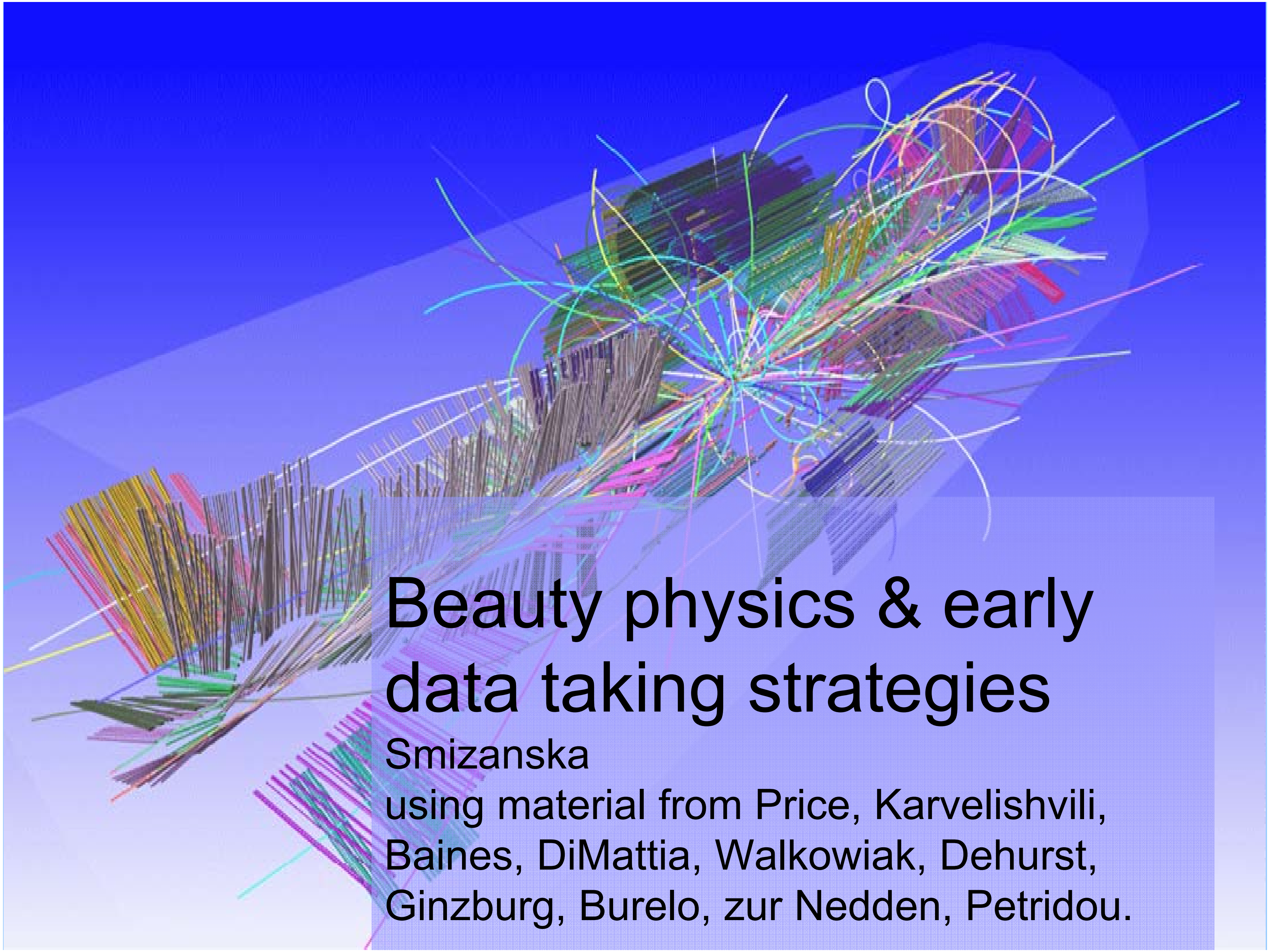


Beauty physics & early data taking strategies

Smizanska
using material from Price, Karvelishvili, Baines, DiMattia, Walkowiak, Dehurst, Ginzburg, Burelo, zur Nedden, Petridou.

