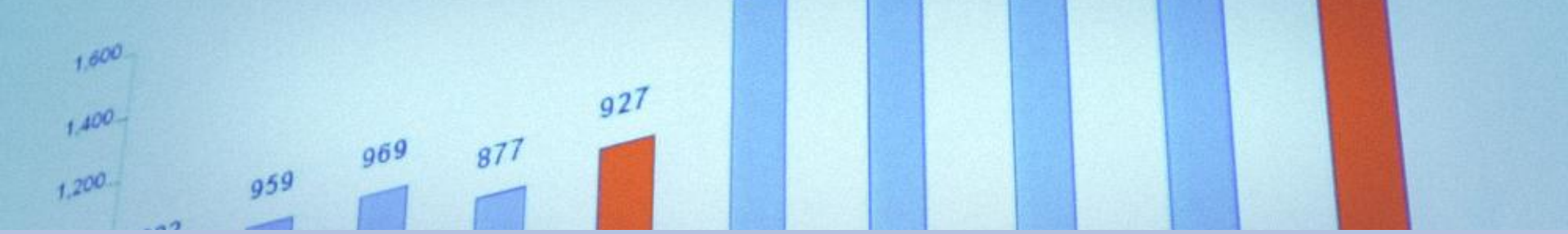

RunnING Risk on GPUs

Answering The Computational Challenges of a New Environment

Tim Wood

Market Risk Management Trading - ING Bank

Nvidia GTC Express September 19th 2012

www.ing.com

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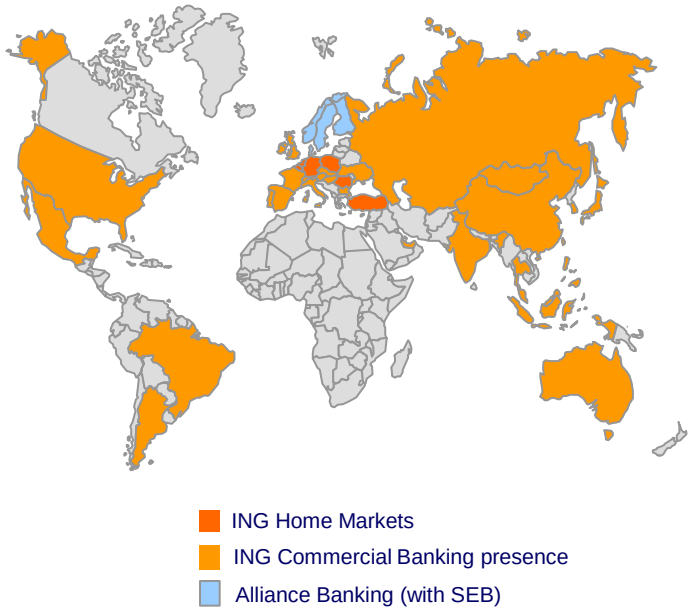
ING Bank

- Part of ING Group
- Leading Commercial Bank in the Benelux and CEE
- Top 10 global player in Structured Finance
- Around 68,000 employees worldwide
- Approximately 37 million customers

ING Bank Headquarters
Amsterdam, Netherlands



Agenda

- *Section 1*
  Financial market risk managment for trading, and how the crisis of 2008 changed the landscape

- *Section 2*
  The computational challenges of a new environment and how they can be addressed with GPUs

- *Section 3*
  The challenges of taking GPUs into production

Financial Market Risk Managment for Trading

- Quantifying and managing financial exposure to market risk factors
  - Value at risk
  - Sensitivity analysis
  - Scenario analysis and stress testing
  - Valuation and P/L decomposition
  - Valuation and risk managing complex instruments

Banking Crisis of 2008

- Implications of the Crisis
  - The realisation of previously hidden risks drove the failures
  - The revalation of hidden risk demands that banks must perform more and deeper analysis to quantify and manage these
  - Changed all valuation and risk management models
- Regulatory Response
  - Introduction of new risk measures to better capture formally hidden exposures
- Complex models, much more computation
  - The underlying technology must support business requirements
  - Growing workloads may be unachieveable with traditional infra

