IV International Conference of Particle Physics and Astrophysics

Experimental program of the COHERENT collaboration

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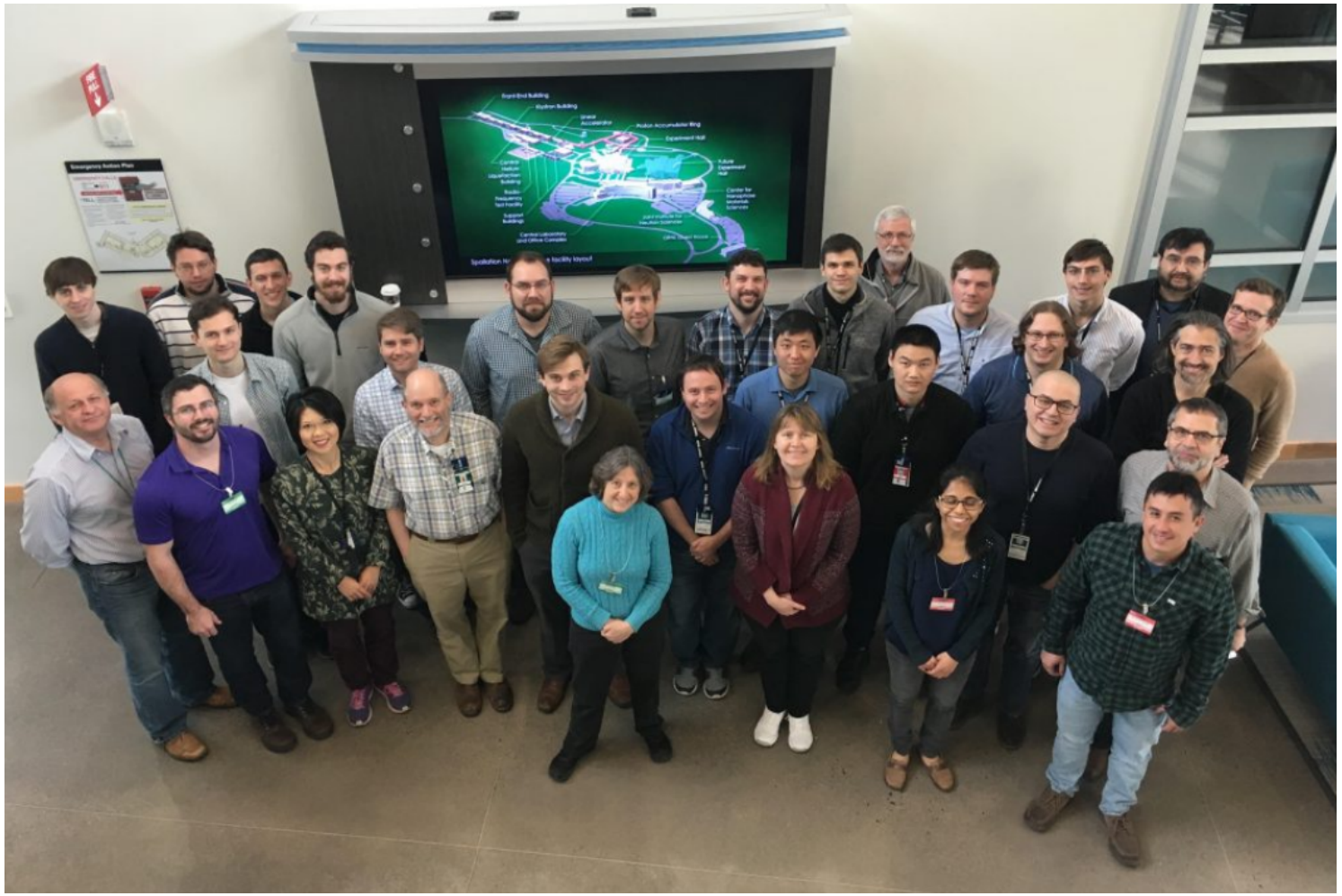
Moscow 2018, October 24

