# The ILC Positron Source Accelerators and RF System

$e^+$ Source KOM

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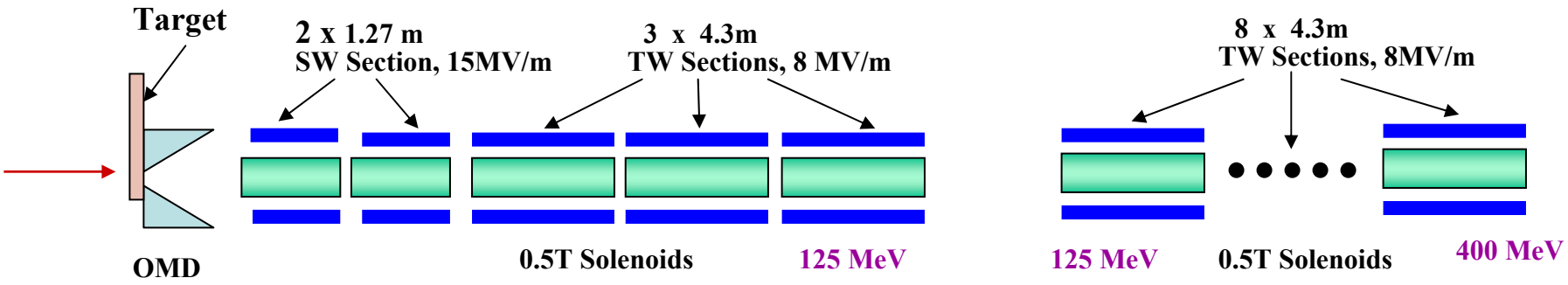
Juwen Wang

# Outline

- System Layout.
- Accelerator Structures and System Components.
- SLAC Expertise in NC Accelerator Structures Design and Fabrication Technology.
- Scope of Work.
- Justification of Funding for NC RF System.

