Ion Source and LEBT Performance and Plans

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for the Department of Energy

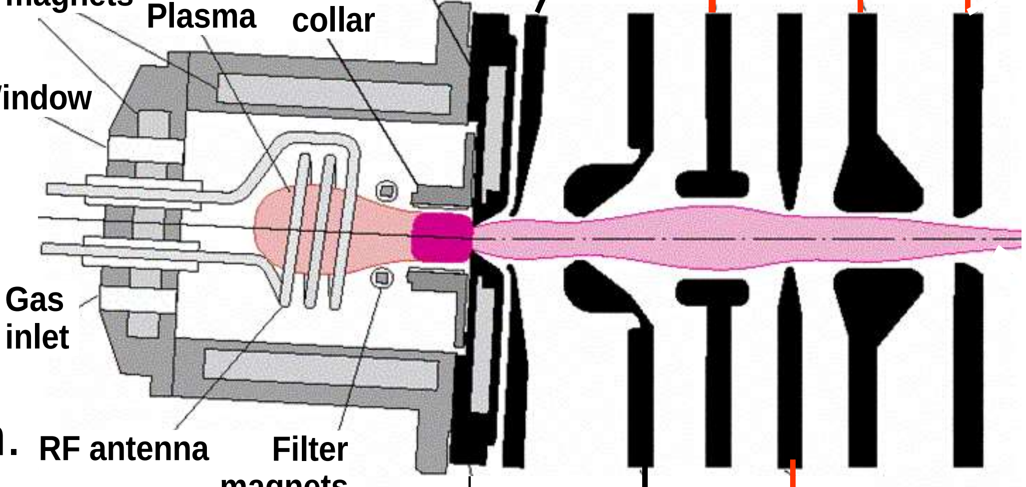
OAK RIDGE
National Laboratory

Content

- Overview
- Milestone Diagnostic Problems & Solutions
- The 2007 LEBT Sparkfest
- The LBNL Cs System and its Operation
- The Beam Current Challenge
- The Plans

The SNS Baseline Ion Source and LEBT

LBNL developed the SNS baseline ion source, a cesium-enhanced, multicusp RF ion source, and the 12 cm long, two-lens electro-static LEBT. Lens-2 is split into four quadrants to steer, chop, and blank the beam.



Commissioning	Availability
FE @ ORNL	85.6 %
DTL-1	92.4 %
DTL-2/3	97.8 %
CCL1-3	98.6 %
SCL	99.8 %
Ring	99.7 %
Target	100.0 %
Run 2006	99.9 %
Run 2007-1 (0.2%)	99.98 %
Run 2007-2 (0.8%)	70.6 %
Run 2007-3 (1.8%)	97.2 %
Run 2008-1 (3.0%)	

- Over the years many low-cost improvements were made to achieve 100% availability for low duty-factor runs.
- Raising the duty factor to ~0.8 % heated the LEBT, which started to arc and break the chopper HV switches. Minor modifications fixed the problem.
- Minor modifications were needed to increased the beam current output.
- The source and LEBT are currently delivering the required 25 mA MEBT beam current with ~100% availability.

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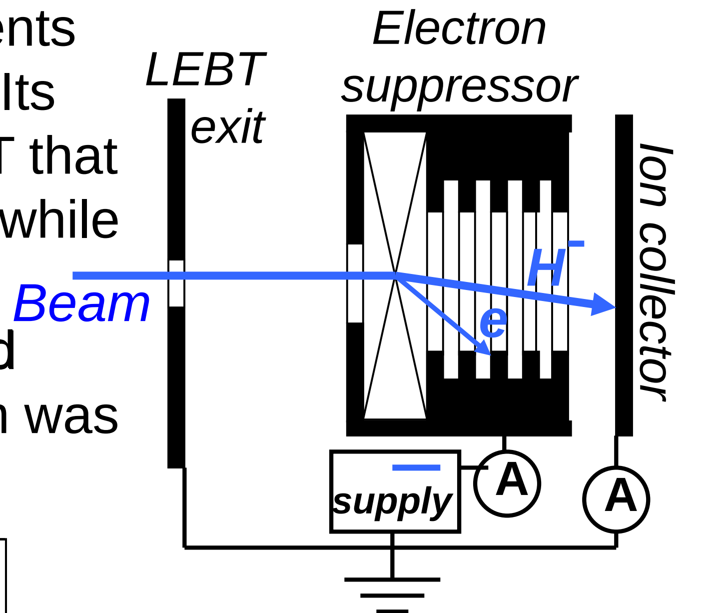
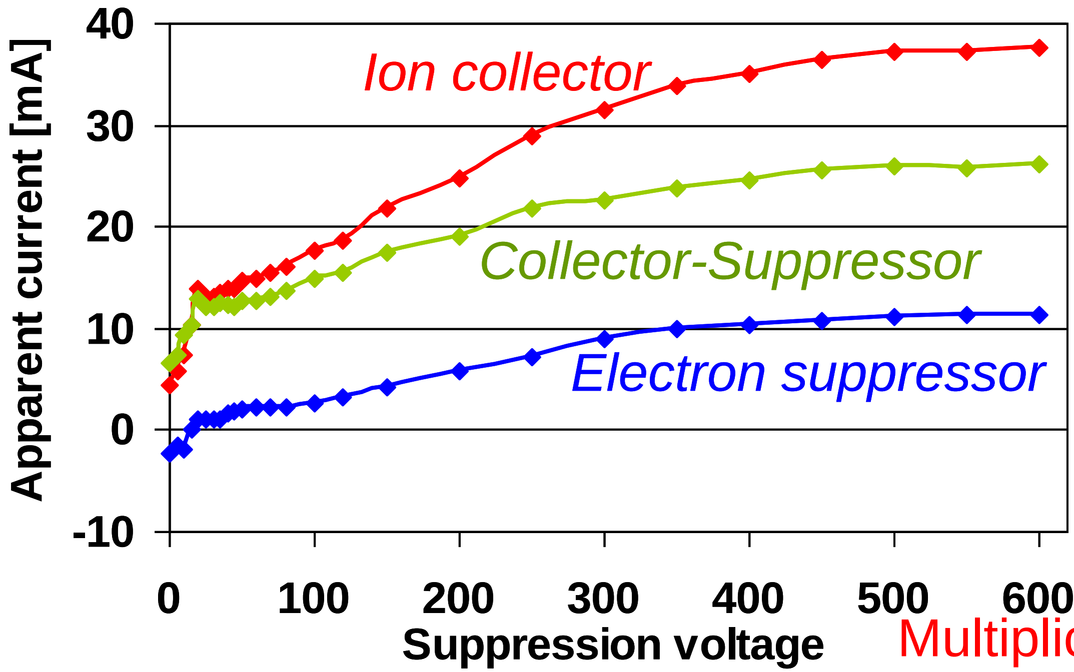
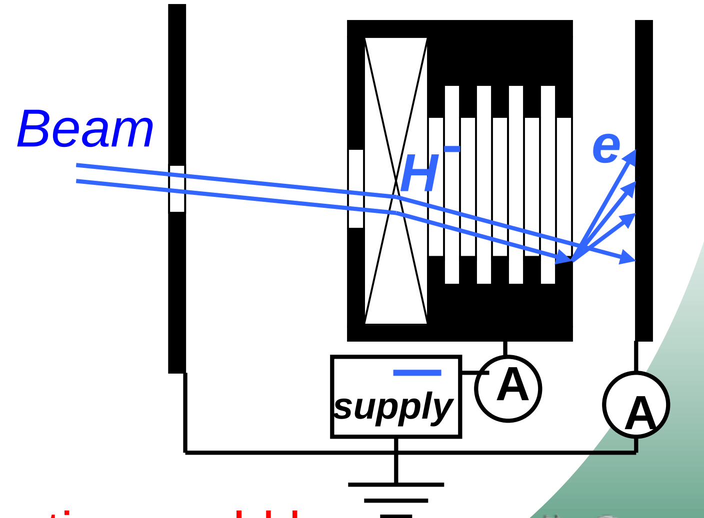
Early Beam Current Diagnostics on Ion Source Test Stand

(From ASAC'04F)

- Concerns about accurate beam measurements drove LBNL to design a special Faraday cup. Its water cooled Co-Sm magnets generate 0.07 T that sweep any 65 kV electrons into a suppressor while the H^- beam is collected on a plate.
- **The required high suppression voltage raised concerns.** Eventually we realized the the beam was multiplied by partly striking the suppressor.



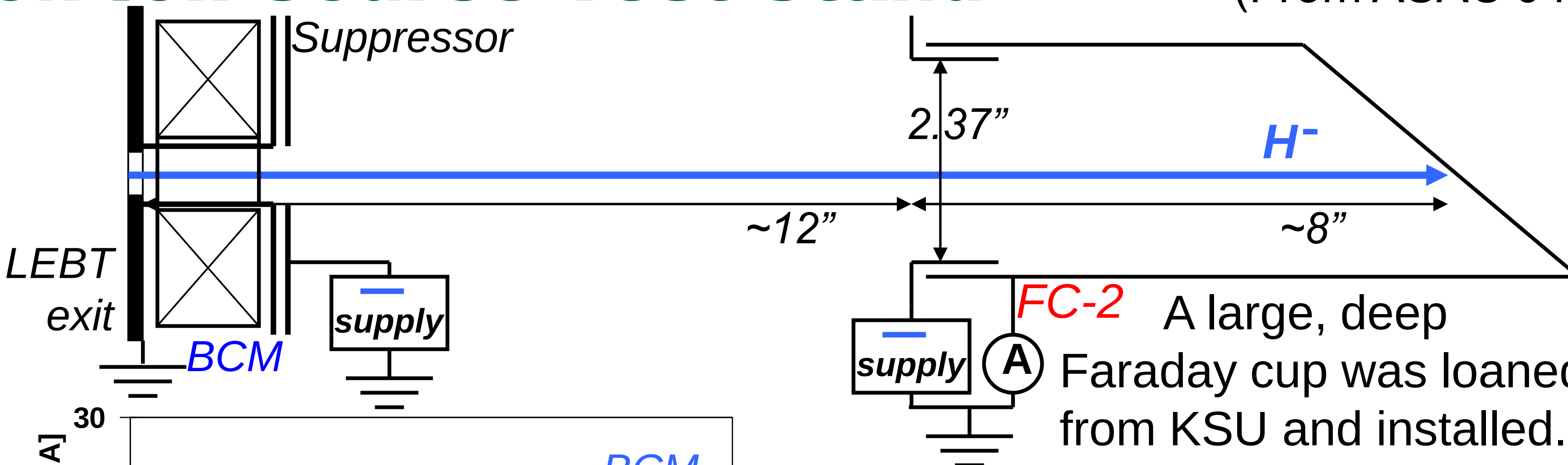




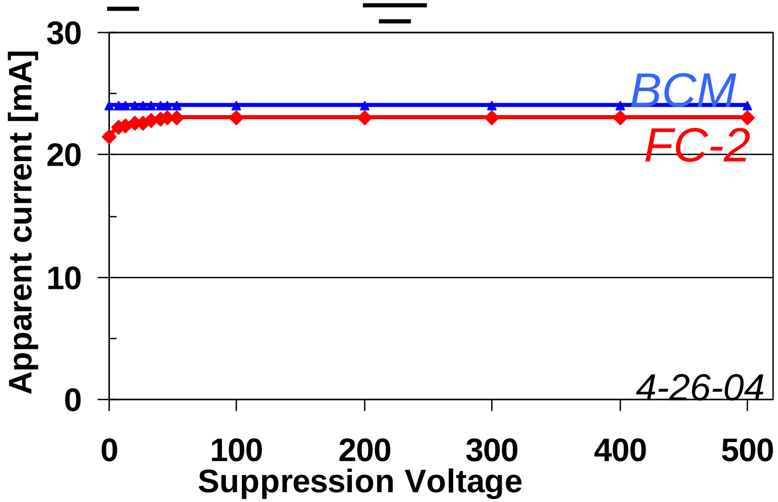
Multiplication could be optimized with lens 2!

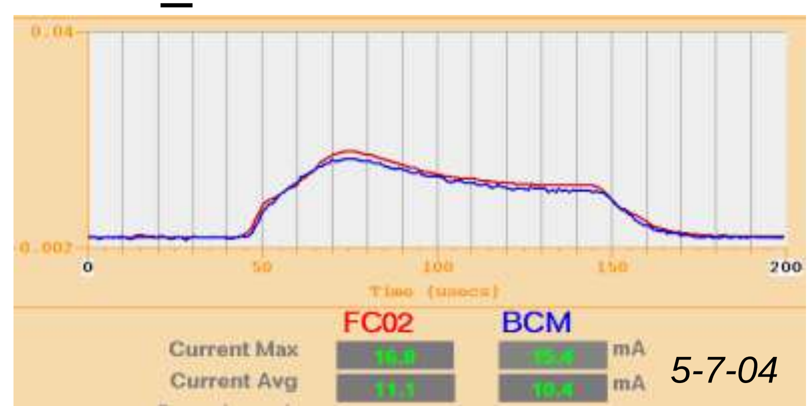
Recent Beam Current Diagnostics on Ion Source Test Stand

(From ASAC'04F)



A large, deep Faraday cup was loaned from KSU and installed.





Measurements agree within a few %! A bit larger, less-distant, water-cooled Faraday cup is being designed. LEBT steerers need to be installed!

2007: Before 5-2004 test stand current measurements are over-optimistic. Today, the BCM remains our most trusted measure! Controls is still planning to install the steerers!

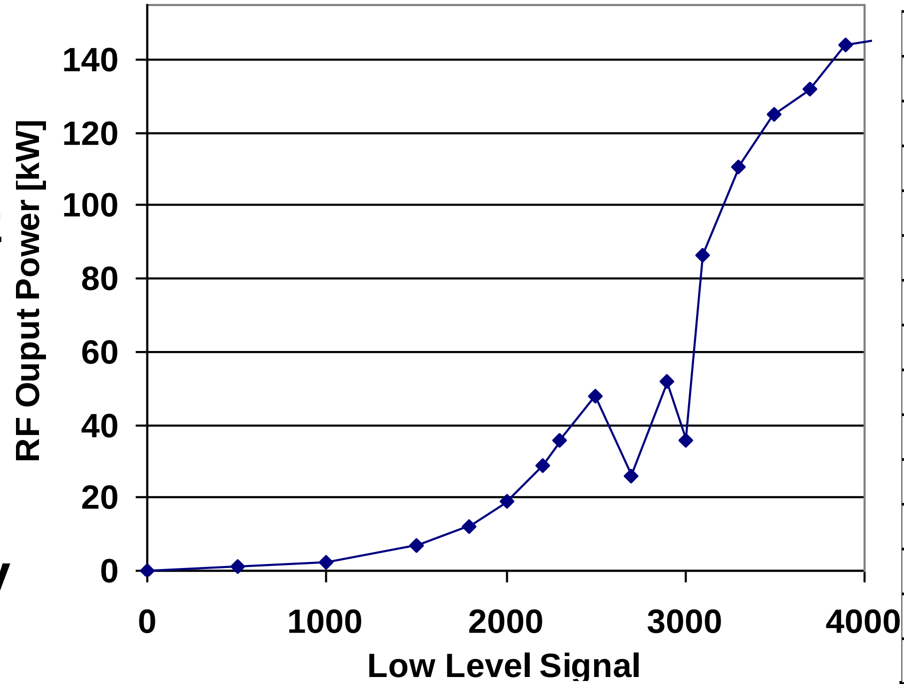
The LBNL 2 MHz Calibration:

LBNL delivered the 2 MHz amplifier with a rather unique look-up table.

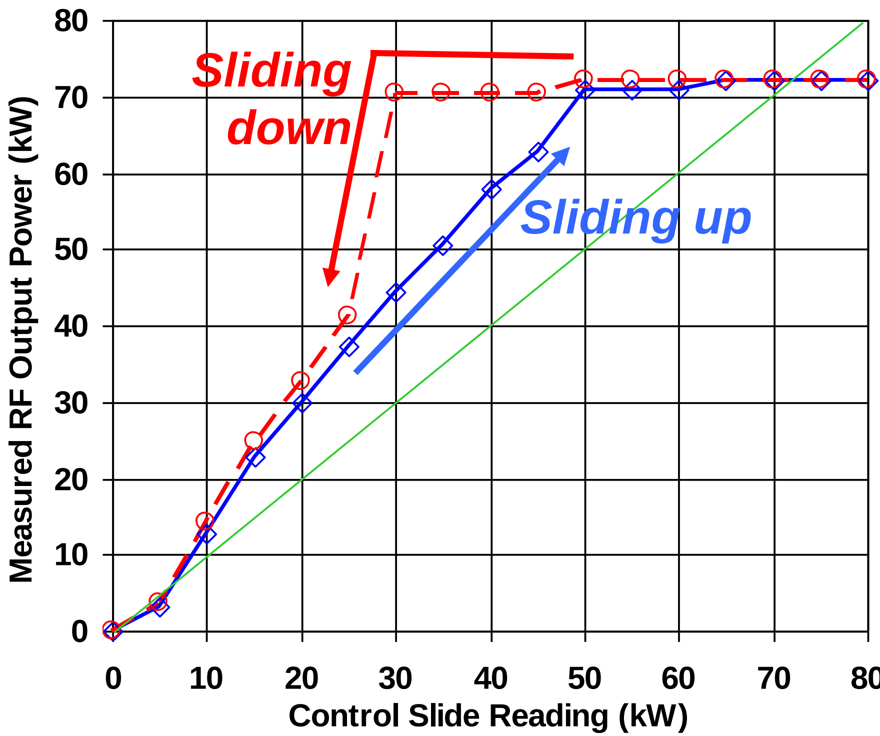
Yoon Kang's 2006 measurements yield interesting results:

- **3 settings are practically correct: 0, 5, and 70 kW.**
- **Most other settings significantly over-deliver, inflating mA/kW efficiencies by ≥50%.**
- **A hysteresis prevents all values between 26 and 50 kW from being recalculated, but likely were near 70 kW.**

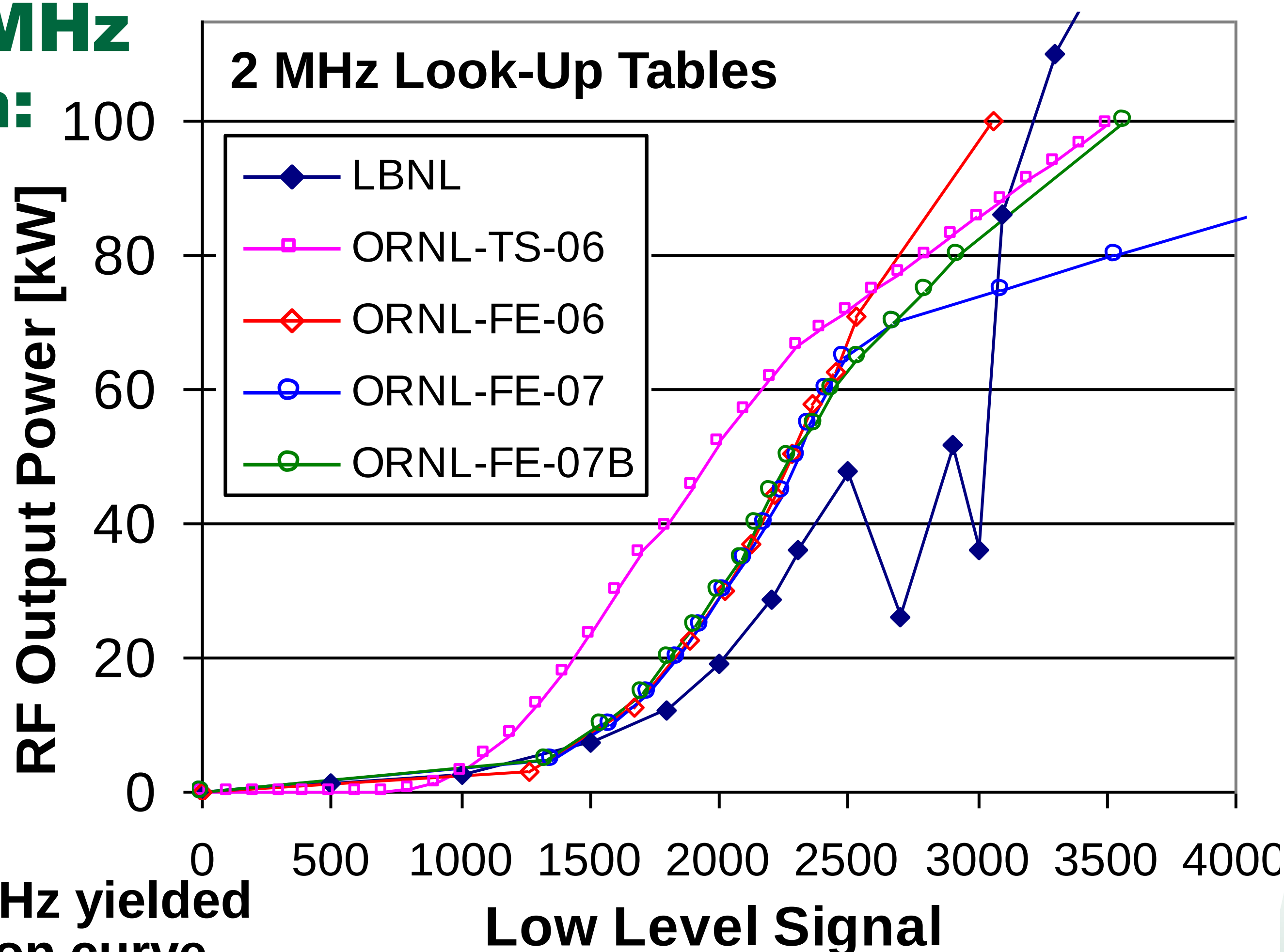
All Pre-October-2006 Frontend RF power values are seriously flawed!



