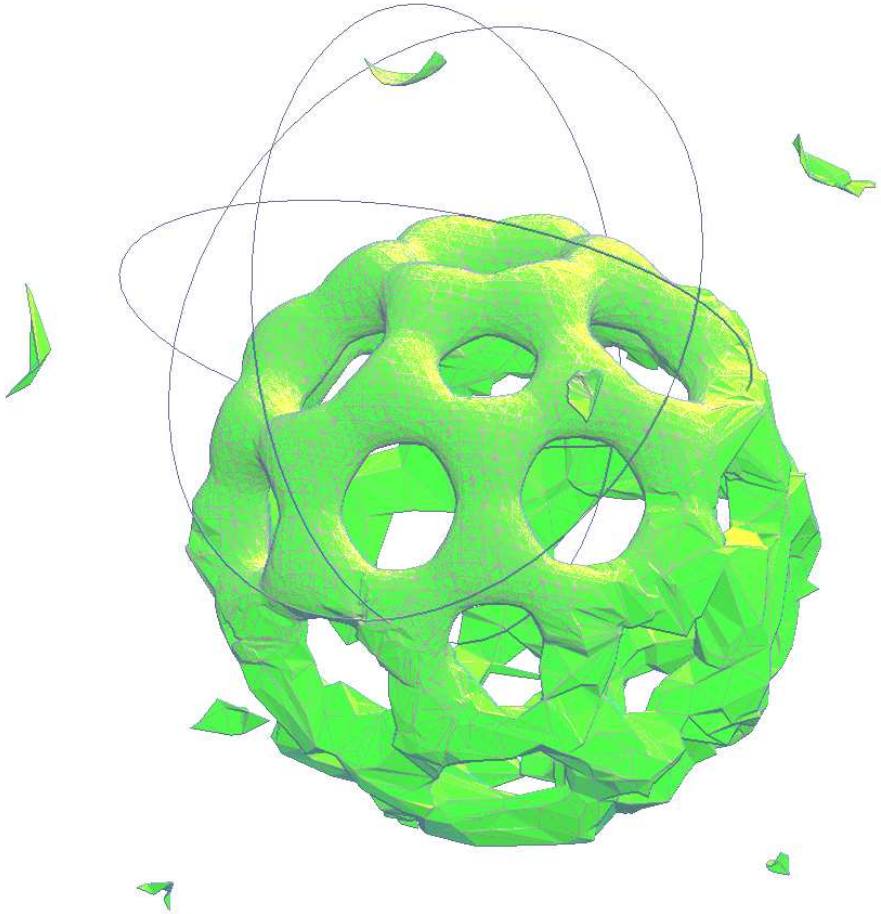
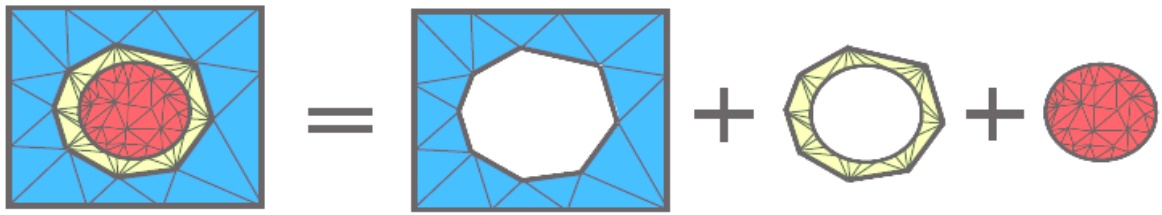


