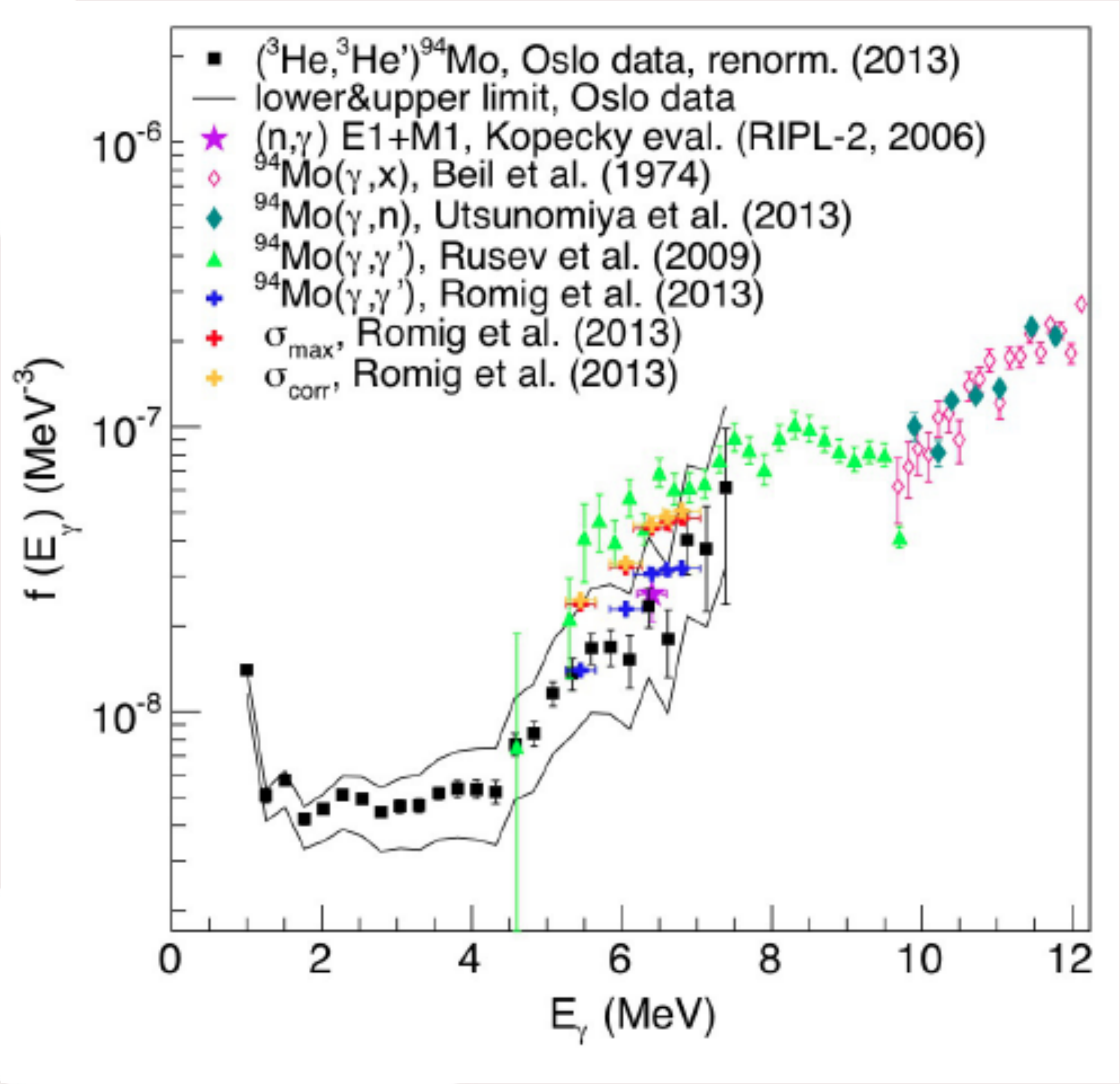
Neutrons, nuclear energy and the role of level densities and strength functions: *May LICORNE be of any help?*

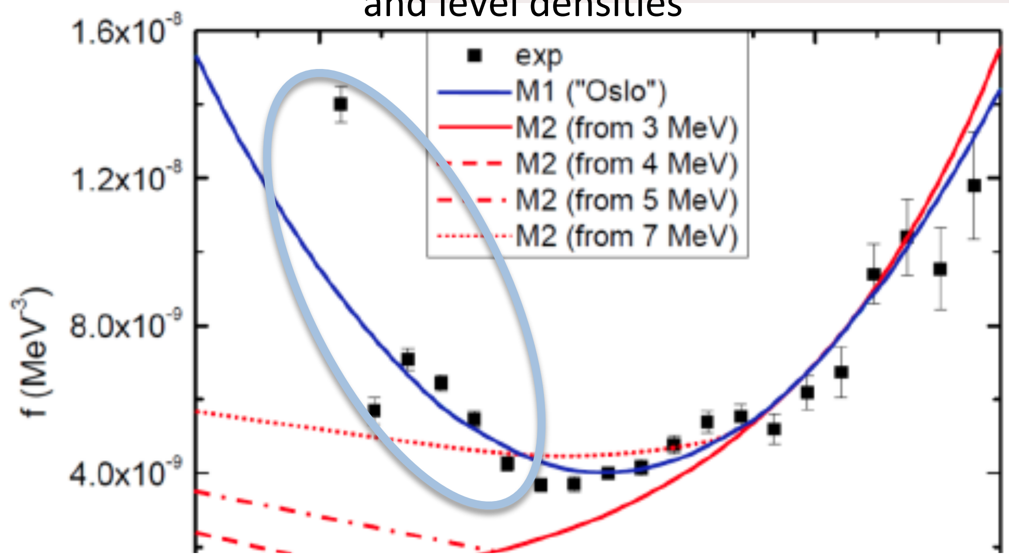
M. Lebois, J.N. Wilson, Q. Liqiang & P. Halipré

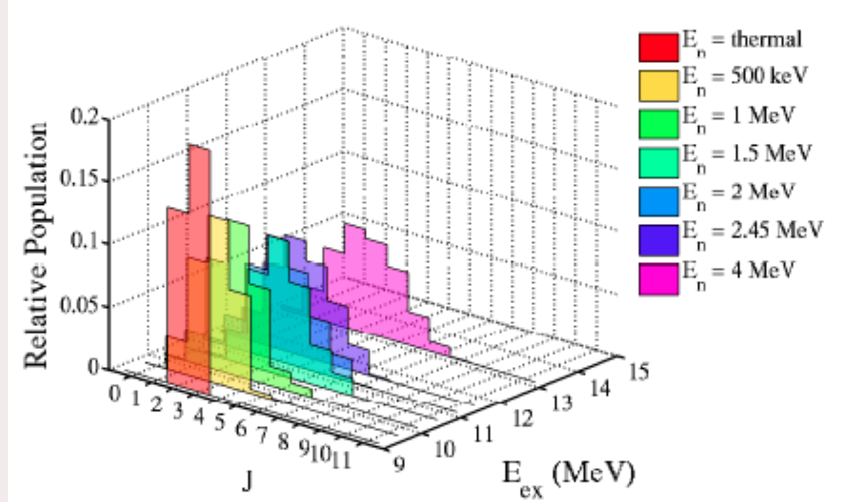
MEASURE OF THE ANGULAR MOMENTUM DEPENDENCE OF Mo γ STRENGTH FUNCTION