COHERENT collaboration



THE UNIVERSITY OF CHICAGO

Carnegie Mellon University

Duke UNIVERSITY

UF UNIVERSITY of FLORIDA

KAIST

Los Alamos NATIONAL LABORATORY EST. 1943

NC STATE UNIVERSITY

VIRGINIA TECH

MEPhI

NORTH CAROLINA CENTRAL UNIVERSITY FOUNDED 1910

SIGILLUM UNIVERSITATIS TUTENSIS PAX ET LUX 1852

LaurentianUniversity UniversitéLaurentienne

NM STATE UNIVERSITY

Sandia National Laboratories

THE UNIVERSITY of TENNESSEE KNOXVILLE

TUNL

UNIVERSITY of WASHINGTON

OAK RIDGE National Laboratory

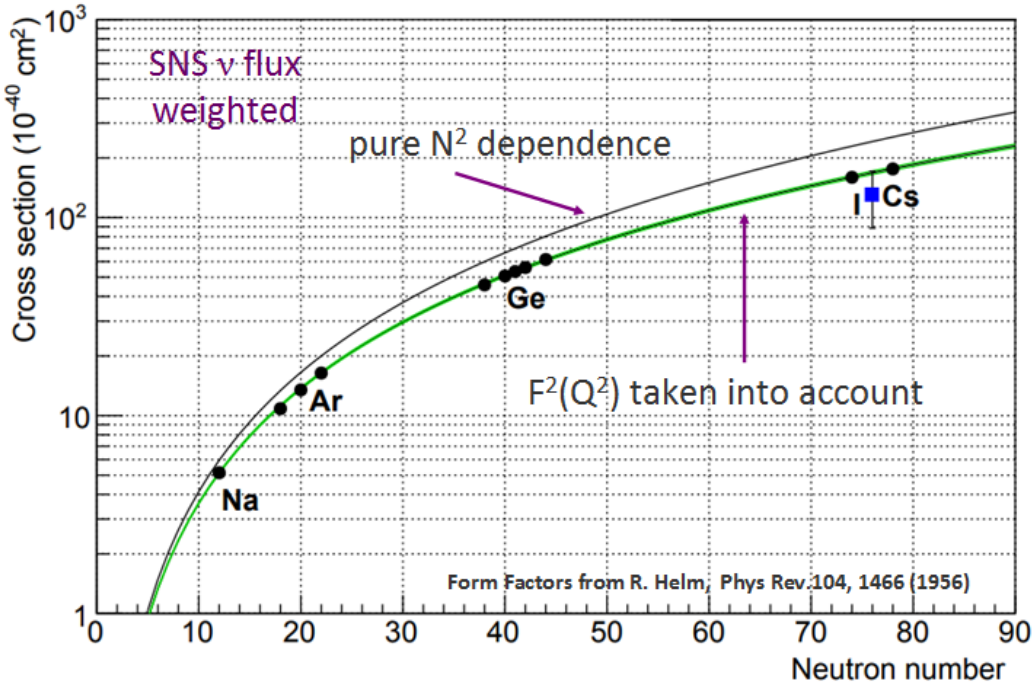
The goals and the way

First CEvNS detection of 2017, but there's much more to do:

test N^2 dependence of SM CEvNS cross section

investigate possible ν-quark NSI contributions

evaluate the distribution of neutrons in nuclei with CEvNS



Multiple target measurements are required!

