HPC in ING FM's pricing systems

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Building the Preferred Bank

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Agenda

- Background
- The problem of CVA
- Where are we as ING?
- Next challenges

Background

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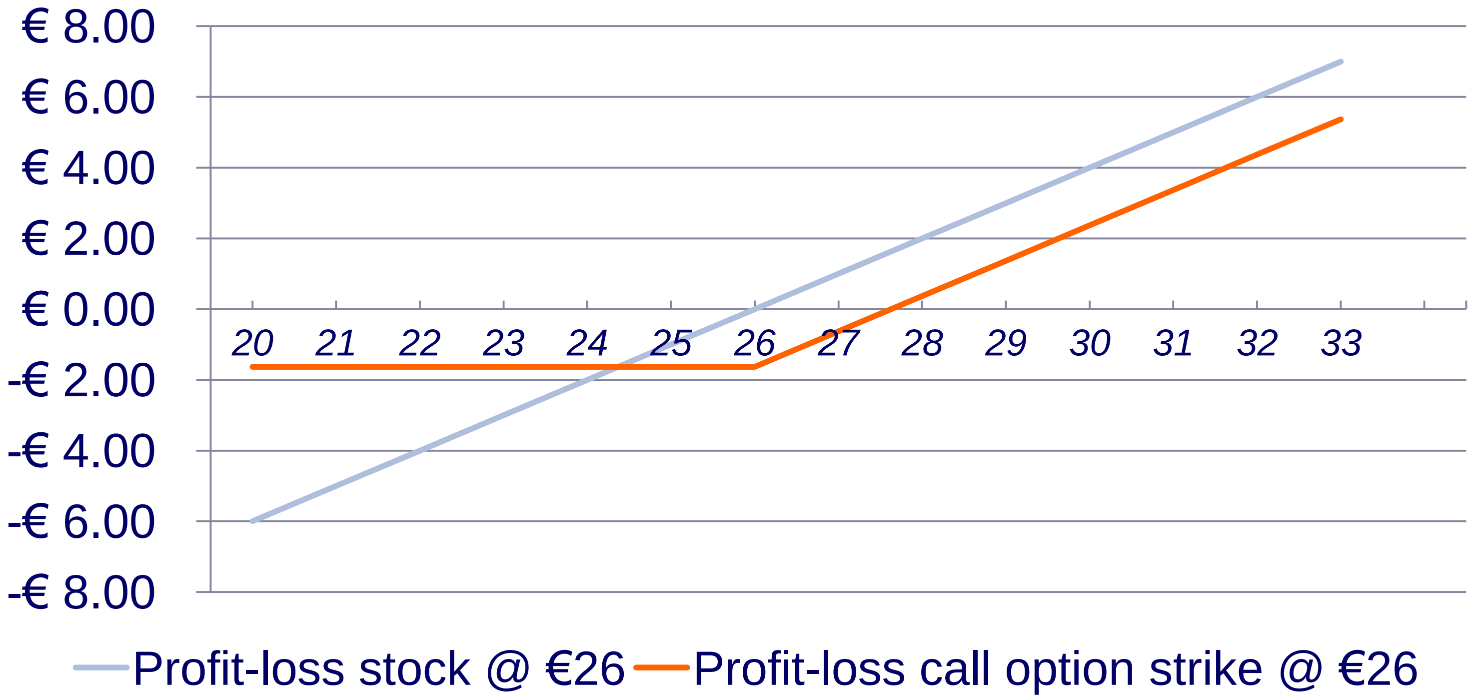
- Large part of ING FM business is trading in various derivatives products with our clients
- What is a derivative?

Example: buying a stock vs. buying a call option for Royal Dutch Shell



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Background

- Derivatives are traded on exchanges as well as “Over The Counter” (OTC)
- An OTC derivative is traded *bilaterally* between two parties giving rise to credit and funding liquidity risks
- The OTC derivatives market is much larger than the exchange-traded one
- The notional value of OTC interest-rate derivatives is approximately $284 trillion!
- Being able to price OTC derivatives fast and correctly and calculate various risk measures is key to ING FM’s competitiveness
- Strong in-house software development and quantitative finance knowledge are of paramount importance to stay in the business

Definition

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- Counterparty credit risk is the risk that a counterparty in a financial contract will default prior to the expiry of the contract and will be unable to make future payments.