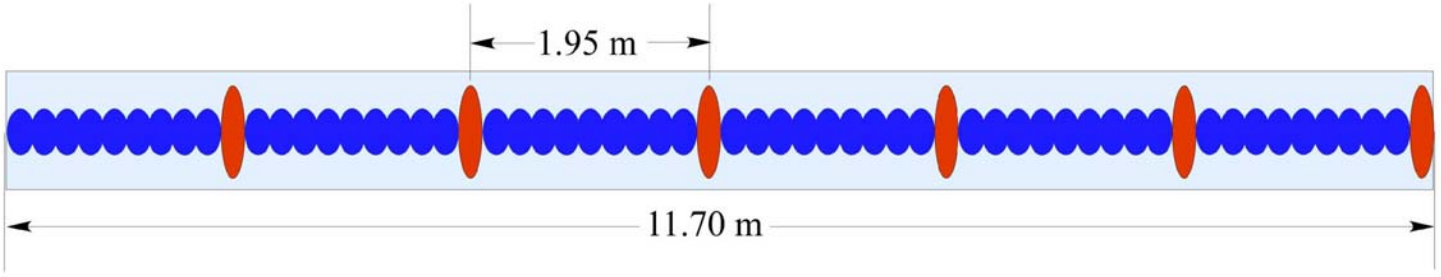
# Layout of NC RF System

Similar Systems for Both
- Main Source
- Keep Alive Source

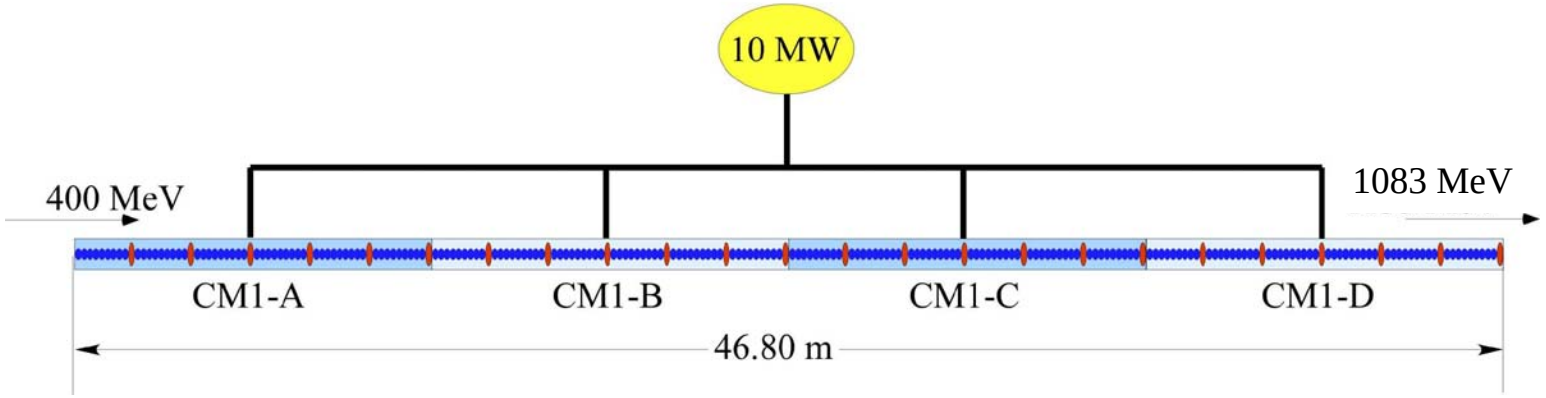


# SC Booster Linac 400 -1083 MeV

Proposed CM1 SC Accelerator Module for e+ Booster



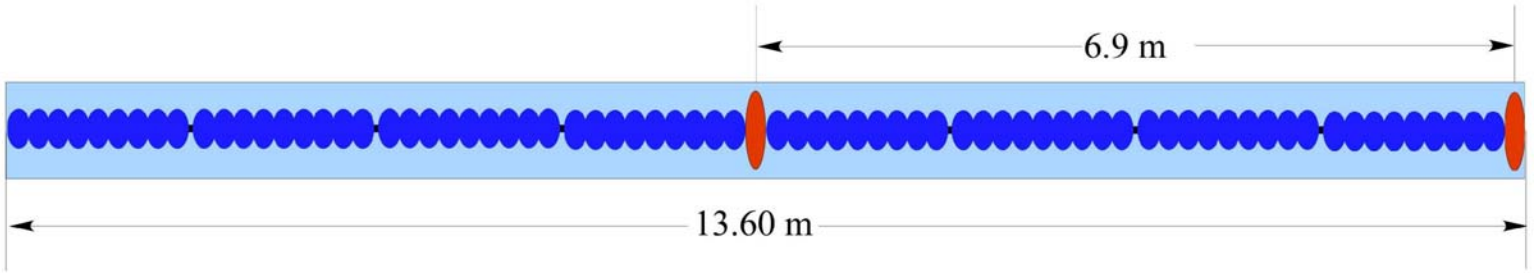

Proposed PBSTR-1: 400- 1083 MeV



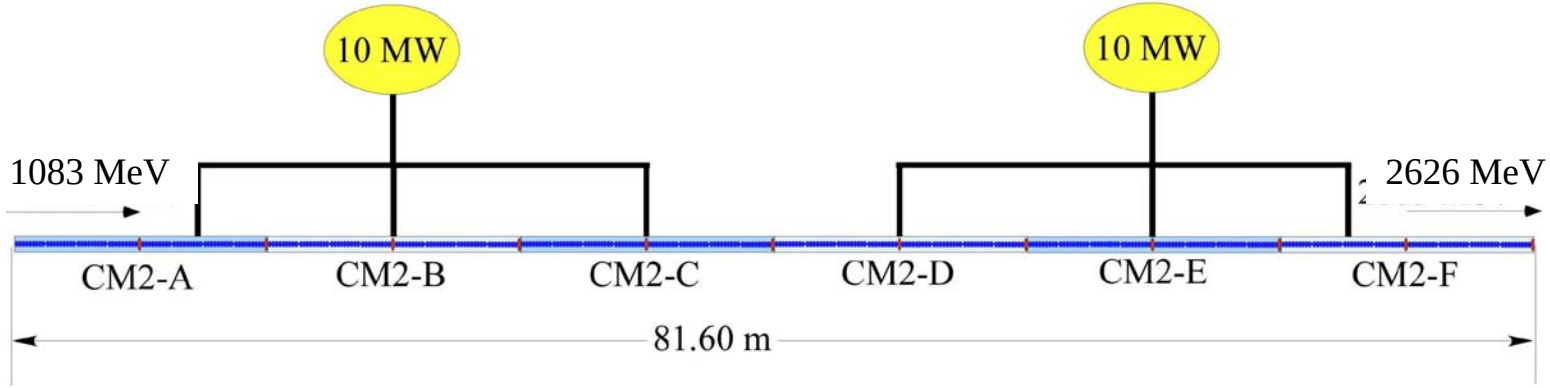

