Experimental Information Required for R-matrix Analysis

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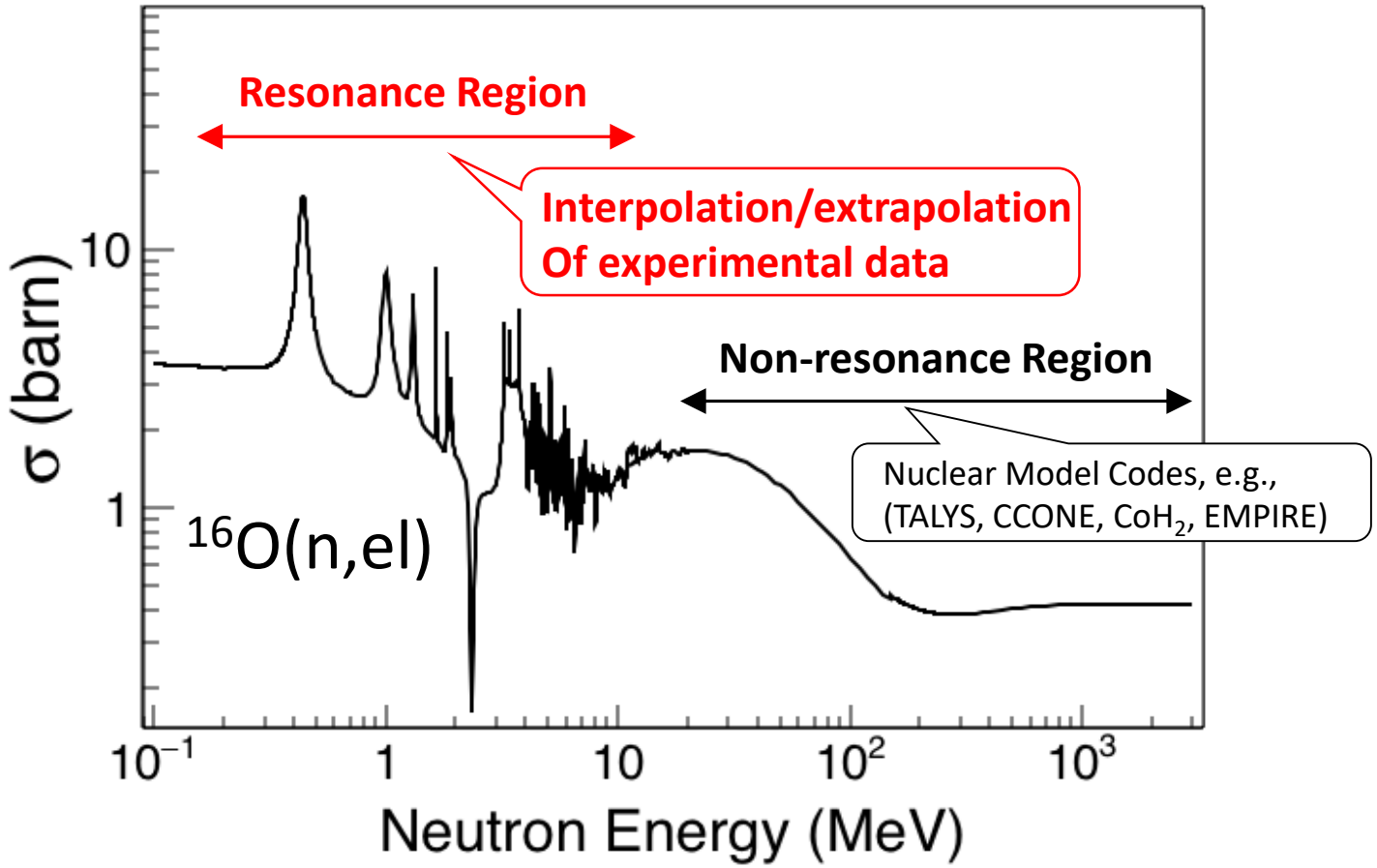
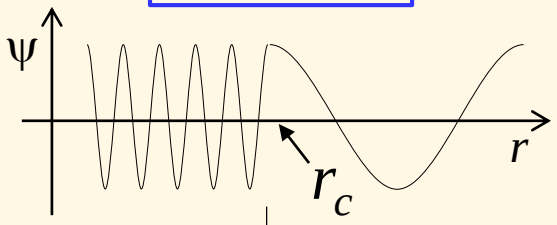
Resonant Cross-sections



Experimental data is definitely necessary for evaluation of resonant cross-sections !

What is R-matrix ? (Cont.)

