JUNO @ Ferrara

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INFN

Two techniques to enhance particle reconstruction in JUNO:
Liquid Scintillator purification and Waveform analysis

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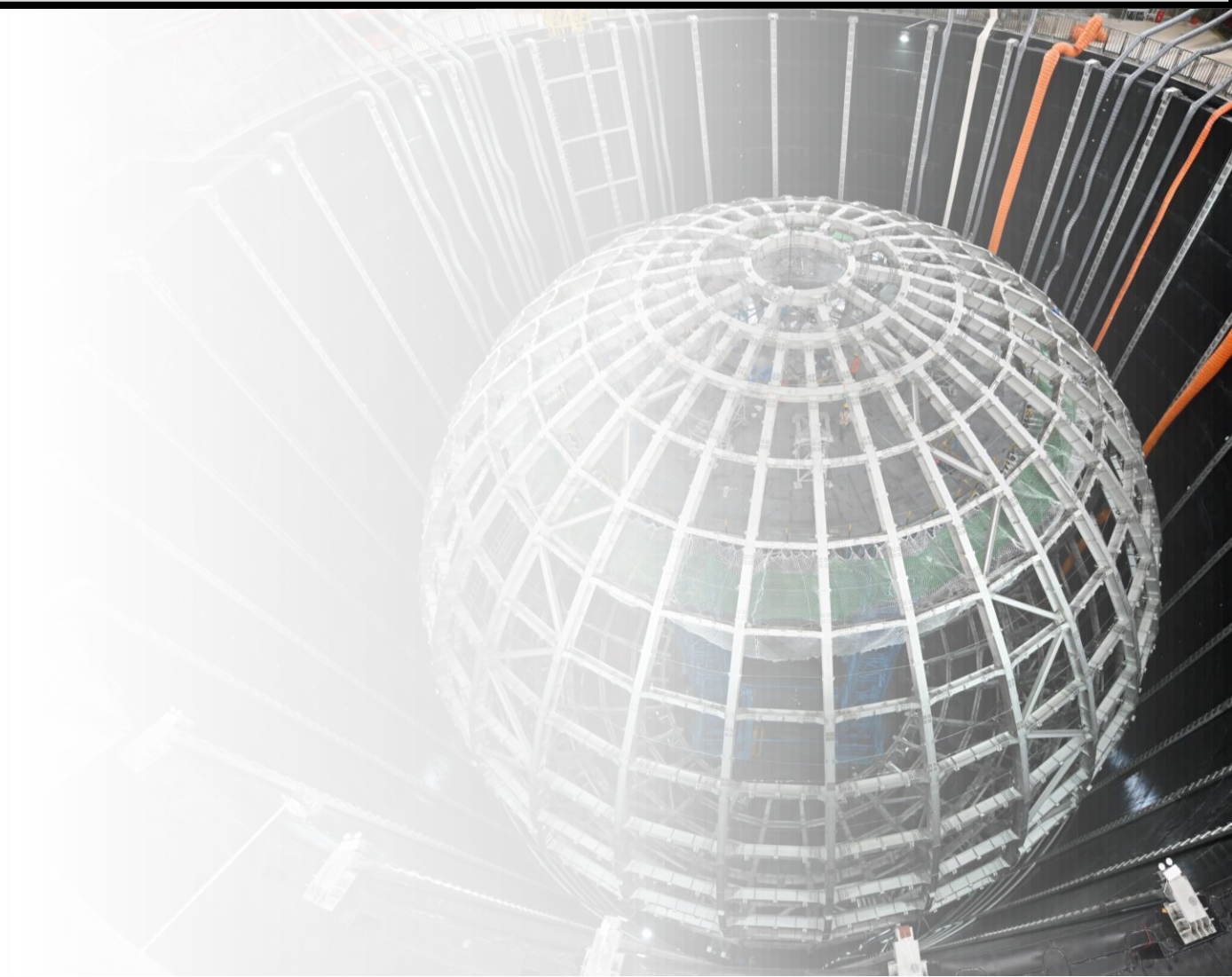
Supervisor: Prof. Fabio Mantovani

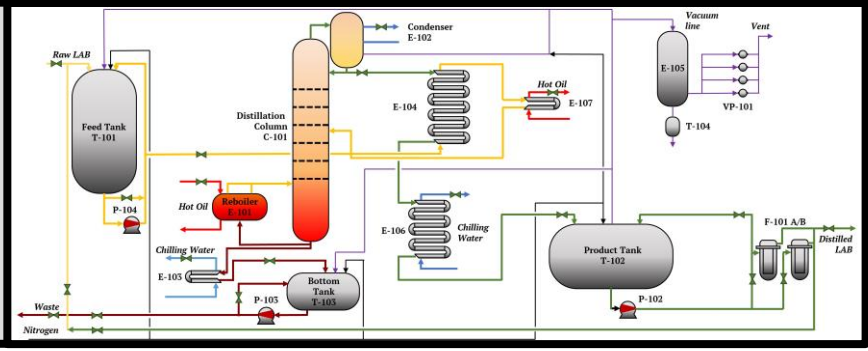
Ph.D. in Physics – Cycle XXXV – Ferrara, 17 March 2023

Summary

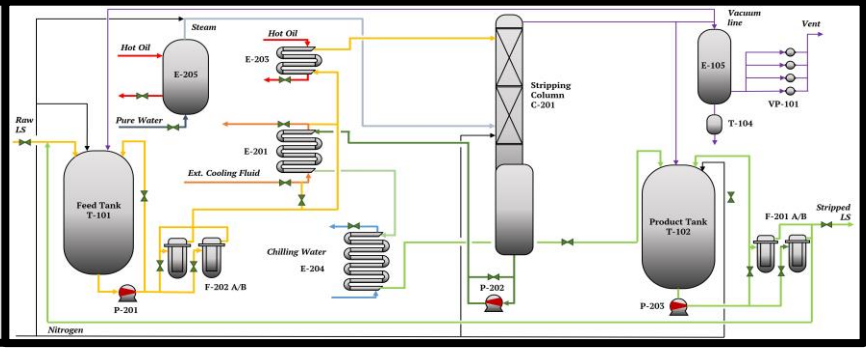
- JUNO Overview
- Liquid scintillator physics
- Technological challenges
- Distillation Plant
- Steam Stripping Plant
- Realization and assembly
- Conclusions



