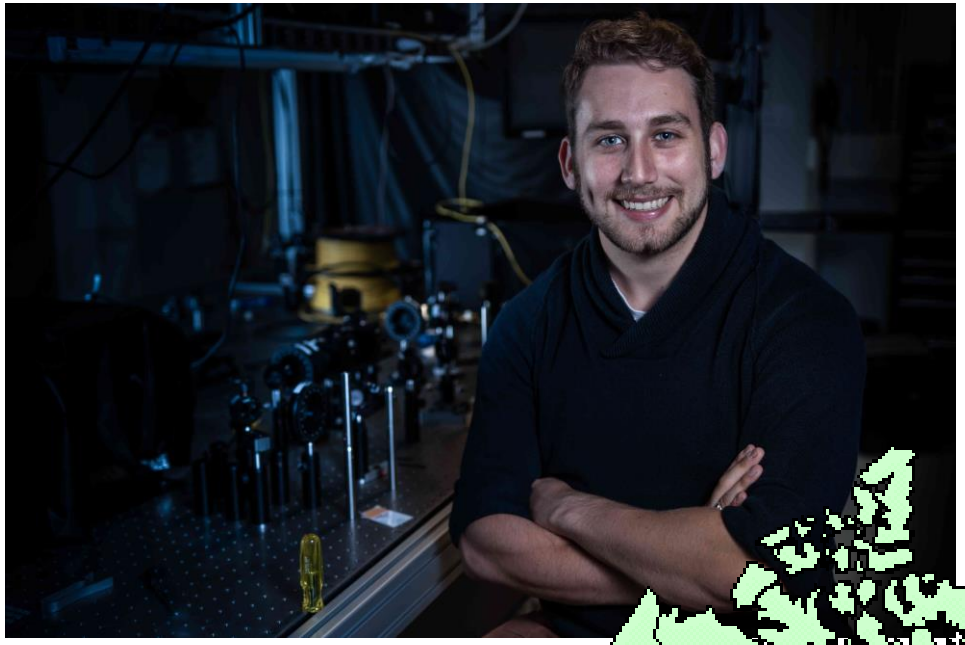
AQNET Fermilab Update

Andrew Cameron

November 14th, 2023

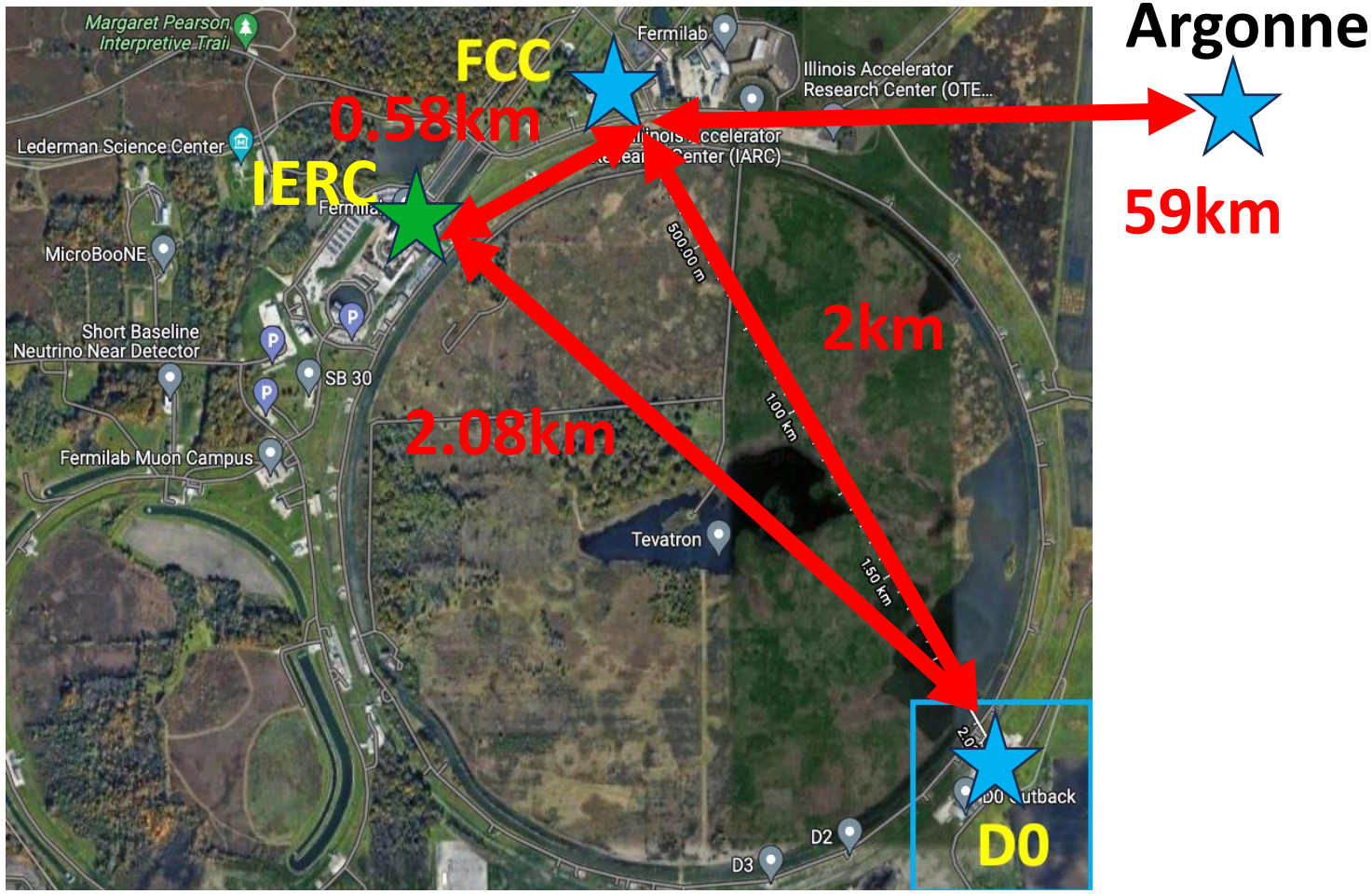
Fermilab

Who am I?