R-matrix

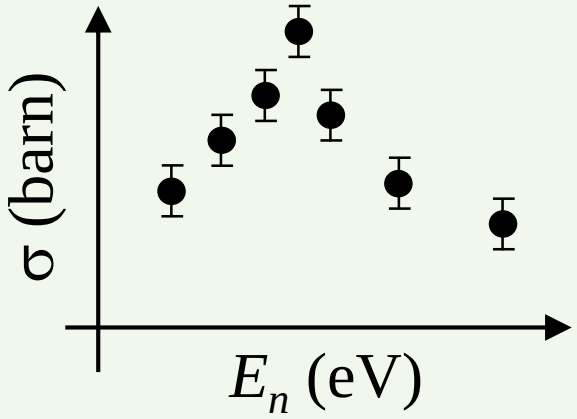


Internal (X) ↔ External (φ)

Reduced-width amplitude $\gamma_c \sim \int \varphi_c^* X_c dS$

+

Experimental C.S.

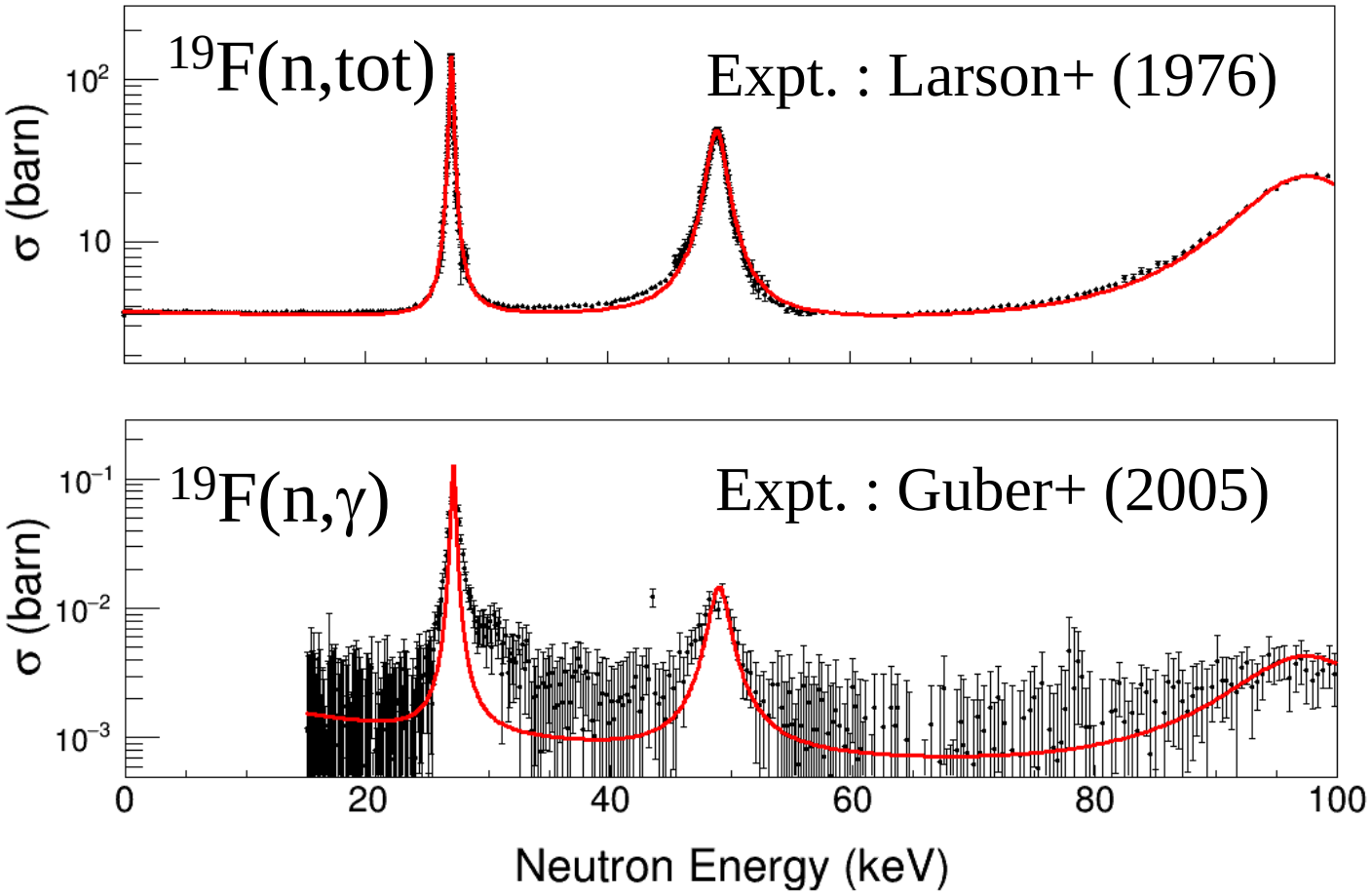


⇨ S-matrix ⇨ Cross-section evaluation

✓ Strictly based on the **"quantum mechanics"**

It is not like the so called "Model"

What is R-matrix ? (Cont.)