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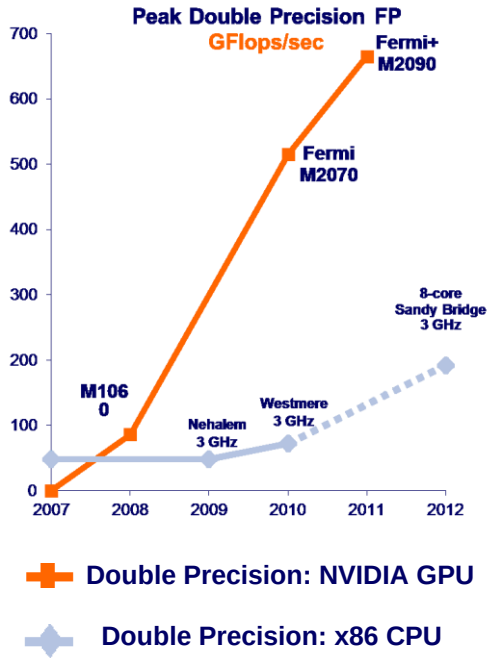
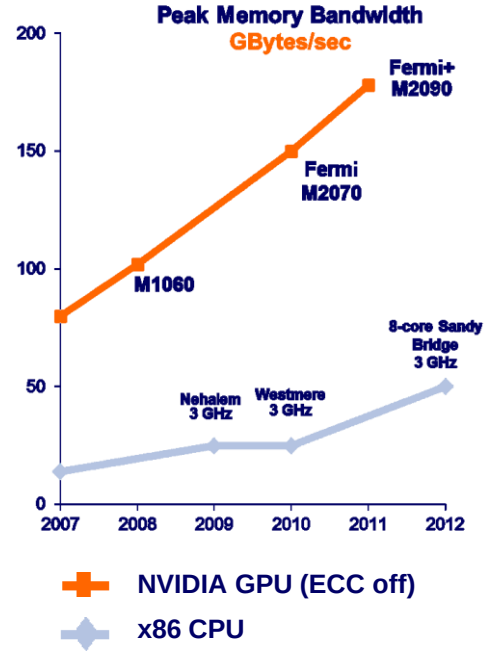
GPUs in Computational Finance

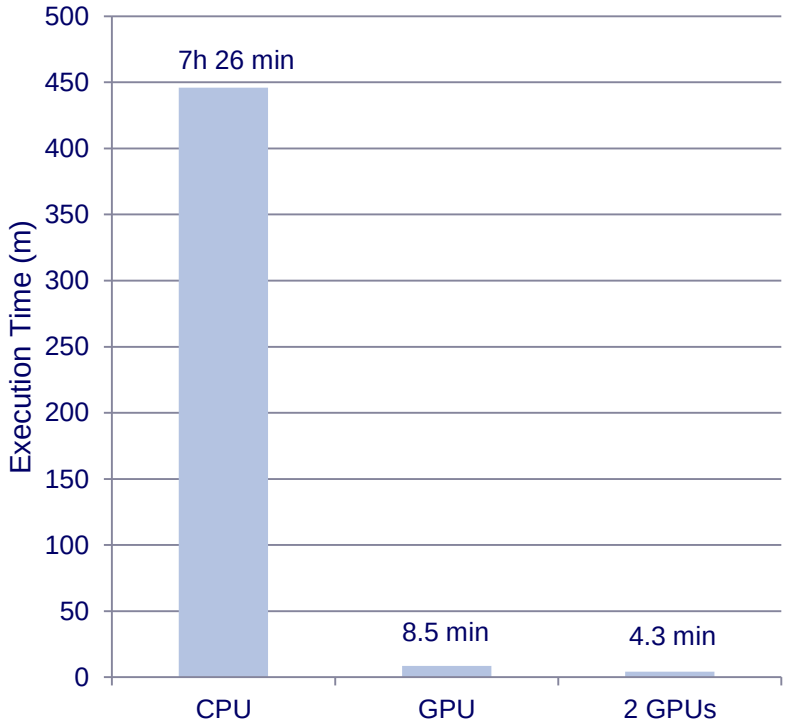
- Many specific cases
  - Solving relevant calcs
  - Pricing specific instruments
- In Risk Management we are interested portfolio level analysis
  - Many positions
  - Different products types
  - Different asset classes





