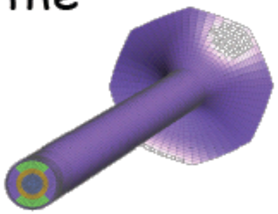
Funded by the Horizon 2020 Framework Programme of the European Union

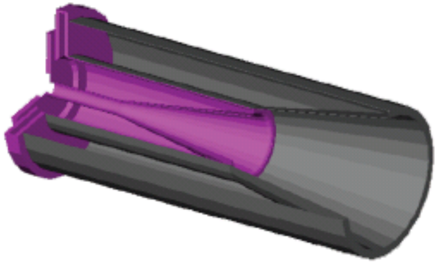
ESSNUSB WP5 SOFTWARE WORKSHOP

1. **OVERVIEW**
2. **SIMULATION STATUS**
3. **DISCUSSION**

OVERVIEW

- Can we conceive a neutrino beam based on a multi-MW proton beam ?
- At the start of EUROν, no proven solution for the target and collector was proposed for this facility !
- Can we design a target for a multi-MW proton beam ?
- Can we do it with a reliable design without compromising the physics reach ?
- **Target**
  - 300-1000 J/cm^3/pulse
  - Severe problems from: sudden heating, stress, activation
  - Solid versus liquid targets
  - cooling
- **Horn**
  - horn+reflector integration
  - pulser (up to 600 kA)
- **Safety**
- **Lifetime** (supposed to run for 10 years)



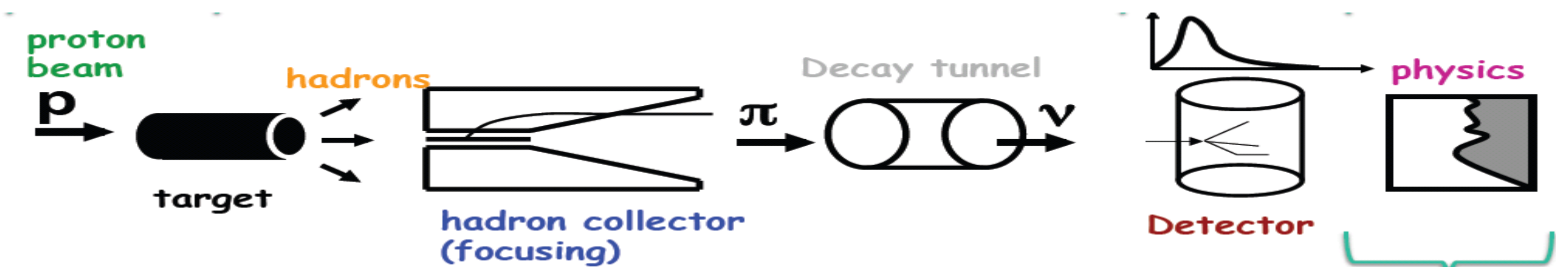


OVERVIEW

- **Superbeam simulation:**
  - **Particle production**
  - **Horn design optimisation**
  - **Decay tunnel optimisation**
  - **Flux Computation**
  - **Sensitivity Estimation at Water Cherenkov detector location**

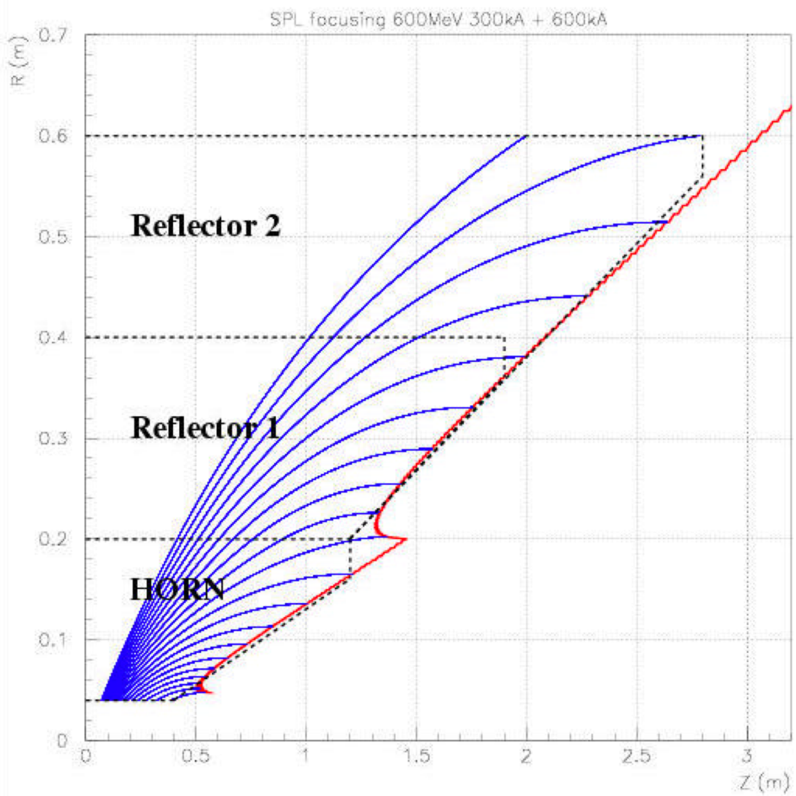
EUROnu Simulation
4.5 GeV, 4 MW
GEANT 4.9.10