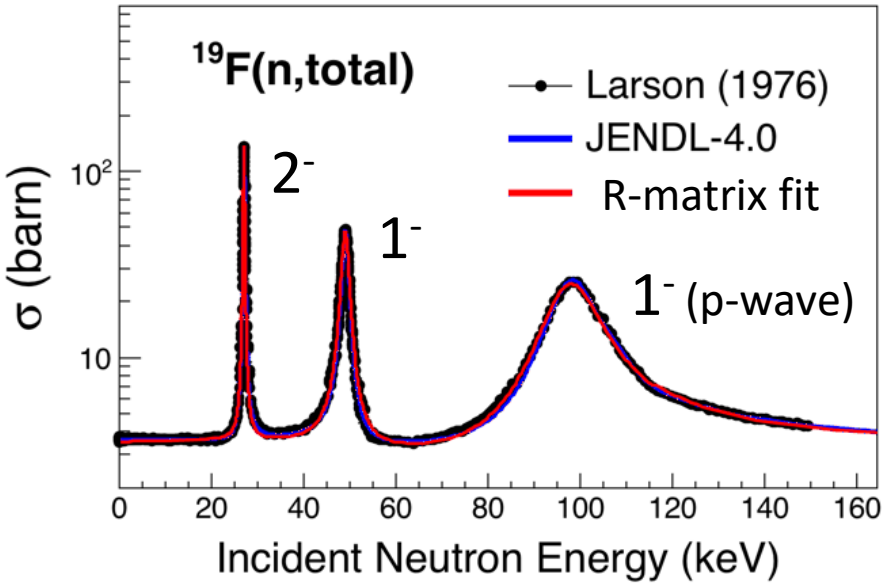


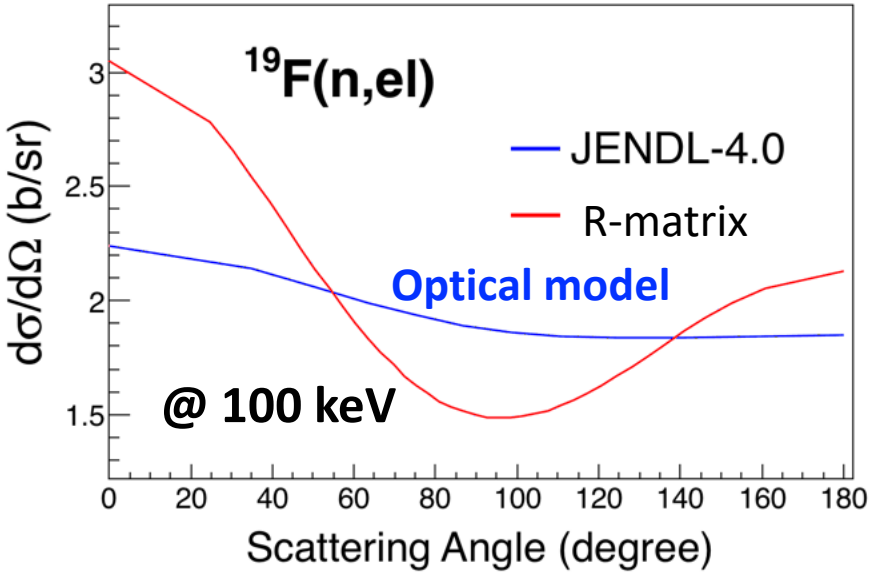
Good framework for

"interpolation/extrapolation" of experimental data

What is R-matrix ? (Cont.)

Angular distribution of (n,n) predicted by R-matrix



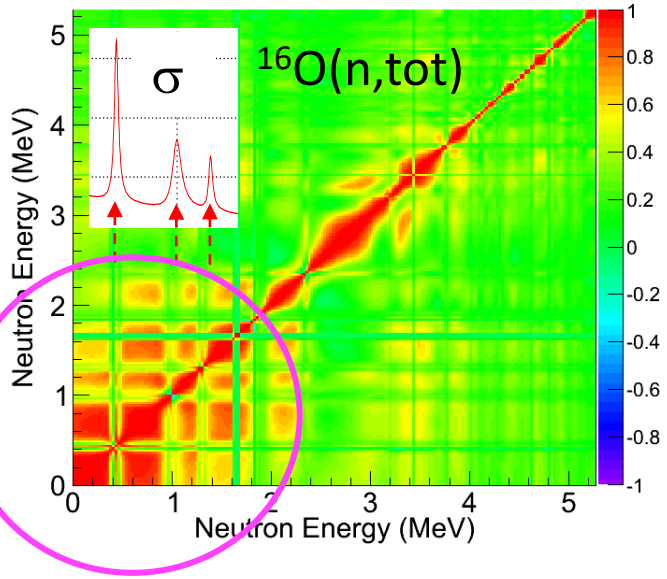


- R-matrix results are very different from the optical model estimation
- How it affects on the neutronics calculation ?