Visualisation Distante Temps-Réel de Grands Volumes de Données

Sébastien BARBIER

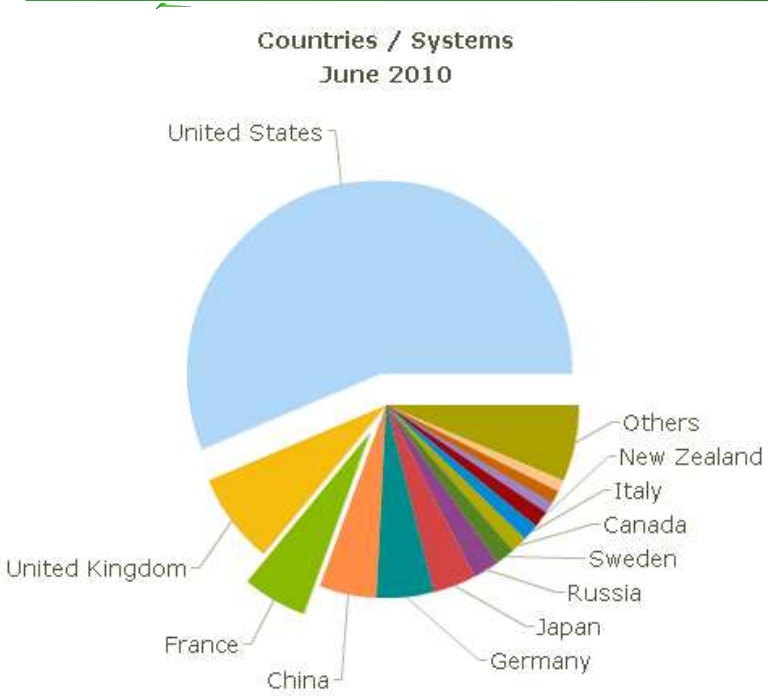


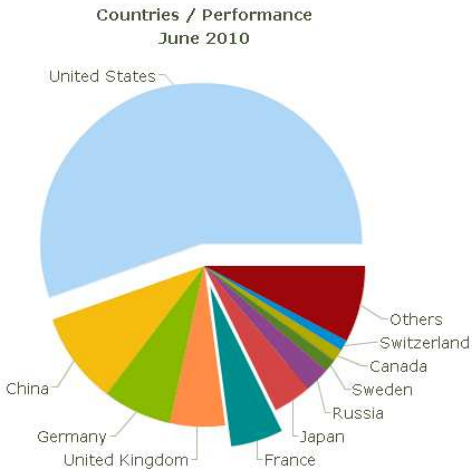
mercredi 3 novembre 2010

UNIVERSITE JOSEPH FOURIER
SCIENCES. TECHNOLOGIE. SANTÉ

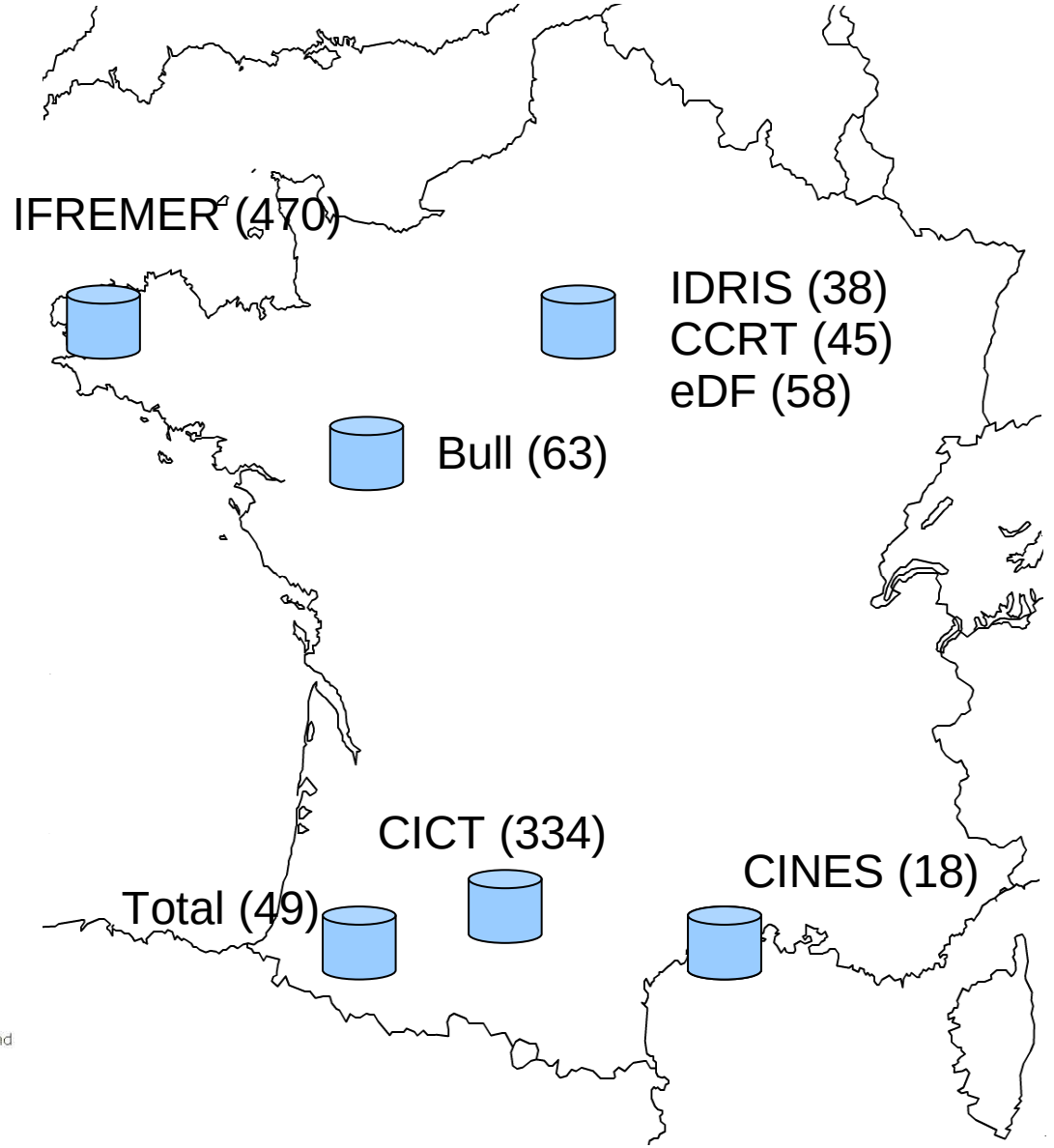
LABORATOIRE
JEAN KUNTZMANN
MATHÉMATIQUES APPLIQUÉES - INFORMATIQUE

SuperCalculateurs





Source : top500.org

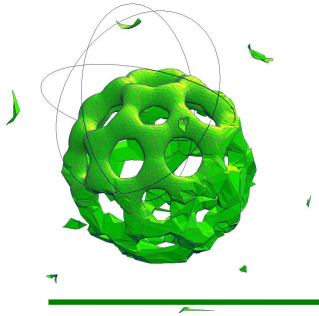


Post-Traitement Distant

Source : idris.fr

Lyon-Villeurbanne

Source : cines.fr



Approches Client/Serveur

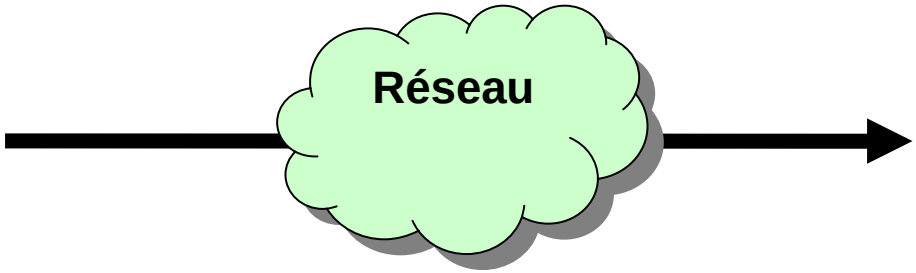
Serveurs de calcul

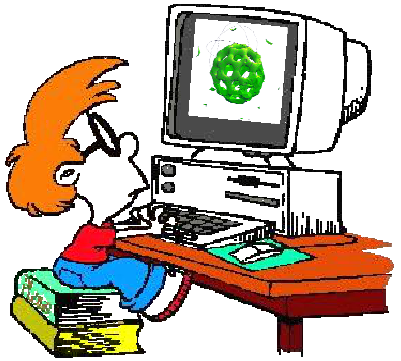
Géométrie simplifiée

+ meilleure interactivité
- dégradation

Client Lourd
=
Memoire Vive
Carte Graphique

Source : idris.fr



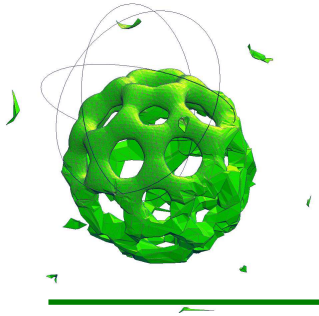


Serveurs de calcul
+
Serveurs graphiques

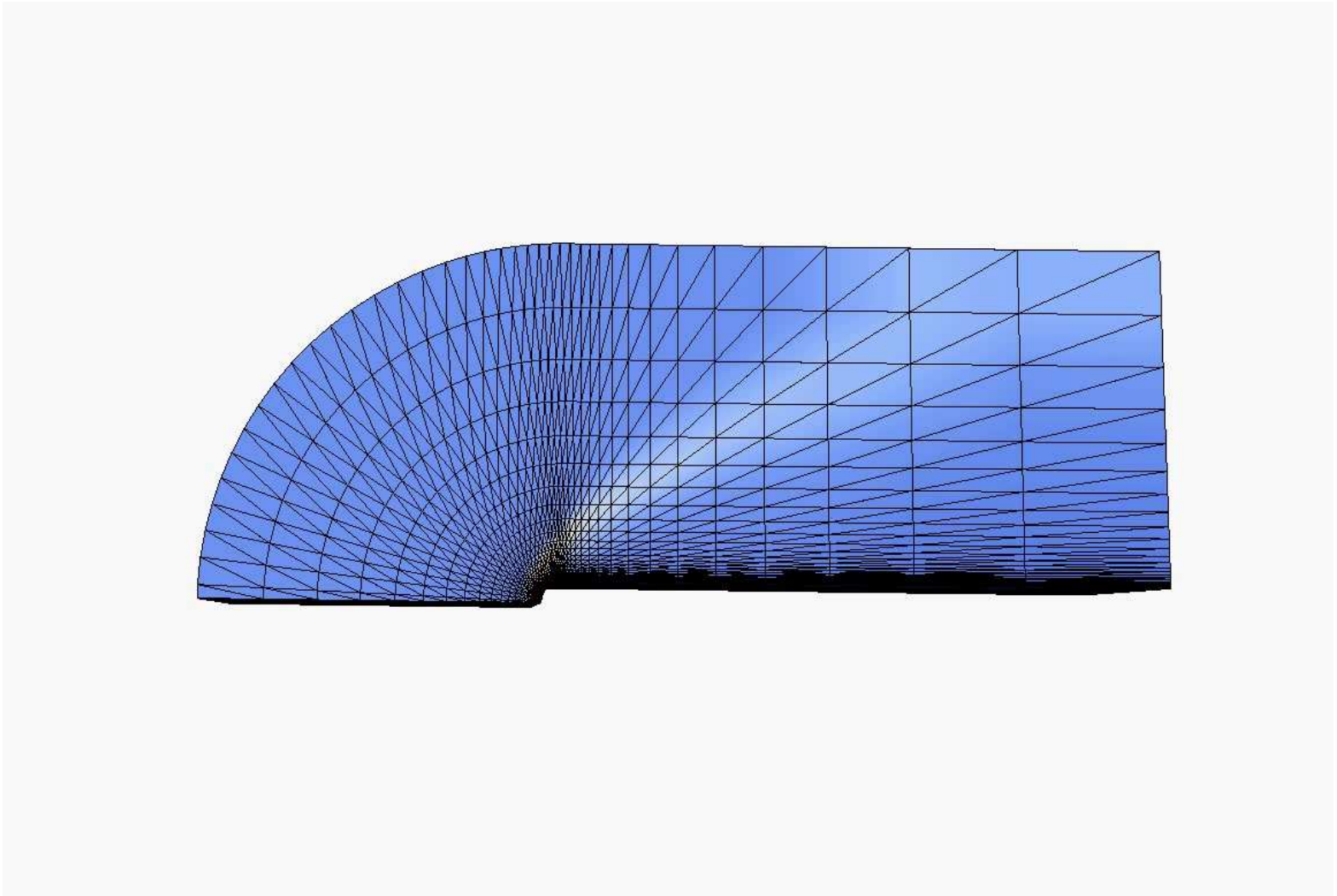
Images

+ haute précision
- latence interaction

Client Léger

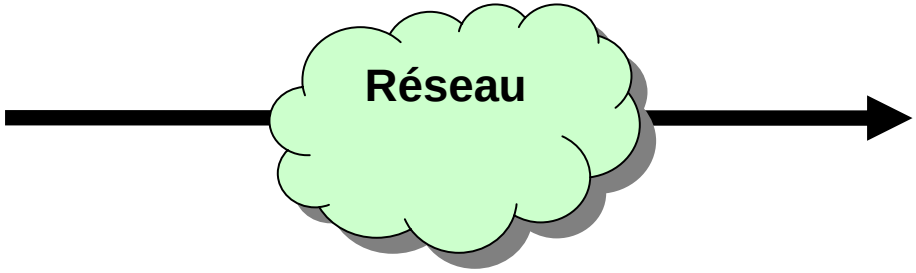


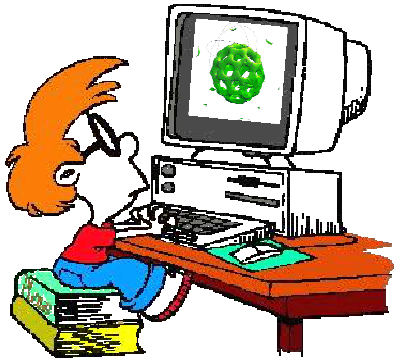
Paraview



MultiRésolution

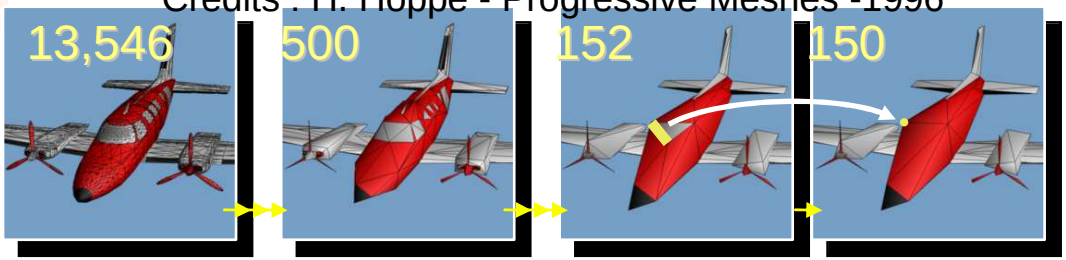
Serveurs de calcul





Client lourd

Crédits : H. Hoppe - Progressive Meshes -1996

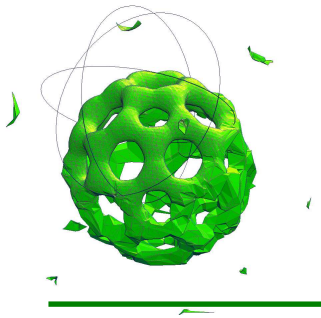


M^n M^{175} M^1 M^0

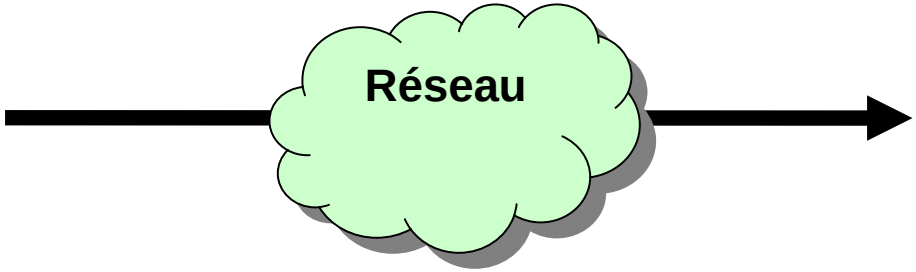
+ Aucun serveur graphique
+ Adapté au besoin de l'utilisateur
+ Compromis Interactivité/dégradation

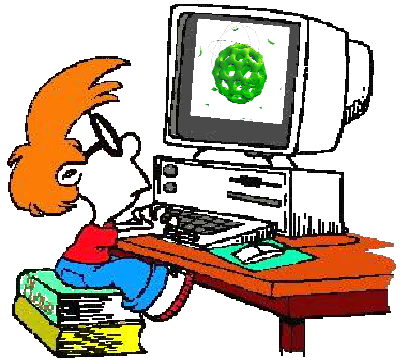
- Aucun traitement en parallèle ou en mémoire externe
- Consommateur temps/mémoire
- Uniquement des complexes simpliciaux (tétraèdres)

Crédits : H. Hoppe - Progressive Meshes -1996



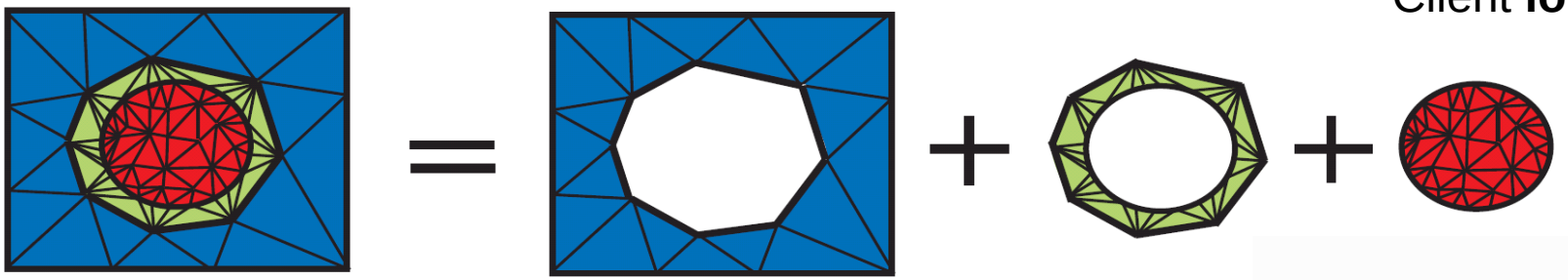
BiRésolution





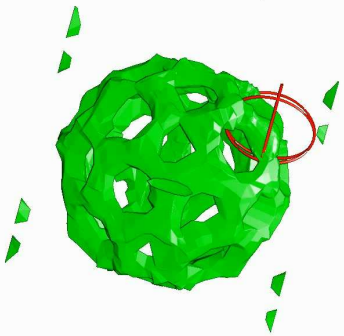
Serveurs de calcul **hybrides**

Client **lourd**

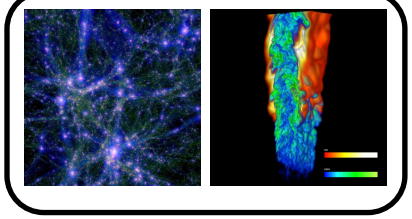


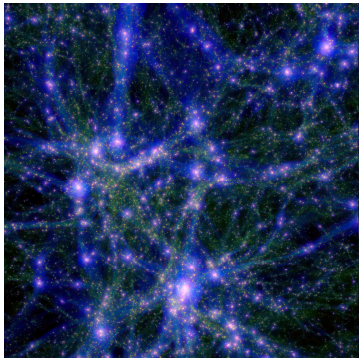
+ Aucun serveur graphique
+ Adapté au besoin de l'utilisateur
+ Compromis Interactivité/dégradation

- Traitement en parallèle ou en mémoire externe
- Faible Consommateur temps/mémoire
- Piste pour généralisation aux maillages hybrides

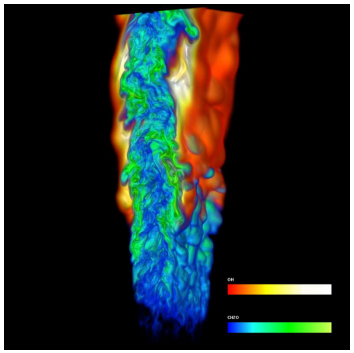


Problématique

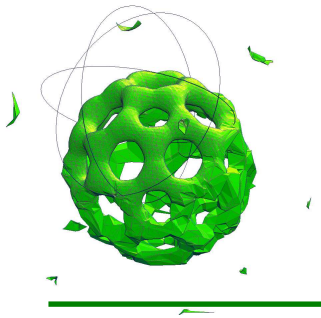




[Crédit: Projet Horizon]



[Crédit: H. Yu K-L.Ma]



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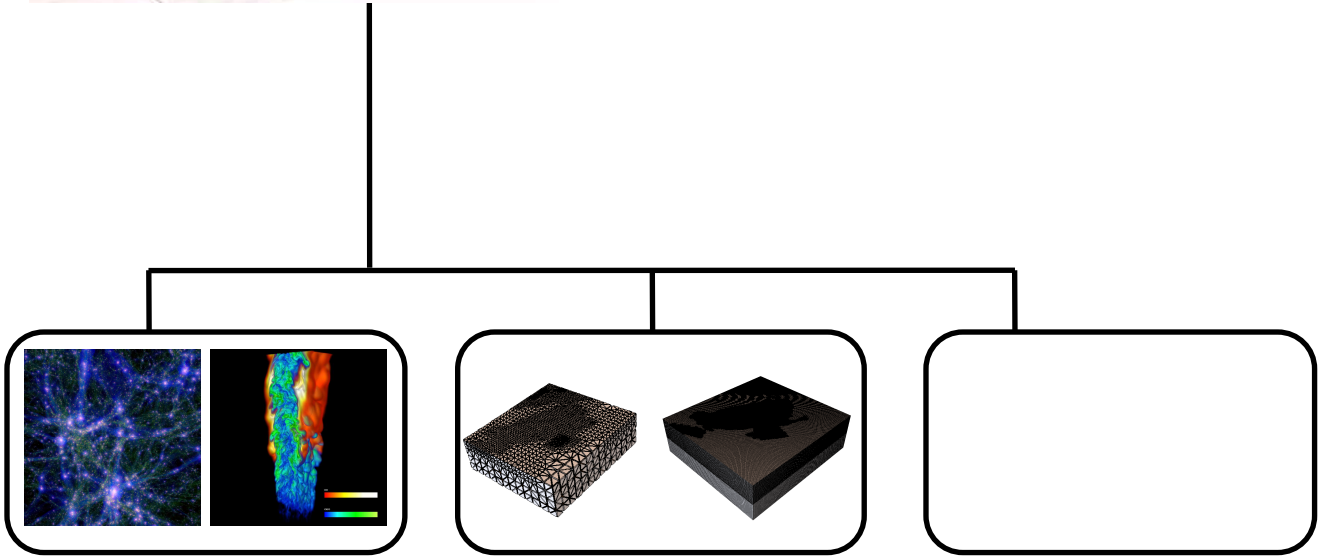
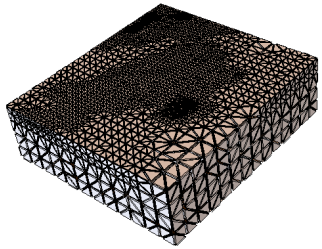
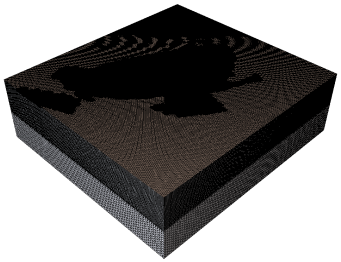




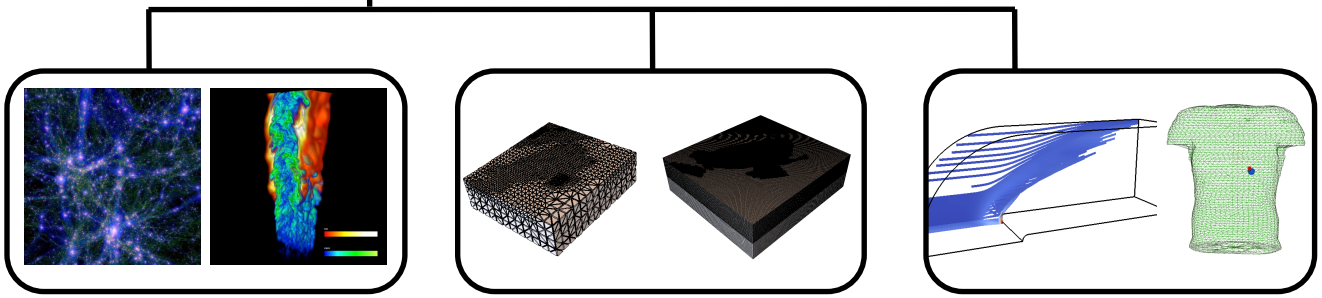
35 025 tétraèdres

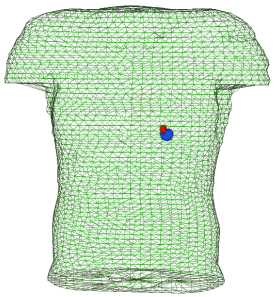


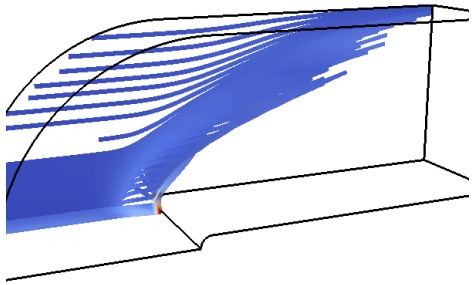
13 980 162 tétraèdres

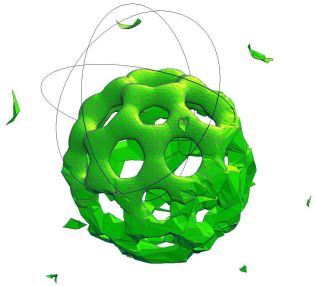
[Quake Project]

Problématique



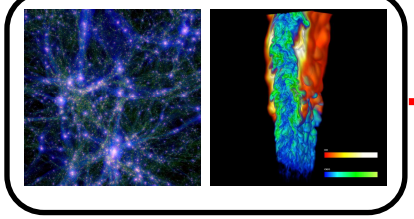






Problématique

Réseau



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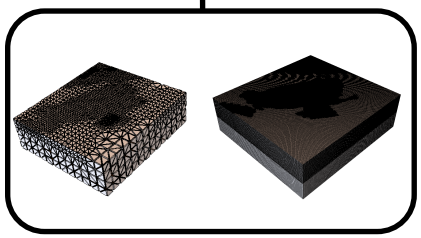

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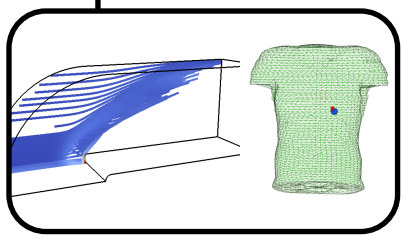

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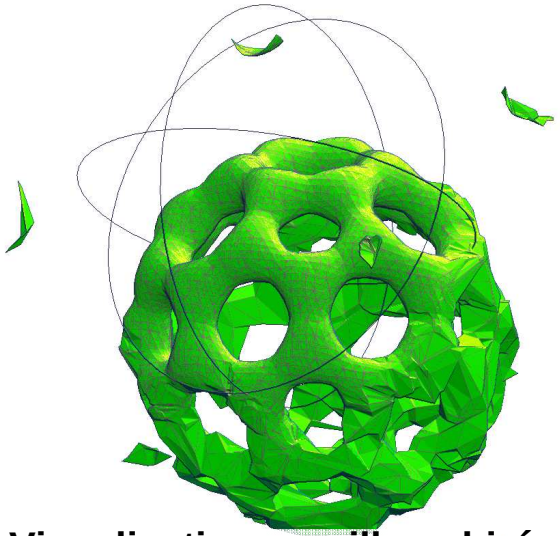
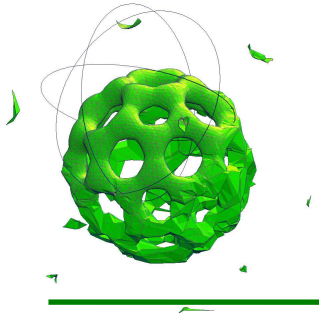


