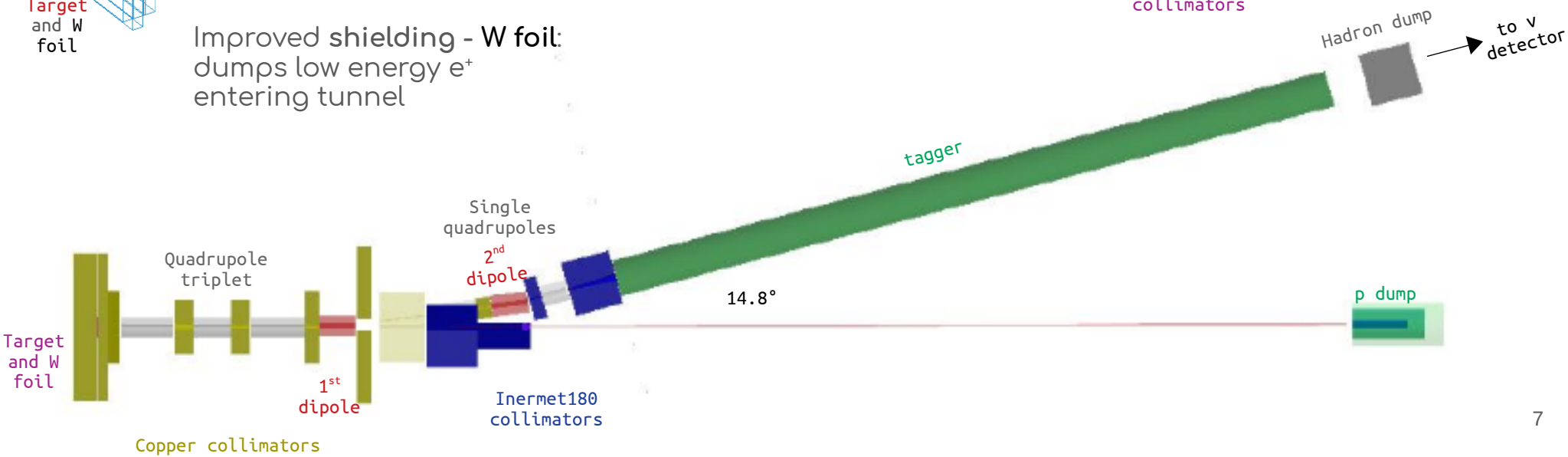
The Transfer Line

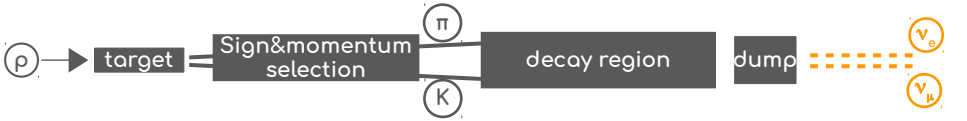


Improved **shielding - W foil**: dumps low energy e^+ entering tunnel

Improved **shielding - W plug**: dumps low energy particles hitting the tagger, backgrounds reduced by large factors





