Design, construction and results in UST_1 , a small low-cost educational stellarator

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Outline

I) Background data

II) **UST_1** : Coils, vacuum vessel, mechaniser, vacuum and control system

III) **SimPIMF** code and **Optimization** of coils

IV) **Experimental results** : Field mapping system and magnetic surfaces

V) **Chronological description** : Evolution, alternatives, difficulties and solutions

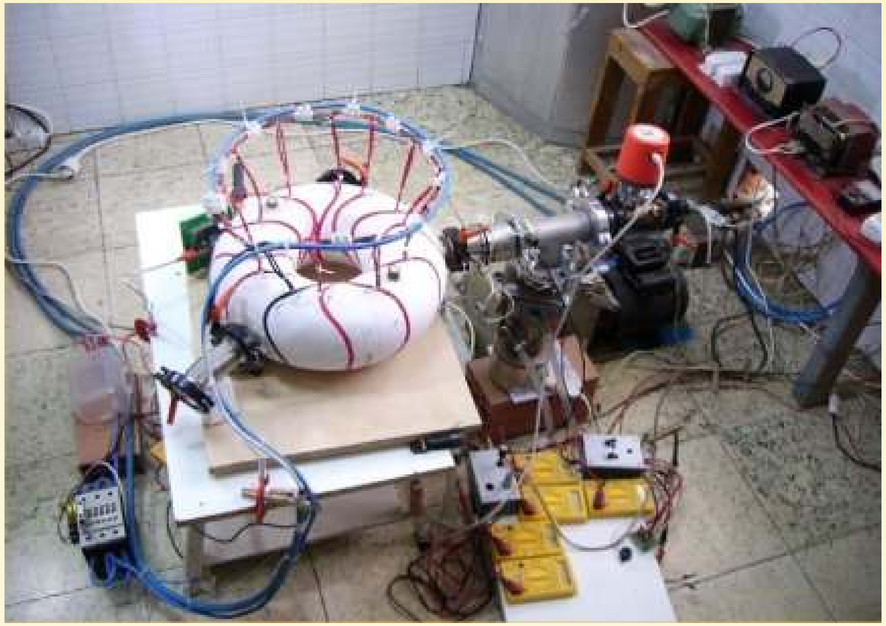
Background data

UST_1 basic features

- UST_1 is a low cost small educational stellarator built in a personal laboratory
- Modular coils, R = 125mm , <a> = 21 mm , Ap = 6 , 2 field periods , Vp = 1.1L
- **Bo = 40mT** , presently (designed for ~0.1T)
- **Pulse length** : 2 s at Bo = 40mT
- **Heating** : ECH : 0.8kW at 2.45GHz . Being developed.
- **Diagnostics** : e-beam field mapping. (RGA and visible spectroscopy)*
- **Vacuum system** : Best 5mPa . Mechanical, diffusion pump, gauges

The cost and the quality

- Objective : Minimum cost
- Quality & precision : medium, but creativity and effort for maximum rate quality/cost



Motivation to built UST_1

- Learn, experiment with fusion technologies and support to my offer in fusion research

Section II

Section II . UST_1 : Coils, vacuum vessel, mechaniser, vacuum and control system, calculated features

Coils and coil structure

Type & Periods	Modular coils ; m=2
Winding surface	Circular pol. & tor. R = 119mm r=57mm
Number of coils	12 (3 different shapes)
Turns per coil	6
Conductor	flexible, special copper 6mm^2
Winding pack **structure**	1 double pancake per coil, 3 layers
Winding pack size	7mm width x 10.5 mm depth
Case	Compact plaster frame
Parameters of **shape**	1.45 ; 1.3 ; 1.55 ; 0.65
Current, present (ECH 2nd)	335 A , 2 kA-turn
Current, planned (ECH 1st)	687 A , 4.1 kA-turn
Power supplies, present	5 batteries DC 12V, ~17Kw supplied to coils

The 12 modular coils finished. (Before installation in the system)

Selection of suitable conductor

Constraints :

- Relatively **large section** and **few turns** to allow low voltage battery operation
- **Maximum ratio copper/total section**
- **Narrow winding pack** to allow a single pass mechanization of the groove
- The **plaster strength is low** and rigid copper conductor was not adequate

Alternatives:

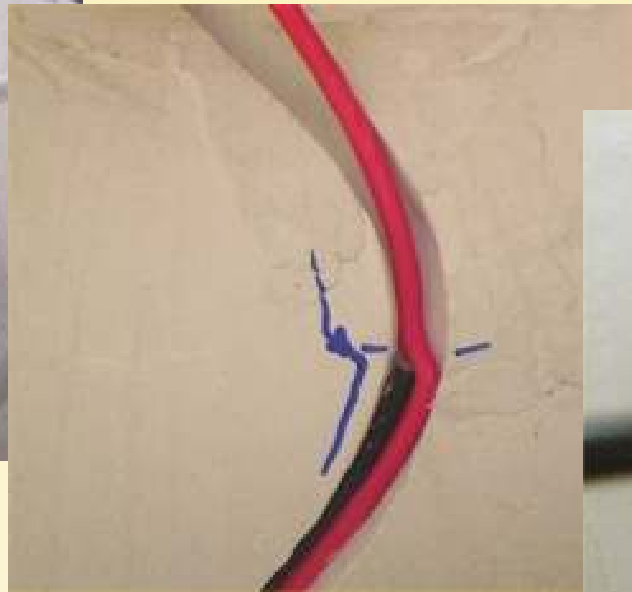
Several test

Selection : ►
6mm2 flexible cond., unsleeved and shrinkable sleeved. Diam. ext =3.5mm

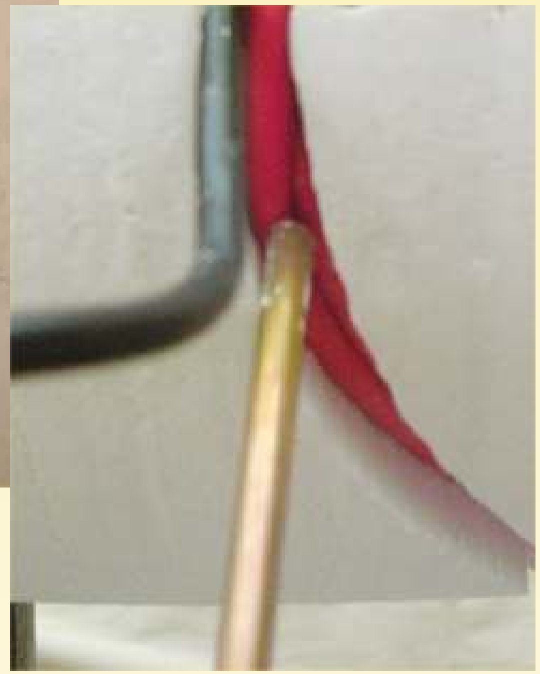
Test of groove-coil

Winding process of coils

◄ Grooves mechanised in the compact frame , 7mm width, 12.5mm depth



Internal crossover and auxiliary winding coil (black conductor)



Compacting and locating conductors in the groove

Detail of the device to mechanise modular coils

Vacuum vessel

Gutter copper elbow.
0.8mm wall thickness

◄ Vacuum vessel formed by 5 elbows of 75º

Tube 80mm diam. R-torus 119mm. Low T silver soldered

Detail of hole for port and two rings to reinforce the VV

Finished VV under leak test. 3 ports of 35mm diam. and NW40, high T silver brazed. One glass window. No ferromagnetic materials.

Coil Support structure

Constraint : **Low cost**

Alternatives were studied to obtain notable accuracy at low cost :

▪ Coils style HSX or W7-X : Expensive to wind, locate, regulate and measure

▪ Style CTH : Very high cost of min. 6 pieces CNC mechanised, difficult to locate and measure.

▪ Internal, like in CNT or QPS. Issues : Vacuum tightness, wind & locate

▪ Frames style QPS : How to fabricate the frames?, many fasteners to fix the coils, assembling, measurement.

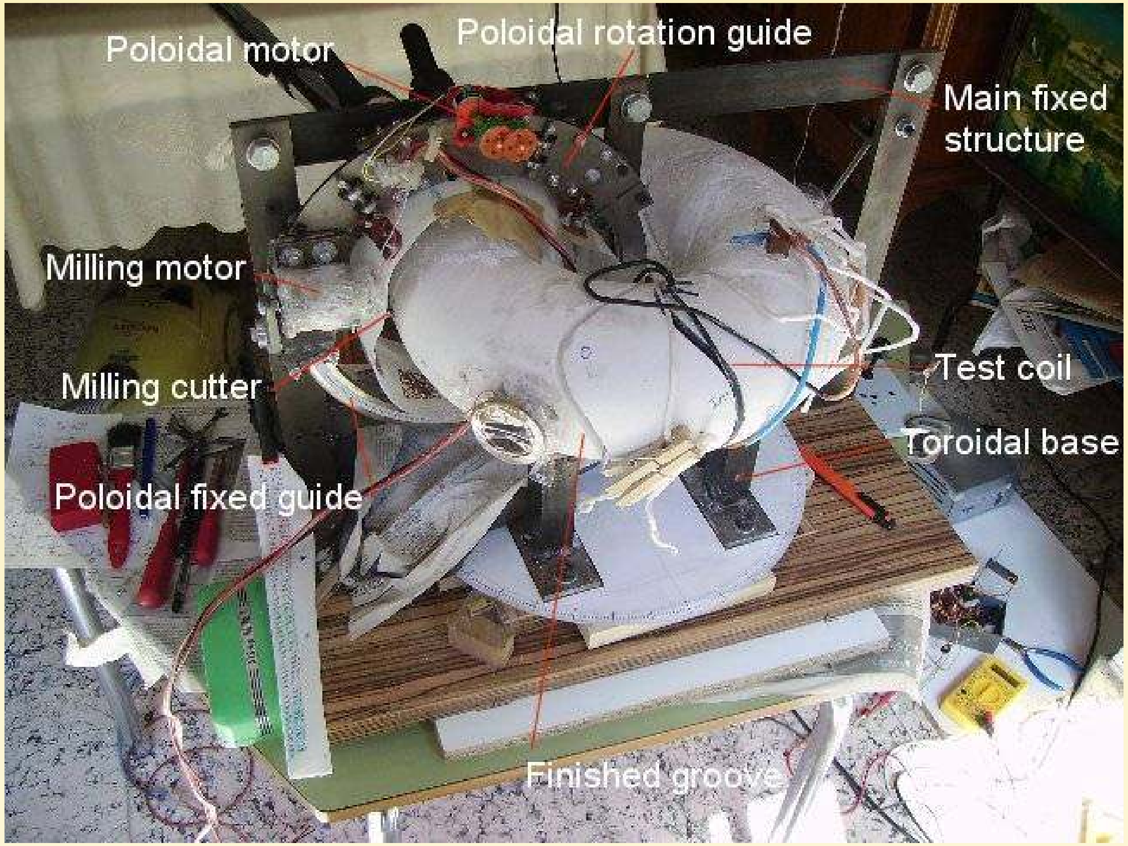
▪ Structural only one turn : Perturbations of magnetic field due to ends. How to conform the turn?

▪ Fasteners on toroidal surface located with **measuring device**: Low accuracy

Solution (patented) : Innovative mechanising device. A ***special milling machine*** working in toroidal coordinates that acts as:

- *measuring device.*
- *mechanising device for grooves*
- *instrument to "locate" the coils*
- *auxiliary apparatus to create toroidal moulds*

Device to mechanise modular coils



- **It was devised, designed, patented, built, tested** and grooves manufactured
- It took long time and effort, but successful result

Advantages :

- Mechanization and positioning of coils is the same process → reduced field errors (<0.2º toroidal, <0.1º verticality in UST_1).
- Errors are similar to CNC deviations, so very small.
- Different prove of principle can be easily built.
- At least four different functions.
- Able for non-circular surfaces.

Drawbacks :

- No suitable for big devices?
- No adequate for highly shaped and compact devices.
- Needs special cutter if wide grooves.

Device to mechanise modular coils

Some elements :

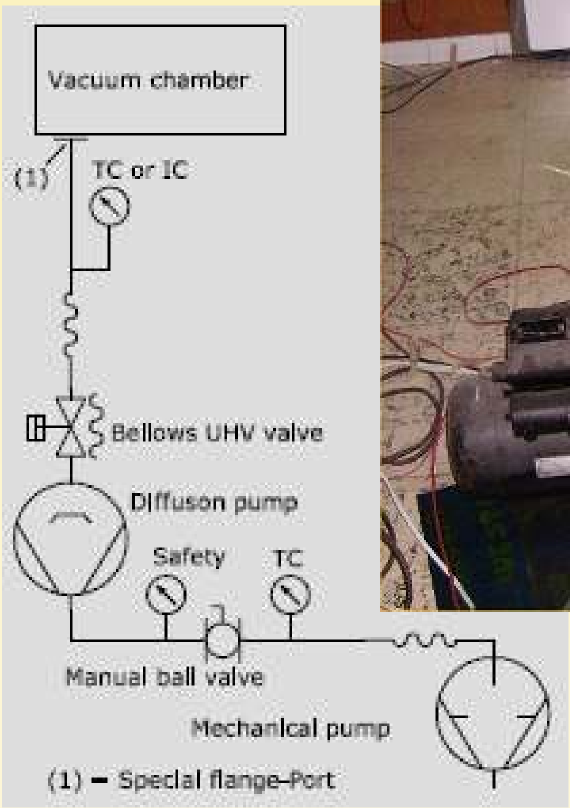
- Poloidal guide + motor
- Milling motor and milling cutter
- Support porch
- Fixed two halves of ring
- Powder sucking tube
- Powder poloidal cover
- List of coordinates

▪ Some mechanised grooves
▪ One test coil (black)

It takes ~2 hours to mechanise a groove 7mm width, 12.5mm depth. Poloidal forward speed adjustable according to slope. Manual (by now) toroidal position

Auxiliary function : Cut toroidal moulds.
Support, hot semicircular wire and mould ►