0	0
500	1.2
1000	2.4
1500	7.2
1800	12
2000	19.2
2200	28.8
2300	36
2500	48
2700	26
2900	52
3000	36
3100	86.4
3300	110.4
3500	124.8
3700	132
3900	144
10000	192



The ORNL 2 MHz Calibration:



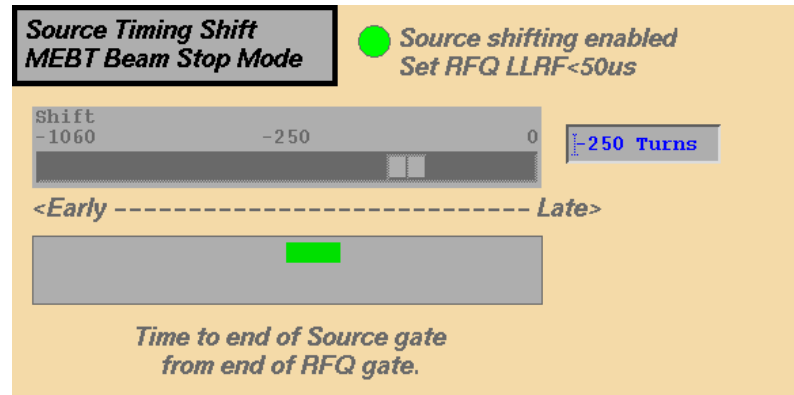
- **We were unable to reproduce the unique LBNL look-up table.**
- **Three calibrations of the Frontend 2 MHz found consistent curves that only differ at the high power end, which are based on extrapolations.**
- **The Test Stand 2 MHz yielded a different calibration curve. Reason is not understood.**
- **Pre-2006 Test Stand RF power-values are likely far off!**
- **We lack a calibration for the spare 2 MHz.**

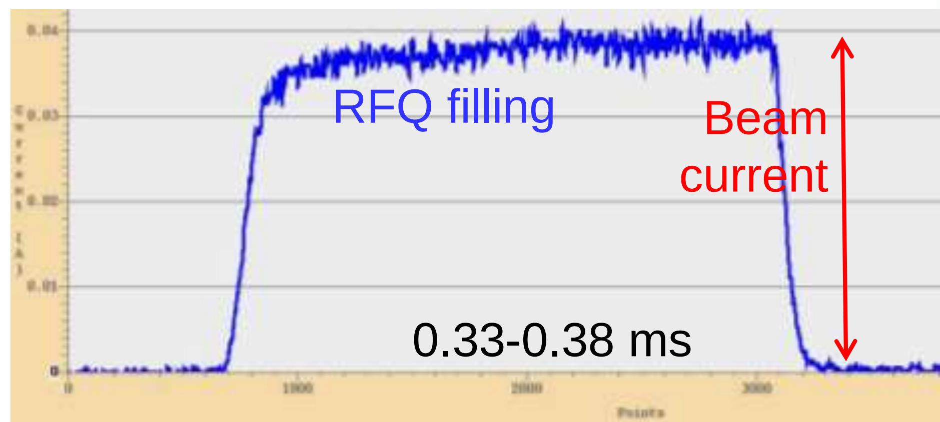
The RF group continues their effort to validate and improve the calibration of our three 2 MHz amplifiers!

Tuning the Ion Source and LEBT

- **The compactness of the LBNL LEBT allows for no beam current diagnostics before the RFQ.**
- **Therefore source tuning has to be delayed until RFQ is running.**
- **The MEBT beam stop power limit allowed only for the 1st 50μs to be measured, which are dominated by the plasma breakdown and initial beam current overshoot.**
- **A time-consuming retune was needed when the entire pulse length could be monitored.**
- **On Halloween 2007 Controls implemented a shift that allows the ion source pulse to be shifted through a 50μs window accelerated by the RFQ.**
- **This has eliminated many, many hours of beam tuning with questionable merit.**
- **Beam Current ≈ Peak Current –1 mA**

A beampulse with large overshoot





The best invention since sliced bread!

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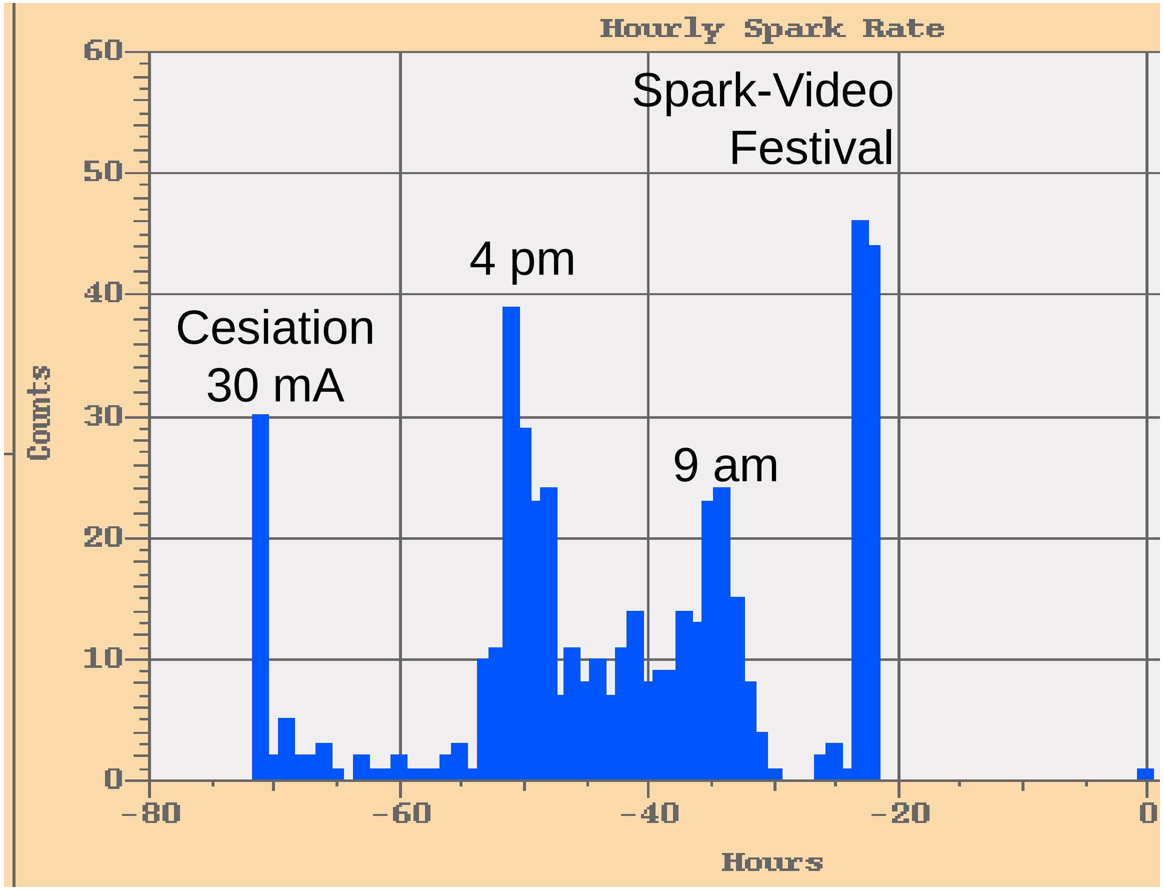
The 2007 LEBT problem



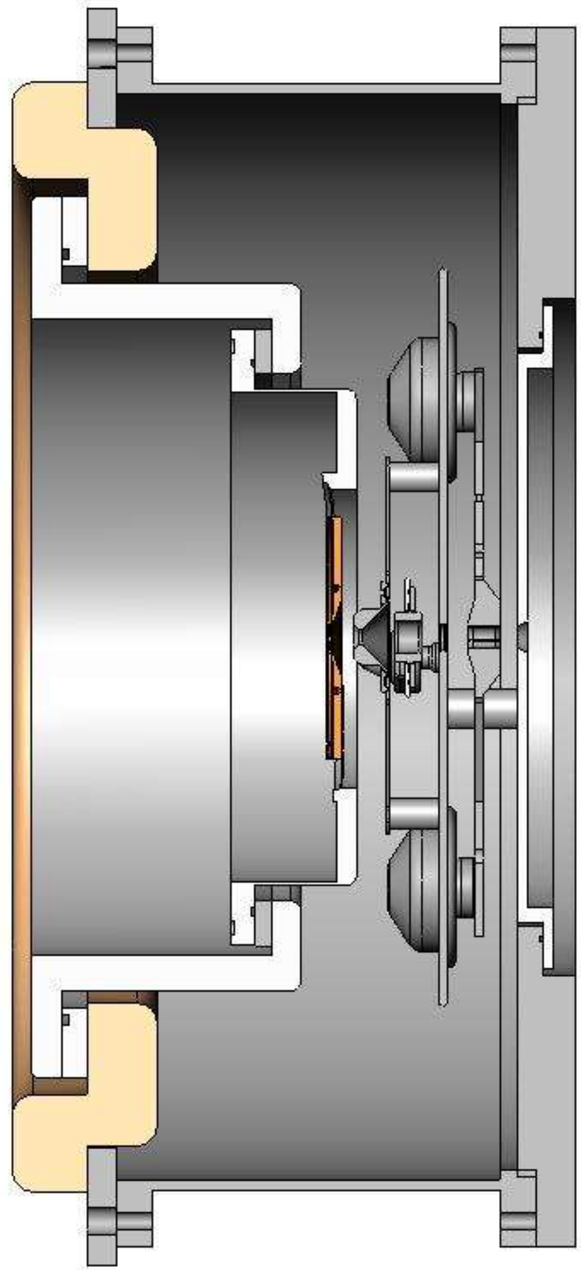
- Early in run 2007-2, when the duty factor was increased from 0.2 to 0.8%, frequent chopper failures suggested a sparking problem.
- ~1week later we had lens-2 spark counters that capacitively picked up high voltage fluctuations. They suggest sparkfest occurring often at random.

A robuster LEBT

Courtesy of R. Welton

A

A



•Exposure of the insulators is a risk!

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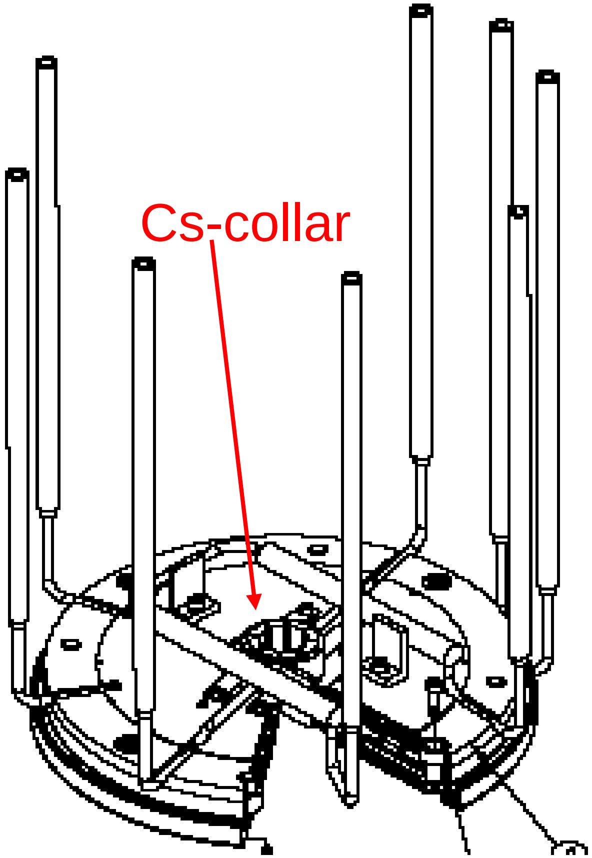
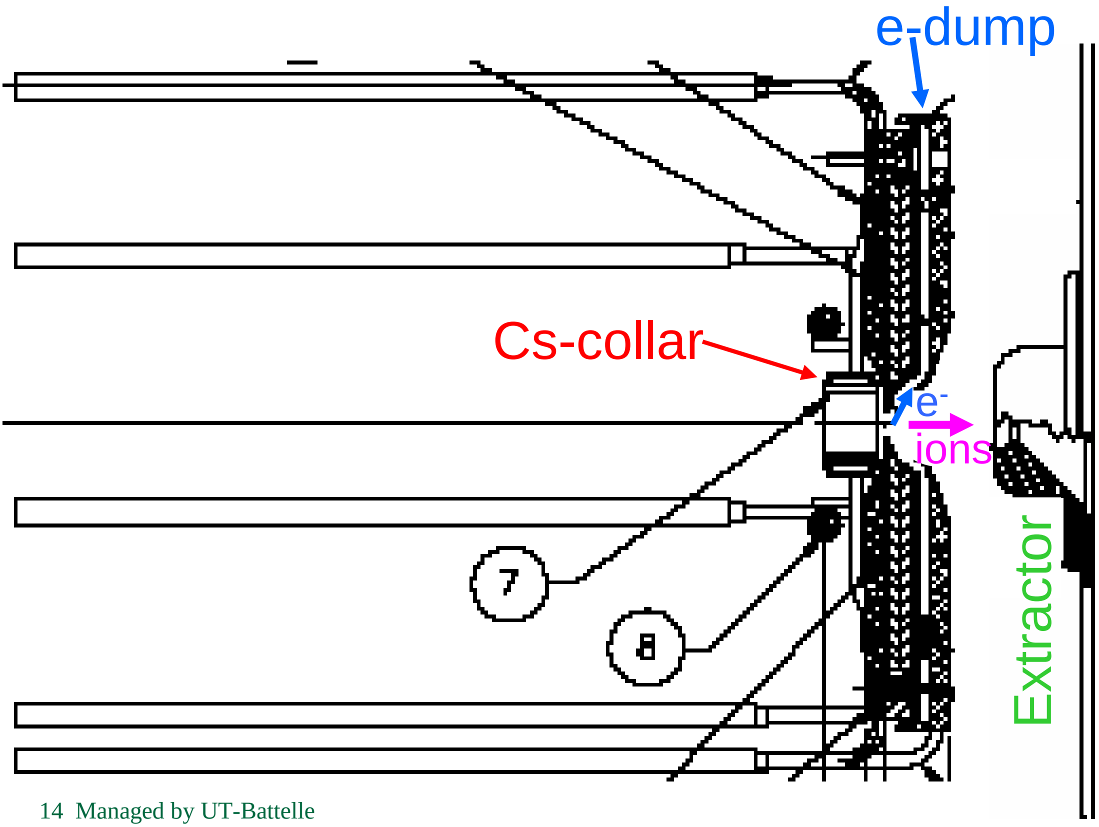
The LBNL Cs System:

The LBNL H- source features a complex outlet electrode assembly that

1. extracts the ions and forms a beam
2. deflects the co-extracted electrons onto the e-dump
3. adds surface produced H- ions to the volume produced ions





The LBNL Cs collar holds the cesium cartridges and its outlet aperture where the surface-produced ions originate. The entire collar can be heated with an external compressed air heater up to ~400 °C.

AAC'07"Stockli

Cs dispensers by SAES Getters

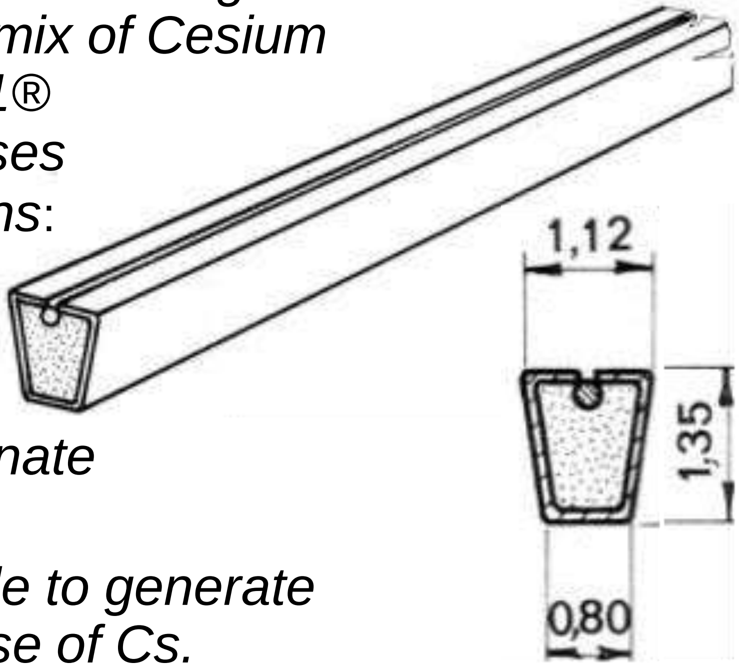
• *The LBNL H- source uses eight 12 mm long Cs cartridges from SAES Getters. The nichrome shell contains a mix of Cesium chromate (Cs_2CrO_4) with reducing agent St101® (84%Zr+16%Al) that also absorbs the active gases that are produced during the reduction reactions*:

$4\ Cs_2CrO_4 + 5\ Zr \rightarrow 8\ Cs\ (g) + 5\ ZrO_2 + 2\ Cr_2O_3$

$6\ Cs_2CrO_4 + 10\ Al \rightarrow 12\ Cs\ (g) + 5\ Al_2O_3 + 3\ Cr_2O_3$

when being heated to 550 – 850℃.

A metal wire partially obstructs the slit to eliminate the escape of loose particles.



