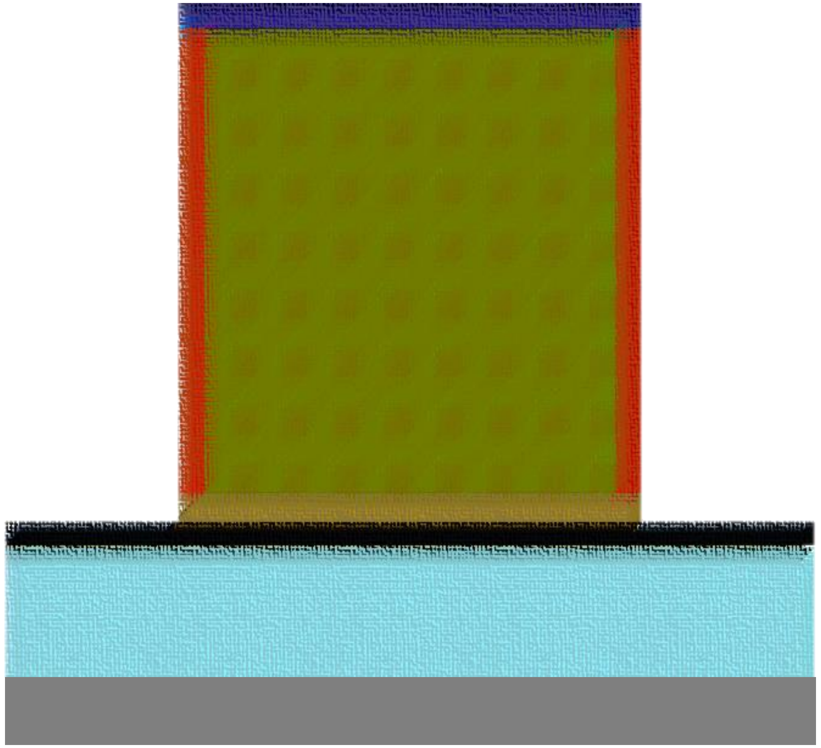
Istituto Nazionale di Fisica Nucleare

The νBDX detector

Simulation for background shielding



What's the sensitivity of the experiment?

Sensitivity of the Theta Weinberg , simple single – bin-chi square analysis (*From Sierra et al Phys. Rev. D 104, 033004 (2021)*)

$$\chi^2 = \left(\frac{N_{\mathrm{Exp}} - (1+\alpha)N_{\mathrm{Theo}}(p)}{\sigma}\right)^2 + \left(\frac{\alpha}{\sigma_\alpha}\right)^2 ,$$

