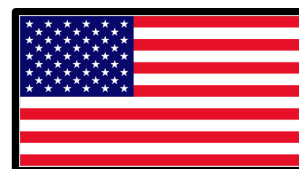
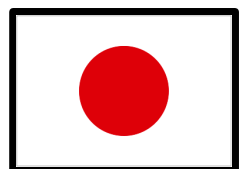


Neutron Electric Dipole Moment Search with a Spallation Ultracold Neutron Source at TRIUMF



Spokespeople: Y. Masuda (KEK), **J.W. Martin** (Winnipeg)

Collaborators: T. Adachi, K. Asahi, M. Barnes, **C. Bidinosti**, **J. Birchall**, **L. Buchmann**, **C. Davis**,
T. Dawson, J. Doornbos, **W. Falk**, **M. Gericke**, R. Golub, K. Hatanaka, S. Jeong,
S. Kawasaki, **A. Konaka**, **E. Korkmaz**, E. Korobkina, L. Lee, R. Mastumiya, K. Matsuta, M. Mihara,
A. Miller, **T. Momose**, W.D. Ramsay, **F. Retiere**, **S.A. Page**, H. Takahashi, K. Tanaka, I. Tanihata,
W.T.H. van Oers, Y. Watanabe

(KEK, Titech, **Winnipeg**, **Manitoba**, **TRIUMF**, NCSU,
RCNP, **UNBC**, **UBC**, Osaka)



* Canadian cosignatories and their institutes indicated in **bold**

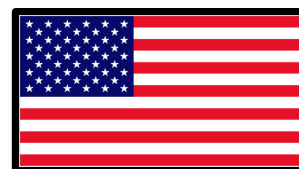
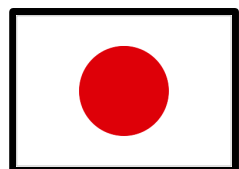
Ultracold Neutrons at TRIUMF

- Purpose of this talk:
 - Neither the CINF nor IPP briefs adequately addressed this project and its relative importance to science in Canada and worldwide.
- Major comment:
 - This is an interdisciplinary project, with several collaborators also doing applied research, that is not adequately represented by either CINF or IPP.

Comments on IPP Brief

- Broad-based support within NSERC-supported university groups in Canada
- CFI-supported labs support EDM experiment:
 - Very Low-field NMRI with Hyperpolarized Noble Gases Lab (UWpg, C. Bidinosti)
 - Centre for Research on Ultra-Cold Systems (UBC, T. Momose)
 - Subatomic Physics Det. Lab. (UWpg, J. Martin)
 - Development Lab. for New Particle Detector Tech. (UM, M. Gericke)
- CFI support from NIF program for UCN project (UWpg, J. Martin)

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IPP Brief

- Total of 34 collaborators with 13 NSERC cosignatories.
- There are *five* IPP members (brief states 3):
 - J. Martin, W.T.H. van Oers, A. Konaka, C.A. Miller, F. Retiere
- Major point: Interdisciplinary project not adequately represented by IPP (nor CINP).
- Collaborators in **nuclear physics, particle physics, atomic physics, medical imaging, chemistry**
- e.g. Polarized Xe program at U. Winnipeg (with C. Bidinosti)

CINP and IPP Briefs

- Correctly identified high scientific priority.
- But, international competitiveness not addressed.
- International Expert Review held at TRIUMF Sept 20-21, 2010, quote from committee report

“The committee strongly endorses the program and finds excellent potential for the group to contribute on a significant and competitive level to the worldwide efforts. The committee was impressed by the effort and creativity within the collaboration. The Japan-Canada UCN project has to be considered as an important research opportunity for KEK, RCNP, and TRIUMF, as well as for university collaborators to take on a leadership roll in an exciting research field.”

