FLUKA SIMULATION AT SOUTH POLE STATION

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OUTLINE

1. Introduction
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3. Methodology
4. Results
5. Summary
6. Future work

1 INTRODUCTION

- Cosmic Rays
- Neutron Monitor
- FLUKA Monte-Carlo Simulation
- Yield Function

COSMIC RAY

cos·mic ray

[cosmic ray]

NOUN

cosmic rays *(plural noun)*

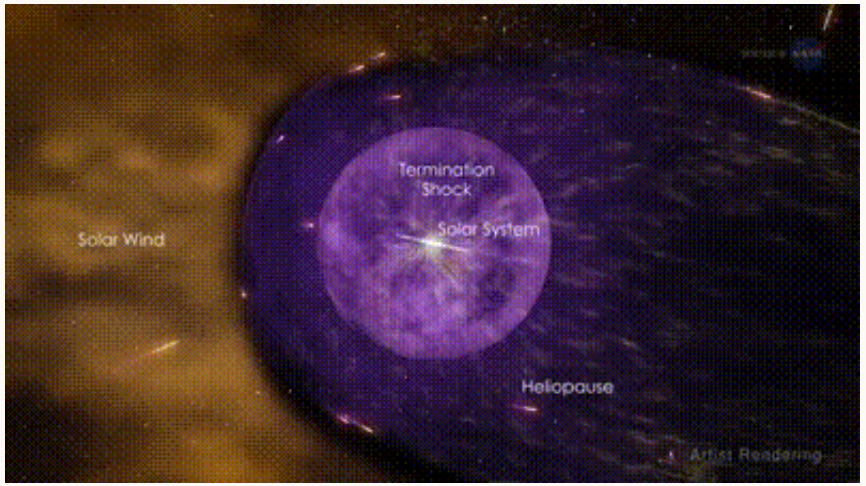
a highly energetic atomic nucleus or other particle travelling through space at a speed approaching that of light.

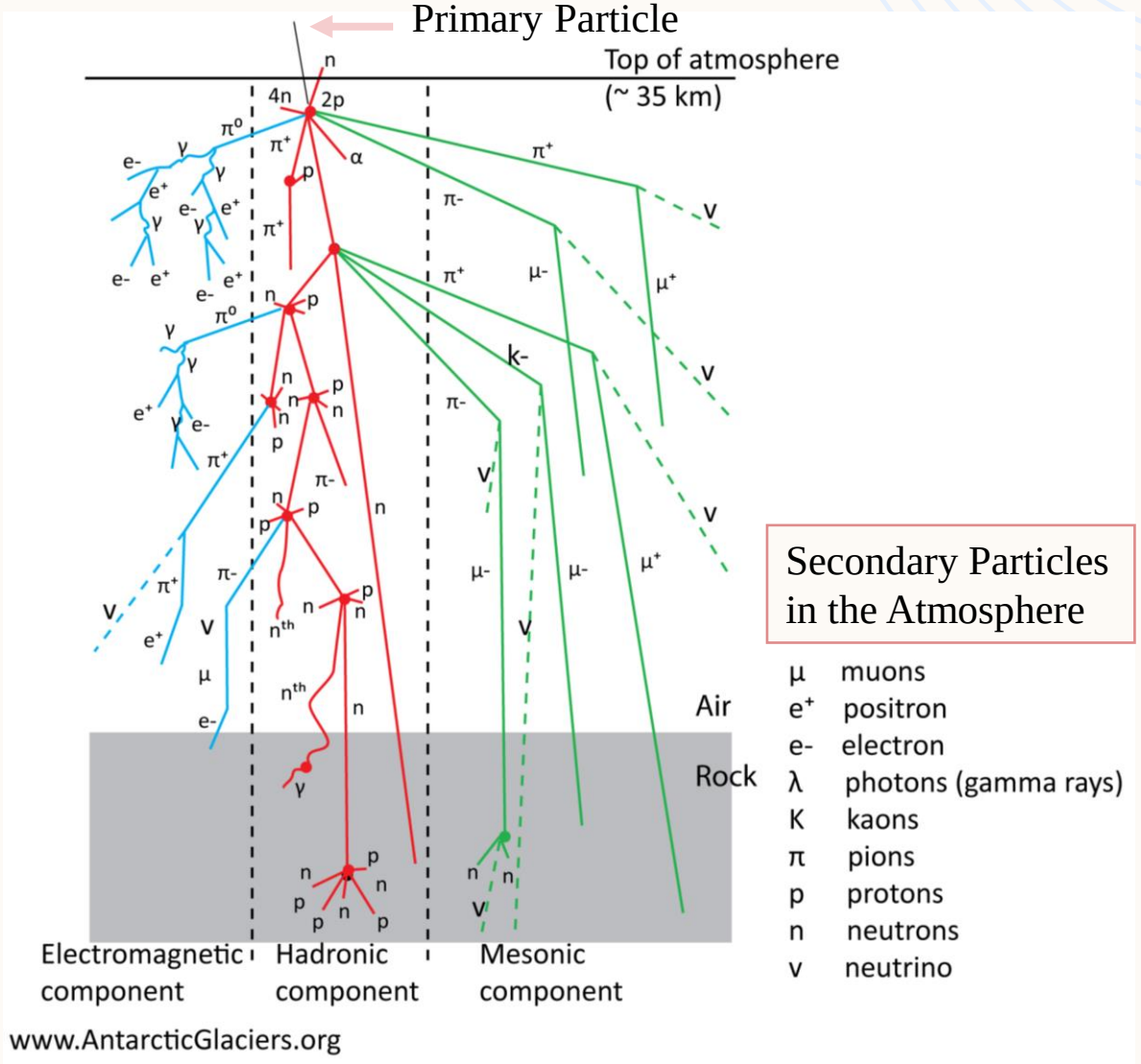
See less

Cosmic rays can be divided into two types:

- Galactic Cosmic Rays (GCRs) and Extragalactic Cosmic Rays, i.e., high-energy particles originating outside the solar system.
- Solar Energetic Particles (SEPs), high-energy particles (protons) emitted by the sun, primarily in solar activities.