$$N_{Exp} = experimental\ events$$

$$N_{Theo} = predictions\ of\ the\ underlying\ hypothesis$$

$$\sigma = \sqrt{N_{Exp} + B}, \quad B\ refers\ to\ background$$

$$B = N_{Exp} \times f\ (f = certain\ fraction\ of\ signal)$$

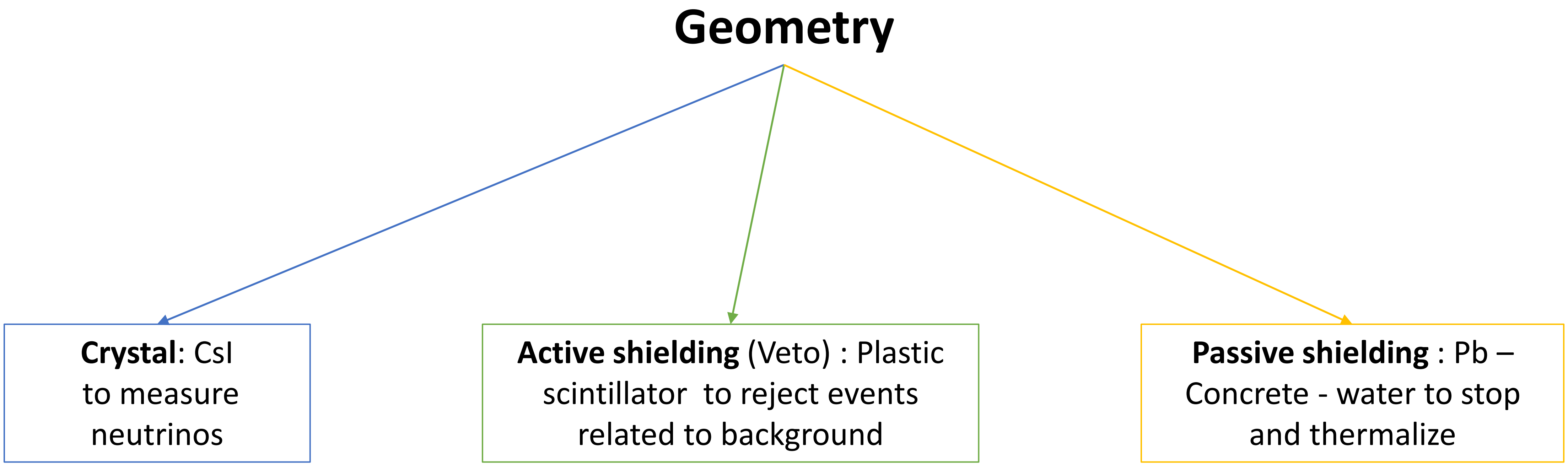