> 10 millions de tétraèdres

2 Résolutions

Localité Information

Visualisation: maillage birésolution



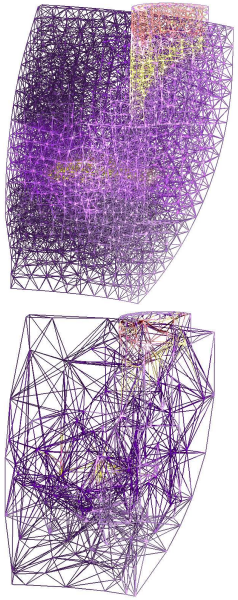
Plan de l'Exposé

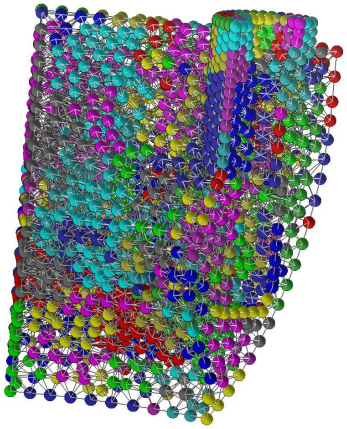
Visualisation Scientifique

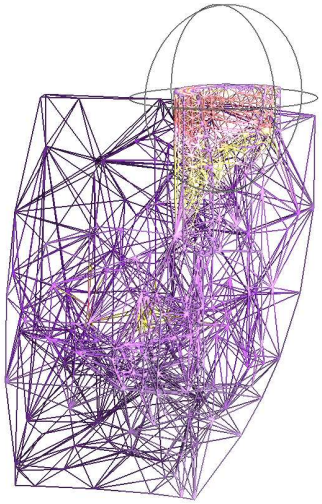
Précalculs

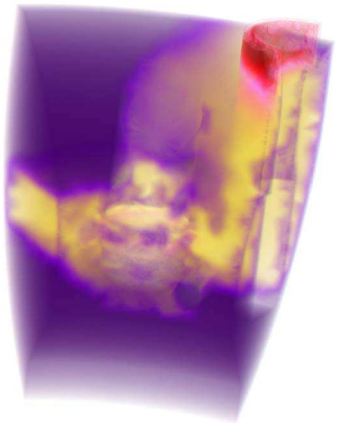
Extraction d'un Maillage

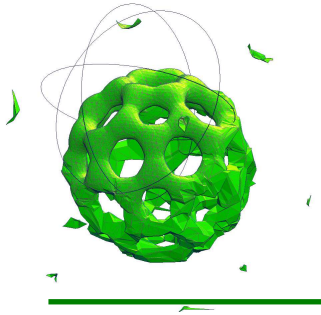
Techniques de Visualisation











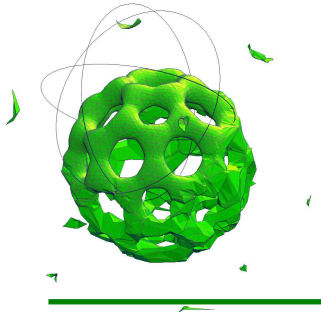
Approche Multirésolution

- Entrée:
  - Un Maillage Haute Résolution

- Précalculs
  1. Simplification

  [Trotts *et al.* Vis98] [Cignoni *et al.* Vis00]
  [Chopra, Meyer Vis02]
  [Natarajan, Edelsbrunner TVCG04]

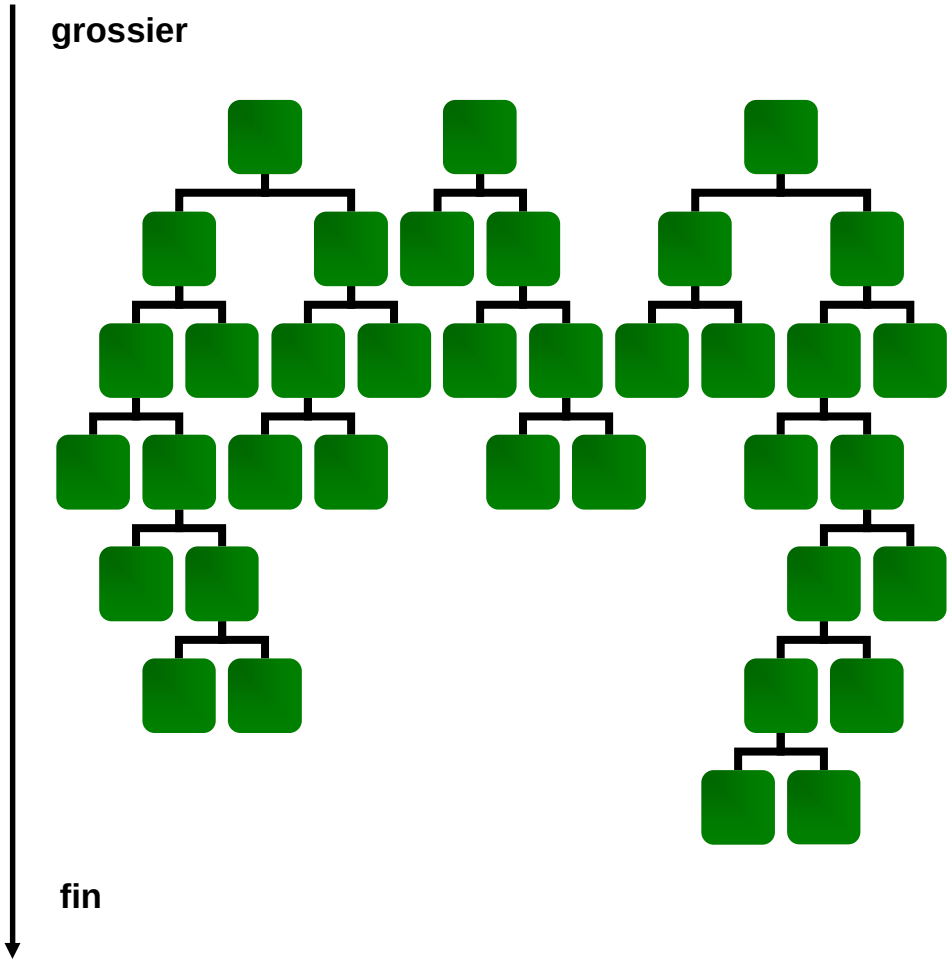
[Vivodtzev *et al.* TiV09]

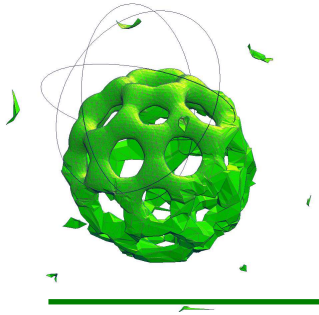


Approche Multirésolution

- Entrée:
  - Un Maillage Haute Résolution
- Précalculs
  1. Simplification
  2. Construction d'une hiérarchie

[Danovaro, De Floriani 00]
[Cignoni *et al.* 04]
[Sondershaus, Straβer 06]
[Du, Chiang 10]





Objectifs

- **Pas de simplification**
  - Utilisation de maillages issus de la simulation

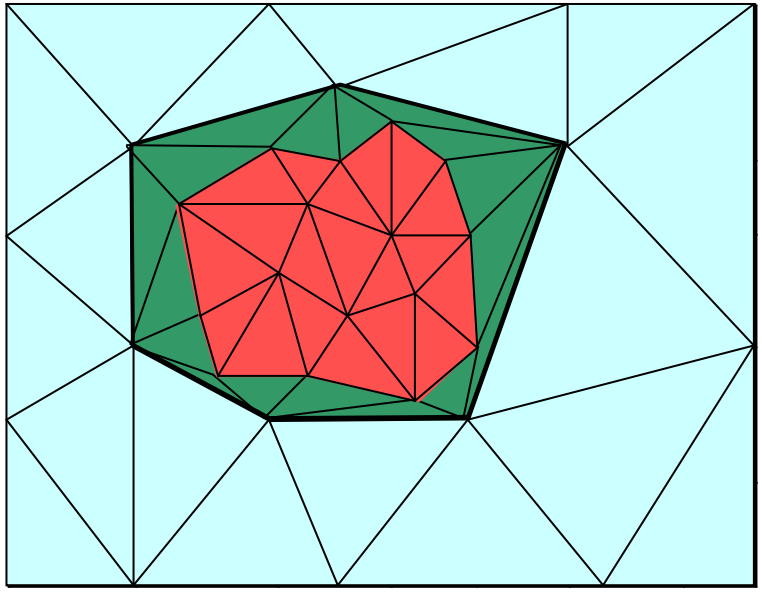
+

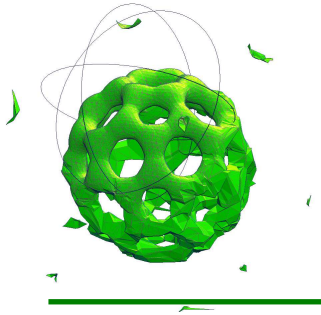
- **Diminuer la complexité**
  - En temps
  - En mémoire

+

- **Traitement en parallèle**

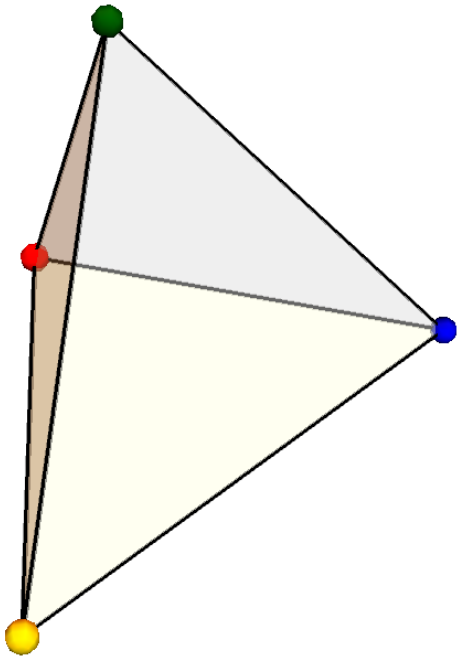
Extraction dynamique d'un maillage **birésolution**

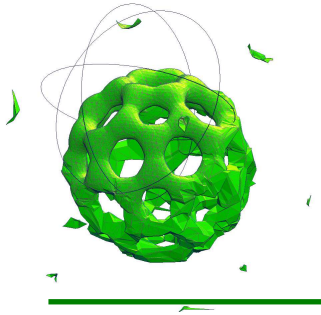




Partition des Sommets

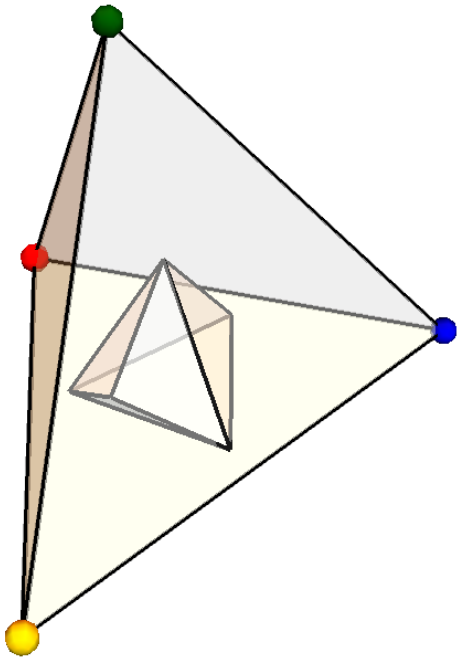
- Principe:

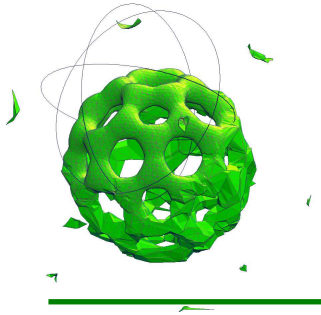




Partition des Sommets

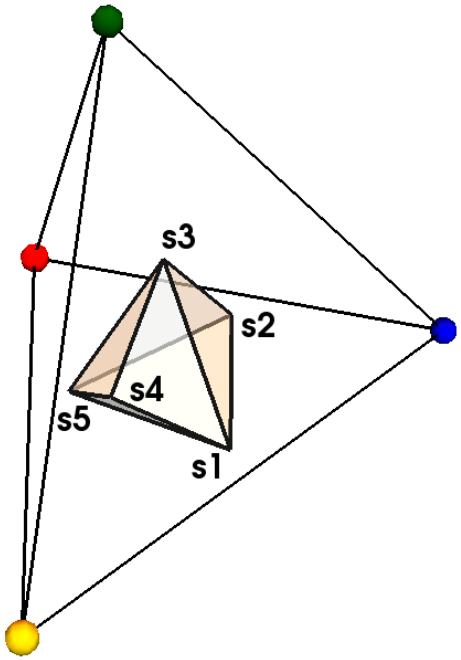
- Principe:

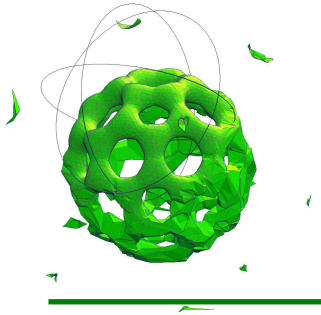




Partition des Sommets

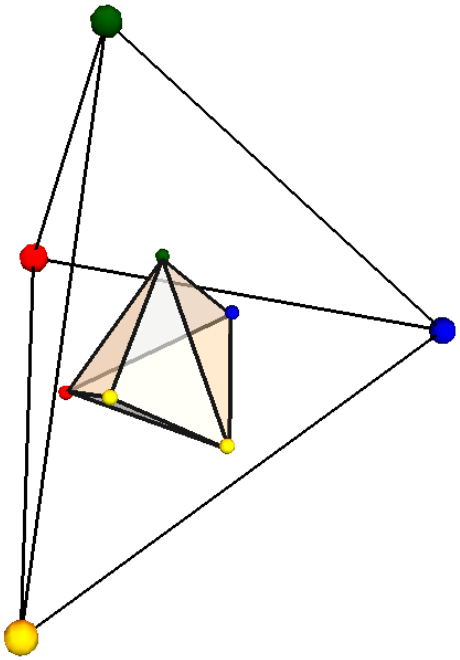
- Principe:





Partition des Sommets

- Principe: définition d'une surjection $\wp$



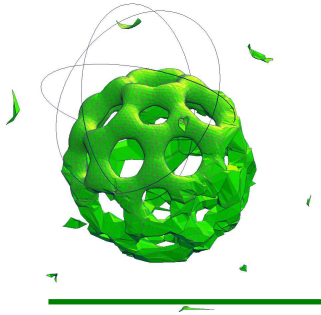
$\wp(s1) =$ ●

$\wp(s2) =$ ●

$\wp(s3) =$ ●

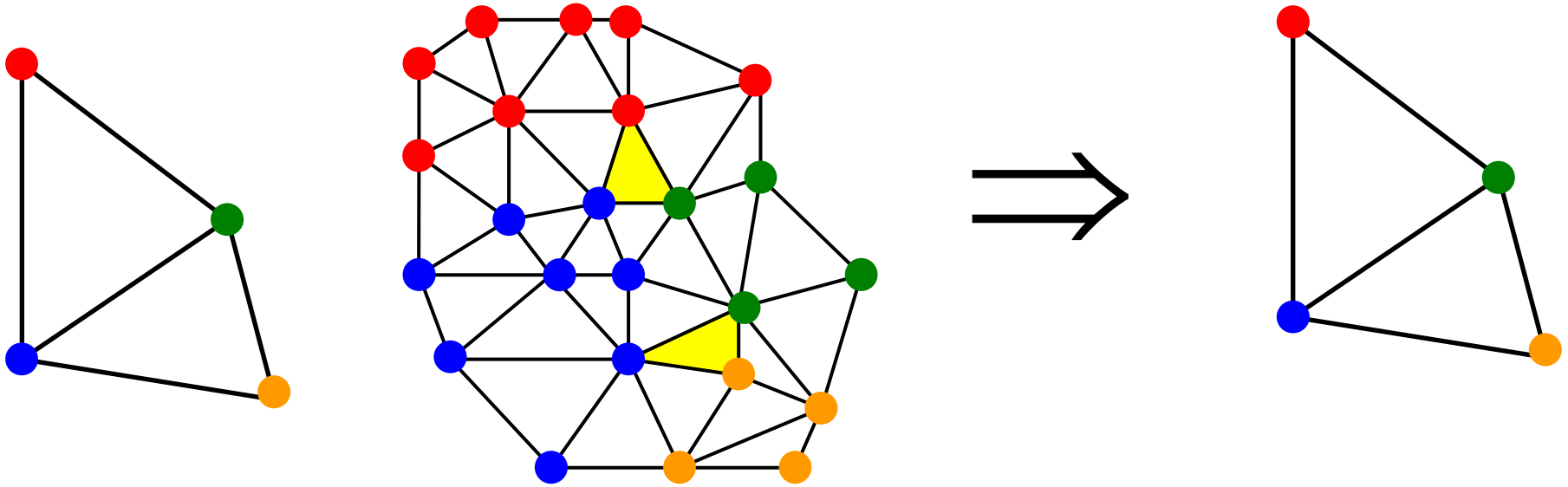
$\wp(s4) =$ ●

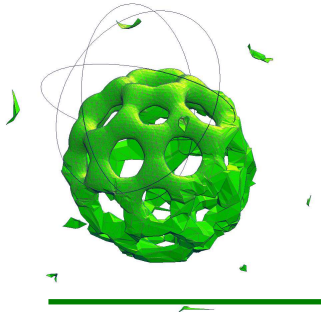
$\wp(s5) =$ ●



Partition des Sommets

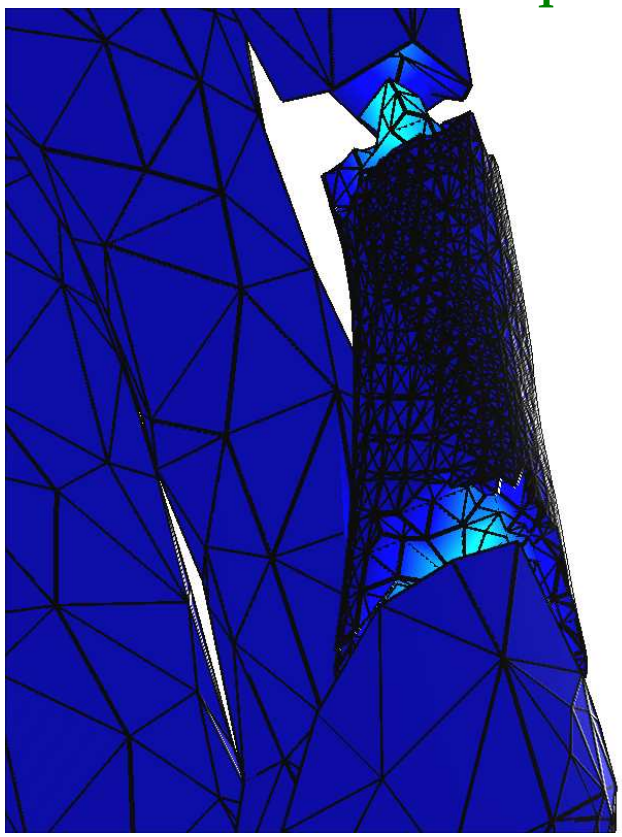
- Conditions sur $\mathcal{P}$
  - Topologique:

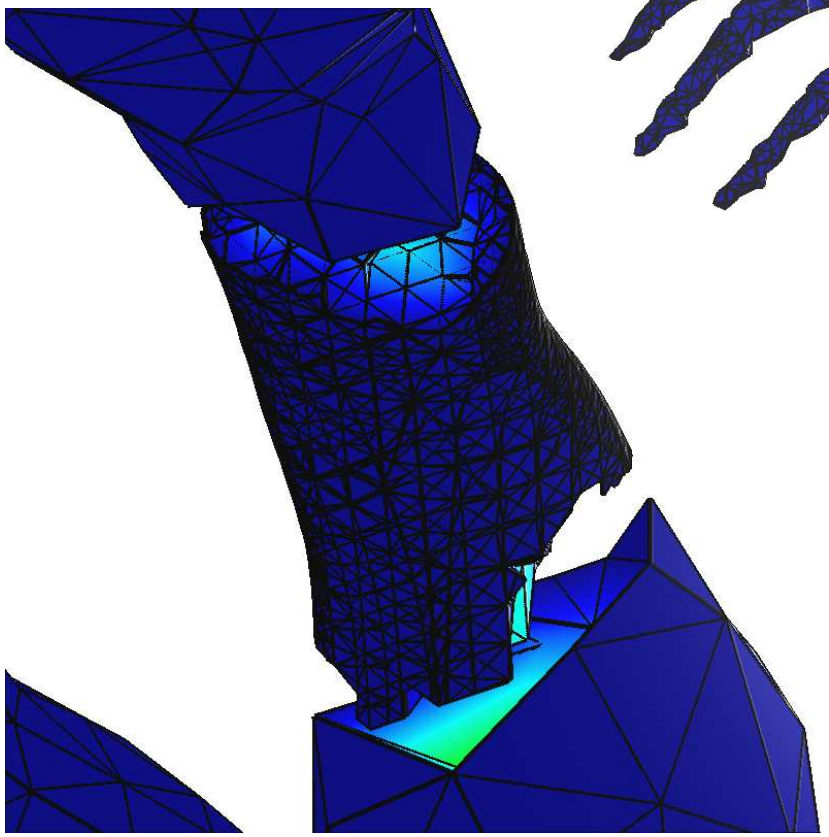


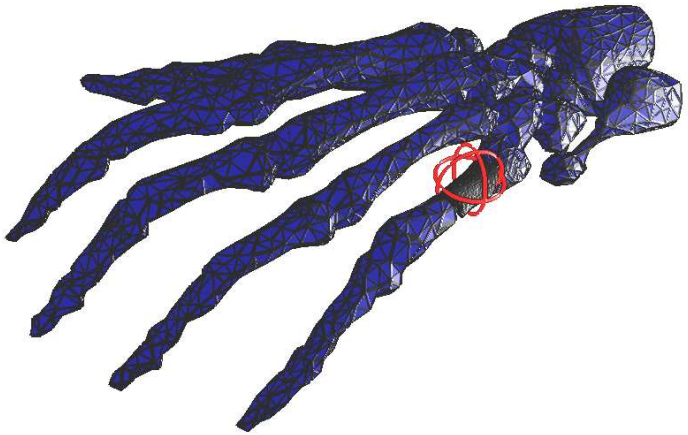


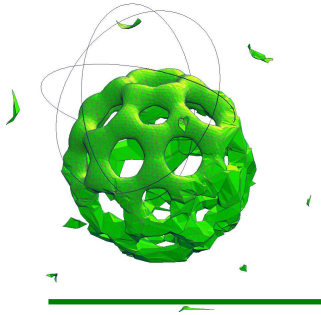
Partition des Sommets

- Conditions sur $\wp$
  - Géométrique:



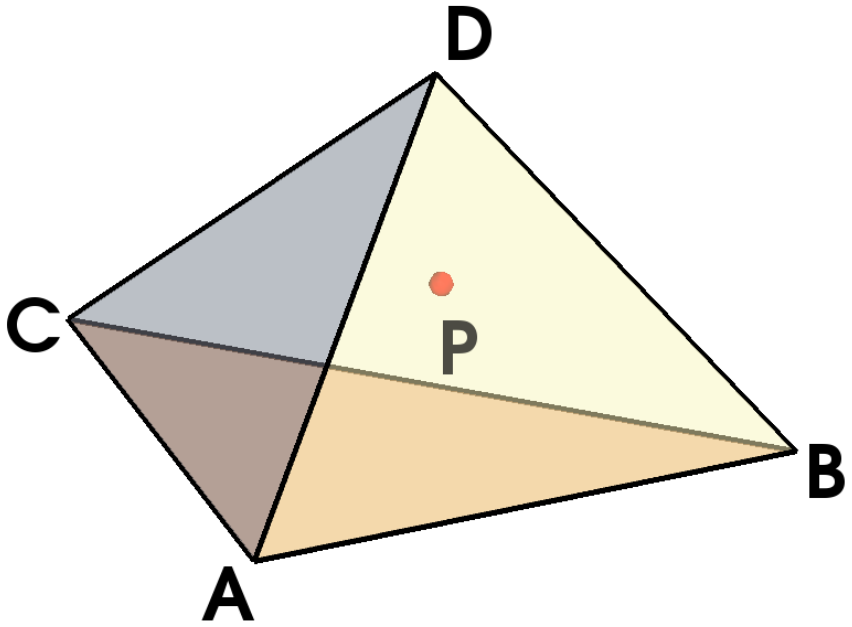






Partition des Sommets

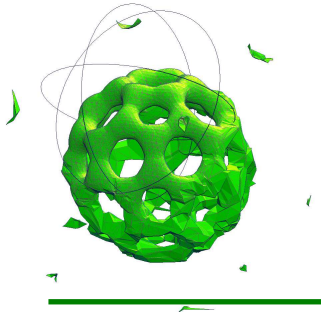
- Calcul de $\wp$



$$P = \alpha A + \beta B + \gamma C + \delta D$$

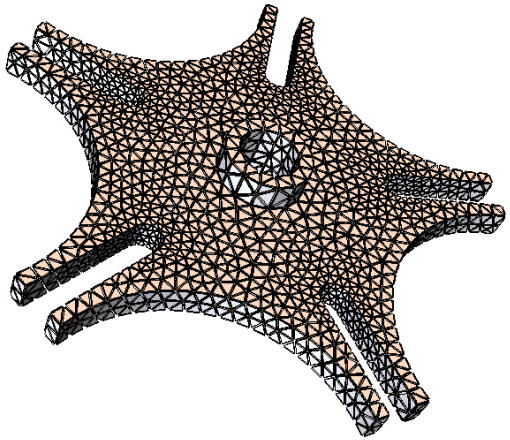
$$\alpha + \beta + \gamma + \delta = 1$$

$$\wp(P) = A \text{ si } \alpha = \max\{\alpha, \beta, \gamma, \delta\}$$



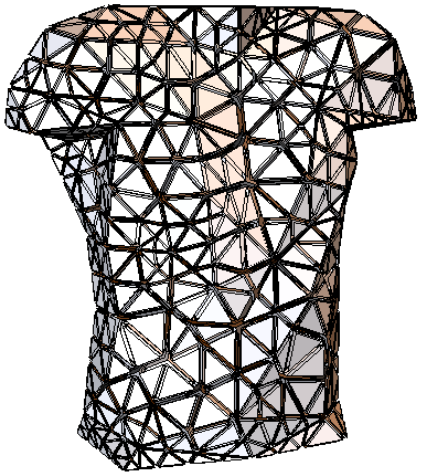
Partition des Sommets

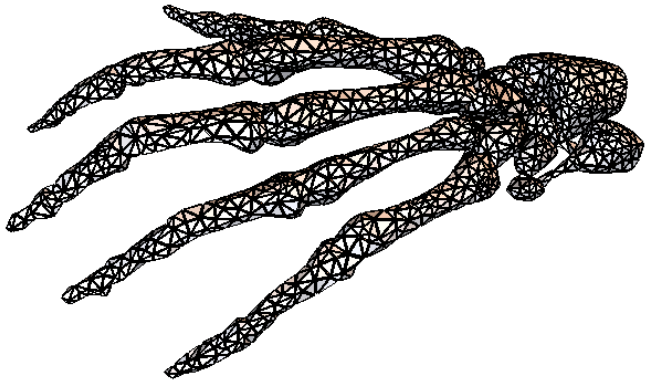
Maillages Grossiers



SIMULATION

[GMSH Geuzaine, Remacle 09]

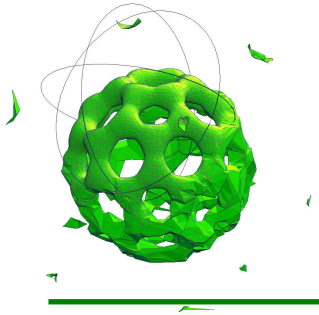




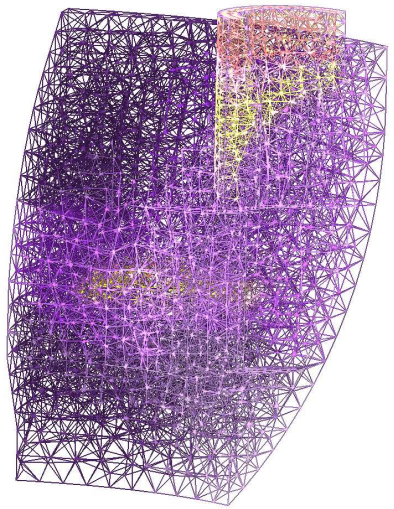
SIMPLIFICATIONS

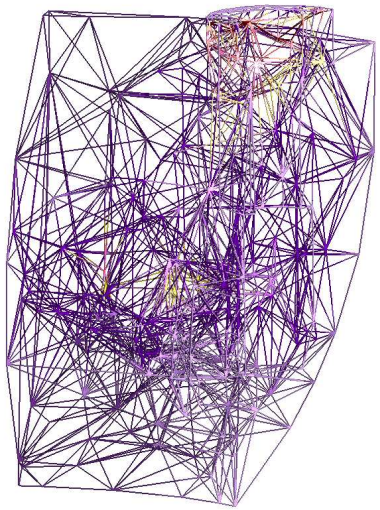
[Uesu *et al*. WVG05]

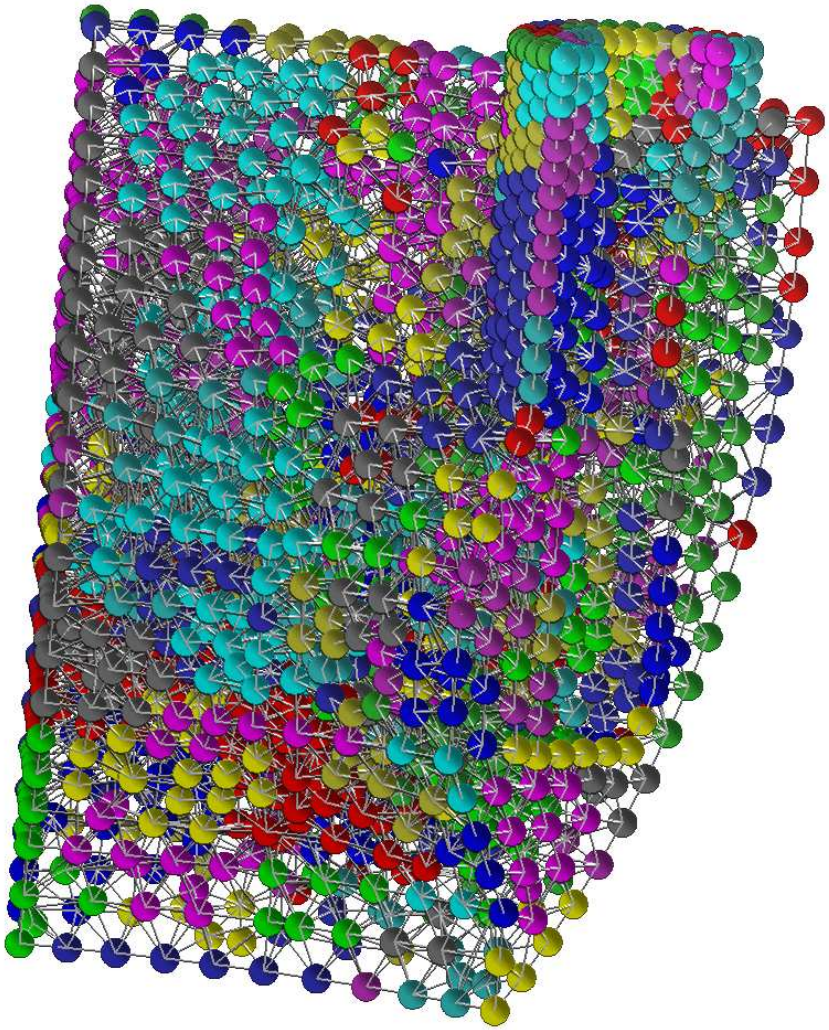
[Cutler *et al.* SGP04]