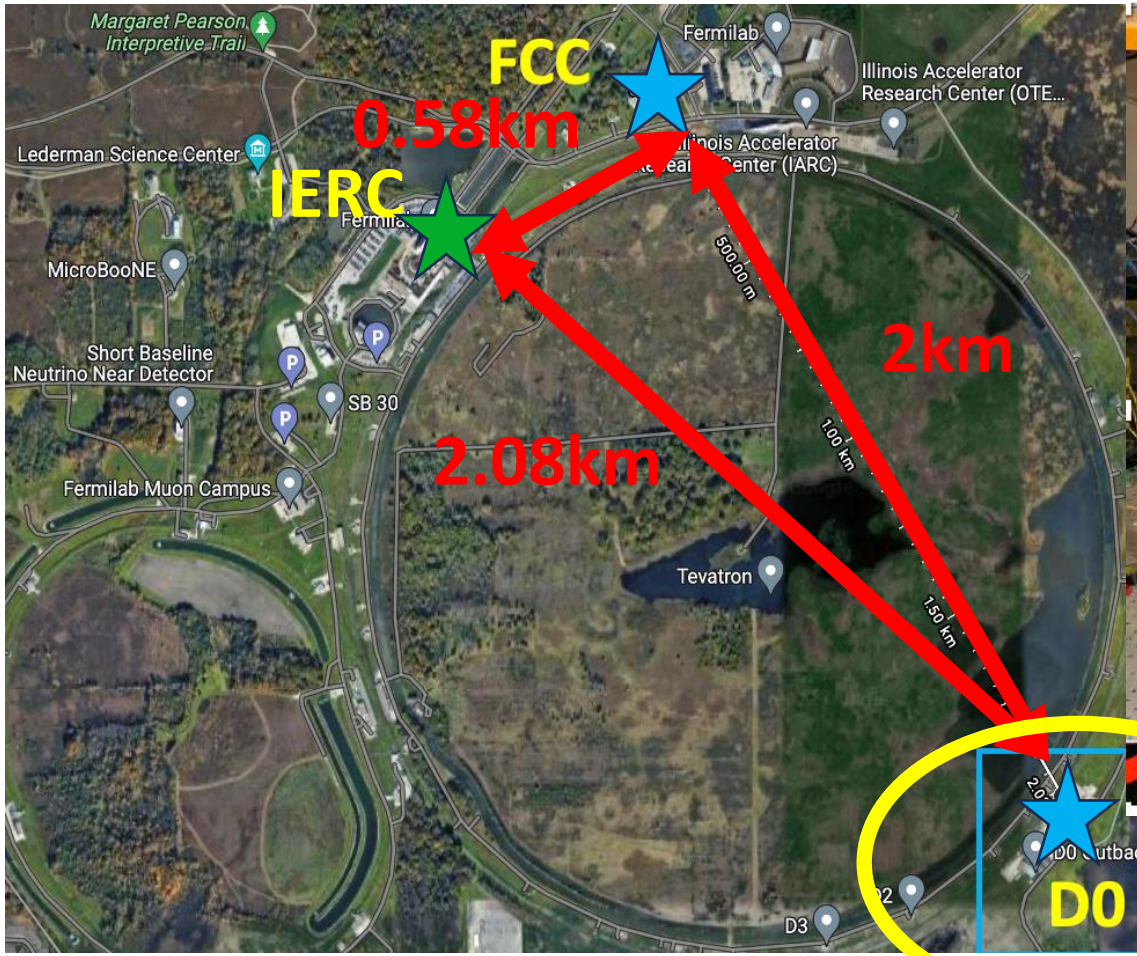


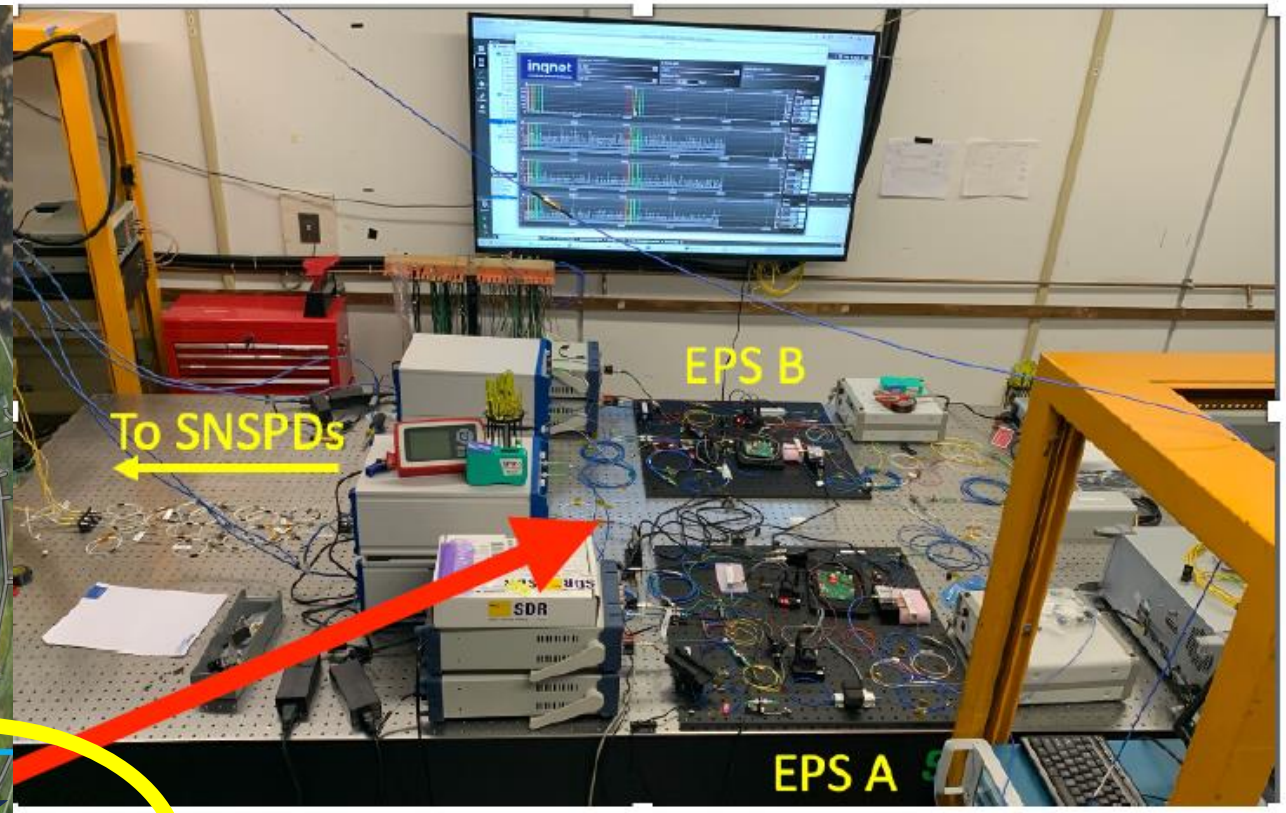
- From Charlottetown, Prince Edward Island, Canada
- Undergrad in Physics @ UPEI (Spring 2017)
- Quantum Optics PhD @ Waterloo University (Summer 2023) Supervised: Kevin Resch

