

Neutrino Factory or Muon Collider R&D as “Mid-Term Priority”

Vladimir Shiltsev

Fermilab

APC Steps in the Long-term plan towards NF and MC as next big facilities

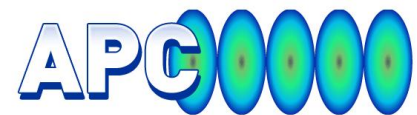
- We are we now
- ILC Situation has changed and that affects everything
- Fermilab Steering group work
- P5 work
- MUTAC next month
- Beyond FY08

Situation in FY07 & FY08

- **Neutrino Factory and Muon Collider Collaboration:**
 - Co-spokesmen: H.Kirk (BNL) and A.Bross (FNAL)
 - Focus on:
 1. MICE experiment in UK
 2. MERIT experiment at CERN
 3. Component development and testing
- **Muon Collider Task Force**
 - Co-leaders: S.Geer and V.Shiltsev
 - Focus on:
 1. Collider Design and simulations
 2. Deep cooling 6D experiment/component development
 3. Final cooling schemes
 4. Main acceleration system (RLA)
- **MCCC (coordination committee) since 2007:**
 - Kirk, Bross, Geer, Shiltsev+Zisman (NFMCC Project Leader)

Current Budget (M\$, fully loaded)

	FY07 Spent	FY08 Allocated
NFMCC	3.6	3.6
M&S	1.4	1.4
SWF	2.2	2.2
MCTF	4.4	4.1
M&S	1.1	0.9
SWF	3.3	3.2
TOTAL	8.0	7.8



FNAL Steering Group (2007)

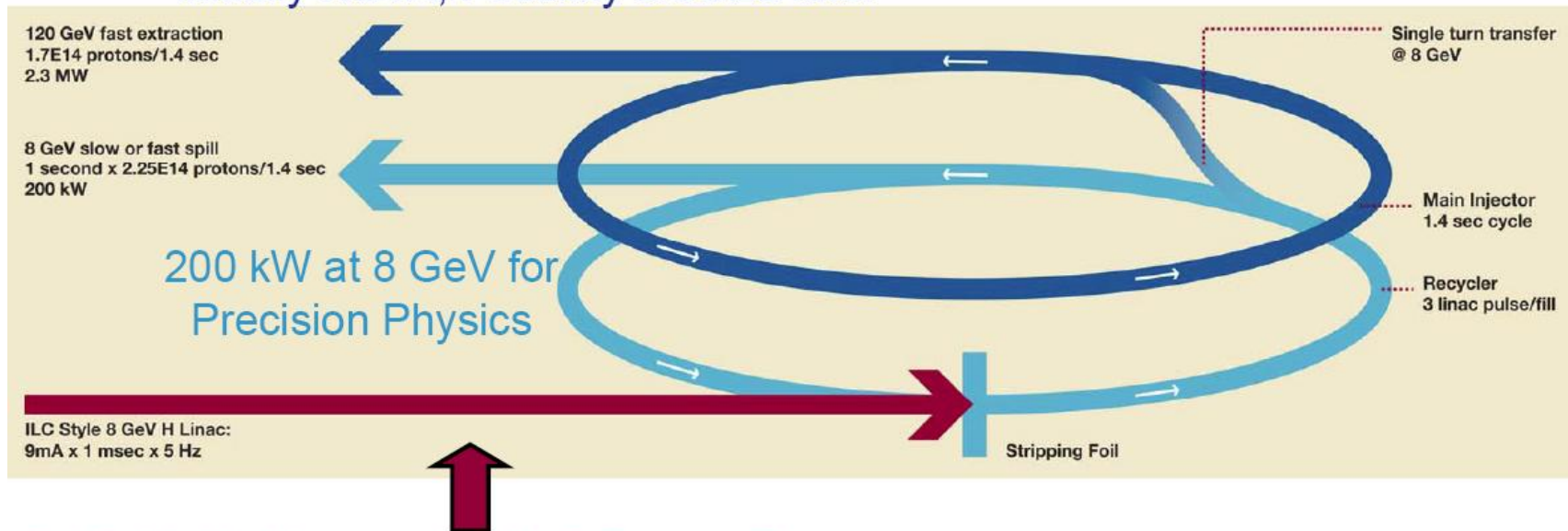
Fermilab and national particle and accelerator physics community

Eugene Beier	U. Penn
Joel Butler	Fermilab
Sally Dawson	BNL
Helen Edwards	Fermilab
Thomas Himel	SLAC
Steve Holmes	Fermilab
Young-Kee Kim (chair)	Fermilab / U.Chicago
Andrew Lankford	UC Irvine
David McGinnis	Fermilab
Sergei Nagaitsev	Fermilab
Tor Raubenheimer	SLAC
Vladimir Shiltsev	Fermilab
Maury Tigner	Cornell
Hendrick Weerts	ANL

- **Advice/Oversight (additional constituents)**
 - Make sure that roadmaps being developed are consistent with EPP2010 and P5 recommendations – J. Bagger, S. Dawson, A. Seiden, M. Shochet (chair)
- **Neutrino Physics (additional constituents)**
 - Develop roadmap for neutrino physics based on NuSAG studies
- **Flavor Physics: quarks, charged leptons, ... (additional constituents)**
 - Develop 10-year plan with reconfiguring existing accelerator complex
- **Accelerator Facilities (based on technical and resources feasibilities)**
 - Develop options of a roadmap that supports ILC R&D for early start, supports Fermilab as a potential host site, and provides an accelerator-based high energy physics program in case of delayed start – H. Edward, T. Himel, S. Holmes (chair), D. McGinnis, S. Nagaitsev, T. Raubenheimer, V. Shiltsev, M. Tigner, (YKK)
- **High Energy Colliders beyond the ILC**
 - Develop steps necessary to explore higher energy colliders that might follow ILC or be needed should results from LHC point toward a higher energy than that planned for ILC – H. Edward, V. Shiltsev, M. Tigner (chair), (YKK)

