High throughput, high precision ^{14}C AMS with a small accelerator

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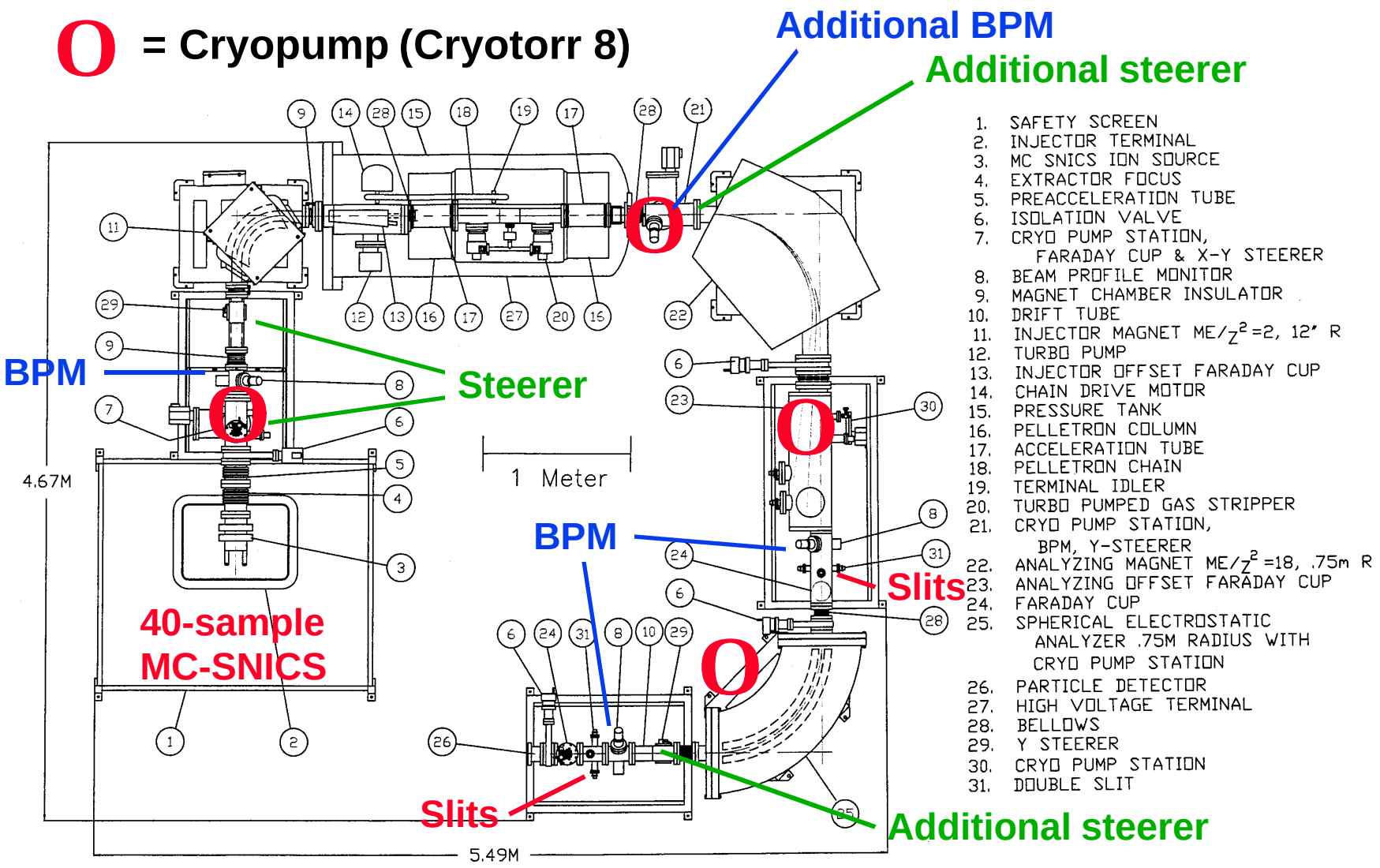
- **Our laboratory was set up to apply ^{14}C AMS to carbon cycle research questions.**
- **Funding came from the W.M.Keck Foundation and UC Irvine.**
- **High sample throughput and high precision are both important**
- **What does it take to measure thousands of sample per year?**

The UCI AMS spectrometer (made by NEC)

(3rd production model - has extra beam diagnostic, steerers, pumps)



Moving the spectrometer 7/8/03
(end of the first day)

Here's what you get for $1.35M
(We knew it would work, now we have to use it efficiently)

