TRIUMF

Canada's national laboratory for particle and nuclear physics

Laboratoire national canadien pour la recherche en physique nucléaire

et en physique des particules

TRIUMF's Proton & Neutron Irradiation Facility and the Two-Step Monte Carlo Simulation

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Overview

PART 1: PIF & NIF

- Motivation
- TRIUMF Neutron Facility

PART 2: Two-step Project

- Project Aim/Intro
- Unphysical results
- 2-step vs. 1-step
- Results Summary

A problem has been detected and Windows has been shut down to prevent damage
to your computer.

DRIVER_IRQL_NOT_LESS_OR_EQUAL

If this is the first time you've seen this Stop error screen,
restart your computer. If this screen appears again, follow
these steps:

Check to make sure any new hardware or software is properly installed.
If this is a new installation, ask your hardware or software manufacturer
for any Windows updates you might need.

If problems continue, disable or remove any newly installed hardware
or software. Disable BIOS memory options such as caching or shadowing.
If you need to use Safe Mode to remove or disable components, restart
your computer, press F8 to select Advanced Startup Options, and then
select Safe Mode.

Technical information:

*** STOP: 0x000000D1 (0x0000000C,0x00000002,0x00000000,0xF86B5A89)

*** gv3.sys - Address F86B5A89 base at F86B5000, DateStamp 3dd991eb

Beginning dump of physical memory
Physical memory dump complete.
Contact your system administrator or technical support group for further
assistance.

Good Bye, World!

PART 1:

Electronics testing at TRIUMF's Proton and Neutron Irradiation Facilities

So, what does proton & neutron radiation do to electronic chips?

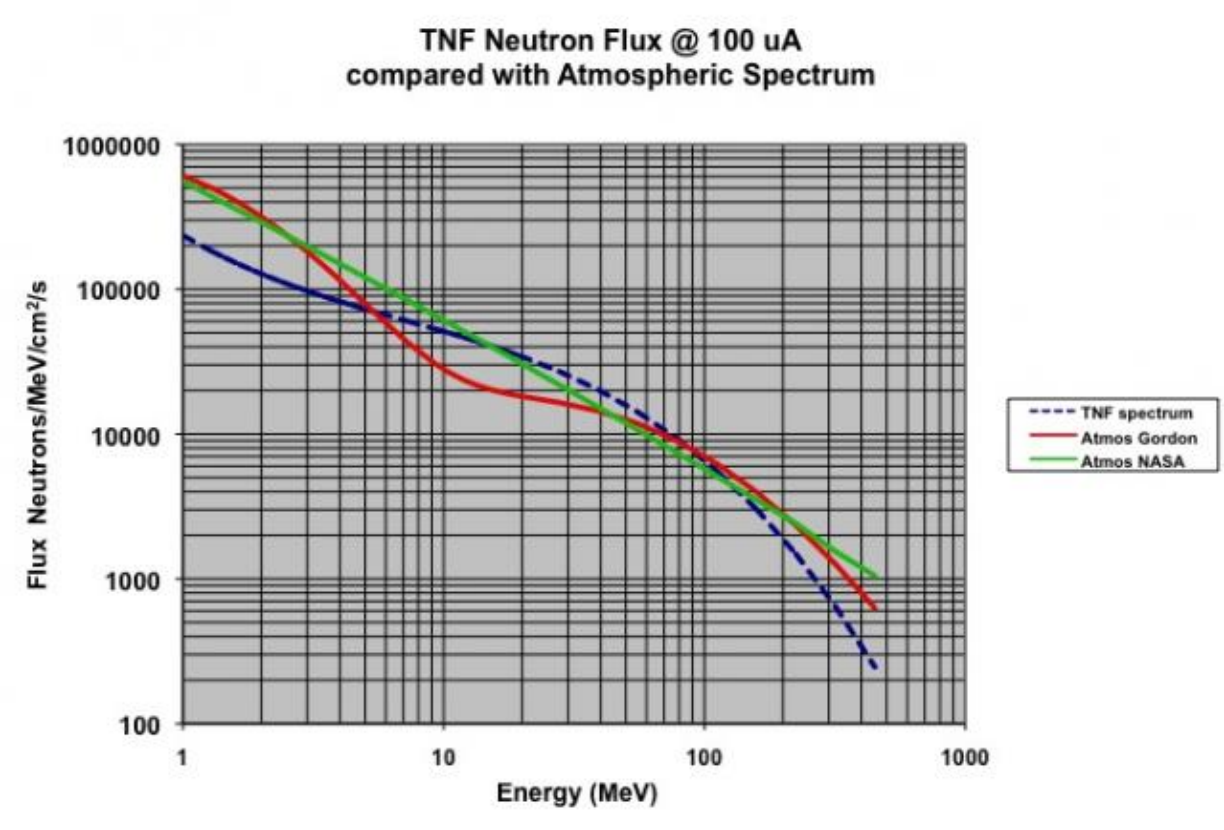
Radiation effects on electronics

- Cosmic radiation can cause soft core errors in CPU processors.
- Messes with the “binary code”
- Can affect computers in the atmosphere, on the ground level, and in space!

