Spokes vs. Ellipical Cavities for the Proton Driver Linac

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Spokes & Elliptical Cavities

- **The Fermilab Proton Driver is organizing a collaboration to develop a complete suite of "Tesla-Compatible" β<1 SCRF Cavities:**
  - 1300 MHz Elliptical-Cell
  - 325 MHz Spoke Resonators

"Open-Source Collaboration"

- **Standardizing on ILC-Compatible Frequencies could produce standard building blocks for future beta<1 linacs:**
  - Cavities, Klystrons, RF distribution..
- **The Concept is for an "Open-Source" Collaboration**
  - All design data, manufacturing, costs, etc. to be posted on the Internet

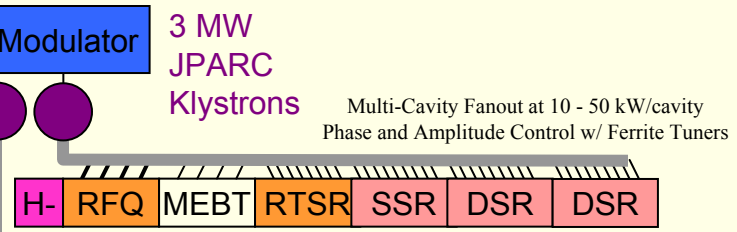
0.5 MW Initial 8 GeV Linac

11 Klystrons (2 types)
449 Cavities
51 Cryomodules

"PULSED RIA"

