Update on the AFP project in ATLAS

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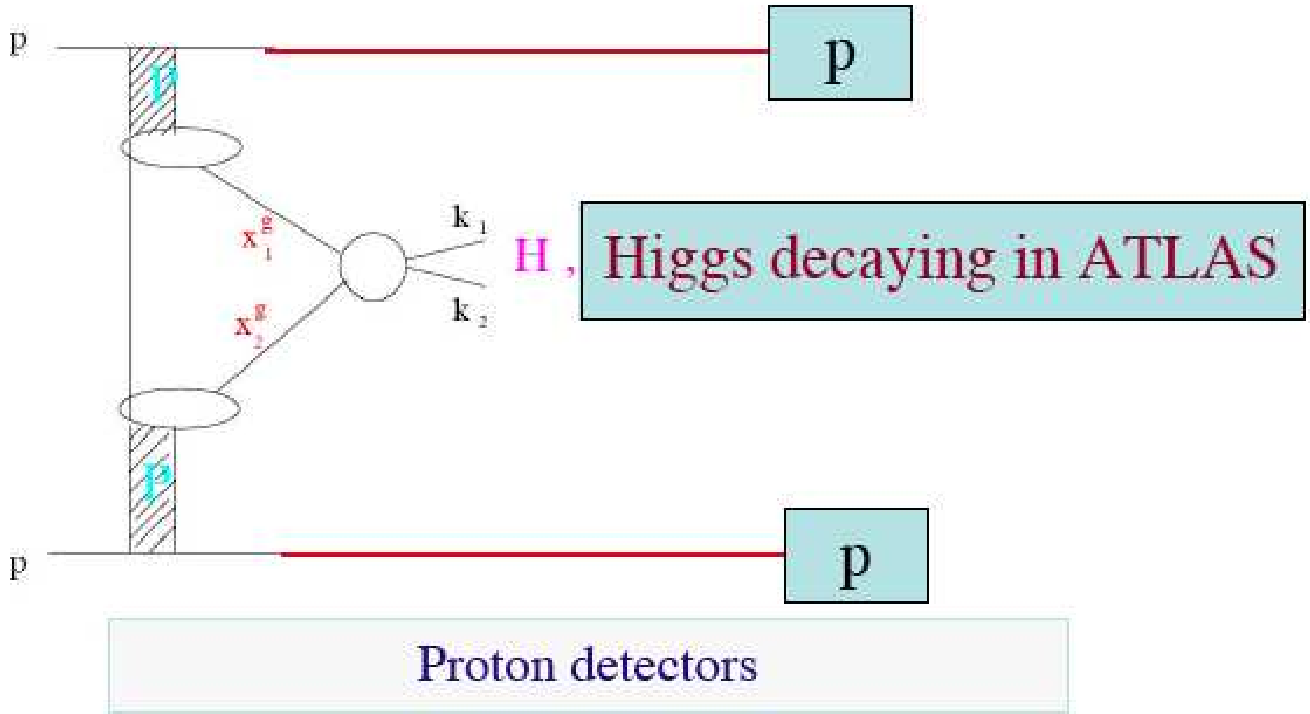
Contents:

- Very short summary on physics topics
- AFP project: ATLAS Forward Physics, focus on 220 m forward detectors
- Movable beam pipe and roman pots
- 3D Silicon detectors
- Timing detectors
- Trigger
- Schedule

Forward detector projects in ATLAS/CMS/TOTEM

- TOTEM project accepted, close to CMS
- ALFA project in ATLAS accepted, measure the total cross section (dedicated runs)
- FP420: Project of installing forward detectors at 420 m both in ATLAS, CMS; collaboration to perform technical tools to do so
- Forward detectors at 220 m in ATLAS:
  - Natural follow-up of the ATLAS luminosity project at 240 m to measure total cross section
  - Complete nicely the FP420 m project
  - One single project in ATLAS: FP420 and RP220 together called AFP
- For more information, see the web pages of FP420, CMS, TOTEM, ATLAS

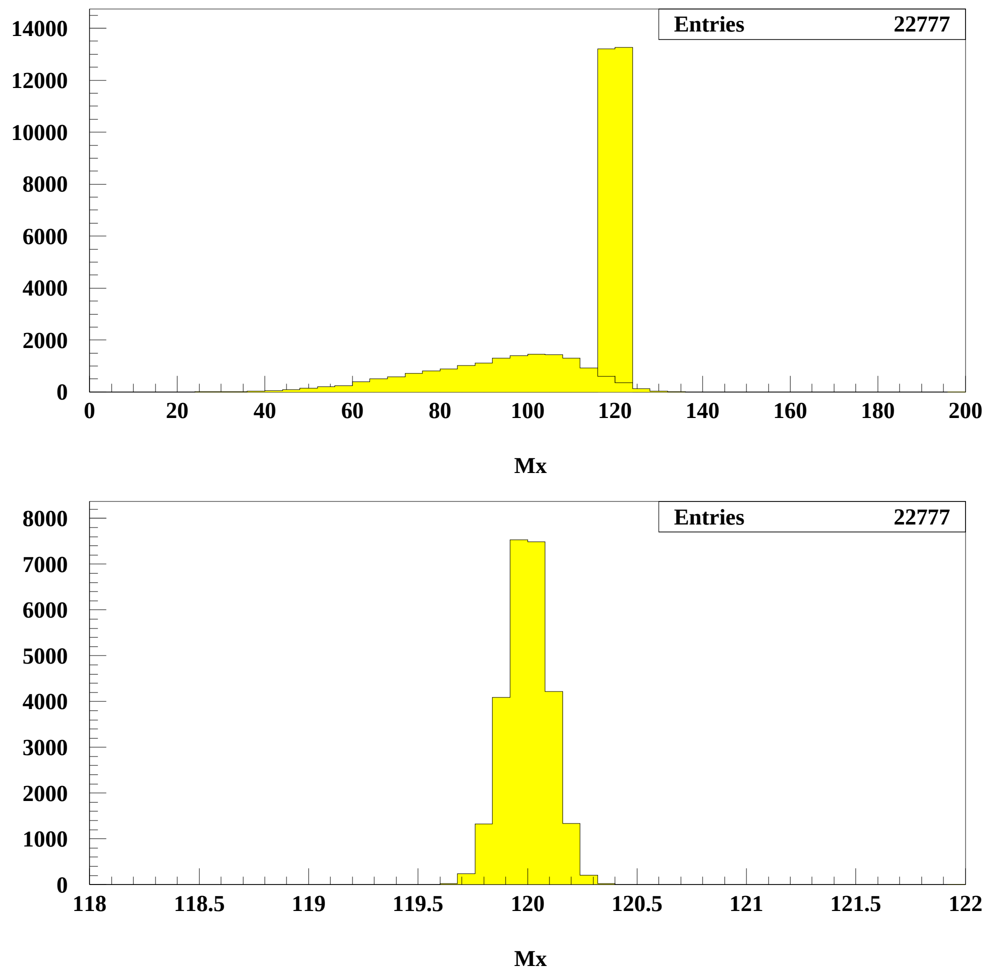
"Exclusive models"



- All the energy is used to produce the Higgs (or the dijets), namely $xG \sim \delta$
- Possibility to reconstruct the Higgs boson properties from the tagged proton: system completely constrained
- See papers by Khoze, Martin, Ryskin; Boonekamp, Peschanski, Royon

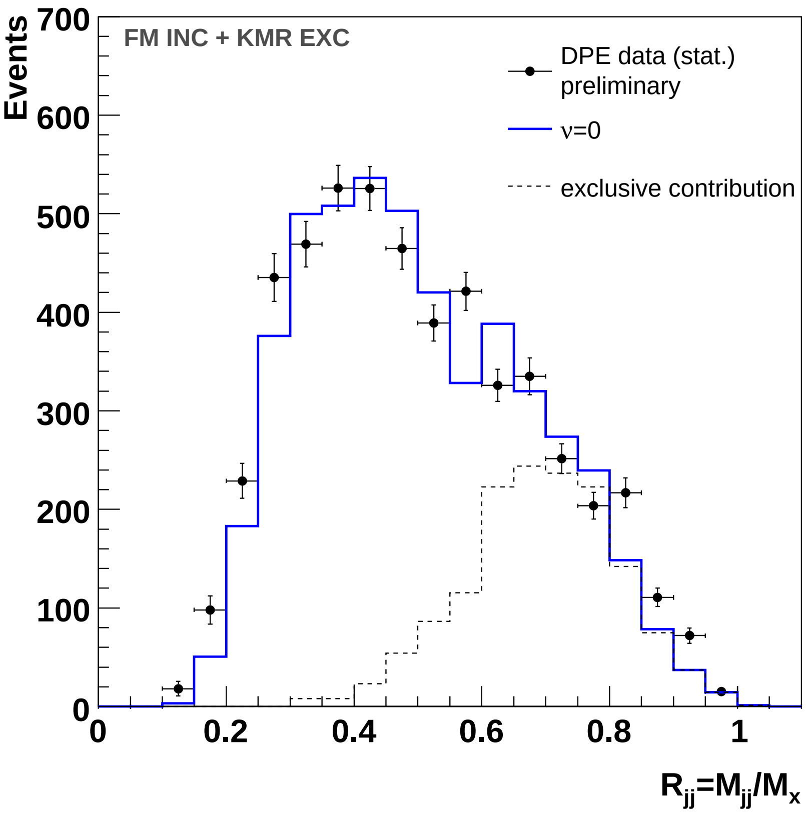
Advantage of exclusive Higgs production?

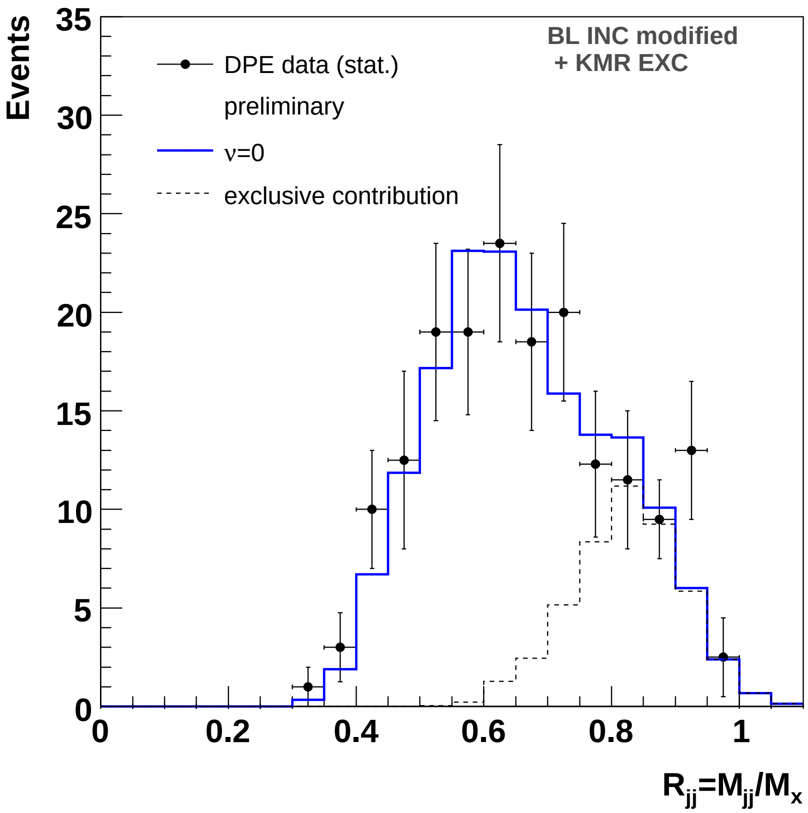
- Good Higgs mass reconstruction: fully constrained system, Higgs mass reconstructed using both tagged protons in the final state ($pp \to pHp$)
- No energy loss in pomeron "remnants"
- Mass resolution of the order of 1% after detector simulation