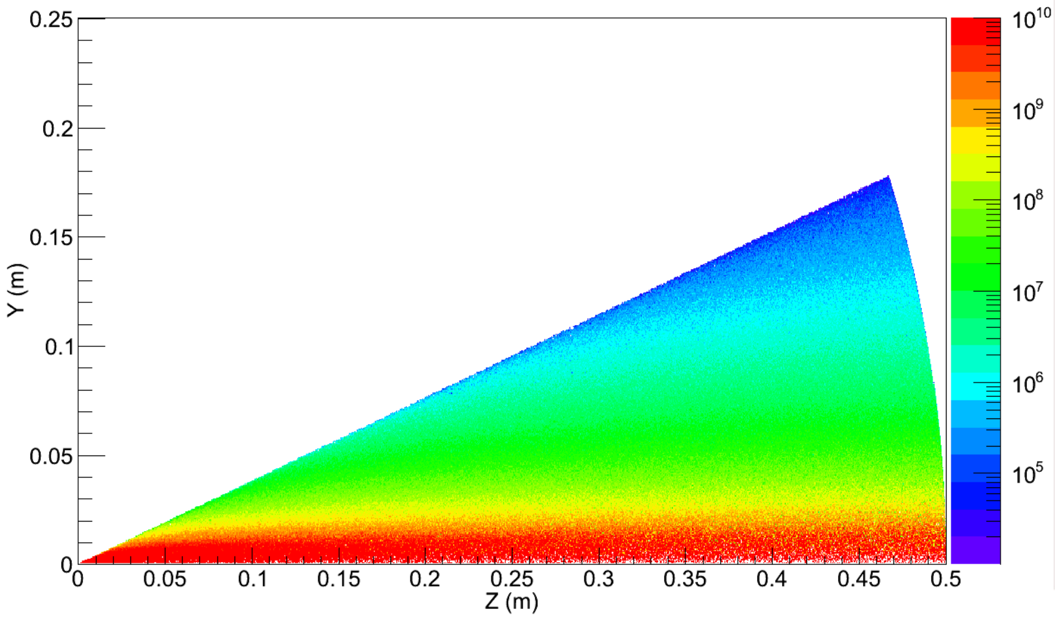


MEASURE OF THE ANGULAR MOMENTUM DEPENDENCE OF THE ^{96}Mo γ STRENGTH FUNCTION

Provides information on radiative strength functions and level densities

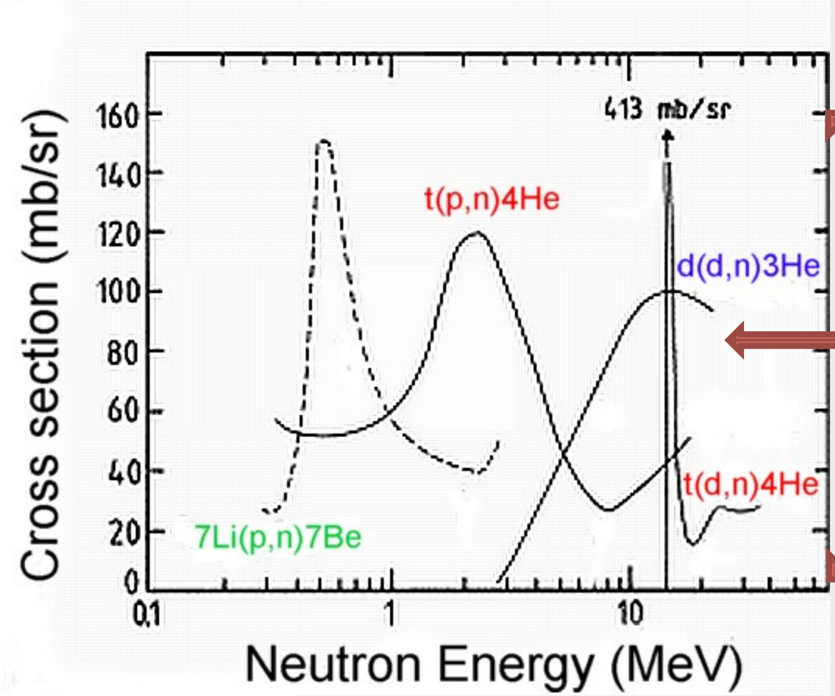


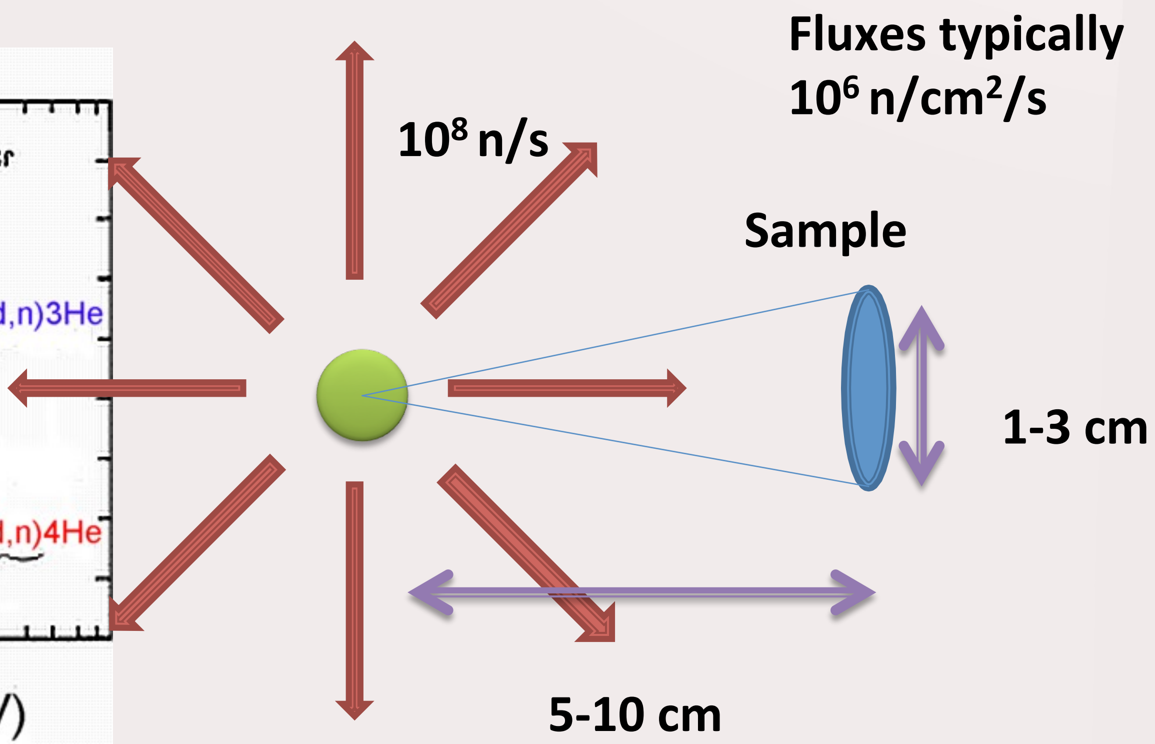




- Cascades originate from above the binding energy for fast neutrons, so unique probe of the continuum above S_n
- LICORNE neutron energy well defined
- 1.5 MeV produce the highest an broadest spin distribution
- MINIBALL provide high efficiency & good resolution required for the TSC technique

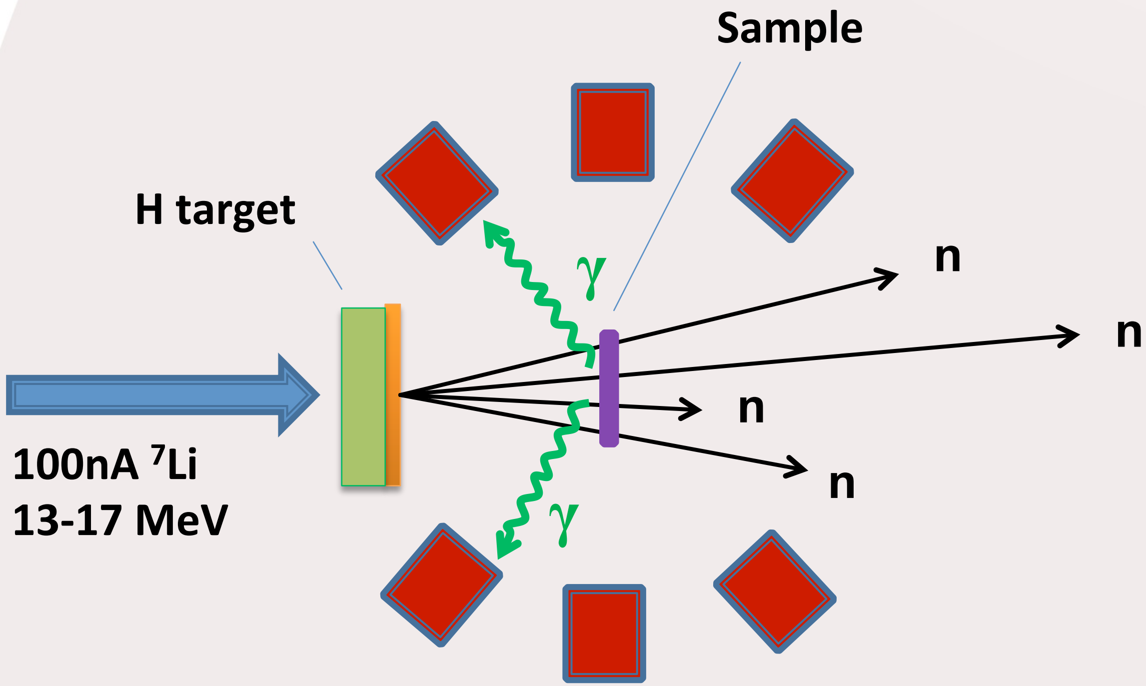
MONO-ENERGETIC NEUTRON SOURCES





- Typically over 99% of neutrons ''wasted''
- Wasted neutrons contribute to the room background
- Placement of gamma detectors impossible without heavy shielding