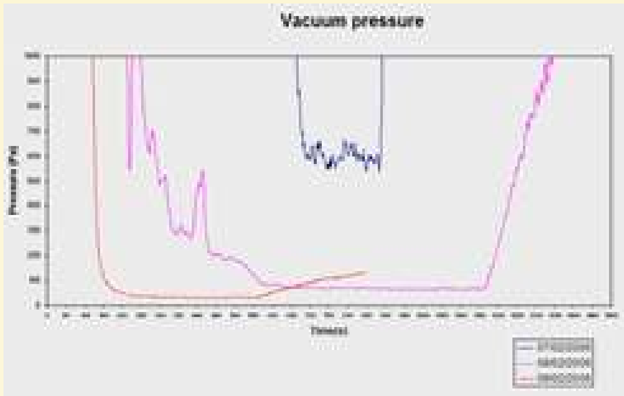
Vacuum system



Vacuum system layout
(The Varian UHV valve was recently removed to increase conductance)

Main elements

- Pfeiffer DUO 004A mechanical pump , 4m3/h
- Leybold diffusion pump ~150L/s (DC-704 oil)
- Edwards AIMS = Active inverted magnetron gauge , 1Pa 10^{-6} Pa
- Lesker Thermocouple gauges x 2: 100 Pa – 0.1Pa
- Capacitance gauge : 5 Torr - ~ 10Pa
- Bourdon manometer
- NW50 fittings for high vacuum,

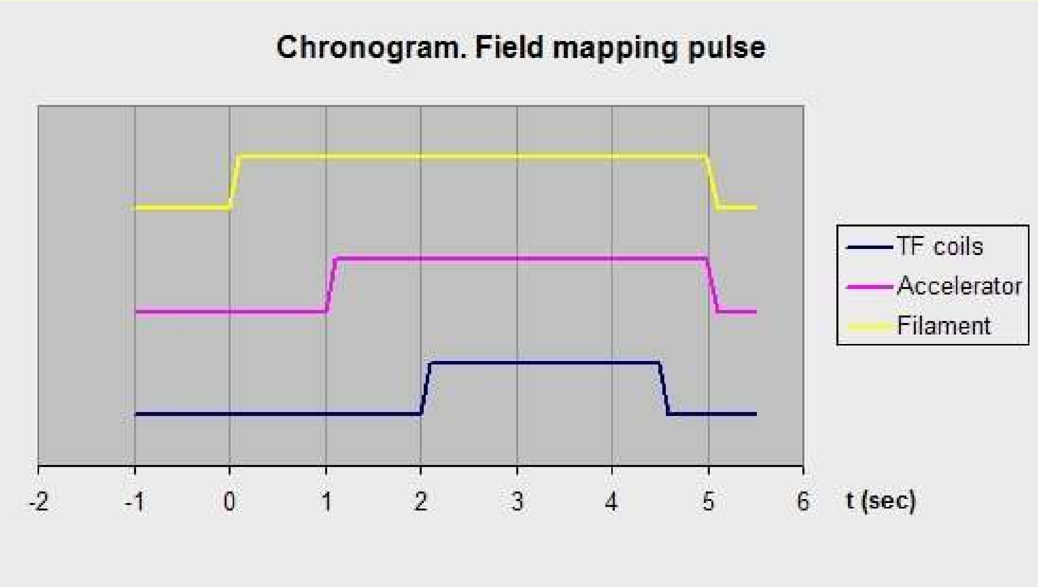


Achieved 5mPa

Outgassing improvement with time

Control and data acq. system

- 2 x PC and short "C" code for control
- Card with 8 digital outputs expansible to hundreds (used 3)
- Card with 4 analog, 5 digital inputs and expansible to dozens (used 2)
- Firewire card for camera data acquisition. 400Mb/s



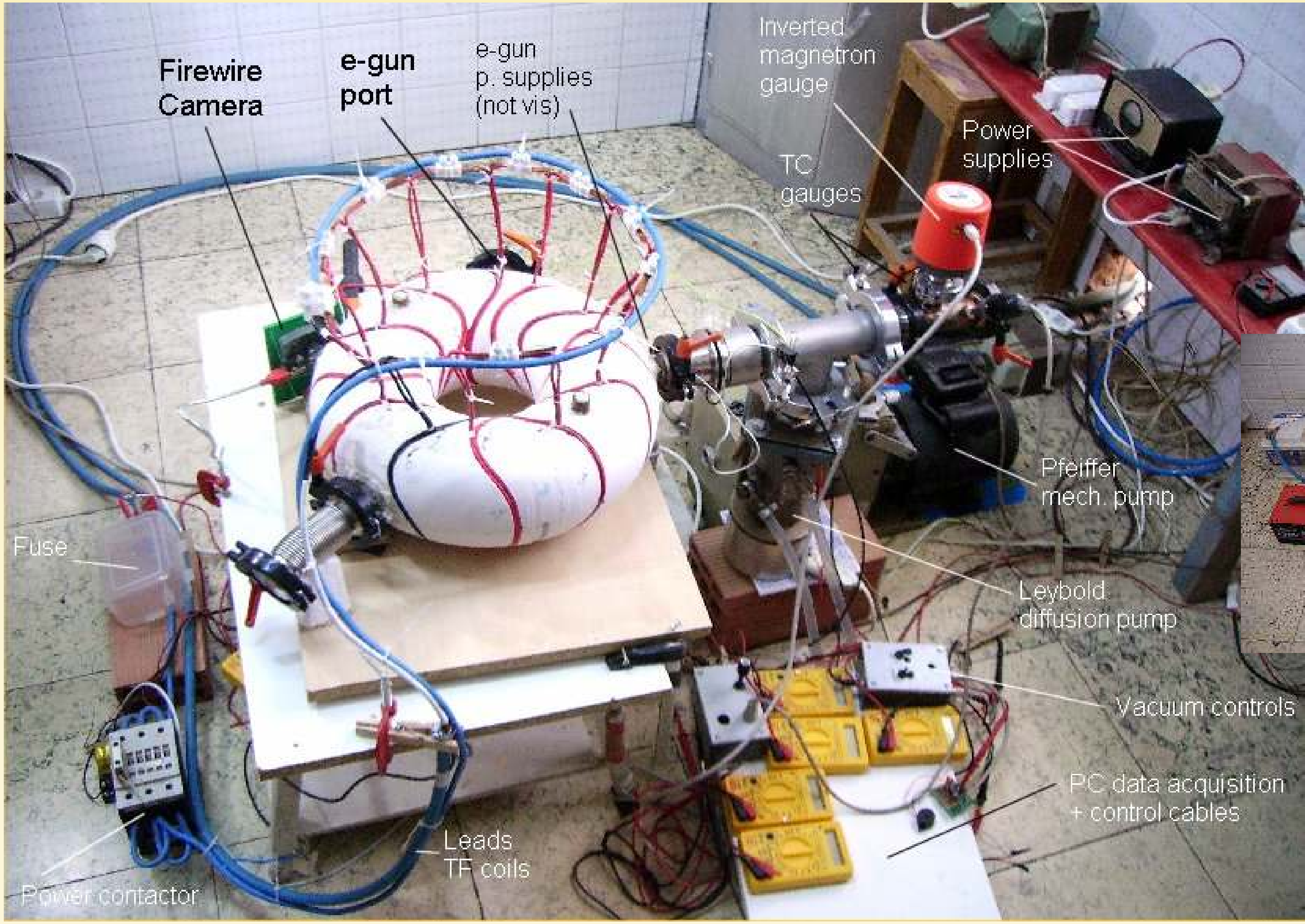
Cost

- Total cost = 2600€,

Including UST_1 core, vacuum , e-gun and control system, but not work.

Work not included Cost, incl. transport	€ (Euros)
Vacuum vessel + frame for coils	61
Conductor	75
Power supplies + main leads + switch	206
Mechanising device (only paid elements)	222
Diagnostics : e-gun + RGA + spectroscope	441
Vacuum system	1610

UST_1 installation



Power supplies

Whole installation. Two PC's for data acquisition and control are out of the image

Calculated expected parameters

- UST_1 project is focussed in **engineering**
- The **physics calculations** are only **estimates** and optimization (in the next pages) is poor in spite of the effort

- Parameters are very modest, similar to any small and/or low B stellarator

	Expected values		Observations and conditions
ne=ni	order of 10^{17} m^{-3}		Limited by τ_E~P heating and cut-off freq. ECH
τ_E	3,4 μs		ISS04 , e.f. = 1, n= 1×10^{17} m^{-3}, P=400W, 0.1T
τ_E	0,15 μs		More real : e.f.=0.1, 0.04T
τ_{Ep} τ_{Ee}	?? (480 μs) ?? (4400 μs)		SimPIMF v2.5 (initial, not contrasted) , Te = 2eV , Ti=0.5eV , n= 1×10^{17} m^{-3} , Only neocl. flux particles
Te max	order of 2 eV		n = 2×10^{17} m^{-3} , Te = Ti , P=400W , e.f.=0.1 , 0.1T
Ti	< 2 eV, ~0.2-0.5eV		Due to ↑ drifts per tor. turn → direct losses
~β	~0 , <0.01%		n= 1×10^{17} m^{-3} , Te = Ti = 2eV , 0.1T , ~WEGA

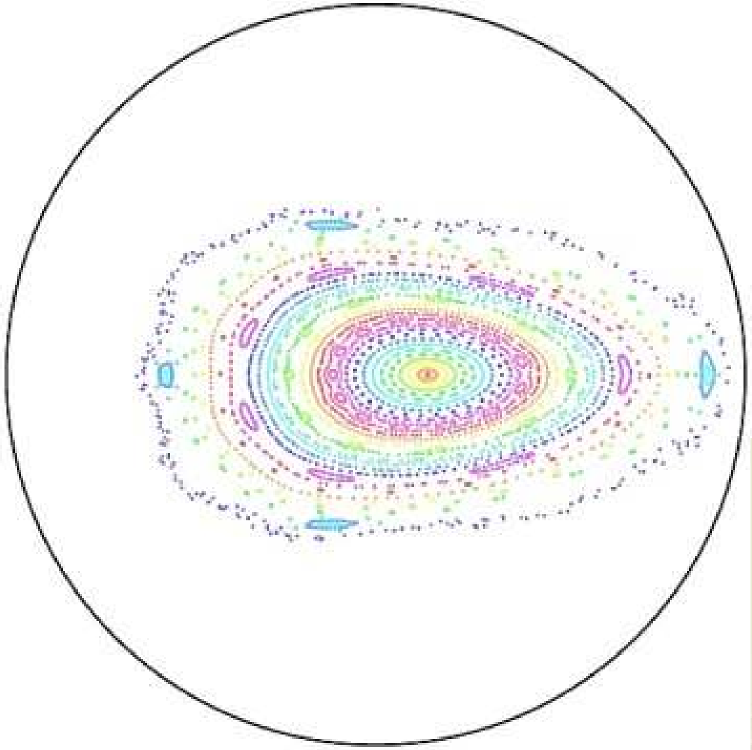
Section III

Section III . SimPIMF code and Optimization of coils

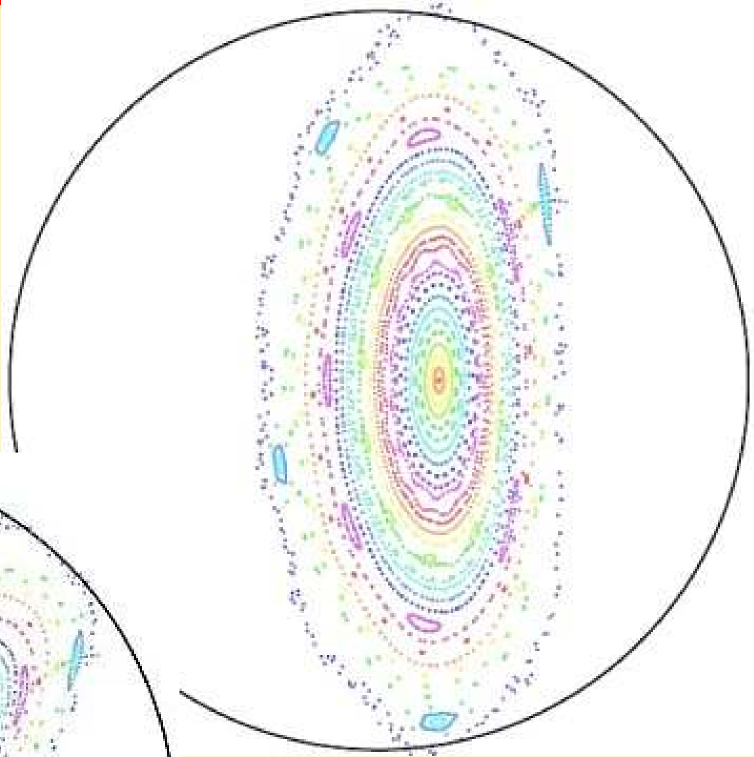
Simulated magnetic surfaces in UST_1

Vacuum magnetic surfaces. Poincaré plots. Simulation without drifts.

