
# UncTools (NS_Lib) – treatment of uncertainties using Monte Carlo

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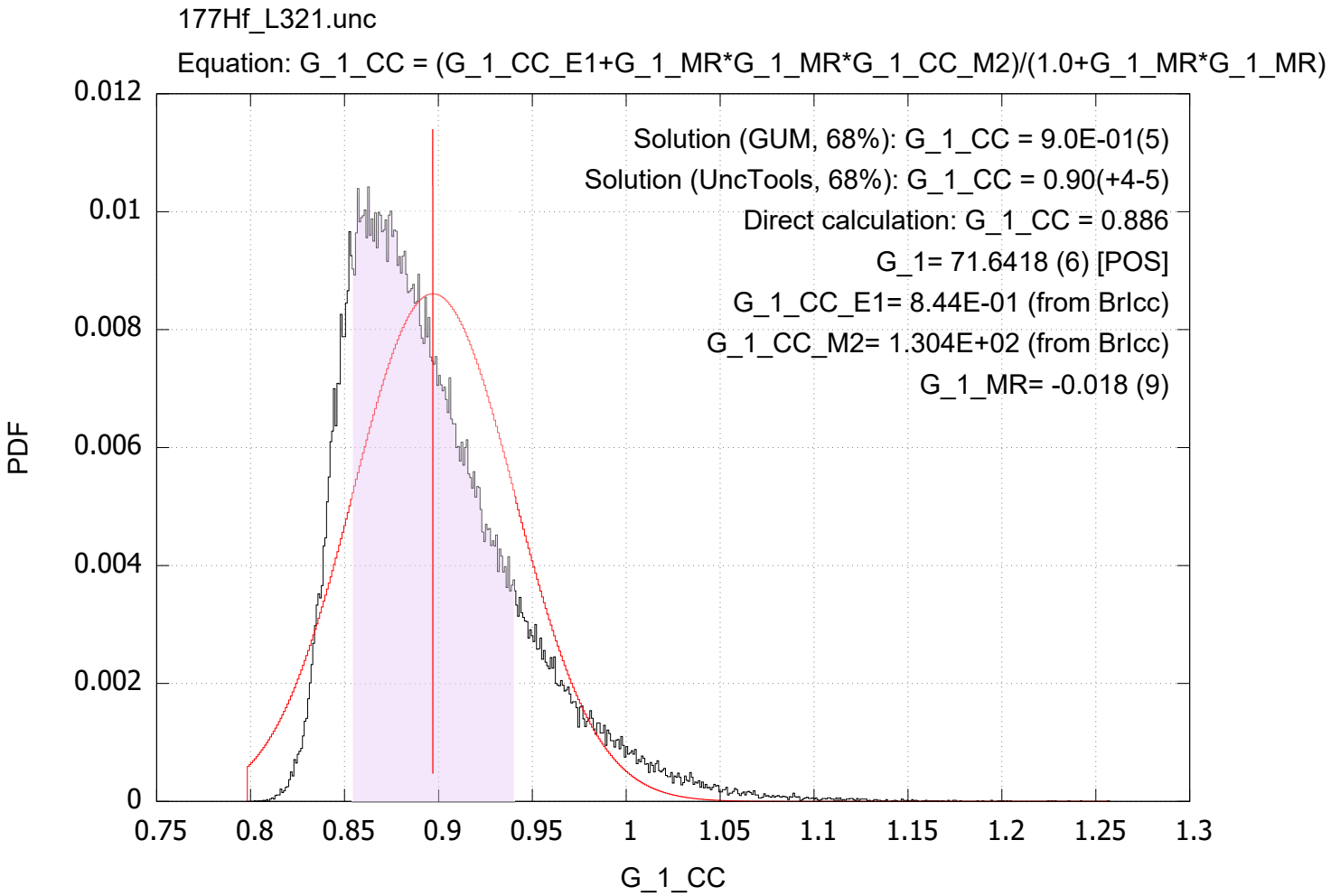
# Experimental quantitates in ENSDF



# Experimental quantitates in ENSDF

2001TuZZ J.K. Tuli, *A Manual for Preparation of Data Sets*

- Single unsigned number: BR, CC, HF, LOGFT, NB, NP, NR, NT, QP
- Single signed number: MR, Q-, QA, SN, SP
- Standard symmetric uncertainty; two character field (ENSDF Manual V.11):
  - an up to two digits integer, up to 99, preferable less than 25
  - LT, GT, LE, GE, AP, CA, S

