THERMAL, COLD, AND VERY COLD NEUTRON MODERATOR SYSTEMS FOR COMPACT NEUTRON SOURCES

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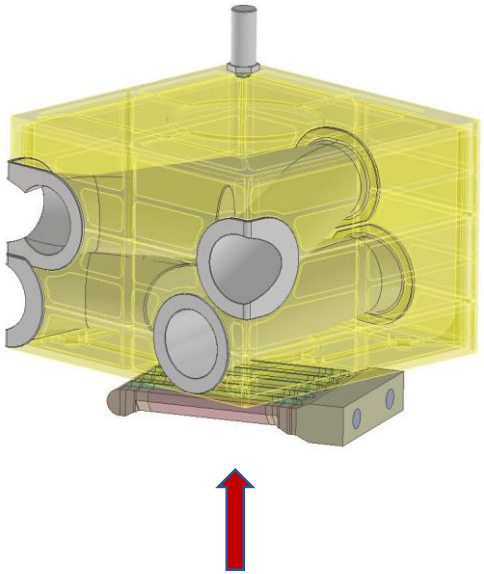
TN, CN, & VCN MODERATOR CONCEPTS FOR HiCANS

Motivation:

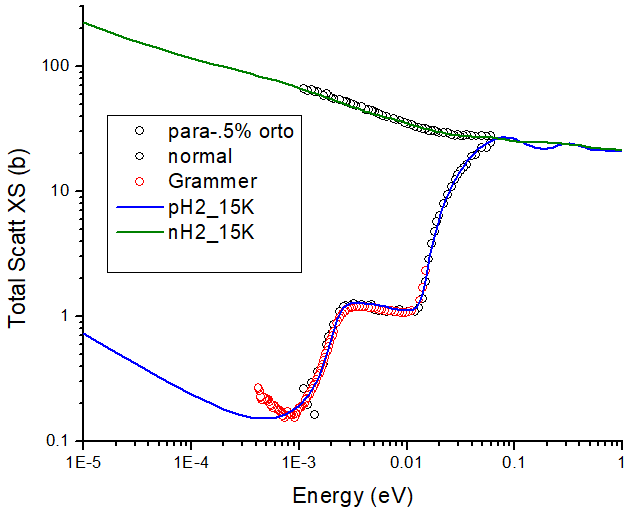
To develop basic concepts for the moderator complex of HiCANS, assuming that they may include thermal (TN), cold (CN), and very cold (VCN) neutron sources.



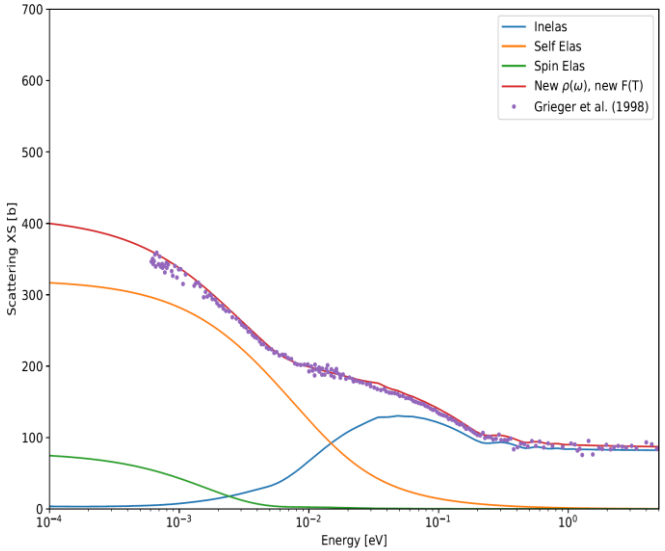
Components and Materials

- ✓ Square (10x10 cm) target (HBS type)
- ✓ TN moderator material: H2O
- ✓ CN moderator material: Liquid *para*-H2 (20K)
- ✓ VCN moderator material: Solid CH4 (4K)
- ✓ Premoderator material: H2O
- ✓ Cold neutron reflector: MgH2 (5 mm thick)
- ✓ Fast neutron reflector: Be (long tail) or Pb (faster)

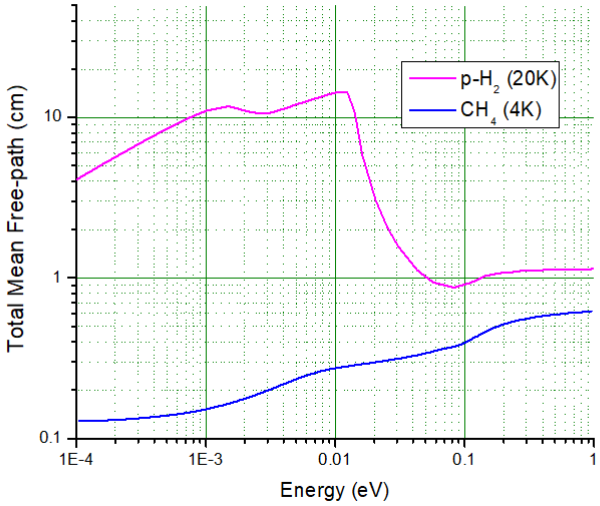
p-H_2 – 15 K

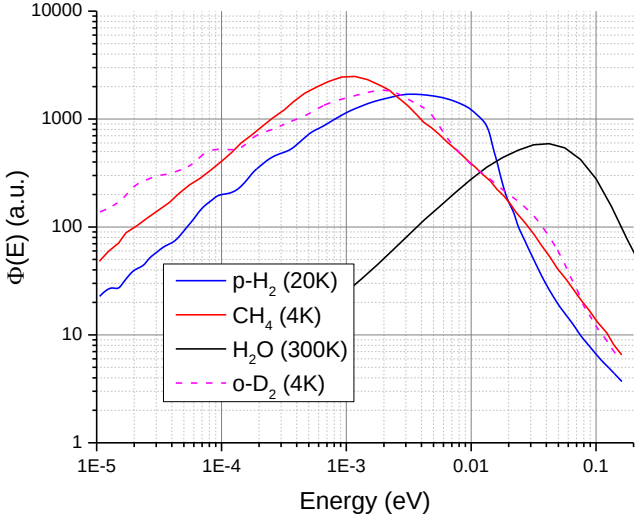


CH_4 phase II – 7 K



Adapted from F.X. Gallmeier et al, Journal of Physics: Conf. Series **1021** (2018) 012083





Energy distributions, not intensities!

TN+CN concept

This concept corresponds to a moderator system able to produce 4 beams of TN and 4 beams of CN (Fig.1)

TN+CN+VCN concepts

A second concept also includes provision of a VCN beam. The latter is based on a Methane (II) moderator at 4K (Fig.2).

A third concept includes high intensity TN, CN, and VCN beams (presented in Fig.3).

A fourth concept is a variant of concept 3, but includes only high intensity CN and VCN beams (presented in Fig.4).

Thin platform (3 cm):	High brilliance
Thick platform (6 cm):	High intensity

Concept 1. TN + CN - High Brightness

- Low-dimensional **CN** moderators (3x3x14 cm) – *para* H2

  4 beams *with best coupling to the thermal source*

  Use of CN reflector (MgH2) to minimize leakage from CN to TN regions.