The Birth of GPU Computing at ING

- Case: Portfolio Analysis for HVaR
  - Plain vanilla and Exotic Portfolios
  - 260 historical scenarios
- Hardware 2 GPUs
  - Cost $1200 each
  - In-house Installation
- Findings
  - Data to computation ratio important
  - Very promising results



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Section 2

Computational Challenges of a New Market Environment

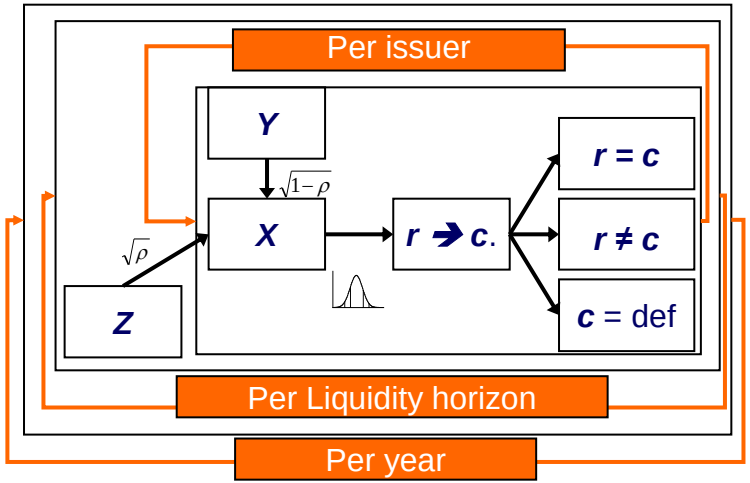
Challenges

- Basel 2.5: Stressed VaR, Incremental Risk Charge (IRC)
- Credit Value Adjustment (CVA)
- Basel 3: VaR of CVA
- Multicurve framework

Incremental Risk Charge (IRC)

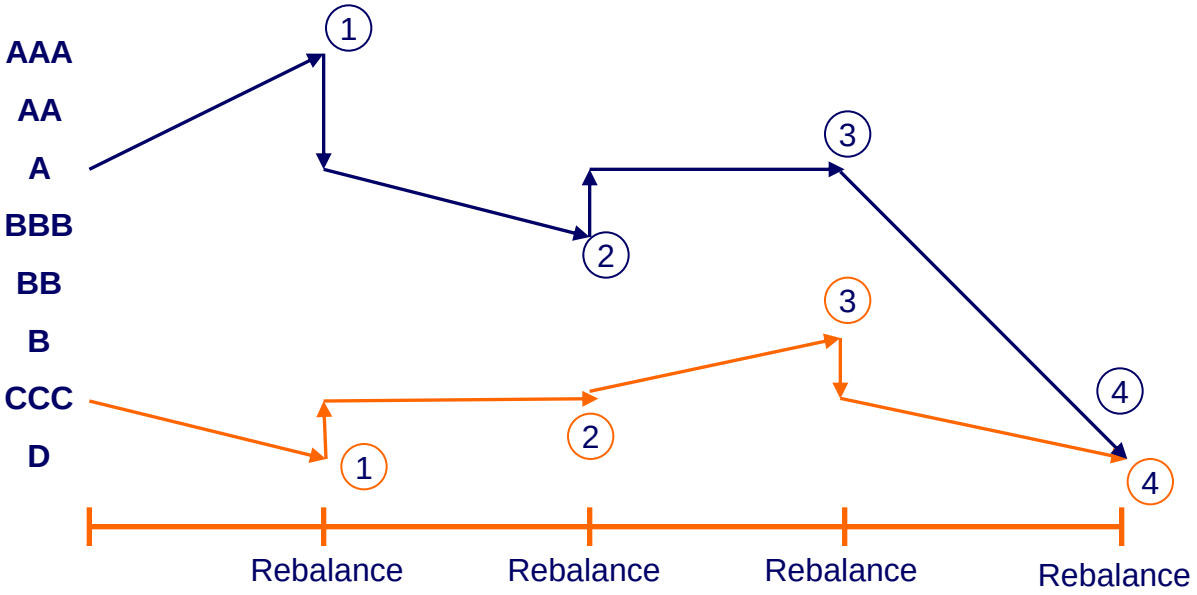
- Part of Basel 2.5
- Capture losses from the credit migration or default of issuers of bonds in trading books