NEUTRON PRODUCTION IN INVERSE KINEMATICS



Lithium Inverse Cinematiques ORsay NEutron source

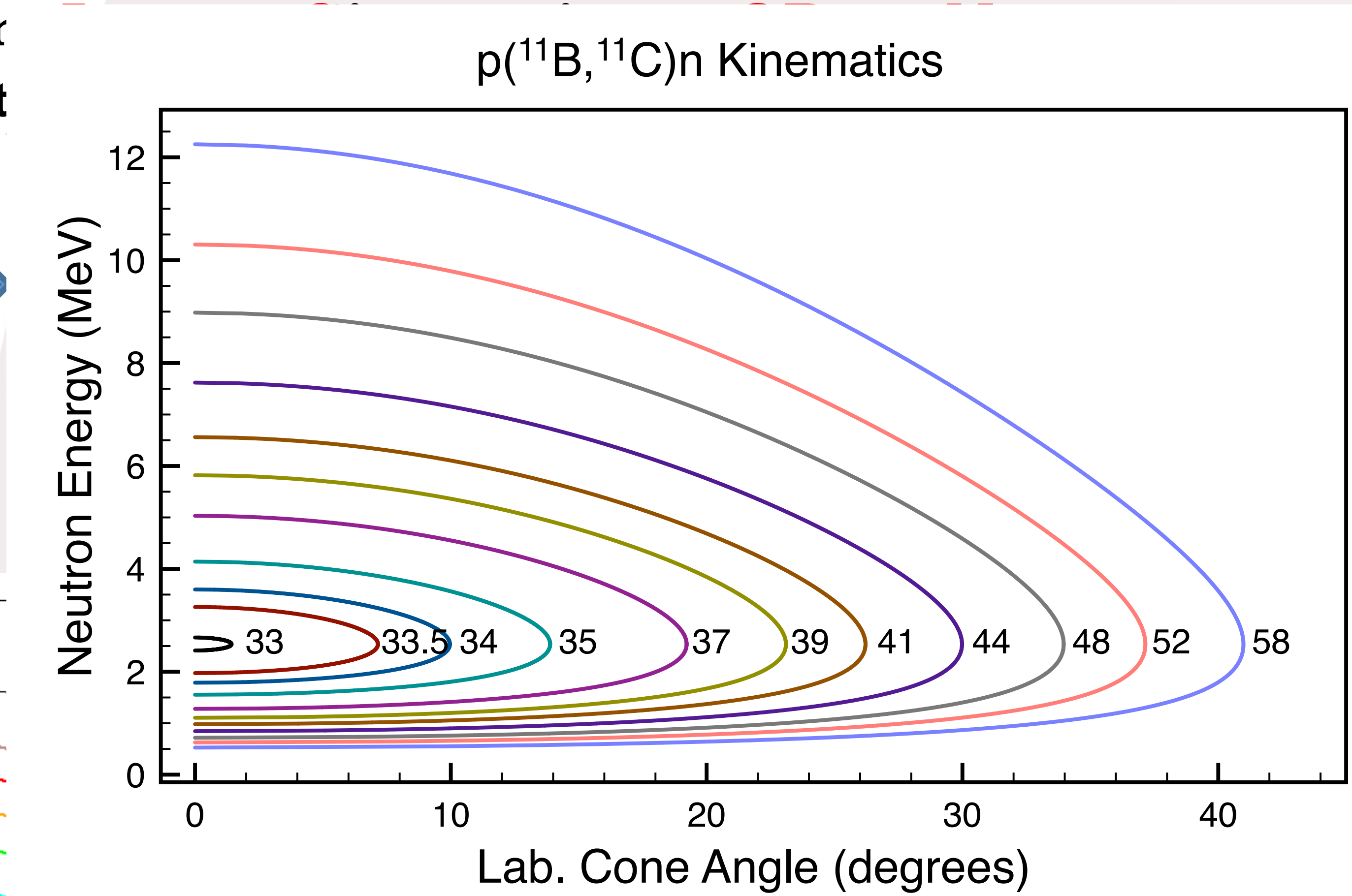
- **p(^{7}Li,^{7}Be)n reaction in inverse kinematics**
- **Focused source of fast neutrons between 0.5 and 4 MeV**

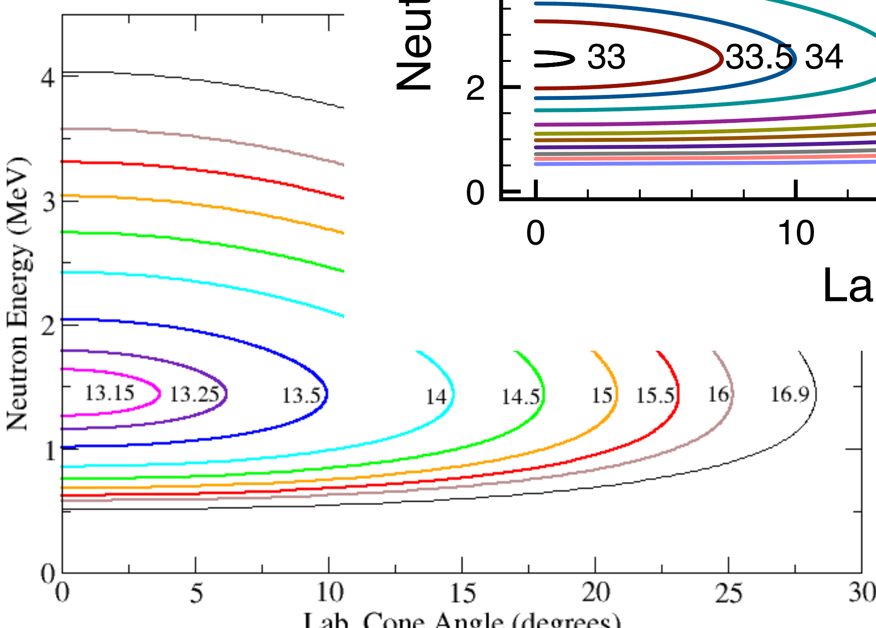
THE NEUTRON BEAM CHARACTERISTICS: ENERGY RANGE, FLUX, ...

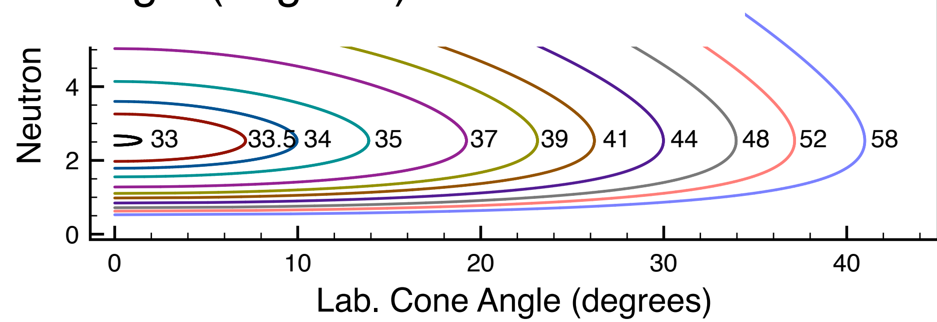
Lithiu ... ce

H target

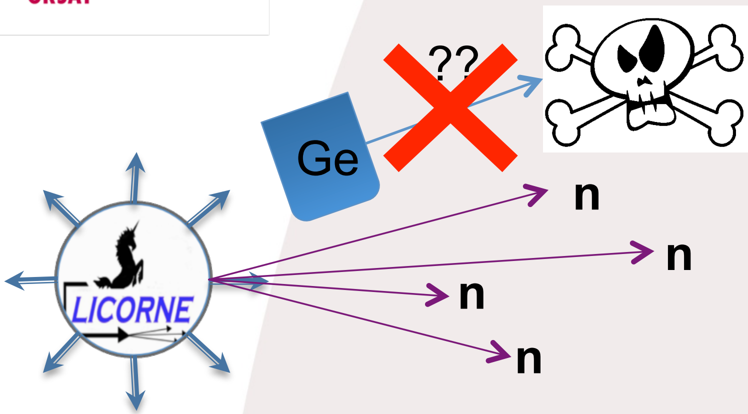
100 nA ^{7}Li 13-17 MeV







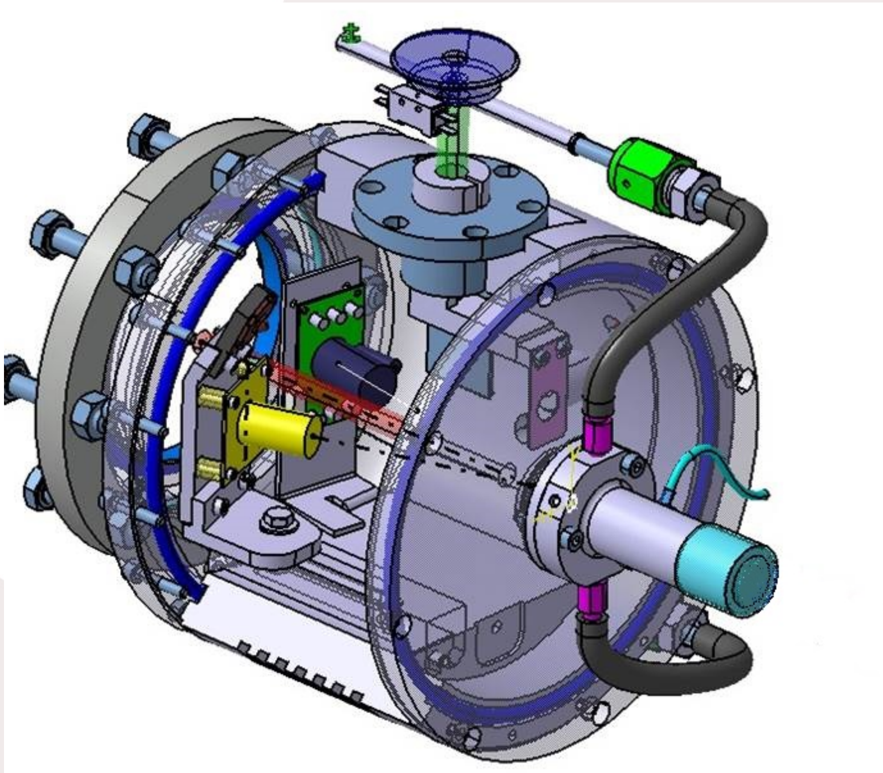
DEVELOPMENT OF A GAS TARGET FOR LICORNE
(commissionning performed nov. 2014)