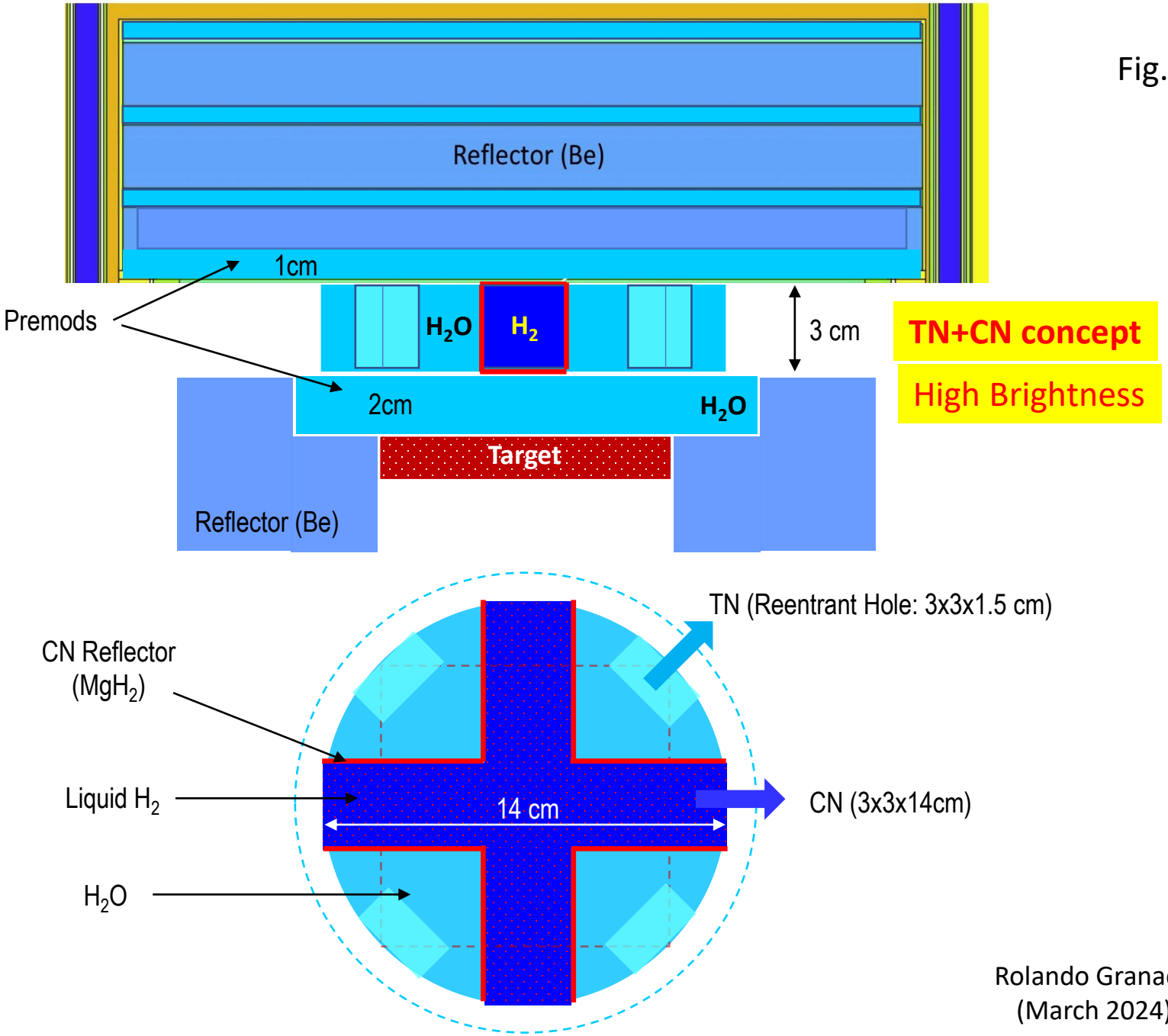
- Fast, intense **TN** moderator (Reentrant, 3x3x1.5 cm) – H2O

  4 beams *using Reentrant holes to extract thermal neutrons from the highest thermal flux region.*

  Thermal source optimally coupled to the fast and epitermal (from the premods) neutron sources

MERIT: High brightness CN beams; fast and intense TN pulse

Fig.1



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Concept 2. TN + CN + VCN – High Brightness

- Low-dimensional **CN** moderators (3x3x14 cm) – *para* H2

  4 beams *with best coupling to the thermal source*

  Use of CN reflector (MgH2) to minimize leakage from CN to TN regions.

- Small (fast) **VCN** moderator (3x3x1.5 cm) – solid CH4 (II)

  1 beam *with best coupling to the thermal source, achieved by placing the VCN moderator at the bottom of a reentrant hole of 2.7 cm in depth*

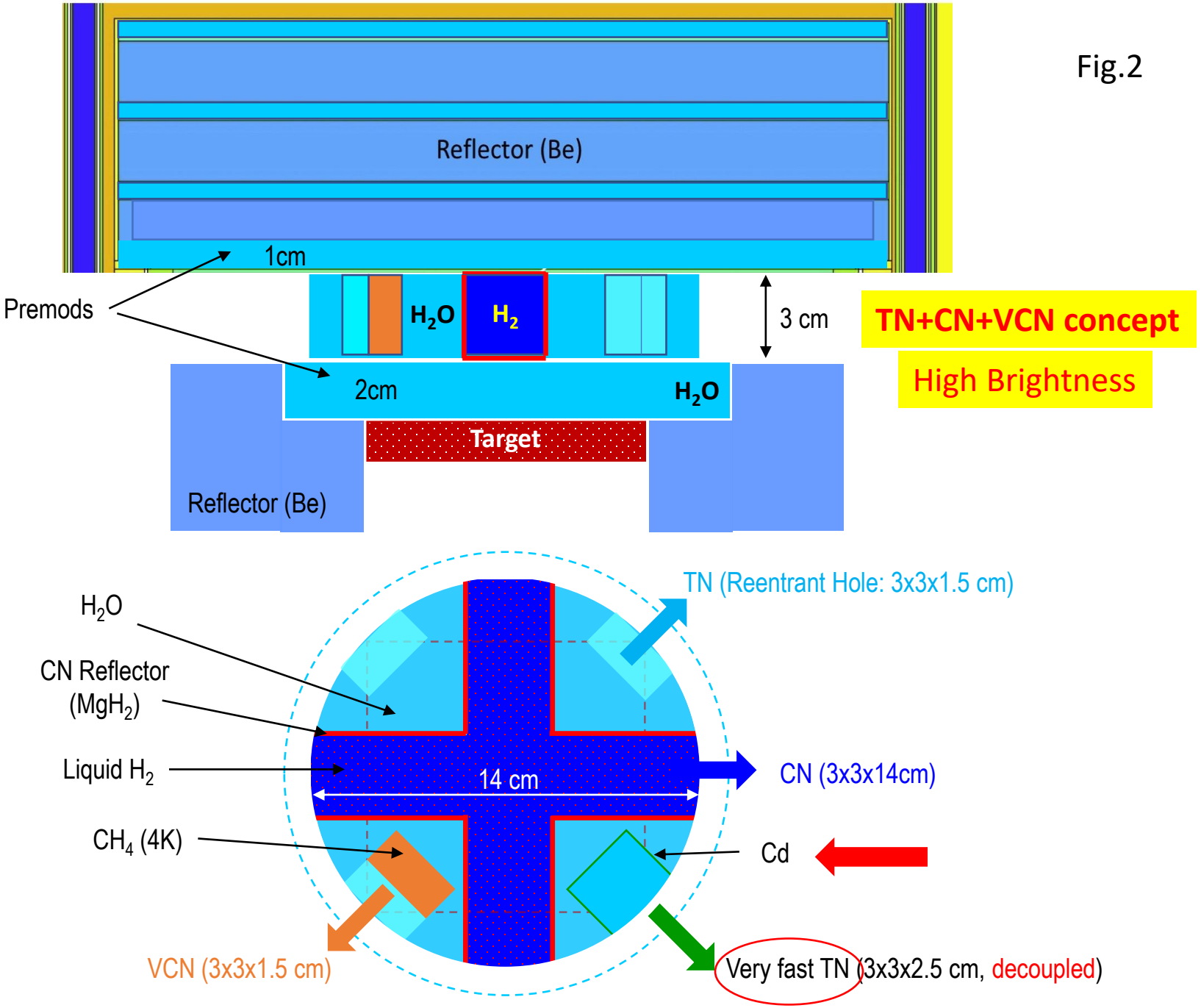
- Fast, intense **TN** moderator (Reentrant, 3x3x1.5 cm) – H2O