COSMIC RAY


Termination Shock
Solar System
Solar Wind
Heliopause
Artist Rendering

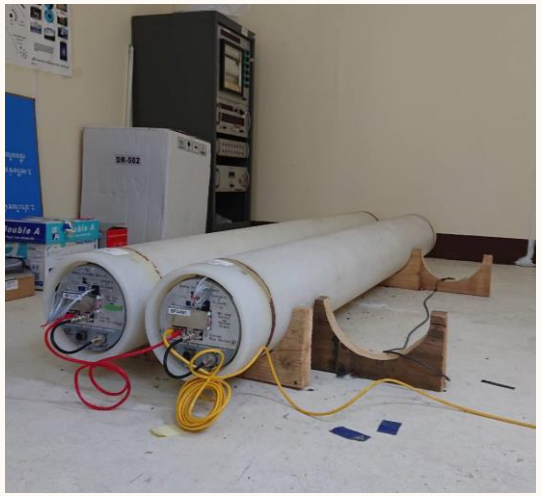

Primary Particle
Top of atmosphere
(~ 35 km)
Air
Rock
Electromagnetic component
Hadronic component
Mesonic component
www.AntarcticGlaciers.org
Secondary Particles in the Atmosphere
μ muons
e+ positron
e- electron
λ photons (gamma rays)
K kaons
π pions
p protons
n neutrons
ν neutrino

COSMIC RAYS DETECTOR

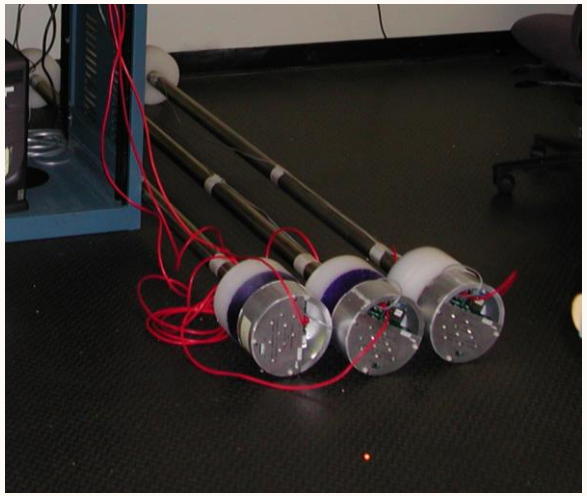
- **Neutron monitors** (**NMs**) are ground-based detectors that detect the secondary particles with high energies

