Summary

Sessions 10, 11:

"Innovative New Technologies for Accelerators and Detectors"

"Special Subjects"

Chip Brock, Michigan State University

Session 10: New Technologies

LHC Plans for Upgrades:
Nessi

Innovative Technologies for Detectors for Future Colliders:
Yamamoto

Linear Colliders:
Stapnes

Plasma Acceleration:
Tajima

Muon Colliders:
Henderson

Session 11: Special Subjects

Large Collaborations:
Denisov

Outreach:
Barnett

Governance:
Yamada

Technology Transfer:
Anelli

Session 10: New Technologies

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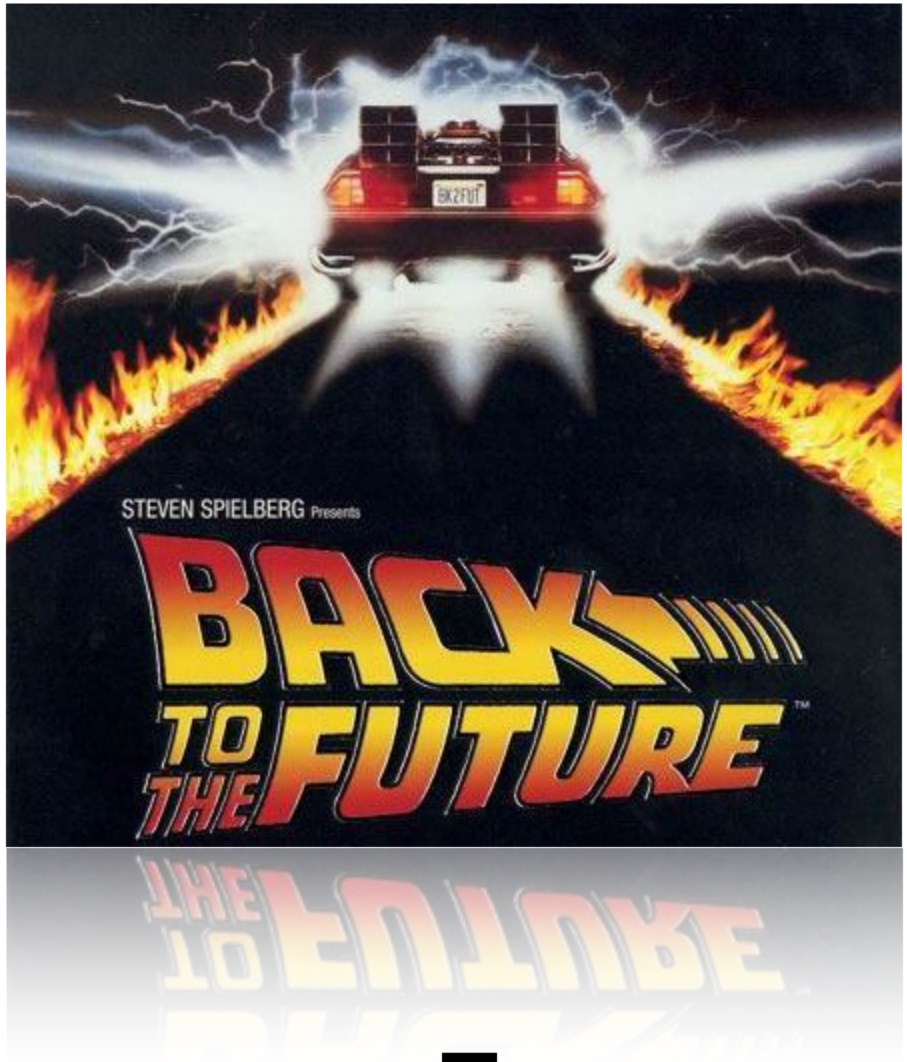

ICFA

Sessions 10 and 11

are about **technologies** enabling the future:

enabling facilities

enabling detectors

enabling the profession

Detector Technologies

LHC Plans for Upgrades:
Nessi

Innovative Technologies for Detectors for Future Colliders:
Yamamoto

Technology Transfer:
Anelli

Facility Technologies

Plasma Acceleration:
Tajima

Muon Colliders:
Henderson

Linear Colliders:
Stapnes

Governance:
Yamada

Cultural Technologies

Outreach:
Barnett

Large Collaborations:
Denisov

	LHC	det	LC	PlasA	muon	Coll	Out	GOV	Tech
LHC		●				●	●	●	●
det									
LC									
PlasA									
muon									
Coll									
Out									
GOV									
Tech									

"LHC" =	LHC upgrades
"det" =	detector technologies
"LC" =	Linear Collider
"PlasA" =	Plasma Acceleration
muon =	Muon collider
"coll" =	Large collaborations
"out" =	Outreach
"GOV" =	Governance
"Tech" =	Technology Transfer

● existing, obvious correlations

○ promising, less-developed correlations

	LHC	det	LC	PlasA	muon	Coll	Out	GOV	Tech
LHC		●				●	●	●	●
det			●		●	○	○	○	●
LC				●	●	●	●	●	●
PlasA							○	○	●
muon						●	●	●	●
Coll							●	●	○
Out								●	
GOV									○
Tech									

"LHC" = LHC upgrades
"det" = detector technologies
"LC" = Linear Collider
"PlasA" = Plasma Acceleration
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● existing, obvious correlations

○ promising, less-developed correlations

	LHC	det	LC	PlasA	muon	Coll	Out	GOV	Tech
LHC		●				●	●	●	●
det			●		●	○	○	○	●
LC				●	●	●	●	●	●
PlasA							○	○	●
muon						●	●	●	●
Coll							●	●	○
Out								●	
GOV									○
Tech									

How well we do here

Will depend on how well we do here

"LHC" = LHC upgrades
"det" = detector technologies
"LC" = Linear Collider
"PlasA" = Plasma Acceleration
muon = Muon collider
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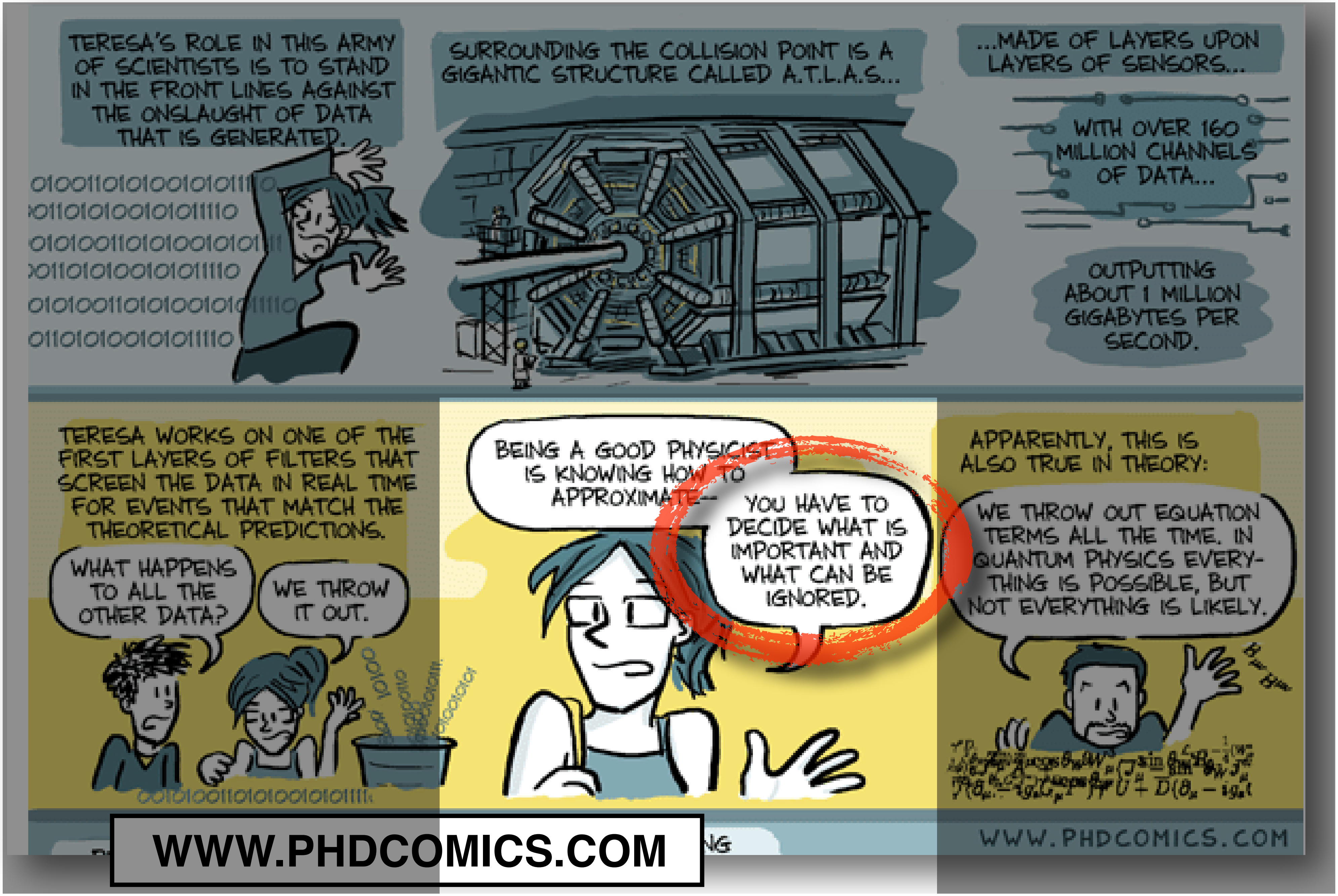
● existing, obvious correlations

○ promising, less-developed correlations


TERESA'S ROLE IN THIS ARMY OF SCIENTISTS IS TO STAND IN THE FRONT LINES AGAINST THE ONSLAUGHT OF DATA THAT IS GENERATED.
SURROUNDING THE COLLISION POINT IS A GIGANTIC STRUCTURE CALLED A.T.L.A.S...
...MADE OF LAYERS UPON LAYERS OF SENSORS...
WITH OVER 160 MILLION CHANNELS OF DATA...
OUTPUTTING ABOUT 1 MILLION GIGABYTES PER SECOND.
TERESA WORKS ON ONE OF THE FIRST LAYERS OF FILTERS THAT SCREEN THE DATA IN REAL TIME FOR EVENTS THAT MATCH THE THEORETICAL PREDICTIONS.
WHAT HAPPENS TO ALL THE OTHER DATA?
WE THROW IT OUT.
BEING A GOOD PHYSICIST IS KNOWING HOW TO APPROXIMATE--
YOU HAVE TO DECIDE WHAT IS IMPORTANT AND WHAT CAN BE IGNORED.
APPARENTLY, THIS IS ALSO TRUE IN THEORY:
WE THROW OUT EQUATION TERMS ALL THE TIME. IN QUANTUM PHYSICS EVERYTHING IS POSSIBLE, BUT NOT EVERYTHING IS LIKELY.
WWW.PHDCOMICS.COM
WWW.PHDCOMICS.COM

detector technologies

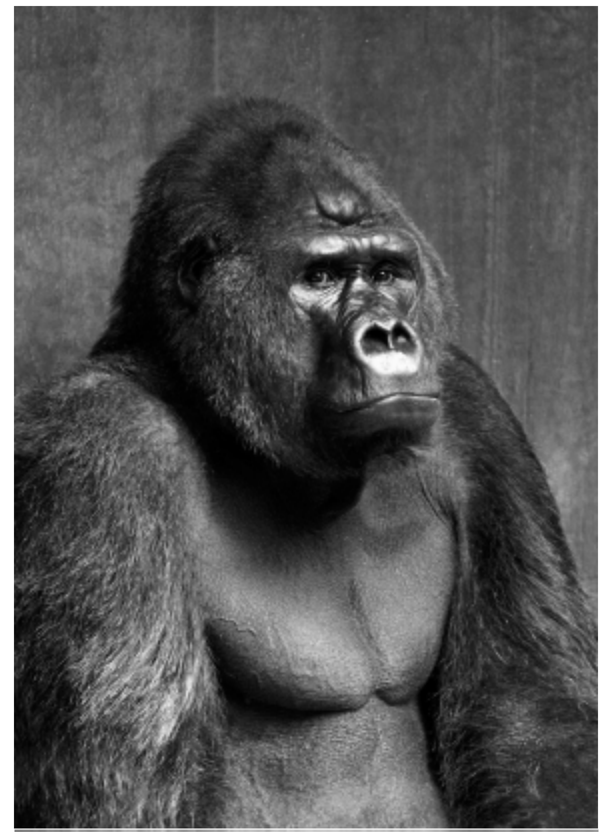
Marzio Nessi

Hitoshi Yamamoto

Giovanni Anelli

any discussion of detector R&D

contends with the immediate & necessary LHC upgrades



Nessi makes an important point about

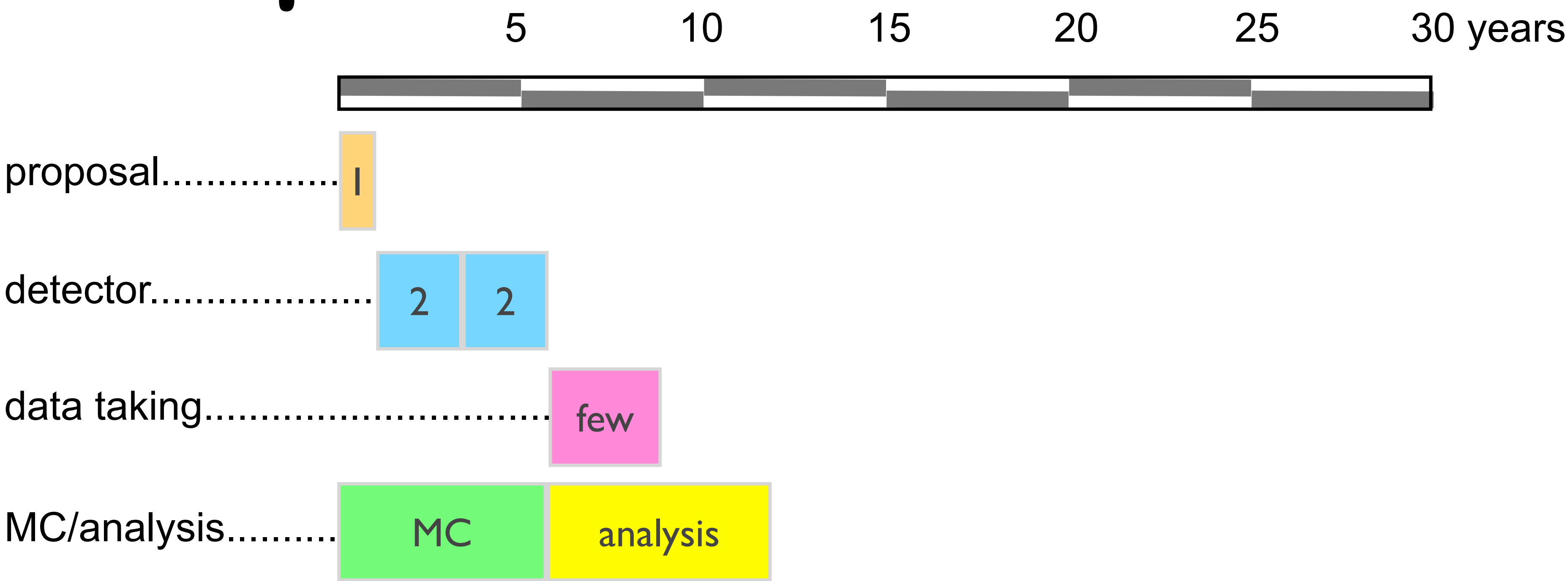
l o n g timescales

by the time of first running...obsolescence is guaranteed

short timescales

during running, fast-track R&D required, especially for tracking upgrades

the past



5
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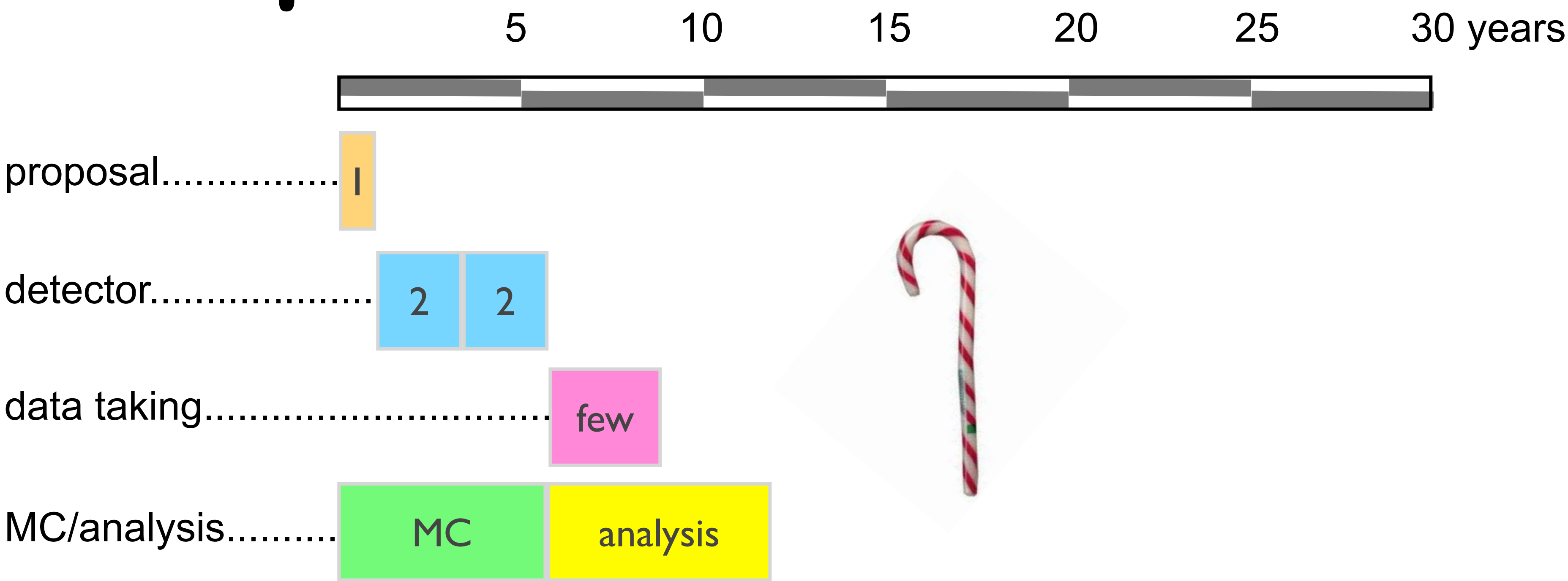
15
20
25
30 years
proposal................
1
detector...................
2
2
data taking............................
few
MC/analysis..........
MC
analysis