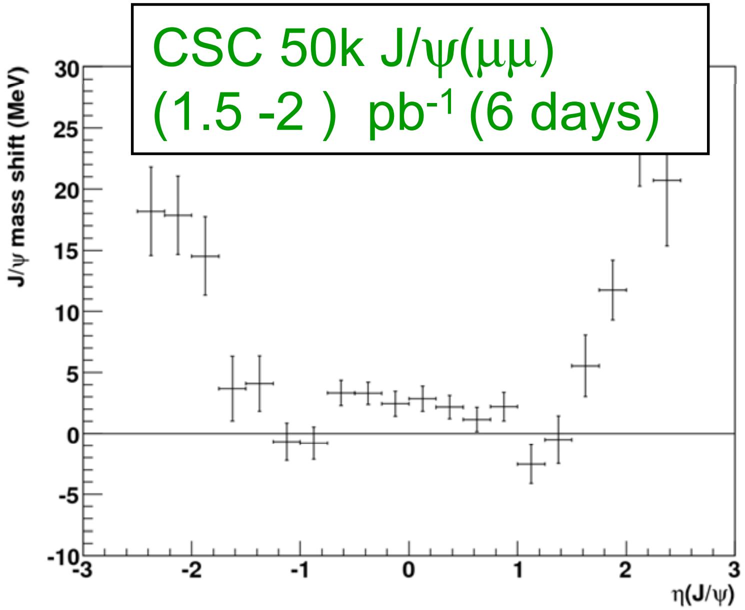
Introduction: B-physics at 10^{31}

- Beauty and Onia events to serve in detector and trigger calibrations.
  - J/ψ – L1 muon efficiency calibrations
  - J/ψ, Υ ($\mu\mu$) masses for offline (later HLT) ID and muon-combined reconstruction (material, field).
  - B life times since 10 pb-1 ID alignment sensitive tests

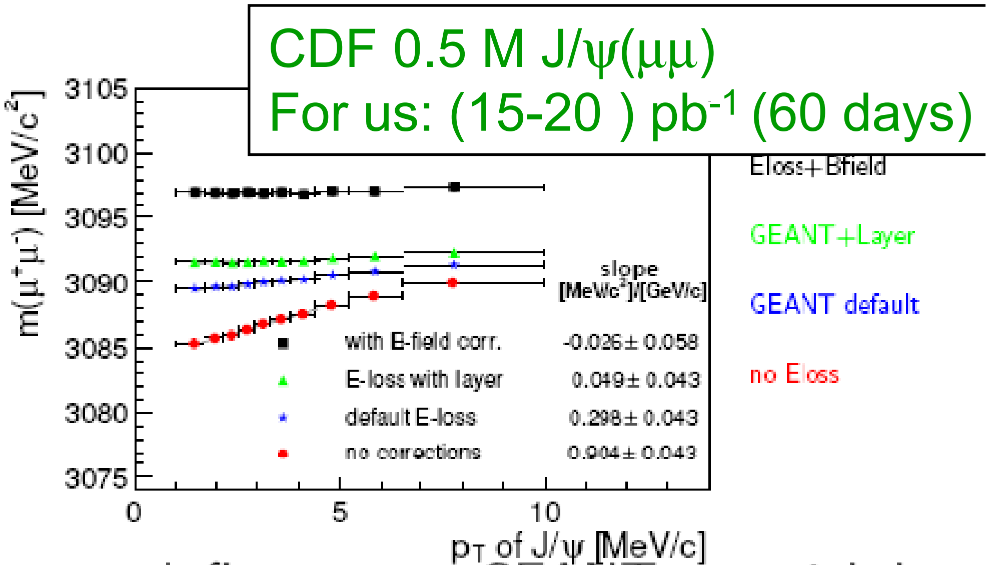
- Early measurements of (semi) inclusive muon, di-muon cross sections needed for HLT strategies
- Control signal channels for beauty measurements: $B^+ \rightarrow J/\psi K^+$, $B^0 \rightarrow J/\psi K^*$
- Strategies for future rare decays with di-muons, BSM discovery physics
- HLT algorithm tests for non di-muon B-channels.

Express stream

- We suggest J/ψ(μμ) and ϒ (μμ) to express stream.
  - Motivation: mass position, width – serve for ID calibrations (energy loss in material, magnetic field, alignment).
- How much statistics is needed and how much time will be needed to get it ? Can we get it in one express stream???