NM64

PE Bare

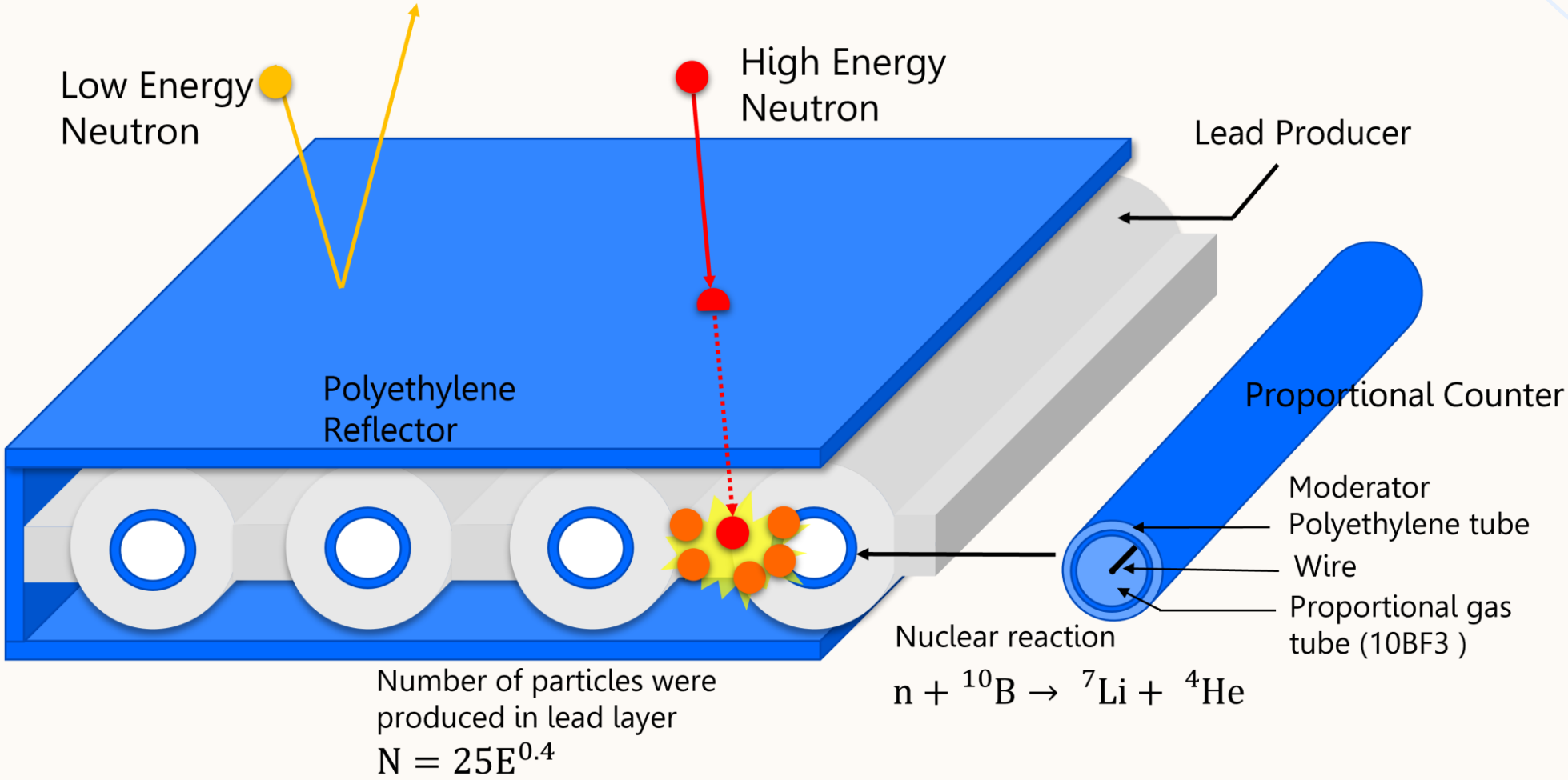


Donut Bare

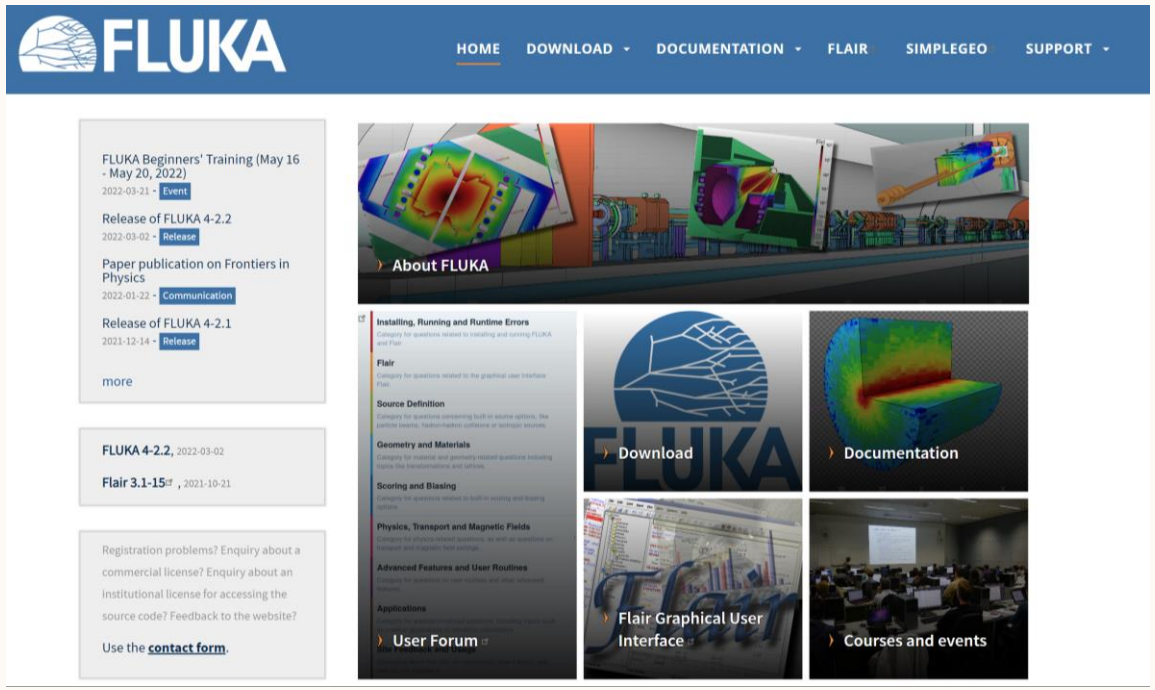


Paraffin Bare

HOW DOES NM WORKS?