Project X

~2.3 MW at 120 GeV for Neutrino Science
Initially NOvA, Possibly DUSEL later



8 GeV H- Linac with ILC Beam Parameters
(9mA x 1msec x 5Hz)



An Accelerator-Based Particle Physics Roadmap for Fermilab

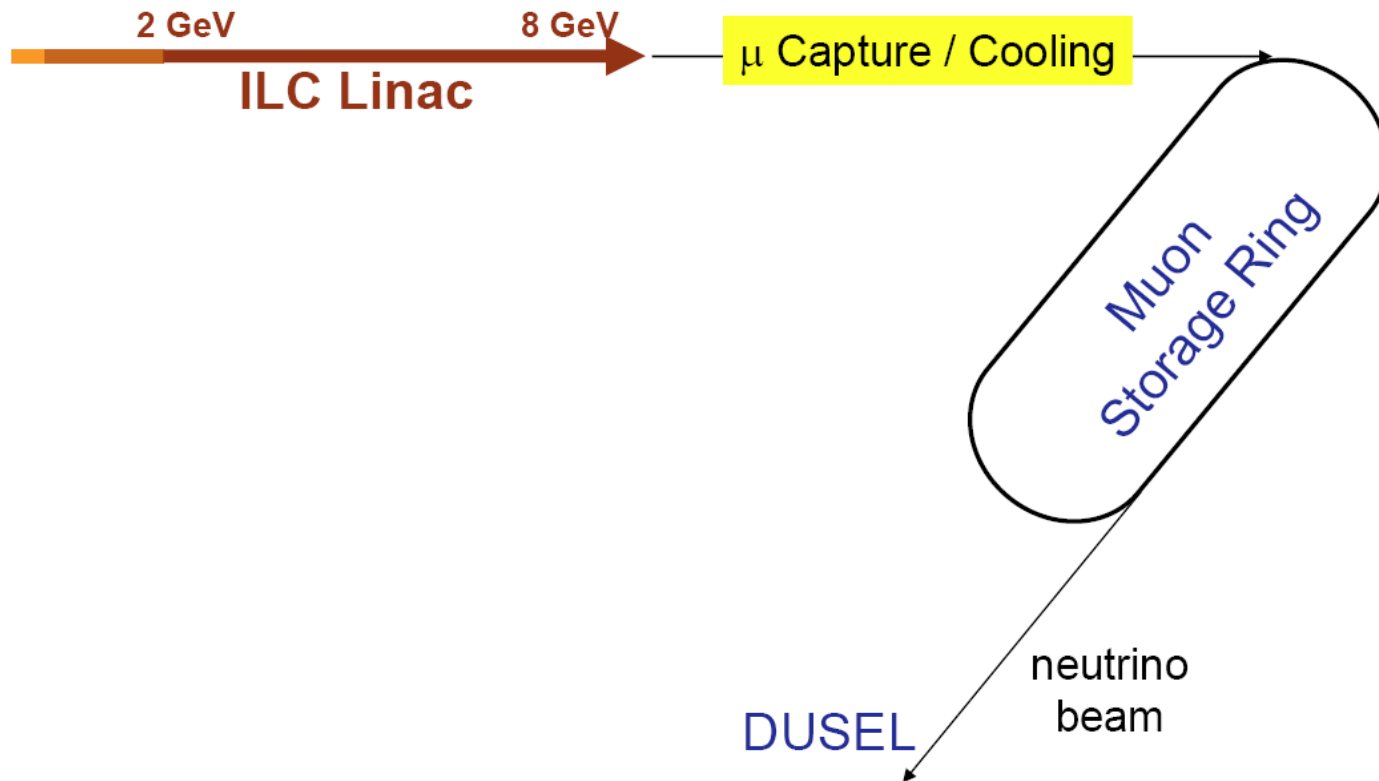
“ ...

- In all scenarios,
 - starting now, give R&D support to Project X. Emphasize
 - expediting R&D and industrialization of ILC cavities and cryomodules
 - overall design of Project X
 - increase R&D for future accelerator options concentrating on neutrino factory and muon collider.
 - support detector R&D for effective use of future facilities

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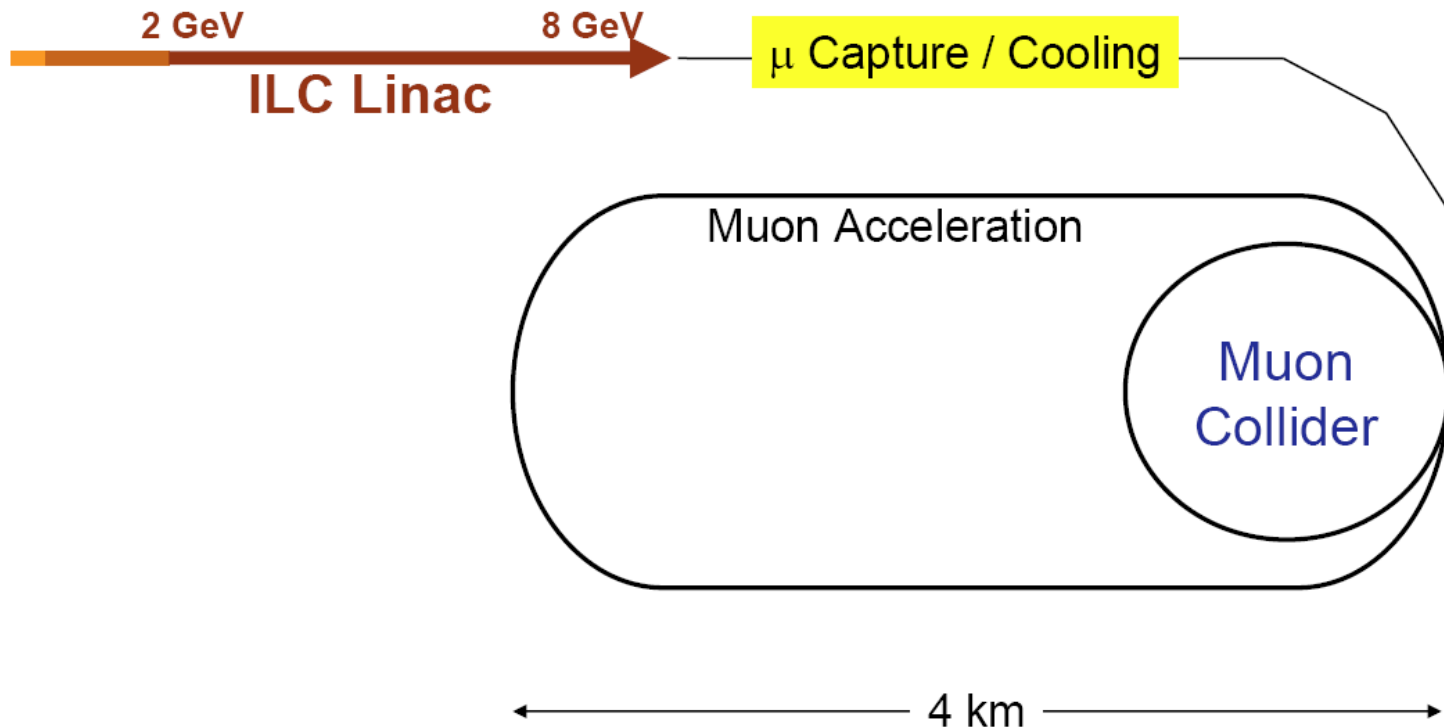
Project X as ...

