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Forward physics requests

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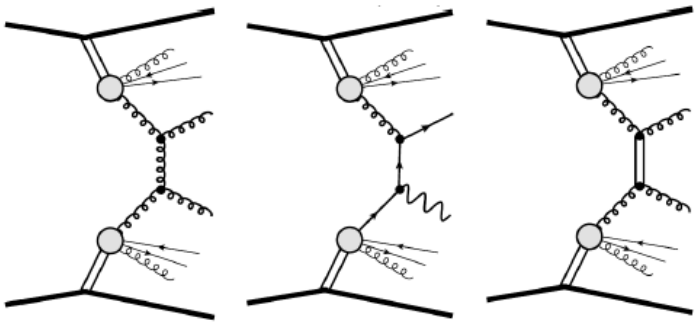
On behalf of the LHC experiments



Introduction

- Want to summarize the potential and actual forward physics requests for Run-2 and beyond
- Covering all of:
  - forward physics during nominal high lumi pp running

  (central exclusive production: new particles, anomalous couplings)
  - running at medium β* (diffraction)
  - running at very high β* (elastic scattering)

LPC/LPCC forward-physics workshop (31/10/16): https://indico.cern.ch/event/575250/

Forward physics in nominal running

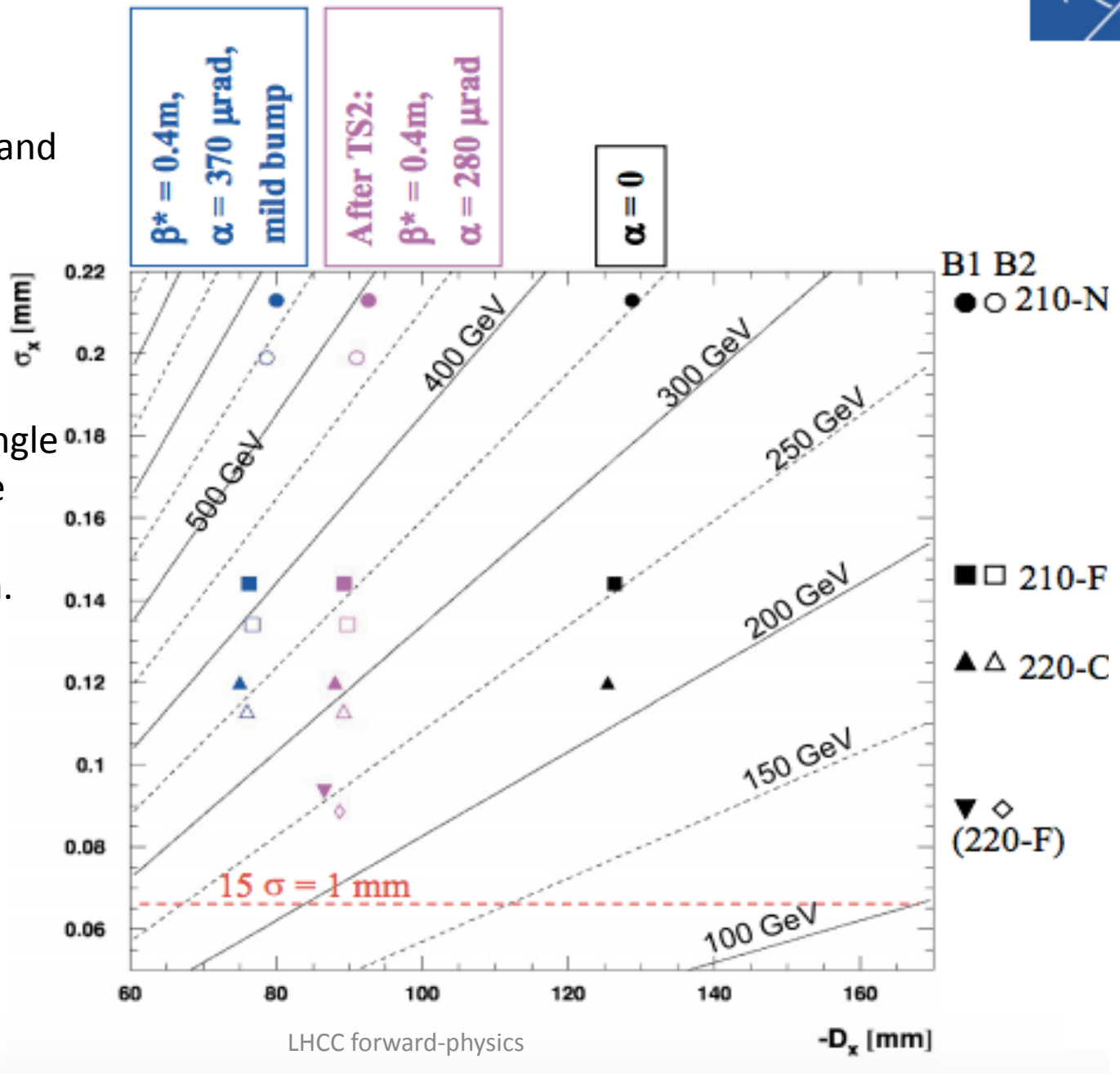
- In 2016 CT-PPS (joint TOTEM/CMS project) took data during nominal high luminosity pp running (~15/fb recorded)
  - In order to improve acceptance for '*750GeV resonance*' special 'TOTEM bump' introduced into the optics (the request fro this came very late). Roman Pots inserted to 15sigma from beam.
  - No problems observed from such insertions in regular high luminosity physics fills
- In 2017 both arms of AFP (part of ATLAS) detector will be installed. AFP also plans to participate in standard high luminosity running
  - Request for pots to be also inserted to 15sigma from beam
- These experiments are currently working with the LHC optics team to come up with best configuration of the optics to give good acceptance for physics (dispersion, beam size) without compromising high luminosity running
  - AFP would like smaller beam size at location of near pot to allow them to go closer to the beam, but are generally happy with the 2016 optics
  - CT-PPS pots would like to increase the dispersion to give them access to lower mass states – however requested lowest mass of 100 GeV is unlikely to be achievable
    - CT-PPS pots are in the crossing plane, and suffer from cancellation in dispersion from crossing angle and D1/2 magnets, hard to generate requested dispersion
    - They would prefer a small crossing angle

