Energy Frontier On Fermilab Site

Options

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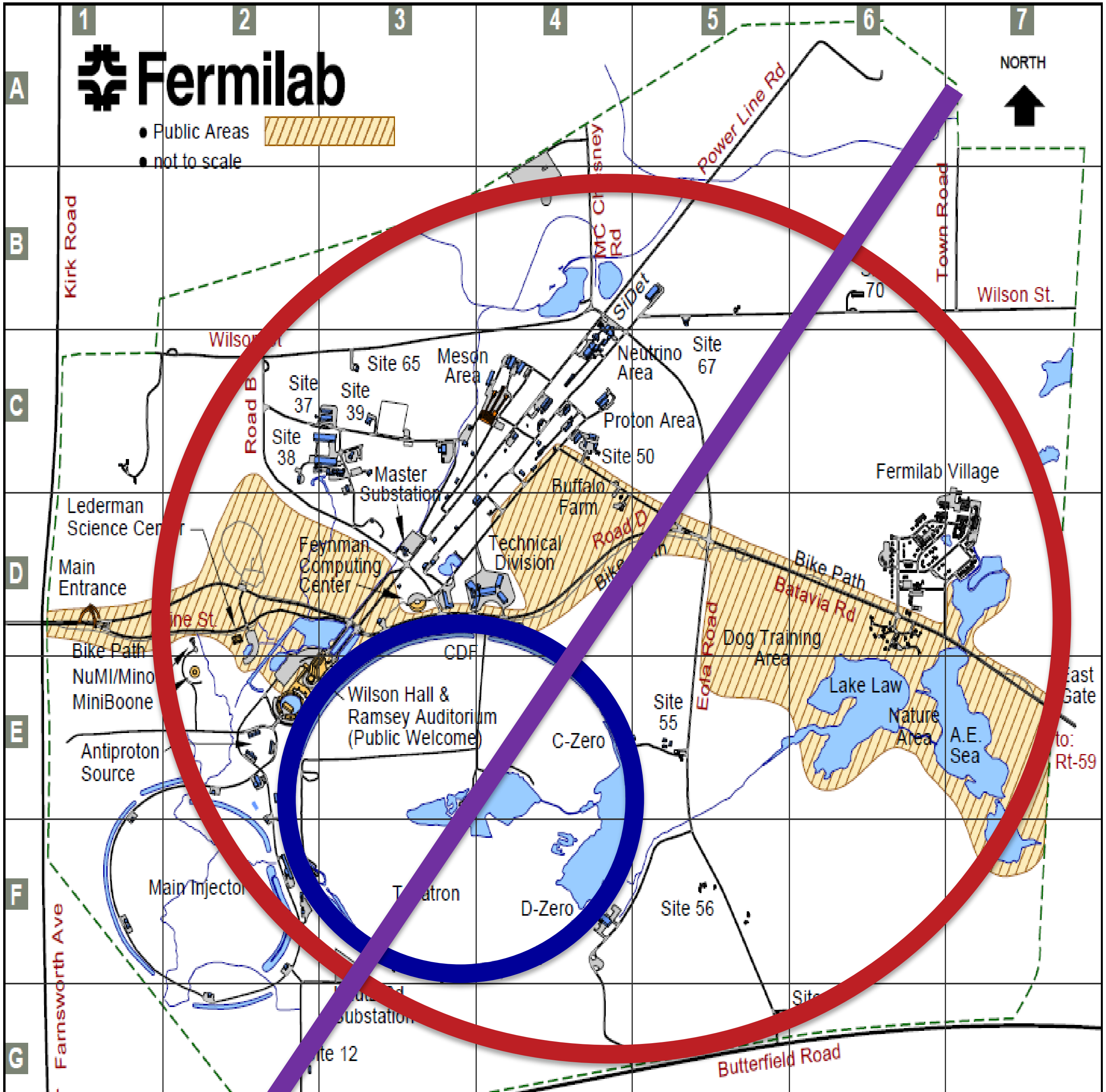
3x5 mi