Geographical Locations



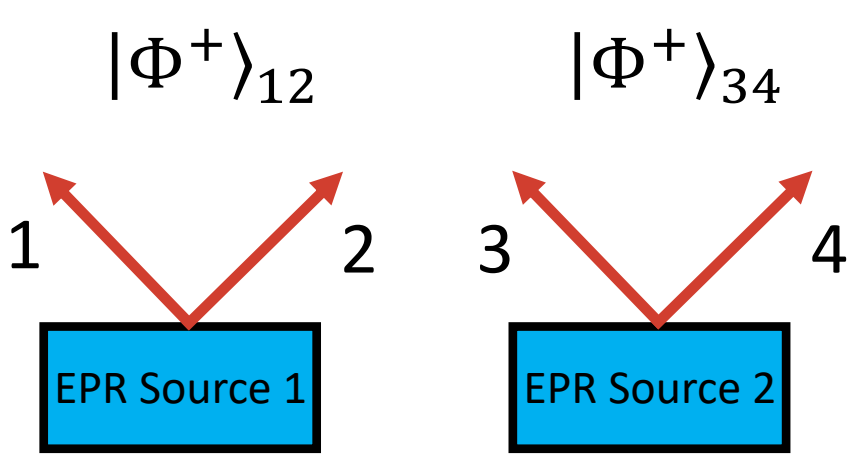
D0 Node





Entanglement Swapping Testbed

Entanglement Swapping Theory



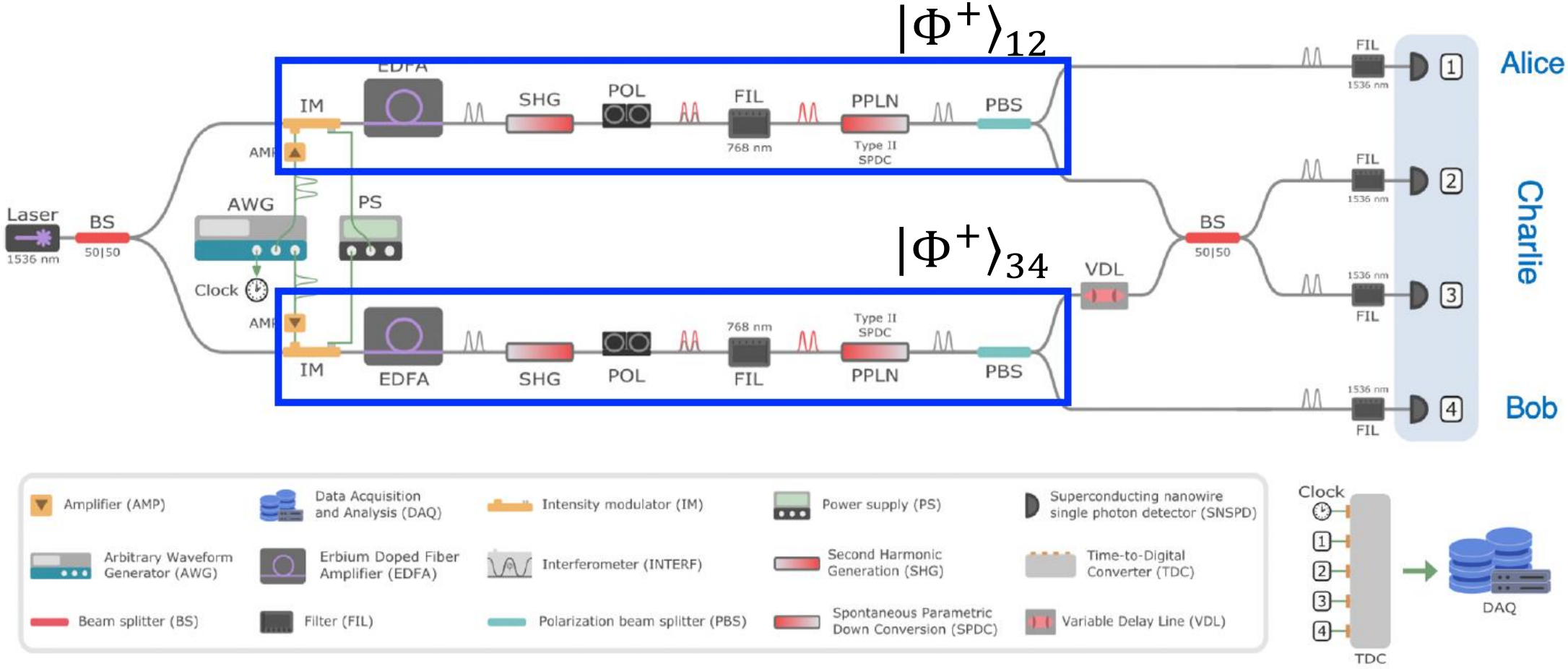
$$|\Psi\rangle_{1234} = |\Phi^+\rangle_{12} \otimes |\Phi^+\rangle_{34}$$

$$= \frac{1}{2}(|ee\rangle + |ll\rangle) \otimes (|ee\rangle + |ll\rangle)$$

$$= \frac{1}{2}|\Psi^+\rangle_{14}|\Psi^+\rangle_{23} + \frac{1}{2}|\Psi^-\rangle_{14}|\Psi^-\rangle_{23}$$
$$+ \frac{1}{2}|\Phi^+\rangle_{14}|\Phi^+\rangle_{23} + \frac{1}{2}|\Phi^-\rangle_{14}|\Phi^-\rangle_{23}$$