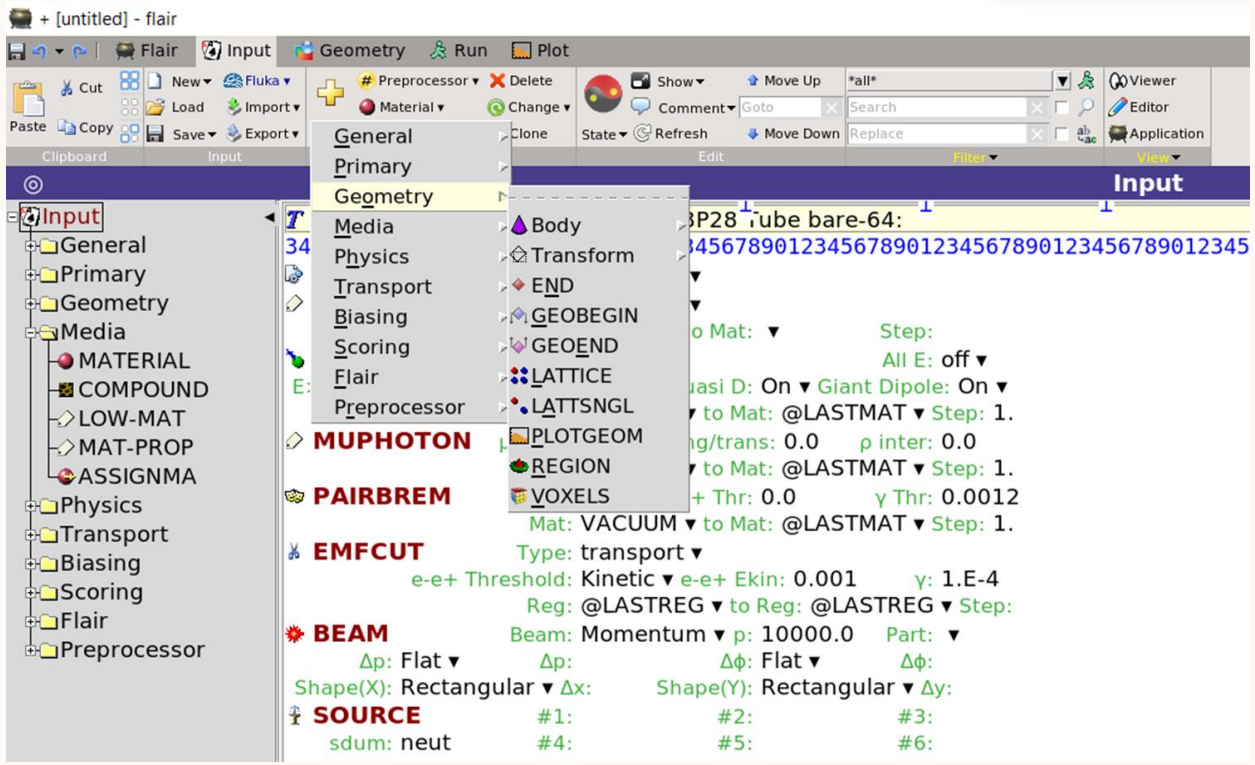
DETECTOR SIMULATION



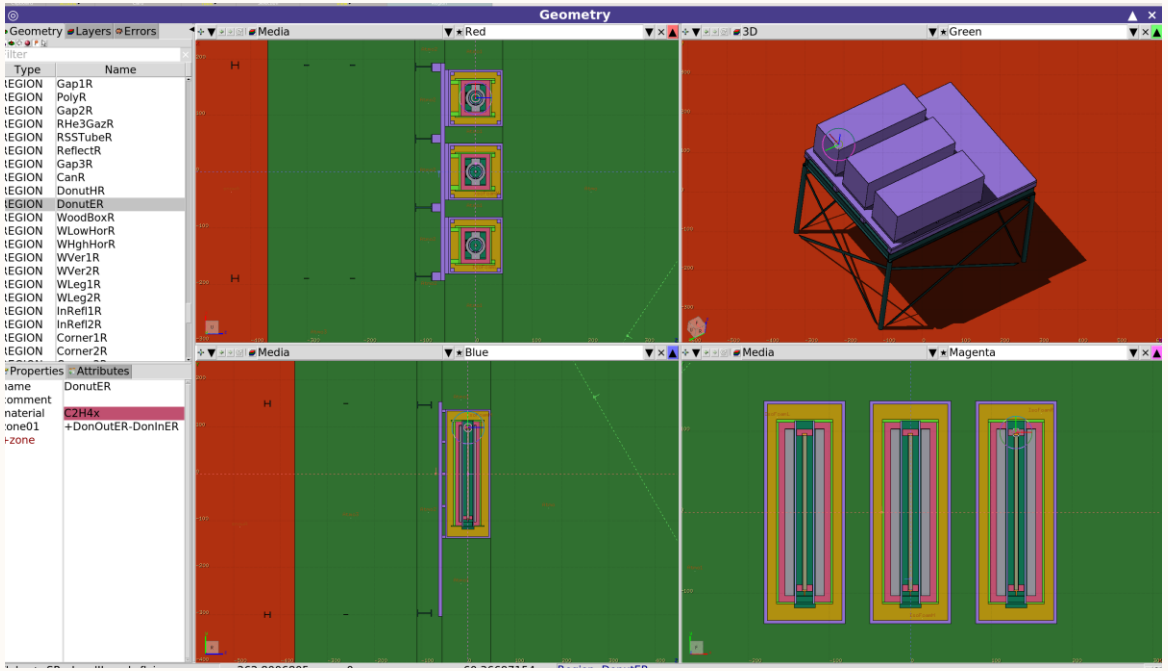
FLUKA is Monte Carlo simulations of particle transport and interactions in matter

flair is an advanced user-friendly interface for FLUKA to facilitate the editing of FLUKA input files