CM1 - four non-standard cryomodules, each has six 9-cell cavities and six quadrupoles. The quad field strength ranges from 0.88 – 2.0 T.

# SC Booster Linac 1083 – 2626 MeV

Proposed CM2 SC Accelerator Module for e+ Booster



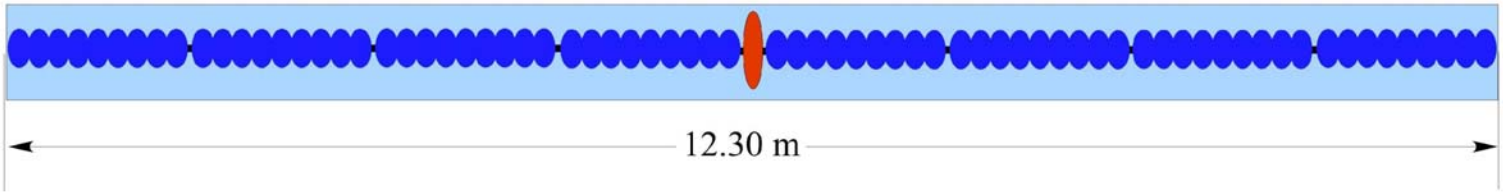

Proposed PBSTR-2: 1083 - 2626 MeV



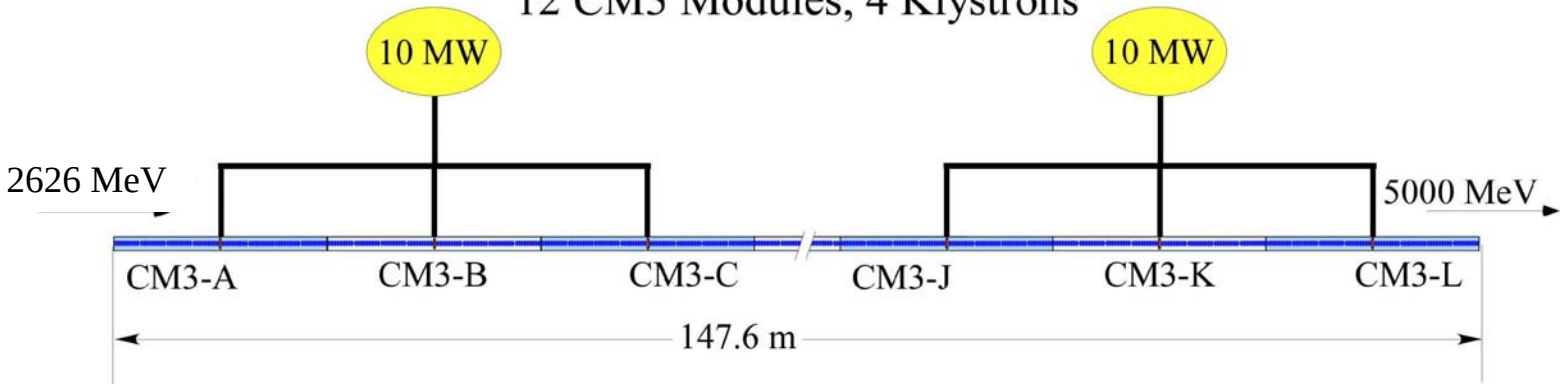

CM2 - six non-standard cryomodules, each has eight 9-cell cavities and 2 quadrupoles. The quad field strength ranges from 0.62 – 1.3 T.

