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OPTIMAD engineering

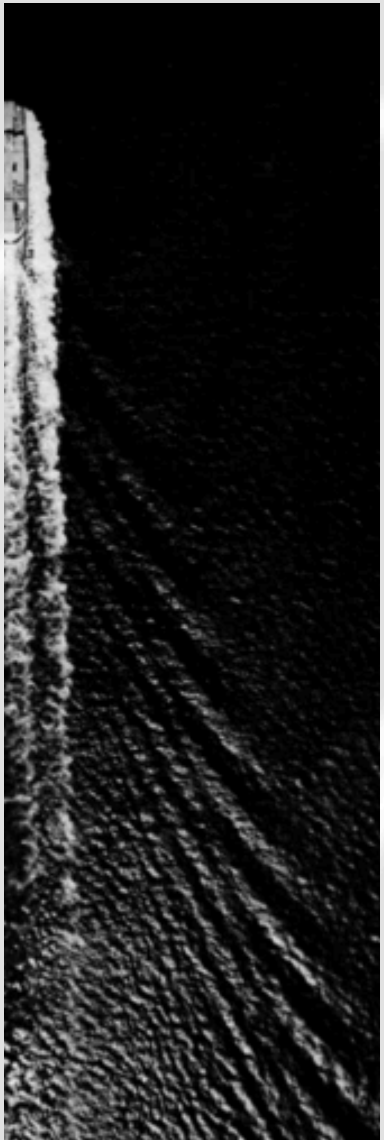
Design Optimization and Design Exploration using an Open Source Framework on HPC facilities

Joel GUERRERO Wolf Dynamics, Genova

Haysam TELIB OPTIMAD engineering, Turin

HPC methods for engineering, @CINECA, June 2015

Outline



1. Introduction to DE/DO; the role of HPC
2. Geometry parametrization
3. *Data Analytics **
4. *Open Source Framework **
5. *Conclusions **

*** presented by JG,** wolf dynamics

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Aerodynamic shape optimization is done only if strategic

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2 major burdens to aerodynamic shape optimization

1. **Difficult**
   - you have to know/explore a lot (physics, uncertainty, parameterization)
   - automatize everything (geometry creation, pre /processing/ post)
   - *especially critical if at advanced design due to project constraints and time*

2. **Expensive**
   - computing resources sized for analysis
   - licenses CAD, CFD…
   - specialized technical staff

(on demand) HPC

FFD parameterization

OS CAE software

Data Analytics for DE

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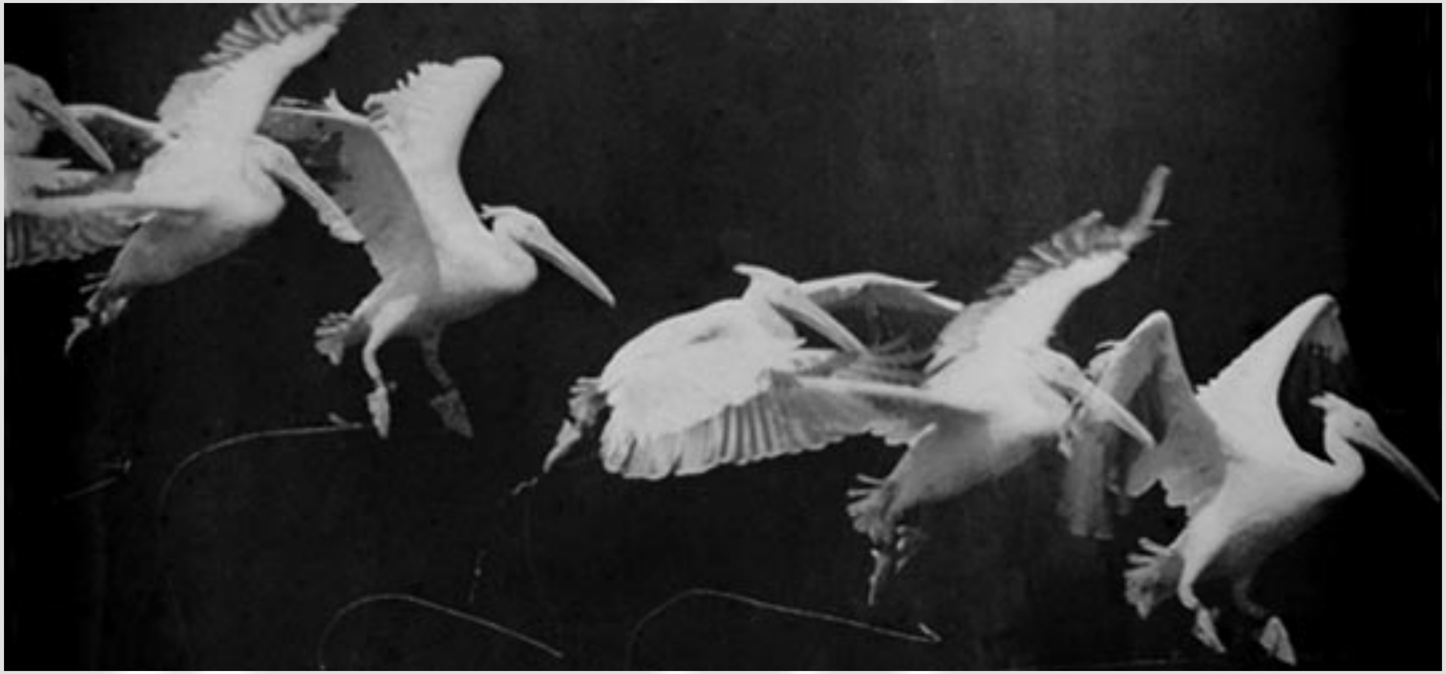