Distillation

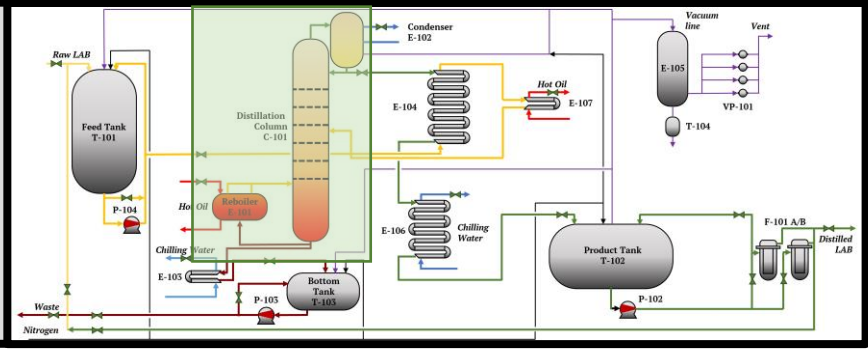


Steam Stripping



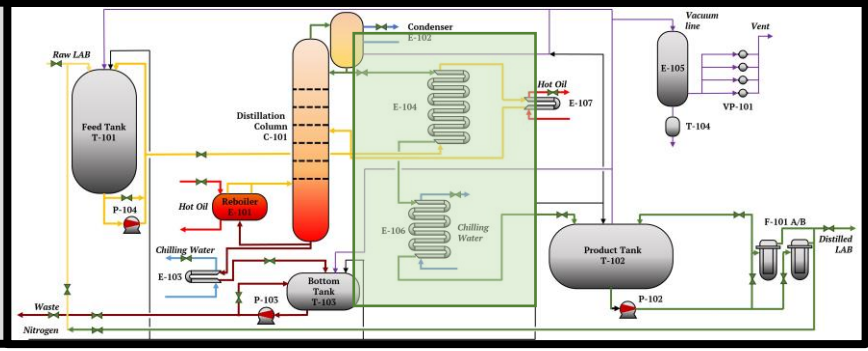
Steam
Hot Oil
Hot Oil
E-205
E-203
Vacuum line
Vent
E-105
Stripping Column C-201
Raw LS
Pure Water
VP-101
T-104
E-201
Ext. Cooling Fluid
Feed Tank T-101
Product Tank T-102
F-201 A/B
Stripped LS
Chilling Water
E-204
F-202 A/B
P-202
P-201
P-203
Nitrogen

Realization



- **The plants were assembled in skids for an easier shipping and mounting**
- **Skids and tanks were assembled at Polaris s.r.l. (Misinto):**
  - Realization of pipes and connections
  - Pre-assembly carried out horizontally
  - Disassembled system in single skids for shipping
- **All connections and the most delicate parts have been assembled by us**
- **Every component and connection of the system has been tested:**
  - Pneumatic and vacuum test
  - Roughness and cleaning quality control
  - Helium leak test
    - Single leak rate < 10^{-8} mbarL/s
    - Integral leak rate < 10^{-6} mbarL/s

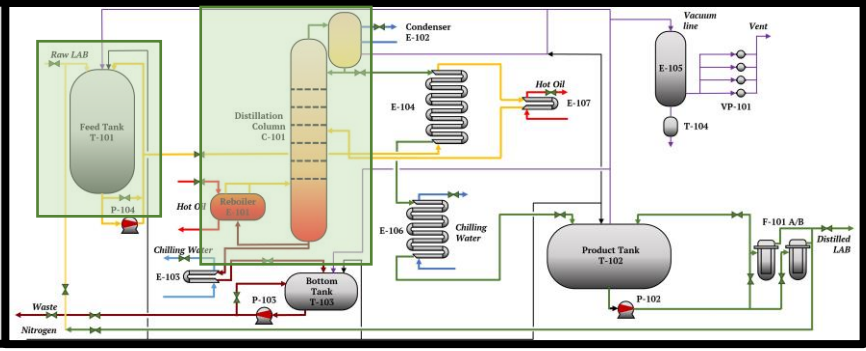
Distillation plant construction

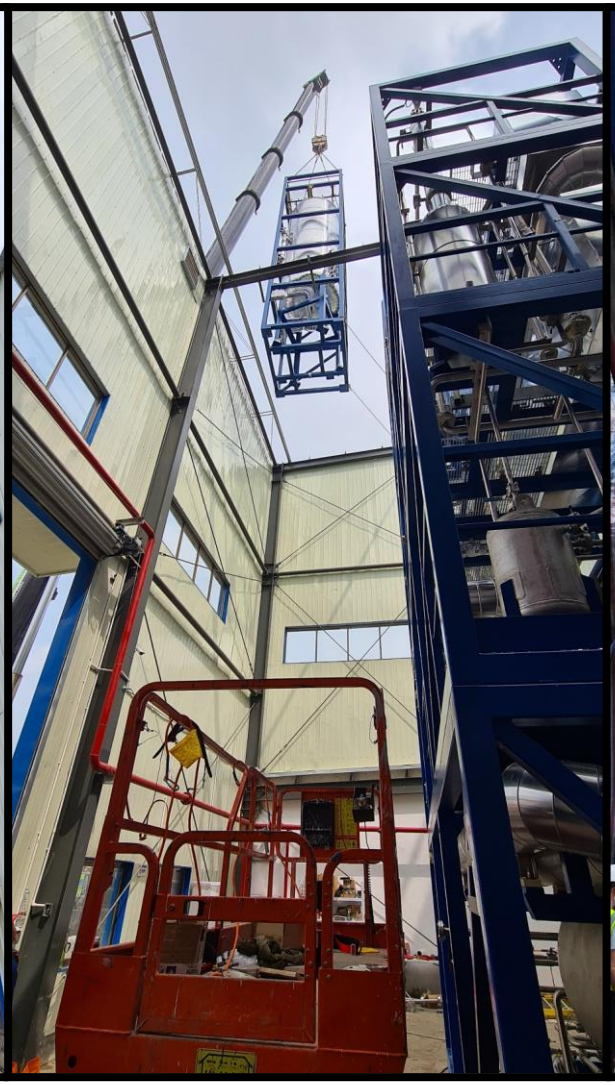


- **Where:**
  installation in the Over Ground LS building
- **When:**
  25 April 2022 - start of the Distillation plant installation
  5 May 2022 - end of "Phase 1" of Distillation plant installation