Location and subsystems

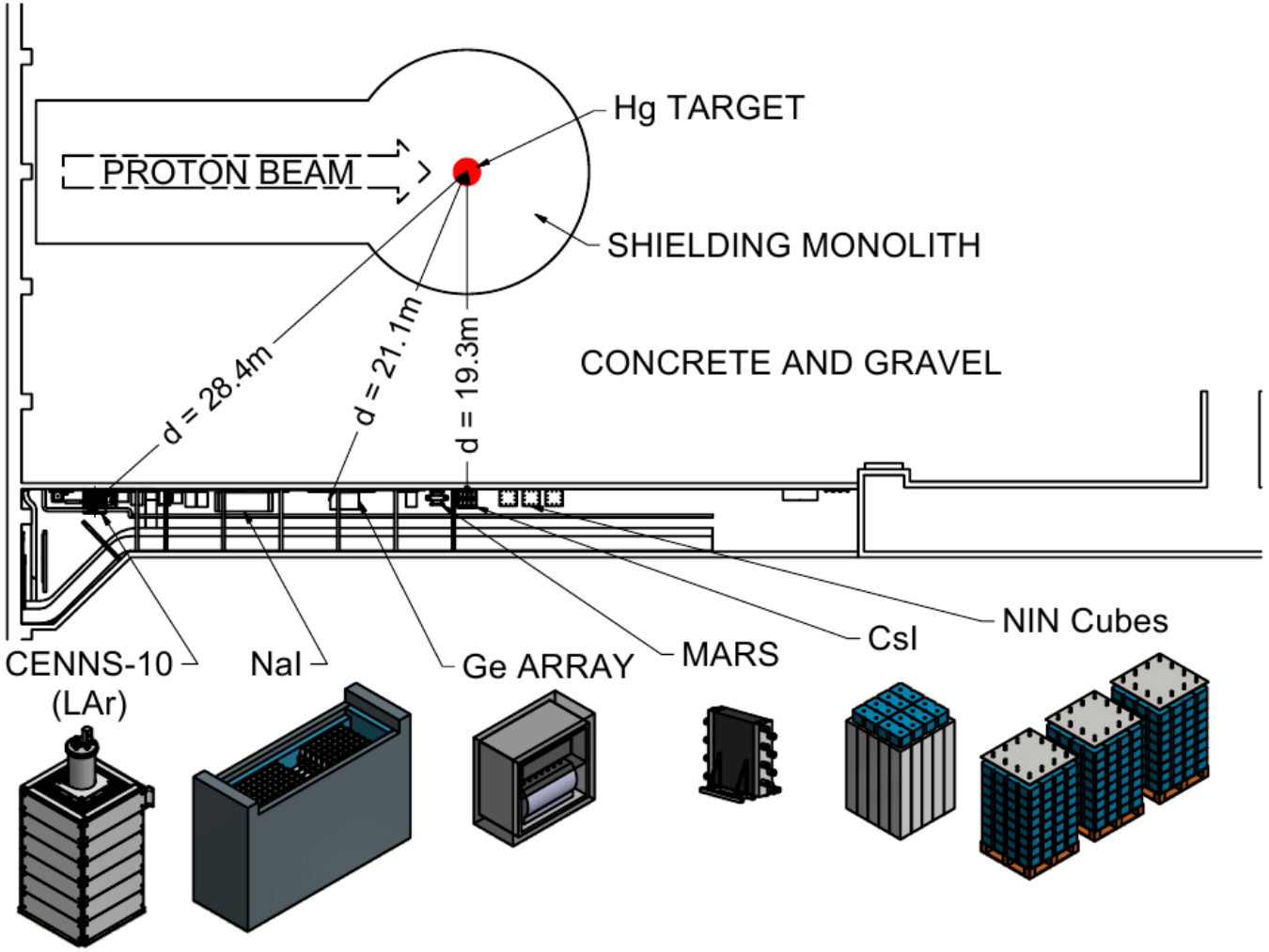
SNS facility at ORNL (USA): total ν flux of $4.3 \cdot 10^7$ $cm^{-2} * s^{-1}$ at 20m