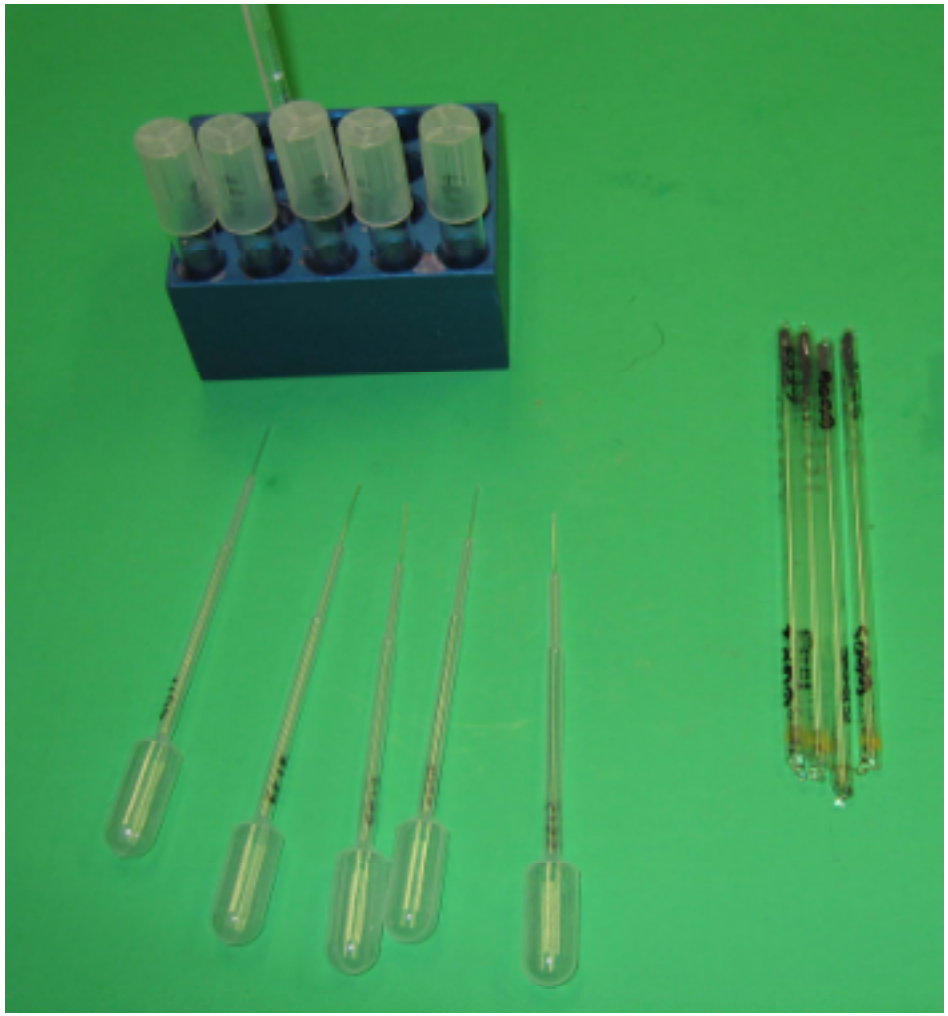
Sample preparation is a major AMS bottleneck

(raw sample > clean sample > CO_2 > graphite)

- Three sample preparation labs in UC Irvine Earth System Science Dept
- Unprocessed samples plus CO_2 plus graphite from outside submitters

Simplify routine chemical pretreatment, work in parallel not in series

Prepackaged reagents, disposable glassware and pipettes, etc.
Batch processing, multiple heads for combustion tube pumpout