the past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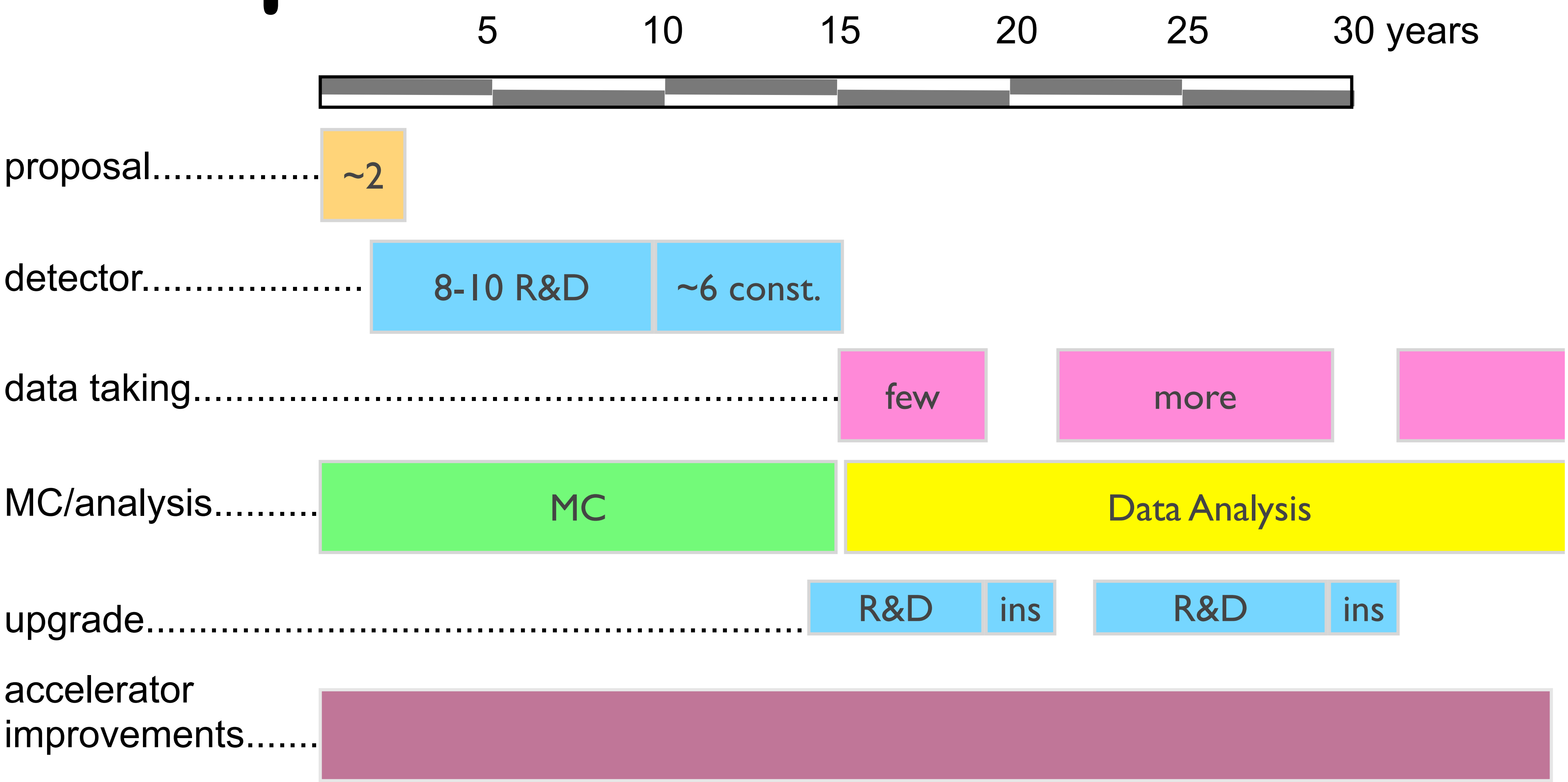
the present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proposal................
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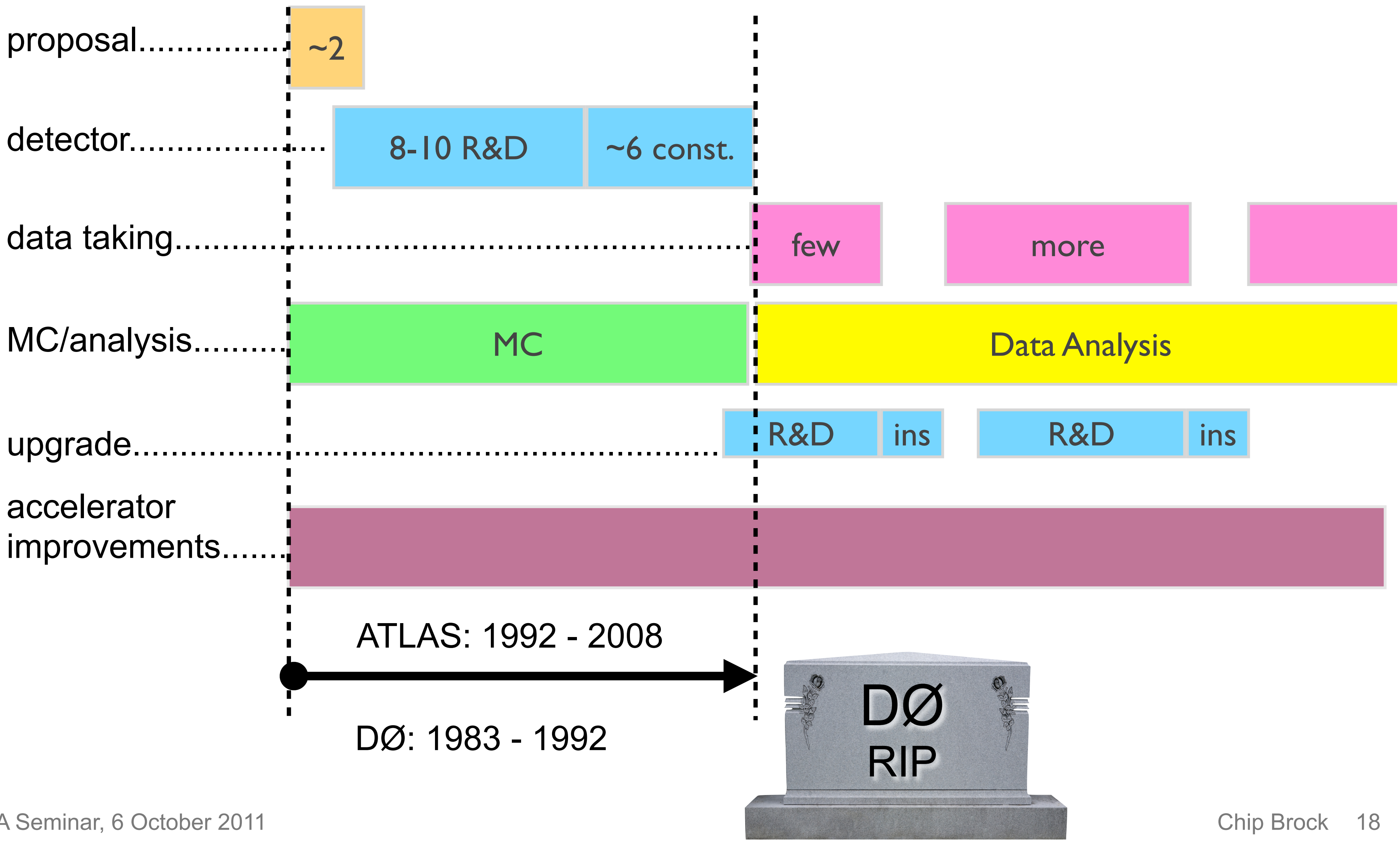
detector....................
8-10 R&D
~6 const.
data taking..
few
more
MC/analysis..........
MC
Data Analysis
upgrade..
R&D
ins
R&D
ins
accelerator
improvements.......

the present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MC
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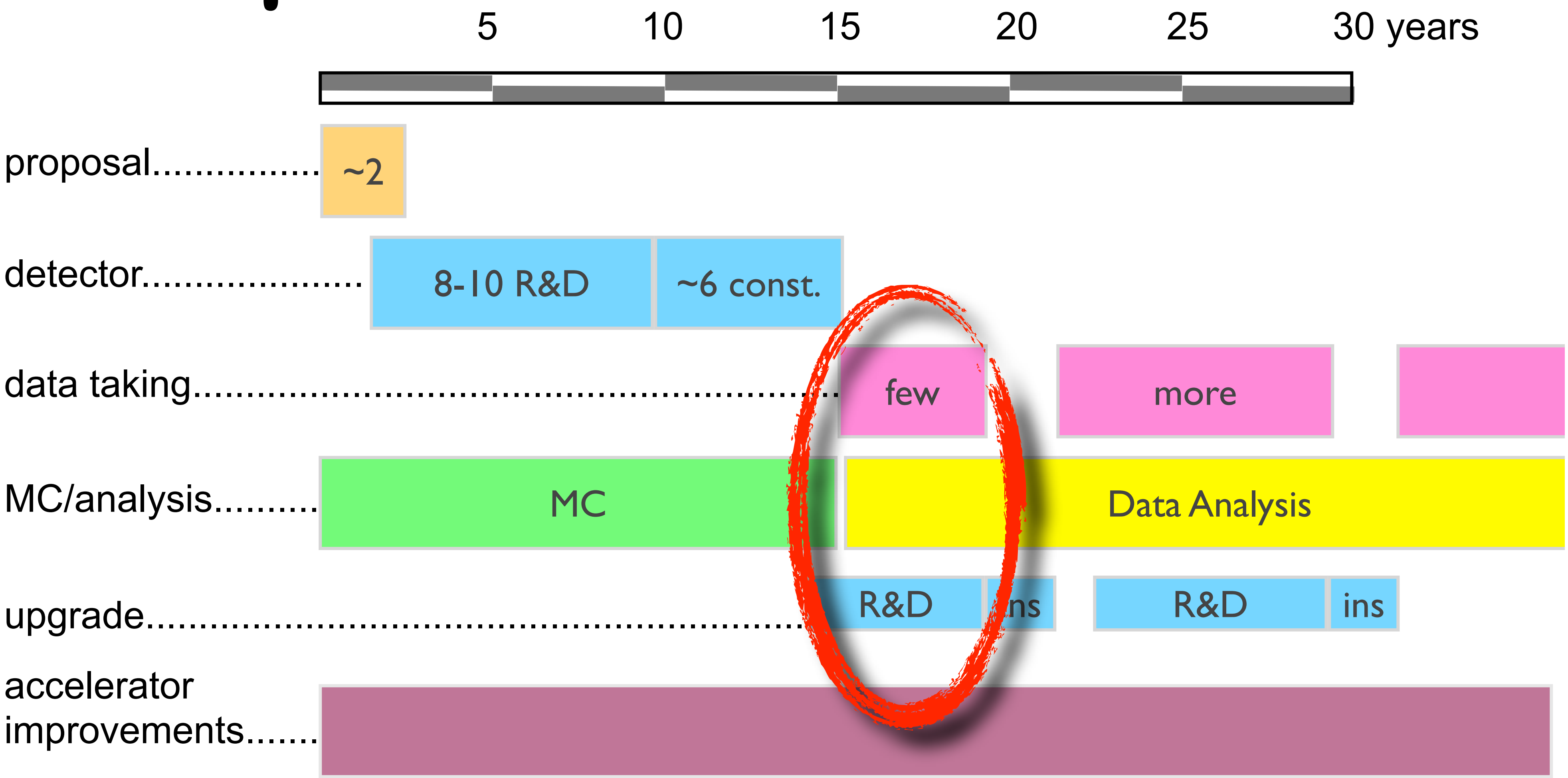
R&D
ins
accelerator improvements
ATLAS: 1992 - 2008
DØ: 1983 - 1992
DØ
RIP

the present



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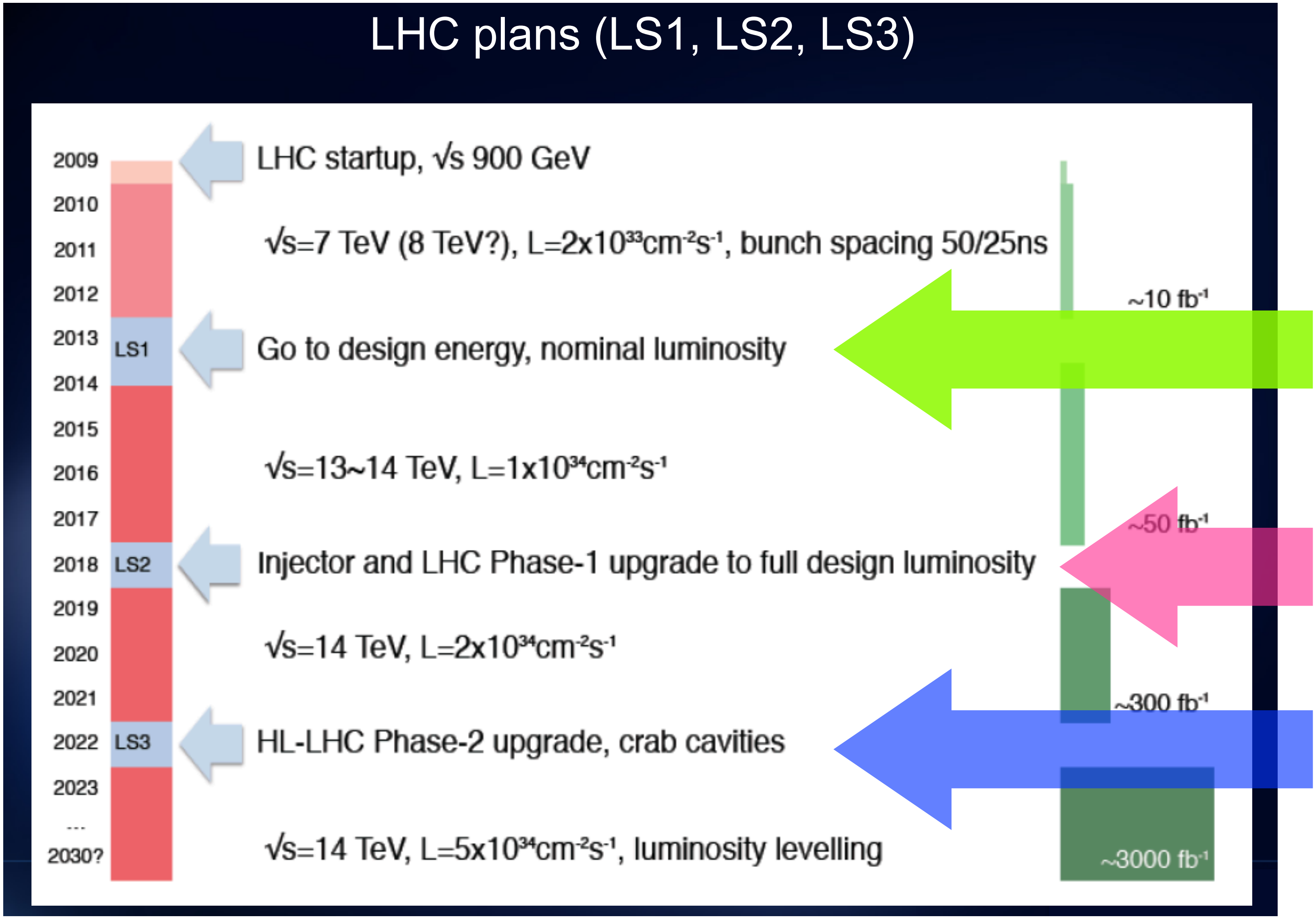
improvements.......