Max C 16 km

Max L 7.3km



“On site” Energy Frontier Options

- **Hadron *pp* colliders:**
  - 16/6.3=2.5 × Tevatron, future SC magnets 24 T (vs 4.5) → 27 TeV cme
- *e+e-*, *γγ* **colliders:**
  - Circular Higgs factory – high lumi
  - Linear Hiss Factory CLIC-NLC type
  - γγ collider (SAPHIRE type)
  - linear plasma beam/laser driven (far future?)
- **Energy frontier** μ+μ- **colliders:**
  - “traditional” with 20T SC magnets (Fermilab site filler) 6 TeV cme
  - Far-far-future Crystal/CNT acceleration 100-1000 TeV cme, low-*L*
- **Below are just high level comments along the line of (potential) FEASIBILITY**

that is a product of (**Y/N**) three “feasibilities”:

ENERGY x PERFORMANCE x COST

! WARNING !

αβγ - Cost Estimate Model:

$$\text{Cost(TPC)} = \alpha\, L^{1/2} + \beta\, E^{1/2} + \gamma\, P^{1/2}$$

a) **±33% estimate, for a "green field" accelerators**

b) **"US-Accounting" = TPC !** (~ 2 × *European Accounting*)

c) **Coefficients** (units: 10 km for *L*, 1 TeV for *E*, 100 MW for *P*)

- **$\alpha \approx$ 2B$/sqrt(*L*/10 km)**
- **$\beta \approx$ 10B$/sqrt(*E*/TeV)** for SC/NC RF
- **$\beta \approx$ 2B$ /sqrt(*E*/TeV)** for SC magnets
- **$\beta \approx$ 1B$ /sqrt(*E*/TeV)** for NC magnets
- **$\gamma \approx$ 2B$/sqrt(*P*/100 MW)**

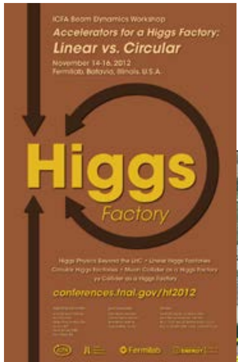
USE AT YOUR OWN RISK!