- Characteristics*
  - Emphasis on Stressed Markets
  - Long liquidity horizon
  - Very high confidence level (99.9%)
  - Constant level of Risk



*** Guidelines for computing capital for incremental risk in the trading book, bcbs159 2009**

Incremental Risk Charge (IRC)



Issuer starts with rating A

1. Upgrade to AAA, with positive spread impact.
2. Downgrade to BBB, with negative spread impact.
3. No migration, no financial impact.
4. Default impact = EAD - Fx(1–LGD).

Issuer starts with rating CCC

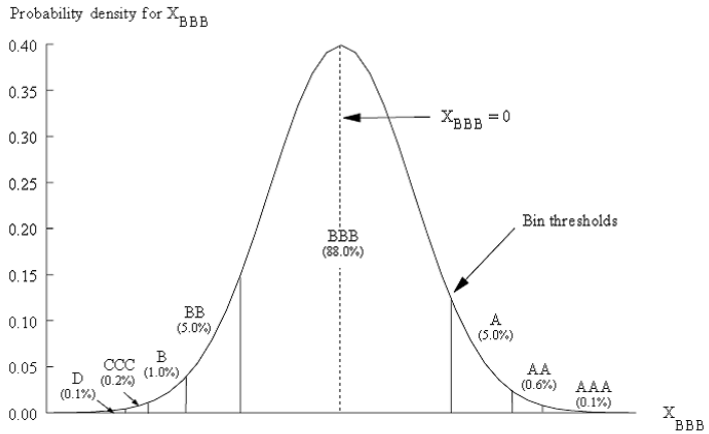
1. Default impact = EAD - Fx(1–LGD)
2. No migration, no impact.
3. Upgrade to B, positive impact.
4. Second default, impact = EAD - Fx(1–LGD).

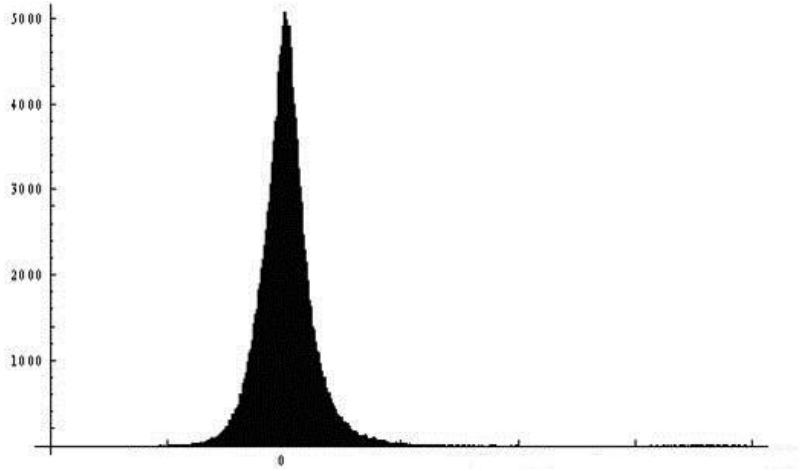
Incremental Risk Charge (IRC)