- *The compressed gas heating system is unable to generate temperatures high enough to initiate the release of Cs.*
- *Accordingly, the release of cesium is initiate by shutting off the air flow and heating the cesium collar with the plasma.*
- *A thermocouple inserted in to the air duct of the collar measures the temperature of the collar. The temperature of the cartridge is higher due to the thermal resistance between the cartridges and the collar.*
- *After initially exploring a wide range of parameters, we settled on heating the collar to 500 or 550℃ for 20-30 minutes.*
- *This was repeated until the desired current was achieved.*

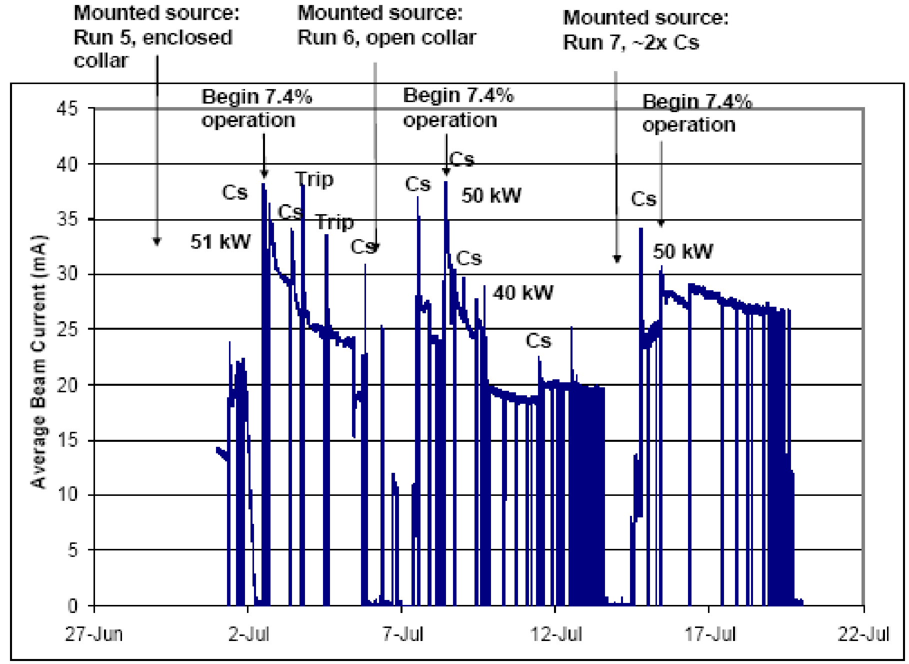
This worked on the Frontend with limited persistence!

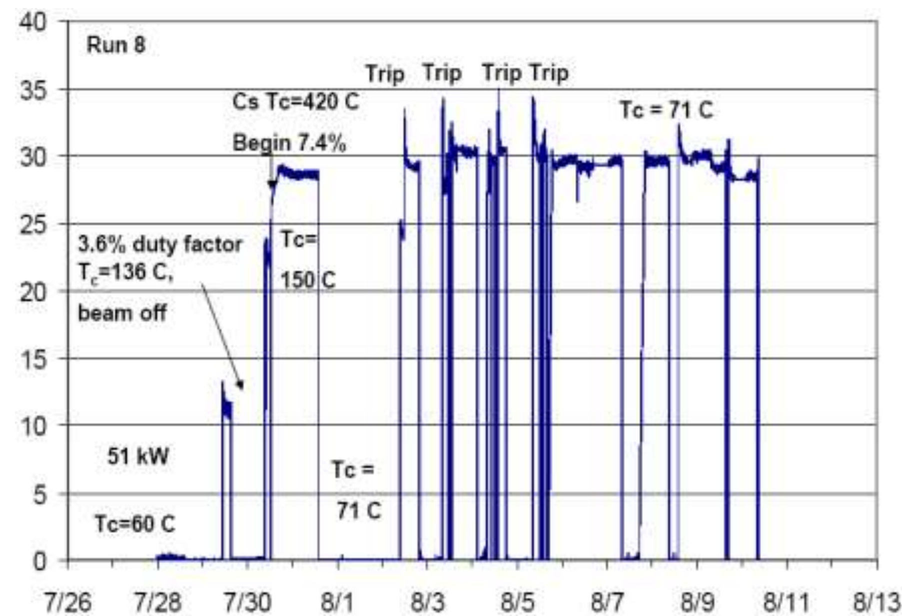
Early Cs R&D

- However, for long pulses on the test stand it generated only 20-25 mA, not the ~41 mA required for 1.4 MW ops.
- In 2006 R. Welton tried to increase the yield by optimizing the positions of the antenna, the cesium collar, etc.
- He then started to suspect the getter in the cartridges to be incapacitated by the residual gases in the source.

> "Unlike …Runs 1-7, in the new technique the source was outgassed at ~7% duty-factor and 50 kW of RF power for ~1 day while maintaining the collar temperature below 150 C. This led to our highest average beam current of any experimental run: 30 mA, suggesting much more Cs was delivered to the source". From R.F. Welton et al, AIP Conf. Proc. No.763 (2005), pp. 296-314.

In addition, the paper calculated that a 0.5 monolayer of Cs is sputtered away in 2.5 s.

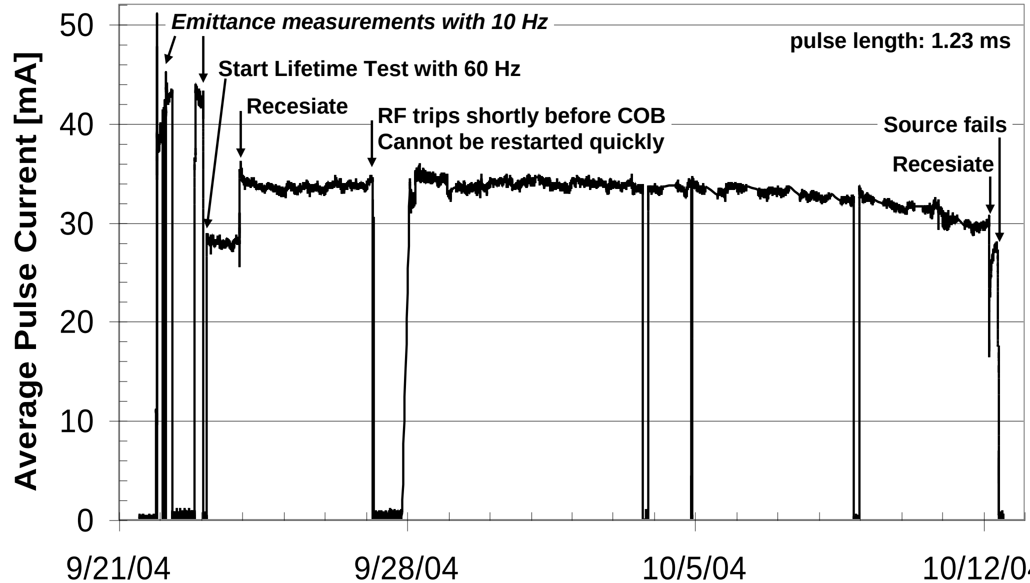


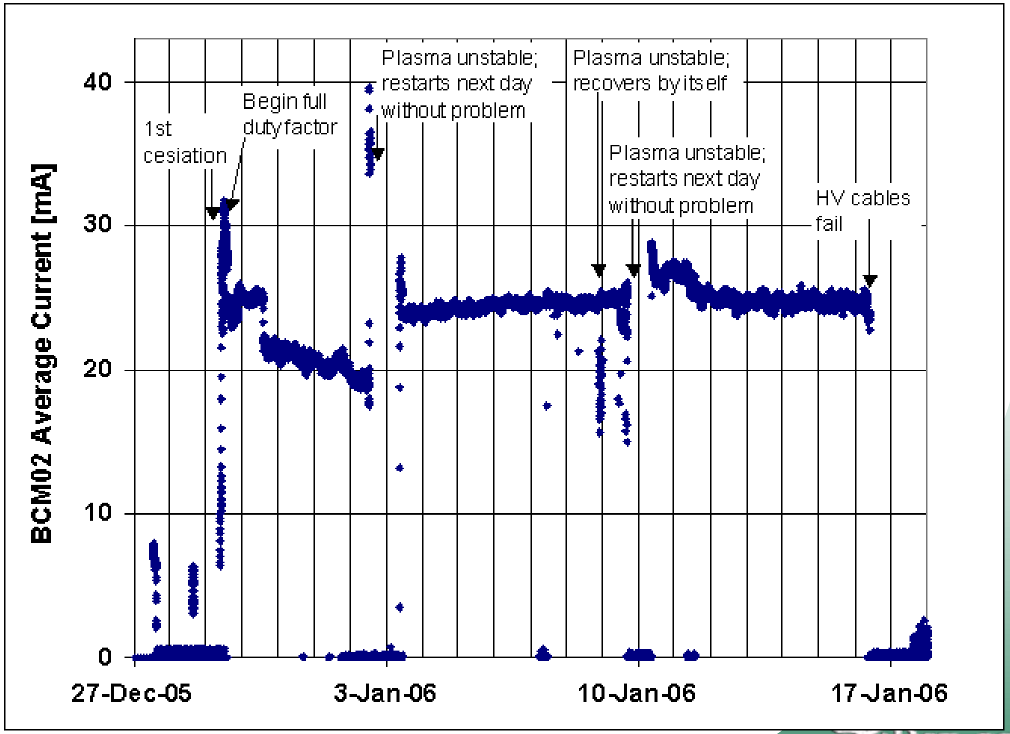


The initial experiment seemed to confirm the hypothesis!

Early Cs R&D

The next experiment was even better! Therefore it was concluded: “these reactions are limited by the availability of Zr and Al rather than Cs_2CrO_4. Computational thermodynamic analysis reveals that at temperatures greater than ~250 C, Zr and Al will spontaneously react and form stable compounds with residual gases evolved from the source during initial out-gassing. Therefore, it is clear that the Cs collar must be maintained at temperatures below 250C, **ideally as cold as possible,** until the source has been conditioned (out-gassed) to full duty-factor before heating the Cs collar”. From R.F. Welton et al, PAC’05, Knoxville, TN (2005) pp. 472-474.



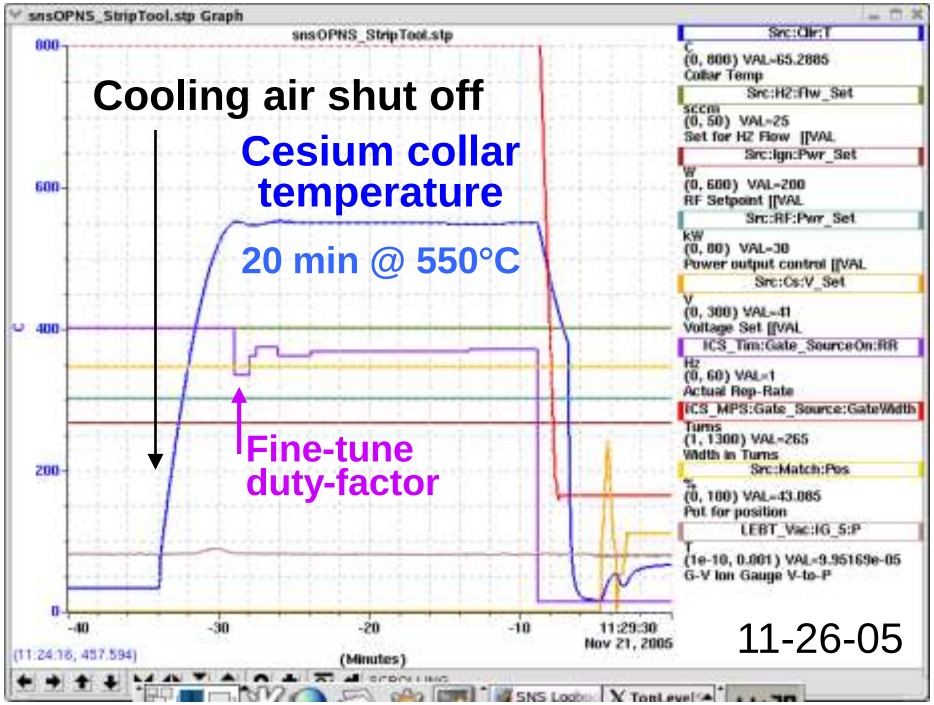


However, a later repetition yielded 25 mA, no more than the early runs!

But we continued to condition as cold as possible!

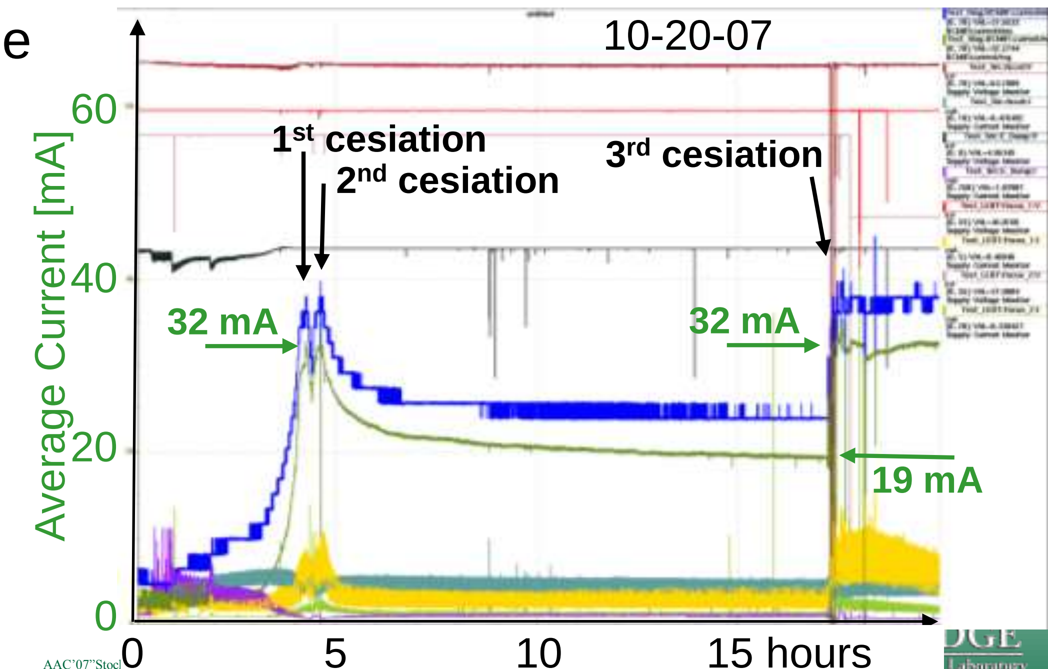
Improving our Cesiation Procedure

- "Repeating 20-30 minutes at 500-550°C until having desired beam" was very unsatisfactory.
- We learned to precisely control the temperature at 550°C and time variations showed that 40 minutes would most frequently produce the desired results, although sometimes it would take an hour.



- Excess cesiations became an issue because of excessive sparking killed the chopper electronics.
  - The beam always decreased rapidly during the first shift. Only cesiation ~10 hours after start up would yield persistent beam.

Clearly, new ideas are needed!



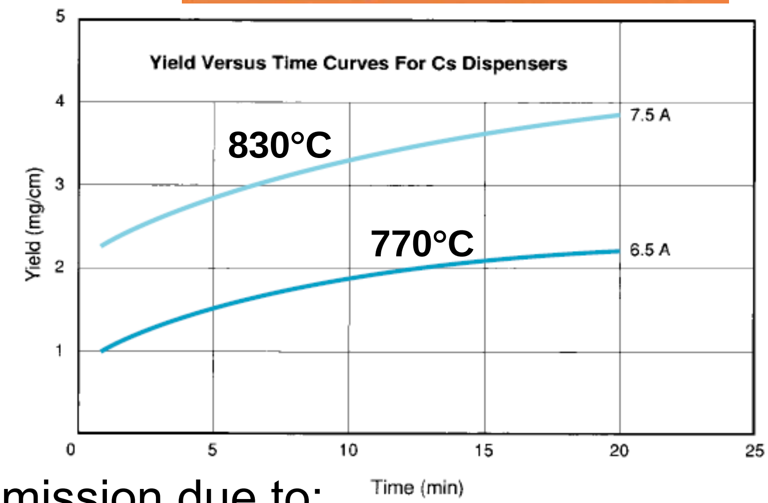
From the "saes getters" manual

saes getters
Gettering Products for The Electronic Industry Throughout The World

•A continuous program of research at SAES Getters S.p.A. into means of controlling the release of alkali metals has led to SAES Alkali Metal Dispensers for the photo-tube industry. …..

•SAES alkali metal dispensers are particularly suitable for … following problems ..:

- •Very pure alkali metal films are required
- •The rate of evaporation of the alkali metal has to be controlled at will
- •The rate of evaporation of the alkali metal must be reproducible



•All SAES alkali metal dispensers have… low gas emission due to:

- •The use of **excess** of ST101 nonevaporable getter alloy as a reducing agent for the alkali alloy which also sorbs, at the source, the gas generated in the reaction.

•The gases released from the SAES dispensers have been measured after having submitted them to a typical bake-out process simulating the conditions in which the photo tubes are normally processed. …. about 1 cc torr/cm, mostly hydrogen.

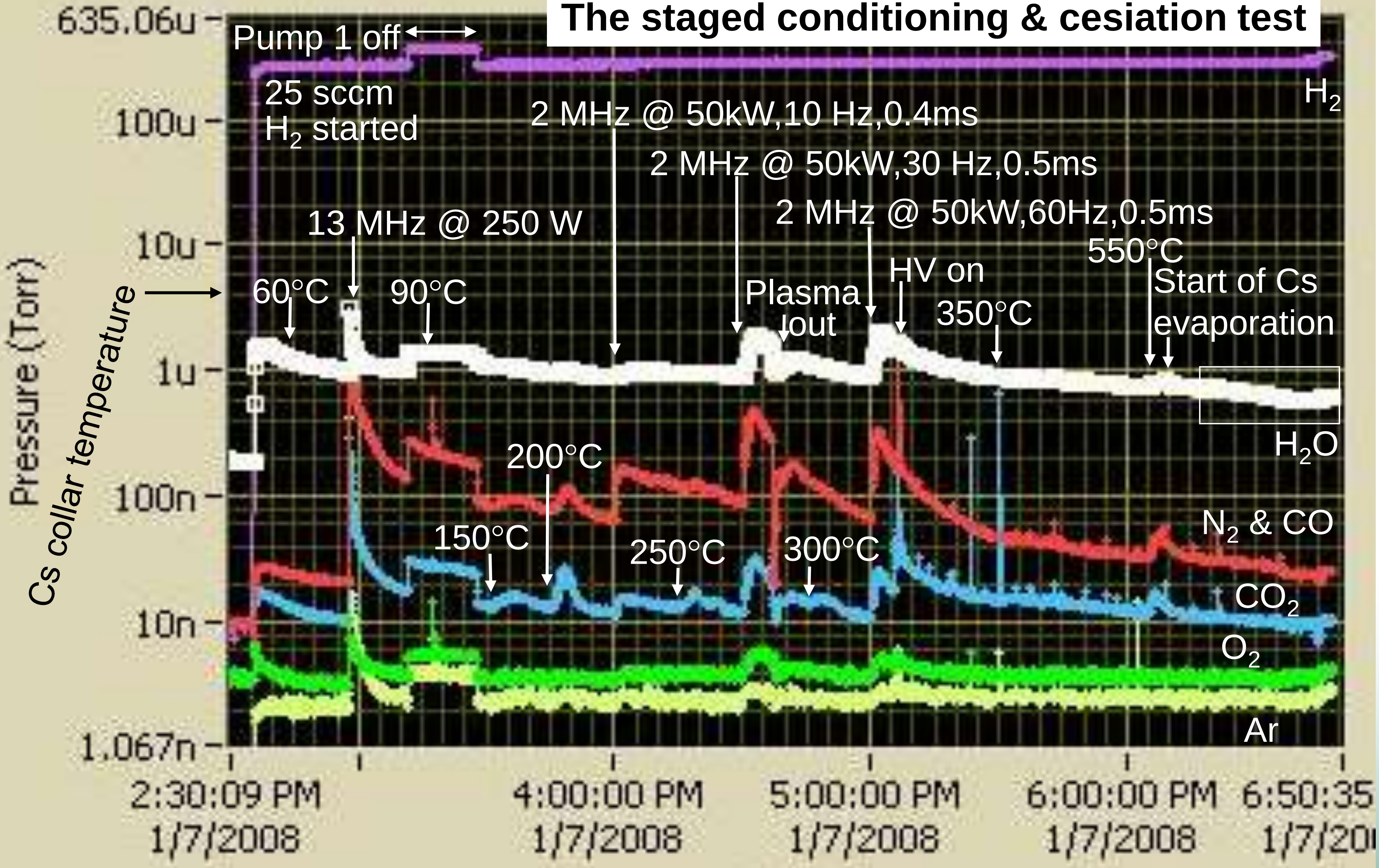
•SAES alkali metal dispenser are normally current controlled. SAES suggest to ramp up the current by 0.1A/min, or about over ~1 hour period.