So electronics need to be tested…

- Protons: best mimic space radiation
- Neutrons: best mimic atmospheric and ground radiation
  - In order to be qualified for use, companies need to test their electronic chips against the appropriate kind of radiation.
  - Satellite, computer, scientific research, aircraft, ATMs, etc.

TRIUMF Neutron Facility (TNF)



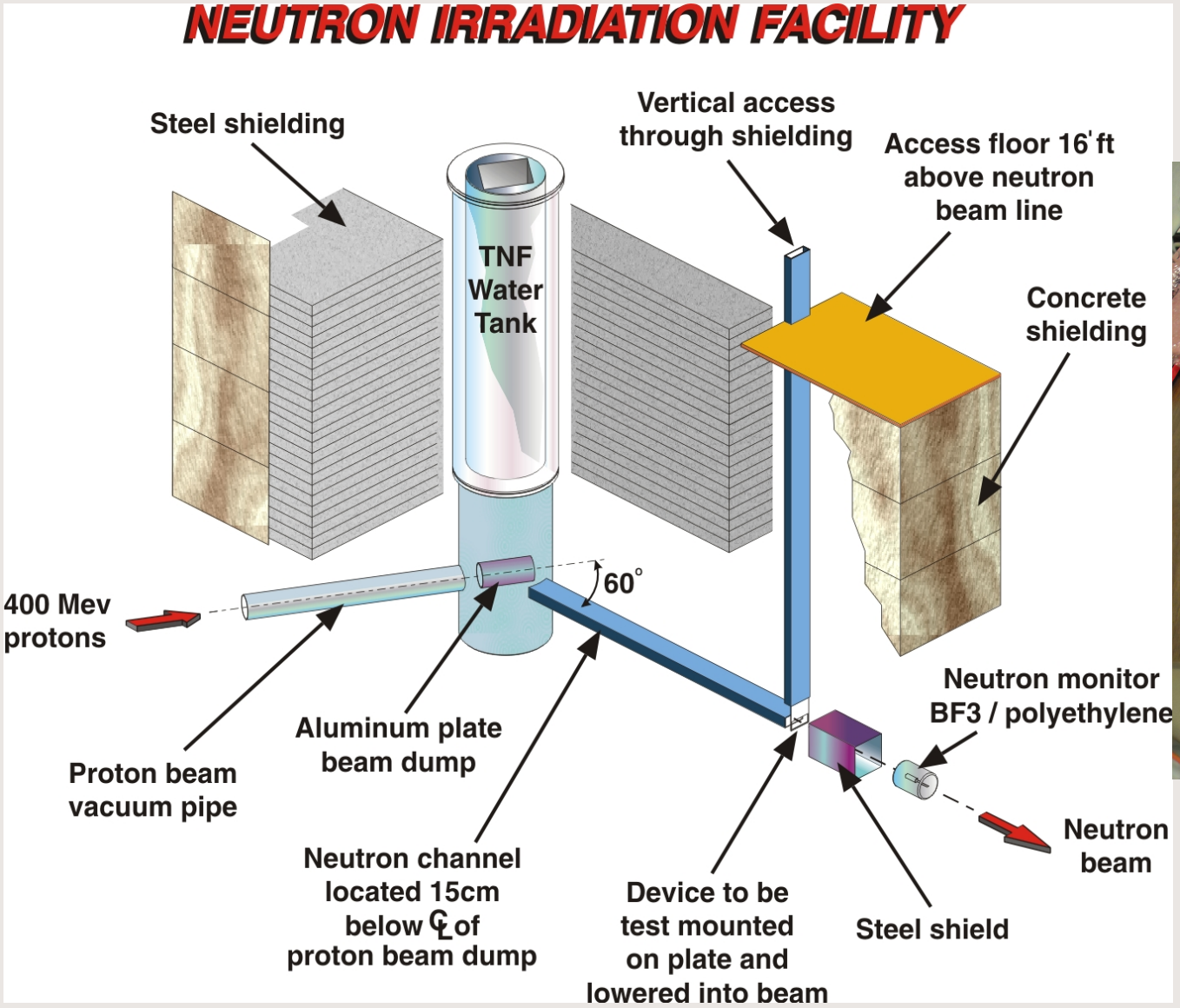
- The neutron flux spectrum here is incredibly similar to that of the atmosphere!
- TNF is reliable place to test electronics accurately → accelerated testing