$$\frac{\alpha}{\sigma_\alpha} = sistematic\ uncertainty\ , mainly\ from\ quenching\ factor$$

- Quenching
  - Difficult to estimate
  - For Coherent experiment was 13%

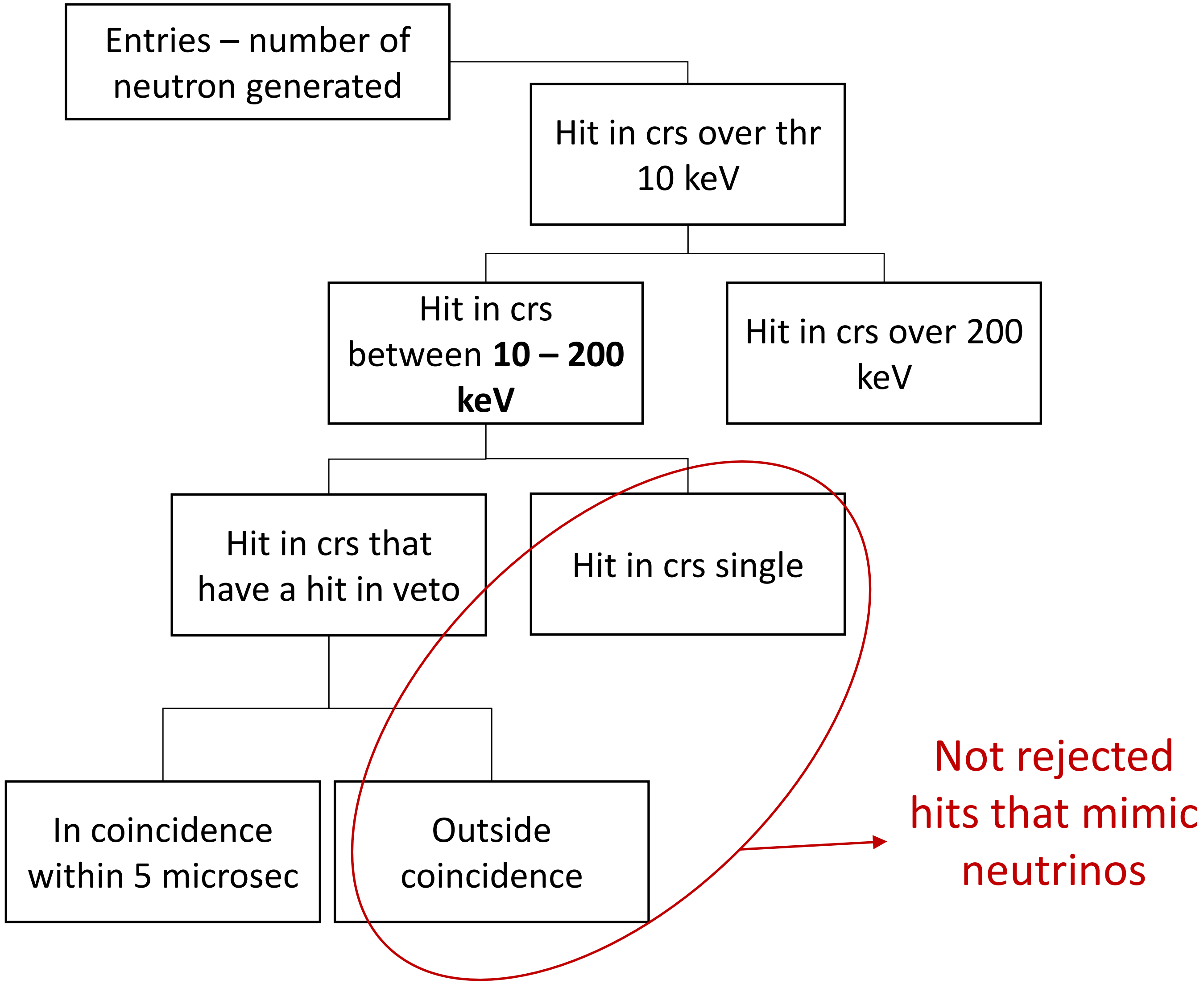
- Background sources
  - Neutron from Dump
  - Cosmics (neutron and muons)