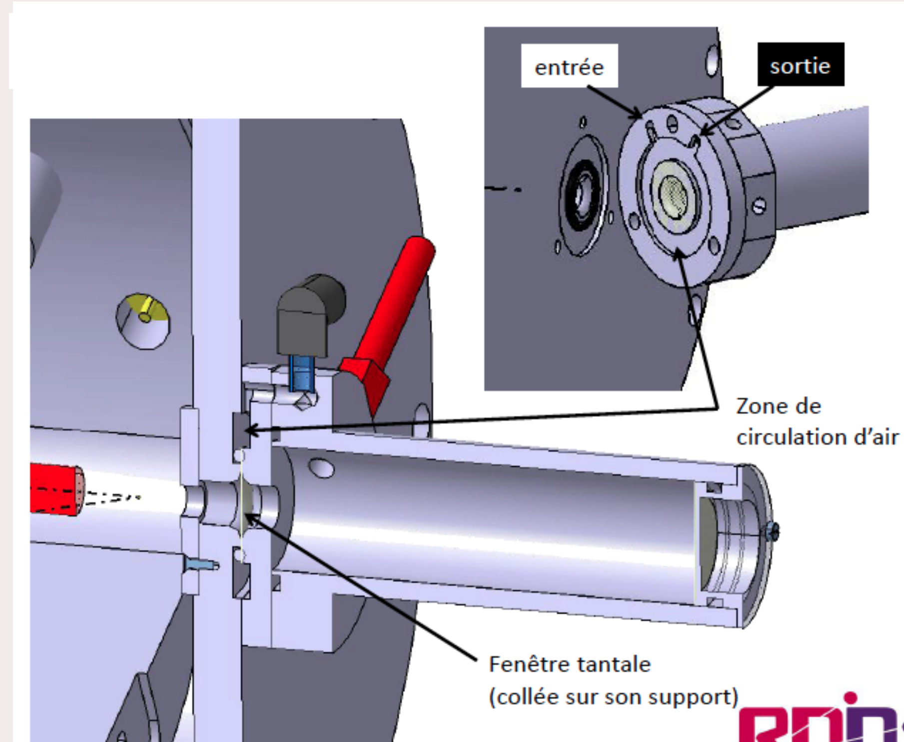


Parasitic fusion evaporation reaction of ^{7}Li on ^{12}C

Need to change the PP target ➔Gas target

Elements with Z > 73 required in the beam path





=> Echauffement et refroidissement du joint ...

LICORNE II – COMMISSIONING NOV. 2014

Hydrogen gas cells

H_2 pressure and flow control system

Development of a kinematically focused neutron source with the p(^{7}Li,n)^{7}Be inverse reaction
M.Lebois, J.N. Wilson et al., Nucl. Instrum. Meth. A 735 145 (2014)

EXOTIC NUCLEI PRODUCTION & STUDY WITH FISSION

Spontaneous Fission
^{252}Cf(SF), ^{248}Cm(SF)
(Gammasphere, Euroball)

^{252}Cf

Thermal neutron induced fission ^{235}U(n,f) ^{241}Pu(n,f)
(EXILL Exogam@ILL)

n + ^{235}U

En ~ 0.025eV

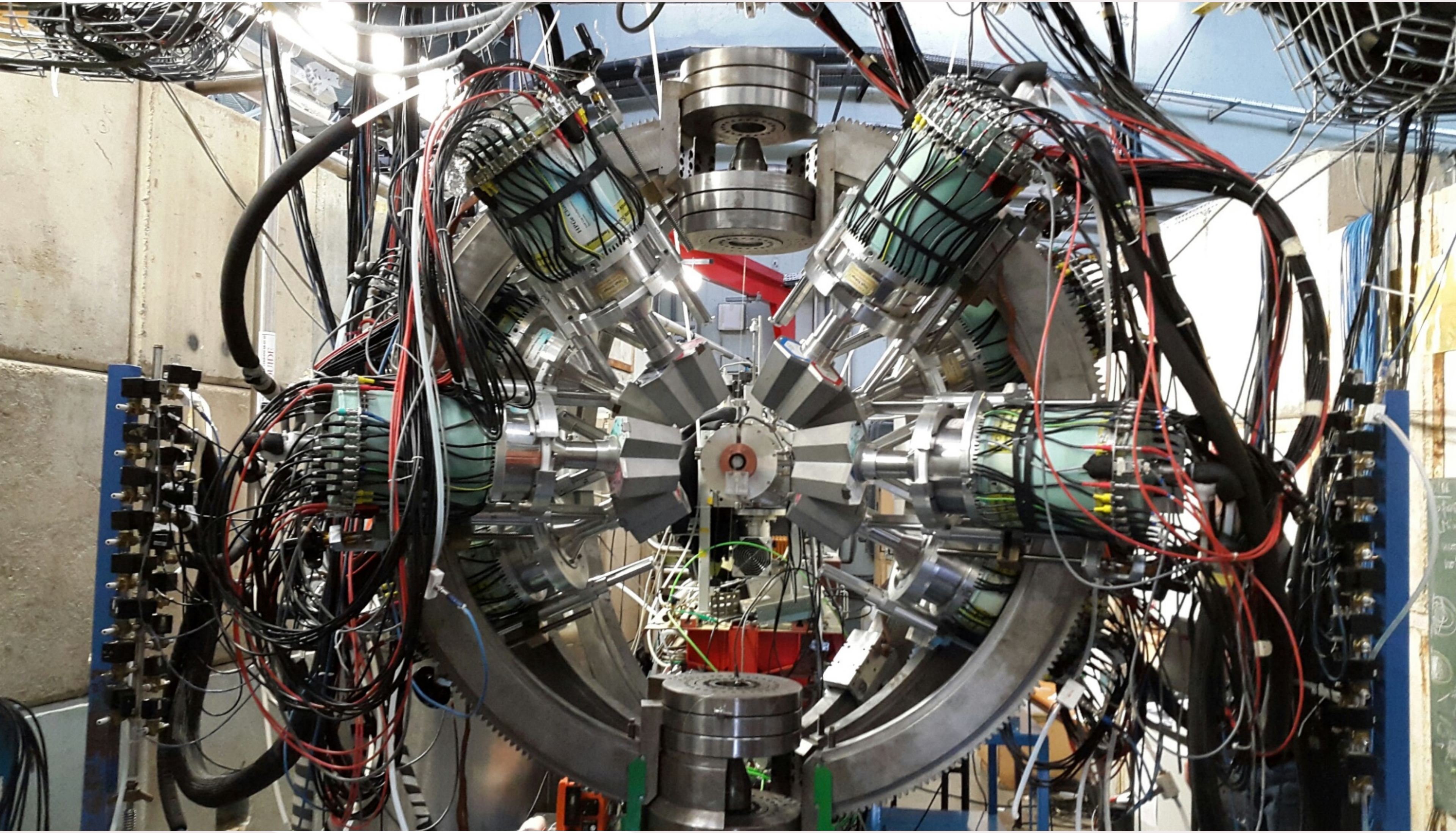
- Study of exotic nuclei at the moment of their formation
- COLD fission: no excessive evaporation of neutrons
- Relatively high spin states are accessible

Fast neutron induced fission ^{238}U(n,f), ^{232}Th(n,f)
(LICORNE, IPN Orsay)