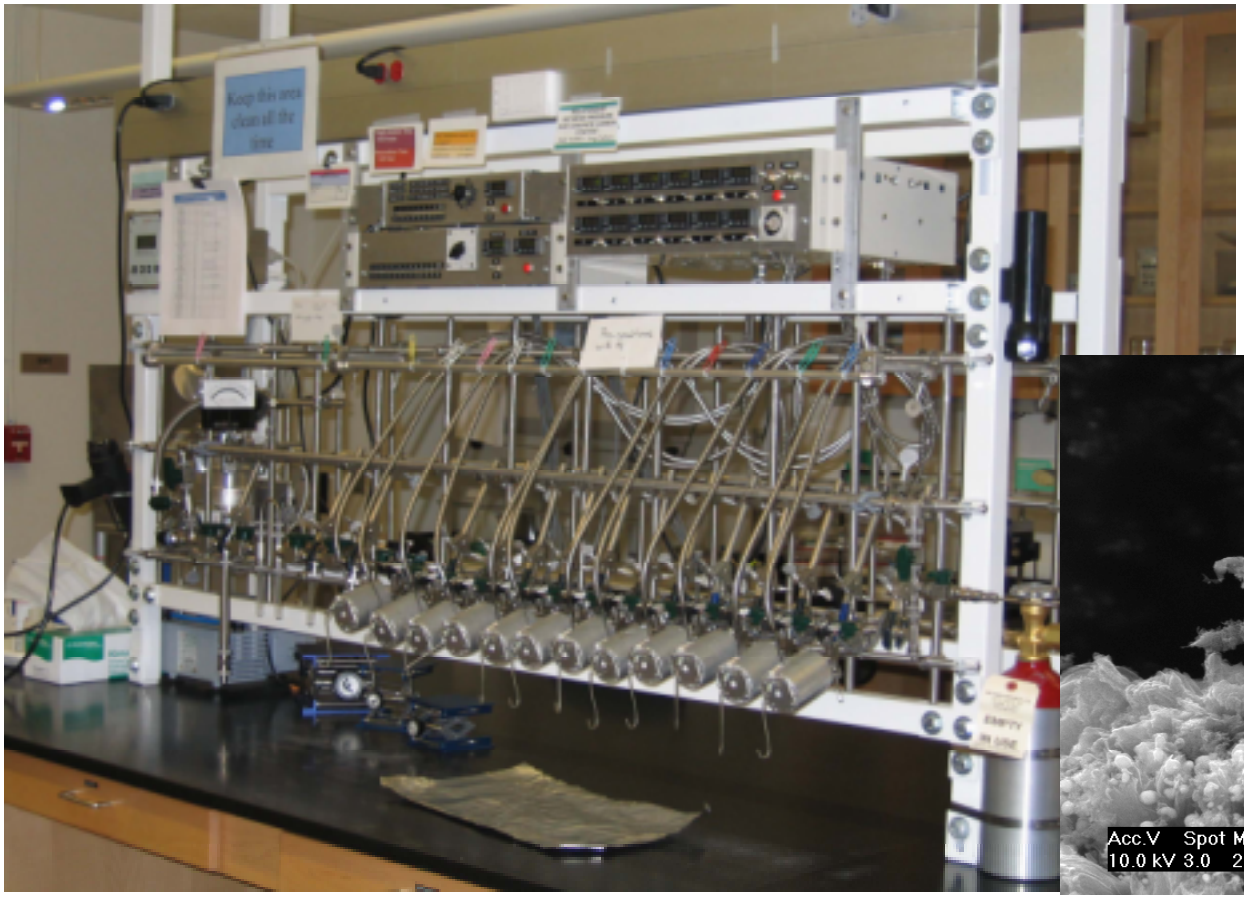


Carbonate sample preparation

Samples are leached and hydrolyzed in disposable blood vials

Graphitization

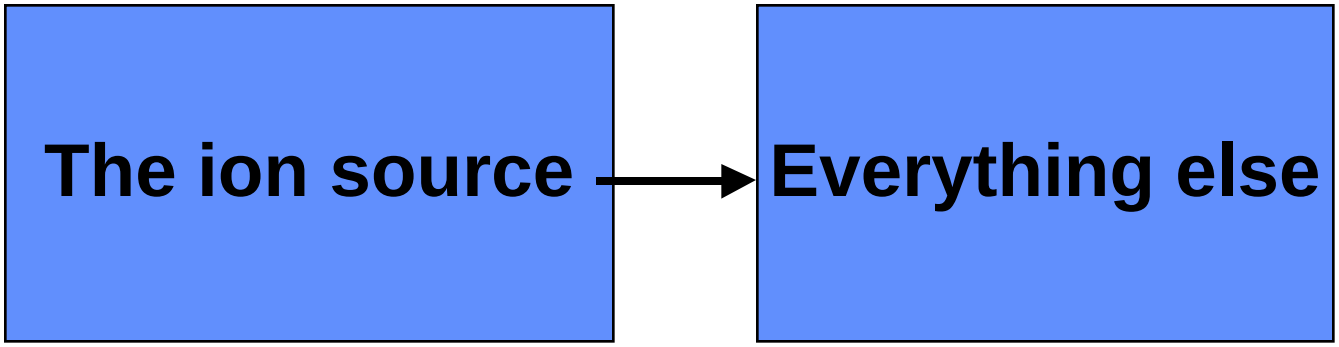
- $CO_2 + 2H_2 \rightarrow C + 2H_2O$ (Fe catalyst)
- 24 hydrogen-reduction graphite reactors (2 samples per head per day)
- PLUS Zn + TiH_2- reduction (sealed tube) graphitizations (40/day)



Packing graphite into sample holders

(Keep it simple)

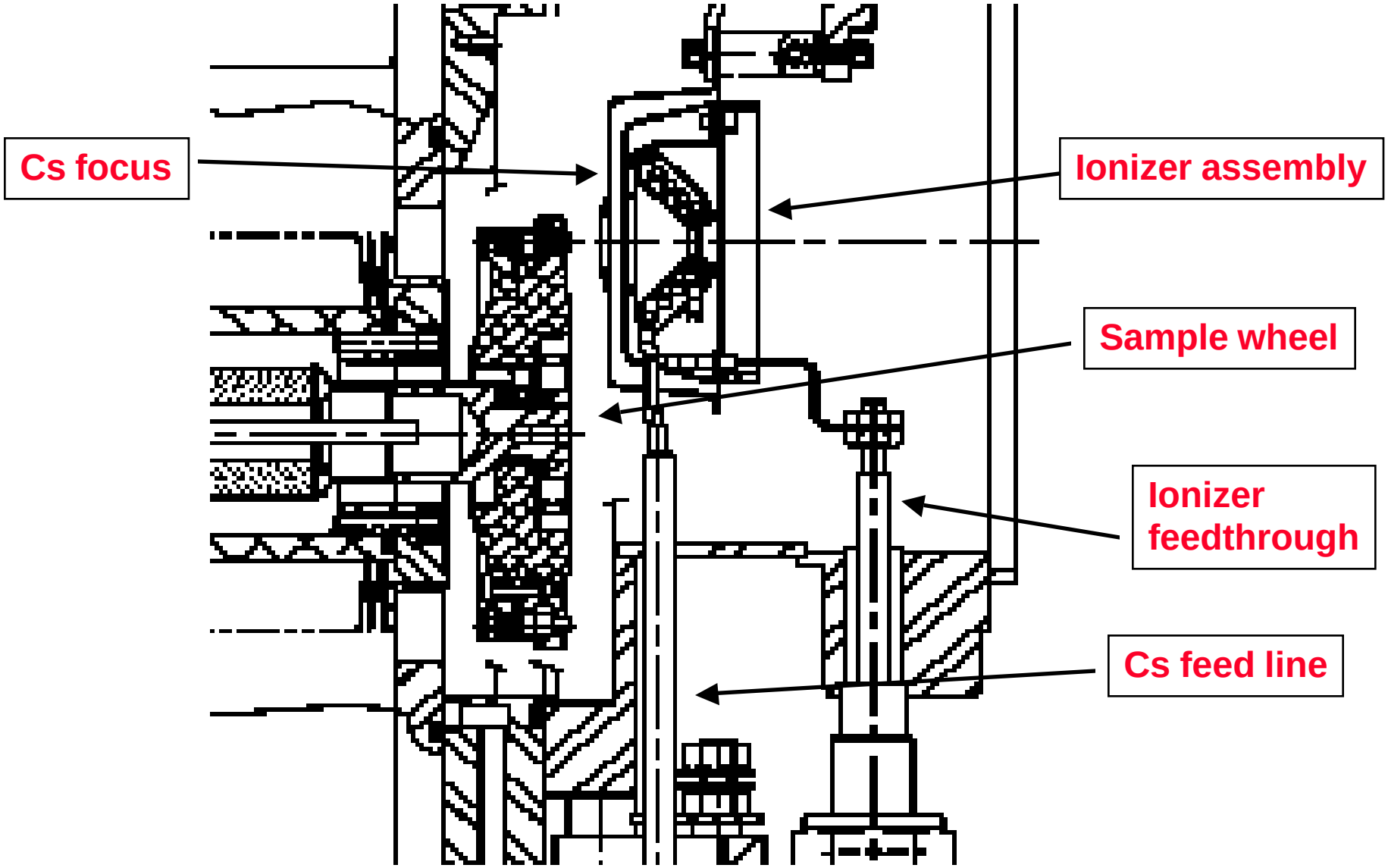
An AMS system (slightly simplified)