Define the best geometry configuration and the best definition of the background event to avoid signals that mimic the neutrino interactions

Rejection of background event



Rejection of background event

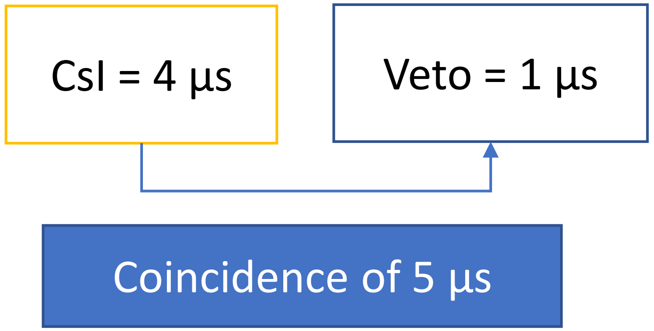


- Threshold → *If in one hits we observe a deposited energy below threshold we defined the hit as "not visible"*

CsI = 10 keV

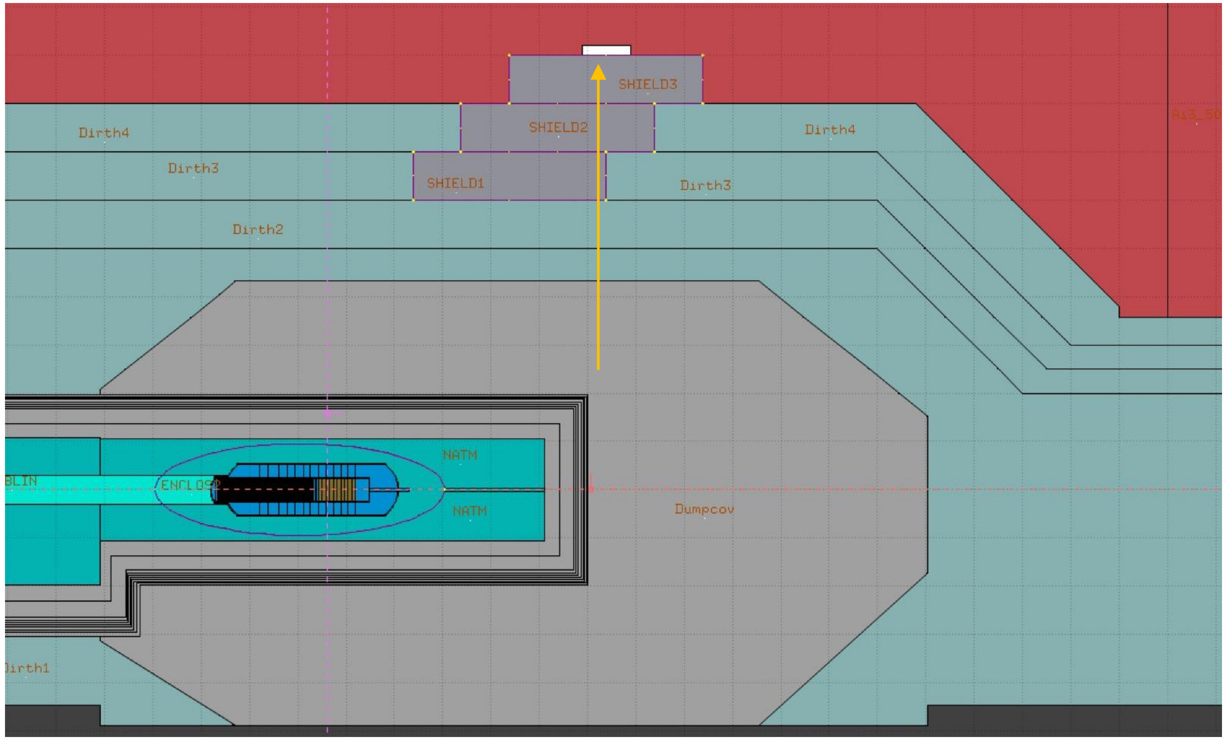
Veto =1000 keV

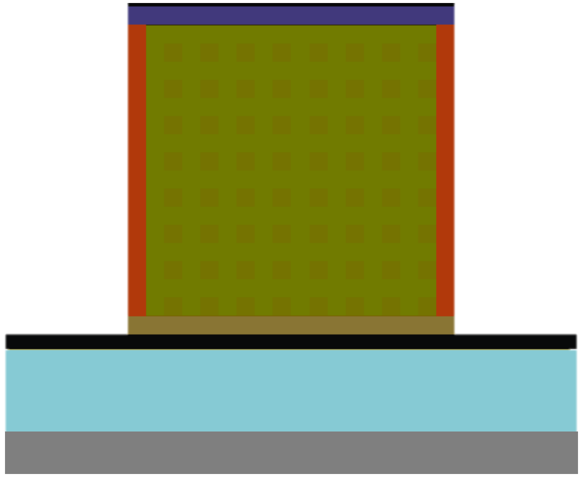
- Time window → *If two or more steps happens within the same TimeWindow, they belong to the same Hit*



Neutron coming from dump

Simulated in Fluka **1.4e18 eot** producing neutron
Neutron exiting from 3 m lead are **6e12**