•The Cs emission threshold is at 4.7±0.2A (standard deviation) ≅ 620 ±20°C

1. **Temperature not a major concern as excess ST101 pumps residual gas!**
2. **Ramping temperature degasses the sintered Cs_2CrO_4/ST101 powder!**
3. **Time variations have to be expected!**

Cs Indicator needed!

The staged conditioning & cesiation test

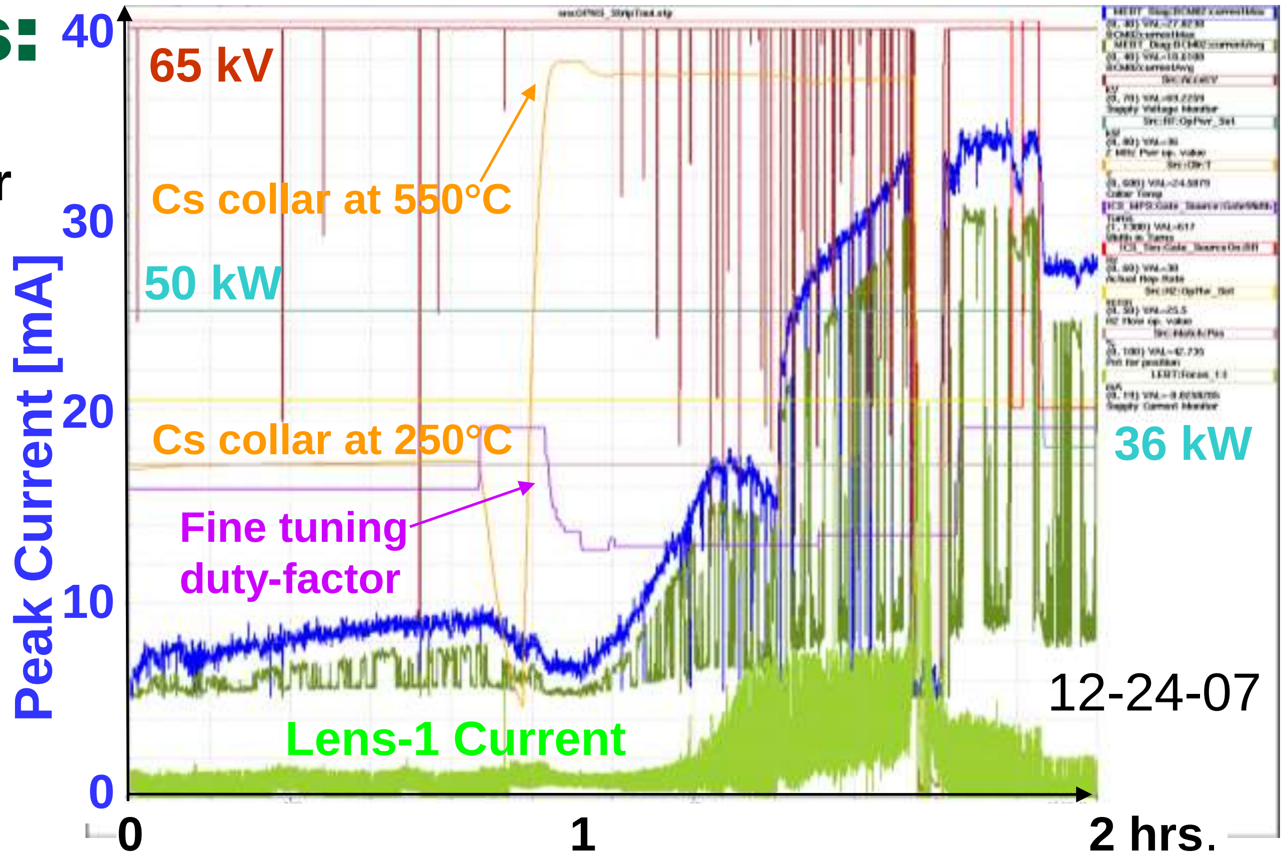


1. **Start Hydrogen flow ASAP!**
2. **Ramping the Cs collar temperature to ~300°C beneficial!**
3. **H_2O not a good Cs indicator!**

Cs indicators:

The release of Cesium is indicated in order of increasing reliability by

1. Drop in H_2O partial pressure
2. Arcing of 65 kV supply
3. Increase of 65 kV load current
4. Arcing of lens 1
5. Increase of load current of lens-1
6. Increase in beam current



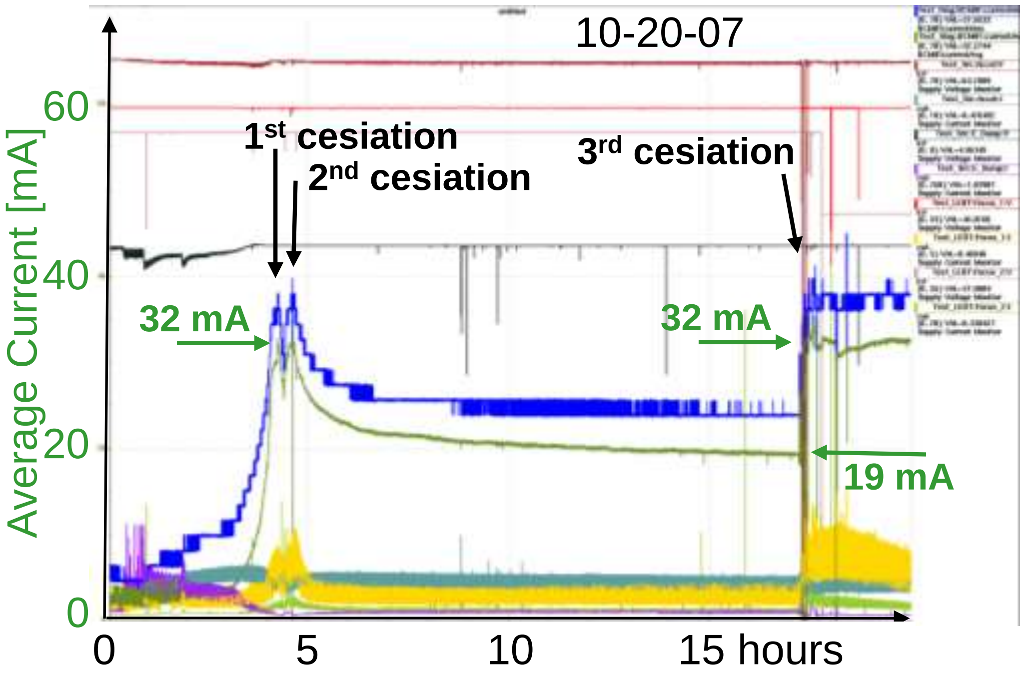
- Therefore we cesiate with beam-on whenever possible. This has added invaluable insight into the process!
- When RFQ not available, or 65 kV arcing excessively, we resort occasionally to observing the lens 1-current. The lens-1 current is less reliable because it can change for other reasons, and not all of them are understood.

What are we observing?

First Cesiations:

- There are some processes and/or work that need to happen at elevated temperature before the cesium cartridges start to release Cs.
- Especially when the temperature is not ramped up during conditioning, the Cs release is delayed by some significant time.
- The time delay depends on collar temperature during conditioning and the RF power. It exhibits a significant spread.

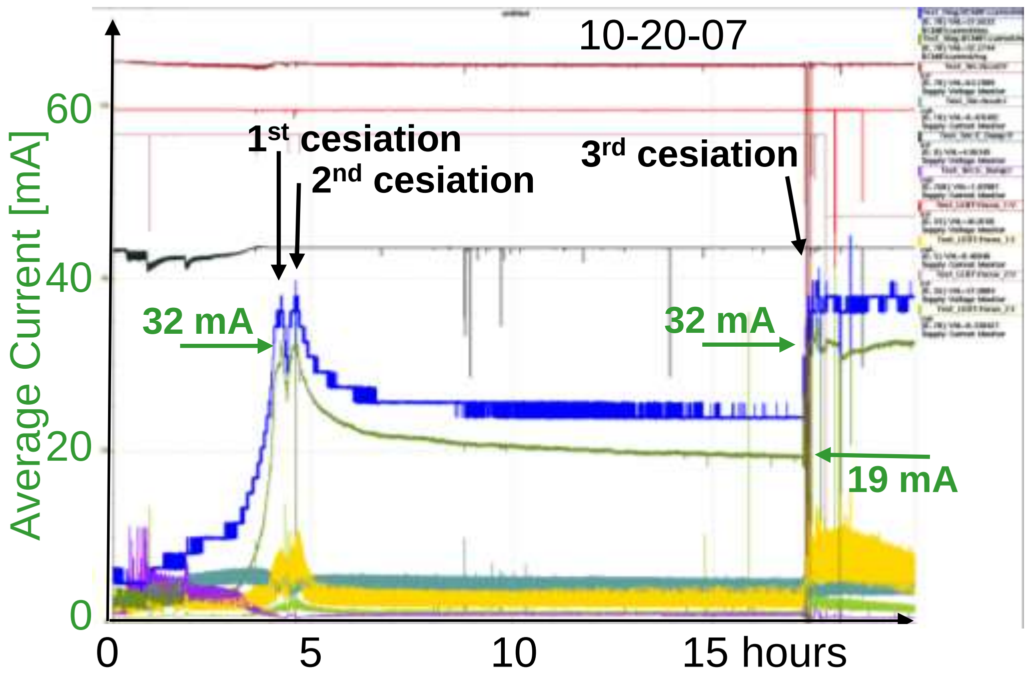
•The persistence of the first cesiation is normally poor. It starts to level off after a few hours at a much lower level.



Final conditioning temperature	Cesiation tempera-ture	Cs release after starting cesiation
~50 °C	500 °C	~120 min.
~50 °C	550 °C	~60 min.
250 °C	550 °C	~10 min.
350 °C	550 °C	~5 min.

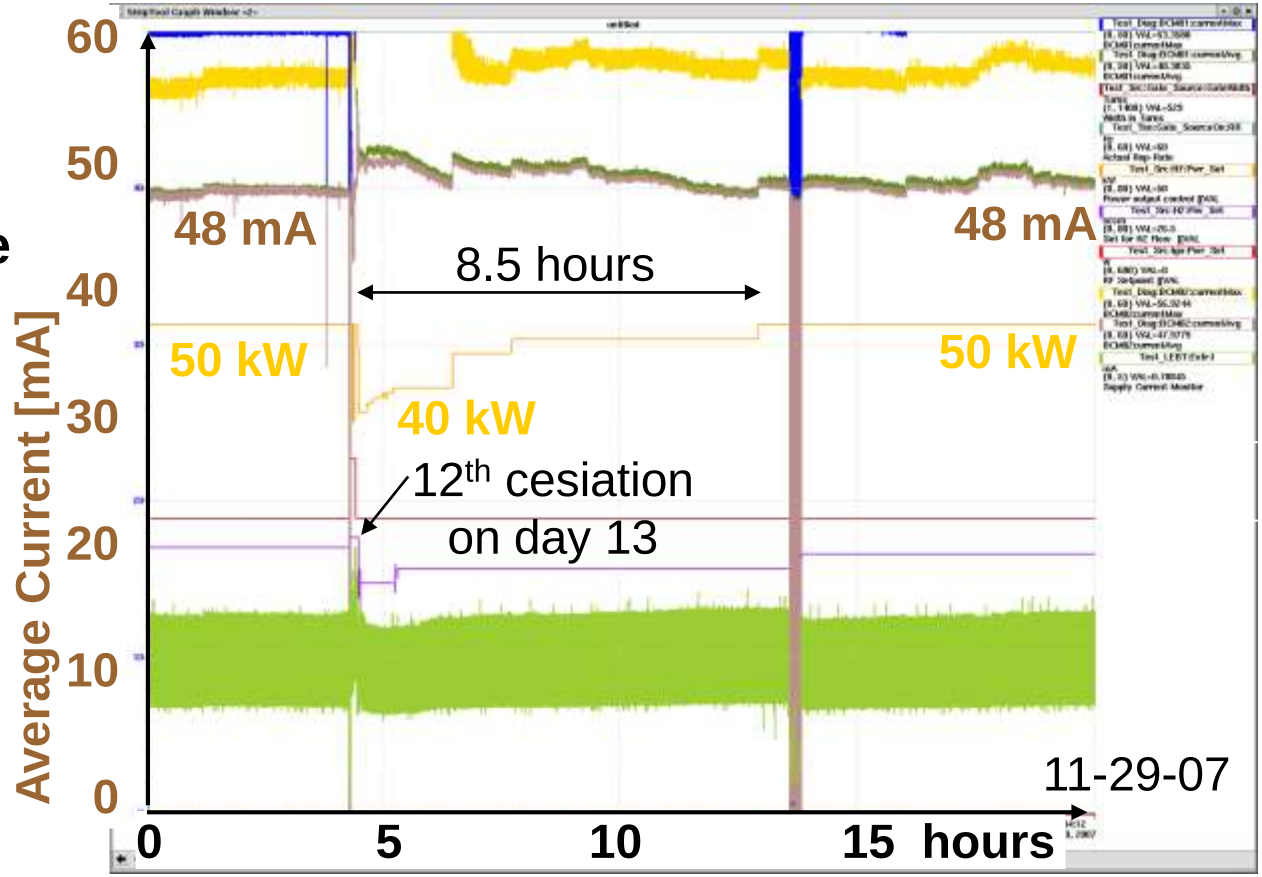
Subsequent Cesiations:

- Once Cs has been released from the cartridges no more prolonged heating is required. Additional cesium is released by simply increasing the cartridge temperature to ~500°C.
- Subsequent cesiations reach normally higher peak values but also with a limited persistence.
- After a few hours the performance levels out on a higher level than before.



Asymptotic Cesiations:

- To understand the ultimate performance that can be achieved with cesiations, we cesiated almost every day during a 2-week run on the test stand!
- Most recesiation consisted of heating the Cs collar to 500° and keeping it there for 2-3 minutes.

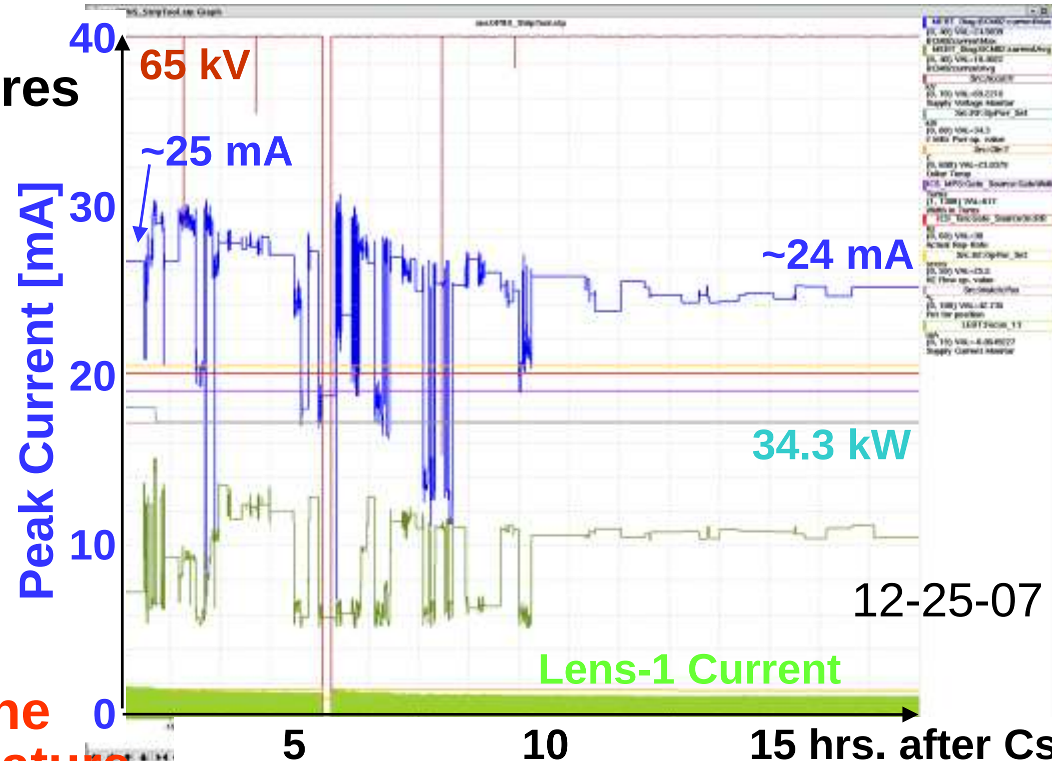


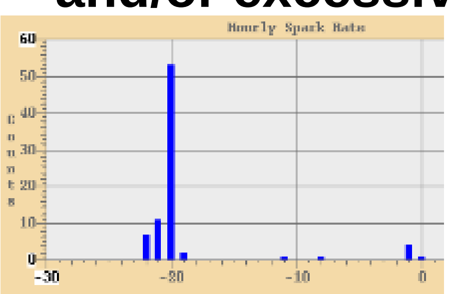
- Recesiations increased the beam current and, assisted by a reduction of H_2 flow, added up to ~30% to the previous 48 mA. Alternatively, we reduced the RF by ~30% to maintain ~50 mA. Over the next few hours the excess current dropped off ~exponentially, or alternatively we restored the RF to maintain the 50 mA. In less than 10 hours, the beam production returned to the previous ~48 mA with ~50 kW.

Obviously at least 2 kind of persistences!

So, what appears to be happening?

- **There are surface states where the Cs atoms are strongly bound and therefore resist sputtering.**
- **Initially a fraction of those states are occupied by absorbed residual gas and or contaminates. As those are sputtered away and replaced by Cs atoms, the highly persistent beam output increases.**
- **There are other surface states, where the Cs atoms bond with less energy, and therefore easily sputter, showing a poor persistence.**
- **Once fully established, the base performance level requires only rarely re-cesiations.**
- **This performance level can be increased by up to 30% if there is a steady flux of Cs replacing the sputtering losses. Such a flux could be established with an external Cs reservoir, a hot Cs-collar, and/or excessive cesiations.**





Combining ramping up the collar temperature with the typical 1 hour cesiation time yielded a heavy cesiation with very high persistence!

So, What is the IDEAL Procedure?

