Status and Perspectives of the Gas Inlet System (GES) on ASDEX Upgrade

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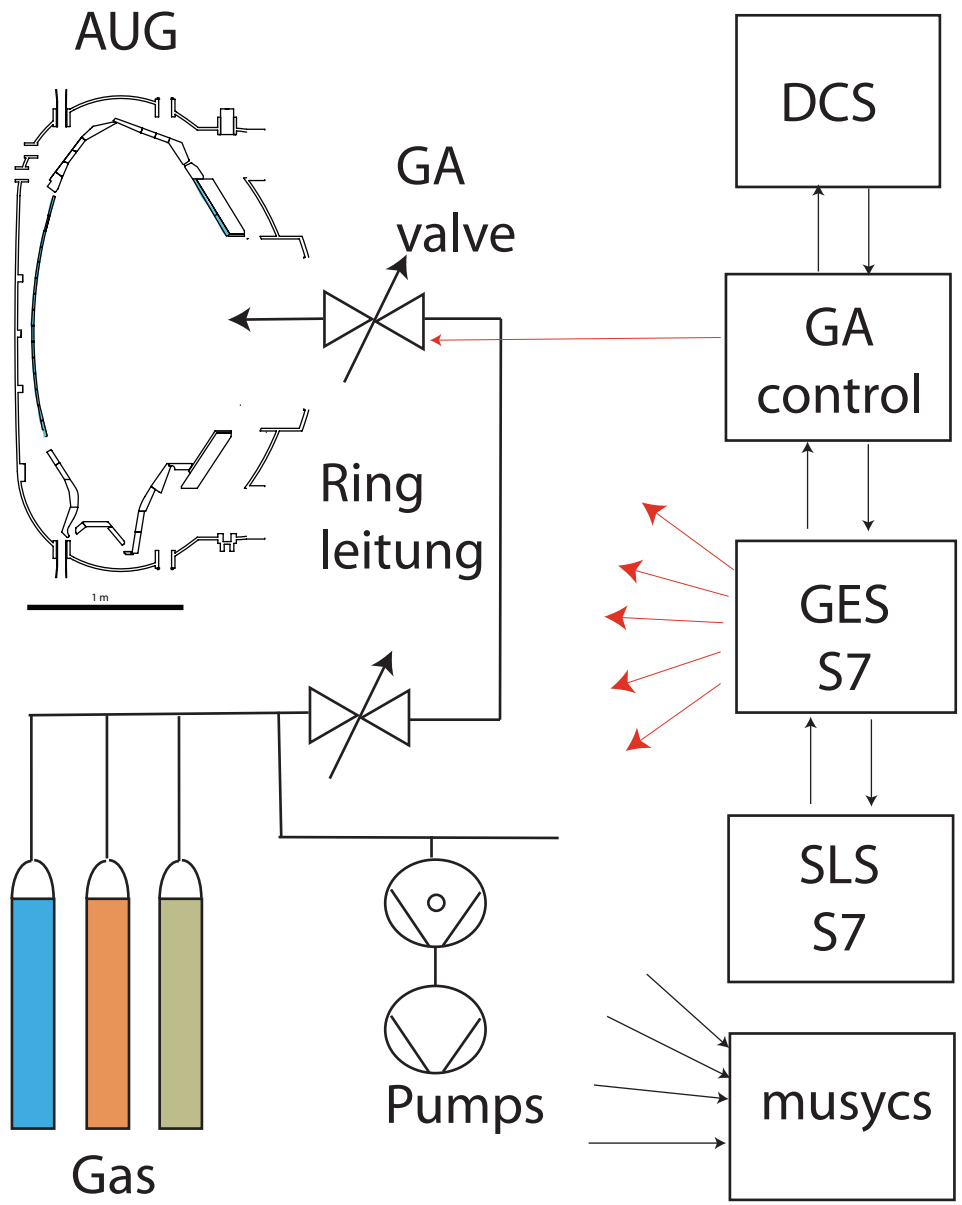
- Status
- Control of the valves
- Changes 2011
- Future

Gas Einlasssystem (GES)

System



Plasma discharges

- 20 calibrated piezo valves

Conditioning / Cryo regeneration

- pressure controllers / valves

Wall coatings

- toxic gas inlet system

Piezo valves direct controlled

System controlled by Simatic S7

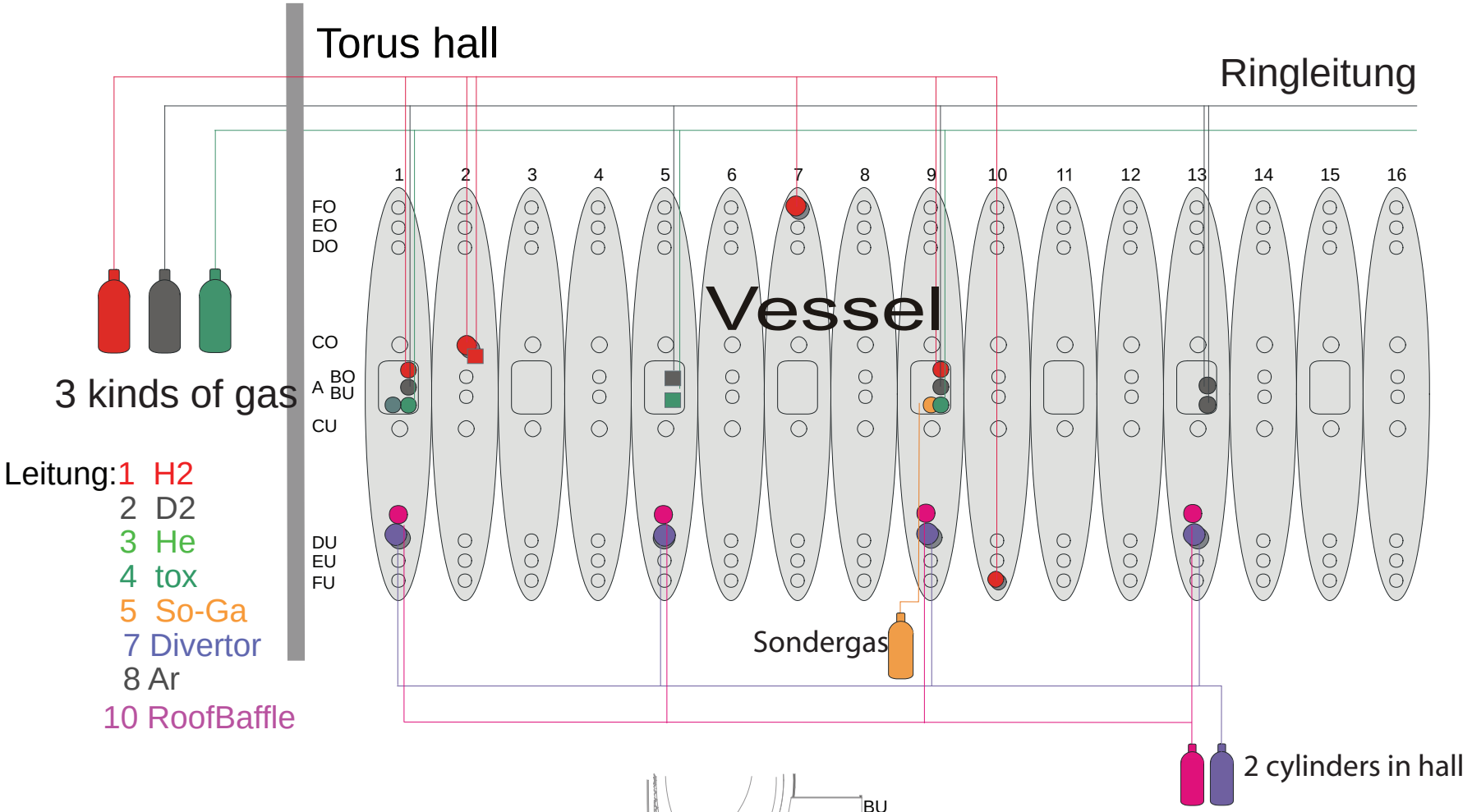
- gas supply
- tubes, valves,.....
- pumpes, controllers, pressure gauges
- plate valves
- switching matrix

data storaged on PC (musycs)

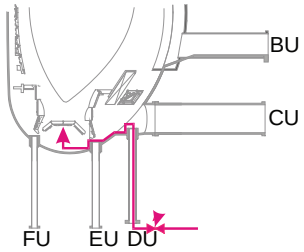
piezo gas flux measured and stored as level-0 UVD

Gas Inlet System

original design



fixed connection to valve
direct puffing to plasma
extra valves for different gas