FLUKA SIMULATION

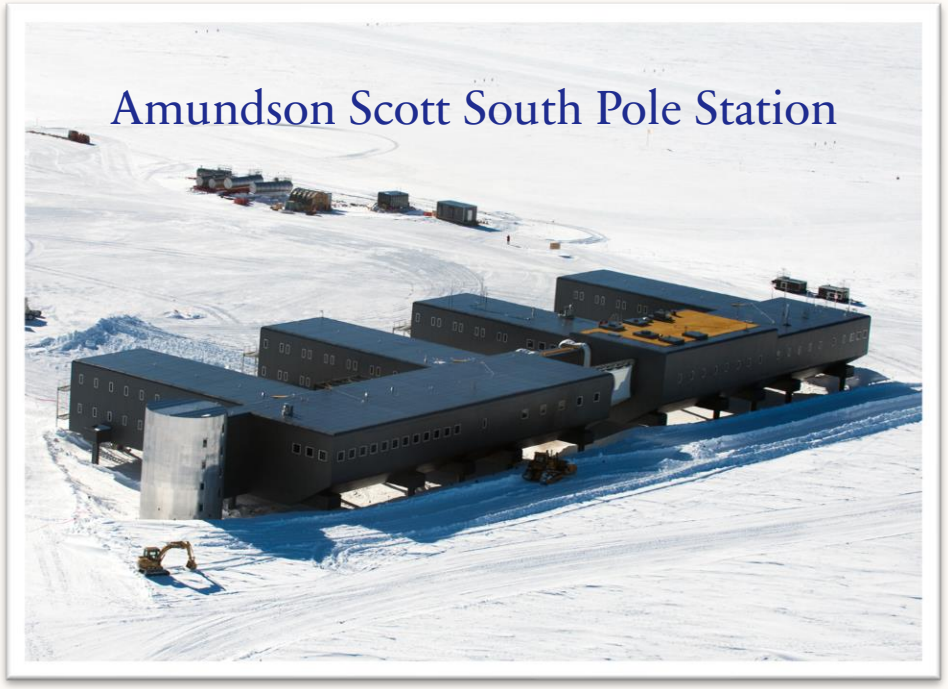


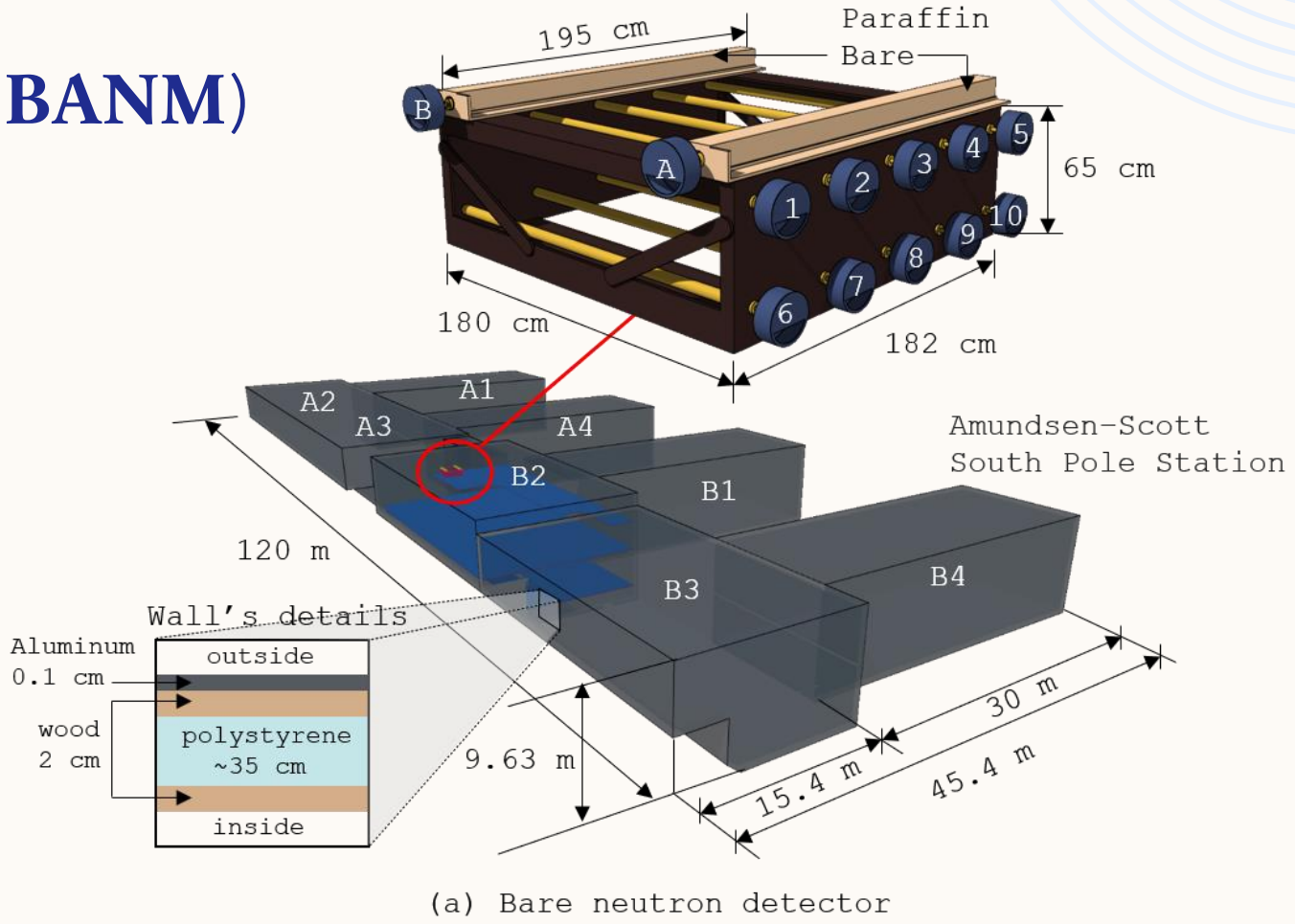
Create Model by using flair interface



FLUKA SIMULATION

Bare Monitor at South Pole (BANM)