Search for exclusive events in CDF

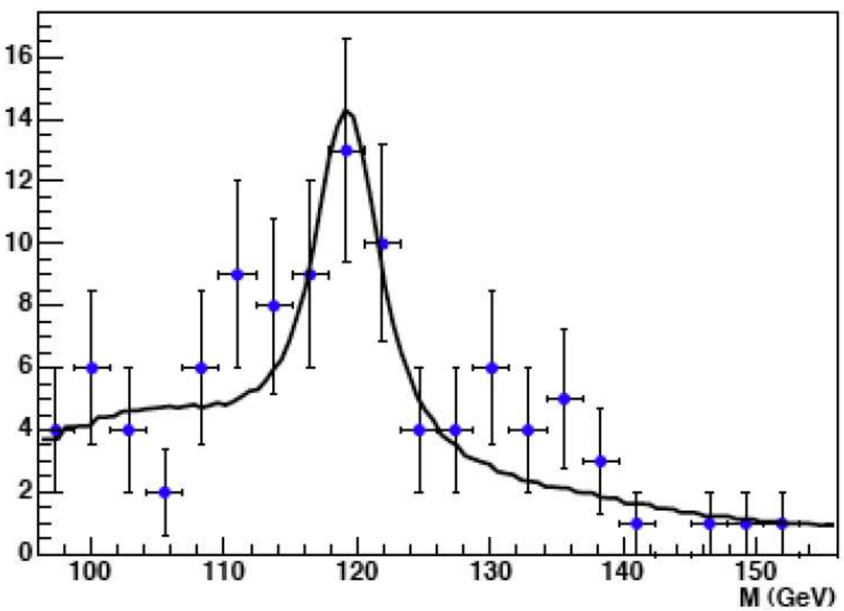
- Inclusive diffraction cannot explain CDF measurement of dijet mass fraction
- Add the exclusive contribution to inclusive diffraction
- Good agreement between measurement and predictions
- See O. Kepka, C. Royon, Phys.Rev.D76 (2007) 034012; arXiv0706.1798

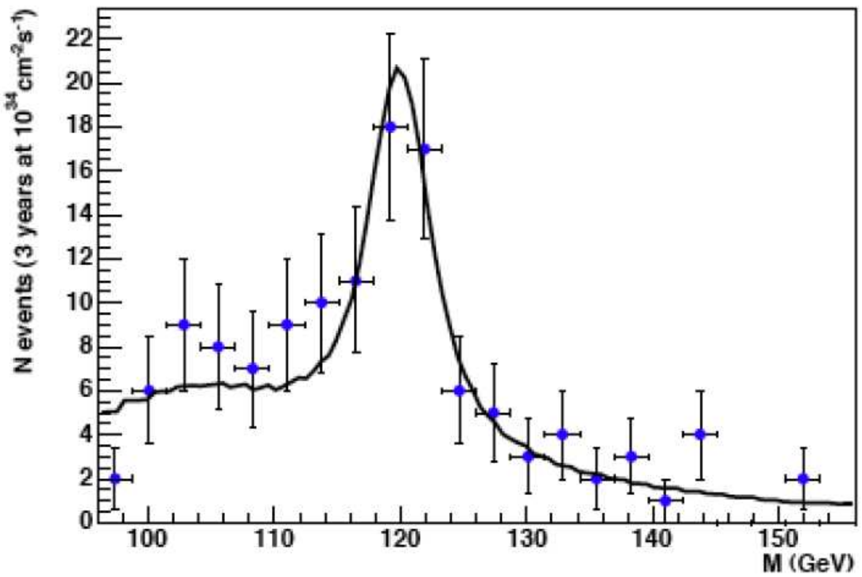




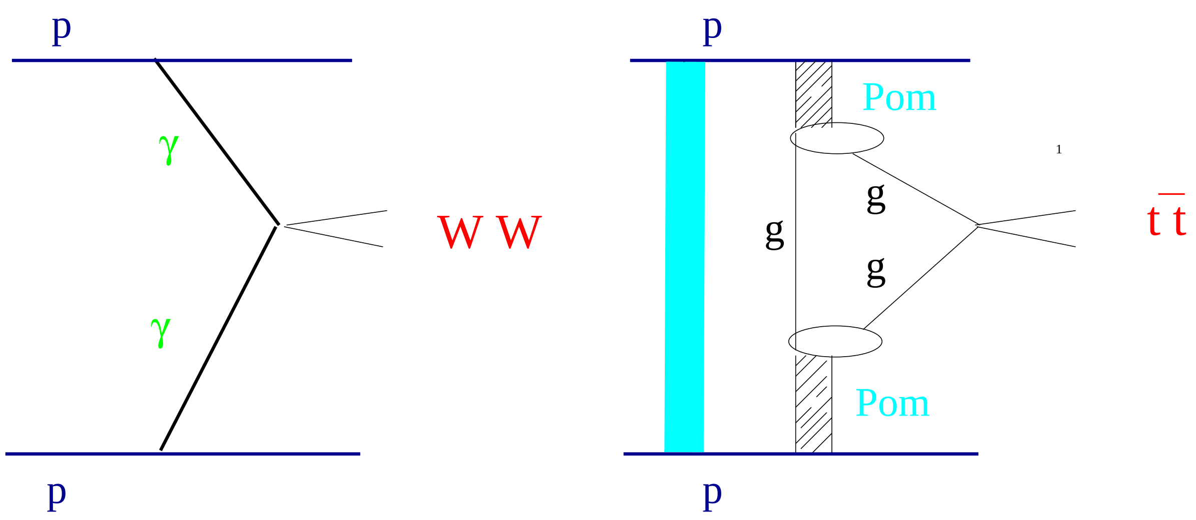
SUSY Signal significance

- Signal and background full simulation, pile up effects taken into account: see B. Cox, F. Loebinger, A. Pilkington, JHEP 0710 (2007) 090
- Significance $> 3.5\sigma$ for 60 fb^{-1} after detector acceptance
- Significance $> 5\sigma$ in 3 years at 10^{34} with timing detectors
- Diffractive Higgs boson production complementary to the standard search





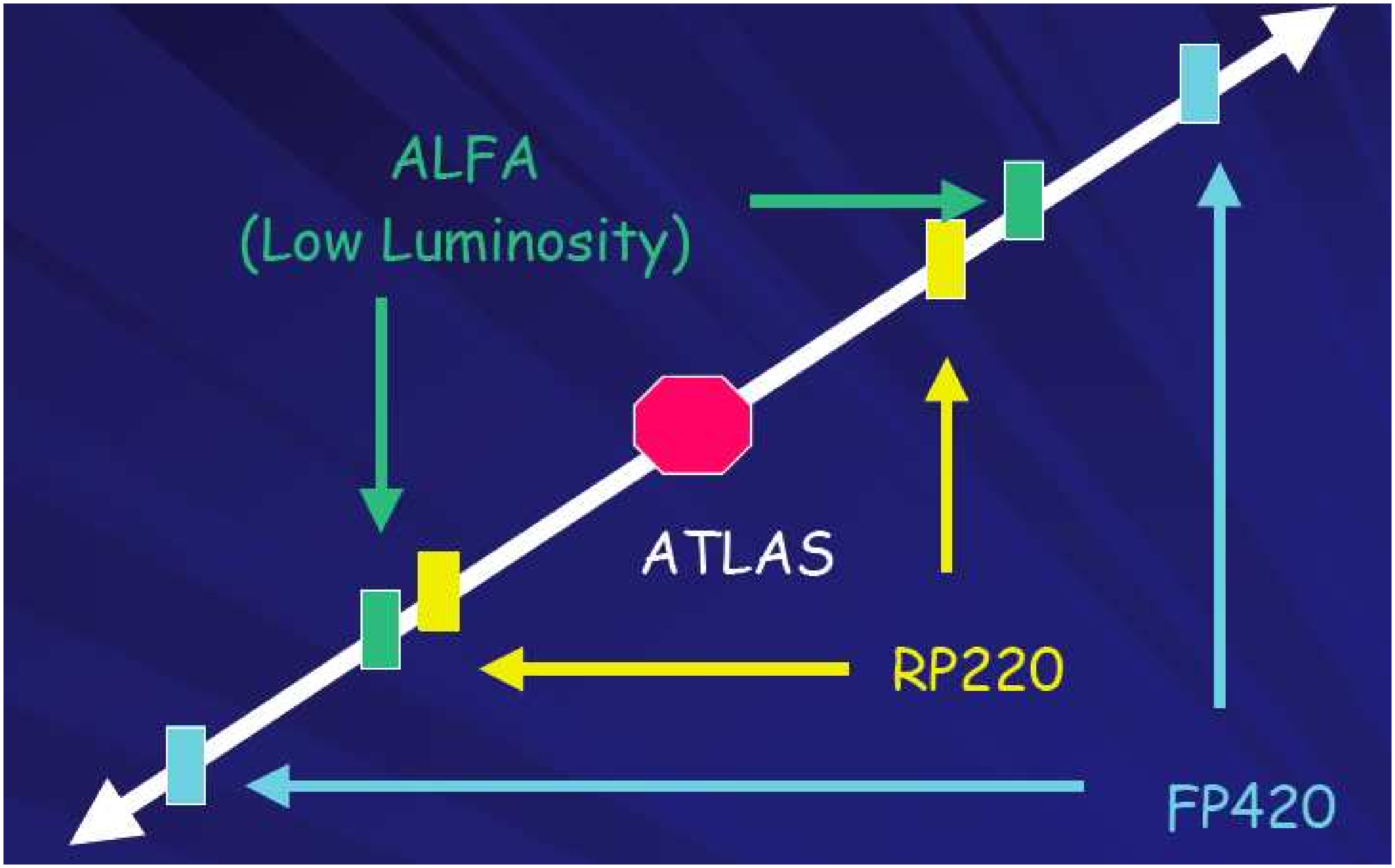
W, top and stops



- All the energy is used to produce the W, top (stop) pairs
- W: QED process, cross section perfectly known, top: QCD diffractive process
- Precise study of photon anomalous coupling: WW cross section perfectly known (QED), any changes due to photon anomalous coupling, high sensitivity since anomalous couling to the 4th power in cross section

