ANNIE
Future Physics Opportunities

NuSTEC NDNN

Thursday: First Discussion

March 18, 2021

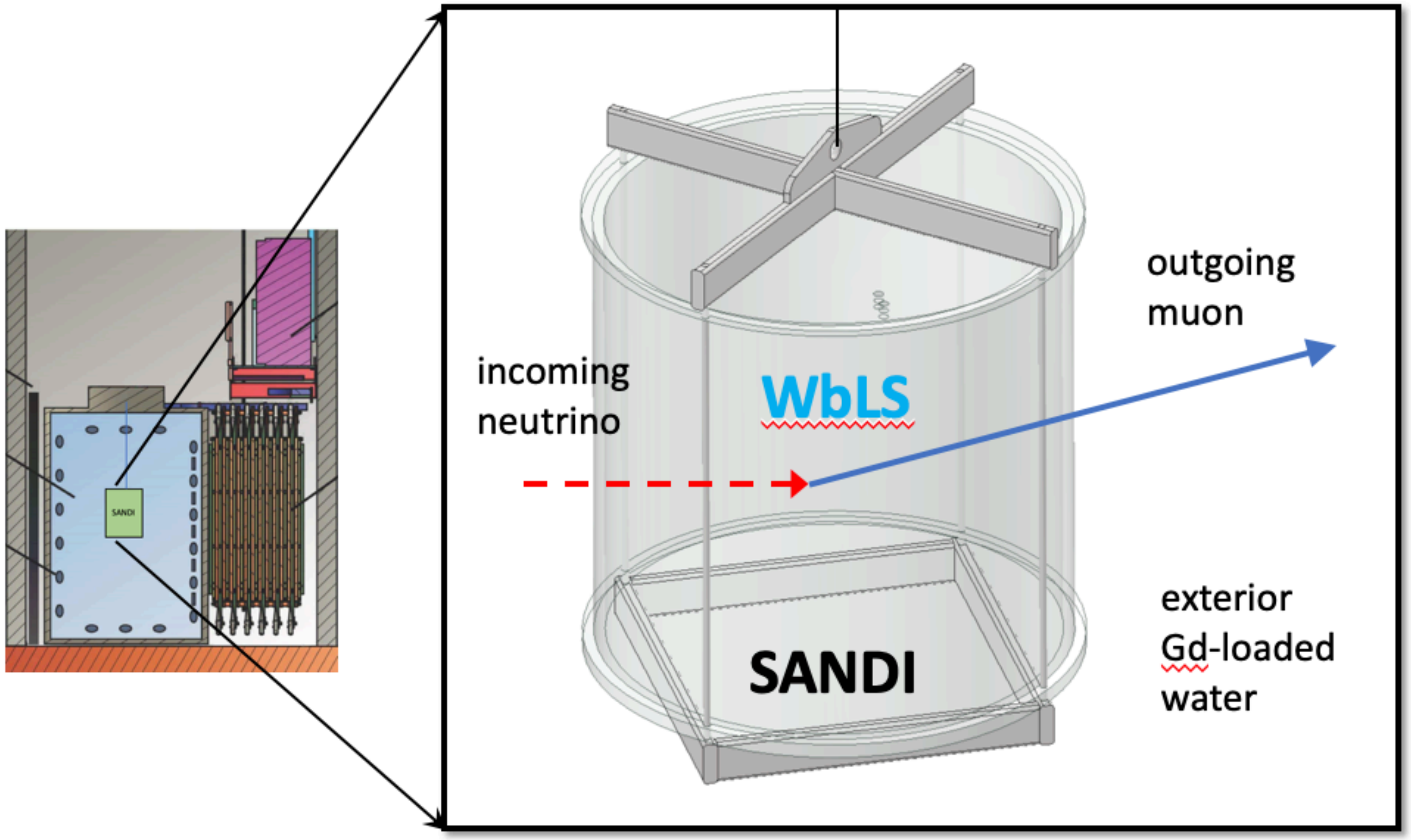
Andy Mastbaum
Rutgers University
mastbaum@physics.rutgers.edu

See Snowmass LoIs: *Physics Opportunities at ANNIE*
ANNIE Detector R&D

SANDI

Scintillator for ANNIE Neutrino Detection Improvement

ANNIE is studying the possibility of deploying **Water-based Liquid Scintillator (WbLS)** in the central fiducial volume to **improve vertex resolution** and also gain sensitivity to **sub-Cherenkov** charged hadrons at the vertex.



