Project Title:

Superconducting RF electron Gun

Collaborators:

Stony Brook University
Brookhaven National Laboratory
Fermi National Accelerator Laboratory
Thomas Jefferson National Accelerator Laboratory

Lead PI Prof. V.N. Litvinenko, Co-PI Dr. I. Petrushina
Co-PI Dr. Y. Jing
Co-PI Dr. V. Yakovlev
Co-PI Dr. R. Suleiman

PI Exchange meeting

NP Accelerator R&D + Data Science AI/ML

November 30, 2021

Content:

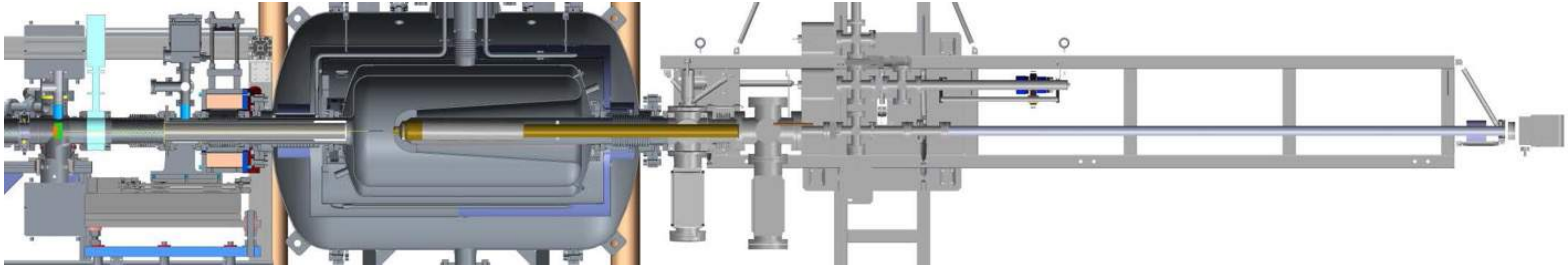
- ☐ Introduction – V.N. Litvinenko
- ☐ Status and plans of high current and polarized beam operations – Y. Jing (BNL)
- ☐ Design of 100 kW FPC and plasma treatment system – S. Kazakov (FNAL)
- ☐ Development of e-beam polarimeter – R. Suleiman (JLab)
- ☐ Beam dynamics and practical experience with SRF gun treatment – I. Petrushina (SBU)
- ☐ Conclusions

Project opportunities & goals:

Exploration of **capabilities of the unique 1.5 MV SRF gun** generating electron beam with record low transverse emittance and providing "year-long" operation with a single CsK_2Sb cathode

The main goals:

- Demonstration of a reliable **operation of the SRF gun with beam current up to 100 mA**
- Generation of **polarized electron beams from the SRF gun**



Project goals & deliverables:

- **Phase 1, Year 1 goals:**

1. **Prepare for operation with 1-3 mA**
2. **Test gun conditioning techniques**
3. **Design 100 kW Fundamental Power Coupler (FPC)**

Deliverable	Completion Status
Simulations of beam dynamics	☑
Deliver beam from the gun to high-power dump	partial success
Evaluate beam quality for 2 nC bunches	☑
Complete simulations of the 100 kW RF system	☑
Design and build electron beam polarimeter	design is complete
Develop and test reliable He conditioning technique	☑

Project goals & deliverables:

- **Phase 1, Year 2 goals:**

1. **Gun operation with 1-3 mA CW current**
2. **Test GaAs operation in SRF gun**
3. **Complete the polarimeter**
4. **Finalize 100 kW FPC design**
5. **Finalize supporting simulations and prepare for Phase 2**

Deliverable	Completion Status
Design the laser for Phase 2 30-100 mA operation	
Optimize gun settings for generating maximum beam current	
Complete design of the 100 kW RF system	
Upgrade cathode deposition and transport system for GaAs	☑
Introduce GaAs cathode into the SRF gun	
Complete simulations and design of plasma processing system for CeC SRF gun	partial success

Annual budget and total received to date

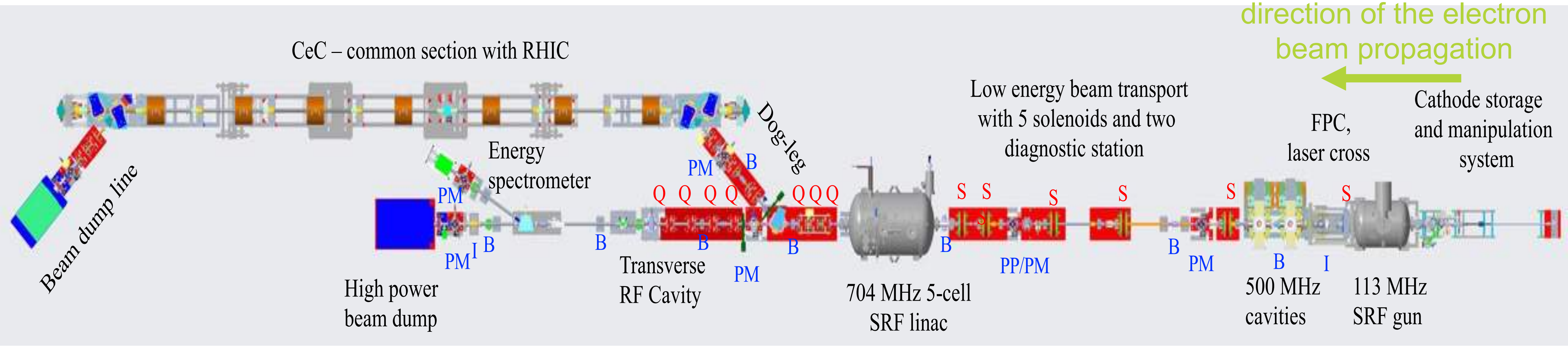
	Totals ($k)
Stony Brook University	
a) Funds allocated	402.6
b) Actual costs to date	92.104
Brookhaven National Laboratory	
a) Funds allocated	361.2
b) Actual costs to date	189.42
Fermi National Accelerator Laboratory	
a) Funds allocated	278.2
b) Actual costs to date	96.368
Thomas Jefferson National Accelerator Laboratory	
a) Funds allocated	400.2
b) Actual costs to date	10.9
TOTAL	
a) Funds allocated	1,442.1
b) Actual costs to date	388.792

Status and plans of high current and polarized beam operations

Yichao Jing on behalf of BNL

Preparation for the gun operation with 1-3 mA

High current SRF gun experiment employs the existing Coherent electron Cooling (CeC) accelerator.

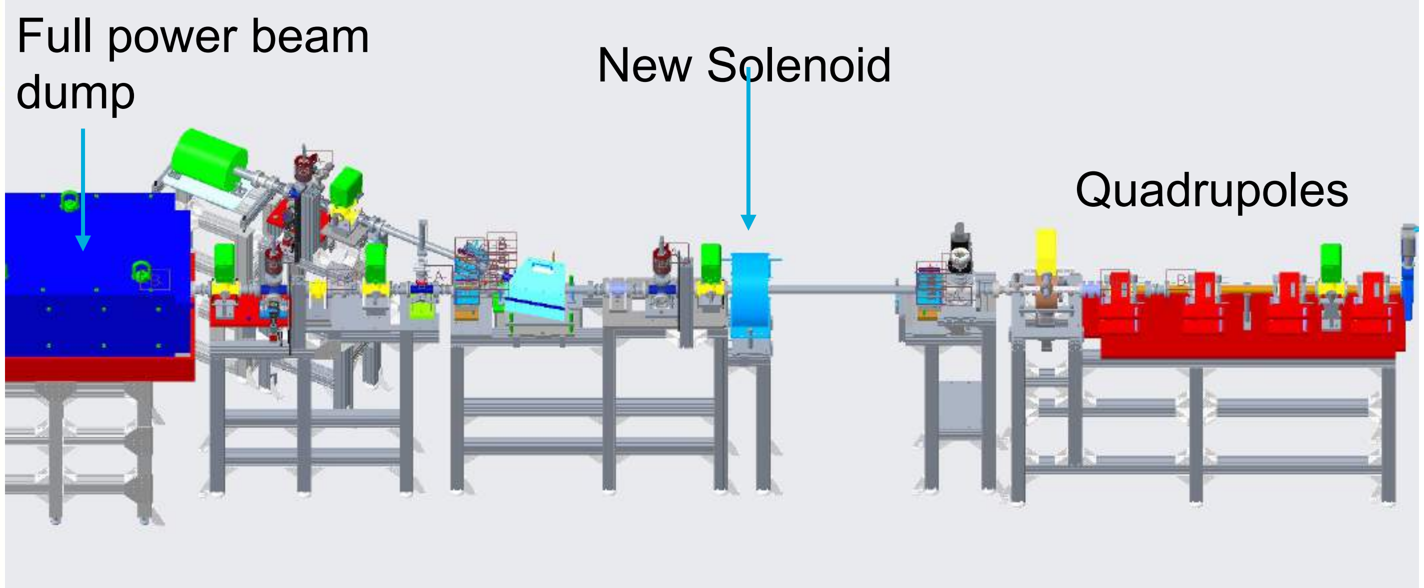


The system required the following modifications:

1. Additional focusing elements are necessary for a successful beam propagation – **new solenoid is installed**
2. Machine Protection System (MPS) requires adjustments to allow use of the bunching cavity and the 5-cell SRF accelerating cavity – **implementation is under way**
3. Additional diagnostic is required – **DCCT is installed**
4. Laser system upgrade is required – **under way, new high rep-rate seed laser is installed**

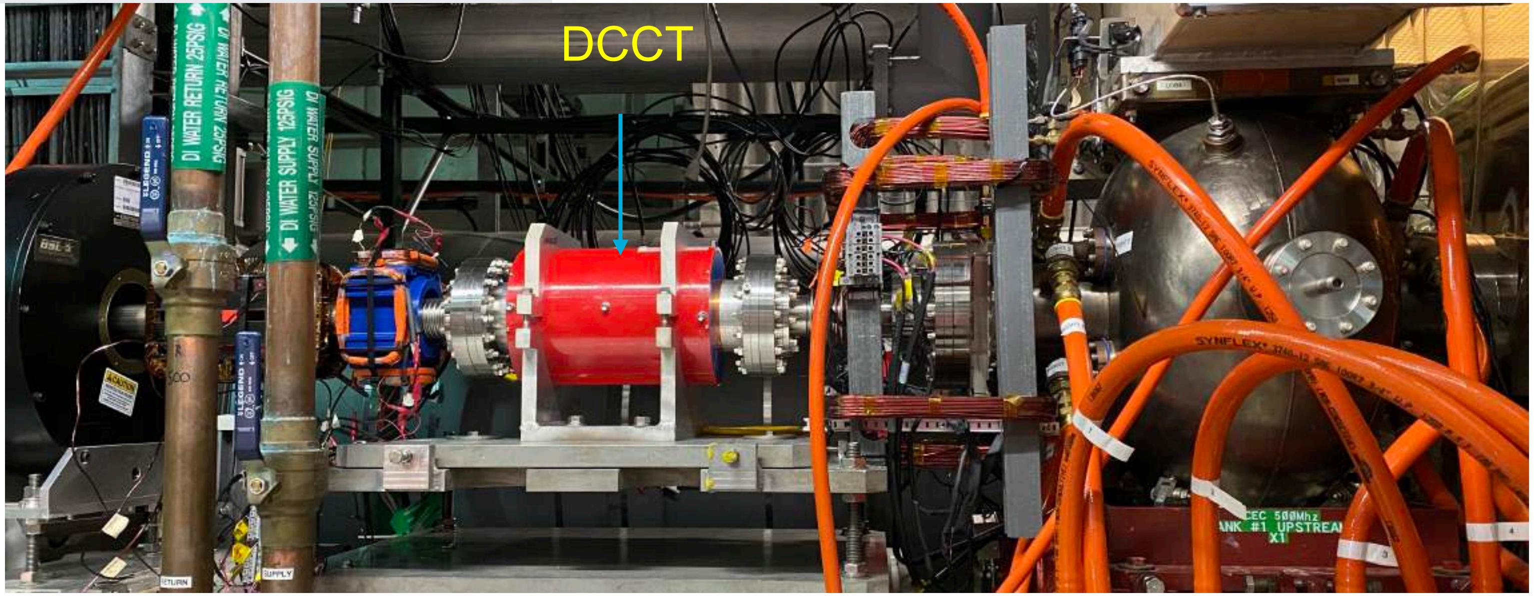
Preparation for the gun operation with 1-3 mA:

Diagnostics beamline upgrade – new solenoid installed
Additional diagnostics installation – DCCT installed



New solenoid will provide additional focusing for low energy beam between quadrupoles and the full power beam dump

This DCCT will use an updated version of the electronics package that is designed to be more stable during thermal variations. This signal will then be processed with a spare channel in the existing Zynq system.



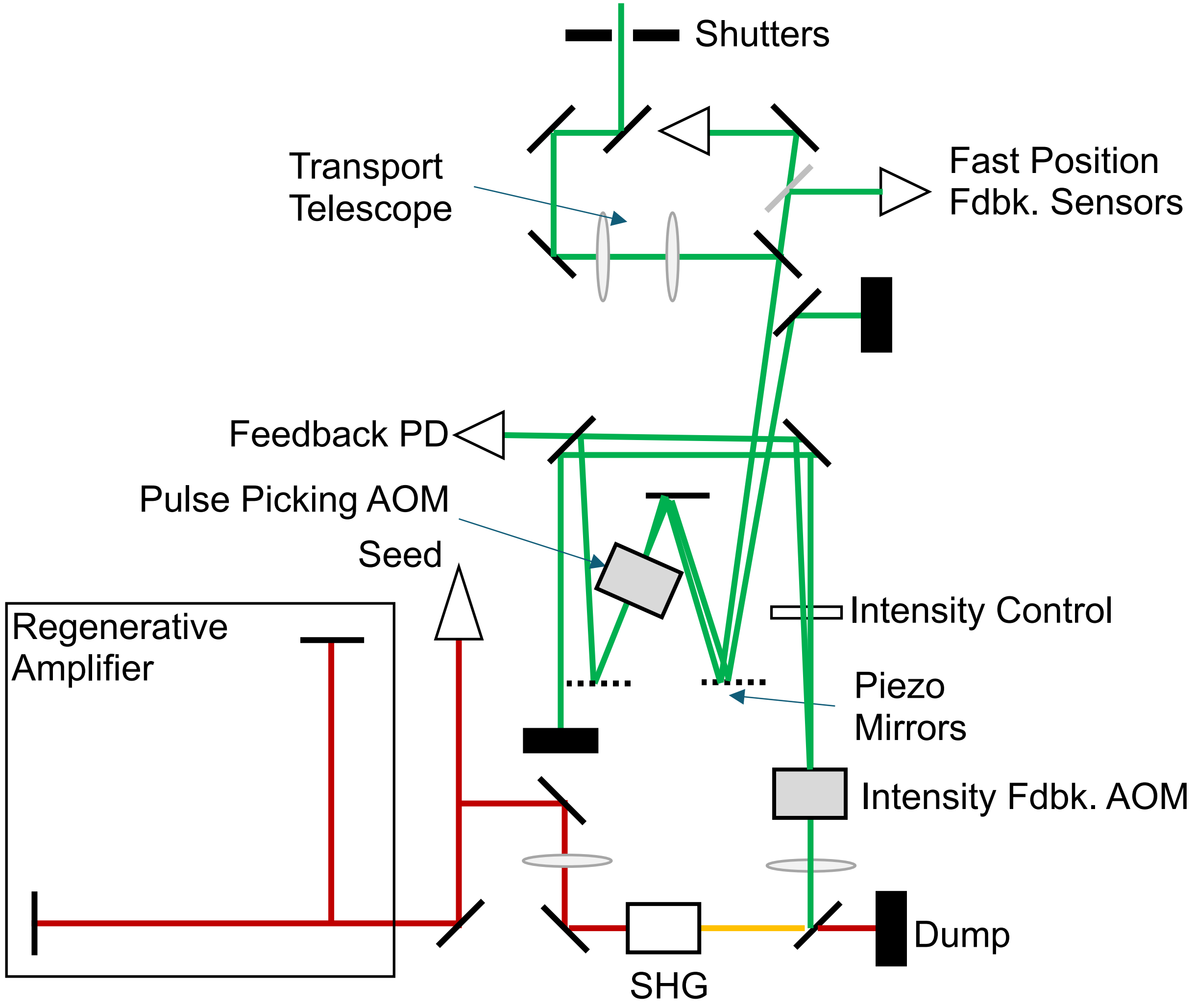
Preparation for the gun operation with 1-3 mA:

Laser layout for Run’22

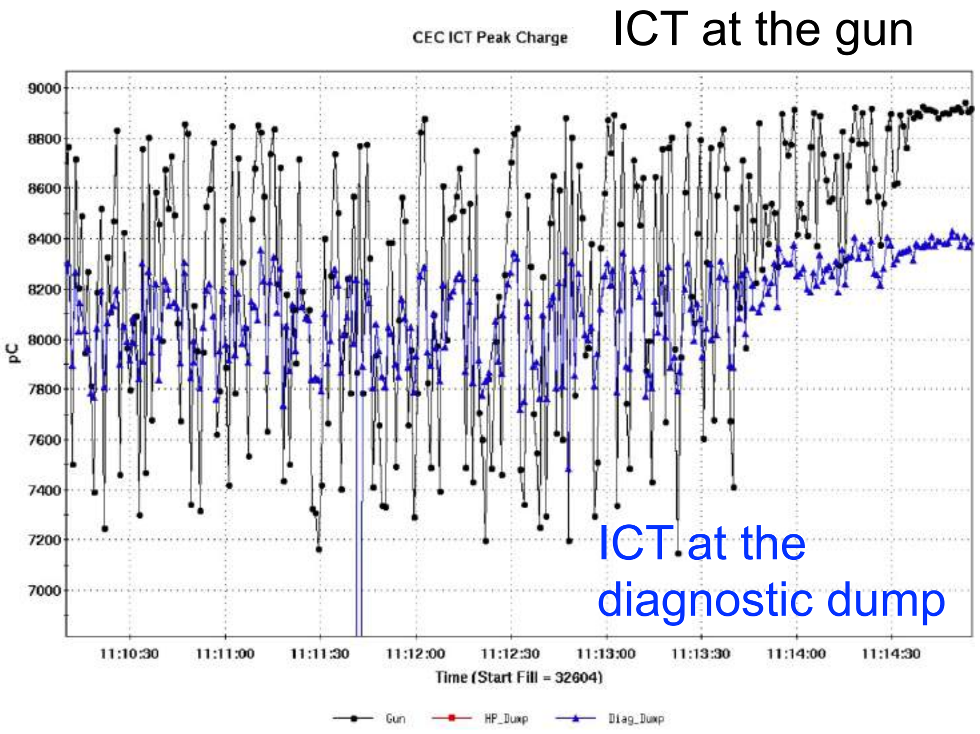
- Exchange of IR Pockels Cell Pulse Picker with AOM to enable 0-100% duty cycle operation for high repetition rate operation (1-5MHz)

- Maintaining CW beam throughout the entire system to enable high bandwidth position and intensity feedbacks and limit thermal effects from repetition rate changes

- Addition of second AOM for fast intensity feedback
  - Still need to work out efficient noise detection method to reach 2kHz Fdbk. Bandwidth for operation at variable repetition rates (78kHz-5MHz)

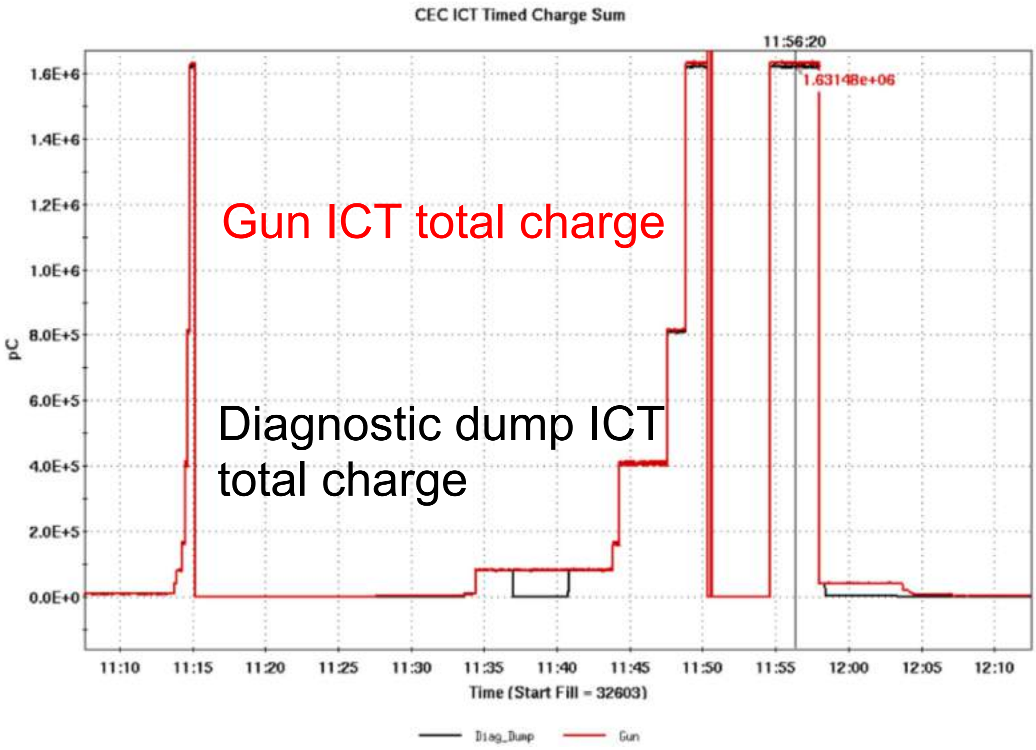


First attempt of high current operation (2021)



ICT at the gun

ICT at the diagnostic dump



Gun ICT total charge

Diagnostic dump ICT total charge

- 200 pulses
- 8 nC per pulse
- 1.6 uA beam current

1. We **demonstrated ultra high bunch charge (~ 8 nC)** with high transmission from the gun in run 21.
2. **Previous MPS mode prohibited** us **from going further** up in total charge (with linac ~ 9 MV).
3. In run 22, a **new MPS mode will be implemented** to allow high current beam with linac running at lower voltages.