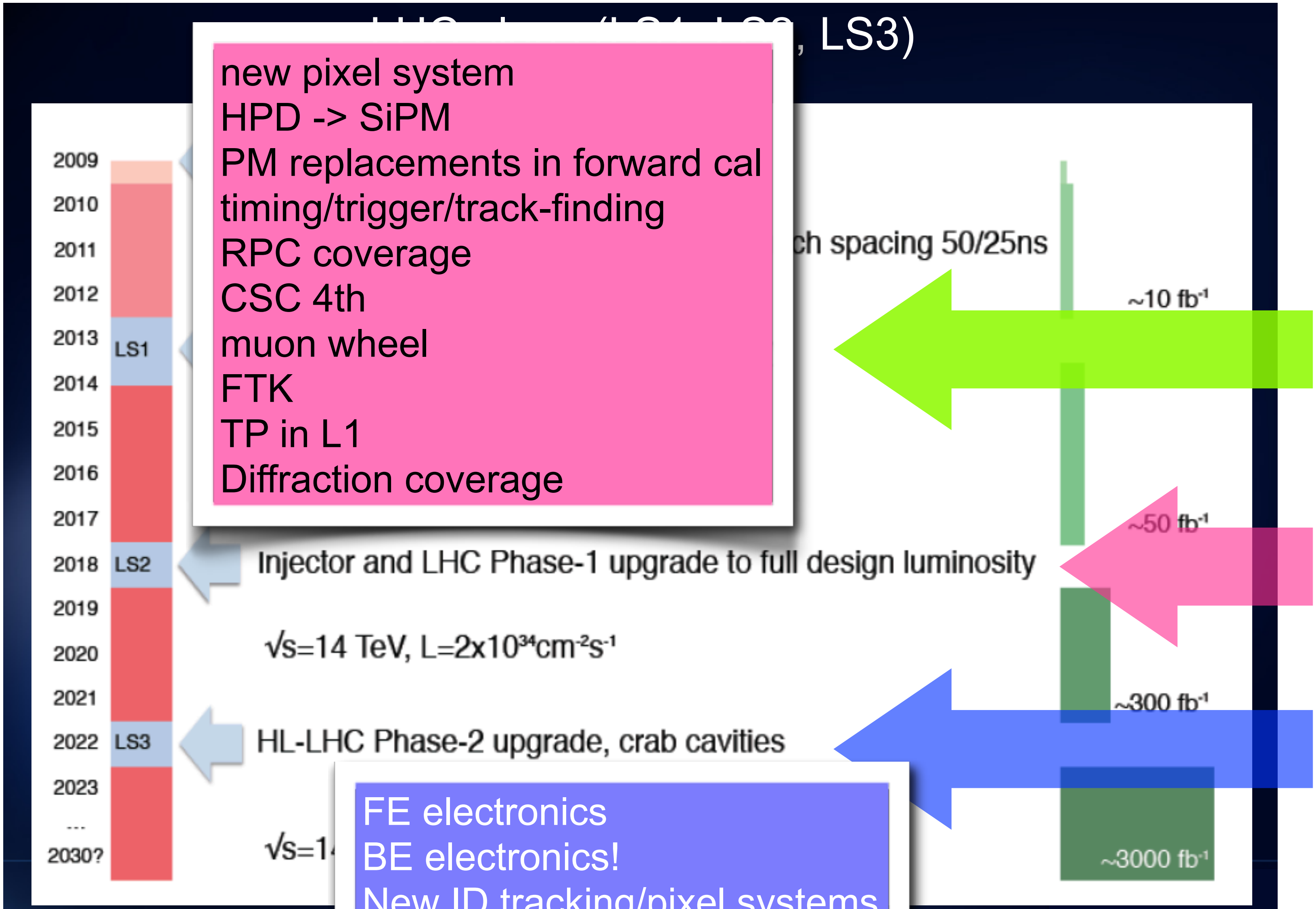


already a big list

already a bigger list

already an enormous list

Marzio Nessi



new pixel system
HPD -> SiPM
PM replacements in forward cal
timing/trigger/track-finding
RPC coverage
CSC 4th
muon wheel
FTK
TP in L1
Diffraction coverage

already a big list

already a bigger list

already an enormous list

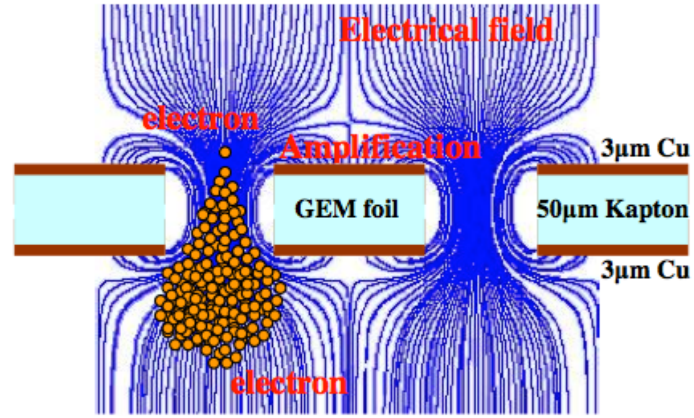
FE electronics
BE electronics!
New ID tracking/pixel systems
radiation/shielding
new track triggering
power-mass-cooling
data volume, RO bandwidth

Marzio Nessi

3 detector technologies

Gaseous Amplifiers

MPGD: GEM, MicroMEGAS

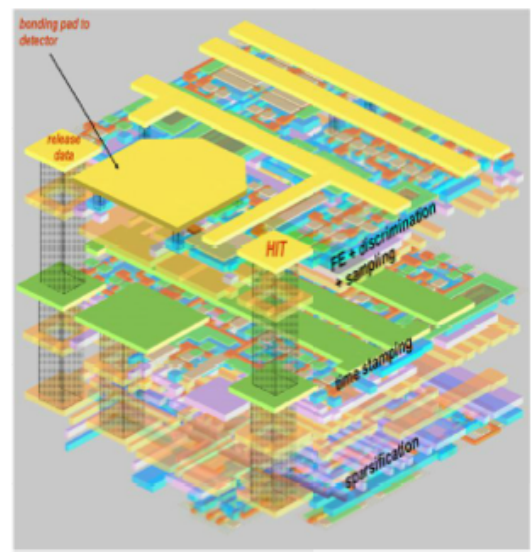


Photon Detectors

PMT, MCP, LAPPD, APD, GPM, microPixel,

Si Pixel Detectors

conventional, deep n-well,

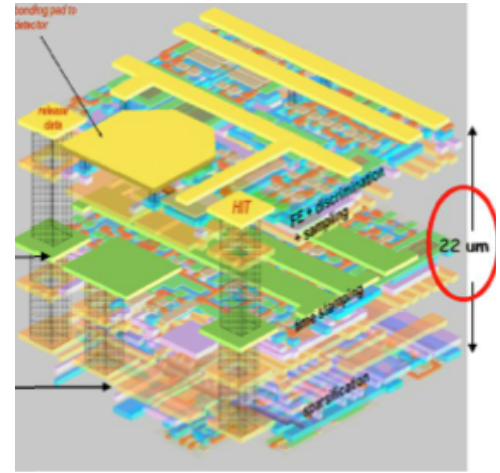


VIP1: demonstrator chip for ILC Vertex detector

Hitoshi Yamamoto

technology transfer

outreach and inreach?



3D IC design - cheating Moore's Law

Fermilab - started small with Tezzaron

now 17 institutions in Multiproject Wafer program

commercialization coming

Significant KEK efforts

medical technologies in particular

先端加速器科学技術推進協議会

AAA

Advanced Accelerator Association Promoting Science & Technolo

Giovanni Anelli

many examples

medical imaging

materials characterization

on the way to something else -

- vacuum techniques

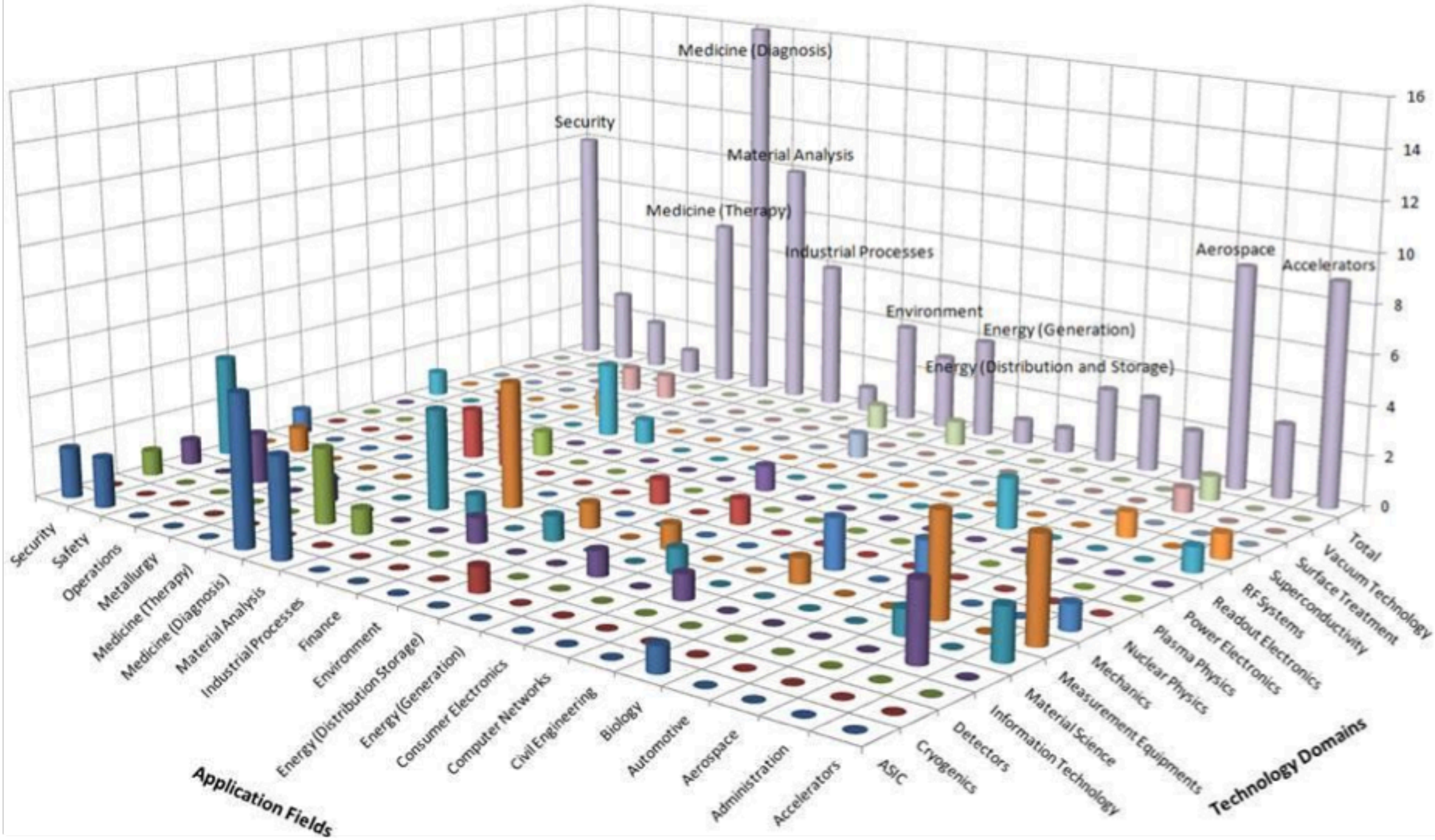
Solar panels?

By the way: WWW?

- we cleaned up on that one!

Giovanni Anelli

Portfolio of CERN Technologies

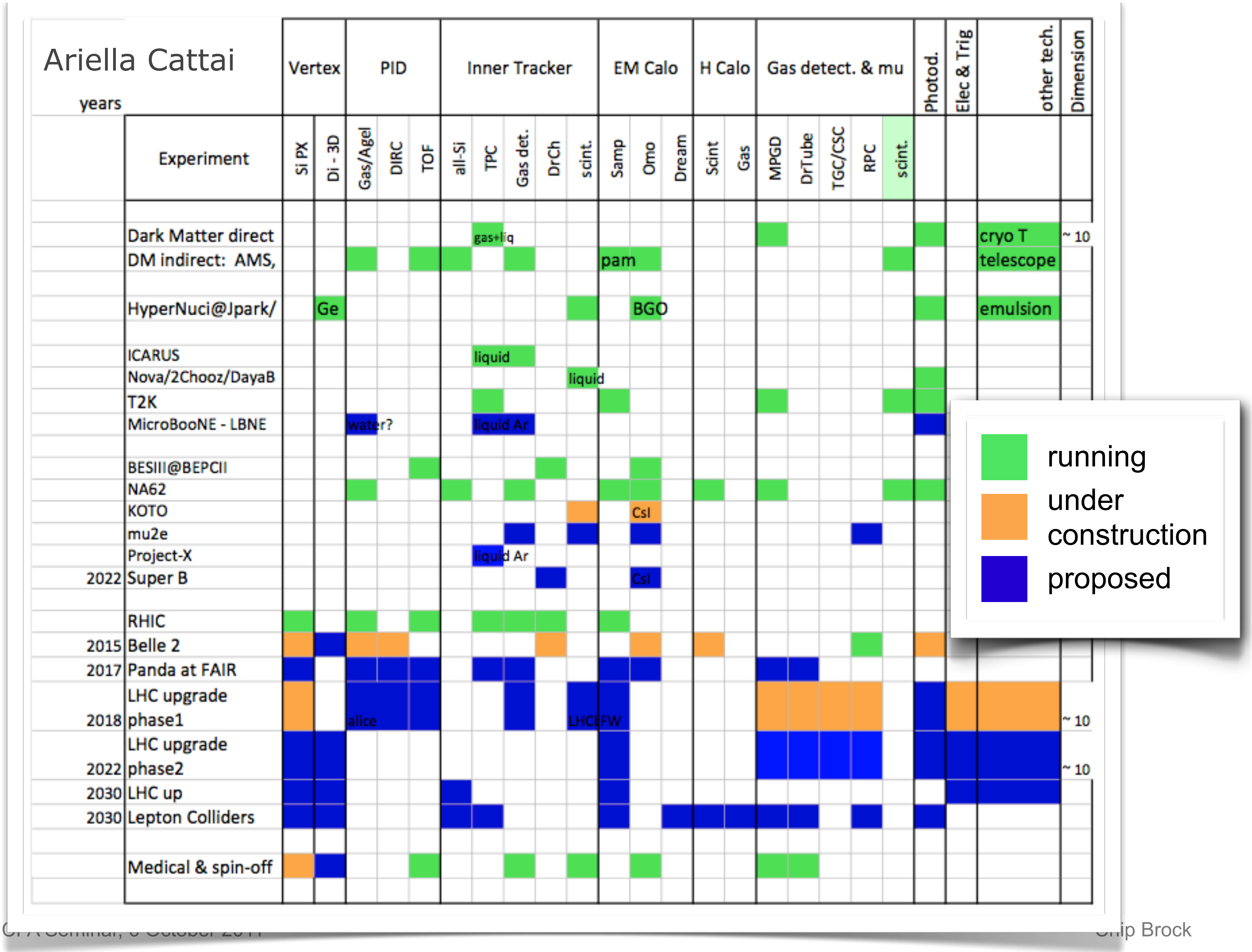


Giovanni Anelli

we have another matrix

just as physics ⟶ facilities

detectors ⟶ physics



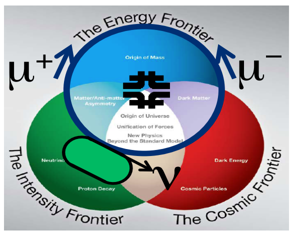
Ariella Cattai
years
Experiment
Vertex
PID
Inner Tracker
EM Calo
H Calo
Gas detect. & mu
Photod.
Elec & Trig
other tech.
Dimension
Si PX
Di - 3D
Gas/Agel
DIRC
TOF
all-Si
TPC
Gas det.
DrCh
scint.
Samp
Omo
Dream
Scint
Gas
MPGD
DrTube
TGC/CSC
RPC
scint.
Dark Matter direct
DM indirect: AMS,
HyperNuci@Jpark/
ICARUS
Nova/2Chooz/DayaB
T2K
MicroBooNE - LBNE
BESIII@BEPCII
NA62
KOTO
mu2e
Project-X
2022 Super B
RHIC
2015 Belle 2
2017 Panda at FAIR
LHC upgrade
2018 phase1
LHC upgrade
2022 phase2
2030 LHC up
2030 Lepton Colliders
Medical & spin-off
gas+liq
cryo T
~ 10
pam
telescope
Ge
BGO
emulsion
liquid
liquid
water?
liquid Ar
CsI
liquid Ar
CsI
alice
LHCbFW
~ 10
~ 10
running
under construction
proposed

facility technologies

Stuart Henderson

MUON COLLIDER
R&D

Steve Geer
Accelerator Physics Center
Fermi National Accelerator Laboratory
(presented by Stuart Henderson)