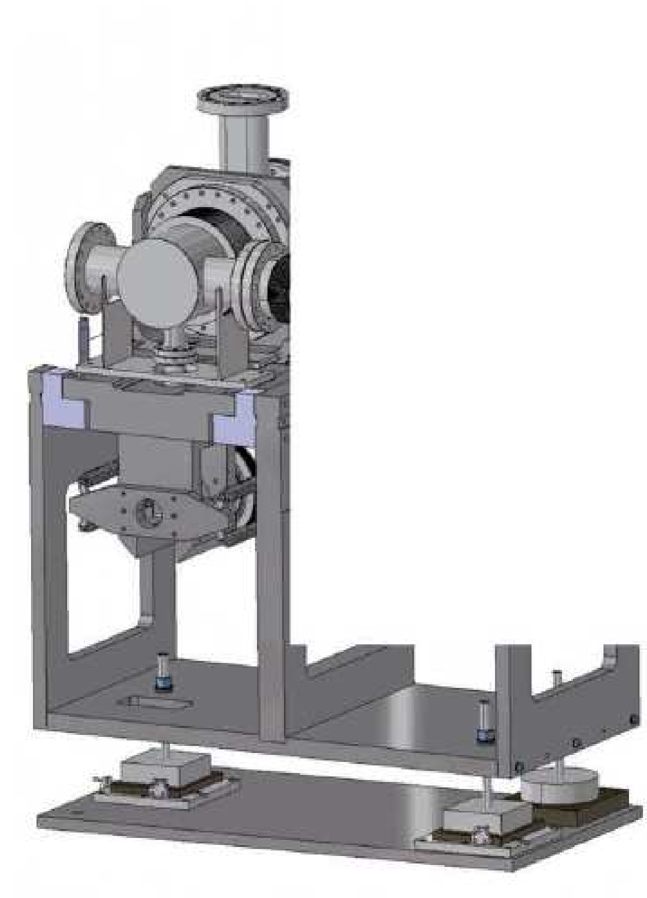
Detector location

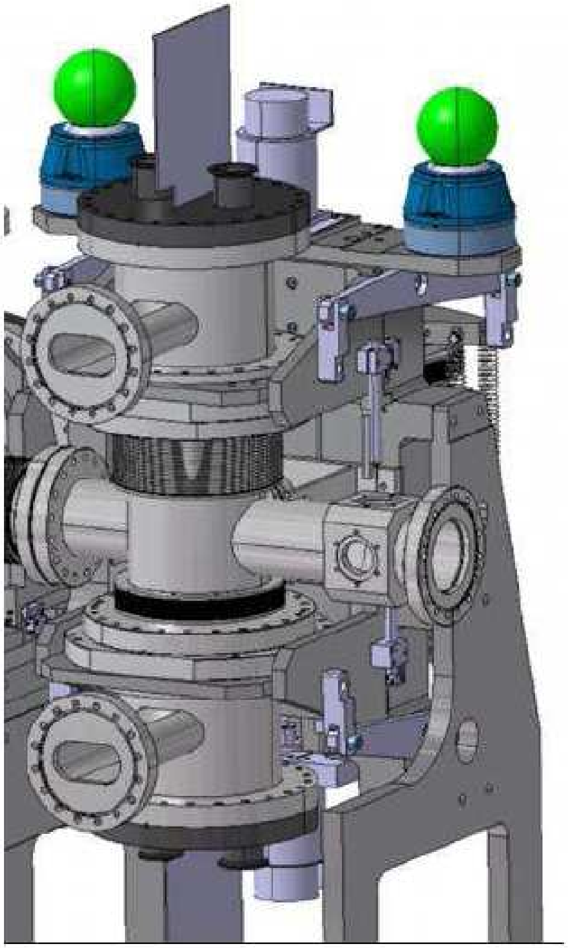
- what is needed? Good position and good timing mrasurements
- 220 m: roman pots and movable beam pipes
- 420 m: movable beam pipe (roman pots impossible because of lack of space available and cold region of LHC)



Roman pots at 220 m

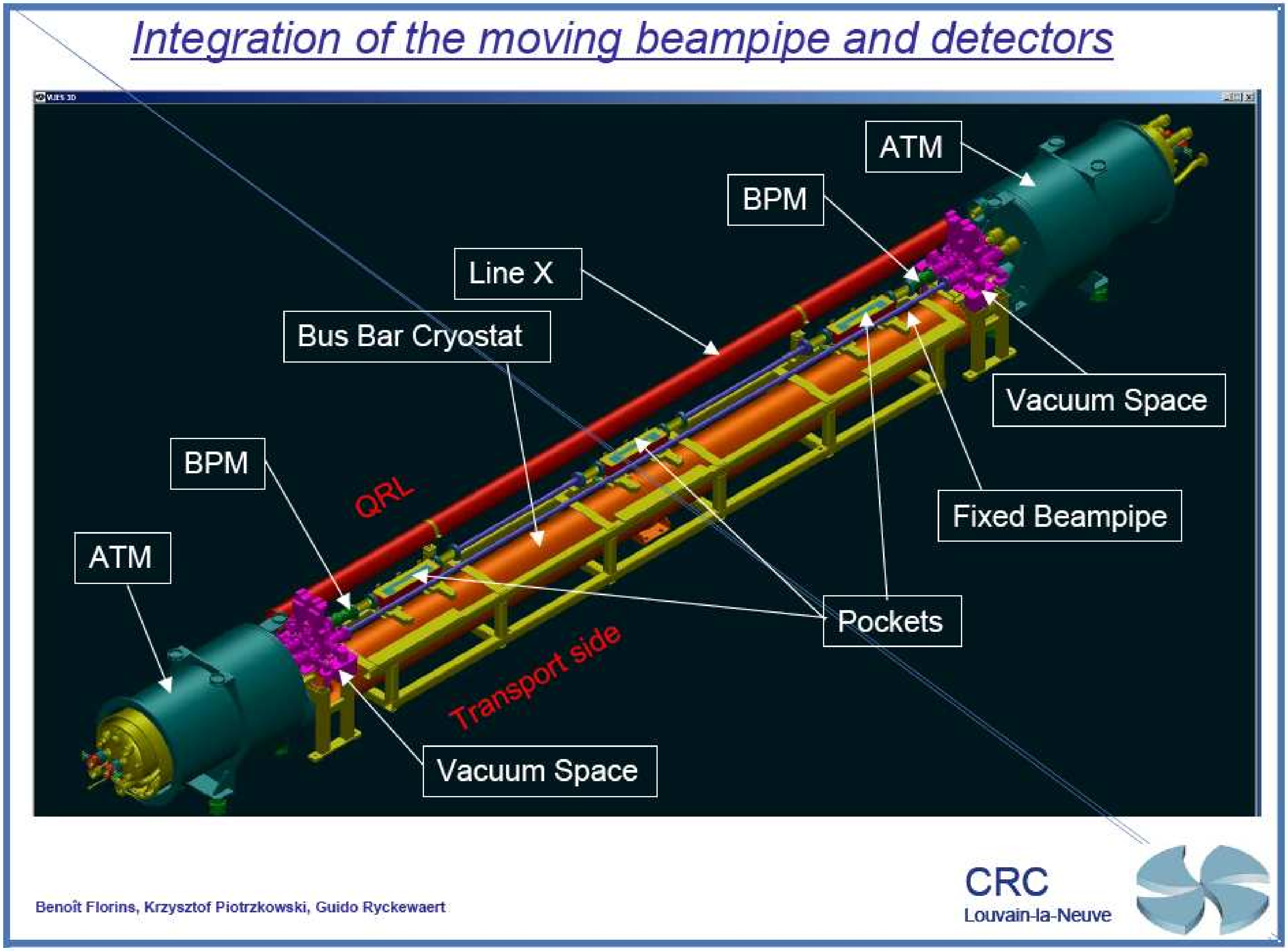
Use the same roman pot techniques as in TOTEM: only vertical detectors needed (vertical pots used for alignment purposes)



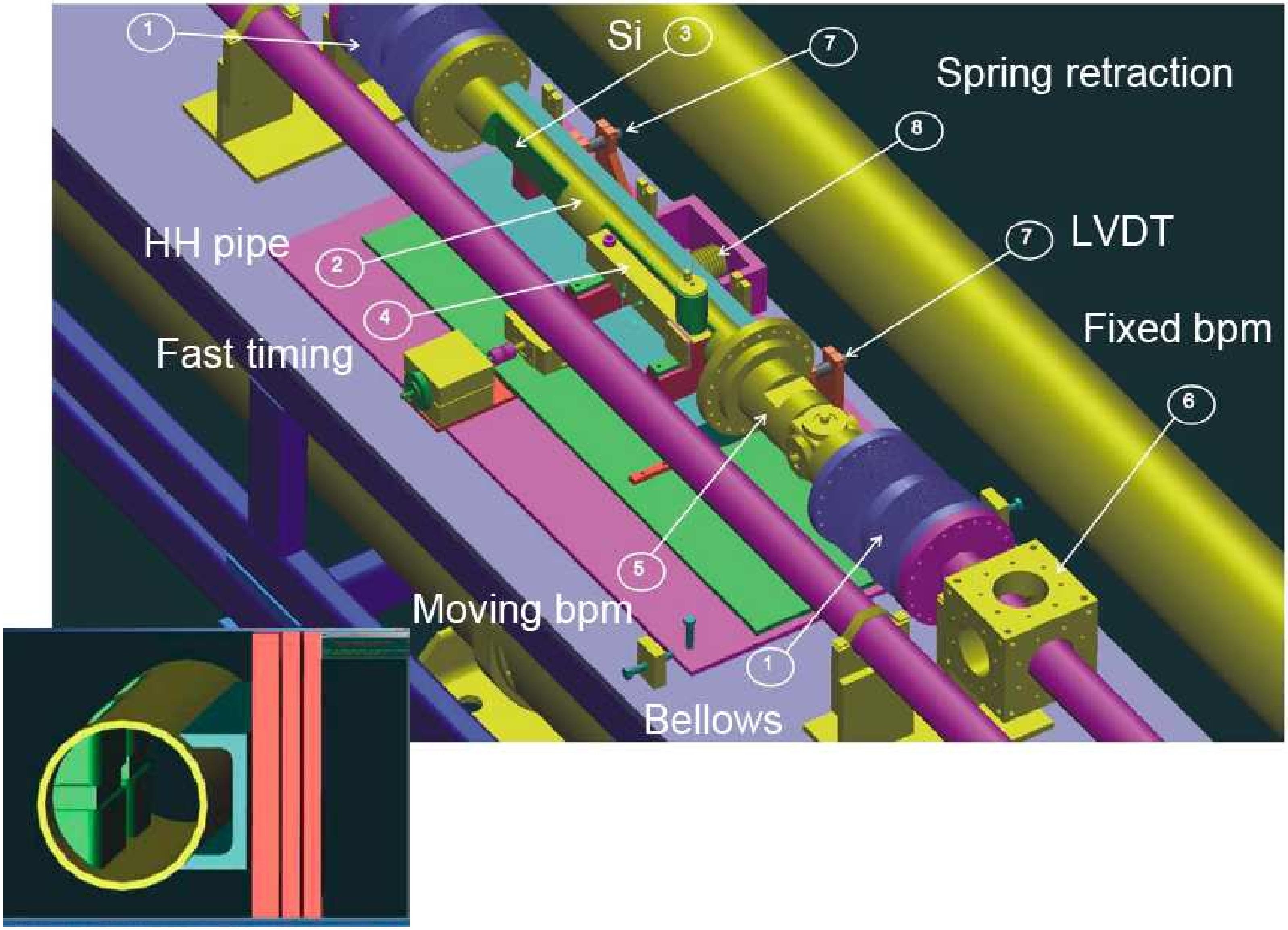


Movable beam pipe at 220-420 m

- Simple idea: use movable beam pipe to locate detectors, takes less space than roman pots
- Use movable beam pipes at 220 and 420 m to host position (3D silicon) and timing detectors