    DBR, DCC, DE, DHF, DIA, DIB, DIE, DIP, DNB, DNR, DNP, DNT, DQP, DQ-, DS, DSP, DTI
- Standard asymmetric uncertainty; two signed integers (ENSDF Manual V.12):
  - DFT, DMR, DT, DNB, DQA
- Special rules for E, M, J, S, L fields

Uncertainty propagation in ENSDF codes:

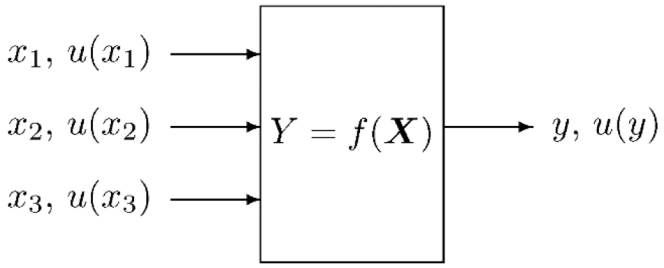
- Gaussian (analytical) method, only valid for small DX/X values
- For multi-variant functions (Ruler, Gabs, Gtol) difficult / impossible to manage

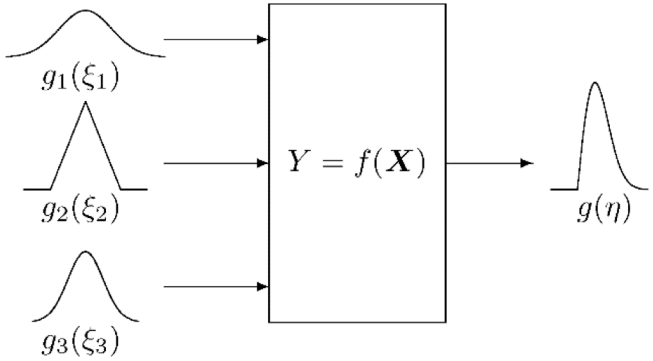
# GUM framework


## Joint Committee for Guides in Metrology (JCGM, 1993)
## Guide to the Expression of Uncertainty in Measurement

**Concept**

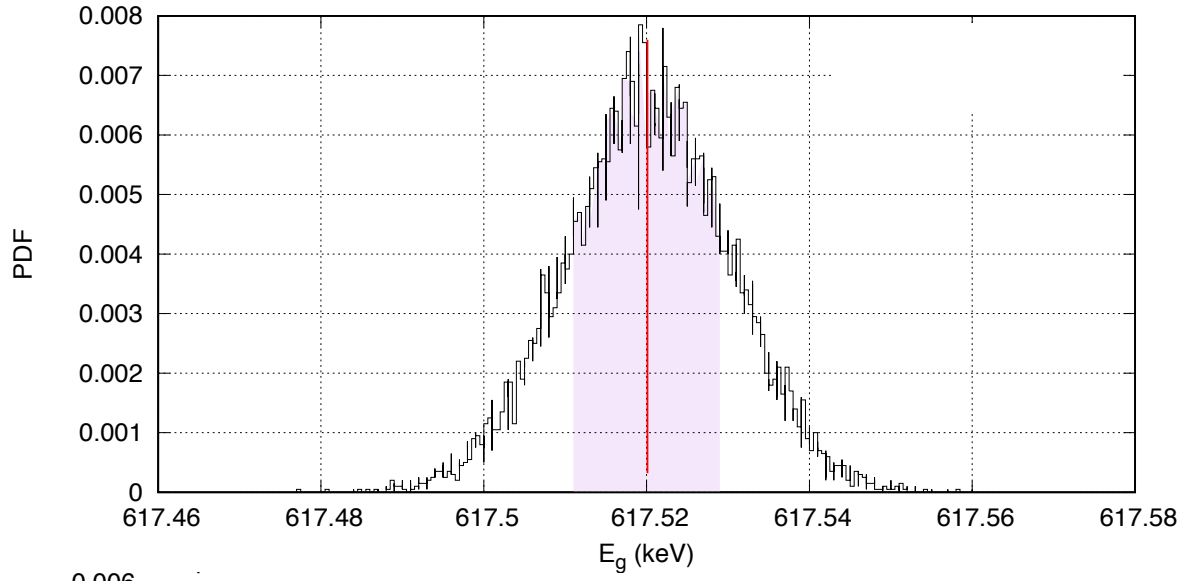
- Define the output quantity, the quantity required to be measured.
- Decide the input quantities upon which the output quantity depends.
- Develop a model relating the output quantity to these input quantities.
- On the basis of available knowledge assign probability density - Gaussian normal), rectangular (uniform), etc. - to the values of the input quantities.