Free-Form Deformation using Level-Sets

Free-Form deformation vs CAD-in-the-loop

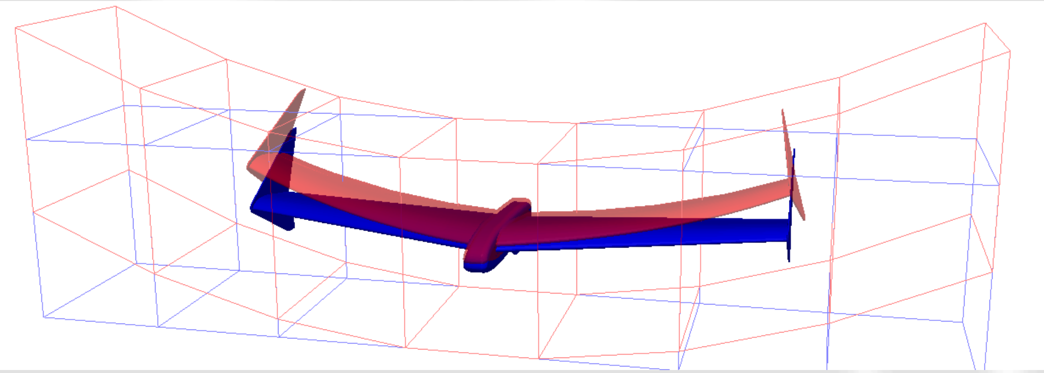
- CAD software often not suited for HPC (licenses and platform)
- ad-hoc CAD needs to be created (which parameters?) -> critical if at advanced design phase

- CAD needs to be re-created from FFD surface mesh
- FFD has difficulty to impose manufacturing constraints

Surface Constraints via Level-Set information

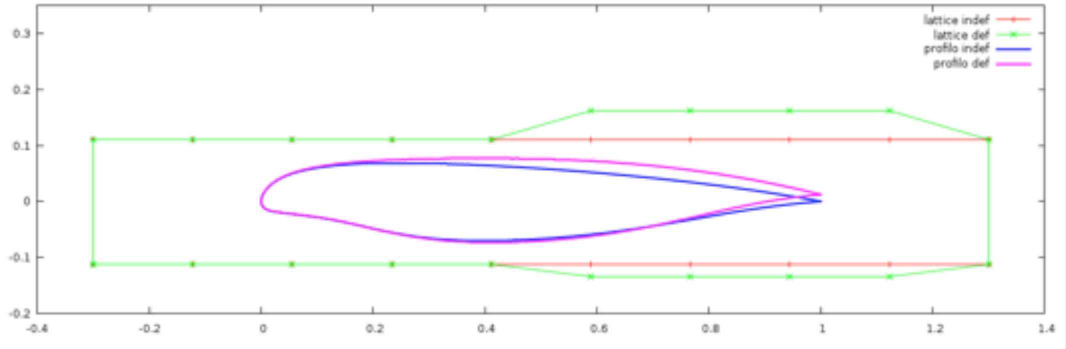
Free-Form Deformation applies a displacement vector $N_i = S_i + D(S_i)$;

- excellent for global deformations



Difficult to impose localized deformations

- often addressed by constraining the CP or ad-hoc shape functions
- ineffective if boundaries do not correspond to the deformation kernel



Surface Constraints via Level-Set information

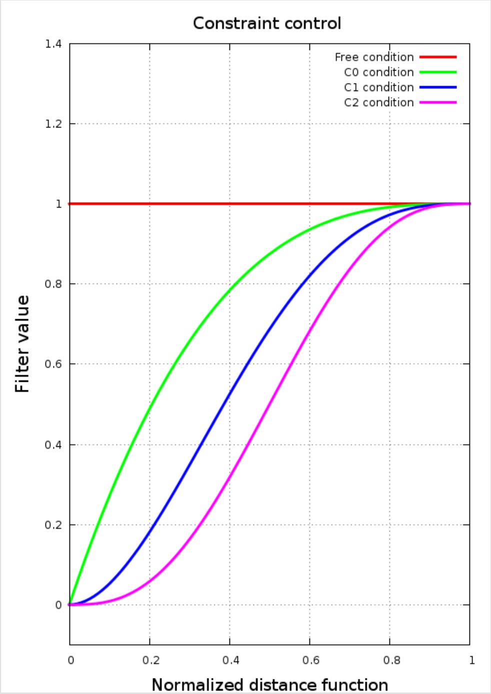
Our approach introduces a weight function