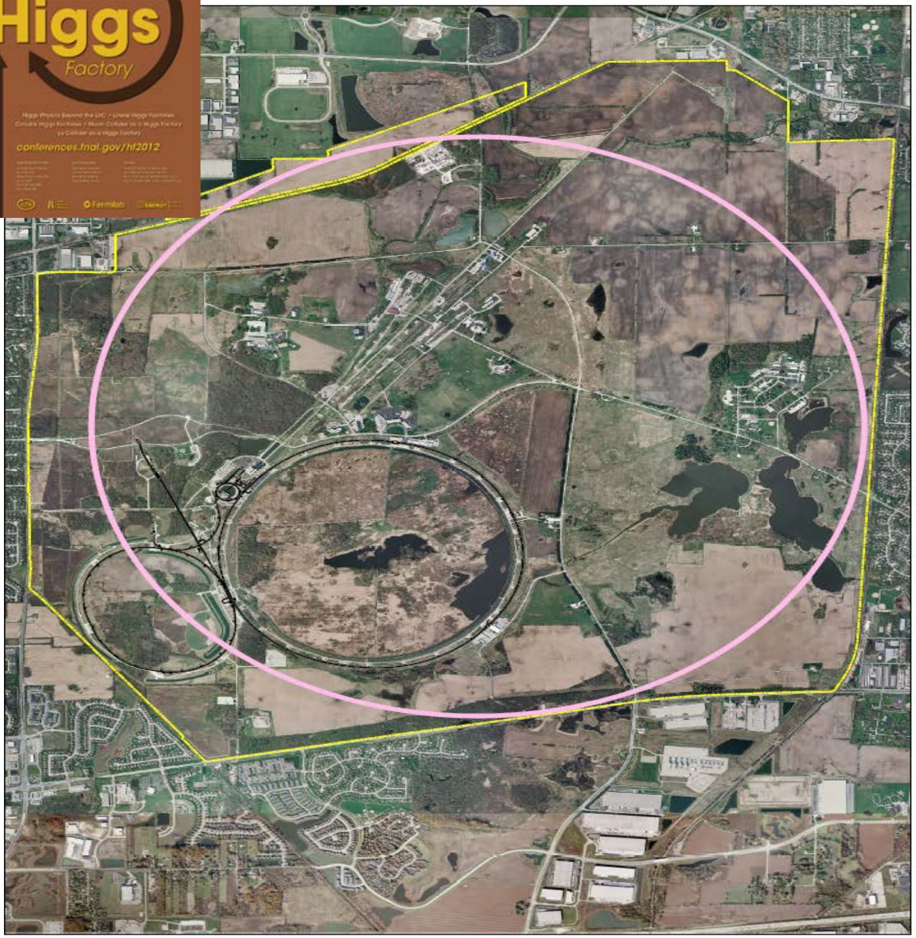
Option 1: 27 TeV cme pp Collider

Piotr Komorowski, R&D engineer at Bruker and Professor Carmine Senator (UNIGE) pointing to the record field of 25T

- Feasibility of Energy : (possibly, **YES**), some 15-20 years
- Feasibility of Performance : (possibly, **YES**), L ~1e34 +
- Feasibility of Cost : (possibly, **NO**) ~15B$

Option 2: Circular Higgs Factory





T.Sen (2012)