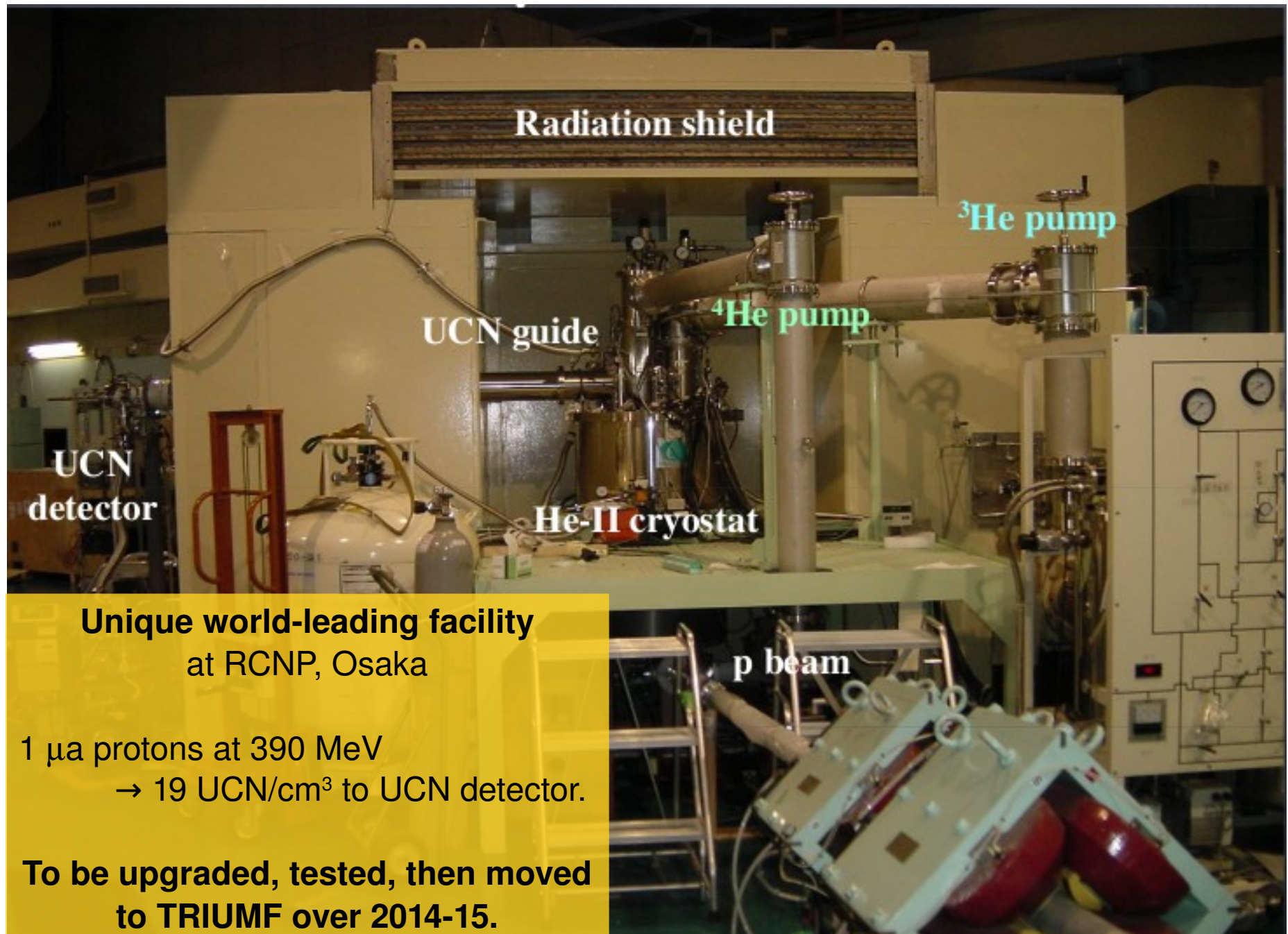
- Final mechanics of international MOU signing underway. (KEK-TRIUMF-RCNP-Winnipeg)

Complementarity

Project	H ₀ field	magnetometer	EDM cell	magnetic shielding
KEK / RCNP / TRIUMF	<i>spherical coil</i>	<i>¹²⁹Xe buffer gas co-magnetometer</i>	<i>small T = 300 K</i>	<i>finemet?/ superconductor</i>
Sussex / RAL / ILL	solenoid	n at E = 0 magnetometer	large T ~ 0.5 K	μ metal superconductor
SNS	cosθ coil	³ He co-magnetometer	large T ~ 0.5 K	μ metal superconductor
PSI	cosθ coil	Cs multi- magnetometer	large T = 300 K	μ metal

Major difference: + our UCN source is totally different.