Front End Linac

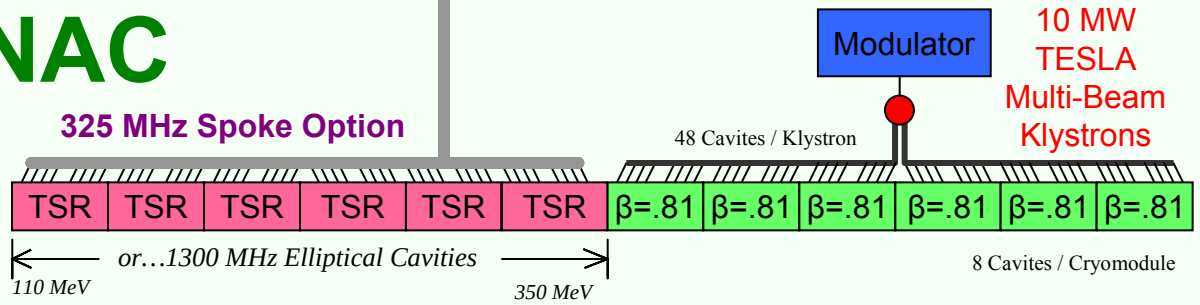
325 MHz
0-350 MeV



β<1 TESLA LINAC

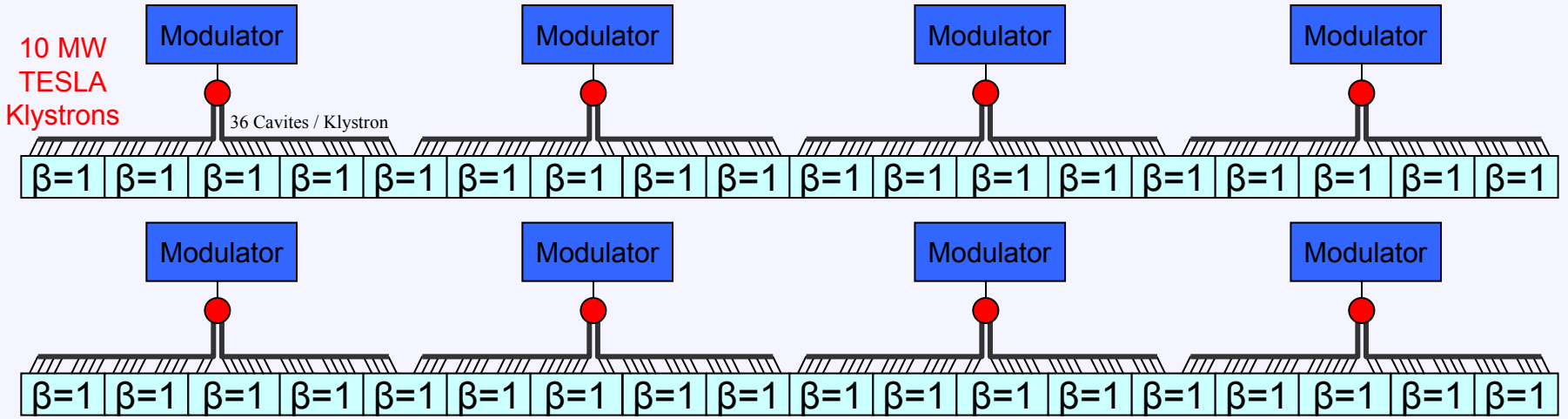
1300 MHz 0.35-1.2 GeV

2 Klystrons
96 Elliptical Cavities
12 Cryomodules



TESLA LINAC 1300 MHz β=1

8 Klystrons
288 Cavities in 36 Cryomodules



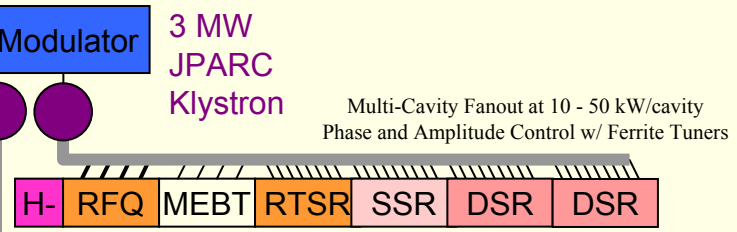
0.5 MW Initial 8 GeV Linac

11 Klystrons (2 types)
449 Cavities
51 Cryomodules

"PULSED RIA"