$N_i = S_i + w[\, LS(S_i|\mathbf{\Gamma})\,]\, D(S_i)$

with

Γ boundary non/deformable

$LS(S_i|\Gamma)$ represents a **topological information of S_i wrt to Γ** and must satisify **$LS(\Gamma|\Gamma) = 0$**



with $w(0) = 1$ for G^{-1} condition

with $w(0) = 0$ for G^0 condition

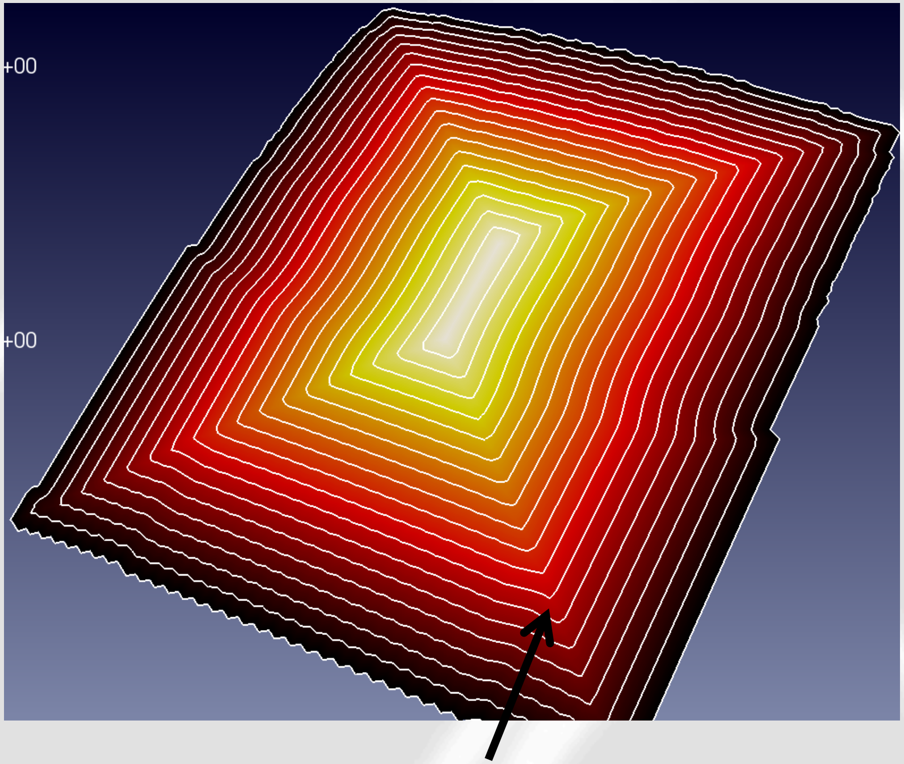
with $w(0) = 0\,,\; w'(0) = 0$ for G^1 condition

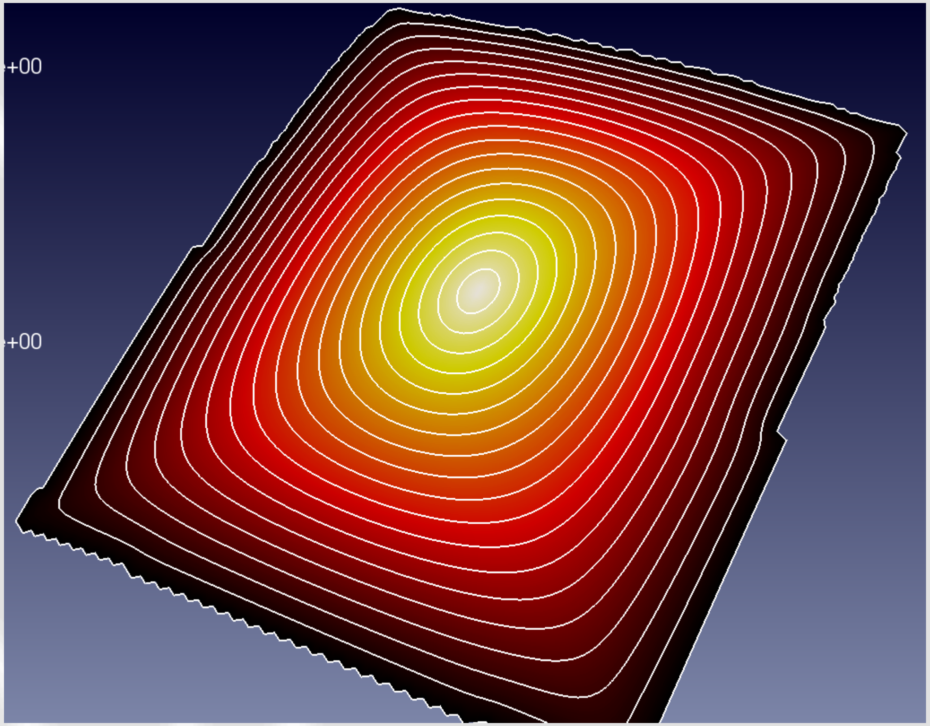
with $w(0) = 0\,,\; w'(0) = 0\,,\; w''(0)=0$ for G^2 condition

The weight kernels are chosen in order to **minimize the risk of inflection** (change of curvature) but cannot be guaranteed

