A Versatile Simulation Software for EUSO

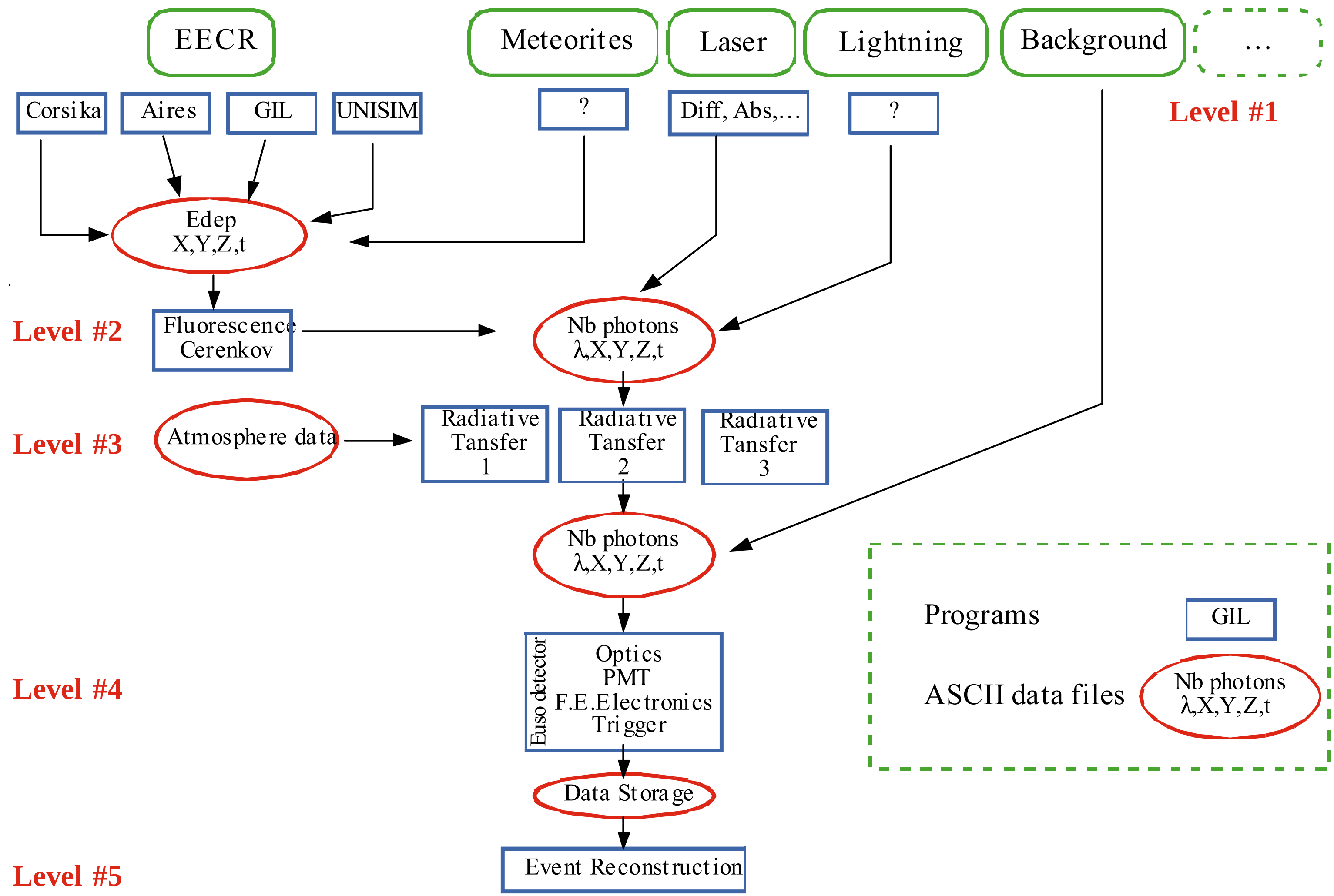
•In the previous Euso meeting, a **general scheme** for the software structure was adopted,

•This scheme was developed in order to accommodate for the **different steps** in the EUSO simulation process as well as for **various versions** of the different simulation software,