A projective measurement of photons 2 and 3 in the **Bell basis** entangles photons 1 and 4

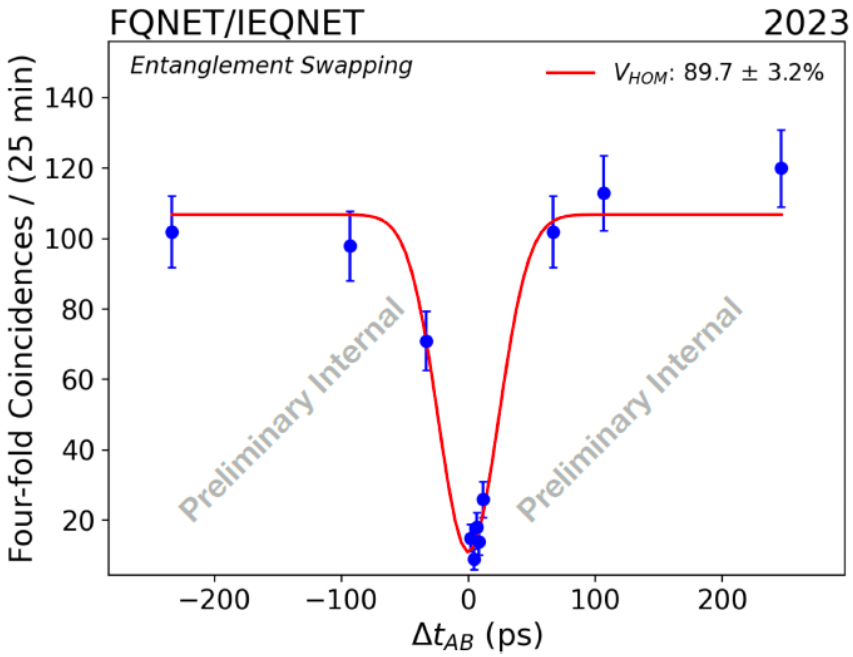
Experimental Setup – D0 Swapping