Estimation of uncertainty/covariance

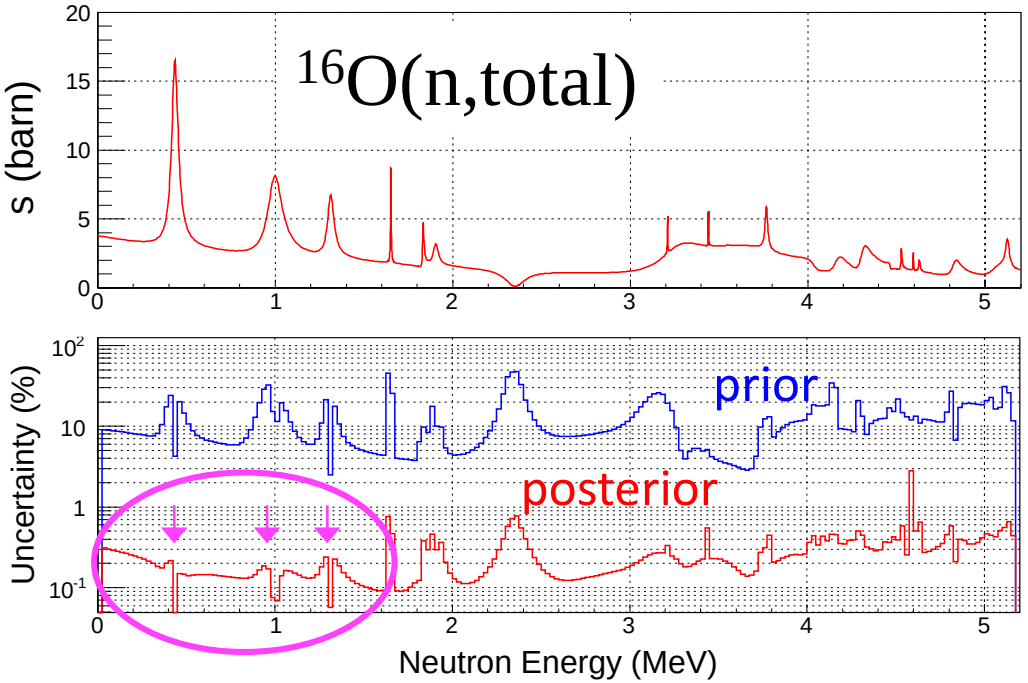
EXFOR ⇨ R-matrix + Kalman filter ⇨ Cov.