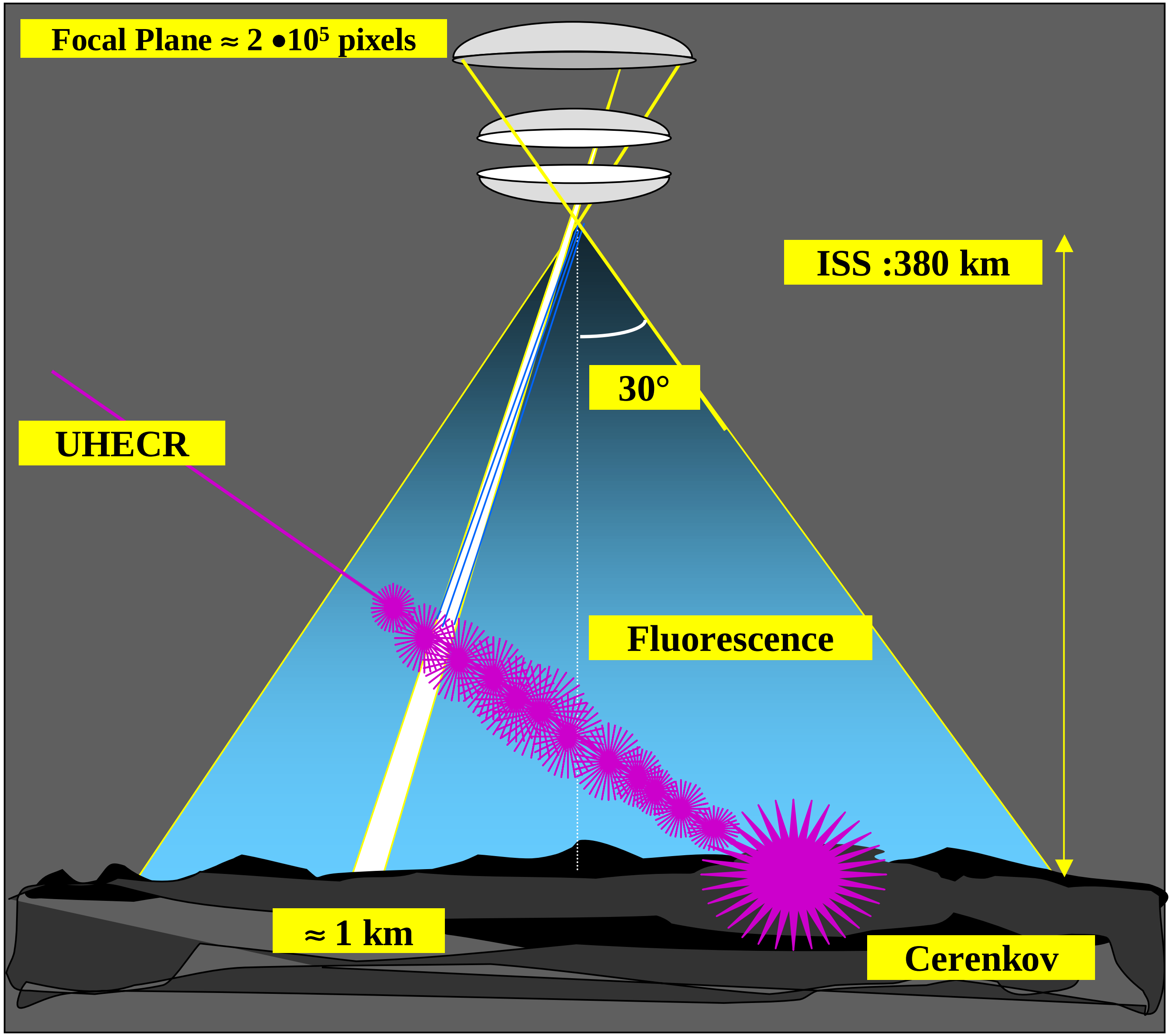
•The implementation of such a scheme is **not straight forward** and implies several tests,

•This report will attempt to demonstrate that such a scheme is **viable** and could be implemented on a **variety of platforms**.