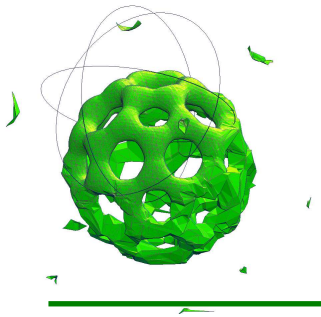


Partition : Résultats

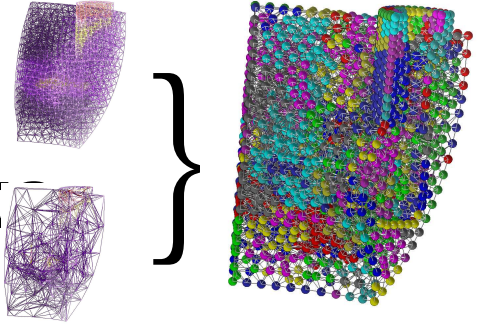






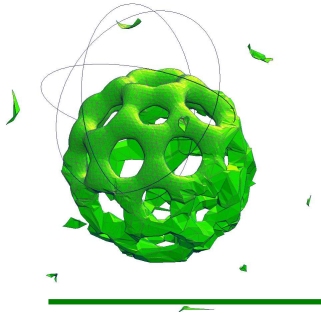


Partition : Résultat



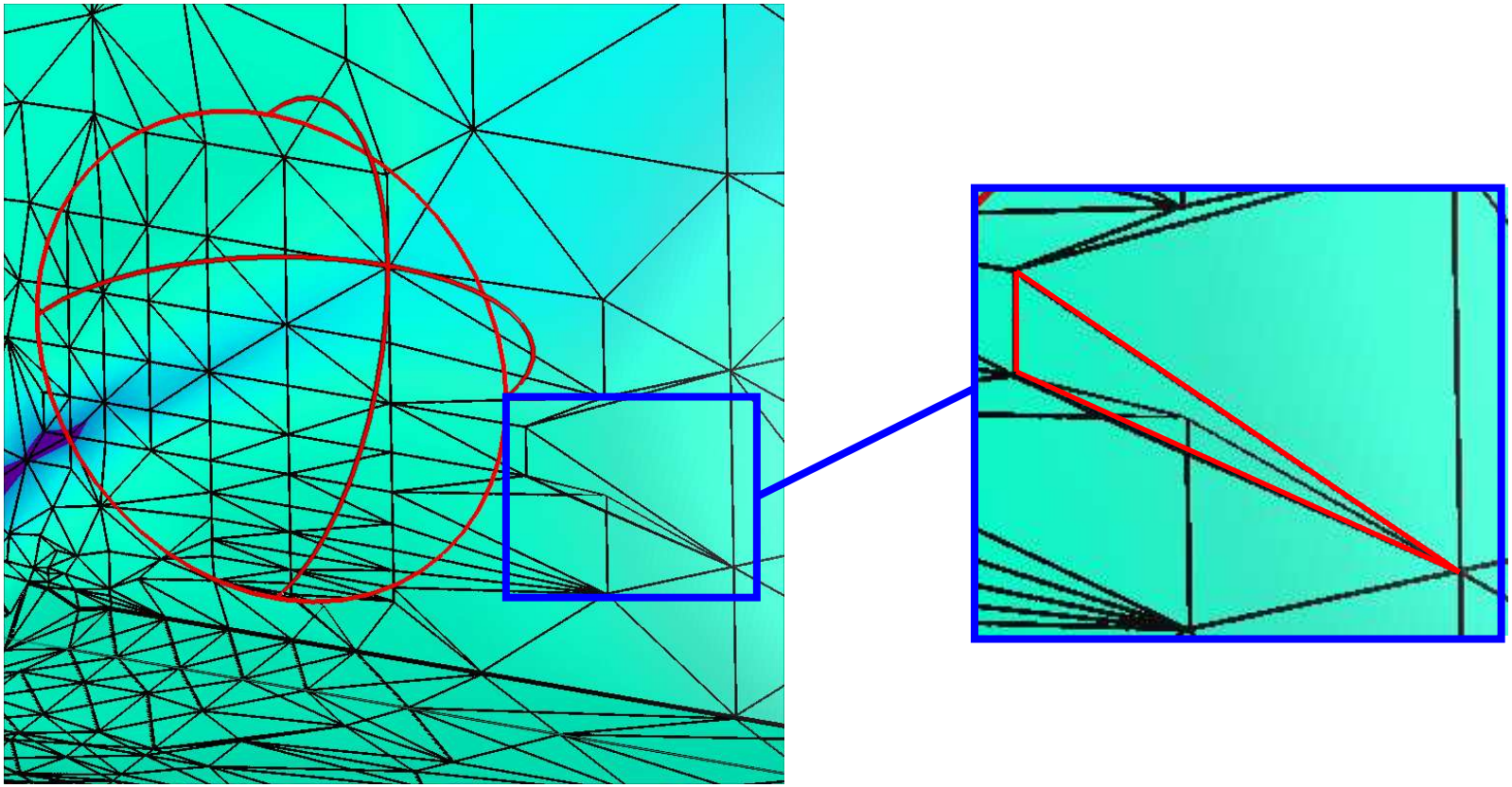
	Mémoire	Temps		
		1,5 M	14 M	42 M
Cignoni *et al.* (MT) **TVCG04**	40*n*	35 min	-	-
Sondershaus, Straβer GRAPHITE06	37*n* à 41*n*	20,4 min	72,8 min	-
Du, Chiang **EuroVis10**	*utilisateur*	2,01min	24,9 min	82 min
Surjection ℘	**9*n***	**28 s**	**16,5 min**	**20,5 min**

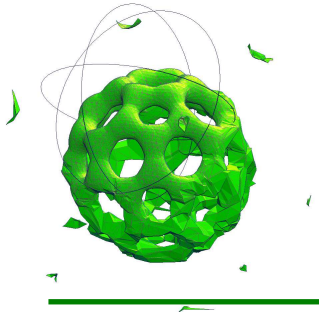
n = nombre de sommets



Limitations

Maillage non conforme **dans tous les cas**





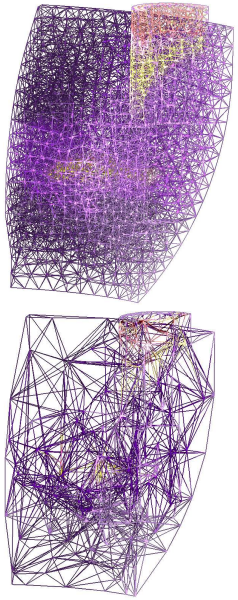
Plan de l'Exposé

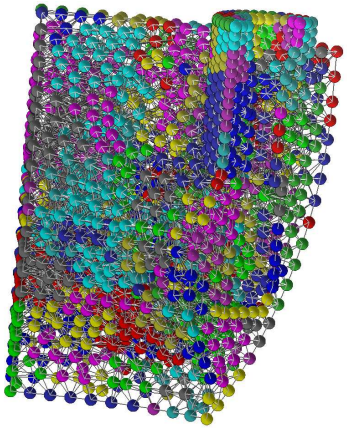
Visualisation Scientifique

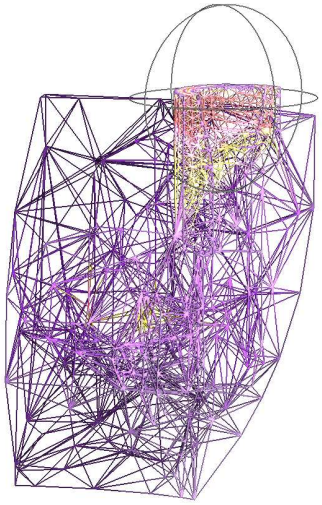
Précalculs

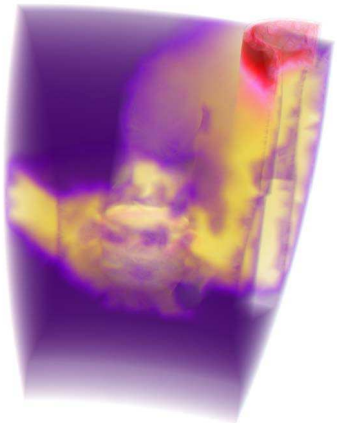
Extraction d'un Maillage

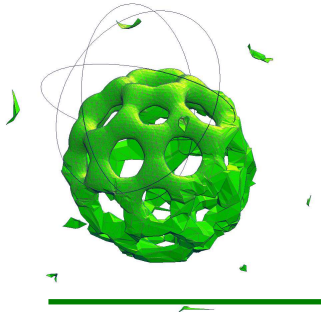
Techniques de Visualisation





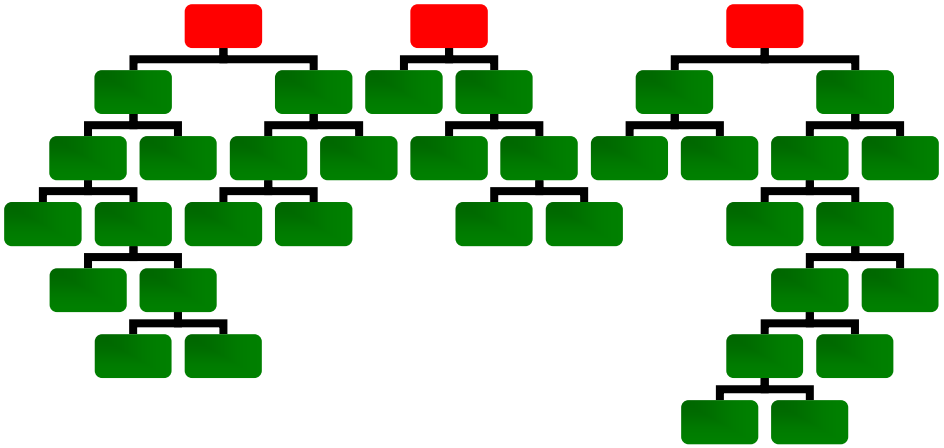


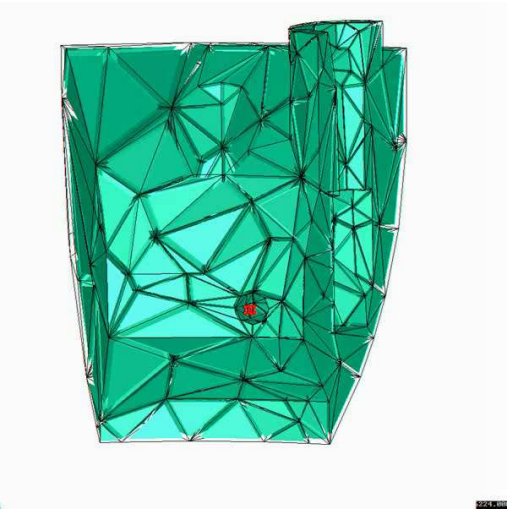




Approche Multirésolution

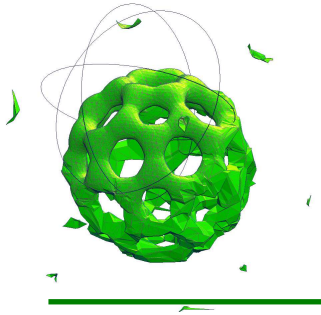
- Entrée:
  - Un Maillage Haute Résolution
- Précalculs
  1. Simplification
  2. Construction d’une hiérarchie
- Lors de l’Exploration
  1. Parcours de la hiérarchie
  2. Extraction d’un niveau de détails





MT

[Cignoni et al. TVCG 04]



Objectifs

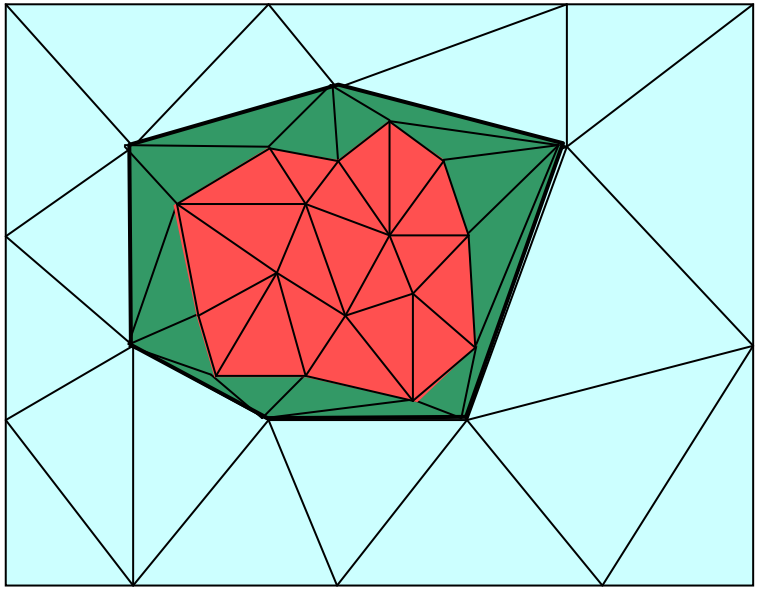
- **Accélération extraction**
  - Moins de mémoire
  - Moins de temps

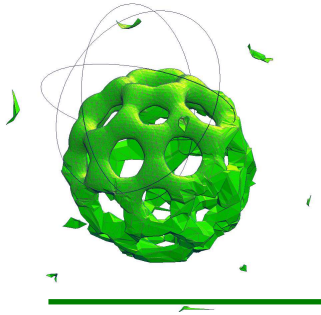
+

- **Implantation**
  - CPU
  - GPU
  - Mémoire Externe

}

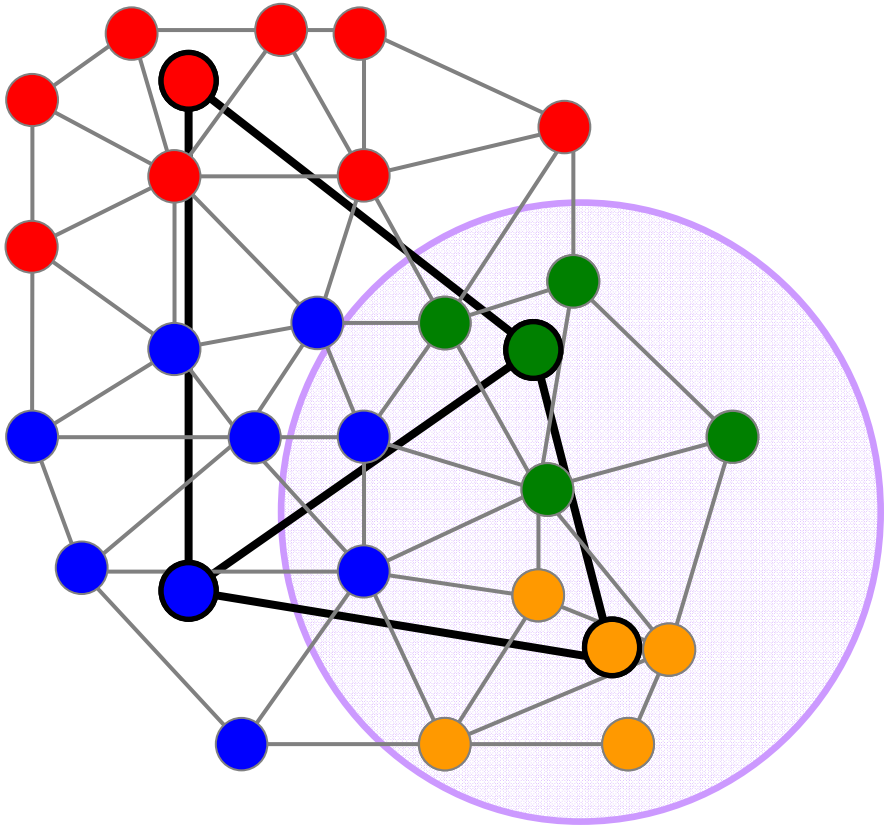
Extraction **interactive** d'un maillage ***birésolution*** pour **l'exploration** de **données massives**