First Stage of Future World Facilities



Project X as...

First Stage of Future World Facilities



- *Current Activities:*
 - international MERIT experiment at CERN and MICE at RAL
 - Neutrino Factory and Muon Collider Collaboration (NFMCC)
 - Muon Collider Task Force at Fermilab
- *Schedule and Cost:* significant evaluation of cooling and other feasibility items might be carried out in approximately **five to seven years** given support for a technically limited schedule. A rough comparison with the U.S. ILC development intensity prior to the ITRP decision would indicate the need for a minimum of **\$20M annually and 100 FTE** of appropriate skills.
- It would be very advantageous **to have more than one muon test facility** where cooling and the associated technologies can be carried out...

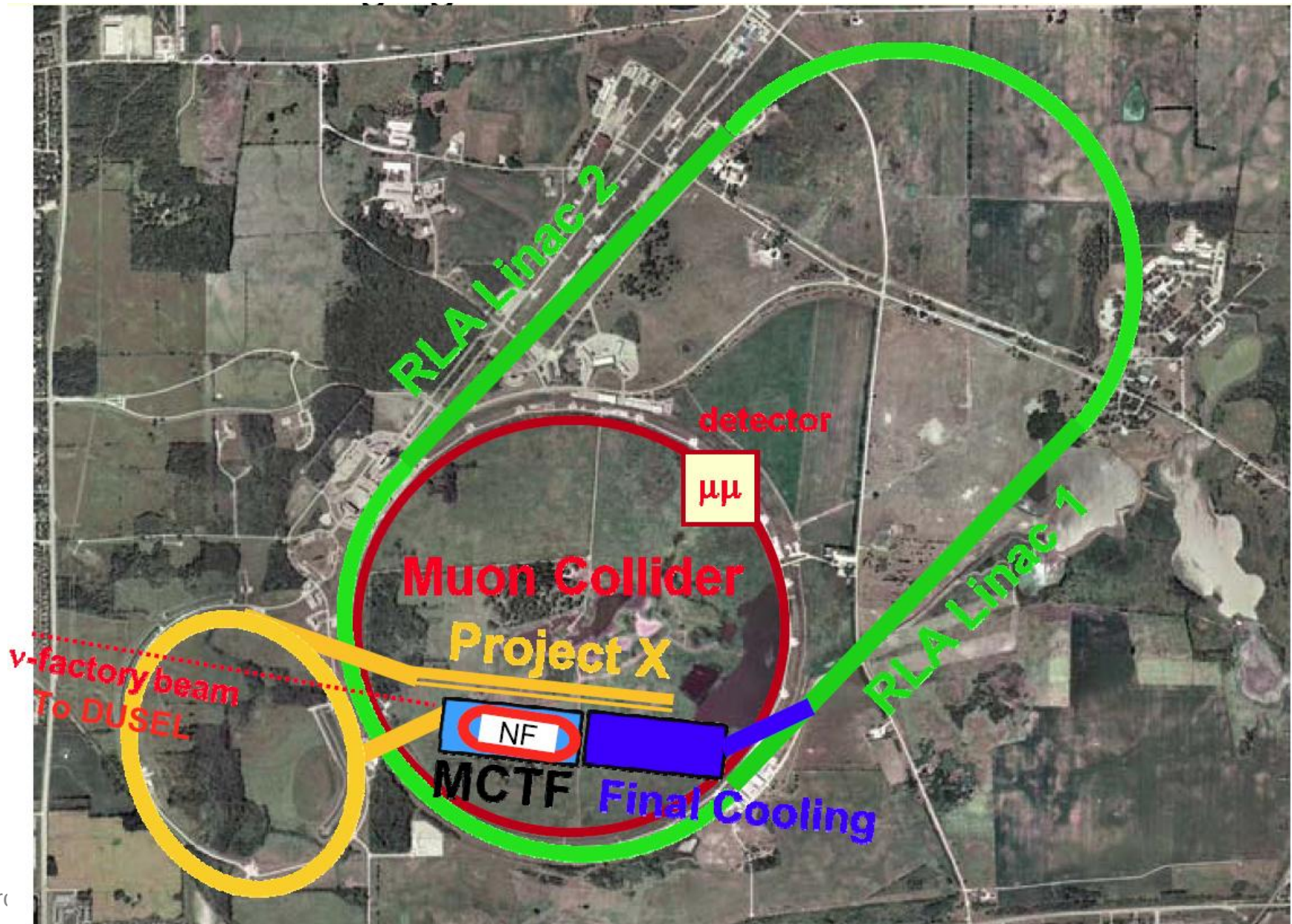
FY08 omnibus bill →

HEPAP P5 subpanel

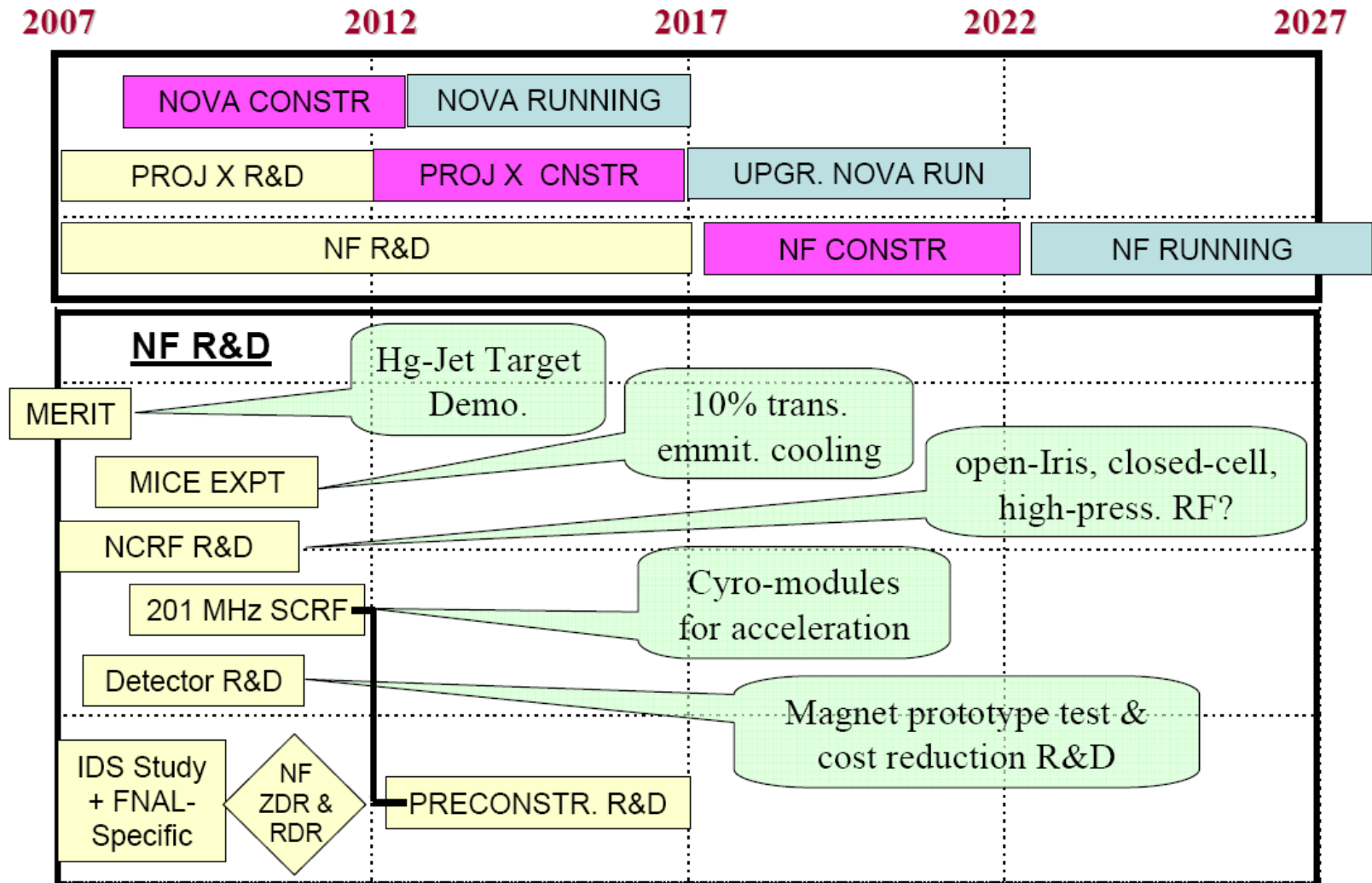
- **Charge to P5:** provide recommendations (to HEPAP and D.Kovar) on the priorities for an optimized high energy physics program over the next 10 years (FY09-FY18), under four funding scenarios:
 - Constant effort at the FY 2008 funding level (i.e.; funding in FY 2009 at the level provided by the FY 2008 Omnibus Bill inflated by 3.5% and thereafter inflated by 3.5% per year in the out-years)
 - Constant effort at the FY 2007 funding level (i.e.; funding in FY 2009 at the level provided in FY 2007 inflated 3.5% per year over two years and thereafter inflated by a 3.5% in the out-years).
 - Doubling of funding over a ten year period starting in FY 2007 (i.e.; funding in FY 2009 at the level provided in FY 2007 inflated 6.5.% per year over two years and thereafter inflated by 6.5% per year in the out-years)
 - Additional funding above the previous level, in priority order, associated with specific activities needed to mount a leadership program that addresses the scientific opportunities identified in the EPP2010 report.
- **3 meetings (FNAL, SLAC, BNL) → retreat → report mid-April**

P.Oddone (2008 P5 at FNAL): neutrino strategy

- **Build NOvA.** Together with T2K and reactor: best shot at neutrino oscillation parameters, first glimpse of mass hierarchy if $\sin^2 2\theta_{13}$ is large enough
- Replace MINOS by 5 kton LAr detector on axis. Together with NOvA, by far best reach into angle CP and mass hierarchy for full decade
- Develop caverns/detectors for DUSEL – with **new beam-line from Project X** it is the ultimate super-beam experiment (water or LAr)
- If **neutrino factory** is needed – Project X is the ideal source.