Extention: roof baffle values:
tubes for direct gas puff

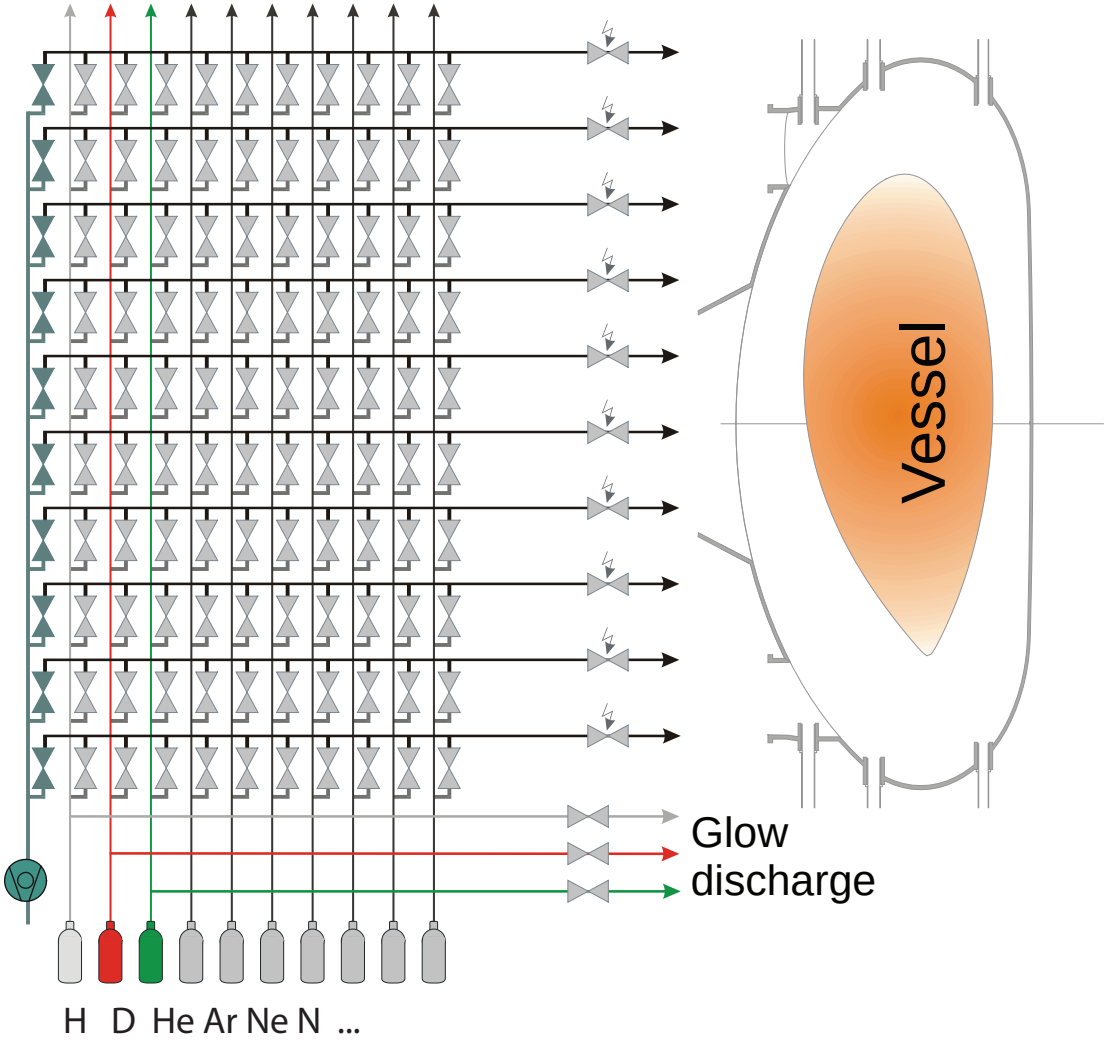
Gas Inlet System

gas matrix

Removal of cyclinders from hall
more gas puffing locations

individual gas feed to valves
> flexibility, extra valve positions
10 kinds of gas
pressure regulated
switch matrix to 20 valves
change of gas in between shots
automated operation possible

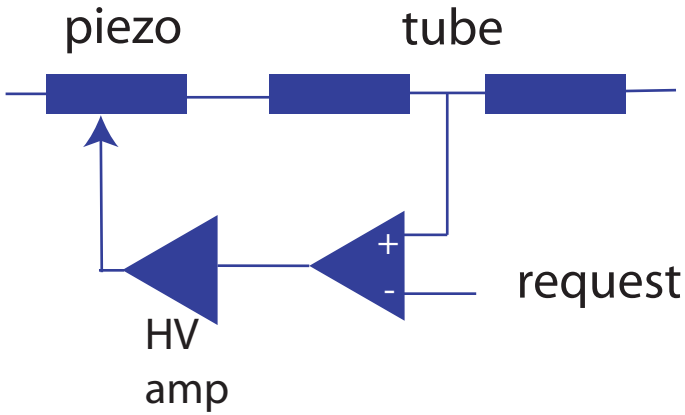
Status:
installed 2005
4 valves feeded by matrix
manual gas change by operator
-pump down
-purge
- pump down
- fill
} 10 min
Manual choice of kind of gas

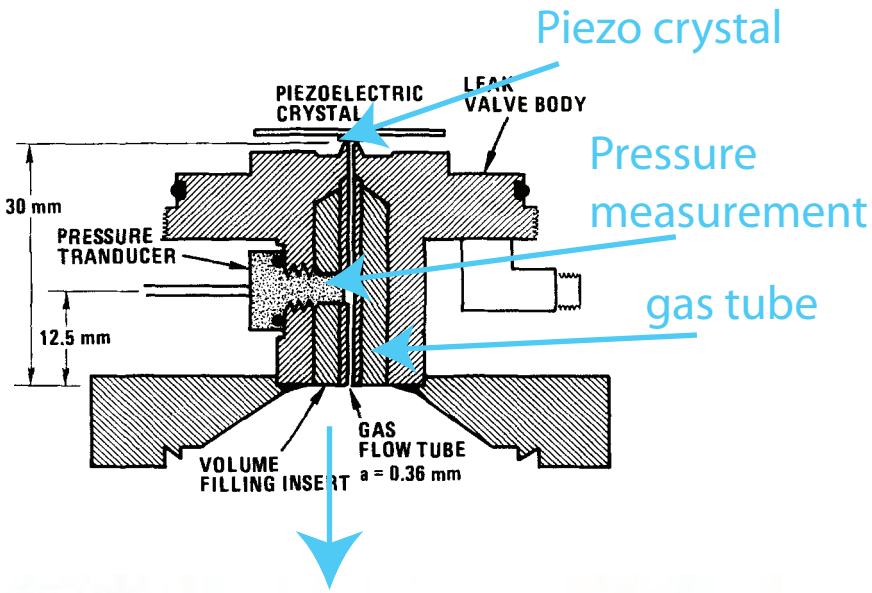


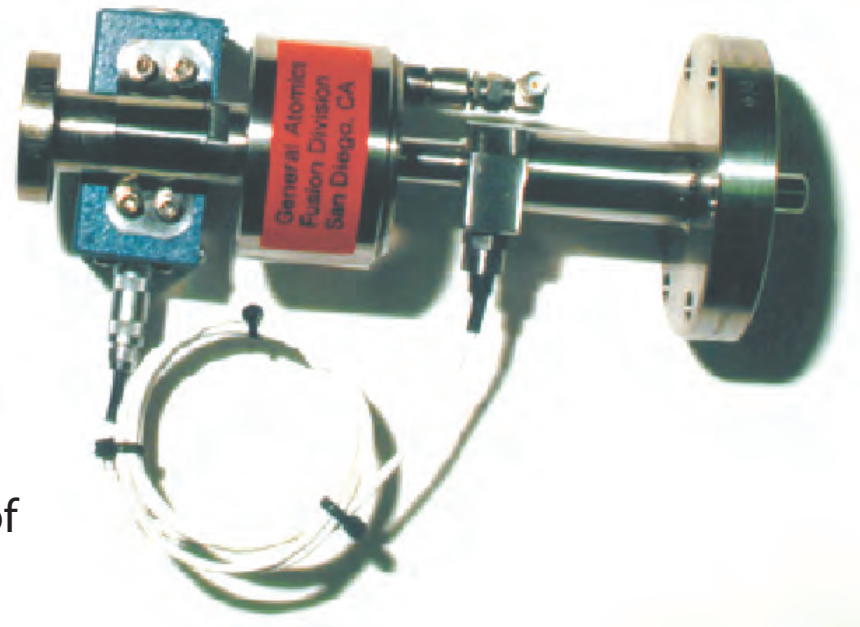
Gas Inlet System

Piezo valves

Fast response gas feed system
use piezo valves (< 2 ms)
high flux (< 2e22 at/s)
but piezo valve are not reproducable
> General Atomic valves (Burrell,1988)
valve is fitted with flow tube
pressure in tube is proportional to flux
feed back control