Muon Accelerator Program - MAP

ICFA Seminar on
Future Perspectives in High Energy Physics
CERN, 3-6 October, 2011

Toshiki Tajima

ICFA Seminars
CERN
Geneva
Wednesday, Oct. 5, 2011

Plasma Acceleration

Toshiki Tajima
LMU and MPQ, Garching, Germany

Acknowledgments for Collaboration and advice: G. Mourou, W. Leemans, K. Nakajima, K. Homma, D. Habs, C.. Barty, P. Chomaz, D. Payne, H. Videau, P. Martin, V. Malka, F. Krausz, T. Esirkepov, S. Bulanov, M. Kando, W. Sandner, A. Suzuki, M. Teshima,, J. Chambaret, E. Esarey, R. Assmann, R. Heuer, A. Caldwell, S. Karsch, F. Gruener, M. Zepf, M. Somekh, E. Desurvire, D. Normand, J. Nilsson, W. Chou, F. Takasaki, M. Nozaki, K. Yokoya D. Payne, S. Chattopadhyay, , A. Chao, P. Bolton, E. Esarey, M. Downer, C. Schroeder, C. Joshi, P. Muggli, J.P. Koutchouk, K. Ueda, Y. Kato, E. Goulielmakis, X. Q. Yan, J. E. Chen, R. Li, J. Rossbach, A. Ringwald, E. Elsen, H. Ruhl, T. Ostermayr, S. Petrovic, C. Klier, B. Altschul, Y. K. Kim, M. Spiro, L. Cifarelli

Linear Colliders (LC)

Outline:
- Why linear ?
- Physics at a LC (brief)
- ILC and CLIC – technology developments, commonality and differences
- Detectors at a LC (very brief)
- A global LC effort
- Main points

Steinar Stapnes

Sakue Yamada

Governance

Sakue Yamada (KEK)
ICFA Seminar, @CERN
October 5, 2011

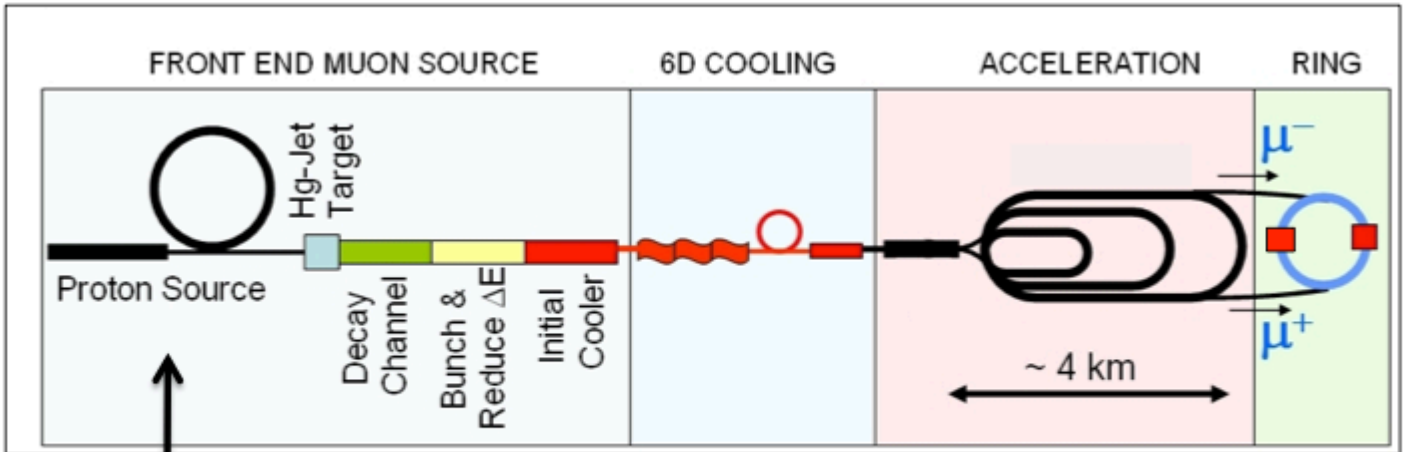
amazing accelerators

Our field works because of repeating, accelerator engineering miracles

tevatron, LEP, LHC, B/C-factories, neutrino facilities

ambitious technologies

Muon Collider Schematic



Proton source: Example: upgraded PROJECT X (4 MW, 2±1 ns long bunches)

10^{21} muons per year that fit within the acceptance of an accelerator:

$e_{\perp N}$=6000 μm

$e_{//N}$=25 mm

$\sqrt{s}$ = 3 TeV

Circumference = 4.5km

$L = 3\times10^{34}$ cm^{-2}s^{-1} μ/bunch = 2×10^{12}

$\delta p/p$ = 0.1%

$e_{\perp N}$ = 25 μm, $e_{//N}$=70 mm

β^* = 5mm

Rep Rate = 12Hz

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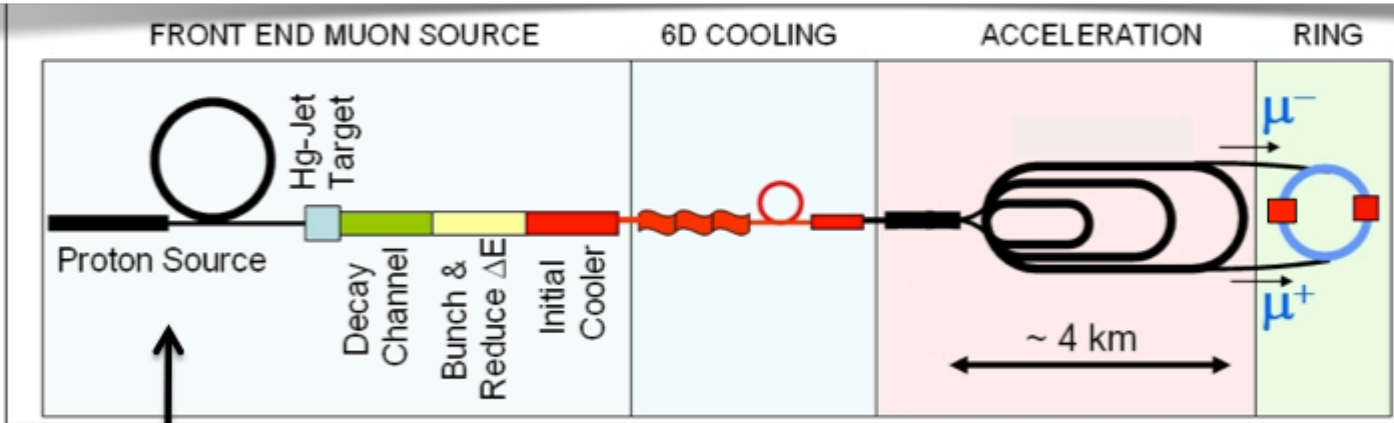
A Muon Collider Has Many Challenging Ingredients



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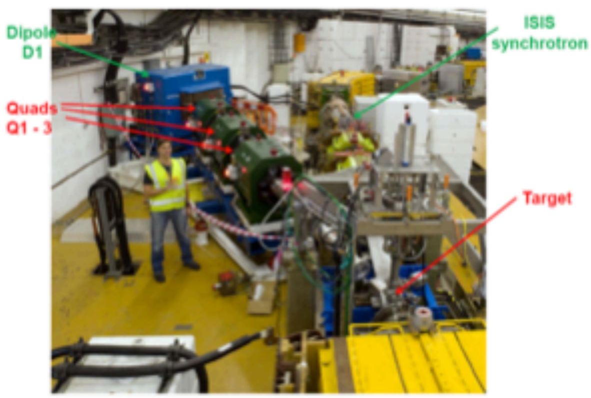
A Decade of Progress:
Muon Ionization Cooling Experiment (MICE)

- Multi-stage experiment at RAL

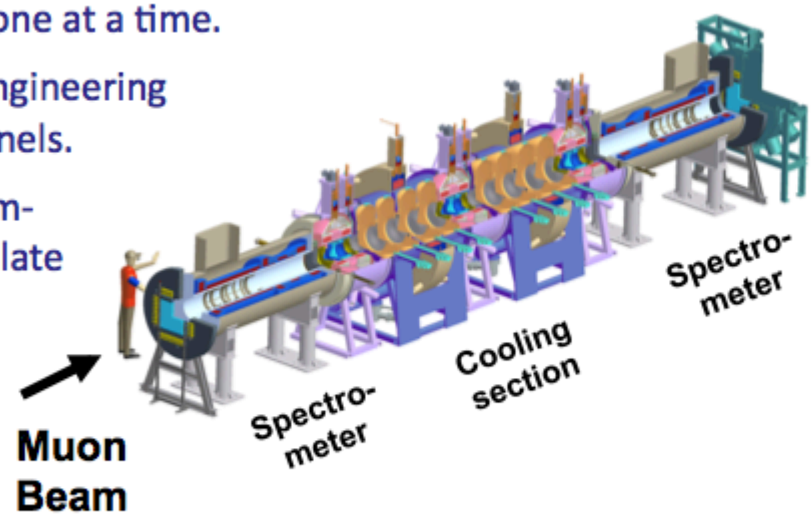
  - Tests short cooling section, in muon beam, measuring the muons before & after the cooling section. one at a time.

  - Learn about cost, complexity, & engineering issues associated with cooling channels.

  -Vary RF, solenoid & absorber param-eters & demonstrate ability to simulate response of muons



MICE – upstream beamline



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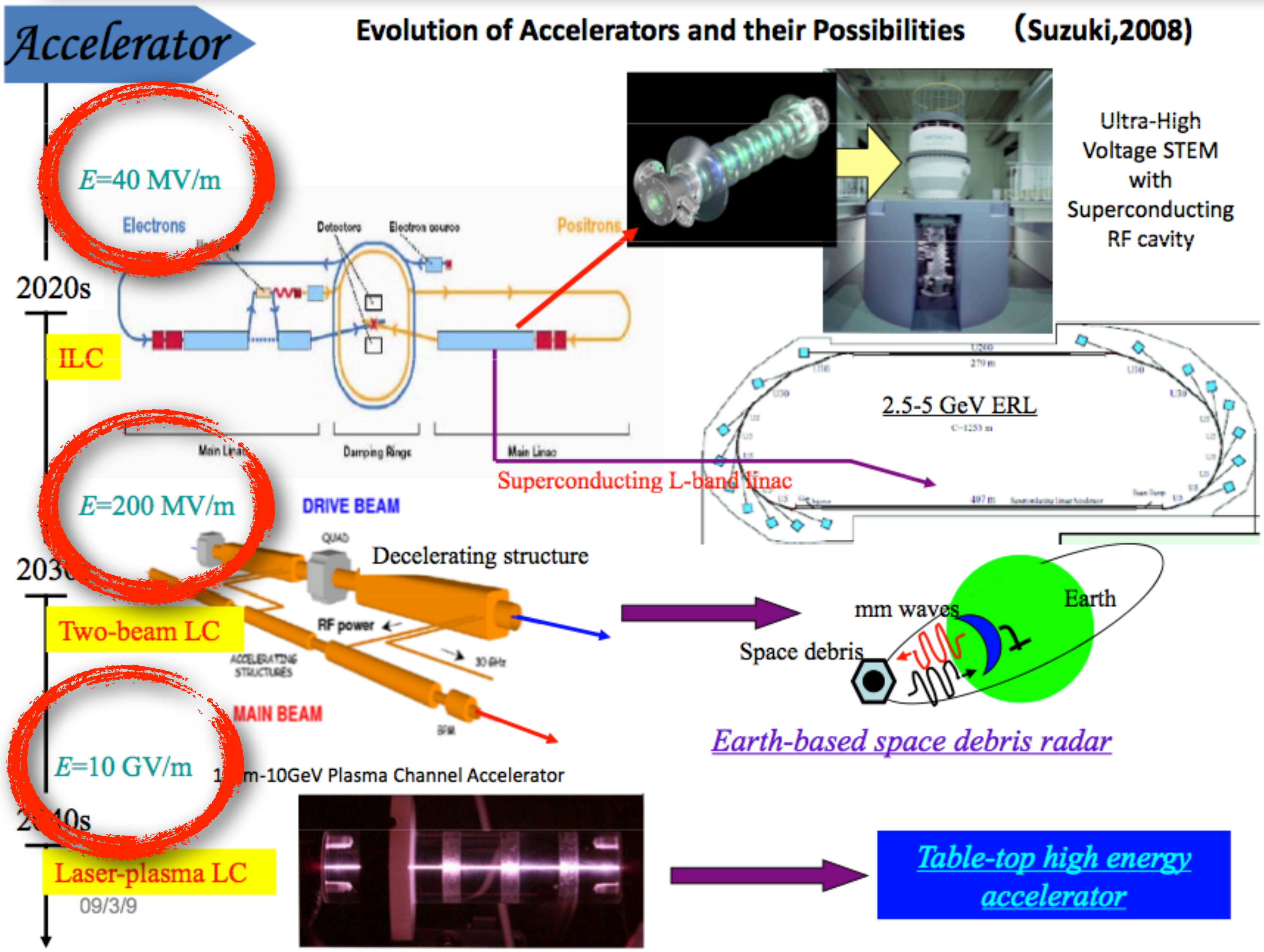
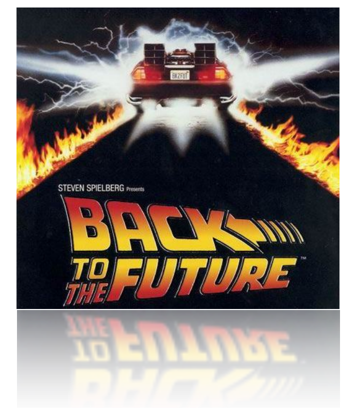
PeV?



we are here

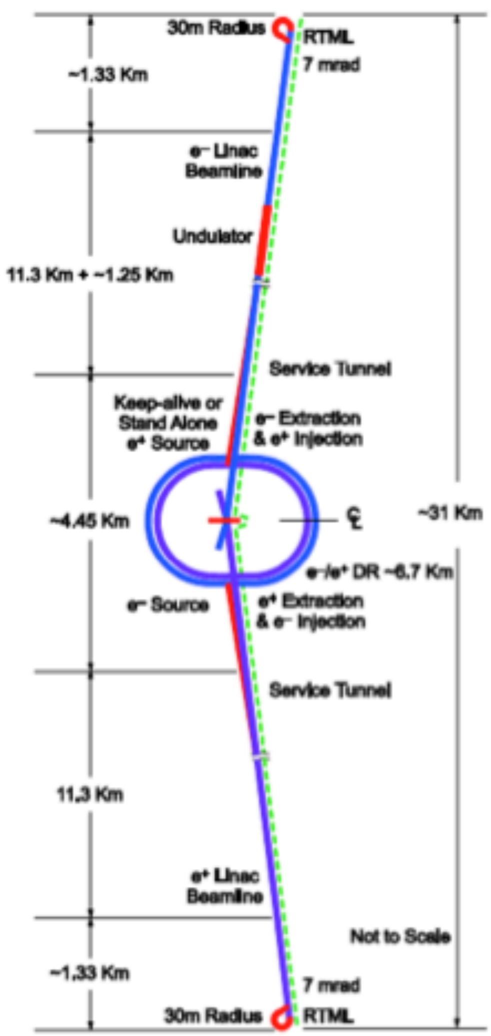


Toshiki Tajima

more mature technologies

ILC maturity is in time for 2012 GDE completion

RDR



SB2009

- **Single Tunnel for main linac**
- **Move positron source to end of linac**
- **Reduce number of bunches factor of two (lower power)**
- **Reduce size of damping rings (3.2km)**
- **Integrate central region**
- **Single stage bunch compressor**