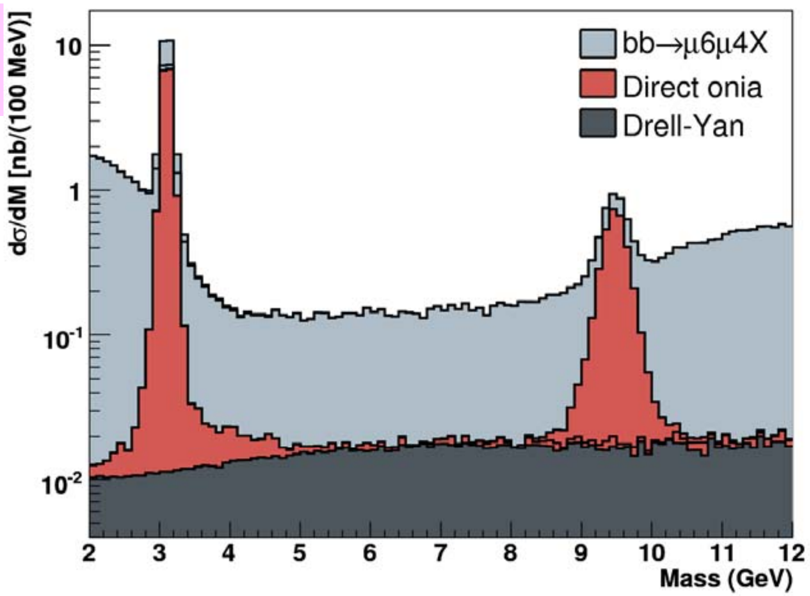
ATLAS CSC example: 50k events used to spot a wrong material description in muon reconstruction in release 12.0.6



CDF example: mass position pT dependence used to calculate corrections due to energy loss and mg field in ID. These corrections were then used for other particles.

Express stream: J/ψ

- 10 hours = 36000 s
  - this is after including a data taking efficiency (30%) and 10% for express stream, so we take all 36000 s in calculations



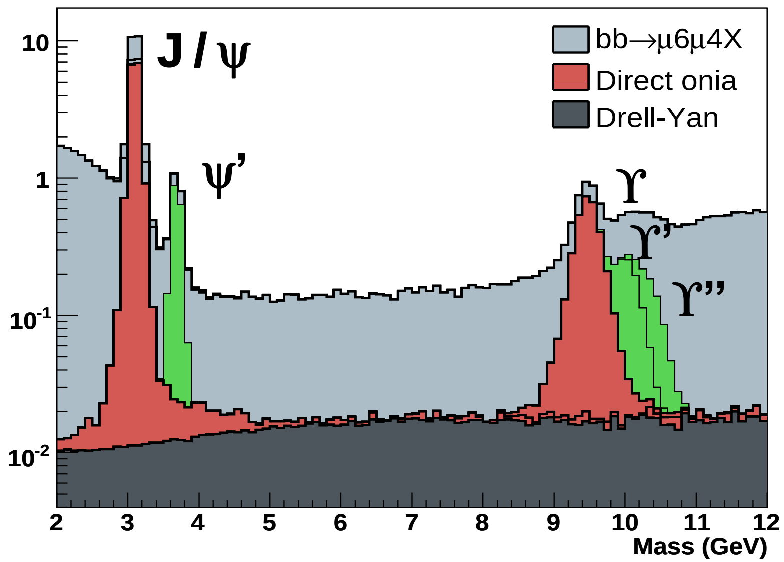
μ4 μ4 10 hours @ 10^{31}			
pp → J/ψ (μ4 μ4)	27 nb		14400 J/ψ
bb → J/ψ (μ4 μ4)	13 nb		
bb + DY background	4 nb		
All		0.44 Hz	15800

- This amount is suitable for monitoring of efficiency and **J/ψ** mass peak but not differential distributions.
  - Since it is only 0.44 Hz, maybe can run even as online monitoring(??)

