

HPC at NTNU

Anne C. Elster, PhD

Co-Director (until Jan. 2007)

Program for Computational Science & Visualization



Anne Elster & Bjørn Lindi with NTNU's old
1 TeraFlops SGI Supercomputer Gridur-Embla



Elster and Linid behind Njord, NTNU's new 7.5 TFlops
IBM Power System P5+ Supercomputer



Trondheim & NTNU

- **Trondheim:** 150 000 innbyggere på 63° N 7° E
- **NTNU:** Nest største universitet i Norge
 - 4000 ansatte &
 - 20 000 studeneter
- **Modern transport makes far away close at hand**
 - Airport (dozens of flights to Oslo, also to Copenhagen, Amsterdam ...)
 - Rail to Oslo & Northern Norway
 - Daily coastal express (Hurtiguten) Bergen - Kirkenes
- **Gulf Stream climate**

--->milder climate in winter than expected (2-3mnths of snow in winter, but few really cold spells. **Summer: Great this year! (2006).**

PROGRAM FOR COMPUTATIONAL SCIENCE & VISUALIZATION (CSV or BVV) at NTNU

Board chair:

Assoc. Prof. Egil Tjøland, Petroleum Engineering

Co-Director & Director CSV infrastructure (from Jan. 2007):

Assoc. Prof. Jørn Amundsen, Computer Science/HPC center

Co-Director & Director Numerical Methods:

Professor Einar Rønquist, Applied Mathematics

www.ntnu.no/satsingsomraader/

Organisasjon

STYRET

REKTOR

INFORMASJONSAVD.

TEKNISK AVDELING

ØKONOMIAVDELING

STUDIEAVDELING

ORGANISASJONSAVDELING

UNIVERSITETSBIBLIOTEK

VITENSKAPSMUSEET

FAKULTETENE

ARKITEKTUR
OG BILLED-
KUNST (AB)HISTORISK-
FILOSOFISK
(HF)INFORMASJONS-
TEKNOLOGI,
MATEMATIKK
OG ELEKTRO-
TEKNIKK (IME)INGENIØR-
VITENSKAP
OG TEKNOLOGI
(IVT)

MEDISIN (DMF)

NATUR-
VITENSKAP OG
TEKNOLOGI (NT)SAMFUNNS-
VITENSKAP OG
TEKNOLOGI-
LEDELSE (SVT)**BVV**

Program for Computational Science & Visualization at NTNU (CSV-NTNU)

NTNU recognizes its national importance in making CSE available for societal and industrial development

- Part of NTNU's strategy in HPC

NTNU i tall

- **53** institutter fordelt på **7** fakulteter
- Universitetsbiblioteket (2.6million volumes w/ focus on technology)
- Vitenskapsmuseet

- **20 000** registrerte studenter, **7000** tas opp/år
- **3000** uteksamineres/år med avsluttet grad
- **220** avlagte doktorgrader/år
- **4320** ansatte (årsverk) totalt
- **2600** i undervisning og forskning, herav **555** professorer
- Driftsbudsjett på **3,6 milliarder kroner**
- **555 000 m²** egne og leide arealer

- Extensive activities on the World Wide Web
- 20-30 large conferences are arranged at NTNU each year
- The research magazine Gemini is issued jointly with SINTEF, circulation: 65 000

- **NOTUR leading edge site (Norway's leading HPC site since the 80's)**

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NTNUs seks tematiske satsingsområder

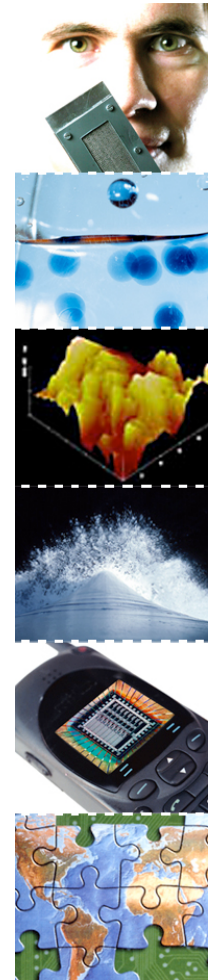
- 1) Energi og miljø
- 2) Informasjons- & kommunikasjonsteknologi**
- 3) Globalisering
- 4) Medisinsk Teknologi
- 5) Materialer
- 6) Marin og maritim forskning

Budsjett:

Strategimidler (2–5 mill. kr/område)

Doktorgradsstipendier og driftsmidler

www.ntnu.no/satsingsomraader/



Satsingsområdet IKT (ICT)

Programmer:

- **Computational Science & Visualization (aka CSV aka BVV)**
- Bioinformatics
- Health informatics
- e-Government
- Information Security
- Language technologies
- Basic ICT

BVV strategi:

Fortsatt klyngesatsning!