- In most cases, counterparty credit risk is not considered in direct evaluation of trades and, therefore, needs to be adjusted appropriately to reflect the risk should either of the counterparties default on their commitments.

- Under IFRS derivatives should be **measured at fair value (IAS 39).** Generally derivatives pricing does not take into account counterparty credit risk**.** Therefore a specific adjustment must be made to the **default-free value** of the derivative (this is **not a 'reserve'** but a 'valuation adjustment' should be part of the daily mark to market)

- **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.**

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Consequences…

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- Essentially two-sided:
  - Both the counterparty and ING 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

- Effectively marks derivatives to ‘fair value’

  Metric should follow the normal ‘risk neutral’ and ‘non-arbitrage’ principles used for pricing, valuation and risk management purposes.

- CVA magnitude depends on
  - The probability of default of the counterparty
  - The possible exposure in the future (only if it is pos
  - The loss given default (loss after recovery)

$$CVA = \mathrm{E}\left[1_{\tau \leq T} V(\tau, T)^{+} (1-\delta)\right]$$

Default — Exposure — 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 and their correlation.

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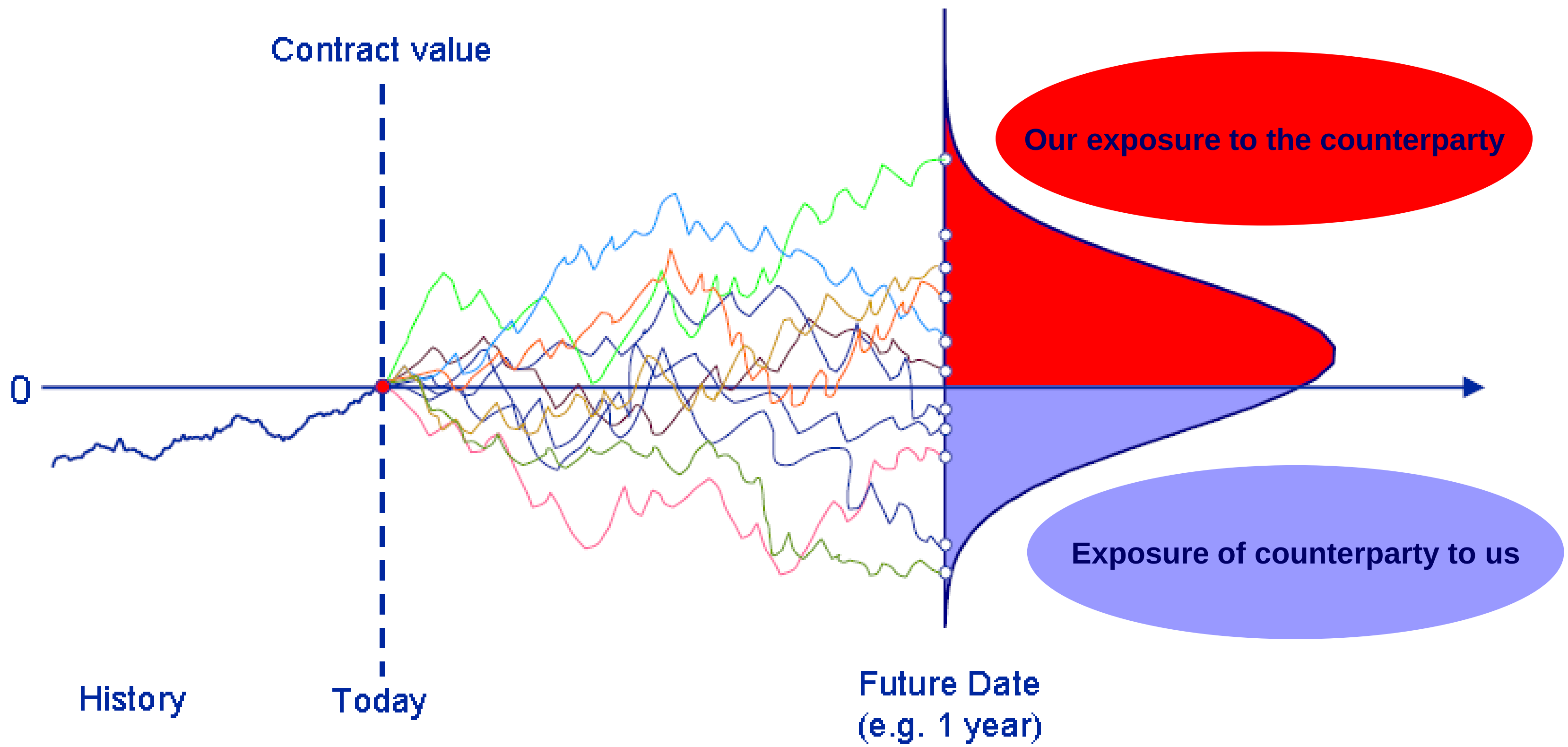
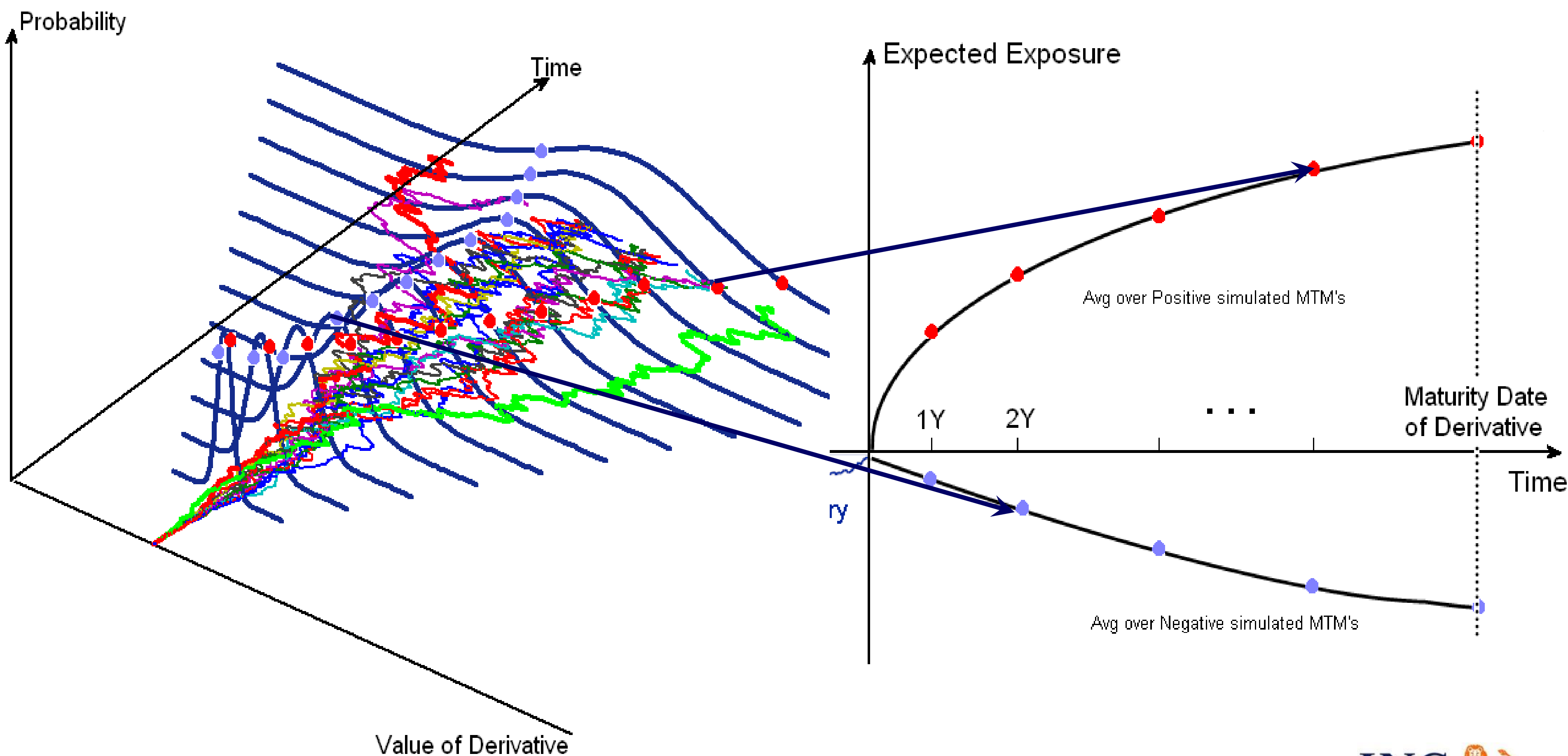
Credit Valuation Adjustment