  2 beams *using Reentrant holes to extract thermal neutrons from the highest thermal flux region.*

  1 beam *from a very fast thermal moderator (decoupled).*

MERIT: High brightness CN beams; fast TN pulse; fast VCN beam

Fig.2


Reflector (Be)
1cm
Premods
H_2O
H_2
3 cm
TN+CN+VCN concept
High Brightness
2cm
H_2O
Target
Reflector (Be)
TN (Reentrant Hole: 3x3x1.5 cm)
H_2O
CN Reflector
(MgH_2)
Liquid H_2
14 cm
CN (3x3x14cm)
CH_4 (4K)
Cd
VCN (3x3x1.5 cm)
Very fast TN (3x3x2.5 cm, decoupled)

Concept 3. TN + CN + VCN – High Intensity

- Semi Low-dimensional **CN** moderators (3x6x14 cm) – *para* H2

  ***4 intense** beams with best coupling to the thermal source*

  Use of CN reflector (MgH2) to minimize leakage from CN to TN regions.

- Large **VCN** moderator (1.5 cm thick, Φ = 6 cm) – solid CH4 (II)

  ***1 beam** with best coupling to the thermal source, achieved by placing the VCN moderator at the bottom of a reentrant hole of 3 cm in depth*

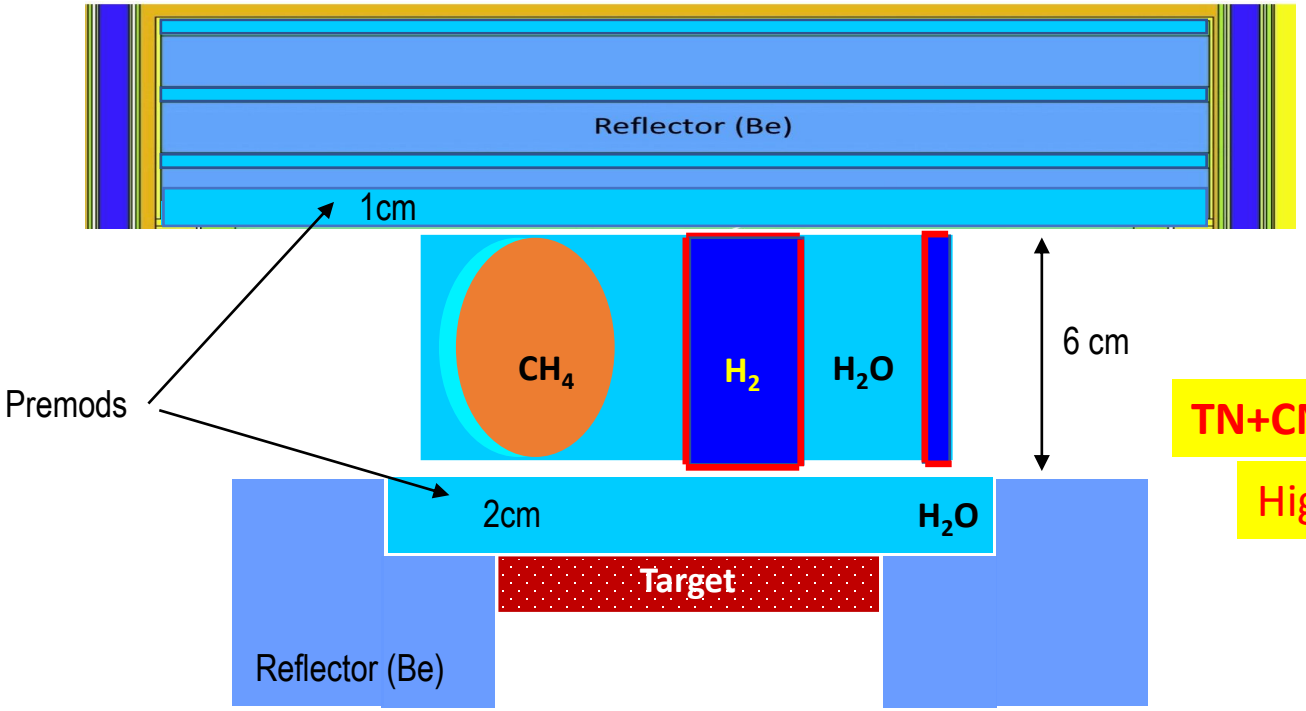
- Large **TN** moderator (Reentrant hole, 3 cm depth, Φ = 6 cm) – H2O

  ***1 beam** using Reentrant hole to extract thermal neutrons from the highest thermal flux region.*

  Thermal source optimally coupled to the fast and epitermal (from the premods) neutron sources.