S.Geer (P5 Mtg at SLAC): NF



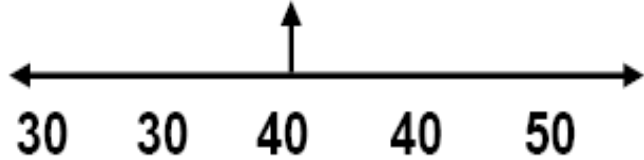
S.Geer @ SLAC P5 Mtg: NF

- **FY07/08 annual U.S. funding level for NF+Muon Collider R&D:**
5.5M\$ (SWF) + 2.4M\$ (M&S)=7.9M\$ (of this 2M\$ is Muon Collider specific)

R&D estimates corresponding illustrative timeline

	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
MICE M&S	0.8	1.3	0.2	0.2					
NCRF M&S	1.0	1.0	1.0	2.0					
SCRF M&S	1.0	1.0	2.0	3.0					
DET M&S	0.1	0.2	1.0	1.0					
OTHER M&S	0.8	0.8	0.8	1.5					
M&S TOTAL	3.7	4.3	5.0	7.7					
SWF+Indir.	8.5	10.4	12.1	13.8					
TOTAL	12.2	14.7	17.1	21.5					

$\Sigma = \sim 10\%$ of project cost



4 GeV NF Cost Estimate (excluding 2 MW proton source)

Start from Study 2 cost estimate scaled to account for post-study 2 improvements (ranges reflect uncertainties in scaling) →

ILC analysis suggest loading coeff = 2.07 for accelerator systems and 1.32 for CFS. Labor assumed $1.2 \times \text{M\&S}$ →

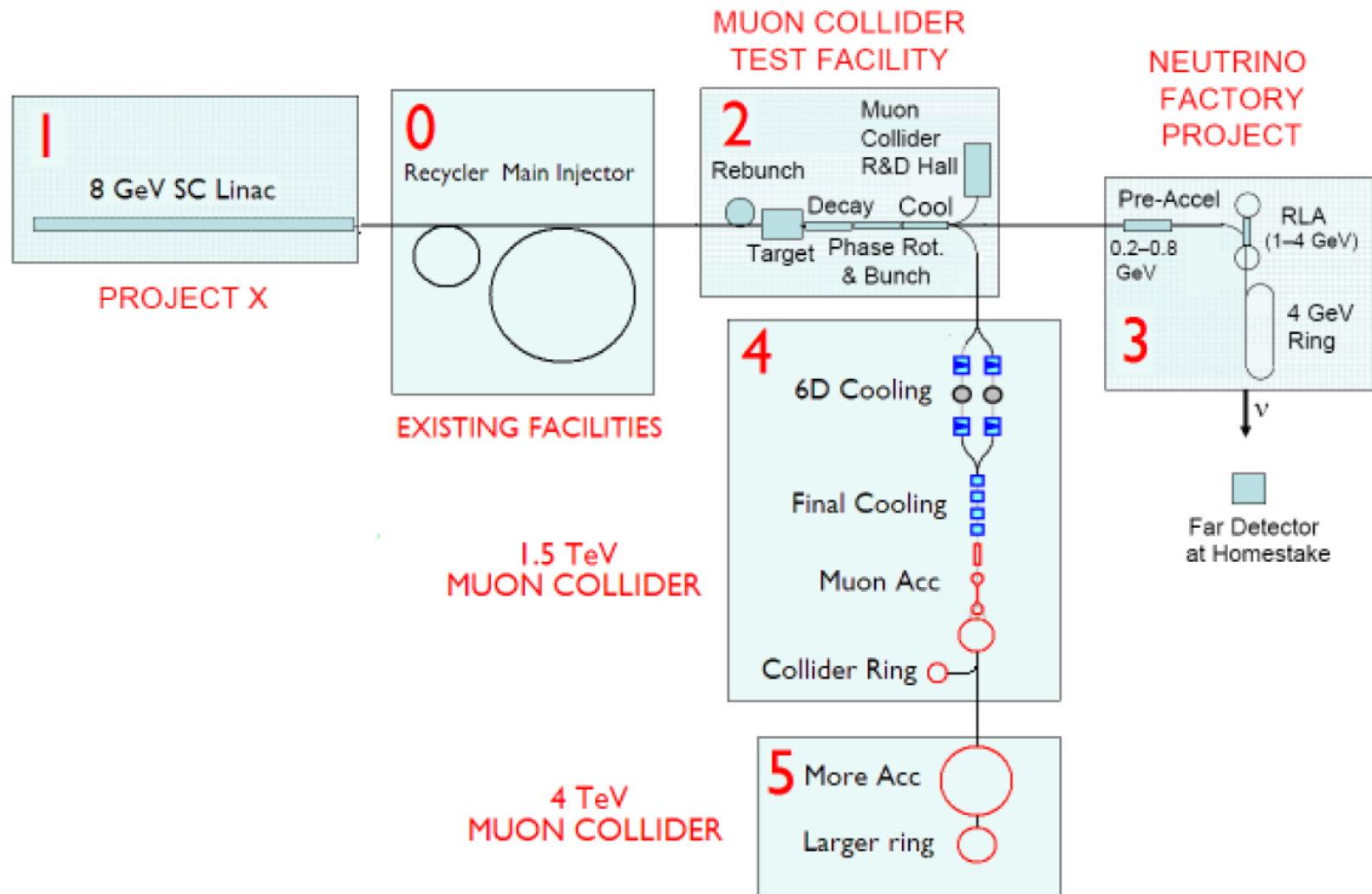
Loaded estimate = 2120 - 2670 (FY08 M\$)

Unloaded estimate (M\$)

Target Systems	110
Decay Channel	6
Drift, Ph. Rot, Bunch	112-186
Cooling Channel	234
Pre-Acceleration	114-180
Acceleration	108-150
Storage Ring	132
Site Utilities	66-156
TOTAL (FY08 M\$)	881-1151

