Total simulation of the Absolute Air Fluorescence Yield Measurement

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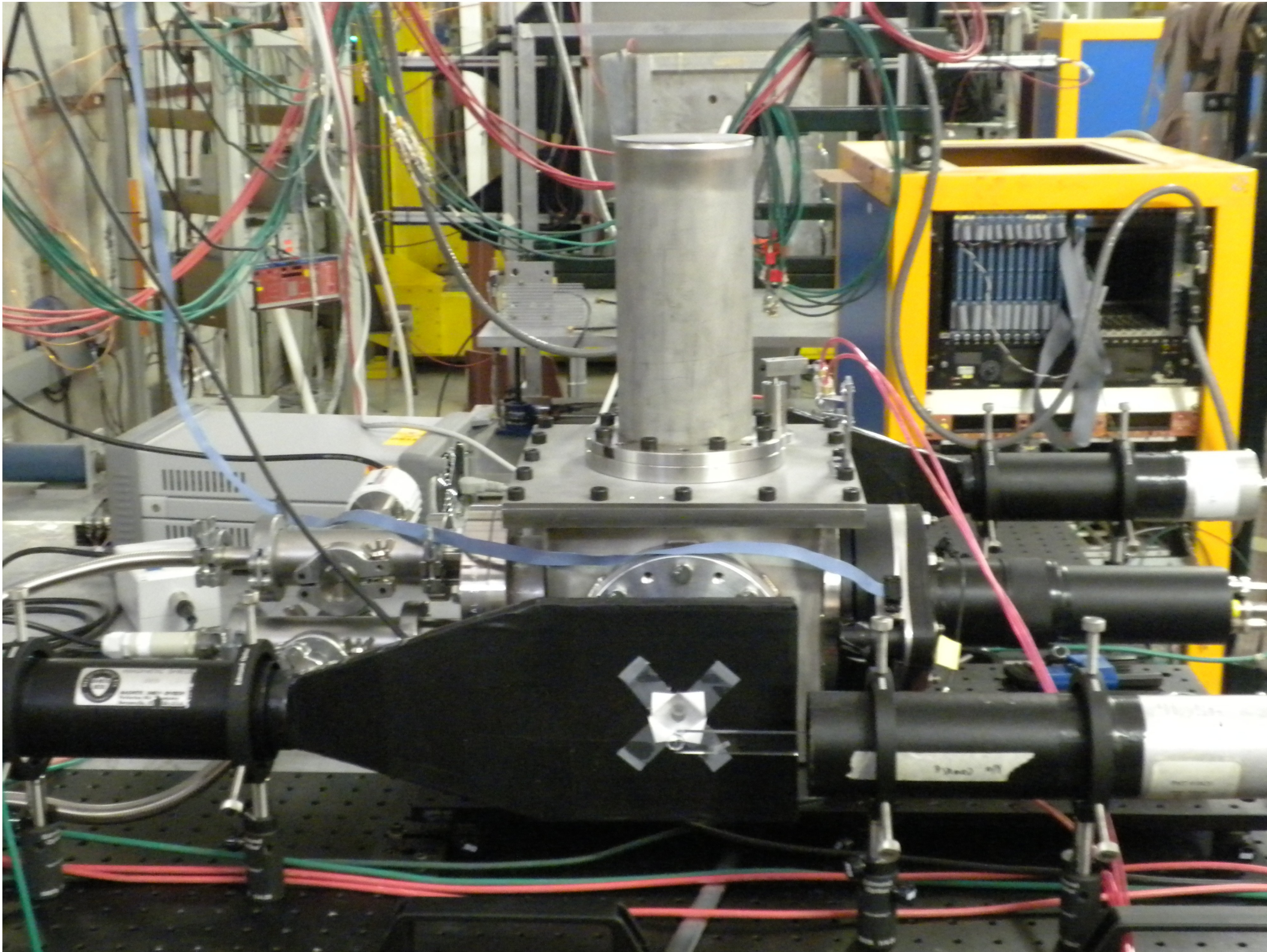
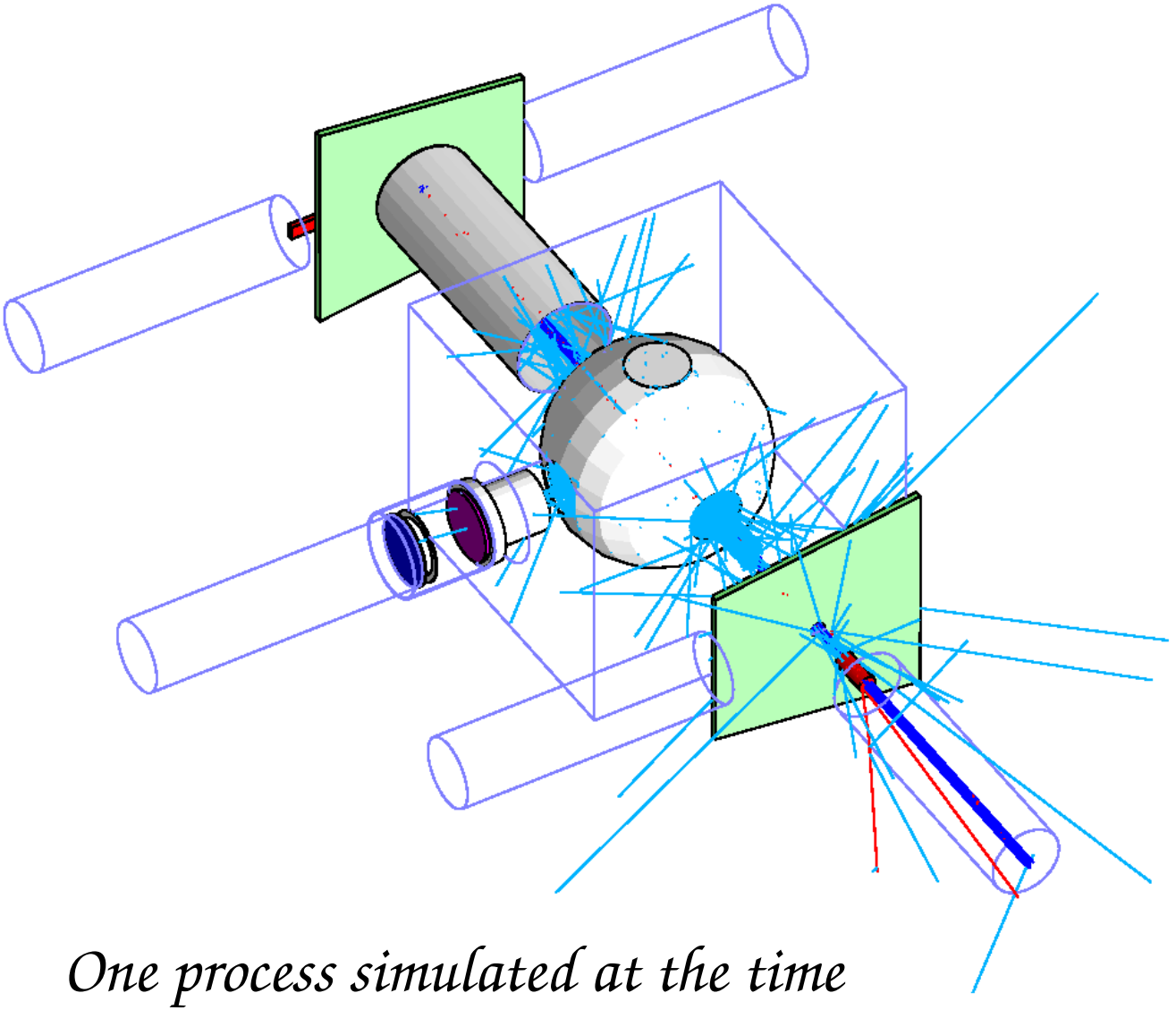
for the AIRFLY collaboration