Forward physics in nominal running

CT-PPS plot on lowest mass acceptance as function of dispersion and beam size at pots.

Even with 0 crossing angle not possible to achieve 100GeV limit without going 1mm from beam.

High mass limit comes from location of TCL4



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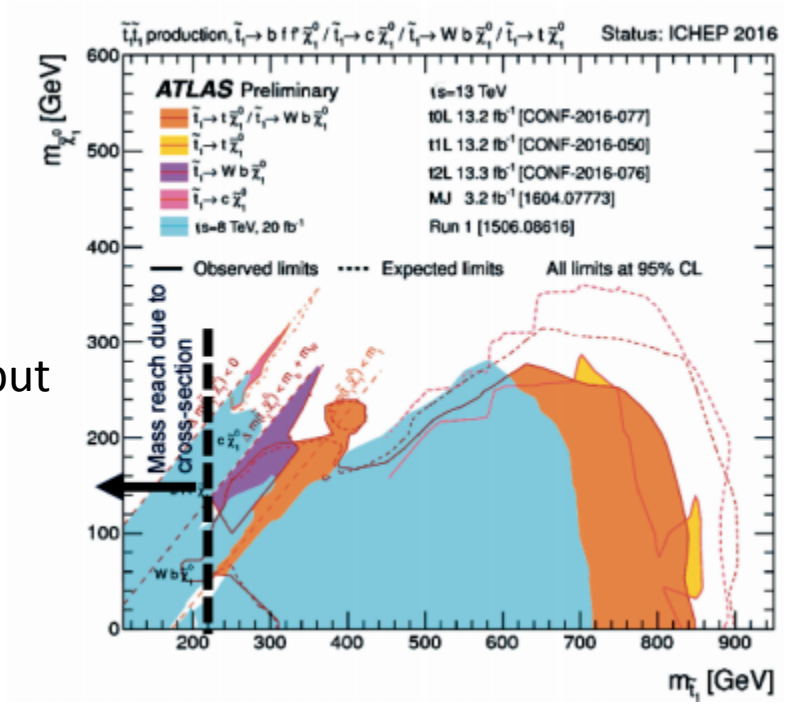
Running at intermediate β*