Higgs factory

- Beam Energy = 120 GeV
- SR power, both beams=100MW
- Initial luminosity=5x10^{33} cm^{-2} s^{-1}
- βx*, βy* = (20, 0.2) cm
- Beam-beam tune shifts =(0.067, 0.095)
- Beam current = 5 mA

Z Factory

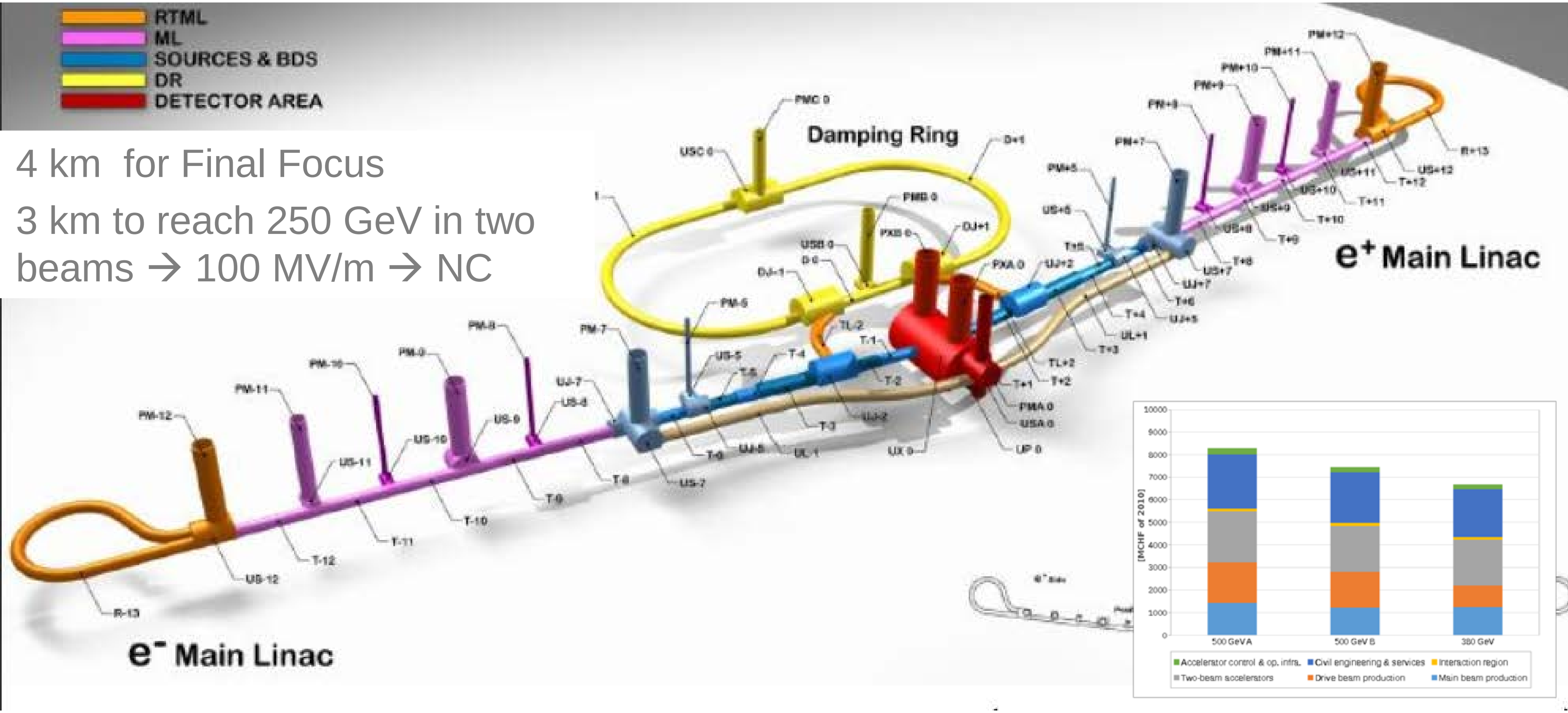
- Beam Energy = 46 GeV
- SR power, both beams= 60 MW
- Initial luminosity=3x10^{34} cm^{-2} s^{-1}
- Beam-beam tune shifts= (0.032, 0,045)
- Beam current = 134 mA