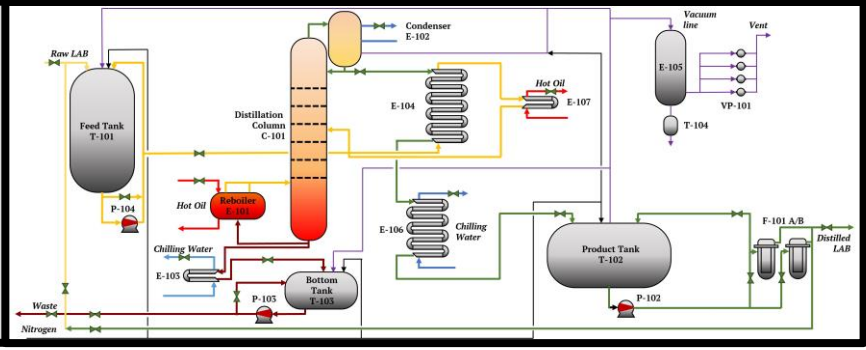
- **6 skids, 1 vertical tank, 1 horizontal tank, 1 pump skid**
- **Main issues:**
  - Installation to be performed from the roof of the building using dedicated truck cranes (QY220T – 220 tons truck crane; QY25T – 25 tons truck crane)
  - Removal of the roof of the building
  - Some heavy and large flanges need to be mounted (DN500 - DN1000 flanges)
  - Huge plant, a lot of components, to be aligned very precisely (1 mm)

