1- Introduction/overview [Roberto]

Status before CRP

2- Experiments

(from experiments group meeting)

Actions:

- All: Produce complete list of experiments
- Capote: Provide preliminary files (x,y,dy) for all experiments/isotopes plus PDF of references on web site (Nov. 2013)
- Provide updated files (x,y,dy,dy1,dy2,…) (~June 2014)
- All: Provide draft Section to Roberto (June 2014)

- Isotopes of interest for full covariance analysis: U235all, Pu239all, U238, Th232
- Less important isotopes: U233

- Check EXFOR entries for description on uncertainty estimation

- Request missing documents (NK, RCN or VS)

- Detailed experiment description: emphasis on sources of systematic uncertainties
- Stability, detector thresholds, …

- Table with a list of: experimental details like detector type, flight path, time resolution, efficiency determination – either absolute or relative, fission trigger, sample characteristics, multiple scattering, angular information with respect to fission and neutron emission, bin-width correction, time resolution correction (?)

- Rejection of data sets? Include a recommendation in the table

- Assess uncertainties quantitatively
- Discuss inter-experiment correlation?

- Overview of on-going experiments provided by each group member
- Recommendations for future experiments.

- Guideline on Uncertainty Quantification from Denise (end of November 2013)
- Exchange of drafts
- All drafts to SO (mid February 2014)
- Homogenization of chapter (2) and submission to Denise by end of February 2014
- Exchange of opinion along March 2014
- Finalization of the document for submission
- Submission of document to Roberto (end of June 2014)

1. List of all experiments, isotopes used in this study [add tables]
    a. U235: thermal (6 data sets) ["standard"]
    b. Cf252sf: "standard"
    c. U235: all other energies
    d. Pu239: thermal, up to 3.5 MeV + Chatillon Einc=1-60 MeV
    e. U233: thermal, 0.5 MeV
    f. U238: all energies
    g. Th232: all energies
    h. Minor Actinides: EXFOR data list (Simakov)

Isotope	Incident Energy (MeV)	Source (EXFOR#, private comm., …)	First Author	Year	Outgoing Energy Range	UQ	Main Reference
U235	thermal						
	0.5						

2. Each (important!) isotope: table including sources of uncertainties, corrections, etc.
   - U235, thermal: Kornilov, Pronyaev (Neudecker)
   - U235, other energies: Kornilov
   - Cf252sf: not considered, taken from Mannhart
   - Pu239, thermal, 0.215, 0.5-3.5: Neudecker (appendix, LA-UR…) + Chatillon?
   - U233: Pronyaev, Vorobyev
   - U238: Oberstedt, Saxena
   - Th232: Saxena, Oberstedt
   - Minor actinides (just a list of data sets): IAEA

3. Overview of ongoing or planned future experiments: Chi-Nu (LANSCE), U238 (Bruyeres-le-Chatel; BARC, India; IRMM?), Cf252sf (Eout>8 MeV; Ohio U.); Cf252sf (IRMM, Chi-Nu?)

4. Recommendations for future experiments, future detectors, etc. Kornilov

5. Web repository of experimental data sets with uncertainty quantification. IAEA
   Common format for all experimental sets: (x,y,dy) to be used in comparison plots evaluations/experiments (see below).
   (Mention if bin-width correction taken into account or not.)

6. Uncertainty quantification of experiments: write-up on the UQ methodology used for Chi-Nu data (Neudecker)

3- Modeling

Actions:

- Capote:
  - Place fission fragment yields (Cf252sf, U235th, Pu239th, and Th232 at 2.0 MeV) on CRP web repository (ASAP)
  - Provide (web site) Nuclear Data Sheets template with agreed upon structure to be used for draft document (ASAP)
  - Write Section on "Two-Watt" model (with Kornilov) (March 2014)
- Kornilov:

