RTML Vacuum System RDR Summary FermiLab October 24, 2007

John Noonan

Yusuke Suetsugu, Paolo Michelato

GDE Vacuum Technical Group

Vacuum Design

- Accuracy of manufacturing
  - Total length = ±2 mm for 10 m.
  - Tilt between the end flanges is 0.5 degree.
  - Displacement of the duct against the axis in the horizontal and vertical plane is ±2 mm.
  - Slant of the end flanges against the axis of the duct is 1 degree.
  - Displacement of the center of end flanges against the axis of the duct is less than ±0.5 mm.
  - Width of a gap inside should be less than 0.5 mm.
  - Inside step should be less than 0.5 mm.

Vacuum Design

- Gate valves
  - All metal valves
  - Each region (EFF1 and so on) has at least one gate valve.
  - Valves are located every 250 m at minimum
  - Apertures of gate valves are :

    [*D*: Diameter, *A*: Aperture size]

    $D < 60$ mm : *A* = ICF114

    $60 \text{ mm} \leq D < 100$ mm : *A* = ICF152

    $100 \text{ mm} \leq D < 150$ mm : *A* = ICF203

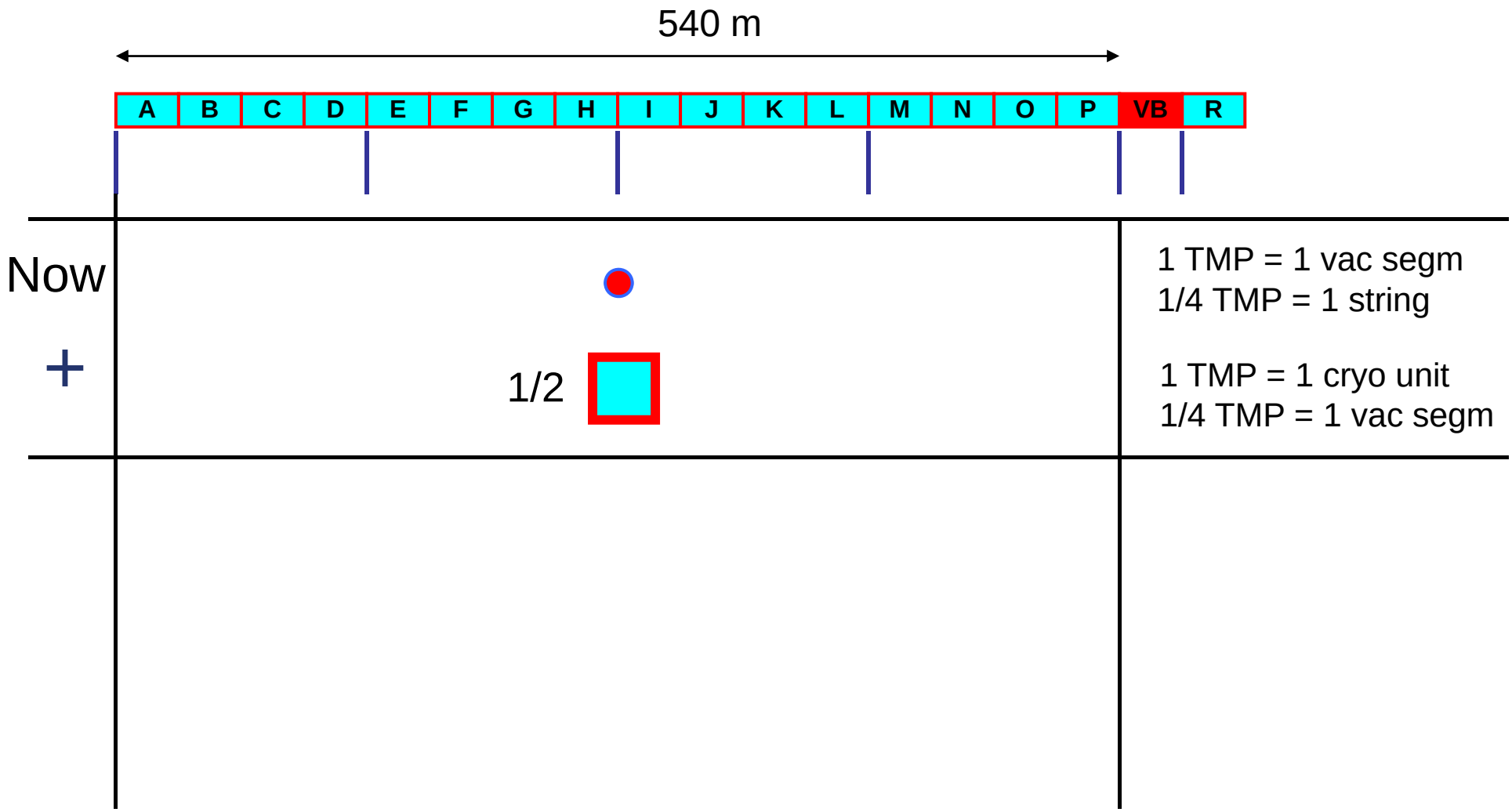
    Etc.....