Chart 1

Relationship between continuous credit index *X* and rating transitions

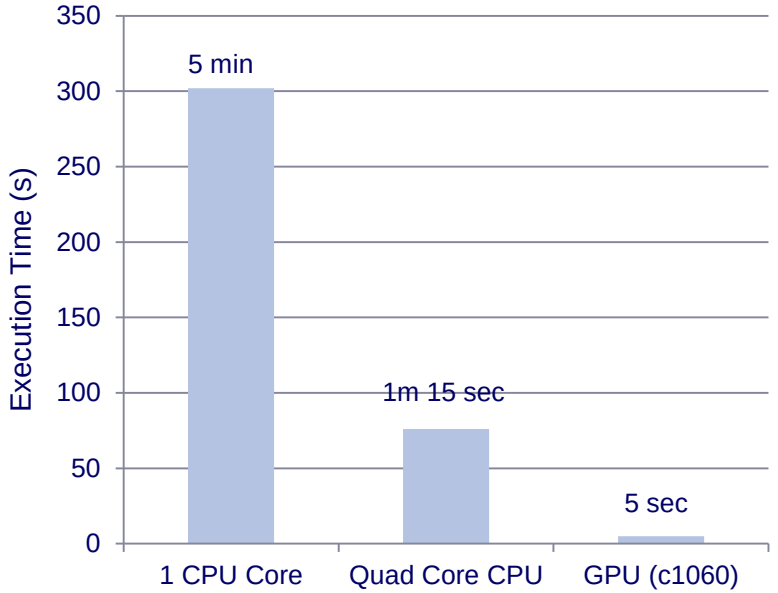
Historical average transition rates determine bin thresholds





IRC GPU Performance

- 20M Simulated Capital Horizon (1yr)
- Multiple Liquidity Horizons
- 1000+ Issuers
  - 800 Billion trials for base run
- Sensitivities per issuer
- Breakdown per
  - Location
  - Industry sector
  - Geographic region
- Approx 1,200 nightly runs



Credit Value Adjustment (CVA)

• **Credit value adjustment (CVA)** is the difference between the risk-free portfolio value and the true portfolio market value that takes into account the possibility of a counterparty's default. In other words, CVA is the **market value of counterparty credit risk.**

• Essentially two-sided:

- Both the counterparty and Bank can default.
- DVA is the "CVA" that the counterparty has on us.
- "Two-sided" or "Bilateral" CVA is thus BVA = CVA – DVA
- NPV "Risky" derivative = NPV "Risk-free" derivative - BVA