Japan UCN Source (Masuda, et al)



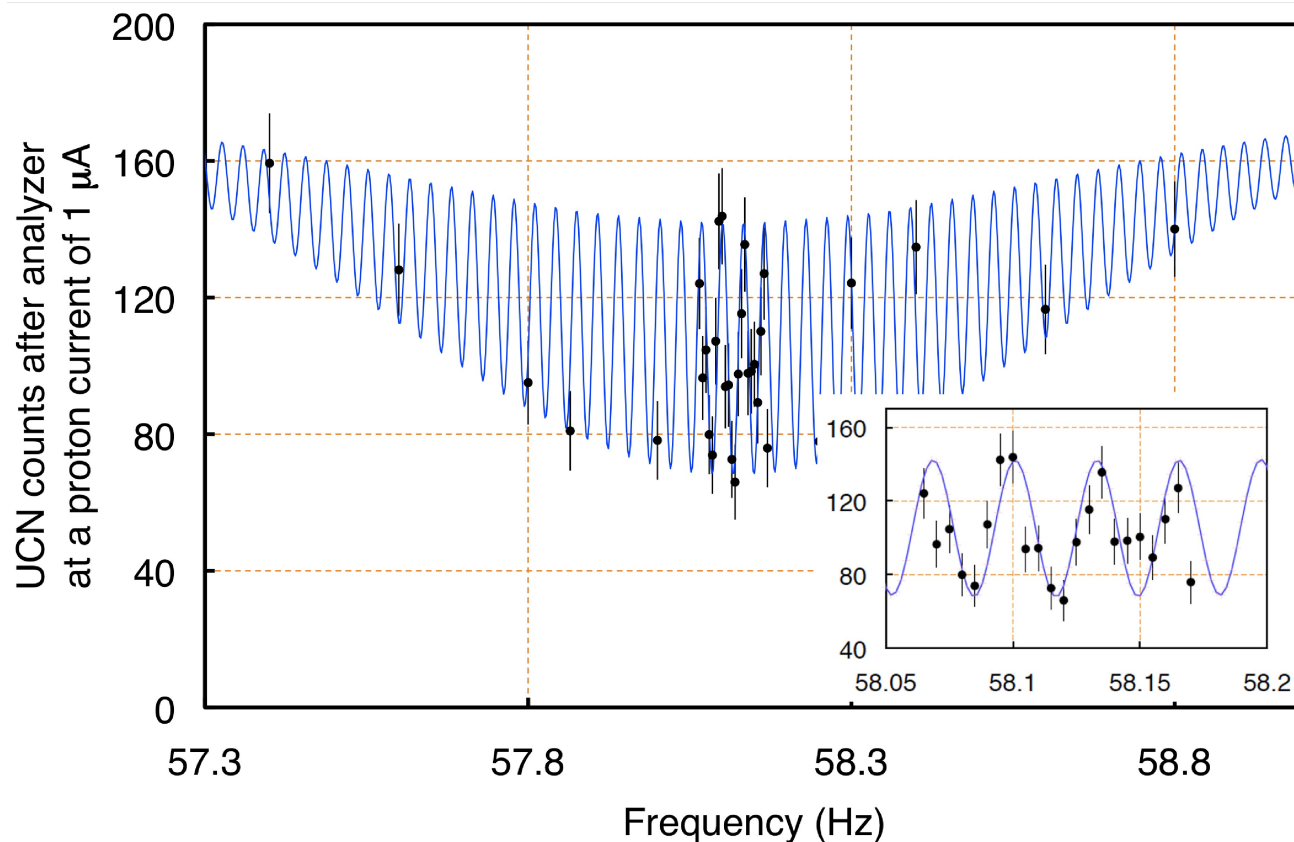
**Unique world-leading facility
at RCNP, Osaka**

1 μa protons at 390 MeV
→ 19 UCN/cm³ to UCN detector.

**To be upgraded, tested, then moved
to TRIUMF over 2014-15.**

Ramsey Resonance Results

Thank you G. Gwinner for putting our most impressive result in the CINP brief



Dec. 2009, achieved:

$$T_2 \sim 300 \text{ ms}$$

April 2010, achieved:

$$T_2 > 30 \text{ s !!!}$$

competitive with ILL/PSI,
where $T_2 = 120 \text{ s}$ (typ.)

Near state-of-the-art in low-field NMR!

- Successful demonstration of the basic technique behind precision EDM measurements.
- Improvements in field homogeneity, profile, magnitude, shielding for longer T_2 , Feb. 2011.

Comments on CINP Brief

- Referring to the executive summary, request:
Lead with the Science!
- Use the section headings (nuclear structure, nuclear astrophysics, fundamental symmetries, QCD) to explain the field.
- Identify the top questions for each and who is addressing them.
- Our project, for example, should be identified as one of three top EDM projects in fun. sym.
 - n-EDM, Rn-EDM, Fr-EDMeach with its own unique sensitivity.