Assumptions

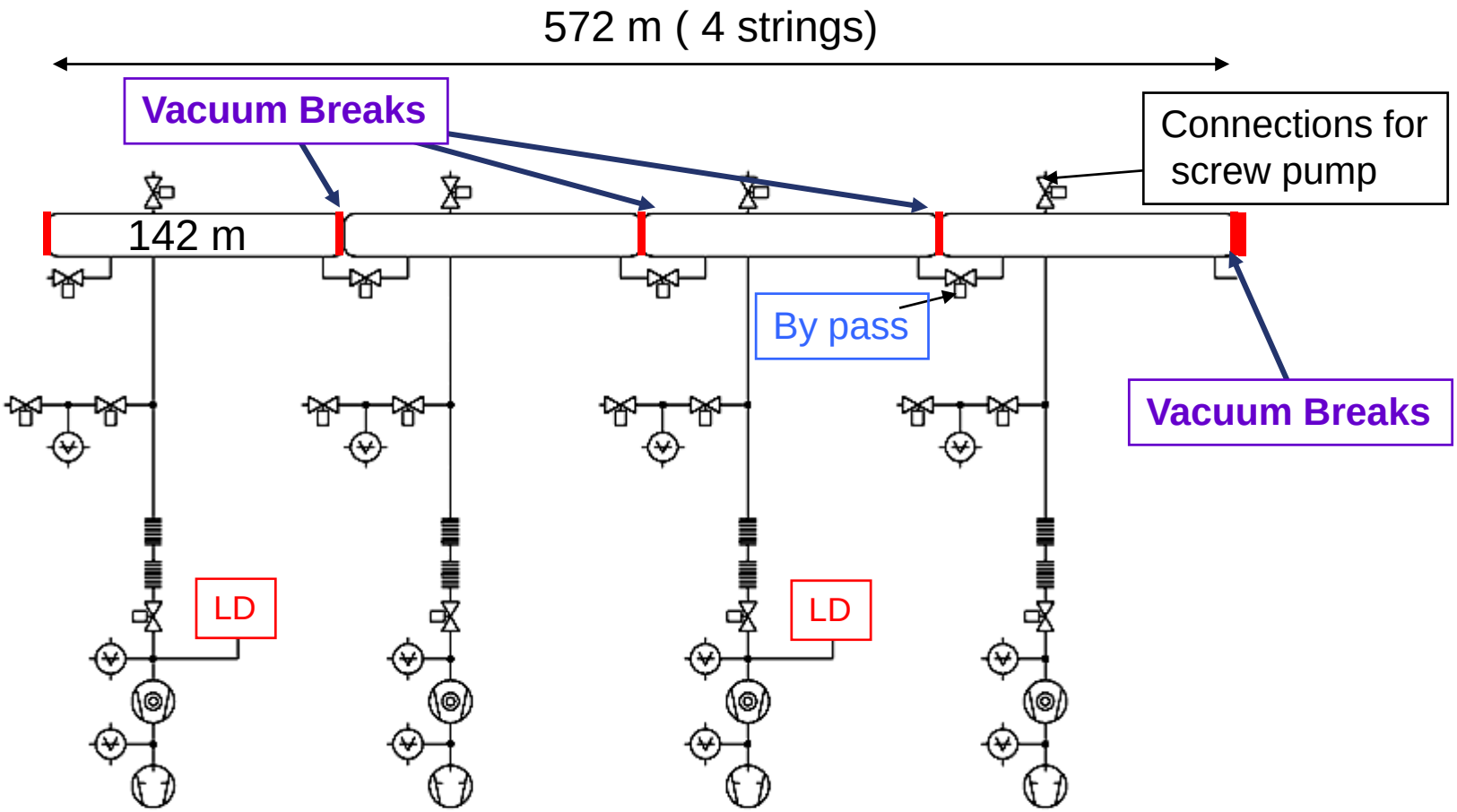
- **Beam Pipe**
- The thickness (*t* mm) of duct will follow the conditions as follows.
- *D*: Diameter, t: thickness
- *D* < 20 mm : *t* = 1 mm
- 20 mm < *D* < 60 mm : *t* = 2 mm
- 60 mm < D < 100 mm : *t*= 3 mm
- 100 mm < D : *t* = 4 mm
- The gap between a duct and cores of a magnet should be larger than 1 mm, in order to avoid any interference with magnets. The beam pipes with a different aperture should be connected through a taper, in order to suppress HOM excitation, if necessary.
- In general the transport beam pipe is stainless steel. The exceptions are where heat loads are present.

- **Outgassing Rate**
- The thermal gas desorption rate, *q*th, will be assumed as
- Then, if the pipe diameter is *D* [m], the linear gas desorption rate, *Q*th, is
- *Q*th = p*D* × *q*th Pa m3s-1m-1.
- Unbaked outgassing rate:*q*th = 5×10-8 Pa m3s-1m-2, or 5×10-11 Torr l s-1cm-2
- Baked outgassing rate: = 1x10-9
- Passivated outgassing rate: = 1x10-9, it could be as low as 2x10-10 but before
- we take credit for that it should be tested.