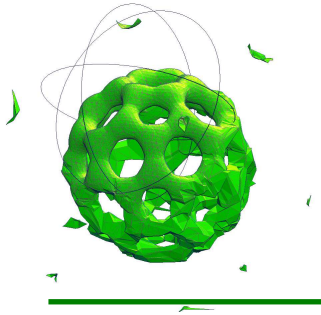




Maillage Birésolution

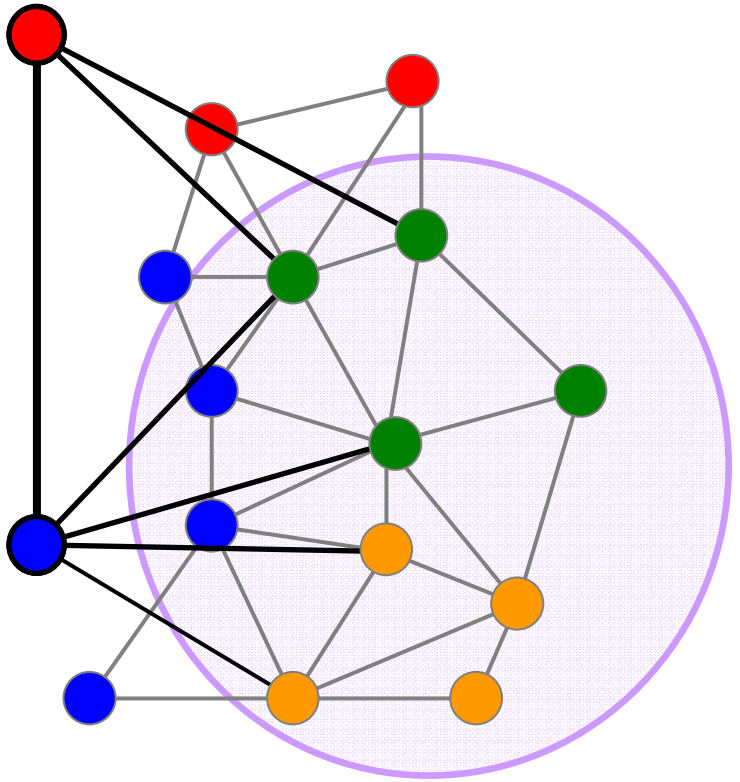
- Maillage fin
- Surjection $\wp$
- Boule d’intérêt $\mathcal{B}$
- Maillage grossier

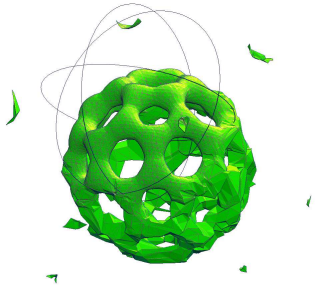




Maillage Birésolution

- Maillage fin
- Surjection $\wp$
- Boule d’intérêt $\mathcal{B}$
- Maillage grossier
- Cellules de lien

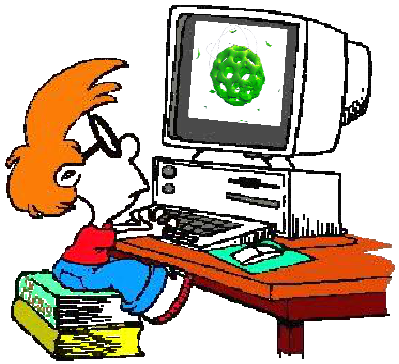




Principe

Source : idris.fr

Réseau



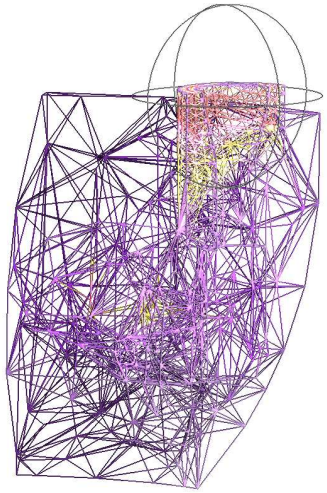
BOULE D'INTÉRÊT $\mathcal{B}$

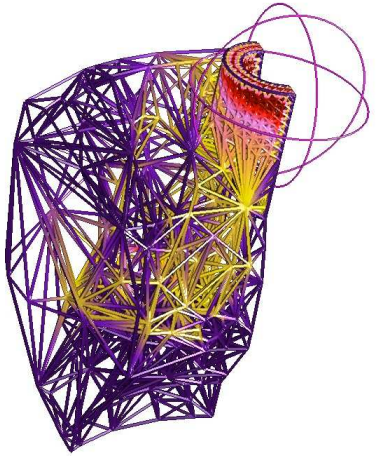
MAILLAGE FIN

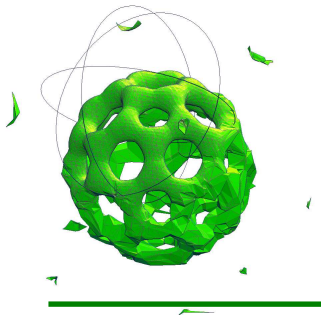
SURJECTION $\wp$

MAILLAGE GROSSIER

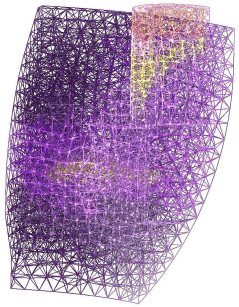
MAILLAGE BIRÉSOLUTION



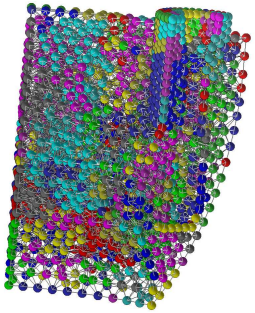




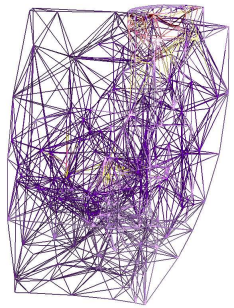
Implantations : CPU, GPU, OoC



MAILLAGE FIN



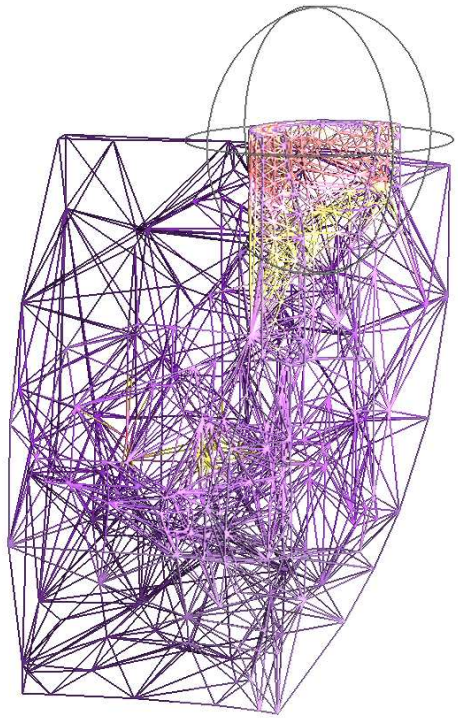
SURJECTION $\wp$

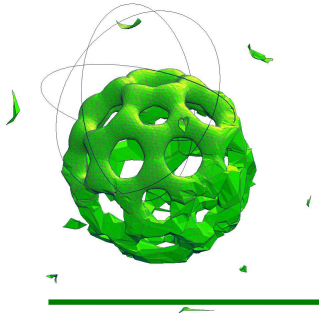


MAILLAGE GROSSIER

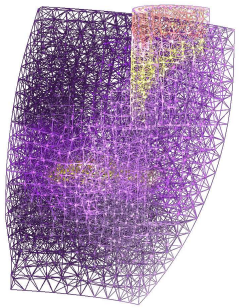
BOULE D'INTÉRÊT $\mathcal{B}$

MAILLAGE BIRÉSOLUTION

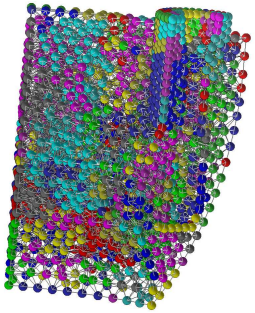




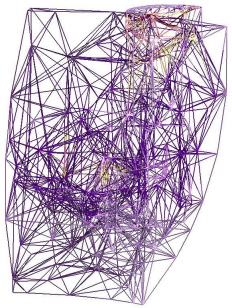
Implantations : CPU, GPU, OoC



MAILLAGE FIN

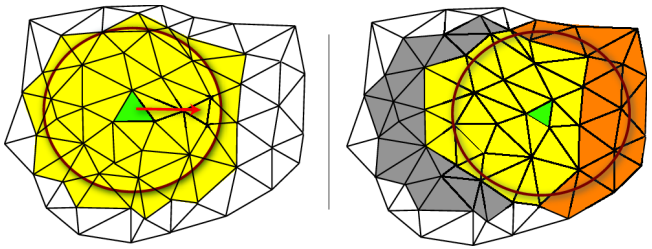


SURJECTION $\wp$



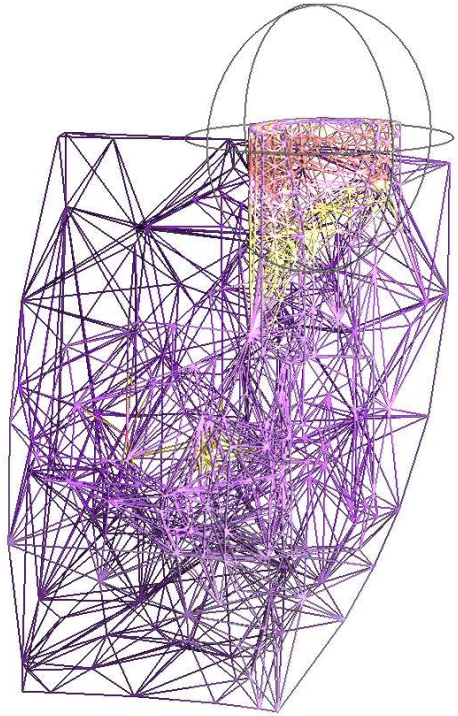
MAILLAGE GROSSIER

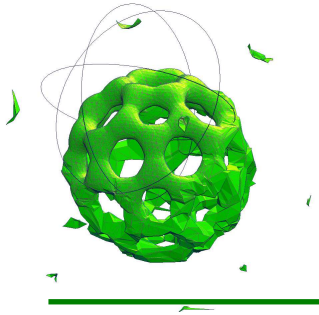
Cohérence temporelle



BOULE D’INTÉRÊT $\mathcal{B}$

MAILLAGE BIRÉSOLUTION

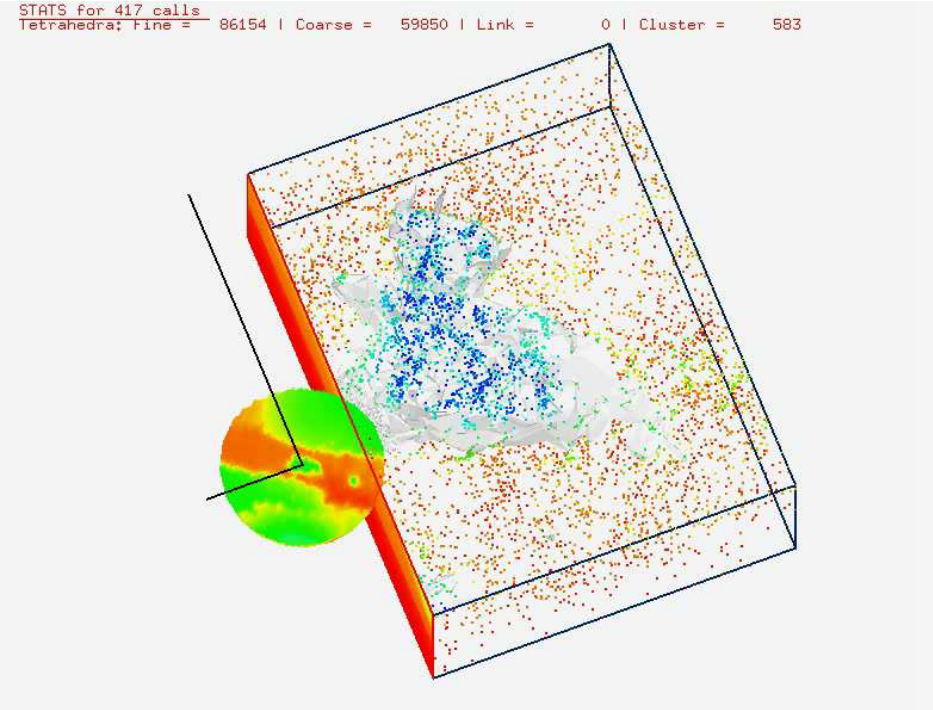




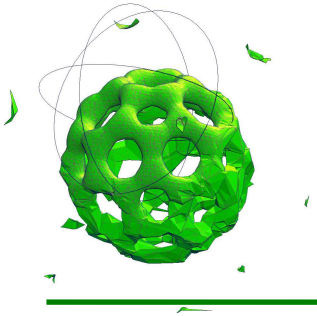
Implantation CPU
Résultats

	Extraction (milliers par seconde)
Cignoni *et al.* TVCG04	330
Sondershaus *et al.* GRAPHITE05	150
Sondershaus *et al.* GRAPHITE06	500 (*sans décomp.*) 300 (*avec décomp.*)
Du, Chiang EuroVis10	600
CPU BiRes	**778**

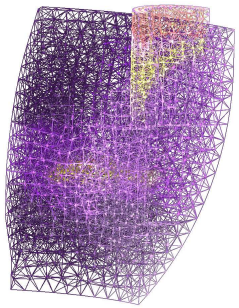
[Barbier, Bonneau REFIG08]