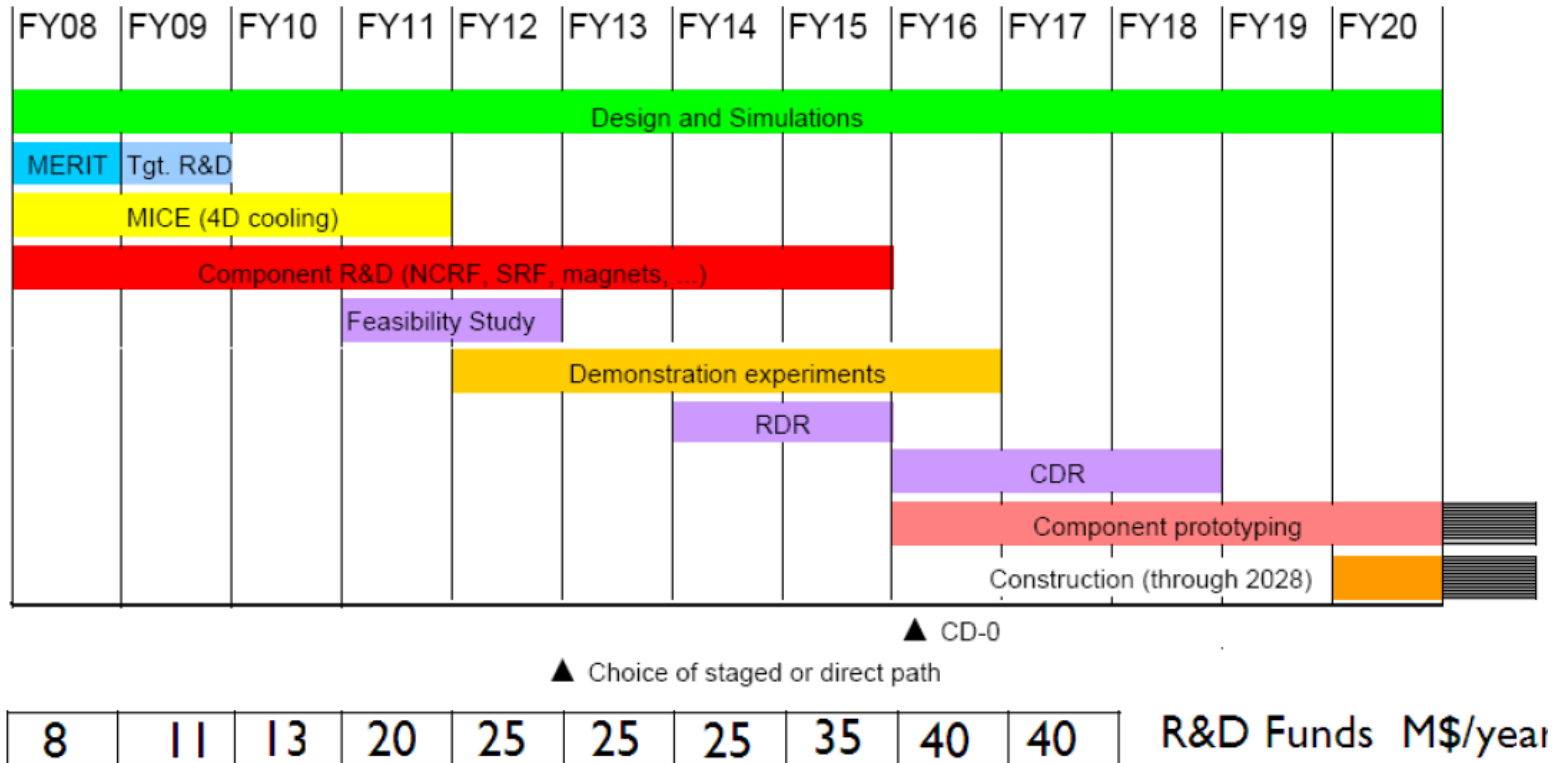
R. Palmer (P5 @ BNL): MC

A Phased Approach



R.Palmer @ P5 mtg at BNL

Time Line and Funding Needs



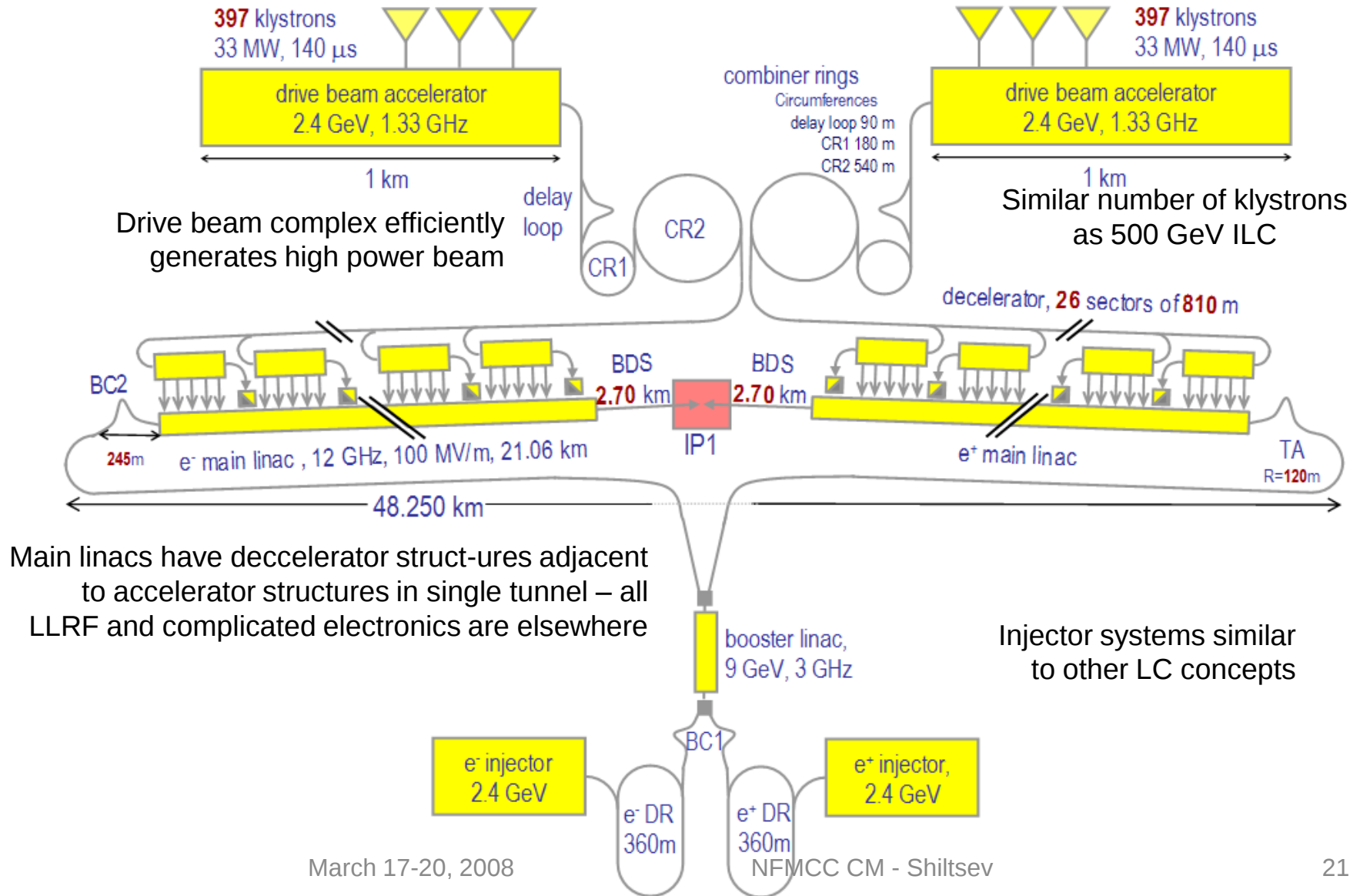
- Funding request includes that for Neutrino Factory R&D
- Funding increase ($\approx 3\times$) needed if Muon Collider is to be credible option by 2012

R.Palmer: conclusions

- A broad and significant R&D program is already underway
- With an expanded program, we expect to be able to complete a "Feasibility Study" by 2012, that would