26-Sept-11
LCWS - Granada

Global Design Effort

Steinar Stapnes

10

Main parameters

		500GeV Reference no TF	TF
Ecm	GeV	500	500
gamma		4.89E+05	4.89E+05
N	e10	2.0	2.0
frep	Hz	5.0	5.0
Nb		1312	1312
PB	MW	10.5	10.5
sigz	mm	0.3	0.3
enx	m	1.0E-05	1.0E-05
eny	m	3.5E-08	3.5E-08
betax	mm	11.00	11.00
betay	mm	0.48	0.20
sigx	nm	474.2	474.2
sigy	nm	5.9	3.8
theta_x	ur	43.1	43.1
theta_y	ur	12.2	18.9
Dx		0.3	0.3
Dy		24.6	38.2
Upsilon		0.1	0.1
Ngamma		1.7	1.7
deltaB		4%	4%
HDx		1.1	1.1
HDy		6.1	2.8
HDy		2.0	1.5
Δp/p e+	%	0.087	0.087
Δp/p e-	%	0.22	0.22
P e+	%	22	22
P e-	%	80	80
L			
Lgeo		7.51E+33	1.16E+34
L (formula)		**1.47E+34**	**1.75E+34**
Simulation (noTF)			
Ngamma			
deltaB(%)		4.30	
L		1.49E+34	
L(1%)		62.5	
Simulation (TF)			
Ngamma			
deltaB(%)			4.33
L			2.05E+34
L(1%)			60.8
L(TR)/L(no)			

parameter	symbol		
centre of mass energy	E_{cm} [GeV]	500	3000
luminosity	$\mathcal{L}$ [10^{34} cm^{-2}s^{-1}]	2.3	5.9
luminosity in peak	$\mathcal{L}_{0.01}$ [10^{34} cm^{-2}s^{-1}]	1.4	2
gradient	G [MV/m]	80	100
site length	[km]	13	48.3
charge per bunch	N [10^9]	6.8	3.72
bunch length	σ_z [μm]	70	44
IP beam size	σ_x/σ_y [nm]	200/2.26	40/1
norm. emittance	ϵ_x/ϵ_y [nm]	2400/25	660/20
bunches per pulse	n_b	354	312
distance between bunches	Δ_b [ns]	0.5	0.5
repetition rate	f_r [Hz]	50	50
est. power cons.	P_{wall} [MW]	240	560

1-2 TeV interm. parameter sets exists for CLIC – using 3 TeV performance parameters

Other key ILC parameters, 31 km, 31.5 MV/m gradient, distance between bunches ?? ns, power 215 MW (RDR value)

1 TeV parameter set(s) being developed for ILC:

- Power < 300MW AC
- New linac grad = 45 MV/m
- Improved $Q_0 = 2\ 10^{10}$

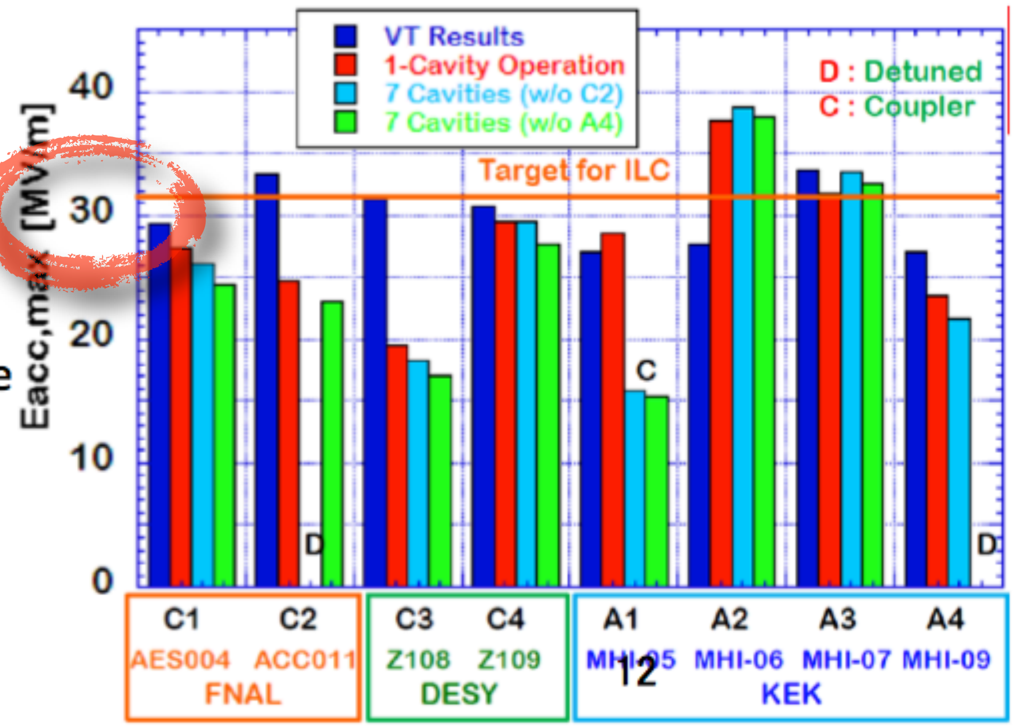
Steinar Stapnes

S1Global

- 8 cavities in 2 cryostat from over the world tested at KEK
- Goal
  - 31.5MV/m, stability DV/V<0.07%, Df<0.24deg)
  - Plug-compatibility
  - Various tests (heat load, LFD, etc)

- Achieved gradient (VT: 30MV/m)
  27MV/m (1cav), 26MV/m (7cav)
- Successfully finished before the 3.11 earthquake
- Summary Report writing in progress

2011/9/30 LCWS11 K.Yokoya

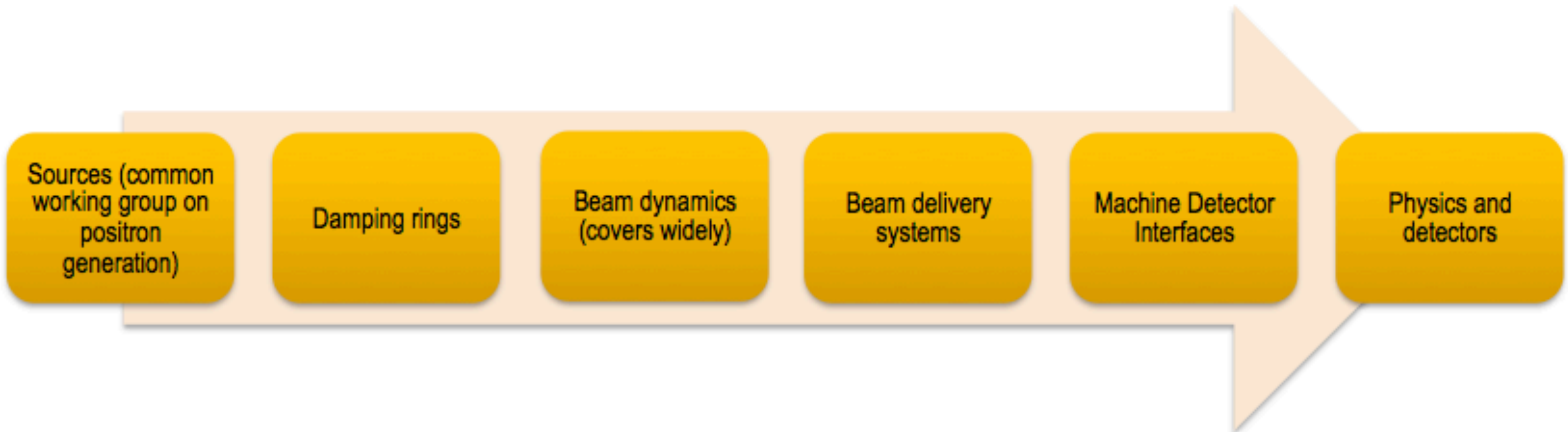


12

Steinar Stapnes

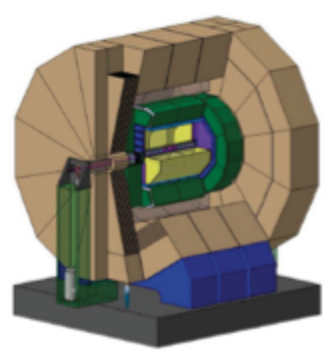
synergy

Many common problems and solutions even though the basic core acceleration methods differ, and the parameters to be achieved by the systems below differ – in some cases leading to different solutions



In addition common working groups on: Cost and Schedule, Civil Engineering and Conventional Facilities – and a General Issues Working Group

- In general the detectors are very highly granular solenoid based detectors, with very powerful inner trackers and calorimeters optimized for energy flow measurements
- The requirements for granularity, material, power, time-resolution are very challenging



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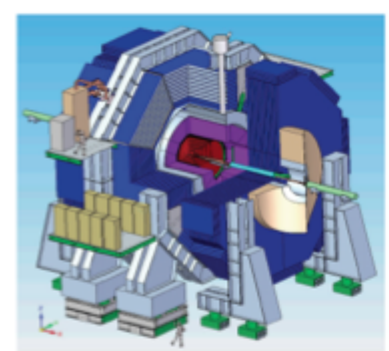


SiD

Main messages

- Physics potential of a LC formidable - but LHC results and guidance very much needed
- Technical progress good with the ILC technologies and tests-setups maturing, and CLIC technologies moving from feasibility studies towards implementation studies and optimizations
- Increased focus on energy flexibility and staged implementation
- Common work in a large number of areas and also common use of facilities – common working groups and workshops (for both accelerators, detector/physics and site studies)
    - Moving towards a common LC organisation post 2012
- CDRs for CLIC underway, and ILC TDRs by end 2012

Steinar Stapnes

governance

Sakue Yamada

Anticipating the phase-out of the ILC GDE

Why Governance ?

Consensus:

- The next HEP accelerator to be built is an e+e- Linear Collider, which can study the new findings of LHC/Tevatron.
- ***This LC will be built under the world wide cooperation.***

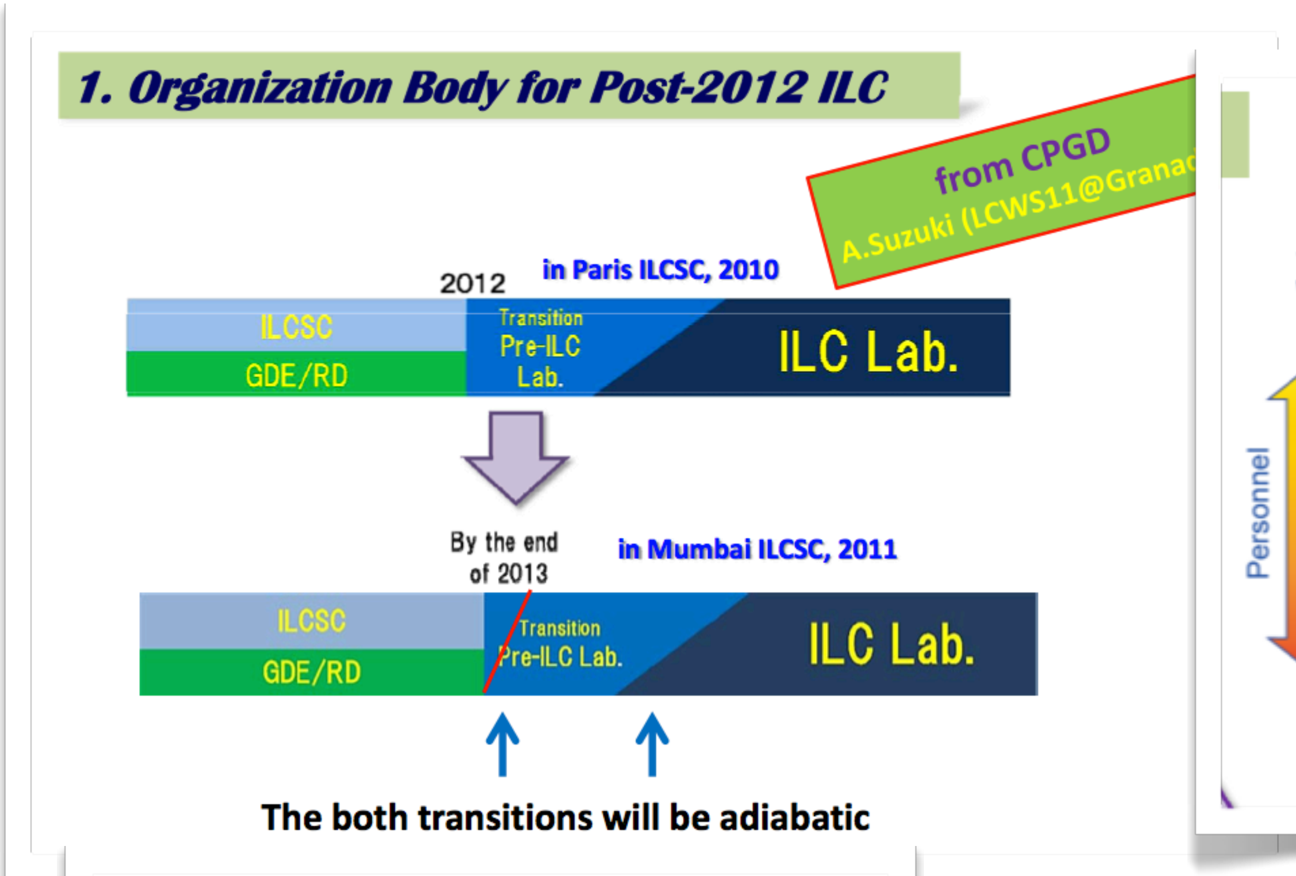
When realized,

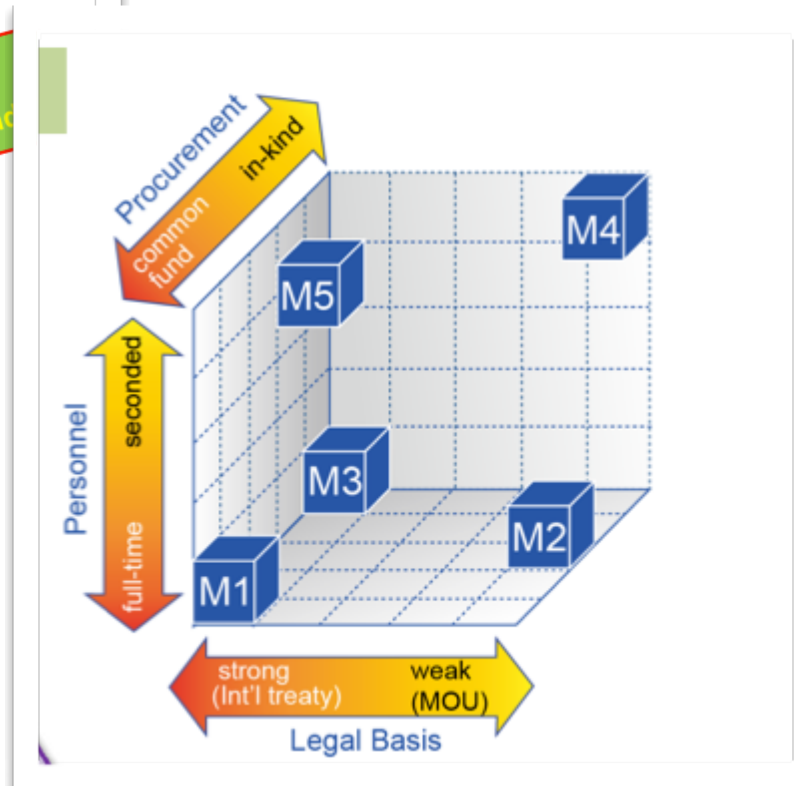
it will be the first case for a HEP facility.