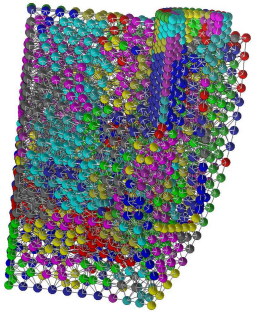
Sf1 fin: 13 980 162 grossier: 65 159



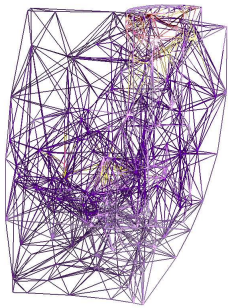
Implantations : CPU, GPU, OoC



MAILLAGE FIN



SURJECTION $\wp$

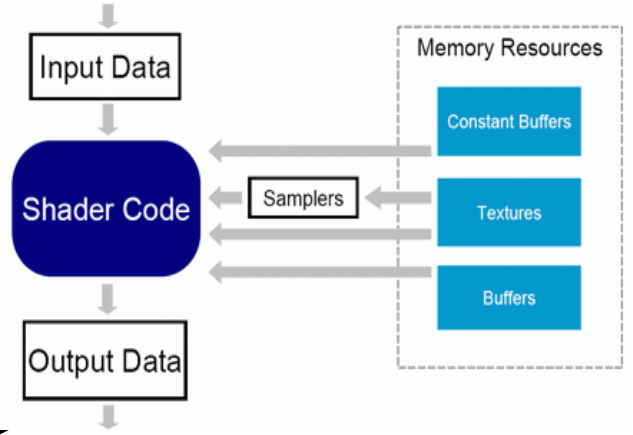


SOMMETS GROSSIERS

Shaders, kernels

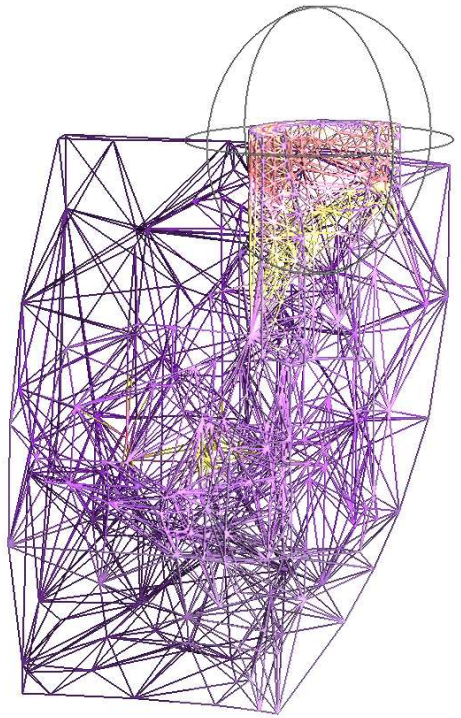
OpenGL

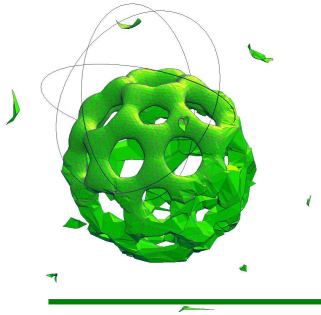
NVIDIA CUDA



BOULE D'INTÉRÊT $\mathcal{B}$

MAILLAGE BIRÉSOLUTION

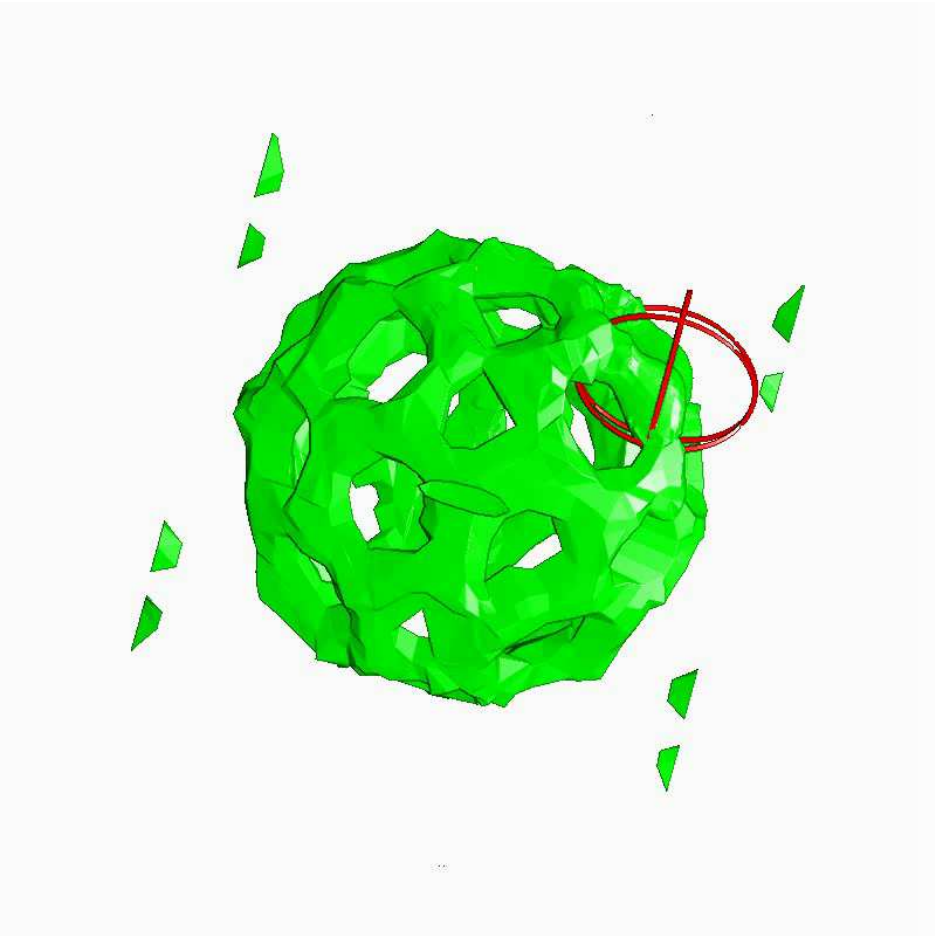




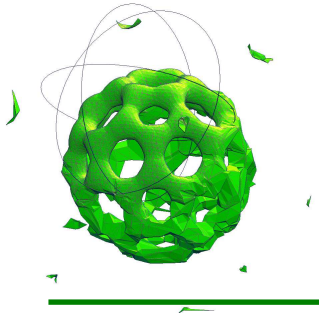
Implantation GPU
Résultats

	Extraction (milliers par seconde)
Cignoni *et al.* TVCG04	330
Sondershaus *et al.* GRAPHITE05	150
Sondershaus *et al.* GRAPHITE06	500 (*sans décomp.*) 300 (*avec décomp.*)
Du, Chiang EuroVis10	600
CPU BiRes	**778**
GPU BiRes	**9 000**

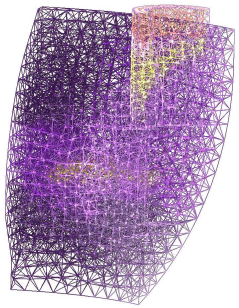
[Barbier, Bonneau Poster Session PG08]



Bucky fin: 1 250 235 grossier: 7126



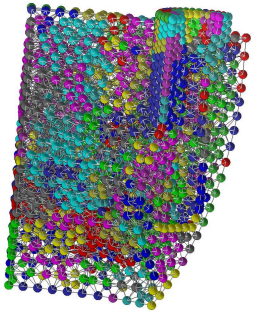
Implantations : CPU, GPU, OoC



BLOCS

MAILLAGE

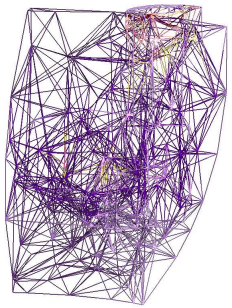
FIN



BLOCS

SURJECTION

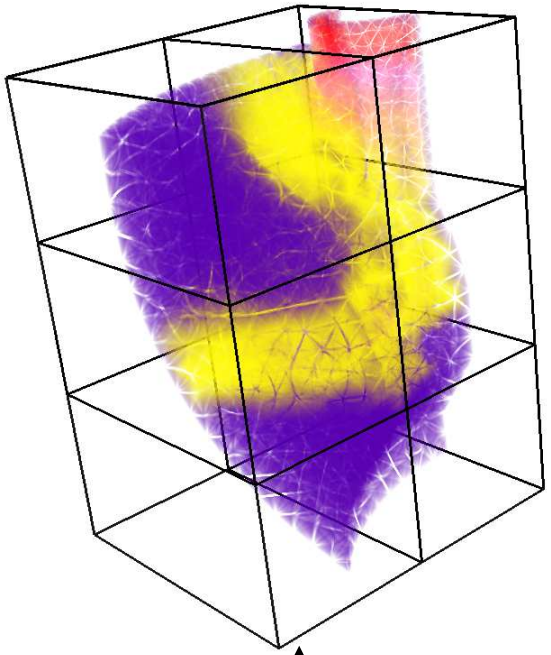
$\wp$



SOMMETS

GROSSIERS

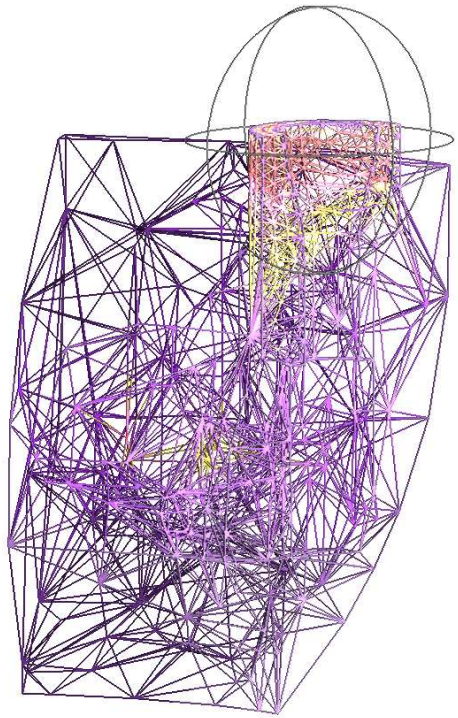
Precalculs
Pagination

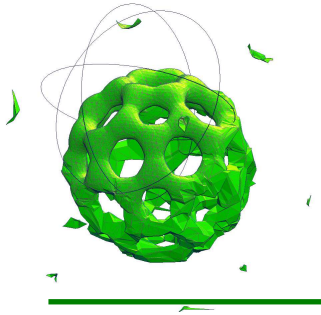


BOULE D'INTÉRÊT $\mathcal{B}$

MAILLAGE

BIRÉSOLUTION

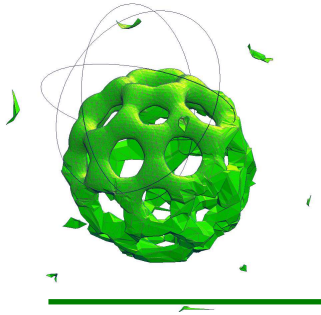




Implantation en Mémoire Externe
Résultats - Précalculs

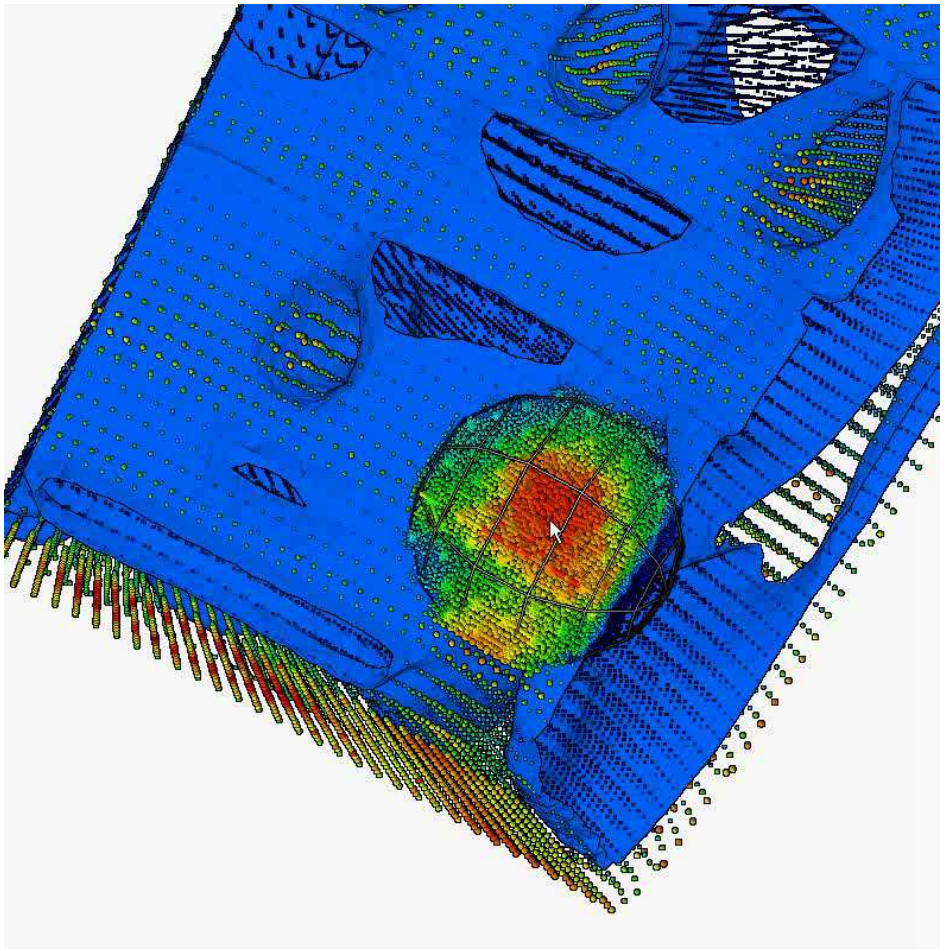
	Mémoire	Temps		
		1,5 M	14 M	42 M
Cignoni *et al.* TVCG04	40*n*	35 min	-	-
Sondershaus, Straβer GRAPHITE06	(37-41)*n*	20,4 min	72,8 min	-
Du, Chiang EuroVis10	*utilisateur*	2,01 min	24,9 min	82 min
Surjection $\wp$	9*n*	28 s	16,5 min	20,5 min
Surjection $\wp$ + Pagination	**9*n***	**42 s**	**18,9 min**	**27,5 min**

n = nombre de sommets

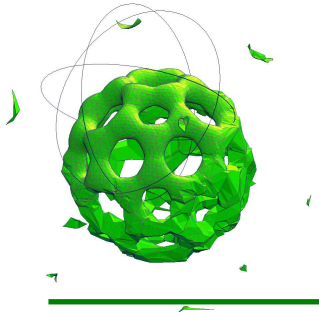


Implantation en Mémoire Externe
Résultats - Extraction

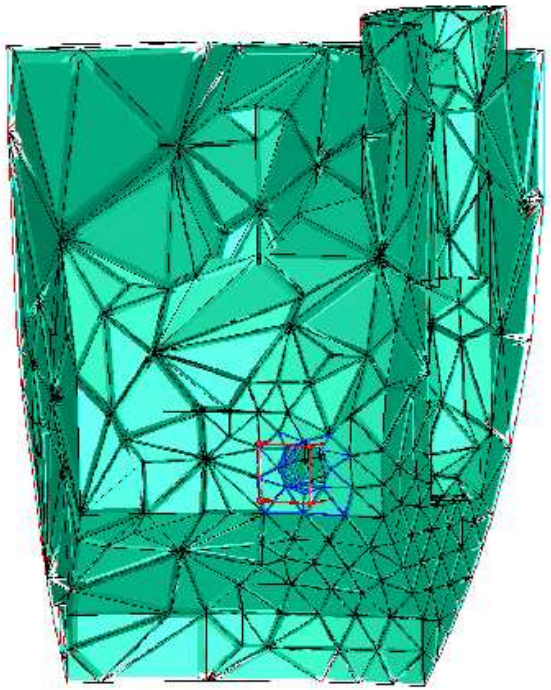
	Extraction (milliers par seconde)
Cignoni *et al.* TVCG04	330
Sondershaus *et al.* GRAPHITE05	150
Sondershaus *et al.* GRAPHITE06	500 (*sans décomp.*) 300 (*avec décomp.*)
Du, Chiang EuroVis10	600
CPU BiRes	**778**
GPU BiRes	**9 000**
OoC BiRes	**3 500**