Comment on CINP and IPP Briefs

- Failed to give explicit timelines linked to goals for our project. (Also speaks to competitiveness.)

Project Plan 2011 and beyond

Phase	Goals	Year
RCNP	T_2 to 130 s, HV	2011
	New source, improved UCN density	2011-12
	Horizontal EDM experiment, improvement of UCN density in EDM cell to 900 UCN/cm ³ , SC polarizer, precision Xe comagnetometry	2012-13
	In 20 days production running, $d_n < 1 \times 10^{-26}$ e-cm	2013-14
TRIUMF	Commissioning and first experiment with same setup.	2015-16
	Further improvements to magnetic shielding, (co)magnetometry, EDM cell, detectors, $d_n < 1 \times 10^{-27}$ e-cm	2016-17
	Improvements to cold moderator, magnetic shielding, beam current, targetry, remote handling, cryogenics, (co)magnetometry, $d_n < 1 \times 10^{-28}$ e-cm	2018-

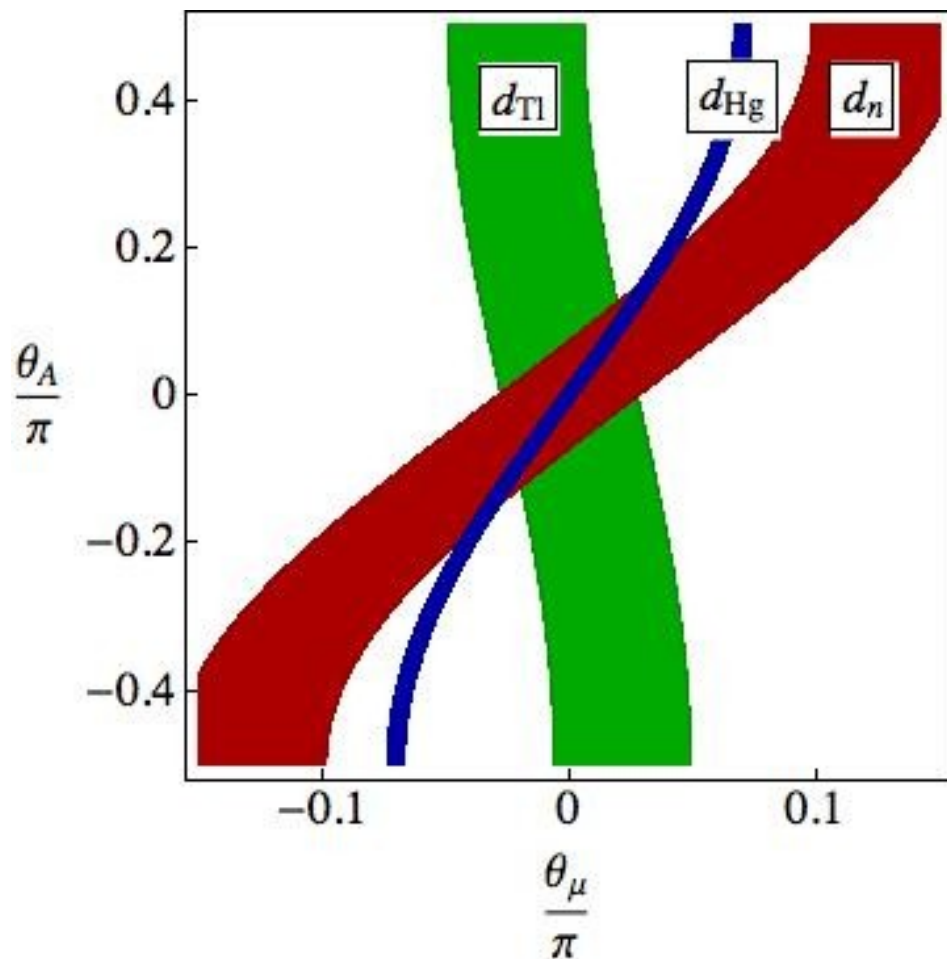
Other comments

- International aspects:
 - Major Japan-Canada collaboration building on successes of Japanese colleagues.
 - Half the financial support coming from Japan.
 - US collaborator
 - Bob Golub, UCN and EDM world-renowned expert.
 - Potential for large user base attracted to Canada.
 - Other physics experiments:
 - Gravity, nnbar, quantum optics, beta-decay.
- Theory support