- *using version Geant4.9.2.p02*
- *Standard electromagnetic processes (protons 120 GeV)*
- *Cerenkov process implemented by Geant4*
- *G4ScintillationProcess simulates the fluorescence – nominal yield 20 ph/MeV sampled from the AIRFLY spectrum*
- *337 nm line forms 25.75% of the spectrum*
- *Cut in range 1 mm – particles with shorter range deposit all their energy on the spot*

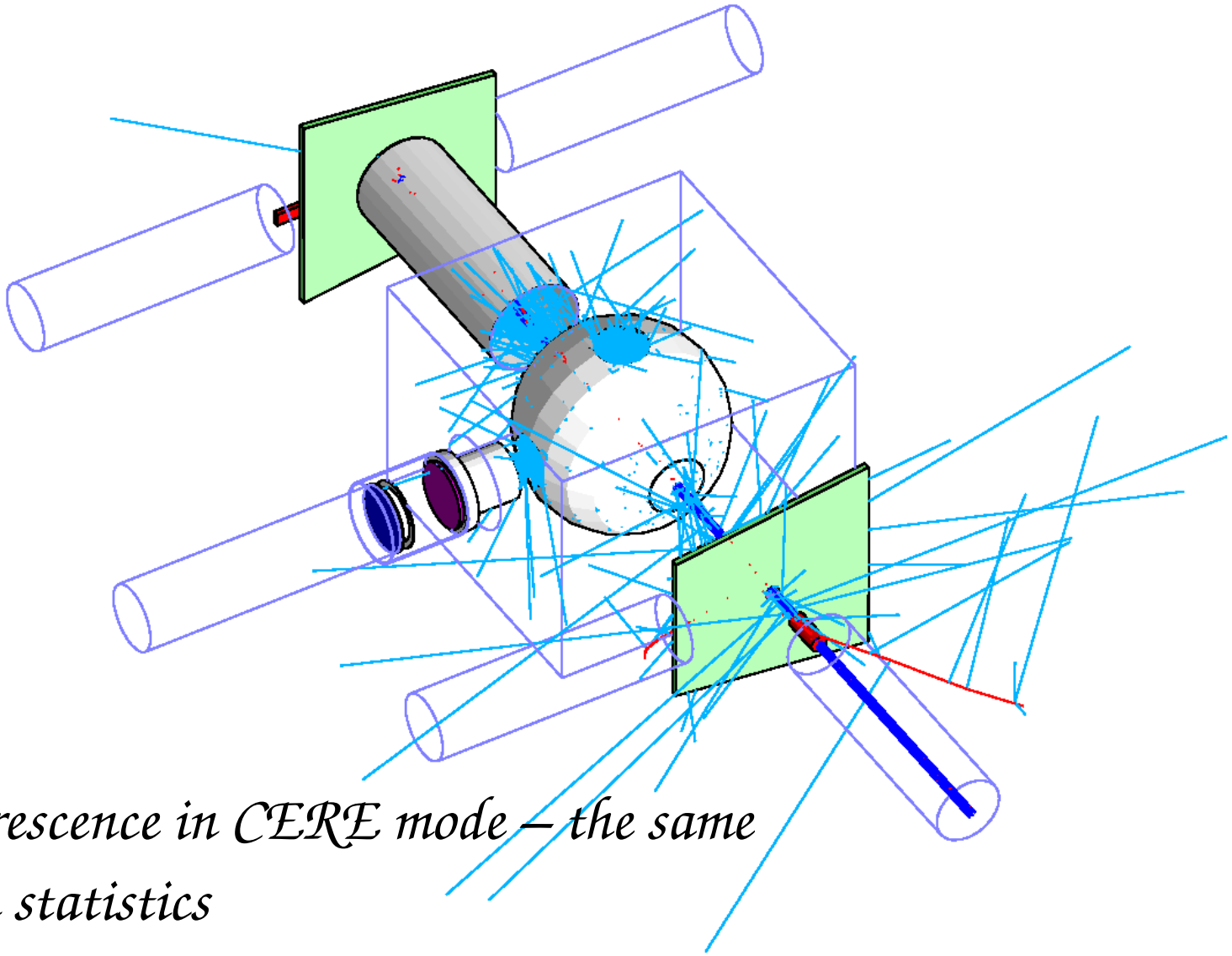


Absolute measurement setup



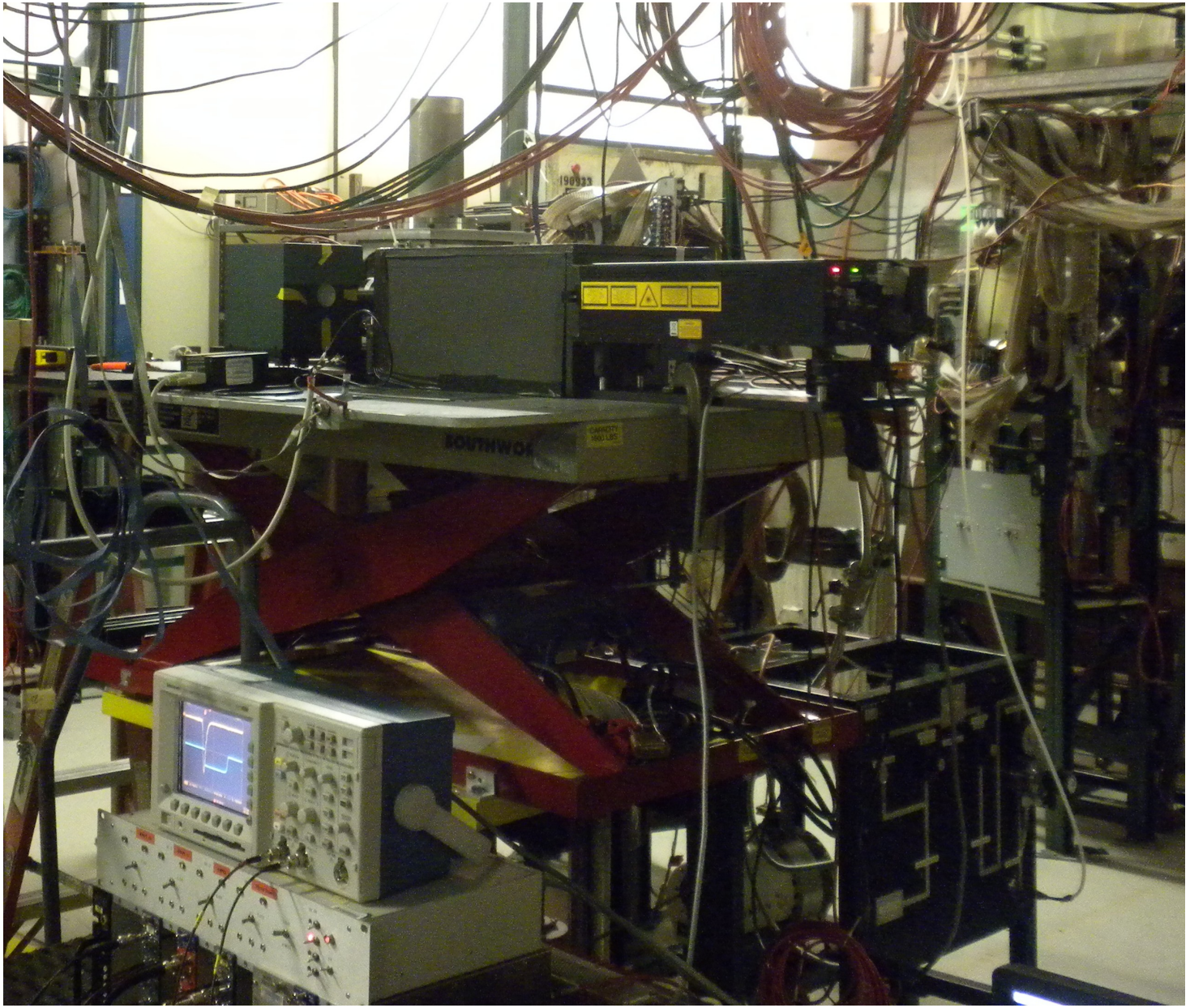
One process simulated at the time

Cerenkov mode

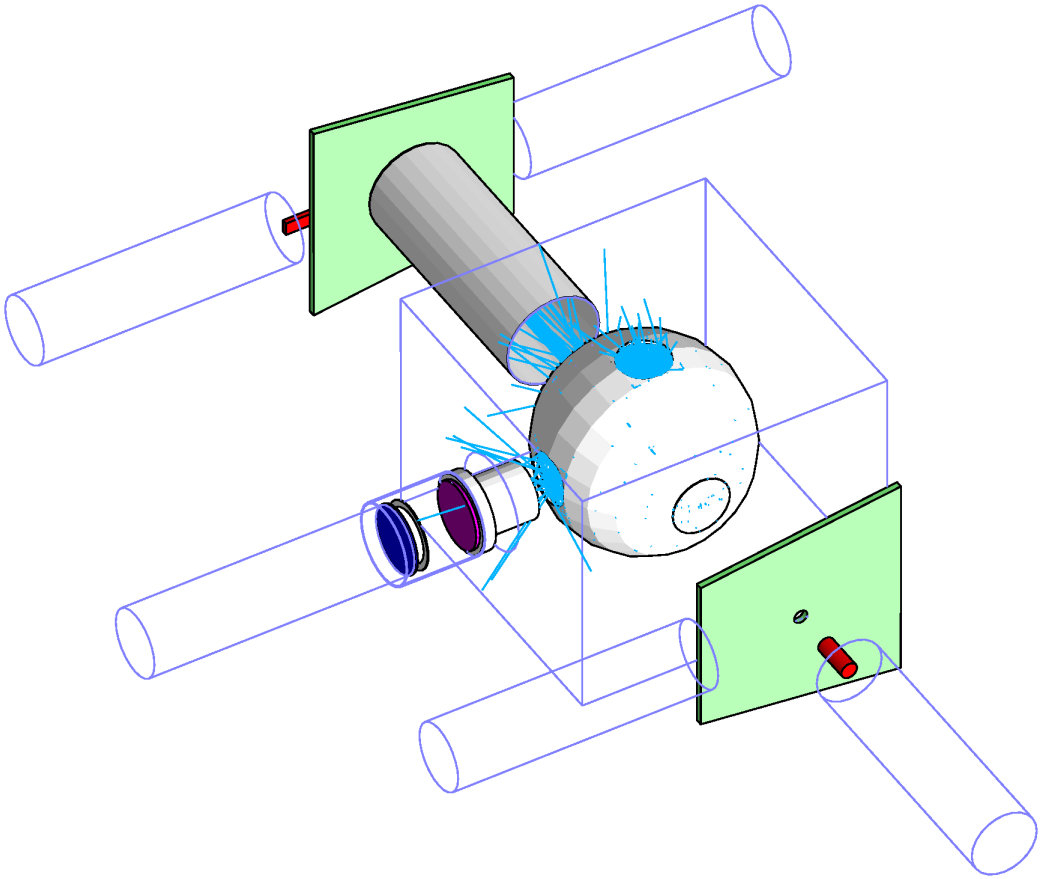


- Fluorescence in CERE mode – the same within statistics
- Cerenkov in FLUO mode practically zero