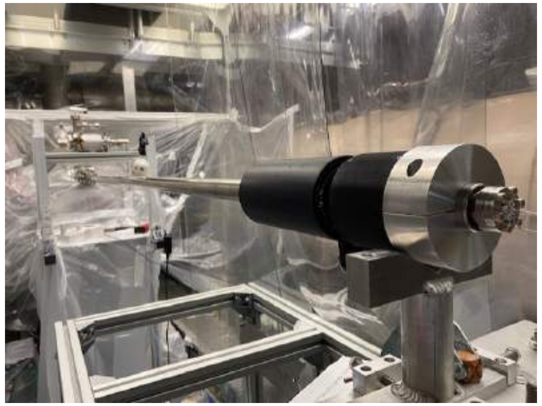
Preparation for polarized beam operation

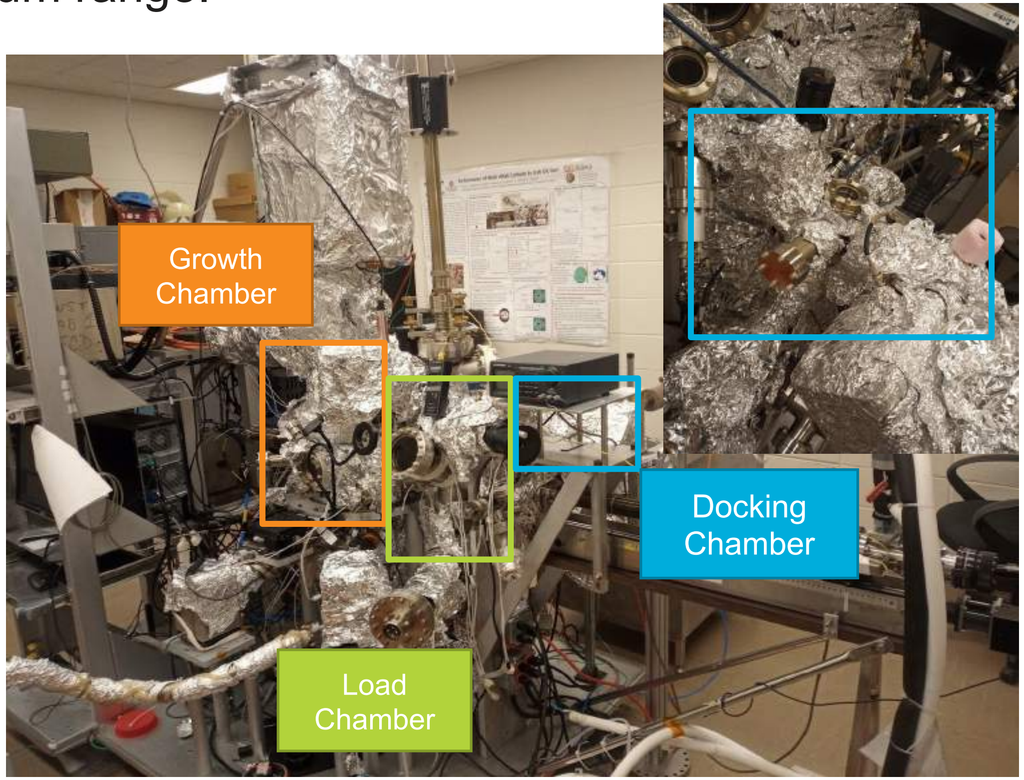
Goals:

1. Upgrade cathode deposition and transport system for GaAs **– completed**
2. Introduce GaAs cathode into the SRF gun **– first tests will be performed at the end of CeC Run'22 (February-March 2022)**

New extreme vacuum cathode system:

Load lock and cathode transfer chambers achieved 10^{-12} Torr vacuum range.
This is about **100X better than the old system**.



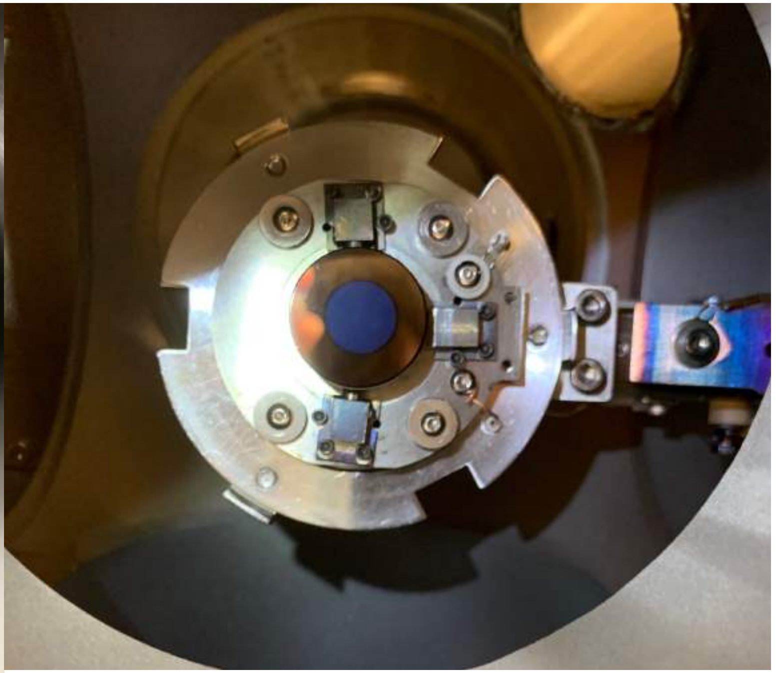


CeC cathode system upgrade:

- **Multiple clustered alkali sources;**
  - Sources for Na-K-Sb;
  - Growth in co-deposition;
  - Te and O_2 leak valve for GaAs;
  - Protective coatings;
- **Quantum efficiency 2D maps;**
- **New cathode magazine for 4 cathodes;**
- **New cathode manipulation system to mitigate particulate.**

3 cathodes for run 22 already delivered

- FY22 completing upgrade
  - installing the new sources;
  - Install components for GaAs;
    - O2 leak valve;
    - Te source;
    - NEG pumping module;
  - 3 cathode magazine for GaAs;
  - test stand integration.



Design of 100 kW FPC and plasma treatment system

Sergey Kazakov on behalf of FNAL

Design of 100 kW FPC

Constrains of the design:

- **No change in** cavity **geometry** (single port D = 100 mm);
- Keep the **same beam channel**, D = 60mm;
- Coupler must provide an ability to **tune the cavity 7 kHz** (± 3.5 kHz);
- **Keep existing solenoid** configuration (desirable);
- New configuration must **fit into space** L = 862 mm

Possible problems:

- **High thermal losses in antenna**. To avoid high losses in antenna the RF mode in coupler shall be close to pure traveling wave.
- **Inconsistency of tuning range** (7 kHz) and coupler matching
- **Multipactor** can be in antenna channel and ceramic window(s). Multipactor can be suppressed by HV bias. If we use a HV bias, antenna has to be DC isolated from “ground” and water cannot be used as cooling media of antenna.

Design of 100 kW FPC

Coupler parameters
(the same antenna configuration as the existing)

Parameter	Value	Unit
Coupler length (approximate)	680	mm
Outer conductor diameter	97.4	mm
Antenna diameter	80	mm
Outer conductor total resistance	6.14e-3	Ohm
Antenna total resistance	7.47e-3	Ohm
Coupler impedance	11.81	Ohm
Input power	100	kW
Current (ampl.)	130.1	A
Voltage (ampl.)	1.537	kV
Losses in outer conductor	**52**	**W**
Losses in antenna	**63.2**	**W**

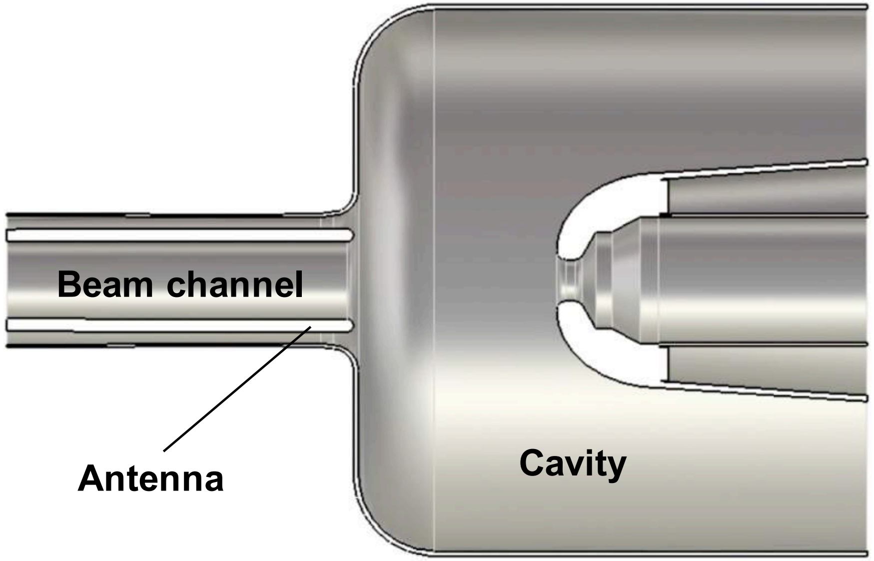
Air can be used for antenna cooling

Coupler has to provide Q external ~ 9.4e4 to match 1.1 MW 100 kW electron beam

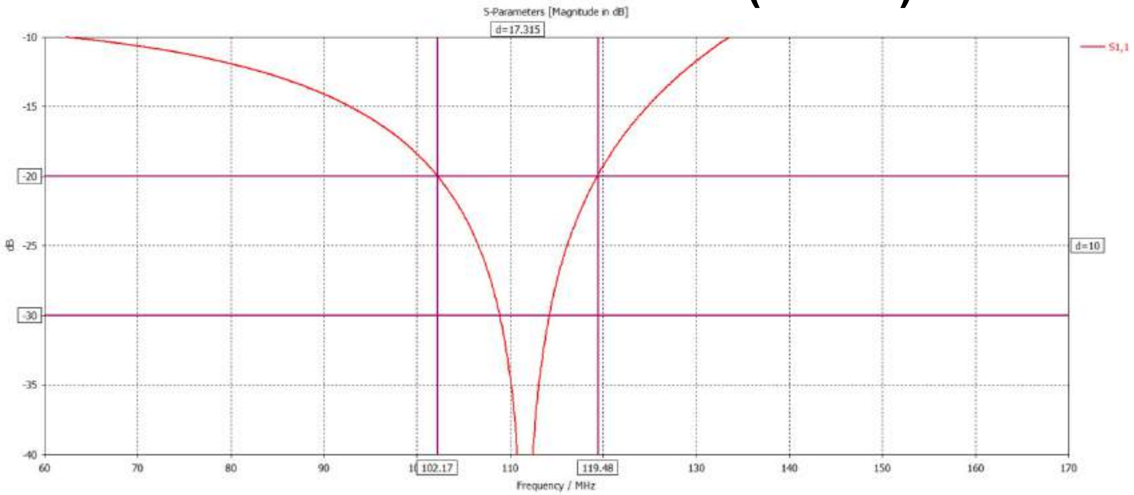
Design of 100 kW FPC

RF configuration of 100 kW coupler(s)

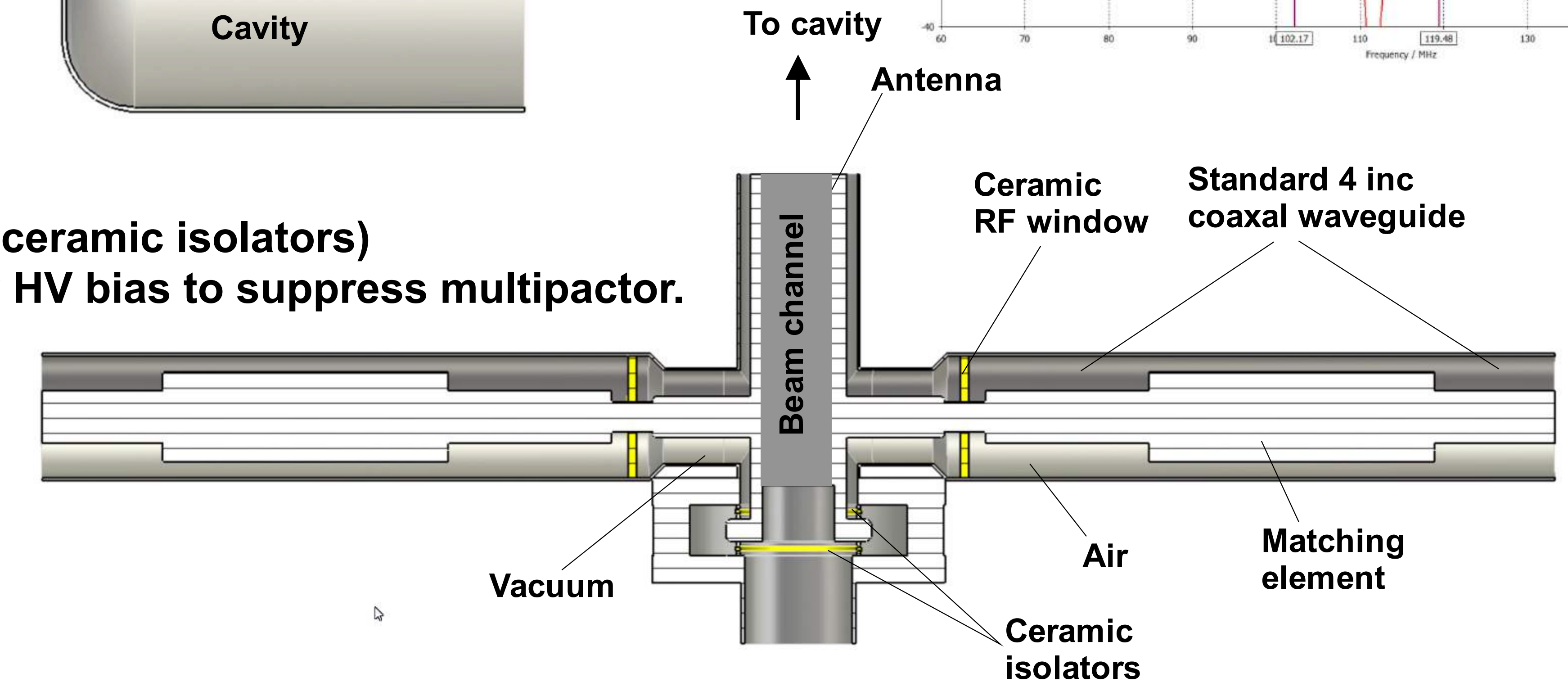
Antenna position of $Q_{ext} = 9.4e4$



Passband ~18 MHz (~ 16%)



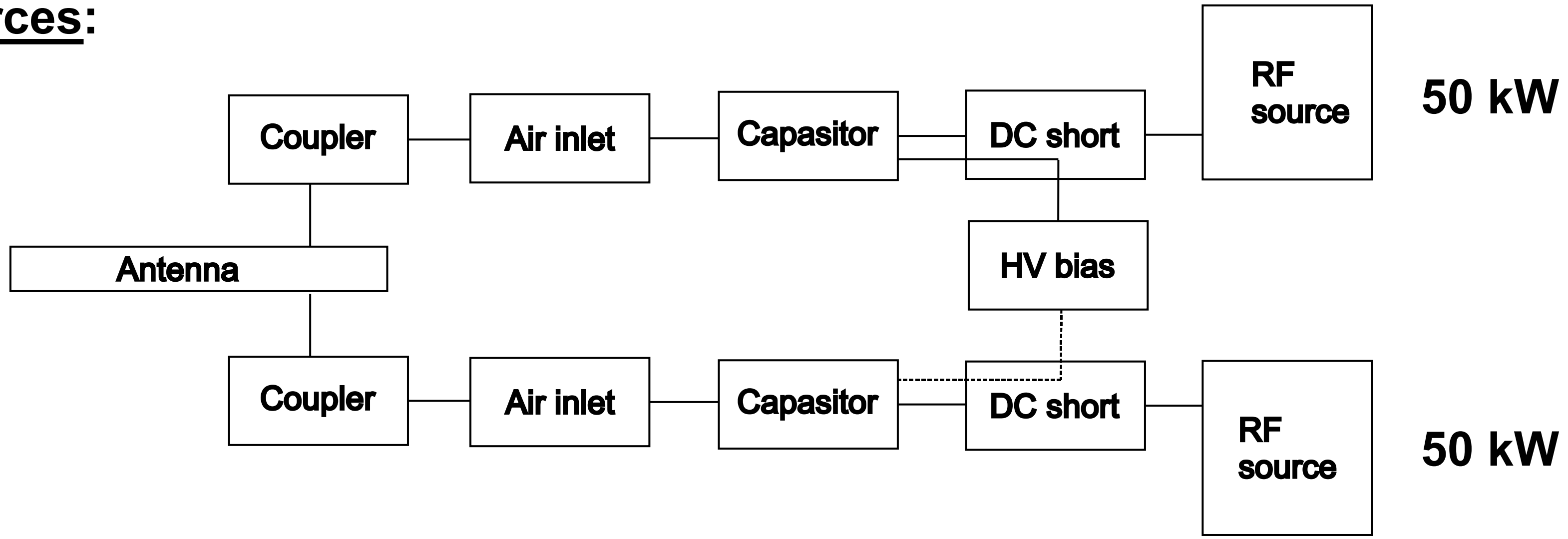
**Configuration (ceramic isolators)
allows to apply HV bias to suppress multipactor.**



Design of 100 kW FPC

Possible RF configuration

Two RF sources:

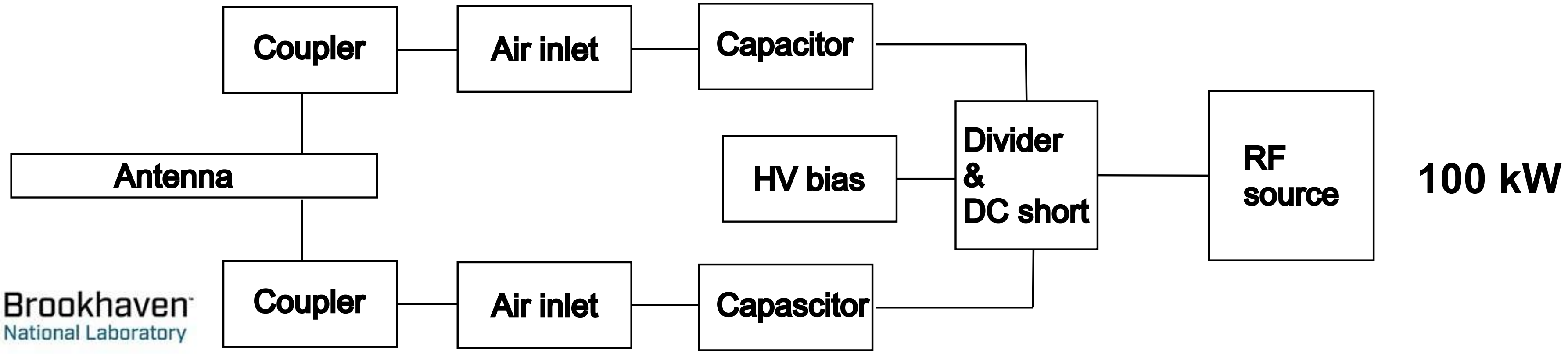


Coupler
Air inlet
Capasitor
DC short
RF source
50 kW
Antenna
HV bias
Coupler
Air inlet
Capasitor
DC short
RF source
50 kW

One RF source:

All elements between RF source and divider (including divider) are 6-inch diameter.