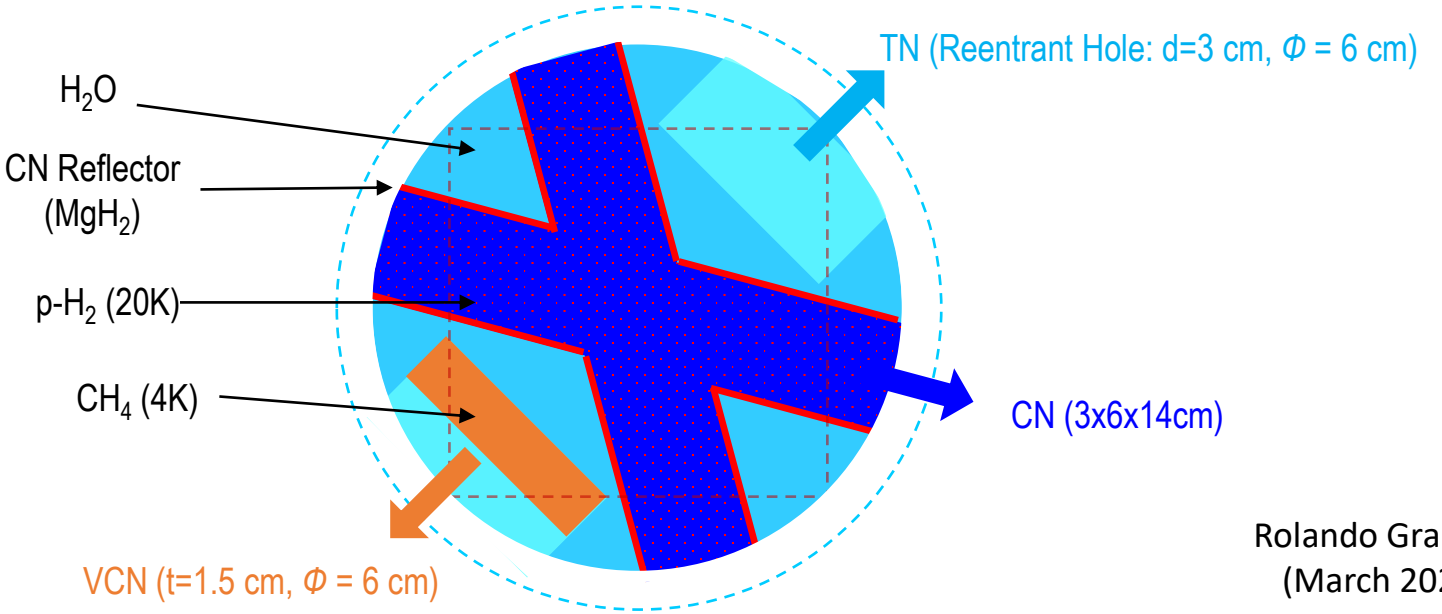
MERIT: Intense CN beams; Very intense TN beam; Intense VCN beam

Fig.3



TN+CN+VCN concept

High Intensity



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Concept 4. CN + VCN – High Intensity

♦ Semi Low-dimensional **CN** moderators (3x6x14 cm) – *para* H2

***4 intense** beams with best coupling to the thermal source*

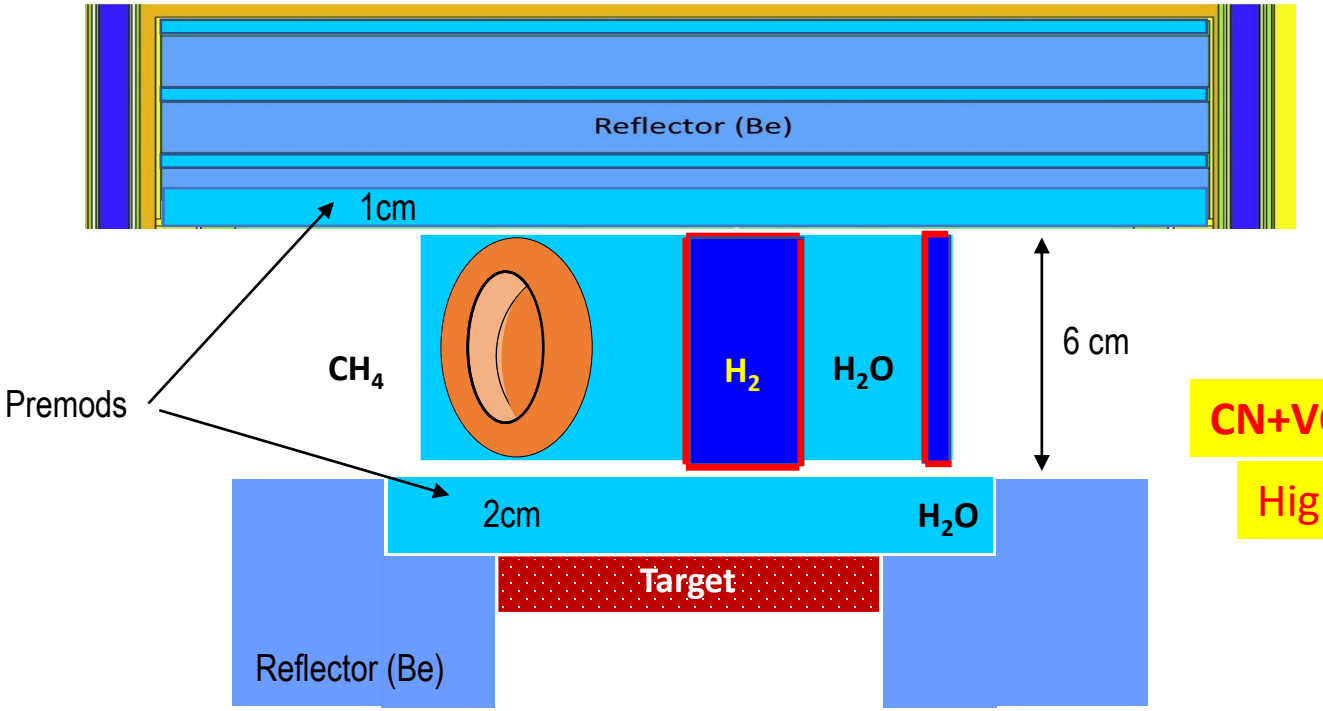
Use of CN reflector (MgH2) to minimize leakage from CN to TN regions.

♦ Very intense **VCN** moderator (3 cm thick, Φ = 6 cm) – solid CH4 (II)

***2 beam** with best coupling to the thermal source, achieved by extracting the VCN from a reentrant hole of 1.5 cm in Depth and 4 cm diameter*

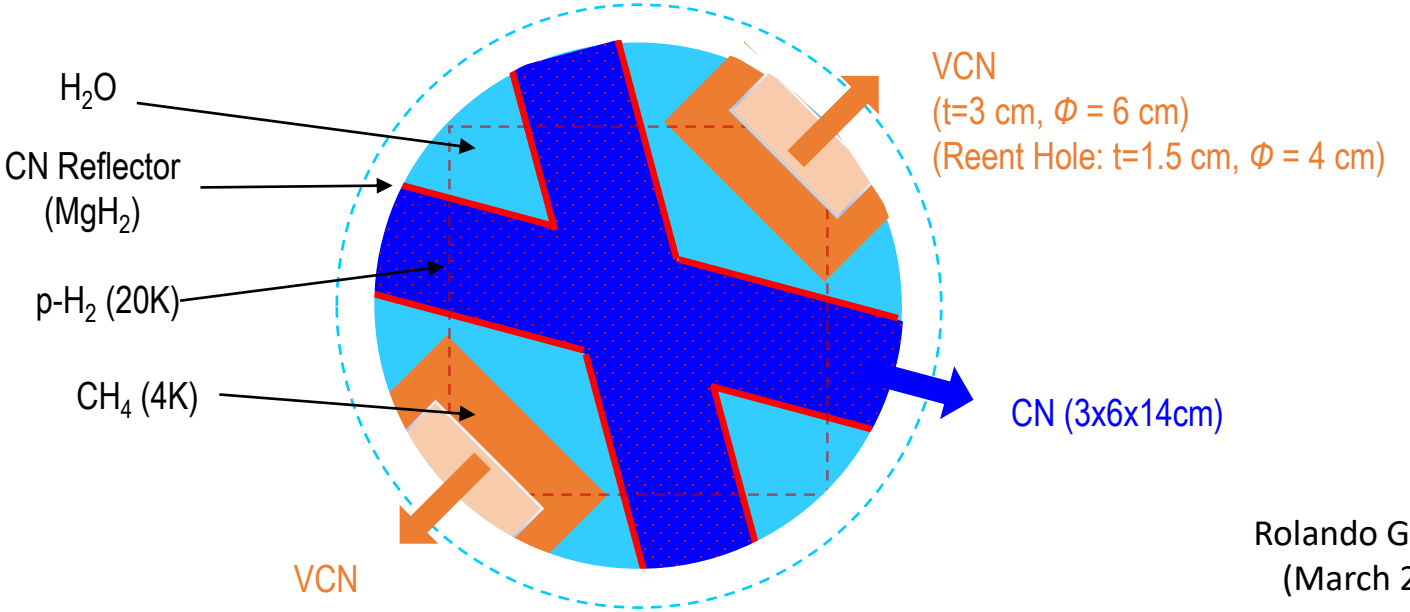
MERIT: Intense CN beams; Very intense VCN beam