Correlation matrix



trace of ~unitarity limit

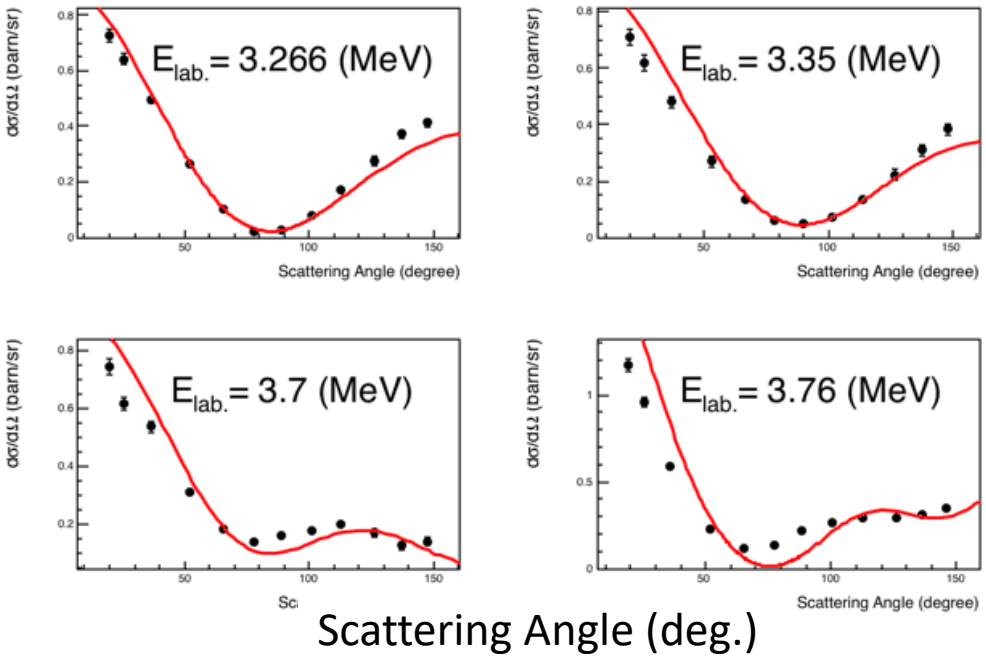
Uncertainty estimation

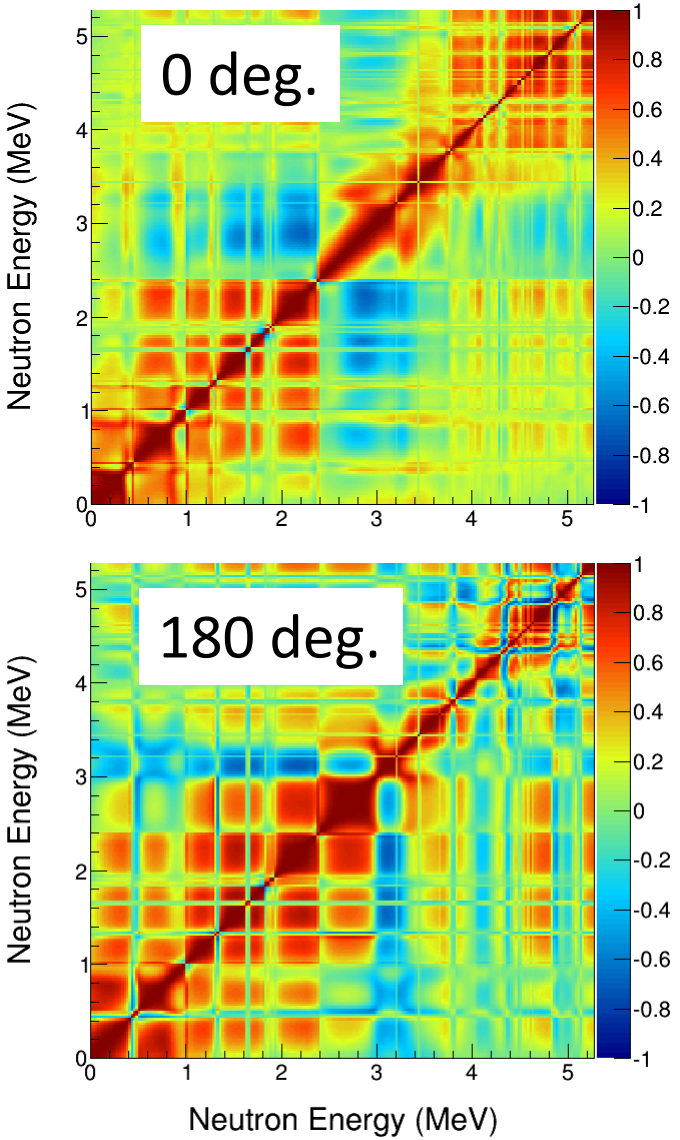


- Visualization of nature of resonant reaction
- Covariance/uncertainty estimation