- Sentrale klynger < 64 prosessorer
 - Unngå mange nivå med switch
 - Unngå for komplisert drift (for mye nede-tid)
- Kjøp inn en hvert år med spleisemidler
- Raskeste interconnect på siste maskin
- Behold to foregående klynger for mindre krevende brukere

Hvor er Njord?



FEIRING AV ÅPNINGEN AV NJORD
30. NOVEMBER, 2006

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Anne C. Elster

HPC systemer ved NTNU

NTNU 2006:

20 år med supercomputere i Norway

- siden vår første CRAY XMP/22 in 1986

Nåværende HPC systemer:

- **SGI Altix (32noder – del av NOTUR2 søknad ("snehvit"))**
- **Dell Cluster (sentralklynge "norgrid")**
- **Cray XD1 med FPGAer (biomedical) ("musculus")**
- **NJORD!**

NTNU's New IBM (IBM Power 5 575+)

- Most powerful supercomputer in the Nordic countries
- 9th in Europe on roll-in
- 112th on current Top500-list
- **7,5 TeraFlops peak** (Current SGI system has about 1 TF)



–For comparison: "Roadrunner" -- The new IBM system built on the Cell processor announced at Los Alamos Labs:

- 16 000 Cell-processors with a combined 1 Petaflop (10^{15}) peak performance!
- Delivered in 2008

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New NTNU Supercomputer ("njord") from IBM

- Also runs Norway's operational weather forecasts (met.no)
- NOK 30 millions for system
- NOK 20 million for infrastructure
 - incl. new machine room, back-up power generator & batteries ++
- Comparison:
 - Our 1986-Cray cost NOK 130 million in today's currency!