Theory Relationships in Canada

Particle theory support for the program in Canada:

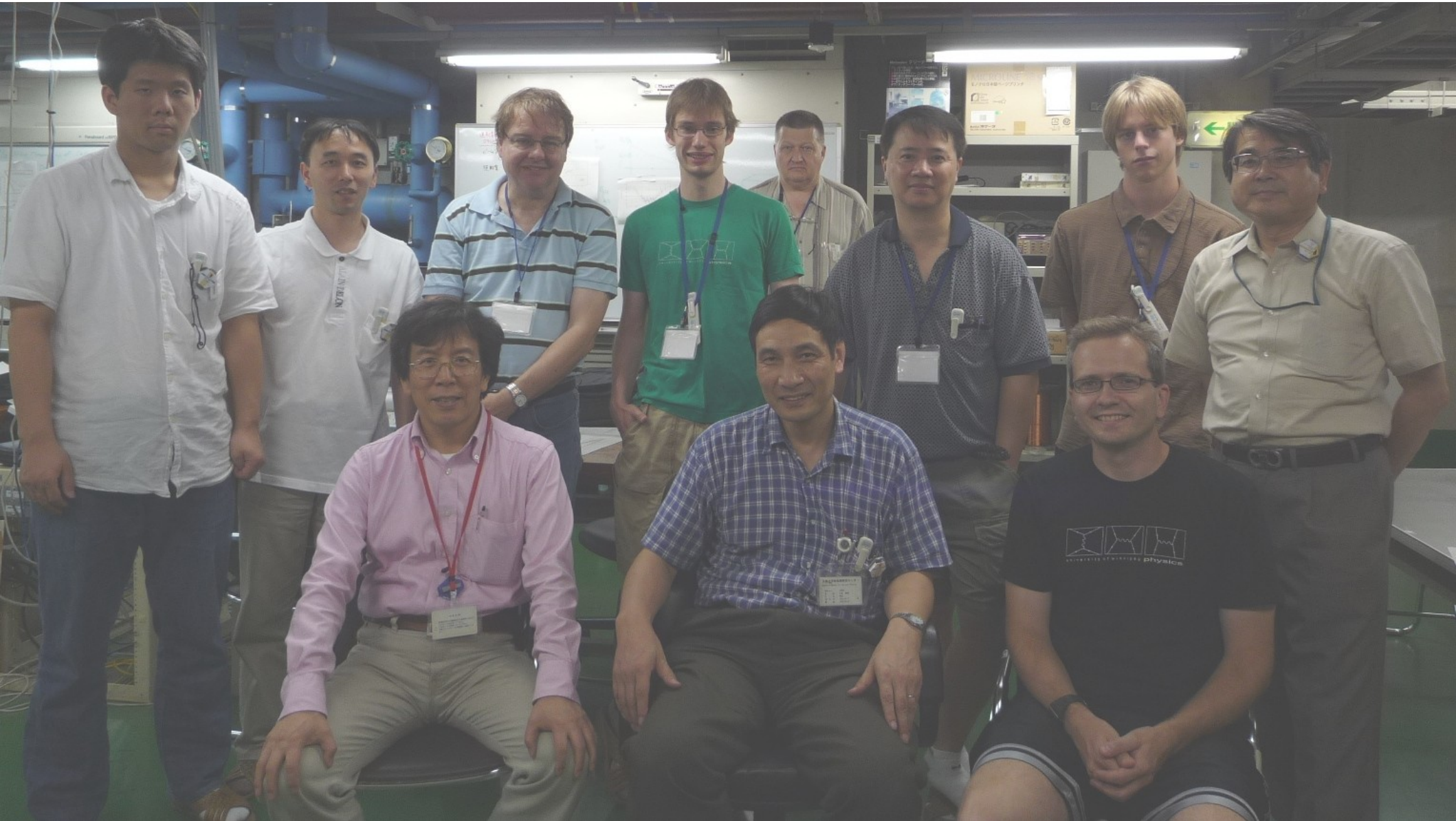
SUSY $M = 1$ TeV, $\tan\beta = 3$



A. Ritz, M. Pospelov (UVic)

Also, recent papers by
P. Winslow and J. Ng
(TRIUMF) on neutron-
antineutron oscillations

Thank you!



Osaka, July 2009.

Pictures

- Neither brief had many pictures of our project.
- So here are some from the Research Center for Nuclear Physics, Osaka University, Osaka, July 2009.