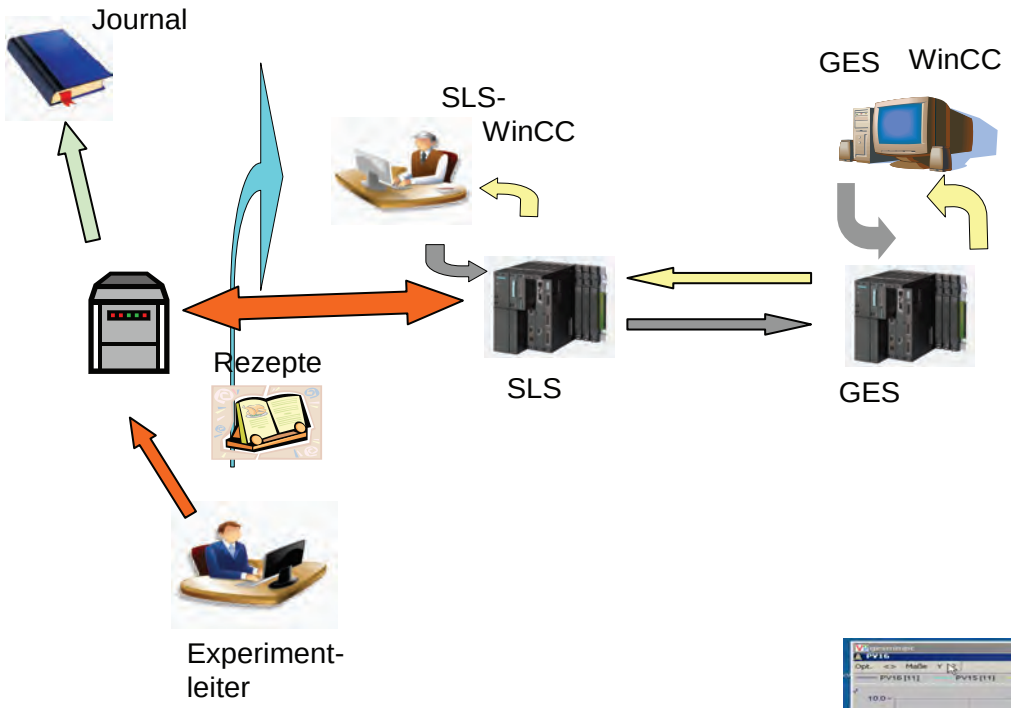




I- 1989 delivered
\+ 20 + 5 valves exists
\- no replacement available
W7X: GA valves, used redevelopment of control electronics started

Gas Inlet System

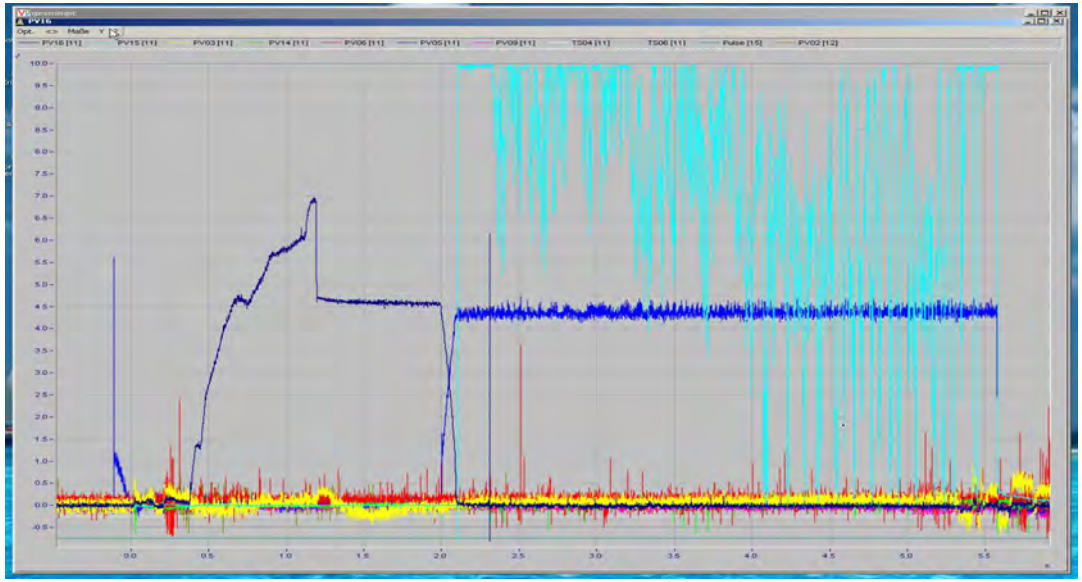
Control by DCS (Discharge Control System)



DCS controls up to 5 channels
switching channels/ valve by recipes
recipes are loaded manually
~ 60 recipes exists
new produced manually

GES sends status to SLS/ DCS
list : valve/ channel/ kind of gas
gas flux stored by UVD
mysics monitors valves

feed back control can sometimes
asks for impossible signals
(5- 10 V within 2 ms)
stress to piezo actors



Gas Inlet System

active valves 2009

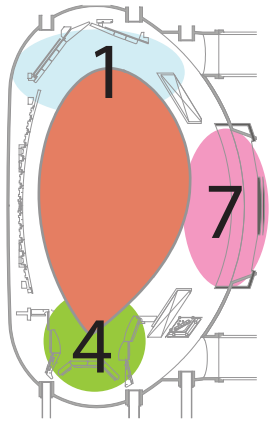
PV/UVD-Kanal	Sektor	Stutzen	Gasleitung	UVD-Name	Eichung	Kommentar
1	1	A	I (H2)	CFA1I	H2	
2	2	Co	I (H2)	CFCo2I	D2	verrohrung weg
3	9	A	III / V (He/SG)	CFA9V	Ne	
5	9	A	II (D2)	CFA9II	D2	
6	7	Fo	I (H2)	GFFo7I		unter div mit langem schlauch
7	5	Du-roof	X (SGInnen)	CFDu5X		Roof Baffle, zwei Auslässe
8	5	Du	VII (SGDiv)	CFDu5VII	D2	
9	9	A	I (H2)	GFA9I		
10	1	Du	VII (SGDiv)	GFDu1VII		
11	9	Du	VII (SGDiv)	CFDu9VII	Ar	
12	10	Fu	I (H2)	GFFu10I		ZS13 Halle abgeklemmt.
13	10	Fu	IV(TOX)	GFFu10IV		Leitung getrennt
14	1	A	III (He)	CFA1III	He	
15	13	A	II (D2)	CFA13II	D2	
16	1	A	II (D2)	CFA1II	D2	
17	9	Du-roof	X (SGInnen)	CFDu9X		Roof Baffle, zwei Auslässe
18	13	Du-roof	X (SGInnen)	CFDu13X		Roof Baffle, zwei Auslässe
19	13	Du	VII (SGDiv)	GFDu13VII		
20	1	Du-roof	X (SGInnen)	CFDu1X		Roof Baffle, zwei Auslässe
23	13	A	II (D2)	Lena		ICRH

Standard Operation

DuX valves

special valves

to be discussed



Gas Inlet System

Flux Calibration

Valve calibration procedure

- measure vessel volume
- calibrate baratron
- gas pulse into closed vessel
- measure pressure
- fit results to polynom
- repeat calibrations later
- repeat calibration after changes
- needed for each kind of gas

General behaviour

output up to 1.5e22 at/s

individual valves ..

