International MUON Collider Collaboration

CERN

Parameters

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MuCol

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Tentative Parameters

Need to build database with tentative parameters

- Will iterate to arrive at consolidated parameters for the strategy
- Important to get the structure of the data right, numbers will change

Goals:

- **Define realistic high-level targets for the areas and components**
  - Interface parameters and scalings to make studies more independent
  - Reference design goals discussed at the study level
- **Document current designs and assumptions**
  - Not yet a “reference design” but a moving target
  - To be provided by the areas, will be reviewed as needed

Review the document to see if it contains the relevant information

- Put in parameters you consider important, even if they may change later

Note: should not consider use of existing infrastructure at this moment

- in conflict with global collaboration, details distract from other key studies

Will consider use of existing infrastructure at a later stage with limited detail

General Status

- **Goal: define tentative target parameters**
  - basis for studies of key limits and dependencies
  - documentation of specific parameters
  - basis for further improved parameters (improved, consolidated)

- **Started to work on many key systems**
  - started to gain knowledge on driving factors

- **Are not yet ready to know where to go to**
  - do not move targets if not clearly supported by studies
  - rather try to clarify tentative boundaries and goals

- **For all areas: Put in parameters that are important, even if they might change to get structure right**

- **Need to clarify key studies to make parameter choices more robust**
  - **no one can assume that the parameters are final**
  - **find out the boundaries**

Key Tentative Target Parameters

- **Beam parameters along the machine**
  - energy, charge, emittance, …
  - targets for the accelerator designers
- **Basic machine parameters**
  - length, number of components, etc.
- **Key performance specifications for the components**
  - e.g. dipole field and aperture in the collider ring
  - e.g. cross section of the collider ring magnet, shielding and cooling
  - e.g. similar cross section for the target
  - targets for the component designers and basis for the accelerator designers
- **Parameters will be refined later**
  - need to understand scaling
  - e.g. cost and power scales
- **Obviously, need to closely interact and iterate**

High-level Target Parameters

- **Luminosity**
  - Do we have a strong reason to change integrated luminosity target?
  - How much luminosity would already make a physics case?
  - Angular coverage etc.

$\sqrt{s}$	$\int \mathcal{L} dt$
3 TeV	$1\ \mathrm{ab}^{-1}$
10 TeV	$10\ \mathrm{ab}^{-1}$
14 TeV	$20\ \mathrm{ab}^{-1}$

High-level Target Parameters

- **Detector parameters**
  - Is 3 TeV detector based on CLIC good?
  - What does need to change for 10 TeV?
  - Need to develop table with key parameters:
    - angular coverage
    - vertex detector geometry
    - resolution of tracker/calorimeter
    - particle identification
    - …

- **Background**
  - best to try operation with peak luminosity
  - luminosity reduces as beam is circling

Luminosity (Collider Ring)

$$\mathcal{L} \propto \gamma \langle B \rangle \sigma_\delta \frac{N_0}{\epsilon \epsilon_L} f_r N_0 \gamma$$

High energy

Collider ring circumference
- Collider ring dipole fields
- Filling factor

Energy acceptance
- beta-function = bunch length

Bunch charge
- target and muon survival

Emittances
- cooling and blow-up

Beam power
- neutrino flux
- target and muon survival
- power consumption

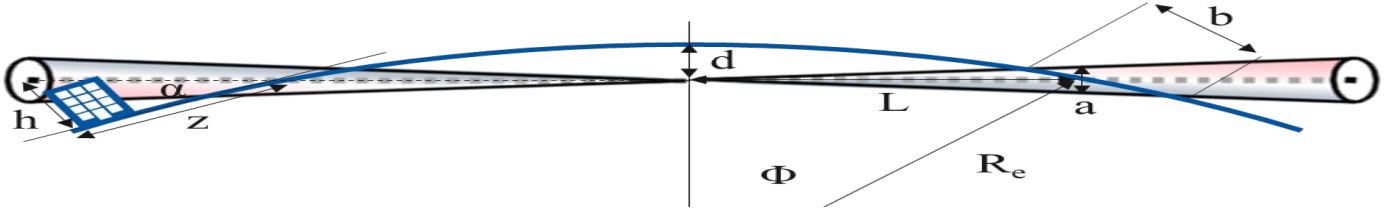
High-level Tentative Target Parameters

If there are strong opinions can change and clarify the definition of parameters

But for the moment should stay with these goals

Parameter	Unit	3 TeV	10 TeV	14 TeV
L	**10^{34} cm^{-2}s^{-1}**	**1.8**	**20**	**40**
N	10^{12}	2.2	1.8	1.8
f_r	Hz	5	5	5
P_{beam} (injected)	**MW**	**5.3**	**14.4**	**20**
C	km	4.5	10	14
<B> (average)	T	7	10.5	10.5
ε_L (norm, 1σ)	MeV m	7.5	7.5	7.5
σ_E / E	%	0.1	0.1	0.1
σ_z	mm	5	1.5	1.07
β	mm	5	1.5	1.07
ε (norm, 1σ)	μm	25	25	25
$\sigma_{x,y}$	μm	3.0	0.9	0.63