Fig.4



CN+VCN concept

High Intensity



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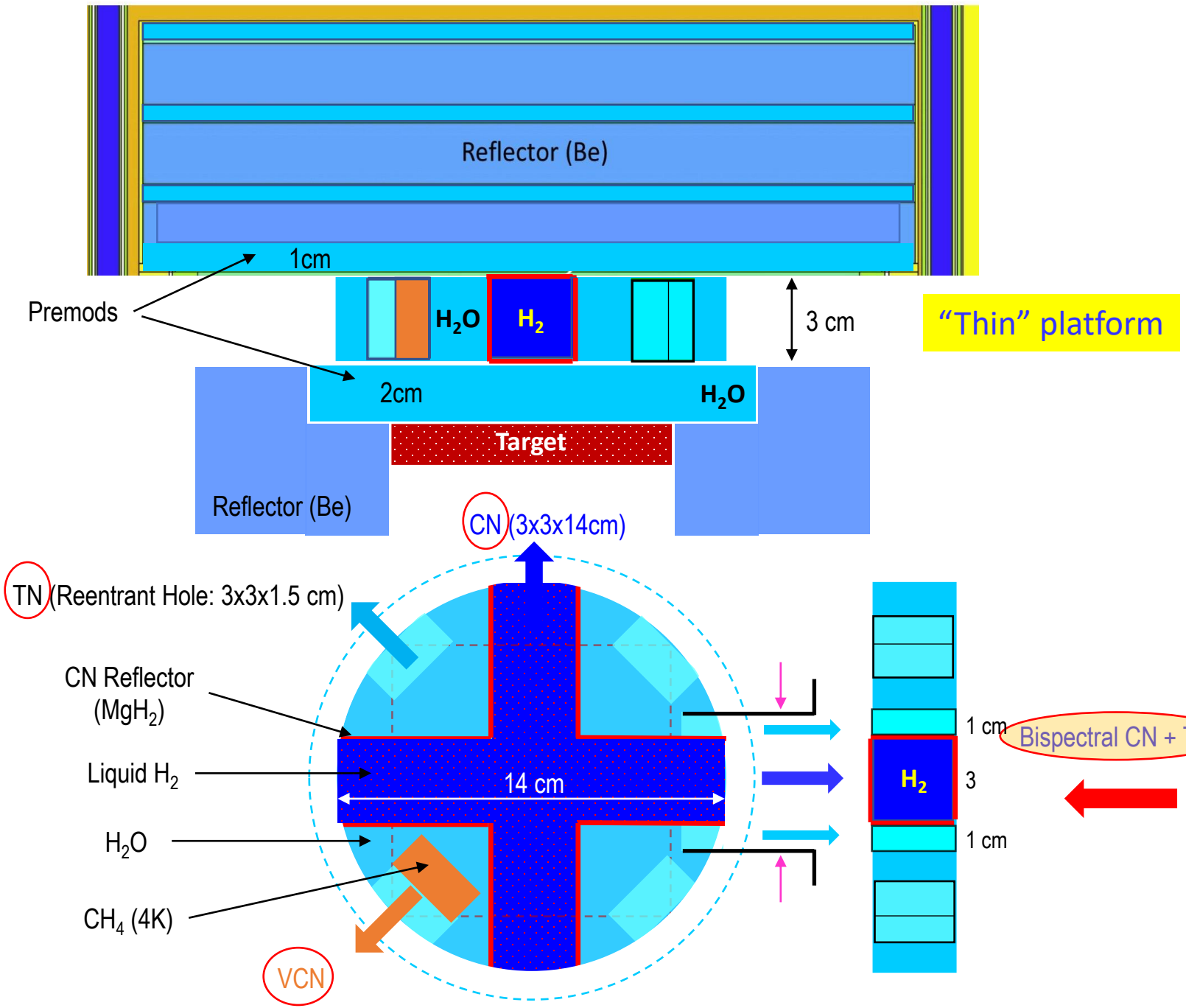
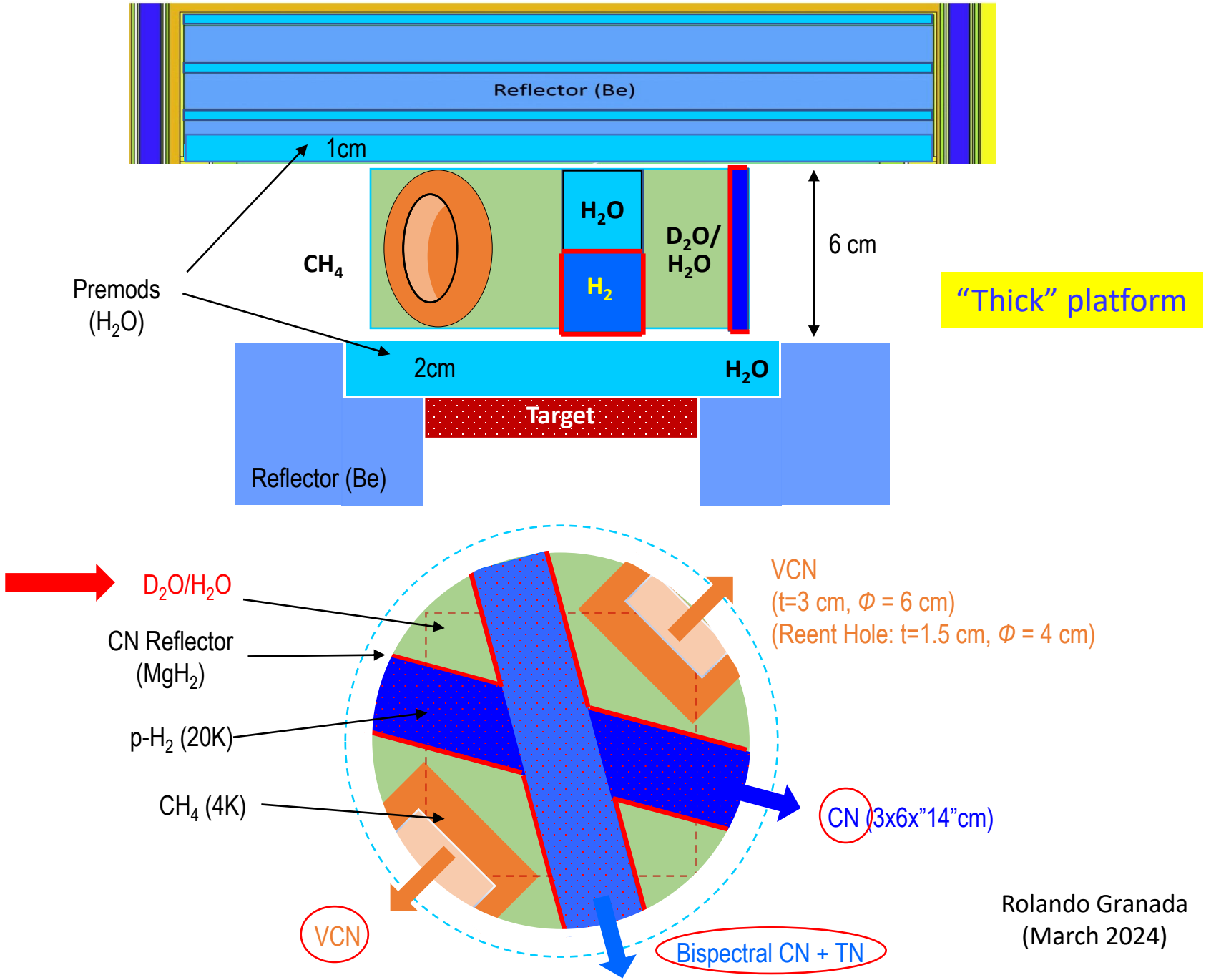
OTHER COMBINATIONS…