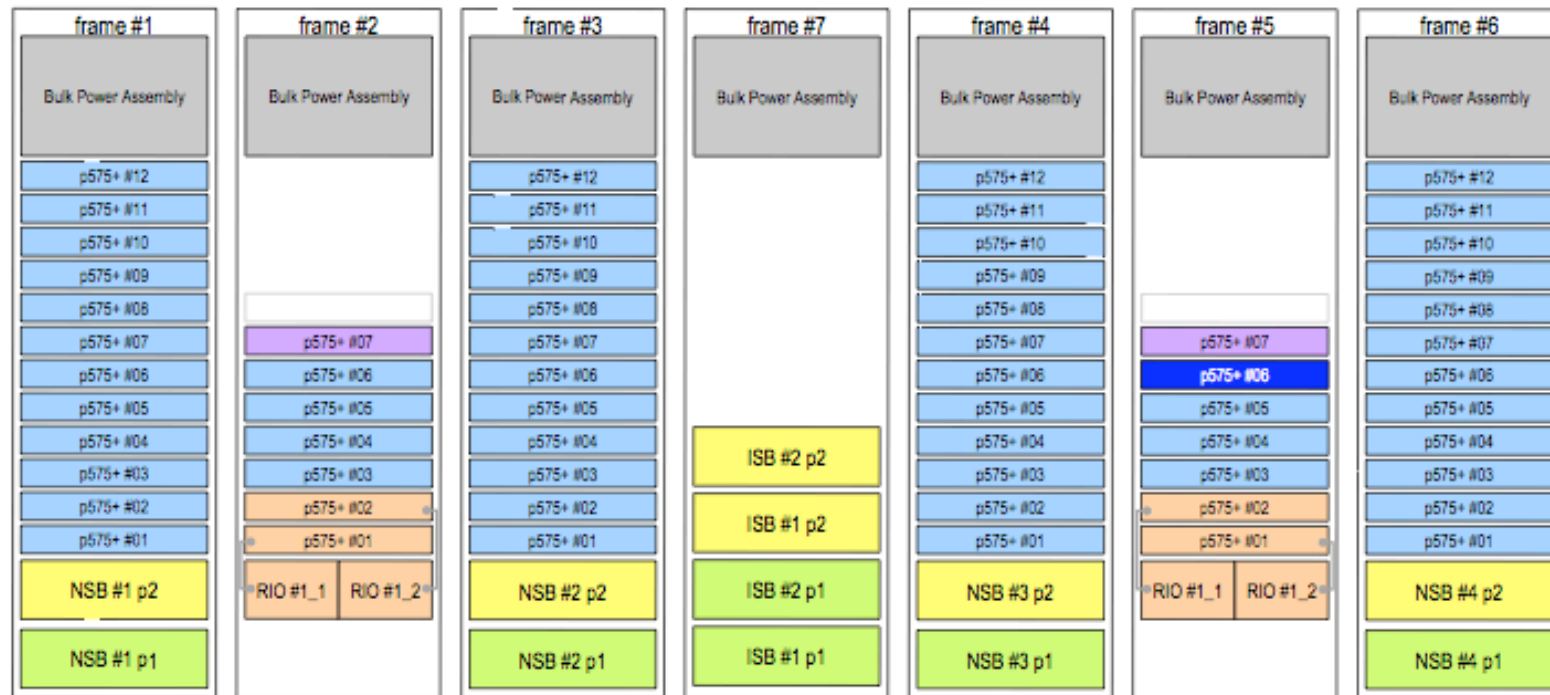


Jørn Amundsen, Roar Skålin (it-sjef met.no) og Bjørn Lindi ved Njord



Digging of hole for 2000 hp (horsepower) back-up power generator

Frame layout – node placement



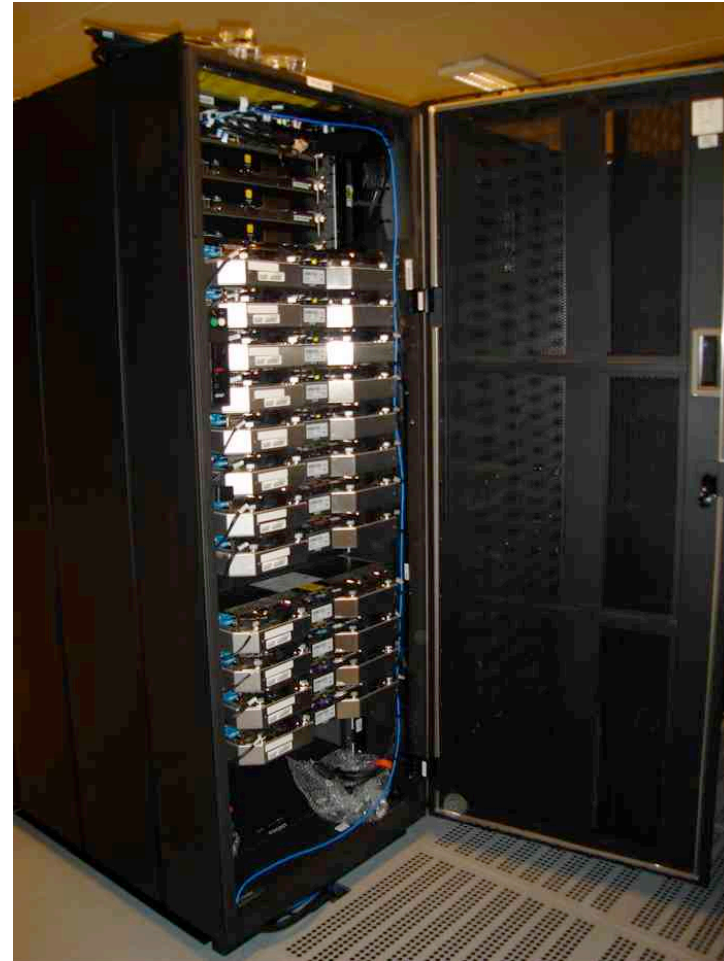
- p575+ #01 IO node (GPFS/VSD server); 16-way 1.9 GHz, 16 GB memory [4]
- p575+ #07 Login node (FEN); 16-way 1.9 GHz, 32 GB memory [2]
- p575+ #03 Compute node; 16-way 1.9 GHz, 32 GB memory [55]
- p575+ #06 Compute node; 16-way 1.9 GHz, 128 GB memory [1]

Some HW details -- IBM Power 5 575+)

- 7 frames
- 62 nodes
 - 52 compute
 - 4 I/O
 - 2 log-in
- Each node has:
 - 8 dual-core CPUs
 - 32GB Mem
 - one node has 128GB

Total RAM ca. 2TB!