- AMS transmission efficiencies for radiocarbon (ions detected as a fraction of source output) are 35-50%
- Ion source currents for C^- vary from a few microamps to >300μA

Ion source output determines spectrometer throughput

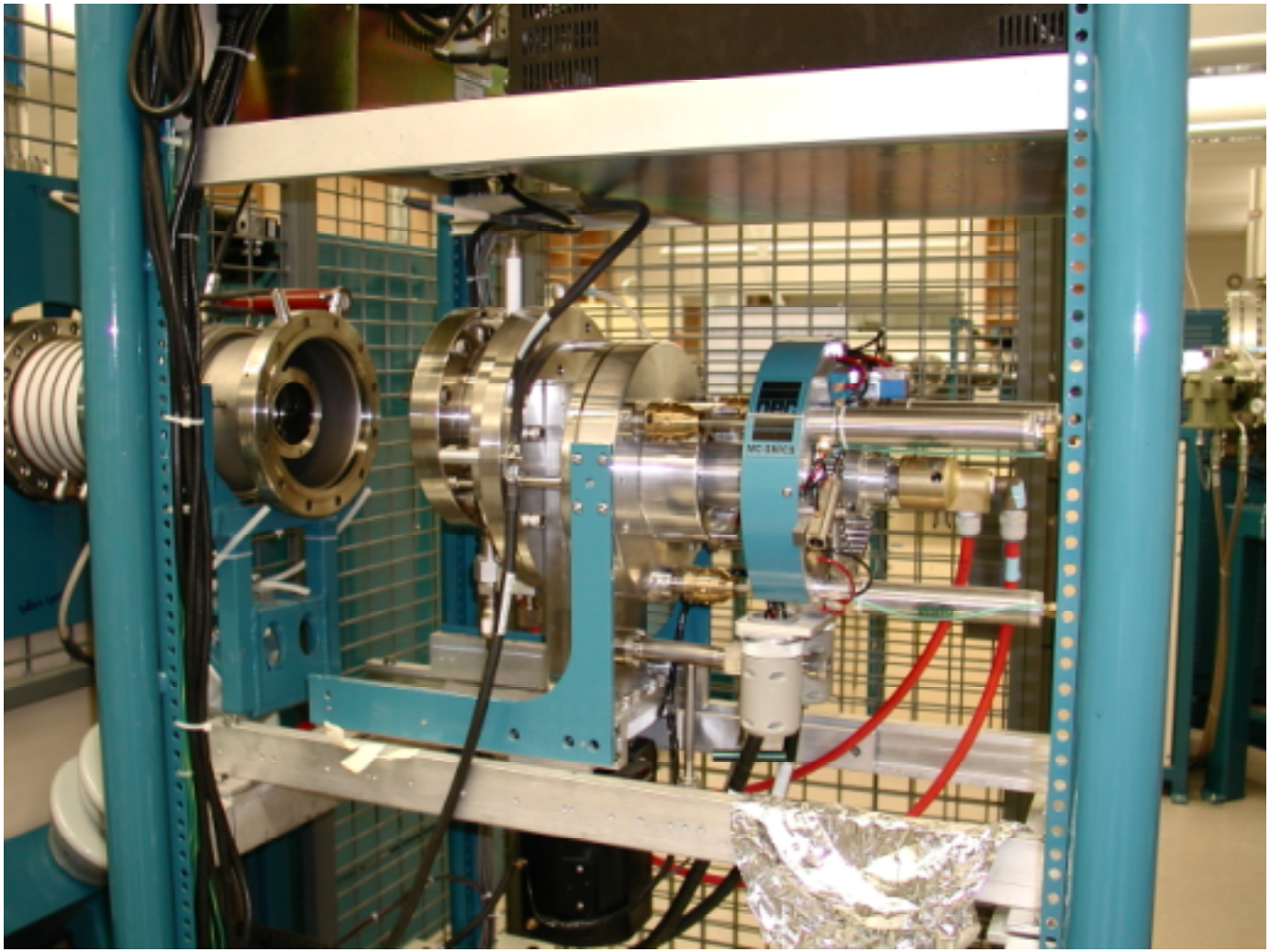
MC-SNICS: Cs ion source



Serviceability

If you can’t work on it, how can you maintain or improve it?