Structure of the EUSO simulator



The Euso Detection Scheme



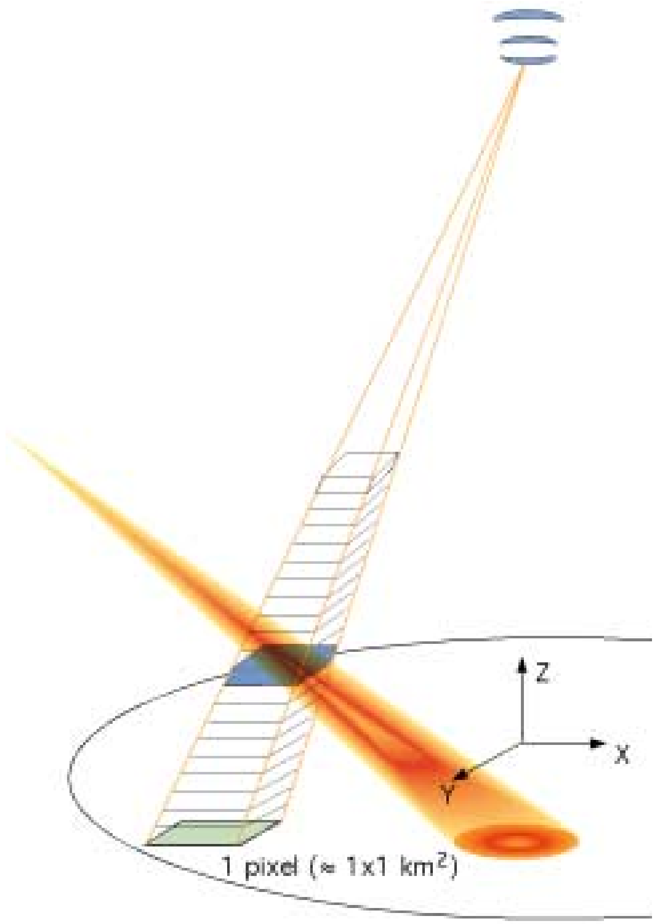
Paving the Calorimeter

• In order to allow for the successive steps of simulation, and in particular the radiative transfer, the **locus of production** of the photons must be known,

•This implies that the volume overseen by EUSO be **paved** into elementary cells of known altitude (z),

•A **first level** of paving is defined with Δz=3m (≈10nsec) and Δx,Δy given by the corresponding pixel size,

•If the number of particles (photons) is > to a present number (typically 10^{-2}, at the EUSO level), the **cell position and "content"** is recorded and stored to disk (ASCI file).



The Time-Probability Spectra of Fluorescence Photons

•The information stored in a cell allows for an interpolation of the photon production as a function of position inside the cell.

•If no radiative transfer is considered, one can calculate the probability of arrival of photons at the pixel level and the time-arrival spectra (Poisson distribution)

No Background !

A GIL Shower :