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Njord frame

National HPC systems at Norwegian Universities

University	Hardware	Class	Processors	Nettwork	Aquired
NTNU	embla Origin3800	SMP	1 x 512	Numalink	2002
	gridur Origin3800	SMP	1 x 384	Numalink	2000-2002
	snehvit Altix350	SMP	2 x 16	Numalink	2004
	norgrid	cluster	64 x 1	GigE	2004
JiB	en/to/tre p690 Regatta	SMP cluster	3 x 32	IBM	2002
	fire IBM 1300	cluster	1 x 32	100 Mbit	2002
	fimm	SMP cluster	2 x 86	GigE	2004
JiO	magnum HP Superdome	SMP	1 x 64	HP	2003
	Parmaster	cluster	88 x 1	GigE	2004(?)
	?	cluster	?	Infiniband	2005
JiTø	nana HP Superdome	SMP	1 x 32	HP	2001
	snowstorm	SMP cluster	4 x 49	GigE	2004

NTNU's New IBM (IBM Power 5 575+)

- 7 TeraFlops peak (Current SGI system has about 1 TF)
- Most powerful supercomputer in the Nordic countries
- 9th in Europe on roll-in
- About 72nd on current the Top500-list (more likely much below 100)
 - Current No. 1: LLNL's Blue Gene at 280.6TFlops!
 - Current No. 3: LLNL's IBM p575 with 75.76 TFlops





Tematiske
SATSINGOMRÅDER



NTNU - Science communication (2005)

775 popular scientific lectures

280 popular scientific articles

1000 contributions from NTNU in the press

70 art productions/performances/presentations

15 000 visitors to the annual Science Festival

60 events in “Town, Rural areas and Knowledge”

About 20 stands at the Technoport festival, 14 000 visitors

Popular periodicals published by NTNU: *Gemini* and *Spor*

Websites *Universitetsavisa* and *forskning.no*

Media training courses for 100 NTNU researchers

CSV – recent events:

- **Supercomputer Day (for highschoolers) (Nov 2006 & Jan 2007)**
- **Opening celebration of new supercomputer (Nov. 30, 2006)**

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Some of the main NTNU faculty members involved in HPC:

Faculty of Info. Techn., Mathematics and Electrical Engin. (IME):

Kværnø, Nørsett, Owren, Rønquist, NN (Numerical Analysis, Mathematics)

Holden, Omre, Rue, Tjemedal (Statistics, Mathematics)

Blake, Brattbergsengen, Elster, Halgren, Natvig +++ (Visualization Parallel Computing., Large data sets, etc, IDI)

Several faculty members in EE also involved (large sim., security, etc)

Faculty of Natural Sciences and Technology (NVT):

Sudbø, Holmestad, Hansen, Olausen, Støvneng, Borg, Elgsæther,

Løveseth Skagerstam (Physics)

Hafskjold, Aastrand, Martens Koch, M. Trætteberg, Hagen, Stølevik (Chemistry)

Hertzberg, Preisig, Haug-Warberg, Chen, Rønning, Svendsen, Jakobsen (Chem. Proc. Tech)

Faculty of Engineering Science and Technology (IVT):

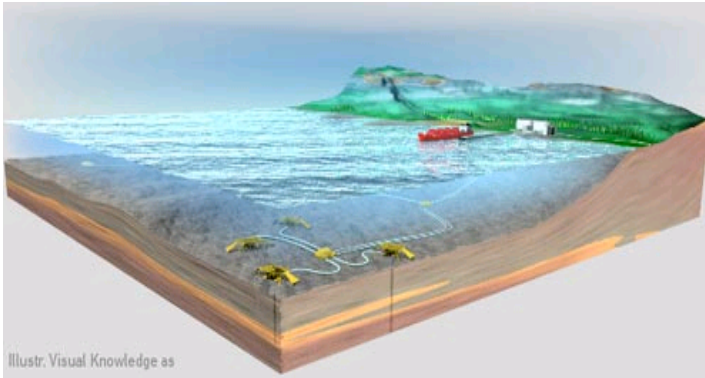
Kleppe, Landrø, Tjåland, Ursin (Petroleum Tech.)