$LS(S_i|\Gamma)$ must be **C^p if G^p continuity** is required

Toplogical information: Eikonal equation vs heat kernel

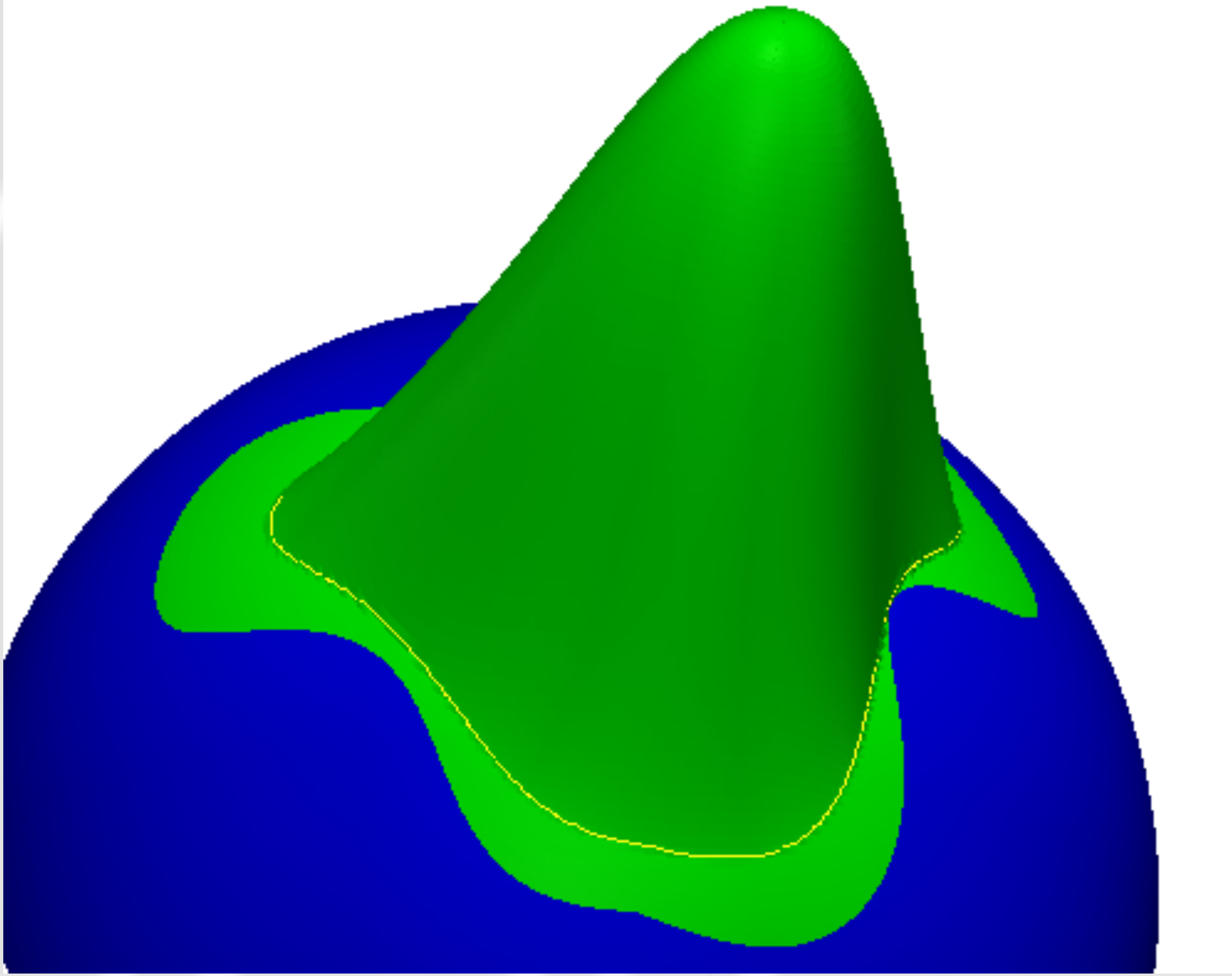




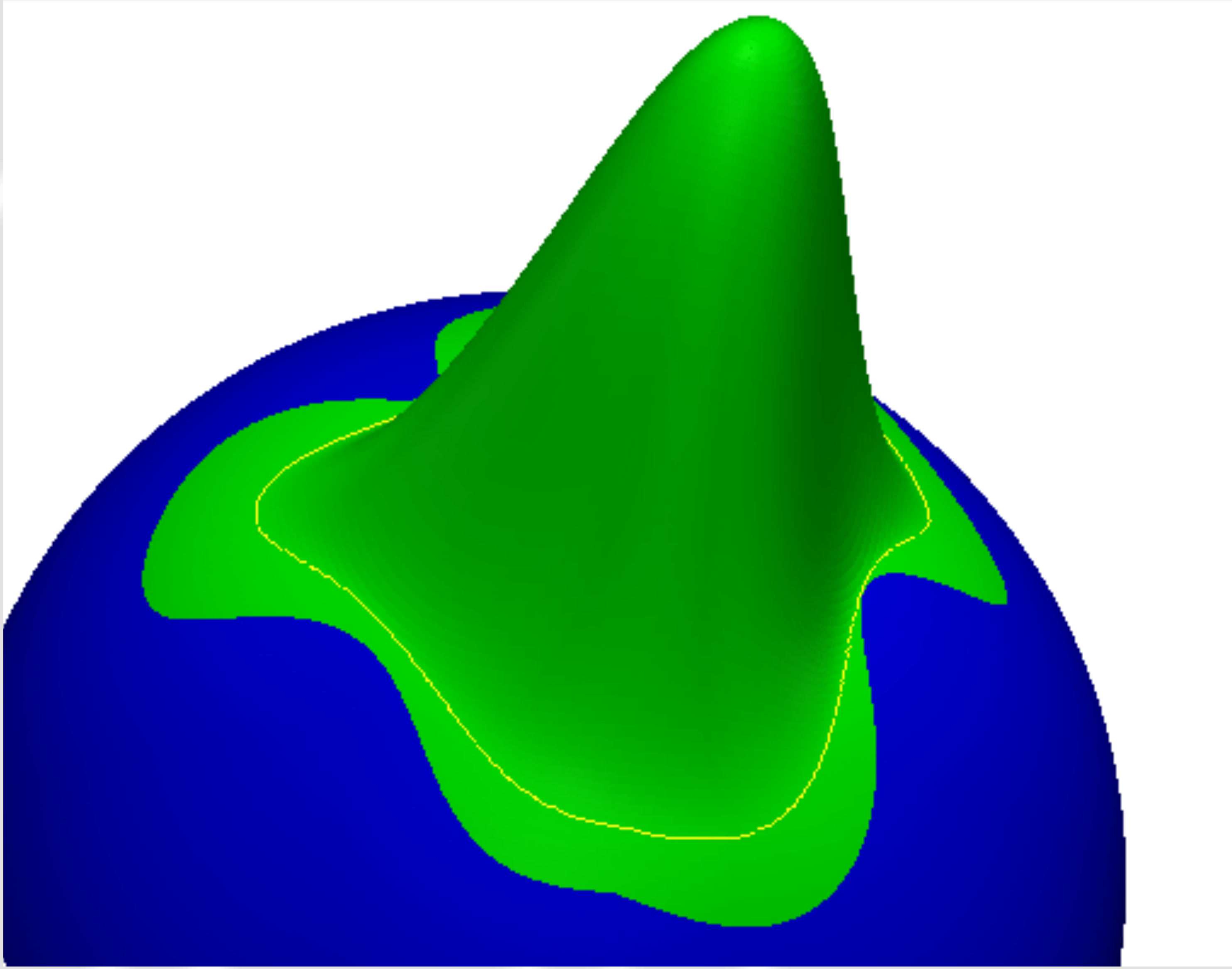
- distance function wrt to boundary
- C^0 function
- ca 0.01s for 100K triangles on Intel Xeon

- as close as possible to geodesic LS to keep topology
- constraint on C^2 continuity
- ca 3s for 100K triangles on Intel Xeon