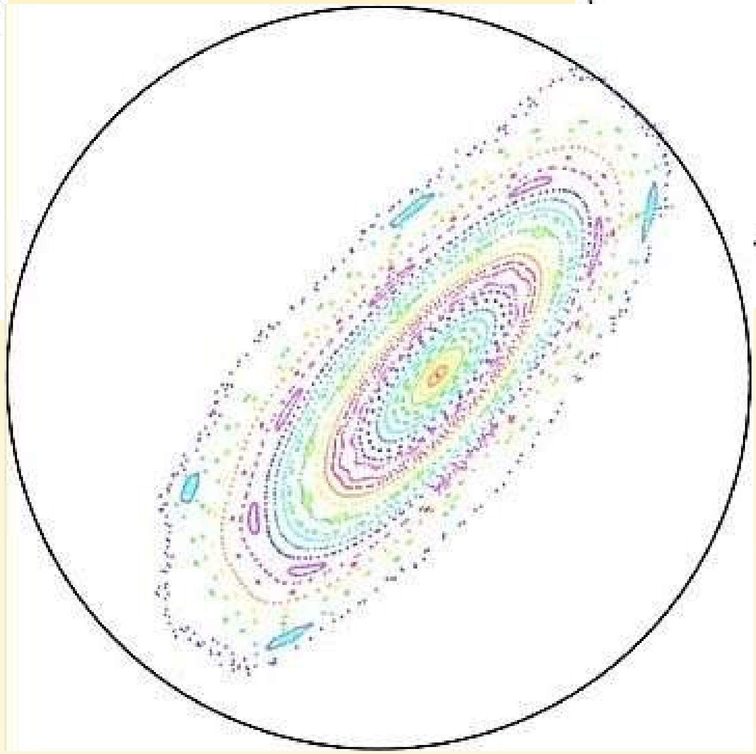
SimPIMF code v2.3 is used



Φ=0º



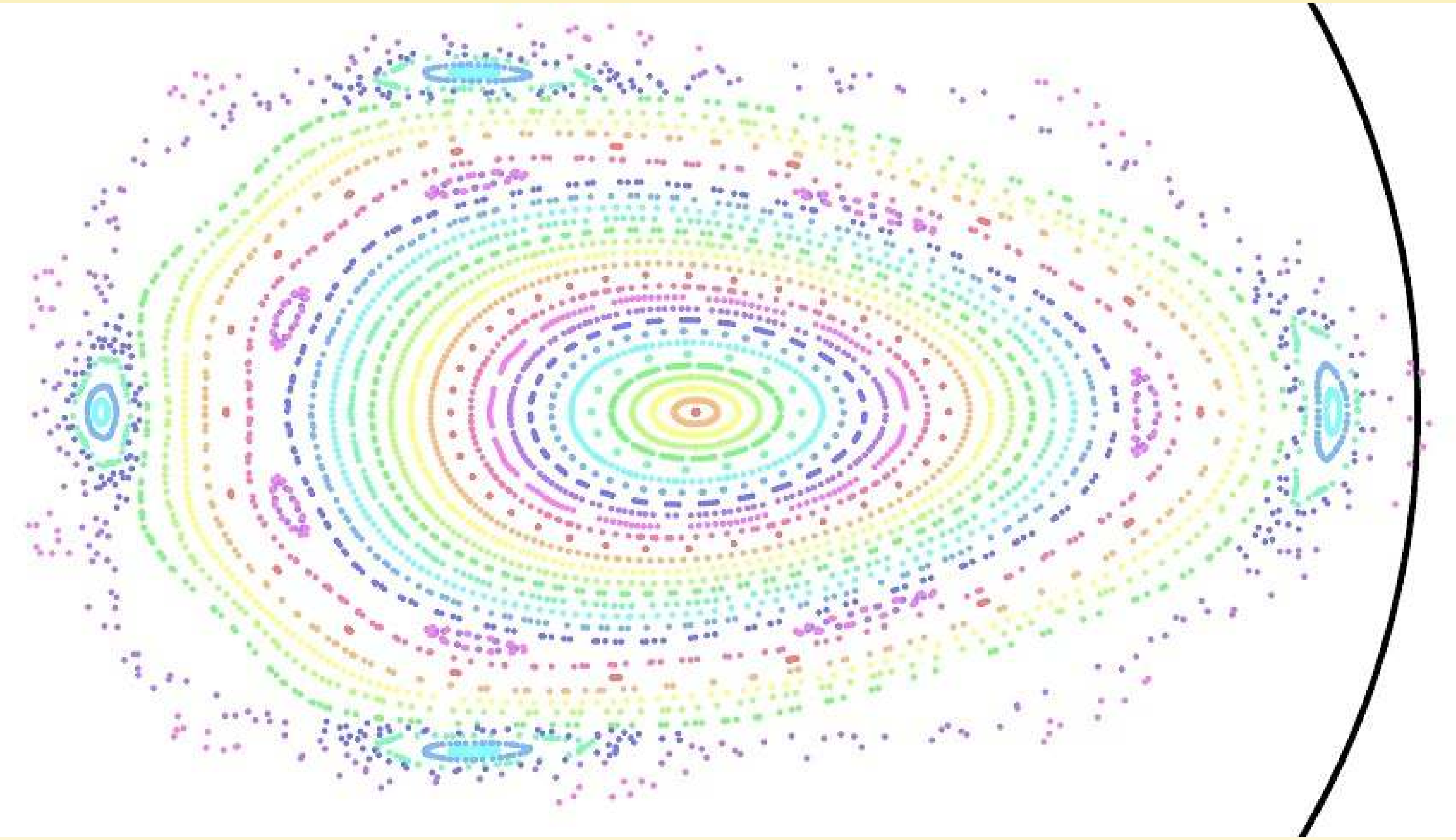
Φ=90º



Φ=45º

Note : The black circumference is the internal surface of the vacuum vessel.

Magnetic surface in UST_1



Φ=0º

Rationals:

- **Low order rationals are avoided,** except :
- 2/7 =0.2857…
in magenta is the higher order but not excessive.
- Blue : 1/4 rational, out of the LCFS
- Outer stochastic region

Simulation using accurate grid 1/400m = 2.5mm side.

Optimization : Avoid large islands by tailoring Iota profile below 1/3 . Most of the plasma have Iota from 0.32 to 0.27

SimPIMF code

General features :

- Developed in **JAVA**
- 15 modules and 8250 lines of code
- Developed from scratch during **1.5 years** according to needs and knowledge
- **Output are files** which can be easily transferred or represented by many codes
- **Object oriented** code easily expansible and very suited to this style of simulation

Functions and methods:

a) B in 3D . (Forces 3D not in JAVA)

b) Simulation of orbits with and without drifts, Larmour, E field(slow)

- Outputs: Iota profile , Magnetic Well profile, Ripple and Averaged ripple, Plasma Size, δ |B|min, % of trapped particles, Min. distance among coils, 3D polygon of mag. axis, and magnetic surfaces

c) Generation of parametric 3D coils : Modular 'circular', HF ,TF and PF

d) Collision simulations. Only first rough results, little contrasted

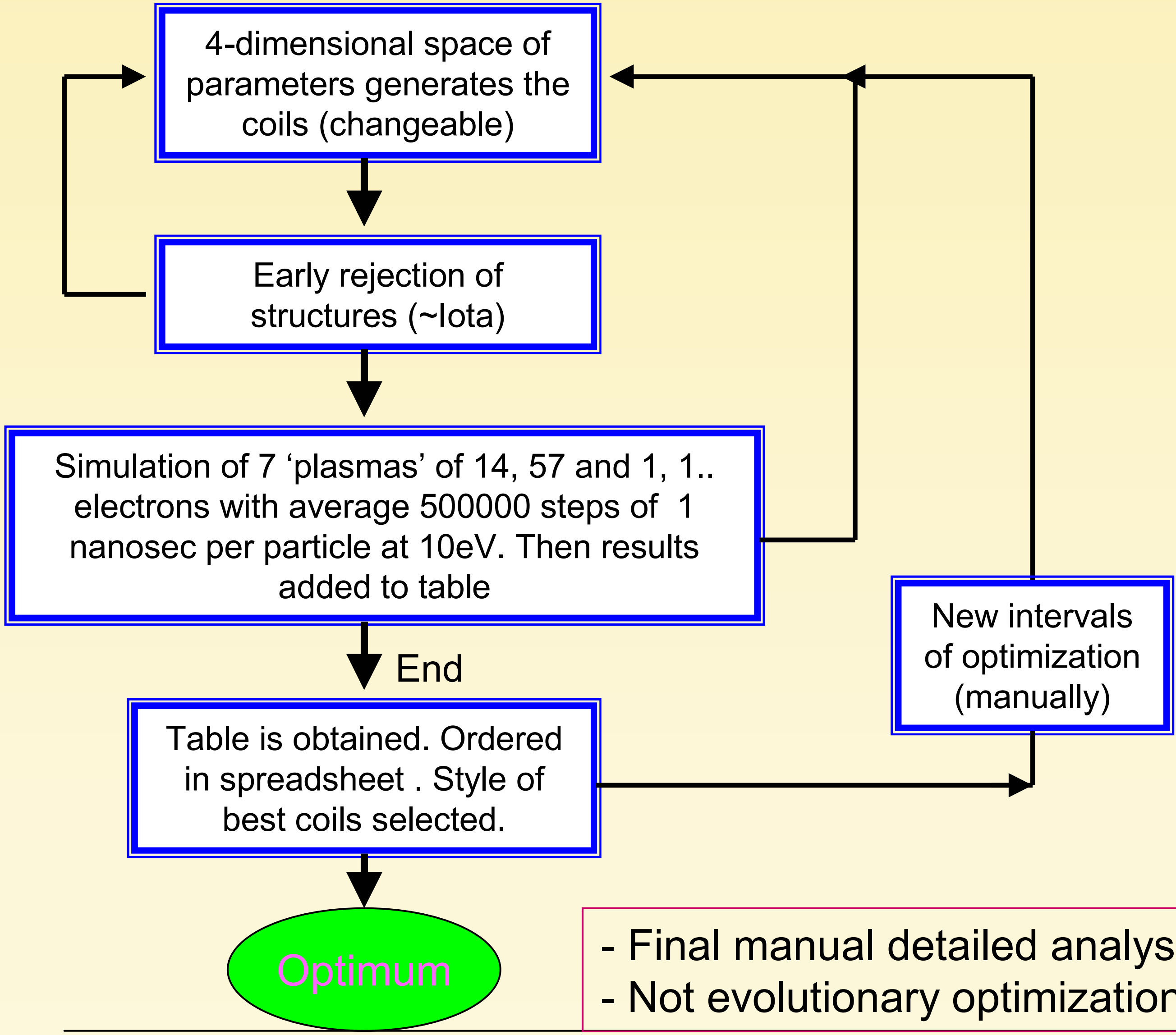
Validation and tests

a) Tested by calculation of fields and forces in EAST and CTH coils

b) Field mapping in UST_1 (agreement, but still weak test). Banana widths.

- Each output needs further comparison with other codes and experiments

Optimization of coils



Features and drawbacks

- **Fast** simulation of each orbit.
- The early selection speeds up the process.
- **Time consuming** if more than 4 parameters
- 6 to 27 PC-hours for **~6000 structures of coils**
- However this optimization is mostly **useful in final steps** after a NESCOIL-like run, similar to COILPLOT method.

- Final manual detailed analysis of optimum
- Not evolutionary optimization but easy to implement