Front End Linac

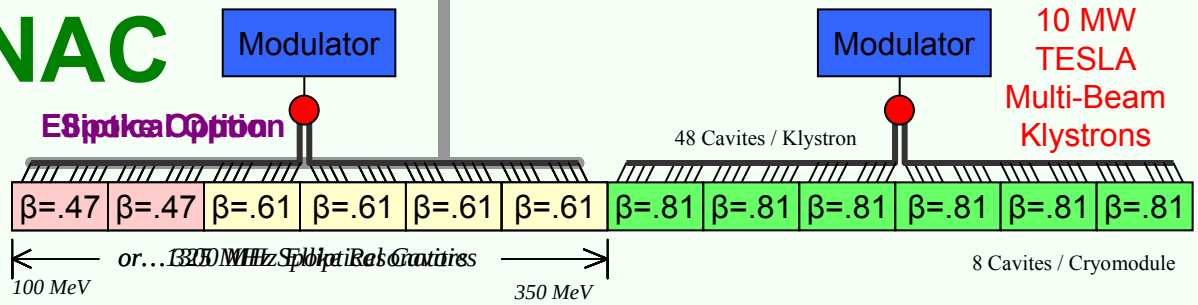
325 MHz
0-110 MeV



β<1 TESLA LINAC

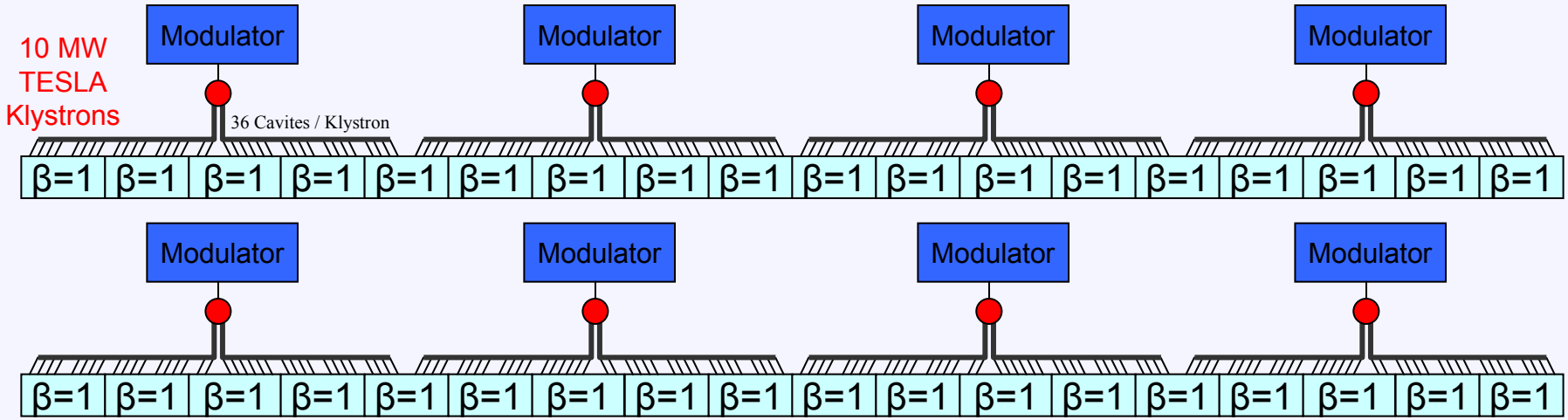
1300 MHz 0.1-1.2 GeV

2 Klystrons
96 Elliptical Cavities
12 Cryomodules

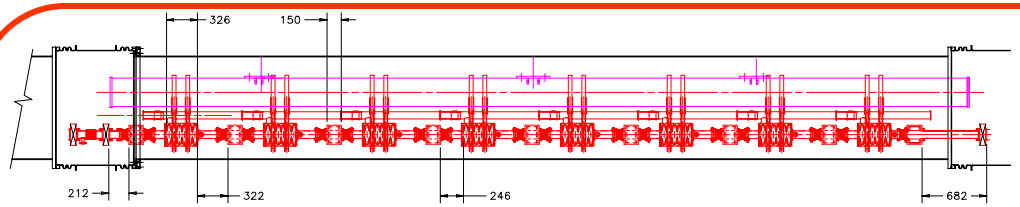


TESLA LINAC 1300 MHz β=1

8 Klystrons
288 Cavities in 36 Cryomodules

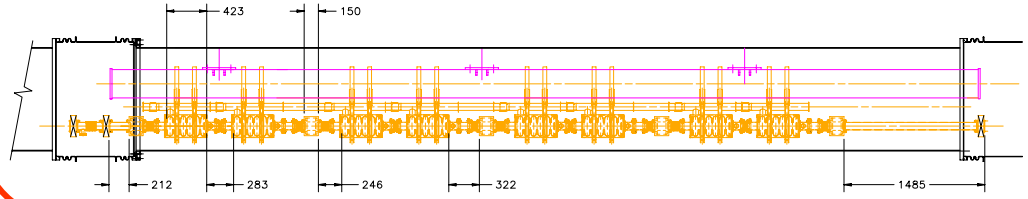


Elliptical β=0.47, 0.61, 0.81

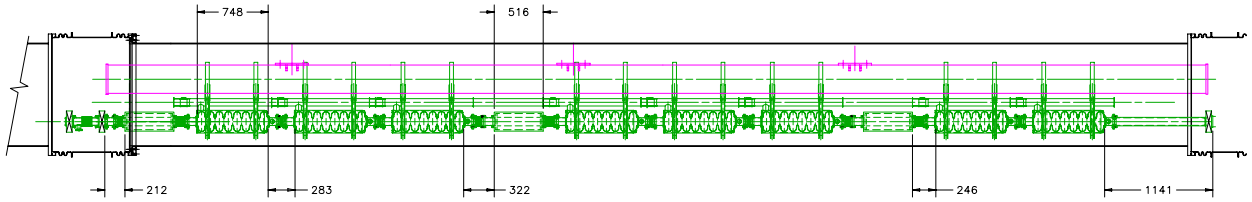


β=0.47
8 Cavities, 6 cells/cavity
9 focusing quads

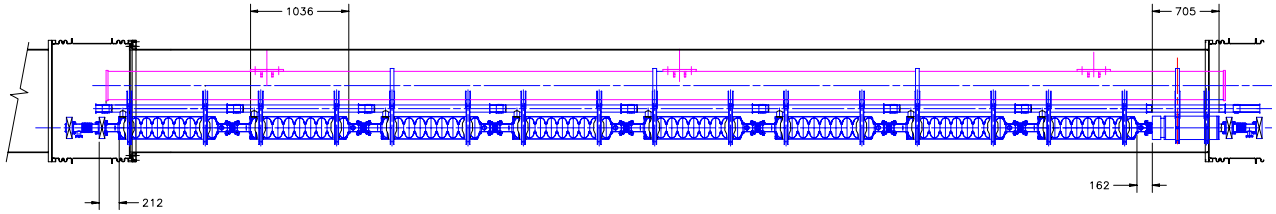
Open Technical Choice



β=0.61
8 Cavities, 6 cells/cavity
5 focusing quads



β=0.81
8 Cavities, 8 cells/cavity
3 focusing quads



β=1.0
8 Cavities, 9 cells/cavity
1 focusing quad

Spokes vs Ellipticals for 110-400 MeV

- **6 cryomodules ~10 m long for either option**
- **Quadrupole focusing in both cases**
- **Transition from 325 MHz to 1300 MHz**
  - 4:1 frequency jump has Accelerator Physics Implications

LINAC SEGMENT DETAILS

Open Technical Choice: 3-spoke or Elliptical

	RFQ	Room Temp TSR	SRF 1-spoke	SRF 2-spoke	Spoke Option 3-spoke	Elliptical Option Low	Elliptical Option Medium	High	TESLA
Frequency, MHz	325	325	325	325	325	1300	1300	1300	1300
Energy Range, MeV	0.065-3	3-15	15-33	33-110	110-400	110-175	175-400	400-1200	1200-8000
Beta geometrical	-	0.08 to 0.18	0.21	0.4	0.61	0.47	0.61	0.81	1.00
Number of cavities or resonators	4	21	16	28	42	16	32	48	288
Number of accelerating gaps / cavity	-	4	2	3	4	6	6	8	9
Epeak, MV/m	32.1	TBD	32	32	32	52	52	52	52
Eacc, MV/m	-	2.3 to 3.7	10.67	10.67	10.67	15.2	19.2	23.7	26
Cavity effective length, cm	-	15 to 32	13	36.9	85.8	32.5	42.2	74.8	103.8