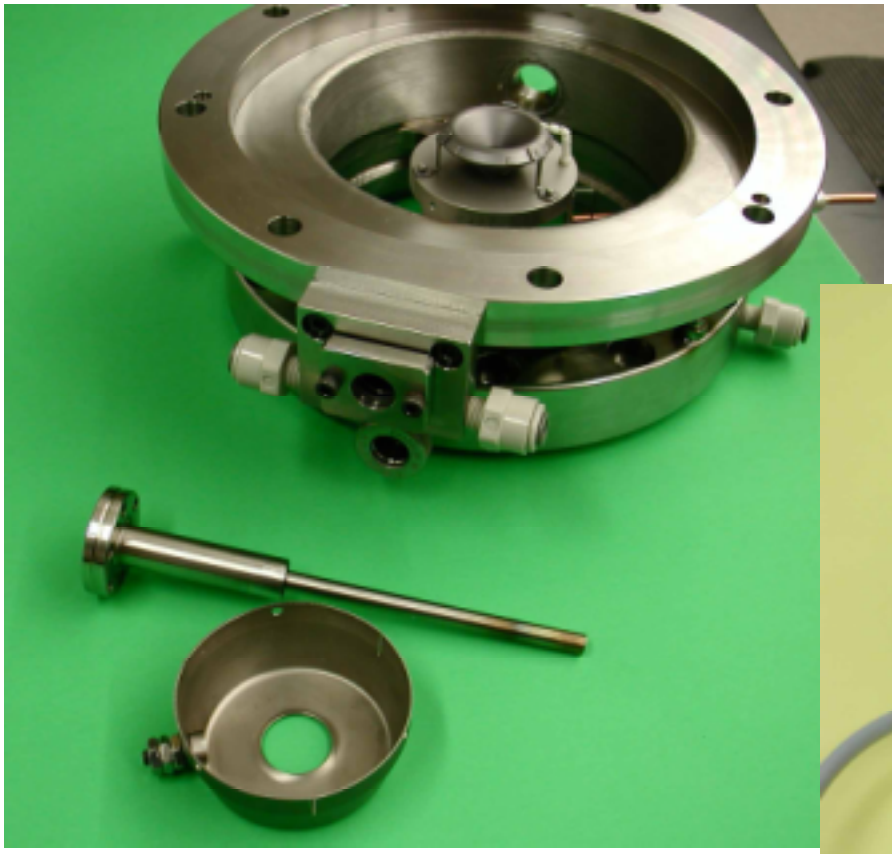
Track system for in-place servicing

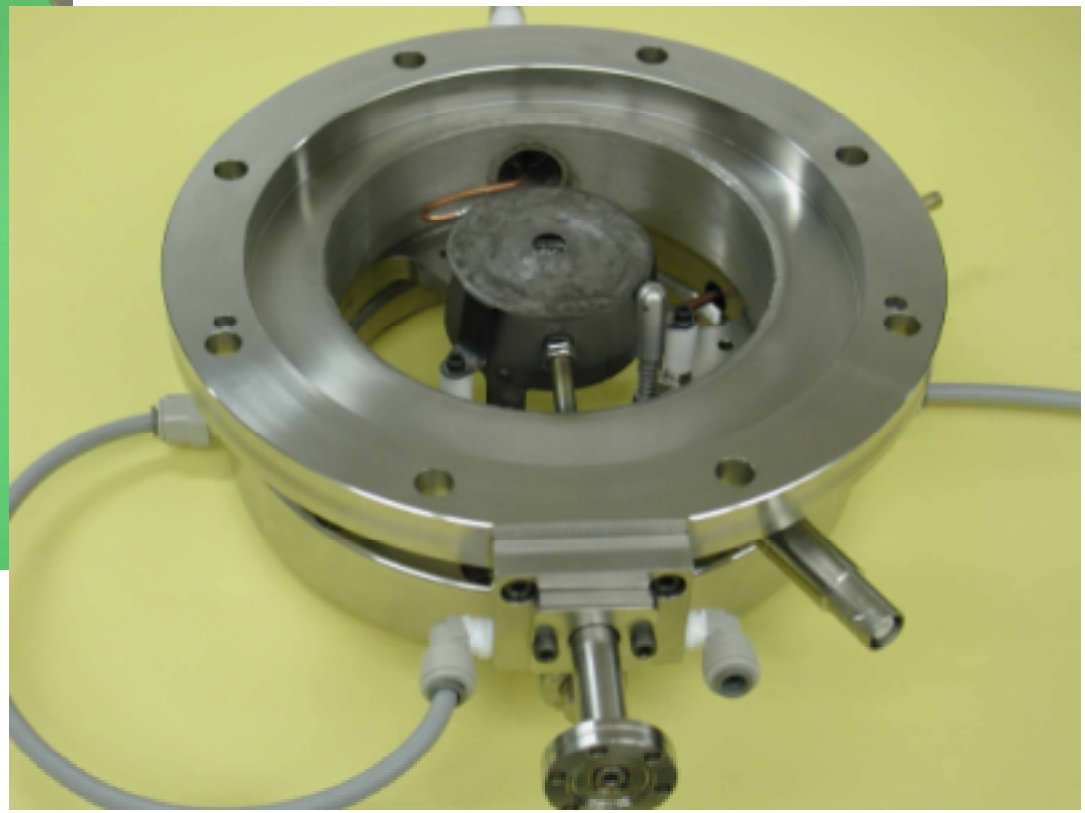


Cs feed (i)
New Cs oven - easier to fill

Cs feed (ii)