 - Establish the feasibility of a Muon Collider
 - Greatly narrow the technology options
 - Include, as near as possible, an end-end simulation, and
 - Give a first rough cost estimates for two energies
- A Muon Collider could then be part of a phased program:
 - Project X
 - Muon Collider R&D area
 - Neutrino Factory
 - 1.5 TeV collider
 - 4 TEV collider
- But for a Muon Collider to be a realistic option in 2012, increased funding for R&D is needed now

CLIC Schematic

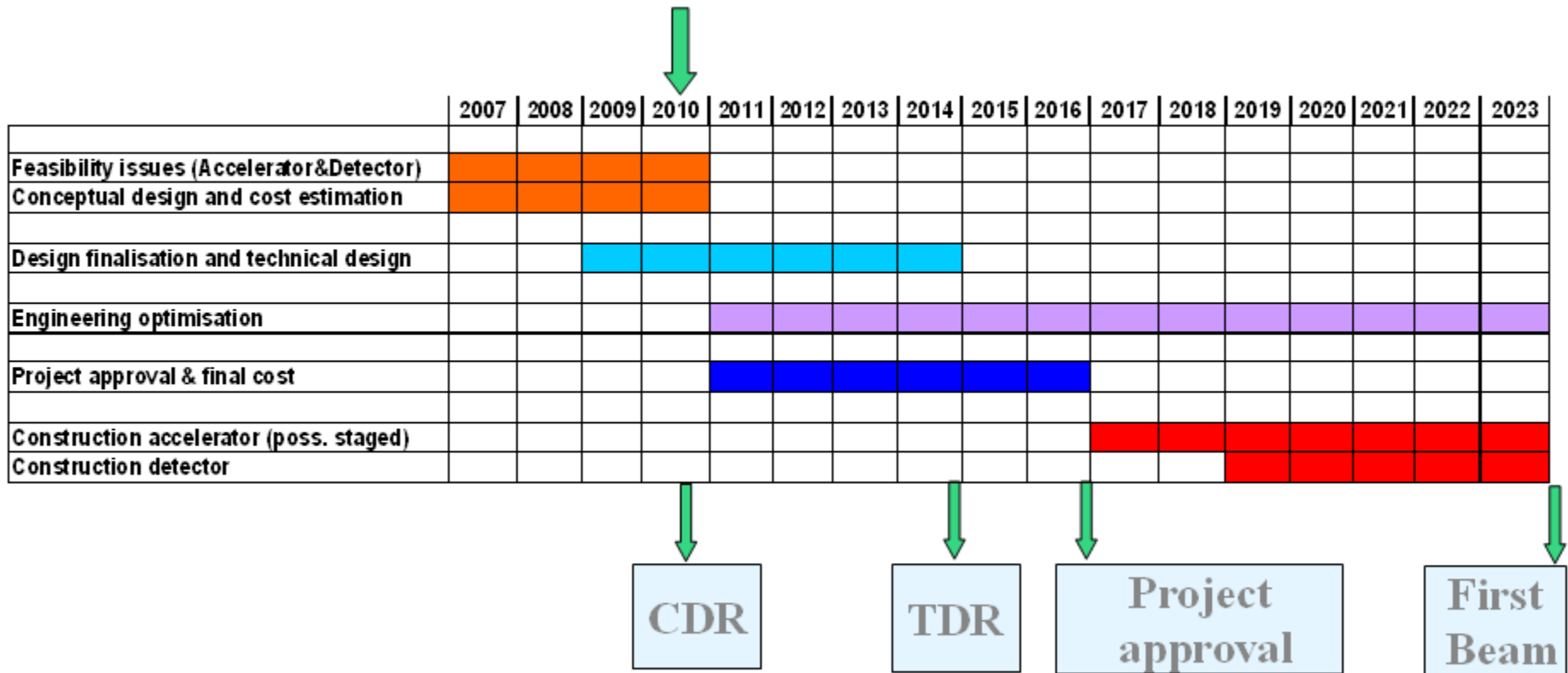
(2007 Parameters for 3 TeV)