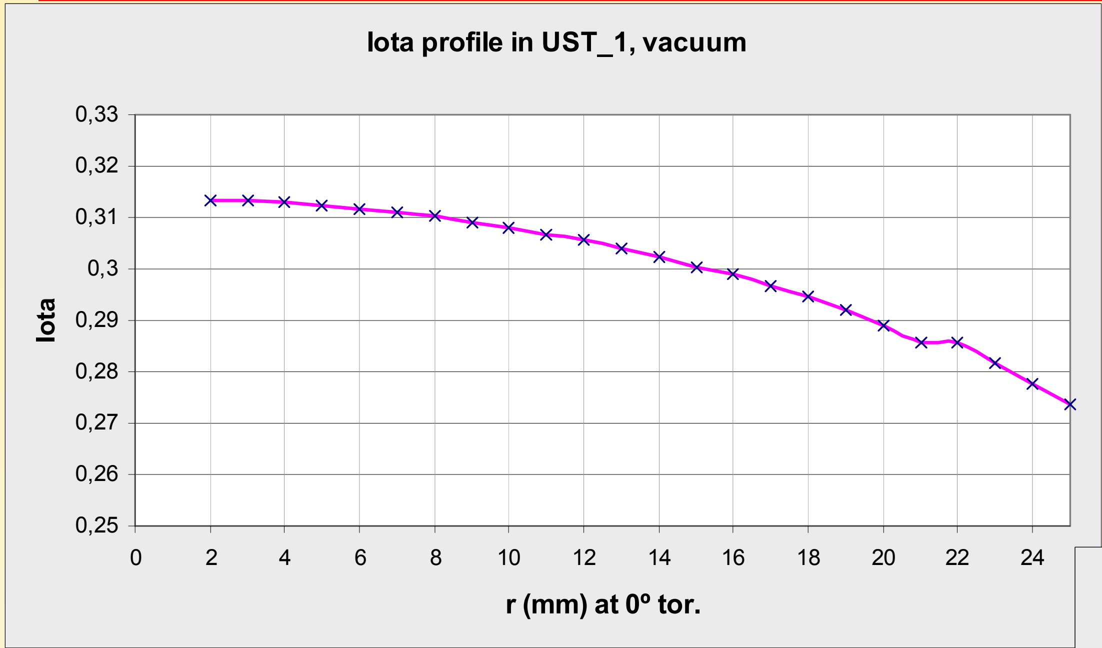
Optimization . Table of results

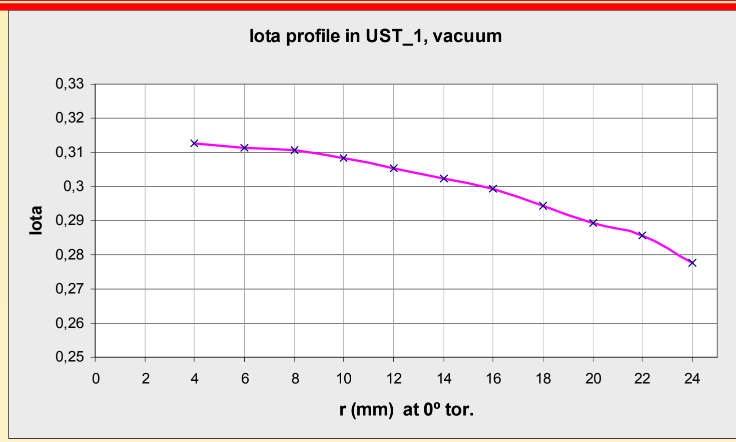
Order	Iota_1	Ripple_1	%T	Bmin_Desvia	Average_Rip	PlasmaSiz	Iota_2	Speci	Speci	MinDistanc	Fr	Pitch_On	Pitch2	Pitch3	Pitch4	H	Positi	up/dwon	well	
5	0,32121037	0,21300687	0	0,00374385	0,11439581	0,05125	0,33552672	9,98	10	0,009852	0	1,4	1,25	1,6	0,65	1	0,13	1,045	0,005	
73	0,32177544	0,19787124	0	0,00318734	0,11406053	0,05	0,33412121	9,75	9,82	0,007882	0	1,5	1,35	1,55	0,6	1	0,13	1,038	0,007	
65	0,32024554	0,20227083	0	0,00373036	0,10963253	0,05125	0,33327691	9,59	9,7	0,008333	0	1,5	1,3	1,55	0,65	1	0,13	1,041	0,011	
66	0,31997029	0,21509815	0	0,00312266	0,11926719	0,05125	0,33323999	9,88	9,96	0,008333	0	1,5	1,3	1,6	0,55	1	0,13	1,041	0,008	
58	0,31962951	0,21167492	0	0,00411215	0,11538991	0,05125	0,33303551	9,76	9,81	0,008784	0	1,5	1,25	1,6	0,6	1	0,13	1,042	0,006	
100	0,32221723	0,20706325	0	0,00441405	0,11215376	0,055	0,33275596	9,55	9,68	0,007348	0	1,55	1,35	1,55	0,6	1	0,13	1,033	0,013	
21	0,31750303	0,22302173	0	0,00378824	0,12245854	0,05	0,33218611	10,2	10,3	0,00895	0	1,4	1,35	1,6	0,55	1	0,13	1,046	0,002	
38	0,31735654	0,21121886	0	0,00379767	0,11032161	0,0525	0,33182238	9,74	9,83	0,008867	0	1,45	1,3	1,55	0,65	1	0,13	1,046	0,009	THIS
46	0,31811712	0,20618378	0	0,00347575	0,11421107	0,0525	0,33172369	9,91	9,94	0,008416	0	1,45	1,35	1,55	0,6	1	0,13	1,043	0,004	
31	0,31552703	0,22044592	0	0,0037769	0,1160773	0,05125	0,33076228	9,89	9,98	0,009318	0	1,45	1,25	1,6	0,6	1	0,13	1,048	0,009	
39	0,31629678	0,22423351	0	0,00345106	0,12014642	0,0525	0,33013713	10	10,1	0,008867	0	1,45	1,3	1,6	0,55	1	0,13	1,044	0,006	
84	0,31663715	0,2027263	0	0,00370281	0,11769417	0,055	0,32961367	9,7	9,78	0,008056	0	1,55	1,25	1,6	0,55	1	0,13	1,041	0,009	
91	0,31780244	0,19299761	0	0,00414231	0,11246796	0,05375	0,32909387	9,54	9,63	0,00778	0	1,55	1,3	1,55	0,6	1	0,13	1,036	0,009	
99	0,31631804	0,20671245	0	0,00468787	0,11574988	0,055	0,32851403	9,66	9,76	0,007348	0	1,55	1,35	1,55	0,55	1	0,13	1,039	0,011	
83	0,3154783	0,19315352	0	0,00436111	0,10875171	0,0525	0,32830247	9,39	9,51	0,008056	0	1,55	1,25	1,55	0,65	1	0,13	1,041	0,013	
11	0,31369671	0,21665571	0	0,00410095	0,11192947	0,05125	0,32827982	9,9	9,98	0,009401	0	1,4	1,3	1,55	0,65	1	0,13	1,046	0,007	
4	0,31422598	0,2092244	0	0,0035935	0,11873827	0,05125	0,32806725	10	10,1	0,009852	0	1,4	1,25	1,6	0,6	1	0,13	1,044	0,006	
19	0,31346058	0,21258333	0	0,00432119	0,11584367	0,05	0,32744505	10,1	10,1	0,00895	0	1,4	1,35	1,55	0,6	1	0,13	1,045	0,003	
	Cut																			
90	0,30859755	0,21014439	0	0,00433755	0,11578788	0,055	0,32115361	9,61	9,69	0,00778	0	1,55	1,3	1,55	0,55	1	0,13	1,041	0,009	
63	0,31314478	0,20095219	0	0,00297516	0,1167087	0,05625	0,32018027	9,75	9,83	0,008333	0	1,5	1,3	1,55	0,55	1	0,13	1,022	0,008	
18	0,30694923	0,2152499	0	0,00340183	0,12000274	0,0525	0,32006331	10,1	10,2	0,00895	0	1,4	1,35	1,55	0,55	1	0,13	1,043	0,007	
55	0,30714644	0,20132164	0	0,00371561	0,1123814	0,05375	0,31927263	9,61	9,72	0,008784	0	1,5	1,25	1,55	0,6	1	0,13	1,039	0,012	

Table for the last loop of fine intervals of parameters for UST_1

- The option marked with 'THIS' was the final selection for UST_1
- Optimization of Iota, Iota profile, Plasma Size, |B|min, Magnetic Well, Averaged Ripple, min. distance between coils
- Only 4 parameters and 7 variables to optimise, so not easy final decision
- More extended simulations necessary to obtain a better design

Iota and Magnetic Well in UST_1

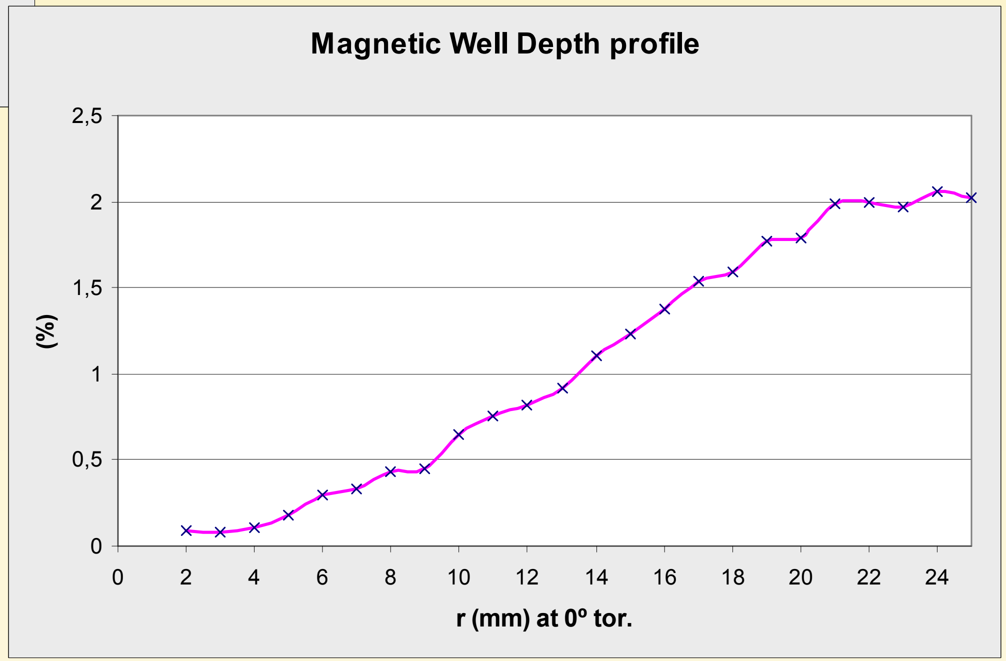




B) Iota Fast calculation, 90 s . Similar to A)

A) Iota profile : Accurate simulation

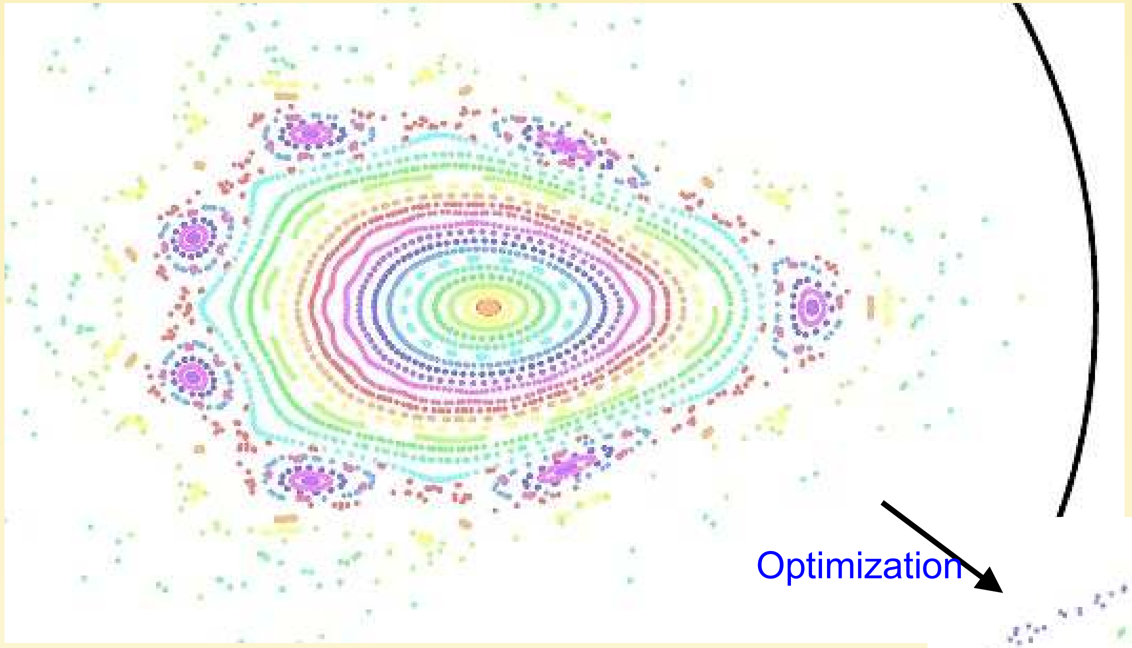
- **Low Shear** but not low enough
- **Decreasing Iota**. Not OK, but SimPIMF was unable to obtain increasing profiles. ~ MHH2
- However some flatter cases were found but not considered at that time.



Notable magnetic well , 2% at edge

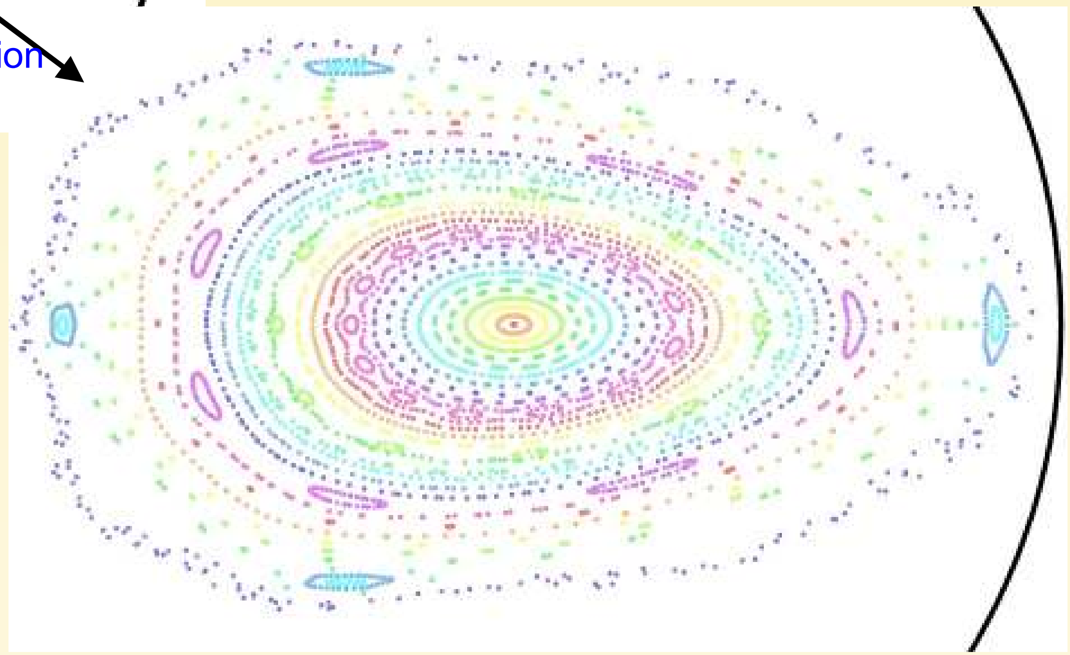
The accurate calculation of Iotas + Magnetic Well lasted 1960 s but fast calculation, 90 s

Improvements from Optimization



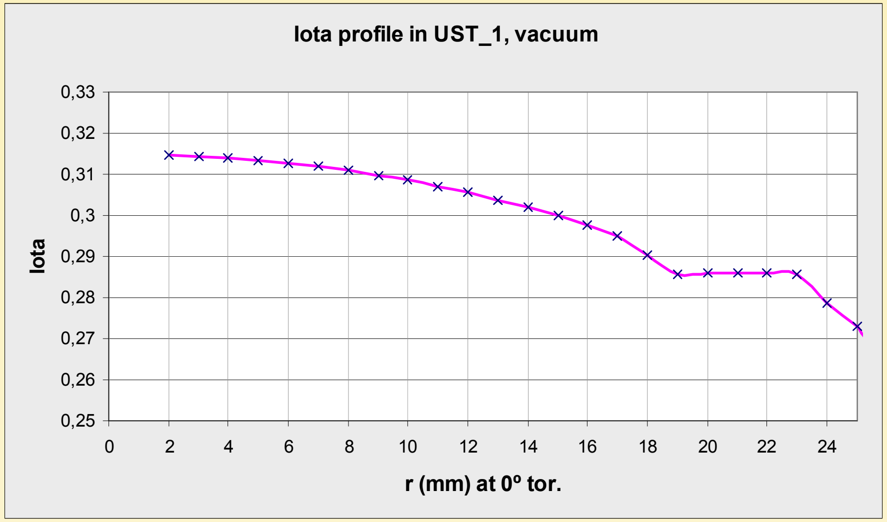
UST_1 parameters of shape
1.45 1.3 1.55 0.65
- Larger plasma
- Narrower stochastic region