Laser measurement setup

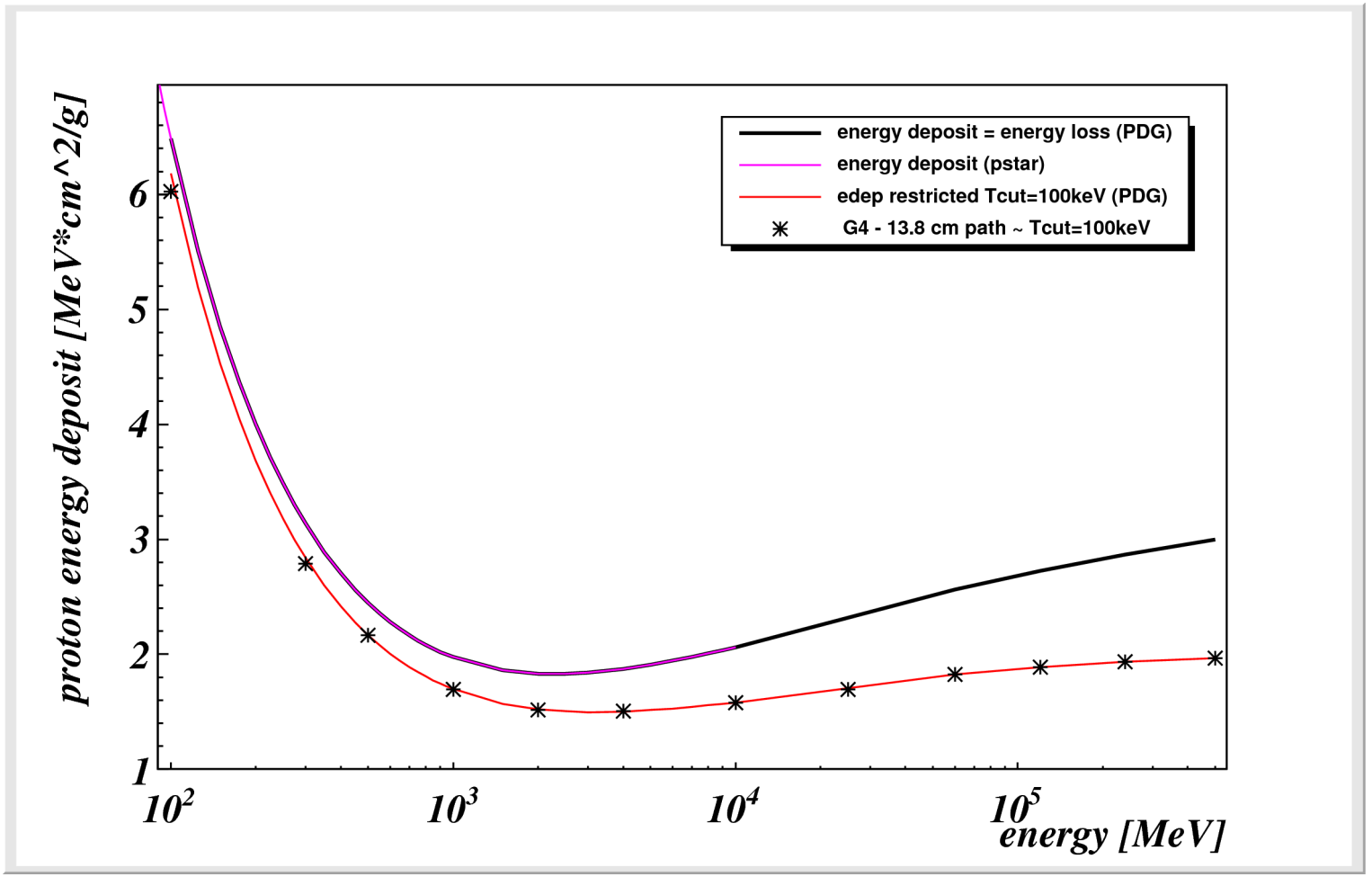


Laser calibration



CERE mode – 3.68 eV optical photon as a primary

Energy deposit of protons in N_2



Energy deposit

- G4HadronicProcesses
- G4PAIphoton model
- Material in front of the chamber

increase of the deposit by at most 4% - cut on the veto eliminates such events

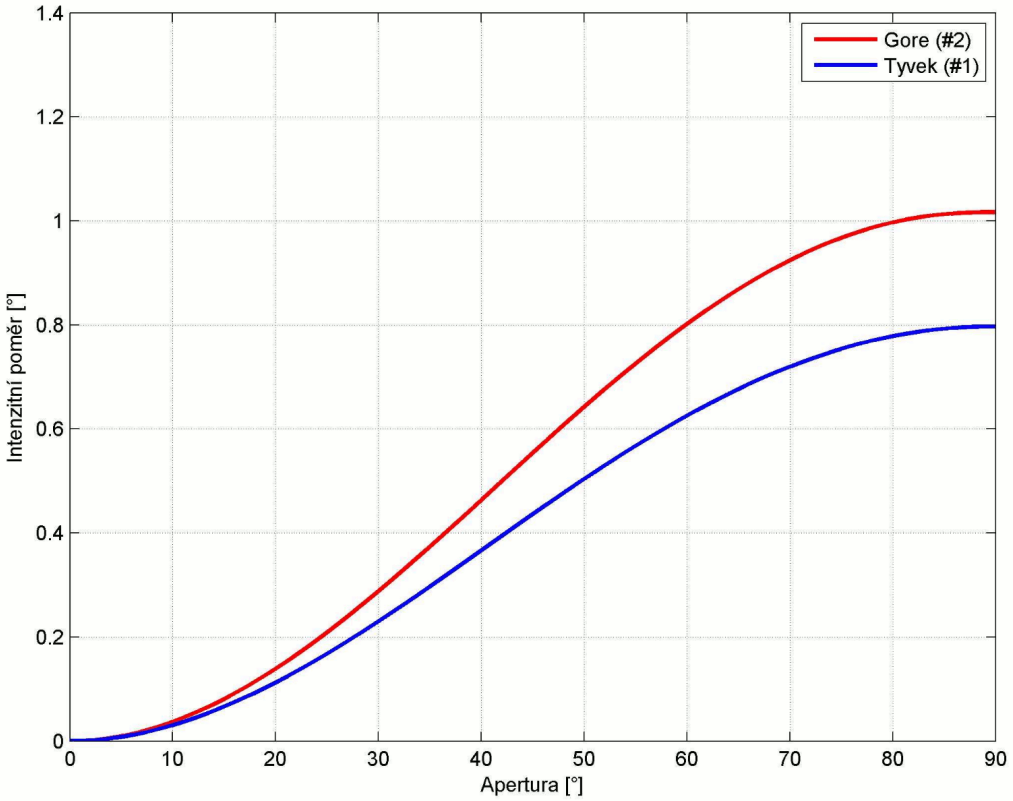
Reflectivity of GORE material

- Relative efficiency of the sphere measured using laser and silicon probe

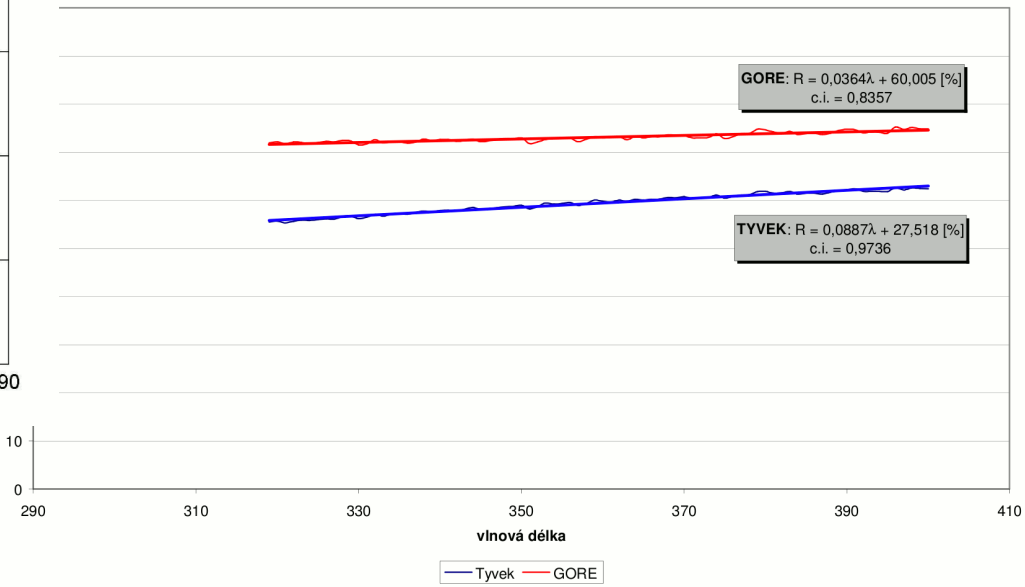
- Reflectivity of the diffuser adjusted to reproduce the measured efficiency => 99.43%

- Determines the fraction of direct photons (~13%)