Express stream-3 Υ ($\mu\mu$)

- Good to have another point higher in mass scale.
- mass resolution at Upsilon region σ =150 MeV – simultaneous mass fit to ϒ, ϒ', ϒ''

Sources of low invariant mass di-muons



μ4μ4			In express Stream 10 hours
ϒ (μ4μ4)	42 nb	0.42 Hz	15 120
ϒ', ϒ'' (μ4μ4)	20 nb	0.20 Hz	
bb + DY background	30 nb	0.30 Hz	
all	100 nb	1 Hz	36 000

Express stream: conclusions

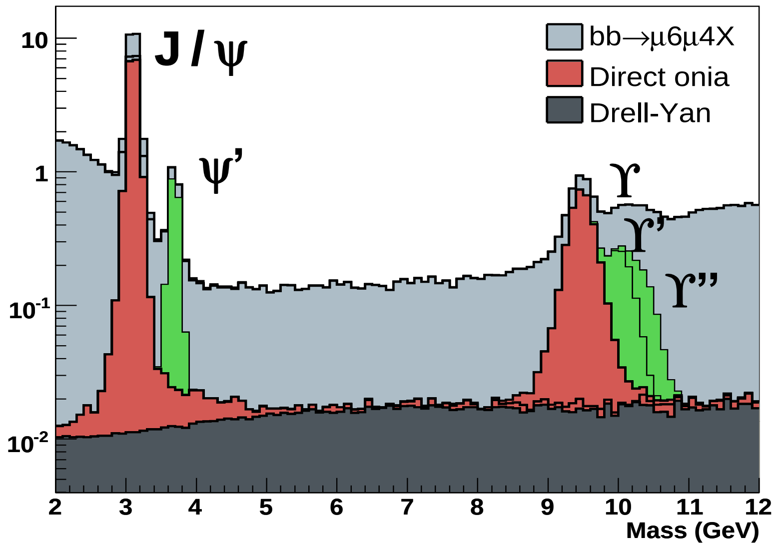
1. Statistics of $J/\psi(\mu\mu)$ and Υ $(\mu\mu)$ in express stream useful for global tests:
   - monitoring of efficiency, mass position and width.
2. But not sufficient for ID calibration studies
   - energy loss in material, magnetic field, alignment require higher statistics, differential distributions
3. This can only be taken in physics streams
   - that will allow to accumulate statistics.
   - allow enough time for analyzers – express stream data will be deleted – are only for fast tests not for calibrations

Early selections for B-physics: dimuon events

With early data: we should get an unbiased di-muon spectrum

- **Di-muon events is a rich ground for many calibrations and physics studies**
- **no HLT mass cuts to select J/ψ(μμ),ϒ (μμ) - all spectrum needed**
- **no vertex cuts at HLT! Until calibrated, validated (see further)**
- **Di-muon rates are moderate μ4μ4 6.7 Hz , μ6μ4 3.9 Hz –physics**
- **Instrumental backgrounds may give additional rates of this order, but can be resolved**

Sources of low invariant mass di-muons



- B-Lifetimes to test ID alignment, vertexing
- Direct-indirect J/ψ(μμ) to measure b-cross sections
- b-b̄ NLO QCD
- First checks of backgrounds for rare B-decays – below 3GeV and around 5 GeV

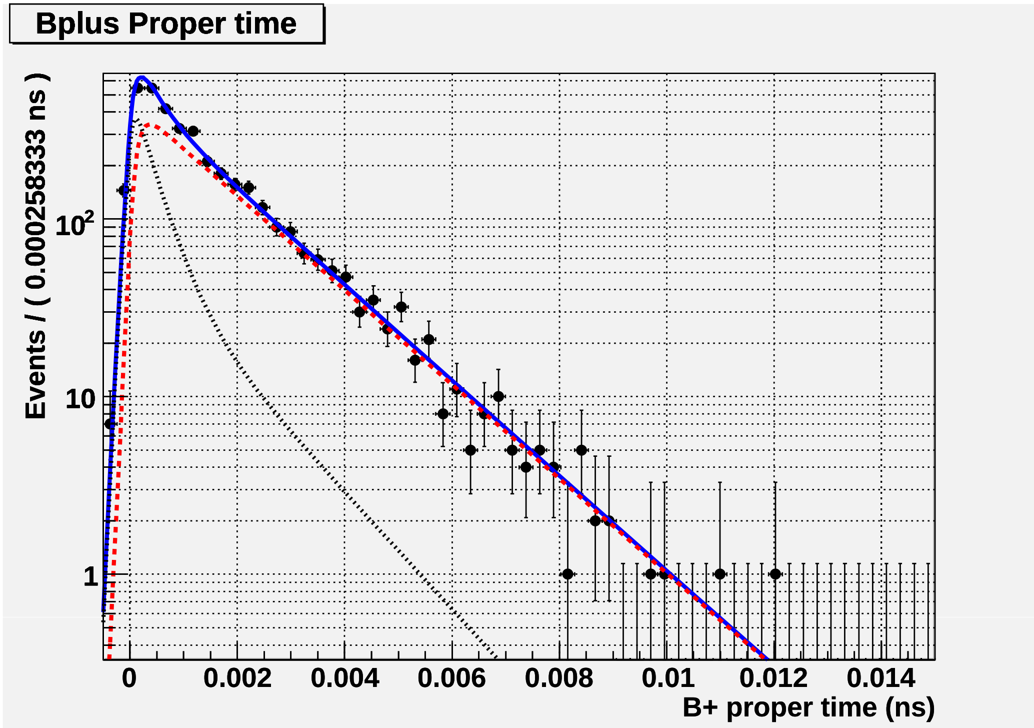
B-Lifetimes with early J/ψ data, test of ID alignment