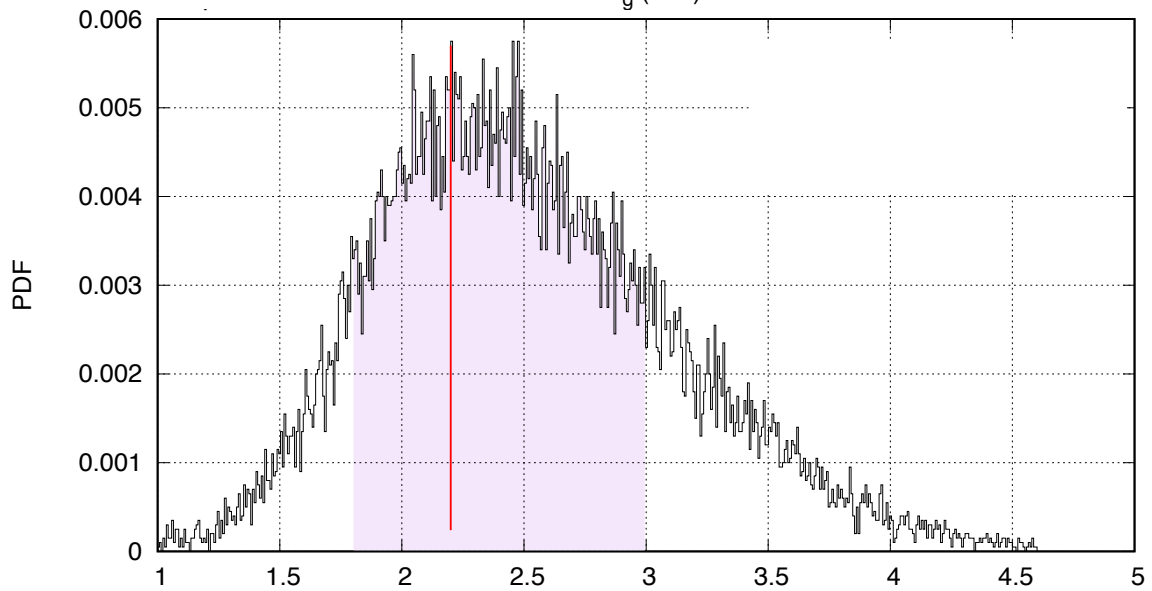



# Probability Density Function (PDF)

Symmetric Normal Distribution:
$E_\gamma$=617.520(10) keV




Asymmetric normal distribution:
MR=+2.2(+8-4)



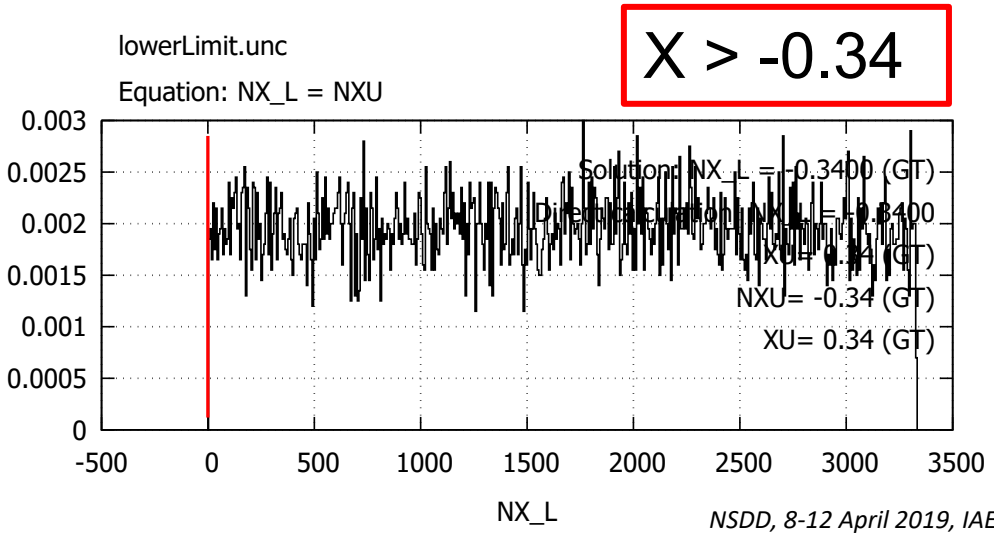
# Probability Density Function (PDF)