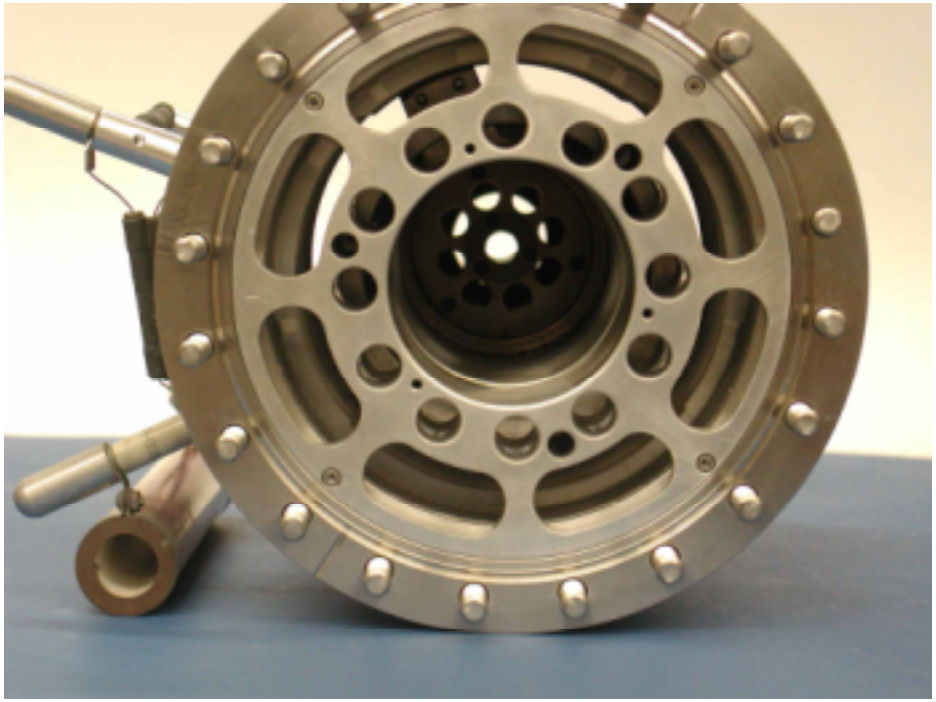
New source body: better control of Cs, extra cooling

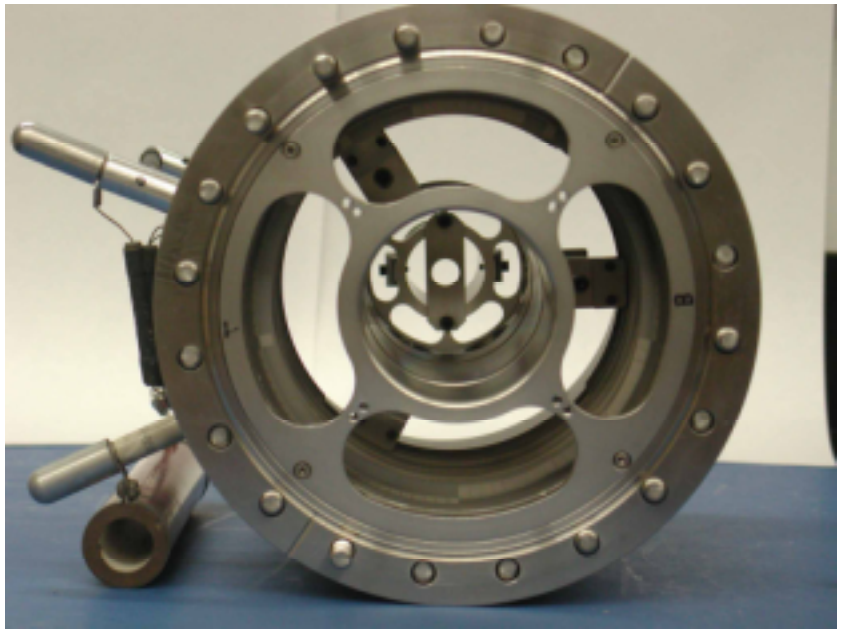


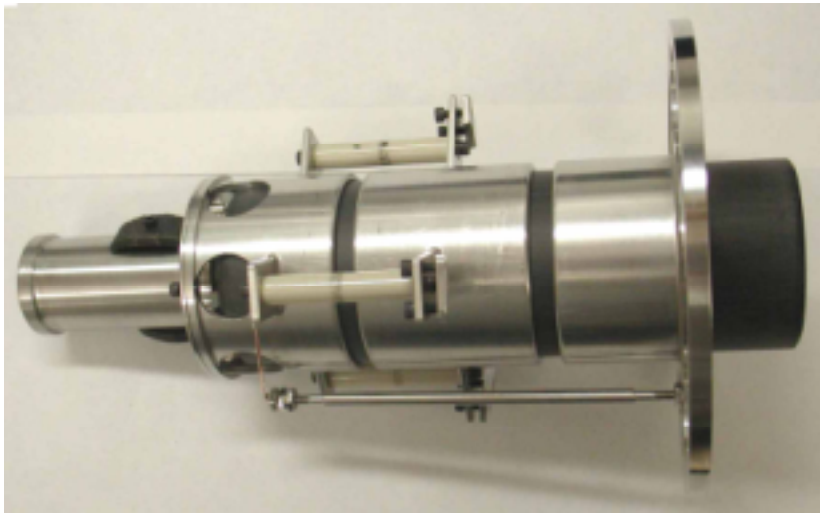


Better pumping

New extractor/lens assembly







Spherical ionizers (NEC, Spectramat)