16 faculty members in Structural Engineering, 10 in Energy & Process Engineering +++

Faculty of Medicine (DMF)

Several faculty members involved in visualization and biomedical sciences

The Gas Technology Center NTNU-SINTEF



Unifies the combined efforts of NTNU and The Foundation for Scientific and Industrial Research (SINTEF) to exploit the synergism of multidisciplinary research into the natural gas value chain.

- Is the largest natural gas research- and educational center in Norway.
- There are 300 scientists affiliated with the Gas Center
- At NTNU, the Center has the combined resources of 203 researchers, totaling an effort of 150 active man-years. This includes :
 - 53 professors,
 - 133 dr.ing. (PhD) candidates and
 - 16 post doc researchers

More info at www.ntnu.no/gass

www.ntnu.no/satsingsomraader/

Preparing for the future: GRID

Vision: Offer a next generation infrastructure for large-scale global collaboration.

National network infrastructure already in place.



CERN: European Organisation for Nuclear Research

- **World's largest particle physics lab situated in Geneva, Switzerland (part of experiment extends into France)**
- **"Father of the WWW"**
- **Leader of Europe's largest GRID project**
- **Research primarily done by teams of visiting scientists based at their parent university or research centre**
- **Staff drawn from 20 European Member States, but scientists from any country may be invited to spend a limited period at CERN.**
- **CERN has 2,500 staff members**
- **6,500 visiting scientists from all over the world carry out research at the Laboratory each year.**

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NTNU Collaborations with CERN:



- Two Norwegian students in summer 2003:
 - 1 Master student from Elster's NTNU group (Hisdal)
 - + 1 from Ousada's Univ. of Oslo's Physics group
 - Hisdal went on to do his MS thesis at CERN (with CERN staff and Elster)
- **Four MS** students from NTNU in summer 2004
 - Three of these went on to do their MS Theses at CERN (with CERN staff and Elster)
- + **Two MS** students this past summer

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Beregningsvitenskap

Hovedfokus for gruppen er parallelle beregninger.

Infrastruktur

Ytelsesmålinger, SMP vs. klynger; GRID; MPI; annet

Parallelle algoritmer

Teoretiske, dynamiske, feiltolerante

Parallelle applikasjoner

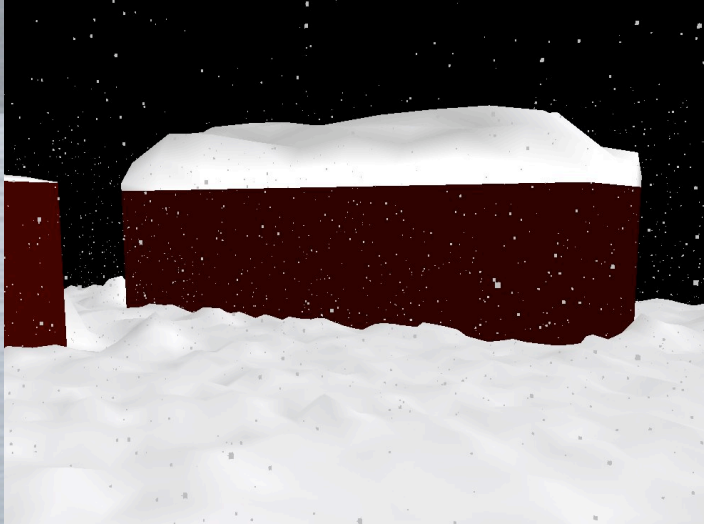


Beregningsvitenskap

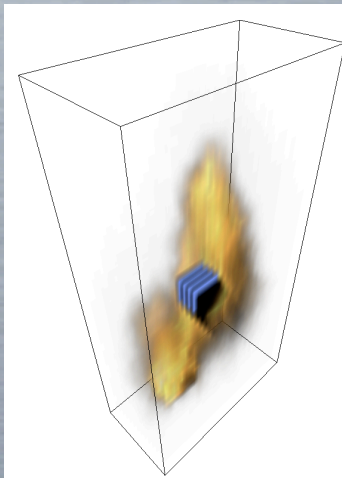


Samarbeide med:

- CERN
 - internets vugge,
 - EUs største datagrid prosjekt.
 - 5 av våre diplomstudenter har vært på sommer jobb der, 2 til til sommeren. Tre fra gruppen har tatt diplom der)
- SCALI
 - 2 diplomstudenter har tatt diplom der. Første nå ansatt der, siste fullfører til sommeren
- Statoil
 - diplomstudenter og sommer jobber
- Schlumberger Voxel Vision
 - diplomstudent
- Hydro
 - prosjektstudent
- andre institutter og fakulteter ved NTNU



Foto



Gruppen består av:

- Anne C. Elster
 - Jørn Amundsen (II-er)
 - Henrik Nagel (PostDoc)
- 2 Dr. Ing studenter & 5 Master.