The ideal conditioning procedure

- Pump down
- Add 25 sccm hydrogen when p<10-4 Torr
- After a while rapidly ramp up RF to desorb residual gas and sputter clean Cs collar outlet aperture while
  - Letting Cs collar outlet aperture get as hot as possible
  - Ramp the cesium cartridges temperature to ~200°
- XX minutes before cesiation
  - Ramp the cesium cartridges temperature to 400 C
- Cesiation
  - Turn on cooling air to Cs collar outlet aperture
  - Shut off cooling air to Cs collar
  - Raise Cs collar to ~550 C
  - Use time to dose Cs
  - Turn on cooling air
- Next 10 hours
  - Maintain Cs collar at XXX C to maintain a small Cs flux

However, we do not have separate temperature controls for the Cs collar and its outlet aperture. A compromise is needed!

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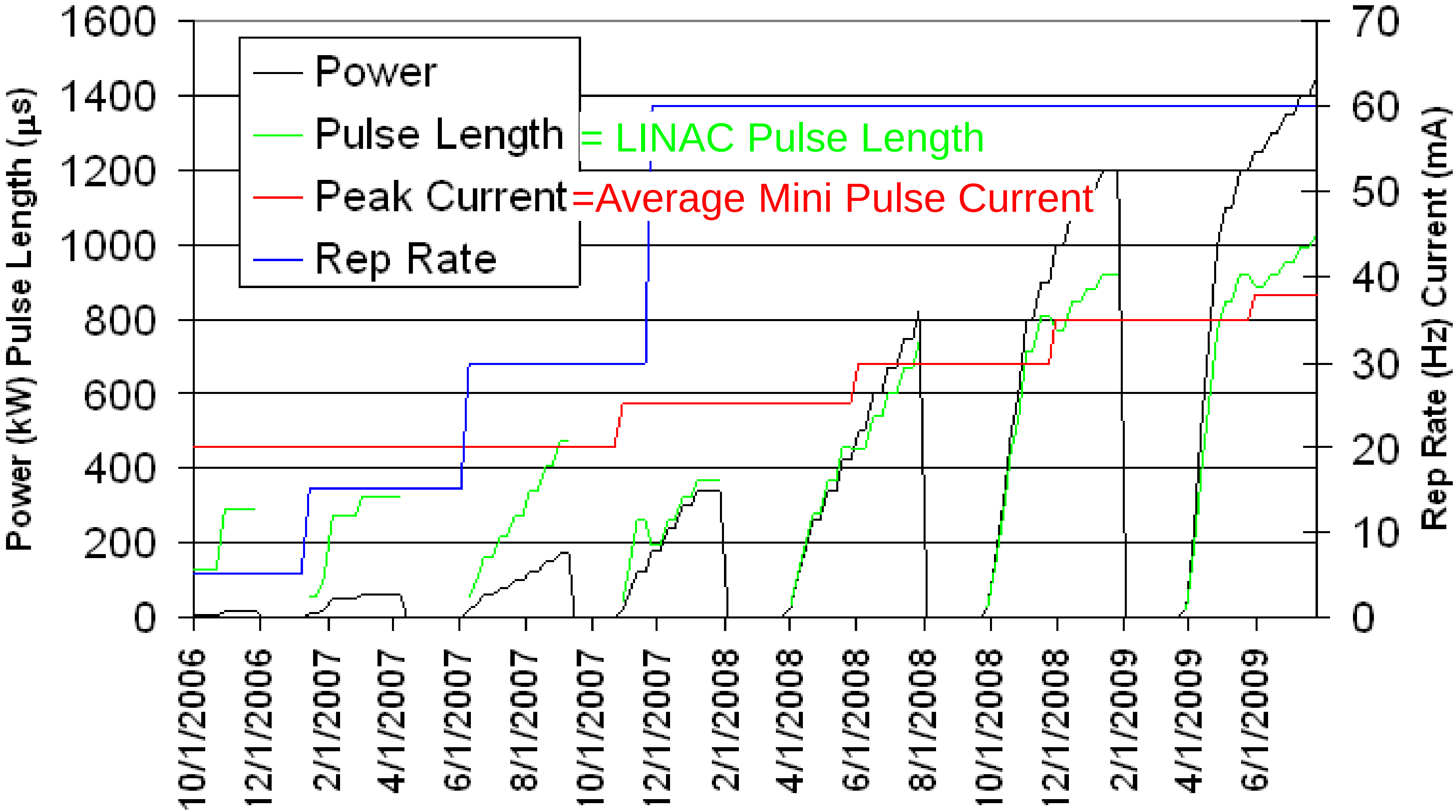
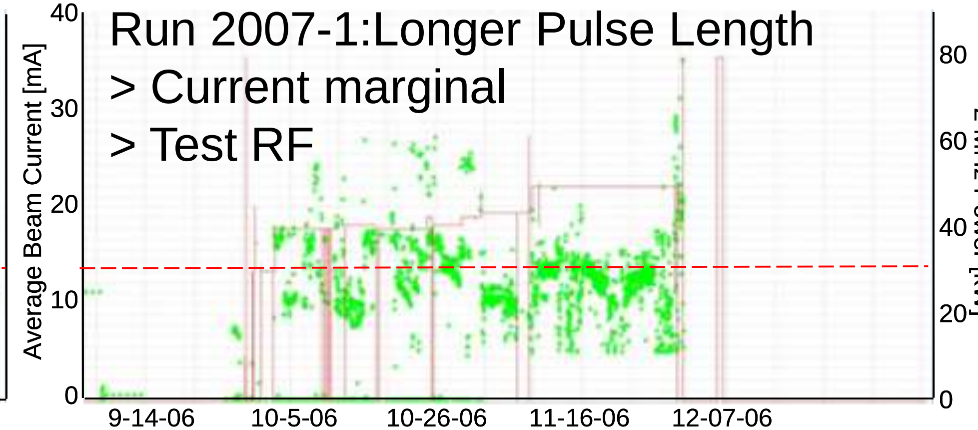
The SNS Power Ramp Up:

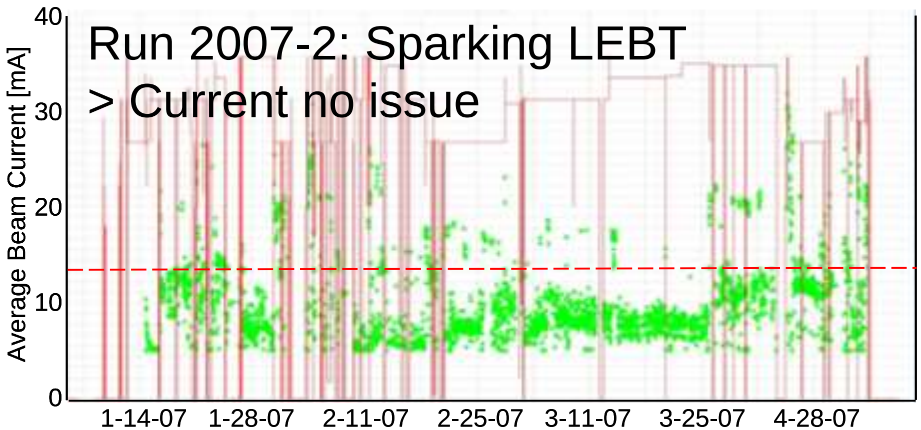


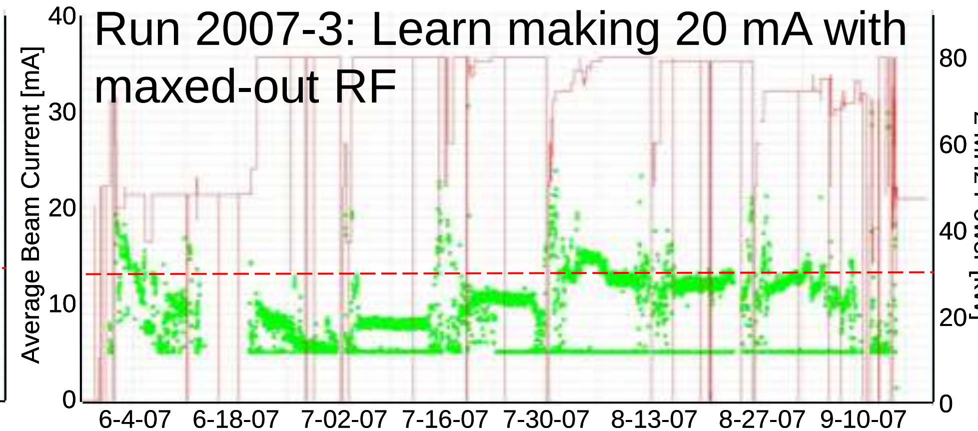
(Source Pulse Length) = (LINAC Pulse Length) + 0.2 ms

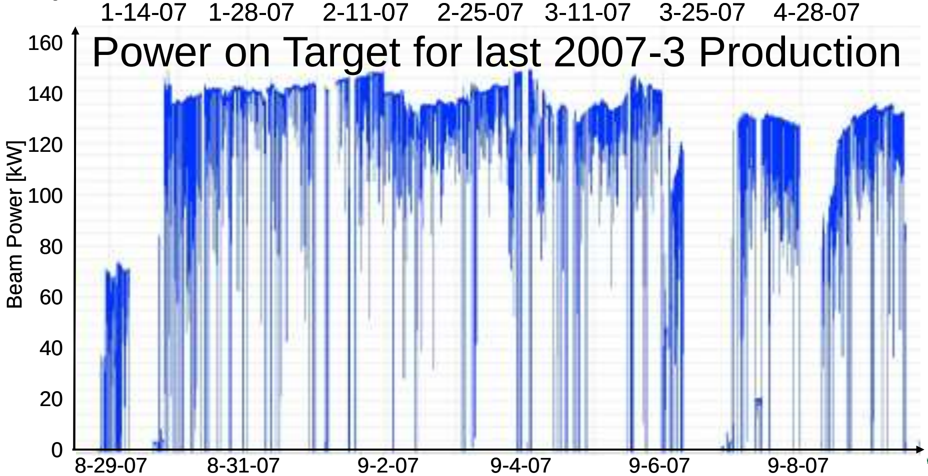
Can the SNS ion source and LEBT provide the required MEBT beam currents at the rep rates and pulse lengths given by the ramp-up plan?

The 20 mA Challenge: (=13.6 mA average chopped)









With maxed-out RF, the beam power depends on Ion Source mood swings, etc. It is better to use **less** RF for producing the **25 mA** for Run 2008-1.

Need to increase efficiency!

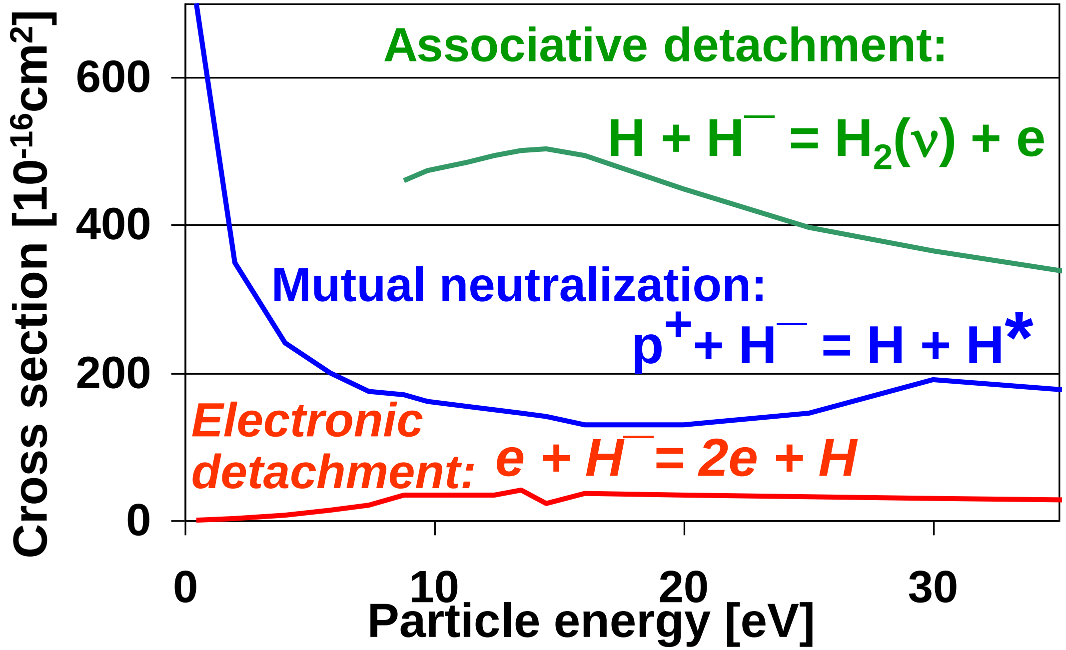
Need to reduce inefficiencies!

The p⁺ac-Man Problem!

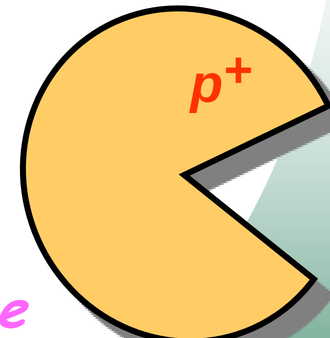
From LINAC'06

H^- ions are mainly destroyed by 3 mechanisms:

In cold plasmas losses are dominated by mutual neutralization (σ =70 Gb for $T_{p^+} \approx 0.5$eV). After a path length x through a proton density n_{p^+}, the number of surviving H^- ions is : $N_{H^-} = N_0 \cdot e^{-n \cdot x \cdot \sigma}$, or for $n_{p^+} = 5 \cdot 10^{13}$ cm^{-3}, only about ⅓ survive a path length of $x = (n_{p^+} \cdot \sigma)^{-1} \approx 0.3$ cm ≈ ⅛"!



The p⁺ac-Man problem can be reduced by producing the H^- ions as close as possible to the outlet aperture so they can get out before being caught by the hungry p⁺.

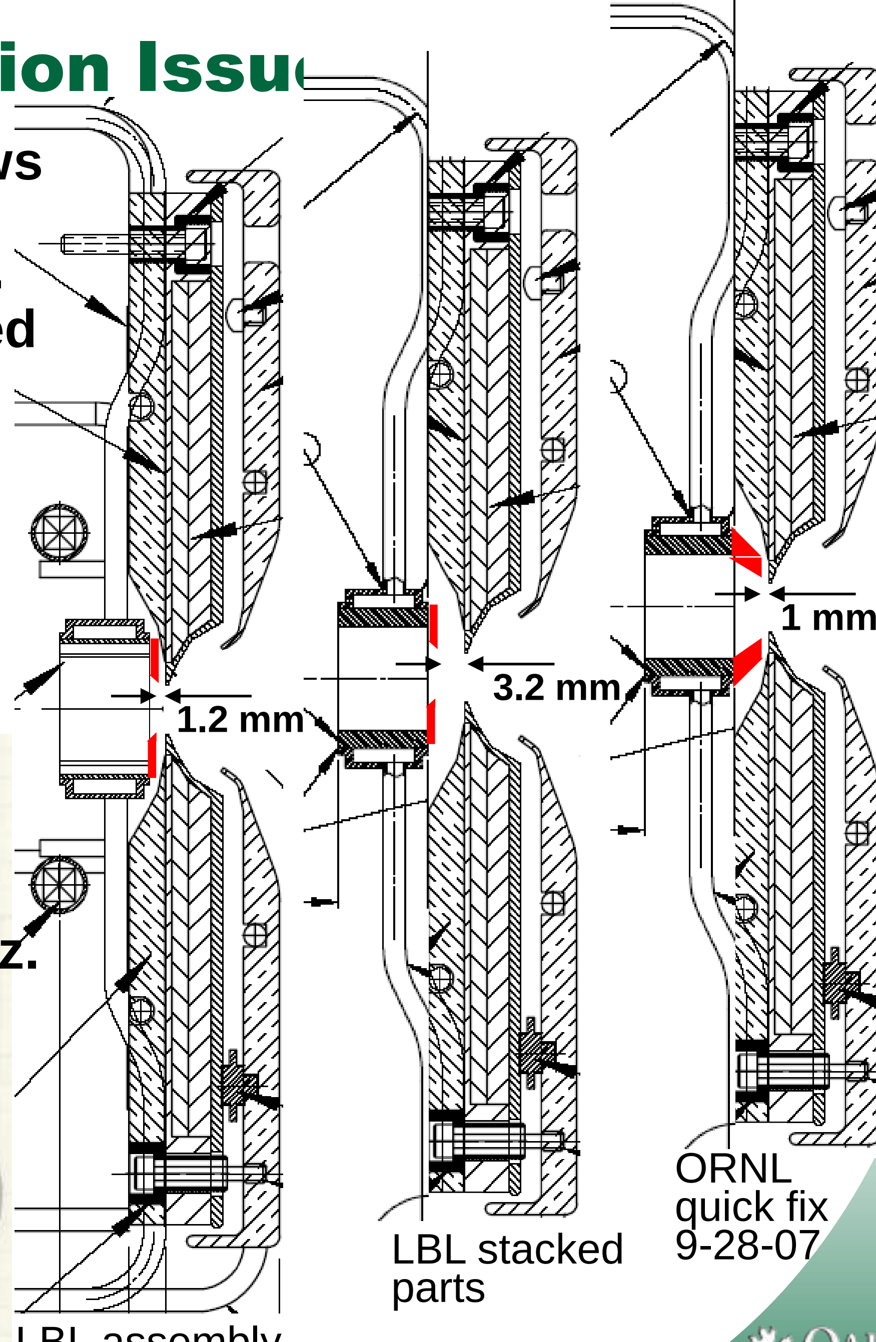


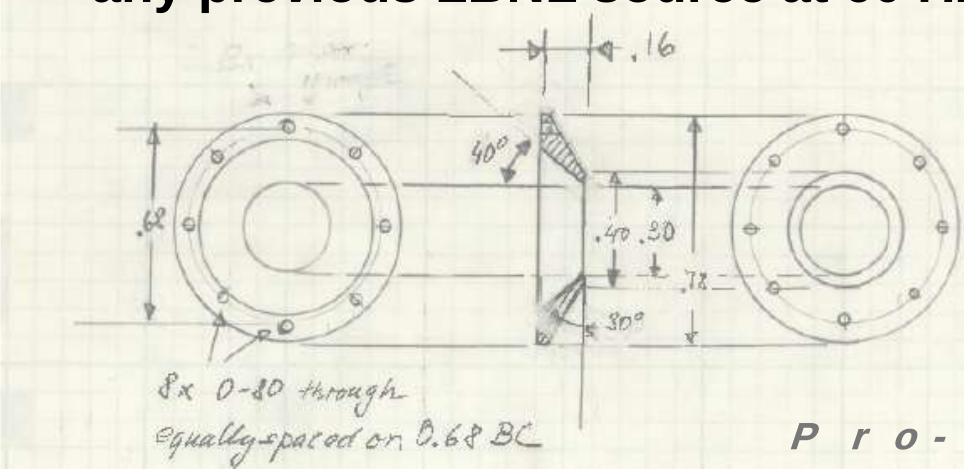
H^- surface production is most effective on a surface surrounding the outlet aperture that is facing the plasma, and that can be kept at optimal temperture!