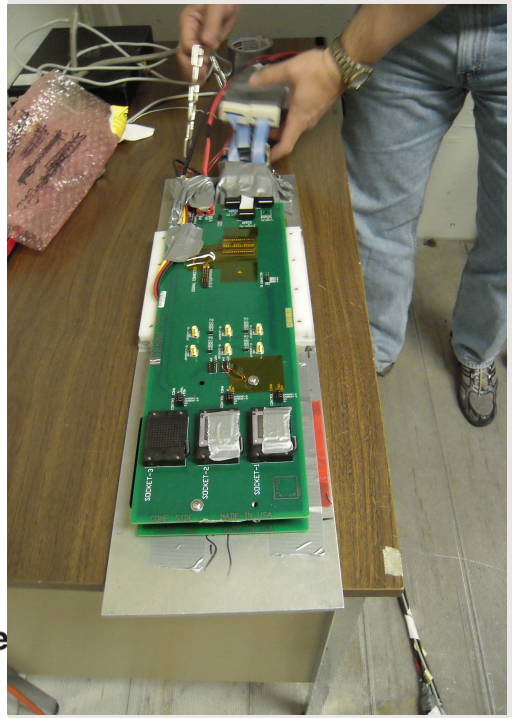
PART 2:

My work in perfecting the two-step Monte Carlo simulation

A tale of trials, tribulations, and faulty neutrons.

NEUTRON IRRADIATION FACILITY





Aim of the Project

- Measure neutron flux at the electronics lowering zone (the “test point”).
- Measure beam dose profile at test point.
- Measure neutron activation of different foils at test point for calibration.

However...

- TNF neutron duct is small – hard to get decent neutron statistics in one shot of protons!

- Two-step simulation is in order:

  1. Write crossing neutrons at entrance of duct to a collision tape file.

  2. Sample those neutrons as a source then record neutrons at test point.

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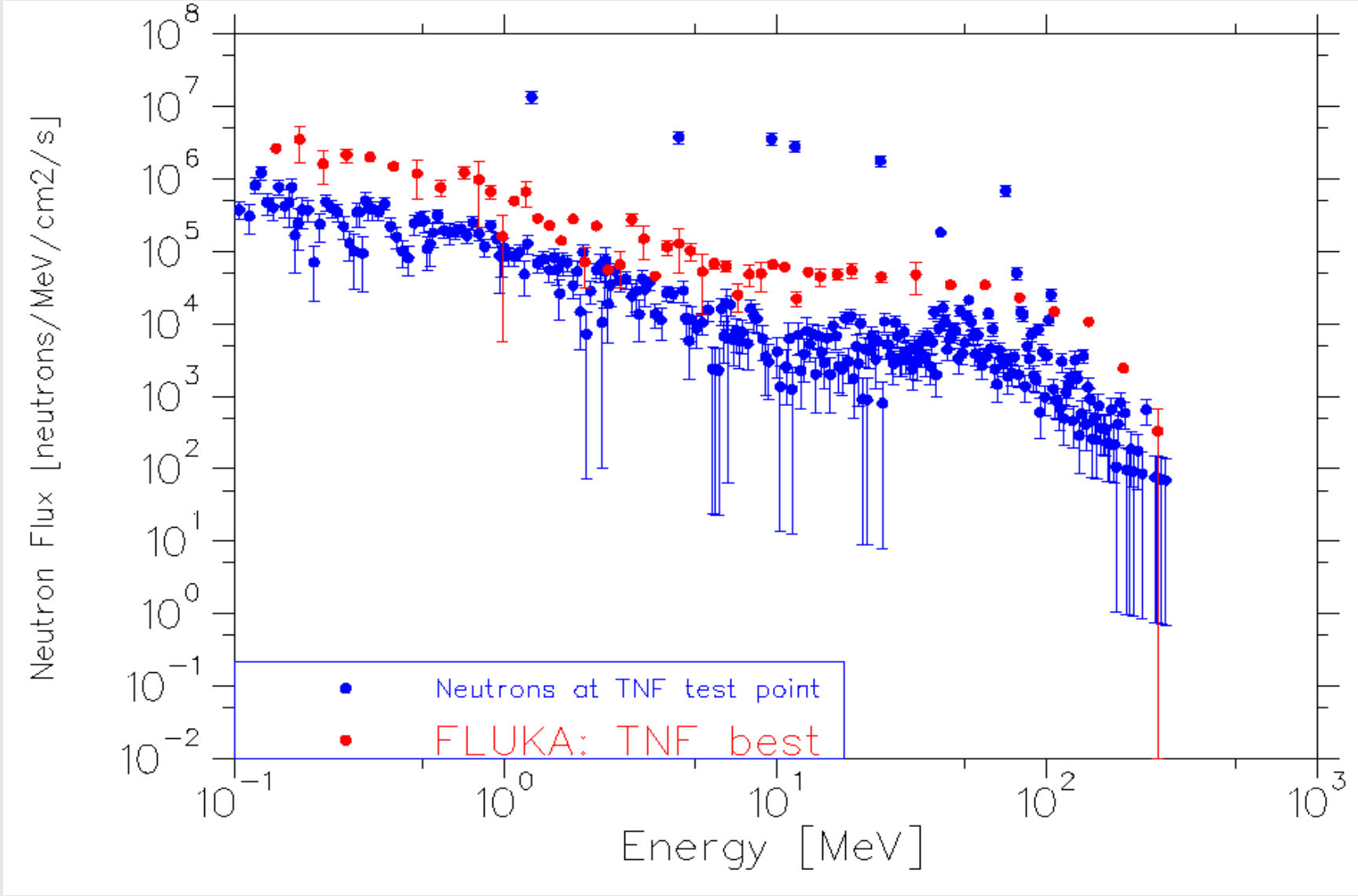
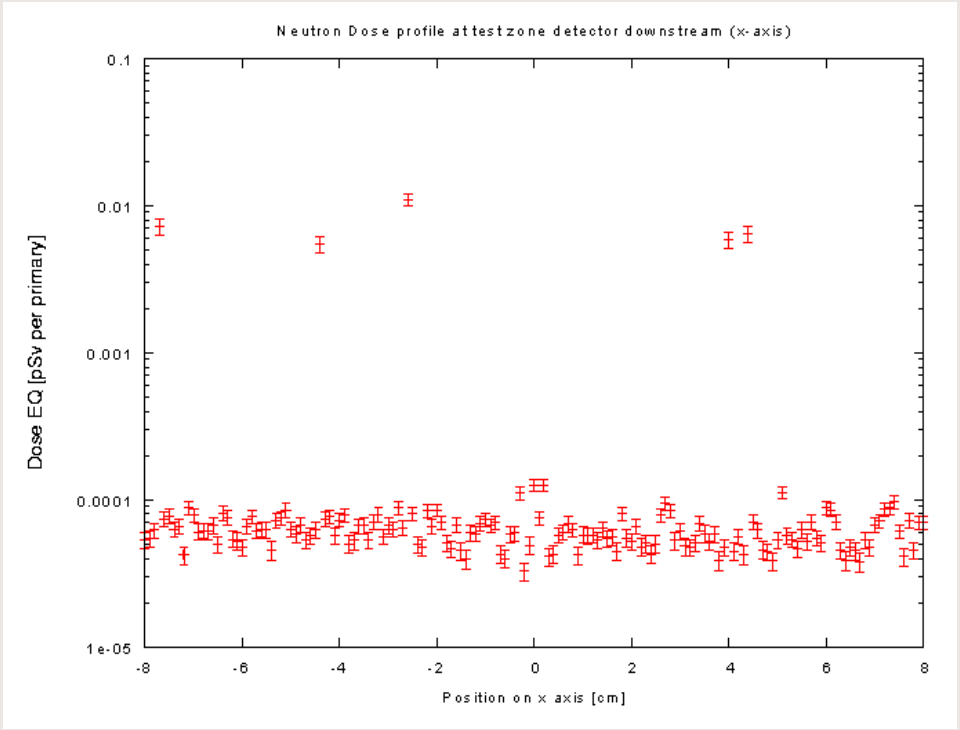
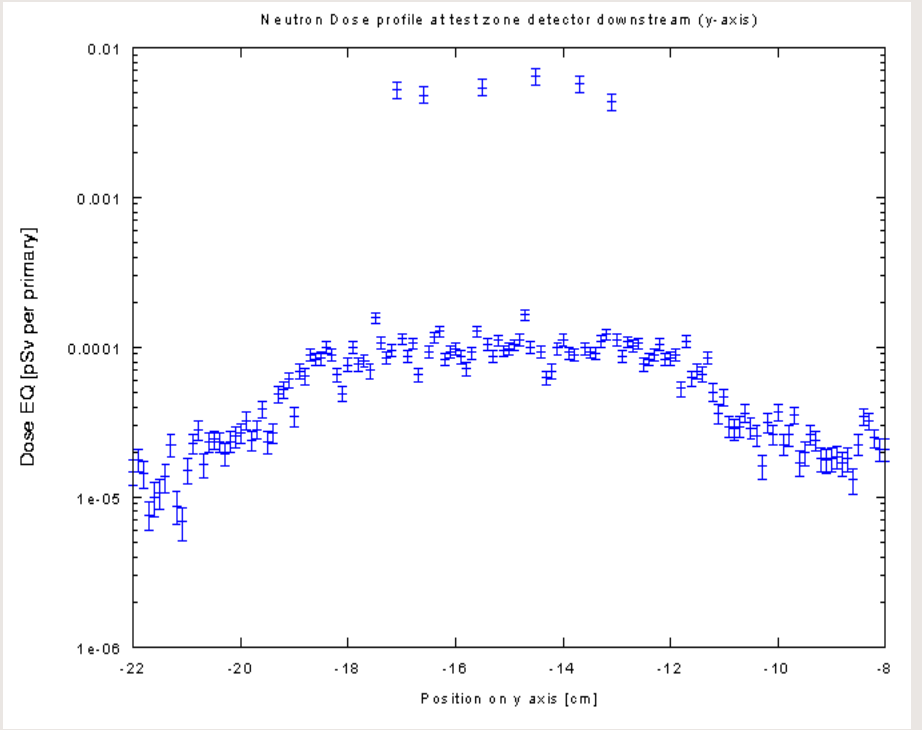
At the test point...



