Low Emittance Muon Accelerator

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Argomenti tesi:

ottica e dinamica dei fasci, alte energie sperimentale, diagnostica dei fasci

Introduction

Conventional production:

from **proton on target** π, K decays from proton on target have typical $P_\mu \sim 100$ **MeV/c** (π, K rest frame) whatever is the boost P_T will stay in Lab frame → **very high emittance** at production point → **cooling needed**!

HERE: Muons produced from $e^+e^- \rightarrow \mu^+\mu^-$ at √s around the $\mu^+\mu^-$ threshold (√s~0.212GeV) in asymmetric collisions (to collect μ^+ and μ^-)

Advantages:

1. **Low emittance possible:** Pμ is tunable with √s in $e^+e^- \rightarrow \mu^+\mu^-$ Pμ can be **very small** close to the $\mu^+\mu^-$ threshold
2. **Low background:** Luminosity at low emittance will allow low background and low ν radiation (easier experimental conditions, can go up in energy)
3. **Reduced losses from decay:** muons can be produced with a relatively high boost in asymmetric collisions
4. **Energy spread:** Muon Energy spread **also small at threshold**, it gets larger as √s increases, one can use correlation with emission angle (eventually it can be reduced with short bunches)

Disadvantages:

Rate: much smaller cross section wrt protons

$\sigma(e^+e^- \rightarrow \mu^+\mu^-) \sim 1$ μb at most

i.e. Luminosity(e+e-)= 10^{40} cm^{-2} s^{-1} → gives μ rates 10^{10} Hz

Possible Schemes

With low energy e+ beam (in the GeV range):

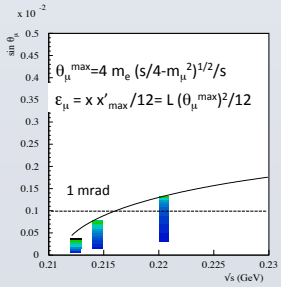
1. Conventional asymmetric collisions (required L is beyond current knowledge)
2. Positron beam interacting with continuous beam from electron cooling (too low electron density need 10^{20}electrons/cm^{-3} to obtain an reasonable conversion efficiency to muons)

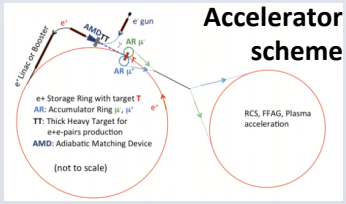
→ **Electrons at rest is the only viable option**

3. e+ on Plasma target (focusing from pinch effect, high density…more studies)
4. e+ on standard target (crystals are a good option)
   - Need Positrons of ~45 GeV
   - Get γ~200 and laboratory lifetime of about 500 μs

Ideally muons will *copy* the positron beam

Target



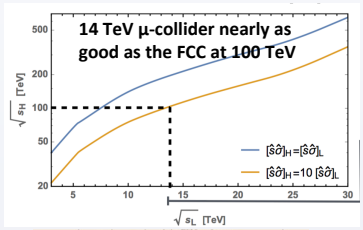


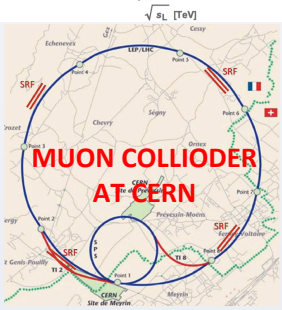
- **Heavy materials**
  - minimize emittance
  - high e^+ loss (Bremsstrahlung is dominant)
- **Very light materials**
  - maximize production efficiency → H_2
  - even for liquid need O(1m) target → emittance increase
- **Not too heavy materials(Be, C)**
  - Allow low emittance with small e^+ loss

optimal: not too heavy and thin

Muon Collider

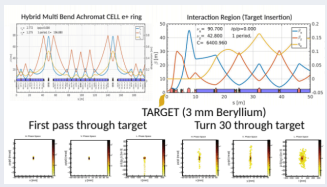
Parameter	Units	MUFACT MultiTeV	MUFACT MultiTeV
LUMINOSITY/IP	cm^{-2} s^{-1}	5,08E+34	2,03E+35
Beam Energy spread	%	0,07	0,03
Beam Energy	GeV	3000	6000
Hourglass reduction factor		1,000	1,000
Muon mass	GeV	0,10566	0,10566
Lifetime @ prod	sec	2,20E-06	2,20E-06
Lifetime	sec	0,0623	0,1249
c*tau @ prod	m	658,00	658,00
c*tau	m	1,87E+07	3,74E+07
1/tau	Hz	1,60E+01	8,00E+00
Circumference	m	6000	12000
Bending Field	T	15	15
Bending radius	m	667	1333
Magnetic rigidity	T m	10000	20000
Gamma (Lorentz factor)		28392,96	56785,92
N turns before decay		3113,76	3113,76
β_x @ IP	m	0,0002	0,0002
β_y @ IP	m	0,0002	0,0002
Beta ratio		1,0	1,0
Coupling (full current)	%	100	100
Normalised Emittance x	m	4,00E-08	4,00E-08
Emittance x	m	1,41E-12	7,04E-13
Emittance y	m	1,41E-12	7,04E-13
Emittance ratio		1,0	1,0
Bunch length (full current)	mm	0,1	0,1
Beam current	mA	0,048	0,048
Revolution frequency	Hz	5,00E+04	2,50E+04
Revolution period	s	2,00E-05	4,00E-05
Number of bunches	#	1	1
N. Particle/bunch	#	6,00E+09	1,20E+10
Number of IP	#	1	1
σ_x @ IP	micron	1,68E-02	1,19E-02
σ_y @ IP	micron	1,68E-02	1,19E-02
σ_s @ IP	rad	8,39E-05	5,93E-05

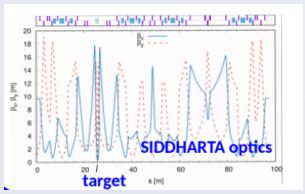




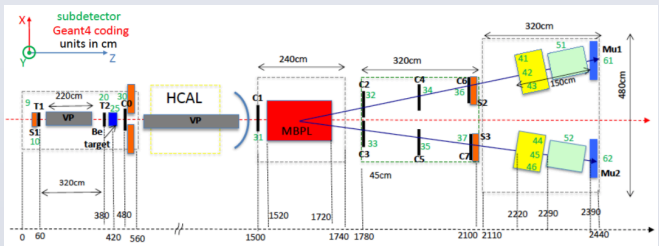
Thesis on Accelerator physics

- Positron ring plus target optimization:
  - Matching of emittance contributions
  - Increase momentum acceptance
  - Optimization of ring circumference
- Design of muon accumulators:
  - High momentum acceptance
  - Design beams separation
  - Design target region
- Positron source
  - High rate positron source
- Test at DAFNE
- beam diagnostic





Thesis on experimental HE physics



- Goal: Study of kinematic properties of the produced muons
  - Measure the $\mu^+\mu^-$ production rate for the provided positron beam features (momentum and energy spread)
    - Use Bhabha events for normalization
  - Measure muons momentum and emittance

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