Assembling of the distillation column and vertical tanks

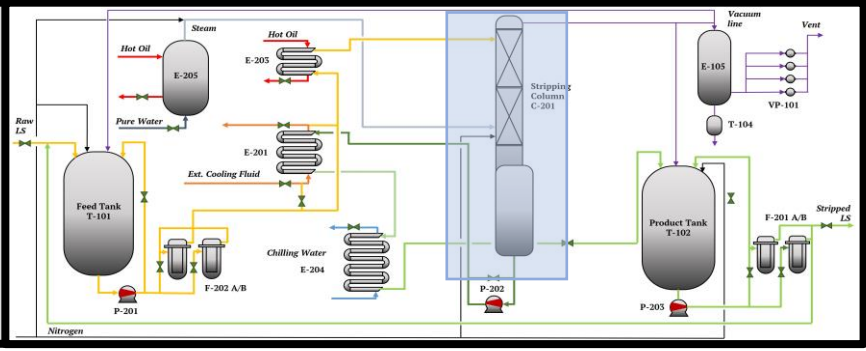


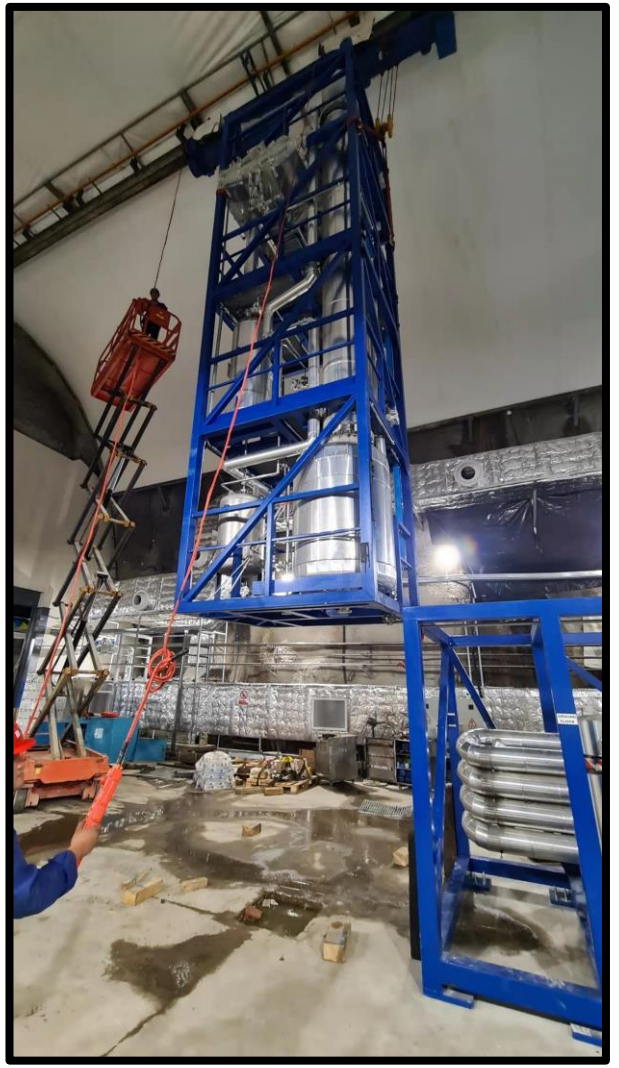


Final Assembly

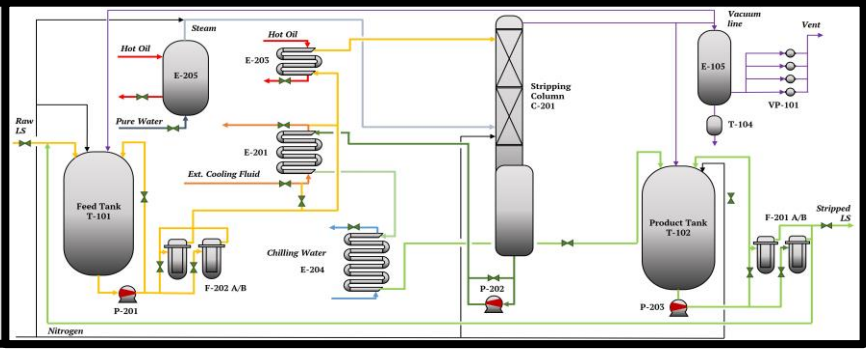


Construction of the column

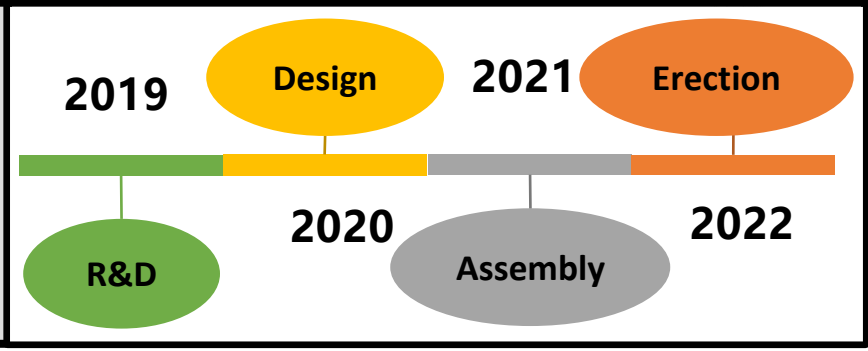




Steam stripping final assembly

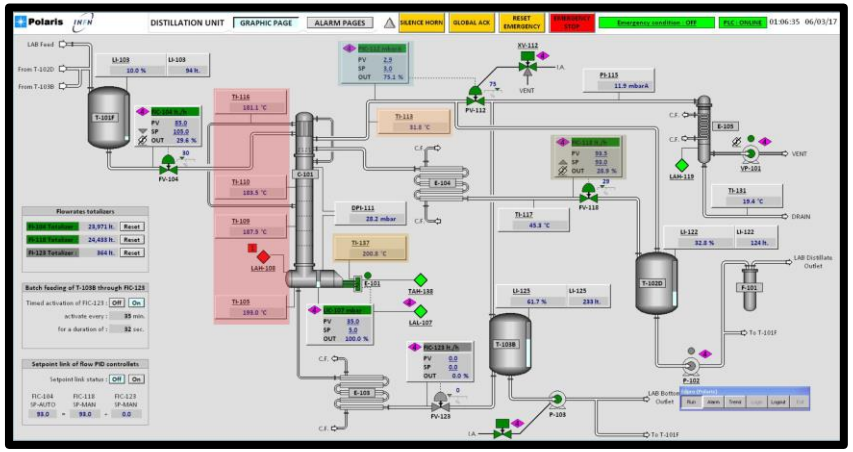


Conclusions



R&D

I helped to design and to build a pilot LS purification system, focusing on the control system and operations. As a result, the LS absorption length increased to 24.4m and Rn content was reduced by 96%



Final Plant Design

I contributed to LS purification plant design, implementing the control system and writing the operative procedures. This allowed to comply with the European (PED and ATEX) & Chinese (SELO) safety standards and JUNO collaboration's physics/technical constraints (Flow = 7000 l/h, T<210 °C, energy recovery).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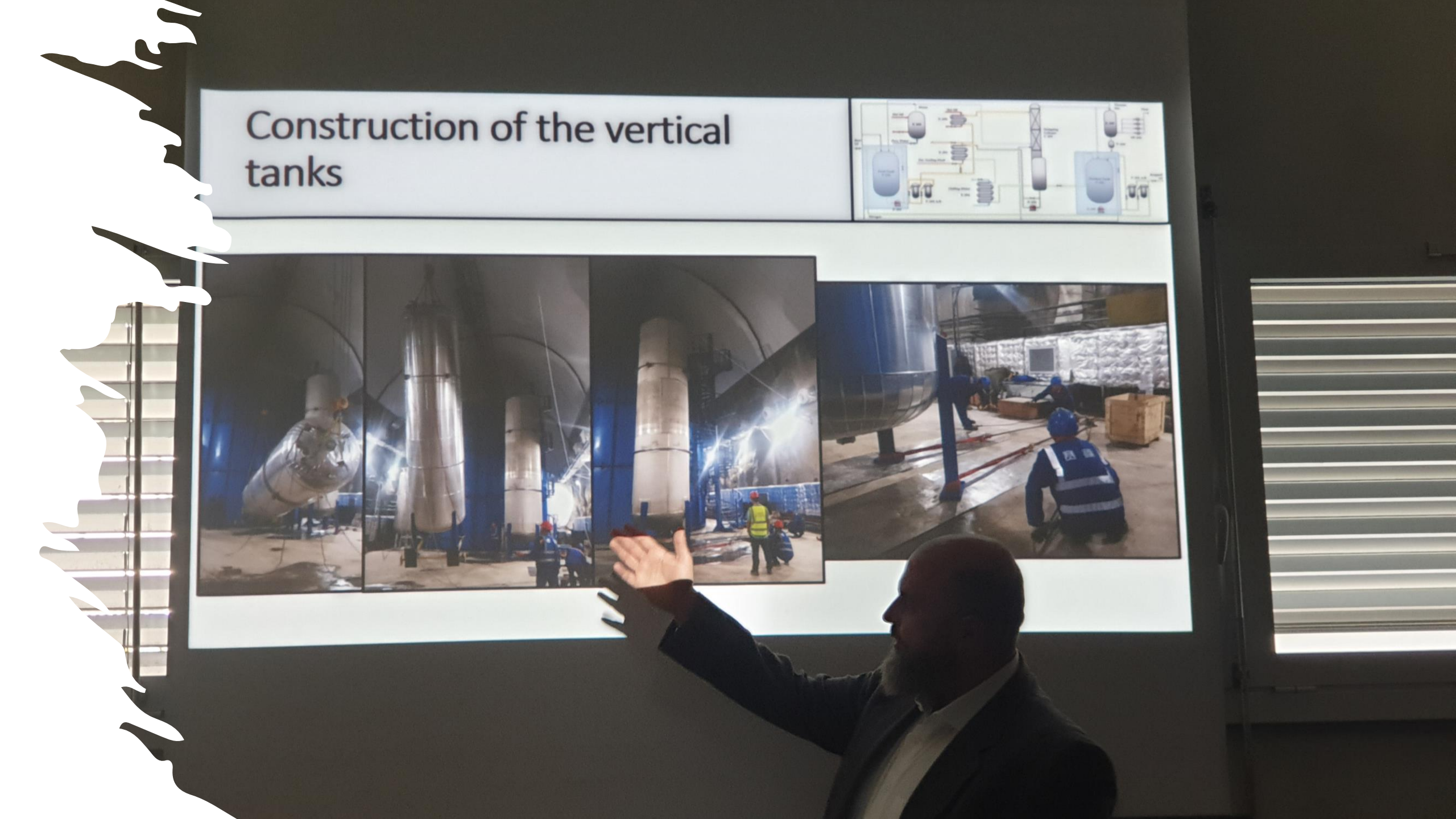

Construction of the vertical tanks


Hans Steiger
Francesco Piacentini
Paolo LENISA
H
Hans Steiger
P
Tu
11:59 | Doctorate Commission in Physics - University ...