WbLS + Gd

Water-based Liquid Scintillator with Gadolinium

Newly developed at BNL, **WbLS-Gd** is now undergoing testing for scattering, absorption, stability, and ability to recirculate.

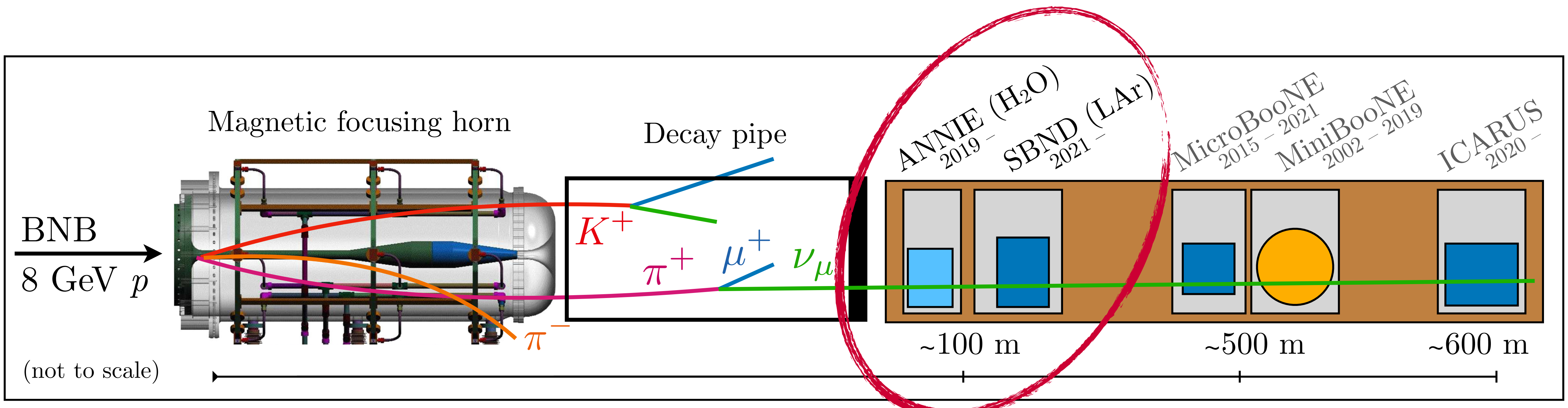
Candidate for use in SANDI, as this would improve neutron efficiency near the vertex

WbLS long arm attenuation measurement device

Multi-Target Measurements

Potential for H_2O + Ar Analysis with SBND

- **Proximity of ANNIE & SBND presents an opportunity for joint Ar+H_2O measurements at ~1 GeV**
- Nearly identical flux → high precision on ratios
- Oscillations: DUNE/HK, WbLS *Theia* FD + DUNE ND, ...
- Neutrino interaction physics
    - Neutron tagging in ANNIE + proton tagging in SBND
    - Modeling neutron production in LAr
- Cross section (ratio)s, generator *validation*, generator *tuning*, ...