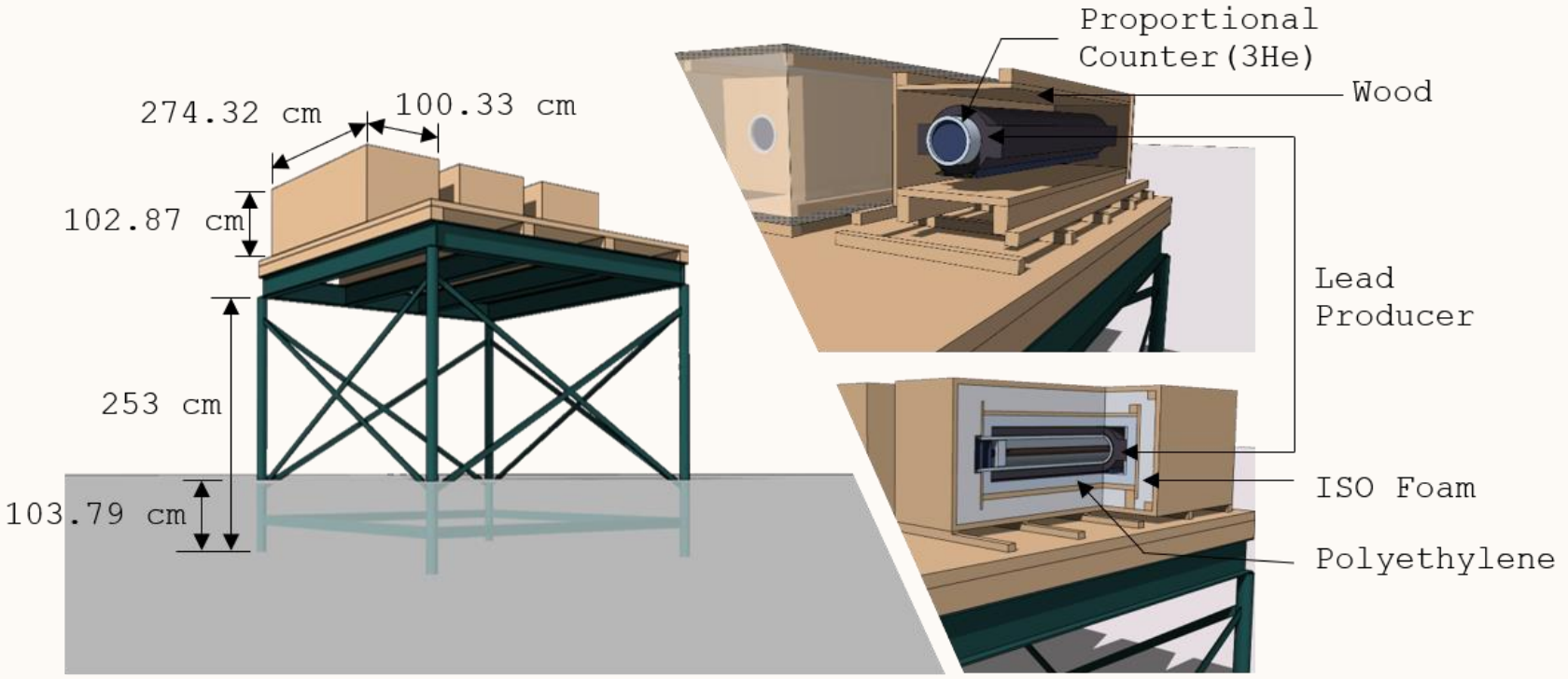




(a) Bare neutron detector

FLUKA SIMULATION

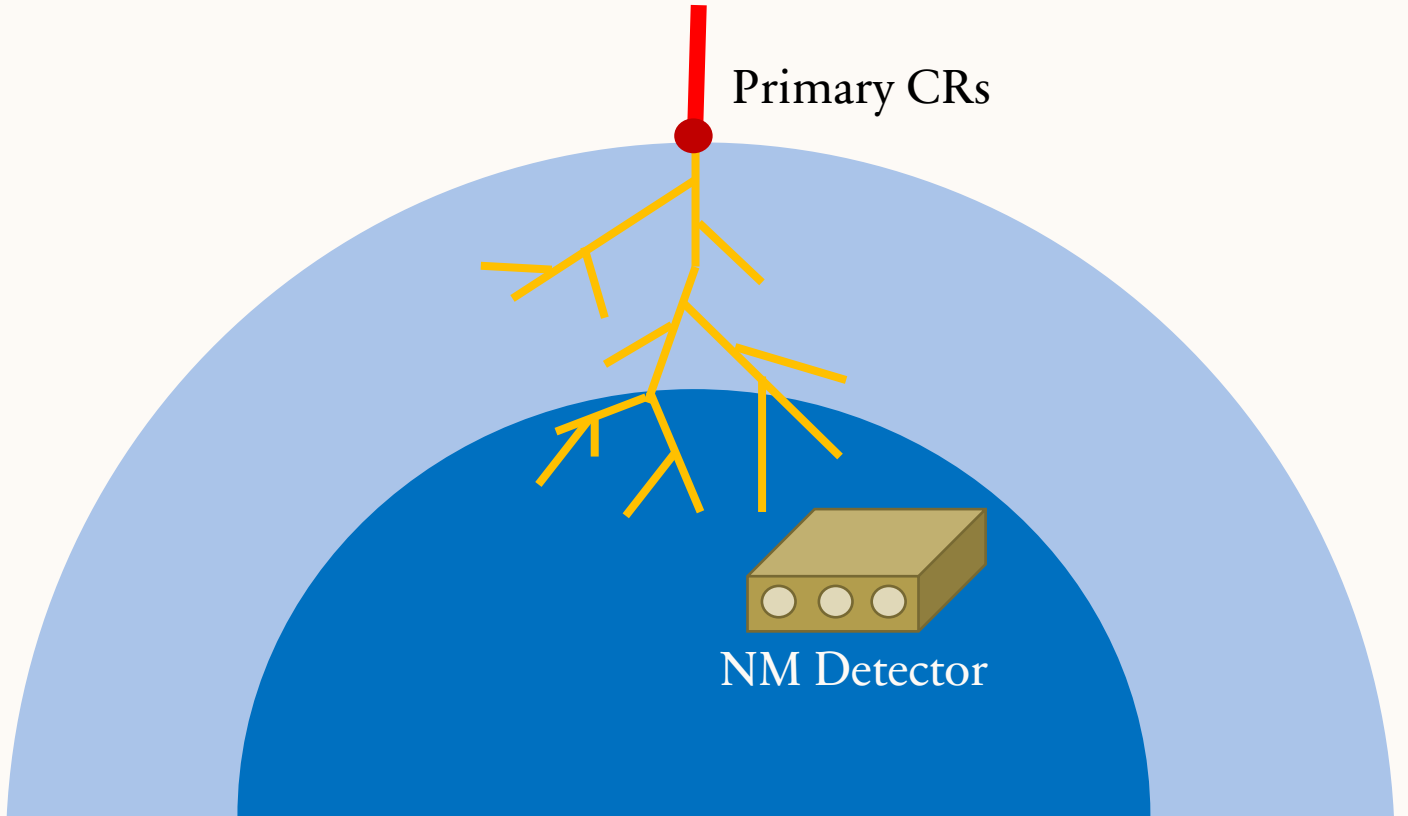
Bare Monitor at South Pole (BANM)



(b) Neutron monitor

YIELD FUNCTION

- **The yield function** is the actual relationship between count rates, observed by detectors and fluxes at the top of atmosphere.
  - ❑ Atmospheric Simulation → We use data from GDAS and NRLMSISE-00 (From Pierre Simon)
  - ❑ Detector Simulation → SPNM, BANM



2 OBJECTIVE

- To find the **Count Rate** from simulation
- Compare the count rate from simulation with the actual count rate

3 METHODOLOGY

- Atmospheric Simulation
- Detector Simulation

FLUKA SIMULATION

Get the detector's details (dimension, material, etc.)