- Special runs with intermediate β*allow diffractive studies in low mass regime
  - missing mass searches (e.g. low mass SUSY), glue ball searches, study structure of pomeron, QCD studies, etc..
- Past runs carried out with β*=90m optics in IP1/5
- TOTEM interested in highest possible luminosity in such a case, try to get to pileup of μ=1 (request ~50/pb)
  - Need an optimization of machine parameters to maximize the luminosity (β*, ε, bunch-intensity) – see next slide

Request:

- TOTEM request ~50/pb in 2017 (~2 weeks of running)
  - Could be spread over multiple years
- Request would be joint TOTEM/CMS analysis of data but CMS do not support this request
- ATLAS/LHCb/ALICE do not support such a request



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Running at intermediate β*

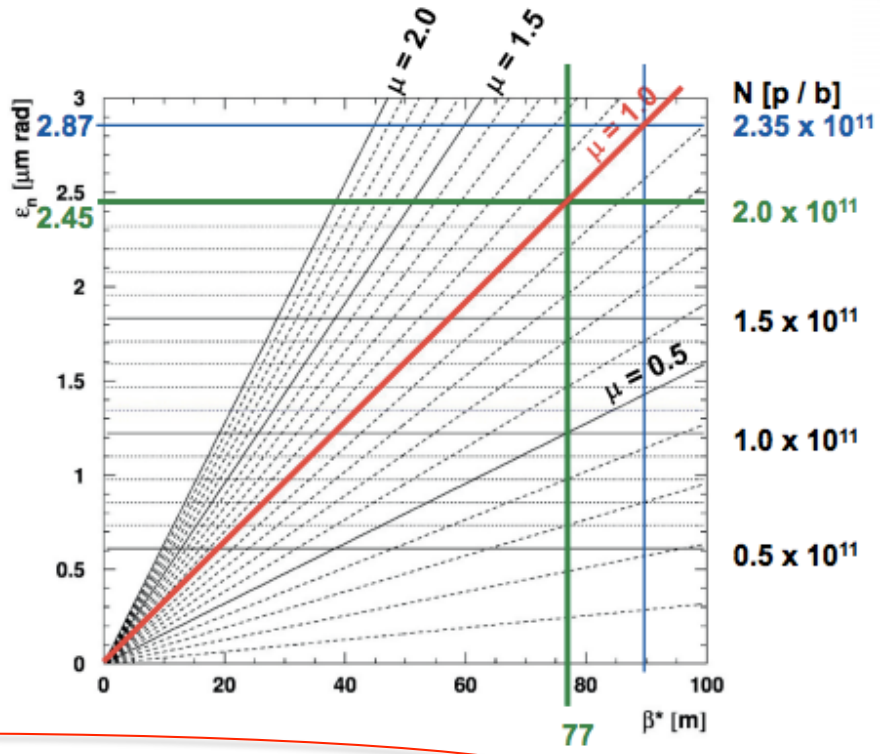
TOTEM working with Helmut Burkhardt on optimization of machine parameters for such a run. Challenging but μ=1 possibly in reach.

$$\mu = \frac{\gamma\sigma_{in}}{4\pi} \cdot \frac{N^2}{\varepsilon_n \beta^*}$$

Optimise (N, ε_n, β*)

Plot for fixed, maximum tolerable beam-beam parameter $\xi_{bb} = 0.01$:

$$\xi_{bb} = -\frac{r_c}{4\pi} \cdot \frac{N}{\varepsilon_n} = 0.01$$



Pileup of μ = 1 is reachable with β* = 77 m, N = 2.0 x 10^{11} p/b, ε_n = 2.45 μm rad.

Physics case requires ~50 pb^{-1} .
For μ = 1, $\alpha_{cross,full}$ = 100 μrad, 671 bunches: L = 8.7 x 10^{31} cm^{-2} s^{-1} = 7.5 pb^{-1} / 24h

2015: total run efficiency H = 0.36 (excluding commissioning period) → **38 pb^{-1} in 2 weeks**
Run efficiency has always increased with length of high-beta runs !