Oak Ridge National Laboratory

The Cesium Collar Position Issue

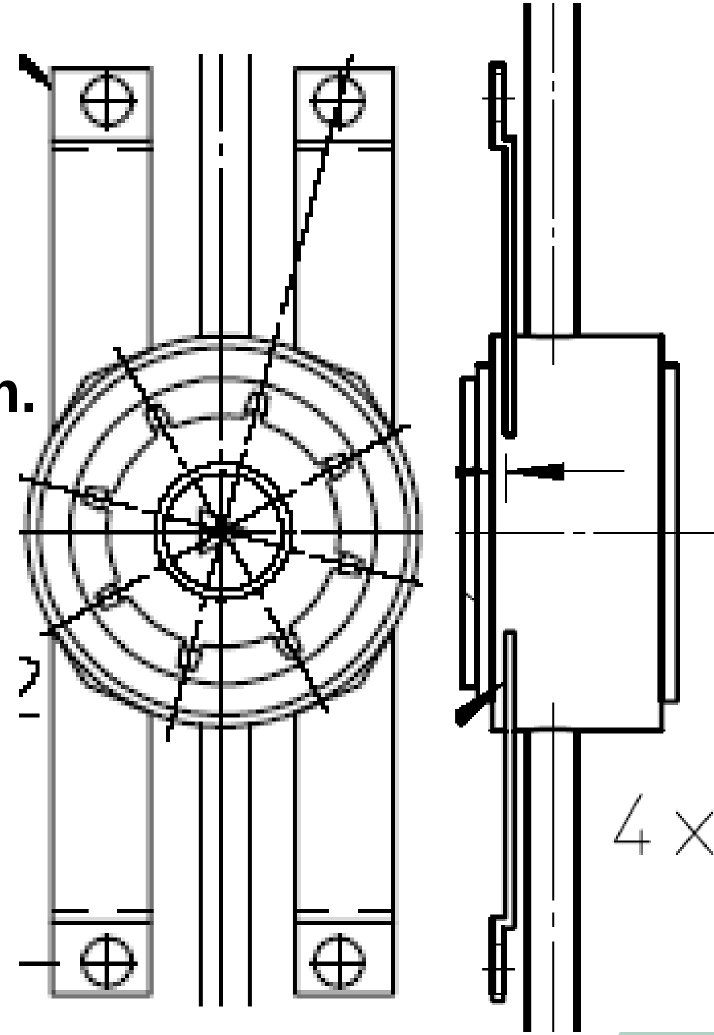
- **The LBNL assembly drawing shows a 1.2 mm gap between the cesium collar outlet and the source outlet.**
- **Correctly fabricated and assembled LBNL parts leave a 3.2 mm gap.**
- **Refabricating the Cs collar takes many weeks and ~5k$/collar.**
- **The two aperture were brought closer together with 4-mm thick, conical Cs collar outlet apertures.**
- **On test stand, a 304 SS aperture yields 38 mA with 40 kW of 2 MHz; a Mo aperture yields 40 mA with ≥29 kW, ≥90% more efficient than any previous LBNL source at 60 Hz.**





The Cs collar position, a hidden variable?

- The Cesium collar is mounted to the outlet electrode with four 5-40 screws.
- If two neighboring screws would be missing, and the collar is heated to 200 or 500°C, the radial distance of the mounting holes grows by 0.06 – 0.2 mm. This causes a slight misalignment.
- However, if all screws hold all legs in place, heating it to 200, 300, 500, or 550°C will move the collar in axial direction by >1.5, >1.8, >2.4, or >2.5.
- Depending on the initial, unintentional slight bends of the mounting legs, the Cesium collar moves either away from or towards the outlet aperture.



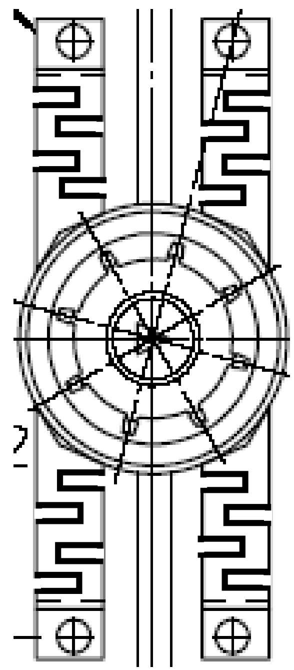
Hidden Good Source / Bad Source Variable???

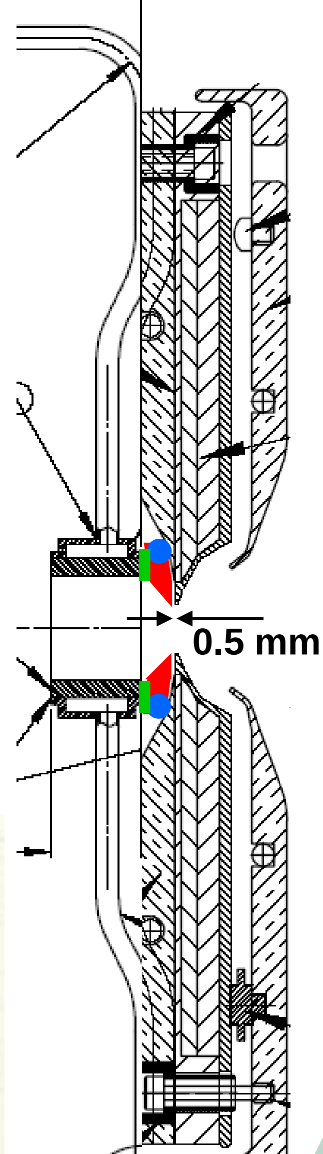
Unique, but not very robust engineering!

The Cesium collar mitigation:

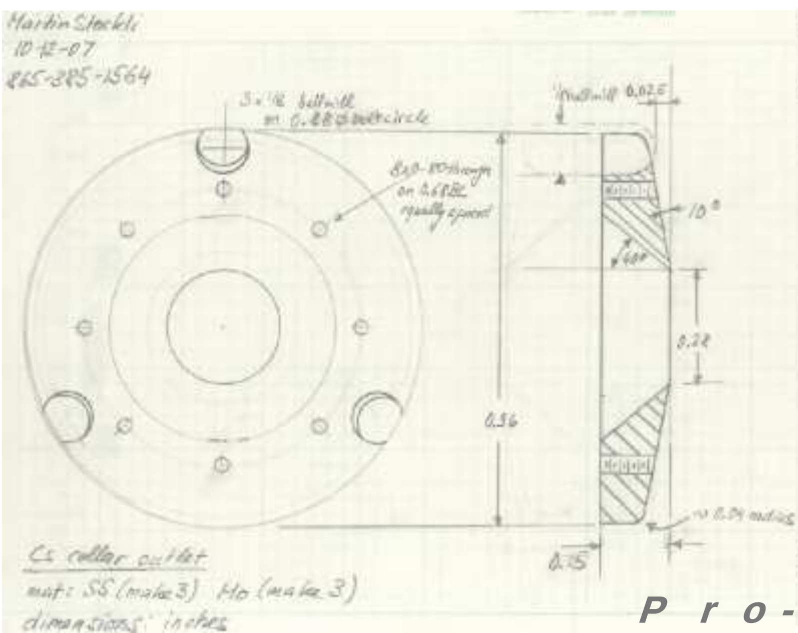
Mitigation include

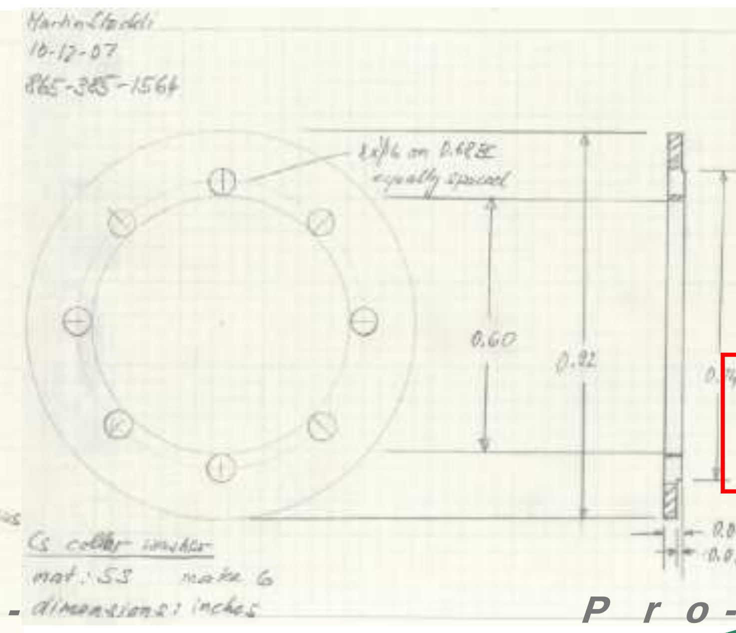
- **meandering Cs collar mounting legs**
- **backset mounts and bend legs to assure forward force**
- **Design a outlet aperture with ceramic balls (blue) that guarantee a ~0.5 mm gap and centering in the groove of the outlet aperture.**
- **This yielded 40 mA with ≥27 kW 2 MHz at 0.5 ms and 60 Hz on the test stand,** **an additional ≥7% increase in efficiency.**



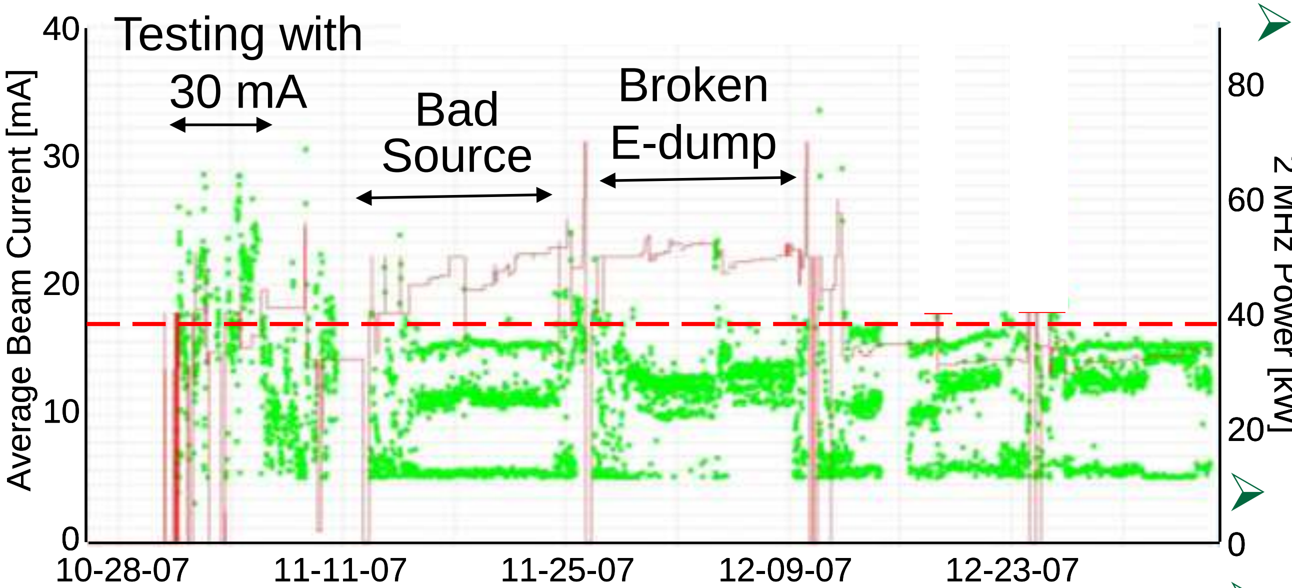


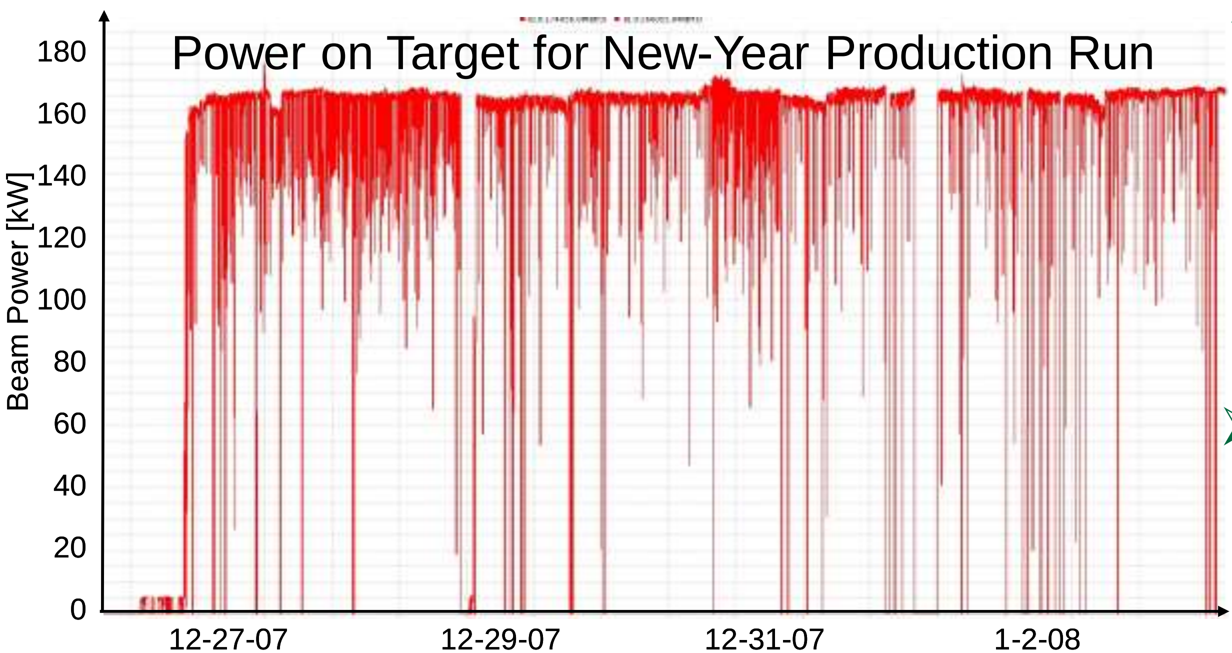
Ion Source configuration for run 2008-1





The 25 mA Challenge: (=17 mA average chopped)





- **In the 5 days before run 2008-1 three source configurations were tested on the Frontend before deciding on the ball-centered Cs collar outlet as workhorse for this run.**
- **The 2nd source was bad, requiring ~50 kW.**
- **The e-dump of the 3rd source shortened out after several hours of stable operation. It was decided to run it with ~50 kW.**
- **Recent sources make 25 mA with <<40 kW.**
- **Operations has now a knob to keep the target power fixed, even when sub-systems struggle.**

Testing 2008-2 requirements:

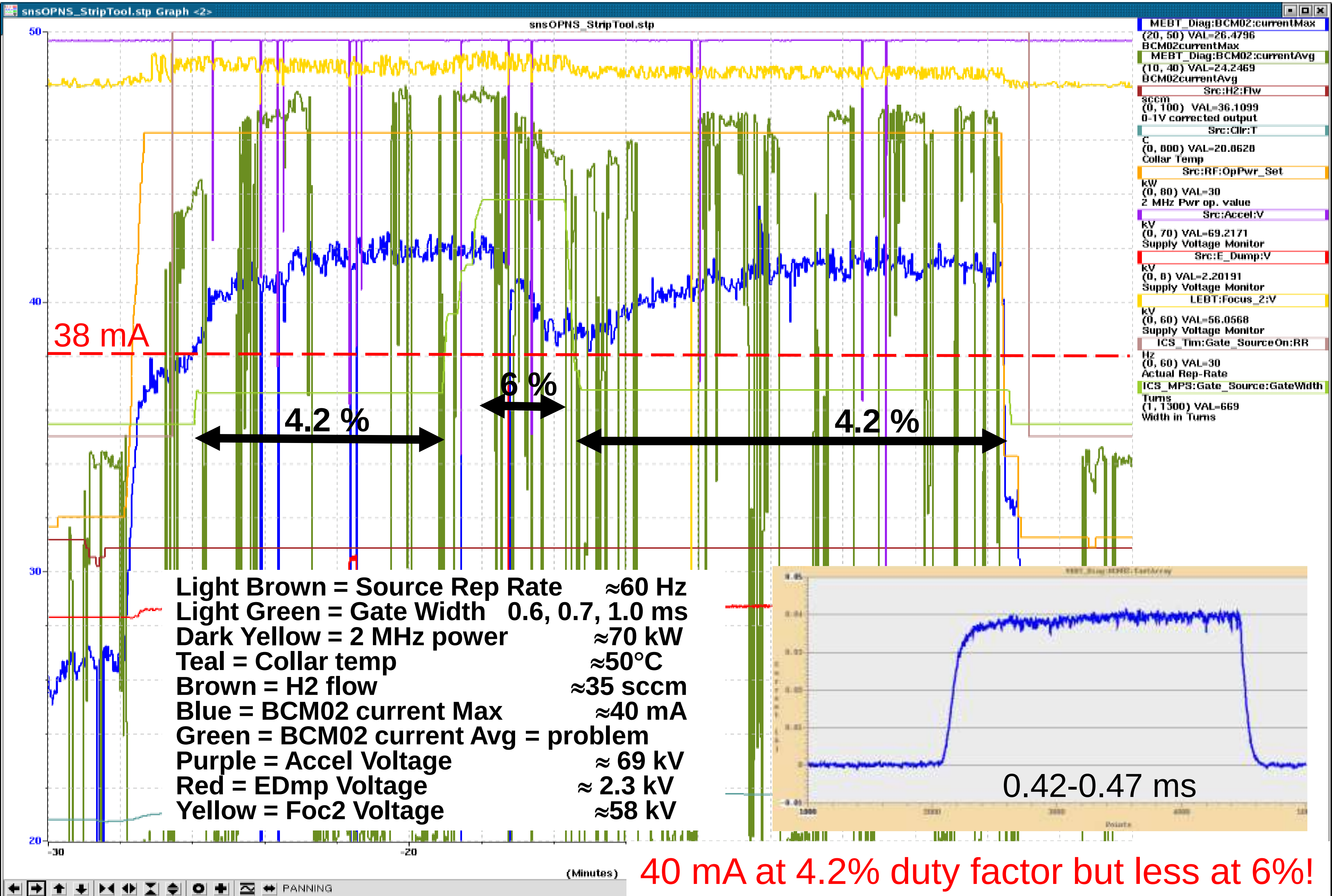
12-25/26-2007

Red = Source Rep Rate = 60 Hz
Purple = Gate Width = 0.7 ms
Teal = 2 MHz power = 29.5 -35.2 kW
Dark Yellow = Collar temp = 187°C
Yellow = H2 flow ≈29 sccm
Blue = BCM02 current Max >30 mA
Brown = Accel Voltage ≈ 69 kV
Light green = Foc1 Current < 2 mA

>30 mA at 4.2% duty factor for >20 hours!