Create a model

Export picture from flair

Run FLUKA in server

Analyze Data using python code

4 RESULTS

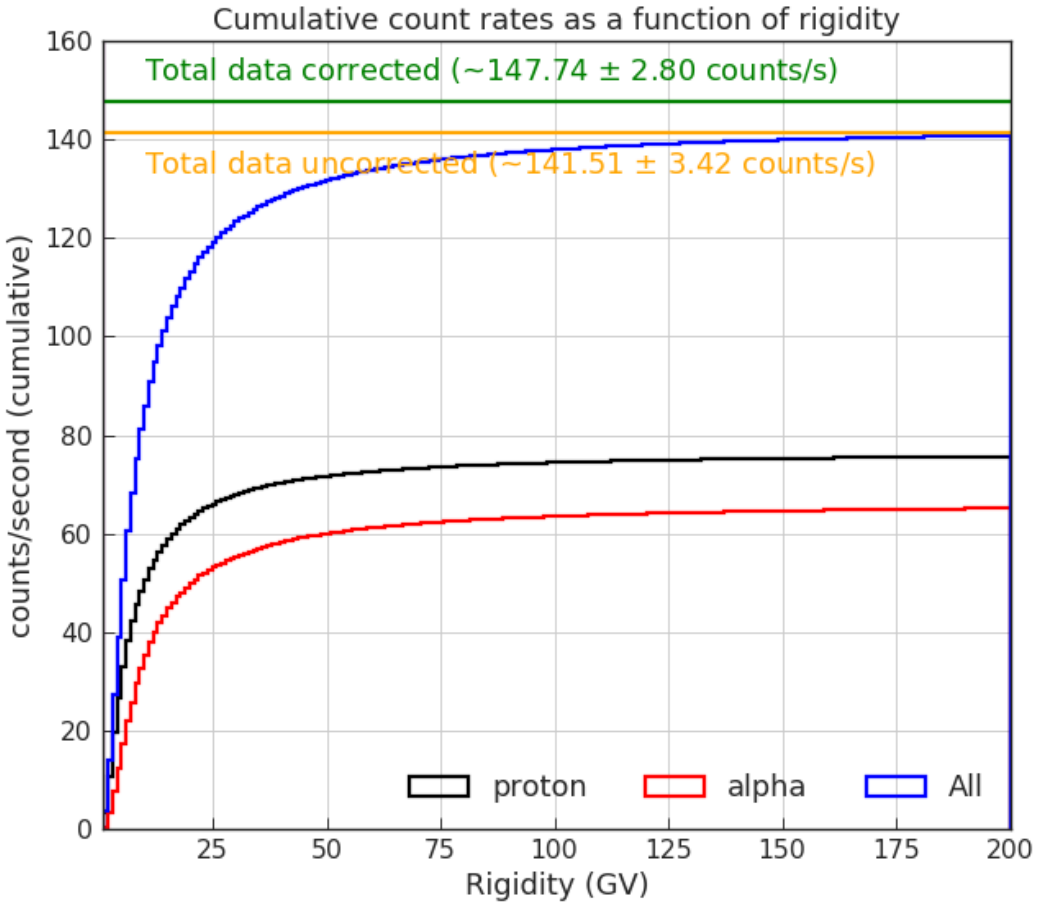
BARE MONITOR AT SOUTH POLE

Atmospheric Simulation

	Proton	Alpha
# Cycles	200	200
# Particle	10,000	10,000

Detector Simulation (139.43 counts/s at 1GV)

	neutron	proton	muon
# Cycles	500	500	406
# Particle	1M	1M	1M



PHI = 576.5 MV (average Jan 2011 to 2016 - US17)
Real Count rates of 1-31 January from 2011 to 2016 from **NMDB**

SIMULATION TESTS

1. Lead
   - Lead ring density → 11.35 g/cm^3
   - None Lead
2. ISO Foam
   - Varies density of ISO foam
     - 0.0419 g/cm^3
     - 0.0504 g/cm^3
     - 0.0671 g/cm^3
     - 0.1.007 g/cm^3
   - None ISO foam ~595.05 counts/s
3. Polyethylene
   - PE300 (Donut & reflector) ~507.20 counts/s
   - PE1000 (Moderator)
4. Snow surrounding → hemisphere (Snow height 98.7 cm) ~543.52 counts/s
5. Wood structure of SPNM
   density = 0.9 g/cm^3
   - Remove Wood inside ~597.05 counts/s
   - Remove Wood outside ~598.85 counts/s