Proton : $E=10^{20}$ eV

$\theta=45°$; $\varphi=0°$

$X_0,Y_0,Z_0= 0,0,50$ km

$X_{max},Y_{max},Z_{max}= 46.4,0,3.6$ km

R_Euso = 219 km

Shower length = 70.7 km

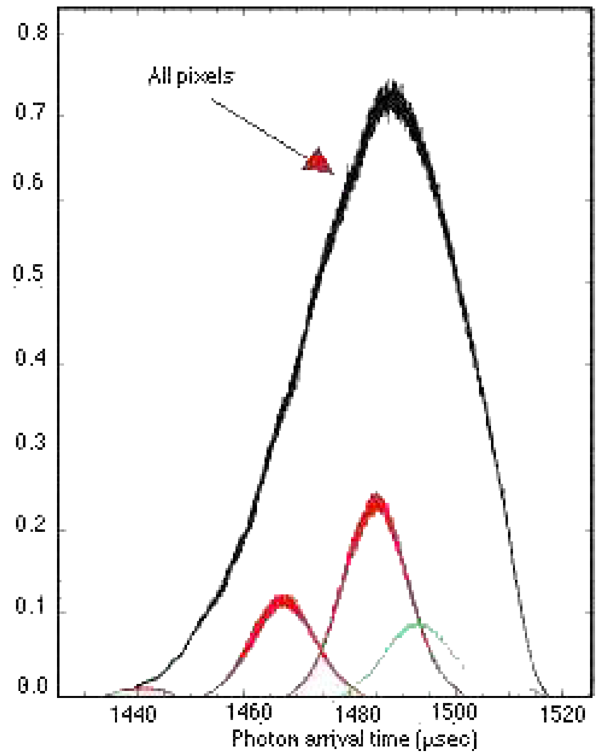
Nb of pixels = 28

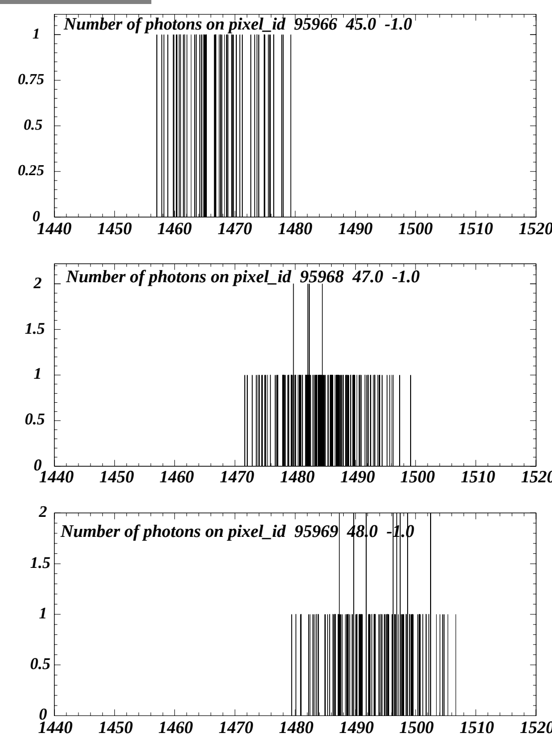
Nb of photons = 2665

Nb of cells = 31420

Atm. Standard - No Temp.

No Cerenkov





Numerics and Precision

• The program is built to determine automatically the final size of the ASCI file ≈ **3Mbyte**s (700 Kbytes compressed)

•The precision (number of photons recorded versus the predicted number) of the calculation is close to **98%**

•These numbers can be **optimized** if necessary.

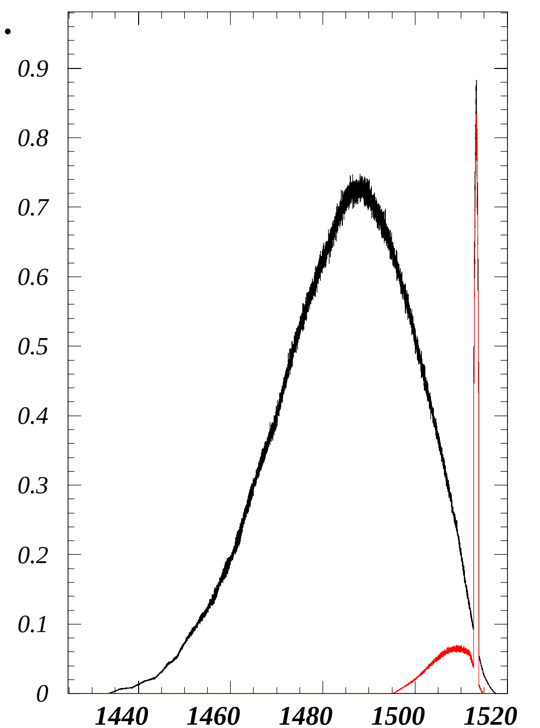
The Cerenkov Photons

• The simulation of the Cerenkov photons is **more complicated** than for the fluorescence photons.

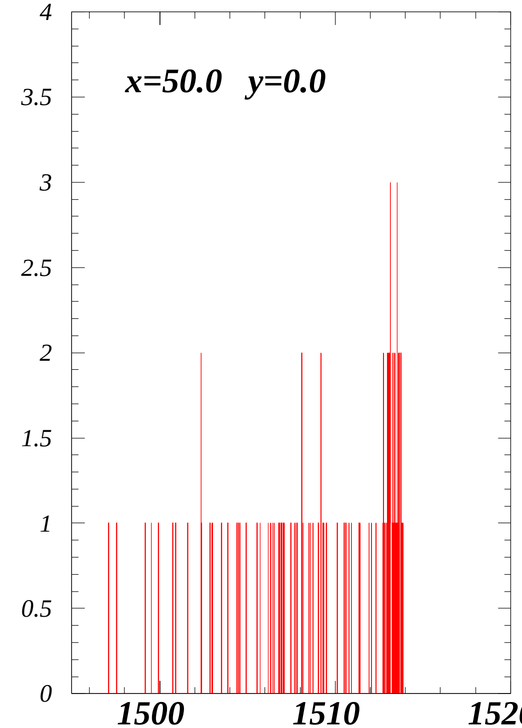
•This is because these photons travel from the **locus of production** to the **reflection point** (ground or cloud layer) and then to **EUSO**.