Synchronous phase, deg (typ.)	-	-40 to -30	-30	-30	-30 to -20	-30	-25	-20	-16
Length of Segment, m	~4	10.4	12.5	17.2	64	18.8	38.5	70.1	438.3
Number of Cryomodules	-	-	1	2	6	2	4	6	36
Cavities per Cryomodule	-	-	16	14	7	8	8	8	8
Magnetic Focusing Type	-	Solenoid	Solenoid	Solenoid	Quad	Quad	Quad	Quad	Quad
Coupler Power Initial {Ultimate}, kW	125	40 {54}	9 {26}	34 {102}	80 {238}	42 {125}	72 {214}	133 {398}	220 {660}
Cavities per Klystron Initial {Ultimate}	72 {36}				42 {14}	48 {24}		48 {24}	36 {12}
Number of Klystrons Initial {Ultimate}	1 {2}				1 {3}	1 {2}		1 {3}	8 {24}

Cost Comparison Spokes vs. Ellipticals

1. **Cost Estimate for Director's review March '05**

   linked from: http://protondriver.fnal.gov

2. **Estimates (RFQ's) from Experienced Vendors**

   Costs estimates public but vendors remain anonymous

3. **Assume Coupler Costs equal at 1300 and 325 MHz**

4. **In-House Estimates for Cryostats**

CONCLUSIONS:

- **Costs are equal within errors**
- **We will know more after the first prototypes**

How We Are Proceeding

1. **Design and Prototype where Decision is Clear:**
   1. MSU / FNAL Collaboration for β=0.81 8-cell Elliptical *(see posters)*
   2. ANL / FNAL Collaboration for Single-Spoke 325 MHz *(see posters)*
   3. ***→ Active Search for other "ILC-Compatible" Collaborators ←***
2. **Preserving two technical options (110-400 MeV):**
   1. 325 MHz triple-spoke Resonators **(AP BASELINE)**
   2. 1300 MHz Elliptical Cavities β=0.47, 0.61 **(AP design in progress)**
3. **Our Decision will be based on:**
   1. Accelerator Physics
   2. Cost (looks like a wash for now)
   3. Collaboration