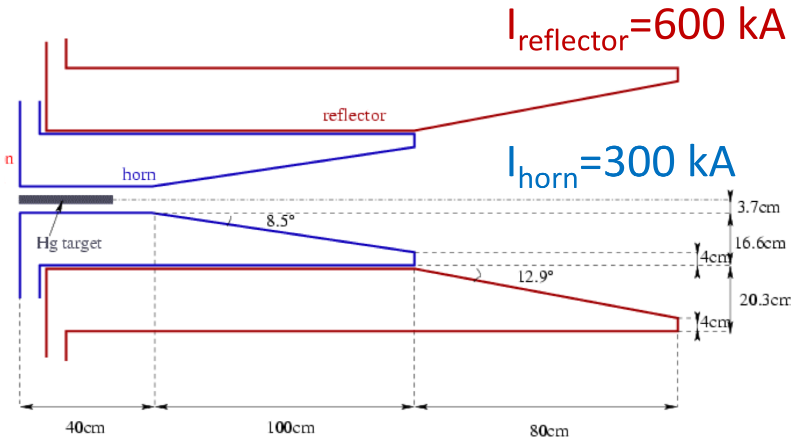
GENERATE GLOBES INPUT FILES

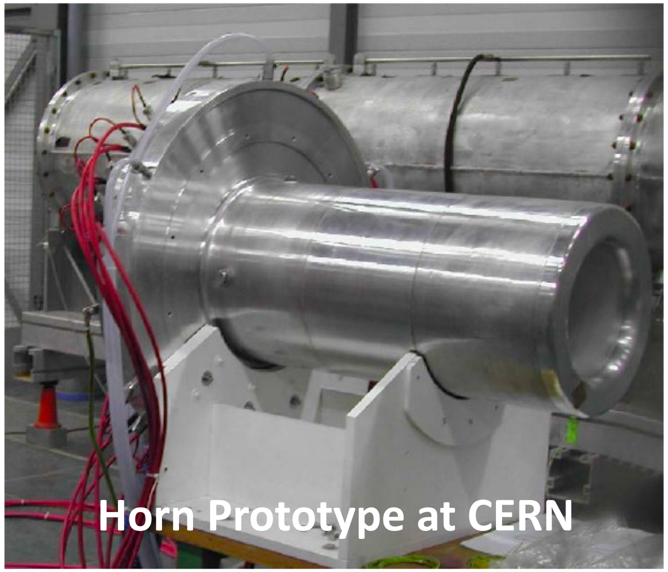


HORN DESIGN

Horn Design First Approach





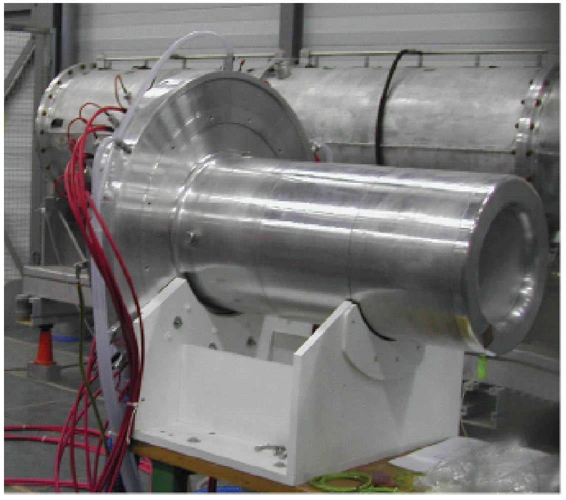


The outer conductor is placed where the slope becomes parallel to the beam (dr/dz =0) (A. Cazes, J.E Campagne)

PROTOTYPE AT CERN

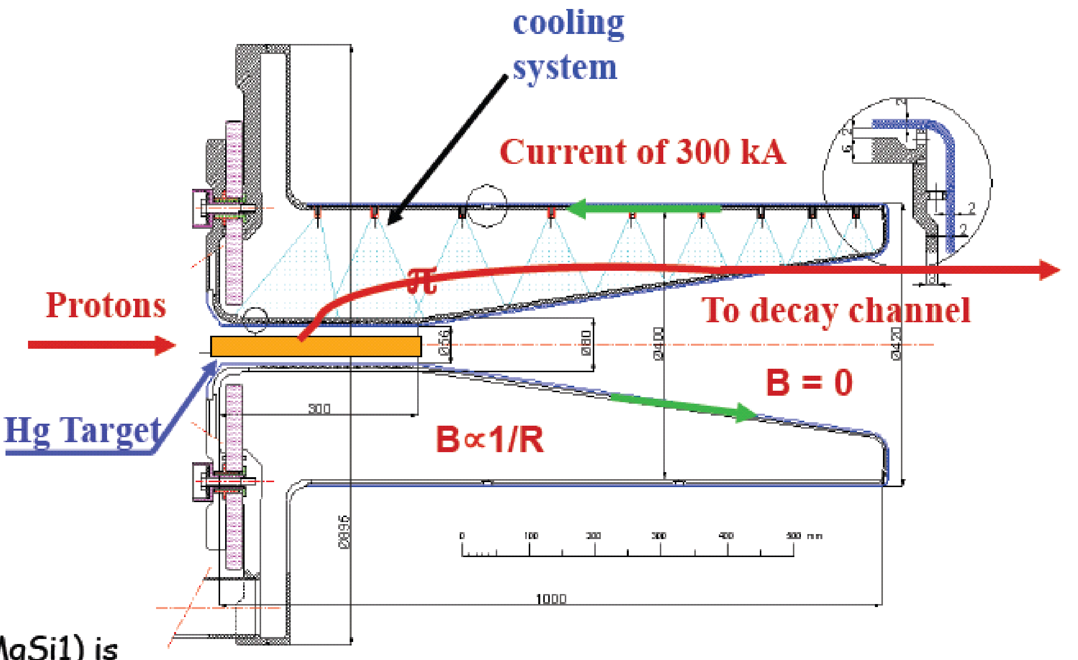
First studies with old SPL characteristics:

- 2.2 GeV proton beam



For the horn skin AA 6082-T6 / (AlMgSi1) is an acceptable compromise between the 4 main characteristics:

- Mechanical properties
- Welding abilities
- Electrical properties
- Resistance to corrosion
- Same for CNGS

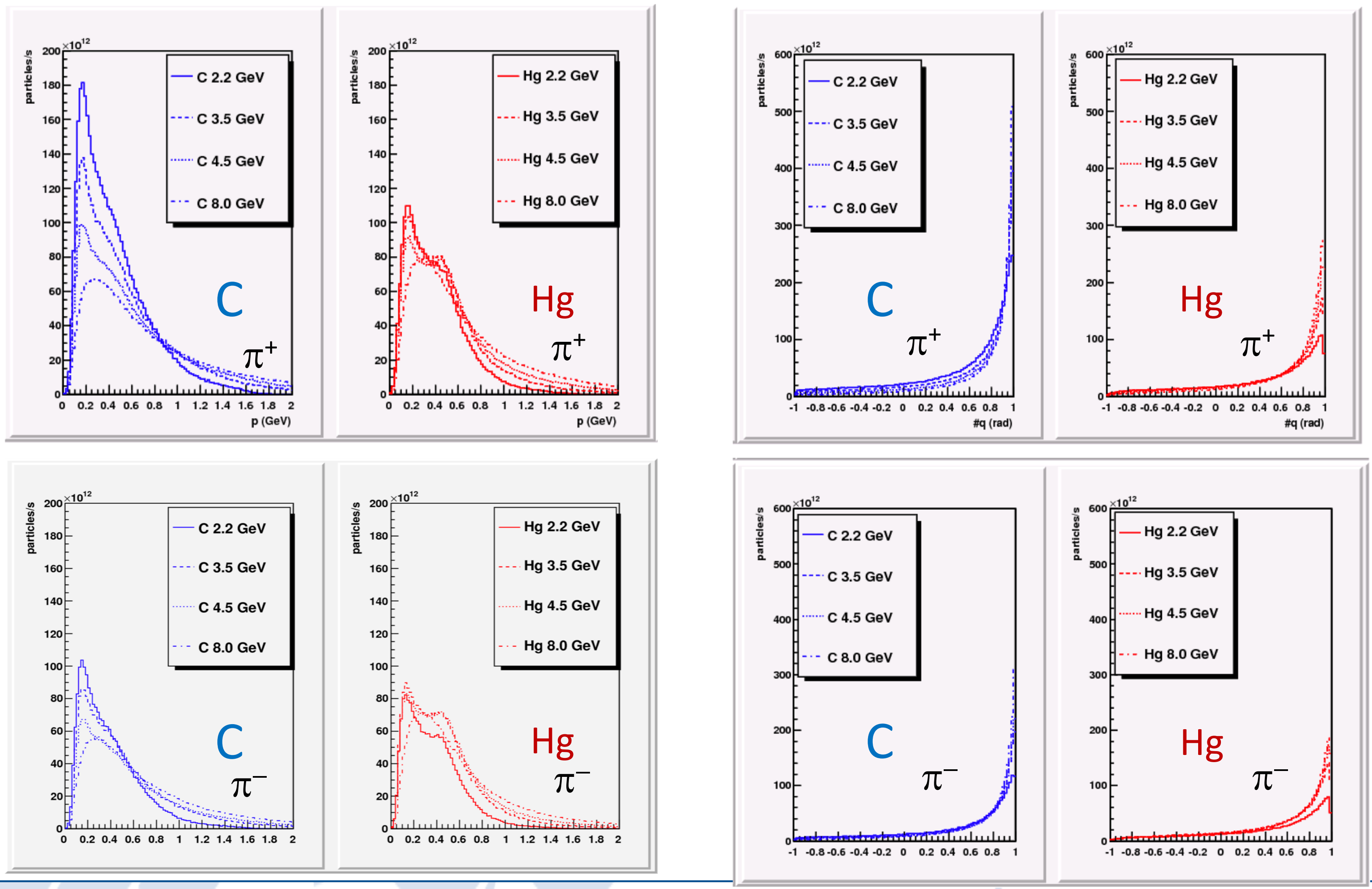


initial design satisfying both, Neutrino Factory and Super Beam

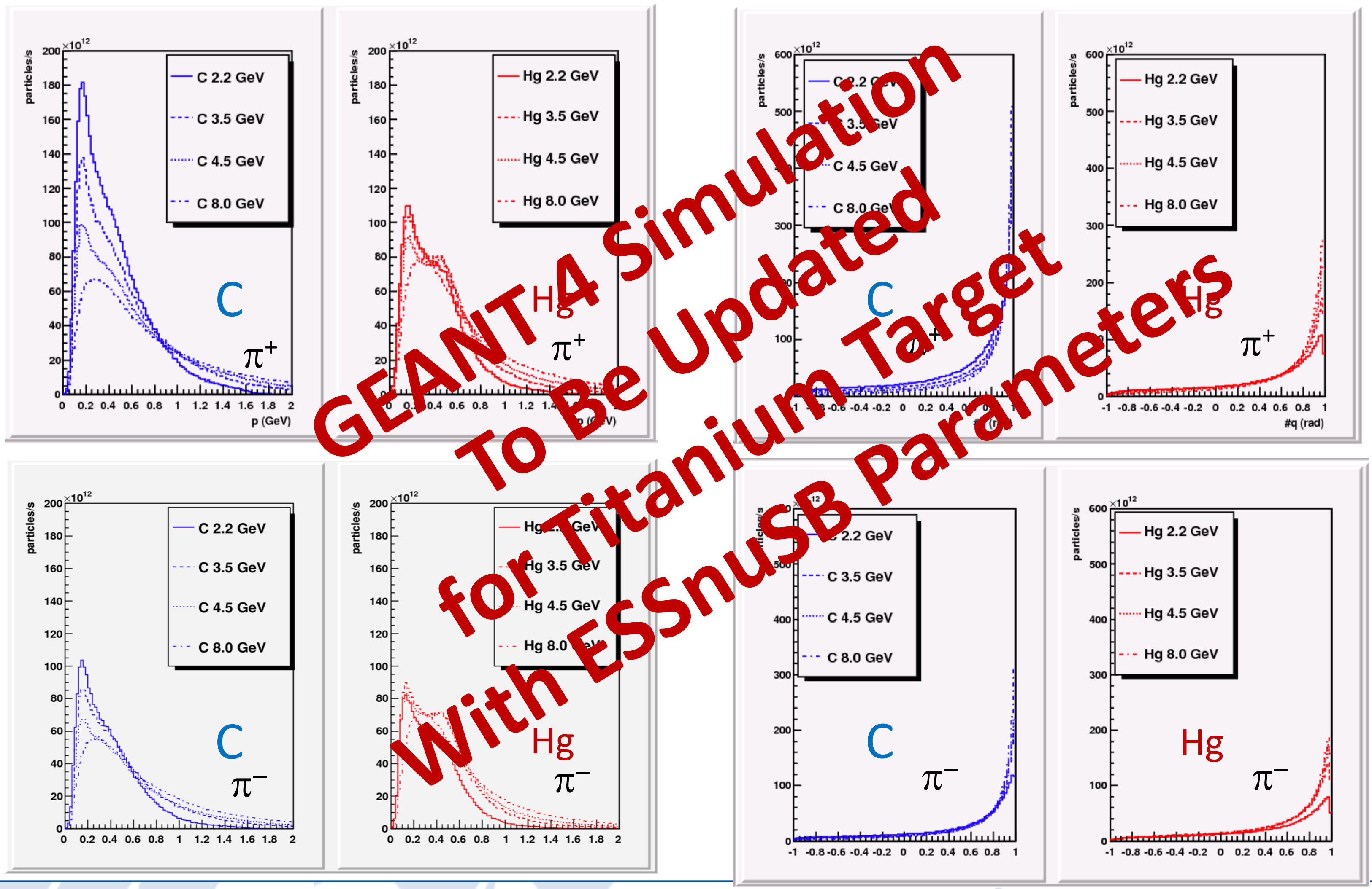
(see S. Gilardoni's thesis)

...but Al is not compatible with Mercury!