    - Write FINE code description (~5 pages) (March 2014)
    - Compute U235th output for code inter-comparison (see below) (March 2014)
    - Perform "best" PFNS calculations for Cf252sf, U235th, Pu239th, Th232 (2.0 MeV) (June 2014)
- Ohsawa:
    - Write Los Alamos model Section (March 2014)
    - Perform "best" PFNS calculations for Cf252sf, U235th, Pu239th, Th232 (2.0 MeV) (June 2014)
- Schmidt:
    - Provide Th232 FF Yields at 2.0 MeV from GEF code (ASAP)
    - Write Section 1 draft (can we use what he already sent?) (March 2014)
    - Write GEF code description (~5 pages) (March 2014)
    - Compute U235th output for code inter-comparison (see below) (March 2014)
    - Perform "best" PFNS calculations for Cf252sf, U235th, Pu239th, Th232 (2.0 MeV) (June 2014)
- Serot:
    - Provide FF Yields from FIFRELIN for Cf252sf, U235th, Pu239th (ASAP)
    - Write FIFRELIN code description (~5 pages) (March 2014)
    - Compute U235th output for code inter-comparison (see below) (March 2014)
    - Perform "best" PFNS calculations for Cf252sf, U235th, Pu239th, Th232 (2.0 MeV) (June 2014)
- Shu:
    - Write Section on Semi-Empirical Model (March 2014)
    - Compute U235th output for code inter-comparison (see below) (March 2014)
    - Perform "best" PFNS calculations for Cf252sf and U235th (June 2014)
- Talou:
    - Provide FF Yields format template & write README (ASAP)
    - Provide FF Yields from CGMF for Cf252sf, U235th, Pu239th (ASAP)
    - Provide script to project FF Yields in Y(A), Y(TKE) and <TKE>(A) (ASAP)
    - Write CGMF code description (~5 pages) (March 2014)
    - Write Introduction/Technical Framework to Monte Carlo codes (March 2014)
    - Compute U235th output for code inter-comparison (see below) (March 2014)
    - Collect all U235th results from code inter-comparisons and prepare tables/plots (April 2014)
    - Perform "best" PFNS calculations for Cf252sf, U235th, Pu239th, Th232 (2.0 MeV) (June 2014)

- Tudora:
  - Provide FF Yields for Cf252sf, U235th, Pu239th (ASAP)
  - Write PbP Section (March 2014)
  - Compute U235th output for code inter-comparison (see below) (March 2014)
  - Perform "best" PFNS calculations for Cf252sf, U235th, Pu239th, Th232 (2.0 MeV) (June 2014)
- Vogt:
  - Provide FF Yields for Cf252sf, U235th, Pu239th (ASAP)
  - Write FREYA code description (~5 pages) (March 2014)
  - Compute U235th output for code inter-comparison (see below) (March 2014)
  - Perform "best" PFNS calculations for Cf252sf, U235th, Pu239th, Th232 (2.0 MeV) (June 2014)
-

*To be covered in **each model section**: physics assumptions, input data & model parameters, output data, sensitivity of calculated results to input data and model parameters. Calculations of selected spectra (Cf252sf, U235th, Pu239th).*

1. Physics of nuclear fission starting near scission point, Schmidt (draft manuscript as starting point)
   a. Fission fragment yields (A,Z,TKE) – web repository with yield data, Talou (provide scripts for projected distributions), Capote
   b. Emissions from fully accelerated fragments, during the acceleration of fragments, at scission, before scission
   c. Neutron-gamma competition
   d. Excitation energy partitioning
   e. Angular momentum in the fragments
   f. Nuclear structure and level density of neutron-rich nuclei
   g.
2. Los Alamos model, Ohsawa
   a. "Original"—main assumptions, input, output (average spectrum & multiplicity)
   b. Newer developments: anisotropy, different temperatures, multi-modal fission, different multiplicities, …
3. Point-by-Point, Tudora
   a. Based on Los Alamos model for each fragment pair
   b. Properties: level density, TXE partitioning, P(T) residual distribution, …
4. SEM, Shu
5. Two-Watt "model" (Minsk library), Kornilov, Capote