•Furthermore, the Cerenkov photons should depend on the nature of the **secondary particle** and the Cerenkov angle should depend on the **local refraction index** (local density)..

A simple example : Normalization of Cerenkov has to be adjusted (albedo,…)



Probability of photons on all pixels



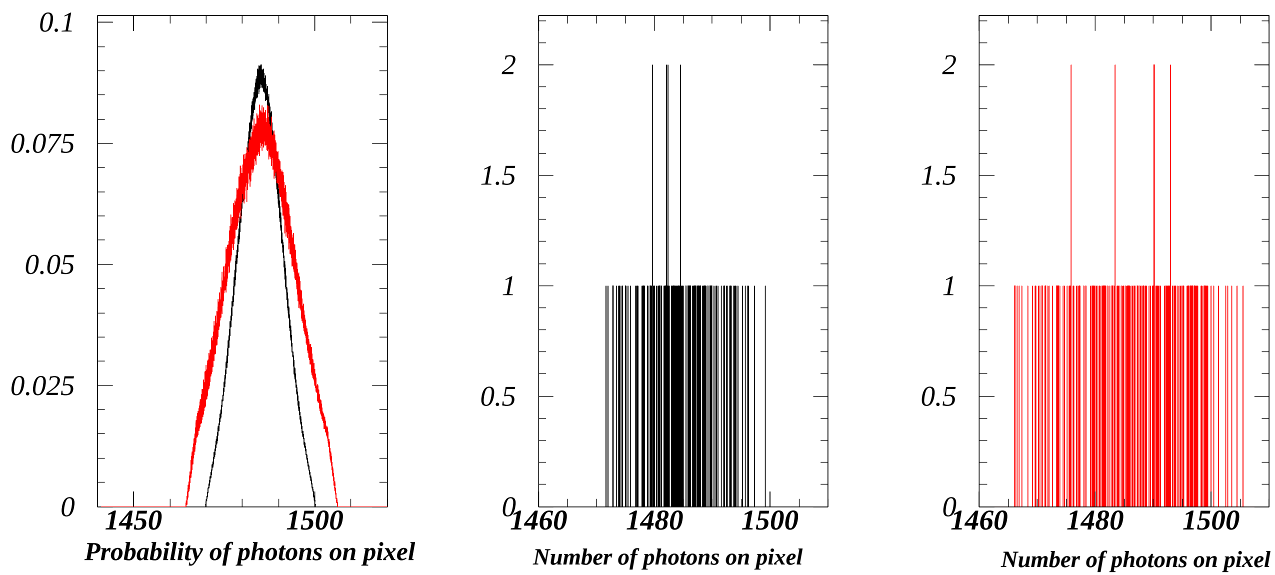
Number of photons on pixel

On the importance of the transverse extension of the shower

•The proper estimation of the background photons is as **very high priority**,

• A first estimate shows that this value (≈0.14 photons/pixel/10nsec ?) is **comparable** to probability of observing the fluorescence,

• This brings special attention to the **transverse** extension of the shower since this will spread out the time arrival of the photons on a given pixel



Conclusion & Perspectives

• A **versatile** scheme for EUSO simulation has been tested and appears to be valid.

• It requires that the number of particles at a given location **N(x,y,z)** be accessible from the physics input : GIL, Aires, Corsika,…

• The size of the intermediate ASCI, allowing for a sufficient level of precision, allows to implement this scheme on all platforms.

• Its present status should allow for a **number of technical studies** : electronics, energy calibration,…

Next steps :

• The numerical parameters **have to be checked and optimized**,

• The effects of the **transverse extension** of the shower should be examined,

• Some **specific points** have to be discussed : Cerenkov,…

• **Other simulation steps** have to be included : radiative transfer, detector response, trigger, final output format,…

• It should be **interfaced** with ROOT (IDL) and made available on **different platforms**.