flux: 0.5 V closed

-2. V non linear

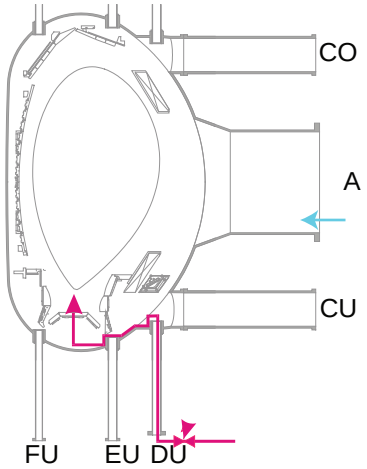
-10 V linear response

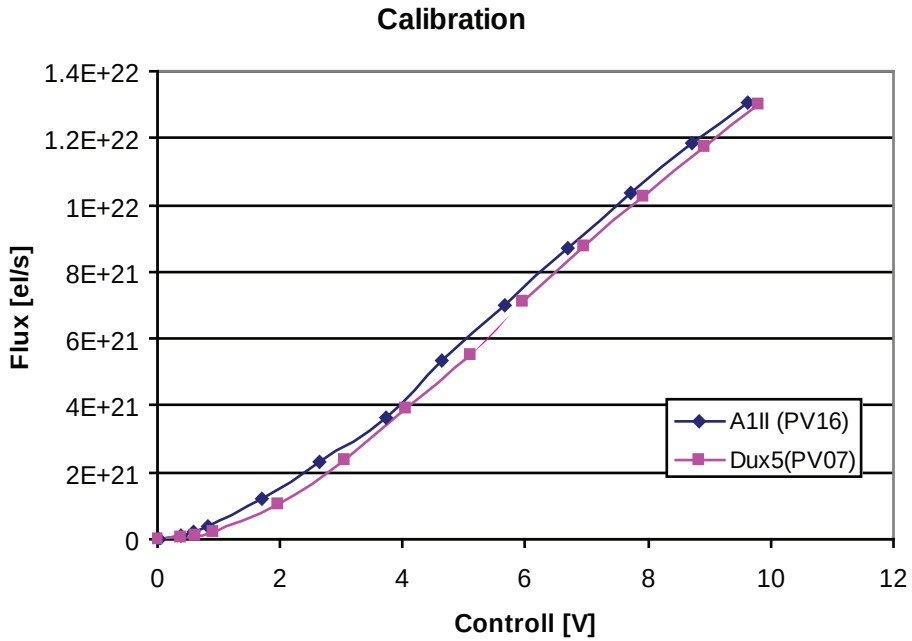
only low temporal drift

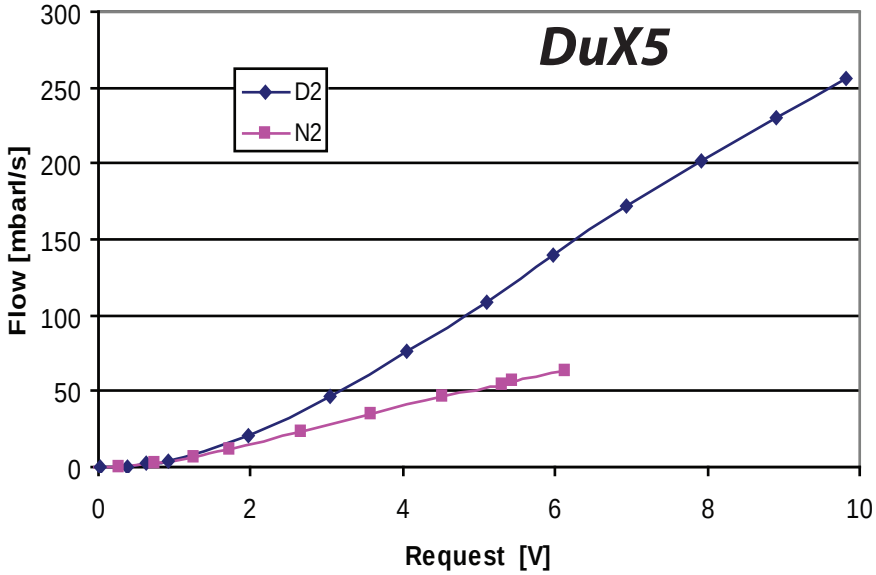
A-Port versus DuX

similar for D2

DuX saturates for N2

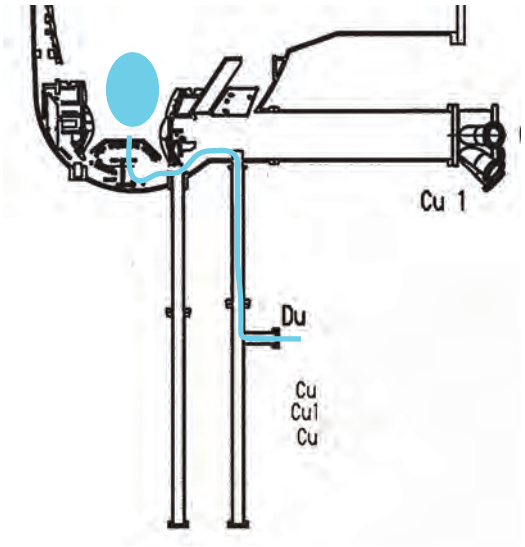




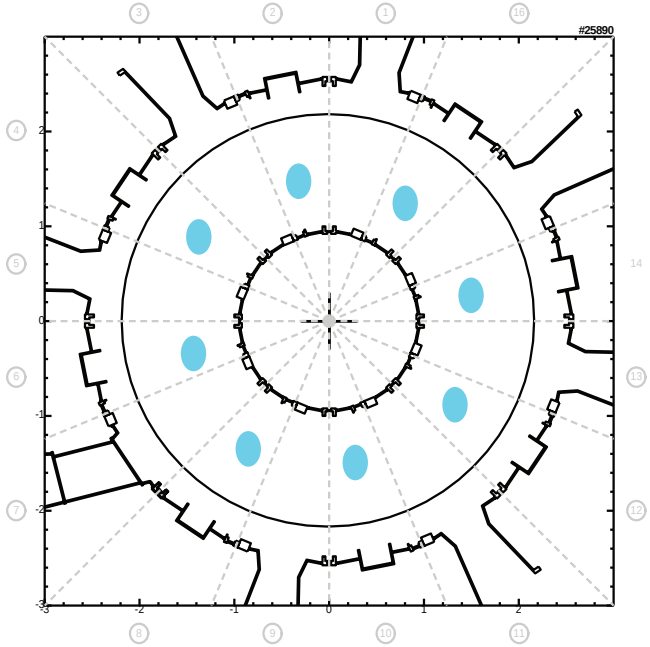


Gas Inlet System

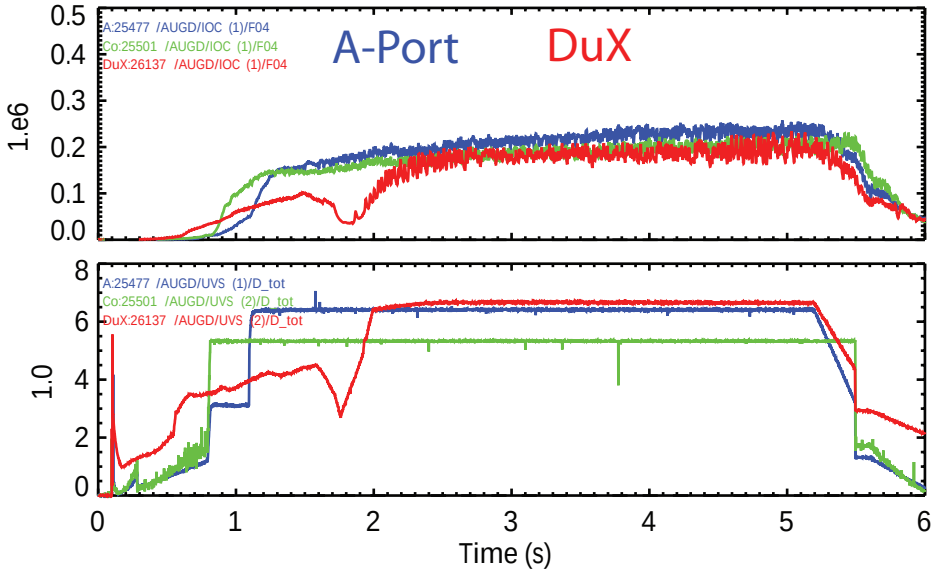
DuX



Installed 2000
4 toroidal distributed valves (Du1,5,9,13)
2 oulets each (2,4,6,8,10,12,14,16)
8 mm dia, 3m long tube
toroidal symmetic
all valves feeded by one Ringleitung
switch to matrix after summer 2011
individual gas feed



Std H-mode discharge: divertor pressure



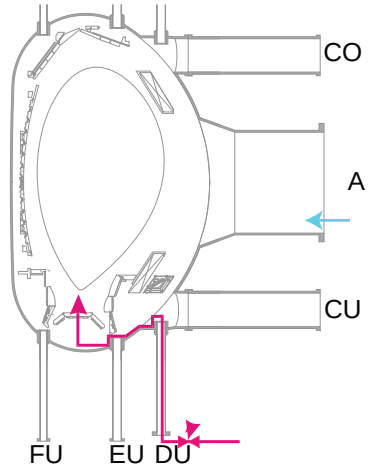
A-Port 30% more effective than DuX

Gas Inlet System

tube system

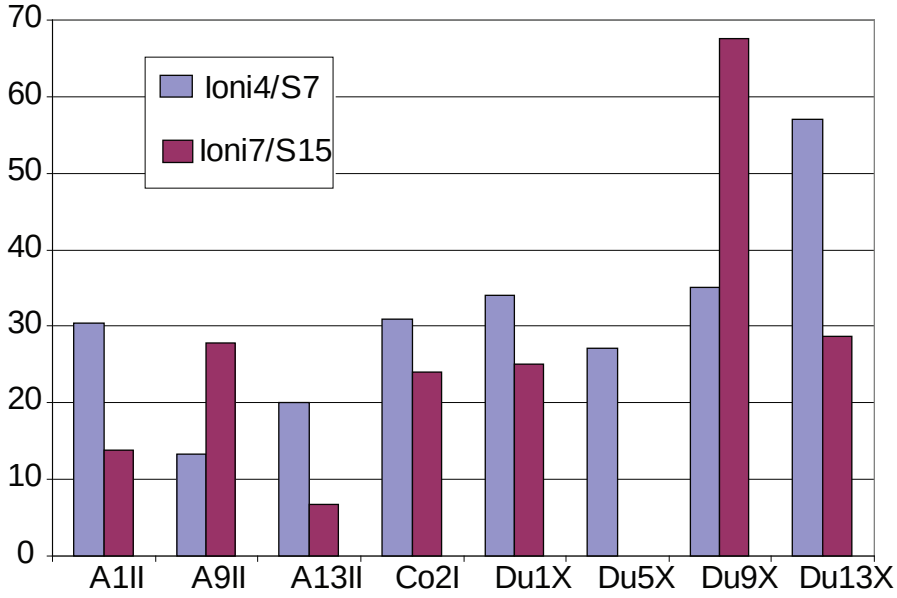
Most valves mounted directly at A-Ports
Alternative: use tube to guide gas
small tube: flux reduction
(DuX: D2: 250 mbarl/s N2: 70 mbarl/s)
volumen reduces time response
(fill time: 8mm tube 0.8s 12mm 2.3s)
Response time measured using ASDEX gauges
valve + propagation in vessel