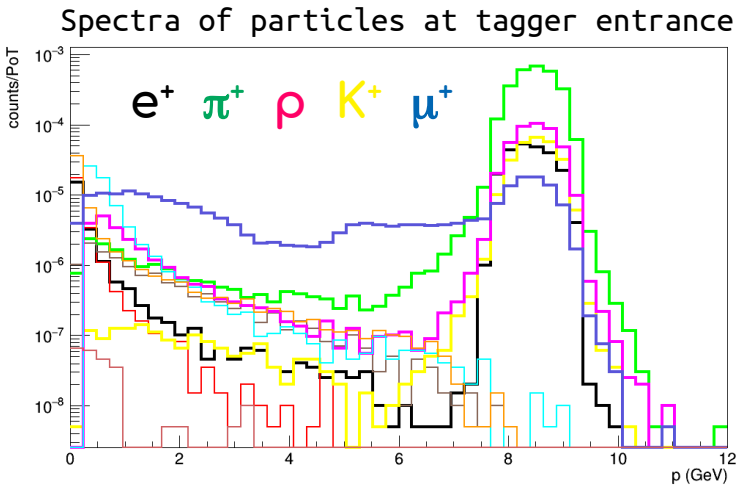


Neutrino fluxes @ detector

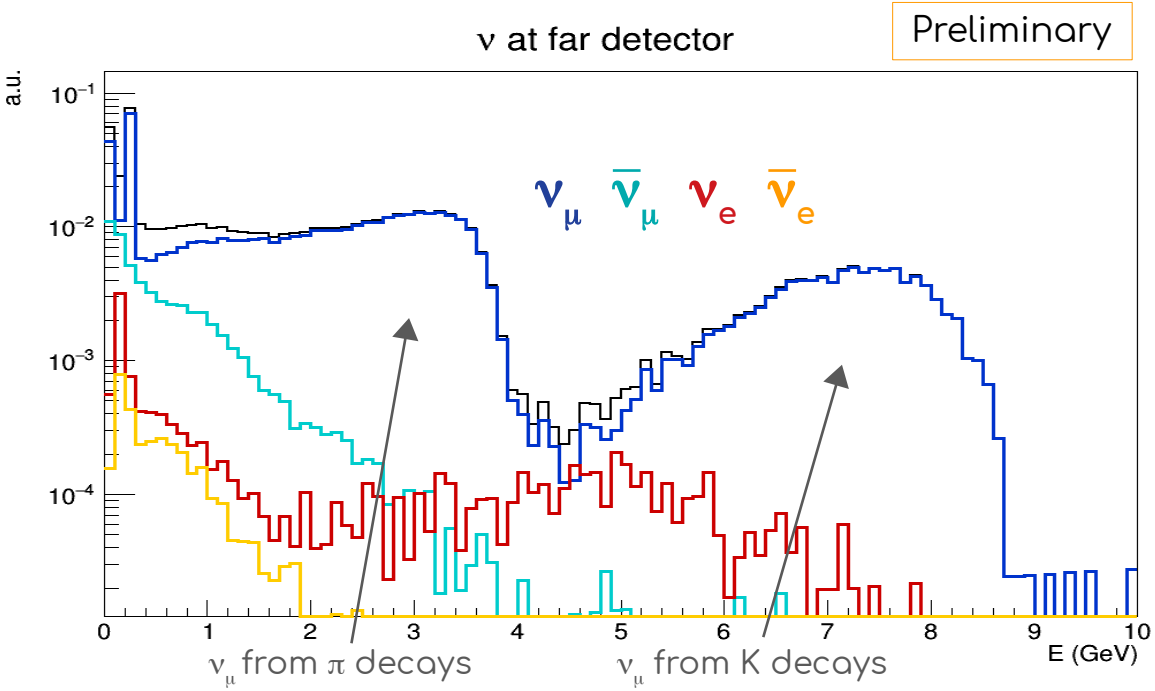
GEANT4 reproduces geometry and outcome of G4beamline simulation.
Contains information on particle decay along the beamline.

Possibilities:

- map origin of background
- fine tuning of the beamline design
- study of flux systematics



Preliminary



Neutrino flux (weighted by energy) on a 6x6m² surface at 70m from the tagger exit

Summary

- The ENUBET project aims at reducing the flux systematics through the monitoring of leptons in an instrumented decay tunnel
  - ν_e source: K_{e3} decays
- Key element: design of a suitable transfer line
  - proton extraction scheme
  - particle yield from target
  - optics optimization
  - simulation of particle transport and interactions
  - doses estimation
  - fine tuning of shieldings and collimators
- Importance of redundancy in the simulation tools: G4beamline, GEANT4, FLUKA