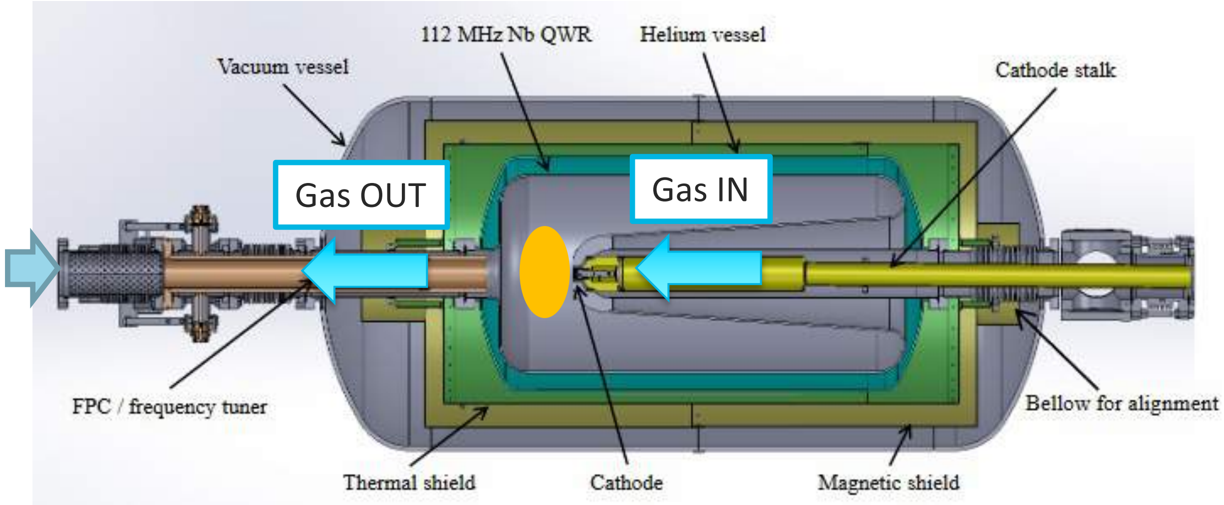
All elements between divider and coupler are 4-inch diameter.



Coupler
Air inlet
Capacitor
Antenna
HV bias
Divider & DC short
RF source
100 kW
Coupler
Air inlet
Capascitor

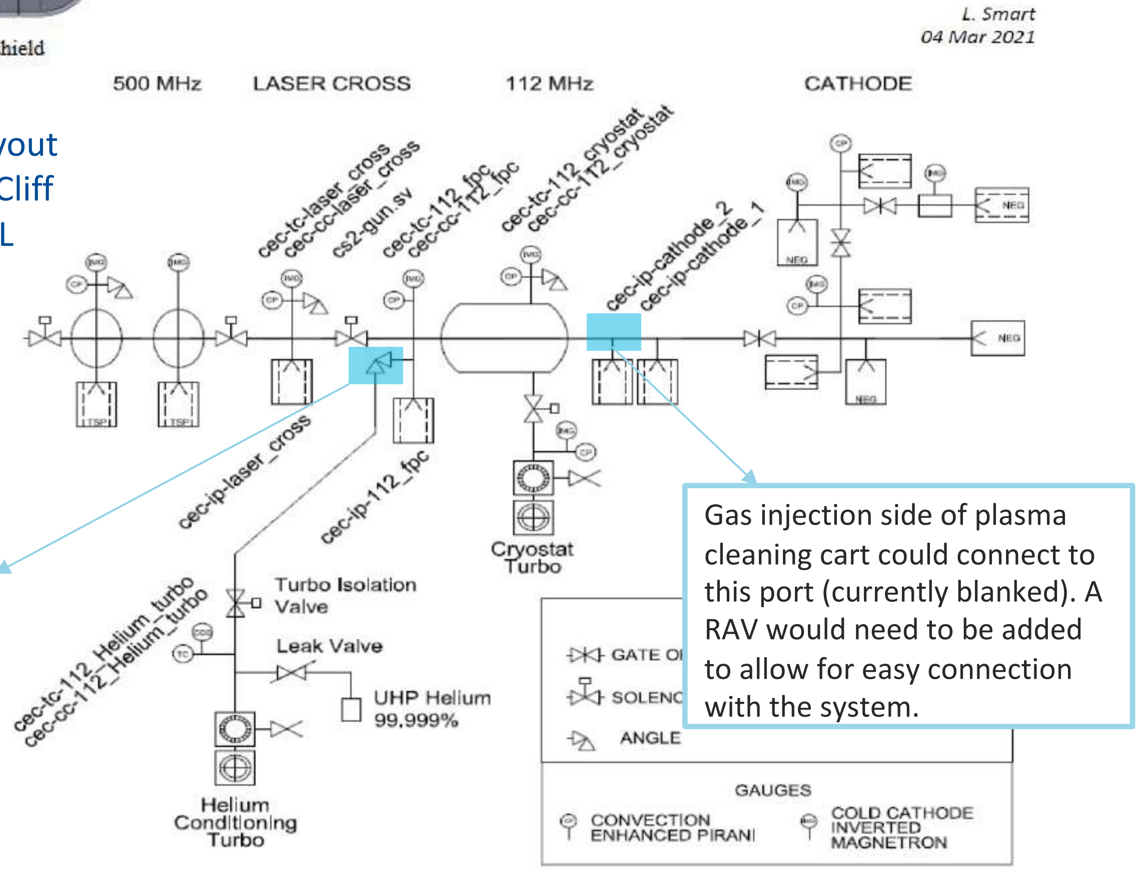
Plasma treatment system

RF excitation



- ➢ In order to create a gas flow inside the cavity, gas is injected from one side and pumped out from the other side; this appears to be feasible in the SRF gun system: gas can be injected from cathode side and pumped out from the FPC side;

SRF gun layout curtesy of Cliff Brutus, BNL



Vacuum side of plasma cleaning cart could connect to this RAV.

Gas injection side of plasma cleaning cart could connect to this port (currently blanked). A RAV would need to be added to allow for easy connection with the system.

- ➢ Same design of the gas injection and vacuum system cart currently in use at Fermilab can be used.

Achievements & Milestones

Design of 100 kW FPC:

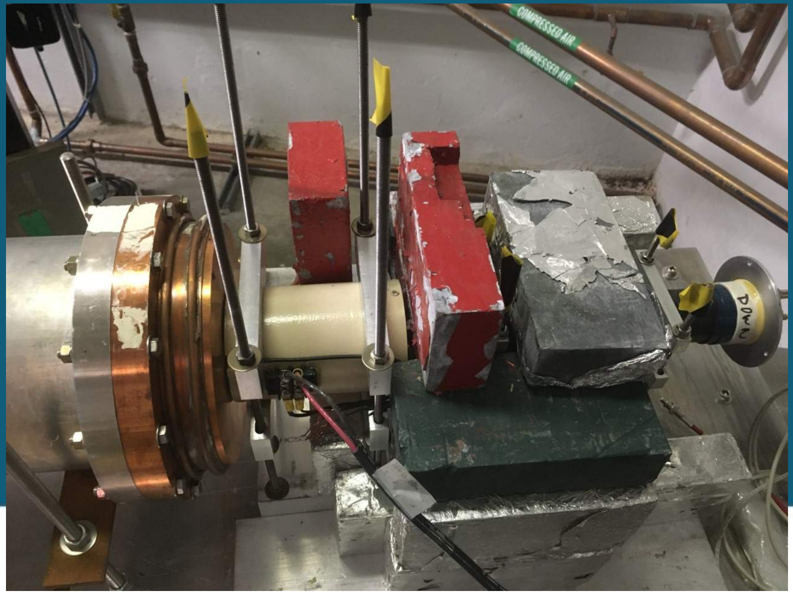
- Found the configurations of couplers which can be accommodated by existing facility with minimum changes.
- According to the simulations the couplers satisfy technical requirements:
  - Operating power 100 kW;
  - Q_{ext} ~9.4e+5;
  - Tuning range > ±3.5 kHz;
  - Multipactor is suppressed by HV bias.
- RF, thermal designs of coupler(s) are practically finished.
- RF design of the waveguide elements is done.
- Mechanical design of the coupler and the waveguide system is under way.

Plasma treatment system:

- Preliminary analysis suggests that plasma processing looks easily applicable to the 112 MHz SRF gun;
- From simulation it appears as **plasma ignition can be achieved** by exciting the cavity at its fundamental mode by using few Watt -> needs to be experimentally verified, Epk needed for ignition may be higher than in case of elliptical cavities, requiring more power than the one calculated;
- **No risk of igniting plasma at the antenna tip** since field is maximized at the cavity surface;
- FNAL gas injection and vacuum **cart design can be applied to SRF gun system**, only minor modifications expected.

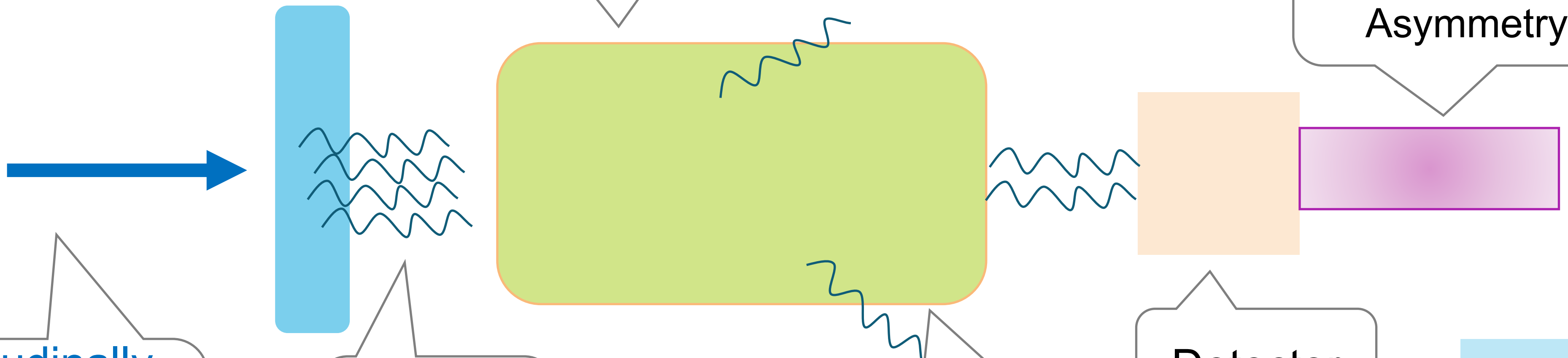
Development of Beam Polarimeter for BNL SRF Gun

Riad Suleiman on behalf of JLab



An Example of Polarimeter at Jefferson Lab CEBAF – Summer 2018

Compton Transmission Polarimeter



Radiator

Polarized Iron (Longitudinally polarized Electrons, $P_T(B)$~8%)

Calculated

Measured

PMT
(Compton Transmission Asymmetry, A_{Comp})

Longitudinally Polarized Electron Beam, P_b

Circularly Polarized Gammas

Polarized Compton Scattering
(Analyzing Power, $A_p(E,t)$)

Detector

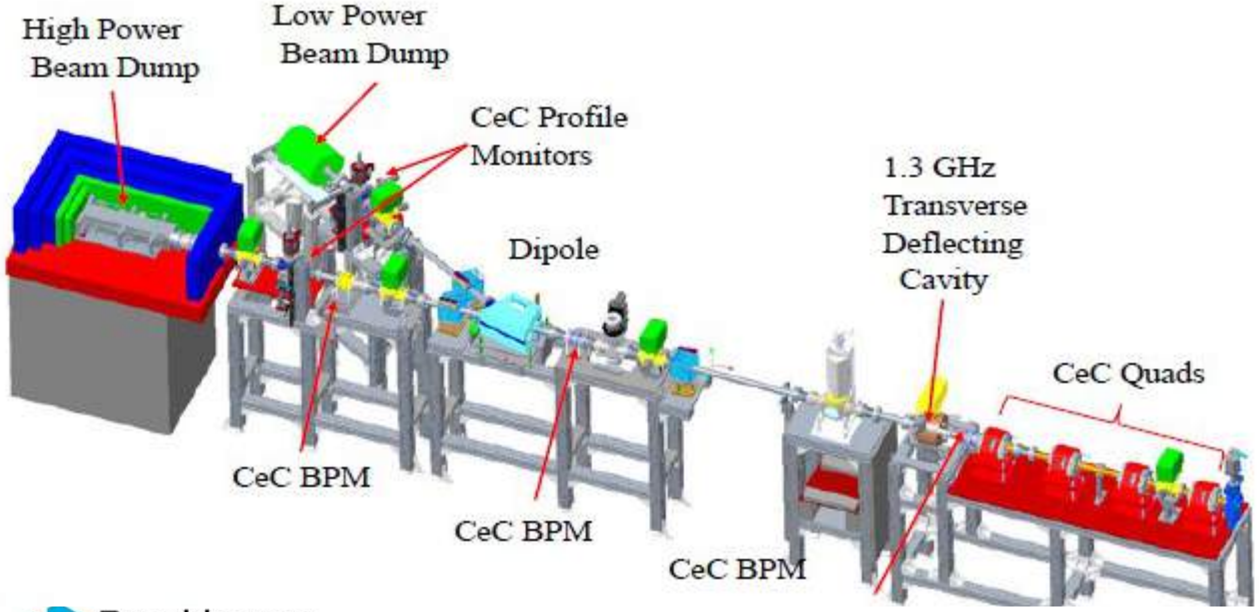
$$P_b = \frac{A_{Comp}}{P_T \times A_p}$$

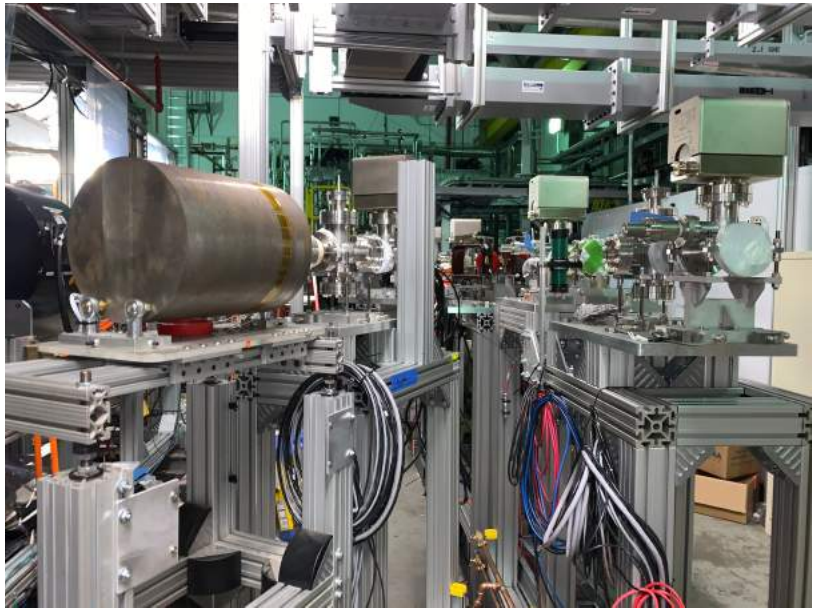
GEANT4 Simulation

$(P_T \times A_p)$ from Calibration at JLab

Polarimeter Parameters

- CEBAF Injector can deliver electron beam with 5 – 9 MeV kinetic energy
- CEBAF Mott polarimeter ideally works at 5 MeV kinetic energy
- At BNL, electron beam kinetic energy will be 5.0 MeV (total energy 5.5 MeV)
  - Minimum radiation levels and no risk of activation
- Compton Transmission Polarimeter will be installed in place of Low Power Beam Dump
- Maximum average current is limited to 2.5 μA by Low Power Dump