Neutrino Flux



Parameter choices have been done with the goal to have **not more impact than the LHC**

- This should not be changed, can express in **neutrino flux**

Collider arcs:

- Calculated that mover range should yield +/- 1 mradian
- Assuming short straights are compensated with horizontal wiggling (14 TeV)
- Detailed study of interaction between mover and beam

- Need to identify the range of angles that can be achieved
  - this might be a limit for even higher energies

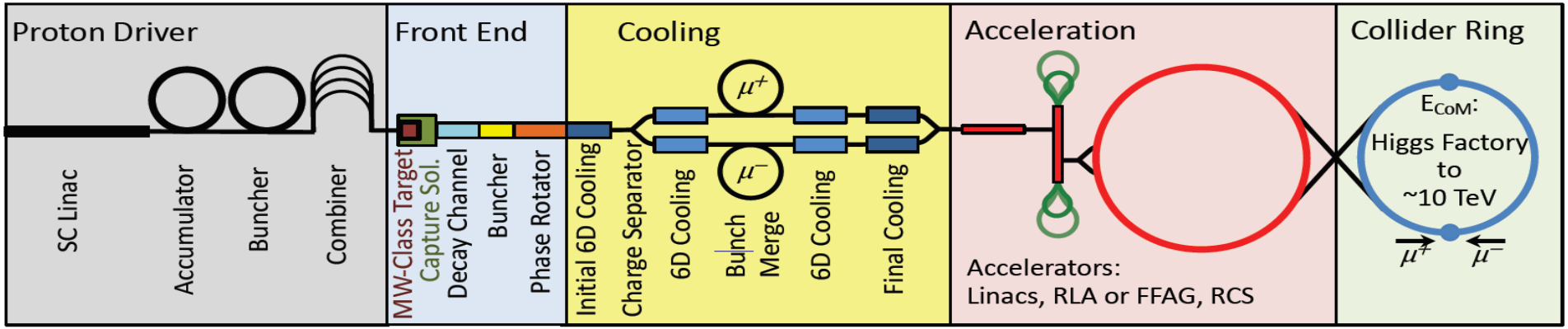
Detector straights are treated independently

Tentative Component Limits

- **Educated guesses of performance limits to be developed by the experts**
  - required for the accelerator design
- **Magnets**
  - Potential technologies
  - Performance parameters with dependencies
    - field level
    - field quality
    - aperture
    - radiation resistance
    - heat load resistance
- **Target**
  - Limits for shock and radiation
  - …
- **RF**
- **Cooling**
- **…**

Muon Beam Parameters

- **Define parameters at the interfaces of different areas**
  - allows to locally optimise, e.g. acceleration chain
- **Ideally transmit full beam phase space to evaluate performance**
  - However, for target parameters use simplified approach for now
- **At production and cooling muons behave in a very special fashion, after cooling like protons**
  - Fix parameters at pivotal point at the end of final cooling



Muon Bunch Charge

Based on J-P Delahaye/some MAP studies
- but used 2 MW target not 1.5 MW

Location	N [10^{12}]
5 GeV protons at target (400 kJ)	500
muons after front end	48
…	…
muons after final cooling (5-20 MeV)	6?
muons after reacceleration 0.2 GeV	4
…	…
muons at 60 GeV	2.7
…	…
muons in collider (3 TeV)	2.2
muons in collider (10 TeV)	1.8

Likely need some reserve in muon number
- e.g. acceleration to 200 MeV after final cooling has not been included, I think
- can be used to boost performance, if not required as reserve

Bunch charge increase is more important than power increase
- Go for 800 kJ per pulse at 5 Hz?

Proton energy is a local optimisation of proton complex, target and capture efficiency

Acceptance in RCS/collider ring in range of +/- 2σ
- charge should refer to muons in this range

Muon Bunch Emittances

- **Emittance target at final cooling end should remain as a target for now**
  - Do not know better for the moment
- **Emittance blow-up from final cooling to IP should remain limited**
  - The specifications for equipment imperfections should be made accordingly
  - Would assume **a total budget of 10%** (most relaxed acceptable tolerance) or **1%** (no issue for the moment)
  - Need to distribute fractions to the different systems and imperfections (for the area team)

rel. emittance blow-up	relative tolerance	relative luminosity
0.1%	0.03	0.999
1%	0.1	0.99
10%	0.3	0.9
100%	1	0.5
1000%	3	0.1

Conclusion

- **Everybody and area leaders:**
  - Review if required parameters are foreseen in the document
  - Or can some be removed?

- **Area leaders and other experts**
  - Fill in best guesses where possible
  - Provide scalings and justification

- **Need this to have time before the annual meeting to go through the numbers**

- **Will then review the parameters data-base**

- **Later will introduce formal method to update parameters**

- **Need to also handle alternatives**

Reserve

Key Considerations

- **Public acceptance is the key for a new collider**
- **Energy and luminosity**
  - to have an attractive physics case to convince that it is worth doing it
- **Detector performance and background**
  - to be able to realise the physics programme
- **Cost, power consumption and environmental impact**
  - to ensure that people are willing to pay the price
- **Technical risk and schedule**
  - to ensure that the project is realistic