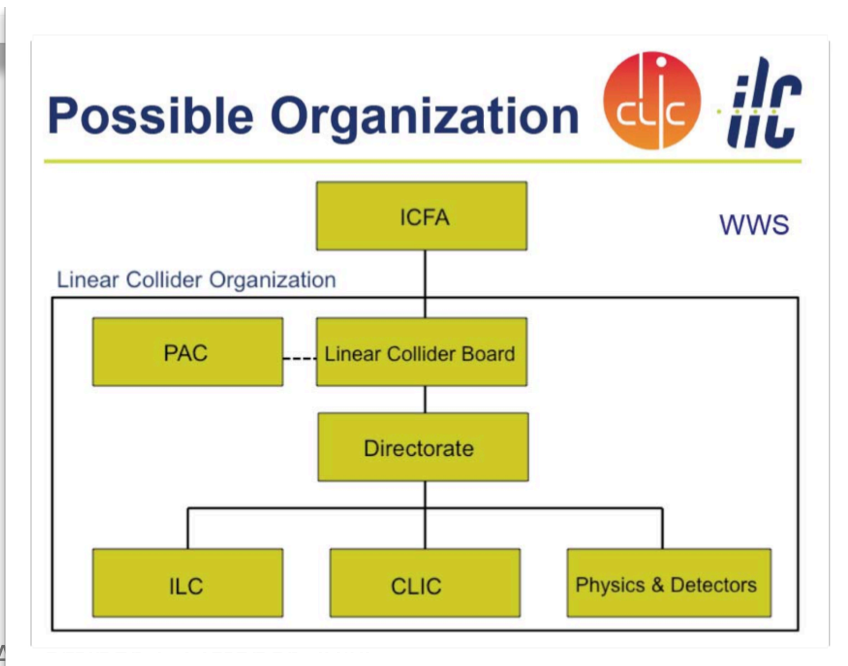
Governance for the facility is an important issue to be studied in parallel with the scientific/technological R&D studies.

Sakue Yamada

Preparation for a true world-laboratory...astonishing.





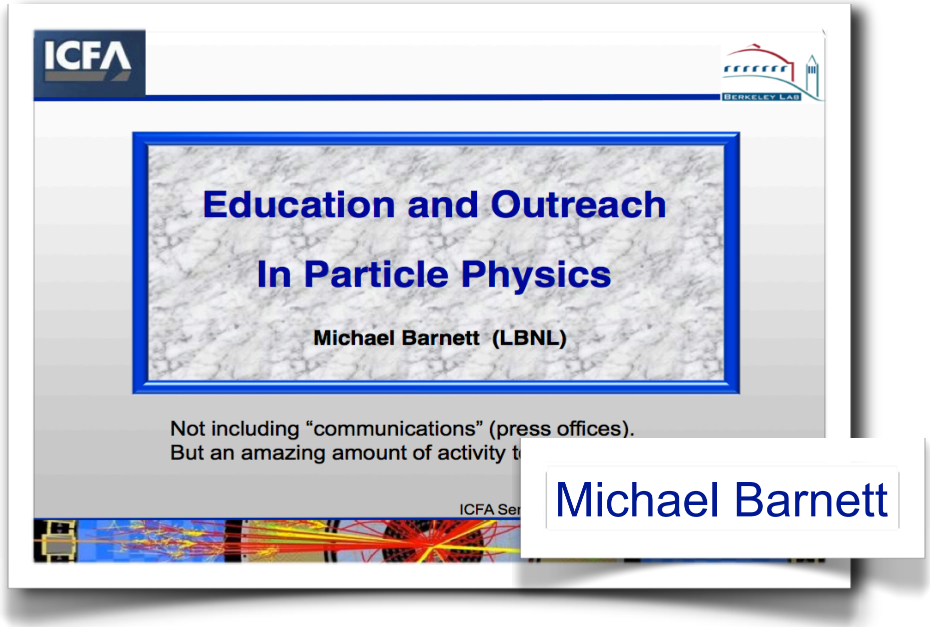


Many issues!

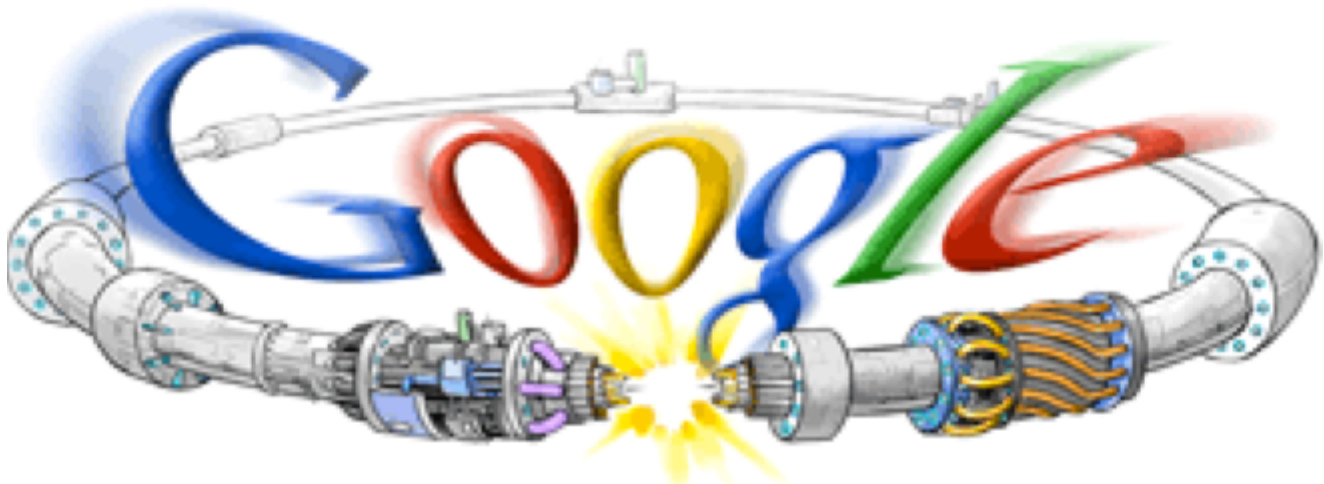
Impressively systematic trajectory

Sakue Yamada

cultural technologies



what more do you have to say?

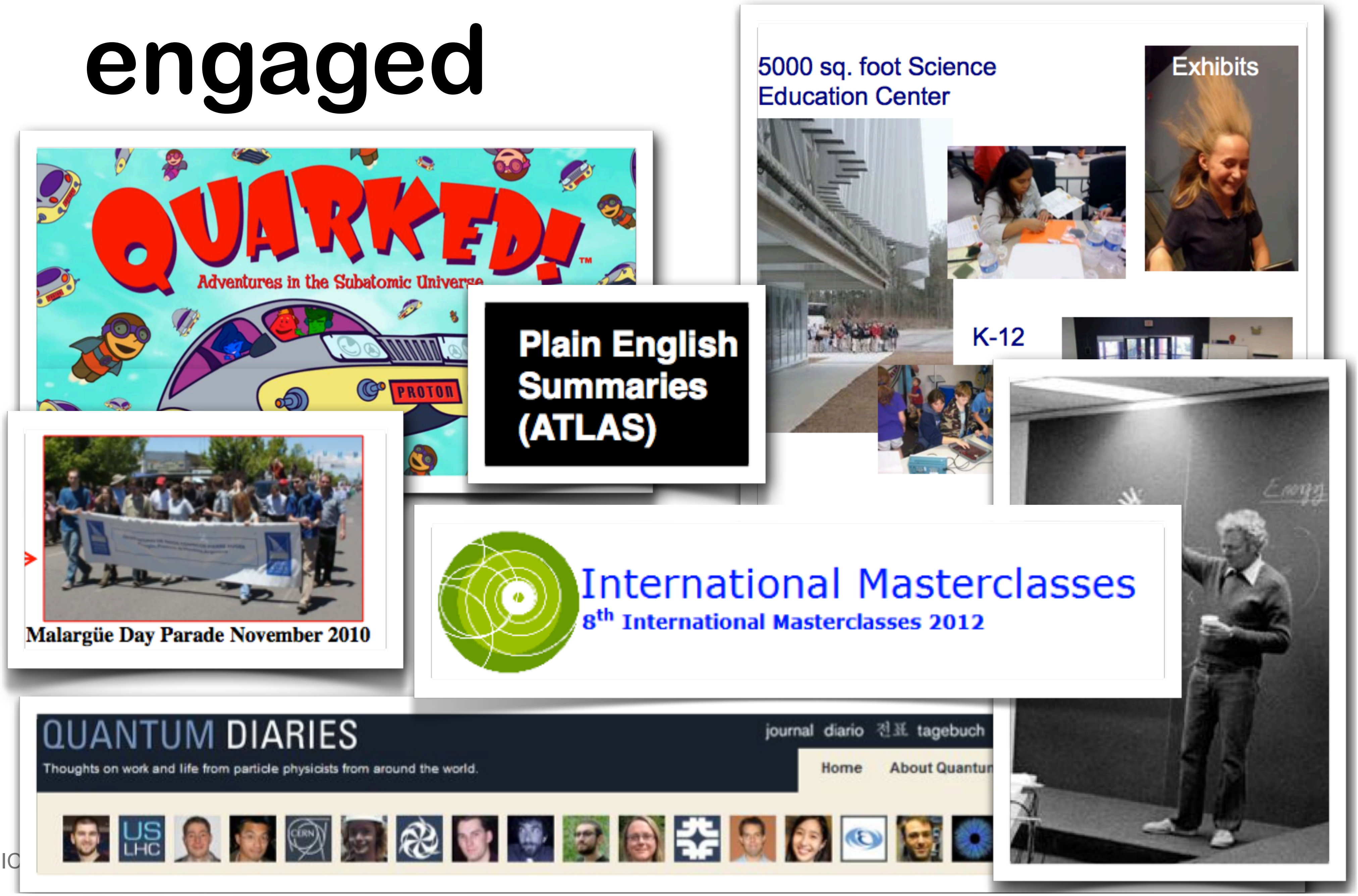


outreach

The Large Hadron Collider

The LHC - and hence, HEP - has become a brand.

HEP scientists are engaged



HEP has become a collection of the largest volunteer efforts ever.

Large Collaborations

- **CDF: start year 1979, ~500 scientists, 15 countries**
- **DØ: start year 1983, ~500 scientists, 20 countries**
- **BaBar: start year 1993, ~400 scientists, 12 countries**
- **Belle: start year 1993, ~400 scientists, 15 countries**
- **LHCb: start year 1998, ~600 scientists, ~12 countries**
- **ATLAS: start year 1992, ~3000 scientists, 38 countries**
- **CMS: start year 1992, ~3000 scientists, 40 countries**

- **Number of groups involved**
  - **~50 at B factories**
  - **~100 at the Tevatron**
  - **~200 at the LHC**

- **Time between start of the collaboration and data taking**
  - **~6 years for B factories**
  - **~8 years for the Tevatron**
  - **~15 years for the LHC**
- **Data taking period length is correlated with construction time**

"Physicists Without Borders"

Dmitri Denisov

I didn't know that!

Alternatives to Large Collaborations?

- **Many small experiments**
  - Expensive infrastructure, especially for colliders
  - 4π geometry requires large detectors
  - Multipurpose detectors are flexible to adjust to new/unexpected changes in physics priorities
- **"Telescope use model"** – professionals build/support the detector, small groups come for short periods to perform experiments/analyze data
  - Detectors are complex/unique, require experts to run
  - Detectors construction teams are motivated by physics to be done later
  - Reconstruction/analysis require deep understanding of the detectors
  - Short runs are usually not useful as best results are obtained on full data sets due to statistical limitations
- **Professional teams** of scientists employed by the host laboratory
  - Expensive even for large laboratories
  - No students/postdocs
  - No access to international resources

- **In all cases over last ~40 years large international collaborations are the best option to obtain best physics results**

Dmitri Denisov

Some Challenges of the Large Collaborations

- **Long construction/operation time**
  - No wide experience in different areas by young scientists
  - Physics priorities might change making design not optimal
- **Complexity**
  - Promotes specialization in narrow areas
  - Few see "overall picture"
- **Management overhead**
  - Stability of collaboration organization/rules minimizes impact
- **Limited number of talks at major conferences**
  - CDF/DØ each get ~200 talks per year or 1 talk per 2 years per collaborator
  - As number of talks at major conferences is about constant above rate means ~1 talk per collaborator in 10 years for ATLAS/CMS
  - More meetings with parallel/poster sessions and/or specialized conferences will be useful

Plus: authorship is always difficult

Dmitri Denisov


Be provocative.

themes:

detector and accelerator R&D

test beams

the world!

decades!

themes:

detector and accelerator R&D

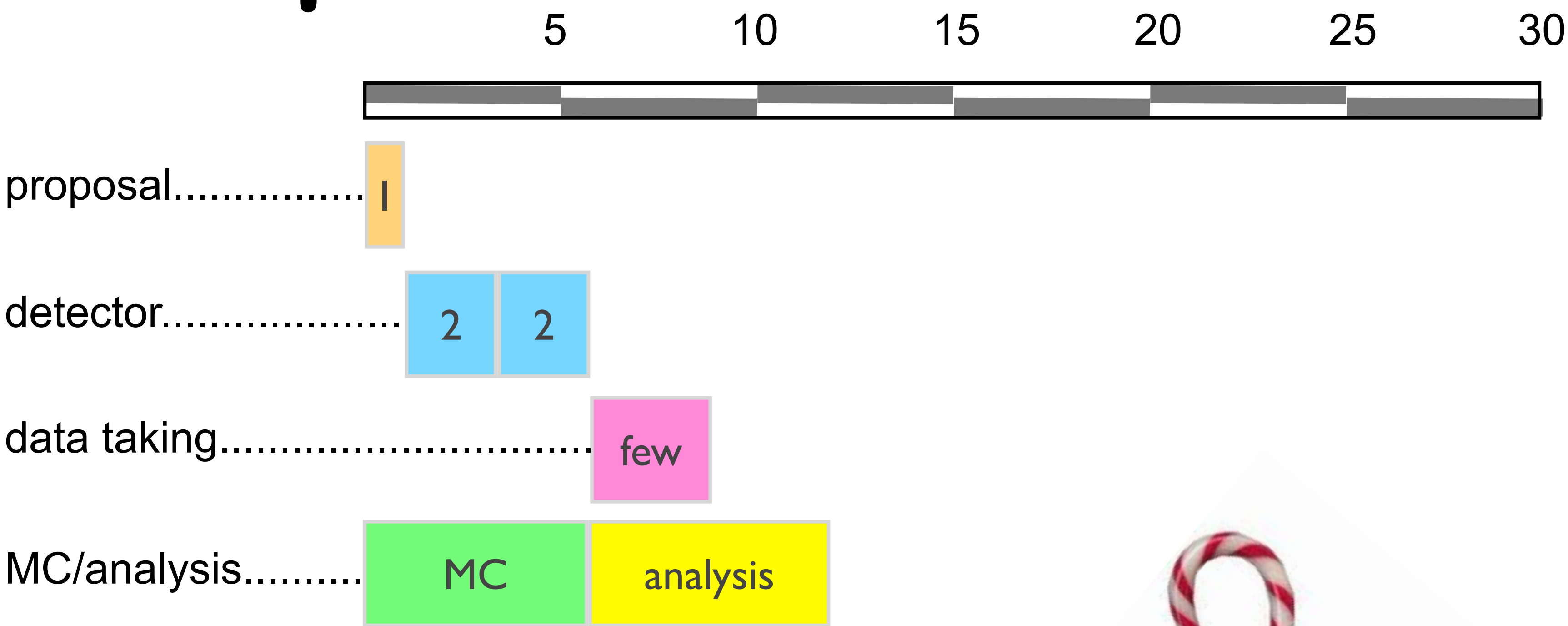
test beams

the world!

decades!