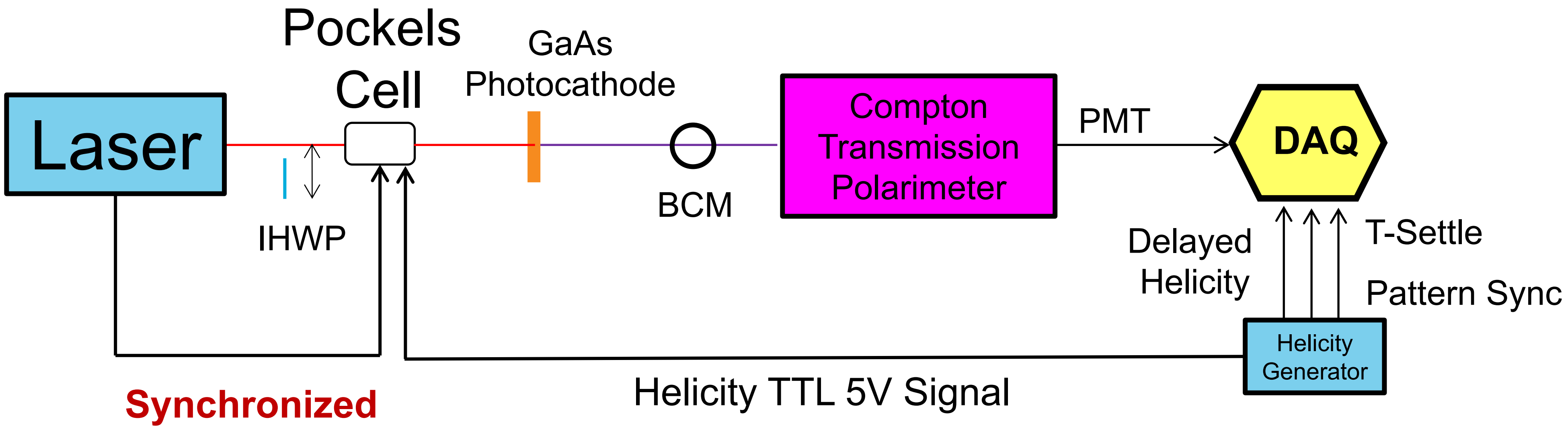




Brookhaven National Laboratory

Jefferson Lab

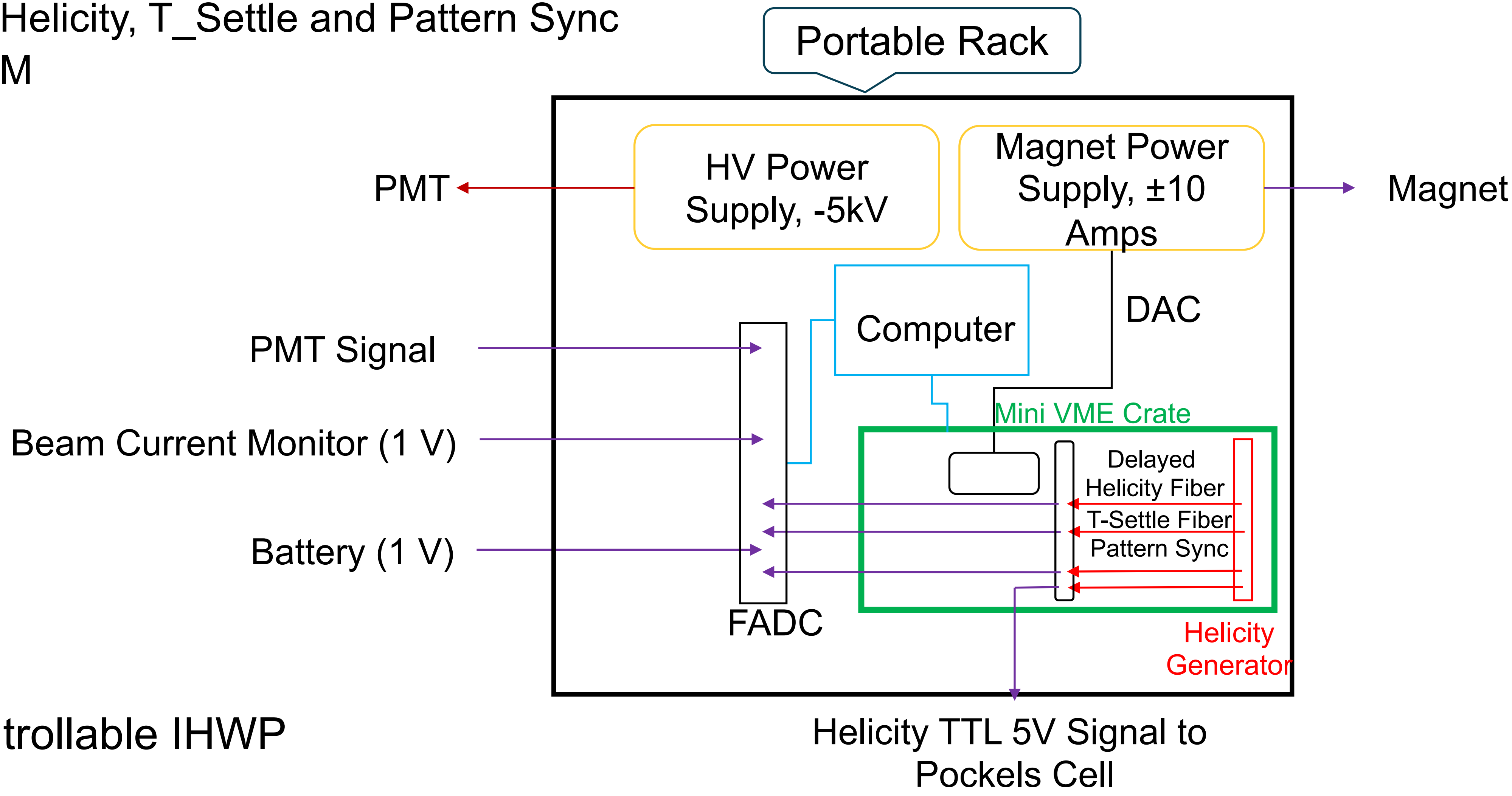
Polarimeter Schematics at BNL



- Pockels Cell is synchronized to laser
- Helicity board will just provide a gate to determine which voltage (helicity) Pockels Cell gets set to

New Portable Data Acquisition System (DAQ)

- DAQ Readout:
  - Delayed Helicity, T_Settle and Pattern Sync
  - PMT, BCM
  - Battery



- Remote controllable IHWP

Polarimeter Design Optimization

- Student Benjamin Fernandes Neres (from France)

- https://wiki.jlab.org/ciswiki/images/8/82/CompPol_Optimization_B.Fernandes-Neres.pdf

- GEANT4 simulation model of Compton transmission polarimeter was successfully implemented

- Optimization of polarimeter:
  - Radiator length = 7.0 mm, magnet iron core length = 8.0 cm, crystal detector radius = 3.5 cm and length larger than 18.0 cm

- Evaluated of performance within BNL beam conditions (duration of a measurement, radiation damage to crystal detector)

Beam dynamics and practical experience with SRF gun treatment

Irina Petrushina on behalf of SBU

Beam dynamics studies

Desired beam parameters to deliver 1-3 mA

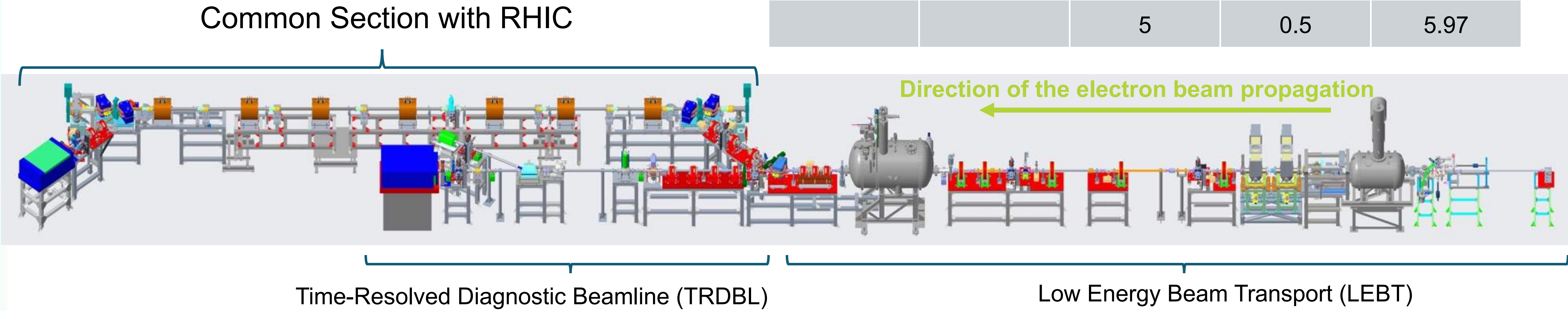
- Charge/bunch: 1.5-3.5 nC
- Operational repetition rate:
  - If using linac & buncher: 0.837 MHz
  - No linac & buncher: 2.974 MHz
- Higher current (3-10 mA) can be achieved by scaling up charge/bunch or repetition rate.

Operation without linac

P [kW]	I_{beam} [mA]	V_{gun} [MV]	Q_{bunch} [nC]
2.5	1	1.35	0.34
f [MHz]	2	1.25	0.67
2.974	3	0.833	1.01
	4	0.625	1.34
	5	0.5	1.68

Operation with linac @ 3-6 MV

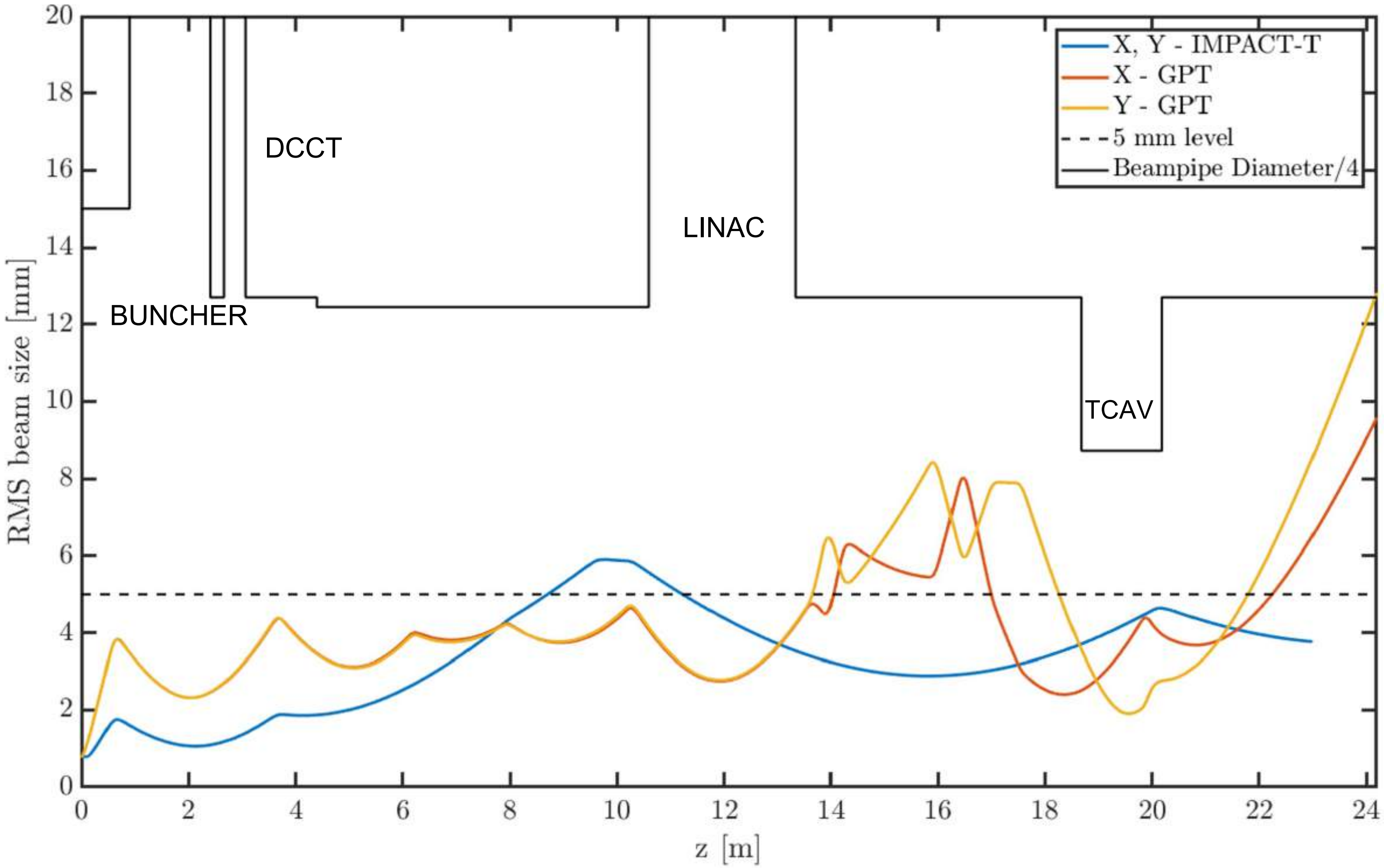
P [kW]	I_{beam} [mA]	V_{gun} [MV]	Q_{bunch} [nC]
2.5	1	1.35	1.19
f [MHz]	2	1.25	2.39
0.837	3	0.833	3.58
	4	0.625	4.78
	5	0.5	5.97



Beam dynamics studies

Linac & buncher are OFF

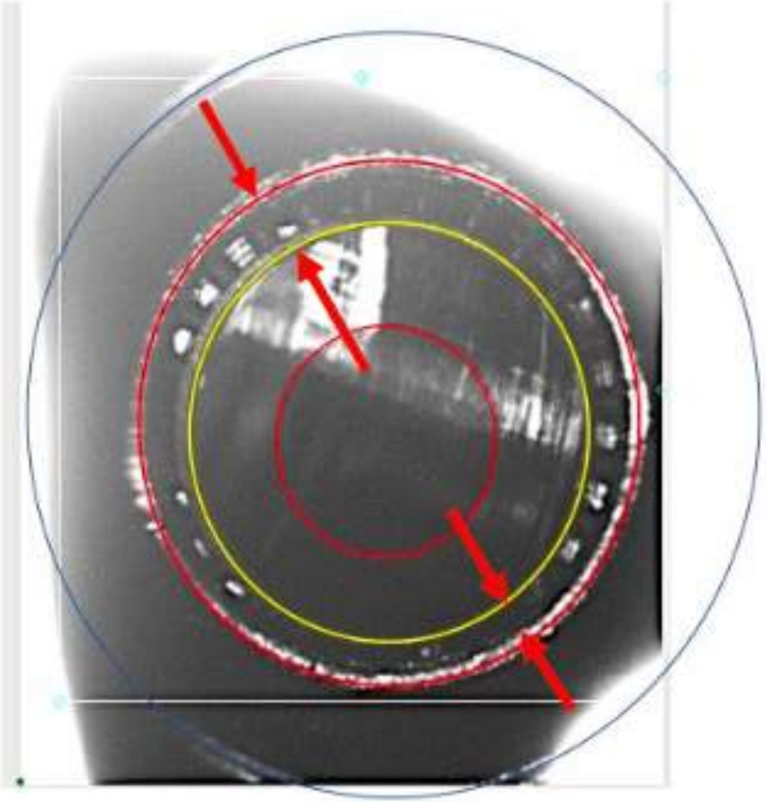
Parameter	Value
Bunch charge [nC]	1.5
Beam current @ 0.837 MHz [mA]	1.25
Laser pulse length [ps]	750
Gun voltage [kV]	833

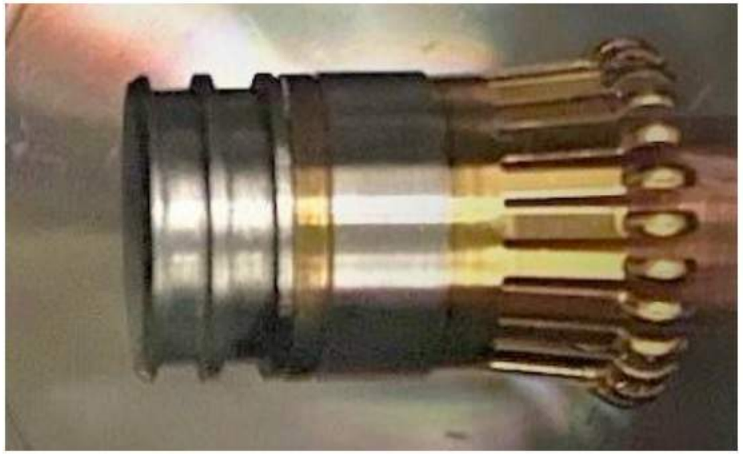


Practical experience with SRF gun treatment

Setback – damaged CeC cathode end effector

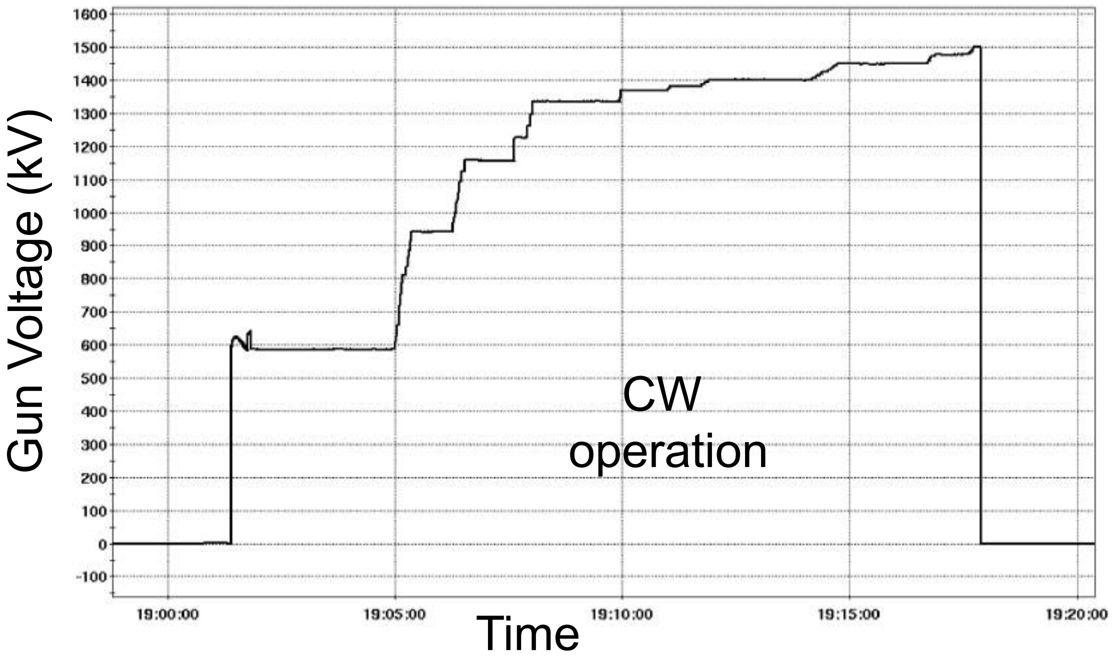
- In February 2021 SRF **gun showed significant performance degradation**
- Upon inspection, **damage** was found **to the cathode end effector within the gun**
- The damage cause significant contamination requiring an **immediate cavity treatment**

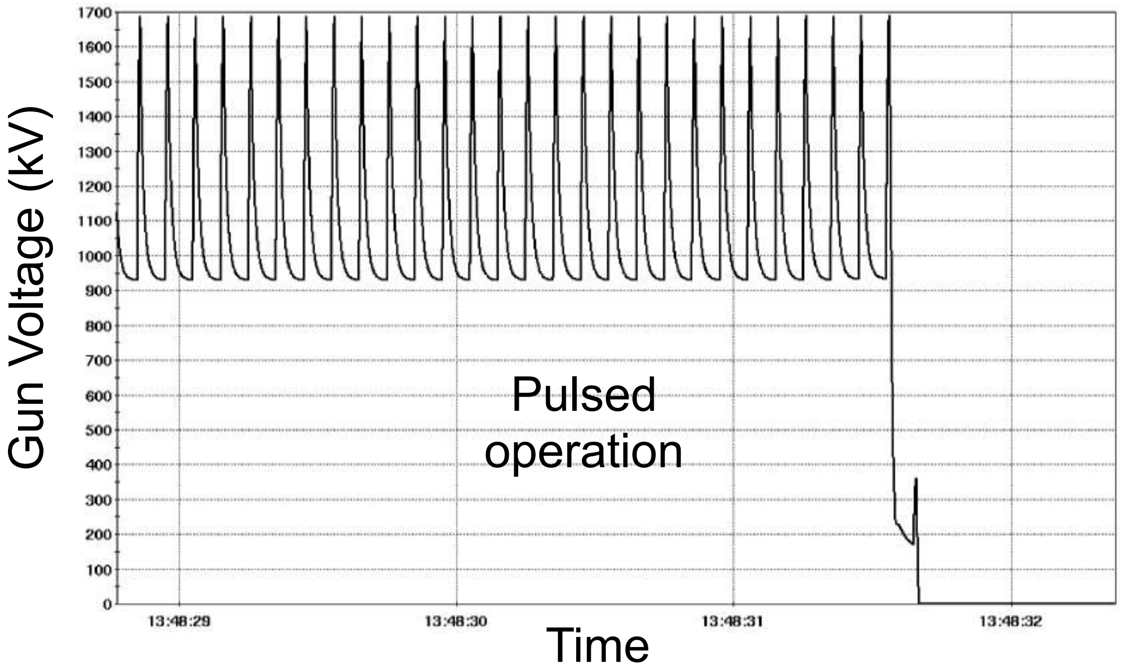




Practical experience with SRF gun treatment

- The maximum **CW voltage** achieved is **1.5 MV**. The **voltage is limited by** the **LiHe consumption** (max. available 8 g/sec).
- **Quench-like limit occurs at 1.7 MV.** This was done with a blank metal cathode and the cathode stalk in place (with recess ~ 8 mm).