# SC Booster Linac 2626 – 5000 MeV

Proposed CM3 SC Accelerator Module for e+ Booster




Proposed PBSTR-3: 2626 - 5000 MeV
12 CM3 Modules, 4 Klystrons




CM3 - twelve standard ILC cryomodules, each has eight 9-cell cavities and one quadrupole. The quad field strength ranges from 0.95 – 1.63 T.

# Linac to Damping Ring (LTR) Beam Line and a Special Cryomodule

- Orients the beam polarization:

Spin vector: longitudinal $\xrightarrow{\text{Bending Arc}}$ horizontal $\xrightarrow{\text{Solenoid}}$ vertical.

- Compresses the beam energy to improve acceptance into the DR.

After the bunch is decompressed by the arc, an RF voltage of 180 MV provided by a 9-m long 6-cavity superconducting linac, rotates the positrons in longitudinal phase space to match with longitudinal DR acceptance.

# Types of NC Accelerator Structures and Basic Properties

## 1. L-Band 11-Cell SW Sections for $e^+$ Capturing.

### Single π mode structure

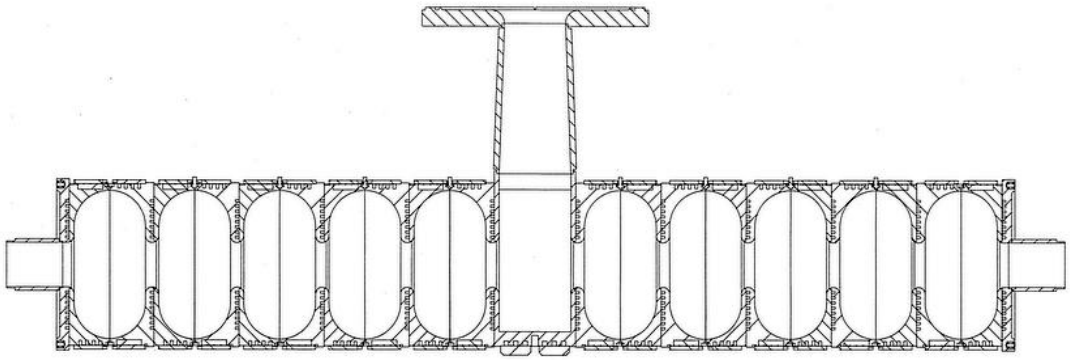
- Accelerating gradient: 15 MV/m.
- It is simpler and feasible (stabilization) for 11-cavity short SW structure.
- Lower pulse heating.
- Larger iris size (60 mm diameter) with reasonable shunt impedance.
- Efficient cooling design.

## 2. L-Band 4.3 m TW Sections for $e^+$ Pre-Acceleration.

### Constant gradient sections with higher phase advances 3π/4 Mode

- Accelerating gradient: 8.5 MV/m.
- Using “phase advance per cell” as a knob to optimize the RF efficiency.
- It is simpler and feasible.
- Lower pulse heating.
- Easier for long solenoids solution.
- Easier cooling design.
- Less concern on multipacting and klystron protection from RF power reflection.