## Limits

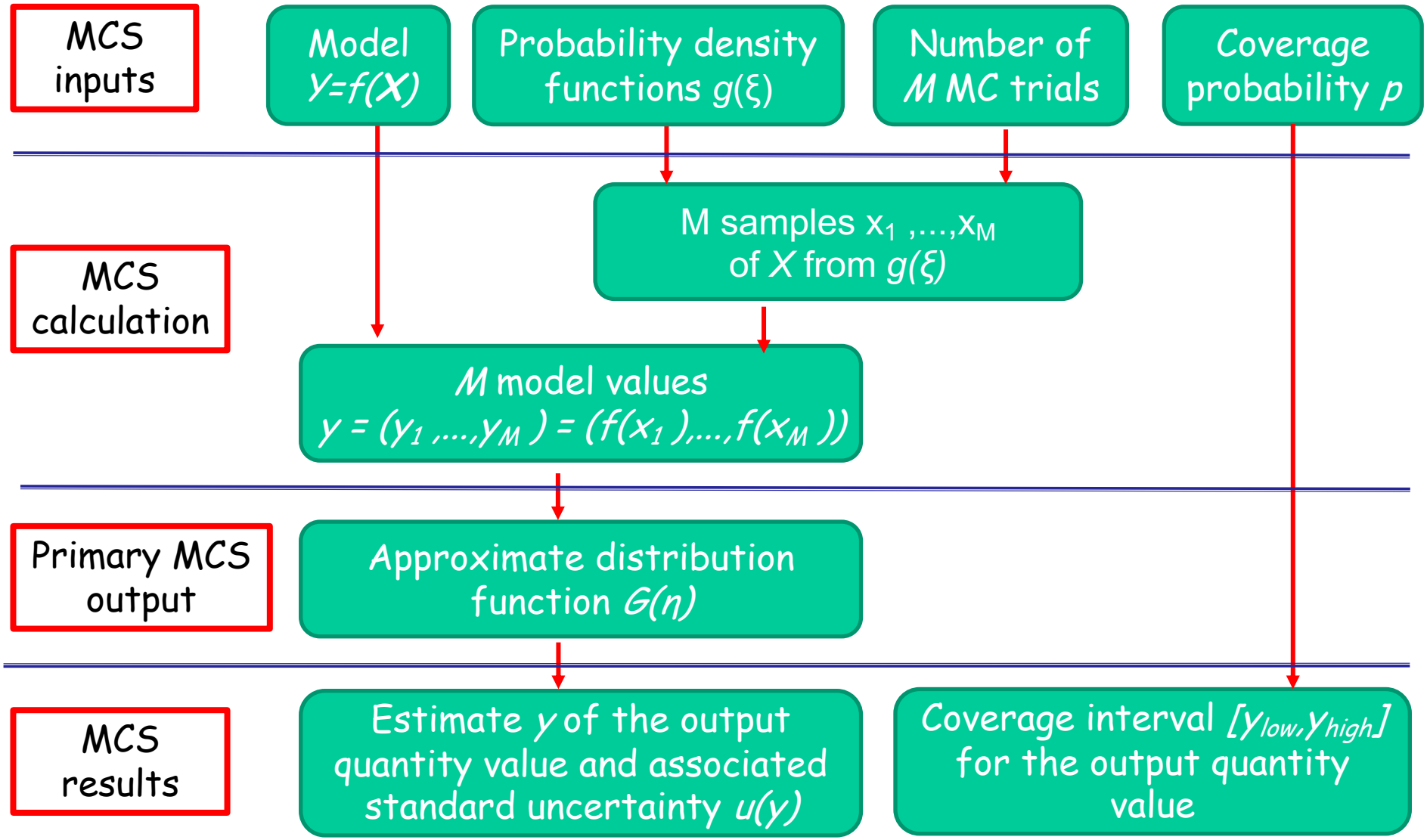
| | Limit | Range | Range Used in MC |
|---|---|---|---|
| UPPER | <0.5 | [0 : +0.5] | [0 : +0.5] |
| | <+0.5 | [-infinity : +0.5] | [-4999.5:+0.5] |
| | <-0.5 | [-infinity : -0.5] | [-5000.5:-0.5] |
| LOWER | >0.5 | [+0.5:+infinity] | [+0.5:+5000.5] |
| | >+0.5 | [+0.5:+infinity] | [+0.5:+5000.5] |
| | >-0.5 | [-0.5:+infinity] | [-0.5:+4999.5] |