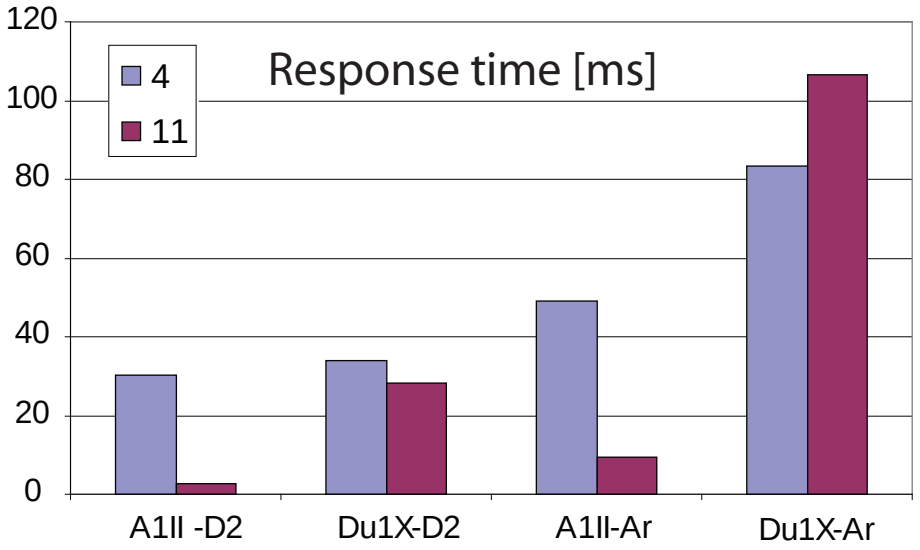
ms	D2	Ar
A1II	3	9
Du1X	28	107
Vc (3m)	3	9



times longer than
sound speed
> filling of volume

Response time
A-Port 5 ms
DuX 30 ms
DuX (Ar) 100 ms





Gas Inlet System

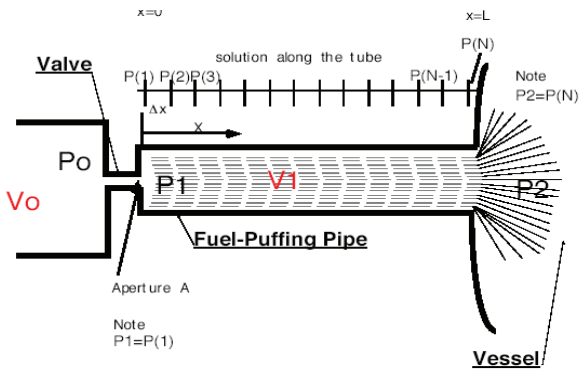
ITER Gas feeding tubes

Reported by W.Li
GIS/GDC Team
SWIP CHINA

Pipe response time Calculation

-- Model, Boundary, Assumption and Results

Model and Boundary



Basic equations

$$D\frac{\partial^2 p}{\partial x^2}=\frac{\partial p}{\partial t}$$

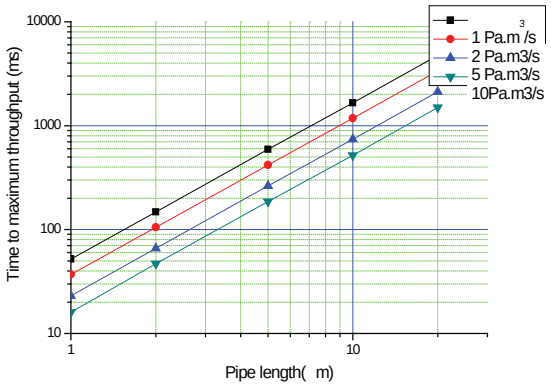
$$Q_{tube}=A\cdot D\left.\frac{\partial p}{\partial x}\right|_{x=L}\approx A\cdot D\frac{p(N-1)-p(N)}{\Delta x}\approx A\cdot D\frac{p(N-1)}{\Delta x}$$

Boundary Conditions

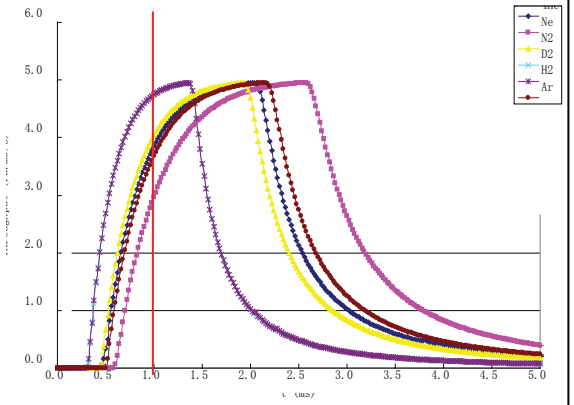
at x=0 $Q(p_1)=A\cdot D\left.\frac{\partial p}{\partial x}\right|_{x=0}=A\cdot D\frac{p(1)-p(2)}{\Delta x}$; x= L $p(N)=0$

* refers to DDD report in 1998

- Not consider the valve's action time
- Pressure of valve upstream is 0.12MPa
- Setting throughput is 1,2,5,10 Pa.m^3/s
- Pipe diameter is 10mm
- Pipe length is 2, 5, 10, 20m
- Ar gas
- Time to maximum throughput



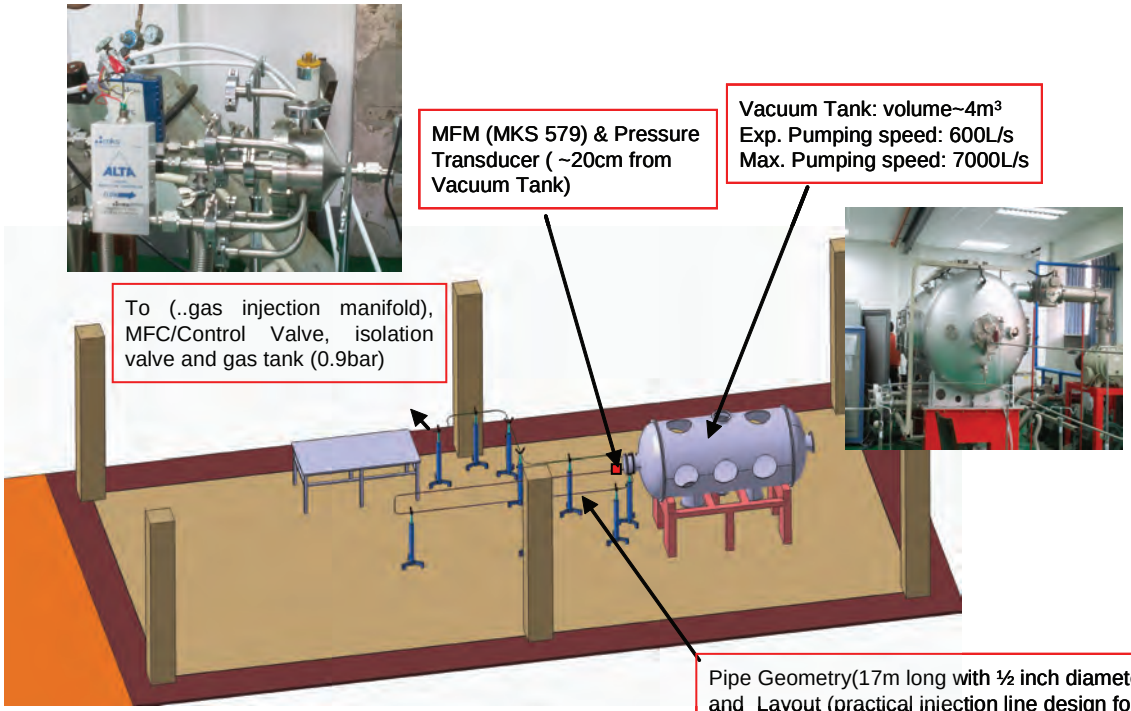
- Not consider the opening time of the valve
- Pressure of valve upstream is 0.08MPa
- Setting throughput is 5Pa.m^3/s
- Pipe diameter is 10mm
- Pipe length is 20m
- H_2、D_2、He、N_2、Ne and Ar gas



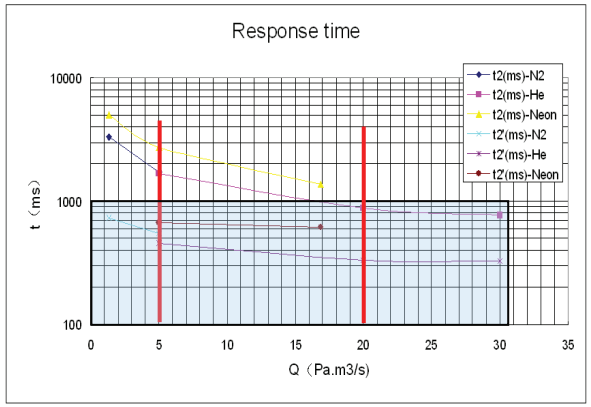
- The GIS response time is closely related with the pipe length
- The GIS response time for higher throughput is faster than that for lower one.
- Neon has the longest response time (≈1s at 5Pa.m^3/s) because of its lowest conductance