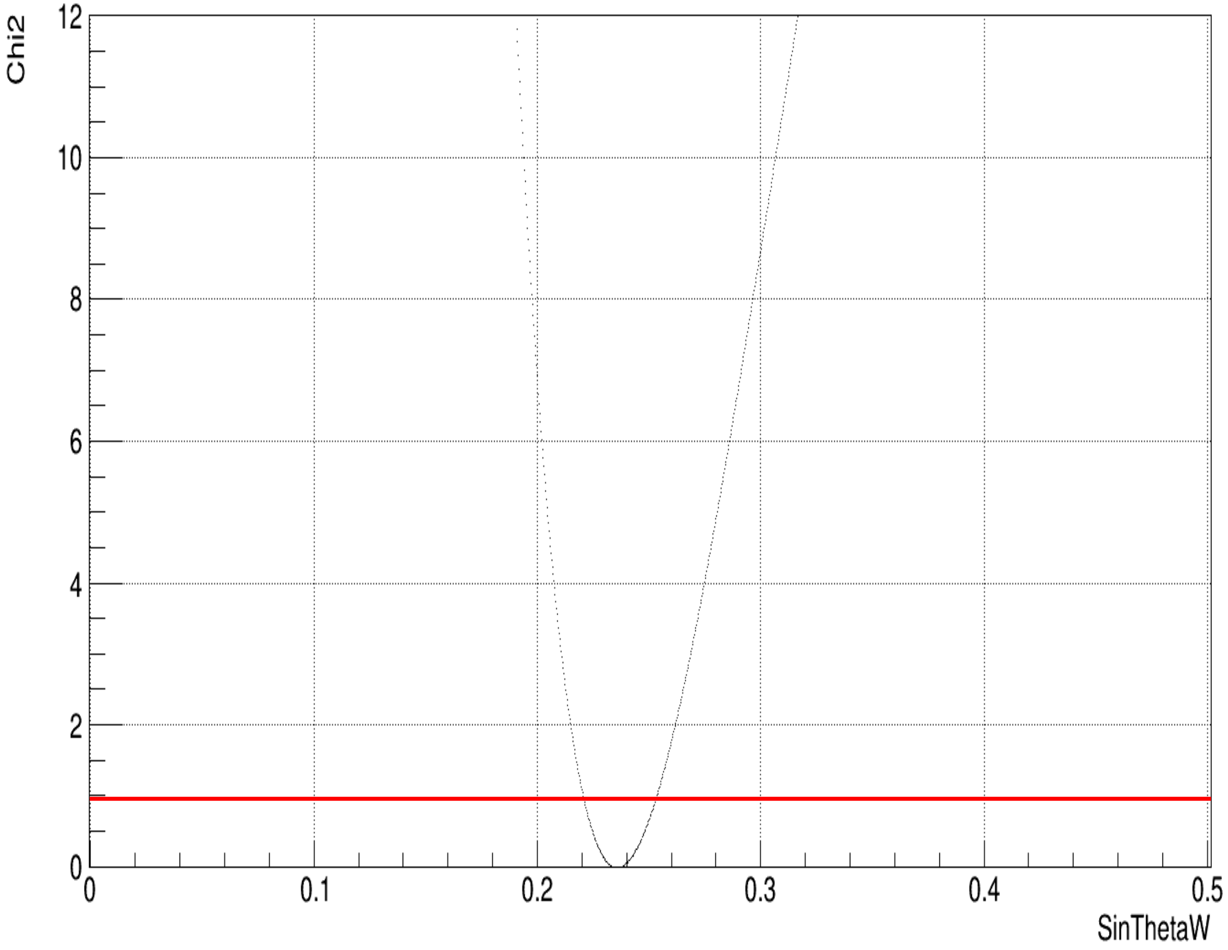


the multiplicity of hits in the matrix it is possible to filter the neutron events

- 768 CsI crystals 6x6x32 cm
- 6 cm of plastic scintillator all around (veto)
- 5 cm Pb
- 20 cm H20
- 10 cm concrete

in a year we obtain **2e5 events**

Theta Weinberg Reach



- ~ $1m^3$ CsI detector
- 1 y data taking
- Background/signal ~ 35
- QF ~ 13%
- Detector efficiency = 100%