Expected Positive Exposure



EPE and ENE



Probability
Time
Value of Derivative
Expected Exposure
Avg over Positive simulated MTM's
1Y
2Y
. . .
Maturity Date
of Derivative
Time
ry
Avg over Negative simulated MTM's

Methodology for CVA (unilateral)

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- Assuming a deterministic recovery rate, we can write:

$$CVA = -(1-\delta)\int_0^T B(s)\mathrm{E}\left[\max\left(V^*(s,T),0\right)\right]dS(s)$$

$$V^*(s,T) = \underbrace{V(s,T) \mid \tau = s}_{\text{Exposure knowing default has occurred}}$$

where B(s) is the risk-free discount factor, and S(u) is the survival probability of the counterparty;

- Assuming that exposure and default probabilities are independent, we can write:

$$CVA = -(1-\delta)\int_0^T B(s)\mathrm{E}\left[\max\left(V(s,T),0\right)\right]dS(s)$$

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Methodology for BVA

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- Discretizing the integral (still under assumption that exposure and default probabilities are independent!), we can write:

$$BVA = CVA - DVA = \left(LGD_C^{MKT} \cdot \sum_{i=1}^{T} EPE_{C\ \ i}^{MKT} \cdot DF(t, t_i) \cdot PD_C^{MKT}(t_{i-1}, t_i) \right) -$$

$$\left(LGD_{ING}^{MKT} \cdot \sum_{i=1}^{T} EPE_{ING}^{MKT} \cdot DF(t, t_i) \cdot PD_{ING}^{MKT}(t_{i-1}, t_i) \right)$$

- One needs a (multi-ccy, multi-asset) model to generate distribution of future exposures…

- Implied market parameters and calibrations need to be used (credit spreads, implied interest and fx volatilities, etc..).

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BVA on portfolio level

- In case of default, there will be a netting applied according to “legal” specifications. This should be reflected in BVA calculation!
- Hence EPE and ENE need to be calculated on counterparty portfolio level, according to defined netting sets.
- Further, any collateral agreements need to be taken into account, in order to reflect the correct EPE and ENE.
- In practice, CVA will be negligible for strong CSA counterparties. These can de discarded from calculation.
- But model should incorporate logic for netting sets and collateral agreements!

Cutting edge CVA implementation– In production

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Portfolio:

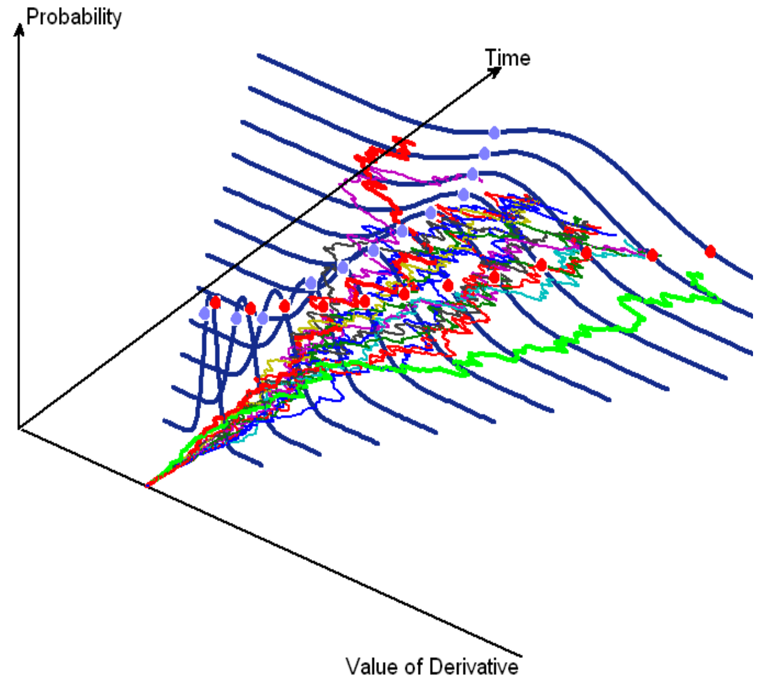
- Roughly 50K instruments
- All market conventions, netting and collateral rules
- >30 currencies
- >6000 counterparties

Model:

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

Usage:

- Official P/L and Risk Reporting



- For one CVA run with 50K instruments 3.75 billion pricing evaluations
- For a full CVA sensitivity run (230 runs) hundreds of billions of evaluations
- For an HVaR run with 50K instruments 13 million pricing calls

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Distinguishing GPU from CPU

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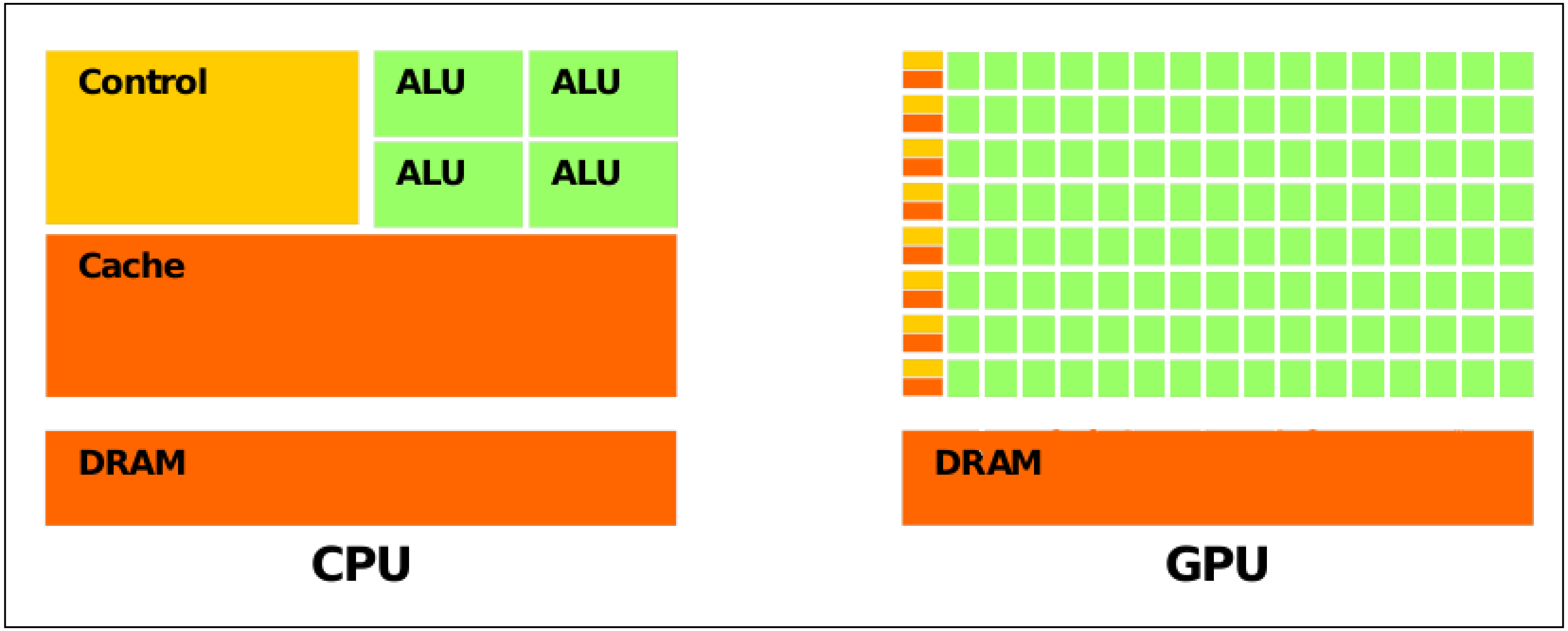

The CPU is a "*Jack of all trades …*"

- Optimized for fast access to cached data
- Control logic for out-of-order and speculative execution

The GPU is a special purpose accelerator specializing in:

- Graphics rendering
- Extremely well suited to massively parallel applications

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Why GPU Computing?