Estimation of uncertainty/covariance

$^{16}O(n,el)$, $d\sigma(\theta)/d\Omega$

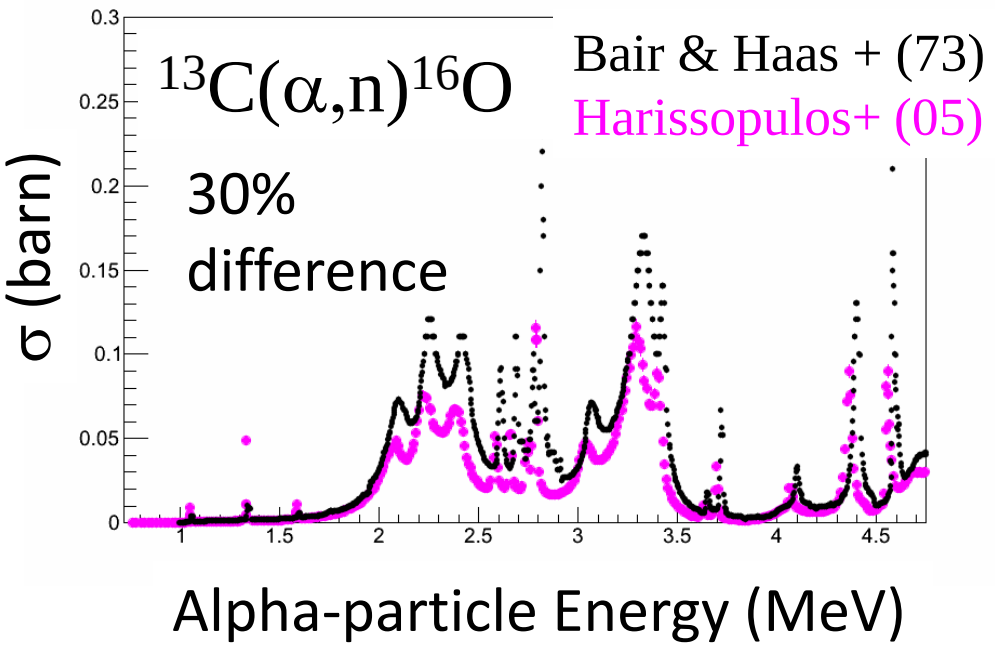


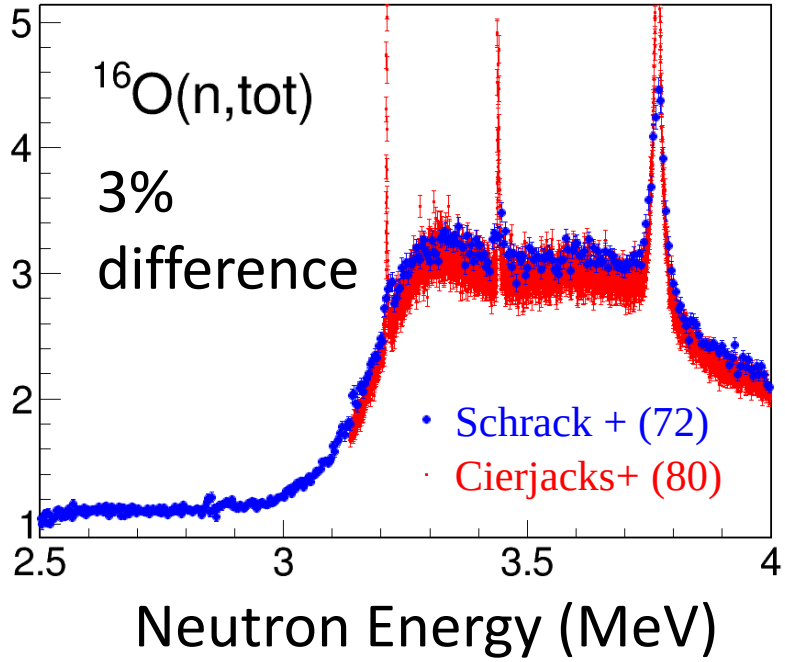


<u>Much constraints</u> should be expected from corresponding measurements.

Issue in data evaluation

"Difference among measurements", e.g.,





Firstly, we need to understand sources of the difference

R-matrix could have a solution because the S-matrix is **unitary**.

AMUR (**A MU**lti-channel **R**-matrix Code)

Evaluation tool for the resonant cross-sections
(under development)

Theoretical calculation

In case of R-matrix

→ σ, $d\sigma(\theta)/d\Omega$, $Pol(\theta)/d\Omega$

--- Parameters ---

- *Boundary condition* (R_c, B_c)
- *Energy eigenvalue* (E_λ)
- *Reduced-width amp.* (γ_c)

Analysis of measurement

KALMAN method (GLSQ)