Testing future requirements:

12-18-07 9:30-10:00

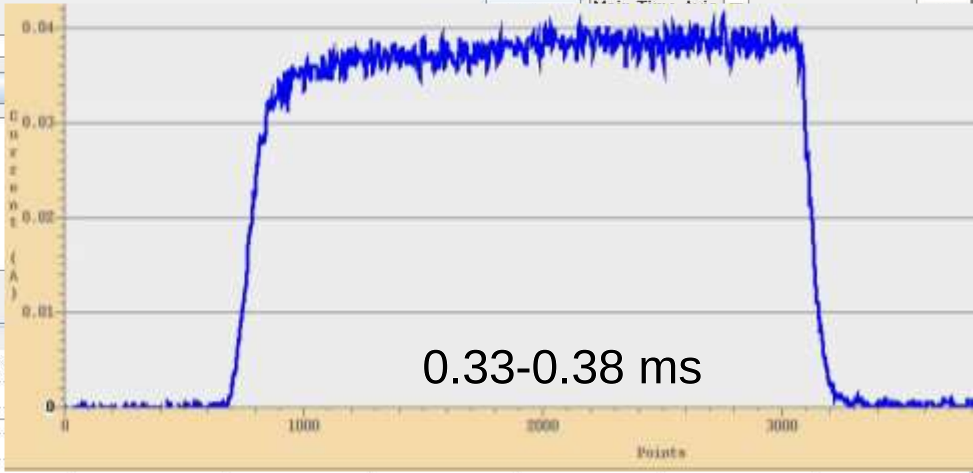


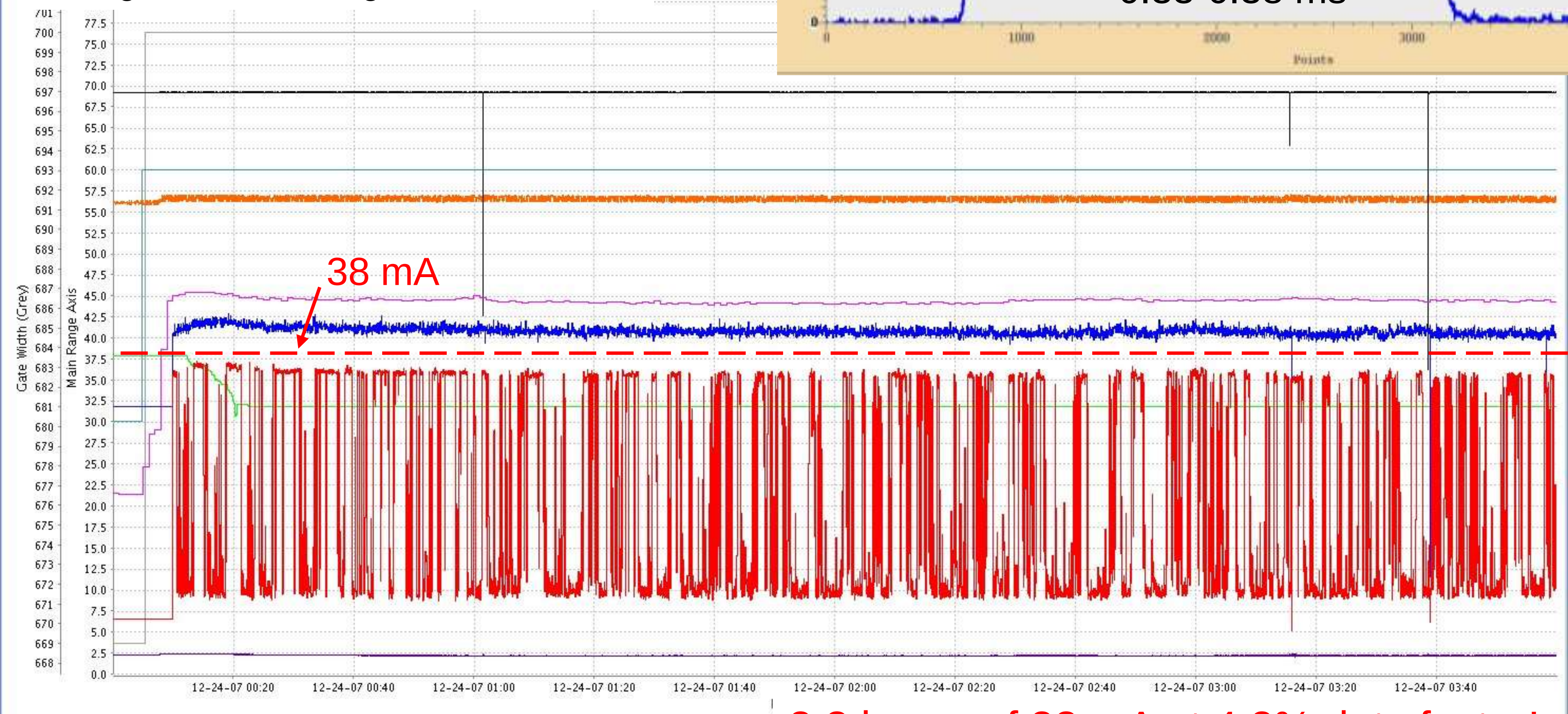
40 mA at 4.2% duty factor but less at 6%!

Retesting future requirements:

12-24-07 00:00-04:00

Teal = Source Rep Rate ≈60 Hz
Grey = Gate Width ≈0.7 ms
White = 2 MHz power ≈70 kW
Magenta = Collar temp ≈45°C
Green = H2 flow ≈32 sccm
Blue = BCM02 current Max ≈40 mA
Red = BCM02 current Avg = problem
Black = Accel Voltage ≈ 69 kV
Purple = EDmp Voltage ≈ 2.2 kV
Orange = Foc2 Voltage ≈57 kV





3.8 hours of 38 mA at 4.2% duty factor!

Content

- Overview
- Milestone Diagnostic Problems & Solutions
- The 2007 LEBT Sparkfest
- The LBNL Cs System and its Operation
- The Beam Current Challenge
- The Plans

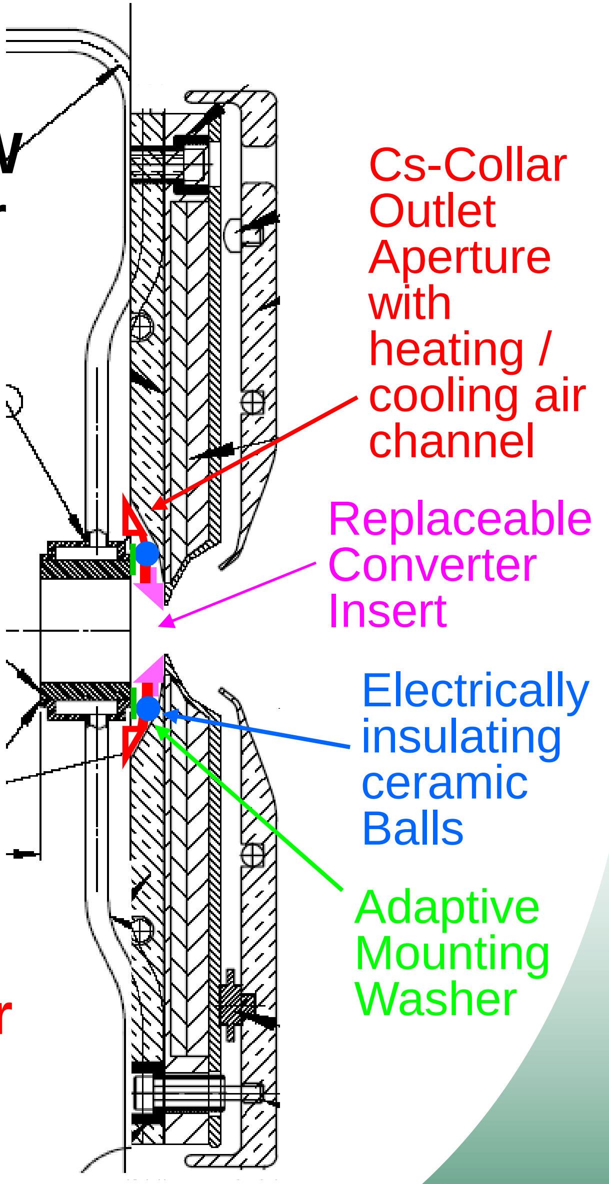
The R&D Cesium collar outlet aperture

- **Producing 38 mA with 70 kW is too risky. We need a source configuration that can produce 38 mA MEBT current with ≤50 kW to allow for operation with not so good or bad sources. Therefore we need to continue our efficiency enhancing R&D!**

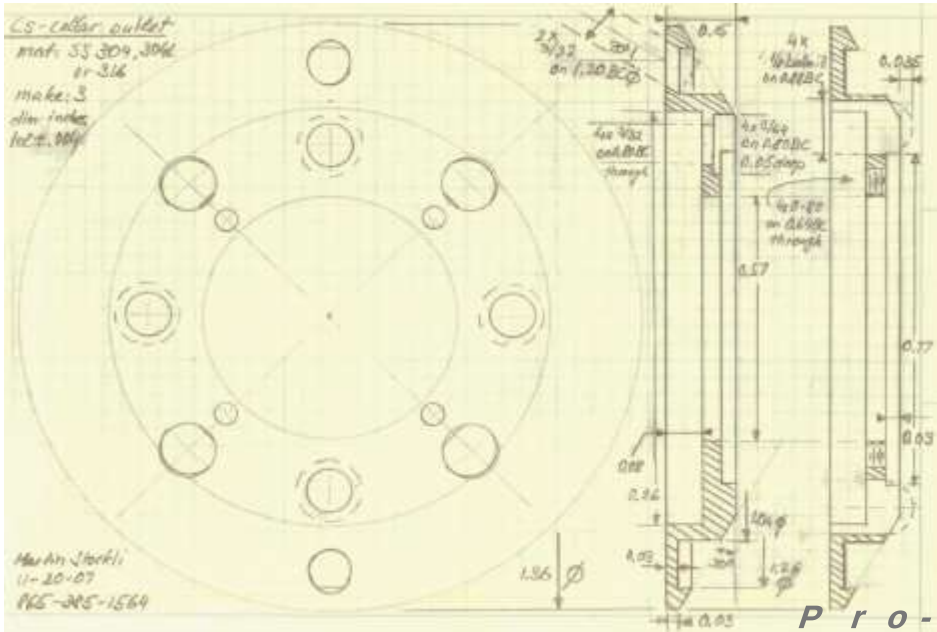
A good R&D source component has

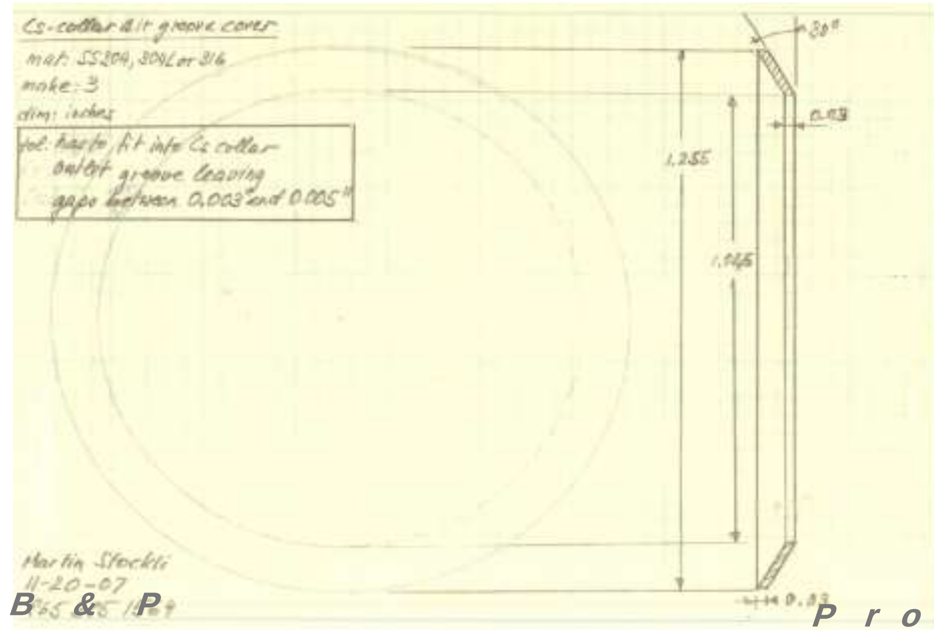
- **A knob for each individual function that can be fine-tuned during operation for squeezing the last mA out of the source!**
- **Screws, allowing the rapid replacement of configuration critical elements!**

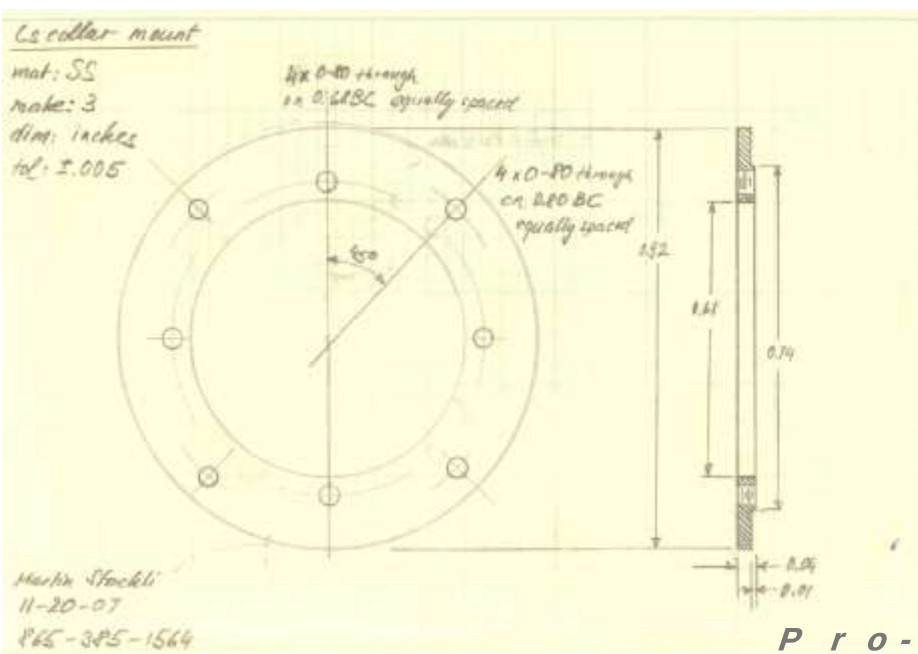
We are fabricating a Cs-collar outlet aperture that has replaceable converter inserts, and temperature- and voltage-controls independent of the cesium collar and the source outlet. This will allow for optimal geometry and conditions during conditioning and operations!

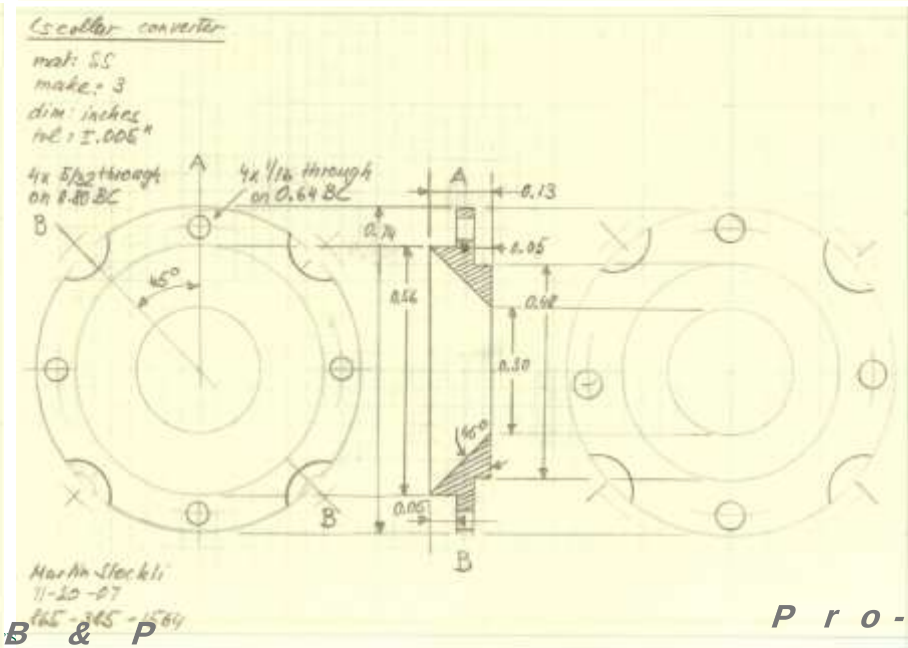


The R&D Cesium collar outlet aperture







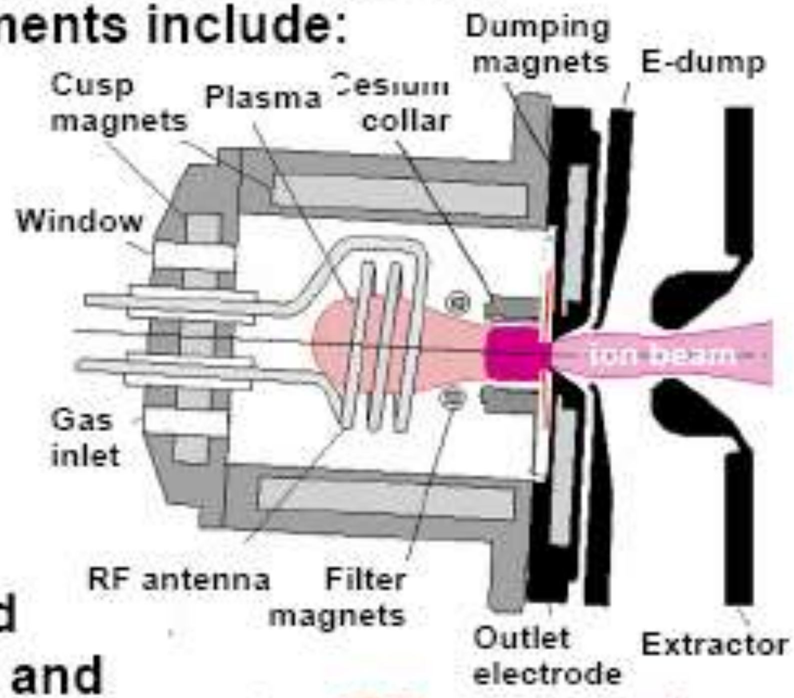


Slide 5 from the PUP Review September 21-22, 2005:

Existing Multicusp RF source

SNS has a cesium-enhanced, multicusp RF ion source. It is under development to meet the requirements for 1.4 MW operations. The developments include:

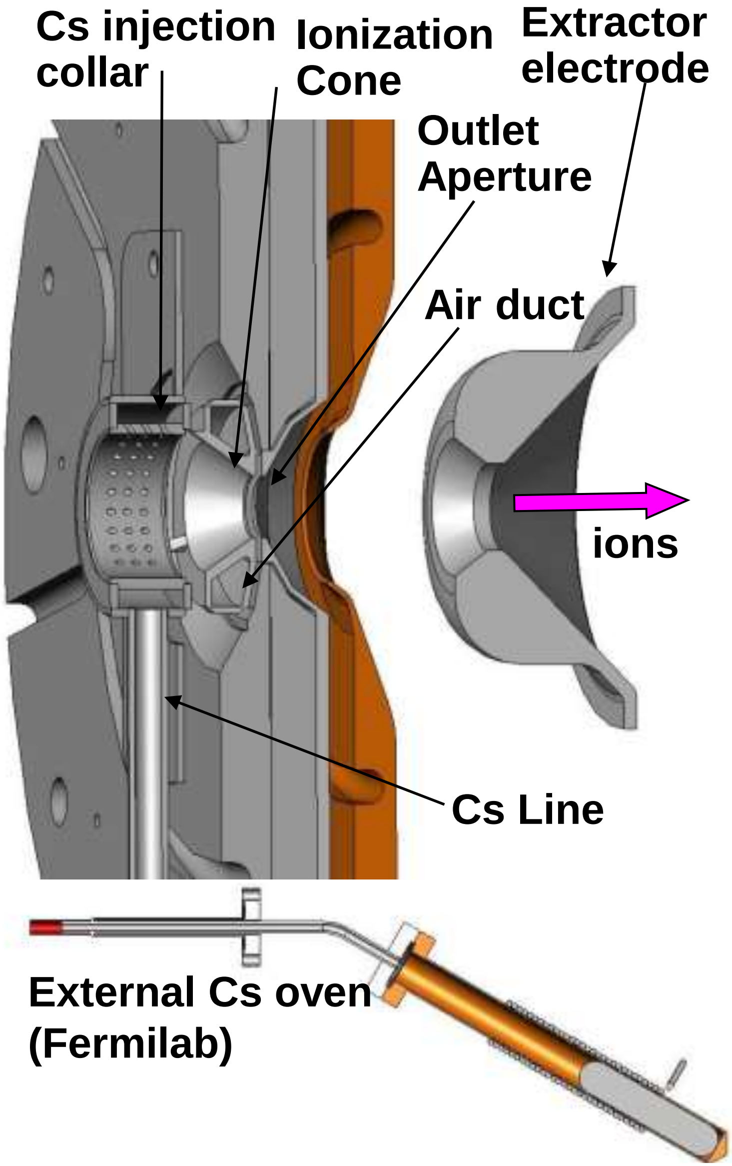
- Improve matching network
- Increase RF power
- External antenna
- Vary magnetic fields
- Vary outlet geometry
- Increase outlet aperture
- Modify and vary cesium dispensing system
- Remove the magnetic field and expansion cup from the outlet and develop a new e-dumping scheme.
- Introduce negative ion emission surface that surrounds outlet, having separate bias- and temperature control.