Fag som undervises av Elster:

TDT4200 Parallele beregninger
(Parallellprogrammering med MPI)

TDT24 Parallele miljø og numeriske metoder

TDT 4205 Kompilorteknikk

Grafikk, visualisering og virtuell virkelighet

Datagrafikk

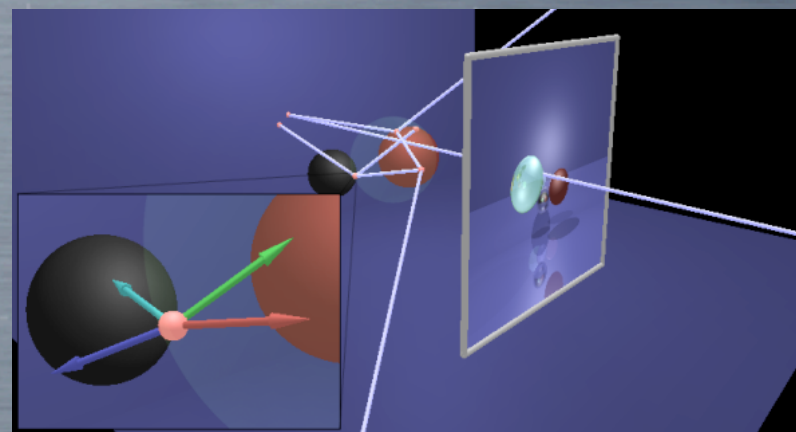
Bygge datamodeller av virkelige eller tenkte objekter

Visualisering

Vise modellene på en eller flere avbildningsflater. Oftest vil en tilstrebe at avbildningen gir inntrykk av å være et fotografi (fotorealisme)

Virtuell virkelighet

La betrakteren vandre rundt i den visualiserte datamodellen ved hjelp av stereoskopisk teknikk og sporing av hvor betrakteren befinner seg og i hvilken retning øyet ser (omslutning – immersive virtual reality)



Strålesporing (ray tracing)

Grafikk, visualisering og virtuell virkelighet

Våre hovedinteresser:

- **Kjerne: Spillteknologi**
- **Anvendelse: Virtuell kulturarv**
Metoder for modeller og animasjoner av historiske gjenstander, bygninger og steder
- **Anvendelse: Anvendelser i medisin**
Hjelpemiddel i anatomiopplæring
Opplæring av kirurger
Planlegging av operative inngrep
- **Sentralt problem: Fysisk basert modellering**
Fysisk realistiske modeller og animasjoner (eks. tekstiler)



Kong Sverres borg Sion på Steinberget vest for Trondheim

Grafikk, visualisering og virtuell virkelighet



Gruppen består for tiden av:

- 2 forskere
- 1 doktorgradsstipendiat
- 1 vitenskapelig assistent

Gruppen veileder årlig rundt 10 mastergrader

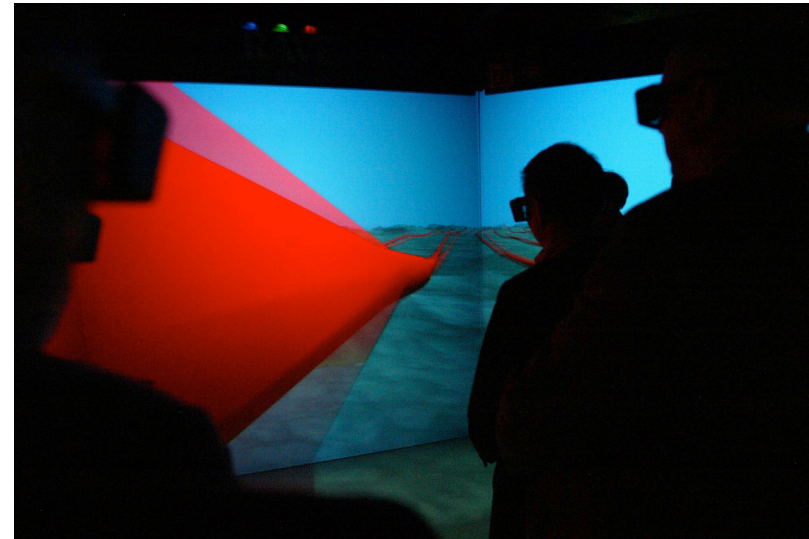
Hjemmeside:
<http://www.idi.ntnu.no/grupper/vis>