- Feasibility of Energy : **YES**
- Feasibility of Performance : (possibly, **YES**), L ~1e34 + if some 100 MW SRF
- Feasibility of Cost : (possibly, **NO**) ~7B$

Option 3: Linear Higgs Factory

4 km for Final Focus

3 km to reach 250 GeV in two beams → 100 MV/m → NC

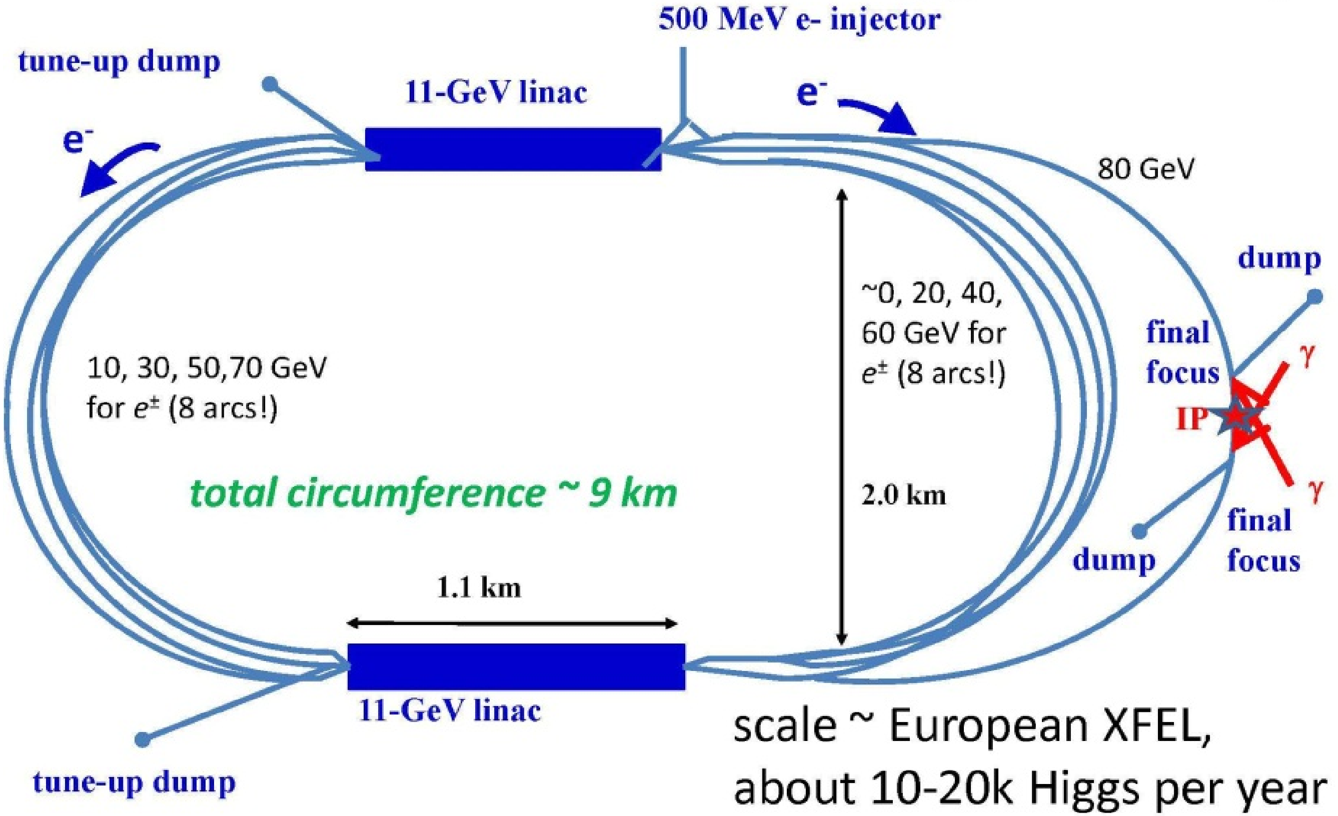


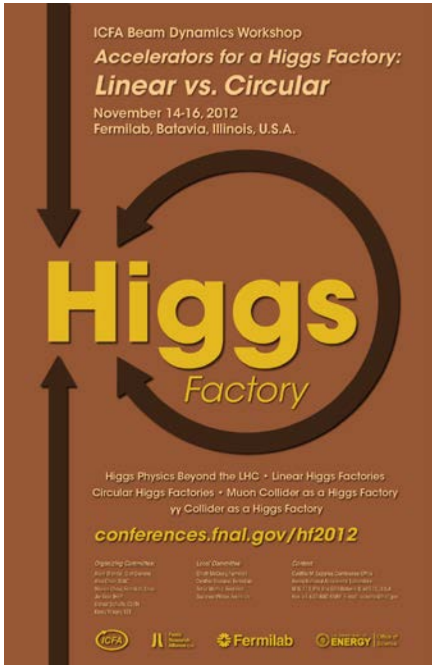
- Feasibility of Energy : (possibly, **YES**), CLIC-scheme or Klystrons
- Feasibility of Performance : (possibly, **YES**), L ~1e34 +
- Feasibility of Cost : (possibly, **NO**) …~80% of CLIC-380 ~5B$ European account