n + ^{238}U

En ~ 1.5 MeV

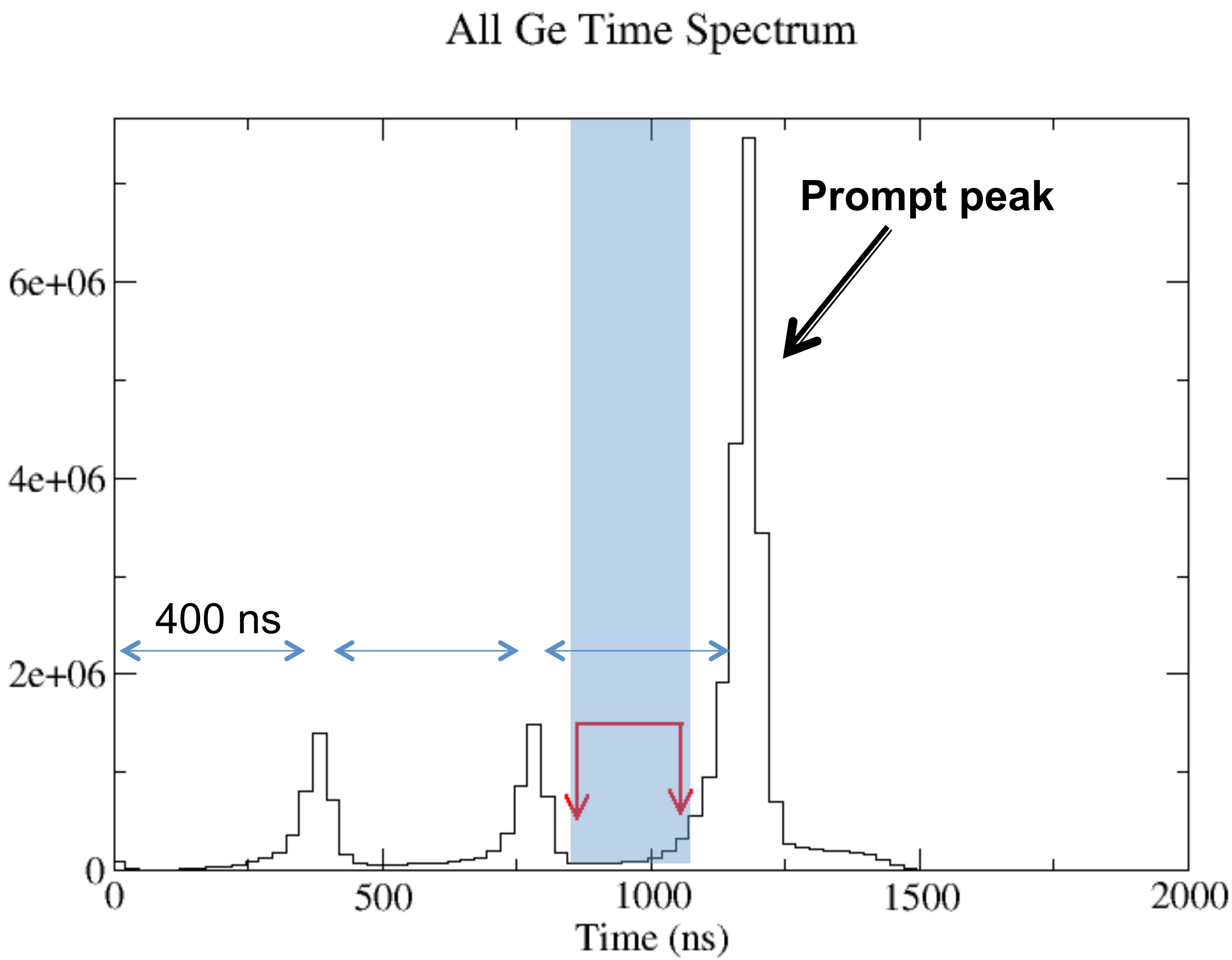
MINORCA + LICORNE EXPERIMENTAL SETUP



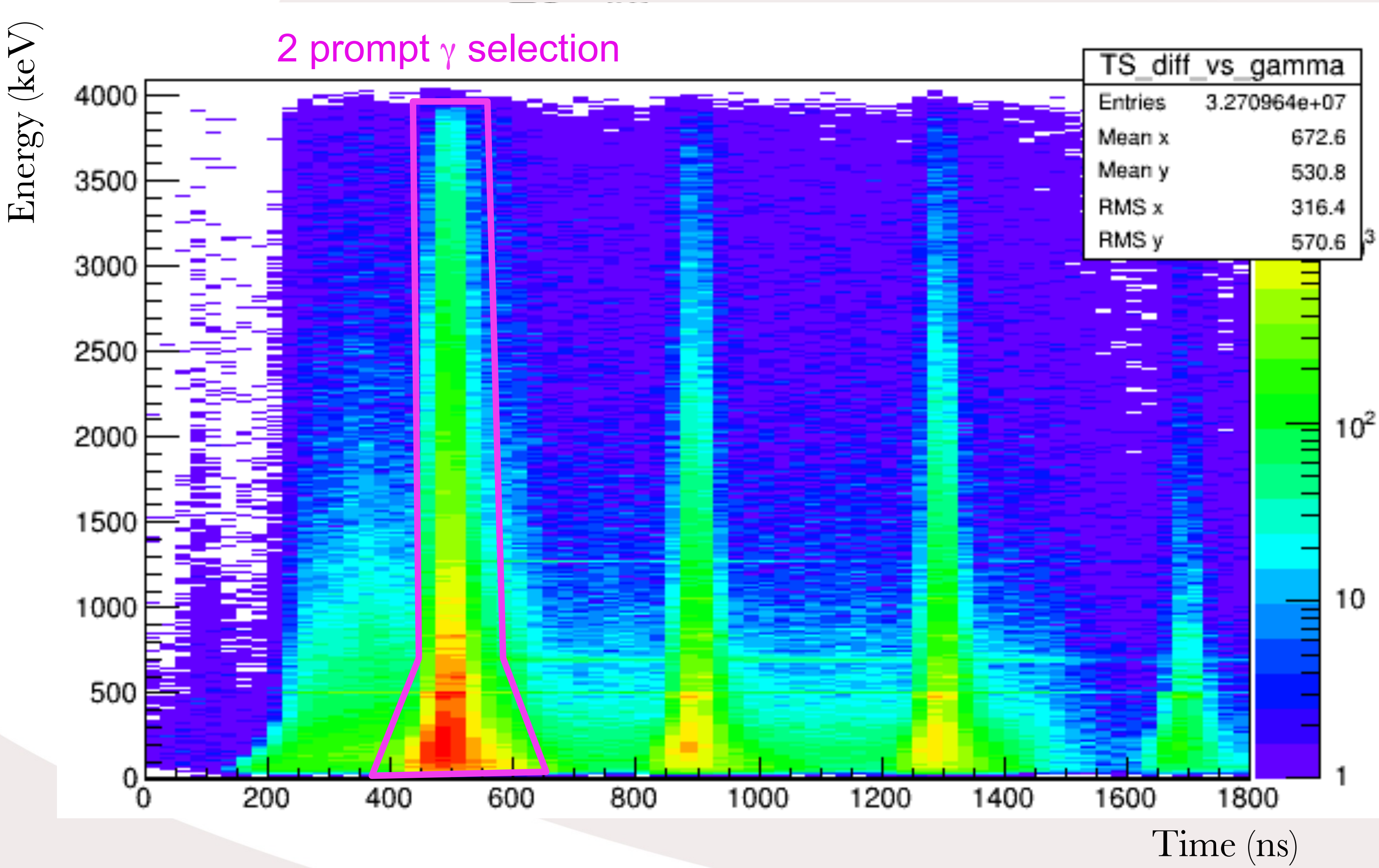
IPN
INSTITUT DE PHYSIQUE NUCLÉAIRE
ORSAY