VR labben

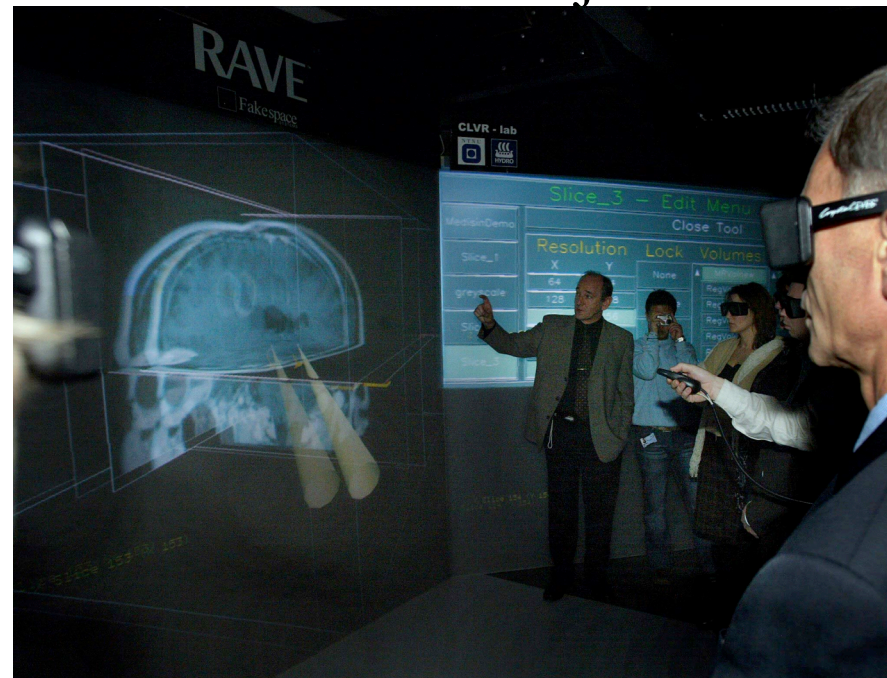
- RAVE (Reconfigurable Advanced Visualization Environment) fra FakeSpace
- Ledet av Professor Jon Kleppe
- Samarbeide mellom Petroleum teknologi og Datateknikk
- Externe partnere:
 - SINTEF Unimed
 - Hydro
 - Ceetron
 - Inside Reality

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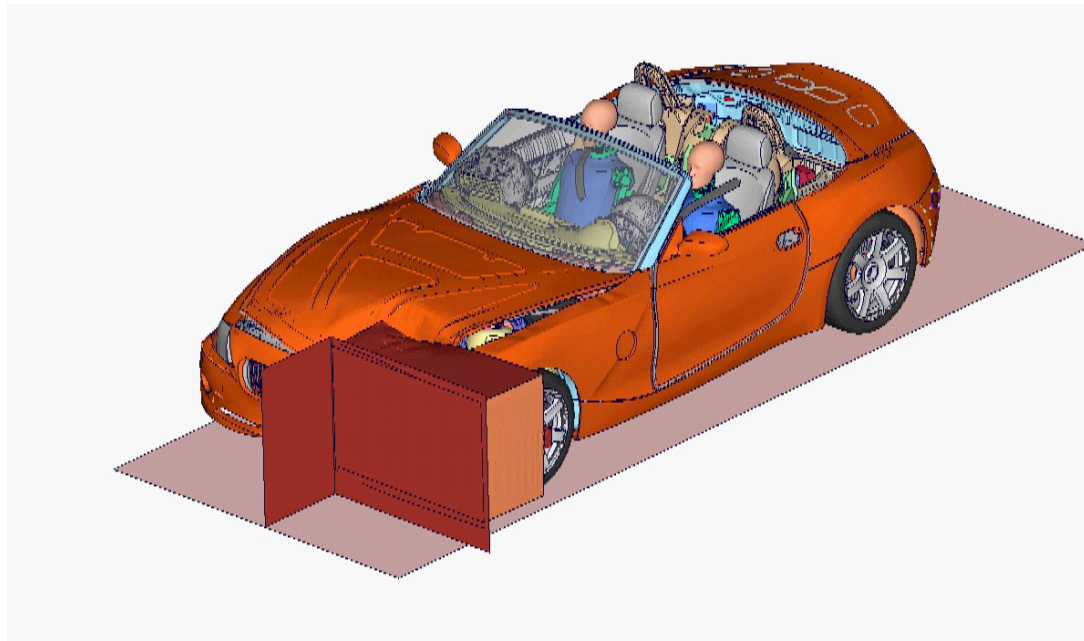
Ormen Lange