How is she going to know how to do this stuff?

the past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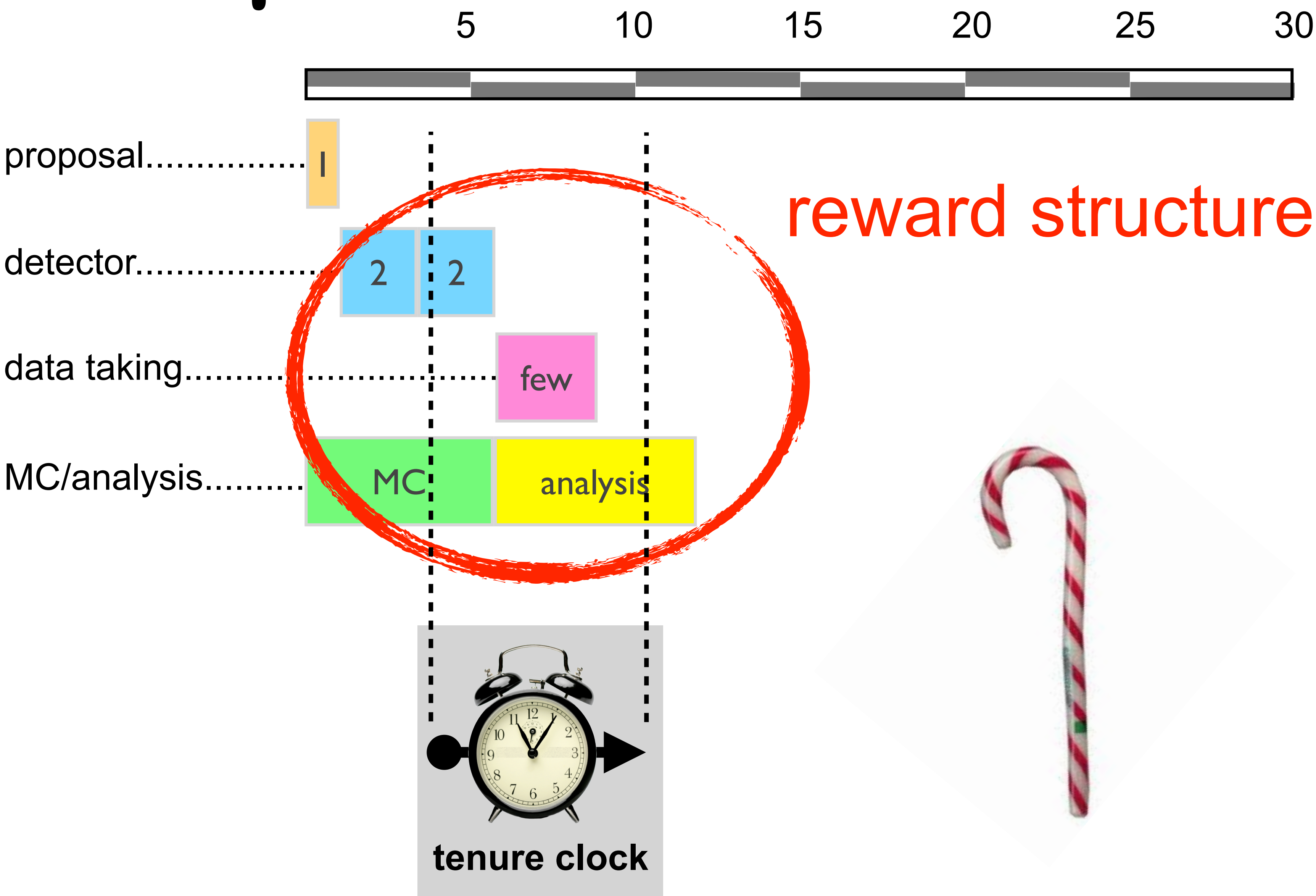
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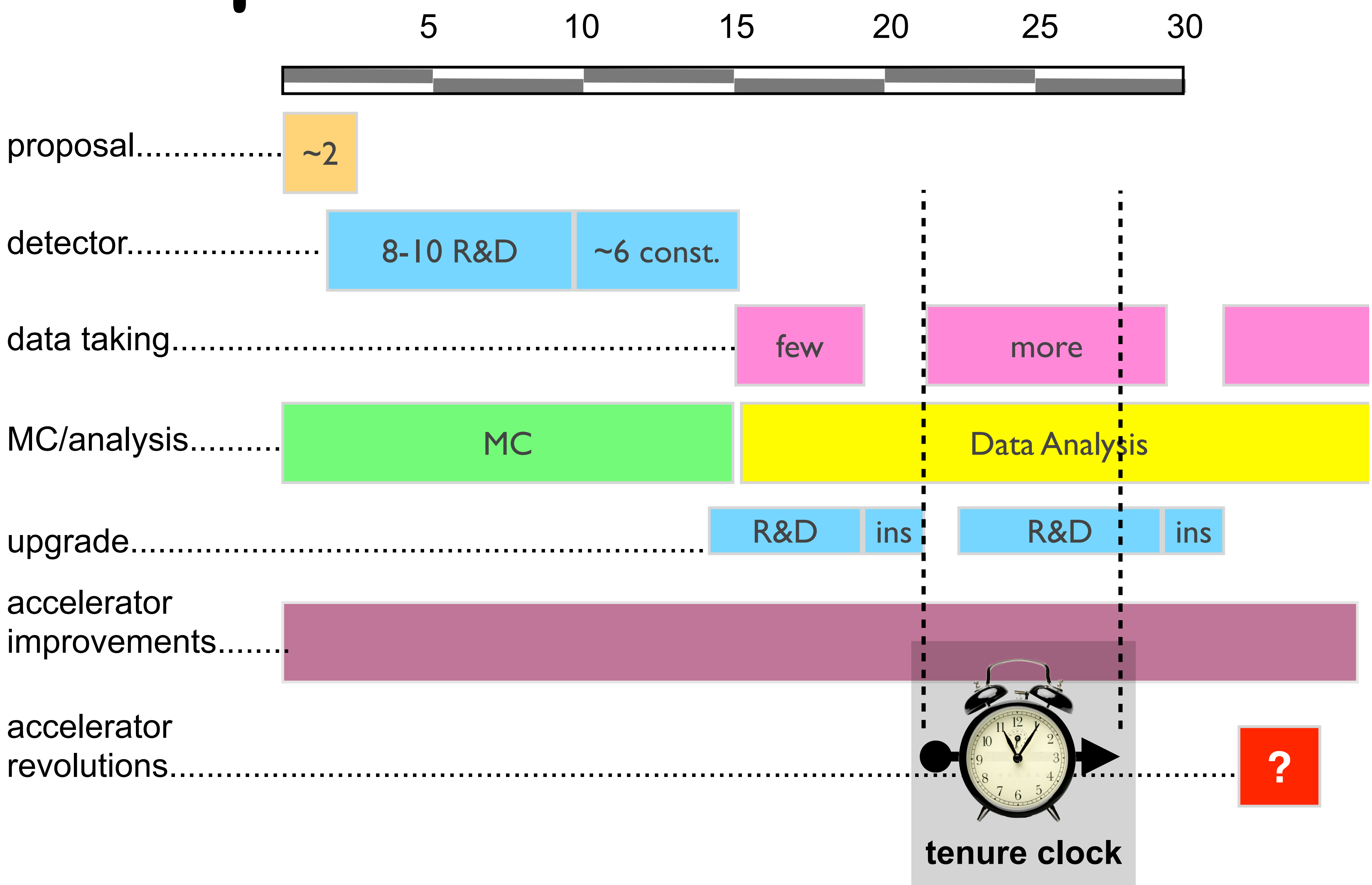
the present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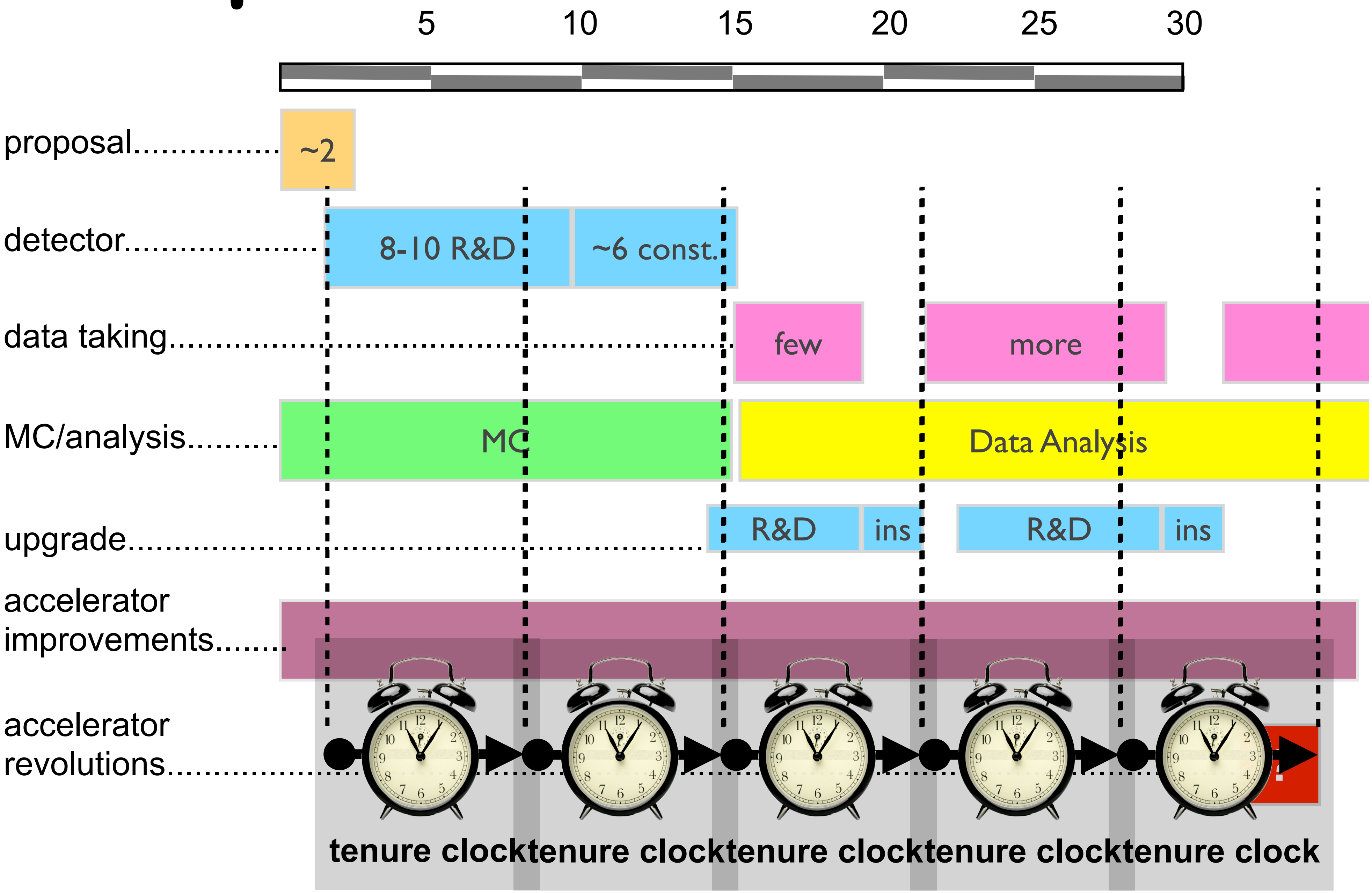
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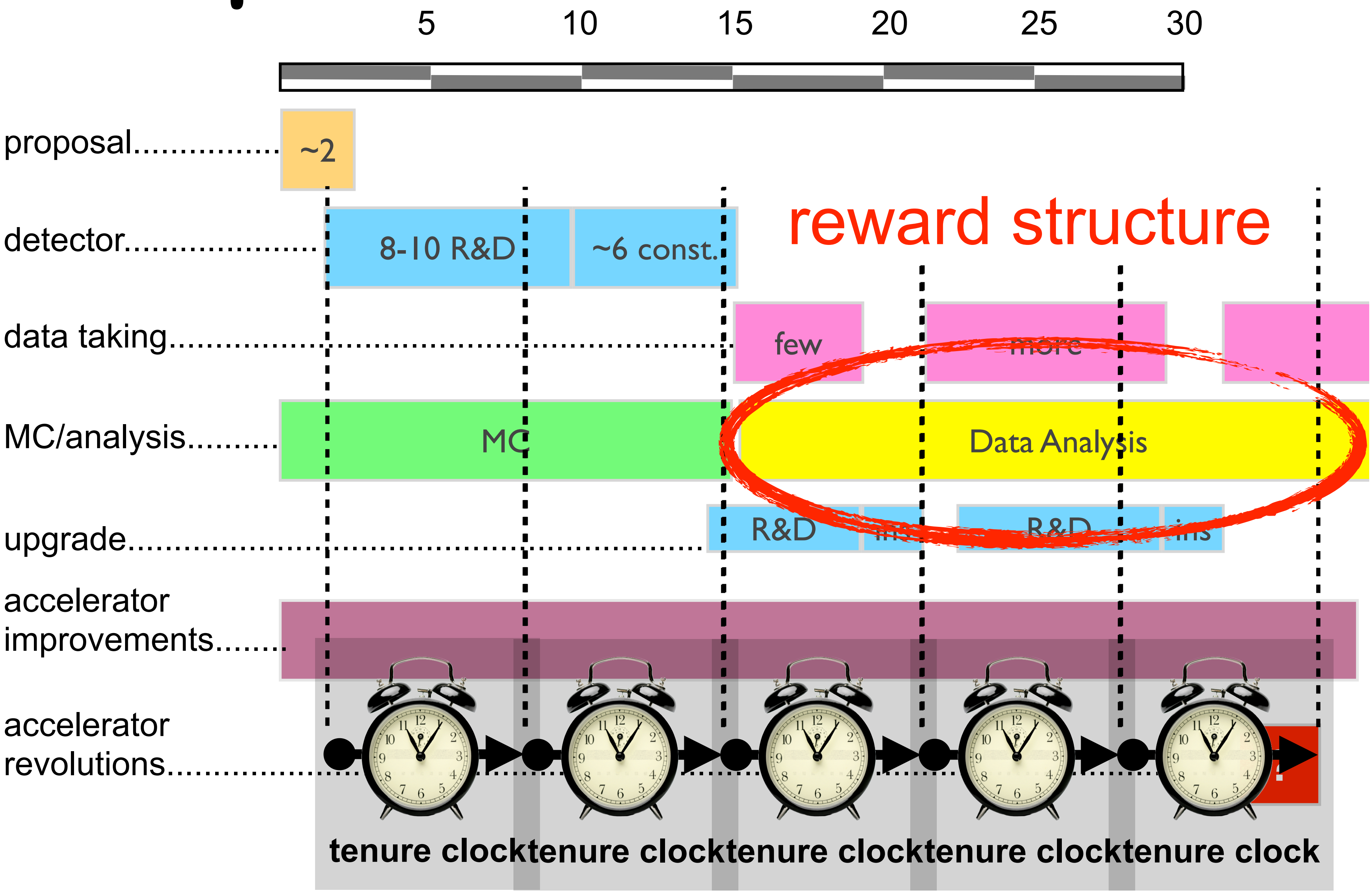
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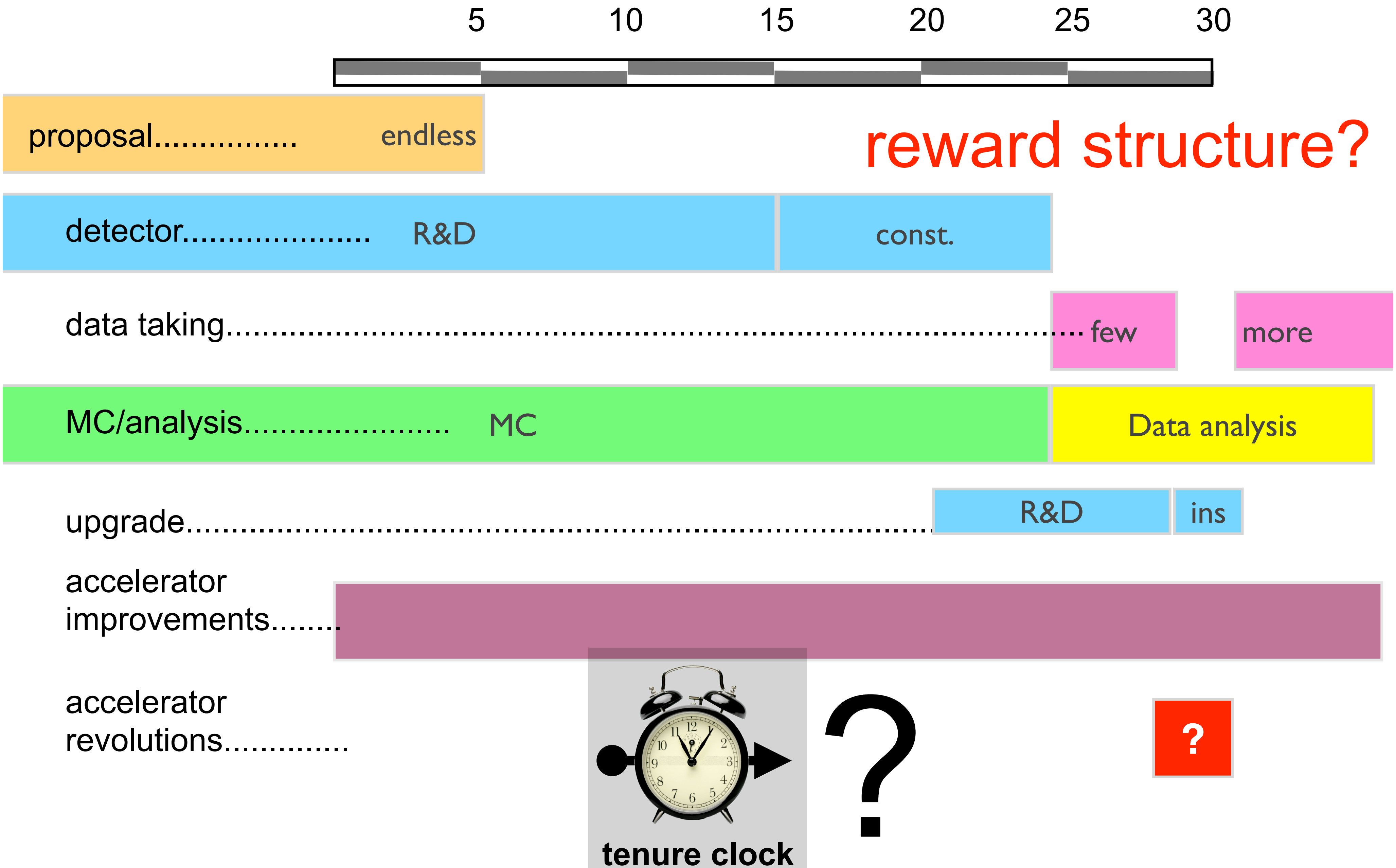
the future