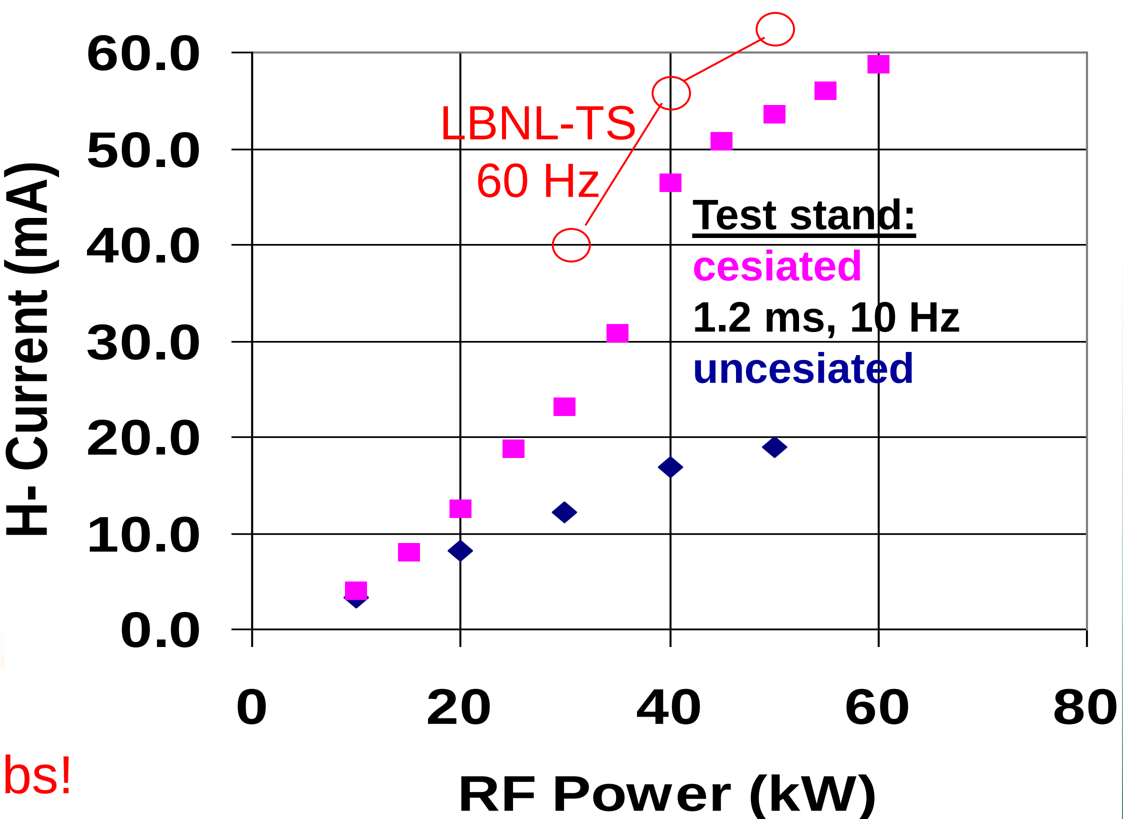
- *Efforts ongoing on our test stand.*
- *Efforts will transition into PUP!*

Alternatives: External Cesium Reservoir

(Courtesy of R. Welton)

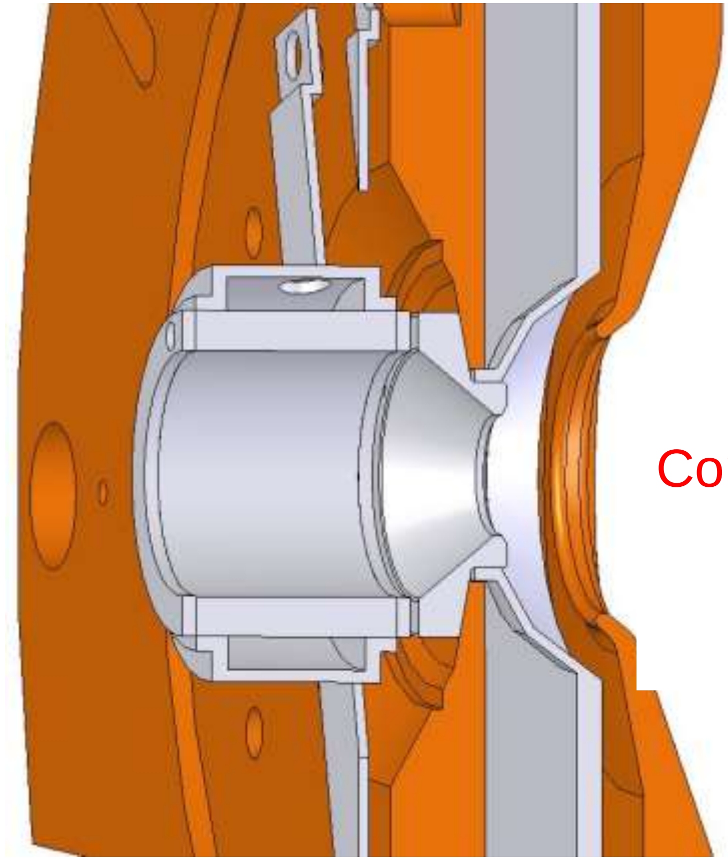


- Baseline Cs_2CrO_4system → limits source lifetime or beam current
- Proven Fermilab reservoir (lifetime: 0.5-1 year) & enhanced geometry
- 65 mA,1.2 ms, 10 Hz with internal antenna
- 50 mA, 0.75 ms, 30Hz with ext. ant. source (T_{res}~110C)



No screws!
Too many knobs!

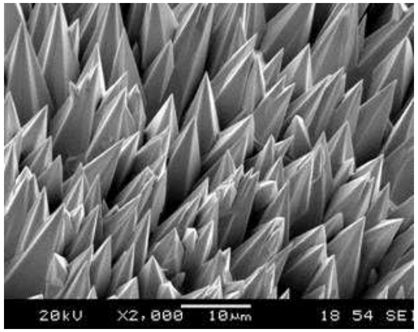
Alternatives: Snap-in Cones (Courtesy of R. Welton)



- Baseline collar modifications
- Allows Cs supply and Cs collection surface to operate at different temps
- Brings ion surface very close to outlet
- Centers and fixes position of collar
- On FE brief demonstration of 30mA with 33kW and a 15% larger outlet area

Comments: -Compare to 30 mA with 29.5 kW with the ball-centered outlet aperture with original 7 mm outlet ∅.
-Temperature cannot be varied

- Higher work function materials yield lower work functions when coated with Cs:
  - •SS-1.67 eV
  - •Mo-1.60 eV
  - •Ni-1.47 eV (also shields magnetic field)
  - •Pt-1.4 eV
  - •Re-1.5eV (10x surface area)



Promising Future Options!

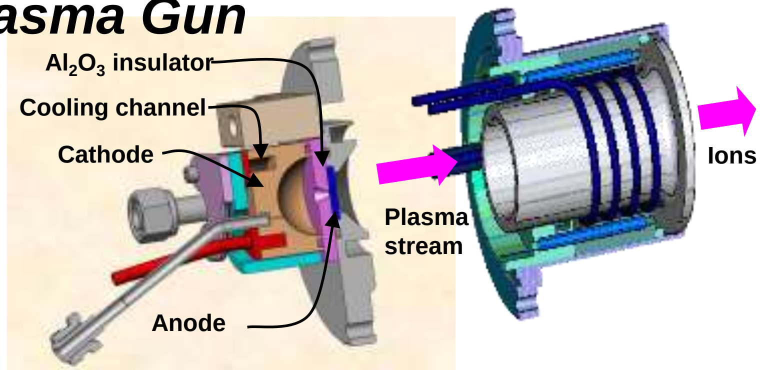
AAC'07"Stockli

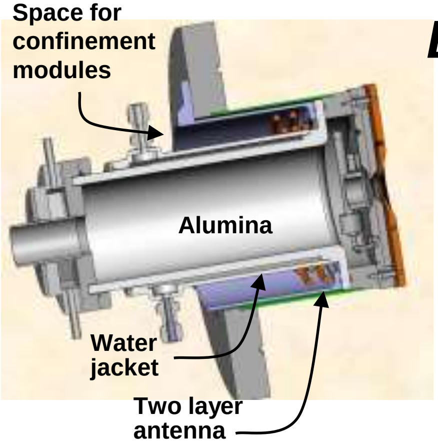
Long-Pulse External Antenna Sources

Courtesy of R. Welton

Prototype External Antenna Source and Plasma Gun

- Multi-year lifetime - DESY (low duty-factor)
- Plasma gun found to enhance H^- up to ~50%
- 50 mA – 1.2 ms pulses achieved at 10Hz – unacceptable pulse droop.



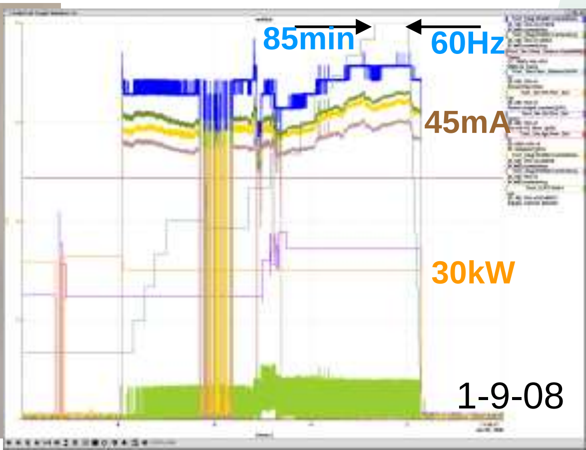


Large Volume External Antenna Source

- Excellent pulse shape: 38 mA, 0.750 ms, 30 Hz pulses produced using baseline and external Cs systems.
- ~25mA delivered over a week period at low-Cs flow & ~40 kW (LEBT arc counting) using external Cs system
- Alumina chamber failed at 45 Hz, 1.2 ms, 60 kW

AlN Source

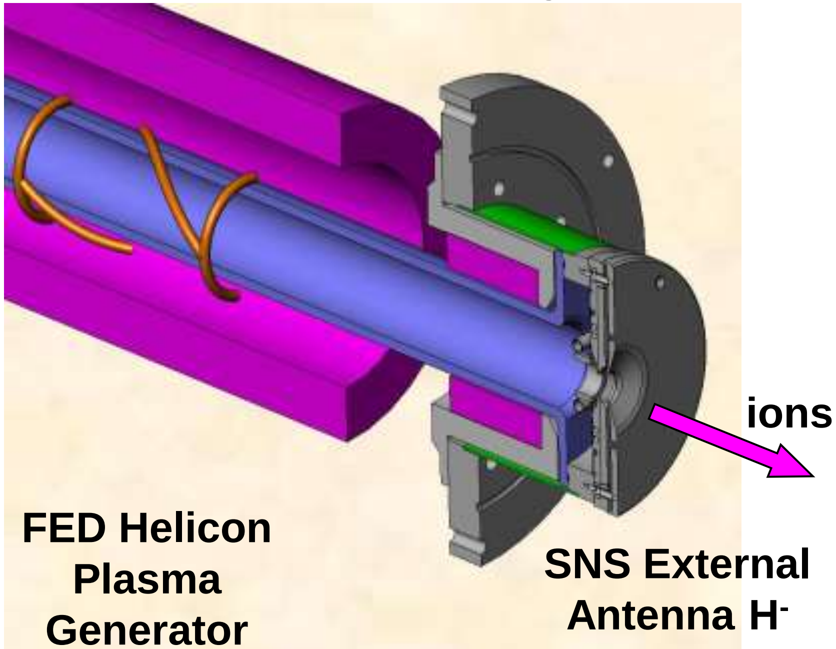
- Heat transfer / thermal stress calculations show this AlN chamber can handle 100kW at 7% duty-factor with a factor of 2 safety margin
- Being tested on test stand

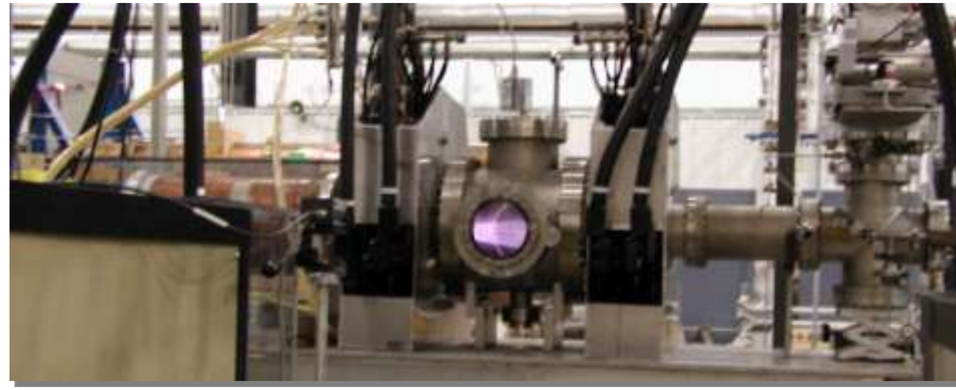


1-9-08

The Helicon H$^-$ Ion Source and Test Facility

Courtesy of R. Welton





- Combines the highly developed VASMIR helicon plasma generator (FED) and ORNL-LBNL H$^-$ ion source – funded by ORNL-LDRD
- Plasma generator proven to produce ~10x higher plasma density using ~10x lower RF power
- Restarted helicon test facility in bldg. 7625 in the FED: 1st plasma 2-23-07
- Operated plasma generator at densities comparable to earlier operations (~1500 W, 13.56 MHz) - Currently retrofitting SNS H$^-$ source in Bldg. 7625

The LEBT Upgrade: A 2-solenoid LEBT

To improve robustness, we design a 2-solenoid LEBT that uses mostly existing equipment.

•After moving the ion source with the LEBT vacuum chamber, the chopper can run near ground potential.

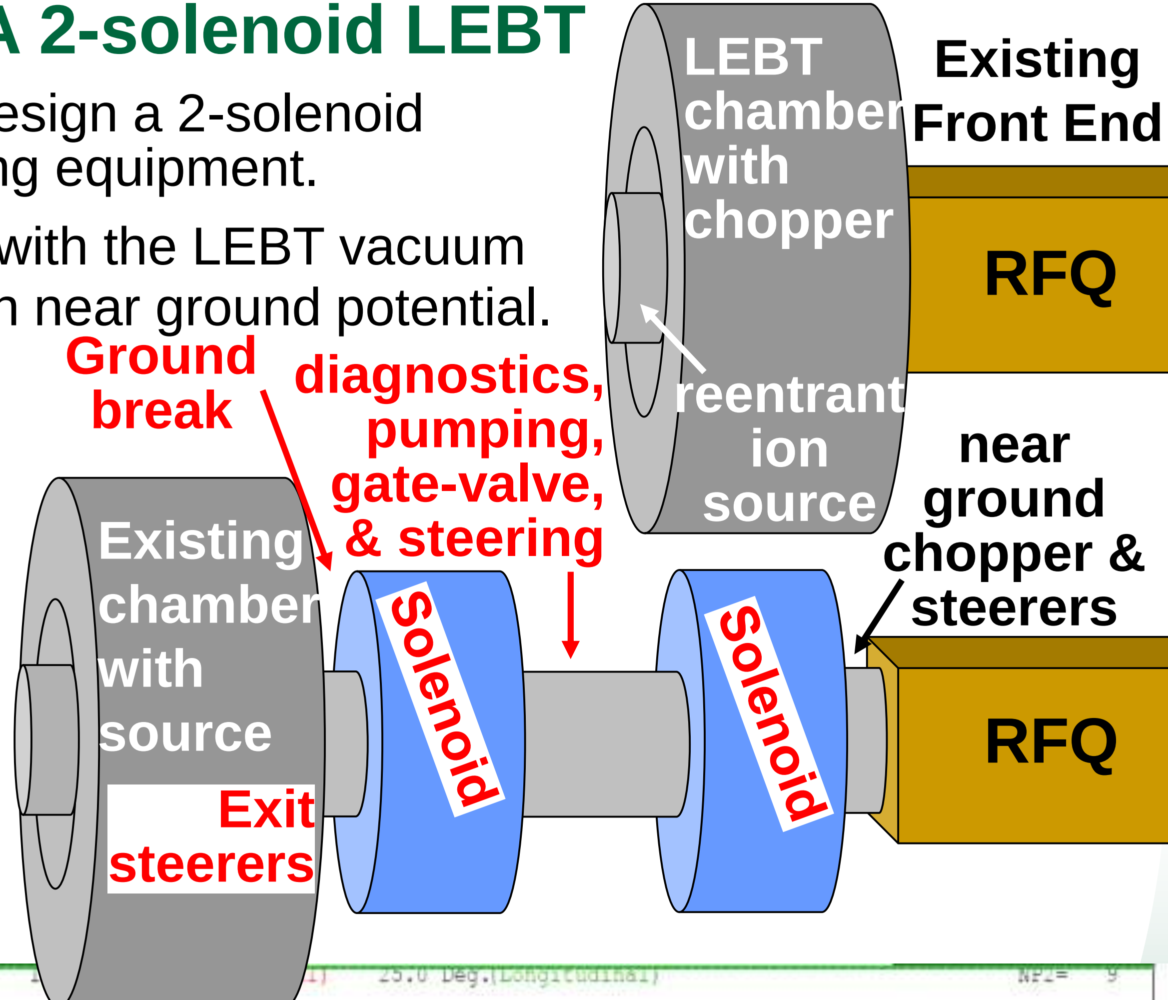
•Two solenoids yield a robust beam transport.

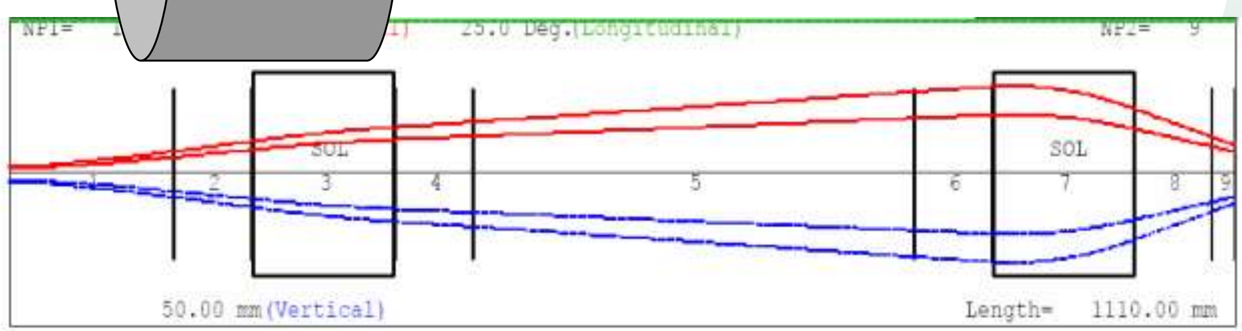
•Differential pumping and a gate valve help the RFQ.

•Diagnostics allows for full power source testing.

•This combines a working chopper with a proven high-power LEBT design.

•Being a novel combination, it needs to be tested on the test stand!





Solenoids are currently being designed in-house!

Conclusions