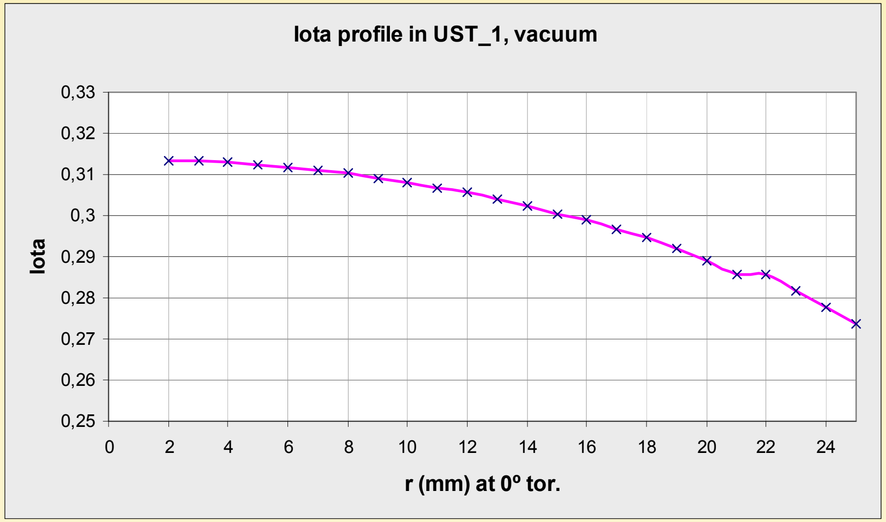
Optimization



Parameters of shape 1.25 1.25 1.25 1.25
Iota at centre similar to UST_1

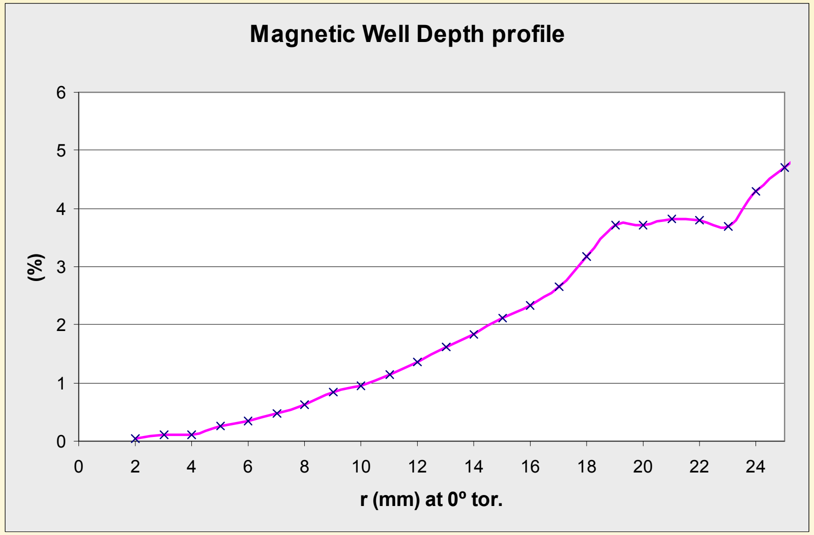
Improvements from Optimization

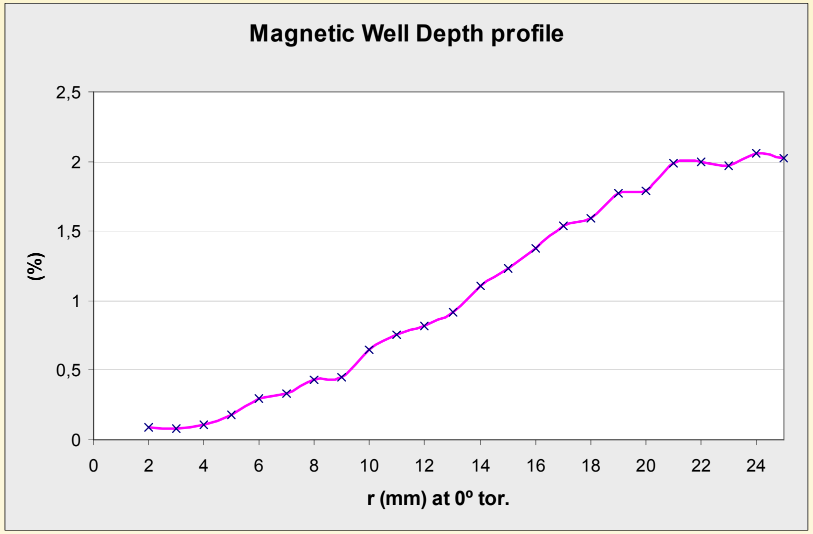




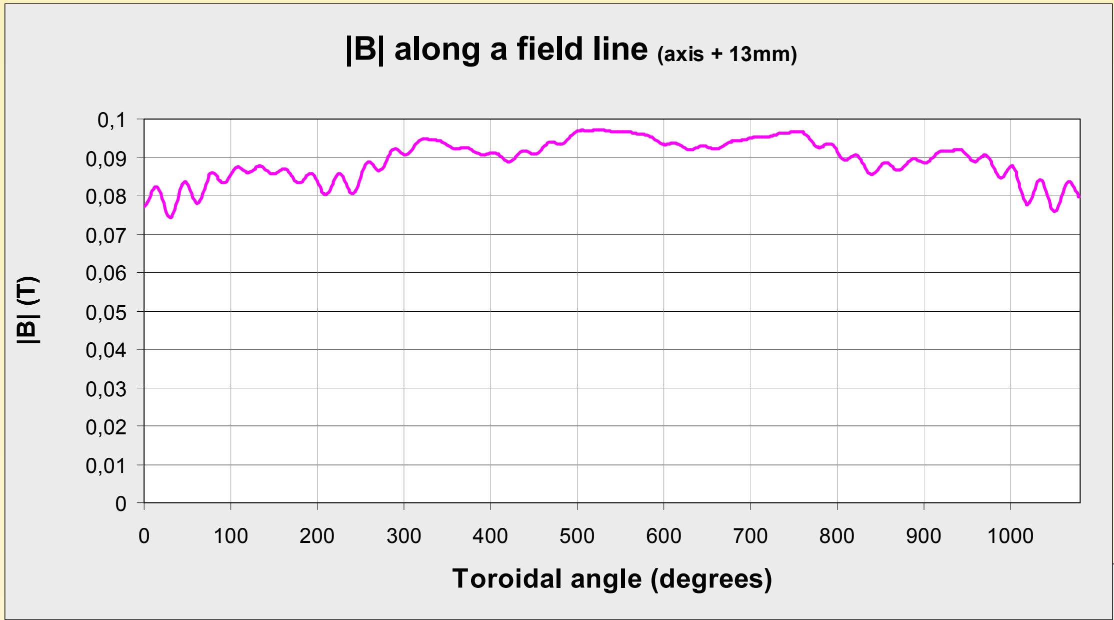
Natural shape : 1.25 1.25 1.25 1.25

UST_1 shape : 1.45 1.3 1.55 0.65





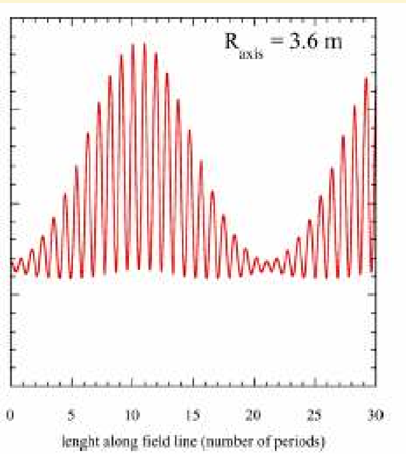
Other improvements



	4x1.25	UST_1
σ Bmin	0.0061	0.0038
Plasma size	0.42 L	1.1 L
Min. dist. coils	6.82 mm	8.9 mm
Ave. ripple	0.08	0.11

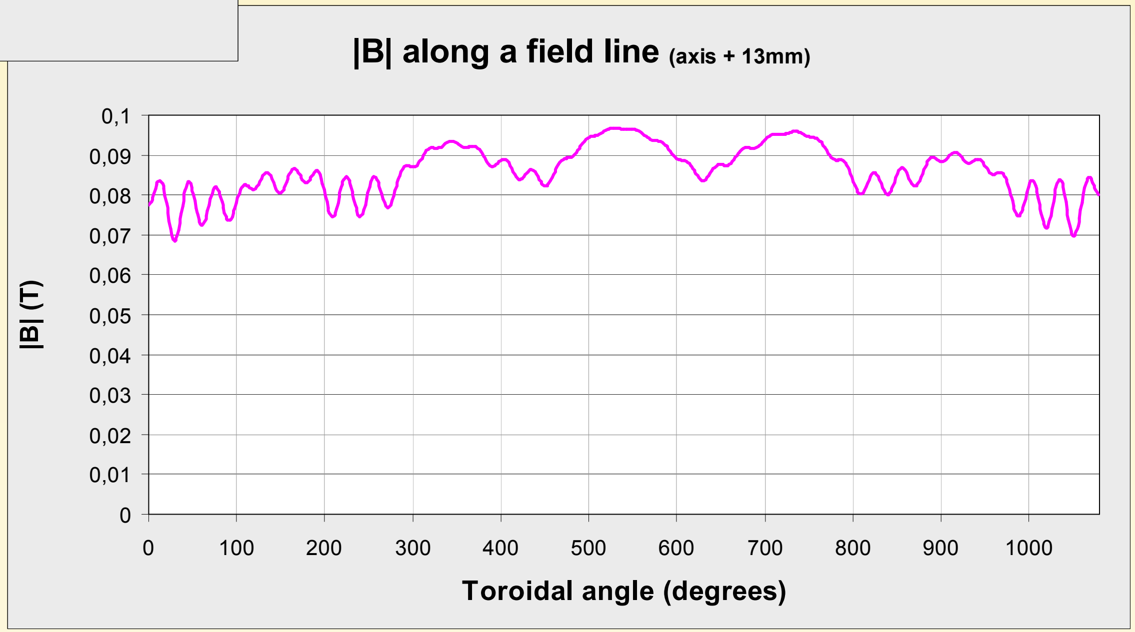
Not all variables are the best, for example Magnetic Well is reduced

4x1.25 coils



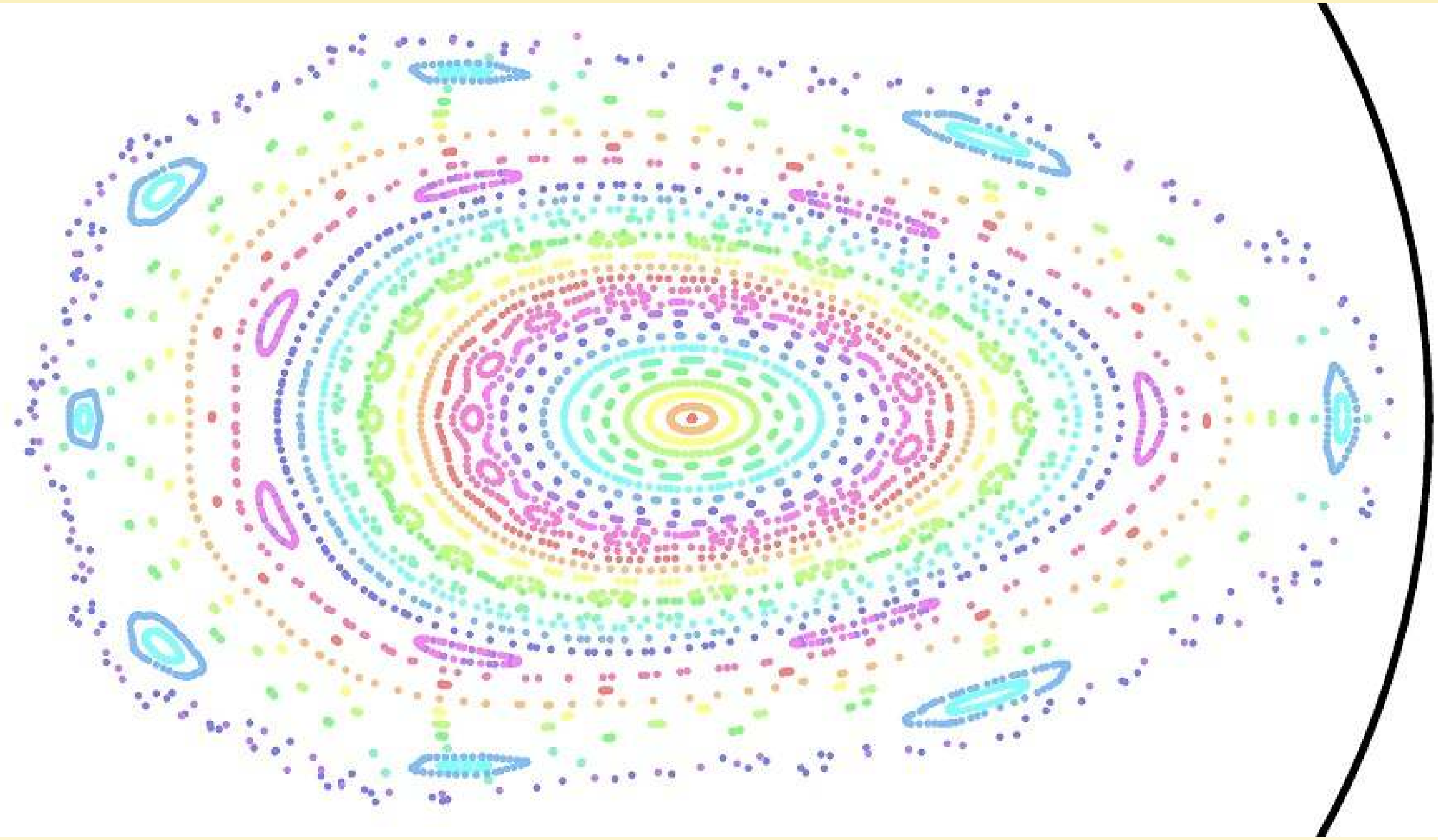
LHD , S. Murakami

UST_1 is far from the aim, for example Bmin in LHD improved



UST_1

Simulation of Magnetic Islands



Φ=0º Some unconnected islands do not appear in the automatic run

Perturbed B : Higher δB seems to appear at coarse 'Grid'. The figure obtained using grid 1/200 m = 5mm side. New islands appear.

Rationals:

(from right to left)

Blue : 1/4 = 2/8

No visible : 3/11, 4/15 ….