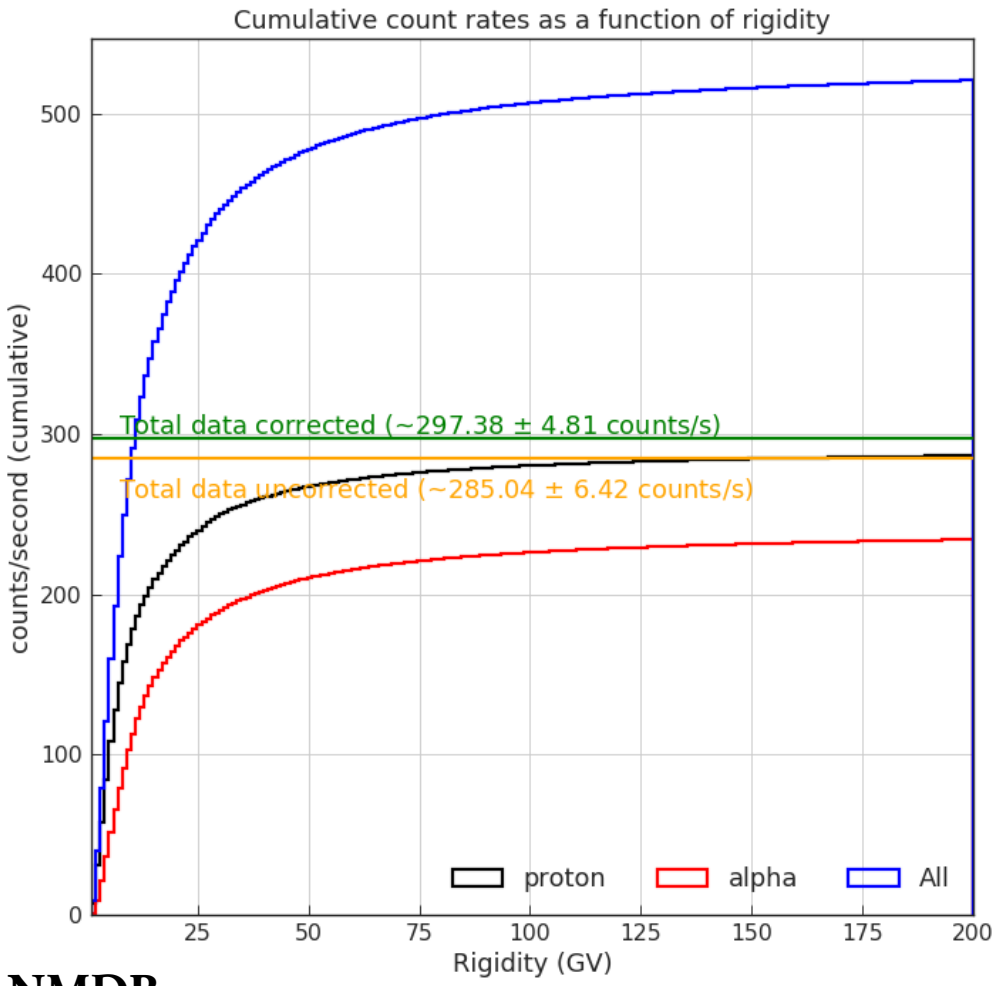
3-NM64 AT SOUTH POLE

Atmospheric Simulation

	Proton	Alpha
# Cycles	200	200
# Particle	10,000	10,000

Detector Simulation (520.61 counts/s at 1GV)

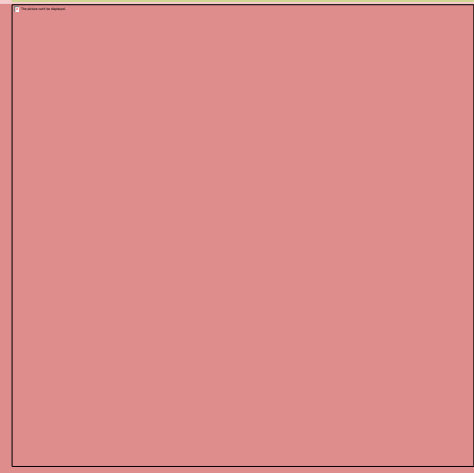
	neutron	proton	muon
# Cycles	98	34	20
# Particle	1M	1M	1M



PHI = 576.5 MV (average Jan 2011 to 2016 - US17)
Real Count rates of 1-31 January from 2011 to 2016 from **NMDB**

5 SUMMARY

- Density of **Lead** in FLUKA simulation, we found that lead density caused significantly greater count rates.
- After modify geometry → count rate decrease 13 %



FUTURE WORK

Geometry

Modified lead compound

Validation yield function by using time series of simulation counts compare with real count rates

Yield Function

THANK YOU

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KAZZINC

PRODUCER'S ASSAY CERTIFICATE

VESSEL NAME	MAERSK JABAL 052S
LOAD PORT:	VOSTOCHNIY PORT
DISCHARGE PORT:	BANGKOK
B/L NO:	207081071
B/L DATE:	08.01.21
B/L NET WEIGHT:	515.895 MT
B/L GROSS WEIGHT:	516.695 MT
CARGO DESCRIPTION	<<YK>> BRAND LEAD METAL INGOTS STRAPPED INTO BUNDLES

ASSAYS, %

# melt	Pb	Ag	Cu	Zn	Bi	As	Sn	Sb	Fe	Cd	Ni	Co	Te
427	99.994	0.00026	0.00011	0.0004	0.0022	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
429	99.994	0.00028	0.00011	0.0004	0.0029	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
430	99.994	0.00029	0.00011	0.0004	0.0022	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
431	99.994	0.00022	0.00011	0.0004	0.0029	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
432	99.994	0.00044	0.00011	0.0004	0.0023	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
434	99.994	0.00032	0.00011	0.0004	0.0022	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
436	99.994	0.00045	0.00011	0.0004	0.0027	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
441	99.994	0.00047	0.00011	0.0004	0.0022	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
443	99.994	0.00034	0.00011	0.0004	0.0023	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002
442	99.994	0.00038	0.00011	0.0004	0.0023	0.0004	0.0004	0.0004	0.0005	0.00013	0.0001	<0.0002	<0.0002

WE , LTD «KAZZINC», CERTIFY THE ABOVE ASSAYS.

Y.Liverinov
Sales Department Specialist
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