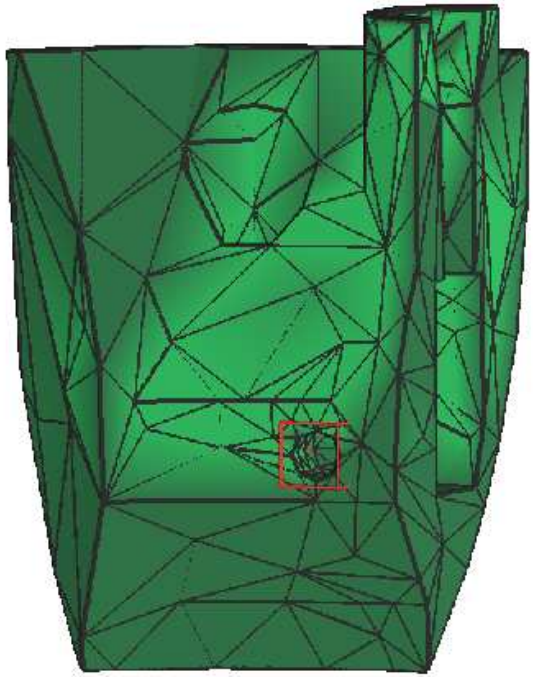
Comb fin: 10 059 999 grossier: 417 737



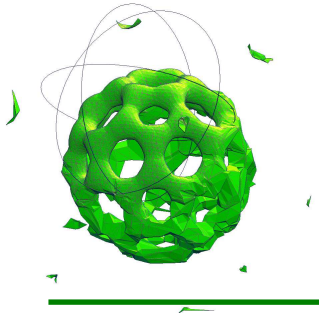
Avantages - Localité



MT



BiRes



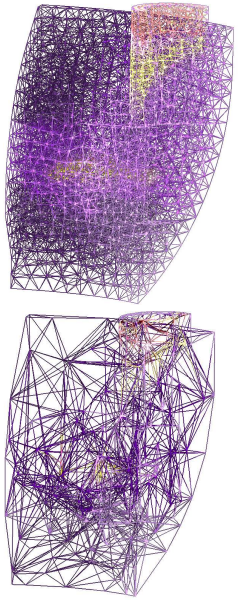
Plan de l'Exposé

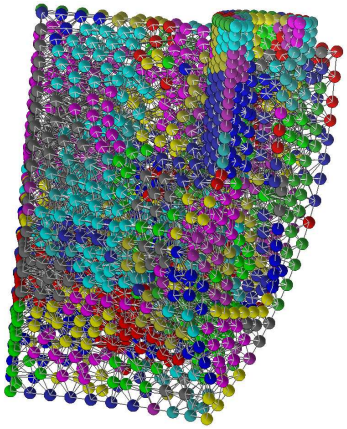
Visualisation Scientifique

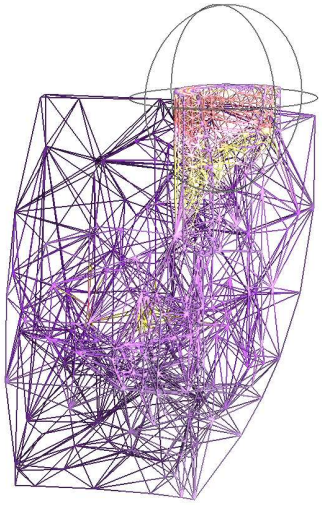
Précalculs

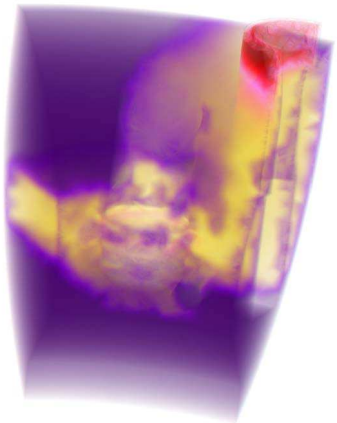
Extraction d'un Maillage

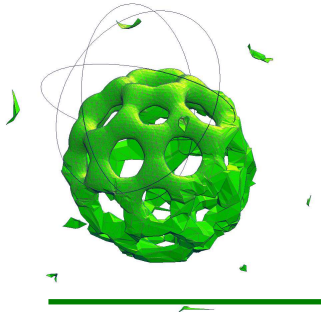
Techniques de Visualisation











Isosurface

Sf1

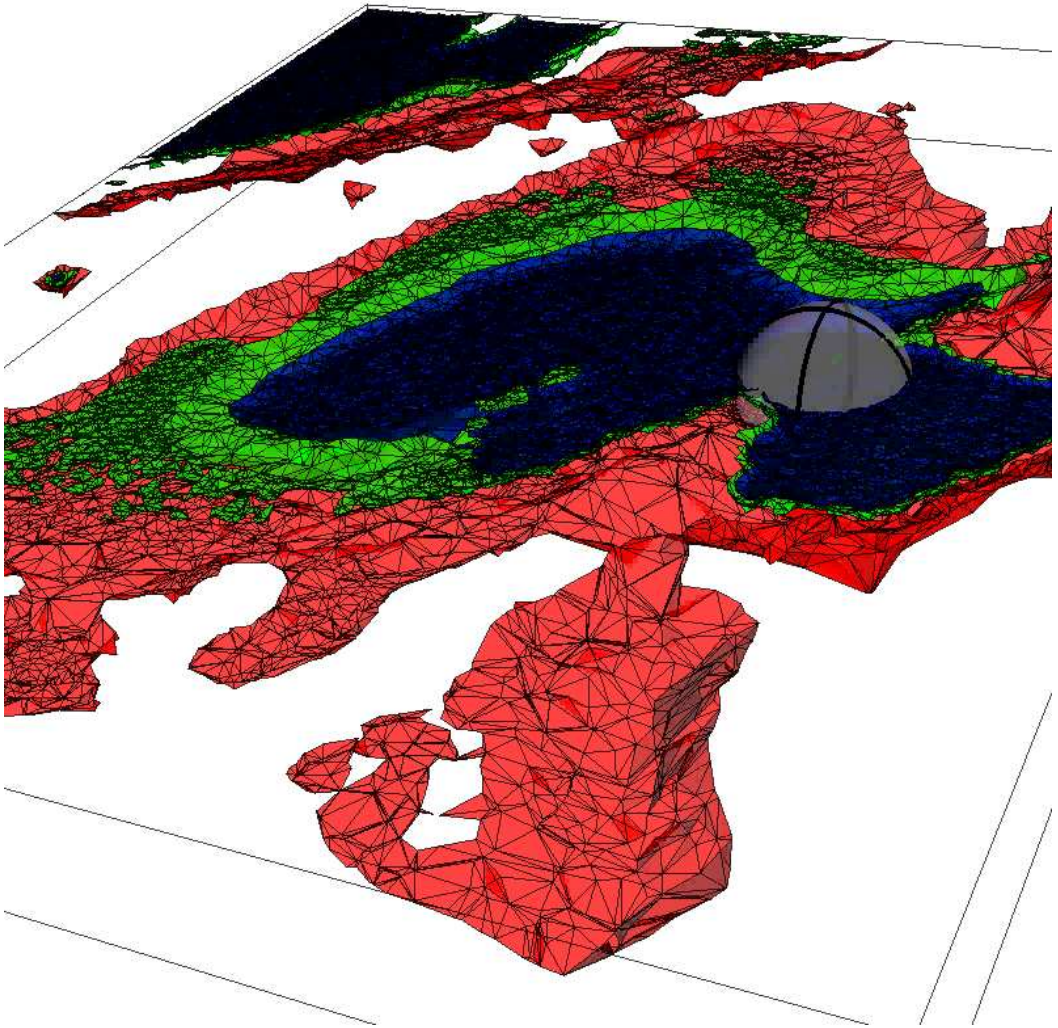
fin

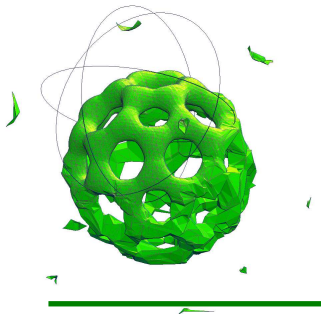
13 980 162

grossier

8 101

Rendu offline





Rendu Volumique Direct

Engine

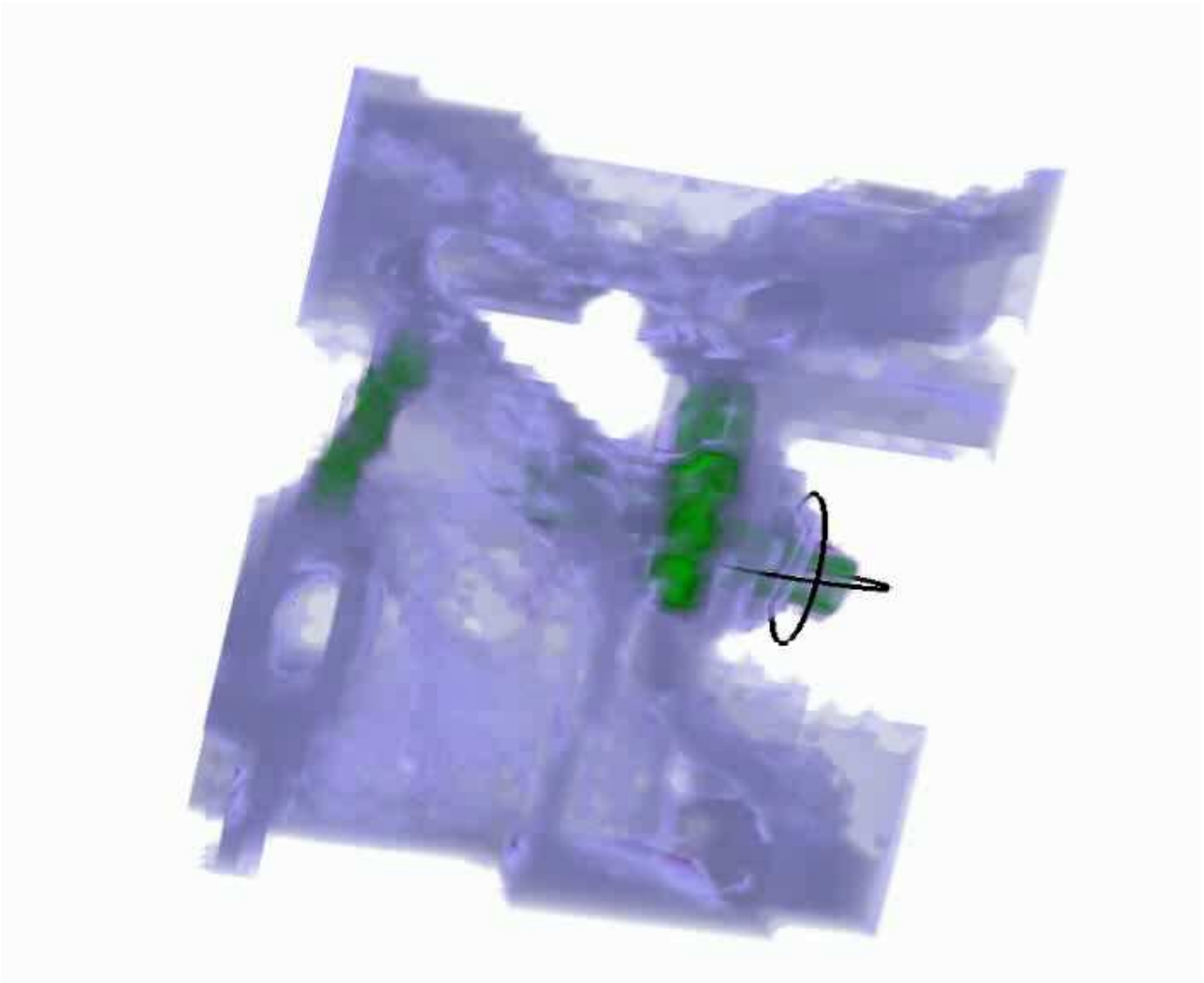
fin

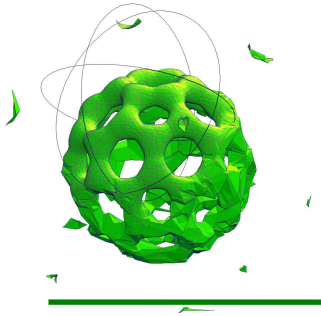
41 943 040

grossier

5 242 880

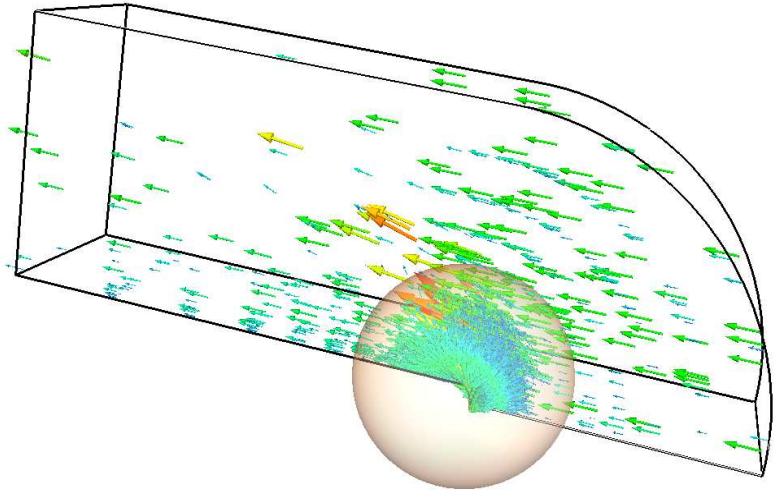
Rendu offline



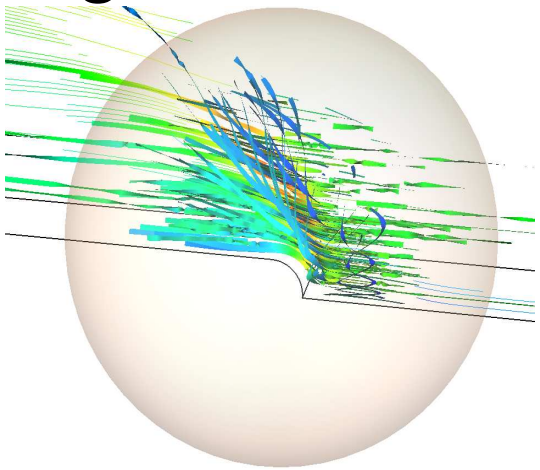


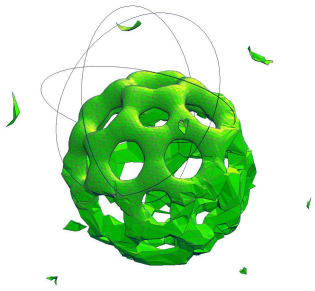
Champs Vectoriels

- **Représentation par glyphes**

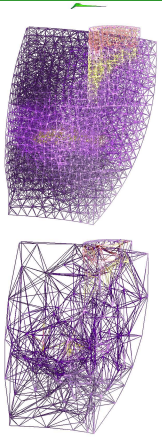


- **Représentation par lignes de courant**
  - **Rendu *offline***

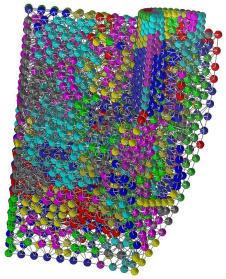




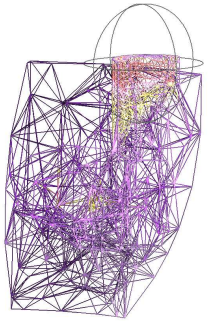
Conclusion



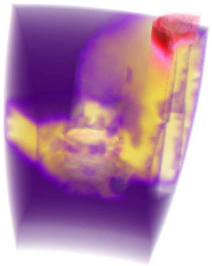
Surjection



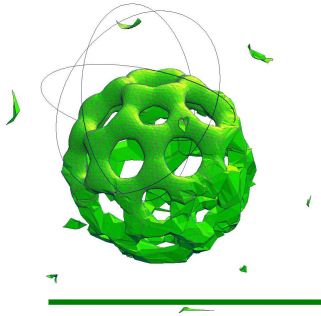
Maillage Birésolution



Techniques de Visualisation



- **Intégré** dans le processus de simulation
- **Faible** consommation mémoire – temps
- Extraction à la volée **rapide** sur GPU
- 42 millions de tétraèdres
- Méthodes de Visualisation **adaptées**



Perspectives

- **Partition**
  - Conformité dans tous les cas ?
- **Généralisation**
  - Hexaèdres, Maillages Hybrides
  - Données temporelles
- **Utilisateurs**