Beam line vacuum system: TMPs



Insulating vacuum system



4 TMP pumping units: 2 with LD (leak detector) +
2 large screw pump for fore pumping

Cost Estimation

- General remarks
  - **Basically, obtained from major vacuum manufactures.**
  - **Discussed among TS leaders to find reasonable numbers in all regions.**
  - **Based on TS leaders' experience so far.**
    - For example, in Asia, KEK B-factory (~1996).
  - **The present cost estimation, however, is not yet well optimized.**
    - Diameter, lengths, etc.

Cost Estimation

- Included terms
  - Beam ducts
  - Bellows chambers (with finger-type RF-shielding)
  - Pumps (and controllers, Rough pumping unit)
  - Vacuum gauges (and controllers)
  - Gate valves (and controllers, with RF-shielding)
  - Manifolds (6 ports for rough pumping unit and gauges)
  - Gaskets, bolts, Supports (in average number)
  - Control cables between components and controllers
  - Interlock box per one gate valve
  - Baking heaters and thermal insulators: Option
  - Preparation before installation, such as assembling, pre-baking of beam pipe, testing, etc.

Cost Estimation

1$ = 120Yen
1$ = 1.2 €

- Beam duct (Base)
  - **Stain-less steel**
  - **Including**:
    - Detergent cleaning
    - Profit of company, Risk factor
    - Flanges, pumping ports
    - No cooling channel

ϕ (Diameter)	US$ /m
20 mm	200
100 mm	300
150 mm	350
200 mm	400

Cost Estimation

Other Beam Duct

Including:

External Design
Overhead and Profit
Flanging and additional ports

Type	Factors from "Base"
Acid cleaning	X 1.2
Aluminum alloy	X 0.6
SS+Cu coating	X 2
Cu	X 2
With Cooling pipe	X 1.5

Ring-to-Main-Linac

SS Chambers

Diameter(m)	Total Length(m)	# of chamber	Material	Unit Cost[US$/m]	Cost [US\]
0.016	402.2004675	135	SS	200	80440.0935
0.016	575.7823148	508	SS+W	300	172734.6944
0.054	60.33390019	23	SS+W	375	22625.21257
0.054	48.75	17	SS	250	12187.5
{total}	1087.066682	683			287,987.50

264.92

W: Cooling channel

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Pumps (Including controller)			
[Pumping Speed]	qty	Unit Cost[US$]	Cost [US$]
0.2 m3/s			
0.16 m3/s			
0.12 m3/s	14	950	13,300
0.08 m3/s			
0.04 m3/s	833	700	583,100
{total}	847		596,400

Manifold for gauges (6 ports)			
[Size]	qty	Unit Cost[US$]	Cost [US$]
ICF152	2	1,250	2,500
ICF114			
ICF70	9	280	2,520

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L-angle Valve for rough pumping			
[Size]	qty	Unit Cost[US$]	Cost [US$]
ICF152	2	5,330	10,660
ICF114			
ICF70	9	550	4,950
{total}	11		15,610

Gate Valve			
[Size]	qty	Unit Cost[US$]	Cost [US$]
ICF306[EX]			
ICF253			
ICF203			
ICF152			
ICF114	9	7,000	63,000
{total}	9		63,000

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Rough Pump Unit (Including Controller)			
[set]	qty	Unit Cost[US$]	Cost [US$]
	5	17,000	85,000
Insulator except for EDL and SR Line			
	qty [m]	Unit Cost[US$]	Cost [US$]
	1,087	3	3,261
Support (1 per one chamber)			
	qty	Unit Cost[US$]	Cost [US$]
	683	400	273,200
Gasket (ICF70 in average)			
	qty	Unit Cost[US$]	Cost [US$]
	2,288	7	16,016
Bolt,Nut (6 in average)			
	qty	Unit Cost[US$]	Cost [US$]
	13,728	.3	4,118
Interlock box (per 1 GV)			
	qty	Unit Cost[US$]	Cost [US$]
	9	500	4,500

RTML Cost Summary

Total Length		Total	
[m]	1087.066682	1,295,732.63	US$
Total Number of Chambers		1,191.95	US$/m
	683		

Cost Estimation

- Ambiguity in the present cost estimation
  - **Overall specifications and requirements are clear.**
    But, the detailed specification are not yet given.
    - Required pressure
    - Accuracy of manufacturing
    - Surface treatment
    - Gap between magnets, etc. ..
  - **Design is not yet fixed. The manufacturer counted a risk factor.**
    - Beam pipe radius, lengths
    - the structure of RF shielding at pumping port , etc. ..

Issues

- Vacuum specifications will be re-evaluated as design evolves.
- Vacuum final design and cost are a derivative of accelerator design.
- Cold vacuum will follow Main Linac design
- Simplification of structures is viable
  - Bellows liners
  - Gate valves
  - Surface treatment and cleaning
- R&D
  - Ways to reduce gas load
  - Quick flange connections