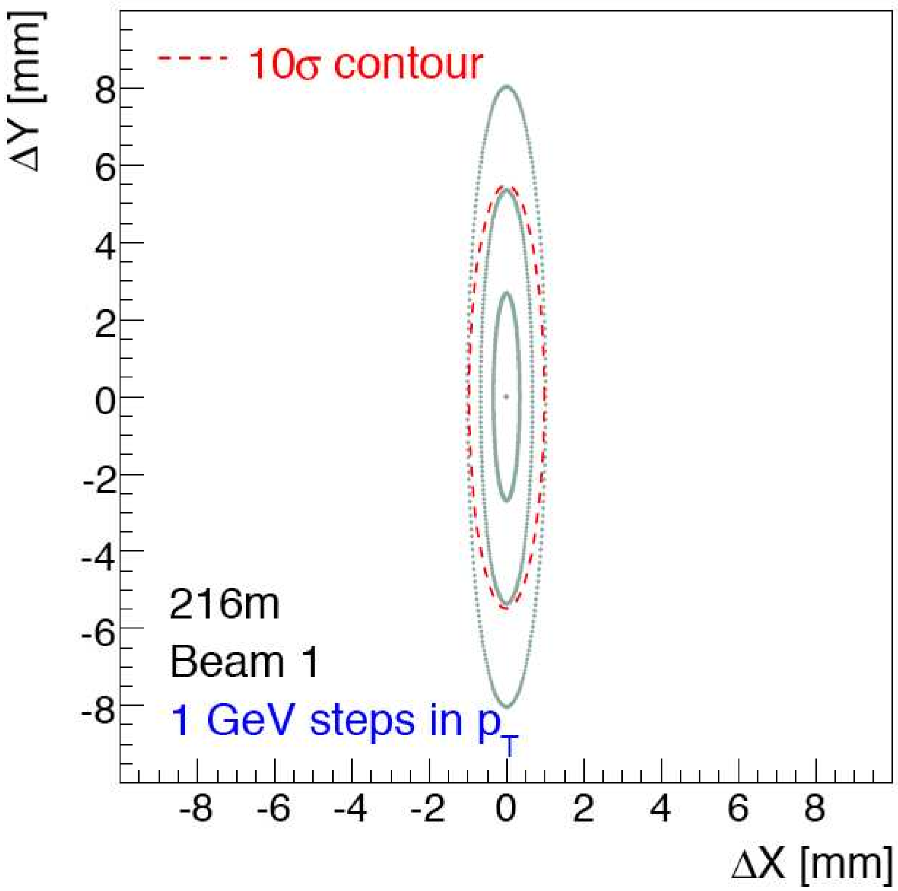


Movable beam pipe at 220-420 m



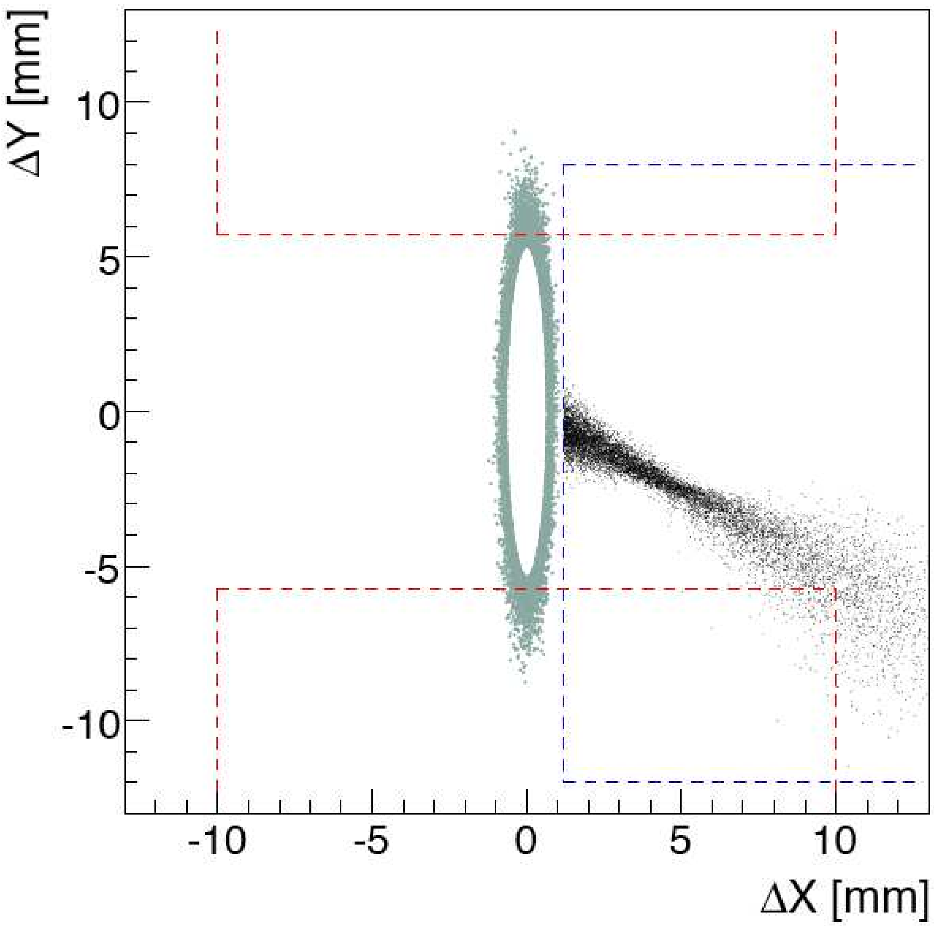
Roman pot alignment: elastics and vertical detectors

- Calibration to be done on store by store basis
- Acceptance: Starts at p_T ~2 GeV for vertical pots for 10 σ (3 GeV for 15 σ)
- Elastic cross section not perfectly known at high $|t|$: Islam model



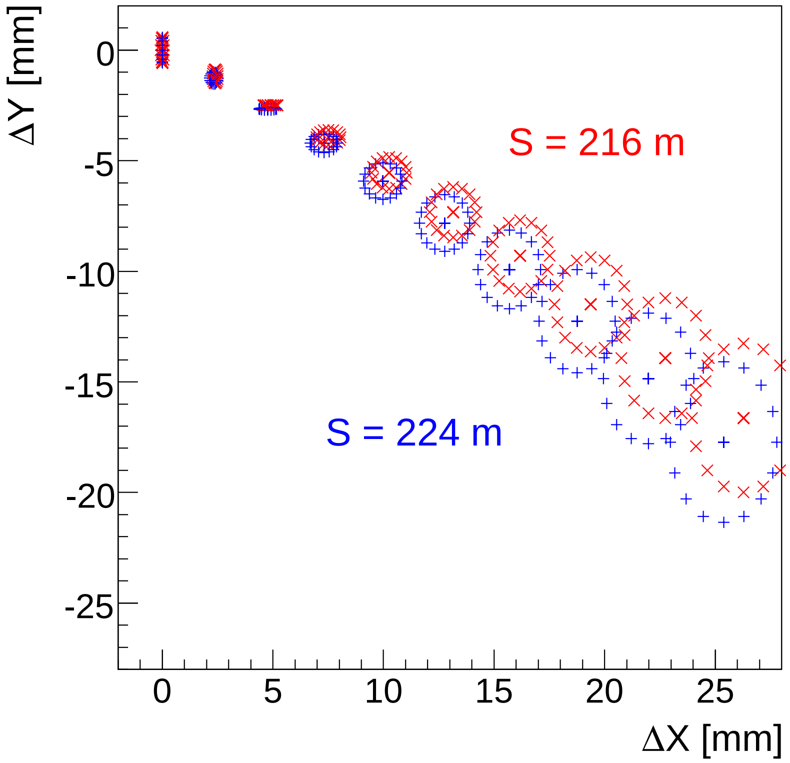
Roman pot alignment: principles

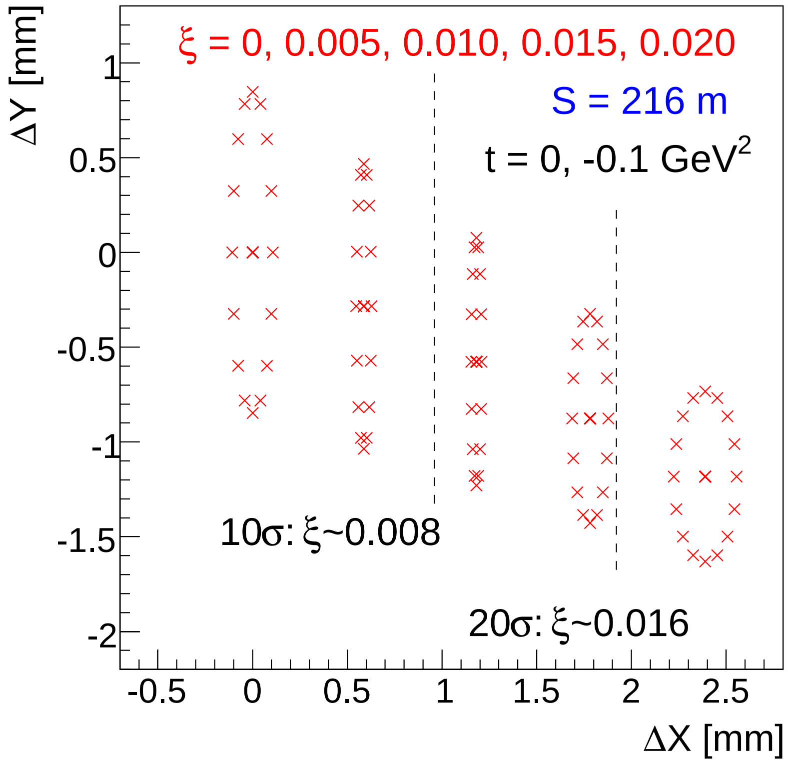
- Elastics to align vertical pots: 10000 events per day at 10 σ (100 for 15 σ)
- Single diffractive events to align horizontal pots with respect tp vertical ones: 10^{12} single diffractive events per day + halo events, with a acceptance $> 0.005\%$ at 15 σ, gives many many events...
- 5-10 μm precision with 100 elastic events



Acceptance for 220 m pots

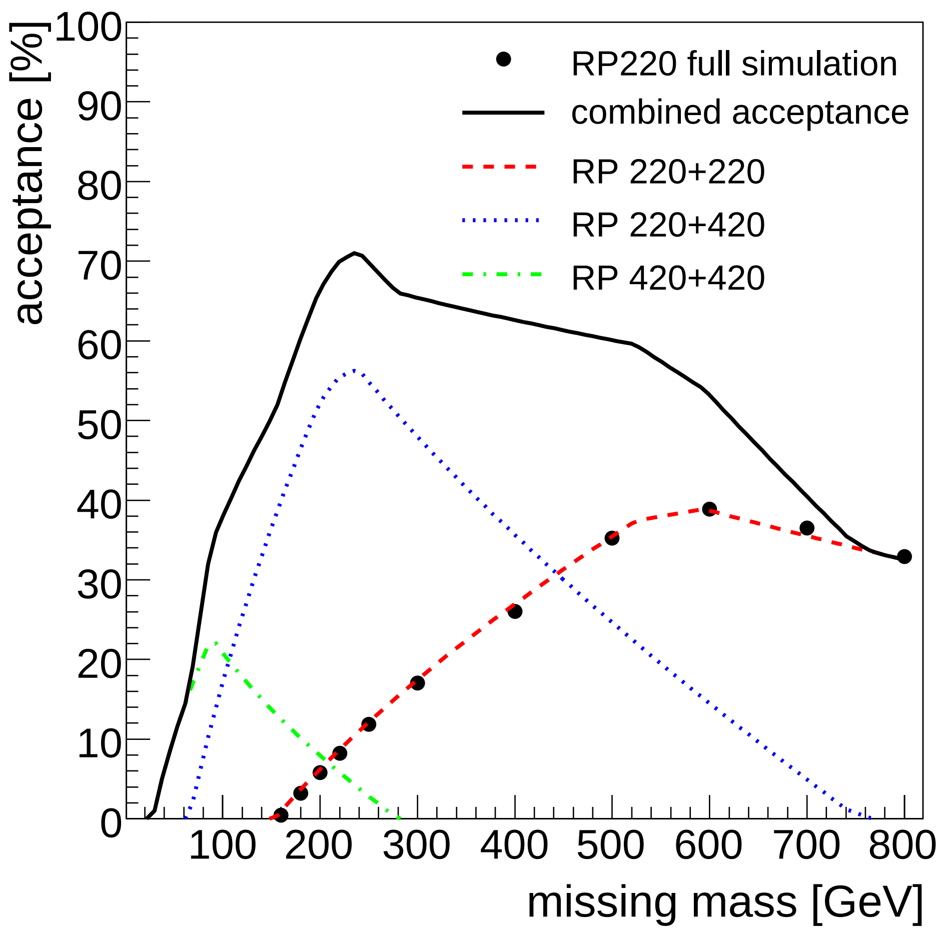
- Steps in ξ: 0.02 (left), 0.005 (right), $|t|$=0 or 0.05 GeV^2
- Detector of 2 cm $\times$ 2 cm will have an acceptance up to $\xi \sim 0.16$, down to 0.008 at 10 σ, 0.016 at 20 σ
- As an example Higgs mass acceptance using 220 m pots down to 135 GeV and upper limit due to cross section and not kinematics