Two-step beam profile at test point





X-axis

Y-axis

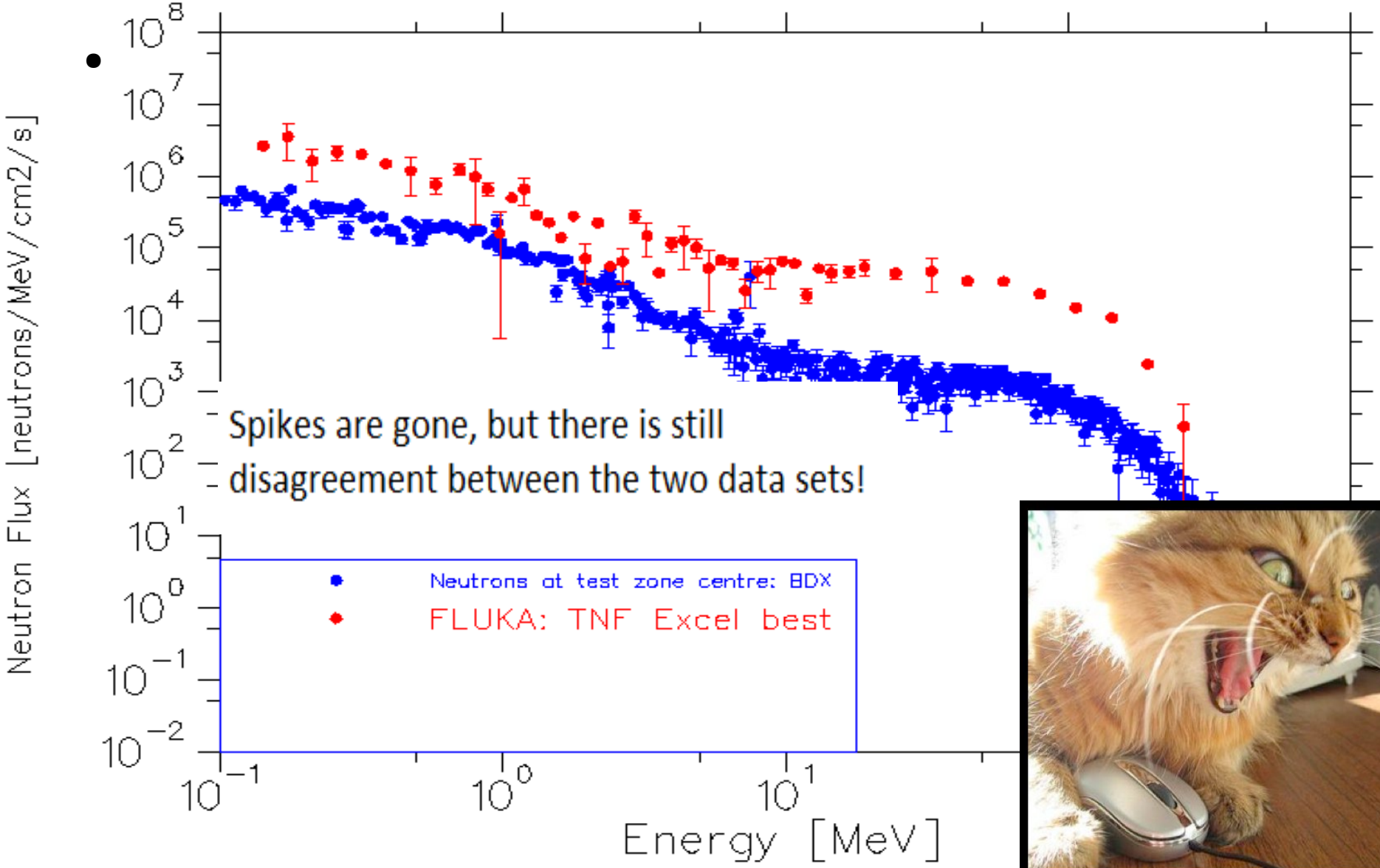
- Suggests “hot spots” of neutrons by position

“Spikes” in the flux/beam profile

- They are unphysical; a code anomaly.
- Are caused directly by beam neutrons from the collision tape sample with a z-cosine value of ~ 1.
- When traced back to the source using direction cosines → non-attenuating neutrons!