Magenta : 2/7

Green : 3/10 = 6/20

Magenta : 4/13

No vis. green : 5/16

Iota accuracy:

Blue : 1/4 calculated 0.2500315

Magenta : 2/7 = 0.28571 , calc. 0.2856076

Green : 3/10 calc. 0.2999538

Each Iota lasted 49 s

The method for FAST simulation

Original ? :

- Maybe the method is original, BUT
  - there are many codes to simulate orbits.
- In any case it is a fast and useful method.
- If new, refer to this Seminar when using it

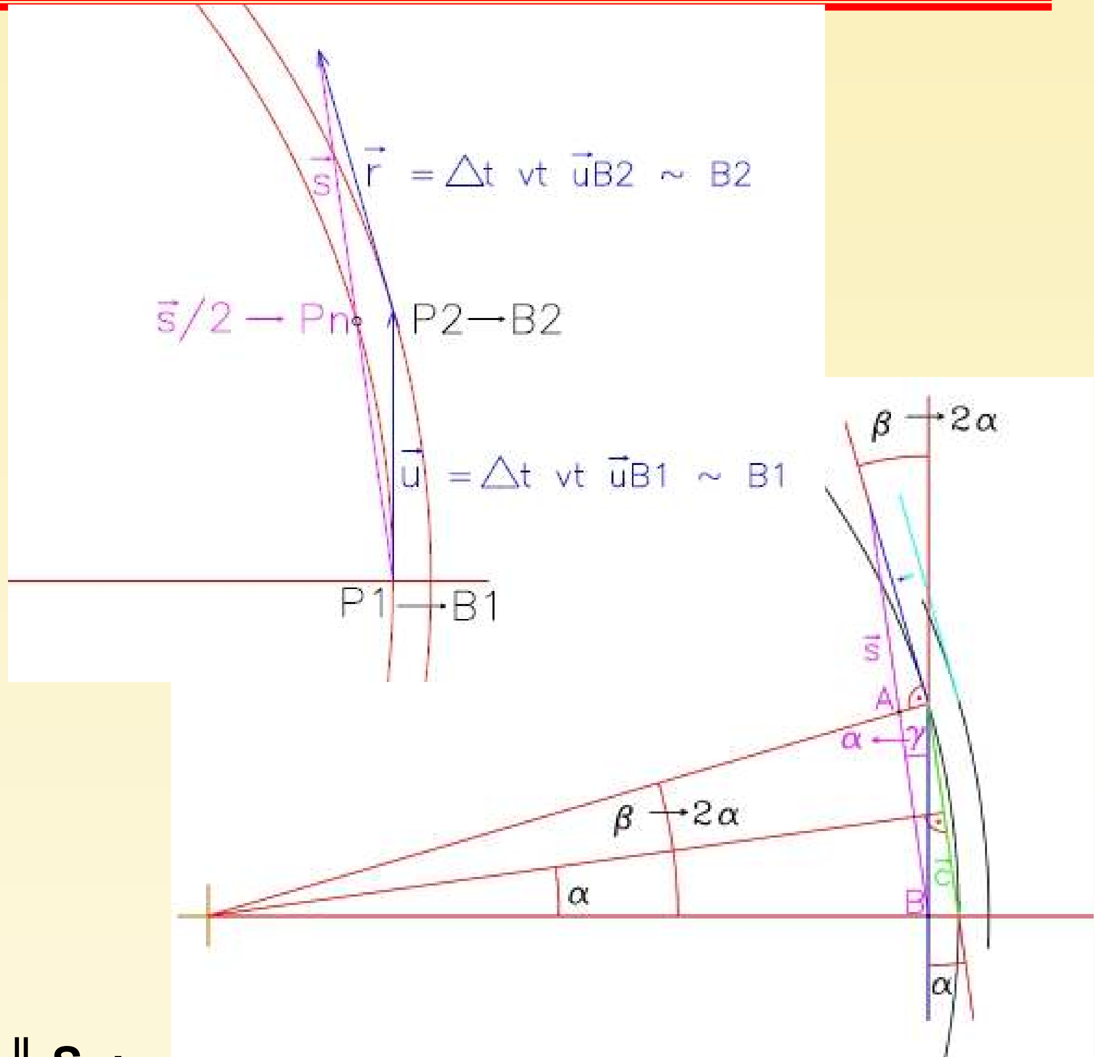
Advantages :

- It simulates 10-20 times faster than $dx/Bx = dy/By = dz/Bz$
- Only one PC is enough instead of 20 PC's for the same simulation.
- Simple.
- Probably it can be improved further.

Hint of the prove :

- A curve can be approximated to a circumference around a point.
- **C** is a Chord ; $\gamma \rightarrow \beta/2 \rightarrow \alpha$ so **C** $\rightarrow \parallel$ **S** ;
  S/2 → AB → |**C**|

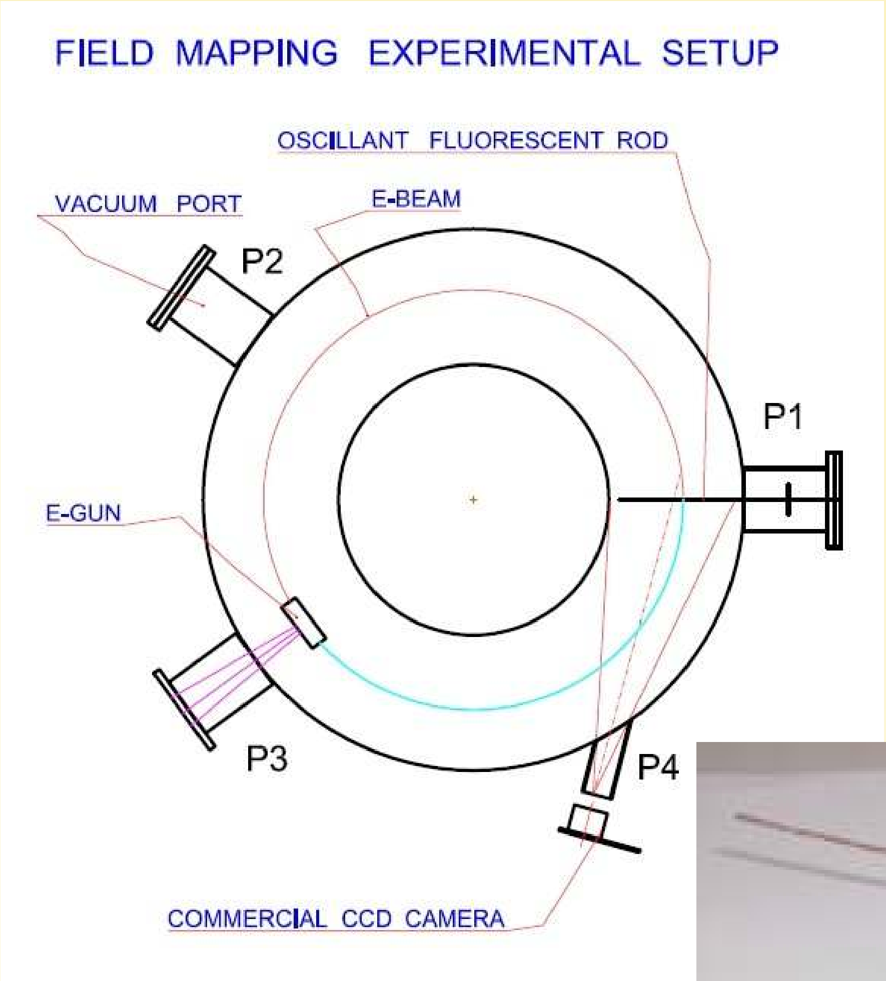
So **S**/2 → **C**



Section IV

Section IV . Experimental results. Field mapping system and experimental magnetic surfaces

Field mapping experimental setup

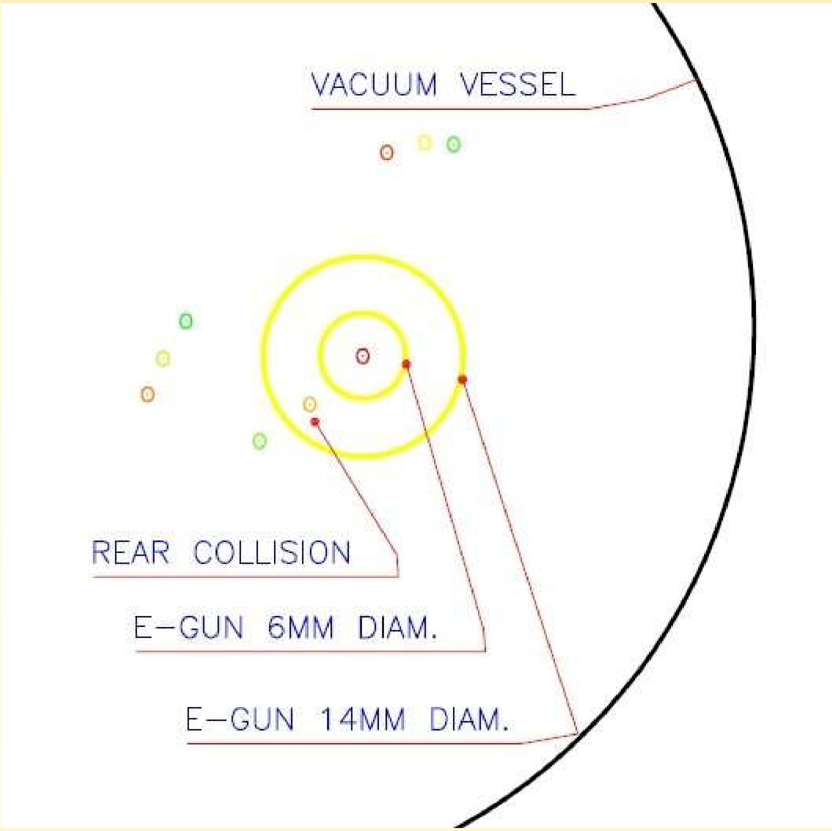


Inside : Tungsten filament 10 W

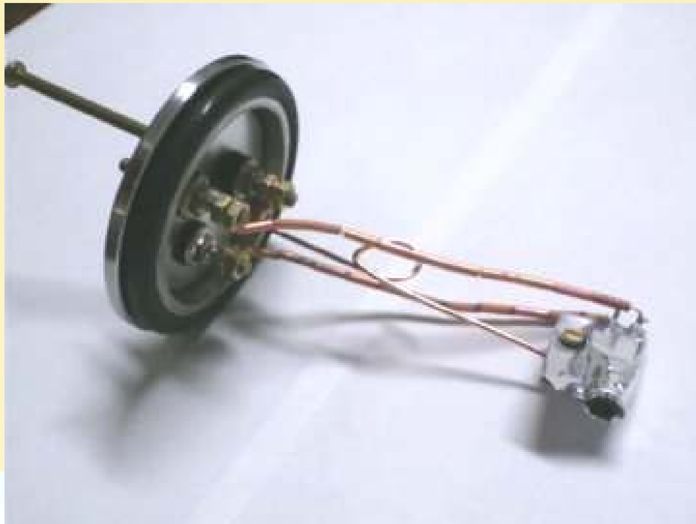
Second model of e-gun :
External diam.= 14mm .
e-beam current < 1 mA

Oscillating fluorescent rod.
P24 phosphor

e-beam rear collision and solution



Very small diameter to see internal surfaces



Third model of e-gun : External diam.=6mm . e-beam current very low . Tungsten filament 10 W

Rear collision. Collision of large e-gun after 4 turns. In colours the sequence of intersections of the beam with the e-gun poloidal plane

Background of the experiments

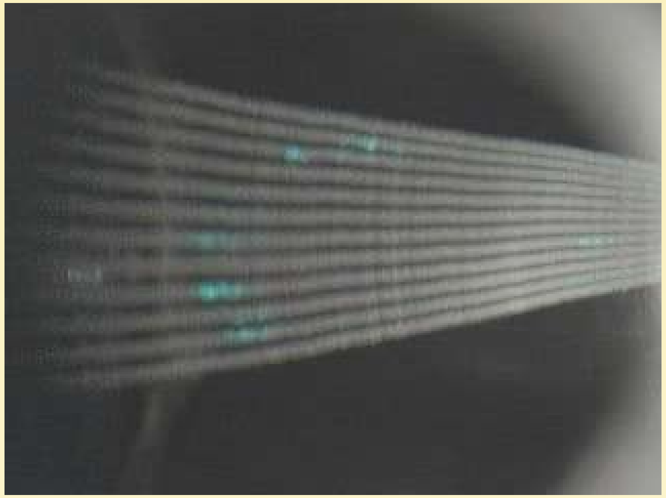
Background

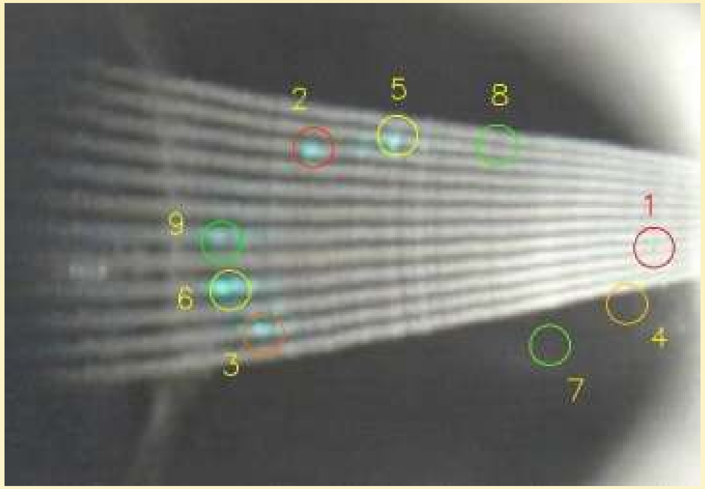
- The next images were taken at the **pulse #198 and #202** after a long process of improvements.
- The PC-firewire camera is the lowest cost (~quality) in the market, 90€ and the **sensitivity is low**. **Visual inspection** has far more sensitivity than the camera.
- 40 eV e-beam gave insufficient luminance for both e-guns and only **> 80 eV were visible** with the small e-gun.
- **Drifts at ~90eV are enormous** for UST_1 (**Bo** = 34 mT for these pulses) so the magnetic surfaces are notably displaced outward and Iota tend to 1/3 .

Background

- **UST_1 is very small** so the e-beam diam.~1.5mm is excessive here. Accurate measurements are more difficult than in larger stellarators.
- **Mean free path** at the poor vacuum, 5mPa only allow less than 10 turns of the beam.
- **Pulse length** : 2.5 sec.
- The small e-gun **melt** at the pulse #204 and field mapping ended temporarily.
- **Perspective effect** is only partially corrected.

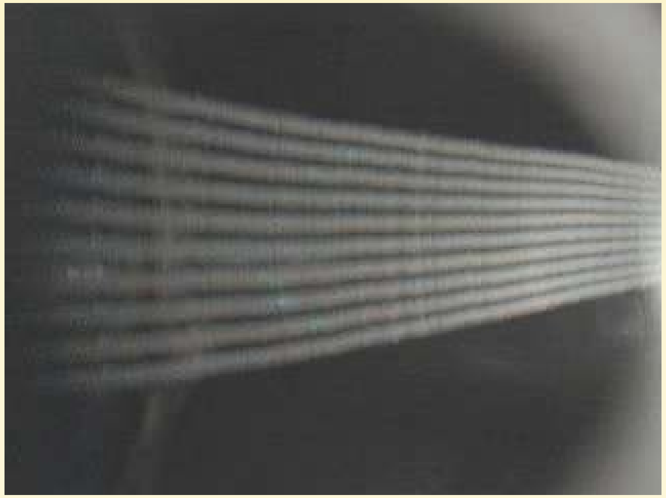
Comparison simulation-experiences

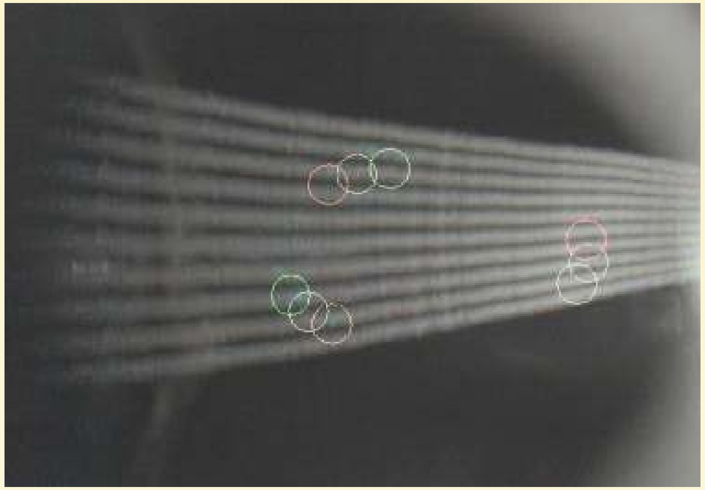




Pulse #202. (94eV). Simulation obtained locating the e-gun at the approx. real measured position and 94eV electrons (drifts simulation).