# 11-Cell SW Capture Section

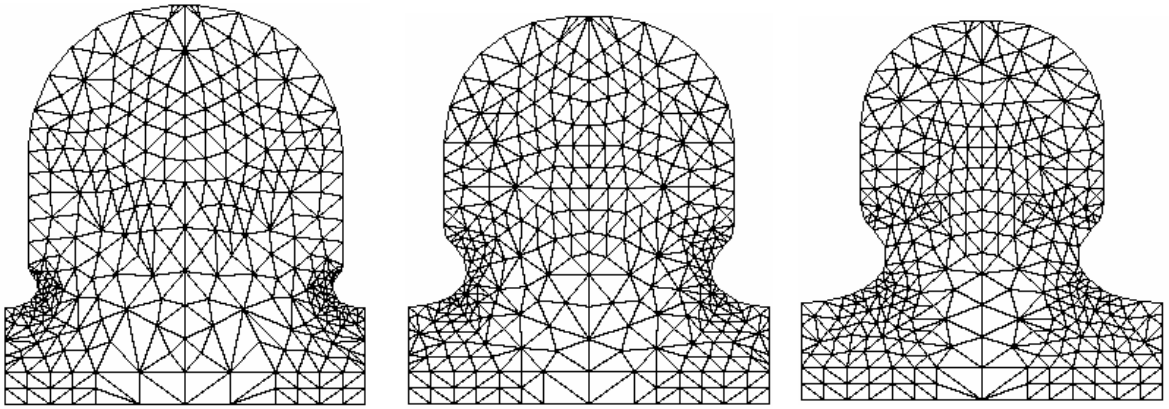


Cut-off View of 11–cell SW structure

| Structure Type | Simple π Mode |
|---|---|
| Cell Number | 11 |
| Aperture 2a | 60 mm |
| Q | 29700 |
| Shunt impedance r | 34.3 MΩ/m |
| E0 (8.6 MW input) | 15.2 MV/m |

Parameters of SW stricture.

# 4.3 m long 3π/4 Mode TW Structures



| Structure Type | TW |
|---|---|
| Cell Number | 50 |
| Aperture 2a | 46 mm |
| Attenuation $\tau$ | 0.98 |
| Q | 24842 - 21676 |
| Group velocity Vg/c | 0.62% – 0.14% |
| Shunt impedance r | 48.60 – 39.45 MΩ/m |
| Filling time $T_f$ | 5.3 μs |
| Power Dissipation | 8.2 kW/m |
| $E_0$ (10 MW input) | 8.5 MV/m |

# Components for Each NC RF System

| SW/TW RF Distribution | |
|---|---|
| Item | Quantity |
| 10 MW 1300 MHz Klystron | 1 |
| Modulator | 1 |
| Window | 2 |
| Circulator | 2 for SW station only |
| Phase Shifter | 2 |
| Load | 2 |
| Directional Coupler | 2 |
| Flexible Waveguide | 2 |
| Waveguide | 40 m |
| Flanges | 30 pairs |

# NC Accelerator Structures Work Done for the $e^+$ Source at SLAC

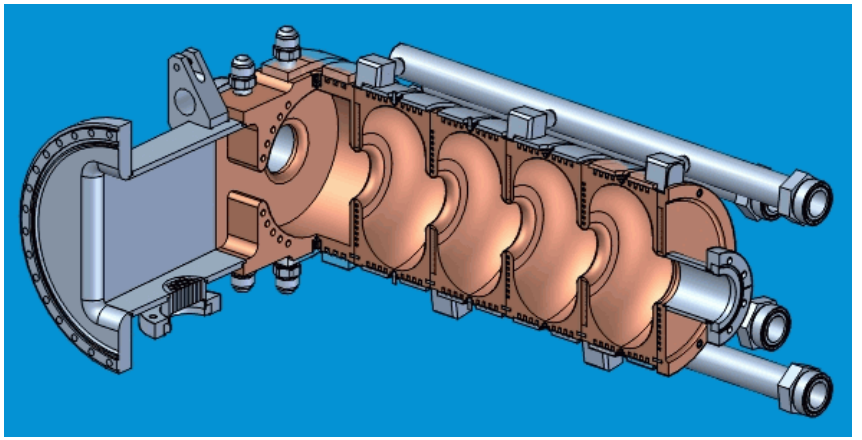
For decades, SLAC has very strong expertise for the normal conducting accelerator structures research and development.