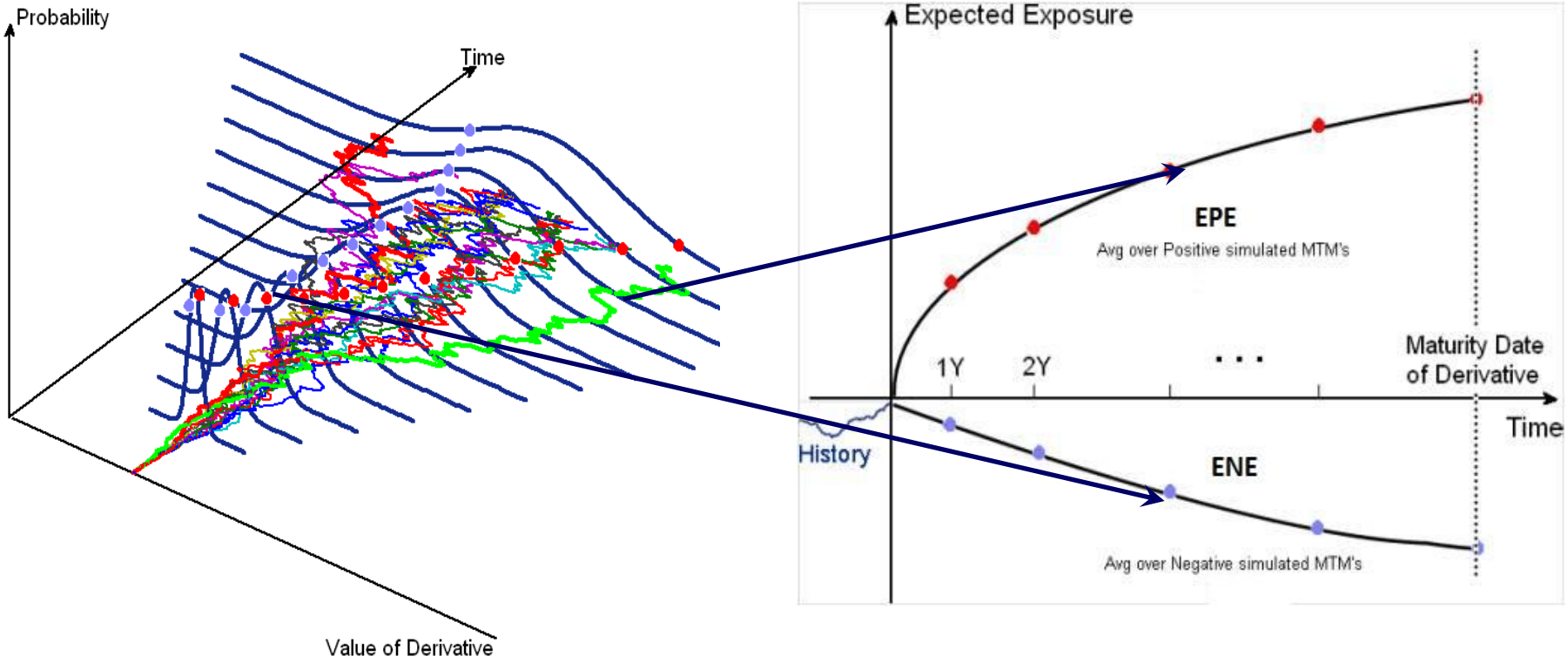
• CVA magnitude depends on

- The probability of default of the counterparty
- The possible exposure in the future (only if it is positive!)
- The loss given default (loss after recovery)

• By definition the most complex derivative risk a bank has to manage.

- Function of the underlying risk-factors of the derivative (both current 'mark to market' and 'future profile'), the credit risk of the counterparty, bank and their correlation.

Credit Value Adjustment (CVA)



CVA on the GPU

- High dimensionality of CVA calculation offers many options for parallelisation
  - Many contracts
  - Many Scenarios, even more threads
  - Time

- Nature of CVA as application lends itself to distribution
  - Task granularity at netting set level

CVA Wrong/Right Way Risk

- *Wrong way risk*
  Where counterparty exposure is adversely correlated with the credit quality of that counterparty

  - *Wrong way risk Example*
    A cross-currency swap with an emerging market counterparty, where the counterparty pays foreign currency and receives local currency.

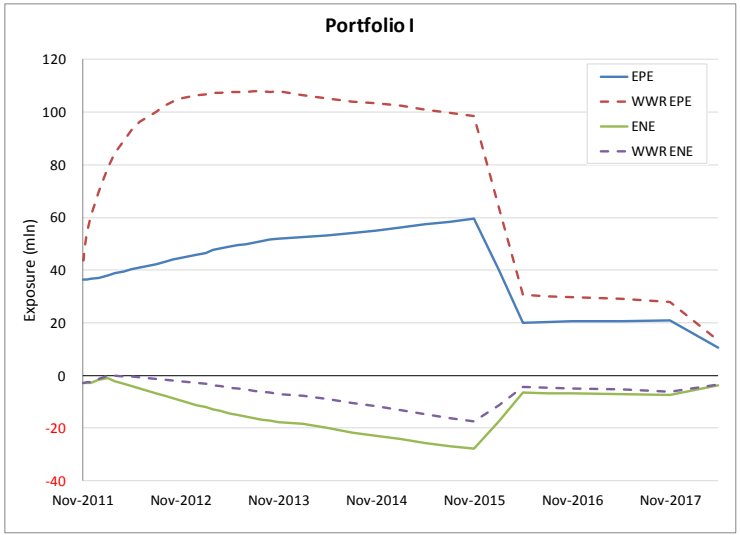
  - *Right way risk Example*
    Call option on a company stock issued by an oil producer in times of increasing oil prices

- Right/Wrong Way Risk is essentially the correlation of the credit quality of the bank or counterparty with the underlying exposure