E_p	1 GeV
F	60 Hz
P	1.4 MW
T_b	~800 ns

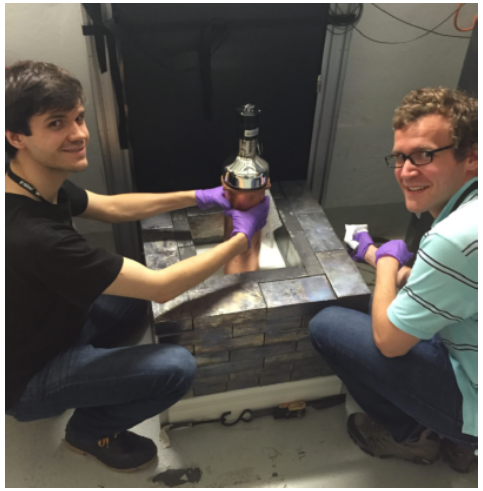
Subsystems located in

~~*SNS basement*~~

Neutrino alley!



The CsI[Na] subsystem



Cylindrical crystal:

- diameter – 11 cm
- length - 34 cm
- weight – 14.5 kg

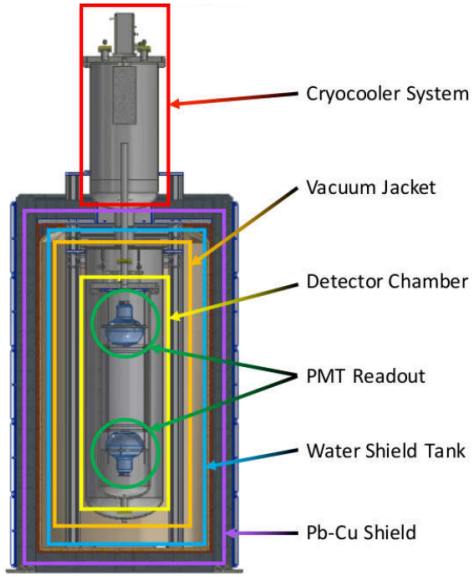
Light collection by R877-100 PMT, LY of 13.35 PE/keV

Data taking started June 2015

The first CEvNS observation!

Science, 357 (2017)
[arxiv:11708.01294]

The LAr subsystem



The LAr chamber of 56.7 liters, fiducial volume of 22 kg

Two 8'' R5912-02MOD PMTs coated with TPB

Data taking with the upgraded configuration started June 2017

R&D: LAr 1T for a precision CEvNS measurement

The NaI[Tl] subsystem

Initial 185 kg deployed in November 2016

Detectors: *7.7 kg crystals with Burle S83013 PMTs, bases doesn't allow the gain needed for CEvNS*

Current goal: *study backgrounds and explore CC on* ^{127}I

Plan: *new bases and ~2T mass (in hand) for* ^{23}Na *CEvNS*

The PPC HPGe subsystem

Plan: 4 state-of-art 2.5 kg detectors with ~150 keV threshold

Funding secured for initial 5 kg *Cryogenics and shielding R&D*

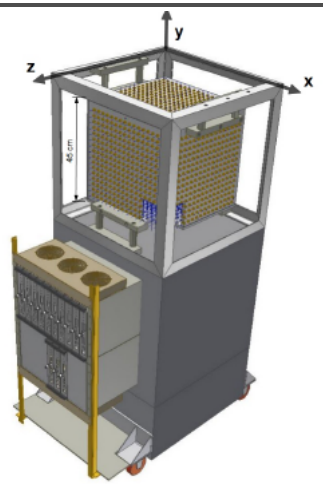
The place in the "neutrino alley" is reserved!

Background measurements

Fast neutrons background correlated with the beam spill

"Scatter camera"

Active: Fall 2013 – Spring 2016



"Scibath"

Autumn 2015

"MARS"