Gas Inlet System

ITER Gas feeding tubes

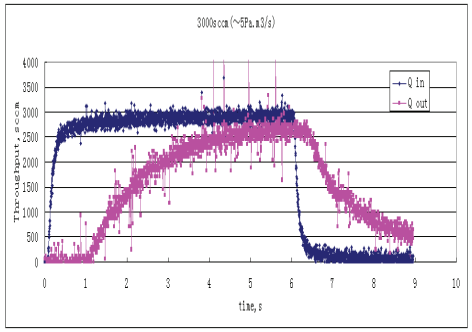


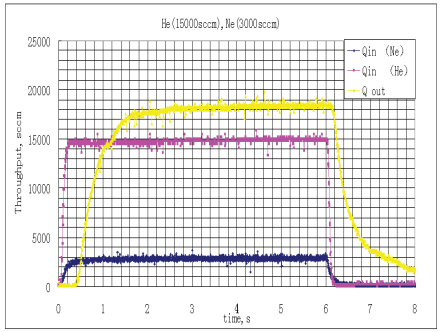
Slow flow controller used:
detailed lab. investigatons
response time 400-7000 ms



t, director control; t', impulse control

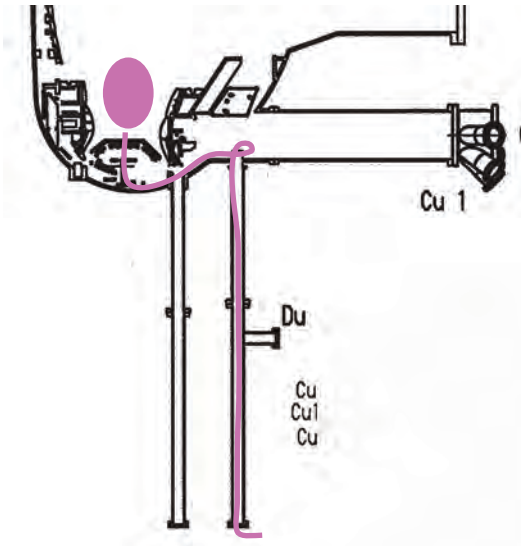
Heavy gases are slow
time response enhanced
by carrier gas

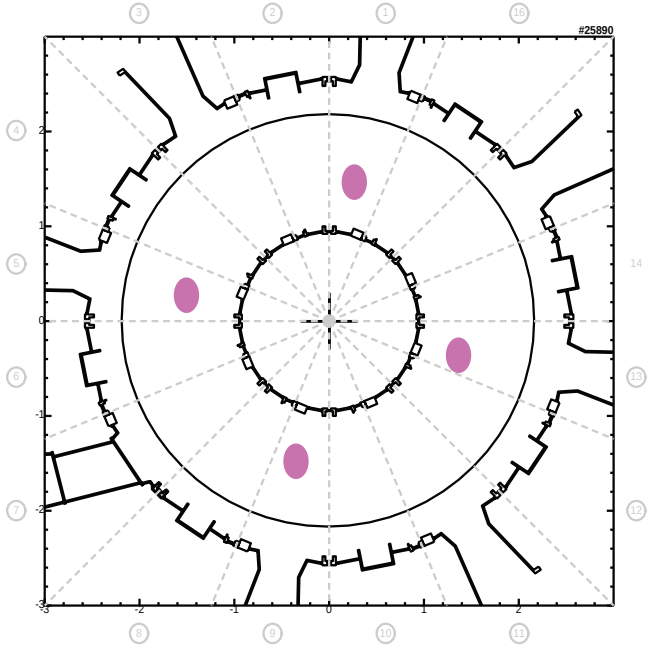




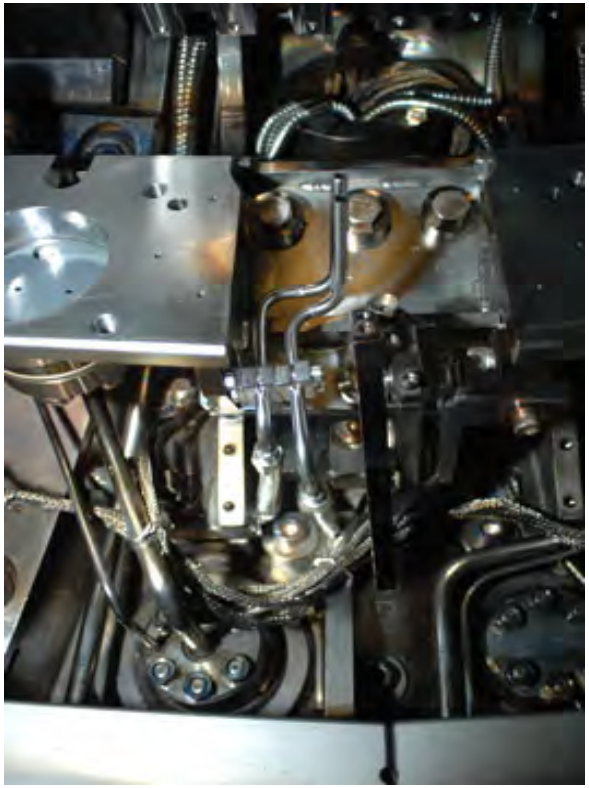
Gas Inlet System

DuX2



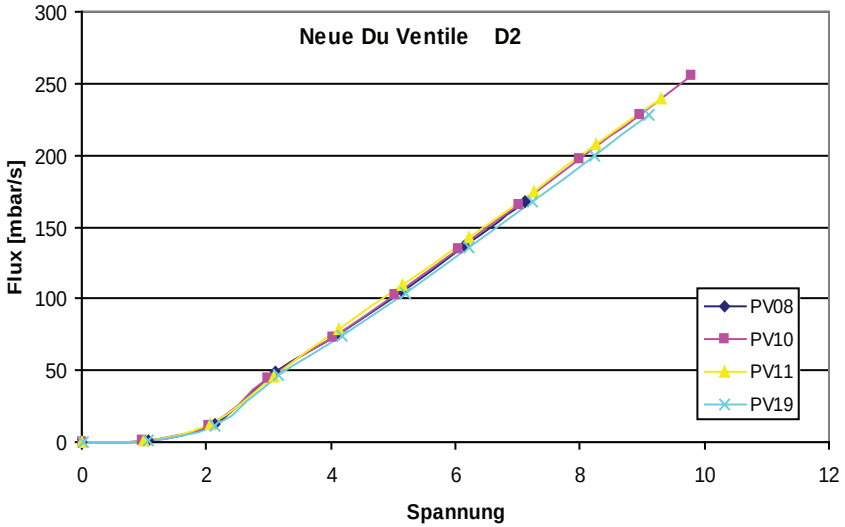


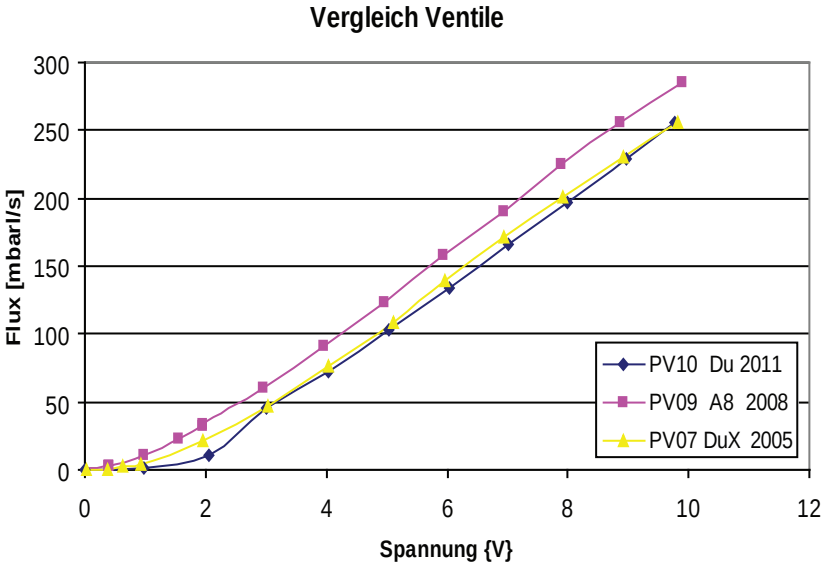
4 toroidal distributed valves (Du1,Du5,Fu9,Du13)
1 outlet each
8 mm dia, 4m long tube
2. system : tube already installed
in operation begin April 2011
calibration April 2011
gas feeded by matrix
higher flexibility
(different gas
species on each valve)



Gas Inlet System

Status of new Div valves (DuB)





In operation since 15.4.2011
> working
leckage with gas feed..(solved)

First calibration done

flux comparable to DuX
10 % less A-Port valves

time response measurements needed
accurate calibration needed
(Juny 2011)

calibration for different kinds of gases needed

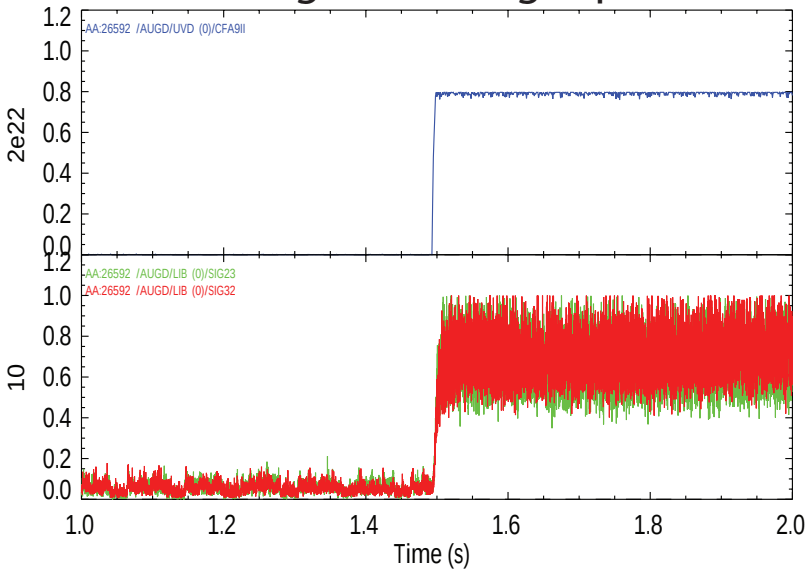
replacement of gas recipe system
desirable