Forward detector projects

Both FP420 and RP220 needed to have a good coverage of acceptance (NB: acceptance slightly smaller in CMS than in ATLAS)

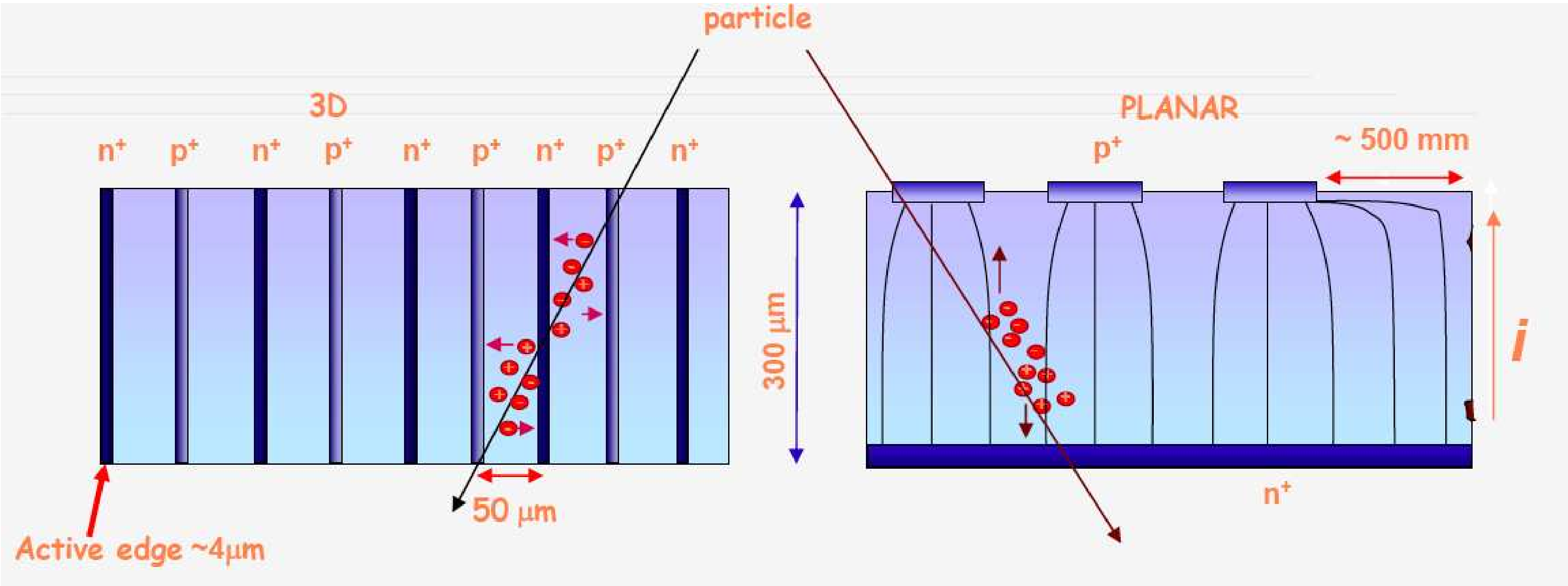


Which kind of detectors?

- Silicon detectors
  - Precise reconstruction of proton position, and then mass: position resolution of 10-15 μm
  - Radiation hardness
  - 3D Si detectors: 10 planes per supermodule, pixels of 50 $\times$ 400 μm; 10 layers
  - Modification of readout chip to include L1 trigger: address of vertical line hit to know ξ at L1
- Timing detectors
  - Why do we need timing detectors? At the LHC, up to 30 interactions by bunch crossing, and we need to identify from which vertex the protons are coming, same problem for FP420
  - Timing detector resolution needed: of the order of a couple of picoseconds
  - Detector space resolution: few mm, the total width of the detectors being 2.5 cm (4.5 cm available in roman pot)
- Same detectors at 220 and 420 m

3D Silicon detectors

3D Silicon detectors from Manchester (Cinzia Da Via) and SLAC: 3D active edge detectors vs planar ones

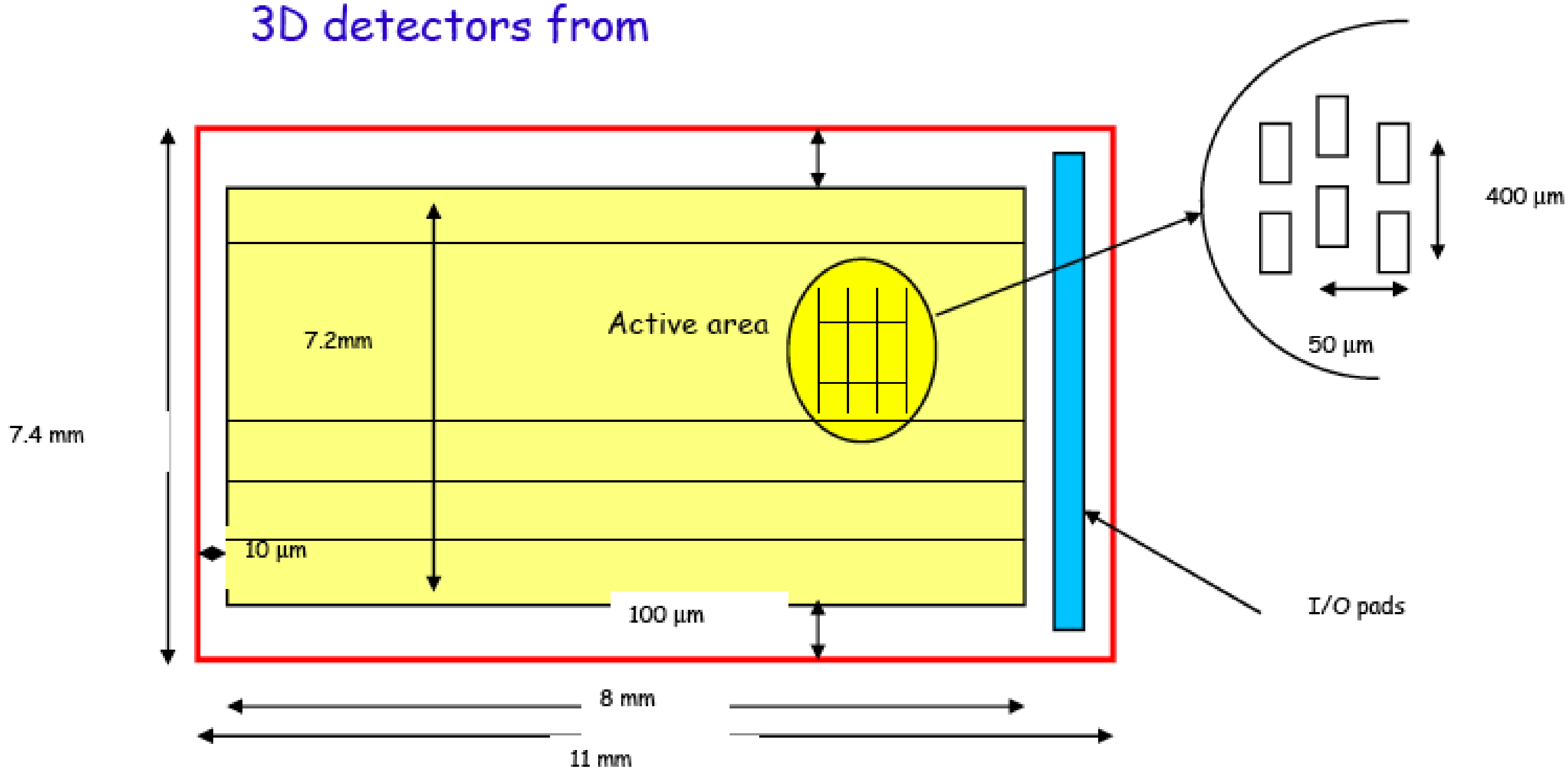


3D Silicon detectors

3D Silicon detectors from Manchester (Cinzia Da Via) and SLAC

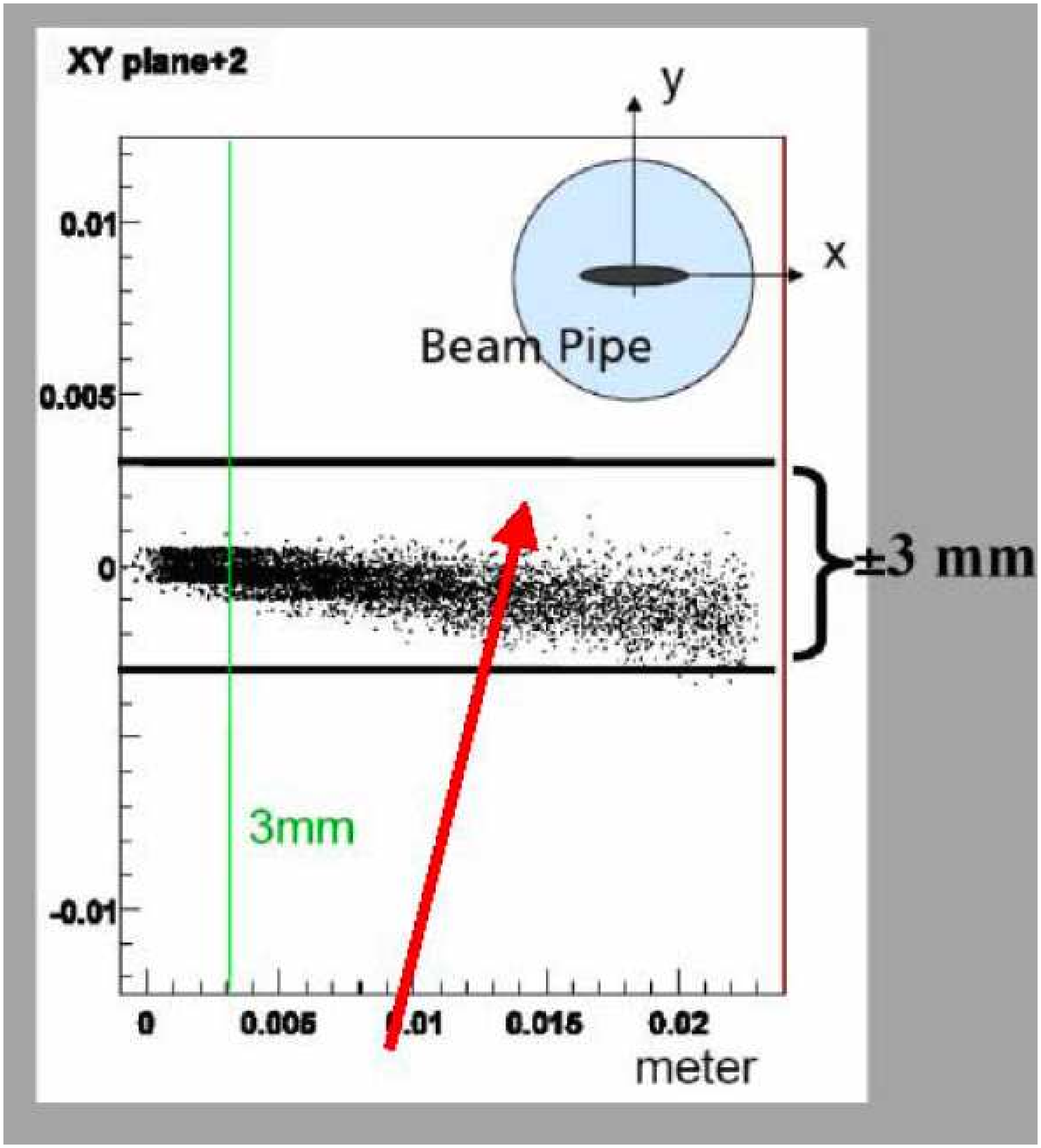
- 9 pairs of columns of 160 pixels 50 x 400 µm.
- 7.2 x 8 mm2 detector, 7.4 x 11 mm2 readout chip
- Thickness allows > 1.2 mm inter-layer distance