Fermilab

Option 4: Higgs Gamma-Gamma

SAPPHiRE: a Small γγ Higgs Factory

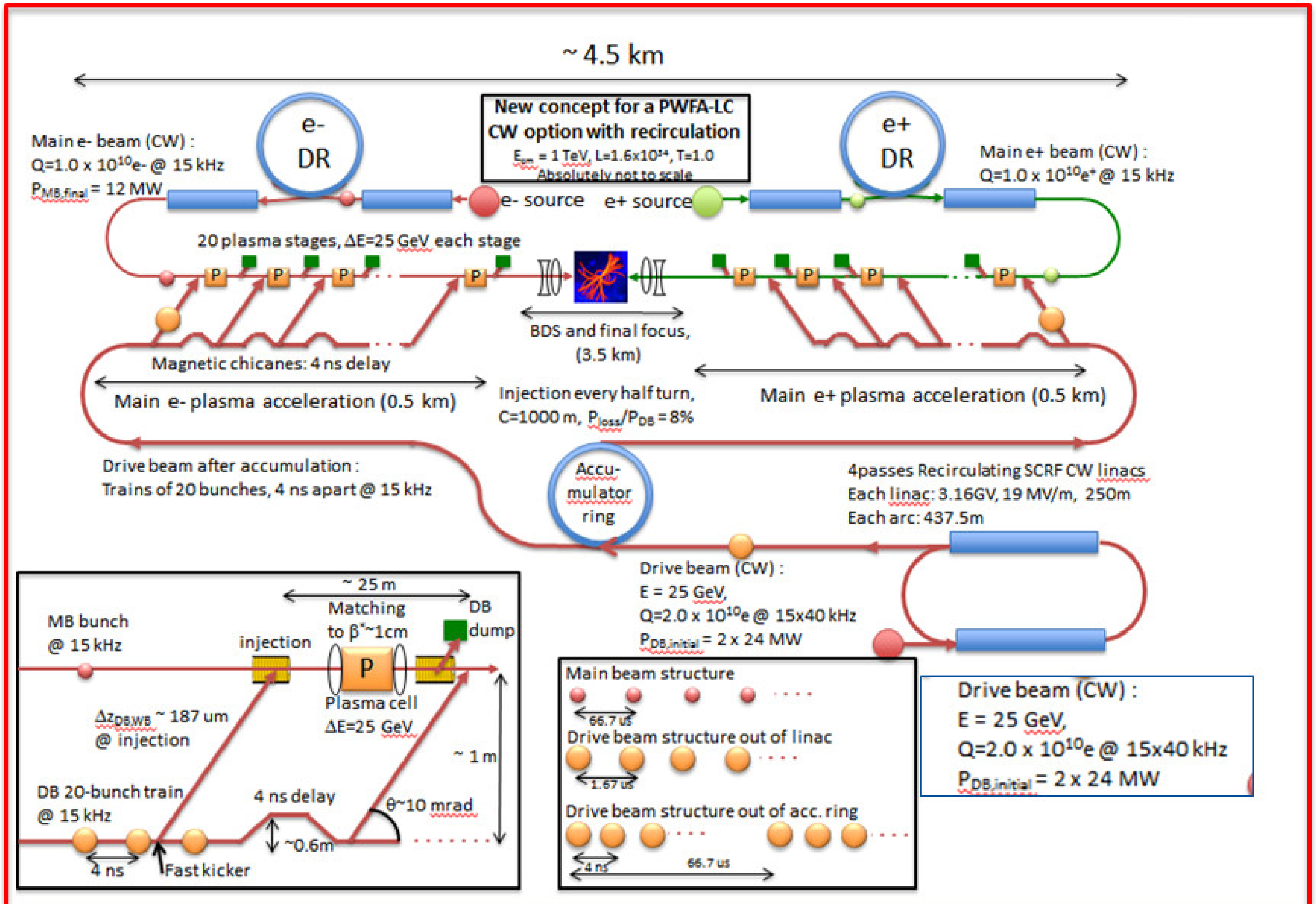




SAPPHiRE: Small Accelerator for Photon-Photon Higgs production using Recirculating Electrons

- Feasibility of Energy : **YES**
- Feasibility of Performance : (possibly, **YES**), L ~1e34 +
- Feasibility of Cost : (possibly, **NO**) ~10B$