PDF uniform over the entire range

- Infinite range: PDF = Zero
- Replace infinity with a sufficiently large range: Infinity ~ 10000 Limit value

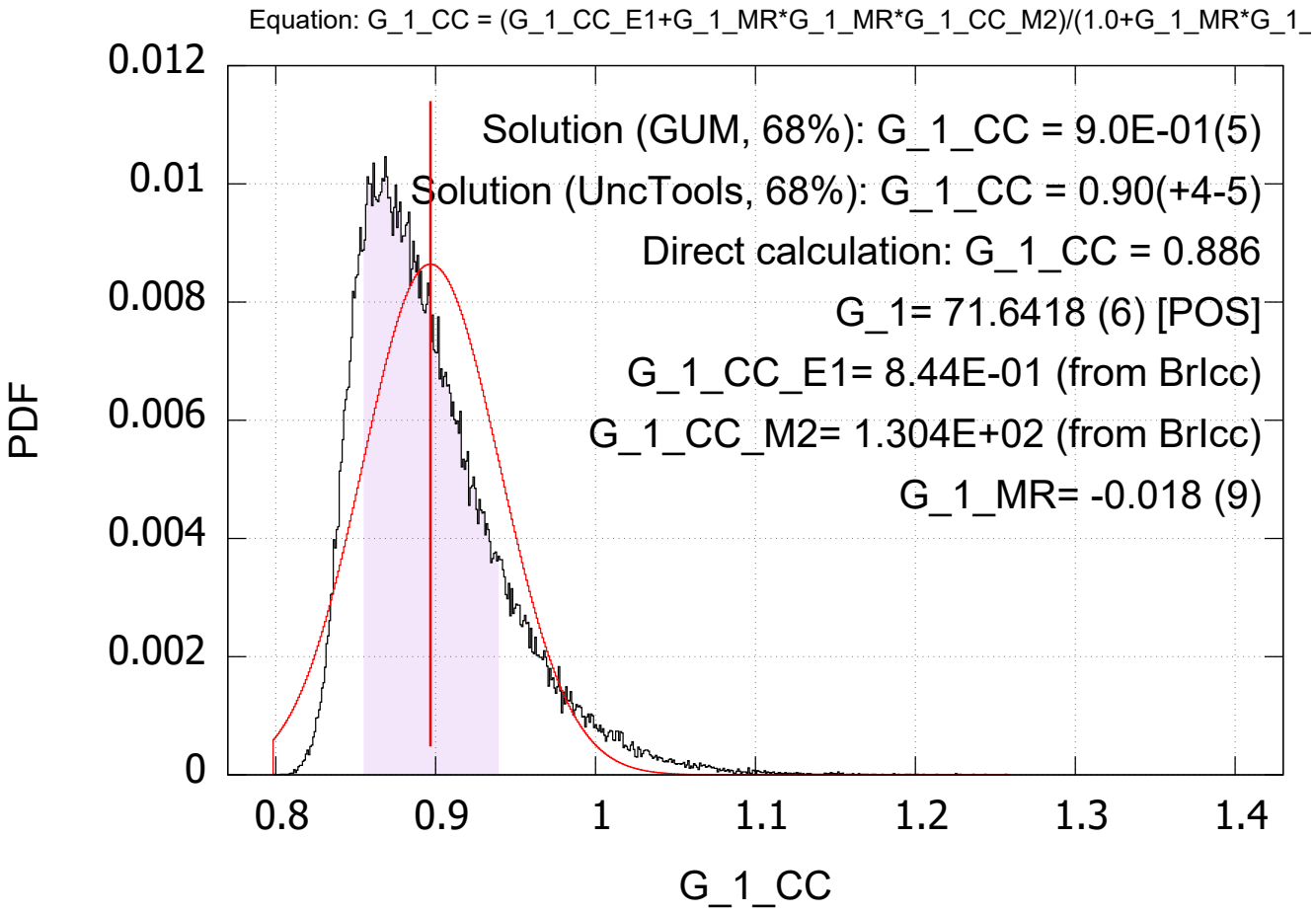


# Monte Carlo simulations to obtain the output quantity



# Mixed ICC

## BrIcc $^{177}$Hf 71.6418(6) keV E1+M2, MR: -0.018(9)

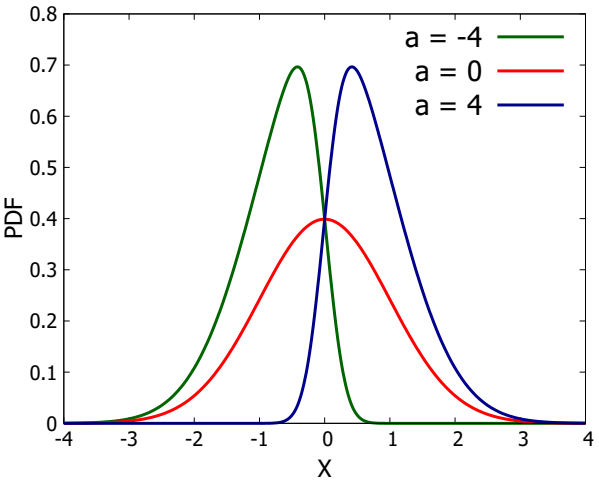



BrIcc
CC=0.89(6)

GUM
CC=0.90(5)

UncTools
CC=0.90(+4-5)

# Skewness & Kurtosis




**Symmetrical:**

$|\gamma 1| < 0.01$; $k \approx 3$

**Asymmetric:**

$0.01 < |\gamma 1| < 0.995272$