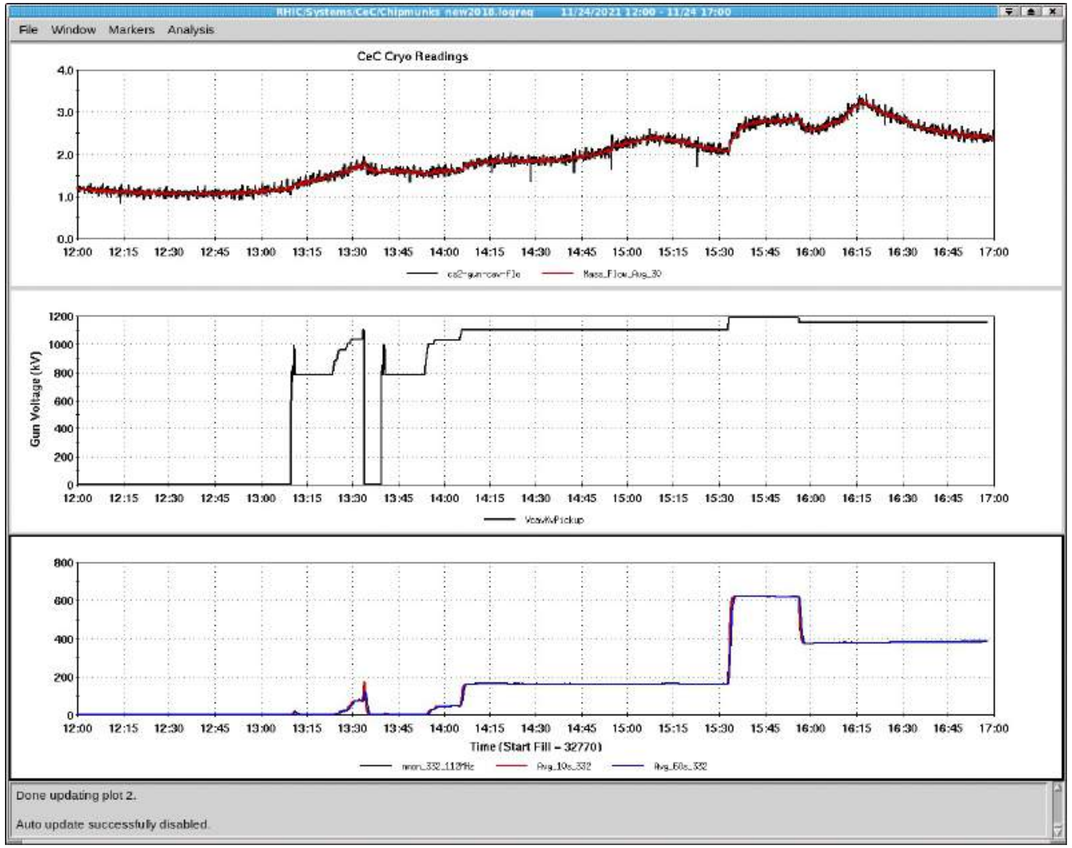




After conditioning we managed to get **19.7 nC** per bunch with 500 ps pulses.

Milestones & Achievements

- Beam dynamics simulations for the high current gun operation in February-March 2022 are nearing completion
- Despite the damaged cathode end effector, we were able to restore and improve the current gun operation:
  - Demonstrated successful He conditioning
  - Achieved 1.5 MV CW, and 1.7 MW pulsed
  - Impeccable gun operation after the system shut-down (July-November)
  - This year we have observed the lowest radiation and LeHe consumption throughout the whole course of the gun operation



Done updating plot 2.

Auto update successfully disabled.

Thank you for listening

List of Participants:

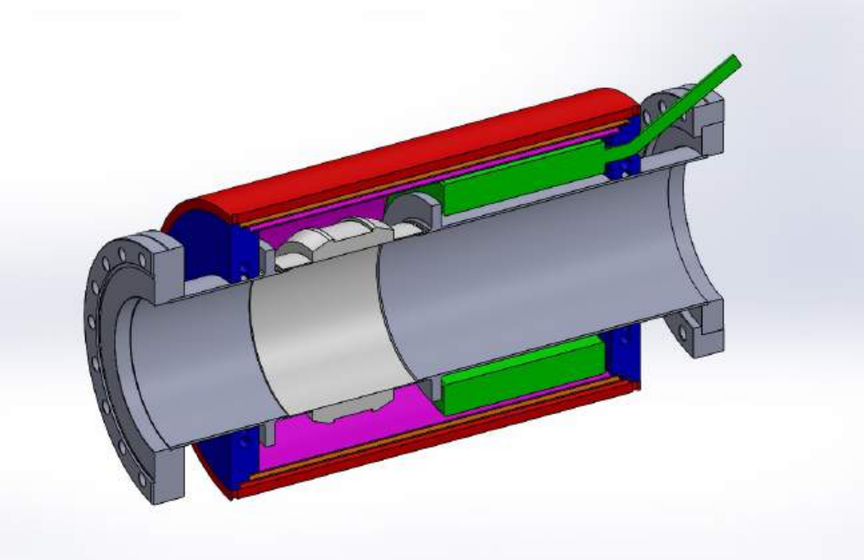
- SBU: V.N Litvinenko (PI), I. Petrushina (co-PI), K. Shih, A. Coakley, machine shop
- BNL: Y. Jing (PI), W. Fischer, I. Pinayev, J. Ma, G. Wang, J. C. Brutus, P. Inacker, E. Wang, J. Skaritka, L. Cultrera, T. Rao, P Bachek, G. Narayan, T. Hayes, A. Zaltsman, F. F. Severino, D. Weiss, L. A. Smart, K. Decker, Z. F. Altinbas, R. Michnoff, M. Minty, M. Paniccia
- FNAL: V. Yakovlev (PI), S. Belomestnykh, S. Kazakov, T. Khabiboulline M. Martinelli, J. Helsper, Y. M. Pischalnikov
- JLab: R. Suleiman (PI), M. Poelker, J. Grames, E. Voutier, B.F. Neres

Back-up slides

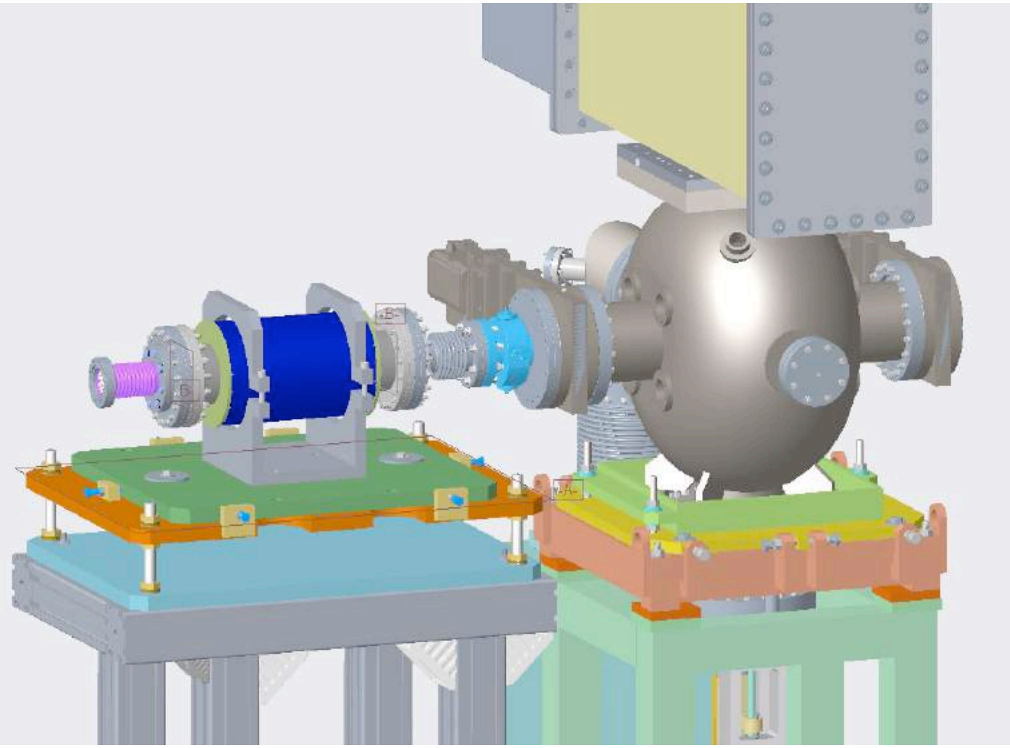
BNL back-up

Preparation for the gun operation with 1-3 mA:

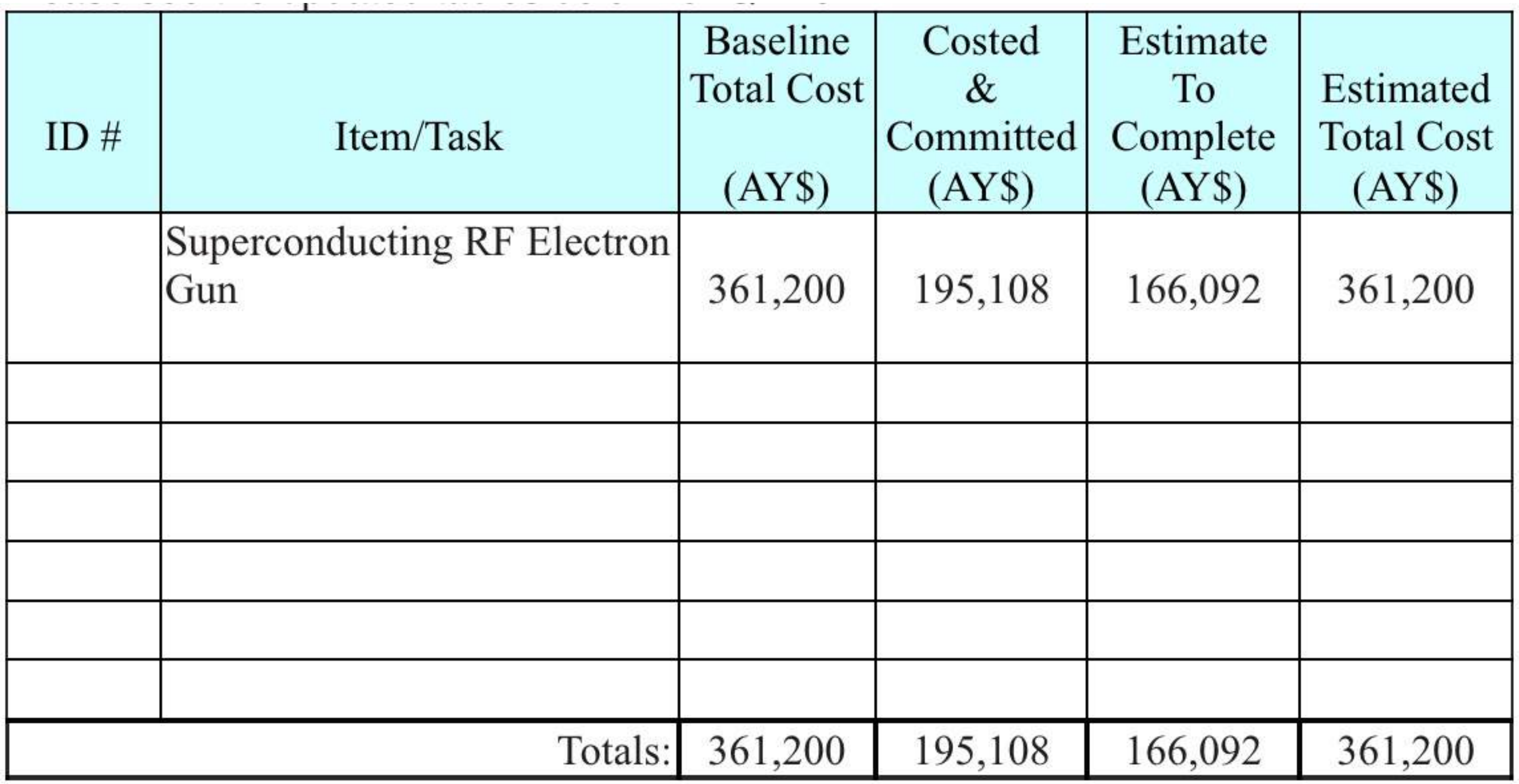
- The second of the two **DCCTs** that were used in ERL **has been rebuilt to have a larger aperture** than the original.
- It was **installed** in place of the second 500MHz cavity that was removed.



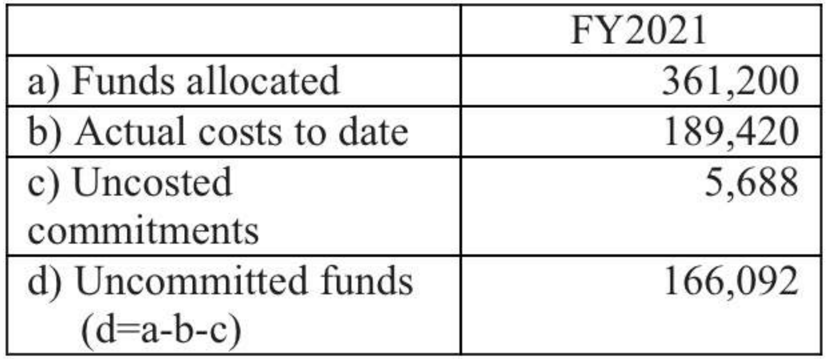
This DCCT will use an updated version of the electronics package that is designed to be more stable during thermal variations. This signal will then be processed with a spare channel in the existing Zynq system.



2021 BNL spending is on track



ID #	Item/Task	Baseline Total Cost (AY$)	Costed & Committed (AY$)	Estimate To Complete (AY$)	Estimated Total Cost (AY$)
	Superconducting RF Electron Gun	361,200	195,108	166,092	361,200
	Totals:	361,200	195,108	166,092	361,200



	FY2021
a) Funds allocated	361,200
b) Actual costs to date	189,420
c) Uncosted commitments	5,688
d) Uncommitted funds (d=a-b-c)	166,092

Brookhaven National Laboratory

Laser Expected Performance

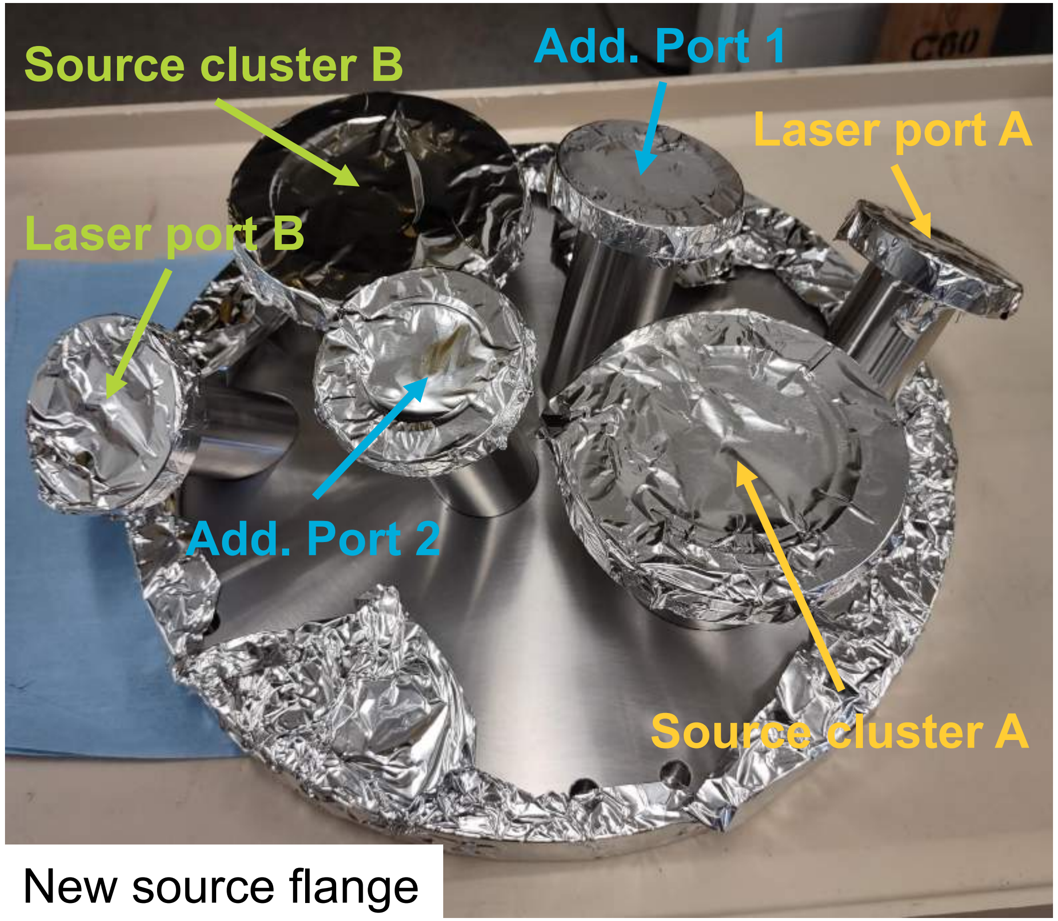
	Unit	Min	Typ.	Max
Seed Wavelength			1064.2	
Output Wavelength	λ		532.1	
Bandwidth	nm		0.05	
Pulse duration (depends on Seed Option)	Ps	50	350	750
Pulse Shape (Identical to Seed)	-		Flat-Top	
Repetition Rate	kHz	10	78	5000
Average Power (532nm)	W	5	6	5
Pulse Energy	μJ	500	75	1
Charge equivalent after spatial shaping (1%QE)	nC	1000	150	2

- The planned CeC upgrade is straight forward, with most specifications already demonstrated at a sister system located at Stony Brook university
- Most parts are in house already, no delays are expected

Main growth chamber

- Replace the main UHV chamber to allow
  - Hosting two cluster of sources (better alignment, co-deposition);
  - 2 additional port for future R&D on protective coatings;