Reflectivity of GORE material

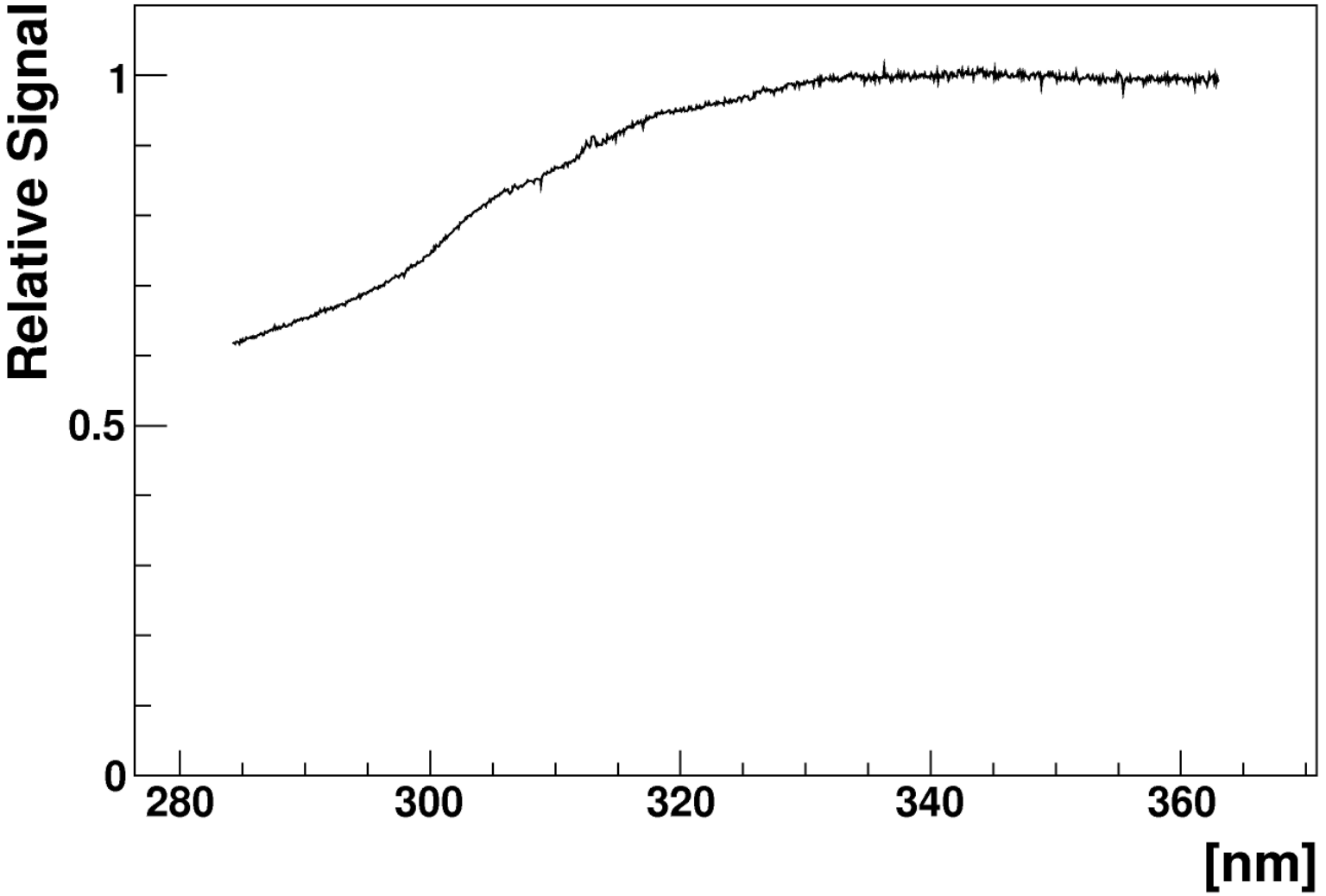


- Lambertianity and wavelength dependence



measured in Olomouc