Option 5: Linear Plasma Collider

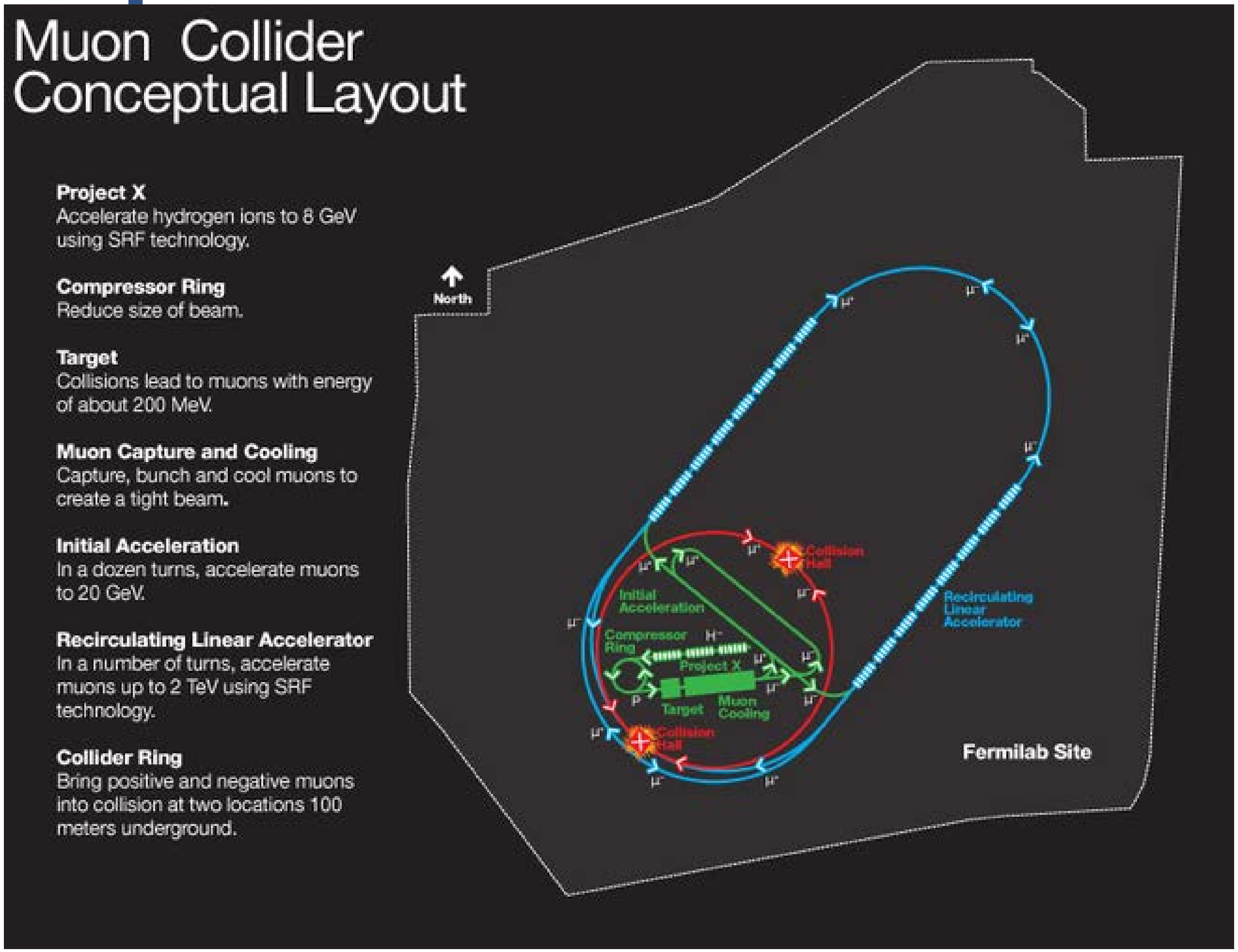


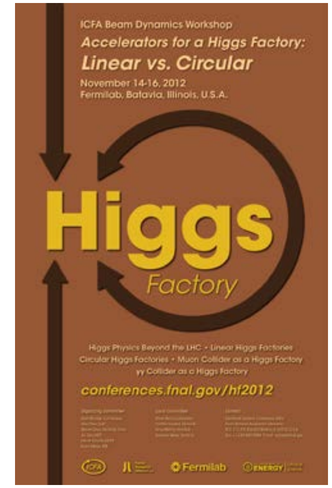
Driven by 25 GeV e- beam… 25 GeV per stage, max energy in **7 km ~ 3 TeV**

Or driven by lasers.. about the same

- Feasibility of Energy : (staging not proven, **N…ES**), for either scheme
- Feasibility of Performance : (possibly, **NO**), L ~1e34 + is impossible e+ ?
- Feasibility of Cost : (possibly, **NO**), > 20 B$ even for 1 TeV

Option 6: Muon Collider





Several options :

Higgs factory (fits the site)