Reflector (Be)
1cm
Premods
H_2O
H_2
3 cm
"Thin" platform
2cm
H_2O
Target
Reflector (Be)
CN (3x3x14cm)
TN (Reentrant Hole: 3x3x1.5 cm)
CN Reflector (MgH_2)
Liquid H_2
H_2O
CH_4 (4K)
VCN
14 cm
1 cm
H_2
3
1 cm
Bispectral CN + TN



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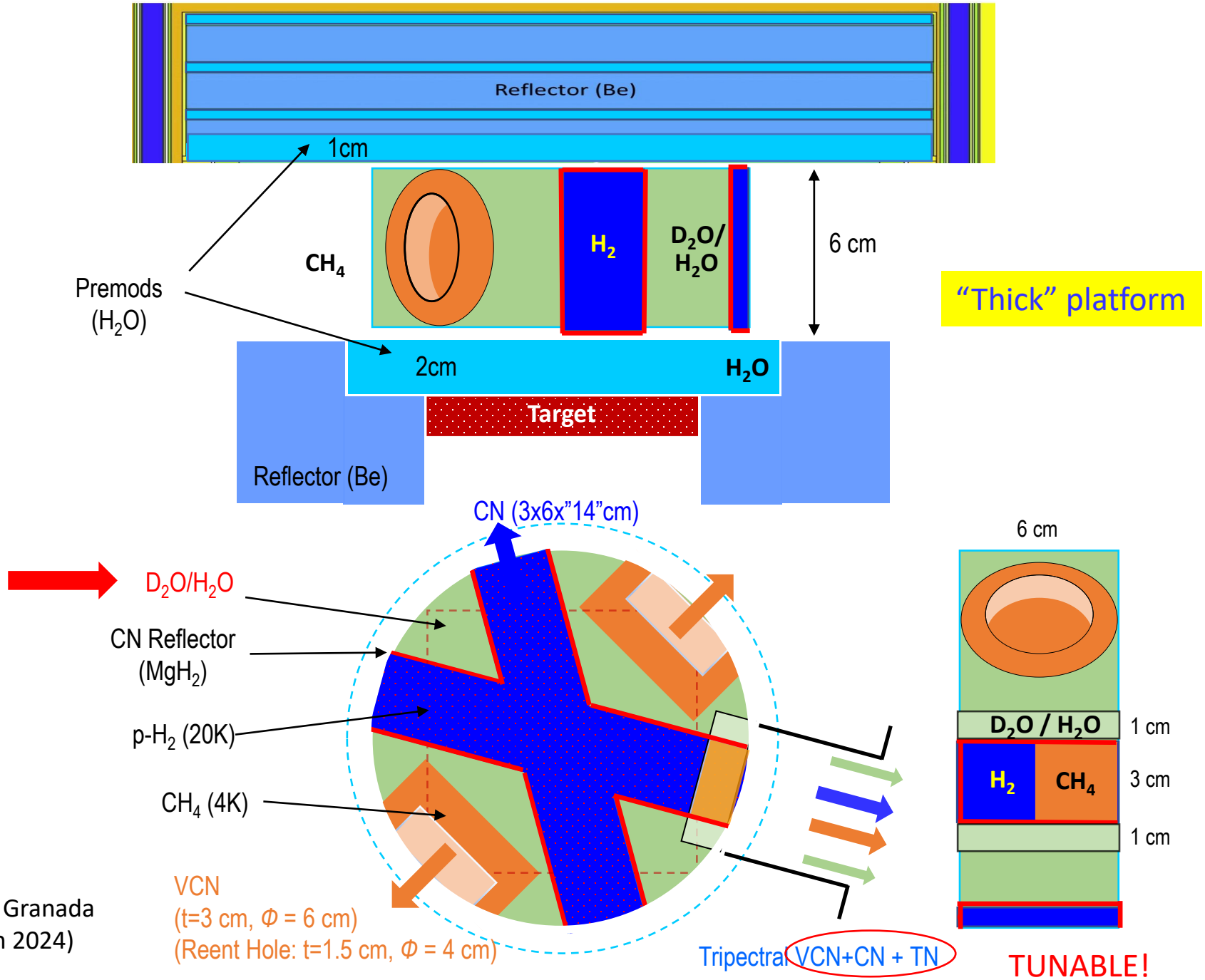