Autumn 2017, still running

Neutrino induced backgrounds: CC on Pb, Cu and Fe + neutrons

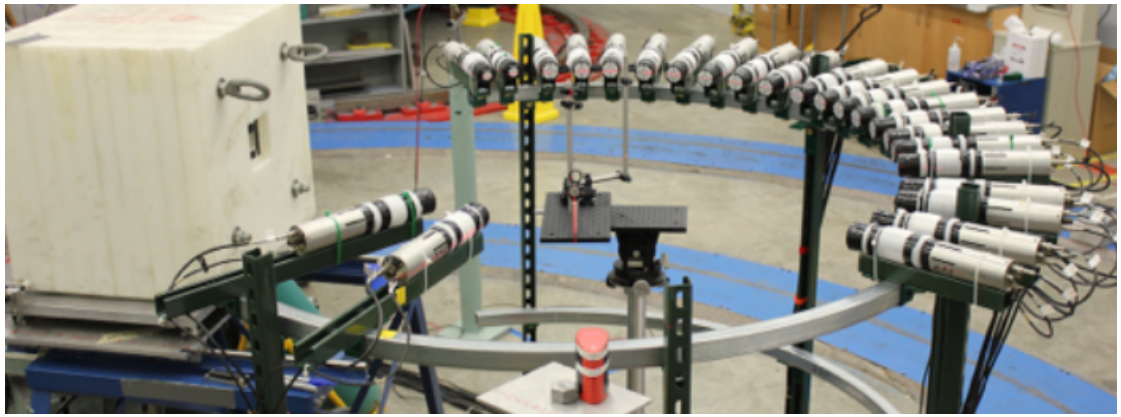
"NIN cubes" – liquid scintillator cells with Pb/Cu/Fe "shield" surrounded by multiple water modules

Taking data: Pb - since Spring 2016, Fe – since Spring 2017

First 2.9σ hint of $^{208}Pb(\nu_e, e^-)^{208}Bi$ process with the test cell!

Reducing systematics

Measurements of the QF in CsI, Ge and NaI at TUNL



D-D and p-Li neutrons for an endpoint or a fixed scattering angle QF measurements

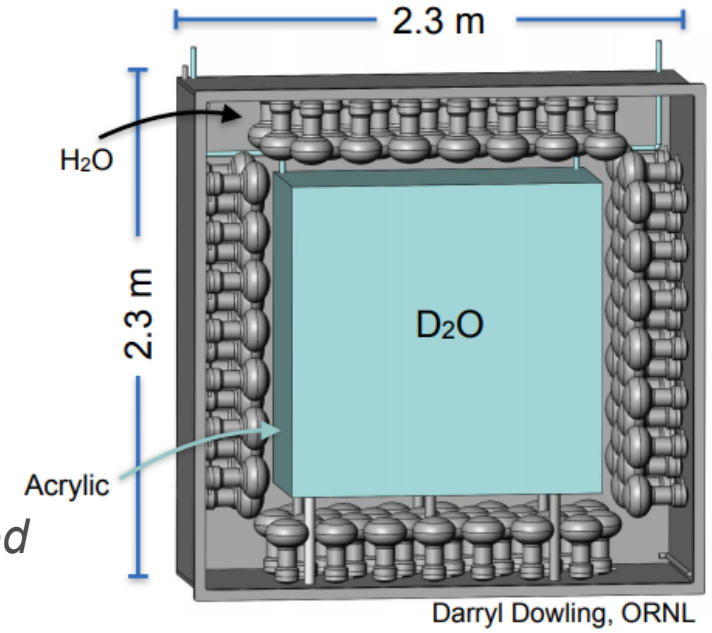
Measurement of the total ν flux at SNS

Idea: *normalize the flux via D_2O*

The σ(ν-D) is well understood and also measured:

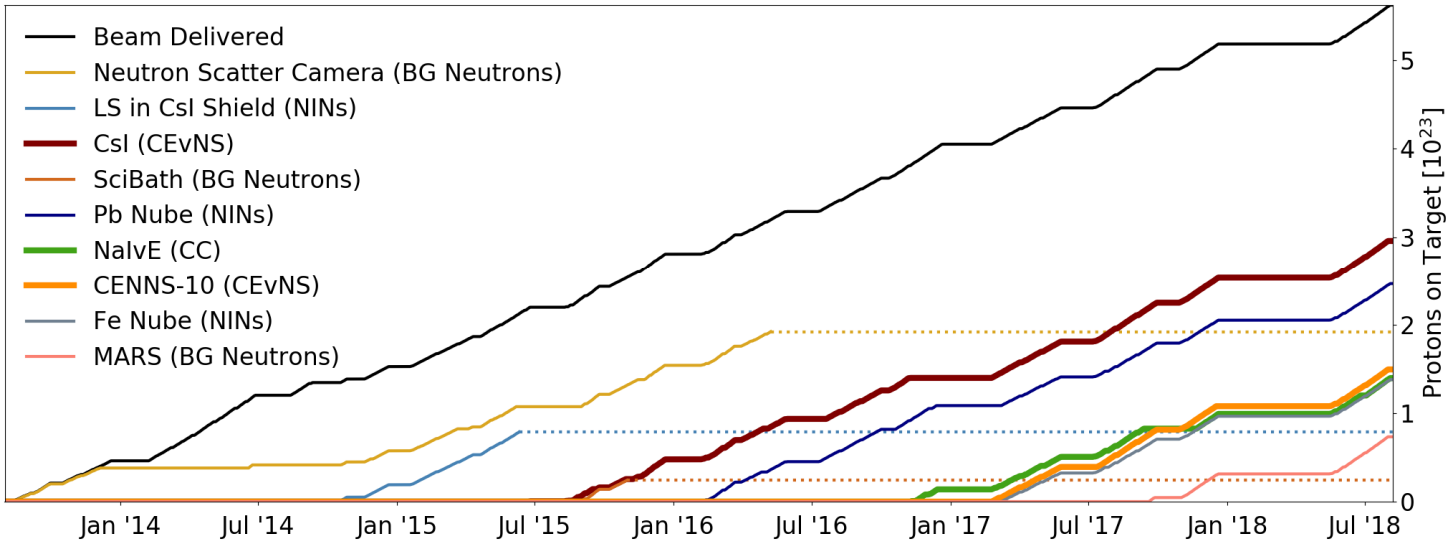
S. Nakamura et al., Nucl.Phys. A721(2003) 549

Concept: *heavy water (1.3T), Cherenkov based*



Conclusion

Multiple detectors are taking data



Efforts to understand backgrounds and reduce systematics

More info on the COHERENT status in [arXiv:1803.09183]!