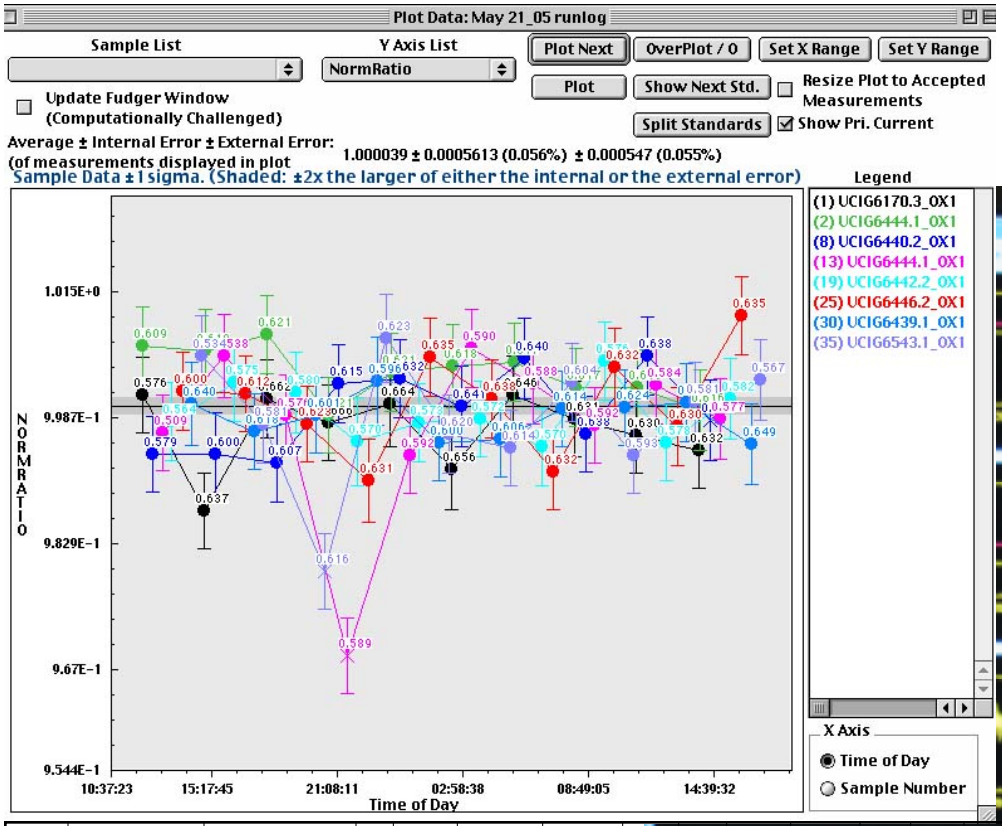
Better focusing, sample used more efficiently

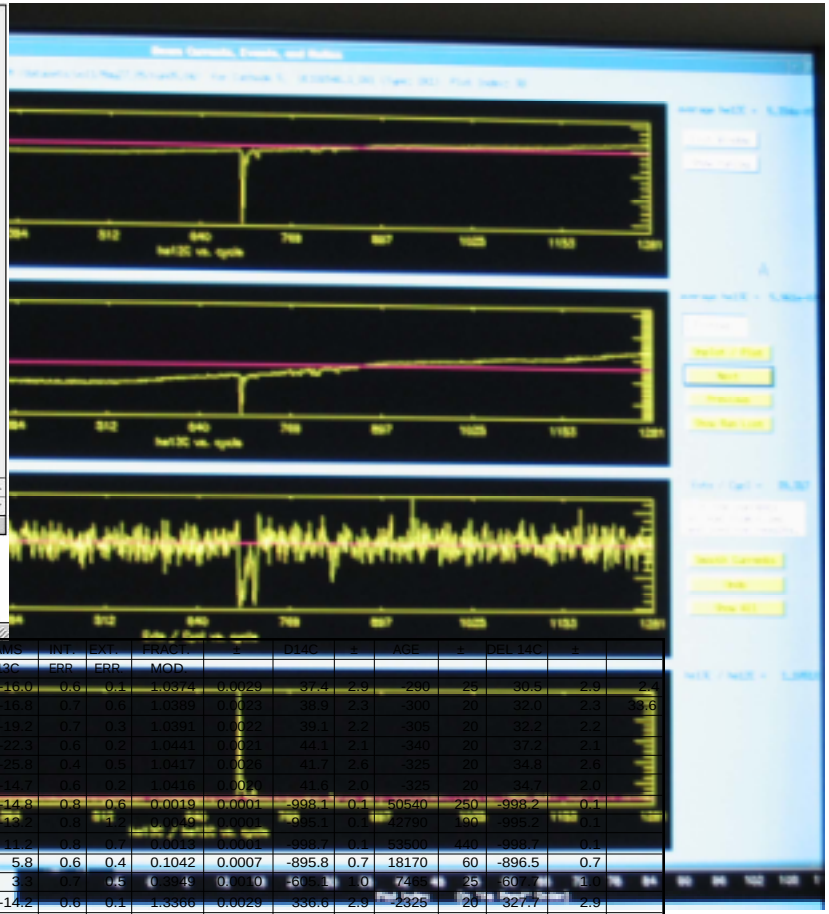
Ion source performance

- Typically 120-150μA of C^- at 7.5kV cathode voltage, (best ever: 275μA).
- Count rate for Modern carbon 450-500 counts/sec.
- About 50 wheels per 5g of Cs.
- Wheel change time < 1 hour.
- Source/ionizer cleaning and bakeout time < 6 hours (every few weeks).