**Limits:**

$|\gamma 1| = 0$; $k < 3$ ?

**Skewness** - degree of distortion from any symmetrical, like normal distribution

$$\gamma_1 = \frac{\sum_{i=1}^{N}(x - \overline{x})^3}{\sigma^3}$$

- Mean – arithmetic mean
- Median – middle number of the ordered list
- Mode – where PDF has maximum

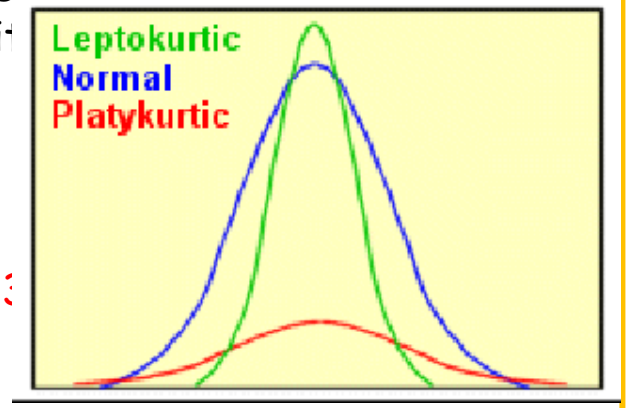
Normal distribution: mode = median = mean

Skew positive: mode < median < mean

Skew negative: mode > median > mean

**Kurtosis** (from Greek: κυρτός, *kyrtos* or *kurtos*, meaning "curved, arching") is a measure of the "tailedness" of the probabili