→ **for a 2-week long run: H = 0.47 or 50 pb^{-1} at μ = 1 is possible**

Running at very high β*

- Special runs with very high β*allow studies of elastic scattering in the Coulomb-Nuclear interference region, and can be used to measure the total cross section and ρ parameter
  - Only needs to be done once for a given energy
- In the past have run at: 1km (8 TeV), 2.5km (13 TeV)
- Challenging scenario for machine, pushing to the limits
- TOTEM/ATLAS(ALFA) interested in having (will request) a very high β* run at 14 TeV when possible (Run-3?)
- In the meantime there is interest in a run at lower energy
  - ALFA discussed 2 TeV, TOTEM 900 GeV or even lower (should converge on one of these to have a coherent request)
  - Complementary to Tevatron measurements (p-p versus p-pbar)
  - No formal request yet, but maybe something for the future (not 2017)

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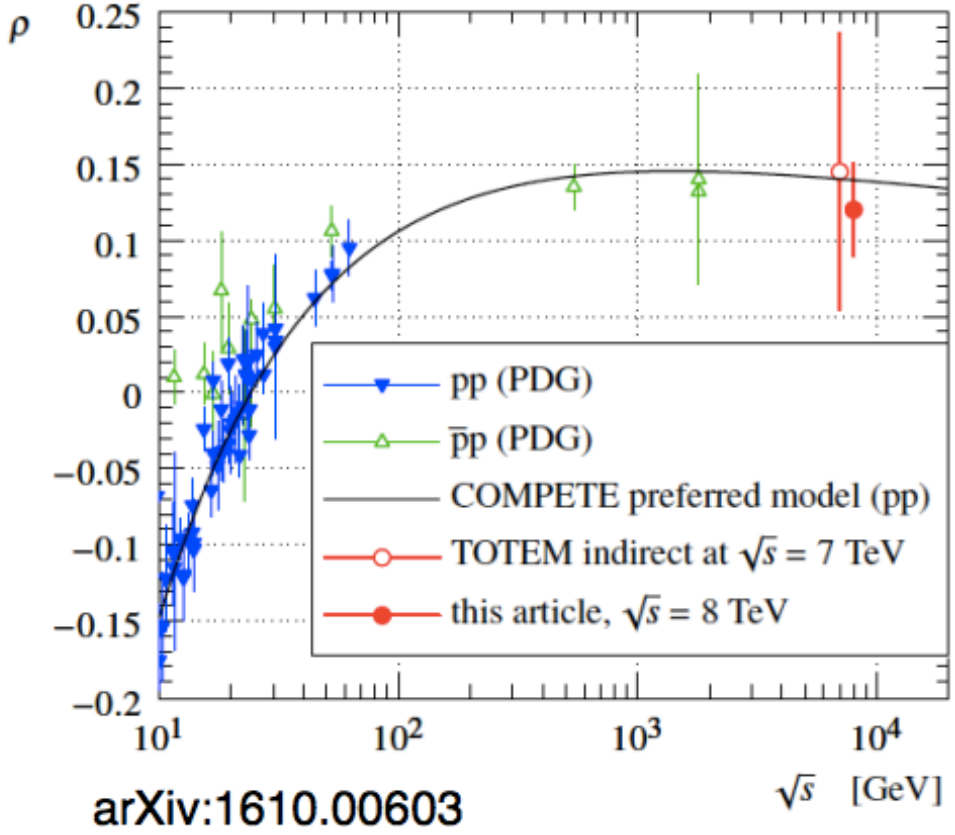
Running at very high β*



Quick look at possible β* reach at different energies.

E_b [TeV]	$E_{cms} = 2\ E_b$ [TeV]	β*[m]
7	14	2690 m
6.5	13	2500 m
4	8	1540 m
2	4	770 m
1	2	380 m
0.45	0.9	170 m

Helmut started to have a quick look at very high β* at lower energy. Very challenging but probably possible!
Running at below injection energy (900GeV) would be very challenging and would likely require a lot of setup time.