URANIUM DISTRIBUTION IN THE VARISCAN BASEMENT


ENGINEER

Combining LOC and ROL geoneutrino signals

Some sketches

General picture

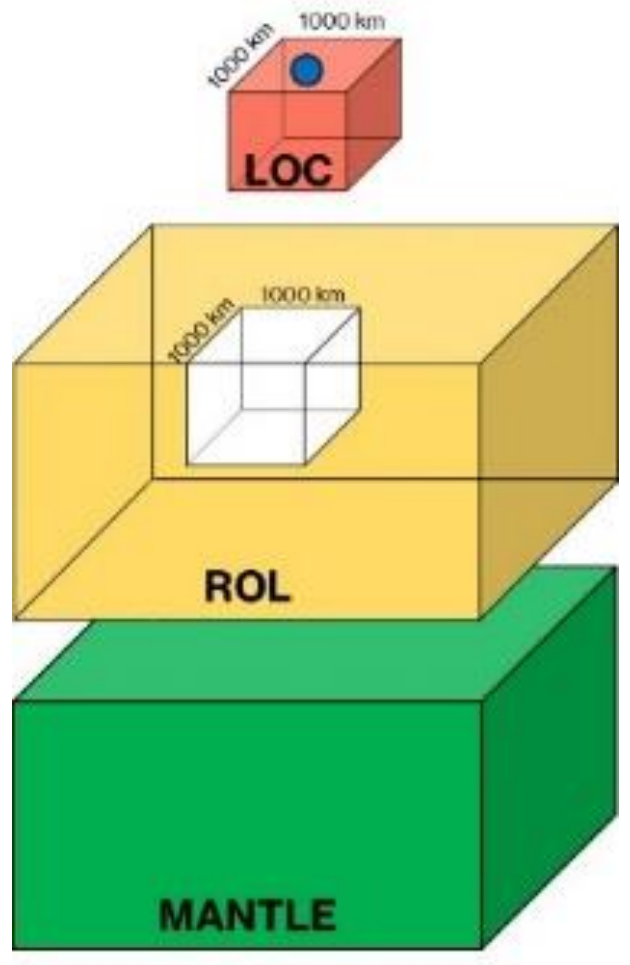
ROC (Local Crust): portion of crust of 10° x 10° centered in JUNO.

ROL (Rest of Lithosphere): continental lithospheric mantle and the remaining crust obtained subtracting the LOC.

MANTLE: sublithospheric mantle

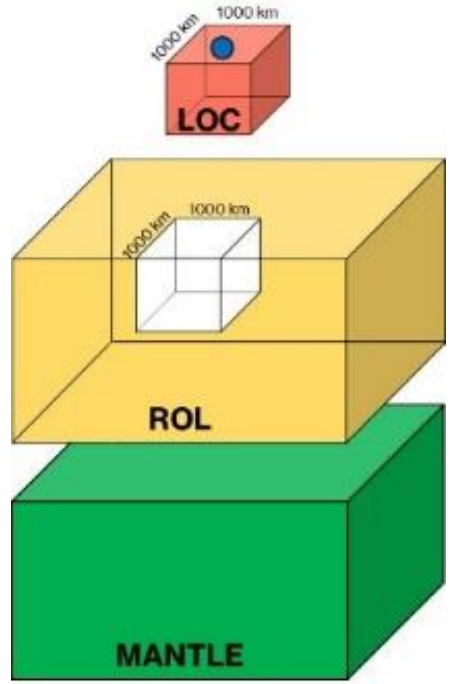
TOTAL: ROL + LOC + Mantle

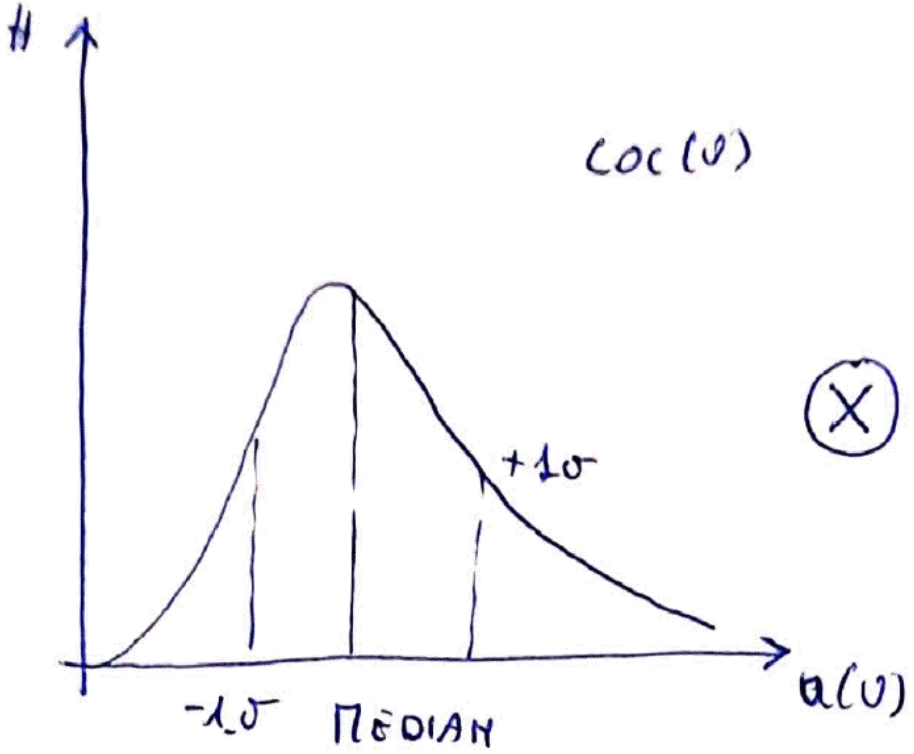
	Oscillated geoneutrino flux [10^6 $cm^{-2}s^{-1}$]		
	U	Th	Th/U
LOC	X ± Y		
ROL			
LOC+ ROL			
Mantle Poor H			
Mantle Medium H			
Mantle High H			
Total Poor H			
Total Medium H			
Total High H			