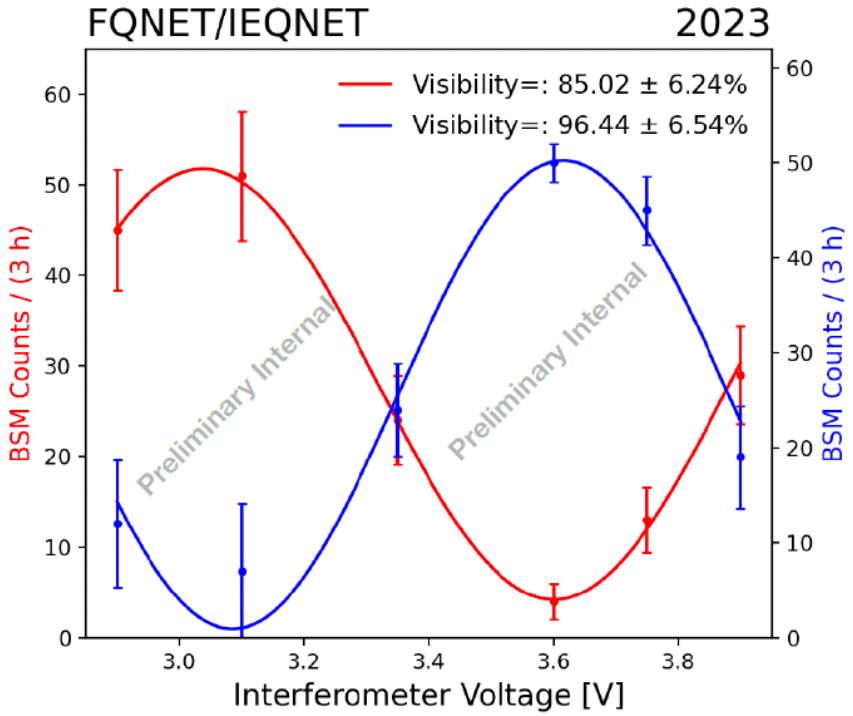
D0 – Preliminary Results

Fermilab

Hong-Ou-Mandel Effect



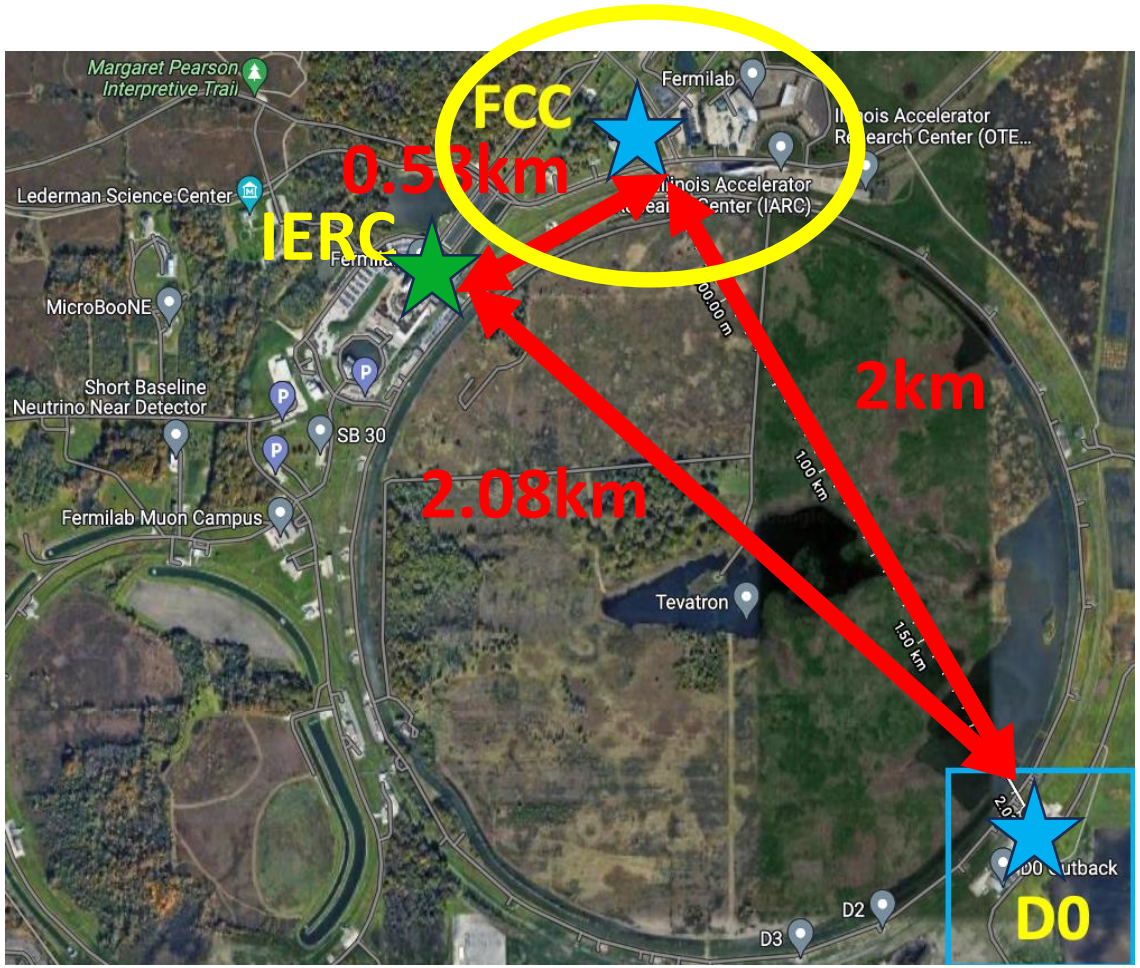
Swapping Visibility