After “silencing” these neutrons…

- Spikes are gone, but there is still disagreement between the two data sets!



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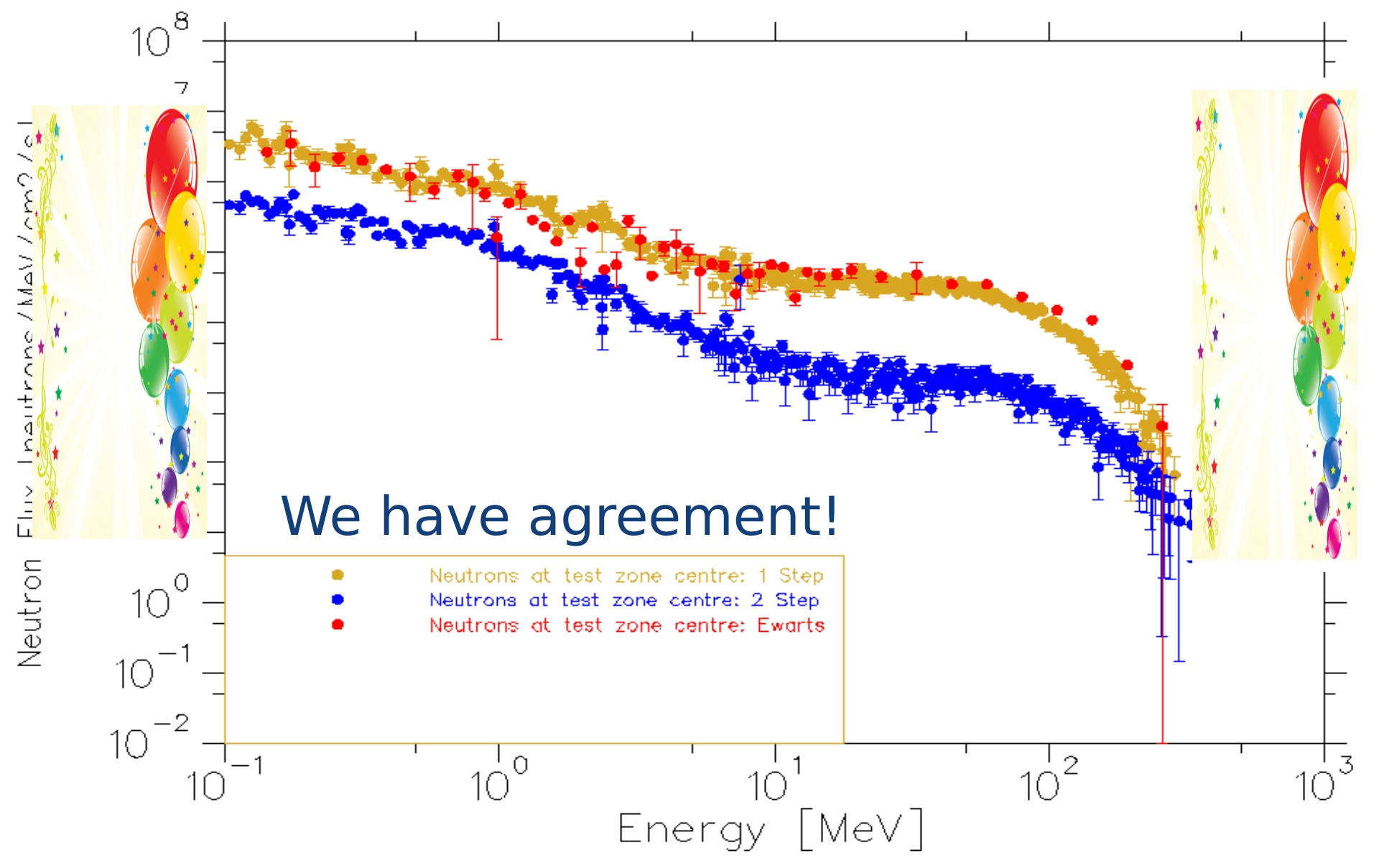
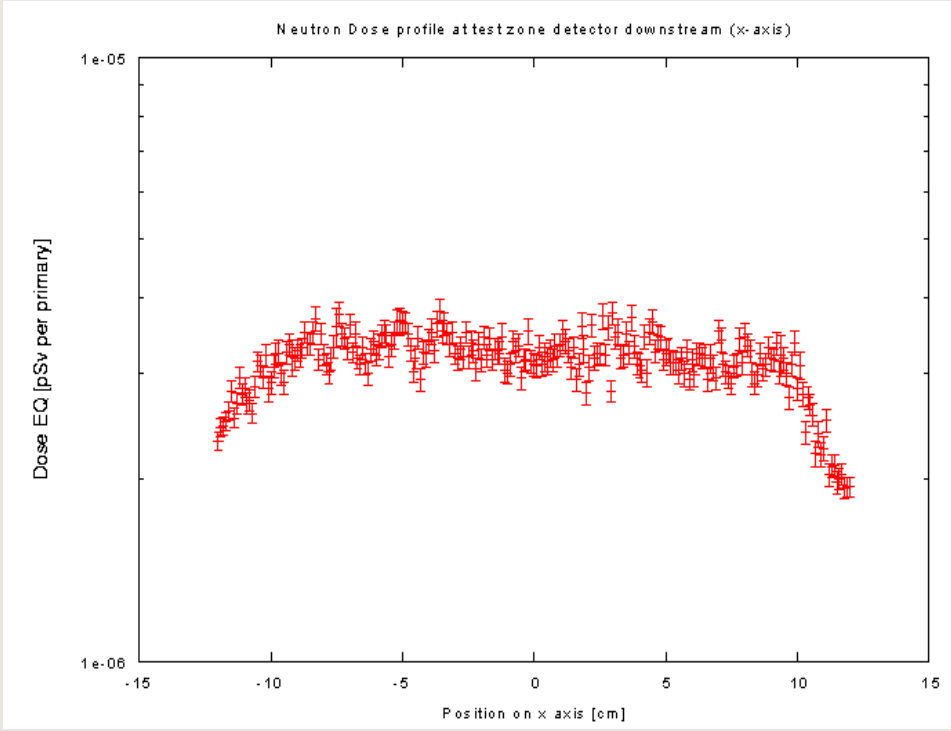
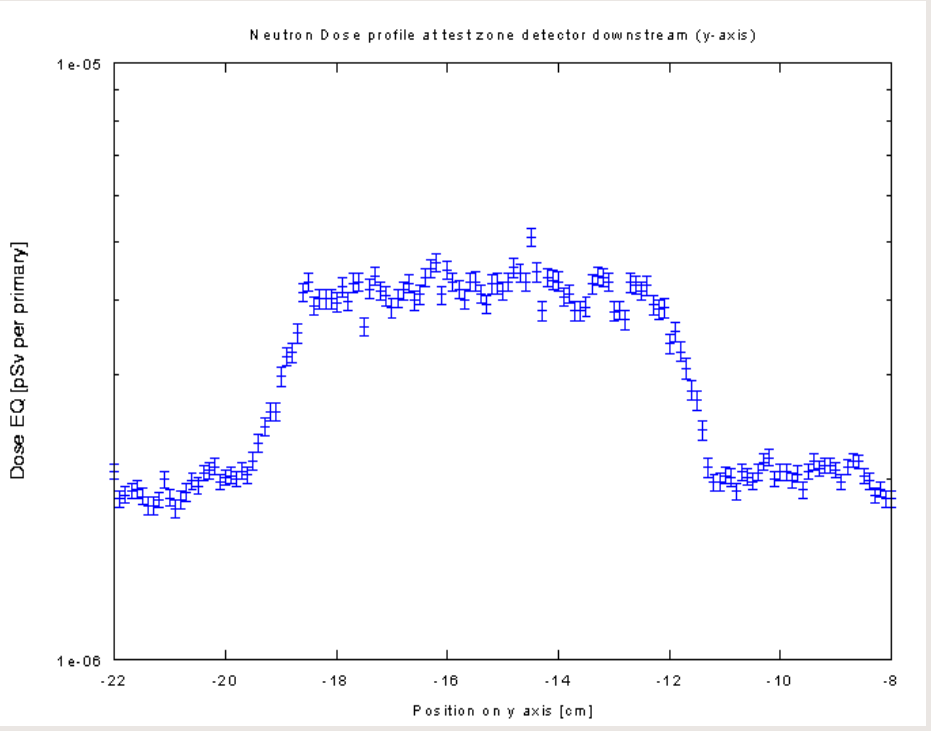
But when we run as a one-step...