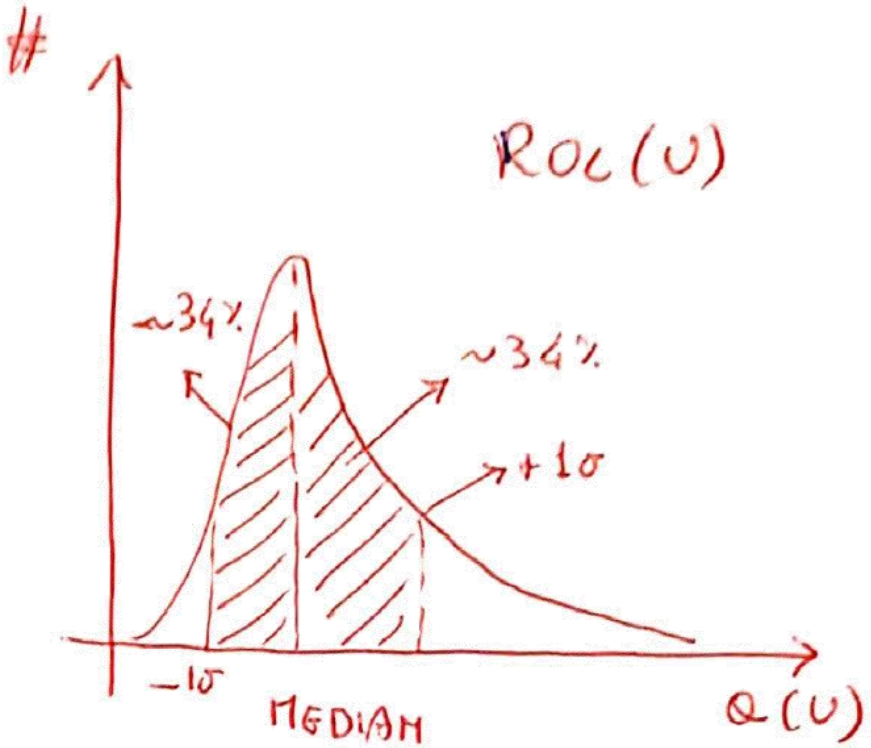


We need the Probability Density Functions (PDF)

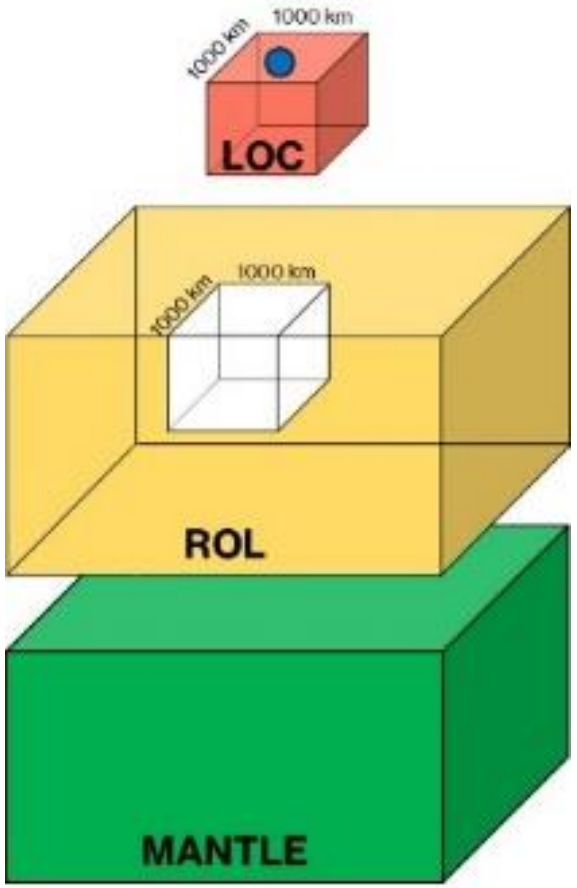
	Oscillated geoneutrino flux [10^6 cm^{-2}s^{-1}]		
	U	Th	Th/U
LOC	$X_L{}^{+YL1}{}_{-YL2}$		
ROL	$X_R{}^{+YR1}{}_{-YR2}$		
LOC+ ROL			