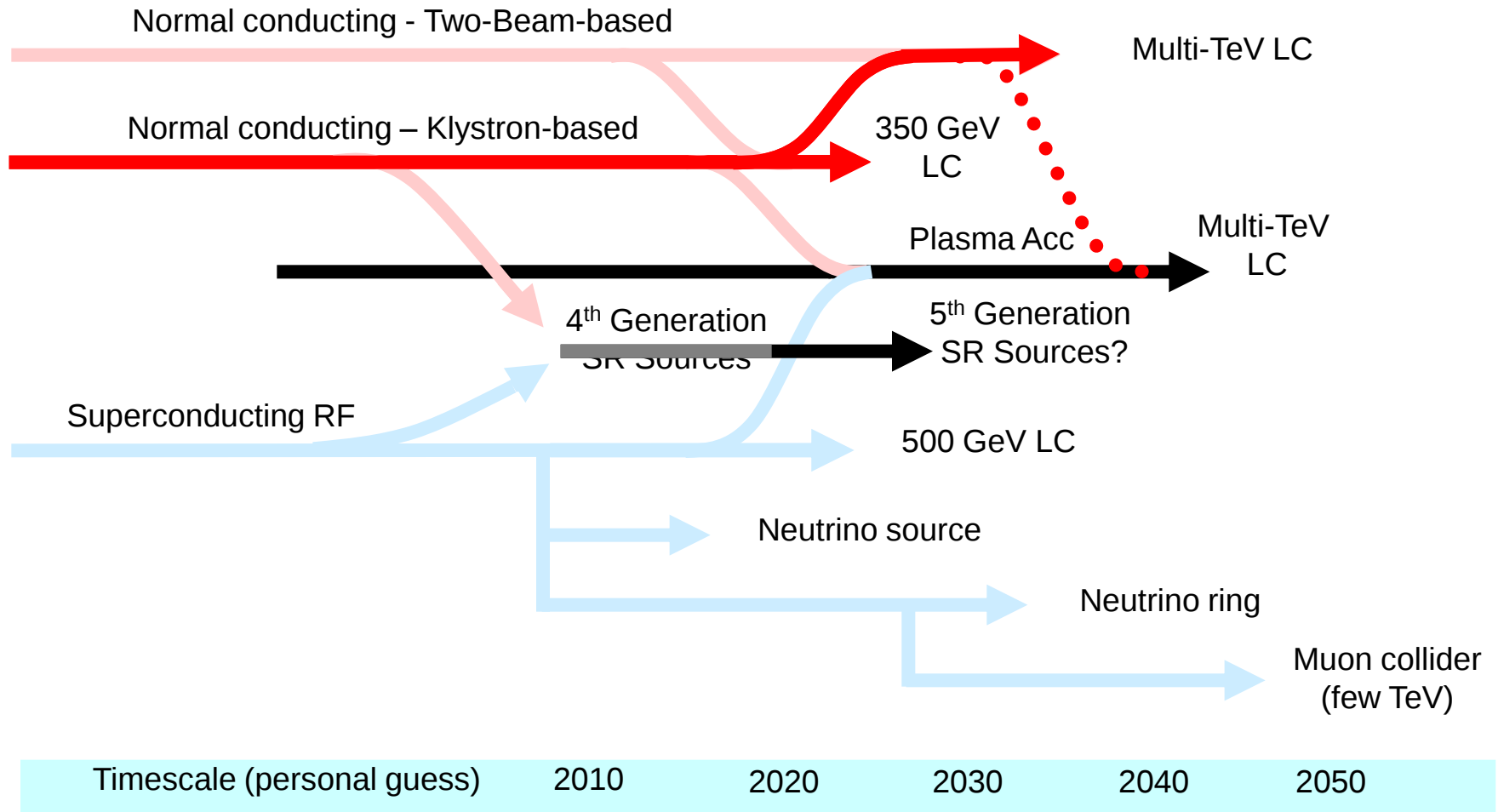
Proposed Timescale

(from JPD presentation to CERN SPC)

Technology evaluation and Physics assessment based on LHC results
for a possible decision on Linear Collider funding with staged
construction starting with the lowest energy required by Physics



T.Raubenheimer (P5 FNAL): Another Possible Path to Multi-TeV Lepton Physics



M.Tigner (P5 BNL): Accel R&D

- This AARD program needs to be aligned with the overall HEP program and its vision for the “medium term” and “longer term” adopted by DOE/NSF following on the P5/HEPAP recommendations to come shortly
 - this will require refocusing, taking great care not to cut off possibilities for the future inadvertently
 - implementation recommendations might best come from a special group able to interpret physics program needs and vision in terms of accelerator R&D elements, priorities and costs
- His personal opinion on “mid term”: CLIC – “nay”, plasma – “nay”, Muon Collider – “yes, should give a try”

Muon R&D Organization

- If NF&MC will be considered as priority mid-term for DoE HEP and budget increased correspondingly, then next step should be to form a joint team to carry out the Muon Accelerator R&D program
- Manpower resources for the program are available in :
 - ✓ National labs (BNL,ANL,FNAL, LBNL, SLAC, Cornell, JLab)
 - ✓ Universities, SBIRs, international (European)
- MCTF and NFMCC – which already have a lot in common – would need to evolve to a LARP-like organization
- First step – set a discussion between NFMCC, MCTF, MCOG at MUTAC in April → prepare ourselves for Accelerator Science review “across the field” in Summer

An example (that works): LARP

US LHC Accelerator Research Program (LARP) Organization Chart

Sep 6, 2007

———— Direction and reporting
 - - - - Advice