→ Parameter & covariance

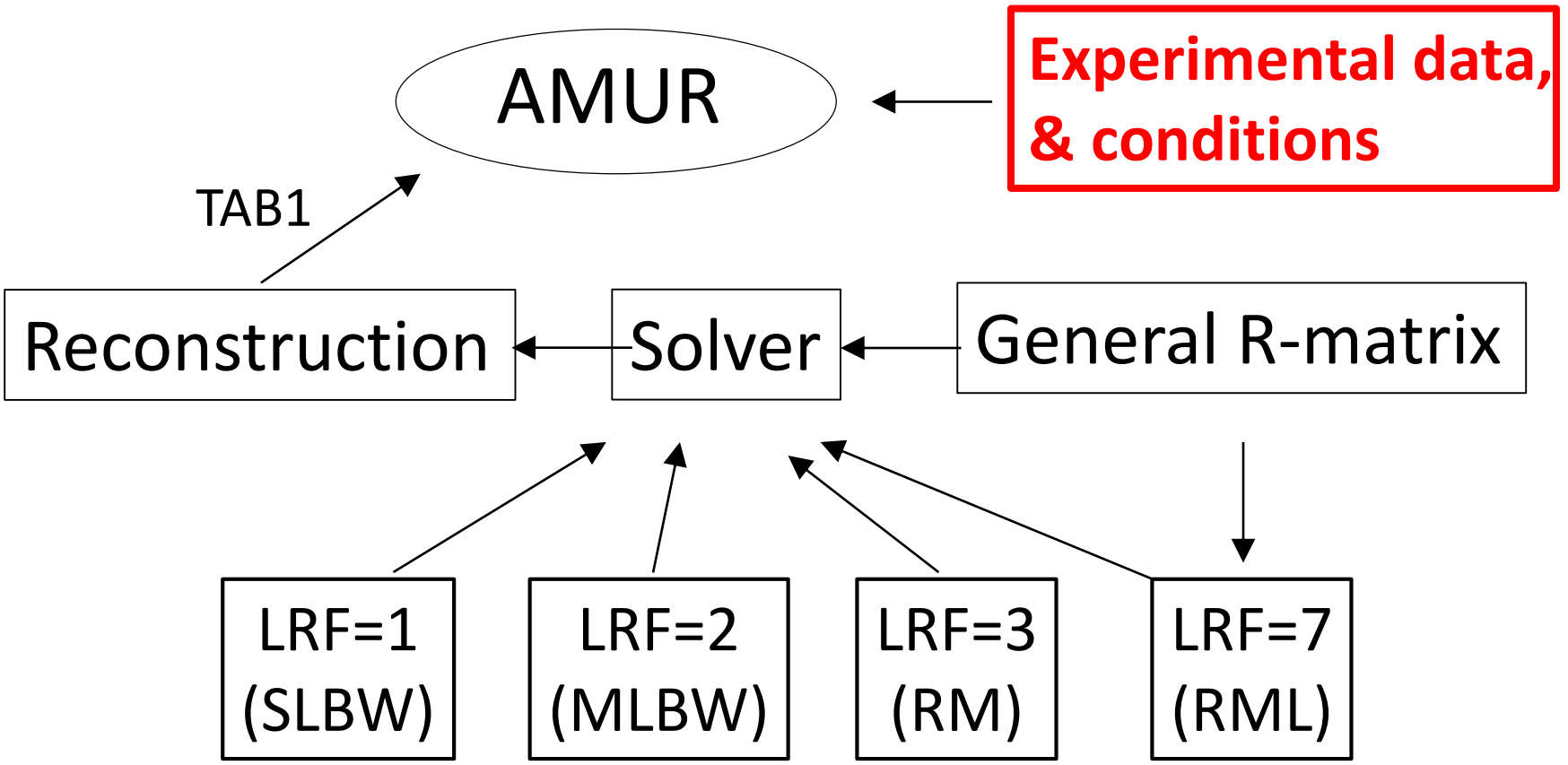
--- Parameters, e.g., ---

- *Renormalization*
- *Resolution*

Dynamic link (**Object-oriented**)

- All the parameter could have prior uncertainty
- Can be operated on ROOT (CERN scientific library)

Structure of the AMUR code



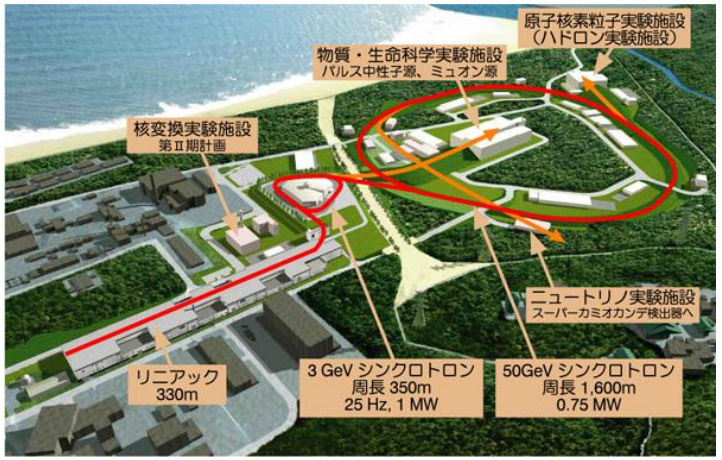
We need to simulate the experimental conditions