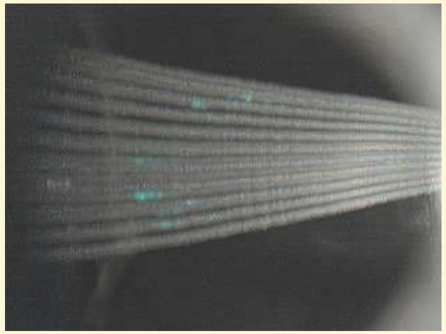
N202_F70-135.mpg



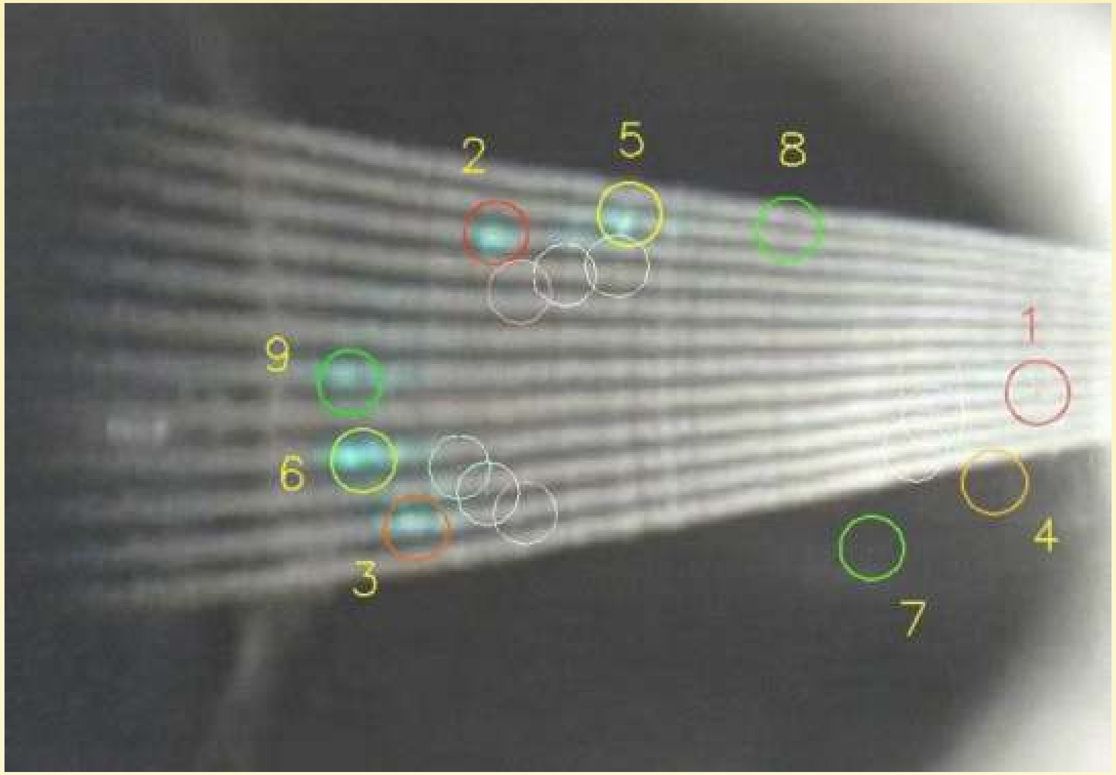


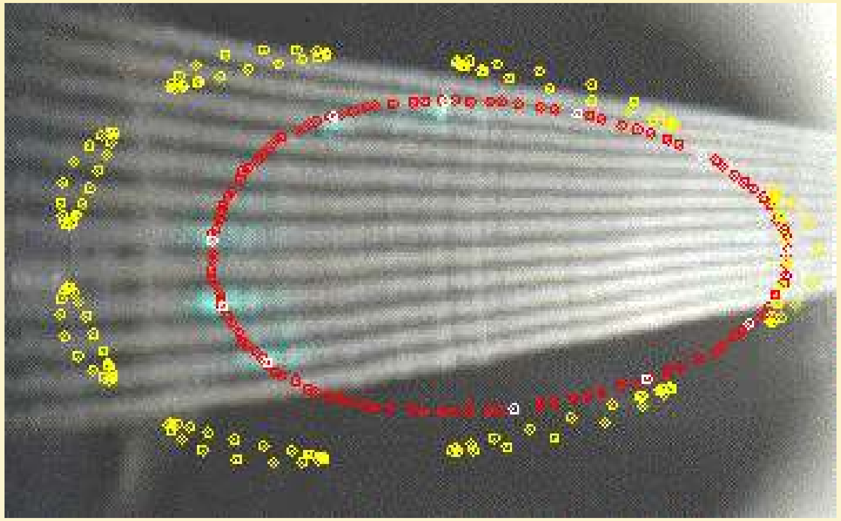
← Pulse #198. Weak points (84eV). e-gun 2.3 mm higher than in #202, so internal surface. The e-gun is ‘moved‘ vertically the same distance in the code.

Both pulses overlapped. Weak points → appears even weaker



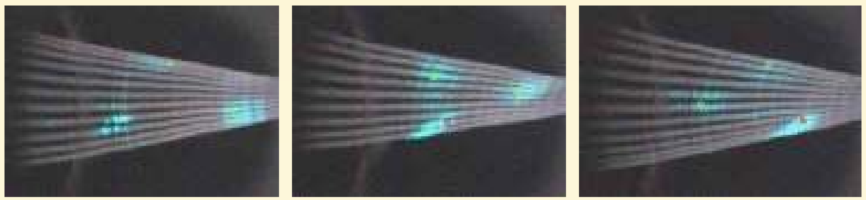
Comparison simulation-experiences





Yellow : Non-drift orbit
Red : Drift orbit = experimental #202

Superposition of all. Two concentric closed magnetic surface appear. Simulated points agree notably well with real points. Superposition reduce the quality of the image and weak points are lost



Other previous pulses, #128 127 126

Conclusions from experiments

Experiments are still few and poor but some provisional conclusions are:

- UST_1 has **a notable degree of accuracy**. ← Magnetic surfaces are obtained and they agree with the theoretical simulations.

- **The stellarator-mechaniser was a satisfactory idea** ← The toroidal device to mechanise grooves for modular coils worked and produced accurate coils at low cost.

- **SimPIMF code has some degree of accuracy and correction** ← otherwise the agreement between the experimental results and simulations is totally improbable.

- **The optimization was useful and correct in some degree** ← SimPIMF is not totally incorrect.

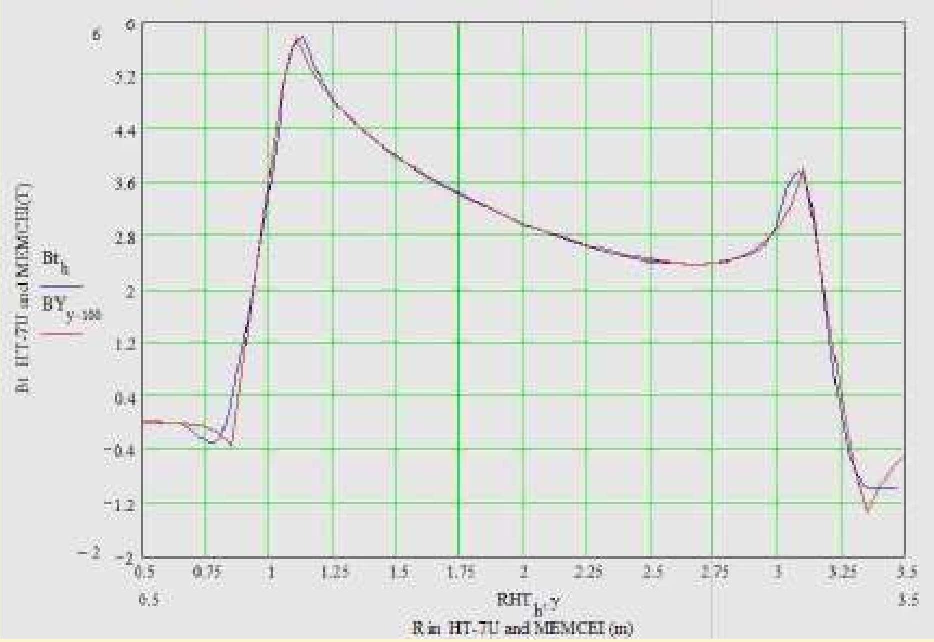
- **The chosen style of stellarator was a feasible one**.

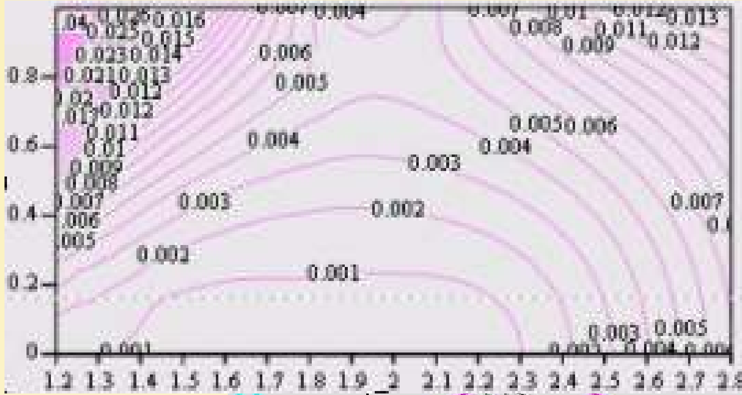
- **UST_1 is a stellarator.**

Section V . Chronological description : Evolution, alternatives, difficulties and solutions

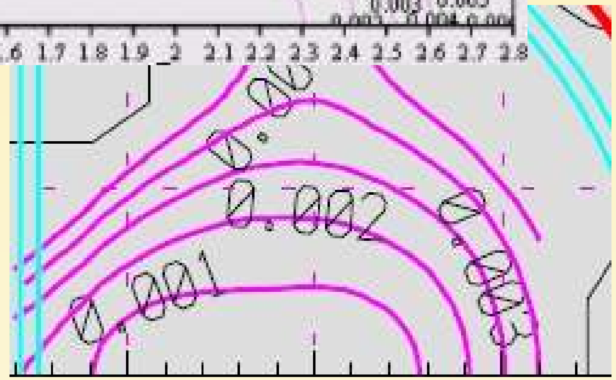
Historical description

The begining of fusion calculations





Stray field MEMCEI

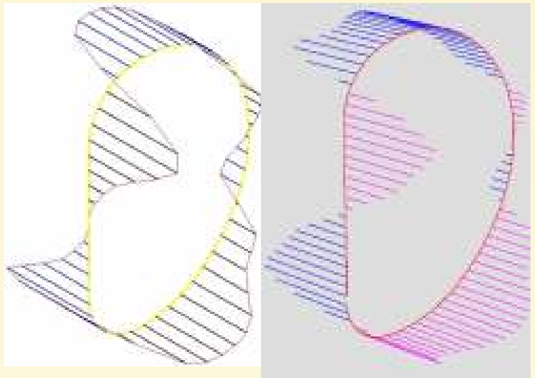


Stray field, EAST team

Comparison of Bequatorial in EAST from MEMCEI and EFFI code

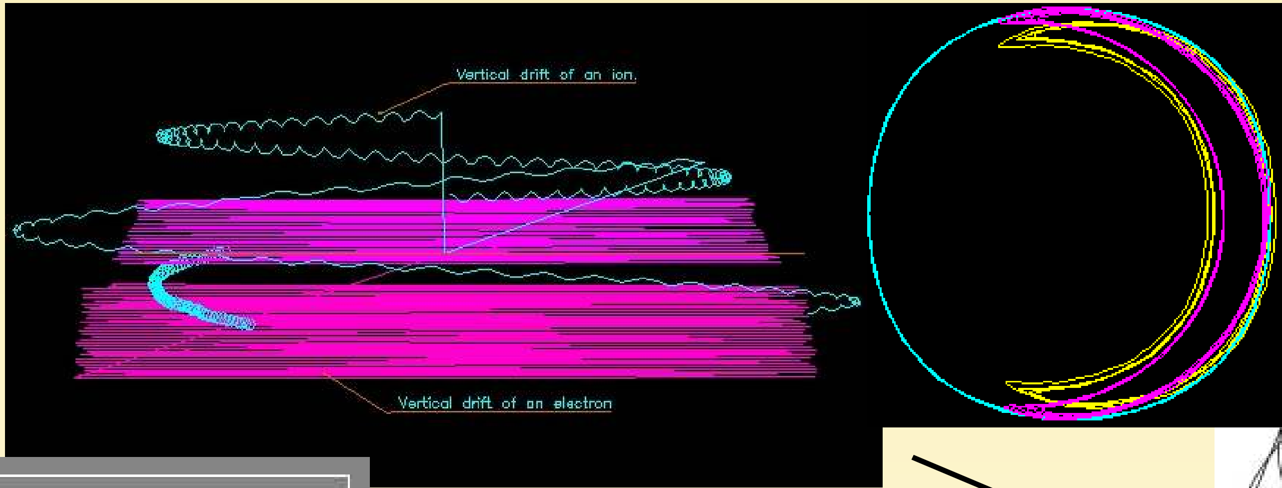
February 2005 : Using MEMCEI v2.1 , 9440 elements of current, 16 TF coils,13 loops per TF, 50 ele. per loop Machine : **EAST tokamak (HT-7U)** . Language :   **VisualBasic** + **MC**