- **With 10 pb-1 we start to be useful for alignment tests**
- **With 200 pb-1 we improve words precisions**

		Statistics with 10 pb-1	Life time Statistical error	World today (stat + syst)
B^+	$B^+ \to J/\psi K^+$	1600	2.2 %	0.67 %
B^0	$B^0 \to J/\psi K^{0*}$	900	3.1 %	0.9 %
		Statistics with 200 pb-1		
B^+	$B^+ \to J/\psi K^+$	32000	0.49 %	0.67 %
B^0	$B^0 \to J/\psi K^{0*}$	18000	0.69 %	0.9 %
B_s (single τ fit)	$B_s \to J/\psi \phi$	1800	4.2 %	2.7 %
Λ_b	$\Lambda_b \to J/\psi \Lambda$	520	5.8 %	5%

Performance control and reference channel $B^+ \to J/\psi K^+$

	$10pb^{-1}$	$100pb^{-1}$	$1fb^{-1}$
$B^{+}_{-} \to J/\psi K^+$	1598.5	15985	159850



B+ proper lifetime fit
red B+ signal, black background, blue all

- **B mass - lifetime fits – sensitive tests of detector alignments**
- **No vertex displacement cuts (especially online) until alignments perfectly understood and validated.**

Lifetime Fit Results		
Signal lifetime τ ps	1.637±0.036	(2.2%)
Bkg1 lifetime τ_1 ps	1.320±0.24	
Bkg2 lifetime τ_2 ps	0.370±0.067	

Table 11: Lifetime fit results based on a luminosity of $13.2pb^{-1}$

World precision today (0.67%)

Early selections for B-physics: single muon events

1. Low pT muon cross sections – predictions uncertain, calculations in progress, however theory stress: uncertainty ~2 possible, even if Tevatron cross sections now understood.
2. Main physics sources: pp $\rightarrow \mu$, bb $\rightarrow \mu$ X, cc $\rightarrow \mu$X Expected rates at 10^{31}
   - mu4 order of <1kHz
   - mu6 order of few 100 Hz.
3. Call for early cross section measurements to resolve HF contributions, from detector influenced sources, methods:
   - Muon pT relative to nearest jet
   - Inclusive Jpsi method – vertexing need to be in good shape. see comments at di-muon physics
   - With 10-30 pb-1 start with exclusive B-decay channels.
4. Early single muon events – important to test methods for non di-muon B-physics studies:
   1. BsDsπ – xs oscillations – can measure x_s already with 10 fb-1 if with mu6
   2. Rare radiative decays Bs- γ K0*
   3. B-Jpsi(ee)X not dominant but complementary method to B-Jpsi($\mu\mu$)X

Conclusions B-physics at 10^{31}

- J/ψ, Υ ($\mu\mu$) should be in express stream however can serve only for monitoring purposes, quick mass checks.
- For ID calibrations J/ψ, Υ ($\mu\mu$) in physics stream is needed: higher statistics, not deleted, long enough time for analyzers teams, can re-calibrate later.
- At 10^{31} single muon events (maybe prescaled) and di-muon events will be important ground for control and preparatory measurements, for cross section measurements.
- No HLT selections with early data, offline will be used to validate HLT algorithms.
- First new physics measurements possible : HF cross sections, Onia - since 10 pb-1, B-Lifetimes at world best since - 200 pb-1