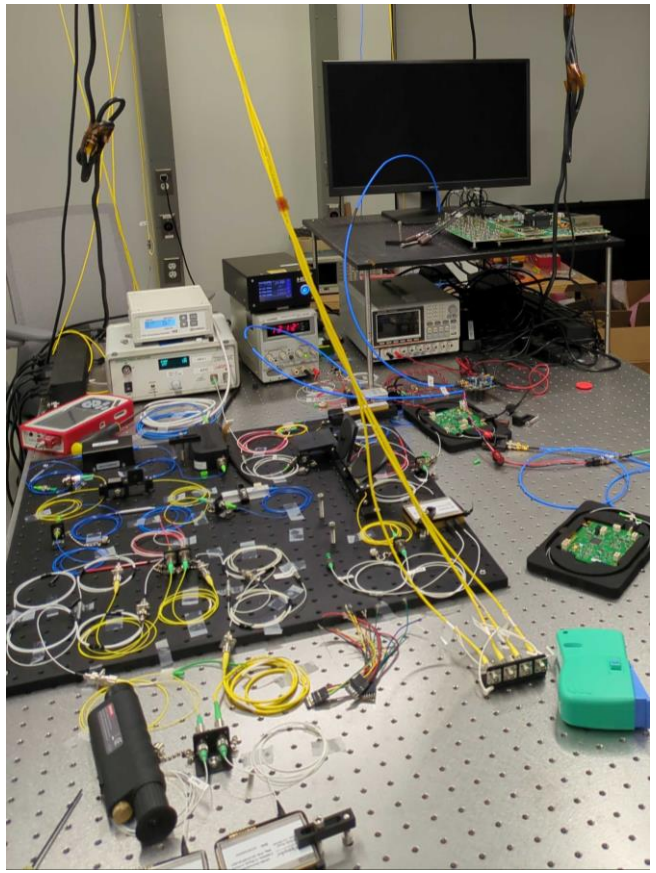


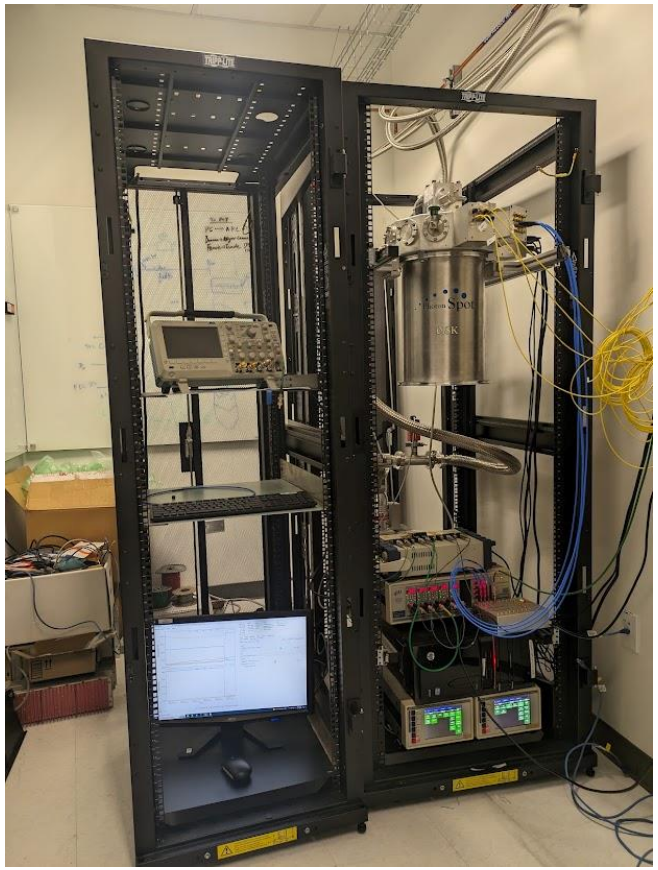
4-fold HOM dip with high visibility

High swapping visibility (x-basis)