6. Monte Carlo
    a. Technical framework (introduction to MC codes)
        i. Sampling fission fragment yields (comparisons between different distributions)
        ii. Sampling gamma and neutron emission probabilities
        iii. ...
    b. Codes
        i. GEF, Schmidt
        ii. FREYA, Vogt
        iii. FIFRELIN, Serot
        iv. CGMF, Talou
        v. FINE, Kornilov
    c. Code inter-comparison *(Use GEF FF yields of U235th)*
        i. PFNS, <ν>, P(ν), <Ecm>, <Elab>, <ν>(TKE), <ν>(A) , ang. dist. n-LF
        ii. Same for prompt gammas
7. Inter-comparison of "best" PFNS calculated by all models
    a. Cf252sf, U235th, Pu239th
    b. Th232 (2.0 MeV, yields to be provided by Schmidt or/and Tudora)
    c. U238 and Th232 at 7.0 and 14 MeV

4- Evaluations (spectrum + covariances)

Actions:

- Talou: Provide updated evaluations U and Pu isotopes (normalization problem; naming convention) (ASAP)
- Shu: Provide U235 evaluation in ENDF format (1st-chance fission) (Nov. 2013)
- Capote: Provide selected files from Minsk library (Nov. 2013)
- Morillon: Provide BRC evaluated files (Nov. 2013)
- Tudora: Provide Np237 evaluation file (Nov. 2013)
- Tudora: Provide LA model input parameters to LANL (done!)
- Vogt: Provide U235 and Pu239 evaluations (Nov. 2013)
- Talou: Provide new U235 and Pu239 evaluations (June 2014)
- Pronyaev: Provide new U235th based on experimental data (June 2014)
- Talou: Provide script to produce plots experiments vs. given model calculation (Dec. 2013)
- Talou/Capote: write introduction on "Evaluation Methodologies" (Dec.2013)
- Capote: Collect all (All) descriptions of evaluated files to include in final document (Feb. 2014)
-

1. Evaluation Methodologies: Capote, Kornilov, Neudecker, Morillon, Shu, Talou, Tudora, Vogt
    a. "Only" (differential) experimental data (Cf252sf, U235th)
    b. Experimental data + model calculations
        i. Manual tuning of parameters
        ii. Generalized Least-Squares search of best parameters
        iii. Monte Carlo sampling of parameters
    c. Uncertainty Quantification
        i. Experimental Uncertainties & Correlations
        ii. Model parameters Uncertainties & Correlations
        iii. Model limitations
    d. Description of each ENDF file containing evaluation methodology details (to be given for each ENDF evaluation)

2. ENDF files available (to be placed on repository- IAEA): (Nov. 2013)
    a. U235th, Kornilov (MF5,MT18)
    b. U235th, Shu (MF5, MT18)
    c. Minsk actinides, Capote, 0-20 MeV (MF5,MT18)
    d. U232-240 (thermal-5.0MeV), Talou (MF5,MT18 + MF35,MT18)
    e. Pu isotopes (thermal-5.0 MeV), Talou (MF5,MT18 + MF35,MT18)
    f. U233,234, (thermal-20MeV), Tudora (MF5,MT18)
    g. Th232, (thermal-20MeV), Tudora (MF5,MT18)
    h. Np237, (thermal-20MeV), Tudora (MF5,MT18)
    i. BRC actinides: U235, U238, Pu239, Pu240 (thermal-20MeV) Morillon (MF5,MT18)
3. To be done within CRP
    a. Tudora to provide LANL with LA model parameters for U233, U234, Th232, Np237 (1^{st}-chance fission) to compute MF35,MT18 (Tudora, Neudecker, Talou)
    b. Complete U235 and Pu239, all energies (Talou)
    c. U and Pu PFNS evaluations to be re-normalized below 5 MeV (Talou)
    d. Pu239, U235, thermal-20 MeV (Vogt)
4. Summary table & plots
    a. Average outgoing energies as function of incident energy
    b. Plots of each evaluation vs. experimental data sets (write script, Talou, Tudora)
    c. Plots of comparisons of evaluations
    d.