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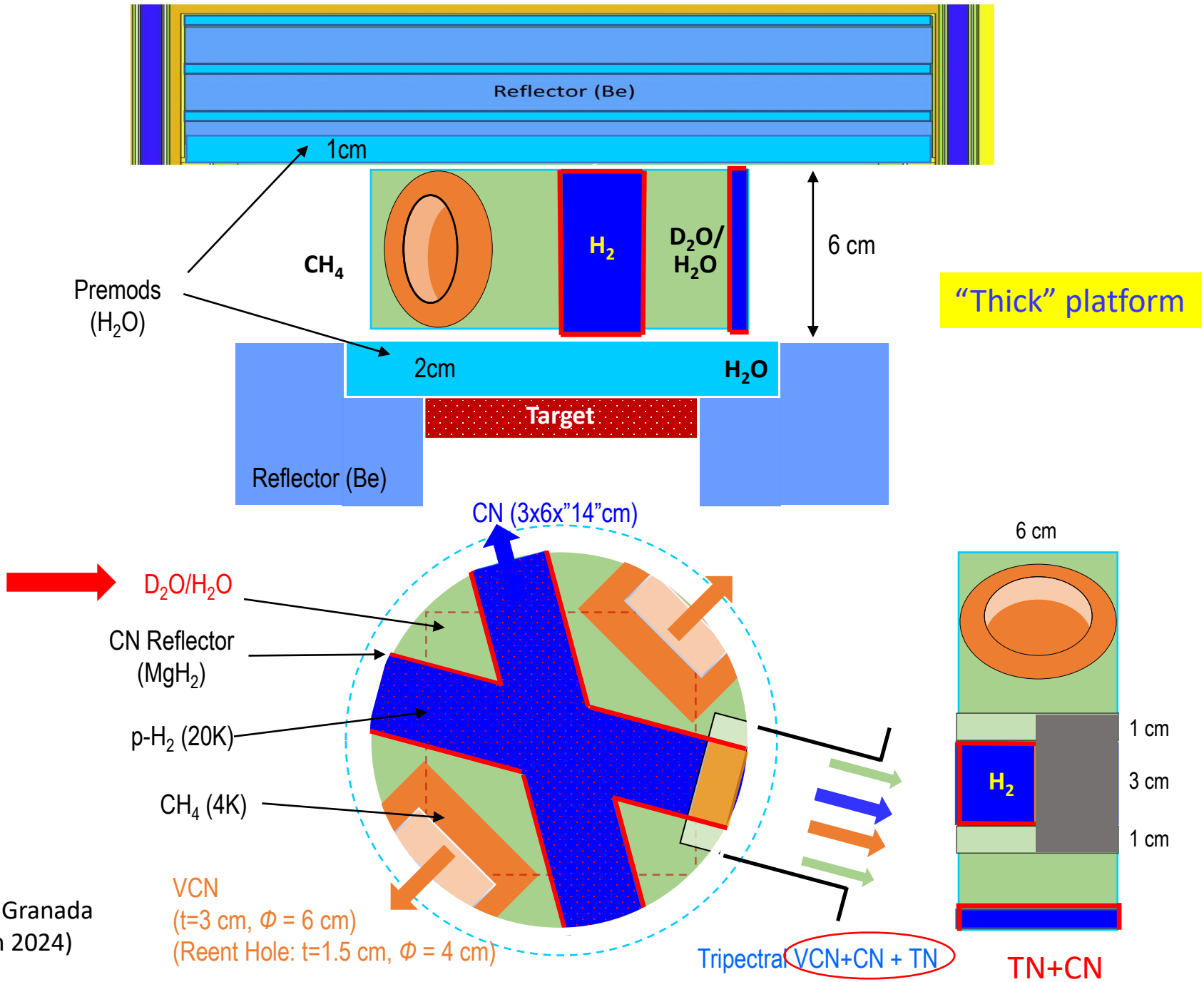
Reflector (Be)
1cm
Premods
(H_2O)
CH_4
H_2
D_2O/
H_2O
6 cm
"Thick" platform
2cm
H_2O
Target
Reflector (Be)
CN (3x6x"14"cm)
D_2O/H_2O
CN Reflector
(MgH_2)
p-H_2 (20K)
CH_4 (4K)
VCN
(t=3 cm, Φ = 6 cm)
(Reent Hole: t=1.5 cm, Φ = 4 cm)
Tripectral VCN+CN + TN
6 cm
1 cm
3 cm
1 cm
H_2
TN+CN
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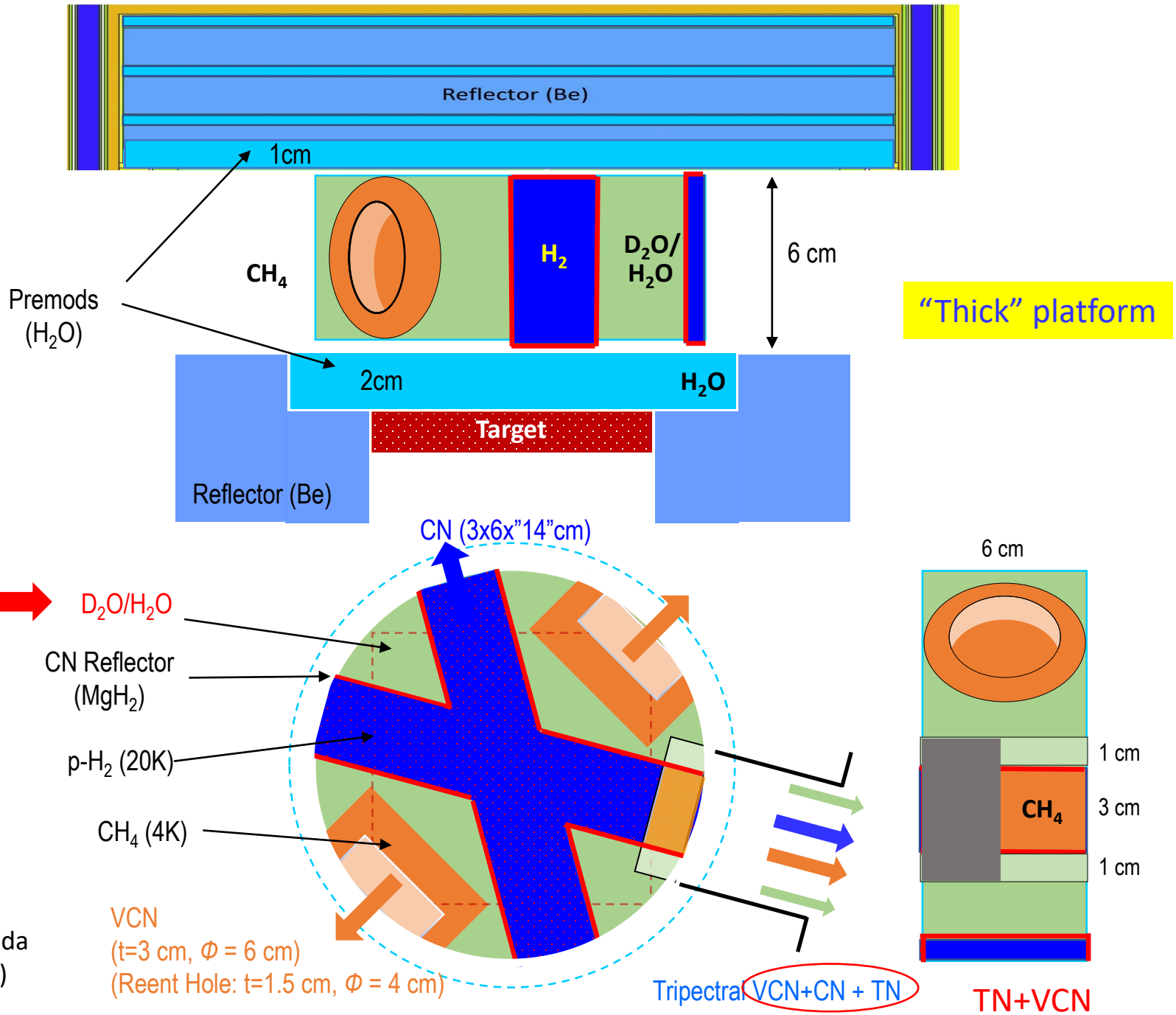