MINORCA + LICORNE EXPERIMENTAL SETUP

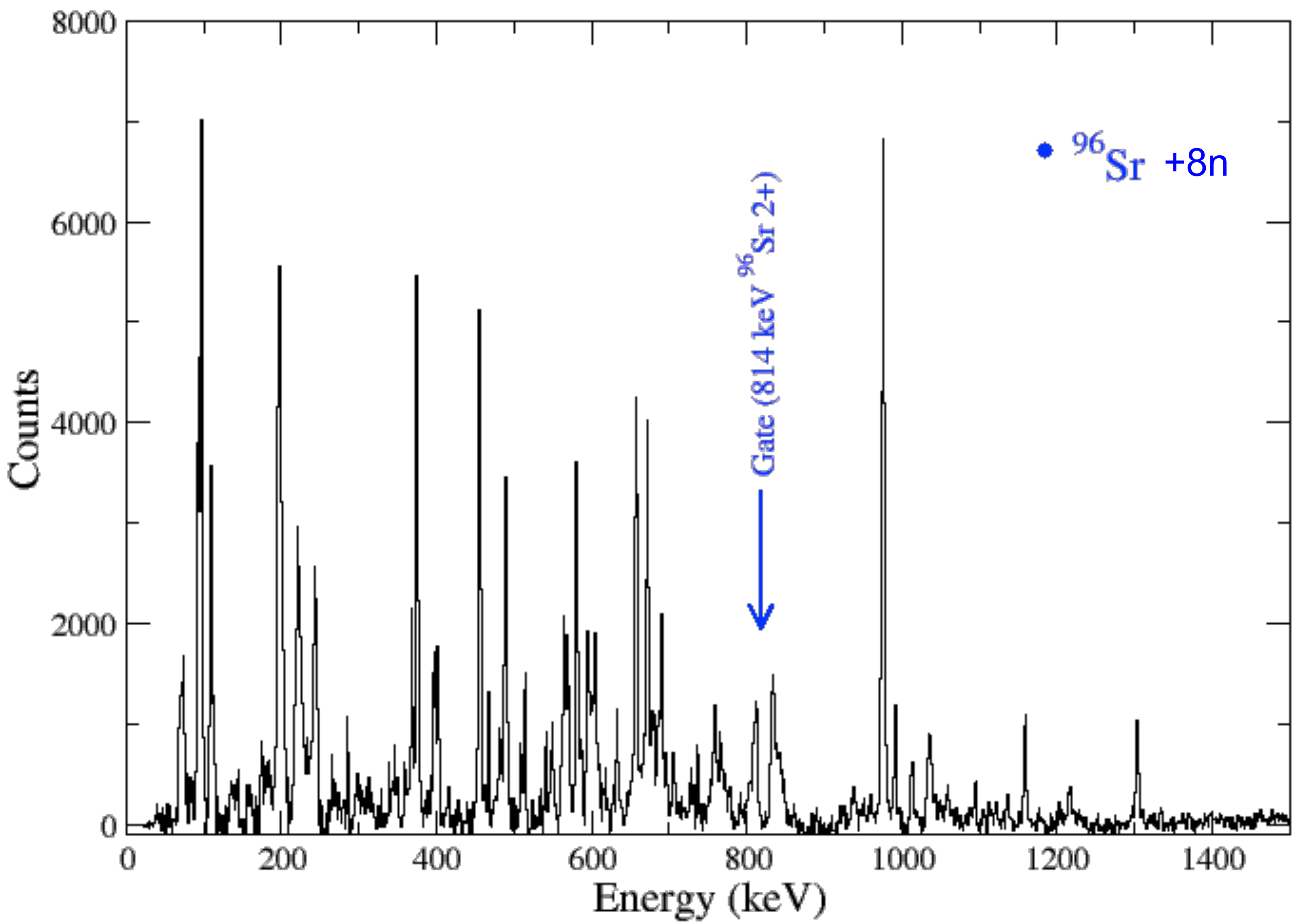
THE USE OF A PULSED NEUTRON BEAM



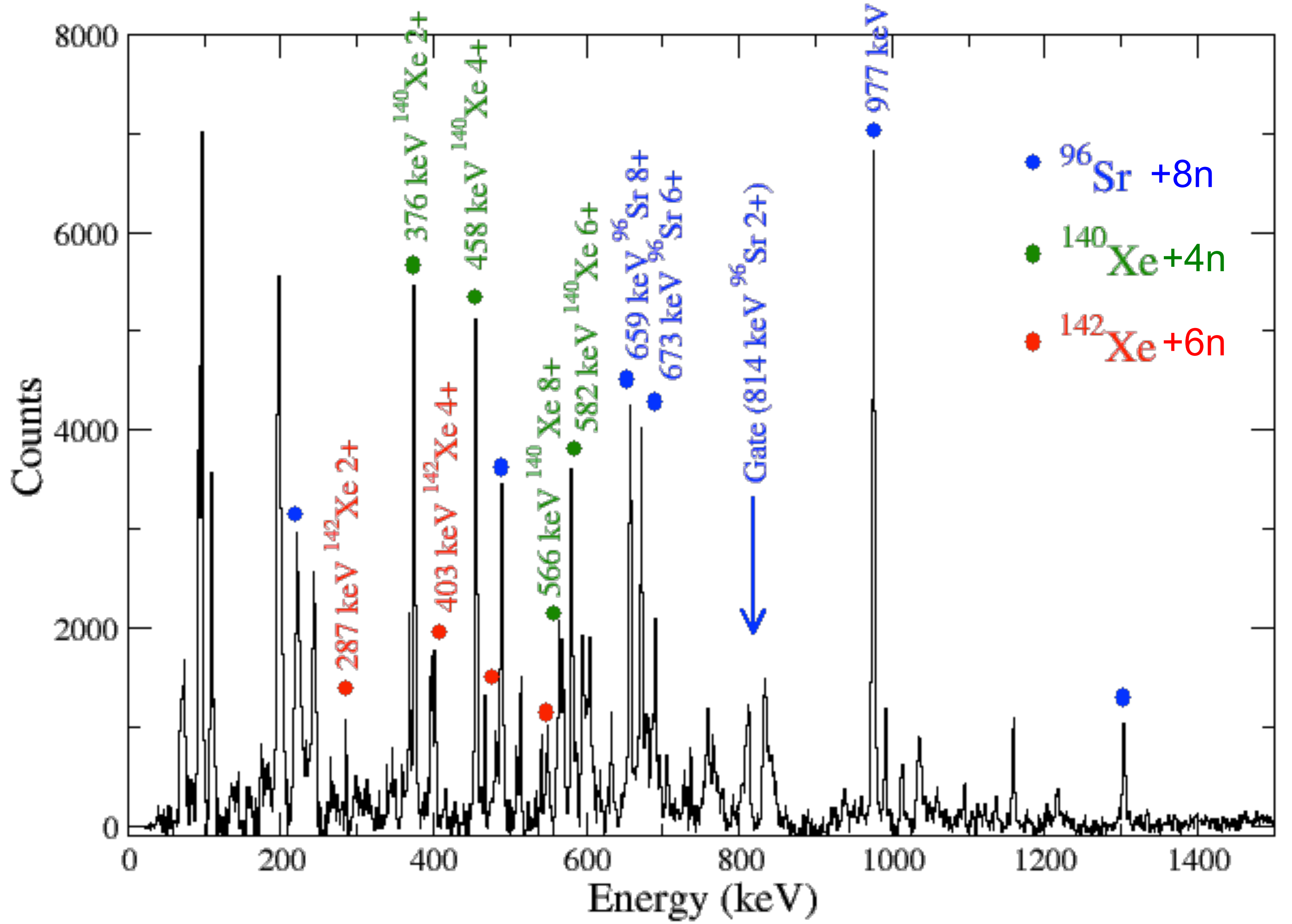
ONLINE TO PRELIMINARY RESULTS

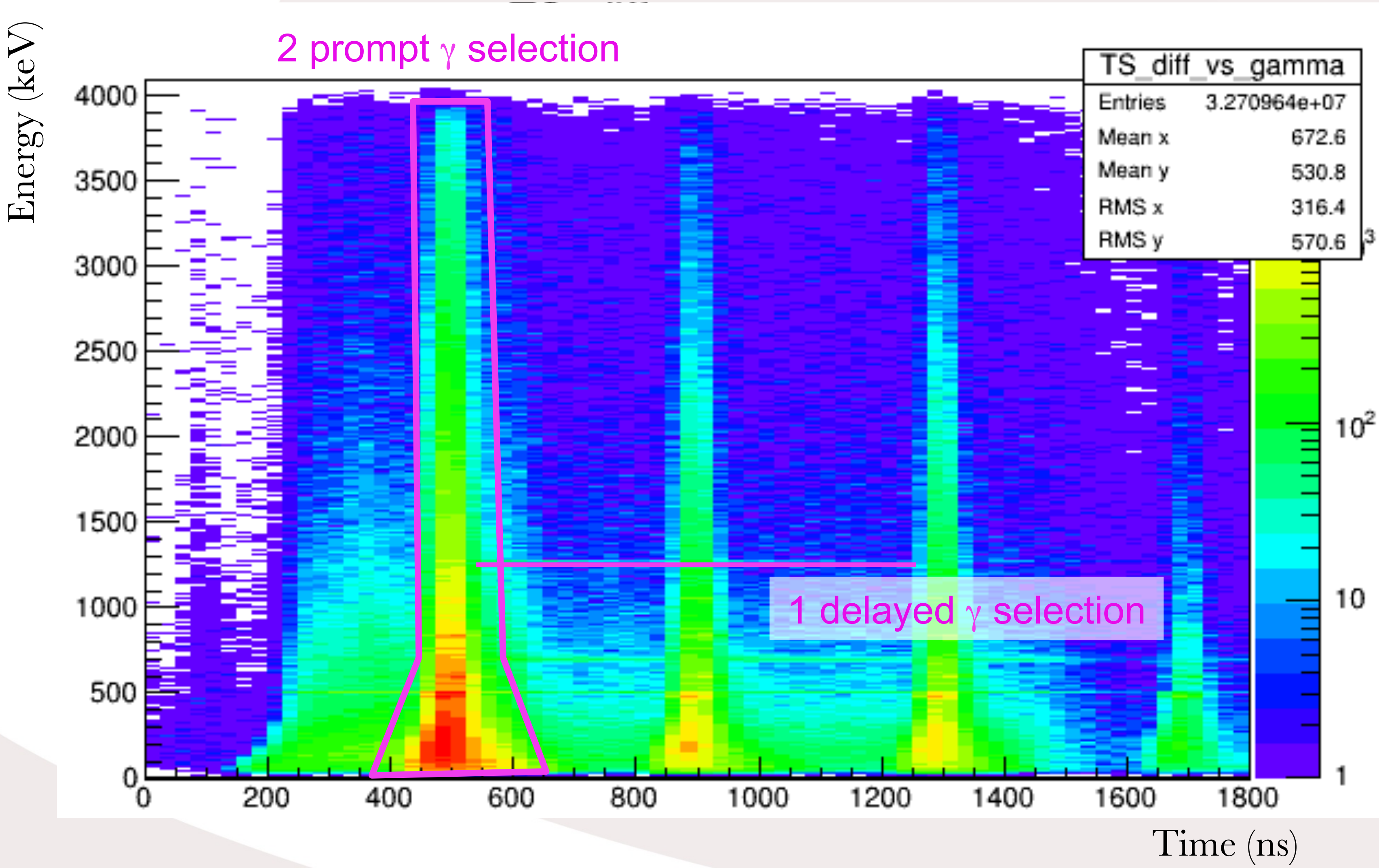


PROMPT-PROMPT GAMMA SPECTRUM



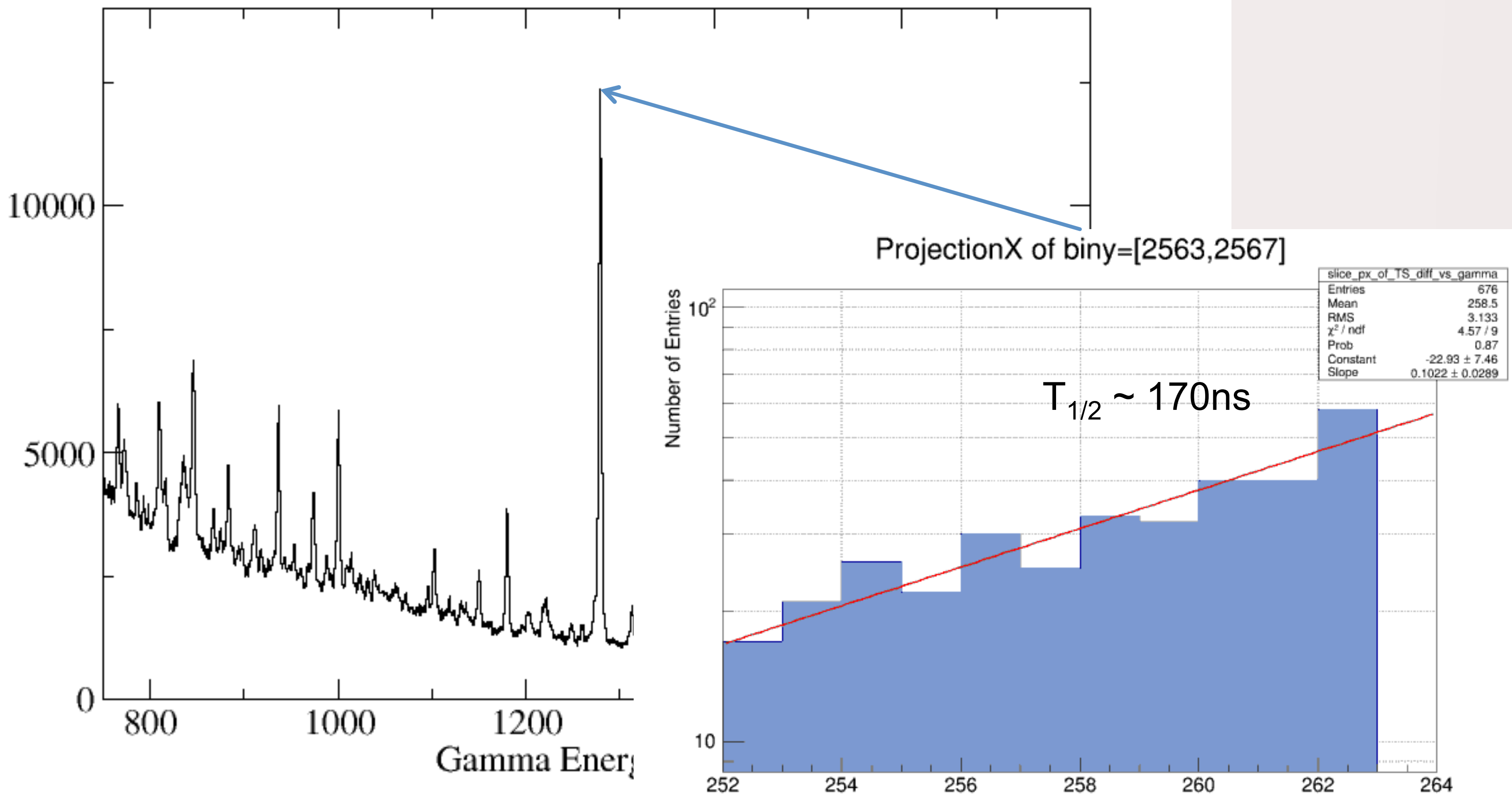
PROMPT-PROMPT GAMMA SPECTRUM




2 prompt γ selection
1 delayed γ selection
TS_diff_vs_gamma
Entries 3.270964e+07
Mean x 672.6
Mean y 530.8
RMS x 316.4
RMS y 570.6
Energy (keV)
Time (ns)
0
500
1000
1500
2000
2500
3000
3500
4000
0
200
400
600
800
1000
1200
1400
1600
1800
1
10
10^2