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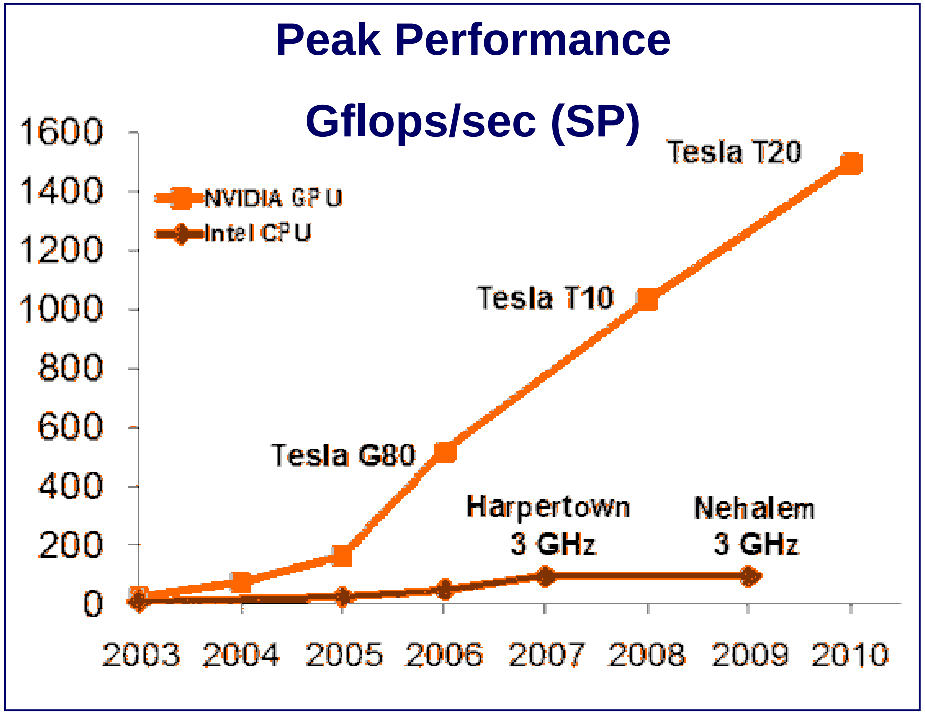