5- Data Testing

ENDF evaluations provided in Nov. 2013 (see Section 4.2 above) to be used for benchmark calculations. Spectrum-average cross section calculations to be performed later on.

Actions:

- All: Establish list of benchmarks (done!) & (Capote) place on web site (ASAP)
- Capote: Provide updated list of reaction rate values on web site (Nov.2013)
- Capote: Provide reaction rate calculations (April 2014)
- All: Provide benchmark results from common list to Roberto (April 2014)
- All: Write benchmark testing Section in paper (May 2014)
- Capote: Write SPA Section in paper (May 2014)
- Talou: Provide NUEX data and documentation from Lestone (Nov. 2013)
- Talou: Provide updated NUEX results with updated evaluations (ask Lestone)

1. Criticality benchmarks, Kodeli, Morillon, Manturov, Serot
    a. Establish list of benchmarks
2. β–eff benchmarks, Kodeli
    a. Establish list of benchmarks
3. Reaction rates (IRDFF + revised values) Capote, Talou (Kahler), Kodeli
    a. Establish updated list of reaction rate values for criticality assemblies (CIELO paper), Capote
    b. Perform reaction rate calculations with other evaluated PFNS (thermal, 0.5 MeV, 14 MeV)—no experiments. Capote
4. NUEX data, Talou (Lestone)

(from benchmark group meeting)

COMMON AND OPTIONAL BENCHMARK LIST

COMMON BENCHMARK LIST

FAST

Pu-239:

- Jezebel (PU-MET-FAST-001): bare sphere of 95 at.% Pu-239 metal, 4.5 at.% Pu-240, 6.385-cm radius
- Popsy (PU-MET-FAST-006): about 20-cm natural U reflected 94 wt.% Pu-239 sphere, 4.533-cm radius;

U-233:

- Skidoo (U233-MET-FAST-001): bare about 98.1 % U-233 sphere, 5.983-cm radius;
- Flat-top 23 (U233-MET-FAST-006): about 20-cm natural U reflected 98 at.% U-233 sphere, 4.2-cm radius;

U-235:

- Topsy (HEU-MET-FAST-028): about 20-cm natural U reflected 93 wt.% U-235 sphere, 6.116-cm radius;
- Godiva (HEU-MET-FAST-001)

U-238:

- Bigten (IEU-MET-FAST-007): cylinder of 10% enriched U with depleted U-reflector, radius 41.91-cm, height 96.428-cm.

OPTIONAL BENCHMARK LIST

FAST

- ZPPR-9 (ZPPR-LMFR-EXP-002): cylindrical 2-zone, MOX core with Na cooling and depleted U blanket;
- SNEAK-7A and -7B (SNEAK-LMFR-EXP-001): MOX fuel reflected by metallic depleted uranium.

THERMAL

Pu-239:

- PU-SOLUTION-THERMAL-004
- PU-SOLUTION-THERMAL-005

U-235:

- HEU-SOLUTION-THERMAL-001
- HEU-SOLUTION-THERMAL-002

6- Open Questions

- Cf252sf: need for new measurements? Valid at all outgoing energies? Relevance to other isotope measurements
- Kornilov, U235, 0.5 MeV: IRMM data not understood yet
- Kornilov, Discussion on the model assumptions regarding neutron emission process
- Kornilov, Integral data vs. microscopic data
- Kornilov, …

- Open questions on how to combine experimental data and model calculations, including covariance matrices
- Recommendations for specific new measurements
- …

7- Conclusions/Discussion

- Note that all PFNS measurements are considered as shape measurements for evaluation purposes
- Make link with the need for a higher energy reference neutron field

Actions:

- Capote, Ask Nuclear Data Sheets for publication in Special Issue (Jan. 2016)