$$\mathbf{Sin^2\theta_W = 0.2351^{+0.016}{}_{-0.0143}}$$

Theta Weinberg Reach

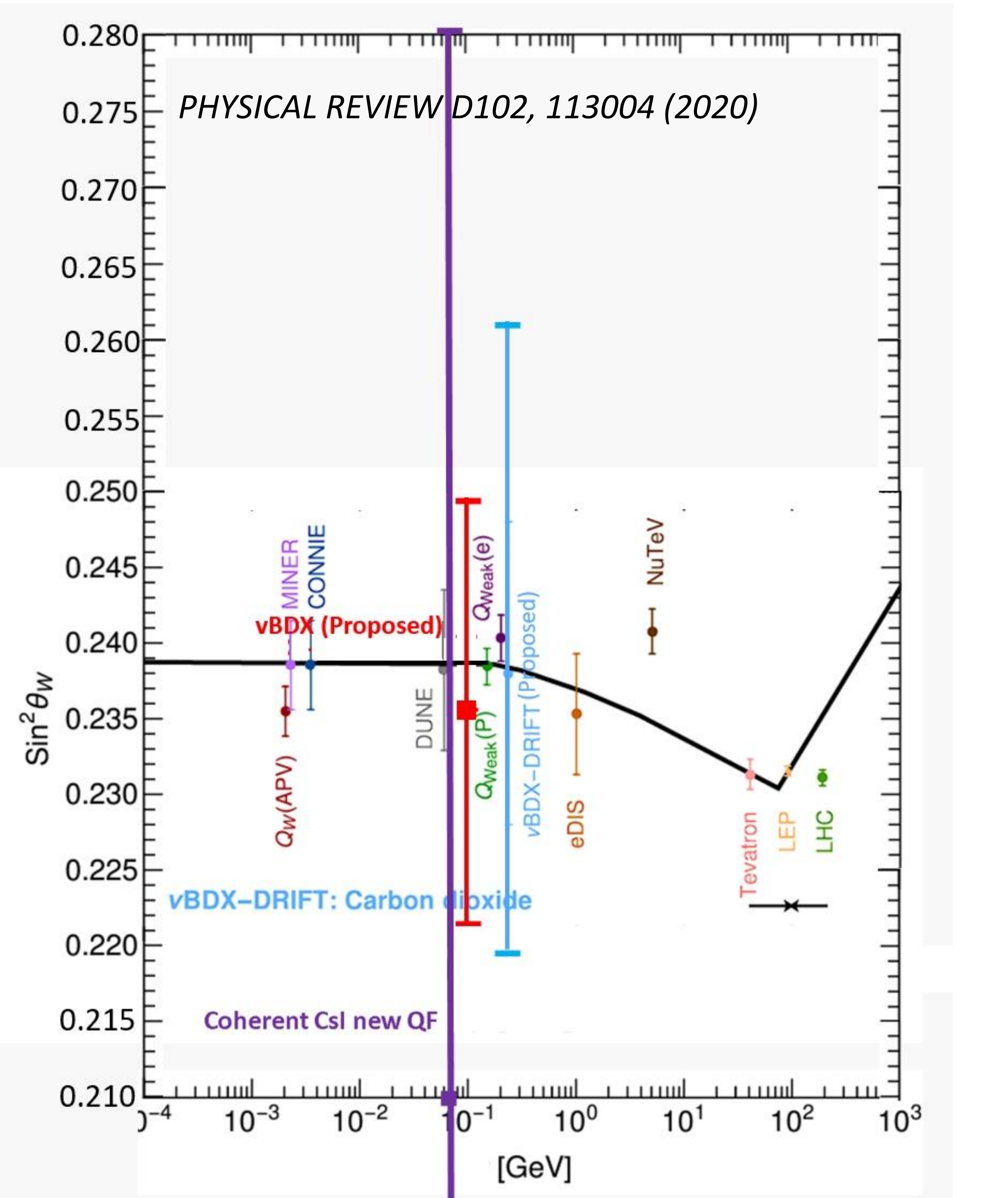
- $\sin^2\theta_W = 0.2351^{+0.016}_{-0.0143}$

- The uncertain obtain are mainly influenced by QF as already note in Coherent collaboration analysis

- Respect to Coherent, νBDX can achieve a precision that is 4 times better

$\sin^2\theta_W = 0.209^{+0.072}_{-0.069}$

Comparison with other experiments shows that νBDX can be competitive



Neutron Cosmic rays

Simple geometry CsI crystal 6x6x32 cm

- 1 mm Pb all around the crystal
- 6 cm of plastic scintillator all around (veto)
- 55 cm Pb only on top
- 30 cm concrete all around (room)

Generated neutrons energy Range	**Total hit not removable expected in a day (5 µs coincidence)**
1 meV-1 eV	2
1 eV- 1keV	14
1keV-1MeV	14
1-2 MeV	3
2MeV- 100MeV	33
100-1000MeV	386
1GeV-10GeV	38
	490

in a year we pass from 1e10 expected neutron to **1.7e5 events**

Conclusion

- **Sensitivity**
  - Quenching
  - Background events
    - Currently under study to optimize and reduce unremovable events
    - Cosmic muons should be studied but potentially less dangerous because charged
- **Weak Mixing angle can be measured with good precision**
  - 4 times better that Coherent
- **ν-BDX reach is competitive respect to other CEvNS experiments**

What to do next?

- Validate simulation with small apparatus
  - For cosmics (like BDX-proto)
  - For neutrons coming from dump (like BDX-hodo)
- The measurement at jlab is interesting also for RadCon