Impact of WWR & RWR

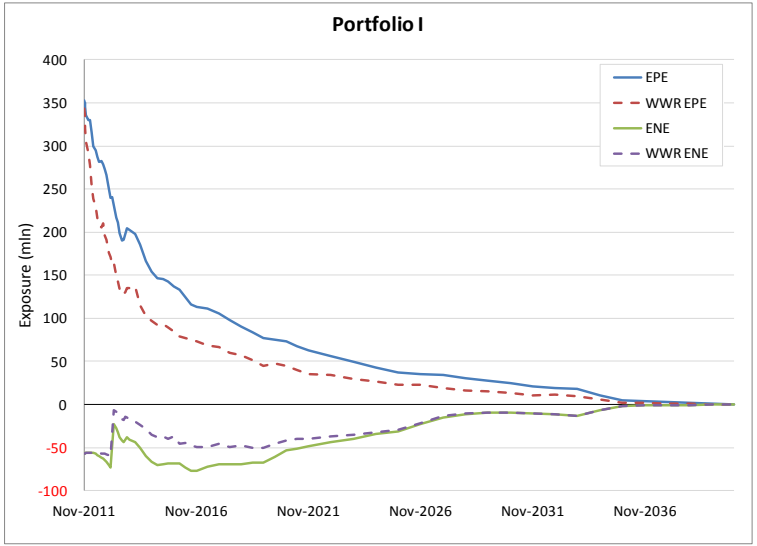
Wrong way risk

- If exposure correlates with the credit worthiness of the counterparty or bank



Right Way Risk

- If the counterparty credit risk is correlated with bank



CVA Sensitivities

- A single CVA figure is not very useful
- Need sensitivies for active management

- Two approaches
  - Brute force, effective but not elegant
  - AD / Pathwise Greeks

CVA GPU Performance

Portfolio A:

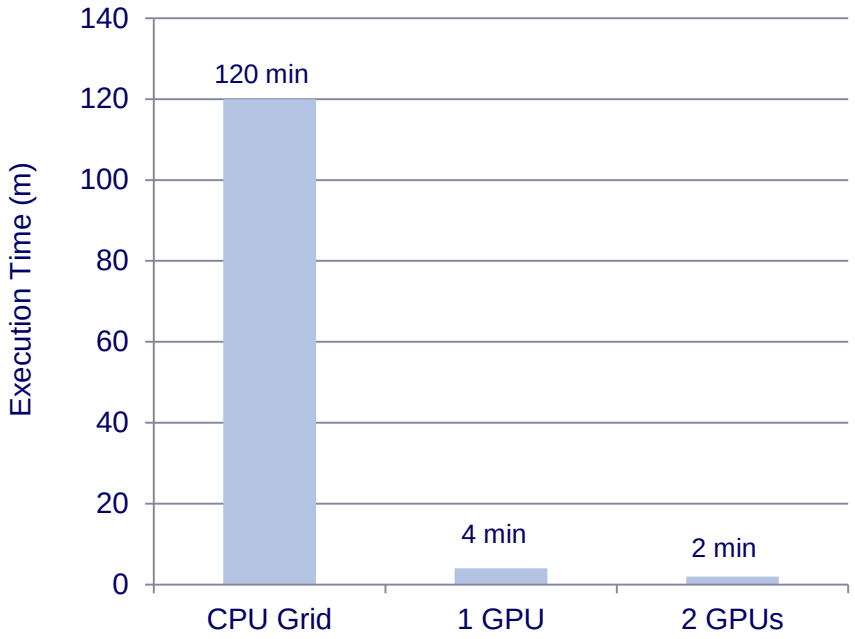
- Roughly 50K instruments
- All market conventions, netting and collateral rules
- >30 currencies
- >10,000 counterparties

Model:

- Multi-currency Hull and White Model
- Monte-Carlo pricing with 3K paths
- Exposure grid with close to 100 points

Calculation:

- For one CVA run with 50K instruments 3.75 billion pricing evaluations
- For a full CVA run with all sensitivities need hundreds of billions of valuations
- For an HVaR run with 50K instruments 13 million pricing calls