Compare with p-pbar at:
2 TeV (Tevatron, but large uncertainties)
0.5 TeV (SPS)

Forward physics with low pileup

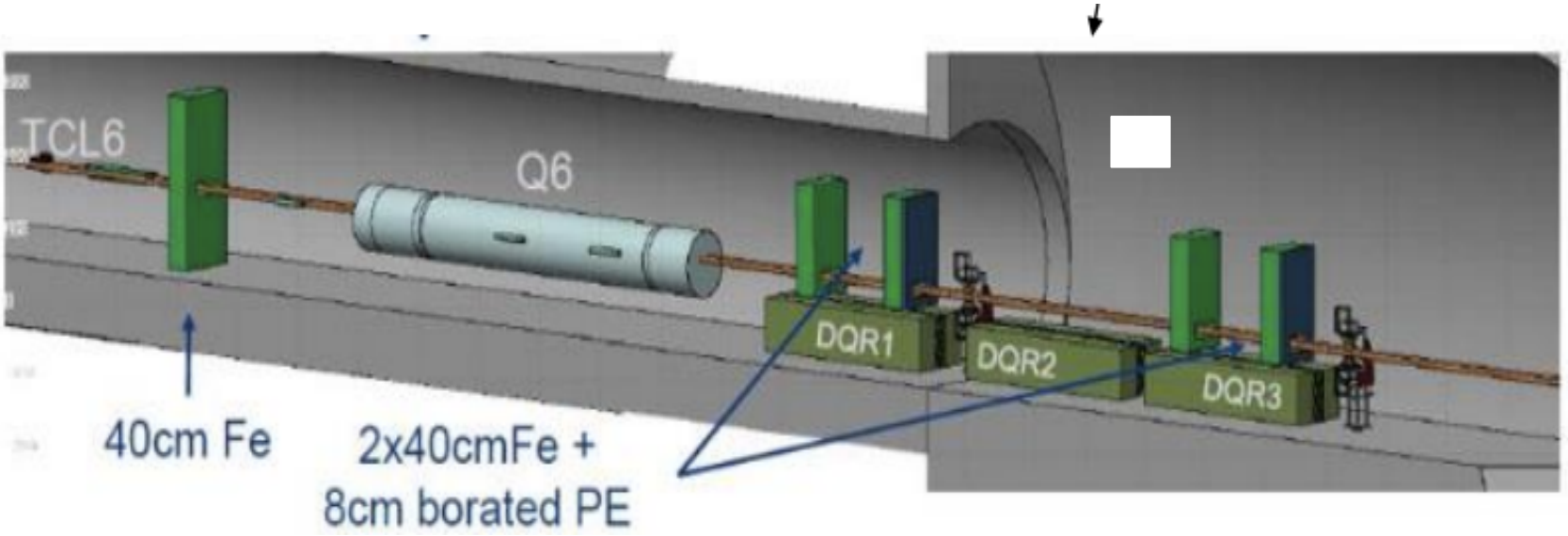
- Both ATLAS and CMS will take data with standard optics but low pileup (from beam separation) for forward physics measurements
  - ATLAS (with AFP) request:
    - ~100/nb at μ=0.05 (soft diffraction) (~7hrs)
    - ~2/pb at μ=1 (hard diffraction / ridge studies) (~7hrs)
  - CMS interested in similar data samples but still discussing exact requests but between O(1) – 50/pb discussed
- From a planning perspective these requests are easy to accommodate as they use standard optics, and the beams can be separated in IP1/5 to give required pileup at any time
  - Often most efficient in the ramp-up fills (with lower number of bunches) after Technical Stop or Machine Development periods

ALICE and LHCb

- ALICE request 100M min-bias events in isolated bunches with ZDC in (constraint on crossing angle in IP2) in 2017 for diffractive analysis
  - Difficult to satisfy this request as not compatible with bunch-train running, can try during VDM scans but not possible to satisfy requested statistics
- LHCb have no requests for special conditions for forward physics, their forward physics programme is done in parallel with standard running
  - 5 stations of scintillating forward shower counters ('Herschel detector') does not need to be moved for Run-3, but would need to be upgraded for 'high pileup' running, if manpower is identified (otherwise can only be used in ion or special runs)
  - Run 3 forward physics case developing

Miscellaneous

- LHCf do not plan to take data unless there is a *proton – light-ion* run (e.g. proton-Oxygen)
- ALFA electronics irradiated when AFP pots inserted. To allow AFP to run in standard high luminosity running planning to install light shielding to protect ALFA, or (if needed) to remove ALFA electronics and re-install in a TS when needed for a special physics run
  - Planning for installation of shielding during EYETS ongoing