PARTICLE PRODUCTION FROM EURONU FROM



PARTICLE PRODUCTION FROM EURONU FROM

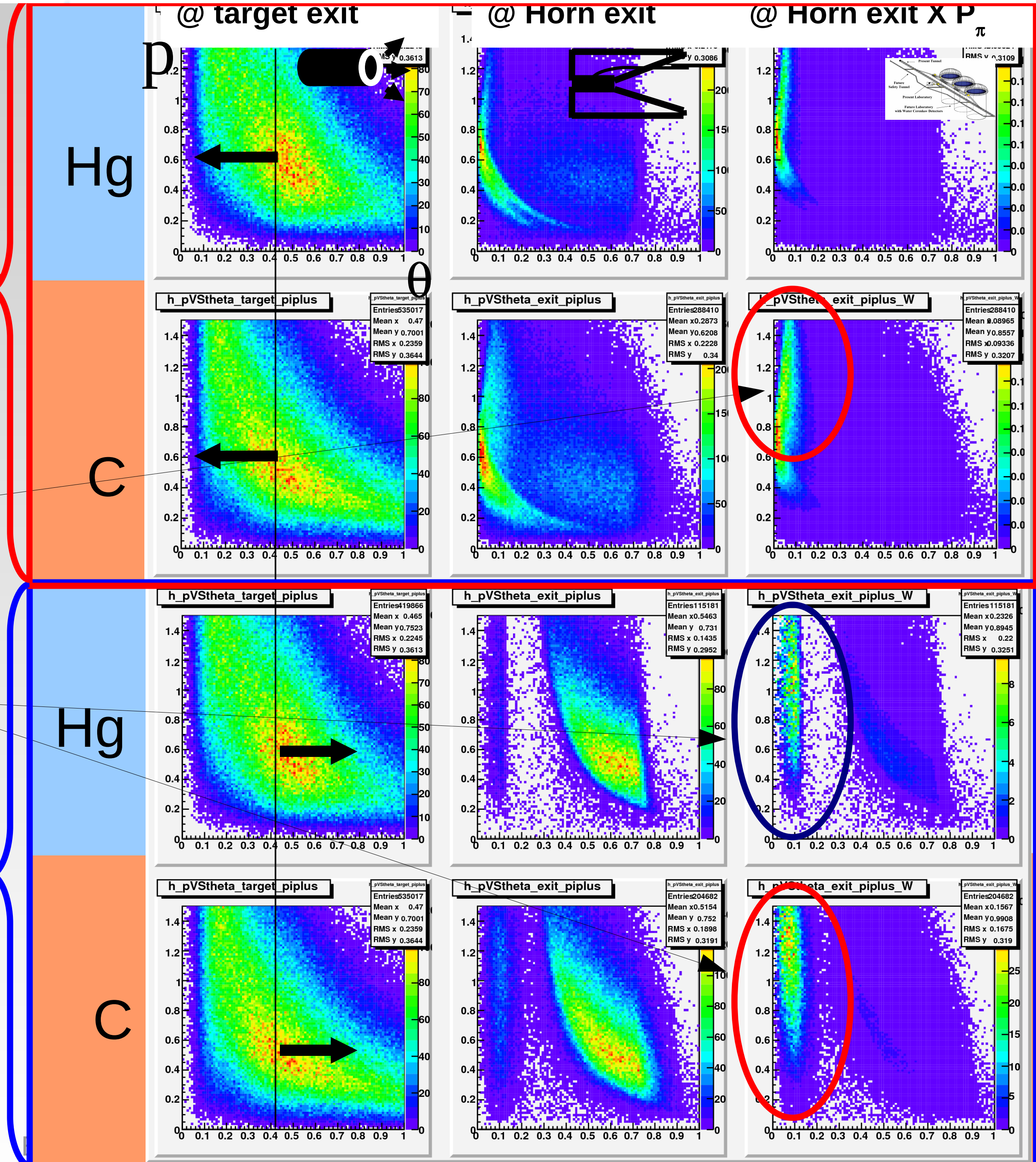


Pi collection: Hg-C

- P vs θ plots
- Positive focusing (negative defocusing)
- Carbon:
  - focused pi+ less "monochromatic" (tail at high momentum)
  - larger fraction of not defocused pi-
- 4.5 GeV

pi+

pi-



P_π := probability to reach the detector

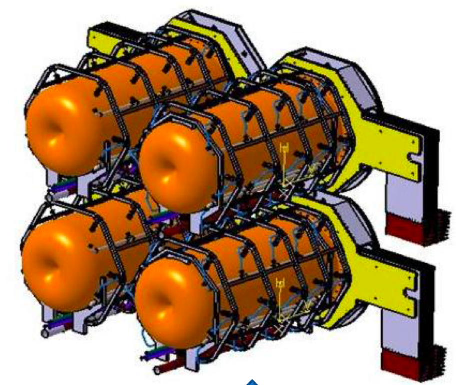
$$\mathcal{P}_\pi = \frac{1}{4\pi}\frac{A}{L^2}\frac{1-\beta^2}{(\beta\cos\alpha - 1)^2}$$