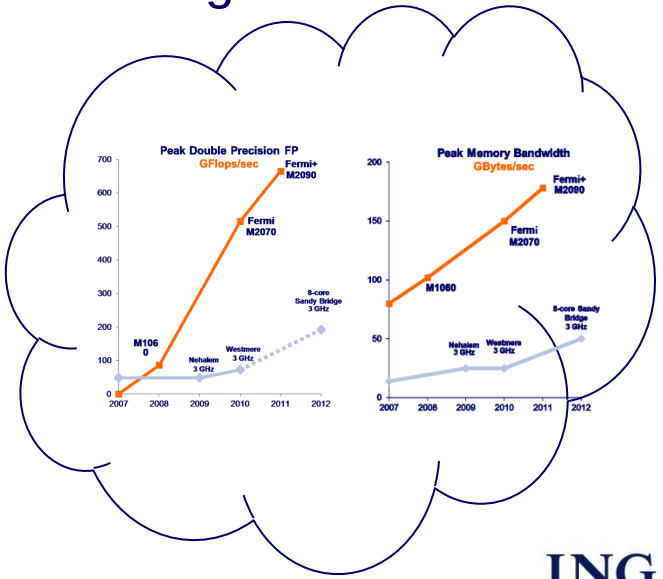


Section 3

Taking GPUs into Production

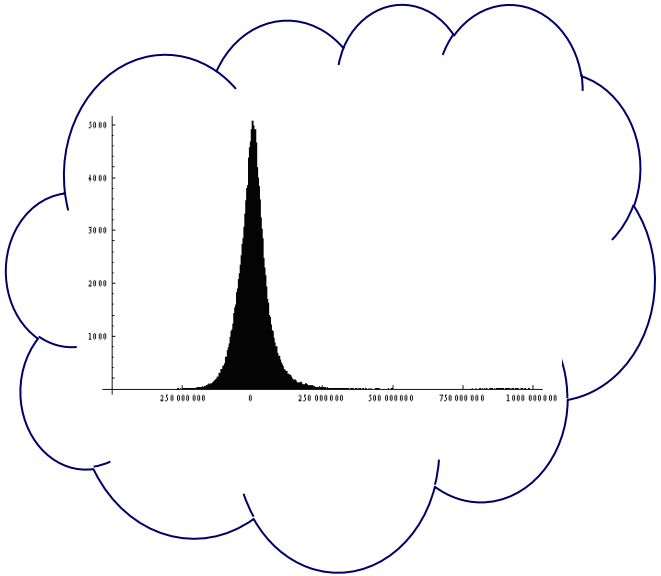
The Story Doesn't End With GPUs

- We have seen that GPUs can indeed answer the computational challenges for Risk Management such as IRC and CVA
- Moving from a PoC to Prod presents new challenges
  - Locality of Data
  - Locality of Compute
  - Interactions with other systems
    - Latencies
    - Formatting translations
- *Let's revisit our examples ...*



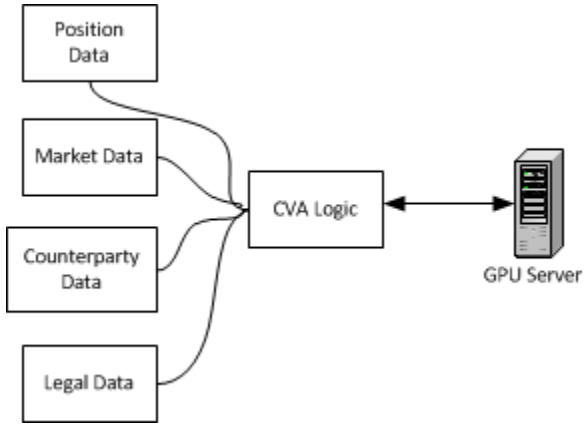
GPU Cases: Case 1 IRC

- Calculation: Small in/output, massive, predictable, distributable
- Implementation: Quantile sampling implies centralisation...
- GPU Impl: Avoid above issues, performance
- User reqs: EoD batch + ad-hoc analysis – no real time
- Input reqs: Generated in daily preprocessing batch



GPU Cases: Case 2 CVA

- Calculation: Large in/output, complex modelling, massive computation
- Implementation: Naturally distributable, nature of CVA implies some centralisation
- User reqs: EoD batch, FO quoting
- Input regs: Many data sources, constantly changing, must be up to date



Summary

- With the introduction of GPUs, the availability of affordable raw-compute is no longer an issue.
- However, realising the true potential of GPU computing in the context of large and potentially globally distributed infrastructure can be a challenge.
- We must keep Amdahl’s law in mind.

Conclusion

- GPU computing can equip banks in a challenging new market environment and for the accompanying regulatory demands
- Many more applications for this and other massively-multi-core computing in our industry
- GPU computing using Nvidia GPUs and CUDA has been a game changer for market risk management at ING Bank and we expect this trend to continue.

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Q&A