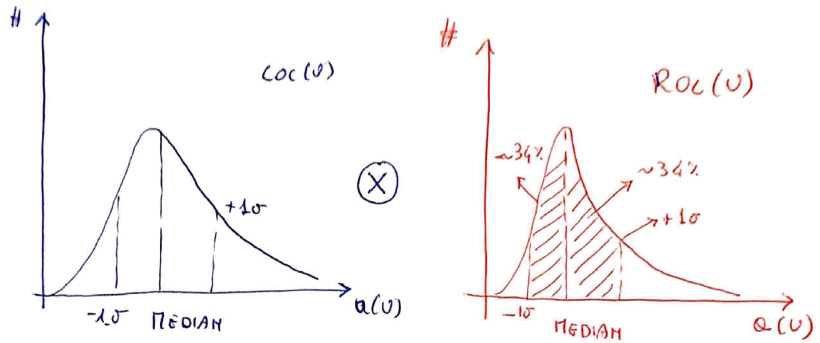




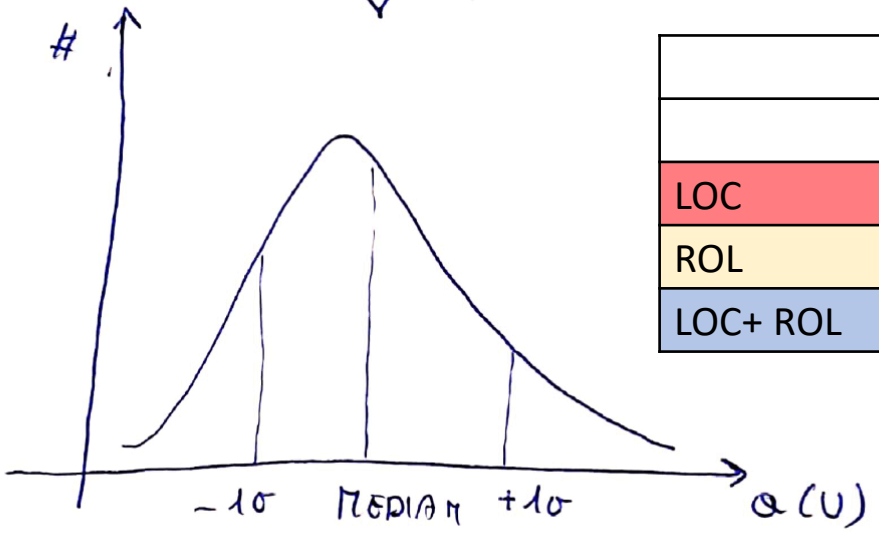


Combining LOC + ROL

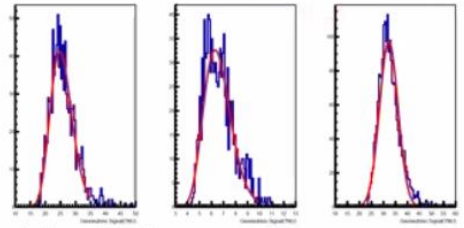




LINEAR INDEPENDENT



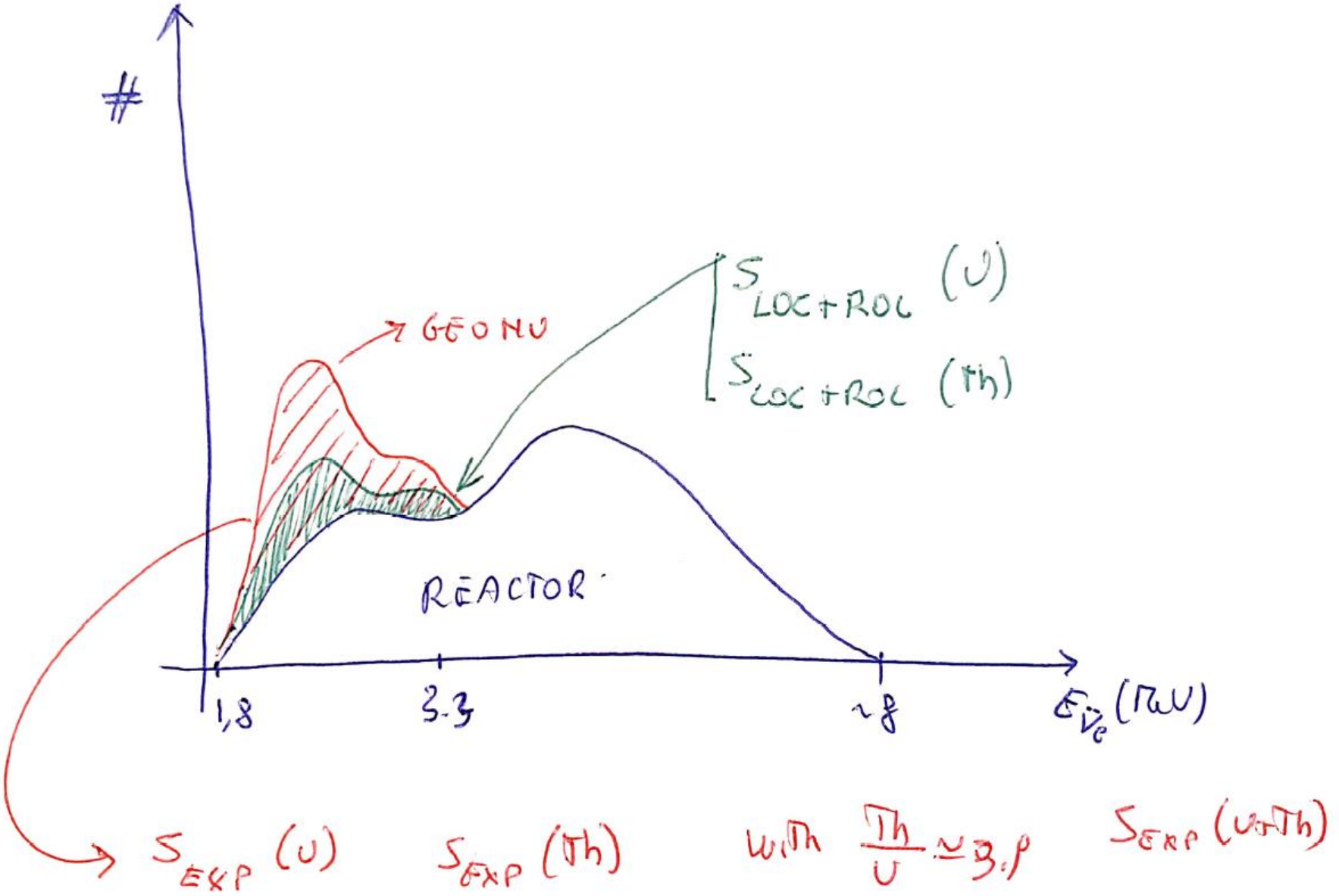
	$S_U \pm \sigma$	$S_{Th} \pm \sigma$	$S_{U+Th} \pm \sigma$
UC	17.2 ±1.3	5.0±0.3	22.3 ±1.4
MC	$5.4^{+3.8}_{-2.2}$	$0.4^{+0.4}_{-0.2}$	$6.0^{+3.4}_{-2.2}$
LC	$1.5^{+0.3}_{-0.2}$	$0.1^{+0.05}_{-0.04}$	$1.7^{+0.3}_{-0.2}$
Continental Crust	24.5±3.3	5.7 ±0.4	30.4 ±3.2
Oceanic Crust	0.2 ±0.05	0.1 ±0.01	0.3±0.05
Total Crust	24.7 ±3.3	5.8 ±0.4	30.7 ±3.2