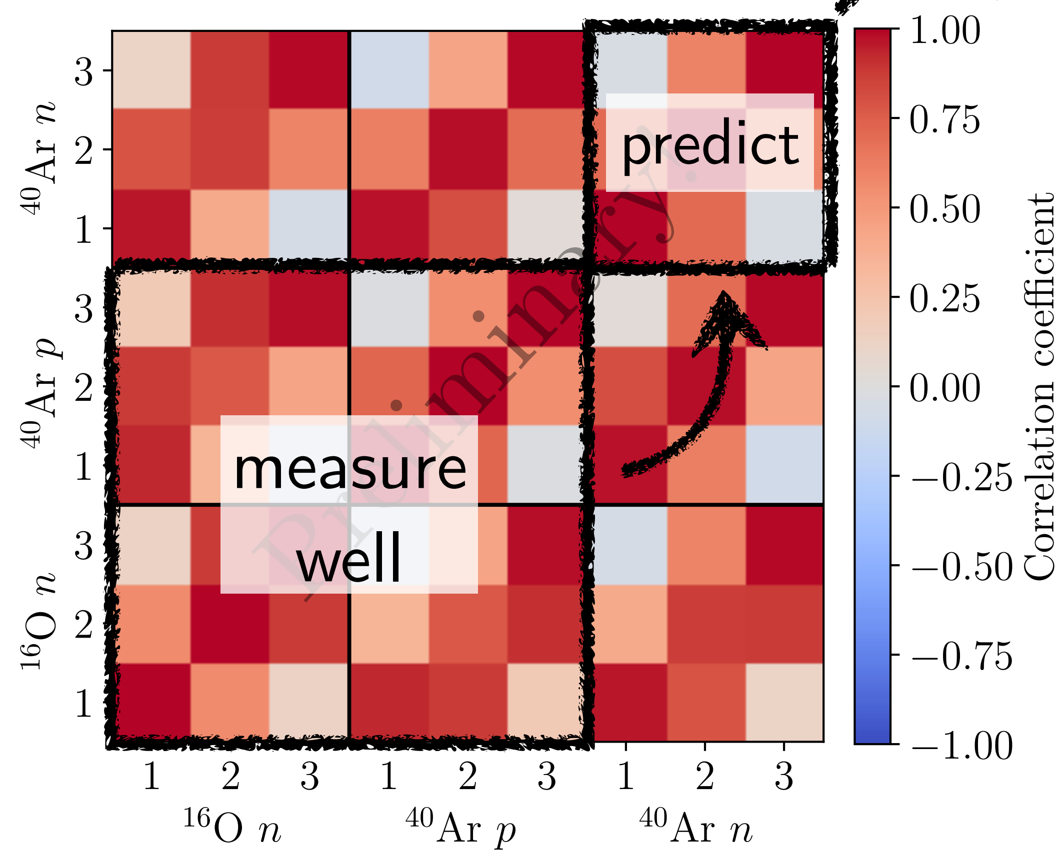


Multi-Target Measurements

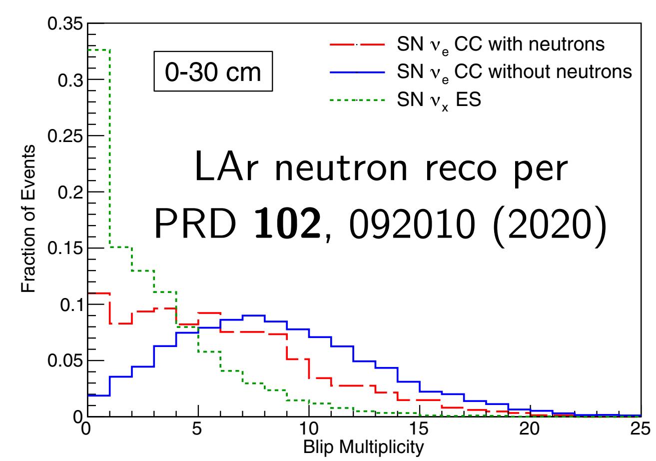
Potential for H_2O + Ar Analysis with SBND

Examples with a generator-level **GENIE v3.00.06** MC and **true CC0π** selection:

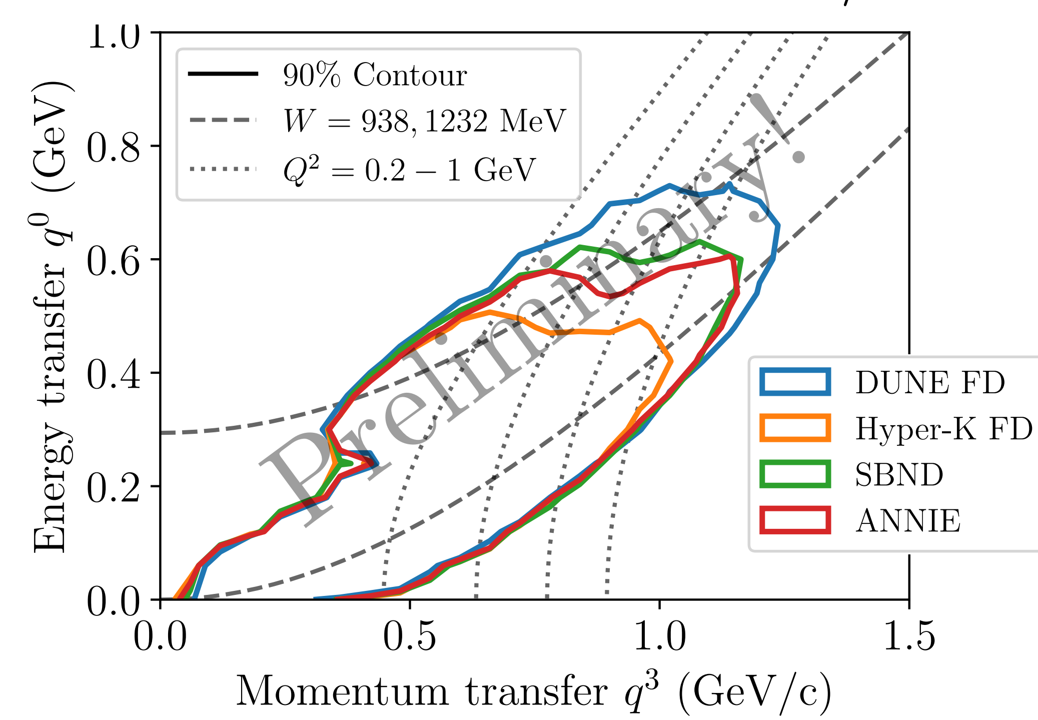
Nucleon multiplicity for ν_μCC0π



validate



Kinematics in DUNE and HK FDs vs. ANNIE/SBND

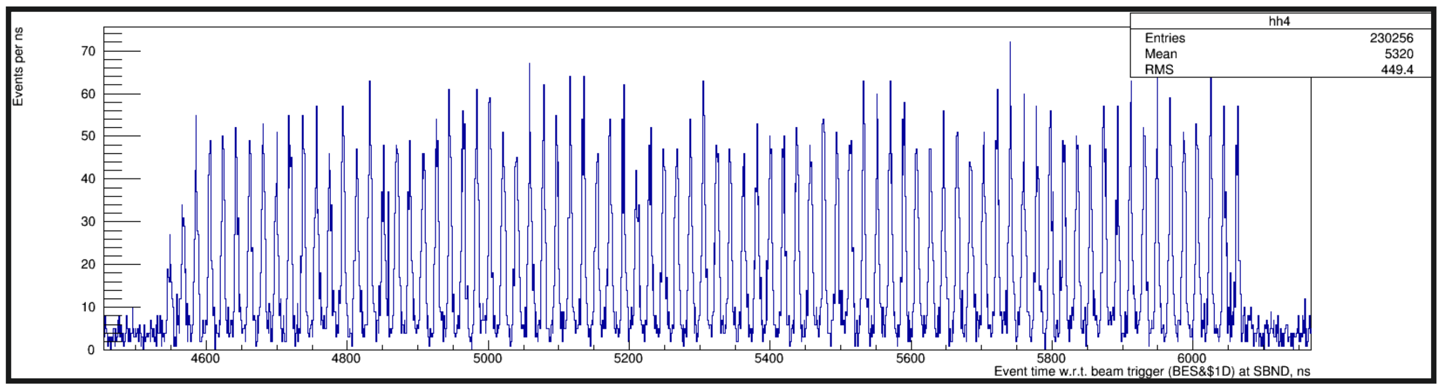


Timing

Precision Neutrino Beam Timing

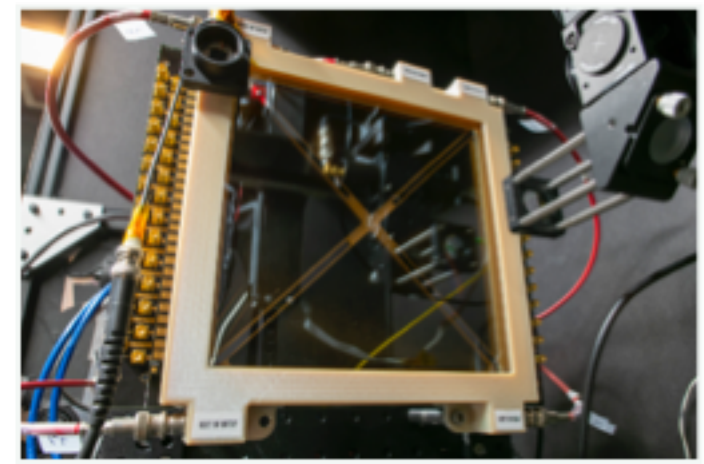
Can precision timing resolve the **time evolution of the flux** composition?