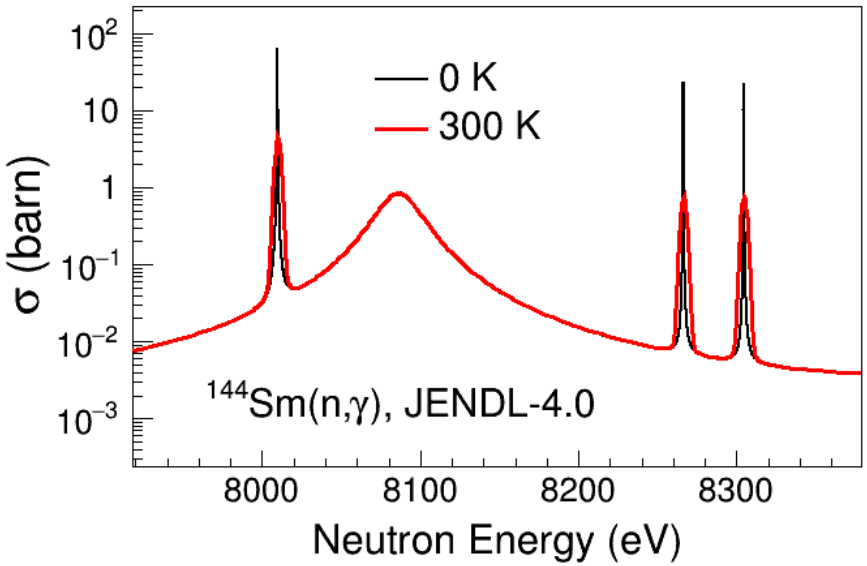
Simulation of Experimental Conditions

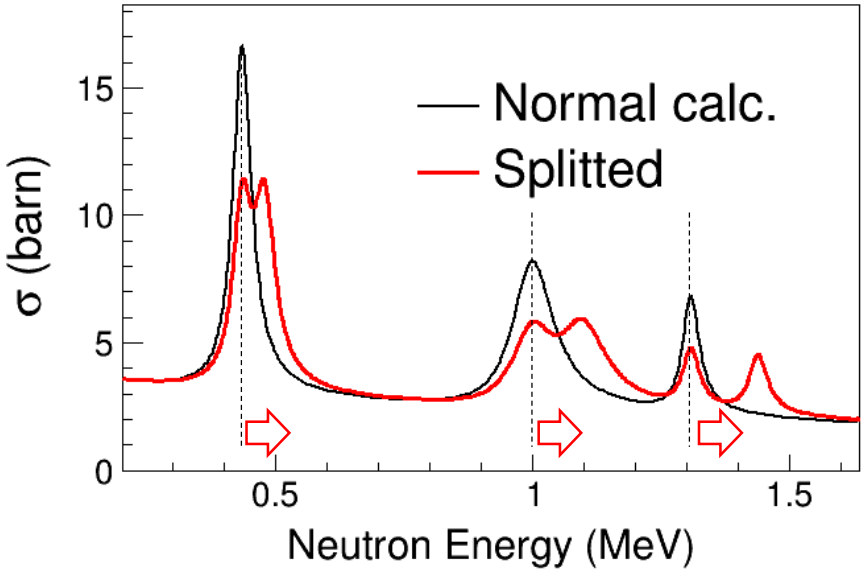
e.g.,

- Doppler broadening (Free-gas model)
- Double-bunch (J-PARC)

J-PARC facility







Amongst the Other Codes

（ ◎：excellent、 ○：good、 △：so so、 ×：insufficient ）

Code	Incident-particle (or Reactions)	Correction to experimental data	Covariance	Publication/ Manual	Object-oriented
SAMMY	○	◎	○	○	△ (F77)
REFIT	△	◎	?	◎	△ (F77)
EDA	○	△	○	×	△ (F77)
AZURE2	○	△	×	◎	○ (C++)
AMUR	○	△	○	×	◎ (**C++**)

Experimental Information Required

(X, Y)

Uncertainty (dStat, dSys)

Resolution

Temperature

Possible contaminants on the sample

Sample thickness

Possible calibration error

Specification of self-shielding/multiple-scattering corrections

Information on “double-bunch” (delay time)

Why don’t we have “dynamic” EXFOR/C5 ?

with e.g., Python, Ruby, ROOT, …

```
C5 a( “X4sShowX4StdOut1” )
    a.Narrow( “Targ=26056, MT=16” );
    a.ScaleEnergy( 1.e+6 );
    a.CutEnergyAbove( 20.0 );
    a.SetMarkerStyle(20);
    a.SetMarkerColor(3);
    a.Draw();

C5 b( “X4sShowX4StdOut2” )
    b.SetMarkerColor(3);
    b.Draw( “same” );
```

```
C5 a( “X4sShowX4StdOut3” )

  int n = a.size();

  for( int i=0; i<n; i++ )
    cout << a.Energy(i) << “ ” << a.Data(i)
```