3D detectors from



3D Silicon detectors

3 "supermodules" of 3D Si detectors needed at 420 m

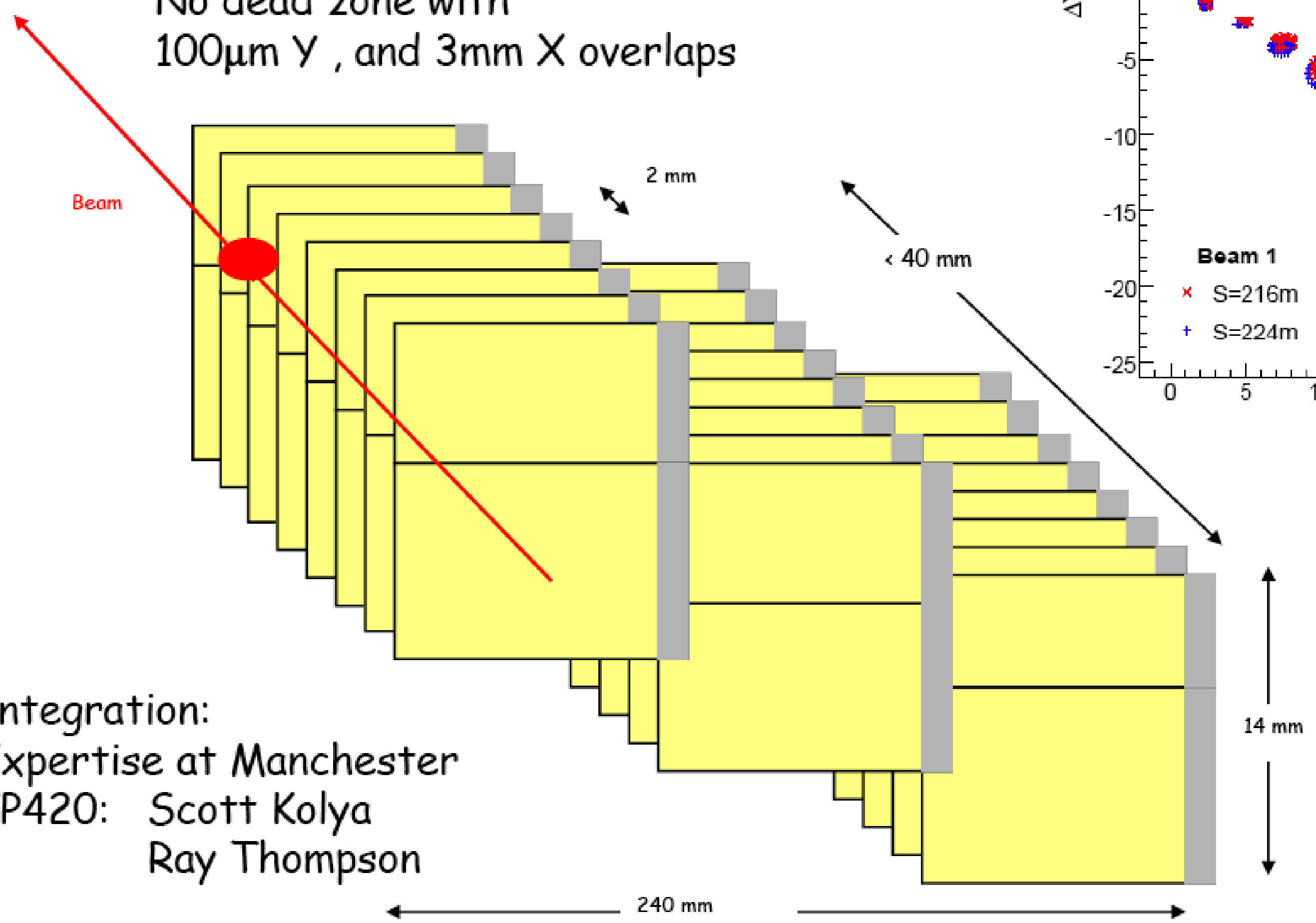


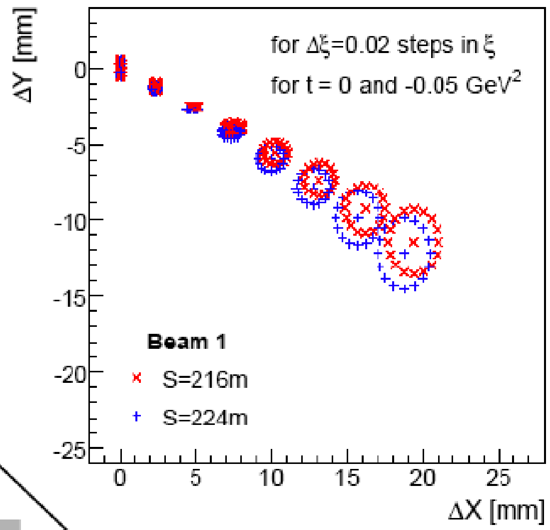
3D Silicon detectors

3D silicon detectors at 220 m: 6 supermodule per horizontal detector (in addition: 2 supermodules for vertical detectors in roman pots)

3D Detectors Layout for Horiz. Pots

Existing FP 420 modules
No dead zone with
100µm Y , and 3mm X overlaps

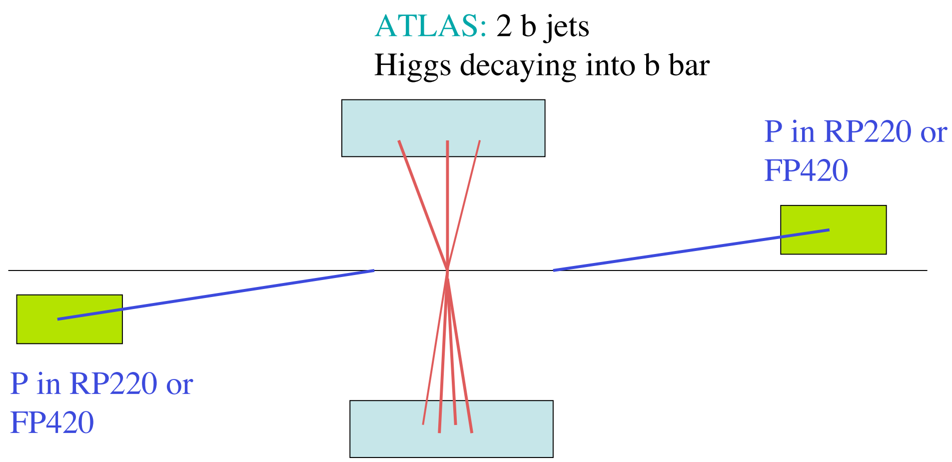


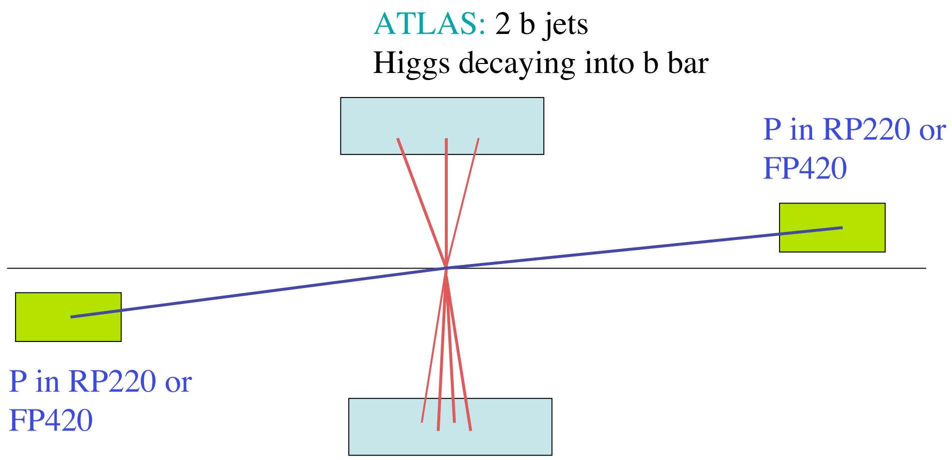


Integration:
Expertise at Manchester
FP420: Scott Kolya
Ray Thompson

Why do we need timing detectors?

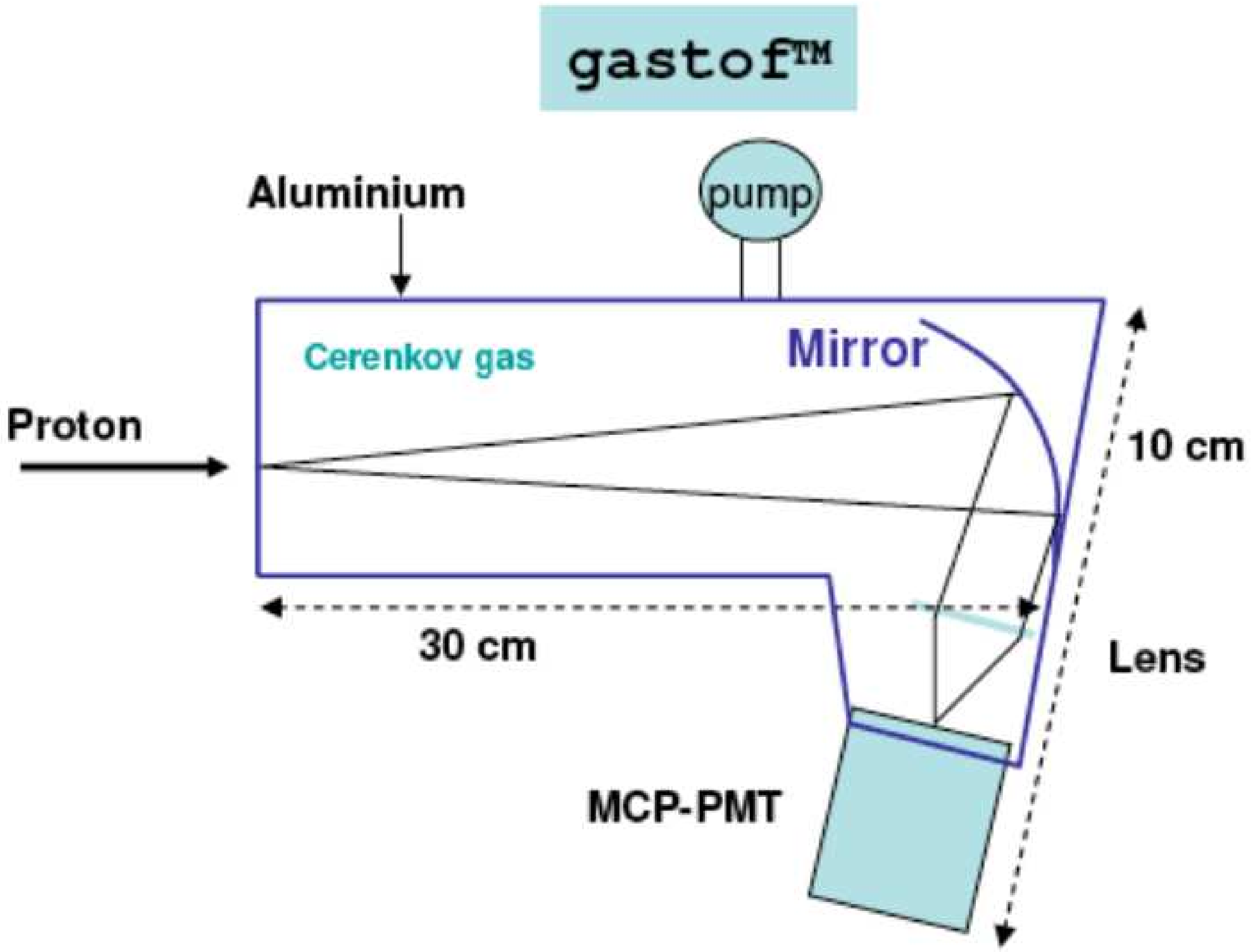
We want to find the events where the protons are related to Higgs production and not to another soft event (up to 35 events occuring at the same time at the LHC!!!!)