Potential **PRISM-like analysis** using time slices with higher-frequency RF



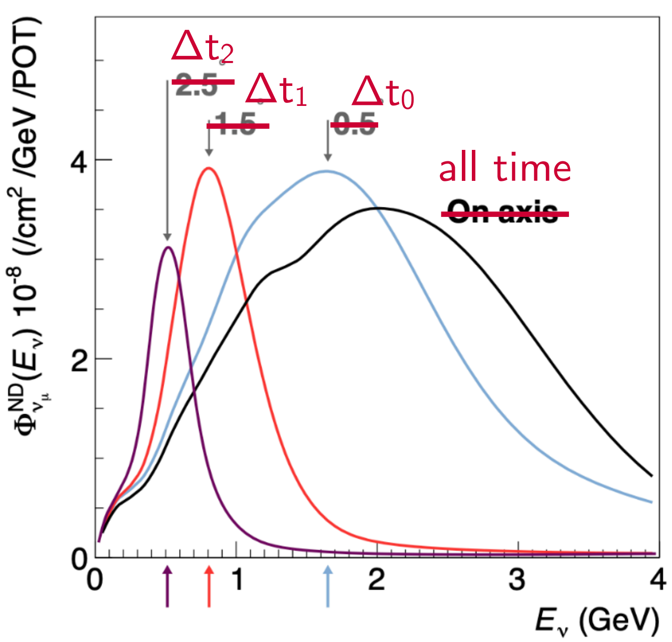
Beam timing, here at SBND (from CRT) Igor Kreslo, Bern

+



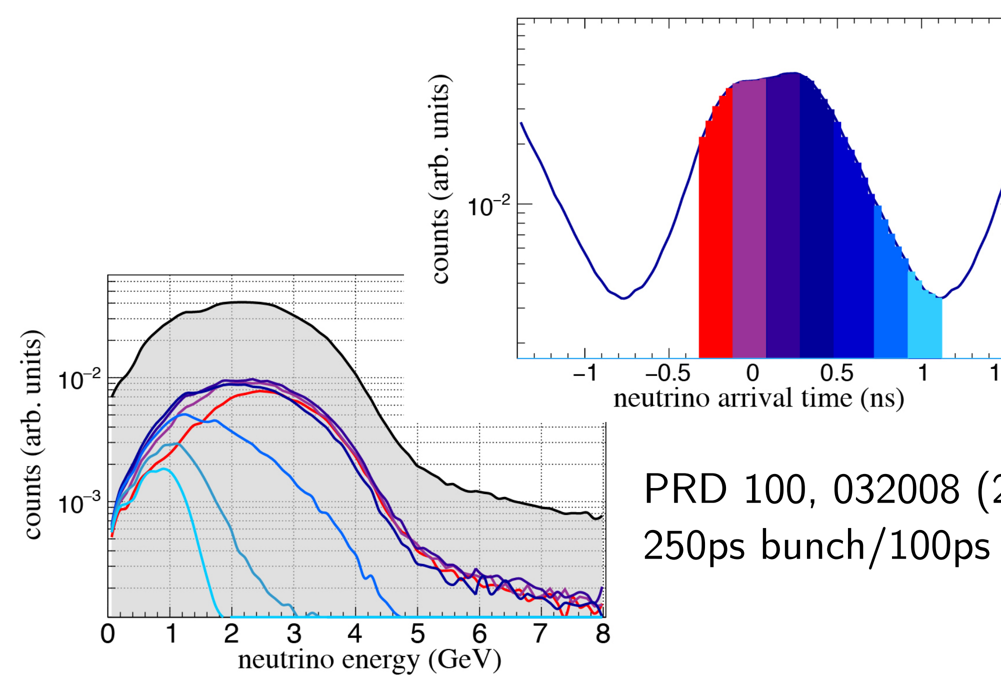
Fast timing (e.g. LAPPD)

=



Original figure: DUNE-PRISM, P. Dunne, ICHEP2020

?



PRD 100, 032008 (2019)
250ps bunch/100ps detector