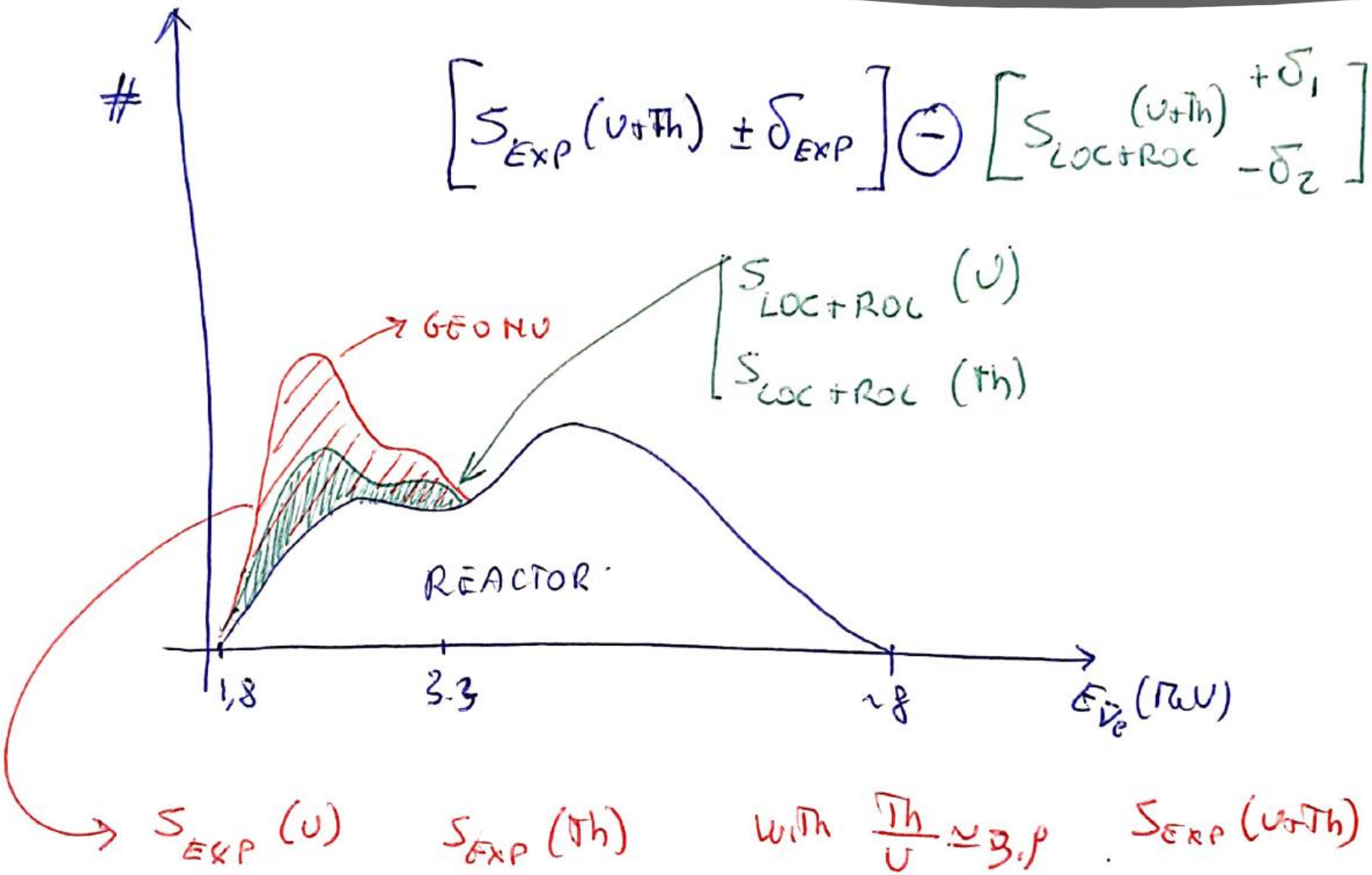
1000 random times
U, Th, U+Th geoneutrino signal

	Oscillated geoneutrino flux [10^6 cm^{-2}s^{-1}]		
	U	Th	Th/U
LOC	$X_L {}^{+YL1}_{-YL2}$		
ROL	$X_R {}^{+YR1}_{-YR2}$		
LOC+ ROL	$X_{LR} {}^{+YLR1}_{-YLR2}$		

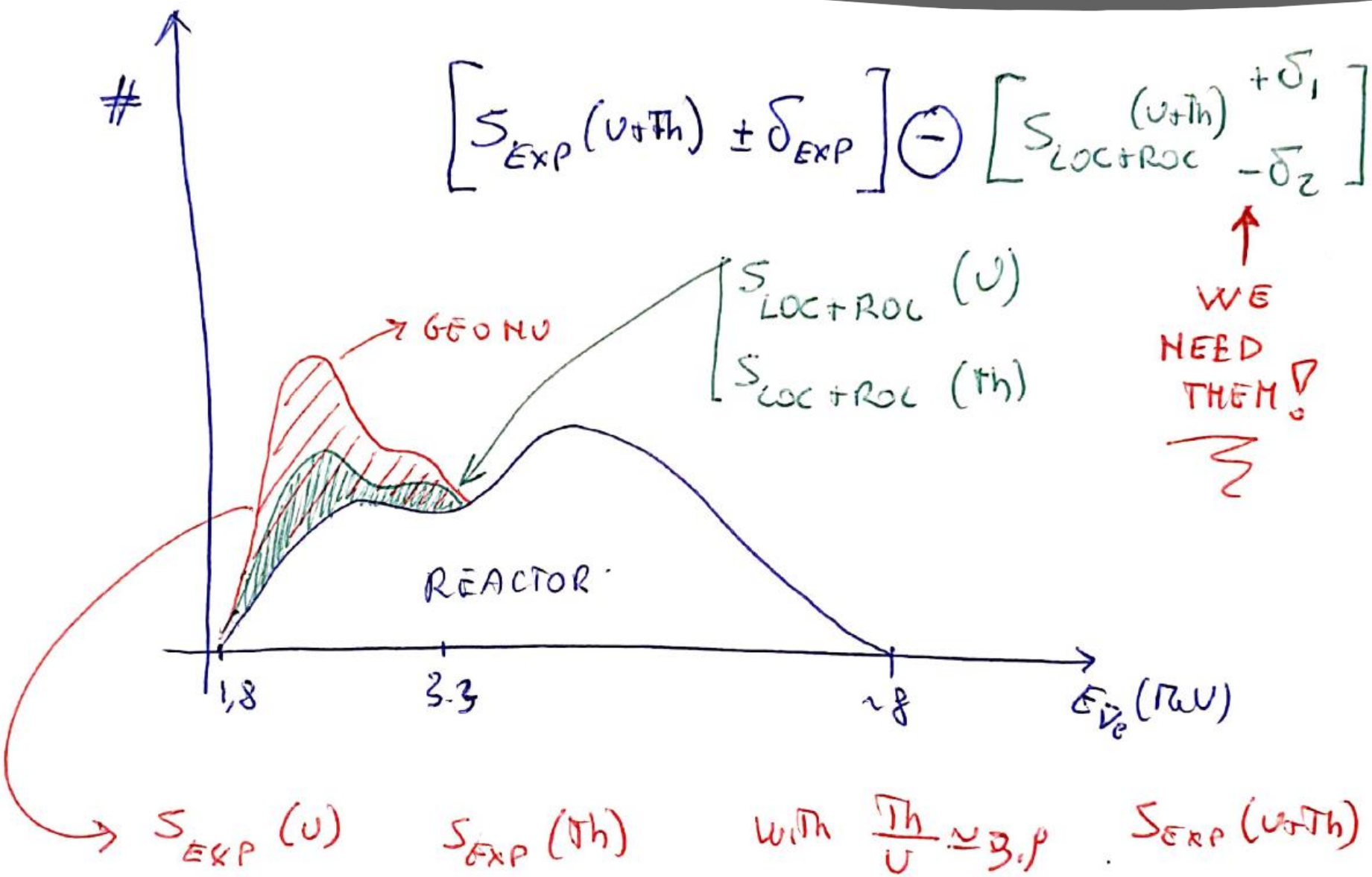
Recognizing (LOC+ROL) in experimental spectrum..



Subtracting (LOC+ROL) from experimental spectrum..



Subtracting (LOC+ROL) from experimental spectrum..



Si sta lavorando bene ☺