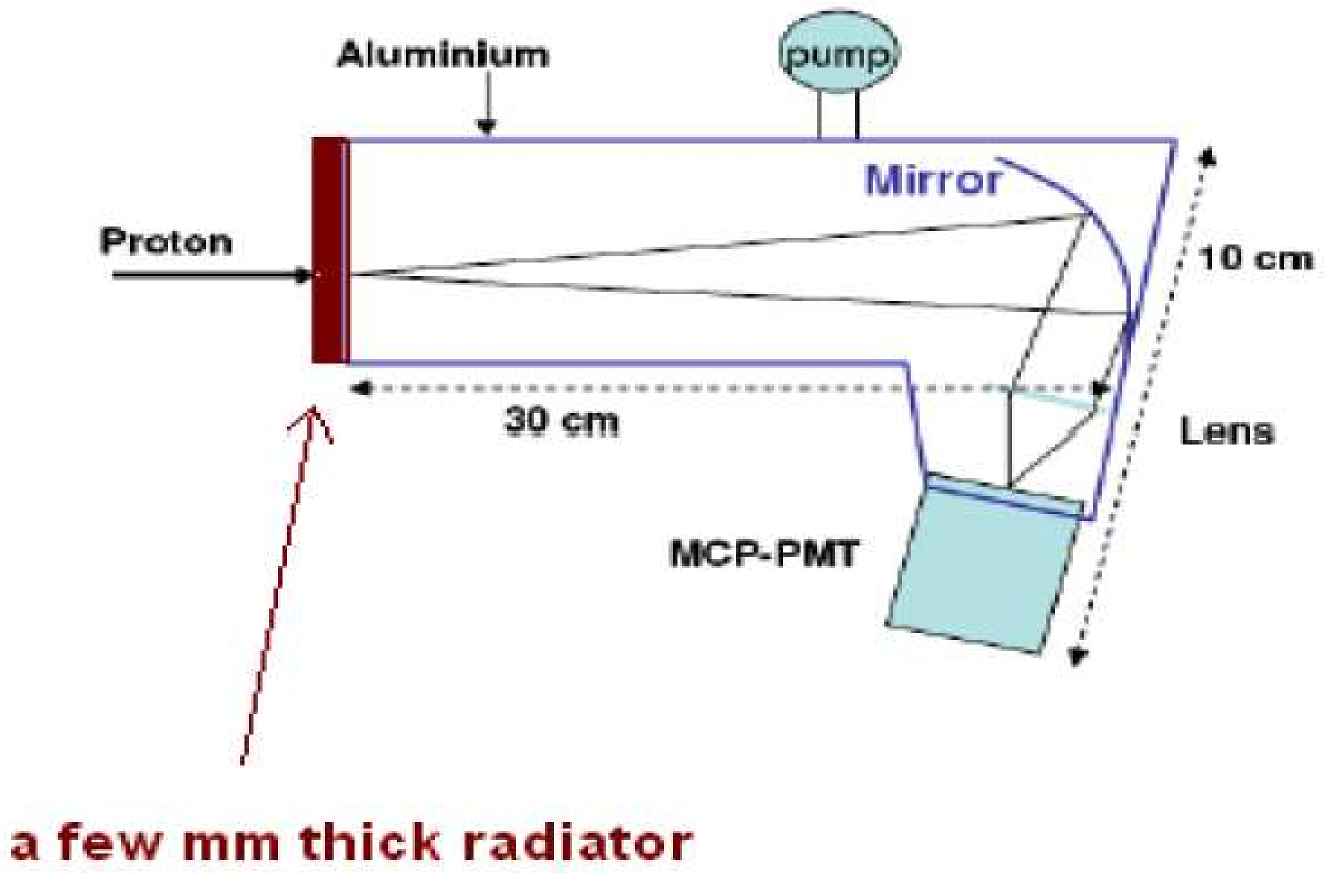
Timing measurements

- Possibility to get presently a timing resolution of $10-15$ ps using gas based detectors, and $30-40$ ps using quartz detector (Louvain, UTA, Alberta, Fermilab)
- Inconvenient of present gas detectors: no space resolution



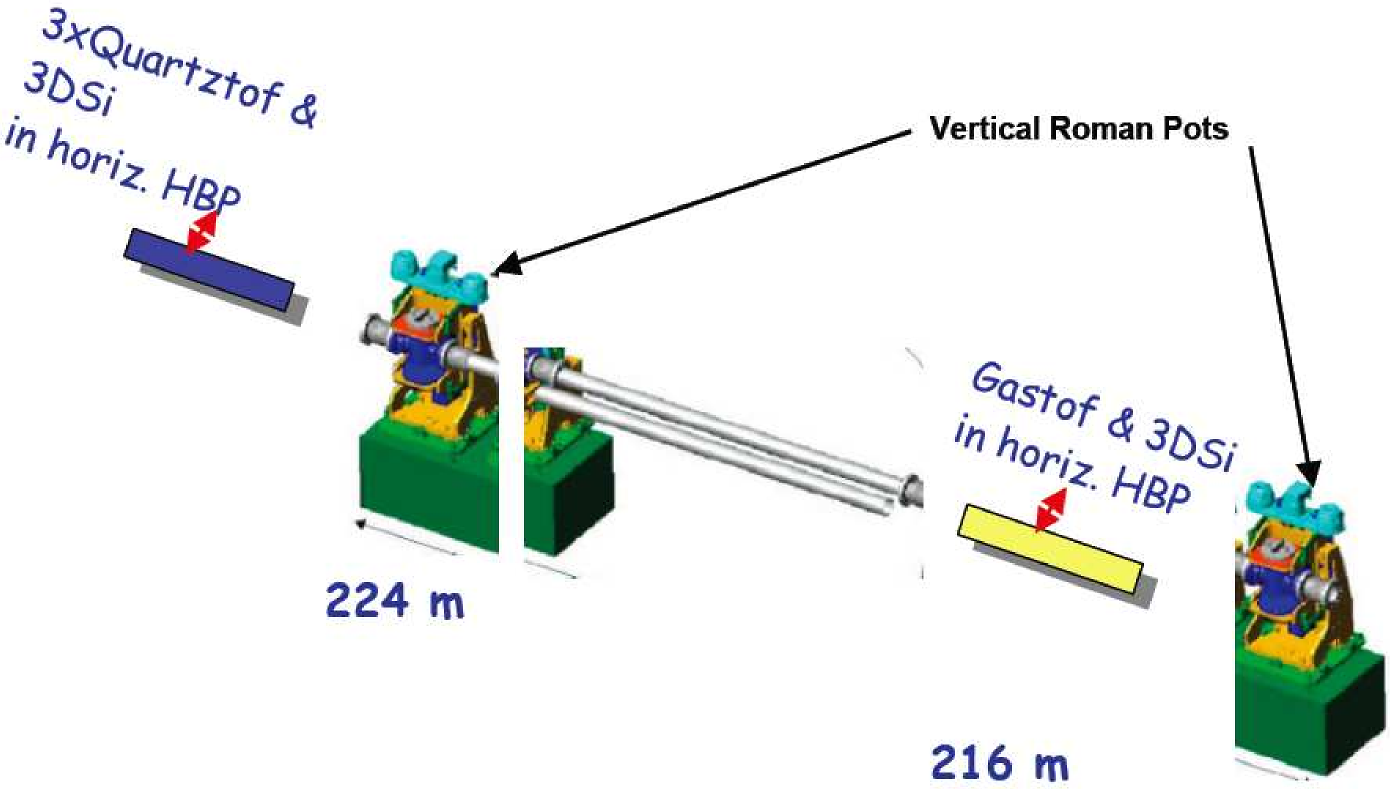
Future timing detectors: towards 1-2 ps

- Aim: reach a couple of picosecond precision
- Issue: number of photoelectrons to be produced to get enough resolution
- Solution: combination of GAS and QUARTZ detectors? (Louvain, UTA, Fermilab, Saclay, Stony Brook, Alberta, Chicago, Argonne...)