DELAYED GAMMA SPECTRUM

Delayed Time Gate : 100-350 ns

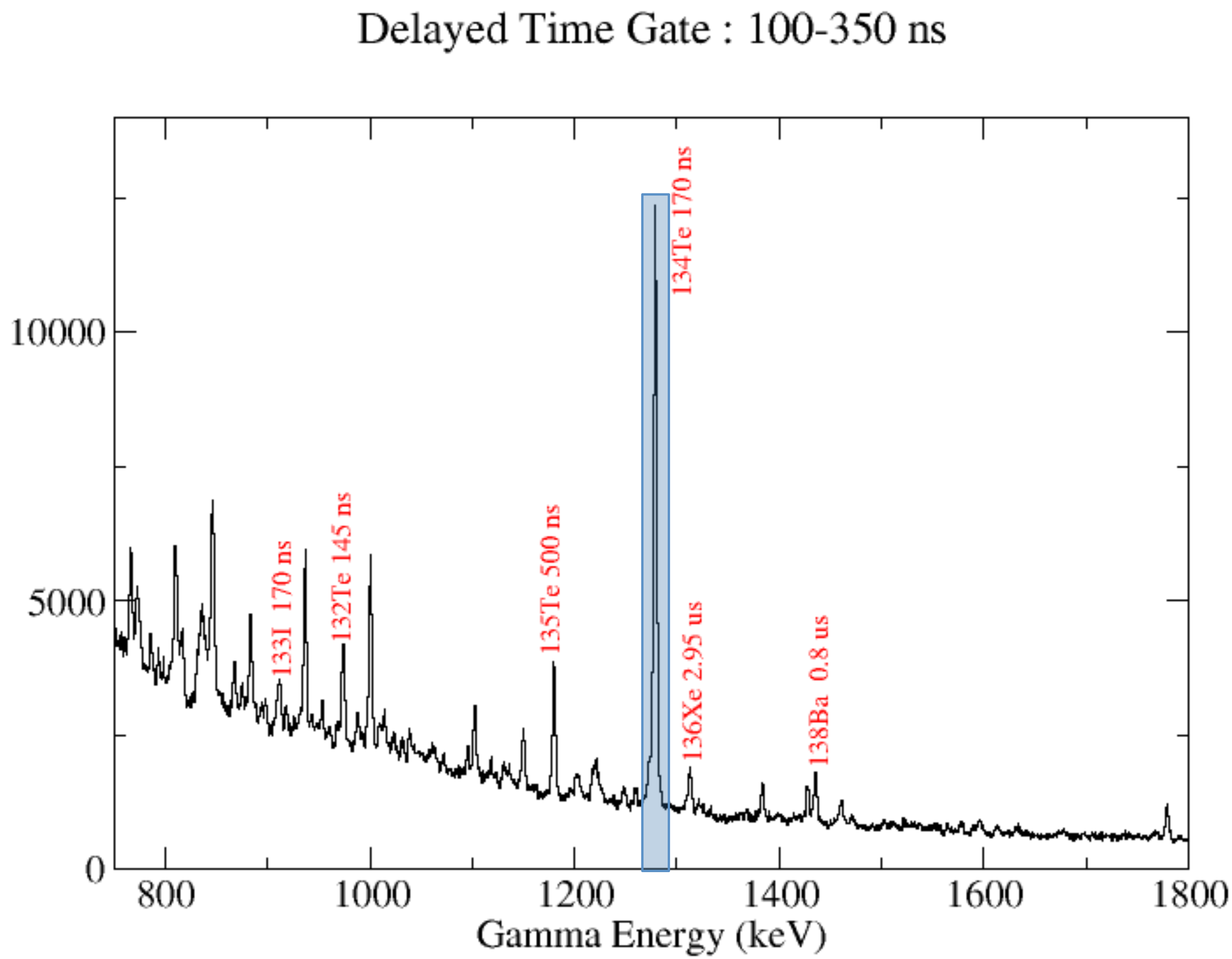


DELAYED GAMMA SPECTRUM

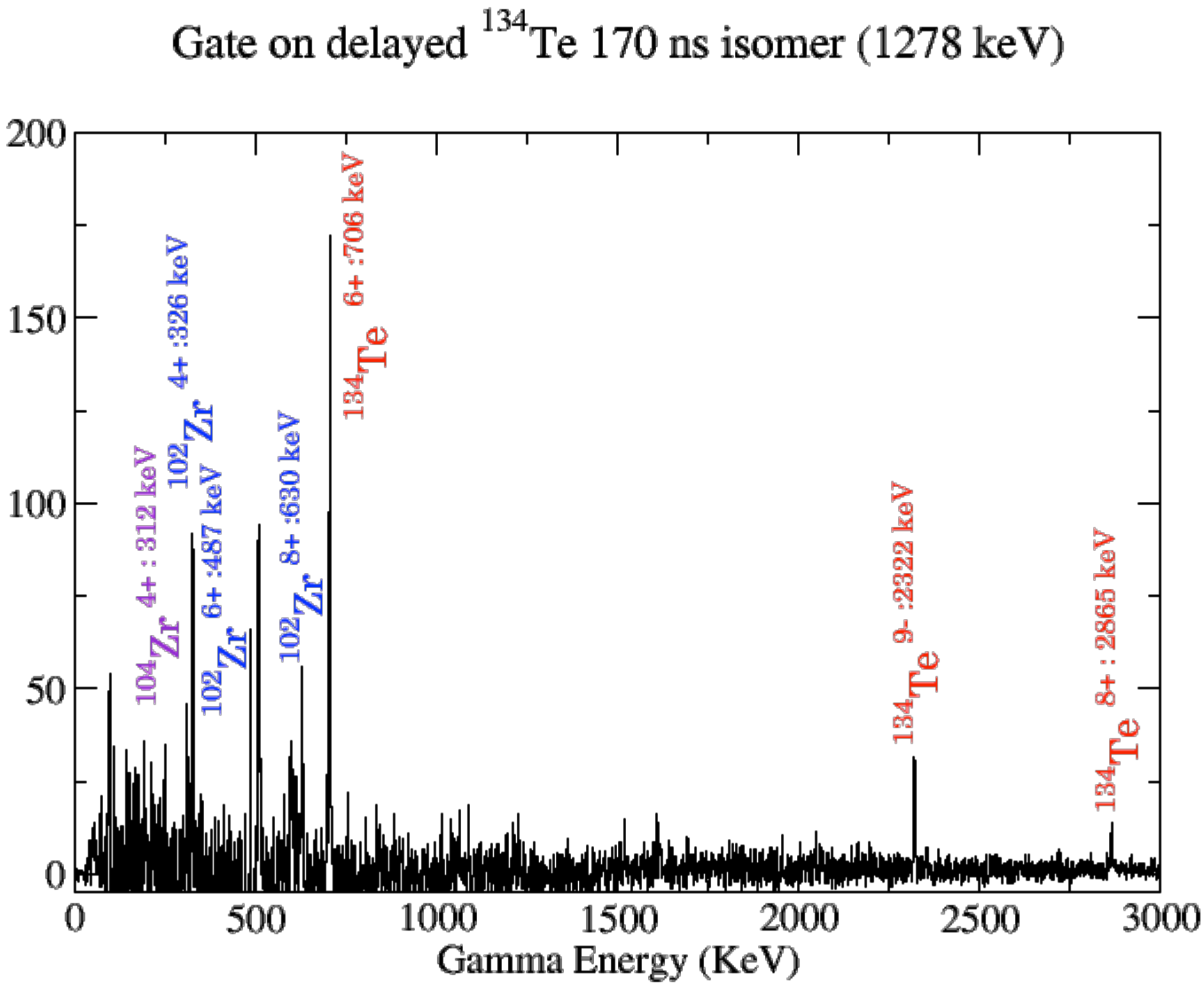
<u>Identified</u>:
^{130,132,134,135}Te
^{132}Sn
^{136}Xe

10 candidates not yet identified

^{130}Te → ^{106}Zr
^{107}Zr not known



PROMPT GAMMA SPECTRUM CONDITIONNED BY A DELAYED



ν-ball

A hybrid $LaBr_3$-Ge array for fast timing spectroscopic studies

at the IPN Orsay

- Detectors: ~20 Ge (Gamma pool + loan pool Orsay) and/or others (max ~64)
Minimum 36 LaBr3 guaranteed by FATIMA collaboration (max ~50)