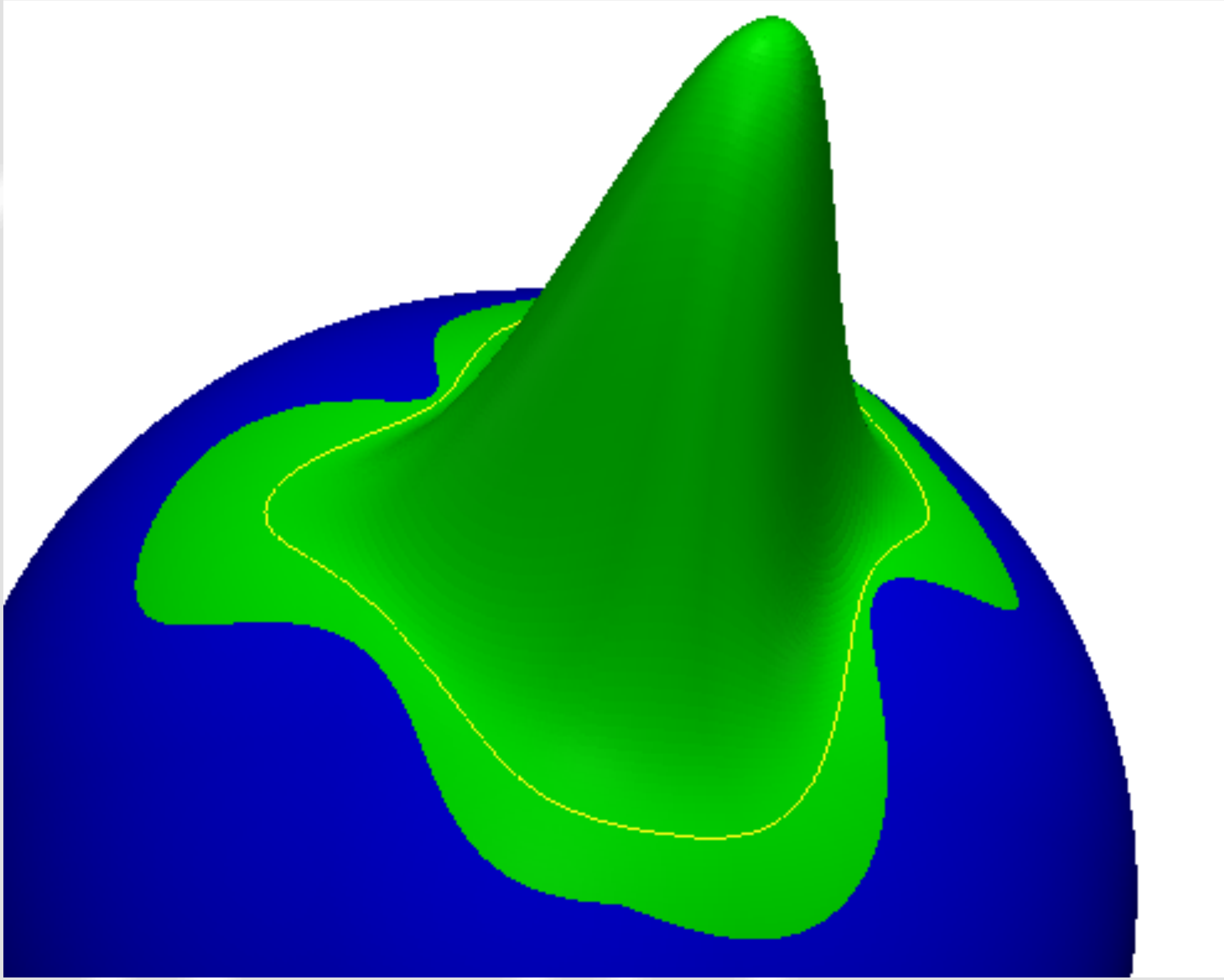
Deformation using C^0 constraint



Deformation using C^1 constraint



Deformation using C^2 constraint



Control of penetration

Distance to a given surface should be maintained

- bounds on CP non-intuitive and often not efficient

User should indicate only intuitive information

- surface (open or closed)
- distance to be maintained

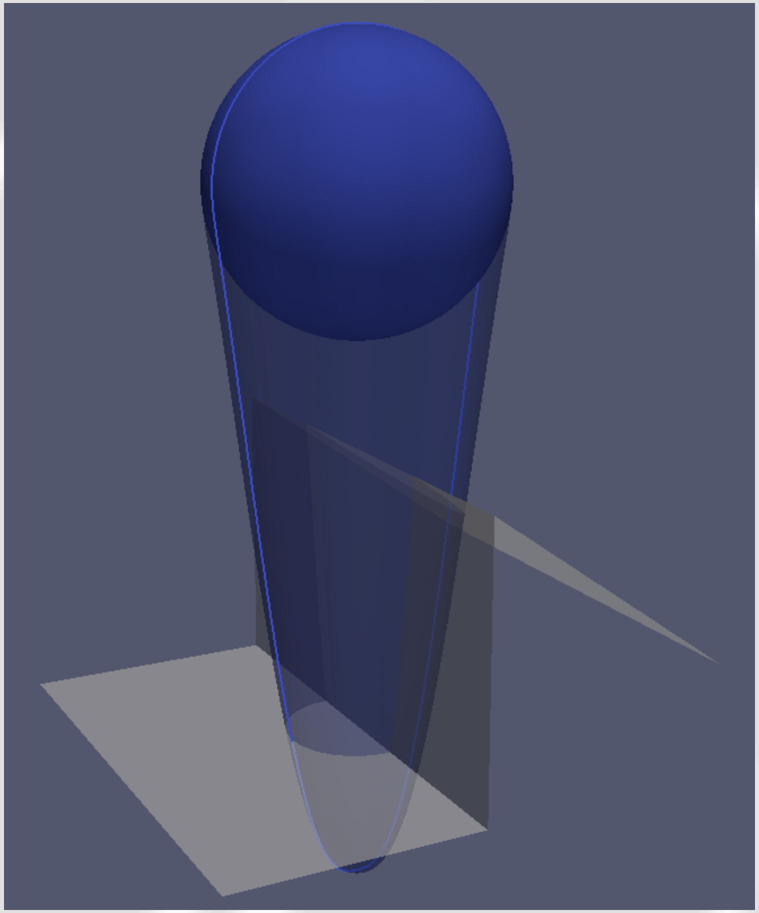
Combined control algorithm

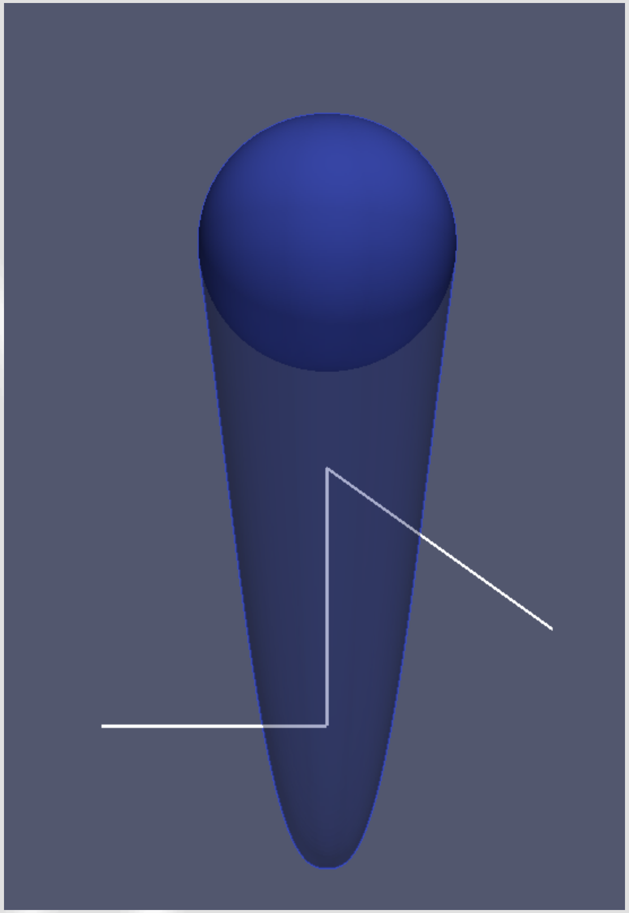
- Ray-tracing
- Level Set