New main chamber

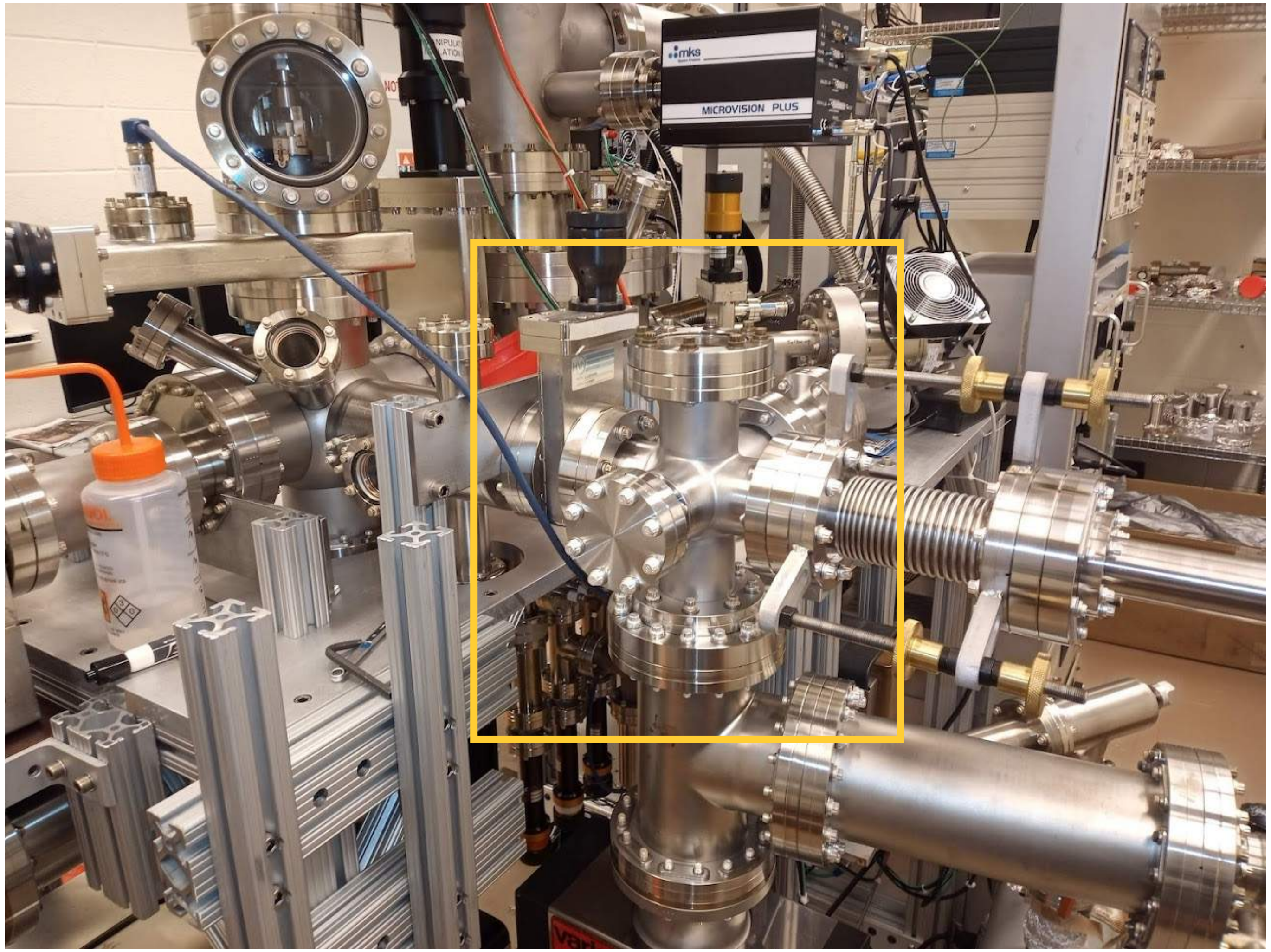


New source flange

Clustered evaporators

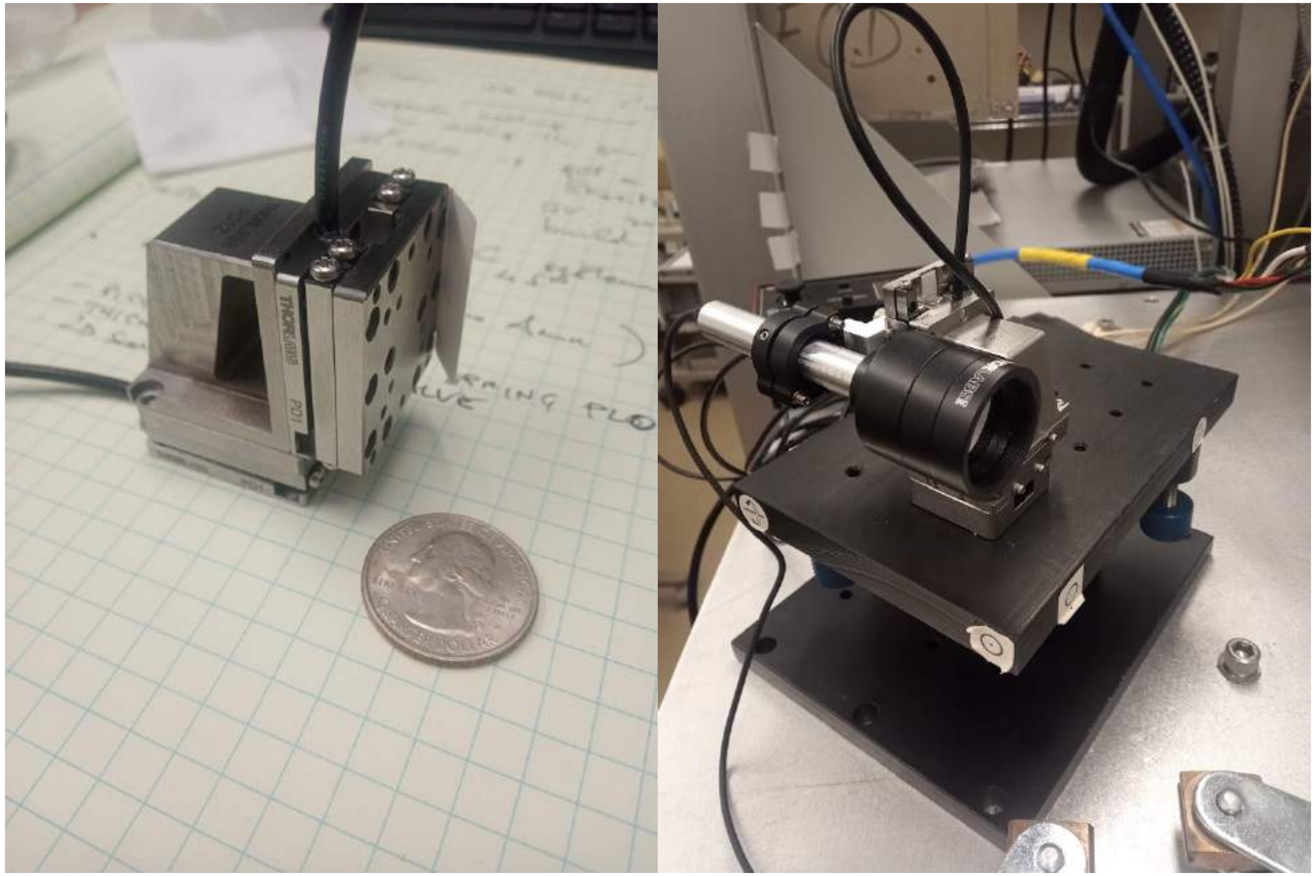
Installation of the new evaporators assembly has been delayed to Dec 2021-Jan 2022 because of delays in the delivery of some required vacuum components.

New docking chamber

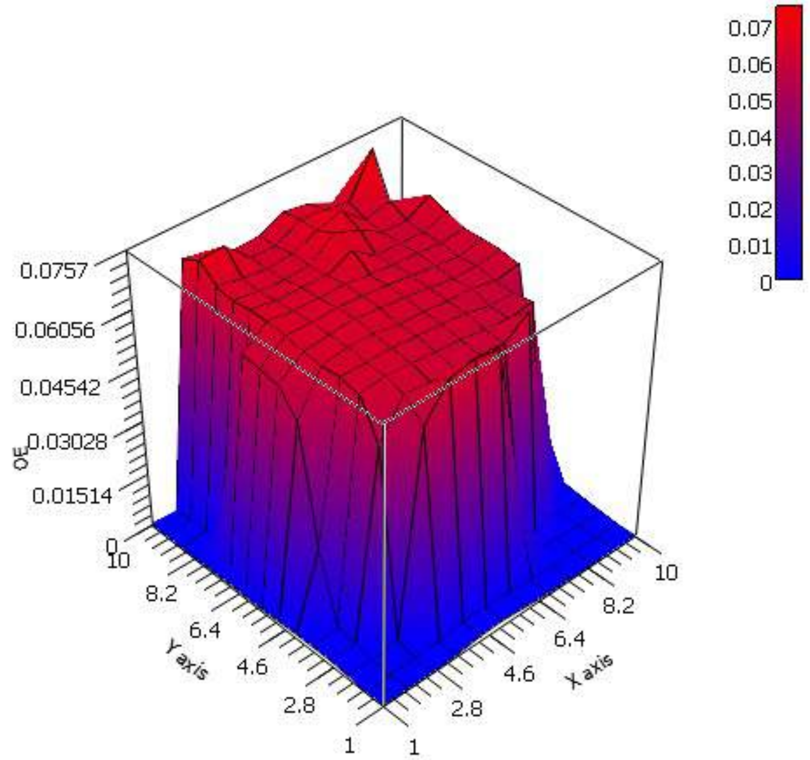


A new docking chamber with a 3.375” port allows for a larger clearance around the magazine minimizing the chances of scraping and of particulate production;

QE 2D scan capability is included



QE map of cathode #2 grown on 10/28/2021

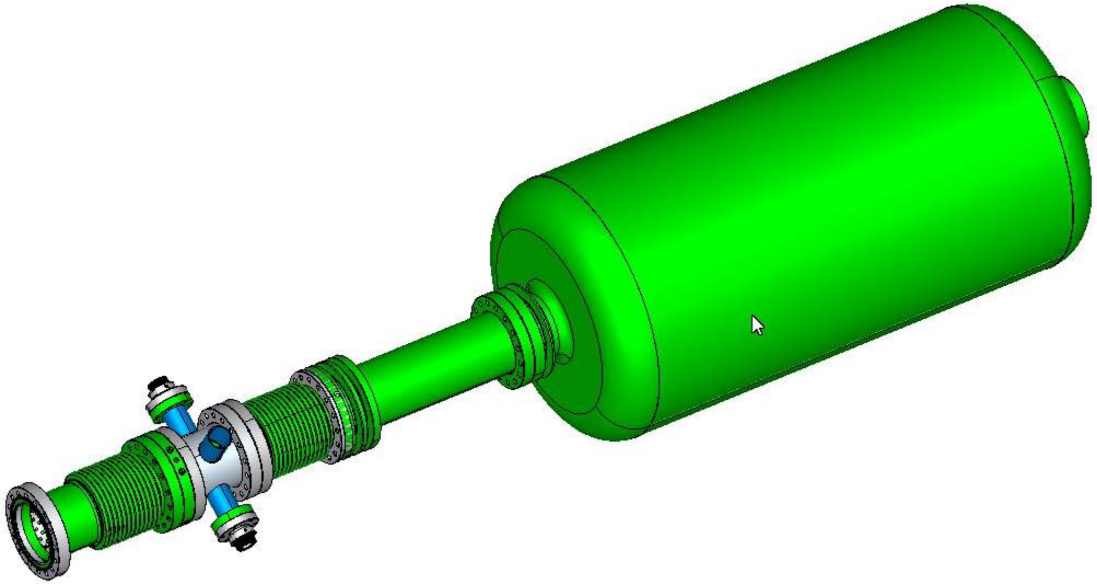


- Piezo motors are probably not the best choice due to their large backlash;
- looking to replace them with stepper motors;

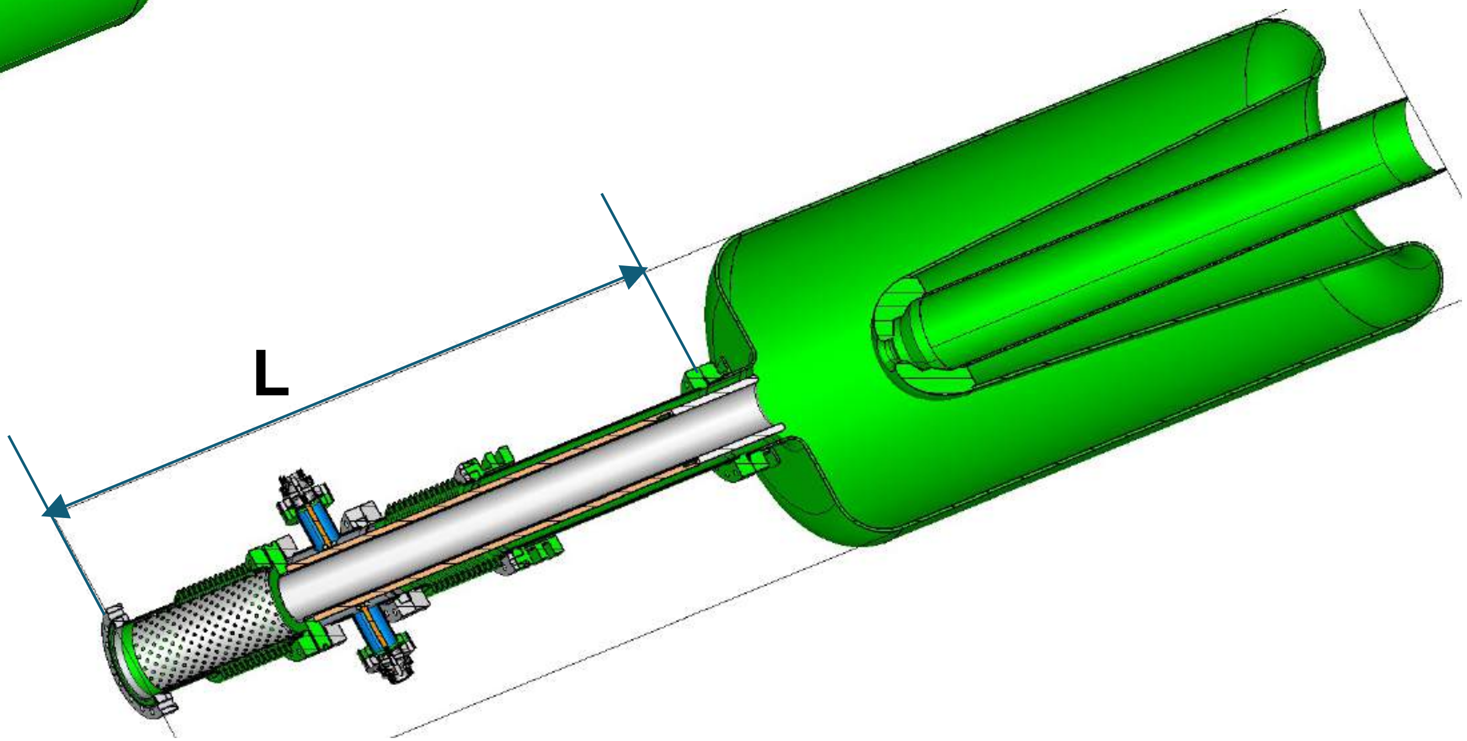
FNAL back-up

Design of 100 kW FPC

Task: replace existing input 1 kW coupler by a 100 kW coupler with minimum change of configuration.



Current configuration of “1kW” coupler



Cavity input port ID	100 mm
Outer conductor ID	97.4 mm
Antenna OD	80.0 mm
Antenna beam ch.	60.0 mm
L ~	862 mm

Achievements & Milestones

Design of 100 kW FPC:

- Found the configurations of couplers which can be accommodated by existing facility with minimum changes.
- According to the simulations the couplers satisfy technical requirements:
  - Operating power 100 kW;
  - Q_{ext} ~9.4e+5;
  - Tuning range > ±3.5 kHz;
  - Multipactor is suppressed by HV bias.
- RF, thermal designs of coupler(s) are practically finished.
- RF design of the waveguide elements is done.
- Mechanical design of the coupler and the waveguide system is under way.

Achievements & Milestones

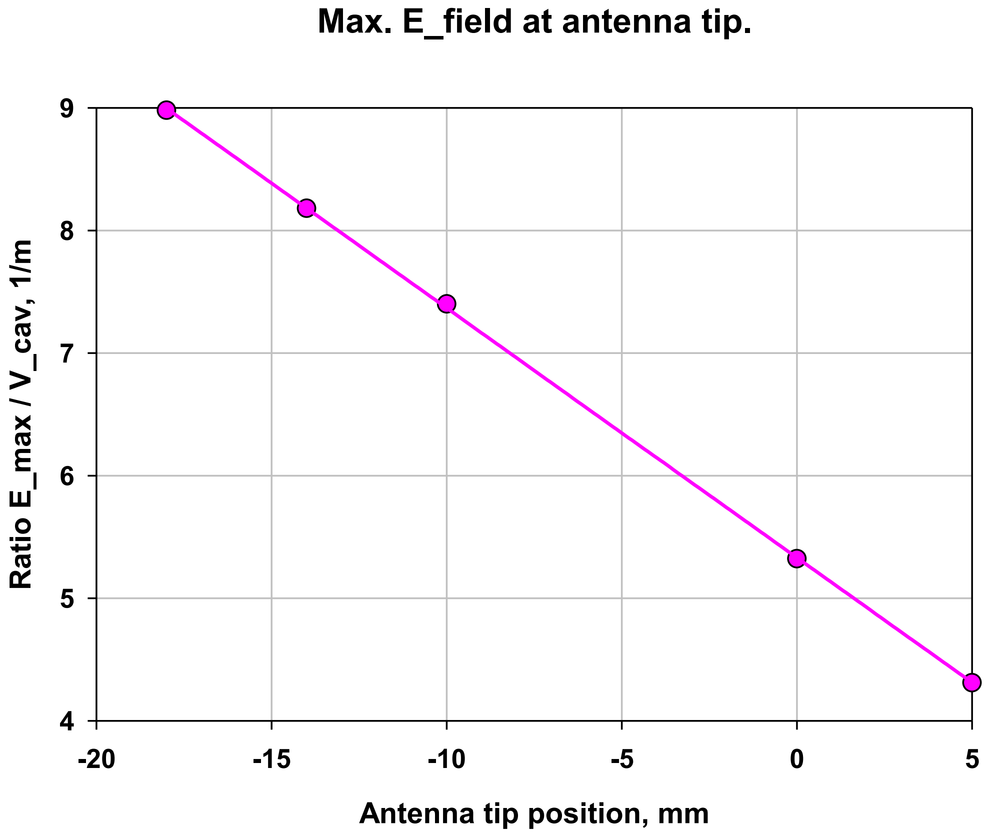
Plasma treatment system:

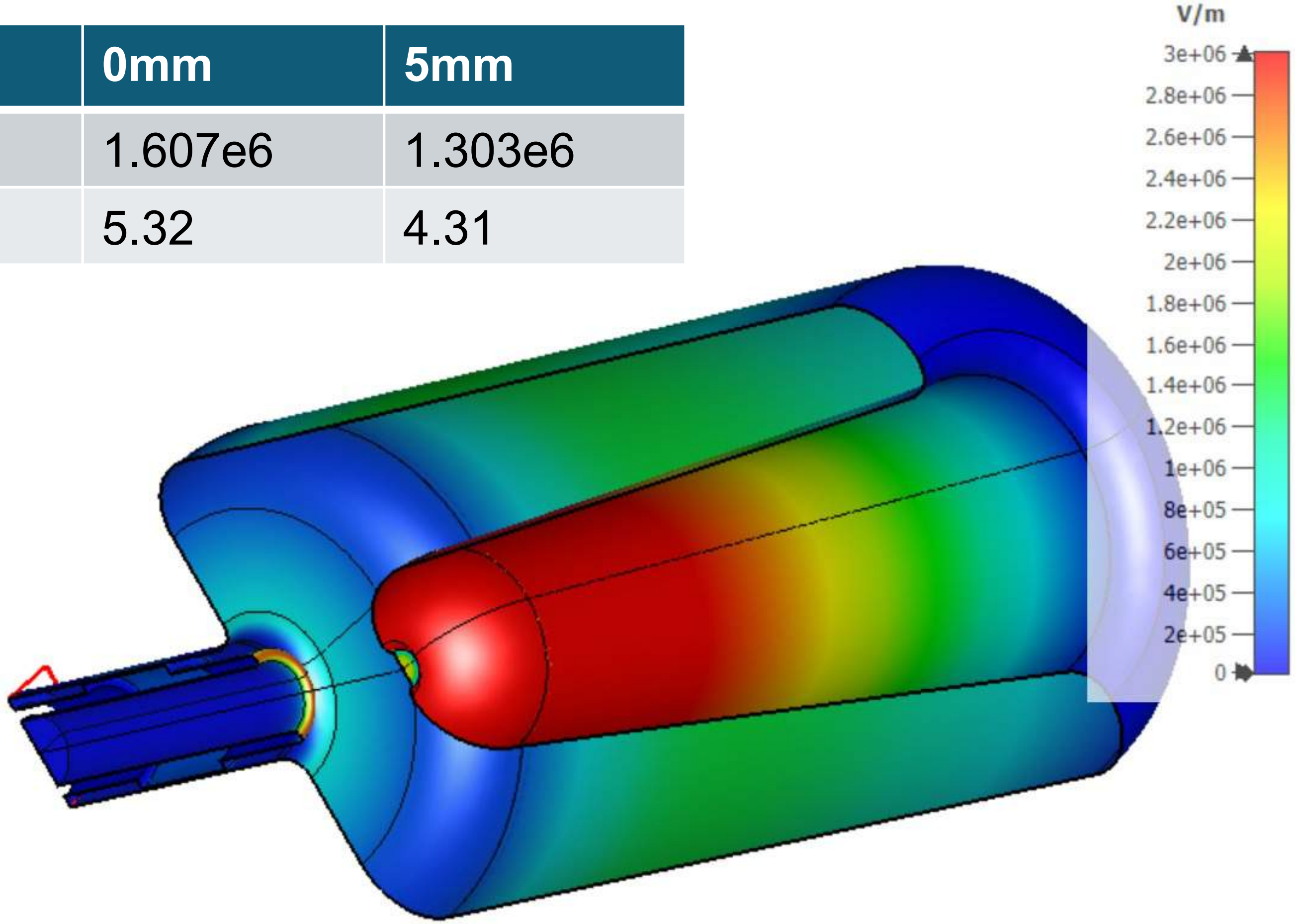
- Preliminary analysis suggests that plasma processing looks easily applicable to the 112 MHz SRF gun;
- From simulation it appears as **plasma ignition can be achieved** by exciting the cavity at its fundamental mode by using few Watt -> needs to be experimentally verified, Epk needed for ignition may be higher than in case of elliptical cavities, requiring more power than the one calculated;
- **No risk of igniting plasma at the antenna tip** since field is maximized at the cavity surface;
- FNAL gas injection and vacuum **cart design can be applied to SRF gun system**, only minor modifications expected.