Hjernesvulst



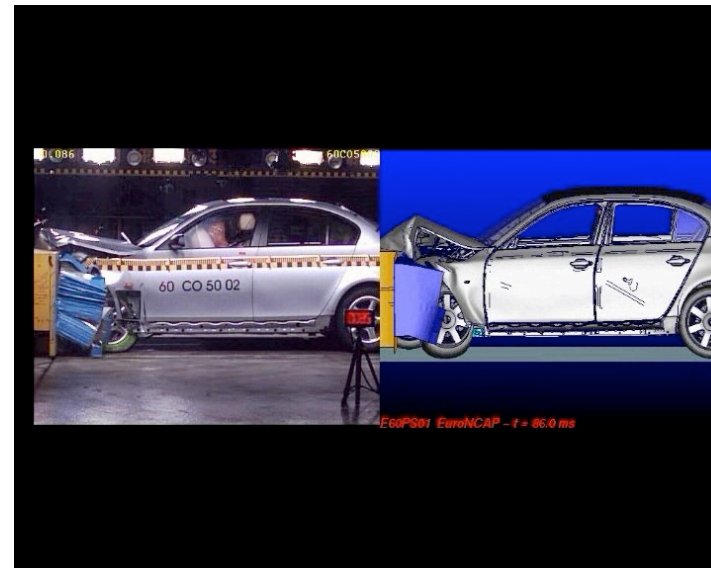
Car crash simulations

- Collaboration with Dpet. of Structural Engineering (konstruksjonsteknikk), Hydro, Audi, BMW and other related to desing om car bumpers:



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Car crashes – prototype *versus* simulation



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Some of the many other applications

- Medicine:
 - ultrasound imaging
 - imaging of vessels before surgery
- Chemistry
 - molecular analysis and simulation
 - CFD
- Physics
 - particle simulations
- Marine technology
- Mathematical methods
- Computer algorithms, benchmarking ...
- ...

Current News & Future Directions

August 2006: (See NTNUs web-page)

- Press release re. New Center for Integrated Operation for the Oil & Gas industry “*E-field*”, “*Smart Field*”, “*digital oil field*” ...
 - save 250 billion towards 2015
 - collaboration between NTNU, SINTEF & IFE
 - contracts with Stanford University, Univ. of Delft, Statoil, Hydro, ...
 - Yearly budget NOK 40 million
 - NOK10 mill From RCN (NFR SFI)
 - (senter for forskningsbassert innovasjon)

- **NanoLab** opened with new tester (Hysitron Tribolentur)

Upcomming HPC events related to NTNU

- article in Under Dusken next week (Jan. 16, 2007)
- article/photo series to be written by digi.no (visiting next week)
- Elster is :
 - on Technical Committee at ParCo 2007 in Germany, Sept 2007
 - on Tutorial Committee as part of Technical Committee for SC'07 in November in Reno. Nevada, USA (ca. 10 000 attendees expected!)
 - General Chair for PARA'08 to be held in Trondheim, Norway

NTNU -- CSV

(BVV: Beregnings Vitenskap & Visualisering)



www.ntnu.no

www.ntnu.no/satsingsomraader/



NTNU

Innovation and Creativity

www.ntnu.no

Sammendrag

- Trondheim & NTNU
 - NTNU i tall
 - Satsningsområder inkl. IKT & BVV
- BVV
 - Formål & strategi
- HPC resurser ved NTNU
 - Njord: vår nye spissresurs (IBM P5 systemet som nå installeres
 - Gridur/Embla, Altix Snehvit & Dvergir),
Norgrid klyngen ...
- Siste nytt & fremtidige satsninger
 - Pressemeldinger m.m.
 - **Omvisning i vårt nye maskinrom!**

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