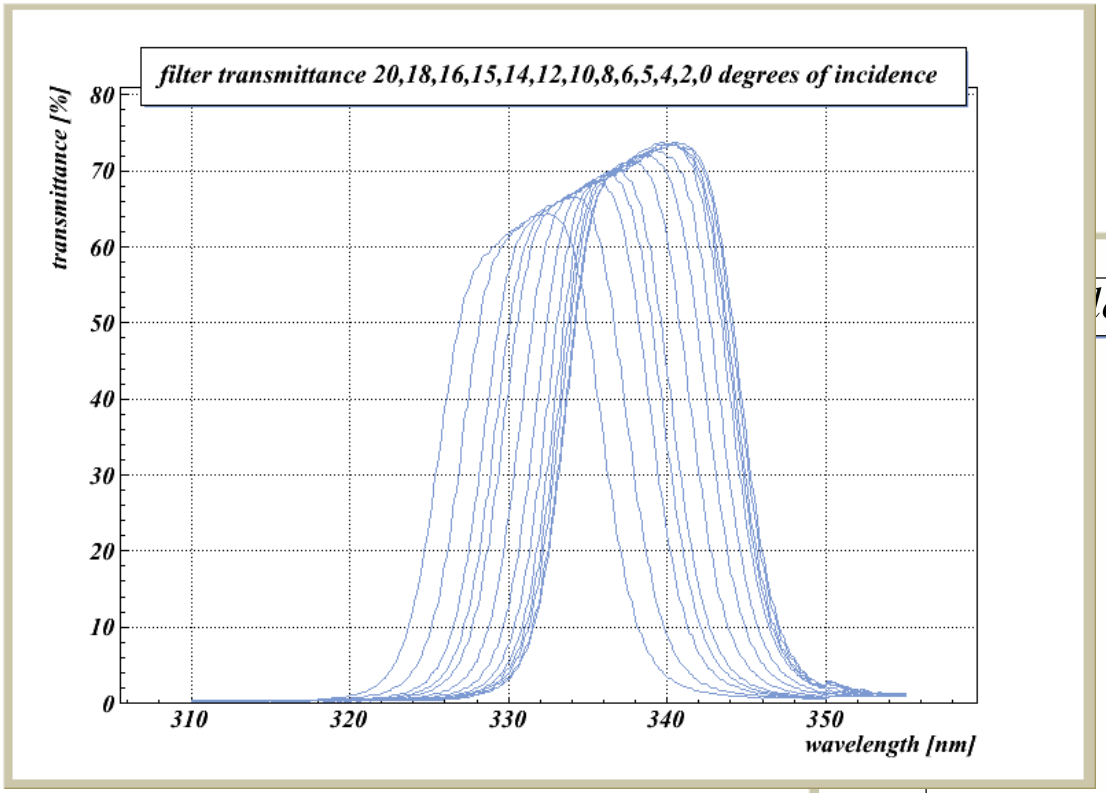
Relative Sphere Transmission



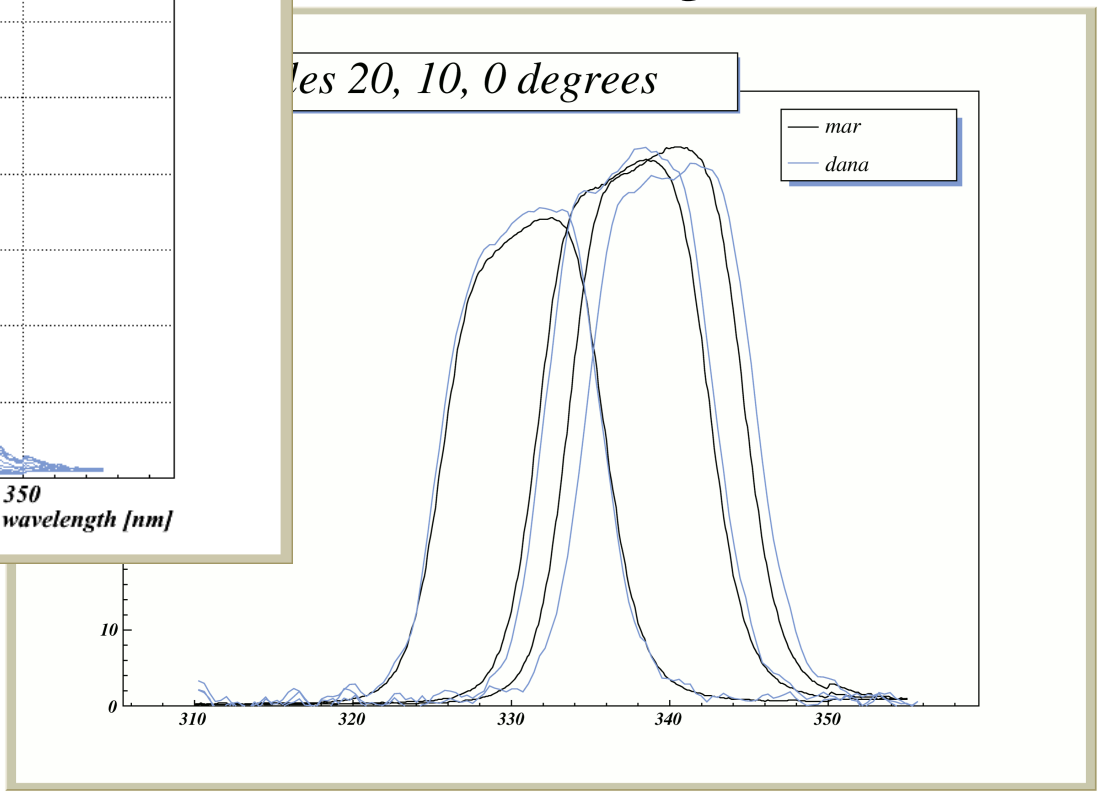
After several reflections

(18 on average)