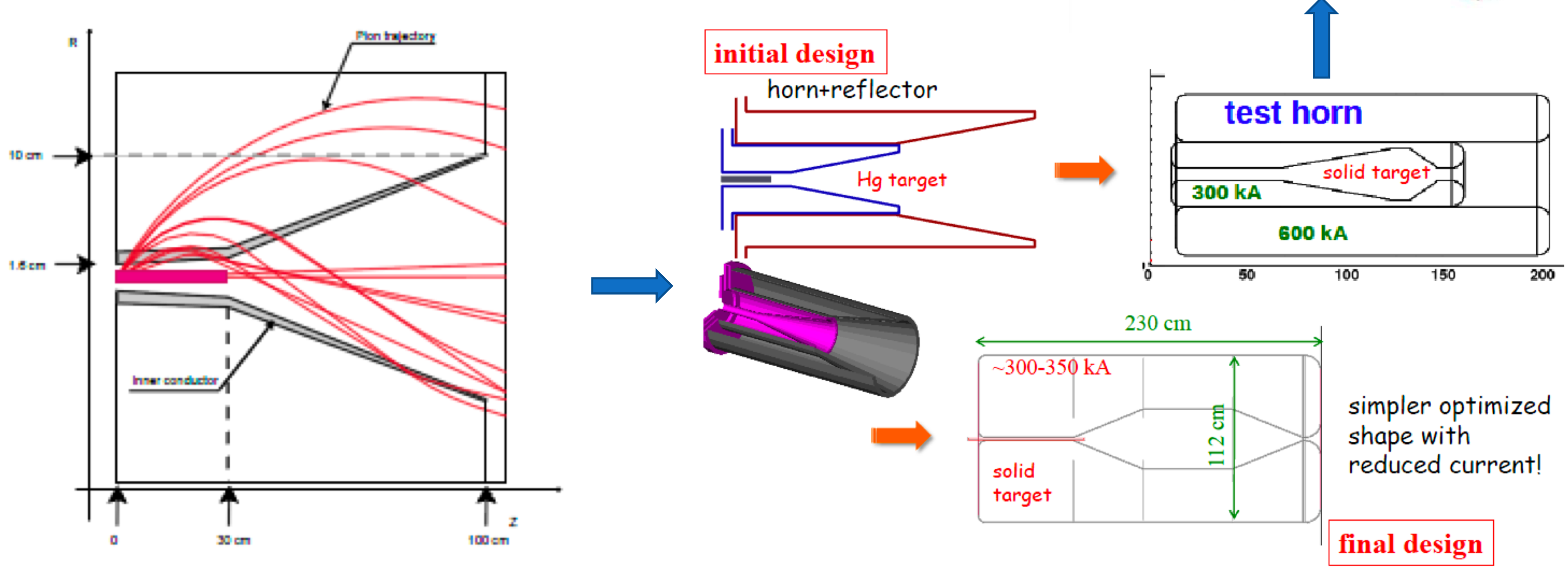
HORN DESIGN

Optimization:

- Depend on beam proton energy range,
- Rejection of wrong sign mesons
- Limited energy deposition
- Reliability

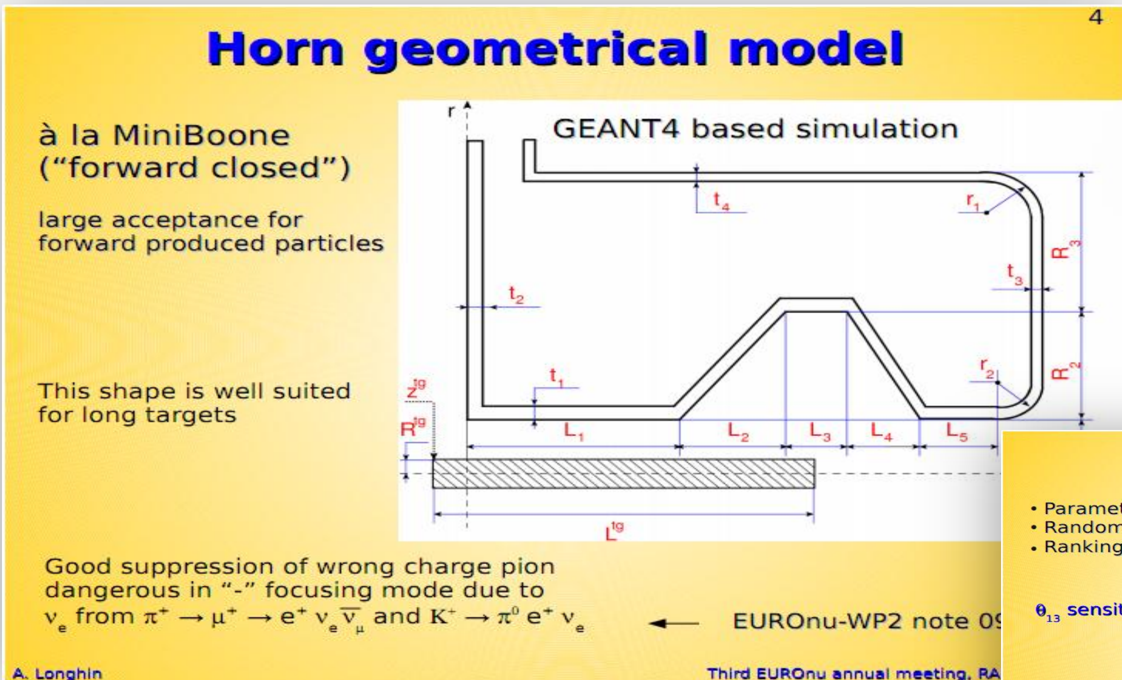
=> MiniBoone-like horn => Four Horn System