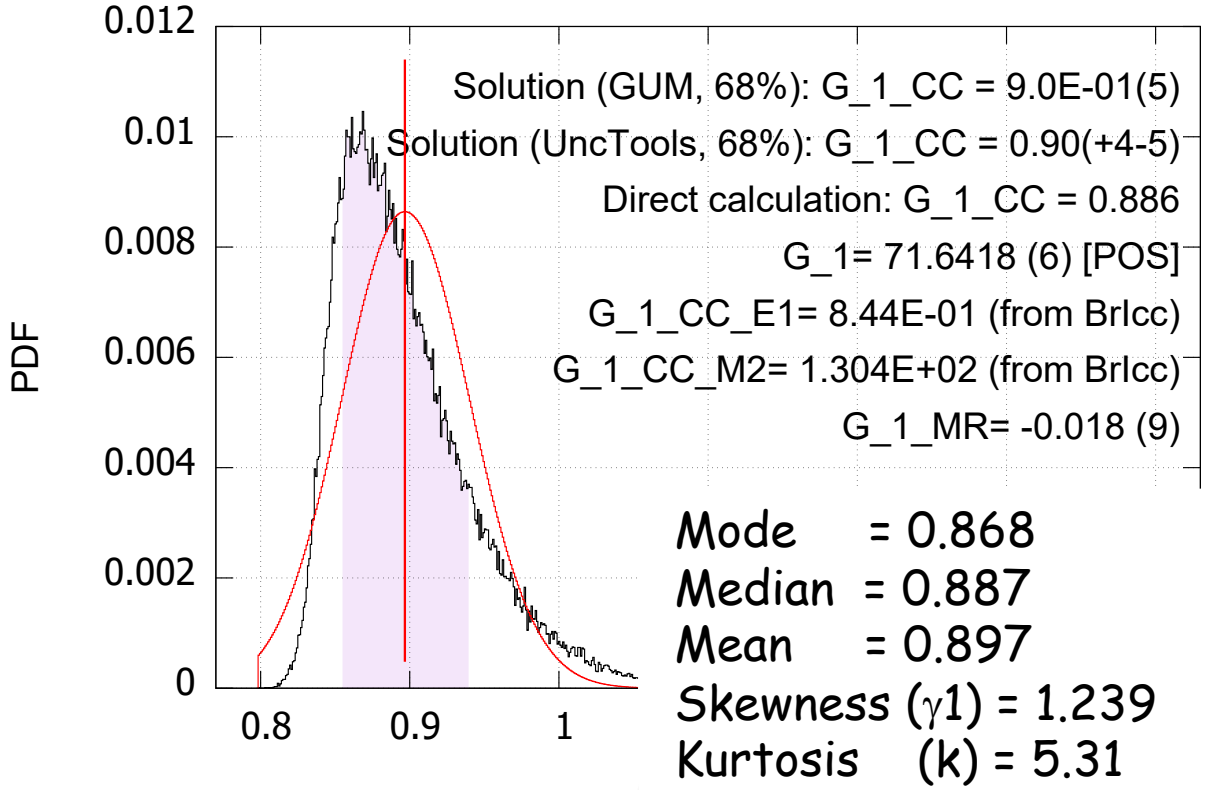
$$k = \frac{\frac{1}{N}\sum_{i=1}^{N}(x - \overline{x})^4}{\sigma^4}$$




- Normal distribution: k = 3
- Platykurtic: k < 3
- Leptokurtic: k > 3

# Mixed ICC

## BrIcc $^{177}$Hf 71.6418(6) keV E1+M2, MR: -0.018(9)




Mode = 0.868
Median = 0.887
Mean = 0.897
Skewness ($\gamma 1$) = 1.239
Kurtosis (k) = 5.31

BrIcc
CC=0.89(6)

GUM
CC=0.90(5)

UncTools
CC=0.90(+4-5)

**Symmetrical:**

$|\gamma 1| < 0.01$; $k \approx 3$

**Asymmetric:**

$0.01 < |\gamma 1| < 0.995272$

**Limits:**

$|\gamma 1| = 0$; $k < 3$ ?