Data analysis: keep it simple

(Do NOT attempt to “rescue” problem runs)





UCIAMS#	SAMPLE	IDENT.	RPTS	RATIO	INT. ERR.	EXT. ERR	STD.	SIZE	BKGD		STD.		AMS	INT.	EXT.	FRACT.		D14C		AGE		DEL 14C		
	(LAB #)	(NAME)		TO STD			MULT	(mgC)	wrt STD		CORR		Δ13C	ERR	ERR	MOD								
16160	UCIG6546.1_OX1	OX1	6	1.0008	0.002029	0.002758	1.020		0.0018	0.0006			-16.0	0.6	0.1	1.0374	0.0029	37.4	2.9	-290	25	30.5	2.9	2.4
16161	UCIG6444.3_OX1	OX1	6	1.0014	0.00209	0.001383	1.020		0.0018	0.0006			-16.8	0.7	0.6	1.0389	0.0023	38.9	2.3	-300	20	32.0	2.3	39.6
16162	UCIG6546.4_OX1	OX1	7	0.9992	0.00191	0.001975	1.020		0.0018	0.0006			-19.2	0.7	0.3	1.0391	0.0022	39.1	2.2	-305	20	32.2	2.2	
16163	UCIG6543.4_OX1	OX1	7	1.0009	0.001919	0.001549	1.020		0.0018	0.0006			-22.3	0.6	0.2	1.0441	0.0021	44.1	2.1	-340	20	37.2	2.1	
16164	UCIG6171.2_OX1	OX1	7	0.9949	0.001868	0.002395	1.020		0.0018	0.0006			-25.8	0.4	0.5	1.0417	0.0026	41.7	2.6	-325	20	34.8	2.6	
16165	UCIG6440.4_OX1	OX1	7	1.0062	0.001876	0.001249	1.020		0.0018	0.0006			-14.7	0.6	0.2	1.0416	0.0020	41.6	2.0	-325	20	34.7	2.0	
16166	UCIG6460.2_COAL	Coal	5	0.0018	5.37E-05	3.08E-05	1.020						-14.8	0.8	0.6	0.0019	0.0001	-998.1	0.1	50540	250	-998.2	0.1	
16167	UCIG6597_COAL	Coal .45mgC	5	0.0047	0.000093	0.000107	1.020	0.45					-13.7	0.8	1.2	0.0049	0.0001	-995.1	0.1	42790	190	-995.2	0.1	
16168	UCIG6599_CALCITE	Calcite	5	0.0013	4.58E-05	6.82E-05	1.020						11.2	0.3	0.7	0.0013	0.0001	-998.7	0.1	53500	440	-998.7	0.1	
16169	UCIG6600_TURB	FIRI turbidite	7	0.1044	0.000379	0.000482	1.020		0.0018	0.0006			5.8	0.6	0.4	0.1042	0.0007	-895.8	0.7	18170	60	-896.5	0.7	
No numb	UCIG6598	WB-178-66 Mytilus	6	0.3897	0.000877	0.000533	1.020	0.59	0.002	0.0007			3.3	0.7	0.5	0.3945	0.0010	-605.5	1.0	7485	25	607.1	1.0	
16170	UCIG5985.4_OX2	OX2	7	1.2913	0.002447	0.002667	1.020		0.0018	0.0006			-14.2	0.6	0.1	1.3306	0.0029	330.6	2.9	-2325	20	327.7	2.9	
16171	UCIG6596	WB-120-66 Salix	6	1.5009	0.003095	0.00124	1.020		0.0018	0.0006			-22.1	0.6	0.2	1.5665	0.0034	566.5	3.4	-3600	20	556.2	3.4	
16172	UCIG6377.4_OX2	OX2	7	1.2909	0.002438	0.000944	1.020		0.0018	0.0006			-15.3	0.6	0.3	1.3377	0.0027	337.7	2.7	-2330	20	328.8	2.7	
16173	UCIG5598.1_ANU	ANU	7	1.4605	0.002756	0.002728	1.020		0.0018	0.0006			-8.2	0.6	0.4	1.5030	0.0030	503.0	3.0	-3270	20	493.0	3.0	
16174	UCIG6611	WB-178-66 Mytilus	7	0.4068	0.000824	0.000676	1.020		0.0013	0.0004			1.6	0.6	0.5	0.4135	0.0009	-586.5	0.9	7095	20	-589.3	0.9	

What happens when the boss is in Dubrovnik? Answer: the lab runs just fine

- **You can't have high throughput without good people (lots of them) who are well trained**

- **Number of staff and students who can prepare samples: 10**
- **Number who can change sample wheels and tune and operate the spectrometer: 6**
- **Number who can analyze data: 10**
- **Number who can completely rebuild the ion source: 2**

Conclusions

- **A small commercially available AMS system can produce thousands of high precision analyses per year.**
- **Few hardware changes are necessary apart from ion source modifications.**
- **Extensive sample preparation facilities are required.**
- **It won't work without enough well trained people.**

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