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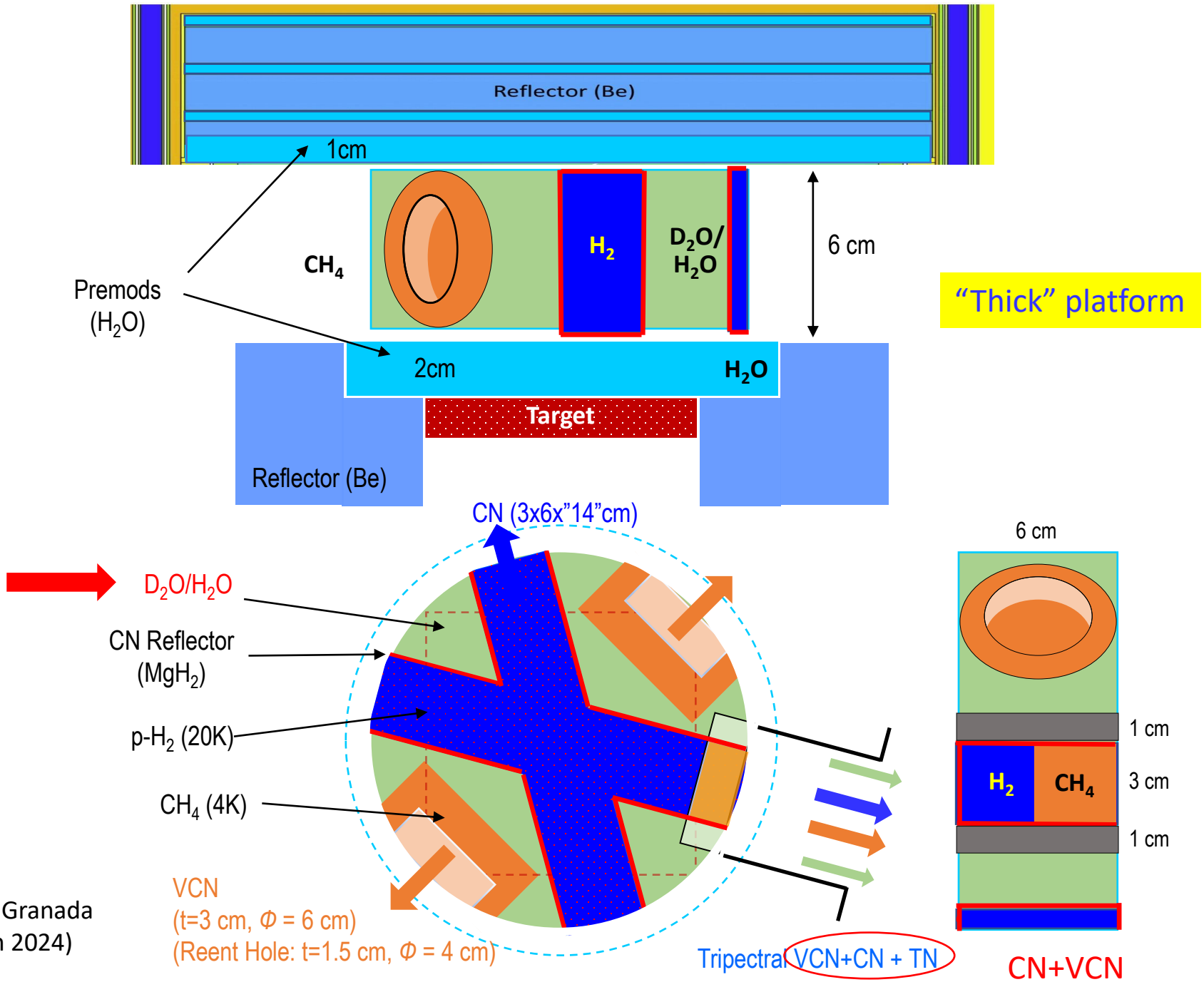

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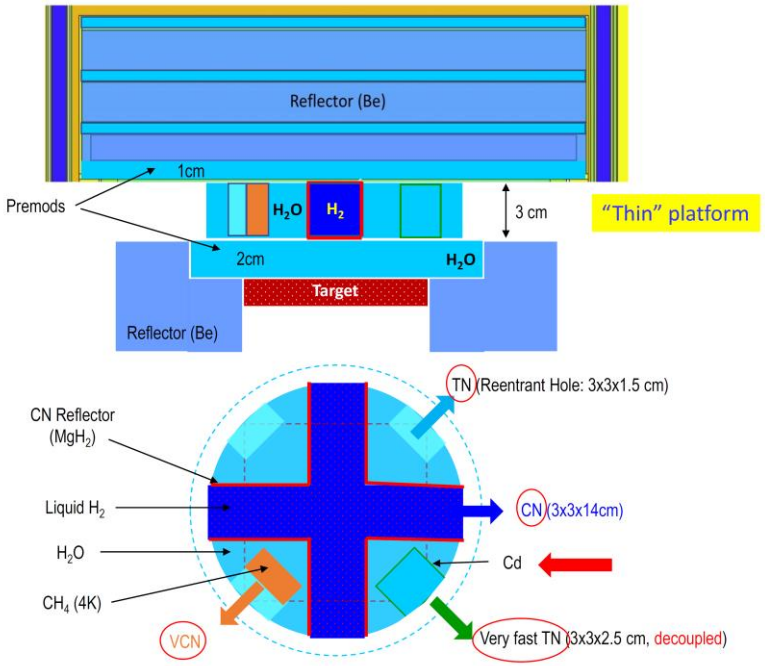
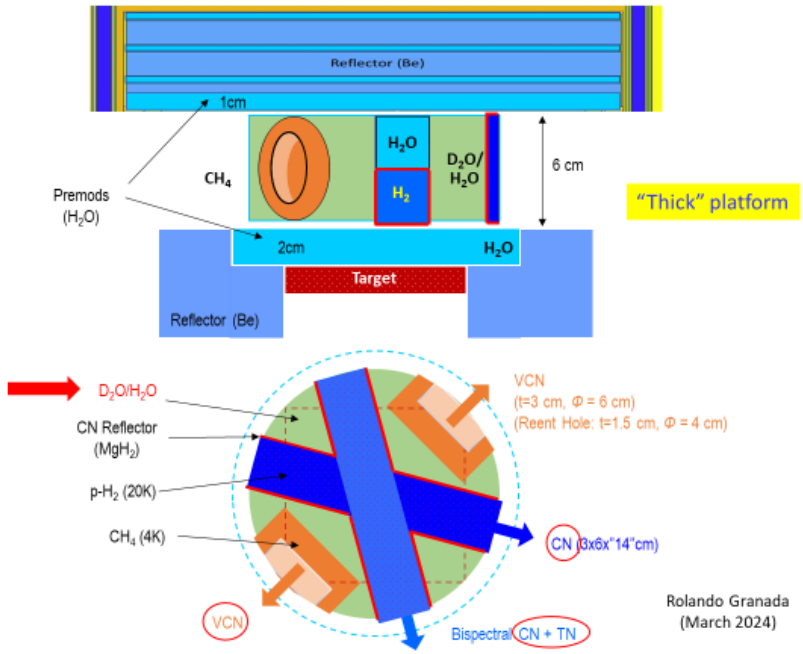
BRIGHT



3 Thermal
4 Cold
1 Very cold

INTENSE



2 Thermal/Cold
2 Cold
2 Very cold

CONCLUSIONS

Compact moderators, and in particular low-dimensional moderators are very well suited for CANS.

Conceptual geometries were presented to motivate simulations aimed at the optimization of different spectral beam characteristics. The dimensions proposed are compatible with the HBS target.

These concepts are oriented to the production of thermal, cold, and very cold neutron beams, either of high brilliance or high intensity types.

The concepts presented here are just indicative of the different combination of sources that can be arranged for each target station.

THANKS FOR YOUR ATTENTION!