$\alpha_T(71.6418)$

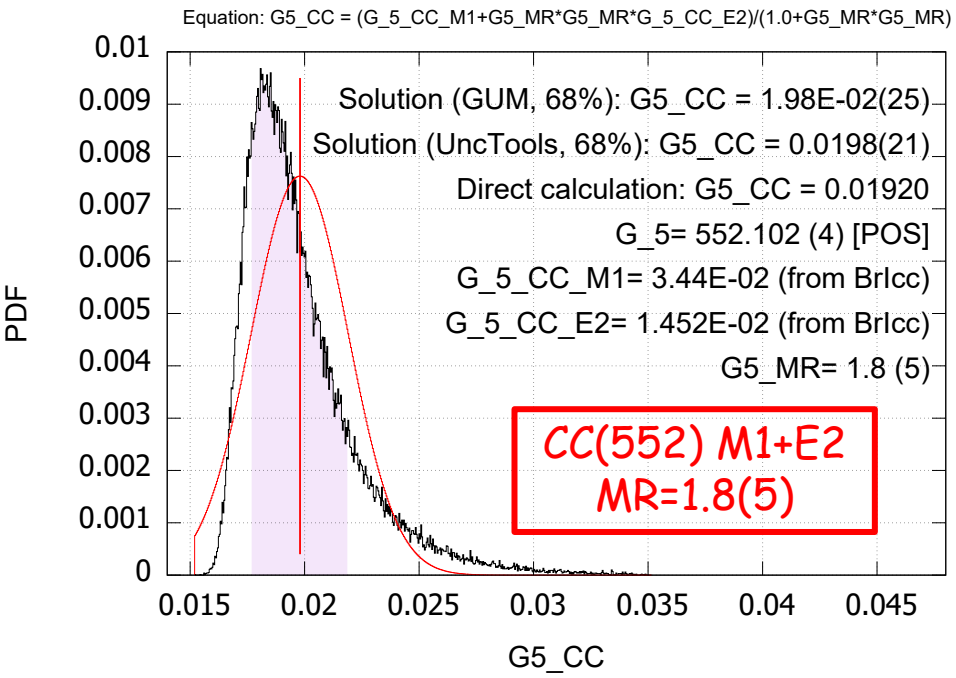
negative skew: Mode < Median < Mean

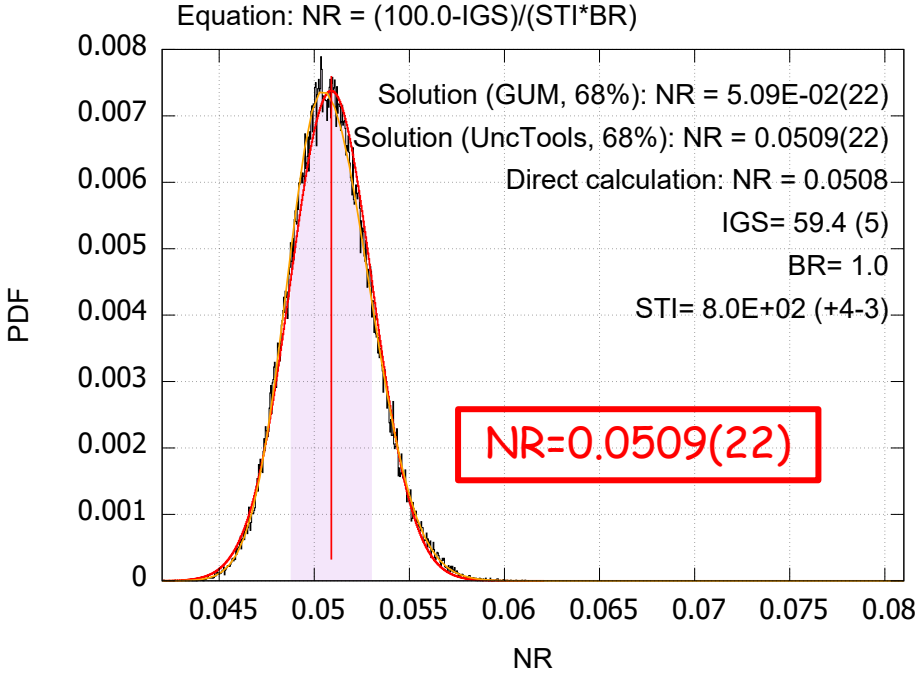
$|\gamma 1| > 1$ not an asymmetric normal distribution

# Benchmarking GABS

$^{177}$Lu B-
12 G`s for
normalisation

| | GABS | Python | UncTools |
|---|---|---|---|
| **Input file** | gabs-test.ens | pycalc-test.py | gabs-test.unc |
| **NR** | 0.0508(21) | 0.0508(21) | 0.0509(22) |
| **%IG(150.399)** | 18.0 (5) | 18.0 (5) | 18.0 (5) |



# Proposal of propagation uncertainties including limits using MC

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**Advantage**

- Consistent treatment of all cases, much simpler program logic (no more jungle of IF statements)
- Sound statistical approach even for larger relative uncertainties and limits

**Disadvantage**

- CPU intensive
- Mean value may not agree with directly calculated value

**Questions/Problems**

- Sampled / output values could be nonphysical: $T_{1/2}$=0.15(7) ns
- Some uncertainties in ENSDF expected to be symmetrical (DBR, DCC, DE, DHF, DIA, DIB, DIE, DIP, DNB, DNR, DNP, DNT, DQP, DQ-, DS, DSP, DTI)