FCC Node

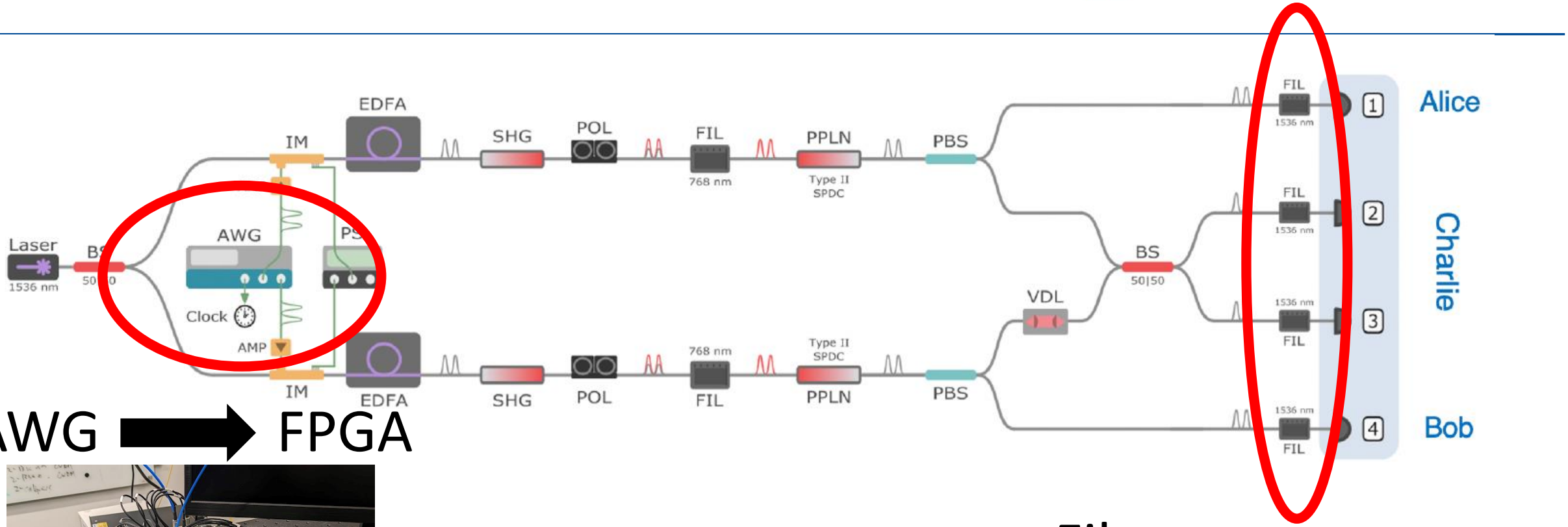

Margaret Pearson Interpretive Trail
Fermilab
FCC
0.53km
IERC
Lederman Science Center
MicroBooNE
Short Baseline Neutrino Near Detector
SB 30
2km
2.08km
Fermilab Muon Campus
Tevatron
D2
D3
D0



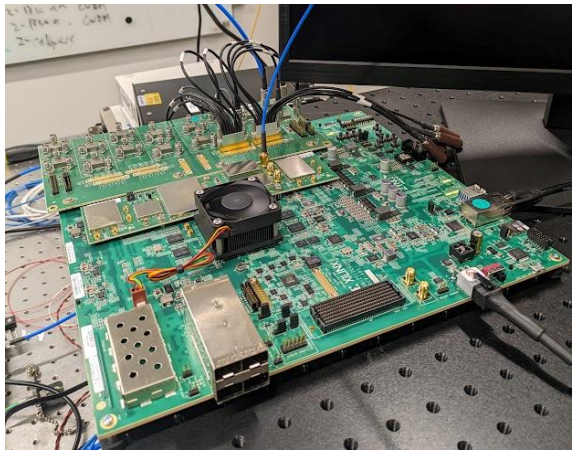


Modifications for New FCC Source

Fermilab



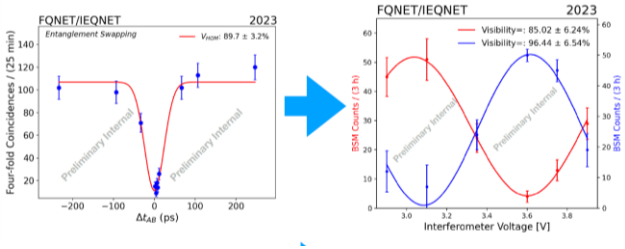
AWG → FPGA



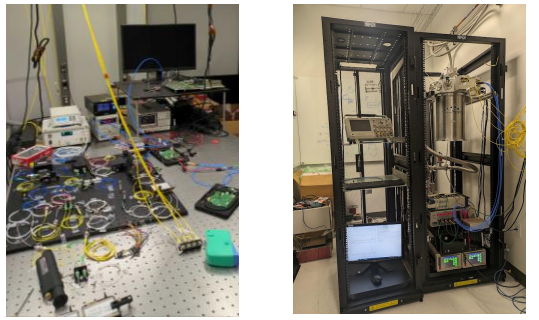
Fiber Bragg Grating → Etalon Filters

Fermilab Campus Network

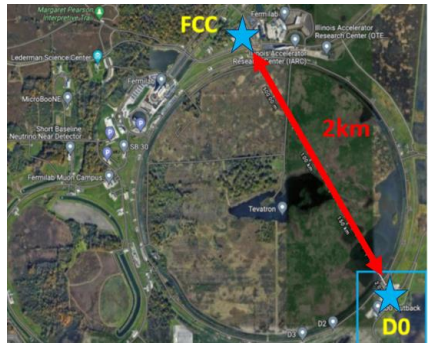
- Swapping between two D0 sources
  Manuscript in preparation



- Swapping between two FCC sources
  One source built



- Swapping between FCC – D0
  2024



Where we're headed

Fermilab

- Working on coexistence of Classical and Quantum signals
- Adding high-rate sources to the network
  - Upgrading existing SNSPDs to lower jitter.
- Swapping between Fermilab and Argonne