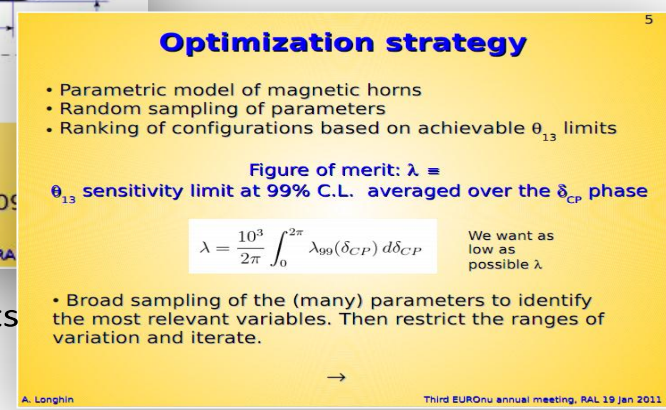


HORN DESIGN

Horn shape and SuperBeam geometrical Optimization I



studies by A. Longhin, C. Bobeth

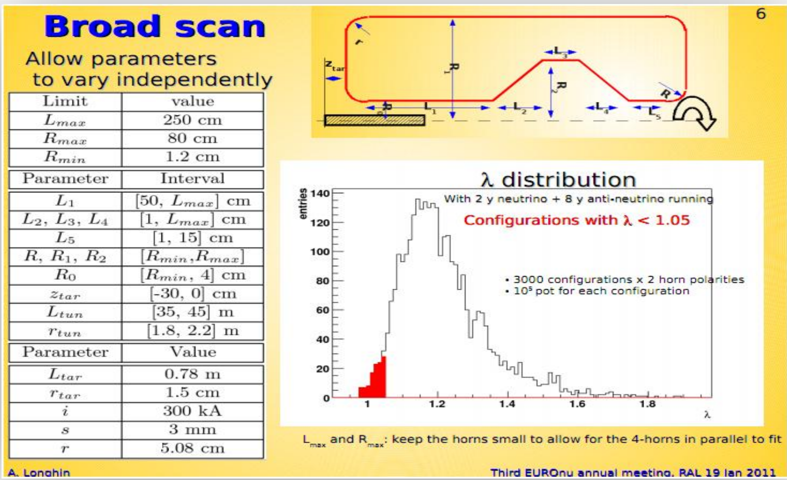


- ✓ parameterise the horn and the other beam elements as decay tunnel dimensions, etc...
- ✓ parameters allowed to vary independently
- ✓ minimize the δ_{cp}-averaged 99%CL sensitivity limit on $\sin^2 2\theta_{13}$

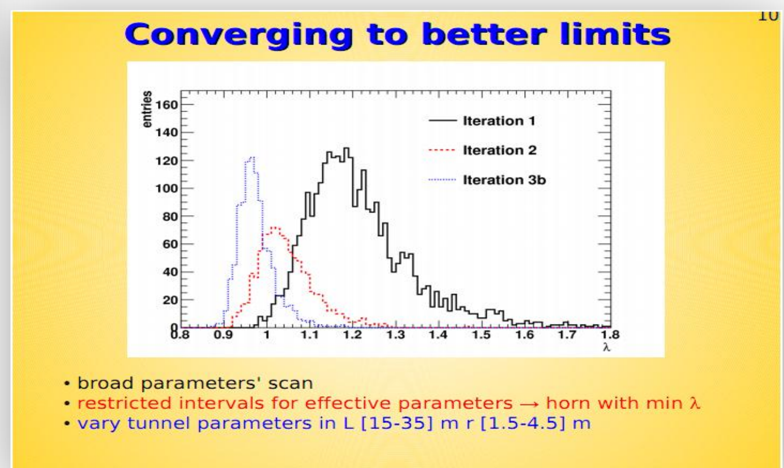
Horn Studies, WP2 @ APC, EUROnu 2012 3

HORN DESIGN

Horn Shape and SuperBeam geometrical Optimization II



fix & restrict parameters then re-iterate for best horn parameters & SuperBeam geometry

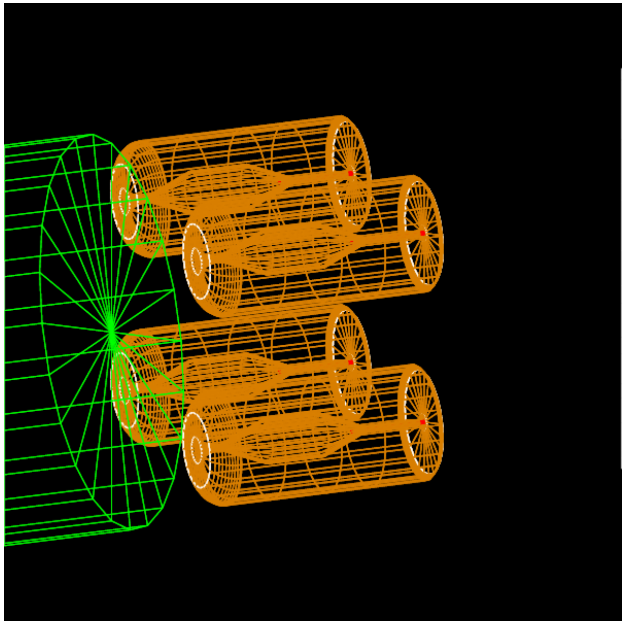


Parameters	value [mm]
L_1, L_2, L_3, L_4, L_5	589, 468, 603, 475, 10.8
t_1, t_2, t_3, t_4	3, 3, 3, 3
r_1, r_2	108
r_3	50.8
R^{tg}	12
L^{tg}	780
z^{tg}	68
R_2, R_3	191, 359
R_1 combined	12
R_1 separate	30