Filter transmittance

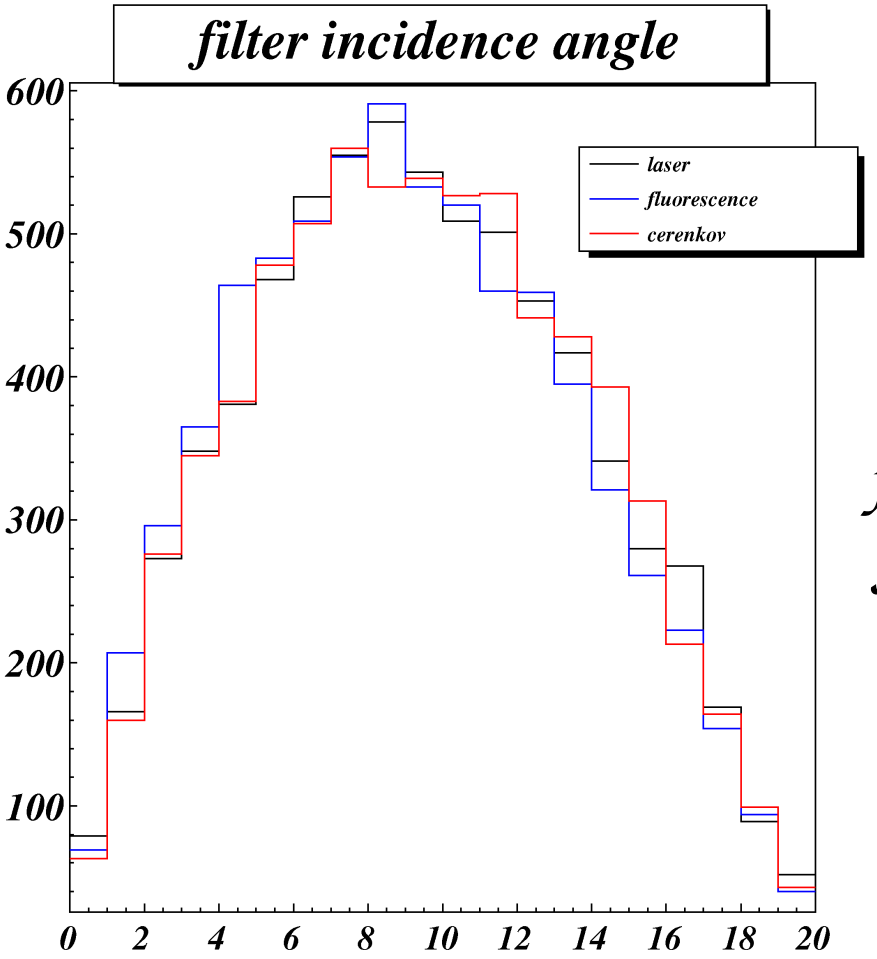


Bilinear interpolation for all angles and wavelength



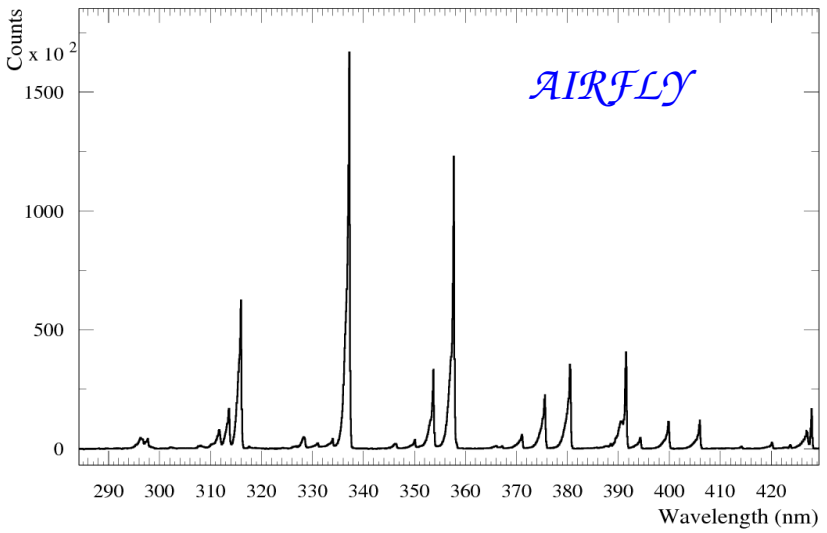
Difference between the measurements changes F/C ratio by ~2%