Two different types of rescaling algorithms available

- choice depends on case considered

Control of penetration – Controll off





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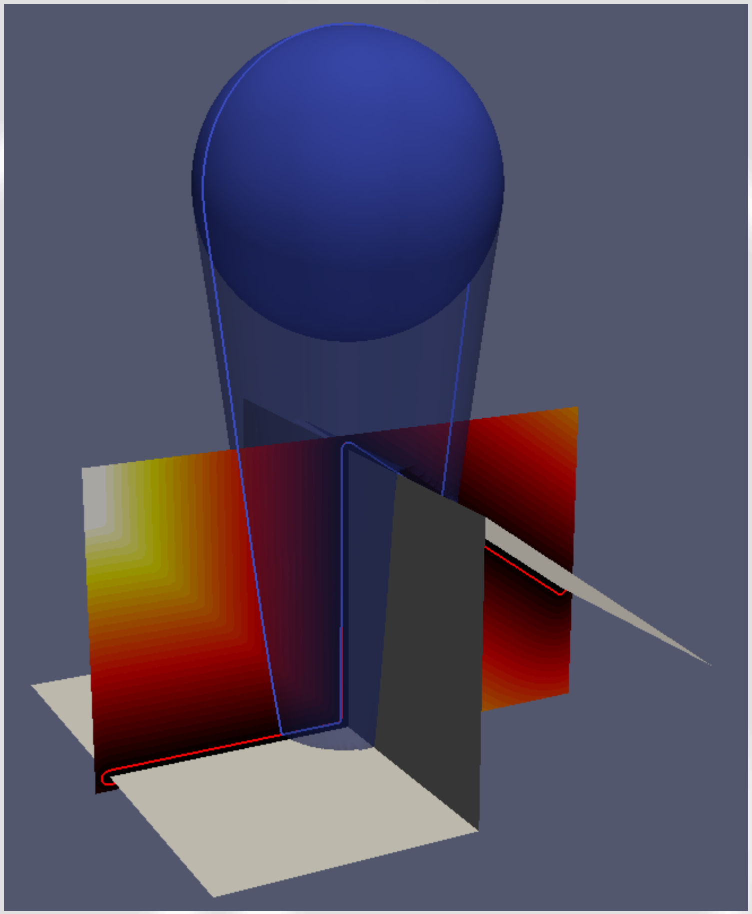
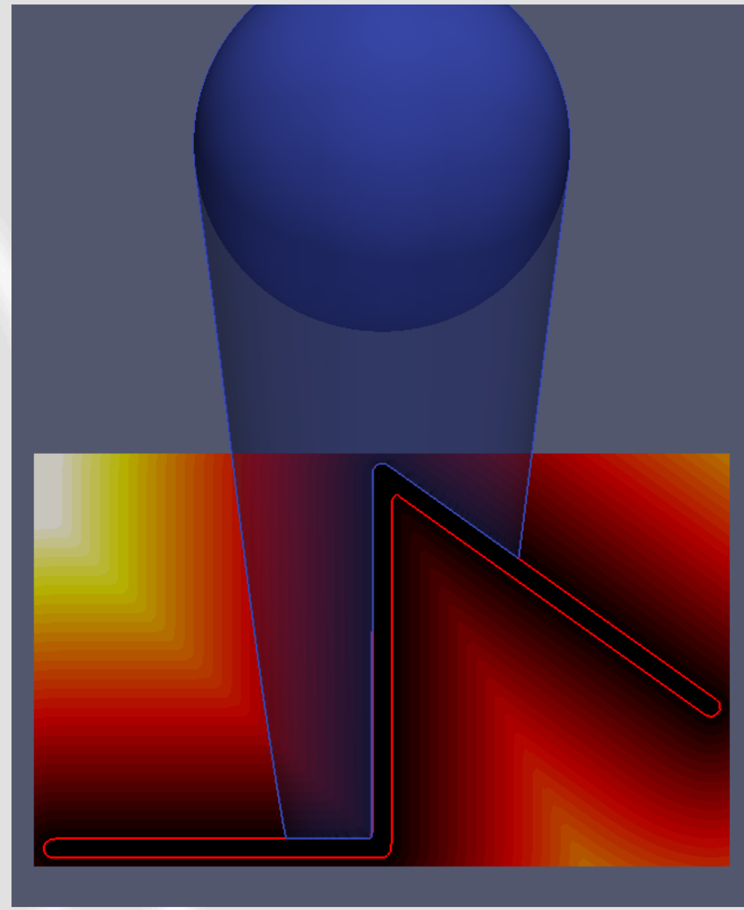
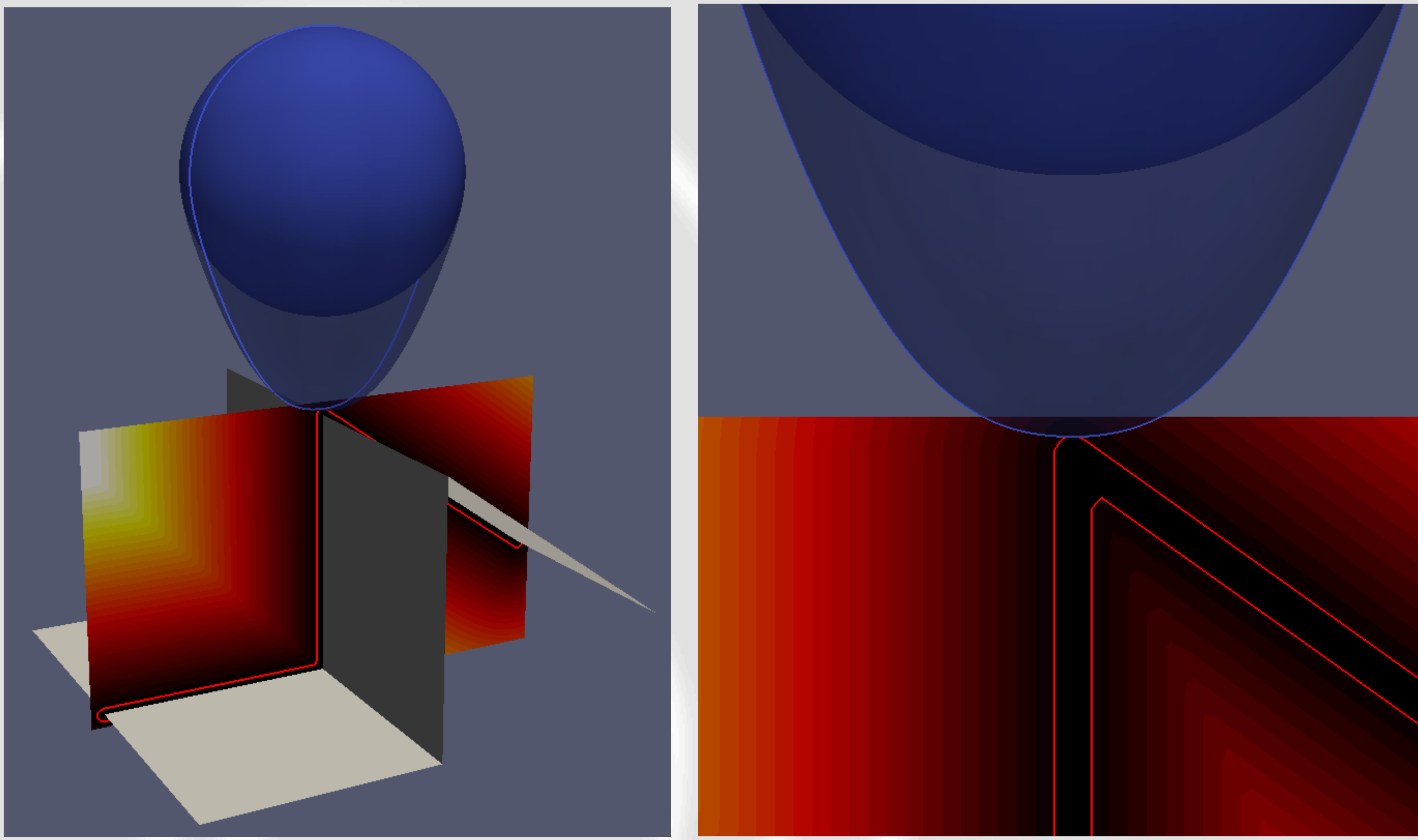
Control of penetration – Local rescaling





distance wrt tangential projection

Control of penetration – Global rescaling



identification of critical point

CAMILO – description of work flow

1. install **GUI on workstation** and put **executable on cluster**
2. import **geometry and surfaces** to be used as constraints in GUI
3. play with GUI in order **to impose parameterization and constraints**
4. export **control and load file** and copy file on cluster
5. **let Dakota change load file** and call executable with **control and load file as argument** -> modified geometry file (e.g. stl)
6. *… pass geometry to pre-processing …*

end of my part…..

→>>> Joel G

→>>> happy to discuss any question at the end of JG's part

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