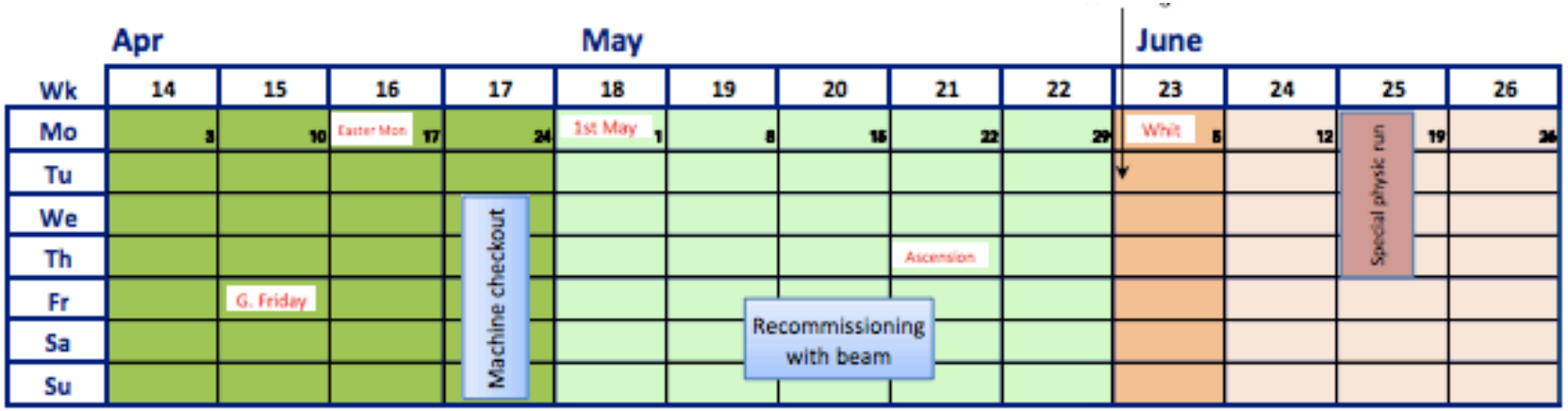
Conclusions

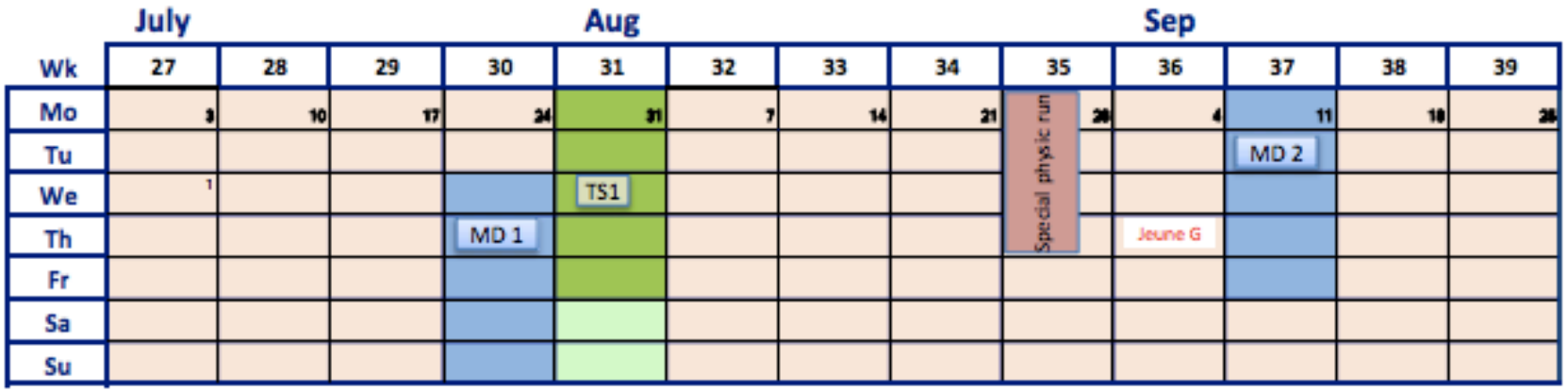
- Future forward-physics requests :
  - CT-PPS/AFP to run in 2017+ high luminosity pp data-taking
    - Constraints on optics being discussed with experts
    - Must not be detrimental to high luminosity running
  - TOTEM request a 90m-like run in 2017/2018
    - Would require CMS data, and CMS do not support this request
    - Interesting optimization of the setup to get maximum luminosity has started
    - Requested luminosity would take ~2 weeks of running
  - Very high β* runs (ALFA/TOTEM):
    - Elastic measurements at 14 TeV (when possible)
    - Also interest at lower energy (900 GeV or lower, 2 TeV ?)
  - Additional forward physics measurements done during nominal running with some requirements: low-pileup, isolated bunches etc..