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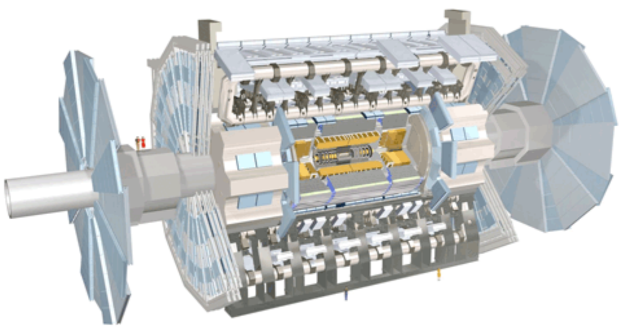
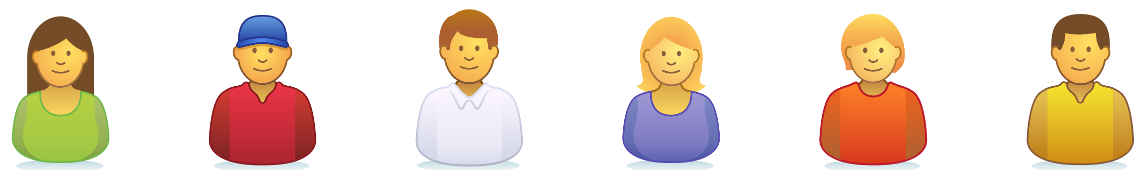
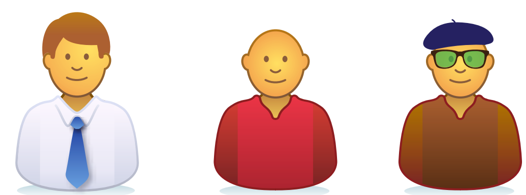
how long can HEP remain “pure”?







how long can HEP remain "pure"?

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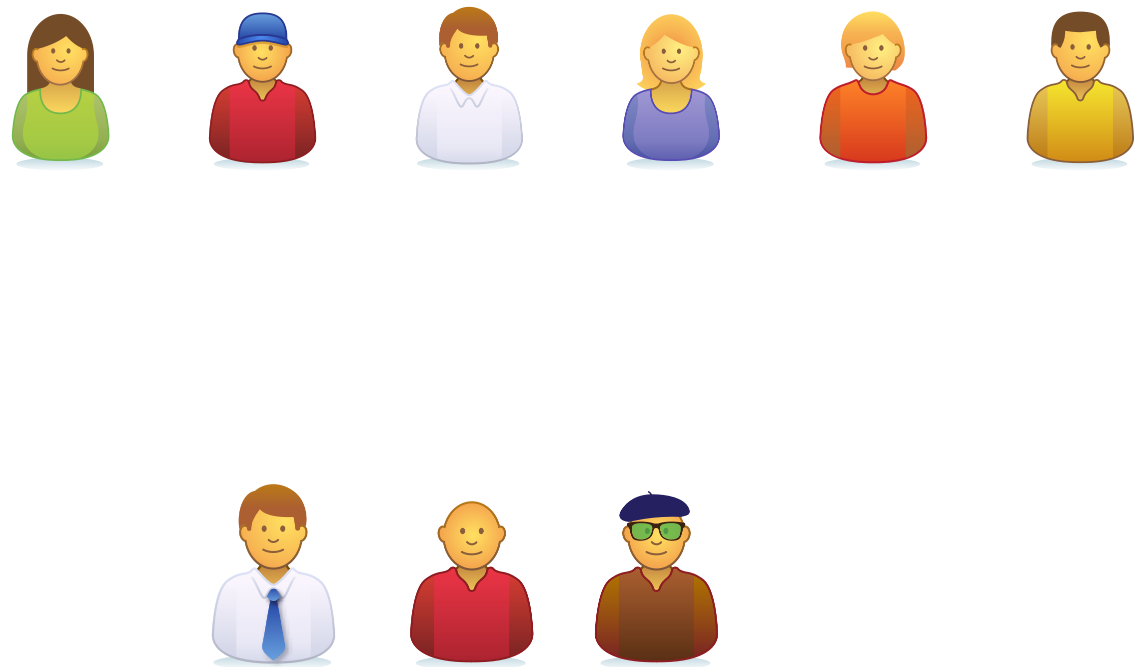

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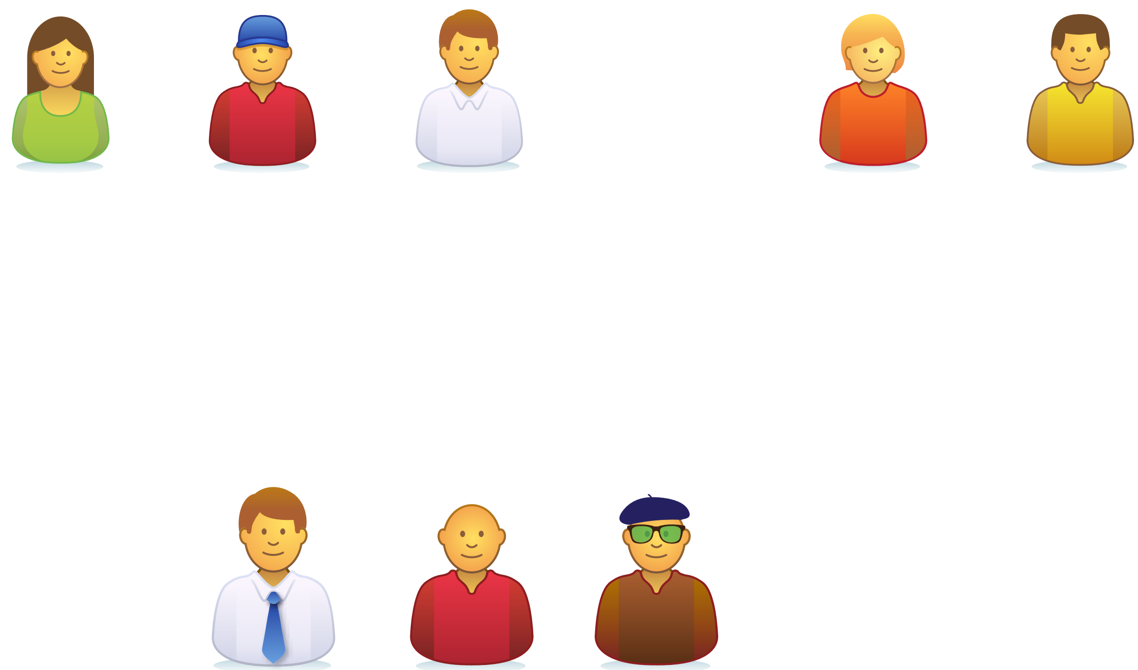

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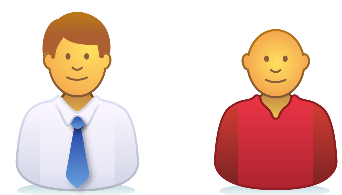

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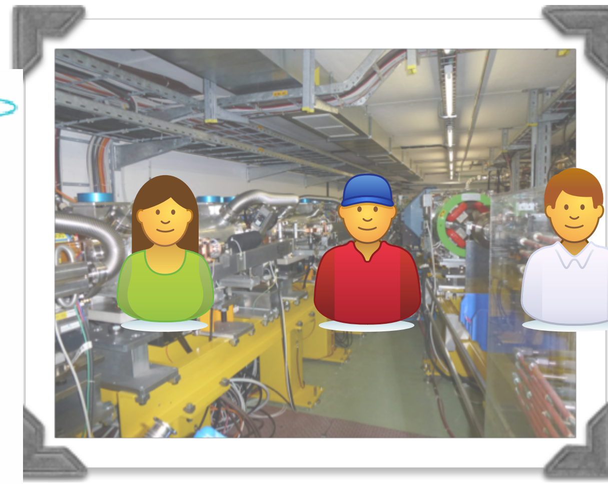

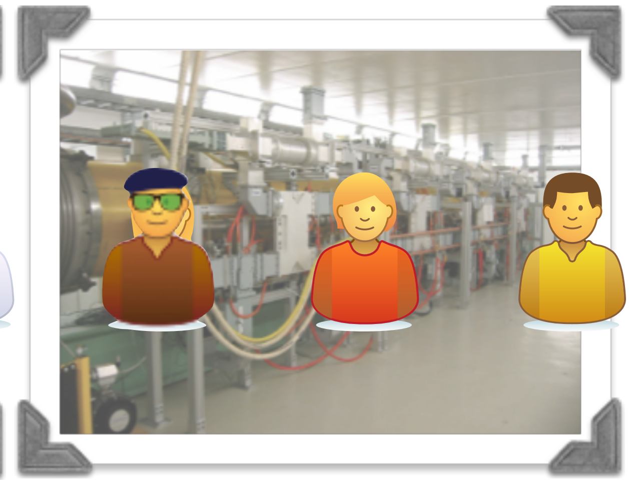

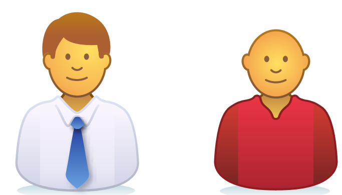

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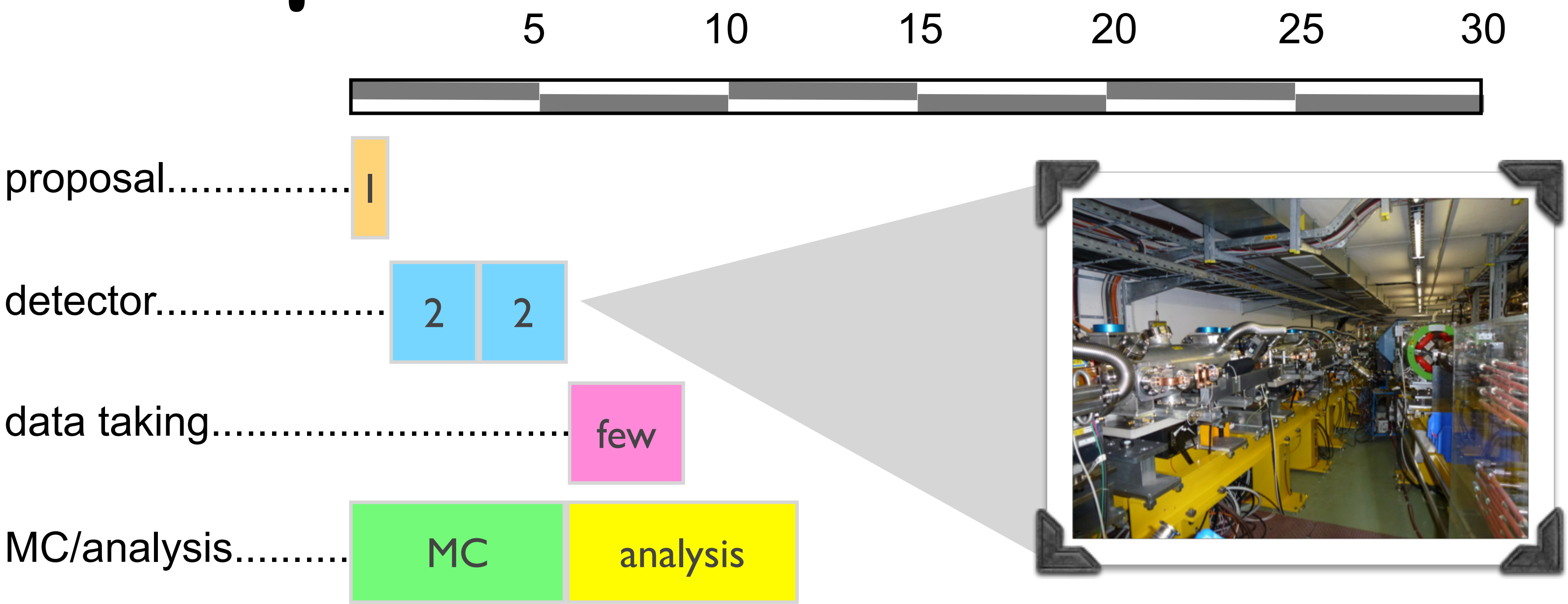
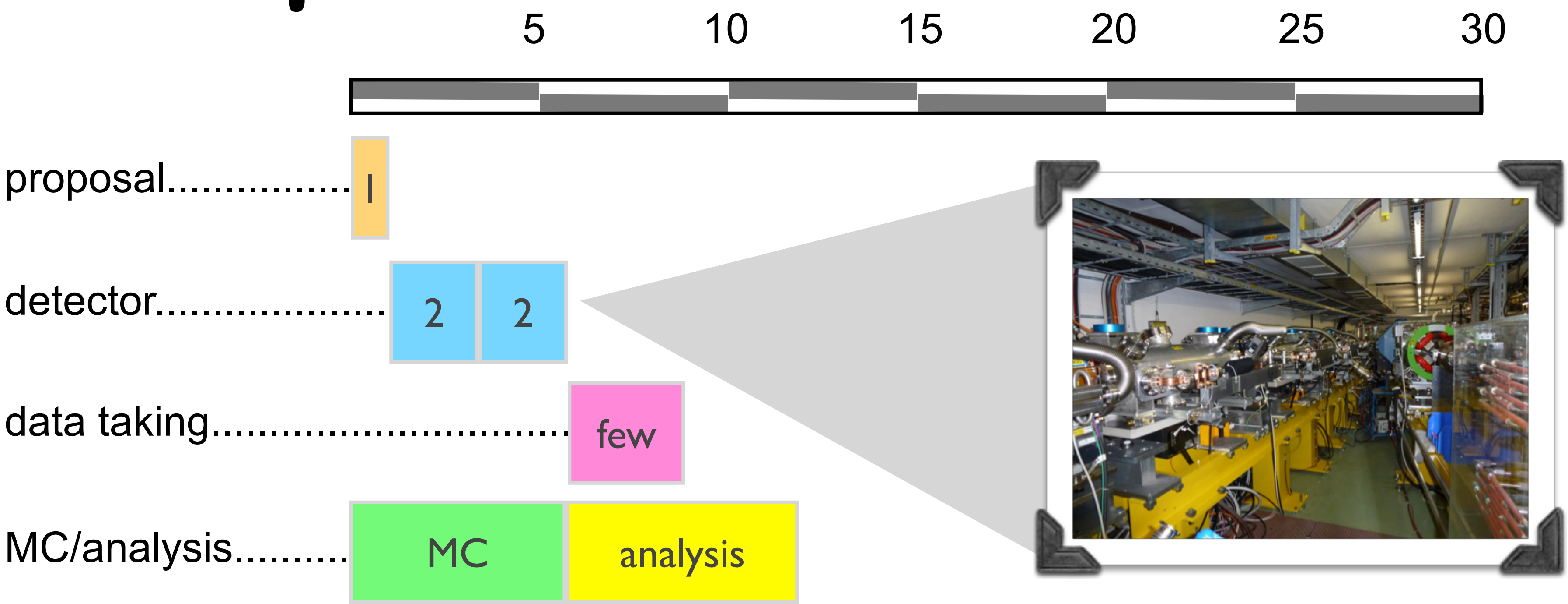


They have beams!
They do experiments...they measure stuff...

the past



They have beams!
They do experiments...they measure stuff...

We have to evolve somehow...might these two communities merge?

The physics is stupendous!

to get there we face:

enormous **technical challenges**

significant **cultural challenges**

we’ll find a way that works