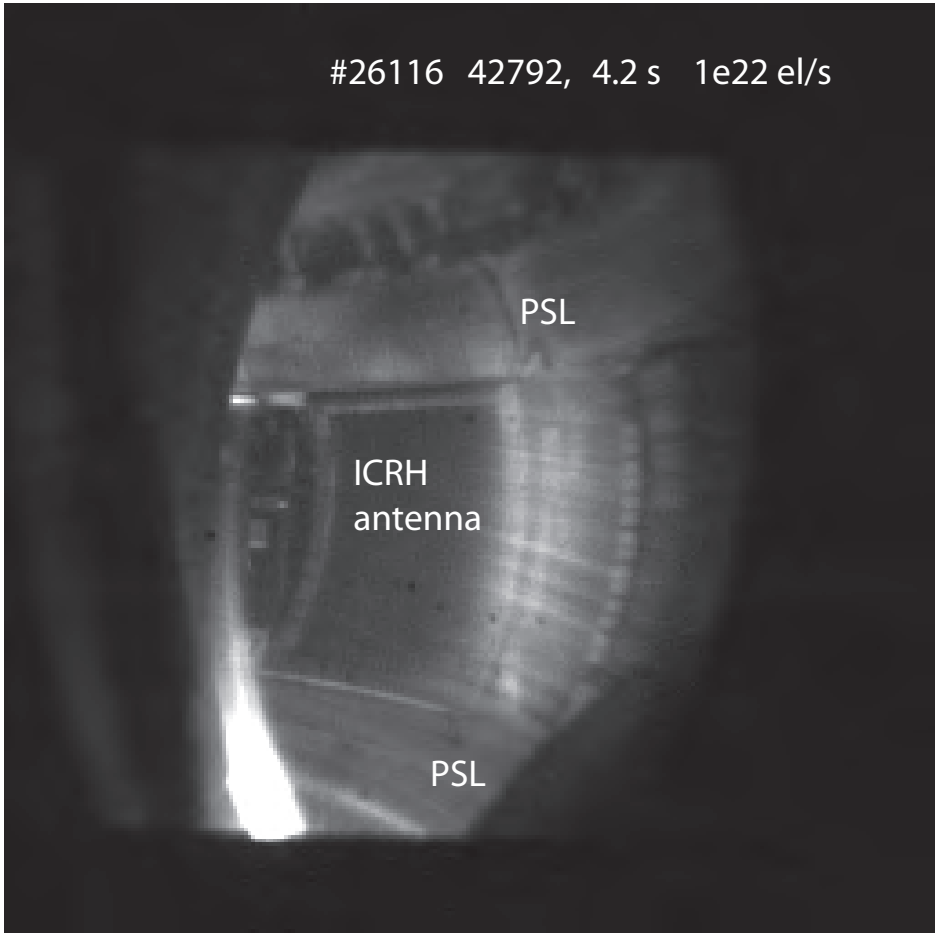
Gas Inlet System

A-Ports gas puff

Puff fills A port with neutral gas
filaments highlighted
recycling at ICRH limiter
may disturb diagnostics:
Li beam: underground higher if
gas puffed in Seg 9
> no reliable data
CER only reliable if
no puff in Seg 1 and 13

Li beam signal wo/w gas puff



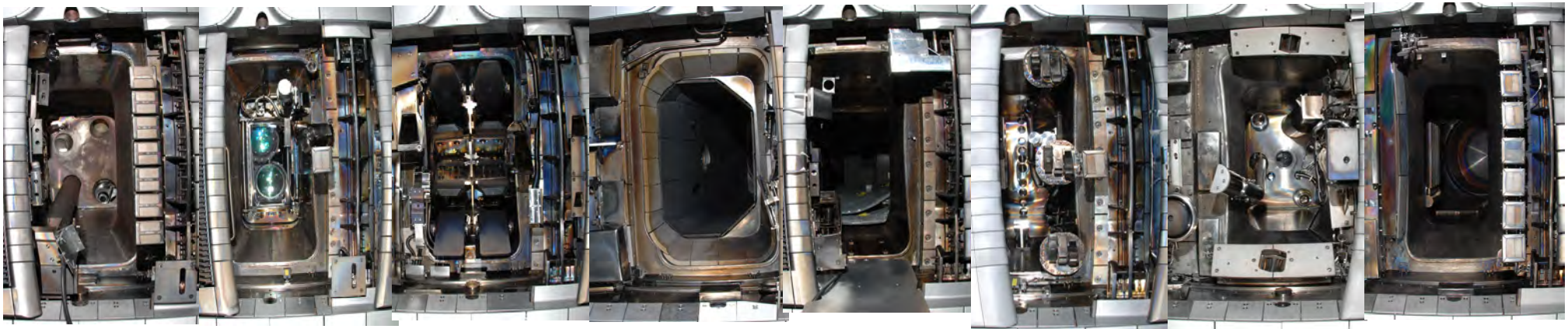


2 inlet positions at LFS are needed
to keep compatibility to older discharges
A-port gas puff was workinghorse ...

Gas Inlet System

A-Ports gas puff

1 3 5 7 9 11 13 15



1I,1II,1III 9I,9II,9V 13II

MSE	Thomson	**ECRH**	**NBI**	**Entrance**	DCN	Lena	**NBI**
CER	Fild 2			**Li-Beam**	SXR	CX-1	
Bragg						CX2	
Spread						CER	
Johann							

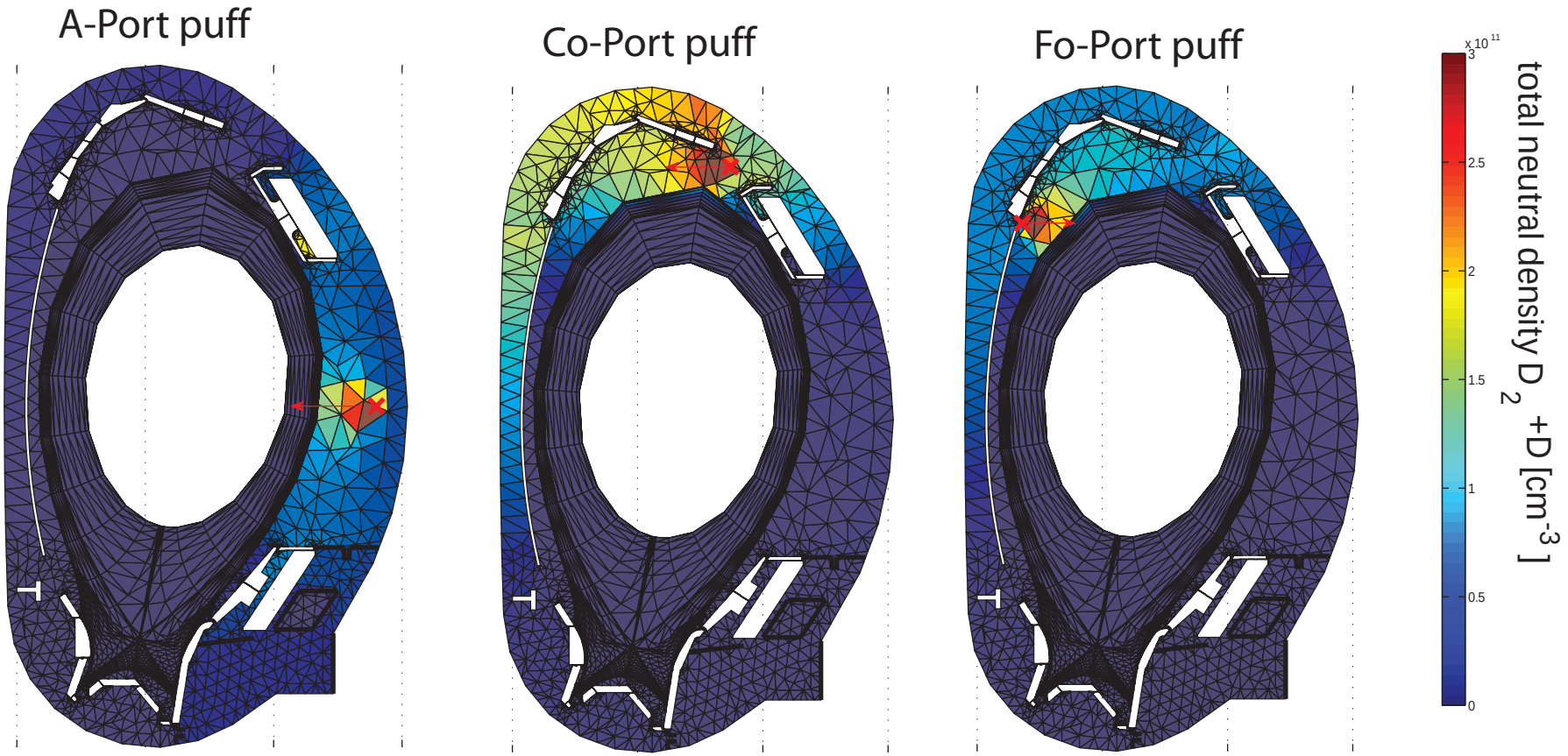
Gas inlet may disturbe diagnostics
but 2 inlet positions at LFS are needed
to keep compatibility to older discharges
A-port gas puff was workinghorse ...
vacate valves for new positions

2011: Remove onlet S9
Keep S1 and S13

2012: 3 options
a: gas matrix: 2* S1 and 1* S13
b: give up LFS gaspuff
c: Move to S3 and S11 total 3 valves