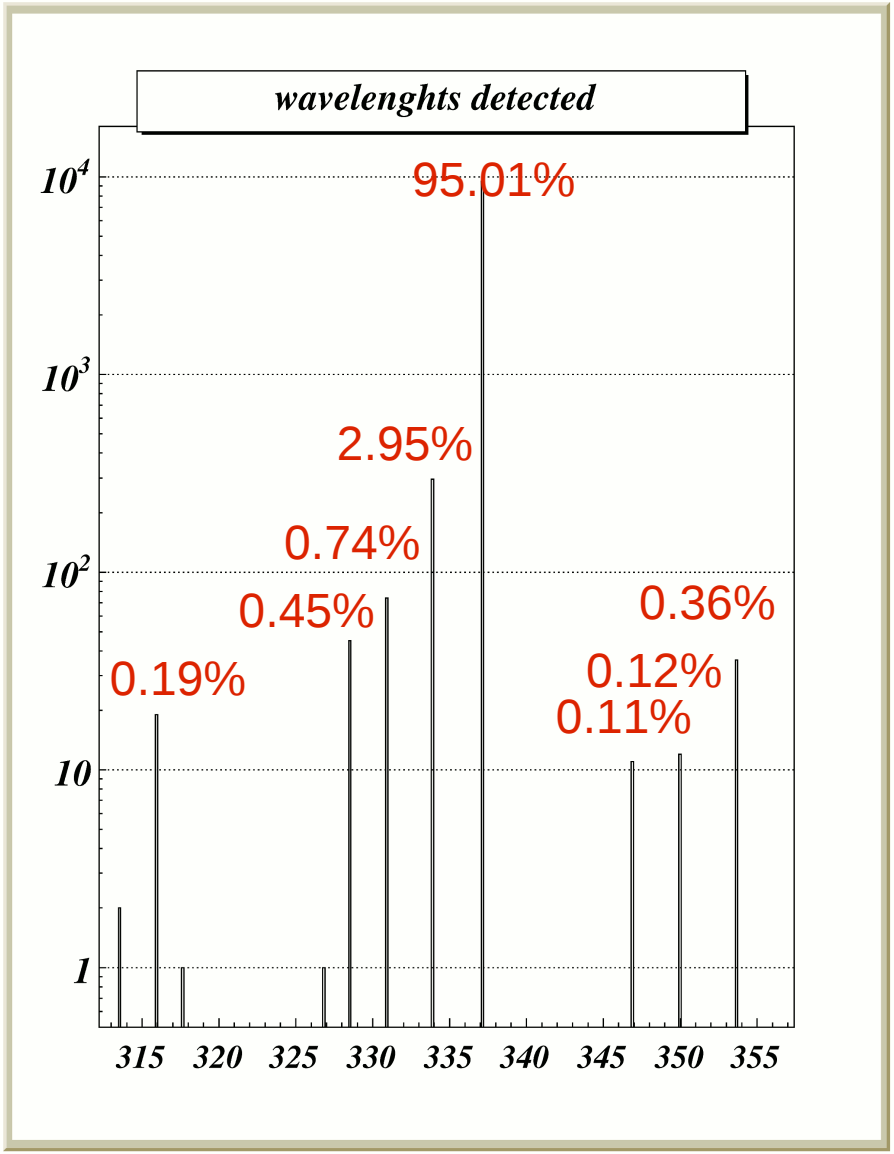
Incidence angles on the filter



The difference between fluoresce and Cerenkov is smeared

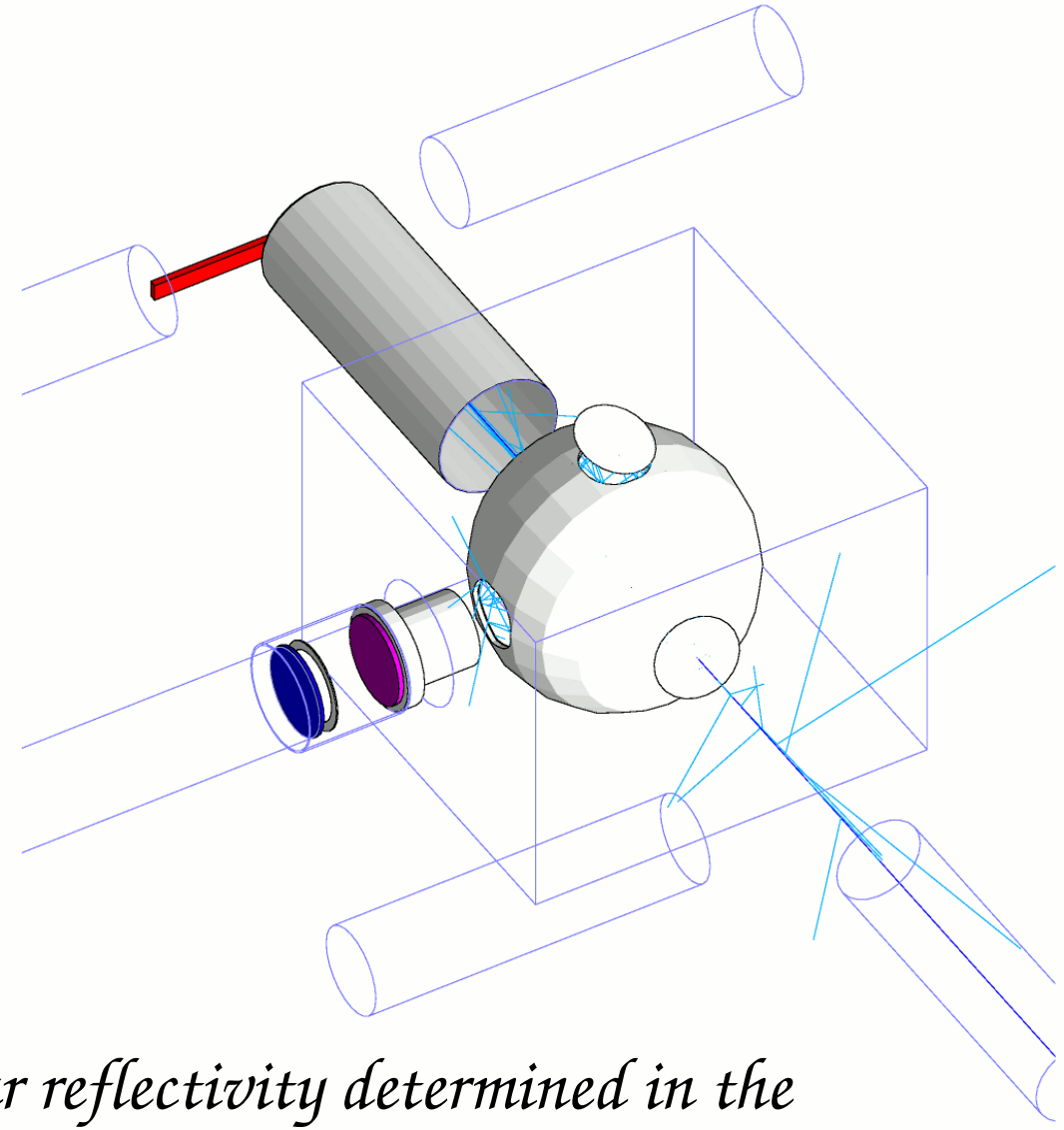
Contamination by other lines





Contribution of other lines ~ 5%

Sphere with mylar ports



Mylar reflectivity determined in the same way as for Gore ports

Results

Simulation

Gore ports

- Fluorescence $2.397\ 10^{-4}$
- Cerenkov $10.25\ 10^{-4}$
- Laser $11.25\ 10^{-4}$

Mylar ports

- Fluorescence $2.126\ 10^{-4}$
- Cerenkov $8.333\ 10^{-4}$
- Laser $8.069\ 10^{-4}$

- Statistical error of simulated results < 1%
- Values are compatible even in an absolute way

Systematic uncertainties

Reflectivity of the sphere	~ 1%
PMT quantum efficiency	~ 1.5%
Monte Carlo statistics	~ 1%
N_2/Air ratio	~ 1%
Geometry	~ 1%
Filter transmittance	~ 2%
Background subtraction	~ 1%
MC energy deposit	?

Other sources of uncertainties are under investigation

Total systematic uncertainty is expected < 5%

Deposit inside the sphere by other particles

Protons	120 GeV	32.15 keV/p
Pions	32 GeV	32.75 keV/p
Positrons	8 GeV	34.11 keV/p

- the measured fluorescence yield is compatible with these values

Alternative Monte Carlo

- using Geant3
- Simple simulation crosschecking the geometry
-

  - reproducing the same value within 3%

Summary

- Total simulation was performed using Geant4 version G4.9.2.p02
- Alternative simulation was done cross checking the geometry part
- Two independent methods give compatible results for FLY

- The study of systematic uncertainties is being completed
- Their level is small as most of the effects cancel