One-step beam profile at test point





X-axis **Y-axis**

- ~14 billion protons @ 427 MeV still isn't quite enough statistics! (Want an error of less than 10%)

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Summary of neutron fluxes

Fluxes of neutrons above 10 MeV	[neu/cm2/s]
On PIF & NIF website	**2E6 - 3E6**
Old FLUKA result	**1.95E6**
My one-step result	**2.83E6**
My two-step result	**1.23E5**

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Summary of foil calibration

FOILS Irradiation Time	Carbon #1 50 min	Carbon #2 70 min	Aluminium #5 90.75 hrs	Nickel #2 90.75 hrs
Experimental Foil Activity [Bq]	4065 ± 98	5986 ± 174	3209 ± 106	393 ± 12
Simulated Foil Activity [Bq]	4970 ± 711	5740 ± 821	3290 ± 616	506 ± 102
Difference	**22%**	**4%**	**3%**	**29%**

Part 2 Conclusions & Future Directions

- The neutron flux spectra agree much better when my one-step simulation is run. Aiming to collect more simulation data to achieve an uncertainty < 10%.

- Foil calibration activities agree to experimental data to within 3-30% → very good for neutron calibrations

- Two-step simulation is still a powerful tool, just not so much in my case → need to find out what causes the spikes.

Thank you!

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science co-op

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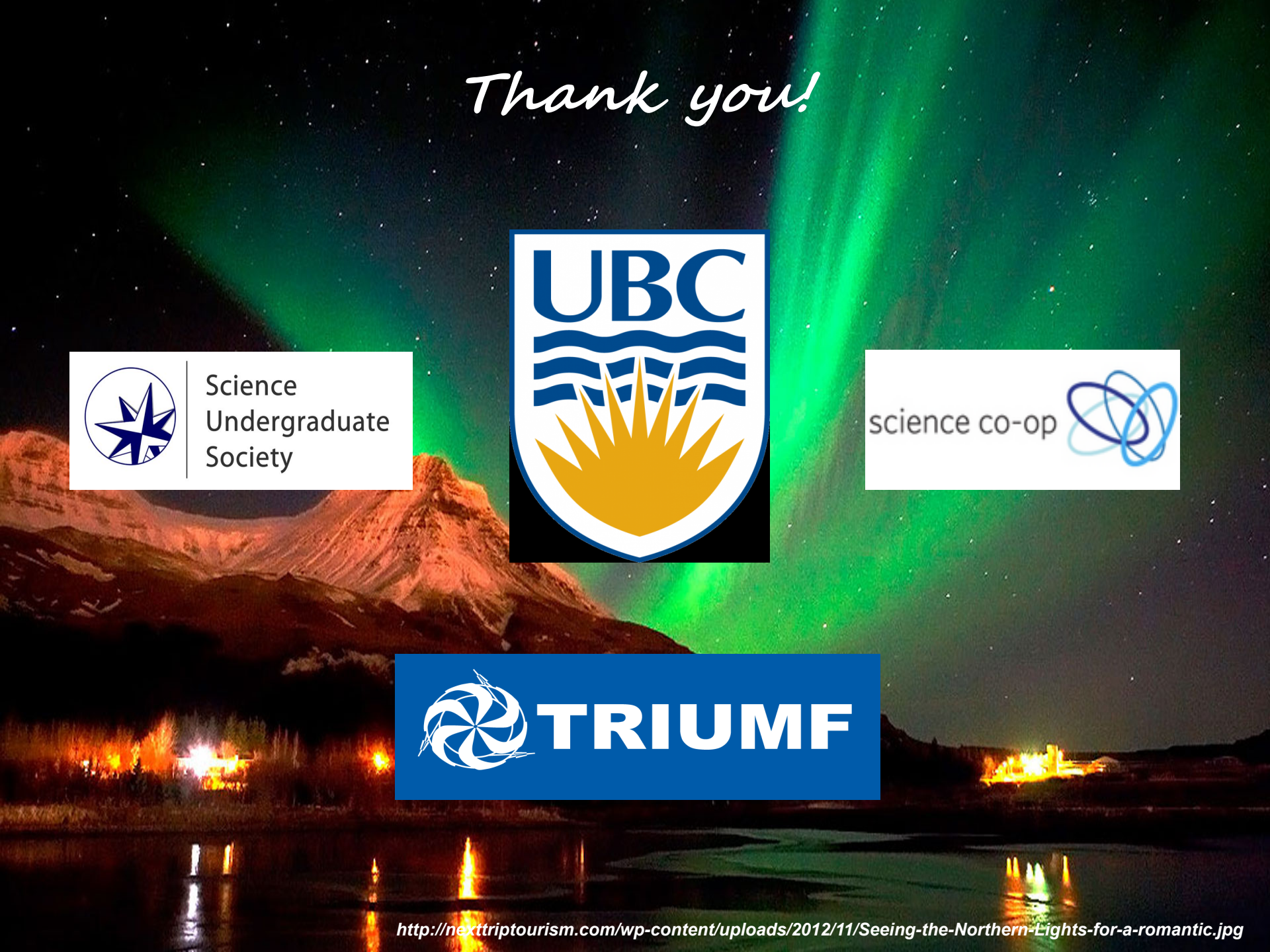

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