Recently, we have developed several key RF structures like the L-Band 5-cell SW structure for positron capturing, L-Band RF windows and gained a lot of valuable experiences in RF as well as mechanical design and fabrication technologies.

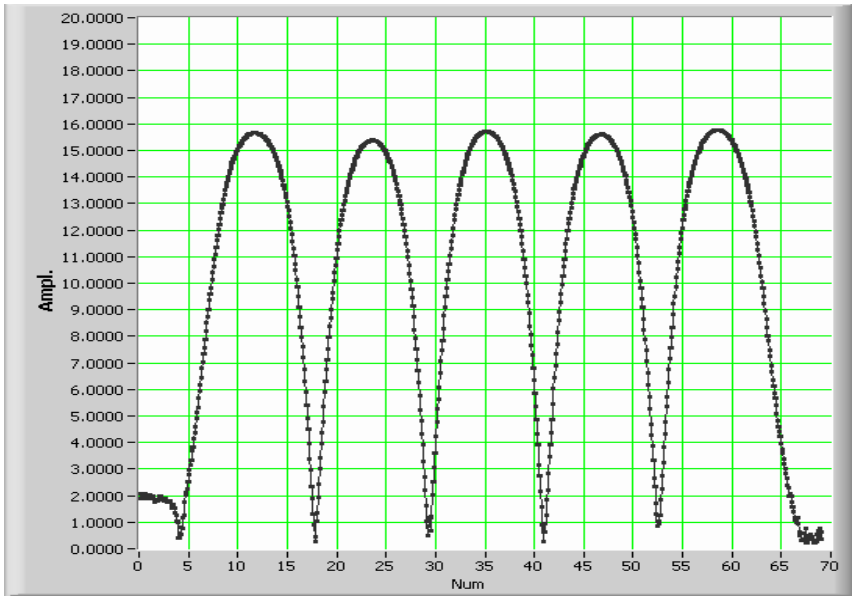
# 5-Cell L-Band SW Structure for the $e^+$ Source


$f_\pi$=1299.68 MHz at Vacuum 45°C

$Q_0$ =29000 VSWR=1.03



Cut-off View of the Structure




Field Distribution after tuning

# NC Structures under Fabrication

L-Band RF Window

A L-Band Structure in Brazing Furnace

# Scope of Work

- Design of Structure RF Parameters and Power Efficiency, Thermal Calculations and Stability Studies.
  - SW Capture Accelerator Structure.

    Design completed and a 5-cell prototype has been built and ready for high power test.
  - TW Pre-Acceleration Structures: completed electrical design.

    Parameter design completed and plan to have funding for the design, fabrication and high power test of a short prototype.
- RF Distribution System.
- Key RF components: phase shifters, circulators, windows…
- Design for Other Related Systems:
  - Solenoids and Power Supplies;
  - Vacuum System;
  - Pressured Gas System;
  - Cooling System;
  - Low Level RF System.
- Detailed Parts Count and Cost Estimation.

# We need Some Funding for the Prototype of TW Structures

In order to have a solid design for both positron and electron sources, It is needed to pay a great attention on R&D program for the traveling wave structures. We need to have funding for a short prototype of TW structure.

This structure has apparent advantages to the original design. But, there are several issues in both electrical, mechanical design as well as fabrication aspects, which need to be studied and confirmed just like we've leant a lot from the 5-cell SW section and have confidence on the SW capture structures.

- For 4.3 m structures, the balanced cooling and pumping system need to be carefully studied and inductive brazing technique needs to be practiced at SLAC.
- They have low group velocity (as low as 0.16%c), the impact of big transient effects need to be investigated and tested.
- They work at long beam pulses (1 ms), the operational stabilization needs to be carefully studied and tested.