F centering = **984.3** ton using MEMCEI v2.1 and   **989.3** ton with EFFI code (HT-7U team)

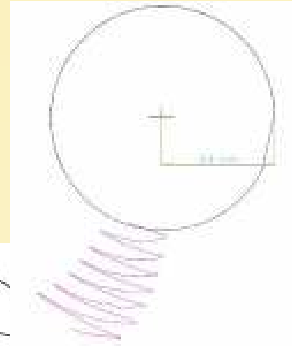


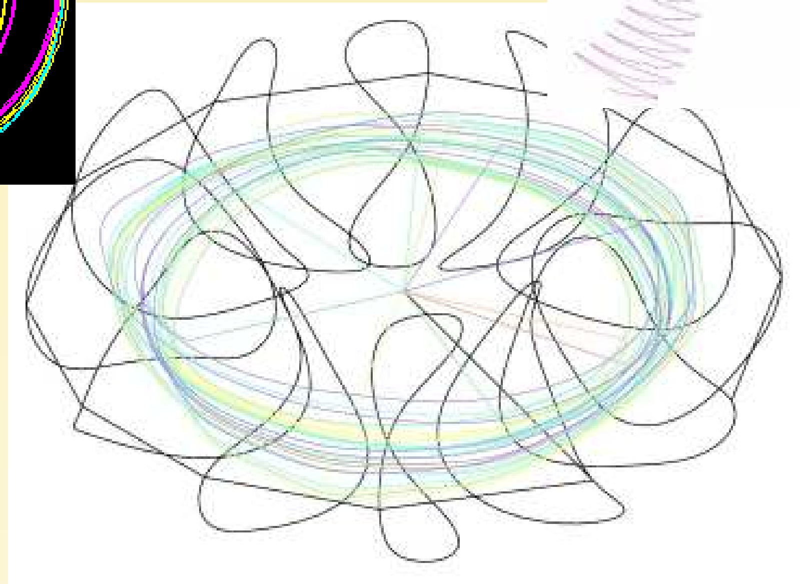
May 2005 . CTH torsatron : Calculation of mutual forces between coils using MEMCEI, for Greg Hartwell , Auburn University

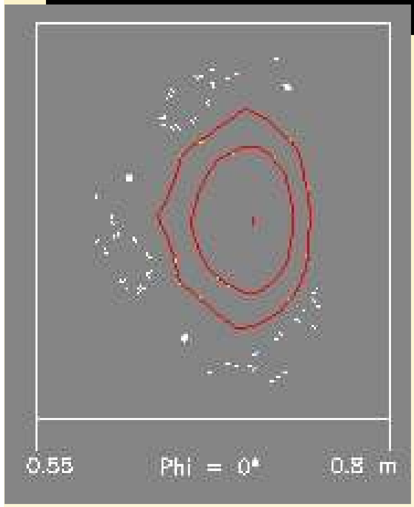
Evolution in simulation



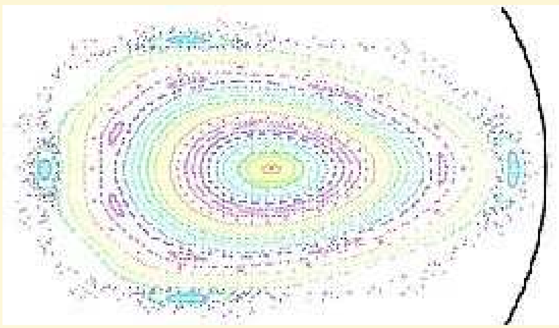
← March 2006
Banana orbit in tokamak ~ size UST_1





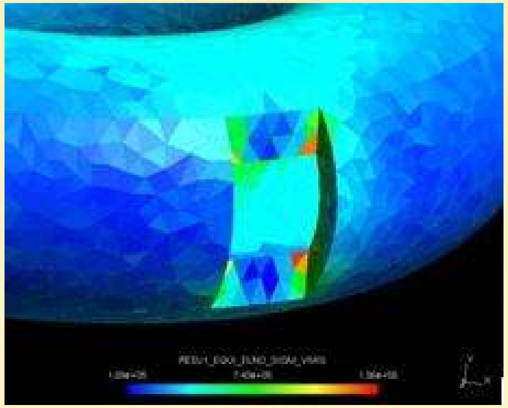


~March 2005 : Simulation of 100 particles with **drifts** for 10μs , and magnetic surfaces**.** Language : **VB**

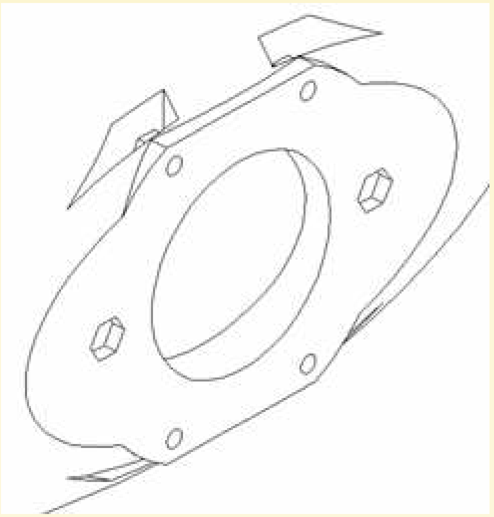


October 2006 ↑ : Simulation of 300 quasi-particles with **drifts, trapped particles and collisions** (only 10 in this graph) for 150μs in 30 PC-minutes. Improved fast guiding centre method. *(Top)* Helically trapped particle in Boozer-like co. Machine : **UST_1** . Language : **JAVA**

Development of vacuum vessel



July 2005 Von Misses stress around the port. Calculation using **ASTER-GMSH**. Machine : A **rough UST_1**



July 2005
Idea about a non-protuberant port

October 2005
A porcelain piece to test the ideas. Cracks appeared + possible excessive outgassing → Idea abandoned

February 2006
The cooper vacuum vessel is tested (leaks, outgassing..)

Decision of machine style

Tokamak? ~ June 2005. An ETE /6 size tokamak was estimated (~the same expressions used for ETE and ITER as a test) ⟶ High TF power for Ip + short pulse , condensers...

→ Rejected

Stellarator? ~ June 2005. Seemed not impossible (long pulse, low T possible,...)

→

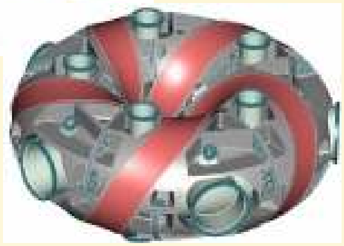
Innovative? CNT
Internal coils?
QPS CNT

Advanced ? (W7-AS) W7-X, NCSX, QPS, HSX... style → Rejected

Classical? W7-A ...

Heliac? : TJ-II , H1 → Rejected

Torsatron? CTH , LHD, ... → Rejected



Classical or modular? ~October2005. Modular seemed the best (several reasons) but no means to design and optimise.

Classical st. , SimPIMF improved → designed + optimized January 2006

→ Rejected

Modular st. , SimPIMF more general → designed + optimized January 2006

Decision process for coils

- How to produce accurate modular coils at low cost?

Internal coils ? Outgassing , vacuum tightness, shaping/casing & locate issues

Rejected

External coils ? Several ideas were evolving and/or returning. October to January 2005

~ October 2005 Wind on the VV in an approx. manner

- ~ end 2005 Some alternatives expressed in “Coil Support structure”

- Many other innovative ideas

~ end 2005
Measuring device for helical coils or any other style.
Preliminary tests

~January 2006.
Measuring + mechanising device is being built

January 2006
Modular st. decided,

Mechanising + Measuring device for modular coils, January 2006

Present tasks and questions

Present and future tasks

- Developing the **Heating system for UST_1** : Some antenna and transmission issues + cost of couplers and waveguides

- Improve **Collisions module** in SimPIMF to better simulate particles in UST_1 ~ transport.

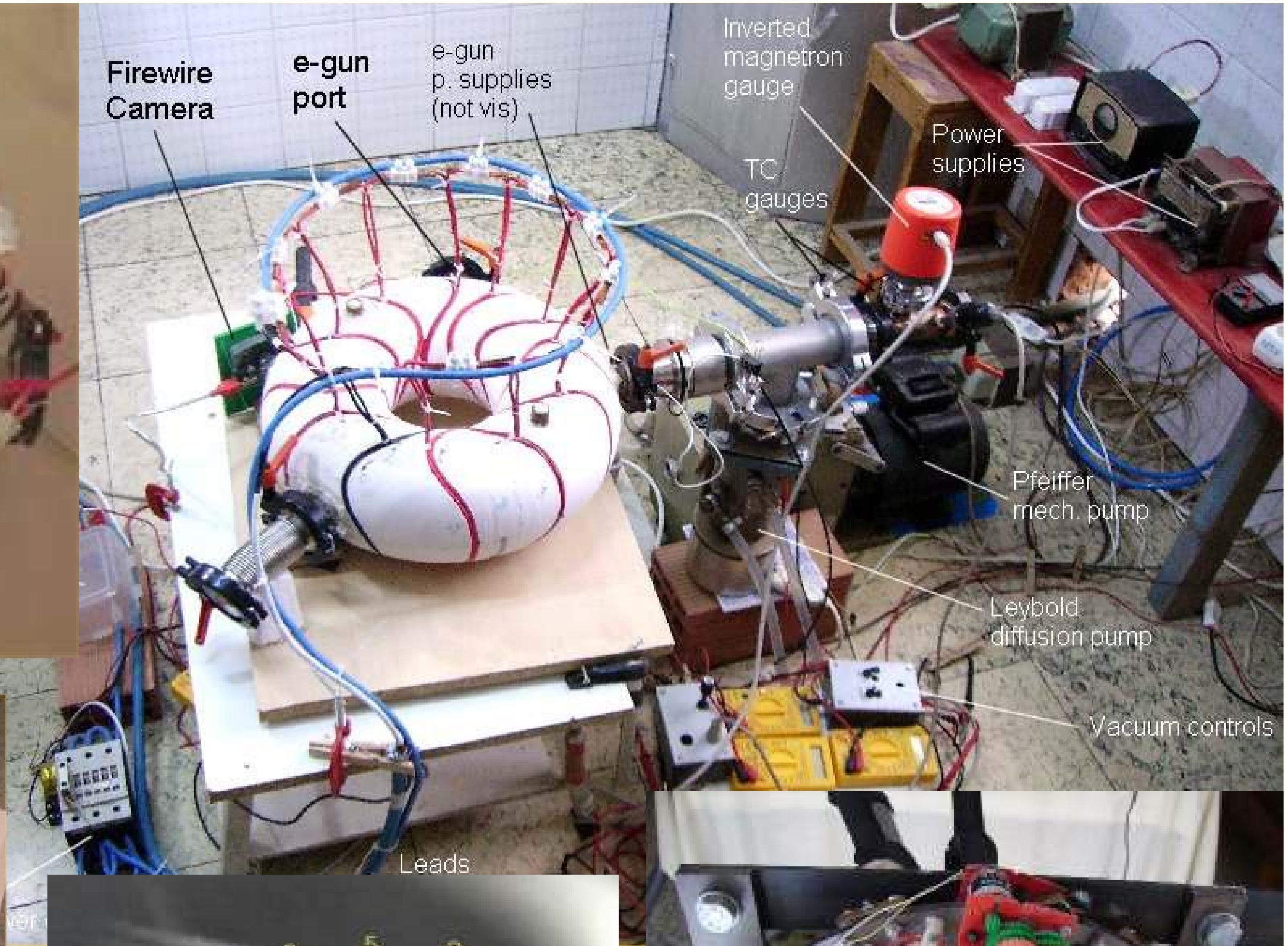
- **Start-up the RGA system** (AMETEK QUADLINK DYCOR mass spectrometer). Issues: very low cost used instrument without warranty nor manual.

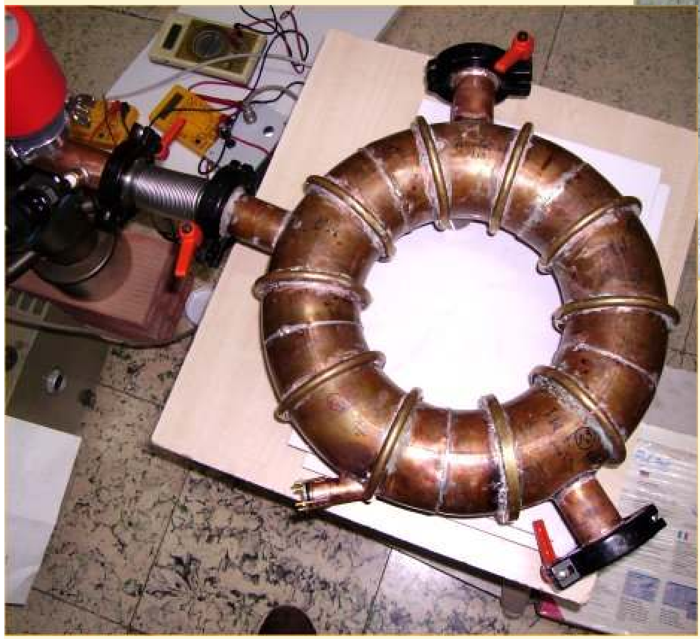
- Is possible to produce accurate real-**3D modular coils,** HSR-3, QPS ... style, at low cost?

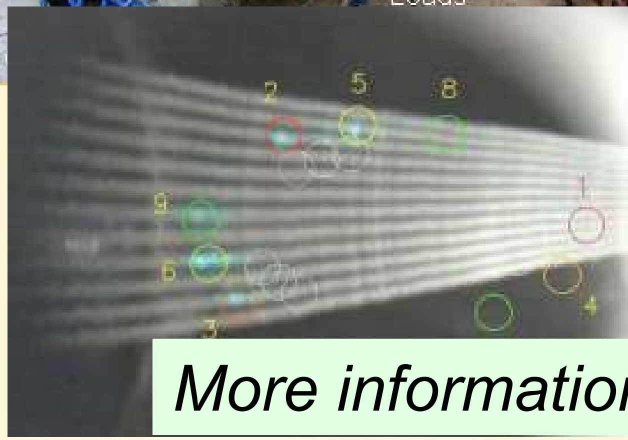
End

of the UST_1 project,

by now.







More information in www.fusionvic.org