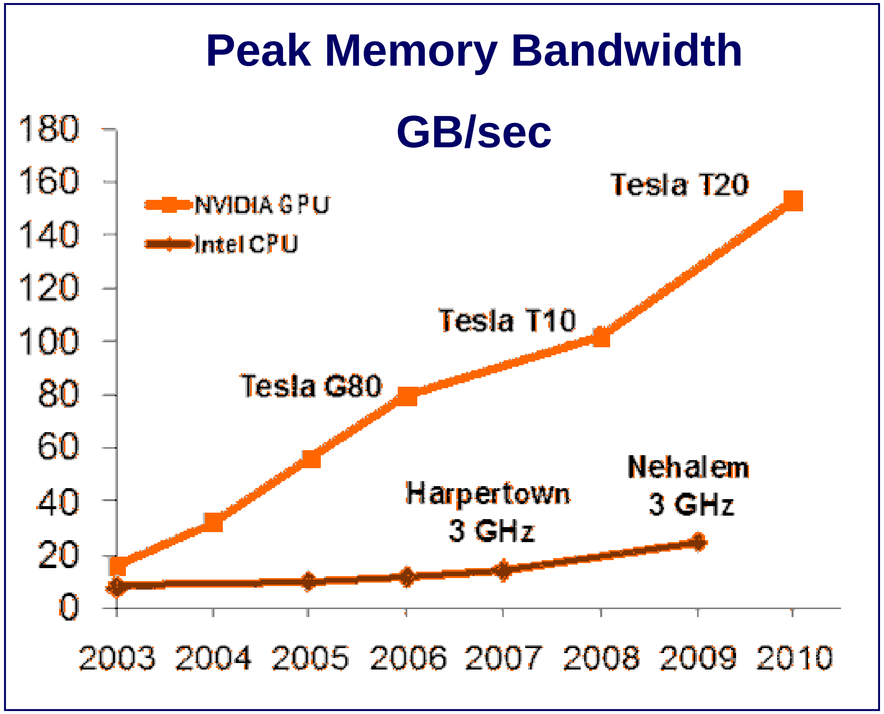

The latest generation CPU vs. GPU

- 20x lower power consumption
- 10x lower cost

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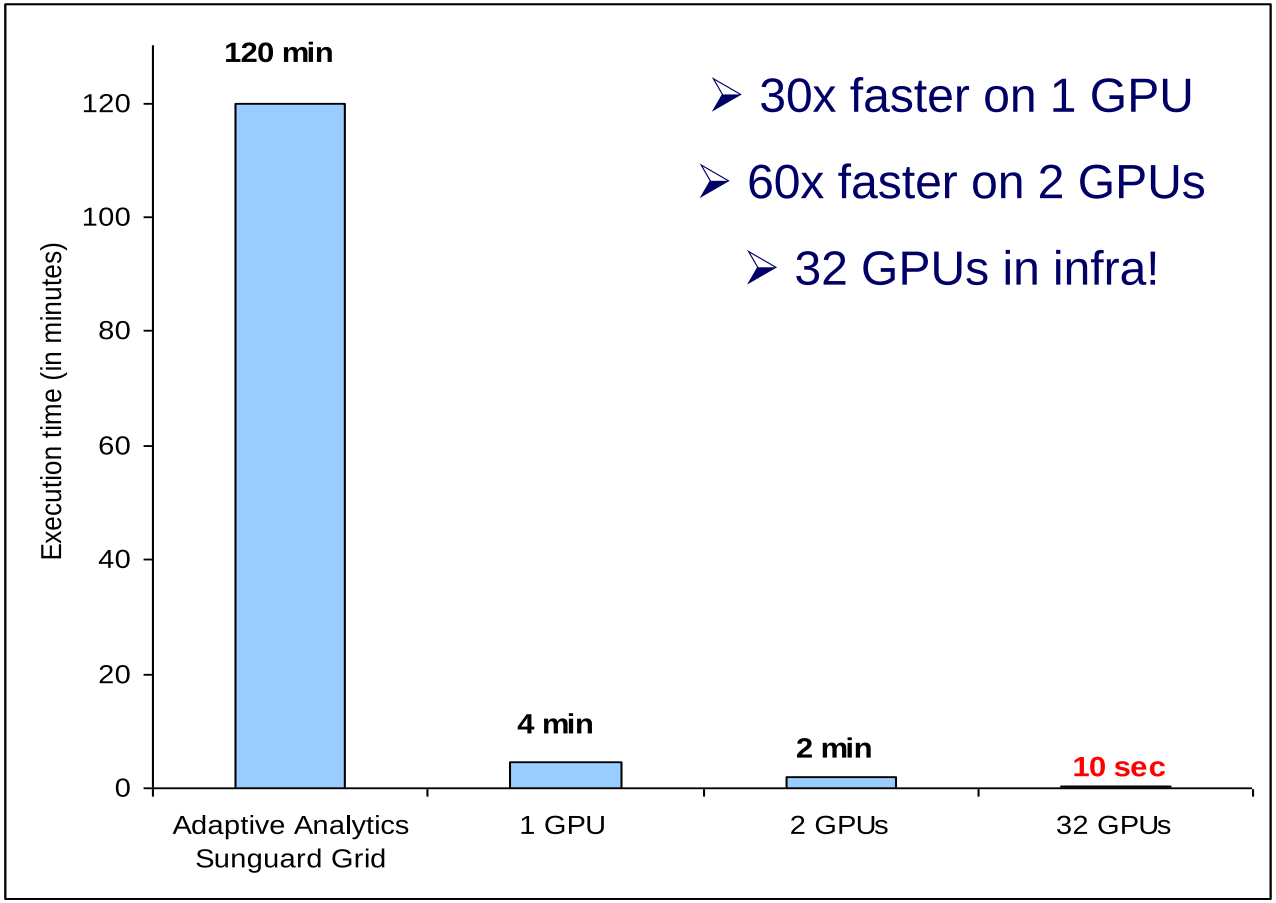
Performance – Portfolio of 50K instruments



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Where are we as ING

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- In the area of in-house software development for credit risk we belong to Top-5 banks in Europe
- Building one the best teams for FM in the NL around people who are passionate about both modern software development and the quantitative aspects of FM business
- Modern tooling where problem chooses the language/tool: Nvidia CUDA, SQL & NoSQL, C++, Java (EE), Python
- Emphasis on functional automated testing of the whole platform
- Working data sizes in 10s of GB & 10s of millions pricing simulations per second
- Gigabytes of risk analytics results per day leading to adoption of modern NoSQL systems such as Hadoop/Hive

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Next challenges

- Larger volumes and bigger demands for HPC driven by new regulatory challenges and the industry's drive for better risk management
- Expecting to grow our systems to deal with working sets comprising more than a million trades
- Supporting FM in calculating additional adjustments beyond CVA to stay competitive
- Moving from batch-oriented to real-time/event-driven risk-management

Q/A