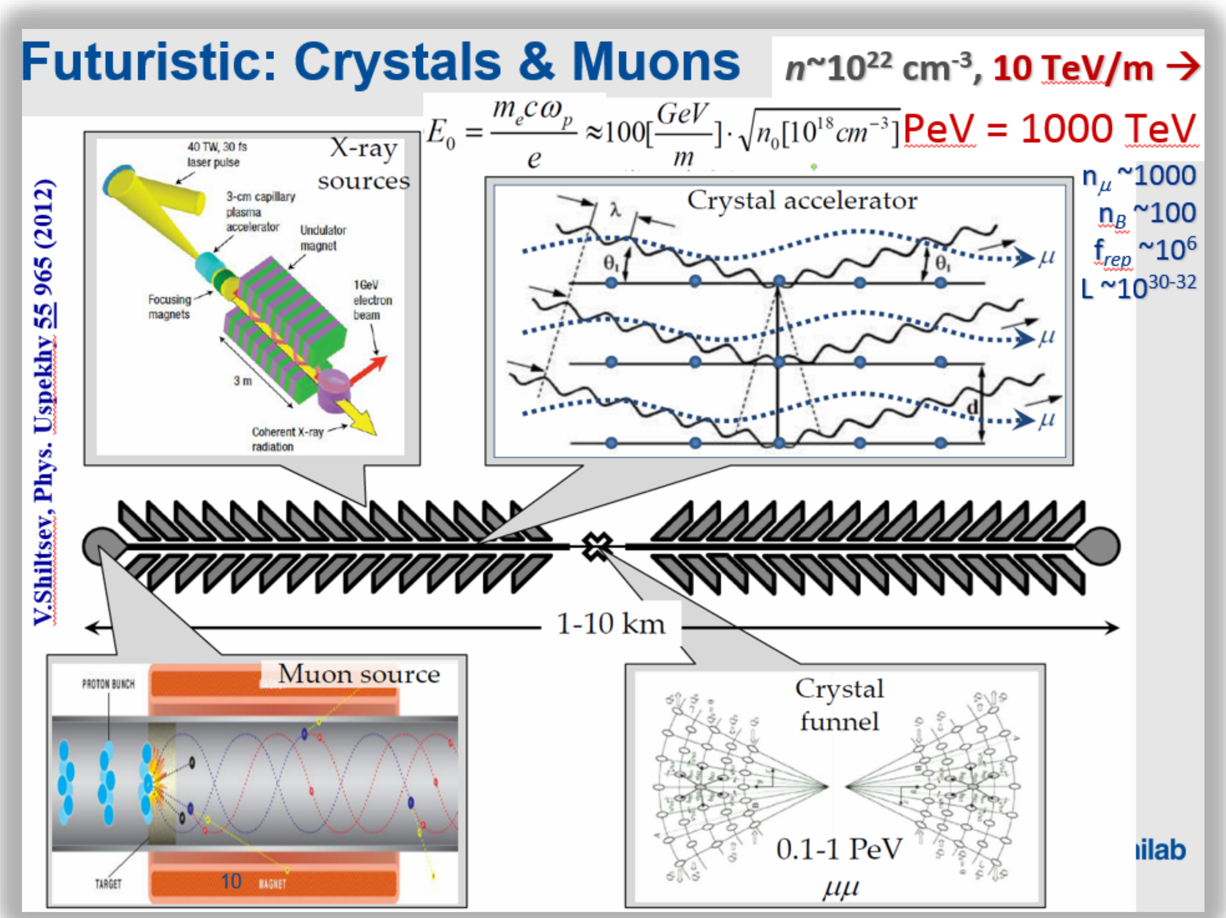
1.5 TeV cme (fits the site)

3 TeV cme (fits the site)

6 TeV cme (site filler)

- Feasibility of Energy : **YES**, 8-10 T for 3, 20 T for 6 TeV option
- Feasibility of Performance : (**NOT** now …R&D → **YES**), L ~1e31 w/o cooling
- Feasibility of Cost : (possibly, **NO**) …~8-10 B$ TPC

Option 7: Muon-Crystal-Plasma



Has no substance now except ~5 papers and ~5 enthusiasts

… "just an idea"

Dream of 1-10 TeV/m

(0.1-1 TeV in CNTs)

… makes possible 1000 TeV collider on FNAL site - ?

- Feasibility of Energy : (just a dream, **NO**), ~2-3 decades of R&D with many "ifs"
- Feasibility of Performance : (surely, **NO**), L ~1e28-1e30
- Feasibility of Cost : (by definition, **YES**) too early to talk about that t