Main Chamber gaspuff

neutral density



2d Eirene calculation by A.Scarabosio: 3 different D2 source locations indicated by red cross

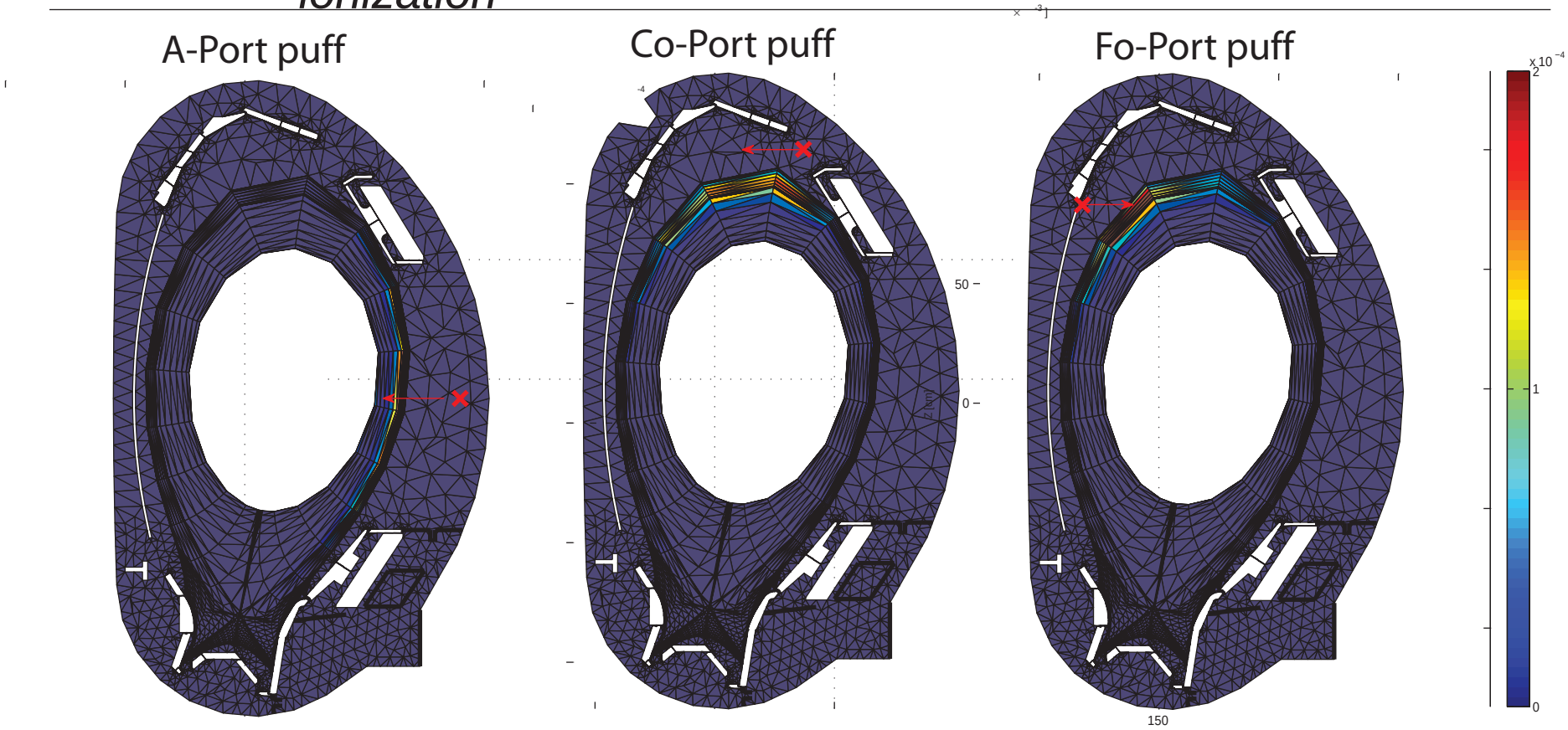
A-Port : fills low field port, more localized than in reality

Co-Port : upper PSL region, huge inventory behind divertor reduces time response
conductance behind divertor/ central column protection unrealistic

Fo-Port : localised puff at high upper divertor

Main Chamber gaspuff

ionization



2d Eirene calculation by A.Scarabosio: 3 different D2 source locations indicated by red cross

A-Port : ionization at whole low field side separatrix

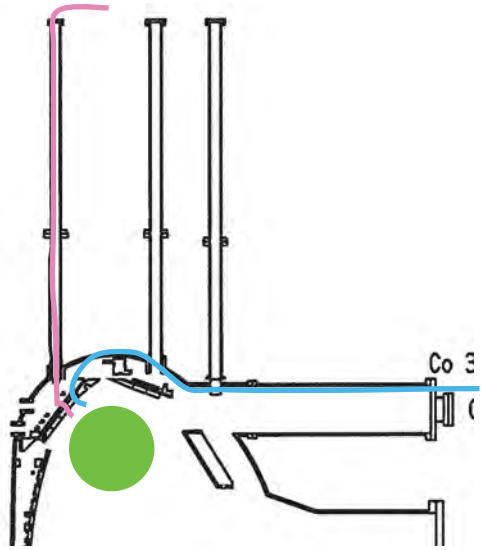
Co-Port : ionization at upper divertor, maximum before upper PSL

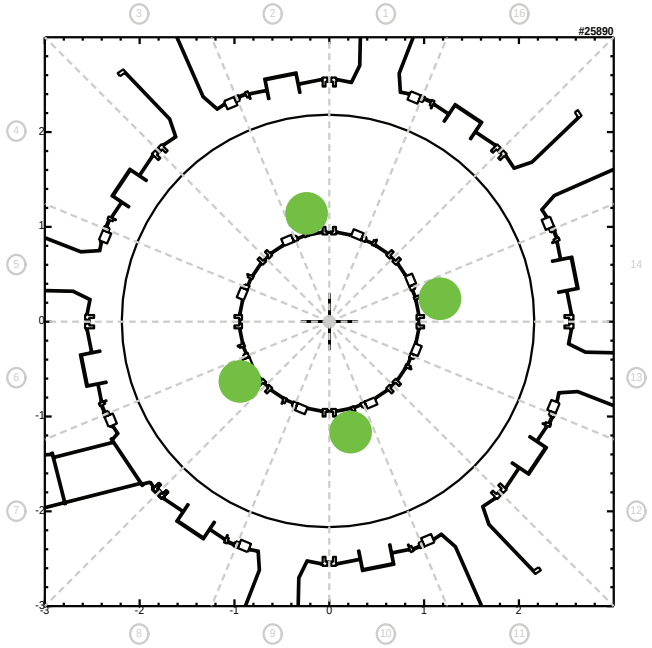
Fo-Port : ionization at upper inner divertor, deeper penetration

prefer Fo port puff

Gas Inlet System

upper divertor





Replacement for LFS A-Port valves
about 4 m tube needed
feeded by Co or Fo ports
Fo prefered: Gas feeding, 1m shorter

suggestion

Seg	Owner
2	GUES
7	GES
10	Spectroscopy/ LWL
14	GUES

Gas feed at inner divertor
between inner divertor and HS ?

Detailed construction / build up
has to be started (Herrmann, Haertl, n.n.)

Gas Inlet System

summary

PV/UVD-Kanal	Sektor	Stutzen	Feed	Gasleitung	UVD-Name	Kommentar	verfuegbar
1	1	A	direct	II (D2)	CFA1I	A-Port	o.k.
2	2	Co	direct	I (H2)	CFCo2I		Nov-11
4	13	A	tube	II (D2)	Lena	ICRH Antenna	o.k.
3	?	Fo	tube	Matrix	CFA9V		2012
5	?	Fo	tube	Matrix	CFA9II		2012
6	7	Fo		I (H2)	GFFo7I	unter div mit langem schlauch	o.k.
7	5	Du-roof	3m tube	MaxtrixRing	CFDu5X	Roof Baffle, zwei Auslässe	o.k.
8	5	Du-roof 2	4m tube	Matrix	CFDu5VII	Roof Baffle 2, ein Auslass	Apr-11
9	?	Fo	tube	Matrix	GFA9I		2012
10	1	Du-roof 2	4m tube	Matrix	GFDu1VII	Roof Baffle 2, ein Auslass	Apr-11
11	9	Du-roof 2	4m tube	Matrix	CFDu9VII	Roof Baffle 2, ein Auslass	Apr-11
12	?	Fo	tube	Matrix	GFFu10I		2012
13	10	Fu		IV(TOX)	GFFu10IV		
14	1	A	direct	Matrix	CFA1III	A-Port	o.k.
15	13	A	direct	Matrix	CFA13II	A-Port	o.k.
16	1	A	direct	Matrix	CFA1II		o.k.
17	9	Du-roof	3m tube	MaxtrixRing	CFDu9X	Roof Baffle, zwei Auslässe	o.k.
18	13	Du-roof	3m tube	MaxtrixRing	CFDu13X	Roof Baffle, zwei Auslässe	o.k.
19	13	Du-roof 2	4m tube	Matrix	GFDu13VII	Roof Baffle 2, ein Auslass	Apr-11
20	1	Du-roof	3m tube	MaxtrixRing	CFDu1X	Roof Baffle, zwei Auslässe	o.k.

A-Port

DuX

special

DuX2

upper