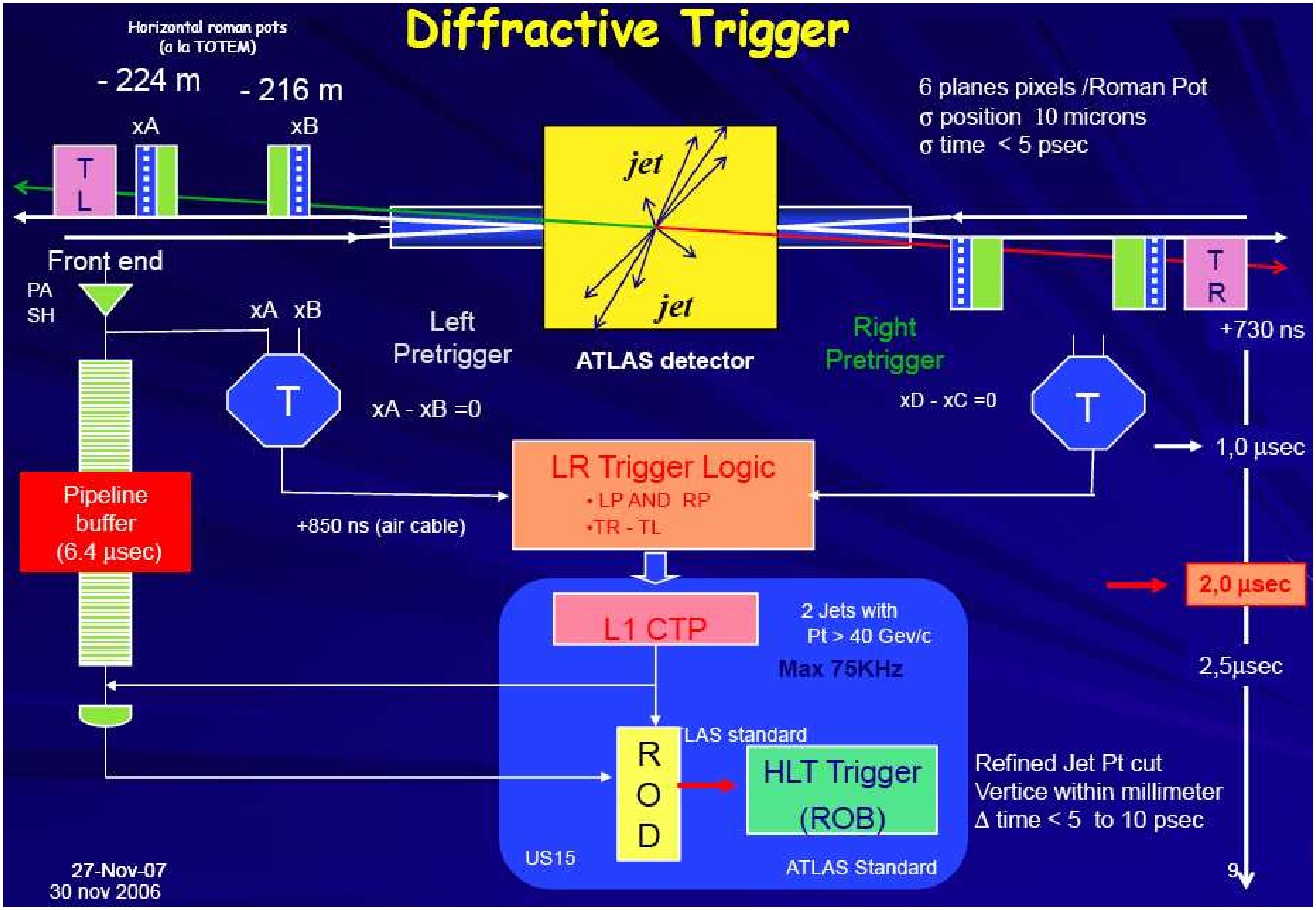


Movable beam pipe and roman pots at 220-420 m

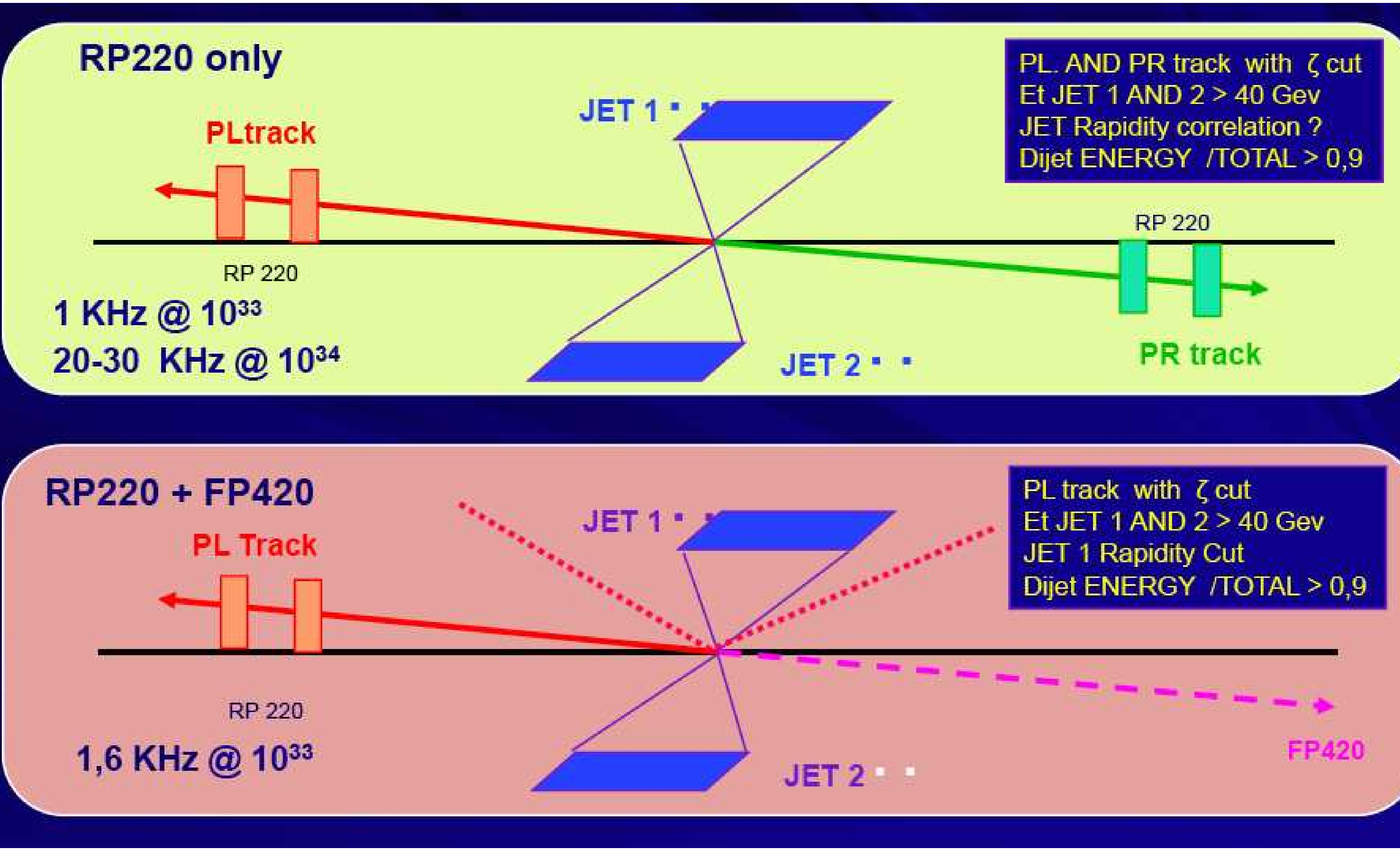
Scheme of the roman pots / movable beam pipes at 220 m



Trigger schematics



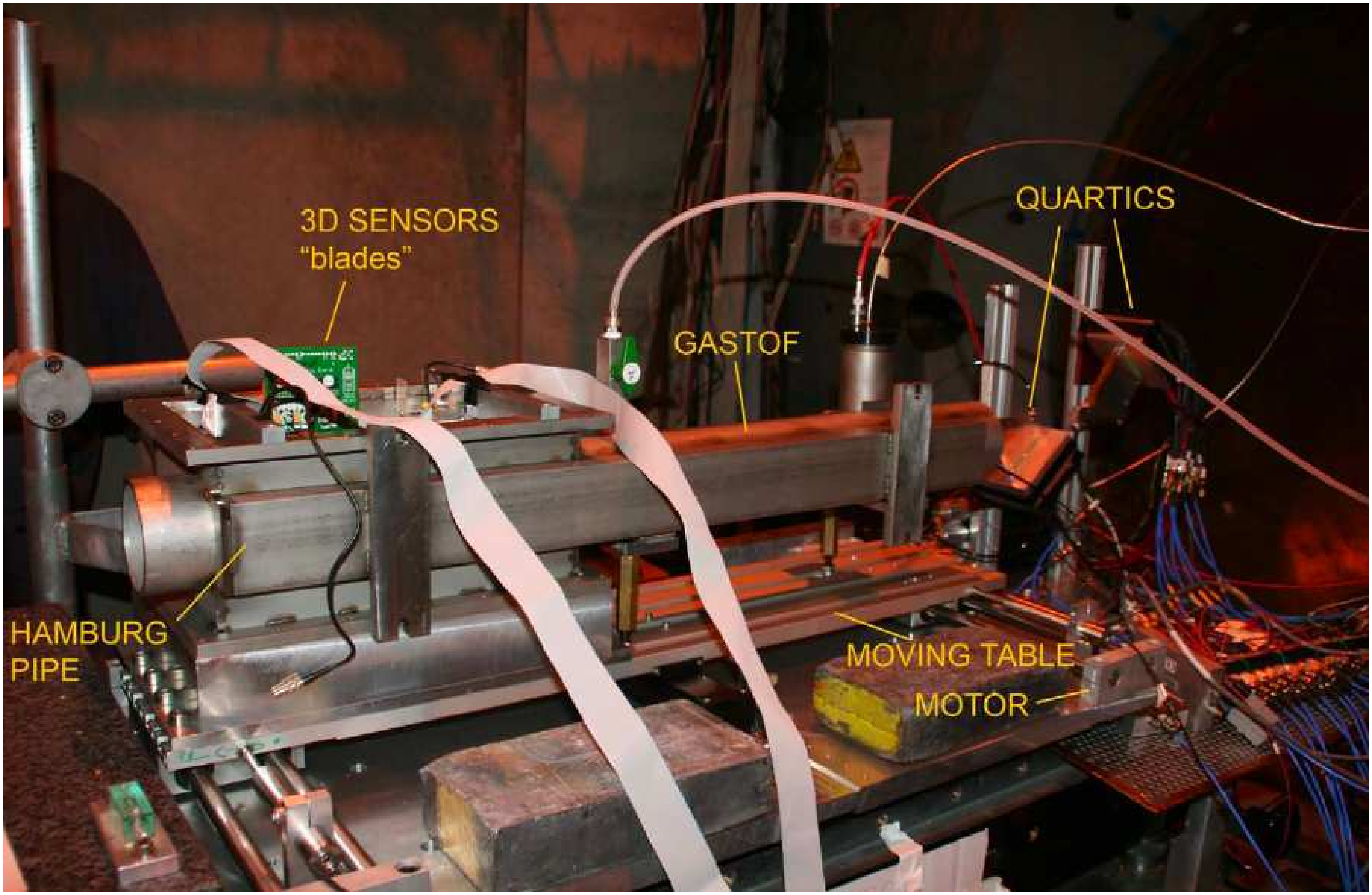
Trigger: principle



Trigger: strategy and rates

- L1 trigger when two protons tagged at 220 m
- L1 trigger when only one proton is tagged at 220 m: in that case, cut on acceptance at 220 m corresponding to the possibility of a tag at 420 m
- Cuts used:
  - 2 jets in central detector with $p_T > 40$ GeV
  - Exclusiveness of the process (2 jets carrying 90% of the energy) $(E_{T_1} + E_{T_2})/H_T > 0.9$
  - Kinematics requirement $(\eta_1 + \eta_2) \times \eta_{220} > 0$
  - At least one proton tagged at 220 m with $\xi < 0.05$ (compatible with the eventual presence of a proton at 420 m on the other side) **or** one proton tagged at 220 m on each side
- With those cuts, possibility to get a L1 rate less than 1 kHz for a luminosity less than 3.10^{33}cm^{-2} s^{-1}
- At Level 2: send timing information and combine it with vertex position: reduces the rates to a couple of Hz

Test beams at CERN/FERMILAB



Conclusion and timescale

- AFP project: roman pots and movable beam pipes needed at 220/420 m
- Position detectors to be used: 3D Silicon
- Timing detectors: High precision needed especially for high luminosity at the LHC (couple of picoseconds)
- Timescale: LOI to be presented in ATLAS in the beginning of July, followed by the comments from ATLAS referees, to be followed by LOI submission to LHCC if ATLAS agrees with the project, and TDR submission to ATLAS/LHCC in Winter timescale
- Test beams at Fermilab (June), CERN (June and September)
- Many topics to be studied at the LHC in diffraction: QCD, Higgs, SUSY...
- Many devolopments performed/in progress for the project and extremly useful for the future in particle physics or medical applications: 3D Si, timing detectors