- Mechanics: Use/fusion of exisiting mechanical structure(s) whenever possible

- Electronics: Needs investment in dedicated digital DAQ (fast timing + high energy resolution)
- Time Frame: First experiments mid-to-late 2016

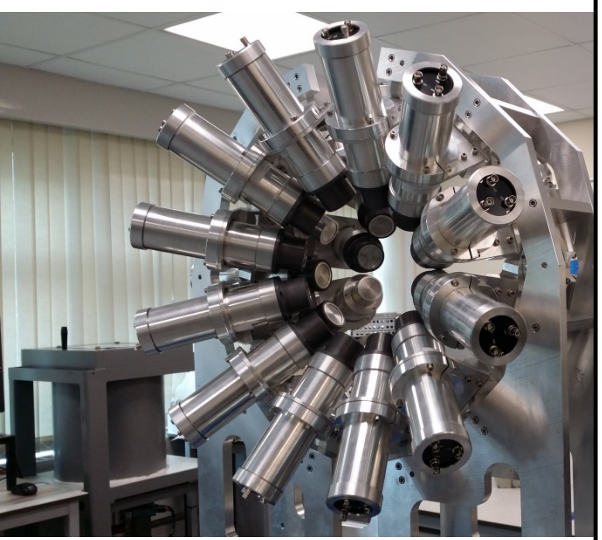
- Campaign Duration: ~6 Months

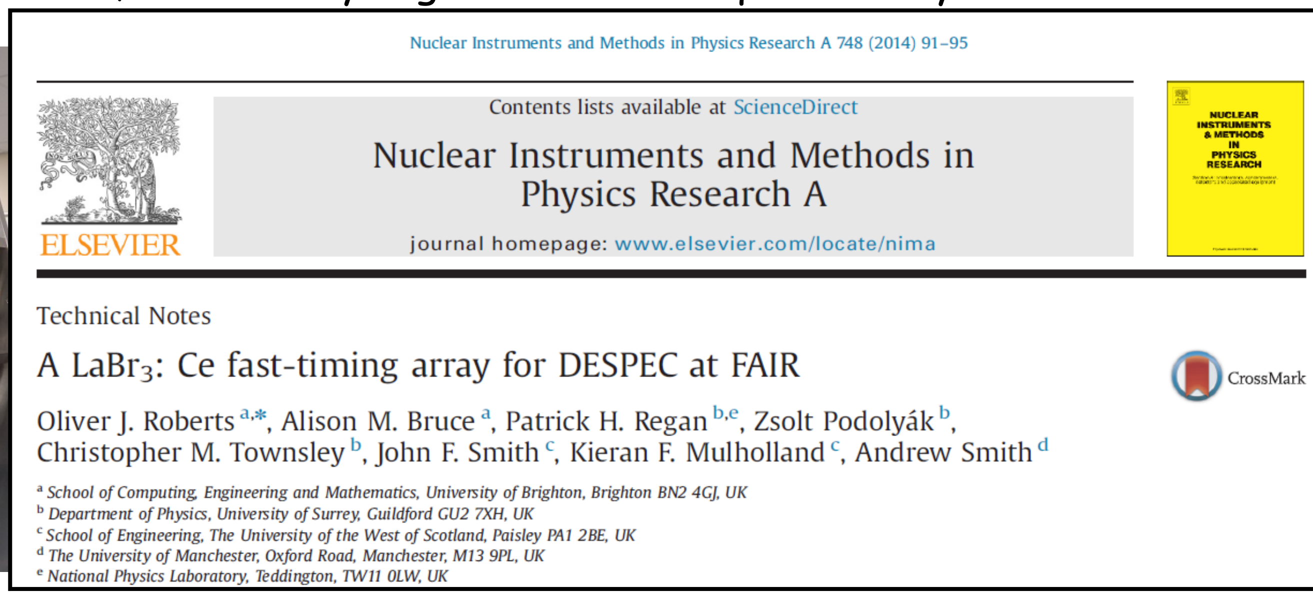
- Workshop(s) to be held in 2015 to discuss physics cases

The Future: FATIMA for DESPEC

- **FATIMA** = FAst TIMing Array = State of the art gamma-ray detection array for precision measurements of nuclear structure in the most exotic and rare nuclei. Part of the ~ £8M STFC NUSTAR project grant (runs 2012-16).
  - Good energy resolution (better than 3% at 1 MeV).
  - Good detection efficiency (between than 5% Full-energy peak at 1 MeV).
  - Excellent timing qualities (approaching 100 picoseconds).

- Use to measure lifetimes of excited nuclear states & provide precision tests of theories of nuclear structure, uses a fully-digitised Data Acquisition System.





Nuclear Instruments and Methods in Physics Research A 748 (2014) 91–95

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

ELSEVIER

Technical Notes

A $LaBr_3$: Ce fast-timing array for DESPEC at FAIR

Oliver J. Roberts [a,*], Alison M. Bruce [a], Patrick H. Regan [b,e], Zsolt Podolyák [b], Christopher M. Townsley [b], John F. Smith [c], Kieran F. Mulholland [c], Andrew Smith [d]

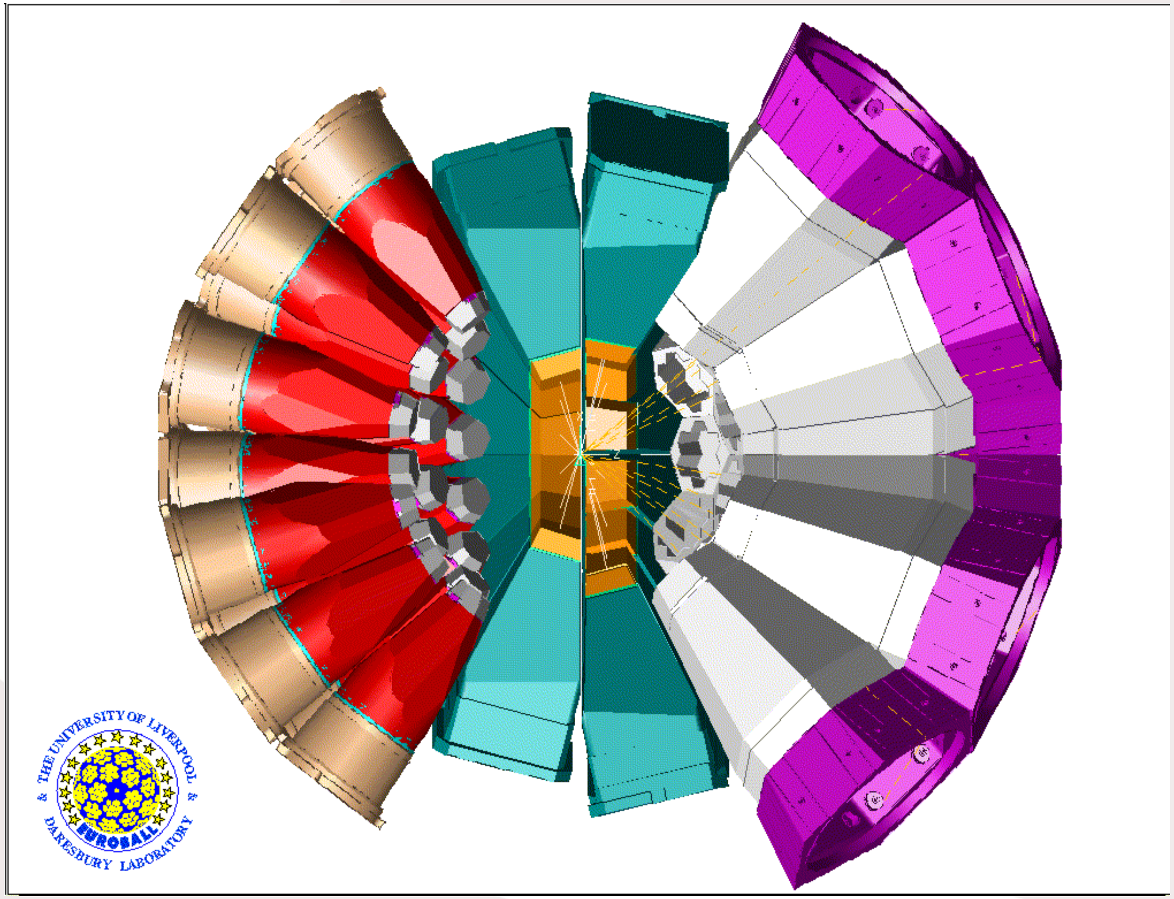
[a] School of Computing, Engineering and Mathematics, University of Brighton, Brighton BN2 4GJ, UK
[b] Department of Physics, University of Surrey, Guildford GU2 7XH, UK
[c] School of Engineering, The University of the West of Scotland, Paisley PA1 2BE, UK
[d] The University of Manchester, Oxford Road, Manchester, M13 9PL, UK
[e] National Physics Laboratory, Teddington, TW11 0LW, UK

- Collaboration with NPL (Radioactivity group) through NMO project on 'Nuclear Data' (Judge, Jerome, Regan et al.,) on parallel development of NPL-based array for use in traceable radioactive standards and traceability to the Bq.

JUROGAM CLOVERS + FATIMA

Coupling 24 JUROGAM Clovers and 33 FATIMA $LaBr_3$

- Access to short lived isomers (<100 ns)
- Detailed spectroscopy of very neutron rich nuclei



Neutrons, nuclear energy and the role of level densities and strength functions: *May LICORNE be of any help?*

Thank you

AVAILABLE FLUXES