Backup: the CsI[Na] detector

CsI[Na] cylindrical crystal manufactured by Amcrys-H, Ukraine

<u>Crystal dimensions:</u>

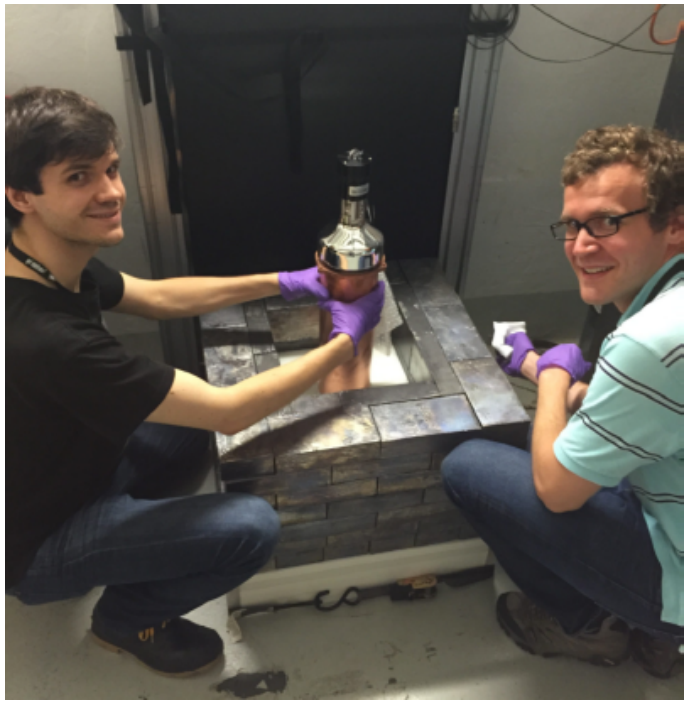
diameter – 11 cm,

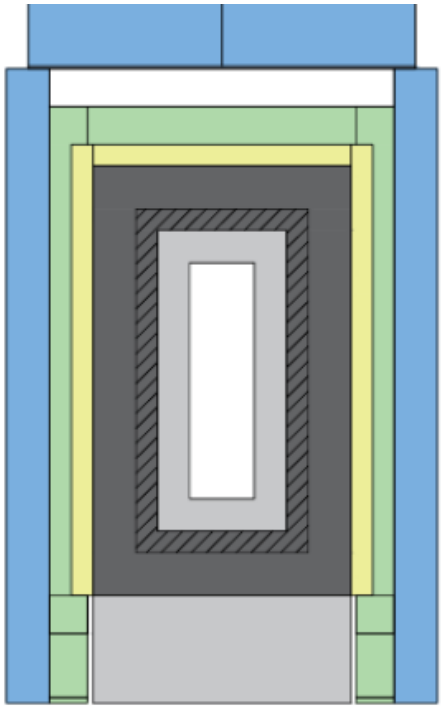
length - 34 cm,

weight – 14.5 kg

Light collection by R877-100 PMT

Light yield of 13.35 PE/keV





J. Collar et al., "Coherent neutrino-nucleus scattering detection with a CsI[Na]…",NIM A773, 56 (2015)

<u>Shielding design:</u>

Layer	HDPE*	Low backg. lead	Lead	Muon veto	Water
Thickness	3''	2''	4''	2''	4''
Colour					

Backup: "prompt" neutrons

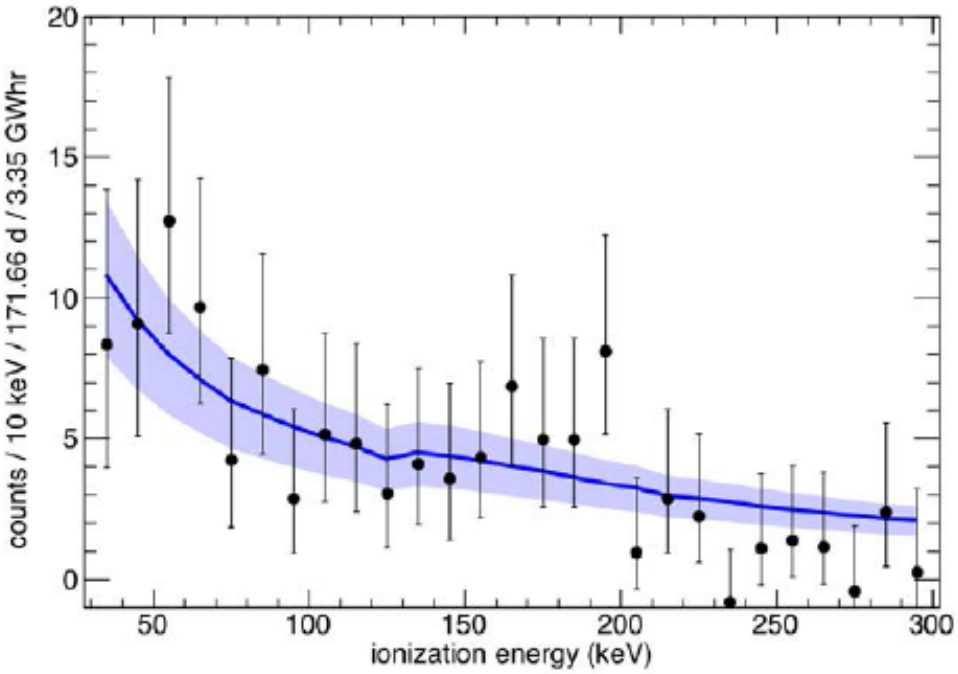
Measurement of total flux and energy distribution of neutrons:

- Scibath
- Sandia Camera

→ The spectrum is power-law in 1-100 MeV energy region + estimate on the flux: $1.5 \cdot 10^{-7}$ $cm^{-2}s^{-1}$

Neutron flux measurement within the shielding:

- LS EJ-301 with PSD capability
  - 3 liters of LS
  - taking data for half a year



Fit procedure:

1. Power-law spectrum on the input
2. Propagation through the shielding
3. Fit of the E_{dep} distribution

Result: $1.09 \cdot 10^{-7}$ $cm^{-2}s^{-1}$, power law exponent $\alpha = -1.6$

Backup: neutrino induced neutrons (NINs)

In situ measurement with LS was also used to constrain NINs rate

Fitting of the arrival times of neutron-like signals

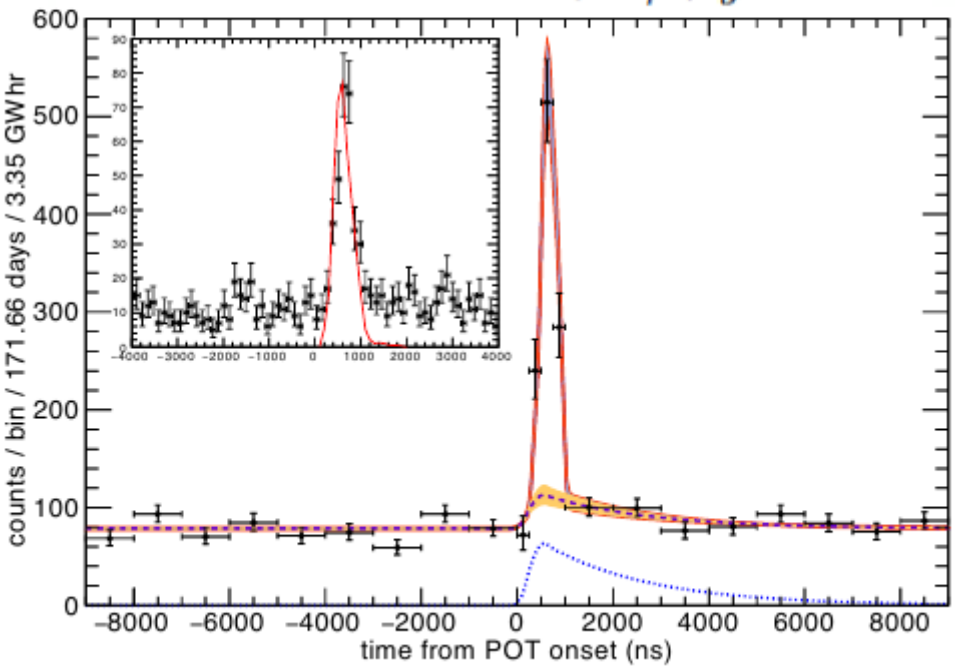
First indication of NINs detection

(1.7 times below theory prediction)

Prompt neutron and NINs rates estimates were used in the final analysis

$$\nu_e + {}^{208}Pb \Rightarrow {}^{208}Bi^* + e^- \qquad (CC)$$
$$\Downarrow$$
$${}^{208-y}Bi + x\gamma + yn$$

$$\nu_x + {}^{208}Pb \Rightarrow {}^{208}Pb^* + \nu_x' \qquad (NC)$$
$$\Downarrow$$
$${}^{208-y}Pb + x\gamma + yn.$$



This process can be important in many stellar environments

E. Kolbe, E. Langanke, “Role of v-induced reactions on lead and iron…”, Phys. Rev. C63 (2001)

Backup: ^{252}Cf calibration and $^{127}I(n,n'\gamma)$

Verification of the simulation

calibration with a neutron - ^{252}Cf

MCNPX-PoliMi: 662 ± 66 events

Fit to the data: 589 ± 68 events

From the SNS data:

Number of events in the 57.6 keV "peak" from $^{127}I(n,n'\gamma)$: 4 ± 11 ev.

Prediction based on EJ-301 data: 1.2 ± 0.2 events