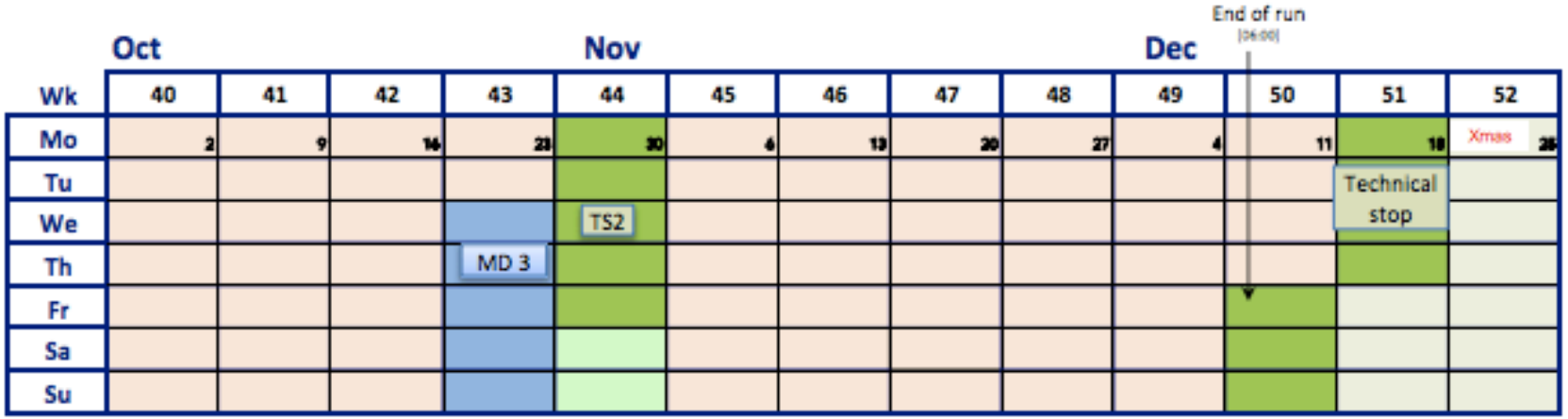
Requests for 2017

- When considering forward physics special run requests for 2017, need to also think about other requests
- Main other request is 5 TeV pp reference run
  - ALICE request ~2 weeks of running (6.7days in stable beam) to get to required 1000M min bias events @1.5kHz rate
    - 130M already collected in 2015 ion period
  - ATLAS/CMS also want 5 TeV pp data, but only 1 week of running
    - ATLAS strongly prefer this for 2018 as detector will be more similar to the 2018 Pb-Pb run
  - Could be taken at end of 2017 as cool-down for YETS (no ion run scheduled in 2017)
- Forward physics request for special running is TOTEM request for 2 weeks at β^*=90m (or less) (not supported by CMS)
- We believe there should be a maximum of ~1 week of special running in 2017 as important to have significant luminosity production to meet Run-2 goal

ALICE request: https://indico.cern.ch/event/586036/contributions/2360976/attachments/1374748/2088009/ALICE-LPC-21-11-2016.pdf







Special runs marked here indicative, and should include VDM scans

from Mike Lamont
17/10 LPC

2017 version v0.5

Phase	Days
Initial Commissioning post EYETS	35
Scrubbing (assuming machine stays cold)	7
Proton physics 25 ns	**152**
Special physics runs	8
Machine development	15
Technical stops	10
Technical stop recovery	4
Total	**231 days (33 weeks)**

- Machine development scaled down
- Might debate: initial commissioning; scrubbing; effect of magnet exchange