Maximum electric field at the antenna tip

V (1J) = 3.02e5 V

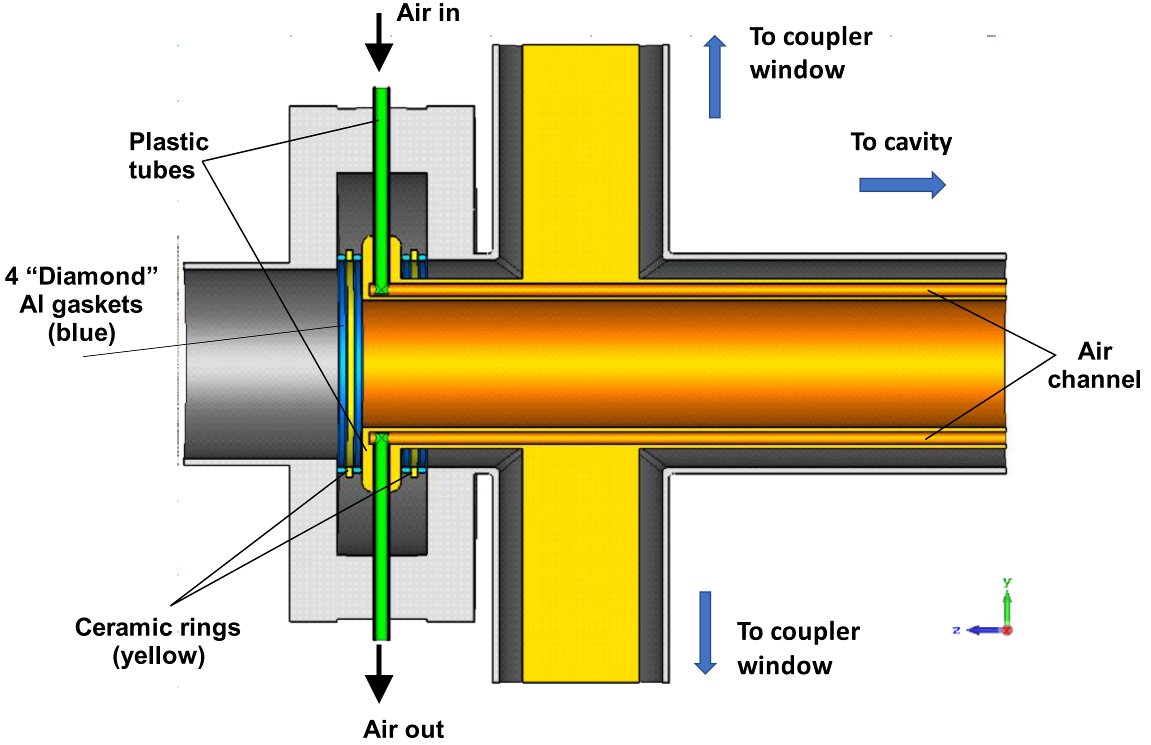
Position	-18mm	-14mm	-10mm	0mm	5mm
E_{max}	2.7107e6	2.469e6	2.234e6	1.607e6	1.303e6
E_{max}/V	8.98	8.18	7.40	5.32	4.31

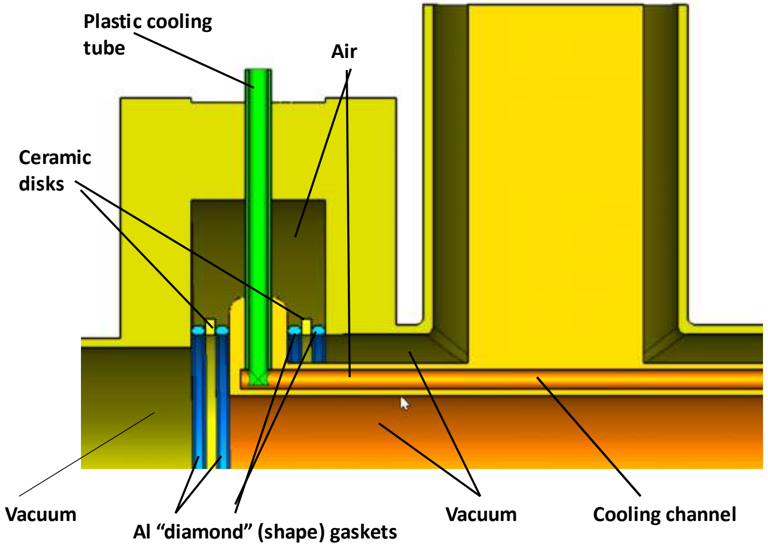




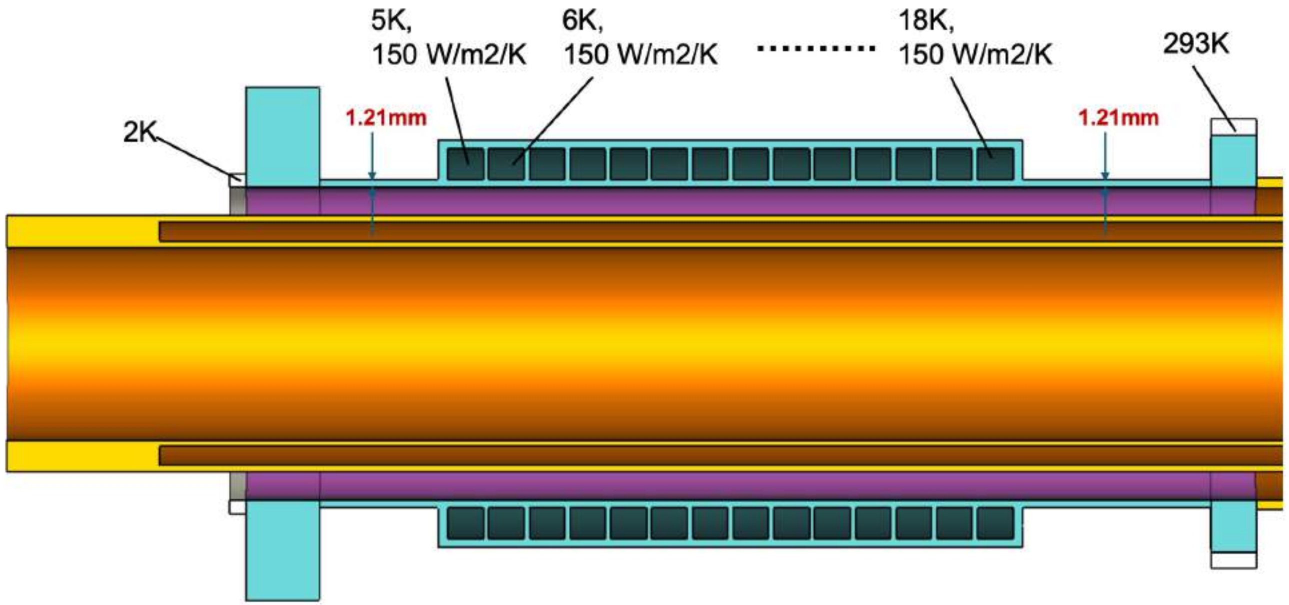
E_{max} < 9 MV/m for V = 1 MV

Schematics of the air cooling for the antenna





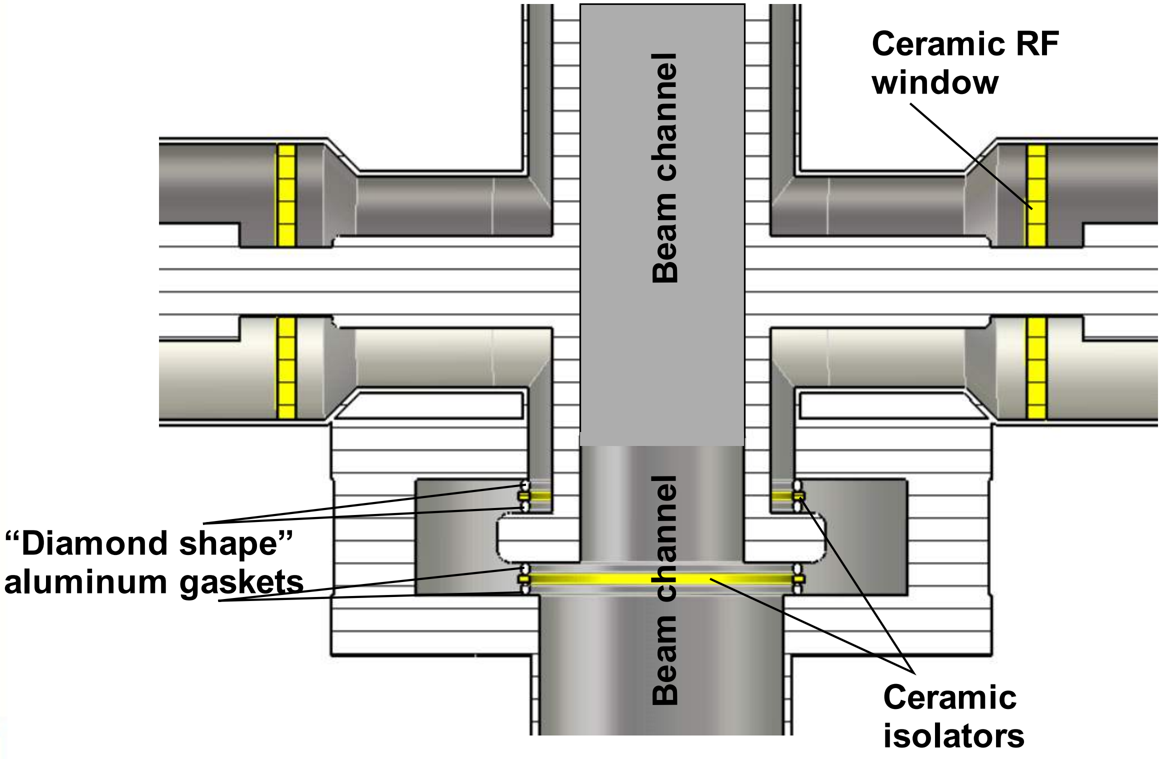
Cryogenic loading simulation, 100 kW, CW



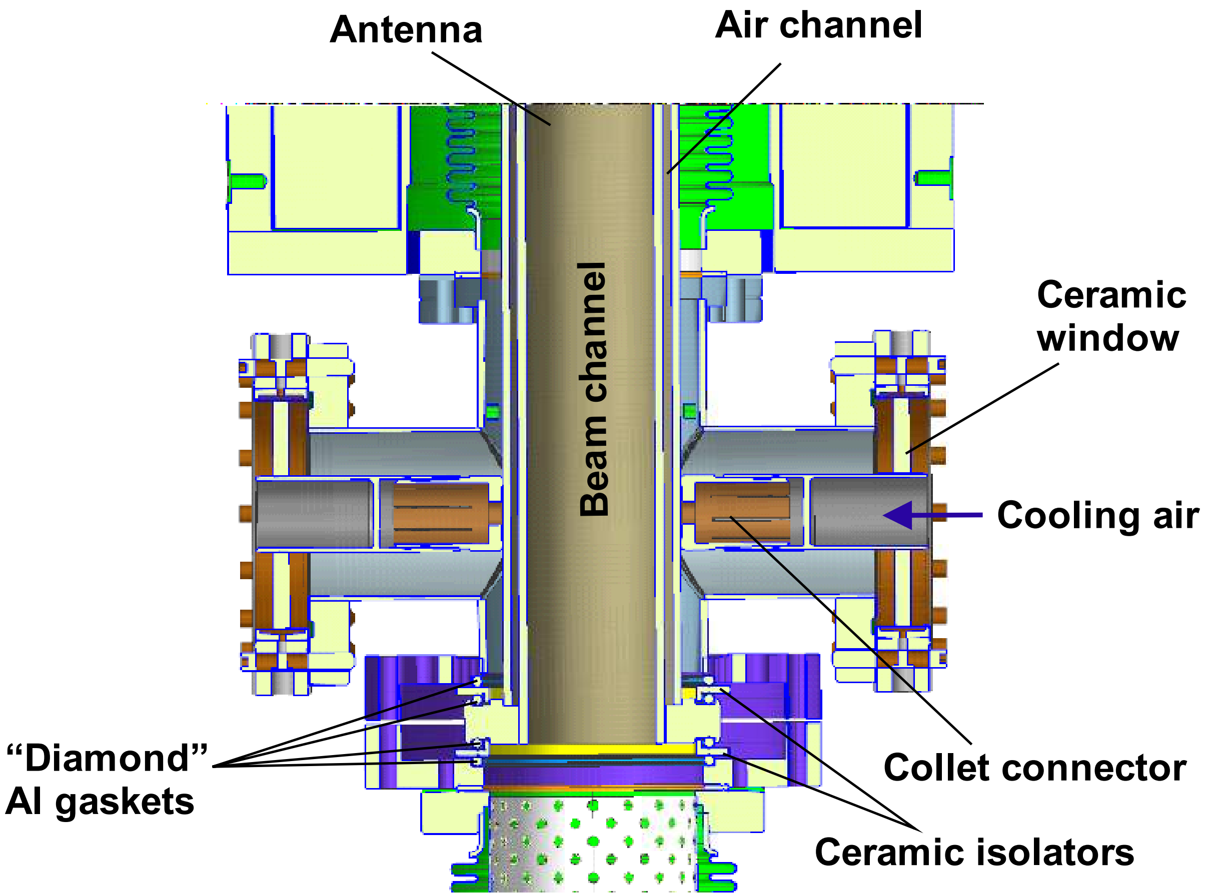
P_{in} = 100 kW   P to 2K = 0.05W   P to 5K He = 24.4W   P from 293K = -16.4W

Details of the window units

RF configuration

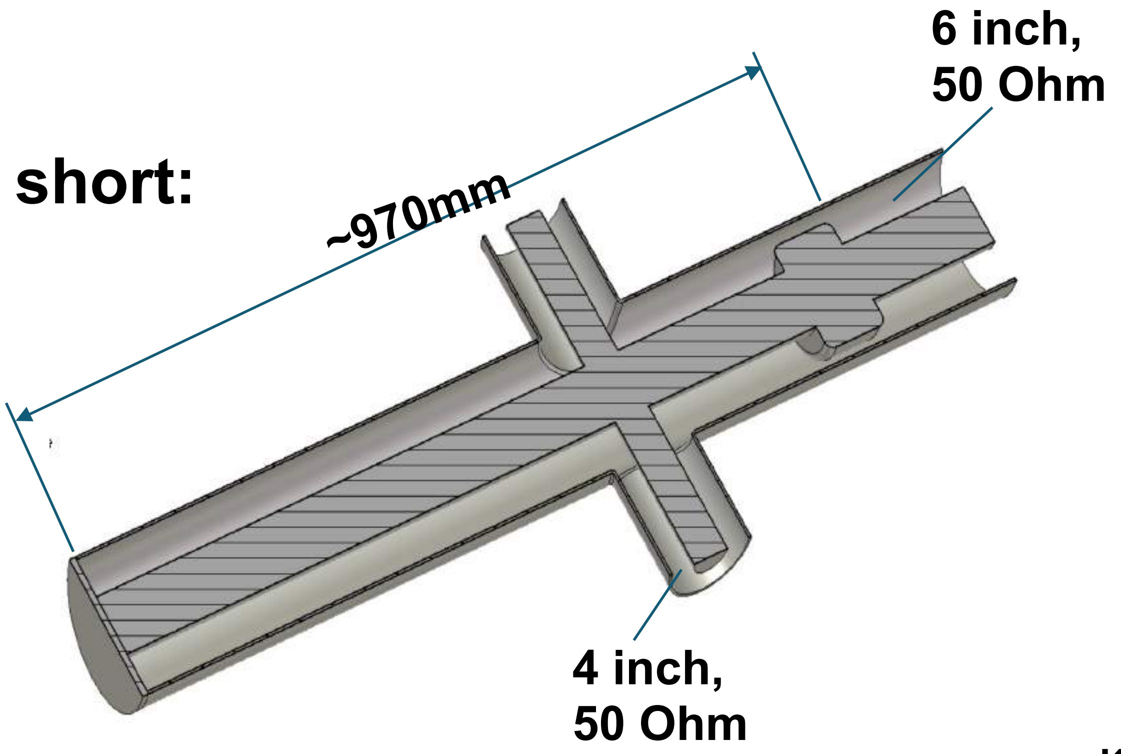


Mechanical design

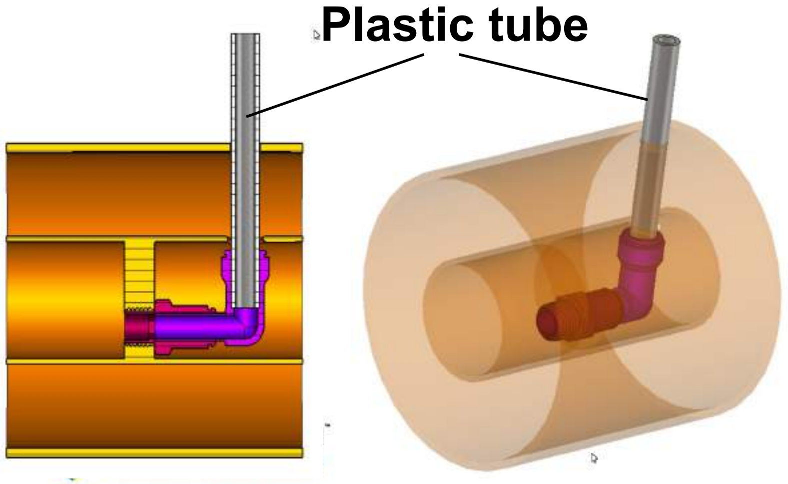


Some elements of the waveguide system

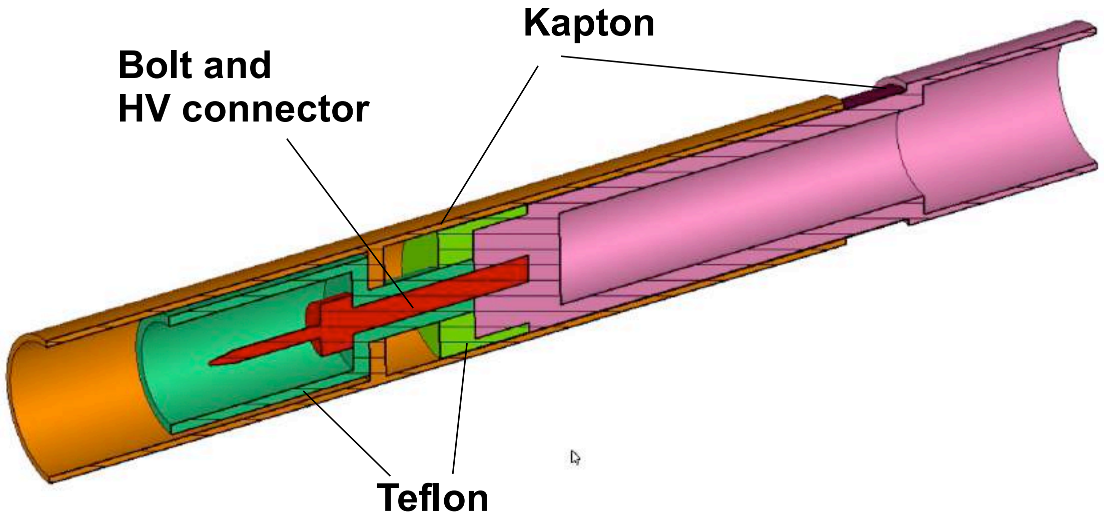
Power divider with short:



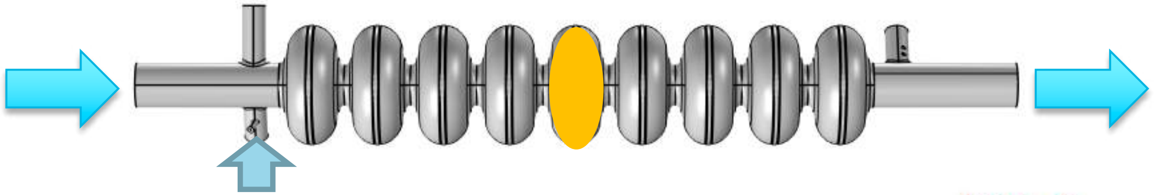
Cooling air inlet:



Inner conductor of capacitor:



Plasma processing for field emission abatement

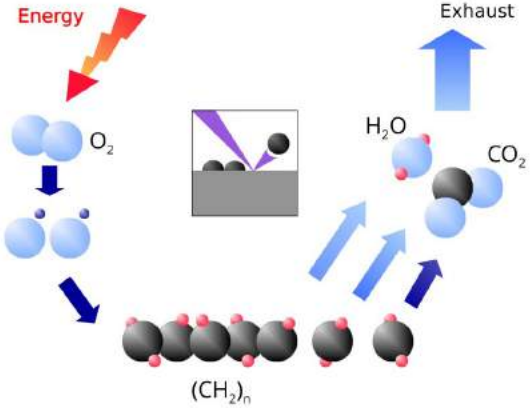


Gas IN

Gas OUT

RF excitation

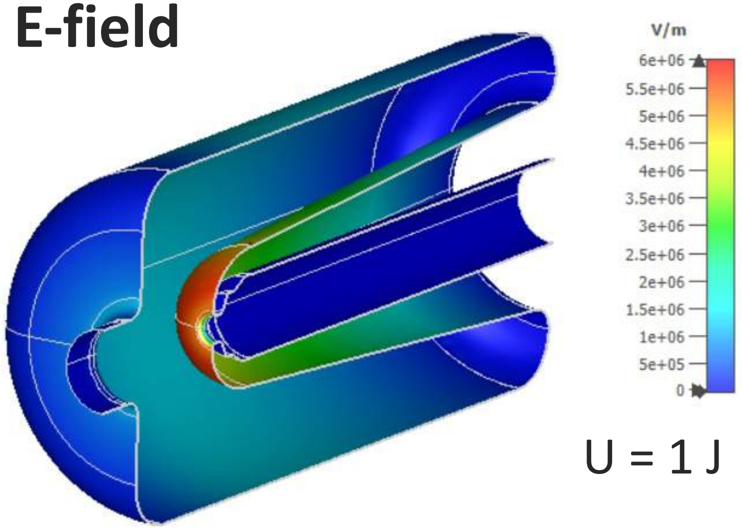
- Gas flow of Ne-O mixture (few % of O_2, mostly Ne) at p ~ 75-150mTorr;
- once plasma ignites oxygen reacts with hydrocarbons;
- reaction products (mostly CO_2, H_2O) are pumped out;
- work function increases, reducing FE;
- Successfully applied to SNS CMs by ORNL and LCLS-II HE vCM by FNAL. **MP reduction was observed as well** in both cases.



M. Doleans, J. Appl. Phys. 120, 243301 (2016)
M. Doleans et al. NIMA 812 (2016) 50-59
P. Berrutti et Al., J. of Appl. Phys. 126, 023302 (2019);
B. Giaccone et Al. Phys. Rev. Accel. Beams 24, 022002 (2021);

Analysis of plasma ignition in the SRF gun

E-field



U = 1 J

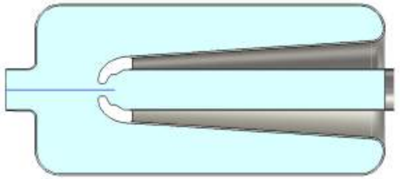
Courtesy of S. Kazakov, FNAL

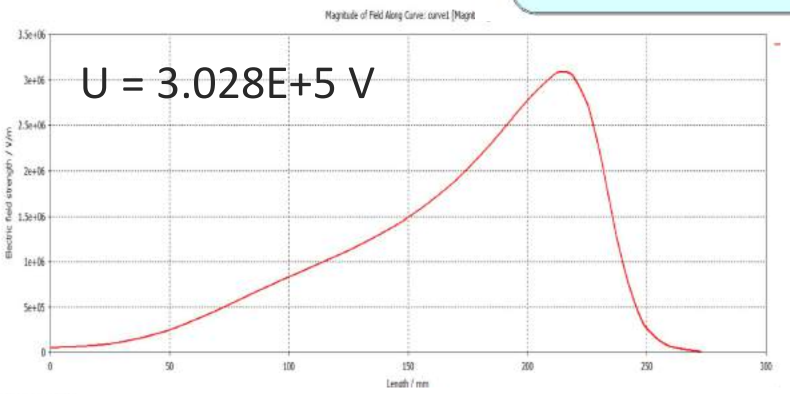
- Electric field maximum close to the cavity inner conductor, this is the region where plasma will ignite;
- Plasma can be ignited at room T by exciting the cavity fundamental mode with just few Watts:

Q_{ext}	9.3e4
Q_0	4.8e3
β	0.051
$\lvert\Gamma\rvert^2$	0.81
E_{pk} [kV/m]	10*
U [J]	2.78e-6
P_c [W]	0.41
P_f [W]	2.2 W

*E_{pk} ~ 10 kV/m needed to ignite plasma in elliptical cavities. We will need to verify experimentally that the same applies to this geometry.

E-field along curve 1:

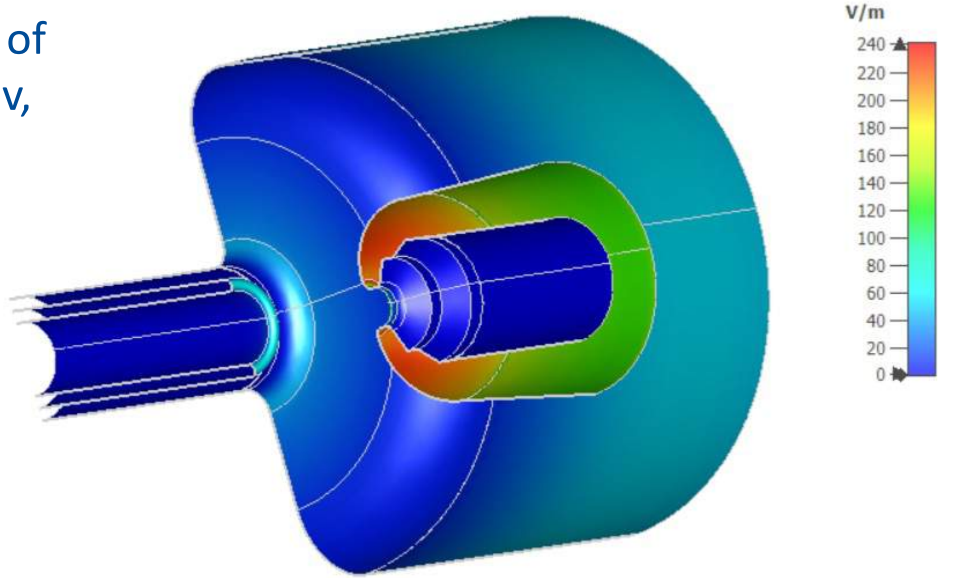




U = 3.028E+5 V

Analysis of plasma ignition in the SRF gun

Courtesy of
S. Kazakov,
FNAL



E field is maximized on the cavity surface, not at the antenna tip:

$$\frac{E_{pk,cavity\ surface}}{E_{pk,antenna\ tip}} = 3.7$$

There should be no risk of plasma ignition at the FPC!

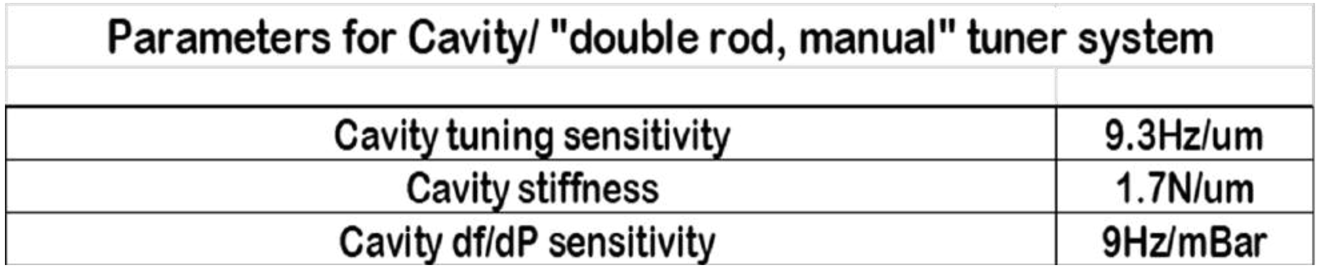
Conceptual Design of the Tuner for SRF Gun

Brookhaven National Laboratory

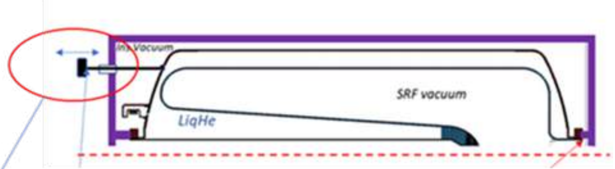
- Approach for cavity tuning will be changed. Cavity tuning by moving /inserting power coupler into cavity volume will be NOT used in upgrade SRF gun system.
- Special SRF cavity tuner will be designed. Cavity tuning will be done by stretching cavity through two rods welded to cavity walls. These rods penetrated through insulated vacuum volume to outside of vacuum vessel. These rods already used during operations of the SRF gun to manually tune cavity. Tuning was done by manually screwing nut on the rods to stretch cavity. Access to this system was very complicated for personnel.
- For upgraded SRF gun newest tuning system will be deployed. Cavity stretching will be done with stepper motor actuator & piezo-actuators. Actuators will operate in ambient environment.
- There are no requirements to tune SRF cavity after cool-down to some particular operational frequency.
- As result, there are no requirements to deploy “slow tuner” with large (10’s or 100’s kHz) range. Required slow tuner range will be in the range of several kHz.
- The fast/piezo tuner will be operated in serious with slow tuner and will have relatively small range that will cover microphonics, df/dp and other small drift of the cavity from “established& fixed operational” frequency after cavity will be cool-down to T=4K.

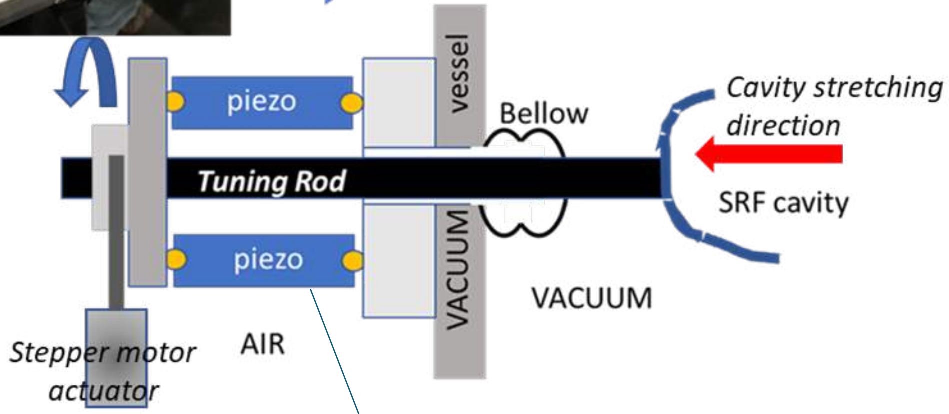
Conceptual tuner design

Stepper motor actuator will stretch cavity but pulling rod welded to cavity. Piezo actuator (developed by FNAL for LCLS II) will worked in serious with slow tuner. Piezo actuators could deliver up to 36um stroke (at V=120V). Stroke of 36um will retune cavity on ~300Hz. Based on previous operational experience of SRF gun, 300Hz range of cavity retuning will cover required microphonics.



Parameters for Cavity/ "double rod, manual" tuner system	
Cavity tuning sensitivity	9.3Hz/um
Cavity stiffness	1.7N/um
Cavity df/dP sensitivity	9Hz/mBar





Assuming required tuning range of fast tuner to cover microphonics ~ 100Hz and to cover df/dp (dp~10mbar) the same value ~100Hz we will need approximately 200Hz range for piezo tuner.

Summary

Review of the existing manual tuner on the SRF gun to use as main SRF cavity tuner system has been performed .

Requirements for cavity stroke (stretching) to cover tuning range of cavity has been estimated

Conceptual design of the SRF cavity tuner has been developed.

Next steps

Development of the tuner’s mechanical model that will fit into available space around SRF gun system

Performed ANSYS simulation of the model

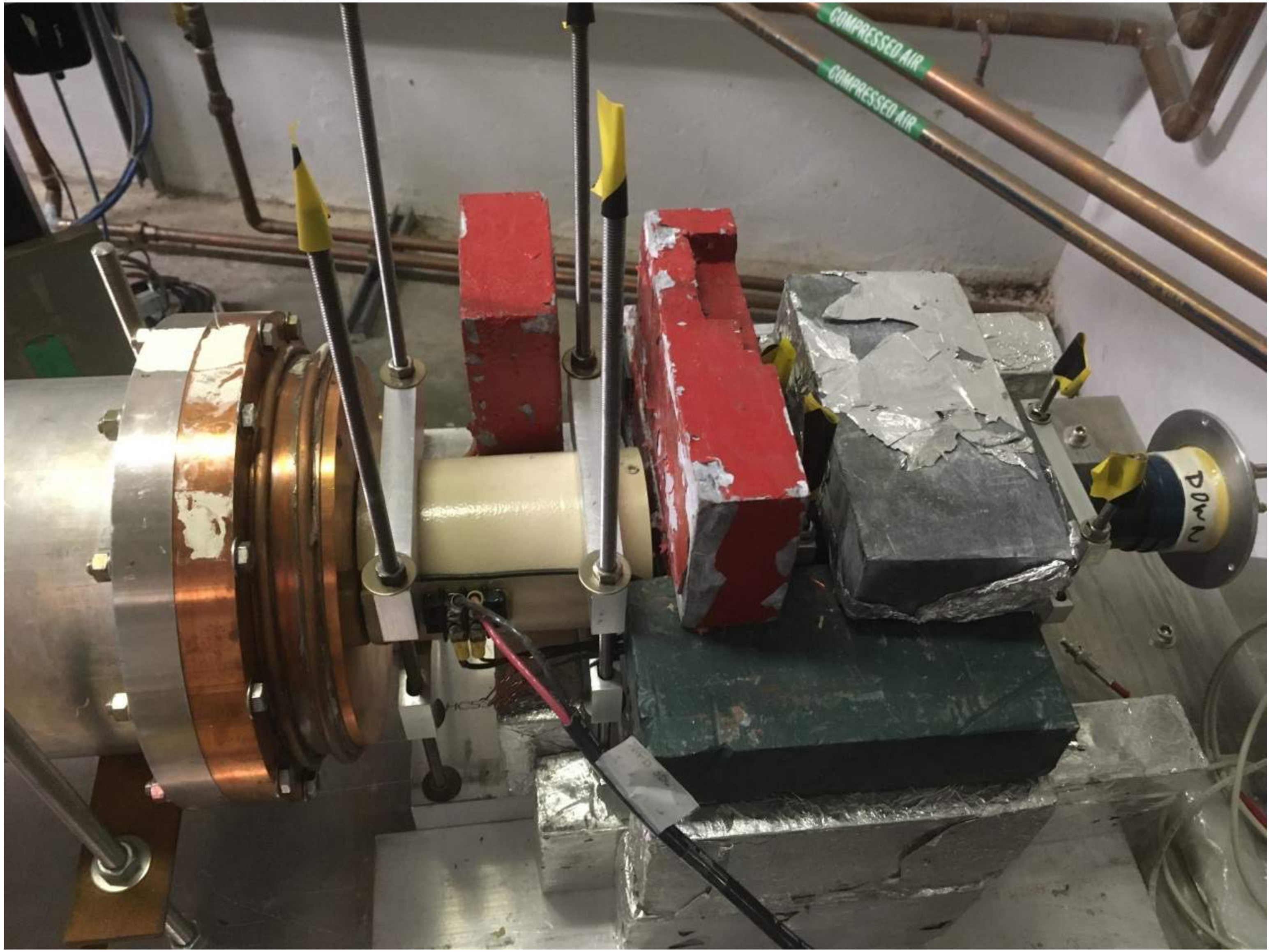
Select small size reliable stepper motor actuator

Develop/test prototype

Build new SRF gun tuning system to be ready installed as needed

JLab back-up

An Example of Polarimeter at Jefferson Lab CEBAF – Summer 2018



Goals, Timeline, and Budget

- Co-Principal Investigator: Riad Suleiman, with Joe Grames and Matt Poelker (Jefferson Lab), and Eric Voutier (IJCLab, Orsay, France)

- Jefferson Lab's contribution to this project is to provide a Compton Transmission Polarimeter, which will be used to measure beam polarization when SRF photogun employs a GaAs photocathode. IJCLab is contributing to Jefferson Lab's effort.

	FY20 ($k)	FY21 ($k)	Totals ($k)
a) Funds allocated	200.1	200.0	400.2
b) Actual costs to date	10.9		

- Goals:
  - Year 1: Design and build electron beam polarimeter
  - Year 2: Install and commission polarimeter at CeC accelerator
- Current Status:
  - Design of polarimeter and new portable data acquisition system (DAQ) is completed
  - NCE for one more year was approved

Achievements, Milestones and New Timeline

- Year 1:
  - Agreed upon basic operational parameters of polarized electron beam and polarimeter
  - Portable DAQ design completed and implementation started
  - Jefferson Lab Fast Electronics Group has finished programming of flash analog-to-digital convertor (FADC) and now working on user interface of DAQ
  - Polarimeter (radiator, magnet, and detector) design was optimized using GEANT4
- Year 2:
  - Magnet engineer started design of electro-magnet with iron core
  - Build two polarimeters (radiator, magnet, and detector) and one portable DAQ – one polarimeter will stay at CEBAF
- Year 3:
  - Calibrate polarimeter at CEBAF with portable DAQ
  - Install and commission polarimeter at CeC accelerator
- When SRF photogun employs a GaAs photocathode: Measure electron beam polarization