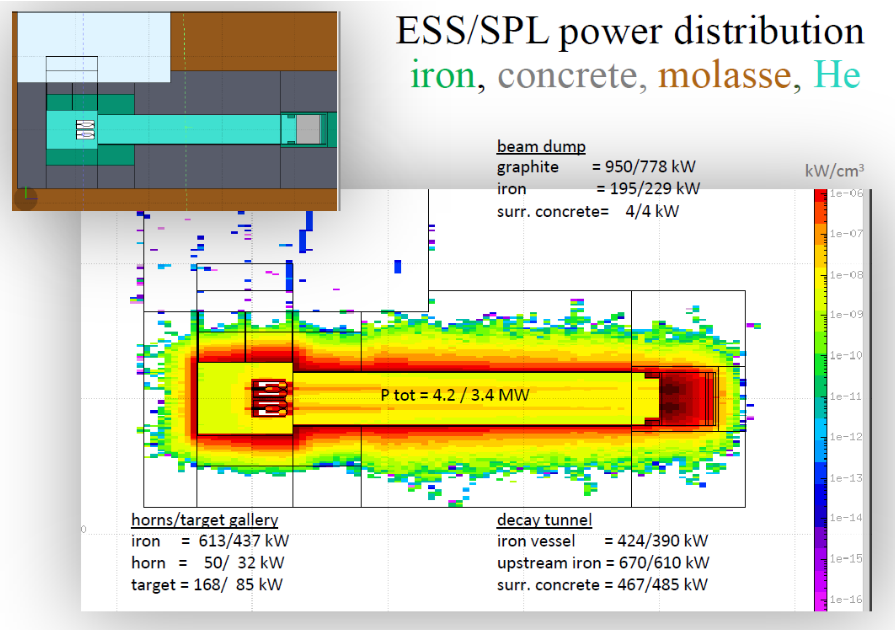
Horn Studies, WP2 @ APC, EUROnu 2012 4

SIMULATION

- **History :**
  - **2004 : SPL-Fréjus Superbeam Studies (A. Cazes and Al.)**
  - **2008-2012 : Euronu (A. Longhin and Al.)**
  - **2012- Present : N. Vassilopoulos (GEANT3 + FLUKA)**
- **Available Frameworks:**

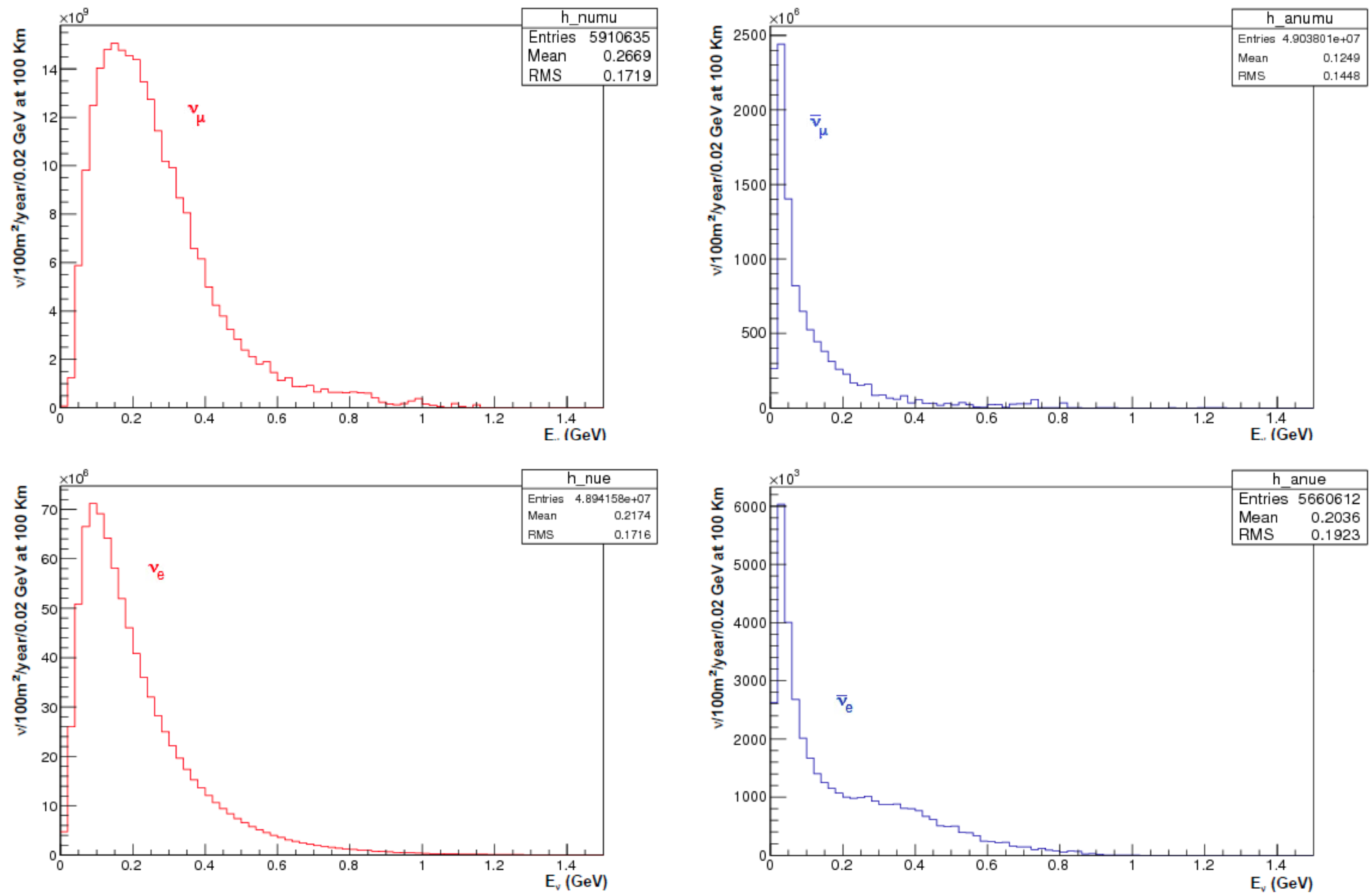


GEANT4 (Neutrino Flux)



FLUKA (Energy deposition/ Safety)

SUPERBEAM SIMULATION (GEANT4) : NEUTRINO FLUX (PI+ FOCUSED)



![ESS Neutrino Super Beam logo header]

SUPERBEAM SIMULATION (GEANT4) : NEUTRINO FLUX (PI+ FOCUSED)